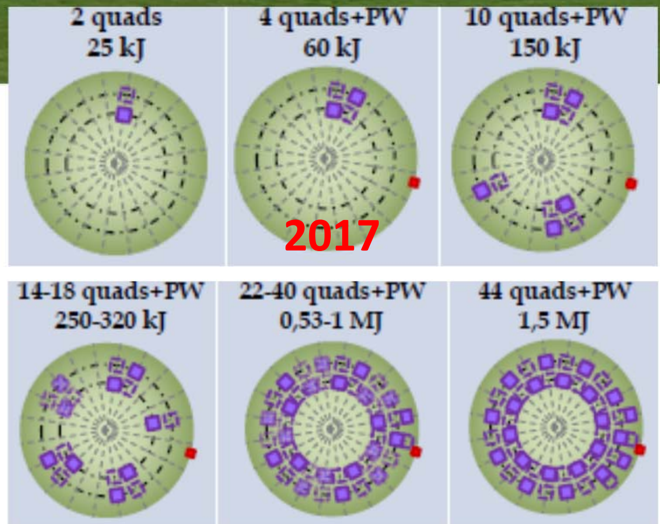
IFE Summary

S. Jacquemot

2 overviews, 6 orals + 19 posters

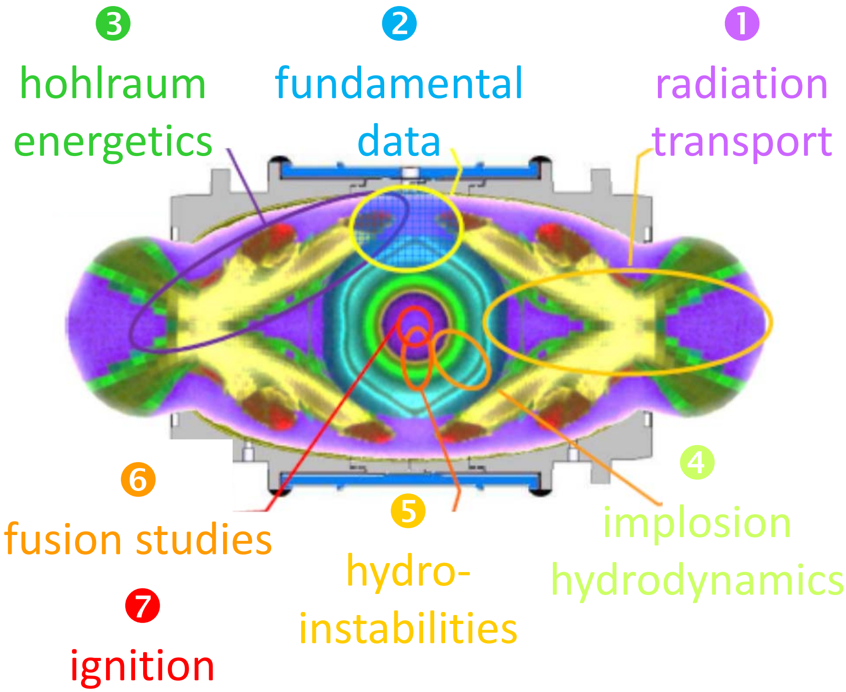
LMJ ramps up power gradually, allowing a robust roadmap towards ignition

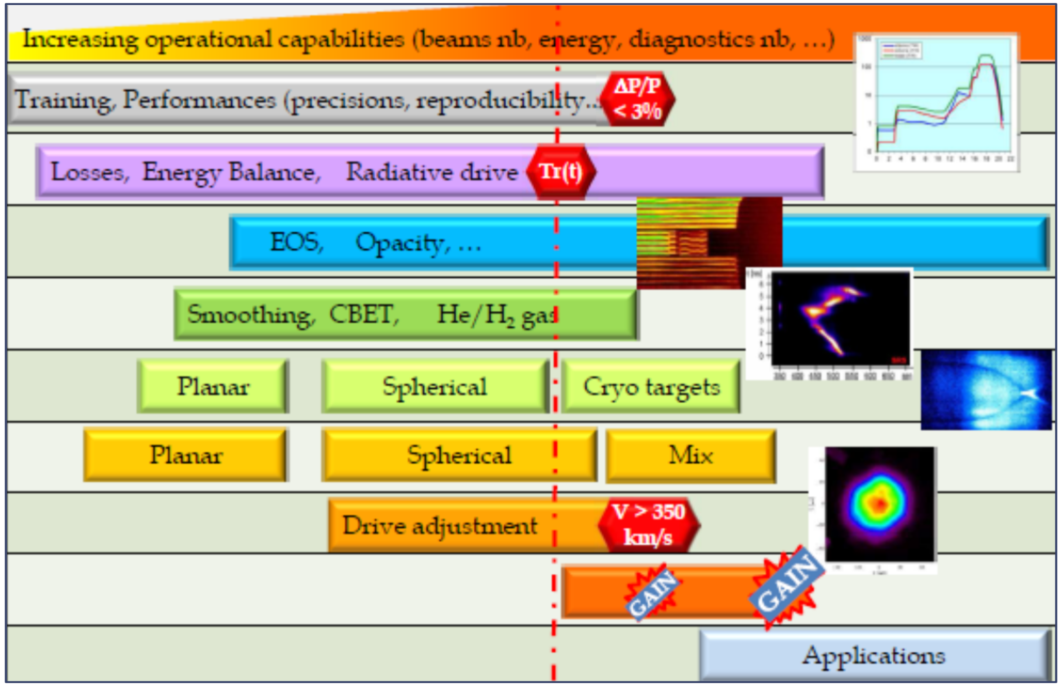
4 diags



26+ diags

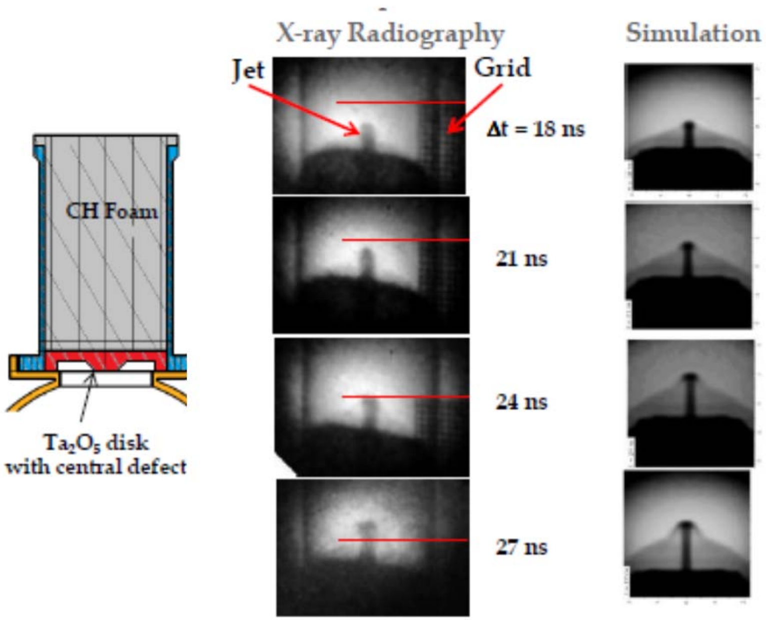
LMJ ramps up power gradually, allowing a robust roadmap towards ignition

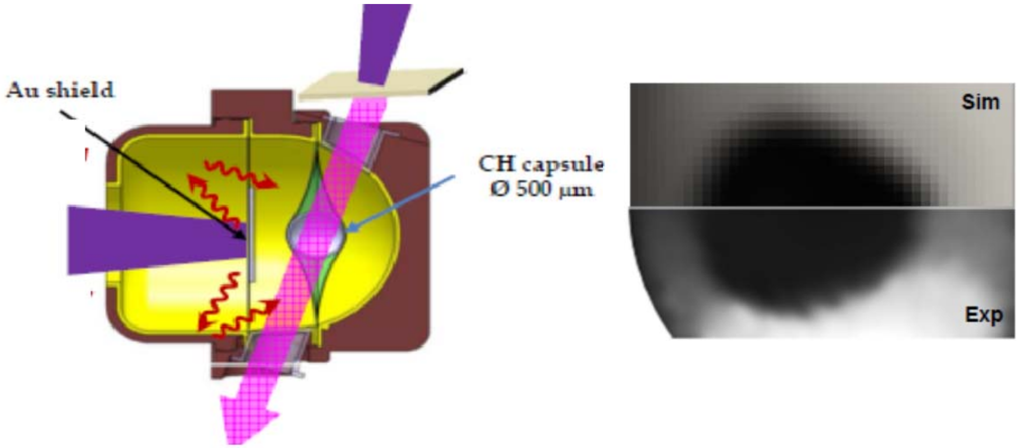




LMJ first experiments already provide valuable information to benchmark ignition codes

