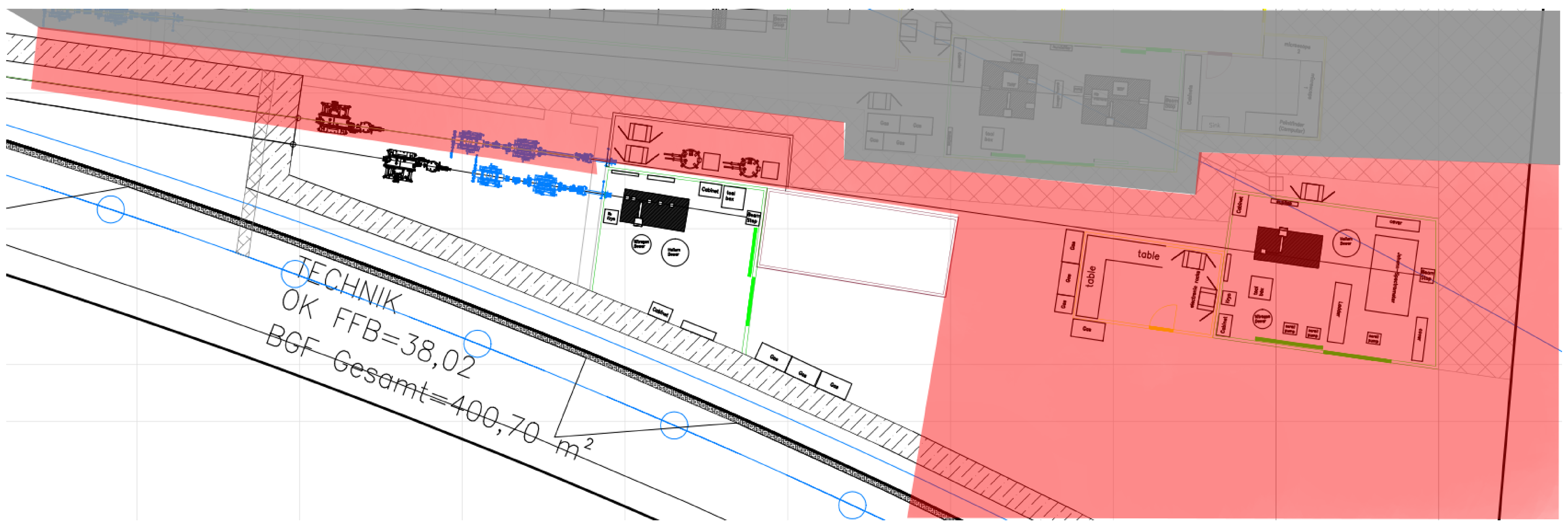
P65 a new beamline for standard XAFS at a small emittance storage ring.

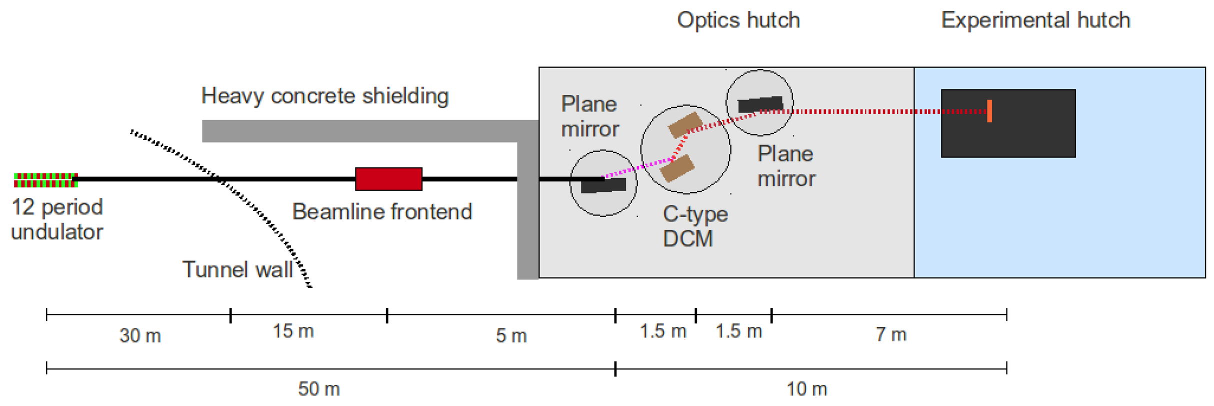
E. Welter, M. Herrmann, R. Chernikov

PETRA III extension: Beamline P65



Floor plan of beamline P65,

Petra III storage ring parameter:
Circumference: 2304 m
e- energy: 6.084 GeV
Ring current: 100 mA (top up mode)
Hor. Emittance: 1 nmrad



