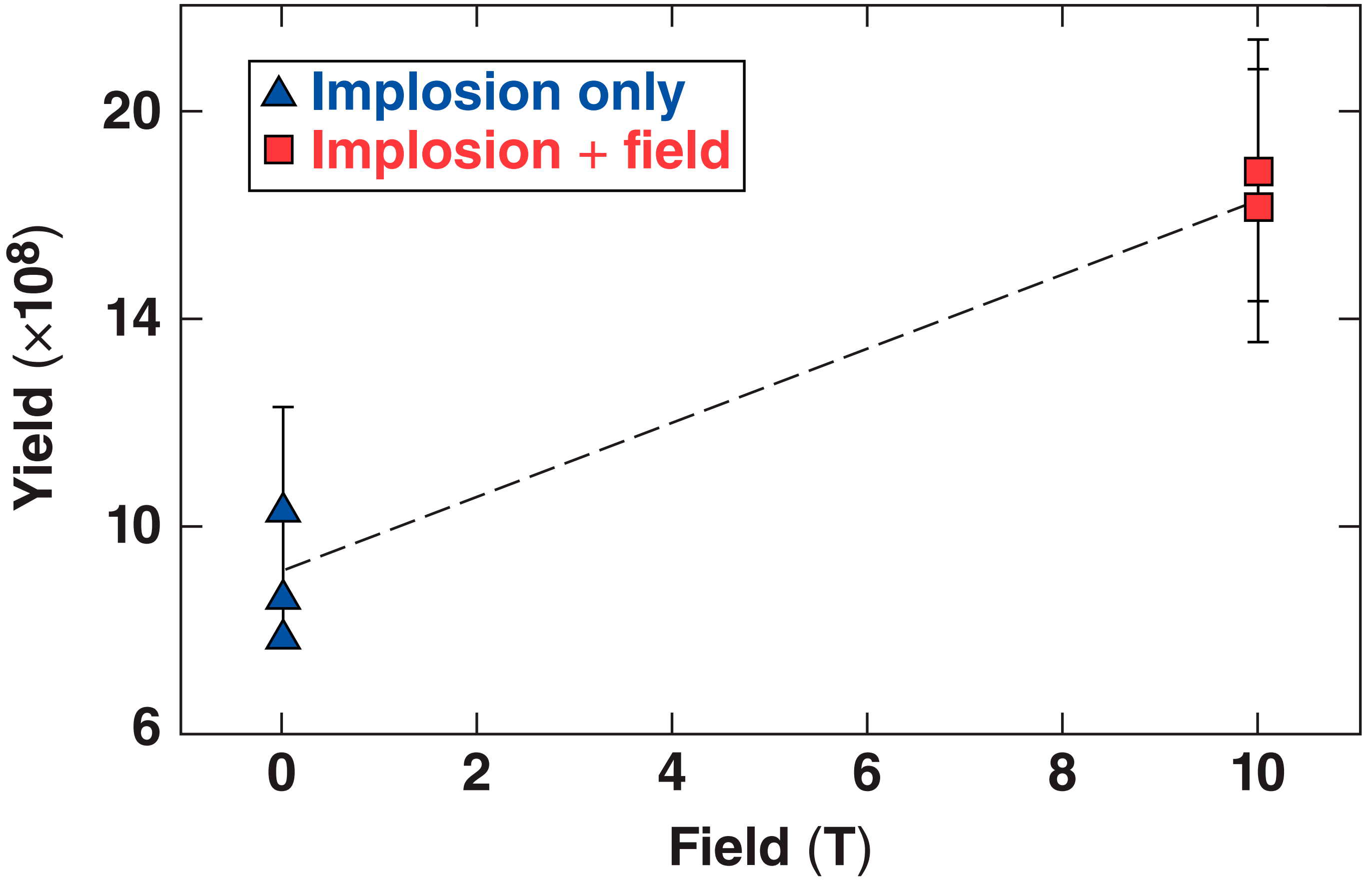
Enhancing Neutron Yield in Cylindrical Implosions with an Applied Magnetic Field



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Applying a 10-T axial magnetic field enhances yield by >40% in laser-driven cylindrical implosions

- A 10-T magnetic field was generated via the magneto-inertial fusion electrical discharge system (MIFEDS) and was verified via proton radiography, Faraday rotation, and Rogowski coil current traces
- An ~75% increase in neutron yield was obtained with D_2 fill pressures of 11 atm and ~40% at 7 atm
- Yields with and without a magnetic field follow trends from 1-D *LILAC*

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Collaborators

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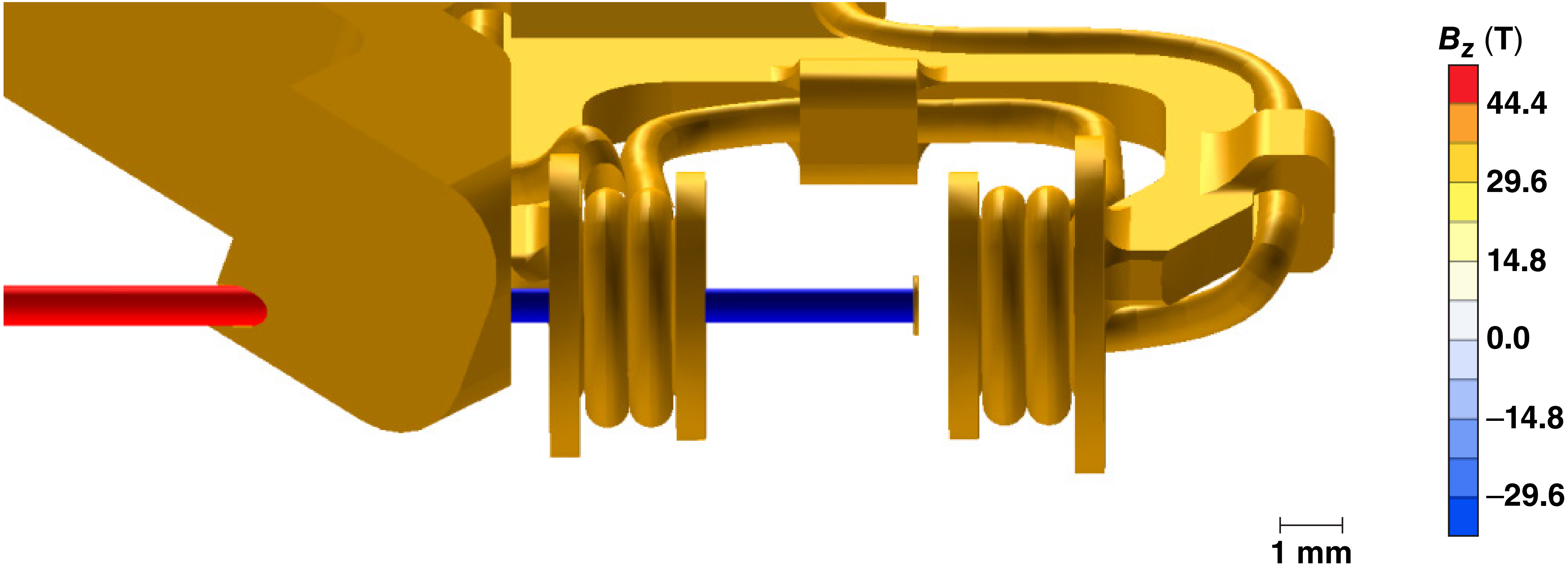
OMEGA can investigate scaled integrated MagLIF* implosions with a high shot rate and excellent diagnostic access



MIFEDS coils deliver a 10-T field at the region of interest while avoiding 40 implosion beams.

