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Update on MagLIF preheat experiments

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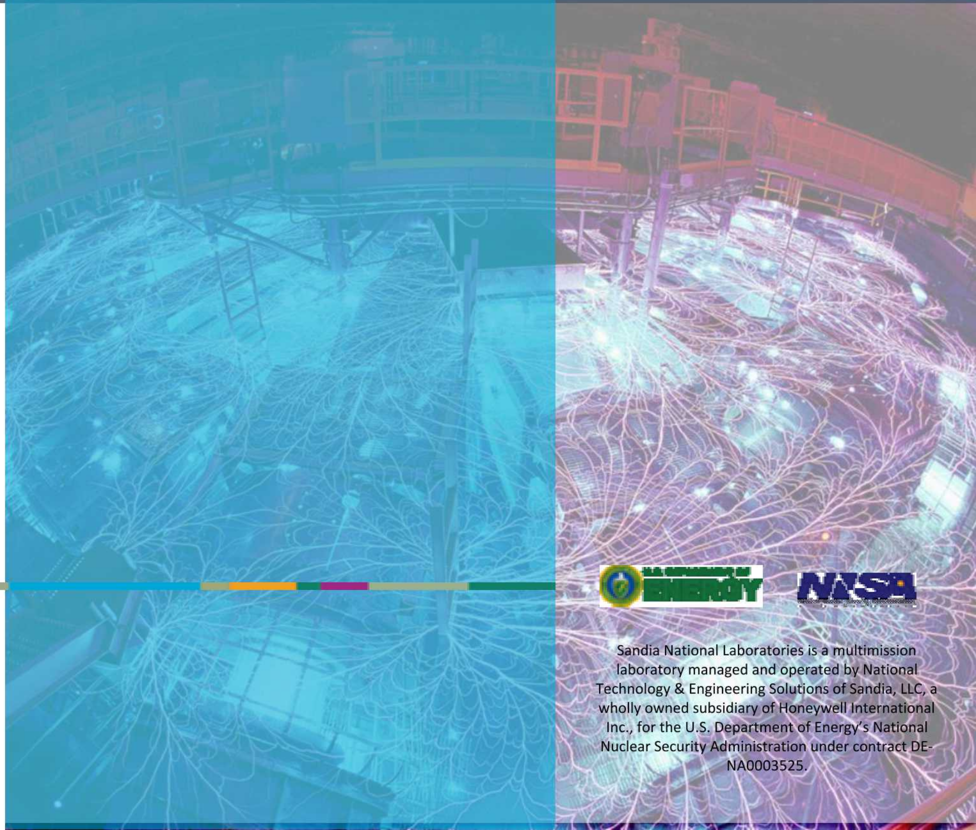

