LEH Transmission and Early Fuel Heating for MagLIF with Z-Beamlet

Exceptional service in the national interest

Sandia National Laboratories

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Sandia National Laboratories

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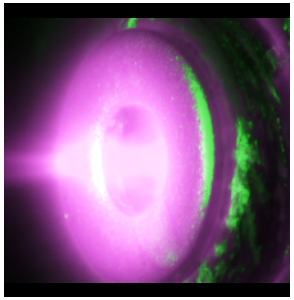

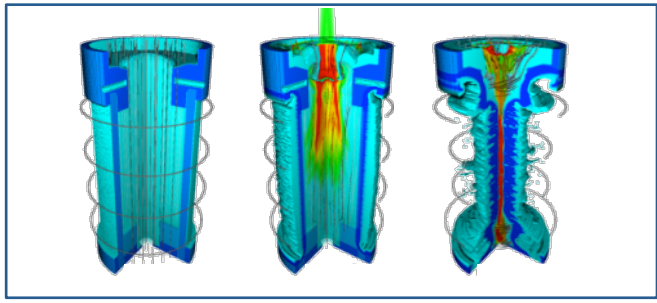

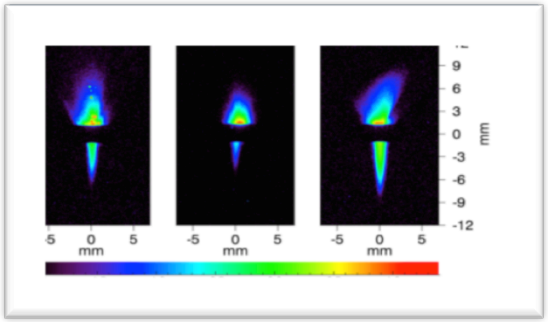

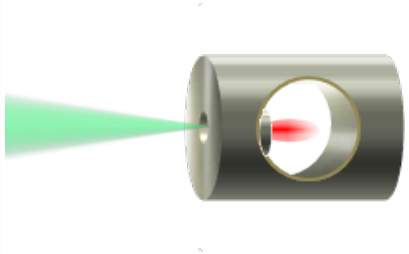

Z Fundamental Science Program Workshop 2015

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Pre-Heat Challenges

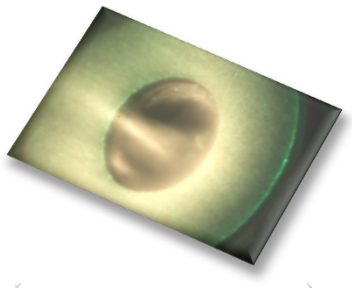
- ***High initial energy density requires high gas density***
  - *High pressure at room temperature*
  - *Thick window: 180 psi D_2 requires 3.5µm kapton across 3mm*
  - *Very high laser absorption and back-scatter in the window*

- ***Laser spot size is always a compromise***
  - *Small spots burn easily through LEH*
  - *Large spots are more efficient in fuel heating*

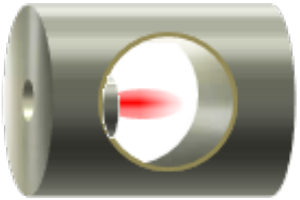
- ***Pre-heated fuel is hard to diagnose***
  - *Substatial high-Z dopants radiate too much*
  - *Need to diagnose fuel for 10s of ns (low T!!)*
  - *Gas cell wall is problem for soft X-ray diagnostics*

Campaigns (and Talk Contents):

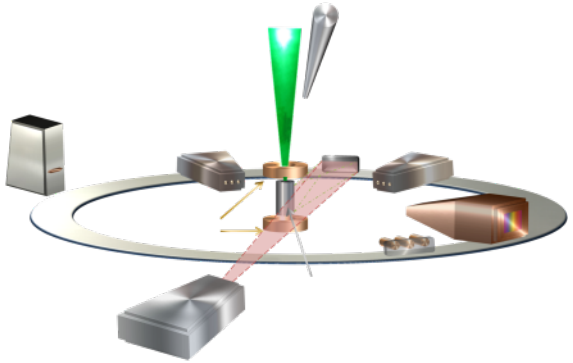
- *Measure transmission through LEH (Pecos Chamber)*



- *Look into gas cell (Pecos chamber)*



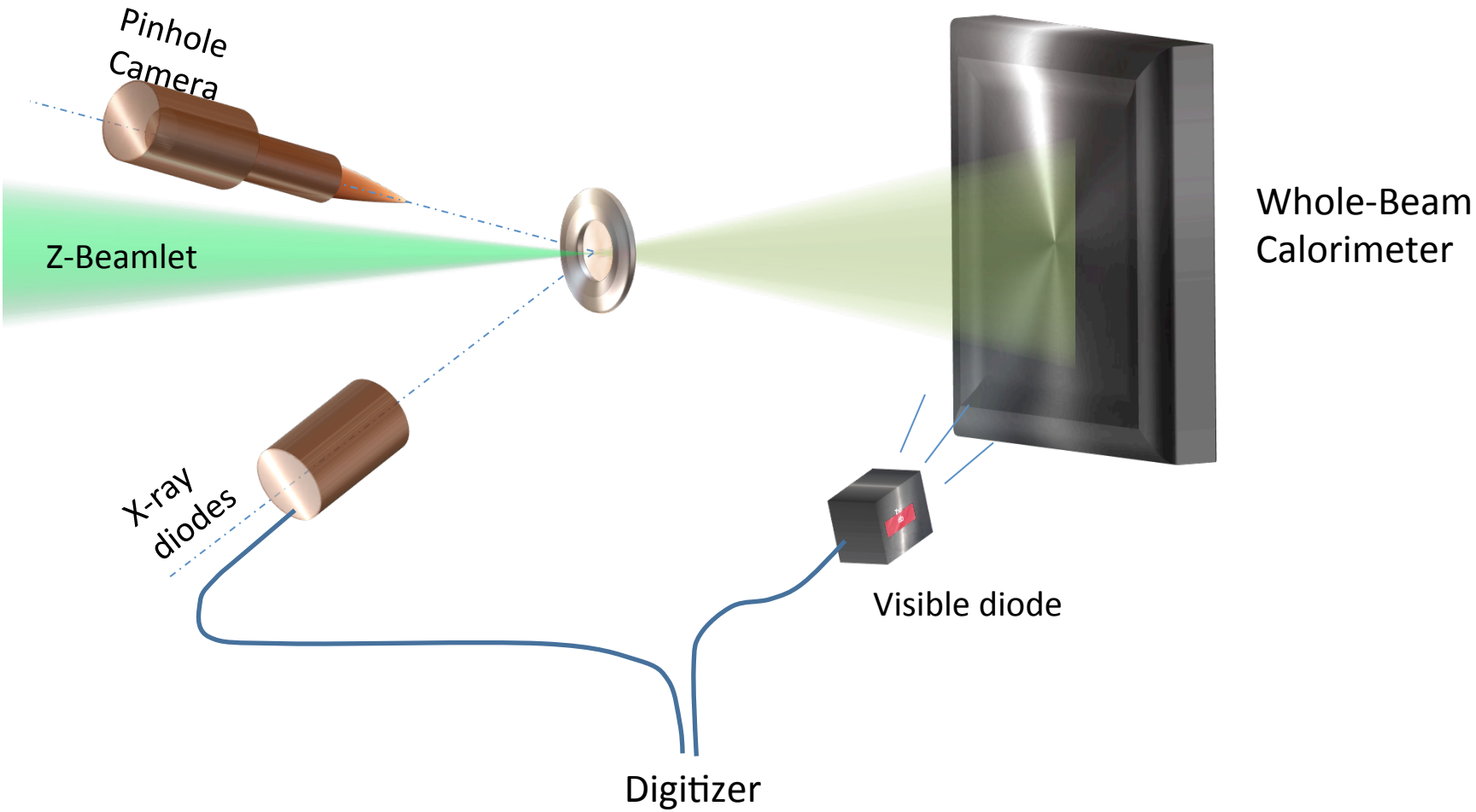
- *Look through gas cell (Pecos chamber)*



