SASE3 instruments – status and plans

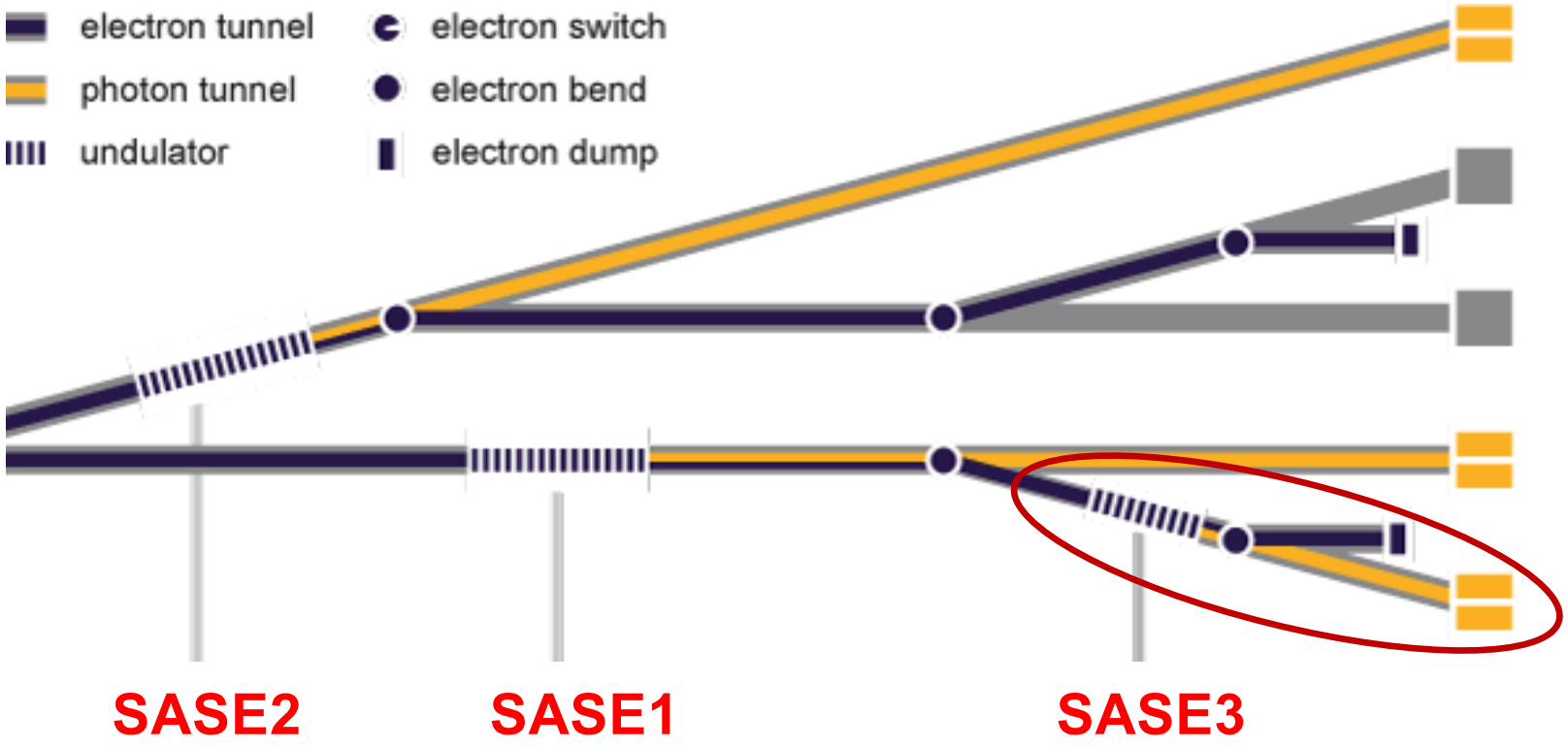
European XFEL Users' Meeting 2018

Serguei Molodtsov
European XFEL, Scientific Director

+ soon….

Overview

- Undulator systems
- Optics and diagnostics
- Experimental hutches
- Optical lasers
- Detectors
- Sample environment
- Scientific instruments



SASE System without

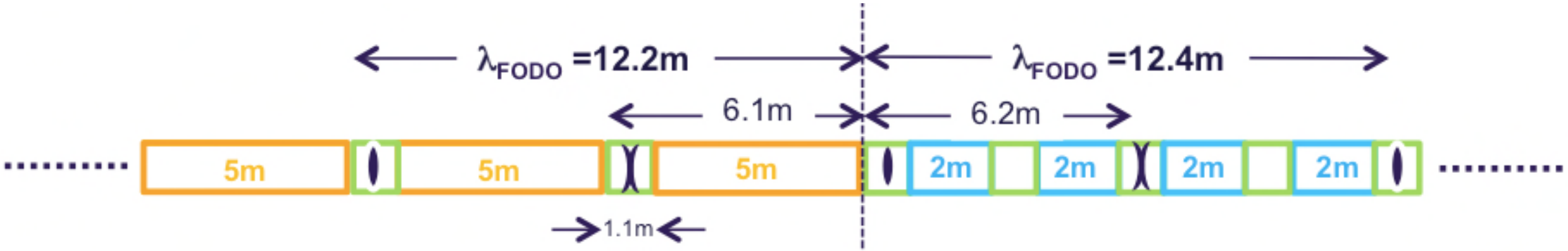
With enclosure

All gaps closed to 10 mm

- Hardware installed & aligned
- Control system & remote controls operational
- Air conditioning commissioned & operational
- All gaps can be closed to 10 mm
- System is fully operational
- Final system tests were done

SASE3 undulator is fully operational since the end of March 2017

Implementation of circular polarization in 2020, cooperation with SwissFEL

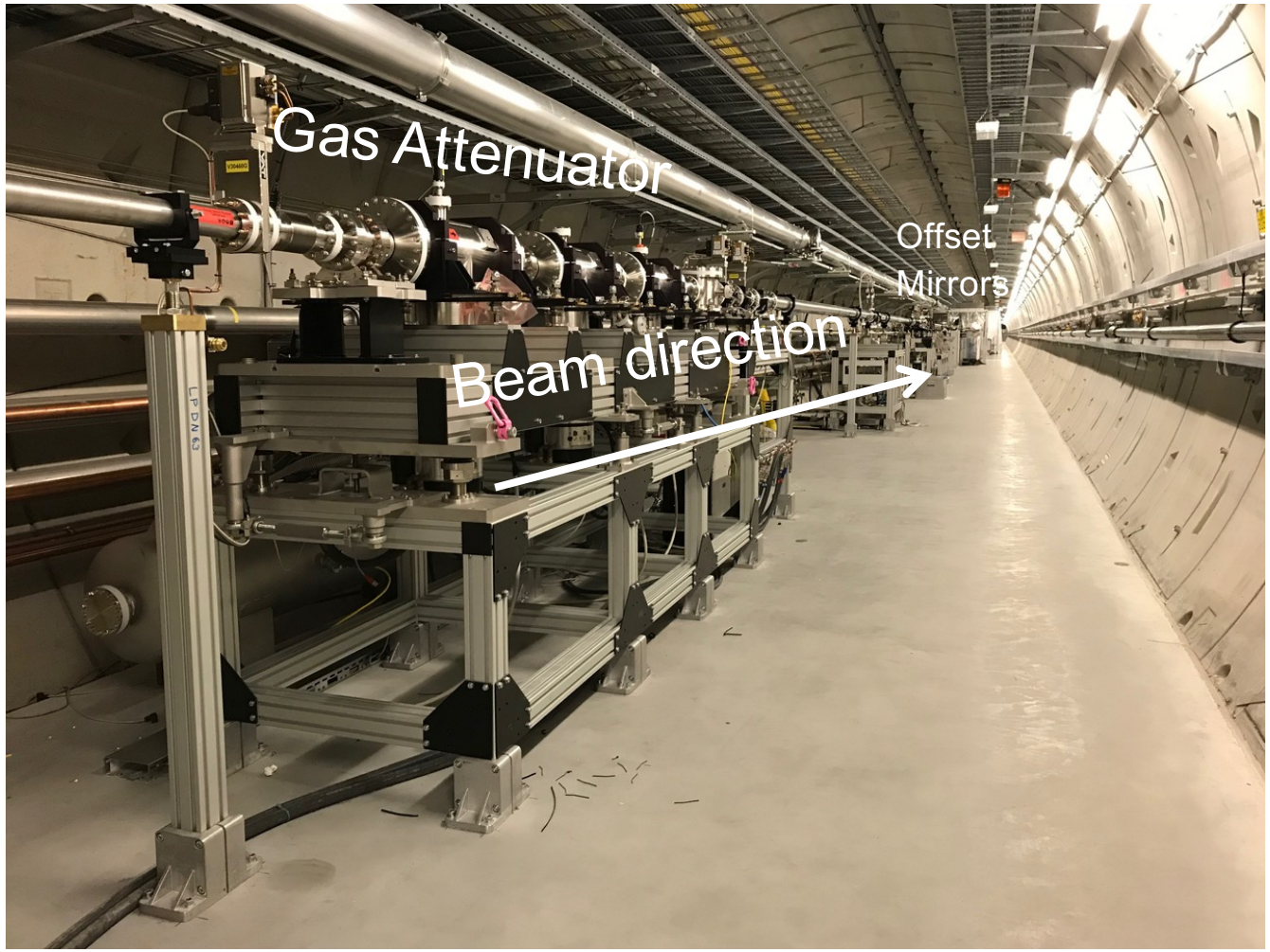


- Boundary condition of the design considered was minimum invasiveness to the SwissFEL/PSI undulator layout with the main goal to decrease implementation costs.
- Afterburner sections length (2 m) and the precise mechanics were selected to be the same in both cases for the European XFEL afterburners and the undulator of SwissFEL/PSI.
- Solution presented allows using intersections, phase shifters, and quadrupole movers already used at the European XFEL.

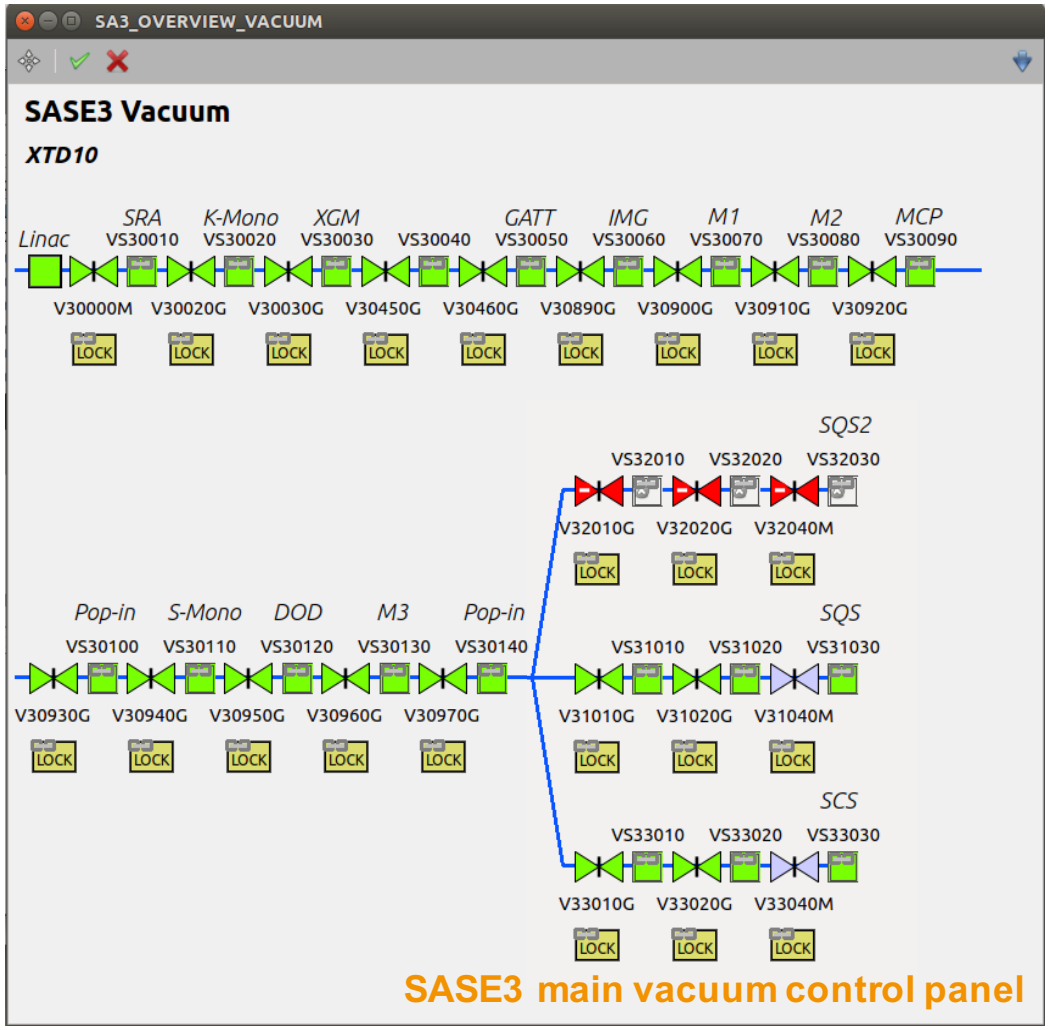
Optics & vacuum components installation summary SASE3

- All components are delivered and installed.
- Racks & cables: Most essential cables for first commissioning are in place.
- Vacuum system is complete and closed.
- Controls: Vacuum complete and in operation. Motion control under local testing and Karabo projects are being set up.
- Optics: Two offset mirrors and optics for soft-X-ray monochromator (2 pre-mirrors, 1 short grating, 1 long grating blank) are installed.
- **First lasing is expected in the beginning of February.** Commissioning of beam transport in XTD10 will start on February 14.

