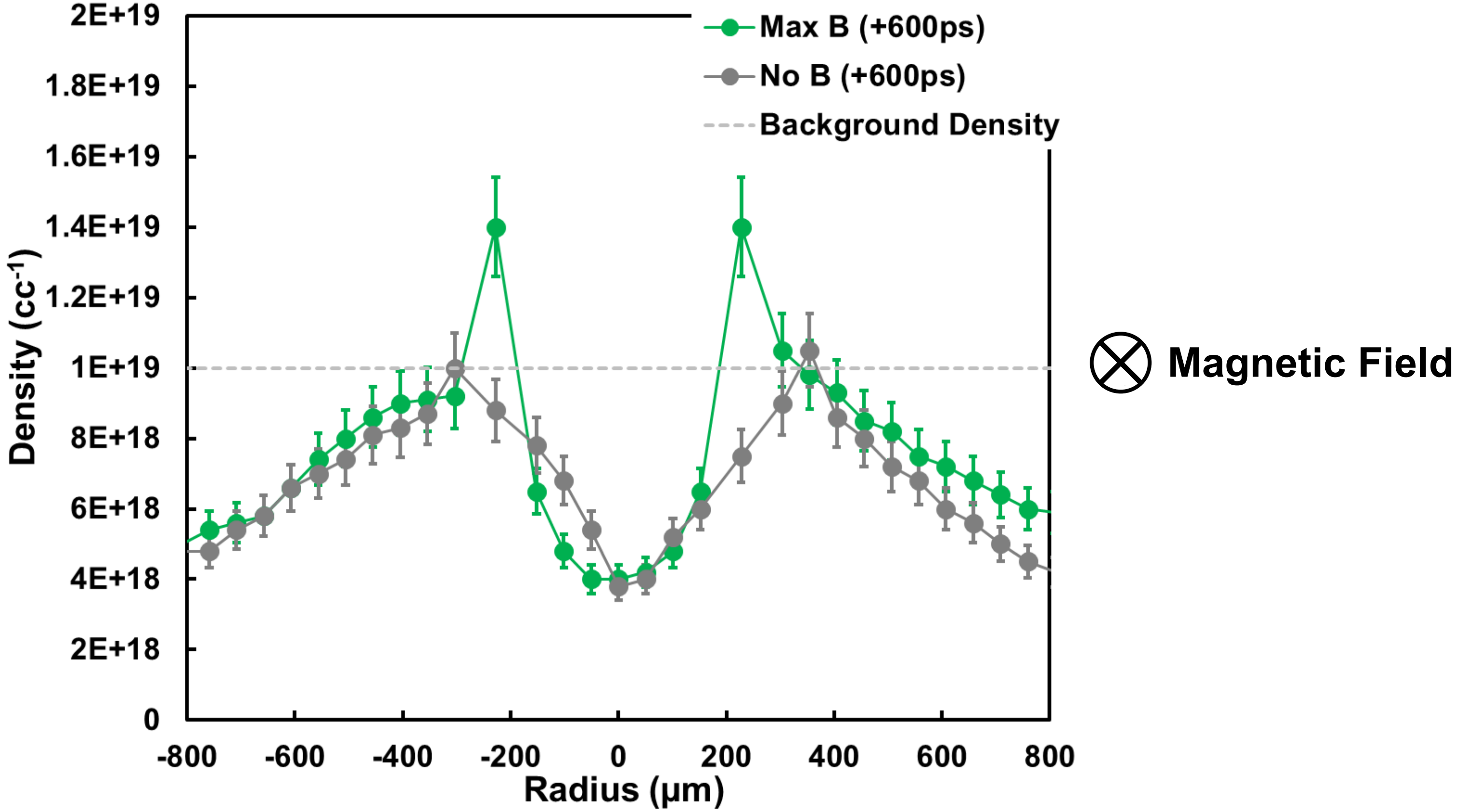
Thermal Transport in Low-Beta Laser-Produced Plasmas



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Gas jet plasmas produced in strong magnetic fields at the OMEGA facility provide a platform for magnetized transport studies

- **The MIFEDS and gas jet systems are being be used to make spatially-resolved Thomson Scattering measurements of low-beta plasmas on OMEGA**
- **Recent experimental results show $\beta \sim 1$ for a $1 \times 10^{19} cc^{-1}$ Hydrogen plasma ($B \approx 33T$, $T_e \approx 150eV$)**
- **The spatial profile of these plasmas have been scanned over multiple shots, showing an expanding heat front that has been inhibited by the magnetic field**
- **The simplicity of this experimental setup makes it a great platform to investigate the physics in different MHD codes or even run scaled-down versions of MCF experiments**

MIFEDS: Magneto-Inertial Fusion Electrical Discharge System

Collaborators

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The experimental parameter space covers three regimes of hydrodynamics

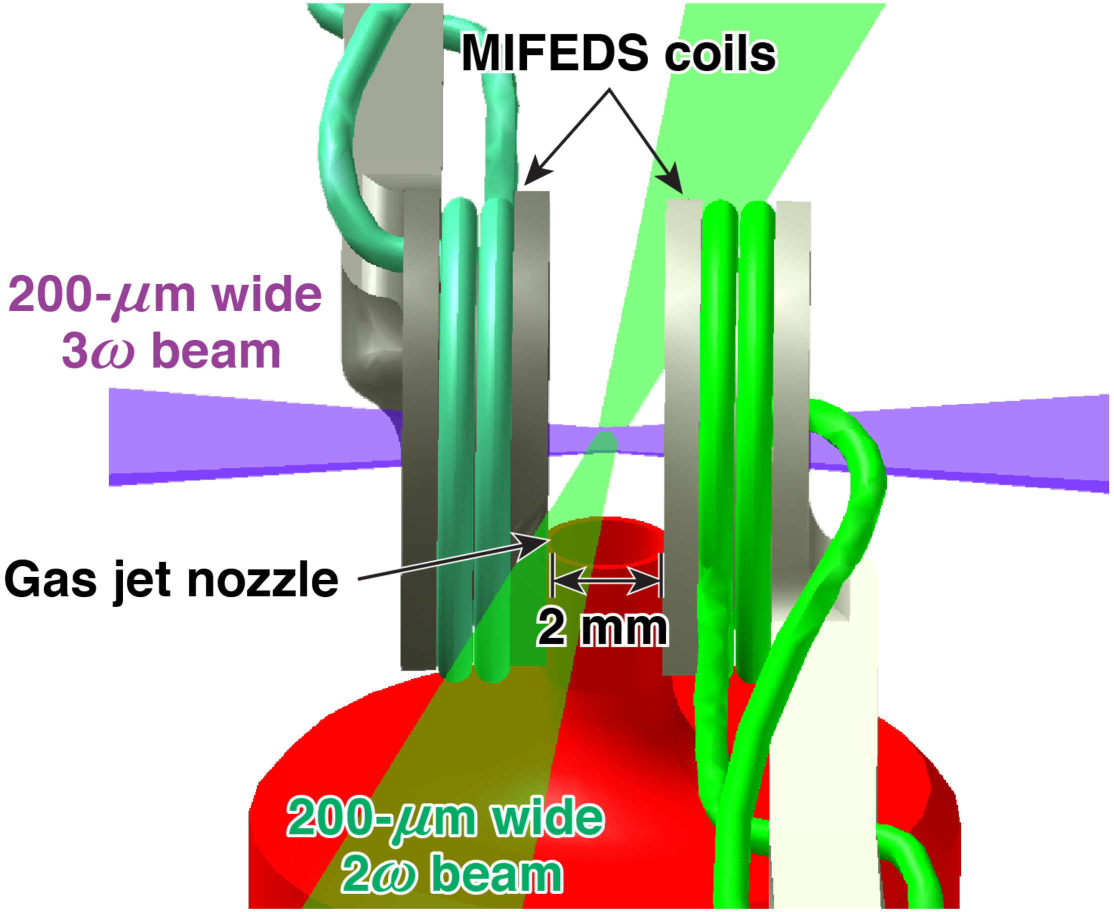
1) **In the absence of a magnetic field, the temperature gradients are large enough to require non-local physics to accurately describe the expansion***

2) **In the presence of a moderate magnetic field, the plasma can be described with classical hydrodynamic equations**

3) **With strong magnetic fields, when $\beta \leq 1$, the plasma requires magnetohydrodynamics to accurately describe the evolution**

*D. H. Froula *et al.*, Phys. Rev. Lett. 98, 135001 (2007)

