Automatic Beamline Alignment at the ESRF
Present status and future perspectives

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ESRF

Automatic beamline alignment at the ESRF: A teamwork

Collaboration within the ESRF:

- Olivier Hignette (the inventor of all algorithms)
- Vicente Rey and Didier Nurizzo (ID 23)
- Elia Chinchio (wavefront and intercorrelation code)
- Jens Meyer (matrox device server)
- Alejandro Homs (ID 22), Laurent Claustre (BM 05) and many more collegaues in the BLISS group

Outline

- What do I mean with “Automatic Beamline Alignment”?
- ESRF present status
- Algorithms
  - The Wavefront analysis method
  - The intercorrelation function
  - KB optics
  - Toroidal mirrors
- ID 23 – a completely automatic beamline
- Future perspectives at the ESRF
- Sharing of software

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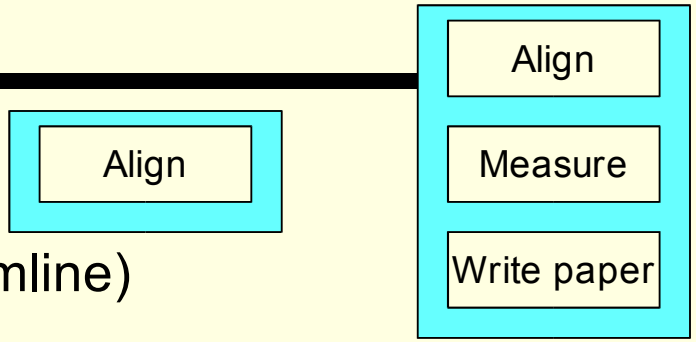
ABA - Automatic Beamline Alignment



All beamline responisbles dream: the “one button beamline”

(Even better – the three button beamline)

Experience learnt at the ESRF:

- ABA algorithms are sharable – i.e. usable on more than one beamline
- ABA sequences much harder to share due to differences in hardware and continuous beamline modifications
- ABA very difficult without detectors in strategic places – must be placed in the design phase of the beamline
- Small area detectors indispensable

“Assisted” beamline alignment

Automatic focusing

A.I. technologies – diagnostic and supervision

ESRF: Status of automatic focusing

ID13, ID19, ID22, ID30, BM05	KB	AF is essential to obtain small spot size
ID03, ID14, ID23, ID24, ID26, ID29	Bender or Toroidal Mirror	Automation in progress
ID10B ID18/22, ID28, ID16,	Bender or KB	Manual focusing
ID08, ID11	Bender or KB	Not commissioned yet, interest in AF

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ABA Algorithms - Wave-front Optimization

A linear procedure derived from adaptive optics techniques:

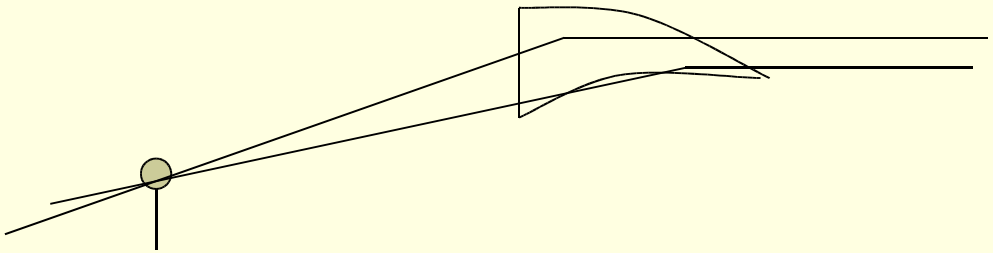
- Acquire the nominal wave-front
- Identify the system by sending a small displacement on each actuator, acquire wave-front after each displacement
- Store the differential metrology
- Build the interaction matrix H
- The correction vector C to be sent to all the actuators is

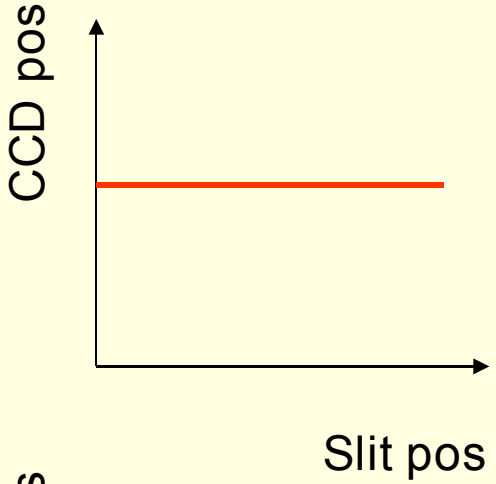
$$C = \left(H^T H\right)^{-1} H^T Y$$

Purely geometrical – the intensity information is not used.