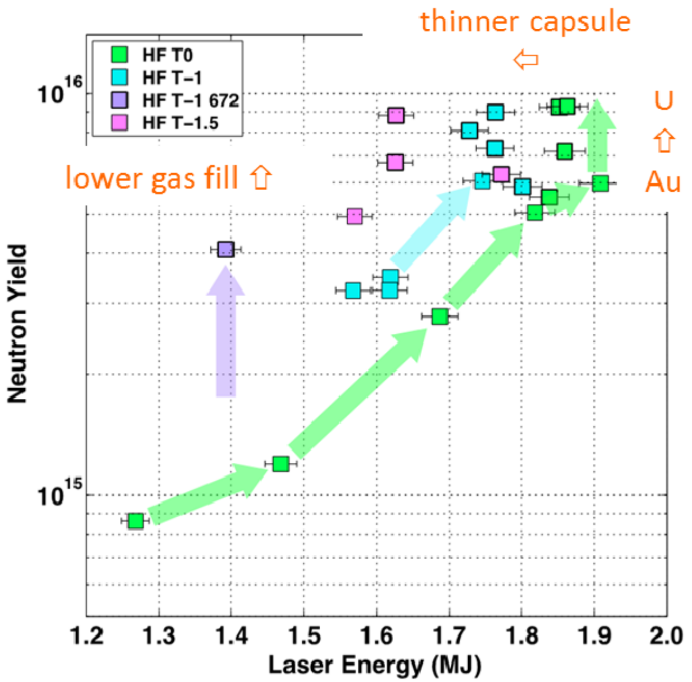
e.g. plasma jet formation due to target defect or implosion non-sphericity due to asymmetric drive





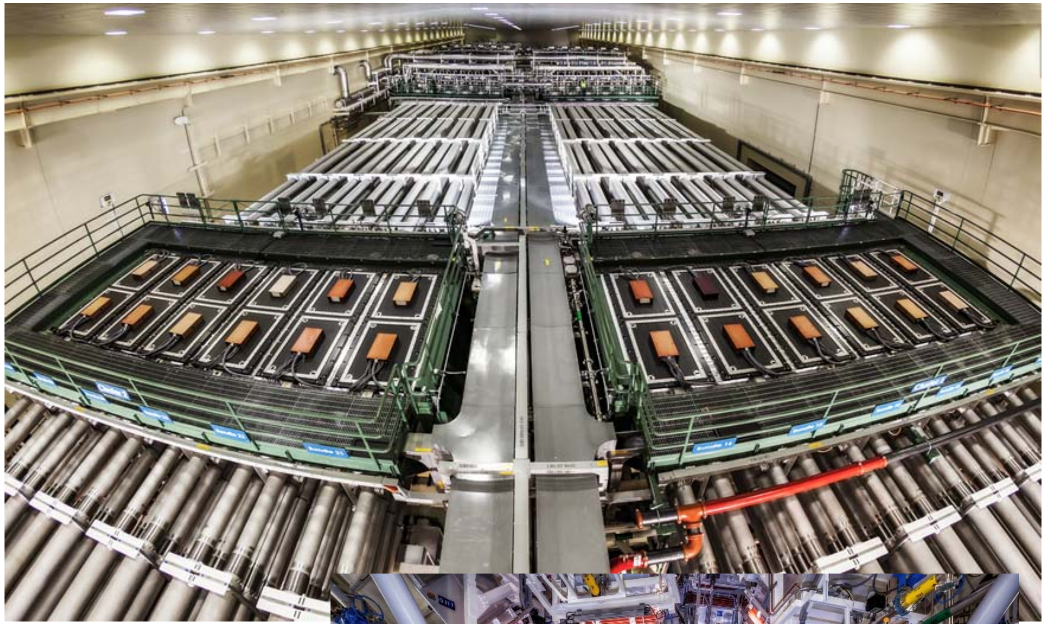
NIF is the premier facility for full-scale ignition & burning plasma physics

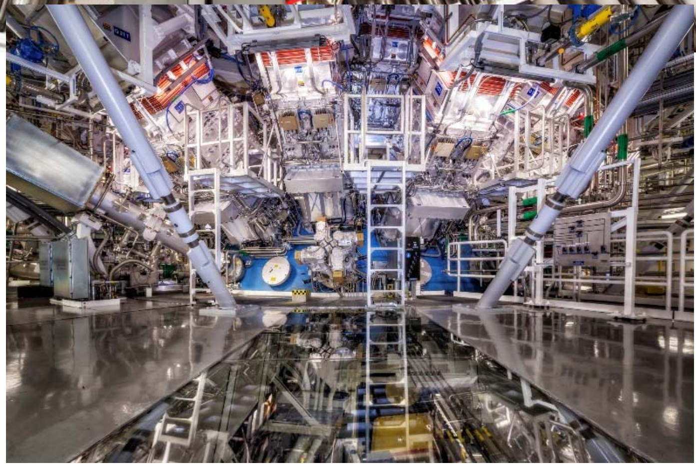
a coherent program since 2009



high-foot implosions

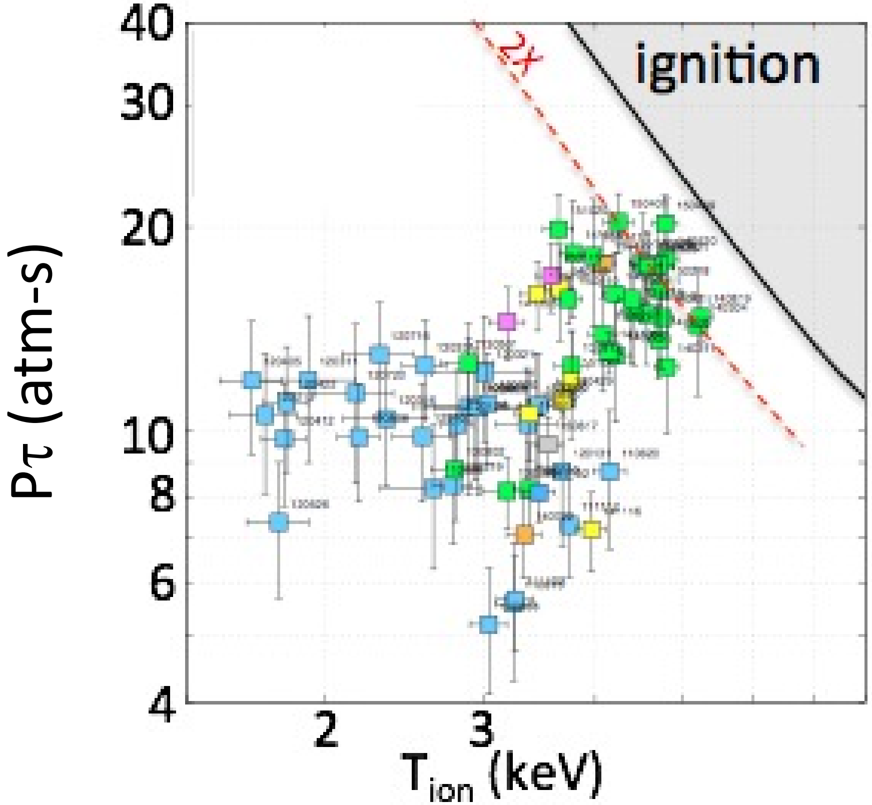
O. Hurricane J. Phys. Conf. Ser. 717, 012005 (2016)