Current view of SASE3, XTD10 tunnel



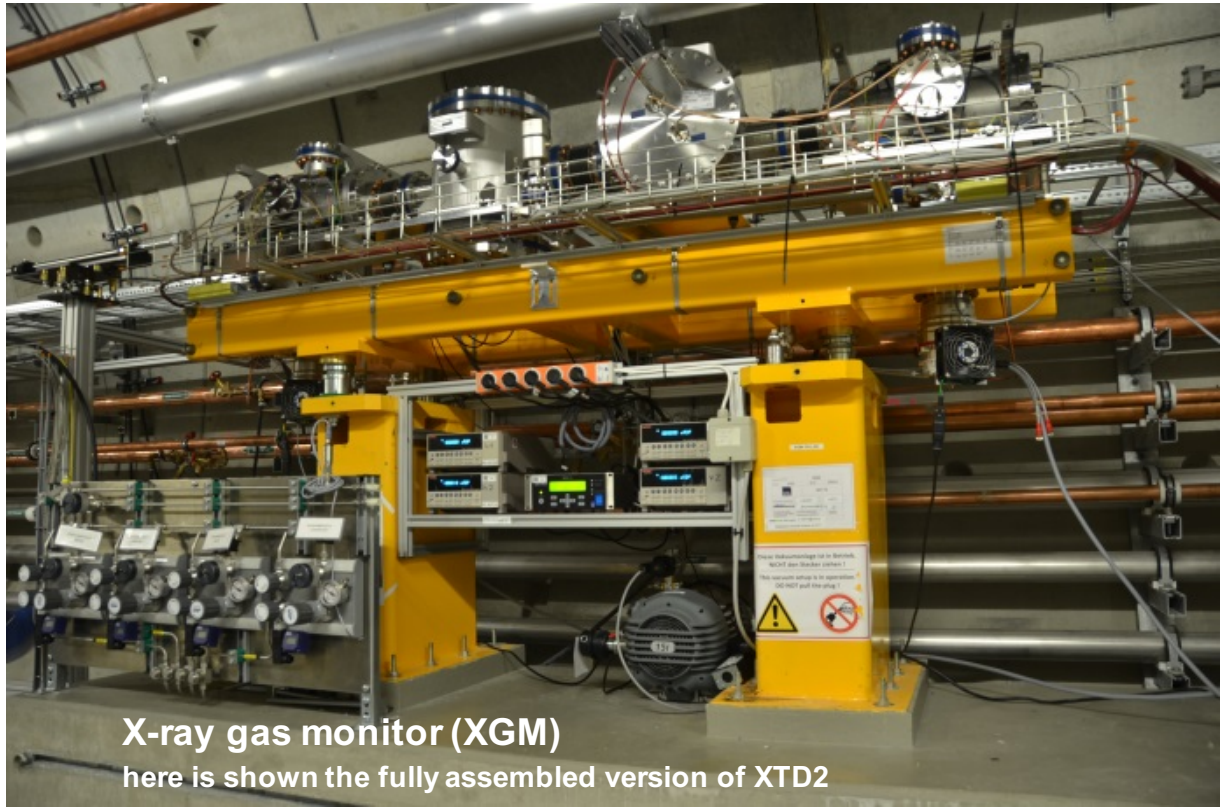
Vacuum Control System (PLC/Karabo)

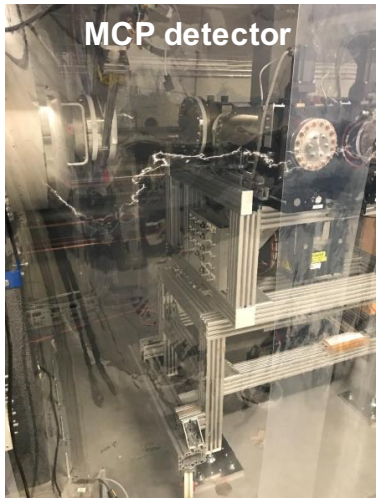


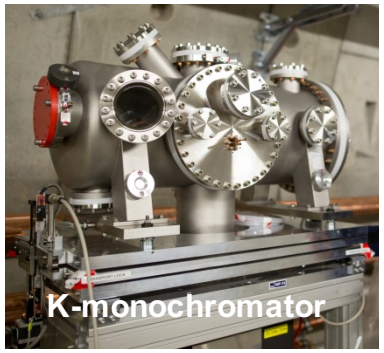
Diagnostics installation summary SASE3

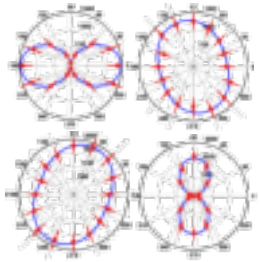
- Systems:
  FILT, IMGTR, KMONO, IMGSR, XGM, DP (PES related differential pumping), PES, IMGFEL, MCP-detector, IMGPIII, IMGPII90, IMGPII45, 2 x IMGES, 3 x IMGPI
- Mechanics / UHV chambers
  - All supports installed and surveyed
  - All vacuum chambers installed and connected to beamline vacuum
- Gas supply system installed, tested, flushed; operational for XGM
- All electronics and cabling installation completed (except PES)
- Technical commissioning without beam
  - Completed for XGM, DP, Imagers. Ongoing for MCP, KMONO
  - not started for PES (on locally controlled vacuum operation)

