xenocs
Exploring the very small

Instrumentation for SAXS and WAXS

- the Xeuss

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Application Scientist at Xenocs

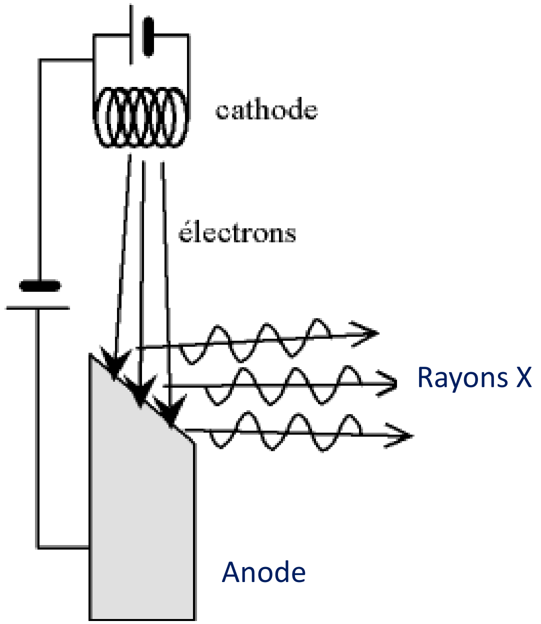
X-ray Instrumentation

- X-ray generation
  - Sealed Tubes, rotating anodes …
  - Synchrotron
- SAXS geometries
  - Pinhole camera
- X-ray Optics and Collimation
  - Crystal monochromators
  - Mirrors
  - Multilayers
- Detectors
  - PIN-diode
  - Image Plate
  - Pixel Detectors
- Xeuss

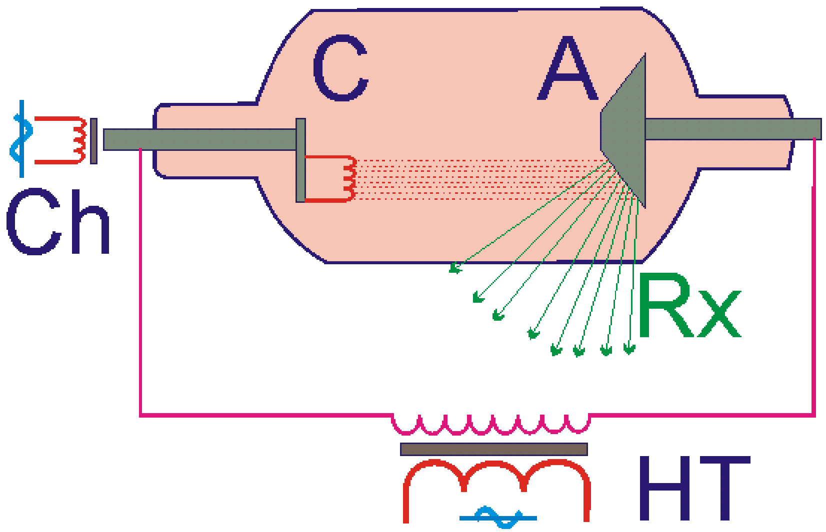
X-Ray sources

Sealed tubes and rotating anodes

- Sealed (fixed anode) tube



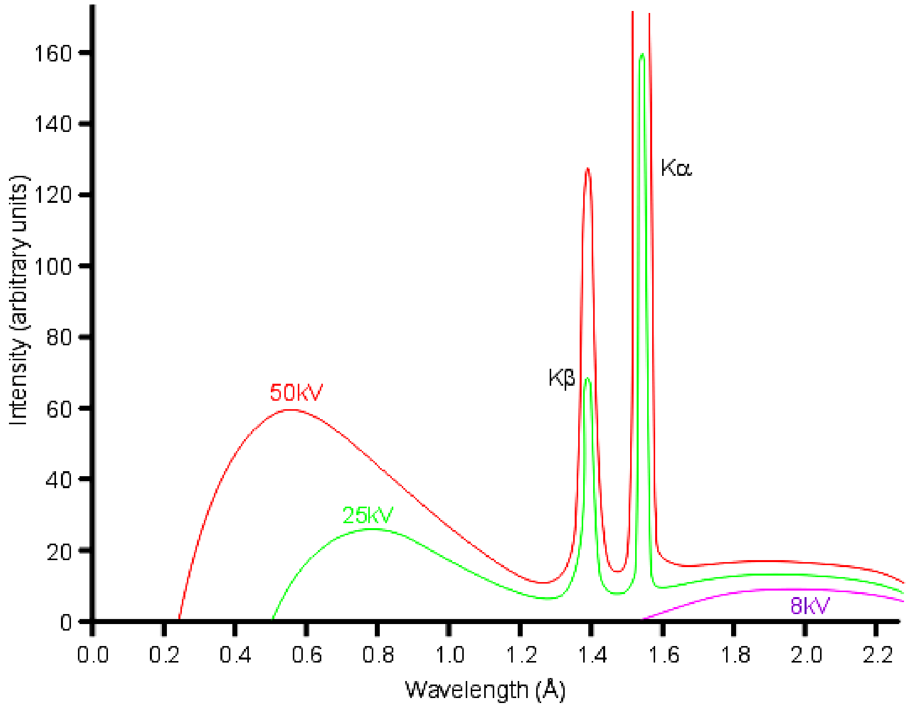
- Rotating anode



X-Ray sources

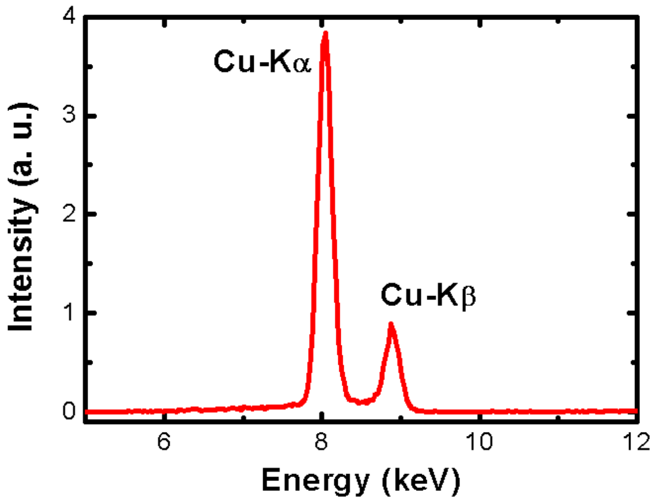
Energy spectrum

- Decelerating the e- from in a random way generate a continuous spectrum : "Bremstrahlung"
- Ionization of some outer edge electron from the target material: specific emission lines



$$E = h\upsilon = \frac{hc}{\lambda}$$

$$hc = 1239.842\,\mathrm{eV}\cdot\mathrm{nm} = 12.39842\,\mathrm{keV}\cdot\text{Å}$$



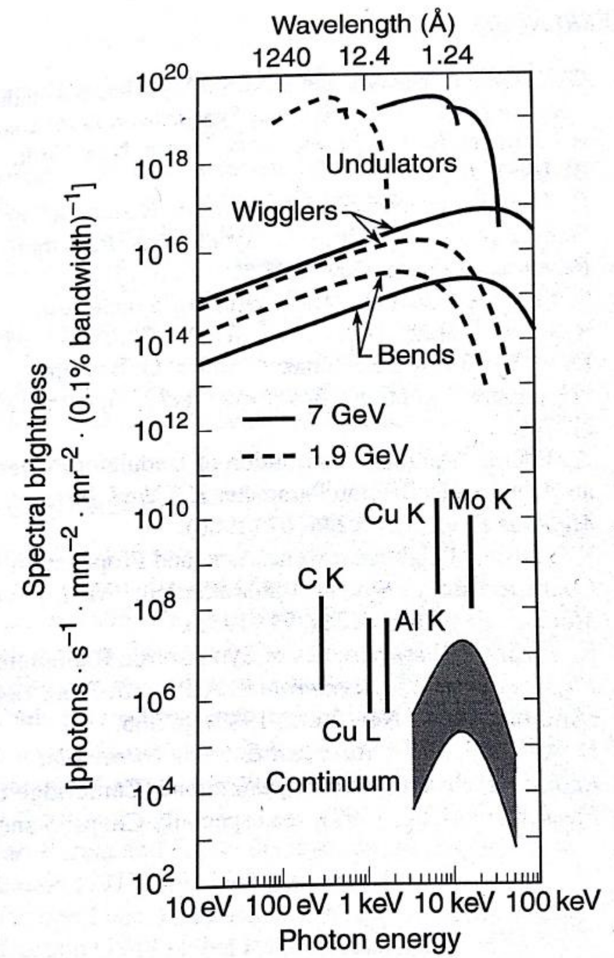
Characterization of sub-micron objects using x-ray light - Pierre Panine - Nanotech2012

X-Ray sources

Synchrotron

Using macroscopic size magnetic field to periodically deflect the course of e- “synchrotrons”

Highly brilliant source (6 to 12 orders magnitude larger than laboratory sources)

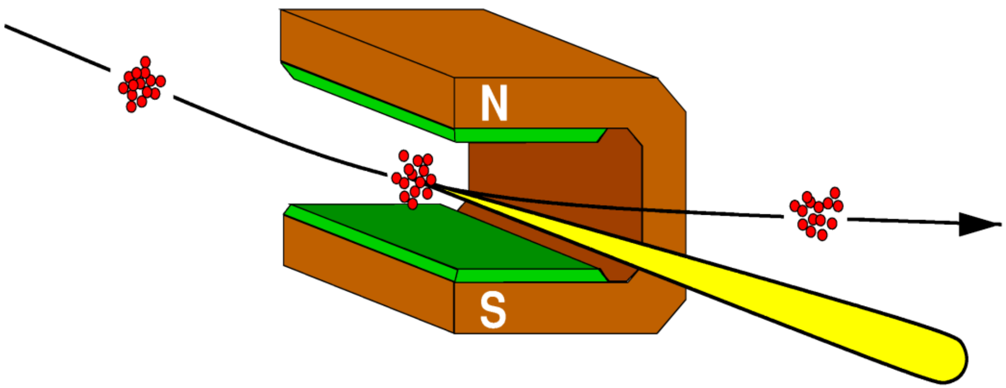


X-Ray Data Booklet. Center for X-Ray Optics, and Advanced Light Source. Lawrence Berkely National Laboratory.

