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The Split-and-Delay Unit for the HED Instrument

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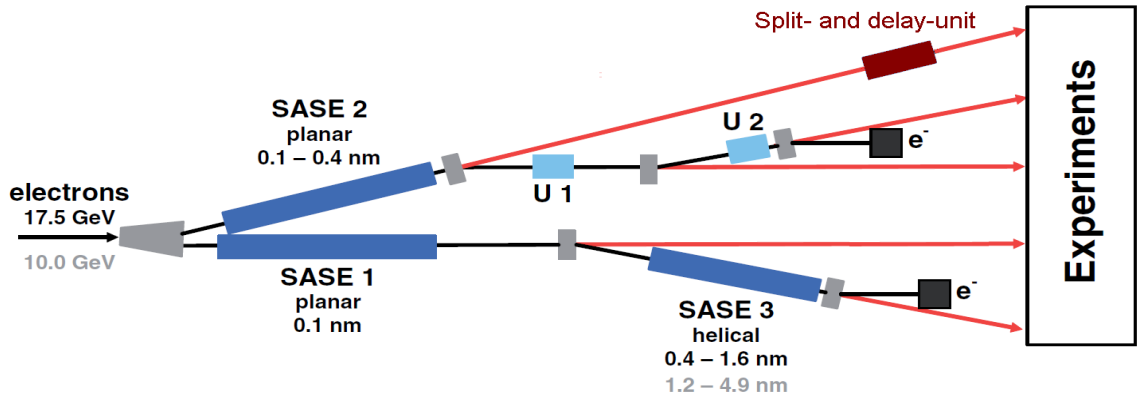
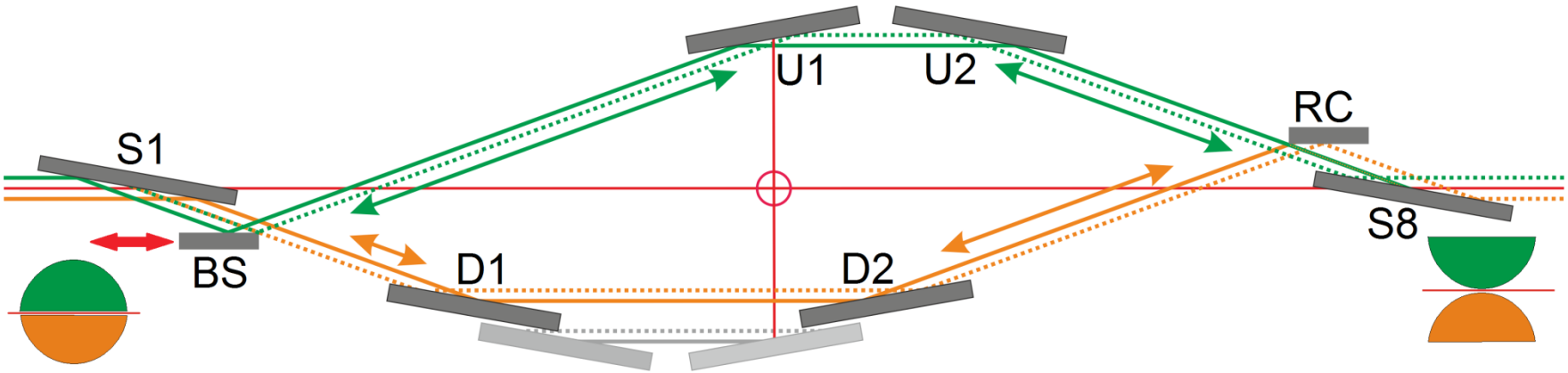
Requirements

- wide photon energy range (5 keV – 24 keV)
- high transmission (~ 30% - 60 %)
- transmission of the whole beam profile
- maximum delays on the order of picoseconds
- sub-100 as resolution (t_{coh} ~ 200 as)
- variable splitting ratio
- two-color pump/probe experiments with fundamental and third harmonic radiation

