Design and ray-tracing of the BEATS beamline of SESAME

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The BEAmline for Tomography at SESAME (BEATS) will operate an X-ray micro tomography station serving a broad user community from the Middle East and beyond

Archaeology and Cultural Heritage:
• Archaeological Materials
• Human bioarchaeology
• Plant remains
• Animal remains and artefacts

Geology and Environment:
• Simulation of rock properties
• Fuel research
• Soil characterization

Health, Biology and Food:
• Musculoskeletal research
• Bone and dental implants
• Soft tissue imaging
• Animal and plant characterization
• Food science

Material science and Engineering:
• Light materials and alloys
• Materials under mechanical stress
• Energy materials research

BEATS

Services to Industry and Private sector

BEATS_eu
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Fixed mask · Photon shutter · Front-End slits · CVD window 1 · Filters · BS stopper · Double Multilayer Monochromator · WB blocker and monitor · Combined stopper · Slits 2 · CVD window 2 · Fast shutter [3] · Sample stage · Detector stage [4]

5.9 m · 8.0 m · 15.0 m · 36.0 m · 45.0 m
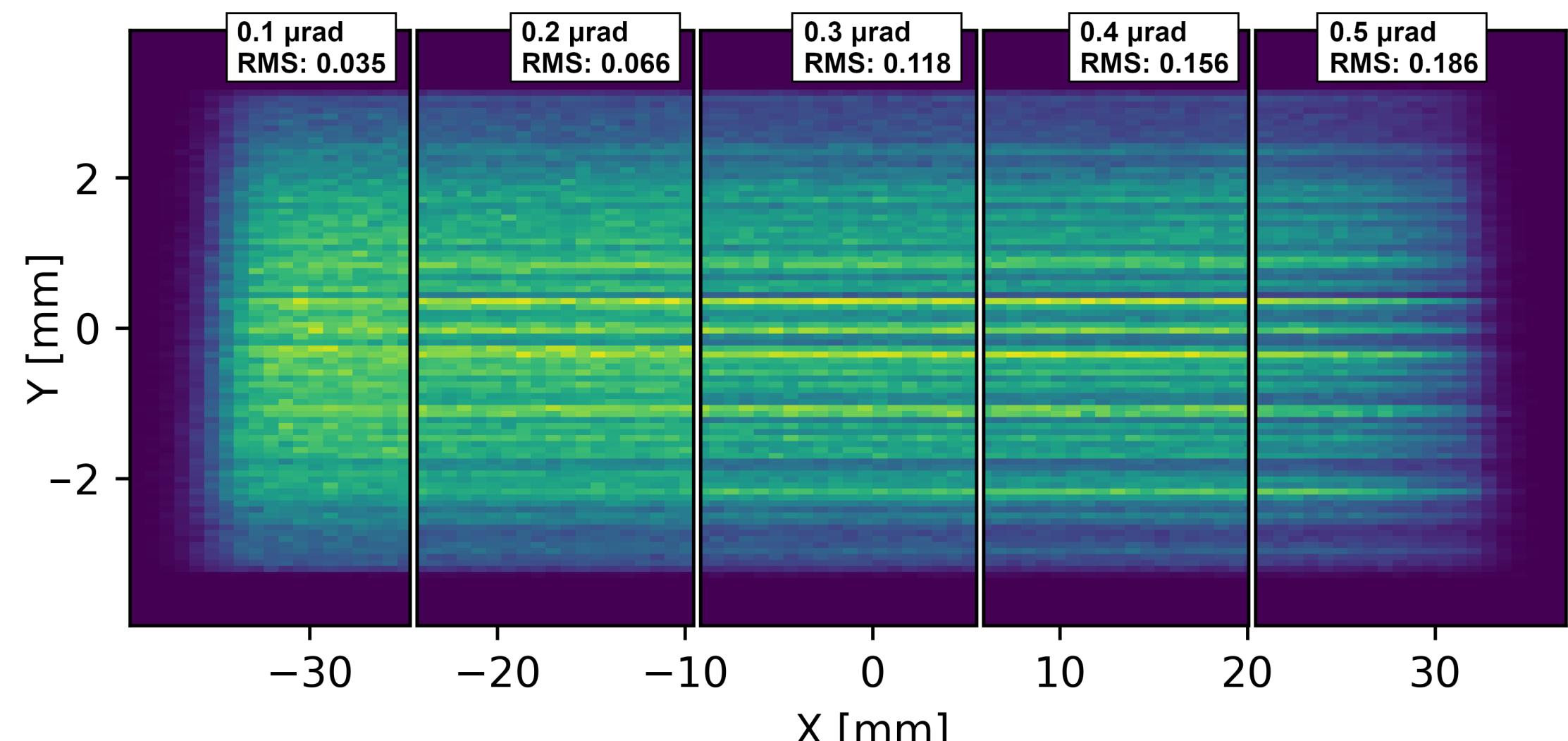
The BEATS beamline at a glance

