Study of Fast Electron Transport Through a Thin Gold Foil into Warm Dense Plasma Targets and its Implications for FI

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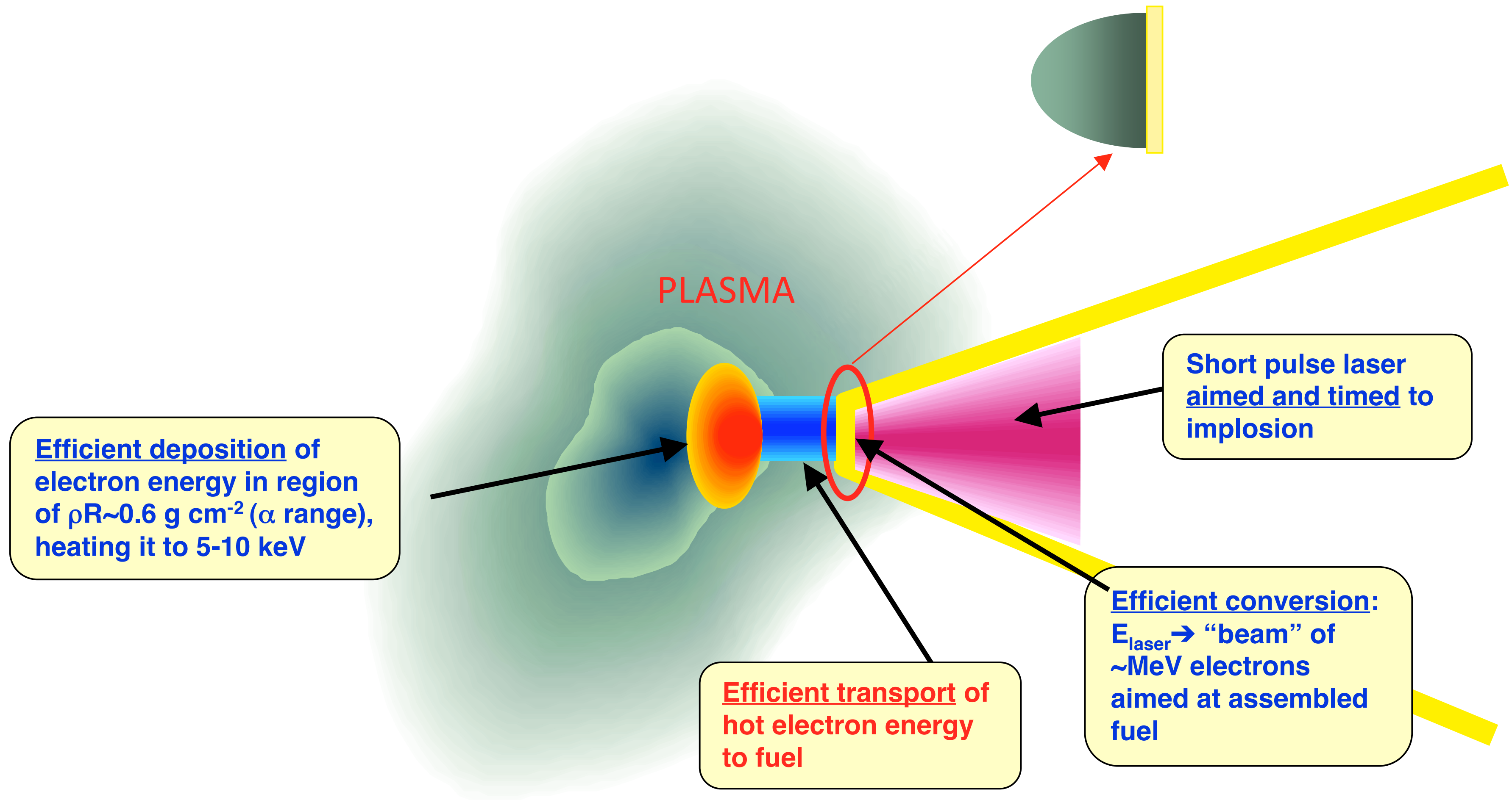
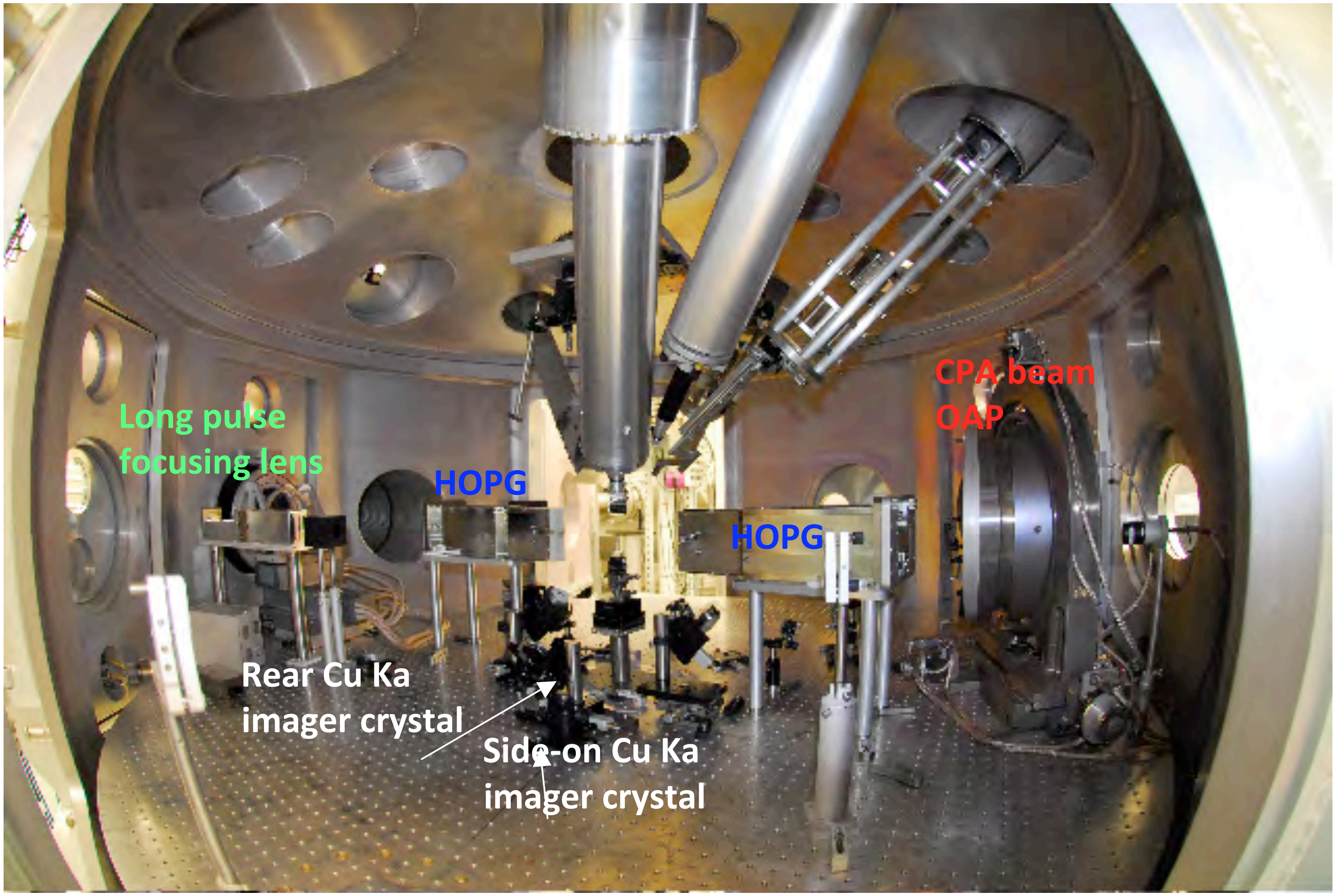
Motivation - study of cone-tip physics using a simplified planar geometry



