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Photon beamline design for CompactLight: *work in progress*

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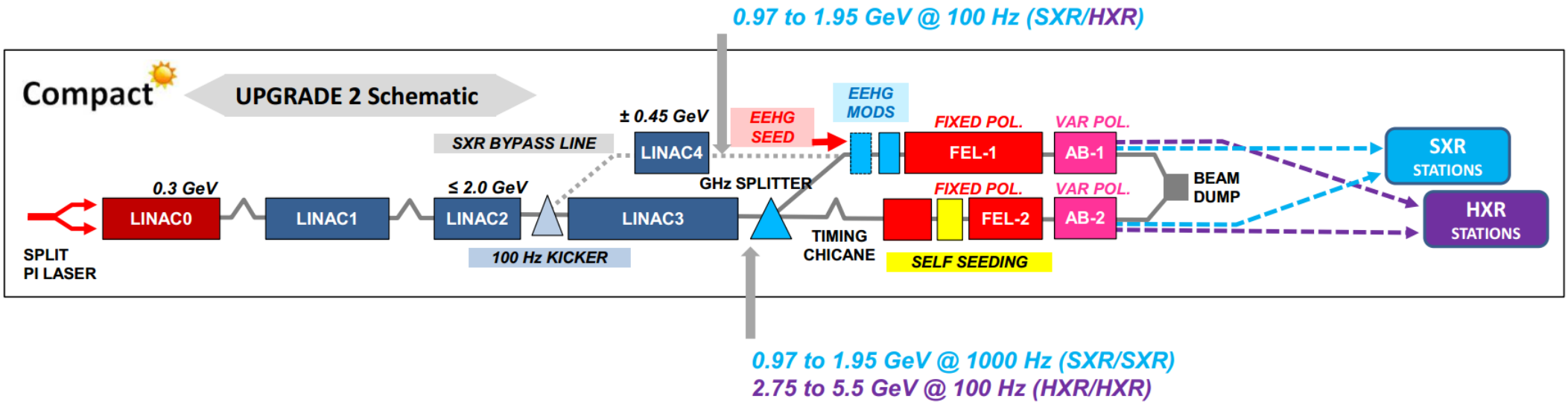
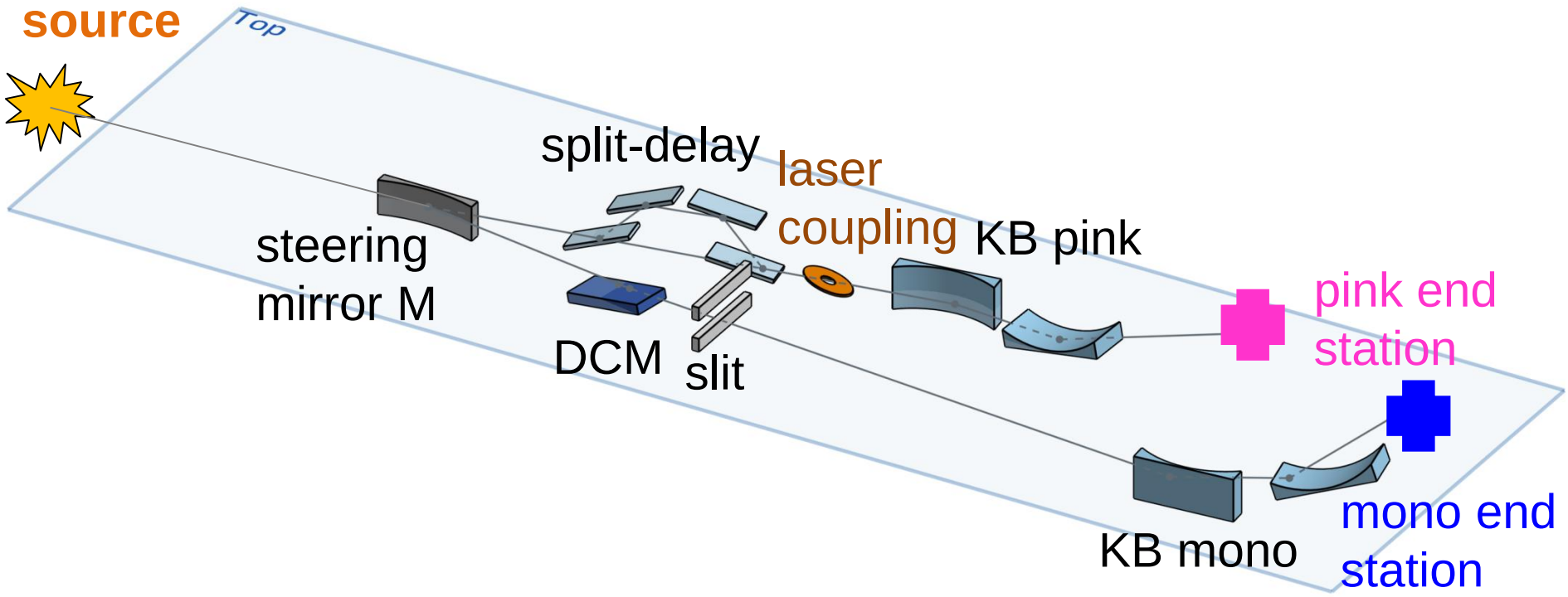
CompactLight Meeting, virtual Glasgow, 2020

