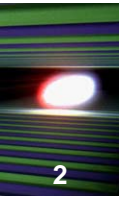




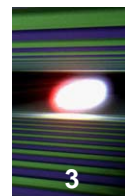
SOFT X-RAY BEAMLINER OPTICS

J. Gaudin, H. Sinn, S. Dastjani, G. Galasso, I. Freijo-Martin,
L. Samoylova, A. Trapp, F. Yang and Th. Tschentscher

*X-ray Optics & Beam Transport
European XFEL
Hamburg – Germany*

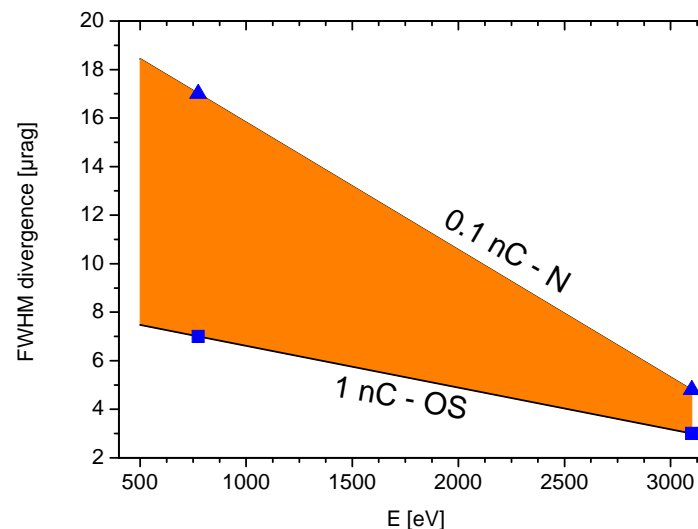
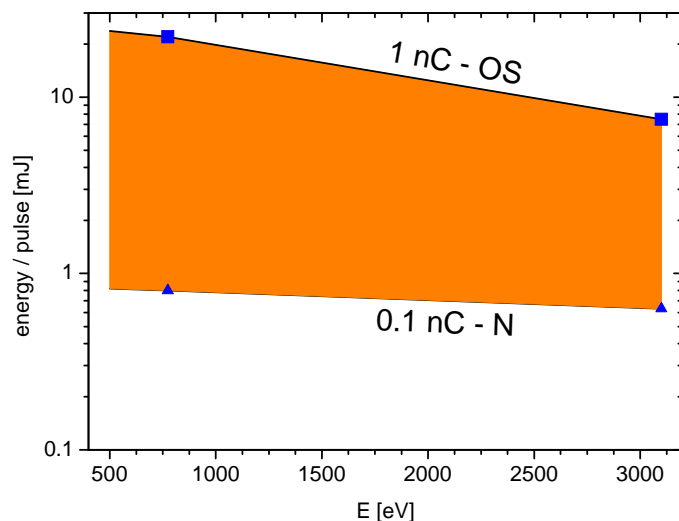


- SASE 3 : general features + beam parameters
- Off-set mirror system
- Beamlines
 - Monochromatized beamline
 - Pink beam
- Considerations for photon energy < 400 eV
- Conclusion

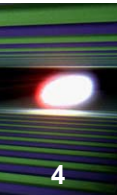


Many operation modes:

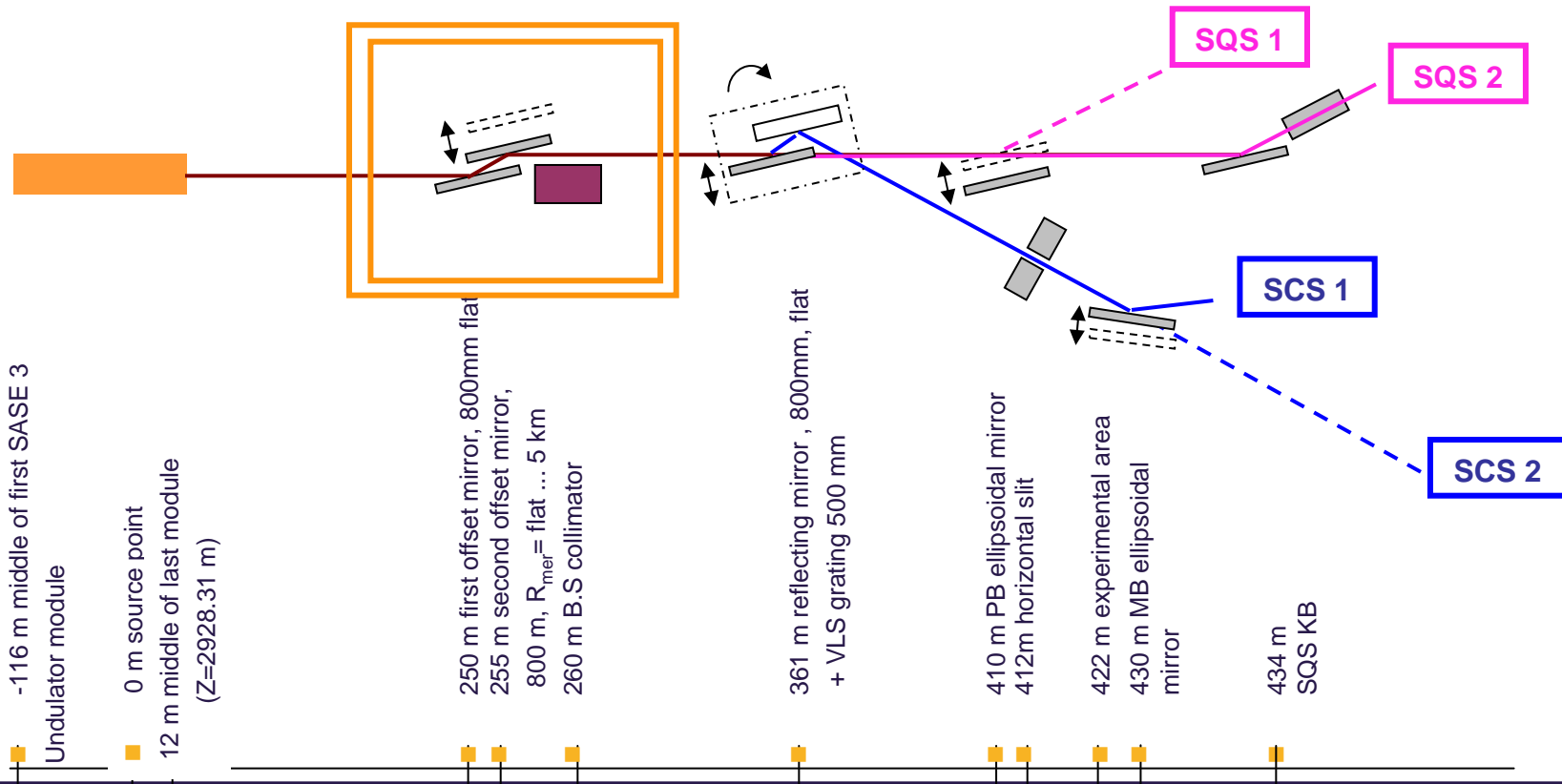
- 17.5 / 14 GeV, 0.1...1 nC, SASE 1 ON/OFF, Saturated / Over Saturated
- 0.1 nC
 - large divergence, low flux = mirror size
- 1 nC
 - high flux, low divergence = damage risk (OS case)

