

# K-Monochromator for Undulator Commissioning at the European XFEL

X-Ray Photon Diagnostics Group (WP74)

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sCMOS \_\_\_\_

### Introduction

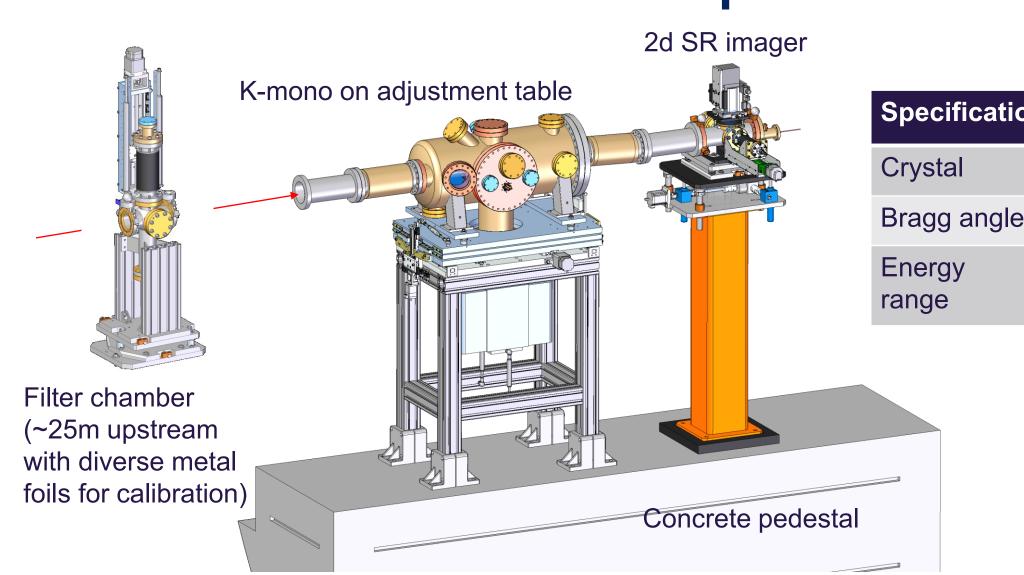
At the European X-ray Free Electron Laser facility (XFEL.EU) one- or two-Si(111) channel (cut) crystal X-ray monochromators (K-Monochromator) [1] are planned for photon beam based alignment: gap tuning of the undulator segments and phase tuning of the phase shifters during commissioning and maintenance of the undulators.

This poster presents the setup of the SASE1 K-mono system and the results from the experimental qualification of the K-monochromator prototype using a single channel-cut crystal.

### Tasks of the K-monochromator:

- Gap tuning method or the relative adjustment of undulator segments [2, 3, 4]: measure photon energy of spontaneous radiation of each undulator segment, to calculate and adjust the K-parameters within an accuracy required for FEL operation
- Phase tuning [2]: intensity optimization by adjustment of the phase shifters between two adjacent segments
- Energy at mid-slope [3]: spectral measurements of spontaneous radiation by scanning the electron energy in order to reduce mismatch of K-parameter between undulator segment pairs
- Trajectory adjustment [2]: spatial evaluation of higher harmonics of the spontaneous radiation, which have a smaller divergence than the fundamental

### K-mono for SASE1 – setup



**Specifications** Si(111) double channel-cut Bragg angle 7° to 55° 2.5-16 keV for Si(111) 7.5 to 48 keV for Si(333)

Precision

CAD model of K-mono system in tunnel Shielding plate optical encoder

K-mono chassis

chassis 2-bounce beam Huber goniometer with 4-bounce beam Si (111) channel-cut monochromator stage X-ray beam from Undu ators Water cooling CAD model of K-monochromator

(2-bounce position) Actual status of subsystems



Position of K-Mono in the tunnel Some tunnel cleaning and infrastructure installation pending



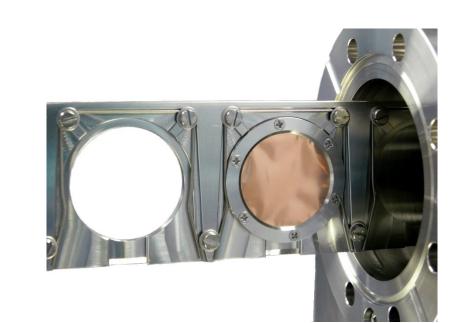
K-Mono with control crate – ready for installation

### 2D spontaneous radiation imager (SR-imager) camera Requirements on SR Imager: Field of view 27 mm tandem Spatial resolution, fwhm 25 μm lens Signal gain and noise adapted for single pulse images of system spontaneous radiation Repetition rate > 10 Hz x-ray beam Determination of low intensity ring structures, pulse signal towards detector appr. 10<sup>2</sup> ph peak / 30 μm pixel, Si(111), 12 keV, 14 GeV scintillator vacuum Design (low noise, large aperture, high gain): chamber Scintillator + Mirror + optics + sCMOS. Scientific CMOS camera Scintillator Gd<sub>2</sub>O<sub>2</sub>S:Pr ceramic and YAG:Ce 2 Mpixel Tandem lens design for large aperture imaging, NA = 0.17 0.9 e- readout noise (Schneider 2.0/110 – Leica 1.4/50) Dark current 0.5 e-/pixel/s 16 bit sCMOS camera Photonic Science Tandem lens system Noise equivalent signal: 2 ph, 12 keV magnification factor 0.47 Effective f ∞ -number 0.95 Scintillator holder 3 scintillators / PIN diode SR beam FEL beam Scintillator manipulator Spontaneous radiation of two undulator segments: kick method [4] Simulation: courtesy of J. Rehanek / HZB

