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Investigating at-scale MagLIF preheat on the NIF

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LLNL-PRES-XXXXXX

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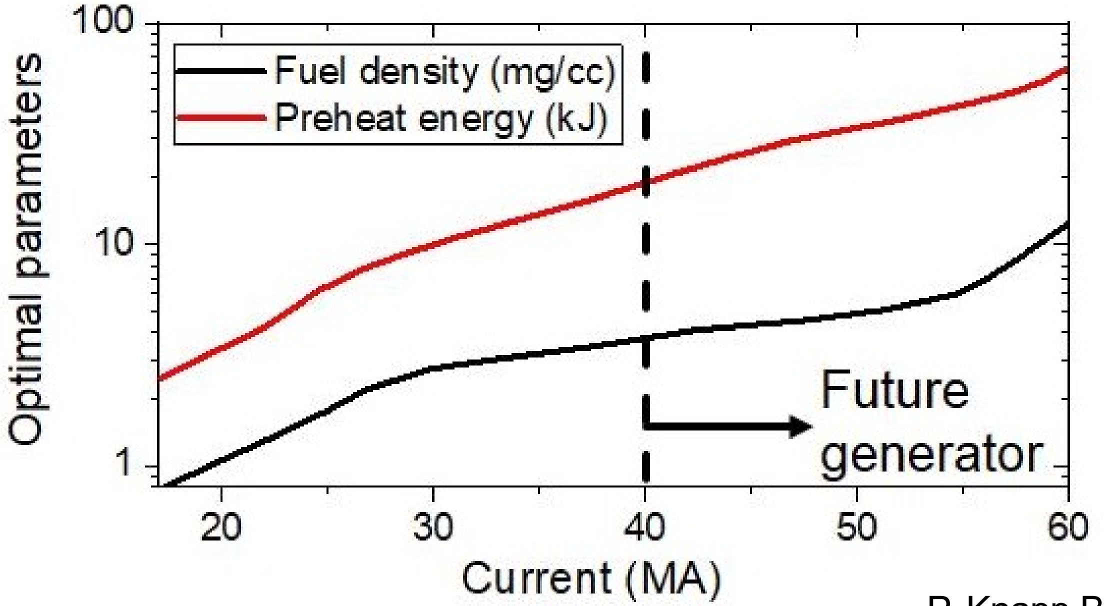
Calculations of the requirements for future high gain MagLIF indicate that for 40 MA drivers, >20 kJ of pre-heat will be required

S. A. Slutz et al., "Scaling magnetized liner inertial fusion on Z and future pulsed-power accelerators", Physics of Plasmas 23, 022702 (2016)



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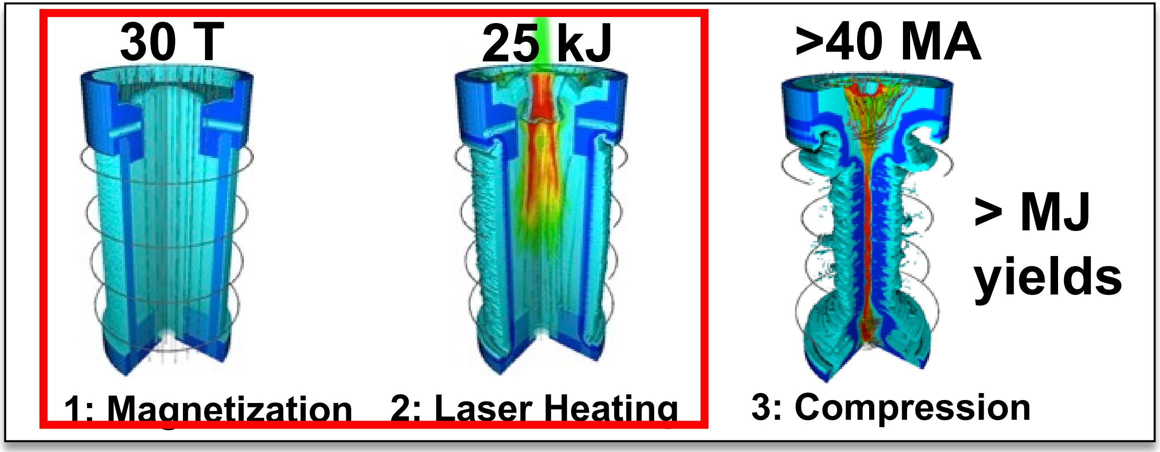
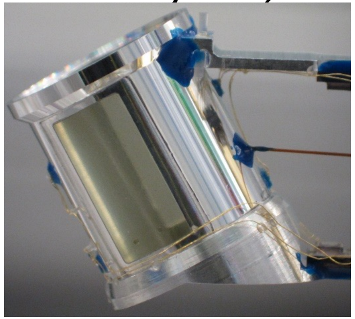
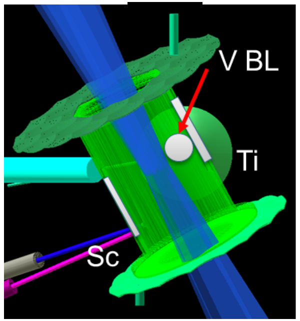
NIF is uniquely capable of addressing preheat scaling to next-gen pulsed power facilities for MagLIF



