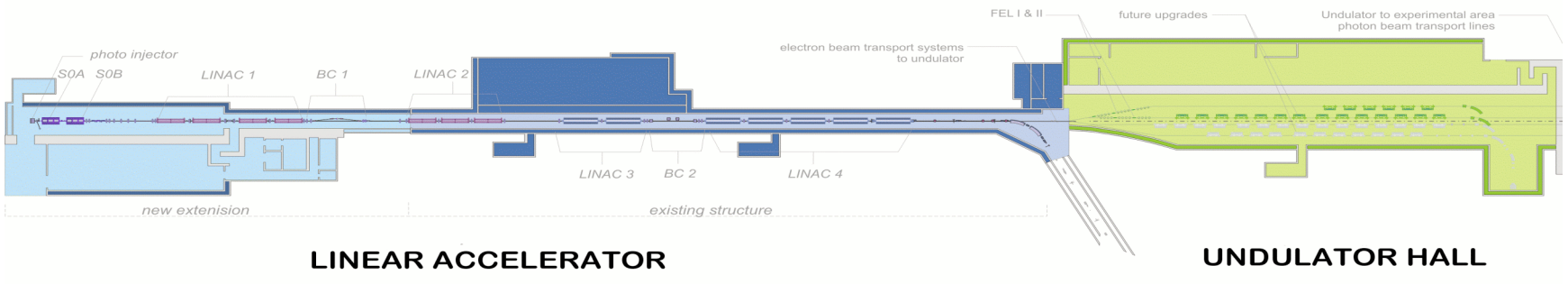
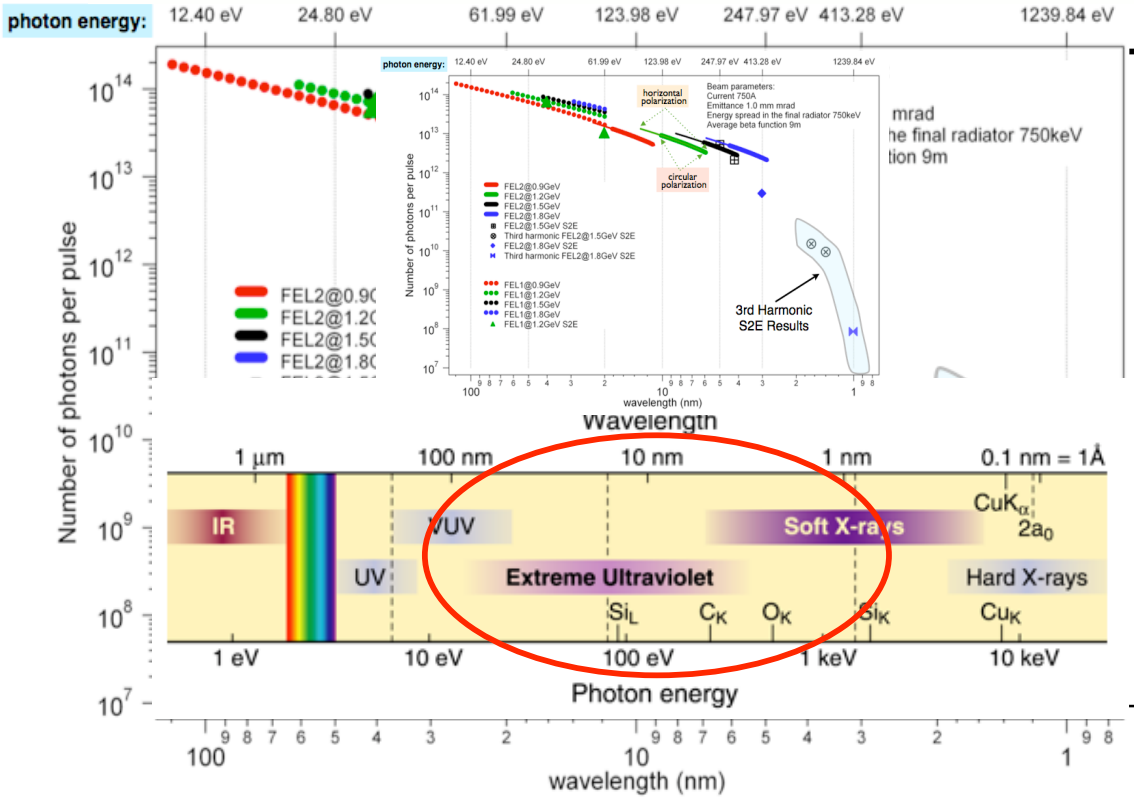
A beam-shaping system for TIMEX beamline

C. Svetina, G. Sostero, R. Borghes, R. Sergo, F. Cianciosi, D. Cocco

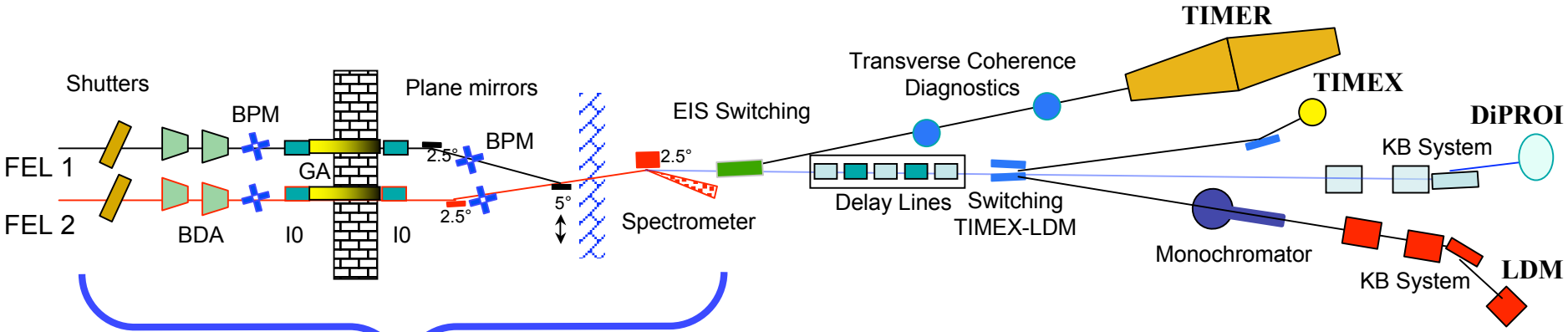
Sincrotrone Trieste SCpA, S.S. 14 km 163.5 in Area Science Park, 34149 Trieste, Italy





Parameter	FEL 1	FEL 2
Wavelength (nm)	100-20	20-4
Pulse length rms (fs)	30-100	<100
Bandwidht rms (meV)	~20-40	~20-40
Polarization	variable	variable
Peak Power (GW)	1-5	~1
Photons per pulse	$\sim 4 \cdot 10^{14}$ (100 nm)	$\sim 10^{13}$ (10 nm)
Source Size FWHM (µm)	290	140
Divergence rms (µrad)	50@40 nm	15@10 nm
Repetition Rate (Hz)	10-50	50