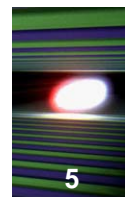


The SASE3 beamline: main features

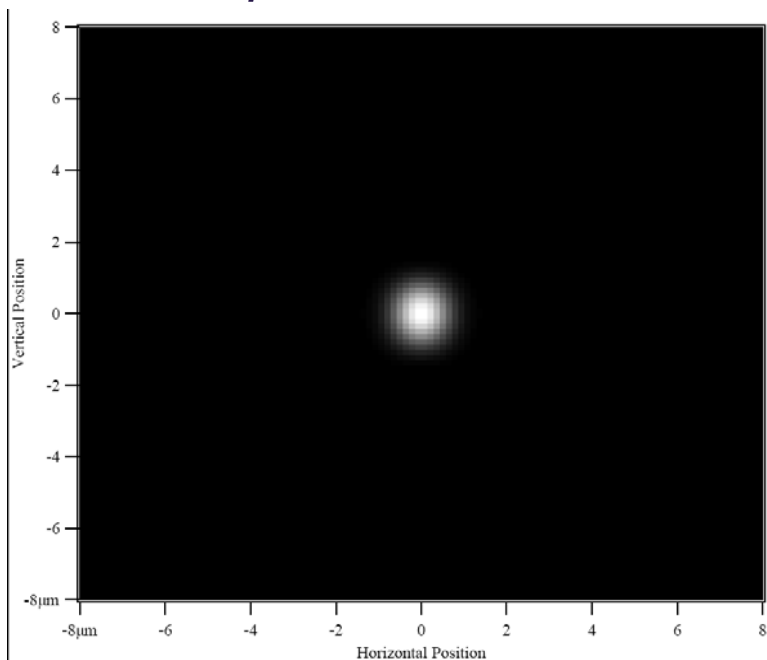
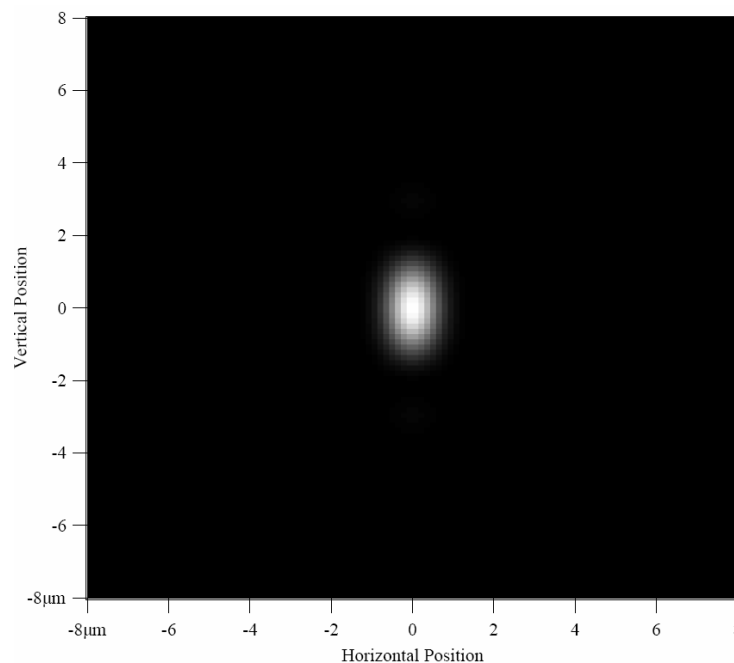


- pink beam → Small Quantum System
- Monochromatized → Spectroscopy and Coherent Scattering



