Overview of NIF Layered Implosion Performance and Anomalies

Kinetic Physics Workshop

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on behalf of the ICF Program

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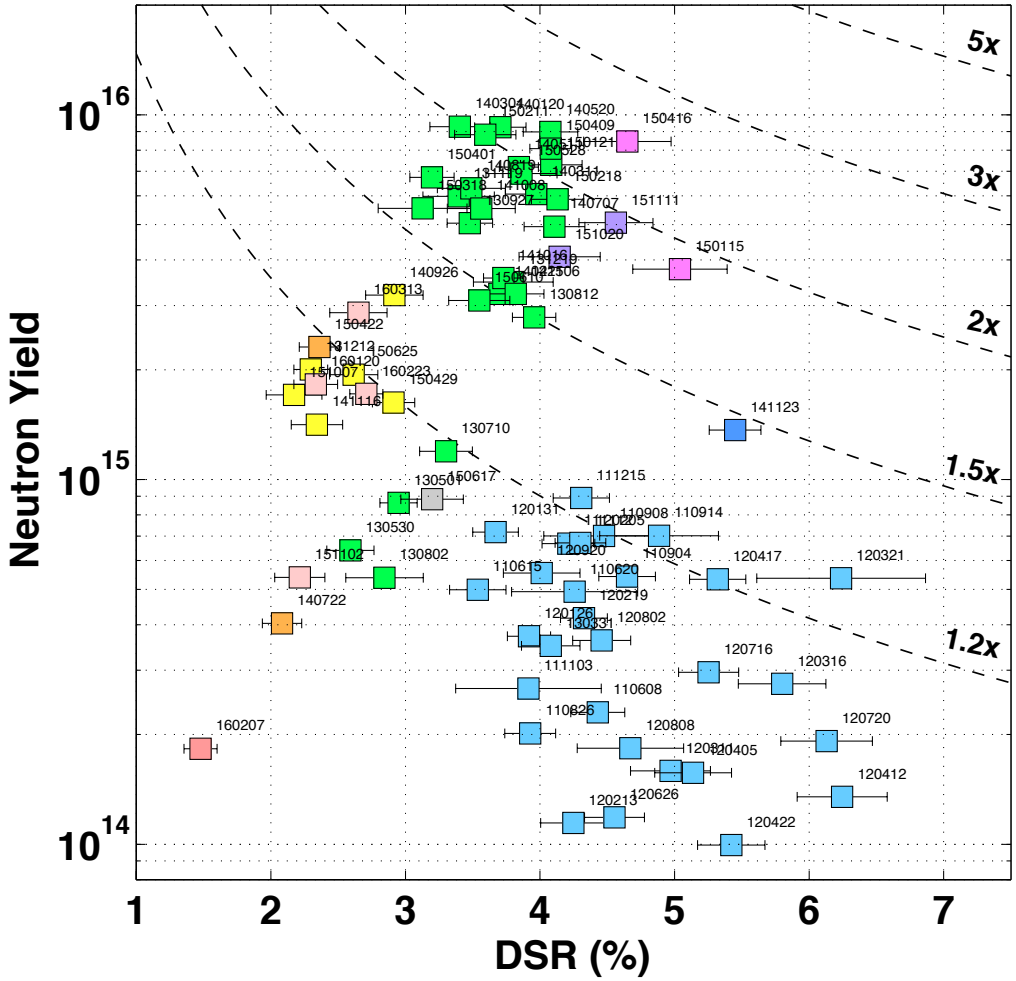
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

We have performed 75 layered DT experiments



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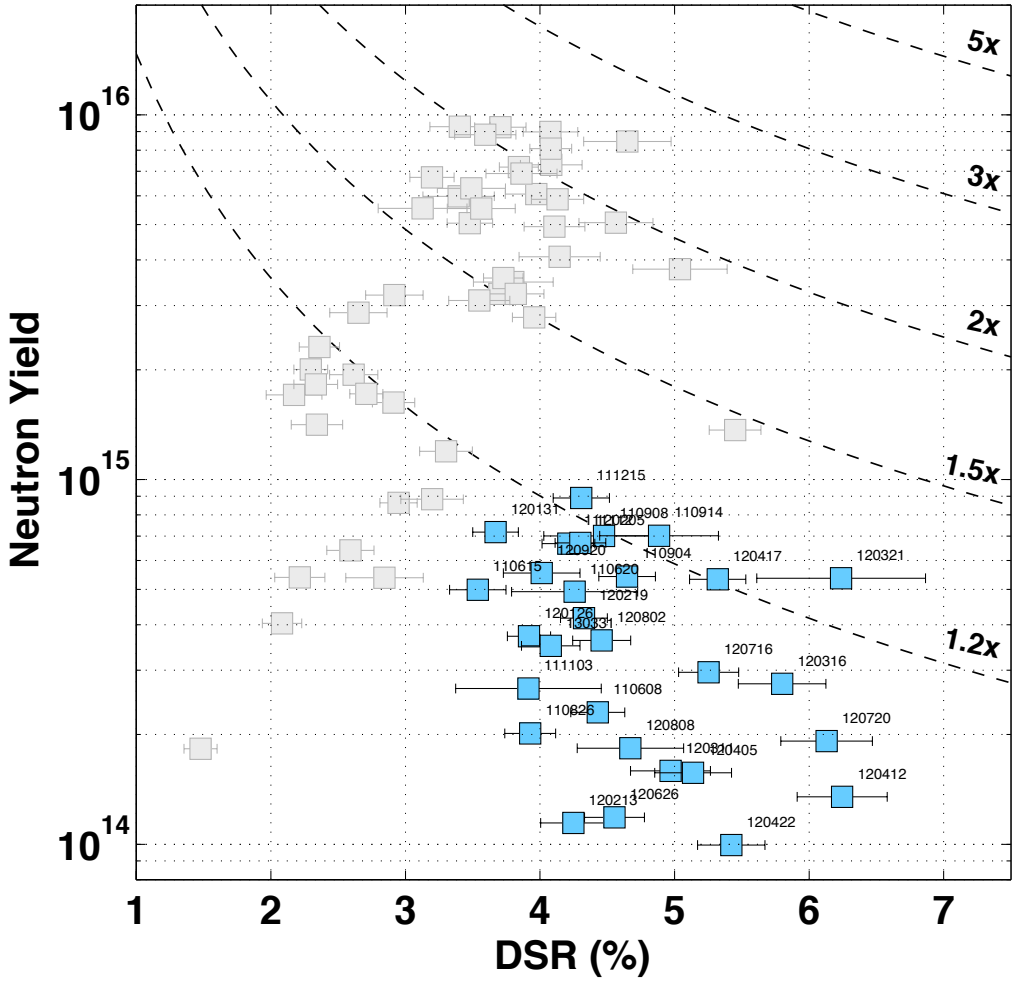

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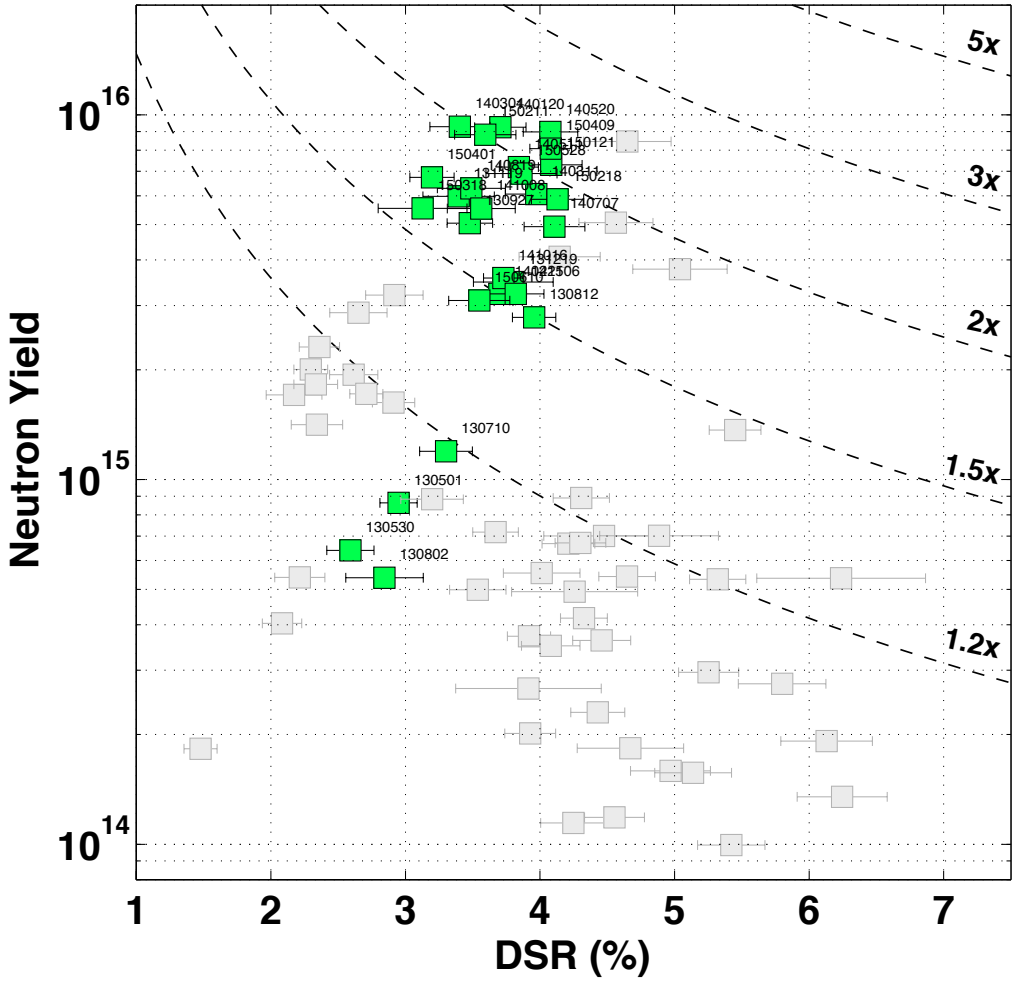

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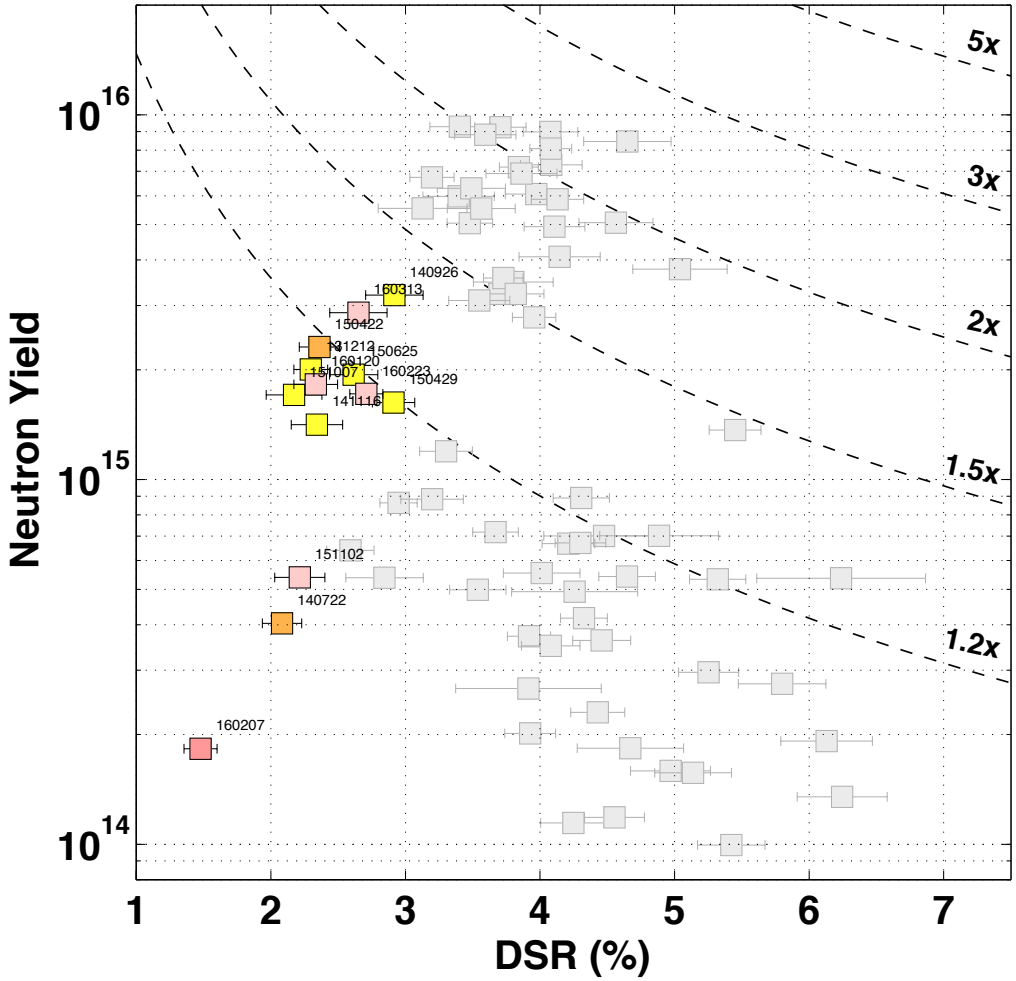

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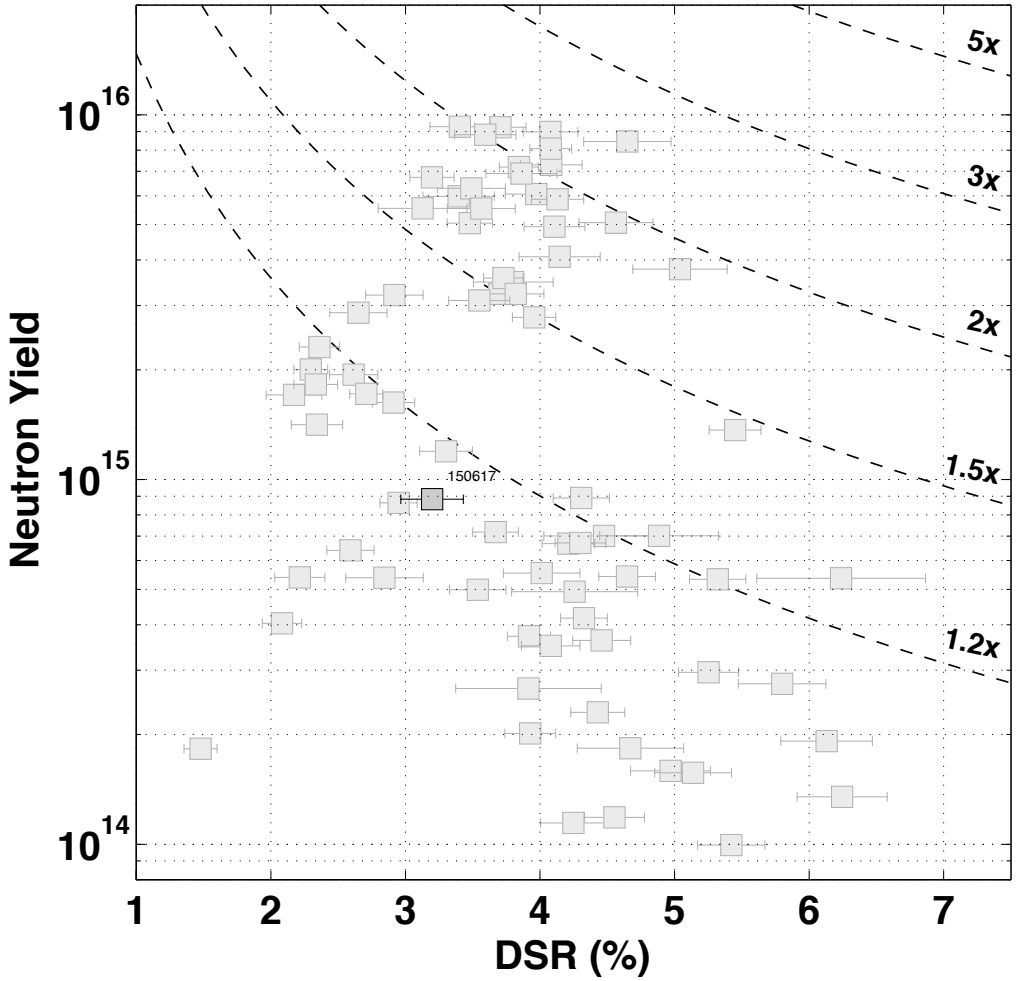

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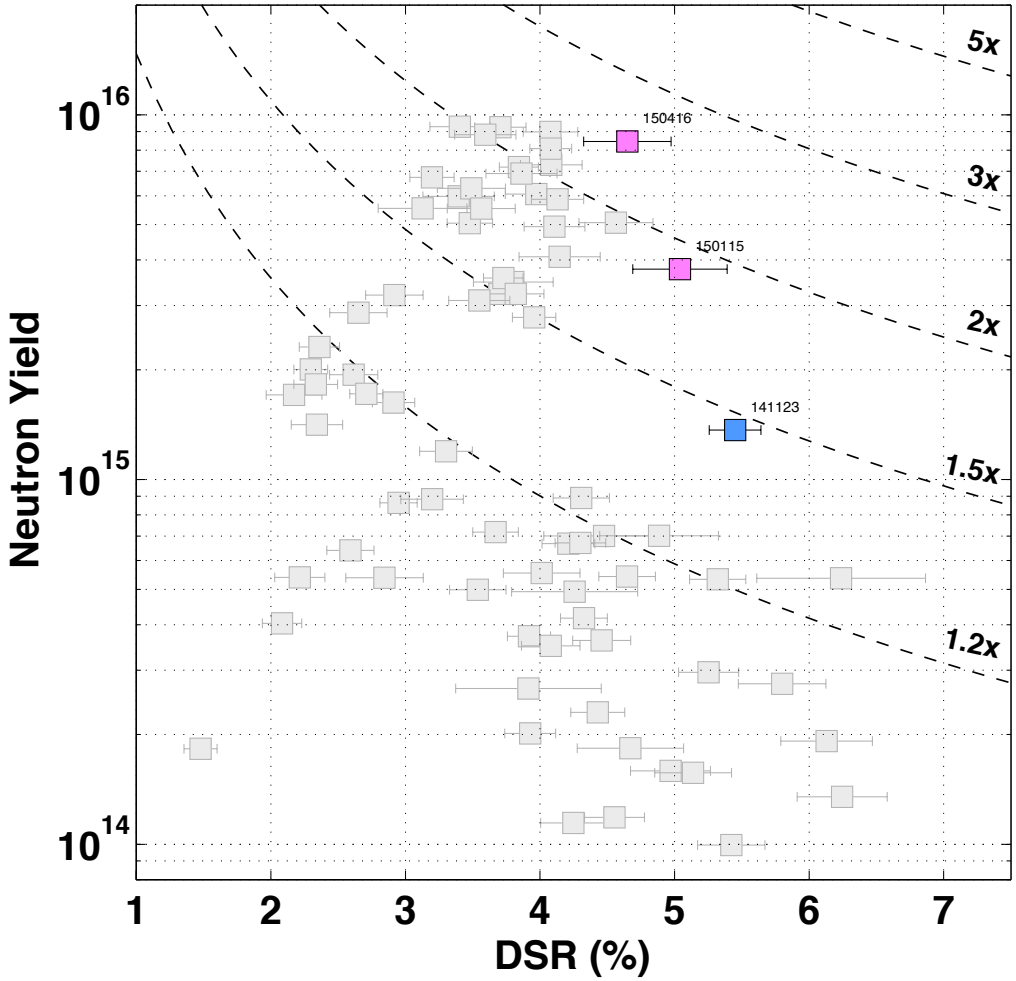

