Improvements in Cryogenic DT Target Performance

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Summary

New capabilities are under development to support high-performance cryogenic implosions* on OMEGA in early 2015

UR LLE

- The implementation of dynamic bandwidth reduction on OMEGA will provide an additional few kilojoules for implosion experiments
- A new set of symmetric-drive phase plates (SG5) will significantly improve the drive uniformity
- New diagnostics are being developed to reduce uncertainty in the inferred $P\tau$ of layered direct-drive implosions
- Impurities in the DT fuel supply (^{1}H) have been removed using the new Isotope Separation System (ISS)
- The first implosions with a T:D isotopic ratio of 60:40 show the expected increase in primary neutron yield

*V. N. Goncharov *et al.*, JO4.00006, this conference.

Collaborators

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Other relevant presentations at this meeting:
1. V. N. Goncharov *et al*., JO4.00006, this conference.
2. R. Epstein *et al*., JO4.00007, this conference.
3. D. H. Froula *et al*., NO4.00013, this conference.
4. F. J. Marshall *et al*., TO4.00001, this conference.
5. C. Stoeckl *et al*., UO4.00011, this conference.

The requirements to increase the stagnation pressure by July 2015 will be mostly implemented by Q2FY15

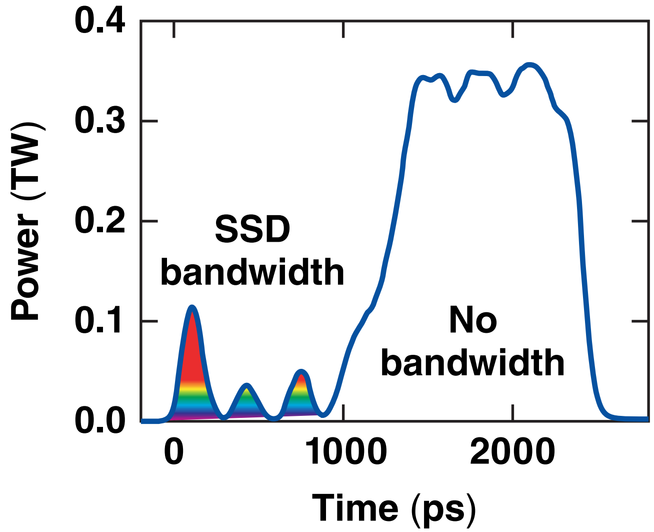
UR LLE

- Reduce laser imprint using doped ablators and high-Z layers*
- Improve drive uniformity with better power-balance algorithms
- Additional energy on target using dynamic bandwidth reduction
- Reduce cross-beam energy transfer (CBET) and improve drive uniformity with a new set of phase plates (SG5)
- Install new instrumentation to improve the measurement accuracy of the central pressure and $P\tau$
- Eliminate target particulate sources to reduce ablation-surface Rayleigh–Taylor (RT) seeds
- Purify the DT fuel supply and adjust the T:D ratio for maximum yield (50:50 in the gas phase)

*A. J. Schmitt *et al*., JO400010, this conference; M. Karasik *et al*., JO400012, this conference.