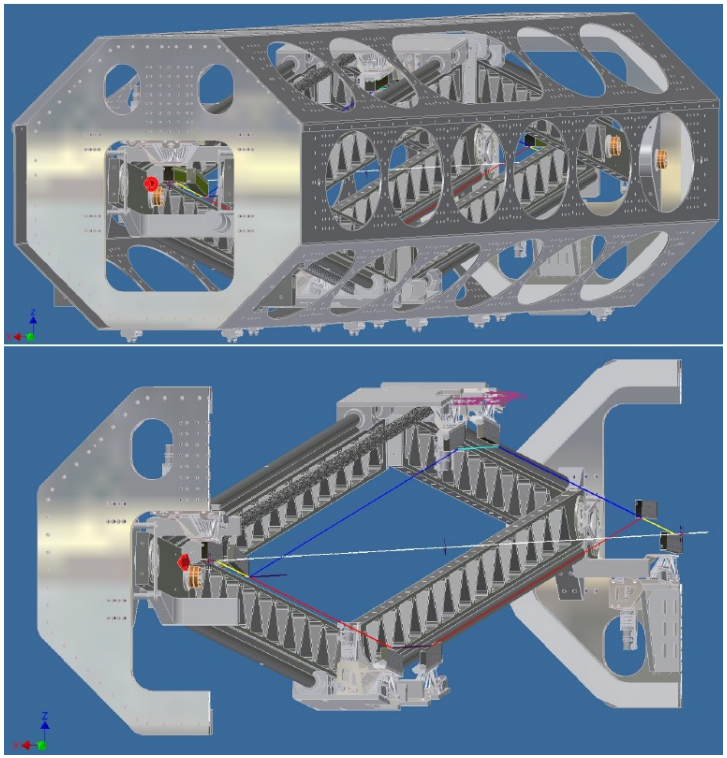


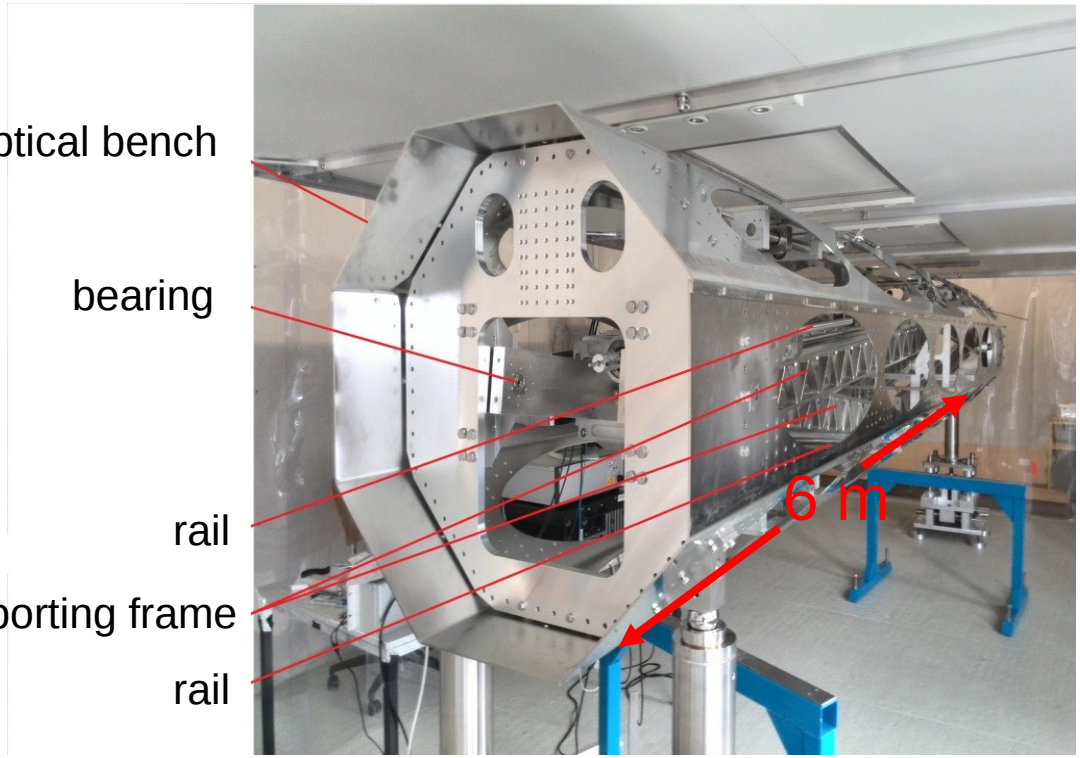
Optical Concept



- point symmetrical concept in one plane
- multilayer mirrors enable steeper reflection angles
- Bragg-angle depends on the photon energy
- mirrors move along the separated beams
- odd number of reflections (beam profile turned by 180°)
- Bragg-angle of BS and RC twice as large compared to the other mirrors
- variation of the splitting ratio: horizontal motion of BS

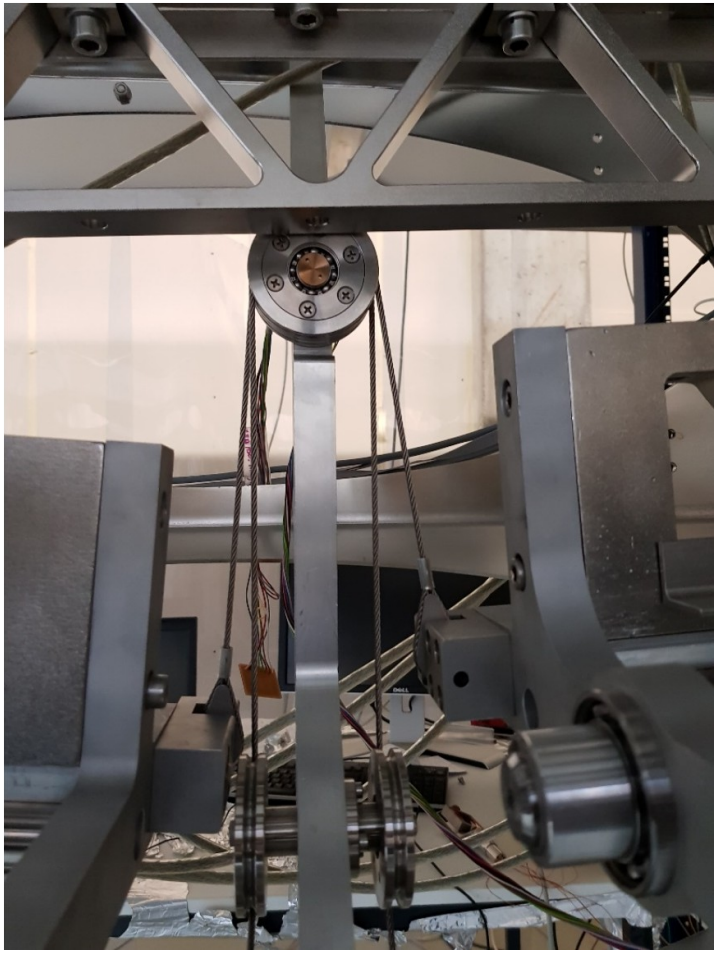
Mechanical Layout

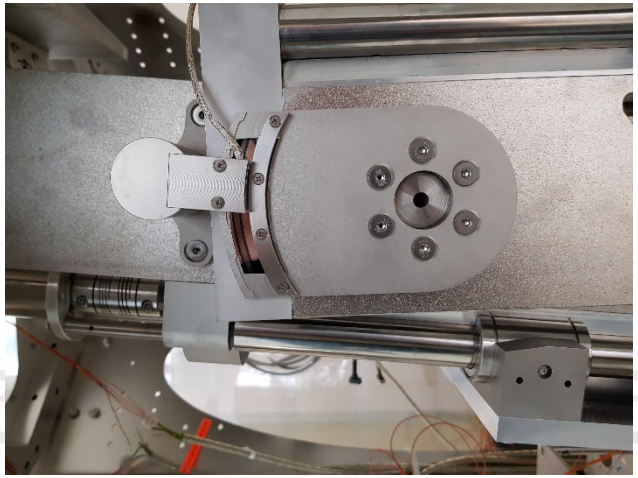




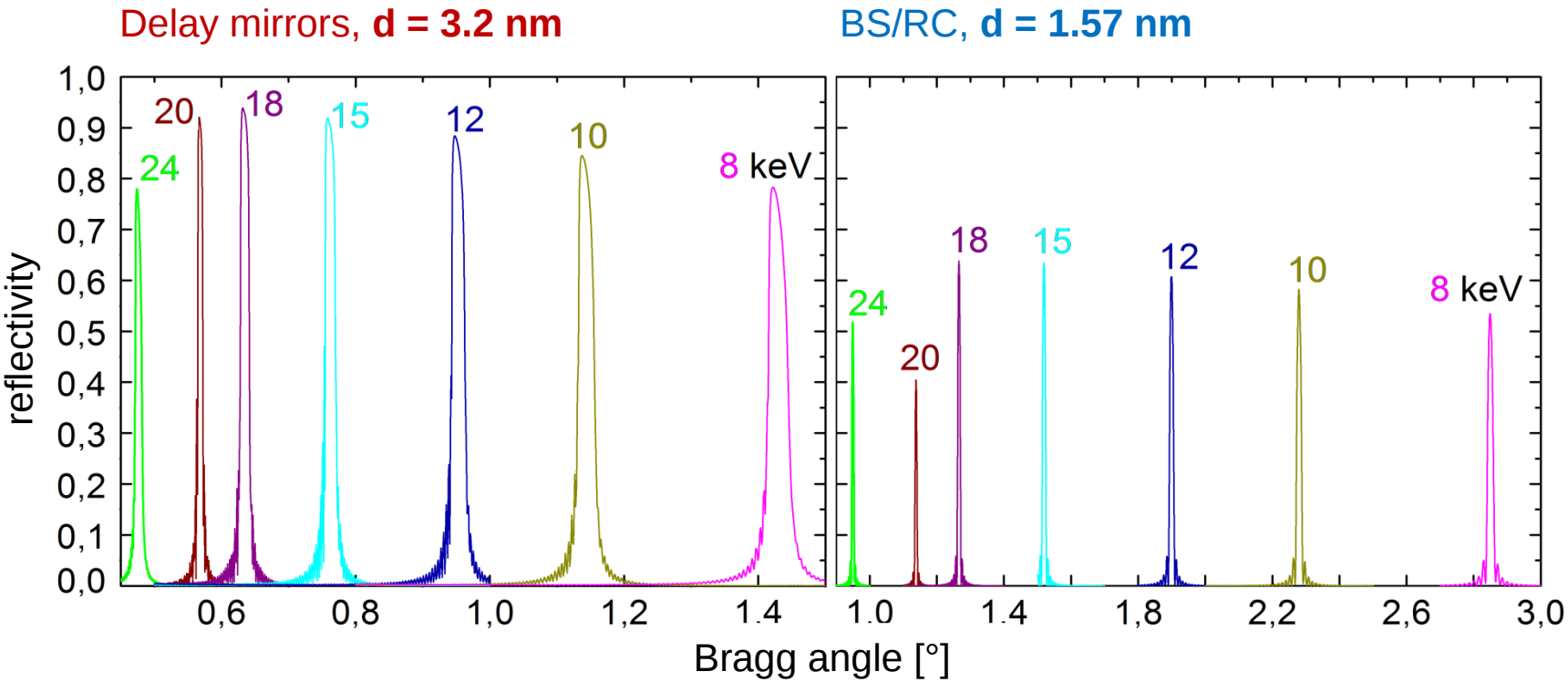
- all components are mounted inside the optical bench
- octagonal structure – increased sturdyness
- mirrors move along guiding rails
- motion of L = 10 µm ⟶ t = 13 as (at 0.56°, 20 keV)