Schematic drawing of P65's main components

User demands / Beamline specifications

User demands:
- Large Samples, often inhomogeneous on µm scale
- Minimised radiation damage (Biological samples)
- "Simple" and stable set-up
- Photon flux larger than at DORIS III

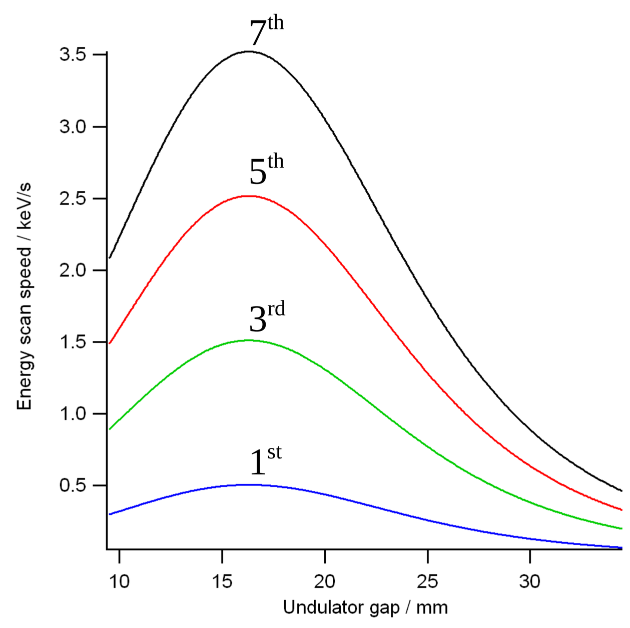
Internal boundary conditions:
- Re-use of C-type DCM (defines E-range + maximum power load)
- Storage ring properties (small emittance, high energy, large circumference)
- Available space

Resulting beamline specifications:
- Millimetre sized beam spot on sample
- No focusing mirrors
- Undulator source
- Photon flux > 10^{11} s^{-1}
- Energy range: 4 – 44 keV
- Easy to handle standard operating procedures for inexperienced users
- Complementary to P64 (see poster by W. Caliebe et al.)

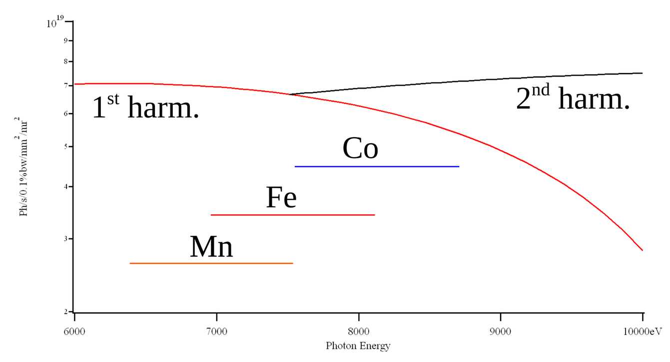
Source

- Storage ring properties exclude use of bending-magnet and wiggler radiation
- Maximum tolerable heat load on 1st DCM crystal ~2 W/mm²
- Energy range (2.4) 4 – 45 keV
- Beam size on sample in the mm² range
- Wide overlap between 1st and 3rd harmonic
- Minimum magnetic gap: 9.5 mm

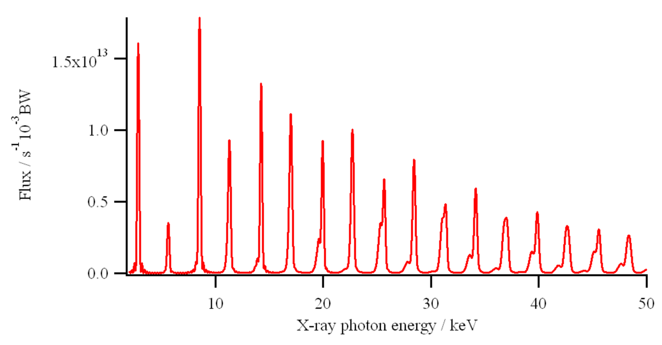
=> Period length: 32.0 mm
Number of periods: 12
Minimum magnetic gap: 9.5 mm
K_{max}: 2.6 (Magnetic gap 10.05 mm)



Maximum energy scan speed for U32.0 undulator



Brilliance of a 12 periods U32.0 undulator with K_{max} = 2.6 (magnetic gap 10.05 mm), overlap between 1st and 3rd harmonic and scan ranges of Mn, Fe and Co standard EXAFS scans.

