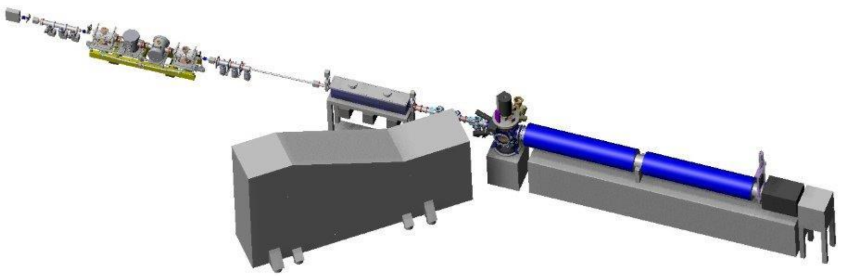
The Spectrocopy &
Coherent Scattering (SCS)
Scientific Instrument

Andreas Scherz

for WP86 European XFEL



SCS Conceptual Design Report

XFEL.EU TR-2013-006

CONCEPTUAL DESIGN REPORT

Scientific Instrument Spectroscopy and Coherent Scattering (SCS)

October 2013

A. Scherz and O. Krupin

for the Scientific Instrument SCS (WP86) at European XFEL

- Imaging station [baseline]

  Coherent diffraction imaging, Spectroscopy

  Small-angle and Bragg diffraction

- Heisenberg RIXS [User Consortium]

  Study of low energy excitation in liquids and solids

  Spokeperson: A. Föhlisch (HZB/Uni Potsdam)

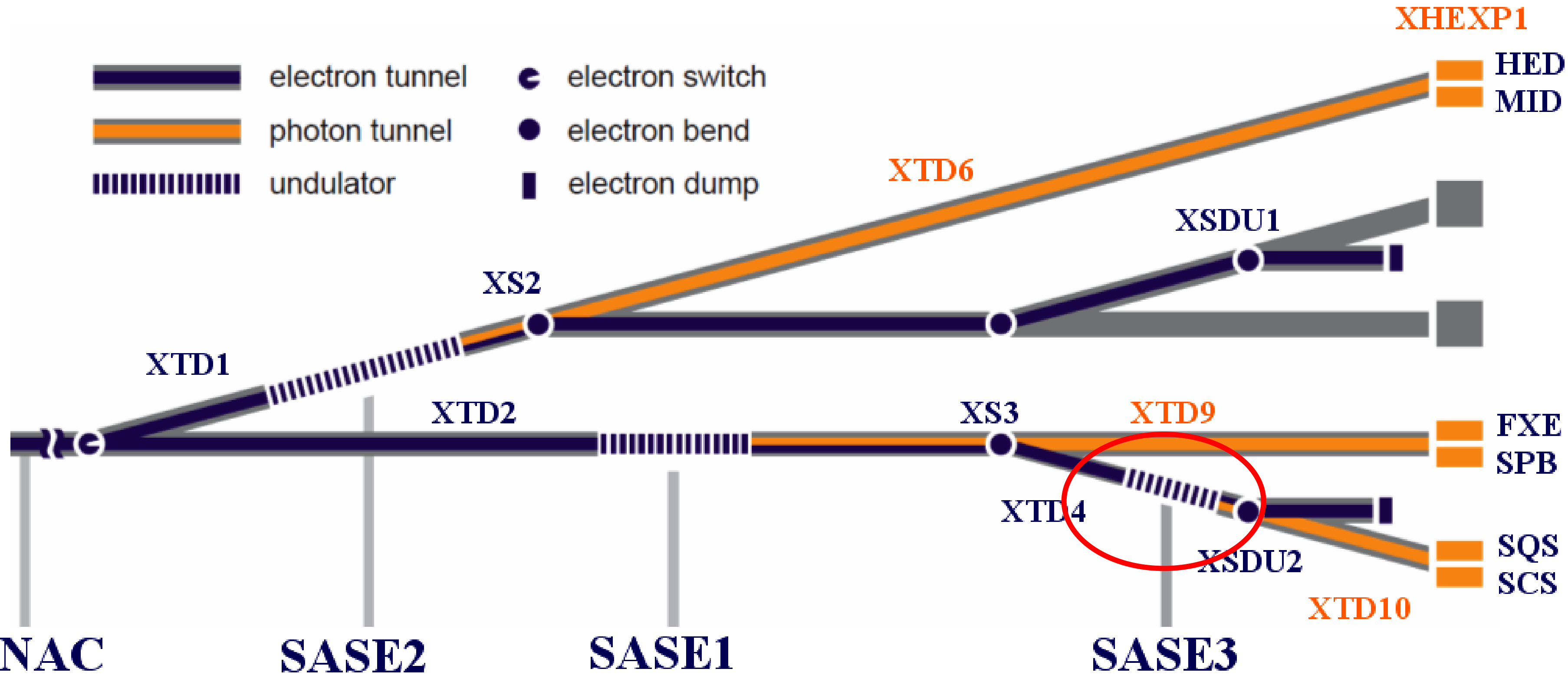
- PES [User Consortium]

  TR-Photoelectron spectroscopy for a broad range of system

  Spokesperson: U. Karlsson (KTH)

XFEL Photon beam transport system

Undulator Segment	FEL radiation energy [keV]	Wavelength [nm]
SASE 1	3 - over 24	0.4 - 0.05
SASE 2	3 - over 24	0.4 - 0.05
SASE 3	0.27 - 3	4.6 – 0.4