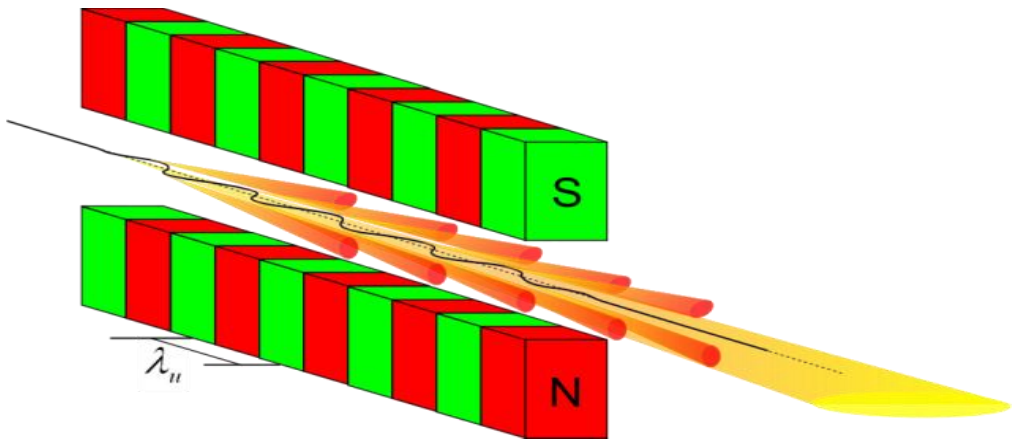
X-Ray sources

Synchrotron

Bending magnet



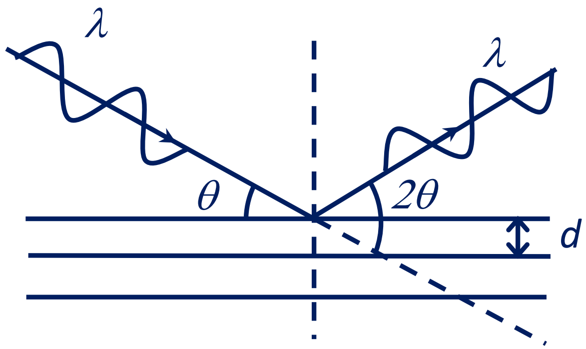
Insertion Device
- Wiggler
- Undulator



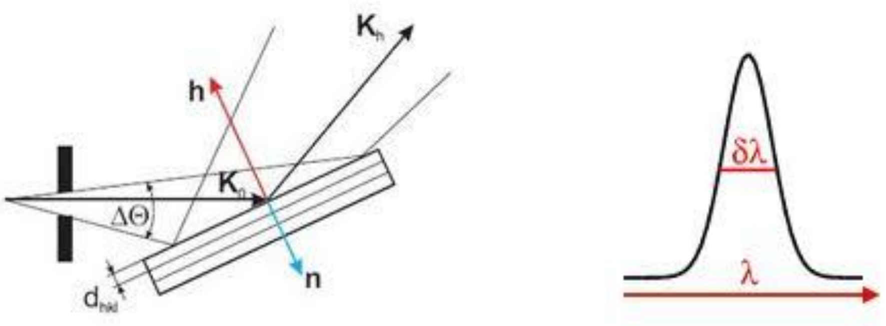
Monochromators

Perfect crystals

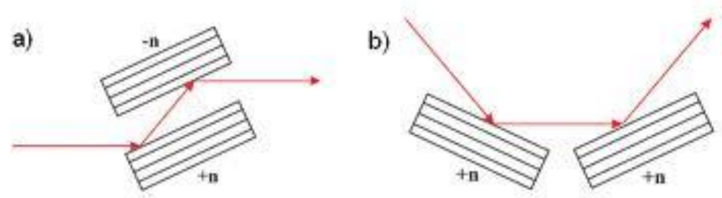
The Bragg's Law for diffraction



$$n\lambda = 2d\sin\theta$$



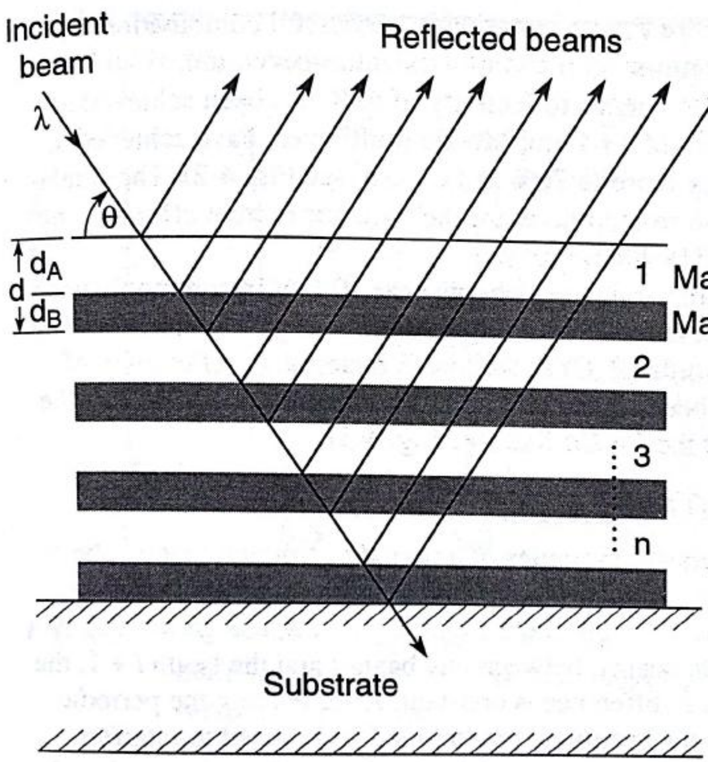
Effect of divergency in spectral purity



Monochromatization by double reflection

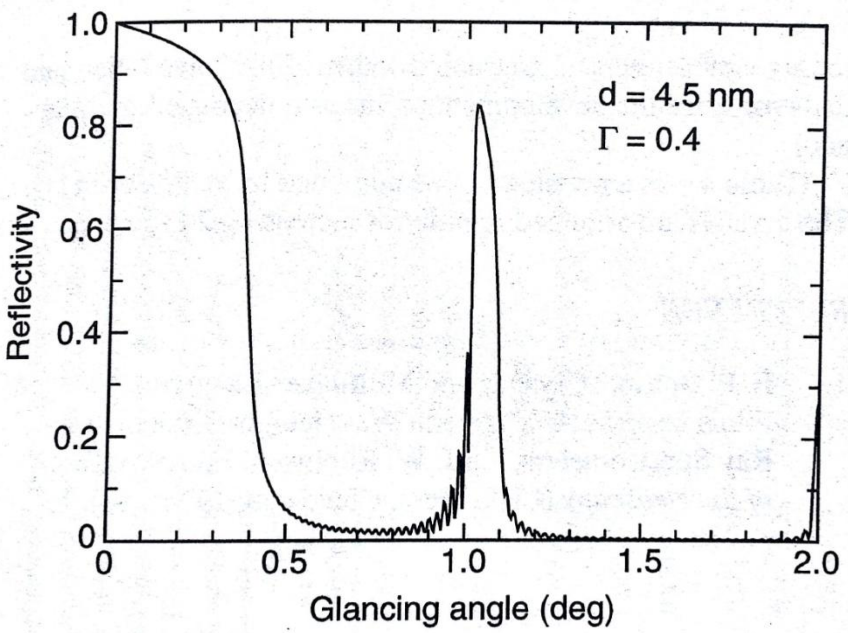
Monochromators

Multilayer mirrors



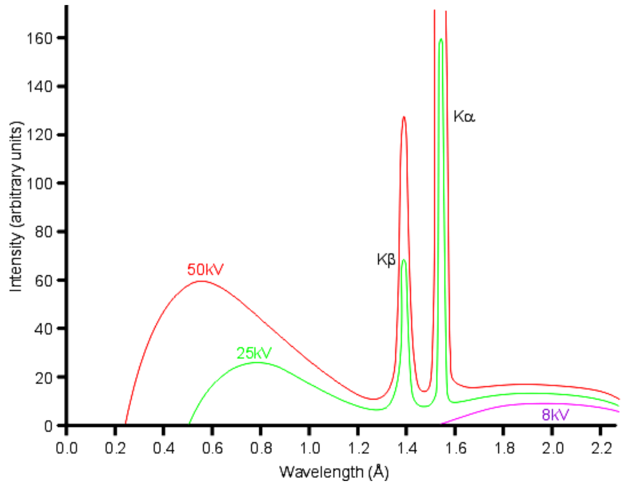
$$2d \sin\theta = k\lambda$$

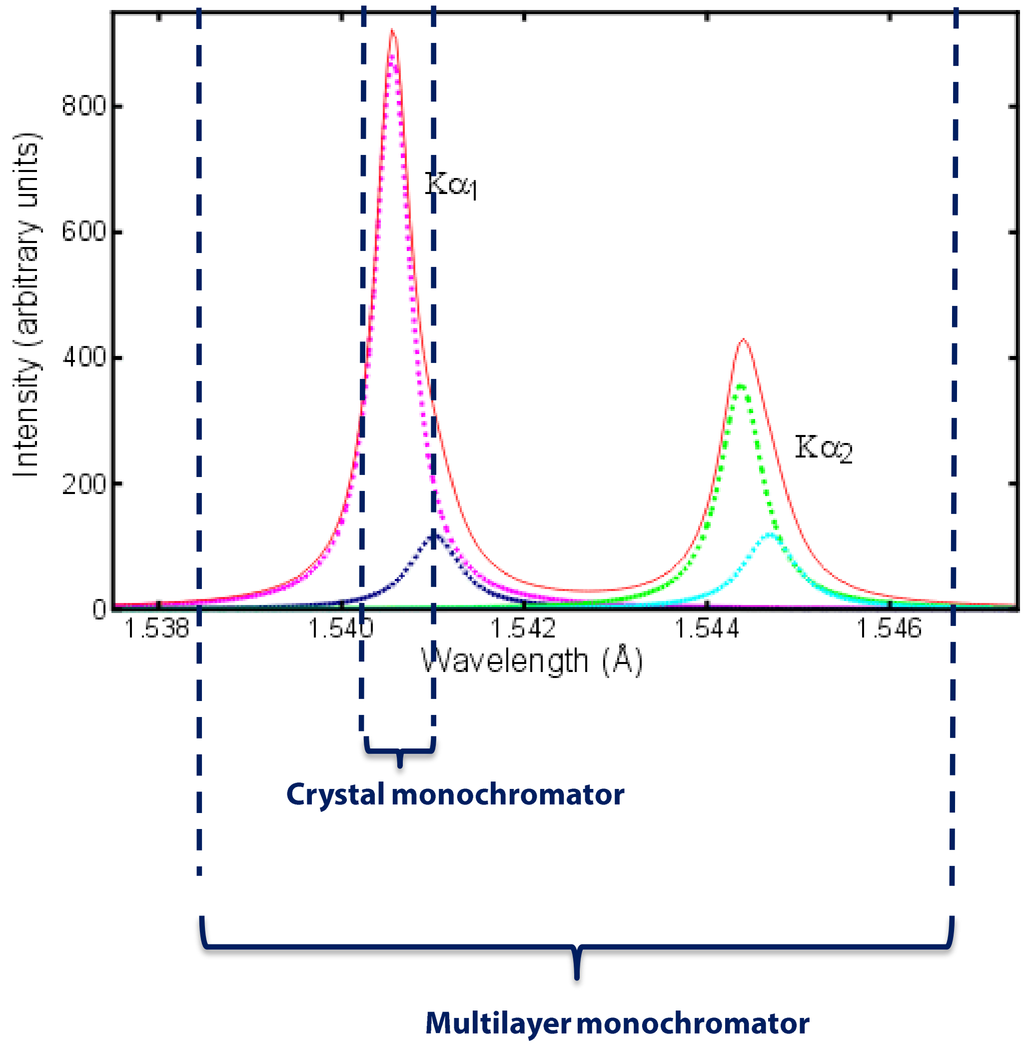
Very small reflection angle



X-Ray Data Booklet. Center for X-Ray Optics, and Advanced Light Source. Lawrence Berkely National Laboratory.

