

Introduction

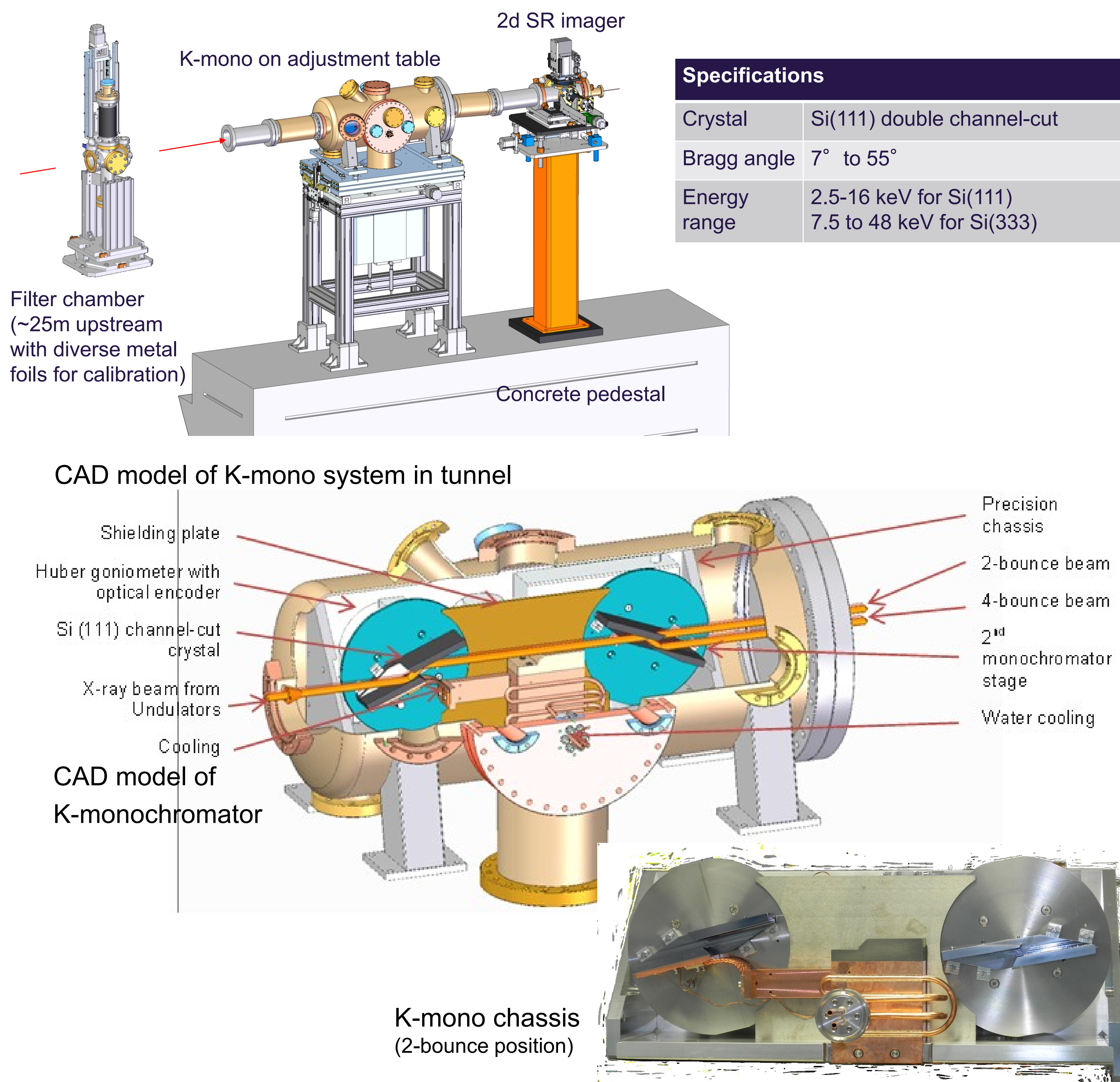
At the European X-ray Free Electron Laser facility (XFEL.EU) one- or two-Si(111) channel (cut) crystal X-ray monochromators (K-Monochromator) [1] are planned for photon beam based alignment: gap tuning of the undulator segments and phase tuning of the phase shifters during commissioning and maintenance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

