In Vacuum HighResolutionMono with sub micro-radian resolution for IXS experiments at P01.

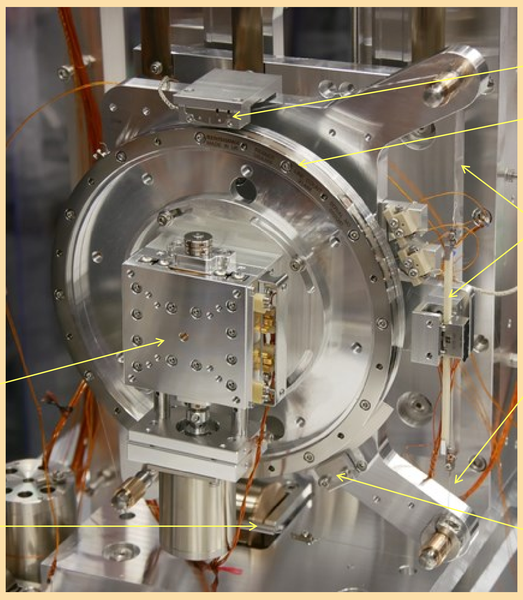
Frank-Uwe Dill, Hasan Yavas, Hlynur Gretarsson, Simon Mayer.

At Petra III Beamline P01 a High Resolution Monochromator for energies down to 2,5 keV was installed in June 2017.

High Precision Goniometer

Description of the concept

A high interpolating Encoder with 1nm resolution in combination with a long piezo driven rod is chosen to cover an angular range of 40 degrees with a resolution of better than 0,5 micro-rad (theoretically 10 nano-rad is possible) The maximal load of the high precision spindle ball bearing is 6 kg. All components must be compatible with a clean vacuum of $5x10^{-7}$ mbar.



Motivation

Due to high absorption of 2.5 keV photons in air (more than 99,9% at 100 mm) our high precision goniometers (three independent stages) for the high resolution monochromator had to be put into high vacuum (5x10-7 mbar). To our knowledge there is no vacuum compatible high precision goniometer at the market for this range of vacuum and for a load of 6kg.

High precision spindle ball bearing for 10^{-7}mbar

Housing
stainless steel
Ø38 mm
Length 120 mm

Ball Cage, bronze

Axial Bearings, bronze

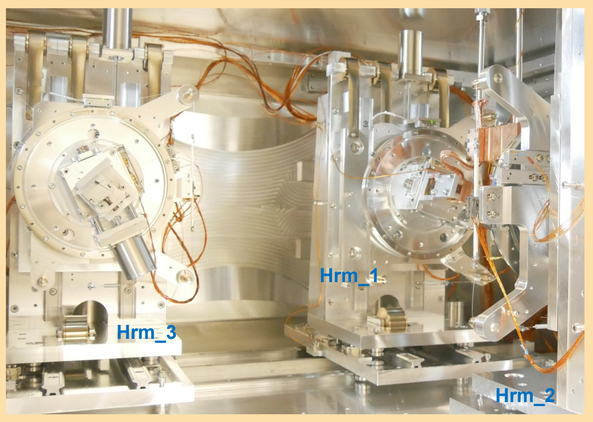
Balls
stainless steel, Ø3 mm

Shaft
stainless steel, Ø16 mm

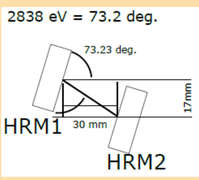
Original design by Hans-Bernhard Peters from ZM1-DESY

Concentric run-out: 1 micron
Axial run-out: 1 micron
Load: 6 kg max.

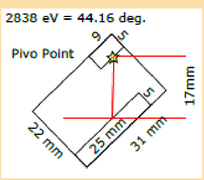
Complete setup 2 bounce (beam offset 17 mm)



Hrm_1 SiO (102)
Hrm_2 SiO (102)



Hrm_3 Si (111)



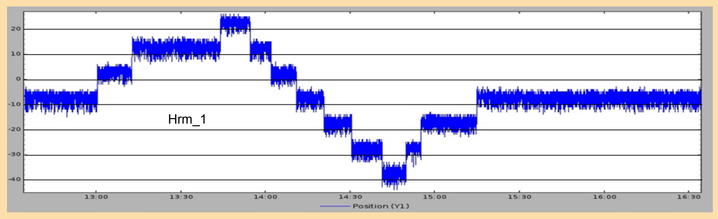
3 Setups with identical high resolution goniometers , x-y-z and tilt stages

(150meV energy resolution)