Mechanical Layout



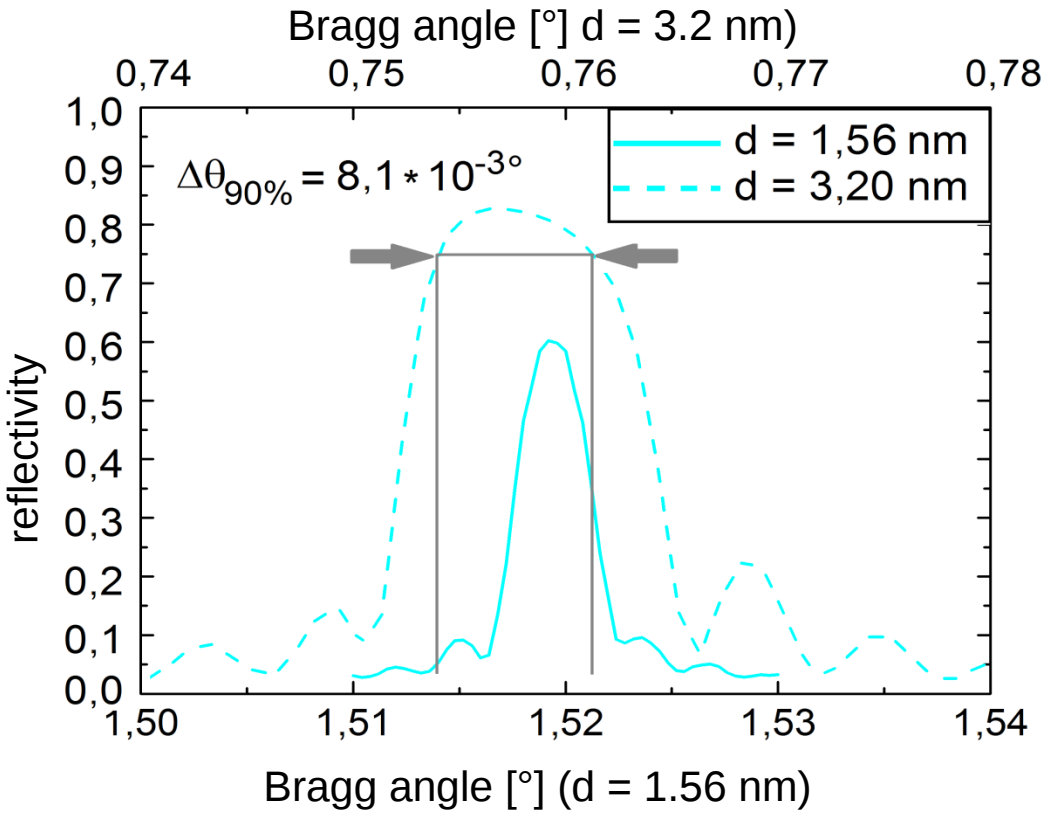


Multilayer Mirrors



- Mo/B_4C multilayer coating on silicon substrates

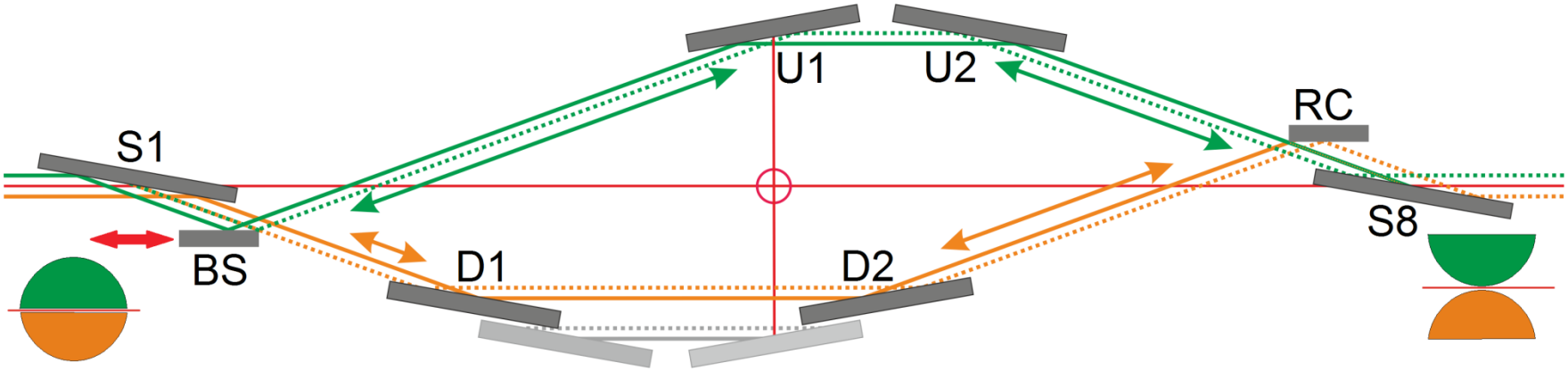
Multilayer Mirrors



- Mo/B_4C multilayer coatings on silicon substrate
- acceptance delay mirrors: 141 µrad
- acceptance BS and RC: 33 µrad

Two-color pump/probe experiments

- two-color pump/probe experiments with fundamental and third harmonic
- fundamental in one beam path, third harmonic in the other