Cryo D_2

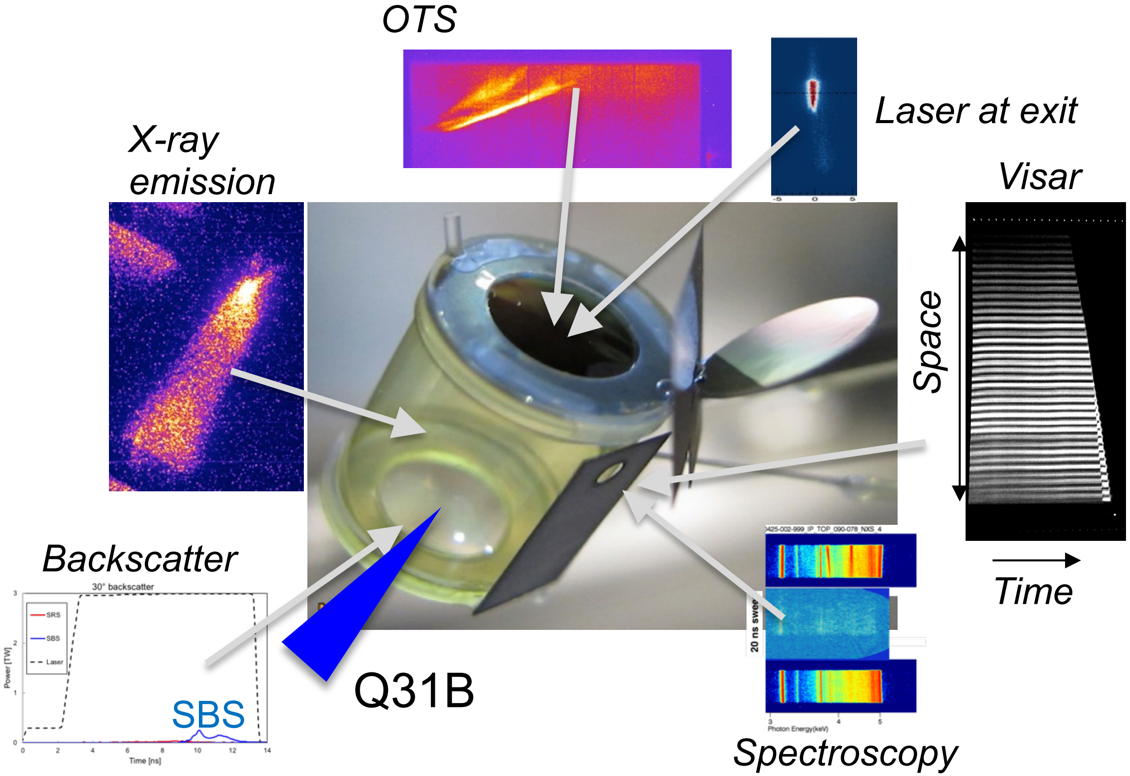


Mix



- Achieving high level goals reduces risks for scaled MagLIF:
  - Assess viability of laser preheating as a scaling path for magnetized liner inertial fusion (MagLIF)
  - Determine laser requirements for next-gen pulsed-power facility
  - Assess our capability to model preheat "at-scale" and address deficiencies in our codes
- This project is called out in the 2020 ICF report as key to addressing MDD scaling risks