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*MagLIF: magnetized liner inertial fusion

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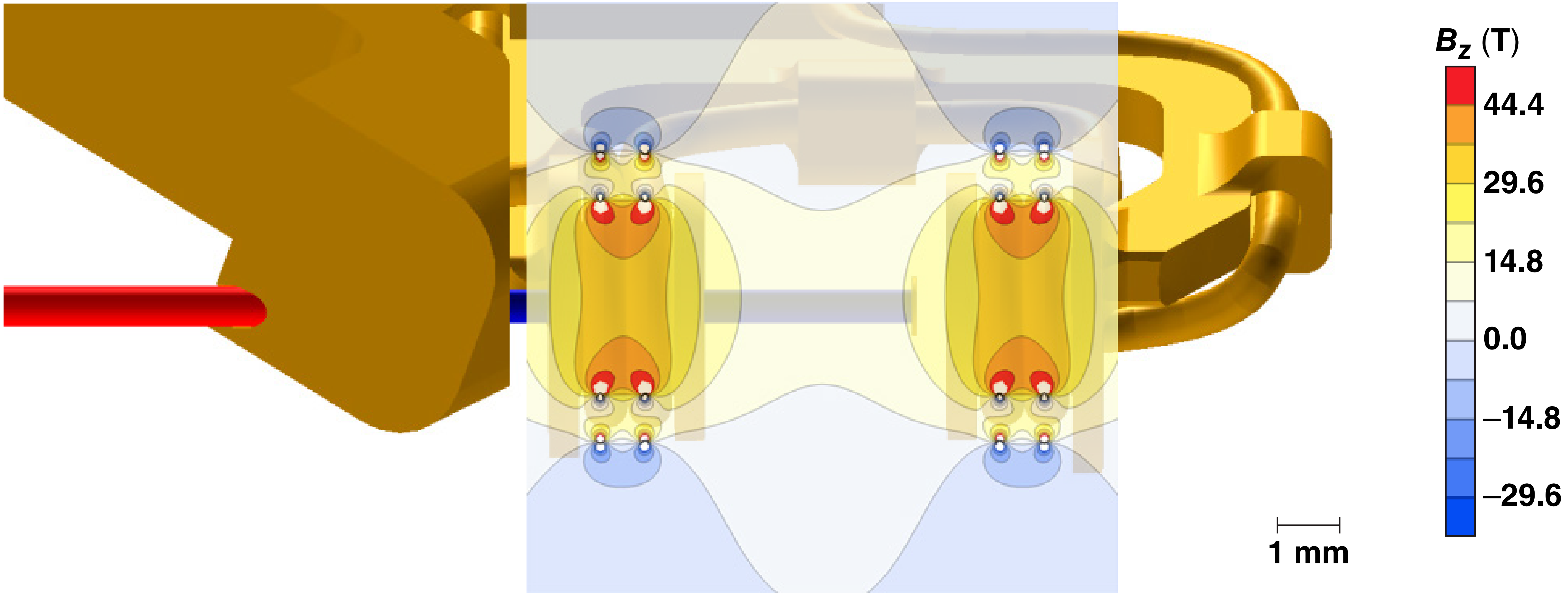

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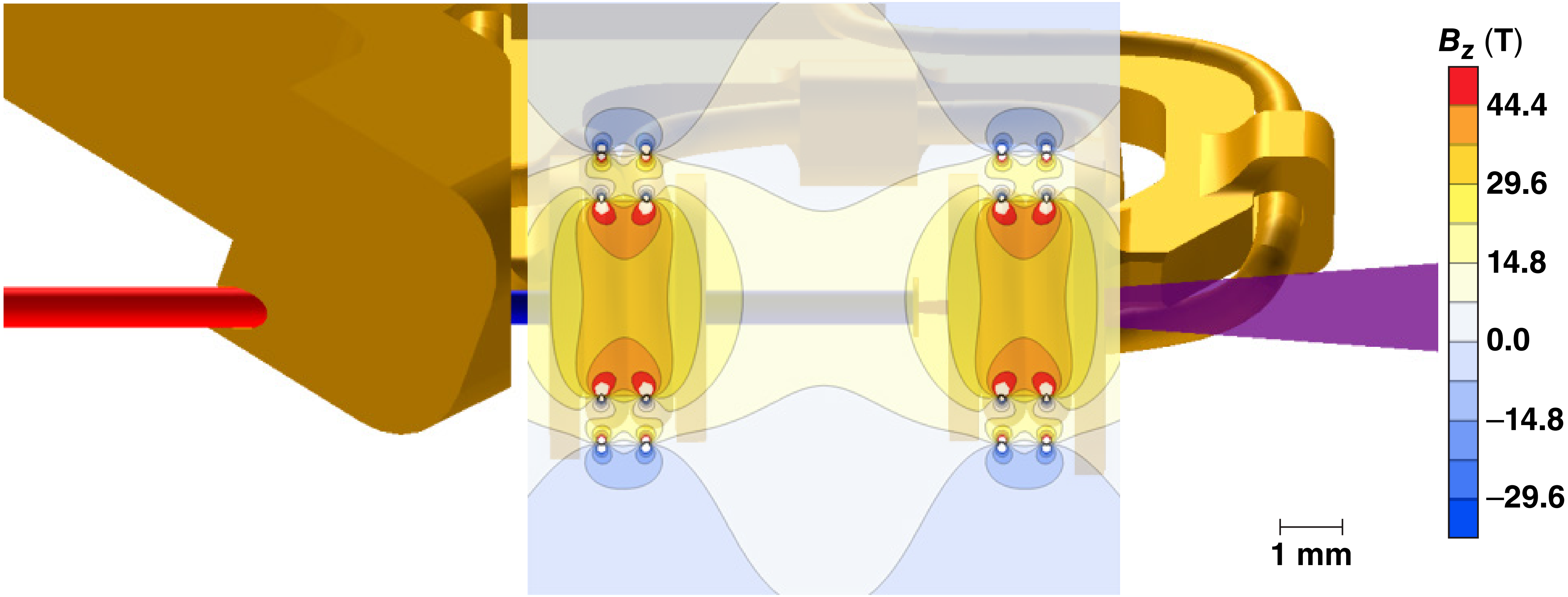

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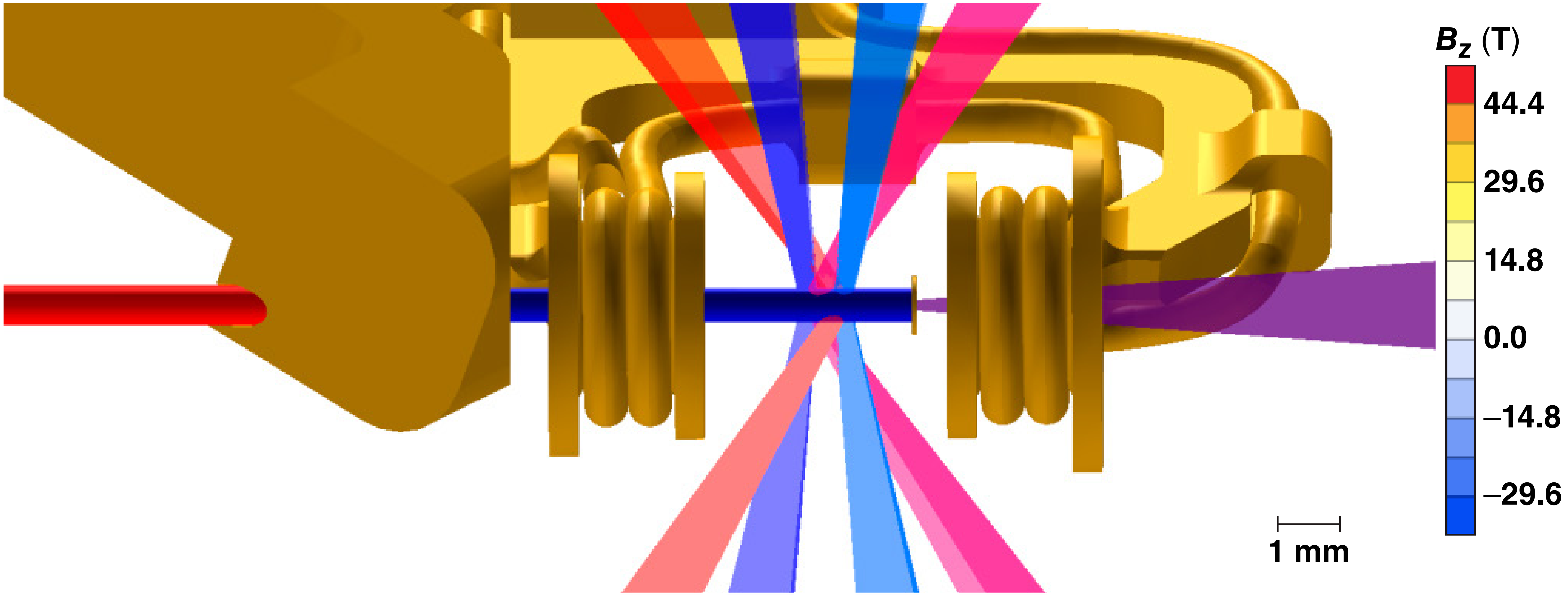