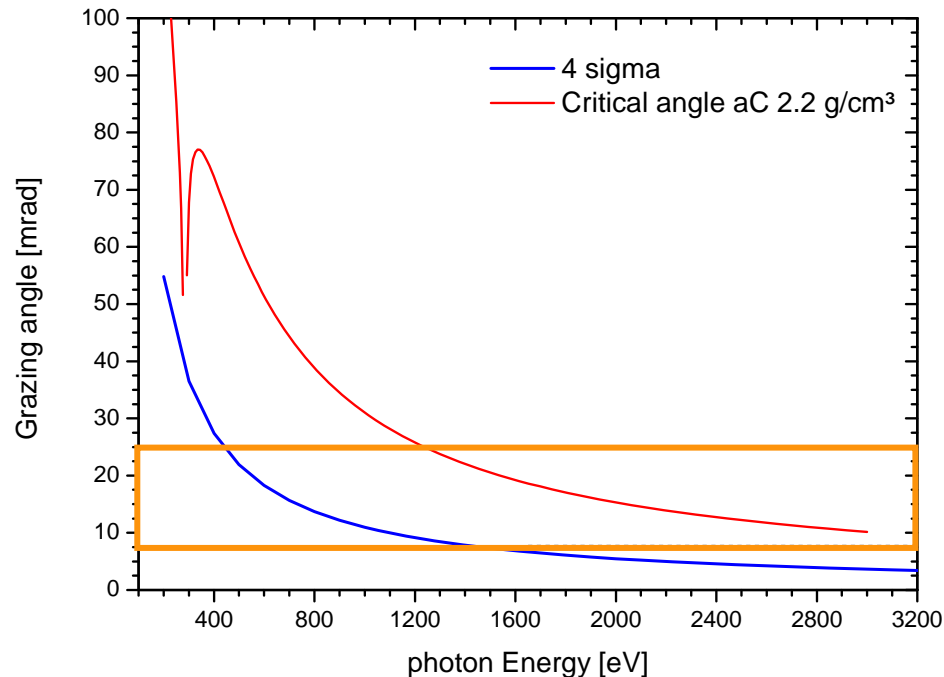


- Effect of the mirror aperture on focus
 - wavefront simulation: 800 eV (1.6nm), 10 m mirror focus located at 400 m/source, offset mirror: 234m, 0.1 nC

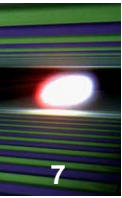
Aperture : 4σ *Aperture : 3σ* 

All simulations by *L.Samoylova, xfel.eu*

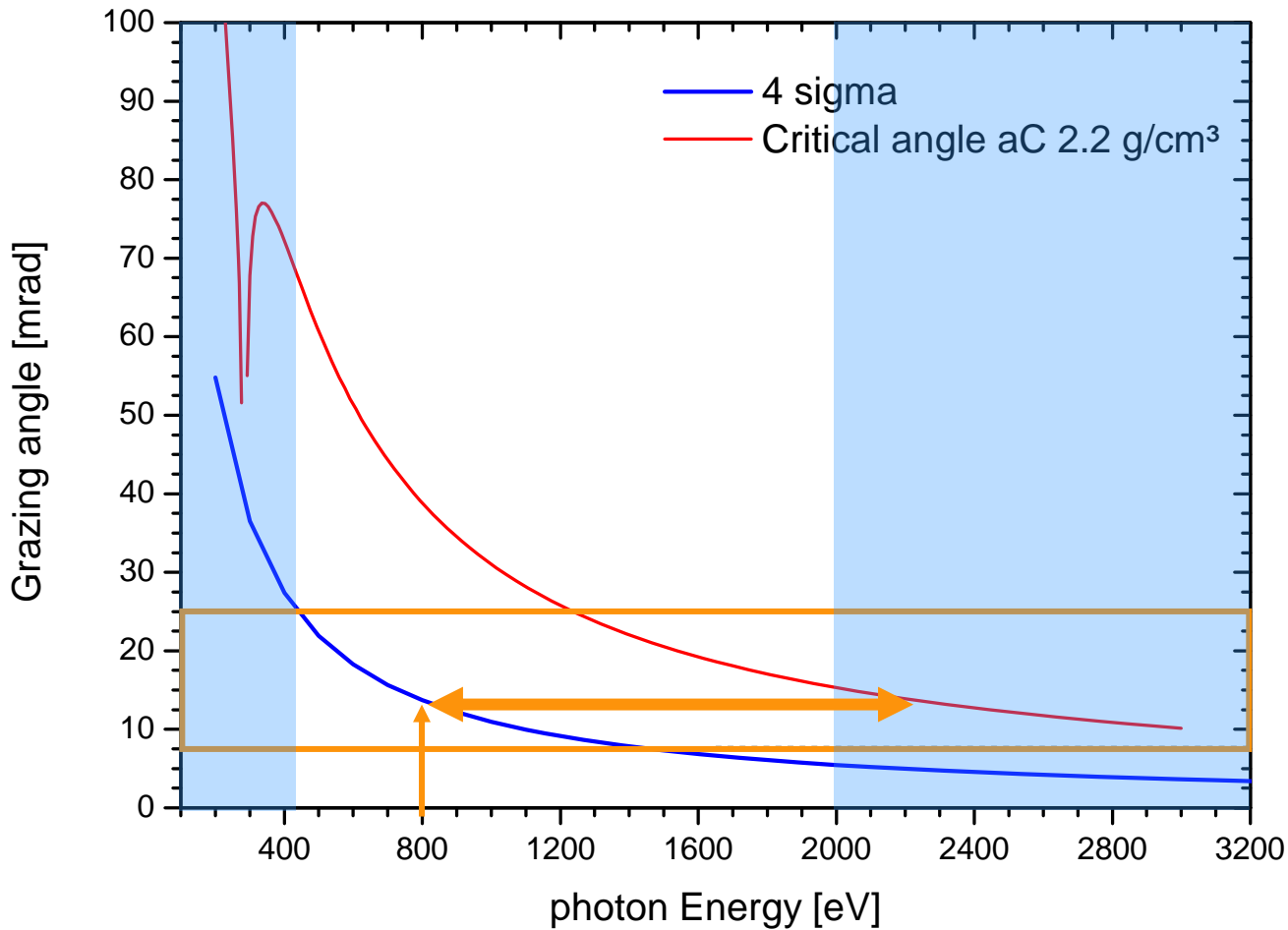
- Mirror size: technological limit of 800 mm
 - ➔ Minimum Grazing angle for 4σ on the mirror ($T=0.95$)