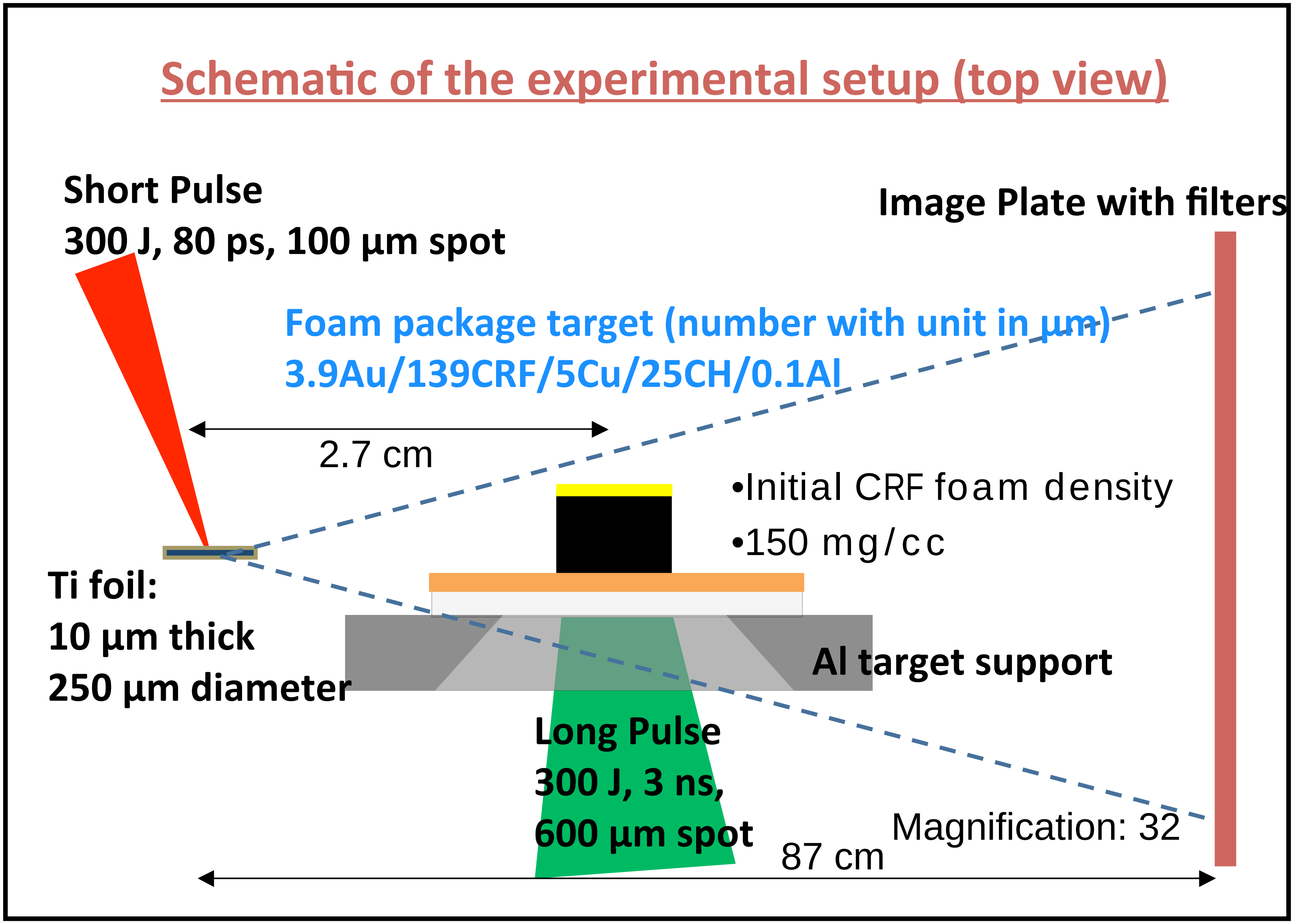
- FI requires efficient energy coupling from ignition laser to the compressed fuel
- Cone tip physics is complicated and extremely important to FI
- Transport from the source (high Z cold Au) into solid density PLASMA targets is not well understood - current experiments mostly performed with cold solid target

