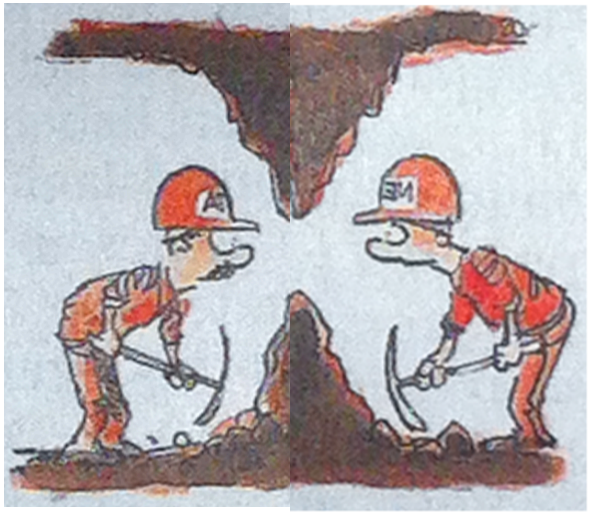
Der Brutale Gotthard,
Feb. 29 1880

Neu Gotthard tunnel
57 km, Longest tunnel
Oct. 15, 2010 , at 14:00

Before
Sigtuna workshop



After
Sigtuna workshop

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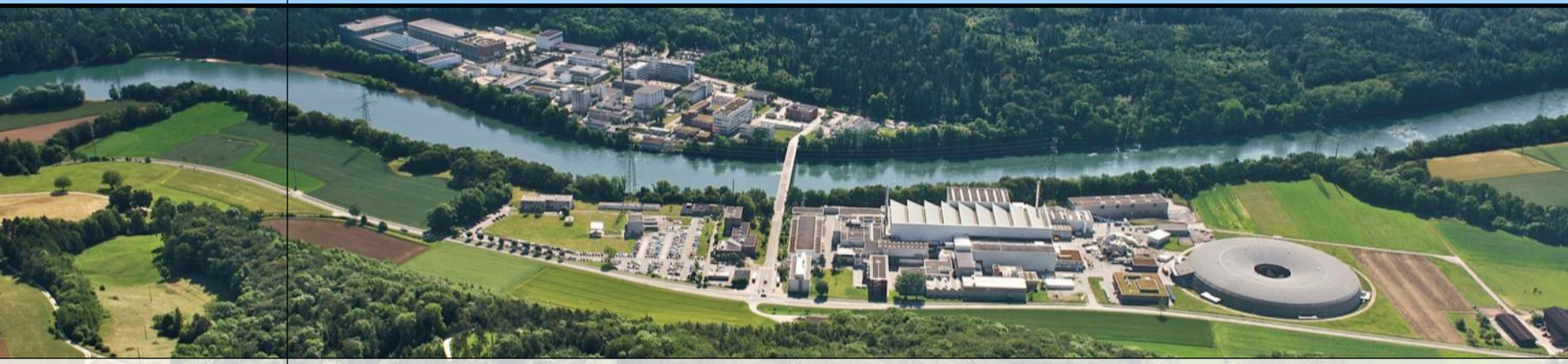
PSI



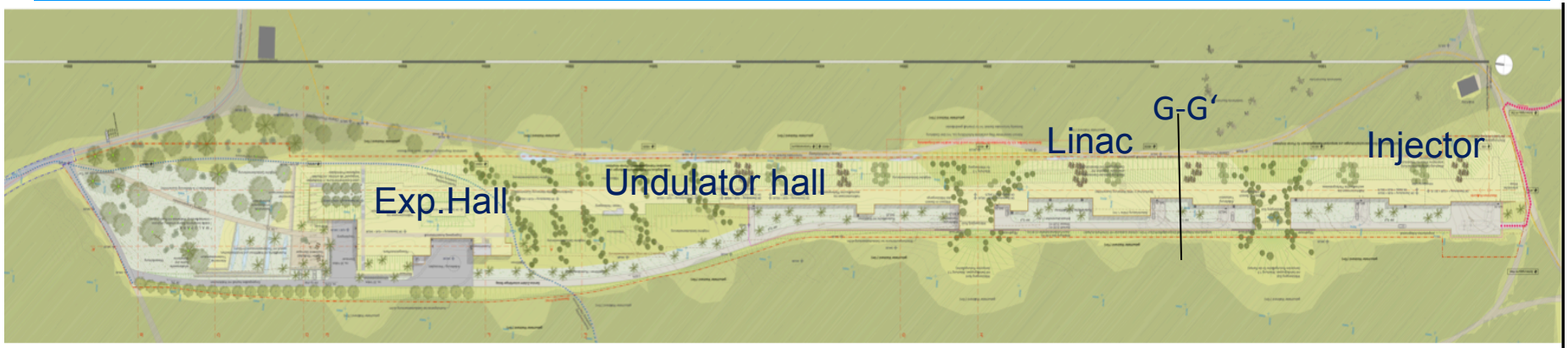
Wir schaffen Wissen – heute für morgen

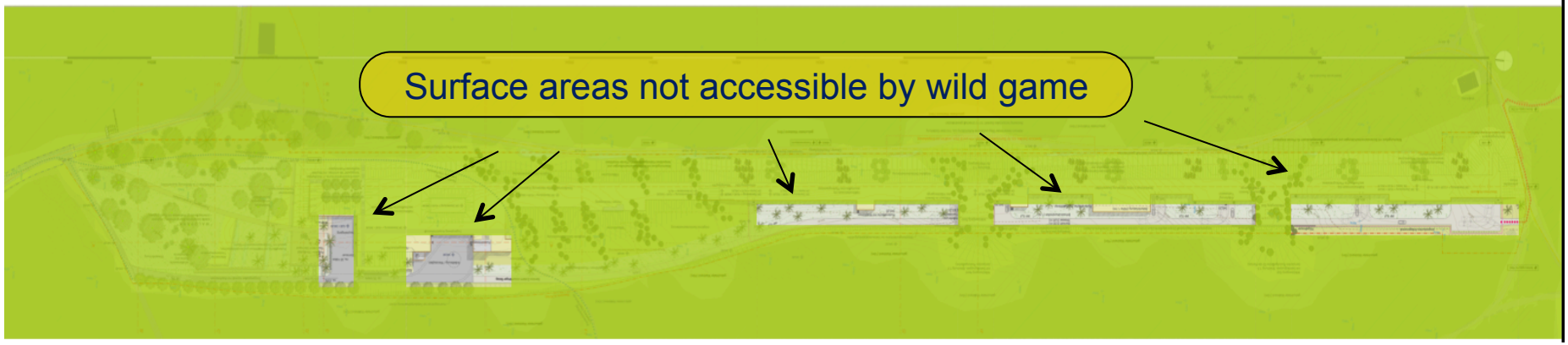
Photon Science at SwissFEL

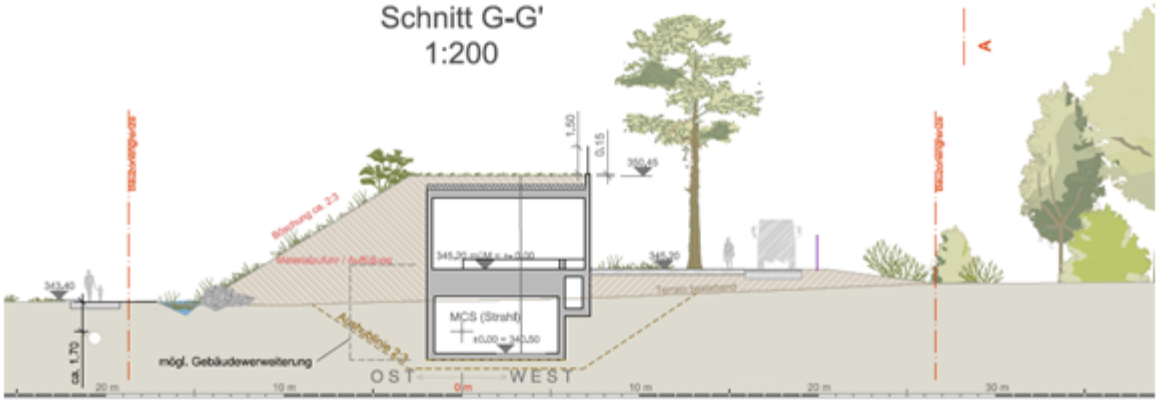
Luc Patthey, Paul Scherrer Institut

Sigtunahöjden, 30-31.01.2012

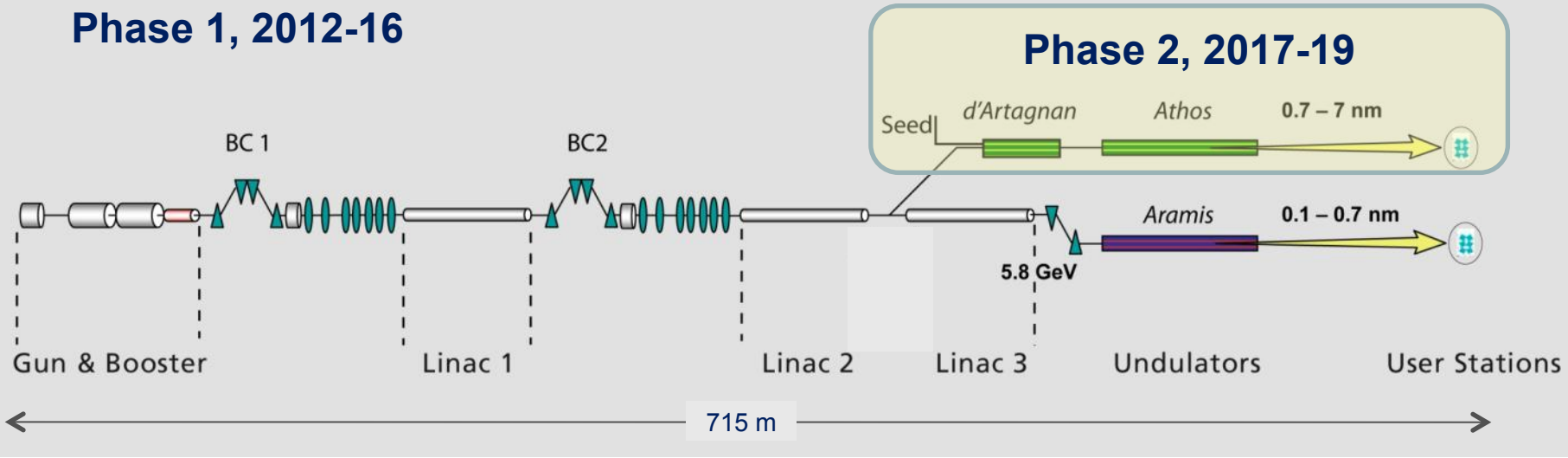
SwissFEL a “green facility”







SwissFEL



Aramis: 1-7 Å hard X-ray SASE FEL,
In-vacuum , planar undulators with variable gap.
User operation from mid 2017

Athos : (2nd phase) 7-70 Å soft X-ray FEL for SASE & Seeded operation .
APPLE II undulators with variable gap and full polarization control.
User operation end 2019?

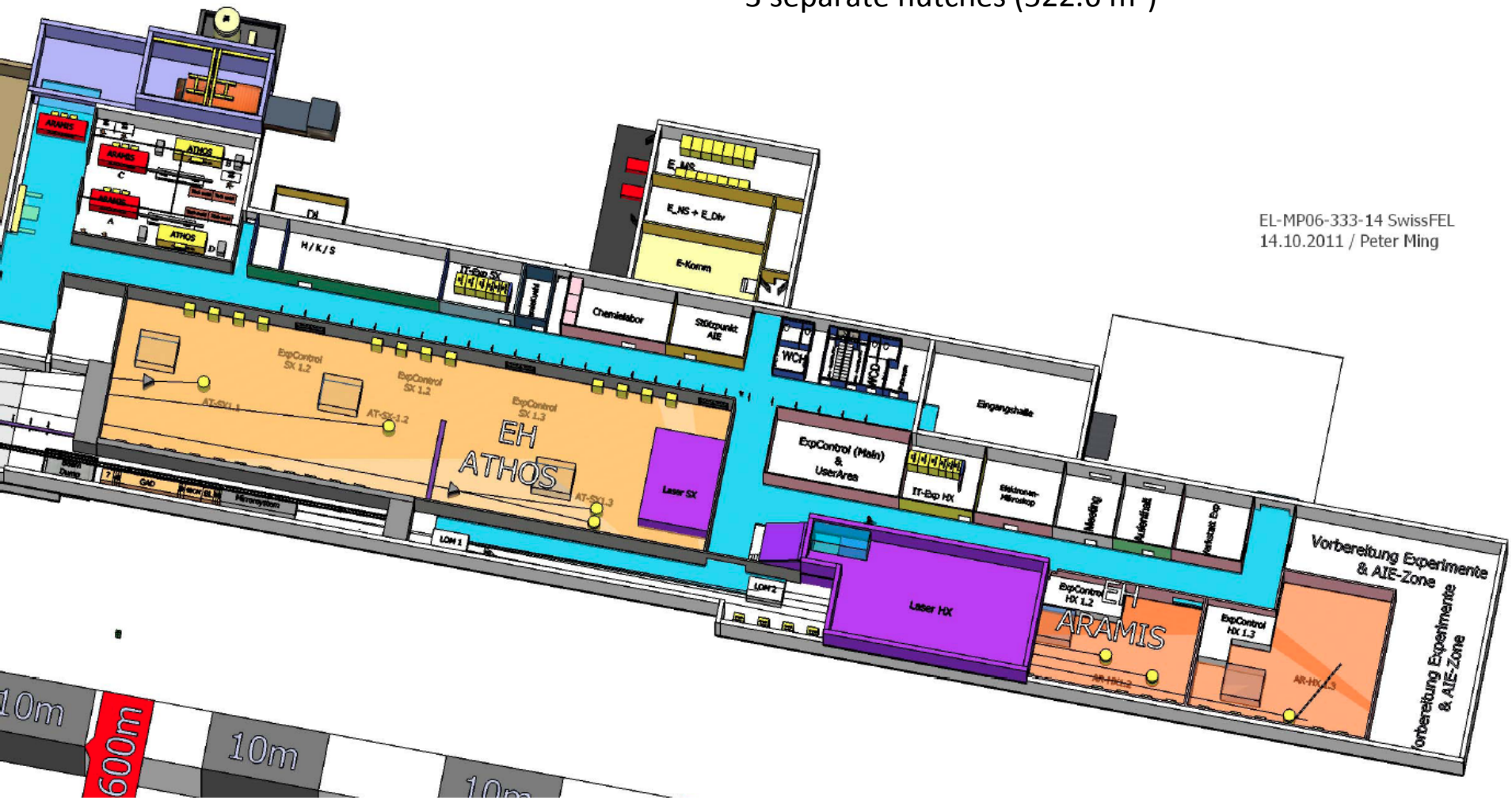
SwissFEL parameters

Wavelength from	1 Å - 70 Å
Photon energy	0.2-12 keV
Pulse duration	1 fs - 20 fs
e^- Energy	5.8 GeV
e^- Bunch charge	10-200 pC
Repetition rate	100 Hz