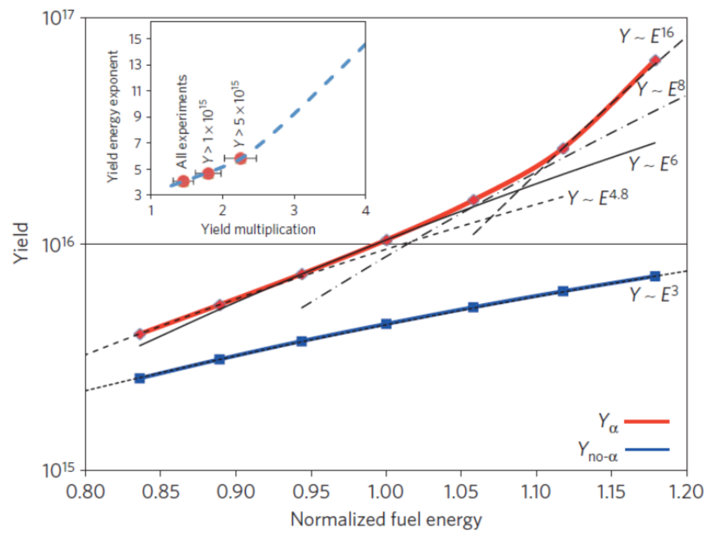


improving hohlraum & capsule design till …

alpha heating was evidenced



from scaling of fusion yield
with fuel energy

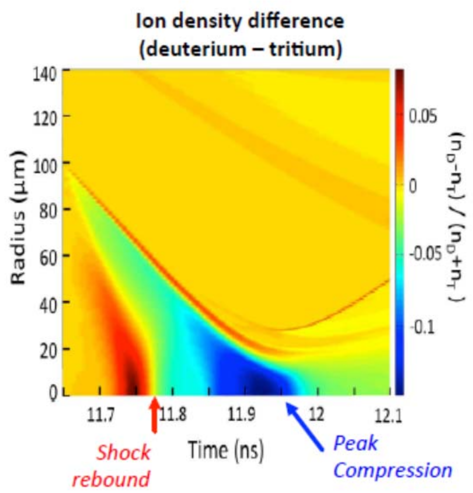


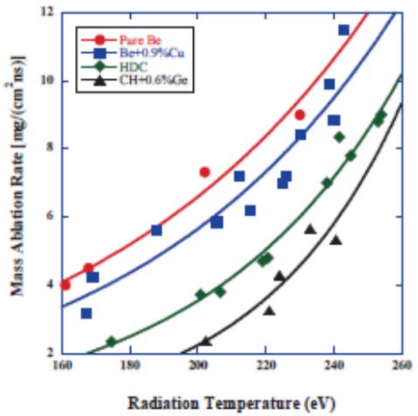
O. Hurricane *et al.*
Nature Phys. 12, 800 (2016)

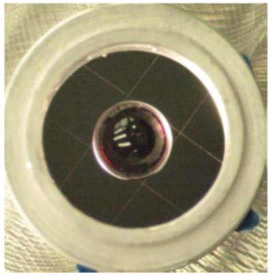
but record yield still below 30kJ
($G_{IR>n}$~0.007)

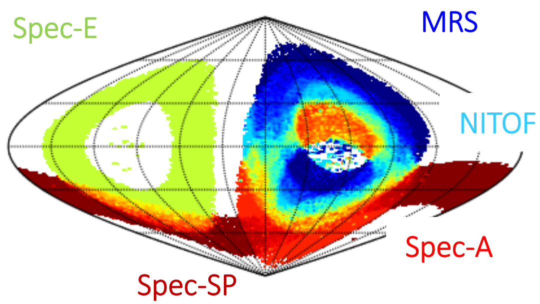
major factors limiting performances are identified

- LPI-driven time-dependent drive asymmetry ↳ new target designs (e.g. capsule shims or alternative ablators) & diagnostic development (e.g. neutron imaging, PW-driven radiography, core dopant x-ray spectroscopy)
- engineering issues (e.g. tent) ↳ innovative mountings under study
- understanding of implosion physics (e.g. kinetics effects) ↳ dedicated studies at reduced scale



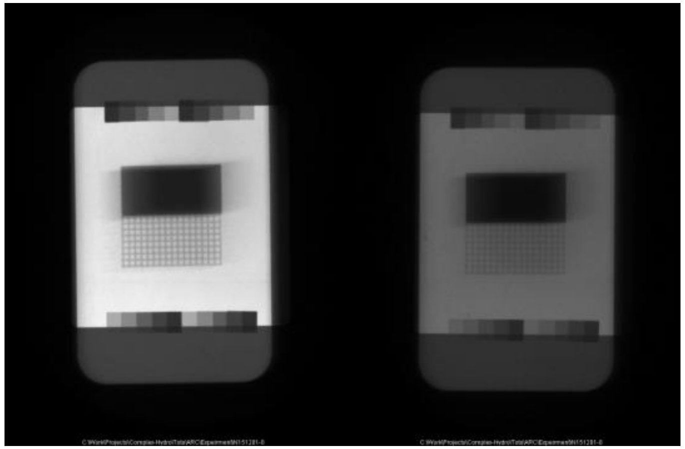






J. Edwards OV/3-2
J. Frenje IFE/1-3
H. Rinderknecht IFE/1-5
A. Simakov P5-7
K. Hill P5-6

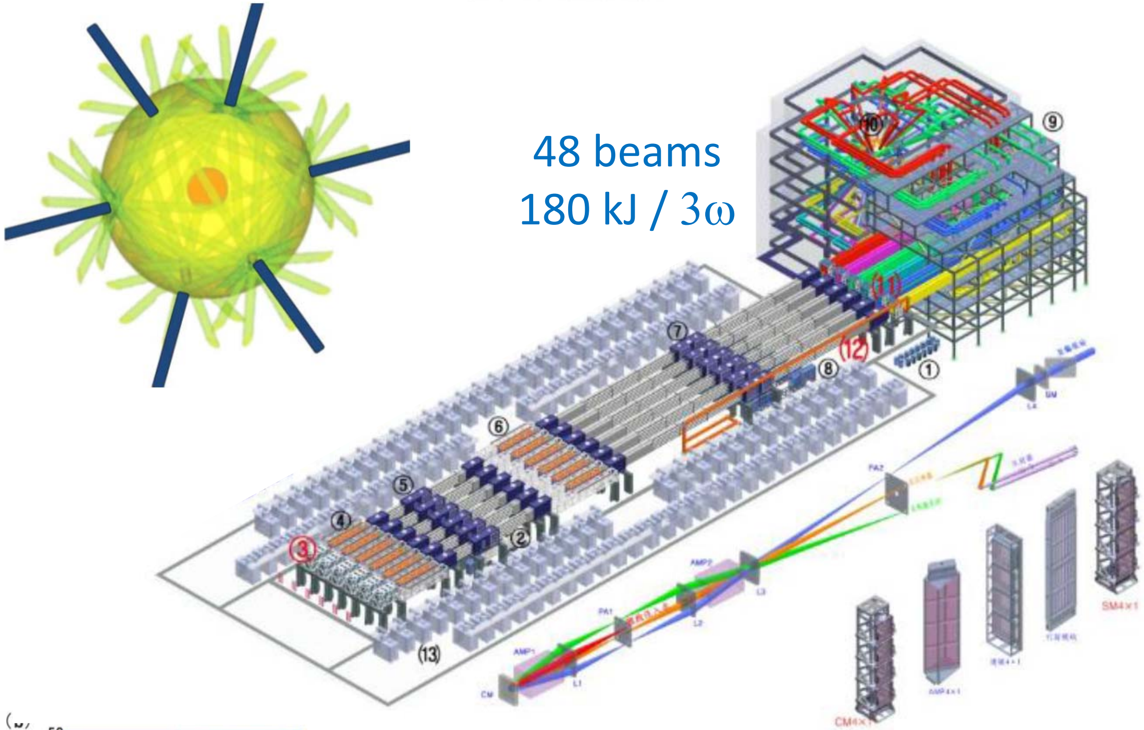
implementing PW beams on MJ facilities allow improved IFE diagnostics & HED science