Orange color: X-ray optics & Beam Transport

European XFEL

SASE 3 Undulator

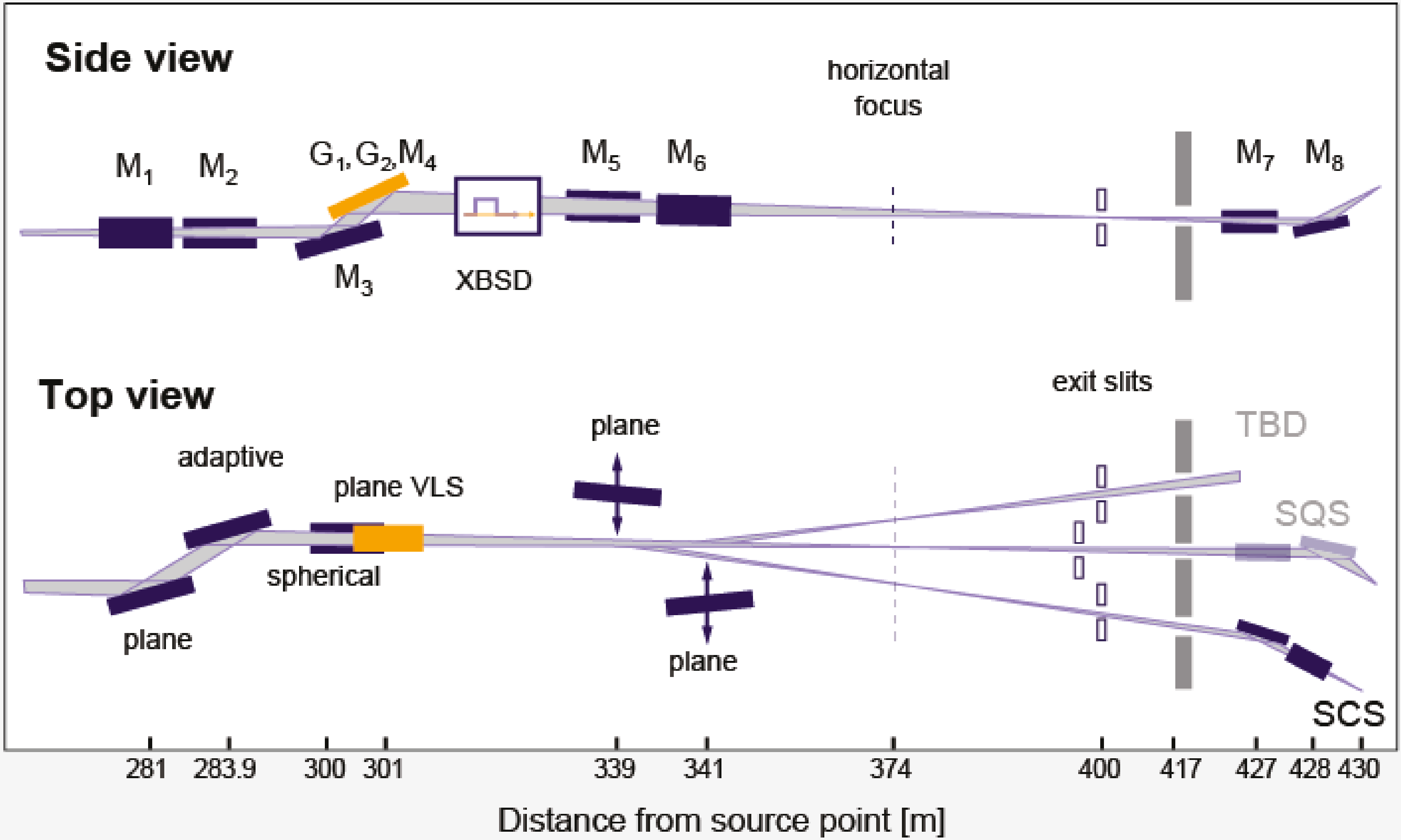
General Soft X-Ray radiation parameters

Pulse widths	**2 – 100 fs**	**Coherence time**	0.3 – 1.8 fs
Pulse energy	**0.2 – 11.0 mJ**	**Bandwidth**	0.25 – 0.7 %
Peak power	50 – 120 GW	**Number of photons**	**0.1 – 2 x 10^{14}**
Average power	3 – 300 W	**Average flux of photons**	0.3 – 5.4 x 10^{18}
Beam size	40 – 80 µm	**Average brilliance**	0.03 – 2.6 x 10^{24}
Rep. rate	**10 Hz (2700 pulses in bunch train)**		

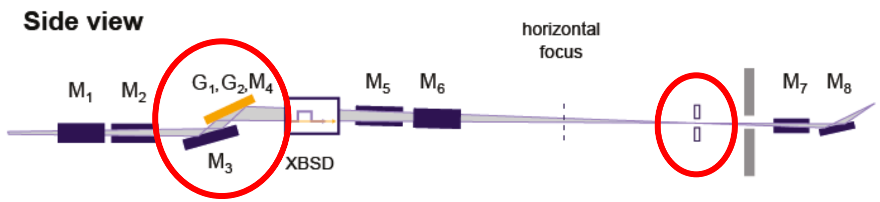
Integral Components in the conceptual design of SCS

- **Afterburner:**
circular (left, right) and linear (hor, ver) polarization
- **Soft x-ray self-seeding**
short pulse, narrow bandwidth, nearly transform-limited pulses

Components overview



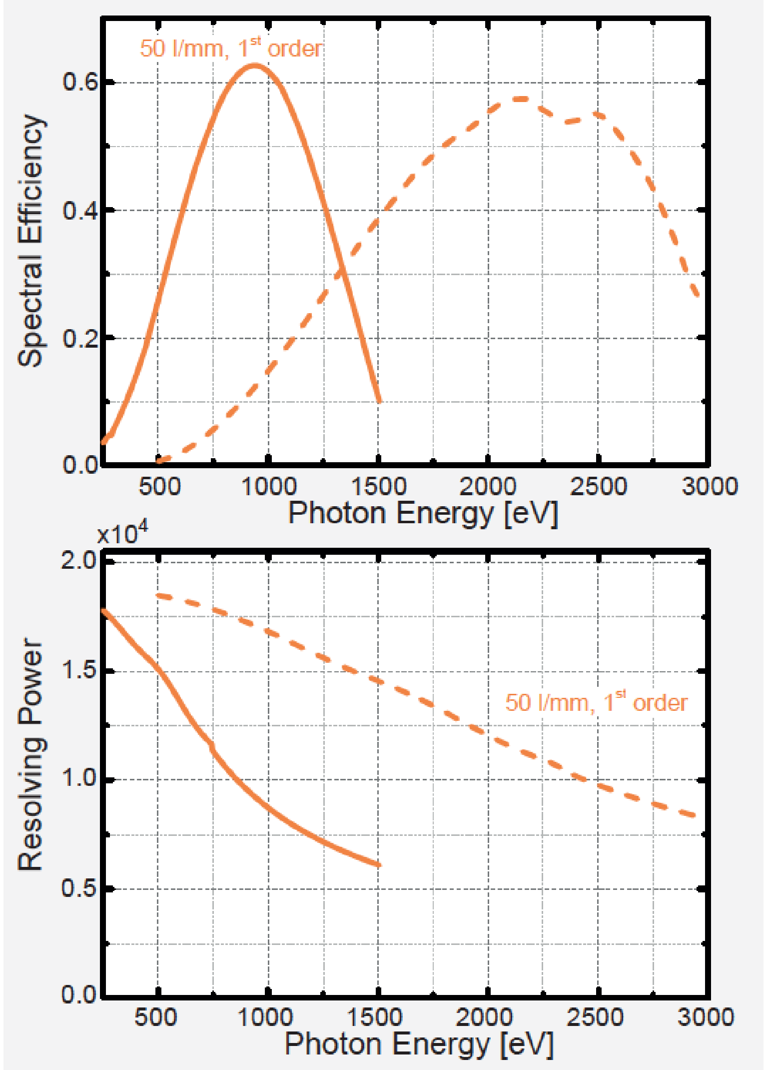
Soft x-ray monochromator (WP-73)



