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Pre-Heat Optimization for Magnetized Liner Inertial Fusion at Sandia

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47th Annual Anomalous Absorption Conference

Florence, Oregon

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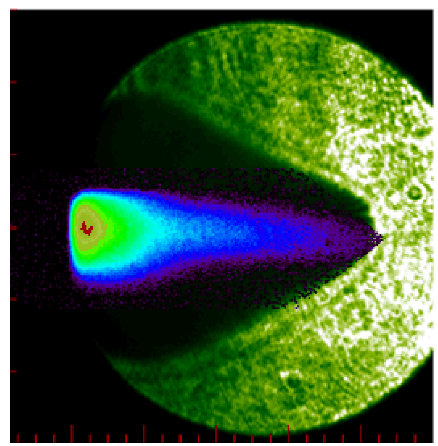

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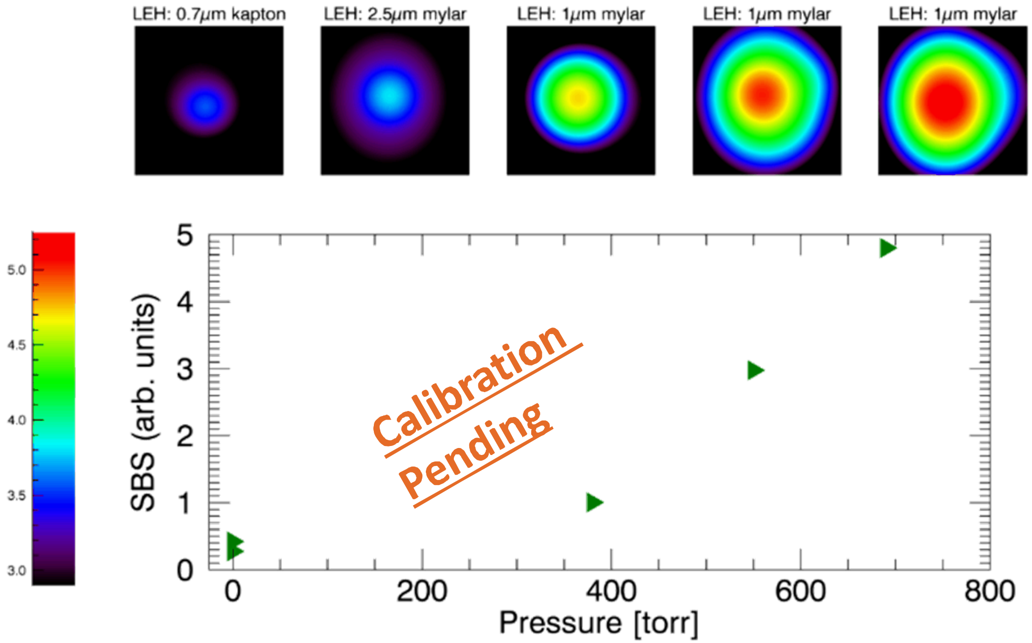
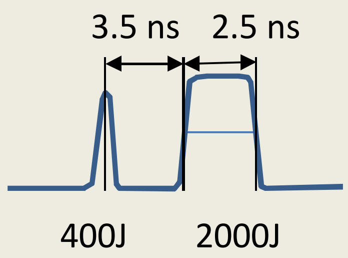
Neon SBS Backscatter Measurements (Last AAC)



Focus: 750 μm phase plate

Pulse train:



Path forward later in 2016/2017

Available parameters for optimization:

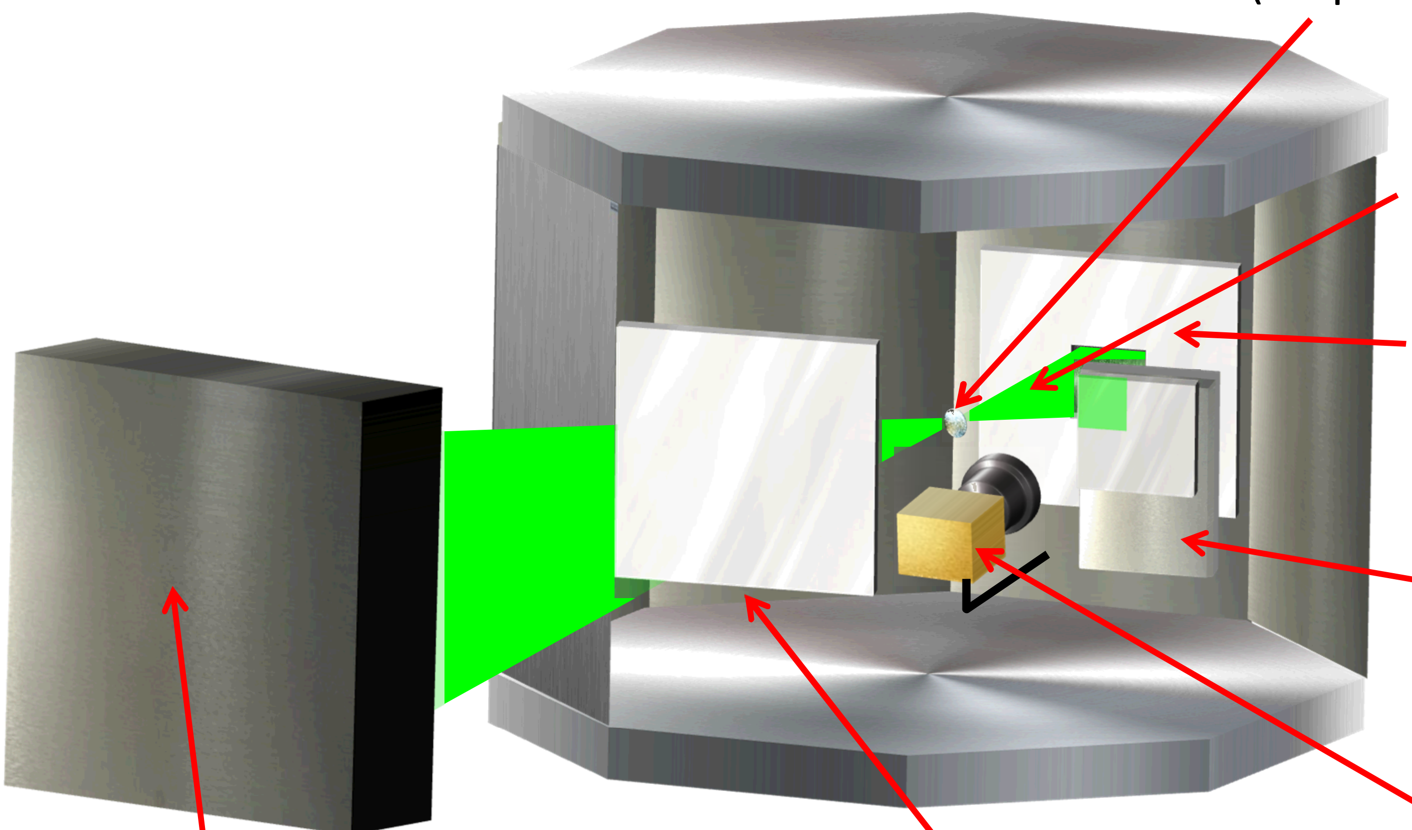
- Pre-pulse energy
- Main pulse power
- Main pulse length
- Phase plate radius

Required Implementations:

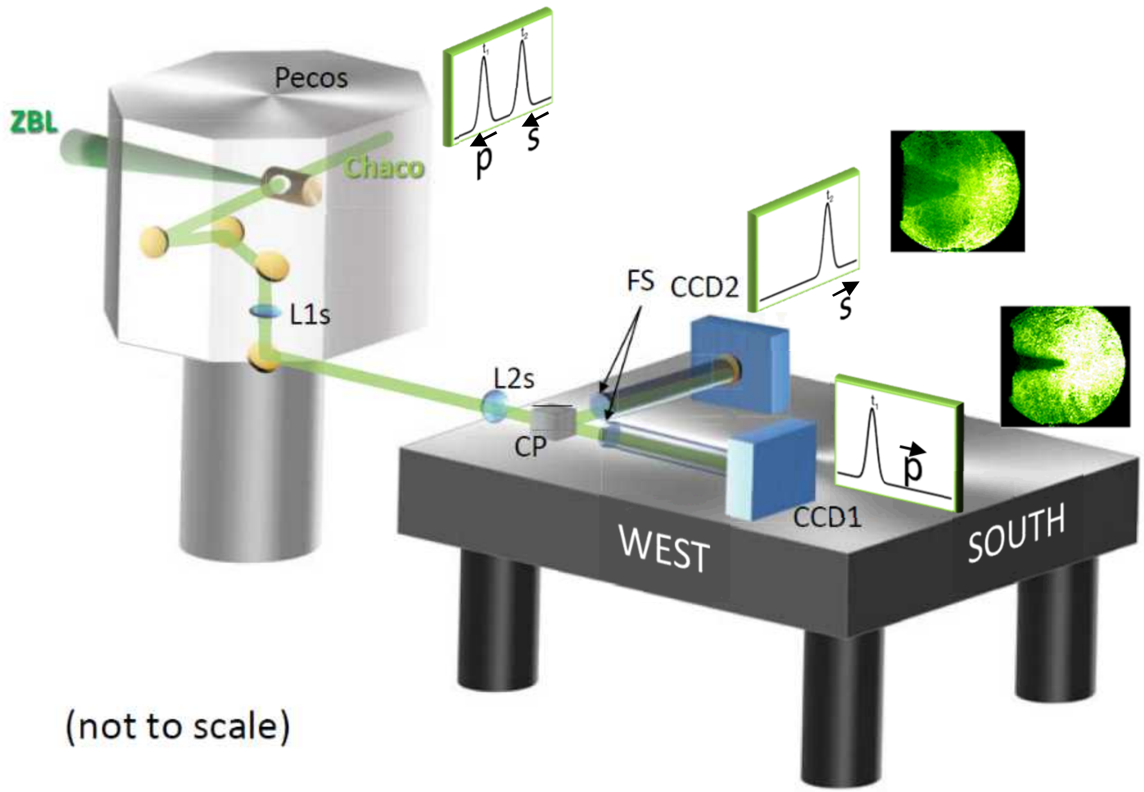
- Equivalent gas fill (He or D_2)
- Calibrated forward and back-scatter
- Energy deposition measurements
- Same LEH window as on Z

SBS Backscatter Measurements

Setup



Shadowgraphy Setup

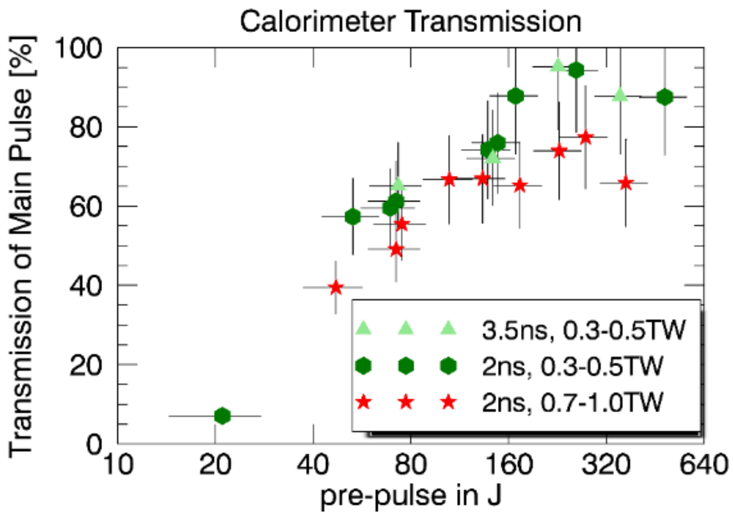


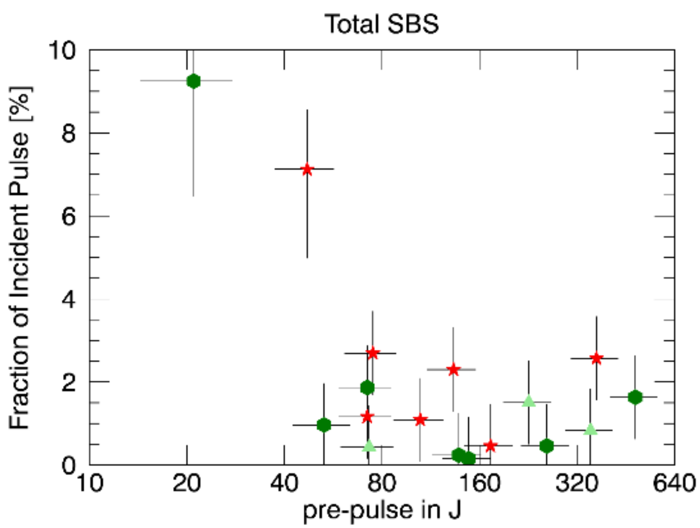
Chaco Probe Laser:

- 532 nm
- few-100 µJ/pulse
- sub-500 ps pulses
- two orthogonally polarized pulses
- arbitrary timing before and/or after Z-Beamlet impact

L1s, L2s:	shadowgraphy imaging lenses
FS:	Filter stacks (ND, IF532)
CP:	Cubic polarizing beam splitter

LEH Measurements





Focus: 750 µm phase plate

LEH: 1.47µm polyimide

Gas fill: none

For all but the weakest pre-pulses, SBS is near 1% of the incoming pulse for a stand-alone LEH window.

