I16U

Exploiting Diamond-II for Investigations of Competing Interactions and Length-Scales

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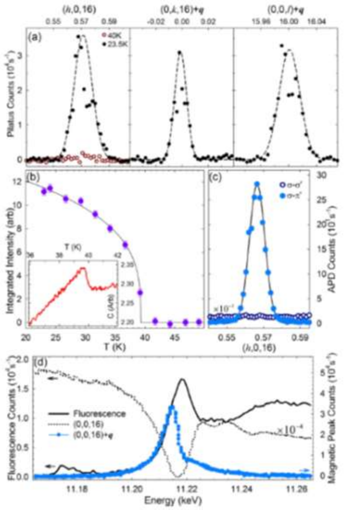
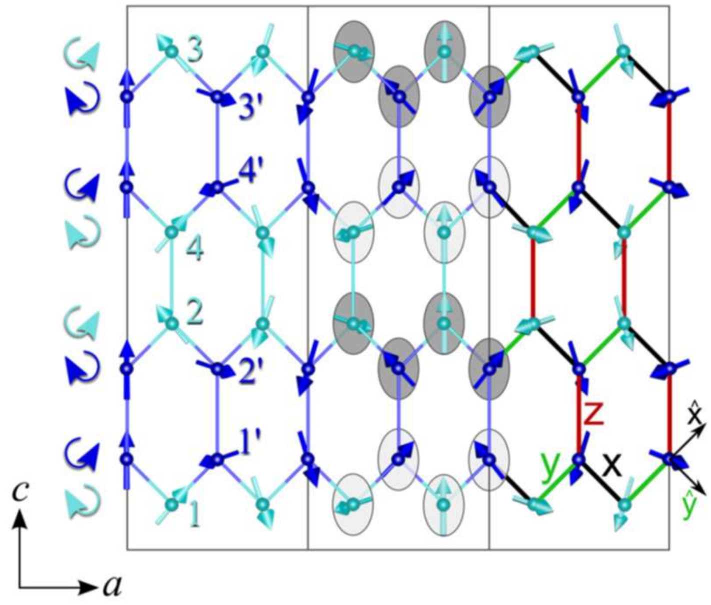
Alessandro Bombardi	DLS
John Sutter	DLS
George Howell	DLS
Steve Collins	DLS
Sarnjeet Dhesi	DLS

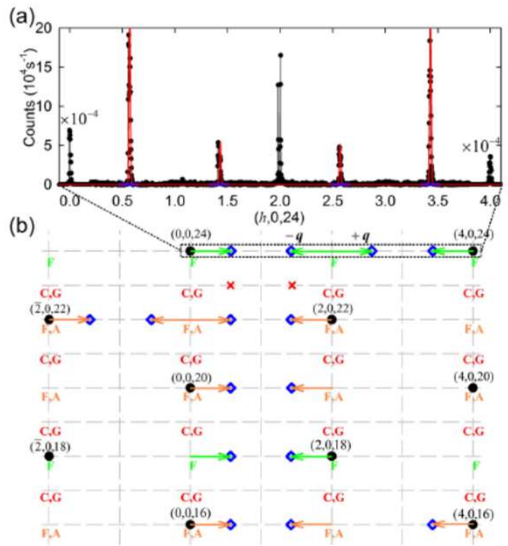
Diamond I16: Anatomy of an experiment (γ-Li_2IrO_3)

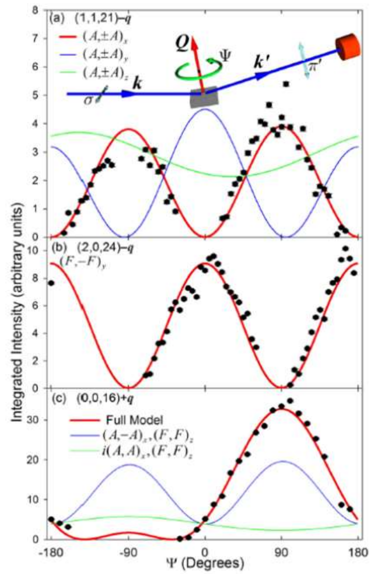


- Measure AF Bragg peaks over a wide range of momentum transfer

- Explore energy (resonance), temperature, azimuthal and polarization dependence.