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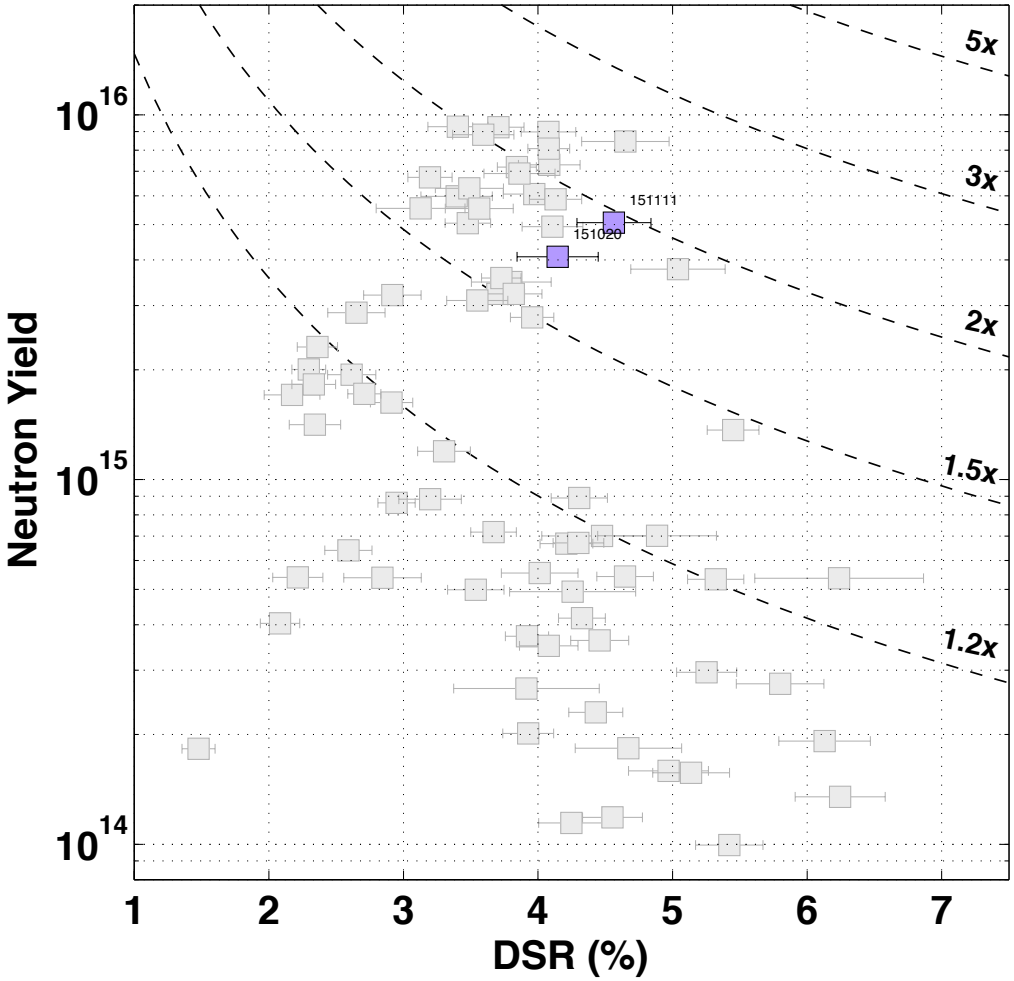
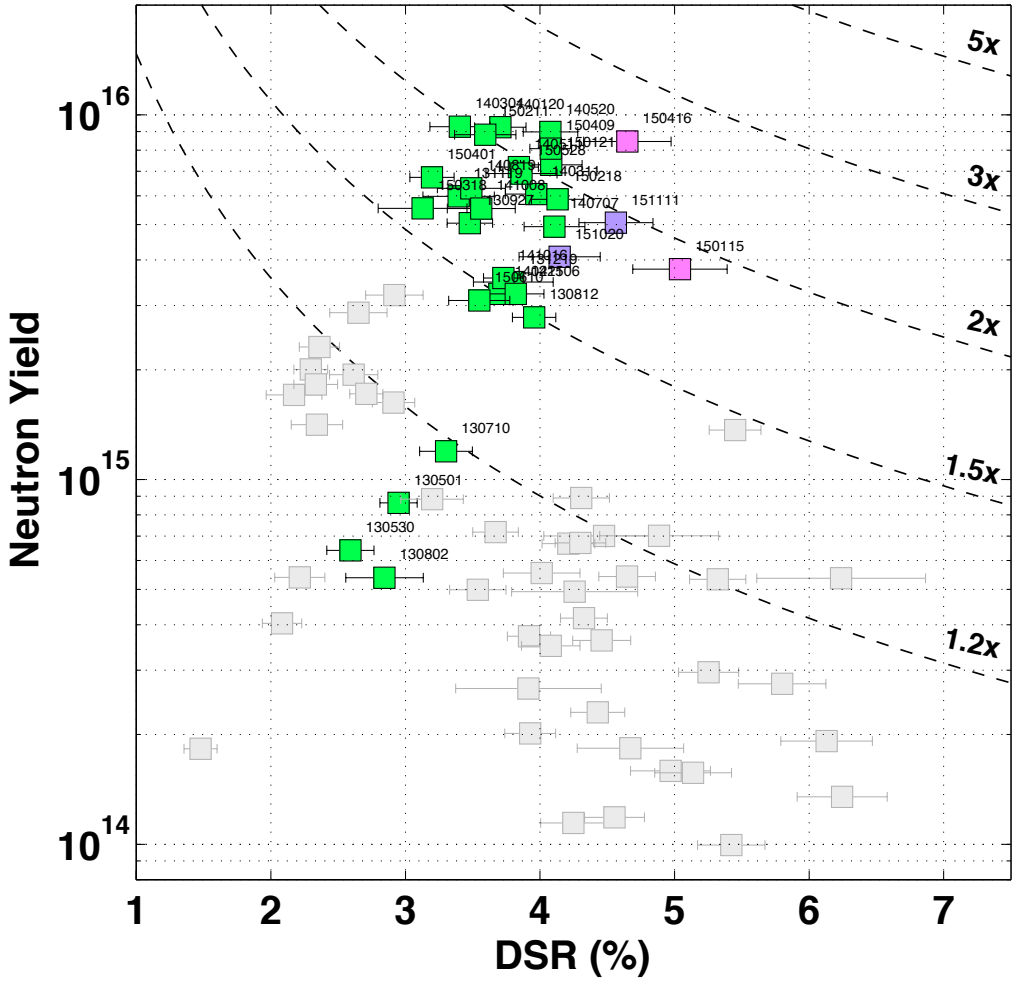
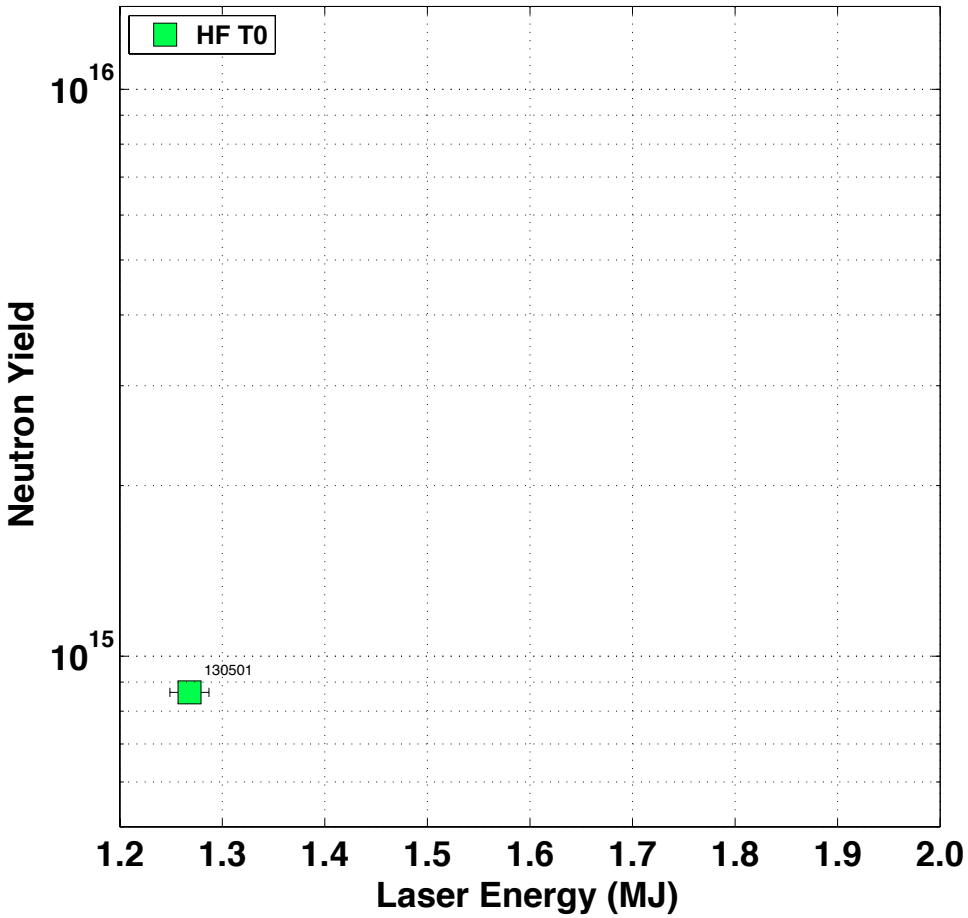
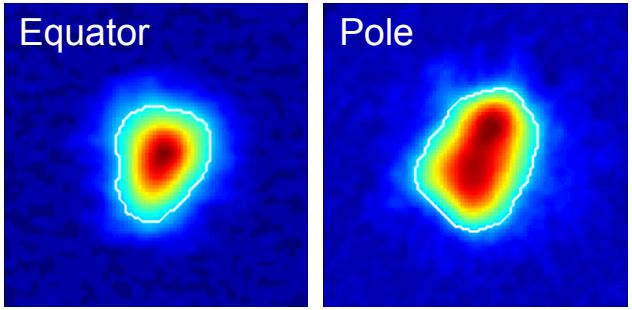


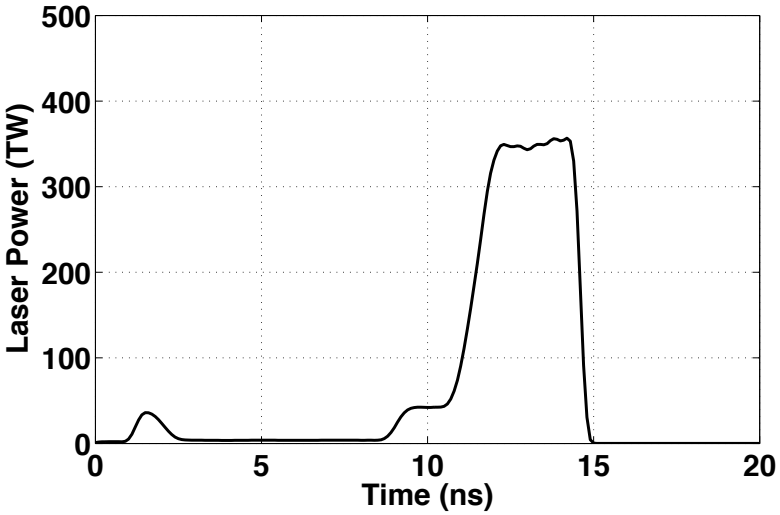
We will focus on the high-foot series



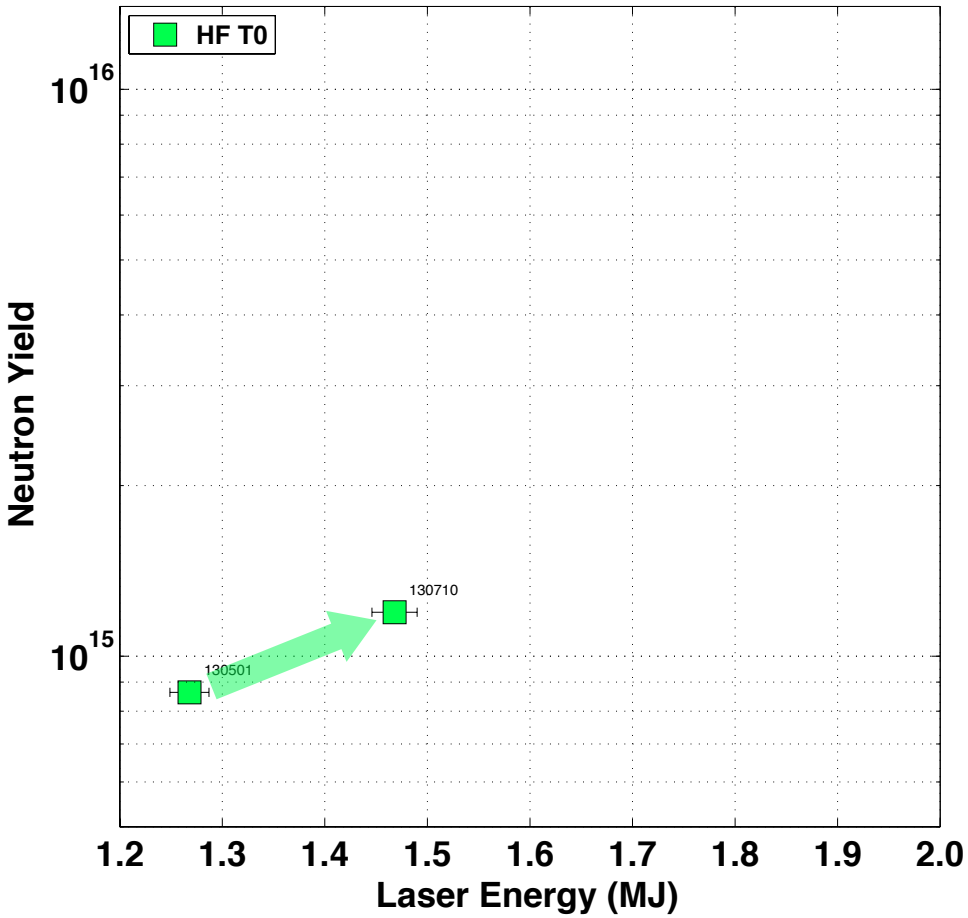
First high-foot DT shot performed close to 1D prediction (~50% of 1D)

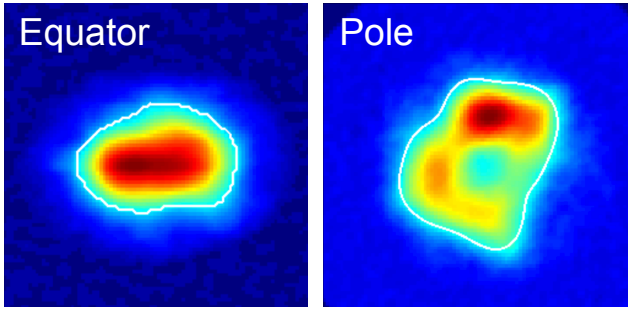


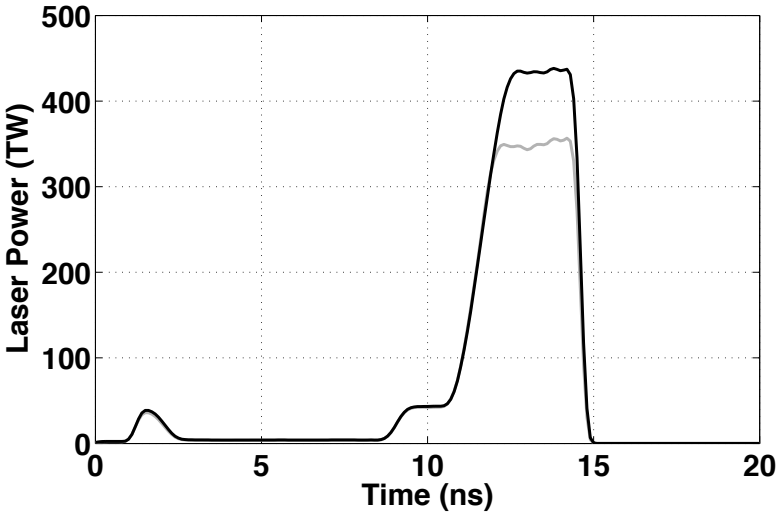




Strategy was to gradually increase velocity while maintaining reasonable control of shape







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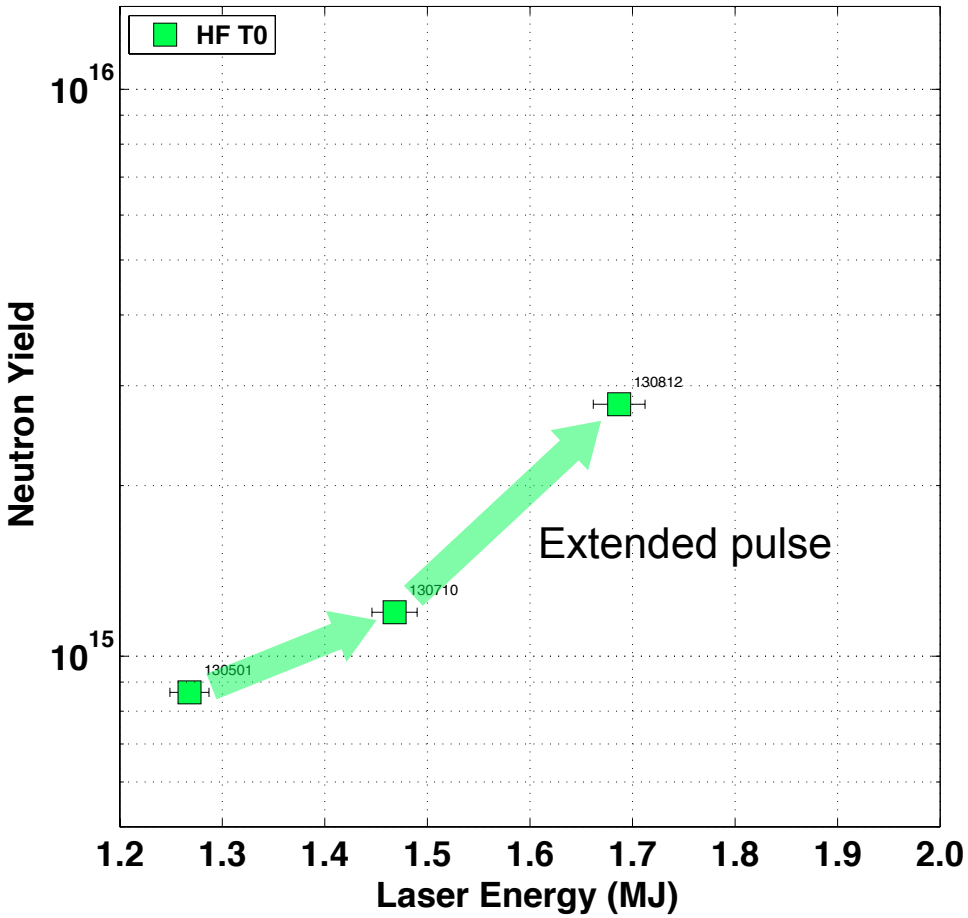