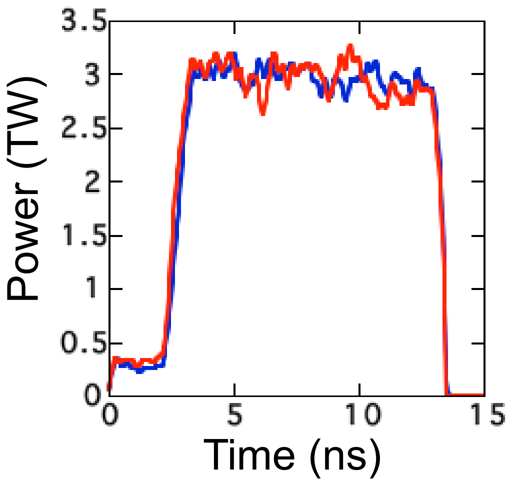
The extensive suite of NIF diagnostics enables experimental studies of many physics processes relevant to MagLIF



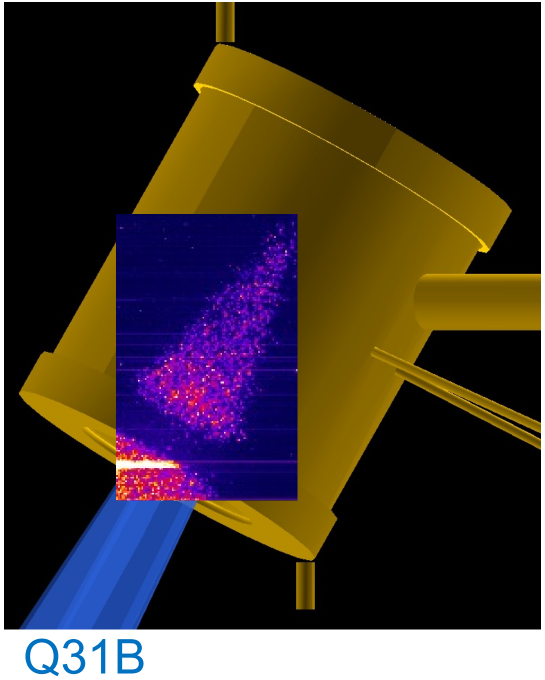
- LPI and laser energy coupling
  - BS and laser propagation
  - Laser transmission
  - Visar
- Thermal conduction and heat transport
  - X-ray imaging
  - Spectroscopy
  - OTS
- Impurity transport
  - Spectroscopy

These full-scale gas pipe targets are driven by a single quad of NIF, delivering ~35 kJ of laser energy to the target

N200310-001 (11.5% crit)
N200310-002 (15% crit)

