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Photos placed in horizontal position with even amount of white space between photos and header

Temperature analysis of MagLIF preheat experiments at OMEGA-EP

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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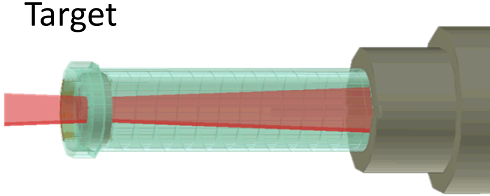
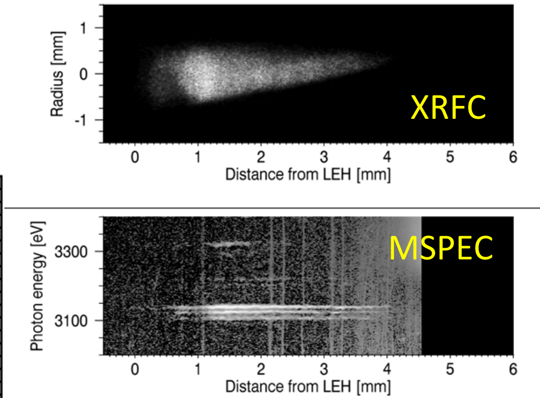
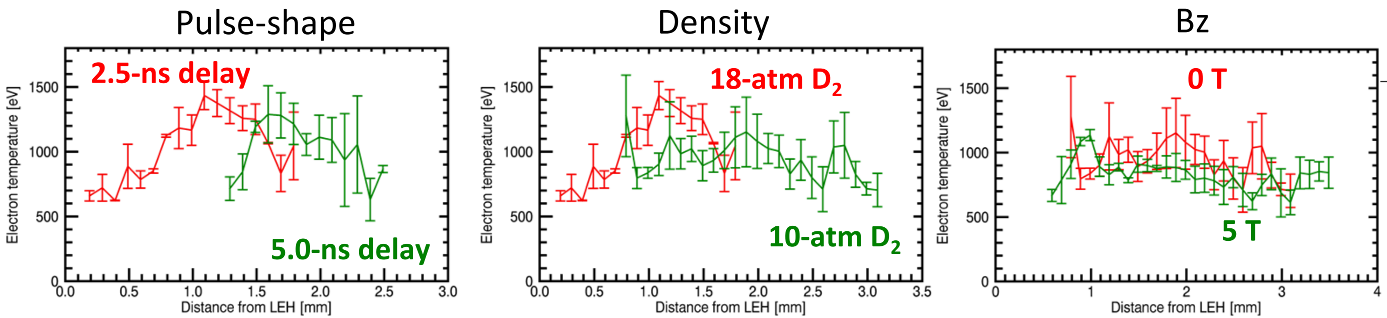
Spectroscopy experiments measure space dependent MagLIF laser preheat, demonstrating a tool to validate MagLIF preheat physics

- MagLIF preheat experiments are performed at OMEGA-EP
- XRFC and MSPEC data constrain laser propagation and heating
- Laser preheat dependence on gas density, pulse shape, and magnetic field are investigated







- Comparison with simulation and scrutinizing data analysis will refine our understanding of preheat physics

More focused experiments will refine our understanding of MagLIF preconditioning phase

MagLIF is a magnetically driven ICF approach that potentially relaxes challenging ignition requirements

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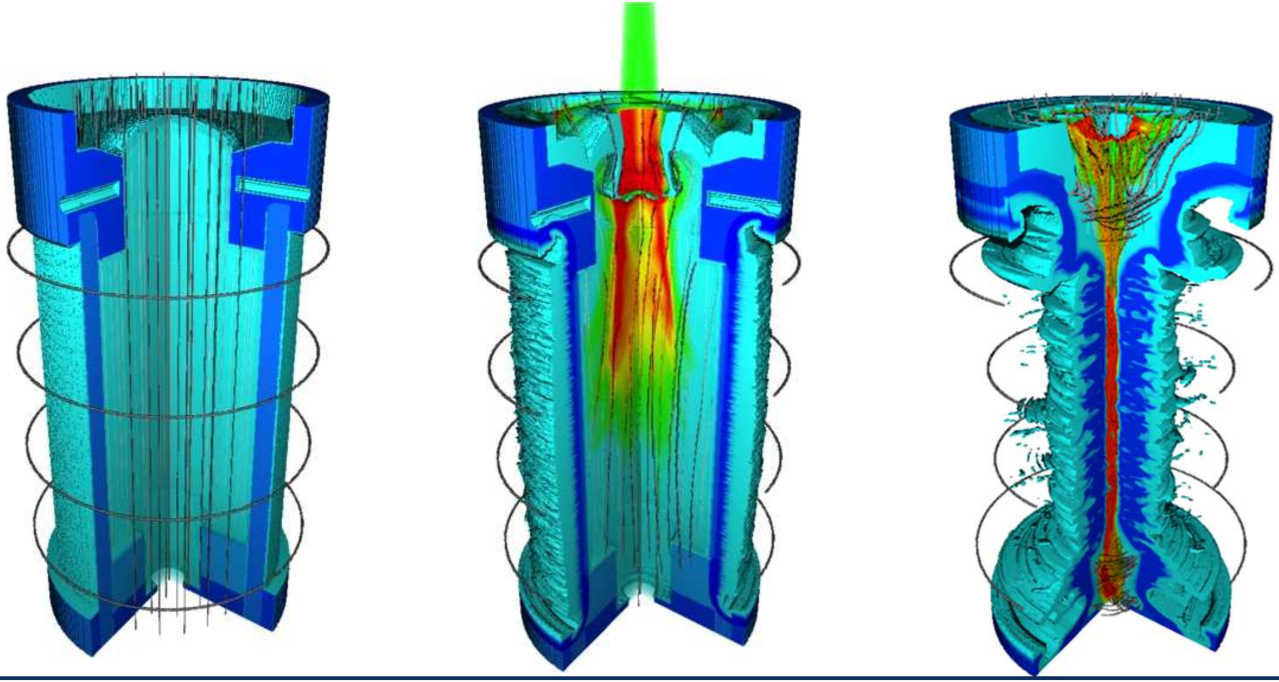
1. Magnetization **2. Fuel preheat** **3. Compression**

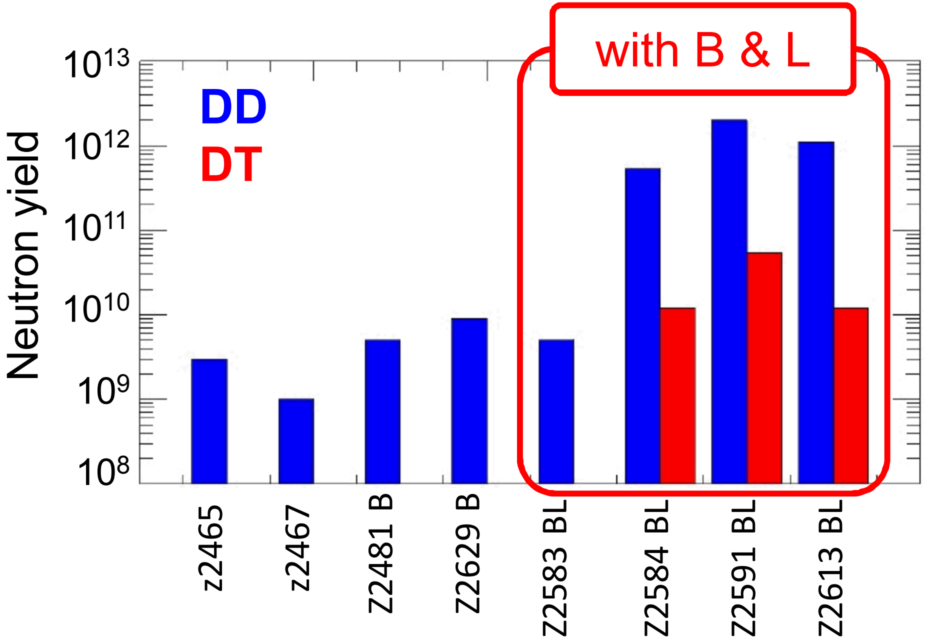


Magnetization and laser-preheat are key concept to relax ignition requirements.

Slutz et al, Phys. Plasmas (2010)

Sefkow et al, Phys. Plasmas (2014)

Initial integrated MagLIF experiments demonstrated 200x yield increase with B and lasers, but …



- 200x more Y_{DD} with B and L
- Y_{DT} supports B trapping power
- But, $Y_{DD}=2x10^{12}$ is lower than predicted ($>1x10^{13}$)

Focused experiments needed to find the source of discrepancies

MagLIF is a magnetically driven ICF approach that potentially relaxes challenging ignition requirements

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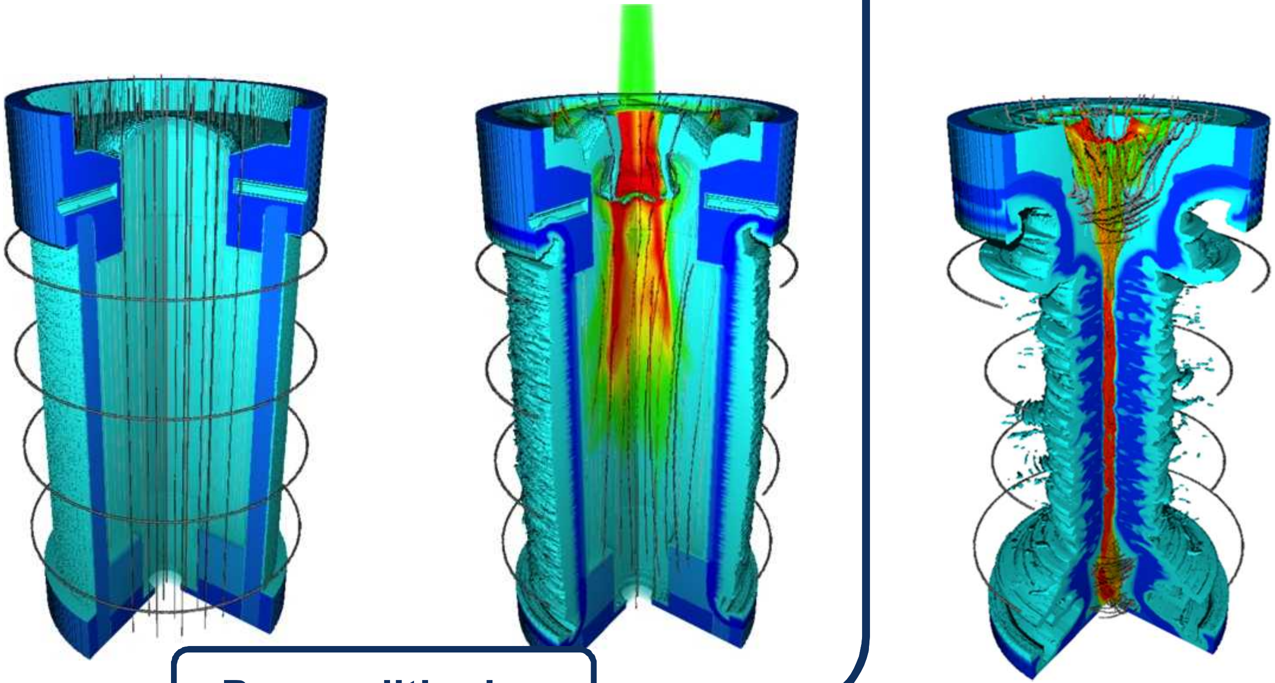
1. Magnetization