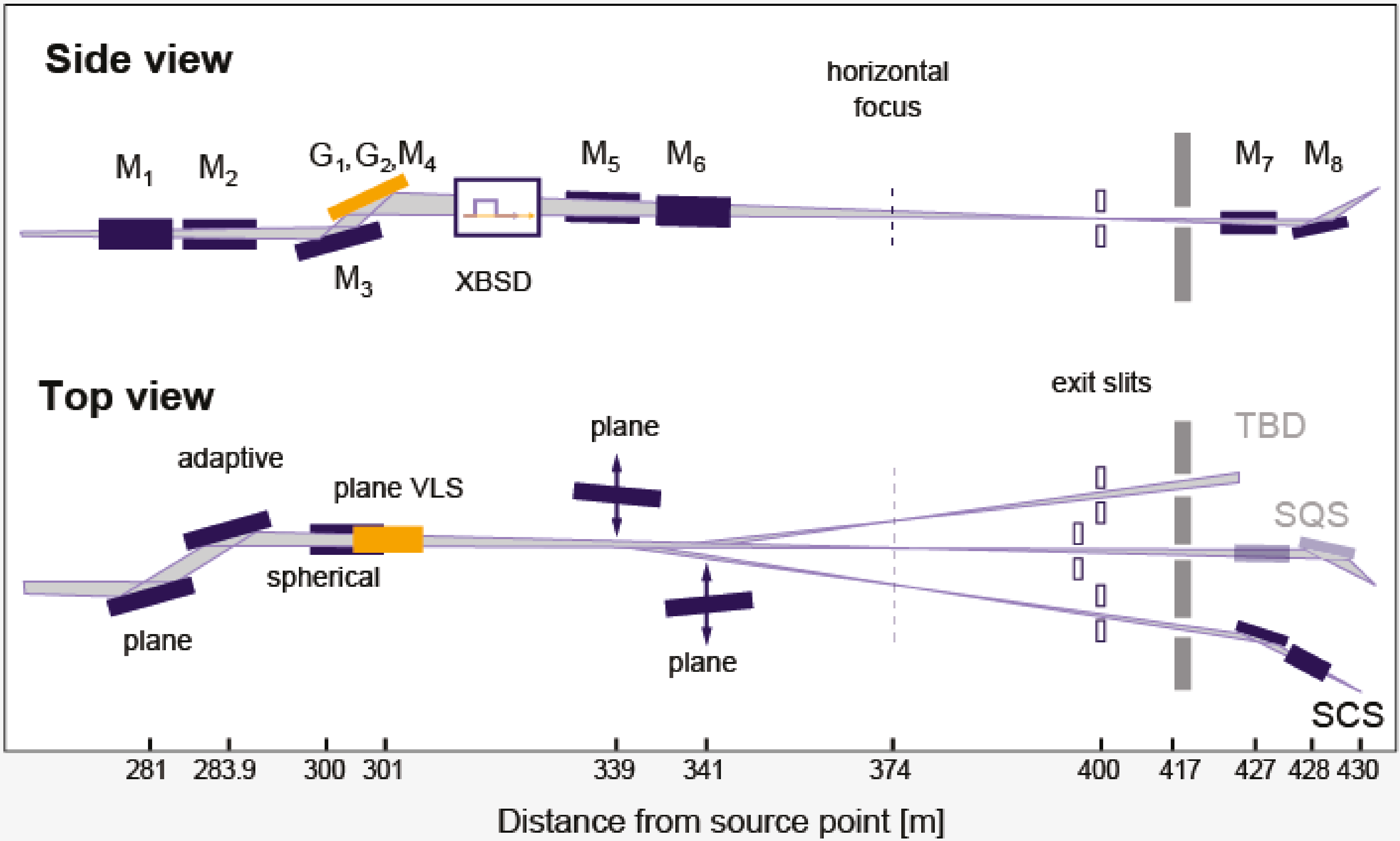
Gratings:

operation near transform limit
tunable resolving power

- Low-medium energy resolution (50 l/mm)
  Resolving power: 3,000-10,000
  pulse stretching: 20-70fs @ 800 eV
- High energy resolution (150 l/mm)
  Resolving power: ~ 40,000
  pulse stretching: ~250fs @ 800 eV
- Plane mirror for pink beam operation
  Resolving power SASE3: 140-400
  Resolving power self-seeding: 800 - TBD
  pulse duration given by source 2-100fs



Components overview



XBSD for SCS/SQS at SASE3

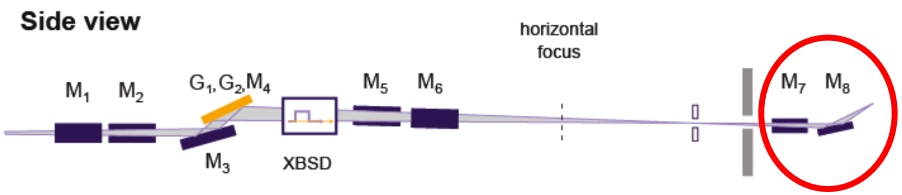
30 January 2014, DESY campus, Bldg. 61, University Auditorium, Hamburg