Experiments using the Titan laser at JLF were performed to study fast electron transport from the Au source foil into warm dense plasmas

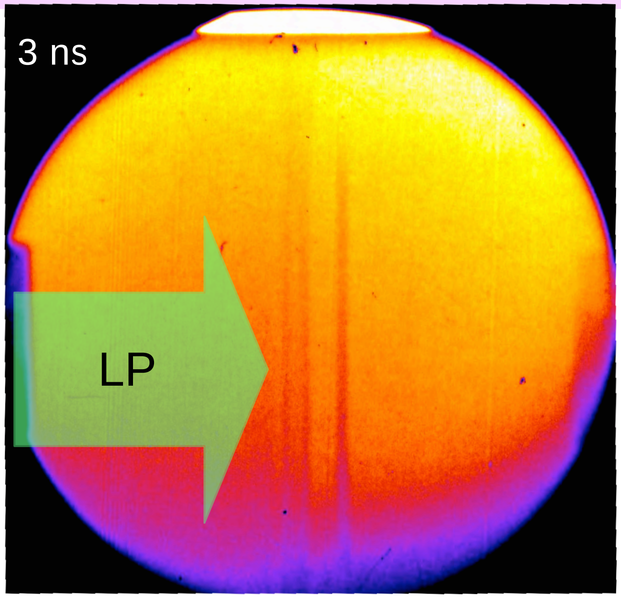


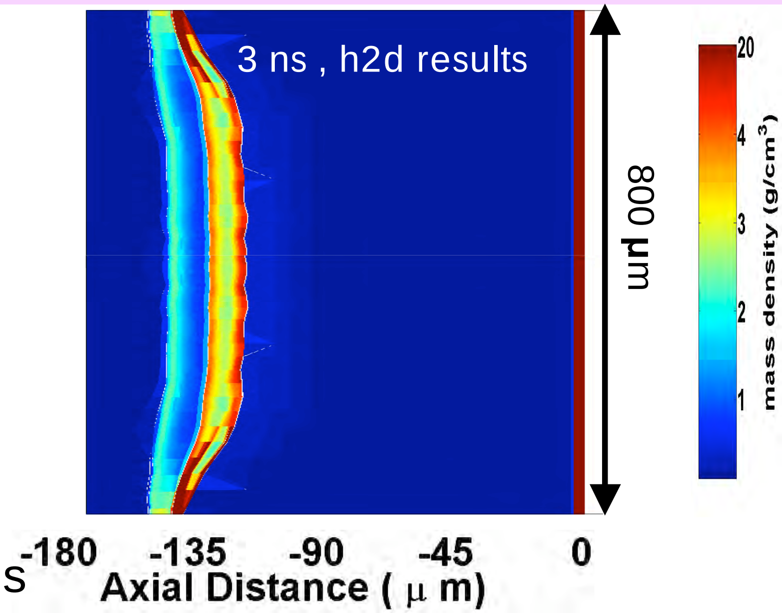
A comprehensive diagnostics suite was used to characterize transport properties by measuring Cu Kα yields and spatial profile as well as fast electron spectrum

Side-on Ti x-ray radiography to characterize shock propagation and provide timing reference for transport study



Radiography data and h2d rad-hydro simulations show shocked Cu propagation in foam targets