Determine magnetic and electronic structure: Counter-rotating spins on a honeycomb lattice, dominated by Kitaev interactions.

PRL 113, 197201 (2014) PHYSICAL REVIEW LETTERS week ending 7 NOVEMBER 2014

Noncoplanar and Counterrotating Incommensurate Magnetic Order Stabilized by Kitaev Interactions in γ-Li_2IrO_3

A. Biffin,[1] R. D. Johnson,[1] I. Kimchi,[2] R. Morris,[1] A. Bombardi,[3] J. G. Analytis,[2,4] A. Vishwanath,[2,4] and R. Coldea[1]

diamond

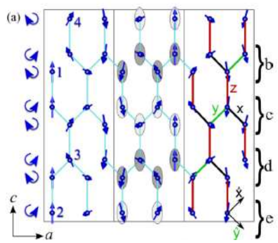
Diamond I16: Evolution

Shrinking samples (here ~ 15 μm crystal with D-I and D-II focus)

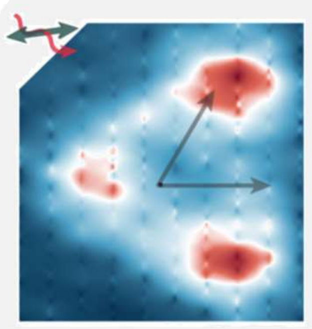
PHYSICAL REVIEW B 90, 205116 (2014)

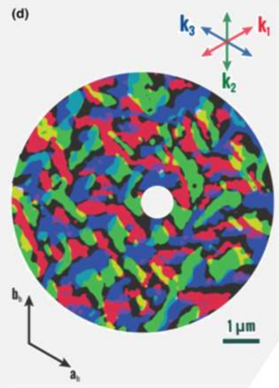
Unconventional magnetic order on the hyperhoneycomb Kitaev lattice in β-Li_2IrO_3: Full solution via magnetic resonant x-ray diffraction

A. Biffin,[1] R. D. Johnson,[1] Sungkyun Choi,[1] F. Freund,[2] S. Manni,[2] A. Bombardi,[3] P. Manuel,[4] P. Gegenwart,[2] and R. Coldea[1]



Transition from bulk crystals to thin films and heterostructures





Early work showed ~100 μm bulk domains
Thin films allow strain engineering & electric fields
Micron-scale domains imaged using PEEM (I06)

PRL 117, 177601 (2016) PHYSICAL REVIEW LETTERS week ending 21 OCTOBER 2016

Coherent Magnetoelastic Domains in Multiferroic $BiFeO_3$ Films

N. Waterfield Price,[1,2] R. D. Johnson,[1,3] W. Saenrang,[4] F. Maccherozzi,[2] S. S. Dhesi,[2] A. Bombardi,[2] F. P. Chmiel,[1] C.-B. Eom,[4] and P. G. Radaelli[1,*]

Use of coherence for imaging

Bragg Coherent Diffractive Imaging of atomic-scale strain around defects, with resolution of 10s of nm.

LETTERS nature materials
PUBLISHED ONLINE: 1 JUNE 2015 | DOI: 10.1038/NMAT4320

Three-dimensional imaging of dislocation propagation during crystal growth and dissolution

Jesse N. Clark[1*†], Johannes Ihli[2†], Anna S. Schenk[2], Yi-Yeoun Kim[2], Alexander N. Kulak[2], James M. Campbell[3], Gareth Nisbet[4], Fiona C. Meldrum[2*] and Ian K. Robinson[1,5]

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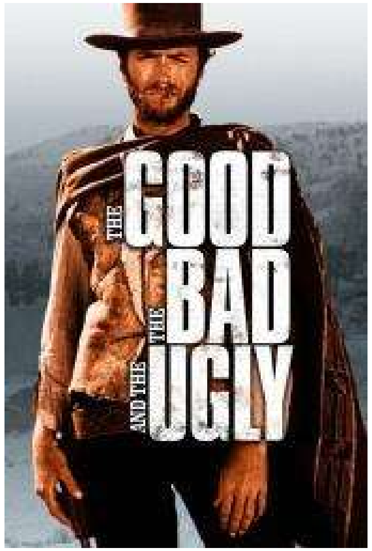