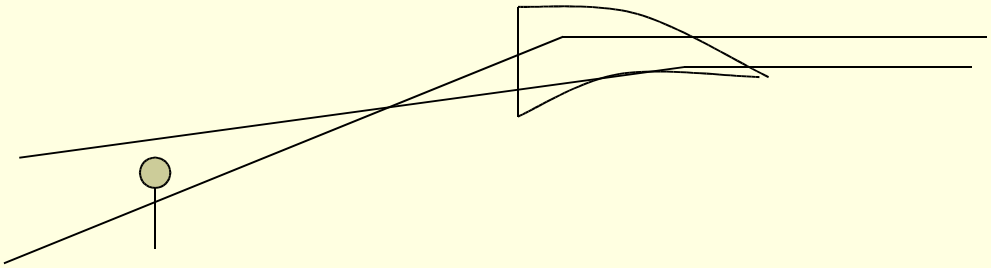
Example 1 – KB mirror

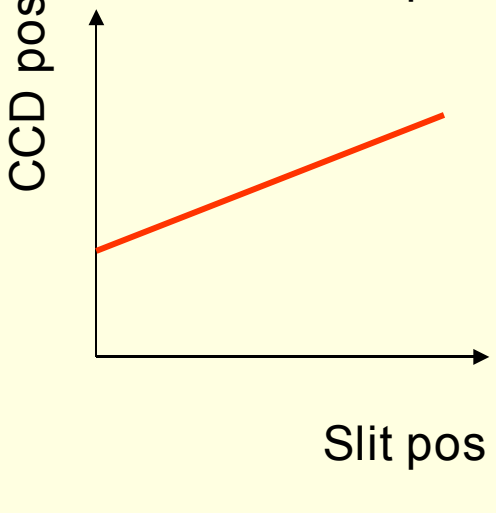
Well focused:





Unfocused:





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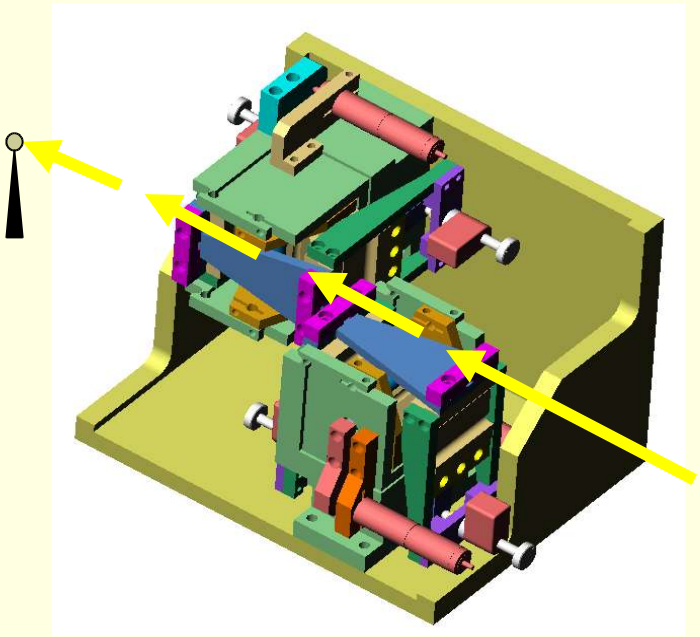
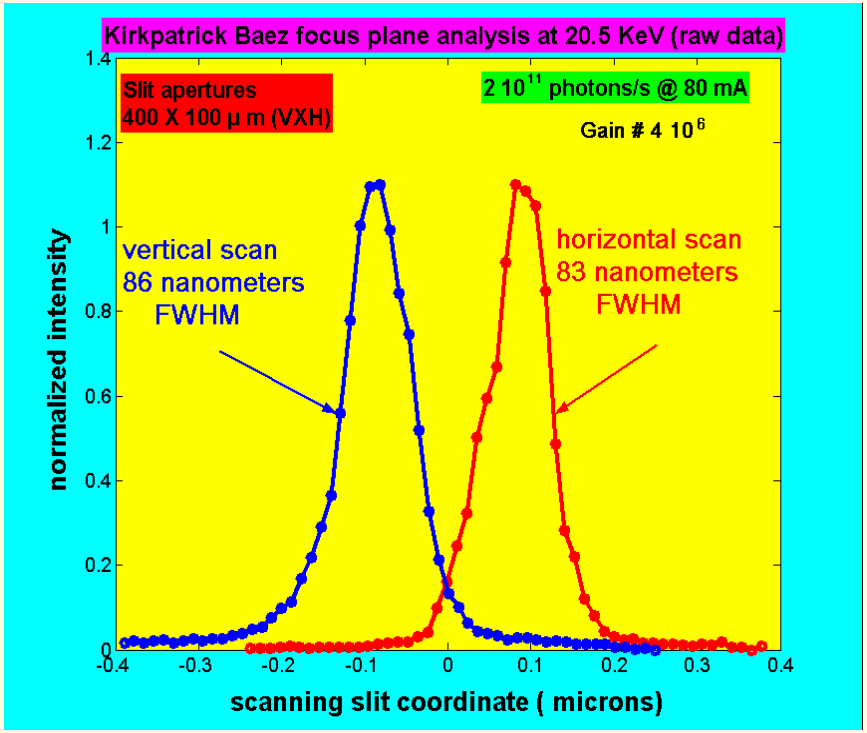
ID19: Submicron focusing KB system





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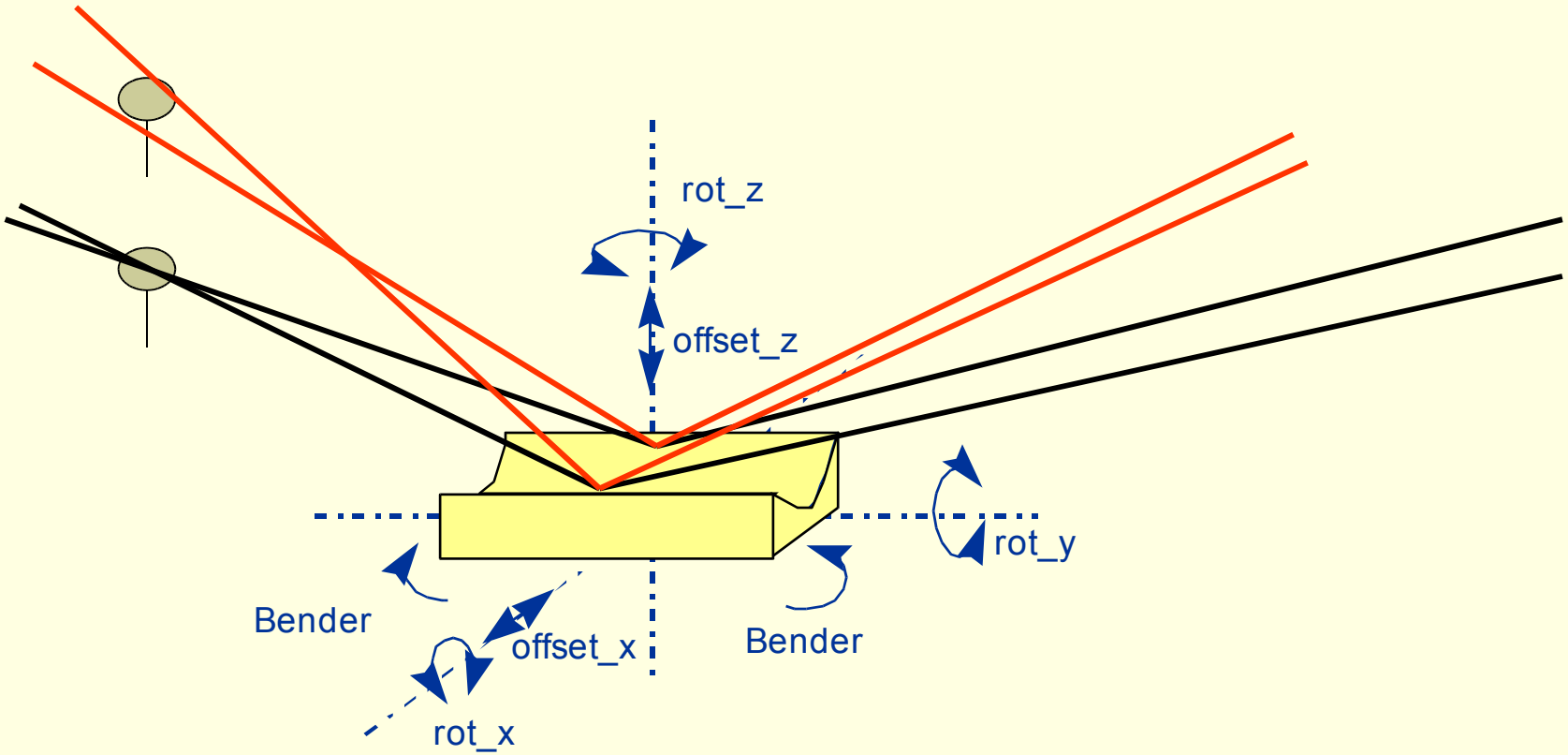
Example 2 – toroid shaped mirror



