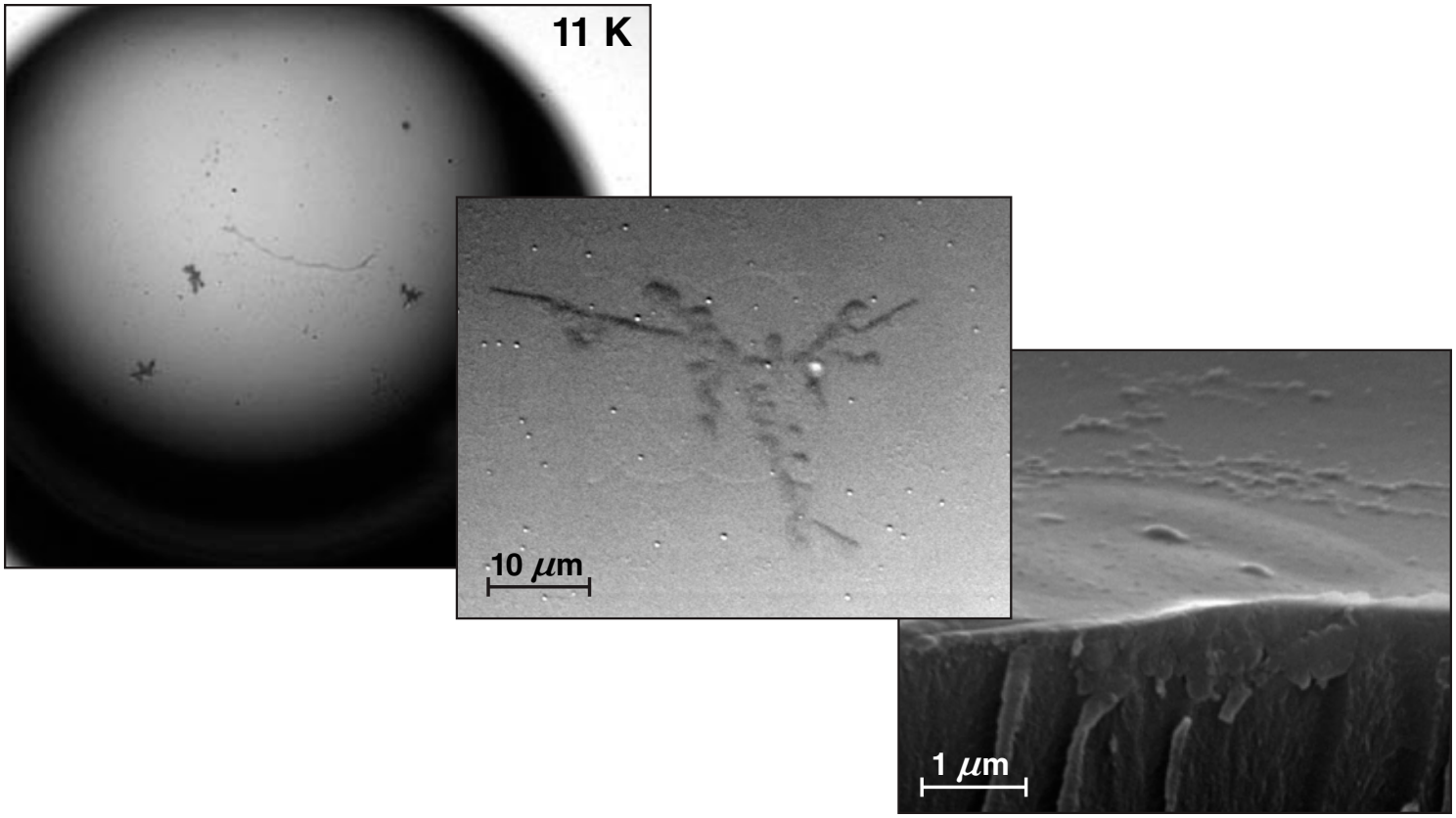
Cryogenic-DT-Implosion Performance with Improved Target-Surface Quality



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Summary

OMEGA cryogenic-DT yields improved significantly following efforts to reduce capsule surface debris

UR LLE

- Capsule surface debris is defined as mass or roughness perturbations that develop once the CD capsules are delivered from General Atomics
- Three sources of surface debris are being addressed
  1. Condensates (frozen gas impurities on the outer CD surface)
  2. Dendrites (stress-induced features on the inner CD surface)
  3. Dust (not all target operations have been in clean room conditions)
- Characterization of the surface debris is incomplete but consistent target to target
- Since May, measured yields have been consistently higher than previous implosions (2–3×) with a commensurate increase in yield-over-clean (YOC)