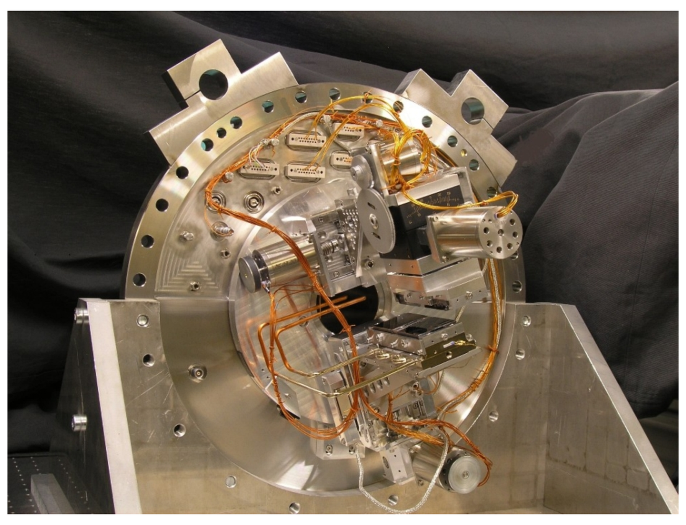


Flux through an aperture (1*2 mm²) in 60 m distance from a 12 periods U32.0 undulator with K tuned to 2.384 (5th harm. at 20000 eV)

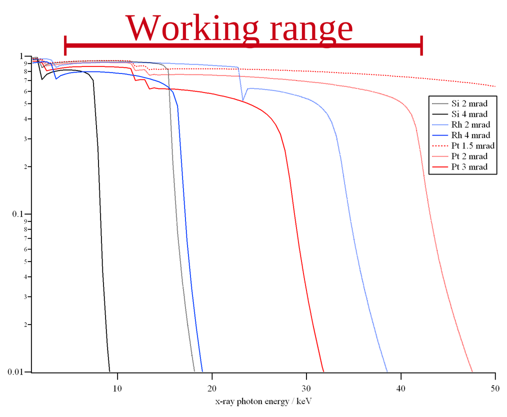
Beamline optics

Water cooled double crystal monochromator
- Si 111 and 311 crystal pairs (2.4 – 44 keV)
- Maximum acceptable power load: 2 W / mm²
-

2 plane mirrors
- 3 optical surfaces each (Si, Rh, Pt)
- Variable angle of incidence, 1.5 – 4.5 mrad for effective higher harmonics suppression
- First mirror acts as low pass filter to reduce power load of 1st DCM crystal



Photograph of the water cooled DCM



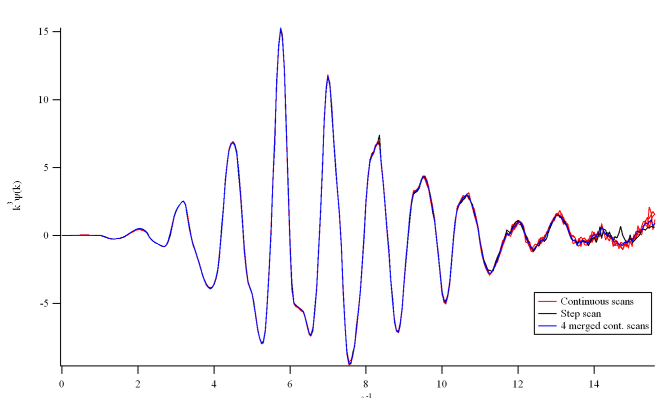
Cumulated reflectivity of two plane mirrors at varying angles of incidence. The presented reflectivities include the efect of a conservatively estimated value of 5 Å for the roughness of the mirror surface. The mirror in front of the DCM is reducing the power load on the 1st DCM crystal.

E / eV	K	Harm.	Mirror	Filter	Power load	Flux / 10^{12} mm^2 s^{-1}
4000	1.867	1	Si 4mrad	——	**0.56 W/mm²**	9.5
7516	2.600	3	Rh 4mrad	——	**1.22 W/mm²**	8.9
15000	2.306	3	Rh 4mrad	——	**1.27 W/mm²**	6.8
20000	2.384	7	Pt 3mrad	C 0.5 mm	**1.53 W/mm²**	4.4
30000	1.767	7	Pt 2mrad	C 2 mm	**1.63 W/mm²**	2.3
44000	1.578	9	Pt 1.8 mrad	C 2 mm	**1.54 W/mm²**	0.62
44000	1.867	11	Pt 1.8 mrad	C 2 mm	**1.87 W/mm²**	0.85

