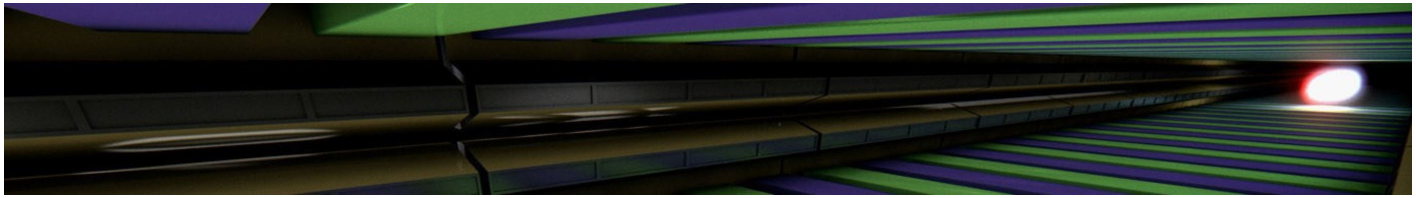


The Split and Delay Line (SDL) for MID

W. Lu[1, 2], T. Noll[1], T. Roth[2], M. Holler[3], I. Agapov[2], G. Geloni[2], J. Hallmann[2], G. Ansaldi[2], H. Xu[2], A. Madsen[2] and S. Eisebitt[1]

[1]Technische Universität Berlin

[2] European XFEL GmbH

[3]Paul Scherrer Institute

Bundesministerium für Bildung und Forschung

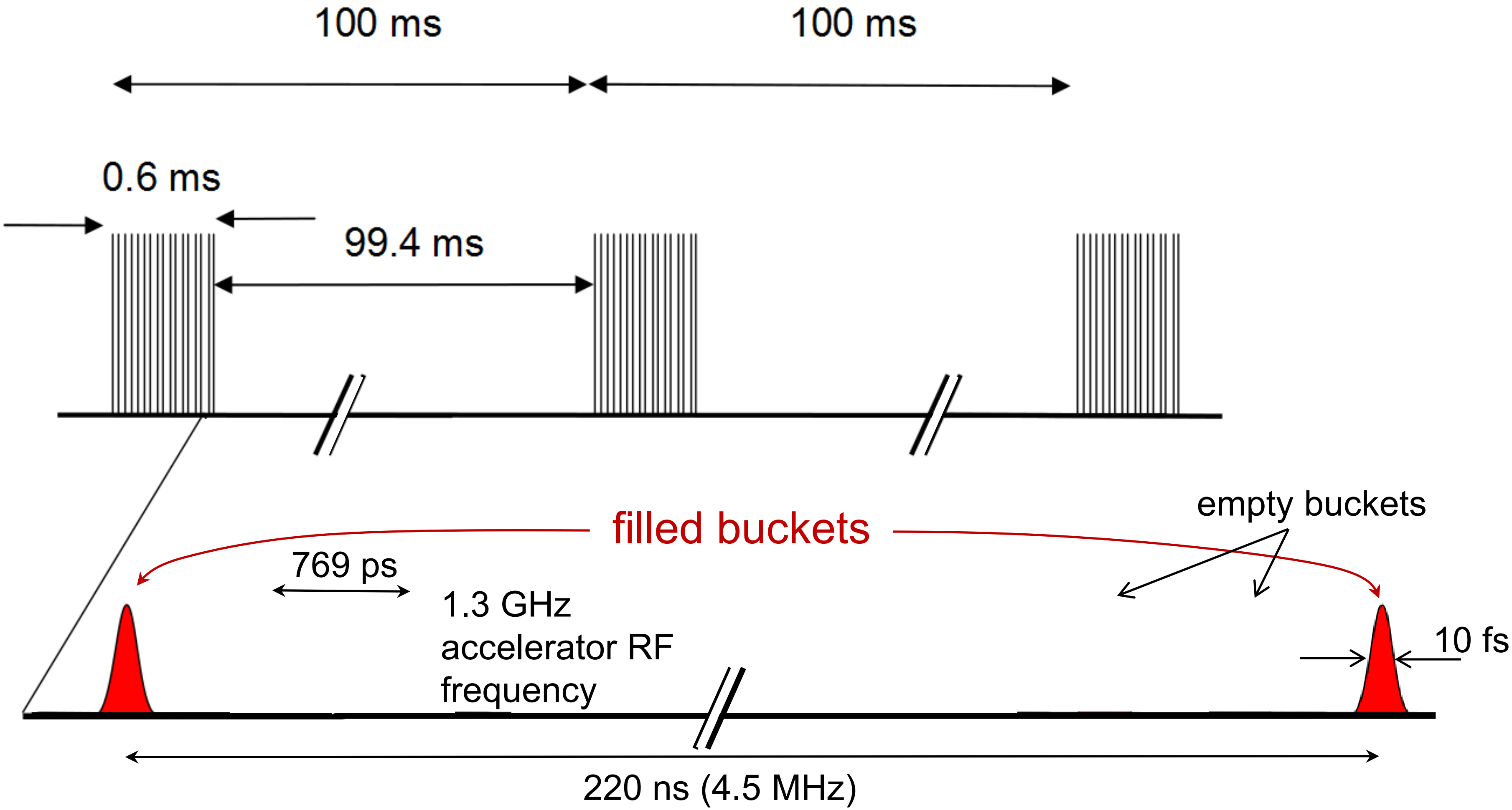
FSP-302

Supported by the BMBF in the "Forschungsschwerpunkt 302: Freie Elektronen Laser“.

Outline

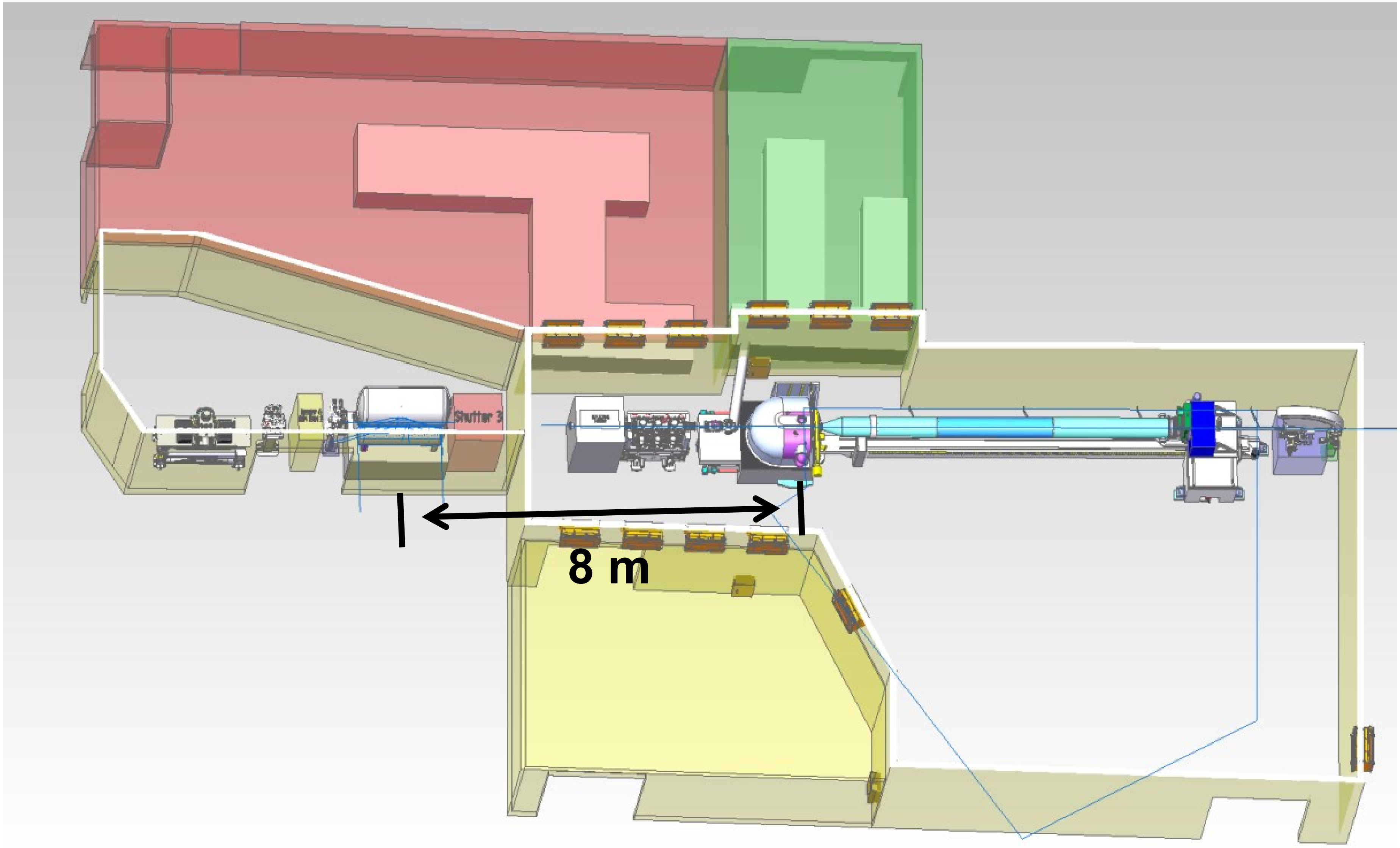
- Overview of the project
- Technical requirements for SDL
- Current status of SDL
  - Mechanical design
  - Crystal Cage Prototype
  - Laser Interferometer
  - In-vacuum Test-stand
  - Open Issues
- Simulation works on SDL