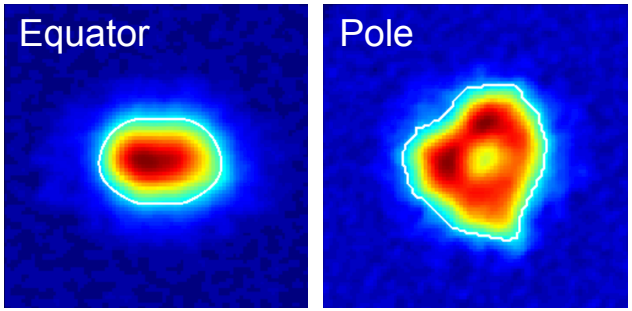

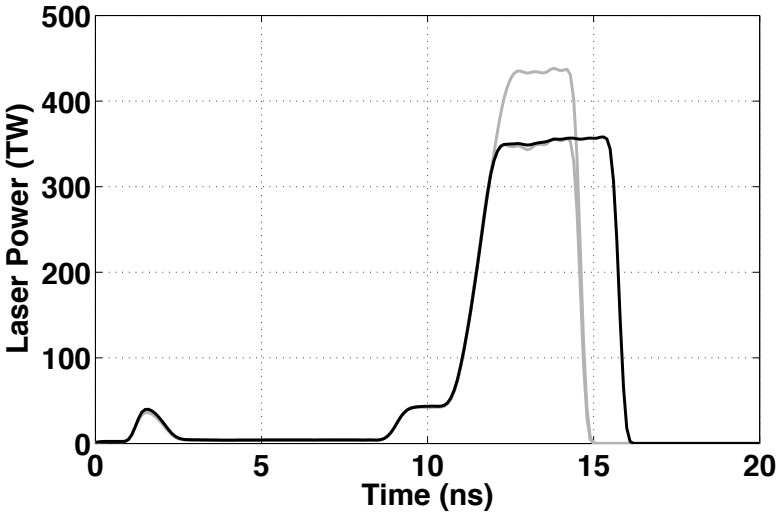

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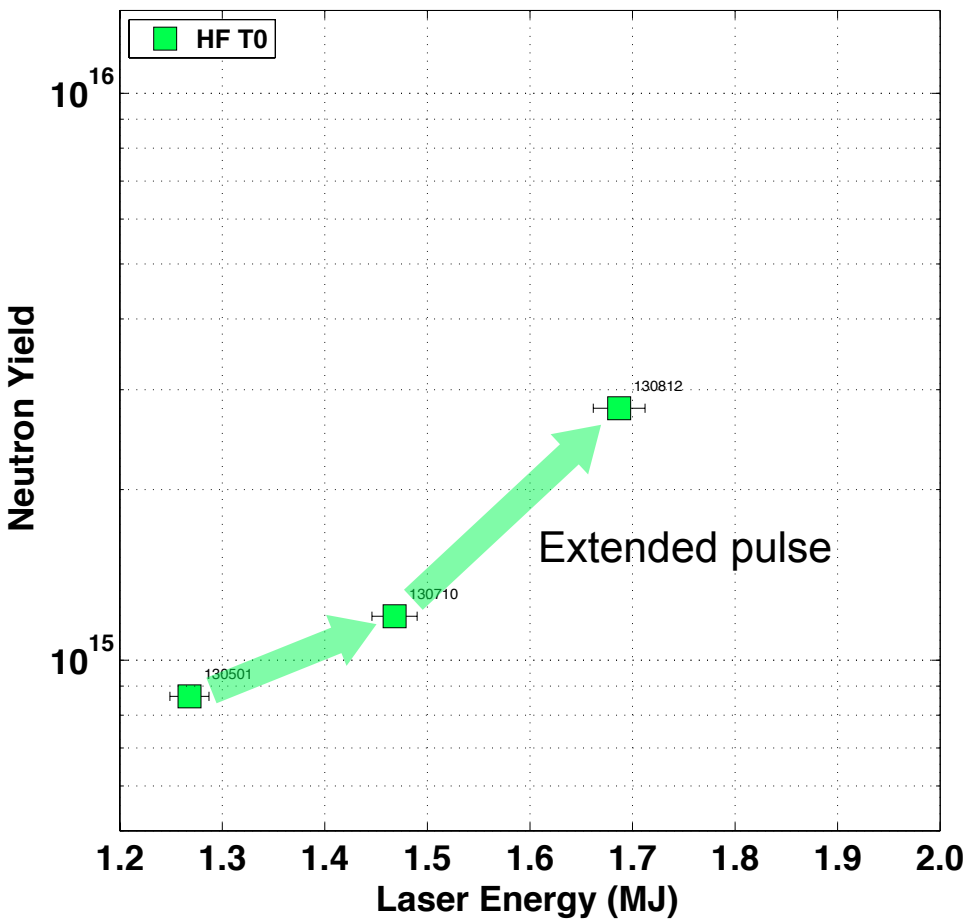

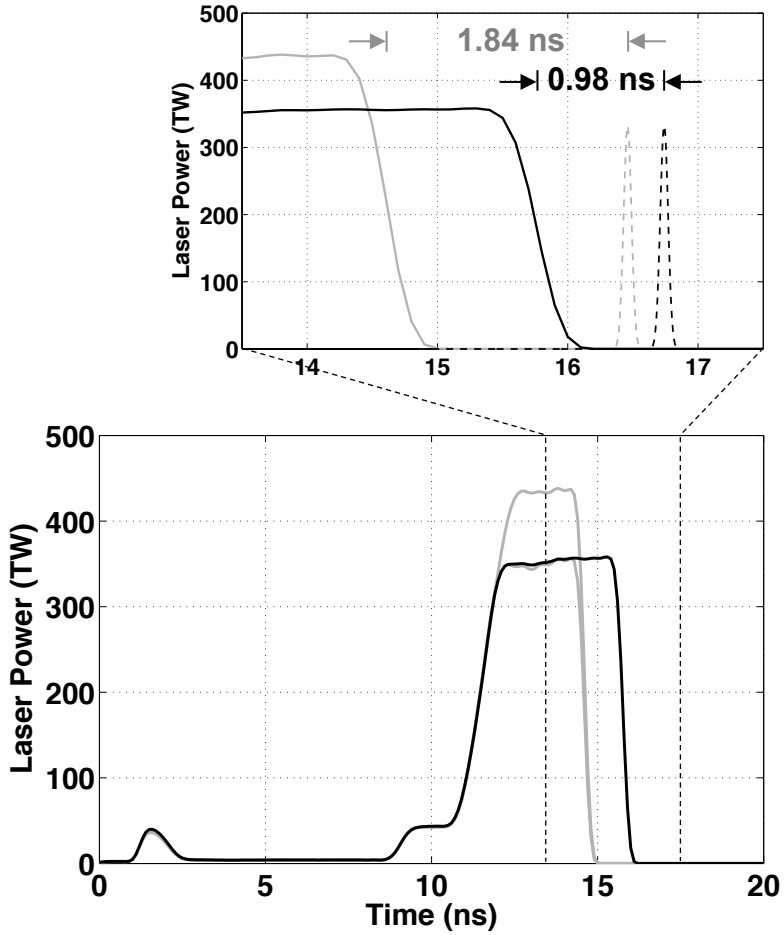

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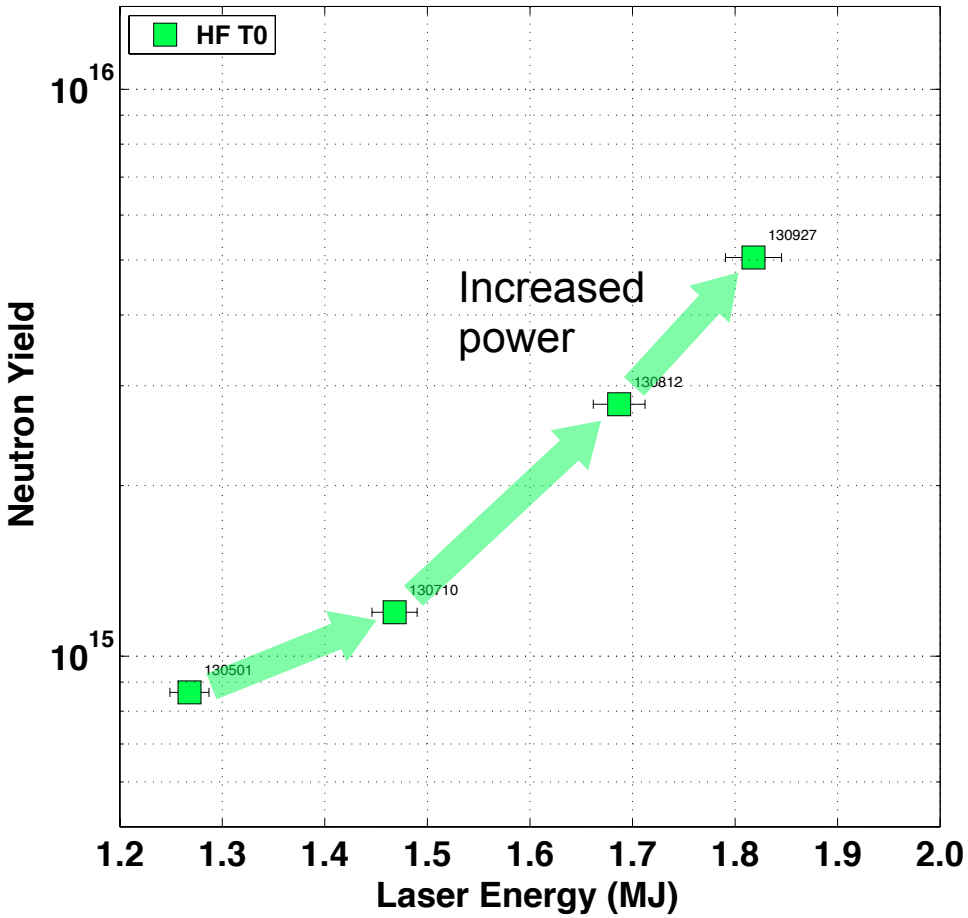

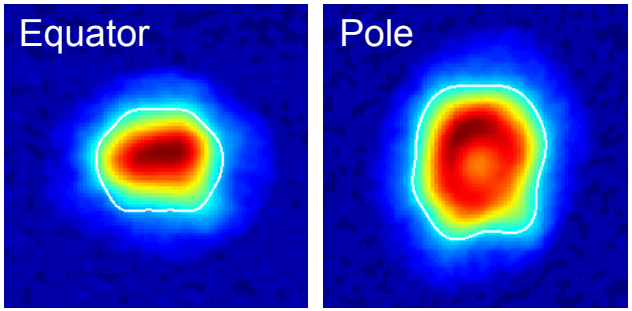

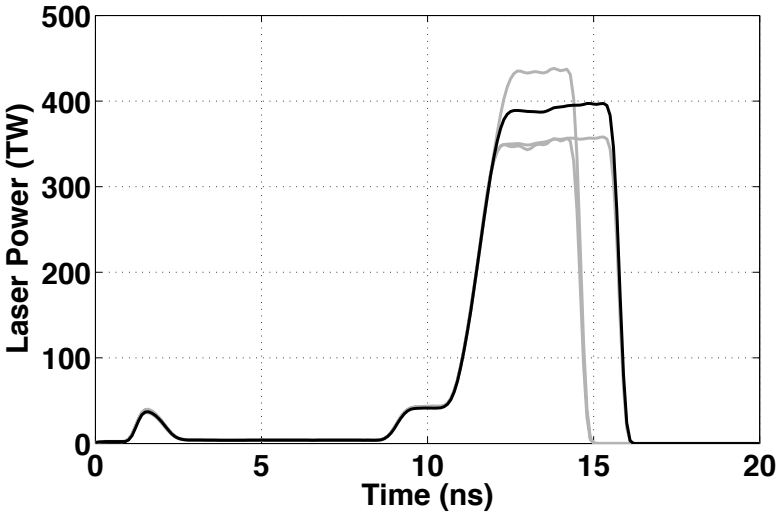

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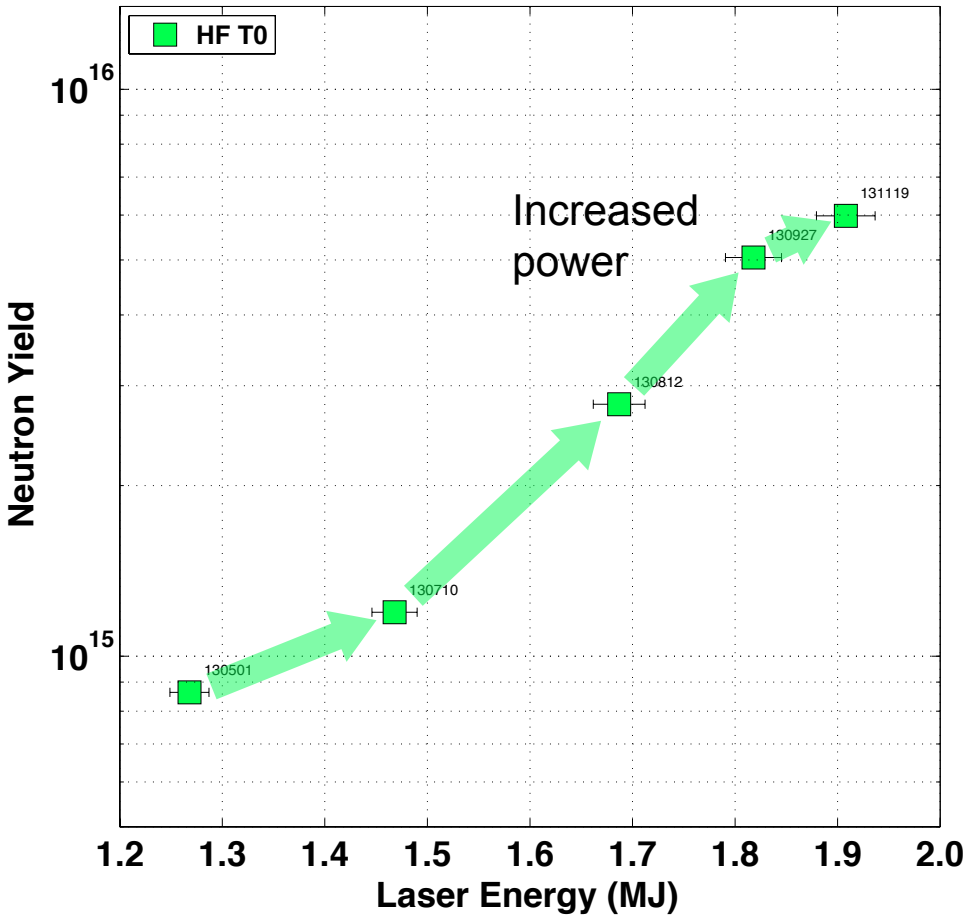
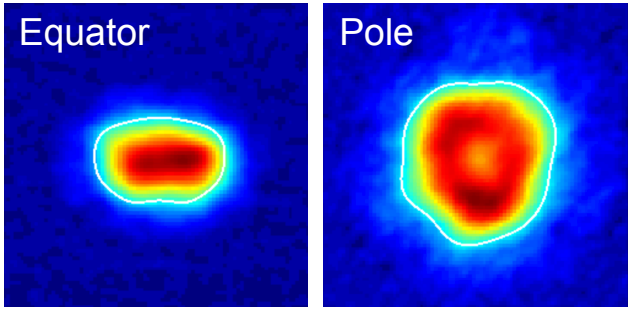
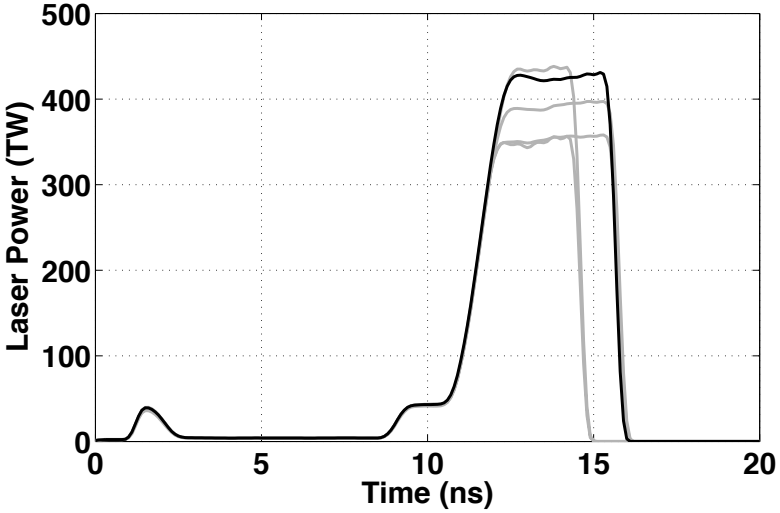
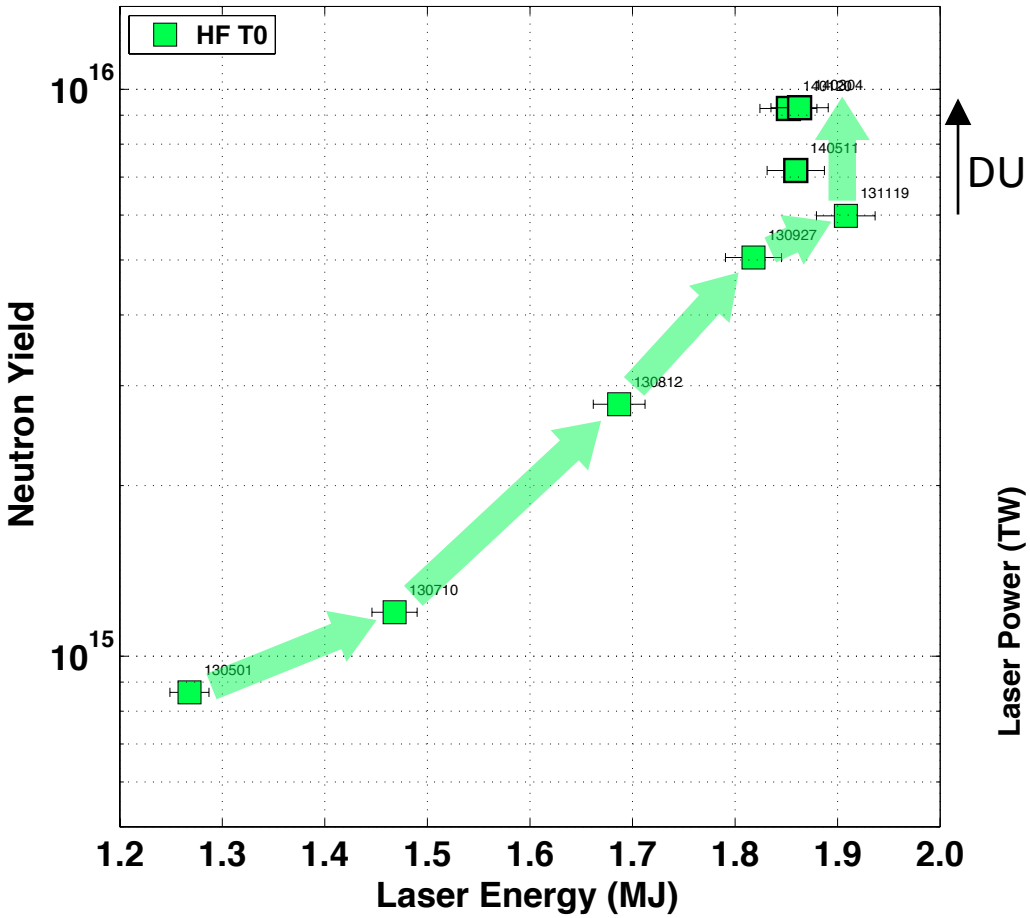
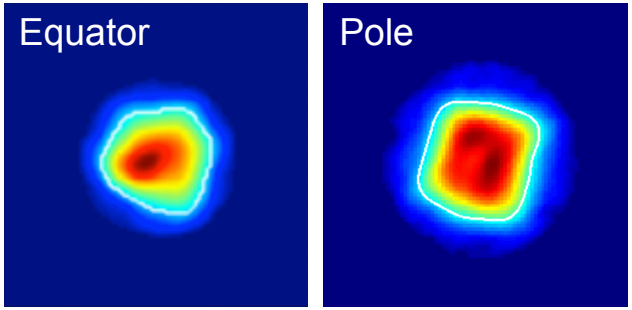