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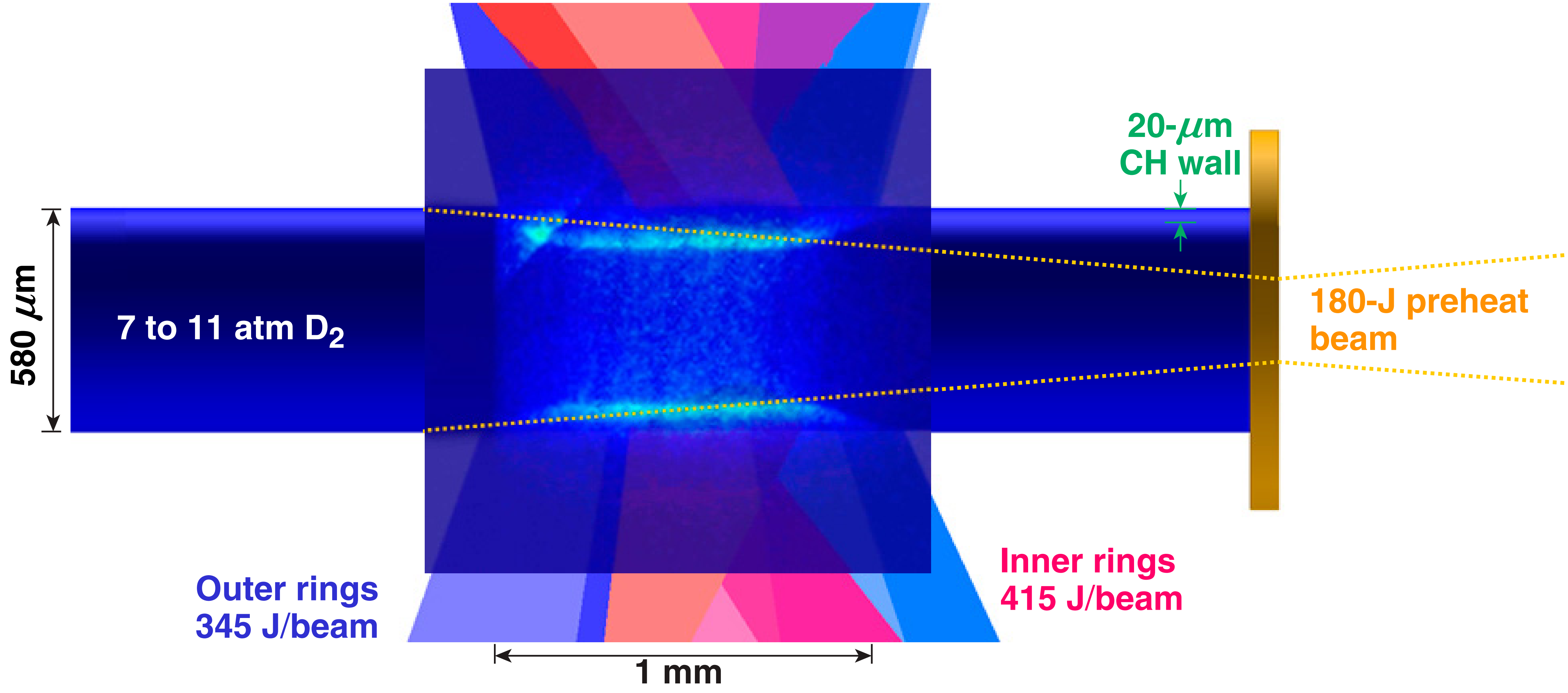
Forty OMEGA beams are tuned and spaced to evenly drive a cylindrical implosion using a 1.5-ns square pulse