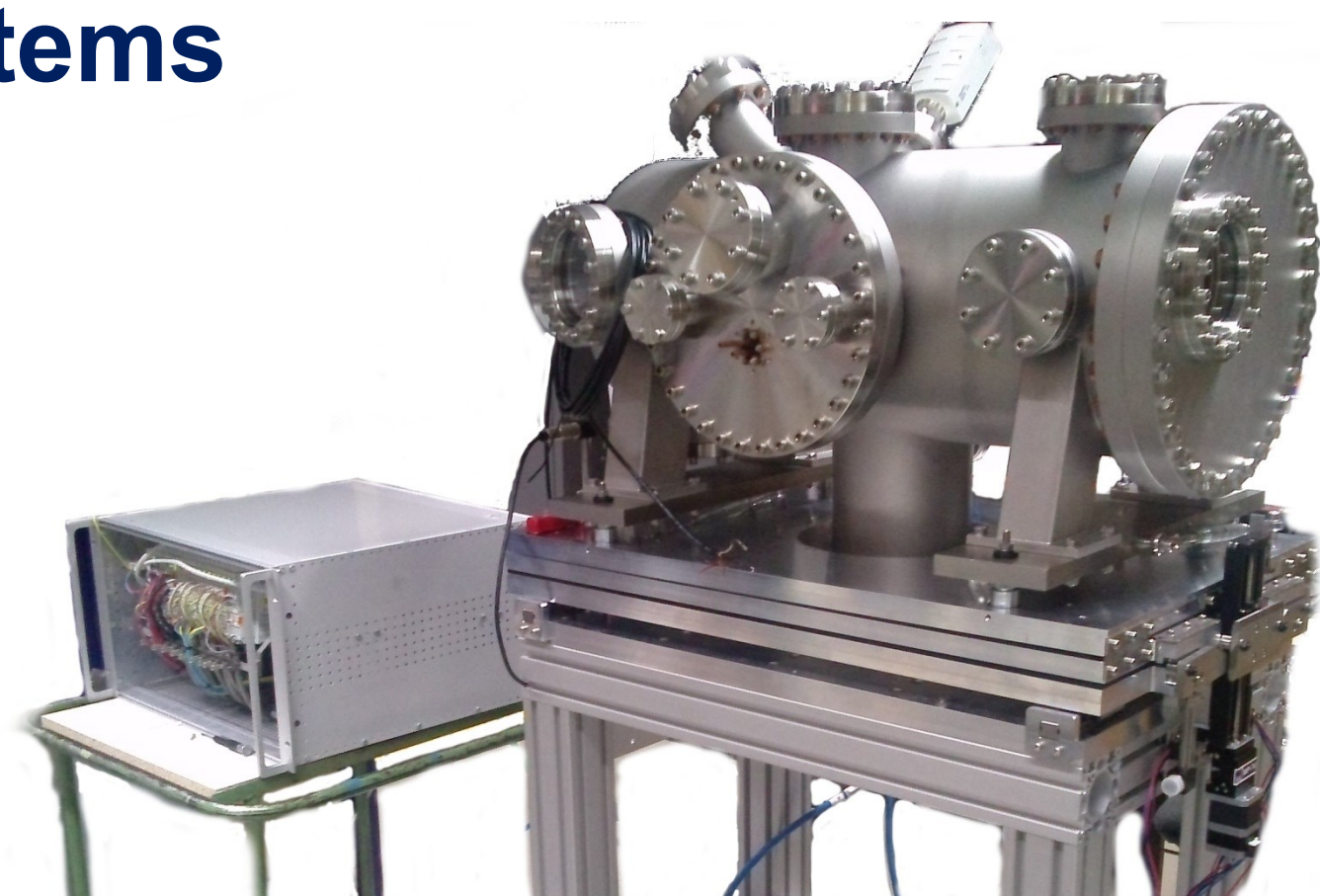
K-mono for SASE1 – setup



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



Filter chamber
Final vacuum test pending

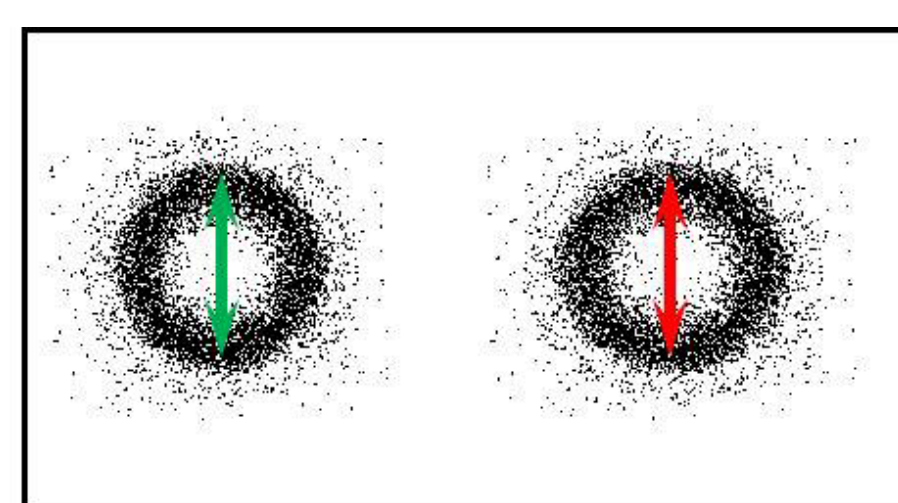
2D spontaneous radiation imager (SR-imager)

