Z-pinch driven IFE target physics – status & plans

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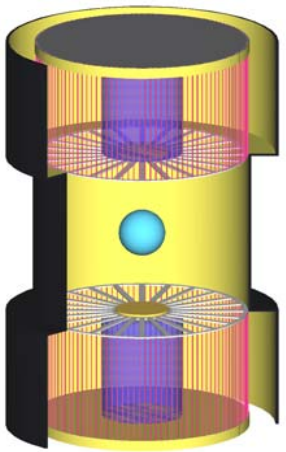
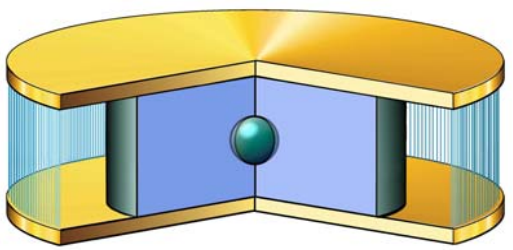
Two complementary Z-pinch indirect drive concepts for high-yield ICF and IFE are being explored

	ICF – IFE Current / Driver / E_{abs} / Yield	Features
Double-Pinch Hohlraum 	2 x 62 MA 16 MJ 1.3 – 2.6 MJ 400 – 1300 MJ	Dual power feed, double-pinch Capsule isolated from z-pinches Symmetry via hohlraum design demonstrated on Z (2x16 MA) η_{hohl} ~ 8-16 %
Dynamic Hohlraum 	54 – 95 MA 12 – 37 MJ 2.4 – 7.2 MJ 530 – 4400 MJ	Capsule inside single pinch and converter Core T_e > 1 keV, dopant x-ray spectra measured on Z (20 MA) η_{hohl} ~ 20 %

J. Hammer, M. Tabak, R. Vesey, J. Lash, S. Slutz

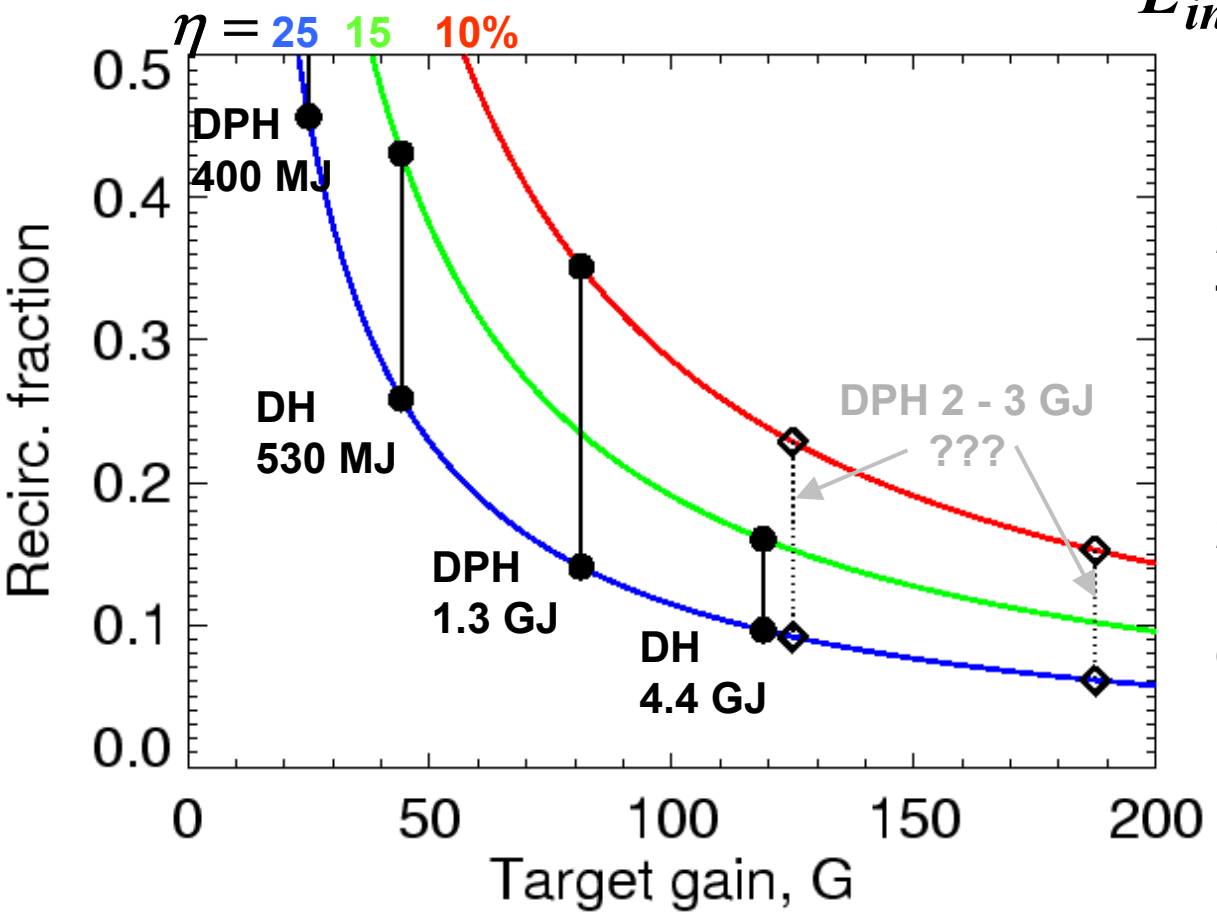
Demonstrated efficiency of pulsed-power z-pinch drivers strongly motivates pursuing these schemes