Subtle indication that low power is resulting in less SBS.

Gas Cell Measurements

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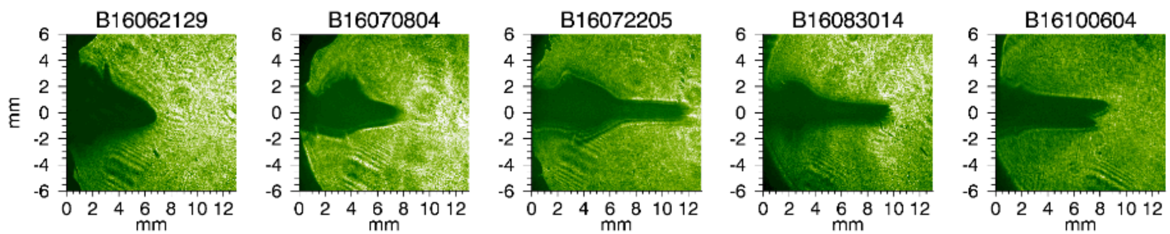
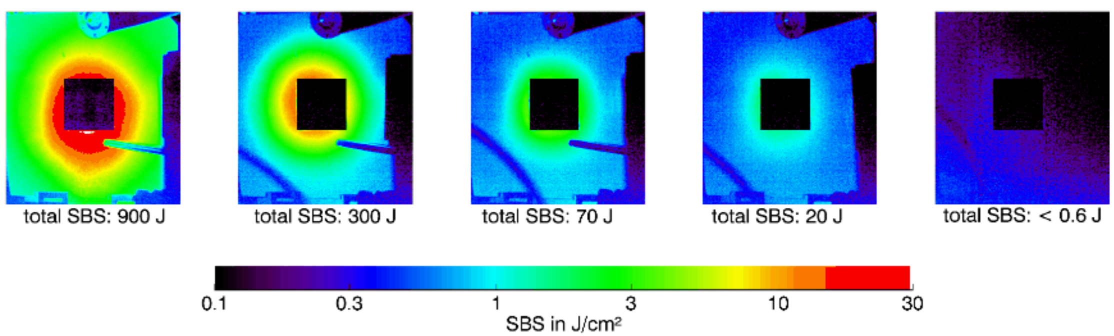
	"Full Intensity"	"Full Intensity"	"Half-Intensity"	"Quarter-Intensity"	"1/8-Intensity"
Av. focal intensity:	(poorly defined)	190 TW/cm²	100 TW/cm²	50 TW/cm²	35 TW/cm²
Pre-pulse:	310 J	230 J	220 J	240 J	60 J
Main pulse:	1800 J	1300 J	1200 J	1300 J	850 J
Phase plate:	no DPP	750 μm DPP	750 μm DPP	1100 μm DPP	1100 μm DPP

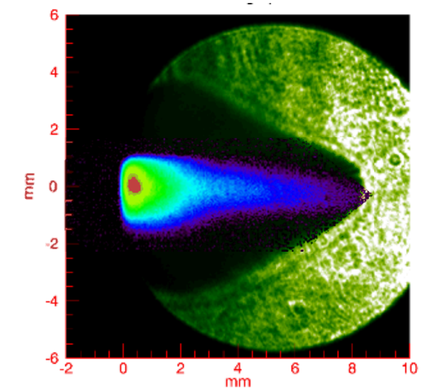
Shadowgraph immediately after the main pulse:



SBS data:



NEW!
Shadowgraphy
+ X-ray pinhole



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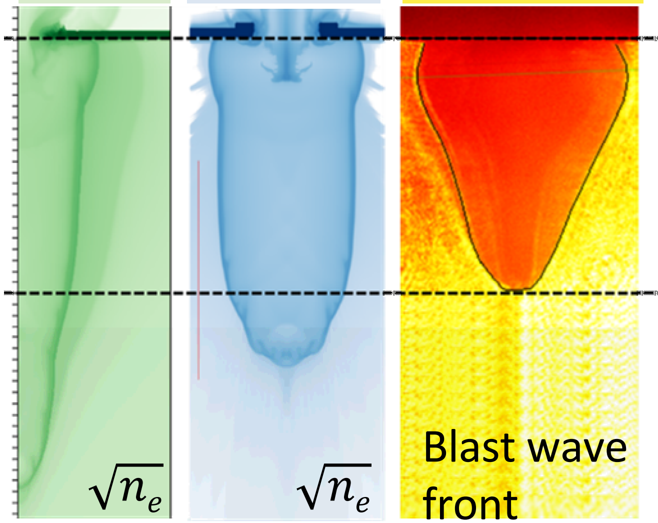
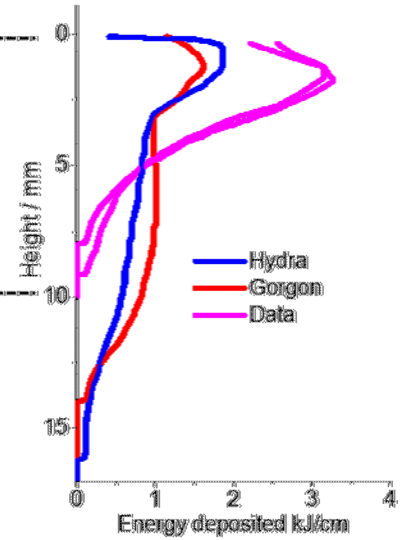
Gas Cell Simulation (Weiss/Jennings)

Benchmark Experiment: Laser Pulse 71 J + 1441 J; 54.3 psi He, t_{shadow}=22.7ns

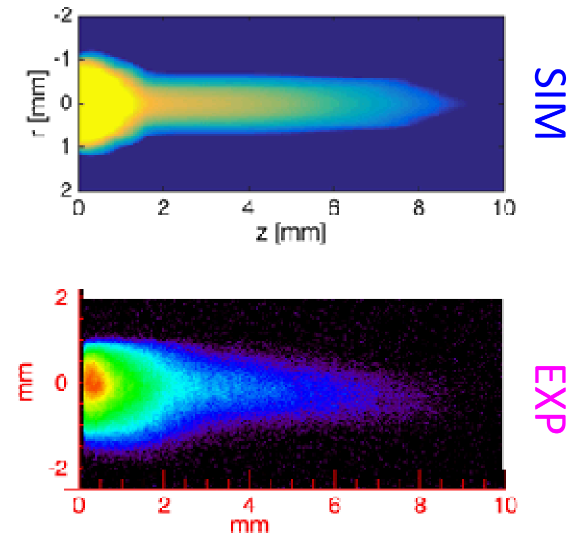
Hydra | Gorgon | Experiment



Energy vs. Depth



X-ray emission, $\log(I)$



Energy deposition:

Hydra	Gorgon	Experiment
1159 J	1267 J	1213 J

Total inferred energy matches well.

Experiment seems more “top-heavy”.

X-ray emission has good qualitative agreement.

> 1 kJ in target, but much of it in LEH material (EXP+SIM) or outside MagLIF liner depth (SIM)!
➡ More laser energy and higher gas density required for better coupling!

Integrated Experiments in Z

Repeat shots in CY17 show high yields, variability

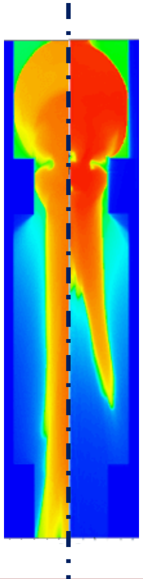
	Z3040	Z3041	Z3057
Laser energy	70 + 1460 J	73 + 1534 J	103 + 1283 J
Y_{DD}	4.1e12 ± 20%	3.2e11 ± 20%	2.0e12 ± 20%
Comments	Highest MagLIF yield to date	Direct repeat of z3040. Factor 12 less yield. Evidence of high mix.	Co coating on LEH used to investigate mix

(All shots use 1100 μm DPP)

Phase plate configuration with low intensity has potential for very high yield, but is less reproducible than unconditioned beam!!!