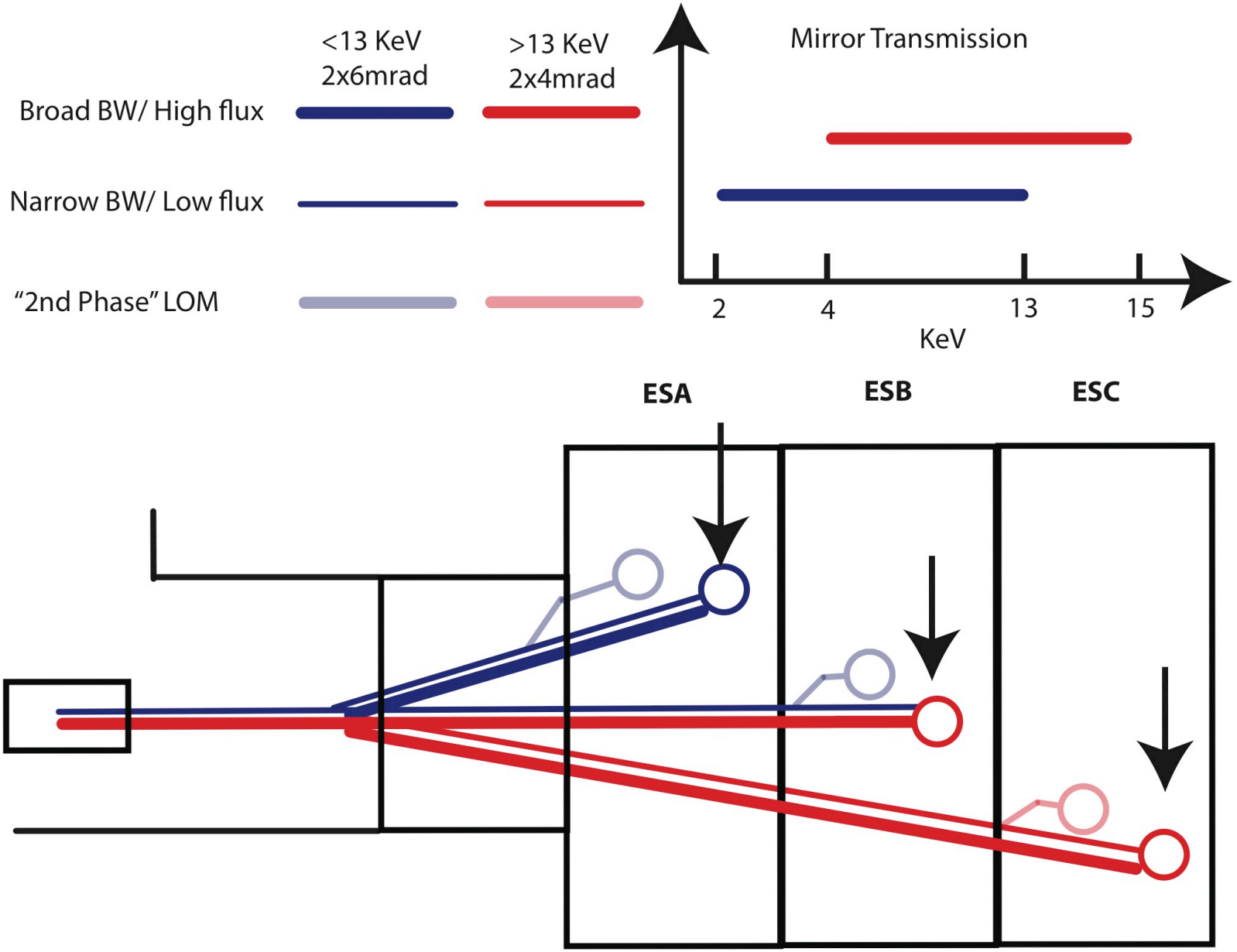
Experimental Areas

ATHOS Exp. surface:
1 single hutch (692 m^2)

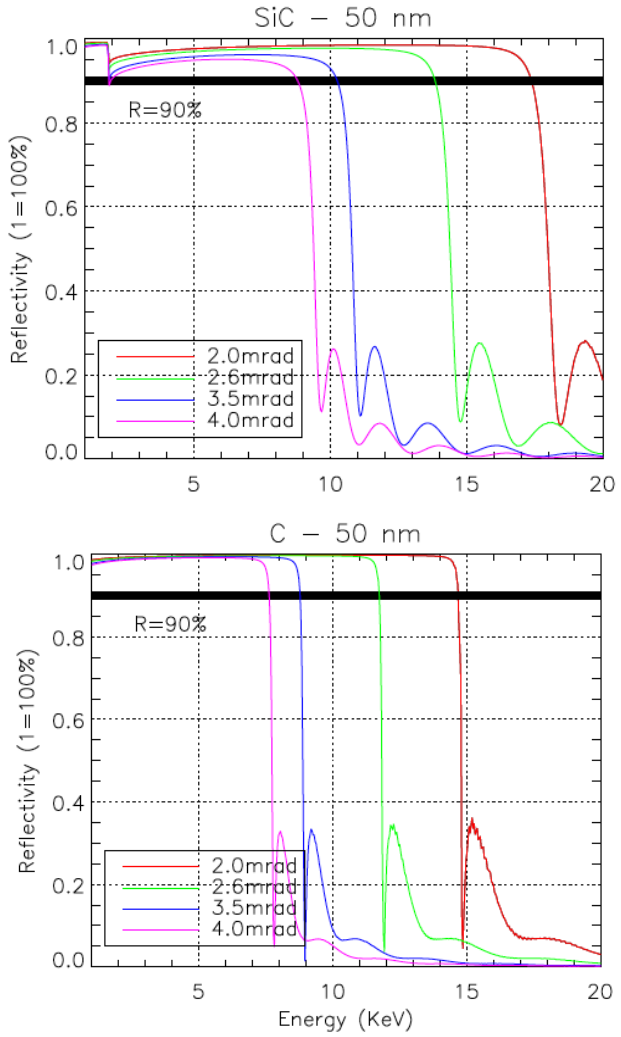
ARAMIS Exp. surface:
3 separate hutches (522.6 m^2)

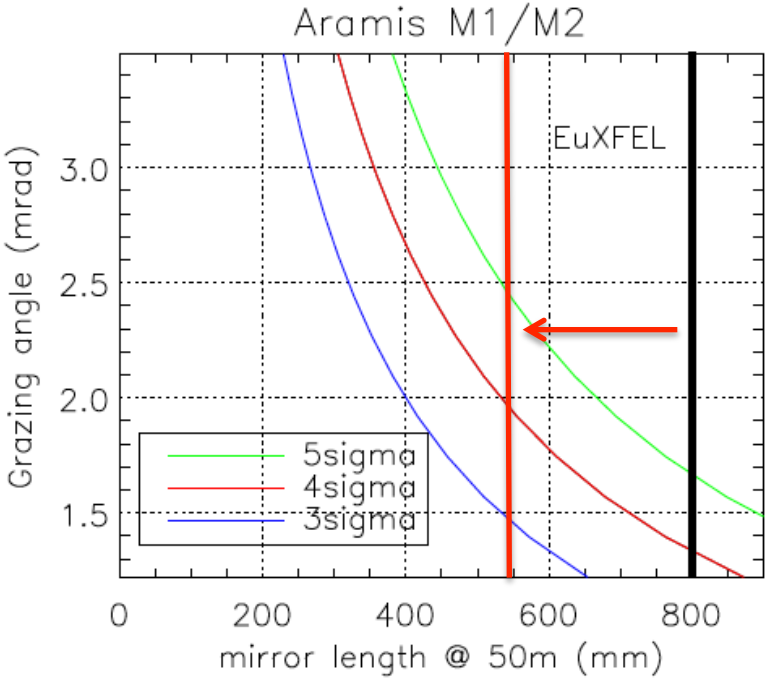


ARAMIS beamlines



Mirrors: low and high energy branch





@ 1.7 KeV

Low and High energy:
Mirror length 800 -> 500 mm

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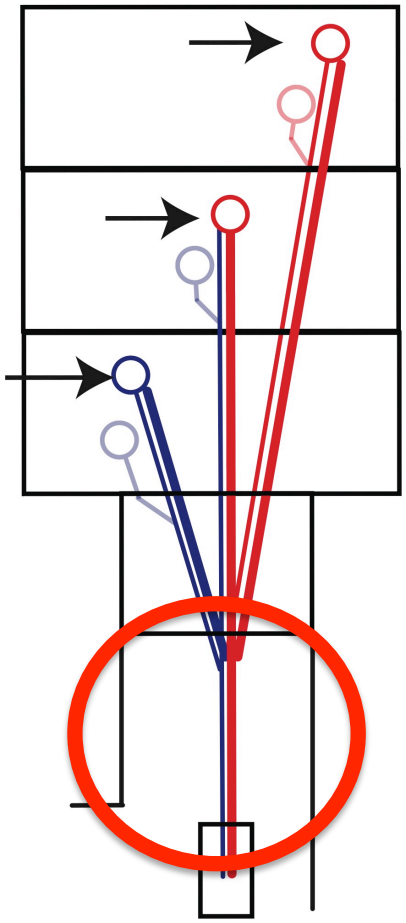
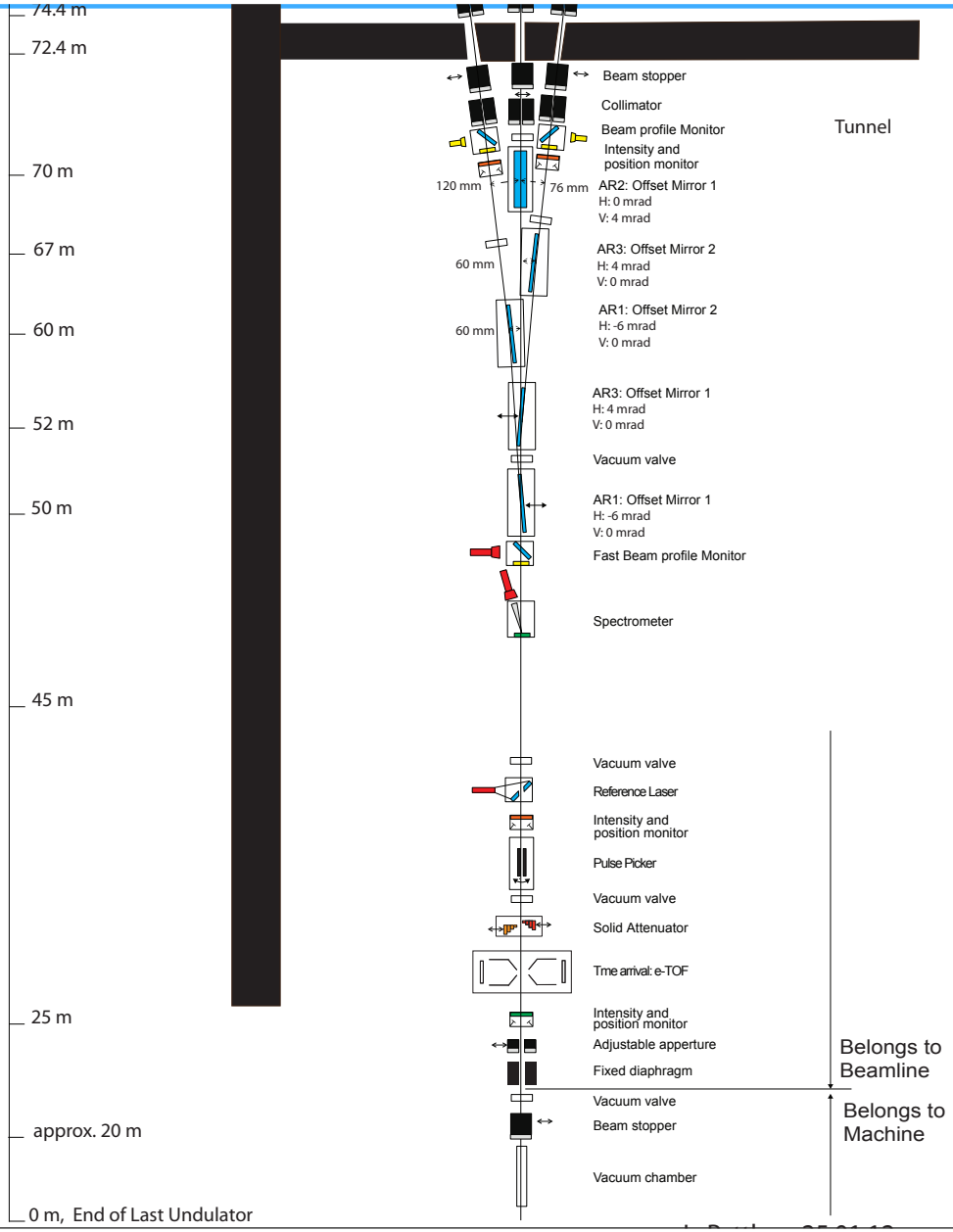
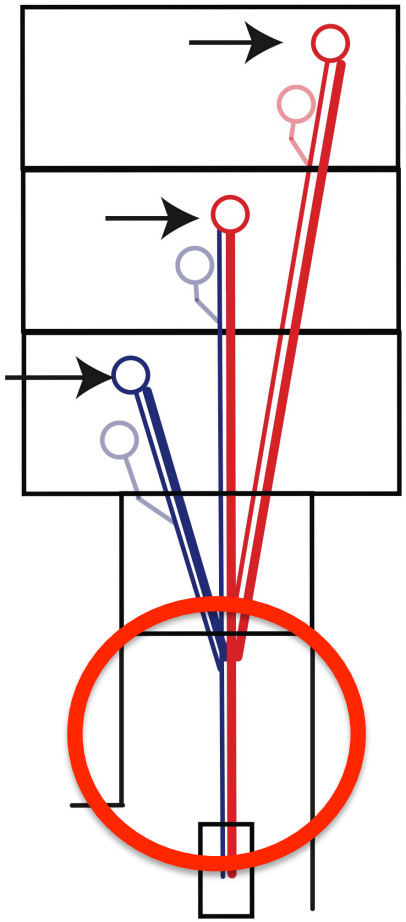
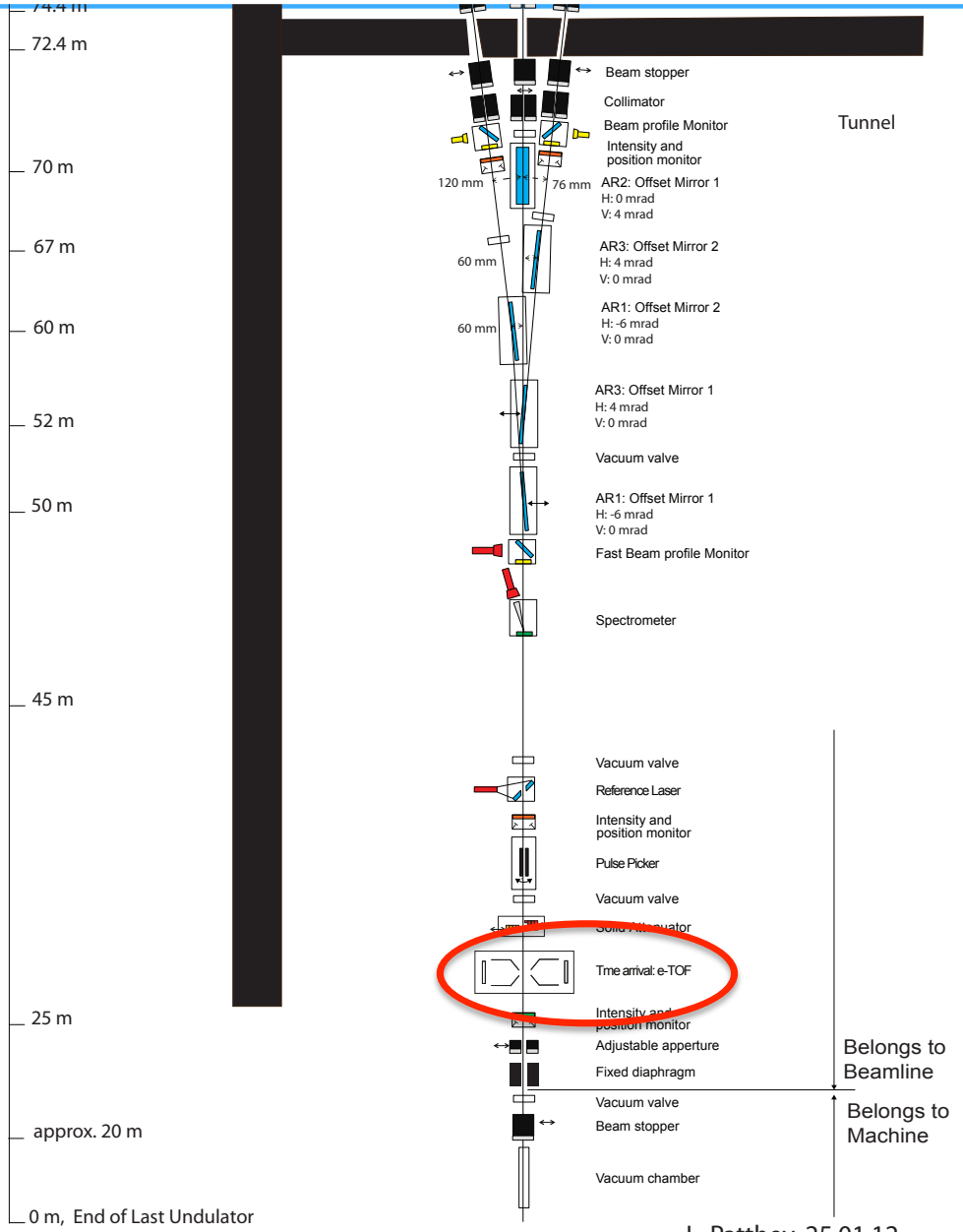
Tunnel





