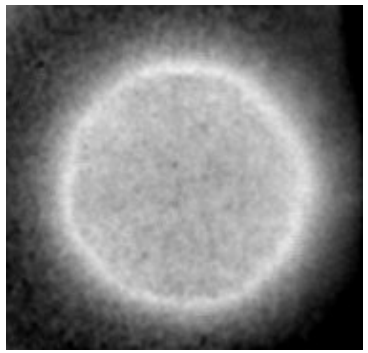
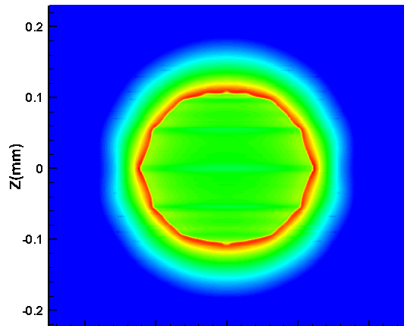
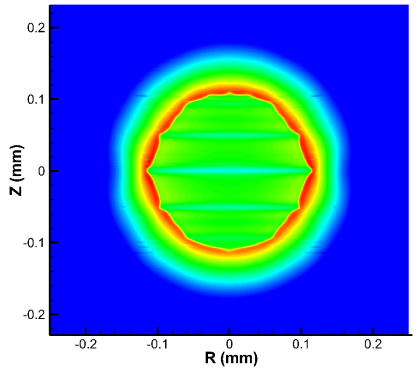
Evaluation of Polar-Direct-Drive, Contoured-Shell Experiments at the National Ignition Facility

N200715-001: without contour

DIM 90-78 (1x mag)







DRACO/Spect3D

N201021-002: contoured shell

P. W. McKenty
University of Rochester
Laboratory for Laser Energetics

62nd Annual Meeting of the
American Physical Society
Division of Plasma Physics
Virtual Meeting
9-13 November, 2020

Summary

Contoured shells help mitigate inflight shell nonuniformities inherent with the use of NIF Polar-drive illumination

- Current goal of the Neutron Source Working Group (NSWG) is to produce routine neutron yields in excess of 100 kJ

- Contour profiles have been developed using inflight density perturbations taken from 2D Draco simulations and successfully manufactured by GA

- There is clear evidence that shell contouring improves the overall in-flight shell morphology.

Initial NIF contoured shell experiments give an inferred ~38% improvement in target performance

Collaborators

M. Rosenberg, F.J. Marshall, D. R. Harding, R. S. Craxton, J. A. Marozas, T. J. B. Collins, R. Epstein, and E. M. Campbell

University of Rochester

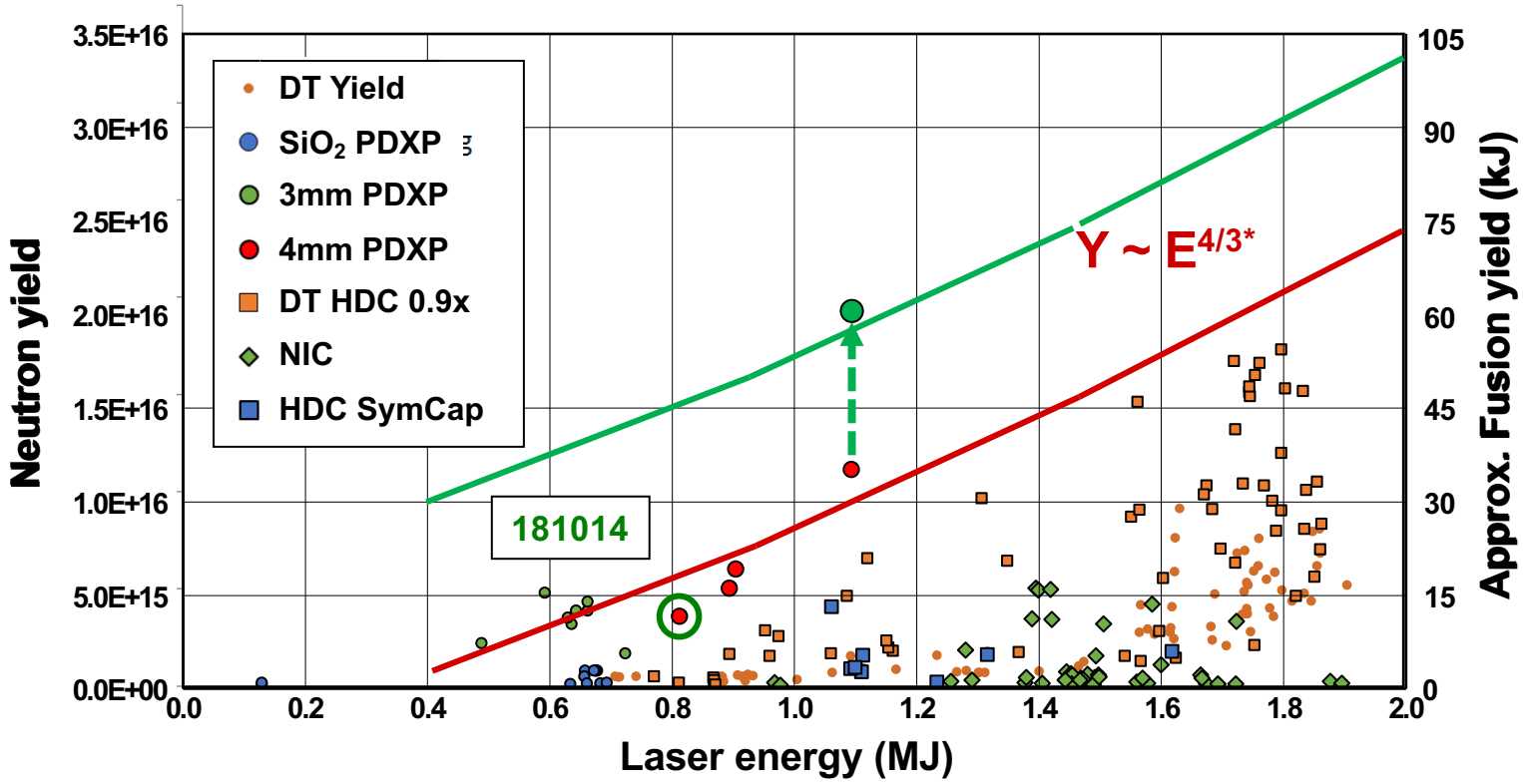
S. Schiaffino, B. Blue, C. Yeamans, L. Divol and W. Hsing