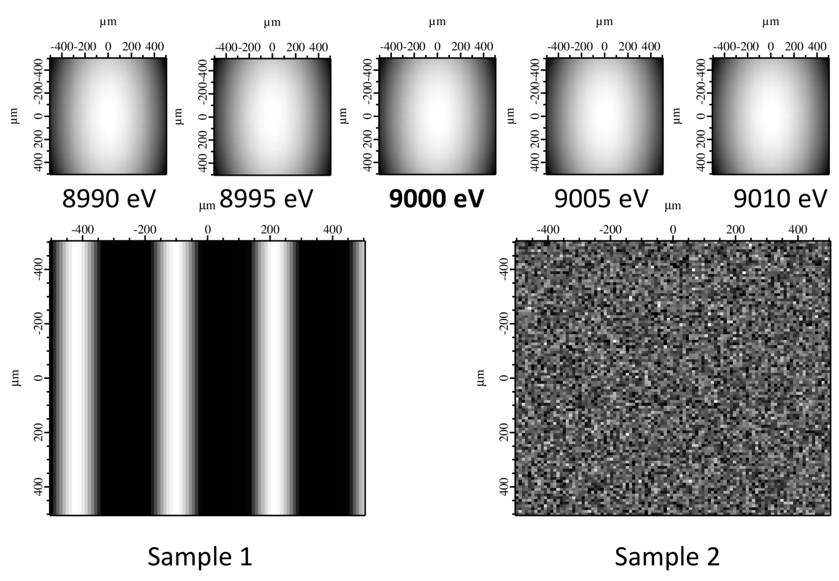
Powerload and flux-density (10^{-3} BW) on the 1st crystal of the DCM at different energies.

Scanmode

- Stepwise scans of the heavy undulator would very soon result in failures of the undulator mechanics.
- Undulator gap and DCM will be scanned in a continuous mode, the anticipated times per scan are between 1 and 5 min.
- DCM and undulator gap scans will be synchronised
- Synchronised gap scans already successfully tested at beamline P06, deviation between undulator and DCM energy < 2 eV at 9 keV



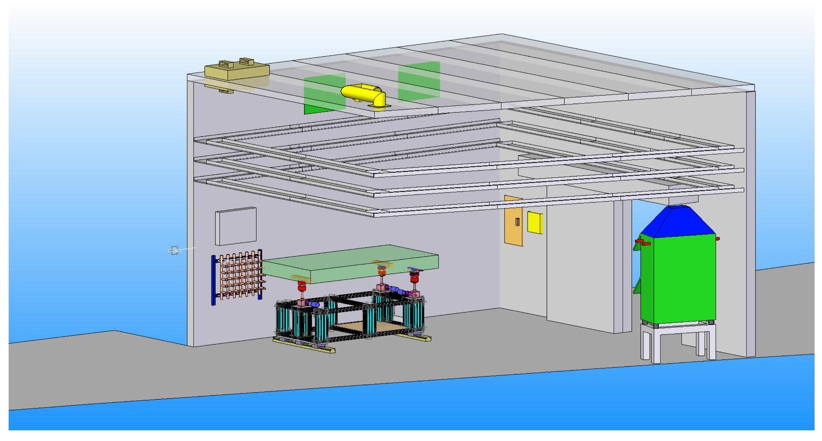
Test scans measured at DORIS III beamline A1.
Red: 4 continuous scans 400 s each.
Black: Conventional stepwise scan, scan time 1800 s.
Blue: Merged continuous scans (Scan time 1600 s)



Upper row: Intensity distributions (I0) at different DCM-energies and constant undulator gap
Lower row: Two 'samples' used for the simulation of the influence of deviations of the undulator gap tuning from the DCM-energy. The resulting Δµ was < 10^{-4}

Experimental hutch

- Large experimental table with standard EXAFS set-up
- Ample space for specialised in-situ set-ups
- Infrastructure for problematic gases
- Temperature stabilised to +/- 1° C
- Experimental table: 2.5 * 1.2 m²
- Detectors: Ionisation chambers, PIPS, energydispersive semi-conductor detectors



CAD drawing of the experimental hutch of beamline P65. Visible are the experimental table, and the air-conditiong system. The size of the hutch is approximately 30 m², the height of the ceiling ~4m.

Photograph of the set-up at the currently operational DORIS III beamline C. The complete set-up will be re-used in the experimental hutch of P65

Sample preparation lab
A sample preparation lab will be shared with beamline P64. It will be adjacent to the 2 beamline's experimental hutches and contain a fume hut, a glove box, lab benches and equipment for sample preparation like an analytical balance and a pellet press