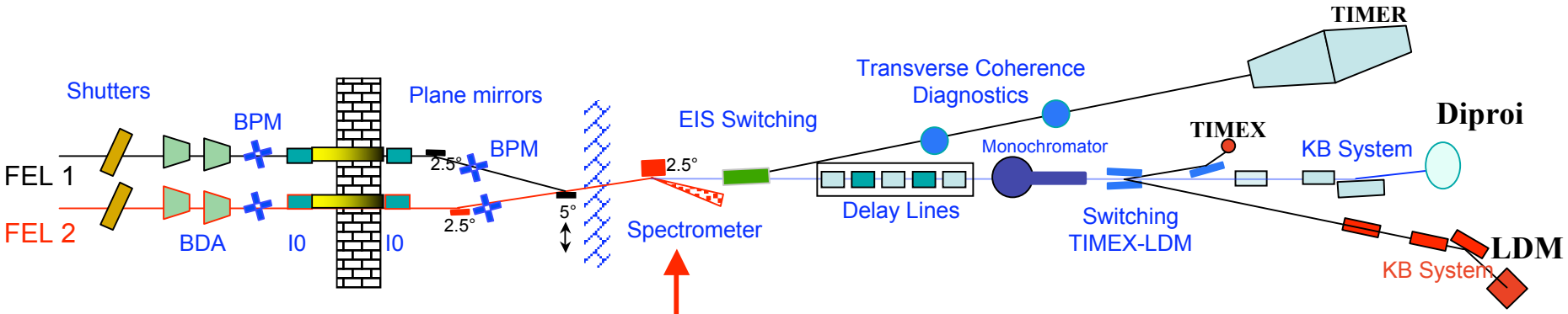
Experimental hall

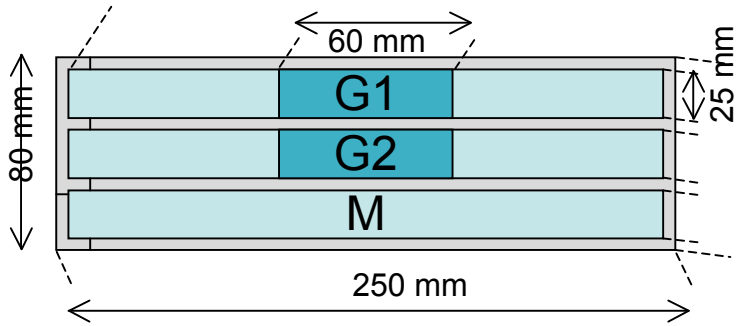


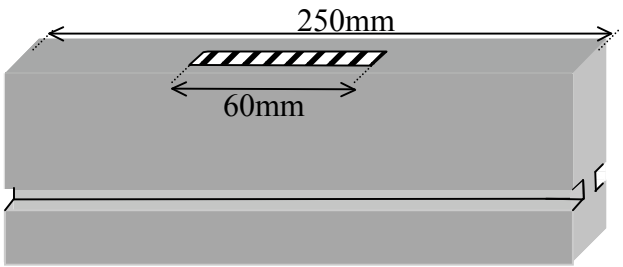
PADReS

Photon
Analysis
Delivery and
Reduction
System

On-Line Photon Energy Spectrometer

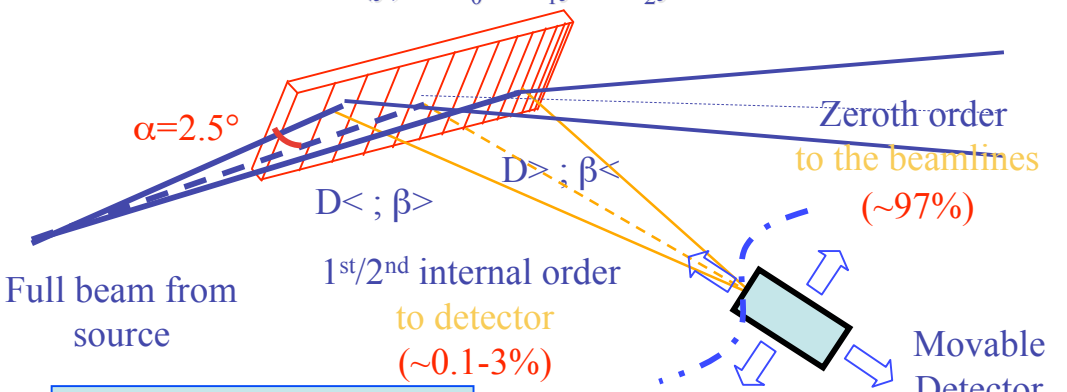






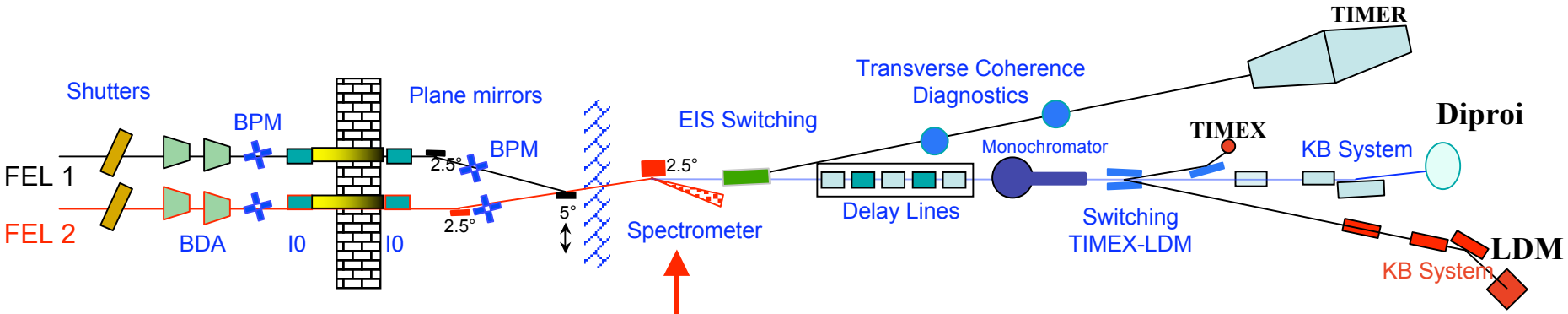
Groove density expanded in Taylor series

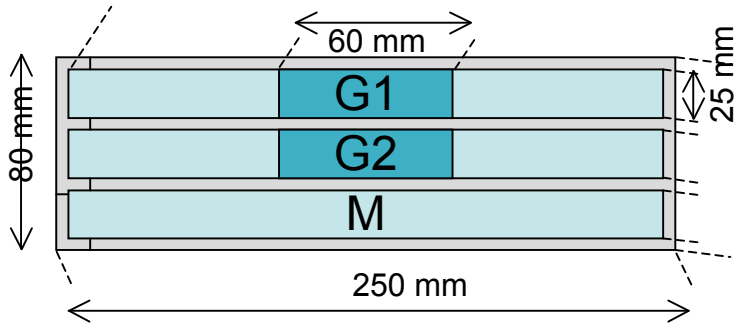
$D(y) = D_0 + D_1 y + D_2 y^2 + \ldots$

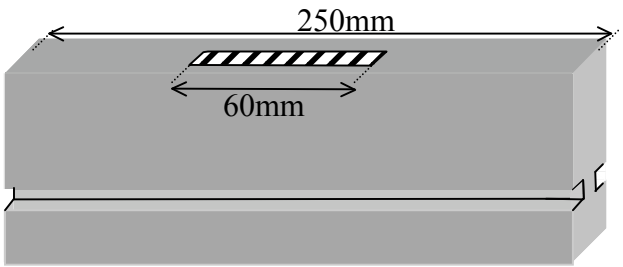


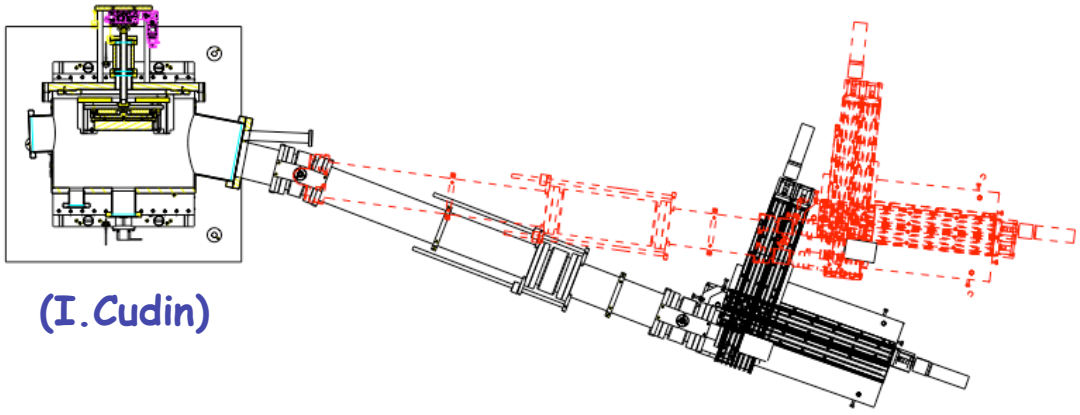
Δr'=290 mm
Δβ=13.0° βmin=6.9°
Δx=455 mm Δy=560 mm

