Abstracts

16-Sep-13 09:00 – 10:30	Lecture Theatre

MOAL — Introduction and News
Chair: G. Rehm (Diamond)

Overview and Commissioning

MOAL1 09:10 20

Welcome and Overview of Accelerators in the UK

R.P. Walker *(Diamond)*

A warm welcome will be given to participants of the second International Beam Instrumentation Conference (IBIC 2013), hosted by Diamond Light Source. An attempt will be made to make an overview of accelerators in the UK, from their early origins to the present day and what might lie ahead in the future.

Time Resolved Diagnostics and Synchronization

MOAL2 09:30 20

First Demonstration of EOS 3D-BCD Monitor to Maximize 3D-Overlapping for HHG-Seeded FEL

H. Tomizawa*, T. Ishikawa, K. Ogawa, H. Tanaka, M. Yabashi (RIKEN SPring-8 Center) S. Matsubara, Y. Okayasu, T. Togashi (JASRI/SPring-8)*

In FEL seeding as a full-coherent light source, a high hit rate of successfully seeded FEL pulses is required. Precise measurements of the electron bunch charge distribution (BCD) and its arrival timing are crucial keys to maximize and keep 3D overlapping between the high-order harmonics (HH) laser pulse and electron bunch. We constructed a relative timing drift monitor based on EOS, which measured the timing differences between the seeding HH-laser pulse and the electron bunch, using a common external laser source of both HH-driving and EO-probing pulses. The feedback system of timing drift was realized with real-time data processing of EO-signal spectra. Our system realized stable seeded FEL operation with a hit rate of 30%. The 3D-BCD monitor enables non-destructive measurements of the longitudinal and transverse BCD at the same time. The transverse detection can be used to control the relative pointing between HH-pulse and electron bunch. We also verified this transverse detection with multiple EO crystals at the EUV-FEL accelerator. Our next target for temporal resolution is 30 fs, with an octave-band EO-probing for DAST crystals, aiming FEL seeding in the soft X-ray region.

MOAL3 09:50 20

Diagnostic for a High Repetition Rate Electron Photo-Gun and First Measurements

***D. Filippetto**, S. De Santis, L.R. Doolittle, G. Huang, W.E. Norum, G.J. Portmann, H.J. Qian, F. Sannibale, R.P. Wells (LBNL)*

The APEX electron source at LBNL combines the high-repetition-rate with the high beam brigthness typical of photo-guns, delivering low emittance electron pulses at MHz frequency. Proving the high beam quality of the beam is an essential step for the success of the experiment, opening the doors of the high average power to brightness-hungry applications as X-Ray FELs, MHz ultrafast electron diffraction etc. As first step, a full 6D characterization of the beam is foreseen at the Gun beam energy of 750 keV. Diagnostics for low and high current measurements have been installed and tested, and measurements of cathode lifetime and thermal emittance in a RF environment are currently being commissioned. The recently installed double slit system will allow the measurements of beam emittance at full current (mA). Also a deflecting cavity and a high precision spectrometer are foreseen at low energy, allowing the exploration of the longitudinal phase space. Here we discuss the present layout of the machine and future upgrades, showing the latest results at low and high repetition rate, together with the tools and techniques used.

Time Resolved Diagnostics and Synchronization

MOAL4 10:10 20

First Results from the Bunch Arrival-Time Monitor at the SwissFEL Test Injector

***V.R. Arsov**, A. Citterio, M.M. Dehler, S. Hunziker, M.G. Kaiser, V. Schlott (PSI)*

Non-destructive electron bunch arrival-time monitors (BAMs) with resolution <10 fs, sensitivity down to 10 pC and high intrinsic bandwidth for double bunch detection are required for reliable operation of SwissFEL. To achieve this ultimate goal, such a monitor based on a Mach-Zehnder electro-optical intensity modulator has been under development at the SwissFEL Test Injector. The high timing precision is derived by a stable pulsed optical reference system. The first BAM is located before the bunch compressor where the bunch energy is 230 MeV and the pulse length is approximately 3 ps. At this position, the bunch arrival time is sensitive to the laser- and gun timing. In this paper, we report on the commissioning of the RF- and optical front ends, the first arrival-time jitter and drift measurements with the entire system, as well as correlation of the arrival-time with different machine and environmental parameters. We achieve a resolution of 20 fs down to 60 pC.

16-Sep-13 11:00 – 12:30 Lecture Theatre

MOBL — Overview and Commissioning

Chair: S.R. Smith (SLAC)

Overview and Commissioning

MOBL1 11:00 40

Instrumentation and Results from the SwissFEL Injector Test Facility

R. Ischebeck *(PSI)*

The SwissFEL Injector Test Facility (SITF) has been equipped with numerous prototype diagnostics (BPMs, screen monitors, wire scanners, optical synchrotron radiation monitor, compression (THz) monitor, bunch arrival time monitor, EO spectral decoding monitor, charge and loss monitor) specifically designed for the low charge SwissFEL operation modes. The design of the diagnostics systems and recent measurement results will be presented.

MOBL2 11:40 20

Thermalized and Reaccelerated Beams at National Superconducting Cyclotron Laboratory

S.J. Williams*, A. Lapierre, D. Leitner, G. Perdikakis, S. Schwarz, C. Sumithrarachchi (NSCL) W. Wittmer (FRIB)*

The National Superconducting Cyclotron Laboratory at Michigan State University is a Radioactive Ion Beam (RIB) facility providing beams of exotic nuclear species through projectile fragmentation. The Coupled Cyclotron Facility accelerates stable ion beams to ~100 MeV/A which are then fragmented and selected with the A1900 separator. A recent addition to NSCL is the gas stopping facility which thermalizes the high energy beam. The RIBs are extracted at <60keV and selected by A/Q for further transport to the low energy areas, currently consisting of the BECOLA beam cooling and laser spectroscopy system, and LEBIT Penning trap. RIBs up to 6 MeV/A will be provided by the ReA post-accelerator, currently consisting of an EBIT, RFQ and superconducting RF cavities. Energies up to 1.5 MeV/A are presently available, and energy increases will be phased in with the addition of further cryomodules. In a campaign of commissioning experiments, RIBs from a fragmentation facility were thermalized and post-accelerated for the first time. Preliminary results will be presented, focussing on the diagnostic challenges of detecting and characterizing beams over a wide range of energy and rate.

MOBL3
12:00 20

Electron Bunch Diagnostic at the Upgraded ELBE Accelerator: Status and Challenges

M. Kuntzsch, *S. Findeisen, M. Gensch, B.W. Green, J. Hauser, S. Kovalev, U. Lehnert, P. Michel, F. Röser, Ch. Schneider, R. Schurig (HZDR) A. Al-Shemmary, M. Bousonville, M.K. Czwalinna, T. Golz, H. Schlarb, B. Schmidt, S. Schulz, N. Stojanovic, S. Vilcins (DESY) E. Hass (Uni HH) C.K. Kaya (Ankara University, Accelerator Technologies Institute)*

Within the ELBE upgrade towards a Center for High Power Radiation Sources (HSQ), a mono energetic positron, a liquid lead photo neutron source and two new THz sources have been installed at the superconducting electron linac at ELBE. A variety of established as well as newly developed electron beam diagnostics were installed and tested. In this paper we want to present first results achieved with the currently existing prototype beam arrival time and bunch compression monitors (BAM, BCM) as well as one versatile EOS set-up. Based on these future developements and upgrades are discussed.

16-Sep-13 14:00 – 15:30	Lecture Theatre

MOCL — Collider Specific Instrumentation
Chair: H. Schmickler (CERN)

Collider Specific Instrumentation

MOCL1 14:00 40

Beam Instrumentation in ATF2

S.T. Boogert *(JAI)* ***S.T. Boogert*** *(Royal Holloway, University of London)*

The Accelerator Test Facility 2 (ATF2) is a scaled demonstrator system for final focus beam lines of linear high energy colliders. Four OTR (Optical Transition Radiation) monitors have been installed at the ATF2. Major characteristics is the fast measurement of projected (2D) and intrinsic (4D) emittances and the coupling corrections with skew quadrupole magnets at the upstream. The high resolution cavity beam position monitor (BPM) system is a part of the ATF2 diagnostics. Two types of cavity BPMs are used, C-band operating at 6.426 GHz, and S-band at 2.888 GHz with an increased beam aperture. The resolution of the C-band system with attenuators was determined to be approximately 250 nm and 1 μm for the S-band system. Without attenuation the best recorded C-band cavity resolution was 27 nm. A laser-wire transverse electron beam size measurement system has been constructed and operated at the ATF2 beam line at KEK. A special set of electron beam optics was developed to generate an approximately 1μm vertical focus at the laser-wire location. Systematic measurements of a micron beam size have been successfully executed.

MOCL2 14:40 20

Design of a Novel Cherenkov Detector System for Machine Induced Background Monitoring in the CMS Cavern

S. Orfanelli*, A.E. Dabrowski, M. Giunta (CERN) M.J. Ambrose, A. Finkel, R. Rusack (University of Minnesota) D.P. Stickland (PU)*

A novel detector system has been designed for an efficient online measurement of the machine induced background in the CMS experimental cavern. The suppression of the CMS cavern background originating from pp collision products and the 25 ns bunch spacing have set the requirements for the detector design. Each detector unit will be a radiation hard, cylindrical Cherenkov radiator optically coupled to an ultra-fast UV-sensitive photomultiplier tube, providing a prompt, directionally sensitive measurement. Simulation and test beam measurements have shown the achievability of the goals that have driven the baseline design. The system will consist of 20 azimuthally distributed detectors per end, installed at a radius of r ~ 180 cm and a distance 20.6 m away from the CMS interaction region. The detector units will enable a measurement of the transverse distribution of the bunch-by-bunch machine induced background flux. This will provide important feedback from the CMS on the beam conditions during the LHC machine setup and comparisons to expectations based on FLUKA simulations.

MOCL3
15:00 20

Emittance and Momentum Diagnostics for Beams with Large Momentum Spread

M. Olvegård, *V.G. Ziemann (Uppsala University)*

In the drive beam complex of CLIC, but also in plasma wakefield accelerators, the momentum spread can be on the order of tens of percent while conventional diagnostic methods often assume a very small momentum spread. This leads to systematic misinterpretations of the measurements. Spectrometry and emittance measurements based on quadrupole scan rely on measuring the beam size, which depends on the beam envelope. This, in turn, depends on the momentum distribution. We have studied the systematic errors that arise and developed novel algorithms to correctly analyze these measurements for arbitrary momentum distributions. As an application we consider the CLIC drive beam decelerator, where extraction of up to 90% of the kinetic energy leads to a very large momentum spread. We study a measurement of the time-resolved momentum distribution, based on sweeping the beam in a circular pattern and recording the beam size on a screen using optical transition radiation. We present the algorithm to extract the time-resolved momentum distribution, together with simulation results to prove its applicability.

Overview and Commissioning

MOPC02 Status of Beam Diagnostics for NSLS-II Booster

V.V. Smaluk, *D. Padrazo, O. Singh, K. Vetter, G.M. Wang (BNL)*
E.A. Bekhtenev, S.E. Karnaev, G.V. Karpov, O.I. Meshkov (BINP SB RAS)

For the NSLS II third generation light source, a full-energy Booster ring has been designed and produced by Budker Institute of Nuclear Physics. For the Booster commissioning and operation, following beam diagnostic instruments have been designed and manufactured: 6 beam flags, 36 electrostatic pickups with BPM receivers, 2 synchrotron light monitors (SLMs), 1 DC current transformer, 1 fast current transformer, Tune Measurement System (TMS) including 2 strip-line assemblies. All the equipment has been installed in the Booster ring and Injector Service Area. Control software of the beam diagnostic devices has been developed and incorporated into the NSLS-II control system using the EPICS environment. A number of high-level applications has been developed using Control System Studio and Python. The Integrated Testing and the System Level Testing have been performed. Current status of the Booster beam diagnostic instrumentation is reviewed.

MOPC03 Overview of the ESS-Bilbao Mobile Diagnostics Test Stand

D. Belver, *I. Arredondo, I. Bustinduy, P. Echevarria, J. Feuchtwanger, Z. Izaola, J. Ortega Mintegui, S. Varnasseri (ESS Bilbao)*

A MObile diagnostics Test Stand (MOTS) is being designed at ESS-Bilbao in order to characterize the beam at the end of the Radio Frequency Quadrupole (RFQ) at 3 MeV. Injection of the beam from the RFQ to the Drift Tube Linac (DTL) tank and acceleration up to 12 MeV is a sensitive operation in the accelerating chain. The output beam of the RFQ should be fully characterized and tuned to optimize this operation. To perform this characterization the MOTS is being designed with a set of diagnostics devices to measure also beam parameters after the Medium Energy Beam Transport (MEBT), and with minor modifications after the first tank of the DTL. The most important beam parameters that will be measured with the test stand are the beam current, the beam energy and the energy spread. Other important parameters are the beam emittance, the transverse beam position and the profile and bunch length. This contribution describes the beam properties that will be measured and the corresponding instrumentation devices, and presents a general layout of the MOTS.

MOPC04 Electron Beam Collimation for Slice Diagnostics and Generation of Femtosecond Soft X-Ray Pulses from a Free Electron Laser

S. Di Mitri*, M. Bossi, D. Castronovo, I. Cudin, M. Ferianis, L. Fröhlich (Elettra-Sincrotrone Trieste S.C.p.A.)*

We present the experimental results of femtosecond slicing an ultra-relativistic, high brightness electron beam with a collimator*. We demonstrate that the collimation process preserves the slice beam quality, in agreement with our theoretical expectations, and that the collimation is compatible with the operation of a linear accelerator. Thus, it turns out to be a more compact and cheaper solution for electron slice diagnostics than commonly used radiofrequency deflecting cavities and having minimal impact on the machine design. The collimated beam can also be used for the generation of stable femtosecond soft x-ray pulses of tunable duration from a free electron laser.

* S. Di Mitri et al., Phys. Rev. Special Topics - Accel. Beams 16, 042801 (2013).

MOPC05 Beam Diagnostics of SuperKEKB Damping Ring

H. Ikeda*, A. Arinaga, J.W. Flanagan, H. Fukuma, H. Ishii, S. Kanaeda, K. Mori, M. Tejima, M. Tobiyama (KEK)*

The KEKB accelerator ceased operation in 2010, and is being upgraded to SuperKEKB. Adopting low emittance and high current beams, the design luminosity is set at 40 times larger than that of KEKB. We are constructing a damping ring (DR) in order to achieve a low-emittance positron beam for injection. Turn-by-turn beam position monitors (BPMs), a transverse feedback system, a synchrotron radiation monitor (SRM), a DCCT, loss monitors using ion chambers, a bunch current monitor and a tune meter will be installed for beam diagnostics at the DR. An overview of the instrumentation of the DR will be presented in this paper.

MOPC06 Beam Diagnostics System for a Photo-Neutron Source Driven by 15MeV Electron Linac

Y.B. Yan*, J. Chen, Z.C. Chen, Y.B. Leng, L.Y. Yu, W.M. Zhou (SINAP)*

A photo-neutron source driven by 15MeV electron LINAC is under construction at Shanghai Institute of Applied Physics (SINAP). Several kinds of beam monitors (BPM, Profile and ICT) have been installed. The stripline beam position monitor with eight electrodes was designed, also for energy spread measurement. Due to the multi-bunch operation mode, a custom RF front end was adopted, which down-converts the signal from 2856MHz to 500MHz and then brings it to Libera Single Pass E. The beam position monitor was based on the integrated step-servo motor and GigE Vision camera. For the beam charge measurement we used the ICT from Bergoz and scope from Agilent. The detail of the whole beam diagnostics system development will be reported in this paper.

MOPC07 **Design Considerations for a New Beam Diagnostics for Medical Electron Accelerators**

D. Vlad *(Siemens AG Healthcare, H CP CV - Components and Vacuum)*
M. Hänel (Siemens Healthcare)

A new beam diagnostics system is under construction at the Siemens Healthcare Sector facility in Rudolstadt, Germany. The project goal is to develop, commission and operate a beam diagnostics system to characterize the compact medical linear electron accelerators and help improve the quality of their output beam. A brief system description together with the main electron beam parameters is given. The diagnostics will allow the characterization of the compact linear accelerators by measuring beam intensity/charge using a toroid, transverse beam profile using scintillating screens and transverse beam emittance by means of the quadrupole scan method. In the longitudinal plane the energy and energy spread will be determined using a spectrometer magnet.

BPMs and Beam Stability

MOPC09 **Development of the Sirius RF BPM Electronics**

R.A. Baron*, F.H. Cardoso, S.R. Marques, J.L.B. Neto, L.M. Russo, D.O. Tavares (LNLS) A.P. Byszuk, G. Kasprowicz, A.J. Wojenski (Warsaw University of Technology, Institute of Electronic Systems)*

A BPM system has been developed for the new low emmitance 3 GeV Brazilian synchrotron light source, Sirius. The Sirius BPM electronics is a modular system based on a PICMG(R) MicroTCA.4 platform using ADC mezzanine cards in ANSI/VITA 57.1 FMC form factor and standalone RF front-end boards. It has been designed under the CERN Open Hardware License (OHL) in a collaboration between Brazilian Synchrotron Light Laboratory (LNLS) and Warsaw University of Technology (WUT). This paper presents: i) overall architecture of the BPM system; ii) performance evaluation of the first prototype of the BPM electronics comprehending beam current, filling pattern and temperature dependencies as well as resolution vs. beam current; and iii) preliminary results with beam at LNLS's UVX storage ring.

MOPC10 **X-ray Beam Position Monitor - from Photoemission Type to Diamond Detector**

P. Ilinski *(BNL)*

Optimization of blade type X-ray Beam Position Monitors (XBPM) was performed for NSLS-II undulator IVU20. Blade material, configuration and operation principle were analyzed. Optimization is based on calculation of the XBPM signal spatial distribution. Along with standard photo-emission blades, Diamond Detector Blade (DDB) was examined as XBPM signal source. Analyses revealed, that Diamond Detector Blade XBPM would allow to overcome drawbacks of the photo-emission type XBPMs.

MOPC11 **NSLS-II Feedback System Algorithms, Architecture and Implementation**

Y. Tian *(BNL)*

The stringent submicron beam stability specification for NSLS-II requires the orbit feedback system to be able to suppress disturbances from low frequency ground motion to relatively high frequency mechanical vibration. The fast orbit feedback system is a multiple-input and multiple-output (MIMO) system and each eigenmode may have a different frequency response. At NSLS-II, we have designed a novel approach to transfer the complicated MIMO system into many individual single input single output (SISO) problems. This enables us to measure the system character in both the time and frequency domains. It also enables us to design a different compensator for each eigenmode. In this paper, the architecture and implementation details are discussed. A fast and redundant serial device interface (SDI) link is designed to deliver all the BPM data around the storage ring. The large amount of orbit feedback calculations, including the decomposition of BPM data into eigenspace and different compensations for each eigenmode, is achieved by using the parallel calculation capability of field program gate arrays (FPGA).

MOPC12 **Development of the New Electronic Instrumentation for the LIPAc/IFMIF Beam Position Monitors**

A. Guirao*, L.M. Martinez Fresno, J. Molla, I. Podadera (CIEMAT)*

Among all the LIPAc/IFMIF accelerator diagnostics instrumentation, the Beam Position Monitors are a cornerstone for its operation. A new approach for the LIPAc/IFMIF beam position monitors acquisition electronics is proposed for the twenty BPM stations distributed along the accelerator. The new system under development is a fully digital instrumentation which incorporates automatic calibration of the monitors' signals and allows monitoring of both fundamental and second signal harmonics. The current state of the development and first experimental results of the system on the test bench will be presented.

MOPC13 **Design of Cold Beam Position Monitor for CADS Injector II Proton LINAC**

Y. Zhang*, X.C. Kang, M. Li, J.X. Wu, G. Zhu (IMP)*

Cold beam position monitor based on capacitive buttons are designed for Chinese Accelerator Driven System (CADS) Injector II proton LINAC. This LINAC is aiming to produce a maximum design current of 15 mA at the 10 MeV energy with an operating frequency of 162.5 MHz. Cold button BPM will be installed in the Cryomodule, which will be in the middle of the superconductor cavity and the superconductor magnet. Some special issues must be considered when designing a cold BPM: low-beta beam in the cryogenic environment, strong rf-field from the superconductor cavity and high magnetic field from the superconductor magnet. In this contribution, the status of cold BPM will be presented, focusing on the

electromagnetic response for low-beta beams and mechanical design in the cryogenic environment.

MOPC14 **Beam Position Monitors for keV Ion and Antiproton Beams**

S. Naveed, *J. Harasimowicz, A.A. Nosych, C.P. Welsch (Cockcroft Institute) J. Harasimowicz,* ***S. Naveed****, A.A. Nosych, C.P. Welsch (The University of Liverpool) A.A. Nosych, L. Søby (CERN)*

Beams of cooled antiprotons at keV energies shall be provided by the Ultra-low energy Storage Ring (USR) at the Facility for Low energy Antiproton and Ion Research (FLAIR) and the Extra Low ENergy Antiproton ring (ELENA) at CERN's Antiproton Decelerator (AD) facility. Both storage rings put challenging demands on the beam position monitoring system as their capacitive pick-ups should be capable of determining the beam position of beams at low intensities and low velocities, close to the noise level of state-of-the-art electronics. In this contribution we describe the design and anticipated performance of BPMs for low-energy ion beams on the examples of the USR and ELENA orbit measurement systems. We also present the particular challenges encountered in the numerical simulation of pickup response at very low beta values and describe an experimental setup realized at the Cockcroft Institute for BPM callibration. Finally, we provide an outlook on how the implementation of faster algorithms for the simulation of BPM characteristics could potentially help speed up such studies considerably.

MOPC16 **FPGA based Fast Orbit Feedback Data Acquisition System for Electron and Hadron Storage Rings**

G. Schünemann*, P. Hartmann, D. Schirmer, G. Schmidt, P. Towalski, T. Weis (DELTA)*

In the course of a BMBF supported development of a fast orbit feedback system for electron and hadron storage rings, in prospect of the upcoming FAIR facility, this paper presents the developed data acquisition system, based on Field Programmable Gateway Array (FPGA) technology, as well as the first results of in-situ measurements. Data was successfully taken at the TU-Dortmunds synchrotron light source DELTA as well as hadron storage rings COSY of the Forschungszentrum Jülich (FZJ) and SIS18 of the GSI Helmholtzzentrum für Schwerionenforschung GmbH (GSI).

MOPC17 **Calibration of a Non-Linear Beam Position Measurement System by Swapping Electrode Signals**

M. Gasior *(CERN)*

Button electrode signals from beam position monitors (BPMs) embedded into new LHC collimators will be individually processed with front-end electronics based on compensated diode detectors and digitized with 24-bit audio-range ADCs. This scheme allows sub-micrometre orbit resolution to be achieved with simple hardware and no external timing. As the diode detectors only operate in a linear regime with signals above a certain threshold, offset errors of the electronics cannot be calibrated in the classical way

with no input signal. This paper presents the algorithms used to calibrate offset and gain errors of these nonlinear electronic channels, showing examples based on beam measurements performed with prototype diode orbit systems at both the CERN SPS and LHC machines.

MOPC18 **Development of a Fast Time Resolution Beam Position Measurement System Using Logarithmic Amplifiers for the SPS at CERN**

***J.L. Gonzalez**, T.B. Bogey, C. Deplano, J.-J. Savioz (CERN)*

A new Front-End electronics, based on Logarithmic Amplifiers, is currently being developed for the CERN SPS Multi Orbit POsition System (MOPOS). The aim is to resolve the multi-batch structure of the beams and cope with their large intensity range (> 70 dB). Position and intensity signals are digitized in the Front-End electronics installed in the tunnel. The data are then transmitted over a serial fibre-optic link to a VME Digital Acquisition board located in surface buildings. A first prototype, equipped with a calibration system, has been successfully tested on the SPS under different beam conditions, including single bunch, 25ns and 50ns bunch trains. The system architecture and the first beam measurements are reported in this paper.

MOPC19 **Status of the Beam Position Monitors for LIPAc**

***I. Podadera** (CERN) F.M. De Aragon, A. Guirao, A. Lara, L.M. Martinez, J. Molla (CIEMAT)*

The LIPAc accelerator will be a 9 MeV, 125 mA CW deuteron accelerator which aims to validate the technology that will be used in the future IFMIF accelerator. Several types of Beam Position Monitors –BPM's- are placed in each section of the accelerator to ensure a good beam transport and minimize beam losses. Prototypes of almost all the BPM's have been already fabricated. Acceptance tests have been carried out on each device. The output of the vacuum leak tests and electrical tests will be analyzed in this contribution. In addition, the test bench to characterize the BPM's has been upgraded and validated using some prototypes in order to obtain a better global measurement accuracy of the electrical center offset. The test bench can be used to crosscheck the simulations with the real response of each BPM. The result of the comparison will be discussed in detail.

MOPC20 **Application of Metal-Semiconductor-Metal (MSM) Photodetectors for Transverse and Longitudinal Intra-Bunch Beam Diagnostics**

***R.J. Steinhagen** (CERN) M.J. Boland (SLSA) T.G. Lucas, R.P. Rassool (The University of Melbourne) T.M. Mitsuhashi (KEK)*

The performance reach of modern accelerators is often governed by the ability to reliably measure and control the beam stability. In high-brightness lepton and high-energy hadron accelerators the use of optical diagnostic techniques for this purpose is becoming more widespread as the required bandwidth, resolution and high RF beam power level involved limit the use of traditional electro-magnetic RF pick-up based methods. This contribution discusses the use of fibre-coupled ultra-fast

Metal-Semiconductor-Metal Photodetectors (MSM-PD) as an alternative, dependable means to measure signals deriving from electro-optical and synchrotron-light based diagnostics systems. It describes the beam studies performed at CERN's CLIC Test Facility (CTF3) and the Australian Synchrotron to assess the feasibility of this technology as a robust, wide-band and sensitive technique for measuring transverse intra-bunch and bunch-by-bunch beam oscillations, longitudinal beam profiles, un-bunched beam population and beam-halo profiles. The used amplification schemes, achieved sensitivities, linearity, and dynamic range of the detector setup are presented.

MOPC21 **Layout of the BPM System for p-LINAC at FAIR and the Digital Methods for Beam Position and Phase Monitoring**

M.H. Almalki, *G. Clemente, P. Forck, L. Groening, W. Kaufmann, P. Kowina, R. Singh (GSI) W. Ackermann (TEMF, TU Darmstadt)* ***M.H. Almalki*** *(IAP)* ***M.H. Almalki*** *(KACST) B.B. Baricevic, R. Hrovatin, P.L. Lemut, M. Znidarcic (I-Tech) C.S. Simon (CEA/DSM/IRFU)*

The planned Proton LINAC at the FAIR facility will provide a beam current from 35 to 70 mA accelerated to 70 MeV by novel CH-type DTLs. Four-fold button Beam Position Monitor (BPM) will be installed at 14 locations along the LINAC and some of these BPMs are mounted only about 40 mm upstream of the CH cavities. The coupling of the RF accelerating field to the BPMs installed close to the CH cavities was numerically investigated. For the digital signal processing using I/Q demodulation a 'Libera Single Pass H' is foreseen. The properties of this digitization and processing scheme were characterized by detailed lab-based tests. Moreover, the performance was investigated by a 80 μA Ne^{4+} beam at 1.4 MeV / u and compared to a time-domain approach and successive FFT calculation. In particular, concerning the phase determination significant deviations between the methods were observed and further investigations to understand the reason are ongoing.

MOPC22 **A New High-Dynamic Range BPM for ELBE with Integrated Differential Current Monitor (DCM)**

A. Büchner, *B. Lange (HZDR)*

ELBE is a LINAC electron accelerator for small energies (12 to 50 MeV). It serves as a beam source for many quite different experiments. The recent ELBE upgrade allows electron beams with bunches in the range of single electrons to 1 nC. The maximum beam current is 1.6 mA CW and the repetition rates covering the range from one shot single bunch pulses to 26 MHz CW. The existing BPMs and especially the DCMs which are used for the Machine Protection System cannot handle this wide parameter range. To improve this situation the development of new BPMs / DCMs was necessary. The DCMs measure the difference of the beam current between two stripline sensors and produce an interlock for differences greater 10 microamps. The new BPM electronics system has been designed including the DCM functionality because both BPMs and DCMs use the same stripline sensor signals at 1.3 GHz.

MOPC23 **Libera Brilliance$^+$ and Libera Single Pass E do Tango**

H. Kocevar, *T. Beltram, R. Hrovatin (I-Tech) V.H. Hardion (MAX-lab) P.L. Lemut (COBIK)*

This article describes the implementation of the Tango Device Server for the Libera Brilliance$^+$ and Libera Single Pass E beam position monitors. The Tango Device Server utilizes the Libera Base framework API and provides integration of the instrument into the Tango control system. The instruments' interface towards the control system strives for simplicity with just a handful of Tango Device server attributes, a practice already seen in the first-generation Libera instrument Tango Device Servers for the predecessors of the instruments under consideration. With the addition of the Tango Device Server, the Libera Brilliance$^+$ and Libera Single Pass E instruments are now ready for off-the-shelf integration into the Tango control system. Laboratories will be able to evaluate and integrate the instruments quickly and reliably. Tango Device Server code is implemented in C++ and runs on Tango release 7; however, forward-porting the code to Tango release 8 should be straightforward.

MOPC24 **Design Of The Stripline BPM For The Advanced Photoinjector Experiment**

S. De Santis, *M.J. Chin, D. Filippetto, W.E. Norum, Z. Paret, G.J. Portmann, F. Sannibale, R.P. Wells (LBNL)*

We describe the design, bench testing, and initial commissioning of the shorted striplines beam position monitors used in the Advanced Photoinjector Experiment (APEX) at Lawrence Berkeley National Laboratory. Our BPM's are characterized by extreme compactness, being designed to fit in the vacuum chamber of the quadrupole magnets, with only a short portion including the RF feedthroughs occupying additional beam pipe length. In this paper we illustrate the design process, which included extensive 3D computer simulations, the bench testing of prototype and final components, and the first measurements with beam. The readout electronics is also described.

MOPC25 **About BPM's to be Used for PAL-XFEL**

H. J. Choi, *H.-S. Kang, C. Kim, S.H. Kim, S.J. Lee, S.J. Park, H. Yang (PAL)*

Pohang Accelerator Laboratory (PAL) has been building the X-Ray Free Electron Laser (XFEL), a fourth-generation accelerator, and the construction will be complete in 2015. To successfully construct the XFEL, PAL built an injection test facility (ITF) in 2012, and the facility is in operation. The ITF examines the efficiency of various diagnostic units through extended tests. A BPM is a diagnostic unit that measures the position of an electron bunch. There are various kinds of BPM, and they have different merits and demerits. A user can select any kind of BPM that is appropriate for their purpose, and install it after going through various design and production

processes. In order to measure the position of an electron bunch, a cavity BPM is installed at an undulator of PAL-XFEL and a stripline BPM is installed at an accelerator. The efficiency of the stripline BPM was tested at the ITF. The X-band cavity BPM was produced and is being tested at the ITF. This paper aims to introduce the specification and properties of the cavity BPM and stripline BPM to be installed at PAL-XFEL, and explain the physical concept and the way of measuring necessary for designing a stripline pickup.