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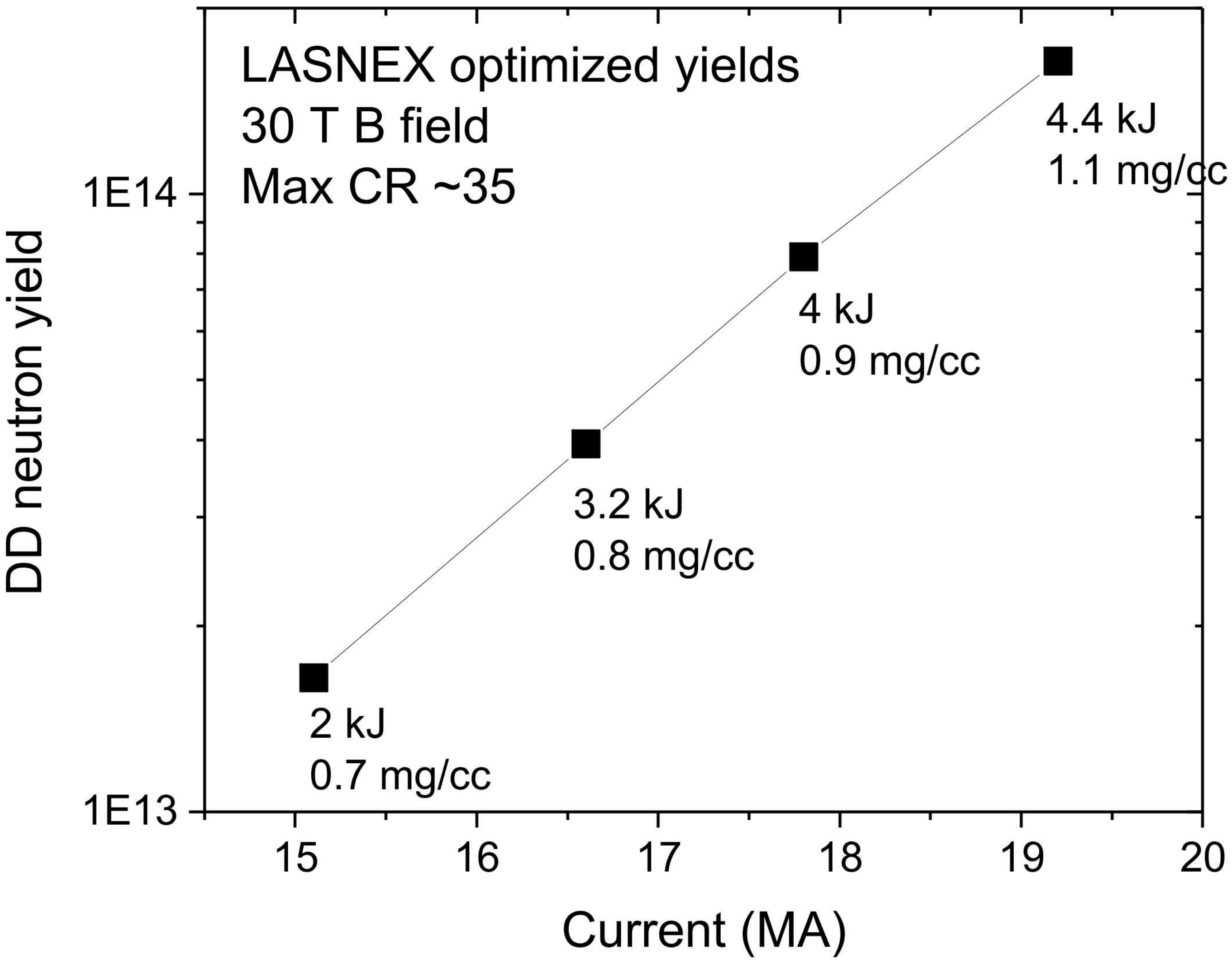
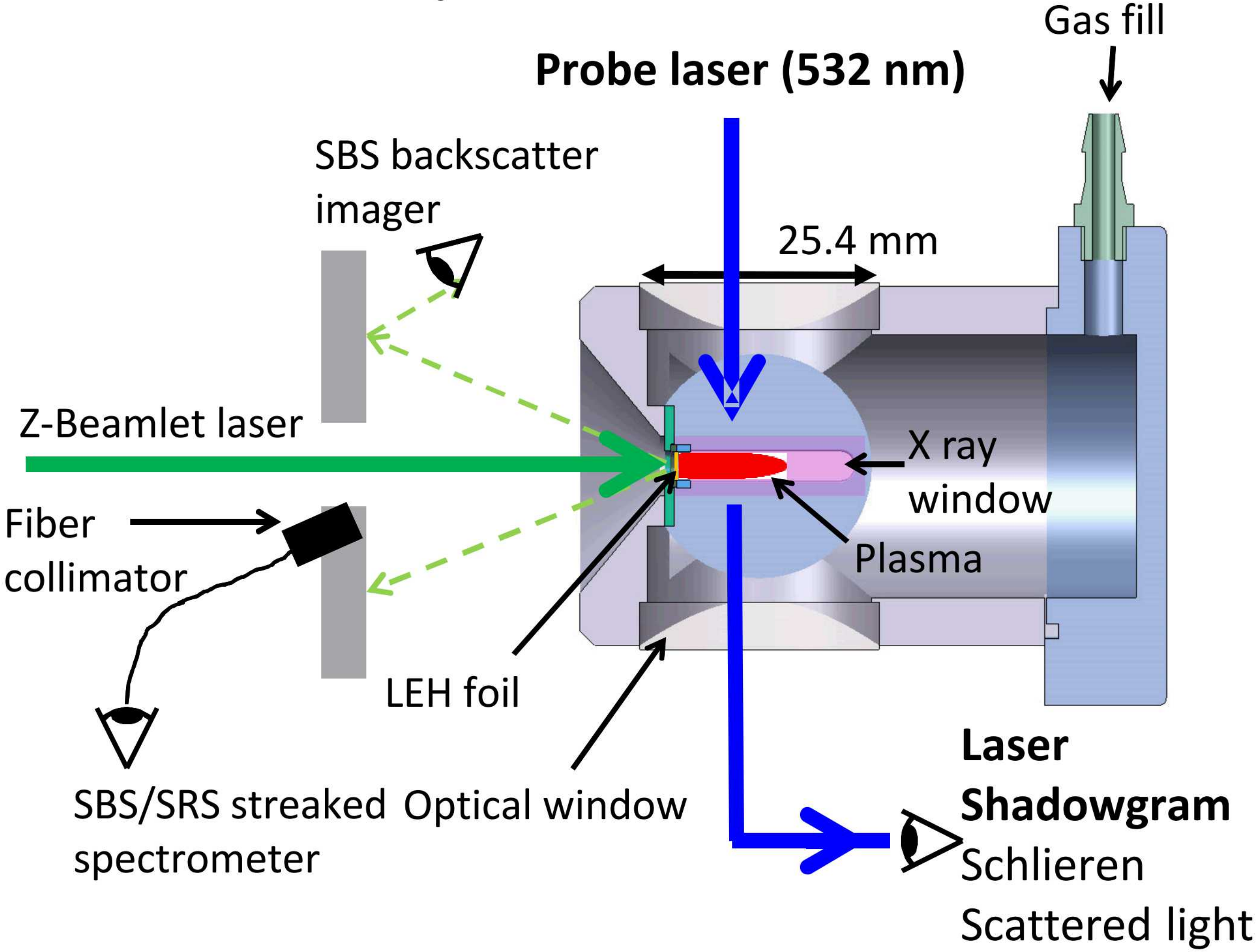
Preheat energy is a limiting factor on MagLIF performance

