

Status of the High Power Laser Facility on ESRF/ID24

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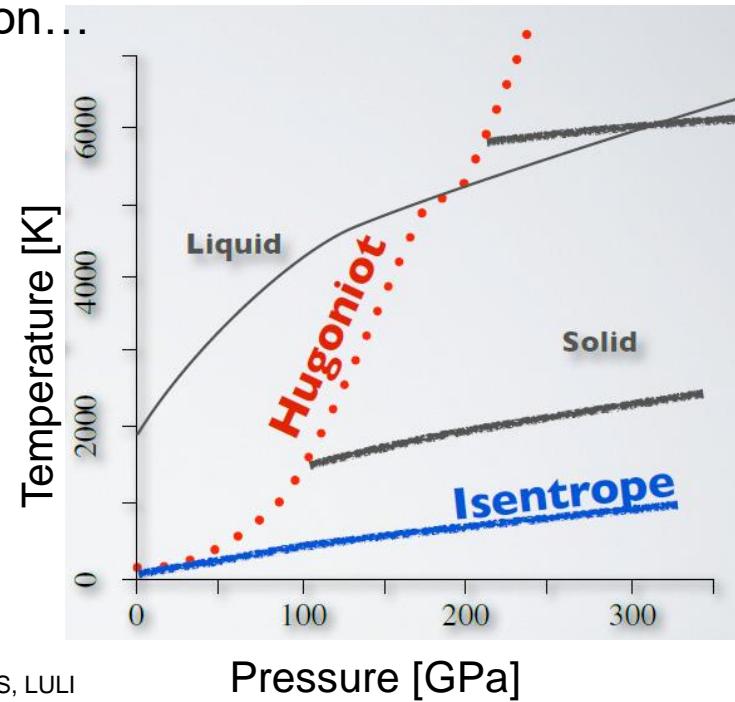
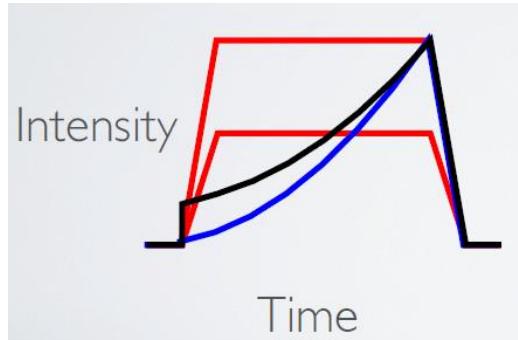
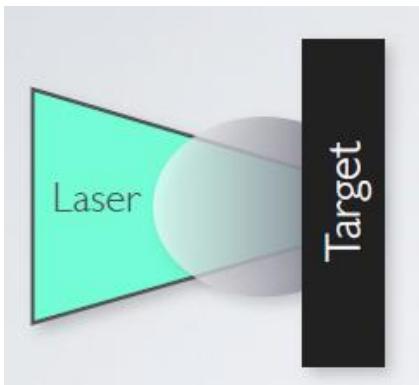
Extreme conditions for geophysics and planetary science

extra solar planets, warm dense matter



Dynamic behavior of matter and materials under high strain rates

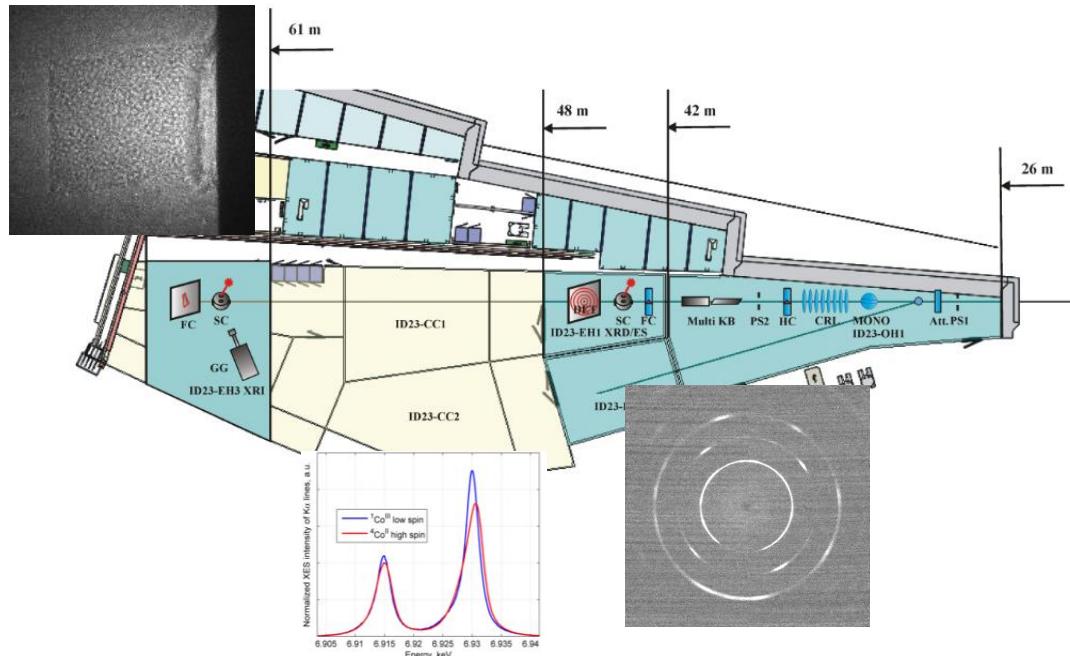
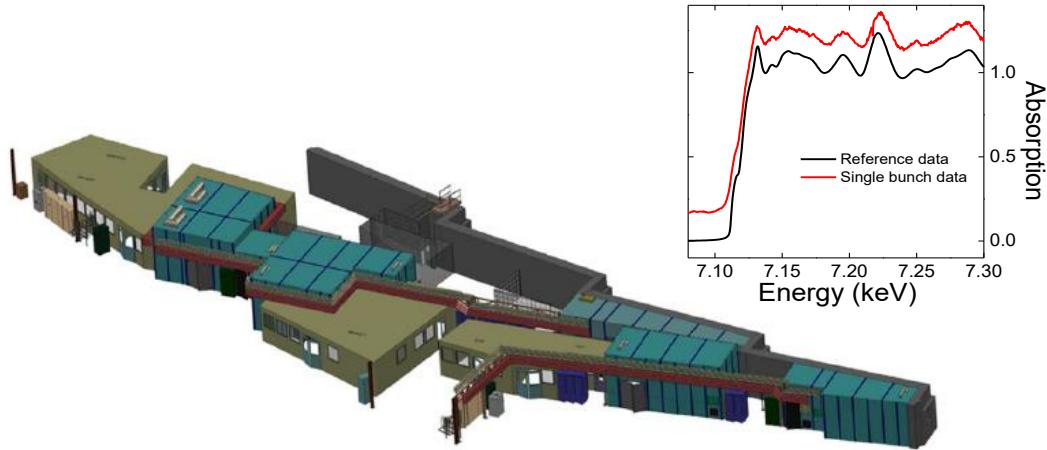
impacts, spallation, materials synthesis, plasticity, phase transitions kinetics, nucleation...