Recap of what the beamline is

Compact





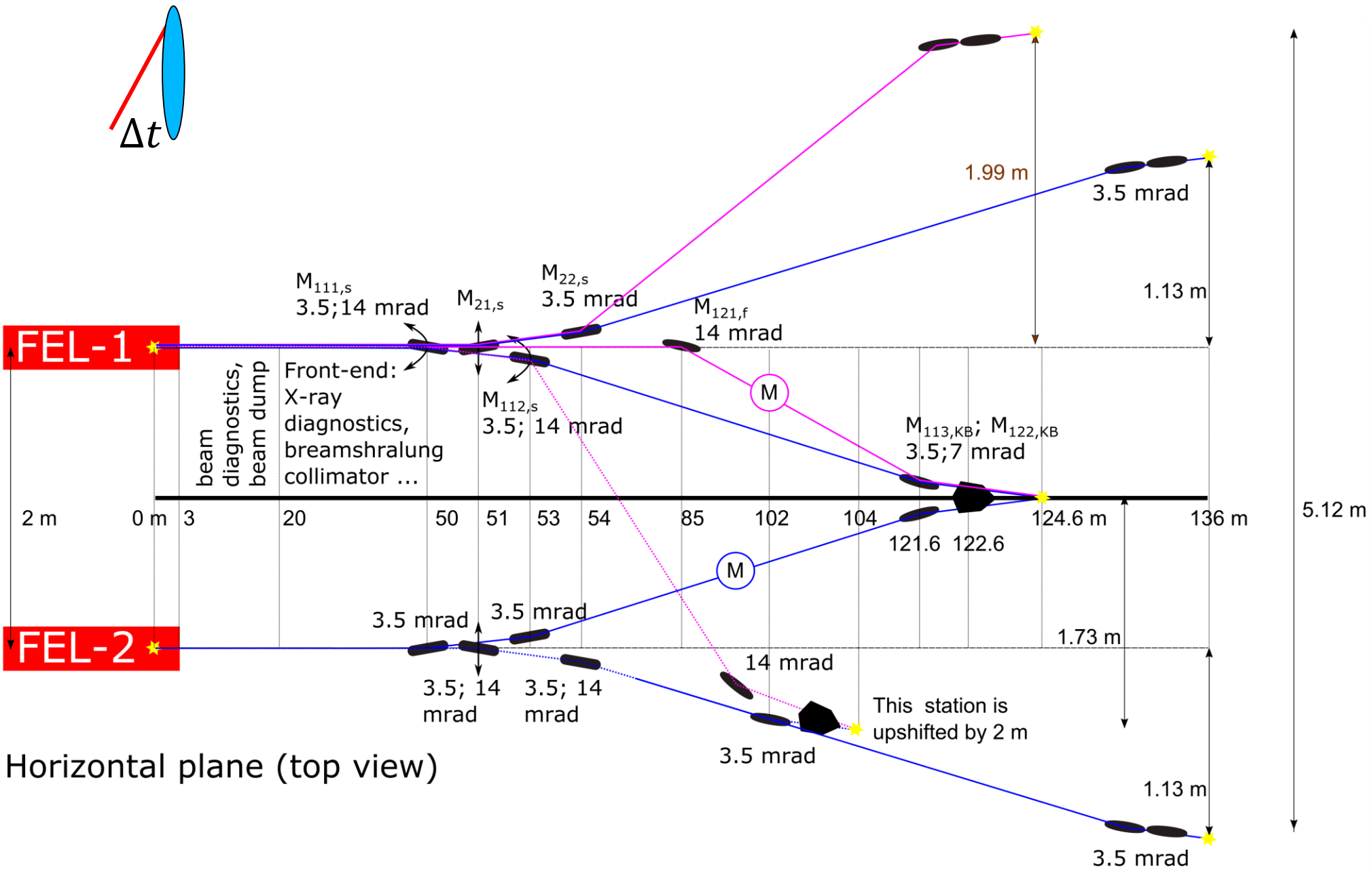
Proposed beamline design

- The design of any beamline involves a dozen of parameters.
- The requirements are often conflicting. Any design is a compromise.
- CompactLight has a unique advantageous configuration of two undulator lines, which must be utilized in the beamline design.
- Below, I present what I think is a balanced solution and give a motivation.
- Other configurations are possible but they face noticeable limitations in utilizing the two FEL simultaneously for pump-probe experiments.

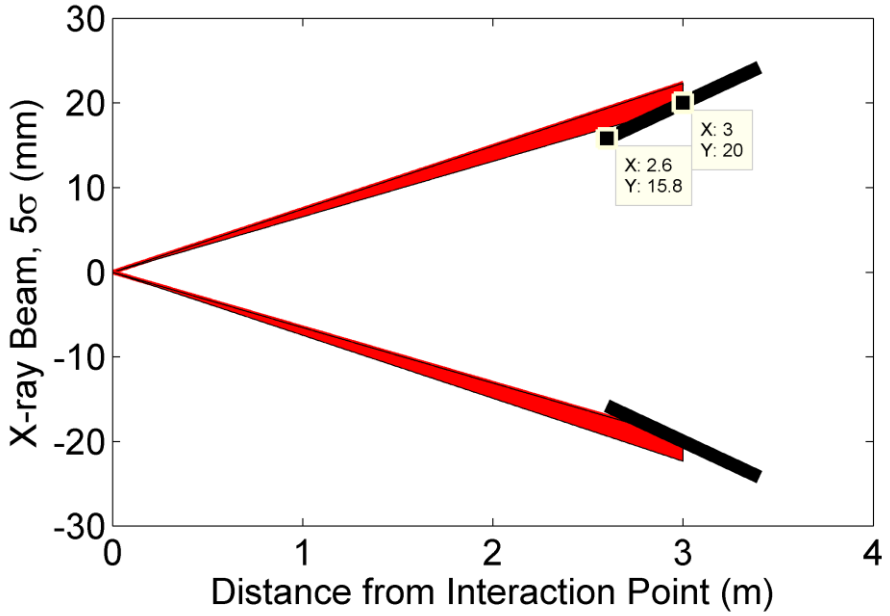
Some general design principles:

- Two modes of operation: pink and mono
- Keep the beamline transmission decently high (70-80% for pink mode)
- Spectral resolution for mono: sub-eV for SRX and eV for HXR
- Transverse separation between the end stations > 2 m
- Longitudinal separation between the end stations > 10 m
- Beam size < 1 um FWHM for pink and 10 um for mono
- Simultaneous pump-probe experiments with two FEL beams.