Why? Still unclear, but DUST on the LEH is a hypothesis (simulation by M. Weis):

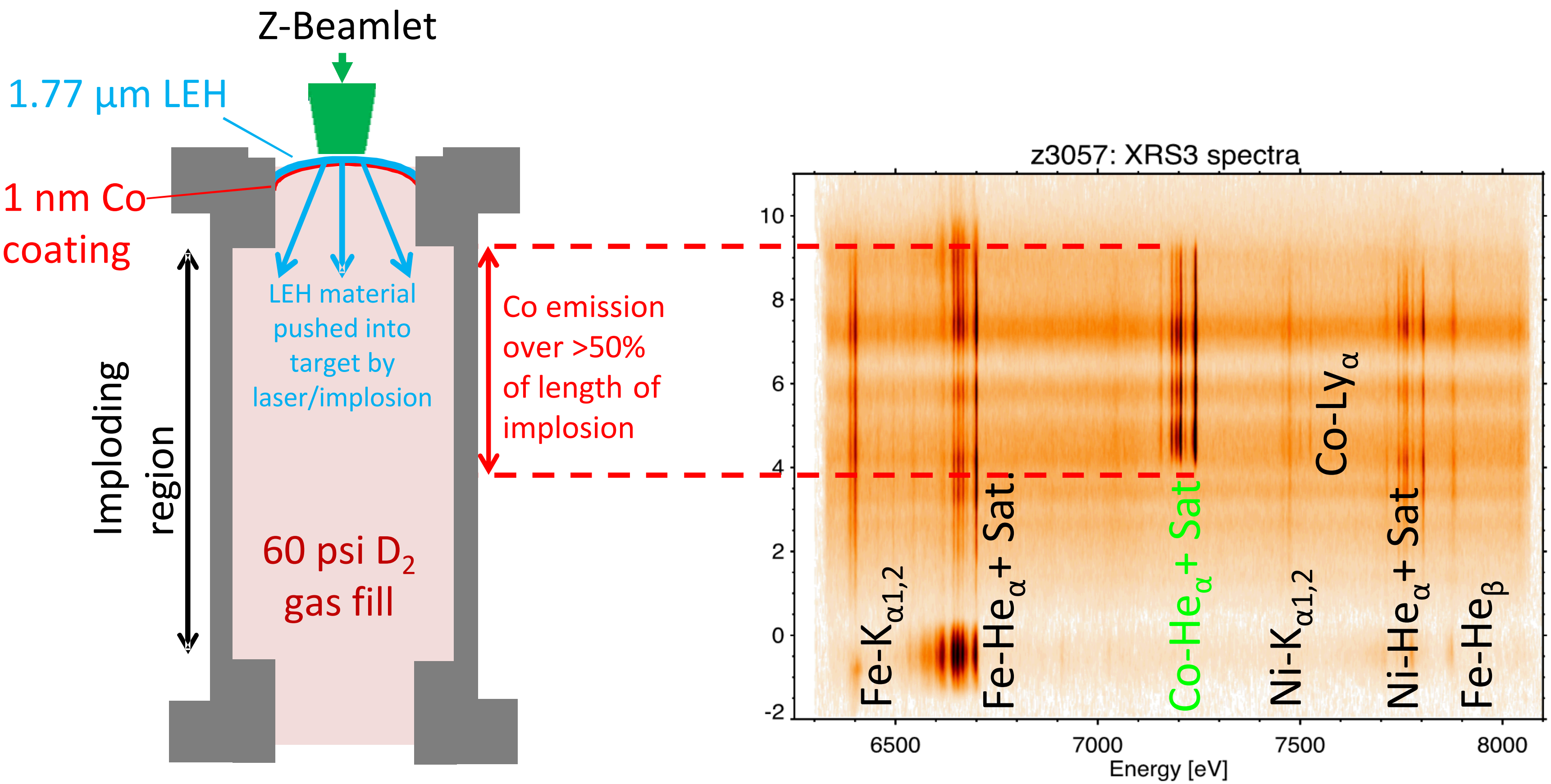
Clean LEH



100 μm dust particle on axis

See also Adam Harvey-Thompson's Poster later today!!

LEH Mix Observation on Z



LEH Mix still a big issue, but yield is still high!

See also Adam Harvey-Thompson's Poster later today!!