Diamond I16 now

- Highly versatile
- Very stable optics
- Excellent scientific publications
- Huge benefit from Diamond-II

- Experiments slow and complex (large expert groups only – no remote access)
- Diffractometer and cryostat stability inadequate for Diamond-II
- Limited sample environments

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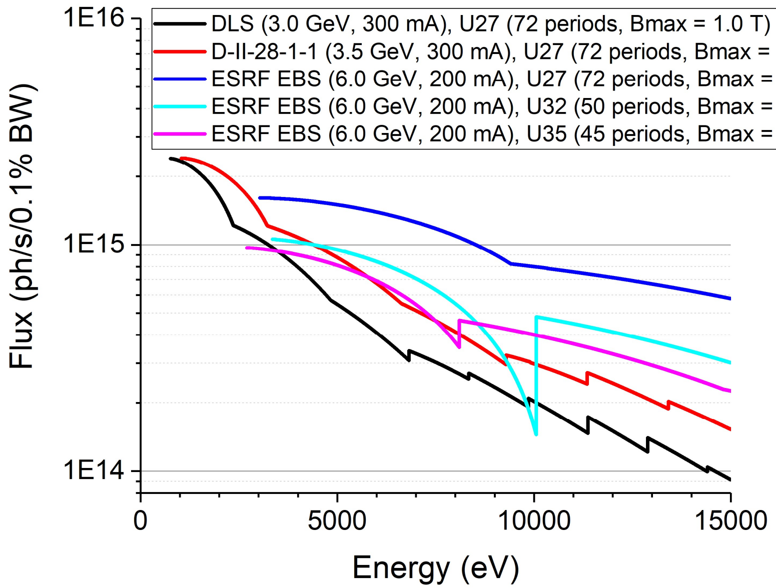
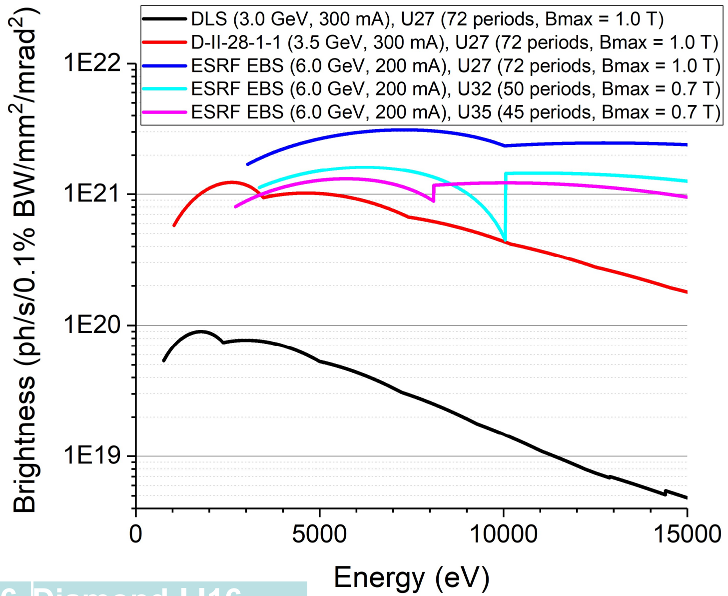
I16: Huge gains from Diamond-II