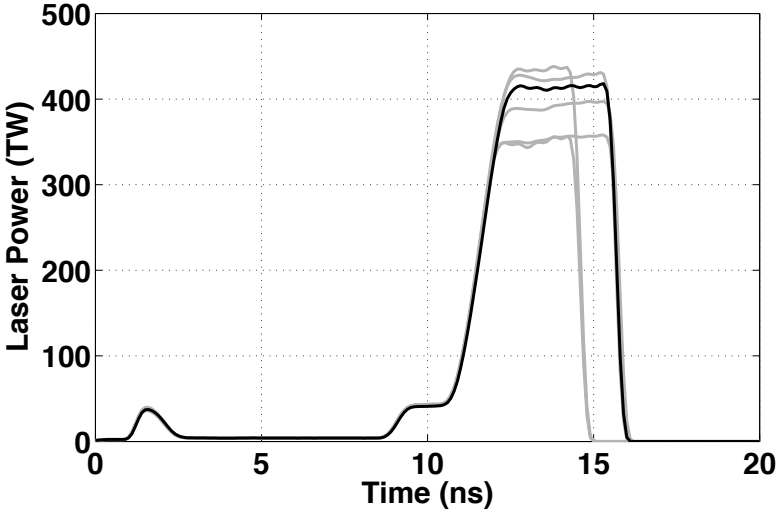




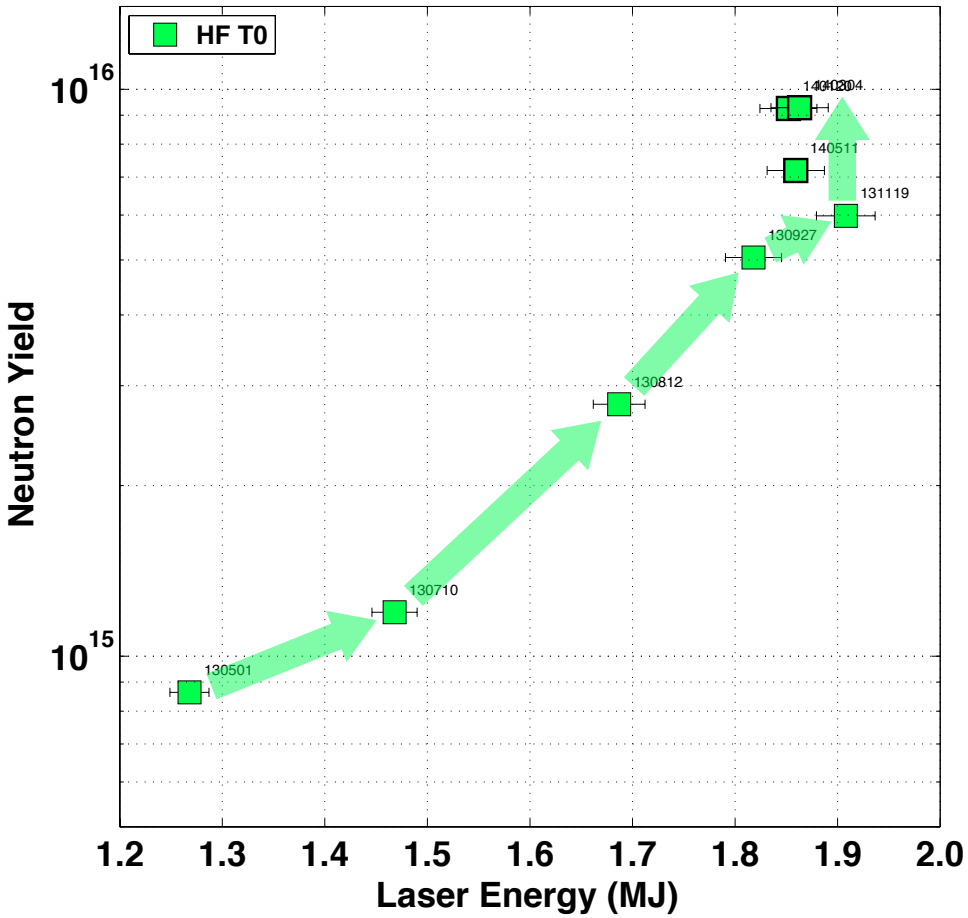
Switch from Au to DU hohlraums added some extra drive

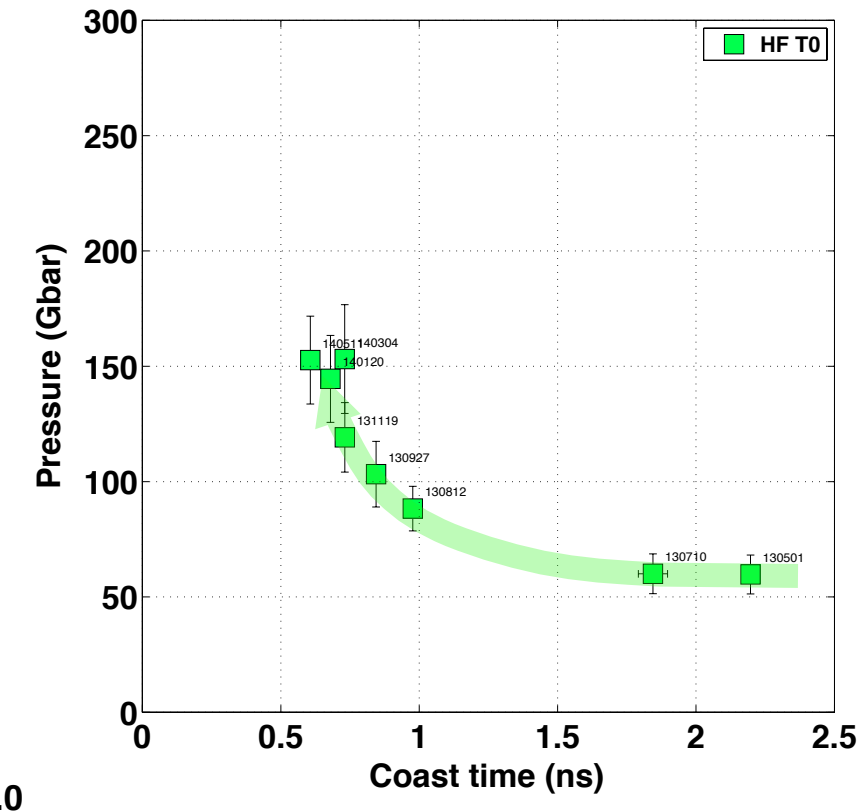




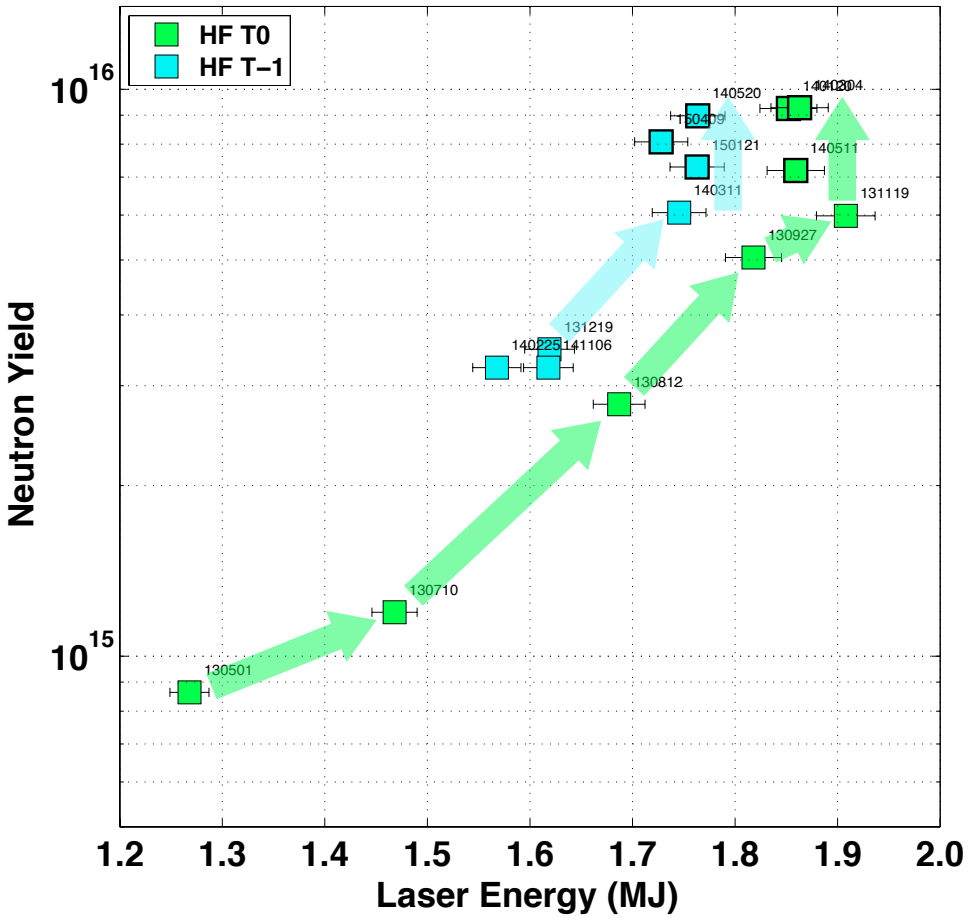


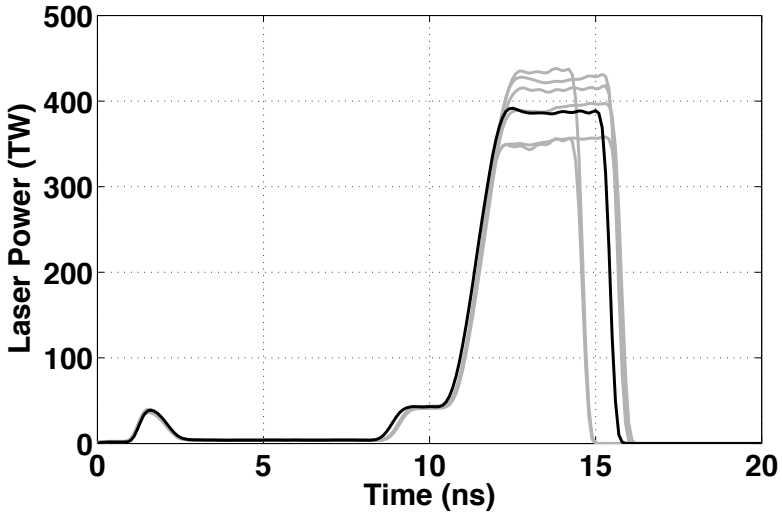
Stagnation pressure continued to increase, no ablator mix was observed





Thinner capsule improved symmetry and did not mix making room to push further





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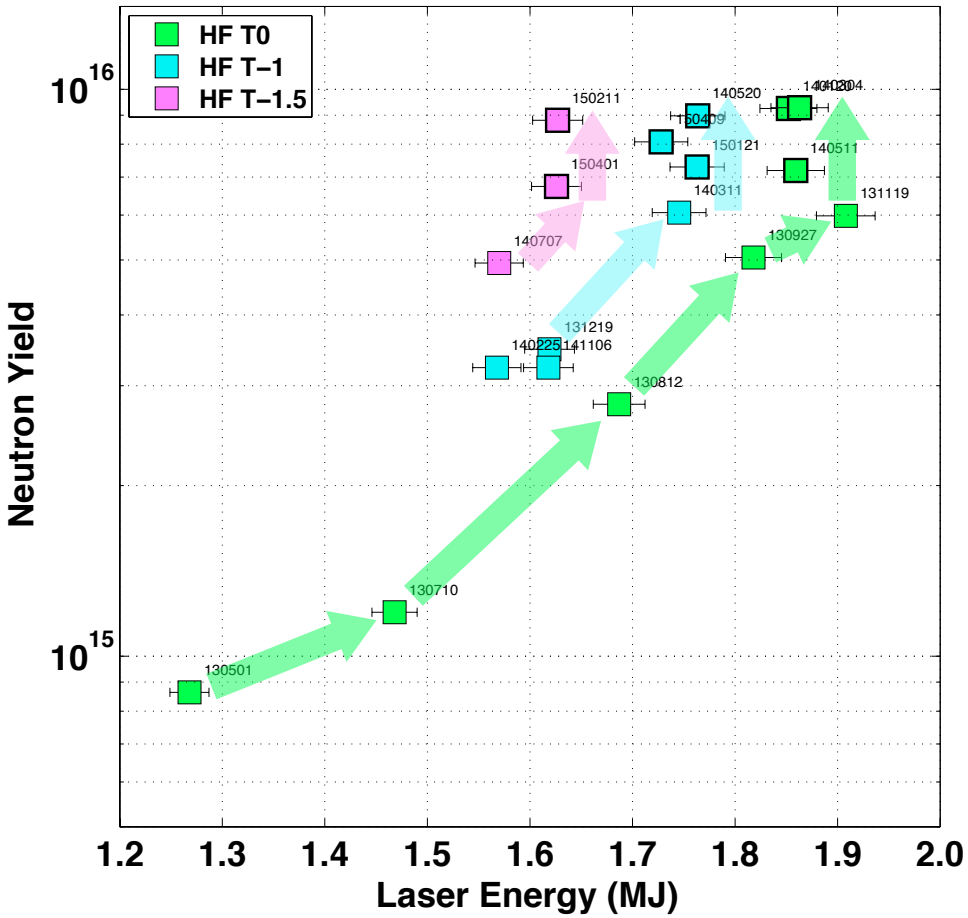

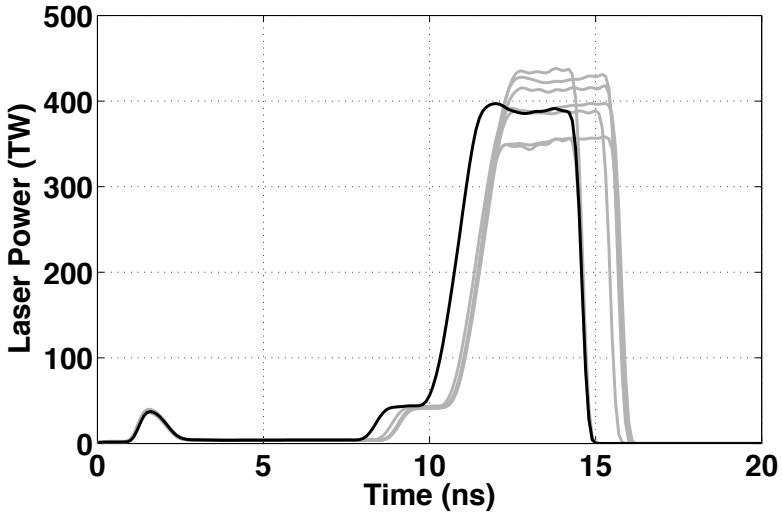

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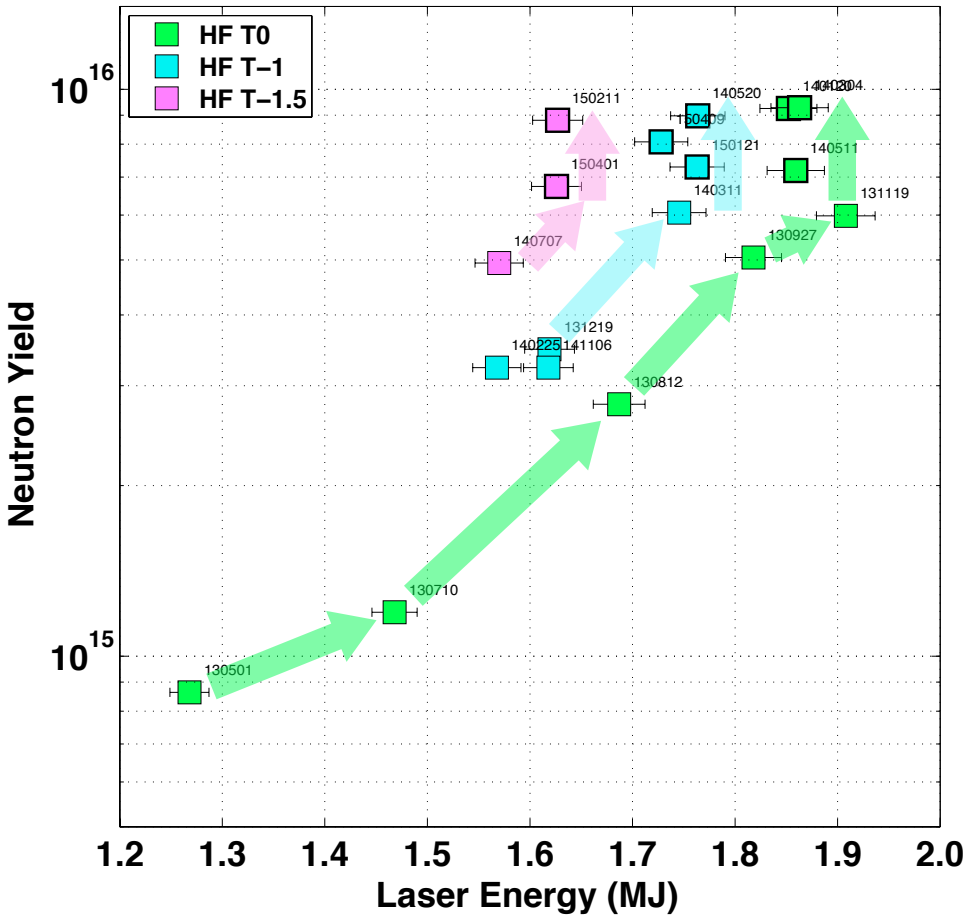