The plasma conditions are resolved along the diameter of a plasma cylinder



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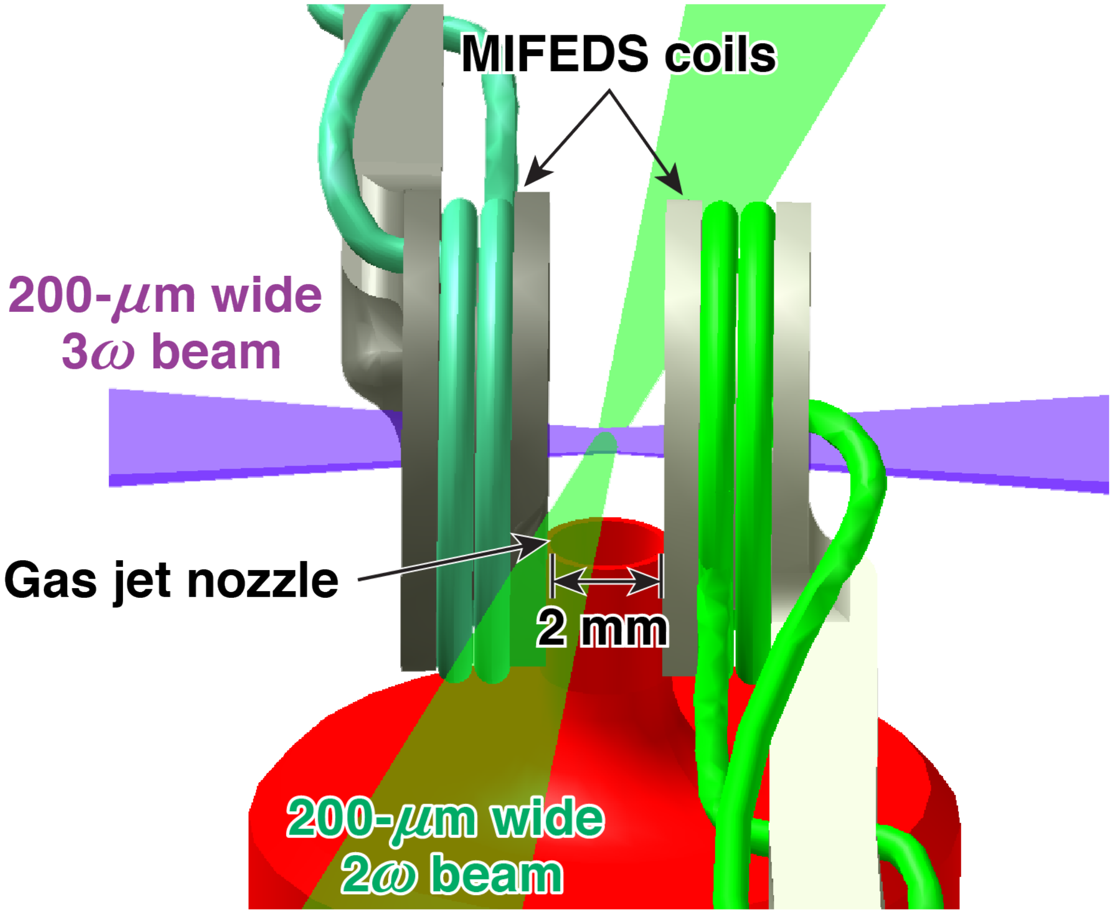
The plasma conditions are resolved along the diameter of a plasma cylinder



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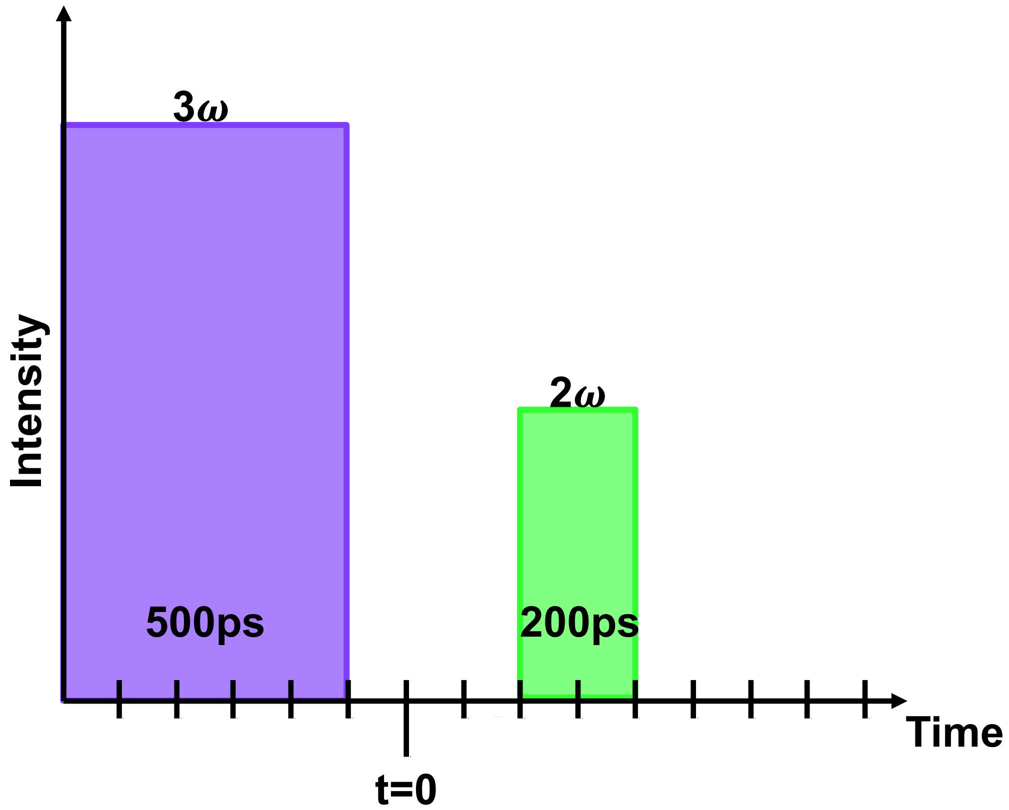

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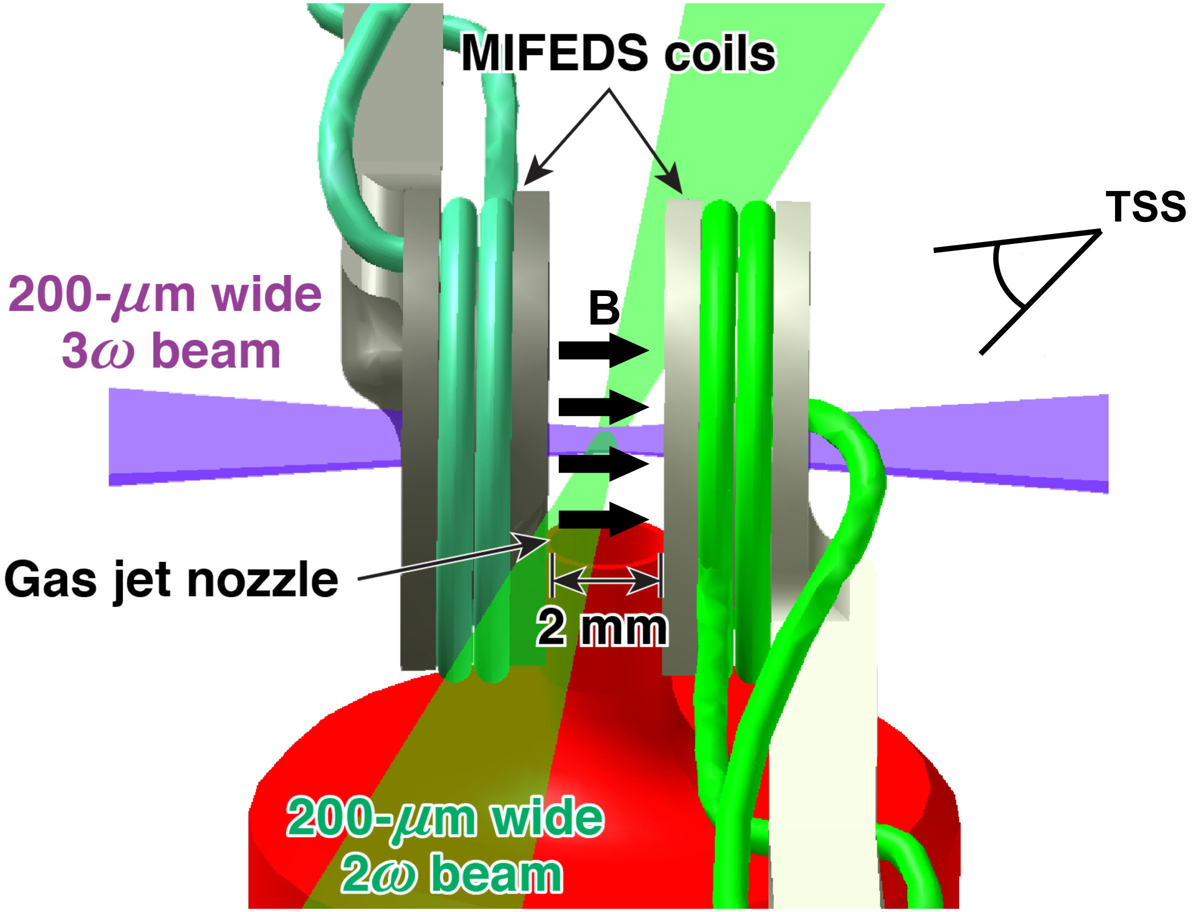

