FUSION SCIENCE CENTER FOR EXTREME STATES OF MATTER
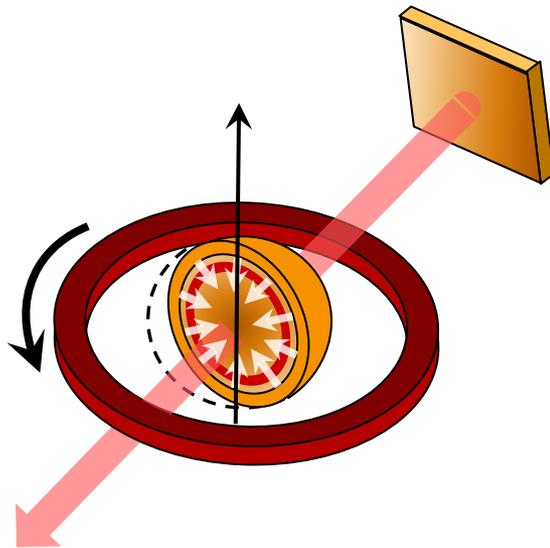
PD simulation
(730-kJ laser energy)
Gain = 50
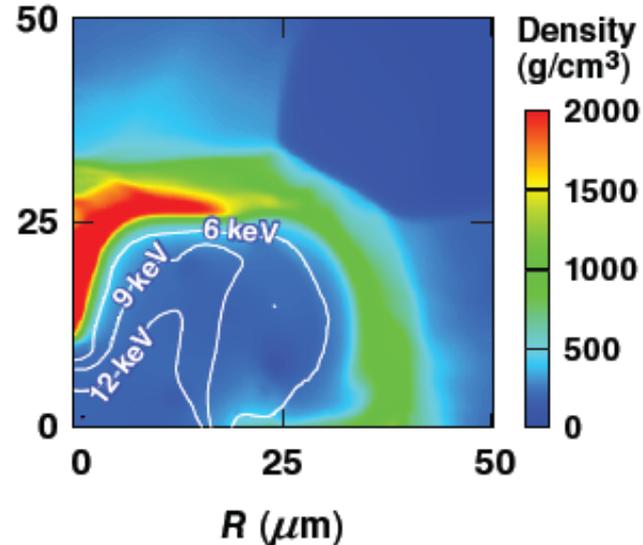
D.D. Meyerhofer for R. Betti and the FSC team:
UR, MIT, UCSD, OSU, UNR, UCLA, GA, LLNL, ILSA

Fusion Power Associates Meeting,
December 14-15, Washington DC

Advancing the science of alternative ignition concepts and basic HED science is the goal of the FSC

FSC

UR
LLE

- Implosion experiments with an embedded seed magnetic field lead to magnetization of the hot spot and higher ion temperatures

- Planar experiments are used to generate high shock pressure and test the shock ignition scheme

- Shock ignition designs for polar direct drive on NIF indicate a minimum laser energy required for ignition of about 700kJ

- New fast ignition experiments are used to infer fast electron temperature using time-resolved measurements of $K\alpha$ emission

- Electron transport experiments in warm dense matter are used to infer the fast electron divergence

FSC members are from 9 institutions across the US

→ **Participating Institutions: UR, MIT, UCSD, OSU, UNR, UCLA, GA, UT, LLNL, ILSA**

→ **FY12 funding: DOE $1.5M, NYSERDA/LLE $150K, UR $81K**

→ **Main facilities in FY10-11: OMEGA, OMEGA-EP, TITAN**

→ **18 faculty and scientists**

→ **8 post-docs**

→ **21 PhD students**

4th FSC HEDP SUMMER SCHOOL

2011 High-Energy-Density-Physics Summer School
University of California, San Diego
July 10 – 16, 2011

University of Rochester, Fusion Science Center
http://hedpschool.lle.rochester.edu

Next Summer School at OSU Summer (2013)

TOPICS:
Implosion hydrodynamics
Laser-matter interaction
Radiation transport
Inertial confinement fusion
Material properties at extreme conditions

12 LECTURERS

SPONSORS:
Fusion Science Center
ILSA-LLNL
General Atomics
IMDEC

120 applications.

88 attendees

56 Graduate Students

14 Postdocs

18 Researchers

43 Scholarships

March FSC + topical meeting on Shock Ignition

http://www.lle.rochester.edu/publications/presentations/shock_ignition11/

About 60 attendees to the SI Workshop on March 8-10, 2011 at the Laboratory for Laser Energetics

FSC topical meeting on Fast Electron Divergence at LLNL on August 5-6, 2010

UR Fusion Science Center

NIF   iLSA

FUSION SCIENCE CENTER MEETING
ON ELECTRON DIVERGENCE IN FAST IGNITION

AUGUST 5-6, 2010

LAWRENCE LIVERMORE NATIONAL LABORATORY

SUMMARY AND CONCLUSIONS

by

R. Betti

The FSC meeting on Electron Divergence concluded that there is evidence of large ~100^0 divergence (full angle) of the electron source.