- *Look into gas cell with B-Field (Z)*

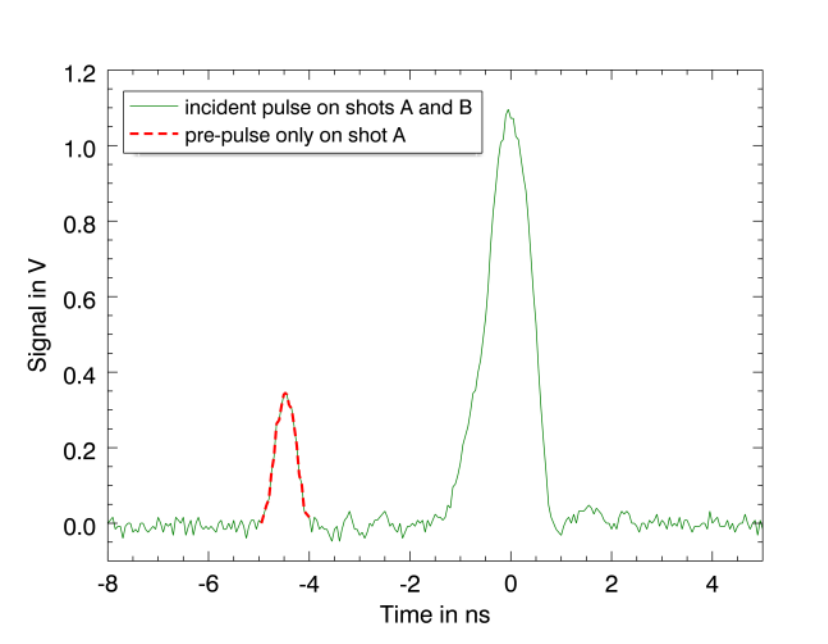
PECOS Chamber Experiments

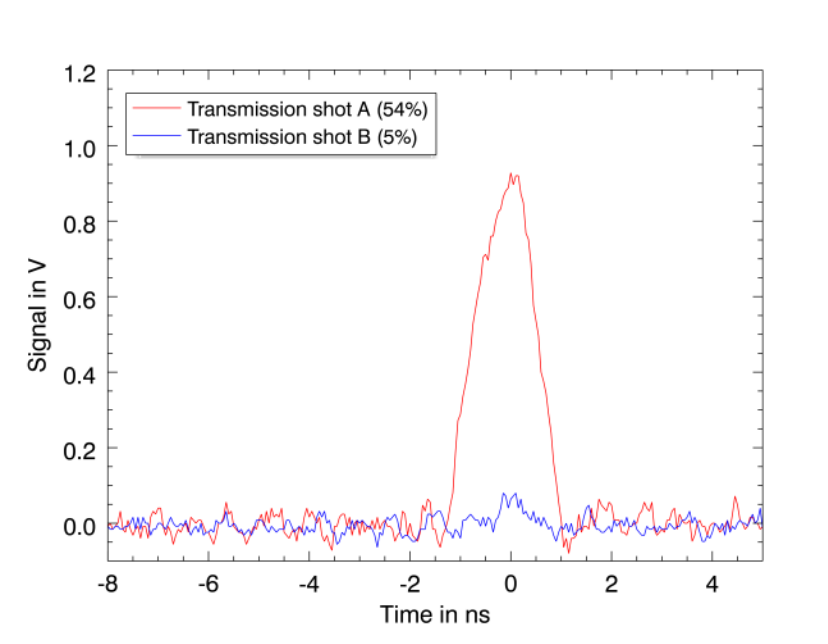
LEH Transmission



Transmission Studies

Importance of a Pre-Pulse

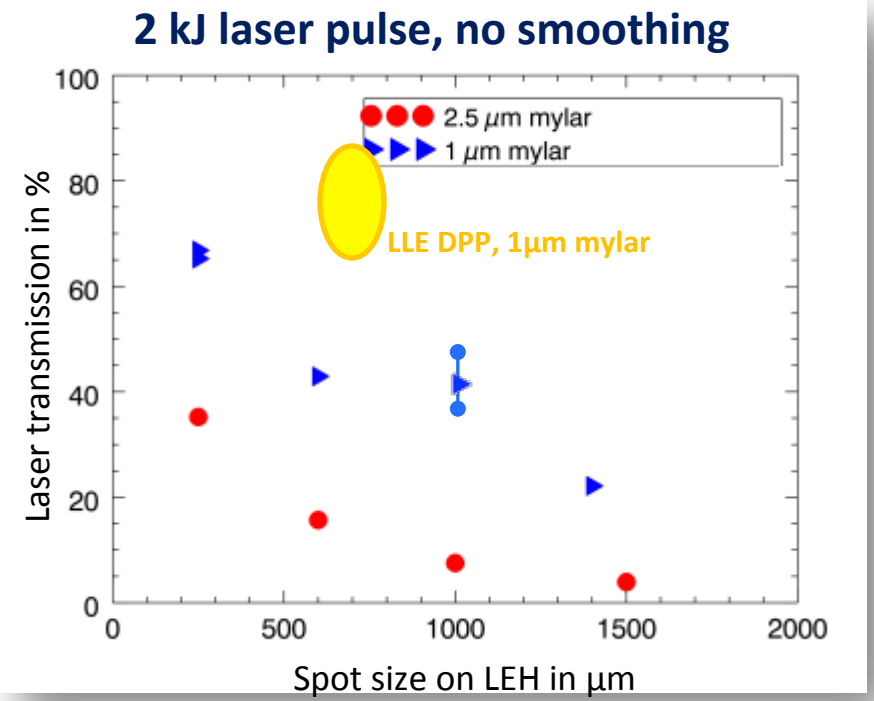


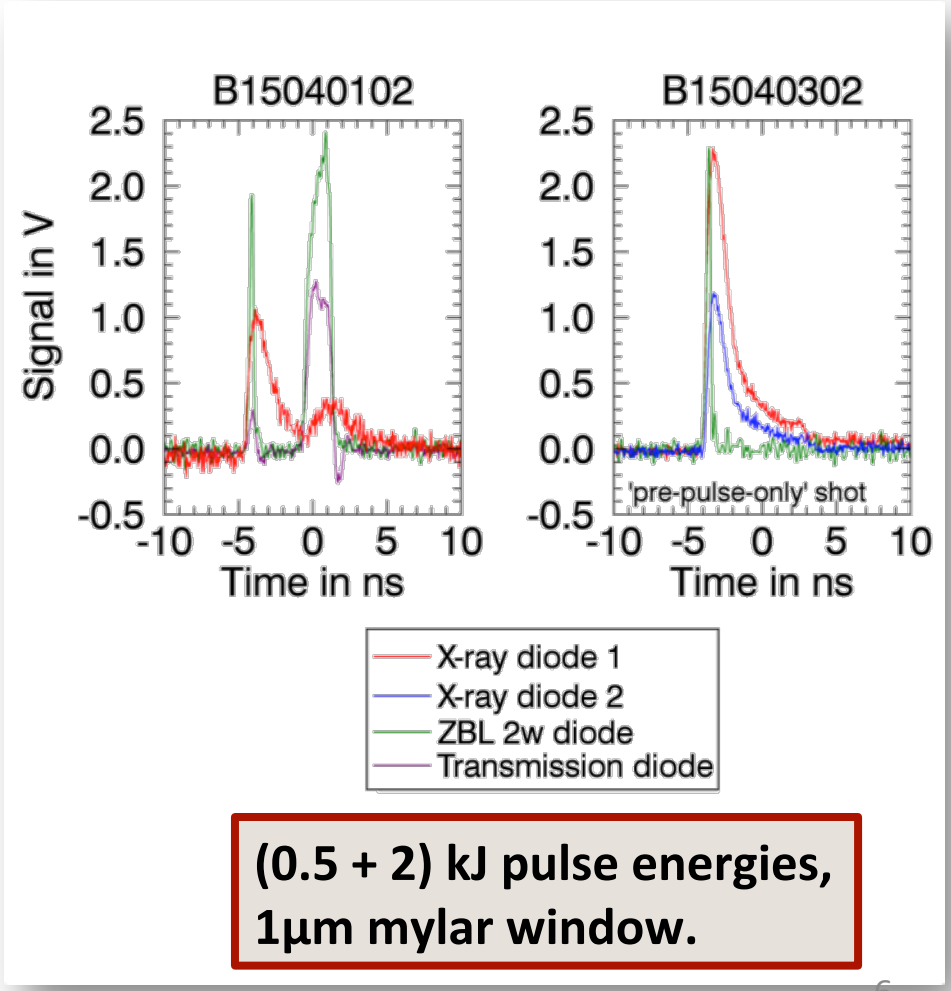


(0.5 + 2) kJ pulse energies, 1µm mylar window.

Transmission Comparison Graphs

Calorimeter Data, Energy and Power

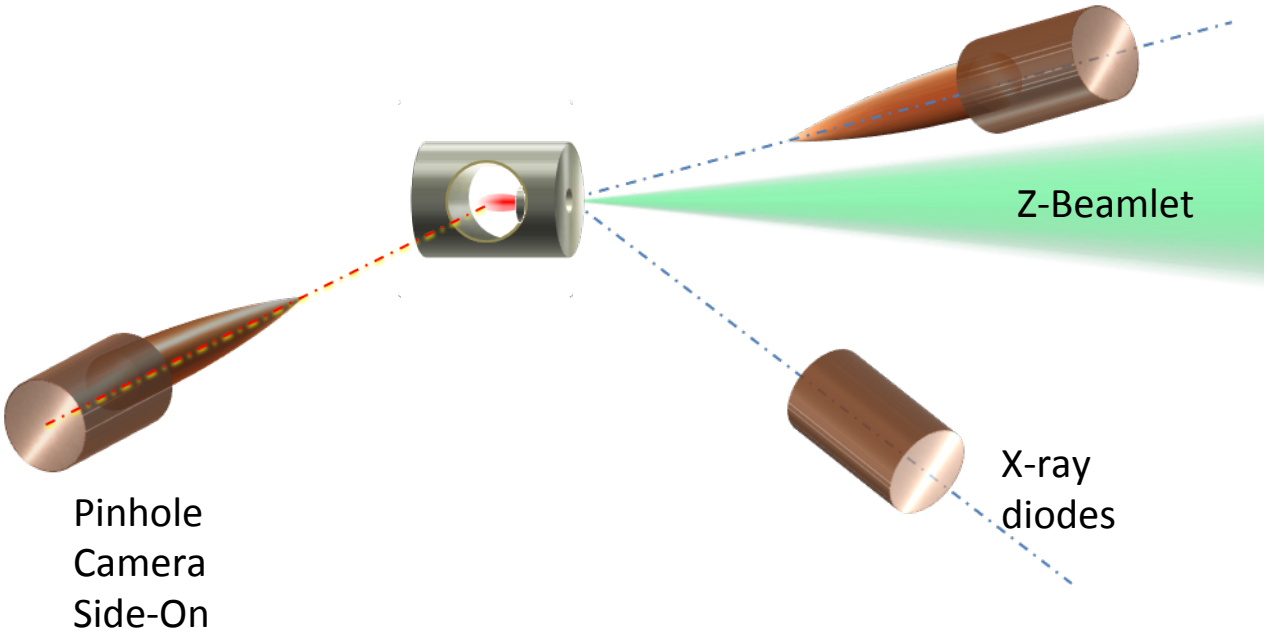




(0.5 + 2) kJ pulse energies, 1μm mylar window.

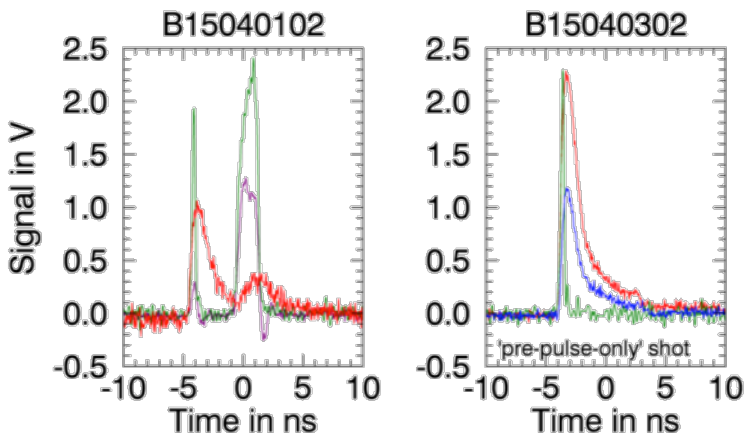
PECOS Chamber Gas Cell Experiments

Neon dopant (~1 keV K-shell):
Effective for low temperatures and
long time scales. Observable through LEH!