Standard time structure of European XFEL:



Aim of the SDL: to enable X-ray pump-probe experiments, XPCS and other fast scattering experiments with Δt < 800 ps

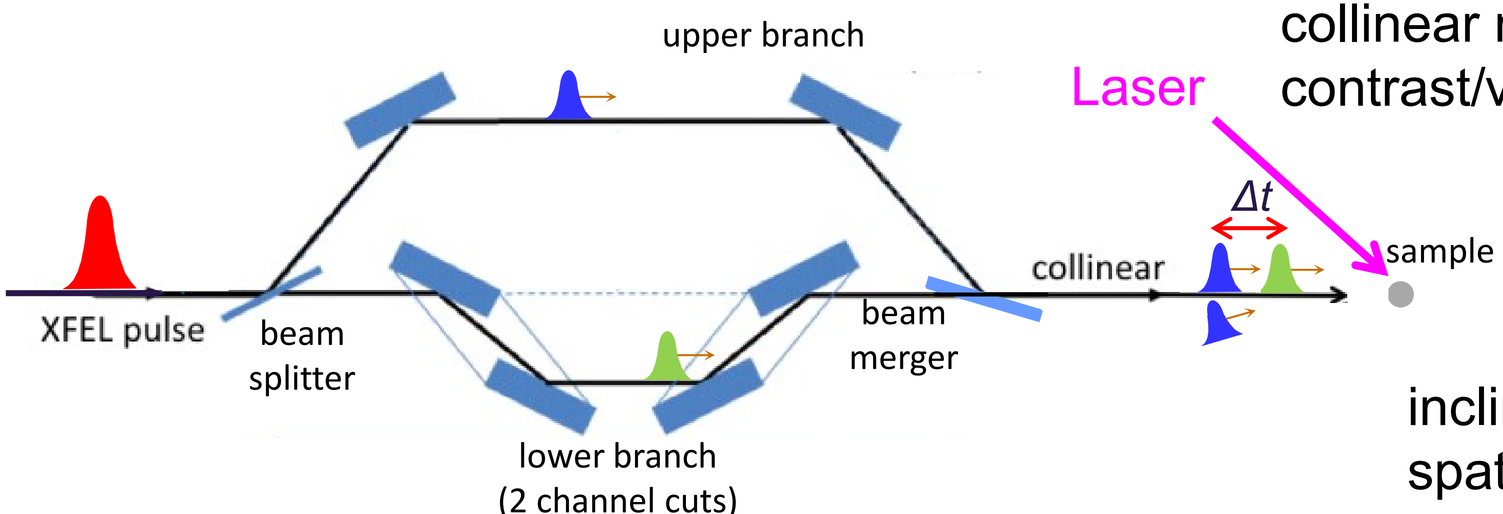
Schematic view of MID in exp. hall



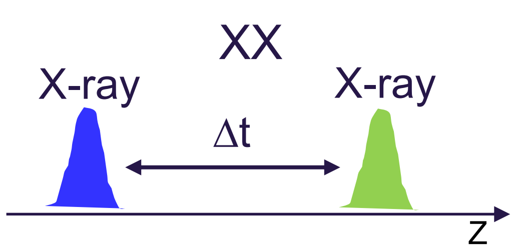
Concept of the Split and Delay Line (SDL)

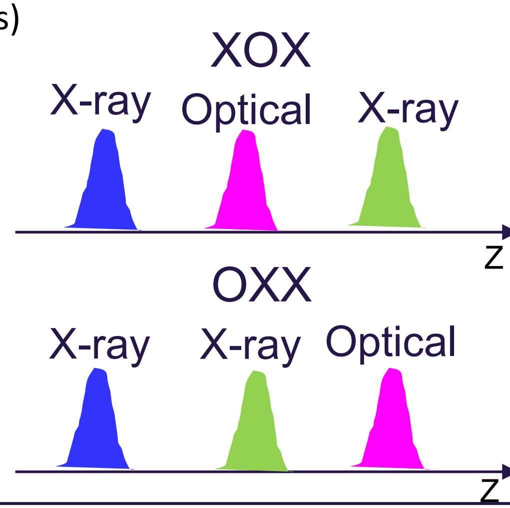
The delay is achieved by detour in the upper branch

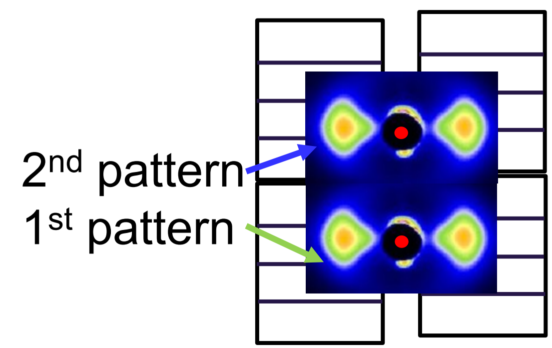
collinear mode:
contrast/visibility changes