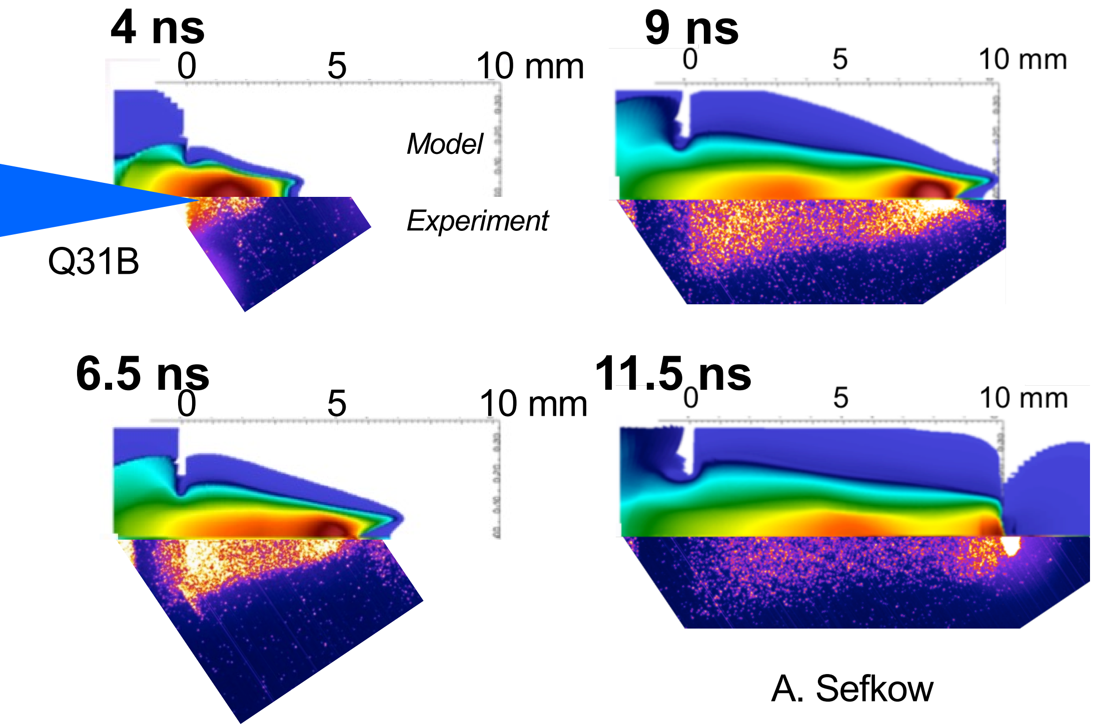


View from GXD in 90-315



- 1 cm-long epoxy gas pipe cylinder
- 150 um wall thickness
- 1-1.4 atm C5H12/C3H8 (with 1% Ar)
- 1.5 um thick kapton windows
- 1.2x1.6 mm laser spot from CPP
- Emission imaged onto x-ray framing cameras

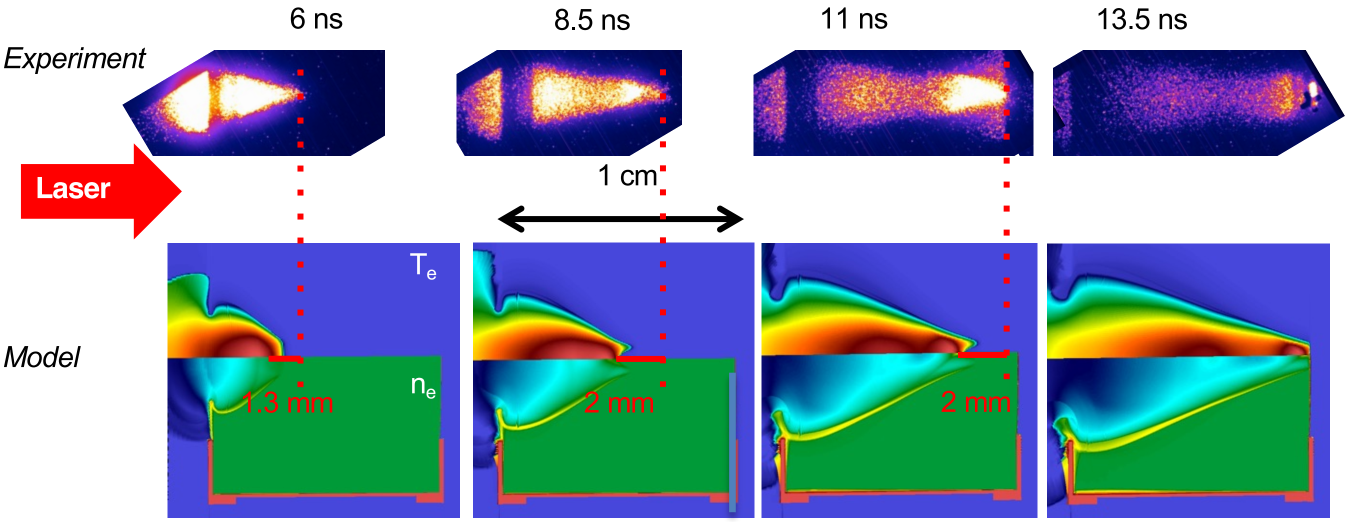
The laser propagation at 11.5% n_{crit} in C_5H_{12} is in good agreement with 2D HYDRA simulations



A. Sefkow

- Measurements of the time required for the laser to burn through the target bound the energy coupled
- For these conditions, the laser burnthrough is ~10.8 ns, and the energy coupling is ~24 kJ
- This includes energy into the plasma and the entrance window

