SASE 3 beamline layout

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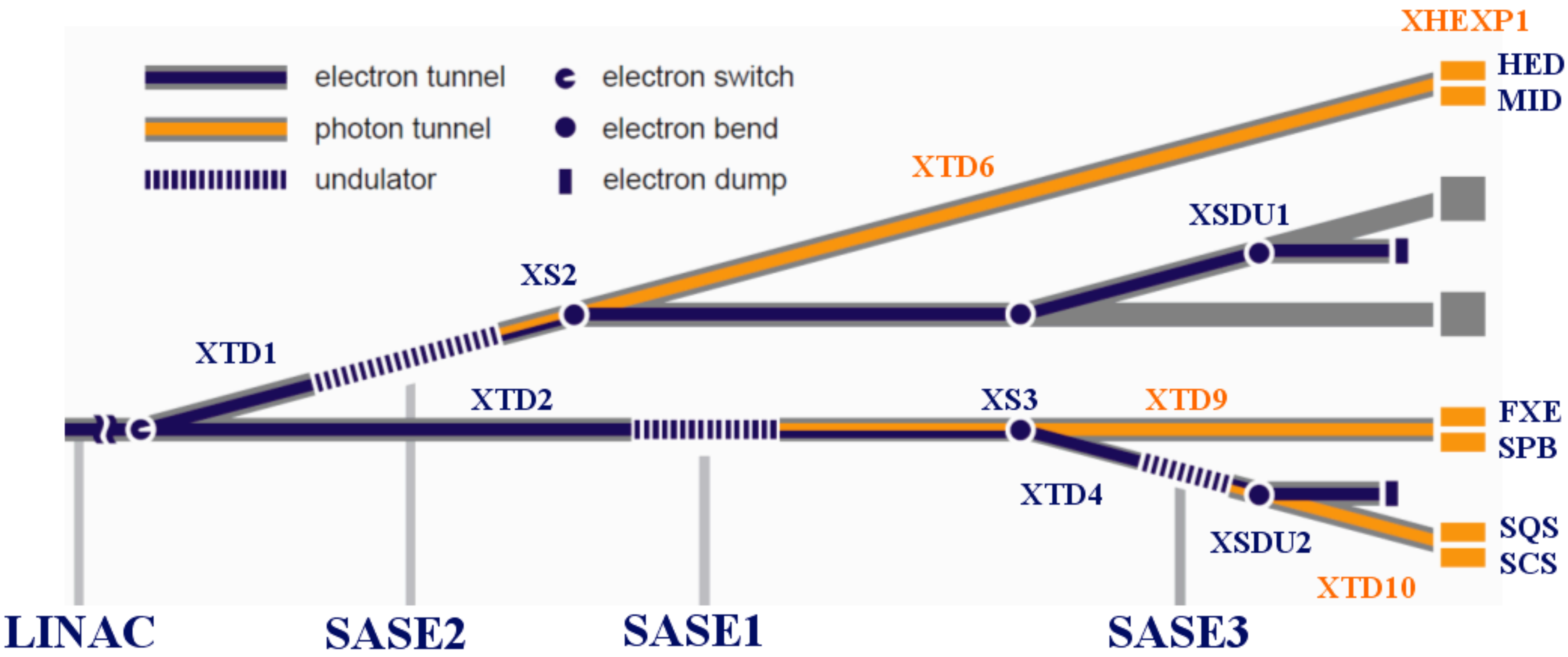
Contents

- Introduction
- Design of SASE3 beamline
- Pink and mono beam operation
- Prototypes and R&D in 2012

Photon beam transport systems



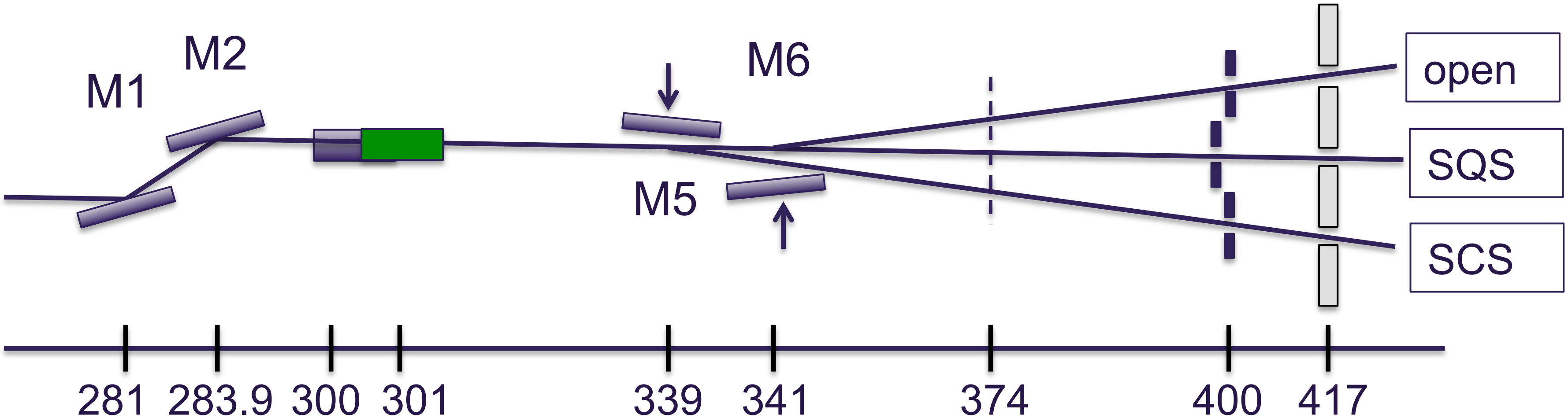
Orange color: Beam Transport and X-ray optics

SASE3 pink beam transport (CDR)