HIGH POWER LASER FACILITY PROJECT

HPLF-I (2018-2021) :

Couple a 100 J ns-shaped laser to XAS on ID24
Front End commissioning and first experiments performed in 2018.



HPLF-II (from 2023) EBS Beamline program To be approved

Extend to XRD, XRI, XES on ID23
Laser upgrade to 200 J IR / 140 J Green

Laser-induced dynamic compression coupled to XAS on ID24

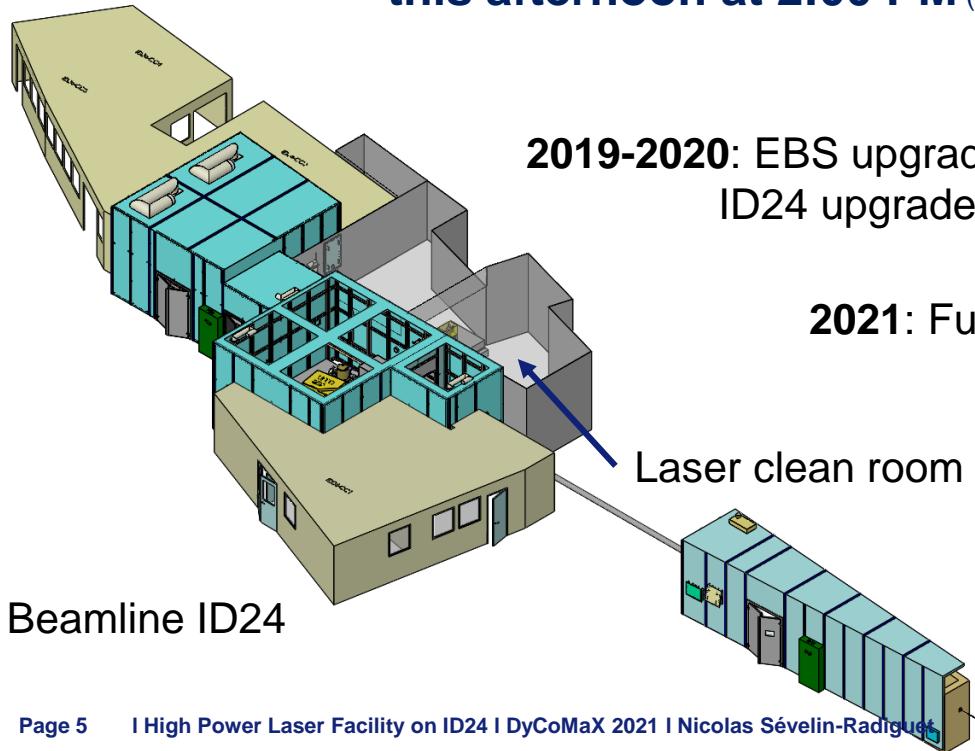


2017: Phase I (2018-2021) approved, CFT for a 100 J ns-shaped laser awarded to

2018: Delivery and commissioning of the laser front end 15 J, 10 ns

Experiments 2018

See talk from K. Voigt and A. Amouretti
this afternoon at 2:00 PM (UTC+01:00)

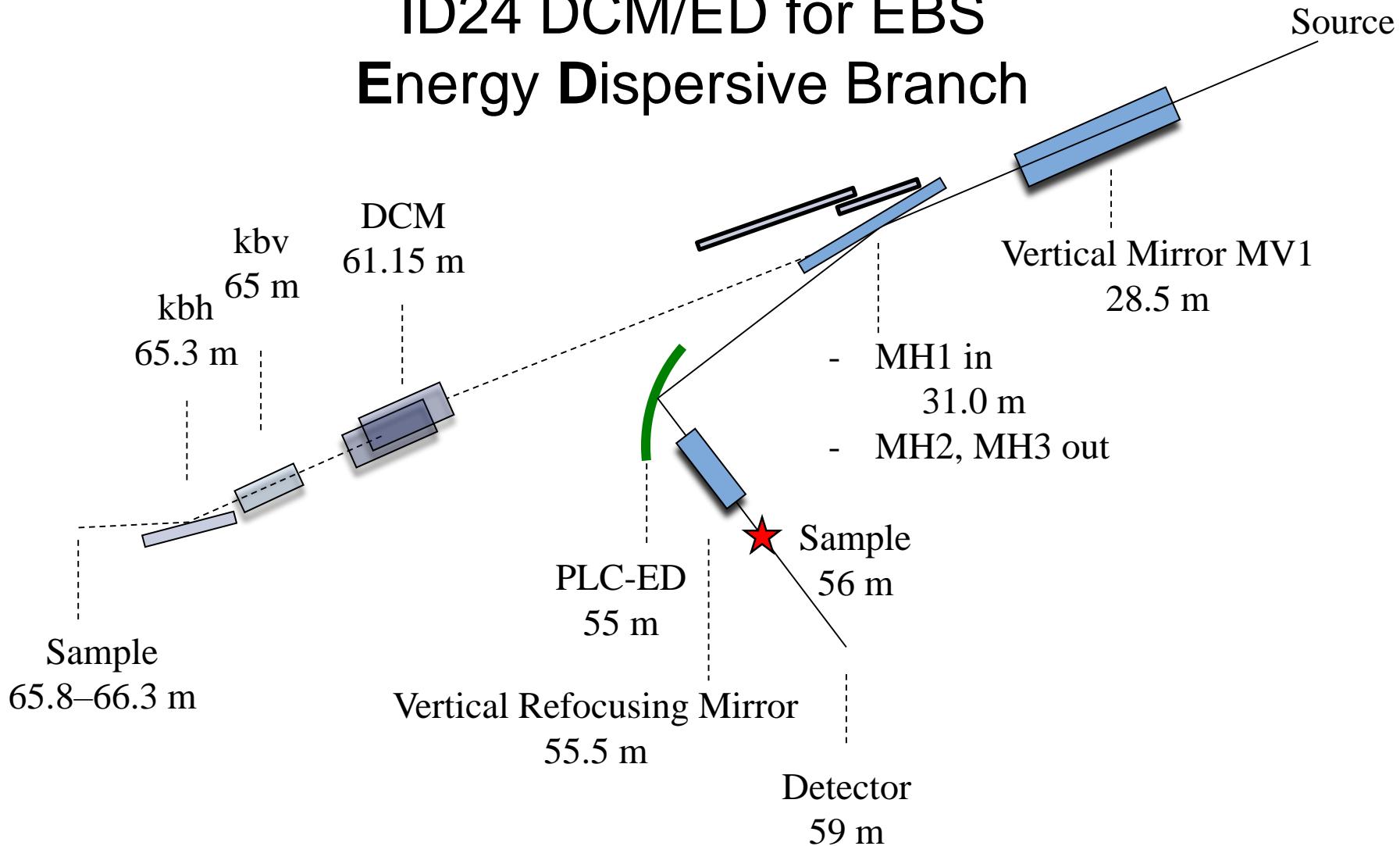


2019-2020: EBS upgrade - Infrastructure realization
ID24 upgrade for EBS and HPLF