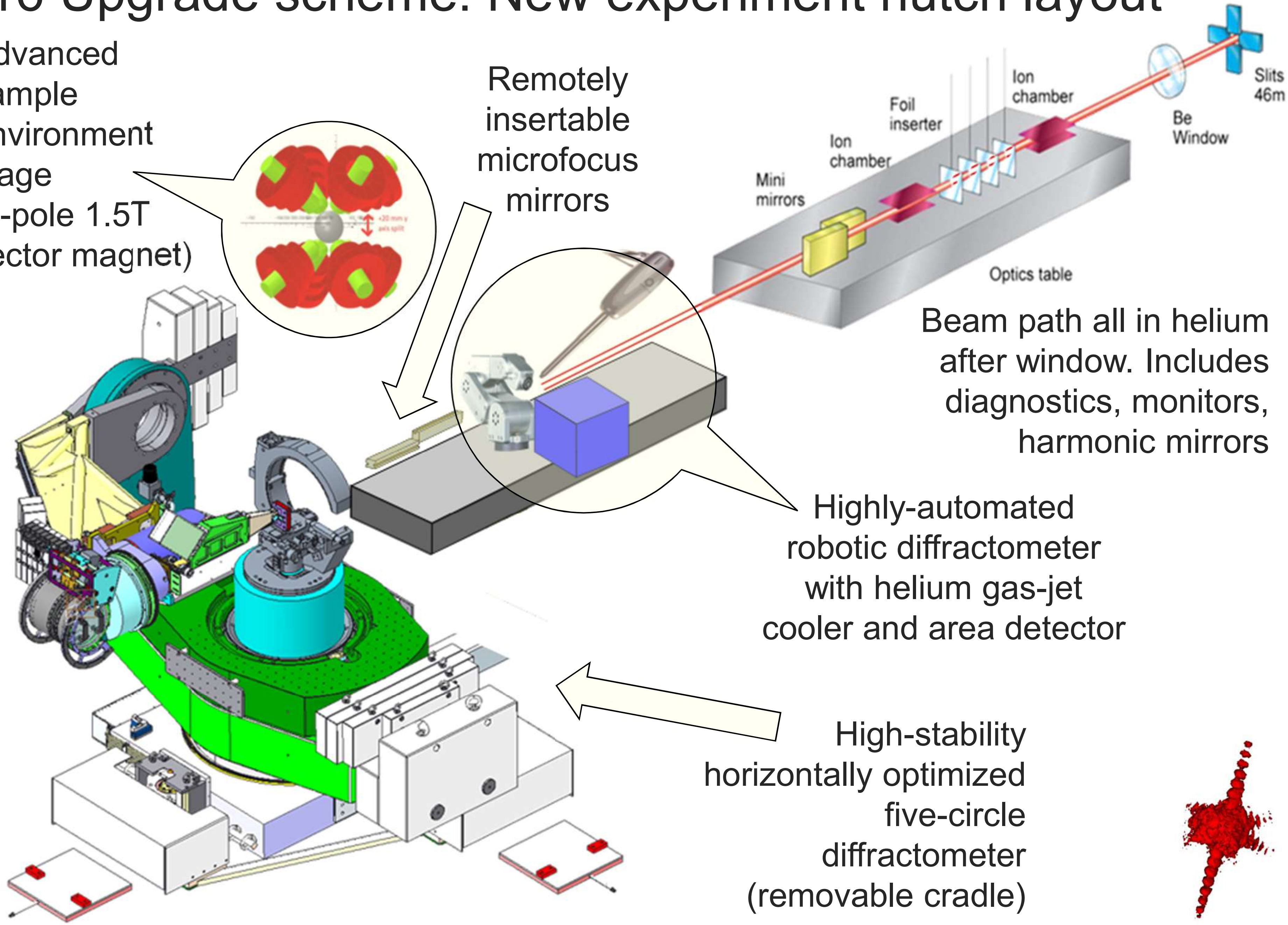
Source	ESRF EBS	Diamond-II I16 CDR (ey = 8 pm)	Diamond-II I16 (ey = 5 pm)	Diamond-I I16
sigmax (um)	27.6	29.1	**29.4**	**122**
sigmay (um)	3.65	4.06	3.21	4.1
sigmax' (urad)	3.99	5.12	**5.18**	**27**
sigmay' (urad)	1.37	1.97	1.56	2.3

- Increased flux
- Huge increase in brightness (coherence flux) ~ ESRF upgrade
- X4 smaller horizontal source (focus)
- X4 smaller horizontal divergence

I16 Upgrade

- Minor changes to optics and hutches
- Major re-design of experiment hutch components

I16 Upgrade scheme: New experiment hutch layout



Advanced sample environment stage (8-pole 1.5T vector magnet)

Remotely insertable microfocus mirrors

Beam path all in helium after window. Includes diagnostics, monitors, harmonic mirrors

Highly-automated robotic diffractometer with helium gas-jet cooler and area detector

High-stability horizontally optimized five-circle diffractometer (removable cradle)

I16 Upgrade

Fully exploit Diamond-II to build on the established new directions for the beamline (small samples, imaging at competing length scales)…

Support the entire research cycle, with three experimental scenarios:

1. A high-speed highly-automated robotic diffractometer with sample changer and helium gas-jet (20-350 K) cooling. Entry-level remote instrument for sample characterization, magnetic propagation vectors, phase transitions…

2. A high-stability horizontally-optimized diffractometer for resonant, magnetic and coherent scattering; low-vibration cryostats (<3 K); full polarization control; remotely insertable microfocus optics

3. Large instrument to support a wide range of future specialist sample environments. Proposal includes a 1.5T 8-pole vector magnet with wide opening. Future stages driven by new priorities.