SCS/SQS joint satellite workshop

Programme

14:00	**Welcome**	S. Molodtsov	XFEL.EU
14:05–16:00	**Split Delay Developments at FELs**		
14:05	XBSD concept for SASE3 @ XFEL.EU	M. Izquierdo	XFEL.EU
14:20	Design and principle of operation of a Soft X-ray Self Seeding Monochromator	S. Serkez	DESY
14:35	Design and first experiences of the split and delay set-up at LCLS	E. Kukk	Uni Turku
14:55	Beam splitting and delay line system at FERMI@Elettra	N. Mahne	FERMI
15:15	Spectroscopy with two x-ray pulses /	W. Wurth	Uni-Hamburg /
	Tailoring the photon beam for non-linear spectroscopy in solids	M. Beye	HZB
16:00	**Coffee Break**		
16:15–18:30	**Science case and XBSD requirements at XFEL.EU/SASE3**		
16:15	Prospects on stimulated x-ray Raman scattering in the gas	N. Rohringer	CFEL /
	phase with XFEL radiation	J.E. Rubensson	Uni Uppsala
17:00	Delay-line XPCS /	G. Grübel	DESY /
	Some thoughts on X-ray pump-probe stimulated Raman scattering	B. Patterson	PSI
17:45	Imaging ultrafast cluster dynamics /	T. Möller	TU Berlin /
	Time resolved coincident Momentum Imaging at XFEL	M.Schoeffler	Uni Frankfurt
18:30-18:45	**Discussion/Summary of the XBSD at SASE-3**	A. Scherz	XFEL.EU
18:45	**Closeout / Adjourn**		

SCS KB bent refocusing optics



KB best refocusing:

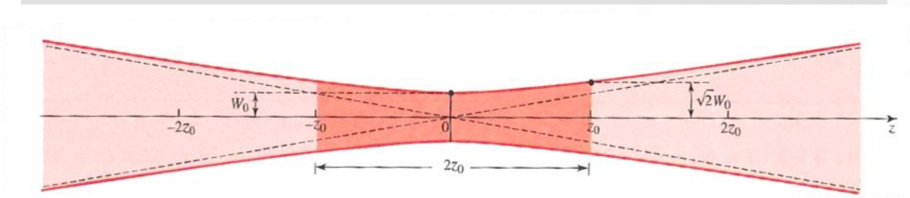
- Minimum beam size: 1.5x1.5 μm^2

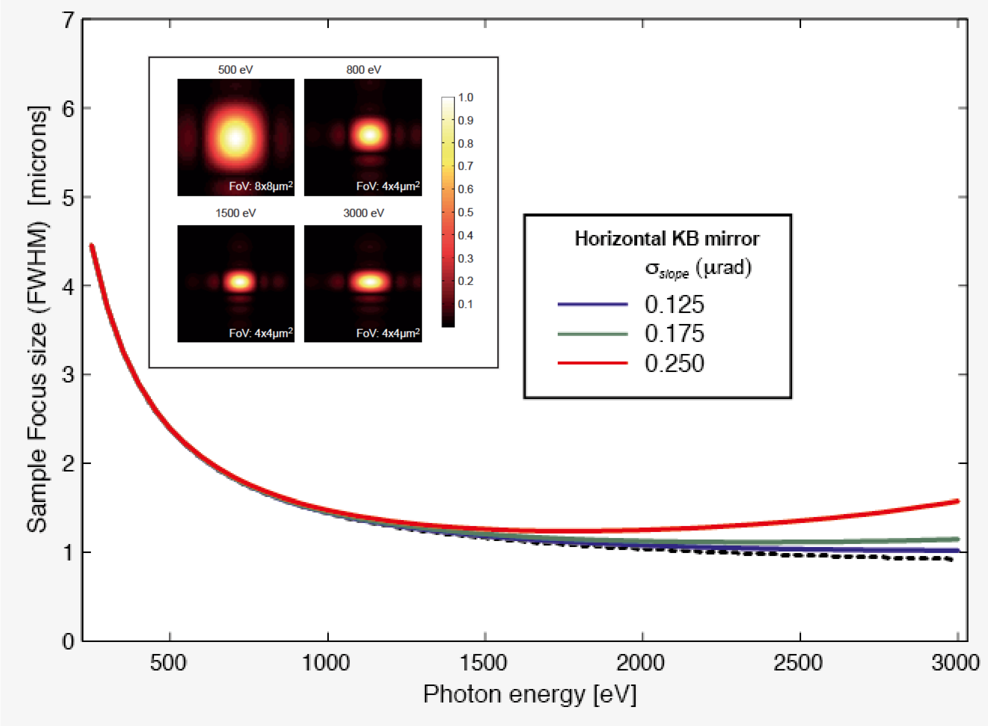
Near-focus conditions soft x-rays:

- 1.5 - 10µm → 0 - 1.6 x Rayleigh range (Rayleigh length ~ 10 mm)

Out-of-focus by bent mechanism:

- Maximum beam size: 1 x 1 mm^2





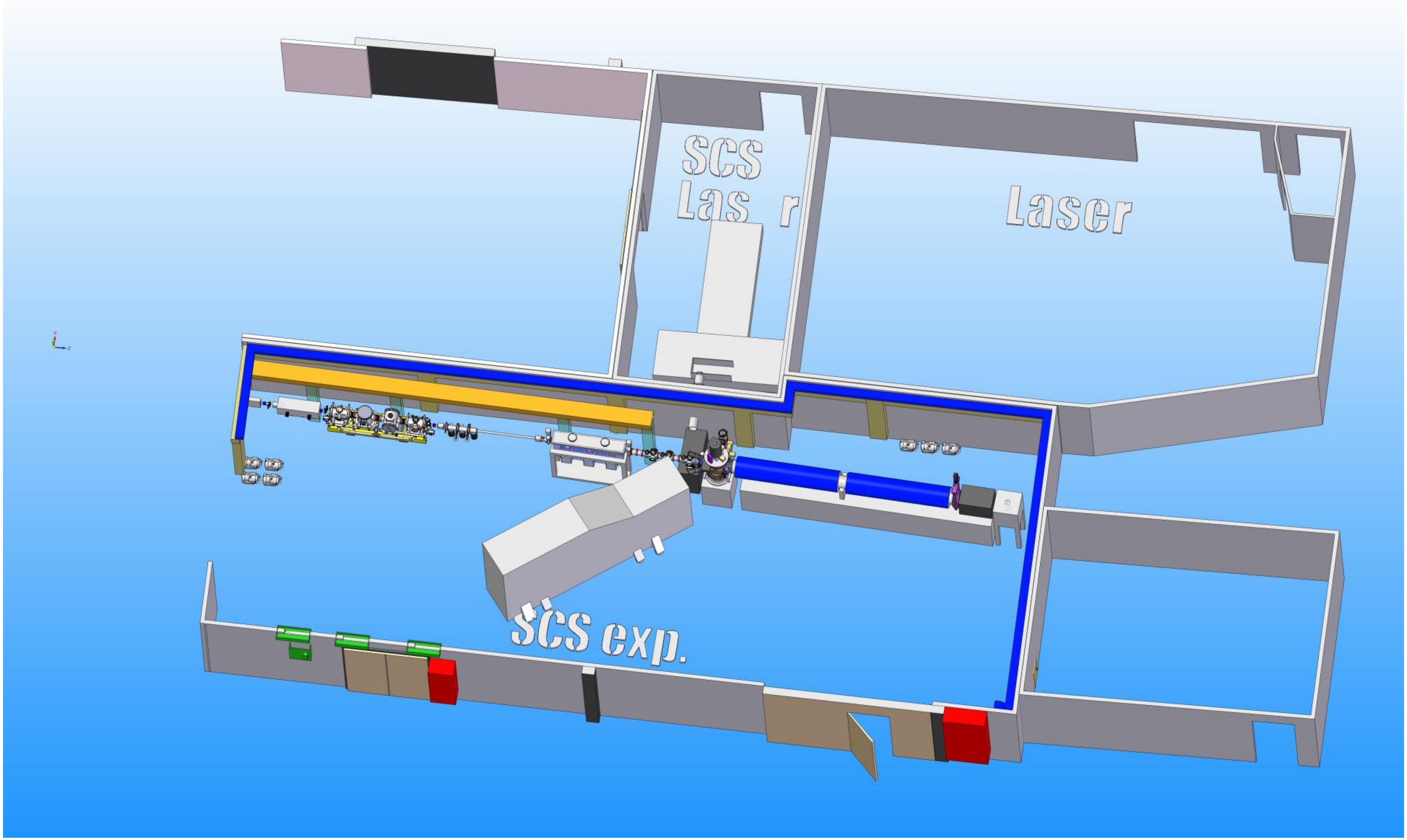
European XFEL

SCS Beam properties at sample

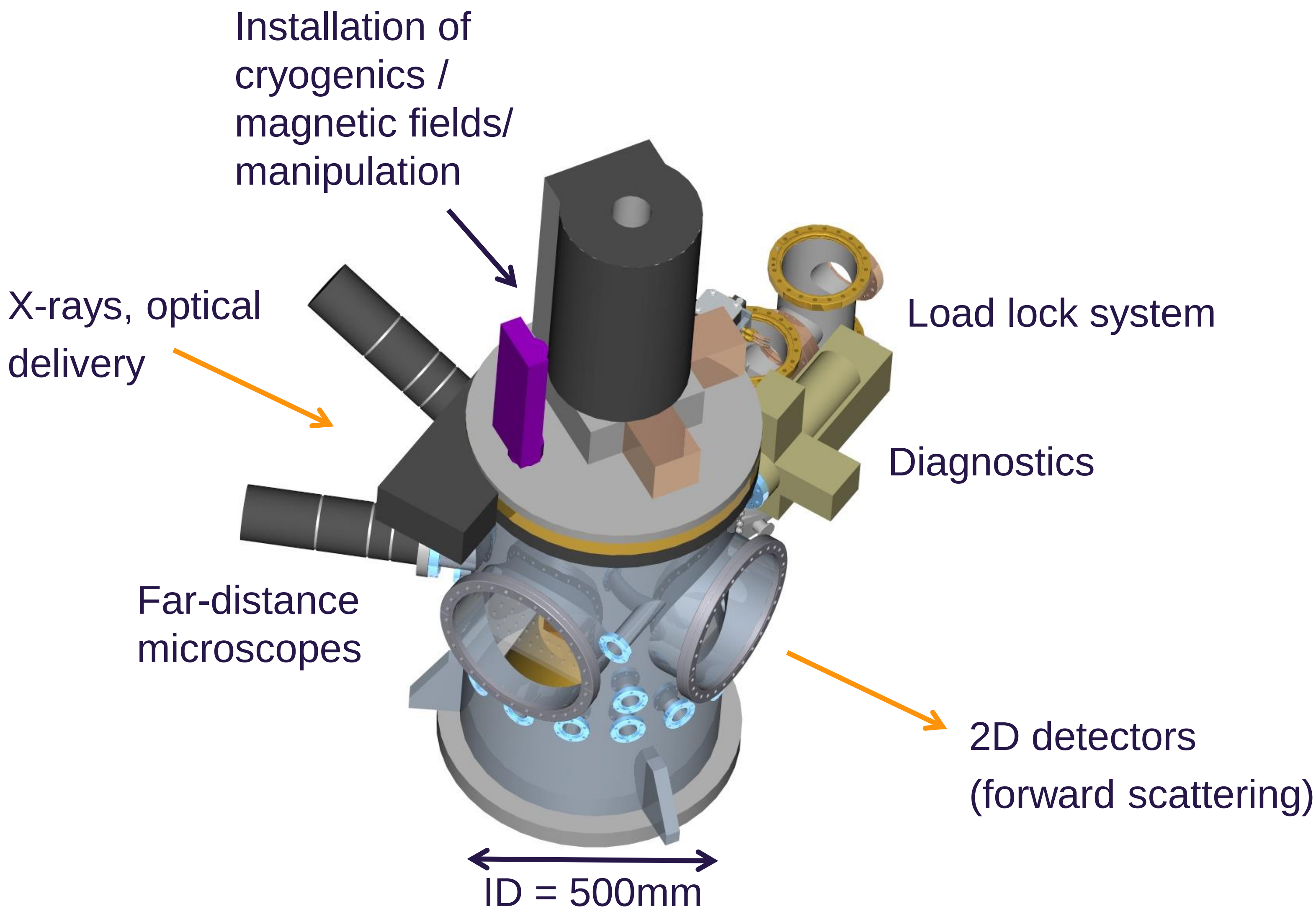
SASE3: 14 GeV, 20 fs pulse

E range [eV]	200-1500	1500-3000
Photons / pulse	$1\text{x}10^{13}$ (pink) $1\text{x}10^{11}$ (mono-medium) $3\text{x}10^{10}$ (mono-high)	$5\text{x}10^{12}$ (pink) $5\text{x}10^{10}$ (mono-medium) $2\text{x}10^{9}$ (mono-high)
Peak intensity [W/cm^2]	$1\text{x}10^{17}$-$1\text{x}10^{18}$ (pink-focus) $1\text{x}10^{14}$-$1\text{x}10^{16}$ (mono-focus) $1\text{x}10^{10}$-$1\text{x}10^{11}$ (mono-unfocused)	$1\text{x}10^{17}$-$1\text{x}10^{18}$ (pink-focus) $5\text{x}10^{13}$-$5\text{x}10^{15}$ (mono-focus) $1\text{x}10^{10}$-$1\text{x}10^{11}$ (mono-unfocused)