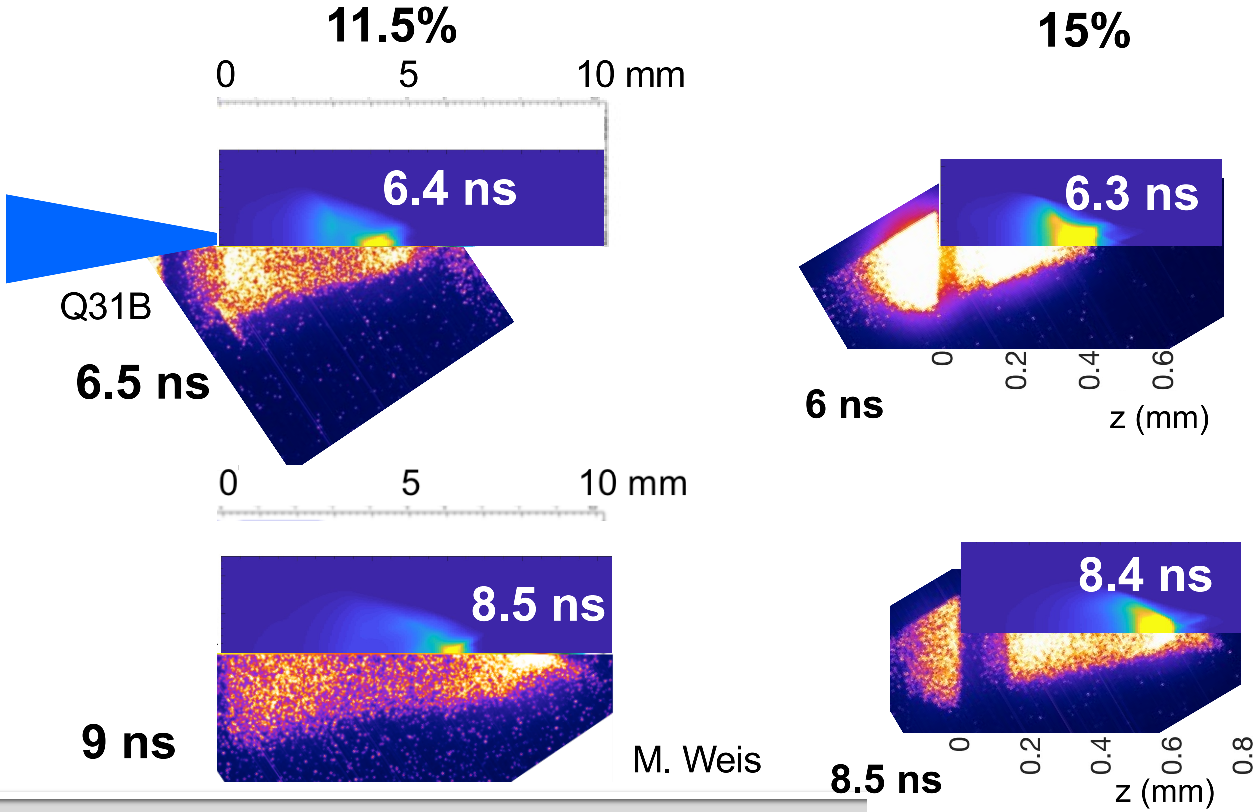
At 15% n_{crit} the measured propagation length is greater than in the simulations for all times



- Experiments at two different fill densities allows testing of the model scaling
- At this density the laser burnthrough is delayed to 12.9 ns, with ~31 kJ of energy coupling

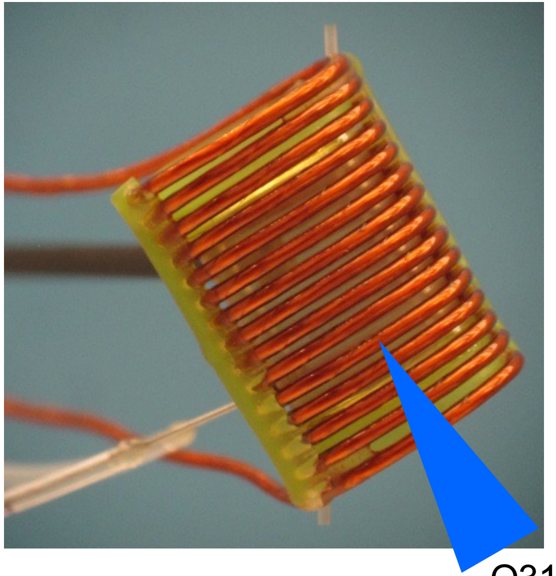
The choice of flux limiter alone is unable to compensate for these discrepancies