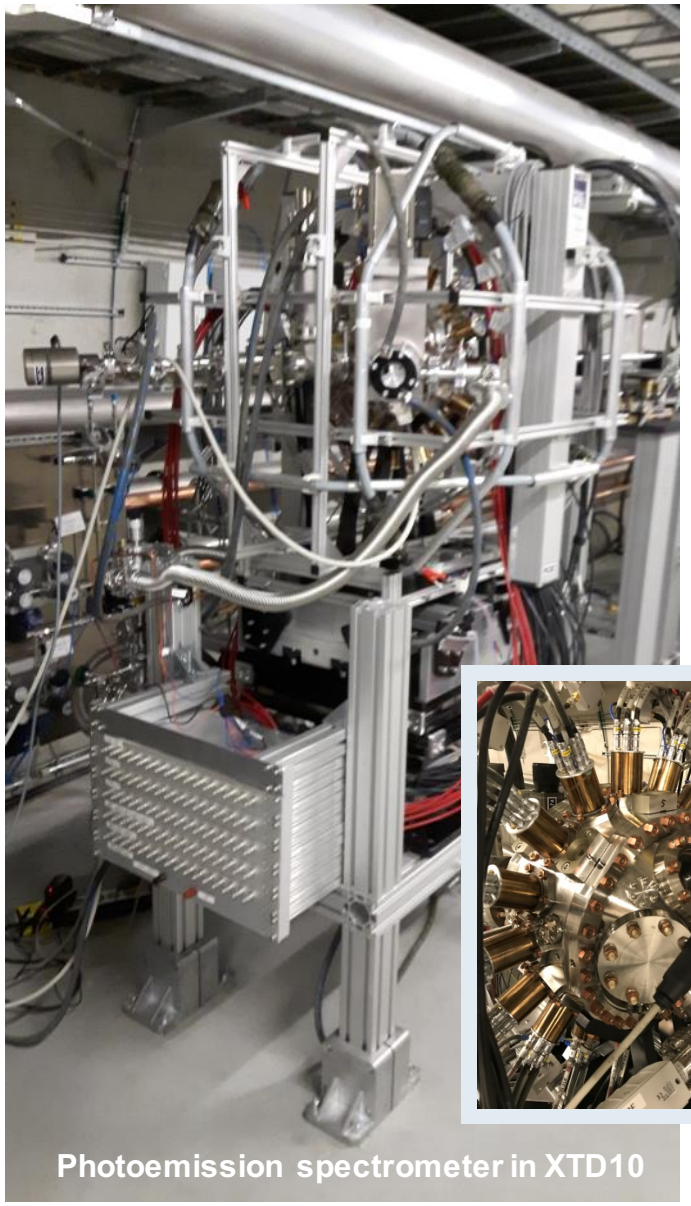
SASE3 photon diagnostics


X-ray gas monitor (XGM)
here is shown the fully assembled version of XTD2

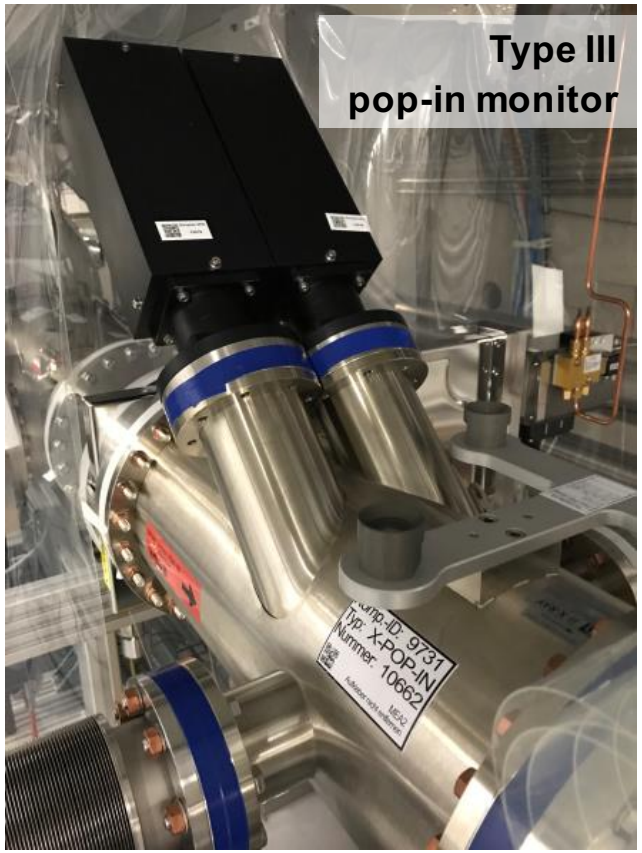

MCP detector

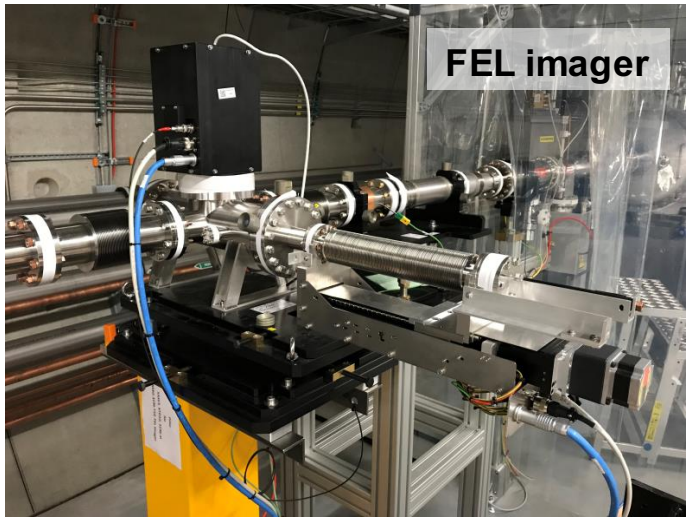

K-monochromator

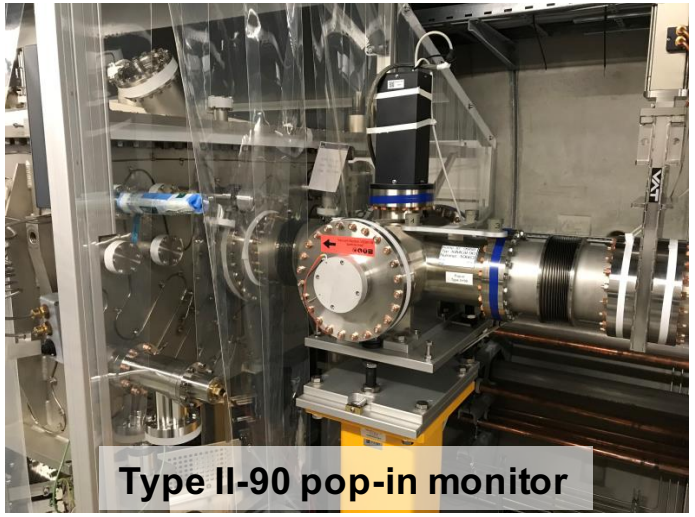


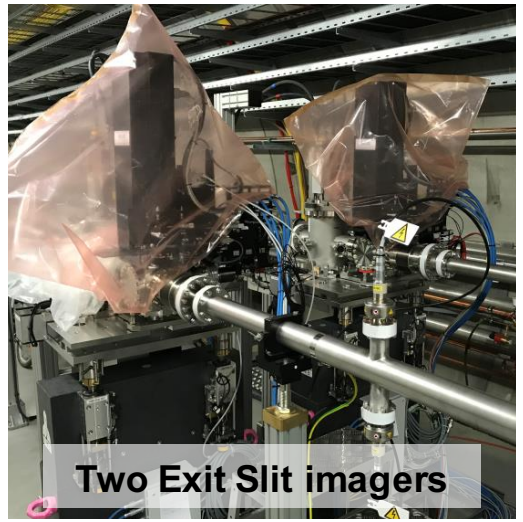

Photoemission spectrometer in XTD10

SASE3 photon diagnostics: imagers





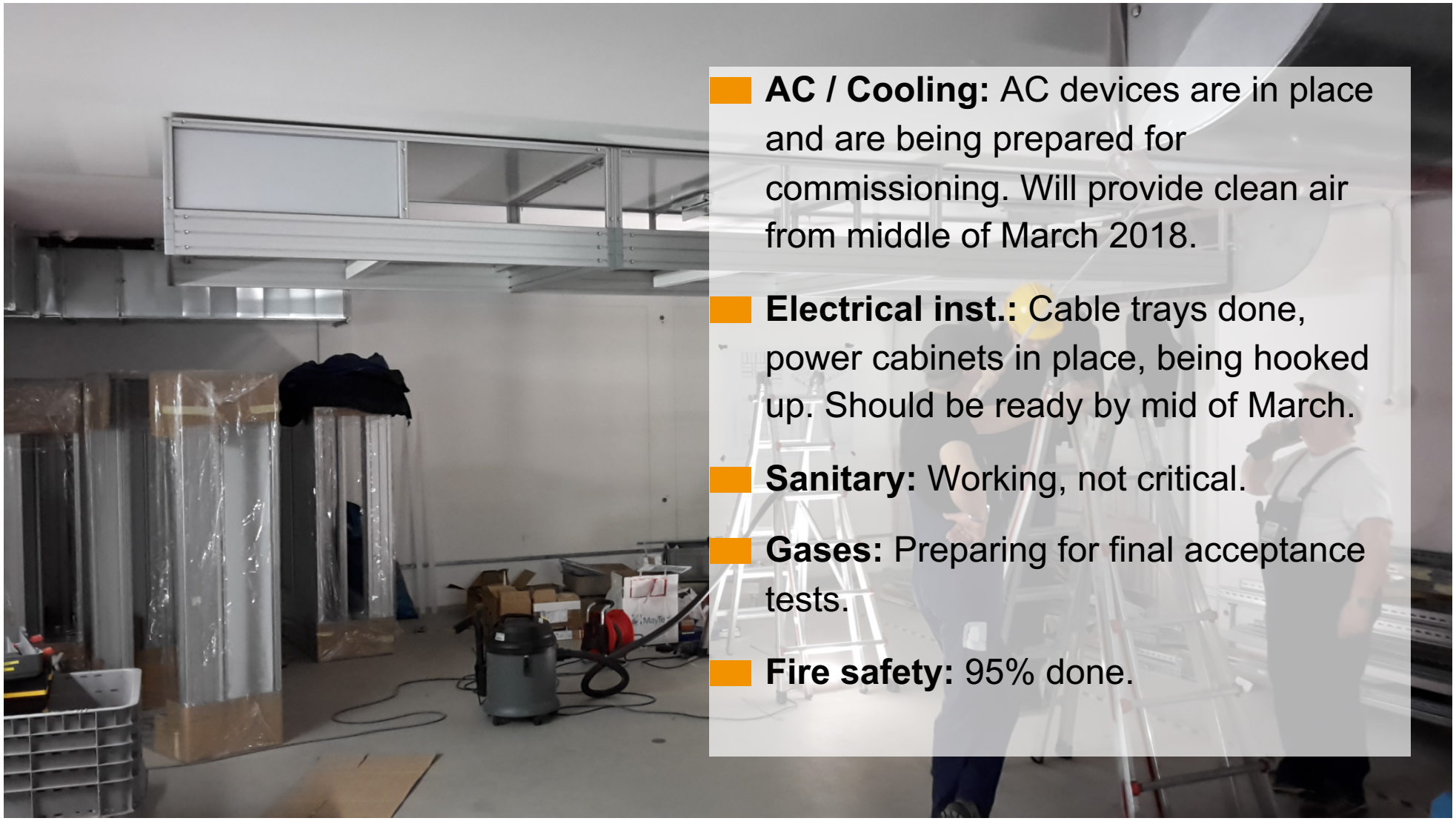




SASE3: Status of the civil construction

- **Laser hutches:** Done.
- **Experimental hutches:** Done.
- **Control and rack hutches:** Done.

SASE3: Status of the technical infrastructure installation



- **AC / Cooling:** AC devices are in place and are being prepared for commissioning. Will provide clean air from middle of March 2018.
- **Electrical inst.:** Cable trays done, power cabinets in place, being hooked up. Should be ready by mid of March.
- **Sanitary:** Working, not critical.
- **Gases:** Preparing for final acceptance tests.
- **Fire safety:** 95% done.

SASE3: Status of the cabling / PLC planning

- **IT cabling:** Done, final acceptance test planned for the middle of Feb. IT connectivity available mid of March.
- **PLC modules production:** ca. 80% produced & tested. Remaining modules produced until March.
- **Phase II cabling (motors, sensors…):** All cabling done in April 2018.
- **Scope of planning & work:** 160+ PLC modules + 3200+ associated cables (not counting power or IT)!
- **Start of electronics and cabling commissioning:** April 2018

SASE3: 2018 schedule

- First Lasing in February 2018, beam brought up to the end of photon tunnels
- Major infrastructure works will finish in March/April
- Day 1 instrument installation starting in full swing in March/April
- Commissioning of instrument controls & electronics without beam in May/June/July
- Instrument commissioning with beam in August/September
- Very first trial experiments in October
- Potential first scheduled users in middle of November

PP-laser installation schedule

General PP-laser installation schedule:

Task 1: Laser tables and infrastructure in PP and ILH-hutches

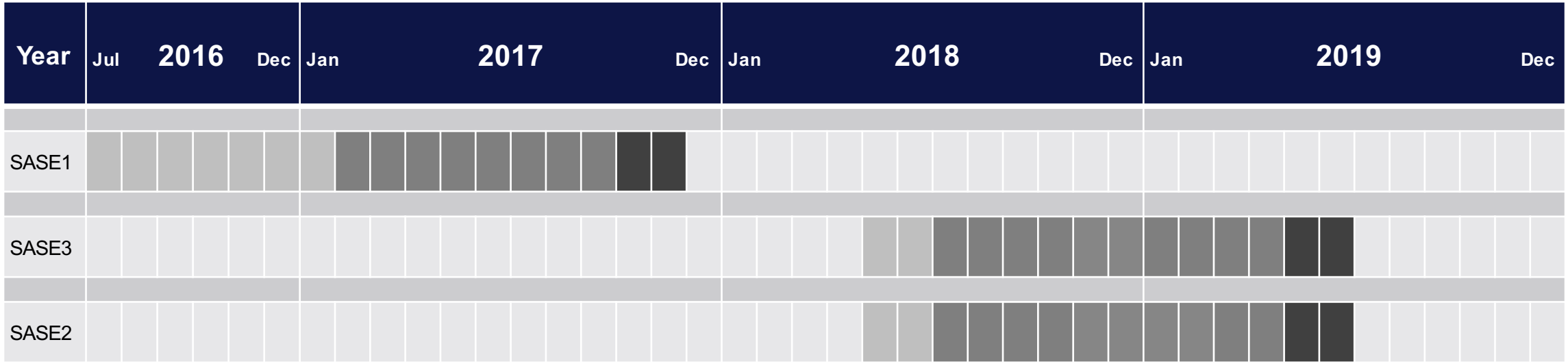
Task 2: Components + commissioning in PP and ILH-hutches

Task 3: Beam to experiment

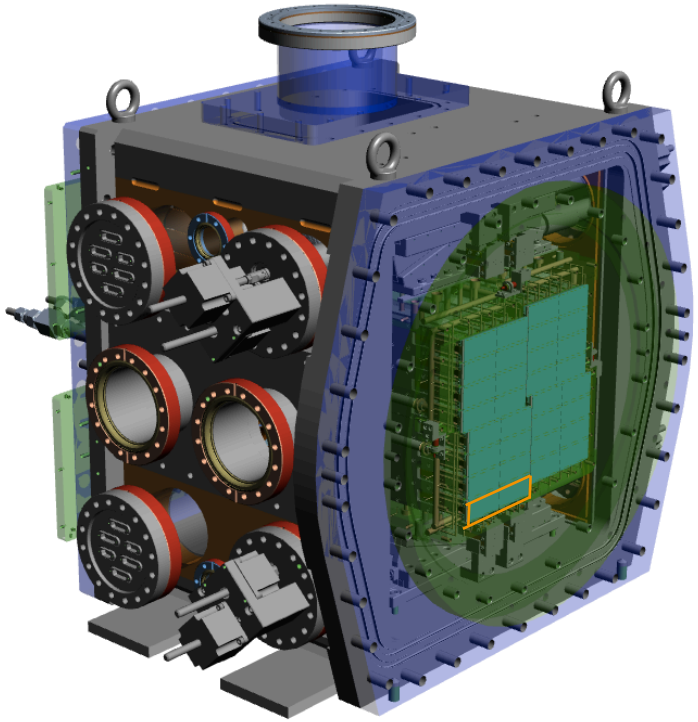
Challenges:

- Parallel installation at SASE 2 and 3
- Simultaneous operation at SASE 1

SASE-specific schedules:

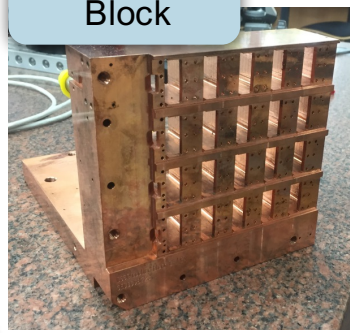


DSSC MiniSDD1 Mpix Detector



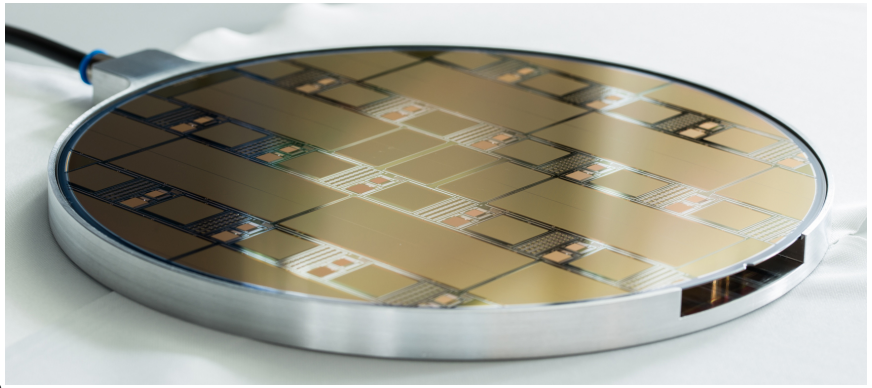
Vacuum Vessel

Cooling Block



Courtesy DSSC Collaboration

Processed DEPFET Wafer

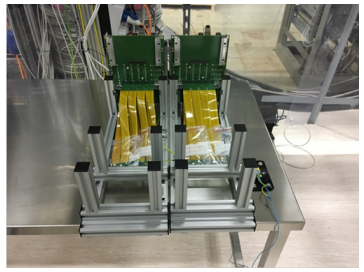


Provided by pnSensor GmbH

Electronics/Power

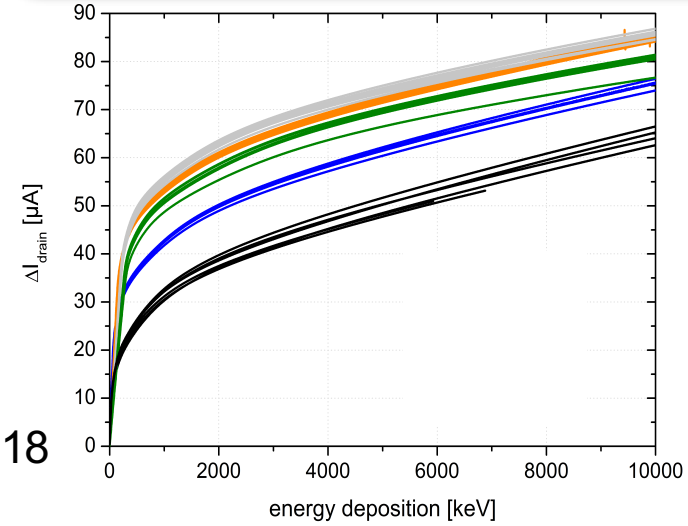
MPOD Crates with 29-m long Cables & Strain Relief

Cables connected to Patch Panels mounted to the Support Frame



Patch-Panel Flex Cables connected to Patch Panels

Measured DEPFET Characteristics



Provided by pnSensor GmbH

- Project started one year later
- Production of detector components almost completed
- Front-end electronics produced and successfully tested
- Collaboration is focused on integrating, calibrating and commissioning of the first full size 1 Mpix camera based on MiniSDD sensors, to be ready in Q3 2018
- Full specs DEPFET based camera will follow in January 2020

FastCCD

Detector arrived at XFEL

Beamline integration at SCS is in progress

Calibration is in progress

Ready for installation at experiment May 2018

pnCCD

Detector for soft- and hard X-ray imaging experiments.

Procurement and testing of first components started.

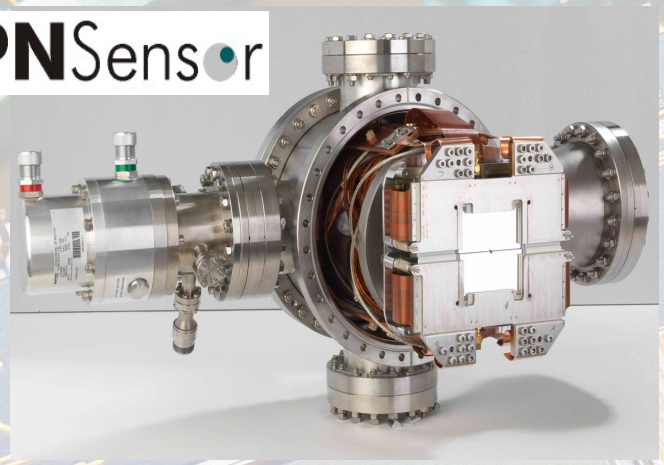
Detector available in autumn 2018.

Primary experiments

SQS and SCS

pnCCD

PNSensor



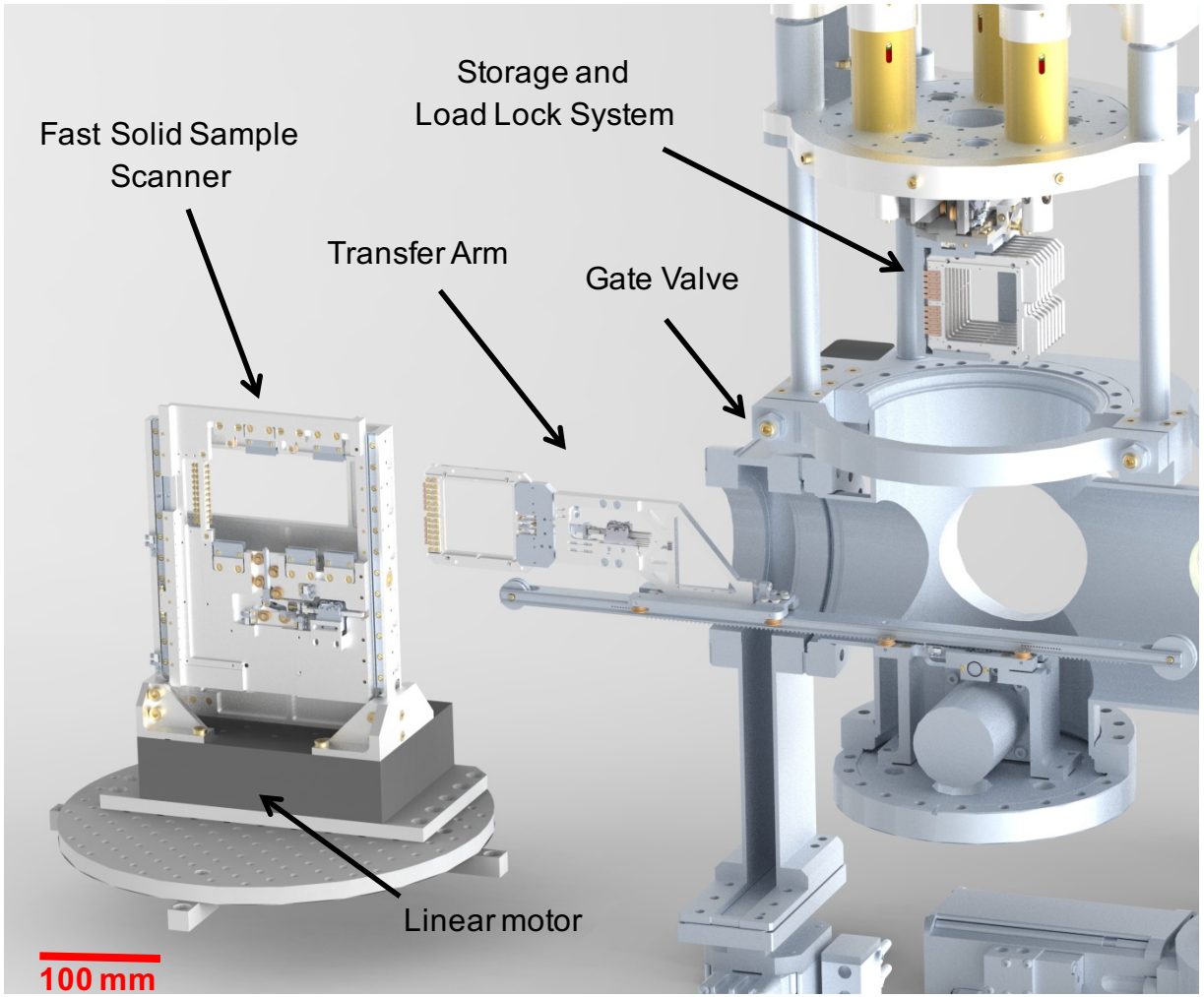
Energy Range
0.03 – 25 keV
Pixel Size 75 x 75 μm^2
1024 x 1024 $Pixels^2$
Dynamic Range
6000 ph@1.keV
Frame Rate
up to 150 Hz
Noise
6 e^- at high gain

FastCCD

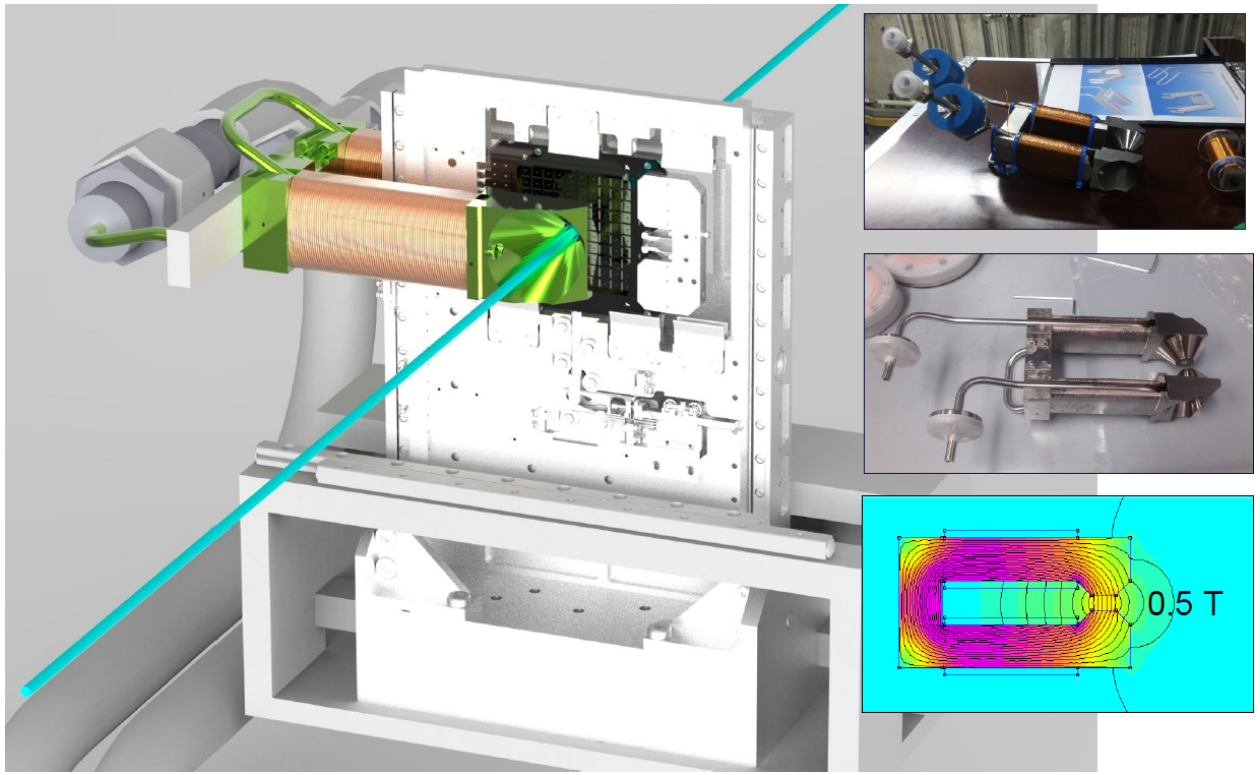
BERKELEY LAB

Energy Range
0.25 – 6 keV
Pixel Size 30 x 30 μm^2
1920 x 960 $Pixels^2$
Dynamic Range
Approx. 350 ph@1 keV
Frame Rate
up to 200 Hz
Noise
25 e^- at high gain