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Backscatter on Z

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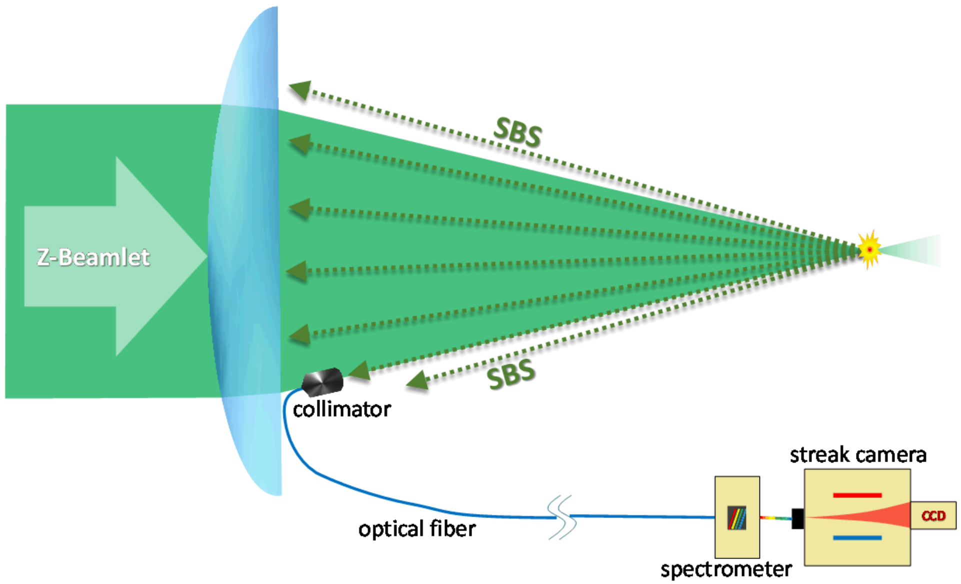
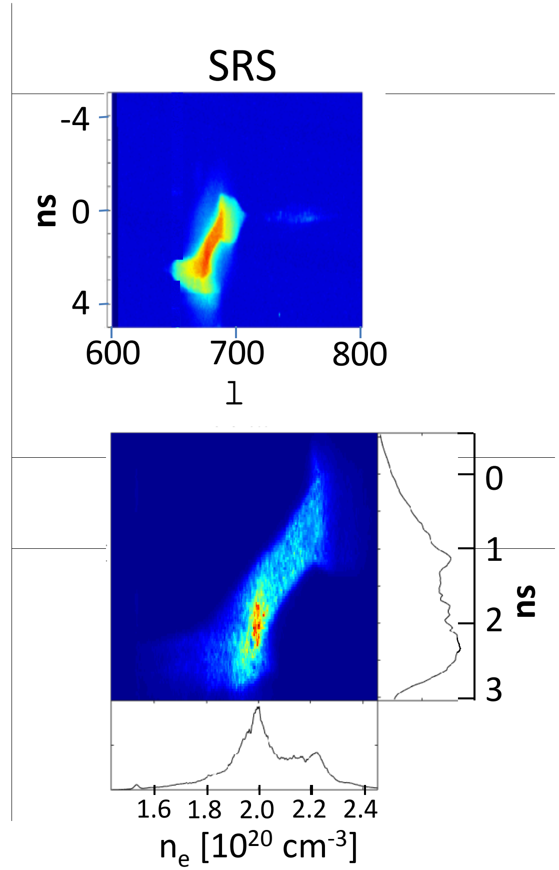
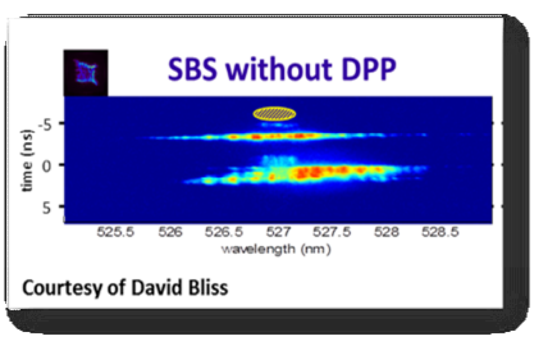
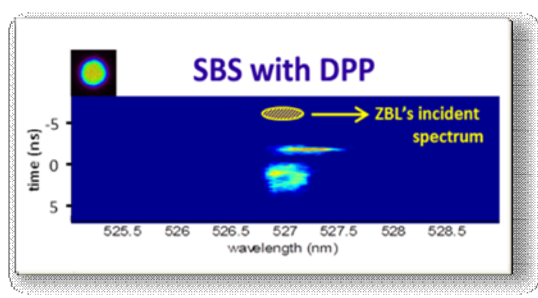
Spectral and temporal resolution: Streaked Visible Spectrometer