Recirculating power fraction

$$f_d = \frac{1}{\eta G M \varepsilon}$$

$M\varepsilon =$ 0.35 assumed

$$\eta = \frac{E_{driver}}{E_{input}} =$$ 10 – 15% routinely on Z now

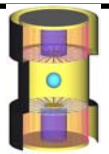


2-3 GJ DPH capsules from 16 MJ driver?

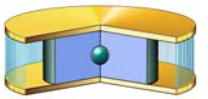
Improvements in η?

2-4 GJ targets for either DPH or DH look attractive even with today's η

Major target physics issues for z-pinch concepts are being investigated



Double-pinch hohlraum

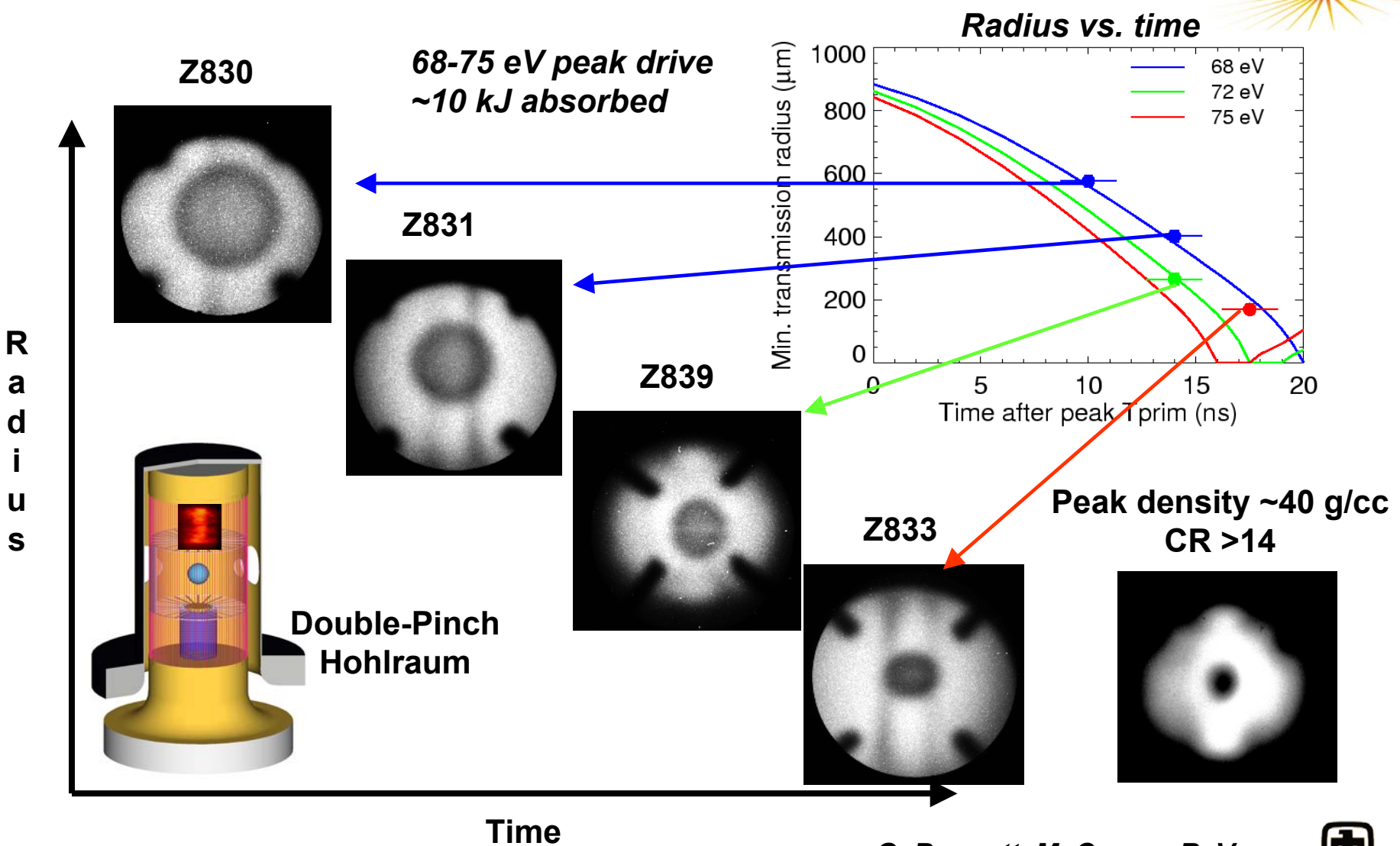


Dynamic hohlraum

	Status	Comments	Status	Comments
Coupling efficiency	C, P, D	Hohlraum η = 7-16% for HY. Spoke transmission > 70%. Capsule drive understood 10kJ	C, P, D	Hohlraum η = 20% for HY. Capsule drive understood (20-25 kJ).
Pulse shaping	C, P, (D)	Multi-shell pinch calculations. Nested wire-array expts. (Early nested-array expts.)	C, P, D	Calc. for HY & IFE. Calc. pulse shape w/ foam convertor agrees with data.
Symmetry	C, P, D	Calc. symmetry for HY ok. Calc. symmetry tuning via hohl. geom. agrees w/ Z data. Close to scaled HY symmetry.	C, P	Symmetry problems in HY. Proposed improvements. Core imaging from side looks promising.
Stability	C	Calc. growth factors for 400 MJ capsule (Hammer) Multi-D multi-mode needed	C	2D multimode calc. for 530 MJ capsule (Lash) Needed for GJ class capsule

C = Calculated *P = Experiments planned* *D = Experimental demo*

Double-pinch hohlraum backlit capsule images agree with simulated capsule trajectory