2. Fuel preheat

3. Compression



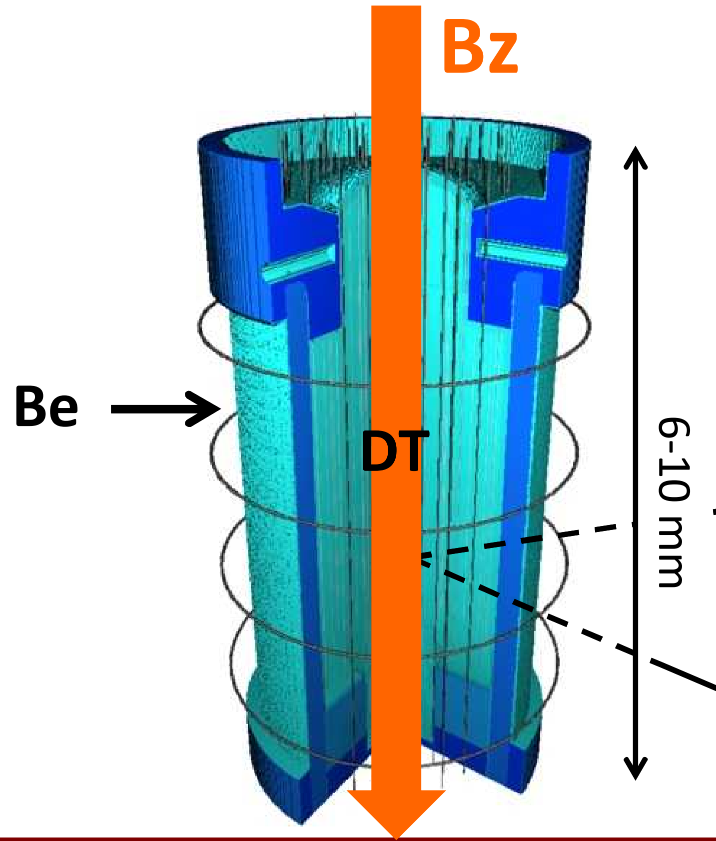
Preconditioning

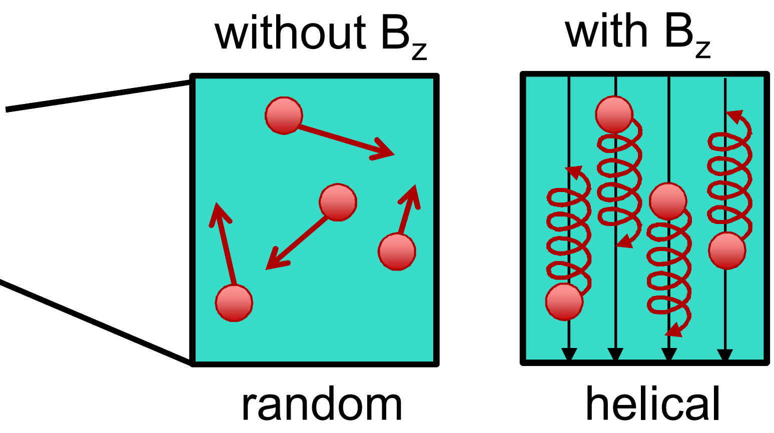
Slutz et al, Phys. Plasmas (2010)

Sefkow et al, Phys. Plasmas (2014)

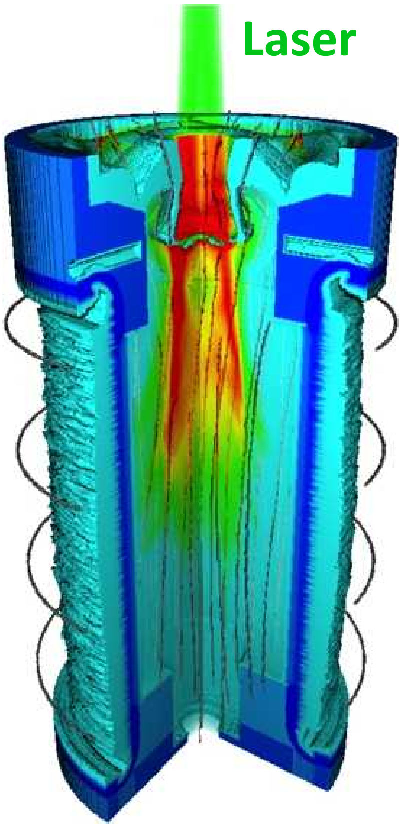
How does magnetization affect the laser-preheat?

1. Magnetization: 10-30T
   - Reduction in heat loss
   - Trapping charged particles





Does laser successfully preheat the gas without introducing wall/window mix?

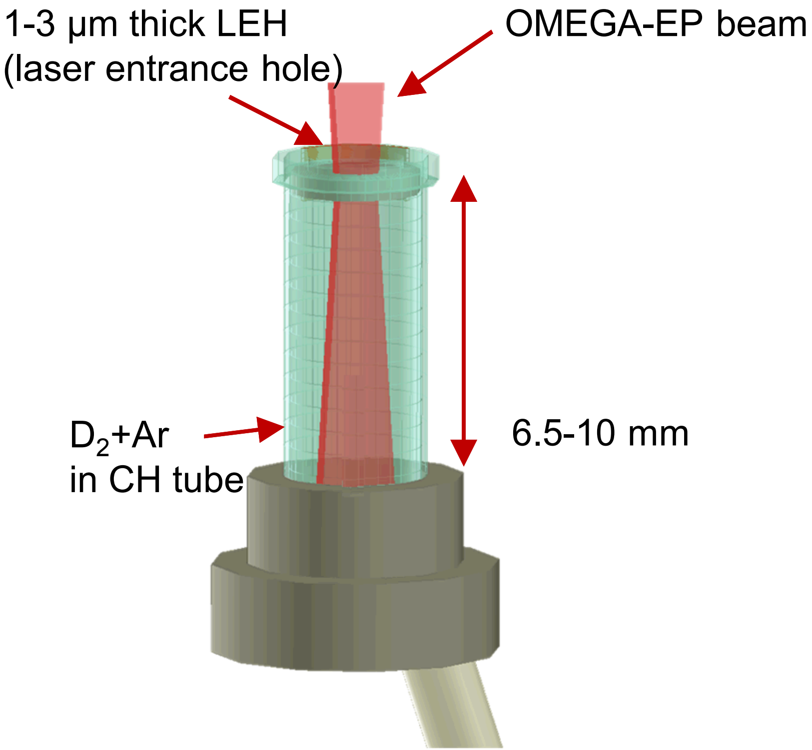


1. Magnetization: 10-30T
   - Reduction in heat loss
   - Trapping charged particles

1. Laser preheat: 100-300 eV
   - Relax convergence requirement
   - $CR=R_{initial}/R_{final}$= 120 → 20-30

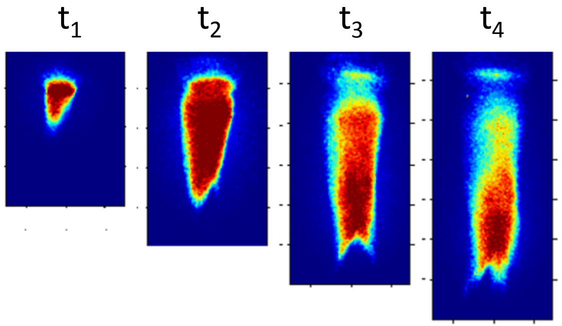
We need focused experiments to scrutinize the preconditioning phase

MagLIF preconditioning is being investigated at OMEGA-EP facility with various diagnostics

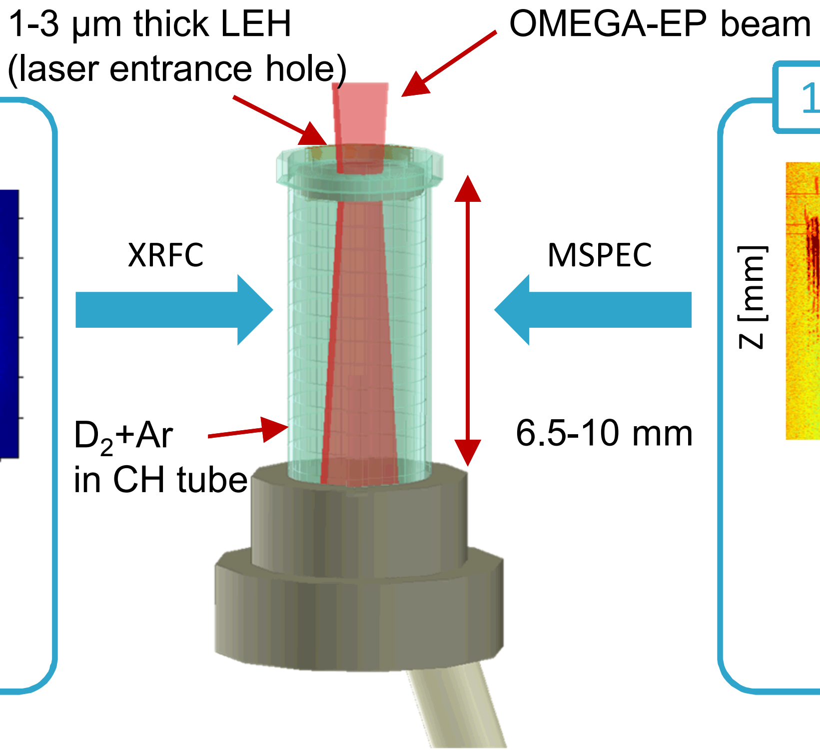


MagLIF preconditioning is being investigated at OMEGA-EP facility with various diagnostics