Collaborators

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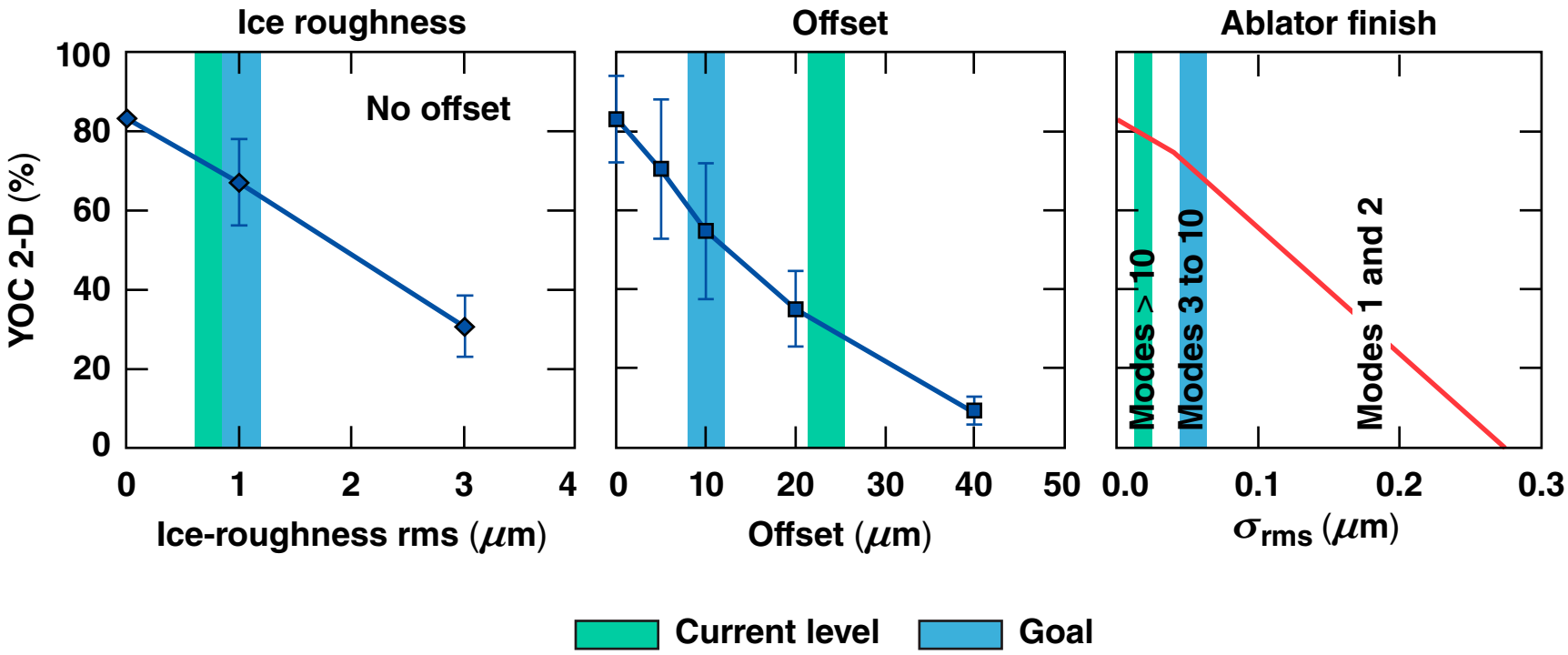
2-D *DRACO* simulations* show yield reduction for various perturbation sources

- Long-wavelength laser nonuniformity is 83% (pointing, power balance, timing)



Ice roughness and the ablator finish suggest that isolated surface defects are responsible for some reduction in target performance.

E19532b

*S. X. Hu *et al.*, Phys. Plasmas 17, 102706 (2010).