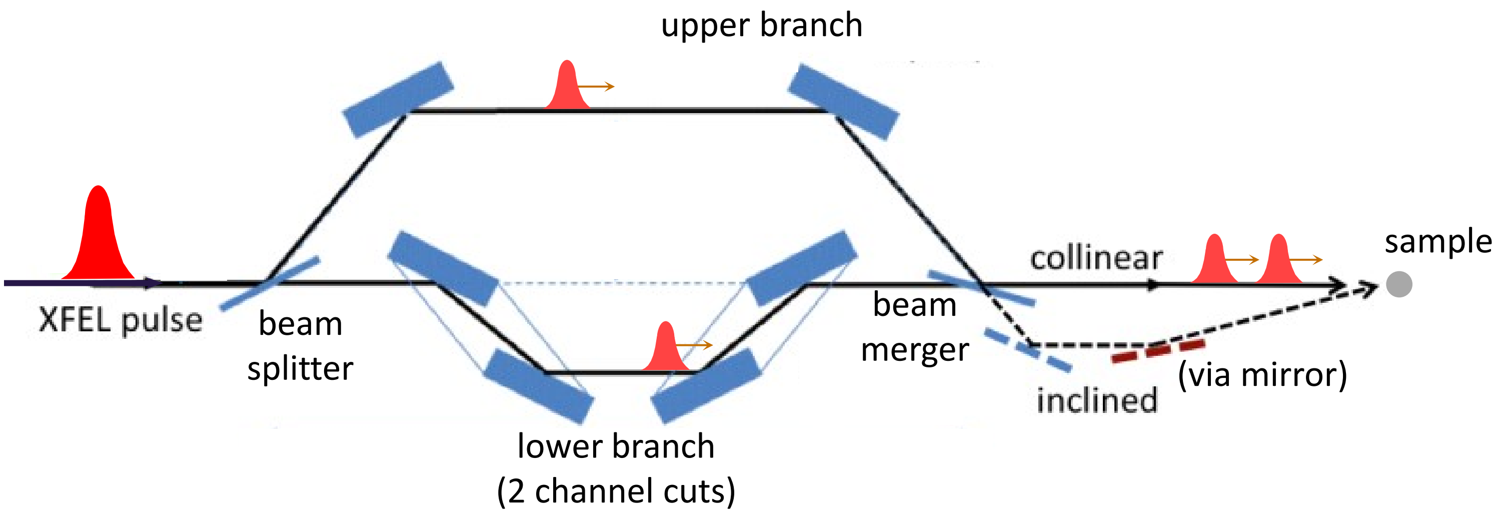
inclined mode:
spatial separation







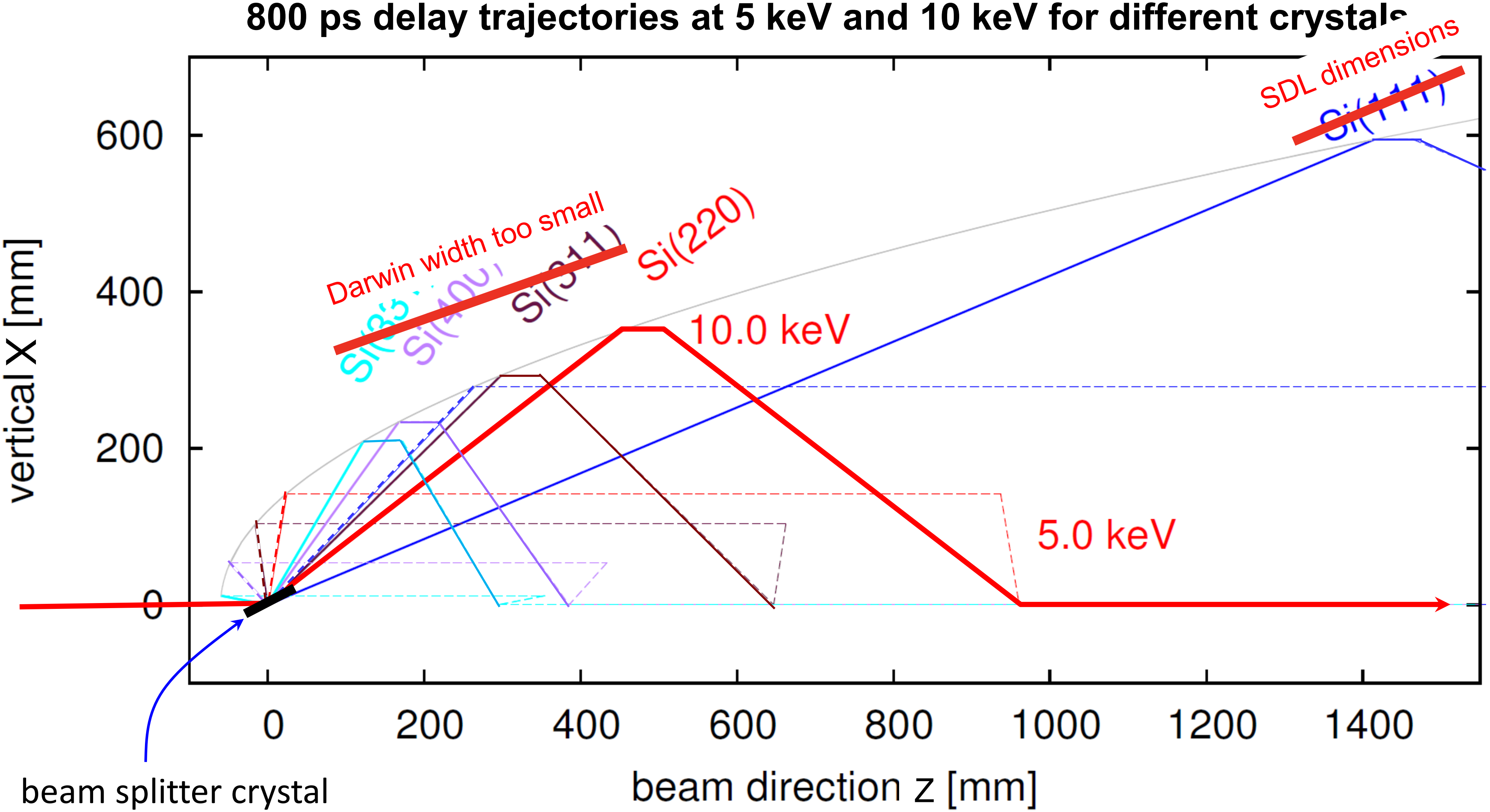
Technical Requirements



Energy *E*	**5 -10 keV**
Delay *Δt*	**-10 to 800 ps**
Maximum length L_{max}	**≈ 2m**
Energy bandwidth *dE/E*	**< 1E-4**