FSC RESEARCH HIGHLIGHTS

Planar experiments on EP are used to infer the strength of shocks generated in the presence of a pre-formed plasma

FSC

UR
LLE
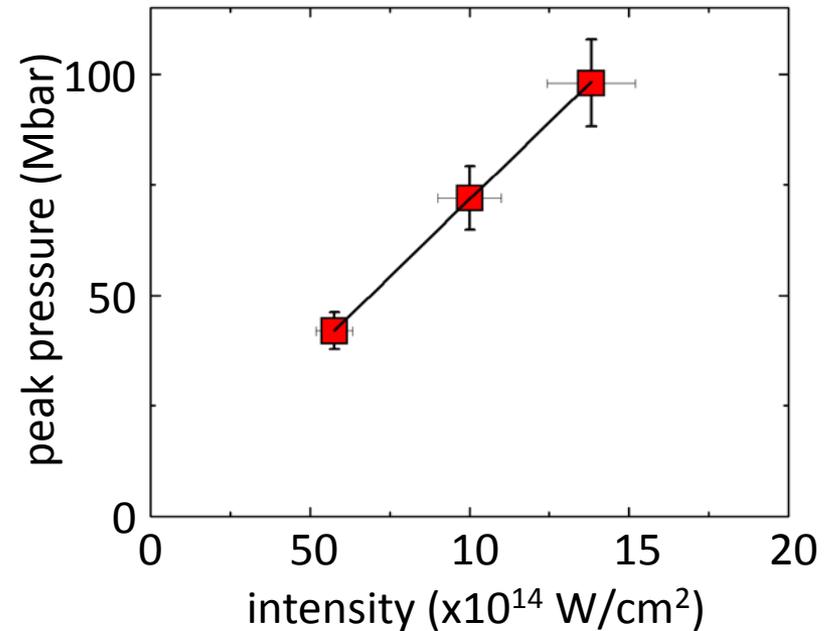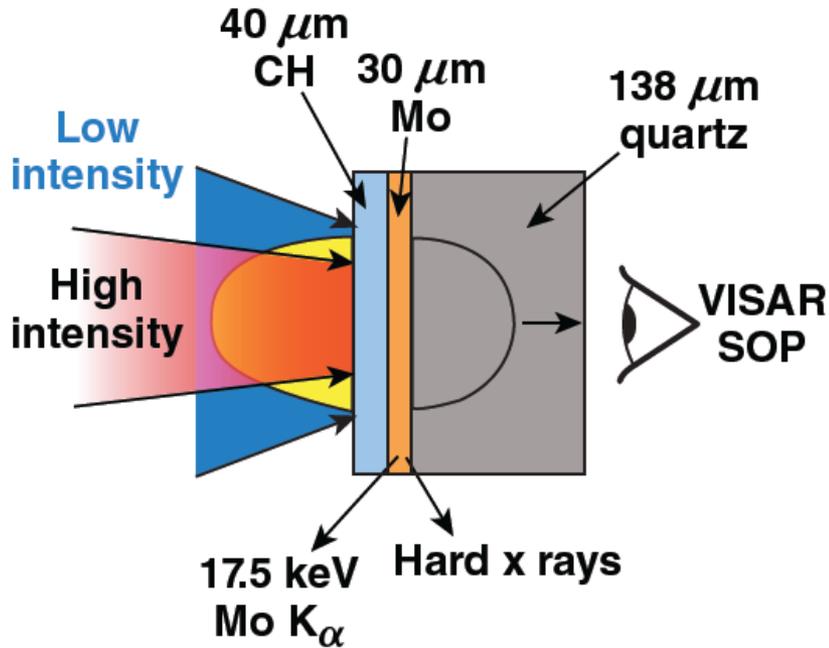
PIC simulations are carried out at shock-ignition relevant intensities and profiles to determine flux of hot electrons

FSC

UR
LLE

energy flux through rear simulation boundary
(simulation box 170 μm around ¼ n_{crit})

16.90%

10.56%

6.15%

2.28%

0.88%

0.38%

0.61%

-3.87%

0-5kev   5-25kev   25-50kev   50-100kev   100-150kev   150-200kev   200-250kev   over 250kev