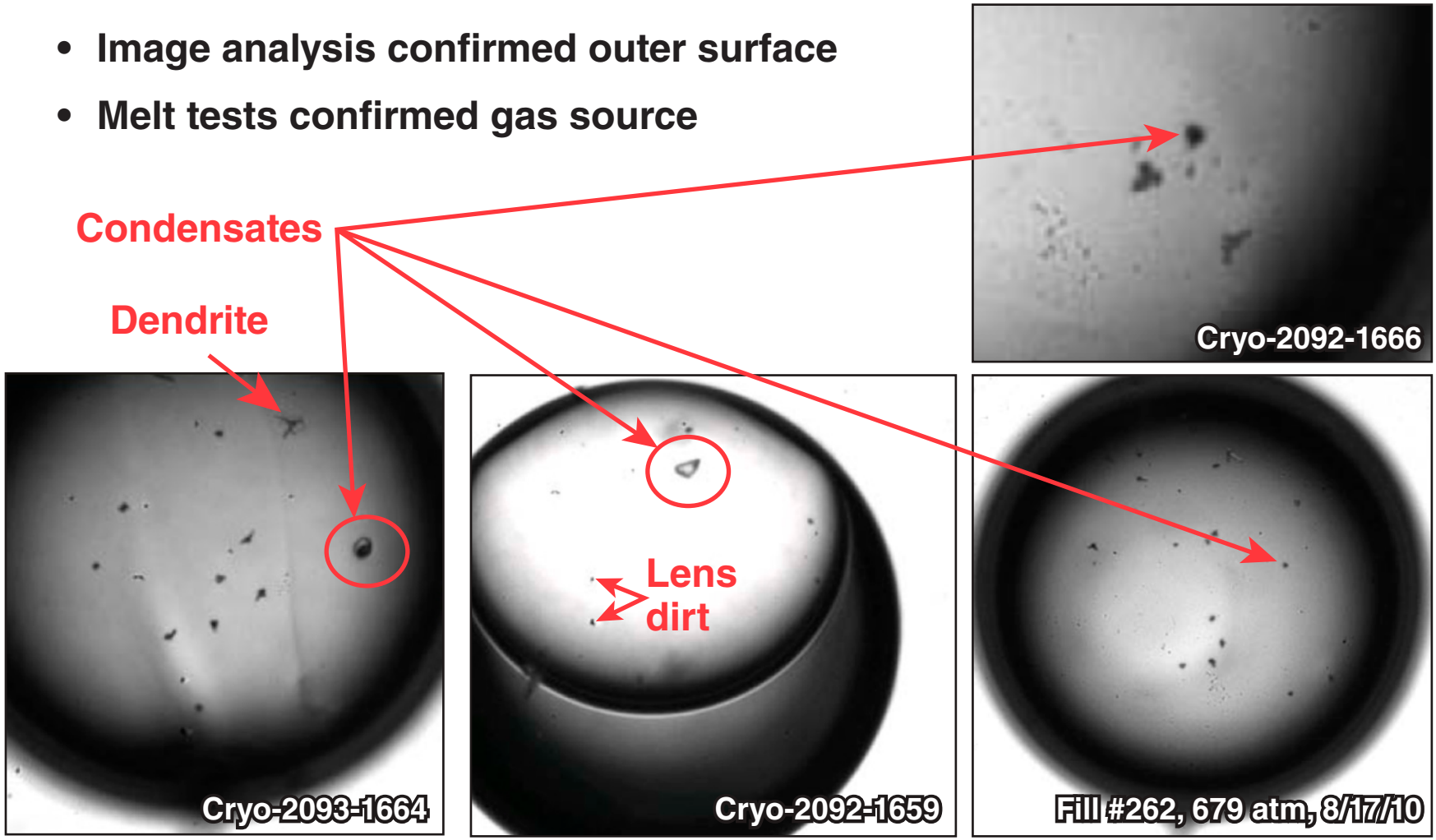
There are several sources for isolated target defects/debris

- Gas-entrained contaminants
  1. Helium exchange gas (despite being scrubbed to ppb, 30 mTorr $\times$ 10 L/s $\times$ 30 h $\rightarrow$ 10^{15} water molecules)
  2. D_2 operations in the tritium fill system (e.g., post-maintenance testing)
  3. DT scavenging of hydroxyls from the surfaces of metal process lines
- CH bond breaking due to tritium beta decay in the shell and recombination into other organic molecules (e.g., methane)
- Electrostatic attraction of particulate debris (dust, target fragments in the permeation cell and dome, …)