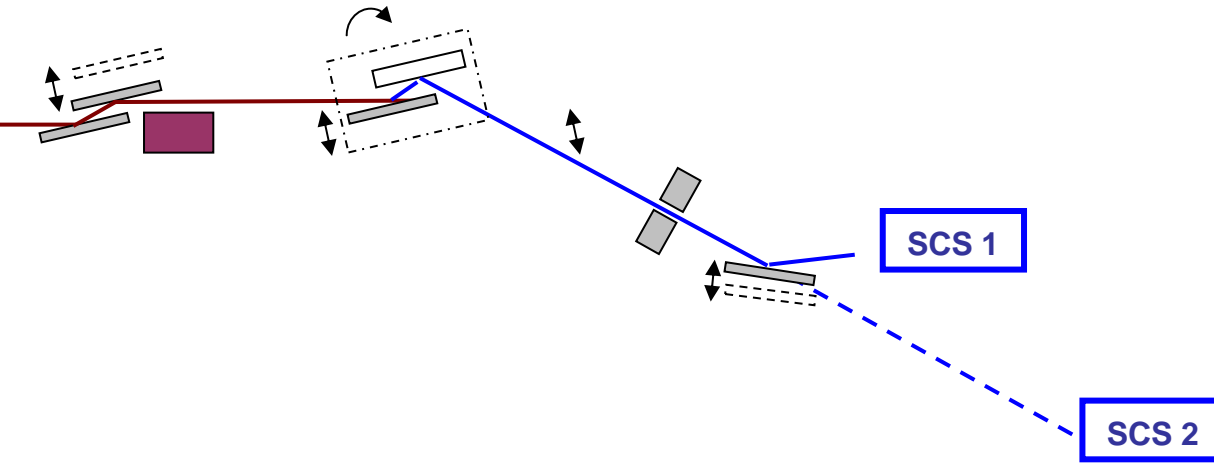


- Solution: Tunable angle in a limited range 25 to 8 mrad

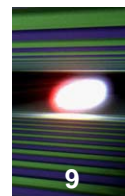


Consequences of the Tunable angle in a limited range 25 to 8 mrad



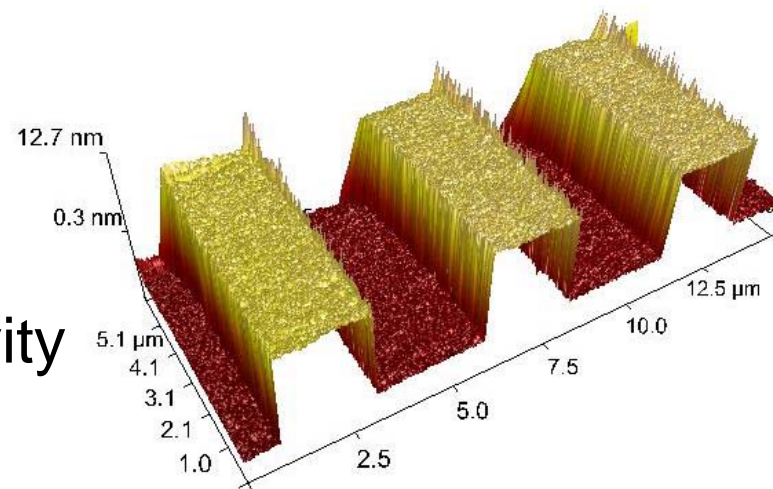


- Very preliminary design, collaboration with BESSY (R.Follath)
- Monochromator
 - Variable Line Spacing + PGM configuration
 - 2nd mirror of the off-set system will focus on the PGM
 - Aim: resolving power $E/\Delta E > 10^4$ (depending on the grating)
- 2 end-station: focused one (SCS 1) + non focused (SCS 2)

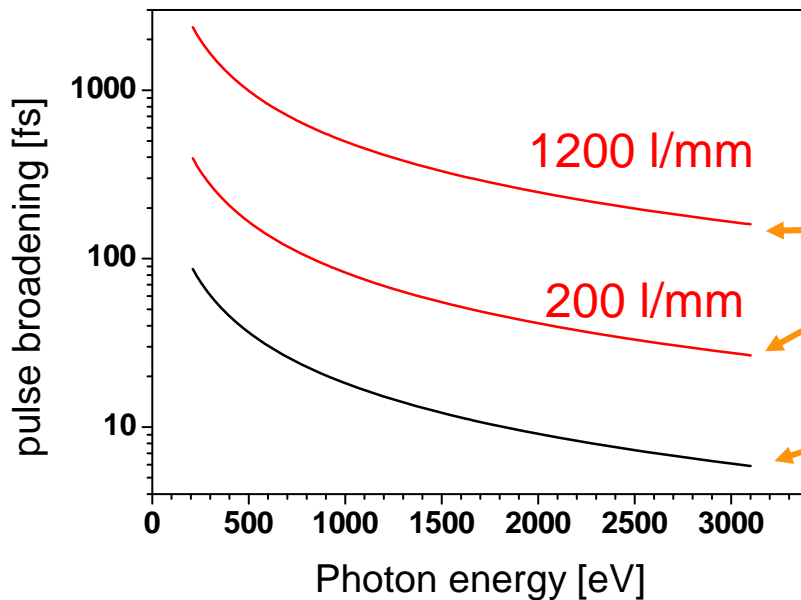


■ Grating Providers

- Zeiss has stopped its grating activity
 - BESSY initiative...delay?
- Shimadzu: size limited to 200 mm
- Jobin-Yvon
 - > 400 mm Si grating (experience from large scale lasers: LMJ...)