Requirements on SR Imager:

- Field of view 27 mm
- Spatial resolution, fwhm 25 μm
- Signal gain and noise adapted for single pulse images of spontaneous radiation
- Repetition rate > 10 Hz
- Determination of low intensity ring structures, pulse signal towards detector appr. 10^2 ph peak / 30 μm pixel, Si(111), 12 keV, 14 GeV

Design (low noise, large aperture, high gain):

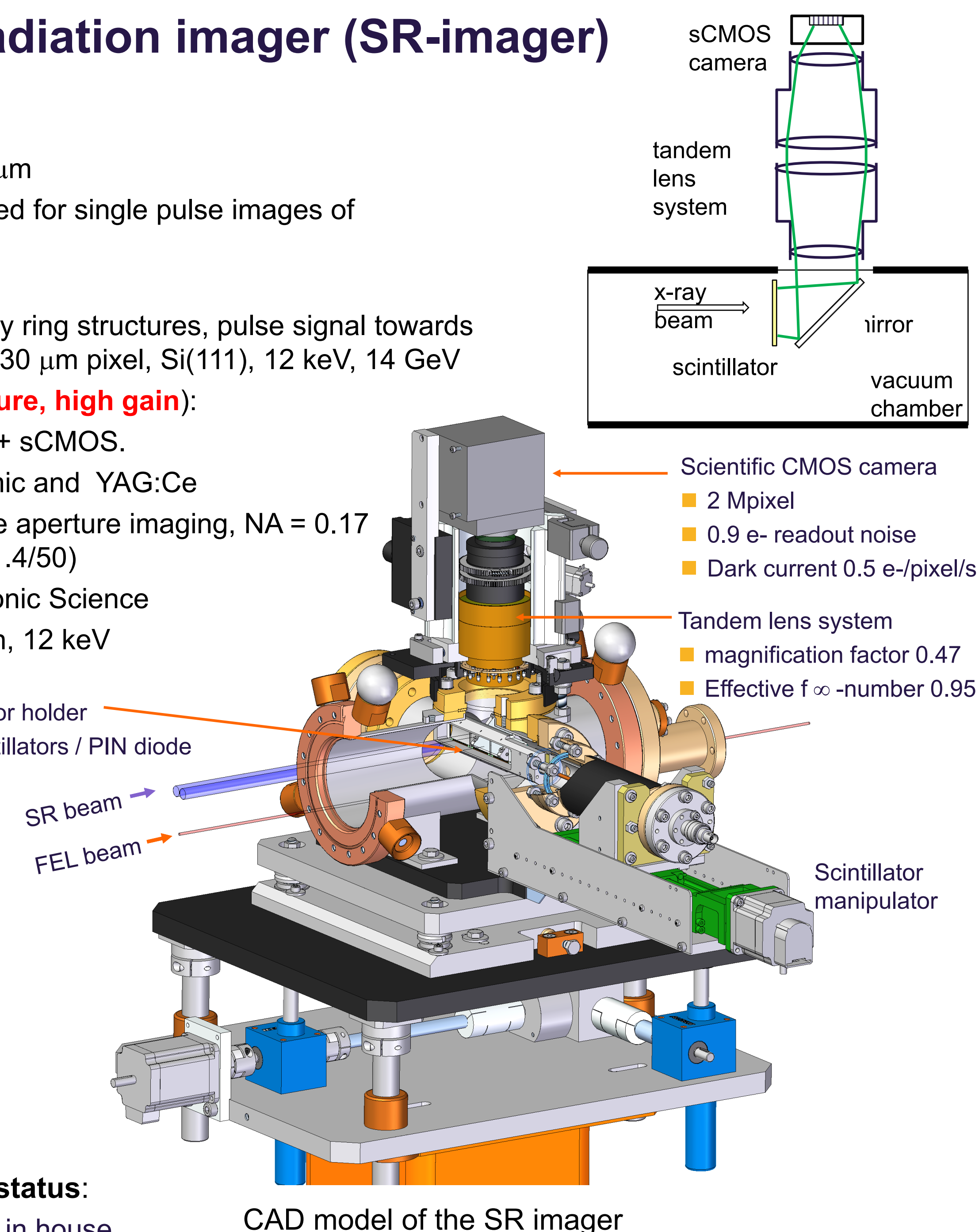
- Scintillator + Mirror + optics + sCMOS.
- Scintillator Gd₂O₂S:Pr ceramic and YAG:Ce
- Tandem lens design for large aperture imaging, NA = 0.17 (Schneider 2.0/110 – Leica 1.4/50)
- 16 bit sCMOS camera Photonic Science
- Noise equivalent signal: 2 ph, 12 keV