On-Line Photon Energy Spectrometer





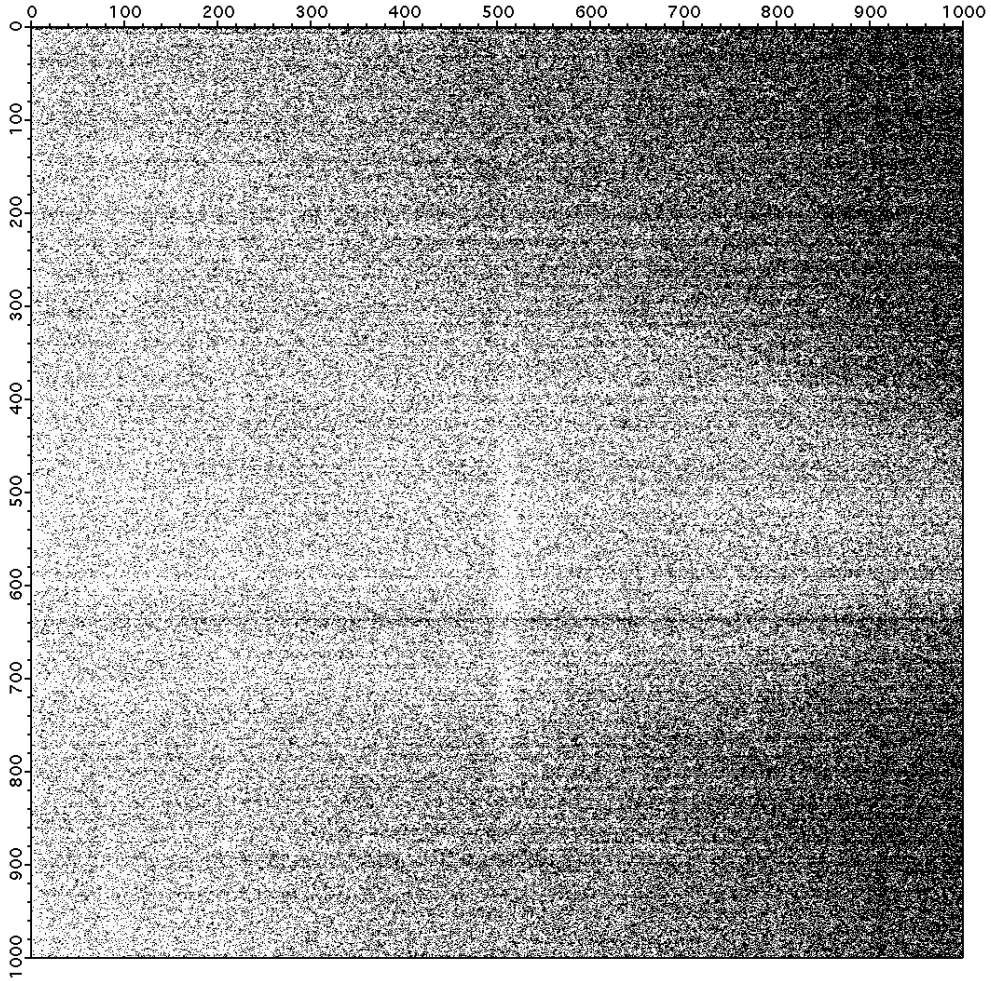




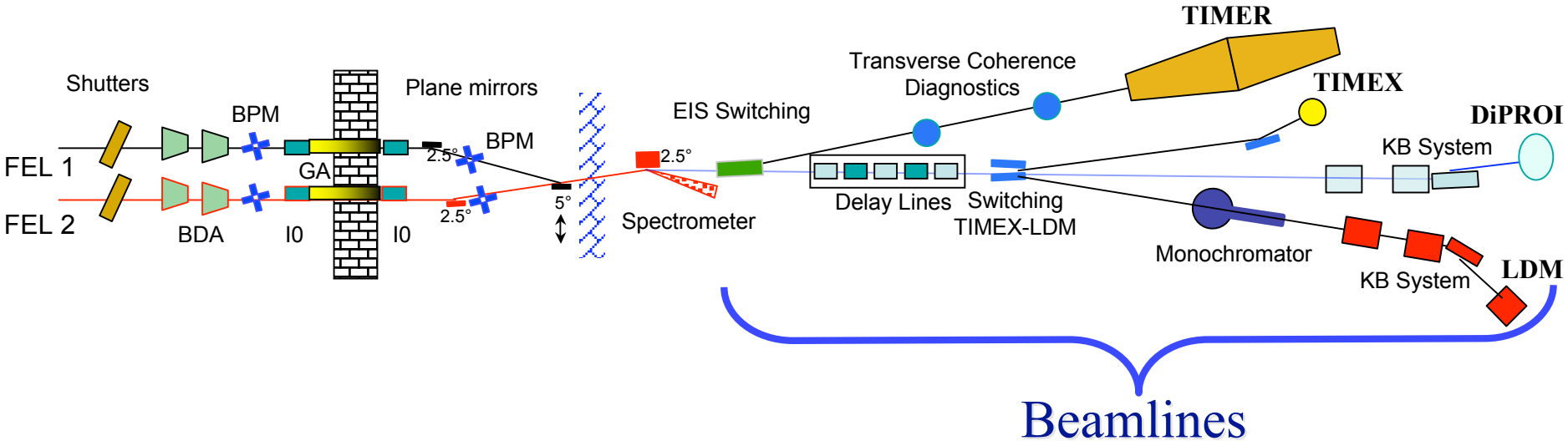
(I.Cudin)

23rd December 2011
First photon energy spectrum acquired
with the photon energy spectrometer.

E=28.6eV
ΔE=60meV



Experimental hall



LDM: Low Density Matter

ref. F. Parmigiani, S. Svenson, K. Prince, S. Stranges, J. M. Dyke, T. Möller, F. Stienkemeier…

DIPROI: DIffraction and PROjection Imaging

ref. M. Kiskinova, F. Capotondi, B. Kaulich, H. Chapman, J. Hajdu, A. Nelson…

EIS: Elastic and Inelastic Scattering

-TIMER: TIME-Resolved spectroscopy of mesoscopic dynamics in condensed matter

-TIMEX: ultrafast TIme-resolved studies of Matter under EXtreme and metastable conditions

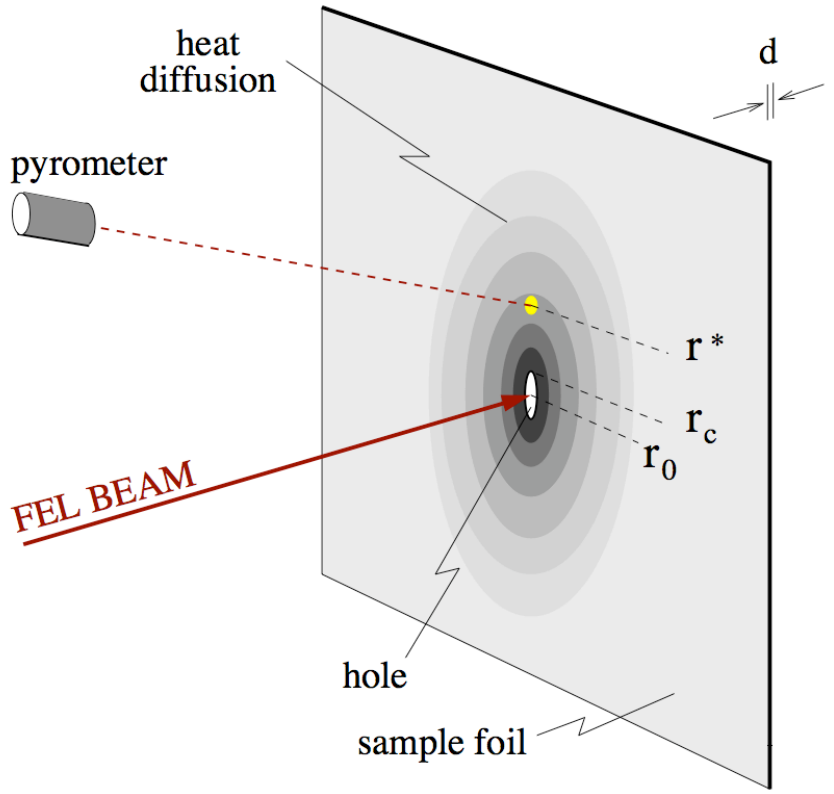
ref. C. Masciovecchio, F. Bencivenga, A. Di Cicco, E. Principi, F. Bencivenga…

TIMEX: ultrafast TIme-resolved studies of Matter under EXtreme and metastable conditions

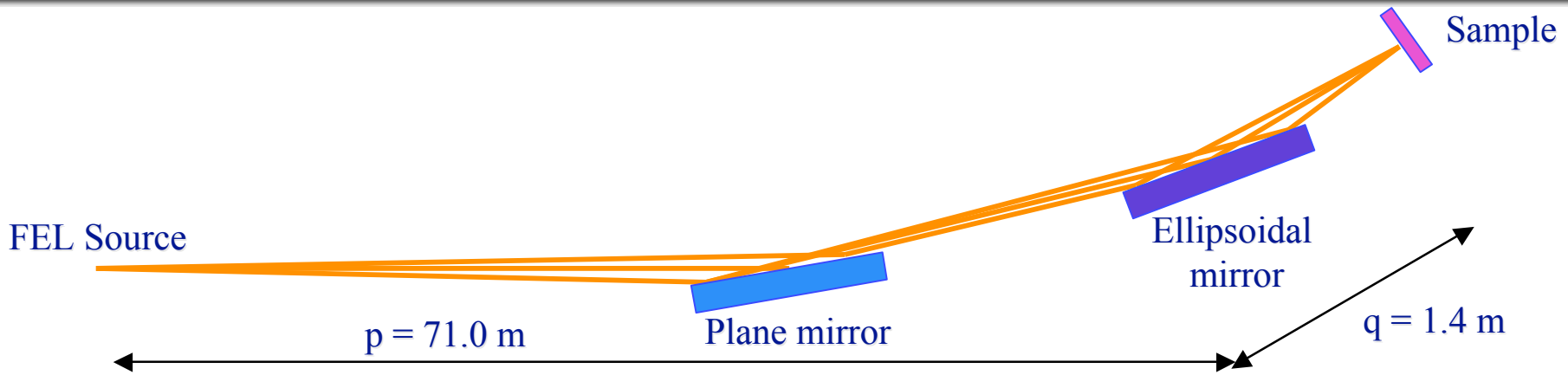
Main TIMEX scientific goals:

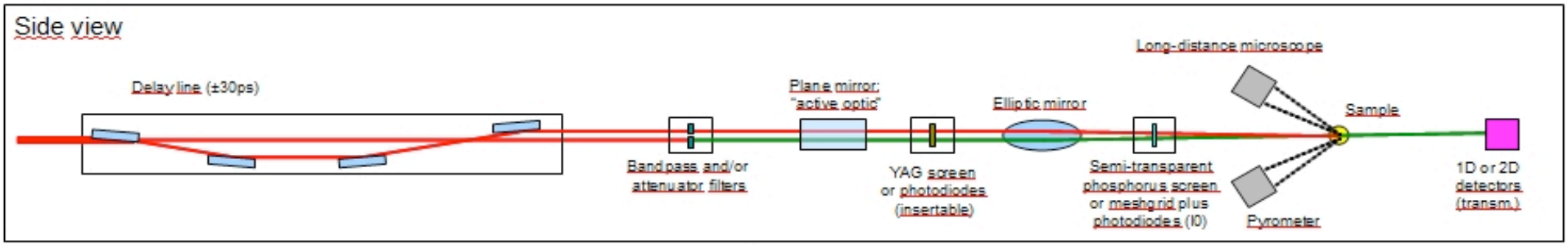
- ultrafast studies (conductance, reflectivity, trasmission, scattering) of warm dense matter (WDM)

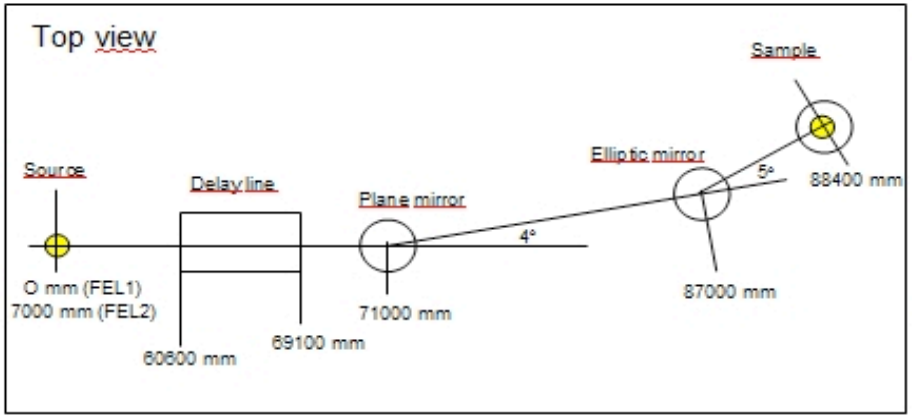
- transitions occurring in stable, metastable and excited states under extreme conditions