MOPC26 **Optimization of Bunch-to-Bunch Isolation in Instability Feedback Systems**

D. Teytelman *(Private Address)*

Bunch-by-bunch feedback formalism is a powerful tool for combating coupled-bunch instabilities in circular accelerators. Imperfections in the analog front and back ends lead to coupling between neighboring bunches. Such coupling limits system performance in both feedback and diagnostic capacities. In this paper, techniques for optimizing bunch-to-bunch isolation within the system will be presented. A new method for improving the performance of the existing systems will be described. The novel approach uses a "shaper" filter in the digital signal processor to compensate for the imperfect response of the power amplifier and kicker combination. An objective optimization method to derive the optimal back end configuration will be presented and illustrated with measurements from several accelerators.

MOPC27 **Cavity Beam Position Monitor System for ATF2**

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The Accelerator Test Facility 2 (ATF2) in KEK, Japan, is a prototype scaled demonstrator system for the final focus required for a future high energy lepton linear collider. The ATF2 beam-line is instrumented with a total of 38 C- and S- band resonant cavity beam position monitors (CBPM) with associated mixer electronics and digitizers. The current status of the BPM system is described, including a study of the CBPM performance over a three week period, including systematic effects such as charge, bunch length and beam offset dependence. The BPM system is routinely used for beam based alignment, wakefield kick measurements and dispersion measurements, the operational experience and example measurements are also reported.

MOPC28 **The Hardware Implementation of the CERN SPS Ultrafast Transverse Feedback Processor Demonstrator**

J.E. Dusatko*, J.M. Cesaratto, J.D. Fox, C.H. Rivetta (SLAC) W. Höfle (CERN)*

An ultrafast 4GSa/s transverse feedback processor has been developed for proof-of-concept studies of feedback control of e-cloud driven and transverse mode coupled intra-bunch instabilities in the CERN SPS. This system consists of a high-speed ADC on the front end and equally fast

DAC on the back end. All control and signal processing is implemented in FPGA logic. This system is capable of taking up to 16 sample slices across a single SPS bunch and processing each slice individually within a reconfigurable signal processor. This demonstrator system is a rapidly developed prototype, consisting of both commercial and custom-design components. It can stabilize the motion of a single particle bunch using closed loop feedback. The system can also run open loop as a high-speed arbitrary waveform generator and contains diagnostic features including a special ADC snapshot capture memory. This paper describes the overall system, the feedback processor and focuses on the hardware architecture, design and implementation.

MOPC29 **Realization of Transverse Feedback System for SIS18/100 using FPGA**

T. Rueckelt *(Technische Universität Darmstadt (TU Darmstadt), Signal Processing Group) M. Alhumaidi, A.M. Zoubir (TU Darmstadt)*

Higher beam intensities in particle accelerator are usually prevented by beam instabilities. To cure these instabilities, additional active system must be used besides passive damping. For this purpose, we have developed a distributed low-latency Transverse Feedback System (TFS) using FPGAs. Data acquisition takes place on multiple BPMs with individual FPGAs and ADCs around the accelerator ring. Acquired data is compressed and sent over broadband fiber optic wires to a central unit. For synchronization, data is tagged using timestamps from a reference time, which is distributed by a specially constrained network time protocol to obtain cycle accuracy. The central unit provides an FIR filter for system bandwidth limitation, and an adaptive IIR filter for stable beam signal rejection. Feedback is given using a linear combination of the pre-processed BPM signals. The system provides substantial flexibility, due to the possibility to configure most parameters online. Filters, feedback sources and parameters, compression rate and more can be adapted via Ethernet interface, which also supplies analysis data. First results are shown.

Time Resolved Diagnostics and Synchronization

MOPC31 **Streak Camera Imaging at ELSA**

M.T. Switka*, W. Hillert, M. Schedler, S. Zander (ELSA)*

The Electron Stretcher Facility ELSA provides polarized electrons with energies up to 3.2 GeV for external hadron experiments. In order to suffice the need of stored beam currents towards 200 mA, studies of instabilities and the effect of adequate countermeasures are essential for appropriate machine settings. For this purpose a new diagnostic beamline has been constructed. It is optimized for transverse and longitudinal streak camera measurements with time resolution down to one picosecond. Operation of the diagnostic beamline has recently started and first measurements are presented.

MOPC32 Development Status of Optical Synchronization for the XFEL

***C. Sydlo**, M.K. Czwalinna, M. Felber, C. Gerth, T. Lamb, H. Schlarb, S. Schulz, F. Zummack (DESY) S. Jabłoński (Warsaw University of Technology, Institute of Electronic Systems)*

Precise timing synchronization on the femtosecond timescale is crucial for time resolved experiments at modern free-electron lasers (FELs) like FLASH and the upcoming European XFEL. The required precision can only be achieved by a laser-based synchronization system. The pulsed laser-based scheme at FLASH, based on the distribution of femtosecond laser pulses over actively stabilized optical fibers, has evolved over the years from a prototype setup to a mature and reliable system. At the same time, the present implementation serves as prototype for the synchronization infrastructure at the European XFEL. Due to a factor of ten increase of the length of the accelerator and an increased number of timing-critical subsystems, new challenges arise. This paper reports on the current development progress of the XFEL optical synchronization, discusses major complications and their solutions.

MOPC33 Status of the Fiber Link Stabilization Units at FLASH

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State-of-the-art X-ray photon science with modern free-electron lasers (FEL) like FLASH and the upcoming European X-ray Free-Electron Laser Facility (XFEL) requires timing with femtosecond accuracy. For this purpose a sophisticated pulsed optical synchronization system distributes precise timing via length-stabilized fiber links throughout the entire FEL. Stations to be synchronized comprise bunch arrival time monitors, RF stations and optical cross-correlators for external lasers. The different requirements of all those stations have to be met by one optical link-stabilization-unit (LSU) design, compensating drifts and jitter in the distribution system down to a fs-level. Five years of LSU operation at FLASH have led to numerous enhancements resulting in an elaborate system. This paper presents these enhancements, their impact on synchronization performance and the latest state of the LSUs.

MOPC34 Longitudinal Beam Profile Monitor for Investigating the Microbunching Instability at Diamond Light Source

***W. Shields**, R. Bartolini, A.F.D. Morgan, G. Rehm (Diamond) R. Bartolini, P. Karataev (JAI) P. Karataev (Royal Holloway, University of London)*

An investigation into the microbunching instability at Diamond Light Source has recently been conducted. Beyond the instability threshold, the bunch emits bursts of coherent synchrotron radiation with wavelengths comparable to the bunch length or shorter. The operating conditions for producing the instability include both normal optics, and low-alpha optics, where the bunch length can be shortened to a few picoseconds. A Michelson interferometer has been designed and installed utilising a

silicon crystal wafer beamsplitter. Large bandwidth, room temperature pyroelectric detectors and low-noise, fast-response Schottky Barrier diode detectors have been employed to generate interferograms. In this paper, we describe the observed spectral content and the resulting calculated bunch length.

MOPC35 **A Beam-Synchronous Gated Peak-Detector for the LHC Beam Observation System**

T.E. Levens, *T. Bohl, U. Wehrle (CERN)*

Measurements of the bunch peak amplitude using the longitudinal wideband wall-current monitor are a vital tool used in the Large Hadron Collider (LHC) beam observation system. These peak-detected measurements can be used to diagnose bunch shape oscillations, for example coherent quadrupole oscillations, that occur at injection and during beam manipulations. Peak-detected Schottky diagnostics can also be used to obtain the synchrotron frequency distribution and other parameters from a bunched beam under stable conditions. For the LHC a beam-synchronous gated peak detector has been developed to allow individual bunches to be monitored without the influence of other bunches circulating in the machine. The requirement for the observation of both low intensity pilot bunches and high intensity for physics requires a detector front-end with a high bandwidth and a large dynamic range while the usage for Schottky measurements requires low noise electronics. This paper will present the design of this detector system as well as initial results obtained during the 2012-2013 LHC run.

MOPC36 **Optimization of a Non-Invasive Bunch Shape Monitor at GSI Ion LINAC**

P. Forck, *C. Dorn, O.K. Kester, P. Kowina, B. Zwicker (GSI) O.K. Kester (IAP)*

At the heavy ion LINAC at GSI, a novel scheme of non-invasive Bunch Shape Monitor has been tested with several ion beams at 11.4 MeV/u. The monitor's principle is based on the analysis of secondary electrons as liberated from the residual gas by the beam impact. These electrons are accelerated by an electrostatic field, transported through a sophisticated electrostatic energy analyzer and an RF-deflector, acting as a time-to-space converter. Finally a MCP amplifies electrons and with a CCD camera the electron distribution is detected. For the applied beam settings this Bunch Shape Monitor is able to obtain longitudinal profiles down to a width of 400 ps with a resolution of 50 ps, corresponding to 2 degree of the 108 MHz accelerating frequency. Systematic parameter studies for the device were performed to demonstrate the applicability and to determine its resolution. The achievements and ongoing improvements for the monitor are discussed.

MOPC37 **Longitudinal Bunch Profile Reconstruction Using Broadband Coherent Radiation at FLASH**

E. Hass *(Uni HH) C. Behrens, C. Gerth, B. Schmidt, M. Yan (DESY) S. Wesch (HZB)*

The required high peak current in free-electron lasers is realized by longitudinal compression of the electron bunches to sub-picosecond length. Measurement of the absolute spectral intensity of coherent radiation emitted by an electron bunch allows monitoring and reconstruction of the longitudinal bunch profile. To measure coherent radiation in the teraherz and infrared range a in-vacuum coherent radiation intensity spectrometer was developed for the free-electron laser in Hamburg(FLASH). The spectrometer is equipped with five consecutive dispersion gratings and 120 parallel readout channels: it can be operated either in short (5-44 um) or in long wavelength mode (45-430 um). Fast parallel readout permits the monitoring of coherent radiation from single electron bunches. Large wavelength coverage and superb absolute calibration of the device allows reconstruction of the longitudinal bunch profile using Kramers-Kronig based phase retrieval technique. The device is used as a bunch length monitor and tuning tool during routine operation at FLASH. Comparative measurements with radio-frequency transverse deflecting structure show excellent agreement of both methods.

MOPC38 **Overview on Electron Bunch and Photon Beam Diagnostic Techniques for CW Linear Accelerators Using the Example of ELBE**

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For future light sources a continuous wave mode of operation enables perspectives for high precision time-resolved experiments. In order to ensure steady experimental conditions, various elements for electron bunch and photon beam diagnostics are used. Bunch Arrival Time Monitors (BAM), Bunch Compression Monitors (BCM), Electro-optical Sampling (EOS) and new types of THz-diagnostic are essential for the understanding of the machine's behavior to generate stable secondary radiation. The detector readout benefits from the high repetition rate and allows data acquisition in frequency domain with enhanced sensitivity. The contribution will give an overview on CW Diagnostic elements at ELBE which are currently in commissioning state and first measurement results which have been carried out.

MOPC39 **Commissioning of the Streak Camera for TPS Project at TLS**

C.Y. Liao*, K.T. Hsu, K.H. Hu, C.H. Kuo, C.-C. Kuo, D. Lee, C.Y. Wu (NSRRC)*

Taiwan Photon Source (TPS) is a 3 GeV synchrotron light source which is being construction at campus of National Synchrotron Radiation Research Center (NSRRC) in Taiwan. A streak camera (C10910, Hamamatsu Photonics) equipped with 125/250 MHz synchroscan unit, fast/slow single

sweep unit, and dual-time sweep unit was chosen for studying the beam dynamics for the TPS project. An ultra short femtosecond Ti-Sapphire laser is used to evaluate the sub-picosecond temporal resolution of the streak camera. In addition, the first beam measurement of the streak camera at Taiwan Light Source (TLS) was performed successfully. The progress of the commissioning results is summarized in this report.

MOPC40 **Measurement of Longitudinal Bunch Profile and Twiss Parameters in SNS LINAC**

***A.V. Aleksandrov**, C. Huang, Y. Liu, A.P. Shishlo, A.P. Zhukov (ORNL)*

We are reporting on the latest progress in the longitudinal beam profile and emittance diagnostics development at SNS. In order to characterize the longitudinal phase space of the beam in the SNS 1GeV proton LINAC the bunch profile needs to be measured with a few picosecond resolution. The original SNS set of diagnostics included only four interceptive Feschenko-style longitudinal profile monitors in the normal conducting part of the LINAC at 100MeV. Two recently added systems are: a non-interceptive laser scanner in the injector at 2.5MeV and a novel non-interceptive method for longitudinal Twiss parameters measurement using the beam position monitors in the Super Conducting LINAC (SCL) at 300MeV. This paper presents details of these two diagnostics and discusses their performance, resolution limitations and future development plans.

MOPC41 **Engineering Design of the New LCLS X-band Transverse Deflecting Cavity**

***P. Krejcik**, E.L. Bong, M. Boyes, S. Condamoor, J.P. Eichner, G.L. Gassner, A.A. Haase, B. Hong, B. Morris, J.J. Olsen, D.W. Sprehn, J.W. Wang (SLAC)*

This paper describes the engineering design and installation of the new X-band transverse deflecting cavity installed downstream of the FEL undulator at the LCLS. This is a companion submission to the paper “Commissioning the New LCLS X-Band Transverse Deflecting Cavity with Femtosecond Resolution” also presented at this conference. The project dealt with the challenge of installing a new high-power RF system in the undulator tunnel of the LCLS, outside of the linac tunnel itself and its accelerator engineering infrastructure. A description of the system design, installation, alignment, cooling, controls, vacuum, waveguide, low level RF, klystron and modulator systems for the XTCAV is given, with emphasis on achieving the performance goals necessary to achieve femtosecond resolution.

MOPC42 **Novel Pickup for Bunch Arrival Time Monitor**

***A. Kalinin** (STFC/DL/ASTeC)*

For an optical-modulator-based BAM, main parameter of the pickup output signal is slope steepness. We suggest a novel pickup with flat thin electrodes in a transverse gap. Increasing the electrode width makes the steepness greater in the same extent as the signal increases. For a given width, reducing the electrode thickness allows to reach ultimate steepness.

Wave processes in the pickup were investigated on a large scale model, using the technique described in *. The DESY 40GHz button pickup was used as a reference. It is shown that steepness of the flat electrode pickup can be achieved two times greater. It is also shown that a BAM electrode pickup has a remarkable feature: the steepness does not depend on electrode sizes, if the ratio w/G (a flat electrode pickup, the width and gap length) or d/D (a button pickup, the diameters) is kept constant. This makes pickup bandwidth that is of the order of c over 2G or 2D, a free parameter. For flat electrode pickup, the steepness can be kept as high with transition to a more practical bandwidth 20GHz. The investigation results are the base for a final pickup optimisation using electrodynamic simulation.

* A. Kalinin, "Pickup Electrode Electrodynamics Investigation", WEPC26, this conference

Beam Loss Detection

MOPC43 Performance of Detectors using Diamond Sensors at LHC and CMS

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Diamond detectors are used as beam loss and luminosity monitors for CMS and LHC. A time resolution in the nanosecond range allows to detect beam losses and luminosities of single bunches. The radiation hardness and negligible temperature dependence allow the usage of diamond sensors in high radiation fields without cooling. Two different diamond detector types are installed at LHC and CMS. One is based on pCVD diamonds and installed at different locations in the LHC tunnel for beam loss monitoring. Measurements of these detectors are used to perform a bunch-by-bunch beam loss analysis. They allow to disentangle the origin of beam losses. The second type uses sCVD diamonds and is located inside CMS for van-der-Meer scan, beam halo and online luminosity monitoring and around the LHC tunnel for beam loss observation. Results on the performance of these detectors will be presented and examples of the use for analyzing the beam conditions will be given. In order to persist the enhanced requirements of the LHC after the long shutdown, e.g. higher luminosity, an upgrade of the detectors is required. The concept of the new detectors will be presented and first results will be shown.

MOPC44 A Gigabit Ethernet Link for an FPGA Based Beam Loss Measurement System

M. Kwiatkowski*, M. Alsdorf, B. Dehning, W. Viganò, C. Zamantzas (CERN)*

A new Beam Loss Measurement (BLM) system is under development at the European Organisation for Nuclear Research (CERN) within the LHC Injector Upgrade (LIU) project. The multi-channel system will measure the beam losses from various types of detectors with a high precision and wide dynamic range. Several modes of data acquisition are supported. The data rate in the single-channel mode is 16 Mbps and in the multi-channel mode 128 Mbps. The Gigabit Ethernet link is implemented in an FPGA, which

allows both a high throughput and a quick validation of the digital data processing algorithms using standard PCs in the initial stages of the development. Both TCP and UDP protocols were explored. The implementation of the Ethernet link is flexible and proved to be highly reliable, leading to its planned use in other measurement systems developed at CERN. The implementation details of the Ethernet link and the results achieved will be described in this paper.

MOPC45 A Prototype Readout System for the Diamond Beam Loss Monitors at LHC

***E. Effinger**, T. Baer, B. Dehning, R. Schmidt (CERN) E. Griesmayer (ATI) H. Helmut (FH WN) P. Kavrigin (CIVIDEC Instrumentation)*

Diamond Beam Loss Monitors are used at the LHC for the measurement of fast beam losses. Results from specimen LHC loss measurements are presented in this talk. The bunch-to-bunch loss measurements make full use of the fast signal response of the diamond detectors with 1 ns time resolution and 6.7 ns double pulse resolution. The data processing is done with a dedicated readout system, which was designed and optimized for particular applications with the diamond beam loss monitors. This FPGA-based system provides on-line, real-time, and dead-time-free data processing. Several examples are presented: the Time Loss Histogram with 1.6 ns binning provides beam loss measurements that are synchronized with the revolution period throughout the full operational LHC cycle. The Post Mortem Recorder with a sampling frequency of 1 GS/s allows beam-loss-based tune estimates for all bunches in parallel. Future applications and upgrades are discussed.

MOPC46 Integration of Halo Scraper Ring to Monitor Beam Loss at Low-Energy Heavy-Ion Accelerators

***Z. Liu**, J.L. Crisp, T. Russo, R.C. Webber, Y. Yamazaki, Y. Zhang (FRIB)*

It is always difficult to monitor the beam losses at low energy heavy ion or proton accelerators, where the low radiation levels and cavity X-ray background eliminate the effectiveness of ion chambers. We have developed the new functionality of loss scrapers to monitor the beam losses. By integrating this 'Halo Scraper Ring' with other loss monitors such as neutron detectors and temperature sensors, the beam losses can be efficiently monitored and manipulated for low energy heavy ion accelerators such as FRIB. A prototype was built and tested with ~12 MeV/u ion beams. The test results and conceptual data acquisition system is discussed.

MOPC47 Monte Carlo Simulations of Beam Losses in the Test Beam Line of CTF3

E. Nebot Del Busto, *S. Mallows, C.P. Welsch (The University of Liverpool)*
E. Branger (Linköping University) S. Döbert, E.B. Holzer, R.L. Lillestøl,
S. Mallows, ***E. Nebot Del Busto*** *(CERN) R.L. Lillestøl (University of Oslo)*
C.P. Welsch (Cockcroft Institute)

The Test Beam Line (TBL) of the CLIC Test Facility 3 (CTF3) aims to validate the drive beam deceleration concept of CLIC, in which the RF power requested to boost particles to multi-TeV energies is obtained via deceleration of a high current and low energy drive beam (DB). Despite a TBL beam energy (150-80 MeV) significantly lower than the minimum nominal energy of the CLIC DB (250 MeV), the pulse time structure of the TBL provides the opportunity to measure beam losses with CLIC-like DB timing conditions. In this contribution, a simulation study on the detection of beam losses along the TBL for the commissioning of the recently installed beam loss monitoring system is presented. The most likely loss locations during stable beam conditions are studied by considering the beam envelope defined by the FODO lattice as well as the emittance growth due to the deceleration process. Moreover, the optimization of potential detector locations is discussed. Several factors are considered, namely: the distance to the beam, the shielding provided by the different elements of the line, the detector sensitivity and possible saturation effects of both the radiation detectors and electronics.

Beam Profile Monitors

MOPF01 **Transverse Beam Size Measurements Using Interferometry at ALBA**

U. Iriso, *L. Torino (CELLS-ALBA Synchrotron) T.M. Mitsuhashi (KEK)*

Double-slit interferometry using visible light has been used for measuring the transverse beam size in different accelerators. The beam size is inferred from the analysis of the spatial coherence of the synchrotron light produced by a bending magnet. At ALBA, this technique has been implemented with moderate success, mainly limited by the present imperfections in the in-vacuum mirror that is used to extract the light out of the vacuum chamber. In this paper, we report the results obtained with the current set-up, and discuss possible improvements.

MOPF02 **The Wire Scanner Control Sytem for C-ADS Injector-II**

M. Li, *P. Li, R.S. Mao, J.X. Wu, Y.J. Yuan, J. Zhang, Y. Zhang (IMP)*

The C-ADS project is a strategic plan to solve the nuclear waste problem and the resource problem for nuclear power plants in China. The first step of this project is to build two 5-MeV test CW linac. The institute of Modern physics (IMP) is in charge of designing one of them. In order to measure the beam profile in this linac, a wire scanner system was designed and tested. In this paper, the mechanical design and control system of this wire scanner system are introduced. A real-time, closed loop control system is being developed and tested for more repeatable and accurate positioning of beam sense wires. All of the electronic and computational duties are handled in one the National Instruments compact RIO real-time chassis with a Field-Programmable Gate Array (FPGA). The beam test result of this system in IMP 320 KV beam line was present. The test result of this system and the measured beam profile result are discussed in this paper.

MOPF03 **Laser Diode Velocimeter-Monitor Based on Self-Mixing Technique**

A.S. Alexandrova, *C.P. Welsch (Cockcroft Institute)* ***A.S. Alexandrova***, *C.P. Welsch (The University of Liverpool)*

Gas targets are important for a number of accelerator-based applications, in particular as cold targets for collision experiments and beam diagnostics purposes where gas jets have been successfully used as least intrusive beam profile monitors, however, detailed information about the gas jet is important for its optimization and the quality of the beam profile that can be measured with it. A laser velocimeter shall be used for an in-detail characterization of atomic and molecular gas jets and allow investigations into the jet dynamics. Existing methods are currently not efficient enough, hard to build, and rather expensive. A laser velocimeter based on the self-mixing technique can provide unambiguous measurements from a single interferometric channel, realizable in a compact experimental setup that can be installed even in radiation-exposed environments. In this

contribution, an introduction to the underlying theory of self-mixing is given, before the design and functioning principle of the velocimeter is described in detail. Finally, preliminary experimental results with different solid targets are presented and an outlook on measurements with fluid and gaseous targets is given.

MOPF04 **Results of the High Resolution OTR Measurements at KEK and Comparison with Simulations**

***B. Bolzon**, C.P. Welsch (Cockcroft Institute) A.S. Aryshev (KEK) **B. Bolzon**, T. Lefèvre, S. Mazzoni (CERN) **B. Bolzon**, C.P. Welsch (The University of Liverpool) P. Karataev, K.O. Kruchinin (Royal Holloway, University of London) P. Karataev (JAI)*

Optical Transition Radiation (OTR) is emitted when a charged particle crosses the interface between two media with different dielectric properties. It has become a standard tool for beam imaging and transverse beam size measurements. At the KEK Accelerator Test Facility 2 (ATF2), OTR is used at the beginning of the final focus system to measure a micrometre beam size using the decrease in visibility of the OTR Point Spread Function (PSF). In order to study and improve the resolution of the optical system, a novel simulation tool has been developed in order to characterize the PSF in detail. Based on the physical optic propagation mode of ZEMAX, the propagation of the OTR electric field can be simulated very precisely up to the image plane, taking into account aberrations and diffraction coming through the designed optical system. This contribution will show the results of measurements performed after a first improvement of the ATF2 OTR optical design to confirm the very high resolution of the imaging system and the performance of this simulation tool.

MOPF05 **Operating Semiconductor Timepix Detector with Optical Readout in an Extremely Hostile Environment of Laser Plasma Acceleration Experiment**

***L. Pribyl** (Czech Republic Academy of Sciences, Institute of Physics)*

The laser plasma acceleration (LPA) experiments produce very intensive electromagnetic pulses (EMP) complicating operation of sensitive electronic detectors. We present our experience with new optical readout and EMP shielding for hybrid silicon pixel detector Timepix*, which enabled its operation in an extremely hostile electromagnetic LPA environment. The Timepix detector provides a matrix of 256x256 spectroscopic channels with 55 μm pitch. An optical readout, battery powering and shielding against electromagnetic pulses (EMP) have been developed as part of the ELI Beamlines/IEAP project for the detector Timepix and it significantly improved its resistance to EMP with respect to previous setup using metallic cables for both data acquisition and powering. The new optical setup was successfully tested under vacuum at Prague Asterix Laser System (PALS) during experiments with laser pulses of energies up to 700 J and duration of 350 ps bombarding thin foil solid target. Electromagnetic field was measured both outside the vacuum chamber and inside. The recorded

spectrometric data were analyzed and interpreted in a context of an independent experimental campaign run in parallel.

* X. Llopart et al.: Timepix, a 65k Programmable Pixel Readout Chip for Arrival Time, Energy and/or Photon Counting Measurements, Nucl. Instr. and Meth. in Phys. Res. A. Vol. 581 (2007), p485

MOPF06 **Beam Profile Monitors at REGAE**

H. Delsim-Hashemi, *K. Flöttmann (DESY) S. Bayesteh (Uni HH)*

A new linac is commissioned at DESY mainly as the electron source for femtosecond electron diffraction facility REGAE (Relativistic Electron Gun for Atomic Exploration). REGAE enables studies on structural dynamics of atomic transition states occurring in the sub-hundred femtosecond time-scale. REGAE comprises a photo-cathode gun followed by normal conducting 1.5 cell rf-cavity to provide sub pC electron-bunches of 2-5 MeV with a coherence length of 30nm. In order to produce and maintain such electron bunches, sophisticated single-shot diagnostics are desired e.g. emittance, energy, energy-spread and bunch-length measurement. REGAE rep-rate can be up to 50 Hz. This relatively high rep-rate makes it more challenging to deal with low intensity detection especially in single-shot mode. In this contribution the conceptual ideas, realization and results of transversal diagnostics will be presented.

MOPF07 **Turn by Turn Profile Monitors for the CERN SPS and LHC**

S. Burger, *A. Boccardi, E. Bravin, A. Goldblatt, A. Ravni, F. Roncarolo, R.S. Sautier (CERN)*

In order to preserve the transverse beam emittance along the acceleration chain it is important that the optics of the transfer lines is perfectly matched to the optics of the rings. Special monitors capable of measuring the beam profiles with a turn by turn resolution are very helpful in this respect. A new type of matching monitor has been developed at CERN for the SPS and LHC machines. This monitor relies on imaging OTR light by mean of a fast line scan CMOS and an asymmetric optical system based on cylindrical lenses. This contribution describes the design of this monitor, presents the results obtained during the 2012-13 run and outlines the plans for further improving the design.

MOPF08 **Design and Performance of the Upgraded LHC Synchrotron Light Monitor**

A. Goldblatt, *E. Bravin, F. Roncarolo, G. Trad (CERN)*

The LHC is equipped with two synchrotron radiation systems, one per beam, used to measure the transverse bunch distributions. The light emitted by a superconducting undulator and/or by a dipole magnet (depending on beam energy) is intercepted by an extraction mirror in vacuum and sent through a viewport to the imaging Beam Synchrotron Radiation Telescope (BSRT). The first version of the telescope, used from 2009 to mid 2012, was based on spherical focusing mirrors in order to minimize chromatic aberrations. However, this required a very complicated delay line in order

to switch the focus between the two different light sources as a function of beam energy. A new system based on optical lenses was designed and installed in mid 2012 in order to simplify the optical line and thus reduce misalignment and focusing errors. The first results with LHC beam using this new system showed a significant reduction in the correction factor required to match the emittance as measured by wire scanners. This contribution discusses the performance of the new optical system, presenting the LHC results and comparing simulations with measurement performed in the laboratory using a BSRT replica.

MOPF09 **A Gas-Jet Profile Monitor for the CLIC Drive Beam**

A. Jeff, *E.B. Holzer, T. Lefèvre (CERN)* ***A. Jeff***, *V. Tzoganis, C.P. Welsch (Cockcroft Institute)* ***A. Jeff***, *V. Tzoganis, C.P. Welsch (The University of Liverpool)*

The Compact LInear Collider (CLIC) will use a novel acceleration scheme in which energy extracted from a very intense beam of relatively low-energy electrons (the Drive Beam) is used to accelerate a lower intensity Main Beam to very high energy. The high intensity of the Drive Beam, with pulses of more than 10^{15} electrons, poses a challenge for conventional profile measurements such as wire scanners. Thus, new non-invasive profile measurements are being investigated. Profile monitors using gas ionisation or fluorescence have been used at a number of accelerators. Typically, extra gas must be injected at the monitor and the rise in pressure spreads some distance down the beampipe. In contrast, a gas jet can be fired across the beam into a receiving chamber, with little gas escaping into the rest of the beam pipe. In addition, a gas jet shaped into a thin plane can be used like a screen on which the beam cross-section is imaged. In this paper we present some arrangements for the generation of such a jet. In addition to jet shaping using nozzles and skimmers, we propose a new scheme to use matter-wave interference with a Fresnel Zone Plate to bring an atomic jet to a narrow focus.

MOPF10 **Off-Axis Undulator Radiation for CLIC Drive Beam Diagnostics**

A. Jeff, *T. Lefèvre (CERN)* ***A. Jeff***, *C.P. Welsch (Cockcroft Institute)* ***A. Jeff***, *C.P. Welsch (The University of Liverpool)*

The Compact LInear Collider (CLIC) will use a novel acceleration scheme in which energy extracted from a very intense beam of relatively low-energy electrons (the Drive Beam) is used to accelerate a lower intensity Main Beam to very high energy. The high intensity of the Drive Beam, with pulses of more than 10^{15} electrons, poses a challenge for conventional profile measurements such as wire scanners. Thus, new non-invasive profile measurements are being investigated. In this paper we propose the use of relatively inexpensive permanent-magnet undulators to generate off-axis visible Synchrotron Radiation from the CLIC Drive Beam. The field strength and period length of the undulator should be designed such that the on-axis undulator wavelength is in the ultra-violet. A smaller but still useable amount of visible light is then generated in a hollow cone. This light can be reflected out of the beam pipe by a ring-shaped mirror placed downstream and imaged on a camera. In this contribution, results of SRW and ZEMAX simulations using the CLIC Drive Beam parameters are shown.