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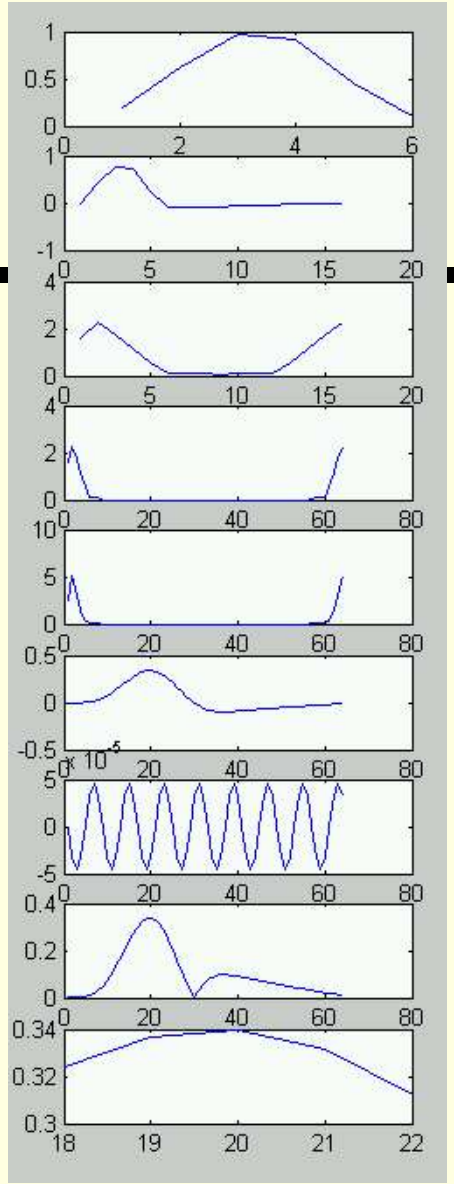
ABA Algorithms: Intercorrelation

- The wavefront method need a robust and accurate algorithm for finding the position of the beam on the CCD detector.
- Using the centre of gravity works only up to a certain accuracy, for very small spots it fails.
- Intercorrelation: parabolic regression on a ‘frequency-interpolated’ profile.
- The intercorrelation method has been proved to be both robust and very accurate.
- The intercorrelation method was developed by Olivier Hignette.