Fluence / pulse [mJ/cm^2]	$1\text{x}10^{7}$-$1\text{x}10^{8}$ (pink-focus) $1\text{x}10^{5}$-$1\text{x}10^{6}$ (mono-focus) 1-10 (mono-unfocused)	$1\text{x}10^{7}$-$1\text{x}10^{8}$ (pink-focus) $1\text{x}10^{5}$-$1\text{x}10^{6}$ (mono-focus) 1-10 (mono-unfocused)

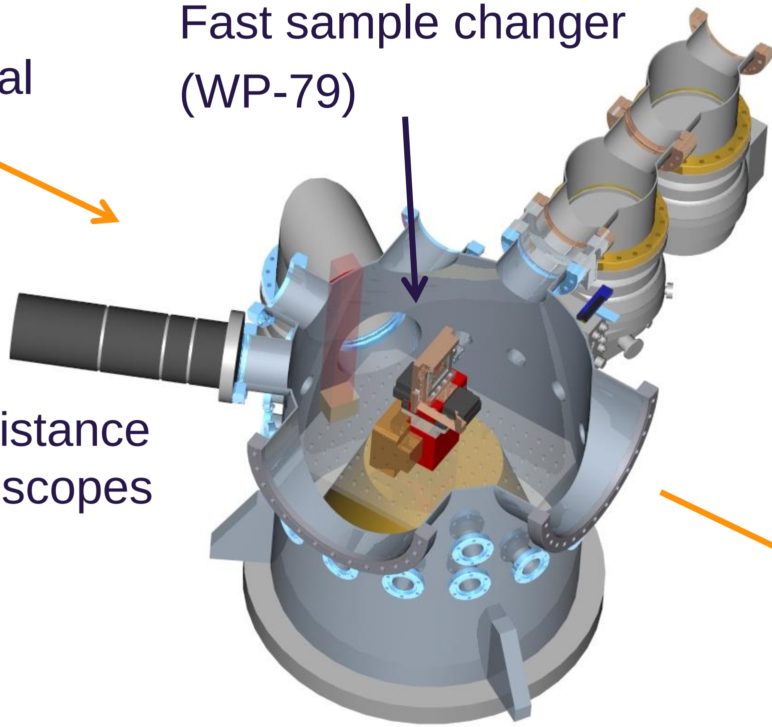
SASE3 experimental floor



FFT chamber (Forward-scattering Fixed Target)



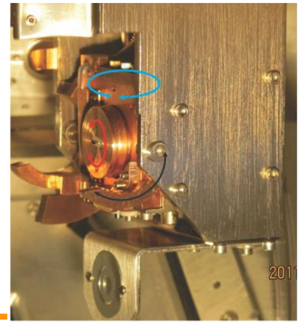
FFT chamber (Forward-scattering Fixed Target)

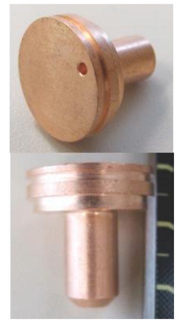


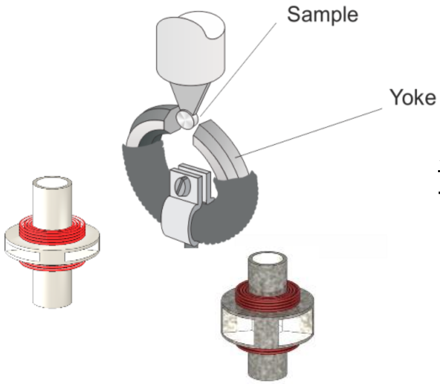
Modular Sample environment – WP 78

Sample holder I:

Low temperature goniometer, 15-400 K, exchangeable sample pucks



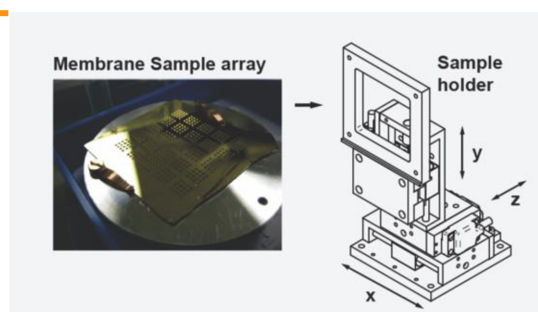


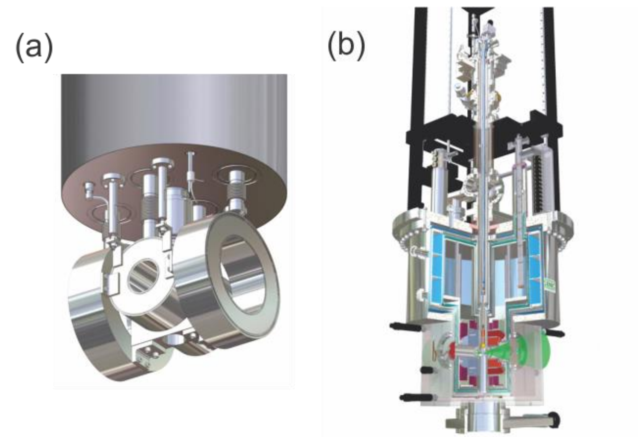


Sample holder II: Ultra low temperature cryostat (T=2K - 300 K, high field pulsed magnets up to 30T