$I = 2 \times 10^{15}$ W/cm^2
$T_e = 1.6$ keV
$T_i = 550$ eV
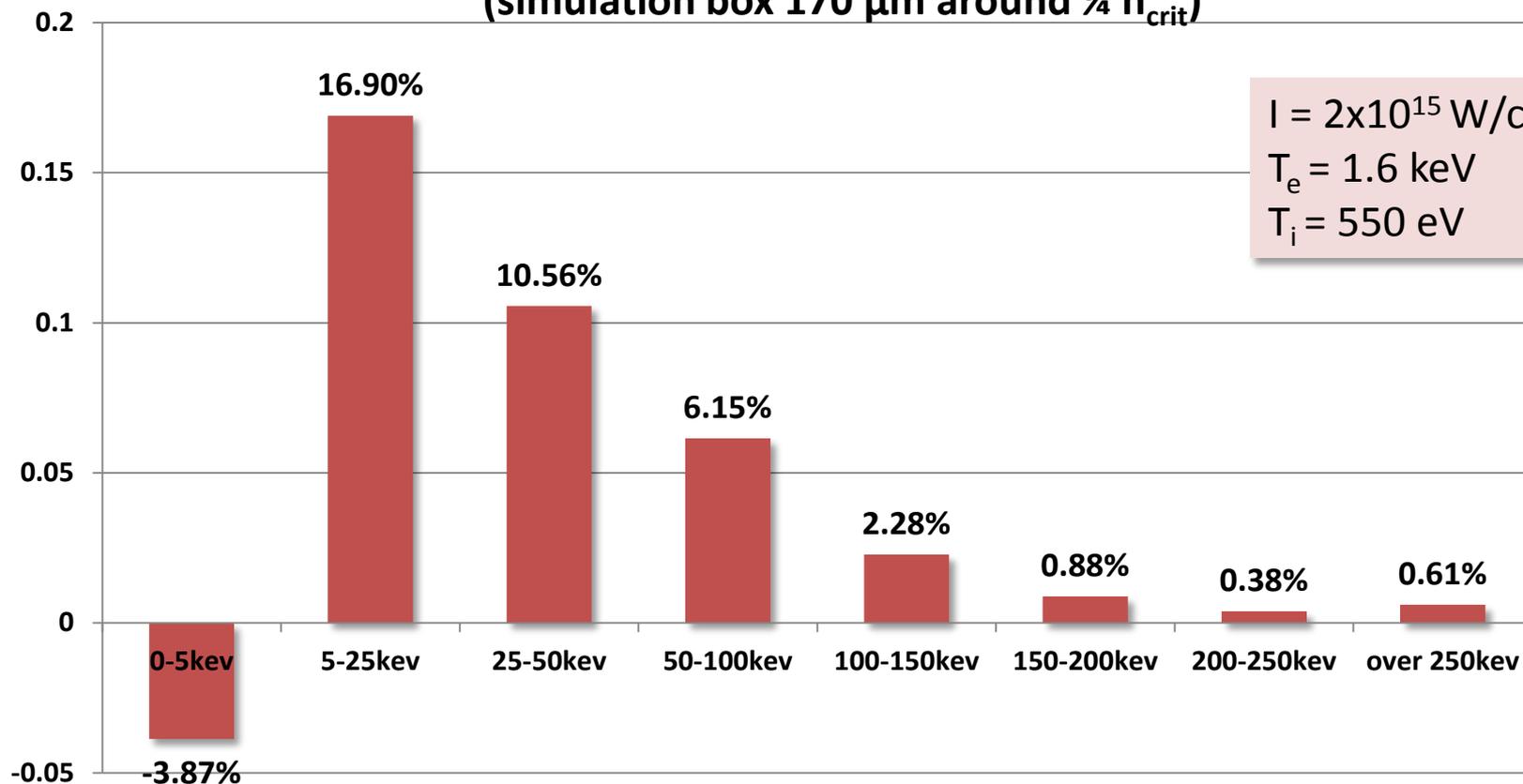
Shock ignition designs for polar drive on NIF are under development

FSC

UR
LLE

Total input energy: 620 kJ
Main drive: 490 kJ
Spike pulse: 130 kJ

1/2 of NIF quads focused at $\sim 0.4\, R_0$

1/2 of NIF quads focused at $\sim R_0$

Laser power (TW) vs Time (ns)