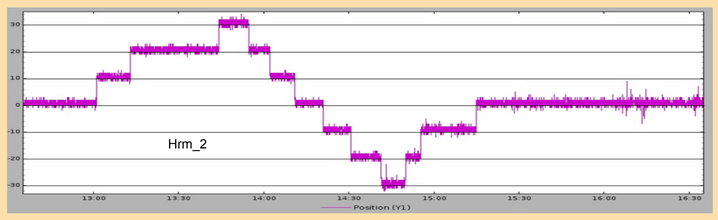
Resolution and stability of the 3 goniometers
(500 nanorad steps required)

100 nanorad steps over 4 hours (the scale shows 10 nanometer, with a radius of 0,1 m you get 100 nanorad)

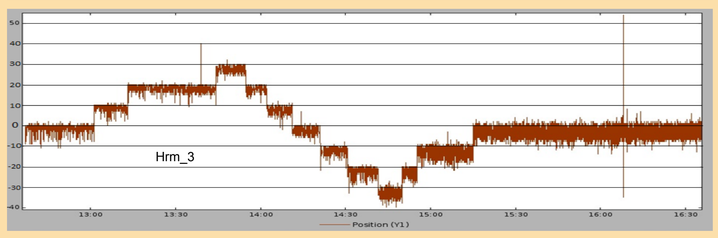
Hrm_1
Oszillation of +-50 nanorad over 4 hours
Offset of ~ -80 nanorad



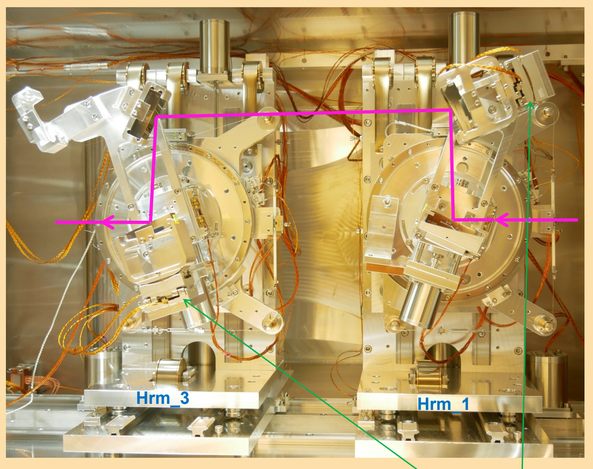
Hrm_2
Oszillation of +-20 nanorad over 4 hours
Offset of ~ 10 nanorad



Hrm_3
Oszillation of +-60 nanorad over 4 hours
Offset of ~ -50 nanorad



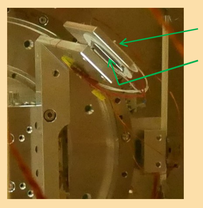
Complete setup 4 bounce (without beam offset / since end of April 2018)



Hrm_1 & Hrm_3 (identical crystals, mirrored)
(100meV energy resolution.)

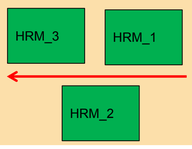
Setup 1 : 4 x Si (111) Bragg 44 deg, Asym 20 deg

Setup 2 : 2 x Si (111) Bragg 44 deg, Asym 30 deg
2 x Al2O3 Bragg 66.5 deg, Asym 54 deg

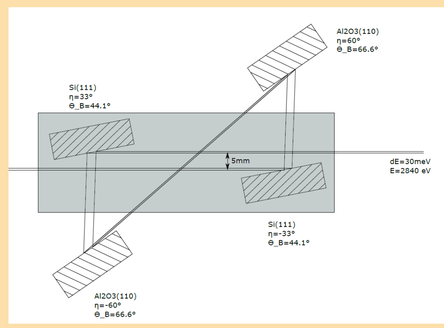


Hrm_2 with 2 PIN Diods form top and bottom side

additional 2-circle Piezo segments



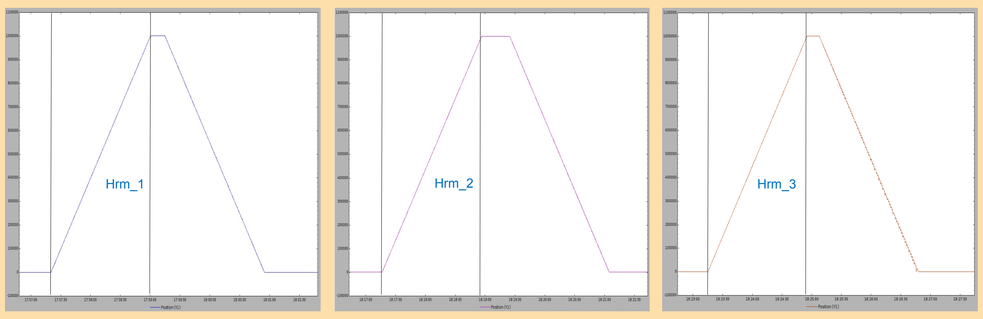
New Setup, planned to be installed in Oktober 2018
(30 meV energy resolution will be possible)