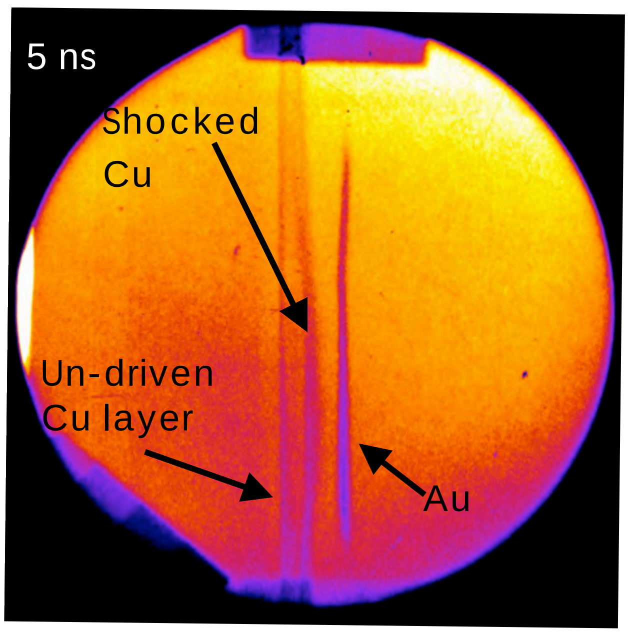


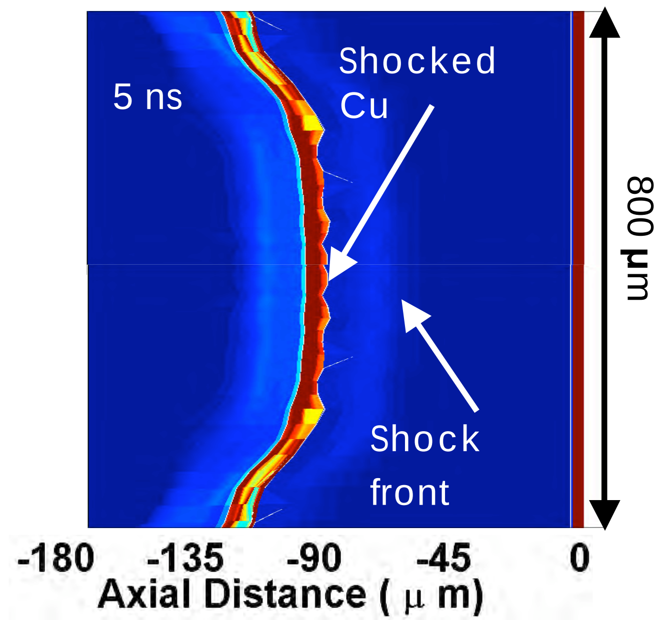


Exp:

V_{ave}: ~9μm/ns

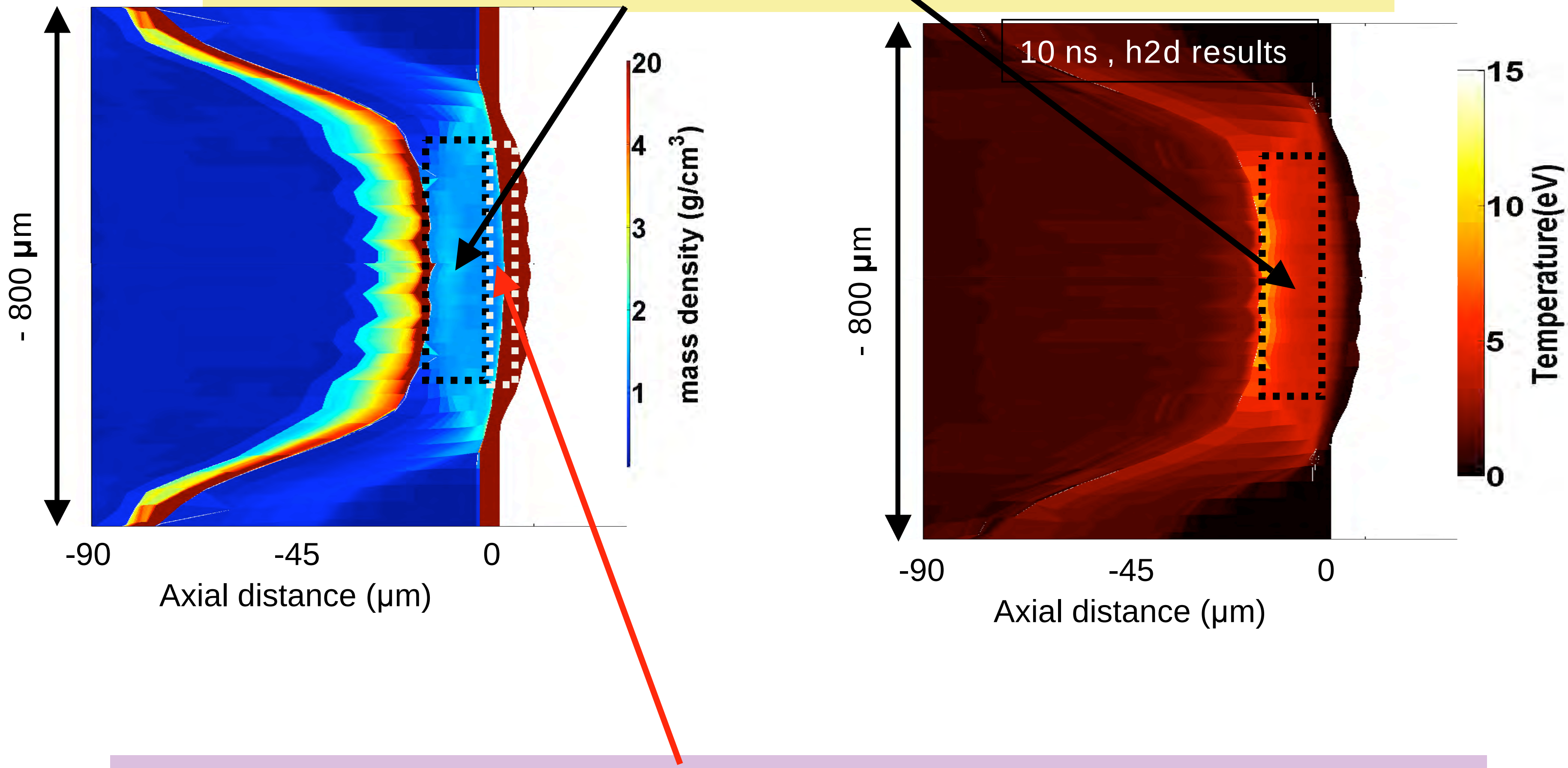
h2d:13.45μm/ns





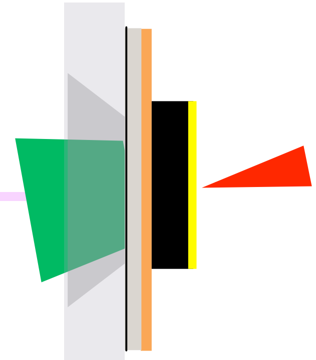
h2d rad-hydro simulations suggests WDM parameters of a few eV and 1.3g/cc at the maximum compression

