

Roadmap to first day short pulse experiments at HED

A. Pelka

On behalf of the HiBEF user consortium and the HED Instrument

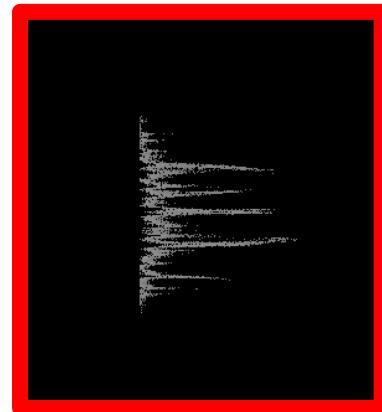
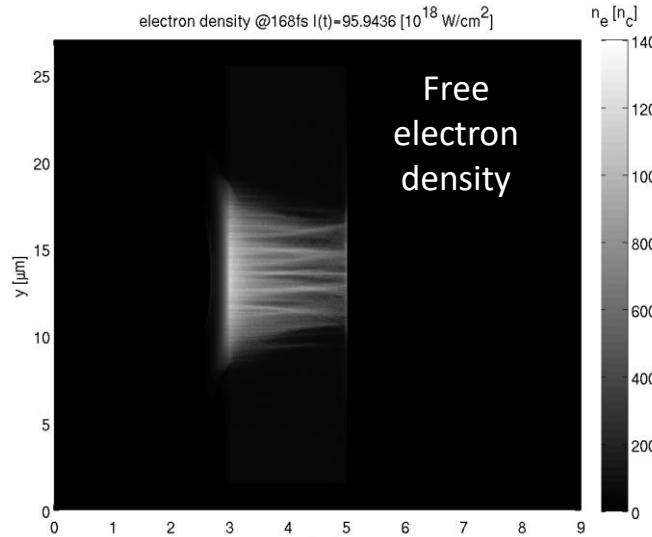


Science Cases for Short pulse laser experiments at HED

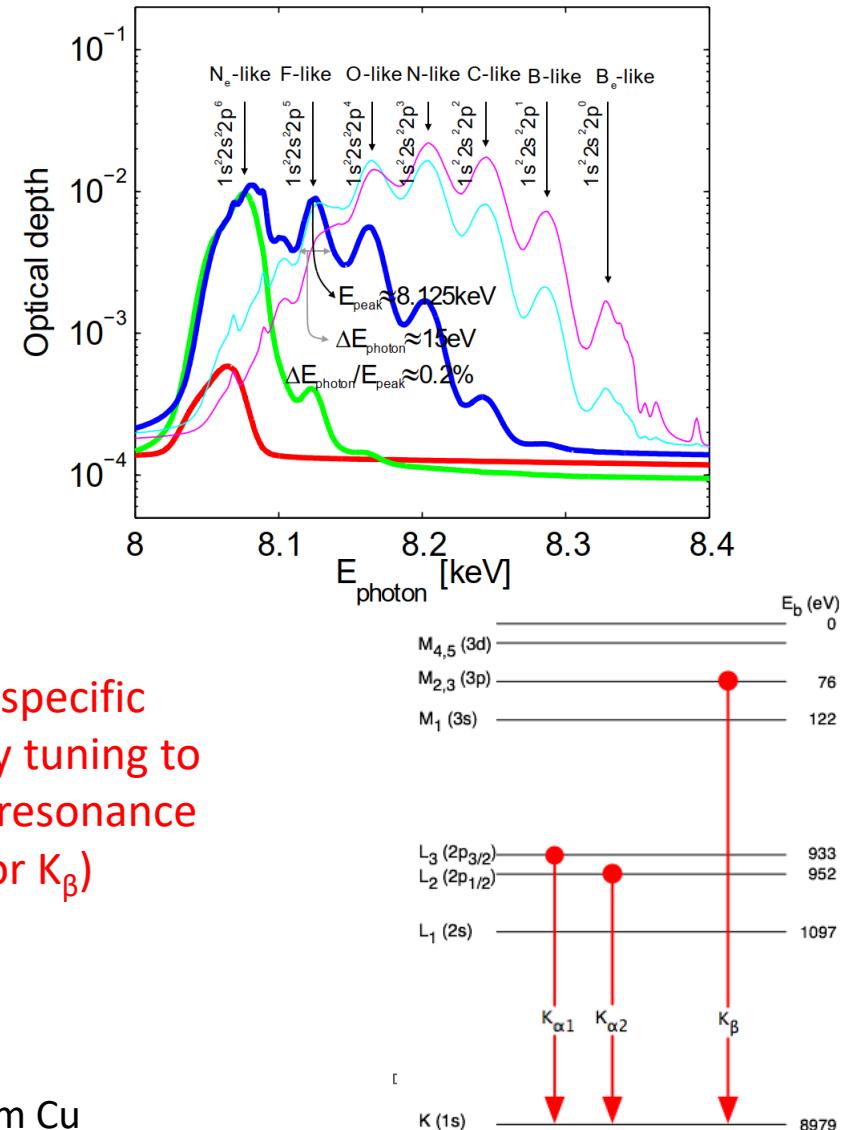
- SAXS/resonant scattering
- ionization dynamics
- vacuum birefringence
- XANES with laser driven X-ray source

Resonant Coherent X-ray Diffraction

Free electron density related to ionization state, Z^* (prior to ion motion)



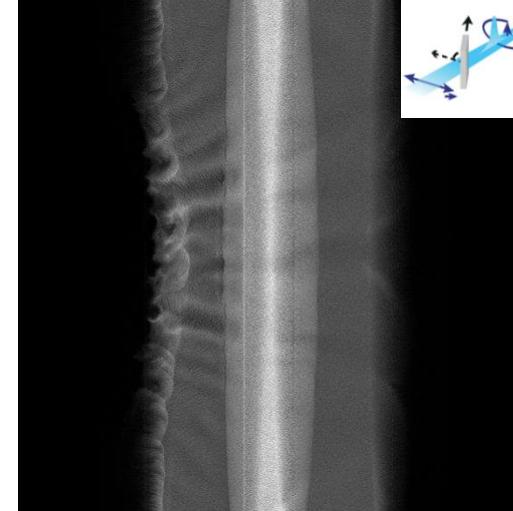
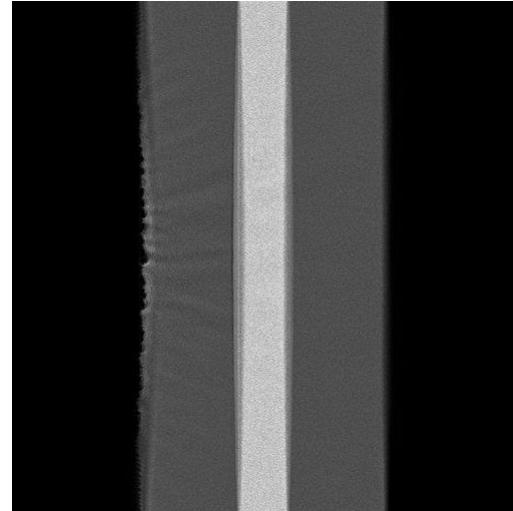
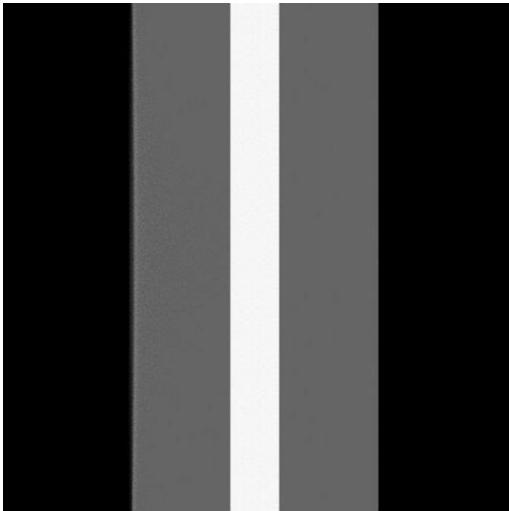
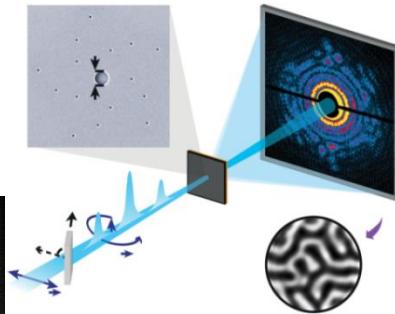
→ Isolate a specific charge-state by tuning to bound-bound resonance
(e.g., K_α or K_β)



Simulation (L. Huang): 10^{20} W/cm^2 , 50 fs → on 2.5 mm Cu

Small Angle X-ray Scattering (SAXS)

- spatial frequencies → mode structure of instabilities
- time history → growth rates, g vs k