- mirror S1 and S8 have to reflect both photon energies at the same Bragg angle

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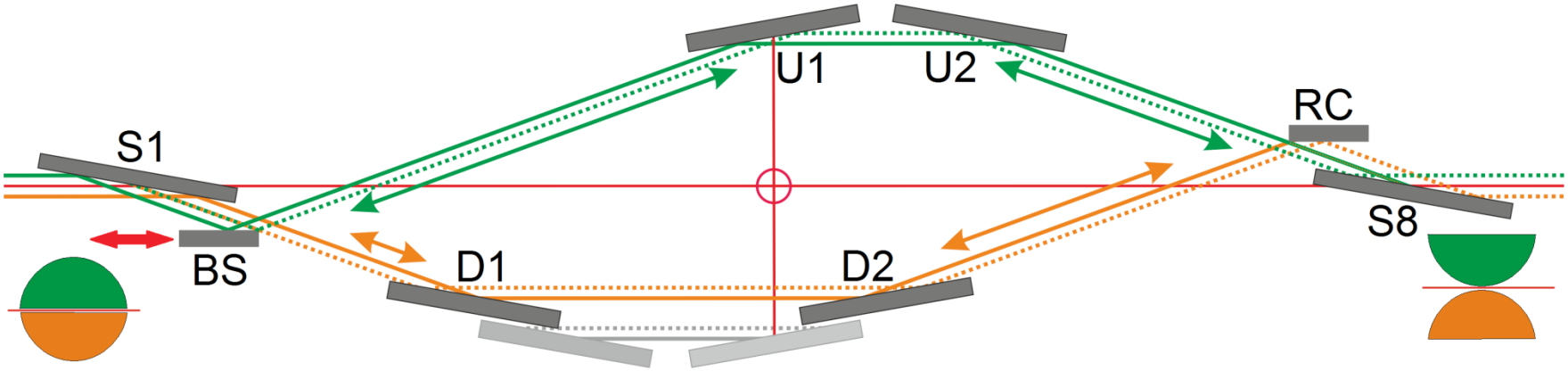
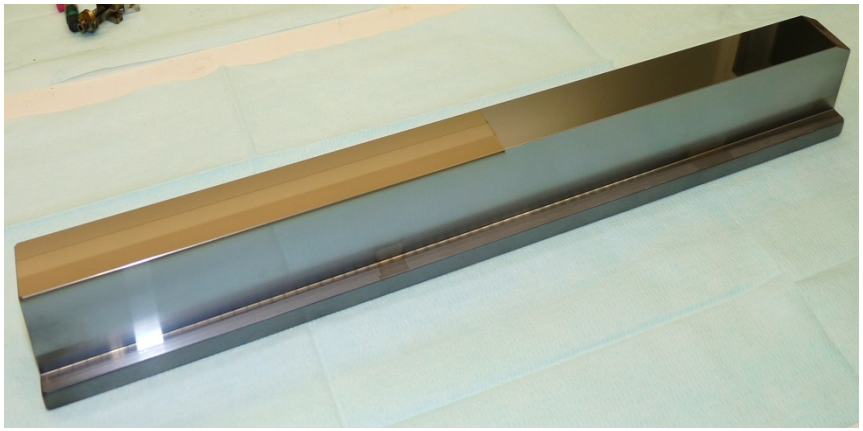


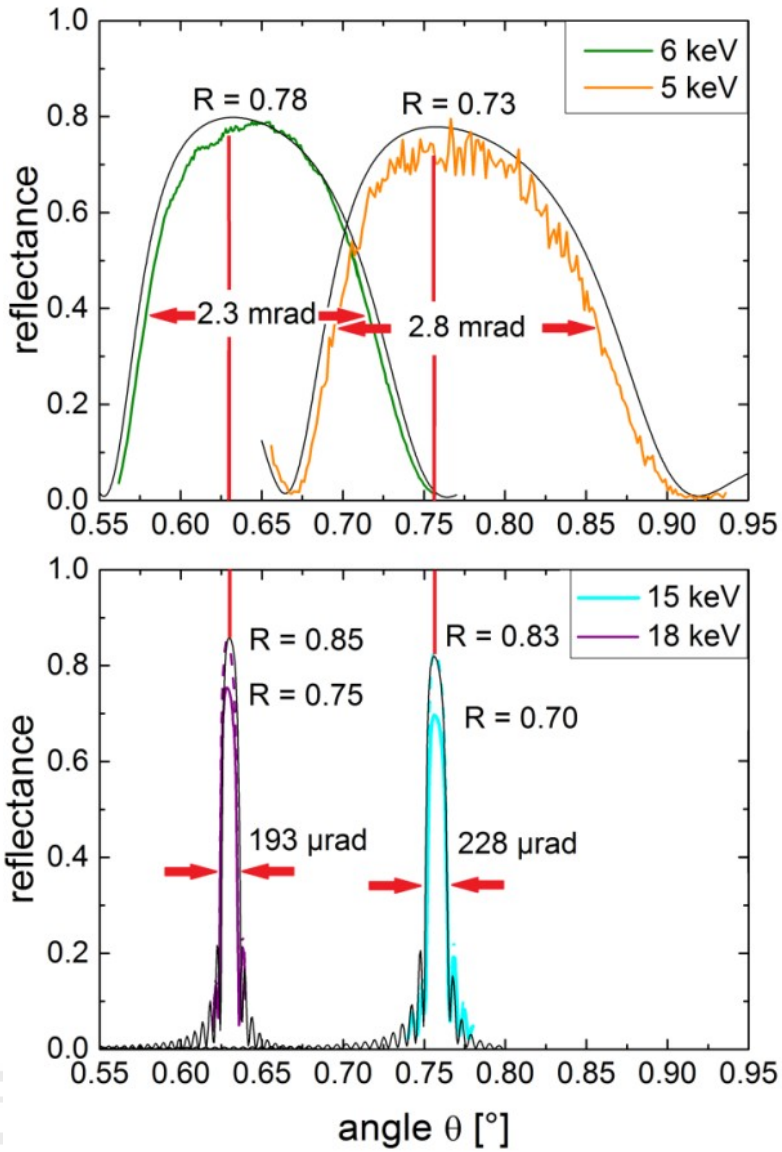
- mirror S1 and S8 have to reflect both photon energies at the same Bragg angle
- **novel two-color multilayer coating**

Two-color pump/probe experiments

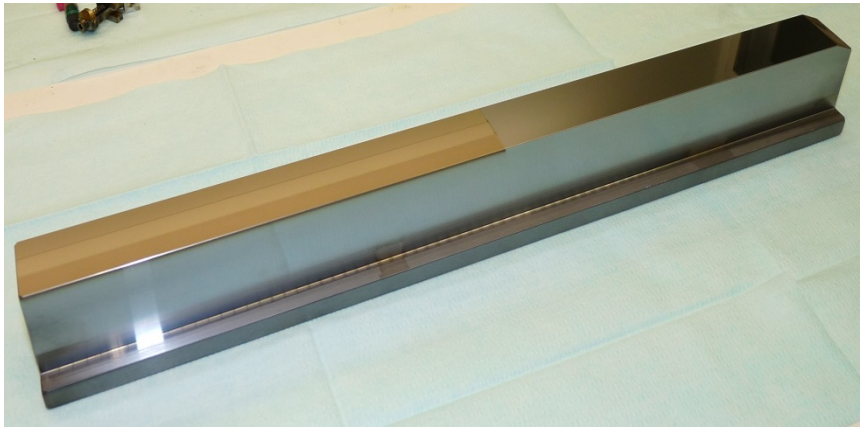
- third coating (two-color) on S1 and S8
- two coatings on top of each other
- fundamental (5 keV – 6.6 keV) is reflected by 4 layers of Ni/B_4C (d = 11.85 nm)
- third harmonic (15 keV – 20 keV) passes the Ni/B_4C system and is reflected by 120 layers of Mo/B_4C (d = 3.2 nm)



