Design of a new beamline for high resolution absorption spectroscopy at the ESRF: FAME-UHD

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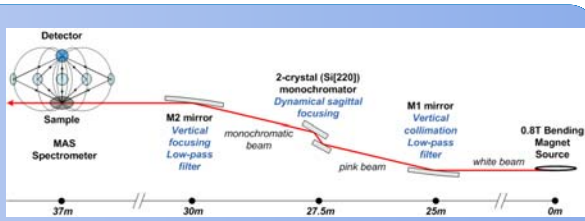
Objectives

Due to an increasing demand for detection of highly diluted elements emerging from the FAME users community, a new beamline dedicated to high resolution spectroscopy and using analyzer crystals spectrometer will be built at the ESRF. This new beamline, FAME-UHD (French Absorption spectroscopy Beamline in Material and Environmental sciences - Ultra-High Dilution), will be complementary to the existing FAME beamline, with the same target scientific communities, particularly well suited to environment, energy and nanosciences. The beamline is under construction and will be opened to users in 2016.



Determination of beamline geometry

- Compacity (to minimize lever arms and optics sizes)
- Maximization of flux (→ max horizontal divergence and mirror lenght)

Monochromator:

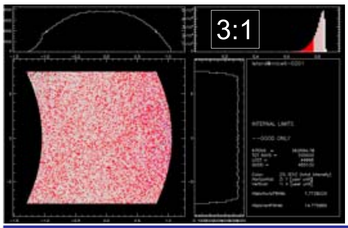
- ***Crystal choice:*** compromise between resolution, flux and accessible energy range (with 5°<θ<40°)

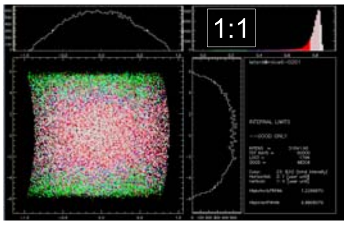
Crystal	ΔE/E	ΔE at Fe K edge	F	Energy range
Si(111)	1.3×10^{-4}	0.973eV	60	4-20keV
Si(220)	5.6×10^{-5}	0.365eV	70	4.8-40keV
Si(311)	2.8×10^{-5}	~0.2eV	46	7-40keV
Core hole width		1.25eV		

➢ Si(220)

- ***Focusing ratio***: important not for spot size but for Bragg conditions

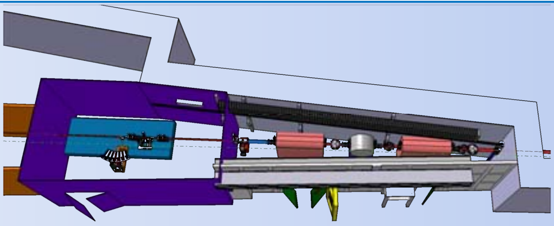
Sparks *et al.*, X-ray monochromator geometry for focusing synchrotron radiation above 10keV *Nuclear Instruments & Methods In Physics Research*, **1980**, *172*, 237-242



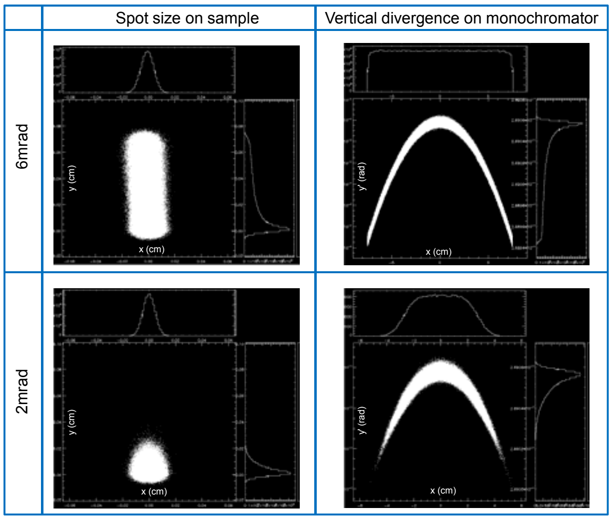


	M1 (m)	Mono (m)	M2 (m)	Sample (m)	4mrad on mono (cm)
3:1	25.2	27.5	29.8	36.7	9
1:1	20	22.3	24.6	40	11