Wavelength range



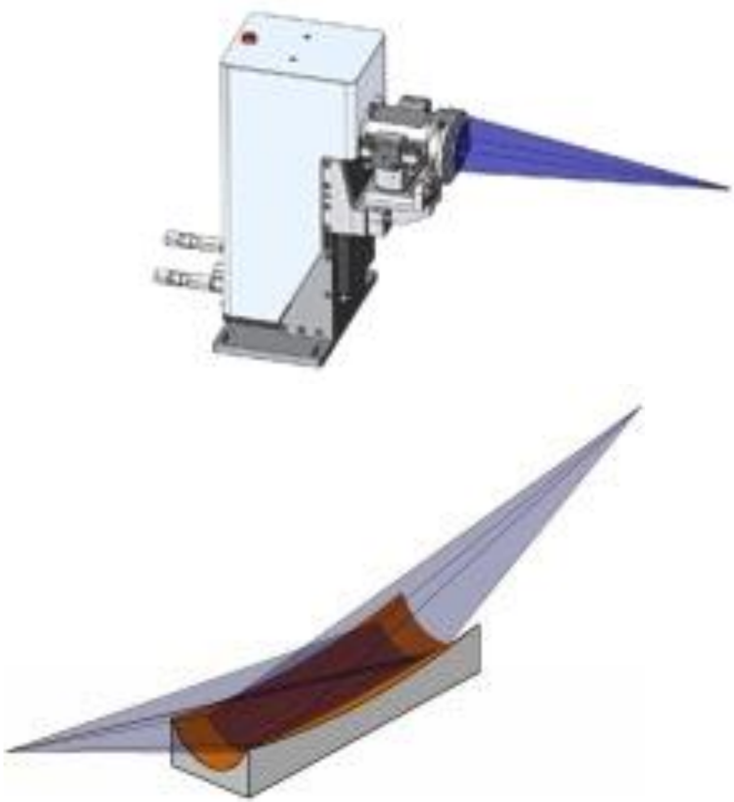


$\lambda Cu = 1.5489$ Å

$\lambda Mo = 0.7108$ Å

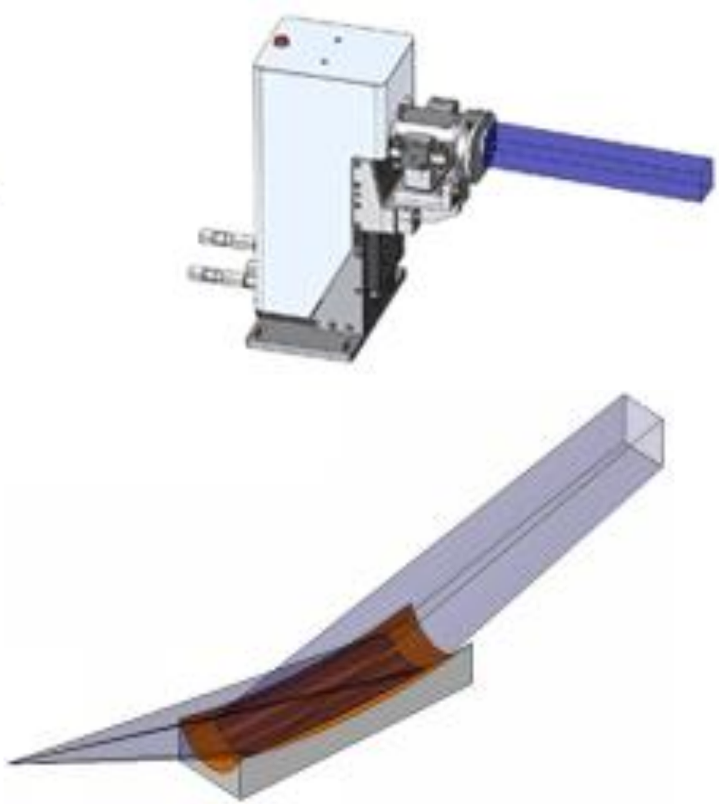
Xenocs Optics

Focalizing collimation



Ellipsoid of revolution

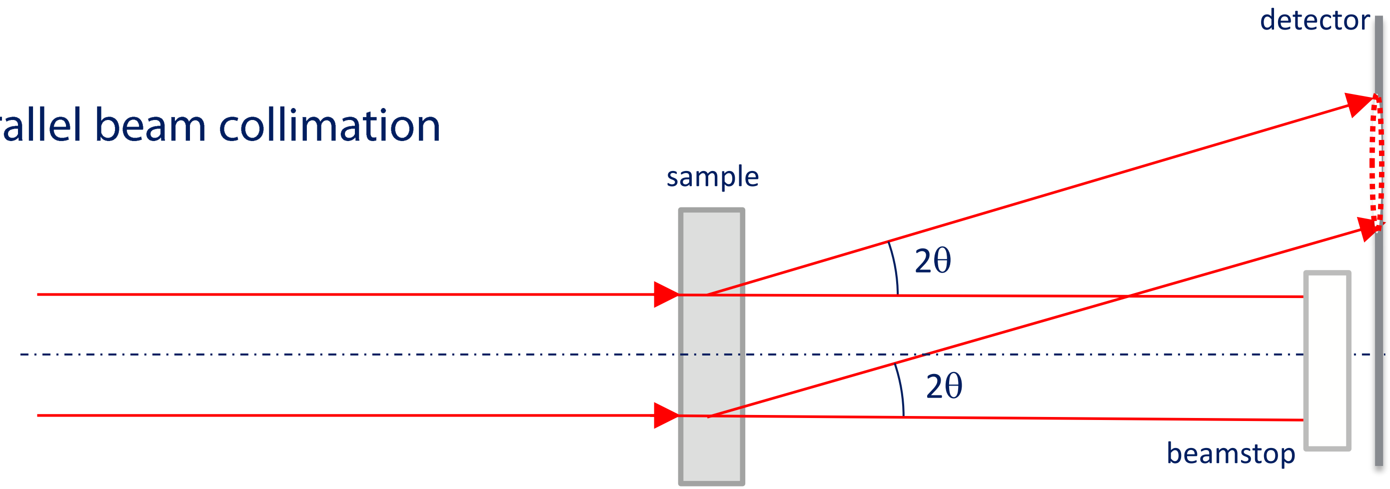
Parallel beam collimation



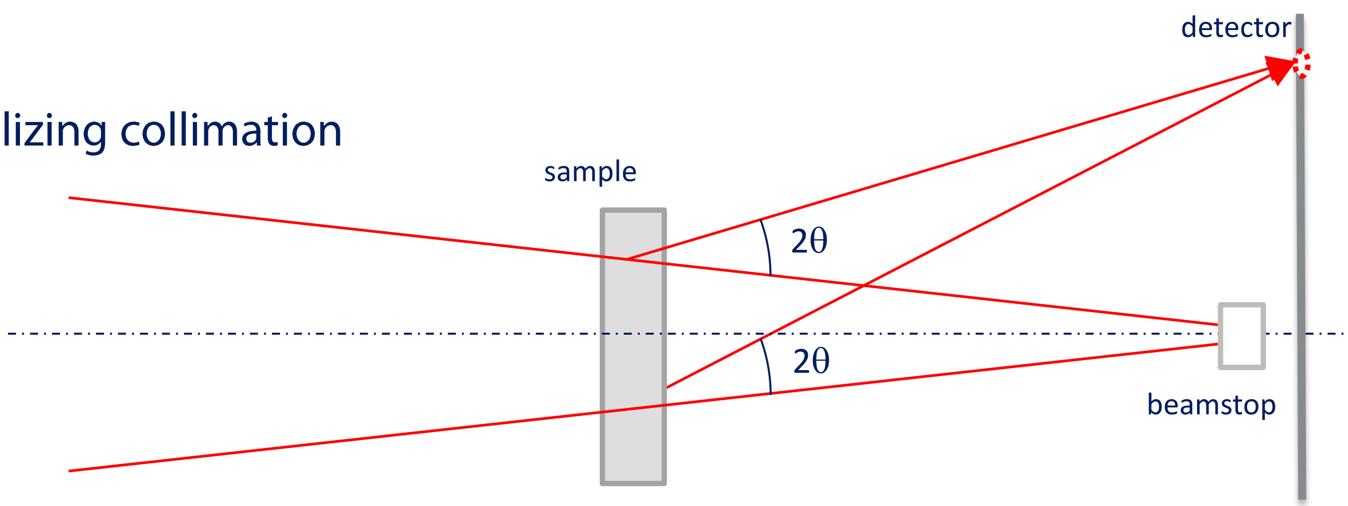
Parabolloid of revolution

Collimation geometry

Parallel beam collimation

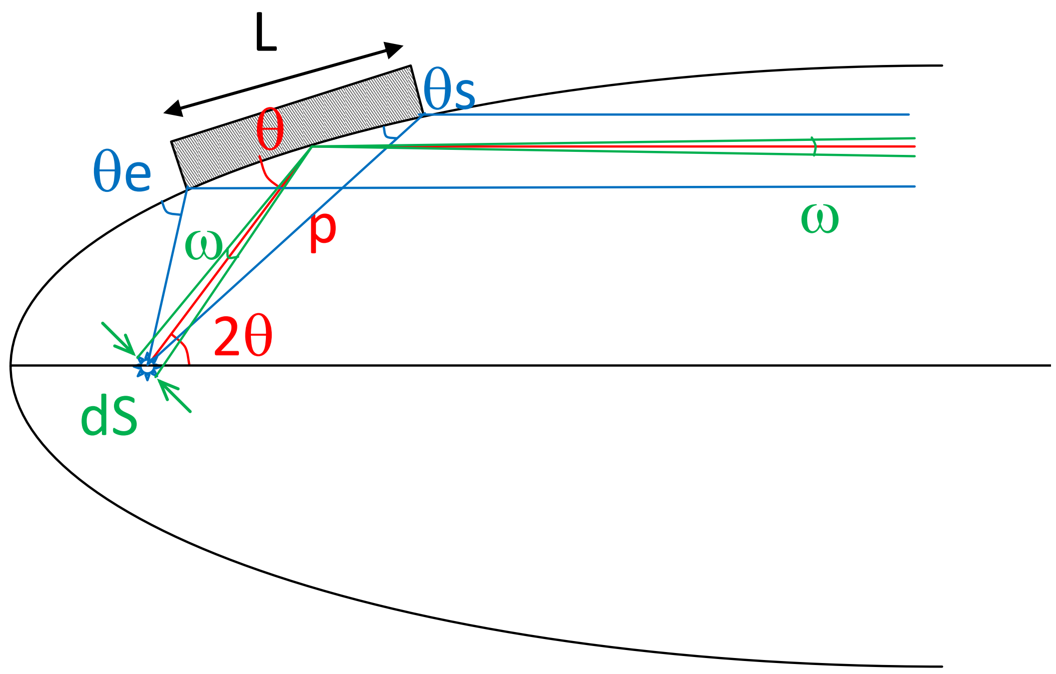


Focalizing collimation



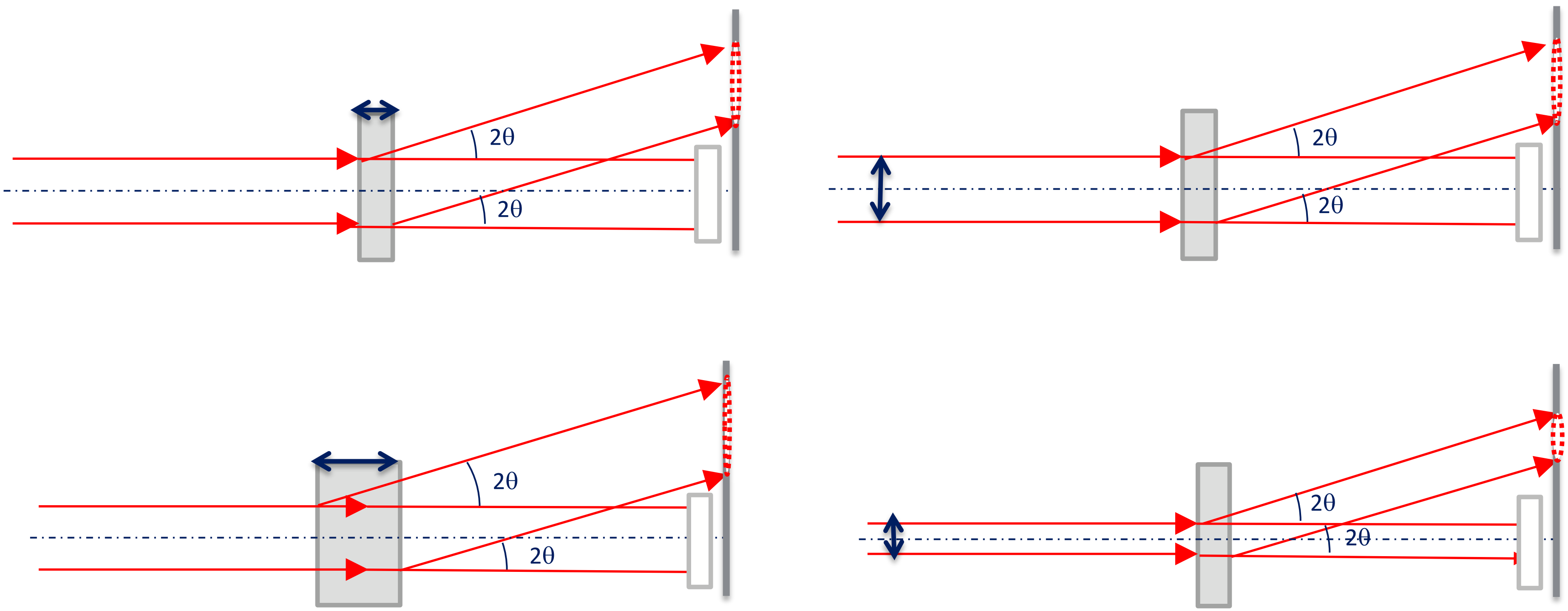
Collimation – Parallel beam Optics

Paraboloid of revolution



Instrumental Function

Beam size and sample thickness



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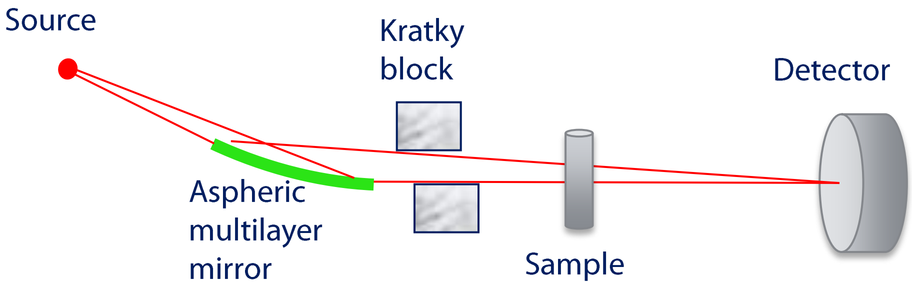
Small-angle X-ray Scattering

