MEC Instrument capabilities for run 23

LCLS Virtual Town Hall

MEC team

January 30th, 2024

SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Proposal guidelines

Engaging MEC staff early in the proposal phase can help strengthen the technical feasibility

Steps to investigate technical feasibility of your proposal:

1. Start investigating about general hutch capabilities here
    - A more detailed set of specifications for each components is under development here
2. Then, engage conversation with any Scientific Staff from this list:
    - **Eric Galtier** Scientist (Instrument Lead), egaltier@slac.stanford.edu
    - **Dimitri Khaghani** Scientist (Instrument), khaghani@slac.stanford.edu
    - **Hae Ja Lee** Scientist (Instrument), haelee@slac.stanford.edu
    - **Bob Nagler** Scientist (Instrument), bnagler@slac.stanford.edu
    - **Philip Heimann** Scientist (Instrument, X-ray Beam Delivery), paheim@slac.stanford.edu
    - **Eric Cunningham** Scientist (Lasers), efcunn@slac.stanford.edu
    - **Nick Czapla** Scientist (Lasers), nczapla@slac.stanford.edu
    - **Gilliss Dyer** Scientist (MEC Dept Head), gilliss@slac.stanford.edu
3. Iterate with the staff above to maximize the use of the hutch experimental supporting infrastructure

Proposal submission avenues

PRP (with X-rays)

- Regular submission route for experiments
- up to 5 shifts
- Includes up to 50% of standard configurations
- Standard configurations
  - LPL collinear
  - LPL perp
  - LPL X-ray imaging
- proposal template is here

- new!
- Includes up to 50% towards IFE

Data Set (with X-rays)

- new!
- To get a more complete set of data from previous LCLS experiments
- Using X-rays and optical lasers in standard configurations only
- Typically 1-2 shifts
- Reviewed within the PRP
- submission form is here

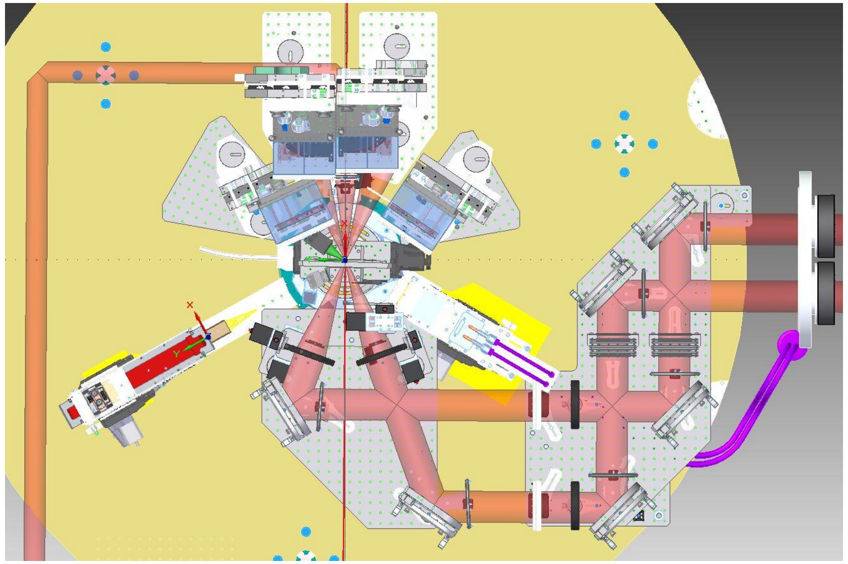
Rapid Access (VISAR only)

- new!
- To obtain any new or improve old VISAR data
- No requirement for having done a previous LCLS experiment before
- Using LPL in standard configuration only
- Typically up to 30 targets (max one day of shots)
- Can be submitted at any point during the run
- Reviewed by MEC staff only
- Look at the published schedule to anticipate when to submit
- submission form is here