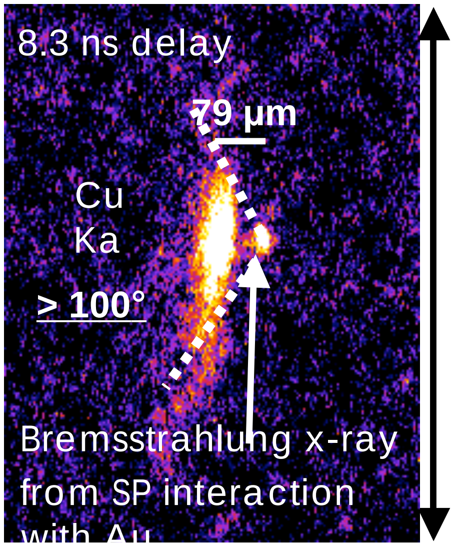
WDM at maximum compression: ~ 1.3 g/cc, 5-10 eV, ~14 µm thick and ~400 µm in height

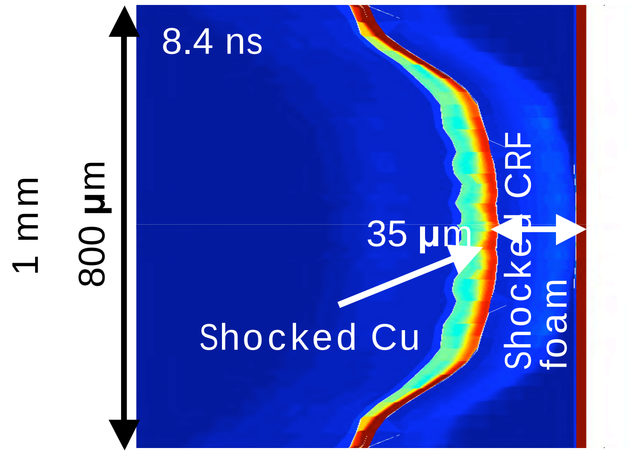


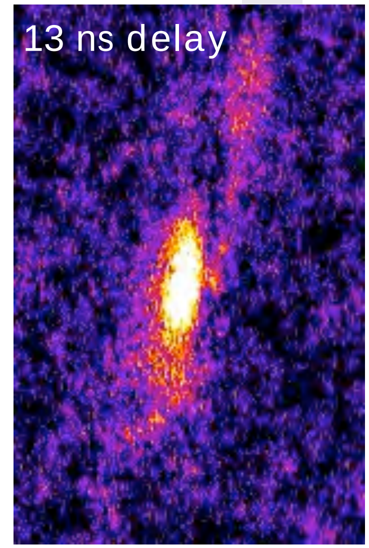
Fast electrons transport across the density gradient at the Au/WDM interface

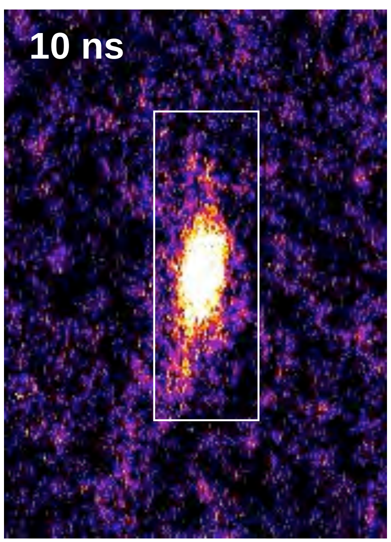
Large extended Cu Kα spot is consistently observed in WDM targets suggesting a large angular spread of fast electrons