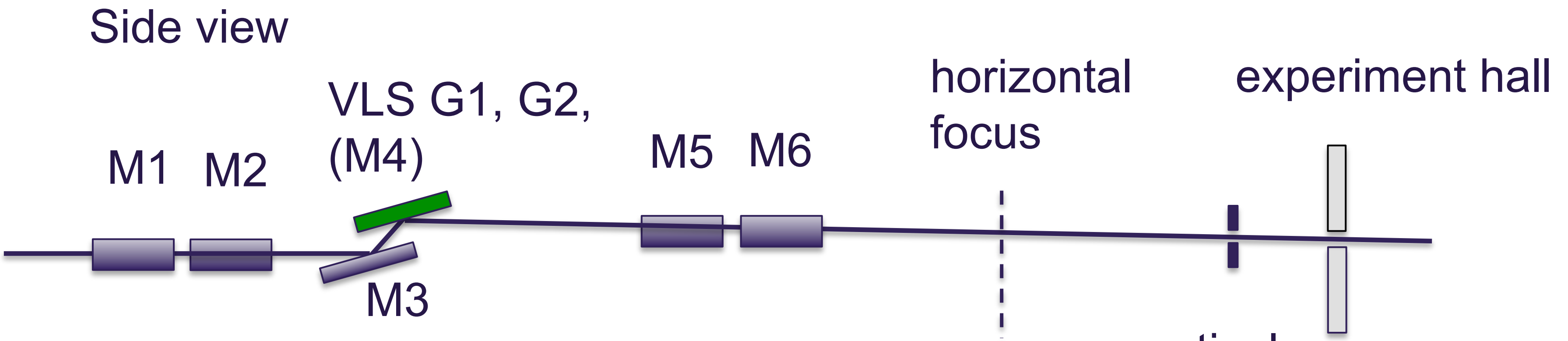
Pink beam operation:

- Mono at 300 can be moved out. Only 2 (SQS) or 3 (SCS) mirrors in the beam
- M1 800 mm flat, M2 bendable (adaptive). M5, M6 adaptive (option flat).
- Minimal horizontal focus (M2 or M2+M5, 100 nrad rms): 60-200 μm
- Vertical beam size: ‘natural’ beam size 16 mm- 2.6 mm
- Mono used as pink beam vertical focusing element (requires bender): 60-200 μm

Top view

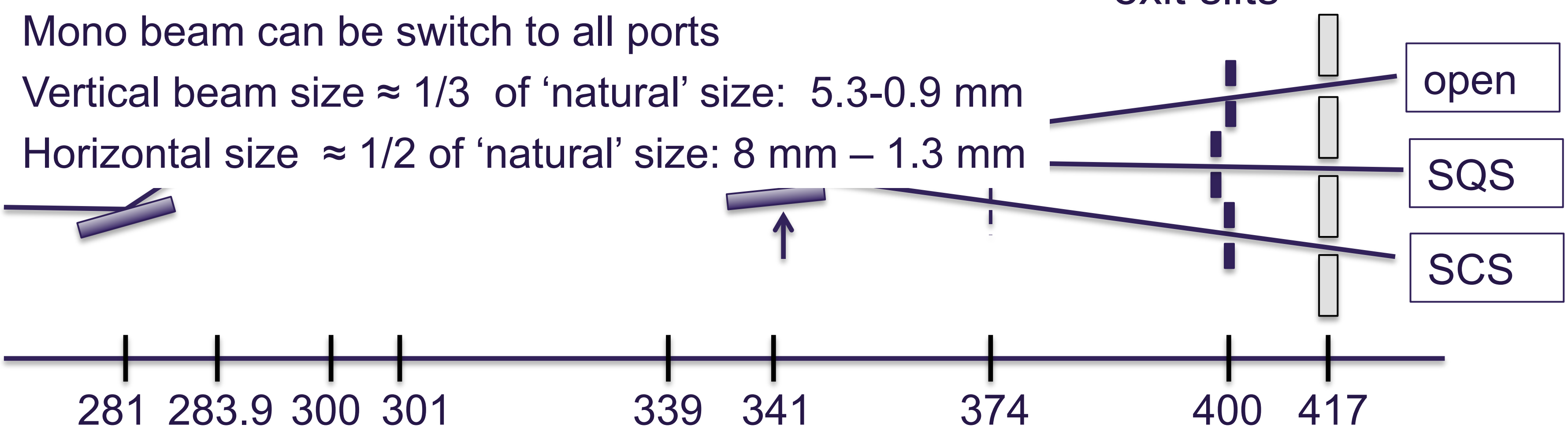


SASE3 mono beam transport (CDR update)



Mono beam operation:

- Mono beam can be switch to all ports
- Vertical beam size ≈ 1/3 of 'natural' size: 5.3-0.9 mm
- Horizontal size ≈ 1/2 of 'natural' size: 8 mm – 1.3 mm