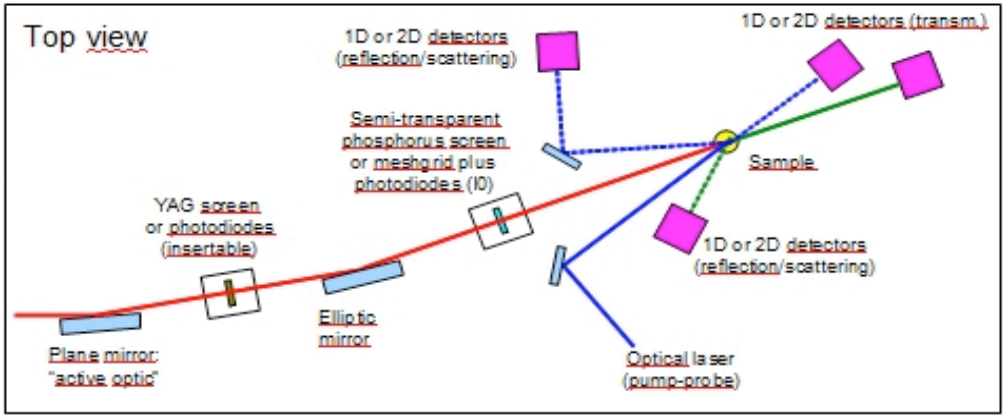


Beamline design

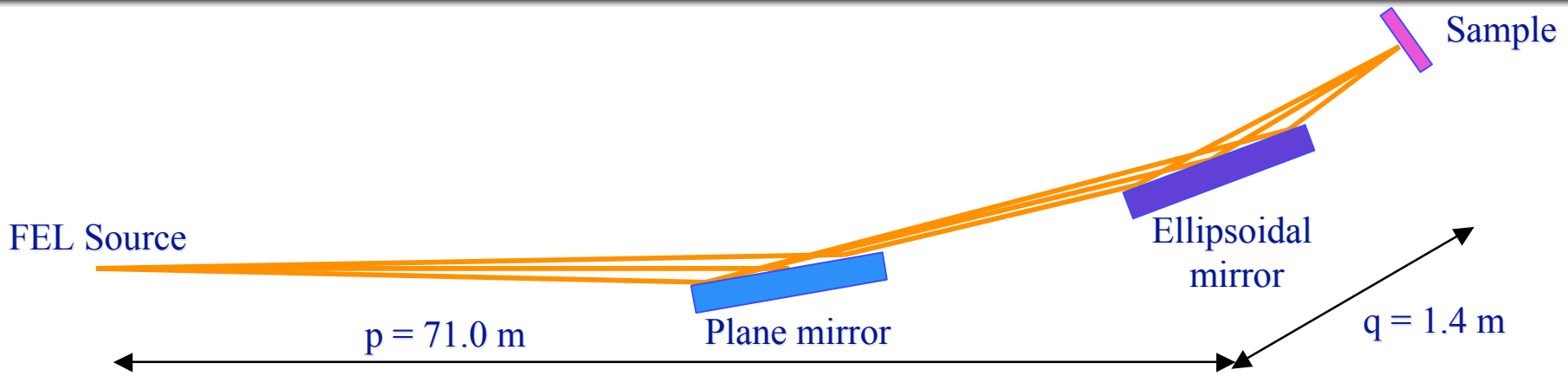








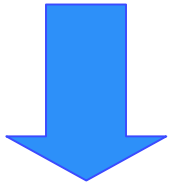
Beamline design



Wavelength (nm)	FEL	Harmonic	Spot size$_{FWHM}$ (μm x μm)	Flux (Ph/pulse)	Fluence W/cm^2
1.7	2	3rd	2.9 x 3.0	$5.9 \cdot 10^{8}$	$3.1 \cdot 10^{13}$
3.3	2	3rd	3.0 x 3.1	$3.4 \cdot 10^{9}$	$8.1 \cdot 10^{13}$
4	2	1st	3.1 x 3.1	$1.9 \cdot 10^{11}$	$3.7 \cdot 10^{15}$
6.7	1	3rd	4.8 x 5.1	$2.2 \cdot 10^{10}$	$8.5 \cdot 10^{13}$
10	2	1st	2.7 x 2.7	$6.9 \cdot 10^{12}$	$6.1 \cdot 10^{16}$
20	2	1st	2.7 x 2.7	$2.8 \cdot 10^{13}$	$1.2 \cdot 10^{17}$
20	1	1st	5.1 x 5.1	$6.5 \cdot 10^{12}$	$6.2 \cdot 10^{15}$
60	1	1st	6.2 x 5.2	$5.1 \cdot 10^{13}$	$1.3 \cdot 10^{16}$
100	1	1st	6.2 x 6.1	$1.0 \cdot 10^{14}$	$1.5 \cdot 10^{16}$

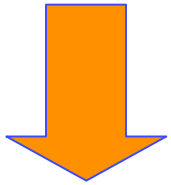
Beam-shaping

The natural spatial Gaussian distribution of the focused photon beam is not suitable for the TIMEX porpuses



Need for a versatile beam-shaping system

In the VUV/soft X-ray range the beam-shaping is possible by using reflective elements with peculiar shapes