Two-color pump/probe experiments



- measurement performed at BM05 at ESRF
- both, fundamental and third harmonic are reflected at the same angle

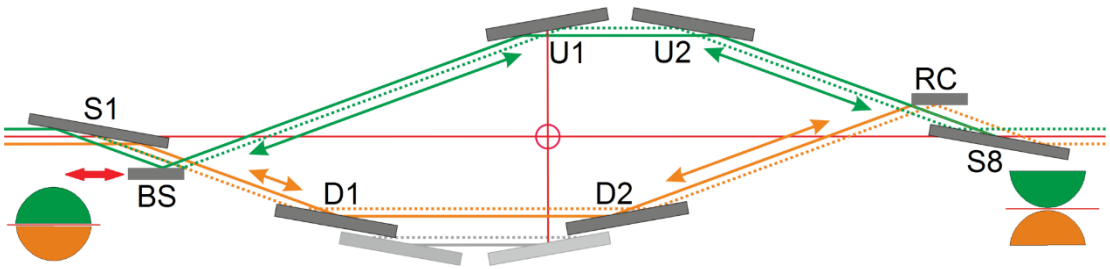


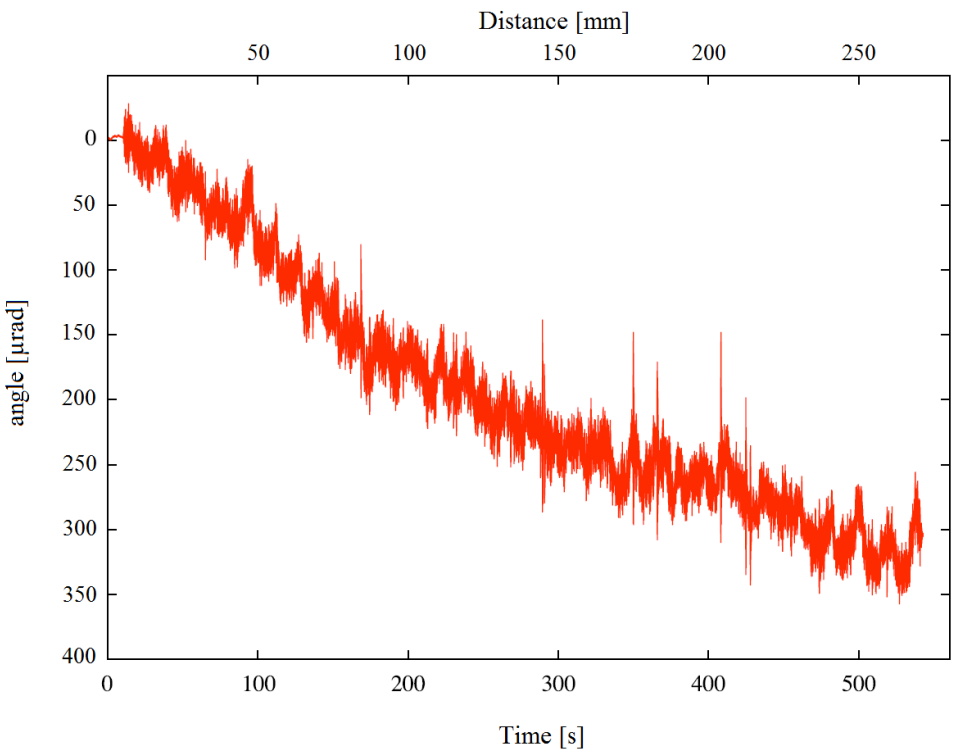
S. Roling et al., Tunable two-color hard x-ray multilayer Bragg mirrors, Opt. Lett. **39**, 2782 (2014)

Performance

Photon energy [keV]	Multilayer Top-Material	Delay [ps]	Transmission
4	Ni	32	0,16
5	**Ni**	**20**	**0,23**
6	**Ni**	**14**	**0,33**
8	**Ni**	**8**	**0,47**
10	**Ni**	**5**	**0,21**
10	**Mo**	**8**	**0,29**
12	**Mo**	**5**	**0,35**
15	**Mo**	**3**	**0,41**
18	**Mo**	**2.5**	**0,43**
20	**Mo**	**2.3**	**0,23**
24	**Ni**	**0.8**	**0,61**

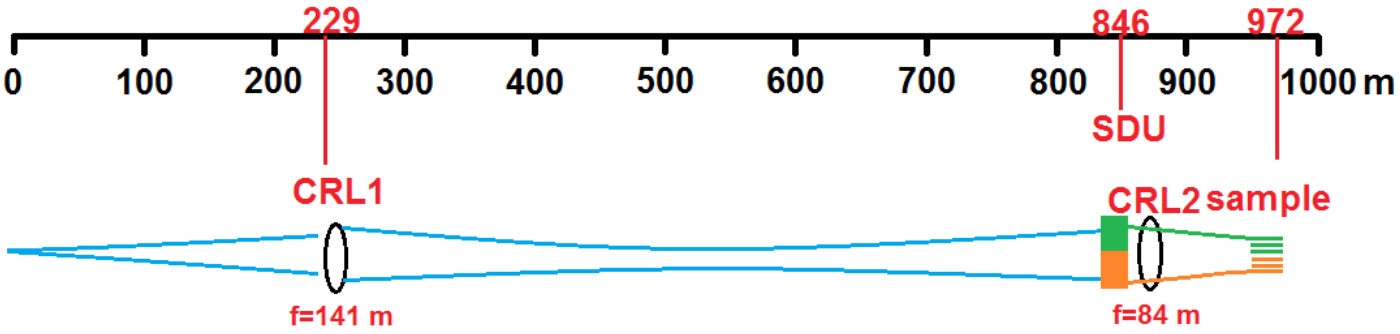
Mirror Re-Adjustment





- non-ideal motion along guide-rails
- parasitic angle ϑ
- overlap of both beams has to be guaranteed