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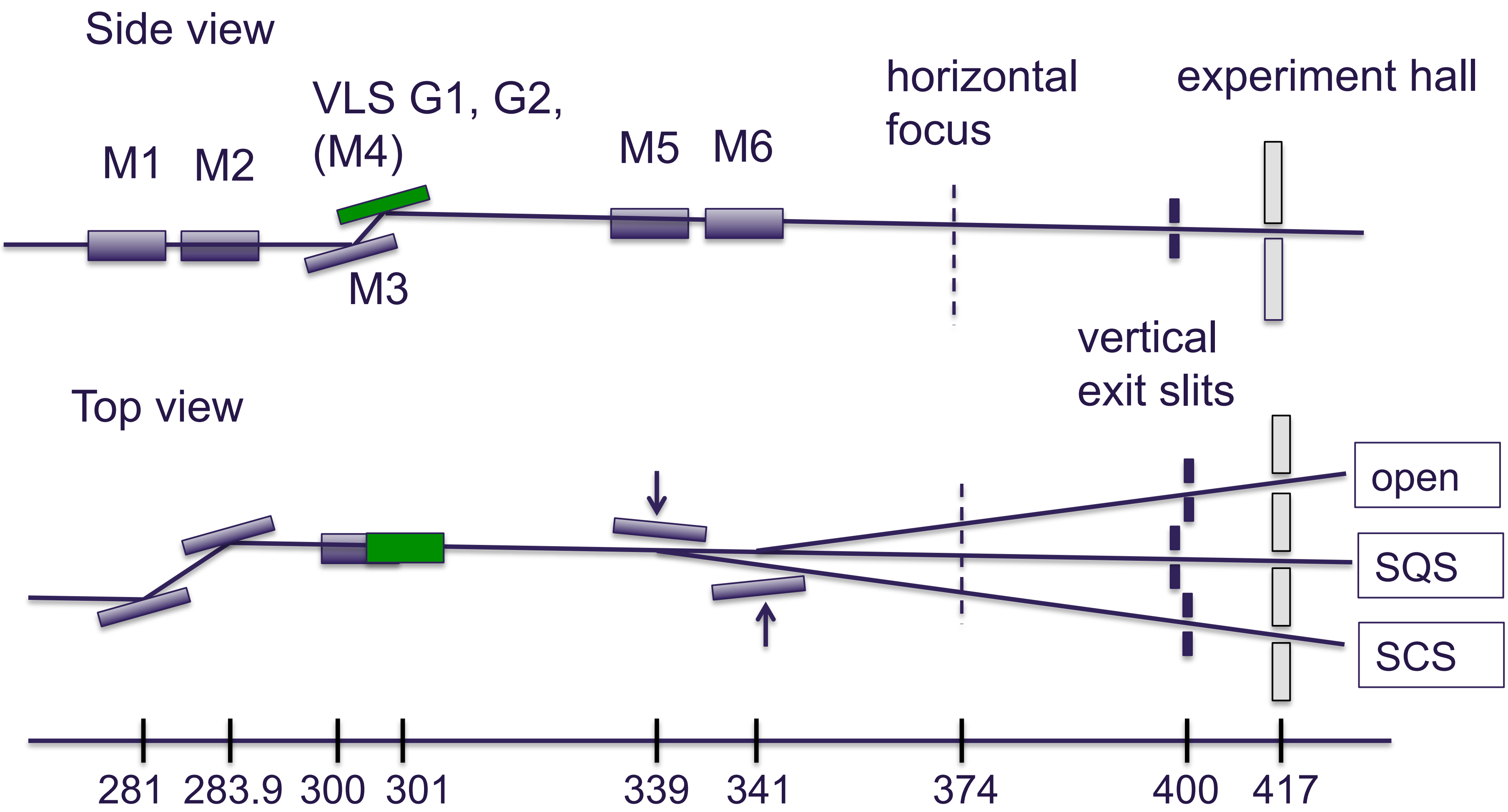
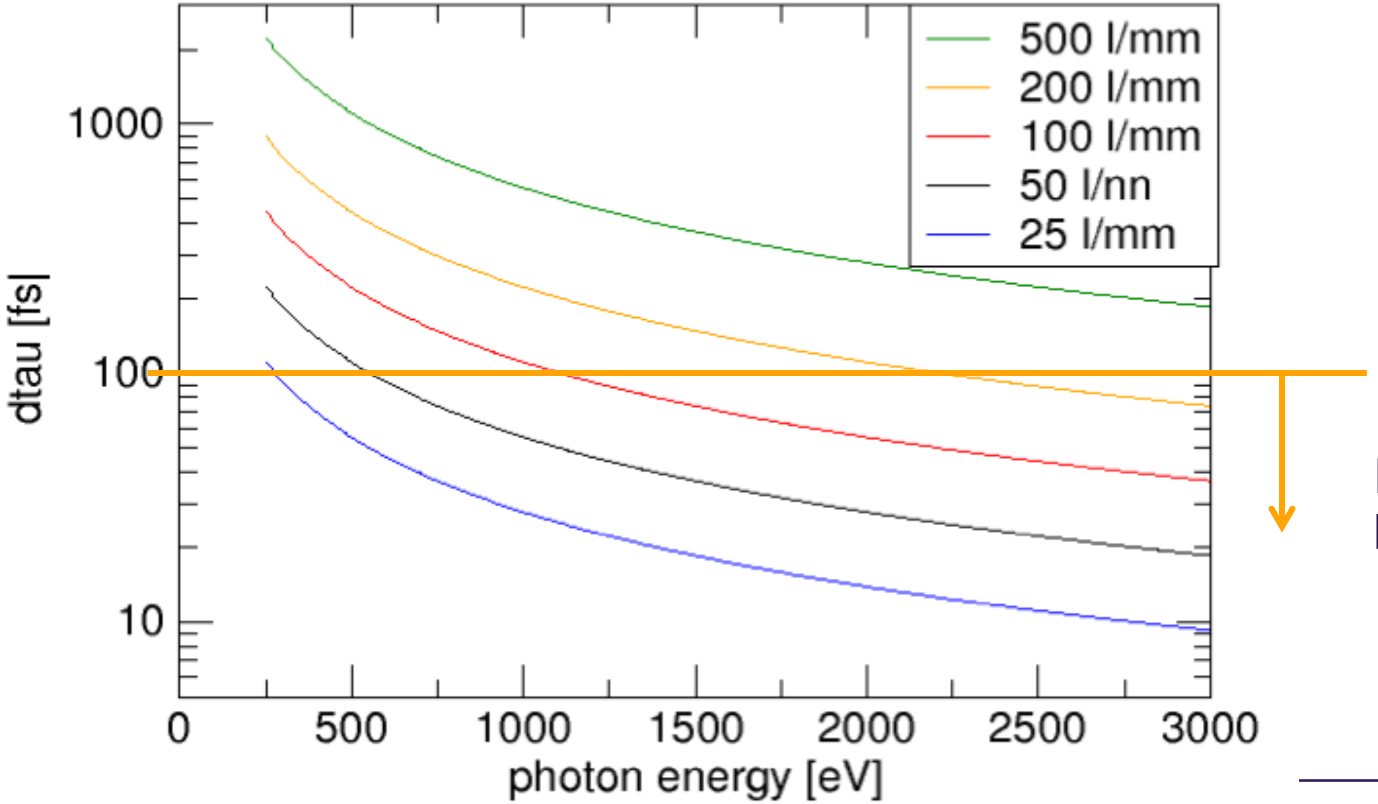


Energy and time resolution

Grating length
460-500 mm (!)

	25 l/mm	50 l/mm	100 l/mm	200 l/mm	500 l/mm
$\delta\lambda/\lambda$	6 700	13 500	27 000	54 000	130 000