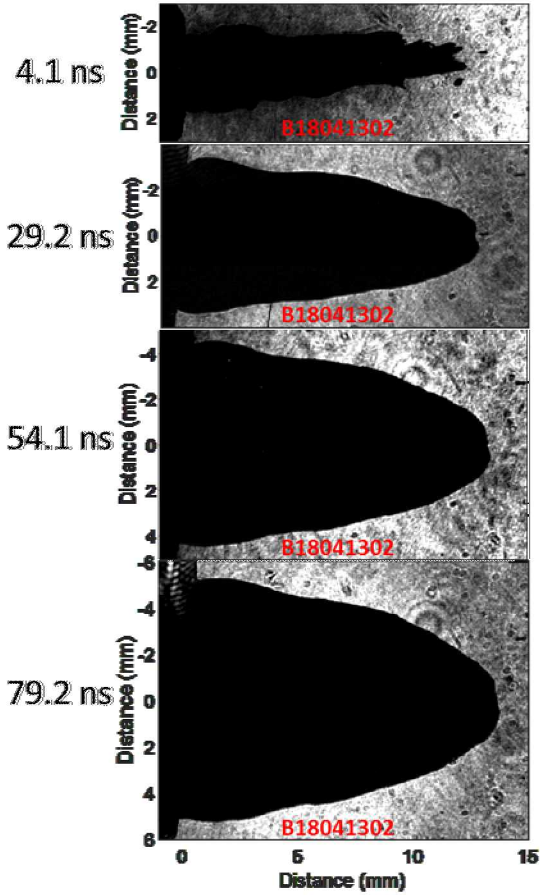


- Optimizing MagLIF yields at B_z=30 T takes LOTS of preheat energy
- Our best warm experiments couple < 2kJ of energy – this limits potential performance
  - Operate at lower currents
  - Reduce preheat energy density increasing stagnation CR
- MagLIF preheat focus: Increase coupled energy through LEH foil mitigation