Dynamic bandwidth reduction is part of the effort to mitigate CBET

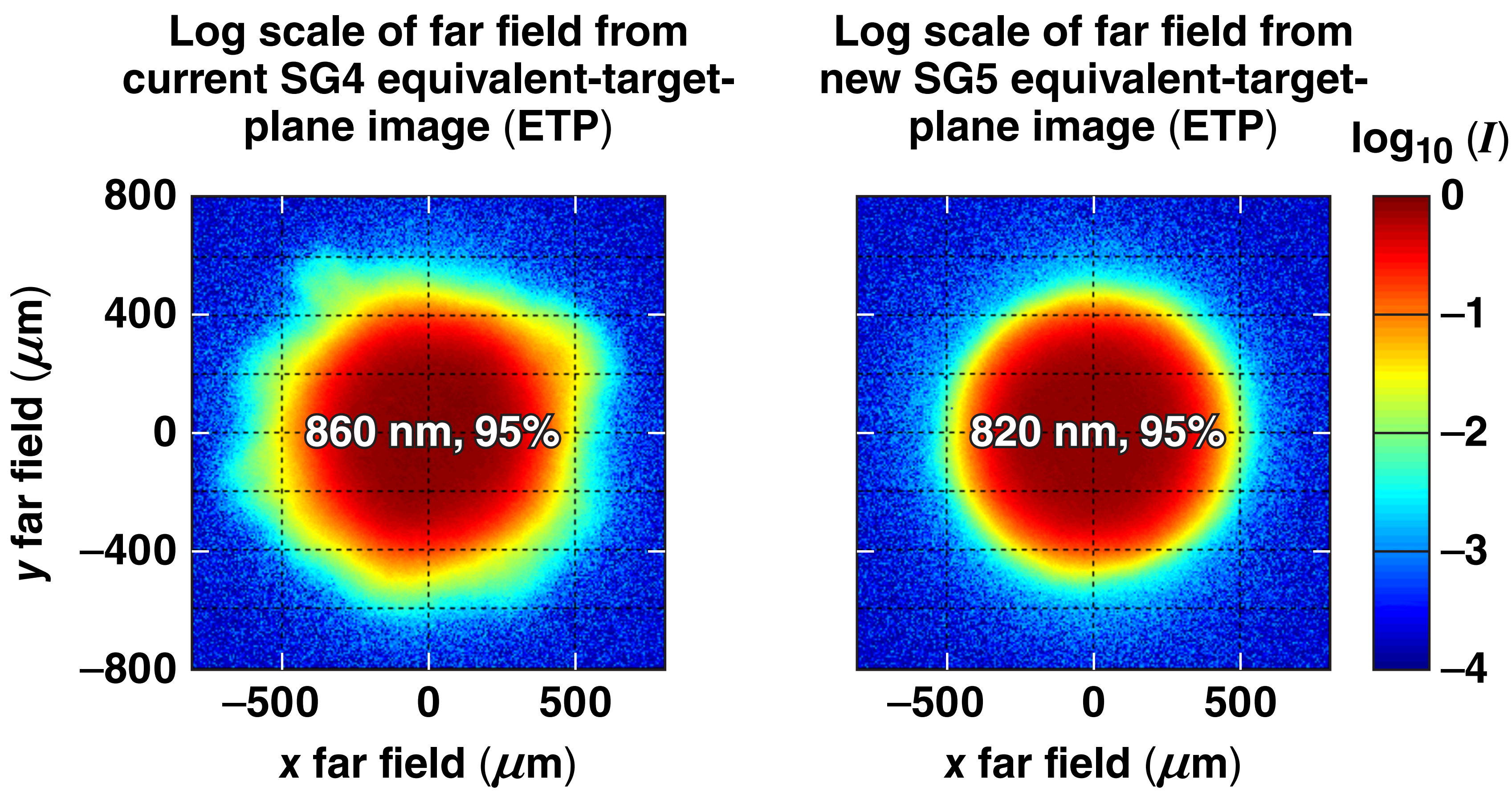
- Front-end modifications currently underway will provide co-propagation of two separate pulse shapes in all 60 OMEGA beams*
- Two-dimensional smoothing by spectral dispersion (SSD) can be applied to either one of the two pulse shapes
- Dynamic bandwidth reduction on a standard cryogenic target drive pulse (bandwidth only on the pickets) provides increased energy in the drive
- Following the modifications, it will be possible to propagate different spatial profiles for each pulse (an option for focal-spot zooming* expected in FY16)



E23690

*D. H. Froula *et al*., NO4.00013, this conference.

A new set of phase plates will improve on-target drive uniformity and reduce light that can seed CBET



E23691

A new neutron temporal diagnostic (CryoNTD) will provide an accurate (estimated 10%) measurement of the burn width

UR LLE

- The pressure of a layered DT implosion can be inferred two ways:
  1. The *central pressure* $P(0)$ at bang time is given by:*

$$P(0) \approx \frac{27}{\tau} \langle \rho R_{\mathrm{g/cm^2}} \rangle_n^{0.61} \left[\frac{0.24 \times \mathrm{Yield} \times 10^{-16}}{M_{\mathrm{DT}}^{\mathrm{mg}}} \right]^{0.34} \left(\frac{4.7}{\langle T \rangle_n^{\mathrm{keV}}} \right)^{0.8} (\mathrm{Gbar})$$