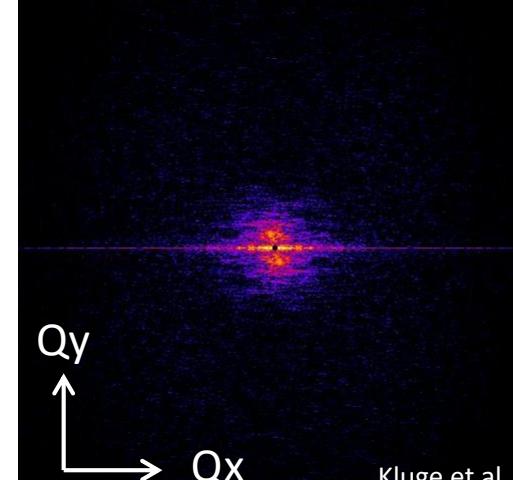


$704 \text{ fs} = T_0 - 606 \text{ fs}$

$1126 \text{ fs} = T_0 - 184 \text{ fs}$

Qy
↑
 $\rightarrow Qx$

Qy
↑
 $\rightarrow Qx$

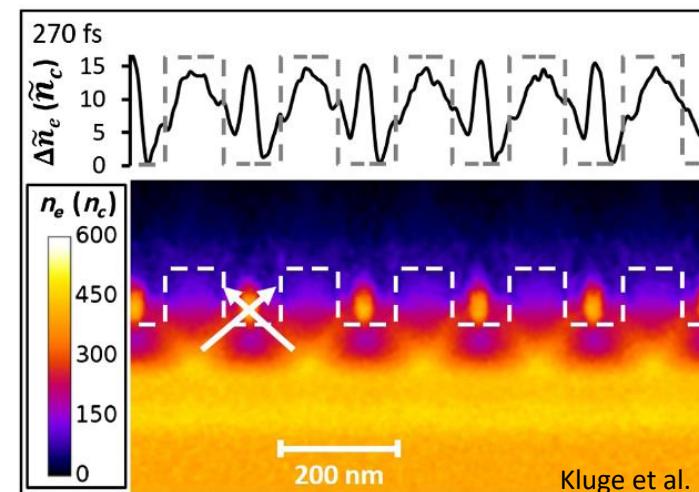
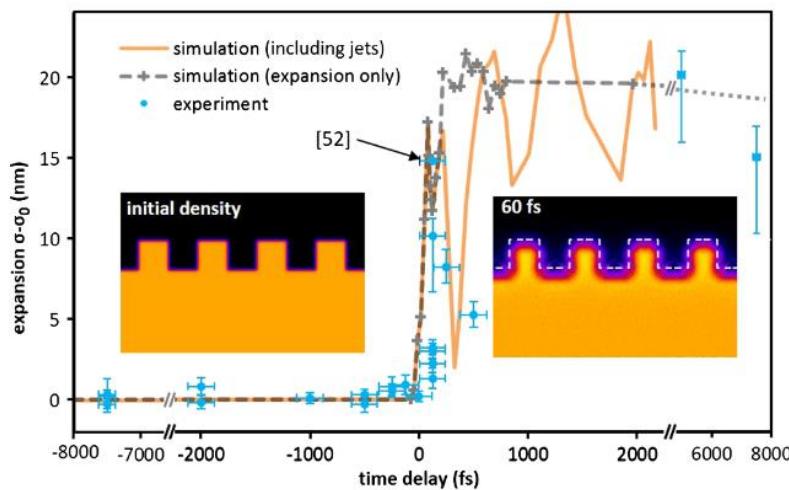
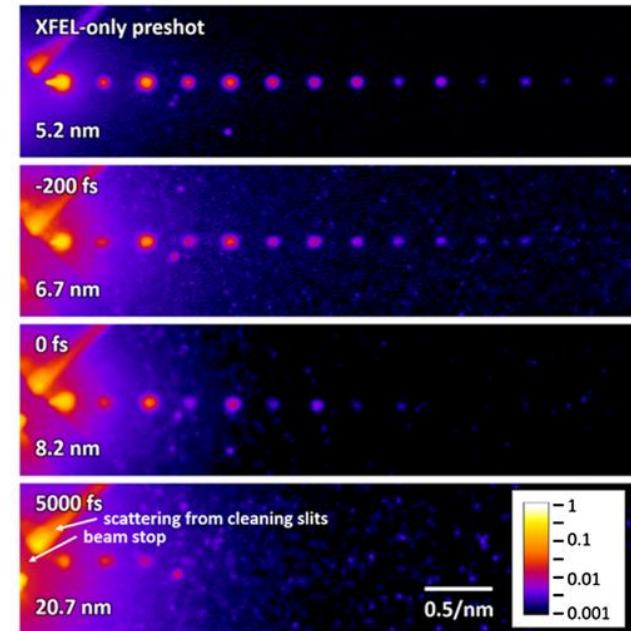
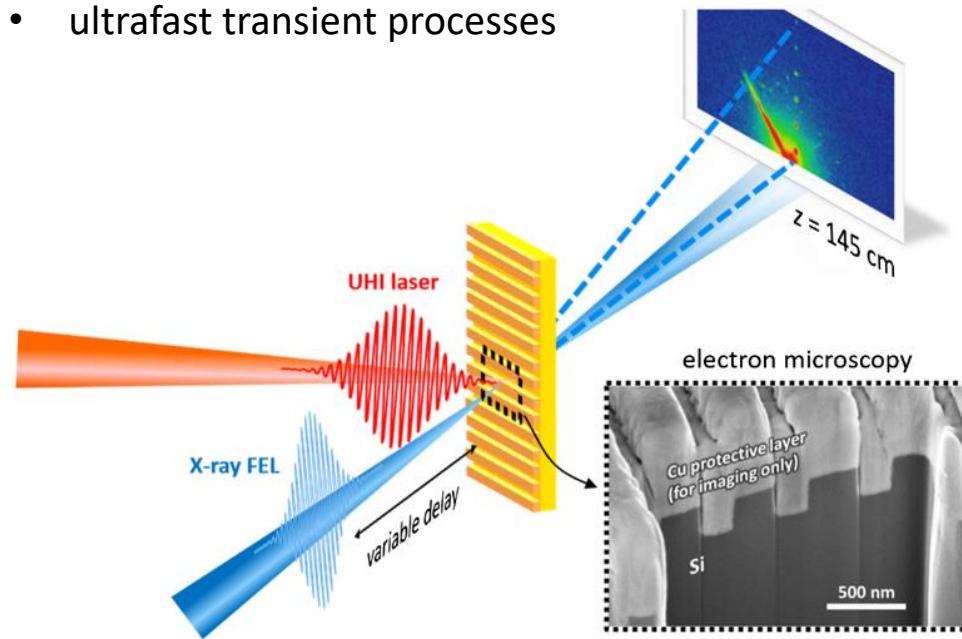


Kluge et al.

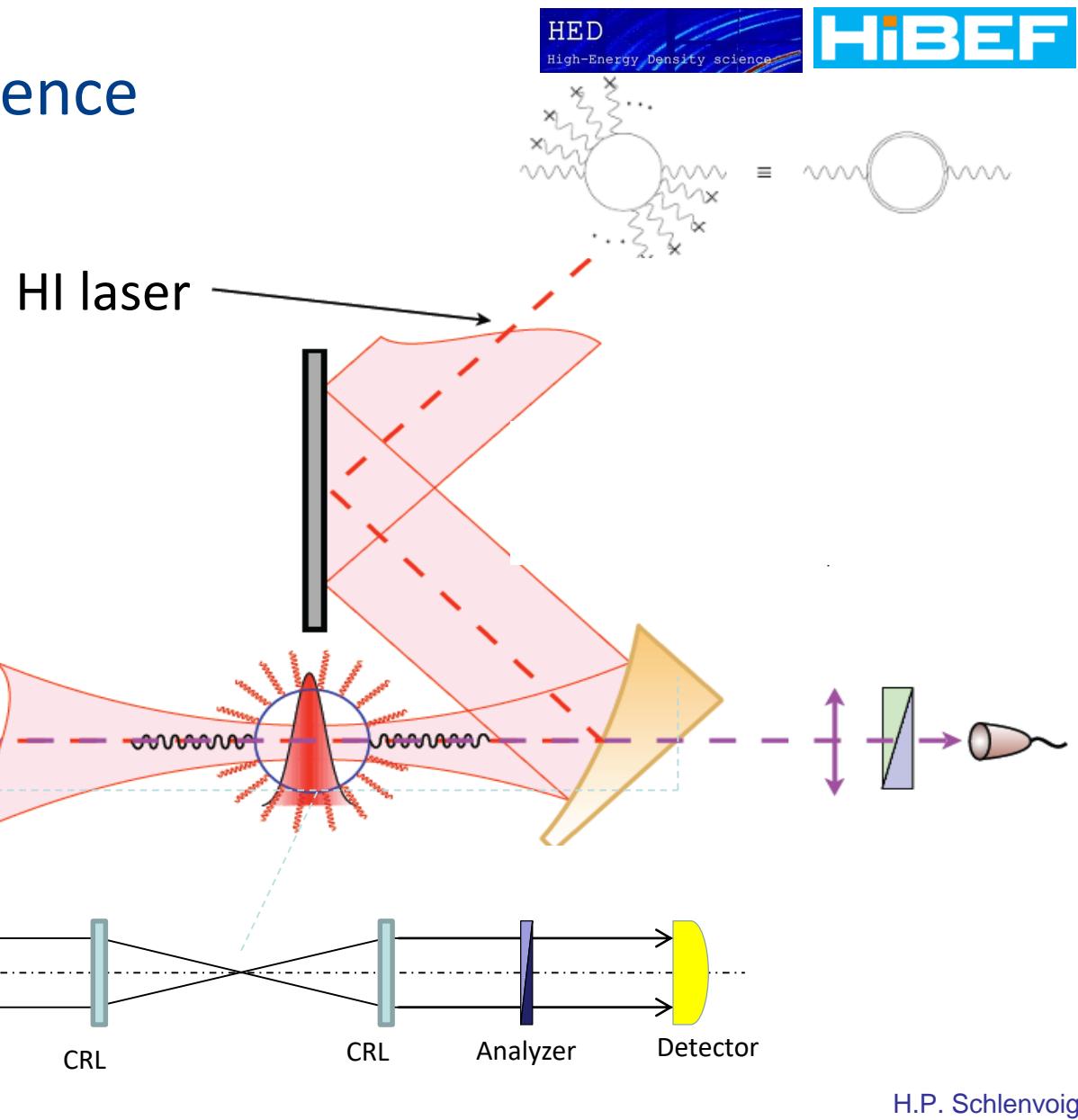
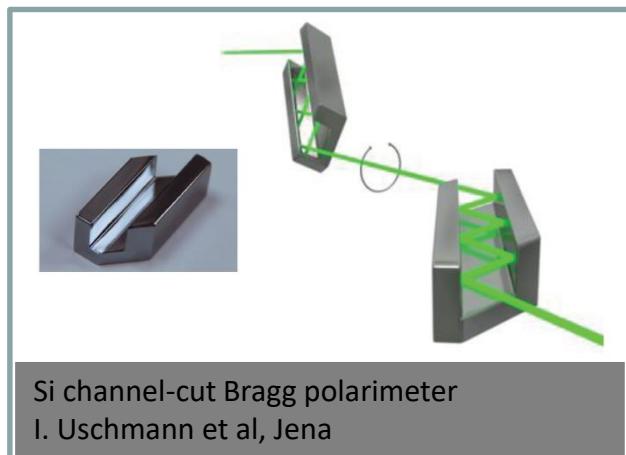
HzDR