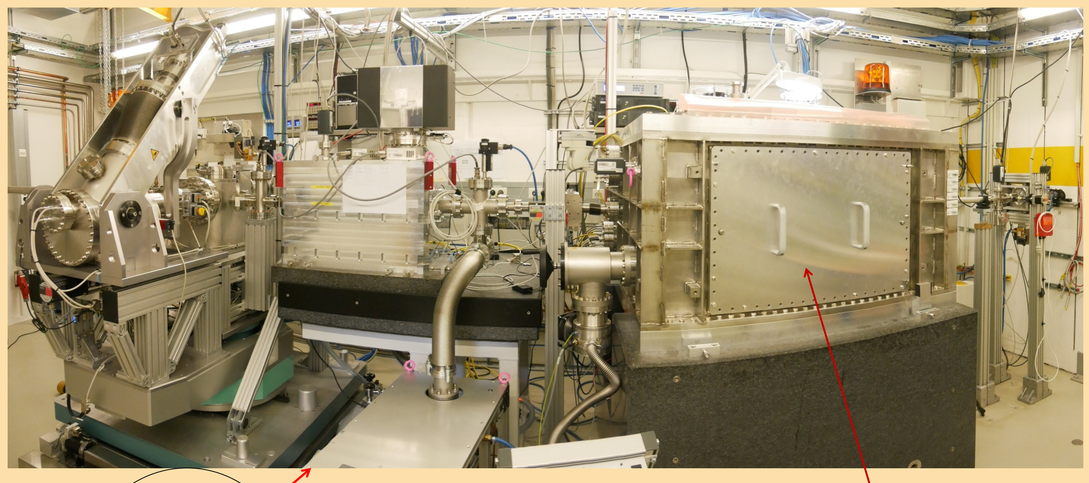


Angular speed

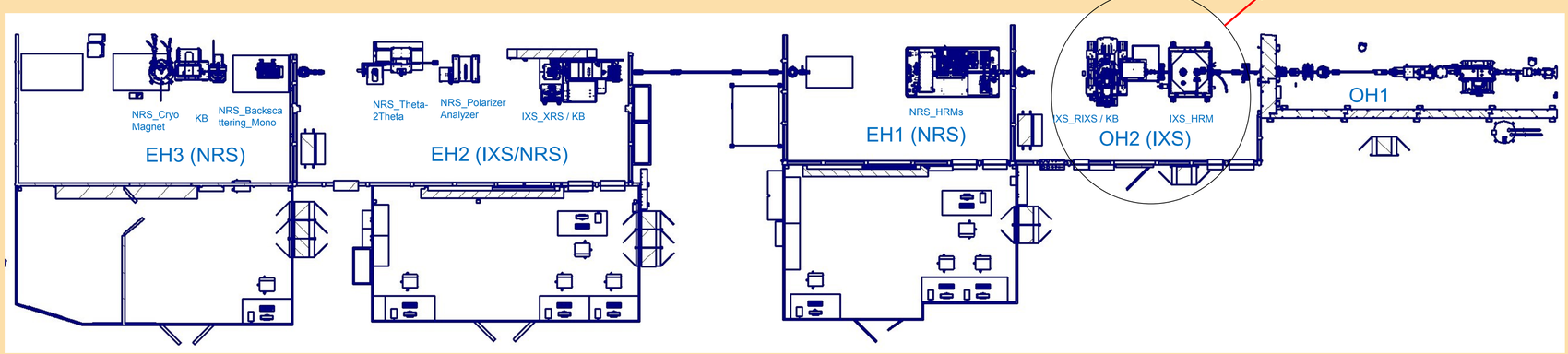
From 0 to 10 millirad in 100 sec

All three setups show almost the same behaviour





The Dynamics Beamline P01 is dedicated to Nuclear Resonant and Inelastic X-ray scattering experiments.



Vacuum Tank (1,4mx1,3mx0,8m)
Body: Stainless Steel
Base plate: Alu (70mm thickness)
Top plate . Alu (100mm thickness)

Vacuum
3,5 x 10-7mbar with two 300l Getterpumps
1,5 x 10-6mbar with 300l Turbopump

Contact: Frank-Uwe Dill, frank-uwe.dill@desy.de, Tel. +49 40 8998 4538,
Hlynur Gretarsson, hlynur.gretarsson@desy.de, Tel. +49 8998 4420