Deposited preheat energy is measured in offline "PECOS" experiments



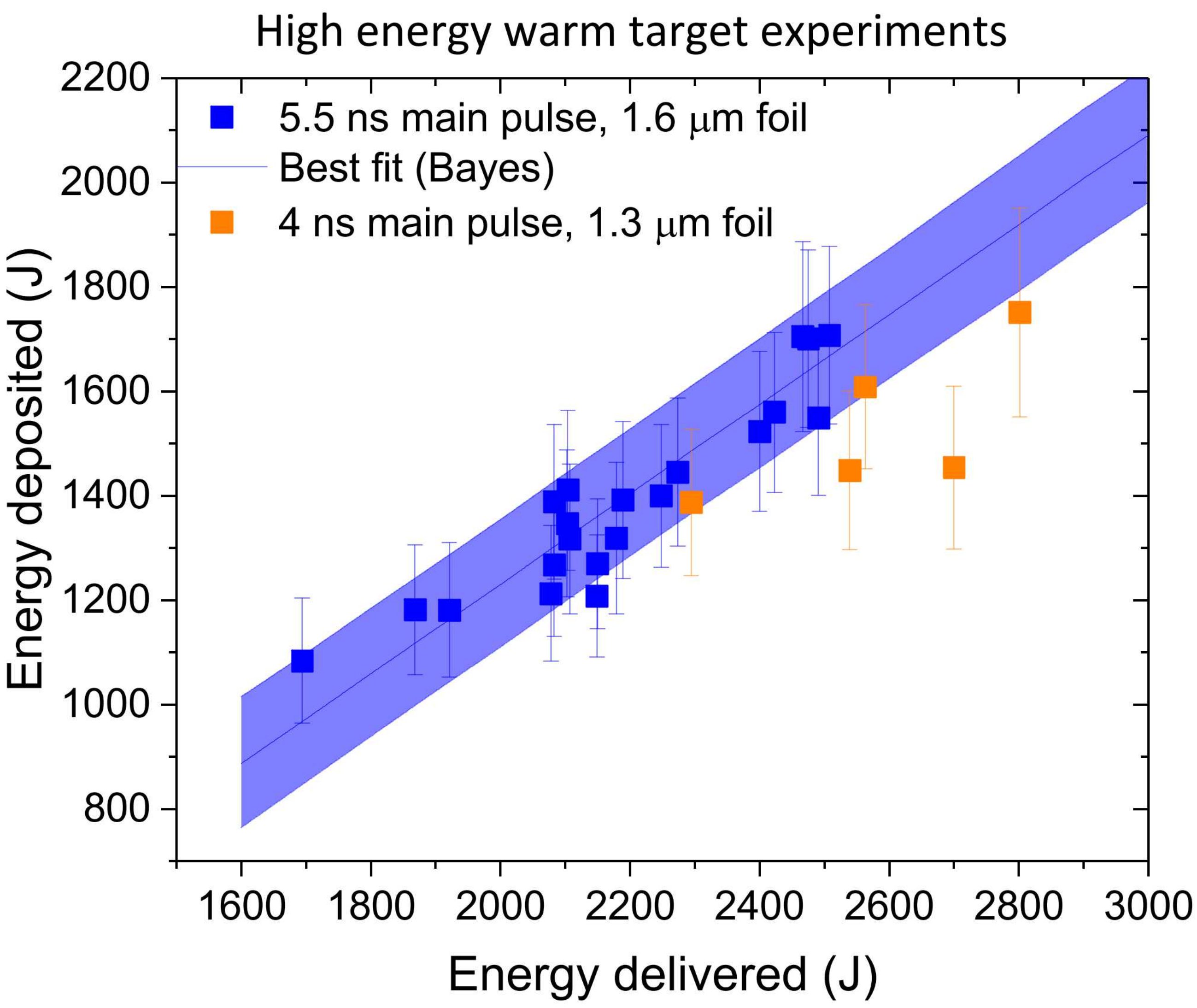
Blast wave expansion – energy deposited



- We cannot measure mix in these experiments – done in integrated experiments

M. Geissel et al., Physics of Plasmas **25**, 022706 (2018)
A. Harvey-Thompson et al., Physics of Plasmas **26**, 032707 (2019)

We can not reach >2 kJ preheat without window mitigation or a bigger laser

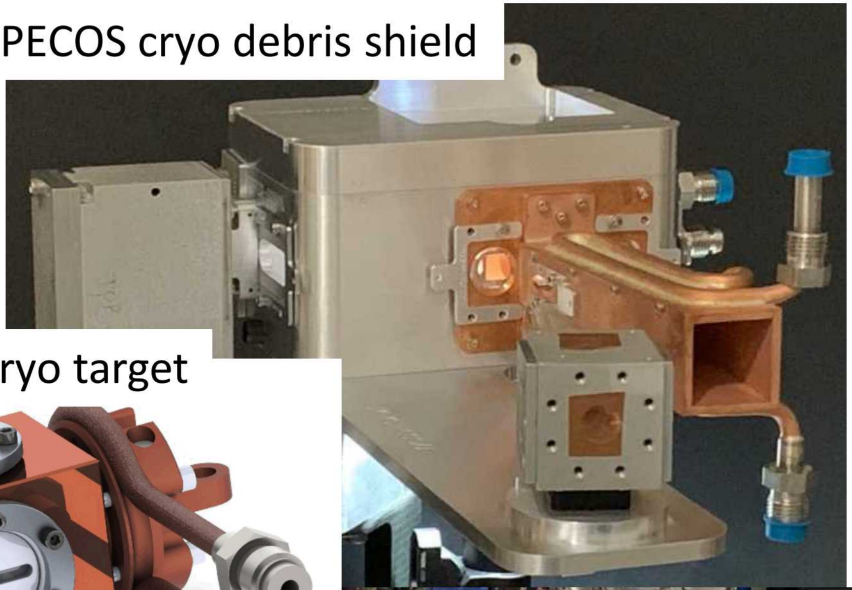


- We are limited to ~70% coupling efficiency by losses
  - LPI backscatter
  - Energy loss to LEH foil
- We are working to mitigate losses in two ways:
  - Cryogenic cooling allowing for thinner windows
  - Laser-gate which "pops" the LEH foil before the main pulse
  - Mitigation enables 1.5 mm spots – prevents overshooting
- We could increase laser energy
  - Transmission into PECOS is <80%
  - More laser energy! (additional amplifiers are being installed)