Small Angle X-ray Scattering (SAXS)

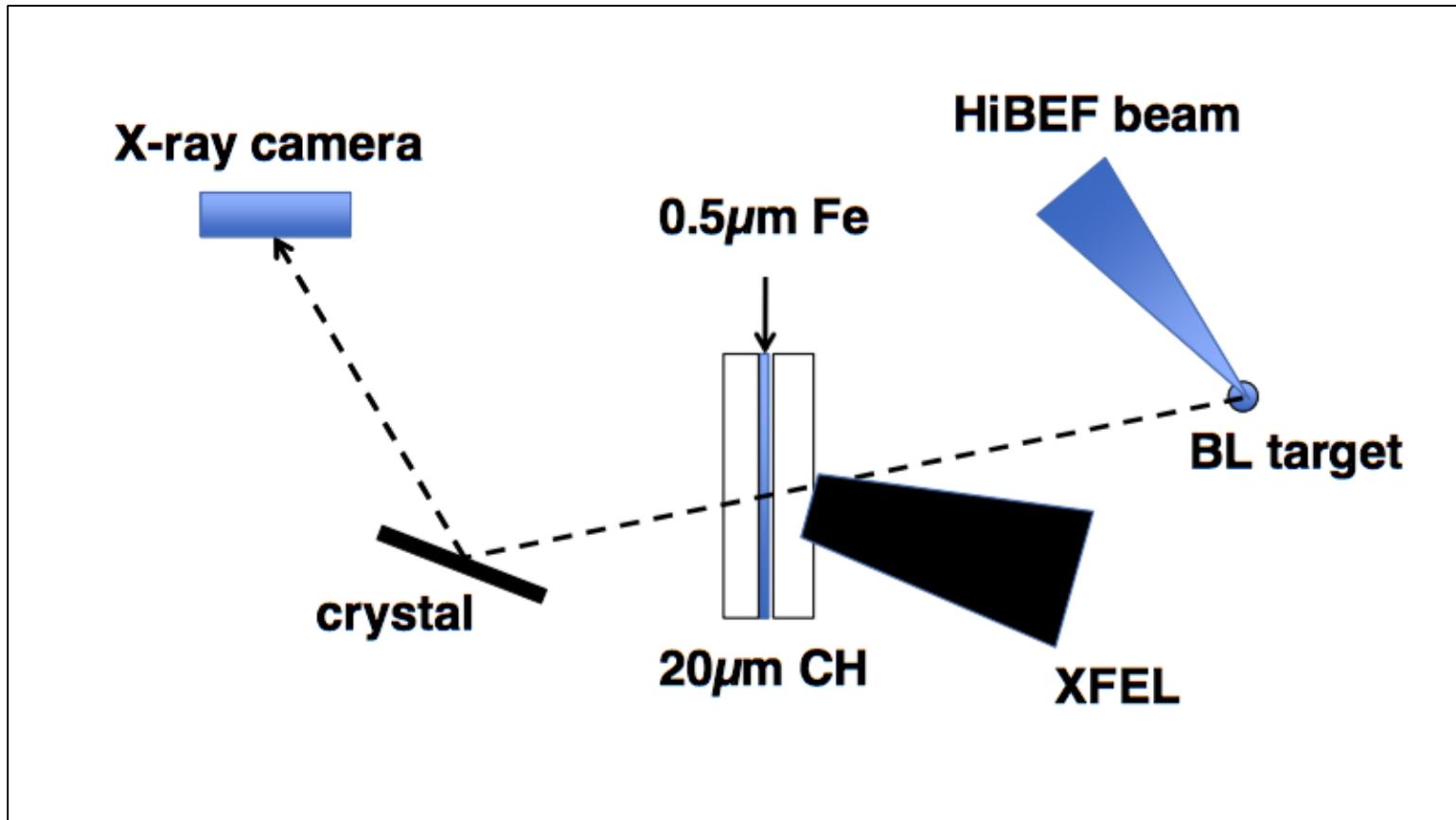
- ultrafast transient processes



Vacuum birefringence



HI Laser as backlighter Source for XANES



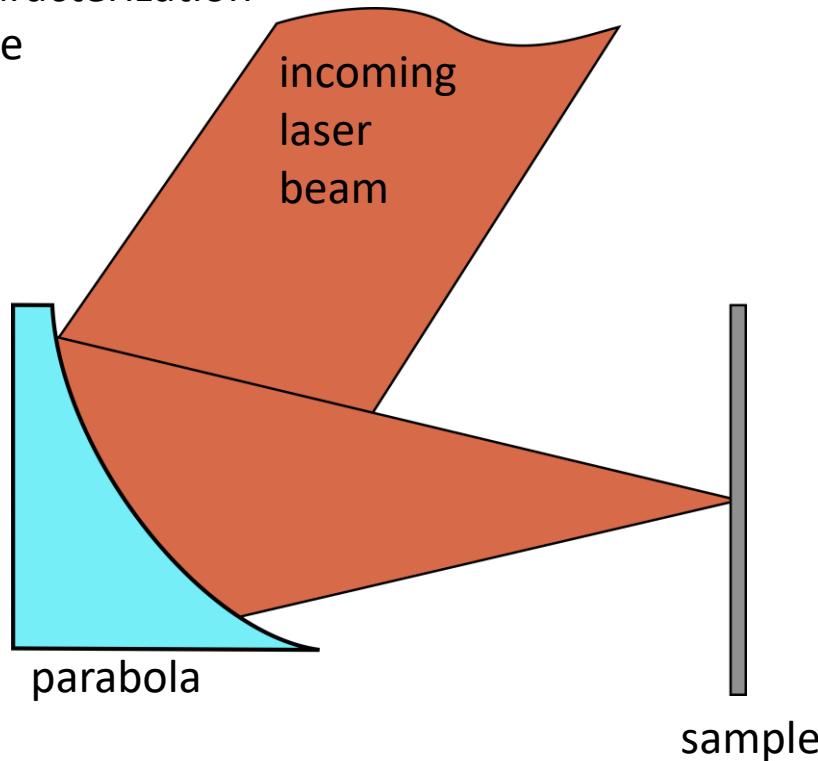
Proposed setup for probing time dependent ionization dynamic in solid density plasmas. A Fe tracer is embedded in CH and heated homogeneously by the XFEL beam. The HI laser is used to generate the backlighter XRAY beam for XANES. (O. Willi)