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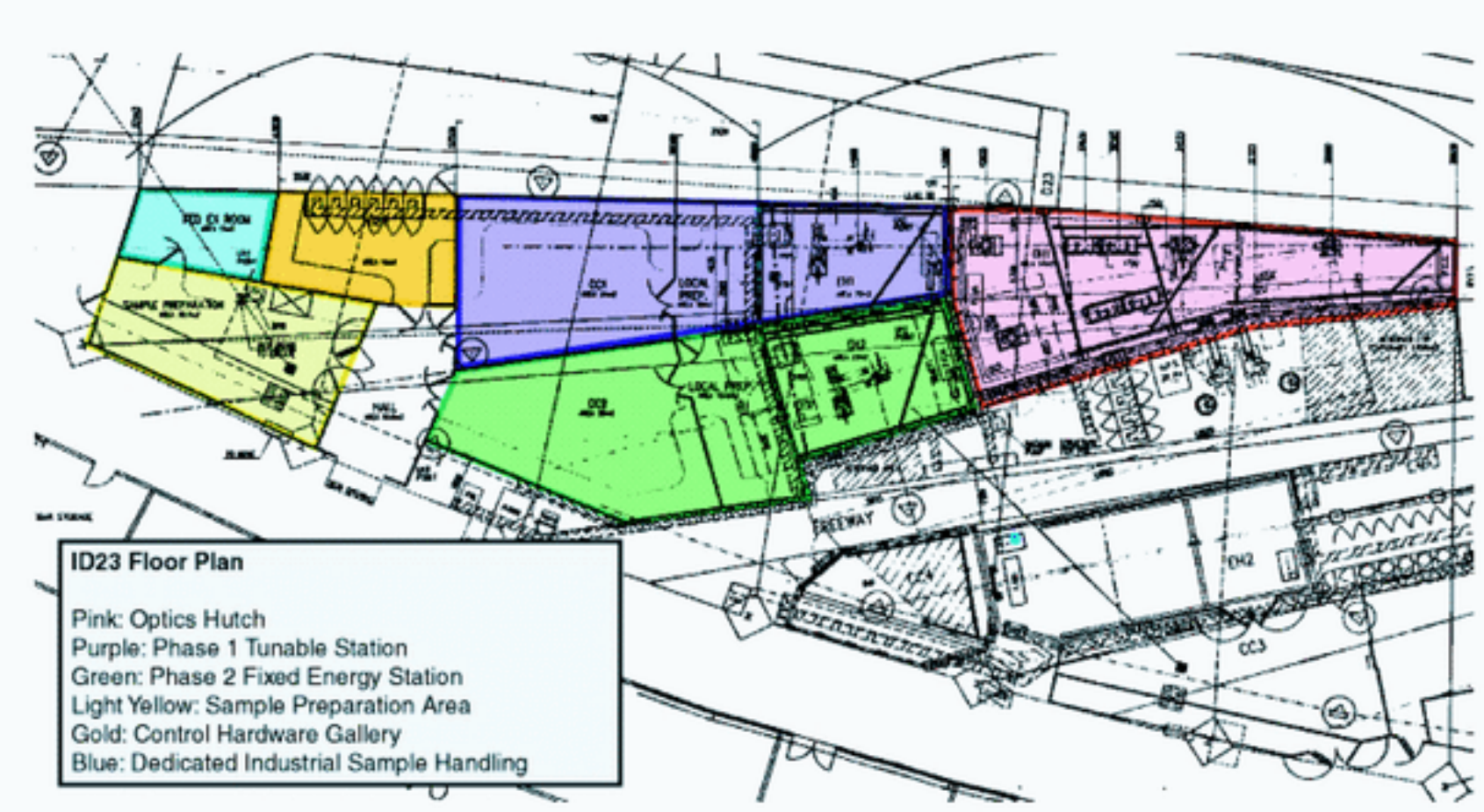
ID 23 – a completely automated PX beamline