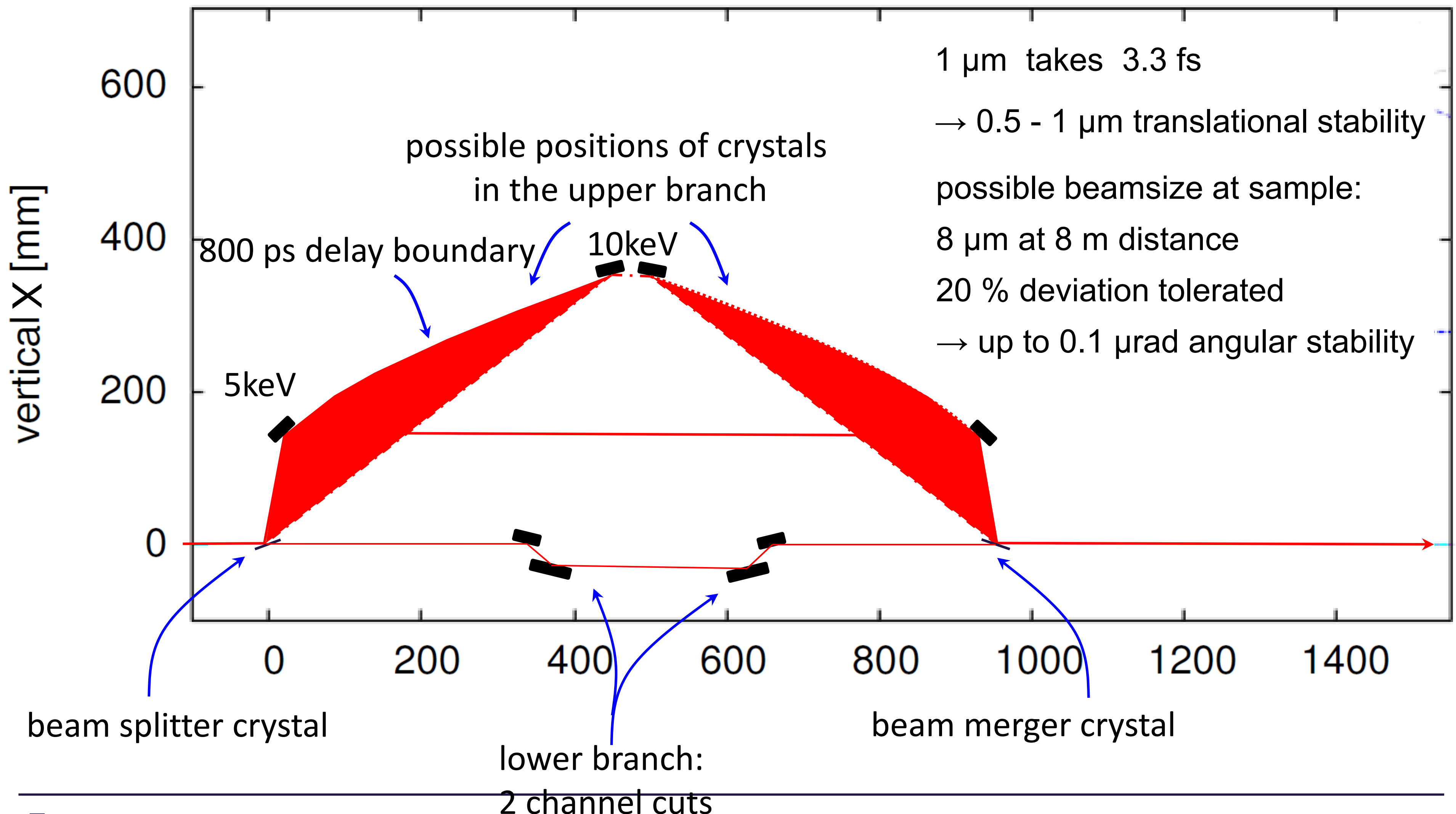
Technical Requirements

800 ps delay trajectories at 5 keV and 10 keV for different crystals



Technical Requirements

Geometry of SDL with Si (220) crystal



1 µm takes 3.3 fs

→ 0.5 - 1 µm translational stability

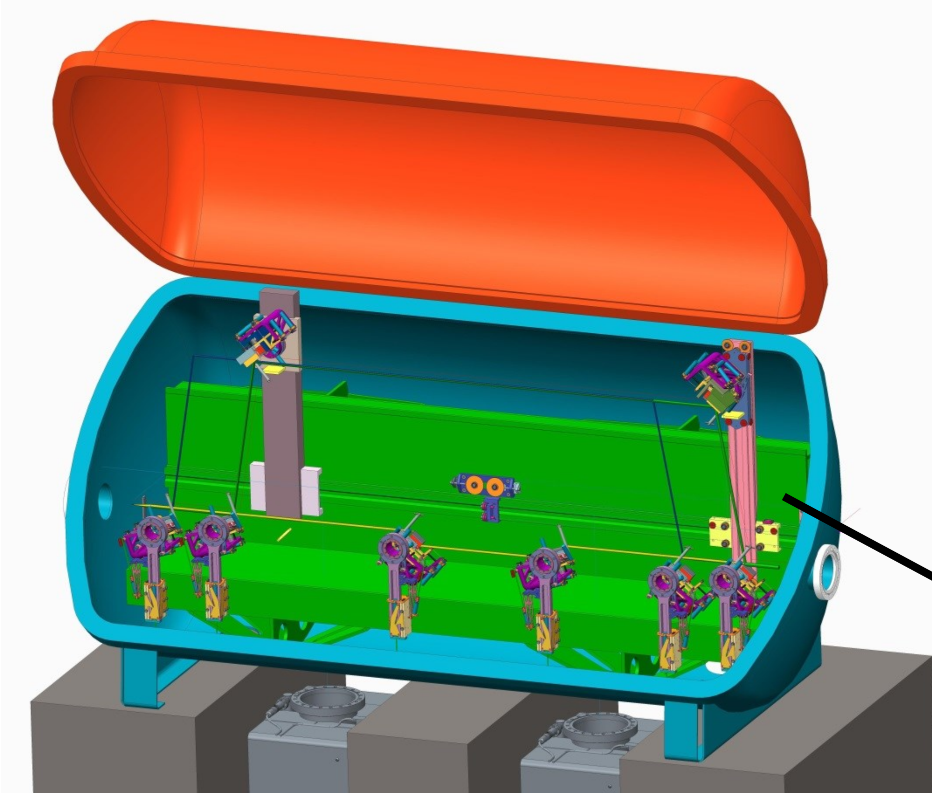
possible beamsize at sample:

8 µm at 8 m distance

20 % deviation tolerated

→ up to 0.1 µrad angular stability

Motion concept of upper branch

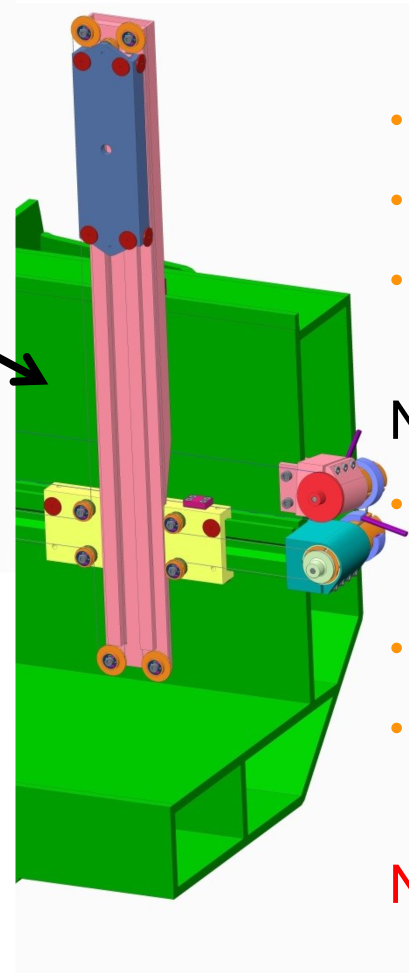


Parasitic tilts are more than ±250 μrad (measurment range)

>>

Required alignment accuracy:
0.1 μrad in Pitch angle (vertical)
0.2 μrad in Roll angle (horizontal)

Tilt sensor



Cable Drive Slider

Advantage:

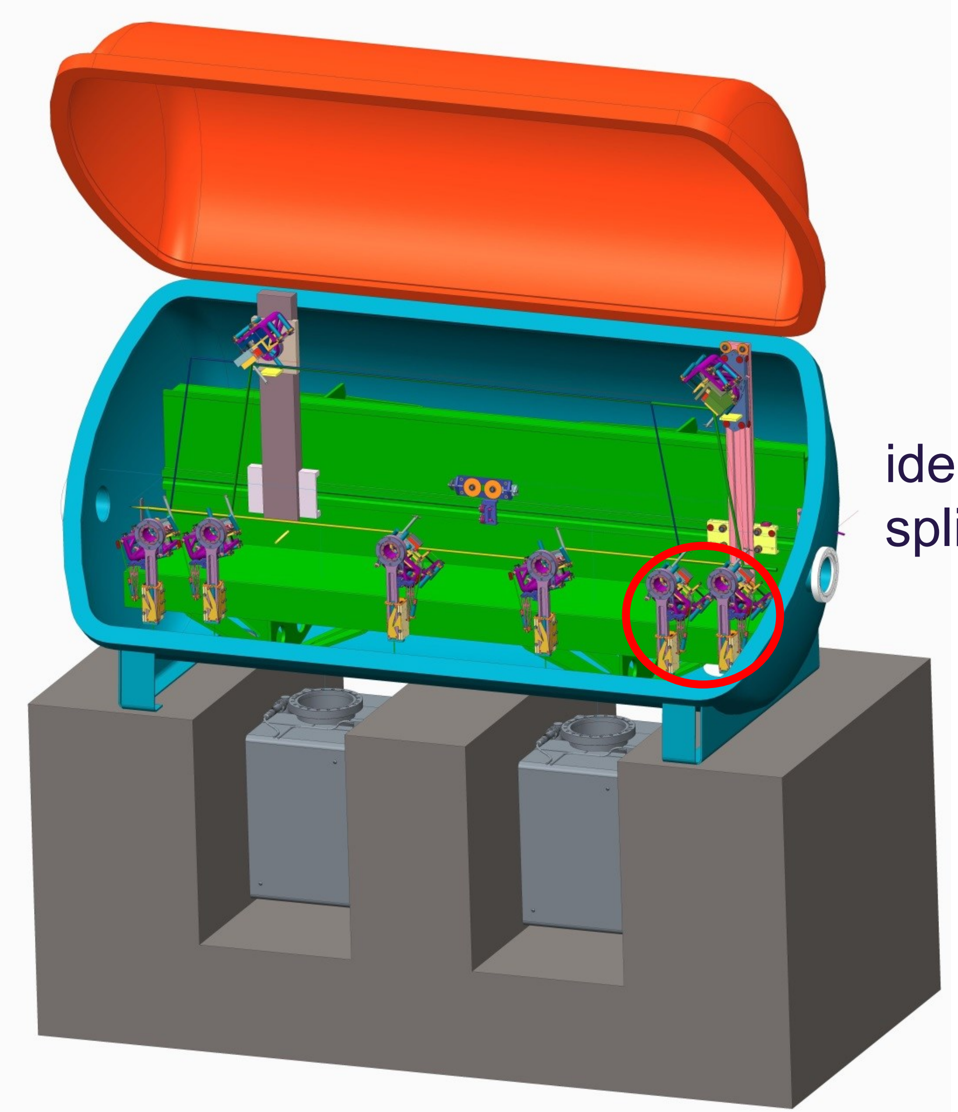
- Long distance translation
- UHV compatible
- Low heat load
- Easy to cool fixed motors

Need to be clarified:

- Accuracy and Repeatability
- Durability of cable
- …

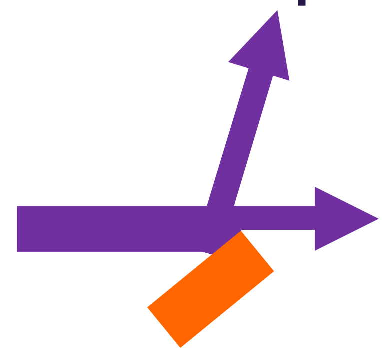
Not the final decision!