Sample holder III:

fast scans across the wafers of sample arrays Moderate low temperatures

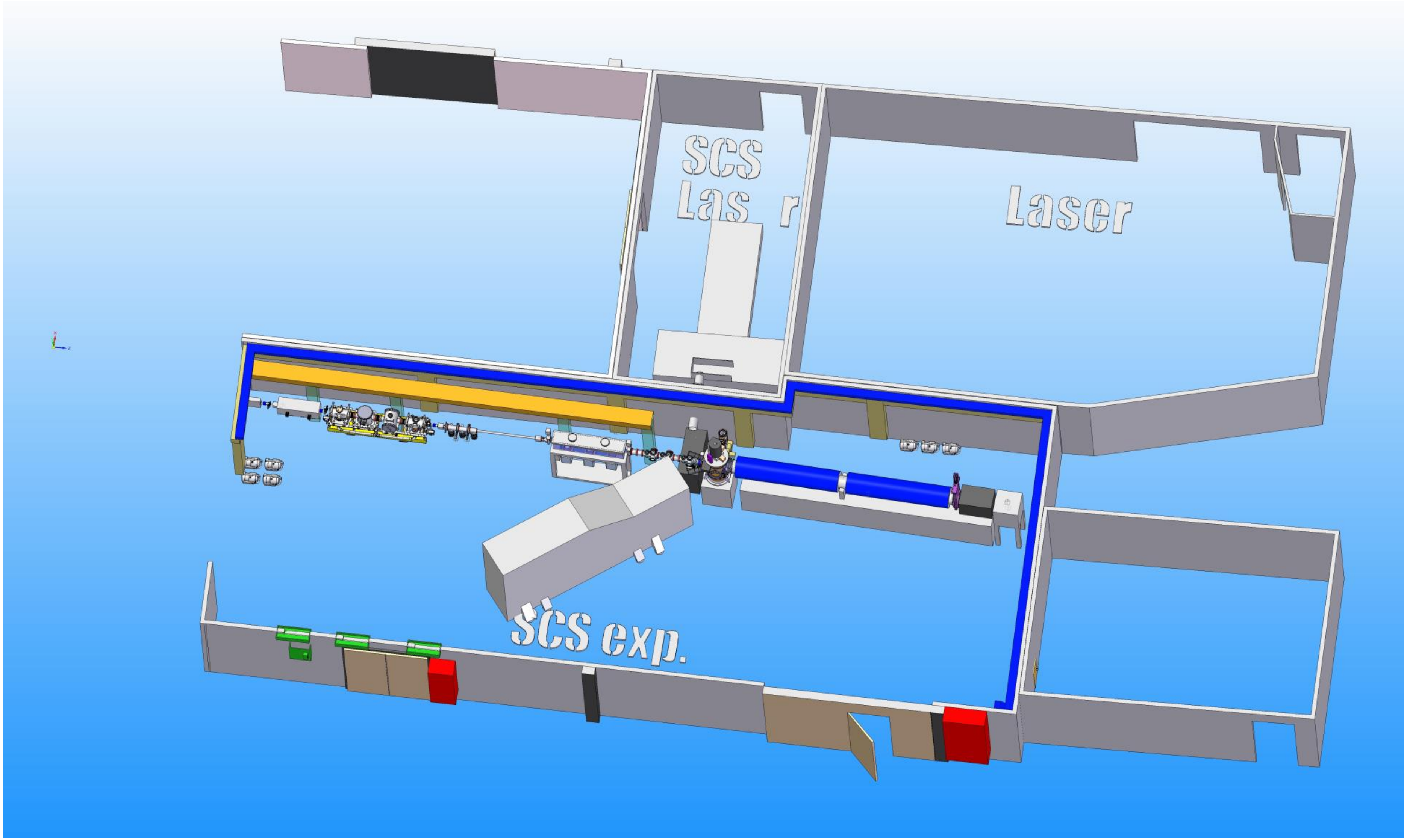




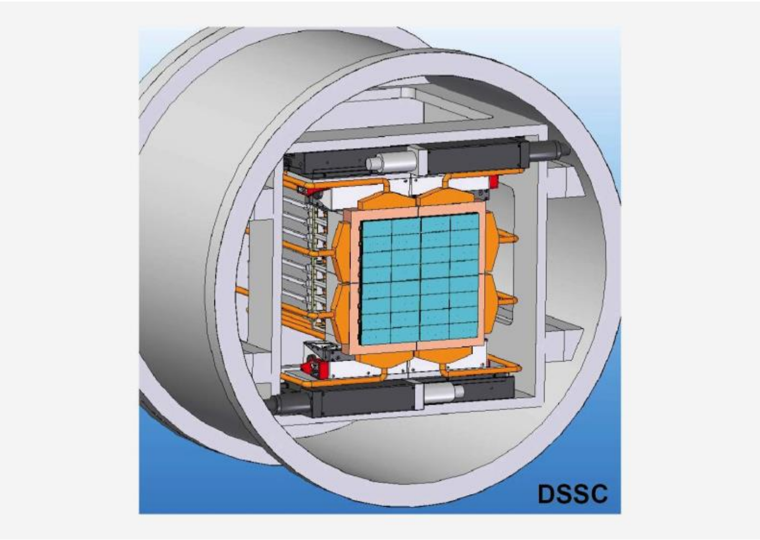
Commercially available static/rapid scan magnets (~8 T): (a) 2D vector magnet from Oxford Instruments and (b) Cryogenics Ltd.