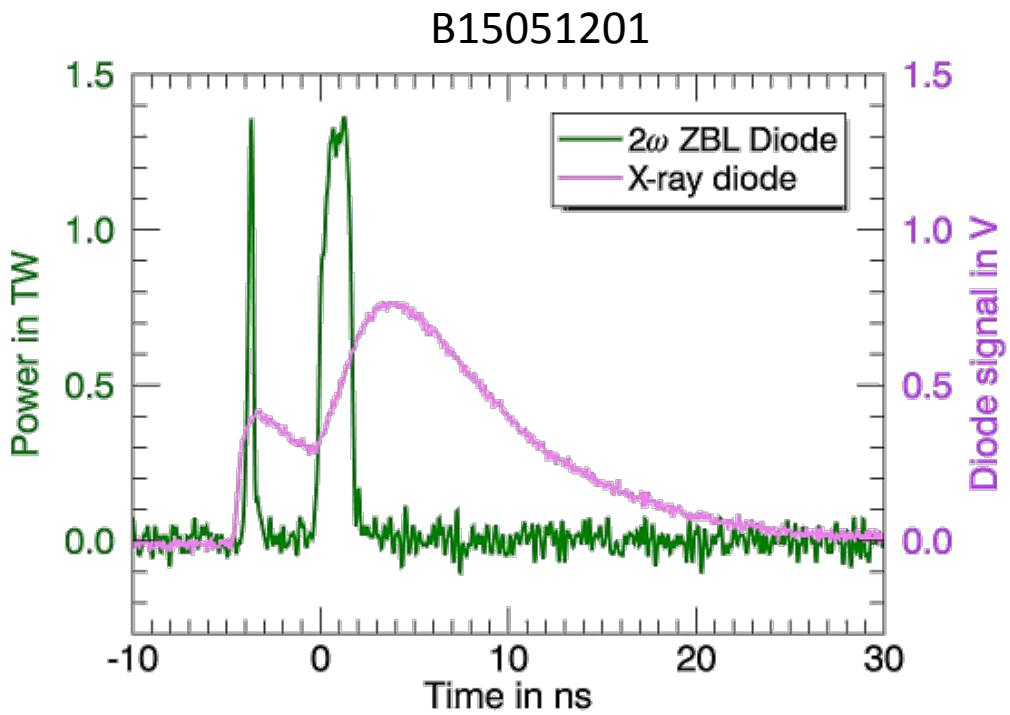


X-Ray Diode Measurements

1 Mylar, 2.5kJ laser energy, 1 mm defocus



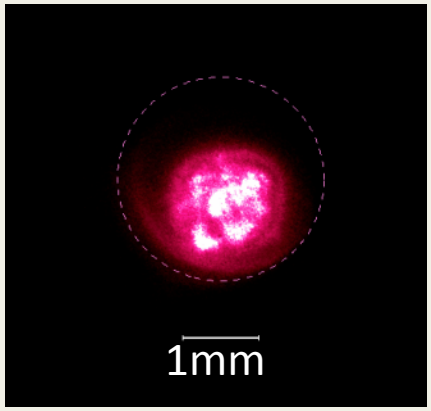
No Gas Fill



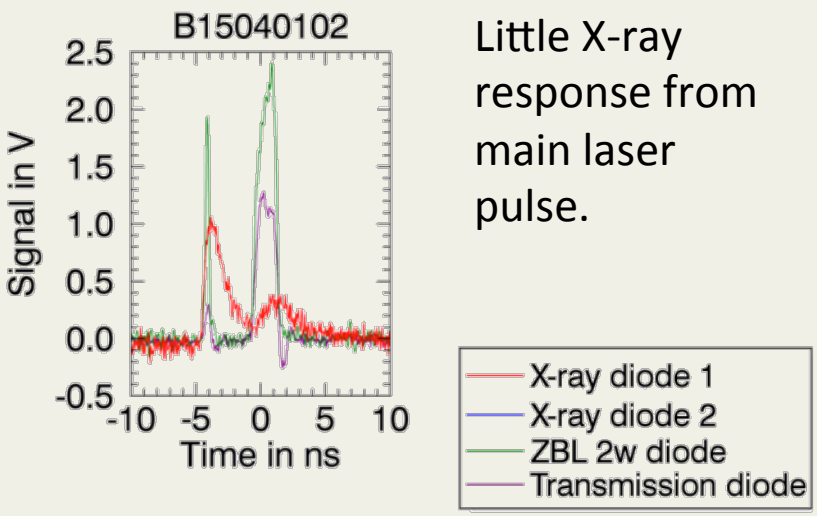
GAS CELL, 400 torr Ne

Ne-Emission through LEH

No gas fill

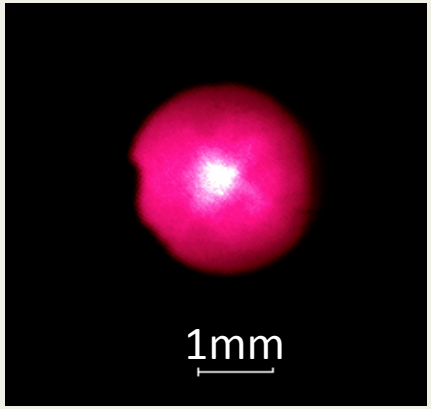


Only area irradiated by the laser lights up.

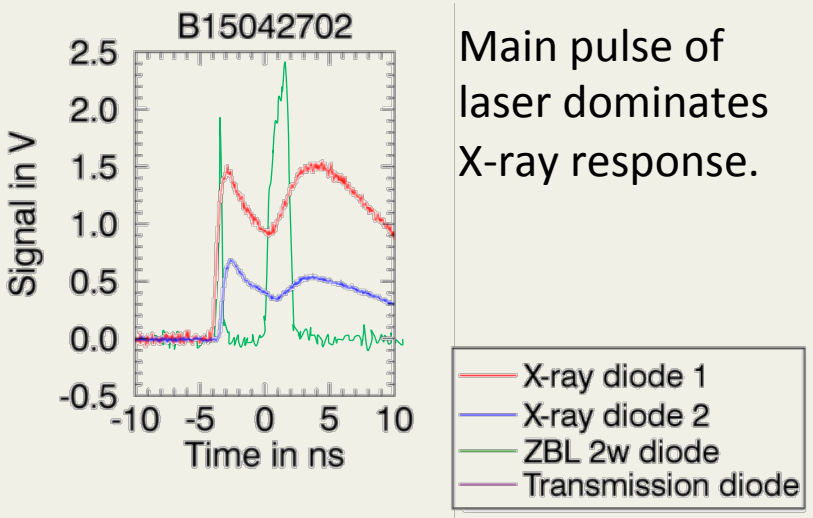


Little X-ray response from main laser pulse.

250 torr Ne



Neon emission fills entire LEH.

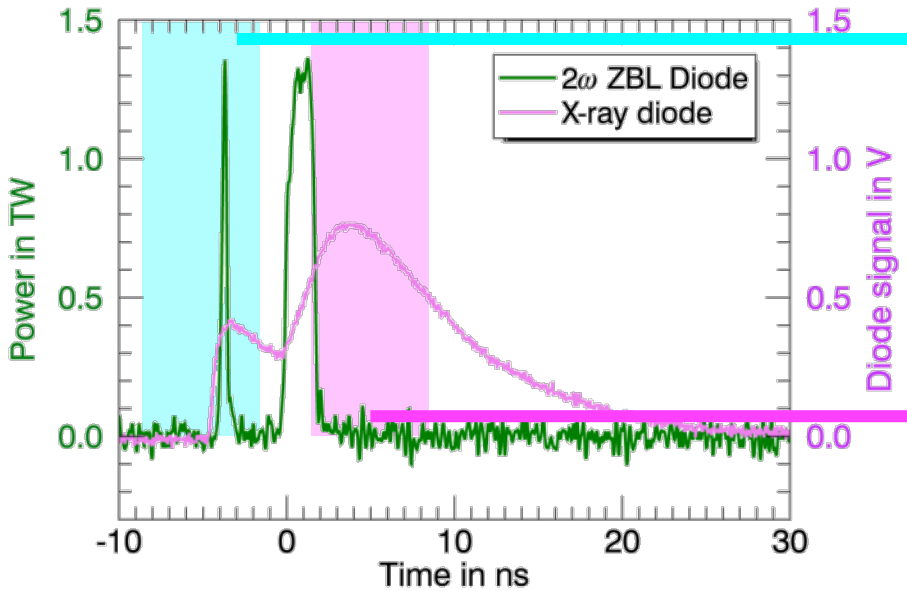


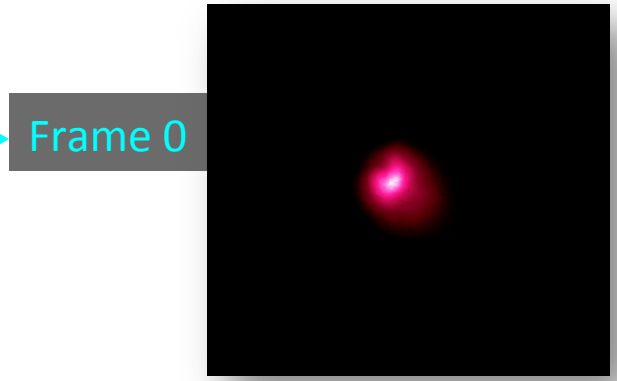
Main pulse of laser dominates X-ray response.