Mirror Re-Adjustment



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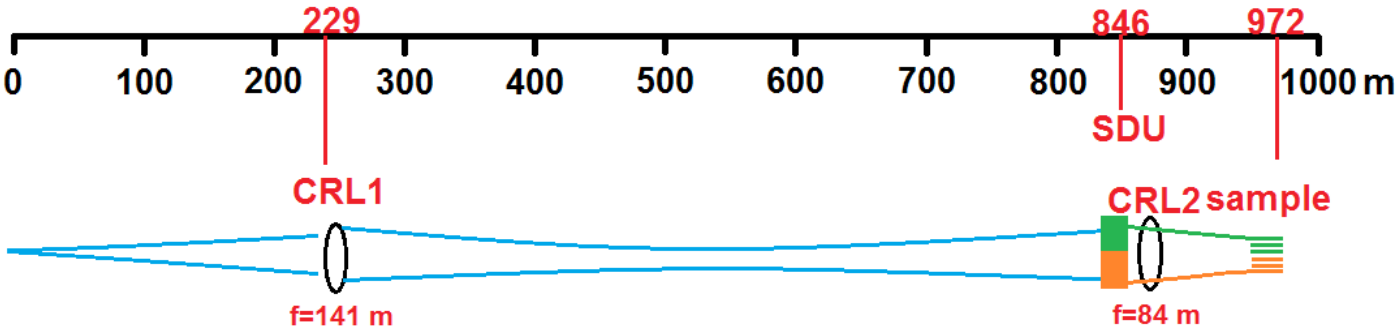
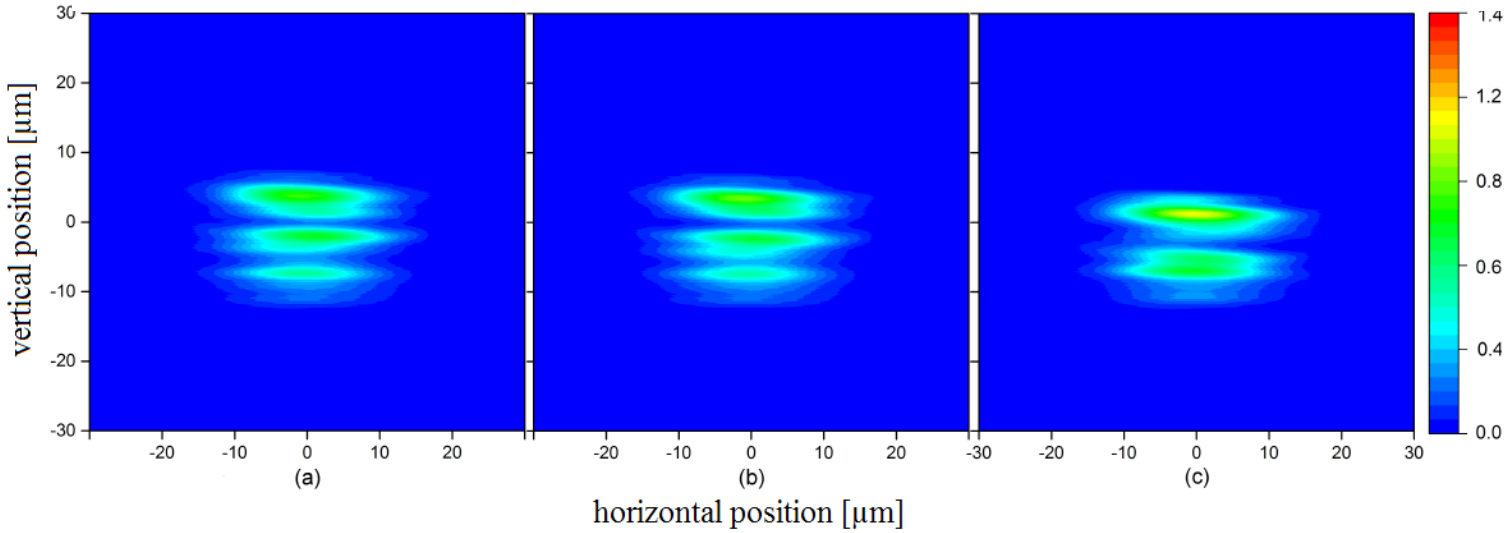
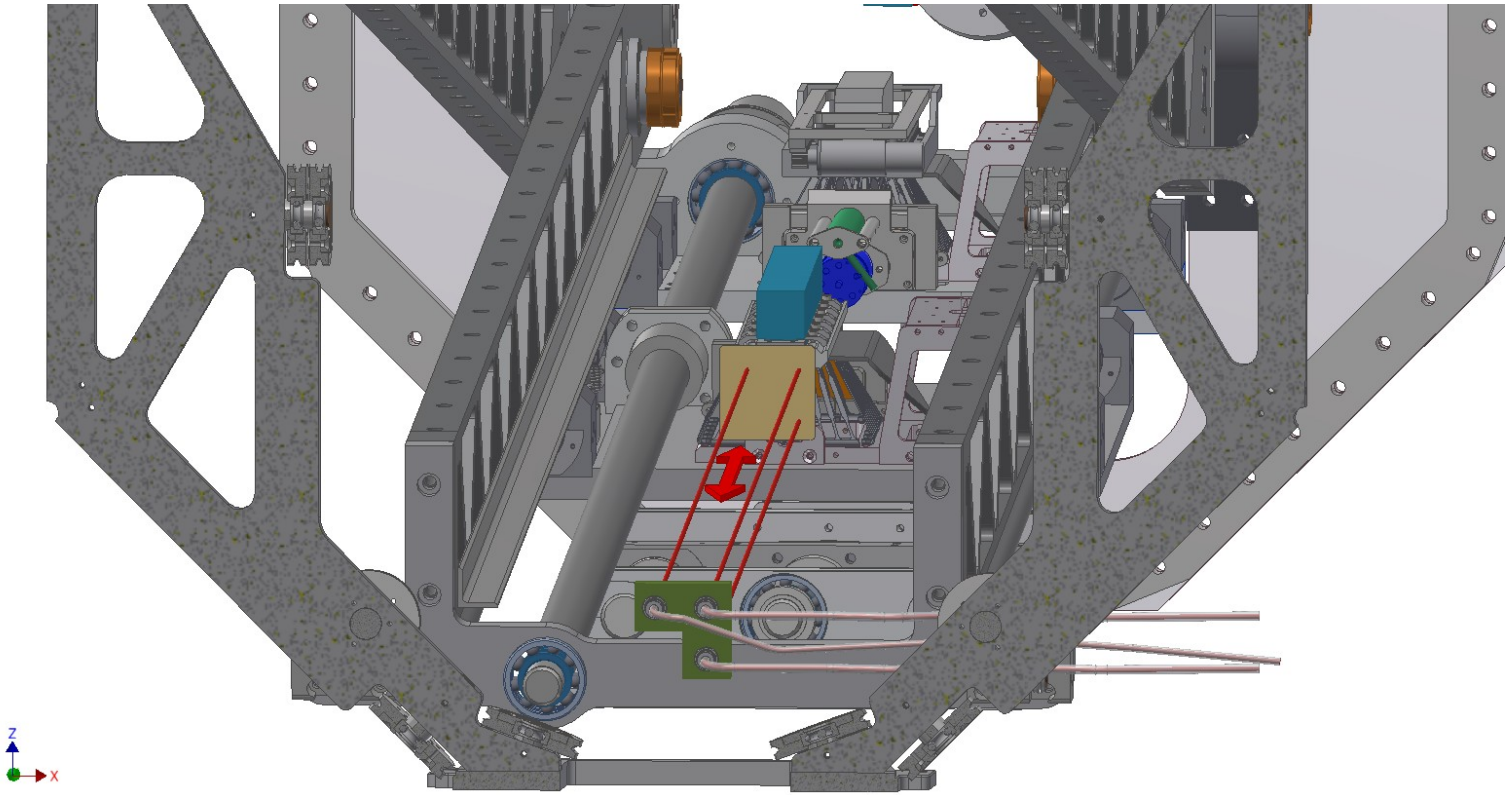




$\Delta\vartheta = 0$ nrad $\Delta\vartheta = 50$ nrad $\Delta\vartheta = 300$ nrad