Run 23 standard configurations

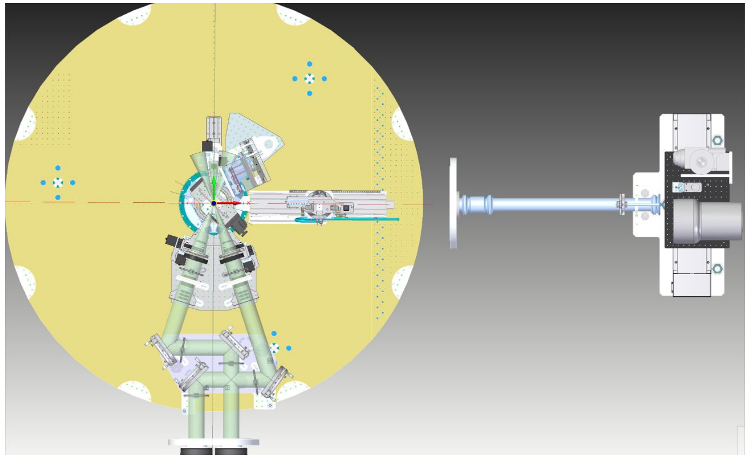
Standard configuration 1 full mode

- Long Pulse Laser collinear beam delivery
- up to 100 J in 10ns, 10 GW maximum
- Target surface perpendicular to FEL
- Detection is (4 x ePix10k) + VISAR + (optional: XRTS upstream TCC)
- backward XRTS is optional and installed when needed only



Standard configuration 2

- Long Pulse Laser perpendicular beam delivery
- up to 100 J in 10ns, 10 GW maximum
- Target holder at 45° from the FEL (but target surface hit by the optical lasers is colinear to the FEL)
- Detection is (3 x ePix10k) + VISAR + (MXI downstream TCC)



MEC source parameters for run 23 (see here for a full list)

LCLS Hard X-ray (FEL)

Parameter	Value
Photon energy range	4 – 25 keV
Pulse energy [a]	0.6 – 2 mJ (25 and 4 keV respectively)
Rep. Rate	up to 120 Hz, single shot with pulse picker
Beamline transmission	10% at 4 keV; 40% at 8 keV
Minimum spot size	~ 1-2 μm with hutch optics; <200 nm with in-chamber optics
Polarization	Vertical
Bandwidth modes [b]	SASE, seeded [c]
Multipulse modes [b]	single pulse, 2 pulses, 4 pulses

[a] Pulse energies are displayed at the end of the FEE. They do not take into account the beamline transmission.
[b] Contact beamline scientist to discuss the details of the operation modes. See previous slide for contact list. 4 pulses are offered at risk.
[c] Contact beamline scientists to discuss use of the K-mono to suppress bandwidth wings in the seeded mode.

Short Pulse Laser (SPL)

Parameter	Value
Wavelength	800 nm fundamental (frequency doubling to 400 nm available)
Pulse energy	1 J compressed at TCC at 800 nm (> 400 mJ at 400 nm); 1.5 J uncompressed at TCC
Pulse duration	<50 fs compressed; 160 ps uncompressed
Rep. Rate	120 Hz for 10 mJ pulse energy; 5 Hz otherwise
Spot size[d]	with OAP (f/6): ~6 μm; with spherical mirror: > 50 μm
Pulse contrast (at 800 nm)[e]	>10^8 @ 3 ps; > 10^{10} (noise floor) @ 30 ps
Synchronization	± 100 fs RMS with LCLS

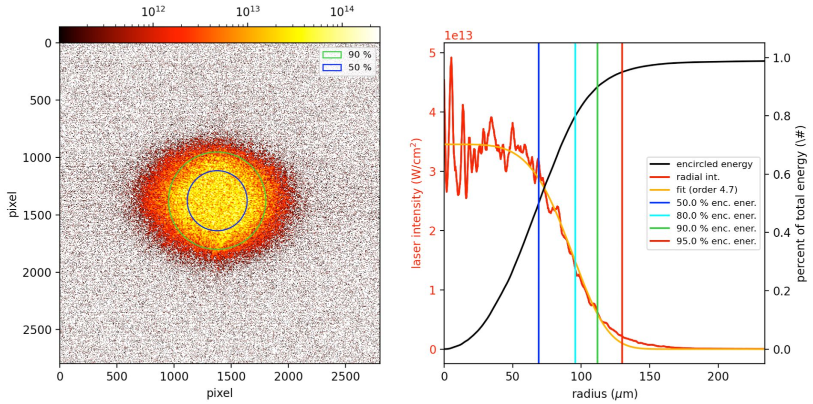
[d] See next slides for more details on spot size characteristics.
[e] E. Cunningham, et al. Appl. Phys. Lett. 114, 221106 (2019).