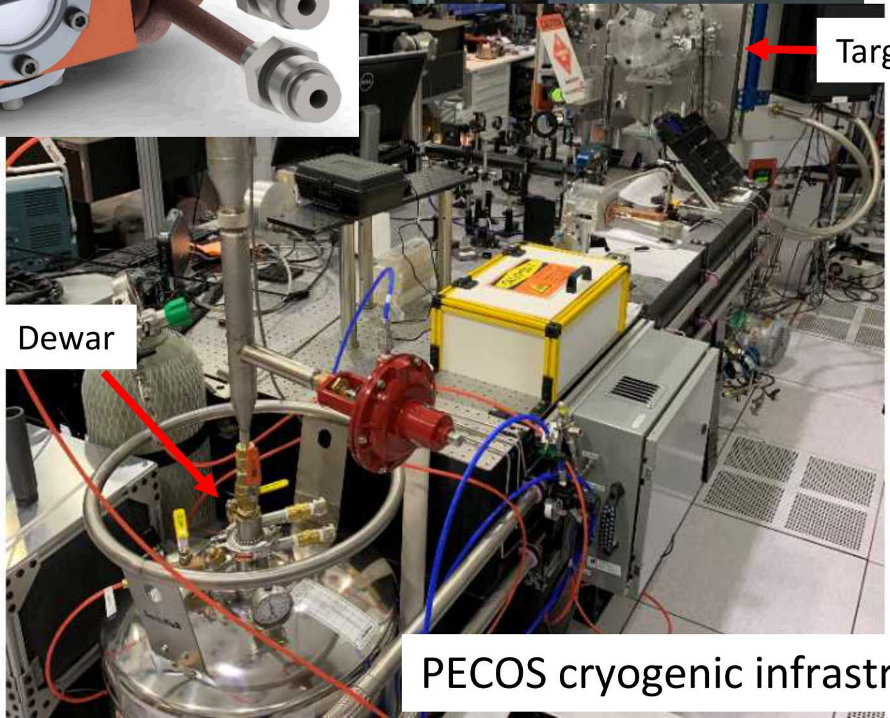
Cryogenic cooling enables >2 kJ preheat

- Hydra suggests 2 kJ in 1 mg/cc fuel is possible with cryo cooling (0.5 μm foil)[1]
- To implement cryo cooling we need to:
  - Perform offline cryogenic experiments
  - Have an effective integrated cryogenic platform
- Cryogenic cooling is *nearly* ready on PECOS (just waiting on targets)
- Cryogenic cooling capabilities may enable other new laser experiments