CH
DT ice
DT gas
31 μm
141 μm
1080 μm
908 μm
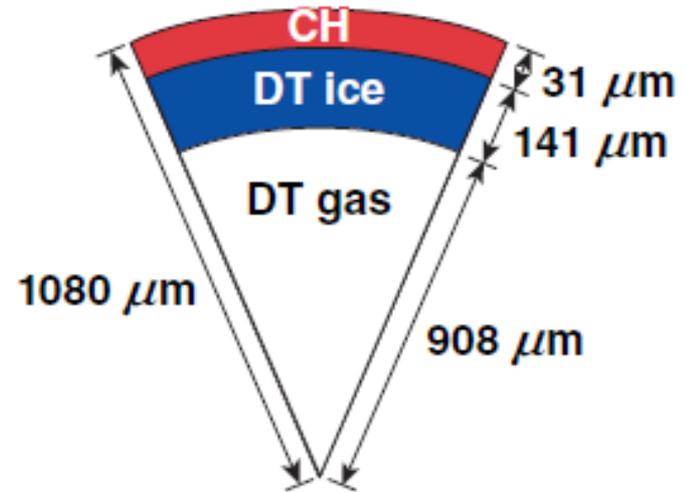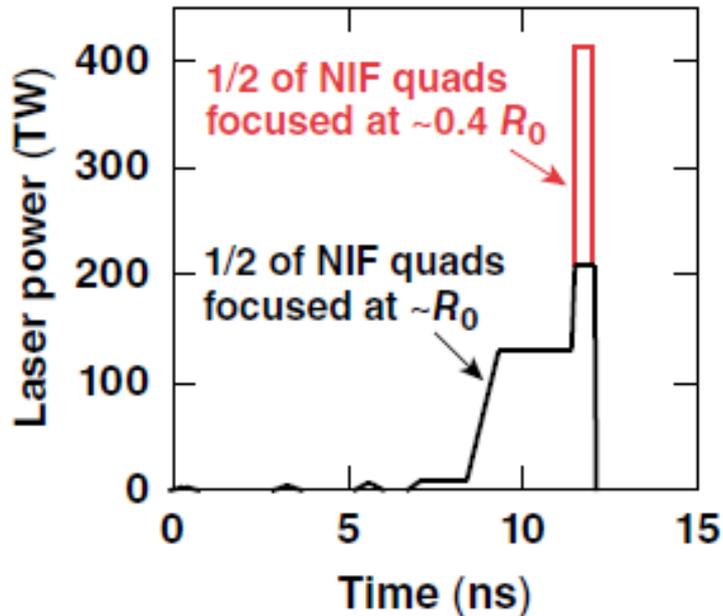
Gain (1-D)	55
ρR (g/cm^2)	1.7
V_{imp} (μm/ns)	305
IFAR$_{2/3}$	29
Adiabat	1.0

TC9719

ITF$_{1-D}$ = 5.5

Shock ignition

2D simulations for polar direct shock ignition show indicate ignition and gain with ~700kJ of laser energy

FSC

UR
LLE

PD simulation
(730-kJ laser energy)
Gain = 50
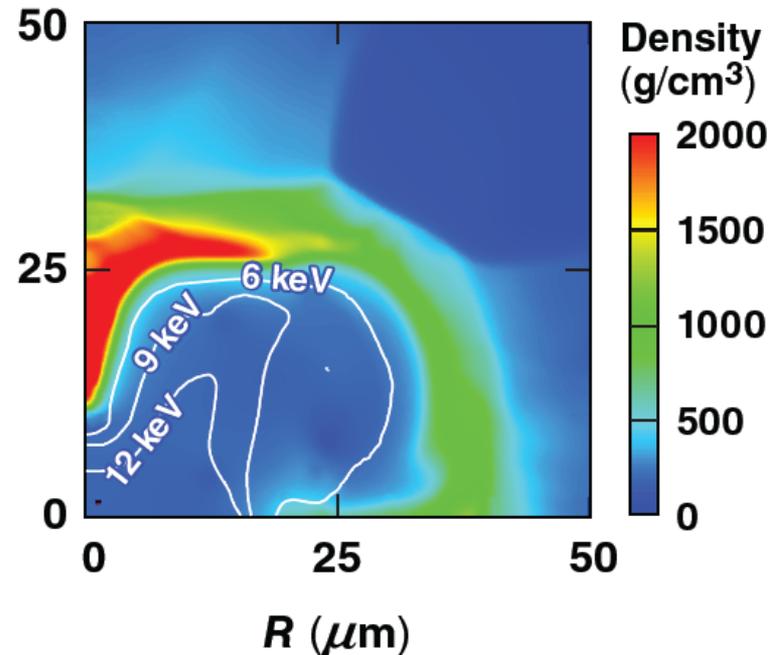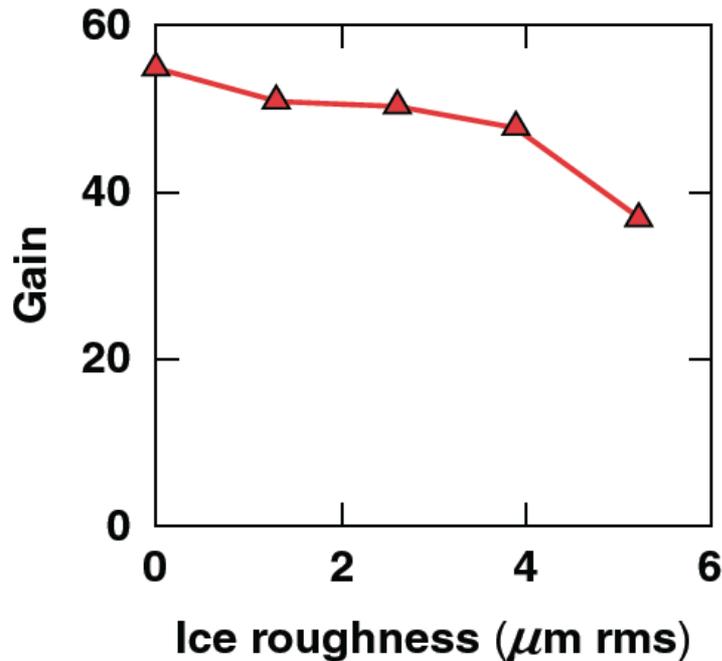
Electron transport experiments in warm dense matter show large K$_\alpha$ spot size ($\rightarrow$ large divergence)