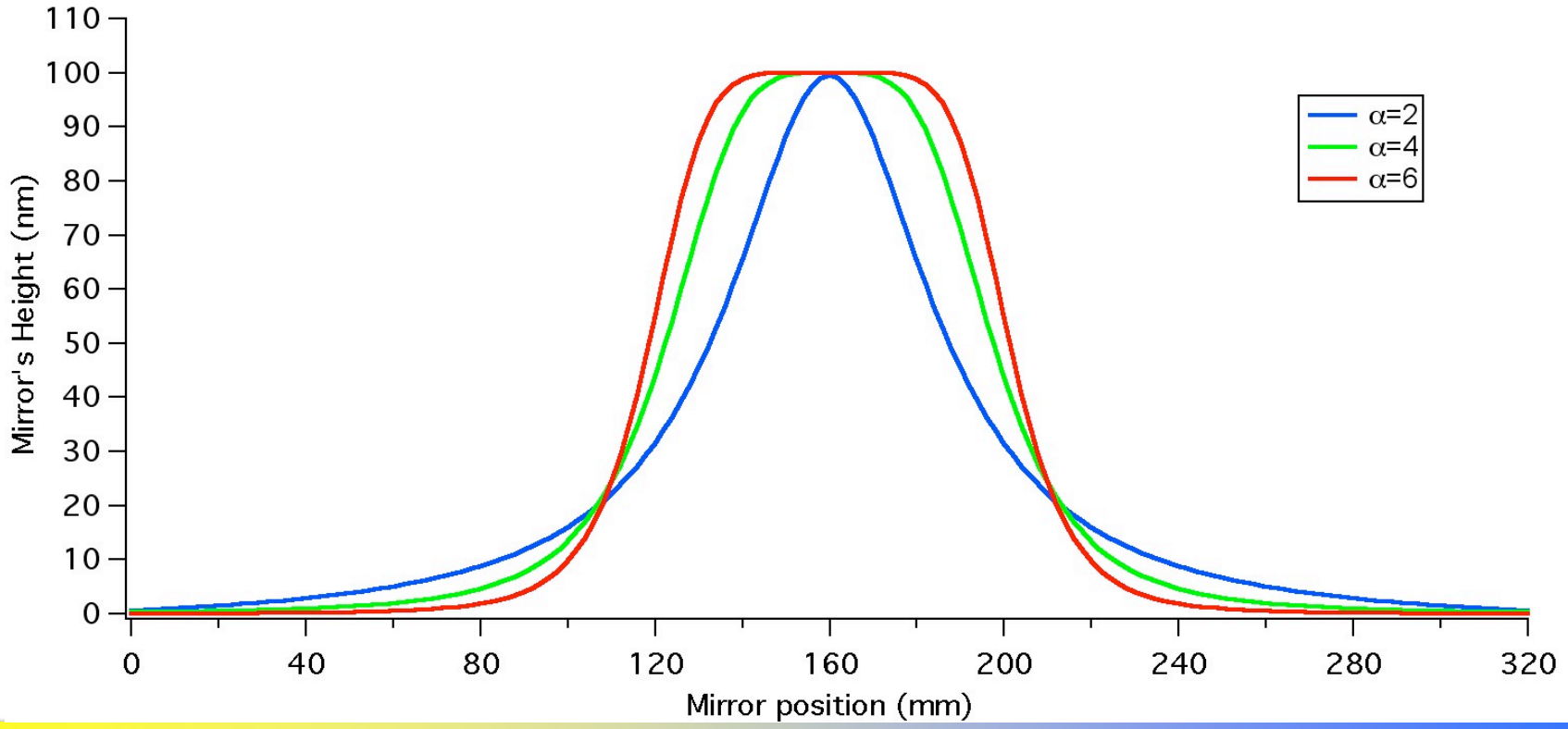


Use the plane mirror as an active mirror

"Lorentzian-like" mirror's shape

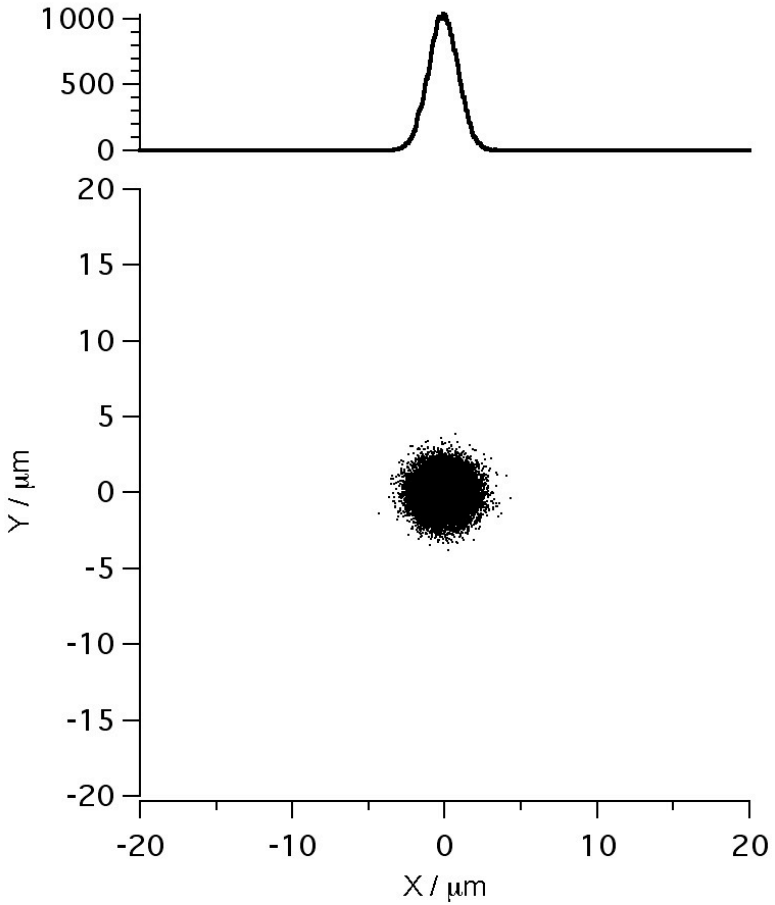
$$L_\alpha(A,\gamma,x_0) = \frac{A\gamma^{\alpha-1}}{\pi\left[(x-x_0)^\alpha + \gamma^\alpha\right]}$$

A=amplitude
x_0=center of simmetry
γ=scale parameter (HWHM)
α=parameter (even number)



Some ray-tracing results

Simulations made for a 5nm radiation with divergence of 7.5 μrad

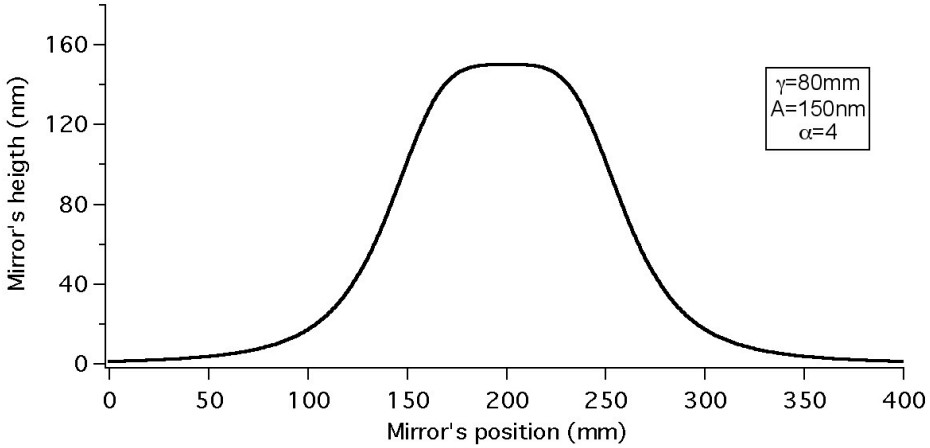


Basic beamline configuration

Expected spot at focus using the plane mirror

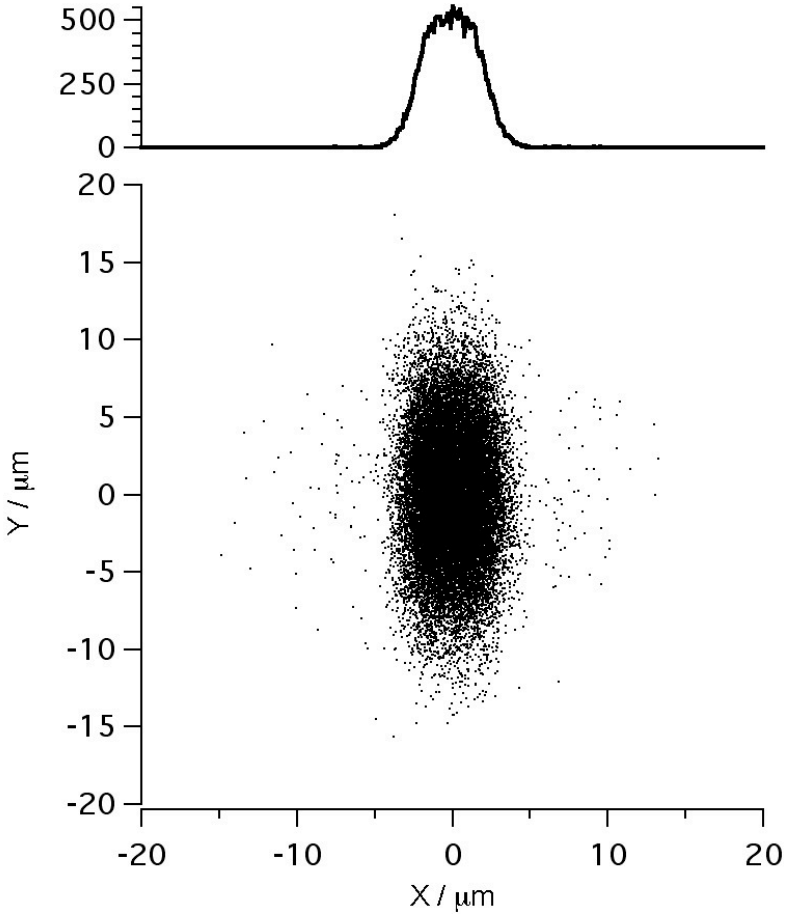
Some ray-tracing results

Almost **Flat-top** spot for irradiating the sample uniformly

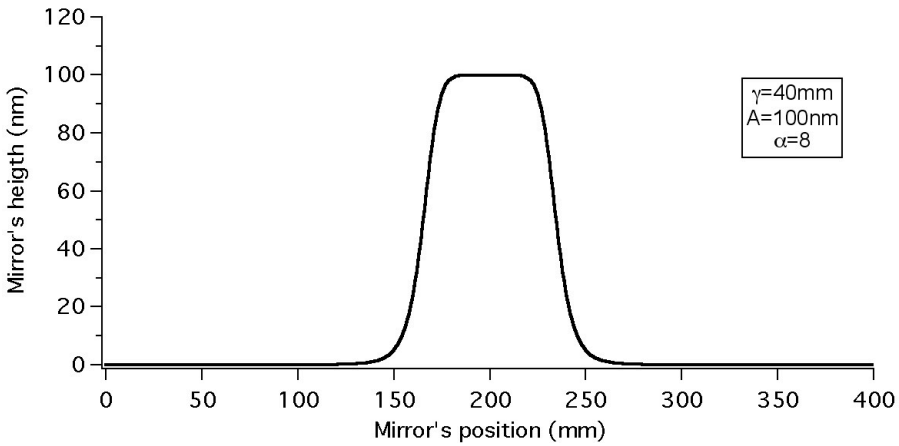


γ=80 mm, α=4 , A=150 nm

Expected spot at focus

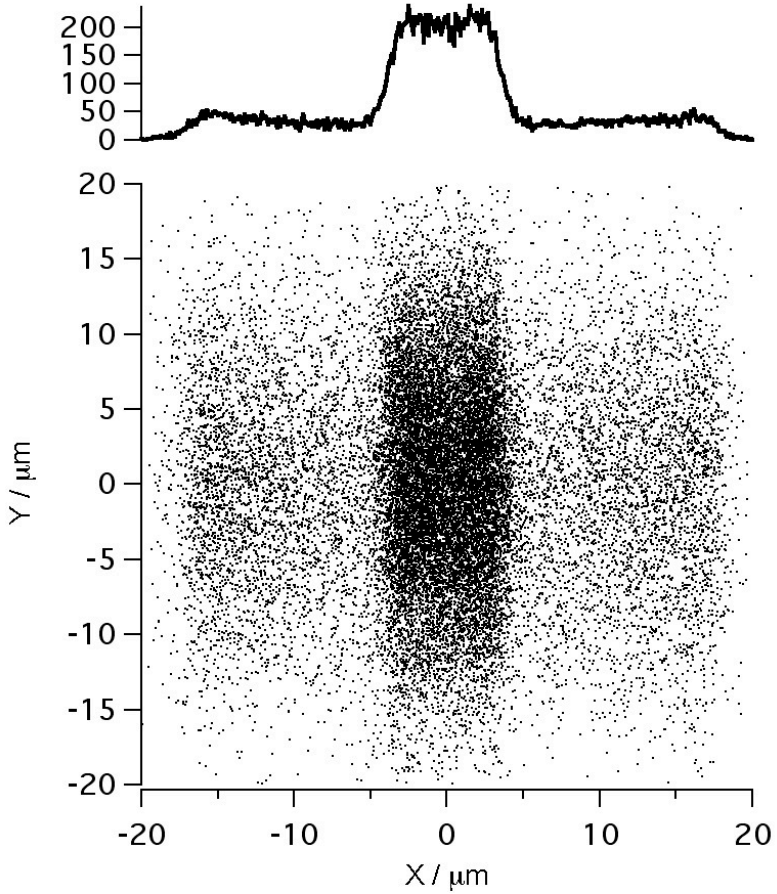


Flat-top spot with tales for irradiating the sample and probing the temperature with a pyrometer