"principal" layout of laser experiments

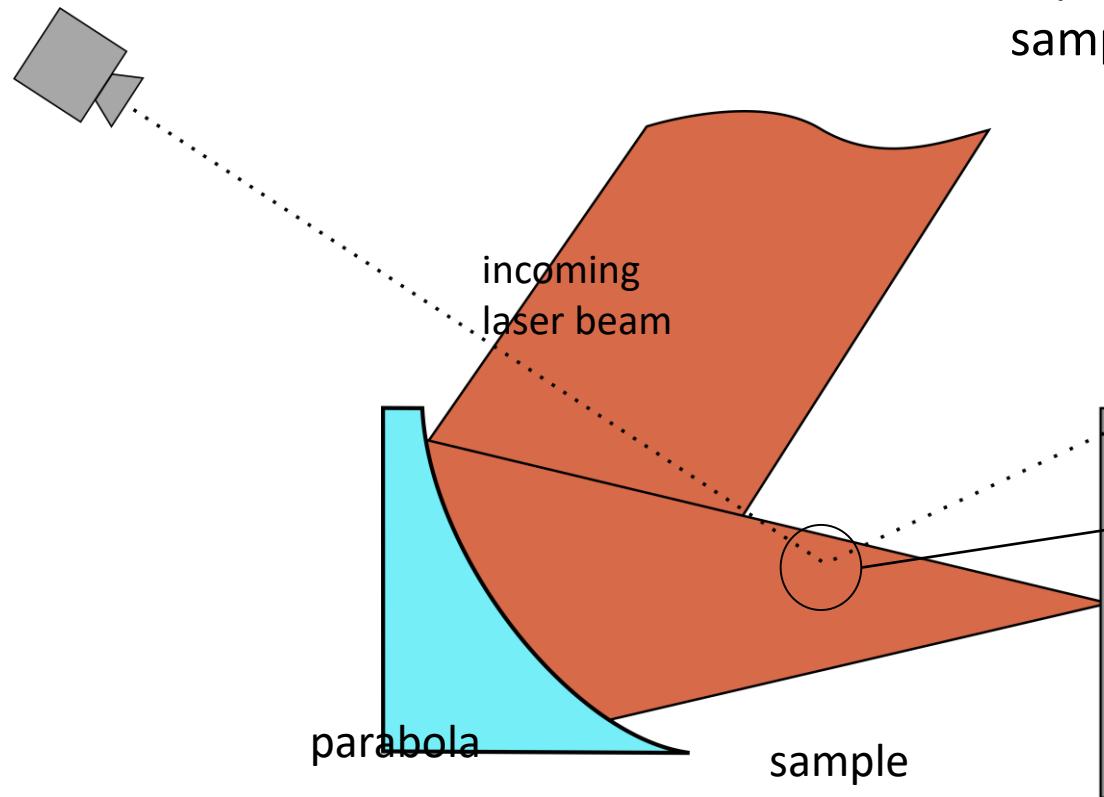
laser diagnostics package:

- near & far field
- energy
- contrast measurement
- wavefront characterization
- spectral profile
- ...

In detail the process is a lot more complicated...

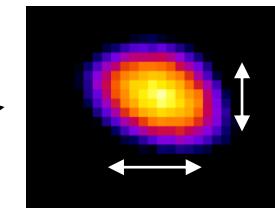


Sample alignment and focus positioning



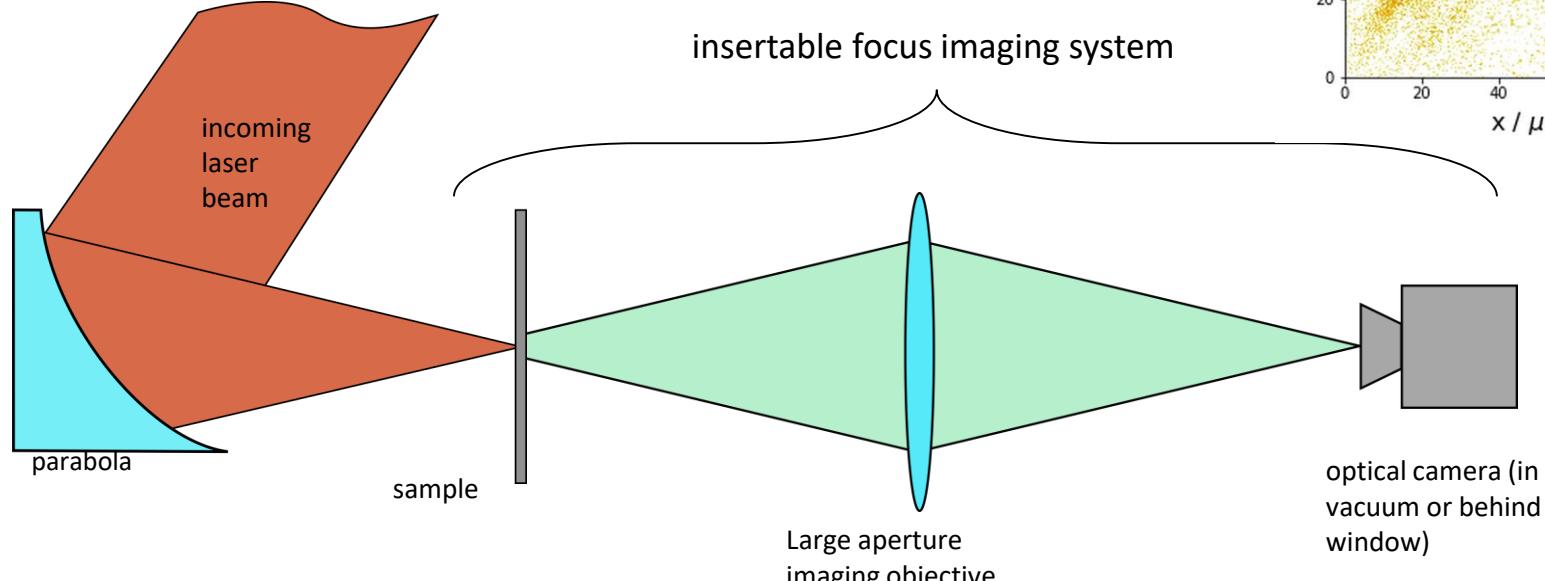
Questars typically reach positioning precision around 10 μm

Laser focus on sample:



focus $\sim 5 \mu\text{m}$
 $f\# \sim 2$
 -> focus depth of a few μm

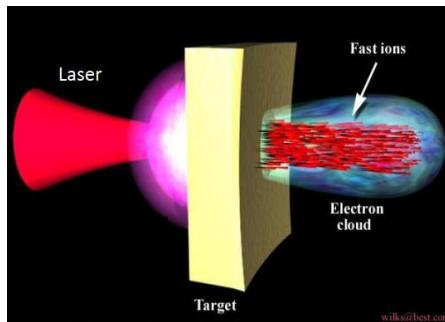
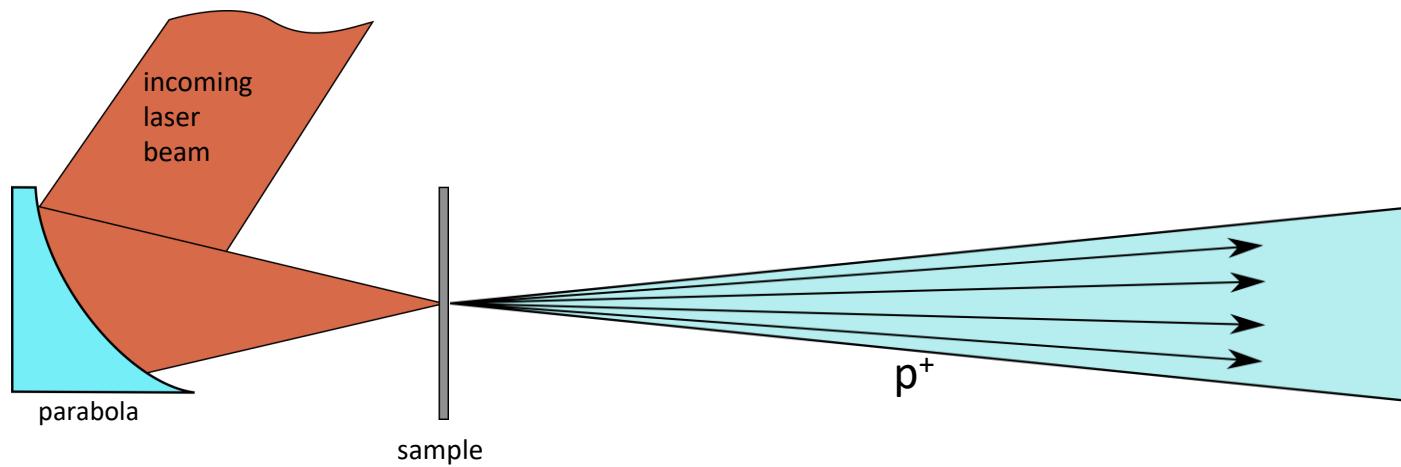
More precise focus imaging



laser in "low power" mode
(without changing focus!)

p^+ diagnostics

laser generated protons are a relatively good method to determine beam quality (focus size, contrast,...)