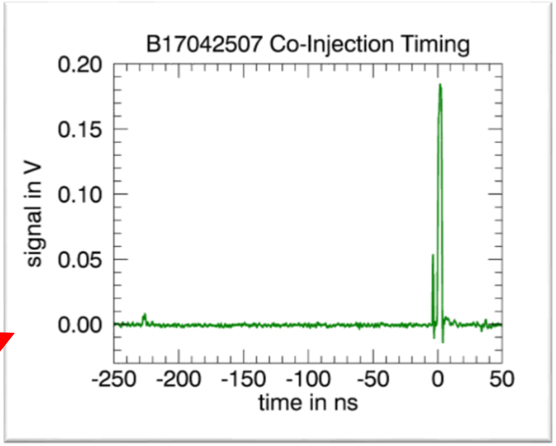


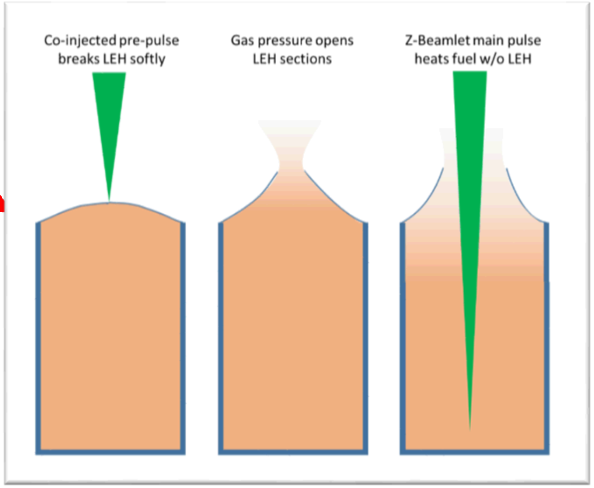


See also David Bliss' Poster later today - soon on PECOS, too !!

Concepts for Improvement

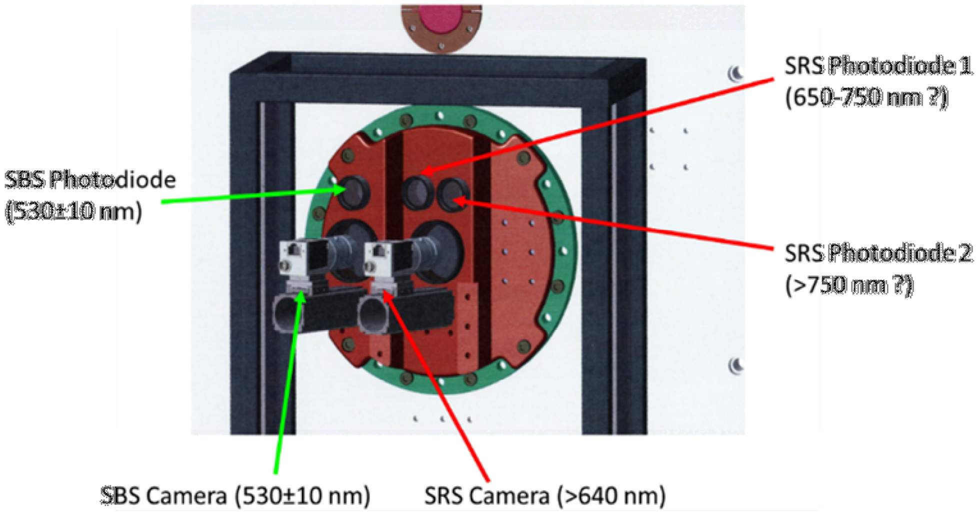
- Higher pressure (for now 90 psi, evtl. up to 120 psi).
- Replace helium with deuterium, possibly Ne-dopded.
- Blow down LEH earlier, gentler ("co-injection").
- Test LEH elimination with "Laser Gate".
- Reduce LEH material with cryogenic cooling





New Implementations

Improved LPI Diagnostics



Also: Streaked vis. Spectrometer
for intra-beam SBS/SRS at PECOS

Deuterium fills

- PLC valve control
- Turbo-pump addition
- New manifold
- 6 safety meetings
- 12 subject matter experts
- 10 documents
  (procedures, analyses, permits, etc.)

The latest generation of targets offers shadowgraphy in the east-west direction and **X-ray diagnostic** access from the top (hot/heated channel imaging, T_e?)

… Last Words

- **While plenty of energy penetrates a (vacuum) LEH with a 750µm phase plate, much of it scatters into large angles for weak pre-pulses.**
- **Low intensities (<100TW/cm²) provide a better, more cylindrical energy deposition profile and almost fully eliminate SBS, but most energy is still near the LEH.**
- **At 3.5ns separation for the pre-pulse, LEH mix is still significant.**
- **Higher energy deposition will require higher densities (90psi or more)**
- ***More experiments with higher pressures and more diagnostics will start this summer*.**