  – *process changes underway to ensure a clean room target life cycle*

Classification of the defects/debris can only be done once the targets are viewable in the characterization stations.

In mid-2010, most targets had dozens of large features with diameters of up to several tens of microns

- Image analysis confirmed outer surface
- Melt tests confirmed gas source



Features do not continue to grow once the capsule is in the moving cryostat.

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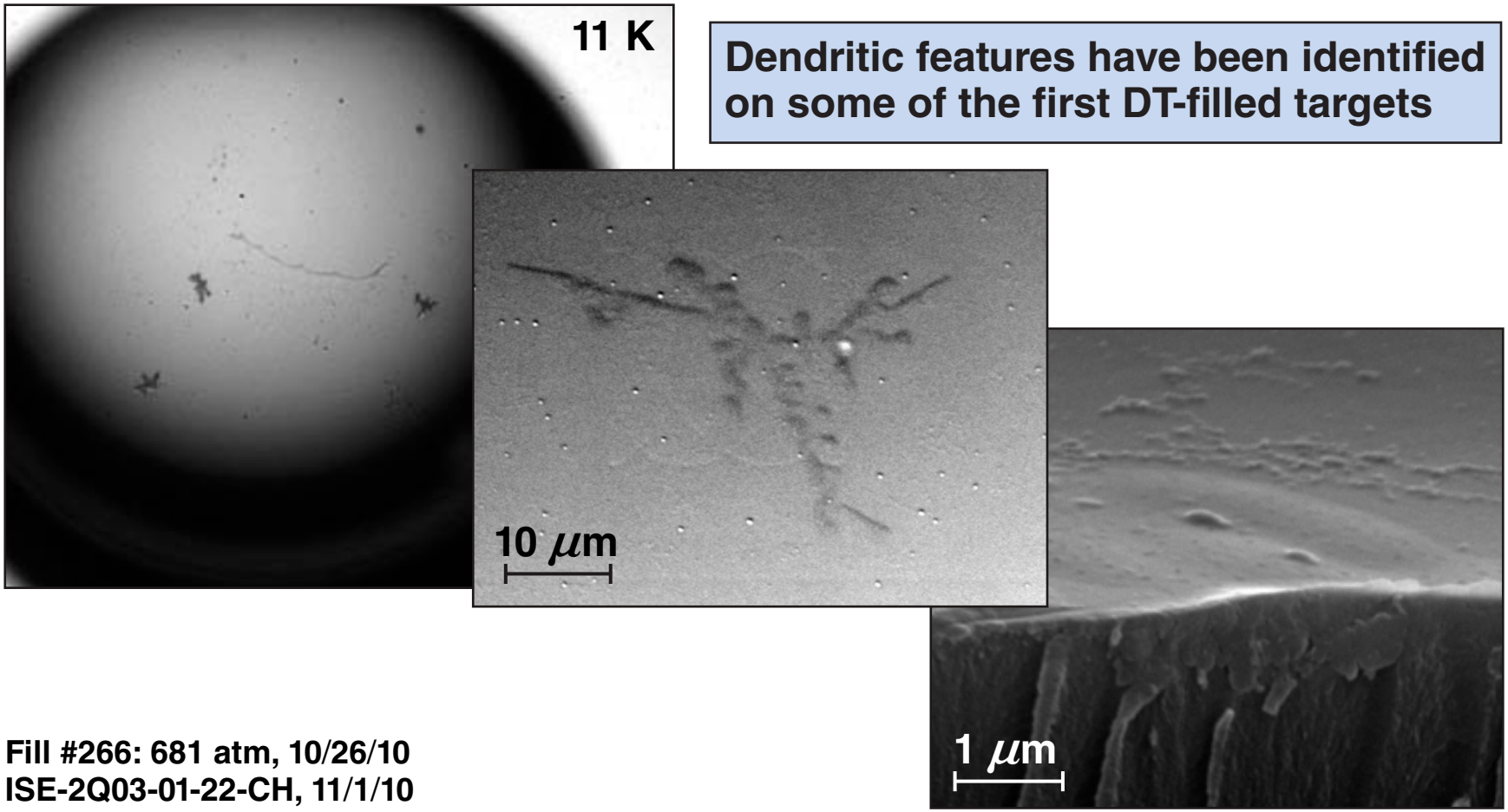
Dendrites are large inner-surface features that appear during the fill and transfer process