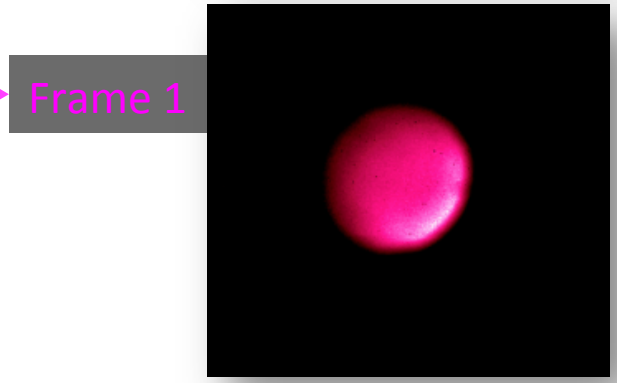
XRD1-filter: 25µm aluminum
XRD2-filter: 25µm aluminum + 6µm mylar

Axial Imager

Application of hybrid CMOS detector (J. Porter)



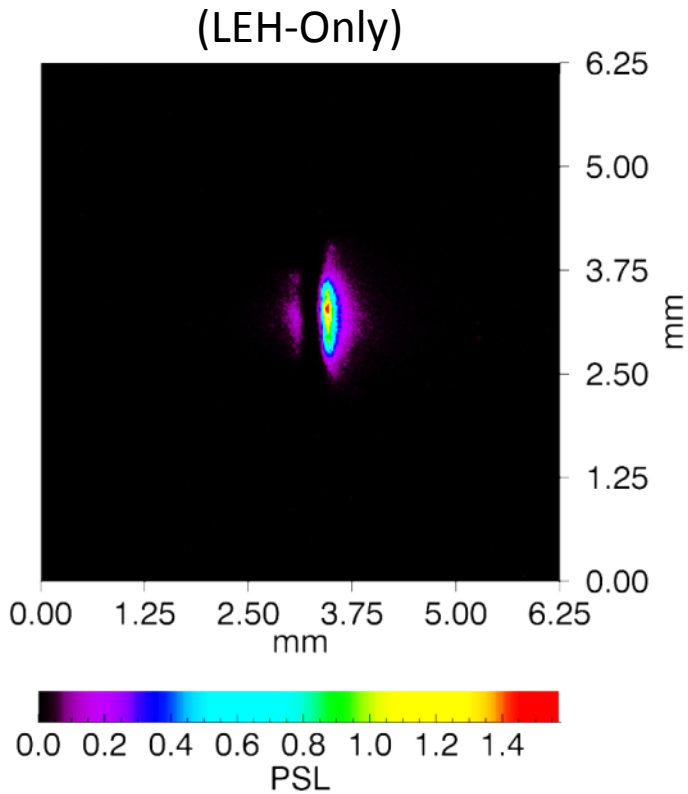


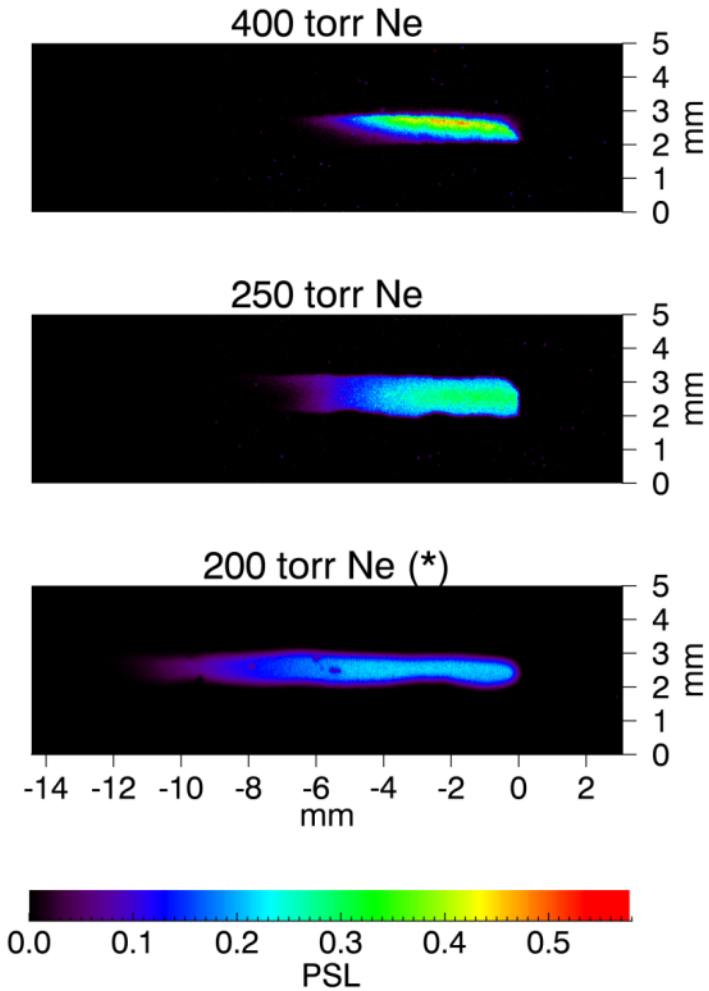


Gas cell with 400 torr neon
1 µm mylar LEH, 1 mm laser spot (defocused)
Frame 0: pre-pulse/LEH response (200 J)
Frame 1: main pulse/gas response (1.8 kJ)

Ne-Emission

Side-On

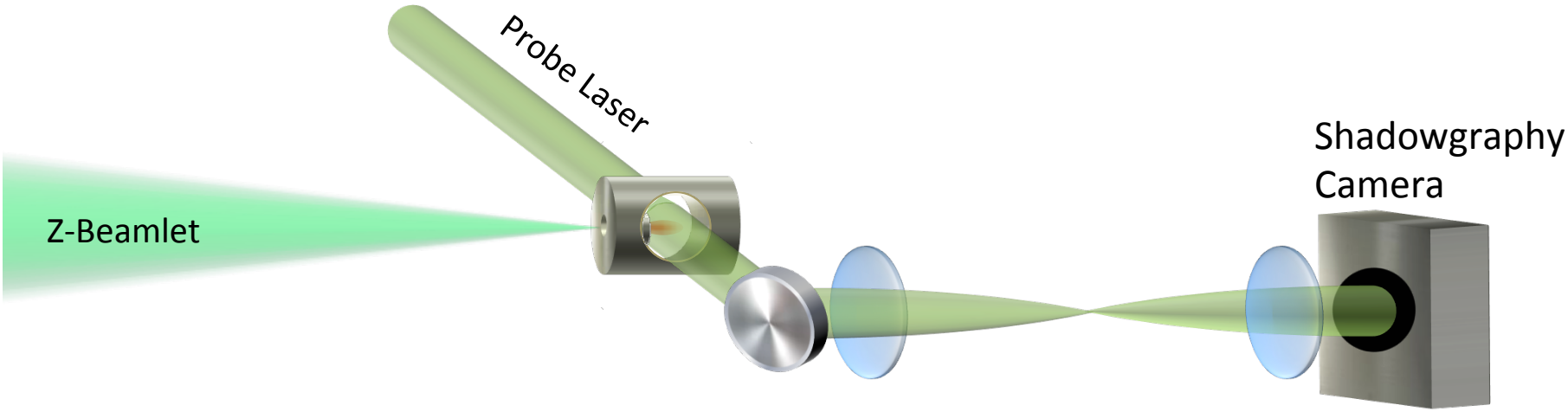


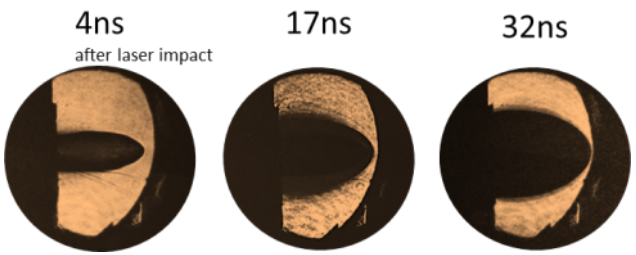


(*) Brightness adjusted for increased pinhole size

PECOS Chamber Gas Cell Experiments

"Hippogriff" Hybrid CMOS Camera (J. Porter)