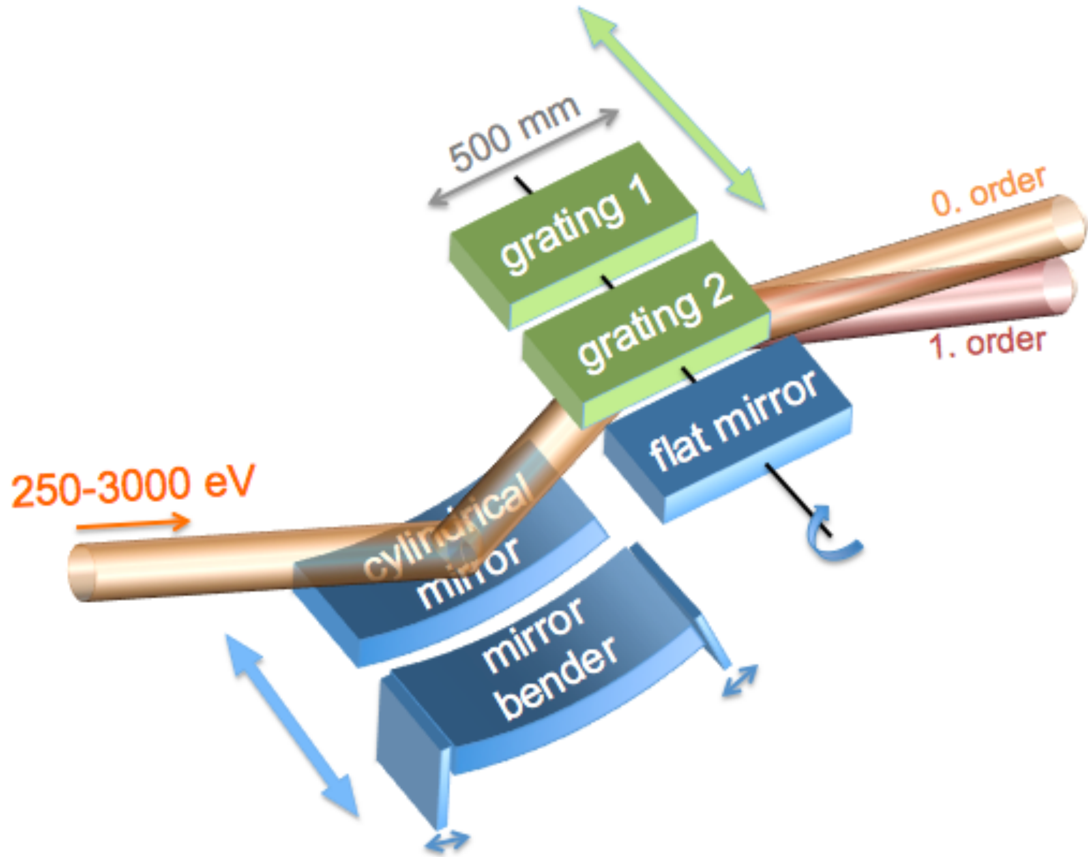


FEL pulse length

Soft X-ray monochromator

Design parameters:
(in collaboration with HZB)

- Optimal footprint of unfocused beam on grating (damage optimized)
- Fourier limited energy and time resolution
- 250-3000 eV
- 500 mm long VLS grating
- Flexible design