Dendritic features have been identified on some of the first DT-filled targets

Fill #266: 681 atm, 10/26/10
ISE-2Q03-01-22-CH, 11/1/10

No dendrites were observed on a target with a hole, which supports the hypothesis that they are driven by overpressure in the capsule.

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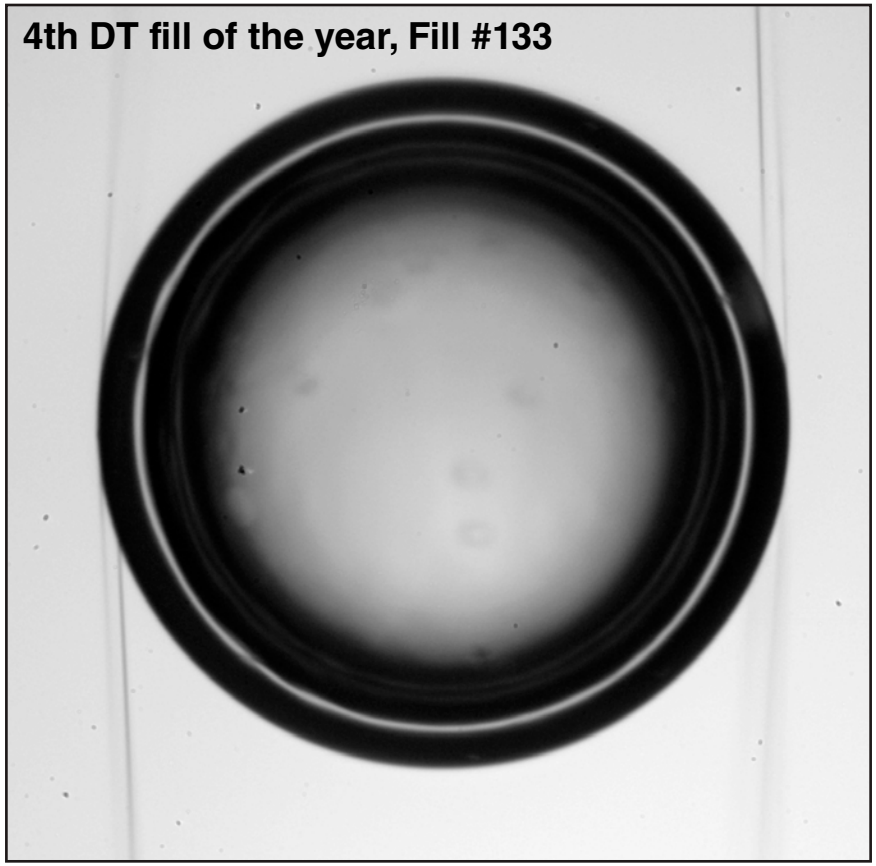
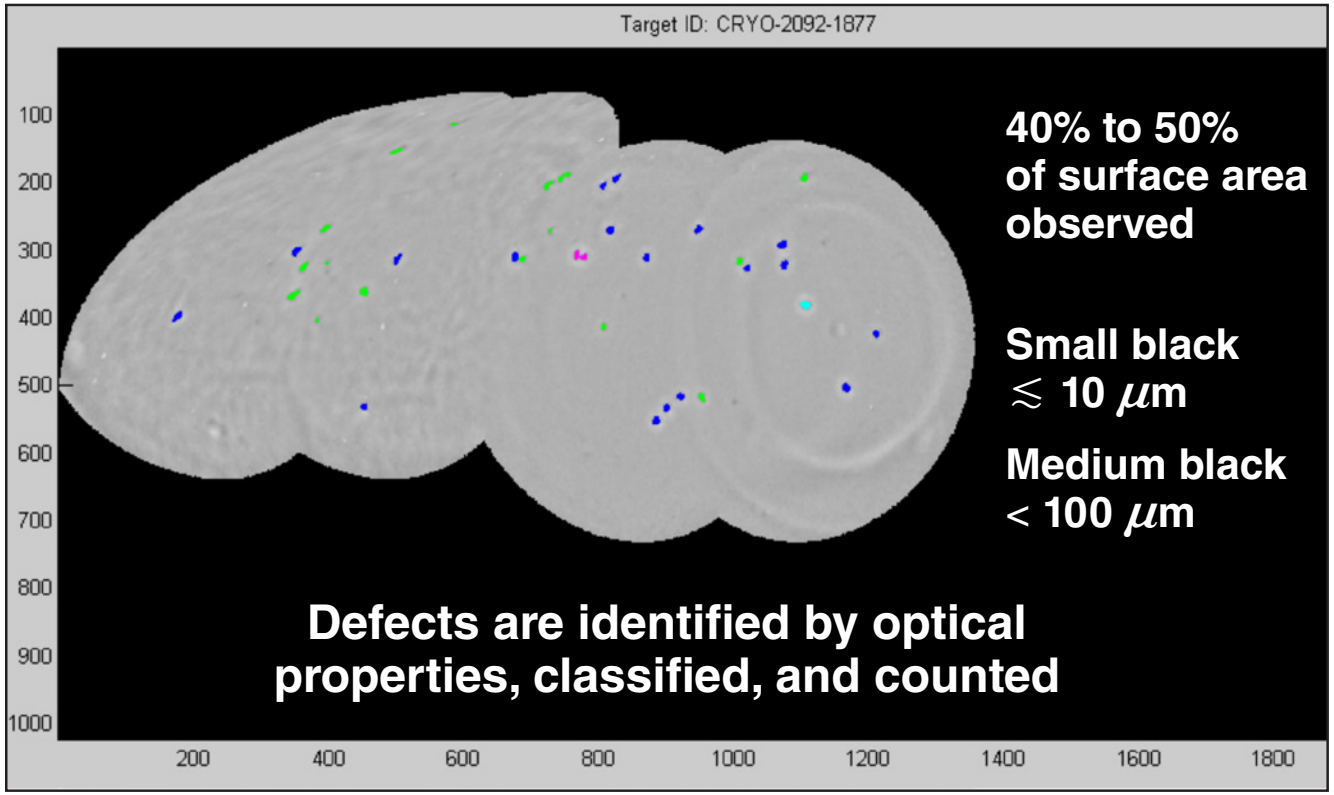
SEM photos by General Atomics

Earlier target data showed that the number of condensates decreased with time following maintenance activities



This realization led to a 10-atm DT "pre-fill" to flush the surface of contaminants prior to high-pressure fills.

A MATLAB routine was developed to consistently analyze target images for defect characterization