2021: Full HPLF laser delivery, ID24 re-commissioning
100 J ns-shaped laser, transport, interaction chamber

2021: User operation
Call for proposal: March
User Service Mode: September

ID24 DCM/ED for EBS Energy Dispersive Branch



ID24-ED remains unchanged

Target experiments on ID24-ED

- **Dynamic compression**
- **Pulsed magnetic field**
- **2D/3D hyperspectral maps**

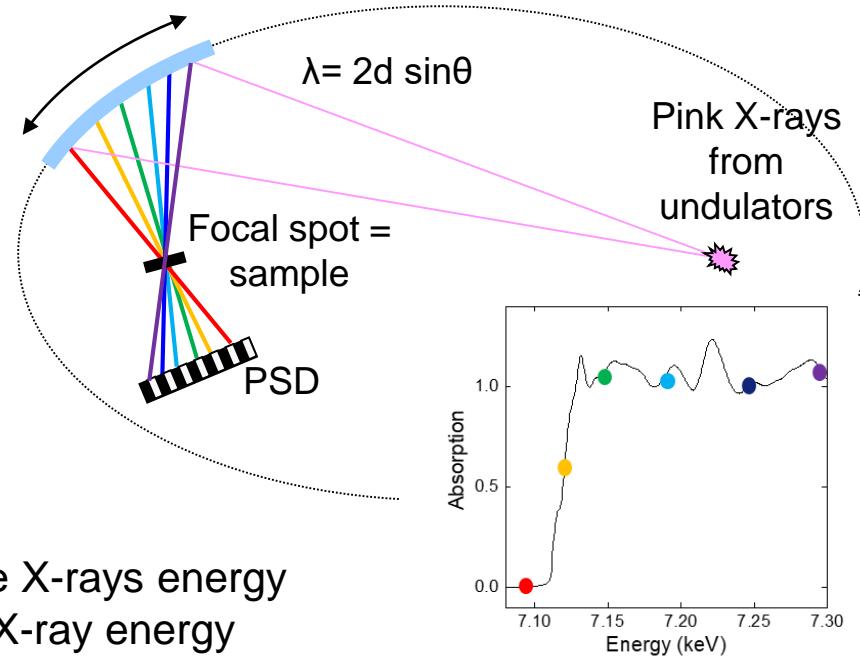
- EBS is expected to deliver up to a factor 3 increase in flux at high energies
- A factor 5 at low energy (5-7 keV) is expected as the beamline will be operated windowless

Additional items:

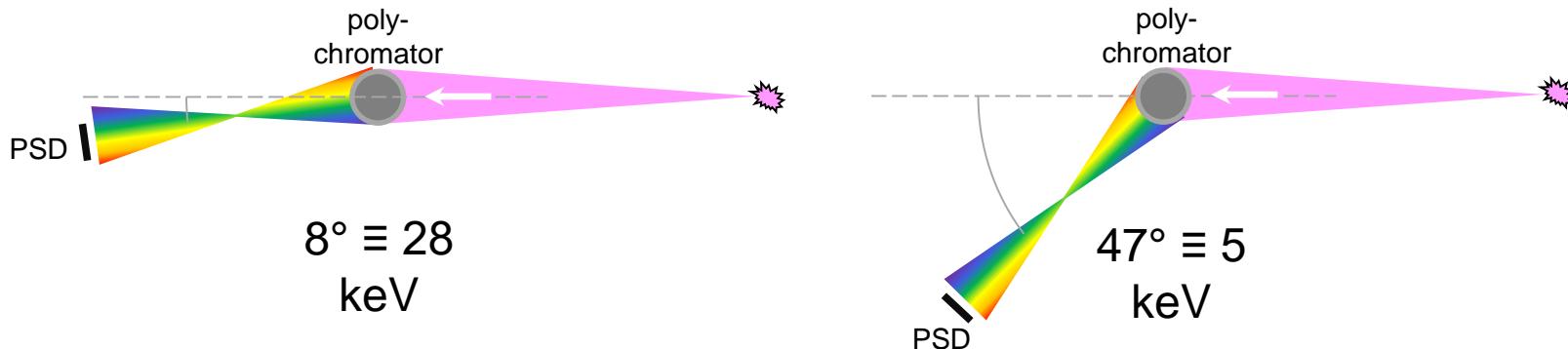
- New X-ray mirrors
- Vacuum refurbishment
- Upgraded version of the fast XH detector
- New control system (BLISS)
- Graphical User Interfaces
- Optimized sample environments

ENERGY DISPERSIVE GEOMETRY FOR XAS

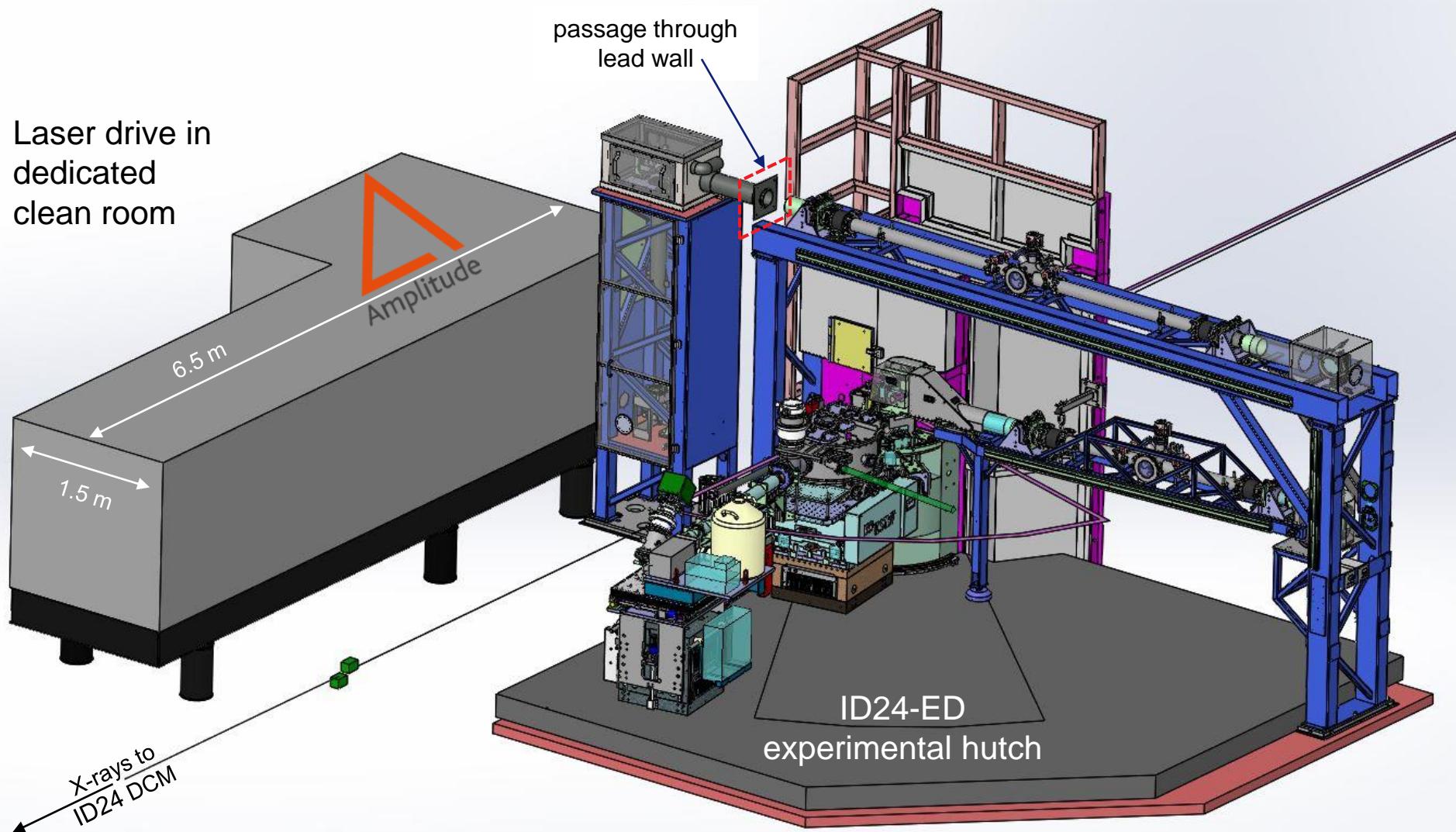
- Bent Si crystal with elliptical shape
→ energy-dispersed X-ray fan
- Position Sensitive Detector:
→ a few 100s of eV simultaneously
- Fast-response synchronized PSD:
→ single-shot/single bunch **XAS**