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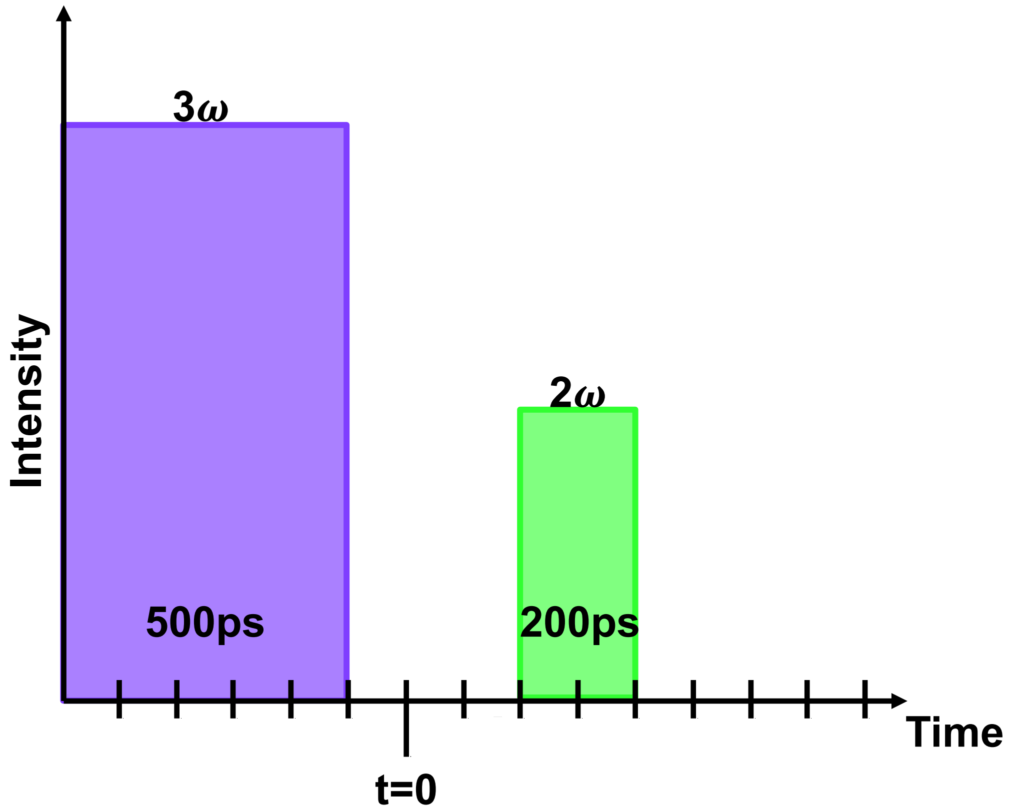
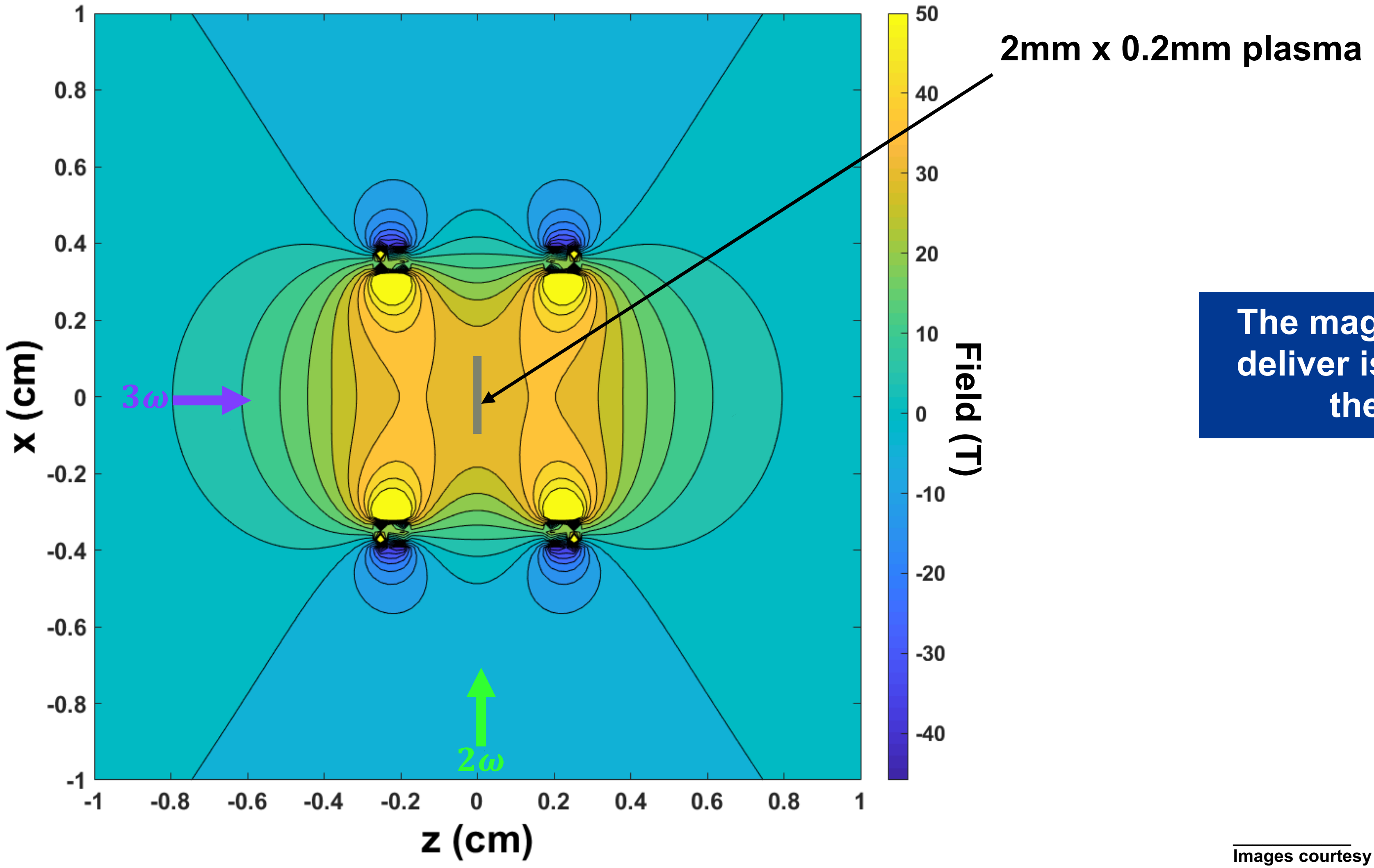