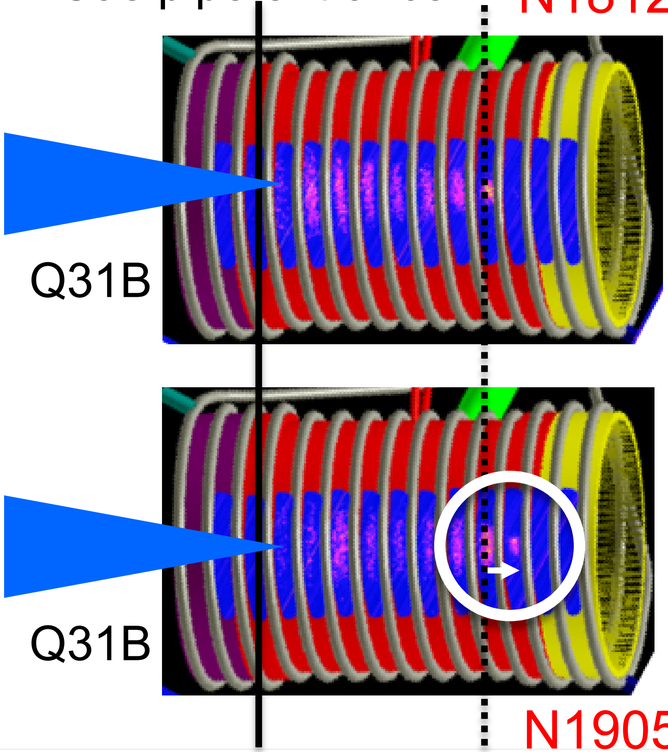
Recent 3D simulations better match the propagation at high density, but not at low density



- Effects of flux limiter choice, ray density, and conductivity model are being investigated to improve agreement at both densities

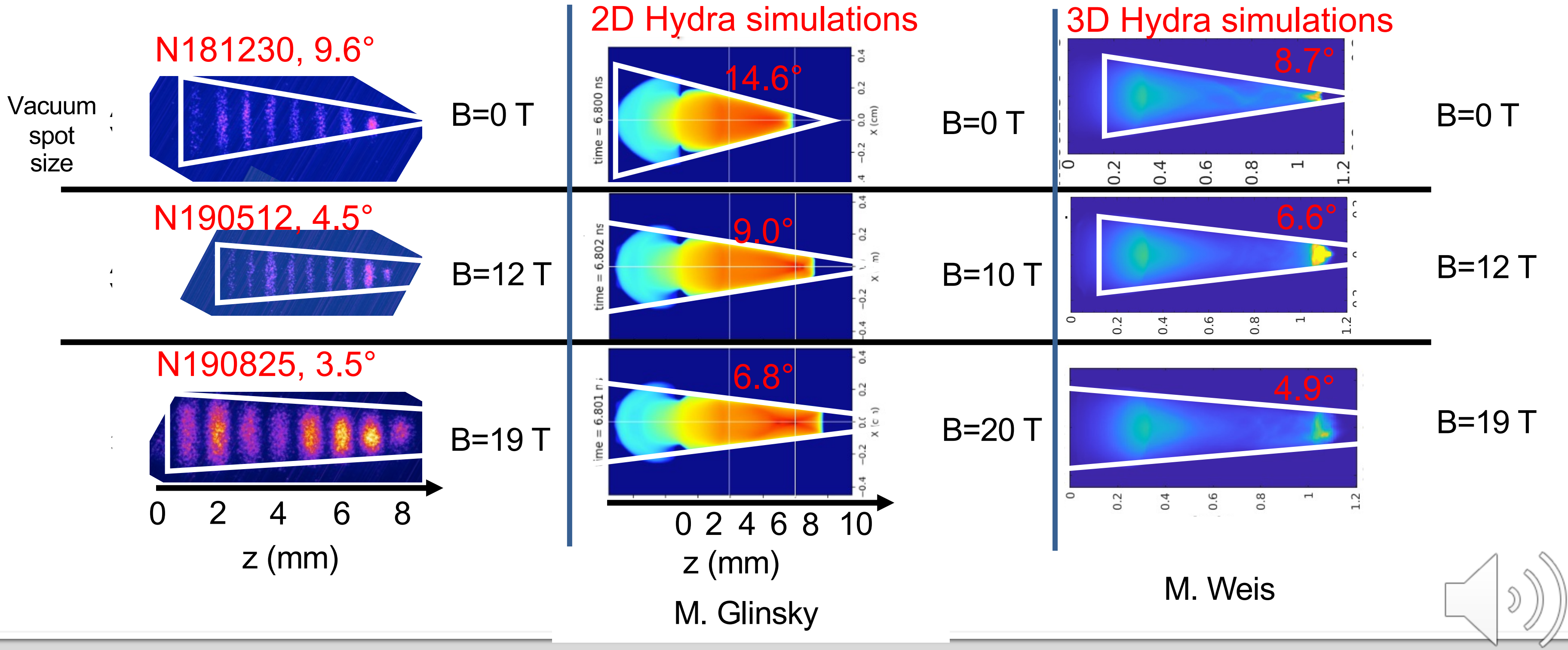
Pre-imposed axial magnetic fields up to 24 T have also been applied for both fill densities