- Temporal aspect : high resolution => long pulse

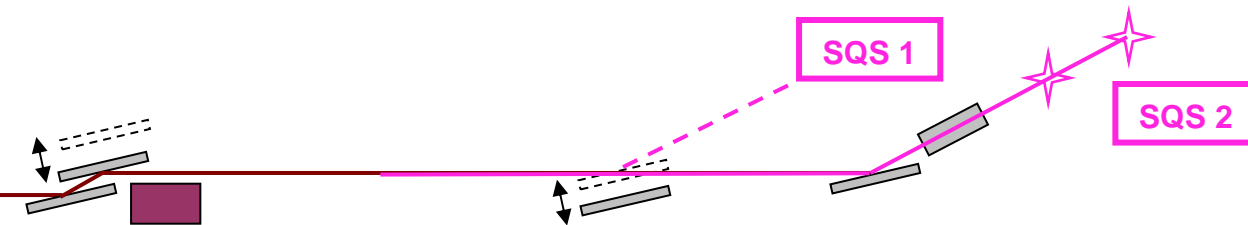
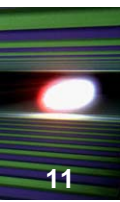


$$\Delta t = m \cdot N_t \cdot \lambda / c$$

$$\Delta \tau \cdot \Delta f \geq 0.441$$

Variable slit width => vary the number of illuminated lines at expense of flux

- ⇒ Finally has to be determined in collaboration with the SCS leading scientist.



- SQS 1
 - Moderately focused beam to 100 μm (depending on users request)

- SQS 2
 - 1 to 10 μm
 - KB optics
 - 2 focus points (exp. chamber + diagnostic chamber)

- Fluence tuning at focal point by attenuation of the energy (gas attenuator + solid attenuator)

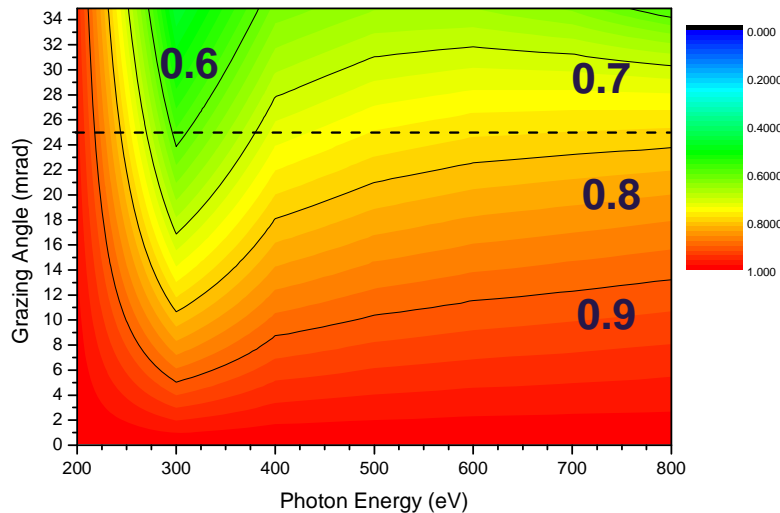
Considerations for photon energy < 400 eV

- Region energy 270 to 400 eV
 - Carbon coating : low reflectivity + higher damage threshold

a-C Reflectivity (from CXRO)