Optical layout

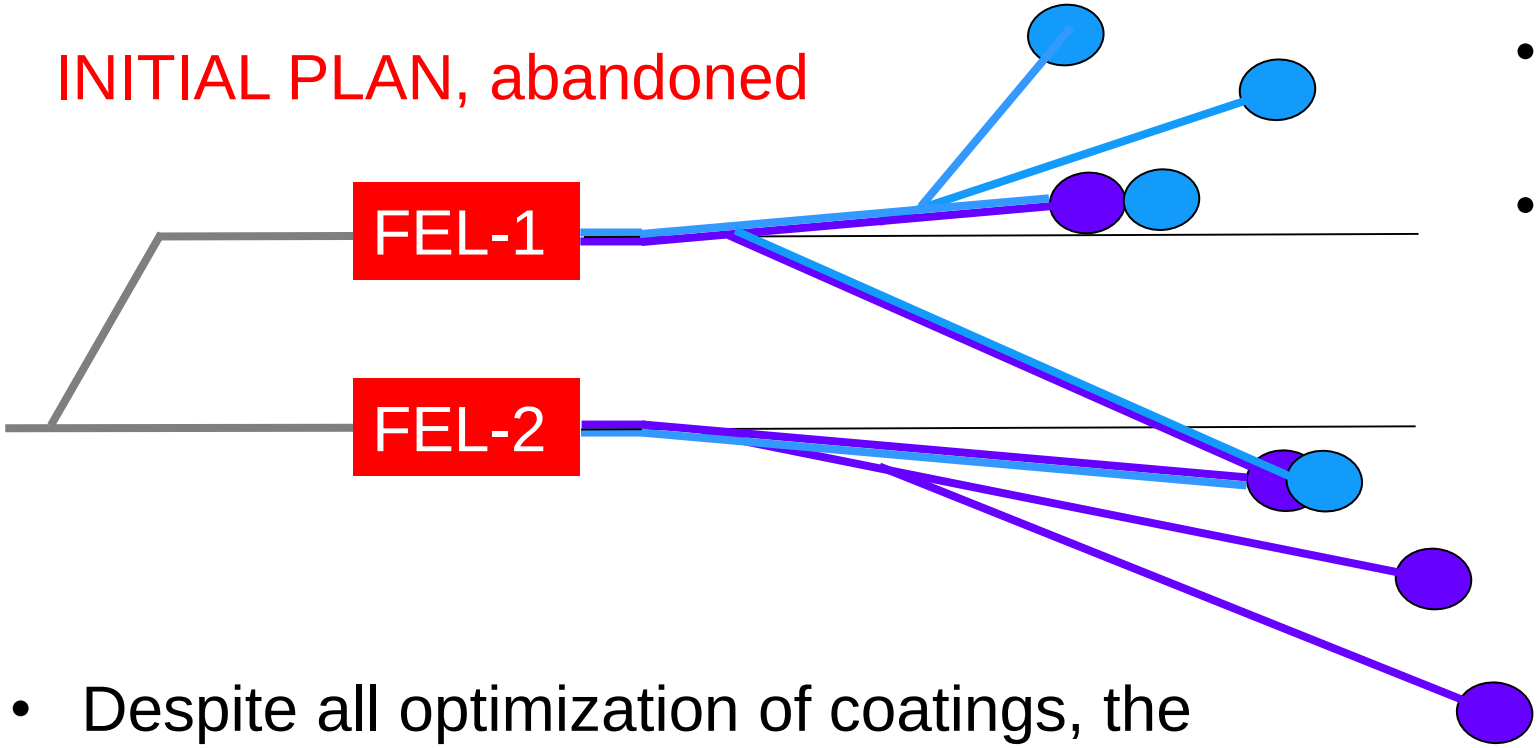


Horizontal plane (top view)


30
20
10
0
-10
-20
-30
0
1
2
3
4
X-ray Beam, 5σ (mm)
Distance from Interaction Point (m)
X: 3
Y: 20
X: 2.6
Y: 15.8

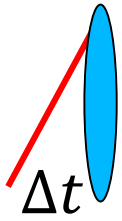
Why the symmetric combined line?

INITIAL PLAN, abandoned



- 3 end stations for each FEL.
- Stay out of bremsstrahlung

- Despite all optimization of coatings, the operation incidence angle is < 4 mrad.
- To shift the beam transversely by 2.5 m over 100 m, 4 mirrors are needed.
- Another 2-3 mirrors are needed to remove the tilt of FEL wavefronts and avoid a time delay across the wavefront.
- The transmission is < 50-60 %.