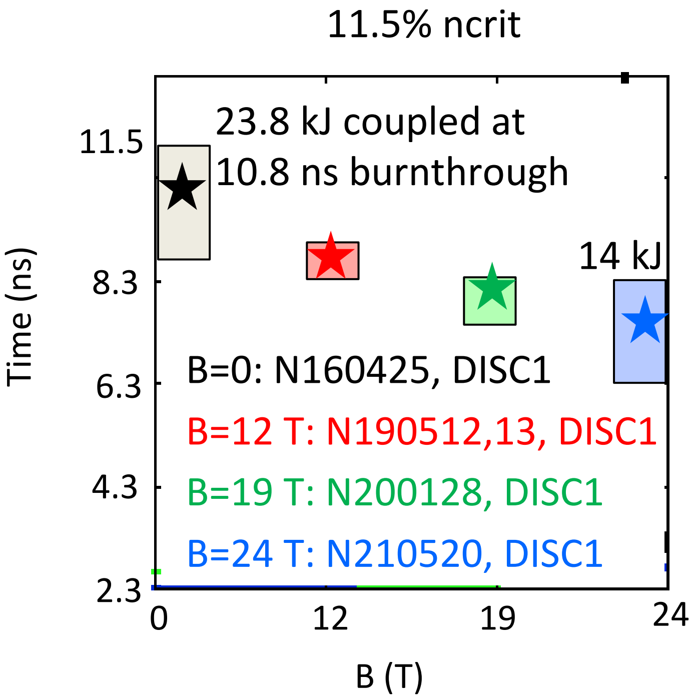


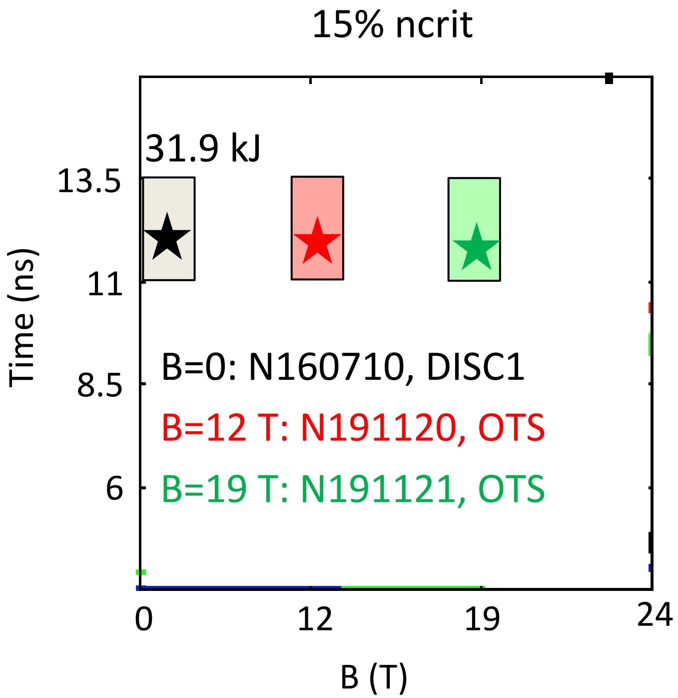
The emission profile becomes more cylindrical with B-fields applied, consistent with 2D r-z and 3D Hydra simulations

Emission profiles for T~1 keV from 2-8 keV at 8.3 ns



The laser burnthrough time is appreciably reduced with increasing B-field at 11.5% n_{crit}, but less so for 15% n_{crit}