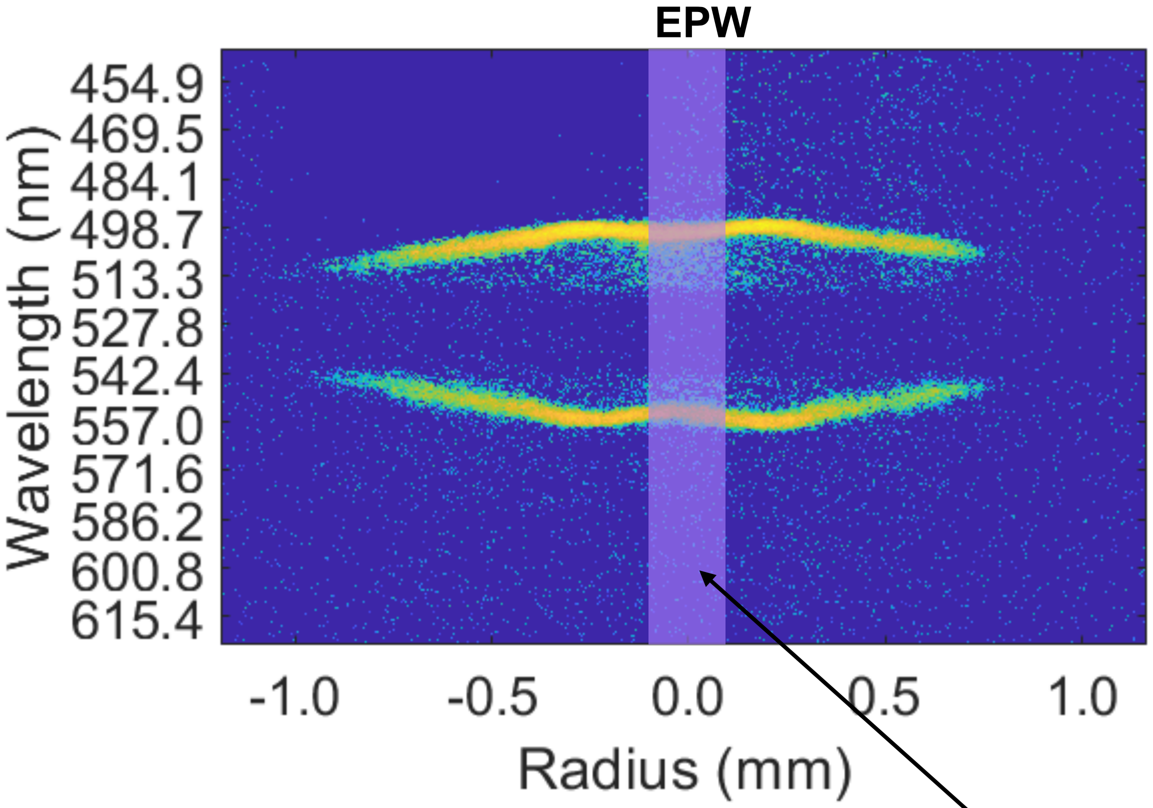
The magnetic field created by MIFEDS is calculated to be approximately uniform across the interaction region

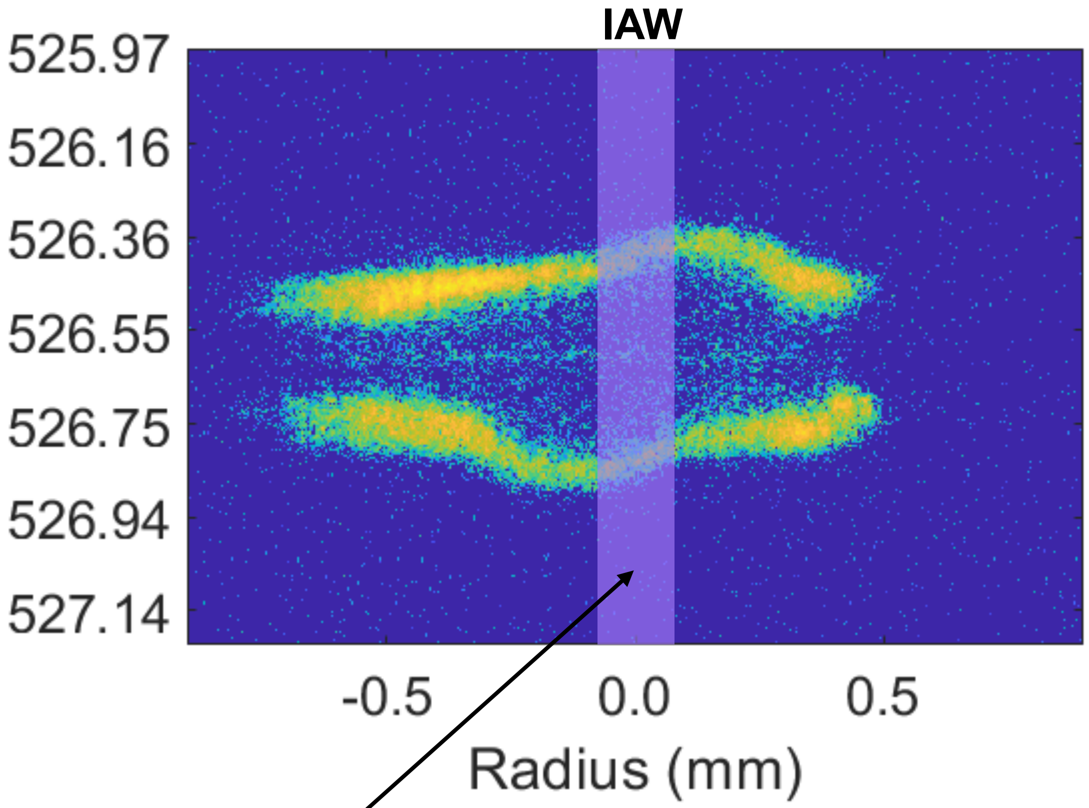


The magnetic field we deliver is ~33T across the profile.

Images courtesy of Jonathan Peebles (LLE)

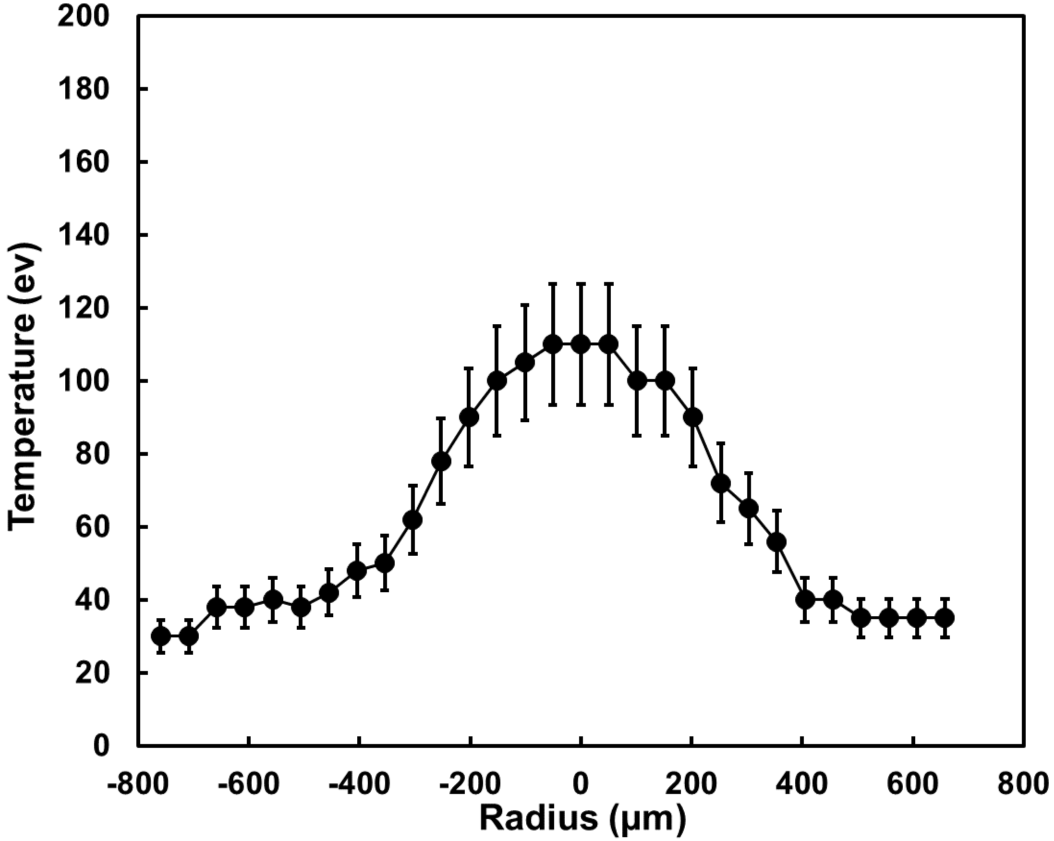
Electron Plasma Wave and Ion Acoustic Wave scattering features were collected by the Thomson Scattering system

