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Nanofocus endstation of the MINAXS beamline

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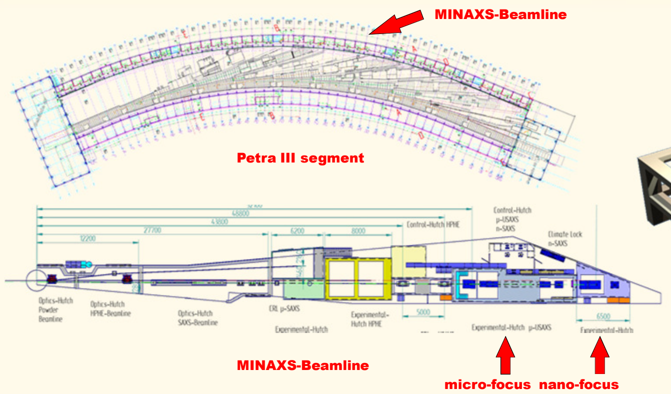
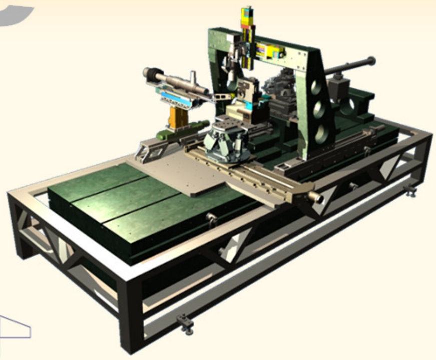
Beamline



Top: Position of the Micro and Nanofocus X-ray Scattering (MINAXS) beamline within the layout of *Petra III*. **Bottom:** The nanofocus hutch is located downstream the microfocus endstation, both of which are fed by a canted undulator.



Preliminary model of the **nanofocus sample stage**, mounted onto a heavy, vibration reductive, two-segment monolith optical table. The headmost component is a hexapod for the sample environment.

Micropositioning devices for the alignment of the sample and nanofocusing optical elements. Hexapods provide 3 linear and 3 rotational degrees of freedom with a freely definable pivot point. The top-mountable XZ-stage provides superior spatial resolution.

Type	P-611 XZ stage	F-206 hexapod	M-824 hexapod
max. load	1.5 kg	2 kg	10 kg
travel range	±100 μm	±6 mm, ±6°	±22.5 mm, ±12.5°
resolution	< 10 nm	100 nm, 2 μrad	300 nm, 3.5 μrad

Optics

Focusing x-rays down to the **sub-μm** range (nanofocusing) requires high precision optical elements and a well defined x-ray. Once vibration issues are carefully taken care of, the incoming beam can be focused to a size close to the diffraction limit (around 20 nm).

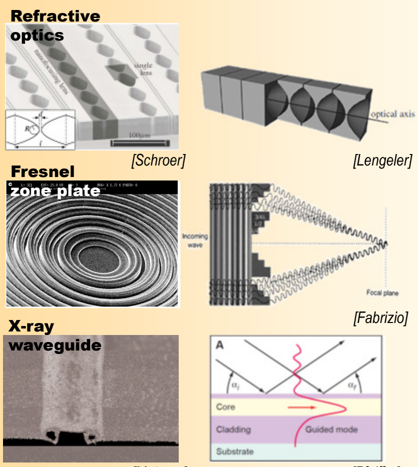
As shown **right** and **below** many types of optics exist, the choice of which depends on the main concern of the experiment – always being a trade-off between conserving flux, spatial resolution and coherence.

Focusing Optics for Hard X-rays: 6 - 60 (200) keV

	REFLECTIVE				DIFFRACTIVE	REFRACTIVE
	Kirkpatrick Baez systems		Capillaries	Waveguides	Fresnel Zone plates	Refractive lenses
	mirrors Kirkpatrick Baez, 1948	multilayers Underwood Barbee, 1986	Kreger 1948	Feng et al 1993	Baez 1952	Snigirev et al, 1996
E	< 30 keV	< 80 keV	< 20 keV	< 20 keV	< 30 keV (80)	<1 MeV
ΔE/E	wide band	10^{-2}	wide band	10^{-3}	10^{-3}	10^{-3}
resolution	25 nm 15keV Mimura (2006)	41×45 nm 24keV Hignette (2005)	50 nm Bilderback (1994)	40×25 nm² Salditt (2004)	30 nm 20keV Kang. (2006) ~15nm <1keV	50 nm@20keV Schroer (2004) 150 nm@50keV Snigirev (2006)
flux	+++	+++	—	—	++	+
spot-size	+++	+++	+++	+++	+++	+++
achromatic	YES	NO	YES	NO	NO	NO *but* f(N,E)
coherence	+	+	+/-	+++	++	+/-
in-line	NO	NO	YES	YES	YES	YES
long-f	YES	YES	NO	NO	YES	YES
easy to use	+/-	+/-	++	+/-	++	++

[Mocuta]

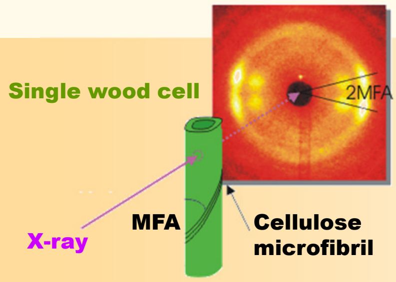
small focus, high coherence



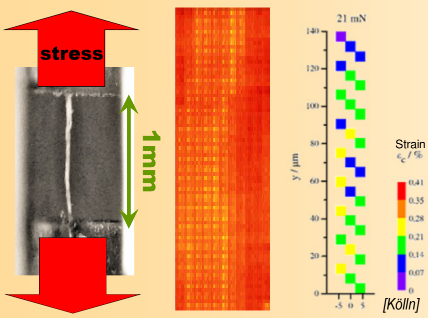
[Schroer] [Lengeler] [Fabrizio] [Metzger] [Pfeiffer]

high acceptance and flux

Science



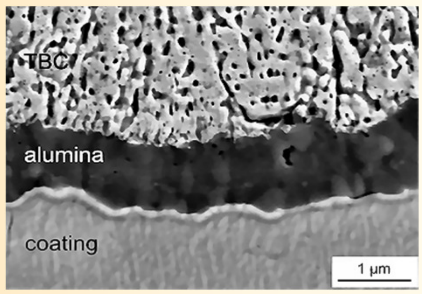
Top: Microdiffraction experiment on a wood cell with the cellulose (200) reflection being an indicator for the microfibril angle (MFA). **Bottom:** (left) Actual experiment, the cell is exposed to lateral stress during irradiation. Combined with a μm-sized x-ray spot the intracellular strain distribution (right) can be determined from the measured MFA-distribution (middle). Yet smaller foci allow for investigation of more finely structured materials, such as fibres, smaller cells etc.



[Kölln]

Nanofocus diffraction is complementary to TEM and SAXS/SANS as it allows for *in situ* experiments (e.g. temperature, mechanical load) to access single grains of polycrystalline materials on a sub-μm length-scale. **Right**: Microstructure of Mg-Al-Zn alloy with & w/o SiC [courtesy of GKSS].

Bottom: A thermal barrier coating (TBC) deposited onto aluminidecoated TiAl alloy Ti-45Al-8Nb. TEM evidenced protective alumina scale formation on TiAl3, providing good adherence of the TBC. If crystallisation or composition of such structures is in question, sub-μm diffraction and spectroscopy methods are beneficial.



[Leyens]

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