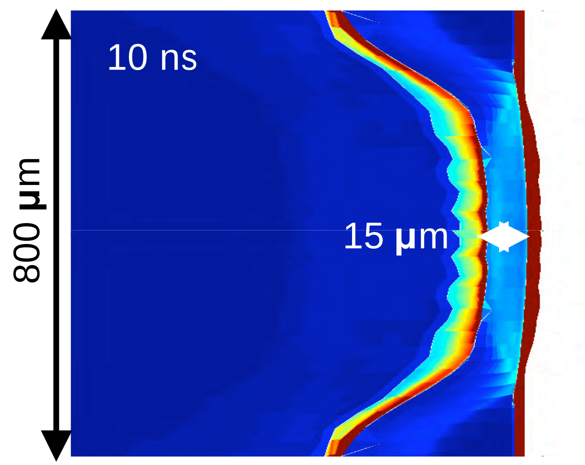








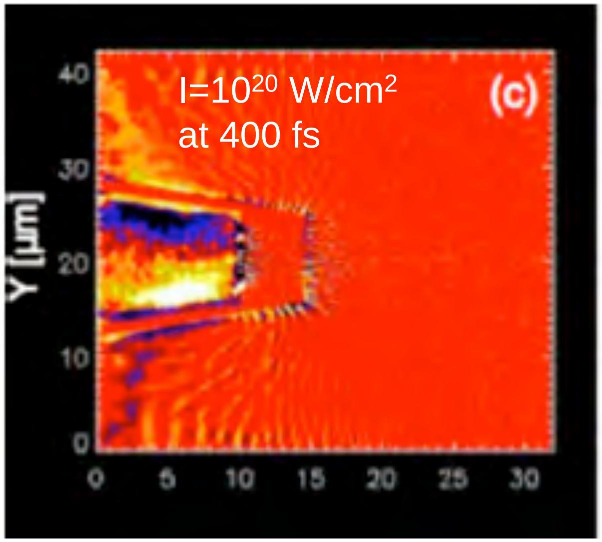


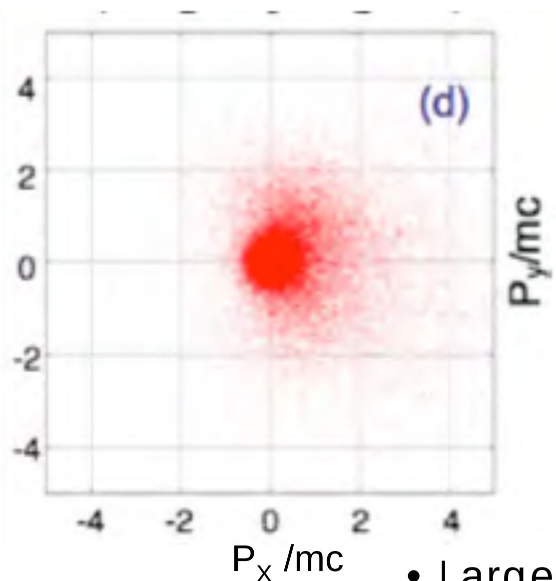


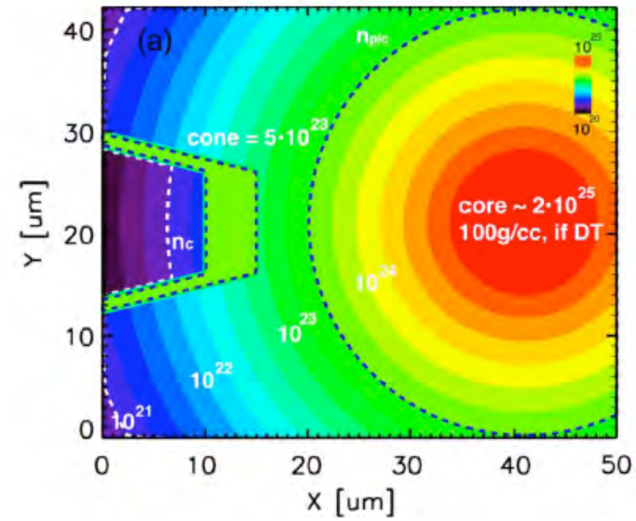
Cu Kα imager revealed critical information of fast electron angular distribution in WDM transport exp.

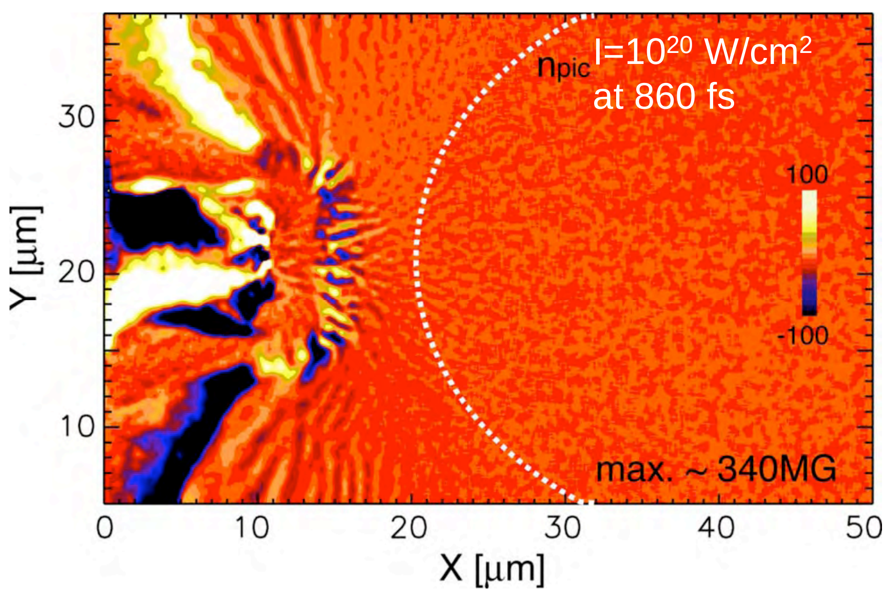
- **SP only or LP only or LP+SP (with 3ns delay) shots did NOT produce such large extended spot in the same type of foam package targets**

Previous hybrid PIC simulations suggested a large angular spread as the result of randomizing effects by strong B-fields generated at the interface of the outer cone tip and the low density plasma*