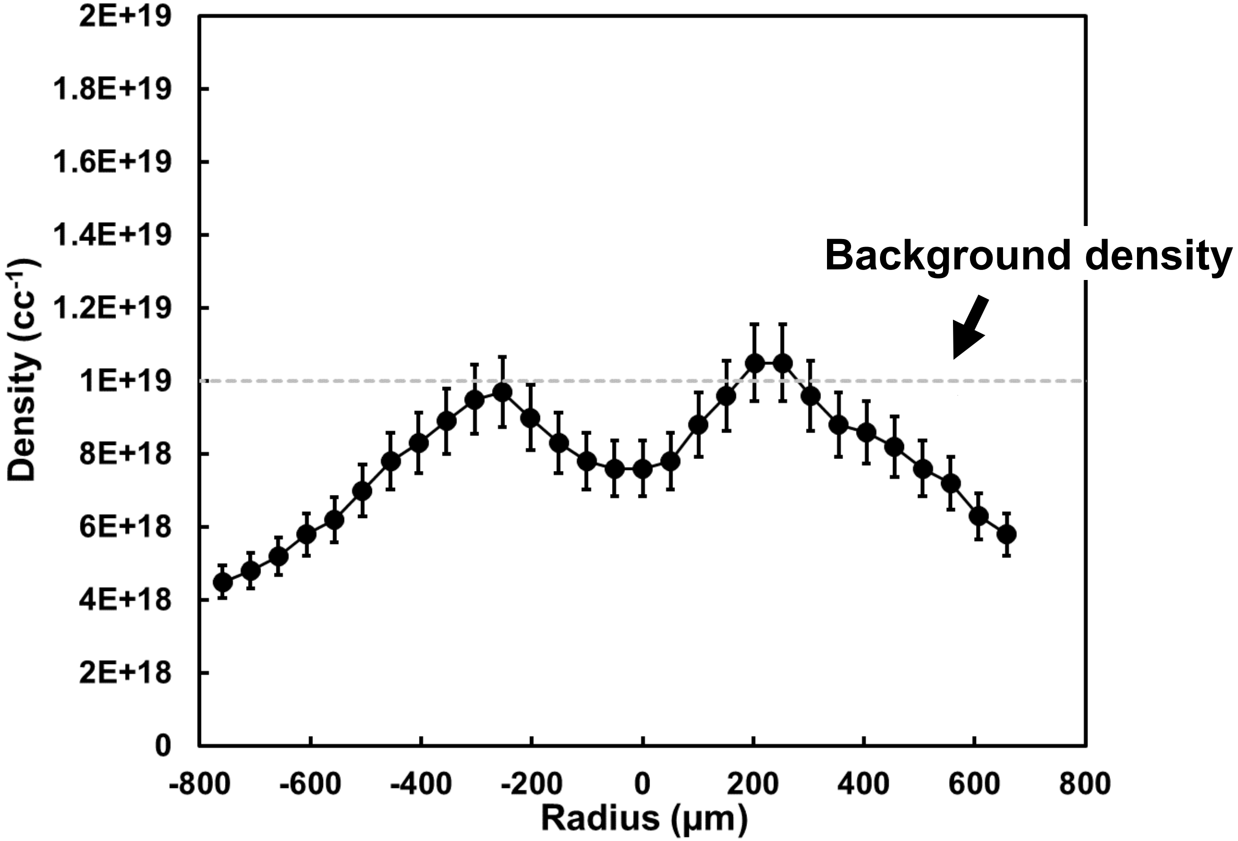




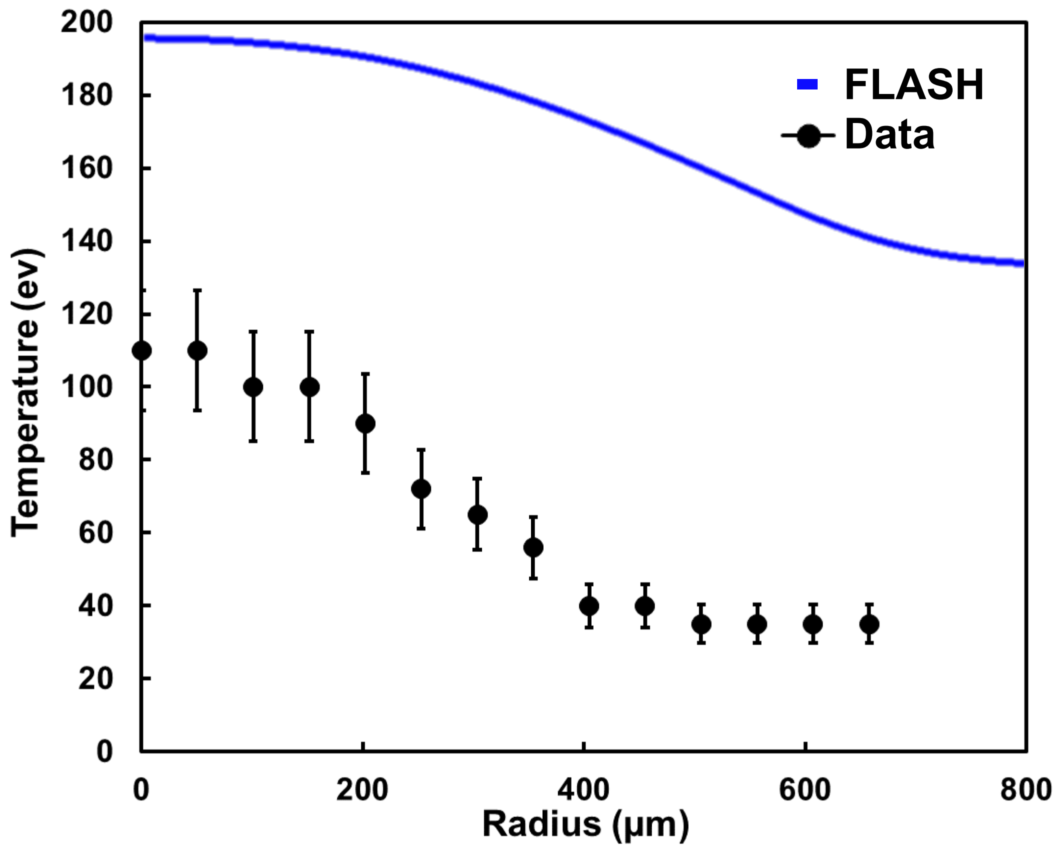
3ω-heated region

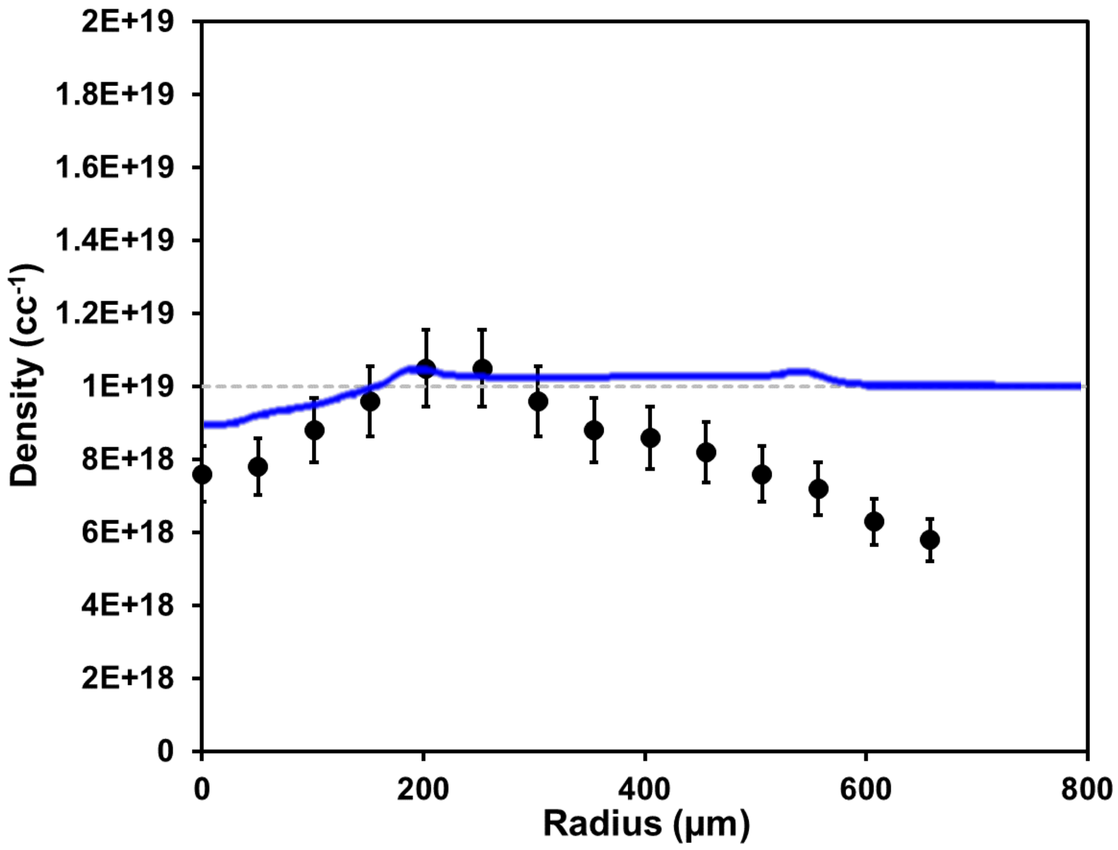
Taking lineouts across both the EPW and IAW yields a spatial profile of the plasma temperature and density