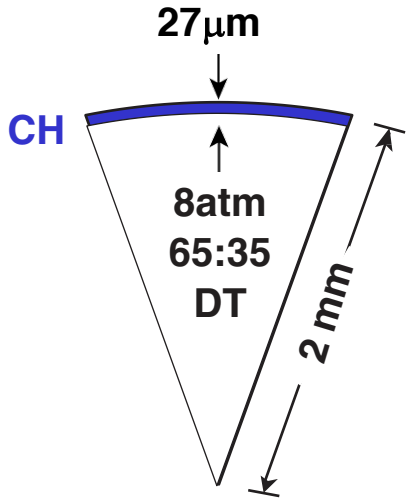
Lawrence Livermore National Laboratory

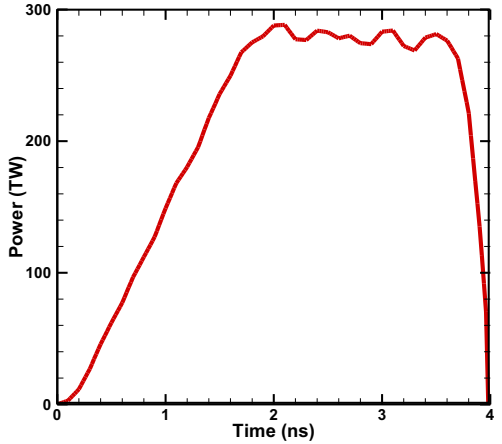
C. Shuldberg and M. Farrell

General Atomics

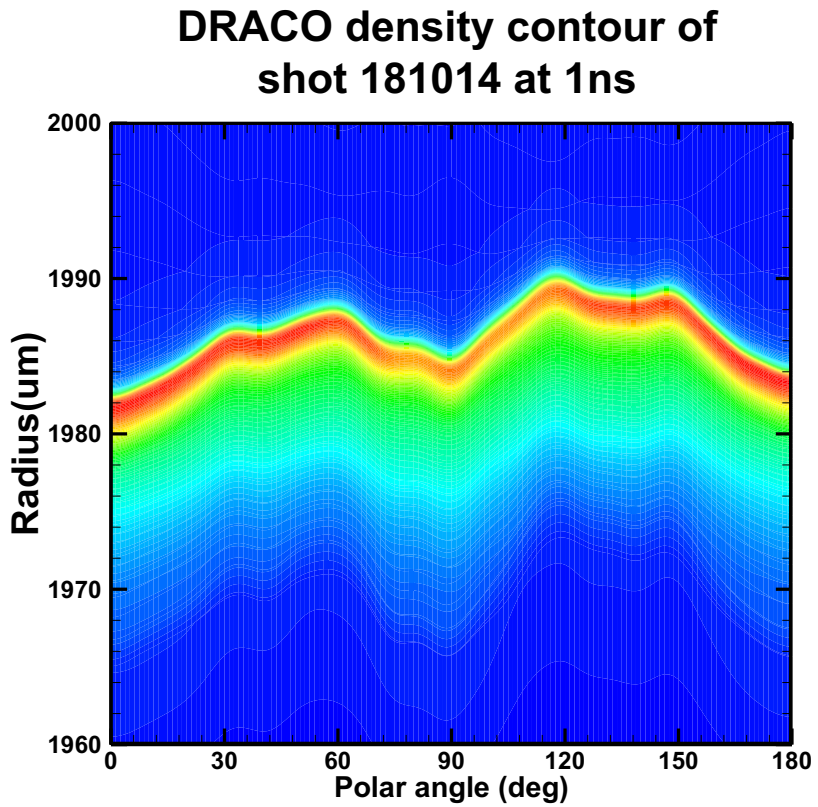
Initial NIF shell-contour studies concentrate on 4mm-shells with sub-MJ energies to limit laser damage exceptions

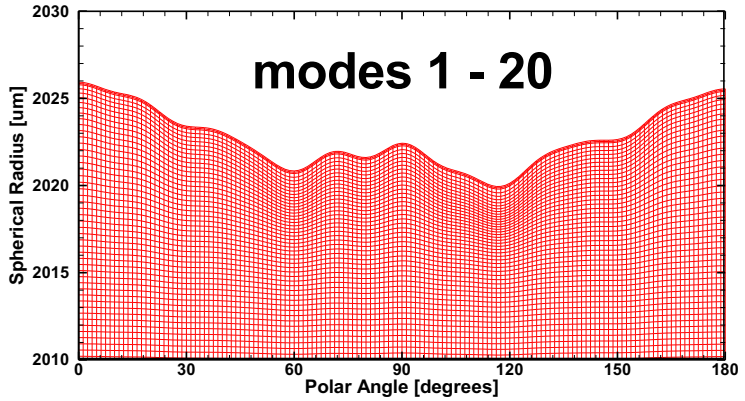


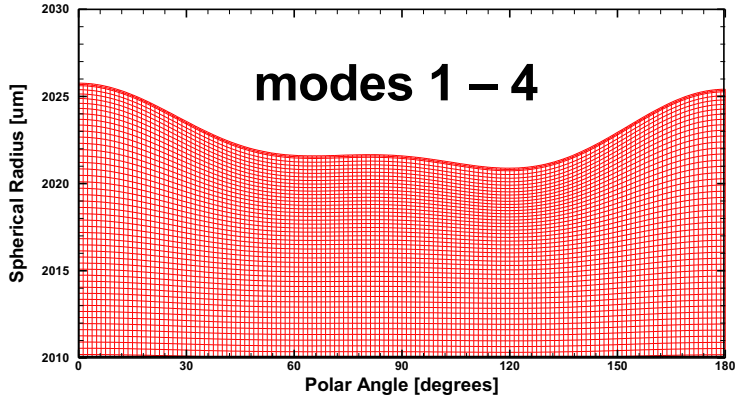




The shell contouring was designed using the inverse modal constituents of shell perturbations taken at 1ns into the implosion







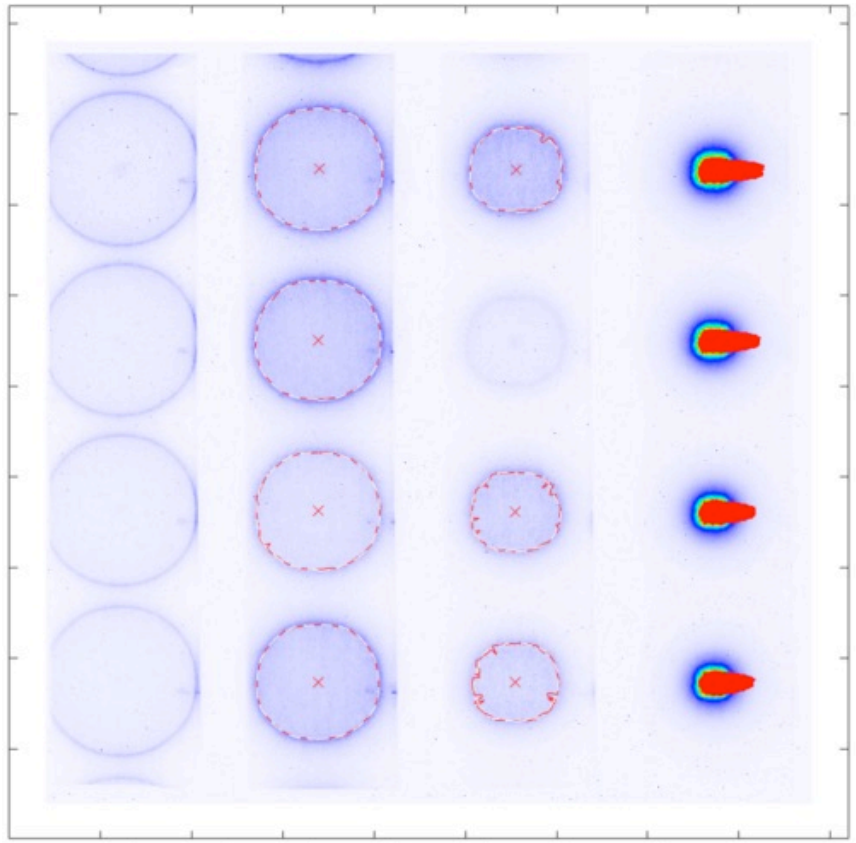
GA delivered 5 contoured shells for implosion experiments

Only the second contoured shell was imploded with full energy along with a baseline, non-contoured shell for comparison