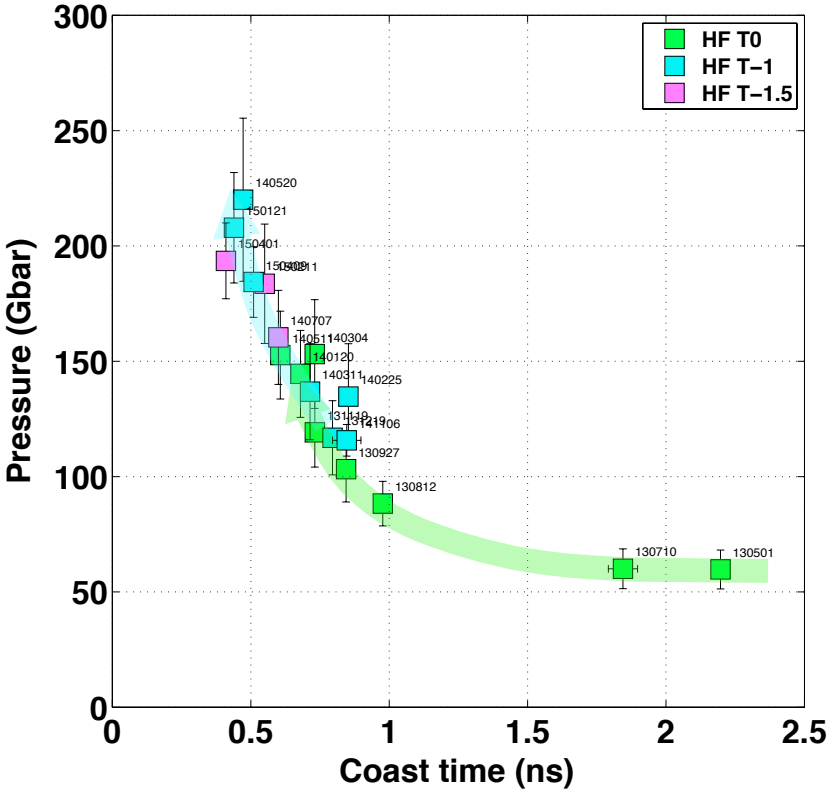

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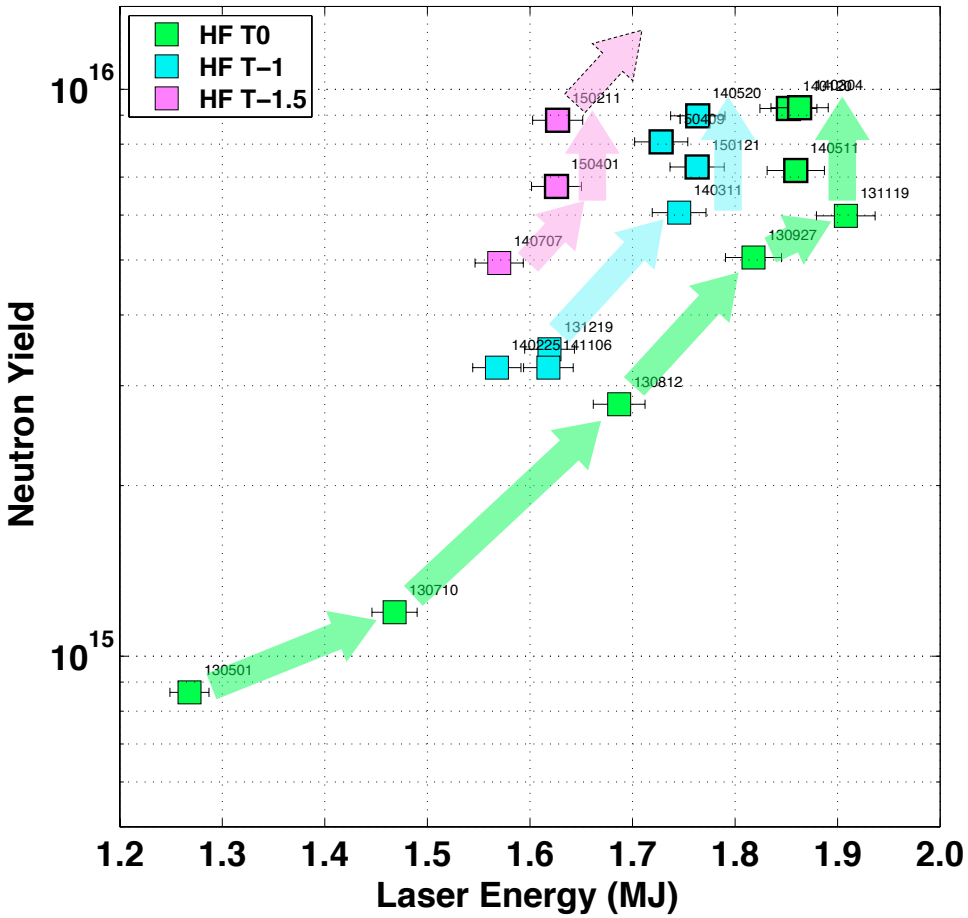
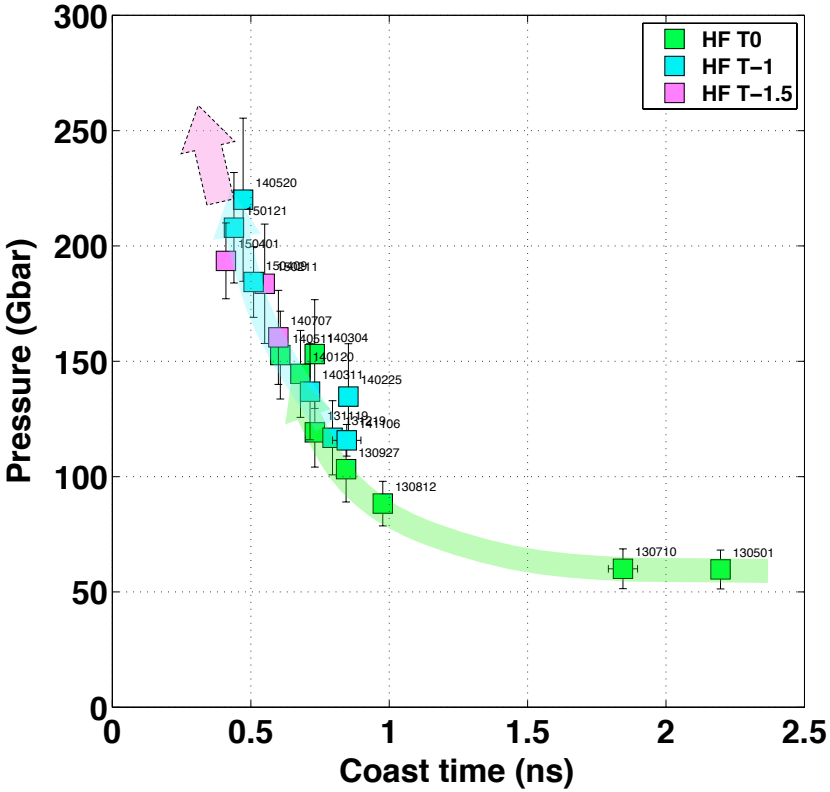
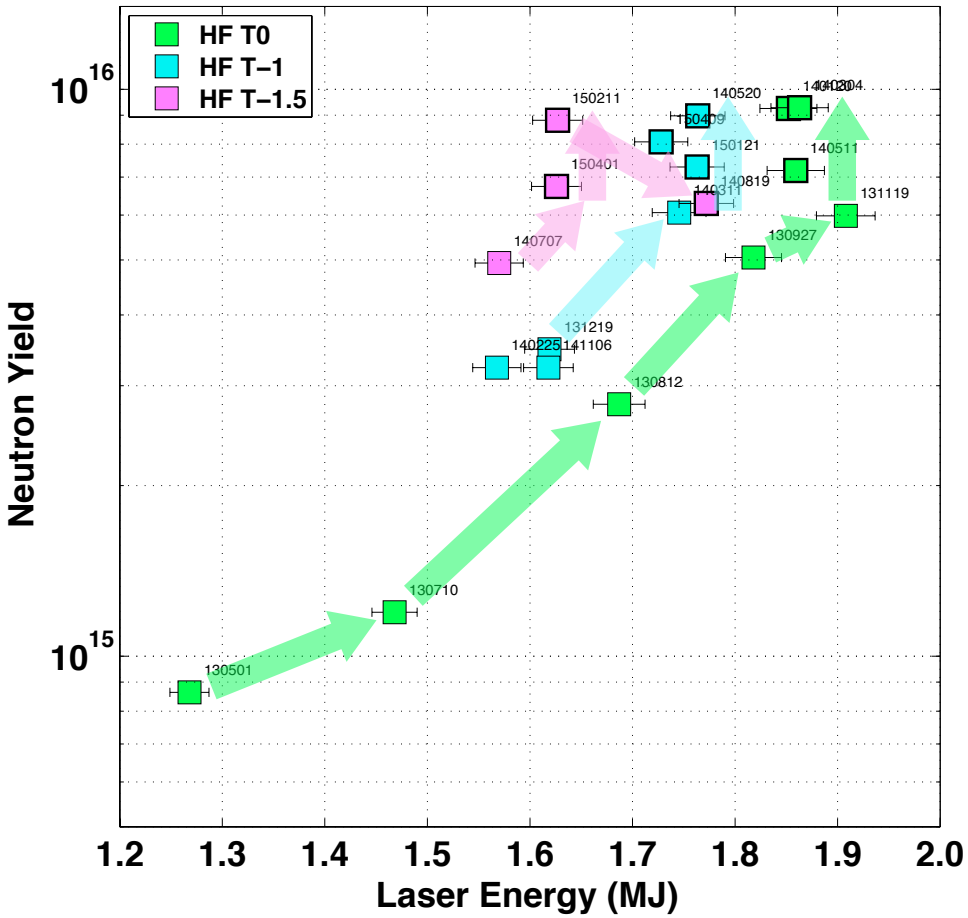
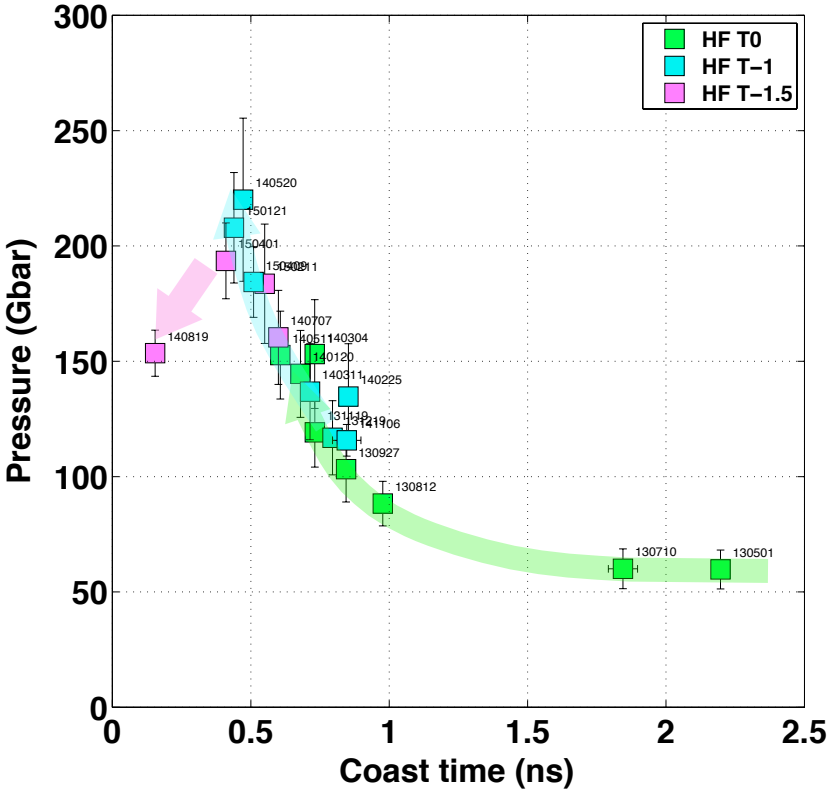


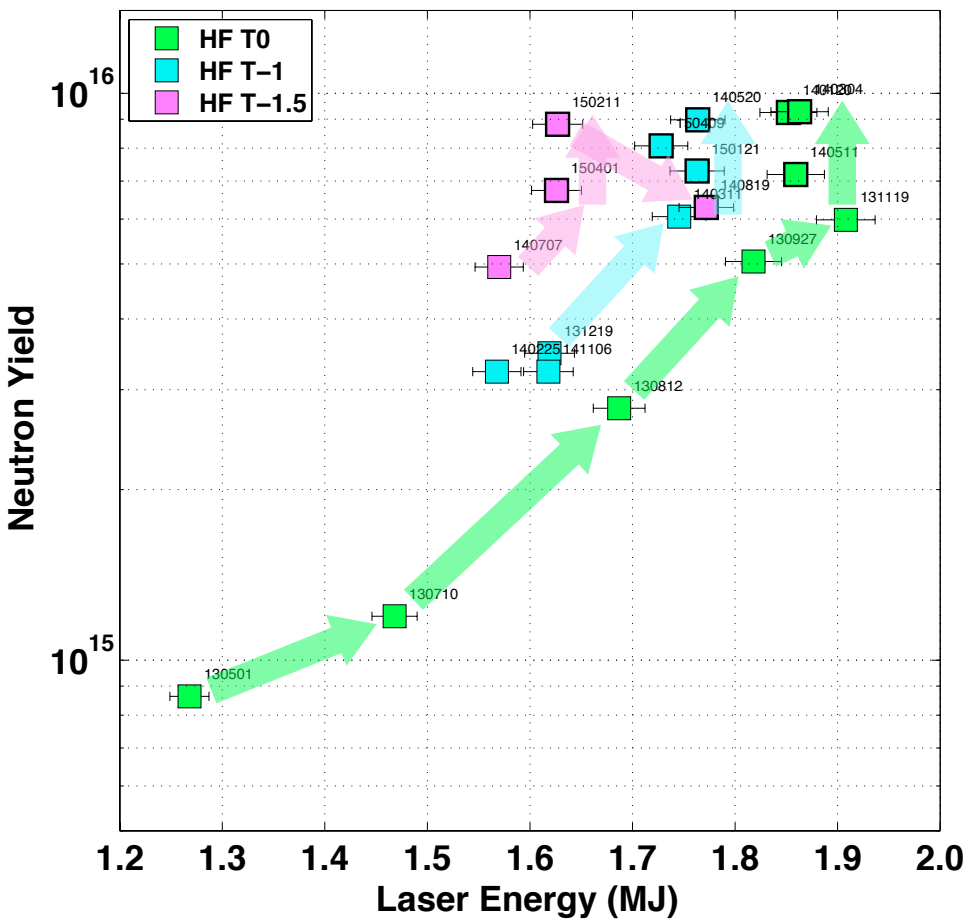


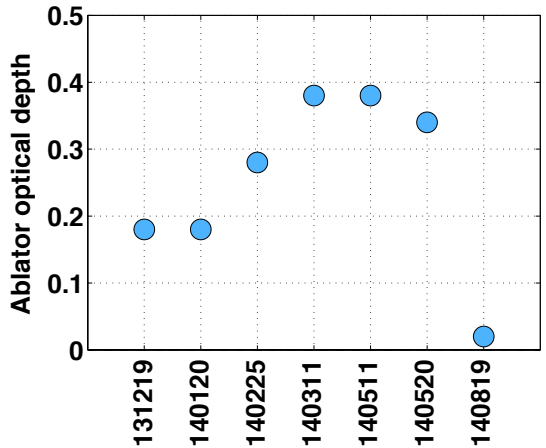
Apparent cliff, but not ablator mix

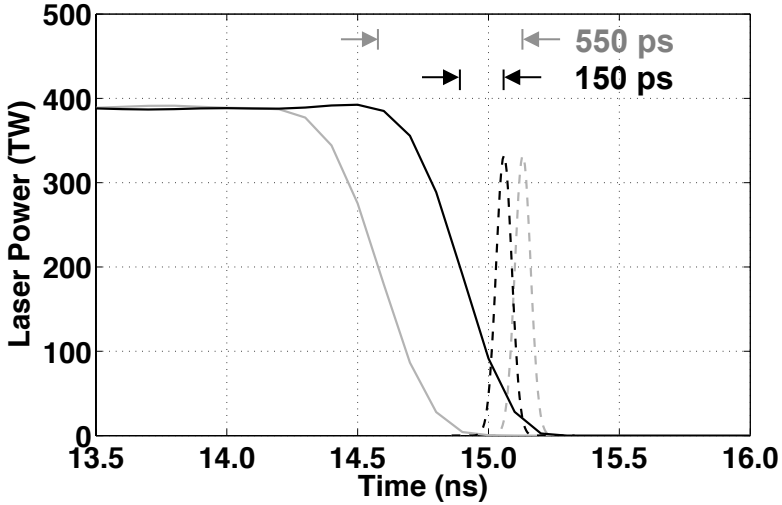




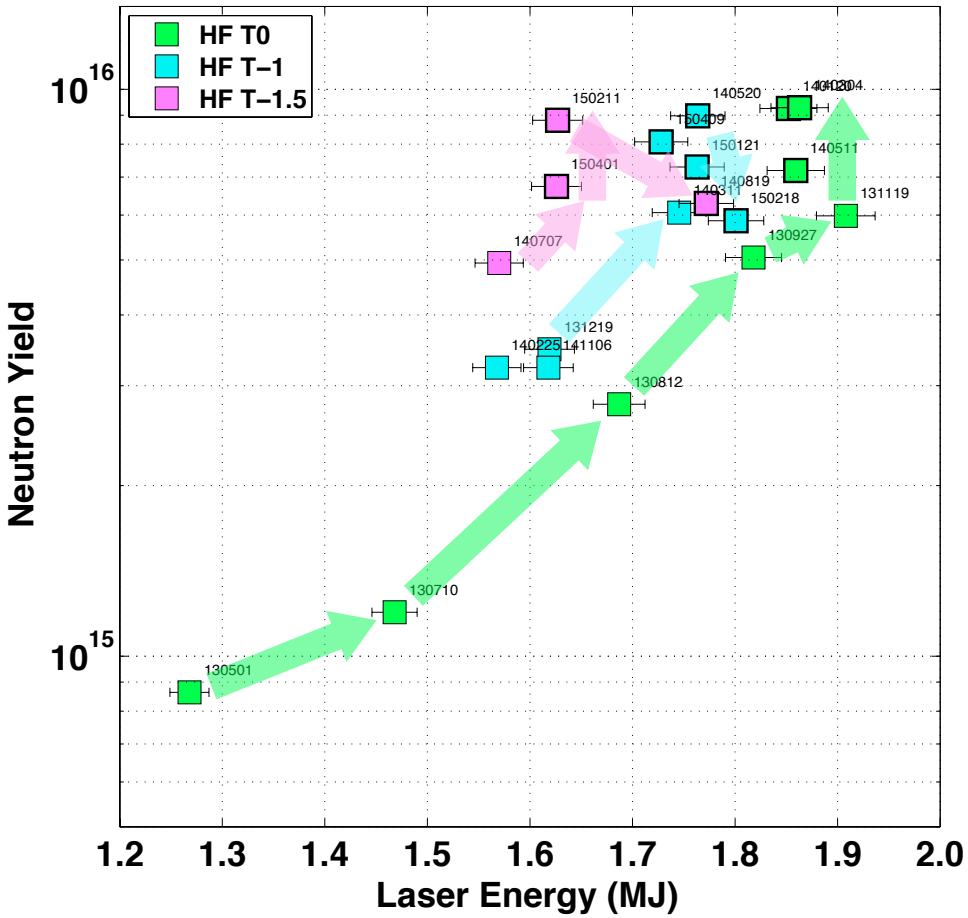
Leading hypothesis is localised burn-through of ablator

