Experimental Platform for Magnetized HEDP Science at the Omega Laser Facility

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Summary

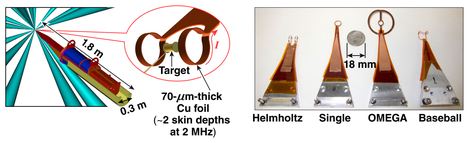
MIFEDS provides the experimental platform for magnetized HEDP at the Omega Laser Facility

- MIFEDS is a ten-inch manipulator (TIM)-based device that provides a seed magnetic field up to ~80 kG on OMEGA. The seed fields have been compressed to ~30 MG in laser-driven implosions
- MIFEDS is being upgraded (MIFEDS-U) to quadruple the stored energy and double the magnetic field
- MIFEDS-U will provide a more robust and more flexible platform
- A variety of experiments using MIFEDS-U have been scheduled for fiscal year 2013

Magnetized HEDP is an exciting new research area.

TC10281

MIFEDS is a TIM-based device and is capable of providing different magnetic field topologies by using different coils



- With different coil designs, a seed magnetic field up to 80 kG has been produced

E19778c

O. V. Gotchev *et al.*, Rev. Sci Instrum. 80, 043504 (2009).

Abstract

Magnetized high-energy-density physics (HEDP) is an increasingly active research area with relevance to inertial confinement fusion (ICF), astrophysical sciences and basic plasma physics. A compact, self-contained magnetic-field generator MIFEDS (magnetized inertial fusion energy delivery system) capable of providing a magnetic field up to 10 T was developed at the Laboratory for Laser Energetics and has been used at the Omega Laser Facility in recent experiments. The MIFEDS device has been upgraded to quadruple the stored energy and to double the magnetic field. In addition, the reliability of the device and the user interface has been improved. The device is now compatible with both OMEGA and OMEGA EP lasers and allows for fielding a wide variety of ICF, HEDP, and astrophysical experiments. Details of these new capabilities are provided and detailed plans for experiments at the Omega Laser Facility are shown.

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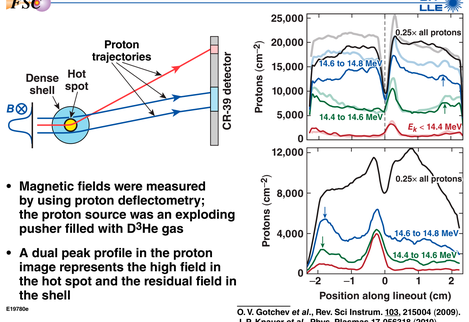
Past experiments

A magnetic field of 30 MG was observed in a compressed target

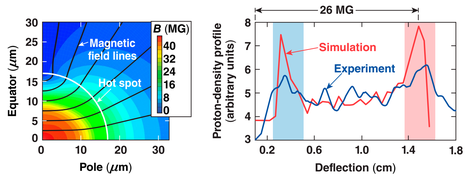


- Magnetic fields were measured by using proton deflectometry; the proton source was an exploding pusher filled with D^3He gas
- A dual peak profile in the proton image represents the high field in the hot spot and the residual field in the shell

E19780e

O. V. Gotchev *et al.*, Rev. Sci Instrum. 103, 215004 (2009).
J. P. Knauer *et al.*, Phys. Plasmas 17, 056318 (2010).

A magnetic field of ~25 MG was inferred in spherical implosions

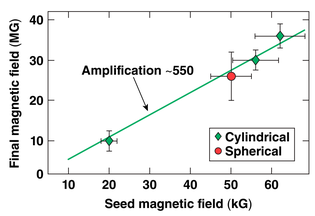


- Single-shot data indicated that the field is compressed to ~25 MG in a spherical target; more shots are needed to confirm the magnetic field measurements

TC9729b

M. Hohenberger *et al.*, Phys. Plasmas 19, 056306 (2012).

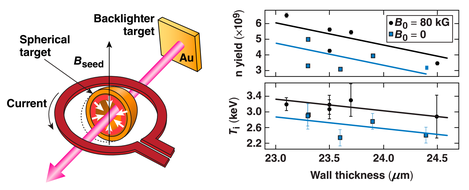
The magnetic field is amplified by ~550 in cylindrical and spherical implosions on OMEGA



E19782d

M. Hohenberger *et al.*, Phys. Plasmas 19, 056306 (2012).

The neutron yields increased by ~30% in magnetized spherical targets



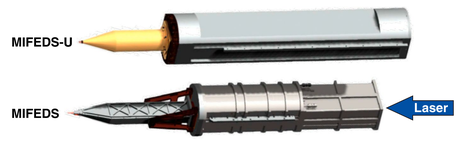
- The measured ion temperature and fusion yield were improved by 15% and 30%, respectively, when the hot spot was magnetized

E19783e

P.Y. Chang *et al.*, Phys. Rev. Lett. 107, 035006 (2011).