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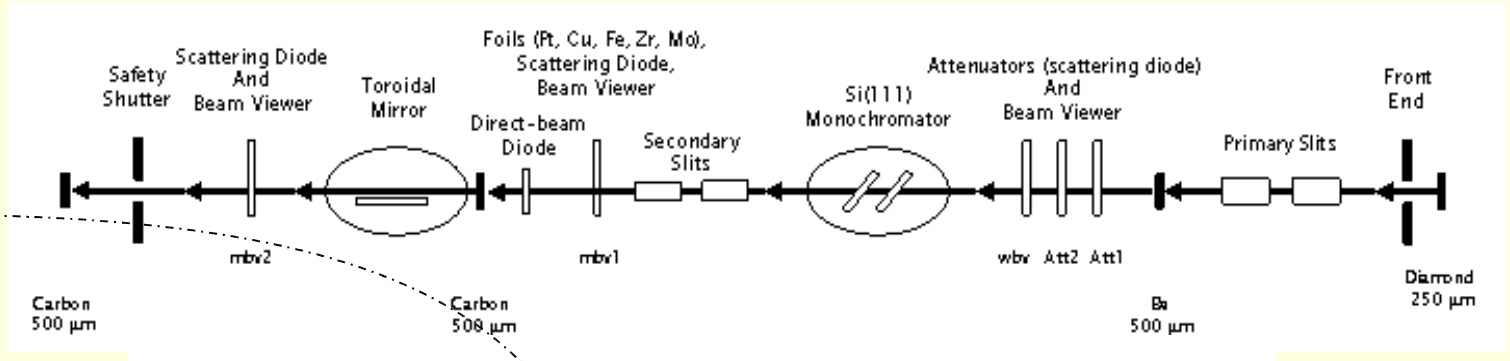
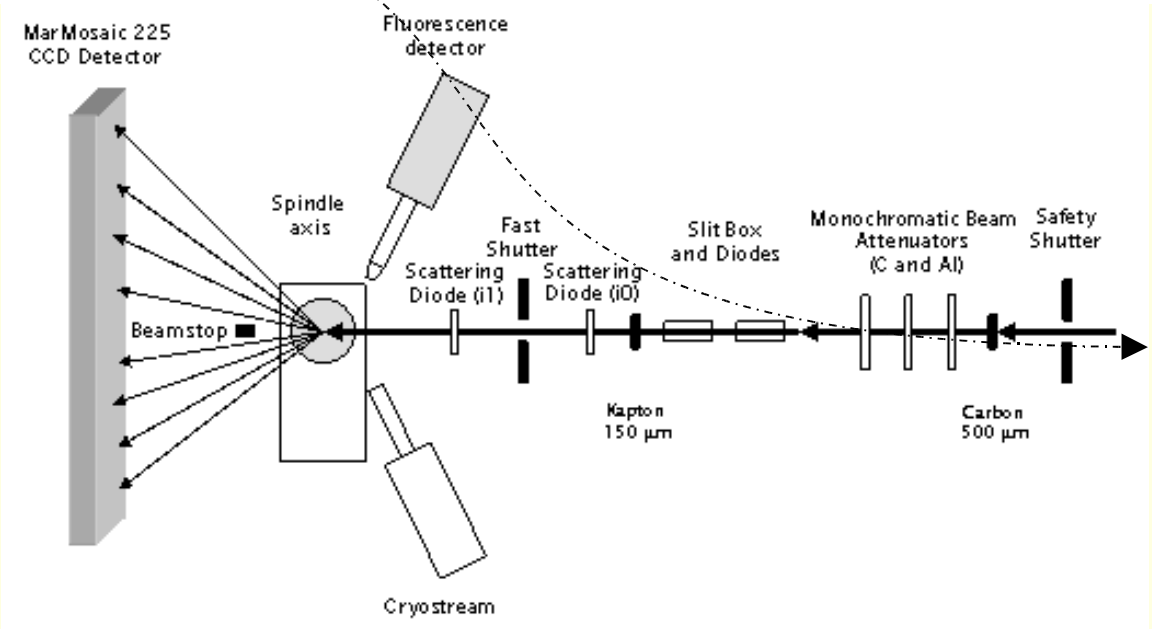
ID 23 Schematic layout