MOPF12 **Turn-by-Turn Measurement of the Transverse Size and Shape of the Injected Beam in the ESRF Storage Ring**

***K.B. Scheidt**, N. Carmignani, A. Franchi, S.M. Liuzzo (ESRF)*

The single turn measurement of the injected beam shape and size is now possible through the use of visible synchrotron light combined with a fast gateable intensifier, which can be triggered on any of the desired orbit turns after injection. The 0.86T dipole is the source of the synchrotron light of which typically 10mrad horizontally and 4 mrad vertically are extracted via only two mirrors. This light is directed into a permanently accessible optics lab to the single achromat optics at 8 meters from the source point, followed by the intensifier and camera. Measurements can be repeated at 1Hz injection rate, when an automatic system of beam dumping of the stored beam, from the previous injection, has been put in place. This same system then also takes care of incrementing the next turn number to be measured. The results obtained with this system have been compared with multi-particle simulations: The observed filamentation of the beam profile is correlated to the amplitude dependent detuning with the beam being injected off axis. This paper presents both the functional aspects of the system, its results for different lattice optics, and the comparison with theoretical simulations.

MOPF13 **Transverse Beam Profiling for FAIR**

***M. Schwickert**, C.A. Andre, F. Becker, P. Forck, T. Giacomini, E. Gütlich, T. Hoffmann, A. Lieberwirth, S. Löchner, A. Reiter, B. Voss, B. Walasek-Höhne, M. Witthaus (GSI)*

The FAIR facility will provide intense primary beams of protons and heavy ions, or secondary beams of antiproton and rare isotopes. The operation includes fixed-target experiments or subsequent facilities of independent storage rings and experiment beam lines. The particle beams greatly differ in ion species, intensity, time structure, spot size and stopping power. Therefore, transverse beam profile measurements require a careful choice of detector type for each location in order to cope with the large dynamic range and operational demands. This contribution presents the actual status of FAIR detector developments for intercepting devices (SEM-Grids, Multi-Wire Proportional Chambers, Scintillating Screens) as well as non-intercepting Beam Induced Fluorescence Monitors and Ionization Profile Monitors. Recently, promising results were obtained with slow extracted heavy ion beams in measurements of optical transmission radiation emitted from thin metal foils. The boundaries for the application area are described and basic detector parameters are summarized.

MOPF14 Scintillation Screen Response to Heavy Ion Impact

E. Gütlich, *O.K. Kester (IAP) P. Forck, O.K. Kester (GSI)*

For quantitative transverse ion beam profile measurement, imaging properties of scintillation screens have been investigated for the working conditions of the GSI linear accelerator. In the ion energy range between 4.8 and 11.4 MeV/u the imaging properties of the screens are compared with profiles obtained using standard techniques like SEM grids and scraper. Detailed investigations with e.g. Calcium and Argon ion beams on various radiation-hard materials show that the measured beam profiles can differ from those measured with standard methods and depend on several beam and material parameters *. For the practical usage of scintillators, it is necessary to have predictions for the response of the scintillator to a given ion beam. An existing model for the light output of scintillators for single particle irradiation has been extended to include the effect of overlapping excitation tracks. To validate the model, dedicated measurements with well-defined Carbon and Titanium ion beams at 11.4 MeV/u have been carried out. To understand the mechanisms, the beam flux and the pulse length has been varied. The measured light yield is compared to the model calculations.

* E. Gütlich et al., "Scintillation screen studies for high dose ion beam applications", IEEE Transactions on Nuclear Science, Vol. 59, No. 5, October 2012, pp. 2354 – 2359.

MOPF15 Advanced uses of a Current Transformer and a Multi-Wire Profile Monitor for Online Monitoring of the Stripper Foil Degradation in the 3-GeV RCS of J-PARC

P.K. Saha, *H. Harada, S. Hatakeyama, N. Hayashi, H. Hotchi, M. Kinsho, K. Okabe, R. Saeki, K. Yamamoto, Y. Yamazaki, M. Yoshimoto (JAEA/J-PARC)*

We have established advanced and sophisticated uses of a Current Transformer (CT) and a Multi-Wire Profile Monitor (MWPM) for measuring as well as online monitoring of the stripper foil degradation during user operation of the 3-GeV Rapid Cycling Synchrotron (RCS) in Japan Proton Accelerator Research Complex (J-PARC). An incoming negative hydrogen beam from the Linac is stripped to a proton beam by using a stripper foil placed in the RCS injection area. Foil degradation such as, foil thinning and pinhole formation are believed to be signs of a foil breaking. A sudden foil breaking is not only a load on the accelerator downtime but also raises maintenance issues. In a high intensity accelerator like RCS, a proper monitoring system of the foil is thus important in order to avoid such above issues by replacing the foil with a new one in the scheduled maintenance day. The thickness of the stipper foil used for the present 181 MeV injection energy is 200 ug/cm^2, where a change of foil thickness as low as 1% or even less has already been successfully monitored by utilizing the presented method. Measured data for the last 6 months operation of the RCS will be presented.

MOPF16 **Sub-Micrometre Resolution Laserwire Transverse Beam Size Measurement System**

L.J. Nevay *(JAI) A.S. Aryshev, N. Terunuma, J. Urakawa (KEK) G.A. Blair, S.T. Boogert, P. Karataev, K.O. Kruchinin (Royal Holloway, University of London) L. Corner, R. Walczak (Oxford University, Physics Department)*

The laserwire system at the Accelerator Test Facility 2 (ATF2) is a transverse beam profile measurement system capable of measuring a micrometre-size electron beam. We present recent results demonstrating a measured vertical size of 1.16 ± 0.06 μm and a horizontal size of 110.1 ± 3.8 μm. Due to the high aspect ratio of the electron beam, the natural divergence of the tightly focussed laser beam across the electron beam width requires the use of the full overlap integral to deconvolve the scans. For this to be done accurately, the propagation of the 150 mJ, 167 ps long laser pulses was precisely measured at a scaled virtual interaction point.

MOPF17 **Optical System with Image Intensifier and Spatial Filters for Large Dynamic Range Transverse Beam Profile Measurements**

P.E. Evtushenko *(JLAB)*

We have previously reported * on transverse beam profile measurements where dynamic range (DR) was increase by a factor of 100 from typical 500 to about 5.0x10^4. It was shown that for non-equilibrium beam with non-Gaussian transverse distribution the RMS beam size can depend significantly on the DR used for calculations. Consequently, measured emittance and Twiss parameters depend on the DR as well. For the optical system used in * diffraction limits the DR at the level slightly above the 5.0x10^4 used in measurements. For further increase of the DR spatial filters needs to be used in a way similar to original solar coronagraph ** and its application to the synchrotron radiation measurements ***. To increase overall sensitivity to allow large dynamic range measurements with low duty cycle tune-up beam, our systems includes an image intensifier. On contrary to a coronagraph-like scheme, where central bright part of the distribution is not measured, our systems is intended for simultaneous, complete distribution measurements including the bright core and low amplitude halo, which is needed for proper beam size measurements. Here design considerations for the system are presented.

* P. Evtushenko et al., in Proceedings of FEL2012

** B. F. Lyot, Month. Notice Roy. Ast. Soc, p580, 99 (1939)

*** T. Mitsuhashi, “Beam halo observation by coronagraph”, Proceedings of DIPAC05

MOPF18 **Nanometer Scale Electron Beam Transverse Diagnostics**

G. Travish *(UCLA)*

Nanometer-scale electron beams are likely to become more commonplace as new machines and new classes of particle accelerators come online. Such beams, with transverse dimensions in the few to tens of nanometer range, have already been proposed for colliders and produced in test facilities. With the exception of microscopes, where nanometer sized beams are widespread already, these beam scales are still the exception in relativistic particle accelerators. To date, the more successful beam profile monitors for nanometer scales have been based on laser interferometers (so-called laser-wire or Shintake monitors). These diagnostics offer high resolution but can be difficult to set up and operate. With the advent of Dielectric Laser Accelerators (DLAs) and other advanced accelerator schemes that rely on optical-scale accelerating modes, it is reasonable to assume that the need to diagnose such small-scale beams will increase. We therefore consider various approaches including a knife-edge-like method already in use for DLAs, and more speculative approaches inspired by electron and optical microscopes.

Beam Charge Monitors and General Diagnostics

MOPF19 **Injection Efficiency Monitoring System at the Australian Synchrotron**

E.D. van Garderen*, S.A. Griffiths, G. LeBlanc, S. Murphy, A. Rhyder, A. C. Starritt (ASCo) M.J. Boland (SLSA)*

The Australian Synchrotron upgraded its user mode from decay mode to top-up mode in May 2012. To monitor the beam charge passing through the accelerator systems at key transfer points the transmission efficiency system has been upgraded. The original system could only measure the efficiency of the booster to storage ring injection. The new one calculates intermediate efficiencies between six points along the injection system, from the electron gun to the booster-to-storage ring transfer line. This is helpful to diagnose in real-time shot-to-shot the performance of the pulsed magnets, ramped magnets and ramped RF systems and their associated triggers. A software-based injection efficiency interlock has also been introduced, that can inhibit the gun when the machine settings are not optimal. This article details the architecture of the injection efficiency system and lists the improvements on the machine that have been carried out to obtain high quality data.

MOPF20 **Bunch Purity Measurement for BEPC II**

H. Jun*, J.H. Junhui (IHEP)*

The bunch purity is very important for time-resolved experiments. It is determined by the quality of the injection system and Touschek effect. The Beijing Electron-Positron Collider (BEPC) II was constructed for both high energy physics (HEP) and synchrotron radiation (SR) researches. It can be operated in the colliding mode and synchrotron radiation mode. It is planned to measure the beam quality in a short time of several minutes by

using a timecorrelated single photon counting method. The method has a time resolution of 450 ps and a dynamic range of five orders of magnitude. In this paper, we describe our experimental set up and give a series of test results for colliding mode. We plan to set up a system which can kick out the unwanted bunches in the next stage.

MOPF22 **The Effect of Space Charge Along the Tomography Section at PITZ**

G. Kourkafas, *M. Khojoyan, M. Krasilnikov, D. Malyutin, B. Marchetti, M. Otevřel, F. Stephan, G. Vashchenko (DESY Zeuthen) G. Asova (INRNE)*

The Photo Injector Test facility at DESY, Zeuthen site (PITZ) focuses on testing, characterizing and optimizing high brightness electron sources for free electron lasers. Among various diagnostic tools installed at PITZ, the tomography module is used to reconstruct the transverse phase-space distribution of the electron beam by capturing its projections while rotating in the normalized phase space. This technique can resolve the two transverse planes simultaneously with an improved signal-to-noise ratio, allowing measurements of individual bunches within a bunch train with kicker magnets. The low emittance, high charge density and moderate energy of the electron bunch at PITZ contribute to significant space-charge forces which induce mismatches to the reconstruction procedure. This study investigates how the phase-space transformations and thus the reconstruction result are affected when considering linear and non-linear self-fields along the tomography section for the design Twiss parameters. The described analysis proposes a preliminary approach for including the effect of space charge in the tomographic reconstruction at PITZ.

MOPF23 **Quantifying Dissipated Power from Wake Field Losses in Diagnostics Structures**

A.F.D. Morgan, *G. Rehm (Diamond)*

As a charged particle beam passes through structures, wake fields can deposit a fraction of the energy carried by the beam as characterised by the wake loss factor. Some part of the deposited energy will be emitted into the beam pipe, some part can be coupled out of signal ports and some part will be absorbed by the materials of the structures. With increasingly higher stored currents, we require a better understanding of where all the energy deposited by wake losses ends up in order to avoid damaging components. This is of particular concern for diagnostics structures as they are often designed to couple a small fraction of energy from the beam, which makes them susceptible to thermal damage due to increased localised losses. We will detail the simulation and analysis approach which we have developed to quantify power deposition within structures. As an example the analysis of a beam position monitor pickup block of the Diamond storage ring is shown.

MOPF24 **Magnetic Materials for Current Transformers**

***S. Aguilera**, P. Odier, R. Ruffieux (CERN)*

At CERN, the circulating beam current measurement is provided by two types of transformers, the Direct Current Current Transformers (DCCT) and the Fast Beam Current Transformers (FBCT). Each type of transformer requires different magnetic characteristics regarding parameters such as permeability, coercivity and shape of the magnetization curve. Each transformer is built based on toroidal cores of a magnetic material which gives these characteristics. For example, DCCTs consist of three cores, two for the measurement of the DC component and one for the AC component. In order to study the effect of changes in these parameters on the current transformers, several interesting raw materials based on their as-cast properties were selected with the annealing process used to tune their properties for the individual needs of each transformer. First annealing tests show that the magnetization curve, and therefore the permeability, of the material can be modified, opening the possibility for building and studying a variety of transformer cores.

MOPF25 **Cryogenic Current Comparator (CCC) for Low Intensity Beam Current Measurement**

***M.F. Fernandes**, J. Tan (CERN) **M.F. Fernandes**, C.P. Welsch (The University of Liverpool) **M.F. Fernandes**, C.P. Welsch (Cockcroft Institute)*

In the low-energy antiproton decelerator (AD) and the future Extra Low ENergy Antiproton (ELENA) rings at CERN, an absolute measurement of the beam current is essential to monitor any efficiency losses during the electron-cooling phase. However, existing DC current transformers can hardly measure beam currents below 1 μA, while at the AD and ELENA currents can be as low as 100 nA. A cryogenic current comparator (CCC) based on a superconducting quantum interference device (SQUID) is currently being designed and shall be installed in the AD and ELENA machines. It should meet at least the following specifications: A current resolution of 10 nA, a dynamic range covering currents between 100 nA and 1 mA, as well as a bandwidth from DC currents to 1 kHz. Different design options are being considered, including the use of low or high temperature superconductor materials, different CCC shapes and dimensions, different SQUID characteristics, as well as electromagnetic shielding requirements. In this contribution we present first results from a comparative analysis of different monitor options, under consideration also of external electromagnetic sources at the foreseen device locations.

MOPF26 **New Booster Tune Measurement System for TLS and TPS Prototype**

***P.C. Chiu**, K.T. Hsu, K.H. Hu, C.H. Kuo (NSRRC)*

Taiwan Light Source (TLS) is a 1.5 GeV synchrotron based light source and its booster synchrotron was delivered in 1992. Initial booster tune measurement which adopted extraction kicker as beam excitation and use digital oscillator to extract tune was obsolete. Recently, the beam excitation device has been modified to provide more effective excitation strength and new BPM electronics is adopted to acquire tune for routine booster tune measurement. It also provides a chance to experience for the TPS project booster prototype with the similar infrastructure. Efforts will be summarized in the report.

MOPF27 **A Beam Current Monitor for the VECC Accelerator**

W.R. Rawnsley, *R.E. Laxdal (TRIUMF)*

TRIUMF is building VECC, the first stage of a 50 MeV electron linac. Beam diagnostic devices will be inserted radially into 8-port vacuum boxes. RF shields, 6.3 cm dia. tubes perforated by pump out slots, can be inserted to reduce wakefields. They will also serve as capacitive probes picking up harmonics of the 650 MHz bunch rate. 100 mV P/P was measured for 3 mA at 100 kV. A SC cavity will accelerate the beam to 10 MeV. The dump current is limited by the shielding to 300 W. We will use a 3 mA beam at 1% duty cycle. Two RF shields will monitor the current. A newly developed circuit will give dc outputs proportional to the peak and average current. It uses a log detector with range of 70 dB for 1 dB of error and a rise and fall time of ~20 ns. Terasic development boards process the log signal. It is digitized by a 14-bit ADC at a 50 MHz rate and passed to a FPGA programmed in Verilog. Altera Megafunctions offset, scale, convert to floating point, antilog and filter the signal in a pipeline architecture. Two 14-bit DACs provide the outputs. Digital processing maintains the wide dynamic range. Beam pulses can be <250 ns and the sample rate insures accuracy at low duty cycle.

MOPF28 **Optics Non-Linear Components Measurement Using BPM Signals**

M. Alhumaidi, *A.M. Zoubir (TU Darmstadt)*

The knowledge of the linear and non-linear errors in circular accelerator optics is very crucial for controlling and compensating resonances and their consequent beam losses. This is indispensable, especially for high intensity machines. Fortunately, the relationship between the recorded beam offset signals at the BPMs is a manifestation of the accelerator optics, and can therefore be exploited in the determination of the optics linear and non-linear components. We propose a novel method for estimating lattice non-linear components located in-between the positions of two BPMs by analyzing the beam offset signals of a BPMs triple containing these two BPMs. Depending on the non-linear components in-between the locations of the BPMs triple, the relationship between the beam offsets follows a multivariate polynomial. After calculating the covariance matrix of the polynomial terms, the Generalized Total Least Squares method is used to find the model parameters, and thus the non-linear components. Finally, a bootstrap technique is used to determine confidence intervals of the estimated values. Results for synthetic data are shown.

MOPF29 **A Non-Invasive Beam Monitor for Hadron Therapy Beams**

T. Cybulski, *C.P. Welsch (The University of Liverpool)* ***T. Cybulski***, *C.P. Welsch (Cockcroft Institute)*

Hadron therapy allows for precise dose delivery to the tumour volume only and hence decreases the dose delivered to the nearby organs and healthy tissue. Ideally, the beam would be monitored whilst being delivered to the patient. A novel, real–time and non-interceptive beam monitor for hadron therapy beams has been developed in the QUASAR Group. It is based on the LHCb VErtex LOcator (VELO) detector and couples to the treatment beam's transverse halo to determine the intensity, position and ultimately the dose of the treatment beam. This contribution presents the design of a stand-alone version of the VELO detector which was developed for the Clatterbridge Cancer Centre (CCC) treatment line. The mechanical and electronic design of the monitor and its data acquisition system are shown, with a focus on the detector positioning and cooling system. Monte Carlo simulations into expected signal distributions are compared against first measurements with the 60 MeV proton beam at CCC.

MOPF30 **Novel Diagnostics for Breakdown Studies**

M. Jacewicz, *Ch. Borgmann, M. Olvegård, R.J.M.Y. Ruber, V.G. Ziemann (Uppsala University) J.W. Kovermann (CERN)*

The phenomenon that currently prevents achieving high accelerating gradients in high energy accelerators such as the CLIC linear collider is electrical breakdown at very high electrical field. The ongoing experimental work is trying to benchmark the theoretical models focusing on the physics of vacuum breakdown which is responsible for the discharges. The CLIC collaboration has commissioned a dedicated 12 GHz test-stand to validate the feasibility of accelerating structures and observe the characteristics of the RF discharges and their eroding effects on the structure. A versatile system for detection of the dark and breakdown currents and light emission is being developed for the test-stand. It consists of a collimation system with an external magnetic spectrometer for measurement of the spatial and energy distributions of the electrons emitted from the acceleration structure during a single RF pulse. These measurements can be correlated with e.g. the location of the breakdown inside the structure using information from the incident, reflected and transmitted RF powers giving a complete picture of the vacuum breakdown phenomenon.

Collider Specific Instrumentation

MOPF31 **Design and Performance of the Biased Drift Tube System in the BNL Electron Lens**

T.A. Miller, *D.M. Gassner, X. Gu, A.I. Pikin, S. Polizzo, P. Thieberger (BNL) J. Barth (Barth Electronics)*

The installation of the Electron Lenses in RHIC will be completed this year. Its design includes a series of drift tubes through which the electron beam copropagates, with the RHIC proton beams. These drift tubes are used

to create an electric field gradient to sweep out ions that become trapped within the central magnetic field where the electron beam interacts with the proton beams. These isolated drift tubes are biased by high voltage power supplies. Without a path for the proton beam image currents, high voltages will develop on the drift tubes that can be detrimental to the electron beam and increase the RHIC machine impedance. This paper presents the design of the drift tubes, axial electric field gradient, and the custom high voltage RF bias tees that were designed to provide separate paths for the high frequency image currents and the DC high voltage bias over the same cables. The design and simulation of the bias tee is discussed, as well as RF signals from the proton beam current imaged on the drift tubes, as measured through the bias tees during the commissioning of the blue RHIC beam electron lens this past spring.

MOPF32 **Development of Gated Turn-by-Turn Position Monitor System for the Optics Measurement During Collision of SuperKEKB**

M. Tobiyama, *H. Fukuma, H. Ishii, K. Mori (KEK)*

Gated turn-by-turn monitor system to measure optics functions using non-colliding bunch has been developed for SuperKEKB accelerators. With the fast, glitch cancelling beam switch, beam position of the target bunch will be measured without affecting the fine COD measurement using narrow-band detectors. The gate timing and the bunch position detection are controlled by the Spartan-6 FPGA. The performance of the system, such as the gate timing jitter, data transfer speed from the system to EPICS IOC and the noise effect to the downstream narrow-band detector are reported.

MOPF34 **Nuclotron Deuterons Beam Parameters Measurements Using SSNTD**

K.V. Husak, *V.V. Bukhal (The Joint Institute of Power and Nuclear Reserach - "SOSNY" NASB) M. Artiushenko, V.V. Sotnikov, V.A. Voronko (NSC/KIPT) A.A. Patapenka, A.A. Safronava, I.V. Zhuk (JIPNR-Sosny NASB)*

ADS are considered as prospective nuclear installations for energy production and nuclear waste transmutation or recycling. The international project “Energy and Transmutation Radioactive Wastes” running in the Laboratory of High Energy Physics at JINR (Dubna, Russia) at the accelerator complex “Nuclotron” is aimed at a feasibility study of using a deeply subcritical natural or depleted uranium or thorium active core with very hard neutron spectrum inside for effective burning of the core material together with spent nuclear fuel. For any ADS experiment a necessary and a key element is beam diagnostics. In this paper a technique for precise measurement of deuteron beam parameters using SSNTD, developed within the bounds of “E&T RAW” project, is presented. The deuteron beam parameters, specifically beam shape, size and position on a target, are obtained from track density distribution on the irradiated track detectors. The presented technique has a resolution of 1 mm. The experimental results of beam parameter measurements for deuterons with energies of 2, 4 and 8 GeV at the irradiation of the uranium subcritical assembly “QUINTA”, obtained with the SSNTD technique, are presented.

MOPF35 **Real-Time Beam Envelope Simulator and Operator Graphical User Interface at the University of Hawai'i**

B.T. Jacobson *(University of Hawaii)*

A software system has been developed at the University of Hawai'i MkV Accelerator and Free Electron Laser Lab in order to provide the accelerator and beamline operator with real-time display of the electron beam parameters and envelope along the evolution through the beam transport system for optimization of the electron beam for Compton back-scattering. Quadrupole currents are digitized using an ADC monitoring the Analog Magnet Programming System (AMPS) and then converted to field gradients for calculations. An Octave routine incorporates the beamline layout, electron beam energy, and quadrupole gradients to calculate and propagate electron beam parameters. These calculated parameters are used to generate a graphical display of the beam envelopes along the beamline, as well as transverse 2-D representations at the locations of the insertable optical transition radiation screens installed on the beamline for direct comparison of calculations with observations.

16-Sep-13 19:00 – 20:00	Lecture Theatre

MOEL — Public Lecture

Chair: P. Burrows (JAI)

Collider Specific Instrumentation

MOEL1 19:00 ⏱

Where Are We Going in the Field of High Energy Accelerators ?

S. Stapnes, *L.R. Evans (CERN)*

The future of particle physics is closely linked to future high energy accelerators. The Higgs discovery and searches for possible beyond the Standard Model phenomena create new challenges for the field. High energy hadrons colliders, ILC or CLIC as linear colliders and neutrino facilities are all be considered - as well as other facilities. The European Strategy for Particle Physics was updated and approved this year. First results from the LHC are available but by 2015-16 LHC running at 14 TeV can open more windows to new physics. What are the scenarios and the decision processes for construction of these new facilities? For this conference a central question is also; what will be their fundamental requirements for beam instrumentation ?

17-Sep-13 09:00 – 10:30	Lecture Theatre

TUAL — Time Resolved Diagnostics and Synchronization
Chair: M. Ferianis (Elettra-Sincrotrone Trieste S.C.p.A.)

Time Resolved Diagnostics and Synchronization

TUAL1 09:00 40

Longitudinal Phase Space Characterization at FERMI@Elettra

__E. Ferrari__, E. Allaria, M. Ferianis, L. Giannessi (Elettra-Sincrotrone Trieste S.C.p.A.)

The seeded FEL FERMI@Elettra has completed the commissioning of FEL1 line, and it is now providing the User Community with a coherent and tunable UV radiation (from 70nm to 20nm) in a number of different configurations, including an original twin-seeded pump-probe scheme. Among the key sub systems for the operation of FERMI@Elettra, there are the femto second optical timing system, some dedicated longitudinal diagnostics, specifically developed for FERMI@Elettra and, of course, state of art laser systems. In this paper, after a short review of the FERMI@Elettra optical timing system and of its routinely achieved performances, we focus on the results obtained from the suite of longitudinal diagnostics (Bunch Arrival Monitor, Electro Optical sampling station and RF deflectors) all operating in single shot and with 10s fs resolution which demonstrate the FERMI@Elettra achieved performances. The results from these longitudinal diagnostics are compared and shot to shot correlated with the results obtained from an independent longitudinal measurement technique, based on a spectrometer measurement of a linearly chirped electron bunch, which further validate the FERMI@Elettra operation.

TUAL2 09:40 20

Commissioning the New LCLS X-band Transverse Deflecting Cavity with Femtosecond Resolution

__P. Krejcik__, F.-J. Decker, Y. Ding, J.C. Frisch, Z. Huang, J.R. Lewandowski, H. Loos, J.L. Turner, J.W. Wang, M.-H. Wang, J.J. Welch (SLAC) C. Behrens (DESY)

The new X-band transverse deflecting cavity began operation in May 2013 and is installed downstream of the LCLS undulator. It is operated at the full 120 Hz beam rate without interfering with the normal FEL operation for the photon users. The deflected beam is observed on the electron beam dump profile monitor, which acts as an energy spectrometer in the vertical plane. We observe, on a pulse by pulse basis, the time resolved energy profile of the spent electron beam from the undulator. The structure is powered from a 50 MW X-band klystron, giving a 48 MV kick to the beam which yields a 1 fs rms time resolution on the screen. We have measured the longitudinal profile of the electron bunches both with the FEL operating and with the lasing suppressed, allowing reconstruction of both the longitudinal profile of the incoming electron beam and the time-resolved profile of the X-ray pulse generated in the FEL. We are immediately able to see whether the bunch is chirped and which parts of the bunch are lasing, giving us new insight into tuning the machine for peak performance. The performance of the system will be presented along with examples of measurements taken during LCLS operation.

TUAL3 10:00 20

Absolute Bunch Length Measurements by Means of a Gap Bunch Length Monitor

R. Appio *(MAX-lab) P. Craievich, G. Penco, M. Veronese (Elettra-Sincrotrone Trieste S.C.p.A.) P. Craievich (PSI)*

Electron bunch length measurements are of crucial importance for many types of accelerators, including storage rings, energy recovery linacs, free electron lasers. Many devices and instrumentation have been developed to measure and control the electron bunch length. A very powerful class of diagnostic tools is based on the coherent radiation power emitted by the electron bunch, that allows a non-destructive shot by shot measurement, well suitable for bunch length control feedback implementation. However they usually provide measurements of the bunch length relative variation, and external instrumentation like a transverse RF deflecting cavity is usually needed to calibrate them and to obtain absolute bunch length estimations. In this paper we present a novel experimental methodology to self-calibrate a device based on diffraction radiation from a ceramic gap. We indeed demonstrate the possibility to use coherent radiation based diagnostic to provide absolute measurements of the electron bunch length. We present the theoretical basis of the proposed approach and validate it through a detailed campaign of measurements that have been carried on in the FERMI@Elettra FEL linac.

17-Sep-13 11:00 – 12:30 Lecture Theatre

TUBL — BPMs and Beam Stability 1
Chair: G. Decker (ANL)

BPMs and Beam Stability

TUBL1 11:00 40

NSLS-II BPM and Fast Orbit Feedback System Design and Implementation

O. Singh, *B. Bacha, A. Blednykh, W.X. Cheng, J.H. De Long, A.J. Della Penna, K. Ha, Y. Hu, B.N. Kosciuk, M.A. Maggipinto, J. Mead, I. Pinayev, Y. Tian, K. Vetter, L.-H. Yu (BNL)*

The National Synchrotron Light Source II is a third generation light source under construction at Brookhaven National Laboratory. The project includes a highly optimized, ultra-low emittance, 3 GeV electron storage ring, linac pre-injector and full energy booster synchrotron. The low emittance requires high performance beam position monitor systems, providing measurement to better than 200 nm resolution; and fast orbit feedback systems, holding orbit to similar level of orbit deviations. The NSLS-II storage ring has 30 cells, each deploying up to 8 RF BPMs and 3 fast weak correctors. Each cell consists of a "cell controller", providing fast orbit feedback system infrastructure. This paper will provide a description of system design and summarize the implementation and status for these systems.

TUBL2 11:40 20

A 4 GS/s Feedback Processing System for Control of Intra-Bunch Instabilities

J.D. Fox, *J.M. Cesaratto, J.E. Dusatko, J.J. Olsen, K.M. Pollock, C.H. Rivetta, O. Turgut (SLAC) W. Höfle (CERN)*

We present the architecture and implementation overview of a digital signal processing system developed to study control of Electron-Cloud and Transverse Mode coupling instabilities in the CERN SPS. The system is based on a reconfigurable processing architecture which samples vertical bunch motion and applies correction signals at a 4 GS/s rate, allowing 16 samples across a single 5 ns SPS RF bucket. The system requires wideband beam pickups and a vertical kicker structure with GHz bandwidth. This demonstration system implements a general purpose 16 tap FIR control filter for each sample. We present results from SPS machine studies showing the impact of wideband feedback to excite/damp internal modes of vertical motion as well as stabilize an unstable beam. These results highlight the challenges of intra-bunch feedback and show proof of principle feasibility of the architecture.

TUBL3
12:00 20

A Multiband-Instability-Monitor for High-Frequency Intra-Bunch Beam Diagnostics

R.J. Steinhagen *(CERN) M.J. Boland, T.G. Lucas (The University of Melbourne)*

To provide the best possible luminosity, even higher beam intensities are needed in the Large Hadron Collider (LHC) and in its injector chain. This is fundamentally limited by self-amplifying beam instabilities, intrinsic to unavoidable imperfections in accelerators. Traditionally, intra-bunch or head-tail particle motion is measured using fast digitizers, which even using state-of-the-art technology are limited in their effective intra-bunch position resolution to few tens of um in the multi-GHz regime. Oscillations at this scale cause partial or total loss of the beam due to the tight transverse constraints imposed by the LHC collimation system. To improve on the present signal processing, a prototype system has been designed, constructed and tested at the CERN Super-Proton-Synchrotron (SPS) and later on LHC. The system splits the signal into multiple equally-spaced narrow frequency bands that are processed and analysed in parallel. Working with narrow-band signals in frequency-domain permits the use of much higher resolution analogue-to-digital-converters that can be used to resolve nm-scale particle motion already during the onset of instabilities.

17-Sep-13 14:00 – 15:30 Lecture Theatre

TUCL — Beam Profile 1
Chair: T.M. Mitsuhashi (KEK)

Beam Profile Monitors

TUCL1 14:00 40

Overview of Imaging Sensors and Systems Used in Beam Instrumentation

E. Bravin *(CERN)*

The presentation will give an overview of applicable image sensors and sensor systems for an application in the beam instrumentation. The overview will cover fast imaging cameras as well as sensors and cameras to be used in radiation fields. The critical parameters will be discussed and measurements presented if available. Frame grabbers and digital cameras will also be included in the presentation.