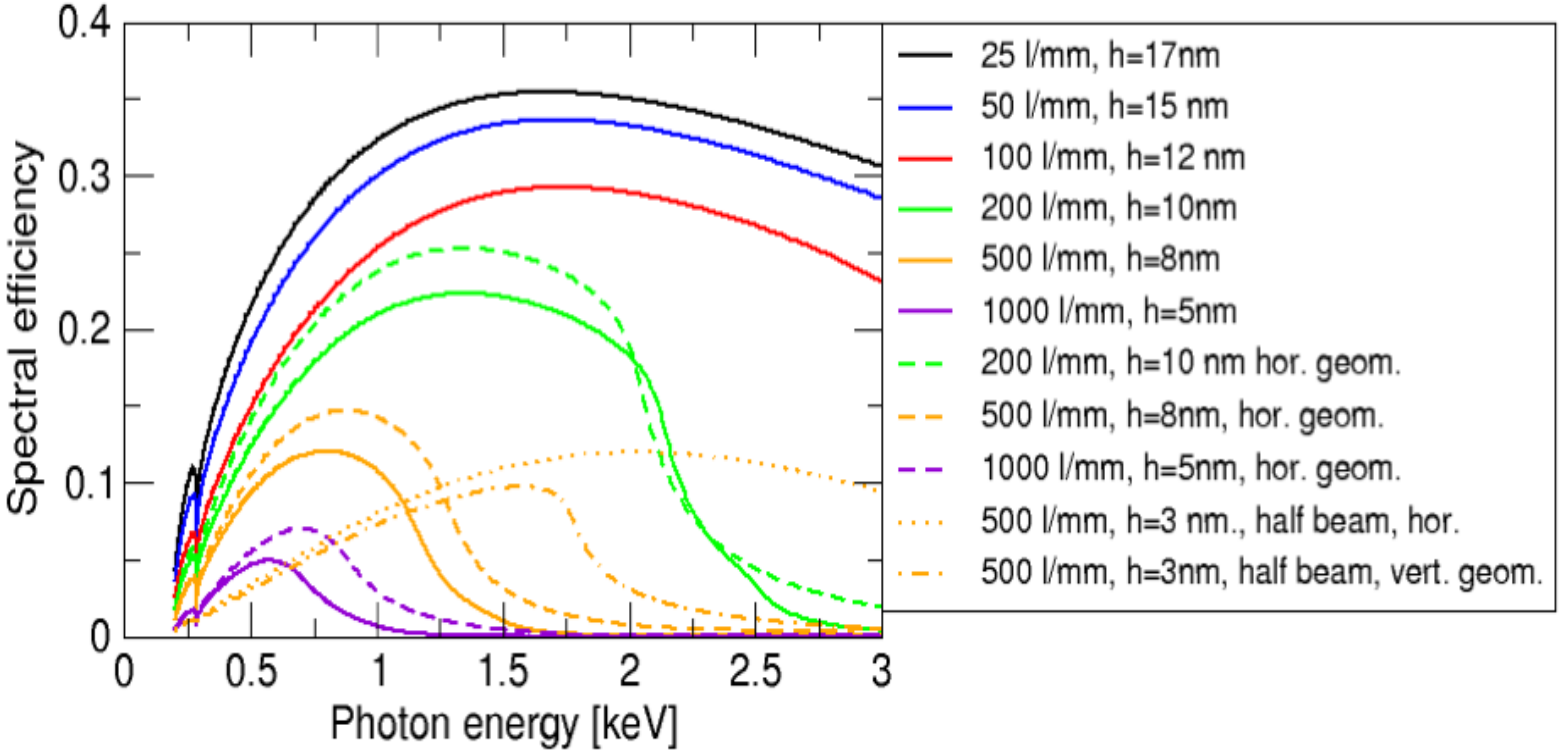


New engineer: Daniele La Civita

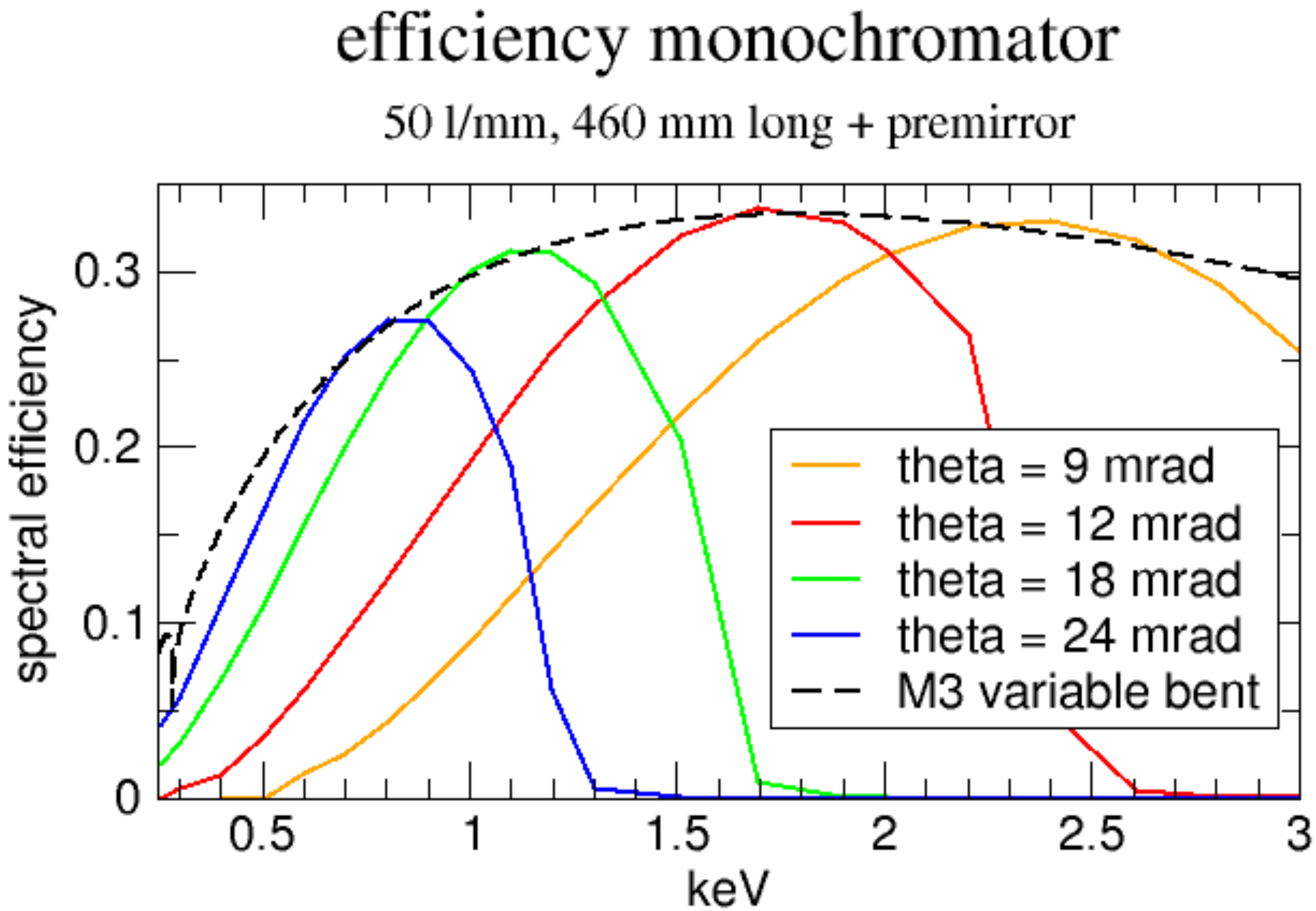
Grating angles and bending radii

Photon energy [keV]	Beam size at 301 m [mm]	α (L1= 460mm) [mrad]	β (50l/mm) [mrad]	cff	R_1' (R_1=99)	θ M3 [mrad]	Length' M3 [mm]	M3 bending radius [km]
0.26	19.81	43.1	48.3	1.12	78	45.6	433	2.7
0.5	12.12	26.4	30.7	1.16	73	28.5	425	4.1
0.8	8.52	18.5	22.3	1.20	68	20.4	417	5.4
1.0	7.21	15.7	19.2	1.22	65	17.4	413	6.2
1.5	5.32	11.6	14.7	1.27	61	13.1	405	7.7
1.7	4.84	10.5	13.5	1.29	59	12.0	402	8.3
2.0	4.28	9.32	12.2	1.31	57	10.7	398	9.0
2.5	3.62	7.89	10.6	1.34	55	9.2	393	10.1
3.0	3.16	6.87	9.40	1.37	52	8.1	389	11.0