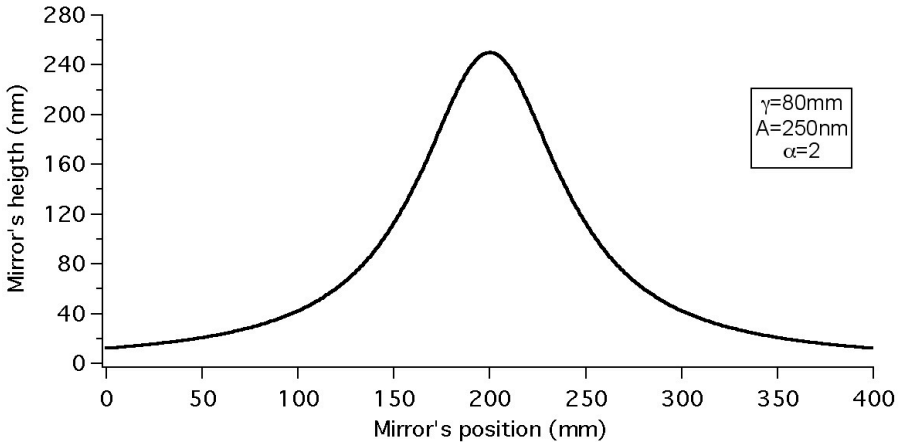


γ=40 mm, α=8 , A=100 nm

Expected spot at focus

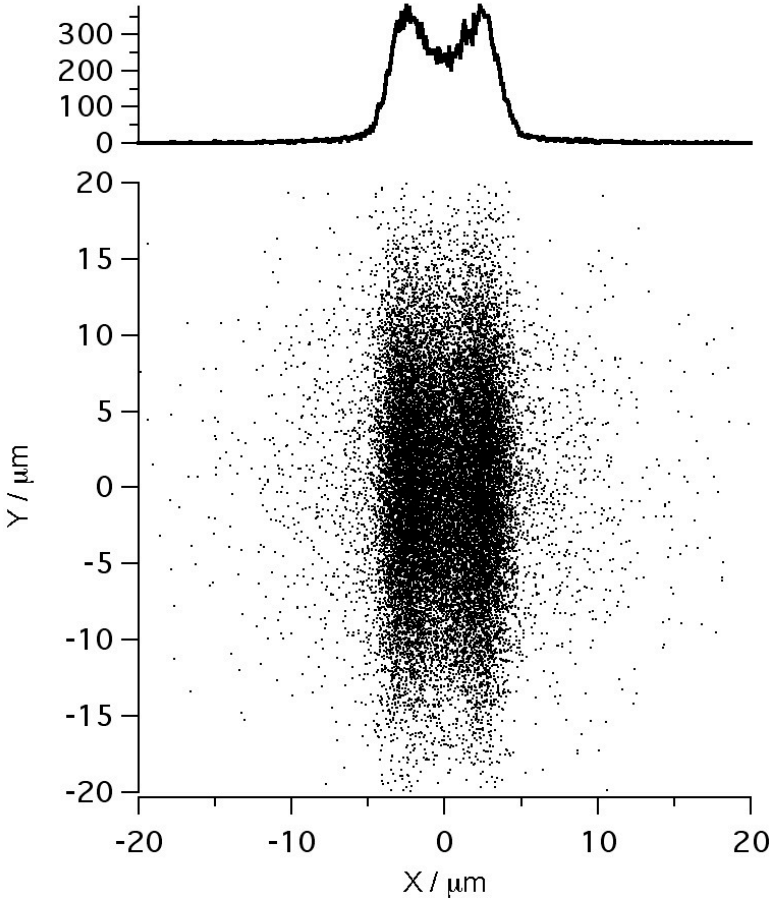


Double peak spot as pre-pump for compressing the sample due to superposition of shock waves



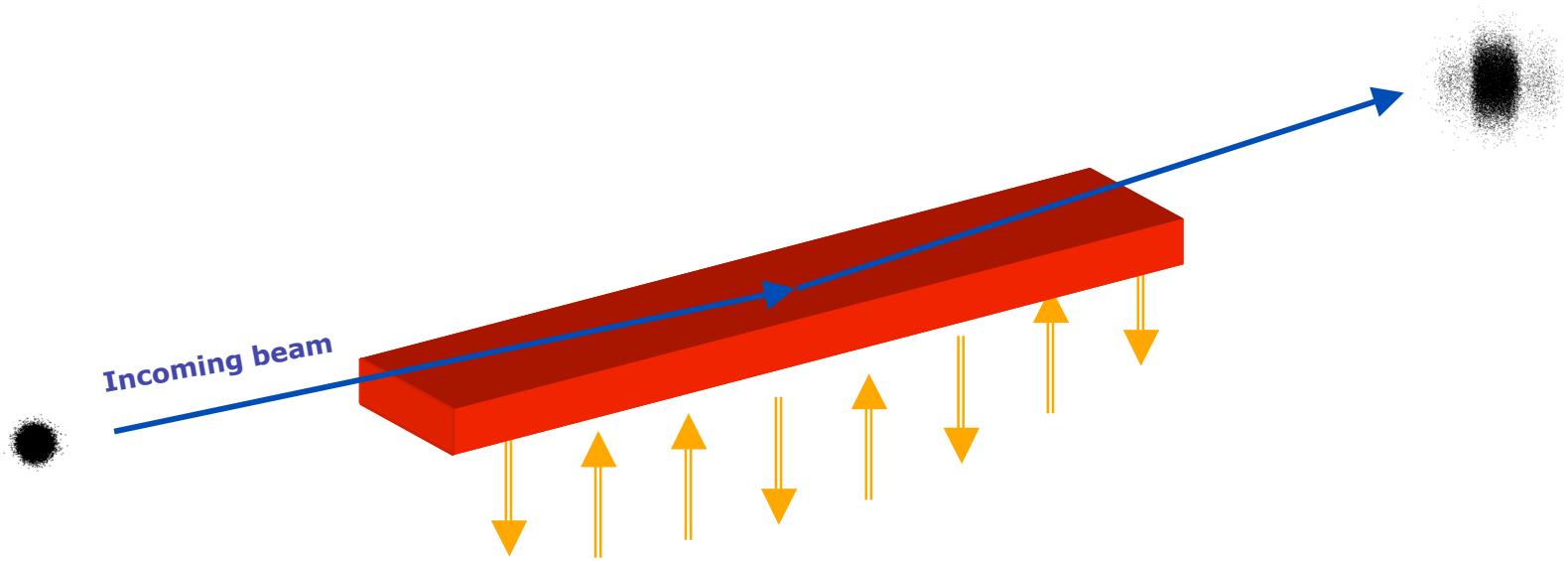
γ=80 mm, α=2 , A=250 nm

Expected spot at focus



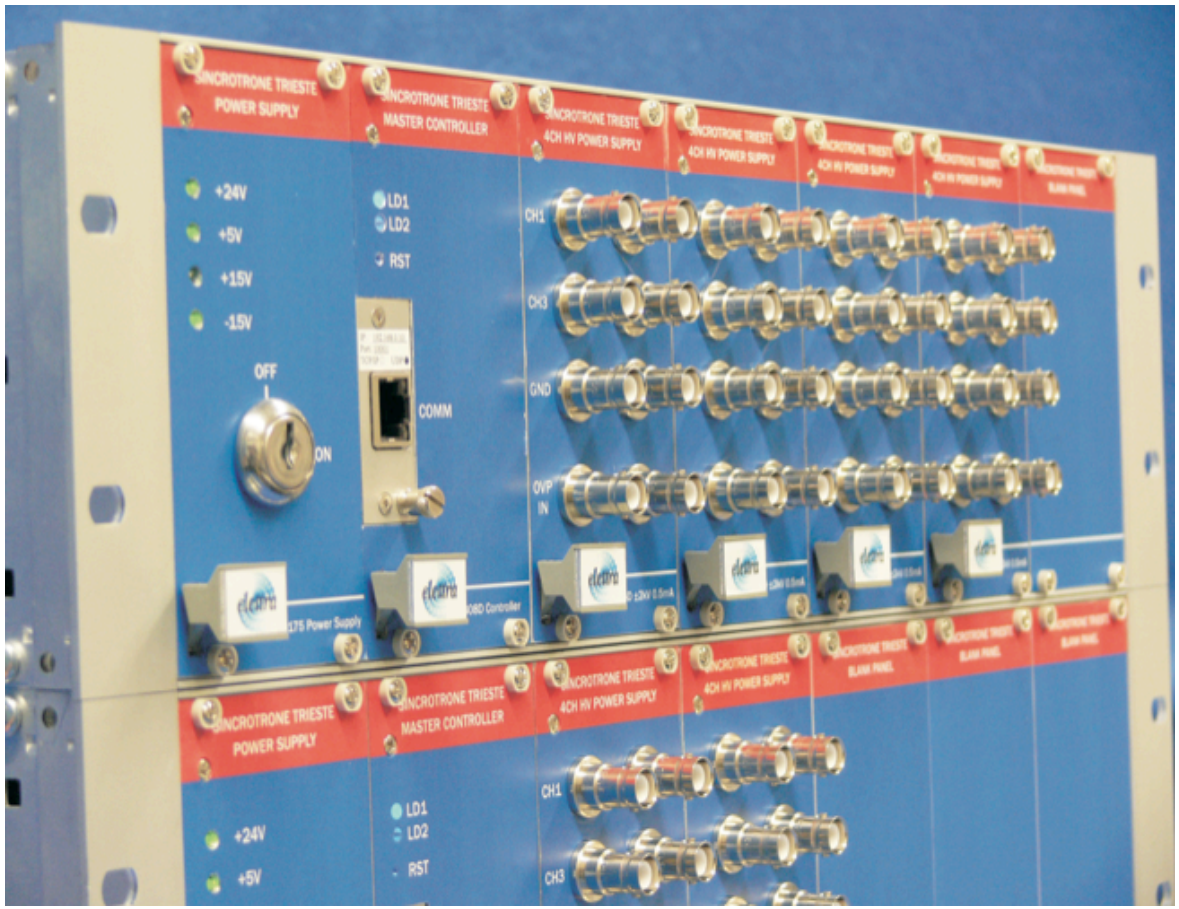
The active mirror

The sides of the mirror are blocked and the shape is changed due to the effect of the applied forces below the substrate