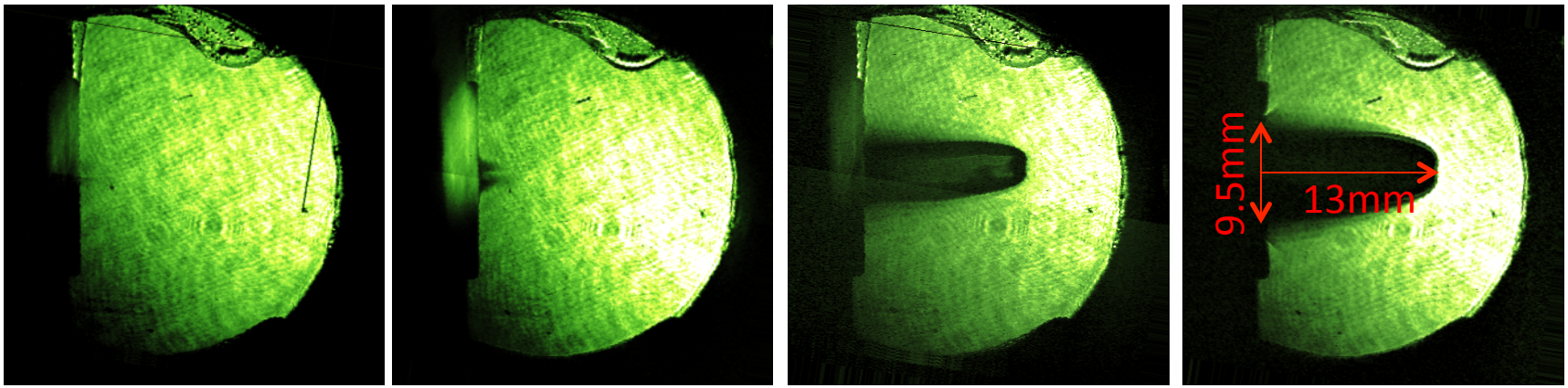


8-frame* probe beam B14121104

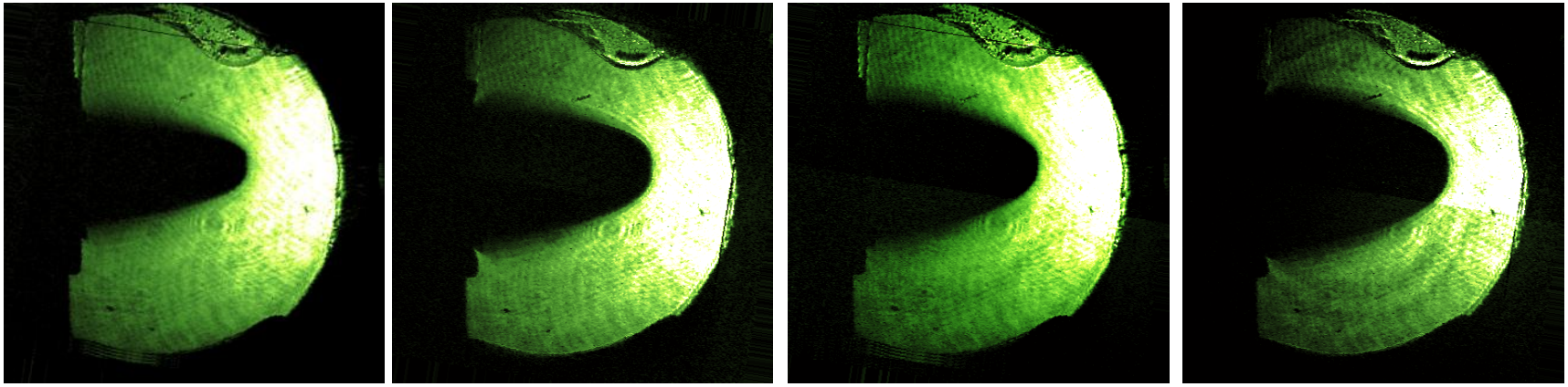
1μm LEH, ~2kJ

Pre-Pulse

Duration of Main Pulse



-2 ns | 0 ns | 2 ns | 4 ns



6 ns | 8 ns | 10 ns | 12 ns

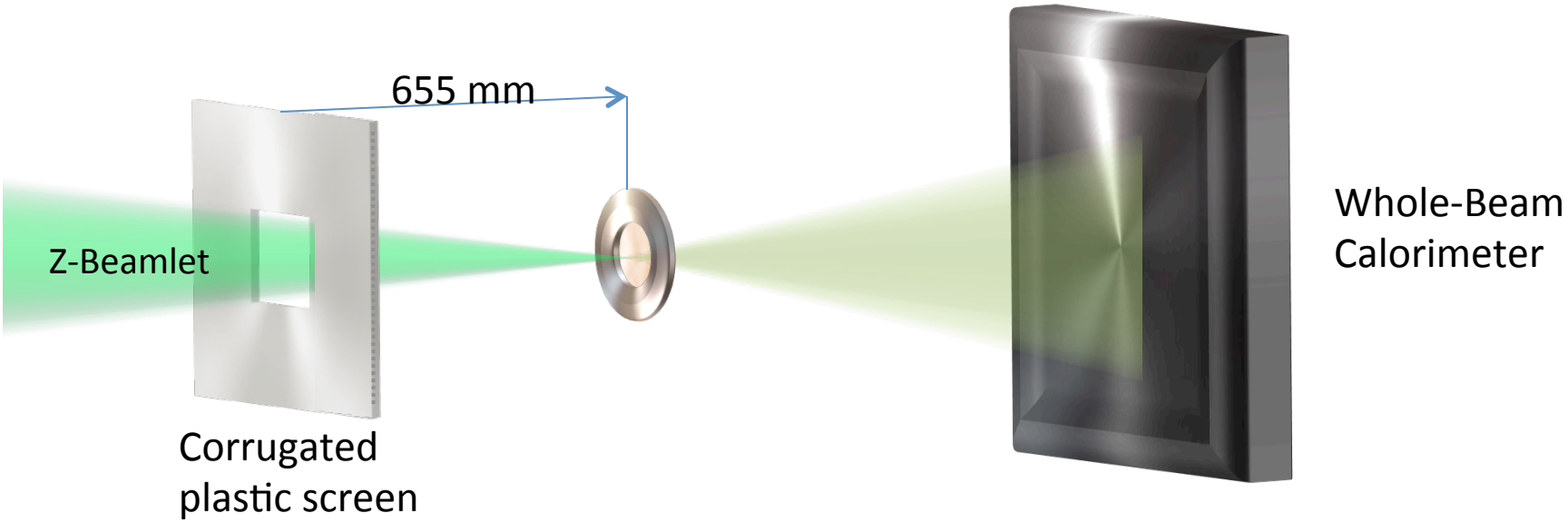
*: 2x interlaced Hippogriff with polarization multiplexing

Courtesy: John Porter, Mark Kimmel, Sean Lewis (break-out session)

SAND2015-4867C

PECOS Chamber Experiments

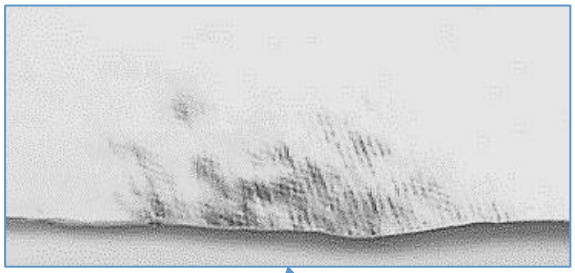
Backscatter Measurements

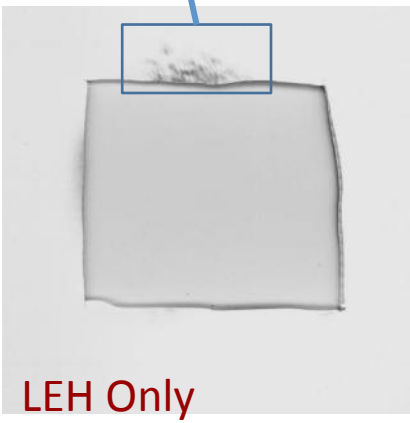


PECOS Chamber Experiments

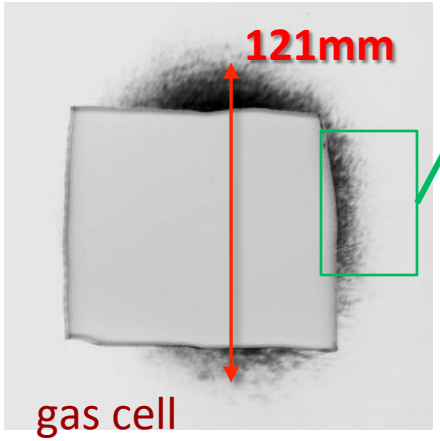
Backscatter Measurements

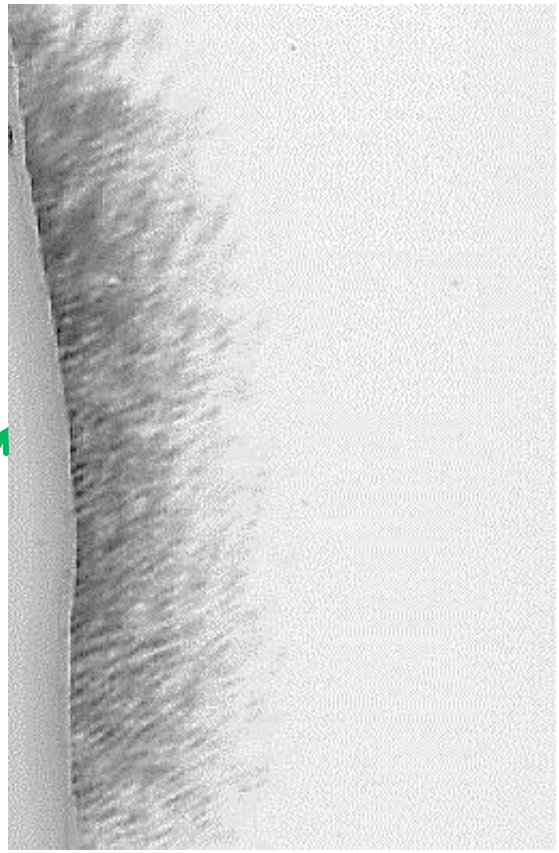
Evidence of filamented backscatter on screen