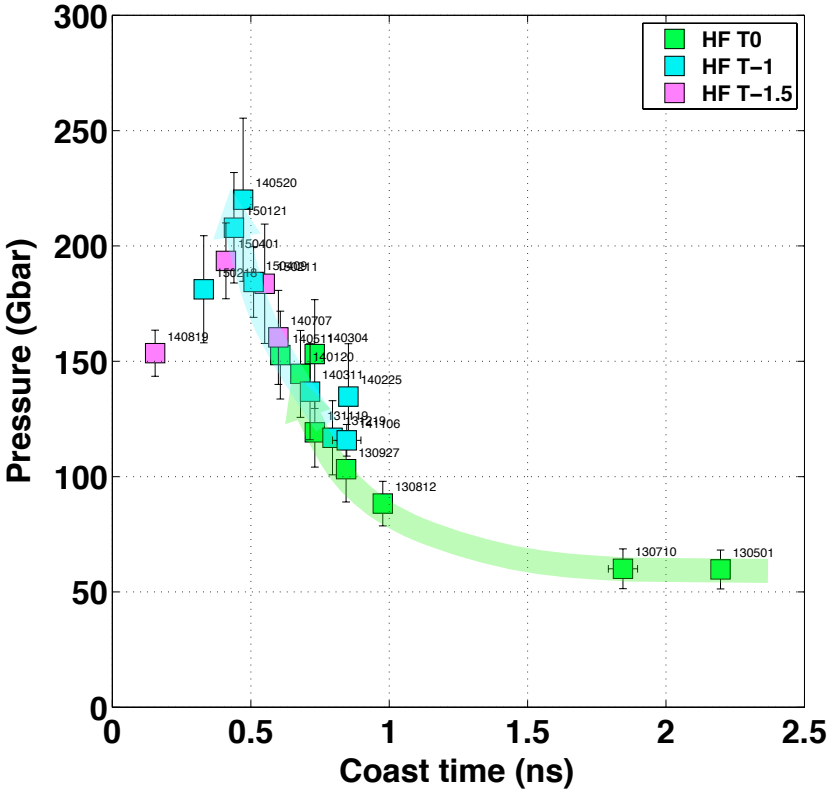




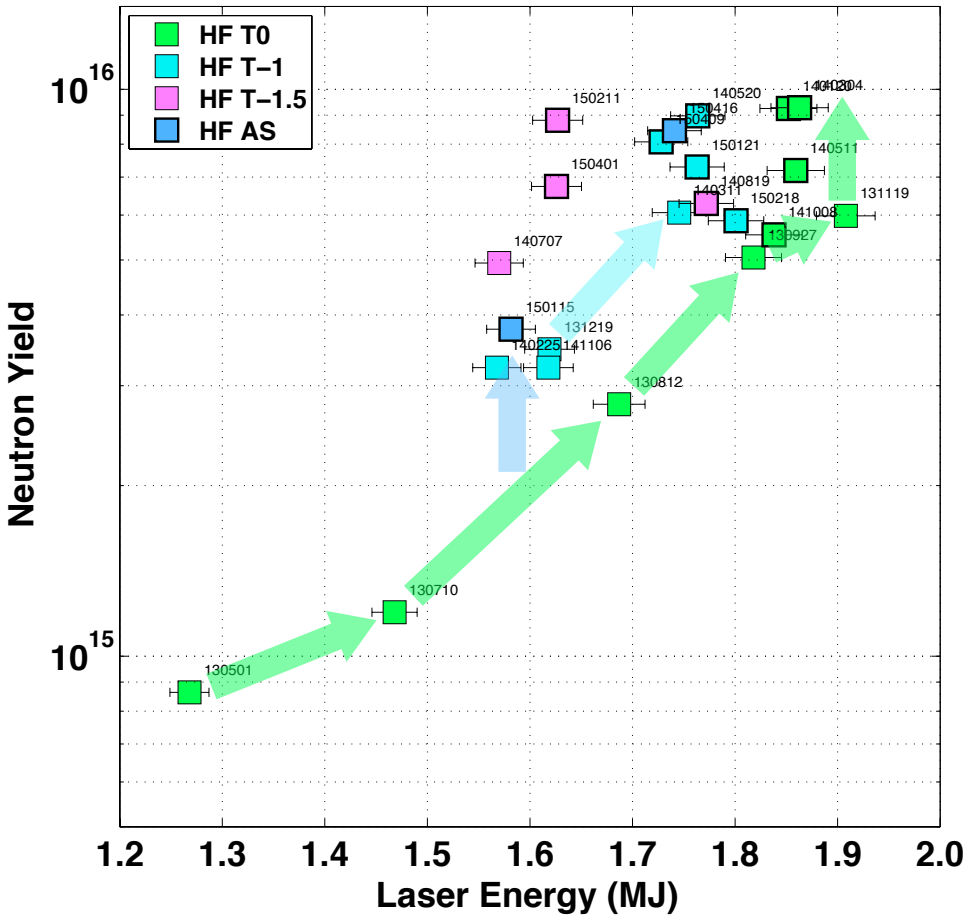


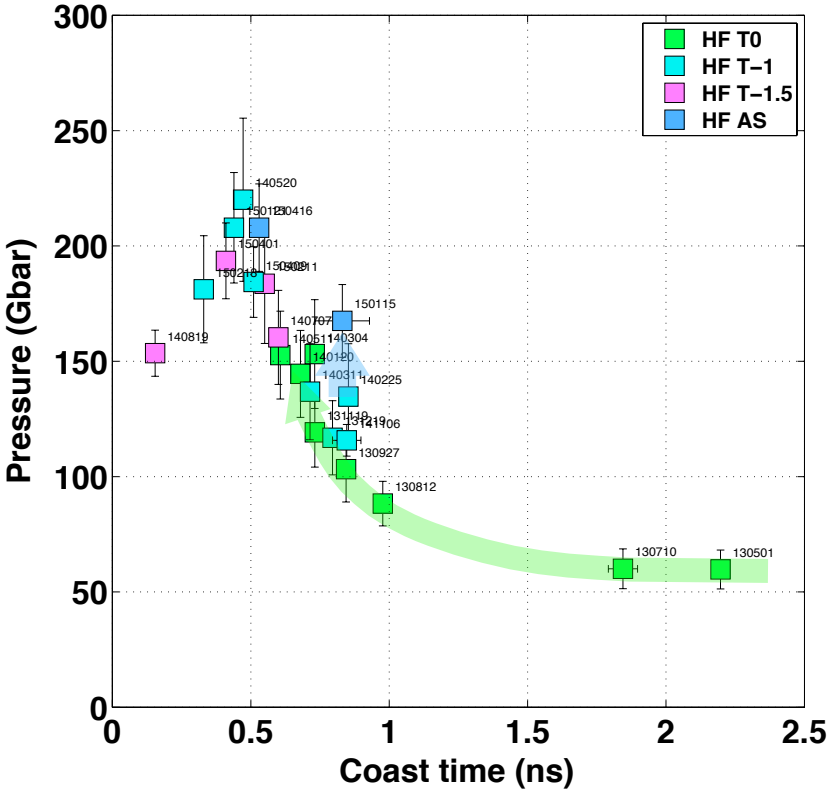
Attempt to push the T-1 ablator produced the same result



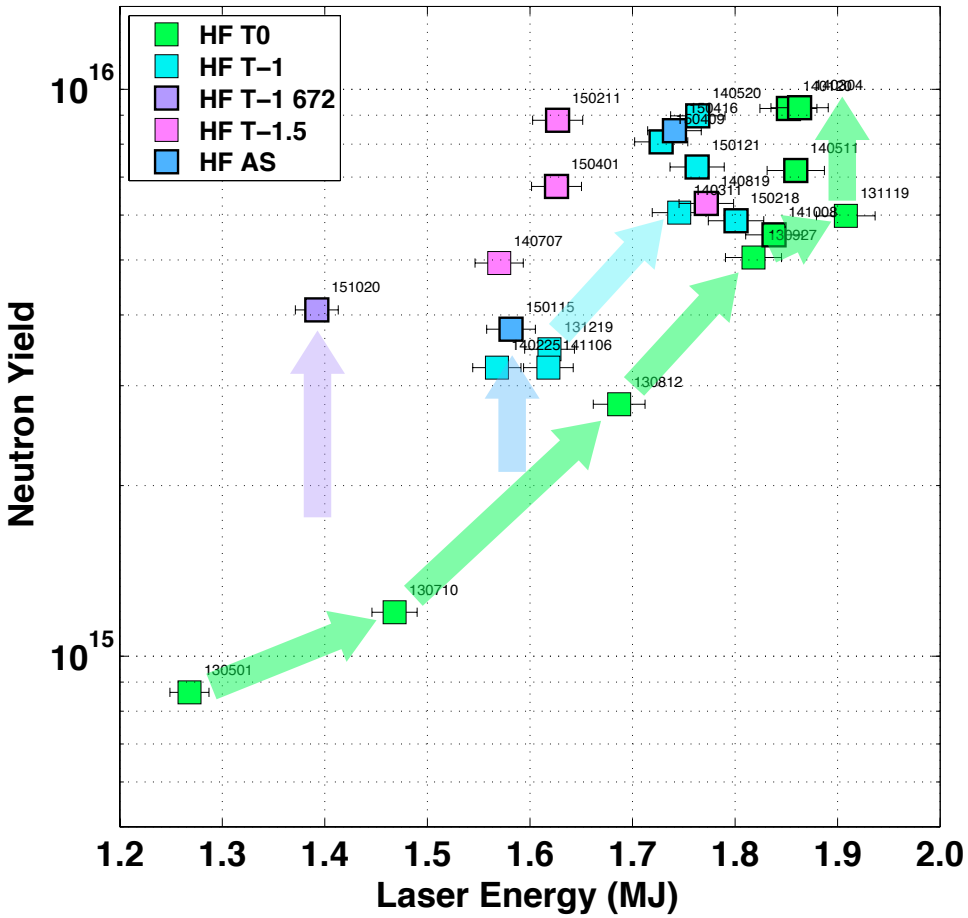


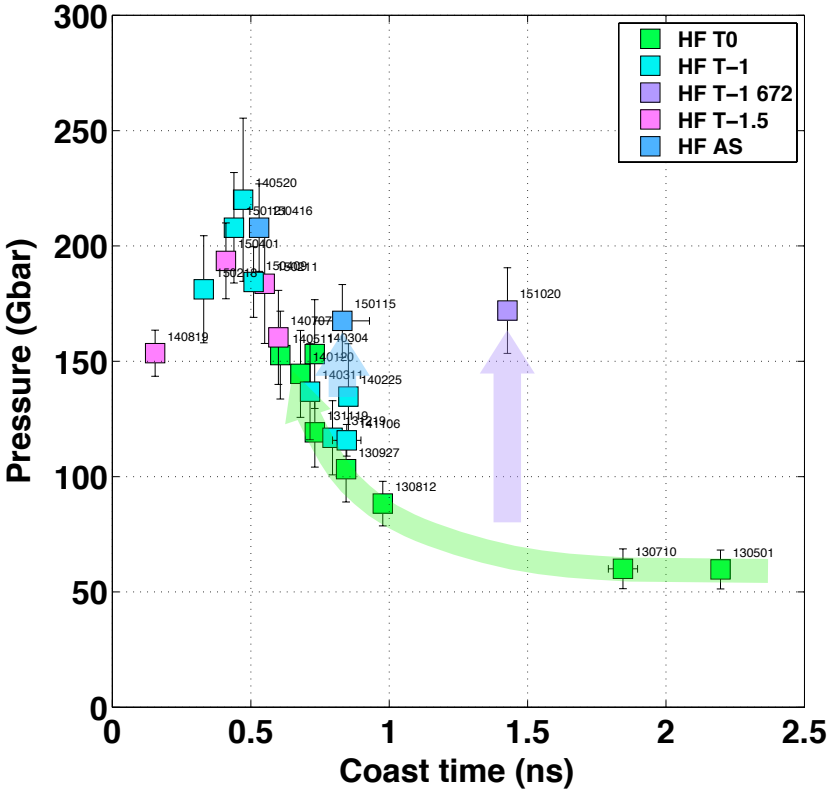
We performed two shots with an adiabat-shaping pulse





We have performed two shots using larger (672) hohlraums with low gas fill





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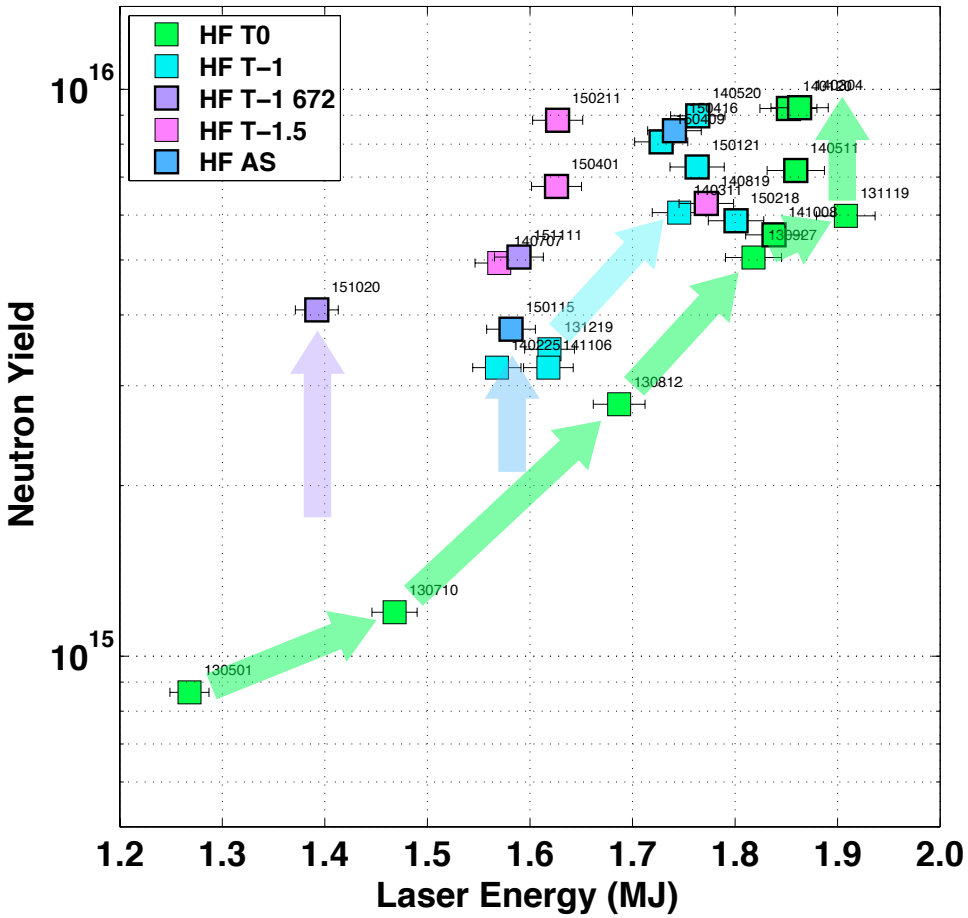