Beam Splitter



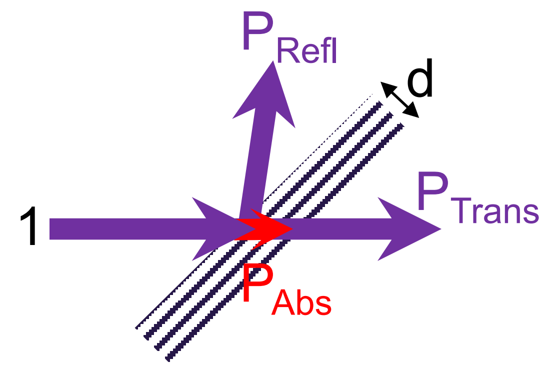
ideally 1:1 splitting

Geometrical Splitting



Thick Si(220) crystal

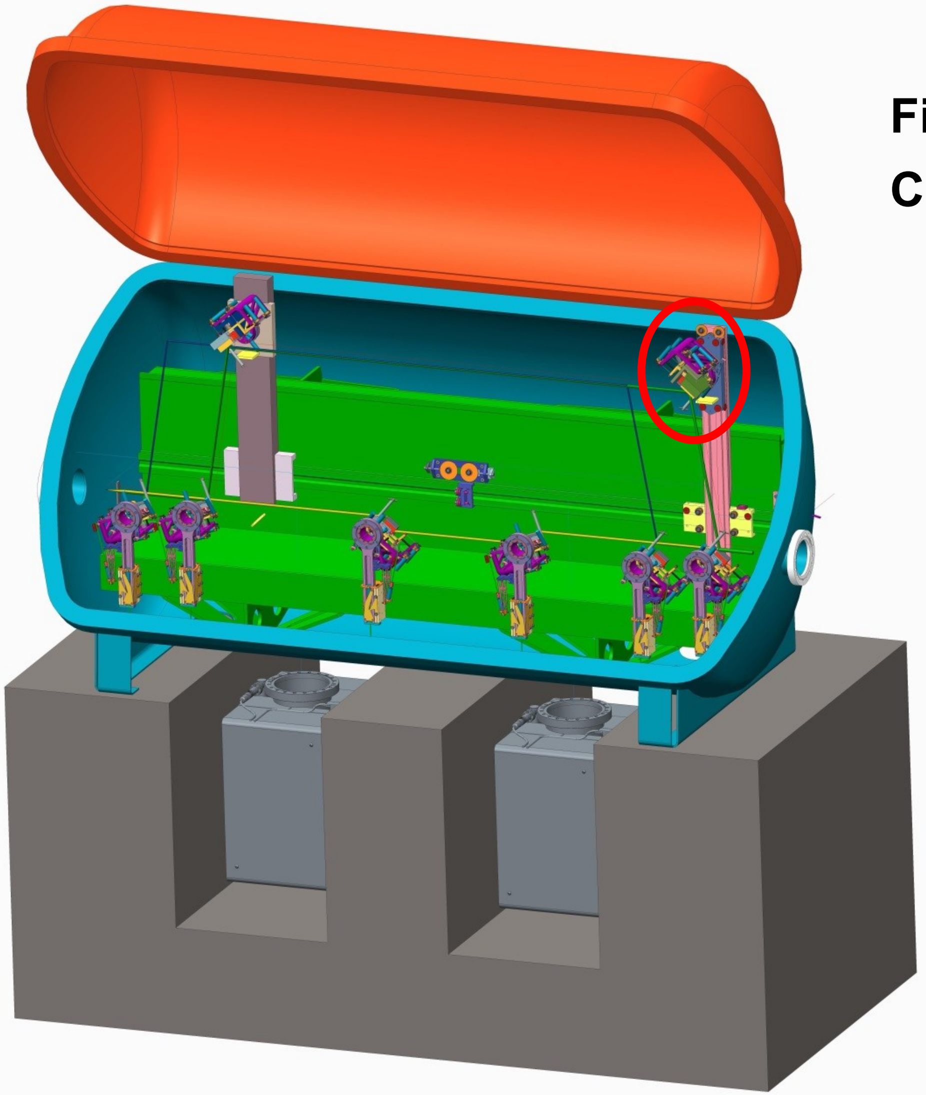
Optical Splitting



on Bragg condition

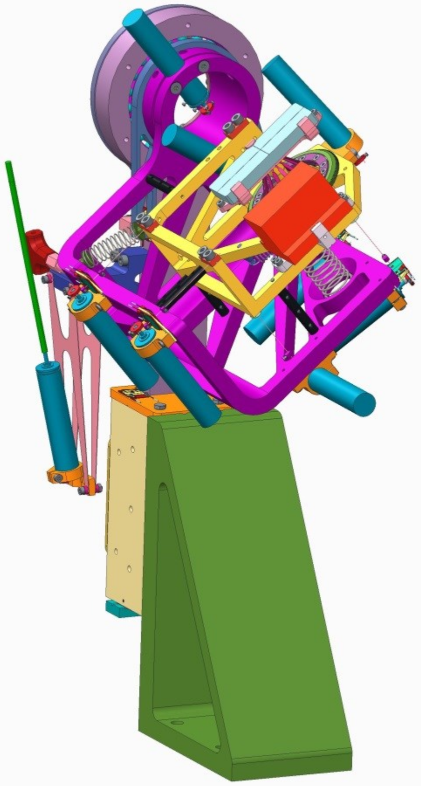
Thin Si(220) crystal
(a few micro)

Upper Branch crystal cage



Fine alignment

Compensate parasitic motion

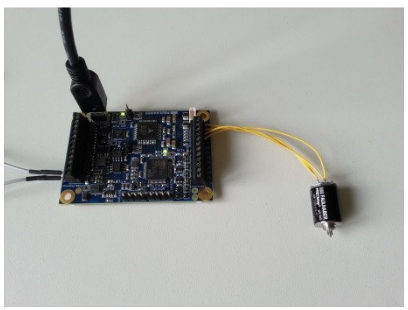


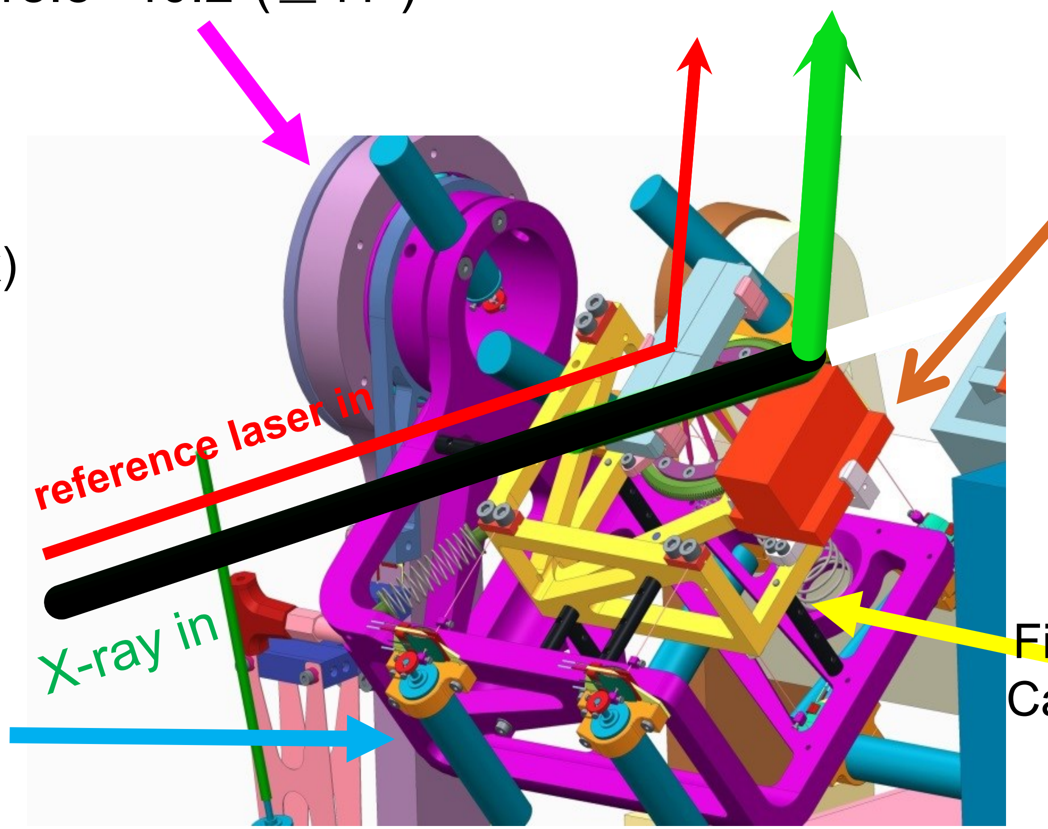
Crystal Cage Prototype

Coarse Bragg
Alignment Cage
18.8º-40.2º(±11º)

Retro-reflectors for
laser interferometer
Work for ±11º ?