TUCL2 14:40 20

A Development of High Sensitive Beam Profile Monitor using Multi-Screen

Y. Hashimoto*, T. Toyama (J-PARC, KEK & JAEA) T.M. Mitsuhashi, M. Tejima (KEK) S. Otsu (Mitsubishi Electric System & Service Co., Ltd)*

The diagnostics of beam halo as well as beam core are very important for the regulation of the beam collimator. We have developed a monitor to observe two-dimensional beam profile with a large dynamic range. The monitor has been installed in 122m downstream from the beam collimator in 3-50 BT in the J-PARC. For measuring the beam core and the halo alternatively, the monitor has three kinds of screens. The first one is titanium foil OTR screen to measure a beam core, the second one is aluminum foil OTR screen having a hole (50 mm diameter) in the center, and the last one is a pair of alumina fluorescent screen with a separation of 80 mm in horizontal to observe the beam halo in surroundings. We designed an optical system based on the Offner optics for the observation of fluorescence and OTR lights. This optical system has an entrance aperture of 300 mm and it can cover the large opening angle (± 13.5 degree) of the OTR from 3GeV protons. A CID camera with an image intensifier (II) was use to observe the profile. We have succeeded to observe a profile of beam halo to 10^{-6} order to the peak of beam core by using proton beams of 9.6 x 10^{12} protons/pulse by this multi-screen scheme.

TUCL3 15:00 20

Gas Electron Multipliers Versus Multi Wire Proportional Chambers

S.C. Duarte Pinto *(Delft University of Technology, Opto-electronic Section)*
J. Spanggaard (CERN)

Gas Electron Multiplication technology is finding more and more applications in beam instrumentation and at CERN these detectors have recently been adapted for use in transverse profile measurements at several of our facilities. In the experimental areas of CERN's Antiproton Decelerator, low energy Gas Electron Multipliers successfully replaced all Multi-Wire Proportional Chambers in 2012 and another detector type has now been developed for high energy applications in the experimental areas of the SPS, totalling a potential of more than a hundred profile detectors to be replaced by GEM detectors of different types. This paper aims to describe the historical evolution of GEM technology by covering the many different applications but with specific focus on its potential to replace Multi-Wire Proportional Chambers for standard transverse profile measurement.

Overview and Commissioning

TUPC01 **Overview of the European Spallation Source Warm Linac Beam Instrumentation**

B. Cheymol, *C. Böhme, I. Dolenc Kittelmann, H. Hassanzadegan, A. Jansson, T.J. Shea, L. Tchelidze (ESS)*

The normal conducting front end of the European Spallation source will accelerate the beam coming for the ion source up to 90 MeV. The ESS front end will consist in an ion source, a low energy beam transport line, a radio frequency quadrupole, a medium energy beam transport line and a drift tube linac. The warm linac will be equipped with beam diagnostics to measure the beam position, the transverse and longitudinal profile as well as beam current and beam losses. This will provide efficient operation of ESS, and ensure keeping the losses at a low level. This paper gives an overview of the beam diagnostics design and their main features.

TUPC02 **Proton Beam Measurement Strategy for the 5 MW European Spallation Source Target**

T.J. Shea, *C. Böhme, B. Cheymol, H. Hassanzadegan, E.J. Pitcher (ESS) S.D. Gallimore (STFC/RAL/ISIS) H.D. Thomsen (ISA)*

Approaching construction phase in Lund, Sweden, the European Spallation Source (ESS) consists of a superconducting linear accelerator that delivers a 2 GeV, 5 MW proton beam to a rotating tungsten target. As a long pulse neutron source, the ESS does not require an accumulator ring, so the 2.86 ms pulses, with repetition rate of 14 Hz arrive directly from the linear accelerator with low emittance. To avoid damage to target station components, this intense beam must be actively expanded by quadrupoles that produce a centimetre size beamlet, combined with a fast rastering system that paints the beamlet into a 160 mm by 60 mm footprint. Upstream of and within the target station, a suite of devices will measure the beam's density, halo, position, current, and time-of-arrival. Online density measurements are particularly important for machine protection, but present significant challenges. Diverse techniques will provide this measurement within the target station, based upon secondary emission grids, ionisation monitors, luminescent coatings, and Helium gas luminescence. Requirements, system descriptions, and performance estimates will be presented.

TUPC03 **Commissioning and Diagnostics Development for the New Short-Pulse Injector Laser at FLASH**

T. Plath, *J. Rönsch-Schulenburg (Uni HH) H. Schlarb, S. Schreiber, B. Steffen (DESY)*

In order to extend the parameter range of FLASH towards shorter electron

pulses down to a few fs SASE pulses, shorter bunches with very small charges of a few tens of picocoulombs are necessary directly at the photo injector. Therefore a new injector laser delivering pulses of 1 to 5 ps has been installed and commissioned. The influence of the laser parameters on the electron beam was studied theoretically. In this paper we discuss the required laser beam diagnostics and present measurements of critical laser and electron beam parameters.

TUPC05 **Laser and Photocathode Gun Instrumentation for the ASTA Accelerator Test Stand at SLAC**

J. Sheppard, *W.J. Corbett, S. Gilevich, E.N. Jongewaard, J.R. Lewandowski, P. Stefan, T. Vecchione, S.P. Weathersby, F. Zhou (SLAC)*

An accelerator test stand has been constructed at SLAC to characterize laser-assisted photocathode processing, electron beam emission physics and front-end rf gun performance. The objective of the research program is to identify definitive 'recipes' for high-reliability cathode preparation resulting in high quantum efficiency and low beam emittance. In this paper we report on timing, optics and instrumentation for the Ti:Sapphire drive laser, diagnostics for the 1.6 cell photocathode gun and instrumentation for the resulting electron beam. The latter include a Faraday cup charge monitor, scintillator screen beam imaging for direct emittance measurements, and high-resolution imaging of the photocathode surface to diagnose the impact of laser processing for enhanced quantum efficiency.

TUPC06 **Status of Beam Diagnostic Systems for TRIUMF Electron Linac**

V.A. Verzilov, *P.S. Birney, D.P. Cameron, P. Dirksen, J.V. Holek, S.Y. Kajioka, S. Kellogg, M. Lenckowski, W.R. Rawnsley (TRIUMF) J.M. Abernathy, D. Karlen, D.W. Storey (Victoria University)*

TRIUMF laboratory is currently in a phase of the construction of a superconducting 50 MeV 10 mA cw electron LINAC to drive photo-fission based rare radioactive isotope beam (RIB) production. The project imposes certain technical challenges on various accelerator systems including beam diagnostics. In the first place these are a high beam power and strongly varying operating modes ranging from microsecond beam pulses to the cw regime. Diagnostics development interleaves with the construction of the diagnostics instrumentation required for the test facility which delivered the first beam in Fall of 2011. The paper reports the present status of various diagnostics systems along with measurement results obtained at the test facility.

BPMs and Beam Stability

TUPC07 **Design and Impedance Optimization of the SIRIUS BPM Button**

H.O.C. Duarte, *S.R. Marques, L. Sanfelici (LNLS)*

Design of several BPM Buttons is presented with detail impedance, heat transfer and mechanical analysis. Special attention is given to the application of ceramics as materials with low relative permittivity inside of the

BPM Button and to the geometric shape of the BPM Button. The heat dissipation is evaluated based on the loss factor calculated for a 2.65mm bunch length. The narrow-band impedance is discussed and its dependence on applied ceramic materials is compared.

TUPC08 **Design and Impedance Optimization of the LNLS-UVX Longitudinal Kicker Cavity**

L. Sanfelici, *H.O.C. Duarte, S.R. Marques (LNLS)*

Performance evolution of parameters achieved during the electromagnetic design of the longitudinal kicker cavity for the LNLS UVX storage ring is presented. The effort on the electromagnetic optimization process of the heavily loaded cavity has been made to reach the required electrodynamic parameters of the kicker. The results for three different geometries are compared and a good compromise between the longitudinal shunt impedance and the effect of the longitudinal Higher Order Modes (HOM's) on beam stability has been found.

TUPC09 **Longitudinal and Transverse Feedback Systems for the BEPCII Storage Rings**

J. Yue, *J. Cao, L. Ma, Y.F. Sui, L. Wang, X.Y. Zhao (IHEP)*

In order to cure the transverse and longitudinal coupled bunch instabilities caused by higher order modes of RF cavities and resistive wall impedance in the BEPCII storage rings, two type bunch by bunch feedback system – a longitudinal feedback system and a transverse feedback system are used. The LFB system are digital system produced by Dimtel Company, the longitudinal kicker is drift-tube type borrowed from SLAC. An analog bunch-by-bunch transverse feedback system was designed and used*. The main components are two sets of beam oscillation detectors, betatron phase adjuster, notch filter and stripline kicker. This paper will describe the achieved results of curing the coupled bunch instabilities by using the LFB and TFB together with current status.

* Performance of the Transverse Coupled-Bunch Feedback System in the BEPCII Storage Ring, Proc. of 40th ICFA ABDW, 2008

TUPC10 **Operation of Diamond Light Source XBPMs with Zero Bias**

C. Bloomer, *G. Rehm (Diamond)*

Tungsten blade X-ray Beam Position Monitors (XBPMs) have been used at Diamond Light Source since 2007, however a long-standing problem with these devices has been the growth of leakage current through the ceramic insulation within the XBPMs over time, often becoming greater than 10% of the signal current after a few years of operation. The growth of these leakage currents has been found to be exacerbated by the application of a negative bias (-70V) to the tungsten blades, a bias suggested for optimum position sensitivity. This bias is applied in order to accelerate free electrons away from the surface of the blades and to prevent cross-talk, however, we have found that the operation of the XBPMs without bias has negligible impact on our measurements. Removal of the bias has been found to prevent the growth of leakage currents over time, and can also significantly reduce the cost of our signal acquisition by removing the need for a low-current amplifier with a bias supply.

TUPC11 **Beam-Based Measurement of ID Taper Impedance at Diamond**

V.V. Smaluk, *R. Bartolini, R.T. Fielder, G. Rehm (Diamond)*

New insertion devices (IDs) are being designed now for a Diamond upgrade. One of the important topics of the design is the coupling impedance of the ID vacuum chamber movable tapers. To get a complete and reliable information of the impedance, analytical estimations, numerical simulation and beam-based measurement have been performed. The impedance of an existing ID taper geometrically similar to the new one has been measured using the orbit bump method. It turns out that in spite of the small magnitude (a few um) of orbit distortion to be observed in this case, the BPM resolution is sufficient for this measurement. The measurement results in comparison with simulation data are discussed in this paper.

TUPC12 **Status of the Stripline Beam Position Monitor Development for the CLIC Drive Beam**

A. Benot-Morell, *L. Søby, M. Wendt (CERN)* ***A. Benot-Morell***, *A. Faus-Golfe (IFIC) J.M. Nappa, S. Vilalte (IN2P3-LAPP) S.R. Smith (SLAC)*

In collaboration with SLAC, LAPP and IFIC, a first prototype of a strip-line Beam Position Monitor (BPM) for the CLIC Drive Beam and its associated readout electronics has been successfully tested in the CLIC Test Facility linac (CTF3) at CERN. In addition, a modified prototype with downstream terminated strip-lines is under development to better suppress any unwanted RF signal interference. This paper presents the results of the beam tests, the most relevant design aspects for the modified strip-line BPM version and its expected performance.

TUPC13 **System Overview and Design Considerations of the BPM System of the ESS Linac**

H. Hassanzadegan, *A. Jansson, R. Zeng (ESS) A.J. Johansson (Lund University) K. Strnisa (Cosylab) A. Young (SLAC)*

The ESS Linac will include in total more than 140 Beam Position Monitors of different sizes and types. The BPM system needs to measure the beam position, phase and intensity in all foreseen beam modes with a pulse rate of 14 Hz, duration of 2.86 ms and amplitude ranging form 5 mA to 62.5 mA. With respect to the BPM connection to the Machine Interlock System, the total response time must be less than 10 us. The signal level variations from one BPM to another along the Linac should be as small as possible to meet the requirements on the analog gain of the front-end electronics and the dynamic range of the digitizer card input. The other requirement is that the BPM system needs to give at least a rough estimation of the beam position and phase, even if the beam is significantly debouched, ex. during the Linac tuning phase. These requirements and their impact

on the design of the BPM detector, the analog front-end electronics and the selection of the digitizer card are discussed in this paper along with a general description of the BPM system.

TUPC14 Development of a Low-Beta Button BPM for PXIE Project

***A. Lunin**, N. Eddy, T.N. Khabiboulline, V.A. Lebedev, V.P. Yakovlev (Fermilab)*

The button BPM is under development for a low beta section of the Project X Injector Experiment (PXIE) at Fermilab. The presented paper includes an analytical estimation of the BPM performance as well a direct wakefield simulation with CST Particle Studio (on a hexahedral mesh). In addition we present a novel approach of a low beta beam interaction with BPM electrodes realized with ANSYS HFSS TD-solver on unstructured tetrahedral mesh. Both methods show a good agreement of BPM output signals for various beam parameters. Finally we describe the signal processing scheme and the electronics we are going to use.

TUPC15 BPM Electronics Upgrade for the Fermilab H^- Linac Based Upon Custom Downconverter Electronics

***E.S.M. McCrory**, N. Eddy, F.G.G. Garcia, S.U. Hansen, T. Kiper, M.Z. Sliczniak (Fermilab)*

As part of the Fermilab Proton Improvement Plan, the readout electronics for the Fermilab H^- Linac has been upgraded. The new custom electronics provide a low cost solution to process the 2nd harmonic of the RF at 402.5MHz. A single 4 channel NIM-bin module is used to readout each 4 plate stripline BPM pickup with each module being locked to an external 805MHz machine reference from the low level RF. For each BPM a number of measurements are provided including average horizontal and vertical position, average intensity, and average relative phase for variable pulse lengths from a few μs up to 50~usec. The system is being exploited in a number of ways with new operations applications.

TUPC16 Bunch-by-Bunch Feedback and Diagnostics at BESSY II

***A. Schälicke**, F. Falkenstern, R. Müller (HZB)*

At the light source BESSY II new digital bunch-by-bunch feedback systems have been put into operation in January 2013, replacing the existing analog as well as the obsolete digital systems. From the first days of operation the new system successfully suppresses transverse and longitudinal beam instabilities in wide range of machine parameters. The system offers also many new diagnostics opportunities, these include the analysis of instability modes, measurement of the feedback loop gain, and determination of the transfer function. A method to systematically optimise the output amplifier response function with the help of shaper coefficients for the optimal bunch separation has been developed. In addition the analysis of the input data stream allows a passive determination of machine properties like betatron and synchrotron frequencies as well as the longitudinal phases for every bunch. The integration of external triggers permits the

analysis of postmortem data, the characterisation of beam-loss events, and monitoring of the injection process. In this contribution first operational experience, the developed data analysis techniques and experimental data will be presented.

TUPC17 **A Multi-Conductor Transmission Line Model for the BPMs at the 3-50 Beam Transport Line in J-PARC**

***T. Toyama**, D.A. Arakara, M. Tejima (KEK) K. Hanamura (Mitsubishi Electric System & Service Co., Ltd) Y. Hashimoto, K. Satou (J-PARC, KEK & JAEA)*

We have developed an accurate and efficient analysis method with a multi-conductor transmission line model. This method combines the two-dimensional electrostatic analysis including beams in the transverse plane and the transmission line analysis in the longitudinal direction. The loads are also included in the boundary condition of the transmission line analysis. Calculation of 2D electrostatic fields can be easily performed with the boundary element method. Taking low frequency limit of the formula, we have obtained an accurate expectation of the BPMs of 200 mm diameter at the 3-50 Beam Transport Line in J-PARC.

TUPC18 **Development of a Highly Efficient Energy Kicker for Longitudinal Bunch-by-Bunch Feedback**

***M. Masaki**, T. Fujita, K. Kobayashi, T. Nakamura, H. Ohkuma, M. Oishi, S. Sasaki, M. Shoji (JASRI/SPring-8)*

A highly efficient energy kicker has been developed for longitudinal bunch-by-bunch feedback to suppress synchrotron oscillation of a high-current single electron bunch, and to cure possible longitudinal multi-bunch instability if lower beam energy is to be adopted for emittance reduction and electric power saving in a future upgrade plan of SPring-8. Through the performance test using a prototype kicker, a new water-cooled copper kicker was designed and fabricated, and it has been installed in the storage ring. The new kicker consists of three cells with each cavity length of 96 mm, its resonant frequency of 1.65 GHz, which is 3.25 times of RF frequency of the storage ring, and low Q-factor of 4.2. In beam kick test, the synchrotron oscillation amplitude of 0.64 ps was excited by kick voltage with continuous amplitude modulation at synchrotron frequency when the RF input power was 132 W/3cells. The kick voltage evaluated from the experimental result is 920 V/3cells. Shunt impedance of each kicker cell is estimated as 1.1 kΩ. As we intended, the shunt impedance per length is about three times higher than those of widely used waveguide overloaded cavity type kickers.

17 September

TUPC19 **First Beam Tests of a Prototype Cavity Beam Position Monitor for the CLIC Main Beam**

F.J. Cullinan, *S.T. Boogert, A. Lyapin, J.R. Towler (JAI) W. Farabolini, T. Lefèvre, L. Søby, M. Wendt (CERN)*

Beam position monitors (BPMs) throughout the CLIC (Compact Linear Collider) main linac and beam delivery system must routinely operate at 50 nm resolution and be able to make multiple position measurements within a single 156 ns long bunch train. A prototype cavity beam position monitor, designed to demonstrate this performance, has been tested on the probe beamline of CTF3 (the CLIC Test Facility). Sensitivity measurements of the dipole mode position cavity and of the monopole mode reference cavity have been made. The characteristics of signals from short and long bunch trains and the dominant systematic effects have also been studied.

TUPC20 **Technologies and R&D for a High Resolution Cavity BPM for the CLIC Main Beam**

J.R. Towler, *S.T. Boogert, F.J. Cullinan, A. Lyapin (JAI) T. Lefèvre, L. Søby,* ***J.R. Towler***, *M. Wendt (CERN)*

The Main Beam (MB) LINAC of the Compact Linear Collider (CLIC) requires a beam orbit measurement system with a high spatial (50 nm) and high temporal (50 ns) resolution to resolve the beam position within the 156 ns long bunch train, traveling on an energy-chirped, minimum dispersive trajectory. A 15 GHz prototype cavity BPM has been commissioned in the probe beam-line of the CTF3 CLIC Test Facility. The performance and technical details of this prototype installation are discussed in this paper, including the 15 GHz analog down-converter, the data acquisition and the control electronics and software. An R&D outlook is given for the next steps, which requires a system of 3 cavity BPMs to investigate the full resolution potential.

TUPC22 **Cavity Beam Position Monitor in Multiple Bunch Operation for the ATF2 Interaction Point Region**

Y.I. Kim, *D.R. Bett, N. Blaskovic Kraljevic, S.T. Boogert, P. Burrows, G.B. Christian, M.R. Davis, A. Lyapin, C. Perry (JAI) Y. Honda, T. Tauchi, N. Terunuma, J. Urakawa (KEK) J. Nelson, G.R. White (SLAC)*

The Accelerator Test Facility 2 (ATF2) at KEK, Japan, is a scaled test beam line for the international linear collider (ILC) final focus system. There are two goals: firstly, to demonstrate focusing to 37 nm vertical beam size; secondly, to achieve a few nanometer level beam orbit stability at the focus point (the Interaction Point (IP)) in the vertical plane. High-resolution beam position monitors around the IP area (IPBPMs) have been developed in order to measure the electron beam position in that region with a resolution of a few nanometers in the vertical plane. Currently, the standard operation mode at ATF2 is single bunch, however, multiple bunch operation with a bunch spacing similar to the one foreseen for the ILC (around 300 ns) is also possible. IPBPMs have a low Q value resulting in a decay time of about 30 ns, and so should be able to measure the

beam position of individual bunches without any significant performance degradation. The IPBPMs in the ATF2 extraction beam line have been tested in multibunch regime. This paper analyses the signals, processing methods and results for this mode.

TUPC23 **Beam Position and Phase Monitors for the LANSCE Linac**

R.C. McCrady, *H.A. Watkins (LANL)*

The linac at the Los Alamos Neutron Science Center (LANSCE) consists of a 100MeV drift-tube linac (DTL) and an 800MeV coupled-cavity linac (CCL). Both protons and H^- ions are accelerated and delivered to several end-stations contemporaneously. A variety of pulse formats are implemented to satisfy the timing requirements of the users. While the linac has never had working beam position monitors, existing beam phase monitors play a critical role in the machine turn-on process via the delta-t method. We are currently developing a system to both replace the existing phase monitors and to provide beam position measurements. The various pulse formats and dual-species operation impose constraints on the signal processing and the interfaces to the timing and data systems. In this paper we describe those constraints and present methods we have developed to meet the challenging requirements for this system.

TUPC24 **Design and Implementation of the Orbit Feedback System for TPS**

C.H. Kuo, *P.C. Chiu, K.T. Hsu, K.H. Hu, C.Y. Liao (NSRRC)*

TPS (Taiwan Photon Source) is a 3 GeV synchrotron light source which is being constructed at NSRRC. The BPM electronic is based on uTCA platform, is used for various request and function reasons. The orbit feedback system design is based on open structure, modularization and highly integration. There are many advantages that orbit feedback system is embedded in the BPM crate with FPGA modules. High throughput backplane, data transfer and processing support rich function for waveform record, diagnostic, beam study and transient analysis. The design and implementation result of the system will be reported in this conference.

TUPC25 **Design of the SwissFEL BPM System**

B. Keil, *R. Baldinger, R. Ditter, W. Koprek, R. Kramert, F. Marcellini, G. Marinkovic, M. Roggli, M. Rohrer, M. Stadler, D.M. Treyer (PSI)*

SwissFEL is a Free Electron Laser (FEL) facility being constructed at PSI, based on a 5.8GeV normally conducting main linac. A photocathode gun will generate two bunches with 28ns spacing at 100Hz repetition rate, with a nominal charge range of 10-200pC. A fast beam distribution kicker will allow to distribute one bunch to a soft X-ray undulator line and the other bunch to a 0.1nm hard X-ray undulator line. The SwissFEL electron beam position monitor (BPM) system will employ three different types of dual-resonator cavity BPMs, since the accelerator has three different beam pipe apertures. In the injector and main linac (38mm and 16mm aperture), 3.3GHz cavity BPMs will be used, where a low Q of ~40 was chosen to minimize crosstalk of the two bunches*. In the undulators that just have single bunches and 8mm BPM aperture, a higher Q will be chosen. This paper reports on the development status of the SwissFEL BPM system. Synergies as well as differences to the E-XFEL BPM system** will also be highlighted.

* F. Marcellini et al., "Design of Cavity BPM Pickups For SwissFEL", Proc. IBIC'12, Tsukuba, Japan, 2012.
** B. Keil et al., "The European XFEL BPM System", Proc. IPAC'10, Kyoto, Japan, 2010.

TUPC26 **Beam-line Diagnostics at the Front End Test Stand (FETS), Rutherford Appleton Laboratory, Oxfordshire, UK**

G.E. Boorman, *A. Bosco, S.M. Gibson (Royal Holloway, University of London)* ***G.E. Boorman***, *A. Bosco, S.M. Gibson (JAI) R.T.P. D'Arcy, S. Jolly (UCL) S.R. Lawrie, A.P. Letchford (STFC/RAL/ISIS)*

The H^- ion source and beam-line at FETS will require the beam current and beam position to be continually monitored. Current transformer toroids will measure the beam current and beam position monitors (BPM) will determine the beam position. The ion source delivers pulses at a rate of 50Hz with a current up to 60mA, each pulse is 2ms long, and a 324MHz micro-bunch structure imposed by the radio frequency quadrapole (RFQ) accelerating structure. The toroid outputs will be acquired on a fast oscilloscope. The BPM design is still under consideration (shorted strip-line or button type) but the processing for both types is similar and has been designed, with simulated measurements made. Each BPM uses four pick-ups, at a frequency of 324MHz, which are mixed using RF electronics to an intermediate frequency of 10.125MHz. The resulting signals are then digitized at 40.500MHz and processed in an FPGA to produce the position and phase of the beam at each BPM location, with a precision of better than 100μm and 0.05rad. The measurements from the toroids and BPMs will be via EPICS servers at every pulse.

TUPC28 **Strip Line Monitor design for the ISIS Proton Synchrotron using the FEA program HFSS**

S.J. Payne *(STFC/RAL/ISIS)*

This paper reports the development of a strip line monitor for the ISIS accelerator main ring. The strip line is still in the design phase and the work reported here is the results of the FEA programme HFSS. The strip line will eventually form part of a beam instability feedback system and will be used to control instabilities both in the current ISIS machine and for all future ISIS upgrades where higher intensities and energies could be realised. The strip line consists of two pairs of 550mm by 160mm broad flat electrodes configured to allow damping in both the horizontal and vertical planes. The paper describes the efforts to achieve a bandwidth of >260MHz which will allow the feedback system deal with instabilities such as those caused by electron clouds. Design of the electrodes including matching of the feed throughs to the electrodes , concerns of materials for the electrode supports are considered. Also considered are methods used to improved inter-electrode decoupling (to better than -30db) . Results in

the form of scattering parameters, smith charts, time domain reflectivity and shunt impedances will be presented.

TUPC29 **Grounded Coplanar Waveguide Transmission Lines as Pickups for Beam Position Monitoring in Particle Accelerators**

A. Penirschke, *A. Angelovski, R. Jakoby (TU Darmstadt) C. Gerth, U. Mavrič, D. Nölle, C. Sydlo, S. Vilcins (DESY)*

Energy beam position monitors (EBPM) based on grounded co-planar waveguide (GCPW) transmission lines have been designed for installation in the dispersive sections of the bunch compressor chicanes at the European XFEL. In combination with beam position monitors at the entrance and exit of the bunch compressor chicanes, measurements of the beam energy with single bunch resolution are feasible. The EBPM consists of transversely mounted stripline pickups in a rectangular beam pipe section. The signal detection for the measurement of the phases of the pulses at each end of the pickups is based on the standard down-conversion and phase detection scheme used for the low-level RF-system. A measurement resolution within the lower micrometer range can be achieved for input signal reflections at the pickup of less than -25 dB at 3 GHz. In this paper, simulation results of a novel pickup geometry utilized with GCPW pickup structures and optimized transitions to perpendicular mounted coaxial connectors are presented. The simulation results exhibit small reflection coefficients with reflected signal components having less than 2% of the peak voltage signal.

TUPC30 **Design of Strip-Line BPM for Large Thermal Stress Conditions**

P.E. Evtushenko, *F.E. Hannon (JLAB) B. Wustmann (HZDR)*

Jefferson Lab FEL operates DC photo gun and GaAs photocathode. Operation with average current of several mA and sufficiently long cathode lifetime requires pressure in the gun region at least at the 10^{-11} Torr level or better. To achieve such low pressure the gun chamber and the adjacent beam line are baked for an extended period of time. This imposes an additional requirement of withstanding the bake on all diagnostic elements. Additionally, analyzing beam line temperature in a high current energy-recovering linac as ones considered for future light sources, it was found that due to the short bunch length the resistive wall losses can be very high, which can cause large thermal stress to the beam line elements. With these in mind we have designed a modified strip-line beam position monitor with a flexible connection between the stip-line electrode and the central pin of conflate mounted SMA feedthrough. The design is based on a BPM previously developed for radiation source ELBE. To make manufacturing of the BPM more precise and less costly, brazing is used in place of welding. Mechanical and microwave design of the BPM is presented with initial microwave characterization.

TUPC31 **New Design of High Order Modes Electronics in MTCA.4 Standard for FLASH and the European XFEL**

***S. Bou Habib**, A. Abramowicz (Warsaw University of Technology, Institute of Electronic Systems) N. Baboi, H. Schlarb (DESY)*

At free-electron linear accelerators, various High Order Modes (HOM) - both monopole and dipole - are excited. Extensive studies at DESY have shown that monitoring and analysis of some of these modes can be used for different applications including Beam Position Monitors (BPMs) and the reduction of wake-fields, the measurement of the beam phase with-respect-to RF signal in cavities, and the measurement of cavity alignment in the 1.3 GHz cryo-modules. Three frequencies were chosen for further experiments: the 1.3 GHz base frequency from the klystron, the 1.7 GHz dipole mode and the 2.4 GHz monopole mode. In order to realize the monitoring and analysis requirements, very high resolution measurements in amplitude, phase and shape (time resolution) are required for all three frequencies simultaneously. In this paper, we present the new HOM electronics prototype including a microstrip and stripline RF tri-passband filter design and measurements and the specialized MTCA.4 Rear Transition Module for HOM measurements with an ultra-fast high-resolution AMC digitizer.

Time Resolved Diagnostics and Synchronization

TUPC33 **Femtosecond Stable Laser-to-RF Phase Detection for Optical Synchronization Systems**

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Optical synchronization systems have become the de facto standard for femtosecond synchronization at free-electron lasers. At the same time a highly phase-stable synchronization of RF subsystems is becoming more important. For pulsed optical synchronization systems like those running at FLASH or being implemented for the European XFEL, a laser-to-RF phase detector is currently the most precise way to provide femtosecond level stabilized RF signals to specific endstations. Specifically for these accelerators, the 1.3 GHz RF signals for the low level RF systems are meant to be stabilized using the laser-to-RF phase detector. The significant phase drift of RF cables along the machines can be suppressed in this way. To achieve this, a femtosecond precise optical reference signal will be supplied by the optical synchronization system to the laser-to-RF phase detector. The measured cable drift is corrected then in a phase-locked-loop. First details on the integrated prototype of this laser-to-RF phase detector will be presented in this paper, together with recent measurement results concerning the long-term stability of this device and an outlook on its future usage.

TUPC34 **Precision Synchronization of Optical Lasers Based on MTCA.4 Electronics**

***U. Mavrič**, M. Felber, C. Gerth, H. Schlarb, B. Steffen (DESY) T. Kozak (TUL-DMCS)*

Optical laser have become an integral part of free-electron laser facilities for the purposes of electron bunch generation, external seeding, diagnostics and pump-probe experiments. The ultra-short electron bunches demand a high timing stability and precision synchronization of the optical lasers. In this paper, we present the proof-of-principle for a laser locking application implemented on a MTCA.4 platform. The system design relies on existing MTCA.4 compliant off-the-shelf modules that are available on the market or have been developed for other applications within the particle accelerator community. Besides performance and cost, we also tried to minimize the number of out-of-crate components. Preliminary measurements of laser locking at the FLASH and REGAE particle accelerators are presented, and an outlook for further system development in the area of laser-to-RF synchronization is given.

TUPC35 **Upgrade of the Read-out Electronics for the Energy Beam Position Monitors at FLASH and European XFEL**

***U. Mavrič**, L. Butkowski, C. Gerth, H. Schlarb (DESY) A. Piotrowski (TUL-DMCS)*

The dispersive sections of magnetic bunch compressor chicanes at free-electron lasers are excellent candidates for beam energy measurements. In the rectangular beamline sections of the bunch compressors at FLASH, energy beam position monitors (EBPM) with transversely mounted stripline pickups are installed. In this paper, we present the upgrade of the read-out electronics for signal detection of the EBPM installed at FLASH. The system is based on the MTCA.4 standard and reuses already available MTCA.4 compliant modules. This is also true for gateware and software development which fits into standard MTCA.4 framework development. The performance of the instrument was studied at FLASH during user operation and the results are presented.