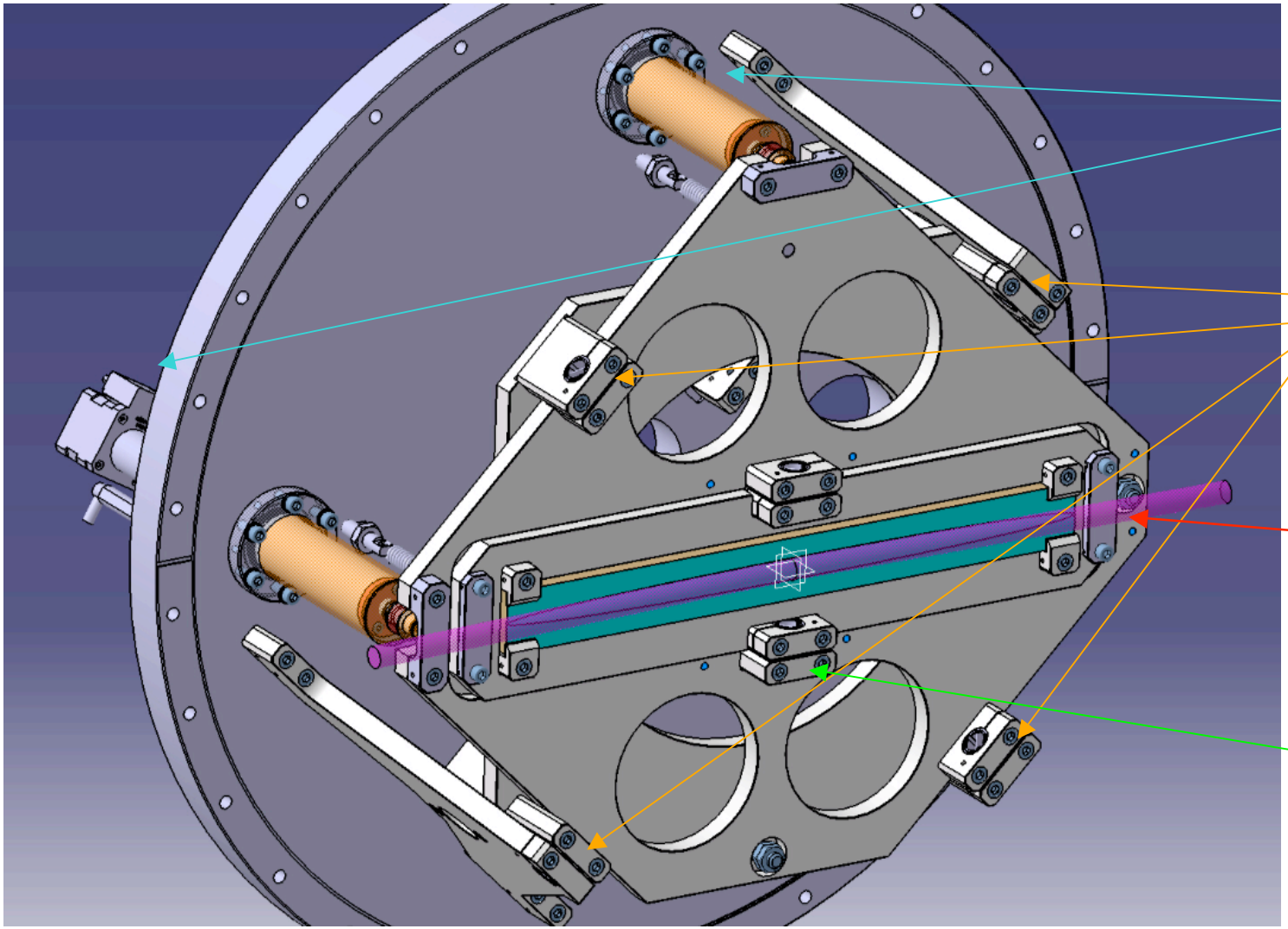
15 Piezo-actuators glued on the bottom of the mirror's substrate

HVPS MAS-TER



The piezo-actuators
are controlled with
an in-house developed
high-voltage power supply
HVPS MAS-TER
(for info please refer to M. Cautero)

Mirror joystick inside the switching chamber



Standard optics actuator modified (0.625 µm/step)

Gimbals mount (2.5 µrad/step)

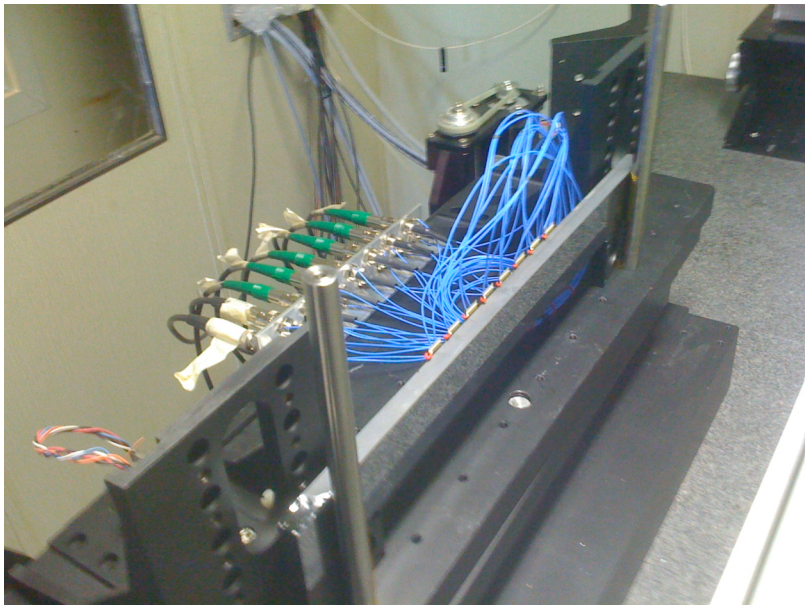
Piezo actuator (fine pitch) (0.11 µm/volt)

Simple rotation (0.5 µrad/volt)

The prototype

Si substrate
400mm x 40mm x 10mm

8 piezo-actuators
OPT 40mm x12mm x 0.6 mm



Supplier Omega Piezo Technology

The Active Correction Tool (ACT) calculates

- the iteraction matrix for a bimorph mirror with N piezos

Adaptive Correction Tool

Calculate New CORRECTION vector

Input error file

Choose File no file selected

Calculate!

Interaction Matrix infos	SLP_files=6 Pulse=100 Fri May 28 13:03:38 CEST 2010

Calculate New INTERACTION MATRIX

Number of Pulse files

Upload Pulse Files

[Close][Howto pdf]

Adaptive Correction Tool

Adaptive Correction Tool

Pulse Files Upload

Remember to upload PULSE files in the right sequence

1st: no pulse on any electrode; 2nd: pulse on first electrode; 3rd: pulse on first & second electrode; ... ; (N+1)th: pulse on ALL n electrodes of the mirror

Shape [00..00] Choose File no file selected

Shape [10..00] Choose File no file selected

Shape [11..00] Choose File no file selected

. . . . Choose File no file selected

Shape [11..10] Choose File no file selected

Shape [11..11] Choose File no file selected

Pulse Voltage (Volt):

Calc Matrix

[Back] [Close]

The Active Correction Tool (ACT) calculates

- the iteraction matrix for a bimorph mirror with N piezos

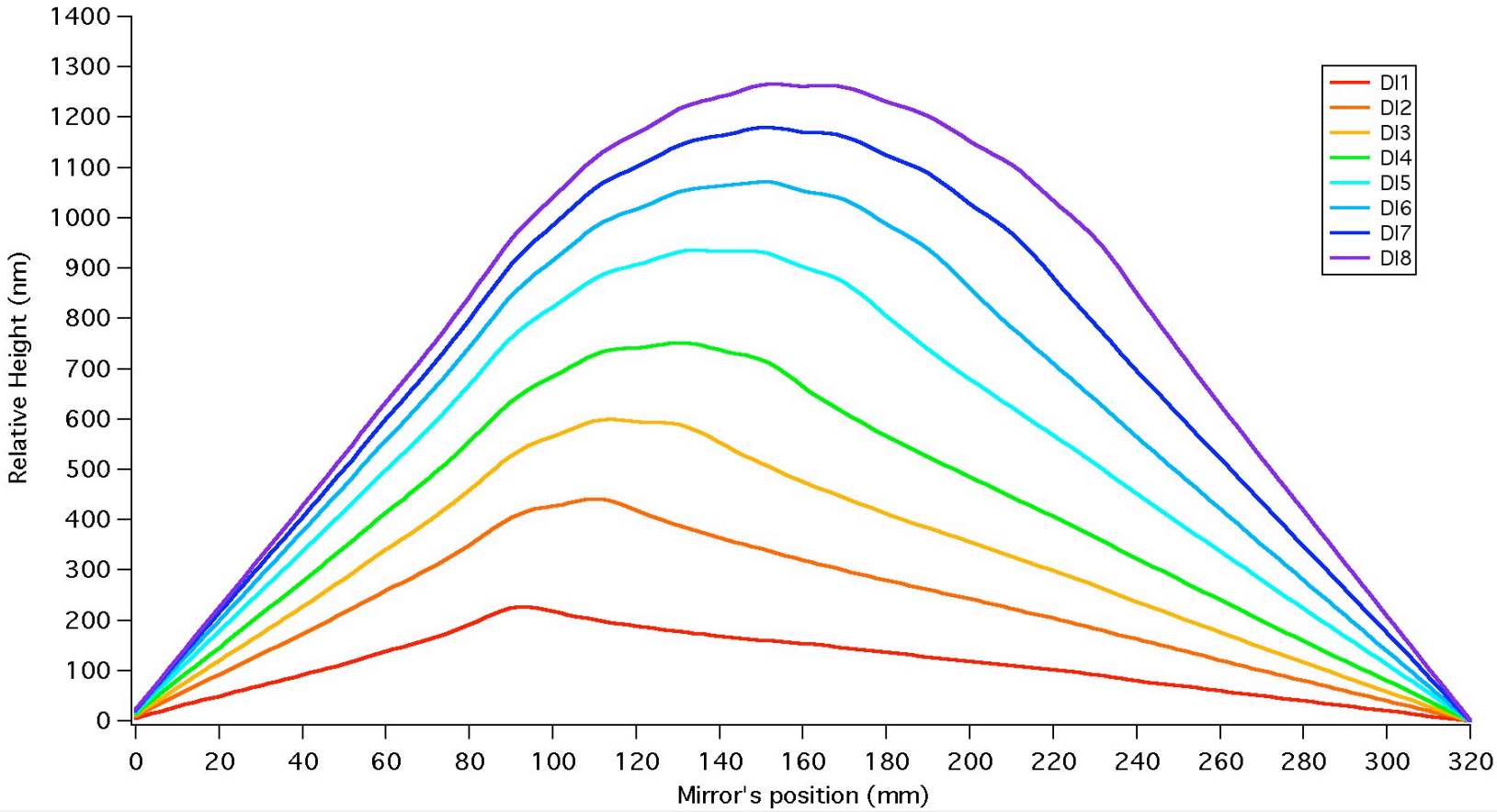
-the voltage to apply to the piezo-actuators in order to obtain the desired mirror profile