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



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:

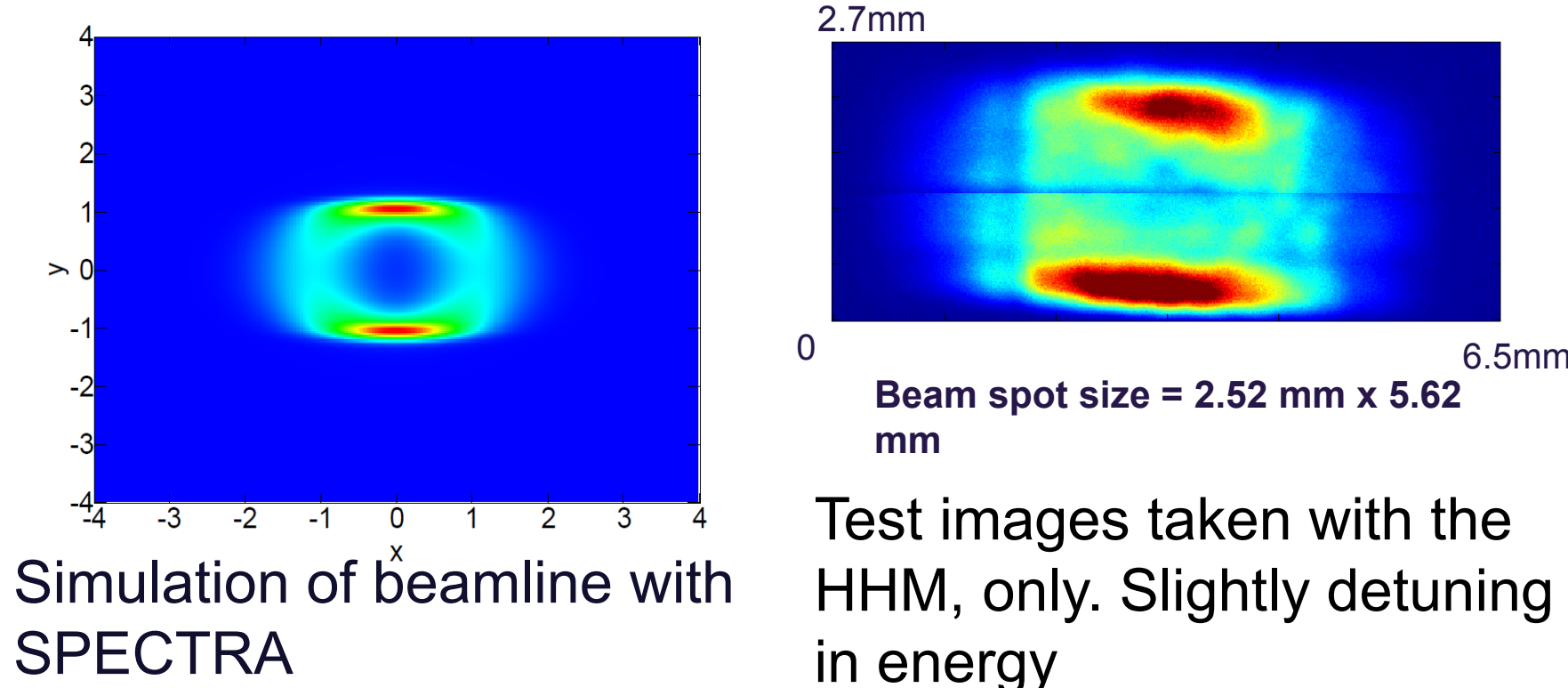
- Gap tuning (single segment) energy spectrum of one undulator segment is measured
- Spatial profile of SR ('donut' diameter)

Two segments method:

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

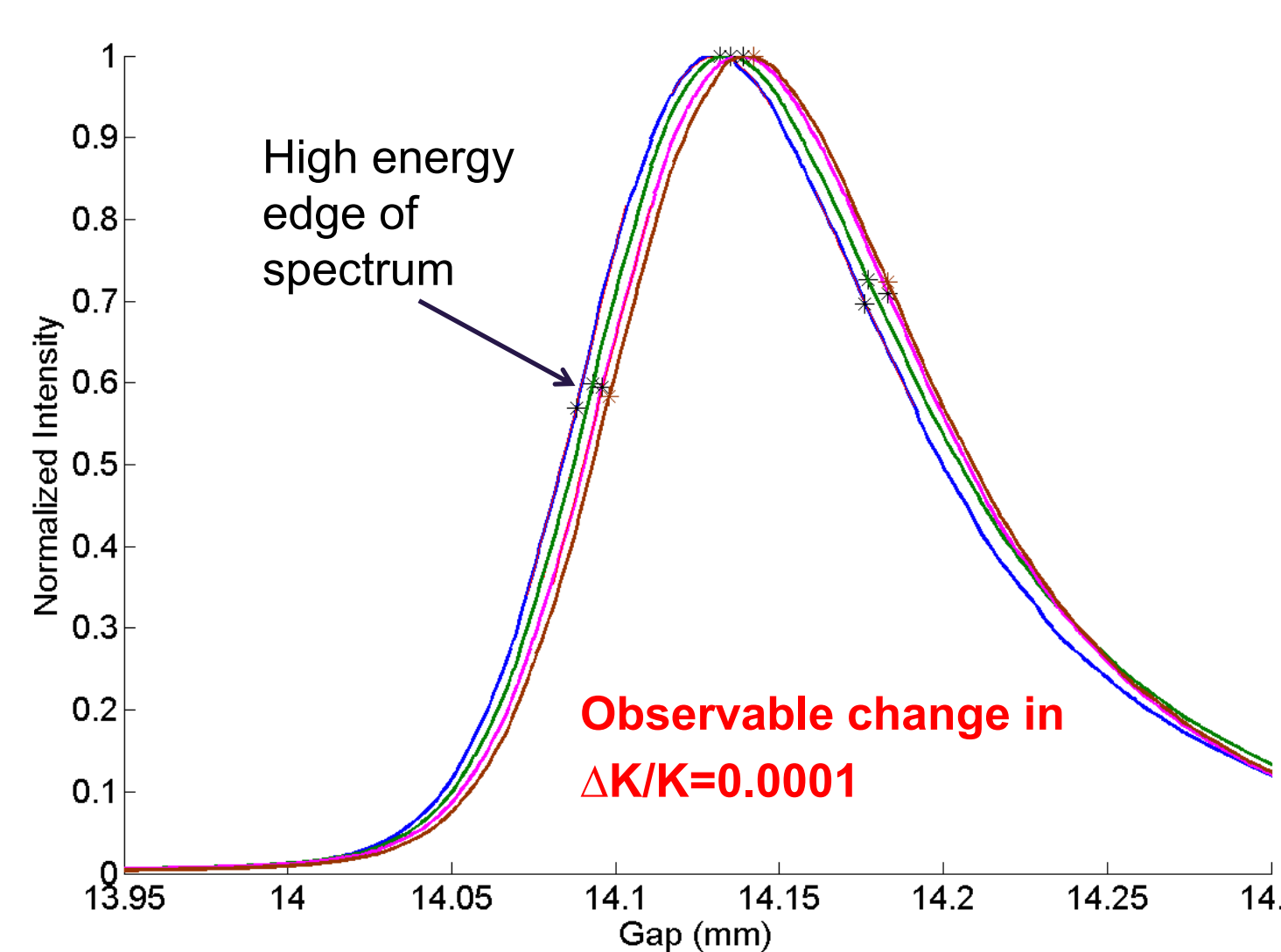
$$E_{ph}[keV] = 0.950 \frac{E_e^2[GeV]}{\left(1 + \frac{K^2}{2}\right) \lambda_u[cm]}$$
$$\frac{\Delta E}{E} = \frac{K^2}{\left(1 + \frac{K^2}{2}\right) K} \frac{\Delta K}{K}$$

with $K = \sqrt{2} \sqrt{\gamma^2 \frac{\lambda}{\lambda_u} - 1 - \gamma^2 \theta^2}$



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

- HHM + K-mono detuned to 14.34keV
- 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	$\Delta K/K$
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

- 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)