Long Pulse Laser (LPL)

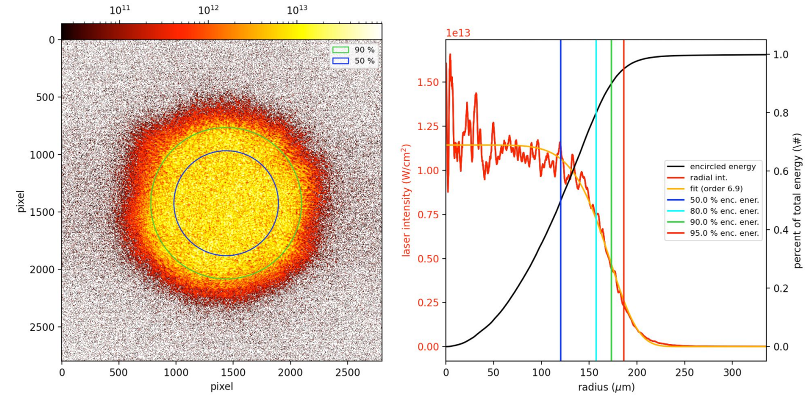
Parameter	Value
Wavelength	527 nm (frequency doubled from the fundamental of 1053 nm)
Pulse energy	4-arms: 100 J in 10 ns (flat top shape) ⇒ 10 GW peak power max
Pulse duration	5-35 ns
Rep. Rate	one shot / 7 min with 4 arms; one shot / 3 min with 2 arms
Spot size [f]	150, 300, 600 μm (spatially flat top using Continuous Phase Plates (CPP))
Temporal pulse shapes	flat top, step pulse, arbitrary (efficient and accurate pulse shaping capability)
Synchronization	± 10 ps RMS with LCLS

[f] See next slides for more details on spot size characteristics.

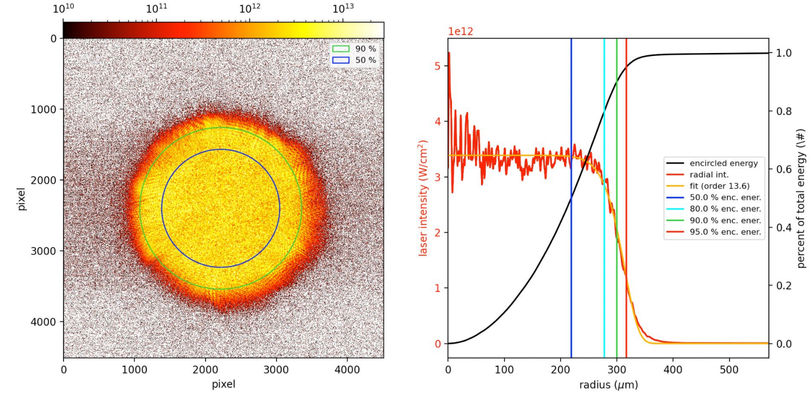
LPL recent work and spot size performances



- 100 J, 10 ns, CPP: 150 µm
- Intensity at plateau: 3.5 e 13 W/cm^2
- 50% contained in ø 138 µm
- 80% contained in ø 181 µm
- 90% contained in ø 224 µm