Fast solid sample scanner



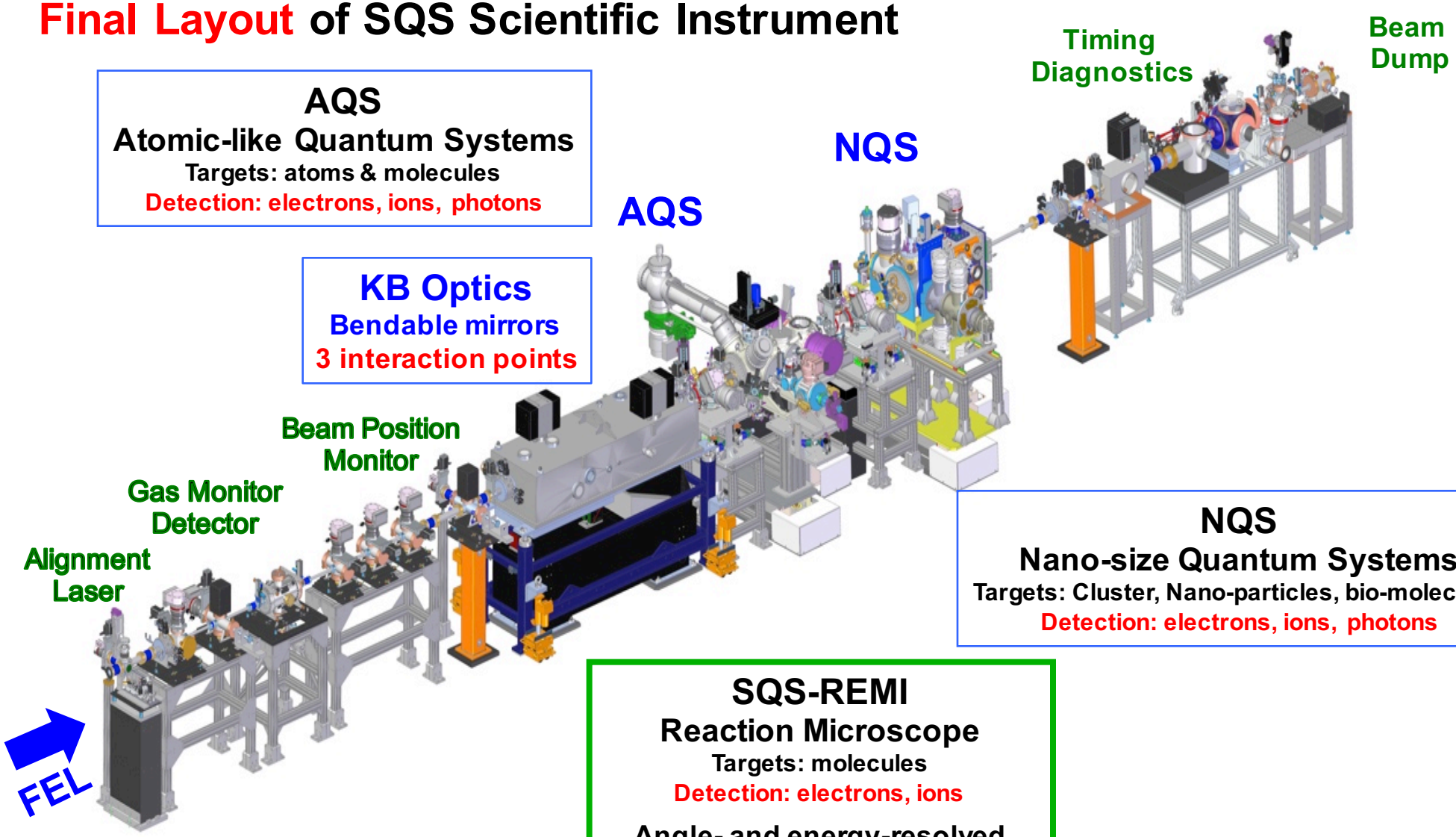
DC electromagnet environment



Final Layout of SQS Scientific Instrument

AQS
Atomic-like Quantum Systems
Targets: atoms & molecules
Detection: electrons, ions, photons

KB Optics
Bendable mirrors
3 interaction points



NQS
Nano-size Quantum Systems
Targets: Cluster, Nano-particles, bio-molecules
Detection: electrons, ions, photons

SQS-REMI
Reaction Microscope
Targets: molecules
Detection: electrons, ions

Angle- and energy-resolved
electron and ion spectra
in coincidence

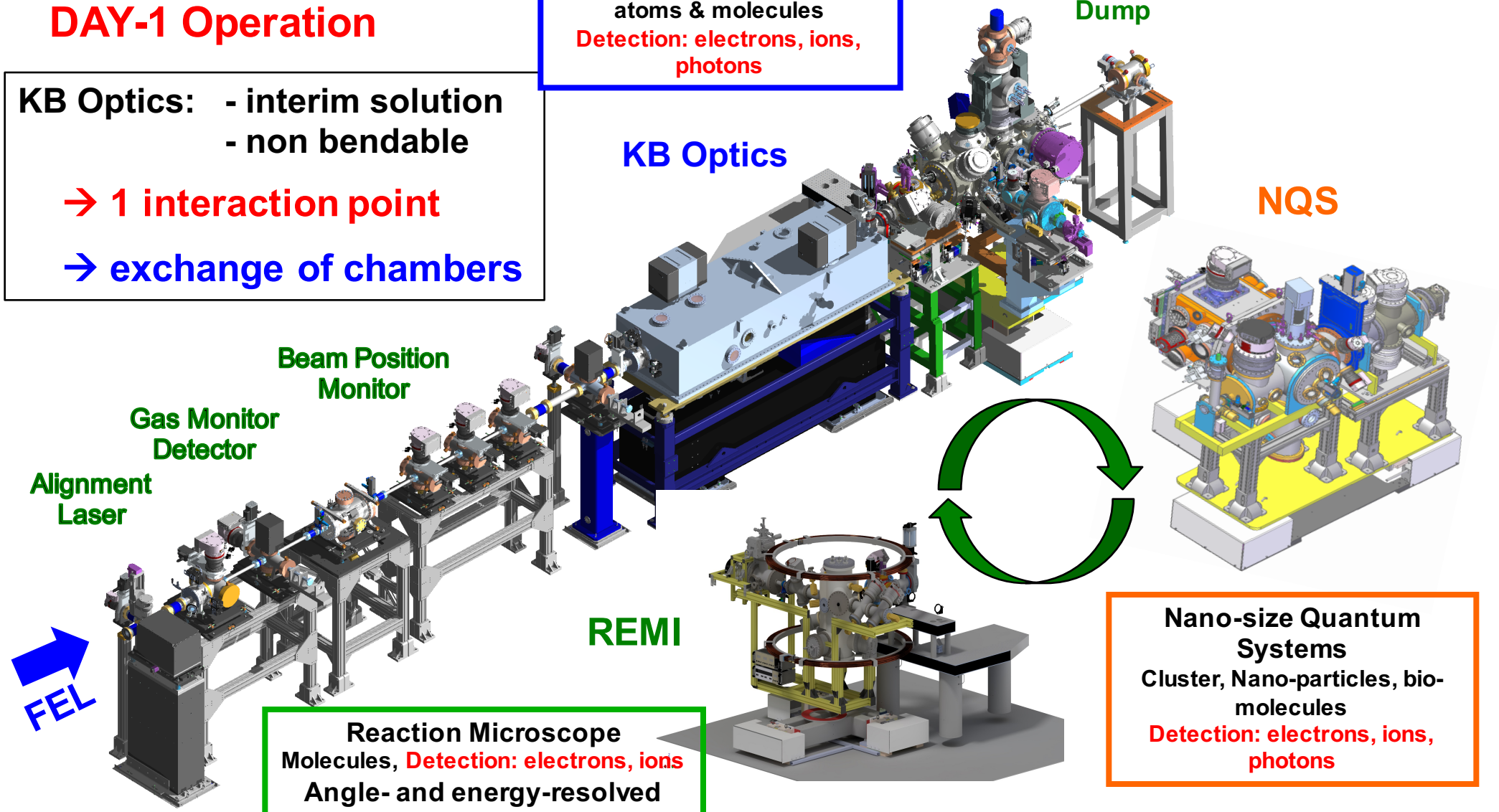
Layout of SQS for DAY-1 Operation

KB Optics: - interim solution
- non bendable

→ 1 interaction point

→ exchange of chambers

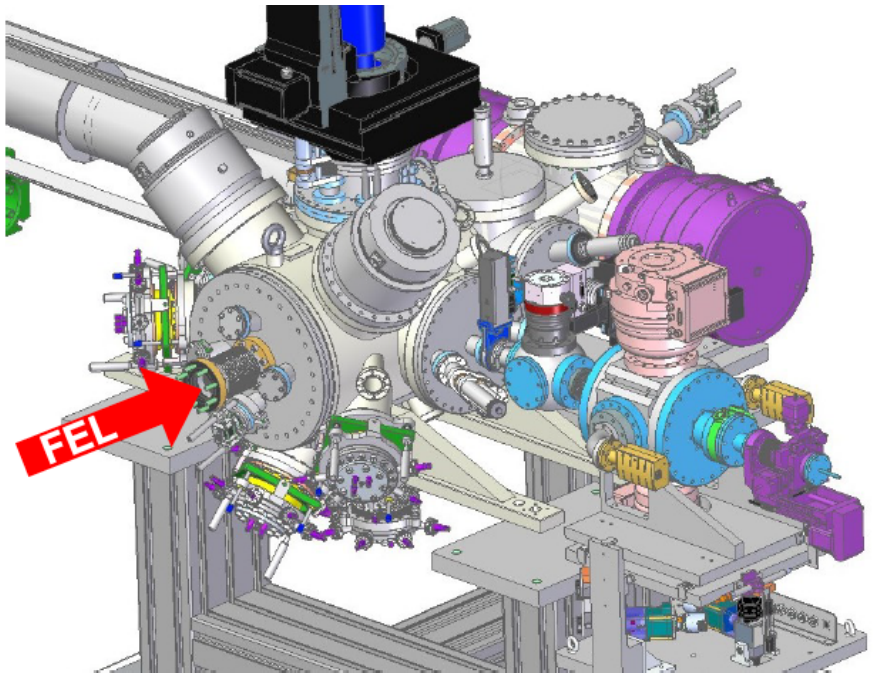
Atomic-like Quantum Systems
atoms & molecules
Detection: electrons, ions, photons



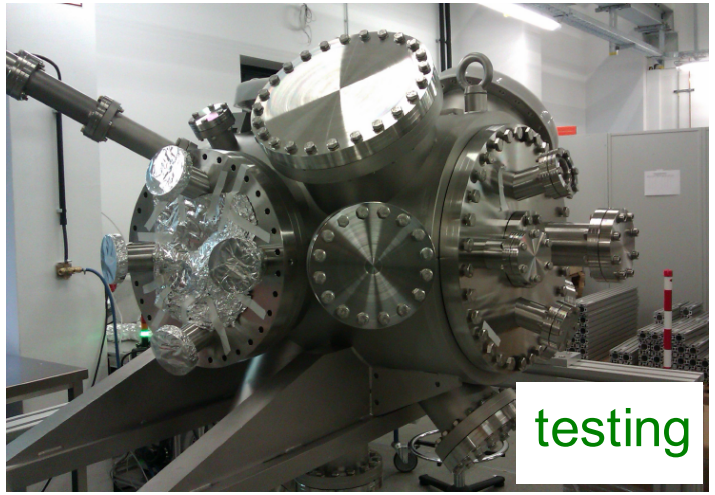
Nano-size Quantum Systems
Cluster, Nano-particles, bio-molecules
Detection: electrons, ions, photons

Reaction Microscope
Molecules, Detection: electrons, ions
Angle- and energy-resolved electron and ion spectra in coincidence

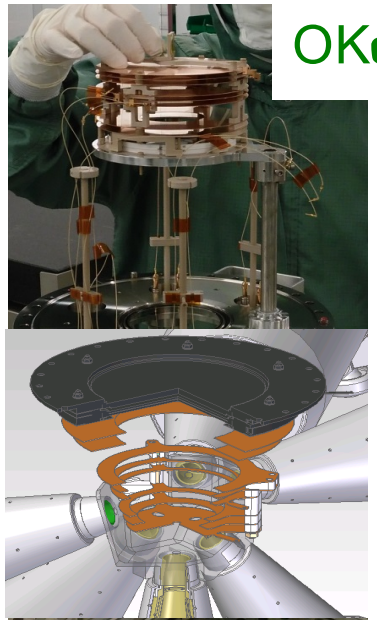
AQS assembly & test



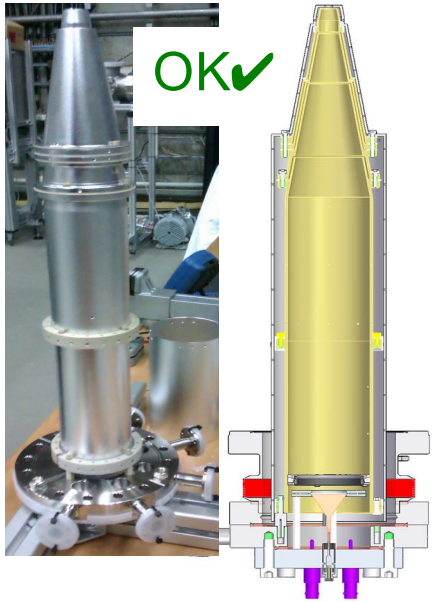
Vacuum vessel
(< 10^{-10} mbar)