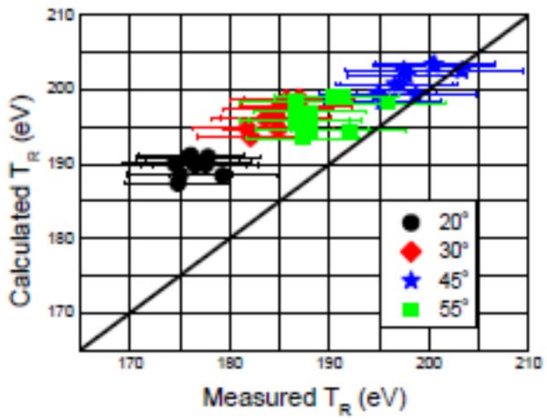
energetic and brief sources of x-rays and protons for multi-axis time-resolved implosion radiography

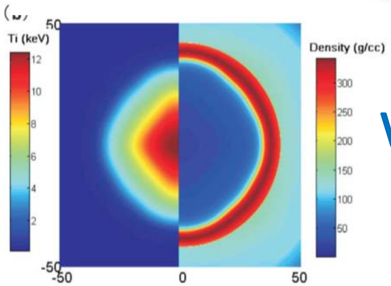
J.-L. Miquel IFE/1-1
NNSA blog

SG-III is coming online soon…



48 beams
180 kJ / 3ω



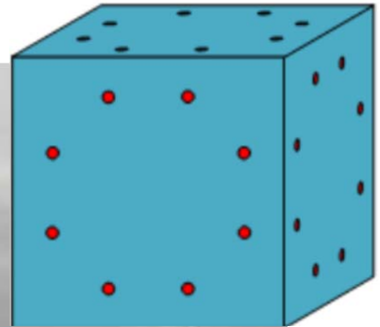


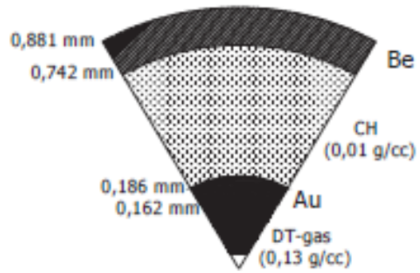
with an approach combining
direct & indirect drive

H. Li PDP-20
J. Liu P5-8
(not shown)

IAPCM

… as well as the Russian MJ facility (UFL-2M)