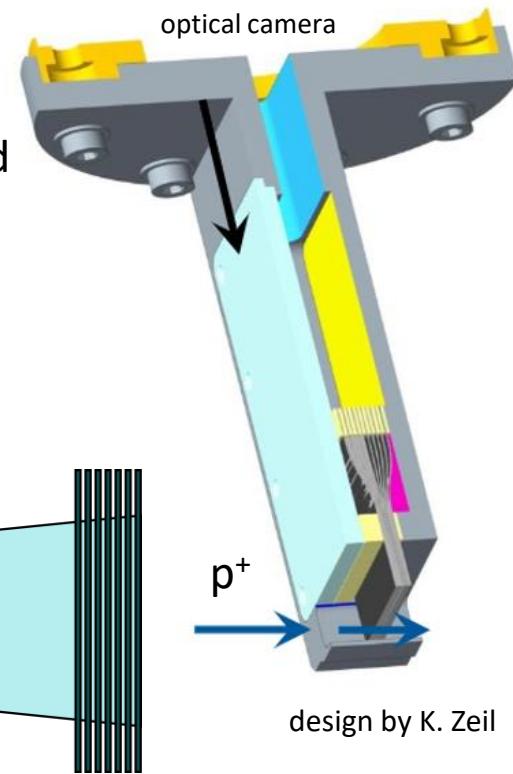
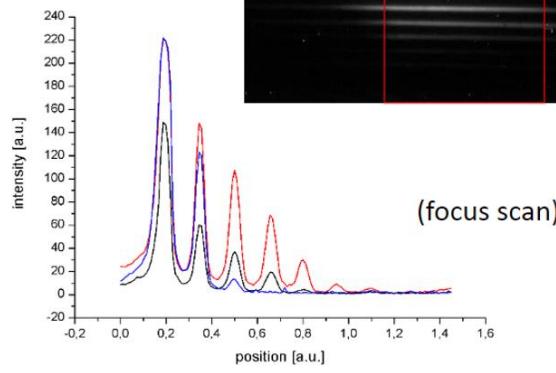
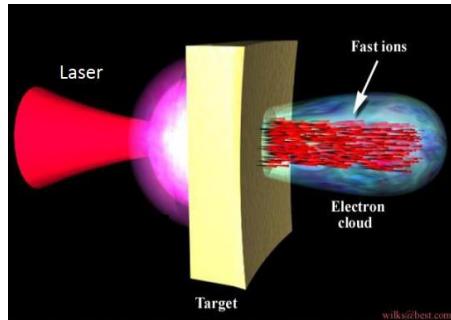
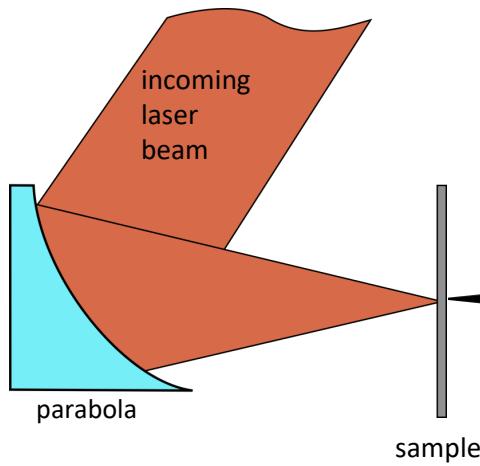


always perpendicular
to rear surface

-> Individual stack scanning,
multiple shot integration or in situ
scintillator readout (K. Zeil)

p^+ diagnostics

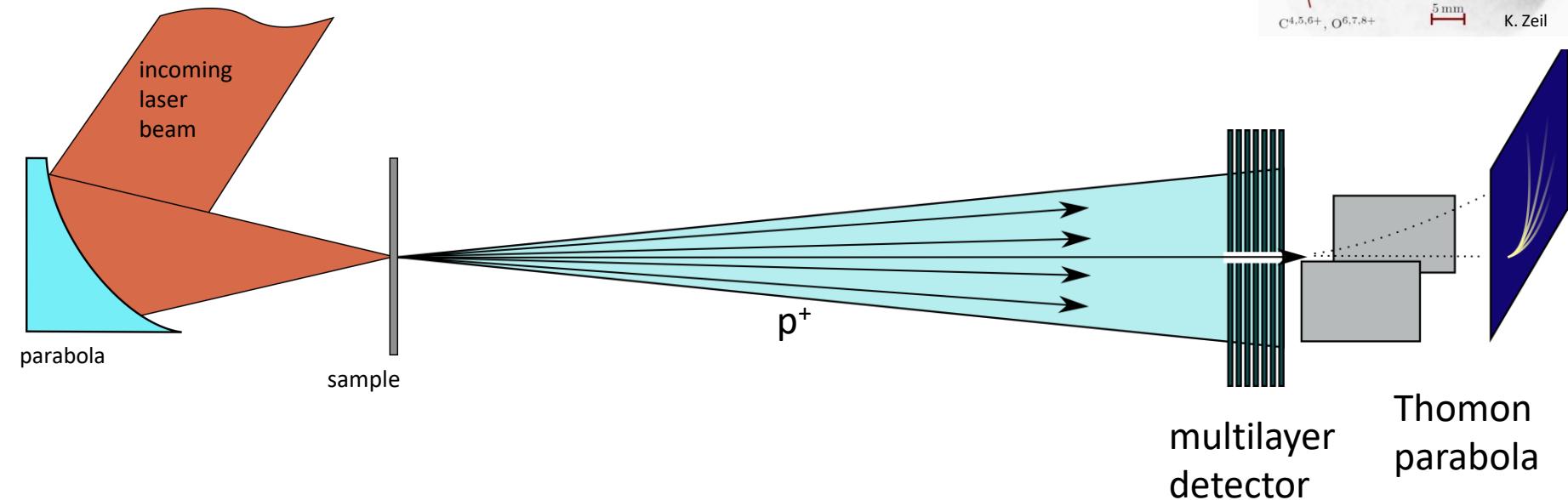
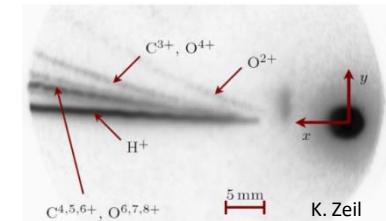
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multilayer
scintillator
detector