Low cost tiny
UHV Compatible
Stepper Motors
2 nm at one full step
(with 154k:1 gear box)



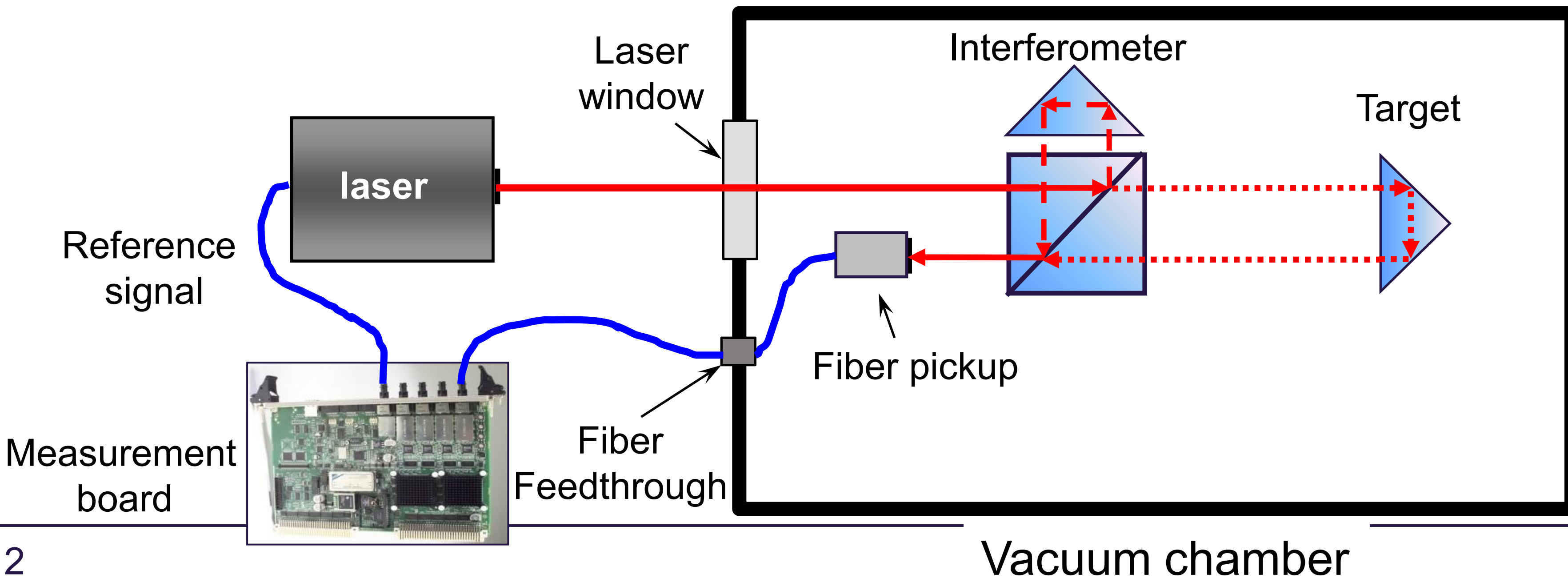


Fine alignment stage
Can be adjusted in μº

Laser interferometer from:

SIOS, Renshaw, Agilent, Zygo, Attocube, Smaract

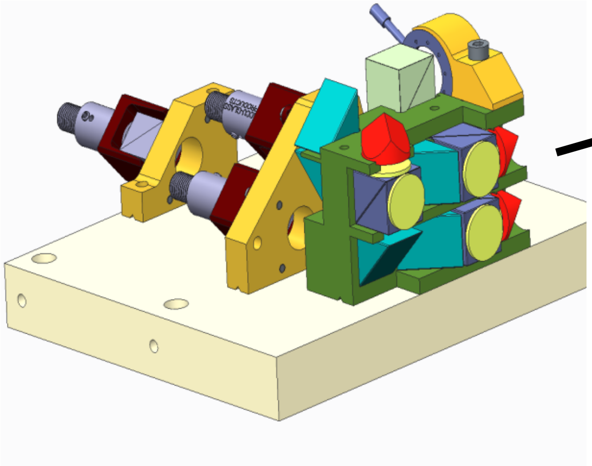
The Zygo system provides linear resolution of 0.3 nm and 8 measurement channels. The interference signal can be guided by fiber to the measurement electronic.