TUPC36 **First Realization and Performance Study of a Single-Shot Longitudinal Bunch Profile Monitor Utilizing a Transverse Deflecting Structure**

***M. Yan**, C. Behrens, C. Gerth, R. Kammering, F. Obier, V. Rybnikov (DESY) A. Langner (Uni HH) J. Wychowaniak (TUL-DMCS)*

For the control and optimization of electron beam parameters at modern free-electron lasers (FEL), transverse deflecting structures (TDS) in combination with imaging screens have been widely used as robust longitudinal diagnostics with single-shot capability, high resolution and large dynamic range. At the free-electron laser in Hamburg (FLASH), a longitudinal bunch profile monitor utilizing a TDS has been realized. In combined use with a fast kicker magnet and an off-axis imaging screen, selection and measurement of a single bunch out of the bunch train with bunch spacing down to 1us can be achieved without affecting the remaining bunches which continue to generate FEL radiation during user operation. Technical obstacles have been overcome such as suppression of coherent transition radiation from the imaging screen, the continuous image acquisition and processing with the bunch train repetition rate of 10Hz. The monitor, which provides the longitudinal bunch profile and length, has been used routinely at FLASH. In this paper, we present the setup and operation of the longitudinal bunch profile monitor as well as the performance during user operation.

TUPC37 **Presentation of the Smith-Purcell Experiment at SOLEIL**

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The potential of Coherent Smith-Purcell radiation as a longitudinal bunch profile monitor has already been demonstrated and has recently been extended to the sub-picosecond range. As a critical step toward the construction of a single shot bunch profile monitor using Coherent Smith-Purcell radiation it is important to measure very accurately the distribution of such radiation. Optimum background suppression techniques need to be found and relatively cheap detectors suitable for the far infra-red need to be qualified. To perform these tasks a test stand has been installed at the end of the linac of the synchrotron SOLEIL. This test stand and the first results from its commissioning will be presented here.

TUPC38 **Longitudinal Profile Monitor Using Smith-Purcell Radiation: Recent Results from the E-203 Collaboration**

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We report on recent measurements made at FACET by the E-203 collaboration to test a longitudinal bunch profile monitor based on Coherent Smith-Purcell radiation. The capacity of this monitor to resolve sub-picosecond bunches will be shown as well as a comparison of profile reconstructed for different beam compression settings. We will also present recent electromagnetic simulations of the interactions between the beam and the grating as well as the expected resolution of such monitor. Comparison between Coherent Smith-Purcell radiation measurement and those made with other techniques will also be discussed. Finally future upgrades of the experiment and steps toward the construction of a single shot longitudinal profile monitor will be presented.

TUPC39 **Dispersive Fourier-Transform Electrooptical Sampling for Single-Shot Modulation Measurement in a Proton-Driven Plasma Wakefield Accelerator**

***O. Reimann** (MPI-P) R. Tarkeshian (MPI)*

The concept of proton-driven plasma wakefield acceleration has recently been proposed as a means of accelerating a bunch of electrons to high energies with very high gradients, and a demonstration experiment (AWAKE) at CERN is now under development. For this a clear understanding of the temporal and spatial modulation of the proton driver bunches after propagating the plasma channel is essential. A single-shot electrooptical sampling system using dispersive Fourier-transform exploiting transverse coherent transition radiation* is proposed here to determine the bunch modulation and field properties in the frequency domain. Frequencies up to the terahertz region with a resolution of less than 10 GHz are measurable. The system with a closed optical fiber path is based on a semiconductor laser source to achieve easy handling and robustness. The principle idea, estimations of the required sensitivity, and first experimental results are presented.

* Pukhov, A. et al. Phys. Rev.ST Accel. Beams 15 (2012)

TUPC40 Bunch Length Measurements using Correlation Theory in Incoherent Optical Transition Radiation

B. Smit, *R. Ischebeck, V. Schlott (PSI)*

As Free Electron Lasers create ultra-short bunch lengths, the longitudinal diagnostic for such femto-second bunches becomes more difficult. We suggest a bunch length method using the spectral analysis of incoherent Optical Transition Radiation (OTR) in the visible frequency domain. The frequency response of OTR is taken by inserting an aluminium coated silicon wafer into the electron beam. The OTR light is collected with mirror optics into an optical fibre, which is coupled to a spectrometer (334 THz to 1500 THz). The resolution of the spectrometer allows us to measure bunch length lower than 100 fs rms. Bunch length was varied from 100 femto-seconds down to a few femto-seconds. The spectral response of Optical Transition Radiation (OTR) showed an increase of the correlation between neighbouring frequencies as bunch length was reduced.

TUPC41 A Femtosecond Resolution Electro-optic Longitudinal Profile Diagnostic Using a Nanosecond Duration Laser

S.P. Jamison *(STFC/DL/ASTeC) W.A. Gillespie, D.A. Walsh (University of Dundee)*

Electro-optic longitudinal profile diagnostic systems with intrinsically improved reliability and a time resolution of 20 fs rms are being developed for CLIC. Exploiting the electro-optic effect, the bunch electric field 'pulse carves' an optical replica from a narrow bandwidth nanosecond duration laser probe. All-optical characterisation of the optical replica is via spectrally resolved auto-correlation, providing a sub-20fs resolution capability. An optical parametric amplification stage following the pulse carving, and driven by same nanosecond laser that provides the probe, enables sufficient intensity for single-shot measurement. In basing the optical system on nanosecond Q-switched lasers, bypassing complex femtosecond laser systems, the potential for robust instrumentation development is enhanced. The bandwidth limitations of the electro-optic materials are being addressed through investigations into multiple crystal detectors, and THz induced second harmonic generation on metal surfaces. Experimental results on the optical subsystems, using laser-produced THz as an electron bunch mimic, are presented together with performance projections for the integrated system.

TUPC42 **Method of Simultaneous Stabilisation of Phase and Group Delays in Optical Fibre Links**

T.T. Thakker, *S.P. Jamison (STFC/DL/ASTeC)*

Optical timing schemes for free-electron laser facilities typically employ a pulsed clock distribution with stabilized group delay or a CW clock distribution with stabilized phase delay. While interferometric stabilisation of phase delay offers higher sensitivity than group delay detection, pulsed distribution systems are frequently favoured for their direct stabilisation of the clock frequency and simpler integration into arrival time diagnostics. We propose a pulsed clock distribution system which stabilises both the phase and group delay in the link. The stabilisation system would use a combination of interferometry and cross correlation techniques to detect for group and phase delay changes in distribution and dual delay lines to simultaneously compensate for both these changes. The proposed system is modelled and preliminary measurements on the phase and group control are presented.

TUPC43 **Bunch Length Measurement With Streak Camera At SSRF Storage Ring**

J. Chen, *Z.C. Chen, Y.B. Leng, K.R. Ye, R.X. Yuan (SINAP)*

A streak camera is installed to measure the bunch length of storage ring at SSRF. The principle, structure, configuration and error analysis of the measurement is introduced. Some result of the measurement are analysed to explain the physical meaning of beam status. The system is used in daily operation and machine study at SSRF.

Beam Loss Detection

TUPC44 **Beam Energy Measurements Using Resonant Spin Depolarization at ALBA**

U. Iriso, *Z. Martí (CELLS-ALBA Synchrotron)*

Polarization effects after fresh beam injections have been observed at ALBA during these last year of operation. Precise energy measurements can be inferred from the lifetime evolution when depolarizing the beam using AC kicks with the Transverse Fast Feedback system. Until recently, lifetime measurements using the DCCT, the BPM sum signals, and pin-diode BLMs have been too noisy for a proper beam energy measurement. We report the actions taken to increase the precision of the lifetime measurements, which consisted on the improvement of the BPM sum signal and the installation of a scintillator based Beam Loss Detector in collaboration with the ESRF. First results obtained with this instrumentation are also reported.

TUPC45 **DOSFET-L02: An Advanced Online Dosimetry System for RADFET Sensors**

***L. Fröhlich**, S. Grulja (Elettra-Sincrotrone Trieste S.C.p.A.) F. Löhl (PSI)*

Radiation-sensing field-effect transistors (RADFETs) are integrating dosimeters that have found wide application in space and particle accelerator environments. We present a new system, the DOSFET-L02, for the readout of up to four RADFET sensors. The system features enhanced readout stability, support for long sensor cables, an adjustable exposure bias voltage of up to 30 V, and integrated temperature measurement. Recent measurements demonstrate the performance of the system with RADFETs at bias voltages of 9 V, 25 V, and under zero bias.

TUPC46 **Beam Loss Monitoring Study for SIS100@FAIR**

***V.S. Lavrik**, L.H.J. Bozyk, O.K. Kester, A. Reiter (GSI) O.K. Kester (IAP)*

FAIR, the facility for antiproton and ion research, is a multi-disciplinary accelerator facility which will extend the existing GSI complex in Darmstadt, Germany. In the FAIR start version, the new synchrotron SIS100 will provide proton or heavy ion beams for a variety of experiments. The GSI synchrotron SIS18 will operate as injector for SIS100. The current study focuses on beam loss measurements for SIS18 and SIS100. The aim of this study is to find quantitative methods to measure beam losses around the machine, mainly SIS100, on an absolute scale. The contribution will present results of two pilot experiments carried out in the high-energy beam lines and at the SIS18 with Uranium ions in the energy range up to 900 MeV/u. In the first experiment the Uranium beam was totally stopped in a Copper target and the particle shower measured with LHC-type ionization chambers. In the second experiment, the beam was slowly excited in the SIS18 synchrotron to create controlled losses on a scraper which were monitored by the DC current transformer and beam loss monitors. Experimental data are compared against the predictions of Fluka simulations.

TUPC47 **Simulation for Radiation Field Caused by Beam Loss of C-ADS Injector II**

***G. Ren**, W. Li, Y. Li (USTC/NSRL) M. Zeng (Tsinghua University)*

CADS is a Chinese ADS(Accelerator Driven Sub-critical System) project. Its injector is a high current, full superconducting proton accelerator. For such a facility, a BLM system is necessary, especially in low energy segments. This paper presents some basic simulation for 10MeV proton by Monte Carlo program FLUKA, as well as the distributions we got about different secondary particles in three aspects: angular, energy spectrum and current. These results are helpful to select the detector type and its location, determine its dynamic range matching different requirements for both fast and slow beam loss. This paper also analyzes the major impact of the background, such as superconducting cavity X radiation and radiation caused by material activation. This work is meaningful in BLM system research.

Beam Profile Monitors

TUPF01 Emittance Measurements in the Brookhaven AGS

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High luminosity and high polarization in RHIC require good control and measurement of emittance in its injector, the Brookhaven AGS. In the past, the AGS emittance has been measured by using an ion collecting IPM during the whole cycle and a multi-wire at injection. The beam profiles from this IPM are distorted by space charge forces at higher energy, which makes the emittance determination very hard. In addition, helical superconducting snake magnets and near integer vertical tune for polarized proton operation distort the lattice in the AGS and introduce large beta beating. For more precise measurements of the emittance, we need TBT measurements near injection and beta function measurements at the location of devices used to measure the emittance. A Polarimeter target has been used as flying wire for proton emittance measurement. A new type electron collecting IPM has been installed and tested in the AGS with proton beam. The Beta functions at the IPM locations have been measured with Orbit Response Matrix (ORM) methods and with a local corrector at IPM. This paper summarizes our current understanding of AGS emittances and plans for further improvements.

TUPF02 Secondary Emission Monitor for keV Ion and Antiproton Beams

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Beam profile monitoring of low intensity keV ion and antiproton beams remains a challenging task. A Secondary electron Emission Monitor (SEM) has been designed to measure profiles of beams with intensities below 10^7 and energies as low as 20 keV. The monitor is based on a two stage microchannel plate (MCP) and a phosphor screen facing a CCD camera. Its modular design allows two different operational setups. In this contribution we present the design of a prototype and discuss results from measurements with protons at INFN-LNF and antiprotons at the AEgIS experiment at CERN*. This is then used for a characterization of the monitor with regard to its possible future use at different facilities.

* Measurements at the AD carried out with the AEgIS collaboration.

TUPF03 **Performance Assessment of Wire-Scanners at CERN**

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This article describes the current fast wire-scanner devices installed in circular accelerators at CERN with an emphasis of the error studies carried out during the last two runs. At present the wire-scanners have similar acquisition systems but are varied in terms of mechanics. Several measurement campaigns were performed aimed at establishing optimal operational settings and to identify and assess systematic errors. In several cases the results led to direct performance improvements while in others this helped in defining the requirements for new detectors.

TUPF05 **Particle Tracking for the FETS Laser Wire Emittance Scanner**

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The Front End Test Stand (FETS) is an R&D project at Rutherford Appleton Laboratory (RAL) with the aim to demonstrate a high power (60 mA, 3 MeV with 50 pps and 10 % duty cycle), fast chopped H^- ion beam. The diagnostics of high power particle beams is difficult due to the power deposition on diagnostics elements introduced in the beam so non-invasive instrumentation is highly desirable. The laser wire emittance scanner under construction is based on a photo-detachment process utilizing the neutralized particles produced in the interaction between Laser and H^- beam for beam diagnostics purposes. The principle is appropriate to determine the transversal beam density distribution as well as the transversal and longitudinal beam emittance behind the RFQ. The instrument will be located at the end of the MEBT with the detachment taking place inside a dipole field. Extensive particle tracking simulations have been performed for various settings of the MEBT quadrupoles to investigate the best placement and size of the 2D scintillating detector and to determine the range and resolution of the instrument. Additionally the power distribution in the following beam dumps has been determined.

TUPF06 **2D Wire Grid Integrated with Faraday Cup for Low Energy H^- Beam Analysis at Siemens Novel Electrostatic Accelerator**

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D.C. Faircloth (STFC/RAL/ISIS) A.J. Holmes (Marcham Scientific Ltd)
R.G. Selway (Inspired Engineering Ltd)

A wire grid with 21 wires each vertically and horizontally with a spacing of 1 mm has been developed for beam analysis at Siemens' novel electrostatic accelerator. The wire grid is integrated in a Faraday Cup and profile measurements can therefore be combined with current measurements. The grid is used to analyse the 10 keV H^- beam coming from the ion source and the obtained beam parameters will be used as input for simulations of the beam transport in the accelerator. All 42 wires can be read out simultaneously with a multi-channel precision electrometer and the data can be fitted instantly with LabVIEW code that was developed for this purpose. This paper reports on some details of the mechanical design and

the data analysis procedure in LabVIEW as well as some results of first measurements at the novel accelerator.

TUPF07 **Covariance and Temporal Causality in the Transition Radiation Emission by an Electron Bunch**

G.L. Orlandi *(PSI)*

A model of the transition radiation emission by a N electron bunch must conform to covariance and causality. The covariance of the charge density must imprint the transition radiation energy spectrum via a proper formulation of the charge form factor. The emission phases of the radiation pulse must be causality correlated with the temporal sequence of the N electron collisions onto the metallic screen. Covariance and temporal causality are the two faces of the same coin: failing in implementing one of the two constraints into the model necessarily implies betraying the other one. The main formal aspects of a covariance and temporal-causality consistent formulation of the transition radiation energy spectrum by an N electron beam are here described. In the case of a transition radiator with a round surface, explicit formal results are presented.

TUPF08 **Characterization of Compressed Bunches in the SwissFEL Injector Test Facility**

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The quality of the beam transverse emittance at the cathode and the uniformity of the longitudinal compression of the electron bunch are essential for the lasing efficiency of a Free Electron Laser. In SwissFEL the longitudinal compression of the electron beam is performed by means of two magnetic chicanes and an off-crest acceleration scheme. The curvature induced on the beam longitudinal phase-space during the compression can be compensated by means of an X-band cavity. The beam longitudinal phase-space can be experimentally characterized by means of a Transverse Deflecting Cavity (TDC) and a profile monitor in a dispersive section. Longitudinal phase-space measurements at the SwissFEL Injector Test Facility under compression with and without X-band linearizer are presented. In addition, energy spread measurements done by monitoring the Synchrotron Radiation (SR) emitted by the electron beam in the dispersive section of the chicane are shown. A comparison with numerical simulations is presented.

TUPF09 **Commissioning Experience and First Results From the New SLS Beam Size Monitor**

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In the context of the TIARA work package “SLS vertical emittance tuning” (SVET), an extremely small vertical beam size of 3.6 μm, corresponding to a vertical emittance of 0.9 pm, was verified using an optical monitor based on imaging of pi-polarized light. Since the existing beam size monitor

reached its limit of resolution, a new monitor beam line was designed and installed at the 08BD bending magnet of the storage ring of the Swiss Light Source SLS. Larger magnification and operation at shorter wavelength provide improved spatial resolution. Reflective optics enables convenient switching between different wavelengths. An optical table is located in a hutch outside the storage ring tunnel to provide access during operation. Movable obstacles in the beam path create interference patterns and thus provide redundancy of model based analysis of the images. In this paper we report on our commissioning experience and provide a comparison of the different measurement methods at different wavelengths.

TUPF10 **A Non-Intercepting Beam Emittance Measurement Device Based on Neutral Beam Fluorescence Method at PKU**

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A new concept to attain ion beam emmitance through measuring the forward neutral beam without intercepting the beam transportion was proposed at PKU. The forward neutral beam produced by space charge compensation and separated from the transporting ion beam with the help of a deflecting magnetic field, carries the entire emittance information of the original particle beam and becomes a fast and non-interceptive beam diagnostic tool. This idea was tested on PKU ion source test bench and the experimental results show that the neutral beam fluorescence method is feasible. Bases on these qualification results, a formal non-intercepting emittance measurement device was designed. It is a 90 degree full-scale dipole analysis magnet combining with the classical pepper-pot technique. Test and commissioning of the device are in progress. Details of design and comnissioning results will be presented in this paper.

TUPF11 **Design and Initial Demonstration Results of Laser Wire Scanner for Energy Recovery Linacs**

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Energy Recovery LINACs (ERL's) can produce electron beams of smaller emittance than in synchrotron rings, with high average current, and without inefficiencies involved in dumping a high-powered accelerated beam. The ERL group at the Cornell Lab for Accelerator-based ScienceS and Education (CLASSE) is currently testing an injector for an ERL based X-ray light source: a superconducting RF (SRF) accelerator coupled to a DC electron gun and high rep rate (1.3 GHz) photocathode drive laser, capable of producing a CW beam of 80 pC bunches (100 mA ave current). Traditional transverse diagnostics are incapable of operation with such high average currents, motivating the the use of a Laser Wire Scanner (LWS). RadiaBeam Technologies, in collaboration with the Cornell ERL group, is developing a LWS system capable of measuring e-beam profiles in both transverse

dimensions as well as obtaining the longitudinal beam profile. Due to the low energy of the injector output (5-15 MeV) and beam halo scraping, detection of laser-scattered photons is significantly more challenging than in previous LWS system. This contribution presents a LWS prototype design and initial demonstration results.

TUPF12 **Development of High Resolution Beam Profile Imaging Diagnostics**

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Accurate characterization of an electron beam profile is often a critical instrumentation task at modern light sources and advanced acceleration facilities. Yet ultra-small emittances presently achievable in photo-injectors are often testing the limits of the traditional diagnostic systems such as scintillating screens or optical transition radiation (OTR) monitors. To mitigate some of the limitations on resolution and accuracy of beam profile measurements, a number of novel experimental approaches are presently under development at RadiaBeam, including optical fiber based Cerenkov radiation monitors, all-reflective optics OTR monitors, and DUV/EUV transition radiation monitors with sub-micron resolution. We report development status and initial experimental results.

TUPF14 **Description of Laser Transport and Delivery System for the FETS Laserwire Emittance Scanner**

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A beam emittance monitor for H^- beams based on laser-induced ions neutralization is being developed at the Front End Test Stand (FETS) at the Rutherford Appleton Laboratory (RAL). The laser system that will be used for the photo-neutralization of the H^- beam is a fiber laser emitting 110 ns pulses at λ=1064nm, with a repetition rate of 30 kHz and peak power of 8 kW. The laser will be conveyed to the interaction area over a distance of 70 m via an optical fiber. An assembly of two remotely controlled motorized translation stages will enable the system to scan across the H^- beam along its vertical profile. A motorized beam expander will control the output size of the collimated laser beam in order to enable the system to operate with different spatial characteristics of the ions beam. In this paper we present a full account of the laser characteristics, the optical transport system and the final delivery assembly. All the relevant measurements such as power, spatial and temporal characteristics of the laser, fiber transport efficiency and final delivery laser beam parameters will be reported.

TUPF15 **Overview of Laserwire Beam Profile and Emittance Measurements for High Power Proton Accelerators**

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Laserwires were originally developed to measure micron-sized electron beams via Compton scattering, where traditional wire scanners are at the limit of their resolution. Laserwires have since been applied to larger beam-size, high power H^- ion beams, where the non-invasive method can probe beam densities that would damage traditional diagnostics. While photo-detachment of H^- ions is now routine to measure beam profiles, extending the technique to transverse and longitudinal emittance measurements is a key aim of the laserwire emittance scanner under construction at the Front End Test Stand (FETS) at the RAL. A pulsed, 30kHz, 8kW peak power laser is fibre-coupled to motorized collimating optics, which controls the position and thickness of the laserwire delivered to the H^- interaction chamber. The laserwire slices out a beamlet of neutralized particles, which propagate to a downstream scintillator and camera. The emittance is reconstructed from 2D images as the laserwire position is scanned. Results from the delivery optics, scintillator tests and particle tracking simulations of the full system are reviewed. Plans to deploy the FETS laser system at the Linac4 at CERN are outlined.

TUPF16 **Analysis of Measurement Errors of INR Linac Ionization Beam Cross Section Monitor**

***S.A. Gavrilov**, A. Feschenko, P.I. Reinhardt-Nickoulin, I.V. Vasilyev (RAS/INR)*

Residual gas ionization beam cross section monitors (BCSM) are installed at LEBT and HEBT of INR RAS proton linac to measure cross section, profiles and position of the beam. BCSMs provide two-dimensional non-destructive real-time beam diagnostics at LINAC operation with repetition frequency from 1 to 50 Hz, pulses duration from 0.3 to 170 μs and wide range of amplitudes, particle energy 400 keV and 209 MeV. The analysis of systematic measurements errors (accuracy) because of nonuniform electrostatic fields, determined by BCSM design features, is presented. New detector model, minimizing these nonuniformities, is shown. Besides that, the analysis of statistical errors (precision) due to the method features, in particular, ions thermal motion and a beam space charge, is done. The simulation results make it possible to estimate measured cross sections size, profiles and beam positions and to draw conclusions about the reliability of BCSM results for beams with various parameters.

TUPF17 **SR Photon Distribution Reconstruction in Phase Space using X-ray Pinhole Camera**

K.R. Ye, *J. Chen, Z.C. Chen, Y.B. Leng, L.Y. Yu, W.M. Zhou (SINAP)*

Since 2009 an X-ray pinhole camera that has been used to present the transverse beam size on diagnostic beamline of the storage ring in Shanghai Synchrotron Radiation Facility (SSRF). Transverse beam profiles in the real(x,y) and phase(Y,Y') spaces are obtained by an X-ray pinhole camera sensitive by moving one pinhole. The large amount of collected data has allowed a detailed reconstruction of the transverse phase space evolution in this paper. An image on a fluorescent screen is observed by a CCD camera, digitized and stored, then the phase space and the real space profiles are reconstructed. A non-linear least square program fits the resultant profiles to a vertical dimensional Gaussian distributions to derive the phase space and emittances for SSRF storage ring.

TUPF18 **Vertical Undulator Emittance Measurement: A Statistical Approach**

K.P. Wootton, *R.P. Rassool (The University of Melbourne) M.J. Boland, B.C.C. Cowie, R.T. Dowd (SLSA)*

Direct measurement of low vertical emittance in storage rings is typically achieved via interferometric techniques. Proof of low vertical emittance is demonstrated by the measurement of a null radiation field, which is also the crux of the vertical undulator emittance measurement. Here we present strategies to improve the sensitivity to low vertical emittance beams. We move away from photon spectrum analysis to a statistical analysis of undulator radiation, showing the measured increase in signal-to-background. Reproducing simulations of previous work, we demonstrate that photon beam polarisation extends the linearity of the technique by several decades in emittance. These statistical and polarisation improvements to the signal-to-background allow realistic measurement of smallest vertical emittance.

TUPF19 **APPLE-II Undulator Magnetic Fields Characterised from Undulator Radiation**

K.P. Wootton, *R.P. Rassool (The University of Melbourne) M.J. Boland, B.C.C. Cowie (SLSA)*

The spatial profile of APPLE-II undulator radiation has been measured at high undulator deflection parameter, high harmonic and very small emittance. Undulators are typically designed to operate with small deflection parameter to push the fundamental mode to high photon energies. This unusual choice of parameters is desirable for measurement of vertical emittance with a vertical undulator. We present 1-D and 2-D measured profiles of undulator radiation, and show that this is reproduced in numerical models using the measured magnetic field of the insertion device. Importantly these measurements confirm that for these parameters, the spatial intensity distribution departs significantly from usual Gaussian approximations, instead resembling a double-slit diffraction pattern. This could be an important consideration for photon beamlines of ultimate storage ring light sources.

TUPF20 Low Noise and High Dynamic Range Optical Interferometer Beamsize Measurements

M.J. Boland *(SLSA) T.M. Mitsuhashi (KEK) K.P. Wootton (The University of Melbourne)*

The technique of optical interferometry to measure beam sizes requires a low noise and high dynamic range digitisation system to push the performance to ultra low emittance on storage rings. The next generation of camera sensor Scientific CMOS (sCMOS) promises to provide the technology to improve optical interferometry. A series of measurements was performed on the Australian Synchrotron storage ring using a sCMOS and a intensity imbalance optical interferometer. The coupling in the storage ring was varied from maximum to minimum using the skew quadrupoles and the beam size at the optical diagnostic beamline was varied from over 100 microns to around 1 micron. A comparison is made between interferometer measurements using the sCMOS with and without an intensity imbalance and with previous measurements using a CCD system.

TUPF21 Response of Scintillating Screens to Fast and Slow Extracted Ion Beams

A. Lieberwirth, *W. Ensinger (TU Darmstadt) P. Forck, B. Walasek-Höhne (GSI)*

For the FAIR project, imaging properties of inorganic scintillators for high energetic heavy ion beams were studied. In order to investigate the characteristics of scintillation response and transverse beam profile, several experiments were conducted with slow (200 ms) and fast (1 μs) extracted 350 MeV/u Uranium beams from SIS18. The extracted particle number was varied between 10^5 and 10^9 particles per pulse for the irradiation of seven different scintillators: YAG:Ce-crystals with different qualities, pure and Cr-doped alumina as well as two phosphors P43 and P46. Additionally radiation resistance tests for all phosphor screens and the Cr-doped alumina screen were performed by irradiating with more than 700 pulses with 10^9 ions each. Linear response in scintillation light output as well as realistic statistical moments over the large range of ion intensities are presented for each material. Only minor changing in target response was observed after 45 minutes of permanent irradiation.

TUPF22 Beam Halo Monitor Based on an HD Digital Micro Mirror Array

B.B.D. Lomberg, *C.P. Welsch (The University of Liverpool)* ***B.B.D. Lomberg***, *C.P. Welsch (Cockcroft Institute)*

A beam halo monitor is an essential device to pursue studies of halo particles produced in any particle accelerator as to investigate the effects of disturbances, such as field kicks, gradient errors, etc. A fast, least intrusive, high dynamic range monitor will allow the detection and potentially control of particles at the tail of a transverse beam distribution. Light generated by a beam of charged particles is routinely used for beam diagnostic purposes. A halo monitor based on a digital micro-mirror device (DMD) used to generate an adaptive optical mask to block light in the core of the emitted light profile and hence limit observation to halo particles has

been developed in close collaboration with CERN and University of Maryland. In this contribution an evolution of this monitor is presented. A high definition micro-mirror array with 1920x1080 pixels has been embedded into a MatLab-based control system, giving access to even higher monitor resolution. A masking algorithm has also been developed that automates mask generation based on user-definable thresholds, converts between CCD and DMD geometries, processes and analyses the beam halo signal and is presented in detail.

Beam Charge Monitors and General Diagnostics

TUPF24 Instrumentation for the Proposed Low Energy RHIC Electron Cooling Project

D.M. Gassner, *A.V. Fedotov, D. Kayran, V. Litvinenko, R.J. Michnoff, T.A. Miller, M.G. Minty, I. Pinayev, M. Wilinski (BNL)*

There is a strong interest in running RHIC at low ion beam energies of 2.5-20GeV/nucleon; this is much lower than the typical operations with 100GeV/nucleon. The primary motivation for this effort is to explore the existence and location of the critical point on the QCD phase diagram. Electron cooling can increase the average integrated luminosity and increase the length of the stored lifetime. Simulations and conceptual cooling subsystem designs are underway. The present plan is to provide 10–50mA of bunched electron beam with adequate quality and an energy range of 0.9–5MeV. The preliminary cooling facility configuration planned to be fully inside the RHIC tunnel will include a 102.74MHz SRF gun, a booster cavity, a beam transport to the Blue ring to allow electron-ion co-propagation for ~10-20m, then a 180 degree u-turn electron transport so the same electron beam can similarly cool the Yellow ion beam, then to a dump. The electron beam instrumentation systems that will be described include current transformers, BPMs, profile monitors, a pepper pot emittance station and loss monitors.

TUPF25 Beam Current Measurement System in CSNS LINAC

P. Li, *F. Li, M. Meng, T.G. Xu (IHEP)*

The China Spallation Neutron Source is being constructed at Dongguan, Guangdogn province. Before RCS Ring there are three beam transport sections in CSNS LINAC : LEBT, MEBT, LRBT, where various beam measurement monitors will be installed. Beam Current Transformers (BCTs) have been designed to measure beam macro-pulse current that will operate between 5mA to 80mA . The BCTs have the same inductance but different size in these three sections. Besides, beam parameters should be monitored also between the DTL four parts. There is no BCT but a FCT would be installed after DTL1 due to space limit. So this FCT is planned to measure the macro-pulse current, and we have to proceed the acquired data to show the original macro-pulse waveform due to the FCT's low inductance.

TUPF26 Laser-Based Beam Instrumentation R&D within LA3NET

C.P. Welsch *(Cockcroft Institute)* ***C.P. Welsch*** *(The University of Liverpool)*

Within LA3NET, Laser Applications for Accelerators are being developed by an international NETwork of more than 30 partner institutions from across the world. Laser-based beam instrumentation is at the core of this EU-funded project which will train 17 fellows during its four year project duration. In this contribution, we will present the consortium's recent research results in beam diagnostics, ranging from development of a laser velocimeter and laser emittance meter, over measurement of the bunch shape with electro-optical sampling in an electron accelerator and precision determination of electron beam energy with Compton backscattered laser photons to measurement of electron bunches with a time resolution of better than 20 femtoseconds. We will also provide a summary of past training events organized by the consortium and give an overview of future workshops, conferences and schools.