SXR end station

HXR end station

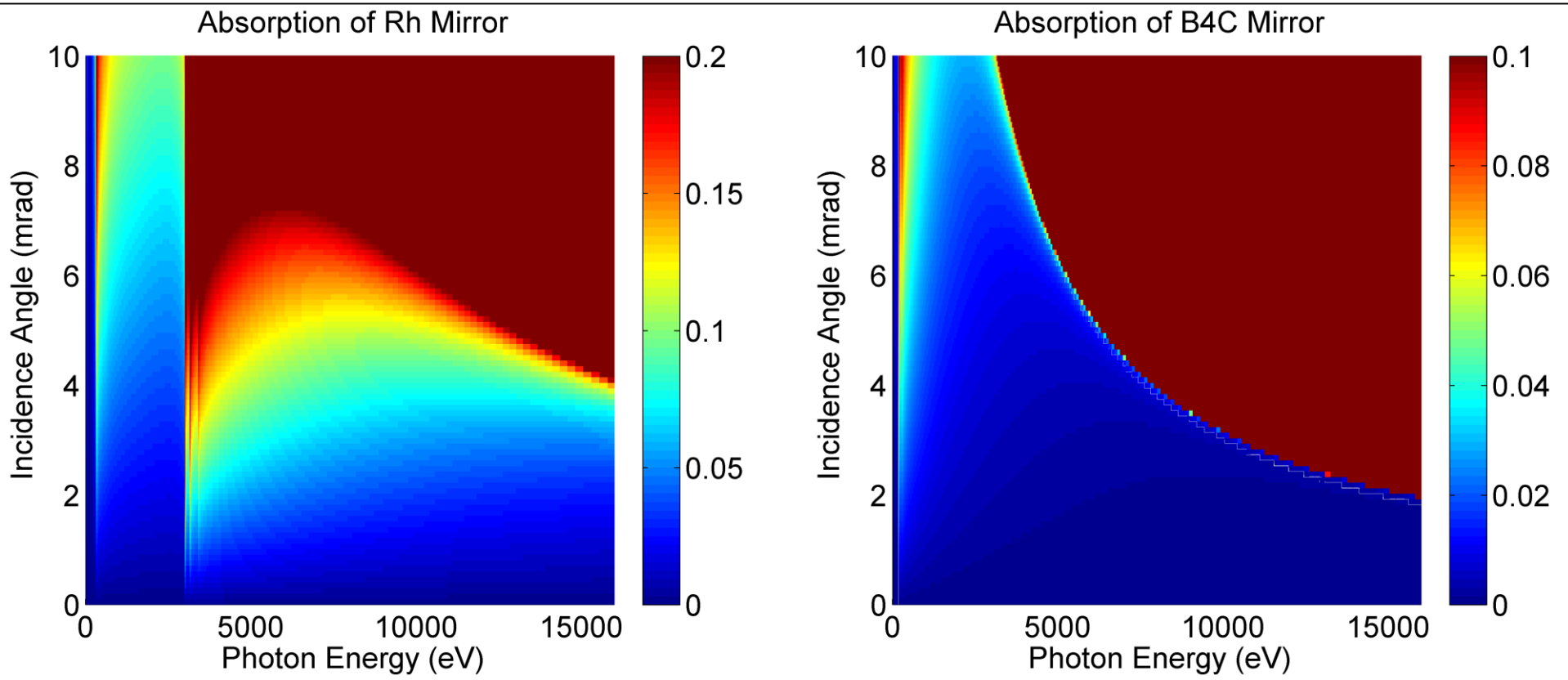
baseline

upgrade

SXR/HXR pump-probe

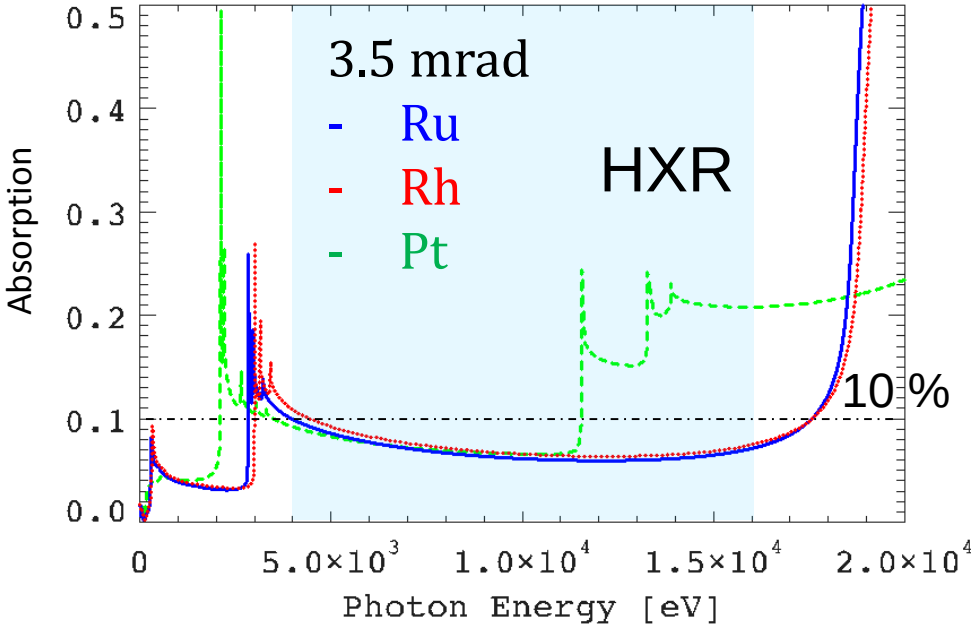
swappable

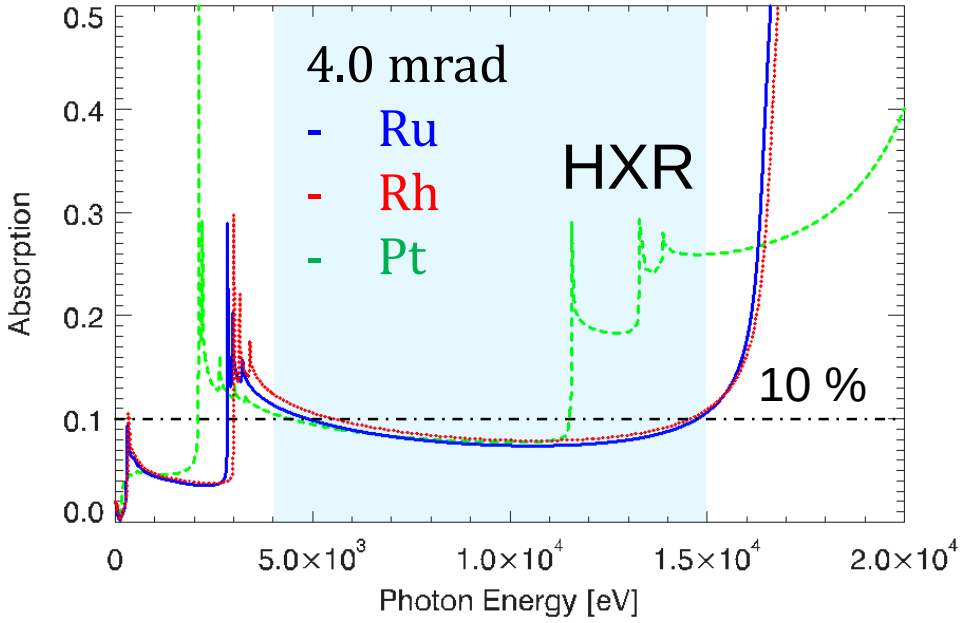
X-ray absorption of materials

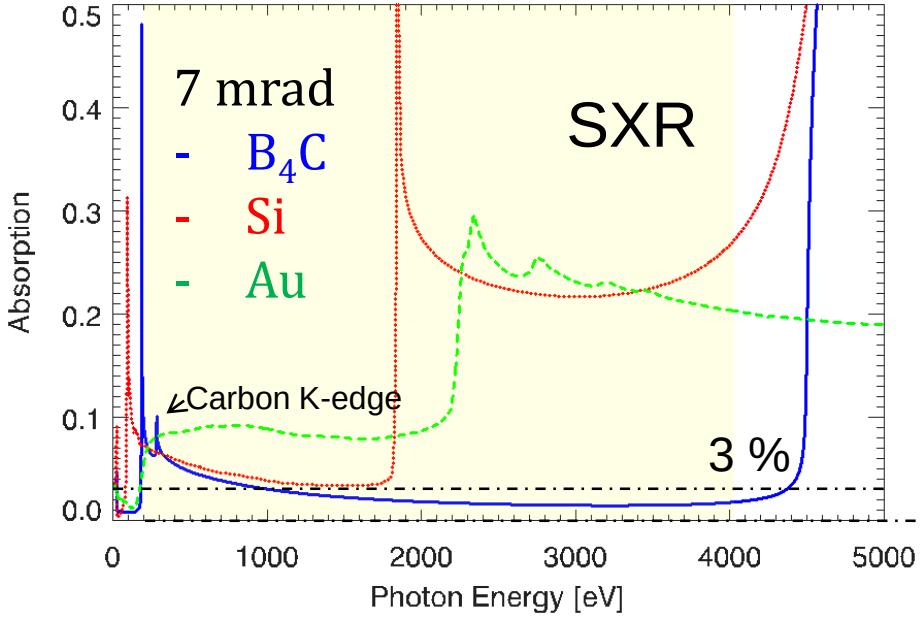


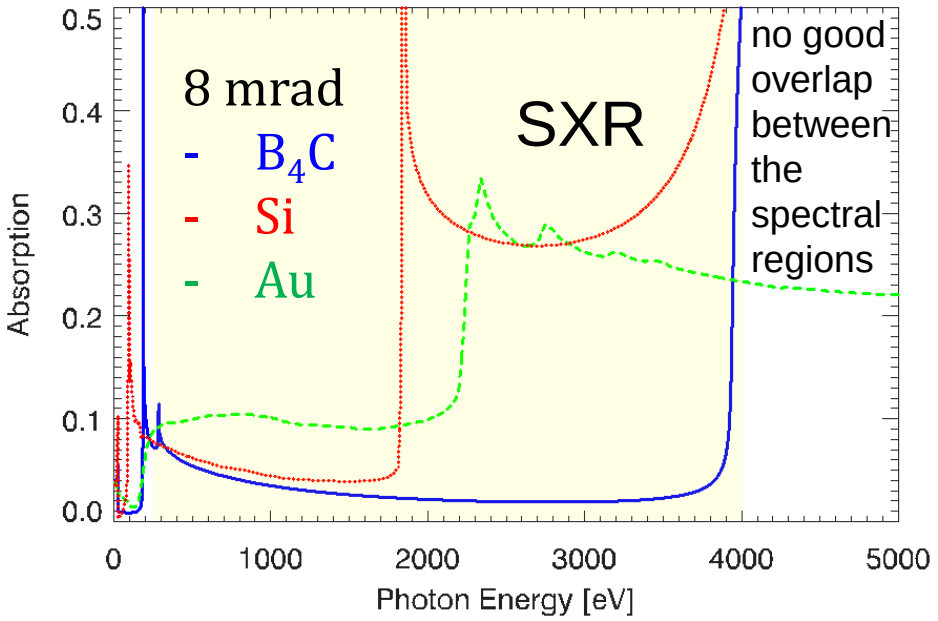
- A wide analysis of different materials (not shown for the sake of time)
- Rh provides a good balance of the critical angle vs absorption
- Sharp absorption peak of Rh at 3 keV
- Switch to B4C below 4 keV
- Absorption of B4C at Carbon K-edge (289 eV)
- In the water window, operate just with a bare Si substrate