Lab source and Kratky camera

- Compact geometry
  - Microfocused source
  - Multilayer monochromator/focusing-collimating mirror
  - Beam clean up by 2 down stream slits or Kratky block

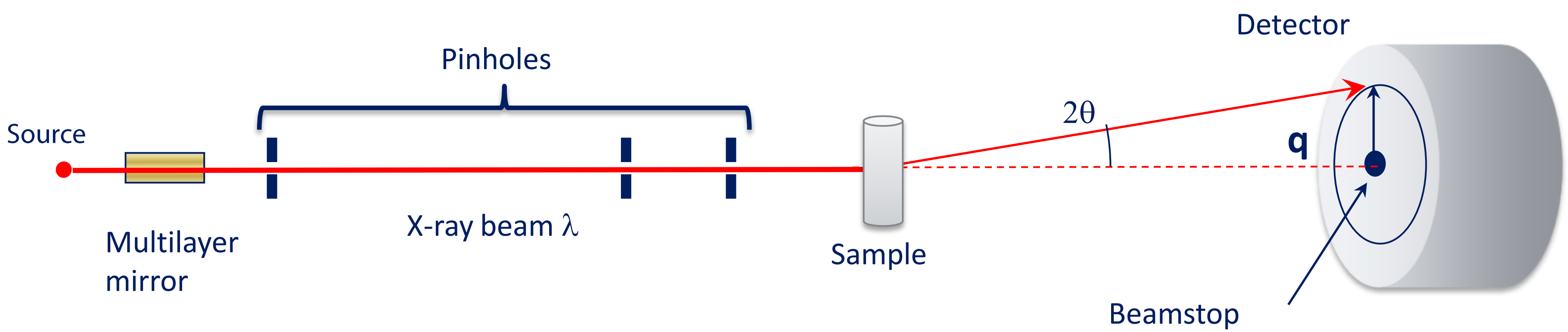


  - Loss of 98% *only* of the power of the source:
    Over x1000 improvement of the flux

Small angle x-ray scattering

Lab source and pinhole camera

- Intense rotating anode/microfocus sealed tube
- Crystal monochromator/collector
- Collimation by 3 sets of crossed slits
- Beam clean up by 2 down stream slit

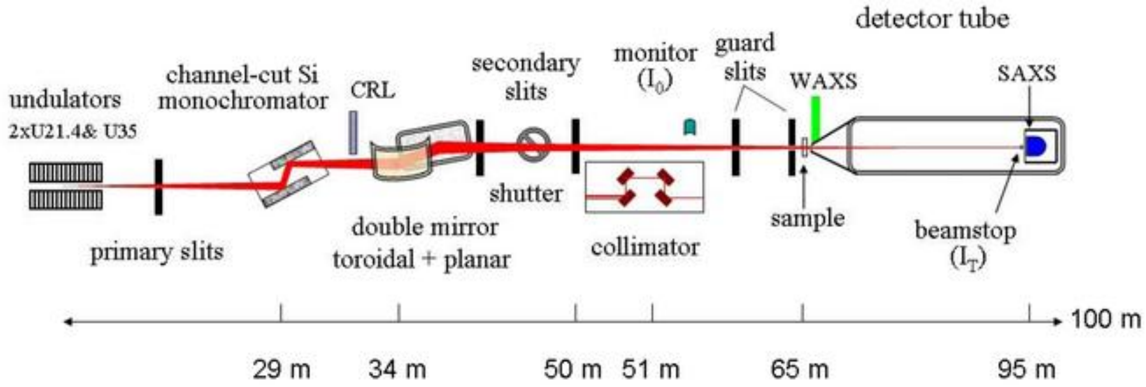


- Loss of 99.99% of the power of the source
- RECENT PROGRESS IN SLITTING leads to increase x5 in flux

Small angle x-ray scattering

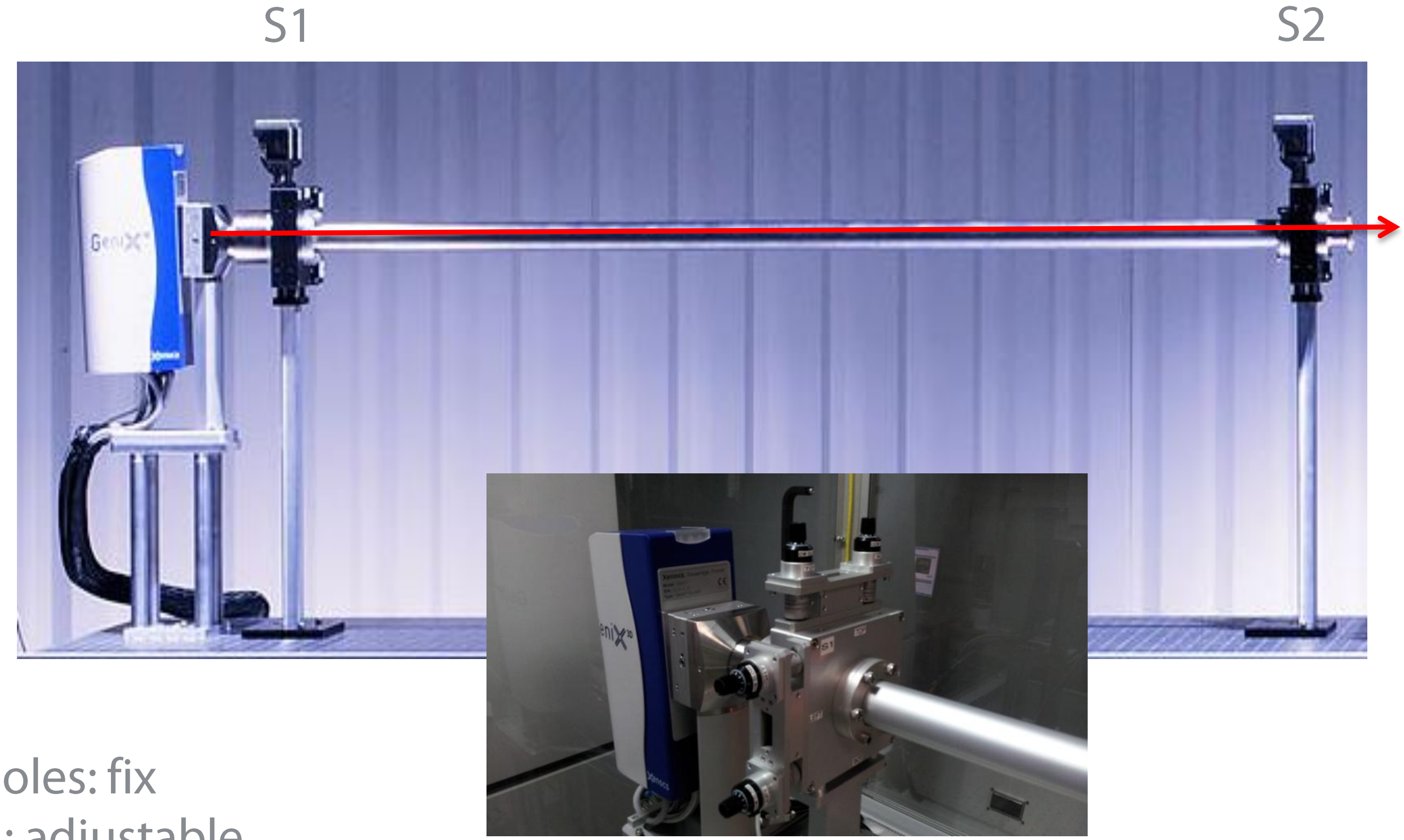
Synchrotron : the E.S.R.F. ID02 beamline

- Beam conditionning
  - Choice of the source
    - ESRF: low divergence, high brilliance straight section: "High Beta section"
  - Monochromator "heat load" remover
  - High precision 1m long toroidal mirror, focal length 33m, image 1:1 of source, slope error < qq Å
  - Collimation by 3 sets of crossed slits
  - Beam clean up by 2 down stream slits



- Beamstop
  - Required with an adapted size, monitoring of transmitted intensity

Scatterless Slits



Pinholes: fix
Slits : adjustable

Collimation

Clean-beam technology

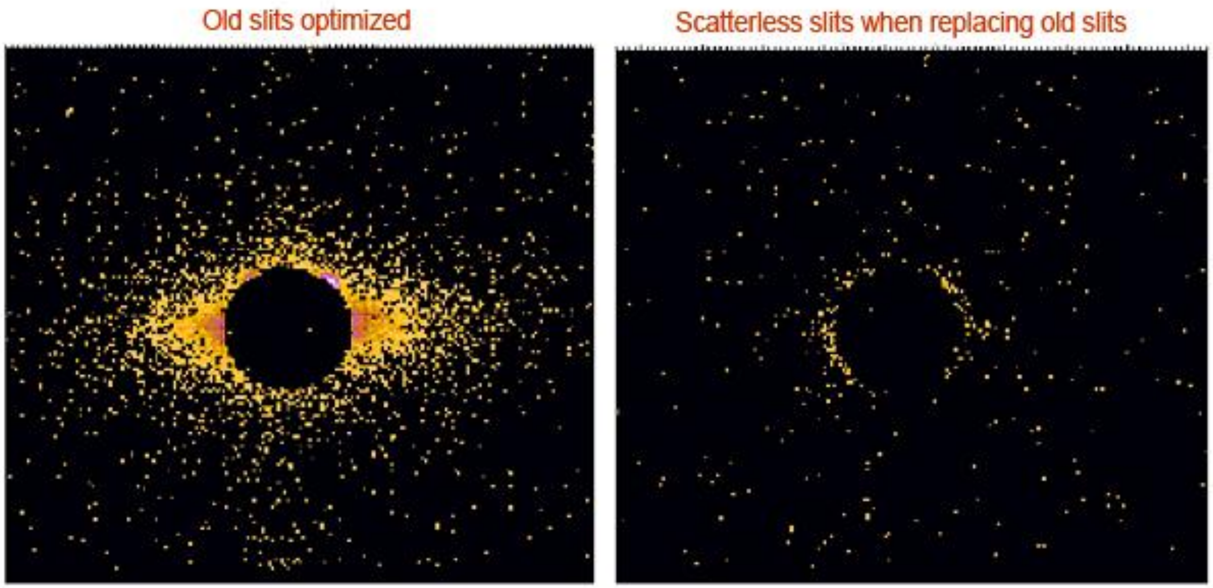
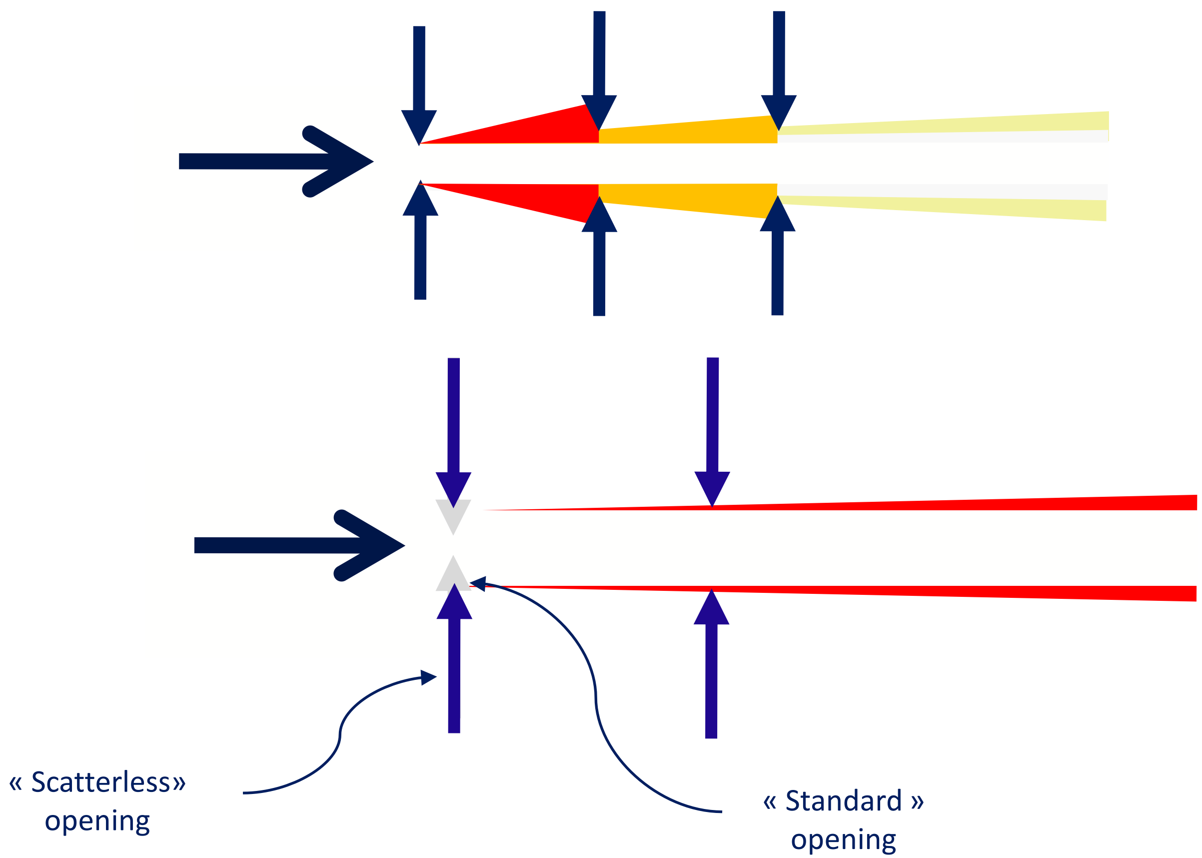