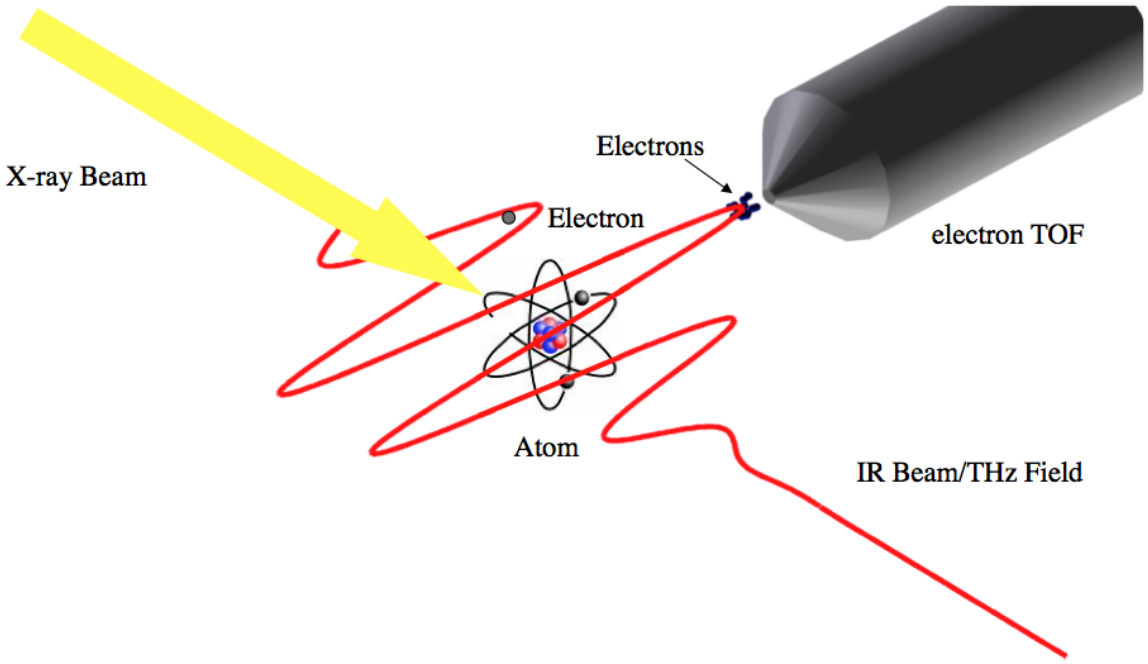
Tunnel




72.4 m
70 m
67 m
60 m
52 m
50 m
45 m
25 m
approx. 20 m
0 m, End of Last Undulator
Tunnel
Beam stopper
Collimator
Beam profile Monitor
Intensity and position monitor
120 mm
76 mm
AR2: Offset Mirror 1
H: 0 mrad
V: 4 mrad
60 mm
AR3: Offset Mirror 2
H: 4 mrad
V: 0 mrad
60 mm
AR1: Offset Mirror 2
H: -6 mrad
V: 0 mrad
AR3: Offset Mirror 1
H: 4 mrad
V: 0 mrad
Vacuum valve
AR1: Offset Mirror 1
H: -6 mrad
V: 0 mrad
Fast Beam profile Monitor
Spectrometer
Vacuum valve
Reference Laser
Intensity and position monitor
Pulse Picker
Vacuum valve
Tme arrival: e-TOF
Adjustable apperture
Fixed diaphragm
Vacuum valve
Beam stopper
Vacuum chamber
Belongs to Beamline
Belongs to Machine

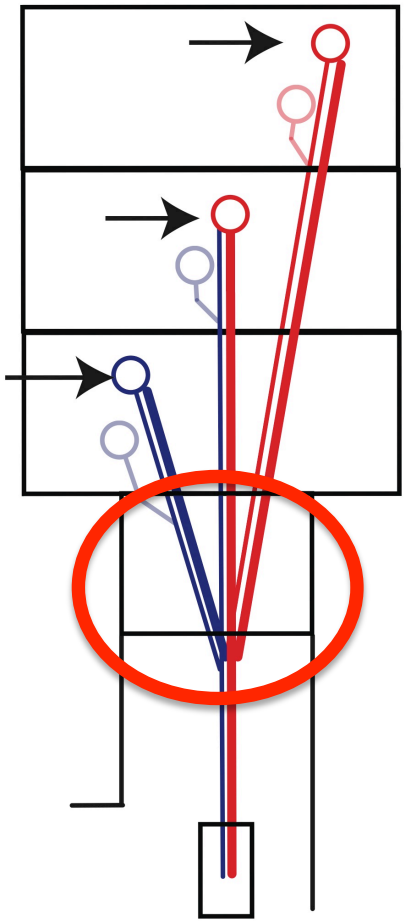
Pulse arrival Time

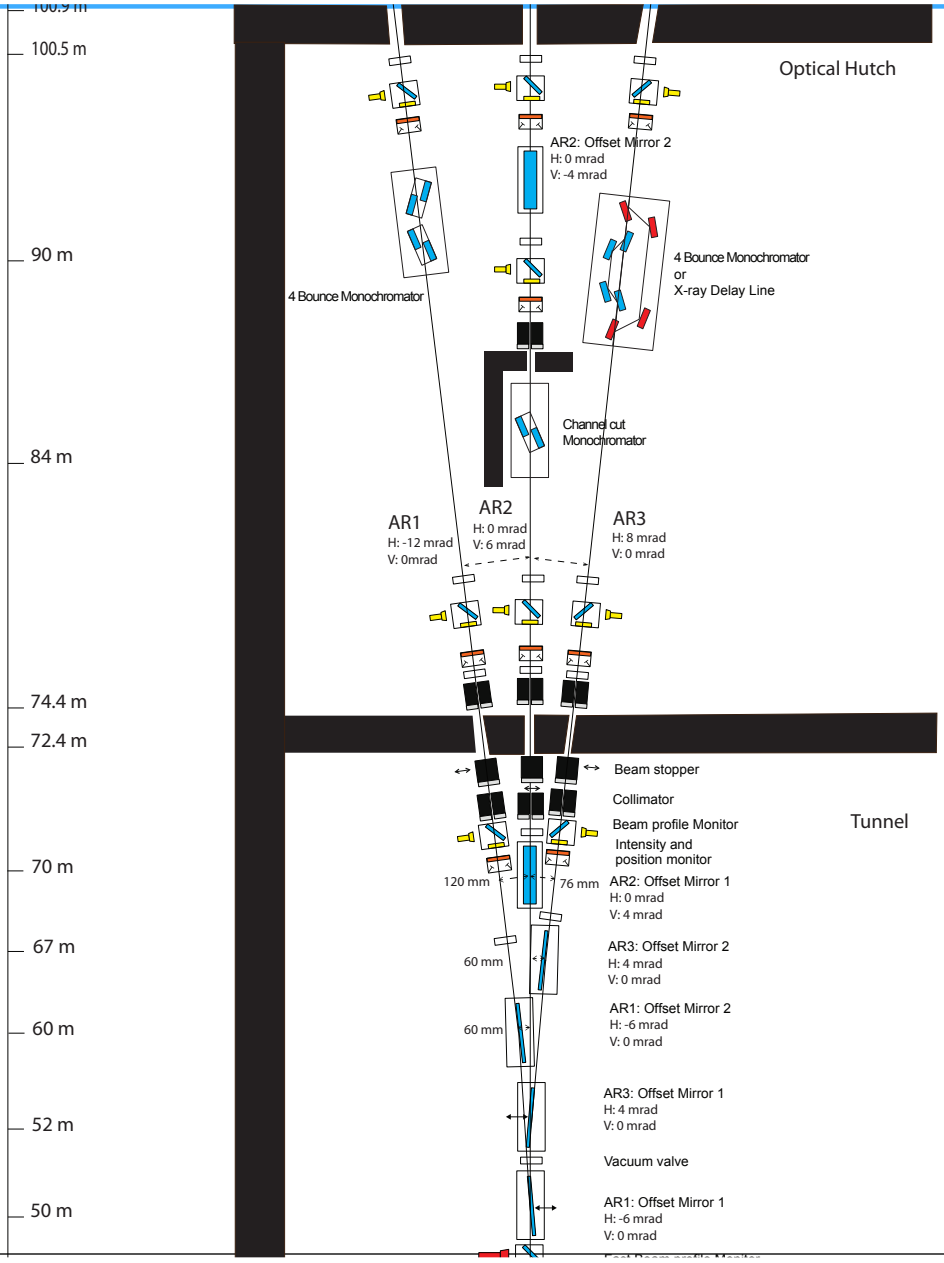
- Use a THz streak camera concept to measure the arrival time and length of the photon pulse.