Efficiency for different gratings

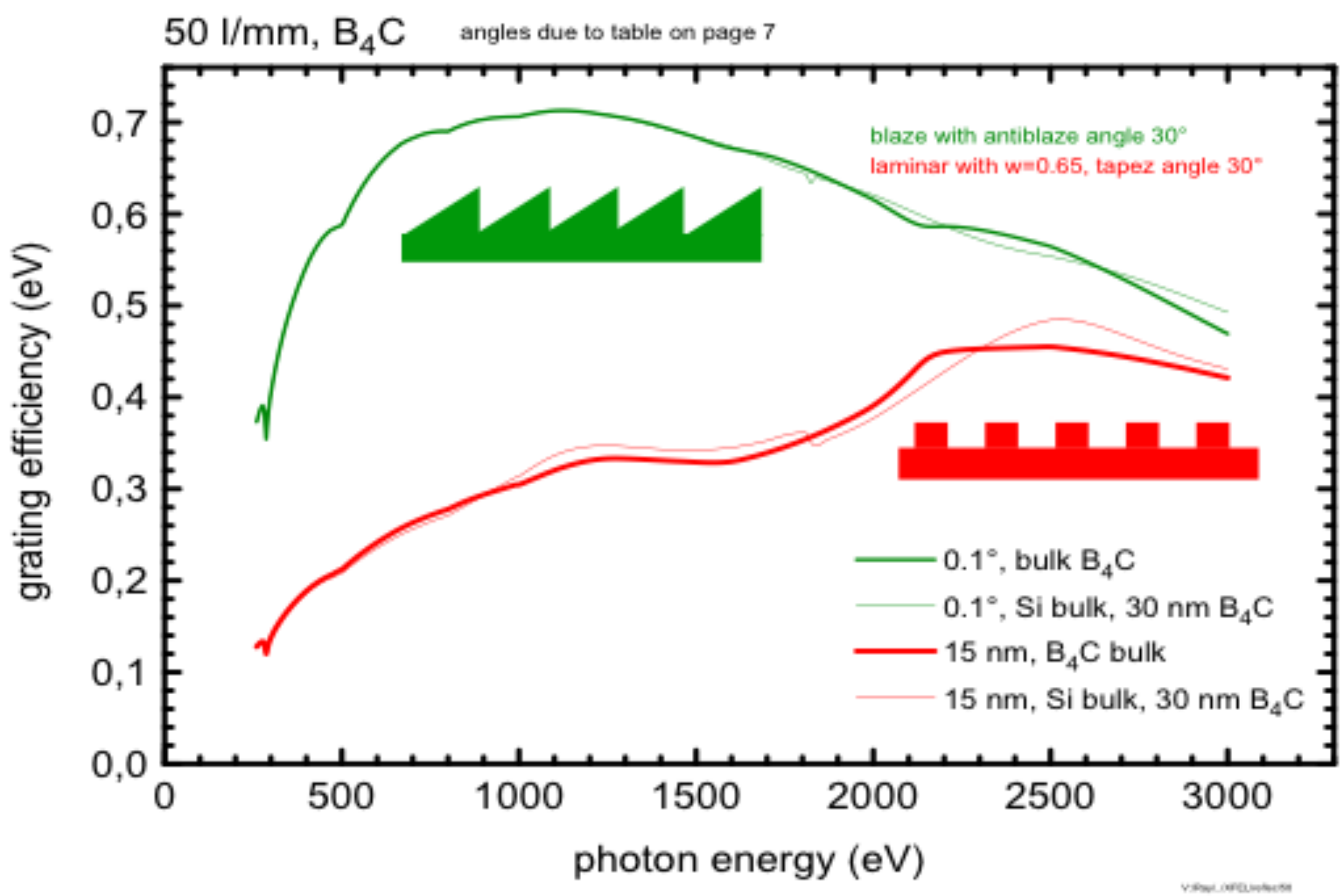


Efficiency with different M3 fixed radius



Numerical calculation of efficiency

1 grating + variable bender

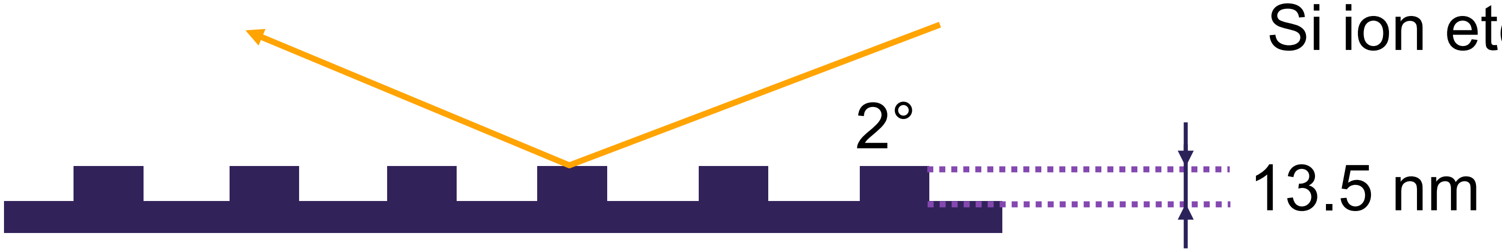


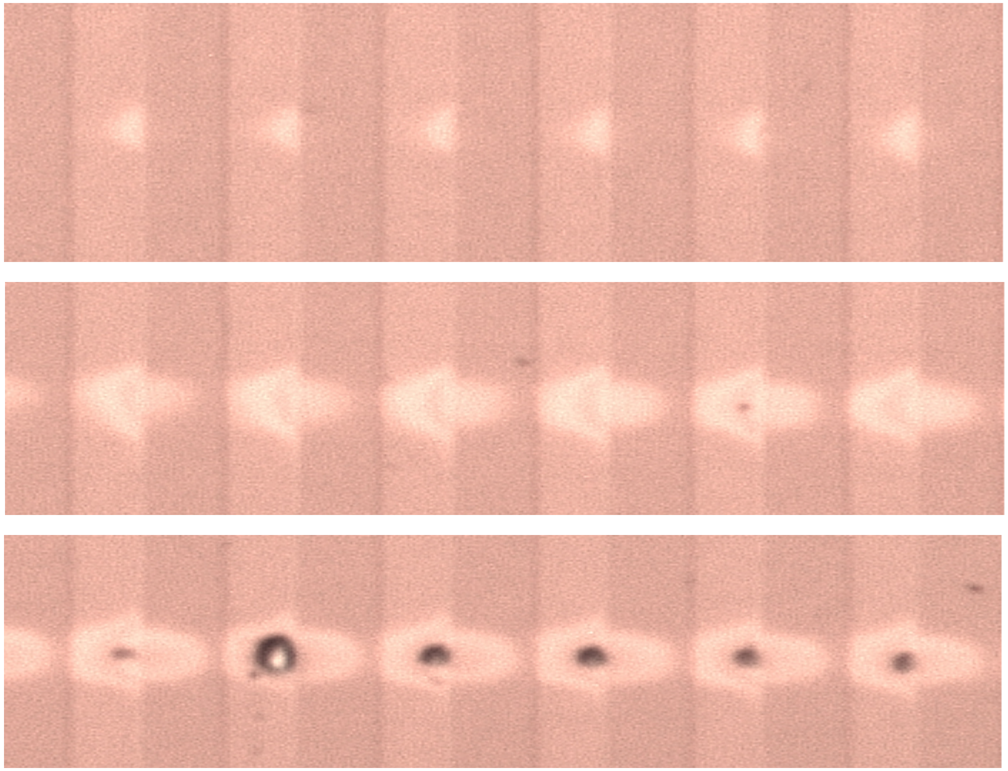
Calculated by Rolf Follath with Nevier code

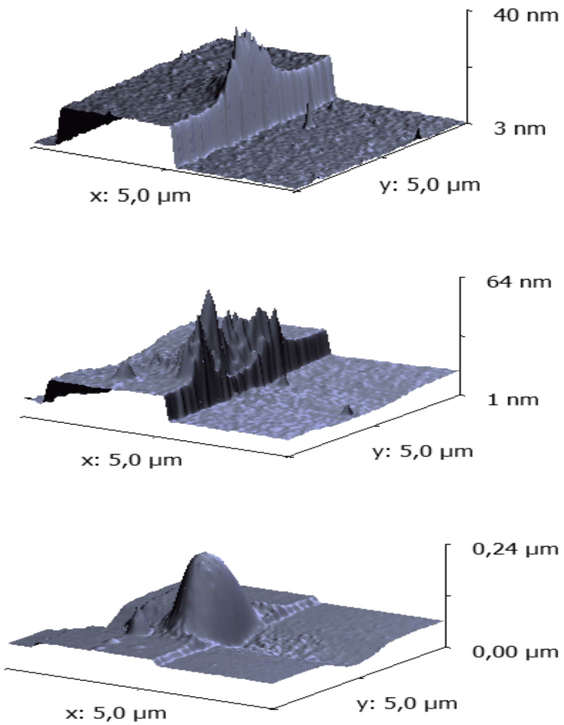
Experimental damage threshold on grating