X-ray absorption: operation angle





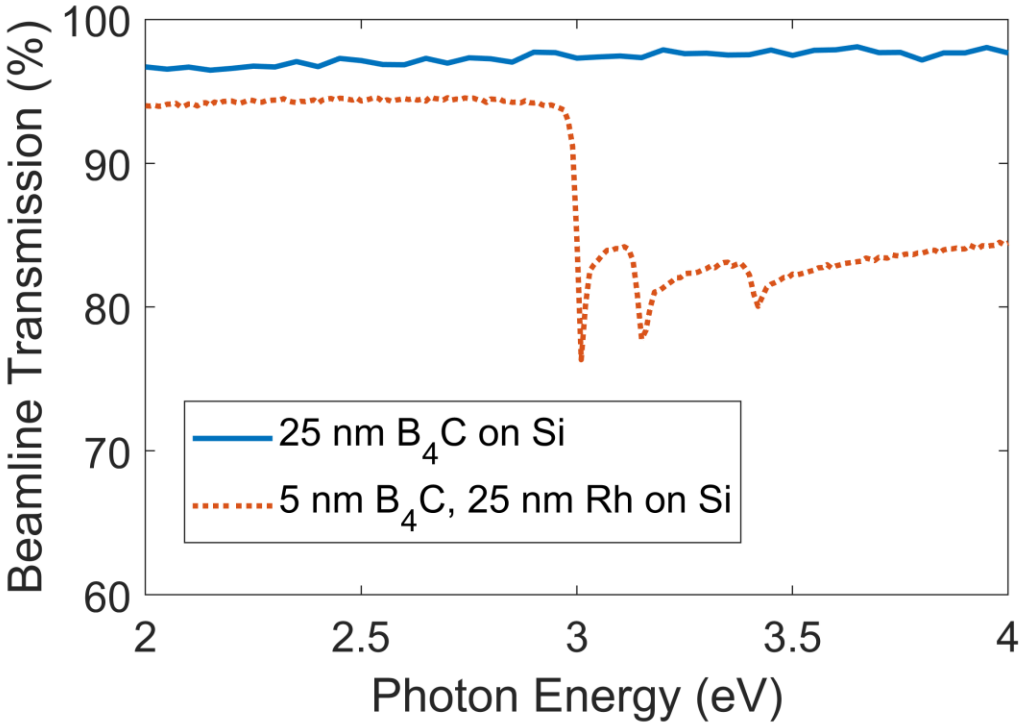


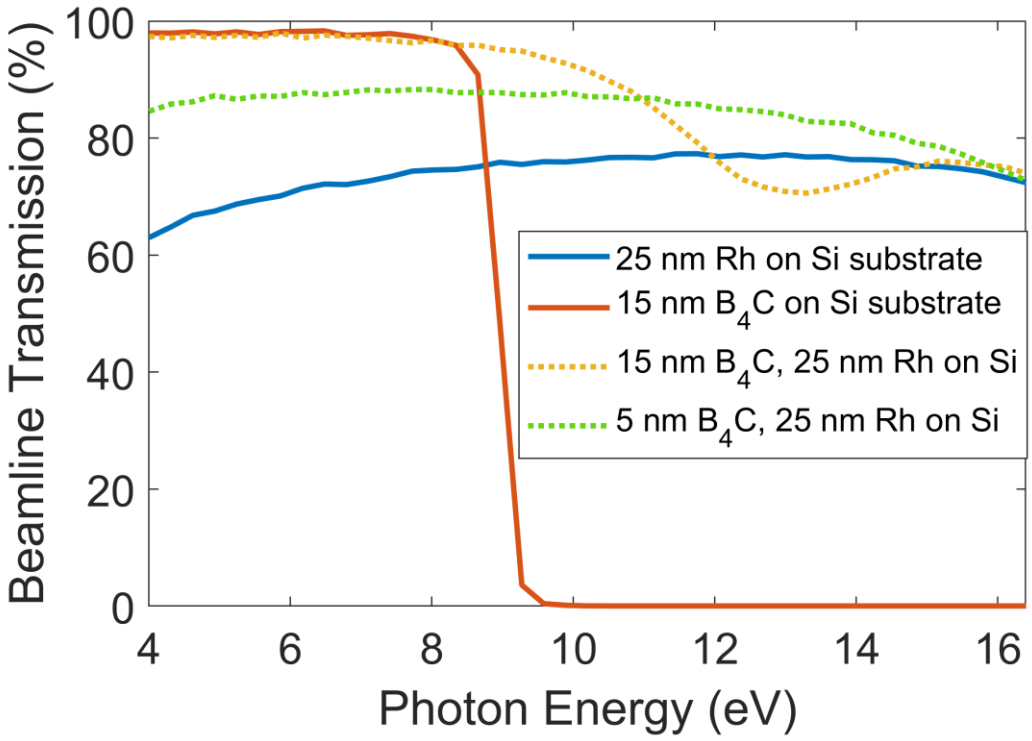


4-16 keV range: Rh at 3.5 mrad

0.25-2 keV range: B_4C at 7 mrad.