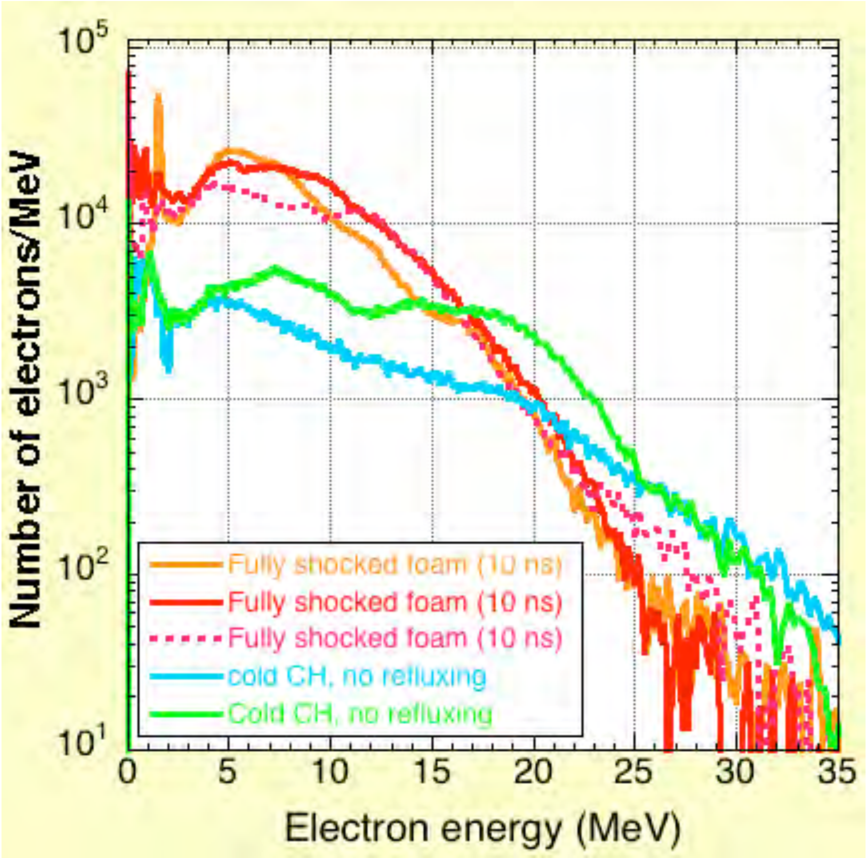
- Large spread could be due to randomizing effects on electron trajectories by intense B-fields generated at the interface of high density Au and relatively low density WDM

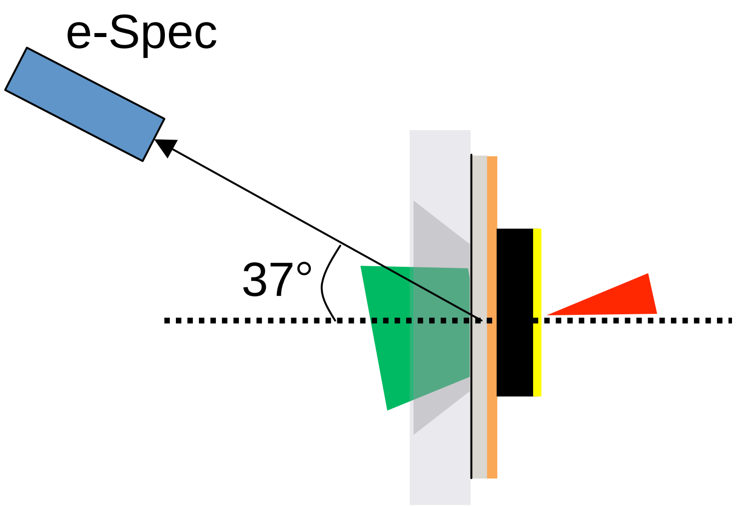
- PIC simulations using the PICLS code# are currently being performed with our experimental parameters to investigate the underlying physics

*B. Chrisman et al., Phys. Plasmas 15, 056309 (2008) #Y. Sentoku et al., J. Comp. Physics 227, 6846 (2008)

Electron spectrometer provided complementary data on the fast electron angular distribution

5X increase in escaped electrons with energy <15 MeV through the fully shocked foams compared to cold CH transport foil with similar ρr





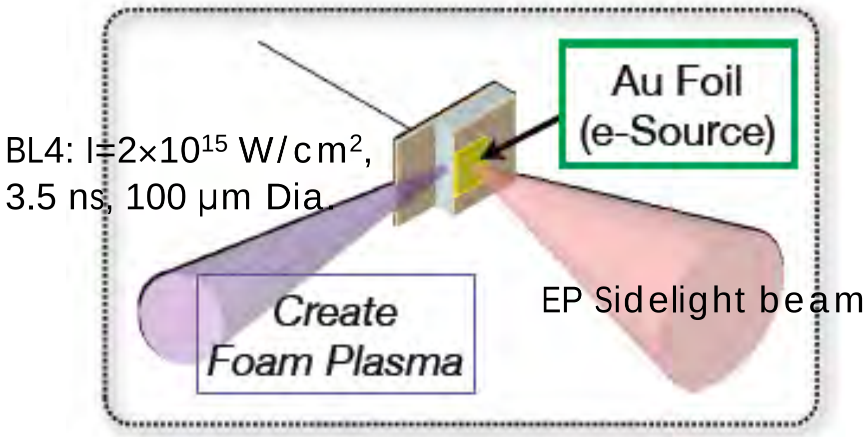
- Consistent with wide disperse of electrons shown by the large **Cu Kα spots**

Summary and future scale-up hot transport experiments using the Omega laser facility …

On Titan (July 2009):