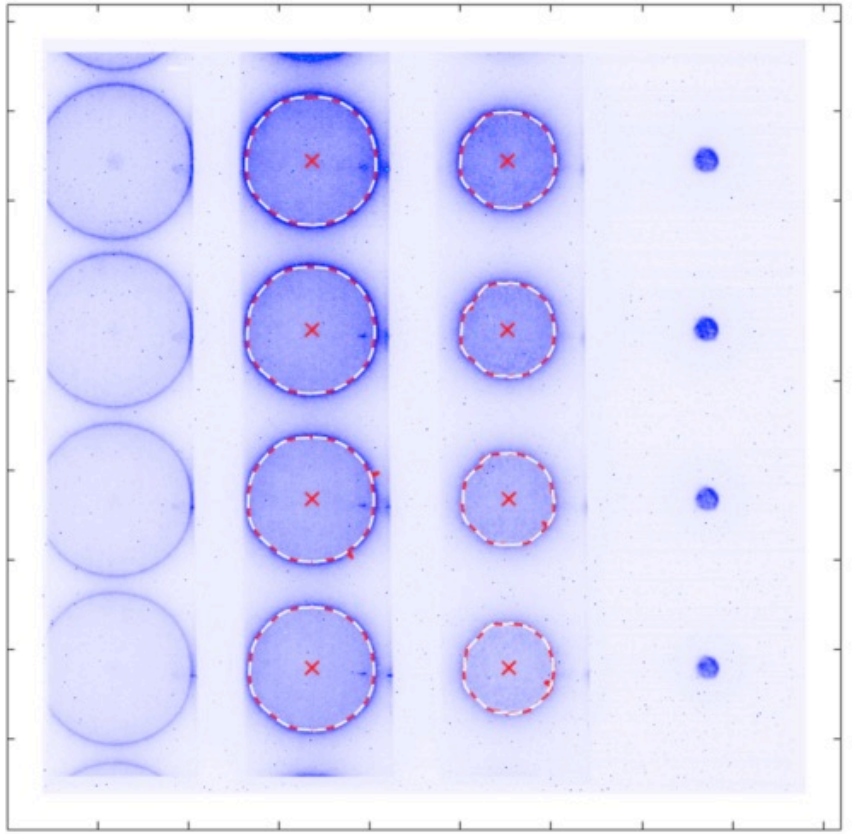
Parameter	N200715-001	N201021-001
Shell contour - Mass	No – 1417μg	Yes – **1491μg**
Laser energy	785 kJ	804 kJ
Gas composition D^3He	6.50 atm - 53/47 (calculated)	**5.45atm** 55/45 (calculated)
DD-n yield – $<T_{ion}>_n$ – BT	1.1e12 - 6.7 keV - 5.65 ns	**1.1e12** - 6.8 keV - 5.73 ns
DRACO – 30/70 D^3He **– 50/50 D^3He**	1.30e12 – 5.5 keV – 5.35 ns 4.29e12 – 5.4 keV – 5.35 ns	1.38e12 – 5.4 keV – 5.45 ns 4.42e12 – 5.4 keV – 5.30 ns
LILACFF – 30/70 D^3He **– 50/50 D^3He**	9.77e11 3.99e12	7.28e11 2.90e12

Examination of self-emission images determines the efficacy of contouring in mitigating the low modes in a PDD implosion