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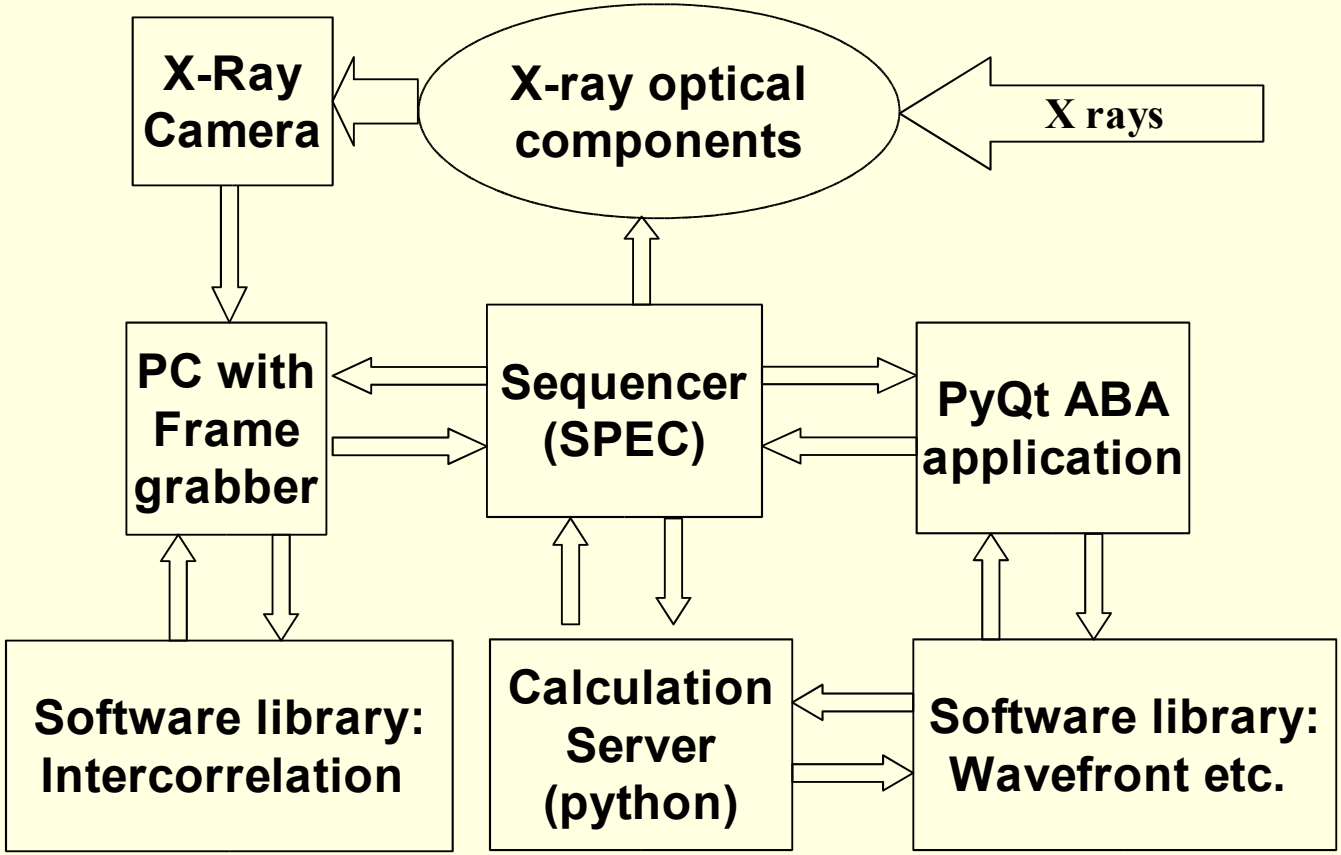
ABA on ID 23 – Status October 2004

The following components are aligned automatically:

- Primary slits
- Monochromator – wavelength optimisation using undulator scan
- Secondary slits
- Mirror pre-alignment
- Experimental table
- Slits in slitbox on experimental table

We are now working on automating the focusing of the toroidal mirror, i.e. optimising the focal spot as function of the mirror tilt, yaw and bending radius.