TUPF27 An Ultra Low-Noise AC Beam Transformer and Digital Signal Processing System for CERN's ELENA Ring

M.E. Angoletta*, C. Carli, S. Federmann, J.C. Molendijk, F. Pedersen, J. Sanchez-Quesada (CERN)*

CERN's Extra Low ENergy Antiproton (ELENA) Ring is a new synchrotron that will be commissioned in 2016 to further decelerate the antiprotons coming from CERN's Antiproton Decelerator. Essential longitudinal diagnostics required for commissioning and operation include the intensity measurement for bunched and debunched beams and the measurement of Dp/p for debunched beams to assess the electron cooling performance. The beam phase information is also needed by the low-level RF system. The baseline system for providing the required beam parameters and signals is based upon two ultra-low-noise AC beam transformers and associated digital signal processing. The AC beam transformers cover different frequency regions and are an adaptation to the ELENA layout of those used in the AD. Two AC beam transformers will also be installed in the extraction lines to provide beam intensity and bunch shape measurements. The digital signal processing will be carried out with the leading-edge hardware family used for ELENA's low-level RF system. The paper provides an overview of the beam transformer and head amplifier, as well as of the associated digital signal processing.

TUPF28 A Leading-Edge Hardware Family for Diagnostics Applications and Low-Level RF in CERN's ELENA Ring

M.E. Angoletta*, J.C. Molendijk, J. Sanchez-Quesada (CERN)*

The CERN Extra Low ENergy Antiproton (ELENA) Ring is a new synchrotron that will be commissioned in 2016 to further decelerate the antiprotons transferred from the CERN's Antiproton Decelerator (AD). The requirements for the acquisition and treatment of signals for longitudinal diagnostics are very demanding, owing to the revolution frequency swing as well

as to the digital signal processing required. The requirements for the Low-Level RF (LLRF) system are very demanding as well, especially in terms of revolution frequency swing, dynamic range and low noise required by the cavity voltage control and digital signal processing to be performed. Both sets of requirements will be satisfied by using a leading-edge hardware family, developed to cover the LLRF needs of all synchrotrons in the Meyrin site; it will be first deployed in 2014 in the CERN's PSB and in the medical machine MedAustron. This paper gives an overview of the main building blocks of the hardware family and of the associated firmware and IP cores. The performance of some blocks will also be detailed.

TUPF29 **Tune Measurement from Transverse Feedback Signals in LHC**

F. Dubouchet, *W. Höfle, G. Kotzian, T.E. Levens, D. Valuch (CERN)*
P. Albuquerque (EIG)

We show how bunch-by-bunch position data from the LHC transverse feedback system can be used to determine the transverse tunes. Results from machine development experiments are presented and compared with theoretical predictions. In the absence of external beam excitations the tune is visible in the spectra of the position data with the feedback loop as a dip, while with external excitation a peak is visible. Both options, observation with and without excitation, are demonstrated to be complementary. Periodic excitation and observation of the free oscillation can also be used to determine the damping time of the feedback in addition to the coherent tune. Plans are outlined for hardware upgrades of the LHC transverse feedback system that will enable fast online processing of bunch-by-bunch, turn-by-turn data using Graphical Processing Units (GPU). By using GPUs we gain the ability to compute and store the spectrum of all bunches in real-time and the possibility to reconfigure test and deploy algorithms. This data acquisition and analysis architecture also allows changes to be made without disturbing the operation.

TUPF30 **Measurements with the Upgraded Cryogenic Current Comparator**

F. Kurian, *P. Hülsmann, P. Kowina, H. Reeg, M. Schwickert (GSI)*
R. Geithner, R. Neubert, W. Vodel (FSU Jena) R. Geithner, W. Vodel (HIJ)

For the measurement of the very low ion beam current -down to nA range- foreseen in the High Energy Transport sections of the upcoming FAIR facility, an improved Cryogenic Current Comparator (CCC) is under development at GSI. The existing CCC unit, initially operated at the high energy beam transport section after the GSI synchrotron SIS18, has been upgraded as a prototype for FAIR. The upgraded CCC is presently being re-commissioned. In this contribution we report on beam current measurements with the improved detector unit down to 5 nA simulated by a wire loop wound around the magnetic sensor. As mechanical vibrations strongly influence the sensitive SQUID detector, vibration analyses have been carried out using an accelerometer. Noise contributions from various mechanical as well as electrical sources were studied and the achieved detector performance is presented

TUPF31 **Intensity Control in GANIL's Experimental Rooms**

C. Courtois, *T. André, C. Doutresssoulles, B. Ducoudret, C. Jamet, W. Le Coz, G. Ledu, C. Potier de courcy (GANIL)*

The safety re-examination of existing GANIL facilities requires the implementation of a safety system which makes a control of beam intensities sent in the experimental rooms possible. The aim is to demonstrate that beam intensities are below the authorized limits. The required characteristics should enable the measurement, by a non-interceptive method, of beam intensities from 5 nA to 5μA with a maximum uncertainty of 5%, independently of the frequency and the beam energy. After a comparative study, two types of high frequency diagnostics were selected, the capacitive peak-up and the Fast current transformer. This paper presents the signal simulations from diagnostics with different beam energies, the uncertainty calculations and the results of the first tests with beam.

TUPF32 **A Cryogenic Current Comparator for FAIR with Improved Resolution**

R. Geithner, *W. Vodel (HIJ)* ***R. Geithner***, *R. Neubert, P. Seidel (FSU Jena) F. Kurian, H. Reeg, M. Schwickert (GSI)*

A Cryogenic Current Comparator is a highly sensitive tool for the non-destructive online monitoring of continuous as well as bunched beams of very low intensities. The noise-limited current resolution of such a device depends on the ferromagnetic material embedded in the pickup coil of the CCC. Therefore, the main focus of research was on the low temperature properties of ferromagnetic core materials. In this contribution we present first results of the completed Cryogenic Current Comparator for FAIR working in a laboratory environment, regarding the improvements in resolution due to the use of suitable ferromagnetic core materials.

TUPF33 **Electron Beam Diagnostics Using Radiation from a Free Electron Laser**

M. Arbel *(H.I.T.) A. Eichenbaum (Ariel University Center of Samaria, Faculty of Engineering)*

In most devices based on a high energy electron beam, which used for electromagnetic radiation production, great efforts are focused on the electron beam quality improvement. This is the case in a Free-Electron Laser (FEL) where electron beam with a low normalized emittance is required. Thus, diagnostic tools are required to investigate e-beam properties, such as beam emittance, longitudinal space charge, energy spread and velocity spread. In this paper we present analysis of radiation measurements obtained from a pre-bunched e-beam FEL. The measurements were made for a wide range of frequencies and for beam currents from low currents to high currents, where space charge effects can not neglected. We apply a frequency domain formulation to analyze the measured radiation. The spectral signature of the radiation emission obtained from a pre-bunched e-beam can provide vital information on e-beam properties. We show that a rigorous analysis of the measured radiation, allows characterization of the e-beam parameters. This analysis can provide some insights to the development of e-beam accelerators and radiation sources devices and to help physicists interpreting radiated signals.

TUPF34 **Resonant TE Wave Measurement of Electron Cloud Density Using Multiple Sidebands**

J.P. Sikora, *J.A. Crittenden (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) S. De Santis (LBNL) A.J. Tencate (ISU)*

A change in electron cloud (EC) density will change the resonant frequency of a section of beam-pipe. With a fixed drive frequency, the resulting phase shift across the resonant section will include the convolution of the frequency shift with the impulse response of the resonance. The effect of the convolution on the calculated modulation sidebands is in agreement with measured data, including the absolute value of the EC density obtained from ECLOUD simulations. These measurements were made at the Cornell Electron Storage Ring (CESR) which has been reconfigured as a test accelerator (CesrTA) having positron or electron beam energies ranging from 2 GeV to 5 GeV.

TUPF35 **Resonant TE Wave Measurement of Electron Cloud Density Using Phase Detection**

J.P. Sikora *(Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education) S. De Santis (LBNL)*

The resonant TE wave technique can use modulation sidebands for the calculation of electron cloud (EC) density. An alternative is to mix the drive and received signals to form a phase detector. Using this technique, the phase shift across the resonant section of beam-pipe can be observed directly on an oscilloscope. The growth and decay of the EC density has a time constant of roughly 100 ns, while the measured phase shift will include a convolution of the EC density with the impulse response of the resonant beam-pipe - typically about 500 ns. So any estimate of the growth/decay of the cloud requires deconvolution of the measured signal with the response time of the resonance. We have also used this technique to look for evidence of EC density with a lifetime that is long compare to the revolution period of the stored beam. These measurements were made at the Cornell Electron Storage Ring (CESR) which has been reconfigured as a test accelerator (CesrTA) having positron or electron beam energies ranging from 2 GeV to 5 GeV.

TUPF36 **Analysis of Modulation Signals Generated in the TE Wave Detection Method For Electron Cloud Measurements**

S. De Santis *(LBNL) J.P. Sikora (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*

The evaluation of the electron cloud density in storage rings by measuring its effects on the transmission of electromagnetic signals across portions of the beampipe is a widely used technique and the most suited for measurements over extended regions. Recent results show that in a majority of

cases the RF signal transmission takes place by coupling to standing waves excited in the vacuum chamber. In such a case the effect of a varying cloud density is a simultaneous amplitude, phase and frequency modulation of a fixed frequency drive signal. The characteristics of the modulation depend not only on the cloud density values and spatial distribution, but also on its temporal evolution and on the damping time of the standing waves. In this paper we evaluate the relationship between measured modulation sidebands amplitude and the electron cloud density when cloud and electromagnetic resonance rise and fall times are of the same order of magnitude, as it is the case in the accelerators where we have conducted our experiments.

WEAL — Beam Profile 2

Chair: Å. Andersson (MAX-lab)

Beam Profile Monitors

WEAL1 09:00 40

Large Aperture X-ray Monitors for Beam Profile Diagnostics

C.A. Thomas, *G. Rehm (Diamond) F. Ewald (ESRF) J.W. Flanagan (KEK)*

Emittance is one of the main characteristic properties of a beam of particles in an accelerator, and it is measured generally by means of the particle beam profile. In particular, when the beam of particles is emitting an X-ray photon beam, a non perturbative way of measuring the particle beam profile is to image it using the emitted X-ray photon beam. Over the years, numerous X-ray imaging methods have been developed, fulfilling the requirements imposed by a particle beam becoming smaller, and approaching micron size for electron beam machine with vertical emittance of the order of 1pm-rad. In this paper, we will first recall the properties of the X-ray photon as function of source and its properties. From this we will derive some natural definition of a large aperture X-ray imaging system. We will then use this selection criterion to select a number of X-ray imaging devices used as a beam profile diagnostics in an attempt to give an overview of what has been achieved and what is possible to achieve with the selected devices.

WEAL2 09:40 20

Extremely Low Emittance Beam Size Diagnostics with Sub-Micrometer Resolution Using Optical Transition Radiation

K.O. Kruchinin, *P. Karataev (Royal Holloway, University of London) A.S. Aryshev, M.V. Shevelev, N. Terunuma, J. Urakawa (KEK) B. Bolzon, T. Lefèvre, S. Mazzoni (CERN)*

Transverse electron beam diagnostics is crucial for stable and reliable operation of the future electron-positron linear colliders such as CLIC or Higgs Factory. The-state-of-the-art in transverse beam diagnostics is based on the laser-wire technology. However, it requires a high power laser significantly increases the cost of the laser-wire system. Therefore, a simpler and relatively inexpensive method is required. A beam profile monitor based on Optical Transition Radiation (OTR) is very promising. The resolution of conventional OTR monitor is defined by a root-mean-square of the so-called Point Spread Function (PSF). In optical wavelength range the resolution is diffraction limited down to a few micrometers. However, in * we demonstrated that the OTR PSF has a structure which visibility can be used to monitor vertical beam size with sub-micrometer resolution. In this report we shall represent the recent experimental results of a micron-scale beam size measurement. We shall describe the entire method including calibration procedure, new analysis, and calculation of uncertainties. We shall discuss the hardware status and future plans.

* P. Karataev et al., Physical Review Letters 107, 174801 (2011).

WEAL3
10:00 20

Diffraction Radiation Test at CesrTA for Non-Intercepting Micron-Scale Beam Size Measurement

L.M. Bobb, *E. Bravin, T. Lefèvre, S. Mazzoni (CERN) T. Aumeyr,* ***L.M. Bobb****, P. Karataev (JAI) M.G. Billing, J.V. Conway (Cornell University (CLASSE), Cornell Laboratory for Accelerator-Based Sciences and Education)*

Diffraction radiation (DR) is produced when a relativistic charged particle moves in the vicinity of a medium. The electric field of the charged particle polarizes the target atoms which then oscillate, emitting radiation with a very broad spectrum. The spatial-spectral properties of DR are sensitive to a range of electron beam parameters. Furthermore, the energy loss due to DR is so small that the electron beam parameters are unchanged. DR can therefore be used to develop non-invasive diagnostic tools. To achieve the micron-scale resolution required to measure the transverse (vertical) beam size using incoherent DR in CLIC, DR in UV and X-ray spectral-range must be investigated. Experimental validation of such a scheme is ongoing at CesrTA at Cornell University, USA. Here we report on the test using 0.5 mm and 1 mm target apertures on a 2.1 GeV electron beam and 400 nm wavelength.

WEBL — BPMs and Beam Stability 2

Chair: V. Schlott (PSI)

BPMs and Beam Stability

WEBL1 11:00 40

Beam Position Monitors: How to Meet the Specifications of Most Recent Accelerators

__G. Decker__ (ANL)

Modern particle accelerators must operate with increasingly restrictive beam stability requirements. Synchrotron light sources require sub-micron stability for time periods extending to one week and for frequencies up to 1 kHz and beyond, and FELs need similar levels of shot-to-shot reproducibility. A variety of beam position monitor (BPM) technologies used at synchrotron light sources, FEL facilities, and other accelerators will be reviewed and future areas of development outlined. This will include an overview of analog vs. digital downconversion, including data acquisition and processing techniques. Orbit and trajectory feedback systems using modern field-programmable gate array technology and dedicated fast data networks have been developed to take advantage of high-speed BPM data streams and will be described.

WEBL2 11:40 20

Applications of Stripline and Cavity Beam Position Monitors in Low-Latency, High-Precision, Intra-Train Feedback Systems

__M.R. Davis__, D.R. Bett, N. Blaskovic Kraljevic, P. Burrows, G.B. Christian, Y.I. Kim, C. Perry (JAI)

Two, low-latency, sub-micron beam position monitoring (BPM) systems have been developed and tested with beam at the KEK Accelerator Test Facility (ATF2). One system ('upstream'), based on stripline BPMs uses fast analogue front-end signal processing and has demonstrated a position resolution as low as 400nm for beam intensities of ~1 nC, with single-pass beam. The other ('IP') system, based on low-Q cavity BPMs and utilising custom signal processing electronics designed for low latency, provides a single pass resolution of approximately 100nm. The BPM position data are digitised by fast ADCs on a custom FPGA-based feedback controller and used in three modes: 1) the upstream BPM data are used to drive a pair of local kickers nominally orthogonal in phase in closed-loop feedback mode; 2) the upstream BPM data are used to drive a downstream kicker in the ATF2 final focus region in feedforward mode; 3) the IP cavity BPM data are used to drive a local downstream kicker in the ATF2 final focus region in closed-loop feedback mode. In each case the beam jitter is measured downstream of the final focus system with the IP cavity BPMs. The relative performance of these systems is compared.

WEBL3 12:00 20

Wake Field Monitors in a Multi Purpose X Band Structure

M.M. Dehler, *S. Bettoni, G. De Michele (PSI) G. De Michele (EPFL) G. De Michele (CERN)*

In a collaboration between CERN, PSI and Sincrotrone Trieste (ST), a series of four multipurpose X-band accelerating structures has been designed and fabricated. These feature integrated wake field monitors (WFMs), which are used to measure the alignment (offset and tilt) between structure and beam. One structure has recently been installed in the SwissFEL Injector Test facility (SITF) at PSI. The WFM front end electronics will be developed within the EuCard2 framework, so for the measurements described in this paper we used the raw WFM signals. We compare these measurements to the theoretical results obtained via an equivalent circuit model used in the design and numerical calculations. The beam tests show that by minimizing the WFM signals, the emittance dilution given by the transverse wakes, crucial because of the small aperture of the structure, is minimized as well.

18-Sep-13 14:00 – 15:30	Lecture Theatre

WECL — Beam Loss Detection
Chair: K. Wittenburg (DESY)

Beam Loss Detection

WECL1 14:00 40 **Optical Fiber Based Beam Loss Monitor for Electron Storage Ring**

T. Obina *(KEK)*

A beam loss monitor using optical fibers has been developed to determine the turn-by-turn loss point of an injected beam at the Photon Factory (PF) 2.5-GeV electron storage ring. Large-core optical fibers were installed along the vacuum chamber of the storage ring that cover the entire storage ring continuously. There are many kinds of beam loss monitors for high energy accelerators, such as PIN diode detector, ionization chamber using coaxial cable, Cherenkov light detector, etc. Among these methods, optical fibers are suitable to determine the beam loss point because of the ease of covering the entire ring with them, they have better time and position resolution, and they are cost effective. In this report, review of beam loss monitors for electron storage rings and LINACs are reported at first, then the result of the optical-fiber beam loss monitor at the KEK-PF are reported. Long-term deterioration by radiation is also reported.

WECL2 14:40 20 **Radiation Damages and Characterization in the SOLEIL Storage Ring Tunnel**

N. Hubert*, P. Brunelle, N. Béchu, L. Cassinari, C. Herbeaux, J.-F. Lamarre, P. Lebasque, F. Marteau, A. Nadji, L.S. Nadolski (SOLEIL)*

After six years of operation, equipment located close to some vacuum chambers of the SOLEIL storage ring show unexpected damages due to radiation. It has been pointed out that, inside the so called "quadrupole" vacuum chambers, fluorescence X-rays are emitted by the materials that intercept upstream dipole synchrotron radiation. The energy of the emitted X-ray is too high to be significantly attenuated by the aluminum of which the vacuum chamber is made. Diagnostics and means used to characterize this radiation are presented, and measurements are compared to calculations.

WECL3 15:00 20 **The LUPIN Detector: Supporting Least Intrusive Beam Monitoring Technique Through Neutron Detection**

G.P. Manessi*, M. Silari (CERN) M. Caresana (Politecnico/Milano) M. Ferrarini (CNAO Foundation) C.P. Welsch (Cockcroft Institute) C.P. Welsch (The University of Liverpool)*

The Long interval, Ultra-wide dynamic Pile-up free Neutron rem counter (LUPIN) is a novel detector initially developed for radiation protection purposes, specifically conceived for applications in pulsed neutron fields. The detector has a measurement capability varying over many orders of neutron burst intensity, from a single neutron up to thousands of interactions for each burst, without showing any saturation effect. Whilst LUPIN has been developed for applications in the radiation protection fields, its unique properties make it also well suited to support other beam instrumentation. In this contribution, the design of LUPIN is presented in detail and its main characteristics are summarized. Its potential use as beam loss monitor and complementary detector for non-invasive beam monitoring purposes (e.g. to complement a monitor based on proton beam "halo" detection) in medical accelerators is then examined. In the context of its application as a beam loss monitor for hadrontherapy accelerators, results of measurements performed at the Italian National Centre of Hadrontherapy (CNAO) are presented and analyzed.

WEPC — Wednesday Poster Session

Overview and Commissioning

WEPC01 **LINCE Beam Instrumentation Overview: A New High Intensity, Light and Heavy Ion Facility Dedicated for ECOS Science and Applications**

J.M. Carmona, *M.A. Carrera (AVS) I. Martel Bravo, A.C.C. Villari (University of Huelva)*

During the past ten years, ECOS (European Collaboration on High Intensity Stable Beams) working group and users strongly supported the construction of a dedicated high-intensity stable-ion-beam facility in Europe, with energies at and above the Coulomb barrier as part of the Long-Range Plan of the Nuclear-Physics community. LINCE facility, which aims producing Protons to Uranium up to 1 mA maximum (e.g. 1 mA for H^+, 10pμA for 48Ca(8+)) and consisting of a fully superconducting (double frequency) ECR source, M-H buncher plus a short RFQ (1≤A/q≤7) followed by four cryo-modules (26+1 resonators), will be able to meet ECOS science and physics application needs. With 7000 hours availability (5000h for ECOS and 2000h for Industry including aerospace, medicine/health and nuclear fusion), the beam instrumentation is key for the successful commissioning and operation of the machine. An overview of the LINCE accelerator together with the beam diagnostics layout along the lines will be presented.

WEPC02 **Project PROMETHEUS: Design and Construction of a Radio Frequency Quadrupole at TAEK**

G. Turemen, *B. Yasatekin (Ankara University, Faculty of Sciences) Y. Akgun, A. Alacakir, A.S. Bolukdemir, E. Durukan, H. Karadeniz, E. Recepoğlu (SNRTC) E. Cavlan (TOBB ETU) M. Celik, Z. Sali (Gazi University, Faculty of Arts and Sciences) S. Erhan (UCLA) Ö. Mete (CERN) G. Unel (UCI)*

The PROMETHEUS Project is ongoing for the design and development of a 4-vane radio frequency quadrupole (RFQ) with its H^+ ion source, a low energy beam transport (LEBT) line and diagnostics section. The main goal of the project is to achieve the acceleration of the low energy ions up to 1.5 MeV by an RFQ (352 MHz) shorter than 2 m. A plasma ion source is being developed to produce a 20 keV, 1 mA H^+ beam. Ion source, transmission and beam dynamics in the RFQ are discussed through simulation results. In addition, analytical studies were also performed resulting into an RFQ design code, DEMIRCI as discussed and presented here in comparison with various existing software. As a result of the simulations, beam transmission of 99% was achieved at 1.7 m downstream reaching energy of 1.5 MeV. As the first phase an Aluminum RFQ prototype, the so-called cold model, will be built for low power RF characterization. In this contribution the status of the project, design considerations, simulation results, the various diagnostics techniques and RFQ fabrication issues are discussed.

WEPC03 **Brookhaven 200 MeV H⁻ LINAC Beam Instrumentation Upgrade**

***O. Gould**, B. Briscoe, D.M. Gassner, V. LoDestro, D. Raparia, K. Sanders, W. Shaffer, M. Wilinski (BNL) D. Persaud (City College of The City University of New York)*

The Brookhaven National Laboratory 200 MeV H^- LINAC beam instrumentation equipment has been in operation for four decades with various changes implemented over this period. There is a need to upgrade the entire beam instrumentation system of the LINAC to improve the diagnostics of the beam from the Low Energy Beam Transport Line through the LINAC and into the LINAC Booster Transfer Line and BLIP line. Profile Monitors, Current Monitors, Beam Position Monitors, Loss Radiation Monitors, and Emittance Measurement devices are to be designed and implemented over the next three years. This upgrade will improve the operation reliability, beam quality and beam losses. Additional improvements will be obtained by designing the beam instrumentation system to integrate with other proposed diagnostics and malfunction detection and display upgrades in the LINAC Control Room to improve the overall performance of the LINAC.

WEPC04 **Beam Diagnostics for Commissioning and Operation of a Novel Compact Cyclotron for Radioisotope Production**

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The AMIT cyclotron will be a 8.5 MeV, 10 μA CW H^- accelerator which aims to deliver a beam for radioisotope production. In order to properly validate all the beam commissioning steps, a set of diagnostics needs to be implemented. They must cover all the commissioning phases: ion source characterization, medium energy acceleration and nominal energy at full current. Due to compactness of the design, the number of beam diagnostics is limited and restricted to the most essential ones during operation. An overview of the diagnostics that are planned for the characterization of the cyclotron will be discussed in this contribution. In all the commissioning phases, beam current probes are essential to validate the cyclotron and each subsystem. As a main diagnostic, a moveable probe has been designed and simulated for optimization of the cyclotron. The thermal simulations of the probe and the mechanical integration will be presented.

WEPC05 **The ELENA Beam Diagnostics Systems**

***G. Tranquille** (CERN)*

The Extra Low ENergy Antiproton ring (ELENA) to be built at CERN is aimed at substantially increasing the number of antiprotons to the low energy antiproton physics community. It will be a small machine which will decelerate low intensity beams ($<4x10^7$) from 5.3 MeV to 100 keV and will be equipped with an electron cooler to avoid beam losses during the deceleration and to significantly reduce beam phase space at extraction. To measure the beam parameters from the extraction point of the Antiproton

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Decelerator (AD), through the ELENA ring and all the way to the experiments, many systems will be needed to ensure that the desired beam characteristics are obtained. Particular attention needs to be paid to the performance of the electron cooler which depends on reliable instrumentation in order to efficiently cool the antiprotons. This contribution will present the different monitors that have been proposed to measure the various beam parameters as well as some of the developments going on to further improve the ELENA diagnostics.

WEPC06 Beam Instrumentation in the ESS Cold Linac

***C. Böhme**, B. Cheymol, I. Dolenc Kittelmann, H. Hassanzadegan, A. Jansson (ESS)*

Parts of the linac of the European Spallation Source will consist of cryogenic cavity modules. In between these will be warm sections at room temperature to host amongst others the beam instrumentation. Each of the warm sections will host two beam position monitors and one or two other instruments, which might be a beam current monitor, invasive and non-invasive transverse beam profile monitor, bunch shape monitor, or halo monitor. The concept of the warm section layout will be shown and the planned instrumentation will be presented.

BPMs and Beam Stability

WEPC07 Development of the RF Front End Electronics for the SIRIUS BPM System

***R.A. Baron**, F.H. Cardoso, S.R. Marques, J.L.B. Neto (LNLS) J.-C. Denard (SOLEIL)*

Tight stability requirements for new low emittance light sources, such as SIRIUS being built in Brazil, strongly depend on the BPM RF Front-End performance. Small nonlinearities, uneven temperature drifts and excess noise can spoil the performance of the whole digital BPM system and orbit correction. Calibration and temperature control schemes have been tested in order to suppress position measurement drifts during user beam delivery down to a fraction of micrometer. A method for measuring electronic component nonlinearities at mdB scale is also presented.

WEPC08 Vibration Measurement and its Effect on Beam Stability at NSLS2

***W.X. Cheng**, A.K. Jain, S. Krinsky, S.K. Sharma, C.J. Spataro (BNL)*

Vibration measurements have been carried out at NSLS2. The floor has more than 100nm RMS vertical motion during workdays (>1Hz). This motion reduces to 30nm RMS during night and weekends. Traffic on the nearby expressway is considered to be the major source of ground motion. Weather (wind) and utility system induced vibrations are other possible factors on floor motion. Vibrations have been measured at various locations, like the tunnel and experiment floor, HXN long beamline satellite building floor, high stability BPMs, Quadrupole magnets etc. Assume a typical un-correlated motion of Quadrpole magnets of 100nm, beam orbit jitter is around 4-7 microns. Fast orbit feedback will control the orbit stability within 10% of beam size.

WEPC09 Performance of NSLS2 Button BPM

***W.X. Cheng**, B. Bacha, B.N. Kosciuk, O. Singh (BNL)*

Several types of button BPMs are used in NSLS2 complex. Coaxial vacuum feedthroughs are used to couple the beam induced signal out. The feedthroughs are designed to match the external transmission line and electronics with characteristic impedance of 50 Ohm. Performances of these BPM feedthroughs are presented in this paper.

WEPC10 Capability Upgrade of the Diamond Transverse Multibunch Feedback

***M.G. Abbott**, G. Rehm, I.S. Uzun (Diamond)*

We describe an upgrade to the Transverse Multi-Bunch Feedback processor used at Diamond for control of multi-bunch instabilities and measurement of betatron tunes. The new system will improve both feedback and diagnostic capabilities. Bunch by bunch selectable control over feedback filters, gain and excitation will allow finer control over feedback, allowing for example the single bunch in a hybrid or camshaft fill pattern to be controlled independently from the bunch train. It will also be possible to excite all bunches at a single frequency while simultaneously sweeping the excitation for tune measurement of a few selected bunches. The single frequency excitation can be used for bunch cleaning or continuous measurement of the beta-function. A simple programmable event sequencer will provide support for up to 8 steps of programmable sweeps and changes to feedback and excitation, allowing a variety of complex and precisely timed beam characterisation experiments including grow-damp measurements in unstable conditions.

WEPC11 Radiation Resistance Testing of Commercial Components for the New SPS Beam Position Measurement System

***C. Deplano**, J. Albertone, T.B. Bogey, J.L. Gonzalez, J.-J. Savioz (CERN)*

A new Front-End (FE) electronics is under development for the SPS Multi Orbit POsition System (MOPOS). To cover the large dynamic range of beam intensities (70dB) to be measured in the SPS, the beam position monitor signals are processed using logarithmic amplifiers. They are then digitized locally and transmitted via optical fibers over long distances (up to 1km) to VME acquisition boards located in surface buildings. The FE board is designed to be located in the SPS tunnel, where it must cope with a radiation dose rate of up to 100 Gy per year. Analogue components, such as Logarithmic Amplifiers, ADC-Drivers and Voltage regulators, have been tested at PSI for radiation hardness, while several families of bidirectional SFP, both single-fiber and double-fiber, have been tested at both PSI and CNRAD. This paper gives a description of the overall system architecture and presents the results of the radiation hardness tests in detail.

WEPC12 Evaluation of Strip-line Pick-up Systems for the SPS Wideband Transverse Feedback System

***G. Kotzian**, W. Höfle, R.J. Steinhagen, D. Valuch, U. Wehrle (CERN)*

The proposed SPS Wideband Transverse Feedback system requires a wide-band pick-up system to be able to detect intra-bunch motion within the SPS proton bunches, captured and accelerated in a 200 MHz bucket. We present the electro-magnetic design of transverse beam position pick-up options optimised for installation in the SPS and evaluate their performance reach with respect to direct time domain sampling of the intra-bunch motion. The analysis also discusses the achieved subsystem responses of the associated cabling with new low dispersion smooth wall cables, wide-band generation of intensity and position signals by means of 180 degree RF hybrids as well as passive techniques to electronically suppress the beam offset signal, needed to optimise the dynamic range and position resolution of the planned digital intra-bunch feedback system.

WEPC13 Optimisation of the SVD Treatment in the Fast Orbit Correction of the ESRF Storage Ring

***E. Plouviez**, F. Epaud, L. Farvacque, J.M. Koch (ESRF)*

The ESRF fast orbit correction system has been in operation since May 2012. The orbit correction scheme relies classically on the calculation of a correction orbit based on the SVD analysis of the response matrix of our 224 BPMs to each of our 96 correctors. The rate of the calculation of the corrections is 10 KHz; we use a PI loop achieving a bandwidth of 150Hz completed with a narrow band pass filter with extra gain at 50Hz. In order to make the best use of the correctors dynamic range and of the resolution of the calculation, it can be useful to limit the bandwidth of loop for the highest order vectors of the SVD, or even to totally remove some of these vectors from the correction down to DC. Removing some of the eigen vectors while avoiding that the loop becomes unstable usually increases a lot the complexity of the matrix calculations: we have developed an algorithm which overcomes this problem; The test of this algorithm is presented. We present also the beneficial effect at high frequency of the limitation of the gain of the correction of the highest SVD eigen vectors on the demand of the peak strength of the correctors and on the resolution of the correction calculation.