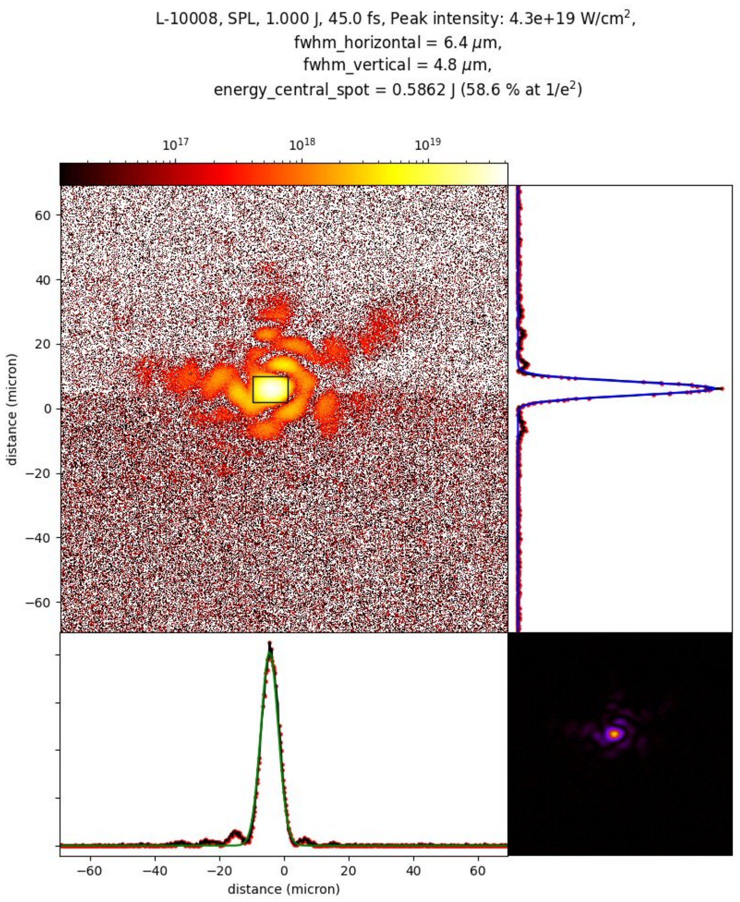
- 100 J, 10 ns, CPP: 300 µm
- Intensity at plateau: 1.1 e 13 W/cm^2
- 50% contained in ø 240 µm
- 80% contained in ø 315 µm
- 90% contained in ø 347 µm

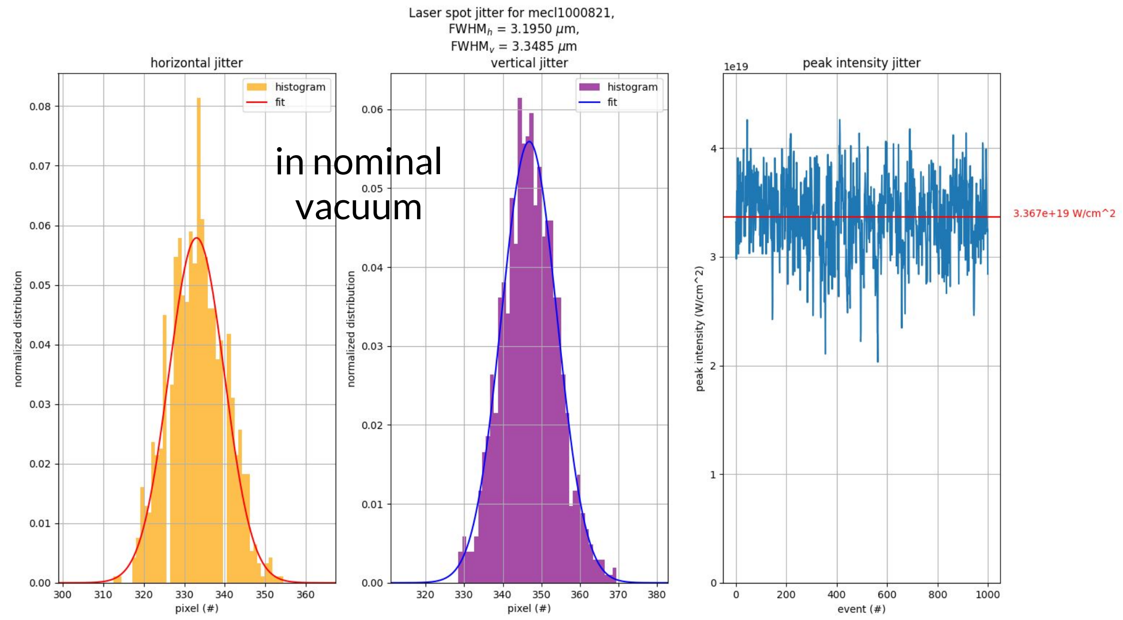


- 100 J, 10 ns, CPP: 600 µm
- Intensity at plateau: 3.4 e 12 W/cm^2
- 50% contained in ø 438 µm
- 80% contained in ø 556 µm
- 90% contained in ø 600 µm

SPL recent work and laser intensity peak performances

Average peak intensity in excess of 3e19 W/cm^2 at 5 Hz.