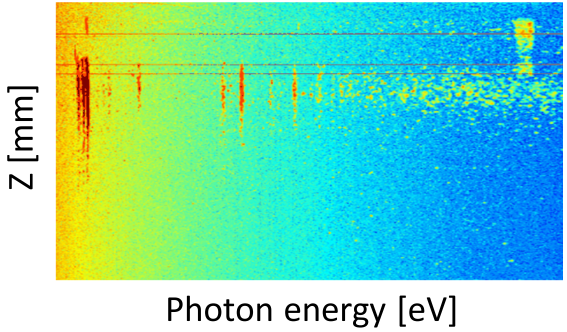
2D image with XRFC



- Laser propagation
- 2D intensity structure
- Beam split



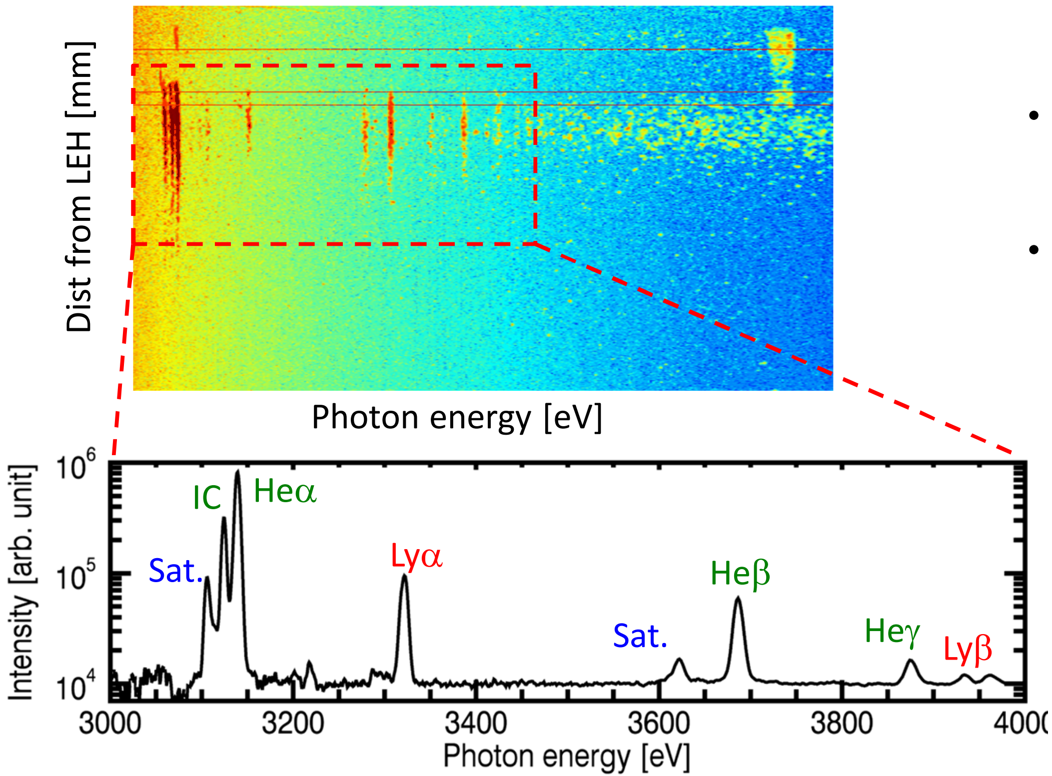
1D spectra with MSPEC



- Laser propagation
- $T_e(z)$

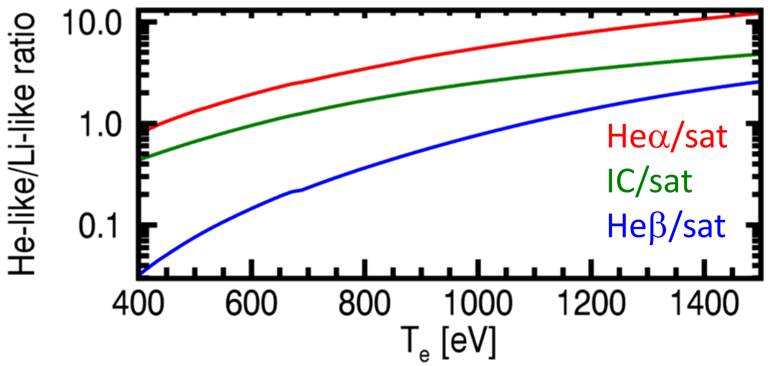
$T_e(z)$ can be inferred from line ratios

MSPEC data



- MSPEC data show many lines from Li-, He-, H-like Ar
- Line ratio of adjacent charge state is sensitive to electron temperature
- We focus on the strongest lines … Heα, IC, Heβ, and their satellites

Line ratio – T_e curve (PrismSPECT)



Recent experiments investigate the effect of n_e, laser pulse-shape, and effect of Bz

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Shot #	Density [atm]	Main pulse delay [ns]	Bz [T]
22636	18	2.5	0
22638	18	5.0	0
22641	10	2.5	0
22643	10	2.5	5
22644	10	2.5	5

Density effect (shots 22636, 22638, 22641)

Reproducibility check (shots 22643, 22644)

Effect of extra 2.5-ns main-pulse delay (shots 22636, 22638)

Bz = 5 T effect (shots 22641, 22643)

Investigation1: Effect of 2.5-ns vs 5.0-ns separation between pre-pulse and main pulse

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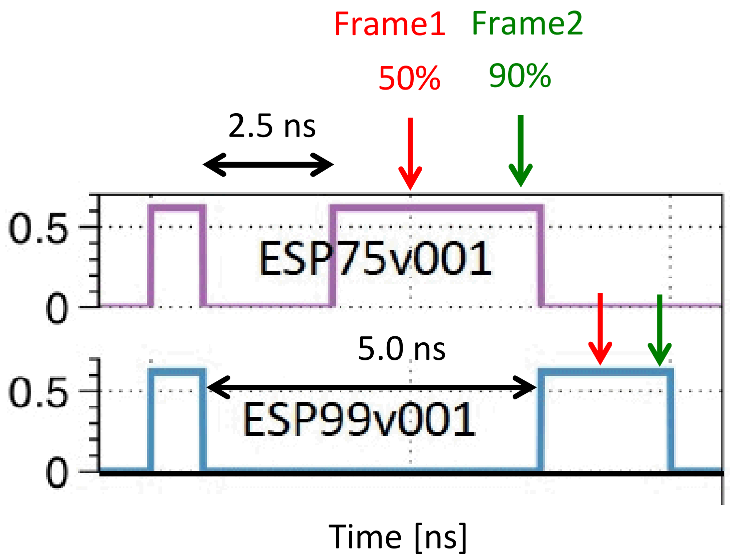
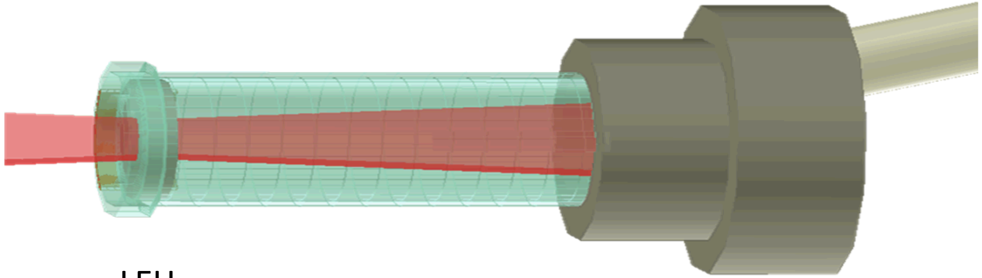
Experimental parameters:

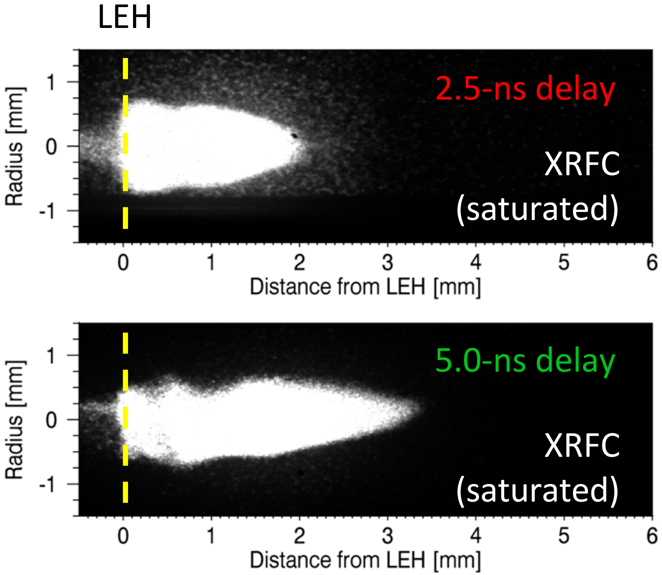
- 18 atm D_2 gas (0.25 % Ar)
- No magnetic field
- Laser
    - 3 w
    - 750-μm DPP
    - 1-ns prepulse
    - 4-ns main pulse
- Difference: pulse separation
    - 2.5 ns
    - 5.0 ns



How does the prepulse to main pulse separation affect the laser absorption?

Investigation1: Extra main-pulse delay results in deeper propagation and lower mean T_e





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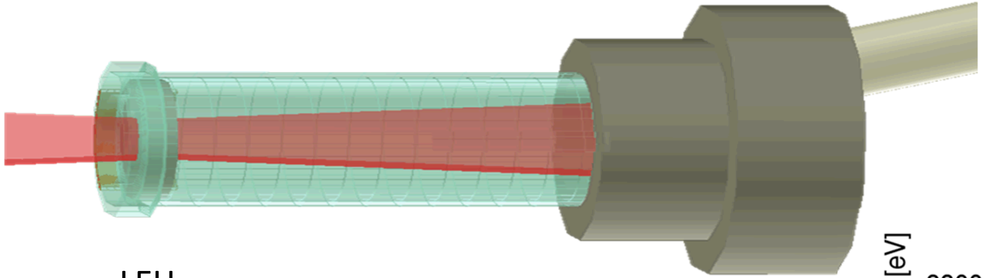

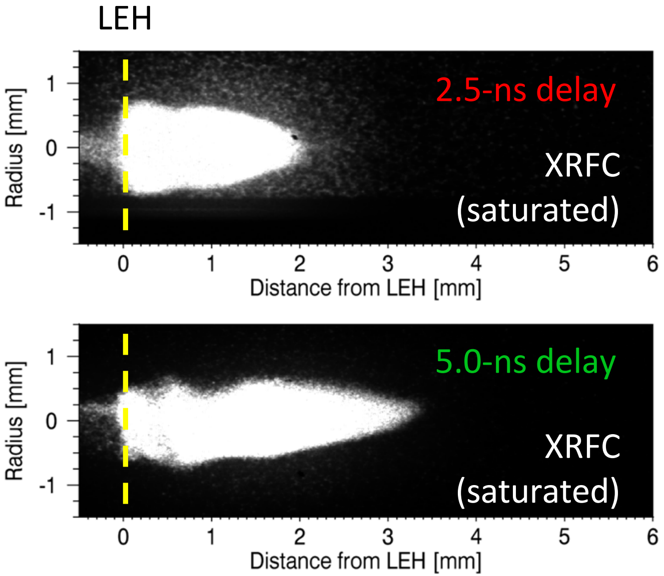

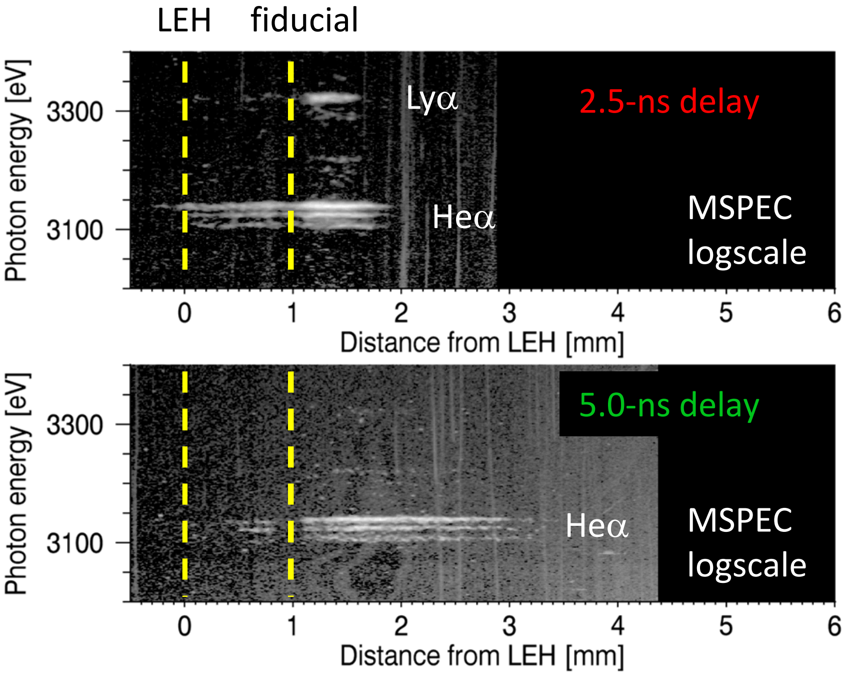

Investigation1: Extra main-pulse delay results in deeper propagation and lower mean T_e