FSC

UR
LLE
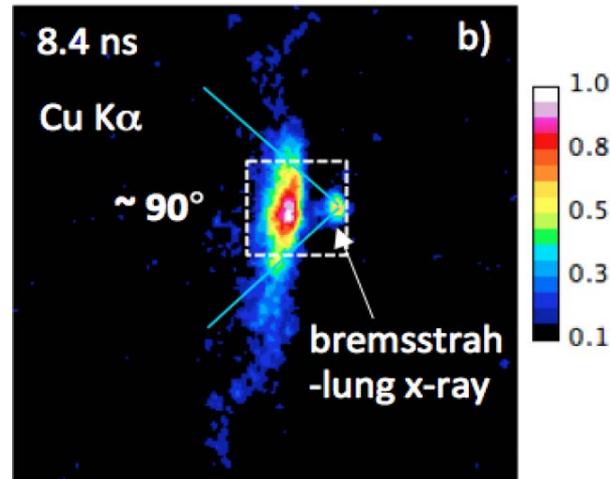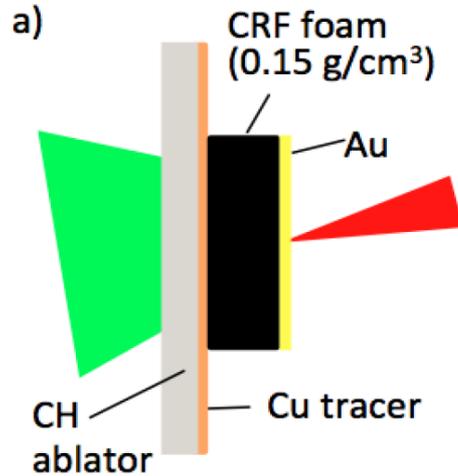
Experiments supported by PICLS simulations
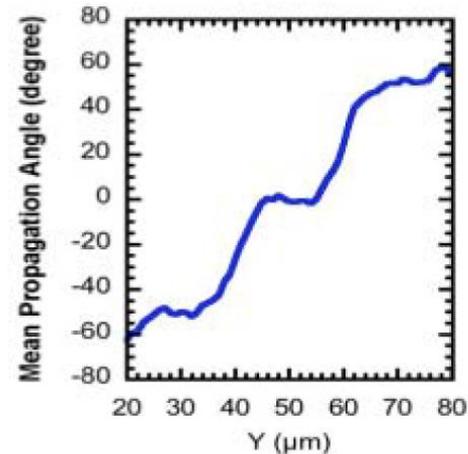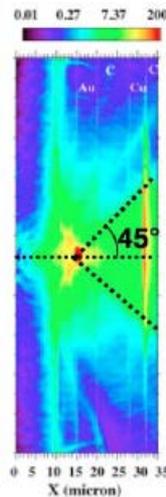
The 2D hydrodynamic code DRACO is improved to reliable simulate cone-in-shell target implosion experiments on OMEGA

FSC

UR LLE

Implosion

2D DRACO

Core heating

Mass density (g/cm³)

rho
20.00
1.68
0.14
0.01
0.00

Mass density (g/cm³)