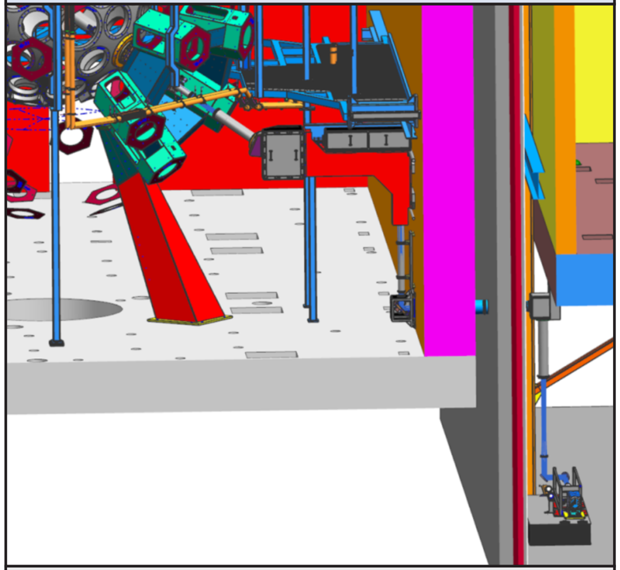
Highest OMEGA $P(0)$ = 43 Gbar for shot 69514

  2. The *burn average* $\langle P \rangle$ at bang time is given by:**

$$\langle P \rangle \equiv \sqrt{\frac{16 \times \mathrm{Yield}}{\xi(T) V_{\mathrm{hs}} \tau}} \qquad \xi(T) \equiv \frac{1}{V_{\mathrm{hs}}} \int V_{\mathrm{hs}} \frac{\langle \sigma v \rangle}{T^2} dV$$

The highest OMEGA burn average pressure for shot 69514 is $\langle P \rangle$ = 31.5 Gbar

The CryoNTD is located in P11 with optical transport to a streak camera in the OMEGA EP plenum (S/B ~ 200)



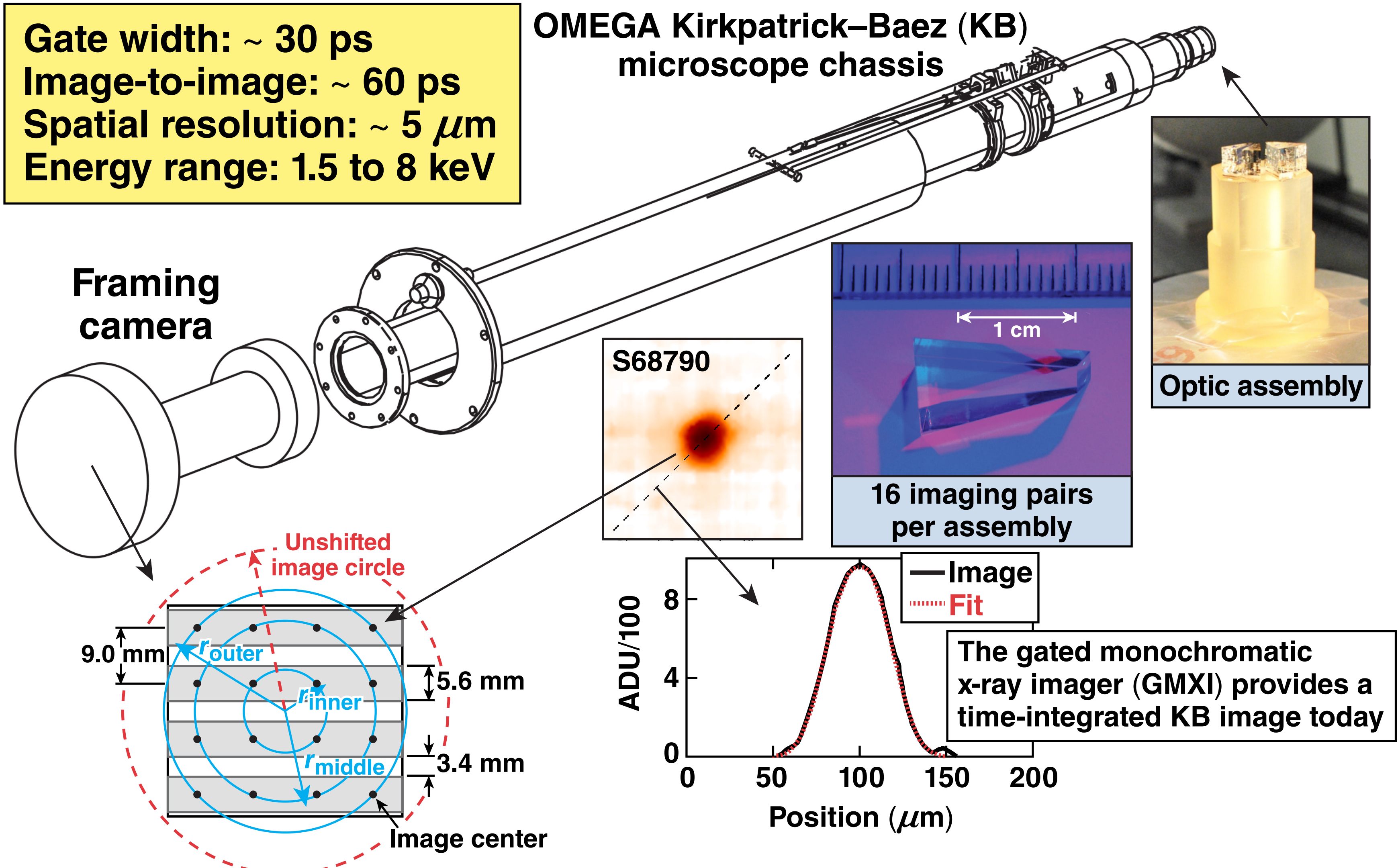
The estimated impulse response is ~50 ps, adequate for 50-to 60-Gbar pressures and widths of 70 to 90 ps

