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MEDSI PARIS 2018
MECHANICAL ENGINEERING DESIGN OF SYNCHROTRON RADIATION EQUIPMENT AND INSTRUMENTATION

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INSTRUMENTATION FOR SYNCHROTRON RADIATION

High-efficiency and compact von Hamos spectrometer for the soft X-ray range

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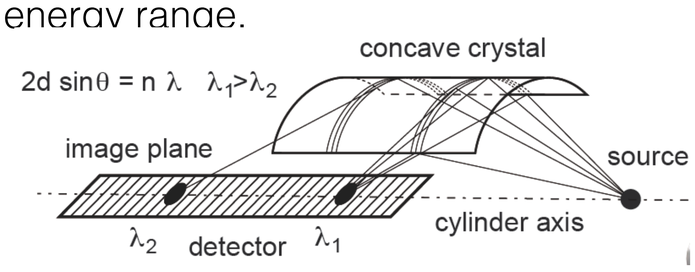
Introduction & Motivation

Samples illuminated by pulsed soft X-rays with a large number of photons per pulse (XFEL, Laser-plasma sources) often restrict analytical methods to ph-in-ph-out techniques, since ph-in-e-out techniques can suffer severely from space charge.
We introduce a compact and large angle acceptance soft X-ray spectrometer for an energy range of 1-3 keV suitable for experiments under the above conditions.

Concept

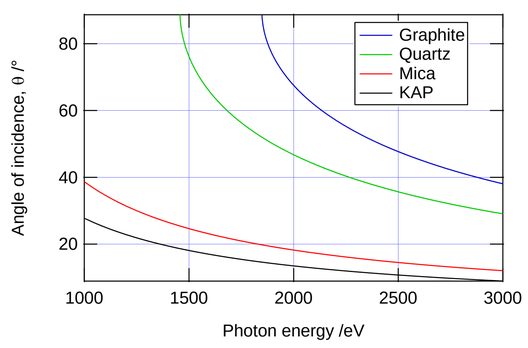
The spectrometer uses a von Hamos optical design and covers a simultaneous energy window of >300 eV over the whole energy range.



Principle of the von Hámos design, where a thin crystal is bent to a cylindrical surface [1,2].

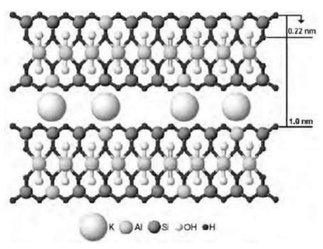
Performance defining criteria:

- Crystal lattice constant
- Bragg reflex line width
- Crystal radius
- Spatial detector resolution
- Crystal figure error
- Alignment & stability

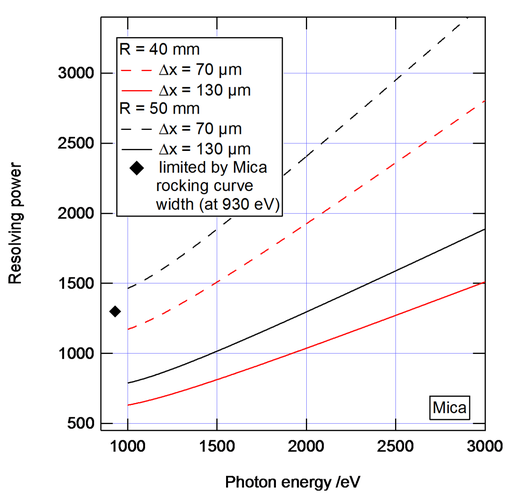


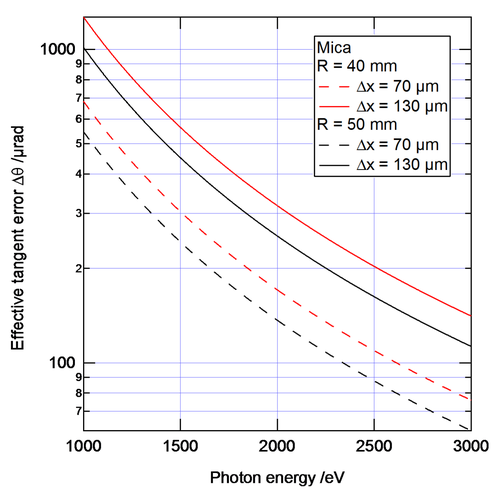
→ Choice of crystal: Mica, 40 mm radius
→ Target effective tangent error: <100 µrad

Mica crystal structure.