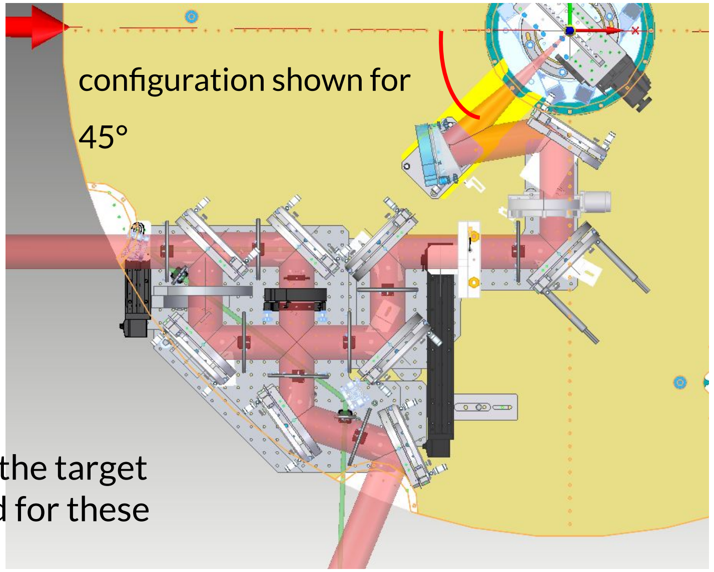
- New compressor design and suite of alignment diagnostics:
  - improves alignment consistency and accuracy to TCC
- New timetool beampath:
  - works independently of the main amplified beam
  - in principle, works at 120 Hz
  - improves consistency in configuration changes

SPL beam delivery

Discuss with staff to evaluate the use of these platforms for your non-standard experiment!

SPL for high peak intensity* (>1e19 W/cm^2)

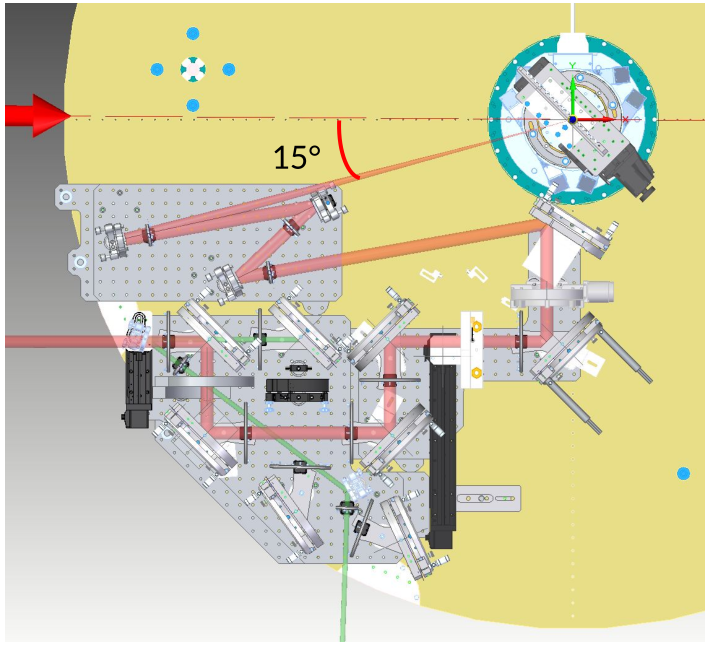
- delivers max peak intensity at TCC at 800 or 400 nm
- angle between SPL focus beam vs FEL: 22.5, 45, 59°
- uses f/6 metallic OAP
- compatible with MXI (up or downstream), XRTS, XTCS, XRD detectors



* Shield walls outside the target chamber are required for these configurations.

SPL for low peak intensity (<1e16 W/cm^2)

- delivers compressed low energy pulse at 400 nm, uncompressed low and high energy pulses at 800 nm
- angle between SPL focus beam vs FEL is fixed at 15°
- uses HR spherical mirror of 900 mm focal length
- compatible with MXI (up or downstream), XRTS, XTCS, XRD detectors