Dispersive (θ - 2θ) geometry where θ depends on the X-rays energy
→ sample and sample environment move with X-ray energy



HPLF-I OVERVIEW



CLEANROOM



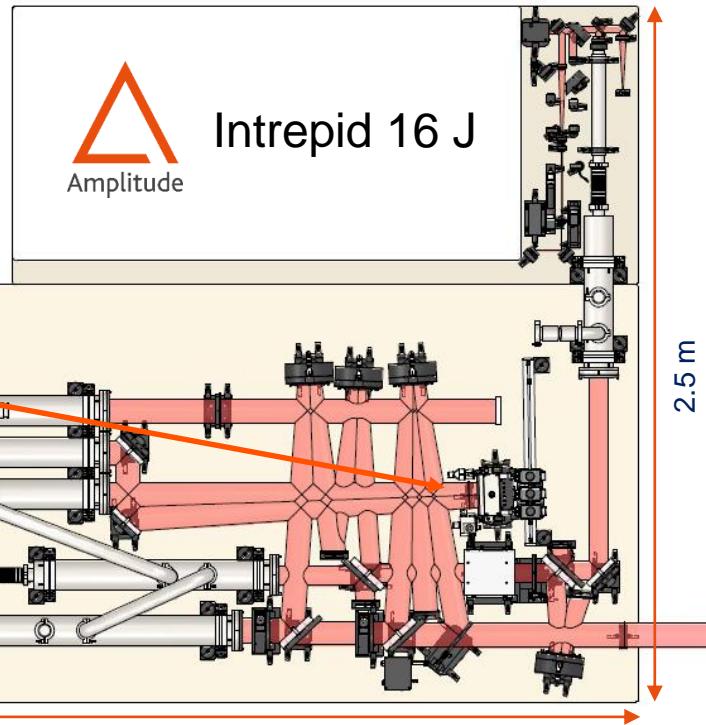
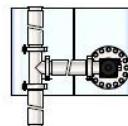
Cleaning and ISO-8 certification: end of January 2021

LASER DRIVE

Premiumlite Glass 100 J @ 1ω

- Temporal shaping: 4-15 ns
- SSD
- 1 shot / 4 minutes
- Top-Hat profile
- Liquid-cooled disk amplifiers