N200715-001-999 90-124

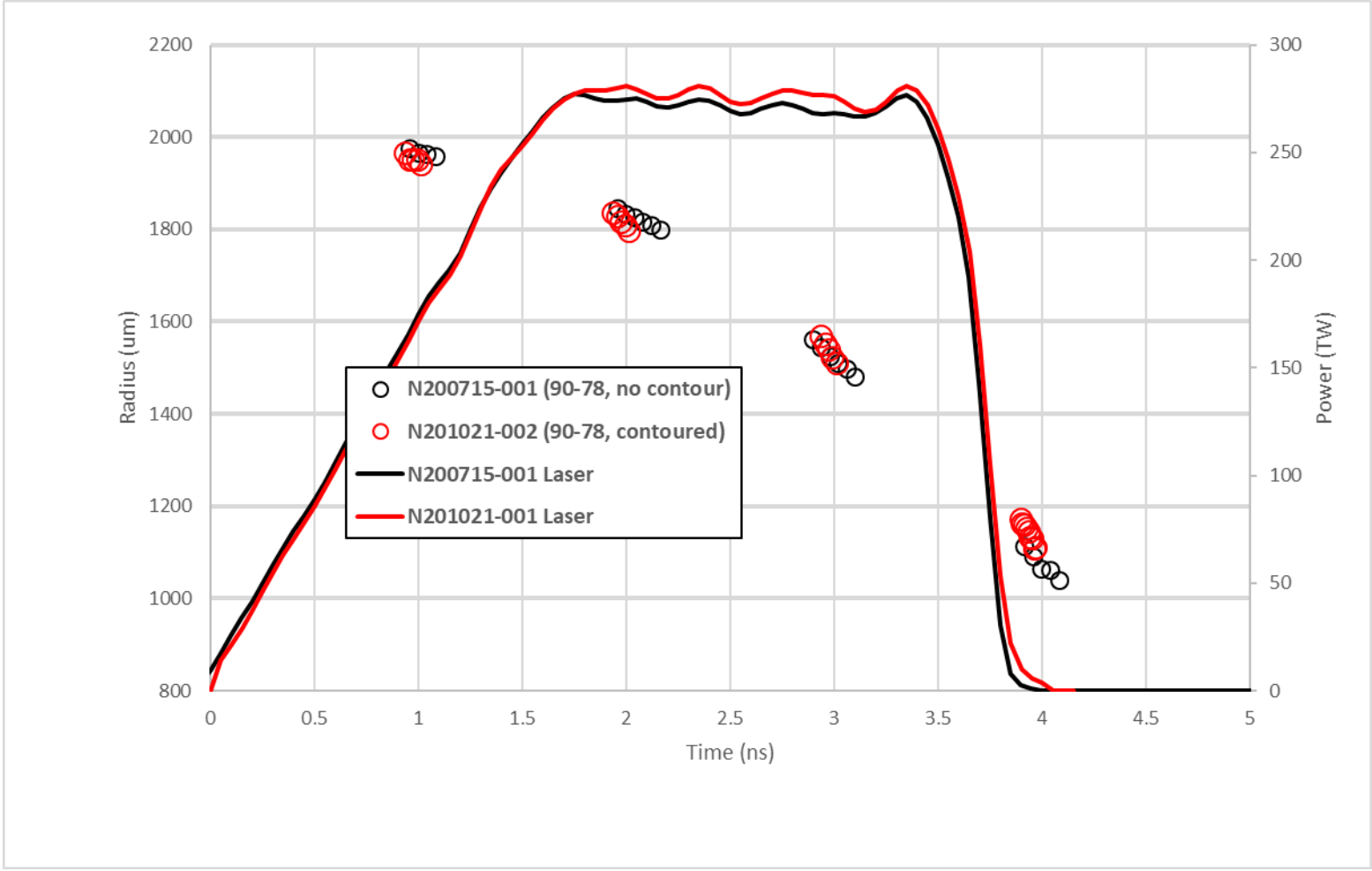


N201021-002-999 90-124

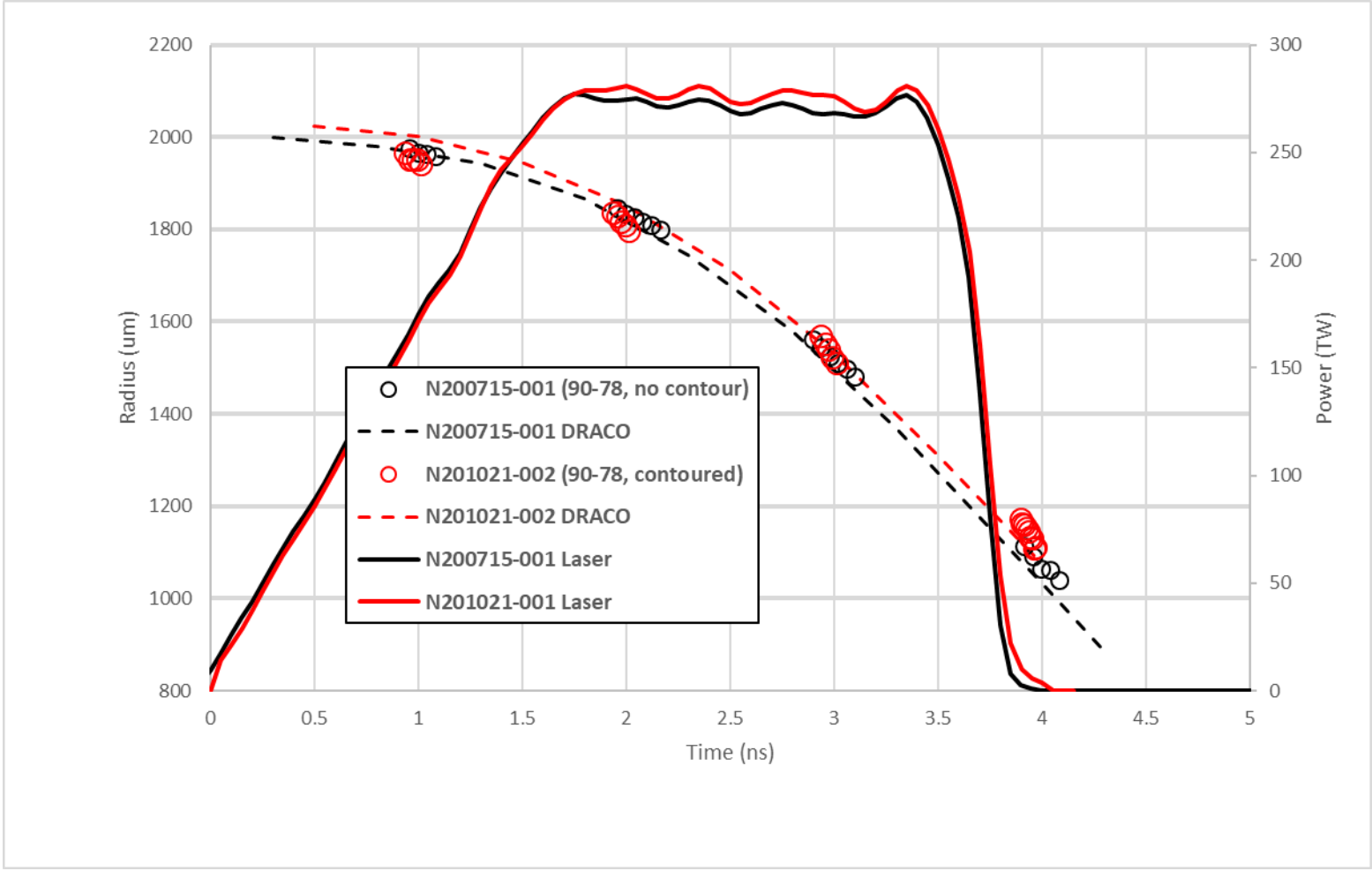


Radius is defined as steepest gradient surface, denoted by red curve
Legendre fit up to mode 8 is white dashed curves (left and right side of each image fit separately)

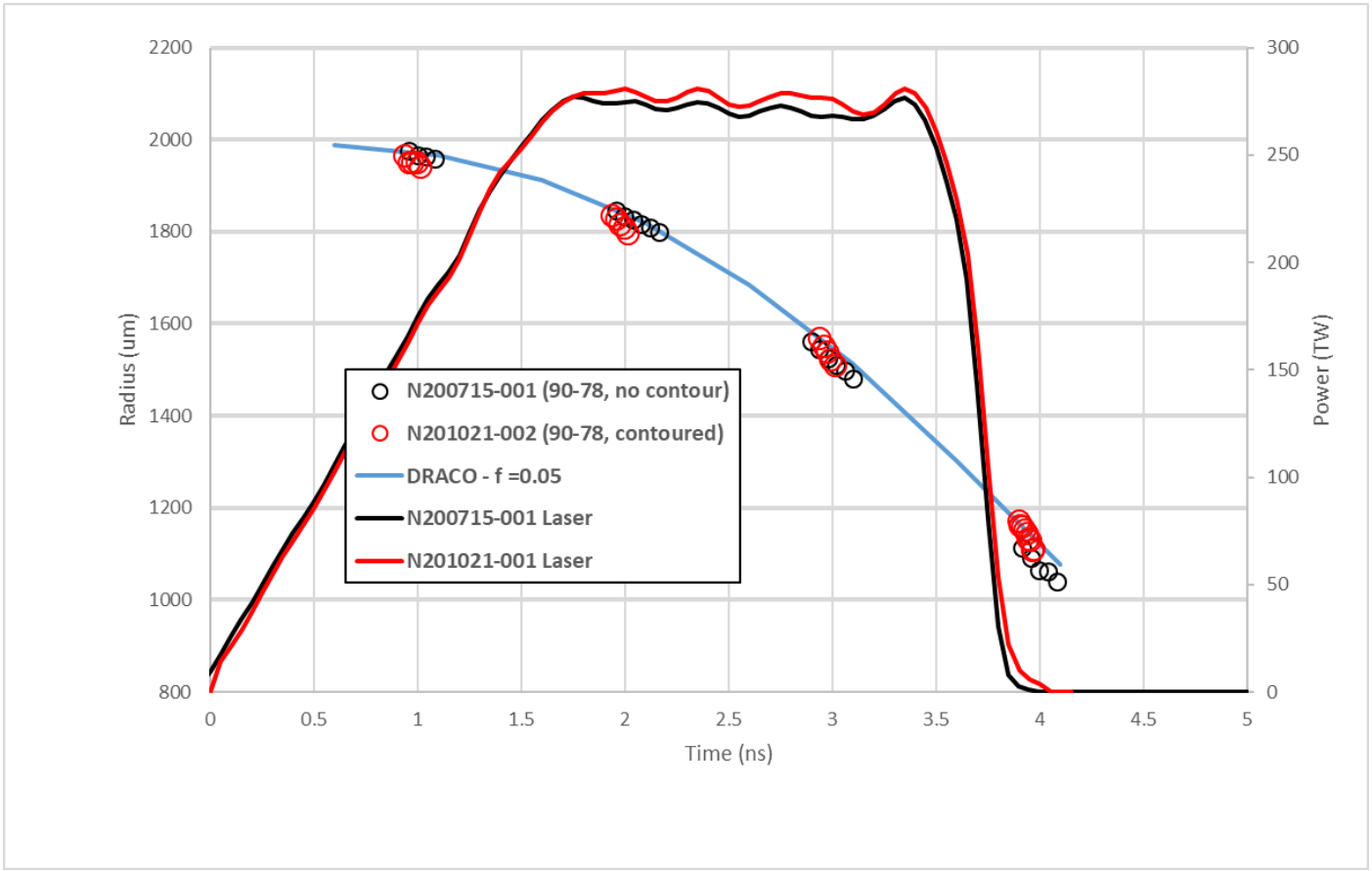
Comparison of the experimental trajectories is consistent with the increased shell mass in the contoured shell implosion