Figure 1 : Comparison of the background scattering close to the beamstopper between our previous setup and the scatterless slits. The images are ROIs taken on a Pilatus 100k detector (Dectris)

Collimation

Scatterless Slits



SAXS – WAXS – USAXS

Small- Wide- and Ultra-small- angle X-ray Scattering: Matter of distance

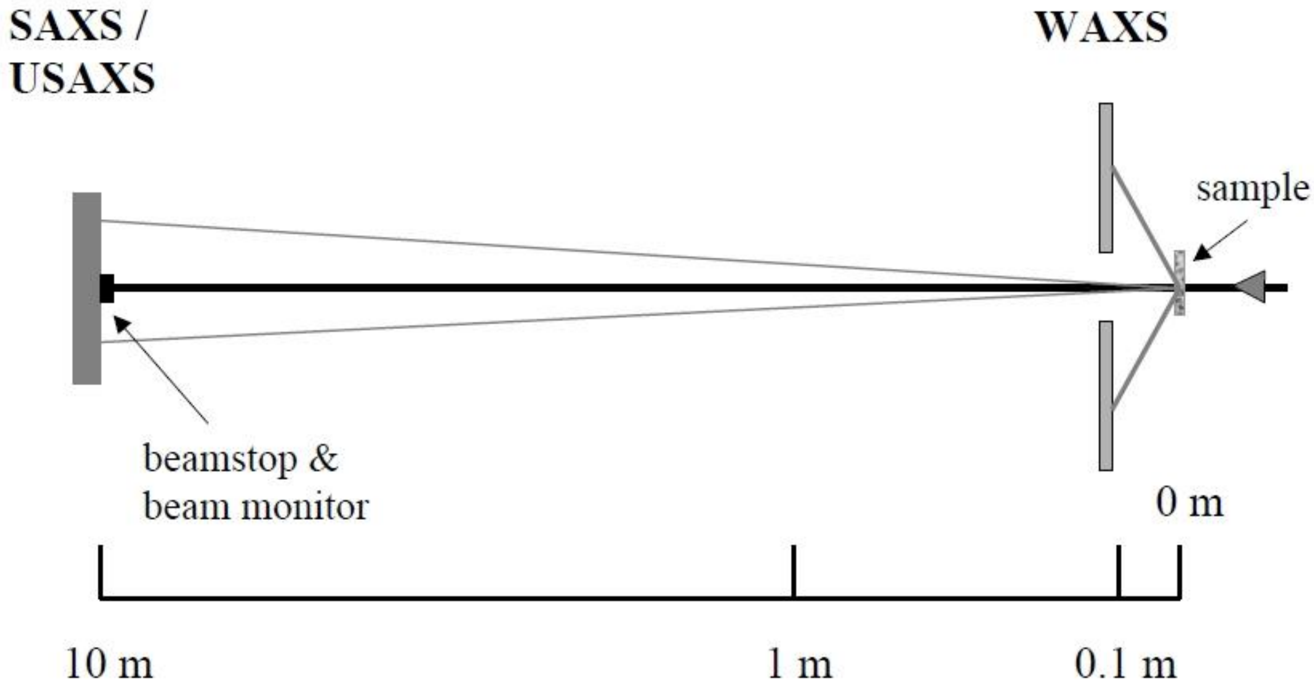


Figure 10: Schematic layout of a combined SAXS/WAXS setup. The SAXS configuration is the same as in Fig. 1 and to which an ideal WAXS detector is added.

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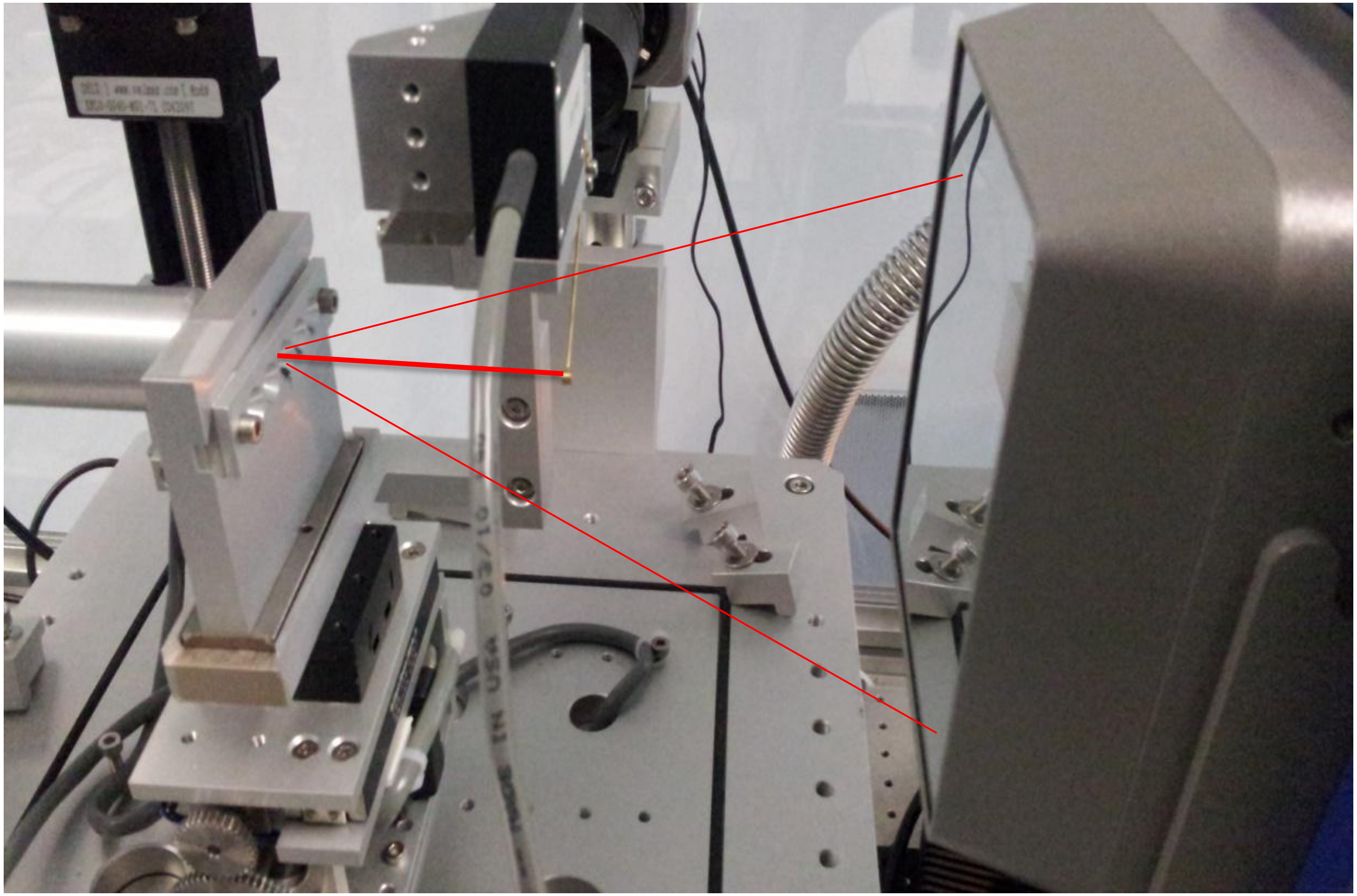
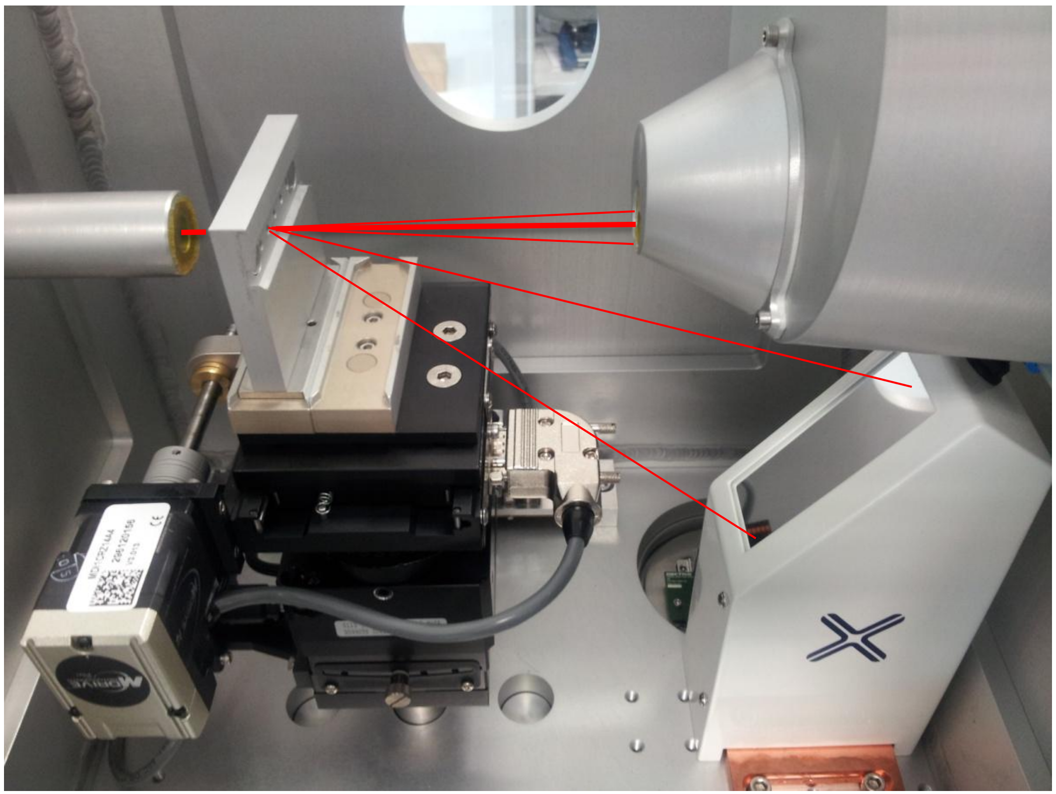
SAXS/WAXS in a Xeuss 1.0 System