Disk Amplifier Modules



Upgradable to 200 J
Possibility of SHG

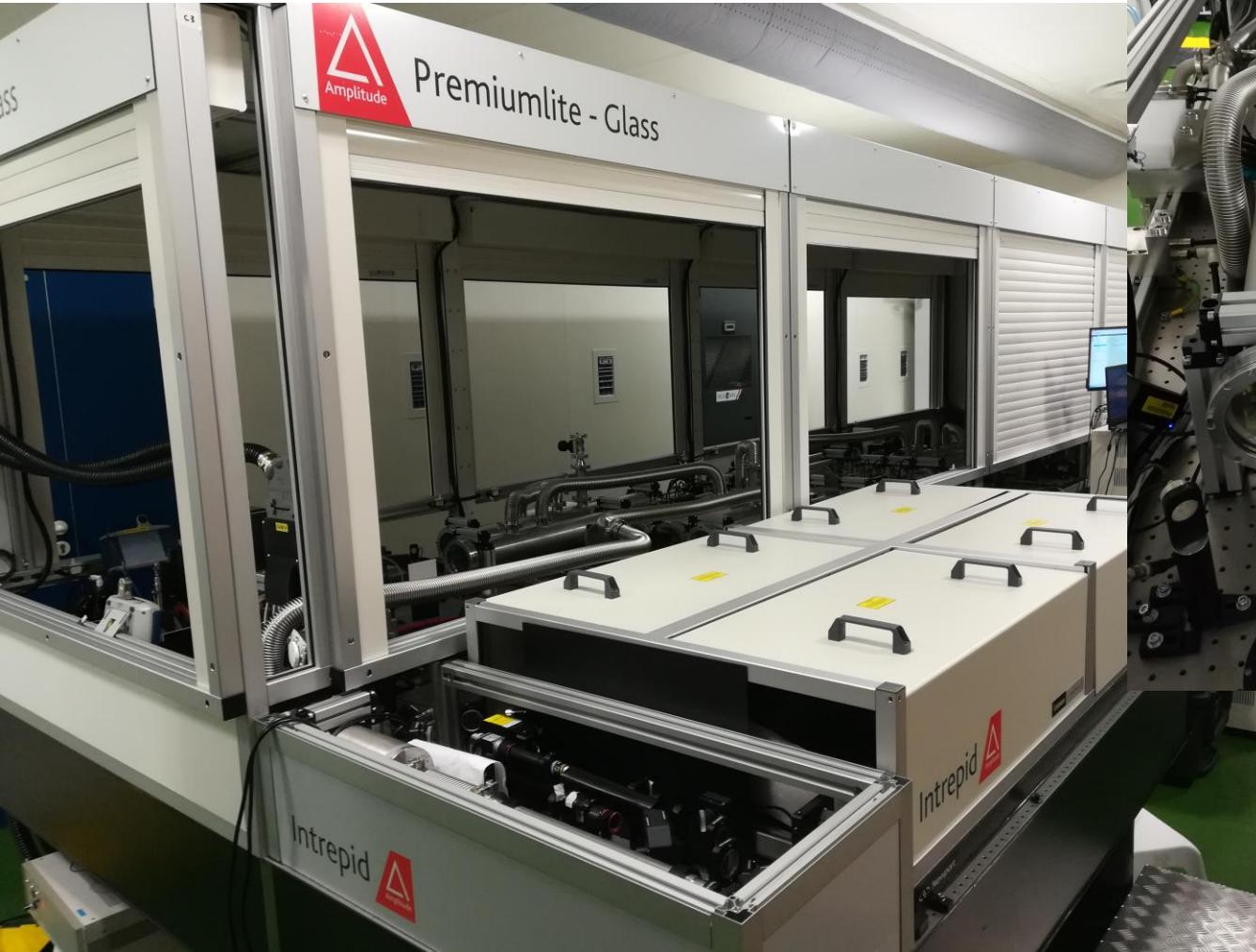
6.5 m

Synchronization from SR RF using ESRF-developed electronics
(White Rabbit based), jitter from X-ray pulses < 50 ps



LASER DRIVE

@ Amplitude facility



VIDEO FROM AMPLITUDE

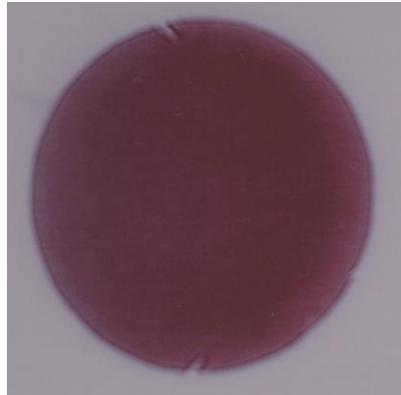
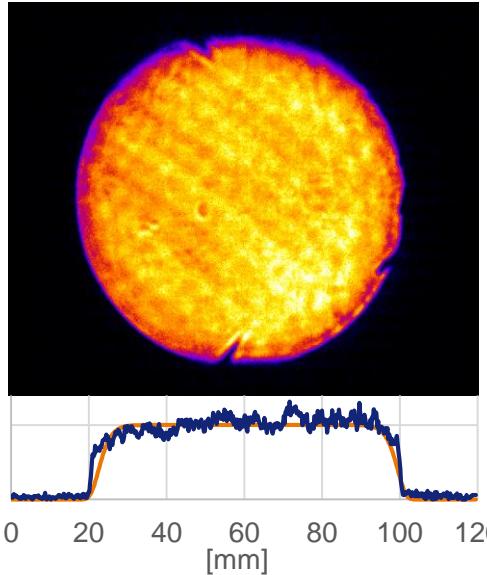
LASER DRIVE

Preliminary characterization at Amplitude's factory

52.3 J @ 0.1 Hz

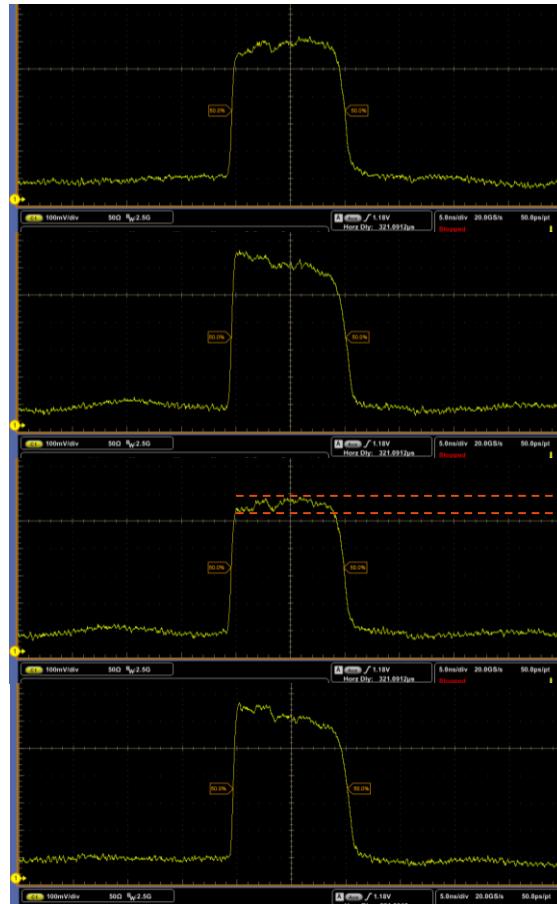
1.7% RMS over 480 shots (80 min)