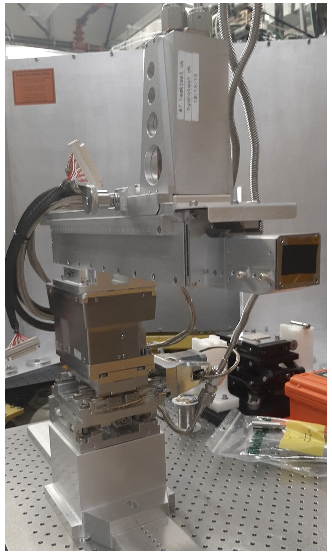
X-ray spectroscopy

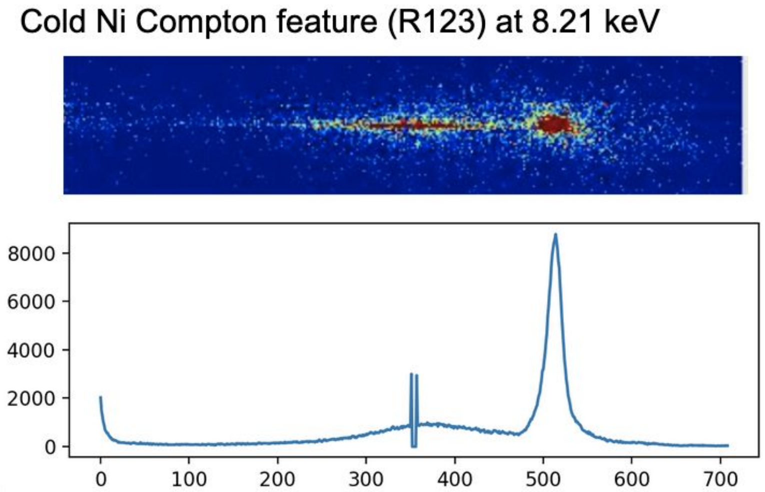
Compact XRTS

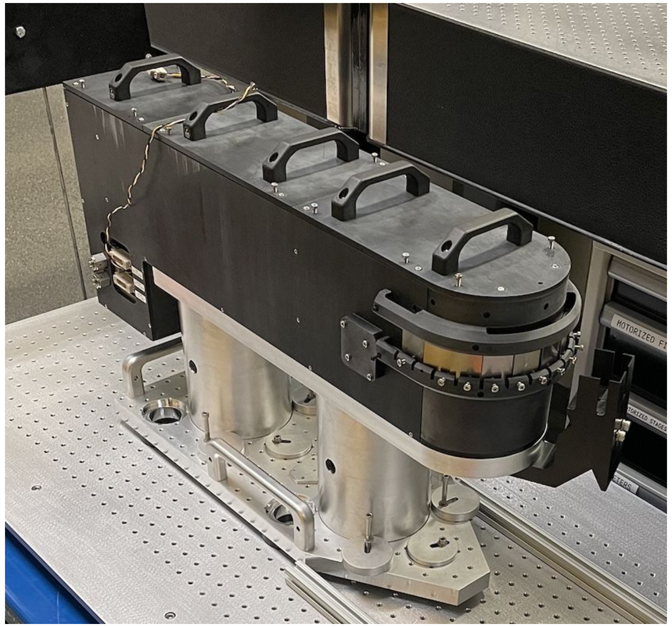
- designed for high throughput X-ray Thomson scattering measurements in low peak intensity matter interaction
- compatible with LPL and SPL beam delivery
- von Hamos geometry
- HAPG crystal allowing central photon energy ranging from 7.5 to 25 keV, with a ~1.15 keV spectral window

X-ray Transmission Crystal Spectrometer (XTCS)

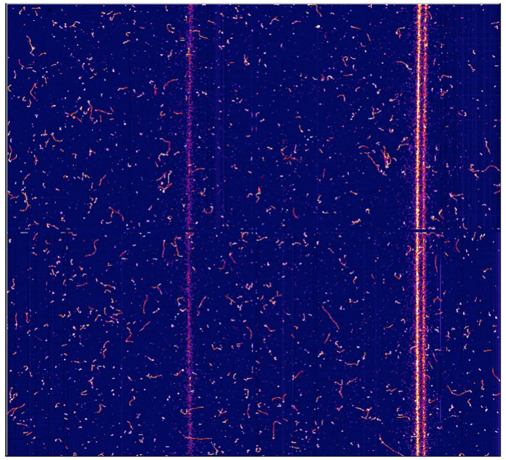
- designed for spectroscopy in max peak intensity matter interaction (e.g. >1e19 W/cm^2)
- compatible with new SPL beam delivery
- Cauchois geometry
- Quartz crystal allowing central photon energy ranging from 6 to 20 keV, with a ~2 keV spectral window at resolving power >1000







>1e19 W/cm^2 on Cu



Kb Ka$_{1\text{-}2}$