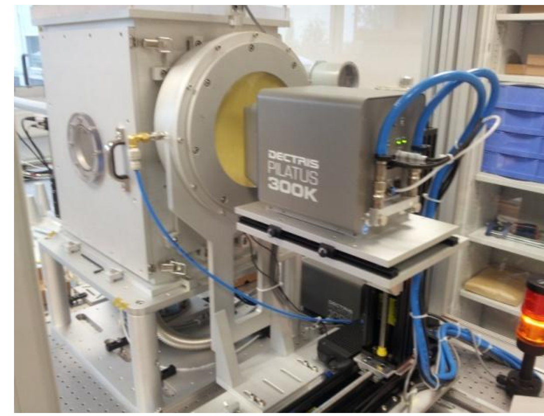
SAXS and WAXS non simultaneous



SAXS/WAXS in a Xeuss 2.0 System

Simultaneous SAXS/WAXS



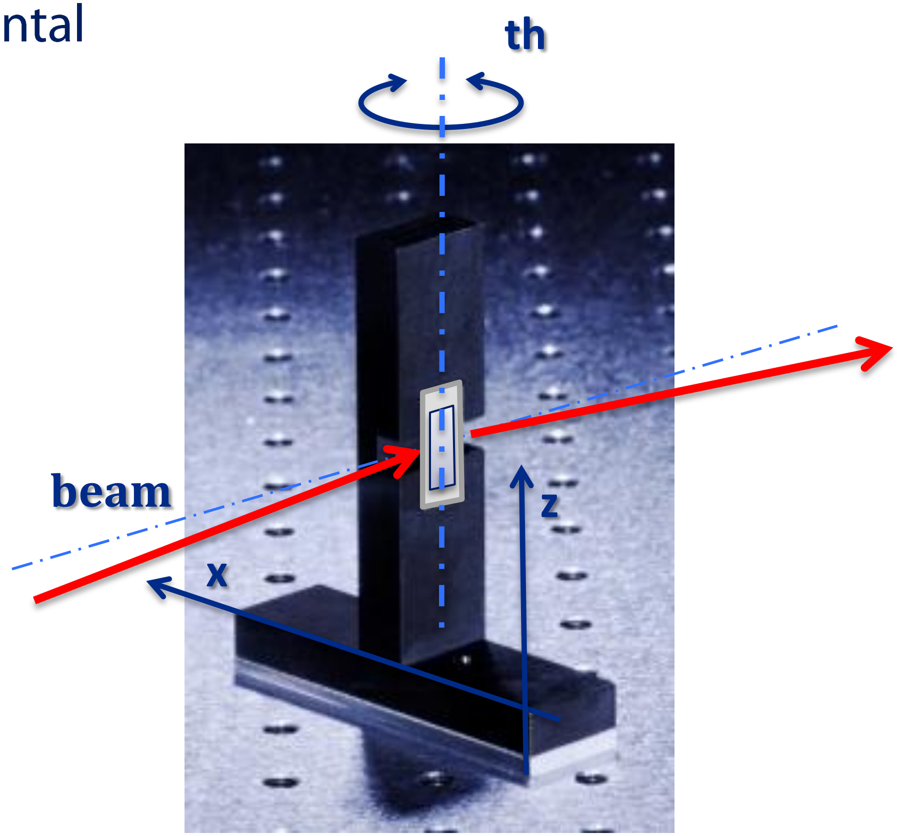


Pilatus 100-200-300k or 1M
SAXS

Pilatus 100k-Xenocs
WAXS

GISAXS / Reflectometry

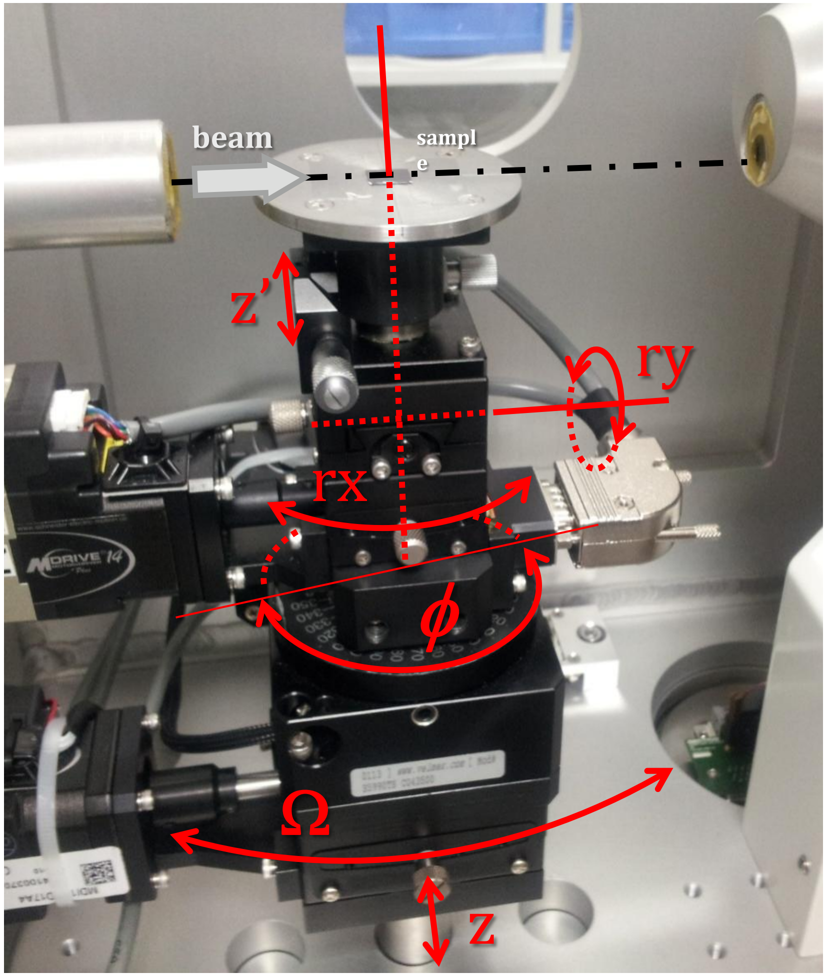
Simple Stage : reflection in horizontal



z : vertical translation
x : lateral translation
th : reflection tilt

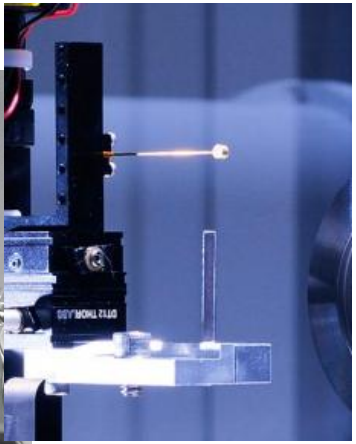
GISAXS / Reflectometry

Horizontal Stage Vertical reflection

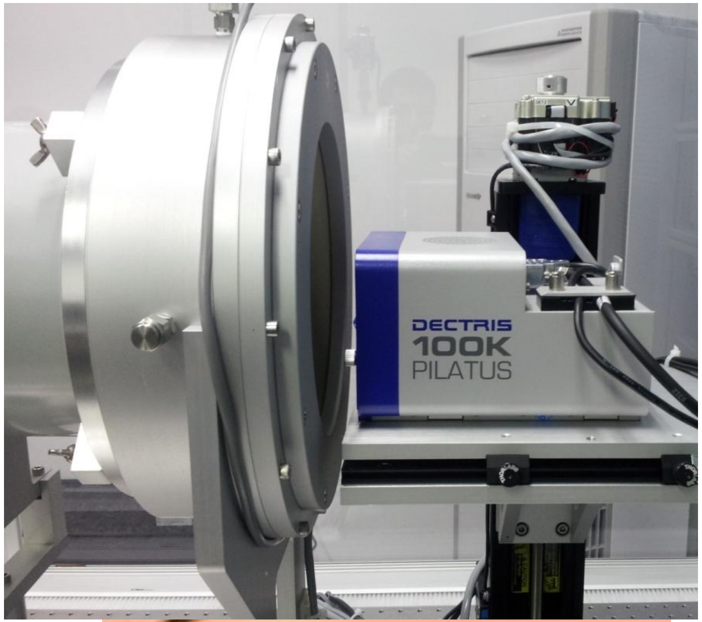


z : vertical translation
om : omega, reflection tilt
phi : vertiocal rotation
rx : fine tilt
ry : fine reflection tilt
z': manual vertical translation