ZBL pulse size: ~ 66mm



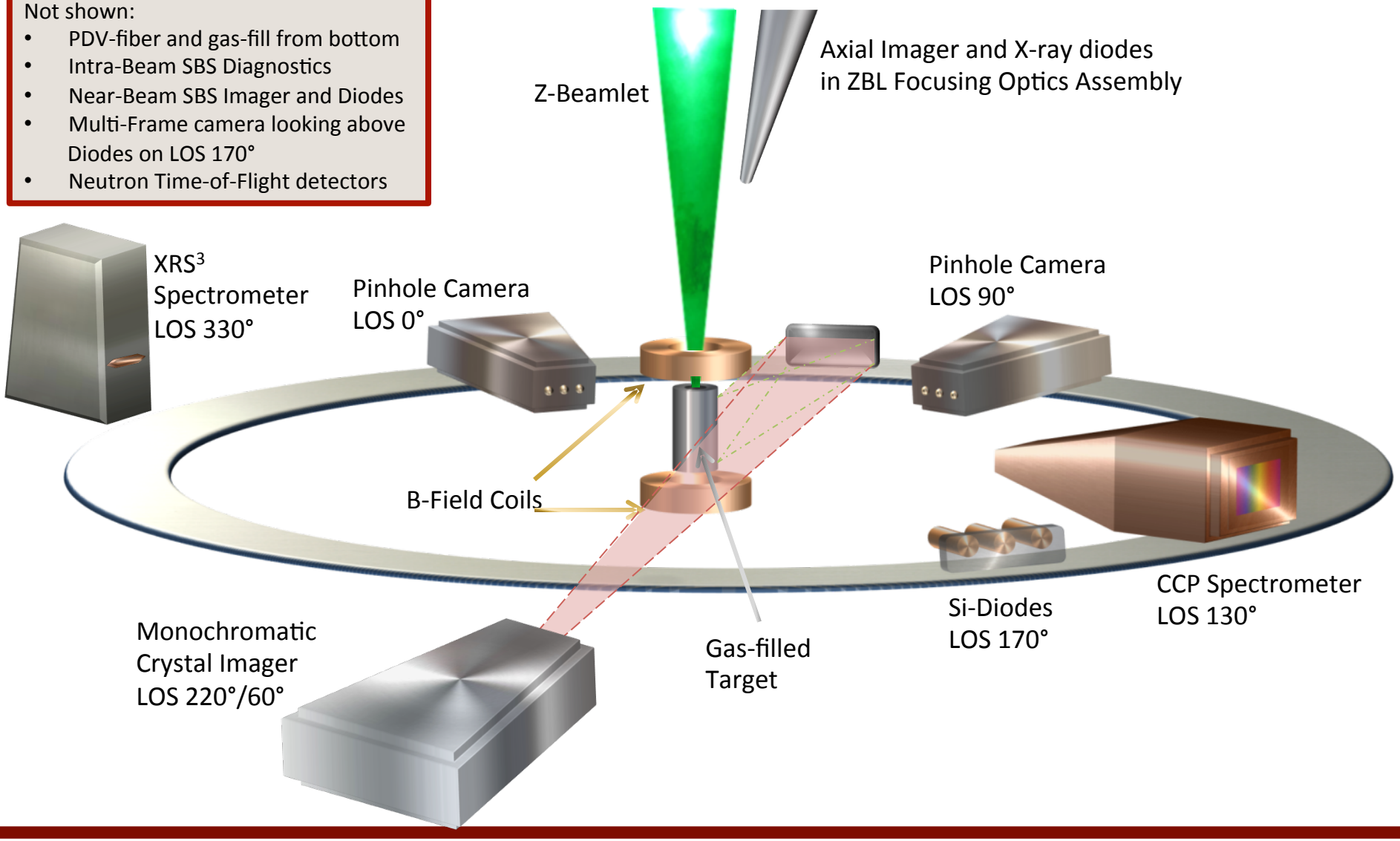


F# of SBS: ~ 1/5.4 (ZBL: 1/10)

Experiments in Z Center Section

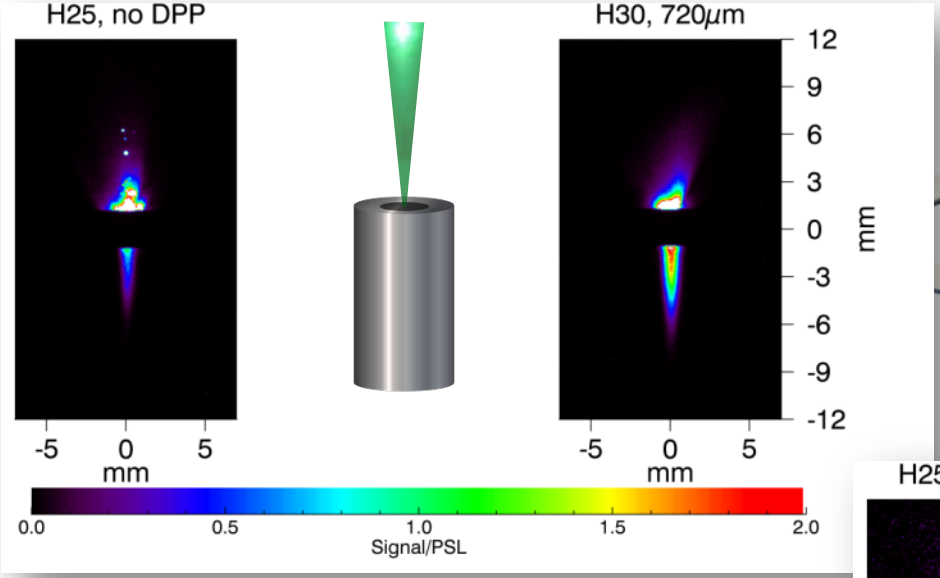
Diagnostic Configuration (not to scale)

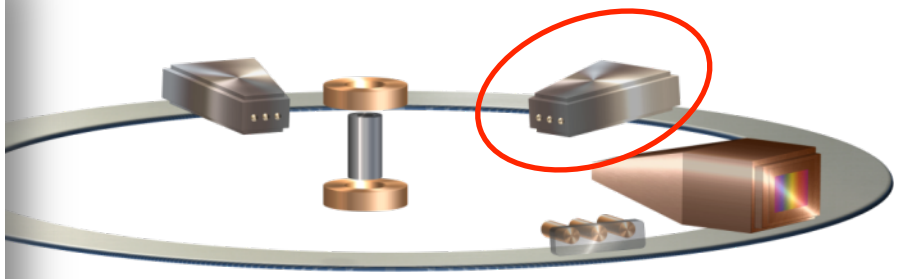
Not shown:
- PDV-fiber and gas-fill from bottom
- Intra-Beam SBS Diagnostics
- Near-Beam SBS Imager and Diodes
- Multi-Frame camera looking above Diodes on LOS 170°
- Neutron Time-of-Flight detectors



Why we like phase plates:

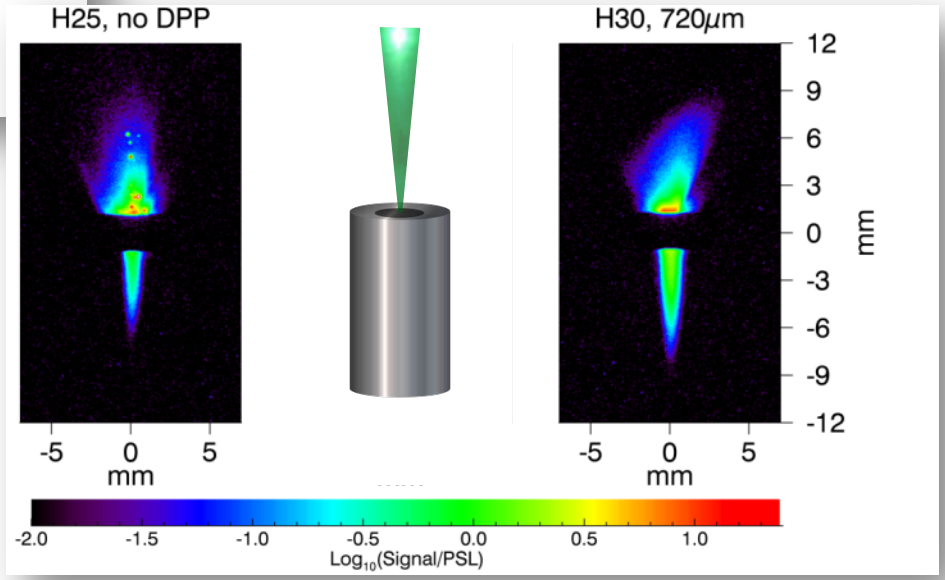
Aperture Ring Camera, 60 psi D_2 with 0.1% Ar-dopant





Linear scale

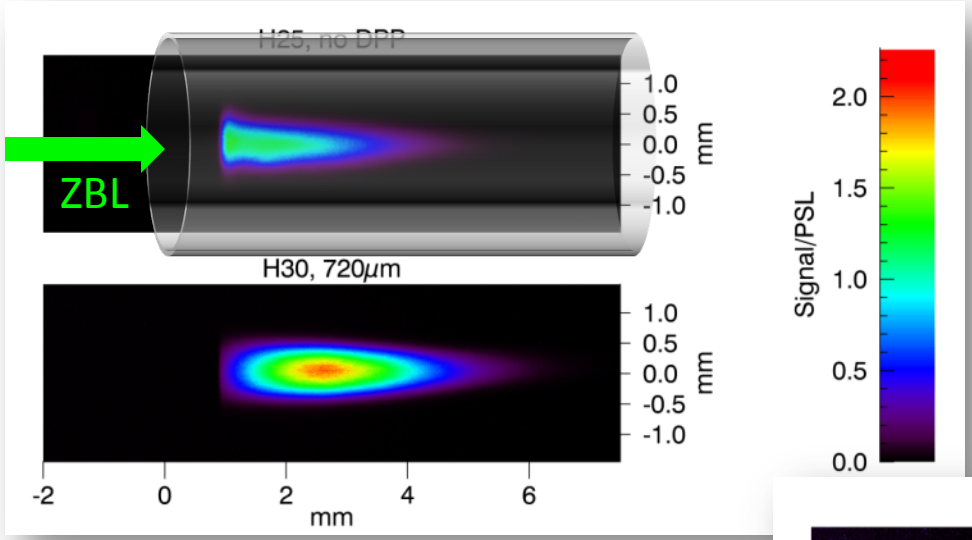
Dust particles hit by laser above LEH in H25.