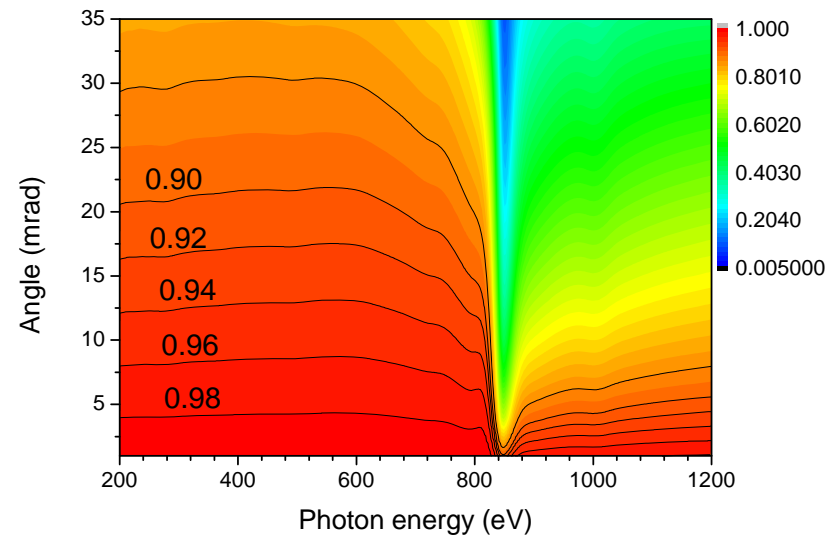
Needed from 0.4 to 3 keV

-> fundamental >400/500eV



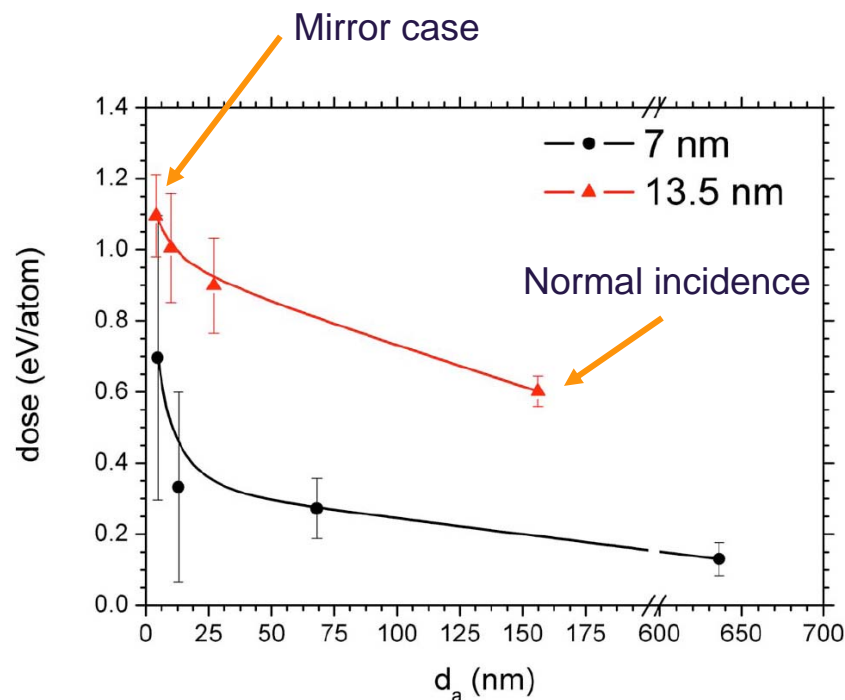
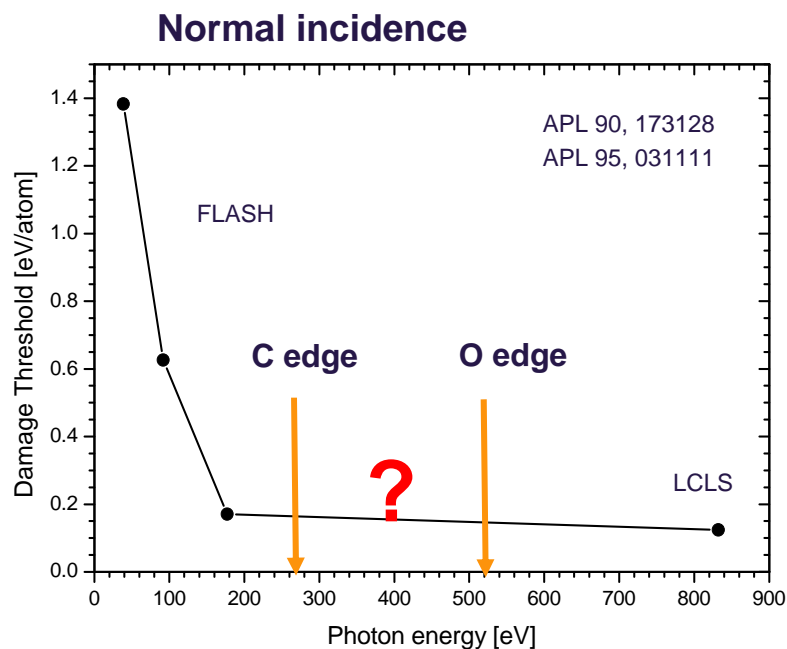
Ni Reflectivity (from CXRO)

Needed from 0.2 to 0.4 keV

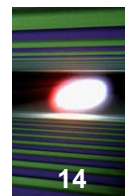


Single shot damage

- First results from LCLS: a-C @ 830 eV $F_{th} = 278 \text{ mJ/cm}^2$
→ dose = 0.12 eV / atom at normal incidence
- FLASH results below the damage threshold : $F_{th} (< \theta_c) = 2 \times F (> \theta_c)$



Chalupsky et al. APL 95, 031111 (2009)



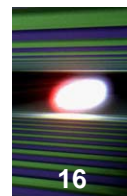
- Summary of the foreseen scheme:
 - main energy range: 400 to 2000 keV
 - » Mirror aperture $> 4\sigma$ \rightarrow undistorted wavefront
 - » Resolving power $> 1e4$
 - » Safe up to 10 mJ/pulse (need to be confirmed)
 - for 2000 to 3000 eV
 - » Resolving power $< 1e4$
 - » Lower transmission
 - For 270 to 400 eV
 - » Mirror aperture $< 4\sigma$ \rightarrow distorted wavefront
 - » Low transmission (single C based coating)

■ 2011 :

- FLASH Beamtime: damage on grating / aC / Ni
- Characterization of optical coating (aC / B₄C / Ni ...)
- Decision on grating development
- Finalizing conceptual design for both beamlines
 - » editing of CDR + review (early 2011)

■ 2012

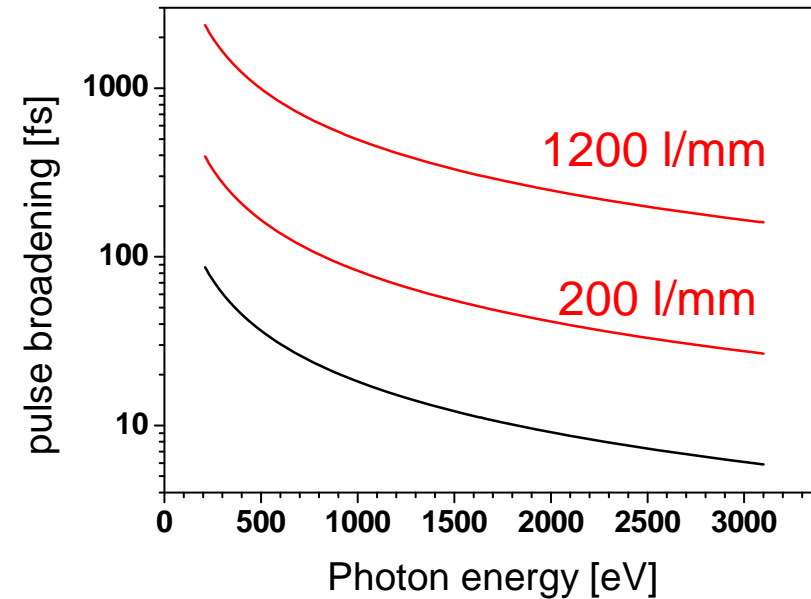
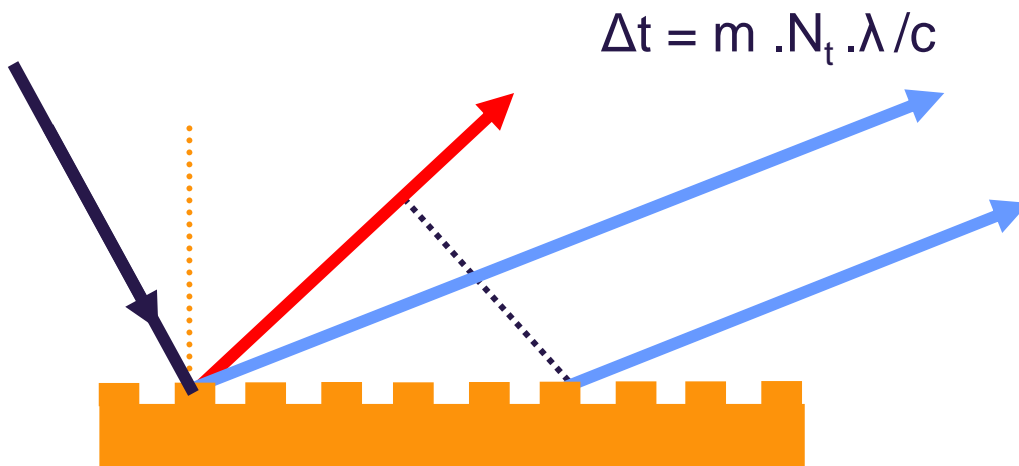
- mechanical design
- ordering 1st optics