Si ion etched substrat

+ 50 nm aC





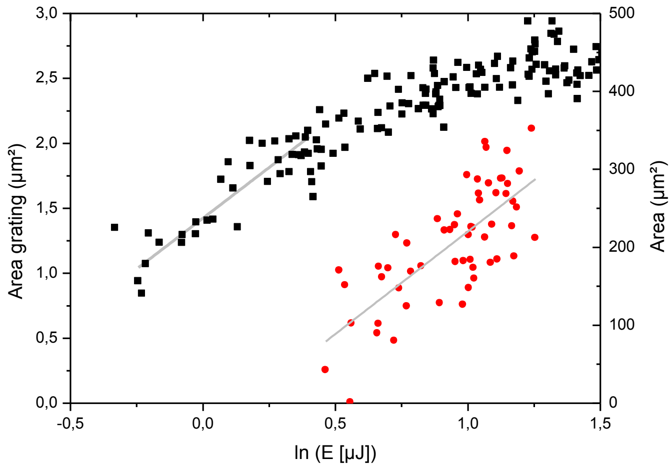


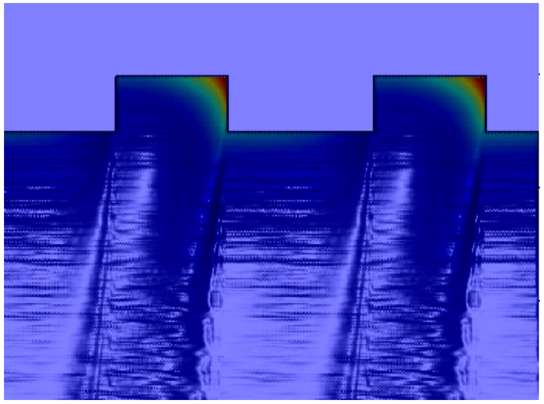
Nomarsky µscope

AFM

Flash experiment + slide by Jerome Gaudin et al.

Experimental damage threshold on grating





Simulations by J. Krywinski – SLAC/LCLS
Paraxial approximation of Helmholtz equation in inhomogeneous media

- Damage threshold (assuming 4.6 nm radiation)
  - grating F_g = 70 mJ/cm²
  - mirror F_m = 205 mJ/cm²
- Theory and experiment
  - $F_m / F_g \sim 3$

Flash experiment + slide by Jerome Gaudin et al.

When will the grating be damaged?

Unfocused beam 300 m from SASE3 source point (one pulse):

Material	290 eV	500 eV	1.2 keV	3 keV
α-C	10.6 (21)	15.0 (33)	36 (97)	111 (360)
B4C	113 (228)	171 (387)	443 (1190)	1413 (4560)
Si	26 (52)	40 (90)	87 (234)	17 (55)
Ni	26 (52)	27 (62)	20 (55)	11 (37)

All values in **mJ/pulse** for smaller (larger) beam size according to the WP73 CDR

B4C	Silicon	Ni	α-C
0.7 eV	0.4 eV	0.4 eV	0.1 eV

Damage at exit slit (B4C)

Photon energy	50l/mm disp. fwhm small div	Beam fwhm at 301m (small div)	27.2% of that	DPE B4C unfocused small div [mJ]	50/mm focusing factor	DPE slit with 30% efficiency [mJ]
0.26	0.49	8.26	2.25	146	62	7.9
0.5	0.39	4.75	1.29	171	44	12.7
0.8	0.34	3.18	0.86	279	34	27
1.0	0.31	2.65	0.71	358	31	38
1.5	0.27	1.86	0.50	578	25	75
1.7	0.26	1.67	0.45	676	23	95
2.0	0.25	1.46	0.39	829	21	128
2.5	0.23	1.21	0.32	1107	19	190
3.0	0.21	1.03	0.28	1413	18	260

European XFEL

Very high resolution?

Grating 600 l/mm (resolution >100.000)

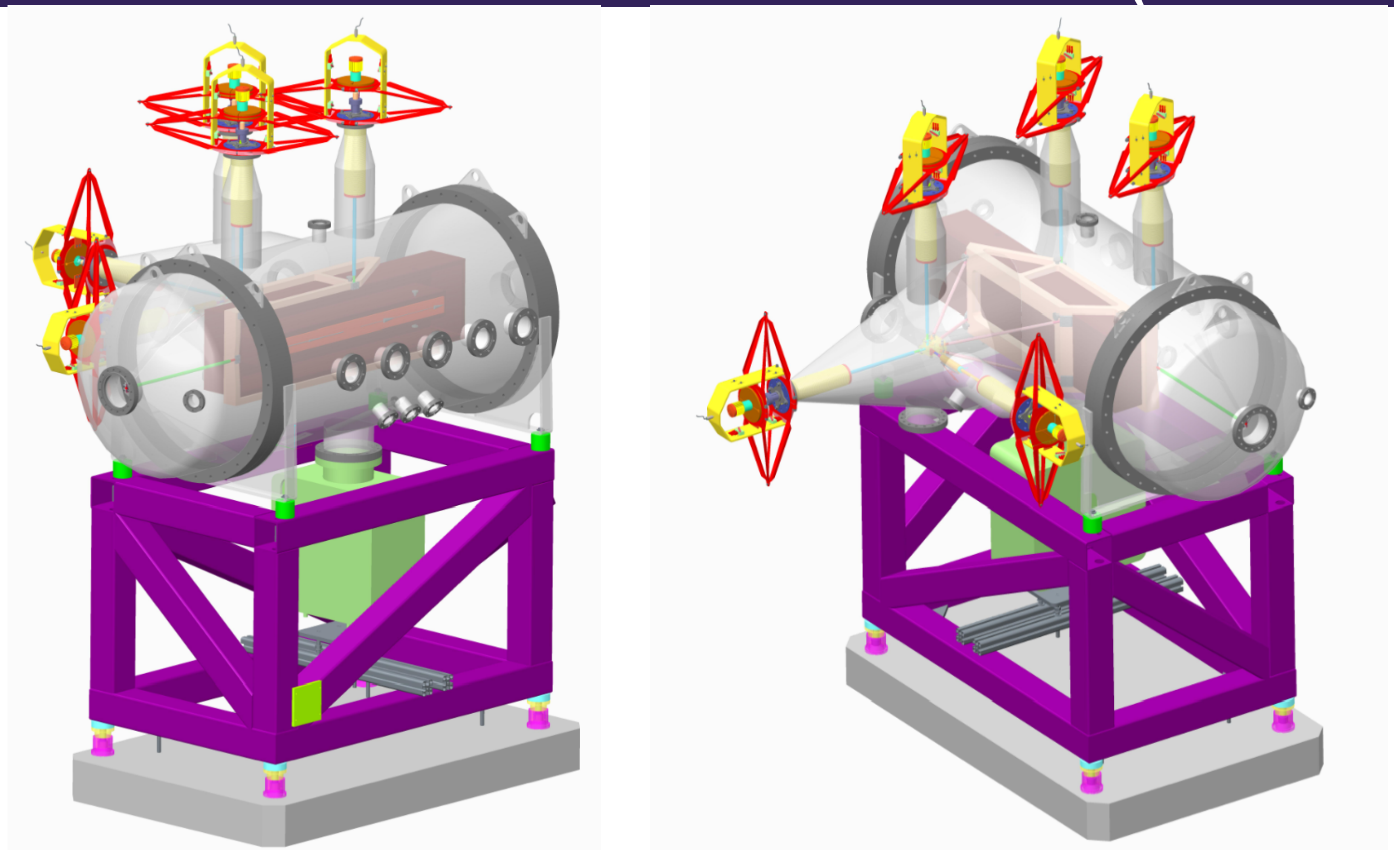
Horizontal geometry (M2 focuses onto exit slit)