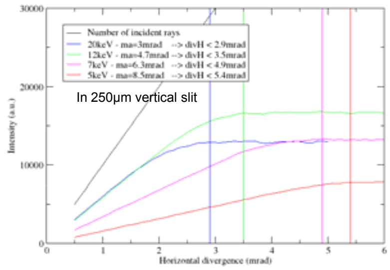
➢ 3:1 geometry



Horizontal acceptance:



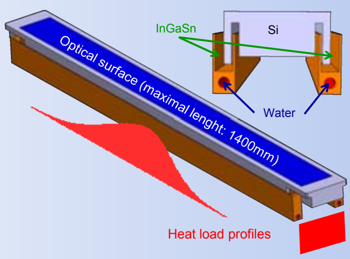
Vertical beam size contributes to spectrometer energy resolution.



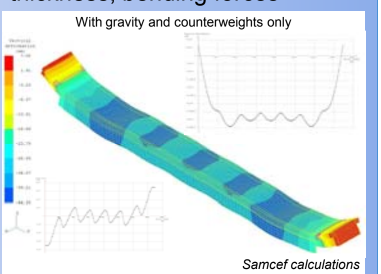
- 4 mrad
- M1 mirror optical width: 100mm

Ray tracing calculations with shadow: Sanchez del Rio *et al.*, SHADOW3: a new version of the synchrotron X-ray optics modelling package, *Journal of Synchrotron Radiation*, **2011**, *18*, 708-716

Thermo-mechanical modelisations of M1 mirror



- Minimisation of surface deformations (curvature), thus thermal gradient in all directions
  - ✓ design of cooling system
  - ✓ adjustment of mirror lenght, thickness, bending forces



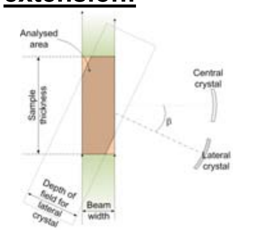
Samcef calculations

- Step 1: optimisation of the mechanical model (position of the counterweights…)
- Step 2: heat load modelisation
  - ✓ total heat load = f($E_{h\upsilon}$)
  - ✓ illuminated lenght = f(α) = f($E_{h\upsilon}$)
  - ✓ cooling efficiency = f(α)

$E_{h\upsilon}$ (keV)	Incident angle α (mrad)	R_c (km)	Gaussian width (mm)	Heat load (W)
20	2.5	20	1085	228
5	8.5	5.9	695	465

Spectrometer design

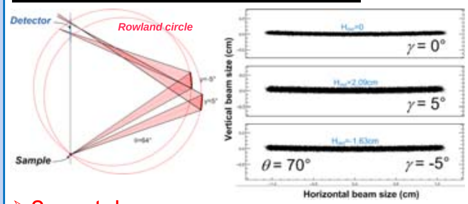
Horizontal maximal extension:



➢β < 30° → 7 crystals

Sample thickness: 2mm – θ = 64°

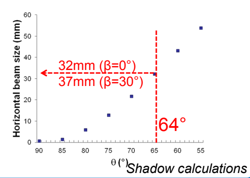
Vertical maximal extension:



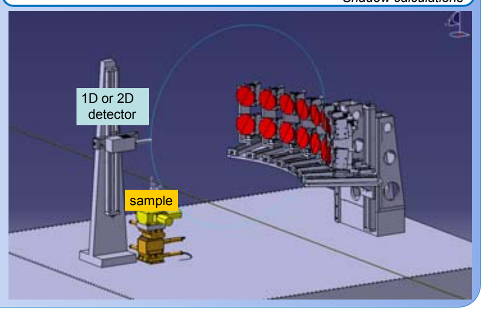
➢2 crystals

Shadow calculations

Width on detector:



Shadow calculations



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