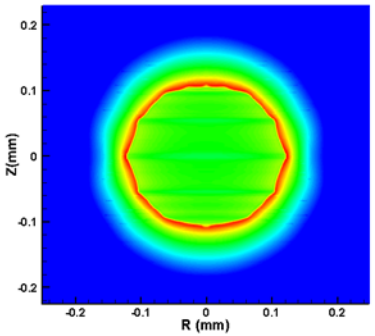
DRACO trajectories are faster which is contributing to an in-depth examination of the interplay between electron transport and CBET



Adjusting the flux limiter can bring the code trajectory into agreement with experiment but introduces more ellipticity into the shell shape.



f = 0.06



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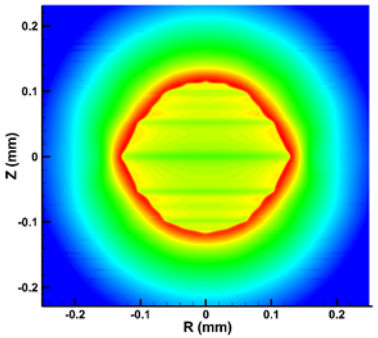
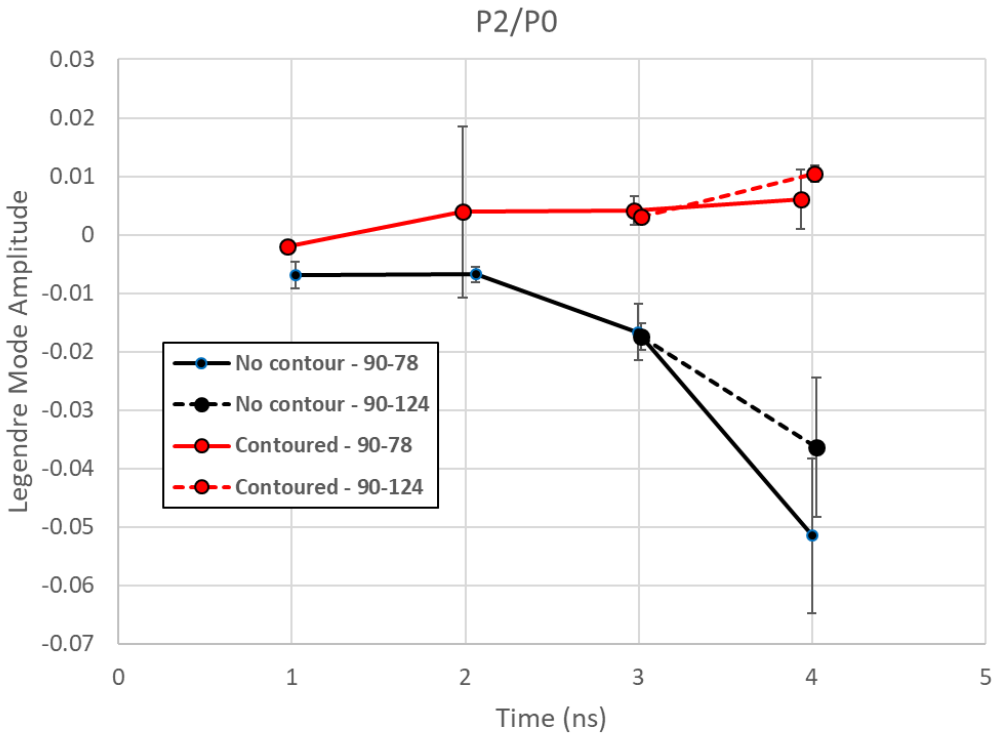
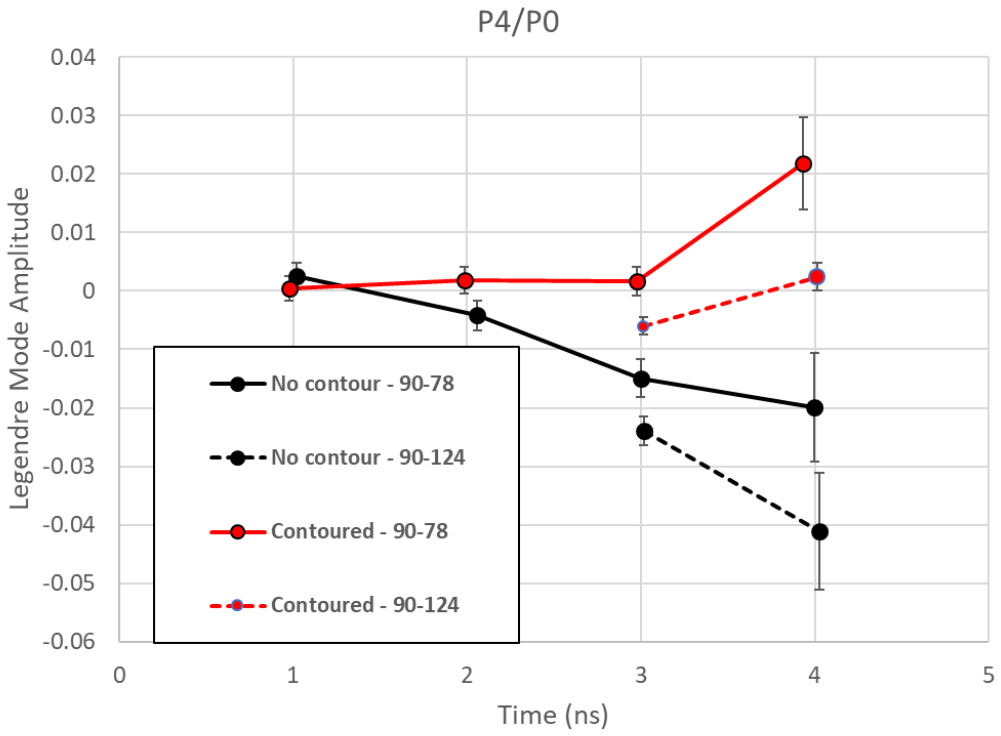


Studies are underway to understand this paradox with the hope to demonstrate agreement with both experimental shell trajectory and shape simultaneously

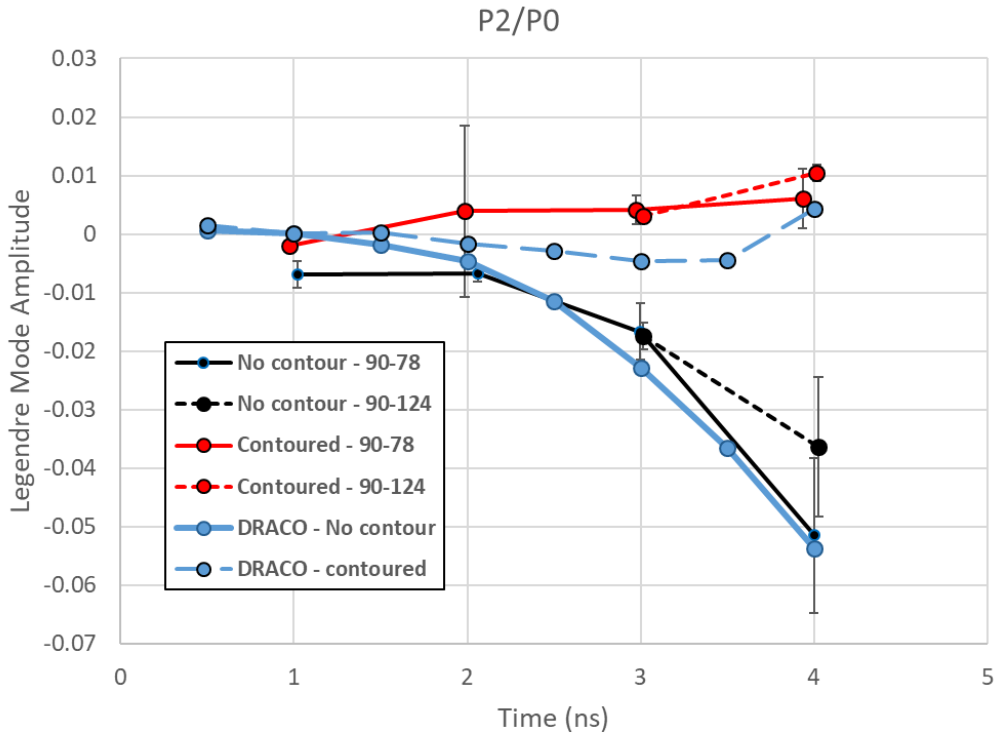
The capsule contouring can be seen to have a definite effect in smoothing the applied low modes due to PDD illumination