$\theta_{1/2}=25°$, $\eta_L=0.25$

$\theta_{1/2}=25°$, $\eta_L=0.15$

$\theta_{1/2}=50°$, $\eta_L=0.25$
$\theta_{1/2}=50°$, $\eta_L=0.15$
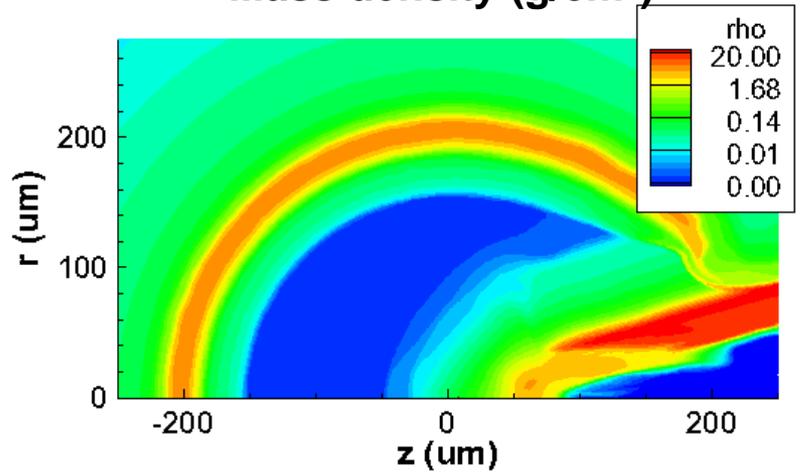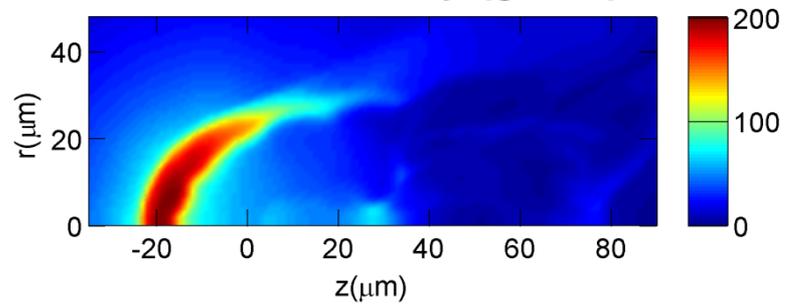
Fast-electron density (×10²¹ cm⁻³)
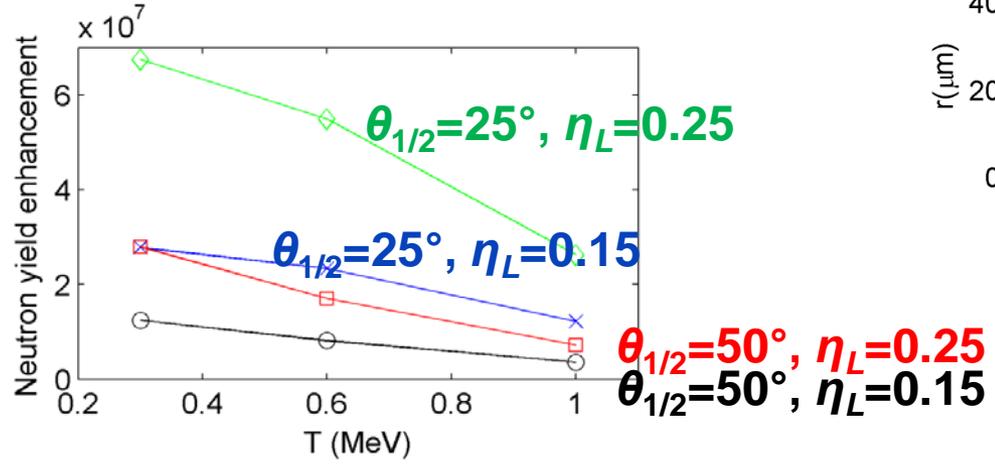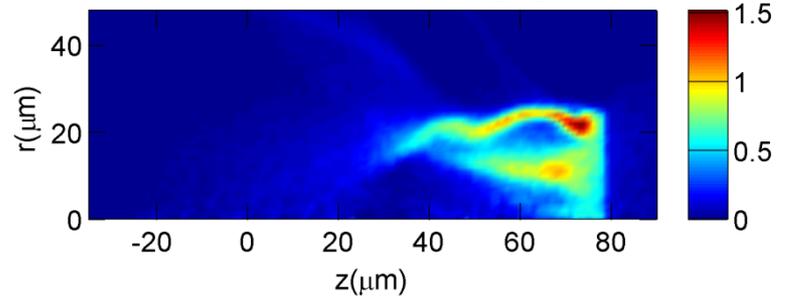
Fast electron temperature is inferred through time-resolved Kα measurements on MTW