**SR-imager status**: Optical parts in house Vacuum system ordered

> Filter foils for energy calibration Thickness K-edge / eV Material (1559.6)Aluminum  $2.5 \, \mu m$ (visible light blocker) 5989 5 µm Chromium 10 µm 7709 Copper Nickel 8333 5 µm Molybdenum 20000 20 µm

CAD model of the SR imager



### Test results at PETRA III

see: Proc. of SPIE 8504, Initial Evaluation of the European XFEL Undulator Commissioning Spectrometer with a Single Channel-Cut Crystal, 85040X-7: doi: 10.1117/12.929755

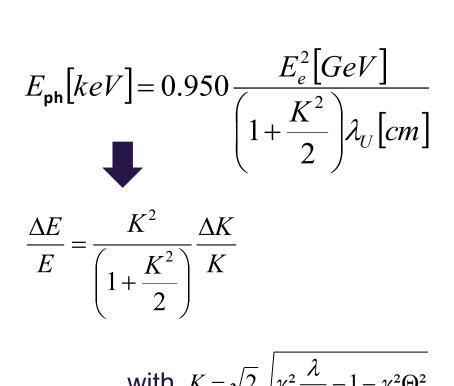
### **K-determination**

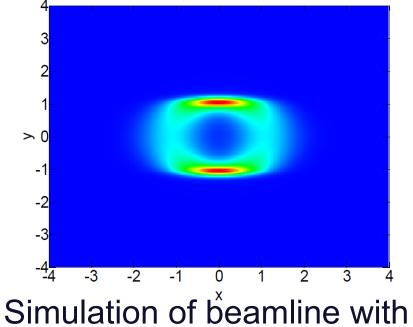
Single segment methods:

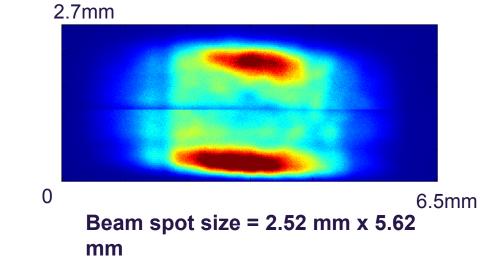
- Gap tuning (single segment) energy spectrum of one undulator segment is measured
- 2. Spatial profile of SR ('donut' diameter)

Two segments method:

- . e-beam kick (two adjacent segments plus e-beam kick, no electron energy dependence)
- 2. Phase-shifter tuning, proposed by undulator group WP71 (Yuhui Li / J. Pflüger)







Test images taken with the HHM, only. Slightly detuning in energy

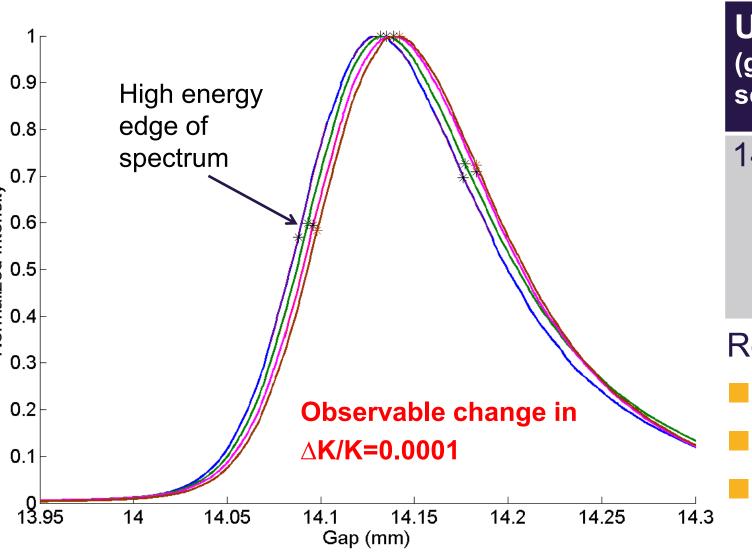
## Gap scanning with K-mono + HHM (4 bounce)

HHM + K-mono detuned to 14.34keV

Filter chamber

Final vacuum test pending

- U1 completely open; Gap-scan U2 around nominal value
- compare flux curves to find smallest observable difference



U2 (gap scanned)	Energy [eV]	Point of steepest slope	K value	Δ <b>K/K</b>
14.13	14338.4	14.088	1.6111	reference
	14339.8	14.093	1.6103	0.00052
	14341.7	14.096	1.6098	0.00083
	14346.6	14.098	1.6094	0.0010
Results:				

Accuracy of K-Mono is sufficient for gap tuning Imaging methods: image processing to be developed

Effect of beam profiling on K measurement under investigation

www.xfel.eu

References

**SPECTRA** 

- [1] W. Freund, "The Undulator Commissioning Spectrometer for the European XFEL", DESY-2014-03060, XFEL.EU TN-2014-001-01
- M. Tischer et al., Nuclear Instruments and Methods in Physics Research A 483, 418-424, (2002)
- J. Welch et al., Undulator K-Parameter Measurements at LCLS, Proceedings of FEL 2009, Liverpool, UK T. Tanaka: "Undulator Commissioning Strategy for SPRING-8 XFEL", Proceedings of FEL2009, WEPC11, Liverpool, UK (2009)

**ASSOCIATION**