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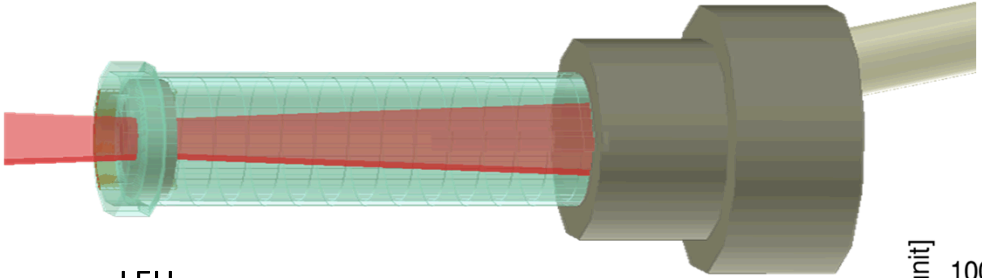

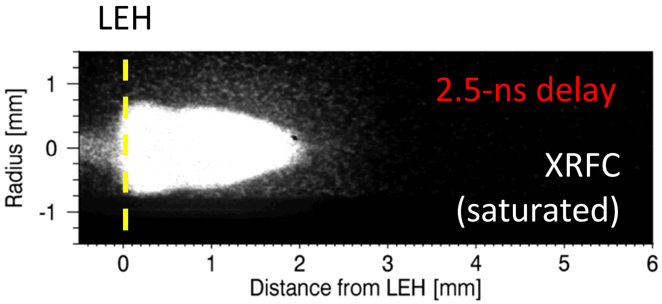

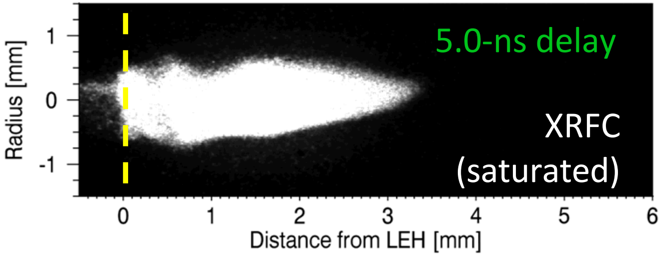

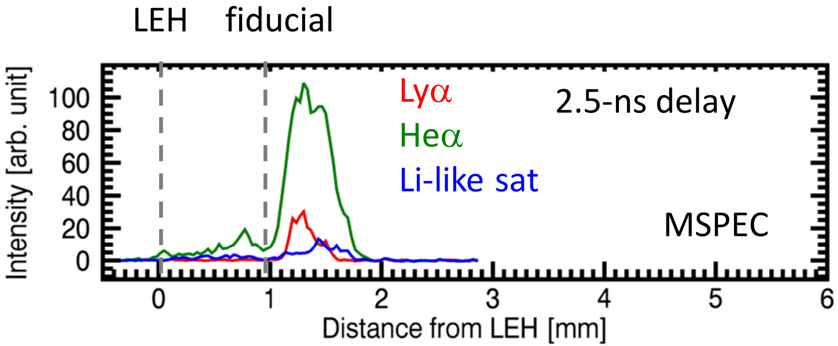

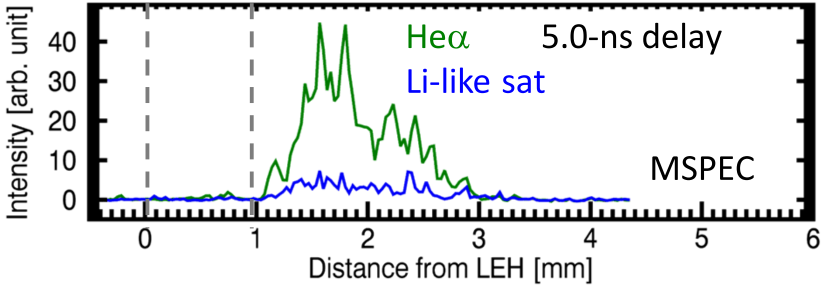

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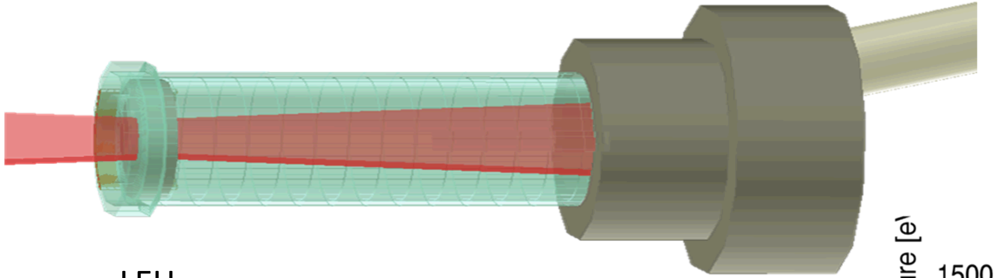
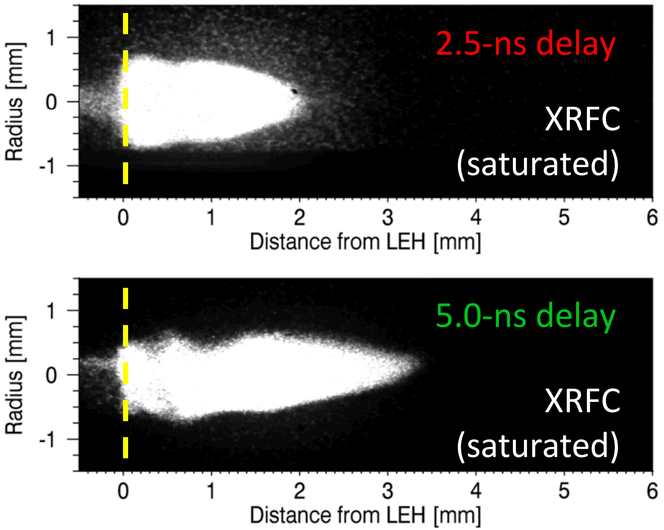
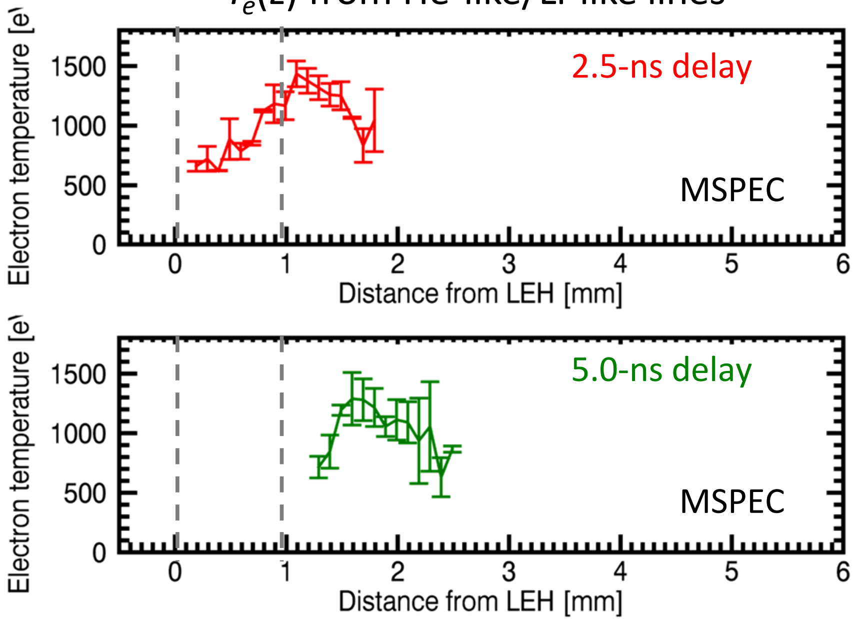




T_e(z) from He-like/Li-like lines



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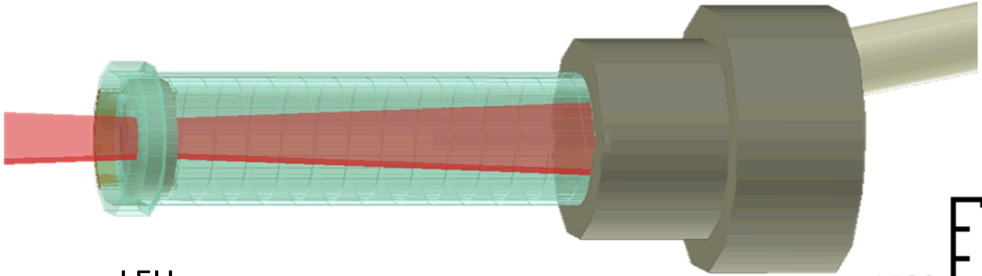
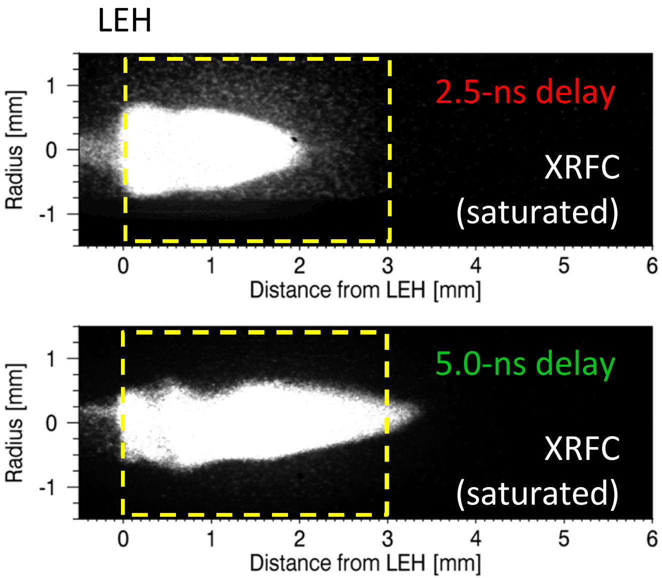
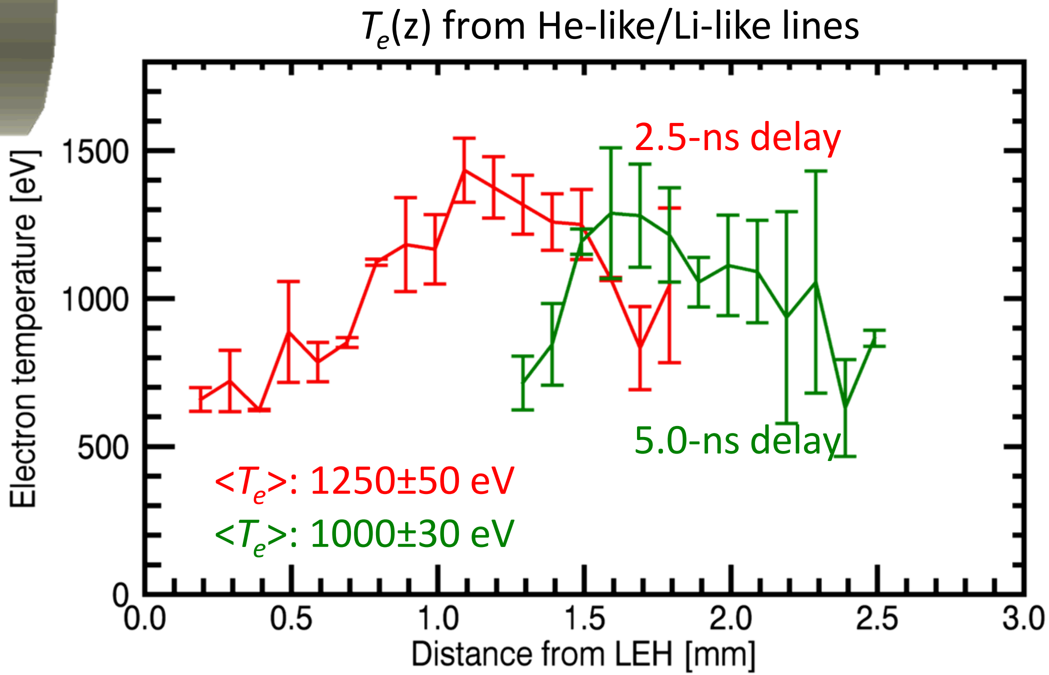