p⁺ diagnostics

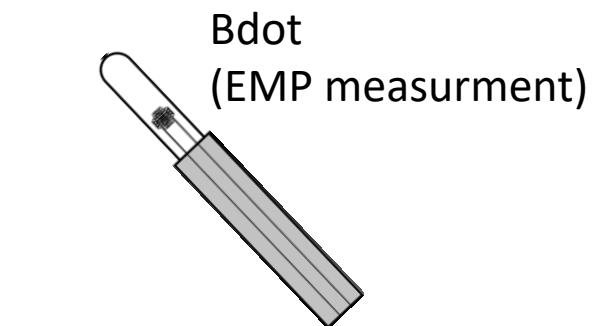
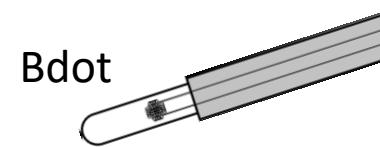
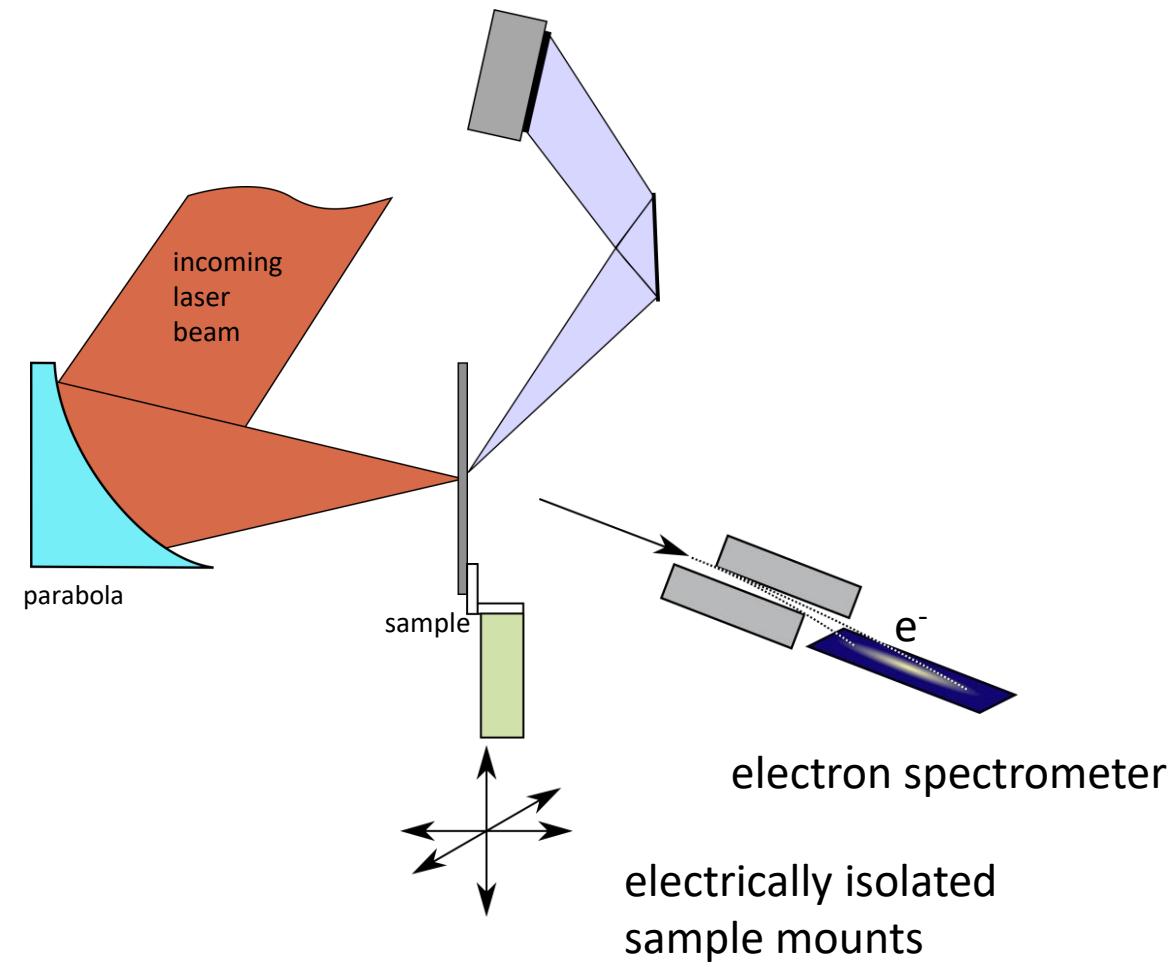
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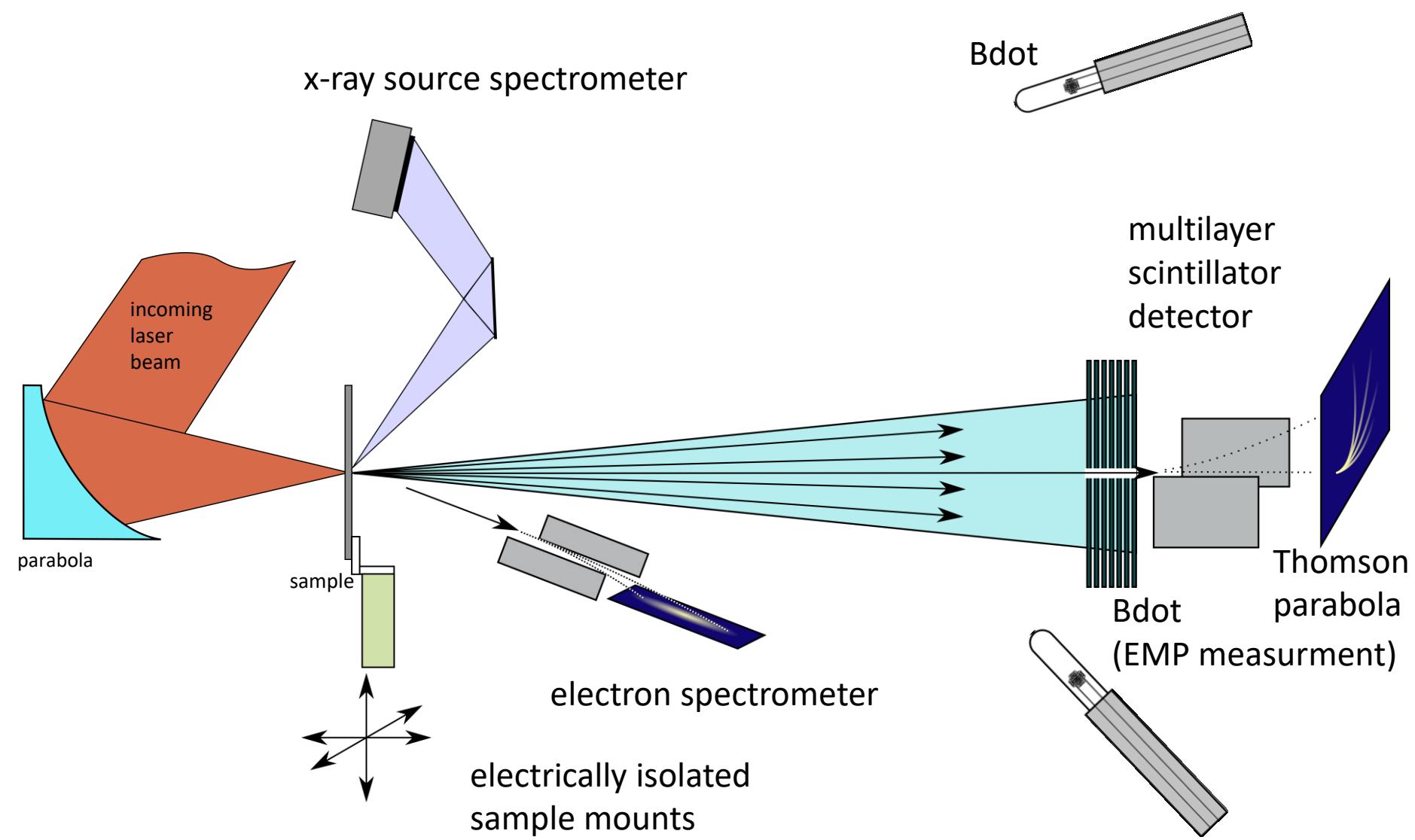
both can be combined, but
at HED RCFs may be
inefficient