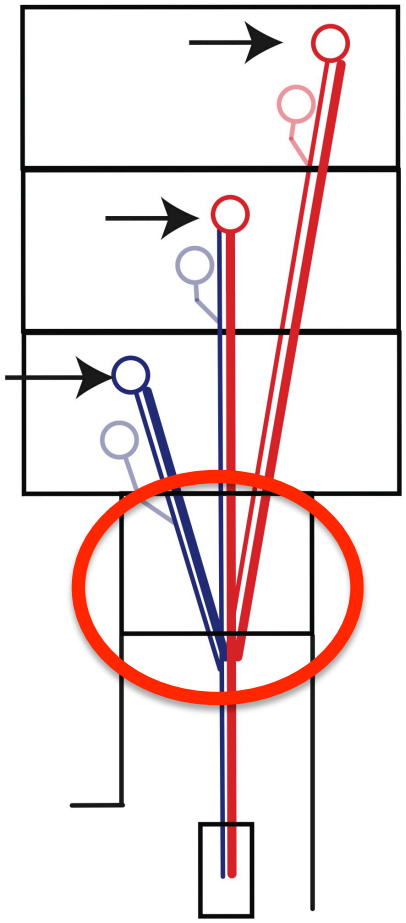
$KE_{electron} = E_{photon} - \text{Binding Energy} \pm W$

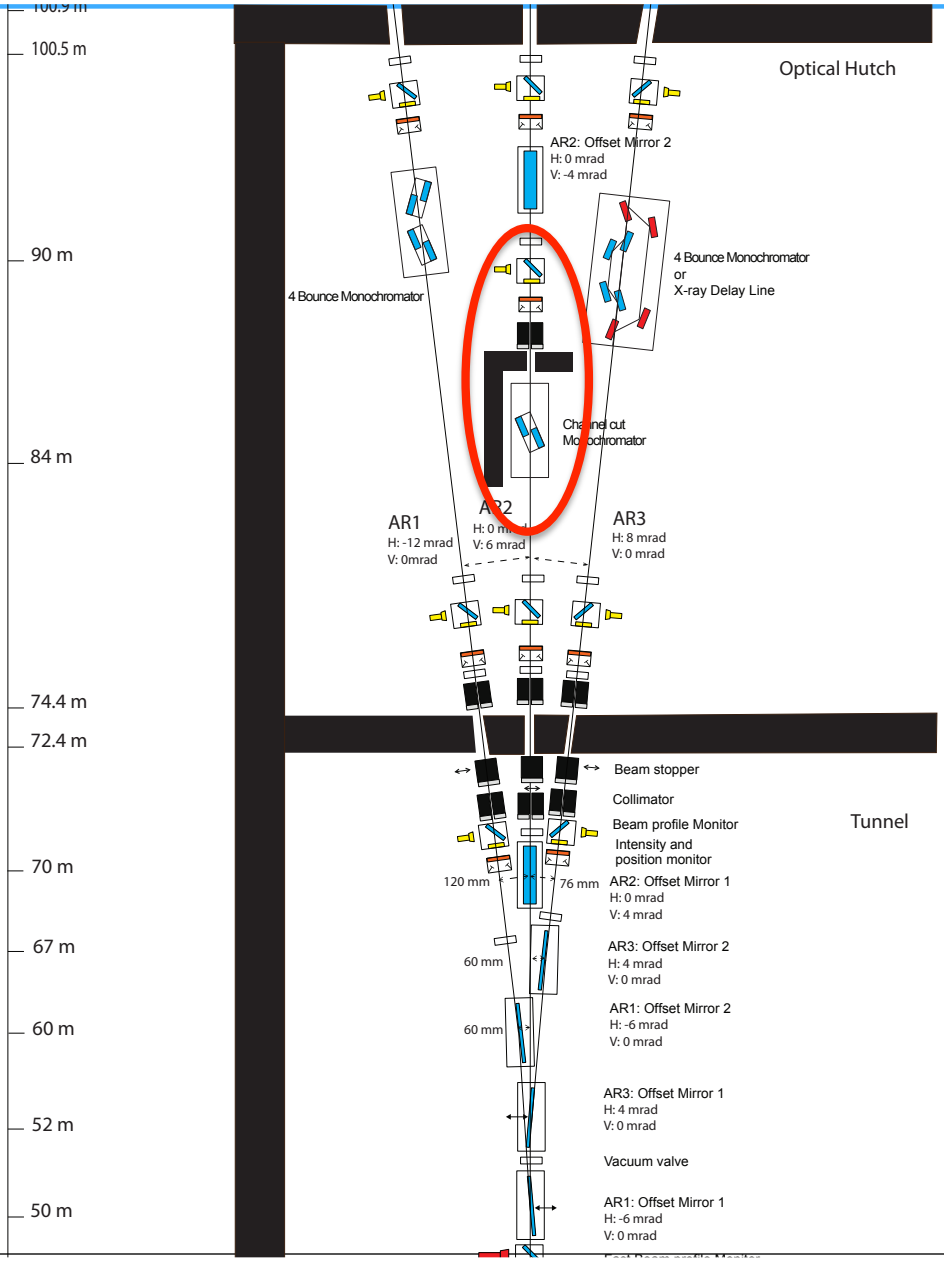
Optical Hutch



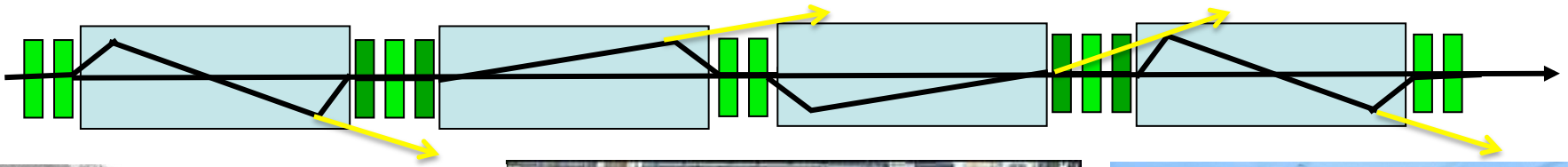


Optical Hutch



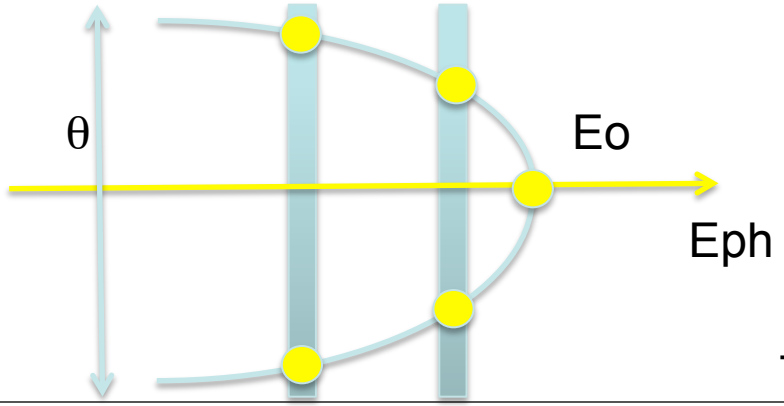


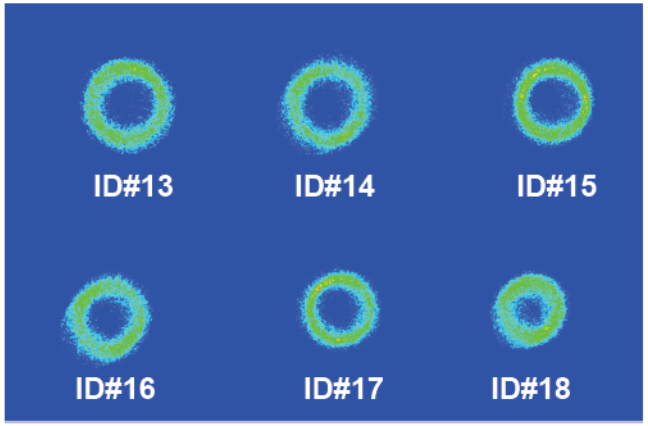
ARAMIS's ID fine tuning

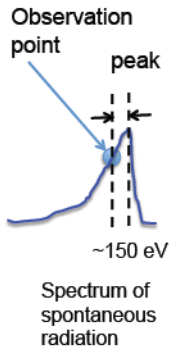


L. Patthey, SAC 11.07.07

Only photon beam overlapp counts!....

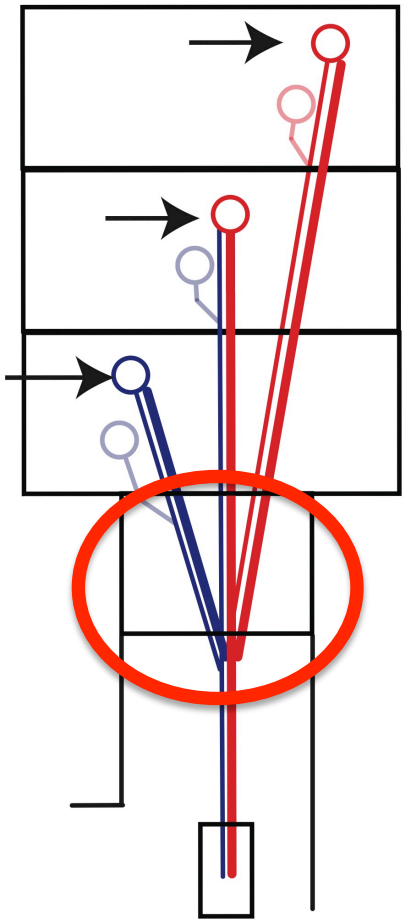


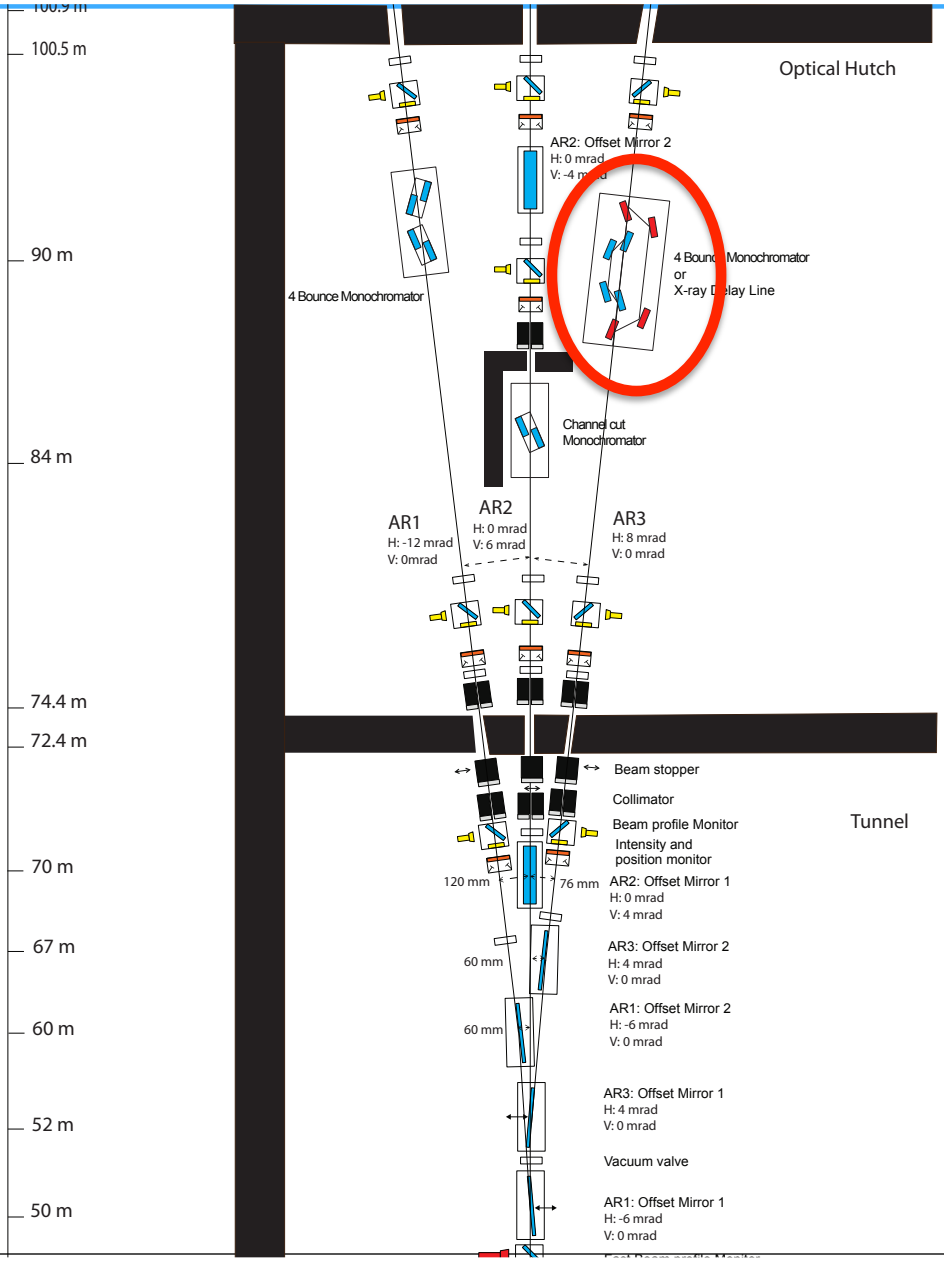




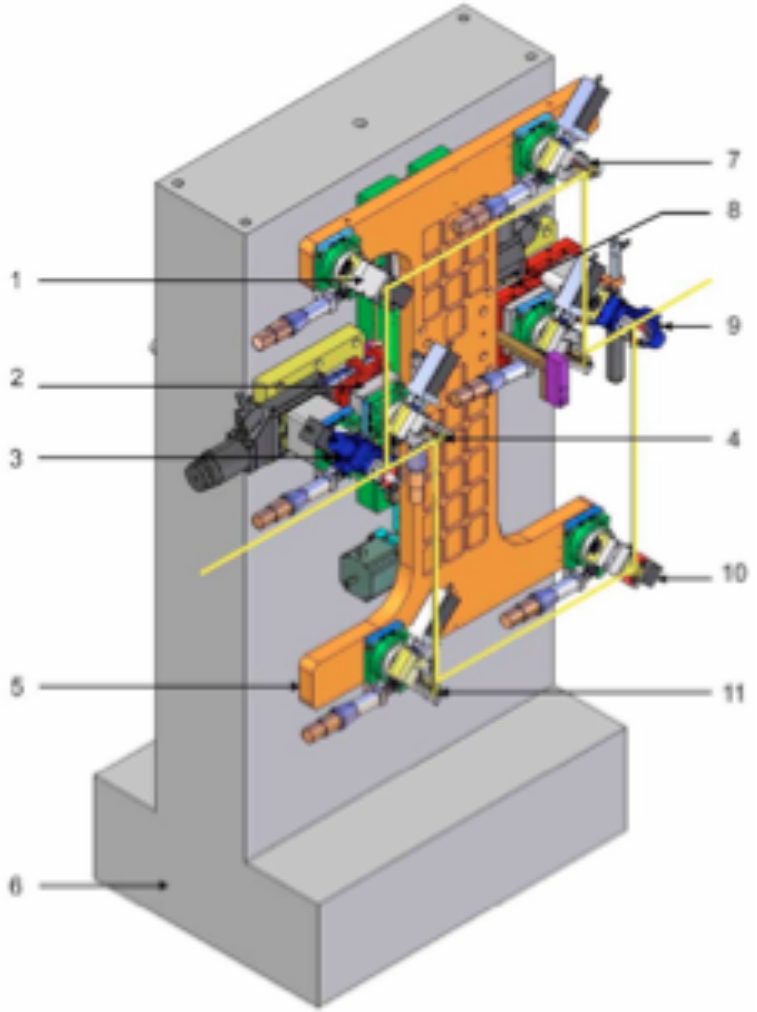
Tetsuya Ishikawa'talk: Jump meeting, 16.09.11