|	
Photon source	Wavelength shifter (3 T @ 11 mm gap; E_c = 12.5 keV)
Length	45 m
Energy range	8 – 50 keV
Divergence	1.8 mrad (H) × 0.4 mrad (V)
Double Multilayer Monochromator	Stripe 1: $[Ru/B_4C]_{65}$; d = 4 nm; dE/E ≈ 3%
	Stripe 2: $[W/B_4C]_{100}$; d = 3 nm; dE/E ≈ 3%
Detectors	1× – 10× optics; 2560 × 2160 sCMOS camera
Voxel size	6.5 – 0.65 μm
Modalities	• Filtered white beam
	• Monochromatic (with DMM)
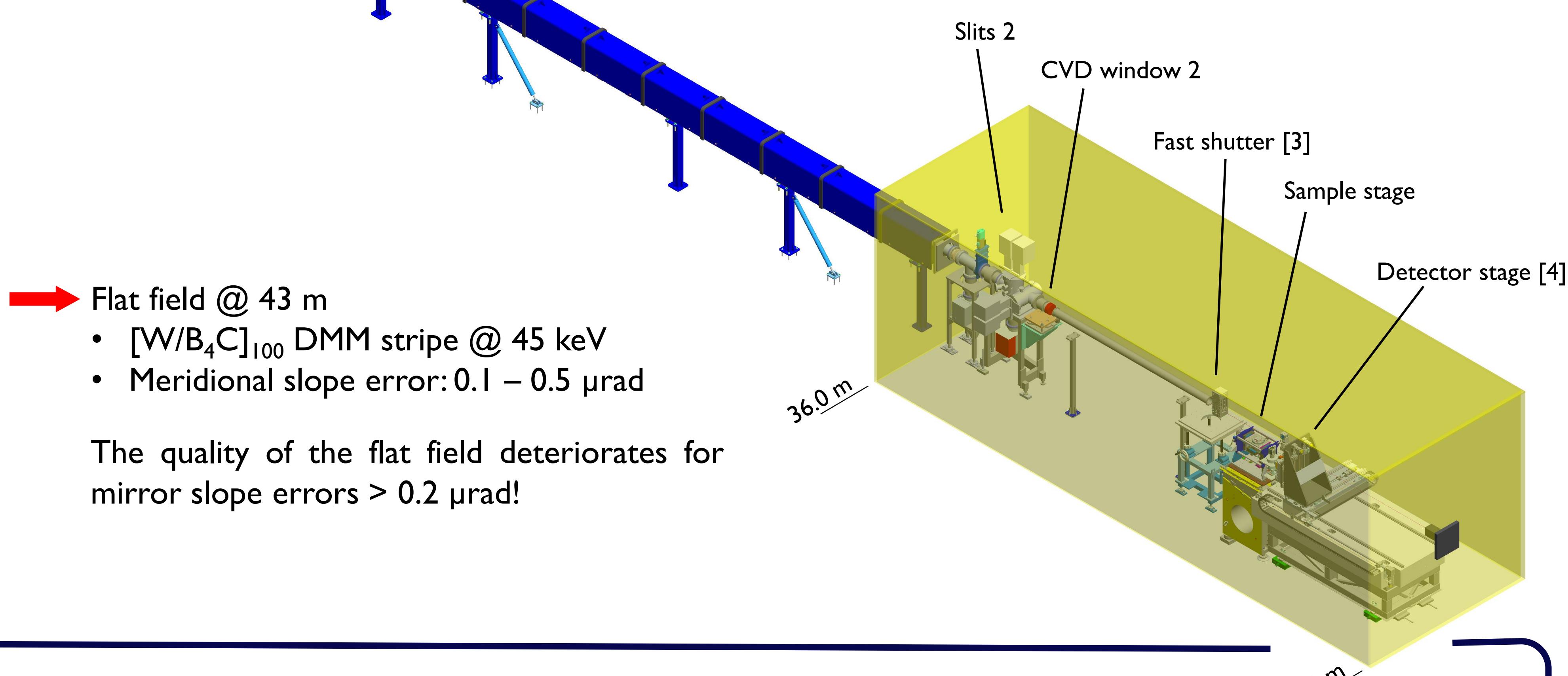
Raytracing