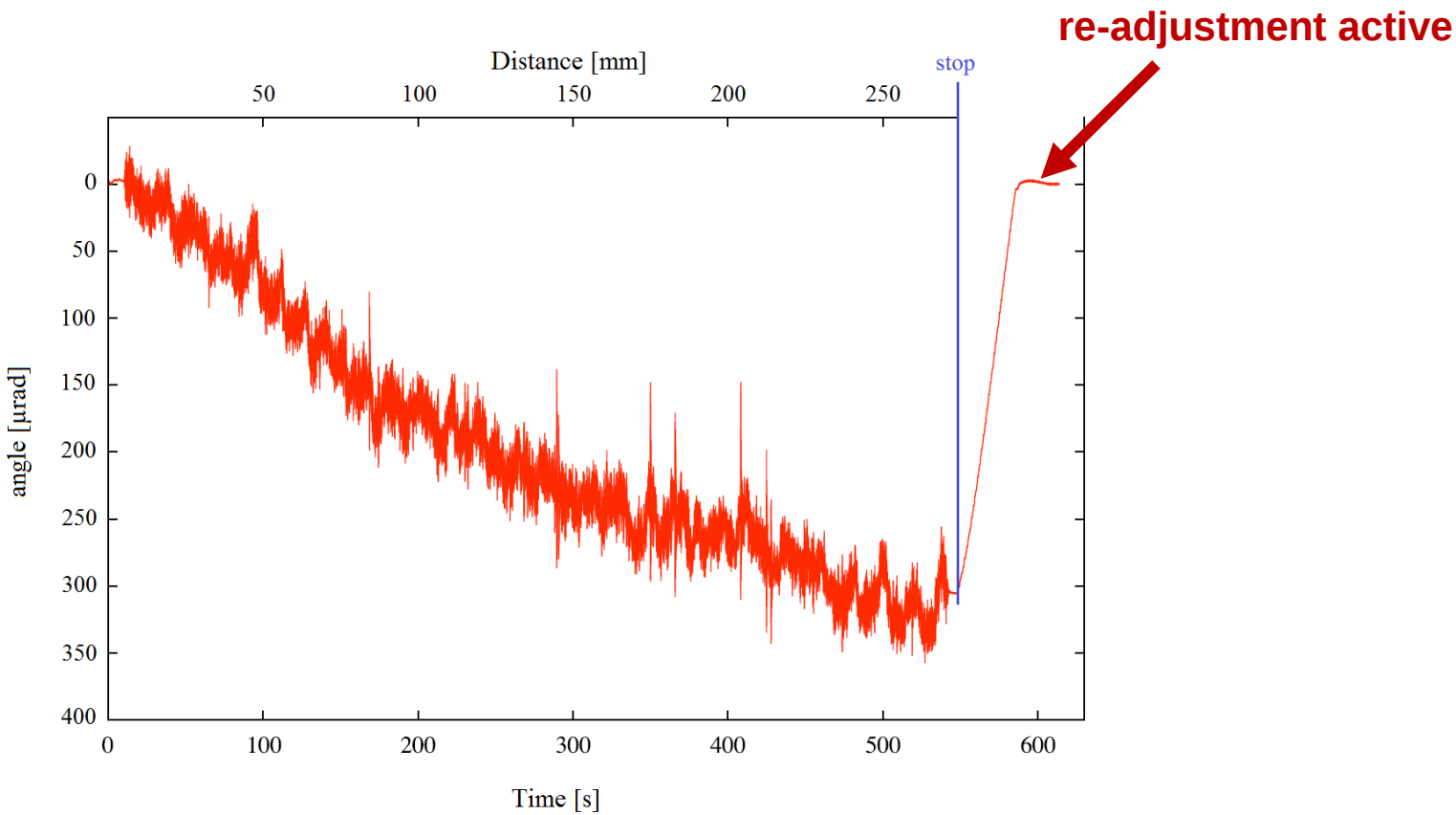
$\vartheta = 100$ mrad → $y = 0.9$ µm

Mirror Re-Adjustment



- 3-axis interferometer
- feedback loop
- piezo actuator for correction of angle ϑ

Mirror Re-Adjustment



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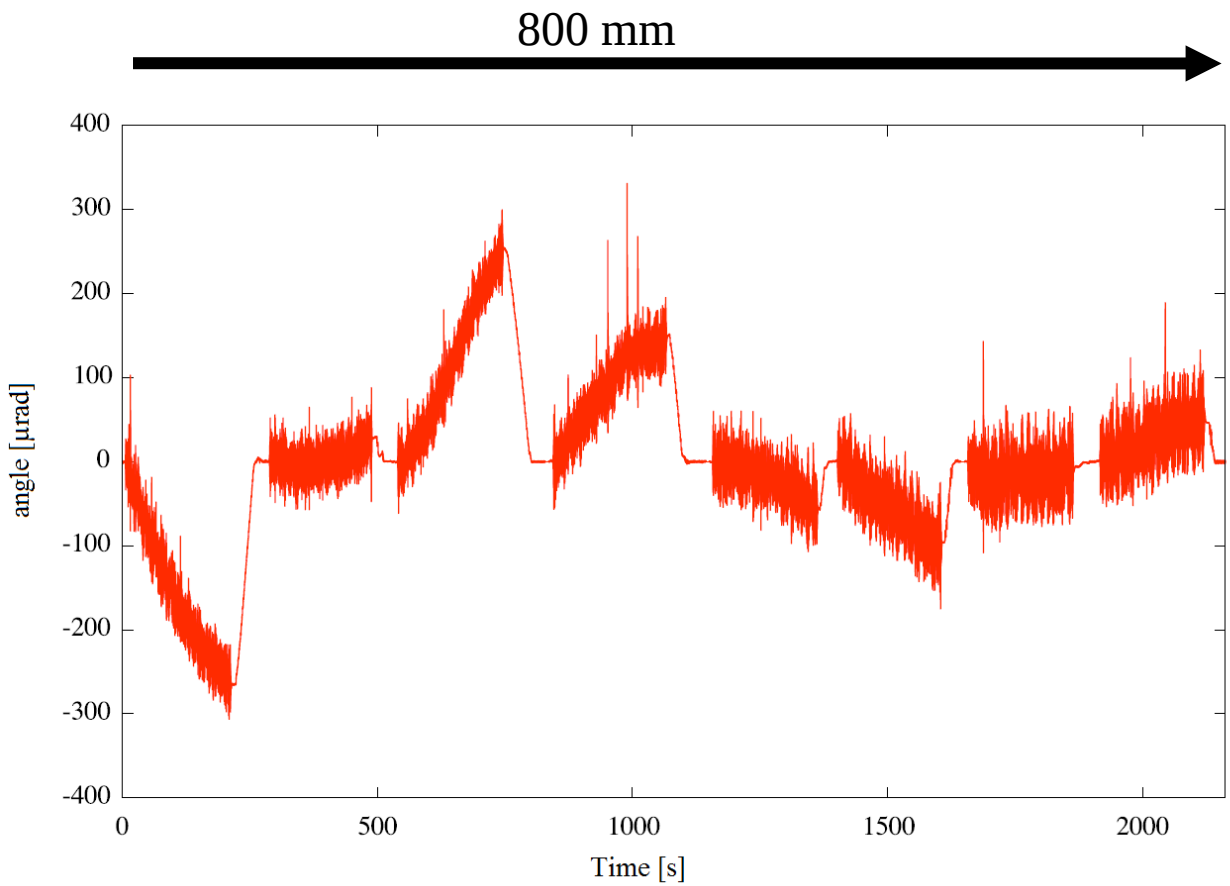