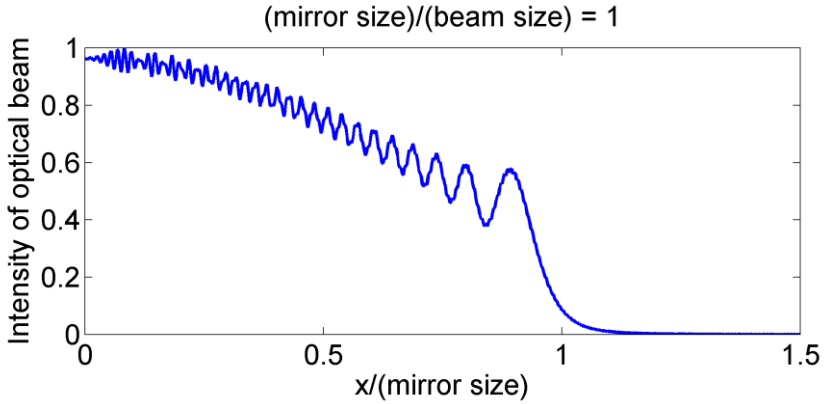
Pink beamline transmission

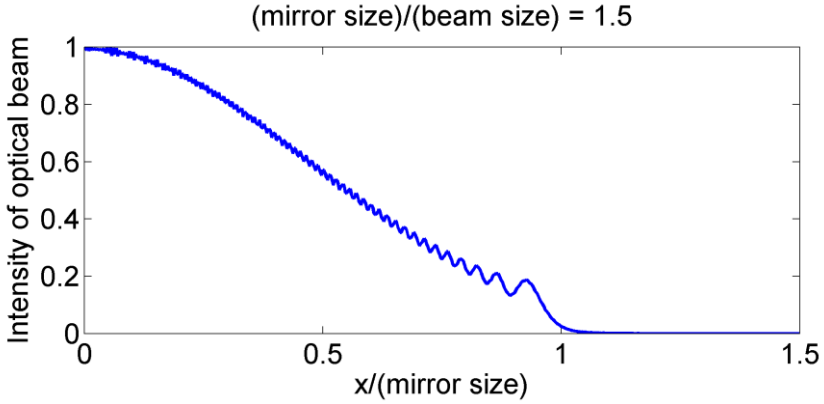


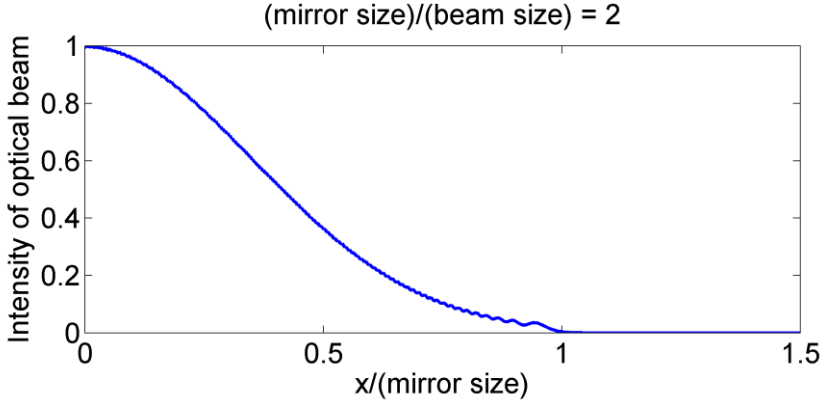


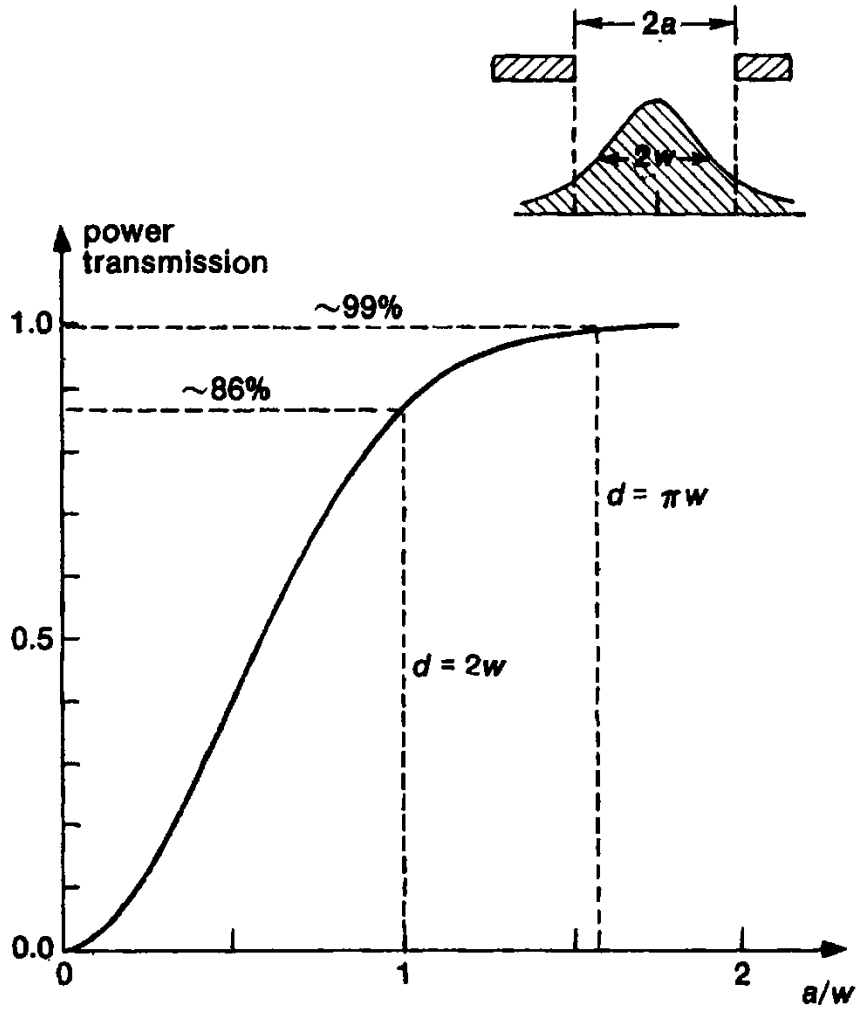
- 25 nm Rh on Si provides a good transmission (75%) up to 16 keV
- By adding 5 nm of B4C on top of Rh improves the transmission to 80%
- Rh has a sharp absorption peak at 3 keV
- 5 nm B4C is not enough to “shield” Rh absorption at 3 keV
- Below 4 keV, use a thick (25 nm) B4C layer on a Si substrate. Around 95% overall beamline transmission.
- Summary: a high-transmission pink beamline is possible.