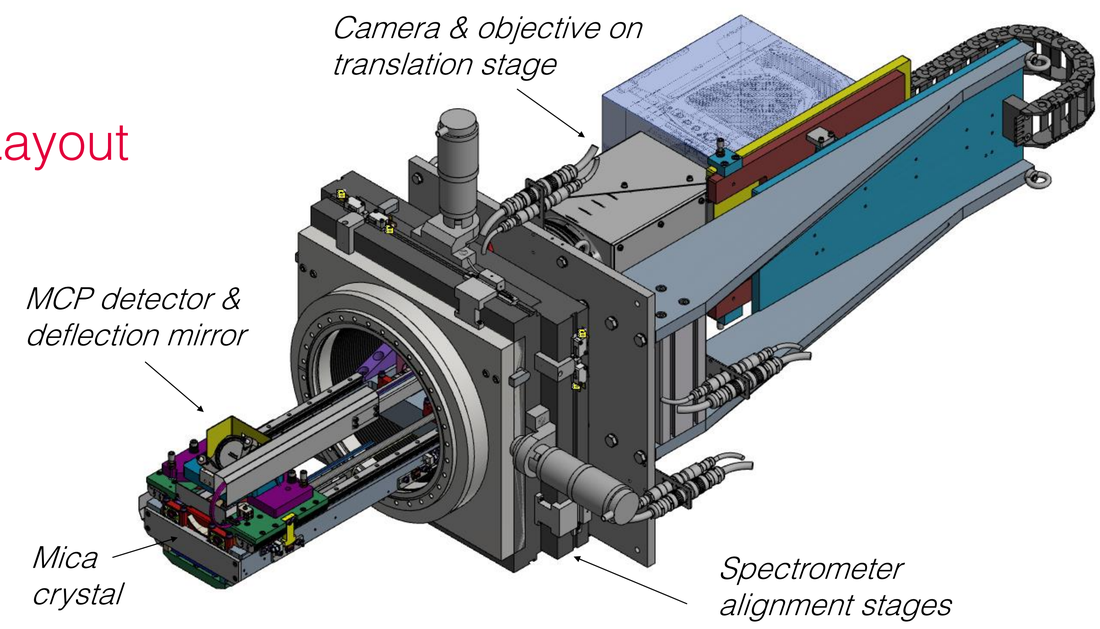


Material	Lattice constant
Graphite	0.335 nm
Quartz	0.425 nm
Mica	0.99 nm
KAP	1.332 nm



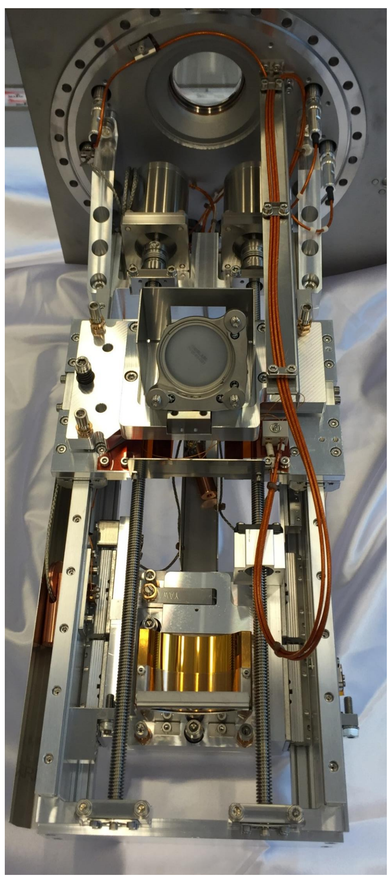


Layout

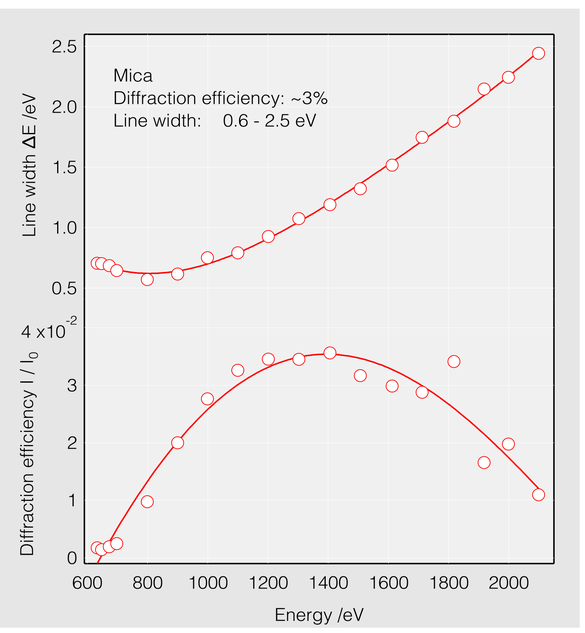


Using a high speed camera (500.000 frames/s at 1024x16 pixels) up to 400 spectra can be recorded within a macro bunch (10 Hz) of the European XFEL.

Performance test results



Internal mechanics of the von Hamos spectrometer.



Diffraction from a thin mica crystal measured at the Optics beamline at BESSY/HZB .

Specifications

Parameter	Typical value
Energy range	800 – 2300 eV
Energy resolution	0.6 – 2.5 eV
Energy spectrum width	~300 eV (simultaneous)
Azimuthal acceptance	>100°
Crystal	Mica
Crystal radius / length	40mm / 25 mm
Detector	MCP
Mechanical repeatability	< 0.5 µrad /< 0.1 µm
Mechanical stability	< 0.2 µrad / <0.1 µm
Dimensions without camera	DN250 CF x 650 mm
Dimensions with camera	DN250 CF x 1800 mm

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ISO 9001 BUREAU VERITAS Certification

Bundesministerium für Bildung und Forschung

References

[1] L. von Hámos, Naturwissenschaften **20**, 705 (1932).
[2] A. P. Shevelko *et al.*, Review of Scientific Instruments **73,** 3458 (2002).

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