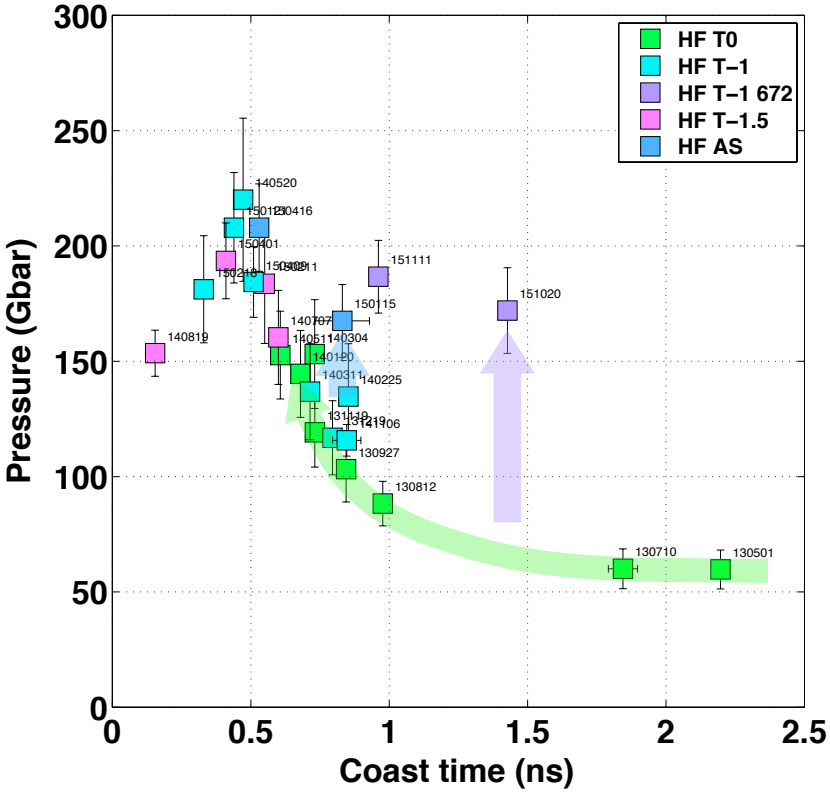

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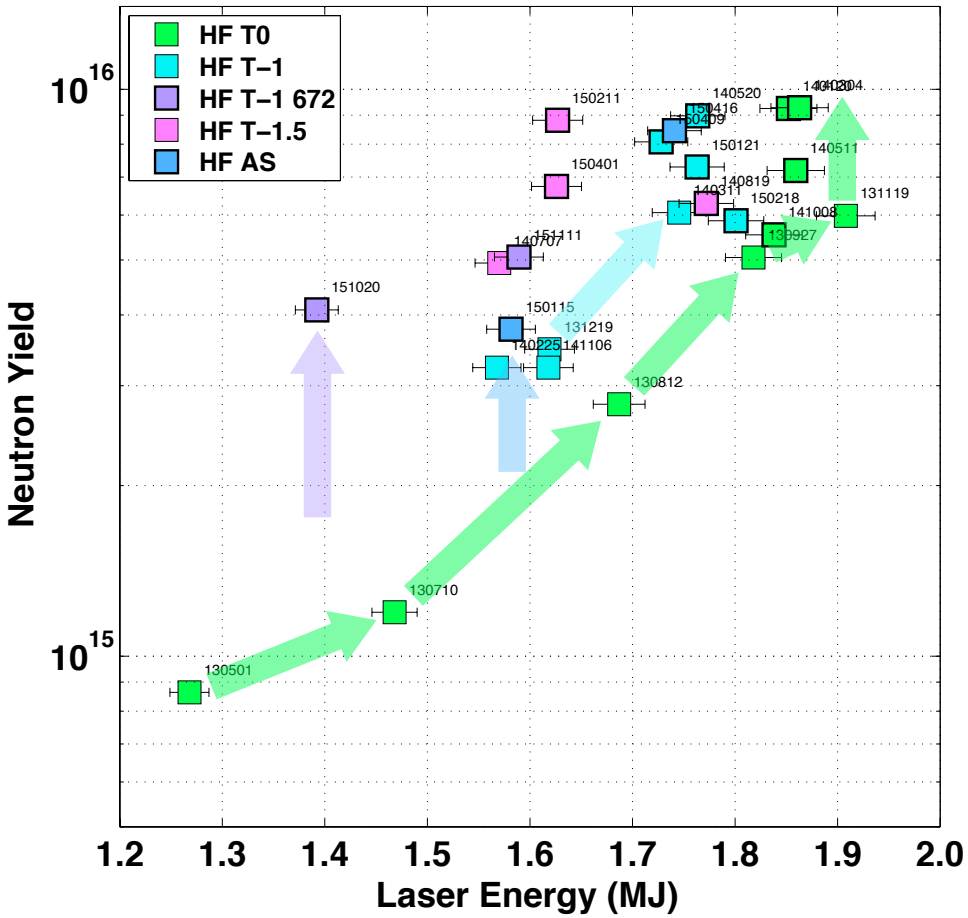
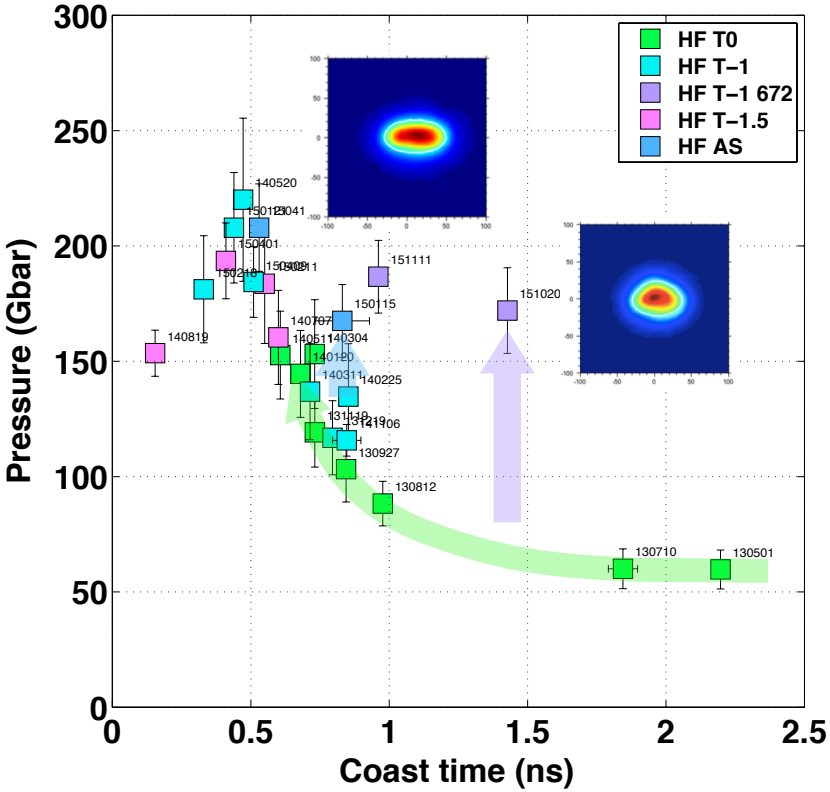
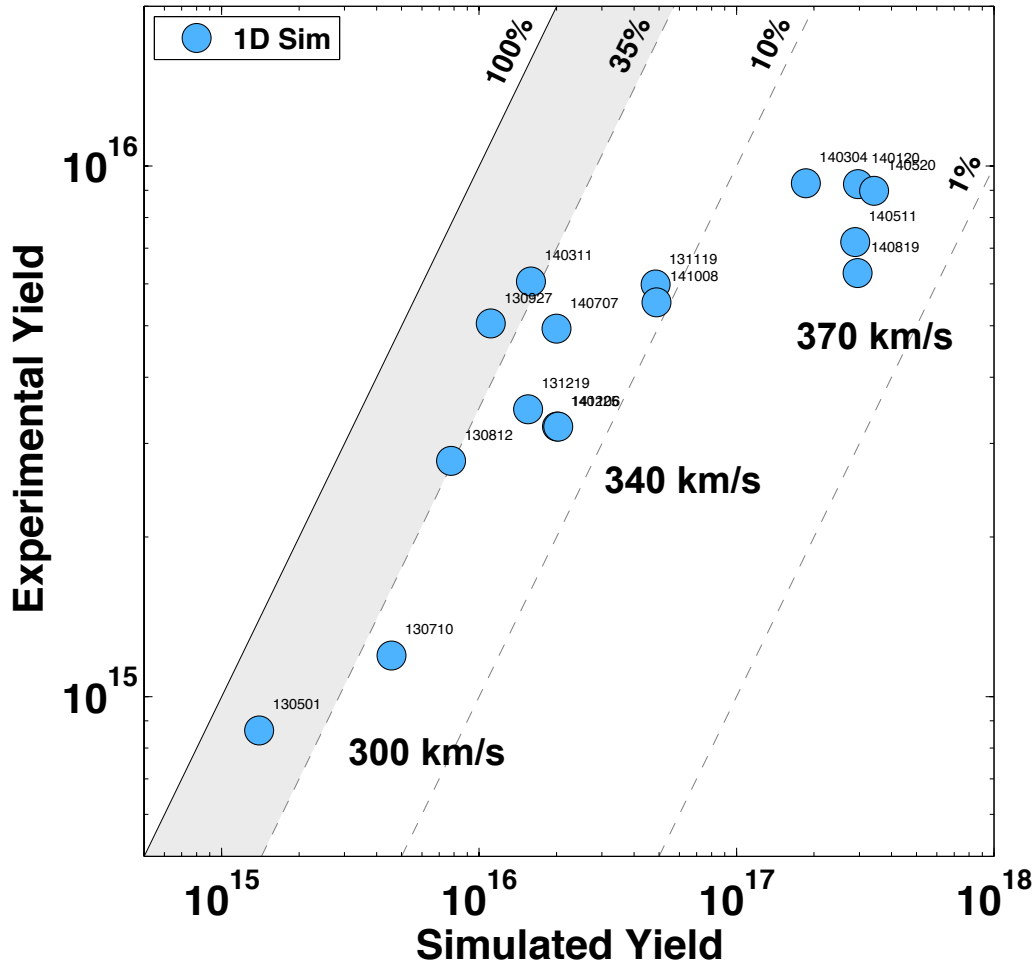




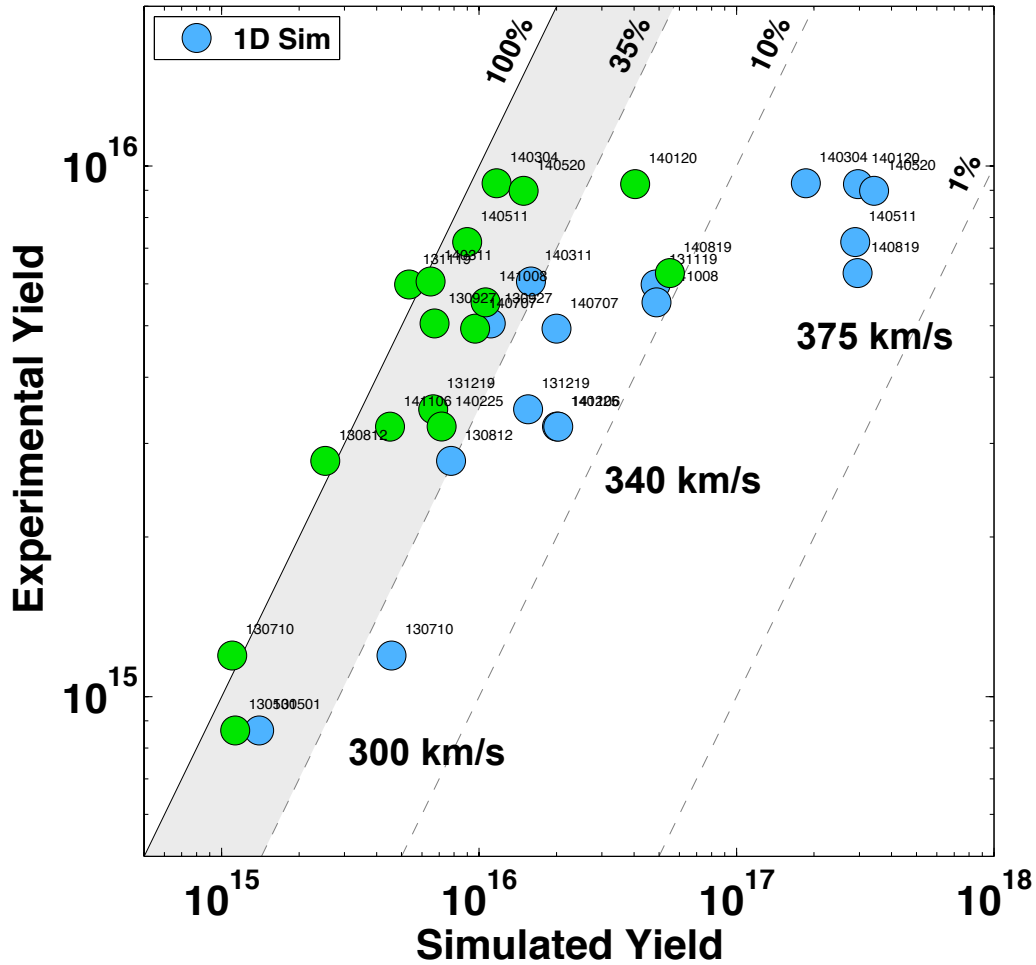
The 1D yield-over-clean started at ~50% but fell as the implosion velocity increased



- Integrated hohlraum simulations with drives tuned to match shock timing measurements, in-flight radiography, and bangtime.
- In 1D simulations predict the highest velocity implosions to ignite

A. L. Kritcher, Phys. Plasmas (submitted)

Including the 2D drive asymmetry most of the experimental yields are reasonably close to simulation



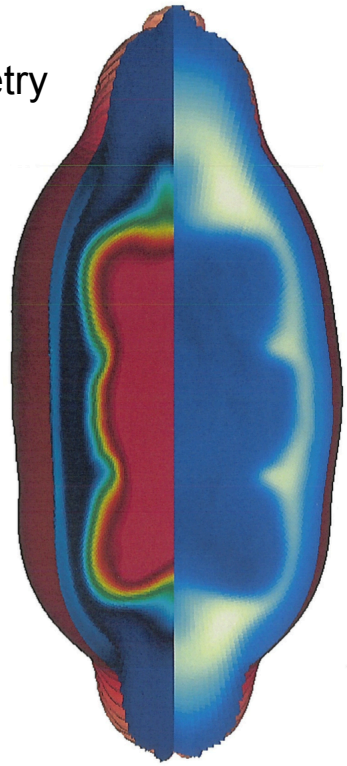
- 2D simulations include low-mode drive asymmetry from hohlraum, but not high-mode features such as surface roughness, tent, etc.

A. L. Kritcher, Phys. Plasmas (submitted)

We have performed highly-resolved 3D capsule-only simulations of selected shots

N140819

Drive asymmetry only

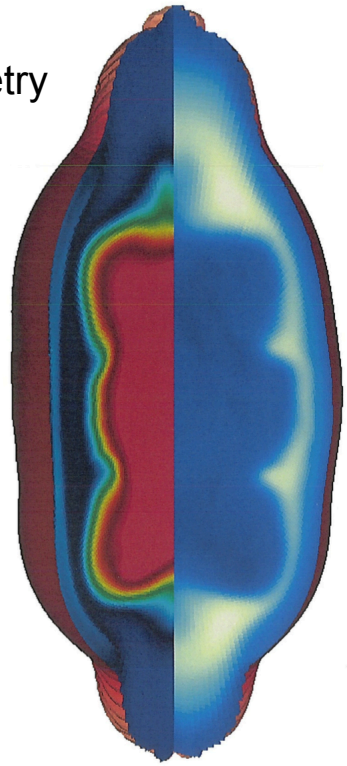


D. S. Clark, Phys. Plasmas 23, 056302 (2016)

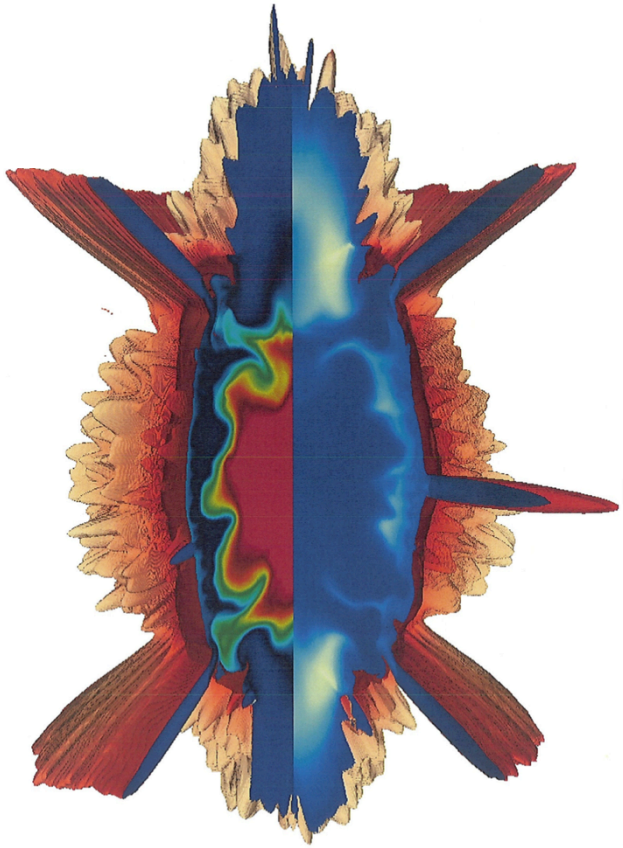
At the highest velocities the tent is likely affecting the integrity of the shell and reducing performance

N140819

Drive asymmetry only



+ roughness
+ fill tube
+ tent

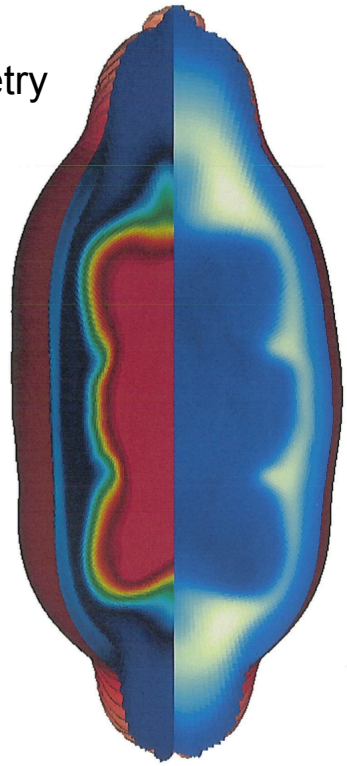


D. S. Clark, Phys. Plasmas 23, 056302 (2016)

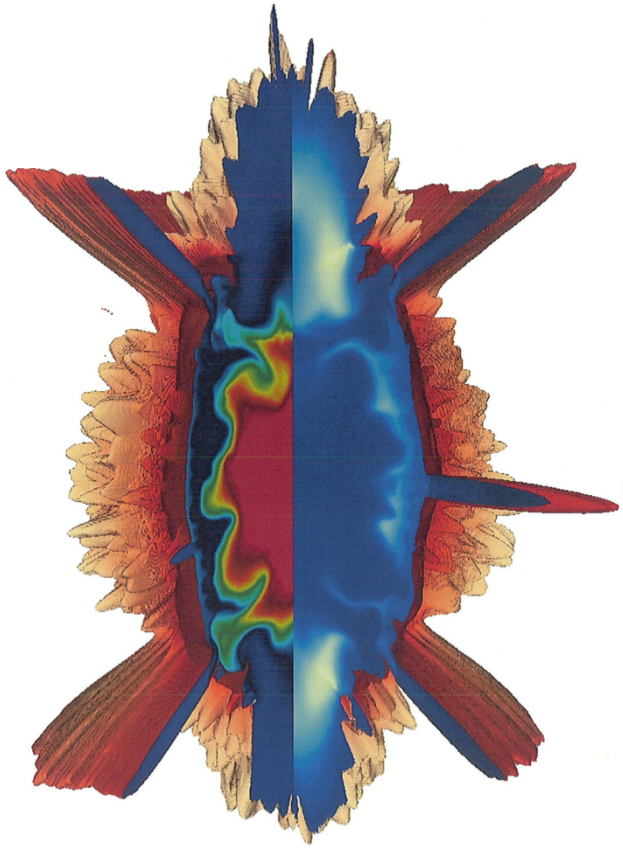
At the highest velocities the tent is likely affecting the integrity of the shell and reducing performance