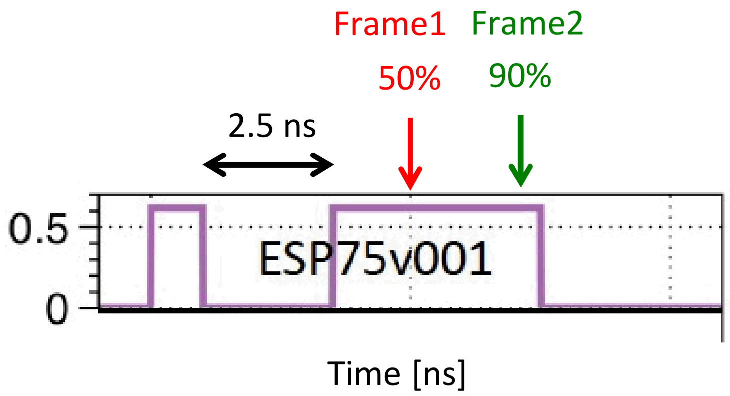




Investigation2: Laser heating into different gas density

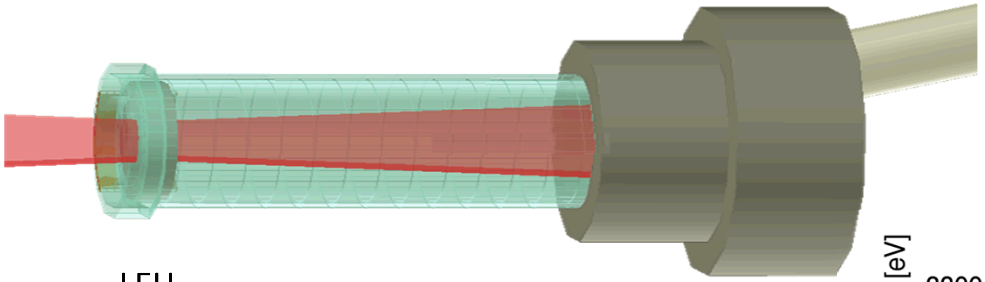
<u>Experimental parameters:</u>

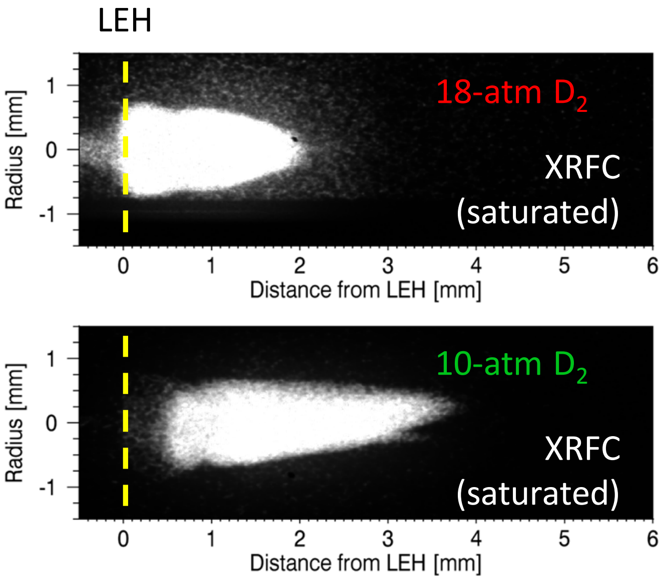
- No magnetic field
- Laser
    - 3 w
    - 750-μm DPP
    - 2.5-ns main-pulse delay
- Difference: initial gas density
    - 18 atm
    - 10 atm

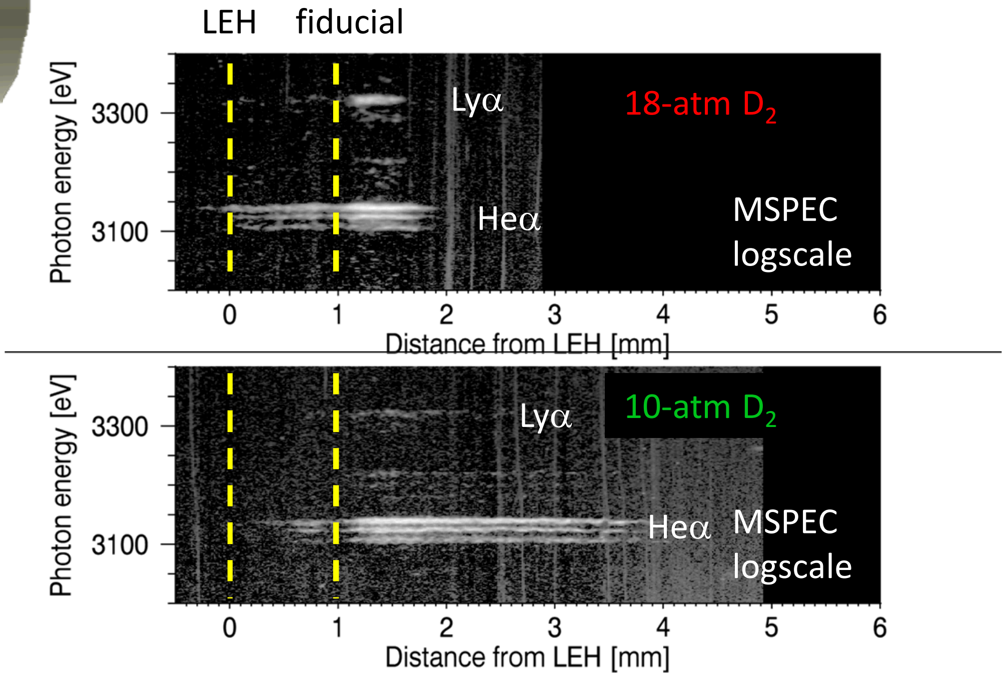


How does the gas density affect the laser absorption?

Investigation2: At lower density, laser propagated farther while mean T_e is lower







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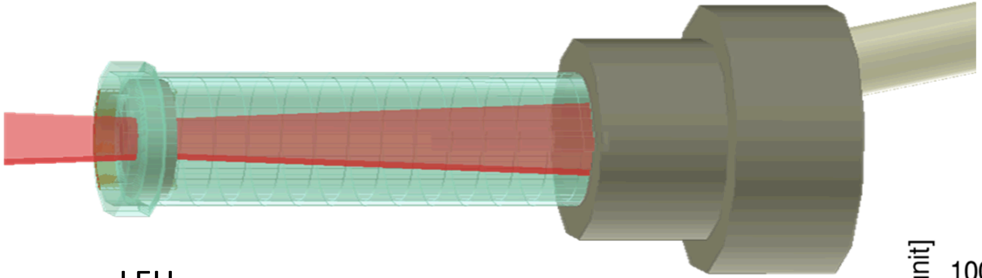