Near field @ output with SSD



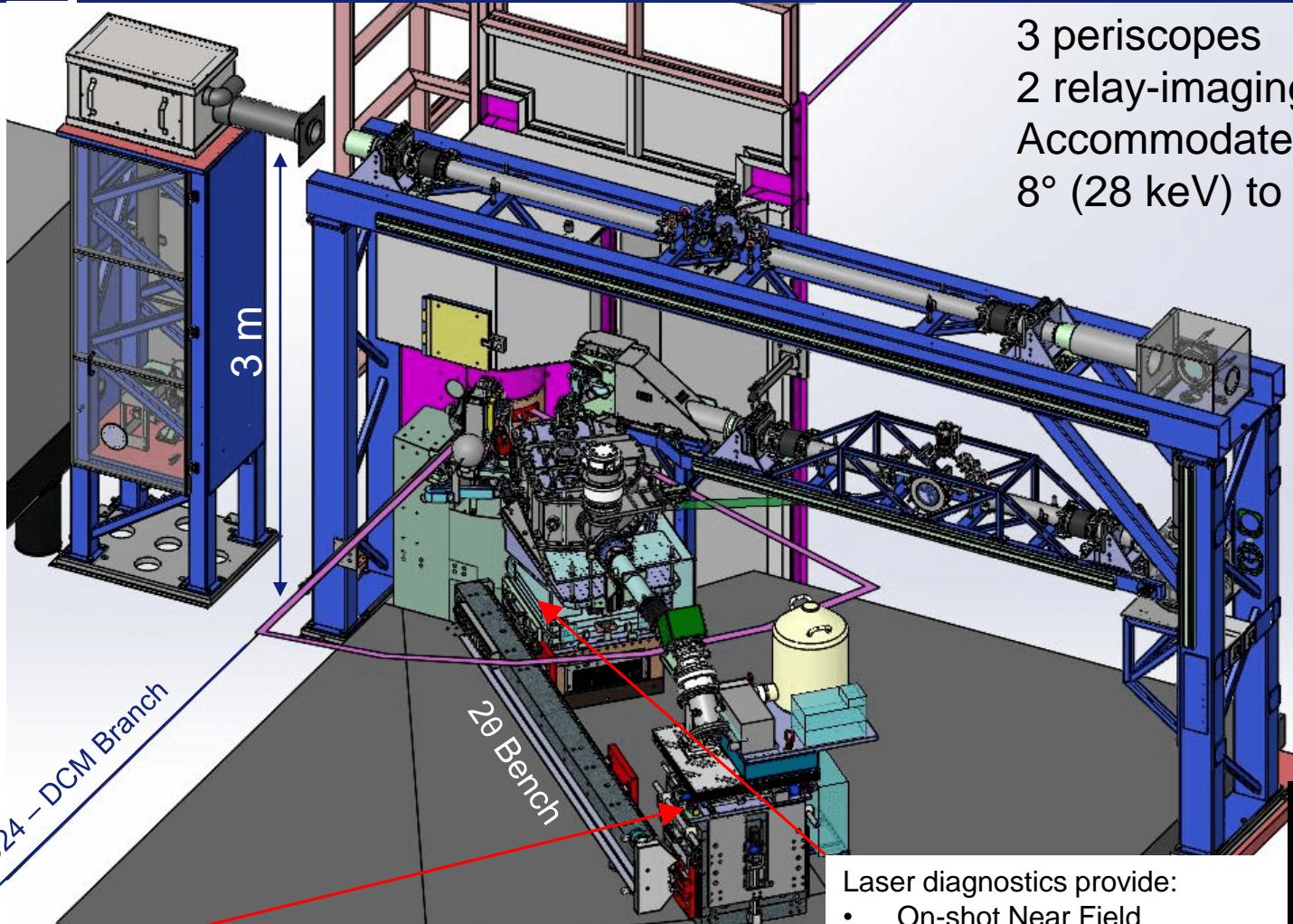
Burn paper

10 ns squares



- Rise time ~ 300 ps
- ns contrast $> 10^5$

LASER TRANSPORT

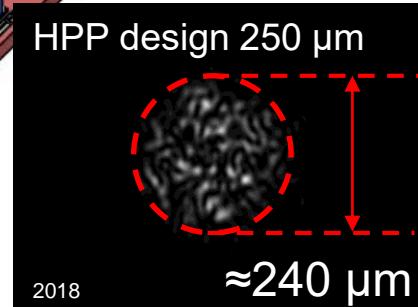


3 periscopes
2 relay-imaging telescopes
Accommodates for angle from
8° (28 keV) to 47° (5 keV)

New module for X-ray detectors provides:

- Legacy ESRF FreLoN
- New XH fast detector with fast shutter
- Ability to switch easily from one to the other

- Laser diagnostics provide:
- On-shot Near Field
 - On-shot Far Field
 - On-shot laser pulse shape
 - On-shot Energy
 - Pre-characterization of focal spot (low energy only)



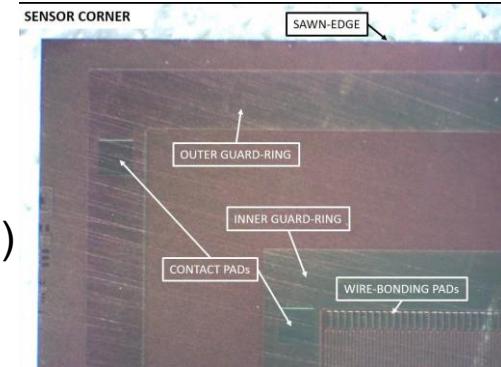
2018



XH Ge detector

Ge sensor:

- 1024 strips (50 μm pitch)
- Back illuminated
- Two guard-rings



Improved cryostat:

- Ge sensor @ 100 K
- Front-end electronics (~12W) @ 230 K

Front-end + DAQ designed by

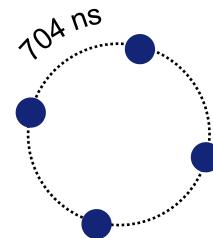


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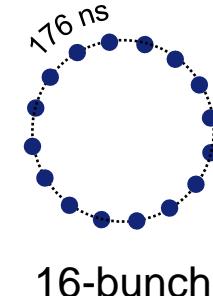
- Variable preamplifier gain.
- **Minimum integration time: 100 ns**
- Readout time: 2 μs
- Repetition rate: 2.8 μs



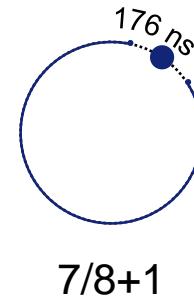
**Ability to record
1 spectrum every orbit (2.82 μs)
in all ESRF timing modes:**