Adaptive Correction Tool

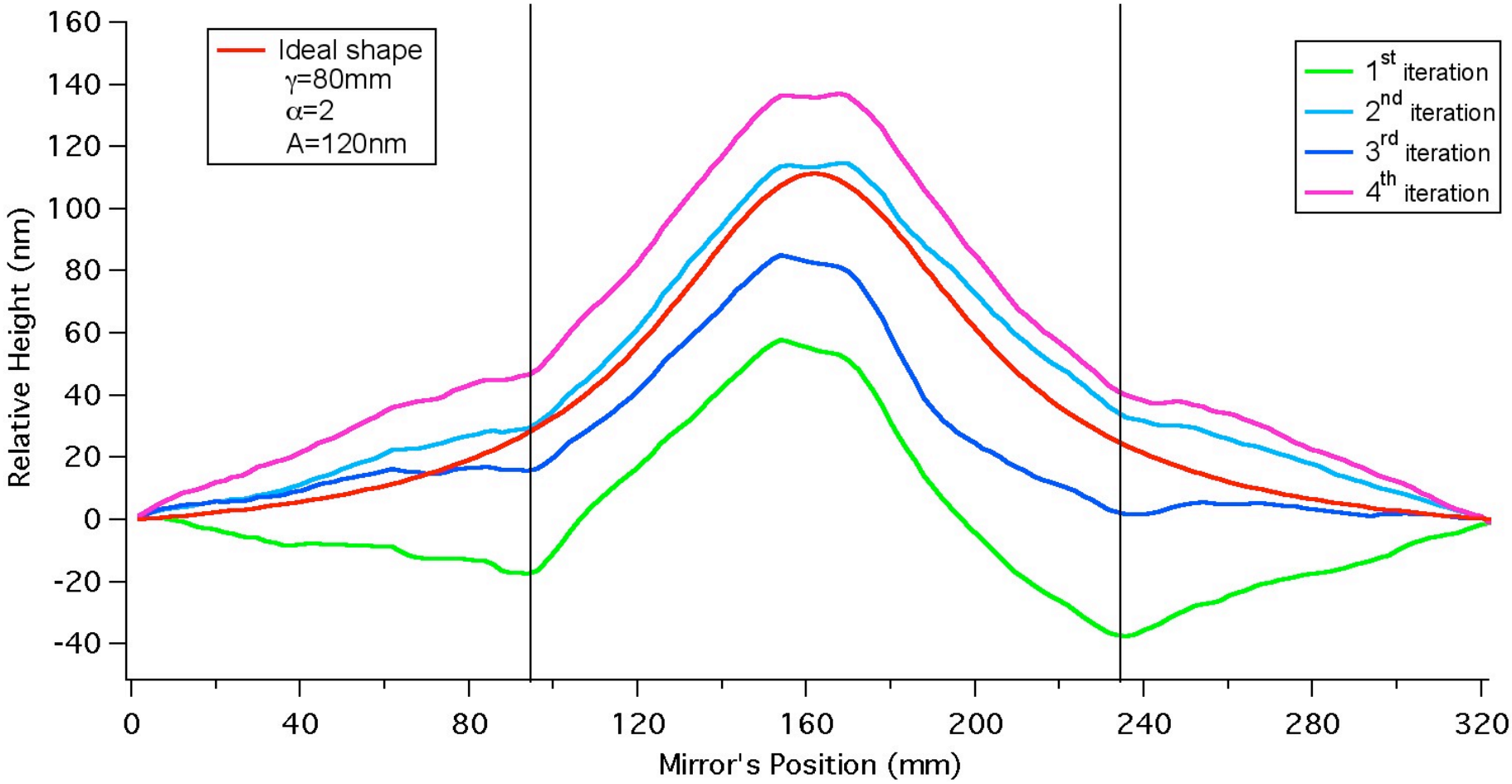
CH.	Voltage Correction
00	+45.1 V
01	+16.6 V
02	-86.9 V
03	+40.9 V
04	+43.7 V

[Back] - [Close]

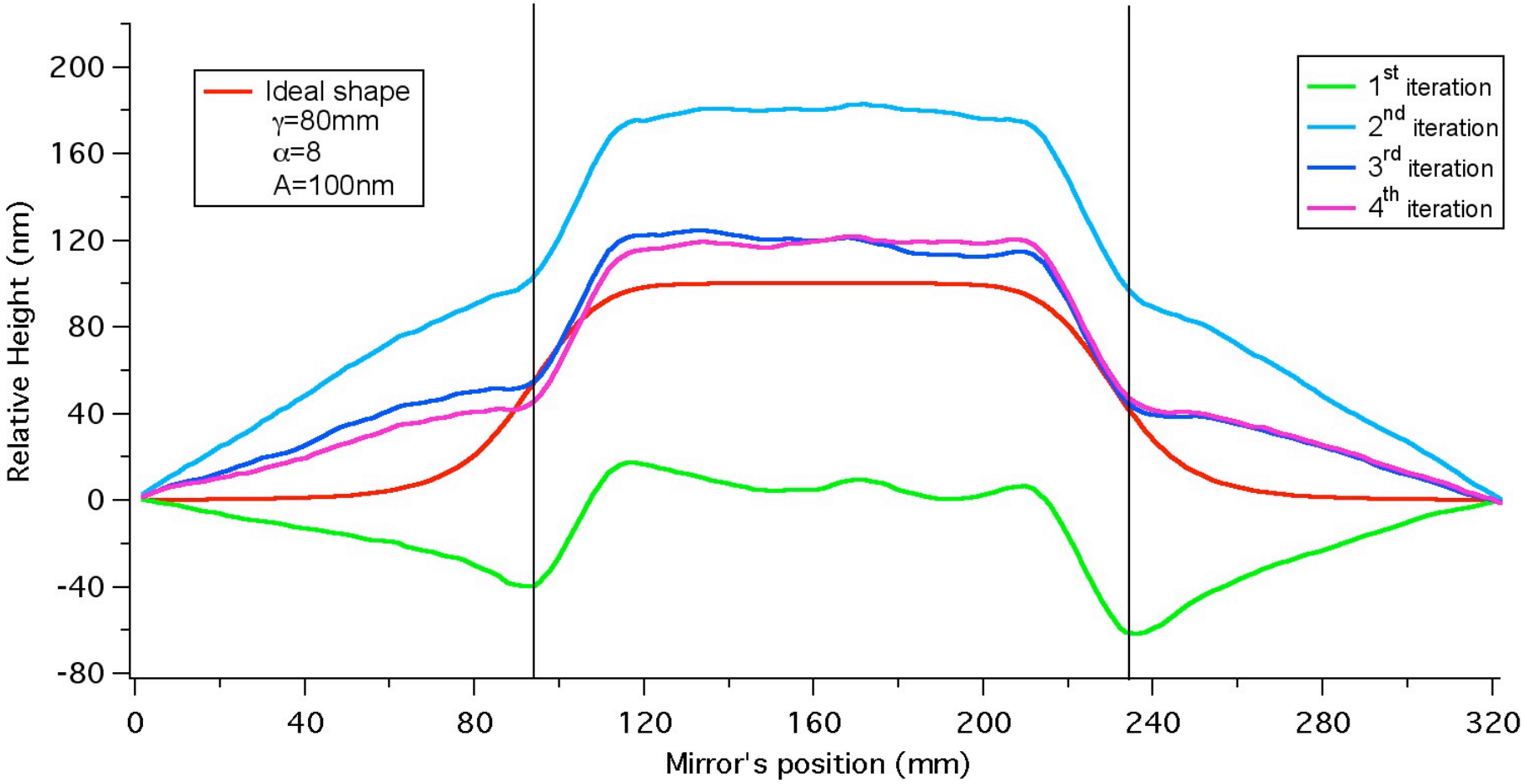
Example of calibration curves for the calculation of the iteration matrix with the ACT



LTP measurement results



LTP measurement results



Within the end of May the final active optic mirror system will be mounted and tested with LTP

Wavefront propagation simulations with FOCUS

Ray tracing simulations to figure out the shape needed to correct the effect of the slope errors in the previous/follow mirrors

TIMEX beamline will be installed within end of June 2011

Thank you for your attention!

Acknowledgments

F. Bencivenga, R. Borghes, G. Bortoletto, C. Callegari, M. Cautero, F. Cianciosi, R. Cucini, D. Cocco, F. D'Amico, A. Di Cicco, C. Masciovecchio, E. Principi, R. Sergo, G. Sostero…