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I16 Upgrade: Who will benefit?

Robotic diffractometer

- Chemists and sample growers – rapid materials discovery and screening
- Users of advanced facilities (I16 main instrument, X-FEL…)
- Materials scientists (diffraction maps *etc*)
- New users & students (training, automation)
- Remote users

Main Instrument

- Bragg Coherent Diffractive Imaging community
- All current users (enhanced flux, smaller focus, microfocus, improved stability, improved cryostat, horizontal scattering)

Advanced sample environment

- Science projects for vector magnet (complex frustrated and topological systems)
- Users of future sample environment provision

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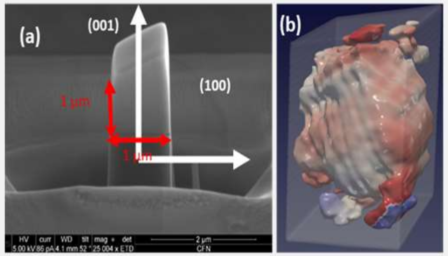
Diamond I16: New Science

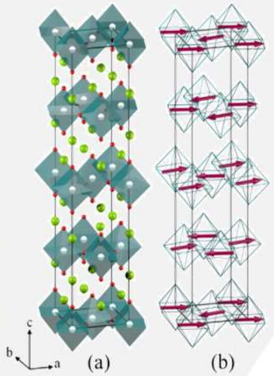
Robotic diffractometer

Magnetic structure from single large crystal grains

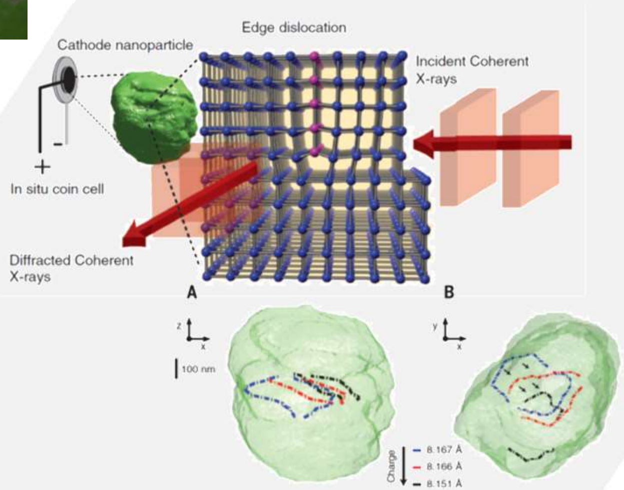
Functional properties of HPHT growth (*Perry, Johnson*)

Bragg Coherent Diffractive Imaging





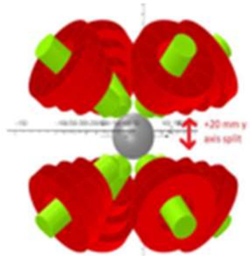
Imaging AF domains in Sr_2IrO_4 (*Robinson*)



Imaging defects and oxidation states during battery charge-cycling (*Ulvestad et al*)

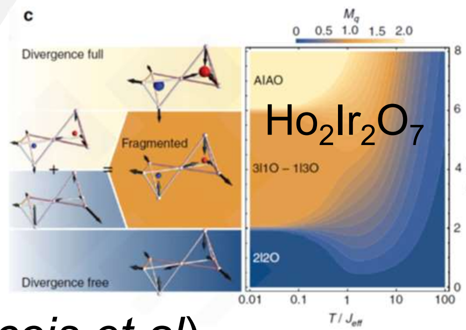
1.5T vector magnet

3d structure of Skyrmion phases



Anisotropy in frustrated rare-earth pyrochlores; coordination polymers (*Johnson*).

'Staggered' physics, complex phases and their Hamiltonians.



(*Lefrancois et al*)