Even more supplementary diagnostics

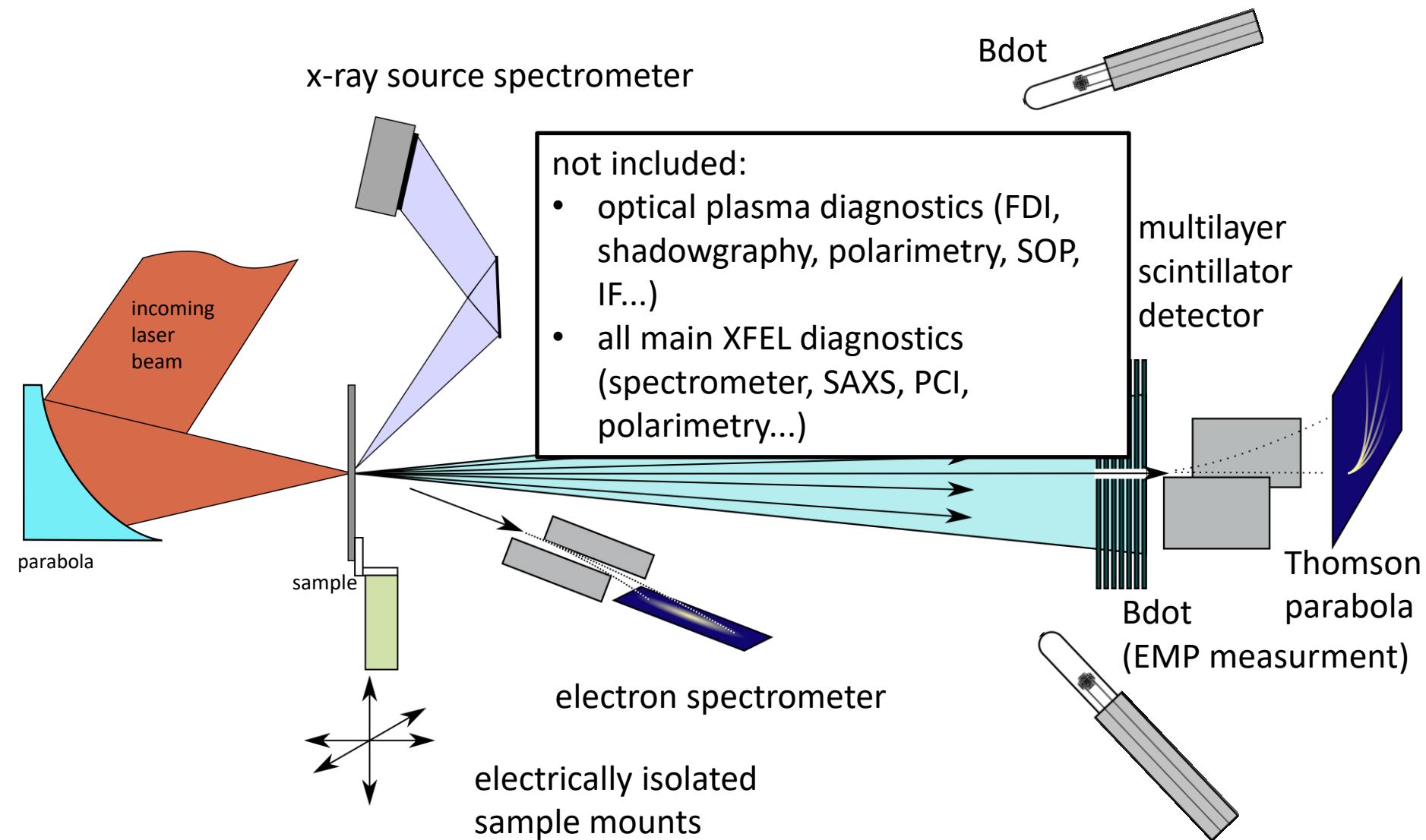
x-ray source spectrometer

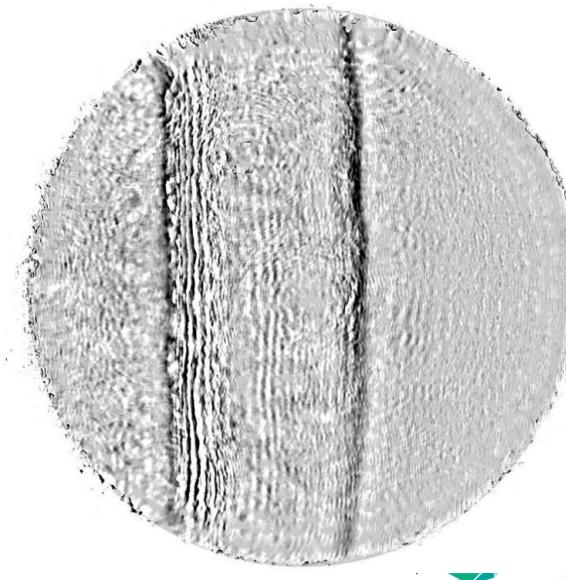
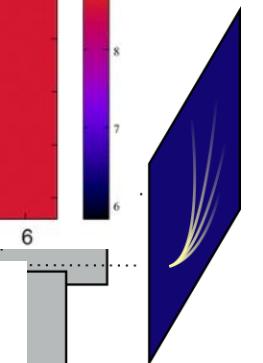
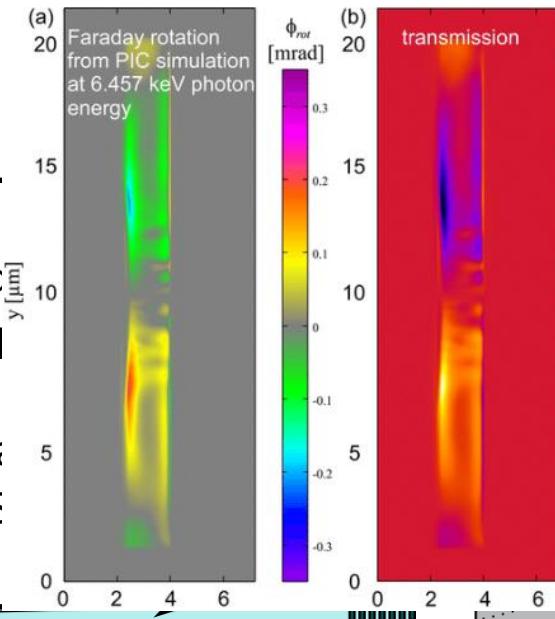
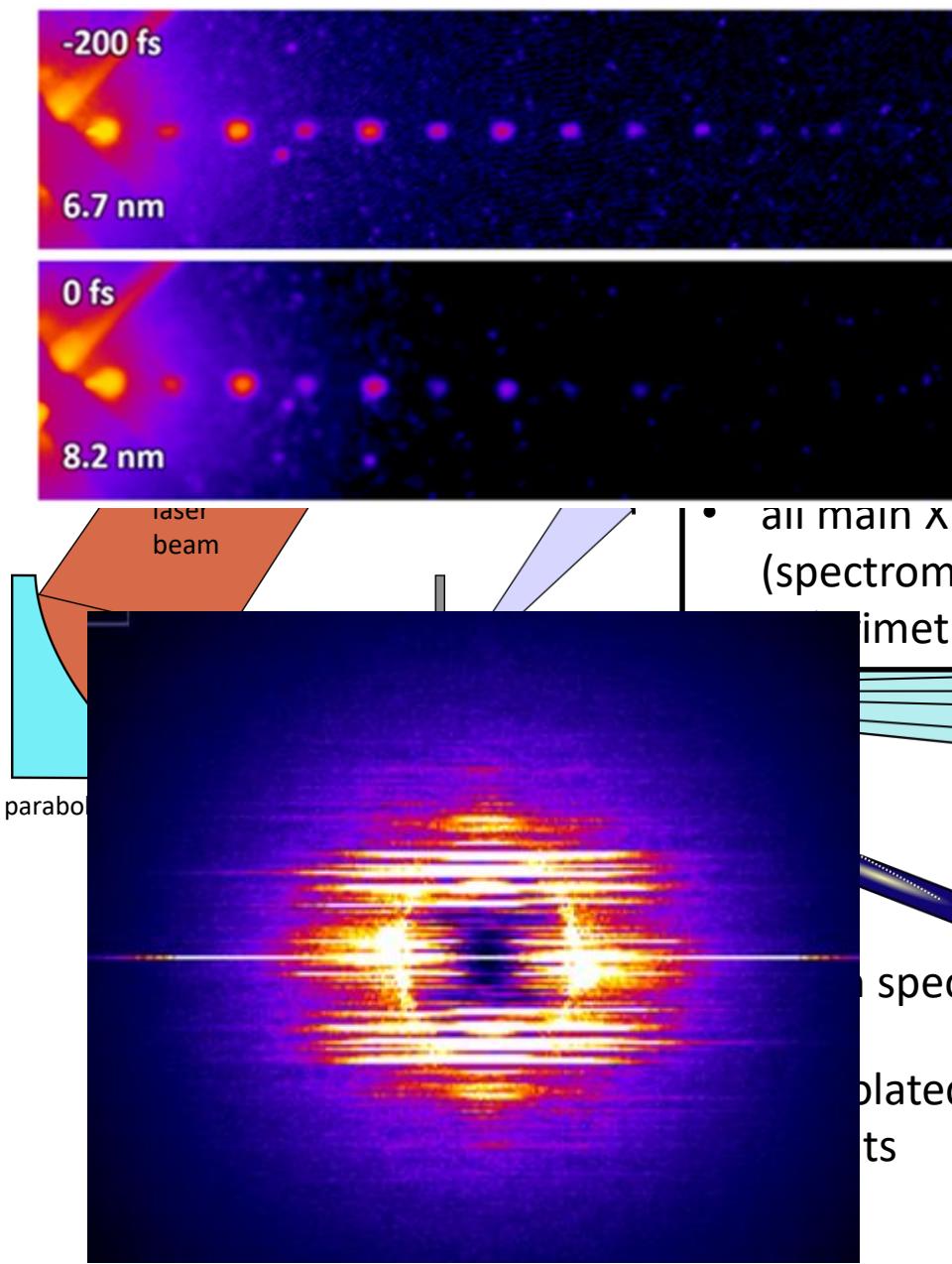