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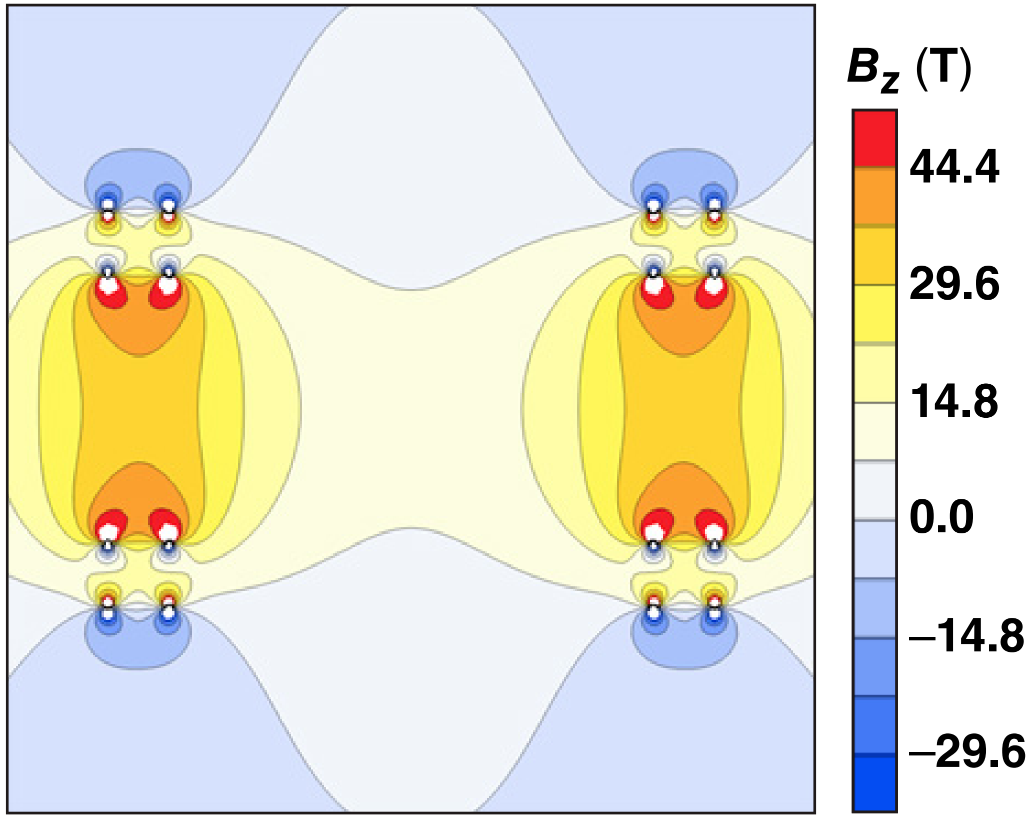
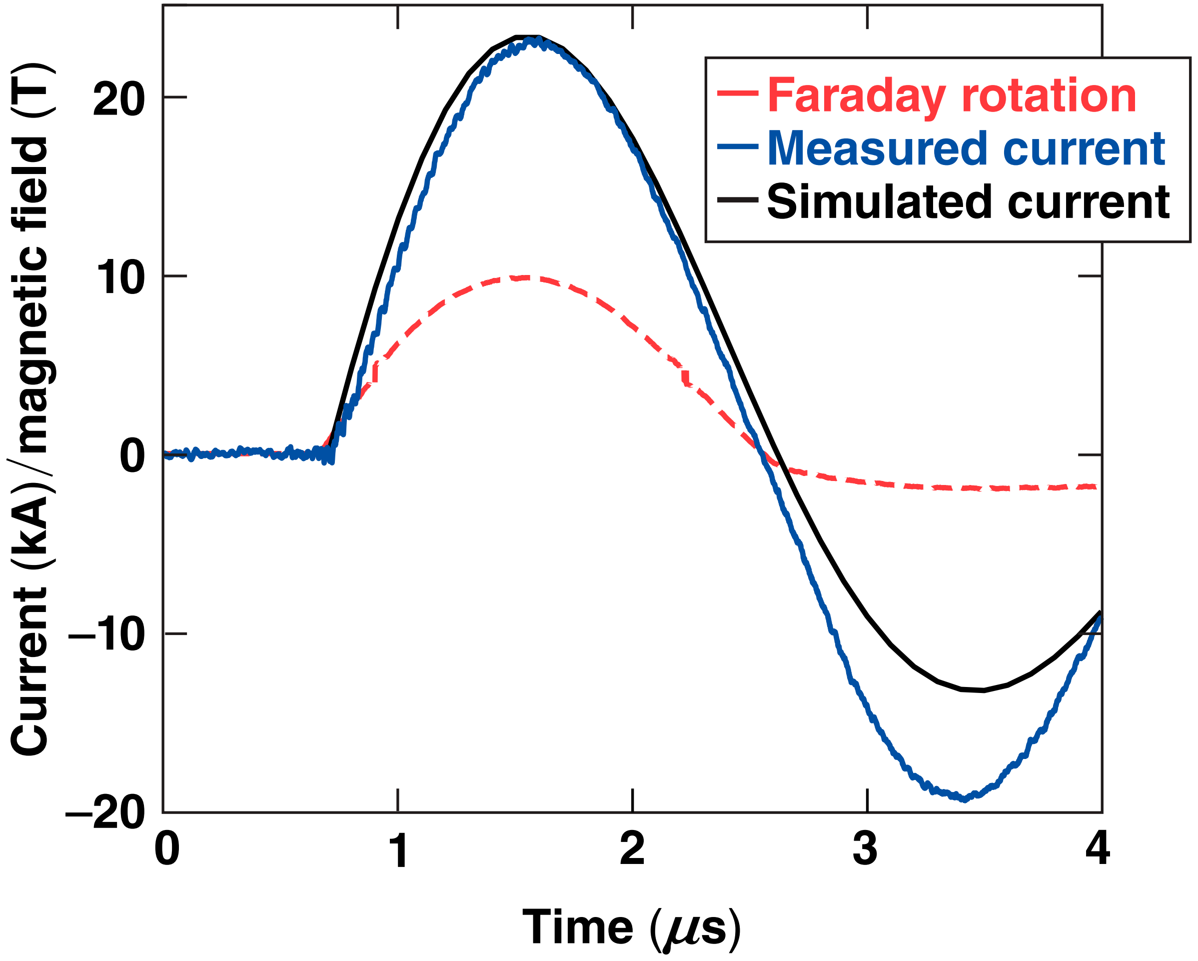
MIFEDS delivers microsecond-duration magnetic fields at the target, confirmed by Faraday rotation

Simulated field map based on coil design and current



Measured current, period, and field closely match simulated values



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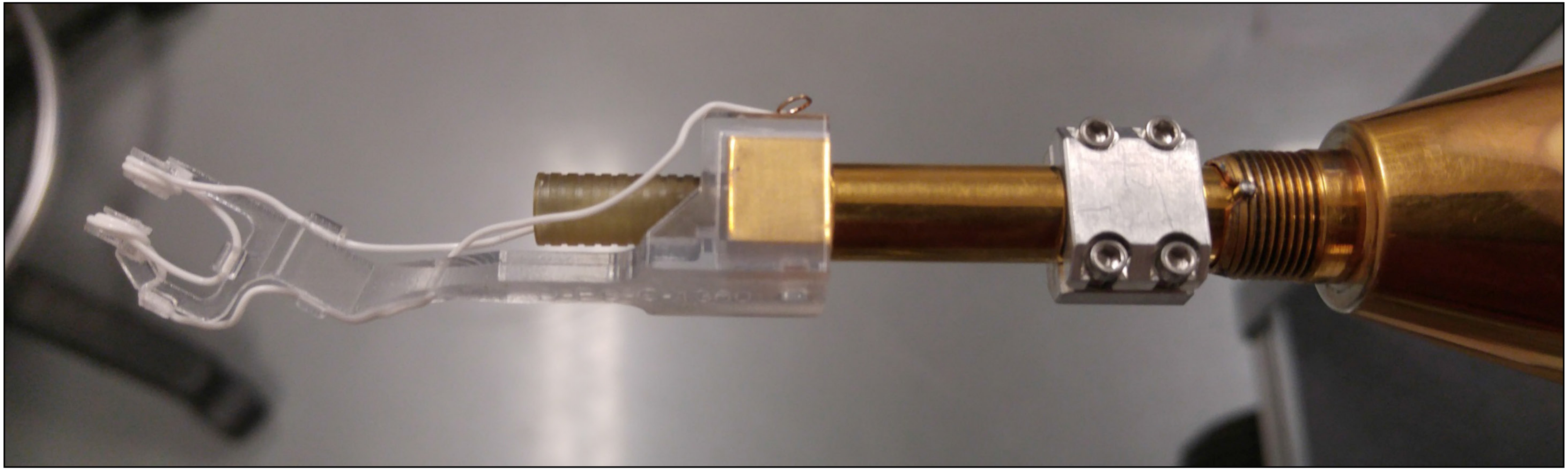
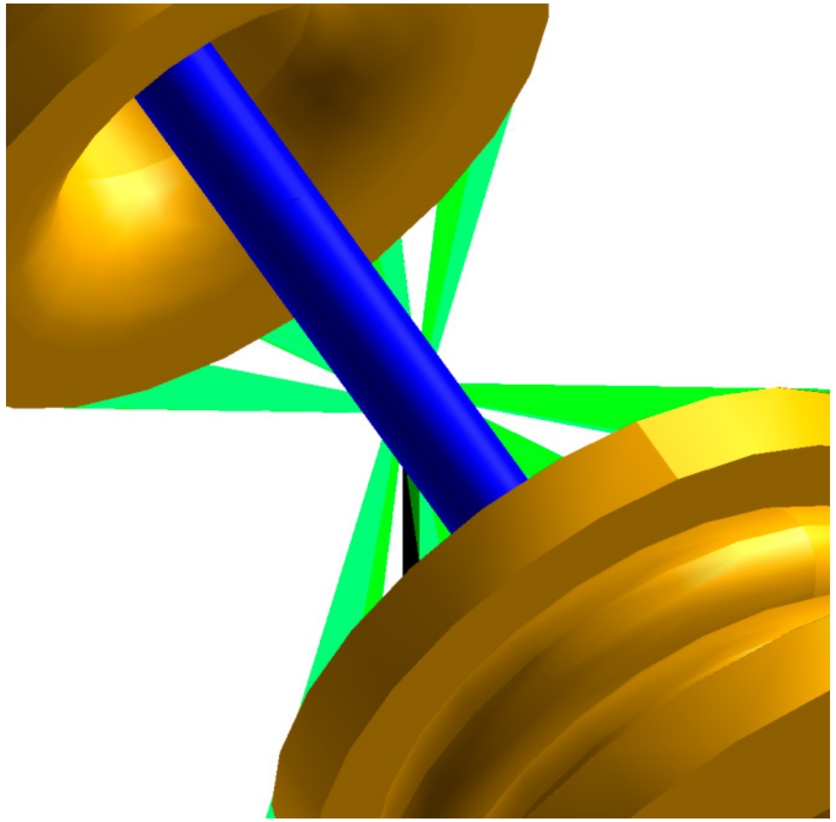
MIFEDS coils used in an experiment