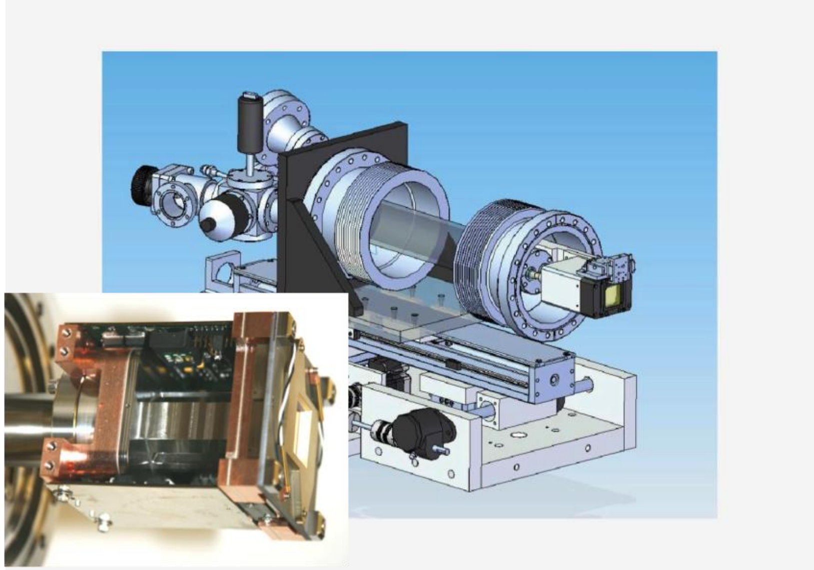
European XFEL

SASE3 experimental floor



Detectors: DSSC & FastCCD



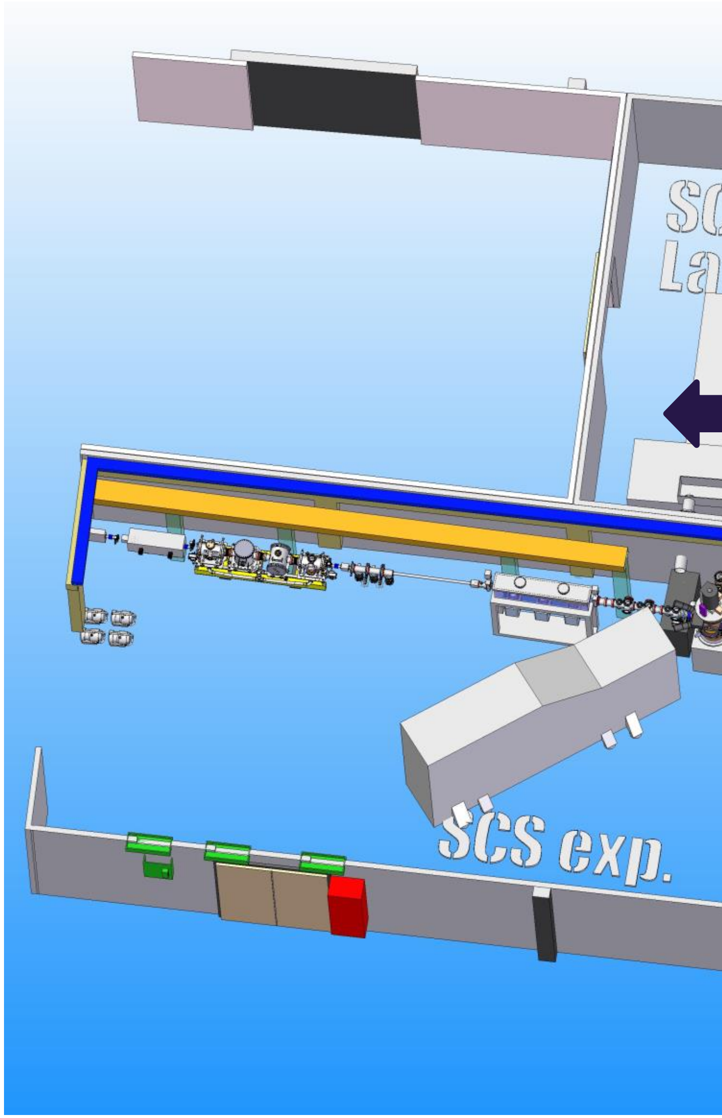


Sample size ϕ_{obj} [μm]	1	3	5	10
FEL diameter [μm]	3	9	15	30
DSSC distance [mm]				
0.5 keV	355	1065	1774	3549
0.8 keV	568	1703	2839	5678
1.2 keV	852	2555	4259	–
2.0 keV	1420	4259	–	–
3.0 keV	2129	6388	–	–
Resolution [nm]	4	12	20	39

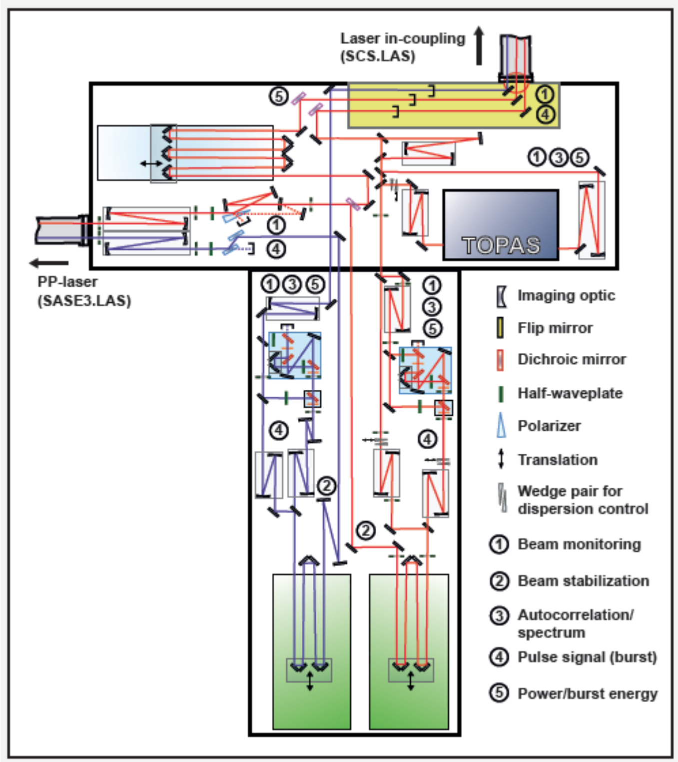
Sample size ϕ_{obj} [μm]	1	3	5	10
FEL diameter [μm]	3	9	15	30
FastCCD distance [mm]				
0.5 keV	48	145	242	484
0.8 keV	77	232	387	774
1.2 keV	116	348	581	1161
2.0 keV	194	581	968	1936
3.0 keV	290	871	1452	2904
Resolution [nm]	4 (2)	13 (6)	21 (10)	42 (21)

European XFEL

Optical laser delivery



Optical Laser delivery (Guido Palmer, Optical Laser Group, WP 78)



Optical table:

- Up and down frequency conversion setups
- Diagnostics
- Delay stages

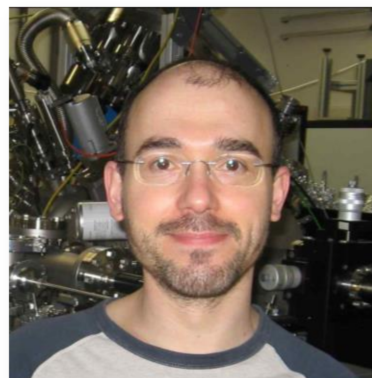
THz setup near the endstation

SCS Team built-up 2013 and next steps…

Jan Torben Delitz
SCS Instrument Engineer

Manuel Izquierdo
SCS Instrument Scientist

Robert Carley
SCS Instrument Scientist



Preparing the Technical Design Report (March 2014)

Start construction of instrument components (test assemblies) in second half 2014