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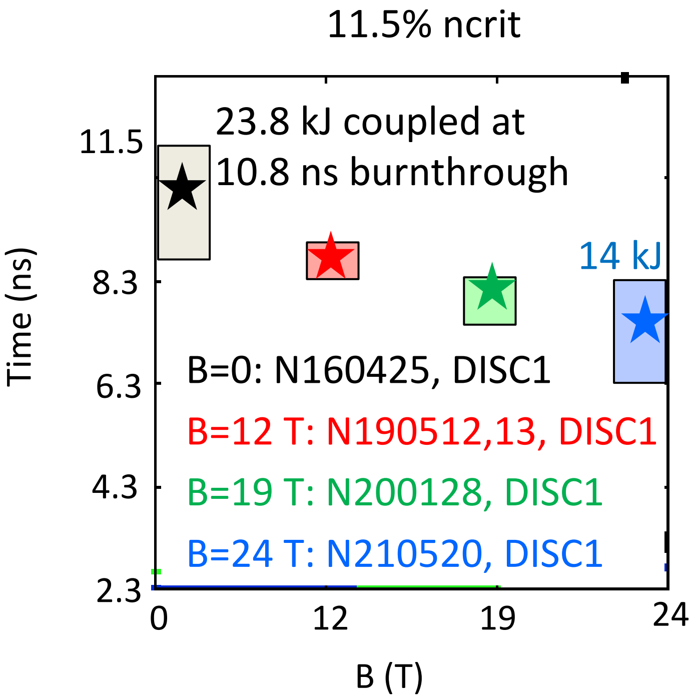
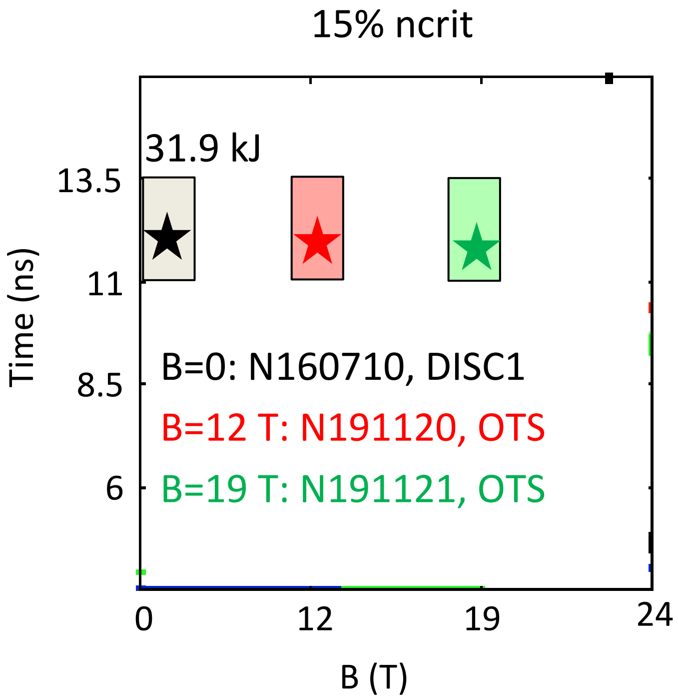
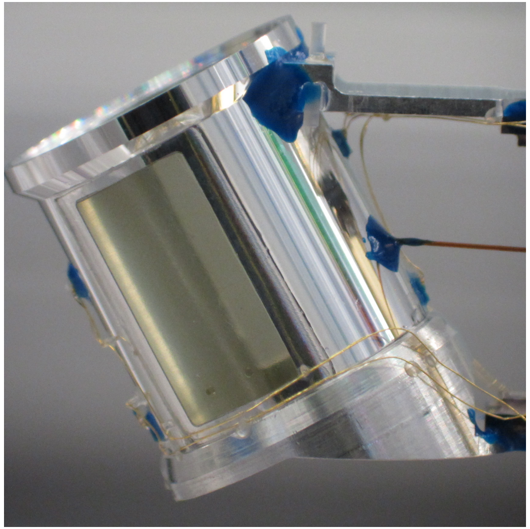




The at-scale MagLIF pre-heat experiments at NIF are showing good energy coupling in warm hydrocarbons

- Additional measurements of energy coupling using Visar with and without B-fields are underway (Glinsky CO05.008)
- Studies of material mixing from the windows and the walls are also being performed (Tubman CO05.007)
- In FY22 we will be emphasizing a cryogenic version of the target with D2 fills up to 5 mg/cc
- The combination of B-fields and cryo targets at NIF is being developed, likely available in FY24

Cryogenic targets with D2 fills



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