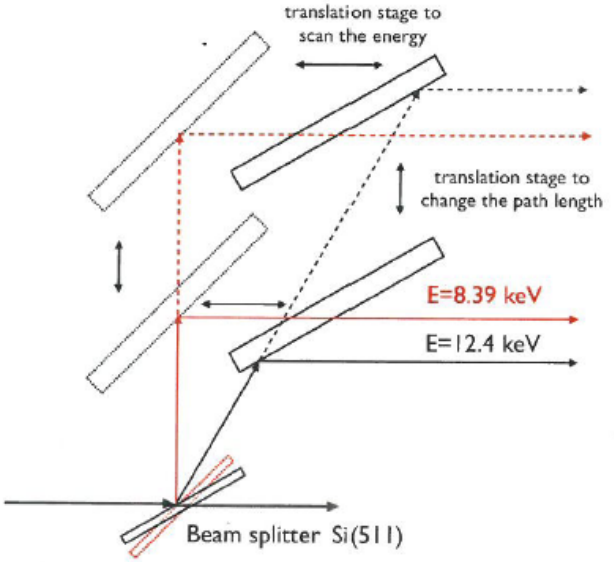
Optical Hutch

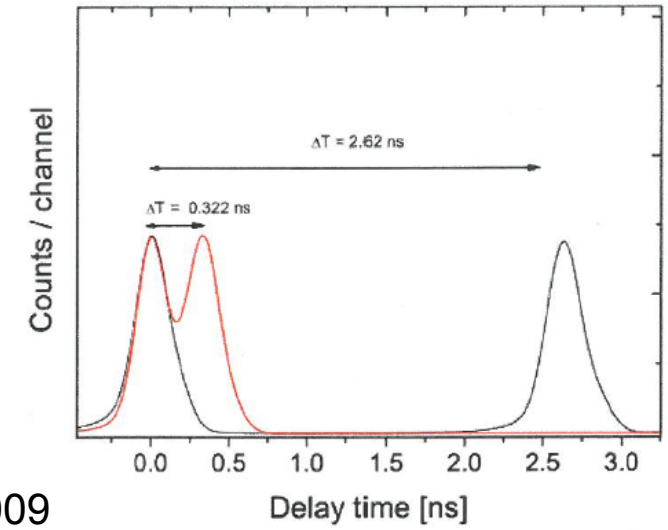




Picosecond X-ray delay for probe-probe experiment

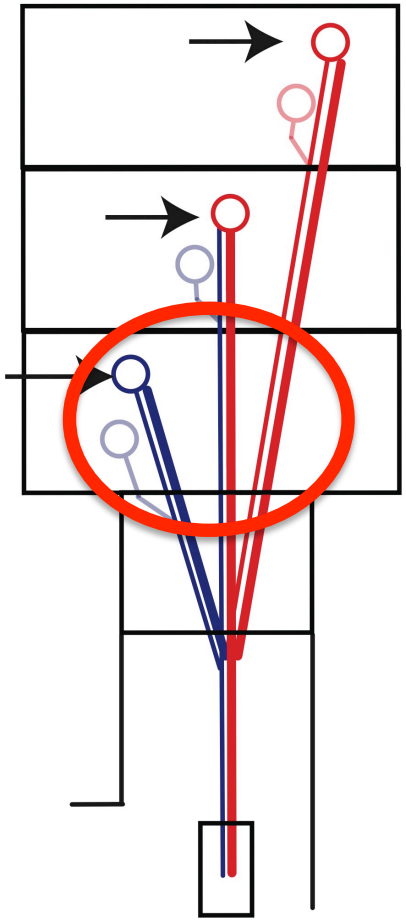


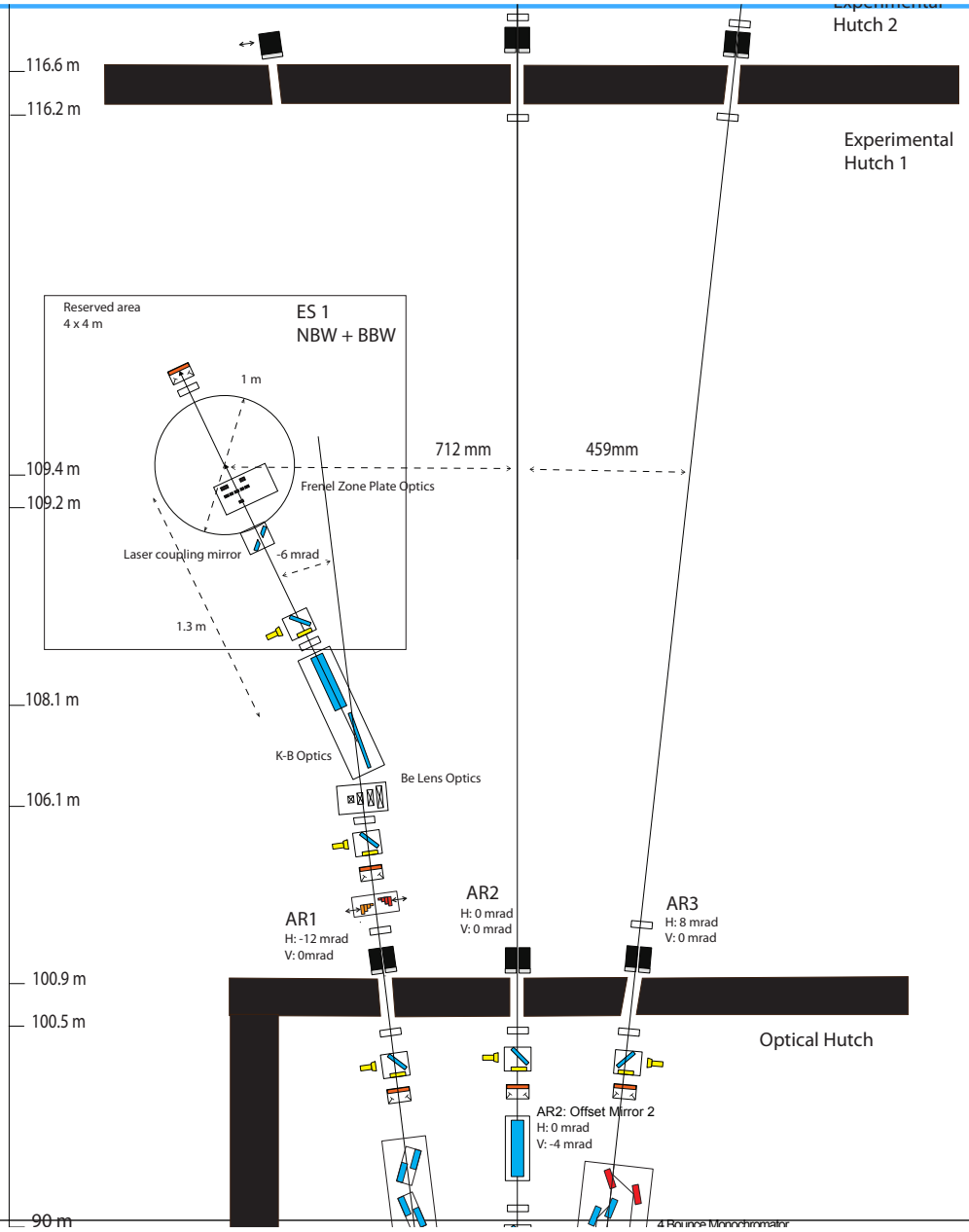




W. Roseker et al. Opticla Letters, 34, 12, 2009

Experimental Hutch 1





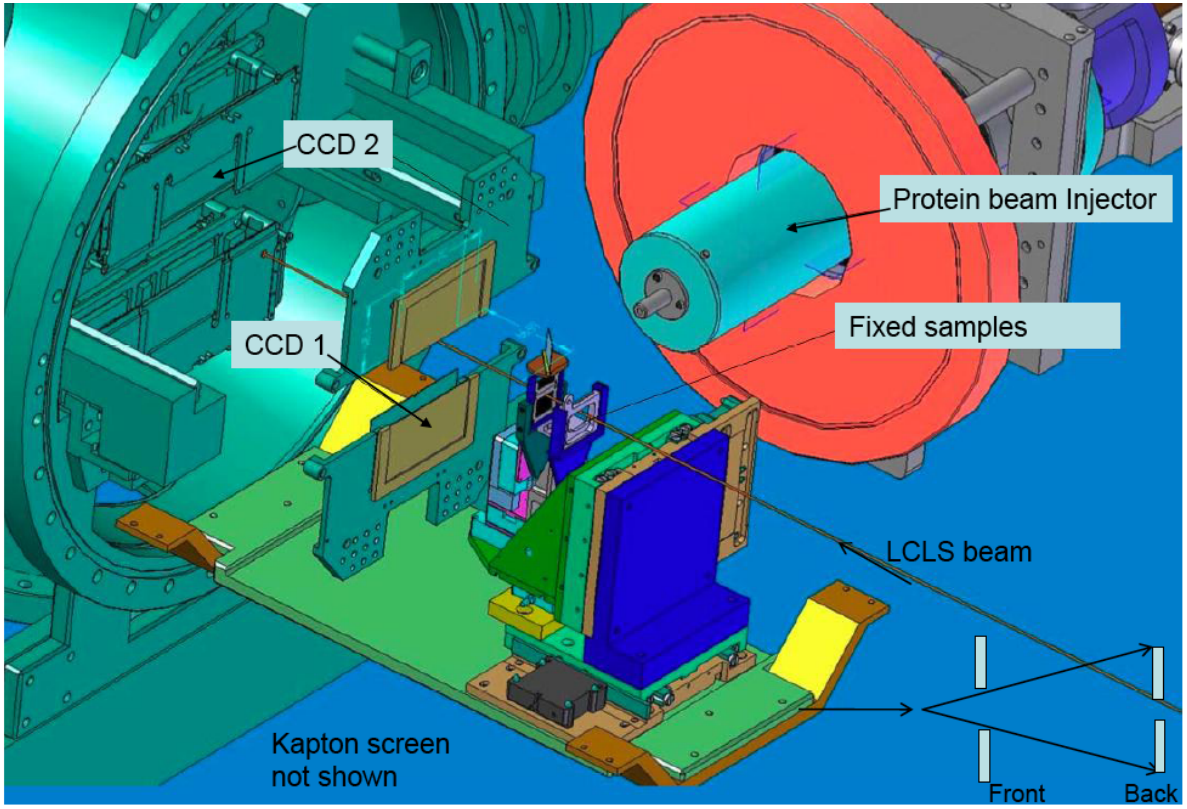
ES-A: Multipurpose pump-probe

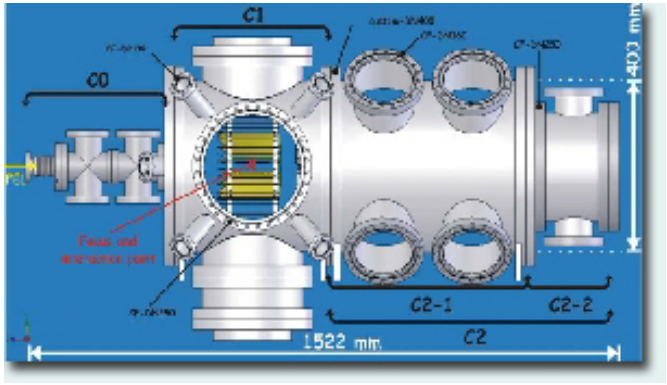
2016

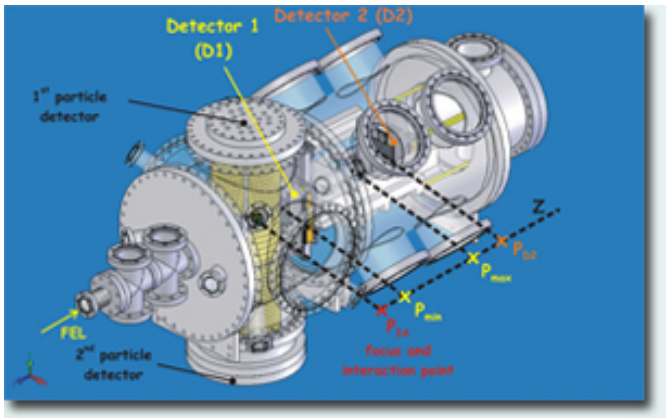
ES-A

- Serial nanocrystallography
- Time-resolved spectroscopy for chemistry
- Time-resolved scattering on molecules in solution