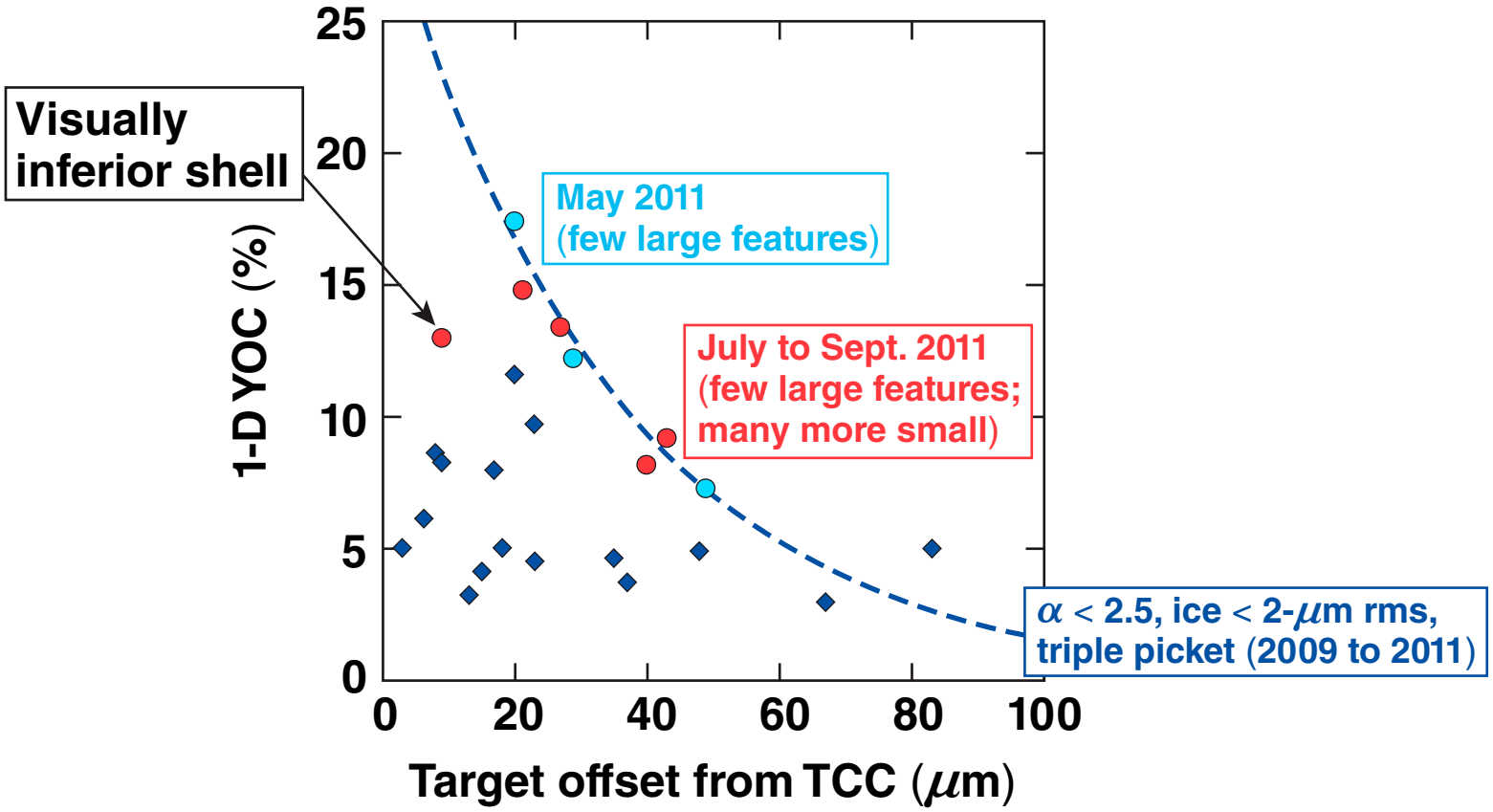
- Dendrites
- Small Black
- Medium Black
- Low contrast
- Ice features
- Unknown class

The area and number of features is used to look for correlations with target performance.

By controlling/eliminating the sources, the number of large surface features has been reduced significantly

- DT "pre-flush" reduced the number/area of the large ("medium black") features by 80% to 90% (implemented in early 2011)
- The dendrite features were eliminated by modifying the target transfer process (implemented in May)
- The number of "small black" features increased over the summer but does not appear to impact target performance (these features should be reduced following the annual maintenance currently underway)
- Before the next fill in December:
  - images of the CD shell's pre-fill will be analyzed using the post-fill surface characterization criteria (may ultimately use for capsule selection)
  - the capsule handing process will ensure the shells remain in a clean room environment cradle-to-grave

Normalized to 1-D, the May to September target performance is identical and shows significant improvement over earlier implosions



Target alignment stability is expected to greatly improve for implosions in 2012.