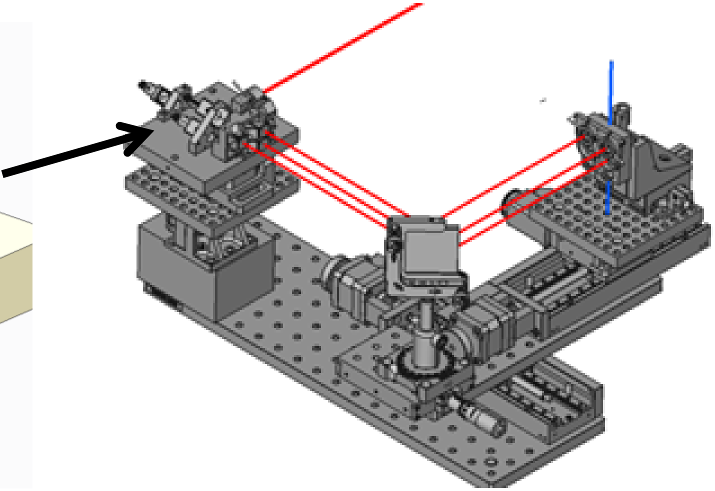


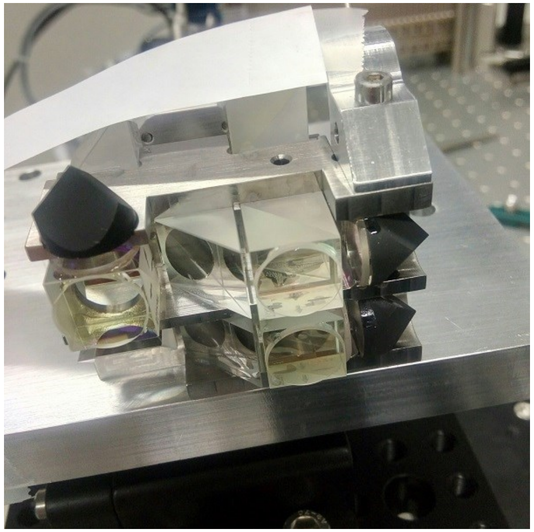
Laser Interferometer

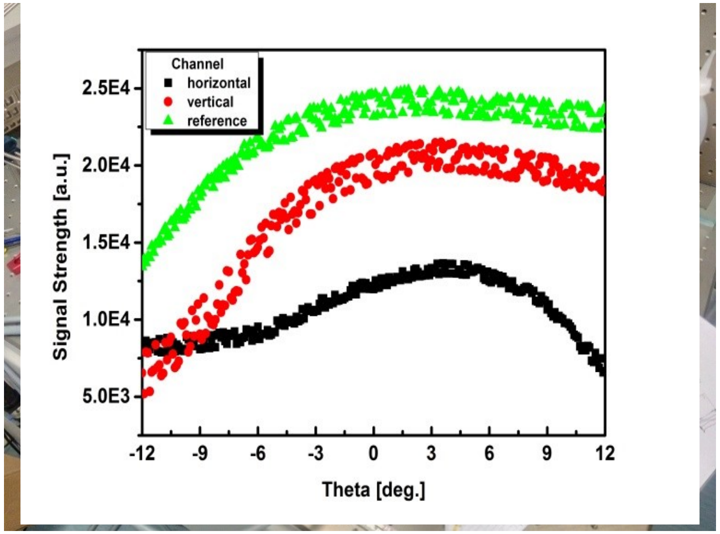
3-axes interferometer

Test-stand for the interferometer



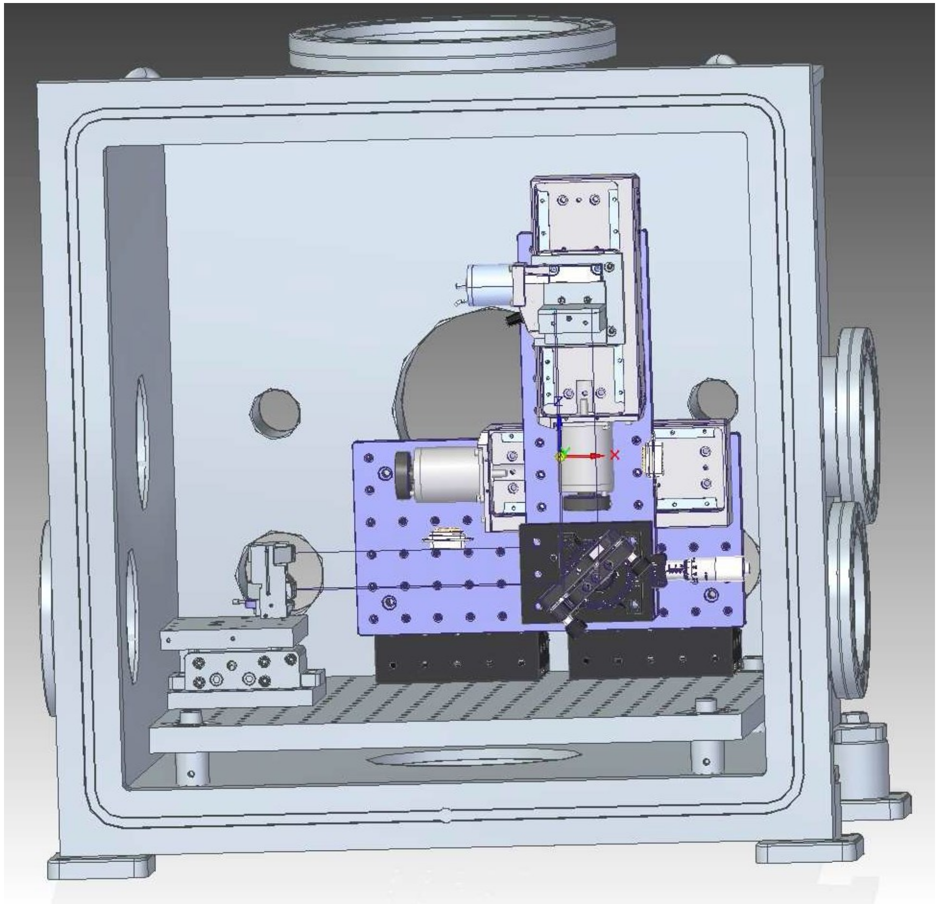






In-vacuum test-stand

In-vacuum test for the crystal cage and laser interferometer



- 0.5 Meter Cube
- Acrylglas Glass door
- 10E-6 mBar Environment
- Two linear translation stages
- One rotation stage
- Optical windows and viewpoints
- Electronic and fiber feedthroughs

Open Issues

- Optical splitter, thin Si(220) crystal

  Provider? Osaka University?
- Channel-Cut Design
- X-ray Diagnostics system

  Retractable intensity monitors

  Transparent detectors
- Temperature stabilization system (0.1K stability)

  Temperature of the vessel

  Evacuate heat from the motors

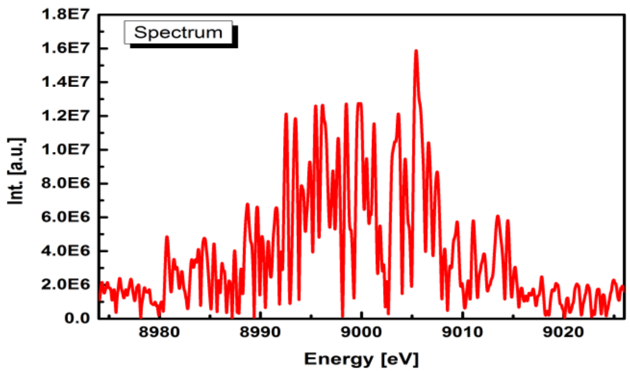
  Cool crystals if necessary
- Controlling system

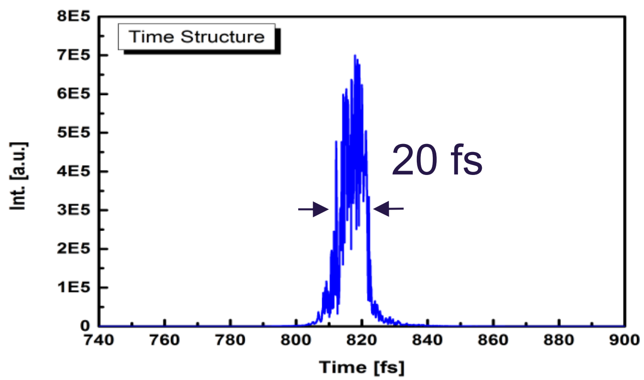
  Coordinated activities (e.g. change Bragg angle for all crystals, change delay)

  Control loop for fine adjustment of crystal cages
- …

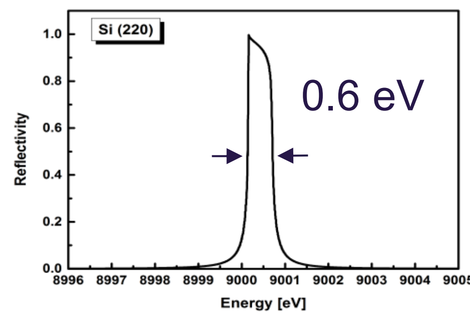
SDL, Simulations on the optical splitting scheme

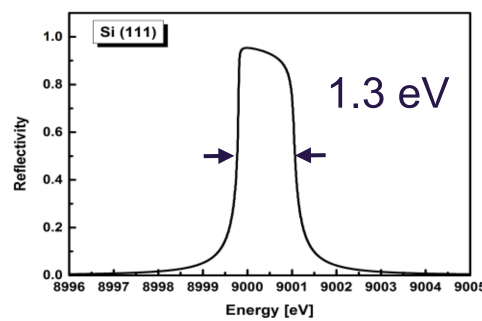
Input SASE pulse
9 keV, 20 fs



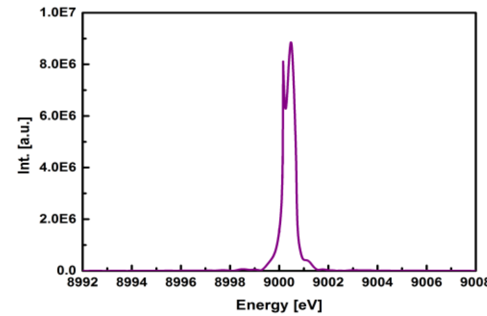


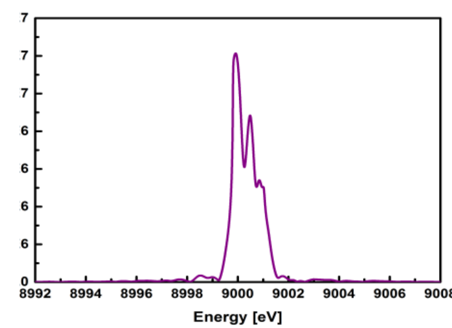
Pre-mono
Si(111) or (220)





Filtered input
spectrum



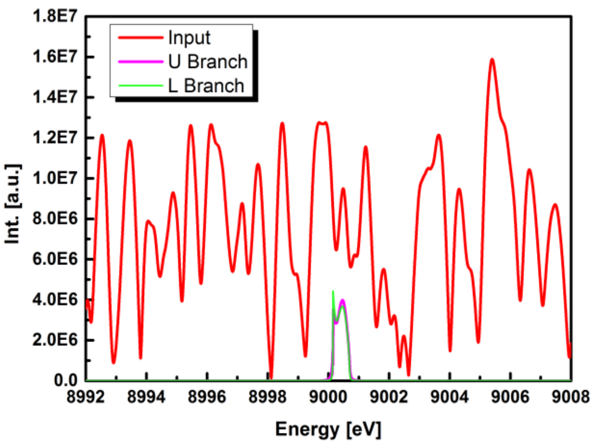


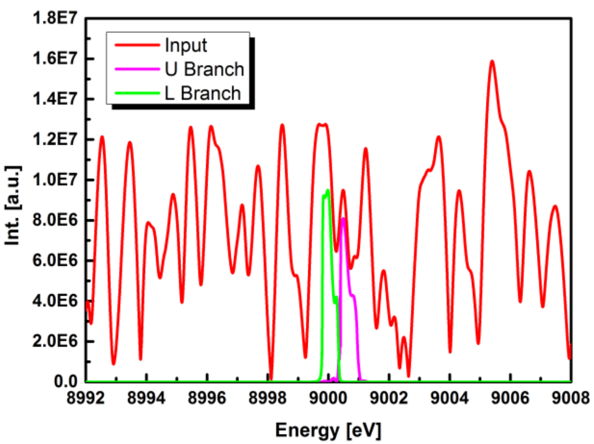
Simulations: W. Lu, I. Agapov, G. Geloni