FSC

UR LLE
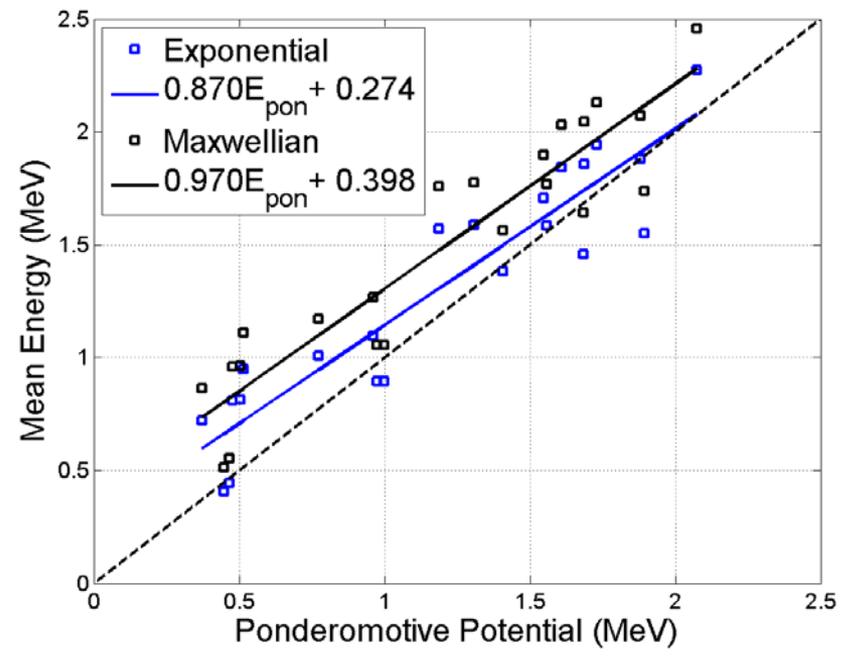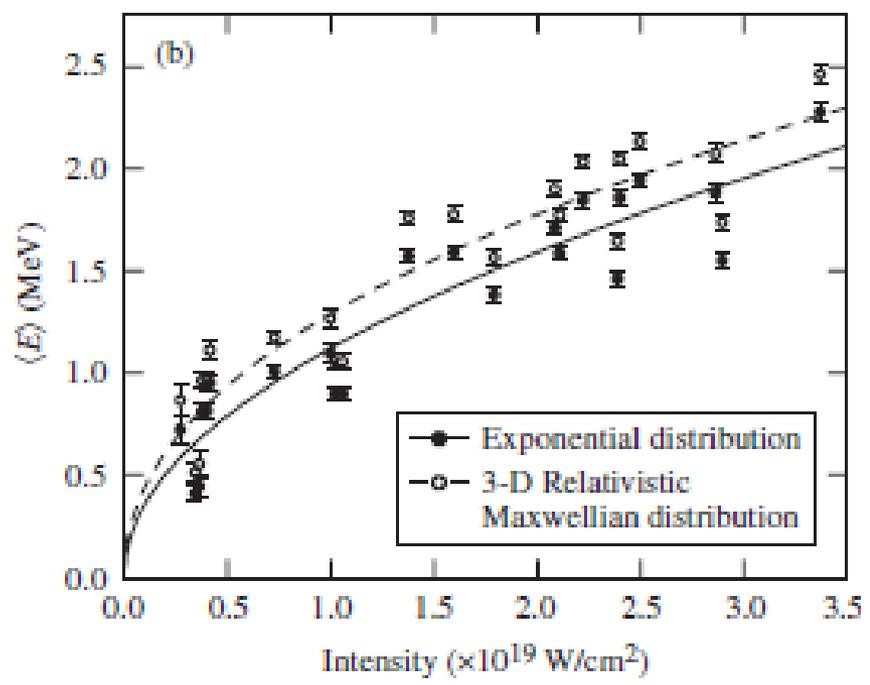
Mean fast electron energy scales like I$^{1/2}$

P. Nilson, J. Davies et al , submitted to Phys Rev. Lett (2011)

First FI integrated experiments are carried out using cone-in-(Cu-doped) CD shell targets

FSC

UR
LLE

Comparison of 8 keV x-ray emission in joint and OMEGA only shots

Joint shot, EP 269J/9ps

Cone-in-CD shell (w/ Cu)

OMEGA only
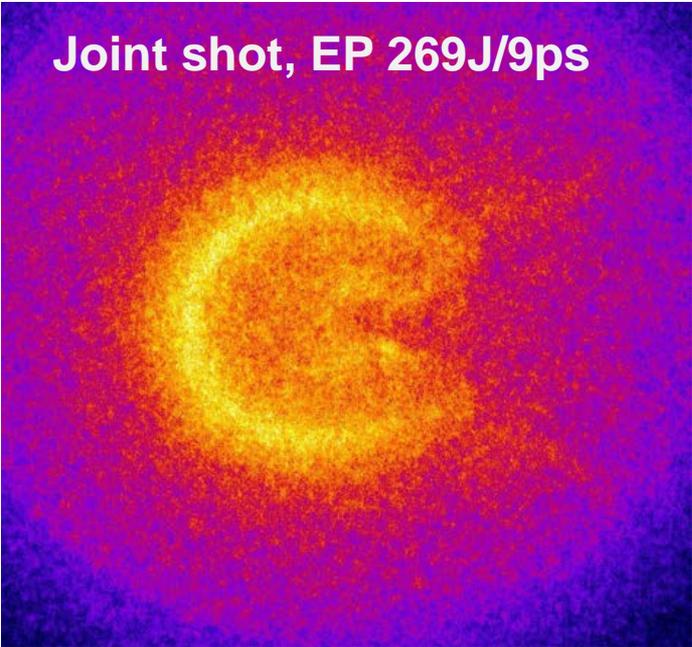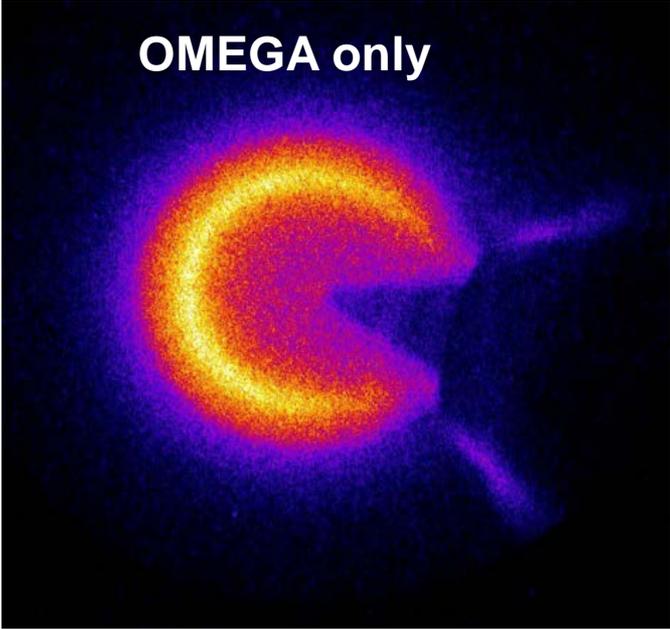
Cone-in-CD shell (w/ Cu)