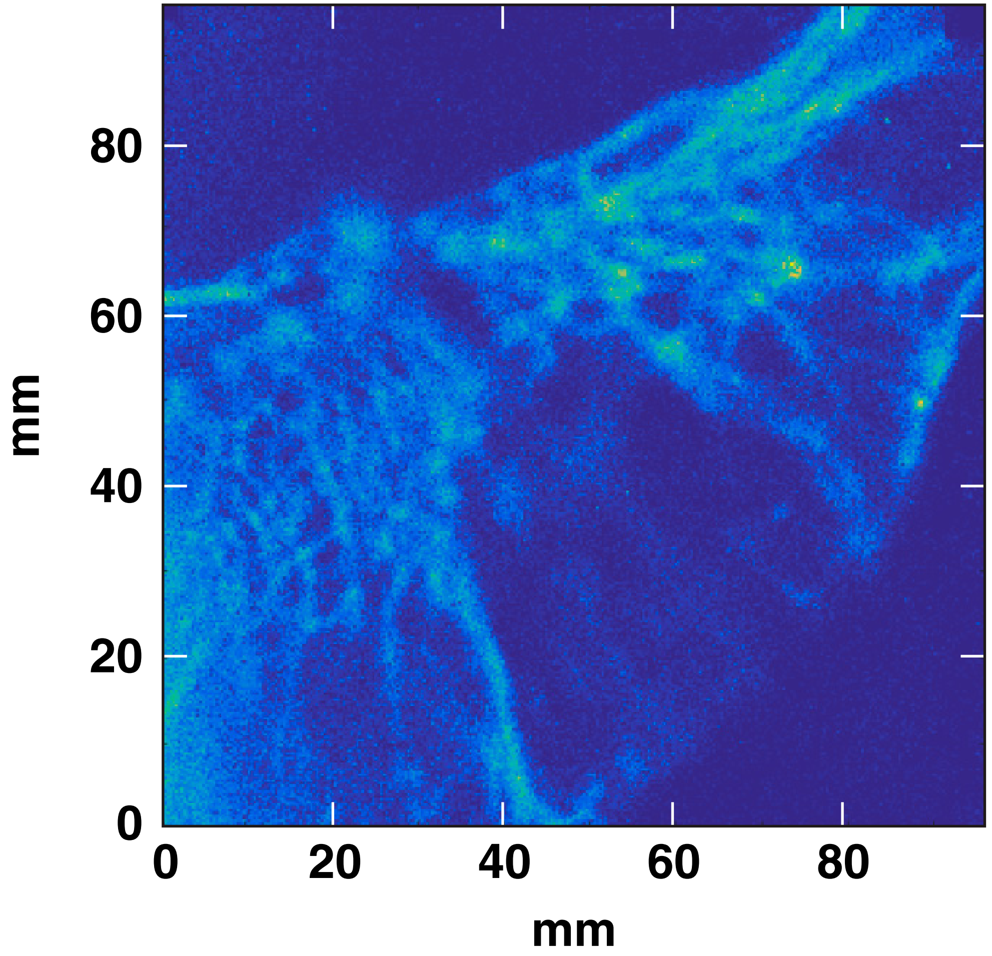


A 10-T uncompressed field was verified on shot using proton radiography

A D^3He sphere was imploded to generate protons for radiography



Vacuum fields near the coils are extremely strong and completely deflect protons



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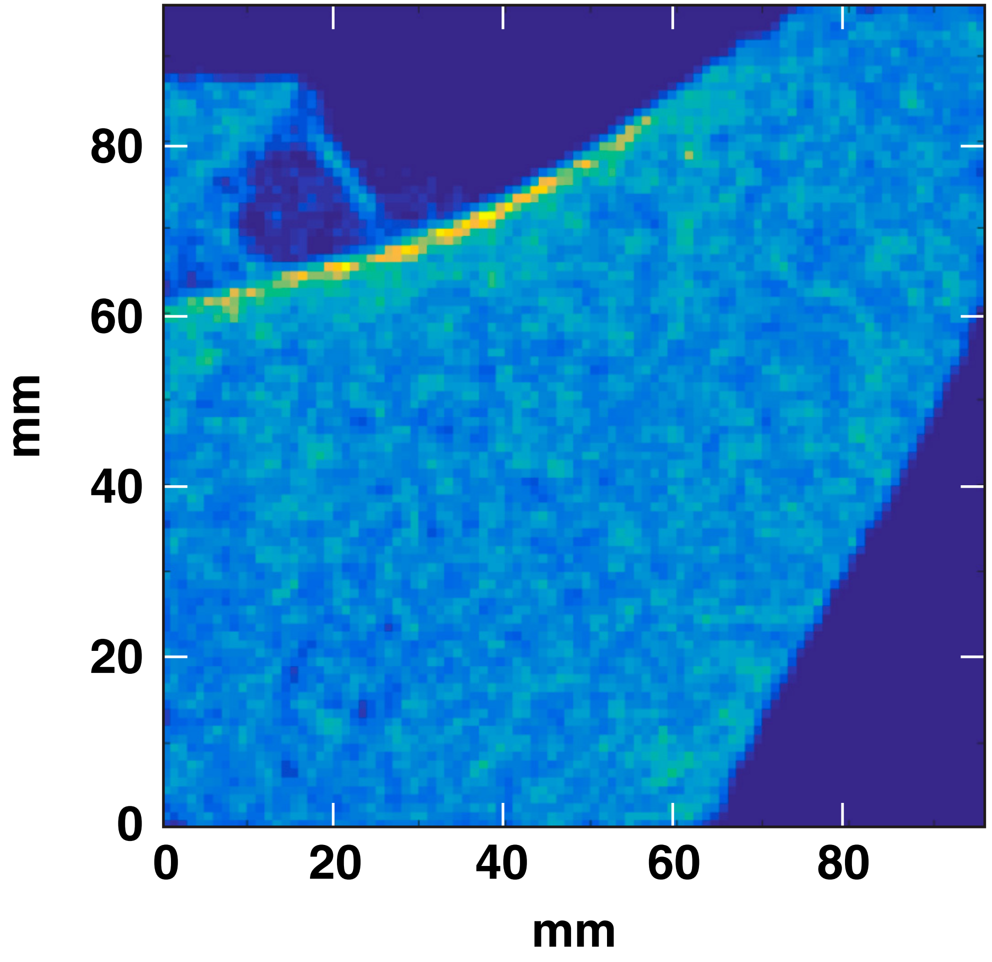
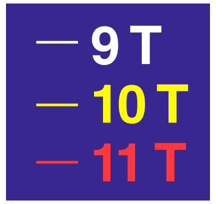
A 10-T uncompressed field was verified on shot using proton radiography