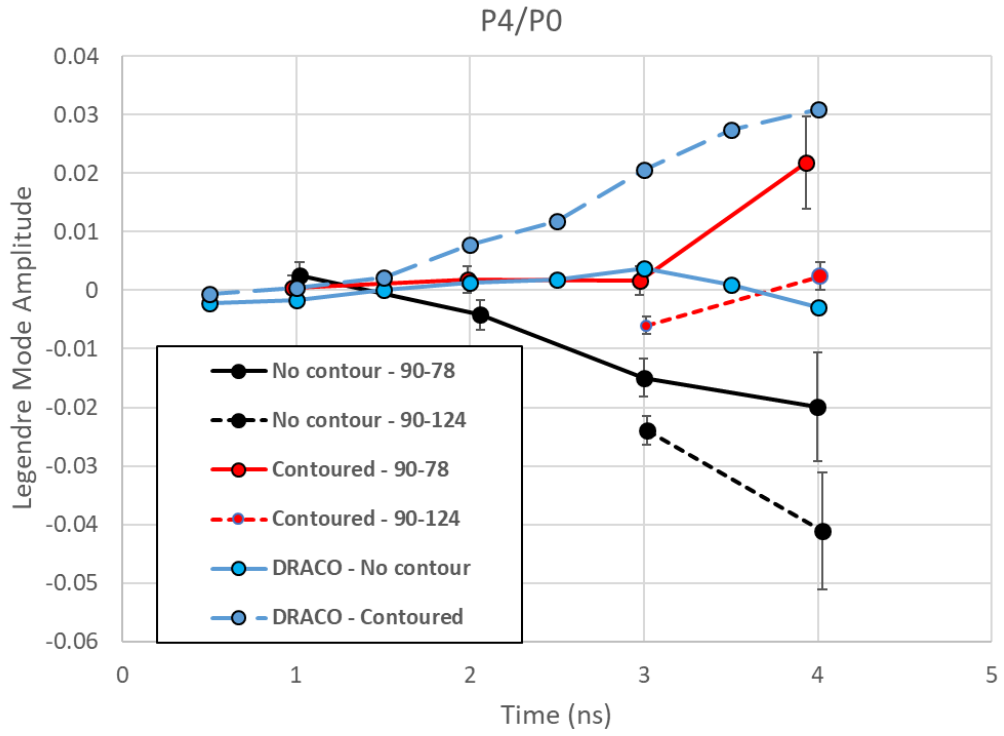




Error bars represent standard deviation of images within a given strip

Simulation results are in qualitative agreement with the experiment, but the l = 4 correlation needs to be examined.





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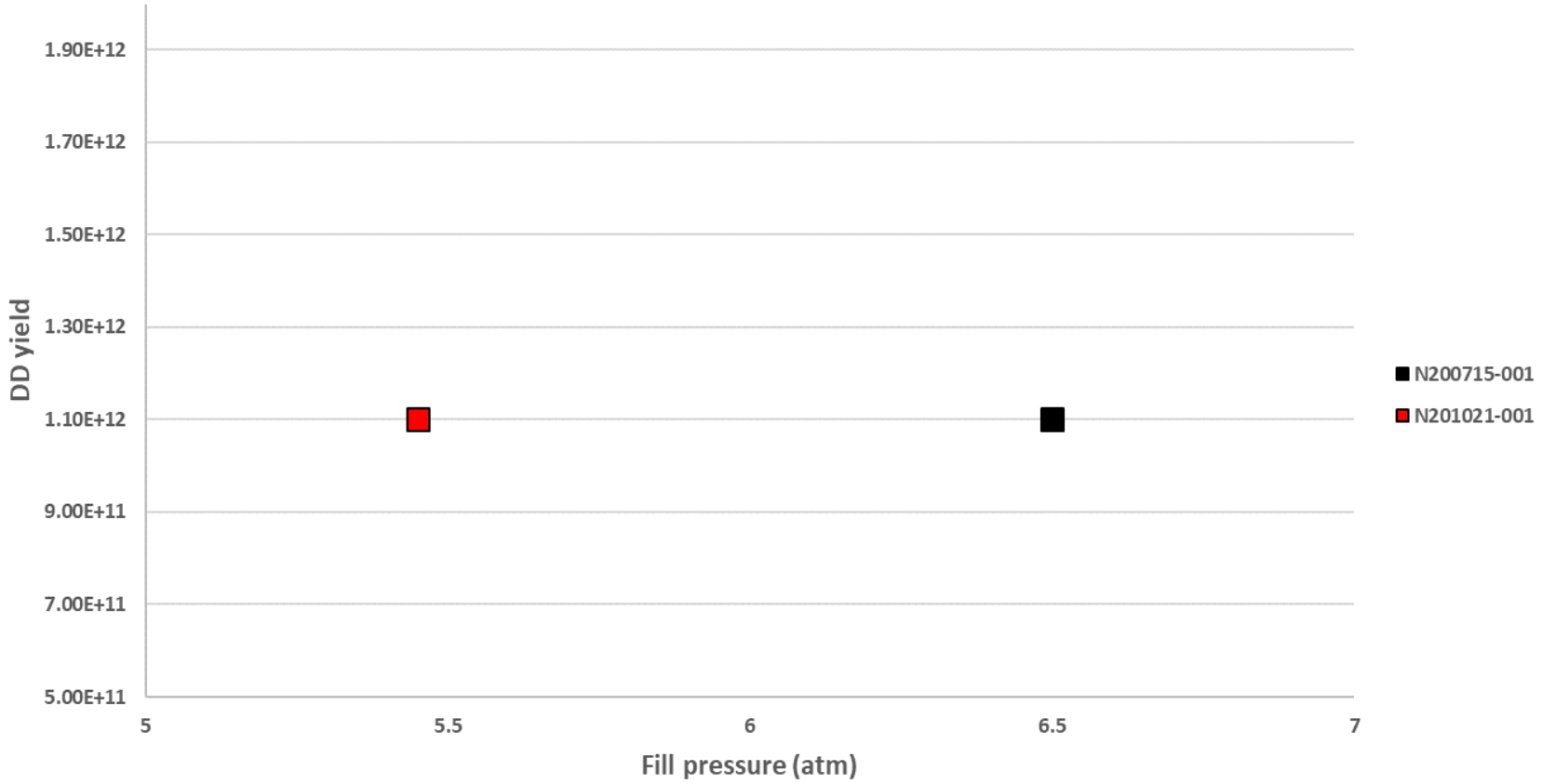
An effective yield improvement of ~38% due to the contoured shell can be inferred through DRACO simulations using capsule parameters of N200715