PECOS cryo debris shield



PECOS cryo target

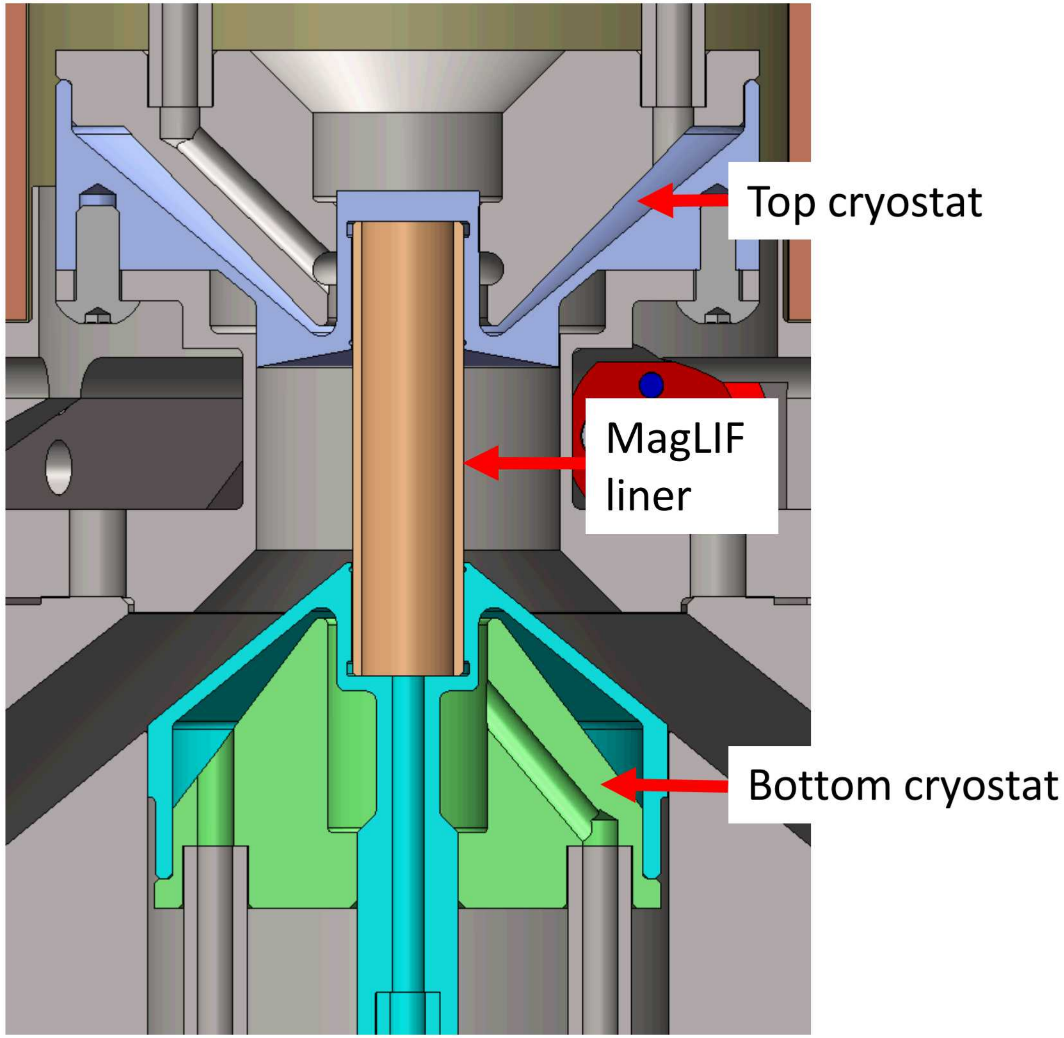


PECOS cryogenic infrastructure

[1] M. R. Weis et al., in preparation

Advanced cryogenic cooling improves temperature control in integrated experiments

Test hardware for bottom side cooling

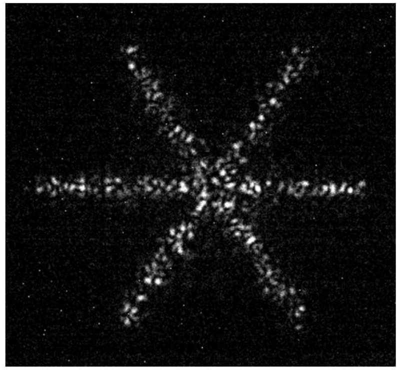


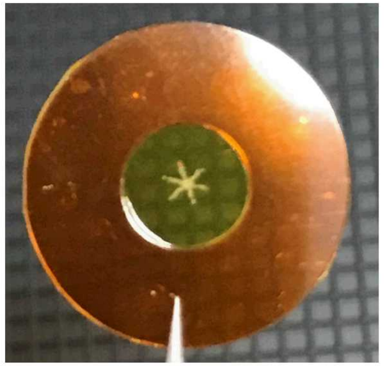
- Recent cryogenic experiments returned neutron yields comparable to warm targets
  - Z3500: 3.08e12 ±30.9%
  - Z3501: 3.02e12 ± 30.4%
  - Current delivery was nominal
  - Temperature uncertainty was high ±25% (no insulating breaks)

- Goals for December series:
  - Demonstrate >2 kJ preheat energy in the fuel
  - <10% temperature uncertainty at <80 K (requires bottom-side cooling)

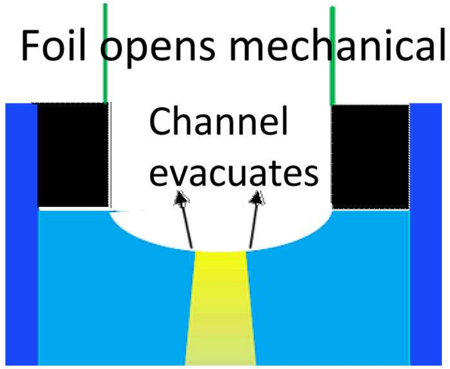
Laser-gate removes the LEH foil without need for cryo cooling