4-bunch

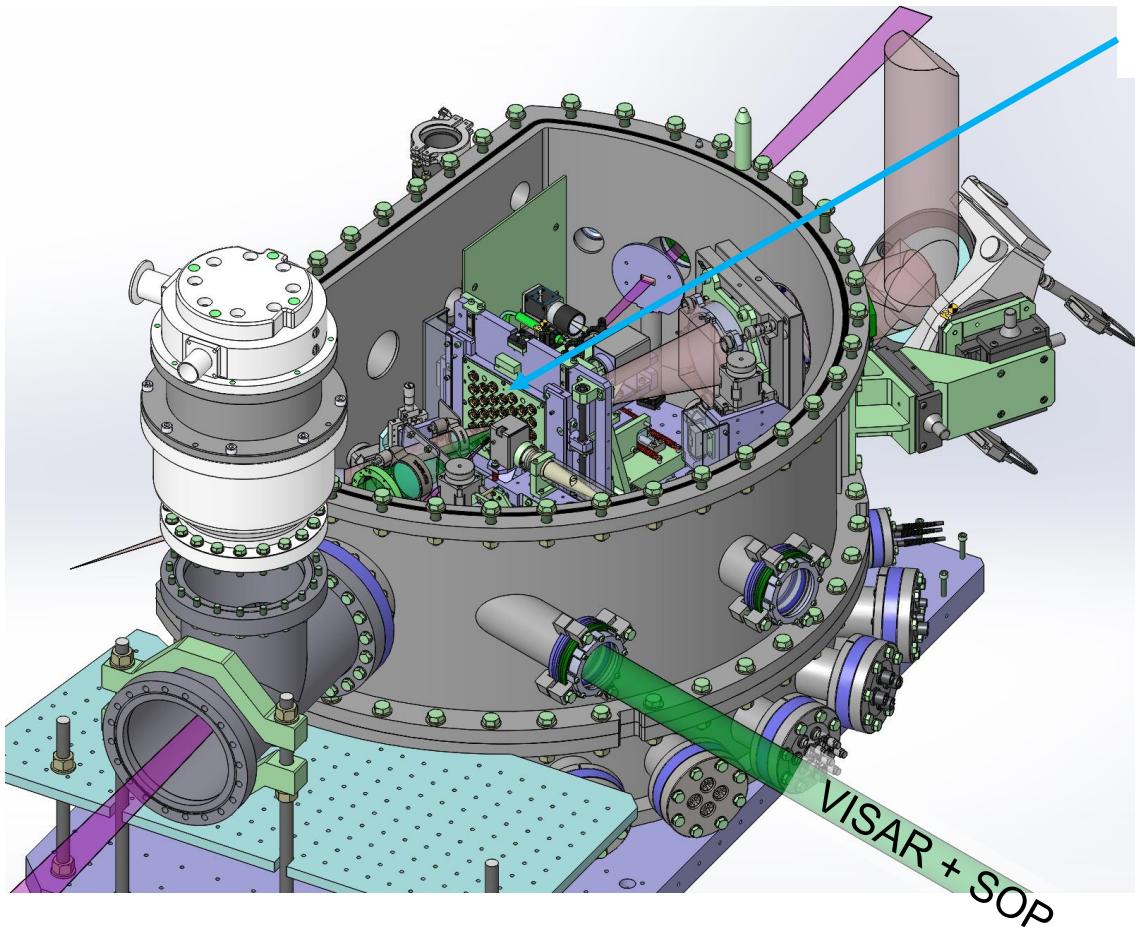


16-bunch



7/8+1

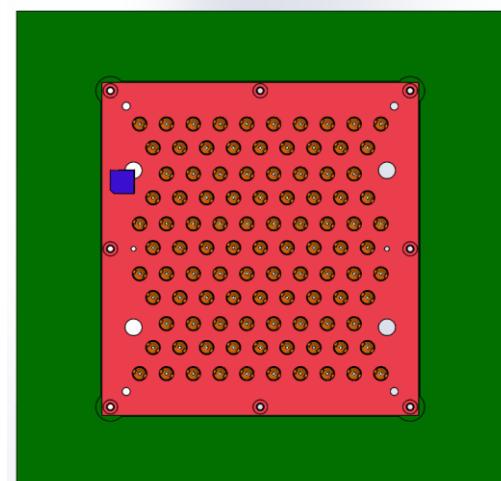
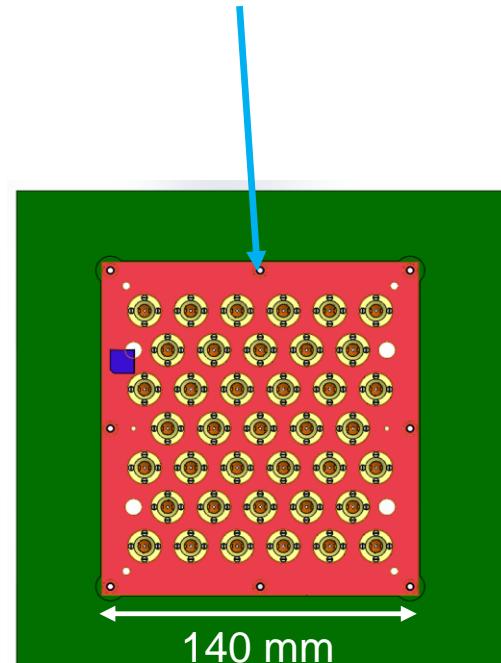
INTERACTION CHAMBER



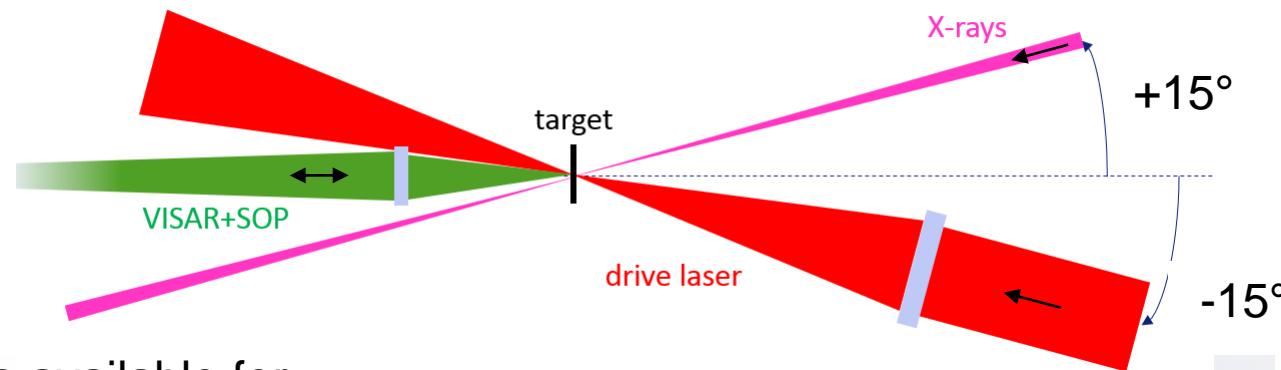
2 in-vacuum microscopes:

- Upstream, larger FoV (color)
- Downstream, higher depth resolution (monochrome)