No mono beam for two other side stations

CDR design 2011: was questioned due to ps time behaviour,
damage limit of only 2 mJ

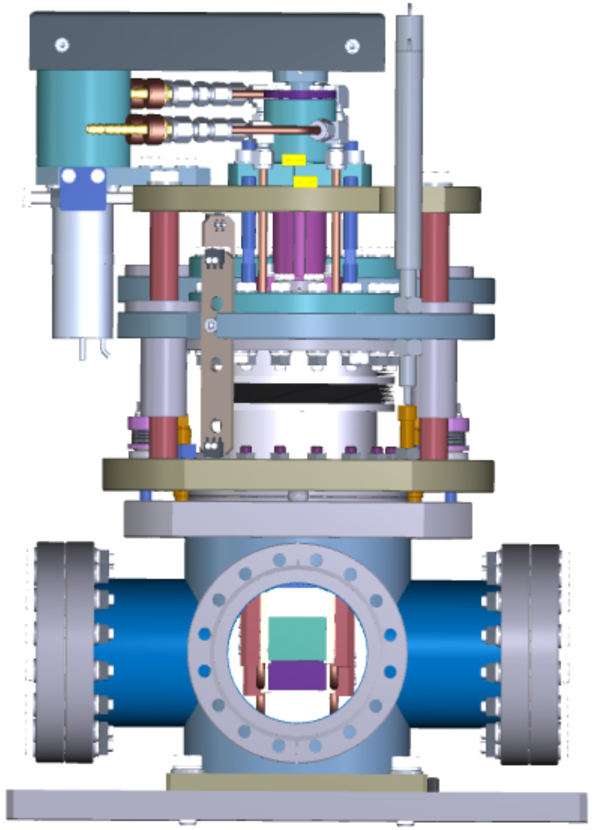
Prototypes and R&D in 2012

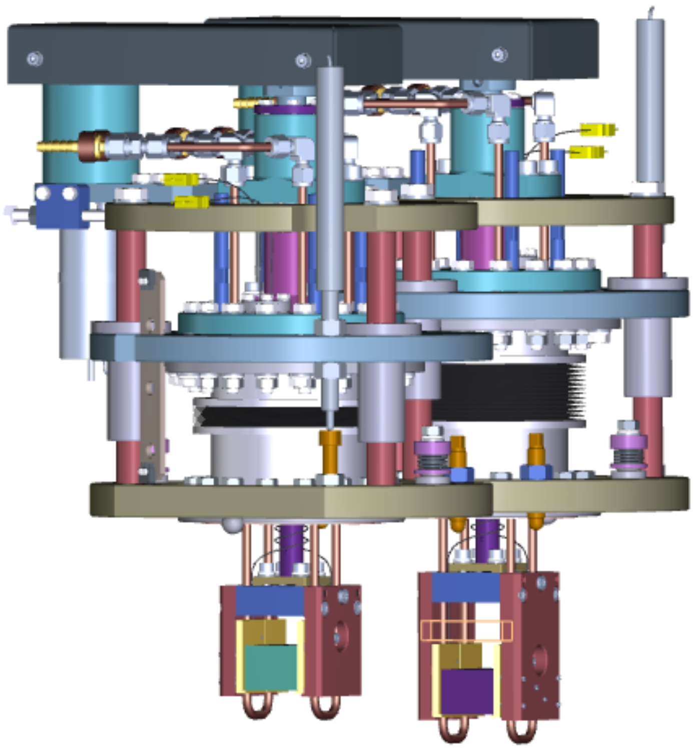
Offset and distribution mirror chamber (fall 2012)



Chamber Design:	Tino Noll (HZB), Antje Trapp
Mirror substrate:	Riccardo Signorato (Bruker ASC), Frank Siewert (HZB)
	Fan Yang, Antje Trapp, Harald Sinn
Stability, vibrations:	Idoia Freijo, Jens Linnemann, Antje Trapp

In production: Slit system





SRA- slit (delivery February) by Germano Galasso (XFEL) and ALCA

Vertical or horizontal operation, design could be used also for exit slit

Summary

- Pink beam and mono beam avialable at all three ports
- Horizontal pre-focusing will be possible with offset and distribution mirrors
- Vertical pre-focusing would be possible by (ab)using mono in pink beam mode
- For the monochromator, a fourier-limited energy resolution around 10.000 and time resolution around 100 fs is targeted
- Required grating for that is 50l/mm 460 mm long VLS grating. 25l/mm or 100l/m are options.
- Technical Design of Monochromator will start 1.2.2012 (by Daniele La Civita)