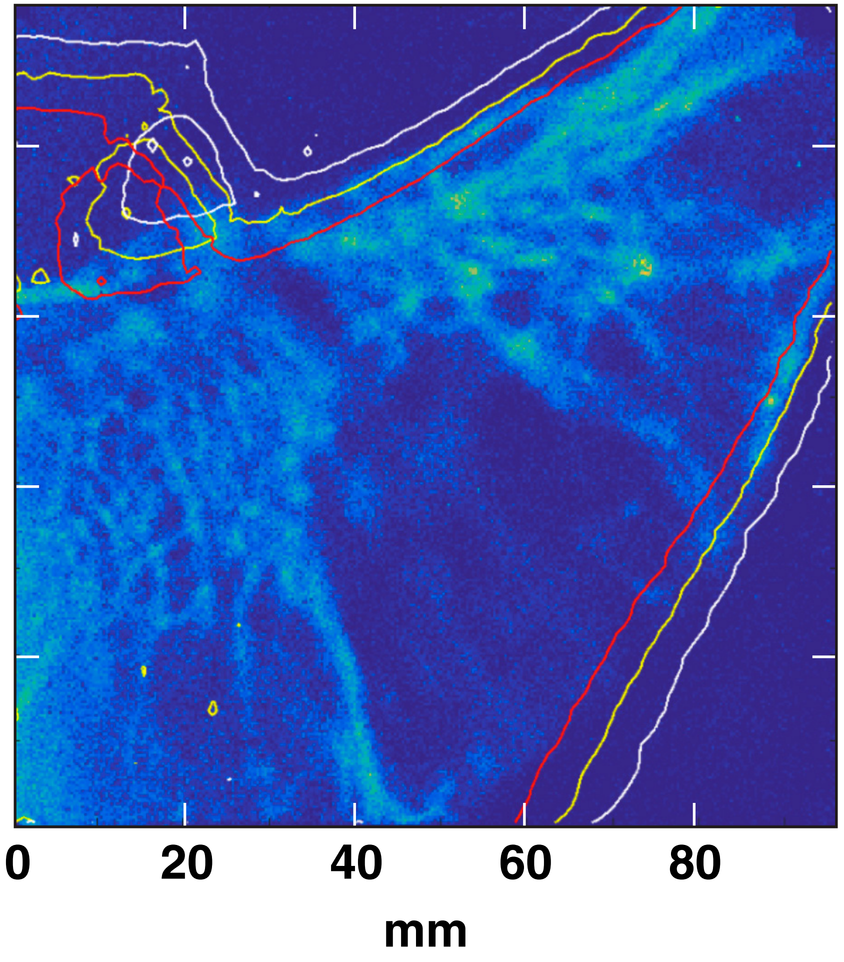
Fields at the coil were extrapolated from central vacuum fields



Vacuum field at center



A 10-T center vacuum field best reproduces the radiographs



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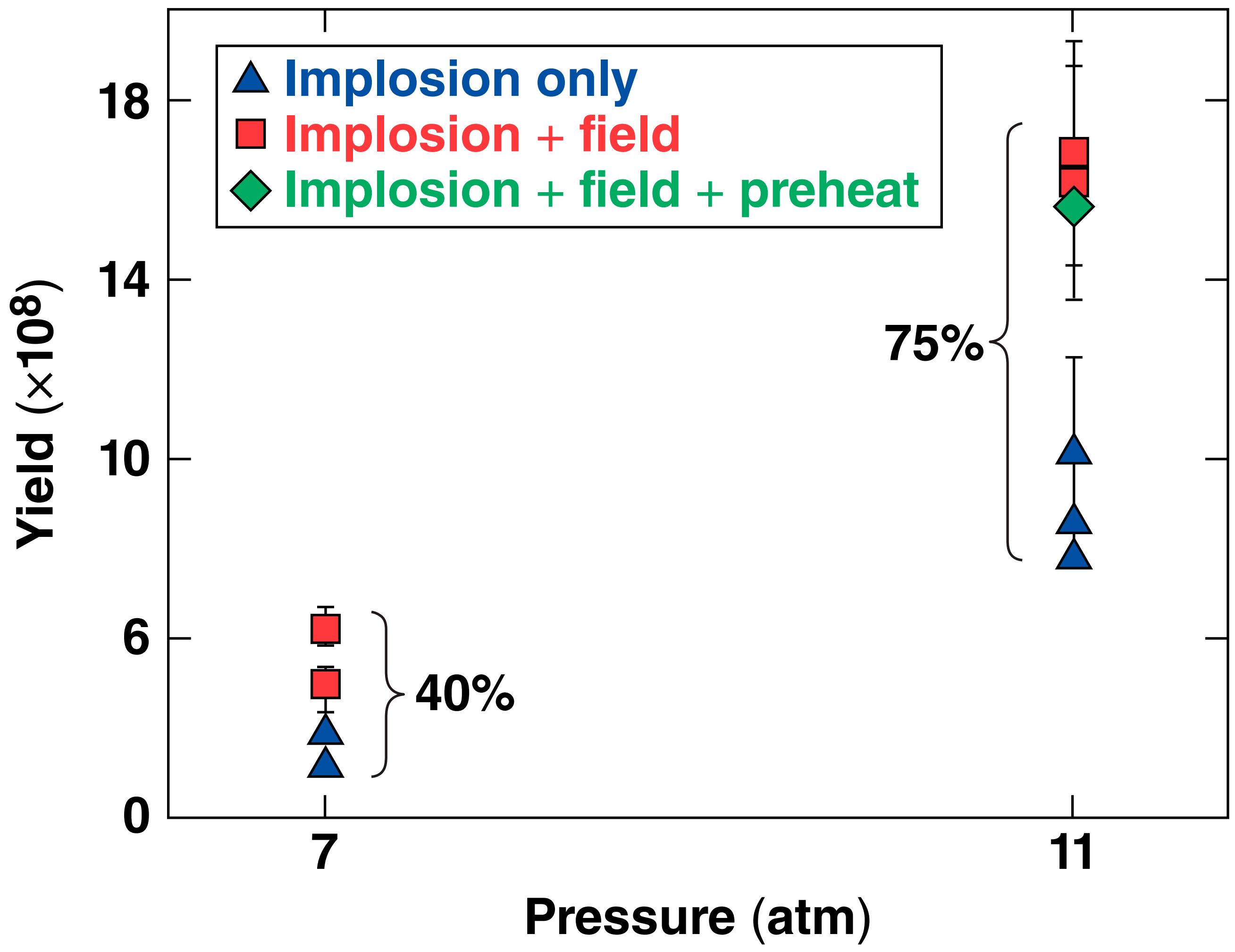
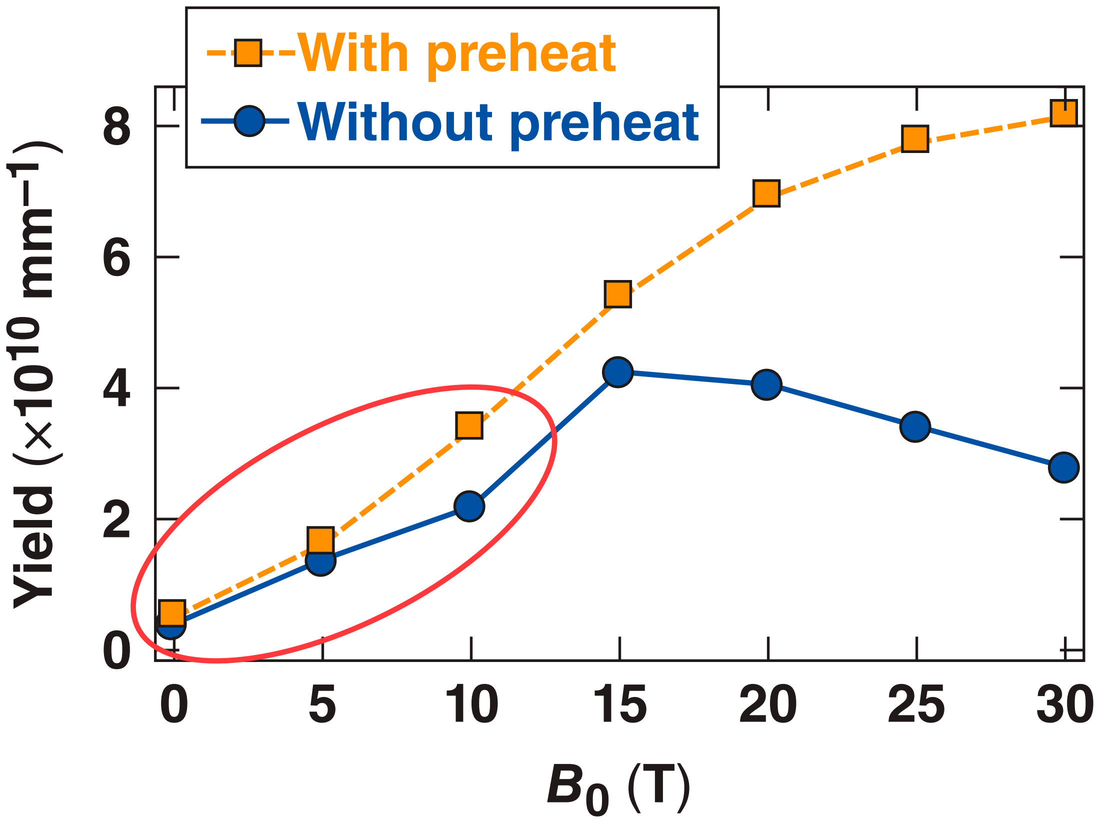
Initial 10-T field enhancement is greater at higher target pressures