Effect of the numerical aperture



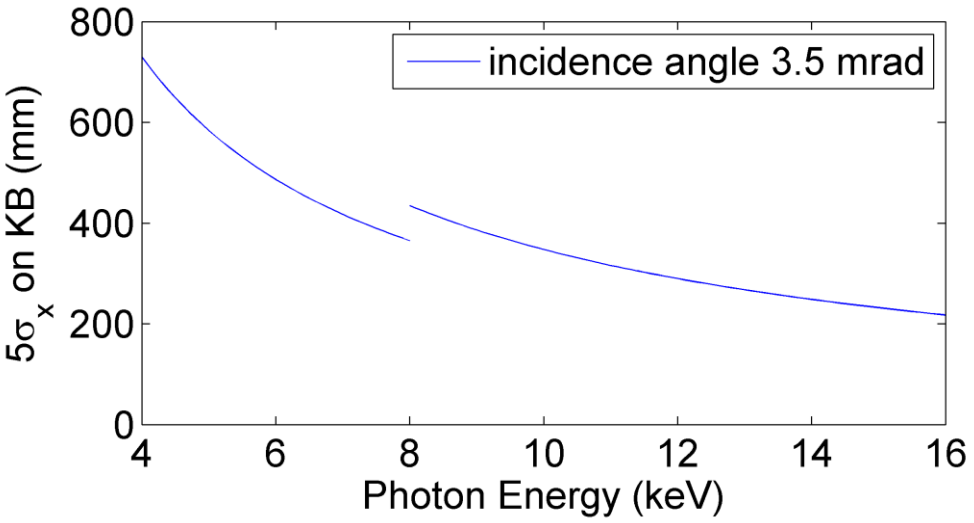


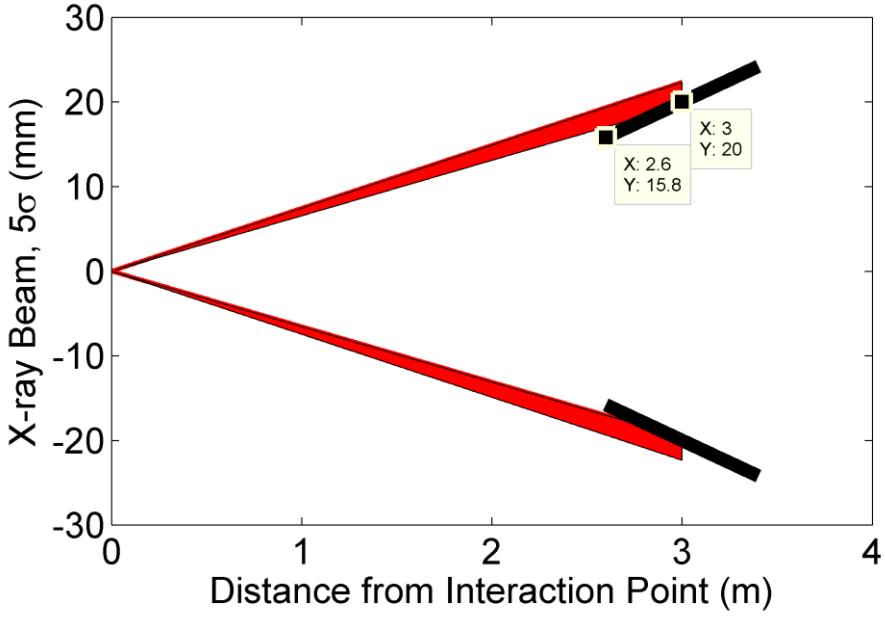




To avoid large diffraction losses and wavefront distortions, the targeted minimum mirror size is 5σ for all photon energies. The power transmission is 95%.

4-16 keV, pink, numerical aperture





Optical layout:

- 2 deflecting mirrors at 3.5 mrad
- Total deflection angle 14 mrad
- Distance from M1 to KB is 72 m
- M1 = 50 m, M2 = 53 m, KB1 = 121.8 m, KB2 = 123 m, focus at 125 m.

16 keV
FWHM = 0.4 x 0.28 um,
Transmission ~ 75%
14 keV: 0.43 x 0.28 um, 77.3%
12 keV: 0.42 x 0.28 um , 78%
10 keV: 0.43 x 0.28 um, 77.5%
8 keV: 0.43 x 0.28 um, 75.5%
8 keV: 0.52 x 0.33 um, ~ 75.5%
6 keV: 0.52 x 0.33 um, 72%
4 keV: 0.5 x 0.33 um, ~ 65%
4 keV: 0.61 x 0.41 um, ~ 65%

Summary

- Still a lot of work ahead, so the EU commission extension is just in time ☺
- Finalized choice of coatings for X-ray mirrors
- Optical layout that allows for pump-probe experiments utilizing the two FEL beams
- Design of a high-transmission (80%) pink beamline.

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Thank you!

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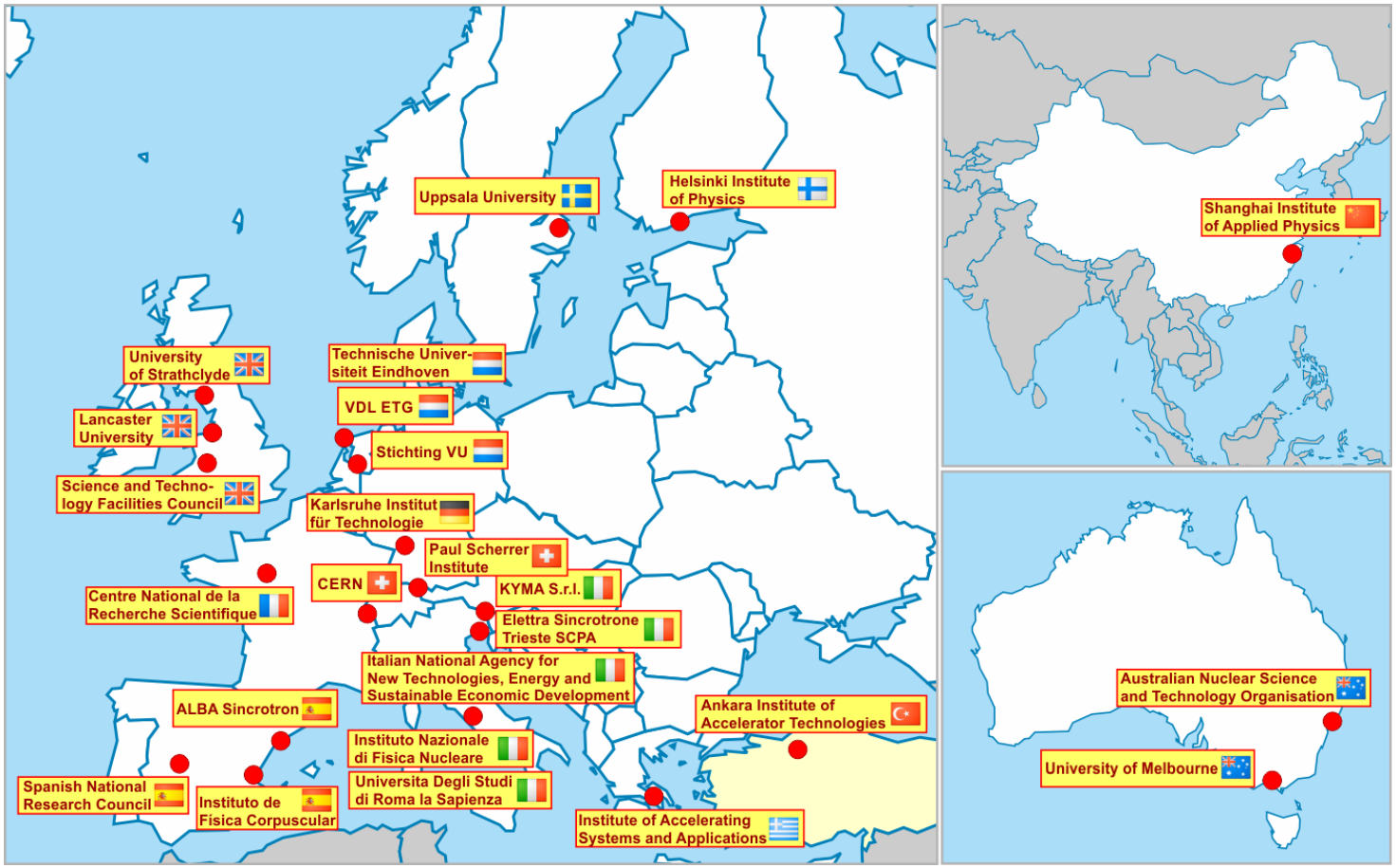

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