Beamstops



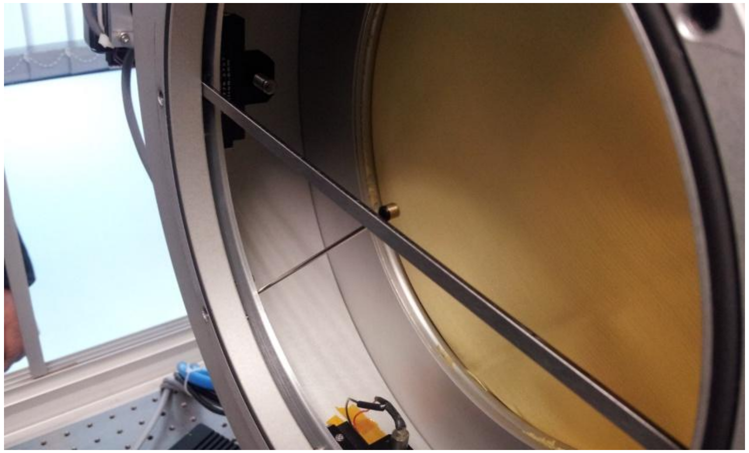
WAXS

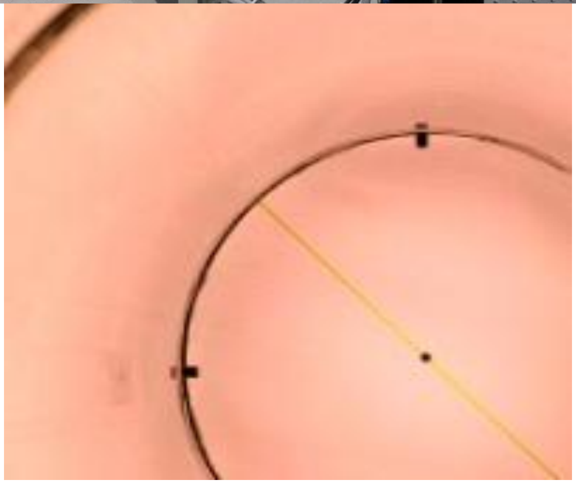


SAXS & GISAXS

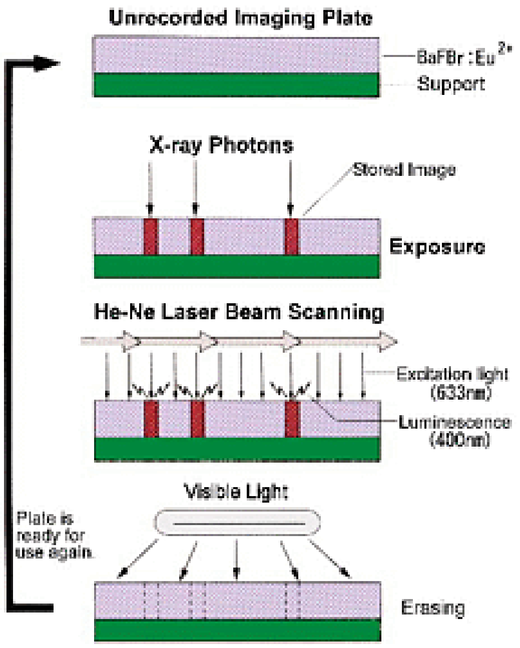
WAXSIN
WAXSOUT

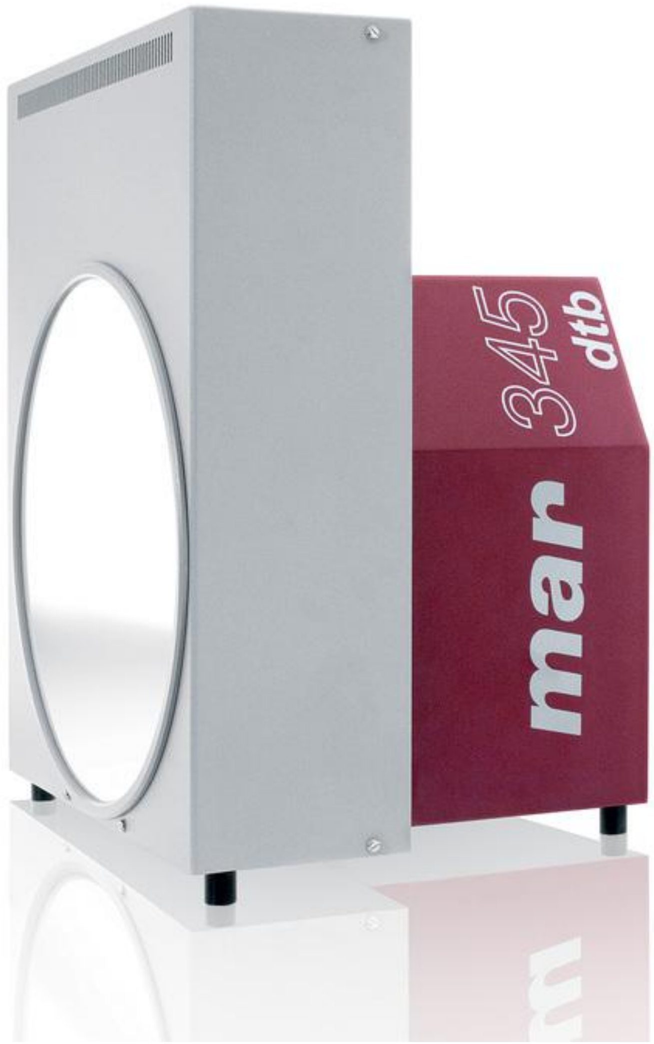
bsx
bsz
take_direct_beam



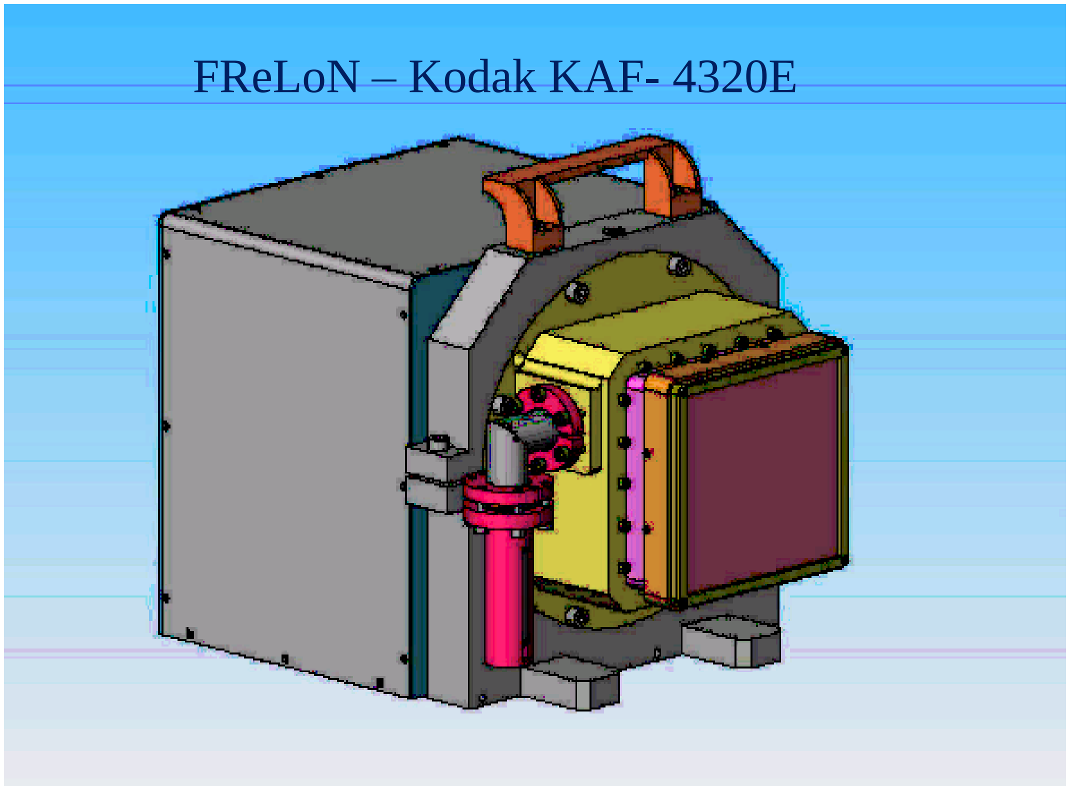


On-line Image Plate





CCD –Pixel Detector



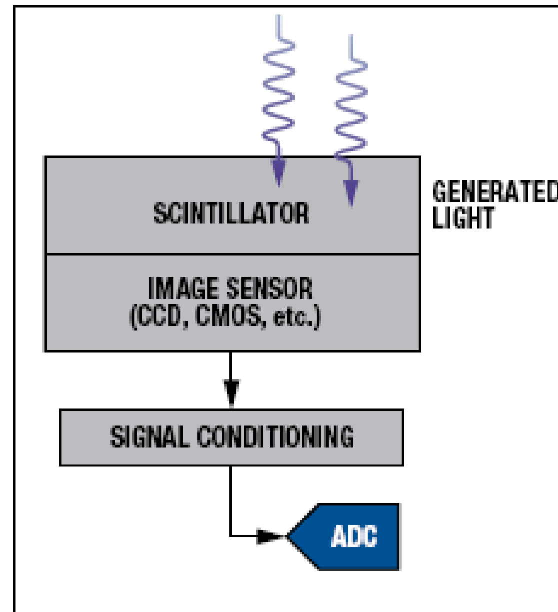
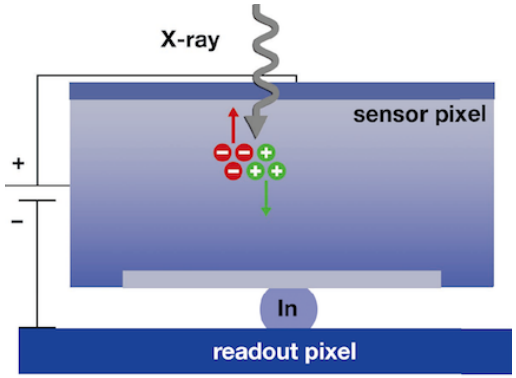
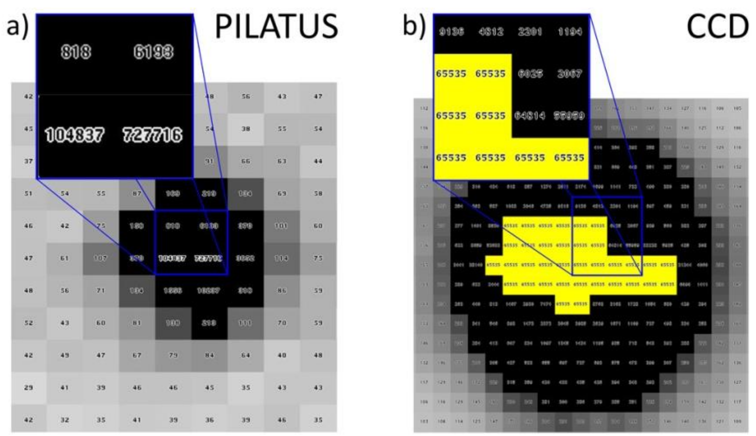


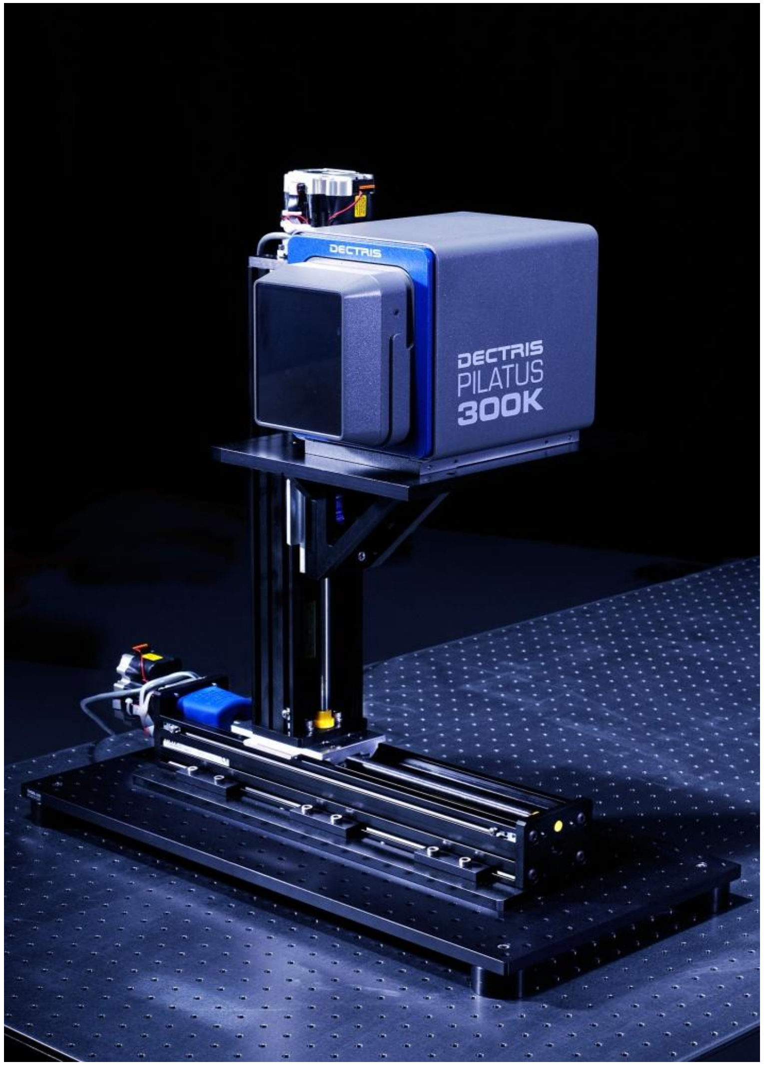
Figure 2: Indirect conversion detection.