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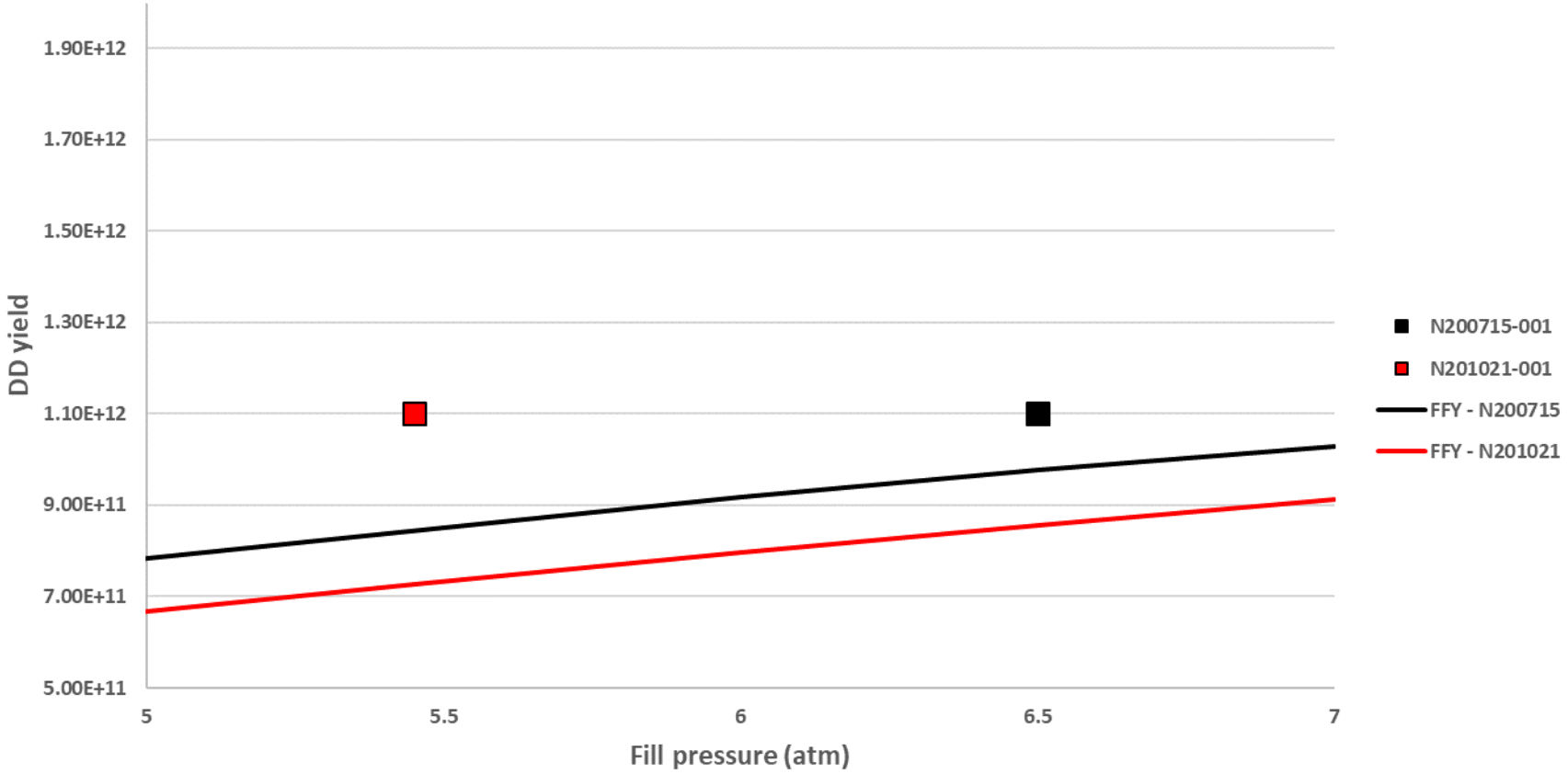

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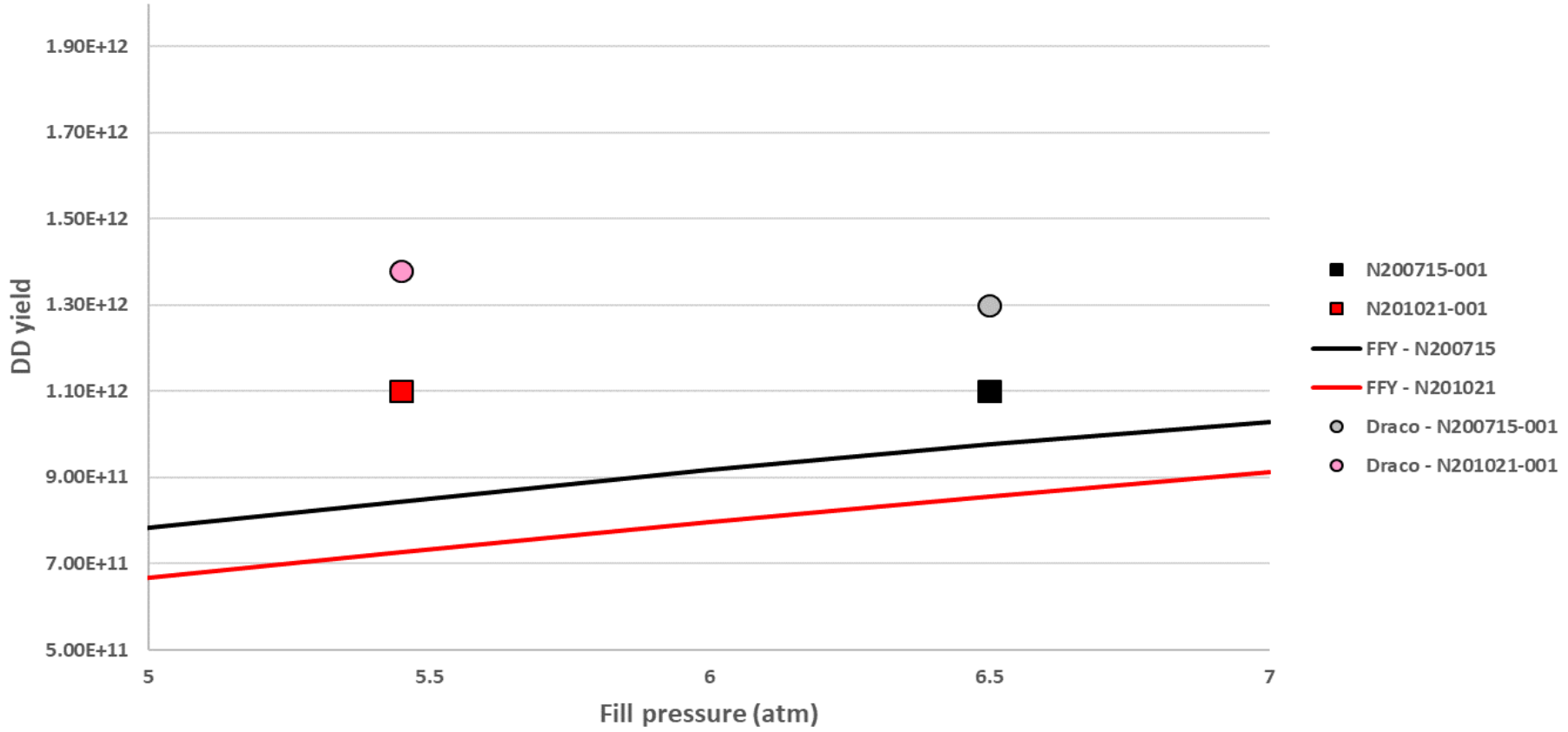