Low energy cross pattern "pops" the window before the main pulse

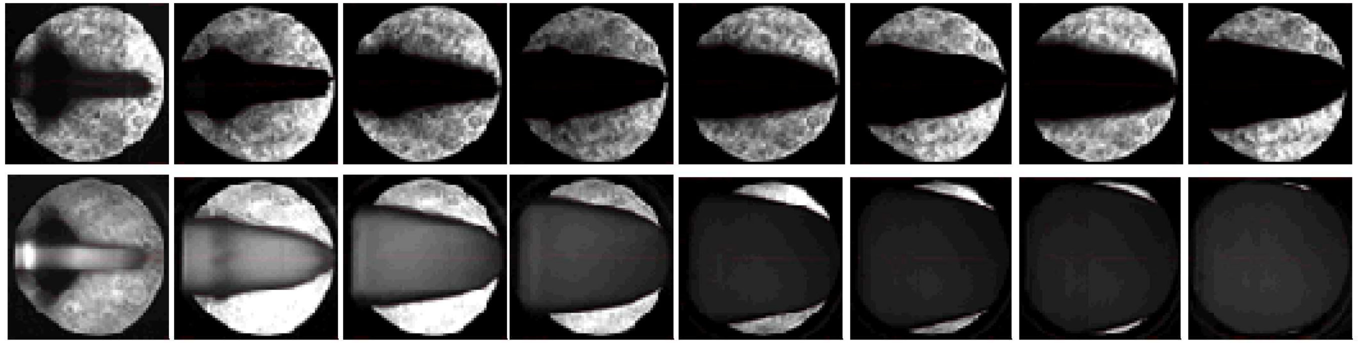




Foil opens mechanically

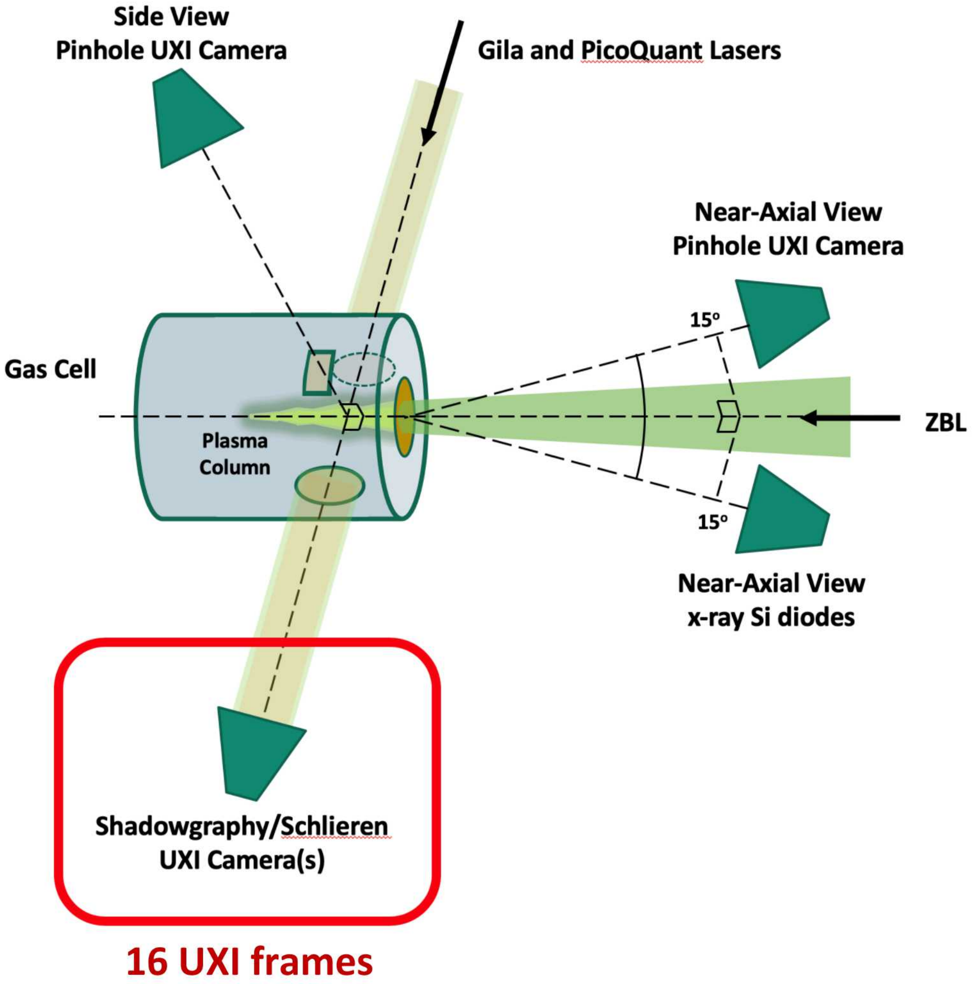


16 frame shadowgraphy shows blast-wave expansion



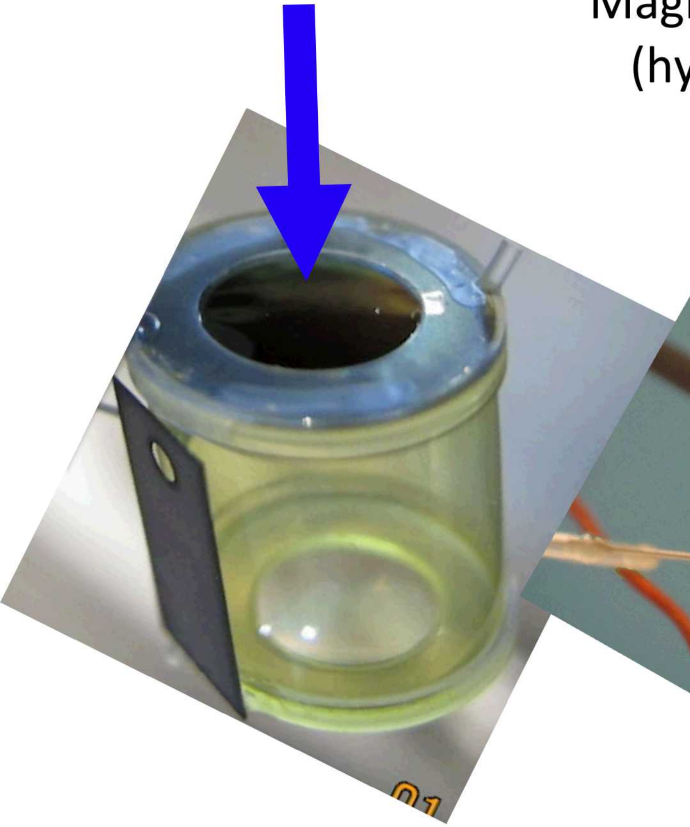
- Preliminary results from 8 shots suggest that Lasergate:
  - Successfully removes the LEH window
  - Data suggests increased total energy deposition