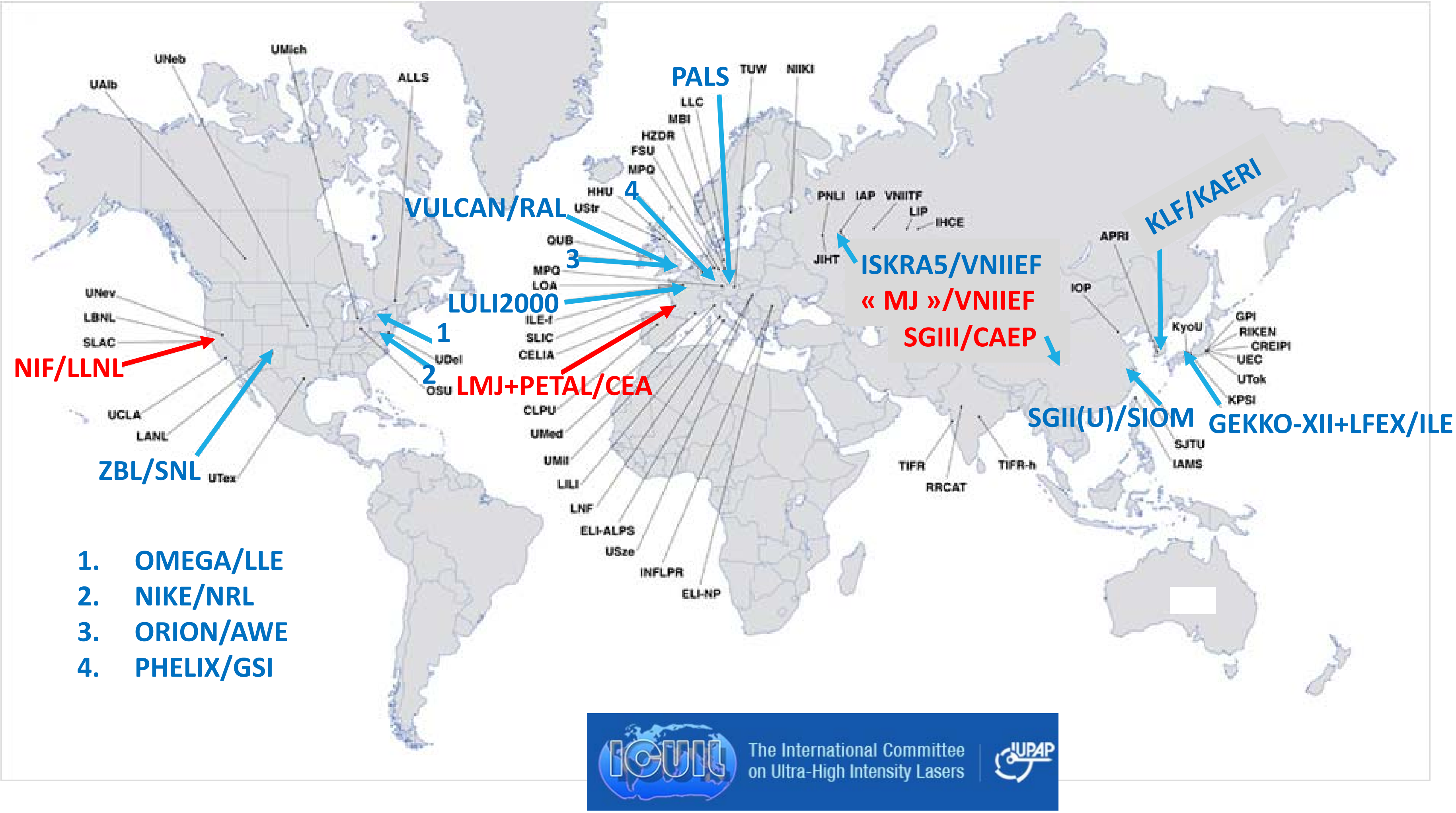


direct drive or indirect drive

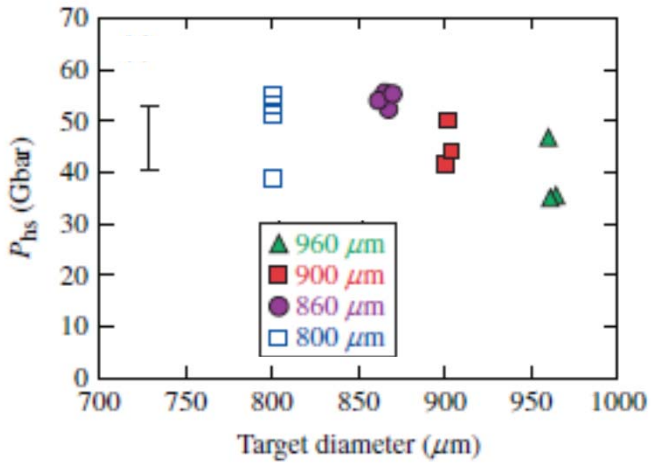
V.A. Lykov
S.A. Belkov
ECLIM2016

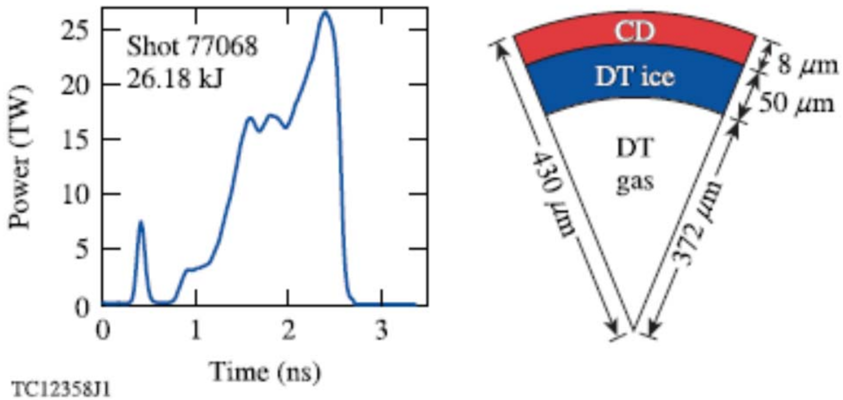
РФЯЦ ВНИИЭФ
РФЯЦ–ВНИИТФ

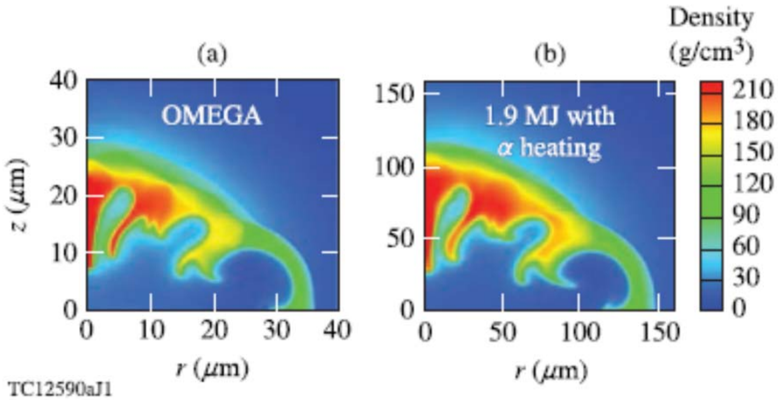
direct drive is investigated on a large variety of intermediate-scale ns+ps facilities



hot spot pressure > 50 Gbars was demonstrated for direct drive DT implosions on OMEGA





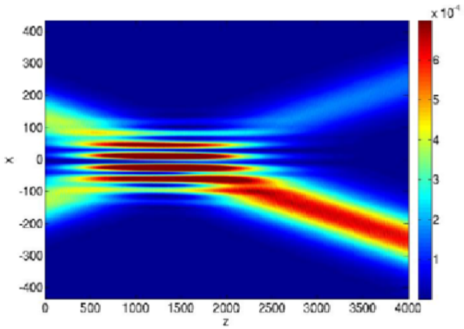


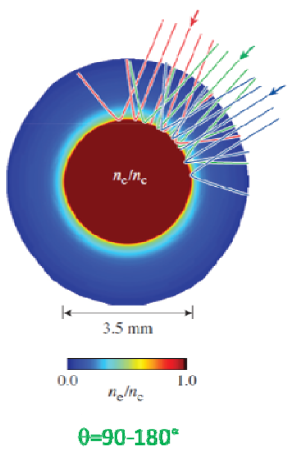
achieving core conditions (pressure, temperature and density) that lead to significant alpha heating if hydrodynamically scaled to NIF energies (from 26 kJ to 1.9 MJ)

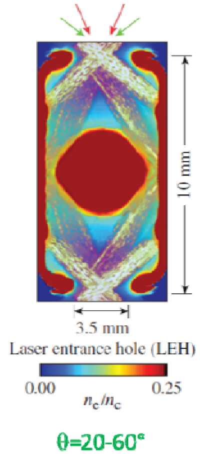
A. Bose *et al*. Phys. Rev. E 94, 011201(R) (2016)

understanding of laser-plasma interaction (e.g. CBET) is improving

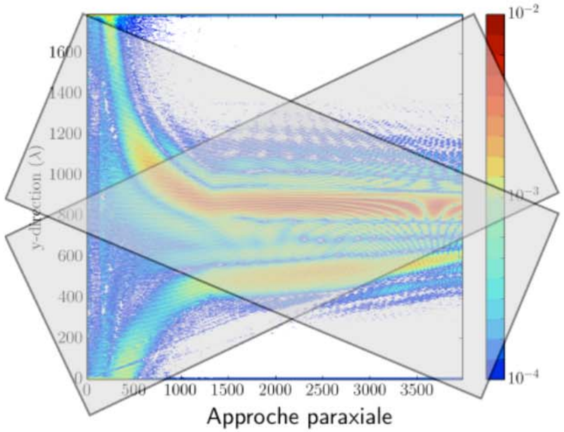
nD multiscale (hydro/PIC) capabilities developed to predict energy transfer due to interferences between 2 (or more) laser beams crossing in a plasma



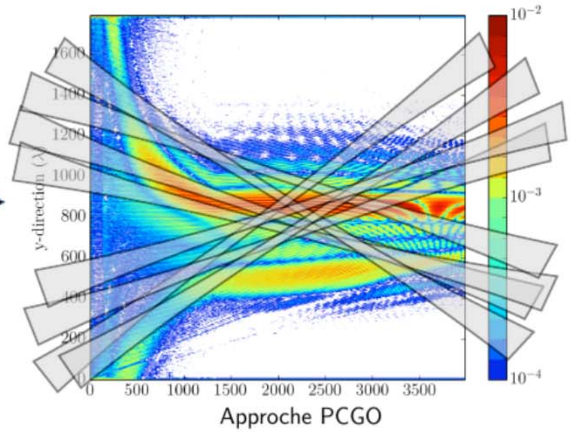


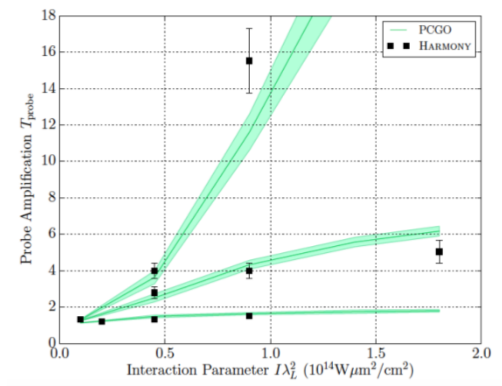


thick-ray PGCO approach validated against 2D PIC simulations & implemented in 2D CHIC hydrocode for fast computations