*R. Nora *et al*., Phys. Plasmas 21, 056316 (2014).
**C. Cerjan, P. T. Springer, and S. M. Sepke, Phys. Plasmas 20, 056319 (2013).

A framed 16-image KB will provide time-resolved x-ray images of the core through stagnation (Q1FY15)

UR LLE

Gate width: ~ 30 ps
Image-to-image: ~ 60 ps
Spatial resolution: ~ 5 μm
Energy range: 1.5 to 8 keV



E22996

The new ISS* purified 23.6 standard liters of mixed D:T:H to extract 3 standard liters of T_2 with a purity of 99.7%

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- 12 mCi released out of 8500 Ci processed in September 2014
- Before: T:D:H was 34%:60%: 5% (estimated)
- After: T:D:H is 60:40: <0.1% (estimated)

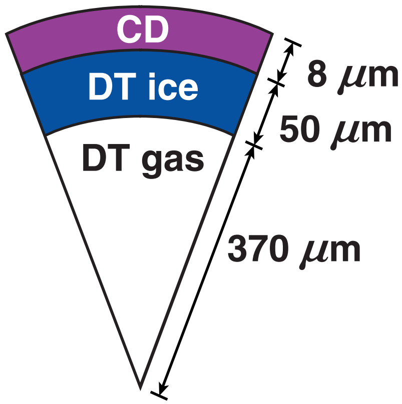
The 60:40 T:D ratio was chosen to provide a 50:50 mixture in the gas phase (fractionation) of a layered capsule.

E23693

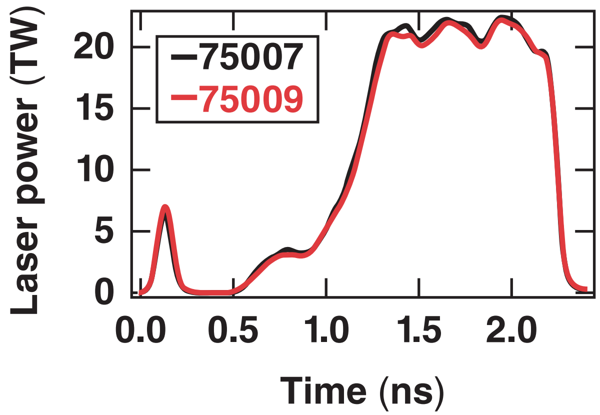
*Developed jointly with Savannah River National Laboratory

The first experiments with the new DT fuel produced the expected increase in primary yield

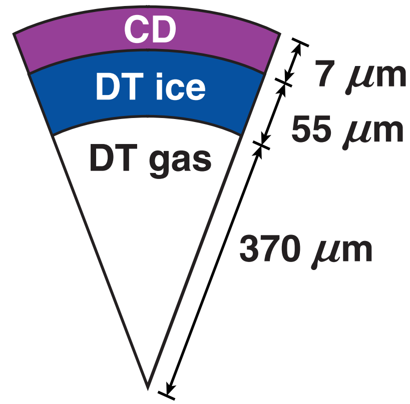
40:60 D:T
shot 75009



Similar pulse used on shot 70805



60:35:5 D:T:H
shot 70805



Measurements:
$Y_n \sim 4.7 \times 10^{13}$ (25% 1-D)
$T_i \sim 3.3$ keV
$\rho R_{nTOF} \sim 140$ mg/cm^2 (60% 1-D)