• Repository of the beamline raytracing [1] using OASYS toolsuite [2] and Jupyter

  o Design and verification of beamline optics
  o Characterization of heat load on critical components
  o Beamline performance
  o DMM operation and multilayers specs

Flat field @ 43 m
• $[W/B_4C]_{100}$ DMM stripe @ 45 keV
• Meridional slope error: 0.1 – 0.5 μrad

The quality of the flat field deteriorates for mirror slope errors > 0.2 μrad!
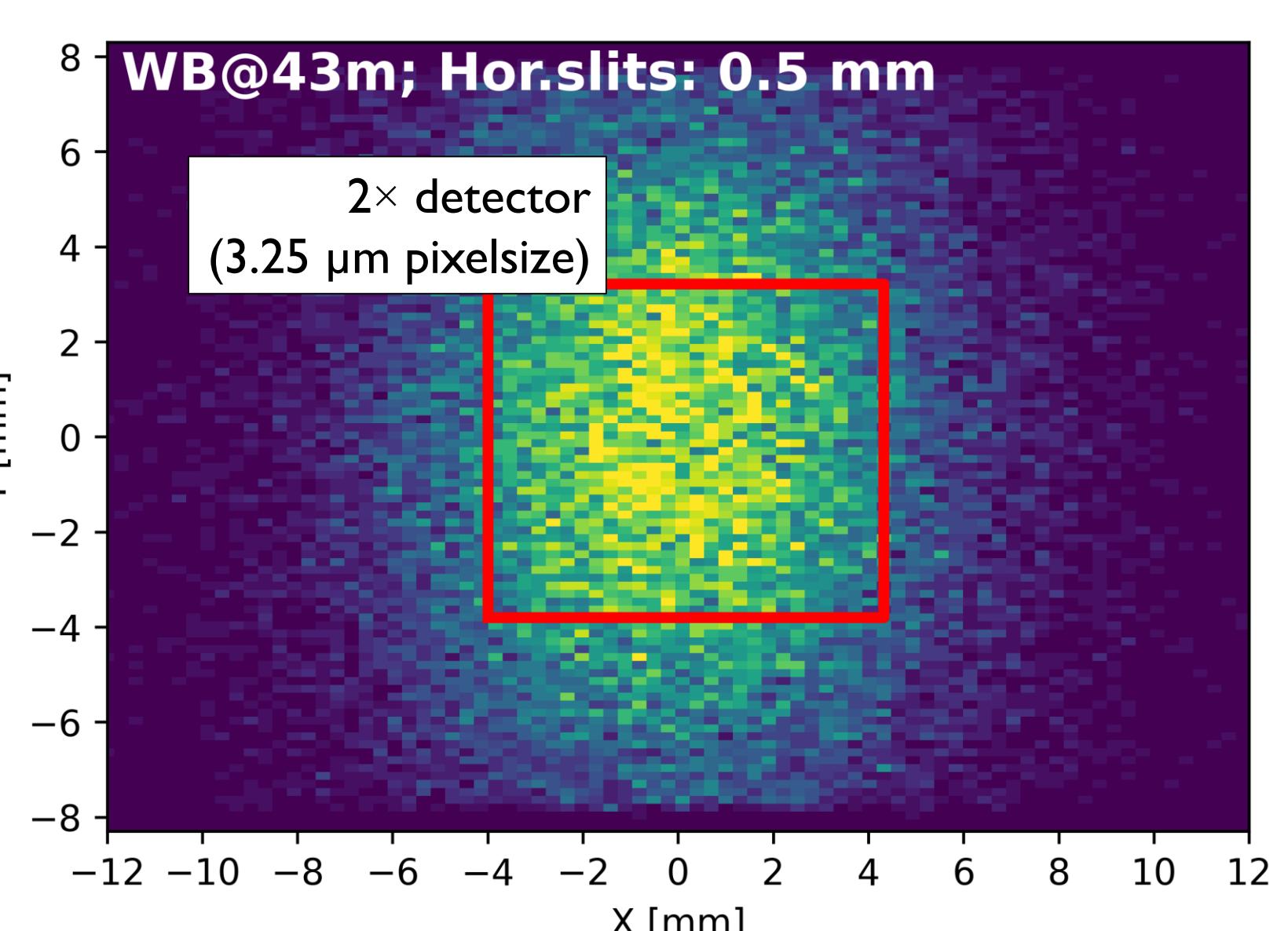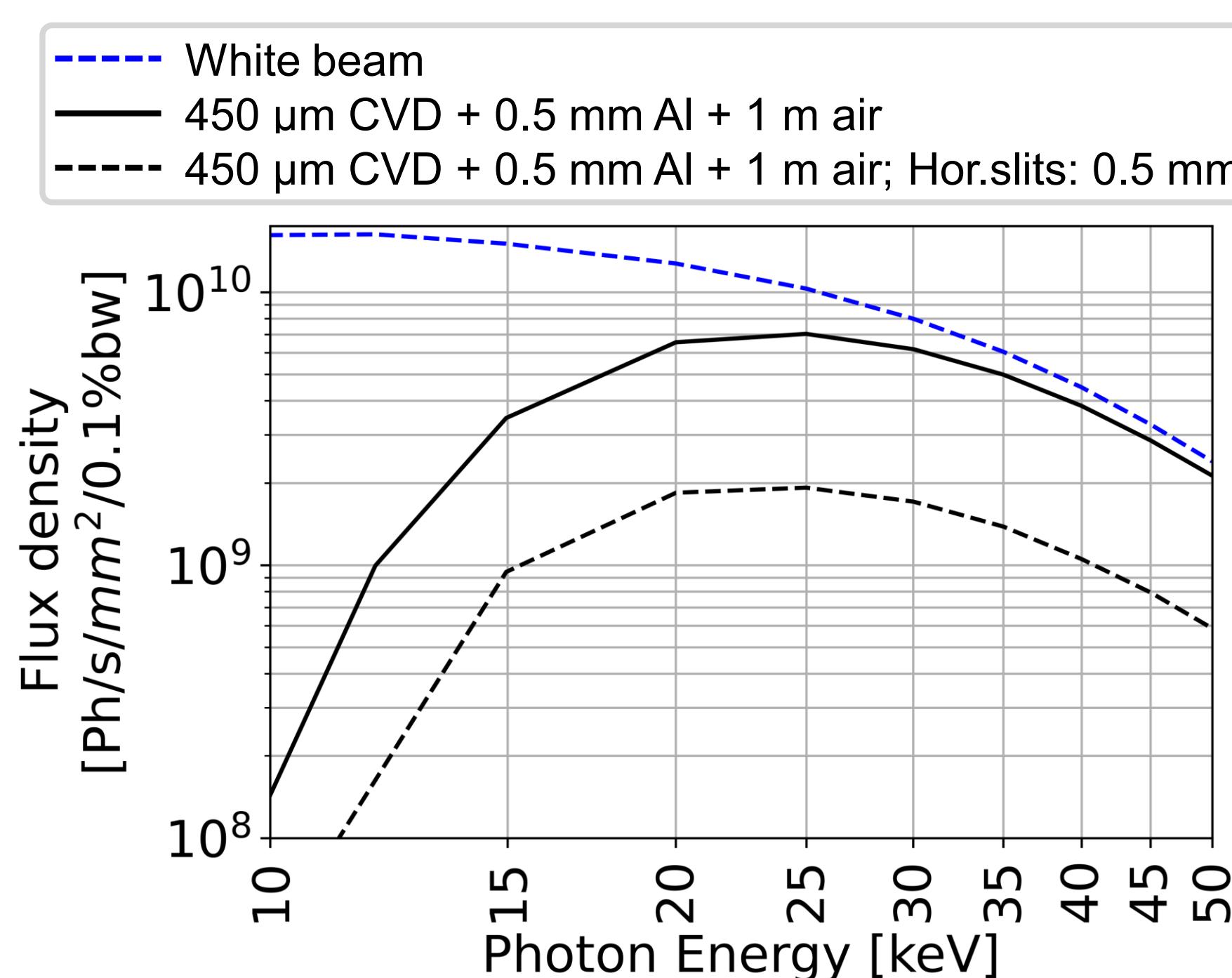
Expected beam properties at sample