WEPC14 Development of High Precision Beam Position Monitor Readout System with Narrow Bandpass Filters for the KEKB Injector Linac Towards the SuperKEKB

***R. Ichimiya**, K. Furukawa, F. Miyahara, M. Satoh, T. Suwada (KEK)*

The SuperKEKB accelerator complexes are now being upgraded to bring the world highest luminosity (L=8x10^{35}/cm^2/s). Hence, the KEKB Injector Linac is required to produce: electron: 20 mm mrad (7GeV, 5nC), positron: 10 mm mrad (4GeV, 4nC). To achieve this, the accelerator components have to be aligned within ± 0.1mm (1 sigma). BPM is essential instrumentation for Beam Based Alignment, and is required one magnitude better

position resolution to get better alignment results. Since current BPM readout system using oscilloscopes has ~50um position resolution, we decided to develop high precision BPM readout system with narrow bandpass filters. It handles two bunches with 96ns interval and has a dynamic range between 0.1nC (for photon factory) to 10nC (positron primary). To achieve these criteria, we adopt semiconductor attenuators and optimized two-stage Bessel filters at 300MHz center frequency to meet both time and frequency domain constraints. To correct position drift due to gain imbalance during operation, calibration pulses are output to the BPM between beam cycles (20ms). The beam position and charge calculations are performed by onboard FPGA to achieve fast readout cycle.

WEPC15 **Development of the Beam Position Monitors System for the LINAC of SPIRAL2**

P. Ausset, *M. Ben Abdillah, J. Lesrel, E. Marius (IPN) T. Ananthkrishnan, S.K. Bharade, G. Joshi, P.D. Motiwala, C.K. Pithawa (BARC) V. Nanal, R.G. Pillay (TIFR)*

The SPIRAL 2 facility will deliver stable heavy ion beams and deuteron beams at very high intensity, producing and accelerating light and heavy rare ion beams. The driver will accelerate between 0.15mA and 5 mA deuteron beam up to 20 MeV/u and q/A=1/3 heavy ions up to 14.5 MeV/u. It is being built on the site of the Grand Accelerator National d'Ions Lourds at CAEN (France) The accurate tuning of the LINAC is essential for the operation of SPIRAL2 and requires from the Beam Position Monitor (BPM) system the measurements of the beam transverse position, the phase of the beam with respect to the radiofrequency voltage and the beam energy. This paper addresses the advancement made during the last twelve months on the realization of the 22 BPM required for the SPIRAL 2 LINAC: All the BPM sensors are now completed, tested and calibrated. The design of the acquisition card for the BPM is given and will be described. The prototype card is now under test and the first results are given. The aim is to verify the main parameters: sensitivity, position and phase measurement and the appropriate behavior of the BPM acquisition card in all cases (pulsed bunch, interlock, post mortem)

WEPC16 **The Design of BPM Electronic System for CSNS RCS**

W. Lu, *H.Y. Sheng, X.C. Tian, T.G. Xu, Y.B. Zhao (IHEP)*

A Beam Position Monitor (BPM) system has been designed for the Rapid Cycling Synchrotron (RCS) at the China Spallation Neutron Source (CSNS) to acquire beam position information. This article introduces the design and implementation of the BPM electronic system. The challenge of designing the BPM electronics is to acquire and process the signal with large dynamic range (5.8mV~32V) and changing width (80ns to 500ns). The analog circuit described in this paper, which is constructed of a single-stage operational amplifier and an analog switch, can cover the input signal with large dynamic range. Because of the minimum bunch length (80ns) and the requirement of position resolution, a 14 bit 250MHz ADC is adopted

to digitize the signal. Besides, for BPM system, the demand of an accurate real-time position monitoring is mandatory. The algorithm developed in an FPGA is able to make Bunch-by-Bunch position calculation and Closed Orbit position calculation in real time. Also, some preliminary test results will be presented and discussed, which show that the resolution of Bunch-by-Bunch position is 0.8mm when the input signal is 5.8mV and the resolution of Closed Orbit position is 50um.

WEPC17 **Design and Simulation of Beam Position Monitor for the CADS Injector I Proton Linac**

Y.F. Sui, *J. Cao (IHEP)*

Beam Position Monitors (BPM) based on both capacitive and stripline pick-ups are designed for China Accelerator-Driven System (CADS) Injector I proton LINAC. The BPM will be installed to measure the transverse beam position in the LINAC, of which the beam parameters are listed as current 10mA, energy 10MeV and the repetition frequency 325MHz. This contribution presents the status of the BPM design development and focuses on the design of the pick-ups and CST Particle Studio simulation results, including impedance, sensitivity, time domain, frequency domain response, etc. Main goals of the simulation is optimization of the mechanical design.

WEPC18 **Development of Compact Electronics Dedicated to Beam Position Monitors in Injectors and Boosters**

G. Jug, *M. Cargnelutti, P. Leban (I-Tech) K.B. Scheidt (ESRF)*

The need for state-of-the-art electronics for data-acquisition and processing of BPM signals in Injector and/or Booster Synchrotrons is being addressed in a development that aims at making such system available with less complexity and yet fulfilling precisely the needs of such specific BPMs. The ESRF Booster Synchrotron uses 75 BPMs in its 300m circumference to measure the orbit along its acceleration cycle of 50 milliseconds for the electron beam from 0.2 to 6GeV. The 25 year old electronics of these BPMs are in need of replacement. While BPM developments in recent years have focused on devices for Storage Rings that face extreme requirements like sub-micron drift with time, beam intensity, etc. that result in complicated implementation schemes. This new development combines both the simplification in the measurement concept and the implementation of novelties like compact design integrating RF electronics, with power-over-Ethernet supply and passive cooling, a powerful System-on-Chip engine and easy communication via SCPI commands. This paper will present the full design concept and its aimed functionalities as a BPM device that should offer an excellent price/performance ratio.

WEPC19 **Performance of Injection Beam Position Monitors in the J-PARC RCS**

N. Hayashi, *P.K. Saha (JAEA/J-PARC) T. Toyama (J-PARC, KEK & JAEA)*

It is important to monitor the injected beam trajectory and position into a synchrotron ring. In the J-PARC RCS, there are two specialized beam position monitors (BPM) in the first arc section in order to perform continuous monitoring. They detect the linac RF frequency 324 MHz or its second harmonics, these contributions quickly decrease after a few turns in the ring. Therefore, they are sensitive only just injected beam. The RCS adopts the multi-turn injection and transverse painting. These monitors are useful to check the beam behavior on-line.

WEPC21 **Design and Beam Test Results of Button BPMs for the European XFEL**

__D.M. Treyer__, R. Baldinger, R. Ditter, B. Keil, W. Koprek, G. Marinkovic, M. Roggli (PSI) D. Lipka, D. Nölle, S. Vilcins (DESY)

The European X-ray Free Electron Laser (E-XFEL) will use a total ~300 button BPMs along the whole accelerator, as well as 160 cavity BPMs. The pickups for the button BPMs have been designed by DESY, whereas the electronics has been developed by PSI. This paper gives an overview of the button BPM system, with focus on the RF front end electronics, signal processing, and overall system performance. Measurement results achieved with prototypes installed at FLASH/DESY and at the SwissFEL Injector Test Facility (SITF) are presented. The position noise obtained with button pickups in a 40.5 mm aperture beam pipe is as low as ~11 um at 20 pC bunch charge.

WEPC23 **Design of an Ultra-Compact Stripline BPM Receiver using MicroTCA for LCLS-II at SLAC**

__C. Xu__, S. Babel, S. L. Hoobler, R.S. Larsen, J.J. Olsen, S.R. Smith, T. Straumann, D. Van Winkle, A. Young (SLAC)

The Linac Coherent Light Source II (LCLS II) is a free electron laser (FEL) light source. LCLS II will be able to produce 0.5 to 77 Angstroms soft and hard x-rays. In order to achieve this high level of performance, the electron beam needs to be stable and accurate. The LCLS II stripline BPM system has a dynamic range of 10pC to 1nC beam charge. The system has a 3.5 micrometer resolution at 250pC beam charge in an one inch diameter stripline BPM structure. The BPM system uses the MicroTCA physics platform that consists of analog front-end (AFE) and 16-bit analog to digital convertor (ADC) module. The paper will discuss the hardware design, architecture, and performance measurements on the SLAC LINAC. The hardware architecture includes bandpass filter at 300MHz with 15 MHz band-width, and BPM calibration process without communicating with the CPU module. The system will be able to process multibunch beams with 40ns spacing.

WEPC24 **Performance Measurements of the New X-band Cavity BPM Receiver**

__A. Young__, J.E. Dusatko, S. L. Hoobler, J.J. Olsen, T. Straumann (SLAC) C. Kim (PAL)

SLAC is developing a new X-band Cavity BPM receiver for use in the LCLS-II. The Linac Coherent Light Source II (LCLS-II) will be a free electron laser (FEL) at SLAC producing coherent 0.5-77 Angstroms hard and soft x-rays.

To achieve this level of performance precise, stable alignment of the electron beam in the undulator is required. The LCLS-II cavity BPM system will provide single shot resolution better than 50 nm resolution at 200 pC*. The Cavity BPM heterodyne receiver is located in the tunnel close to the cavity BPM. The receiver will processes the TM010 monopole reference cavity signal and a TM110 dipole cavity signal at approximately 11 GHz using a heterodyne technique. The heterodyne receiver will be capable of detecting a multibunch beam with a 50ns fill pattern. A new LAN communication daughter board will allow the receiver to talk to an input-output-controller (IOC) over 100 meters to set gains, control the phase locked local oscillator, and monitor the status of the receiver. We will describe the design methodology including noise analysis, Intermodulation Products analysis.

* Commissioning and Performance of LCLS Cavity BPMs, Stephen Smith, et al., Proc. of PAC 2009

WEPC25 **Optimisation of a Split Plate Beam Position Monitor for the ISIS Proton Synchrotron**

C.C. Wilcox, *J.C. Medland, S.J. Payne, A. Pertica, M.A. Probert (STFC/RAL/ISIS)*

A new Beam Position Monitor (BPM) has been designed for the ISIS proton accelerator facility at the Rutherford Appleton Laboratory in the UK. The new monitor, which will be installed in the beam line to Target 1, is of a ‘split plate’ design which utilises two pairs of electrodes to allow the beam position to be measured simultaneously in the horizontal and vertical planes. Simulations carried out using the CST low frequency solver have highlighted the inaccuracies in the measured beam position caused by strong inter-electrode coupling in such a monitor. This coupling, along with imbalanced electrode capacitances, leads to reduced sensitivity to changes in beam position as well as producing a positional offset error. This paper describes how the problems associated with inter-electrode coupling have been removed with the addition of grounded rings placed between each of the four electrodes. The design and positioning of the rings also ensured that the four electrode capacitances were matched. The results are presented both as CST simulations of ‘thin wire’ beam position measurements and results from bench measurements of a prototype dual plane BPM.

WEPC26 **Pickup Electrode Electrodynamics Investigation**

A. Kalinin *(STFC/DL/ASTeC)*

Waves induced in a pickup by beam were investigated on a large scale model, using 10ps step in coaxial line as beam, and a differentiating capacitive probe. The probe signal was observed at 20GHz oscilloscope. In each of the front and rear transverse gaps between pickup electrode and wall (button pickup), a shorter-than-gap bunch excites a ‘plain-wave’ packet which length is of the order of gap length over c. Two packets are spaced by electrode length over c. The packets propagate along the electrode to a coaxial connector. At this low impedance common point each of the

packets partially reflects back and partially passes into the opposite gap. The voltage appearing on the impedance excites two TEM-wave packets: one propagates backwards, another one propagates forward through connector. The connector output is sum of two such packets spaced the same as two incident packets. The packets propagating backwards reflect from the electrode open end, come back to the summing point and generate output in similar way. The same processes occur in a pickup with single gap electrodes (stripline pickup). This phenomenological picture can be used as a guide in pickup design and simulation.

WEPC27 **Research of Synchronous Measurement of Beam Orbit and Relative Environment Parameters**

***L.W. Lai**, J. Chen, Z.C. Chen, Y.B. Leng, Y.B. Yan, L.Y. Yu, R.X. Yuan (SSRF) W.M. Zhou (SINAP)*

The mechanical center of BPM vacuum tube in particle accelerator can drift comparatively far away from the magnetic center of quadrupole due to factors such as foundation vibration, temperature and thermal effects. This problem makes the accuracy improvement of absolute beam orbit measurement difficult. Capacitor sensor can transfer some objects parameters such as displacement and pressure into the change of capacitance. This feature makes it possible to do real-time measurement of the center drift. Based on the analysis of capacitor sensor's equivalent circuit, we made a dedicated sensor, and tested it with data acquisition instruments. Results show that it can monitor 2μm relative movement and up to 300Hz vibration frequency. So it can be applied for the synchronous measurement of beam orbit and relative environment parameters.

WEPC28 **Bunch By Bunch Transverse Beam Position Observation and Analyze During Injection at SSRF**

***Y.B. Leng**, Y.B. Yan, Y. Yang, R.X. Yuan, N. Zhang (SSRF)*

Top-up operation has been performed at SSRF since Dec. 2012. Orbit disturbance every 10 minutes decreased the quality of synchrotron radiation. In order to minimize this disturbance the tilts and the timing of injection kickers need to be tuning carefully based on real beam information. A set of button type pick-up and a scope based IOC were employed to capture the transient beam movement with bunch by bunch rate during injection. Several sets of observation and analyze will be discussed in this paper.

Time Resolved Diagnostics and Synchronization

WEPC31 **New Design of the 40 GHz Bunch Arrival Time Monitor Using MTCA.4 Electronics at FLASH and for the European XFEL**

***M.K. Czwalinna**, C. Gerth, H. Schlarb (DESY) S. Bou Habib (Warsaw University of Technology, Institute of Electronic Systems) S. Korolczuk, J. Szewiński (NCBJ) A. Kuhl (Uni HH)*

At free-electron lasers, today's pump-probe experiments and seeding schemes make high demands on the electron bunch timing stability with

an arrival time jitter reduction down to the femtosecond level. At FLASH and the upcoming European XFEL, the bunch train structures with their high bunch repetition rates allow for an accurate intra-train stabilisation. To realise longitudinal beam-based feedbacks a reliable and precise arrival time detection over a broad range of bunch charges, which can even change from 1 nC down to 20 pC within a bunch train, is essential. Benefitting from the experience at FLASH, the current bunch arrival time monitors (BAMs), based on detection of RF signals from broad-band pick-ups by use of electro-optic modulators, are further developed to cope with the increased requirements. In this paper, we present the new BAM prototype, including an adapted electro-optical front-end and the latest development of the read-out electronics based on the MTCA.4 platform.

WEPC32 **Past, Present and Future Aspects of Laser-Based Synchronization at FLASH**

S. Schulz, *M. Bousonville, M.K. Czwalinna, M. Felber, M. Heuer, T. Lamb, J. Müller, P. Peier, S. Pfeiffer, S. Ruzin, H. Schlarb, Ch. Schmidt, B. Steffen, C. Sydlo, F. Zummack (DESY) T. Kozak, P. Predki (TUL-DMCS) A. Kuhl (Uni HH)*

Free-electron lasers, like FLASH and the upcoming European XFEL, are capable of producing XUV and X-ray pulses of a few femtoseconds duration. For time-resolved pump-probe experiments and the externally seeded operation mode it is crucial not only to stabilize the arrival time of the electron bunches, but also to achieve a synchronization accuracy of external lasers on the same timescale. This can only be realized with a laser-based synchronization infrastructure. At FLASH, a periodic femtosecond laser pulse train is transmitted over actively stabilized optical fibers to the critical subsystems. In this paper we report on the present status and performance of the system, as well as its imminent upgrades and new installations. These include the connection of FLASH2, electron bunch arrival time monitors for low charges, a new master laser pulse distribution scheme, all-optical synchronization of the pump-probe laser and arrival time measurements of the UV pulses on the e-gun photocathode. Along with the coming connection of the acceleration modules to the master laser and the switch of the low-level hardware to the uTCA platform, an outlook to improved feedback strategies is given.

WEPC33 **Upgrade of Beam Phase Monitors for the ESRF Injector and Storage Ring**

K.B. Scheidt, *B. Joly (ESRF)*

The measurement of the phase relation between the stored beam in the Storage Ring and the beam circulating in the Booster Synchrotron is now done with high precision and at high speed using a single unit of commercial BPM electronics. The quadrature demodulation, driven by a common PLL, done in these digital electronics on each of its four RF input channels makes the relative measurement of the I/Q components, hence phase relation, easy and strait forward. The RF signals of the relatively low current

Booster come from two stripline outputs while that of the Storage Ring from two small BPM buttons. Treating simultaneously four signals, thus with a redundancy of two to measure the phase between two sources, allows to perform intrinsic shot-to-shot cross verifications on resolution and reproducibility. The long-term stability of this device has also been successfully assessed by independent verifications against time and temperature drifts. An identical unit has now been added for phase measurements between the Storage Ring beam and the RF cavity signals. Results with beam and assessment of its scope of performance will be presented on both systems.

WEPC34 **Time Trend Observation of Certain Remarked Bunches using a Streak Camera**

T. Naito, *S. Araki, K. Kubo, S. Kuroda, T.M. Mitsuhashi, T. Okugi, N. Terunuma, J. Urakawa (KEK)*

A streak camera with two dimensional sweep function can measure the trend of the longitudinal beam profile in the ring. In the case of the multi-bunch measurement, the different bunch profile sit on same timing, thus, we can not distinguish the behavior of each bunch. We have developed a trigger circuit to measure the bunch-by-bunch longitudinal beam profile, which uses non integer sweep frequency for the acceleration frequency. The bunch profile of each bunch sit on different position in this measurement. We observed the increment of the synchrotron oscillation amplitude from the first bunch to the 20th bunch in the KEK-ATF Damping Ring by using this system. This paper describes the hardware and the measurement results.

WEPC36 **Development of Electron Bunch Compression Monitors for SwissFEL**

F. Frei, *B. Beutner, I. Gorgisyan, R. Ischebeck, G.L. Orlandi, P. Peier, E. Prat, V. Schlott, B. Smit (PSI) P. Peier (DESY)*

SwissFEL will be a hard x-ray fourth generation light source to be built at Paul Scherrer Institut (PSI), Switzerland. In SwissFEL the electron bunches will be produced with a length of 3ps and will then be compressed by a factor of more than 1000 down to a few fs in order to generate ultra short x-ray pulses. Therefore reliable, accurate and noninvasive longitudinal diagnostic is essential after each compressing stage. In order to meet the requirements of this machine, new monitors have to be developed. We will present recent results of setups that measure electro-magnetic radiation, namely edge, synchrotron and diffraction radiation, emitted by the electron bunches (far field, spectral domain). These monitors are tested in the SwissFEL Injector Test Facility. A state of the art S-band Transverse Deflecting Cavity together with a Screen Monitor is used for calibration.

WEPC37 Bunch Length Measurements of a Compressed Electron Beam Using an Electro-optic Monitor at the SwissFEL Injector Test Facility

Ye. Ivanisenko *(PSI) P. Peier (DESY)*

SwissFEL is a LINAC based free electron laser under construction at Paul Scherrer Institut (PSI) in Switzerland. The FEL design relies on a high peak electron bunch current, which is achieved by compressing the beam in two magnetic chicanes. The first compression stage will be equipped with two bunch length monitors (one before and one after the chicane) based on electro-optic spectral decoding technique, which allows absolute and non invasive measurements. The first monitor before the bunch compressor was successfully operated with bunches that were several picoseconds long at the SwissFEL Injector Test Facility (SITF). In this paper the results of measurements with the monitor after the beam compressor (compression ratio of 10) are presented and compared to the results of measurements obtained from a transverse deflecting cavity. The paper also summarizes the operation experience at the SITF and discusses possible system improvements for the SwissFEL.

WEPC38 Current Status of Development of Optical Synchronization System for PAL XFEL

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Optical synchronization system has been developed for higher quality PAL XFEL with low timing jitter since 2011. In last two years, laboratory test was successfully performed, and test in our accelerator environment is ongoing. In laboratory, we tested the synchronization of RF master oscillator and optical master oscillator, the stabilization of 610 m optical fiber link, and the remote optical-to-RF conversion. We report recent our development results and summarize on-going optical timing project.

WEPC39 First Tests of the Top-up Gating at Synchrotron SOLEIL

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Since 2006, Synchrotron SOLEIL is delivering photons to its beamlines. Until 2012, thanks to the excellent performances of the injection system of the storage ring, the perturbation on the position of the stored beam was small enough to be accepted by the users. For some specific experiments, few beamlines expressed their wish to be able to stop their data acquisition during the injection. To fulfill this need, the diagnostics group of Synchrotron SOLEIL has designed the “TimEX3” board which was integrated into the timing system allowing the gating of the Top-up injection. This design was released as open hardware. Towards this aim, we decided to design it with the open source and free EDA software “KiCad”, and to make it available under the CERN’s Open Hardware Repository.

WEPC40 **Pickup Signal Improvement for High Bandwidth BAMs for FLASH and European - XFEL**

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In order to measure the arrival time of the electron bunches in low (20 pC) and high (1 nC) charge operation mode, new high bandwidth pickups were developed as a part of the Bunch Arrival-time Monitors (BAMs) for FLASH at DESY *. The pickup signal is transported via radiation resistant coaxial cables to the electro-optic modulator (EOM) **. Due to the high losses of the 40 GHz RF front-end the signal in the RF path is attenuated well below the optimal operation voltage of the EOM. To improve the overall performance, the signal strength of the induced pickup signal needs to be increased and at the same time the losses in the RF front-end significantly reduced. In this paper, the analysis towards improving the induced pickup signal strength is presented. Simulations are performed with the CST STUDIO SUITE package and the results are compared with the state of the art high bandwidth pickups.

* A. Angelovski et al., Phys. Rev. ST Accel. Beams 15, 112803 (2012)
** A. Penirschke et al., Proc. of IBIC2012, Tsukuba, Japan (2012)

WEPC41 **Comparative Analysis of Different Electro-Optical Intensity Modulator Candidates for the New 40 GHz Bunch Arrival Time Monitor System for FLASH and European XFEL**

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The currently installed Bunch Arrival time Monitors (BAMs) at the Free electron LASer in Hamburg (FLASH) achieved a time resolution of less than 10 fs for bunch charges higher than 500 pC. In order to achieve single spike FEL pulses at FLASH, electron bunch charges down to 20 pC are of interest. With these BAMs the required time resolution is not reachable for bunch charges below 500 pC. Therefore new pickups with a bandwidth of up to 40 GHz are designed and manufactured*. The signal evaluation takes place with a time-stabilized reference laser pulse train which is modulated with an Electro-Optical intensity Modulator (EOM). The new BAM system also requires new EOMs for the electro-optical frontend. The available selection of commercial EOM candidates for the new frontend is very limited. In this paper we present a comparison between different EOM candidates for the new electro optical frontend.

* A. Angelovski et al. Proceedings Phys. Rev ST AB, DOI:10.1103/PhysRevSTAB.15.112803

WEPC42 **Design of a Time-Resolving Laser Wire for Large Dynamic Range Measurements**

P.E. Evtushenko, *M. Marchlik (JLAB)*

Better diagnostics and understanding of beam halo are needed for high average current CW SRF electron linacs. Here longitudinal beam halo upstream of the linac evolves in to transverse halo downstream of the linac. A diagnostic for measurements longitudinal phase space distribution with large dynamic range (LDR) is needed for proper setup of an injector and better understanding of beam halo formation. In addition, one of unsolved ERL's diagnostic problems is the transverse beam size monitoring of a high average current, few MeV energy beam. We present our design for a Thomson scattering based CW laser wire system for LDR transverse beam profile measurements. It is designed to be used with CW beam starting with an average current of about 150 μA, but can, as it is non-destructive and non-intercepting, be use at any average current. When implemented in a dispersive section it can be used for energy distribution measurements. Using a short pulse laser adds time resolution to the diagnostic. Combining time and energy resolution, the system will allow measurements of the longitudinal phase space distribution while keeping the LDR due to the counting nature of the detection scheme.

Beam Loss Detection

WEPC43 **Update on Beam Loss Monitoring at CTF3 for CLIC**

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The primary role of the beam loss monitoring (BLM) system for the compact linear collider (CLIC) study is to work within the machine protection system. Due to the size of the CLIC facility, a BLM that covers large distances along the beamline is highly desirable, in particular for the CLIC drive beam decelerators, which would alternatively require some ~40,000 localised monitors. Therefore, an optical fiber BLM system is currently under investigation which can cover large sections of beamline at a time. A multimode fiber has been installed along the Test Beam Line at the CLIC test facility (CTF3) where the detection principle is based on the production of Cherenkov photons within the fiber resulting from beam loss and their subsequent transport along the fiber where they are then detected at the fiber ends using silicon photomultipliers. Several additional monitors including ACEMs, PEP-II and diamond detectors have also been installed. In this contribution the first results from the BLMs are presented, comparisons of the signals from each BLM are made and the possible achievable longitudinal resolution from the fiber BLM signal considering various loss patterns is discussed.

WEPC44 **Operation of Silicon, Diamond and Liquid Helium Detectors in the Range of Room Temperature to 1.9 Kelvin and After an Irradiation Dose of Several Mega Gray**

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At the triplet magnets close to the interaction regions of the LHC, the current Beam Loss Monitoring system is sensitive to the debris from the collision points. For future beams with higher energy and intensity, the expected increase in luminosity and associated increase of the debris from interaction products is expected to compete with any quench-provoking beam losses from the primary proton beams. In order to distinguish between the two, it is proposed to locate the detectors as close as possible to the superconducting coil. The detectors therefore have to be located inside the cold mass of the superconducting magnets in superfluid helium at 1.9 K. Past measurements have shown that in a liquid helium chamber, diamond and silicon detectors are promising candidates for cryogenic beam loss monitors. This contribution will show the results from new high irradiation beam measurements at both room temperature and 1.9 Kelvin to reveal the radiation tolerance of these different detectors.

WEPC45 **Beam Loss Monitoring at the European Spallation Source**

L. Tchelidze, *H. Hassanzadegan, A. Jansson, M. Jarosz (ESS)*

At the European Spallation Source proton linear accelerator will generate 5 MW protons to be delivered to a target. This high power accelerator will require significant amount of beam instrumentation, among which the beam loss monitoring system is one of the most important for operation. An LHC type ionization chamber will be used with ~54 uC/Gy sensitivity. At most 1.5 mGy/sec radiation levels are expected close to the beam pipe during normal operation, resulting in up to 80 nA current signal in detectors. Loss monitor electronics is designed to be able to measure currents as little as 1% of the expected current up to as much as 1% of the total beam loss, thus ~800 pA – few mA. In order to study beam loss pattern along the accelerator a coherent model of the whole machine is created for the purposes of Monte Carlo particle transport simulations. Data obtained using the model will be stored in a database together with the initial beam loss conditions. The contents of the database will then be processed using custom neural network algorithms to optimize number and position of the loss monitors and to provide reference on the beam loss localization during operation of the machine.

WEPC46 **Beam Delivery Simulation (BDSIM): A Geant4 Based Toolkit for Diagnostic and Loss Simulation**

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BDSIM is a Geant4 and C++ based particle tracking code which seamlessly tracks particles in accelerators and particle detectors, including the full range of particle interaction physics processes in Geant4. The code has been used to model the backgrounds in the International Linear Collider (ILC), Compact Linear Collider (CLIC), Accelerator Test Facility 2 (ATF2) and more recently the Large Hadron Collider (LHC). This paper outlines the current code and possible example applications and presents a roadmap for future developments.

Beam Profile Monitors

WEPF01 Alignment of a Nozzle-Skimmer System for a Non Invasive Gas Jet Based Beam Profile Monitor

V. Tzoganis, *C.P. Welsch (The University of Liverpool)* ***V. Tzoganis***, *C.P. Welsch (Cockcroft Institute)*

A non-invasive gas jet-based beam profile monitor has been developed in the QUASAR Group at the Cockcroft Institute, UK. This shall allow monitoring ultra-low energy, as well as high energy particle beams in a way that causes least disturbance to both, primary beam and accelerator vacuum. In this setup a nozzle-skimmer system is used to generate a thin supersonic curtain-shaped gas jet. However, very small diameters of both, the gas inlet nozzle and subsequent skimmers, required to shape the jet, have caused problems in monitor operation in the past. Here, an image processing based technique is presented which follows after careful manual initial alignment using a laser beam. An algorithm has been implemented in Labview and offers a semi-automated and straightforward solution for all previously encountered alignment issues. The procedure is presented in detail and experimental results are shown.

WEPF03 Scintillating Screen Monitors for Transverse Electron Beam Profile Diagnostics at the European XFEL

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Transverse beam profile diagnostics in modern electron linear accelerators like FELs or injector LINACs are mainly based on optical transition radiation (OTR) as standard technique which is observed in backward direction when a charged particle beam crosses the boundary between two media with different dielectric properties. The experience from modern LINAC based 4th generation light sources shows that OTR diagnostics might fail because of coherence effects in the OTR emission process. As a consequence, for the European XFEL which is currently under construction in Hamburg, transverse beam profile measurements are based on scintillating screen monitors. The LYSO:Ce screens are oriented such that coherent OTR generated at the screen boundaries will be geometrically suppressed. An additional advantage is that the imaging optics operate in Scheimpflug condition thus adjusting the plane of sharp focus with respect to the CCD chip and significantly increasing the apparent depth of field. This report gives an overview of the measuring principle and the monitor setup together with results of laboratory test measurements and a first prototype test at FLASH (DESY, Hamburg).

WEPF04 A New Compact Design of a Three-Dimensional Ionization Profile Monitor (IPM)

***H.F. Breede**, H.-J. Grabosch, M. Sachwitz, L.V. Vu (DESY Zeuthen)*

FLASH at DESY in Hamburg is a linear accelerator, which uses superconducting technology to produce soft x-ray laser light ranging from 4.1 to 45 nm. To ensure the operation stability of FLASH, monitoring of the beam is mandatory. Two Ionization Profile Monitors (IPM) detect the lateral x and y position changes. The functional principle of the IPM is based on the detection of particles, generated by interaction of the beam with the residual gas in the beam line. The newly designed IPM enables the combined determination of the horizontal and vertical position as well as the profile. This is made possible by a compact monitor, consisting of a cage in a vacuum chamber, two micro-channel plates (MCP) and two repeller plates with toggled electric fields at the opposite sides of the MCPs. The particles created by the FEL beam, drift in a homogenous electrical field towards the respective MCP, which produces an image of the beam profile on an attached phosphor screen. A camera for each MCP is used for evaluation. This indirect detection scheme operates over a wide dynamic range and allows the detection of the center of gravity and the shape of the beam. The final design is presented.