"Full" setup

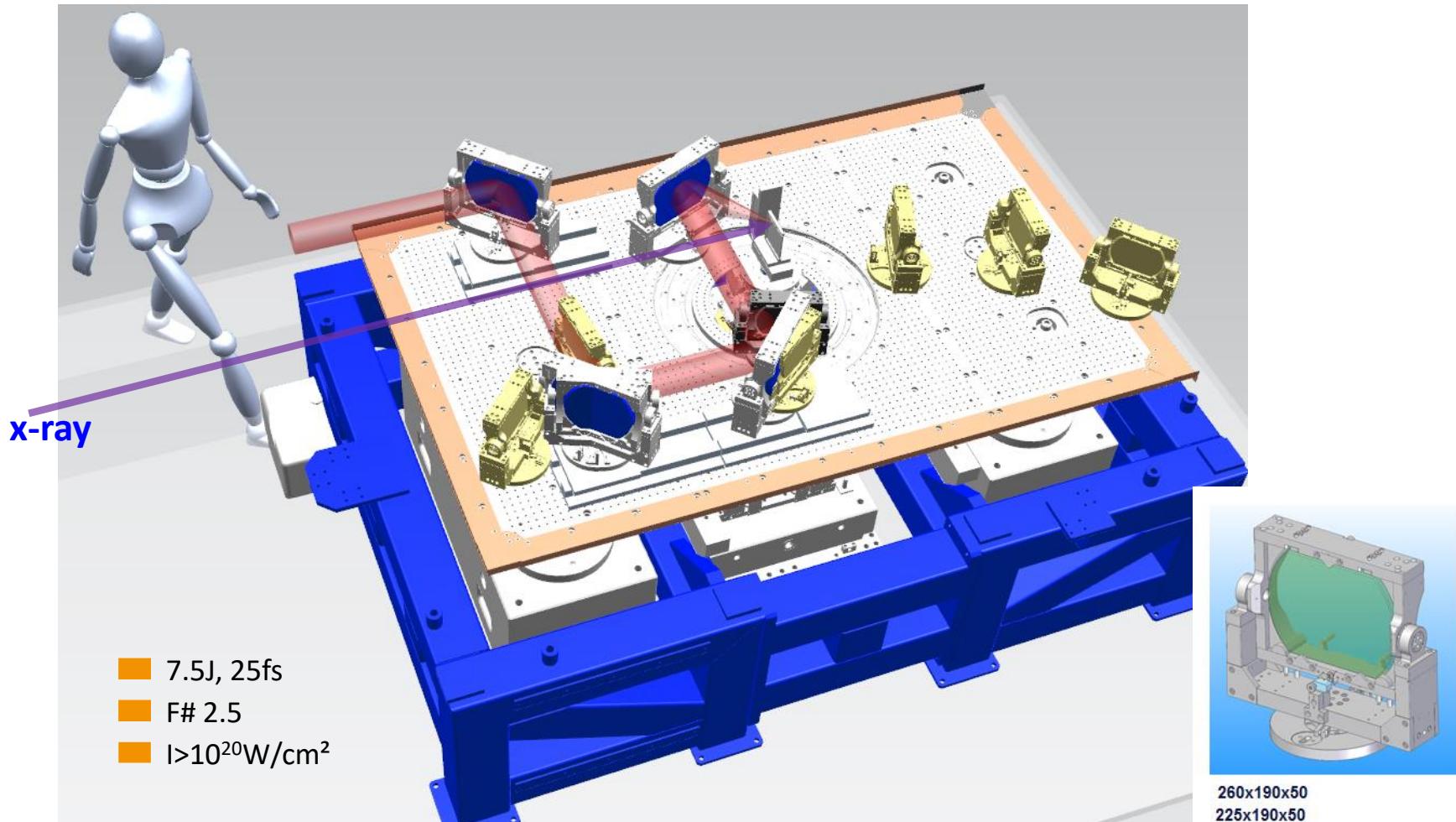


"Full" setup



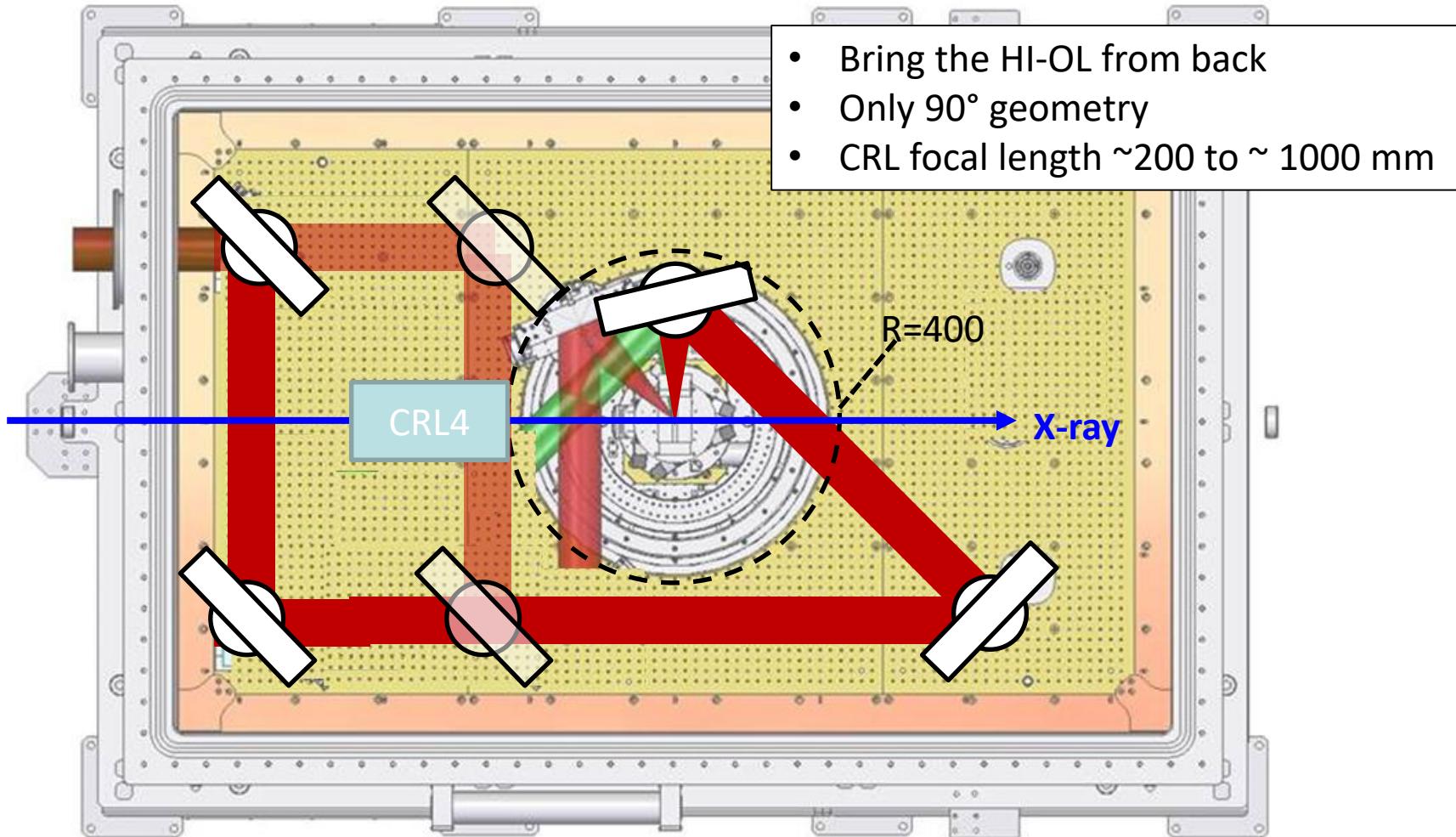


IC1 Geometry constraints



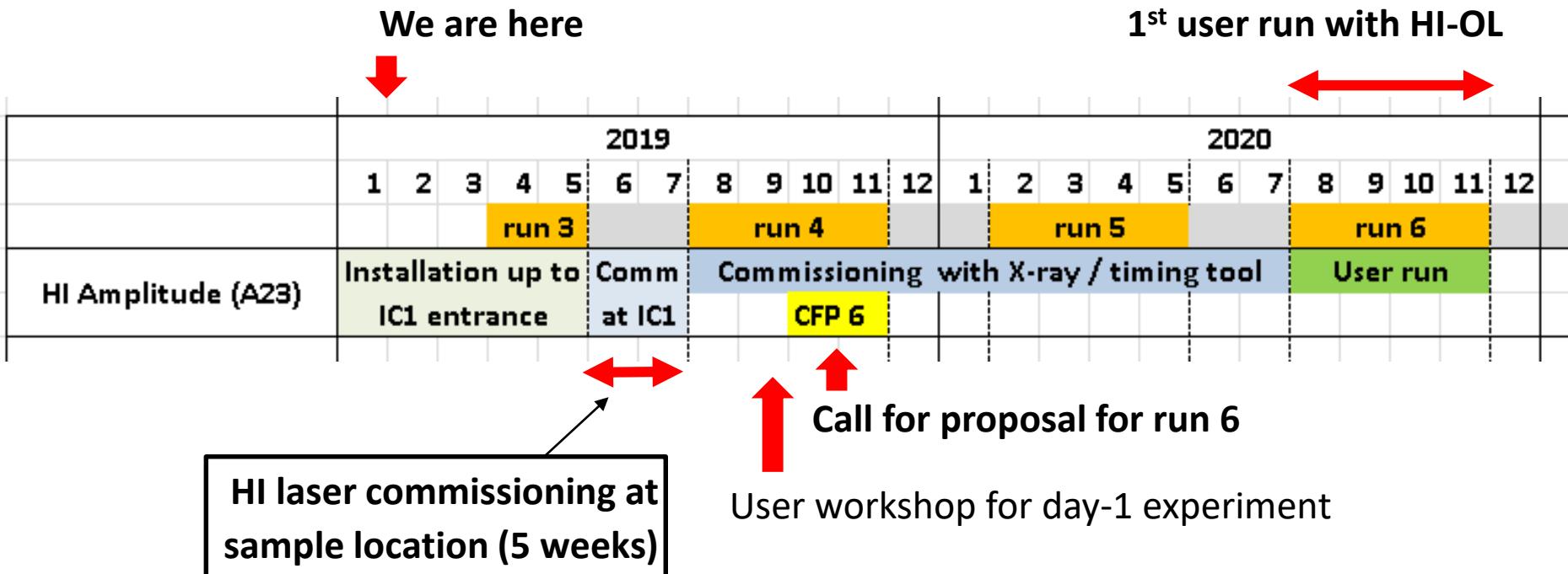
all HI laser related diagnostics have to be adapted for different geometries AND with regard to the XFEL beam and diagnostics!

IC 1 Geometry constraints



all HI laser related diagnostics have to be adapted for different geometries AND with regard to the XFEL beam and diagnostics!

Timeline



- on-site acceptance test / laser handed over

March-May

- Compressor optics, deformable mirror, wavefront, RGA
- Pickup probe transport, compressor
- Laser diagnostics installation and commissioning
- PAM optics installation

Commissioning

Summer shutdown June 10 - July 12 (5 weeks)

1. Focus the beam at sample location. Characterization and optimization (4 weeks)

- Place stages, optics, align beampath, focus OAP
- Spot size, energy measurement, temporal profile, spectral phase
- Must be done with fully amplified beam and in vacuum

2. Benchmark shots on samples ramping to high power (2 weeks)

- Particle / optical diagnostics
- Test performance of mirrors, OAP, optical elements
- EMP test, performance of motors

3. Timing drift measurement between HI-probe and HI-main (2 weeks)

- With optical cross-correlator

4. Photon Arrival Monitor (PAM) commission in Optics hutch (2+ weeks during run 4)

- includes cross correlation with spatial encoding timing tool in IC1

- Tight schedule!
- In parallel with other activities

EMP

- High intensity lasers produce strong electromagnetic pulses, depending (among other things) on
 - laser parameters (energy, intensity, contrast)
 - sample environment (size, material, geometry)
 - sample mount (electrical isolation vs. grounding)
 - chamber geometry (ringing...)
- This can cause damage to diagnostics and motors if not properly shielded and/or isolated and must be minimized!
- EUCALL workpackage 6 (HIREP)
 - design a concept for a high repetition, emp-resistant sample mount
<https://www.eucall.eu/organisation/deliverables/>
 - motors and detectors are tested at similar laser facilities (DRACO...)

HED, XFEL, and HiBEF

- The HED experiment and the HiBEF consortium relies HEAVILY on contributions from the community, and all help is appreciated.
BUT...
- many interfaces are already defined, bringing in additionally diagnostics or components, even temporarily, should be well planned and communicated early.

Thank you for your attention!