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Summary/Conclusions

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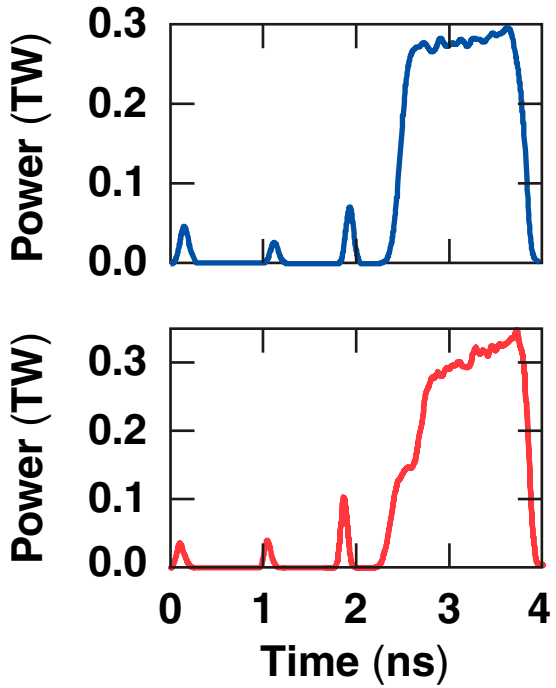
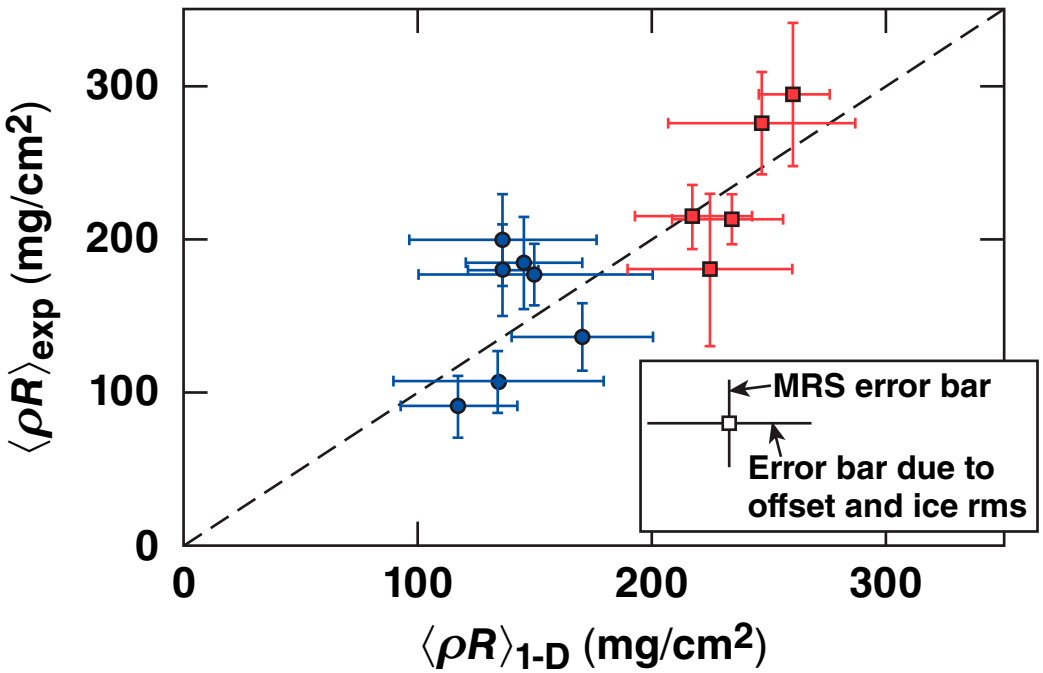
The measured areal densities in symmetric triple-picket cryogenic implosions agree with predictions*,†