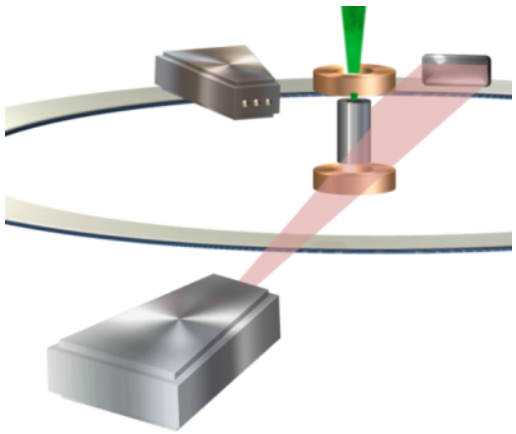
Logarithmic scale: ~ 1.6mm depth increase

3.1 keV Crystal Imager

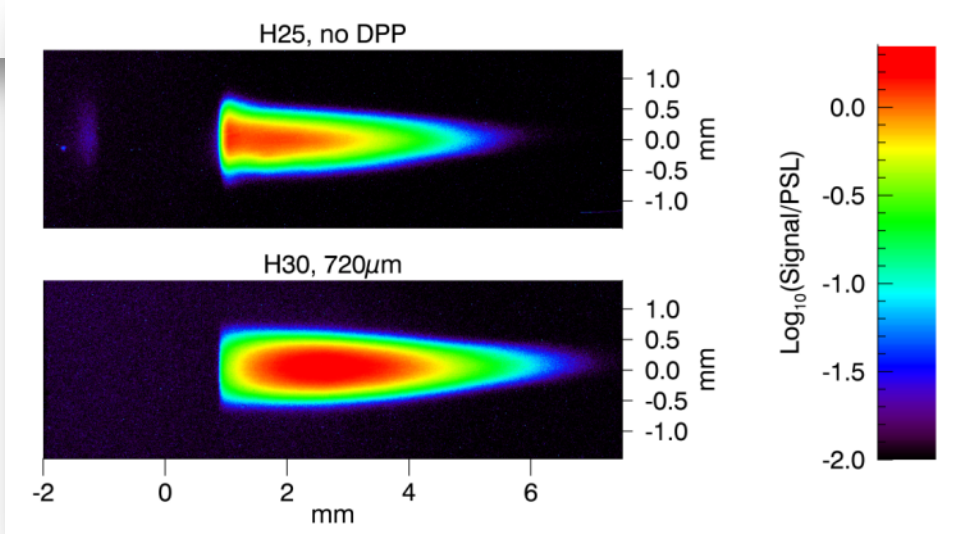
60 psi D_2 with 0.1% Ar-dopant



Linear scale



Scientist in Charge: Erik Harding



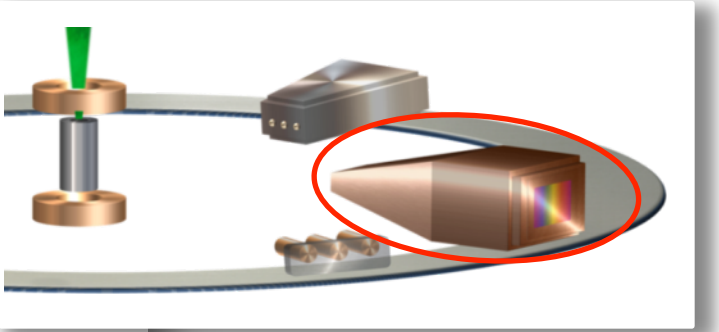
Logarithmic scale

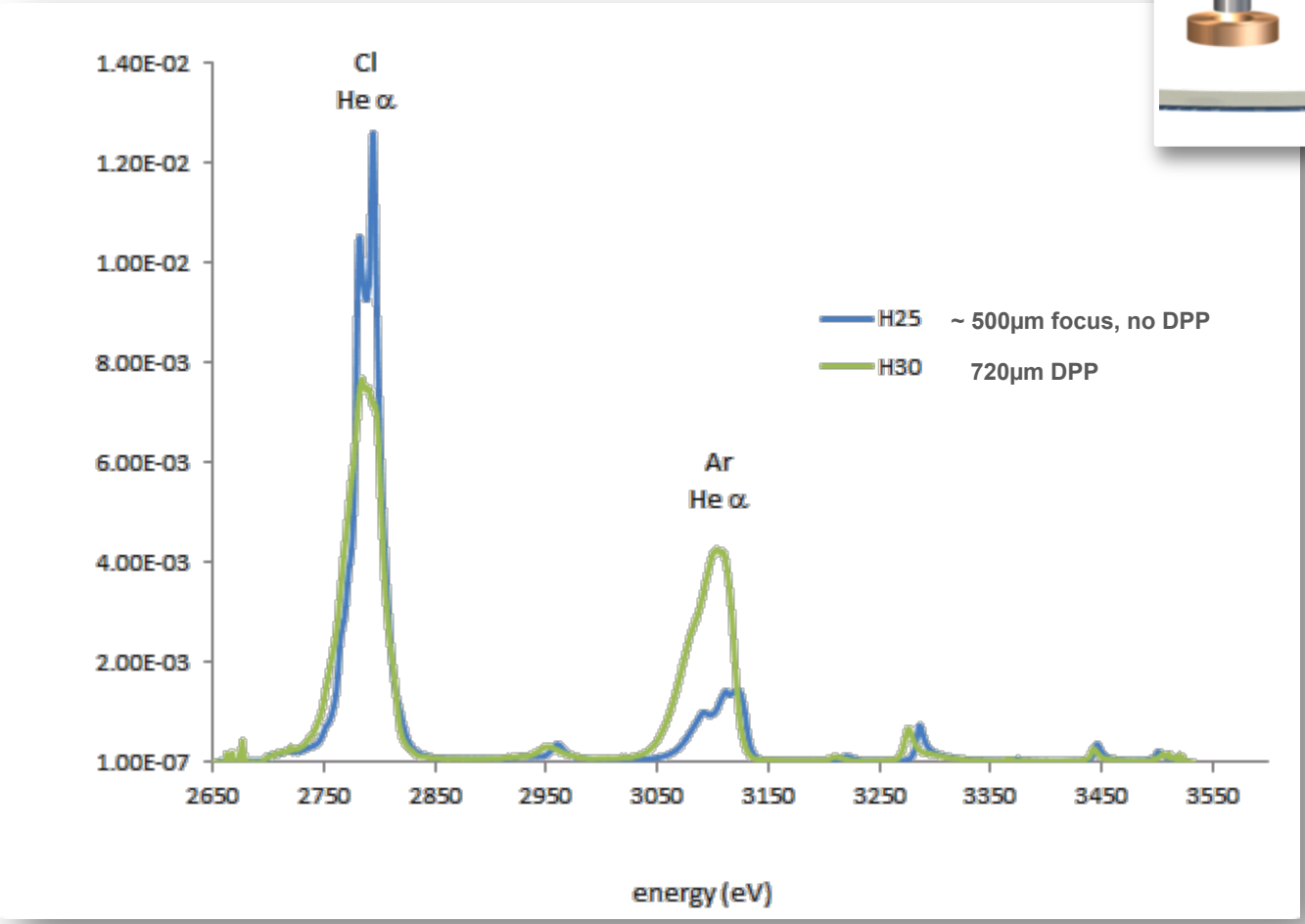
Integral emission H25: **86**k PSL
Integral emission H30: **175**k PSL

~ 1.25mm depth increase (log.)