- *e.g.*, "CAMP" chamber at the LCLS

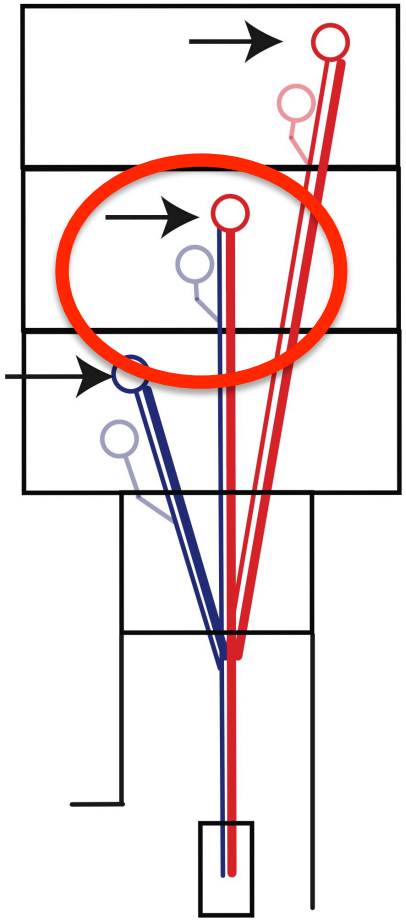


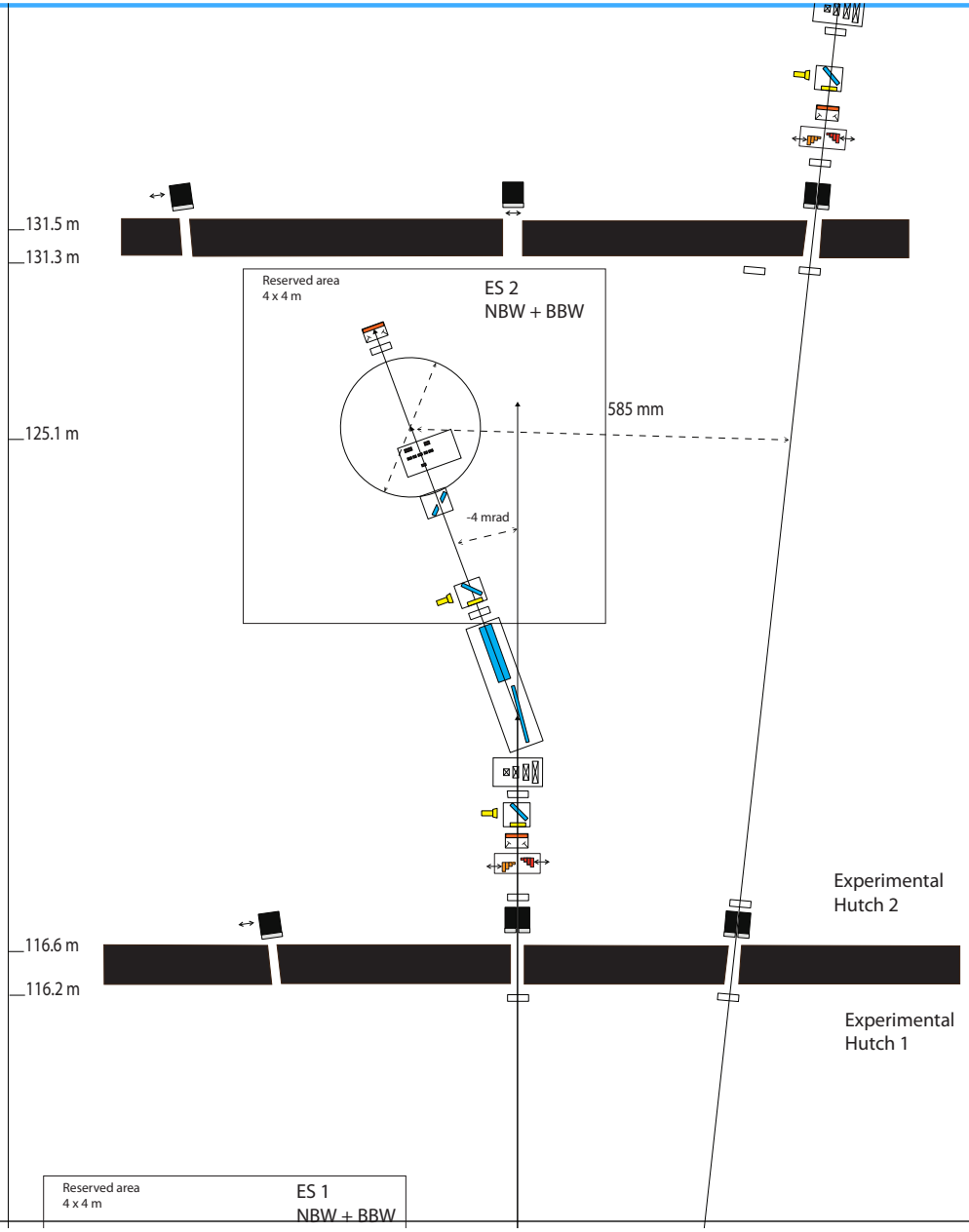




MPI ASG Heidelburg, Munich, DESY (2010)

Experimental Hutch 2





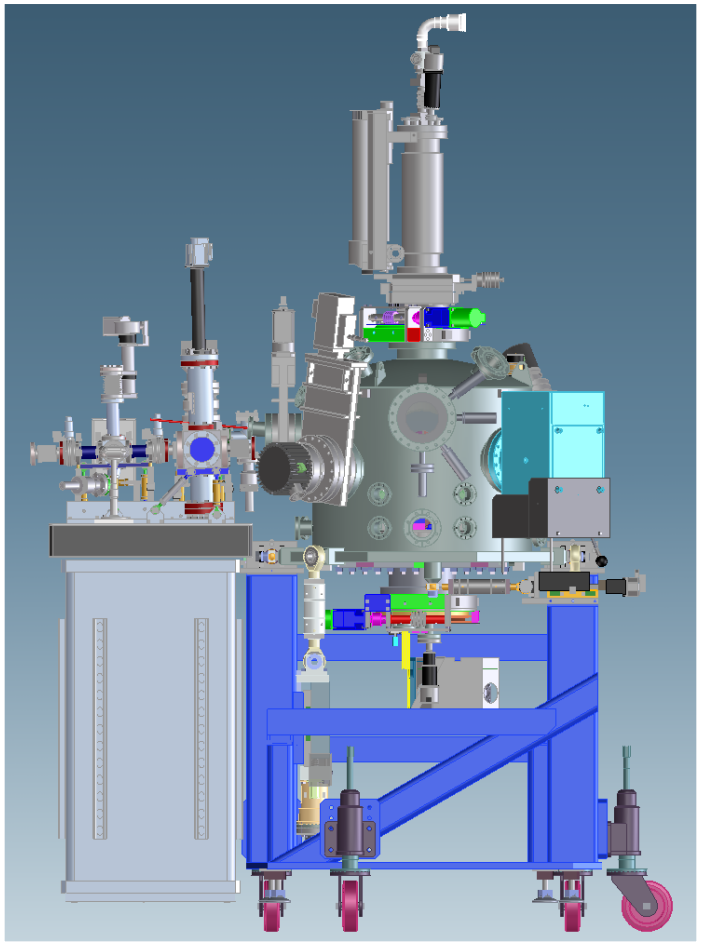
ES-B: pump-probe crystallography

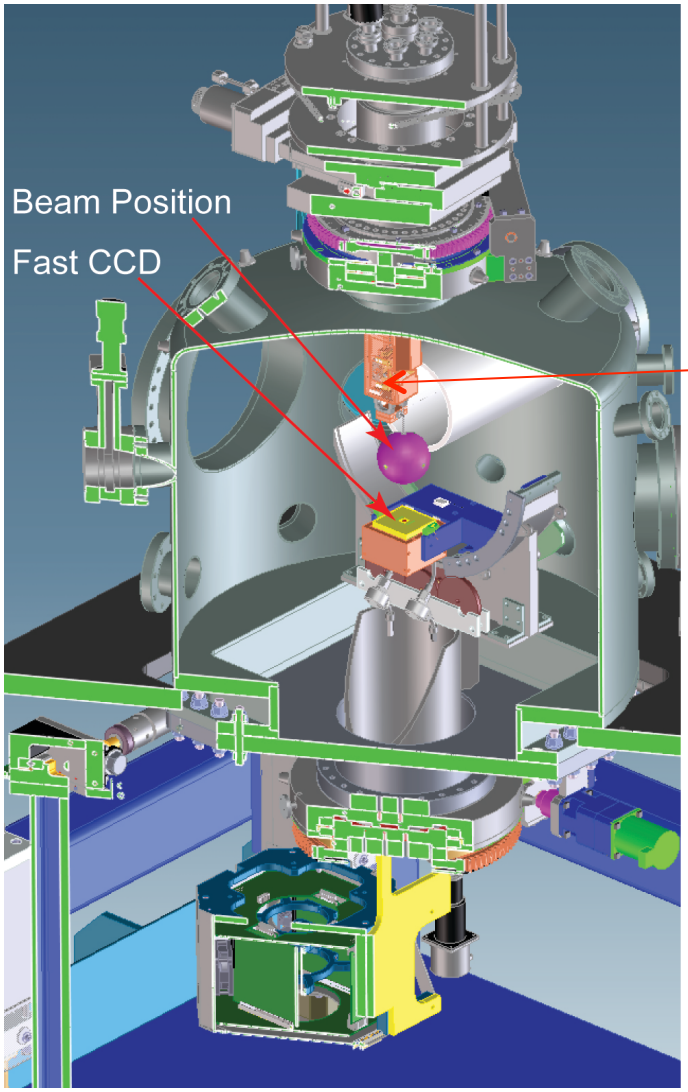
2016

ES-B

Time-resolved diffraction on crystals

- *e.g.*, SXR chamber at the LCLS

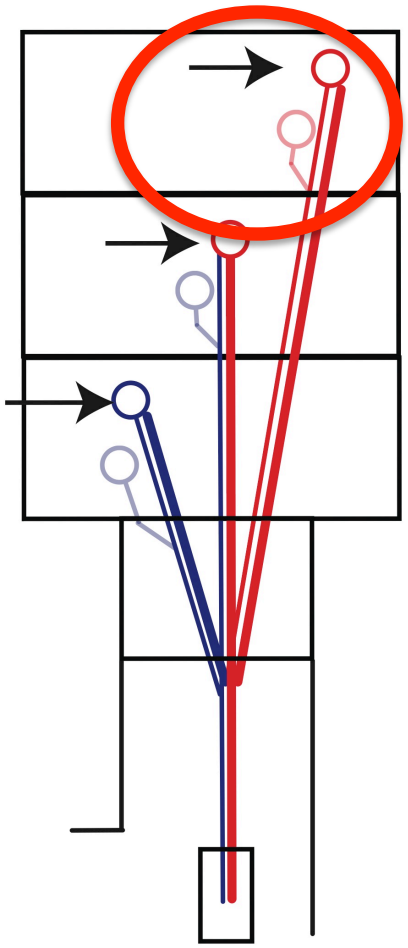


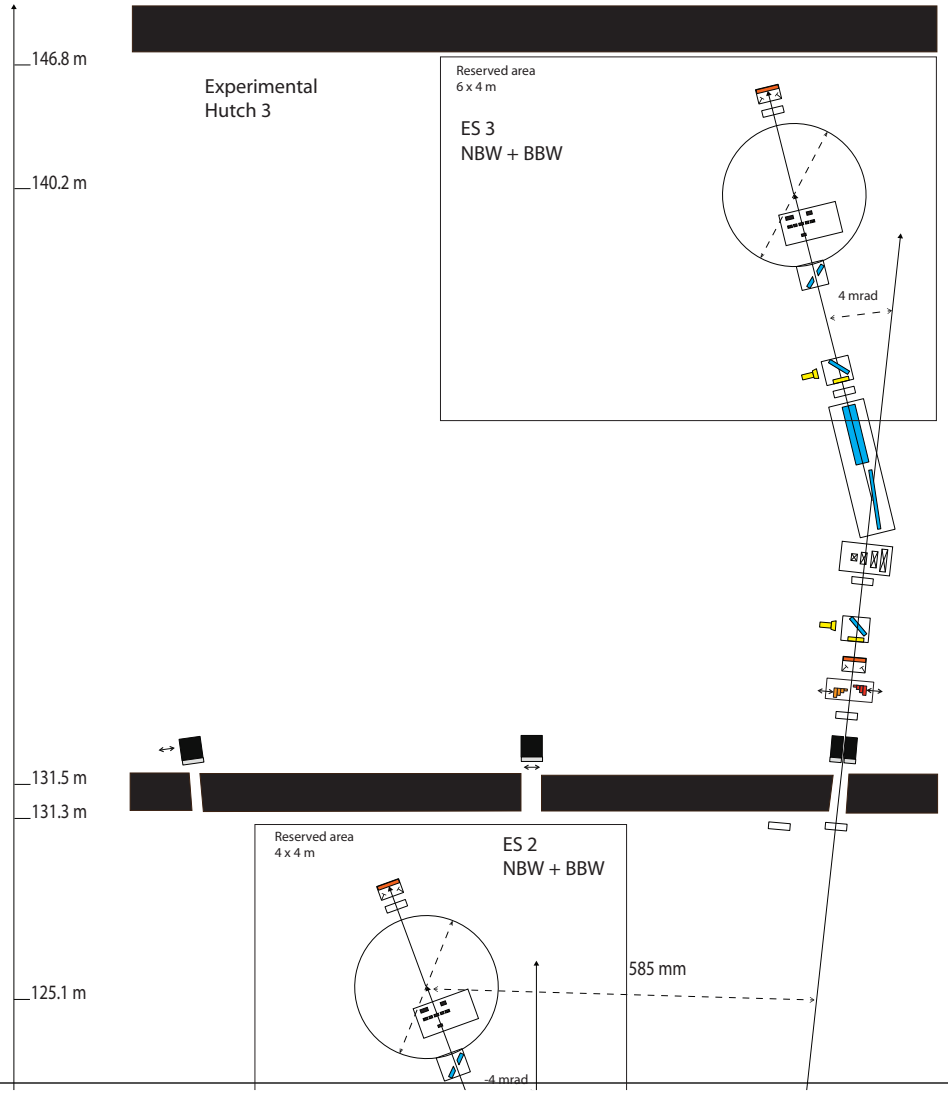


cryo-cooled sample goniometer

Doering, D. *et al. Rev. Sci. Instrum.* **82,** 073303 (2011).