Hybrid pixel detector

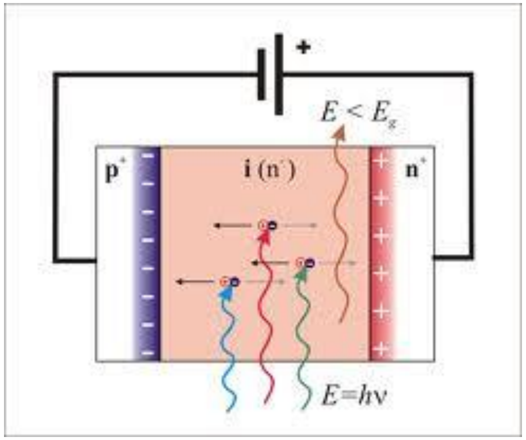
Dectris
Pilatus 300k

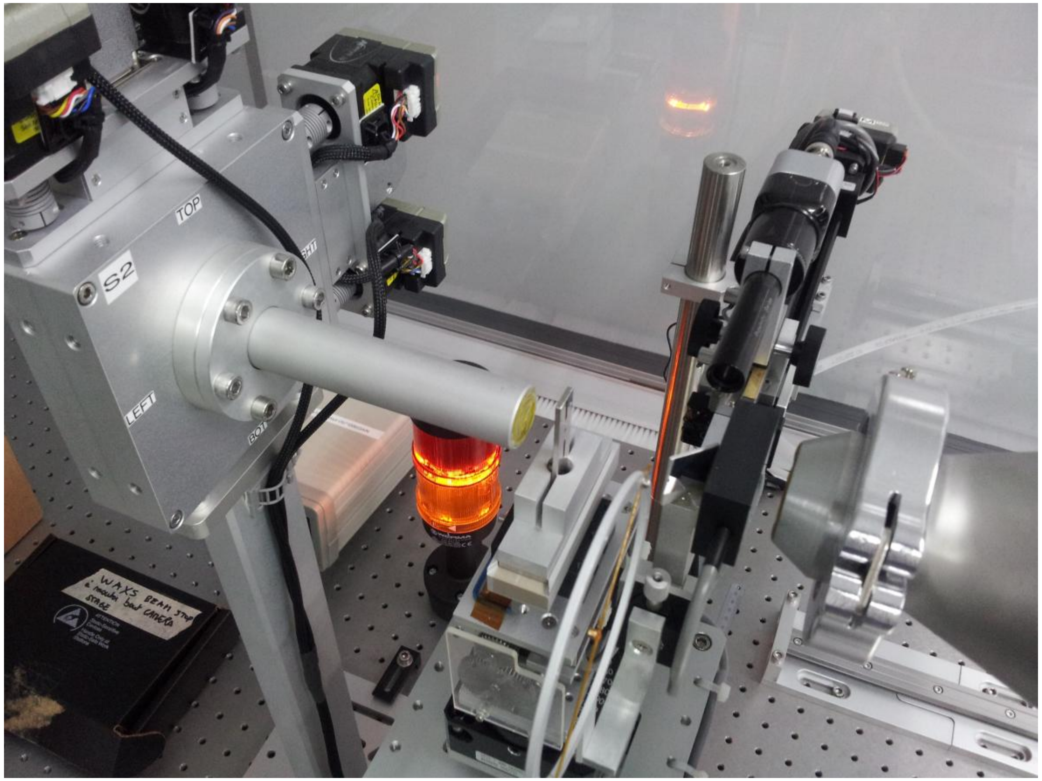




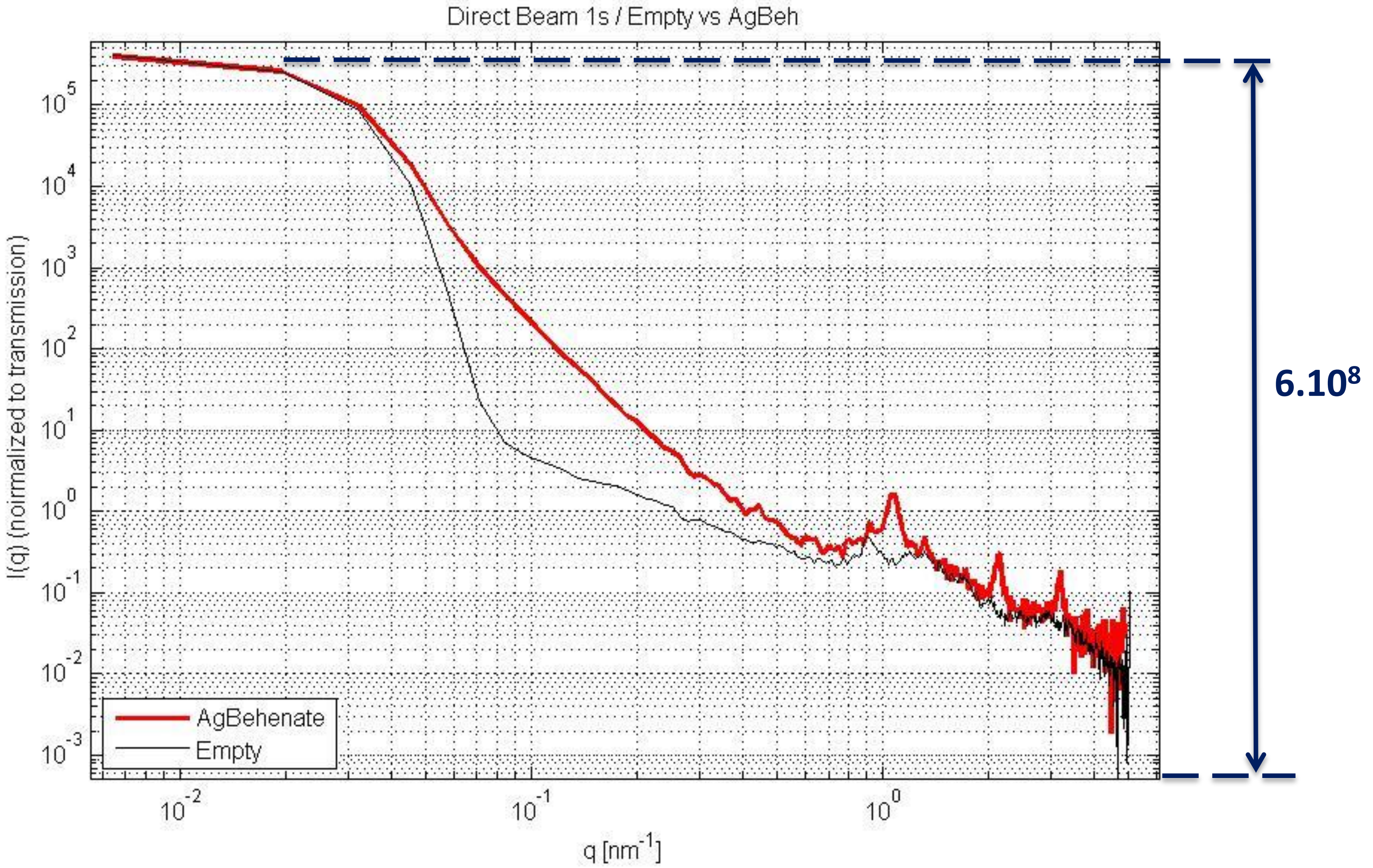


PIN-diode





Hybrid pixel Detector / Direct beam analysis



System details / operation and safety

System details / source and detectors

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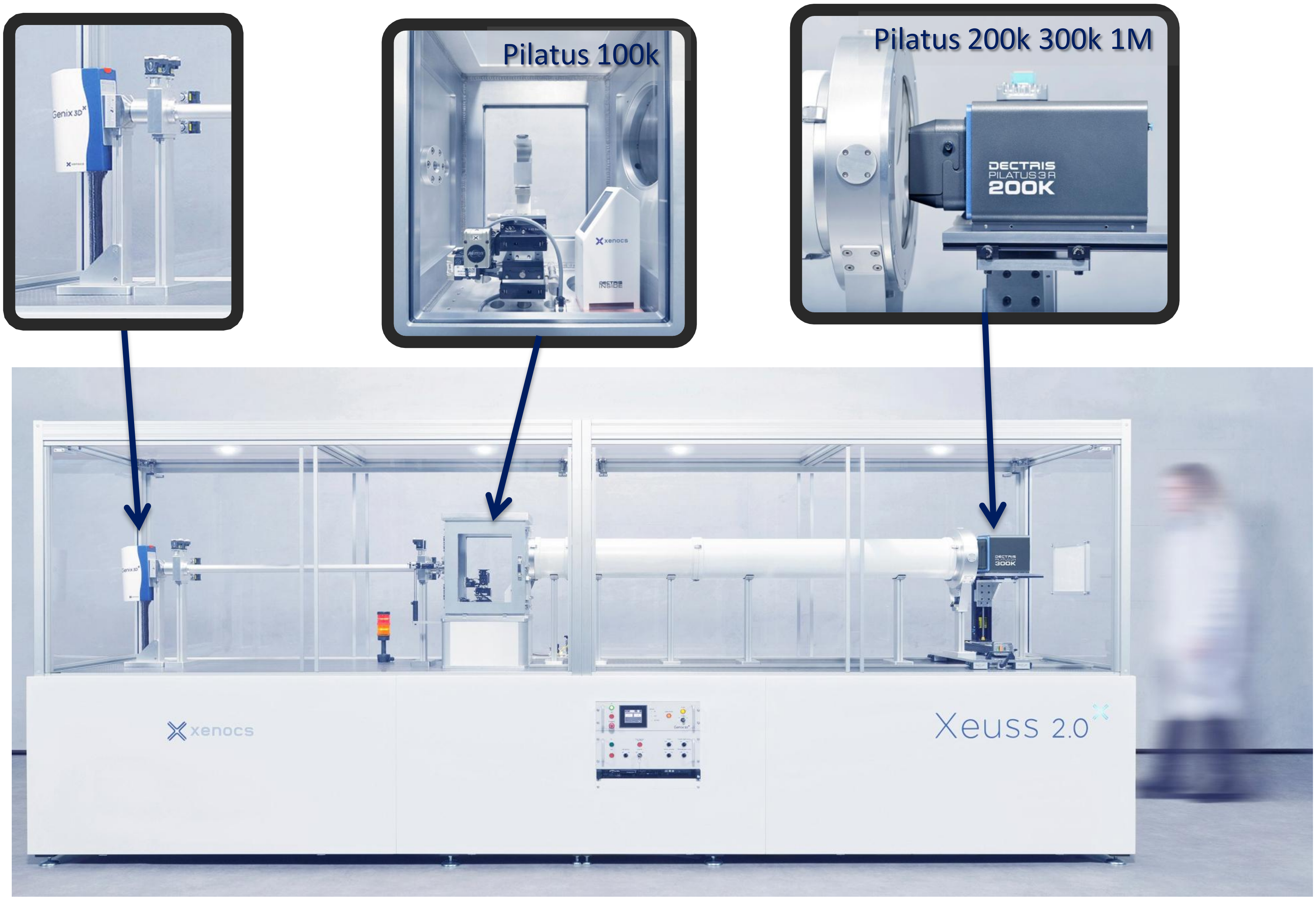
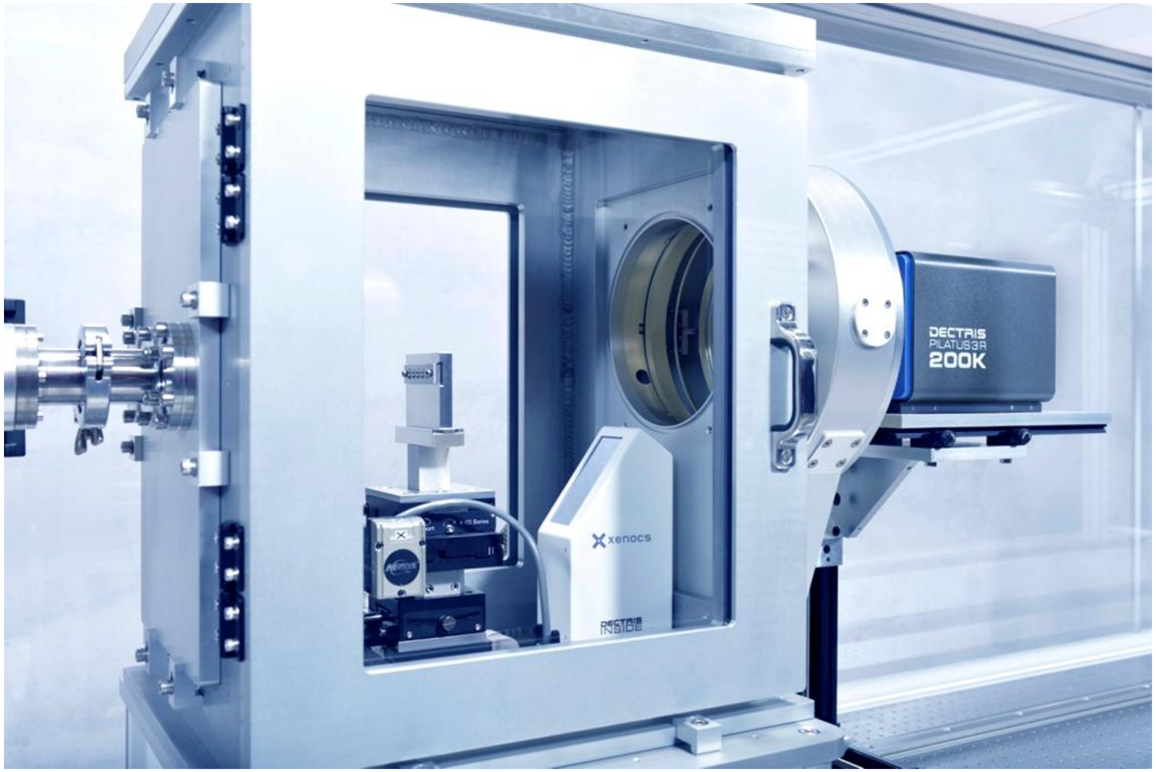


System details

Simultaneous SAXS/WAXS



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Thank you for your attention!