MIFEDS Upgrade

MIFEDS has been upgraded to be more robust and flexible in operation



- A high voltage (HV) trigger is used in MIFEDS-U, whereas a laser trigger was used in MIFEDS
- A coaxial cone is used as the transmission line in MIFEDS-U to provide lower inductance

TC10282

MIFEDS-U will double the magnetic field compared to MIFEDS

	MIFEDS-U	MIFEDS
Capacitor	1 μF (0.5 uf × 2)	0.2 μF (0.1 uf × 2)
Charge voltage	24 kV	20 kV
Stored energy	~288 J	~40 J
Trigger	HV trigger	Laser trigger
Transmission line	Coaxial	Strip line
Coil mount	Rotatable	Non-rotatable
Operation	Facility diagnostic	MIFEDS operator
Impedance	~0.25 Ω	~0.5 Ω

- The first MIFEDS-U shot is scheduled for 20 November 2012 on OMEGA
- MIFEDS-U can be used on both OMEGA and OMEGA EP

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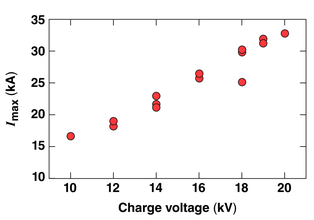
MIFEDS-U preliminary test has shown the capability of providing different currents with different charge voltages between 10 to 20 kV



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A new rotatable coil and high-voltage spark-gap triggers are used in the MIFEDS upgrade (MIFEDS-U)

- The coil is rotatable in MIFEDS-U, giving more flexibility for experimental design
- The commercial PerkinElmer-triggered spark gap GP-12B is used in MIFEDS-U, giving more robust operation

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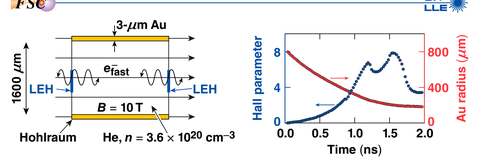
Future experiments

Fast electrons generated in hohlraums can be controlled by using a magnetic field

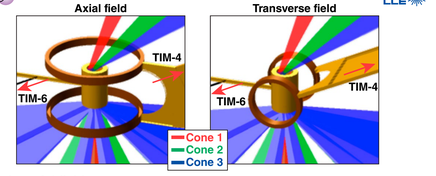


- Fast electrons with temperatures up to 70 keV can be generated in hohlraums by two-plasmon decay (TPD) and by stimulated Raman scattering (SRS) in the gas*
- The Larmor radius of a 70-keV electron in a 10-T field is 89 μm
- Fast-electron trajectories can be controlled with a magnetic field
- Heat flow can be inhibited since the plasma can be magnetized, leading to higher electron temperature and higher SRS threshold

TC10285

*S. P. Regan *et al.*, Phys. Plasmas 17 020703 (2010).

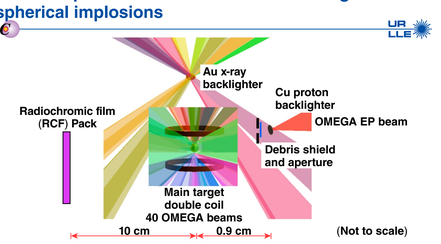
Experiments to control laser–plasma interactions in hohlraums using a magnetic field are scheduled on OMEGA



- In the axial field case,
  - the fast electrons generated at the LEH are expected to be guided away from the hohlraum wall leading to lower hard x-ray emission
  - TPD and SRS are reduced by the higher temperatures expected with magnetic fields
- In the transverse field case, the fast electrons are expected to be guided toward the hohlraum wall leading to higher hard x-ray emission
- The experiment is scheduled for 20 November 2012

TC10287

A copper foil illuminated by an OMEGA EP beam will be used as the proton source to measure the magnetic field in spherical implosions



- The total proton yield from the copper foil illuminated by an OMEGA EP beam is ~3×10^{12} in a ~25° half-angle cone giving a proton fluence of ~5×10^{12} sr^{-1}*
- The number of protons going through the hot spot at peak compression is ~5×10^5
- The experiment is scheduled for 7 February 2013

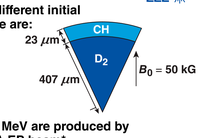
TC10310

*L. Gao *et al.*, Bull. Am. Phys. Soc. 55, 377 (2010).

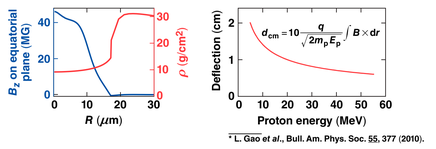
The deflection distance of the protons is between 0.5 to 2.5 cm on the RCF

- The simulated compressed fields for different initial gas fills compressed by a square pulse are:

P_0 (atm)	3	5	10
B_{avg} (MG)	29	19	10
R_{hs} (μm)	13.7	17.1	23.8



- Protons with a maximum energy of 55 MeV are produced by a copper foil illuminated by an OMEGA EP beam*
- The deflected distances are between 0.5 to 2.5 cm on the RCF



TC10383

*L. Gao *et al.*, Bull. Am. Phys. Soc. 55, 377 (2010).