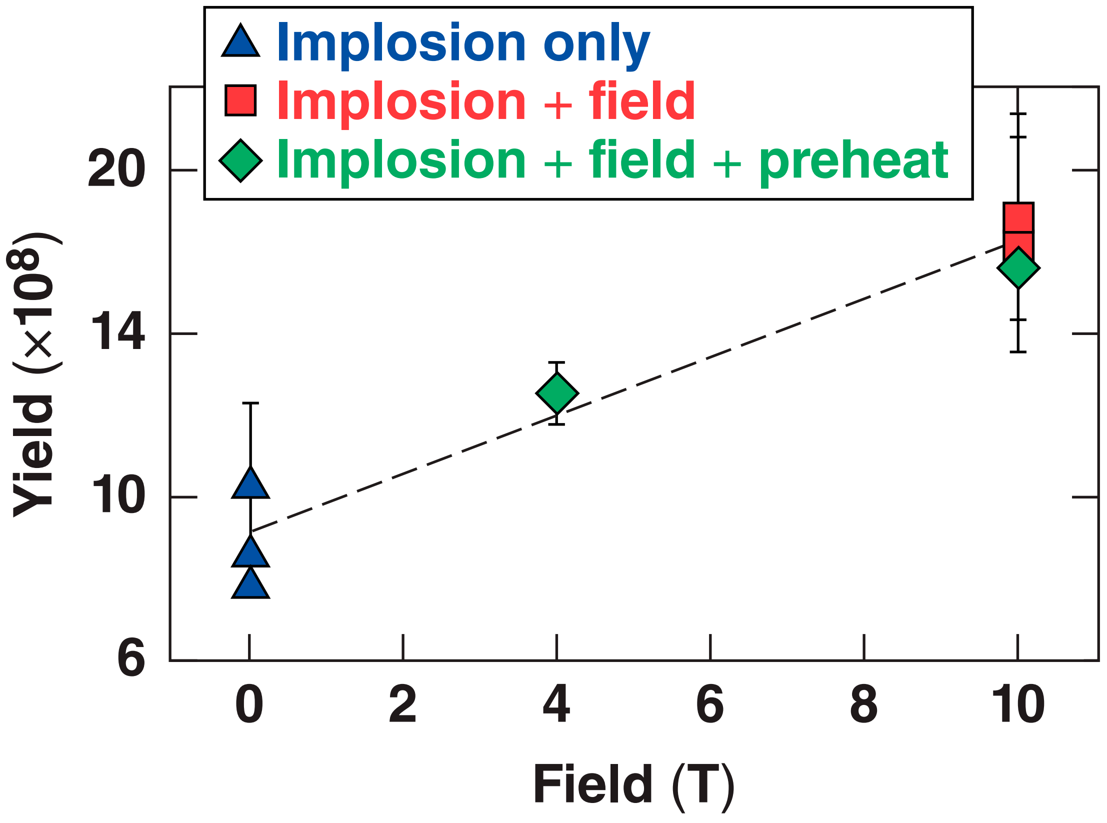
- Imposing an external magnetic field without preheat on the implosion increased yield in different pressure cases
- Yield increased by ~75% in the 11-atm case compared to ~40% in the 7-atm case when the 10-T field was introduced



One-dimensional *LILAC* predicts increased yields up to 15 T without preheat

- **Implosions without preheat have maximized yields at 15 T because of a high convergence ratio, resulting in high magnetic pressure**





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*J. R. Davies *et al.* Phys. Plasmas 24, 062701 (2017).

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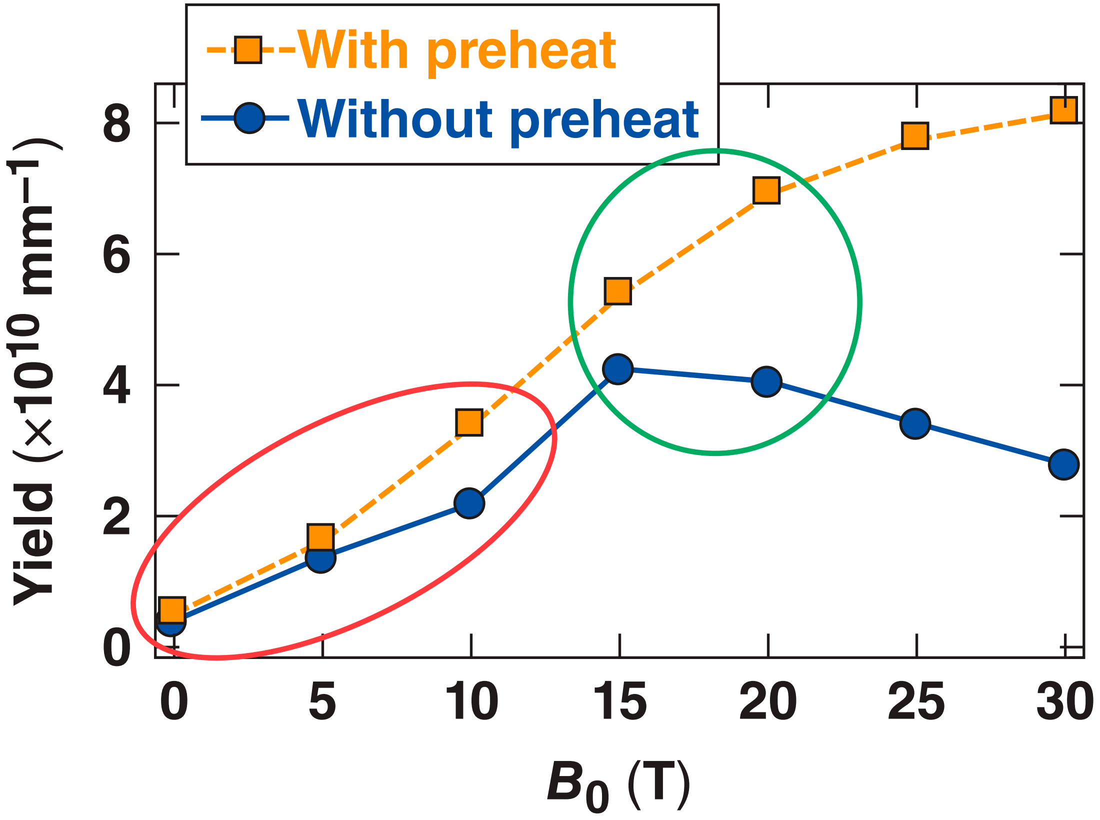