White beam:	• Flux density: 8×10^9 Ph/s/mm²/0.1%BW
	• beam size @ 43m: 75×15 mm²
With DMM stripe 2 @ 25 keV	• Flux density: 1×10^{11} Ph/s/mm²
	• Beam size @ 43 m: 68×8 mm²

Transverse coherence length is improved closing the F-E slits:

Beamline	Length	Source size FWHM	Coh. length
ID19, ESRF	145 m	25 μm	720.0 μm
TOMCAT, SLS	34 m	140 μm	30.2 μm
SYRMEP, Elettra	23 m	197 μm	14.5 μm
BEATS	43 m	1978 μm	2.7 μm
BEATS, F-E slits: 0.5 mm (H)	35 m	500 μm	8.5 μm

Legend:
- - - White beam
—— 450 μm CVD + 0.5 mm Al + 1 m air
- - - 450 μm CVD + 0.5 mm Al + 1 m air; Hor.slits: 0.5 mm

Flux density [Ph/s/mm²/0.1%bw] vs Photon Energy [keV]

WB@43m; Hor.slits: 0.5 mm
2× detector (3.25 μm pixelsize)

References

[1] BEATS Technical Design Report - raytracing, doi:10.5281/zenodo.3988604.
[2] L. Rebuffi and M. Sanchez del Rio, "OASYS (OrAnge SYnchrotron Suite): an open-source graphical environment for x-ray virtual experiments," Proc.SPIE 10388: 130080S (2017).
[3] C. Muñoz Pequeño et al., "Development of a Linear Fast Shutter for BM05 at ESRF and BEATS at SESAME", presented at MEDSI'20, Chicago, USA, July 2021.
[4] F. Mokoena et al., "An FEA Investigation of the Vibration Response of the BEATS Detector Stage", presented at MEDSI'20, Chicago, USA, July 2021.

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