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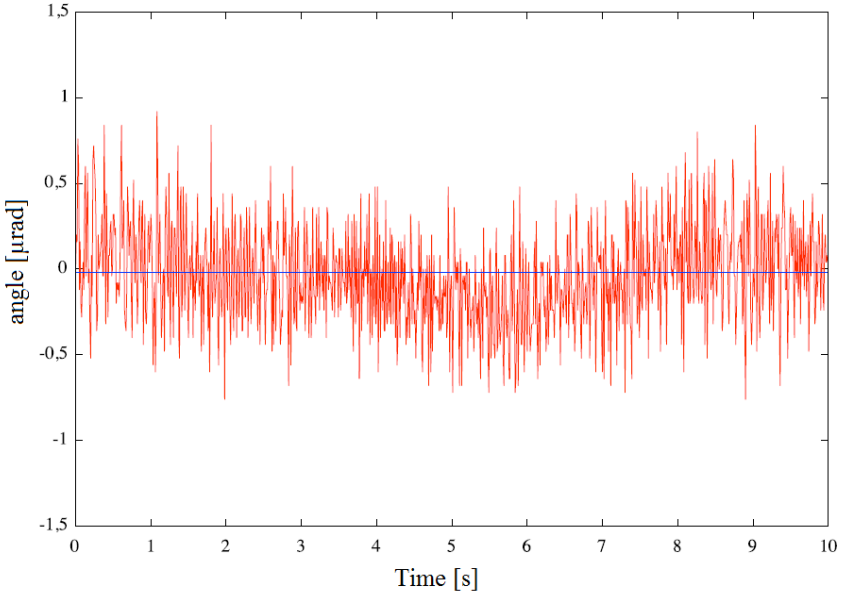
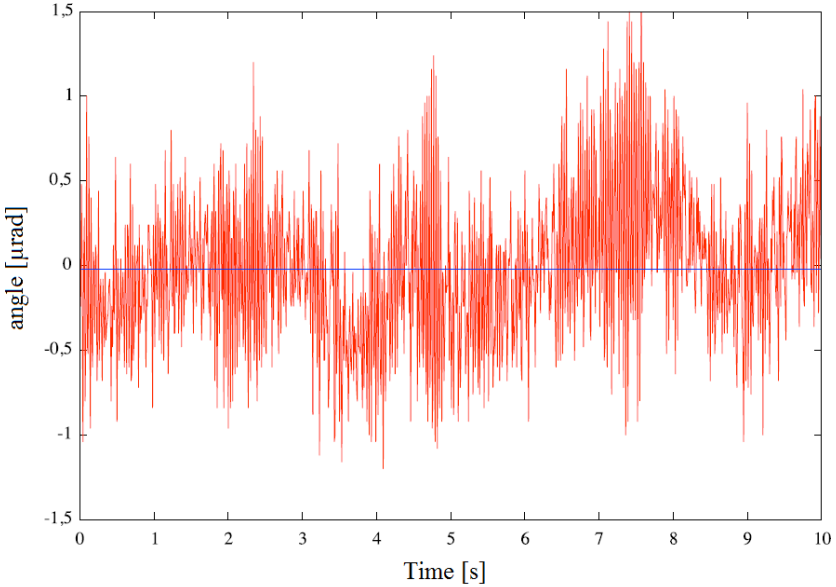


$$\bar{\vartheta} = -16,9\,\text{nrad}$$

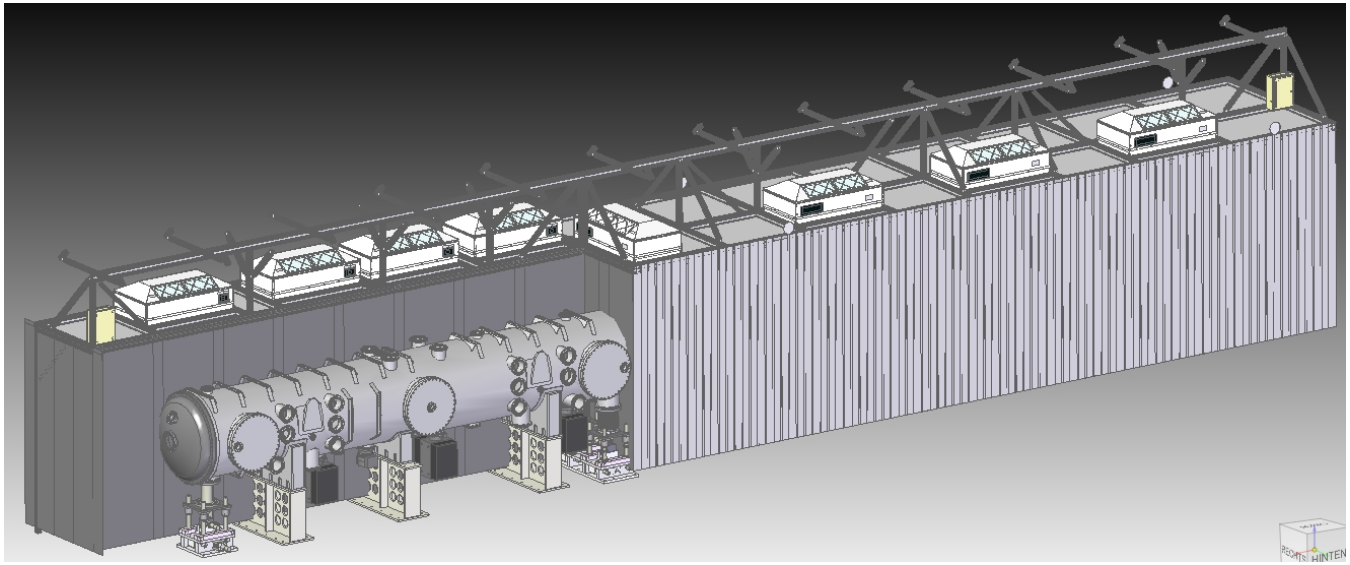
$$\sigma = 29,5\,\text{nrad}$$



$$\bar{\vartheta} = -20,2\,\text{nrad}$$

$$\sigma = 47,9\,\text{nrad}$$

Work to be done



- limit switches
- set up clean-room tent
- installation
- commissioning

Special thanks to the people involved:

H. Zacharias, F. Wahlert, M. Rollnik, V. Kärcher (University of Münster)

K. Appel, U. Zastrau, Th. Tschentscher, H. Sinn, L. Samoylova, N. Kohlststrunk, Ph. Schneider (European XFEL)

F. Siewert (Helmholtz-Zentrum Berlin für Materialien und Energie)

P. Gawlitza (Fraunhofer IWS Dresden)
St. Braun (Westsächsische Hochschule Zwickau)

Funding by the BMBF is gratefully acknowledged (Projects: 05K13PM1, 05K16PM2)

Thank you for your attention!