EUCALL-compatible target holder

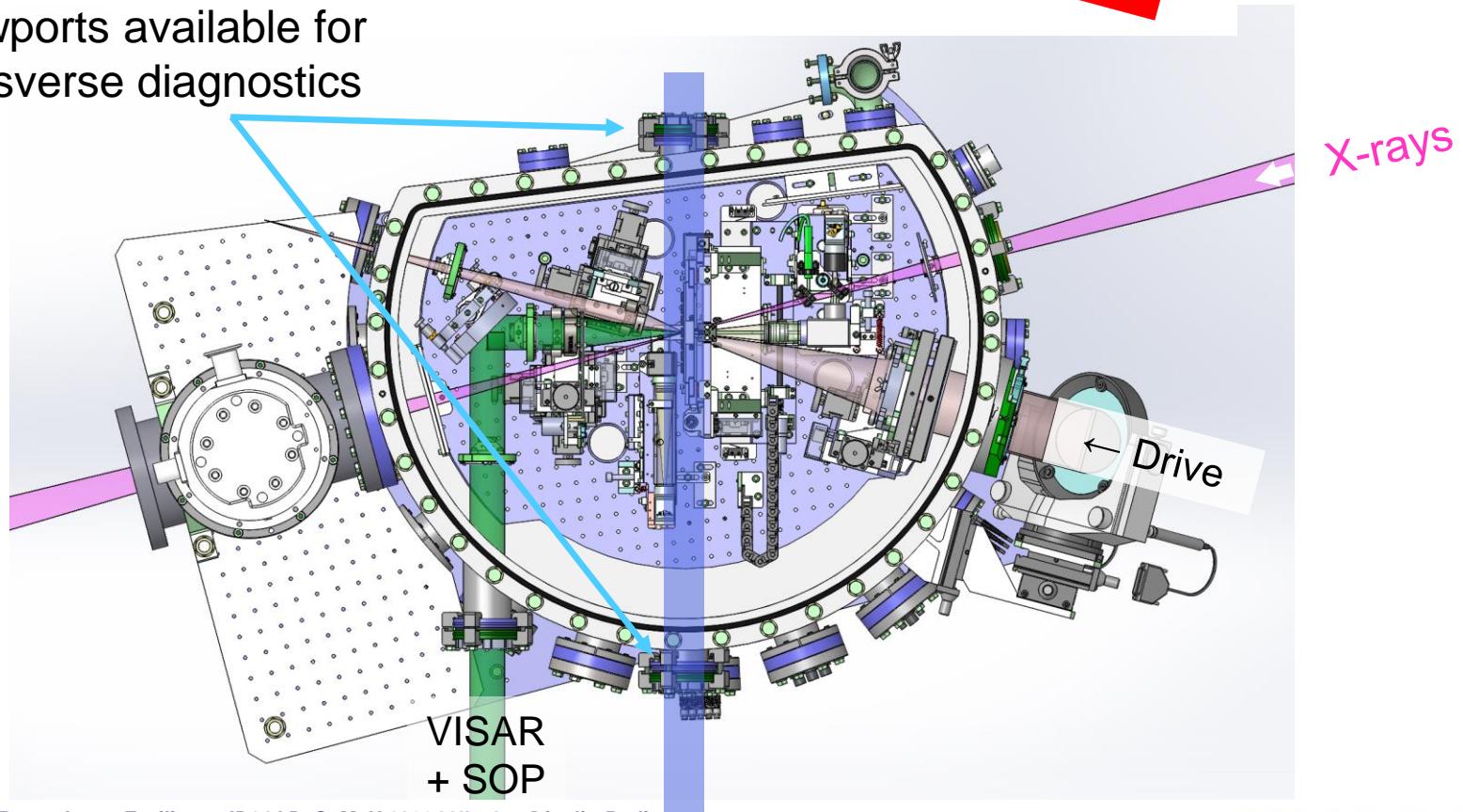


INTERACTION CHAMBER



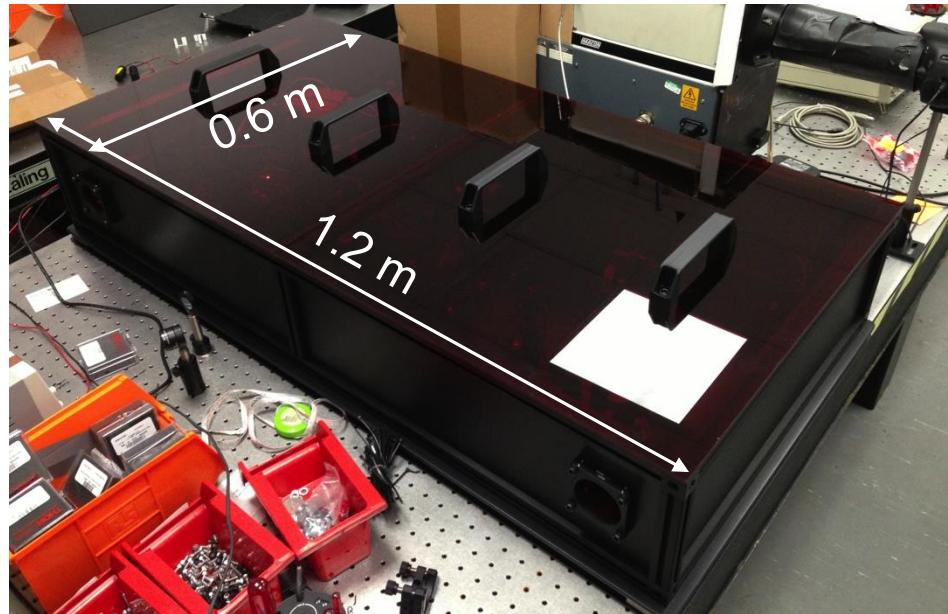
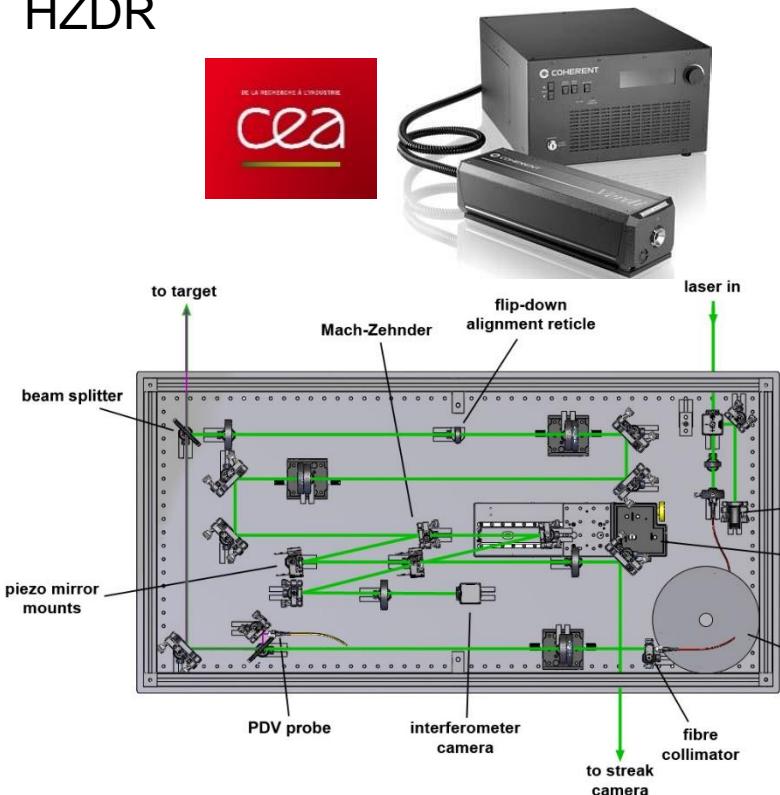
Top-view

Viewports available for transverse diagnostics



SHOCK DIAGNOSTICS COLLABORATION

- 1 VERDI 5W from CEA
- 1 Line VISAR from U. Oxford
- 2 Hamamatsu streak cameras from HZDR



Courtesy of D. Eakins



Round table
tomorrow at
4:30 PM (UTC+01:00)



PARAMETERS

HPLF adjustable parameters:

X-rays

- X-rays energy: 5-28 keV (**Day-1: 5-11 keV**)
- X-rays pulse: \approx 100 ps FWHM (fixed)
- X-rays spot: $10 \times 100 \mu\text{m}^2$ down to $5 \times 5 \mu\text{m}^2$ (HxV) (energy dependent)

Laser

- Laser energy: 1-100 J (@ **1053 nm**) (**Day-1: 50? J max**)
 - Laser temporal shape: 4-15 ns (flat top, adjustable, **Day-1: rectangular only**)
 - Laser spot size on target: $\varnothing 100, 250$ and $500 \mu\text{m}$ HPP
 - Rep. rate: single shot up to 1 shot / 4 min
 - X-rays/Laser delay adjustable
-
- Users' targets! → Round table tomorrow at 4:30 PM (UTC+01:00)

FUTURE EVOLUTIONS

Laser upgrades

- Energy up to 200 J @ 1ω
- Second Harmonic: 140 J @ 2ω
- Deformable mirror

Shock diagnostics

- **VISAR**
 - A second Line-VISAR (ideally at a different wavelength)
 - A pulsed laser for VISAR

VISAR and SOP are crucial to determine P/T conditions

X-rays

- **XRD, XRI and XES** on a second beamline (**HPLF-II**)

→ Round table tomorrow at 4:30 PM (UTC+01:00)

ACKNOWLEDGMENTS



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Questions?