European XFEL

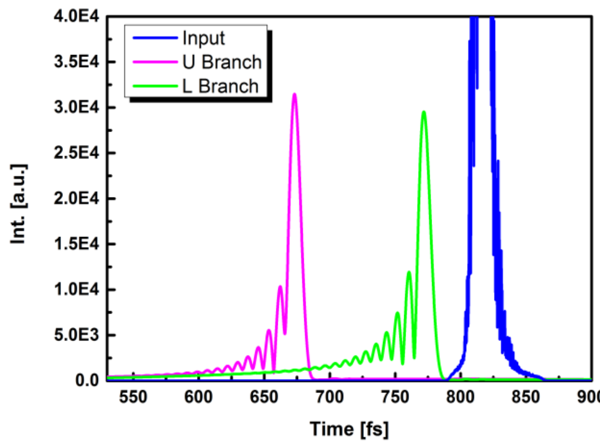
SDL, SASE Simulations

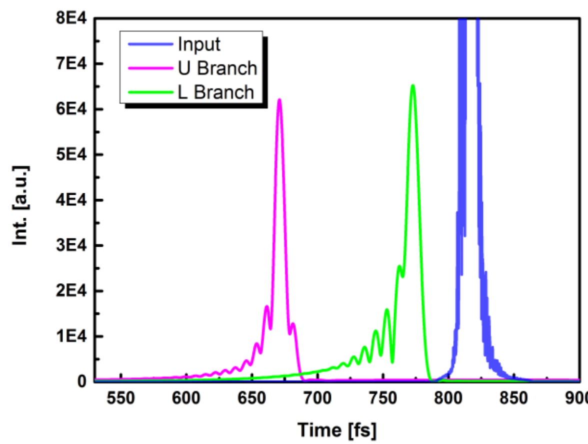
Spectrum output pulses



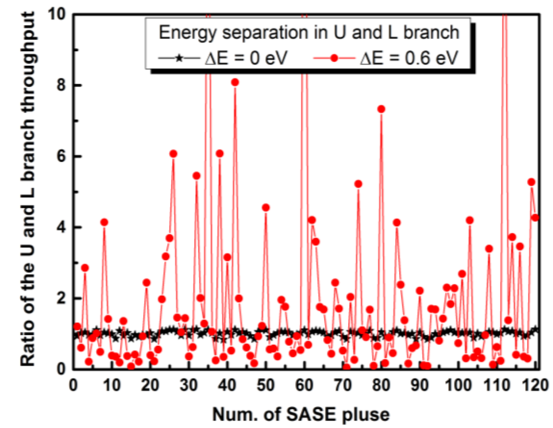


Time structure output pulses





Pre-mono Si(220)
Same photon energy
Thin beam splitter
Low intensity (~1.1%)
Constant Int. ratio

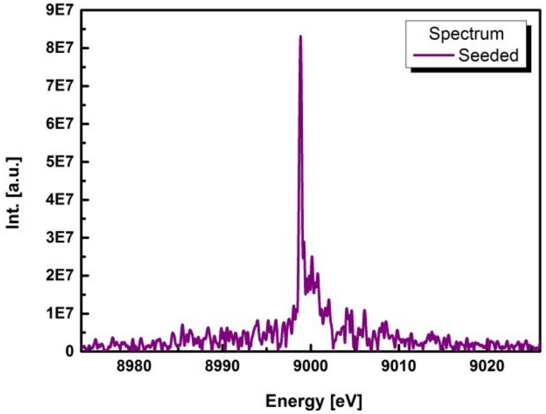


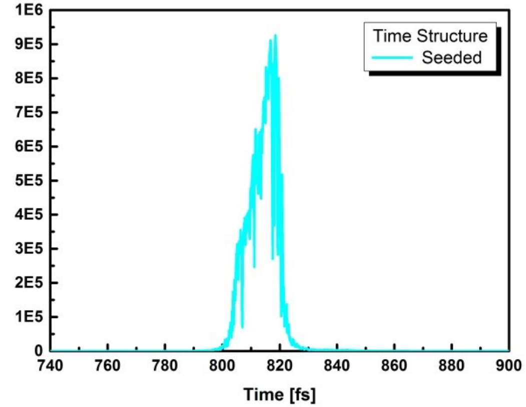
Pre-mono Si(111)
Small photon energy shift (0.6 eV)
3x thicker beam splitter
High intensity (~3.5%)
Fluctuating Int. ratio

Simulations: W. Lu, I. Agapov, G. Geloni

SDL, self-seeded Simulations

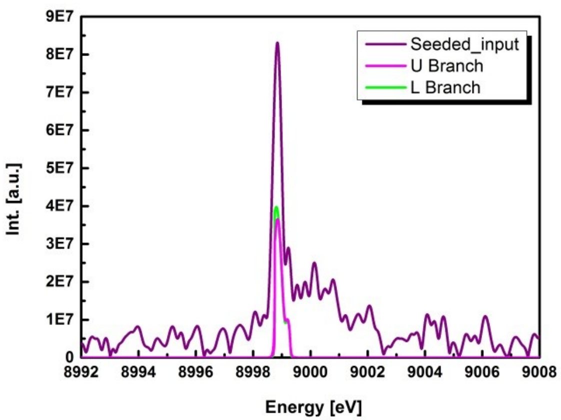
Input seeded pulse
9 keV, 20 fs



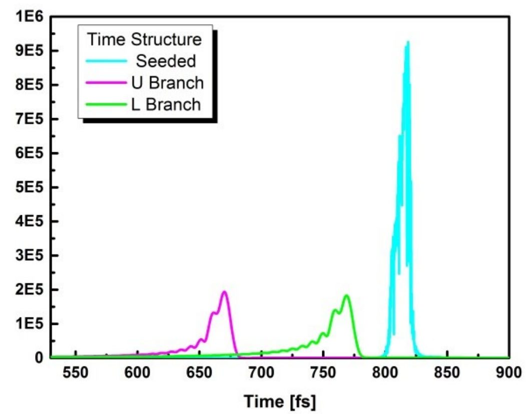


output pulses

Spectrum



Time Structure



Pre-mono Si(220)
Same photon energy
Thin beam splitter 1:1
Constant Int. ratio
High intensity (~11.2%)

Simulations: W. Lu, I. Agapov, G. Geloni

Thank you!

Tilt Sensors

	755-SERIES HIGH-GAIN TYPE	756-SERIES MID-RANGE TYPE
TOTAL RANGE *	±0.9 degree	±10 degrees
RESOLUTION *	0.1 microradian (0.02 arc second)	1.0 microradian (0.2 arc second)
REPEATABILITY	1 microradian (0.2 arc second)	2 microradians (0.4 arc second)
LINEARITY	1% of half span, 7% of full span (typical)	0.5% of half span, 2% of full span (typical)
NATURAL FREQUENCY	0.8 Hz	1.3 Hz
TIME CONSTANT	0.5 second	0.4 second
ENVIRONMENTAL	-8°C to +80°C operation and storage, -25°C version available.	-25°C to +80°C operation and storage, wide ranges available; 0 to 100% humidity
TEMPERATURE COEF. (Typical)	Scale Factor: +0.04%/oC, Zero: ±3 μradians/°C	Scale Factor: +0.05%/°C, Zero: ±10 μradians/°C
CONNECTIONS	12-inch (30 cm) wires with tinned ends or mini connectors; 1-meter Kapton wire leads on vacuum-compatible units	
MATERIALS	304 stainless steel enclosure. Gold anodized 6061-T6 aluminum also available on request.	
SIGNAL CONDITIONING	Model 781 Bench-top Unit, Model 786 Rack Mount Unit, Model 84800 Card (1-channel), Model 84828 Card (1-channel), Model 83162 Card (2-channel), or IRIS-SC Tilt Switch and Controller.	