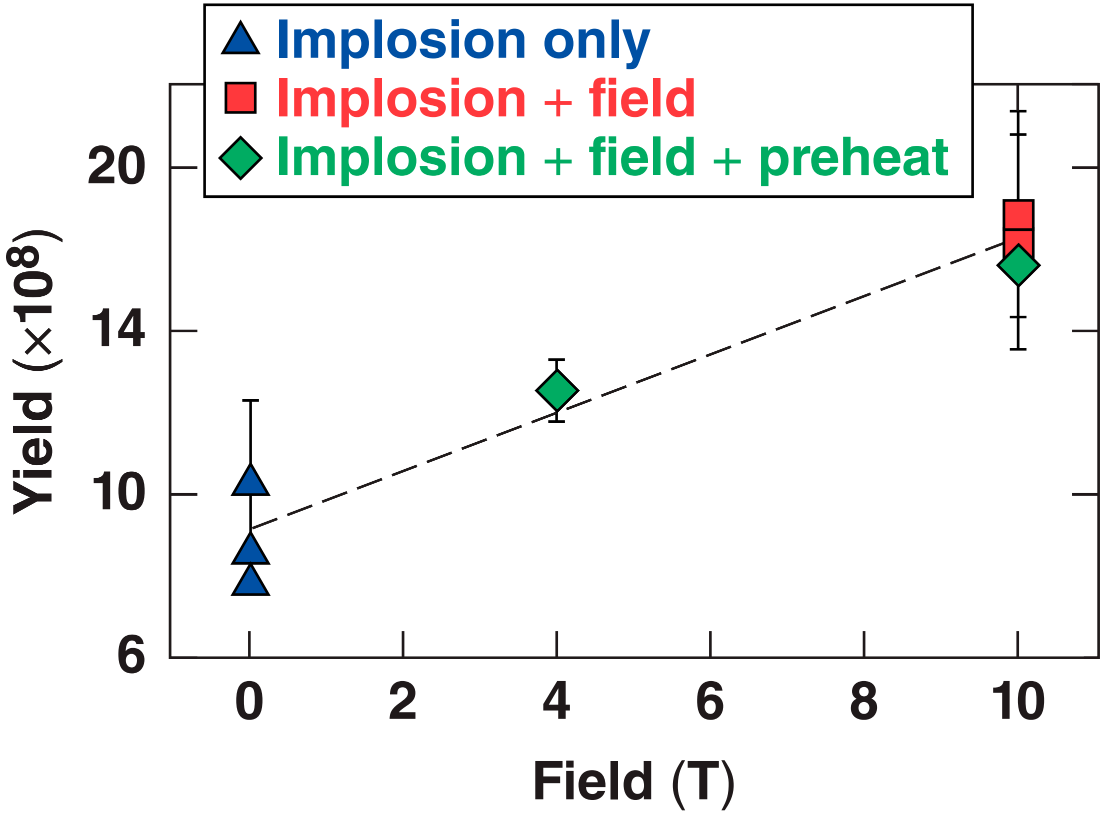

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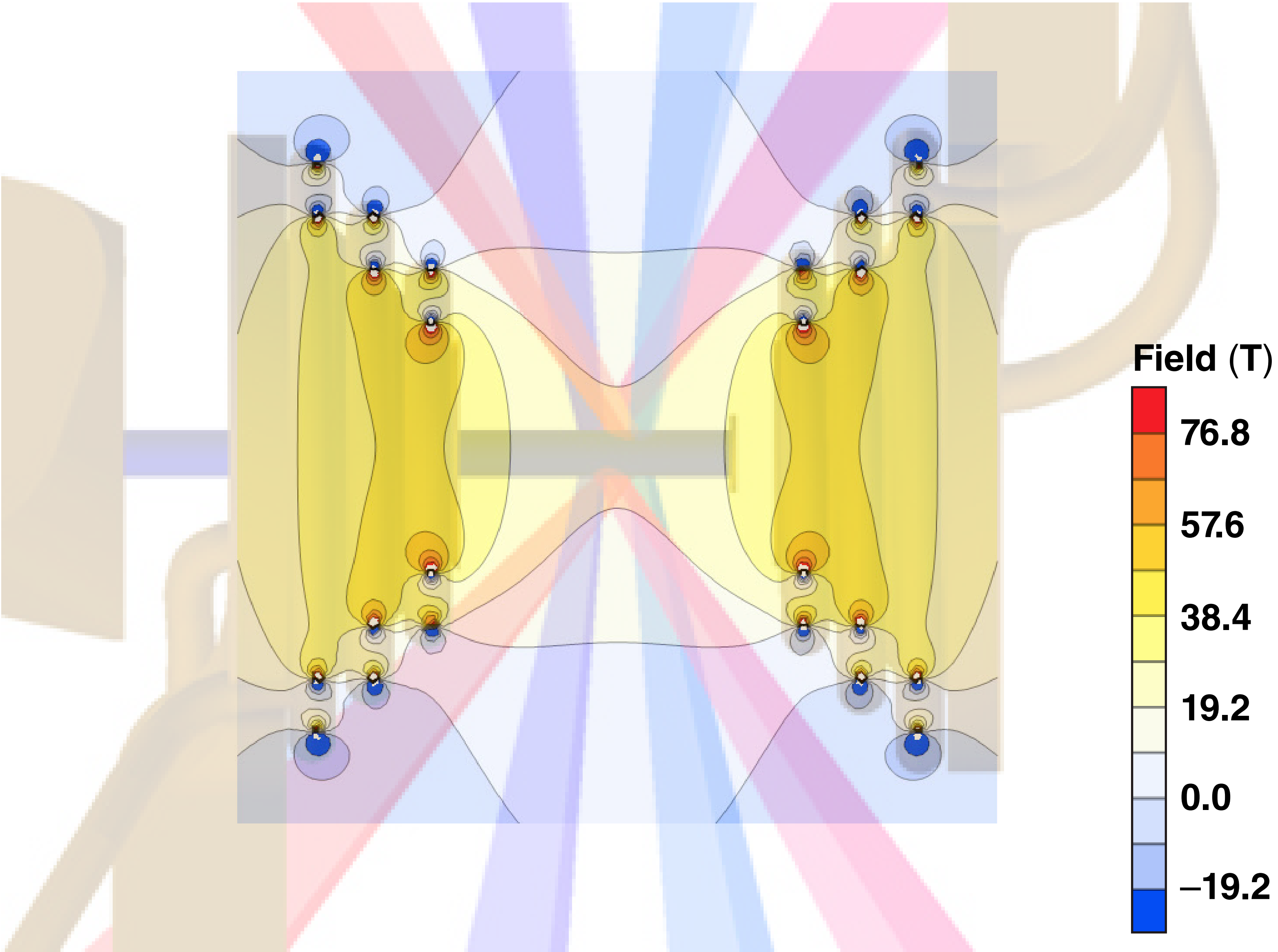
*J. R. Davies *et al.* Phys. Plasmas 24, 062701 (2017).

New coil designs and use of dual MIFEDS allows for exploration of implosions with initial fields of up to 20 T

- Dual MIFEDS splits the inductive load, allowing for more winds with larger radius, leading to higher fields
- Turning preheat on/off should give very different ion temperatures and yields at 20 T



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