Experiments with seeded magnetic fields demonstrate magnetization of the hot spot in imploding shells
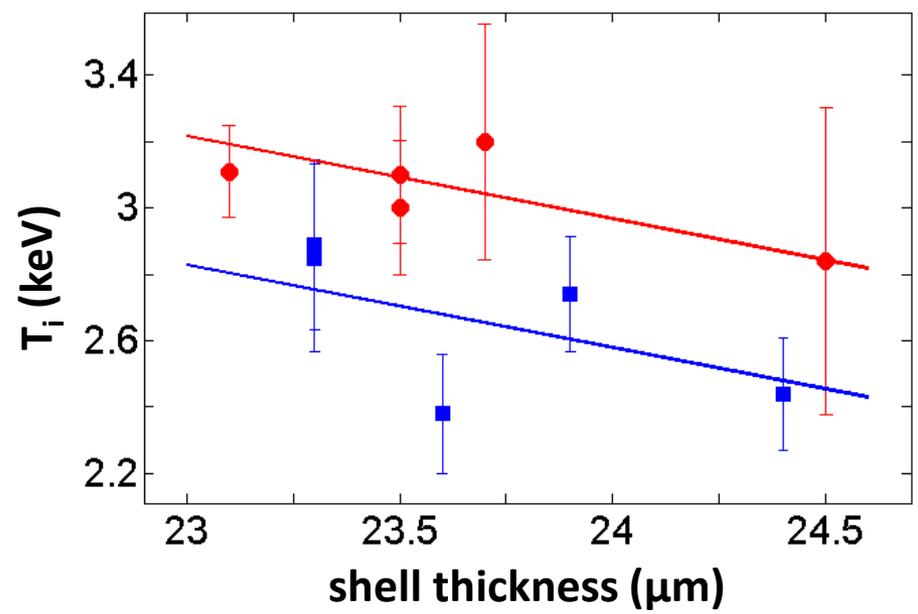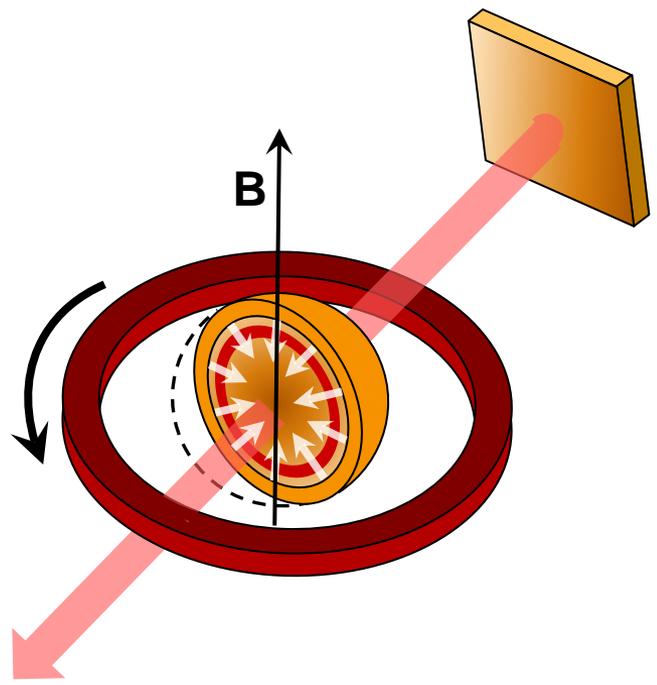
Chang, Hohenberger, Fiksel, Knauer, Betti, Meyerhofer, Seguin, Petrasso, Phys. Rev. Lett. (2011)

A compressed magnetic field of ~26MG is inferred from proton radiography of implosions with an 50kG seed field

. C9785a

Advancing the science of alternative ignition concepts and basic HED science is the goal of the FSC

FSC   UR
                                                                          LLE

- Implosion experiments with an embedded seed magnetic field lead to magnetization of the hot spot and higher ion temperatures

- Planar experiments are used to generate high shock pressure and test the shock ignition scheme

- Shock ignition designs for polar direct drive on NIF indicate a minimum laser energy required for ignition of about 700kJ

- New fast ignition experiments are used to infer fast electron temperature using time-resolved measurements of $K\alpha$ emission

- Electron transport experiments in warm dense matter are used to infer the fast electron divergence