CCP Spectrometer

60 psi D_2 with 0.1% Ar-dopant, Cl-doped LEH

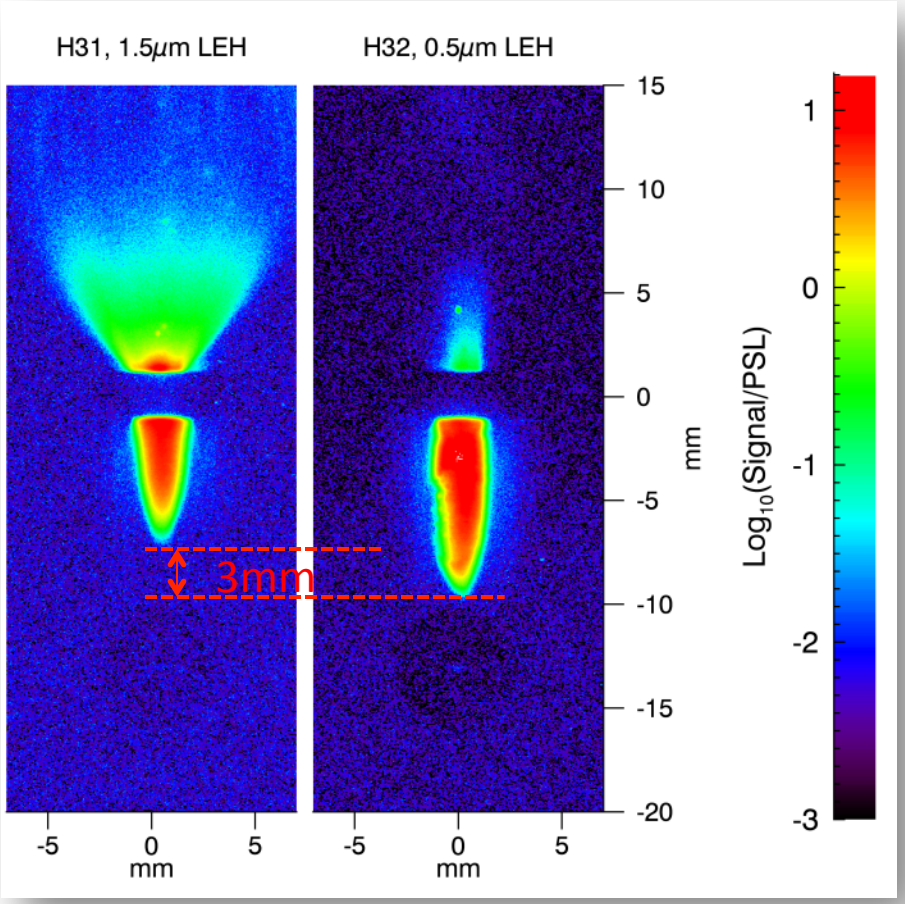




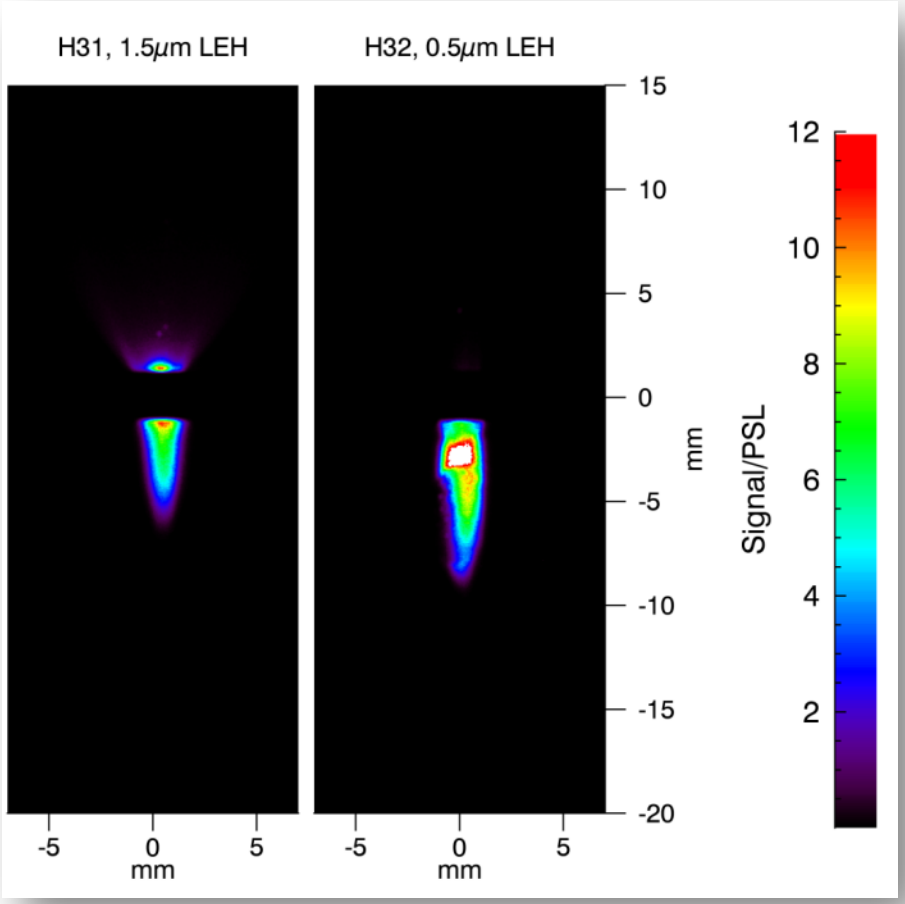
Data analysis: Stephanie Hansen

Why we like thin windows:

Aperture Ring Camera, 15 psi neon, LOS 90



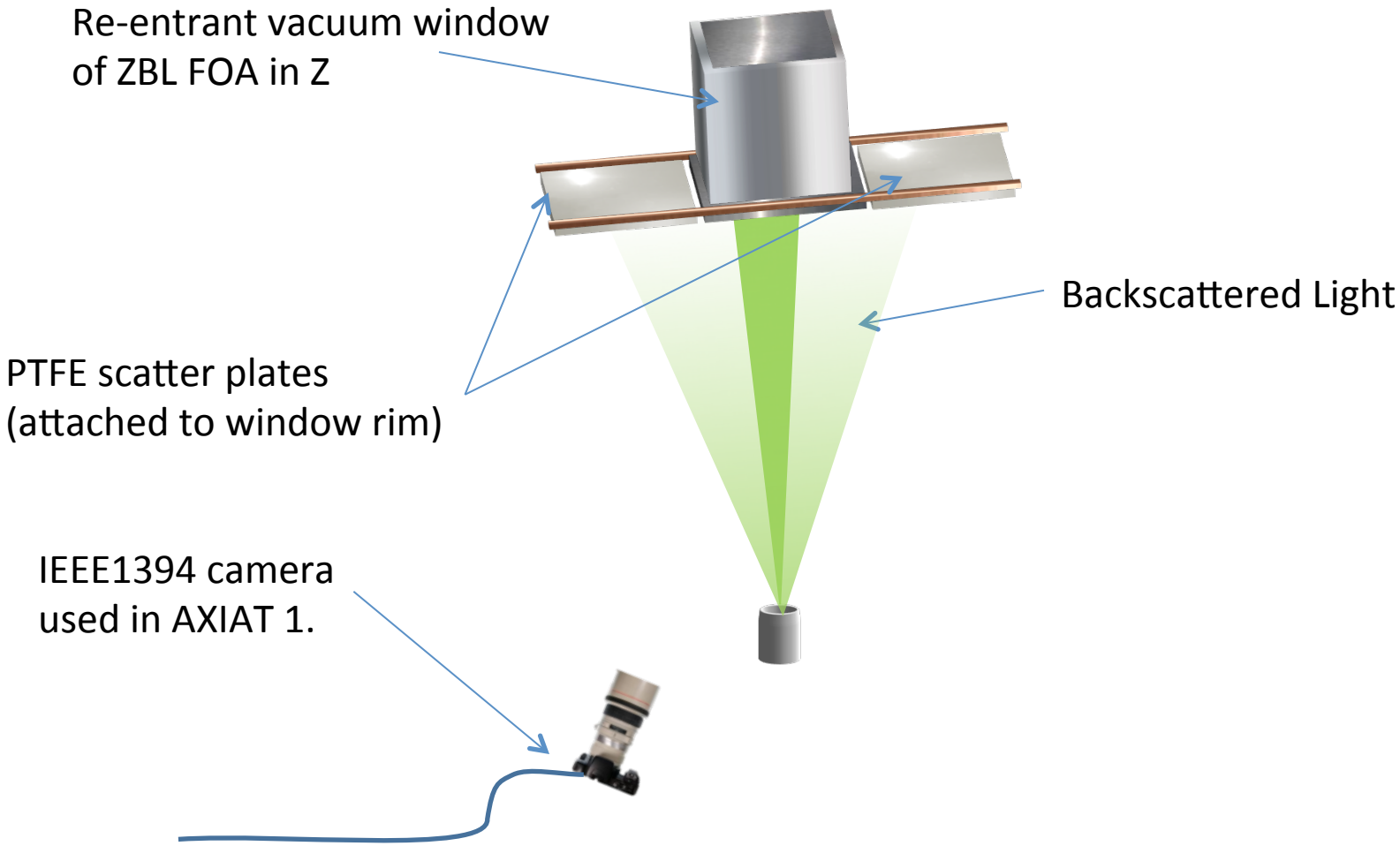
Logarithmic scale



Linear scale

SBS measurements

Near Angle Backscatter Measurements

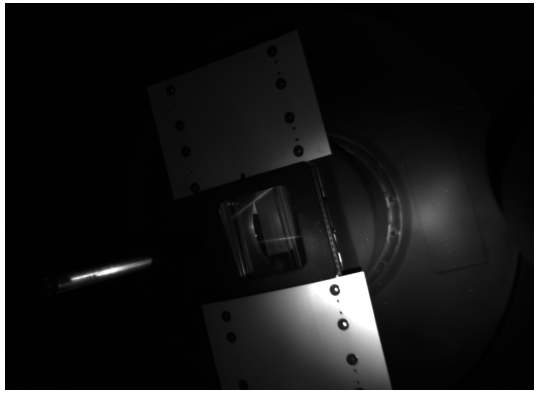


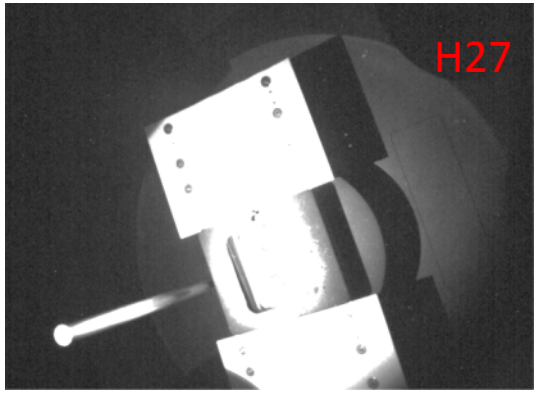
SBS Measurements

Camera: Evaluation pending

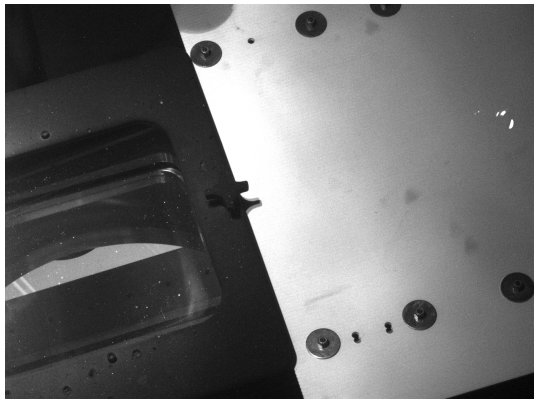
Control image (setup) | Shot

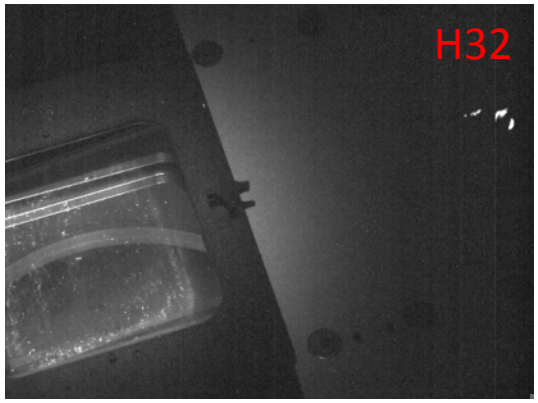
LASPE2 (no phase plate. ND4)



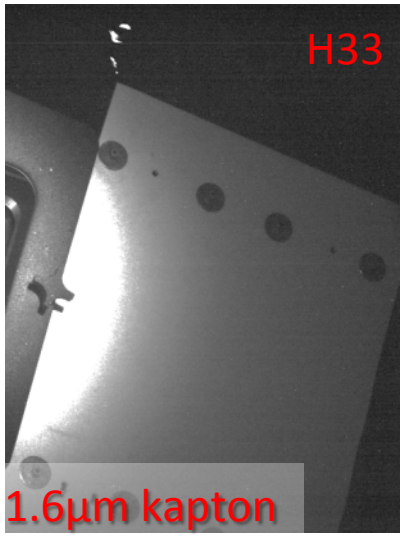


AXIAT2 (LLE phase plate, ND5)





0.5µm kapton, 15 PSI Ne



1.6µm kapton
60 psi D_2

Summary

- *Pre-pulse is important. Potential to optimize (timing, energy).*
- *Phase plate is important!*
- *Neon is promising as dopant for axial diagnostic.*
- *Significant difference between pre- and main pulse interaction!*
- *Use < 1µm LEH (cryogenic campaign with 400nm LEH on Z this week).*
- *Check for (and stay away from) LPI such as SBS, SRS, TPD, etc…*

- *To do:*
  Characterize mix, optimize diagnostics, SRS, analyze, analyze, analyze…