Conchas: Large suite of diagnostics fielded

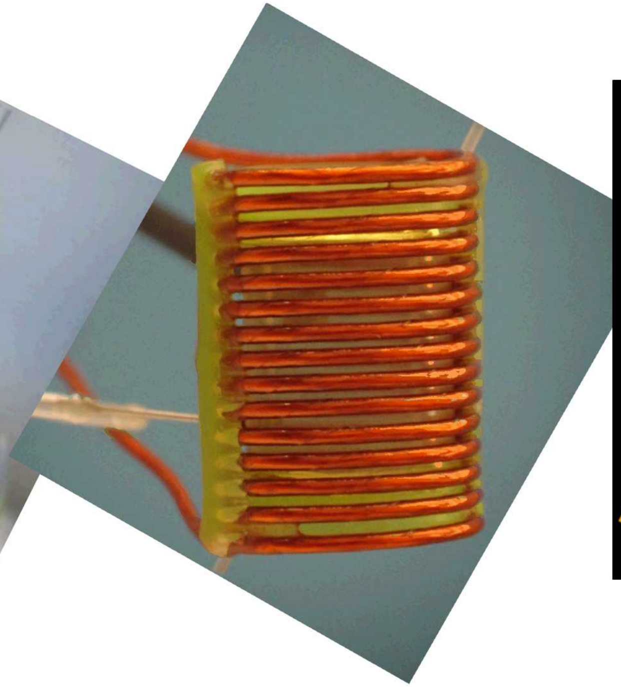


Experiments using one Quad of the NIF significantly reduce scaling risk by demonstrating at-scale preheat for MagLIF

NIF quad (up to 30 kJ)

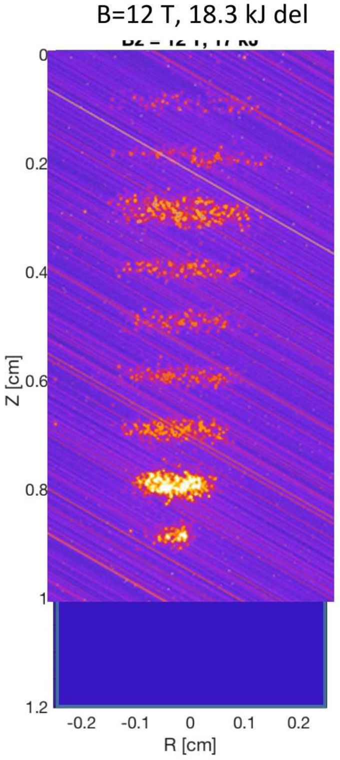


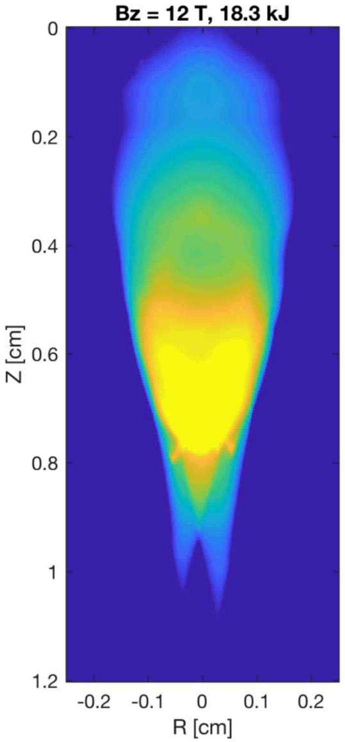
Magnetized target (hydrocarbons)



Cryogenic target (dense D_2)

X-ray imaging shows rad-hydro simulations correctly capture laser coupling dynamics on the NIF





- Experiments have demonstrated ~20 kJ coupled into gas. Minimal LPI backscatter.
- CY21-22 focus on magnetization, cryogenic cooling, energy deposition measurements and mix