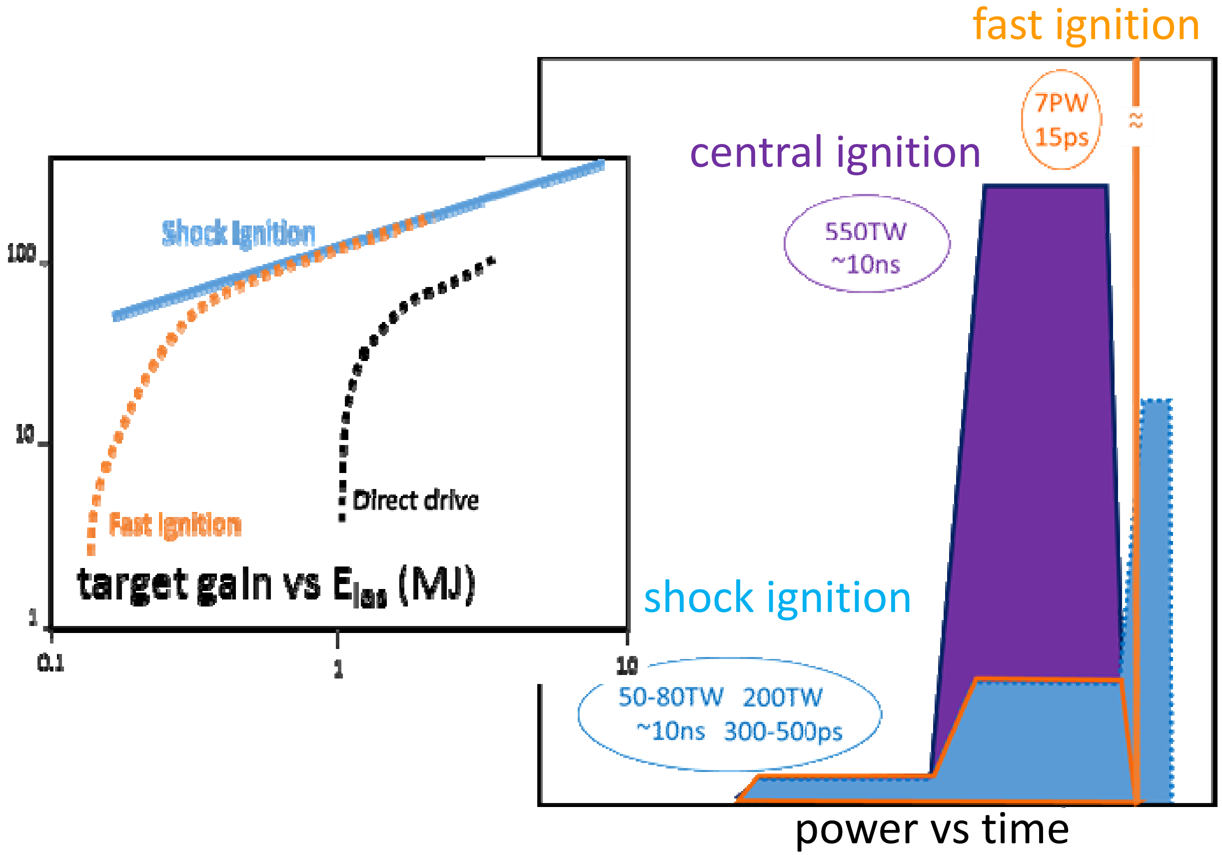


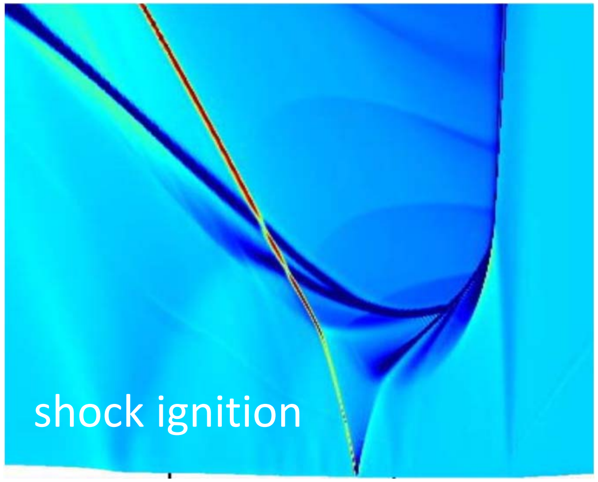
⇒





IFE requires high gain, favoring alternative ignition schemes

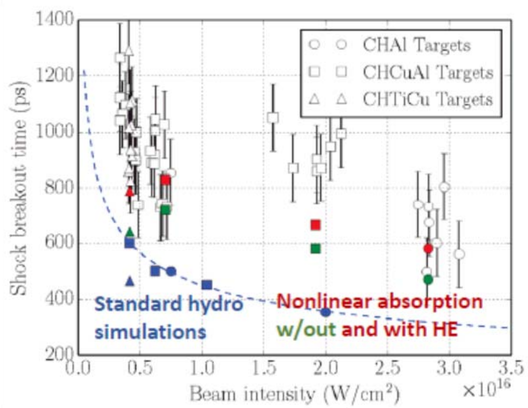


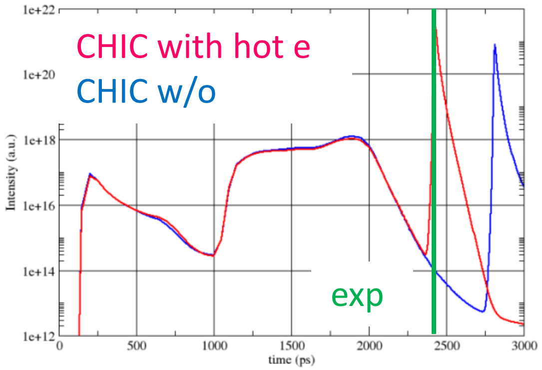


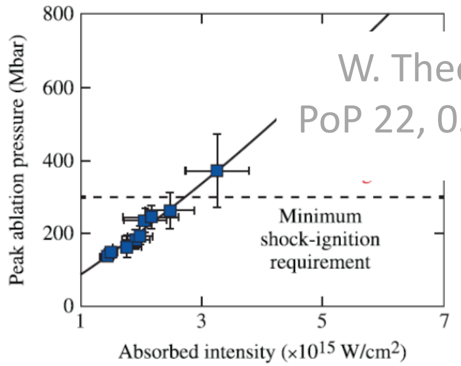
shock ignition studies highlight importance of hot electrons in implosion

PGCO approach ⇨ non-linear laser-plasma interaction, hot electron generation (due to parametric instabilities) & transport

experimental validation on PALS (planar geometry) & OMEGA (spherical geometry)







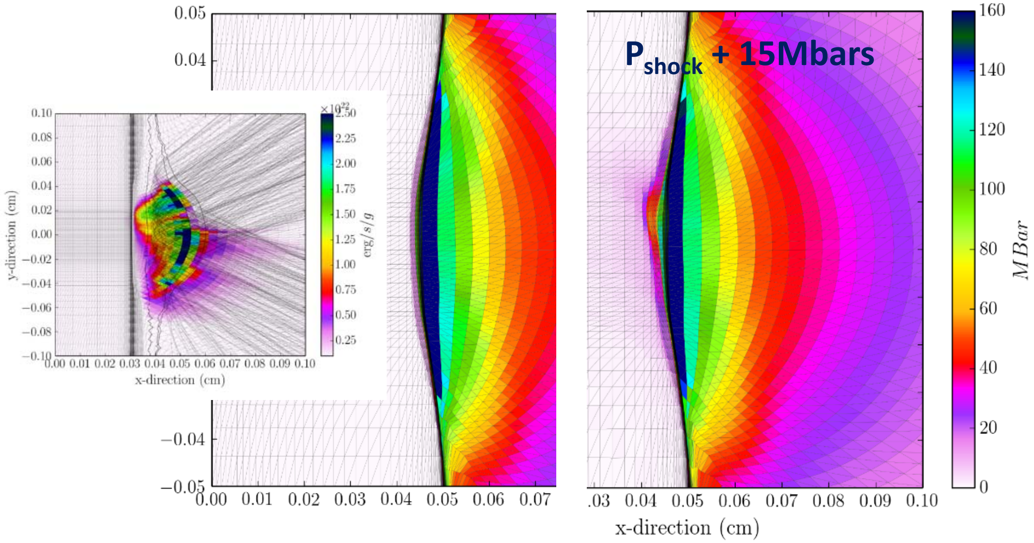
W. Theobald *et al.* PoP 22, 056310 (2015)

OMEGA ablation pressures above min. required

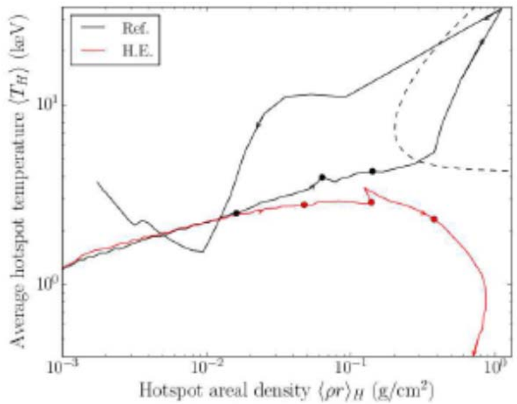
shock ignition studies highlight importance of hot electrons in implosion

PGCO approach ⇨ non-linear laser-plasma interaction, hot electron generation (due to parametric instabilities) & transport

hot electrons increase shock pressure & velocity but decrease temperature ⮌ internal ablation

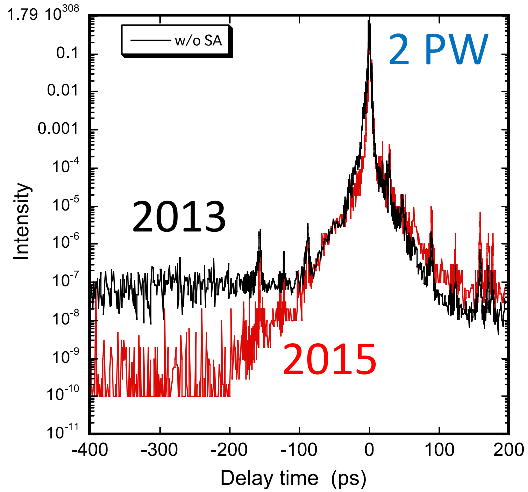


2D CHIC w/o (SSD) & with hot e (no smoothing)