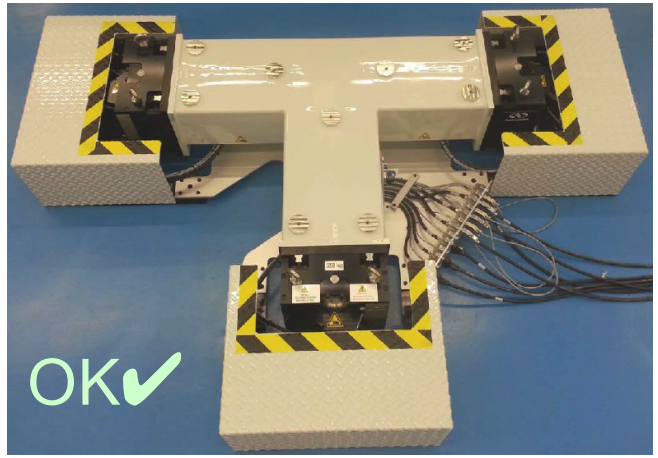
VMI
E ≤ 1 keV, E/ΔE=100



eTOF: E/ΔE > 10 000



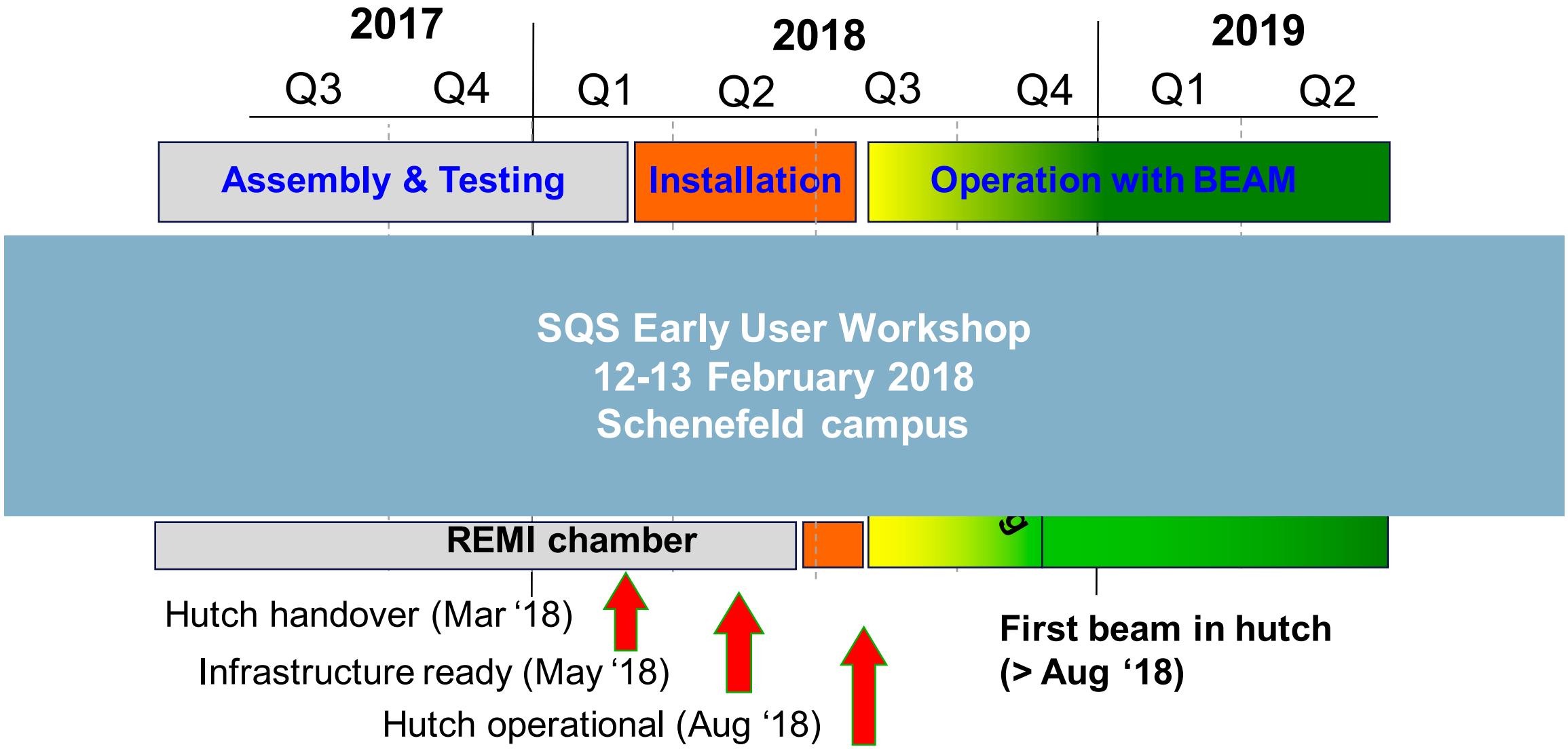
Precision alignment base (1 μm)



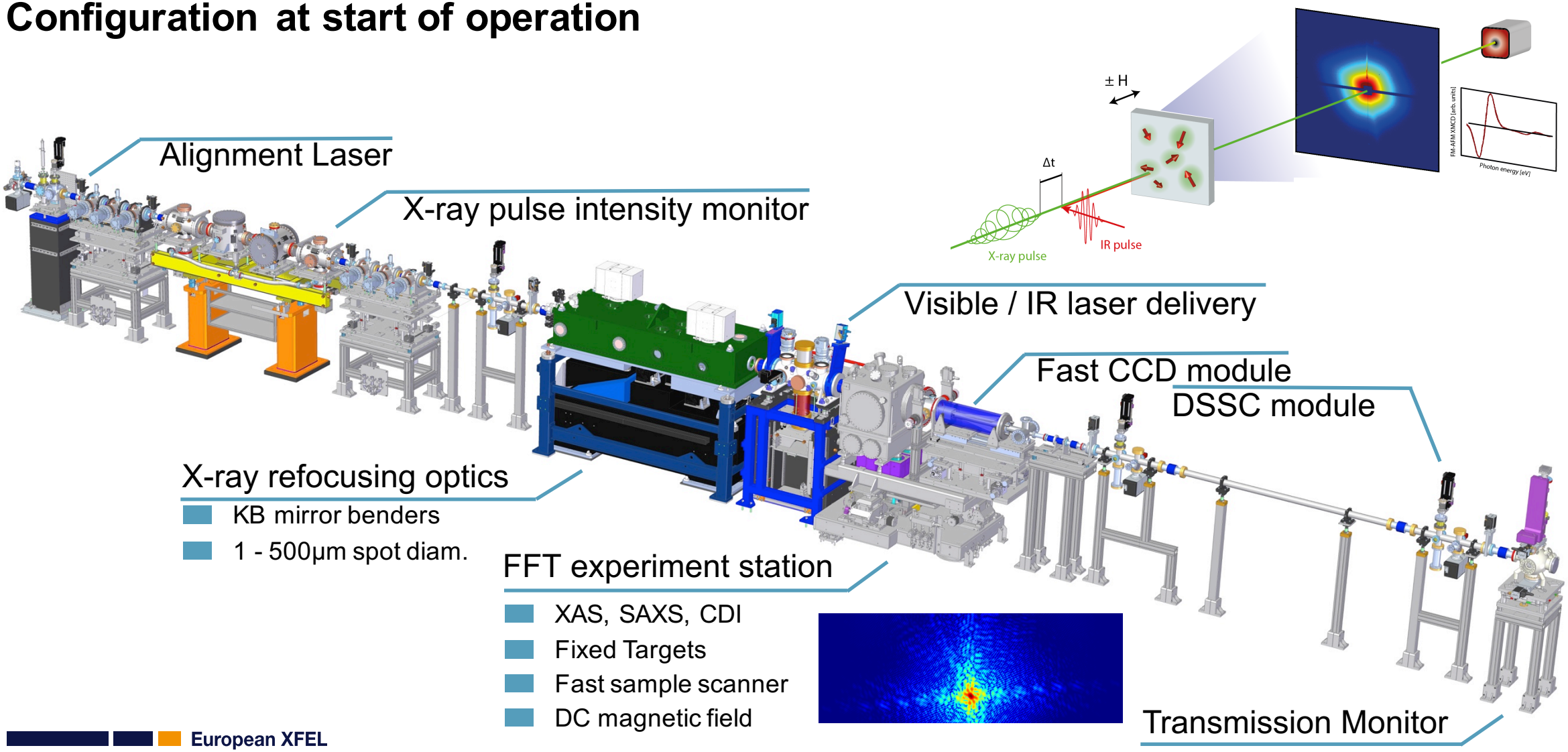
AQS: Atomic-like Quantum Systems

- **6 x eTOFs** High energy resolution, Non-dipole studies
- **1 x VMI** Angular distribution, e / ion – coincidences
- **1 x MBES** e / e – coincidences
- **1 1D Imaging XUV spectrometer**

SQS Installation schedule



Spectroscopy and Coherent scattering (SCS) scientific instrument
Configuration at start of operation

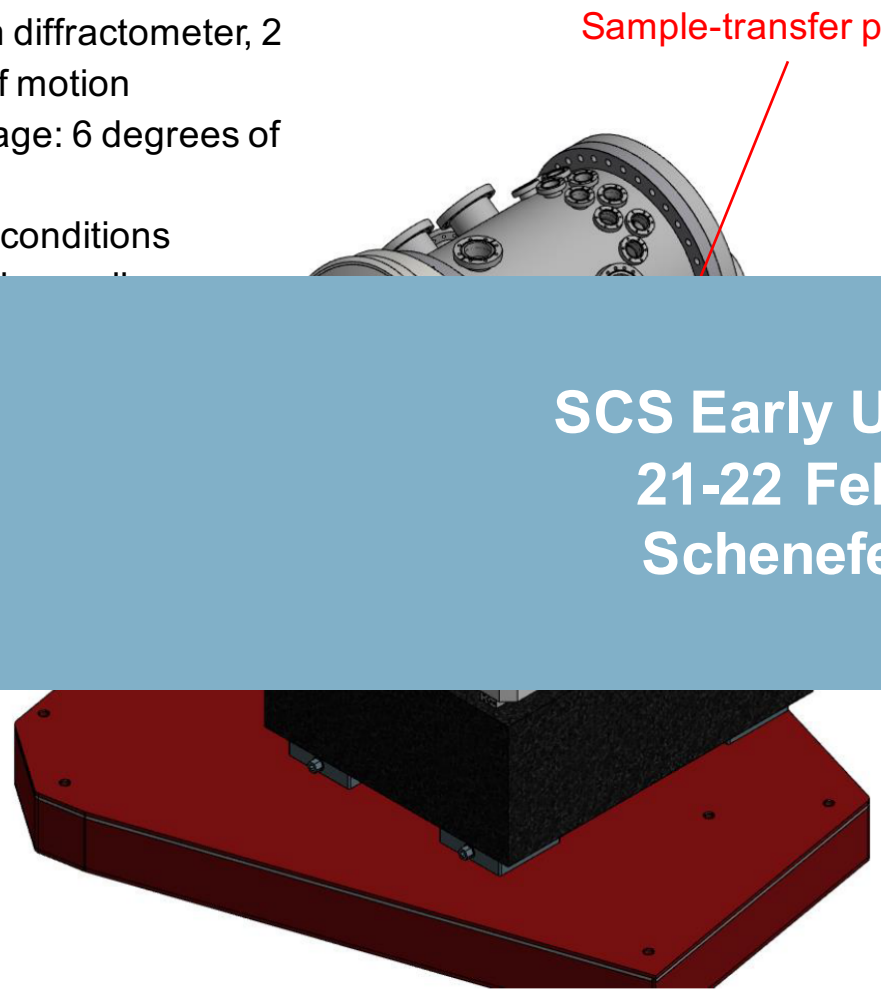


SCS instrument timeline and status

- May 2017 - Instrument components stored in experiment hall, local testing of FFT station and pre-installations
- Dec. 2017 - KB mirror system stored at FMB Oxford
- Jan 2018 – superpolished JTEC mirrors delivered, inspection in metrology labs.
- March 2018 - Start of sensitive component installation
- May/June 2018 Day-one components installed and FastCCD integrated. Controls and DAQ to continue
- August 2018 commissioning start