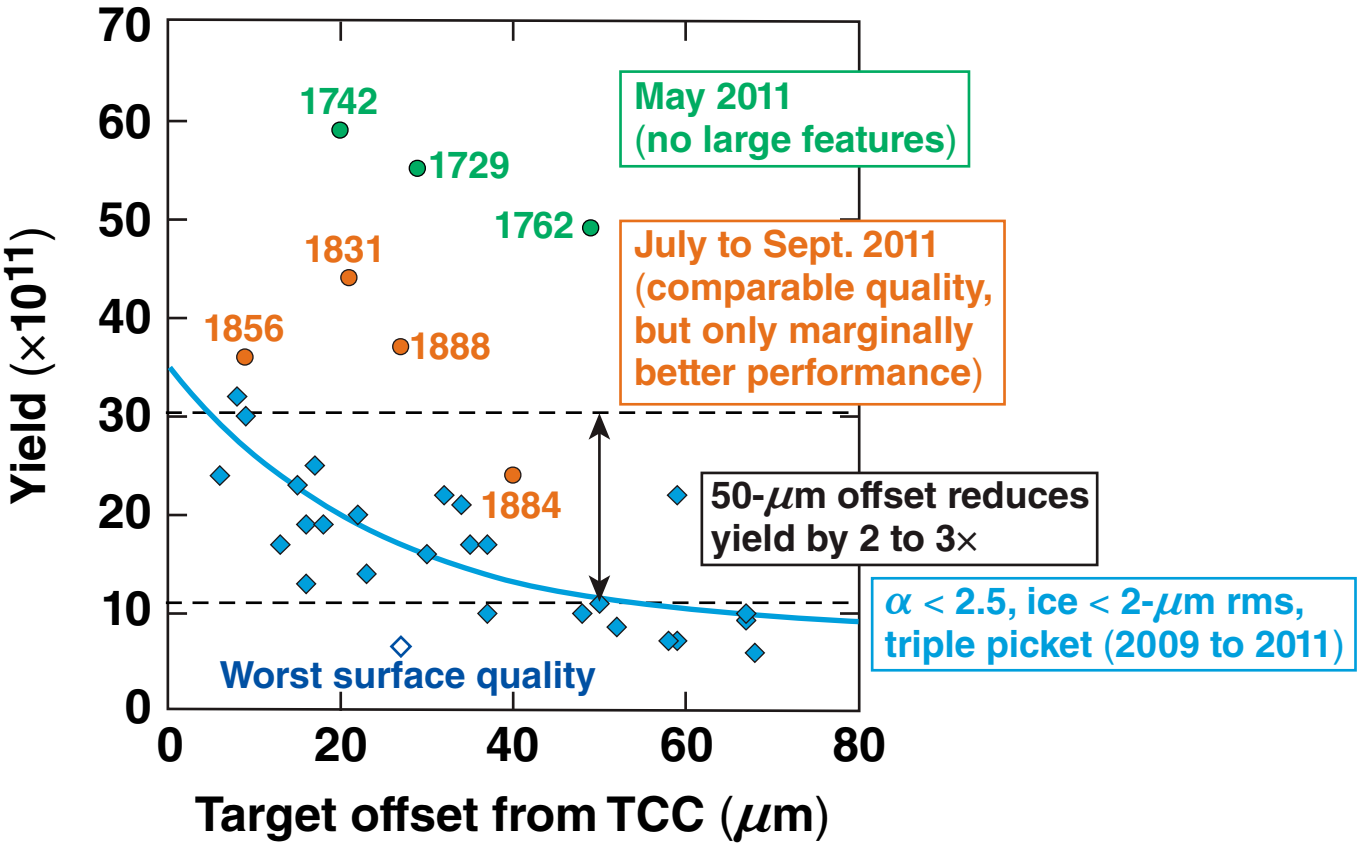


Nonlocal model with crossed-beam energy transfer

Areal-density measurements confirm the accuracy of shock tuning and shell stability to short-wavelength perturbations.

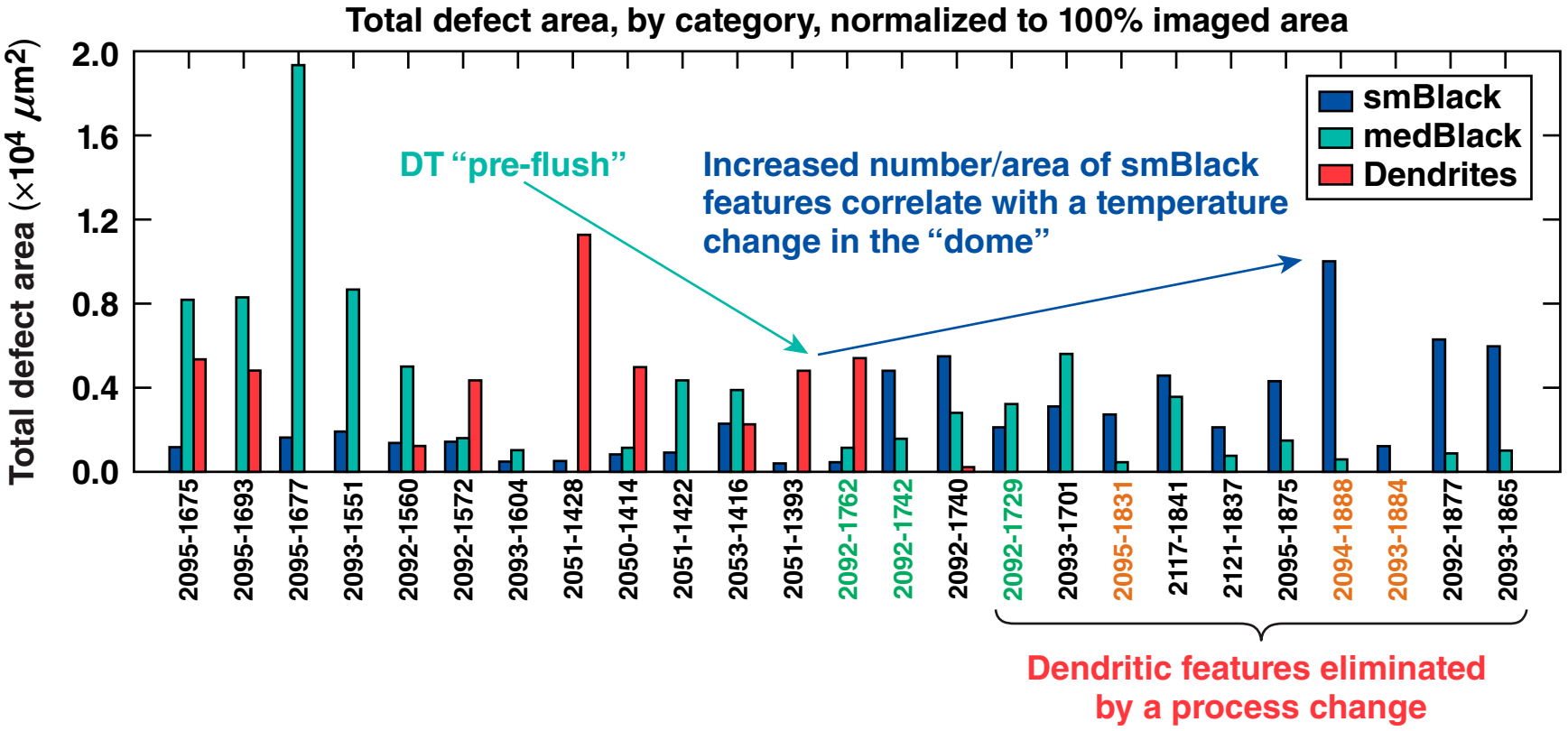
* V. N. Goncharov *et al.*, Phys. Rev. Lett. 104, 165001 (2010).
† T. C. Sangster *et al.*, Phys. Plasmas 17, 056312 (2010).

Targets in May performed 3 to 4× better than earlier targets, but only correlate to a reduction in the largest features



Best performing targets still had dozens of small features (gas condensates)!

Consistent surface data exists for all of the 2011 targets; only limited data is available for 2010 targets



New features do not appear once target is in the MCTC's and existing features do not continue to grow.

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