N140819

Drive asymmetry only



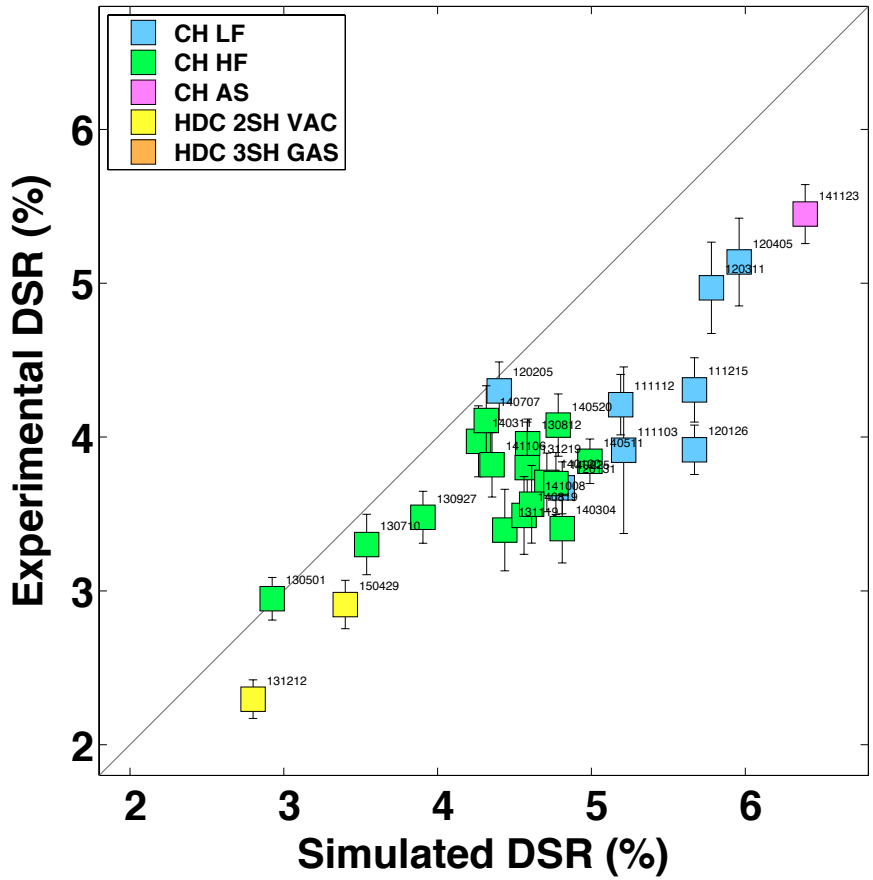
+ roughness
+ fill tube
+ tent



D. S. Clark, Phys. Plasmas 23, 056302 (2016)

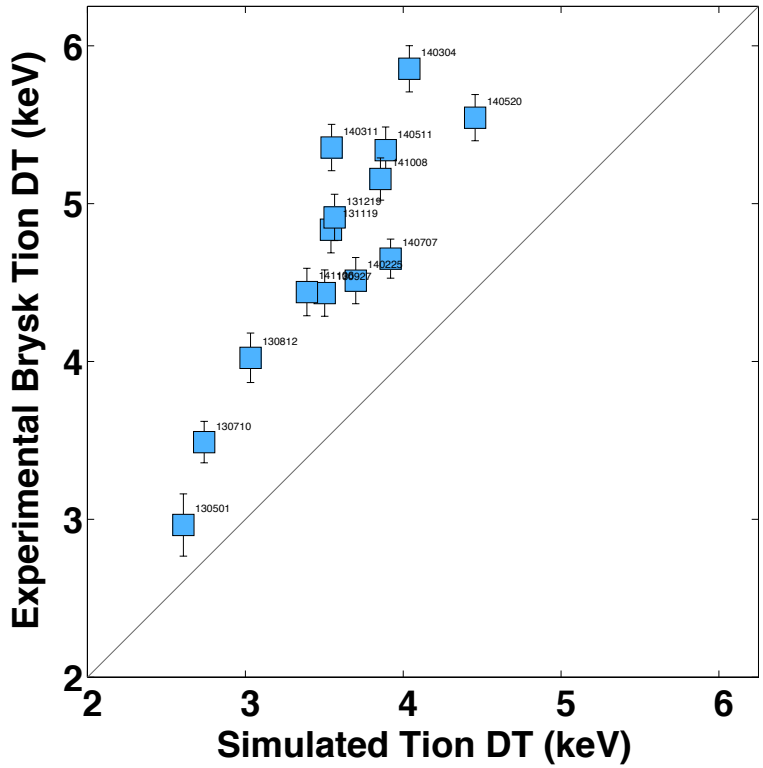
Whilst the yields of the HF experiments follow a reasonably understandable trend, and broadly agree with simulations, several significant anomalies remain

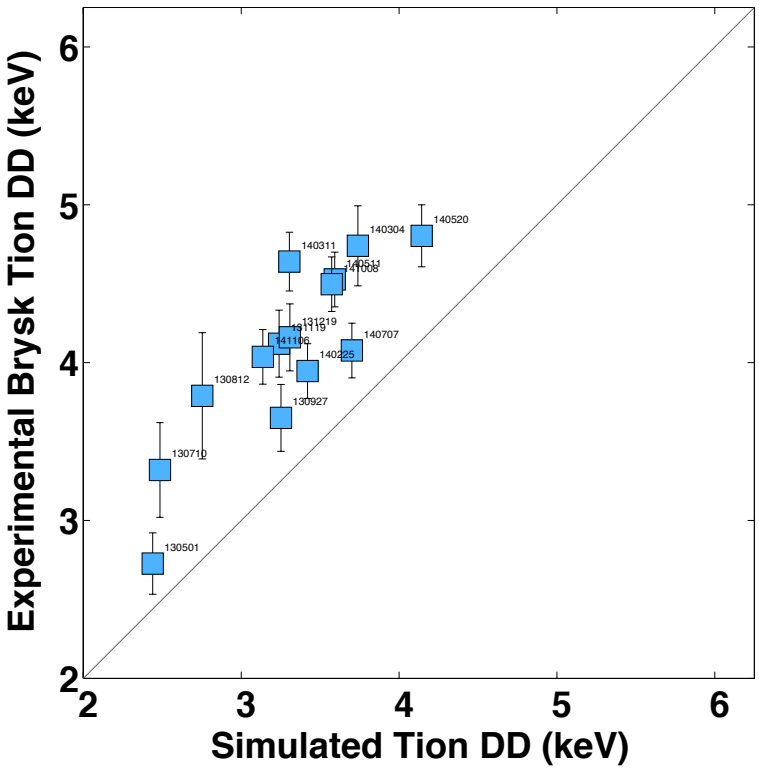
Anomaly: the measured DSR, or fuel areal density, is often lower than predicted



- For high-foot, the experimental and simulated DSRs agree at low implosion velocity, but deviate at high velocity
- Hypotheses include:
  - 3D effects that we are not properly capturing?
  - ablator-ice mix?
  - hot electron preheat?
  - EOS?
  - kinetic effects?

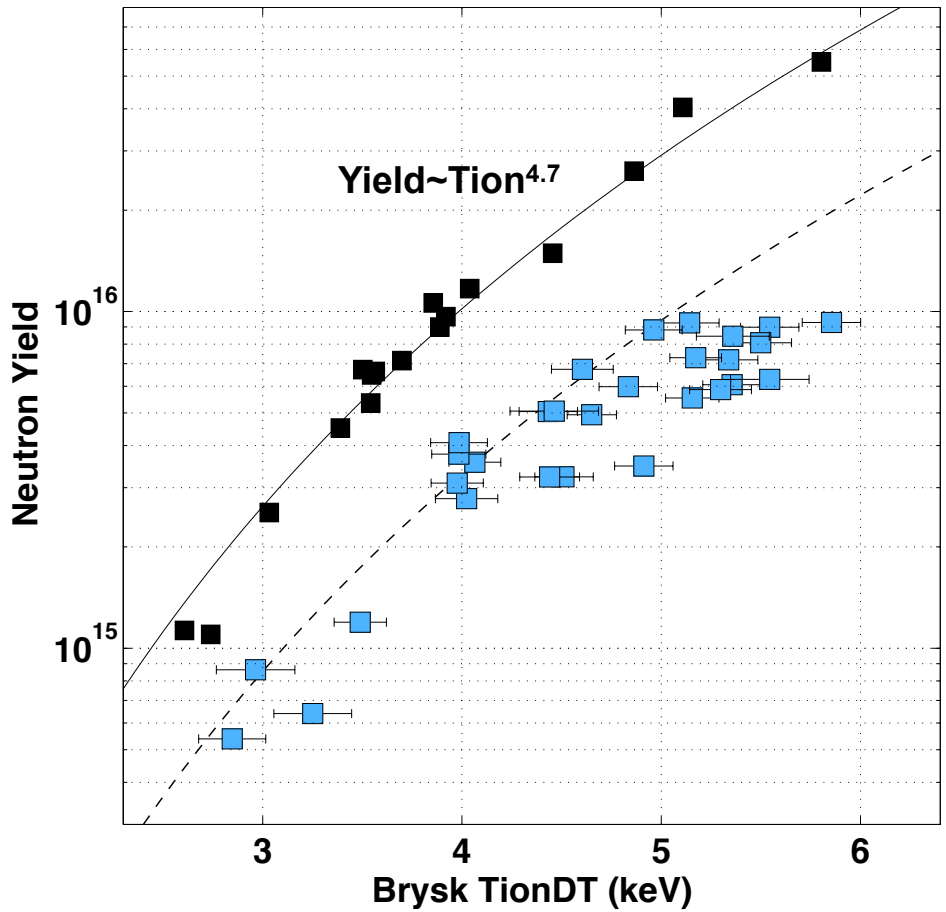
Anomaly: experimental "Brysk ion temperatures" are higher than simulated





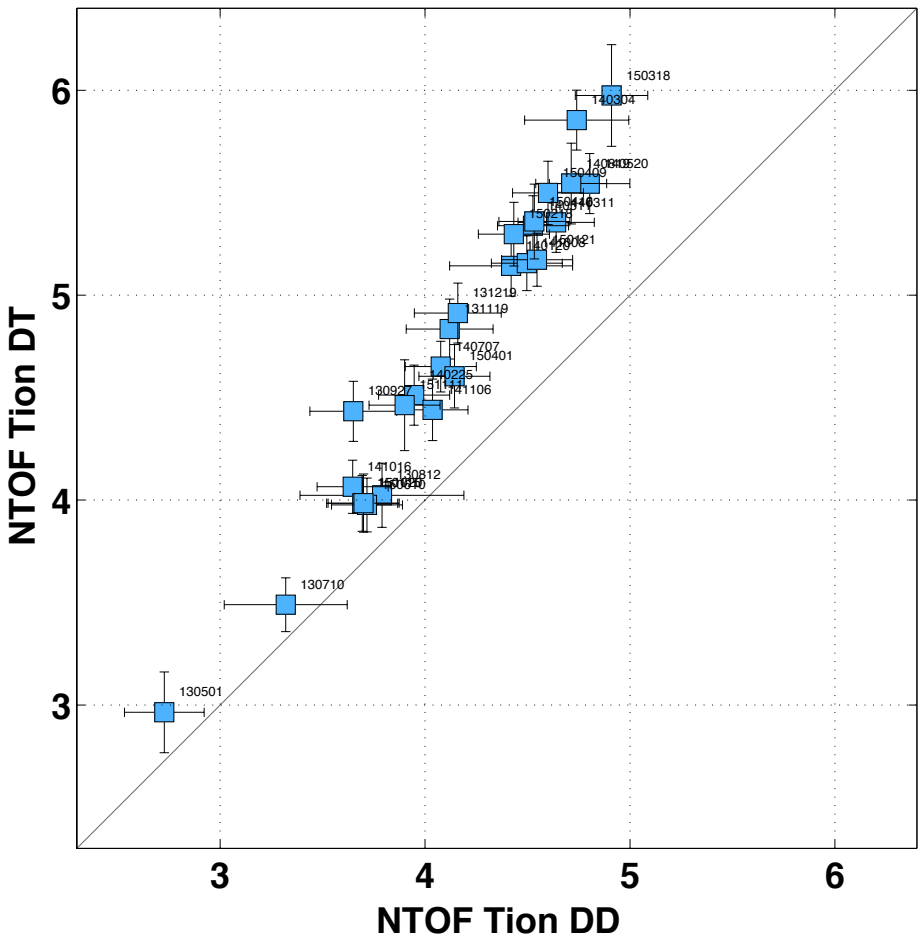
- True for both DT and DD temperatures – differences larger for DT

Anomaly: experimental "Brysk ion temperatures" are higher than simulated



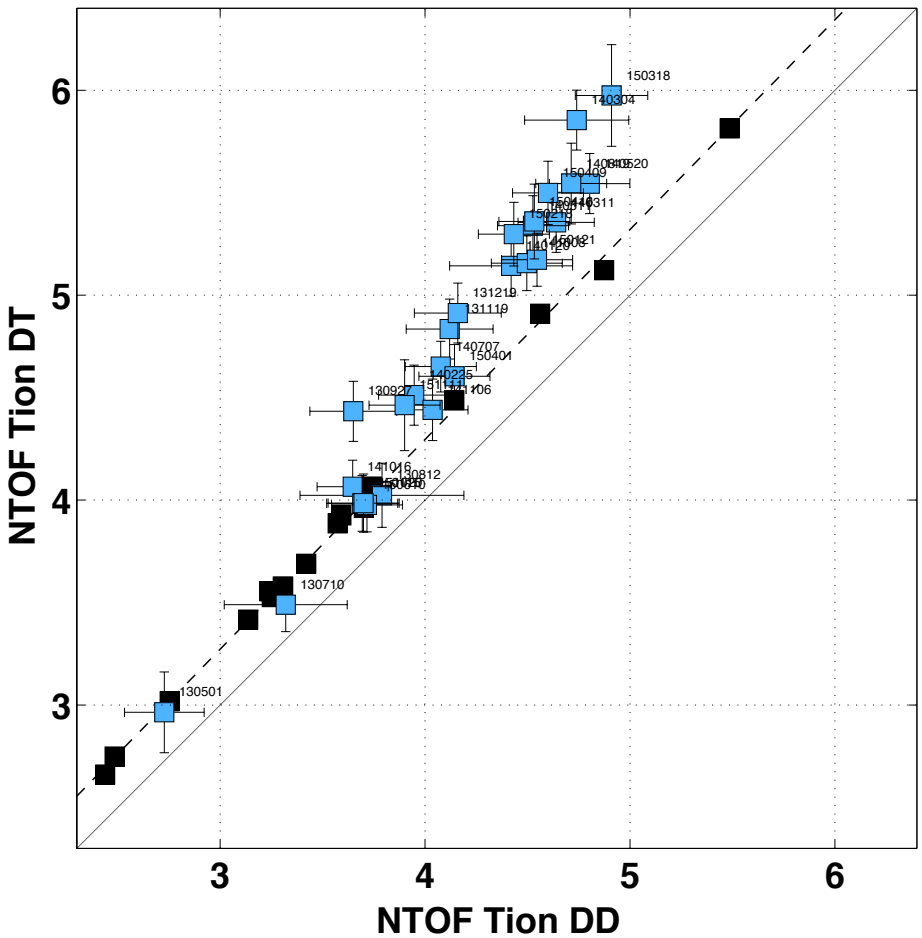
- Both simulations and theory predict a tight correspondence between yield and ion temperature, largely independent of 3D shape effects
- We know that the "Brysk width" or variance of the neutron-time-of-flight DT spectral peak has contributions from both the plasma thermal temperature distribution and non-uniform velocity distribution

Anomaly: difference between the measured DT and DD "Brysk temperatures" is larger than predicted



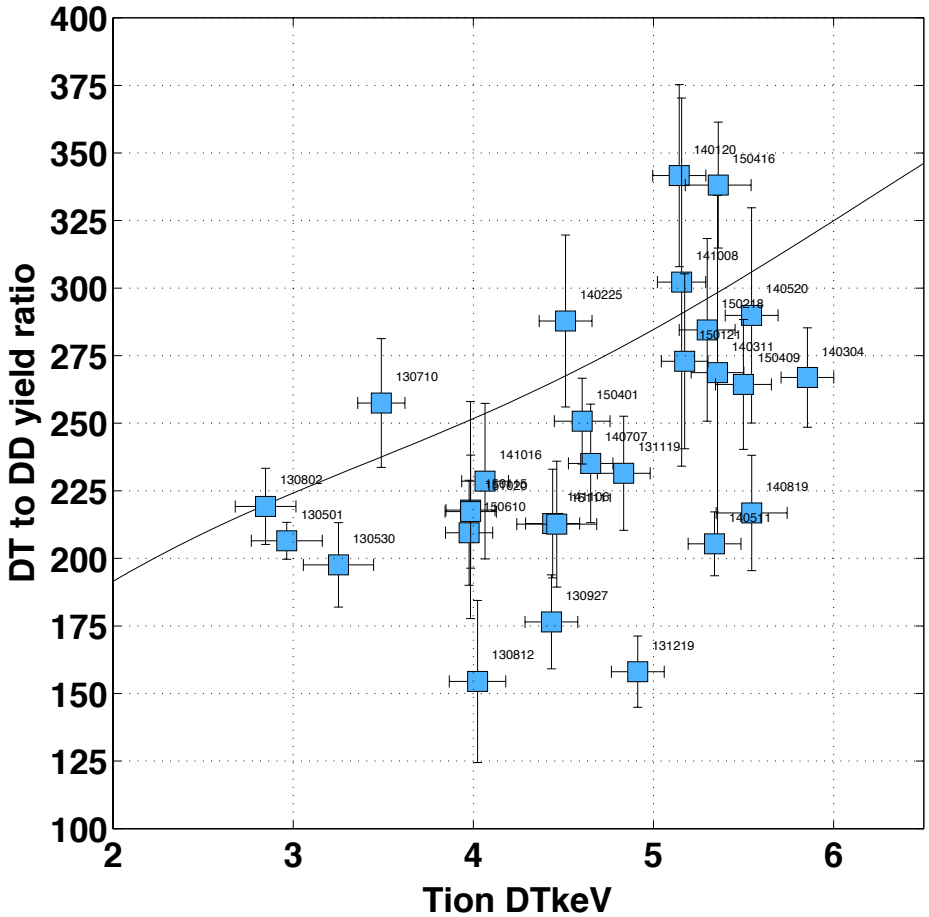
- DT-DD Brysk widths can differ from:
  - non-uniform flow velocity
  - burn-weighting due to reactivity
  - scattering
  - species separation
  - ion tail depletion
- Difference appears too large to arise from just flow velocity

Anomaly: difference between the measured DT and DD "Brysk temperatures" is larger than predicted



- DT-DD Brysk widths can differ from:
  - non-uniform flow velocity
  - burn-weighting due to reactivity
  - scattering
  - species separation
  - ion tail depletion
- Difference appears too large to arise from just flow velocity
- Also larger than we predict due to burn-weighting

Anomaly: We observe more DD neutrons relative to DT than predicted



- DD-DT neutron yield depends on:
  - thermal temperature
  - isotopic composition
  - scattering
- Hypotheses include:
  - lower thermal temperature
  - isotopic composition is actually weighted to D (some recent evidence for this from fill station measurements)
  - scattering corrections not correct
  - kinetic effects

M. Gatu Johnson et al. (submitted)

Lawrence Livermore
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