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

Faraday rotation
Measured current
Simulated current

$B_z (\text{T})$
MIFEDS coils used in an experiment
A $^3$He sphere was imploded to generate protons for radiography.

Vacuum fields near the coils are extremely strong and completely deflect protons.
A 10-T uncompressed field was verified on shot using proton radiography

Fields at the coil were extrapolated from central vacuum fields

A 10-T center vacuum field best reproduces the radiographs
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.

![Graph showing yield vs. pressure for different conditions](image)

- **Implosion only**
- **Implosion + field**
- **Implosion + field + preheat**
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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![Graph showing yield vs. magnetic field strength for implosions with and without preheat.](image)

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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
Summary/Conclusions

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