Implementation



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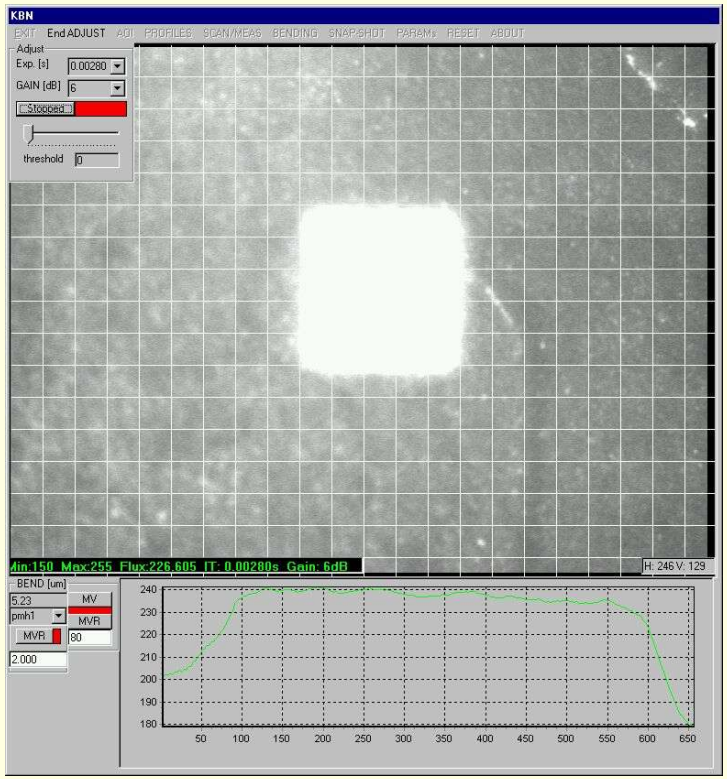
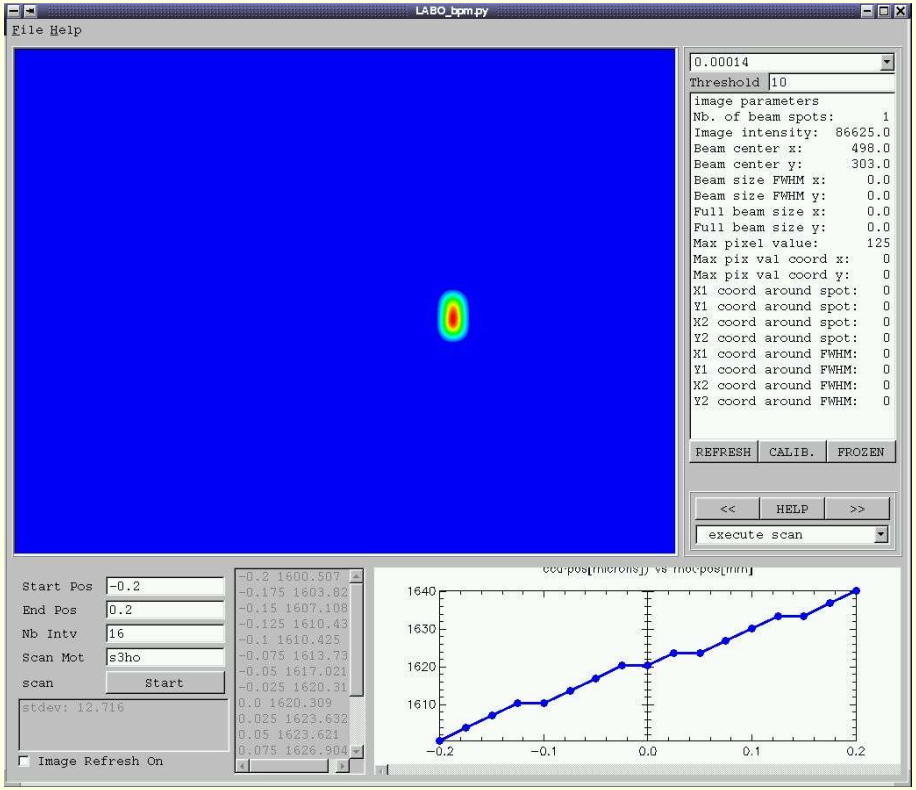
ABA software – VB and PyQt





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ABA at the ESRF: Future perspectives

- Short term goals:
  - ID 23 fully automatic
  - Assisted -> automatic alignment on already equipped beamline
  - PyQt -> BLISS framework application
- Longer term goals:
  - ABA in the beamline control GUI
  - Artificial Intelligence applications for beamlime supervision and diagnostics

Collaborations – How can we share software

Possible levels of collaboration:

- Algorithms: Very easy to share
- Software libraries: Possible to share – we should aim for this!
- Control application: Not easy to share due to facility dependencies.

Collaborations:

BIOXHIT

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