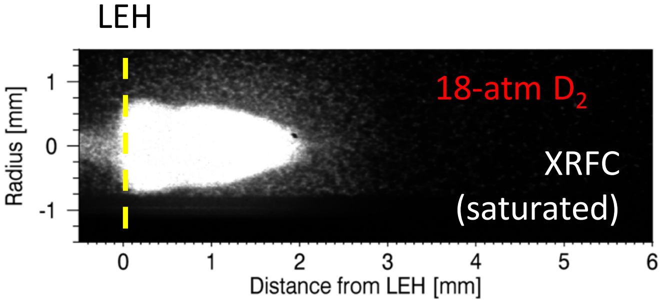

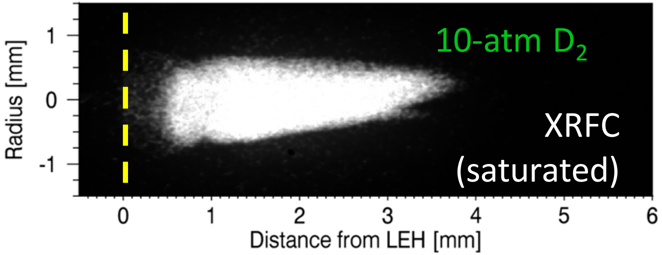

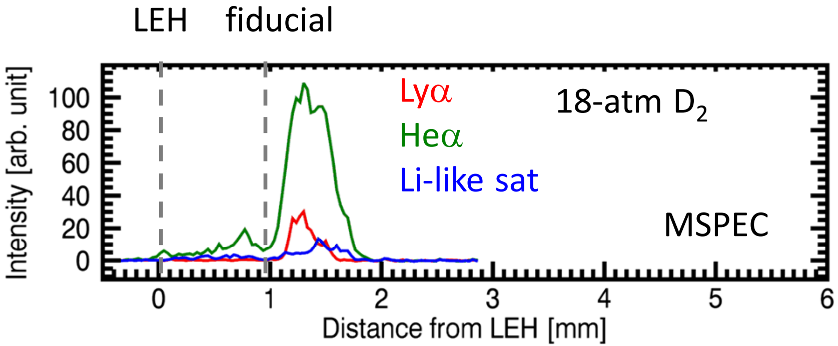

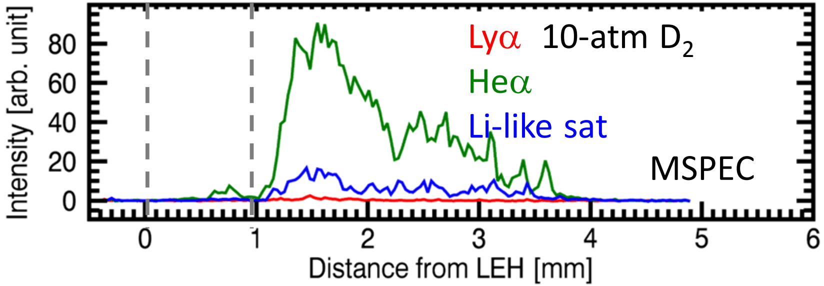

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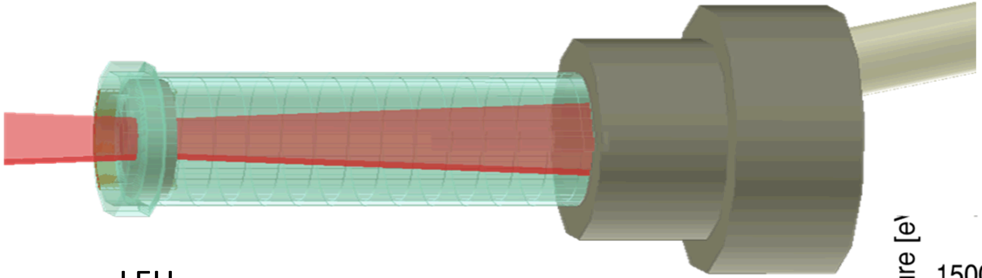
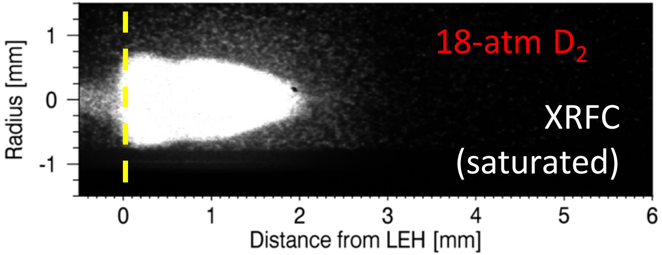
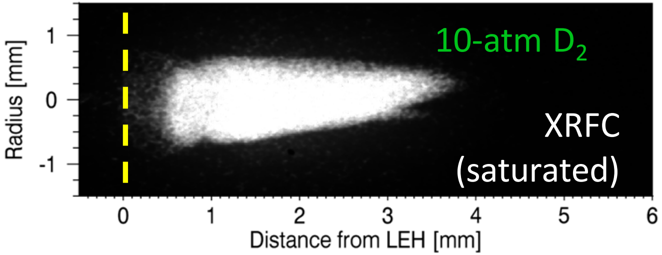
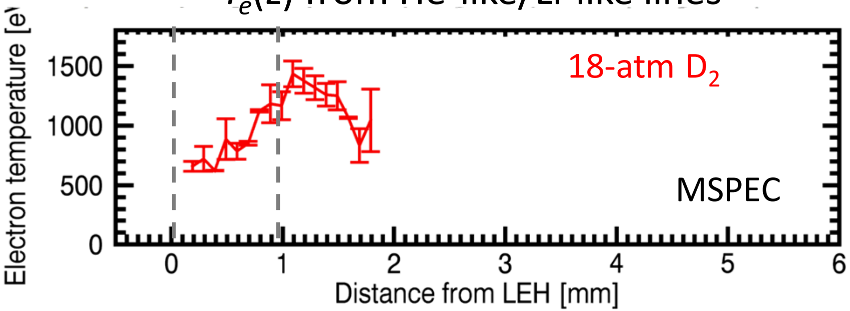


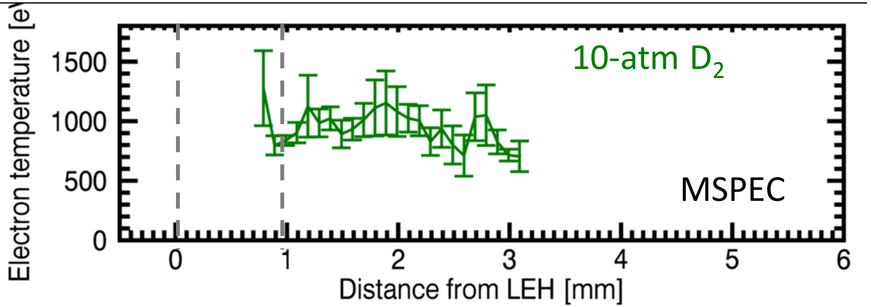
LEH





$T_e(z)$ from He-like/Li-like lines





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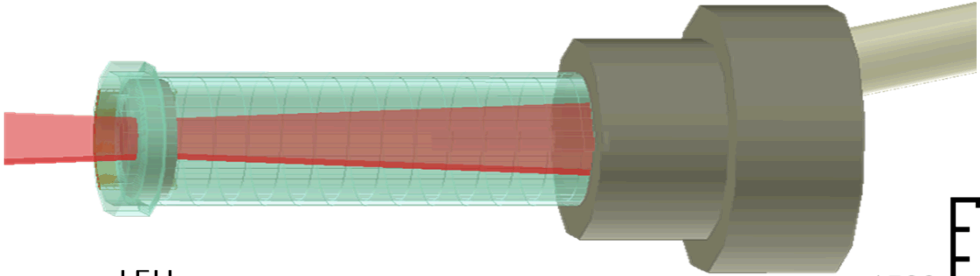
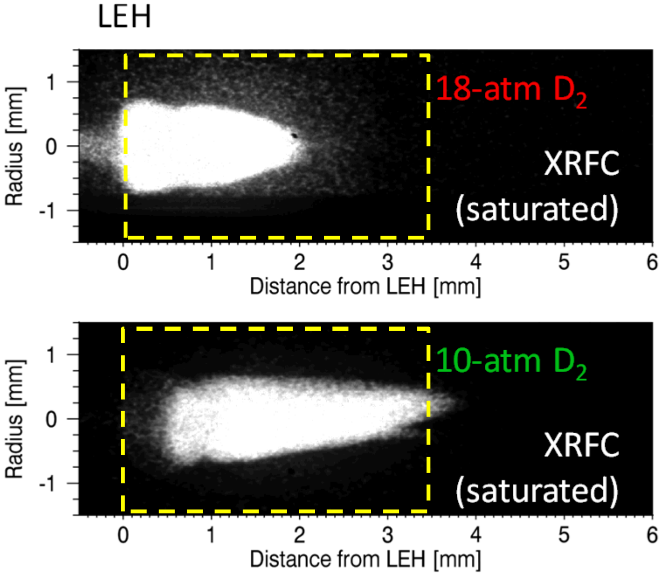
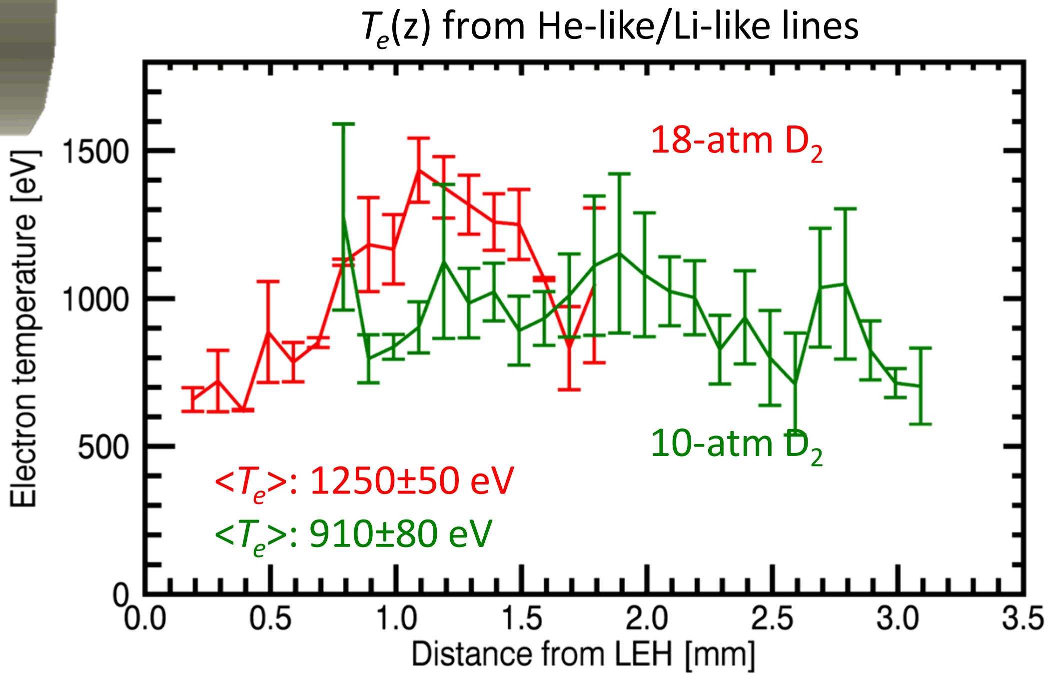


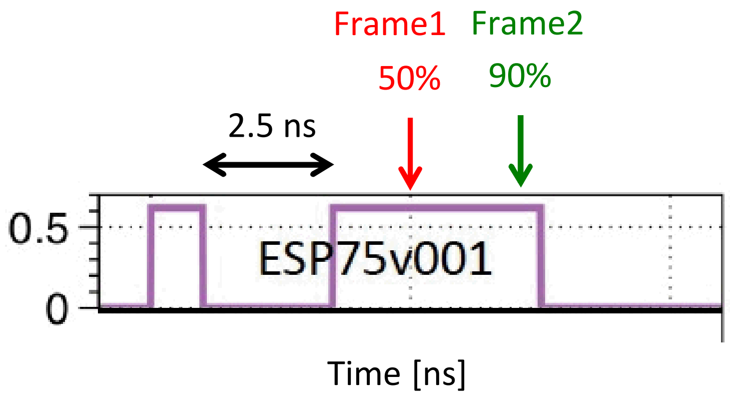




Investigation3: Effect of 5-T B-field on laser propagation

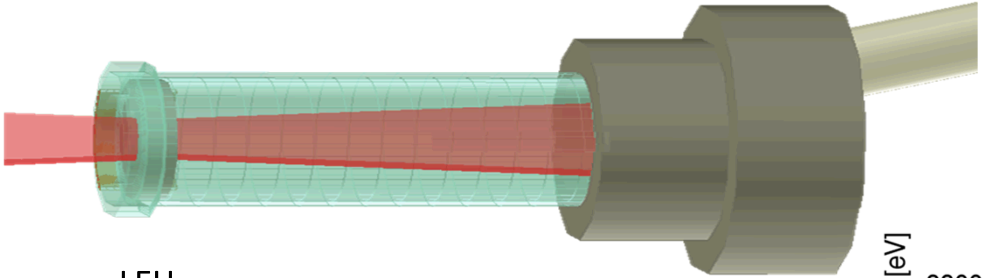
Experimental parameters:

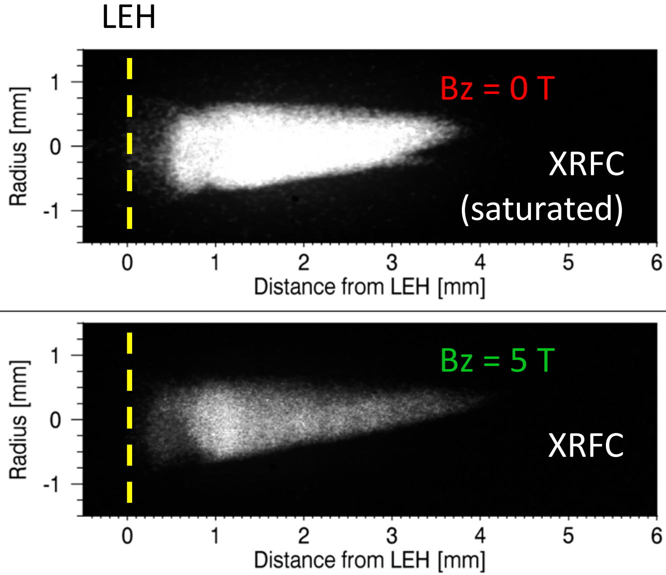
- 10 atm D_2
- Laser
  - 3 w
  - 750-µm DPP
  - 2.5-ns main-pulse delay
- Difference: Bz
  - 0 T
  - 5 T

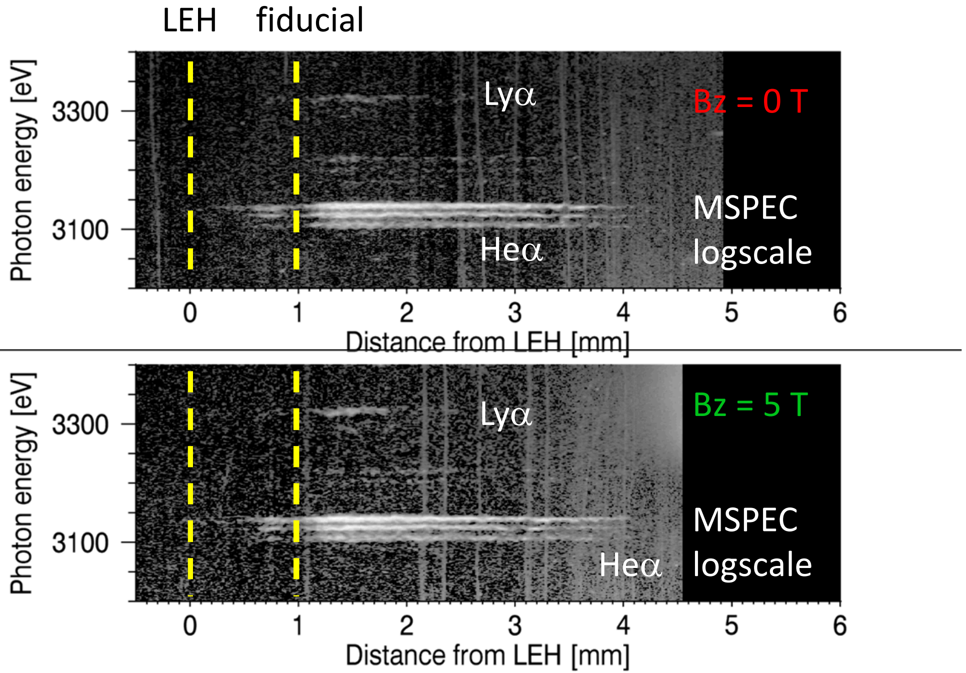


How does the gas density affect the laser absorption?

Investigation3: We observed no clear indication of B-field effects







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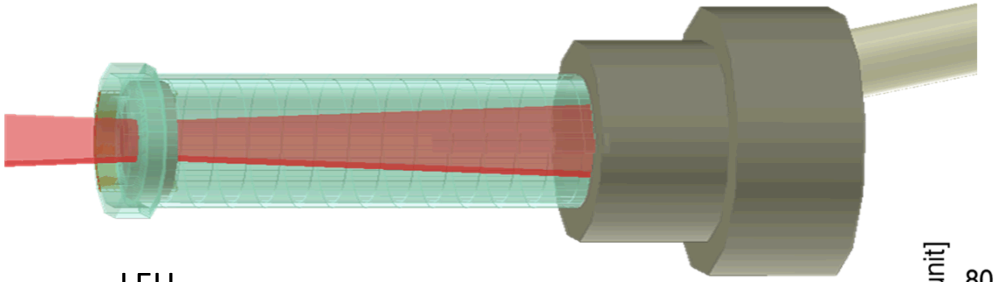

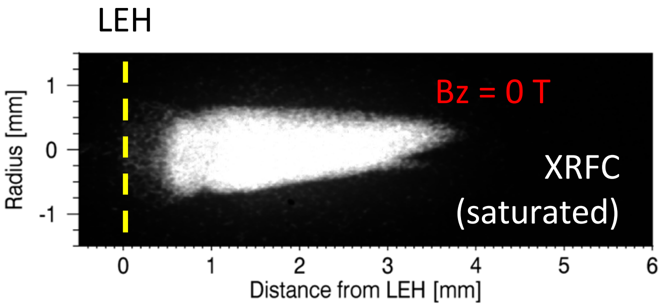

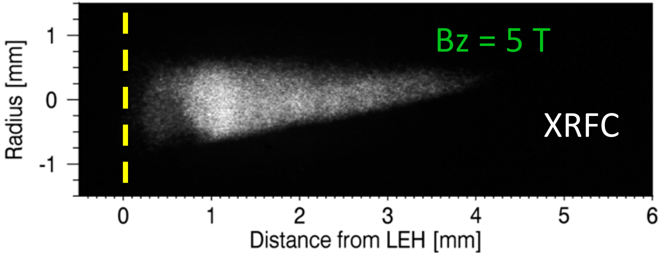

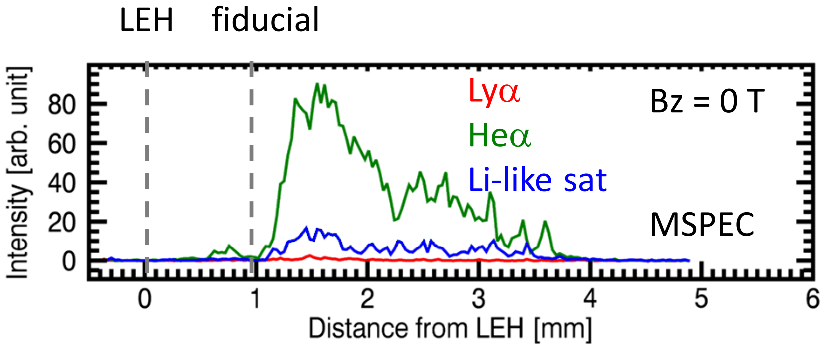

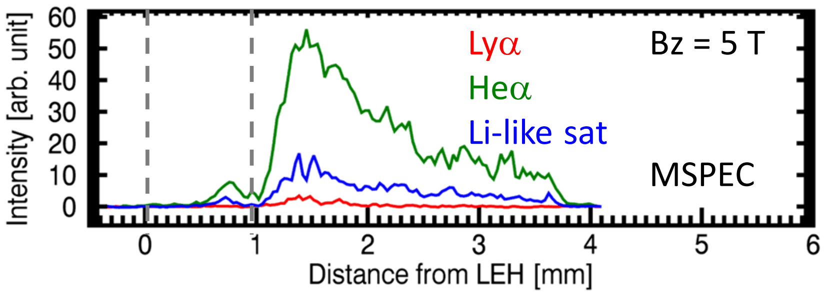

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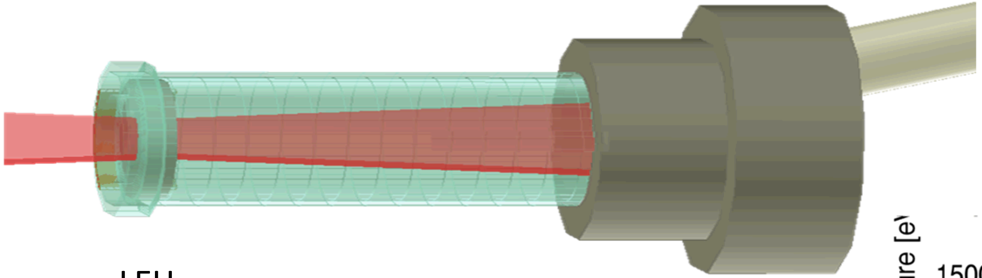
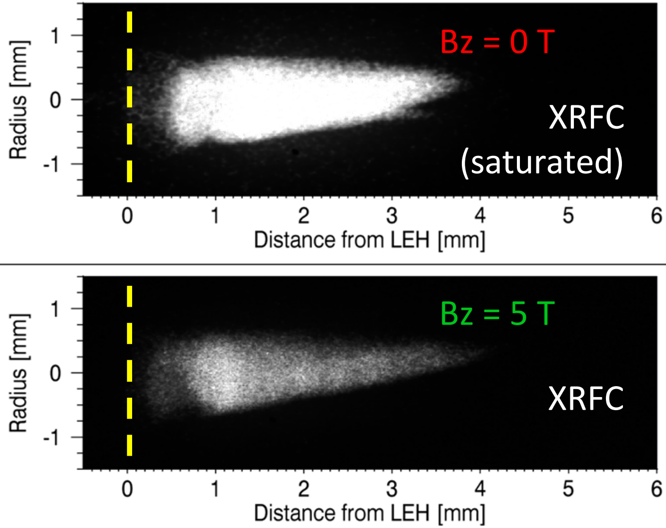
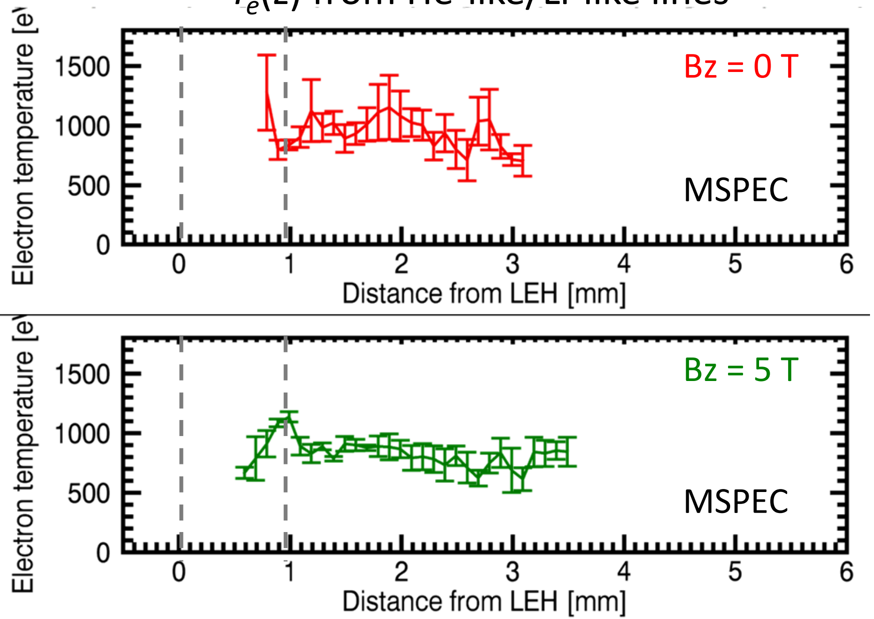
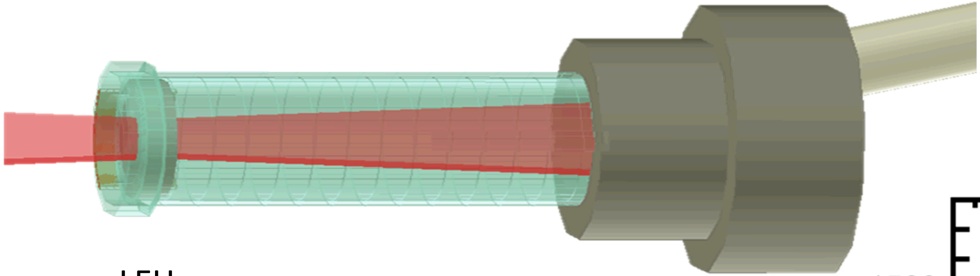
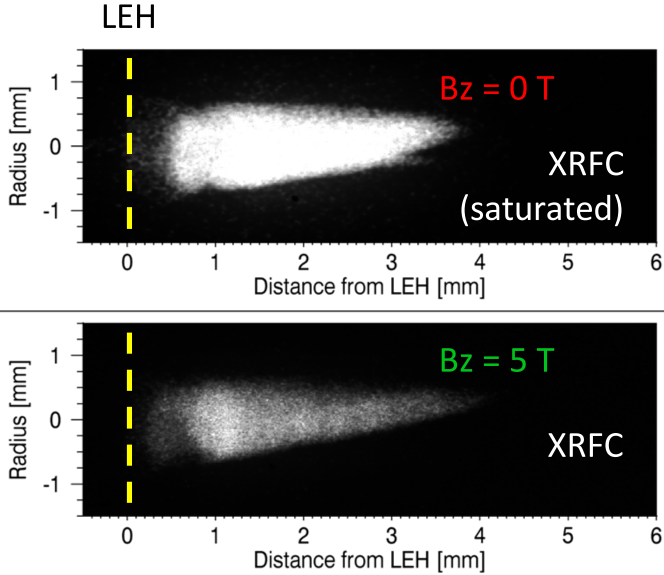