WEPF05 An Electron Beam Detector for the FLASH II Beam Dump

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For the electron absorber at FLASH II a detector is developed to control the position, dimensions and profile of the electron beam. Scintillation light, emitted from a luminescent screen in front of the dump window, is reflected by a mirror, located in 2 m distance from the screen, and passes through a vacuum window. Two different optical systems will be installed redundantly for beam image transfer: a conventional lens-mirror-system and a system using a radiation-hard optical fibre bundle. A CCD camera, located in one and a half meter distance from the beam line, is used for the optical analysis. An experimental setup, where the terms of installation of the components correspond to the FLASH accelerator, has been built up in a lab to coordinate the interaction of the screen with the components of the optical system. It was shown that the resolution of the lens-mirror-system is about one line pair per millimeter. An experiment is set up to test the impact of radiation on the optical qualities of the fibre optic bundle by installing it onto a “radioactive hot spot” at the bunch compressor in the FLASH accelerator.

WEPF06 A Fast Switching Mirror Unit at FLASH

***F. Perlick**, S. Baronin, A. Donat, R. Heller, N. Leuschner, S. Loewendorf, J. Nagler, M. Sachwitz, L.V. Vu (DESY Zeuthen)*

The Free Electron Laser (FLASH) at DESY Hamburg is a linac providing unique experimental opportunities to investigate the atomic structure and the properties of materials, nanoparticles, viruses and cells. At the experimental hall, the incoming FEL beam can be deflected towards five test sites by silicon mirrors mounted into vacuum vessels, of which one is operated in permanent switching mode, allowing the simultaneous use of the light at two different test sites. So far, the entire vacuum vessel with the mirror inside is moved into the beam by a linear motor. This results in high translatory inertia and, to compensate the vessel motion, requires vacuum bellows, which have a limited lifetime especially at higher switching frequencies. Therefore, in the recent design the mirror is shifted by piezo motors operated inside the vessel under ultra-high vacuum conditions. However, temperature measurements revealed that during continuous operation the motor reaches up to 90°C only when exposed to air, necessitating long breaks to allow it to cool. Therefore suitable cooling methods are being investigated to guarantee continuous operation of the motor under ultra-high vacuum conditions.

WEPF07 Profile Grid Monitor and First Measurement Results at the MedAustron Accelerator

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MedAustron is an ion beam therapy center located in Wiener Neustadt, Austria. The design is based on CERN's Proton-Ion Medical Machine Study and the project is currently in the installation and commissioning phase. This paper summarizes the design, production and commissioning of MedAustron's beam profile grid monitor. This monitor measures the beam profile in the low and medium energy beam transfer line where the beam dimensions can be as large as 100 mm. Reasonable position resolution is achieved with a harp consisting of 64 wires per plane and a pitch of up to 1.7 mm. Special effort was needed to produce such harps and bring the signal cables out of the vacuum. As the readout electronics has to cope with DC as well as pulsed beam all 128 wires are acquired simultaneously. This is achieved by integrating the charge during the "flat-top" of the beam pulse and storing it for serial transmission to the back end electronics for conversion. The high accuracy requires calibration of offset and amplification errors for every single channel. A NI PXI FPGA card controls the readout chain. The code for controlling the readout, including the graphical interface, is written in NI LabView.

WEPF08 Pepperpot Design for the First Emittance Measurements of the ESS-Bilbao Proton Source

P. Echevarria, *I. Arredondo, D. Belver, J. Corres, S. Djekic, M. Eguiraun, J. Feuchtwanger, N. Garmendia, P.J. González, R. Miracoli, L. Muguira, S. Varnasseri (ESS Bilbao) J.I. Arrizubieta, A. Lamikiz (UPV/EHU)*

A pepperpot diagnostic system has been designed to characterize the emittance of the Ion Source Hydrogen Positive (ISHP) off- resonance ECR source at ESS-Bilbao. It is placed together with current transformers inside a diagnostic box immediately after the extraction column. Pepperpot main parts are a tungsten drilled layer and a phosphor scintillator. The images are acquired through a vacuum window with a commercial DSLR camera and processed in two separated steps. Firstly, the images are processed using the open source ImageJ software to find the calibration points, remove noise, adjust the threshold and find the location and integrated intensity of each light spot which is stored in a spreadsheet. The calibration information and the spot location spreadsheet are then analyzed using Matlab scripts. The preliminary analysis of images for extraction voltages up to 25kV shows that the emittance values are below 0.5 pi mm mrad.

WEPF09 **Profile and Emittance Measurements at the CERN LINAC-4 3 MeV Test Stand**

F. Zocca, *E. Bravin, M. Duraffourg, G.J. Focker, D. Gerard, U. Raich, F. Roncarolo (CERN)*

A new 160 MeV H^- Linac named Linac-4 will be built at CERN to replace the old 50 MeV proton Linac. The ion source, the 3 MeV RFQ and the medium energy transport (MEBT) hosting a chopper, have been commissioned in a dedicated test stand. Wire grids and wire scanners were used to measure the transverse beam profile and a slit/grid emittance meter was installed on a temporary test bench plugged at the RFQ and MEBT exit in different stages. The emittance meter slit was also used as a scanning scraper able to reconstruct the transverse profile by measuring the transmission with a downstream current transformer. On the same measurement bench, a spectrometer in conjunction with a wire grid allowed measuring the energy spread of the particles. This paper summarizes the measurement results that allowed characterizing the 3 MeV beam and discusses the present understanding of monitor performance.

WEPF10 **Wire Scanner Design for the European Spallation Source**

B. Cheymol, *A. Jansson, T.J. Shea (ESS)*

The European Spallation Source (ESS), to be built in the south of Sweden, will use a 2 GeV superconducting LINAC to produce the world's most powerful neutron source with a beam power of 5 MW. The beam power is a challenge for interceptive beam diagnostics like wire scanner, the thermal load on intercepting devices implies to reduce the beam power in order to preserve the device integrity. For nominal operation, non-disturbing techniques for profile measurements are planned, while for the commissioning phase, accurate measurements and cross checking, wire scanners will be used. This paper describes the preliminary design of the wire scanner system in the normal conducing LINAC as well as in the superconducting LINAC.

WEPF11 **Emittance Measurement Using X-Ray Lenses at the ESRF**

F. Ewald, *J.C. Biasci, K.B. Scheidt (ESRF)*

During the year 2011, X-ray lenses were tested as an alternative way of emittance measurement in the ESRF storage ring. Following these tests it was decided to install a new bending magnet diagnostics beam port dedicated primarily to a permanent emittance measurement using X-ray

lens imaging. The new beam port is equipped with a thin (0.6 mm) double CVD diamond window instead of 3 mm aluminium used at the pinhole beam ports. This increases the X-ray transmission, especially at low energies. The imaging and emittance measurement using aluminium lenses is discussed in comparison to the emittance measurement based on pinhole imaging. Although the principle works correctly, the setup presents different practical difficulties, such as low signal intensity and heat load.

WEPF12 **Characterisation of Al-Compound Refractive Lenses for X-Rays**

***F. Ewald**, J.C. Biasci (ESRF)*

We report on measurements of the surface quality (shape) of aluminium compound refractive lenses using a thin collimated X-ray beam from one of our bending magnet diagnostics beam ports. Two types of lenses were tested for overall radius of curvature, surface quality and thickness: commercially available lenses (RWTH Aachen), and lenses of the same type manufactured at the ESRF. The different surface qualities can be readily discerned with our relatively simple setup. While the technique should be improved for more precise results, it already shows clearly the imperfect surface structure of the ESRF lenses. The image quality of the beam, however, is not affected to a visible extent in our emittance measurement setup at vertical emittances of typically ~ 6 pm.

WEPF14 **A New Low Intensity Beam Profile Monitor for SPIRAL2**

***J.L. Vignet**, J. Pancin (GANIL)*

In order to obtain profiles of SPIRAL 2 ion beams, several beam profile monitors are presently being developed at GANIL. One of them is a low-intensity beam-profile monitor (EFM). This Emission-Foil Monitor (EFM) will be used in the radioactive beam lines of SPIRAL2 and in the experimental rooms of this new facility. The ions produce secondary electrons when they are stopped in an aluminium emissive foil. The electrons are then guided in an electric field placed parallel to a magnetic field in a double-stage microchannel plate (MCP). A 2D pixelated pad plane placed below the MCP is then used to collect the signal. The magnetic field created by permanent magnets in a closed magnetic circuit configuration permits the beam-profile reconstruction to be achieved with good resolution. The EFM can visualize beam-profile intensities between only a few pps to as much as 10^9 pps and with energies as low as several keV. This profiler has been under development since 2011 and is actually manufactured. For the signal acquisition, a new dedicated electronics system will be employed. Recent results of this monitor and its associated electronics will be presented here.

WEPF15 **High-Power Tests at CesrTA of X-ray Optics Elements for SuperKEKB**

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X-ray beam size monitors at SuperKEKB must withstand high, sustained incident power loads. Two prototype optics elements were fabricated and

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tested at CesrTA, using incident X-ray power densities comparable to those expected at the SuperKEKB LER. One element was based on a silicon substrate, the other a CVD diamond substrate, with each substrate supporting a coded aperture mask pattern in gold on its surface. The diamond substrate mask showed superior performance to the silicon substrate mask, with the the mask pattern on the silicon substrate melting at the highest incident power level tested, where the diamond-substrate mask survived. We will present here the high-power test results, along with analysis of X-ray power absorption and heat transfer in the two prototype elements, and the resulting implications for the design of the optics, beam line and heat sink for SuperKEKB.

WEPF16 **Measurement of Small Beam Sizes at the ATF2 Using Coded Aperture X-ray Monitor**

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We have been investigating the use of coded-aperture imaging techniques for X-ray beam profile monitoring of beams with transverse beam sizes below 10 microns at the ATF2. At the ATF2 extraction line, we built an X-ray beam line using the final upstream bending magnet as an X-ray source. Using scanned single-pixel measurements, we successfully measured beam sizes down to ~7.5 microns, the smallest beam size achievable at the source point through tuning of the extraction line optics. This beam size represents a new world record for the smallest beam size measured using X-ray coded aperture optics. The experimental set-up and measurement results will be presented.

WEPF17 **Development of a Beam Profile Monitor using a Nitrogen-Molecular Jet for the J-PARC MR**

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In order to measure a beam profile with a wide dynamic range covering the halo region around the core region of intense proton beams, a non-destructive beam profile monitor using a sheeted jet beam of nitrogen molecules as a target has been developed for the beam of the J-PARC main ring (MR)*,**. Two-dimensional detection of the beam core will be performed using de-excitation light of the nitrogen molecule. On the other hand, beam halo will be detected using ionized electrons. In the detection of the electrons, aμchannel plate (MCP) will be used for charge multiplication. To achieve a sensitivity of about 10^{-6}, a phosphor screen will be employed for the anode of the MCP, and its light will be detected by photo-multiplier arrays for position resolving. Thus the beam core and halo will be detected simultaneously in this scheme. In this paper summaries of recent progress on the development are discussed as below: 1) the detection efficiency and accuracy in the measurement of the halo region, 2) simulation and experiment results of the high intensity jet beam of 5x10^{-4} Pa equivalent or more, 3) the specific design of the detector head in the collision point for J-PARC MR.

* Y. Hashimoto, et al., Proc. of IPAC'10, Kyoto, Japan, p.987-989.
** Y. Hashimoto, et al., Proc. of IBIC'12, Tsukuba, Japan.

WEPF18 **Zemax Simulations for the Diffraction Radiation Beam Size Monitor at CesrTA**

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Diffraction Radiation (DR) is produced when a relativistic charged particle moves in the vicinity of a medium. The target atoms are polarised by the electric field of the charged particle, which then oscillate thus emitting radiation with a very broad spectrum. The spatial-spectral properties of DR are sensitive to various electron beam parameters. Since the energy loss due to DR is so small that the electron beam parameters are unchanged, DR can be used to develop non-invasive diagnostic tools. The aim of this project is to measure the transverse (vertical) beam size using incoherent DR. To achieve the micron-scale resolution required by CLIC, DR in the UV and X-ray spectral-range must be studied. During the next few years, experimental validation of such a scheme will be conducted on the CesrTA at Cornell University, USA. This paper reports on simulations carried out with Zemax, presenting the optical system used to image the emitted radiation and limitations to this system regarding alignment errors.

WEPF21 **Scanning Wire Beam Position Monitor for Alignment of a High Brightness Inverse-Compton X-ray Source**

M.R. Hadmack, *E.B. Szarmes (University of Hawaii)*

The Free-Electron Laser Laboratory at the University of Hawaii has constructed and tested a scanning wire beam position monitor to aid the alignment and optimization of a high spectral brightness inverse-Compton scattering X-ray source. X-rays are produced by colliding the 40 MeV electron beam from a pulsed S-band LINAC with infrared laser pulses from a mode-locked free-electron laser driven by the same electron beam. The electron and laser beams are focused to 60 micron diameters at the interaction point to achieve high scattering efficiency. This wire-scanner allows for high resolution measurements of the size and position of both the laser and electron beams at the interaction point to verify spatial coincidence. Time resolved measurements of secondary emission current allow us to monitor the transverse spatial evolution of the e-beam throughout the duration of a 4 microsecond macropulse while the laser is simultaneously profiled by pyrometer measurement of the occulted infrared beam. Using this apparatus we have demonstrated that the electron and laser beams can be co-aligned with a precision better than 10 microns as required to maximize X-ray yield.

WEPF22 **Non Invasive Optical Synchrotron Radiation Monitor Using a Mini-Chicane**

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We are developing a design for a minimally perturbing mini-chicane which utilizes the optical synchrotron radiation (OSR) generated from magnetic bends to measure the rms emittance and other optical parameters of the beam. The beam is first externally focused at the first bend and the OSR generated there is used to image the beam. Subsequently, any pair of bends produces interferences (OSRI) whose visibility can used to determine the beam divergence. The properties of different configuration of bends in the chicane have been analyzed to provide an optimum diagnostic design for a given set of beam parameters which: 1) provides a sufficient number of OSRI fringes to allow a measurement of the beam divergence; 2) minimizes the competing effect of energy spread on the fringe visibility; 3) minimizes the effect of coherent synchrotron radiation and space charge on the beam emittance; and 4) minimizes the effect of compression on the bunch length, as the beam passes through the chicane. Diagnostic designs have been produced for 100-300 MeV beams with a normalized rms emittance of about 1 micron for application to Fermi@Elettra and similar high brightness free electron lasers.

Beam Charge Monitors and General Diagnostics

WEPF23 **Beam Diagnostics R&D within oPAC**

C.P. Welsch *(Cockcroft Institute)* ***C.P. Welsch*** *(The University of Liverpool)*

Optimization of particle accelerators by combining research into beam physics, beam instrumentation, accelerator control systems and numerical simulation studies is the goal of the oPAC project. Supported with 6 Million Euros by the European Union, the network is one of the largest-ever Initial Training Networks. During the project's four year duration 22 fellows will be trained and a very broad international training program, consisting of schools, topical workshops and conferences will be organized by a consortium of currently more than 30 partner institutions. In this contribution, we will give an overview of oPAC's broad beam diagnostics R&D program, comprising absolute beam intensity measurements for low energy beams, beam diagnostics for synchrotron light sources, cyrogenic beam loss monitors, beam halo monitoring and 3D dose measurements as part of intensity modulated radiotherapy treatment. We will also summarize past oPAC events and give an outlook on future events.

WEPF24 **Beam Charge Monitors at REGAE**

H. Delsim-Hashemi, *K. Flöttmann, M. Seebach (DESY) S. Bayesteh (Uni HH)*

A new linac is commissioned at DESY mainly as the electron source for femtosecond electron diffraction facility REGAE (Relativistic Electron Gun

for Atomic Exploration). REGAE comprises a photo-cathode gun followed by normal conducting 1.5 cell rf-cavity to provide sub pC charge electron-bunches of 2-5 MeV with a coherence length of 30nm. In order to produce and maintain such electron bunches, sophisticated single-shot diagnostics are desired e.g. emittance, energy, energy-spread and bunch-length measurement. There are three methods at REGAE for charge measurement. The most routine method is based on Faraday-cups that are distributed along machine and can provide charge reading down to ~50 fC. The second method, which is non-destructive, is a cavity based antenna that measures beam induced fields. A third method is based on beam-profile measurement diagnostics. By proper calibration of integral intensity that arrives at detector one can measure charges down to fC level. The last method has the potential to reach the limit of few electrons charge when state-of-the-art intensifiers are used in profile monitors.

WEPF25 **Resonator for Charge Measurement at REGAE**

***D. Lipka**, J. Lund-Nielsen, M. Seebach (DESY)*

A resonator has been developed for the diagnostics of dark current and charge measurements at the European XFEL, FLASH and PITZ. The first induced monopole mode TM01 at 1.3 GHz from charged bunches is used to detect the dark current and charge with high resolution at these accelerators. At REGAE this resonator with electronics is installed to detect the bunch charge because charges below pC are used and this device can resolve it non-destructively. The same electronics as for the dark current and charge measurement is used and the resolution is measured to be 2.3 fC for 200 fC.

WEPF26 **Test Bench Experiments for Energy Measurement and Beam Loss of ESS-Bilbao**

***S. Varnasseri**, I. Arredondo, D. Belver, P. Echevarria, M. Eguiraun (ESS Bilbao)*

Various test benches have been developed at ESS-Bilbao in order to characterize different beam diagnostics and control systems prior to their installation on various parts of the accelerator. One test bench includes time-of-flight (TOF) characterization for energy measurement using fast current transformers (FCT). Using FCTs for the TOF measurement would allow us to measure accurately the delay between two successive bunched or un-bunched beam pulses of low energy ions. The other test bench includes a beam loss monitoring and interlock system using ACCTs, cRIO and PXI chassis with some acquisition modules and optical fiber link which represent a complete system of beam loss detection, interlock logic and trigger signal transmission. Having an integration on the ACCT output also allows us to measure the beam charge at the location of monitoring. In the test benches the functionality of hardware and software, the logic and required signal specifications like rise time, jitters and delays are measured. An overview of test benches and their measurement results are reported in this paper.

WEPF27 **Coherent Ultraviolet Radiation Measurements of Laser Induced Bunching in a Seeded FEL**

M. Veronese, *E. Allaria, M. Ferianis, M. Trovò (Elettra-Sincrotrone Trieste S.C.p.A.)*

Optimization of the bunching process in a seeded FEL like FERMI@Elettra is an important aspect for machine operation. In this paper we discuss about the power detection of coherent radiation in the UV range as a valuable method for optimizing the bunching induced by the seeding process on the electron beam. Experimental results obtained at FERMI@Elettra are presented here. Measurements of UV coherent transition and diffraction radiation have been used to quantify the bunching produced by the seed laser at lower laser harmonics. The dependence of the laser induced CUVTR signal on various parameters is experimentally studied. Future upgrades and possibilities for bunching measurements at shortest wavelengths are also discussed.

WEPF28 **Longitudinal Beam Diagnostic from a Distributed Electrostatic Pick-Up in CERN's ELENA Ring**

M.E. Angoletta, *F. Caspers, F. Pedersen, L. Søby (CERN)*

The CERN Extra Low ENergy Antiproton (ELENA) Ring is a new synchrotron that will be commissioned in 2016 to further decelerate the antiprotons coming from CERN's Antiproton Decelerator (AD). Required longitudinal diagnostics include the intensity measurement for bunched and debunched beam and the measurement of Dp/p for a debunched beam to assess the electron cooling performance. A novel method for the calculation of these parameters is proposed for ELENA, where signals from the twenty electrostatic pick-ups (PU) used for orbit measurements will be combined to improve the signal-to-noise ratio. This requires that the signals be digitally down-converted, rotated and digitally summed so that the many electrostatic PUs will function as a single, distributed PU from to the processing system viewpoint. This method includes some challenges and will not be used as the baseline longitudinal diagnostics for the initial ELENA operation. This paper gives an overview of the hardware and digital signal processing involved, as well as of the challenges that will have to be faced.

WEPF29 **The LHC Fast Beam Current Change Monitor**

D. Belohrad, *J.M. Belleman, L.K. Jensen, M. Krupa, A. Topaloudis (CERN)*

The modularity of the Large Hadron Collider's (LHC) machine protection system (MPS) allows for the integration of several beam diagnostic instruments. These instruments have not necessarily been designed to have protection functionality, but MPS can still use them to increase the redundancy and reliability of the machine. The LHC fast beam current change monitor (FBCCM) is an example. It is based on analogue signals from fast beam current transformers (FBCT) used nominally to measure the LHC bunch intensities. The FBCCM calculates the magnitude of the beam signal provided by the FBCT, looks for a change over specific time intervals,

and triggers a beam dump interlock if losses exceed an energy-dependent threshold. The first prototype of the FBCCM was installed in the LHC during the 2012-2013 run. The aim of this article is to present the FBCCM system and the results obtained, analyse its current performance and provide an outlook for the final system which is expected to be operational after the long LHC shutdown.

WEPF30 **System Overview and Preliminary Test Results of the ESS Beam Current Monitor System**

H. Hassanzadegan, *A. Jansson (ESS) K. Strnisa (Cosylab)*

The ESS Linac will include in total 21 Beam Current Monitors, mostly of ACCT type, to measure the average current over the 2.86 ms beam pulse, the pulse charge and the pulse profile. It is also planned to use a few Fast Current Transformers to check the performance of the fast beam choppers with a rise time as short as 10 ns. In addition to the absolute current measurement, the BCM system needs to measure the differential beam current and act on the Machine Interlock System if the difference exceeds some thresholds. The differential current measurement is particularly important in the low energy part of the Linac, where Beam Loss Monitors cannot reliably detect beam losses. This paper gives an overview of the ESS BCM system and presents some preliminary test results with a commercial ACCT and MTCA.4 electronics.

WEPF31 **Data Acquisition for a Beam Transformer in SIS18**

O. Chorniy, *H. Bräuning, T. Hoffmann, H. Reeg, A. Reiter (GSI)*

This contribution presents the development of the data acquisition (DAQ) system for fast beam current transformers (FCT) as installed in the synchrotron SIS18 and foreseen for the FAIR ring accelerators. With the FCT a measurement of the longitudinal bunch profiles within the entire machine cycle is performed. As any profile changes scales with the synchrotron frequency of typically 1 kHz, the DAQ system merely needs to acquire sequences of single-turn data blocks during the typically 1 s long cycle. Therefore, a multi-trigger scheme was implemented in the VME-based DAQ to record the bunch profiles every n-th revolution. The system was controlled by the FESA (Front-End Software Architecture) class. For an online observation a Java based GUI was produced. The DAQ and GUI package was optimized during several beam-based tests. Future applications range from a simple observation of bunch parameters in time domain up to tomographical reconstruction of the longitudinal phase space. The performance of the new DAQ is discussed and experimental results are summarized.

WEPF32 Measurement and Control of the Beam Energy for the SPIRAL2 Accelerator

W. Le Coz, *C. Doutresssoulles, C. Jamet, G. Ledu, S. Loret, C. Potier de courcy (GANIL)*

The first part of the SPIRAL2 facility, which entered last year in the construction phase at GANIL in France, will be composed of an ion source, a deuteron/proton source, a RFQ and a superconducting linear accelerator delivering high intensities, up to 5 mA and 40 MeV for the deuteron beams. As part of the MEBT commissioning, the beam energy will be measured on the BTI (Bench of Intermediate Test) at the exit of the RFQ. At the exit of the LINAC, the system has to measure but also control the beam energy. The control consists in ensuring that the beam energy is under a limit by taking account of the measurement uncertainty. The energy is measured by a method of time of flight, the signal is captured by non-intercepting capacitive pick-ups. This paper presents also the results obtained in terms of uncertainties and dynamics of measures.

WEPF33 Measurement and Control of the Beam Intensity for the SPIRAL2 Accelerator

S.L. Leloir, *T. André, B. Ducoudret, C. Jamet, G. Ledu, C. Potier de courcy (GANIL)*

The phase 1 of the SPIRAL2 facility is under construction at the GANIL (Caen, France). The accelerator including a RFQ and a superconducting linac will product deuteron, proton and heavy ion beams in a wide range of intensities and energies (beam power range: a few 100W to 200kW). The measurements of the beam intensities are ensured by several AC and DC Current Transformers (ACCT/DCCT). These measurements are required for the accelerator tuning and the beam controls for safety requests during the daily operation. The uncertainty has to be taken into account to determine the threshold value. This paper presents the measuring chain description of ACCT/DCCT, the signal processing by integration and the uncertainty studies.

WEPF34 Accurate Measurement of Small Electron Beam Currents at the MLS Electron Storage Ring

R. Klein, *G. Brandt, D. Herzog, R. Thornagel (PTB)*

The PTB, the German metrology institute, utilizes the electron storage ring MLS in Berlin Adlershof for the realization of the radiometric units in ultraviolet and vacuum ultraviolet spectral range. For this purpose the MLS can be operated as a primary source standard of calculable synchrotron radiation with very flexible parameters, especially in terms of electron beam energy and electron beam current. We report on improvements in the measurement of the electron beam current in the nA and pA range. In this range the electron beam current can be very accurately measured by counting the stored electrons.

WEPF35 Status of the Schottky Cavity Sensor for the CR at FAIR

***M. Hansli**, R. Jakoby, A. Penirschke (TU Darmstadt) P. Hülsmann, W. Kaufmann (GSI)*

In this paper the current status of the Schottky Cavity Sensor development for the Collector Ring at FAIR, a dedicated storage ring for secondary particles, rare isotopes, and antiprotons, is presented. Designed for longitudinal and transversal Schottky signals, the Sensor features a pillbox cavity with attached waveguide filters utilizing the Monopole mode at 200 MHz for longitudinal and the Dipole mode at around 330 MHz for transversal Schottky measurements. Separated coupling structures allow for mode-selective coupling to measure the different Schottky planes independently. A ceramic vacuum shielding inside the pillbox is implemented to enable non-hermetic adjustable coupling, tuning devices and waveguide structures. Simulations of the structure with focus on the impact of the coupling structures and the ceramic vacuum shielding on the R-over-Q values and the coupling are presented as well as measurements of a scaled demonstrator including comparisons with the simulations.

WEPF36 X-ray Cherenkov Radiation as a Source for Relativistic Charged Particle Beam Diagnostics

***A.S. Konkov**, A.S. Gogolev, A. Potylitsyn (TPU) P. Karataev (Royal Holloway, University of London)*

Recent progress in development of accelerator technology for future linear colliders and X-ray free electron lasers has generated an interest in developing novel diagnostics equipment with resolution surpassing the unique beam parameters. Cherenkov radiation (CR) in the X-ray region in the vicinity of the absorption edges is one of the promising sources for relativistic charged particle beam diagnostics. In this work we have demonstrated CR characteristics in the X-ray region significantly depend on the energy of the emitted photons, because the CR is only generated in the frequency region in the vicinity of the atomic absorption edges, where the well-known Cherenkov condition is work. This peculiarity can be explained by resonance behaviour of the permittivity in the frequency range. It will result in the fact that the CR will stand out of any other types of polarisation radiation both on intensity and shape of angular distribution giving a unique opportunity to apply this phenomenon for charged particle beam diagnostics.

THAL — Beam Charge Monitors and General Diagnostics

Chair: A. Peters (HIT)

Beam Charge Monitors and General Diagnostics

THAL1 09:00 40
Understanding the Tune Spectrum of High Intensity Beams

__R. Singh__, P. Forck, P. Kowina (GSI) O. Boine-Frankenheim (TEMF, TU Darmstadt)

Tune spectra measurements are routinely performed in most synchrotrons. At high intensity and low energies (i.e. $\gamma \sim 1$), space charge effects can significantly modify the tune spectra in comparison to the classical low intensity spectra. Systematic studies were performed at GSI SIS-18 to observe these characteristic modifications, mainly resulting from the shift of the head-tail modes in direct dependence of beam intensity and synchrotron tune frequency. In this contribution, an interpretation of the tune spectra modification based on quasi-analytical models and numerical simulations will be presented. Extraction of elusive beam parameters such as incoherent tune shift, machine impedances, chromaticity, etc. from the spectra will be demonstrated. Further, the applications and relevance of these results for other synchrotrons will be discussed.

THAL2 09:40 20
A New Differential and Errant Beam Current Monitor for the SNS Accelerator

__W. Blokland__ (ORNL) C.C. Peters (ORNL RAD)

A new Differential and errant Beam Current Monitor (DBCM) is being implemented for the Spallation Neutron Source's Medium Energy Beam Transport (MEBT) and Super Conducting linac (SCL) accelerator sections. This new current monitor will abort the beam when the difference between two toroidal pickups exceeds a threshold. The MEBT DBCM will protect the MEBT chopper target while the SCL DBCM will abort beam to minimize fast beam losses in the SCL cavities. The new DBCM will also record instances of errant beam such as beam drop-outs to assist in further optimization of the SNS Accelerator. A software Errant Beam Monitor was implemented on the regular BCM hardware to study errant beam pulses. The new system will take over this functionality and will also be able to abort beam on pulse to pulse variations. as it is based on the FlexRIO hardware programmed in LabVIEW FPGA and can abort beam in 5 us. This paper describes the development, implementation, and initial test results of the DBCM as well as errant beam examples.

THAL3 10:00 20

Charge Distribution Measurements at ALBA

L. Torino, *U. Iriso (CELLS-ALBA Synchrotron)*

Two different set-ups are used to perform quantitative measurements of the charge distribution at ALBA. The first consists in a real-time analysis of data coming from the Fast Current Transformer or from the buttons of a Beam Position Monitor installed in the Storage Ring. The second is performed at the diagnostic visible beamline Xanadu, using a Photomultiplier that measures the temporal distribution of synchrotron light. In both cases a quantitative estimation of the charge distribution is obtained after a dedicated data treatment and beam current measurements from the DCCT. We compare results with both methods, and discuss differences and limitations with respect to bunch purity measurements with the Time Correlated Single Photon Counting technique.

THBL — Closing Session

Chair: H. Tanaka (RIKEN SPring-8 Center)

Beam Charge Monitors and General Diagnostics

THBL1 11:00 40

RF Heating from Wake Losses in Diagnostics Structures

E. Métral *(CERN)*

Heating of diagnostics structures (striplines, buttons, screen vessels, wire scanners etc) has been observed at many facilities with higher stored currents*. Simulations of wake losses using 3D EM codes are regularly used to estimate the amount of power lost from the bunched beam but on its own this does not tell how much is radiated back into the beam pipe or transmitted into external ports and how much is actually being dissipated in the structure and where. This talk should introduce into the matter, summarise some of the observations at various facilities and illustrate what approaches of detailed simulations have been taken.

* summarizing a workshop at DLS (see http://tinyurl.com/wakeloss)

Time Resolved Diagnostics and Synchronization

THBL2 11:40 40

The White Rabbit Project

J. Serrano*, M. Cattin, G. Daniluk, E. Gousiou, M. Lipiński, E. Van der Bij, T. Włostowski (CERN)*

White Rabbit (WR) is a multi-laboratory, multi-company collaboration for the development of a new Ethernet-based technology which ensures sub-nanosecond synchronisation and deterministic data transfer. The project uses an open source paradigm for the development of its hardware, gateware and software components. This article provides an introduction to the technical choices and an explanation of the basic principles underlying WR. It then describes some possible applications and the current status of the project. Finally, it provides insight on current developments and future plans.

Boldface papercodes indicate primary authors

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