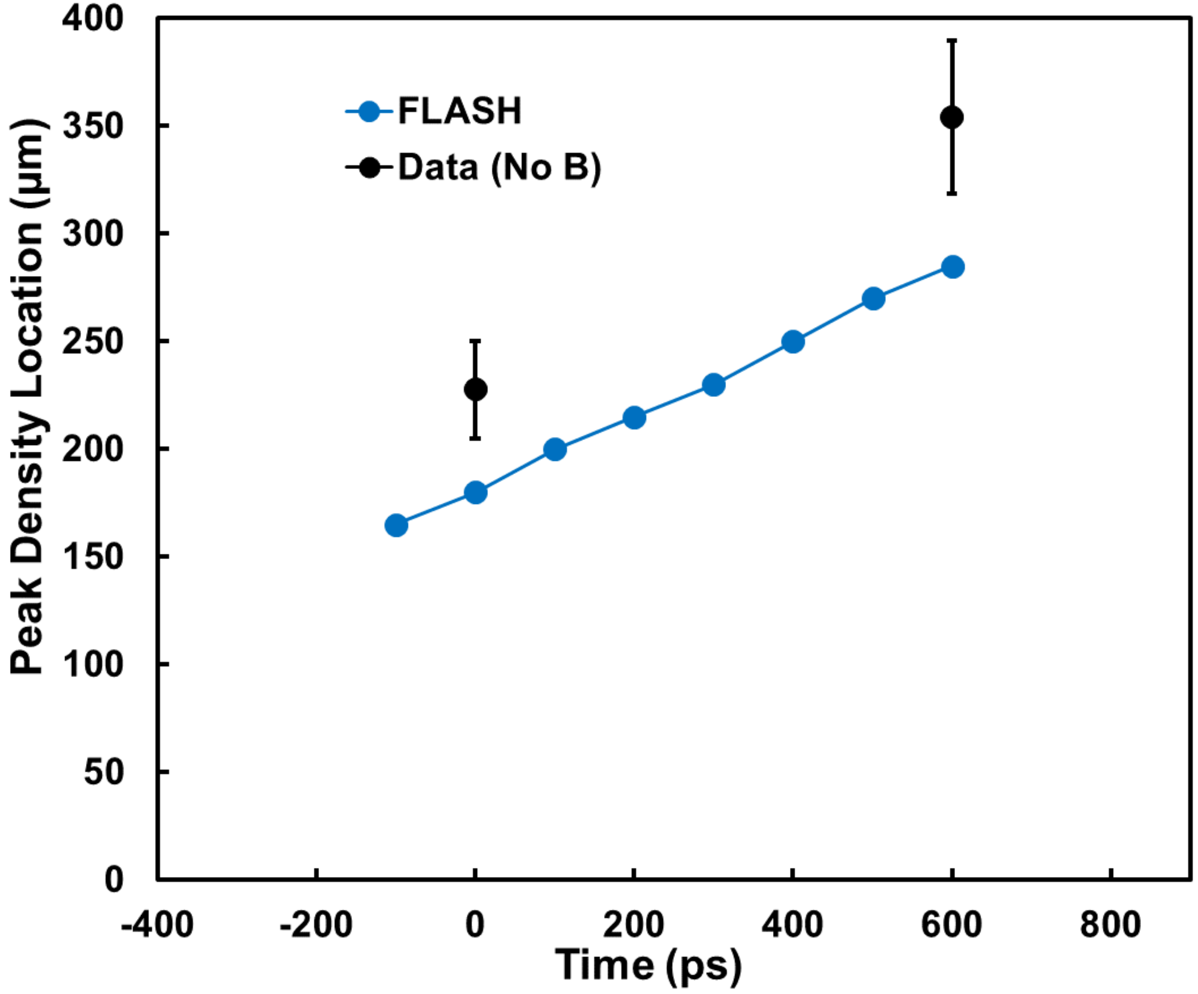


2D, free-streaming, hydrodynamic FLASH simulations show a general agreement with the un-magnetized data