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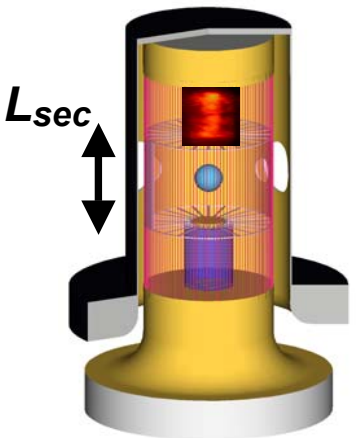
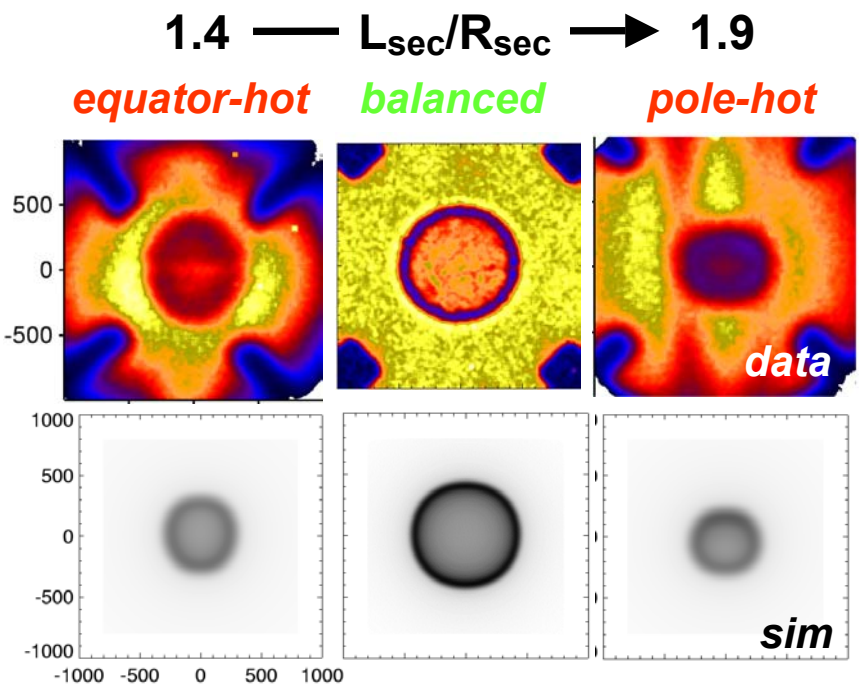
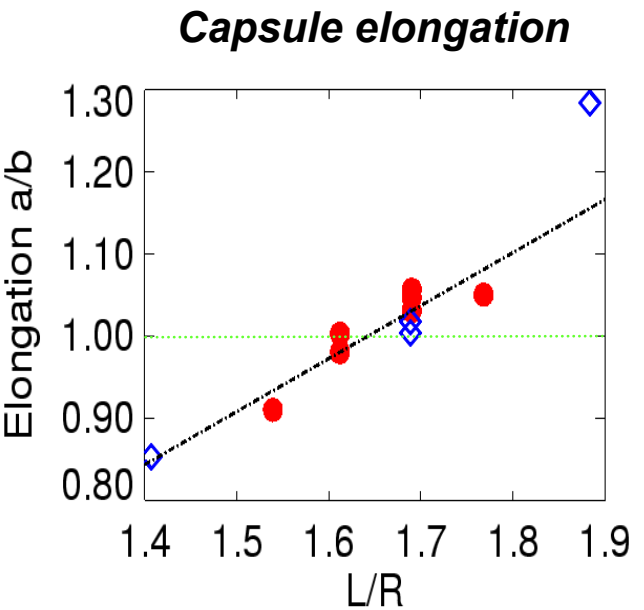
Double-pinch hohlraum experiments demonstrate systematic control of capsule symmetry at the few % level