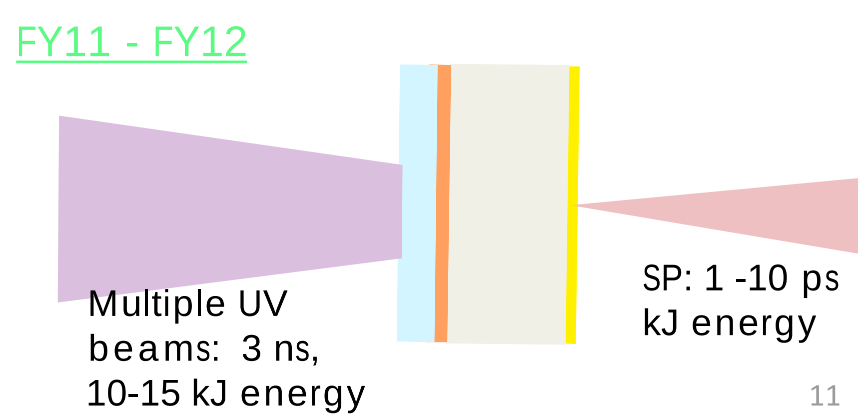
- Warm dense plasma with a few eV temperate and solid density was created by Laser driven shock compression of foam targets
- Study of relativistic electron transport in such warm dense plasmas was performed
- Significant large Ka spots observed as the result of fast electron transport into WDM
  - indicating wide disperse of fast electrons when propagating from the Au source foil into WDM due to randomizing effects by B-fields
  - PICLS simulations are being performed to facilitate transport physics understanding

Transport Shots scheduled on EP: Aug. 2010 (T. Yabuuchi)

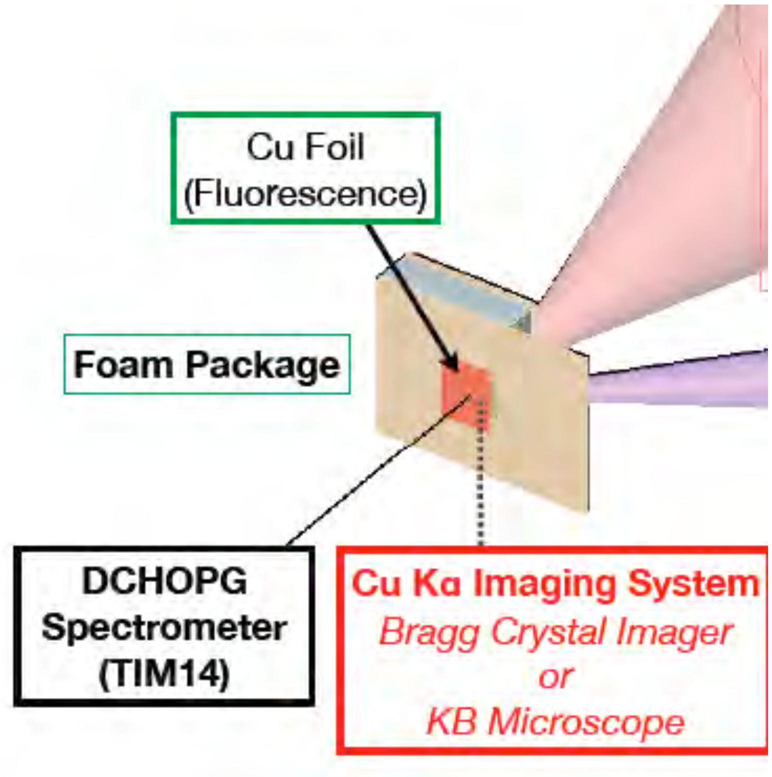


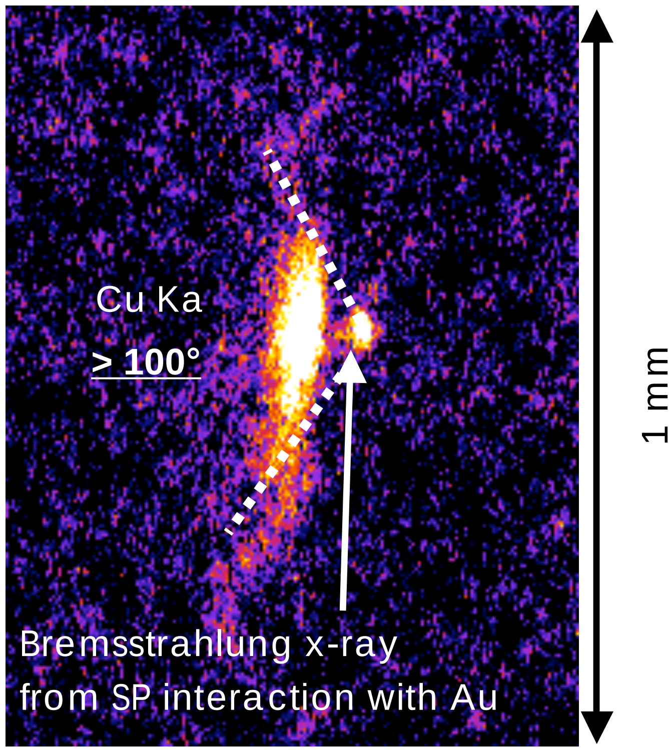
Hot CH plasma: 30-40 eV, n_e= 10^{22} cm^{-3}, 250 µm thick

We propose to further study electron transport in hot dense plasmas at Omega or EP with >30X driver energy to better mimic FI cone tip plasma condition



Request: Kα imager is a must-have and urgently needed diagnostic at Omega Laser Facility for the proposed electron transport experiments





- Fast electron beam divergence is one of critical parameters for FI
- K-shell x-ray imager is an essential diagnostic(and also the most commonly used) providing direct information for beam divergence