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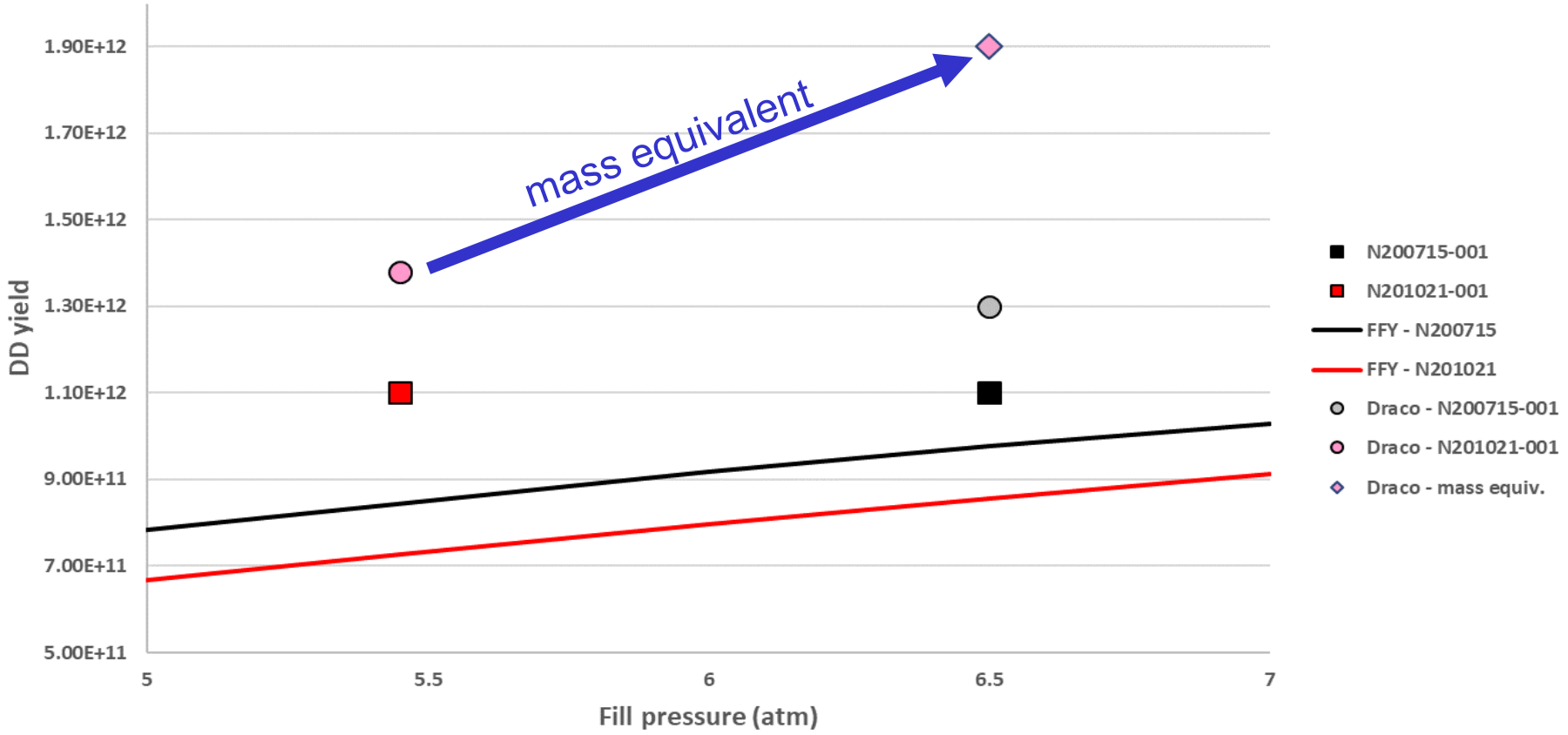

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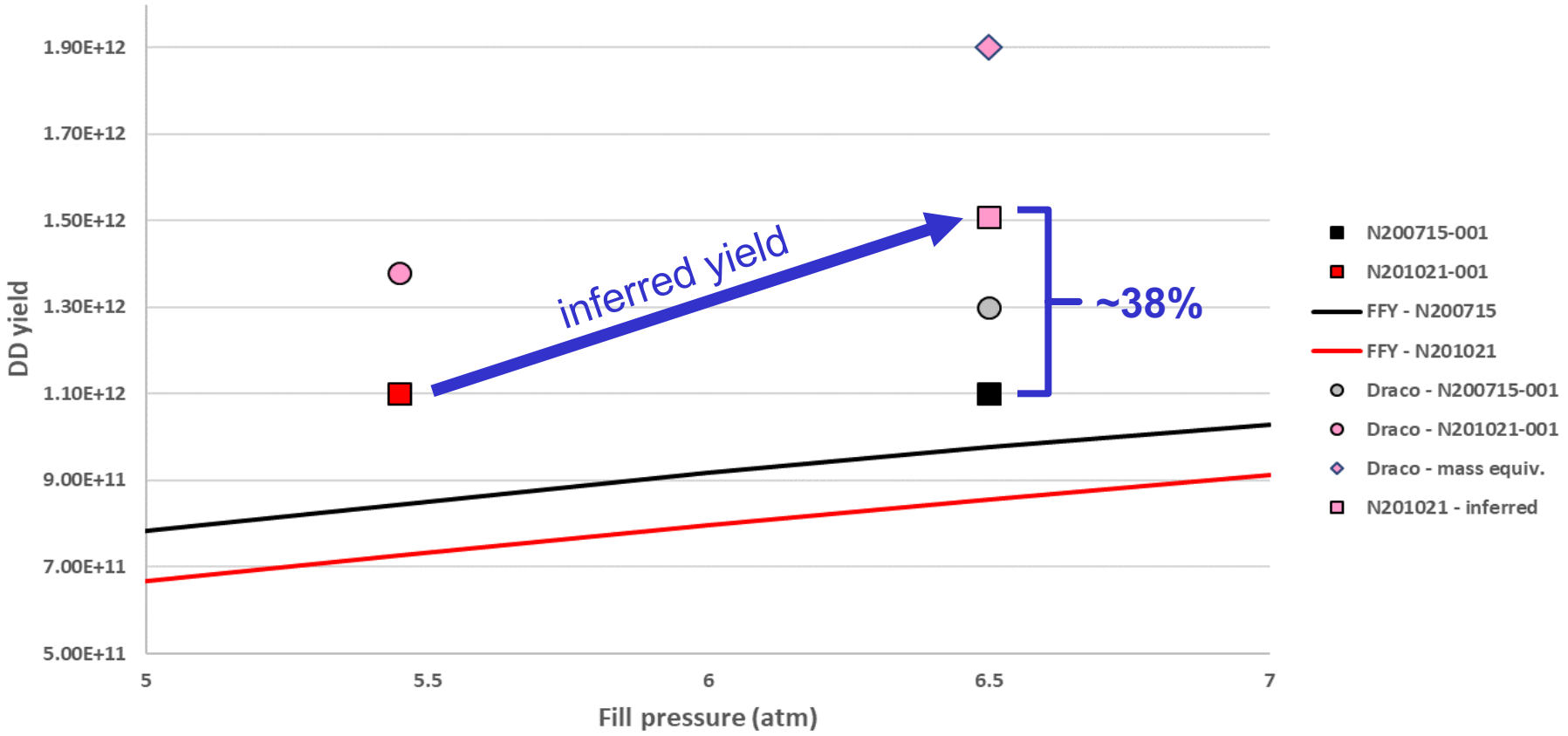

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