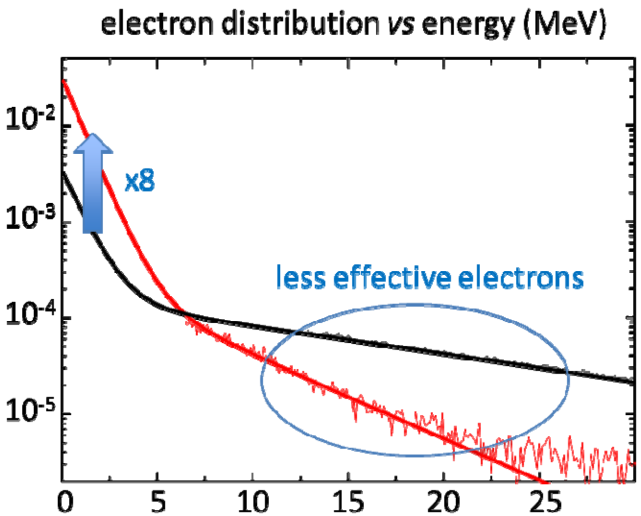


further validation on LMJ scheduled

improved laser performances drive increased heating efficiency for e-fast ignition



LFEX contrast down to 10^{-10}

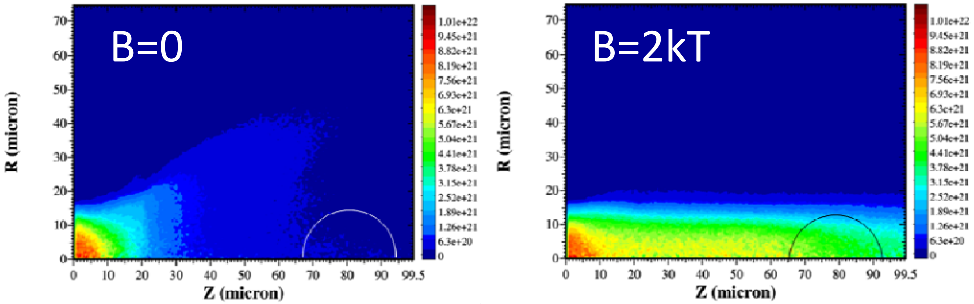


cooler electron distribution

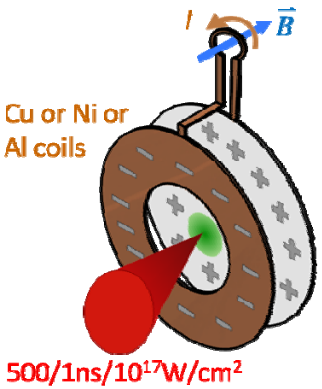
ηx5 on LFEX

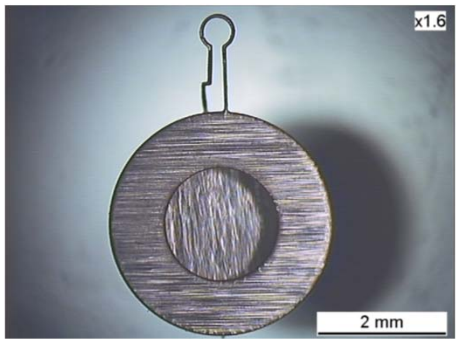
A. Yogo IFE/1-4
R. Khaydarov P5-2
H. Azechi OV/4-2
J. Kanawaka IFE/1-6
A. Morace P5-13
Y. Arikawa P5-11

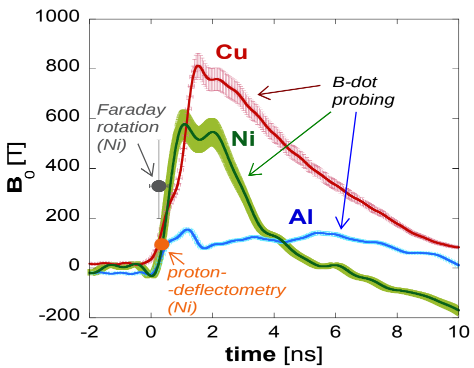
lasers & B-fields on the route to ignition on laser facilities …



collimation by external kT B fields of diverging relativisitic e beams





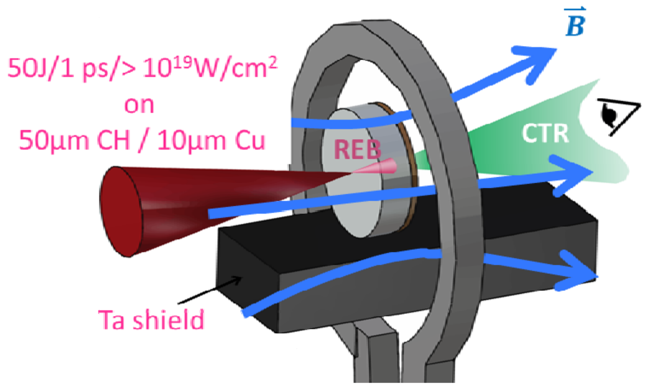


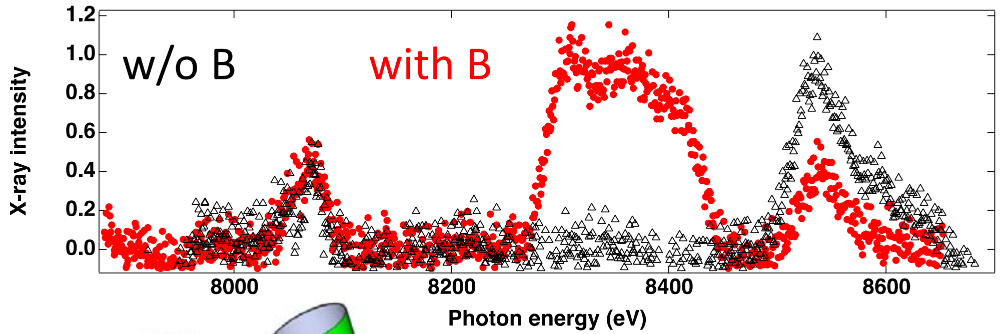
kT, ns, mm^3 B fields can be produced by capacitor-coil targets

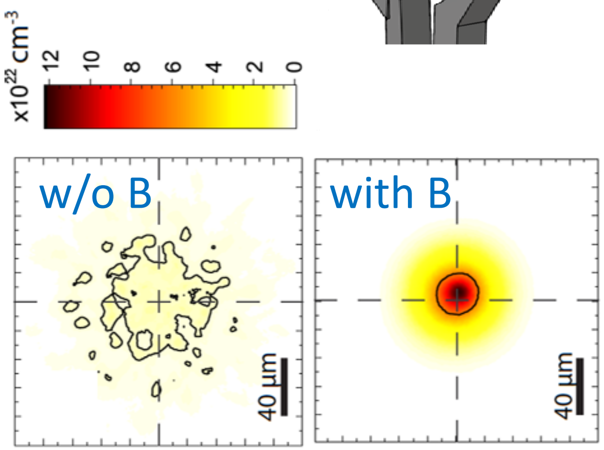
Y. Mori P5-9
H. Azechi OV/4-2
S. Fujioka IFE/1-2
S. Jacquemot PDP-12

lasers & B-fields on the route to ignition on laser facilities ...