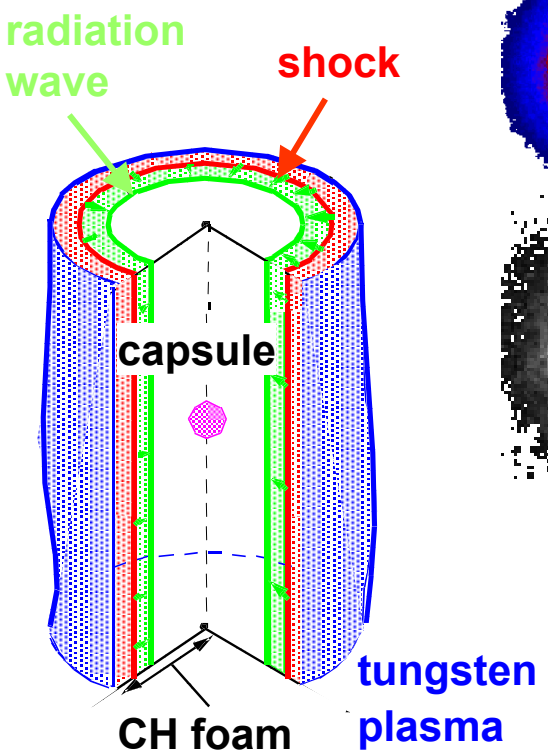


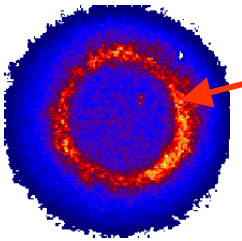


- *Symmetry control via hohlraum design (e.g. L_{sec} variation)*
- *Agreement with viewfactor-RHD + integrated calculations*
- *Modification of time-integrated P_2 coefficient at ± 3% level*
- *Optimum length symmetry (all modes) is close to scaled HY requirement*

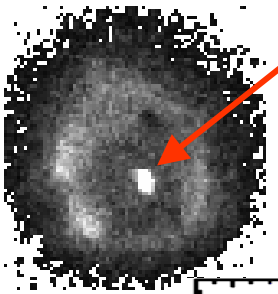
R. Vesey, M. Cuneo, G. Bennett

Dynamic hohlraum experiments obtain core images and argon spectra from capsule absorbing 20 kJ of x-rays



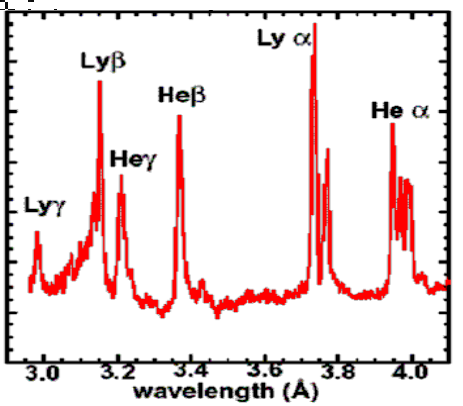


Shock emission width (~250 μm) is consistent with low levels of pinch RT



End-on core x-ray images imply a capsule convergence ratio of ~10

Side-on imaging planned to assess symmetry



Capsule spectra imply core $T_e > 1$ keV, $n_e \sim 2\times10^{23}$ cm^{-3}

Foam dopants, radiation burnthrough shielding, and converter shaping will be implemented to control pole-equator asymmetry

J. Bailey, G. Chandler, S. Slutz

Theoretical work remains to firm up the target physics basis for z-pinch driven high-yield ICF and IFE

Coupling efficiency

- hohlraum efficiency compatible with symmetry req.?

Pulse shaping (→ driver WG)

- capsule – pulse shape optimization
- pulse shape sensitivity
- compatibility of pulse shaping technique with symmetry req., shock standoff (DH), coupling efficiency

Symmetry

- calculations of symmetry sensitivity for optimized GJ capsules
- techniques for macro-symmetry in dynamic hohlraum

Stability

- multi-mode calculations for GJ class capsules for DPH and DH

Target physics principles can be validated on Z and ZR

Coupling efficiency

- neutron producing capsules in DPH on Z (75 eV) and ZR (90 eV)
- x-ray and neutron producing capsules in DH on Z (200 eV) and ZR

Pulse shaping (→ driver WG)

- nested wire array and internal target pulse shaping for DPH
- multi-component pulse-shaping targets for DH

Symmetry

- demonstrate scaled high-convergence symmetry req. in DPH on Z, ZR
- dual power feed double-pinch power balance → P1 in DPH on ZR
- foam dopants, burnthrough shields, shaped converters for DH

Stability

- backlit imaging of thin shell capsules ?
- doped shell/fuel mix experiments in DH and DPH ?