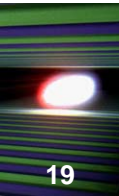


- H. Sinn, S. Dastjani, G. Galasso, I. Freijo-Martin, L. Samoylova, A. Trapp, F. Yang and Th. Tschentscher – *European XFEL, Hamburg*
- Coatings studies: M. Störmer – *HZG Centre for Materials and Coastal Research - Geesthacht*
- Damage collaboration:
 - H. Wabnitz, S. Toleikis, K. Tiedke - *FLASH - Hamburg*
 - J. Chalupský, V. Hájková, Libor Juha - *IOP, AS CR - Prague*
 - R. Sobierajski, M. Jurek, D.Klinger - *Inst. of Phys. PAS - Warsaw*
 - S. Hau-Riege, R.A. London, A.Graf, S. Baker, R. Soufli - *LNBL, Livermore*
 - J. Krzywinski, S. Möller, C. Bostedt, J. Bozek - *SLAC, Menlo Park*
- E. Schneidmiller, M.Yurkov - *DESY, Hamburg*

■ Spectral Resolution vs Time resolution

- Fourier transform limited pulse $\Rightarrow \Delta\tau \cdot \Delta f \geq 0.441$
- Monochromatization with a grating \Rightarrow temporal broadening





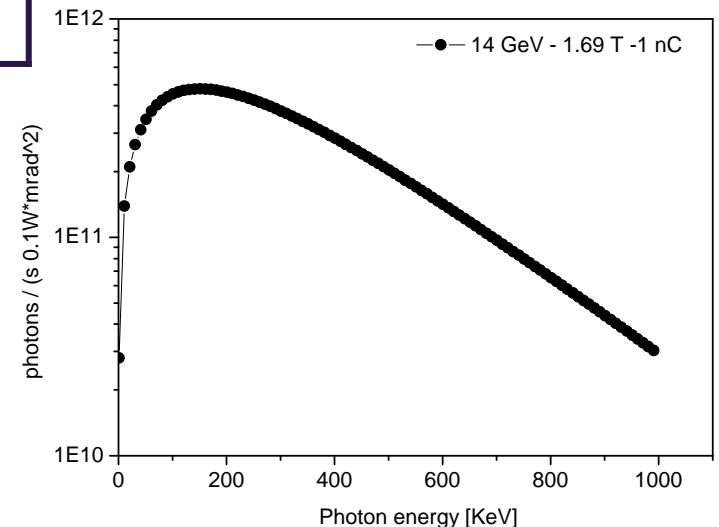
Some feed-back needed:

- on the tunable angle device
- Pink beam : Coherence is a relevant parameters ?
 - If yes, what would be the scientific motivation?
- What is the resolving power needed?
 - Trade off spectral / temporal resolution
- Any feed-back in general is welcome...

- Heat Load for 13500 pulses:
 - Spontaneous emission (through 15x15 mm² aperture)

e- beam (GeV)	17.5	14
B (T)	1.69	1.69
Power (W)	71.54	35.94

- efficient cooling has to be foreseen
- requirement for mono to be precised



All calculations by H.Sinn and I. Freijo-Martin, xfel.eu

- FEL radiation induced deformation
 - FEM calculations => induced heat bump (17.5 GeV - 13500 pulses /s)

Photon energy (eV)	800	1300
P (W/mm ²)	0.5	1.54
Heat bump (nm)	7.5	17

All calculations by F. Yang, xfel.eu

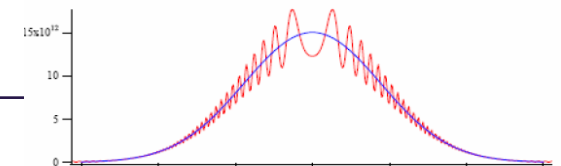
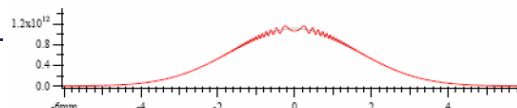
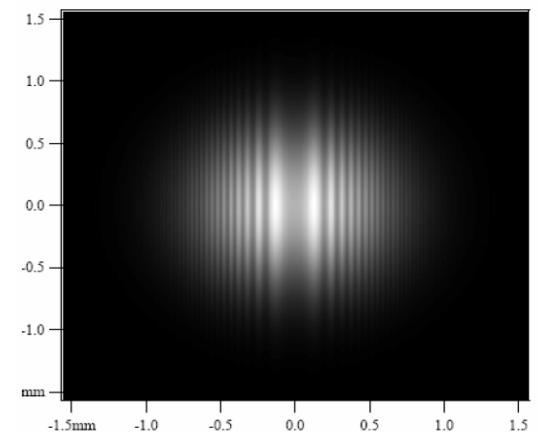
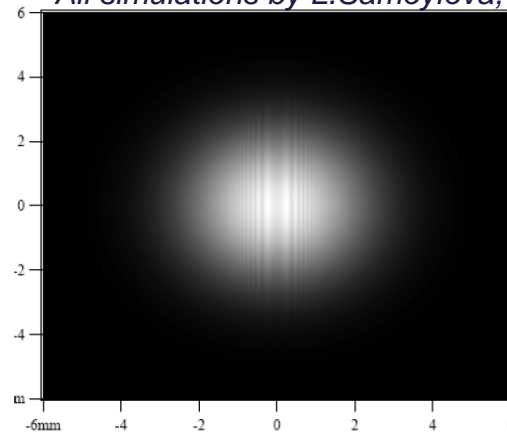
- Wavefront