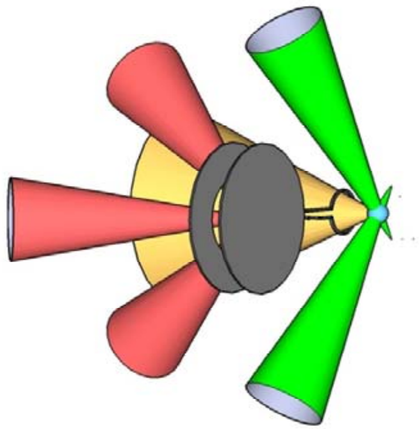
collimation demonstrated on LULI2000 (planar geometry) and LFEX (spherical geometry)







energy density x5

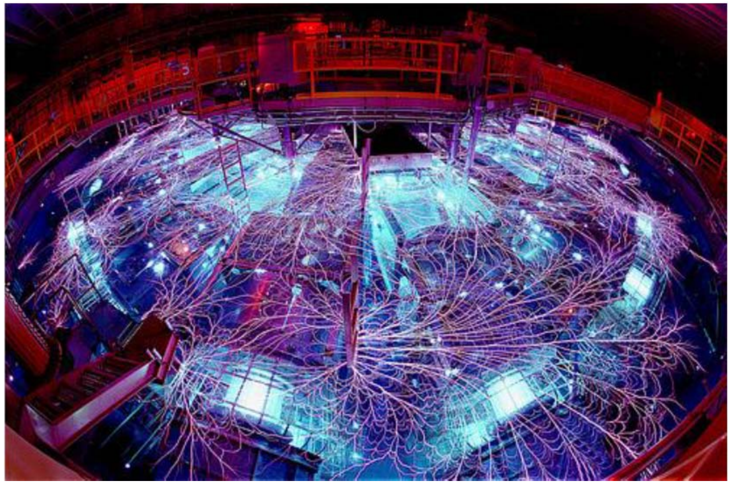


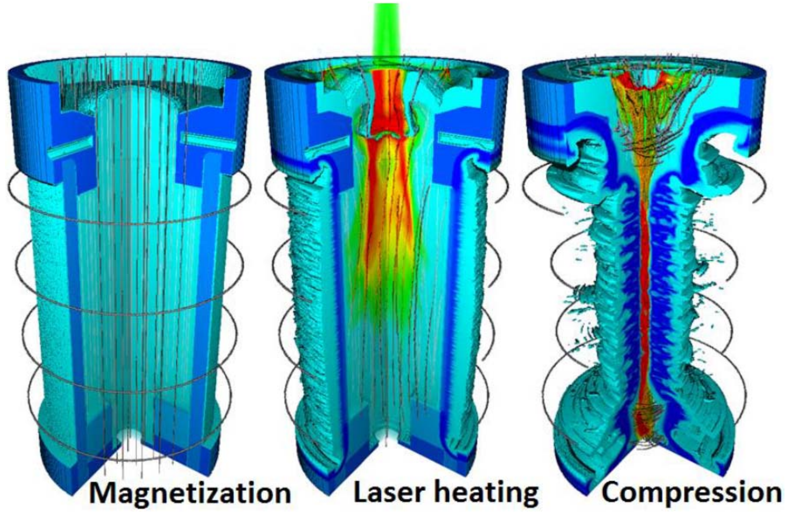
2.7 g/cm^2– 3 keV obtained in a Cu-doped bead

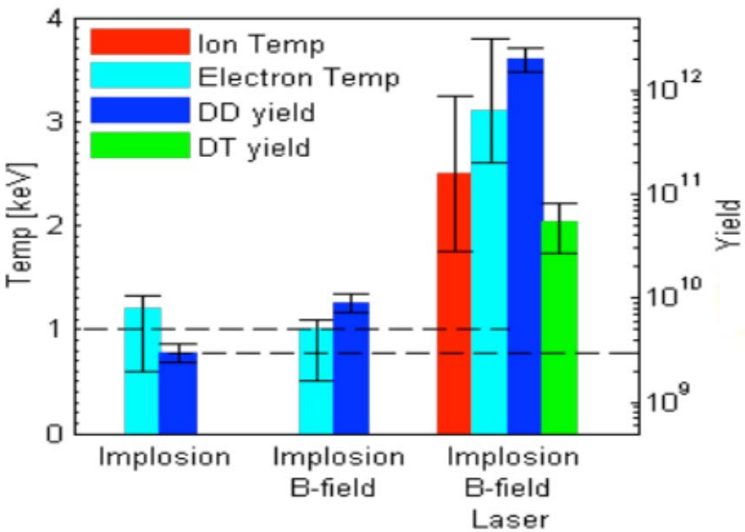
H. Azechi OV/4-21-
S. Fujioka IFE/1-2
H. Nagatomo P5-12
S. Jacquemot PDP-12

CELIA

… and on Z-pinches: Magnetized Liner Inertial Fusion (MagLIF)





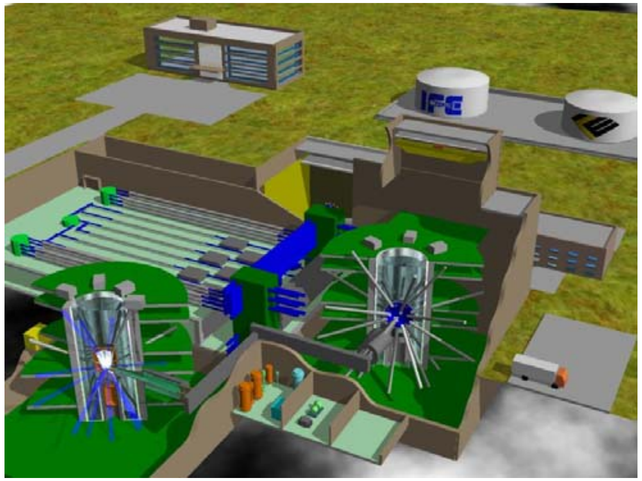


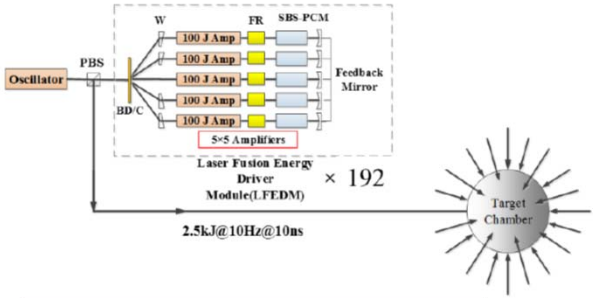
MagLIF combines three complementary design elements into a single target design

1st integrated experiment successfully demonstrated the concept

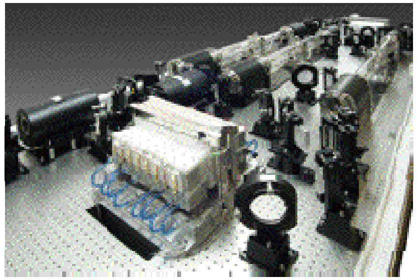
J. Edwards OV/3-2
N. Ding P5-4

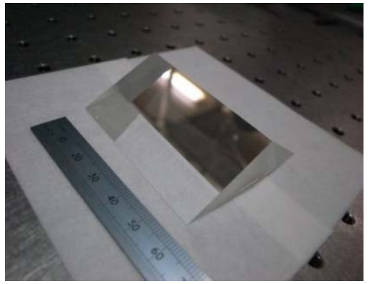
IFE reactors are conceptually designed & adequate technologies studied

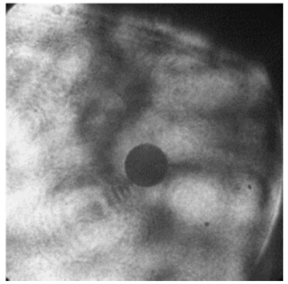




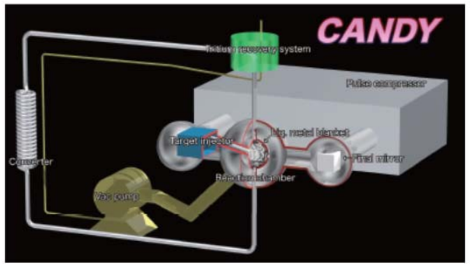
- LIFT & CANDY concepts (Japan)
- high-repetition rate drivers (diode-pumped, ceramics, coherent beam combination) & target injection systems

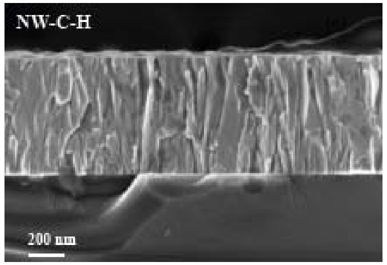






- materials for first walls





H. Azechi OV/4-2
T. Norimatsu IFE/P5-19
Y. Kitagawa P5-10
H.-J. Kong IFE/P5-14
K. Ishii IFE/P5-17
R. C. Issac IFE/P5-18 (not shown)
M. Perlado P5-33
T. Kikuchi P5-5

conclusion

- ✓ our understanding of ICF physics (laser-plasma interaction, hydrodynamics, etc.) is progressing
- ✓ complementary MJ-class facilities will soon allow comparative full-scale experiments on multiple schemes

- ✓ new ideas may arise from this competition paving the way to ignition
- ✓ in parallel, technological bricks for a prospective IFE reactor are developed