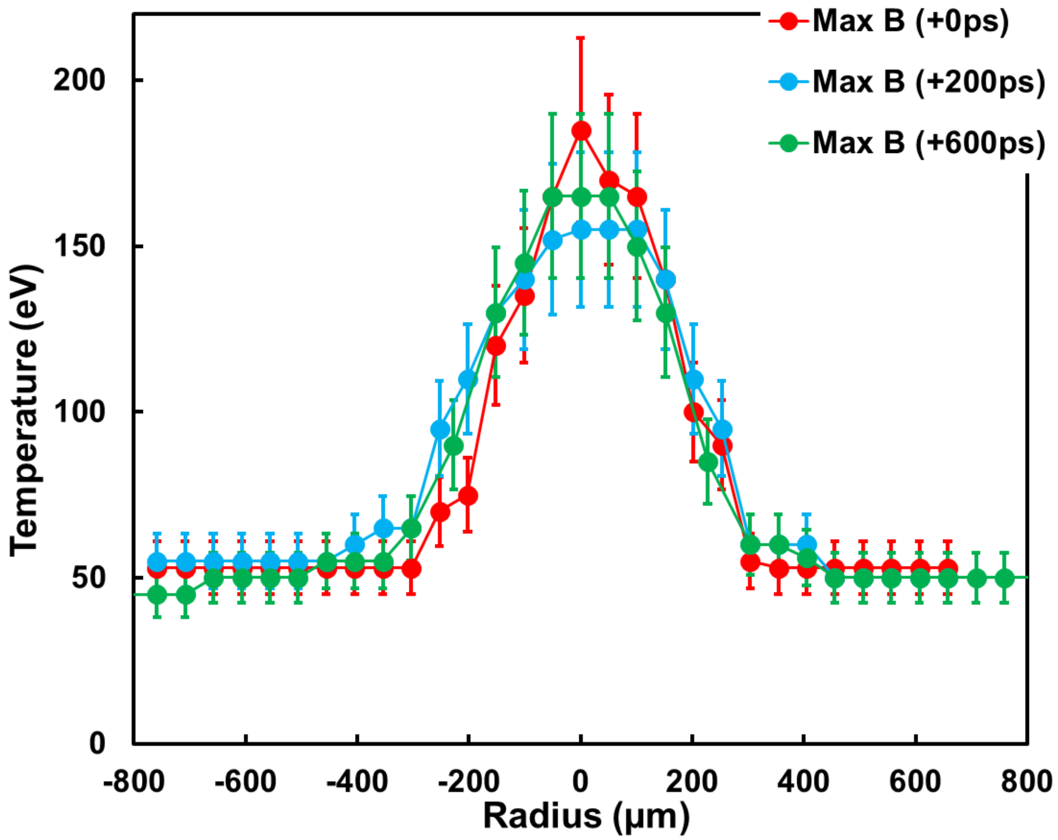


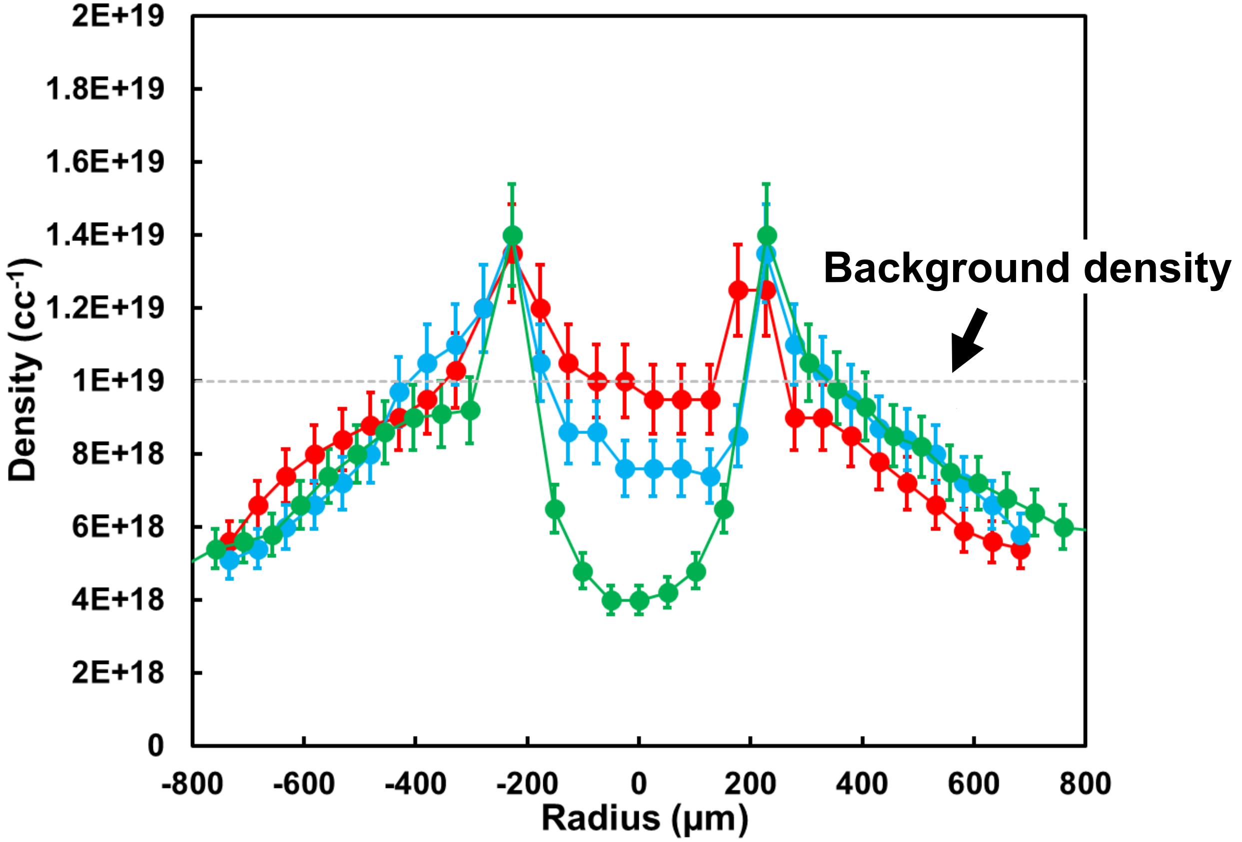


In the absence of a magnetic field the plasma freely expands

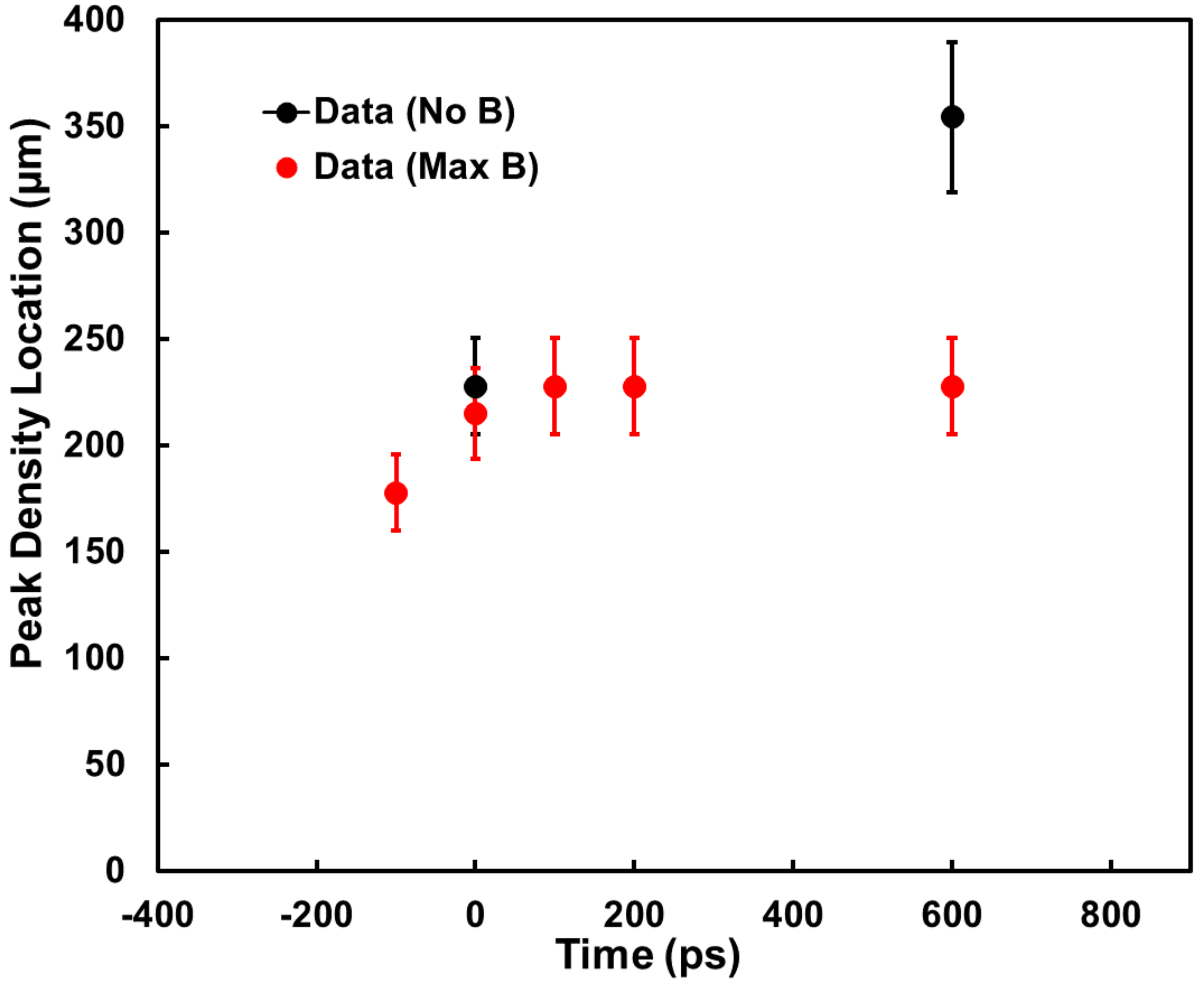


Across multiple shots, in the presence of a strong magnetic field, the expanding heat front is observed to be inhibited in its motion