Experimental Hutch 3





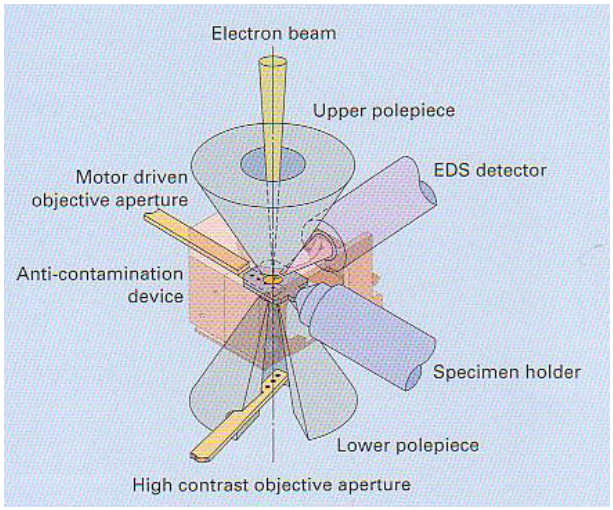
ES-C: cryo X-ray/TEM imaging

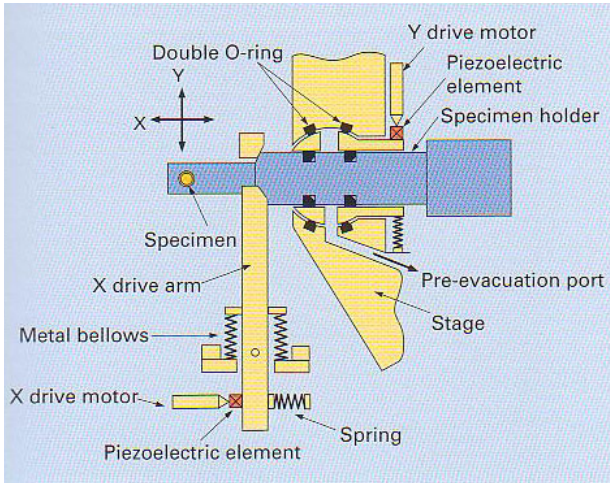
2017

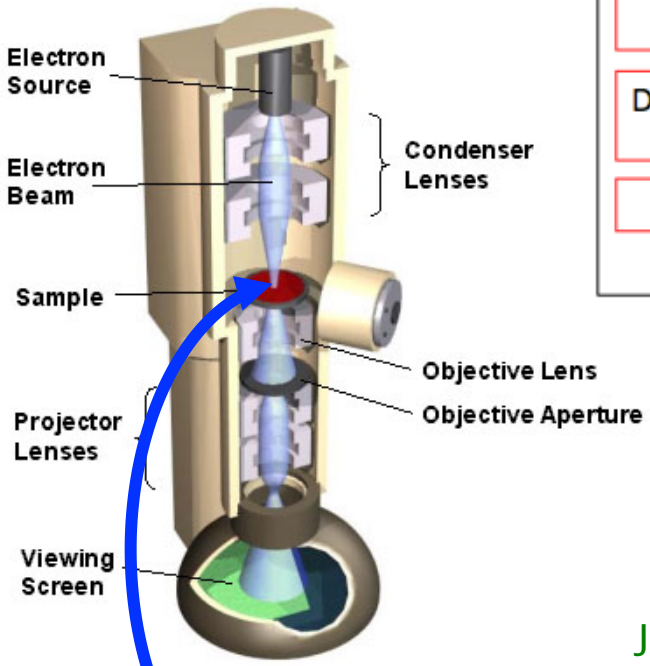
ES-C

- Diffraction on bio-crystals
- Diffraction on 2D membrane protein crystals
- Combined use with TEM

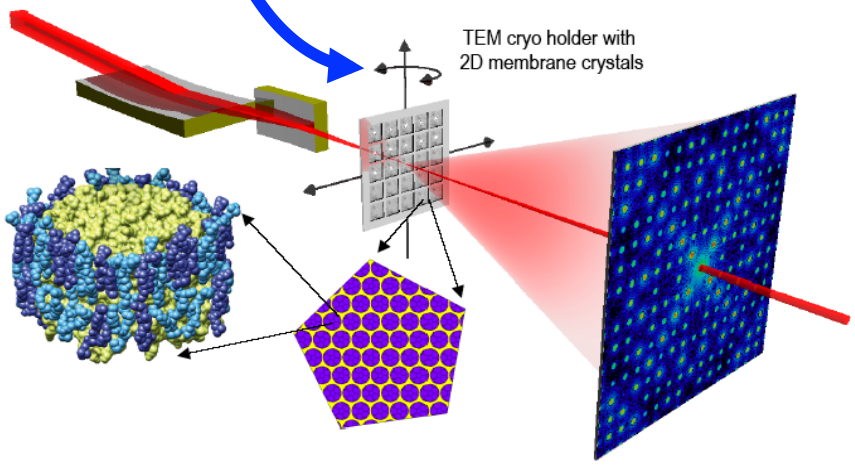
- *e.g.*, tandem XFEL–TEM







JEOL (2011)



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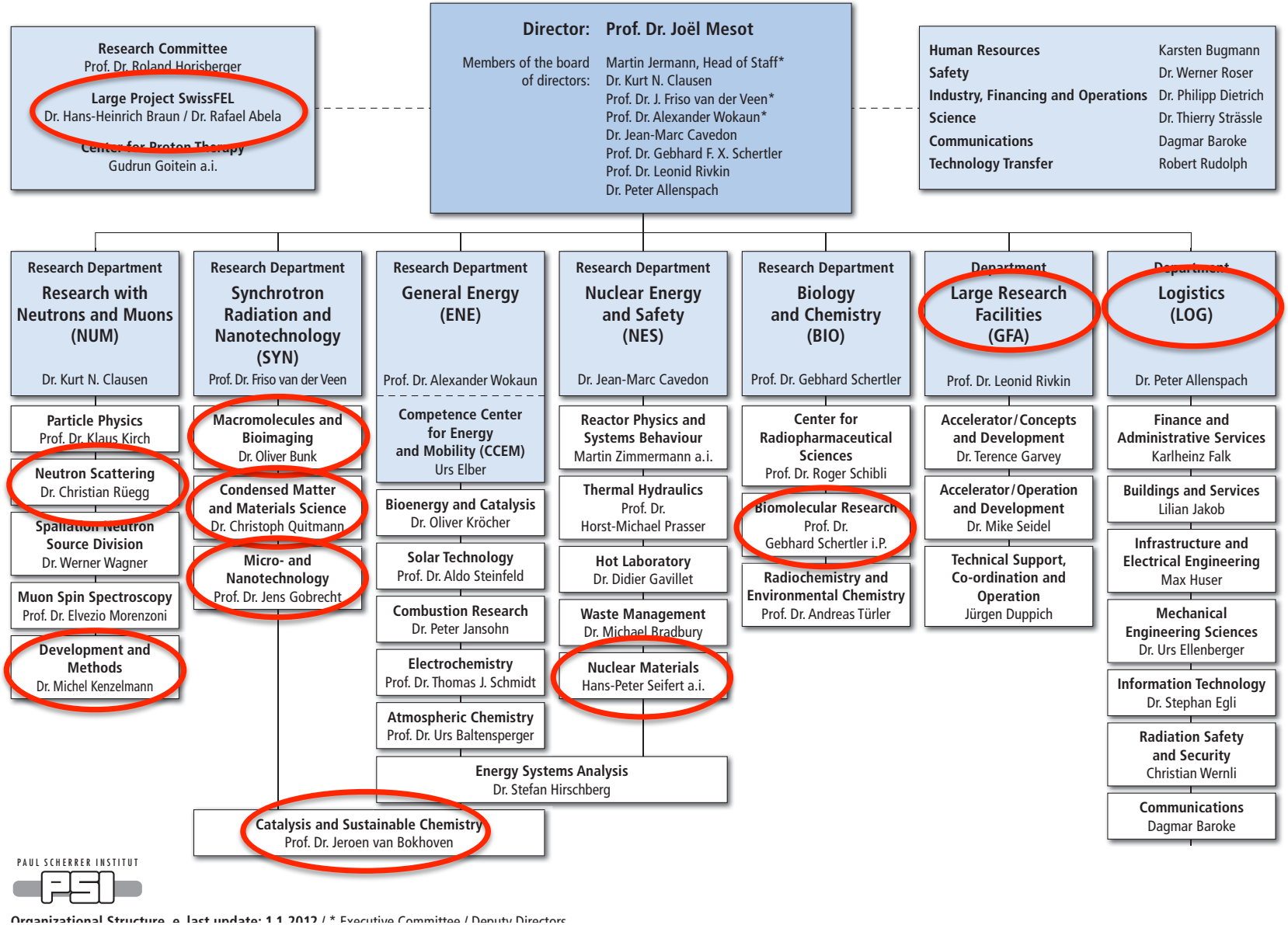
SwissFEL in PSI



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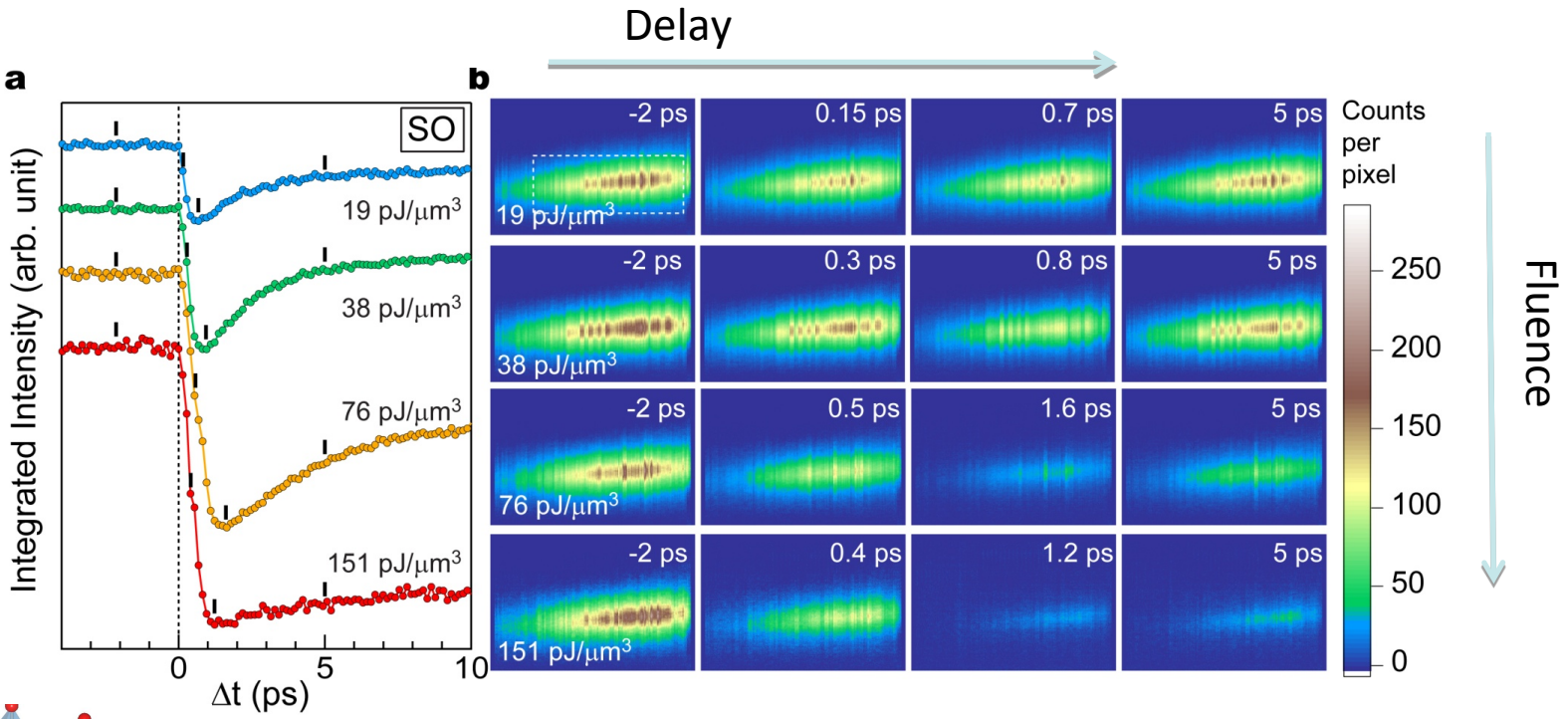
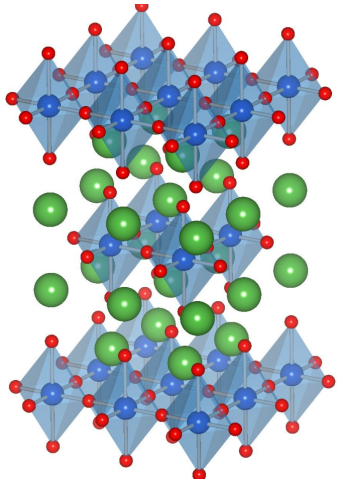
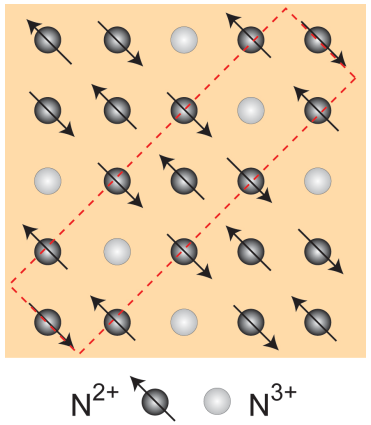
Organizational Structure, e, last update: 1.1.2012 / * Executive Committee / Deputy Directors

Femtosecond resonant soft x-ray scattering experiment
Stripe state of $La_{2-x}Sr_xNiO_4$