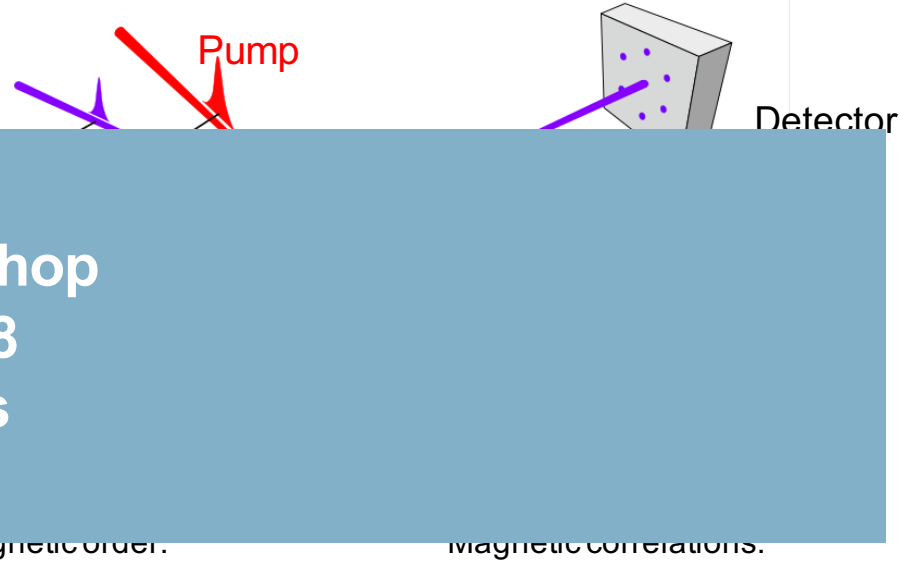
SCS 2nd baseline instrument (2019): XRD experiment station

- UHV, 10^{-9} mbar
- in-vacuum diffractometer, 2 degrees of motion
- sample stage: 6 degrees of motion
- cryogenic conditions

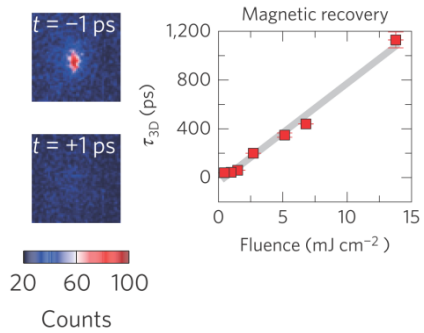


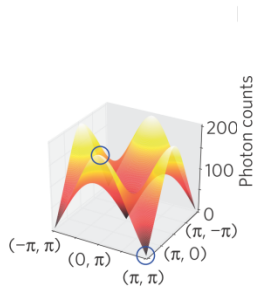
Time-resolved spectroscopy:

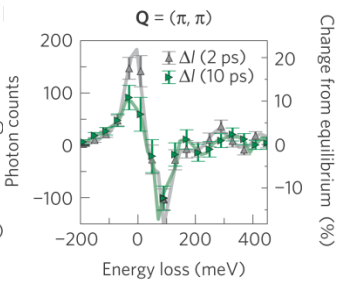
- X-ray absorption spectroscopy (XAS)
- Resonant inelastic x-ray scattering (RIXS)
- Reflectivity / X-ray resonant diffraction (XRD)



SCS Early User Workshop
21-22 February 2018
Schenefeld campus

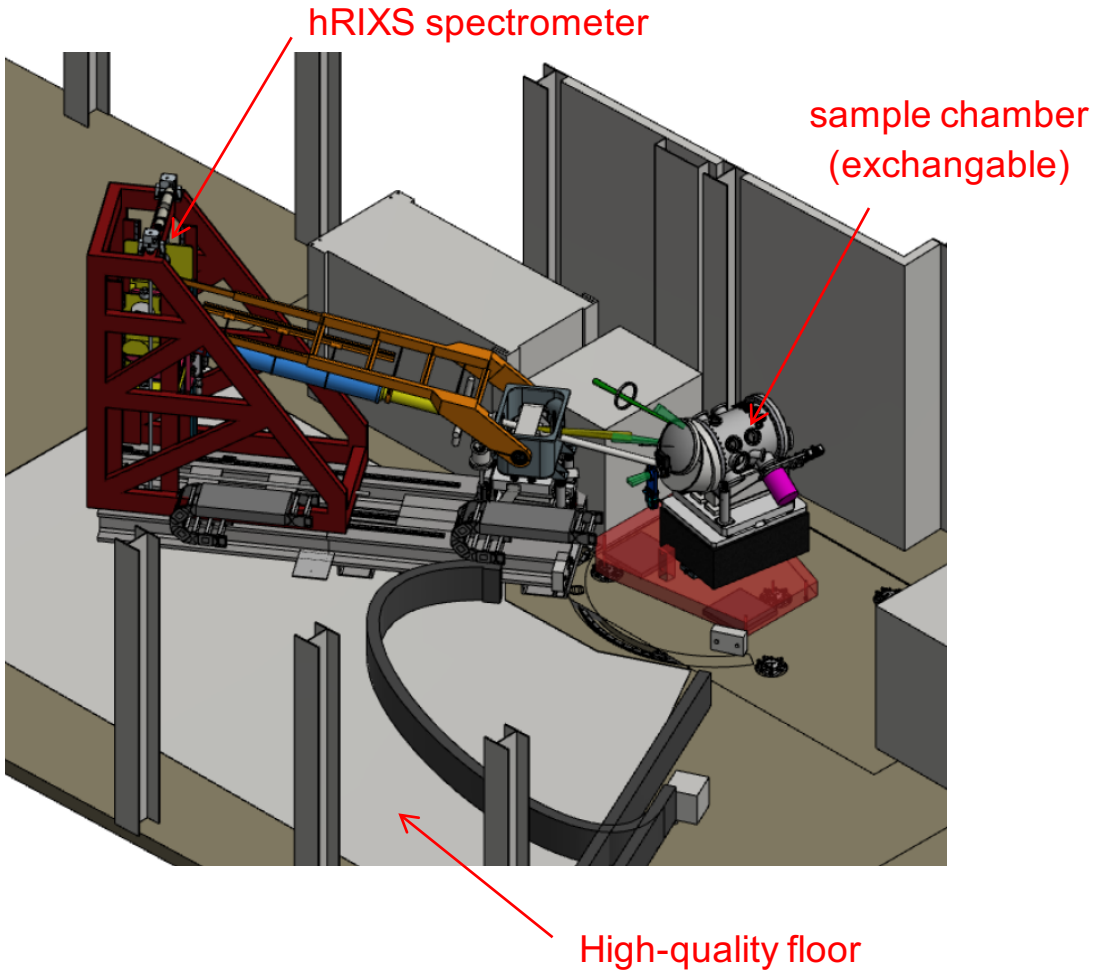






M.P.M. Dean et al., Nat. mat. 15, 601 (2016)

SCS and hRIXS user consortium: Heisenberg RIXS setup



hRIXS working group (on behalf of the consortium):

G. Ghiringhelli, A. Scherz, J. Schlappa, J.T. Delitz, T. Laarmann, S. Techert, S. Huotari, F. Senf, A. Pietzsch, S. Neppl and A. Föhlisch

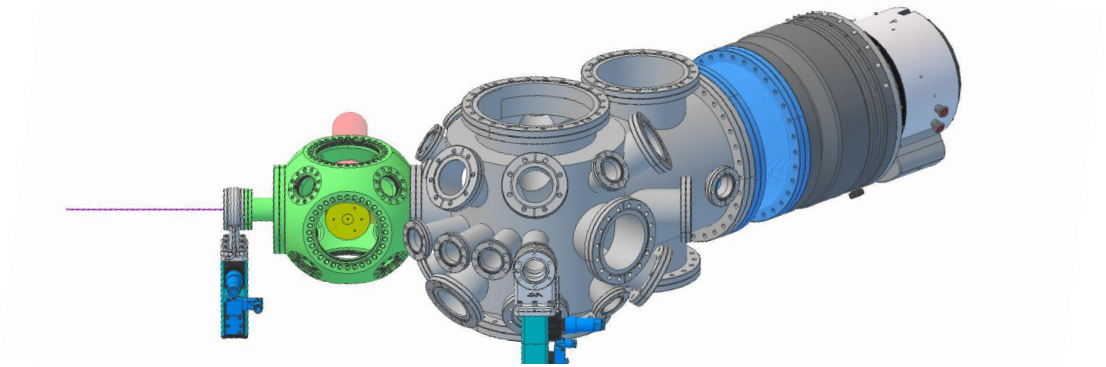
Spectrometer:

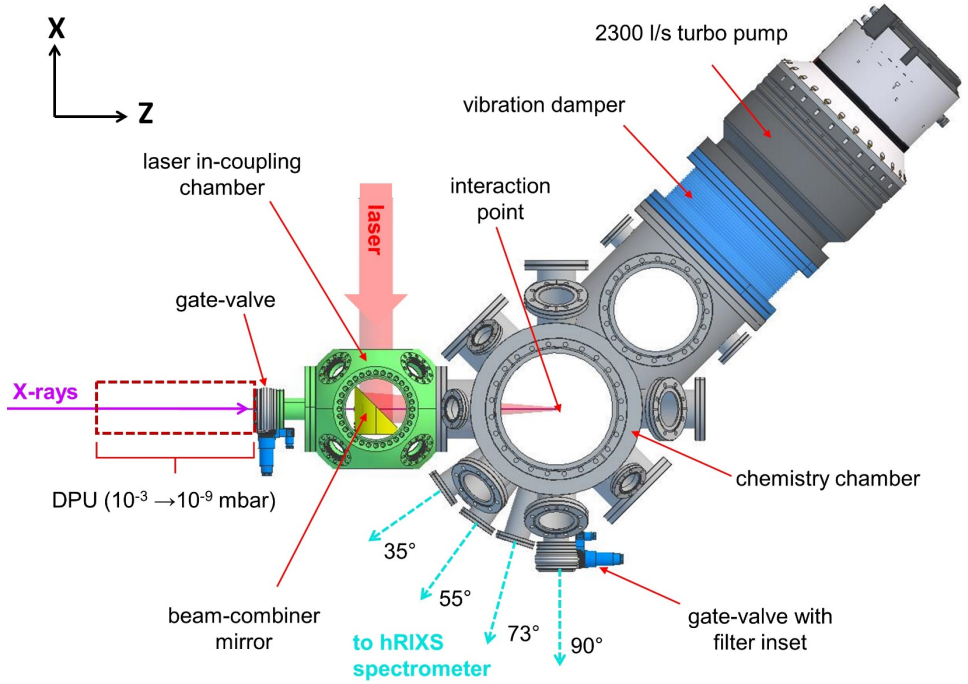
Tender awarded (Bestec GmbH); delivery April 2019

Detector:

Multi-hit compatible delay-line anode contributed by Finnish partner consortium

Chemistry Endstation

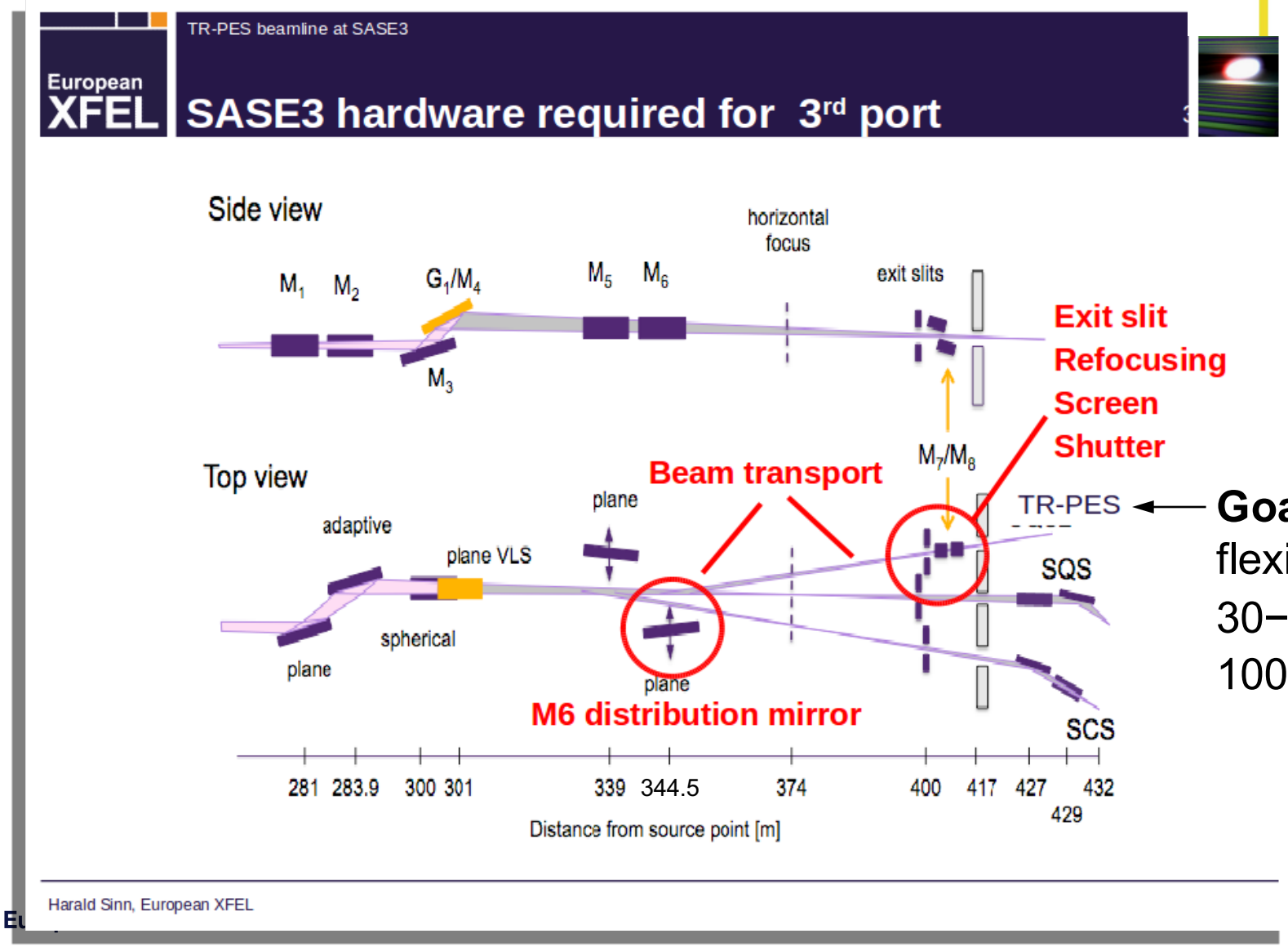




- Flexible multipurpose UHV chamber
- Optimized for liquid jets and gas phase targets
- Up to for selectable hRIXS scattering angles (fixed)
- Vacuum protection: diff. pumping (to beamline) and filters (to hRIXS)
- Collinear laser in-coupling

Tender awarded (Bestec GmbH)
Delivery scheduled for December 2018

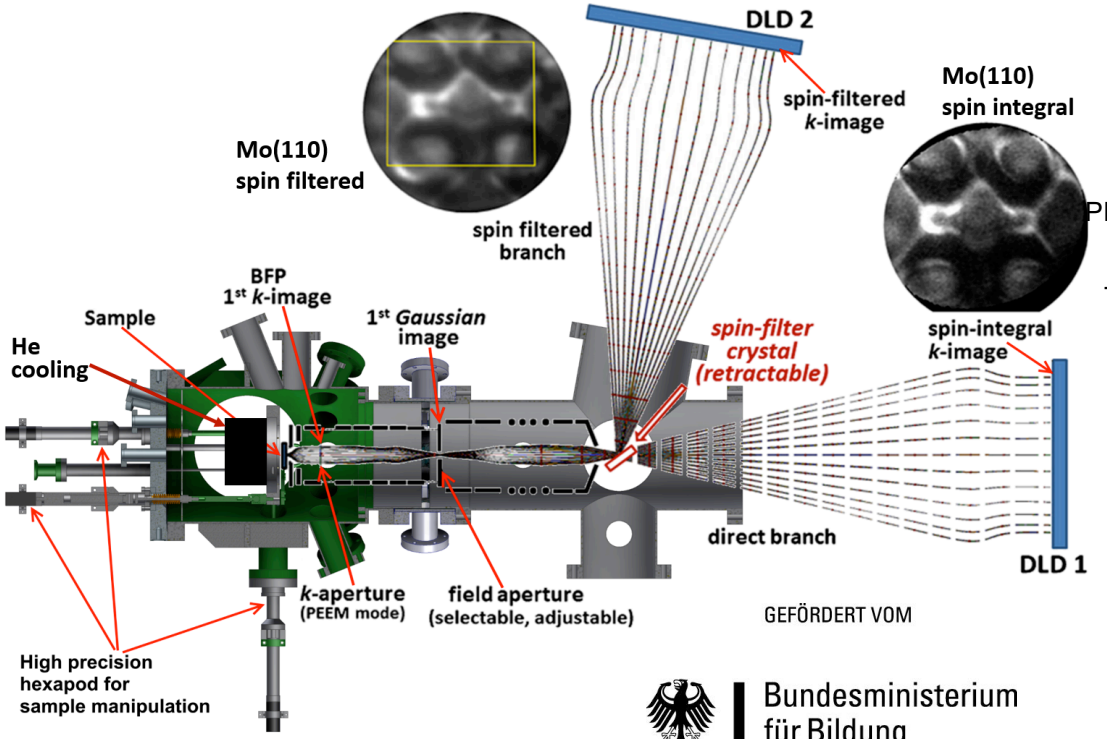
TR-PES beamline at SASE3



Goal:
flexible spot size
30–100 μm (hor)
100 μm (ver)

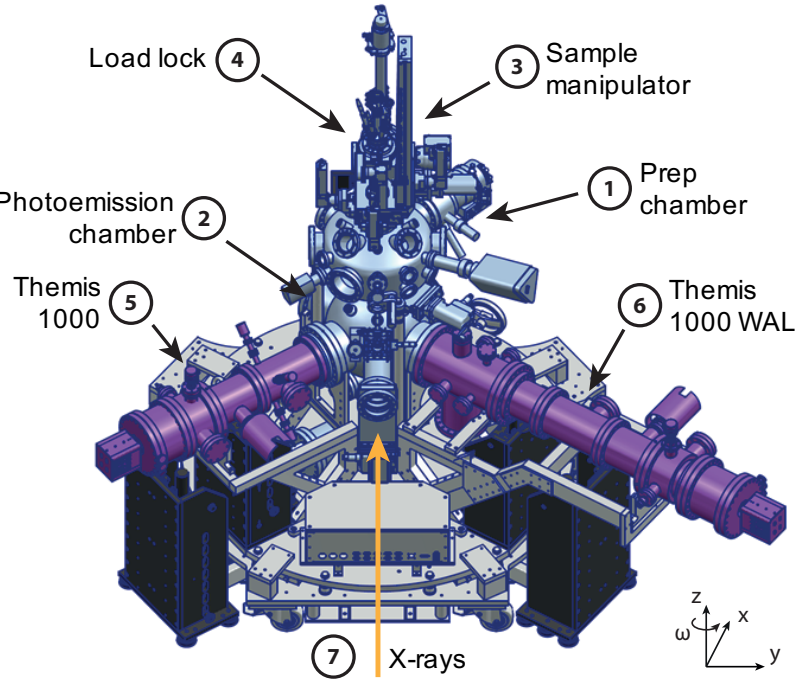
Experimental stations

Spin-filtering ToF momentum microscopy
(Univ. Mainz, G. Schönhense *et al*.)



GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Dual angle-resolving ToF photoelectron spectroscopy
(Univ. Hamburg, W. Wurth *et al*.)



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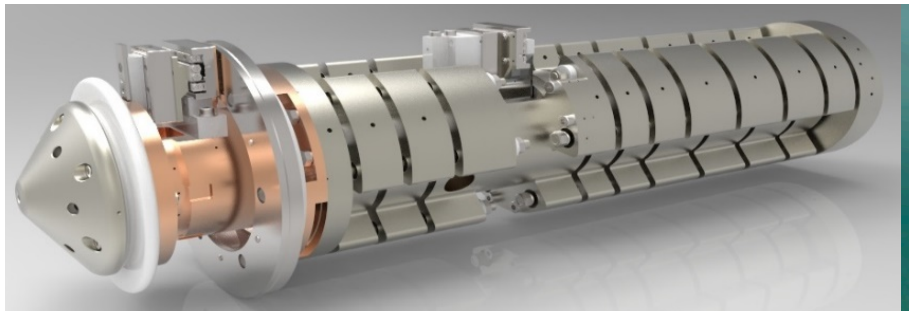
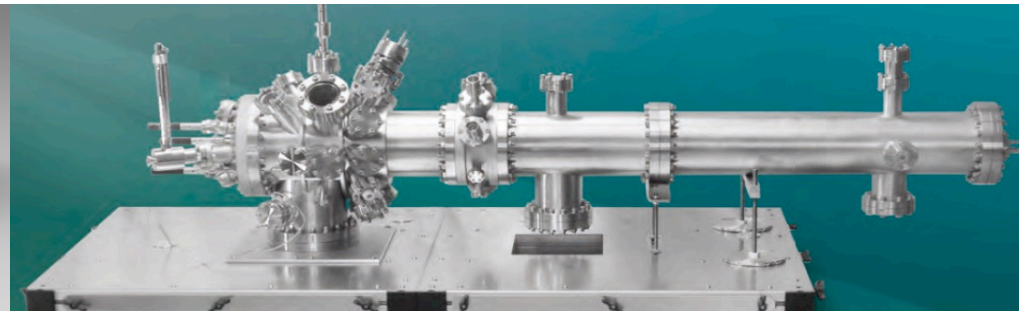
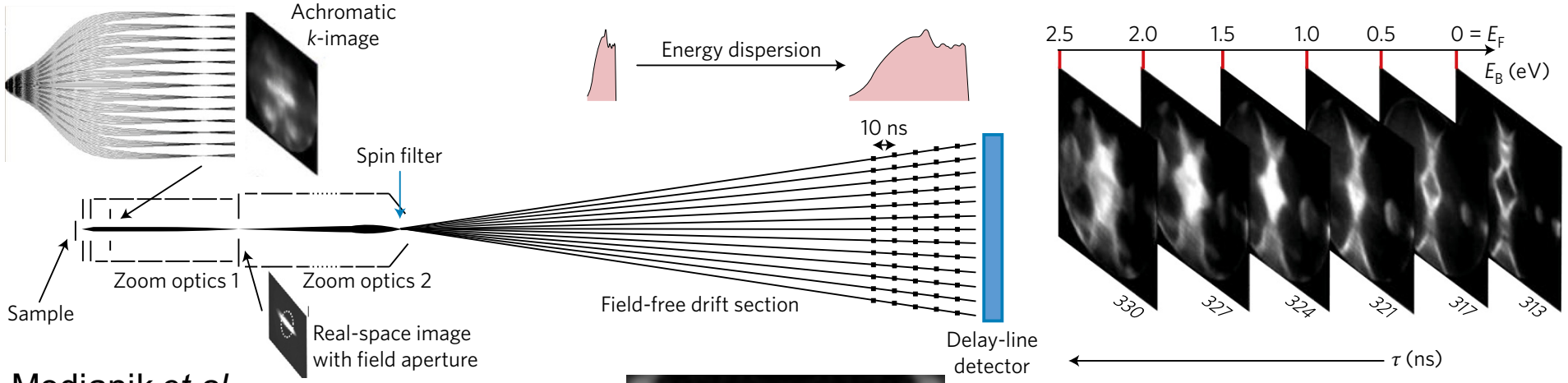
ToF momentum microscopy



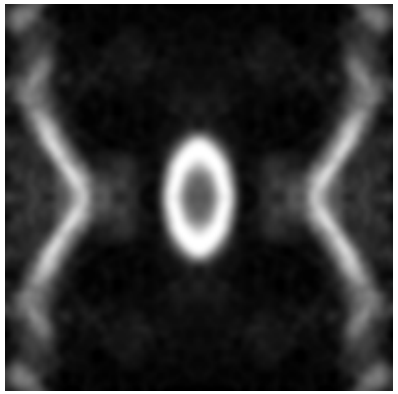




Medjanik *et al.*,
Nat. Mater. **16**, 615 (2017)

$$\Delta k_{\parallel}^{\mathrm{acc}} = 4\,\text{Å}^{-1} \;@\; E_{\mathrm{kin}} = 1\,\mathrm{keV}$$

$$\curvearrowright \quad \frac{\Delta\Omega}{2\pi} = 8 \times 10^{-3}$$



Mo (110)

$T = 30\,\mathrm{K}$

$h\nu = 447 \cdots 574\,\mathrm{eV}$

Beamline P04, PETRA III (Hamburg)

Bad Honnef Physics School on

Physics with Free Electron Lasers

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On behalf of
SQS - M. Meyer (Group Leader)
SCS - A. Scherz (Group Leader)
hRIXS - A. Föhlisch (Speaker)
TR-PES - K. Rossnagel (Speaker)