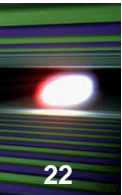
Simulations

800 and 3100eV

3 nm bump

All simulations by L. Samoylova, xfel.eu

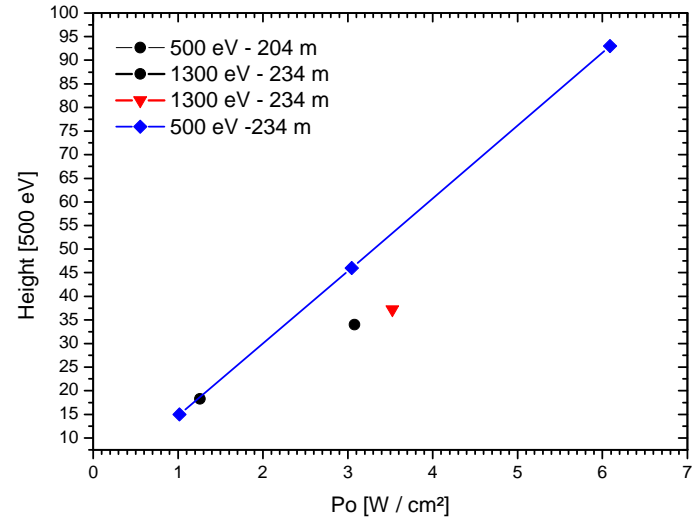
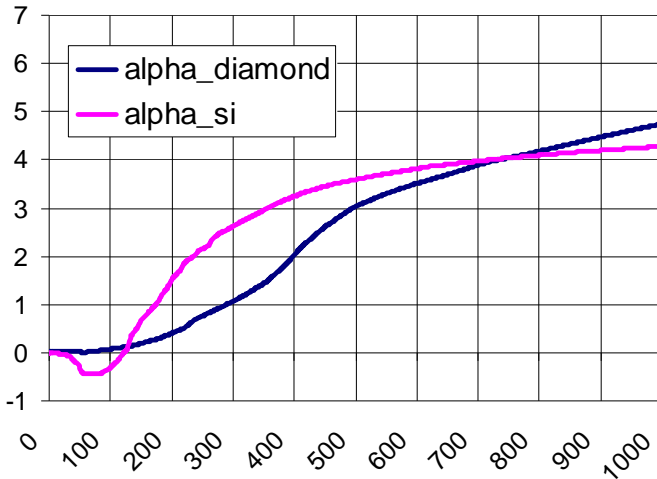


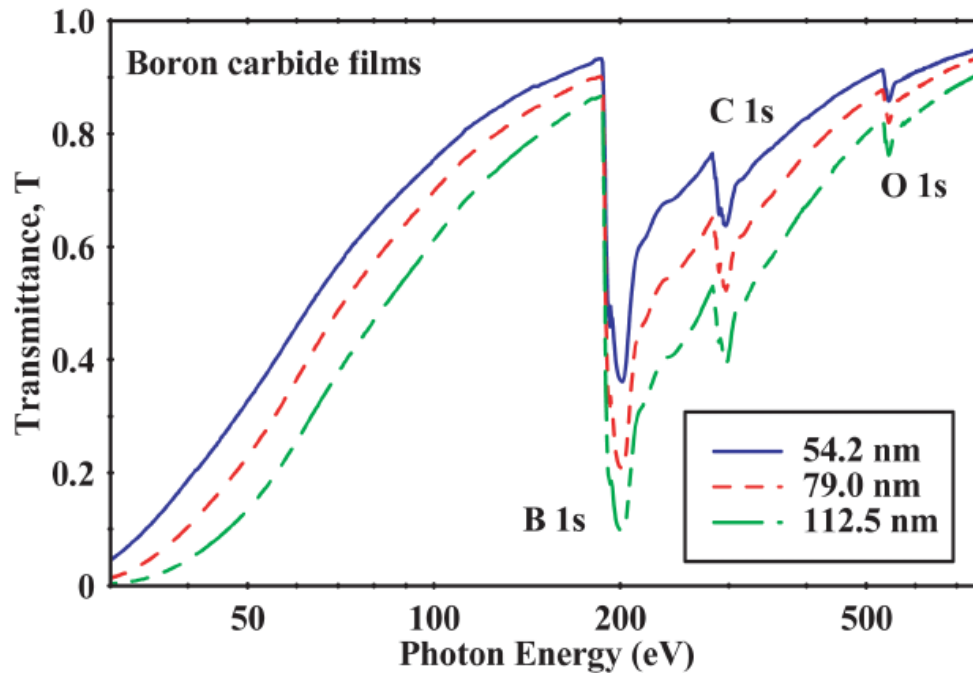


■ Limit the number of pulse / train

■ Mirror at low T

C:\Documents and Settings\gaudin\Desktop\Science\SASE 3 PROJECT\SASE3 beamline design\Fan calculation\resume bump height fan



Transmission through B₄C foils

Souffli et al.

Applied Optics 47, 4633 (2008)