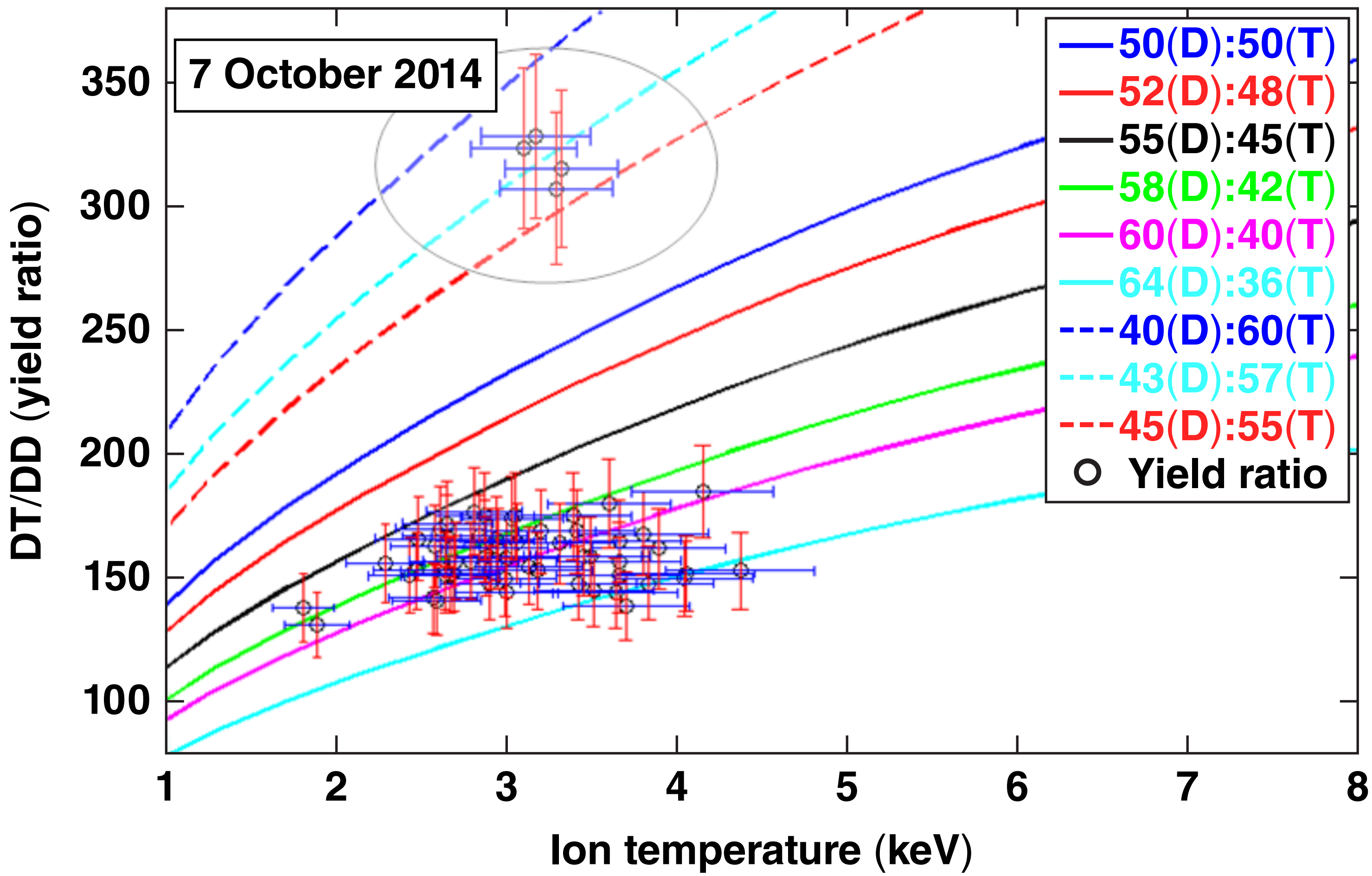
1-D simulations:
$\alpha \sim 3.1$
IFAR ~ 26
$V \sim 380$ km/s

Measurements:
$Y_n \sim 2.9 \times 10^{13}$ (32% 1-D)
$T_i \sim 3.8$ keV
$\rho R \sim 157$ mg/cm^2 (90% 1-D)

1-D simulations:
$\alpha \sim 5.3$
IFAR ~ 22
$V \sim 390$ km/s

A comparison with our best-performing triple-picket design ($\alpha \sim 4$) will be done in November 2014.

The measured DT-to-DD yield ratio shows that the fuel is close to the expected 60:40 isotopic ratio (T:D)



E23695

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E23688