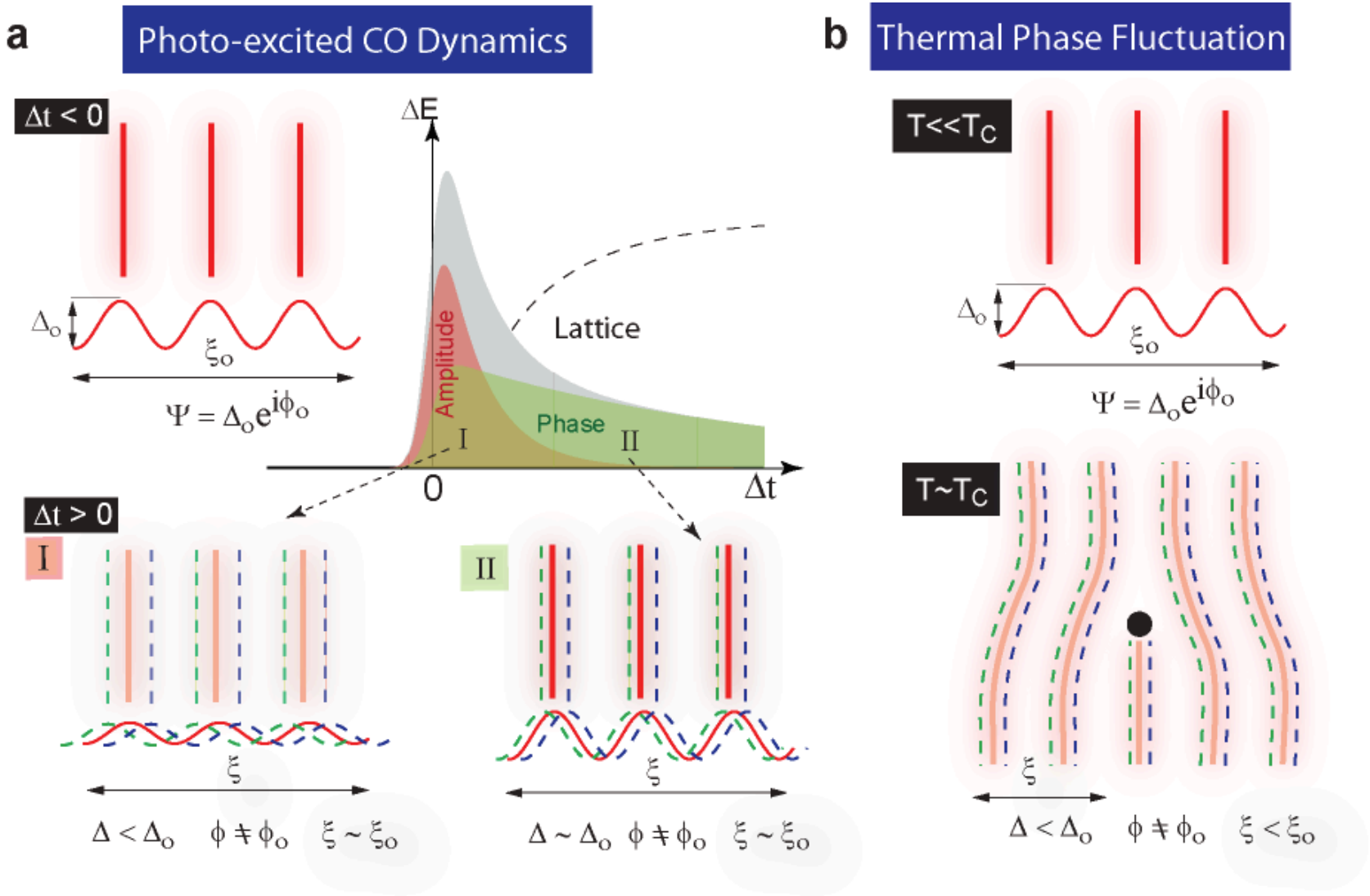




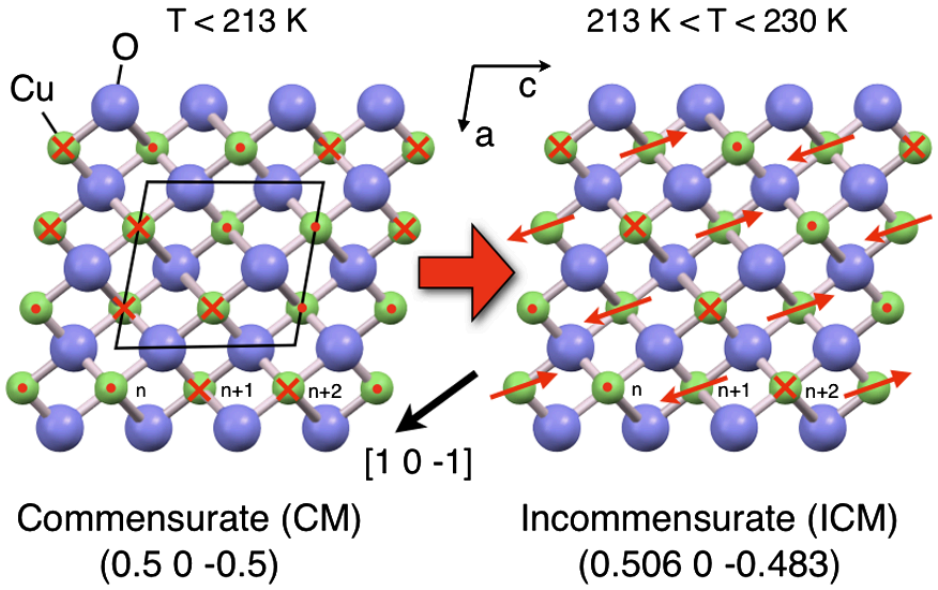


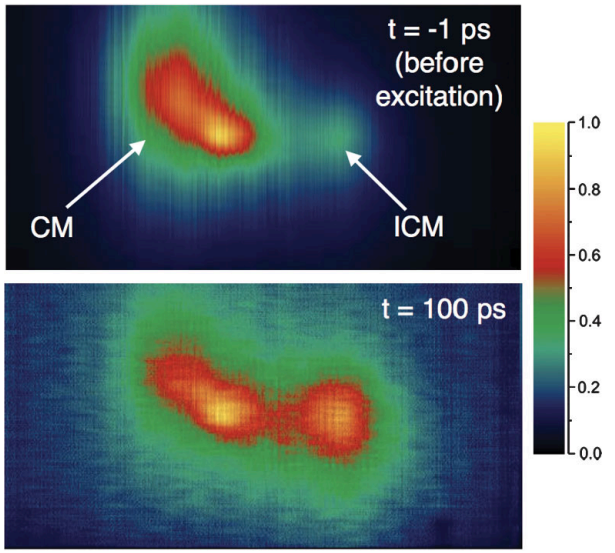
RXS Experiments in the SXR- Station at LCLS (Stanford)
(Collaboration: Stanford, SLAC, ALS, PSI,...)

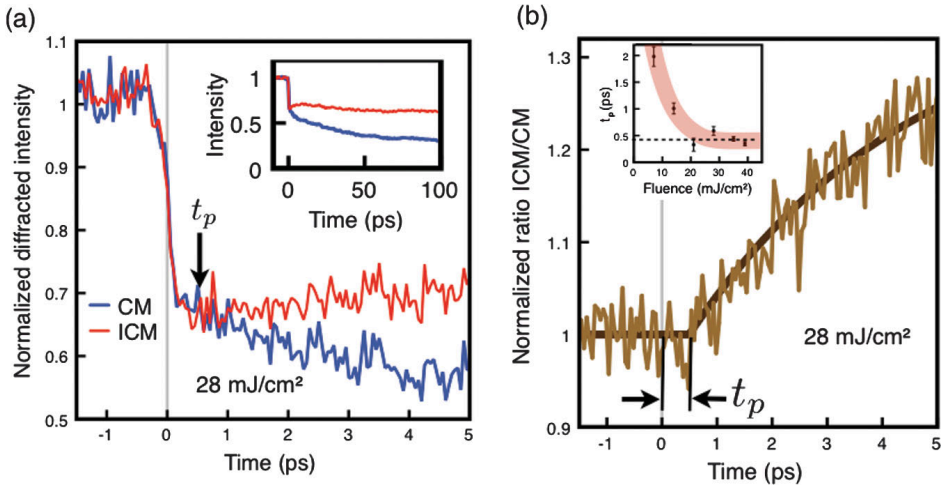
CO order parameter dynamics

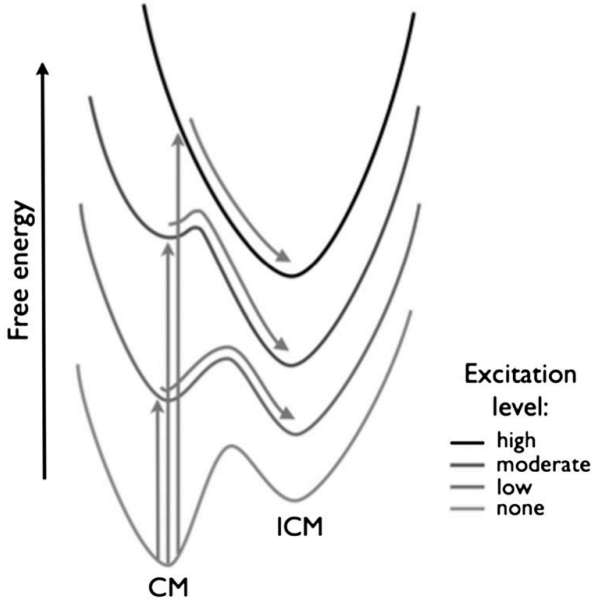


Femtosecond Dynamics of the Collinear-to-Spiral Antiferromagnetic Phase Transition in CuO









S. L. Johnson, et al. PRL (2012)

ESA: Challenges

- **Beam optics**
  - which hutch?
  - monochromator? Wavelength scanning?
  - Focus size? Wavefront quality?
- **diagnostics**
  - intensity (10^-3 ?)
  - pump-probe interval – as close to experiment as possible
  - position, focus, central wavelength (not single shot)
- **liquid jet**
  - aerodynamic focusing; problem of jet evaporation, leading to salt crystallization
  - thin (2 mu), continuous stream
  - recapture material?
  - Detect (synchronize?) sub-mu crystals in beam (SONICC?)
  - Time-vernier mode
- **near and far 2D detectors**
  - AGIP?
  - Size, position; minimize central hole
  - Long-wavelength limit?
  - DAQ, storage, processing

ESA: Challenges

- **limited cryogenic (77K) goniometer and translation stages**
  - thermal contact, LN2 consumption
  - degrees of freedom, movement speed and accuracy
  - sample mounting and exchange philosophy
- **single-shot spectrometer: XAS**
  - resolution, geometry, detector
  - dispersive detection for transmission through jet and fixed sample
  - normalization – statistics; reference for sample out / no pump
- **single-shot spectrometer: XES**
  - resolution, geometry, detector
  - normalization, reference
- **pump laser**
  - which wavelengths, which priority?
  - Variable attenuator; intensity measurement
  - Local laser optics
  - Pump-probe delay – range, accuracy, speed, DAQ
- **add-ons**
  - compact microwave cell (EMPA Thun) ?
  - ion TOF?
  - ...

ESB: Challenges

- **Beam optics**
  - which hutch?
  - monochromator? Wavelength scanning?
  - Focus size?
- **diagnostics**
  - intensity (10^-3 ?)
  - pump-probe interval – as close to experiment as possible
  - position, focus, central wavelength (not single shot)
- **LHe cryostat**
  - Which technology? He return line?
  - Thermal contact, thermometry, Tmin
- **goniometer**
  - which motions (including detector)
  - sampe mounting / exchange
- **near and far 2D detectors**
  - AGIP?
  - Size, position; minimize central hole
  - Long-wavelength limit?
  - DAQ, storage, processing

ESB: Challenges

- **pump laser**
  - which wavelengths, which priority?
  - Variable attenuator; intensity measurement
  - Local laser optics
  - Pump-probe delay – range, accuracy, speed, DAQ
- **add-ons**
  - high T, B, E?
  - ...

ESC: Challenges

- **Beam optics**
  - Maximum flux
  - Sub-mu focus (KB, CRL, zone plates?)
- **diagnostics**
  - intensity (10^-3 ?)
  - illumination function
  - coherence
- **LN2 cryo-stage, cryo-transfer**
  - Thermal contact
  - Sample mounting / exchange / scanning
  - Sample transfer from SLS, TEM (adapt OMNY?)
- **In-situ microscopy**
  - SEM
  - Geometry
  - Measurement philosophy
  - Detection of 2D membrane protein crystals
- **Sample holder**
  - TEM grid – watch Cu grid lines
  - Pre-positioned samples in matrix vs. pre-measurement mapping
- add-ons
  - pump laser?
  - ...

PAUL SCHERRER INSTITUT

ARAMIS Instumentation Workshops

13. March 2012: Endstation ESA, R. Abela

27. March 2012: Endstation ESB, L. Patthey

24. April 2012: Endstation ESC, B. Pedrini

28. May 2012: Others, B. Patterson

19. June 2012: DAQ/scientific computing

Collaboration

Diffraction Optics: Hans Hertz (SU), Ch. David (PSI)

Instrumentation (end-station)
-Long list of Challenges for ESA,B,C from Bruce
-crazy ideas (think out of the box)
-catcher system (injector alignment), plasma emission, spectrofluorimeter, iToF, eTOF, native mass spectrometer
-Fast chopper, for hybride mode at SLS, Magnetic bottle: Raimund Feifel

ARAMIS (3 end-stations) and others

ATHOS, green field!

Spectroscopy
-FELCO Multi-particle correlation Spectro. (spike free spectra), THz pump-probe DCH: Raimund Feifel
-RIXS, XES: alternative spectrometer, 1-D imaging spectrometer, hv2 with BBW (flux issue: may be may be not)
-Solid sample: large sample, scan sample, PLD thin film samples
-Electron spectroscopy, ToF with spin detector (space charge issue: may be may be not)