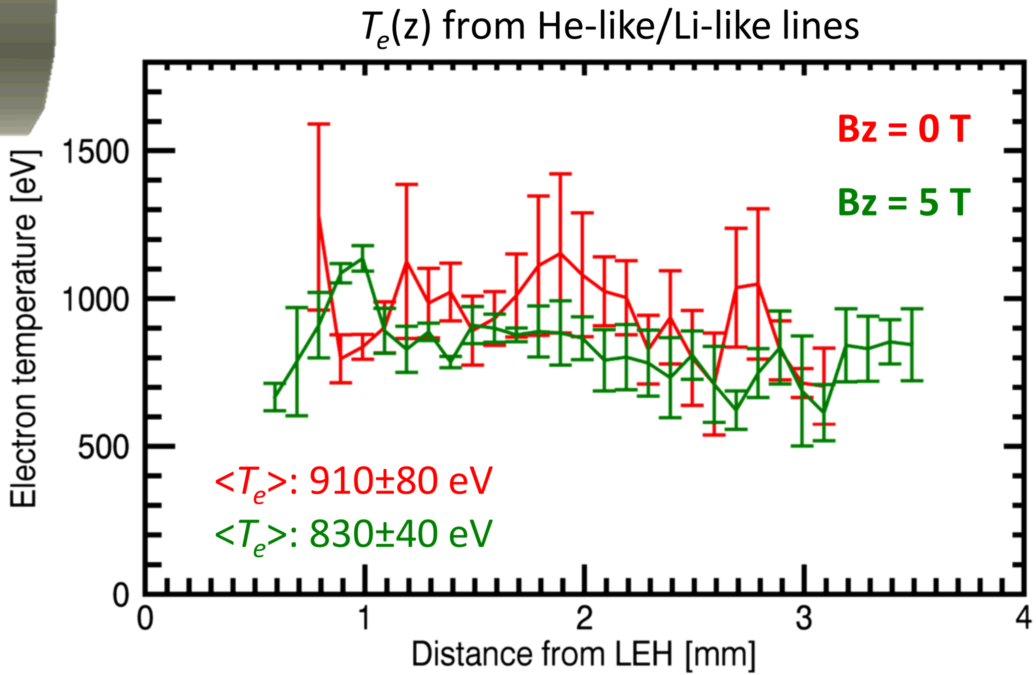




Investigation3: We observed no clear indication of B-field effects







Analysis summary

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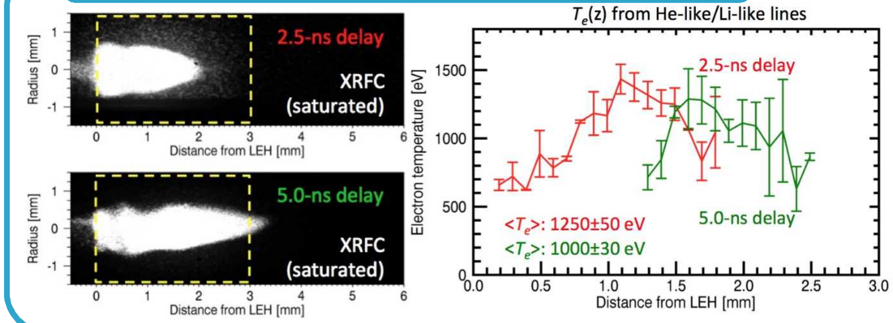
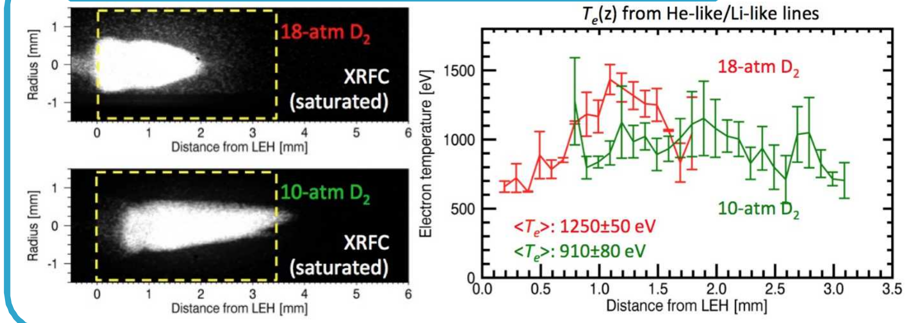
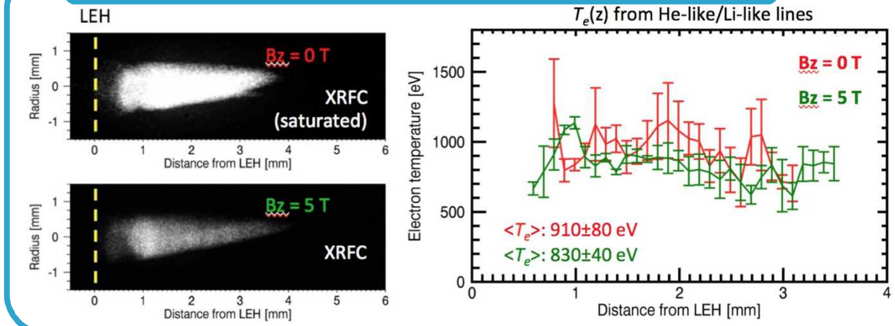
Main-pulse delay drops <T_e>



Lower gas pressure drops <T_e>



No clear indication of 5T Bz effects



Comments:

- When main pulse is delayed, the gas expands more and density drops
- As density drops, beam propagates farther and <Te> is lower
- Maybe, 5 T is too weak to see its effect

Waiting for simulations to be done for comparisons

MSPEC diagnostics for MagLIF preconditioning experiment is challenging

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Ar dopant

- Optical depth vs S/N
- Signal changes significantly:
  - Across the axis
  - At different times
- Diagnosable temperature is too high
  - Ne dopant is more ideal to diagnose colder region
  - Need to redesign crystal and filtering for Ne spectroscopy

Alignment

- Hard to see where detector ends from the raw data
- MSPEC sees 6 mm out of 10 mm tube
- Spatial misalignment
  - One of the frames is truncated
- Spectral misalignment
  - Misses LEH blow-in signal

Gradient effects

- Radial gradient
- Temporal gradient

In June, we will follow up on laser pulse-shape scan

- 0 ns, 2.5 ns, 5.0 ns main-pulse delays
- Investigate their impacts on:
  - Beam propagation
  - $\langle T_e \rangle$ *and* $T_e(z)$
  - LEH window blow-in
- We need to make sure:
  - Repeat experiments
  - No saturation on XRFC images
  - Good S/N from Ar spectra
  - No spectral or spatial clipping
    - Spectral: LEH blow-in
    - Spatial: 2-nd frame

Spectroscopy experiments measure space dependent MagLIF laser preheat, demonstrating a tool to validate MagLIF preheat physics

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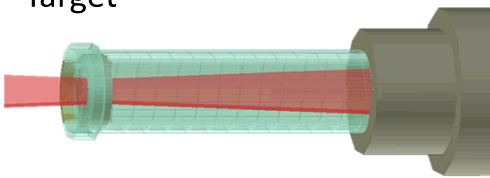
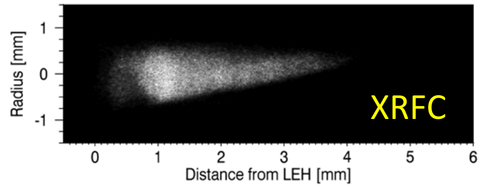
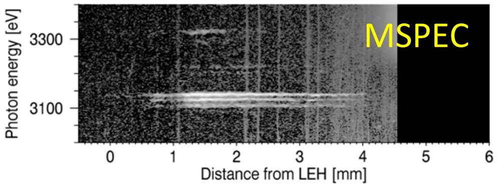
- MagLIF preheat experiments are performed at OMEGA-EP
- XRFC and MSPEC data constrain laser propagation and heating
- Laser preheat dependence on gas density, pulse shape, and magnetic field are investigated

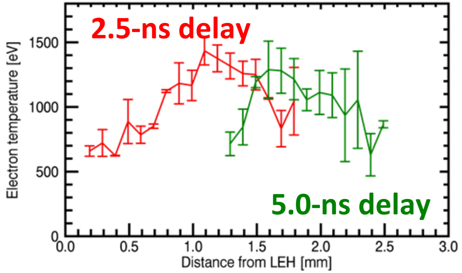
Target



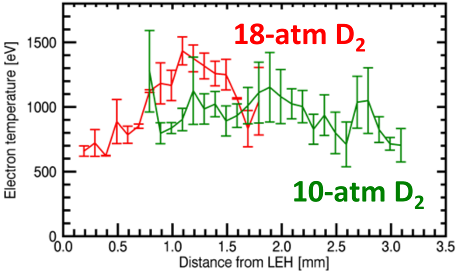




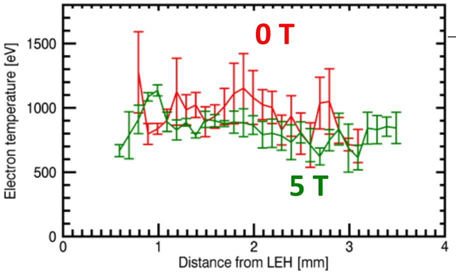
Pulse-shape



Density



Bz



- Comparison with simulation and scrutinizing data analysis will refine our understanding of preheat physics

More focused experiments will refine our understanding of MagLIF preconditioning phase