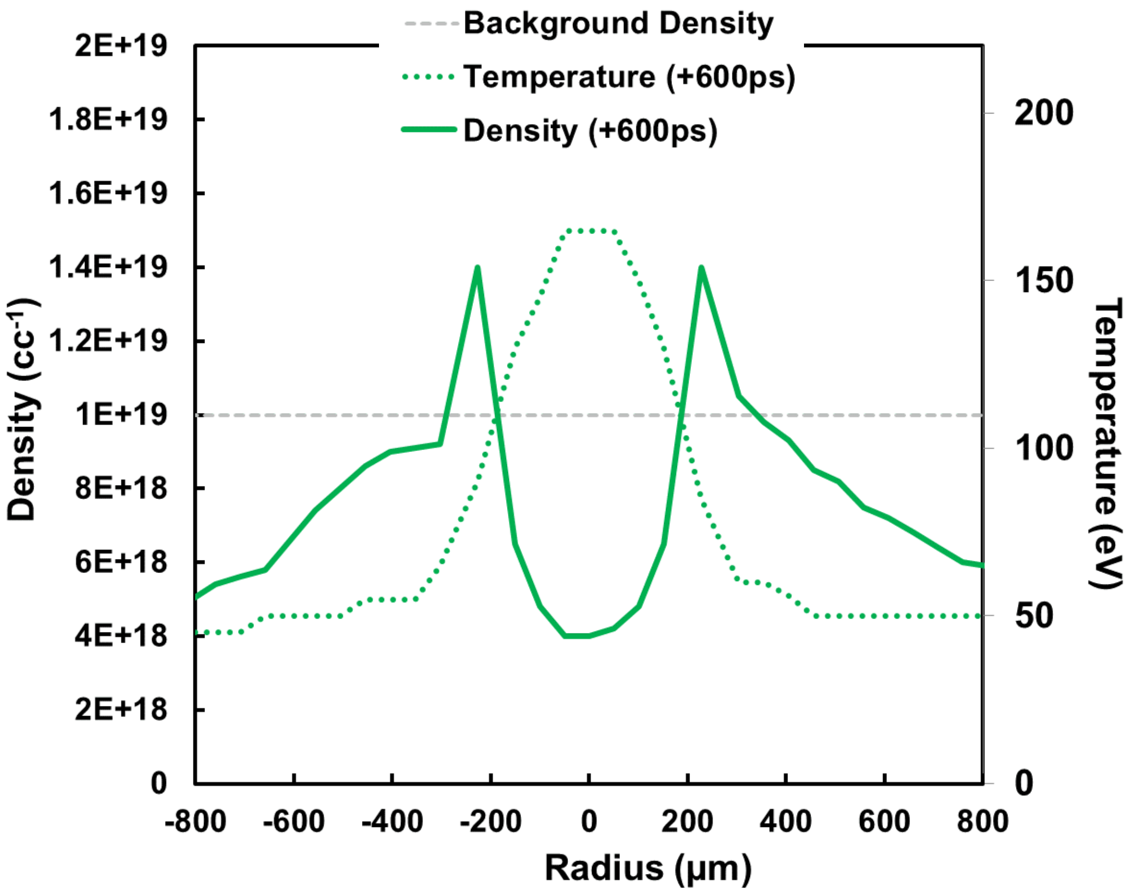


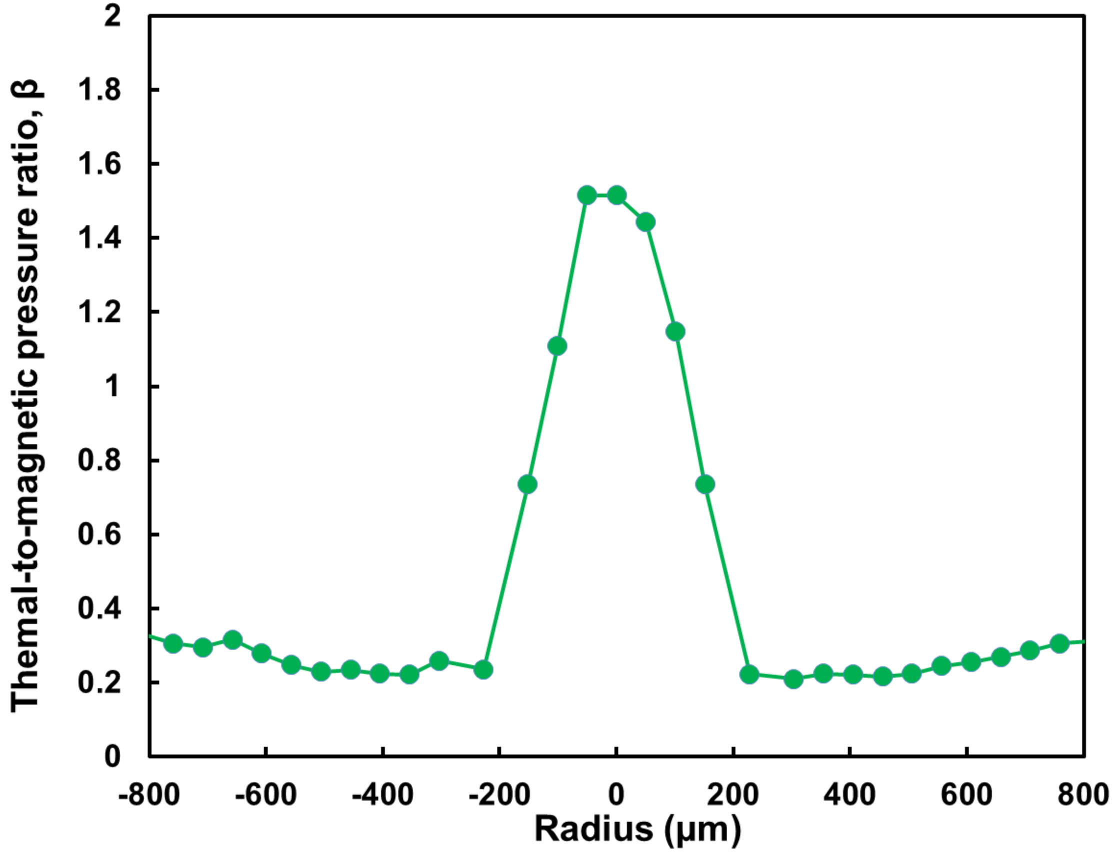


Analyses of the magnetized profiles at separate times show the peak location to be halted after a short expansion



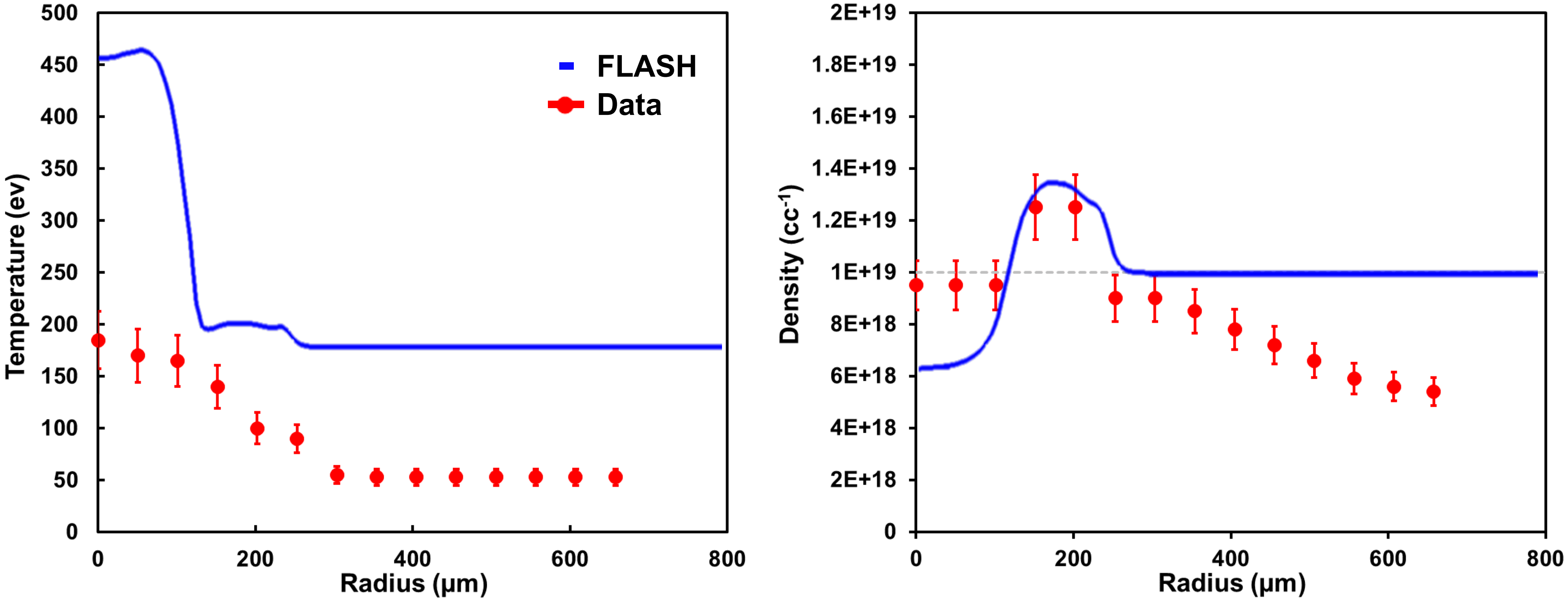
Calculation of the thermal-to-magnetic pressure ratio place β between 0.25-1.6 across the plasma profile





In this regime the magnetic field is “frozen-in” to the plasma, changing the dynamics of the expansion.

2D magnetohydrodynamic FLASH simulations show the magnetic field carried outward and an increase in the electron density



The disagreement in the electron temperature is being investigated.

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- Recent experimental results show $\beta \sim 1$ for a $1\text{x}10^{19}\text{cc}^{-1}$ Hydrogen plasma ($B \approx 33$T, $T_e \approx 150$eV)
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- Experiments to measure the magnetic field are being planned for March 2021

UR LLE

Thank you!

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