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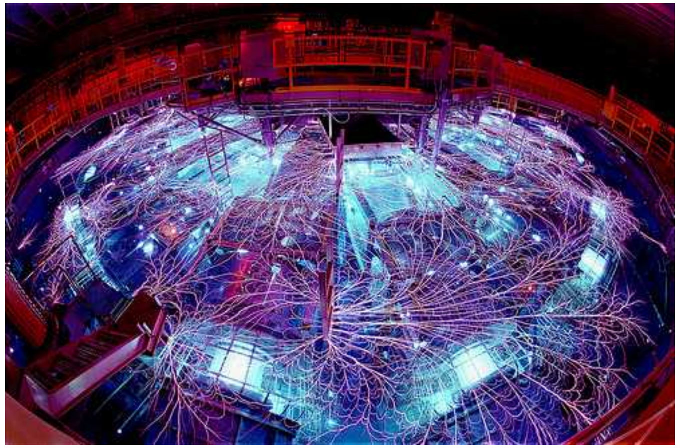
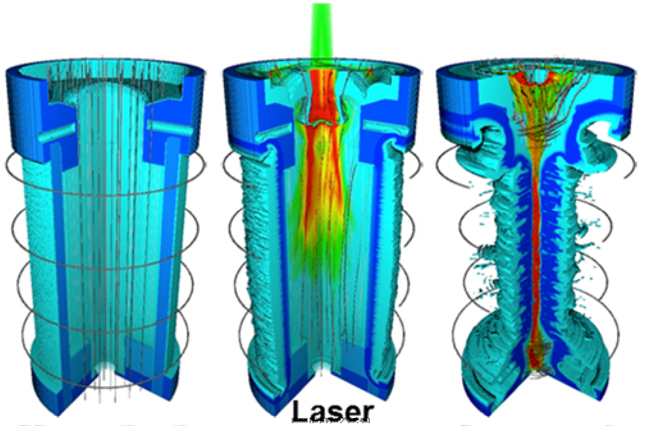


Stagnation Morphology in Magnetized Liner Inertial Fusion Experiments



M. R. Gomez, E. C. Harding, D. J. Ampleford, C. A. Jennings, T. J. Awe, G. A. Chandler, M. E. Glinsky, K. D. Hahn, S. B. Hansen, B. Jones, P. F. Knapp, M. R. Martin, K. J. Peterson, G. A. Rochau, C. L. Ruiz, P. F. Schmit, D. B. Sinars, S. A. Slutz, M. R. Weis, E. P. Yu

Sandia National Laboratories

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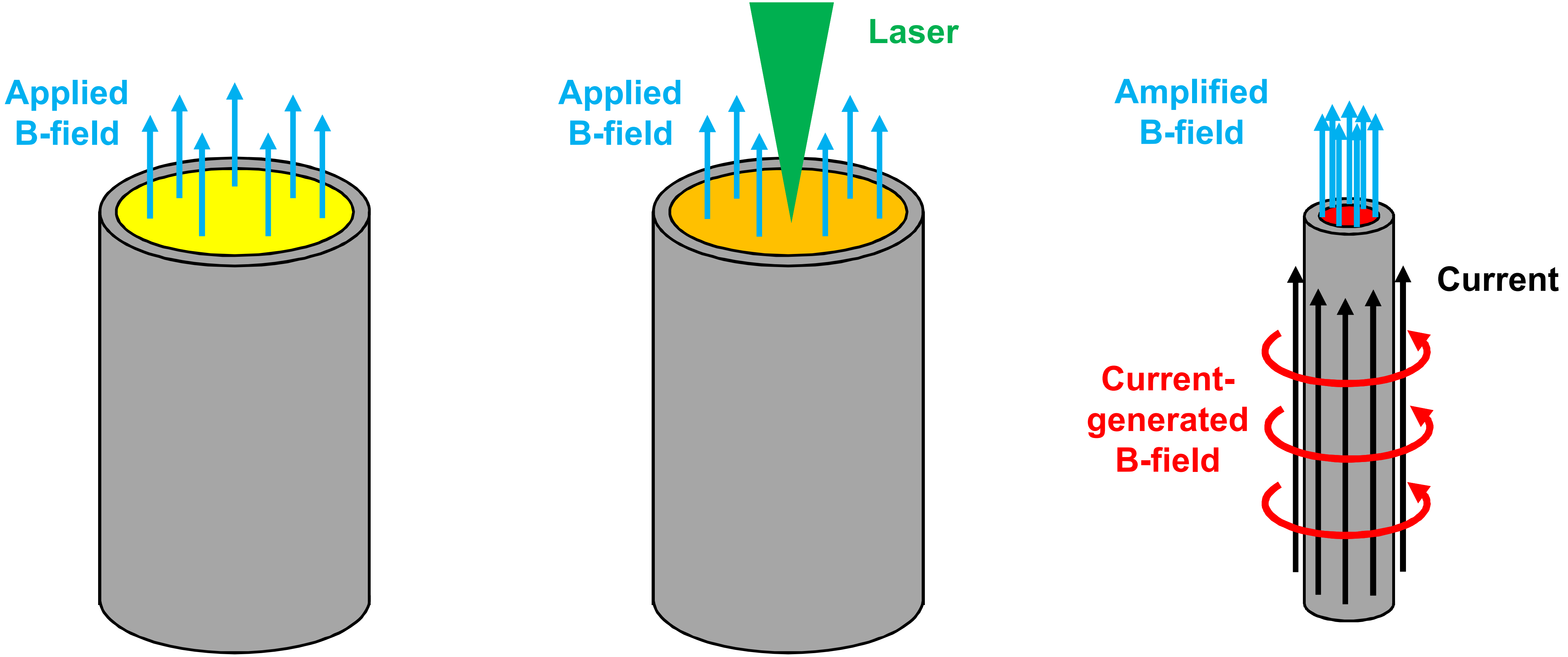
U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Magnetized Liner Inertial Fusion relies on three stages to produce fusion relevant conditions



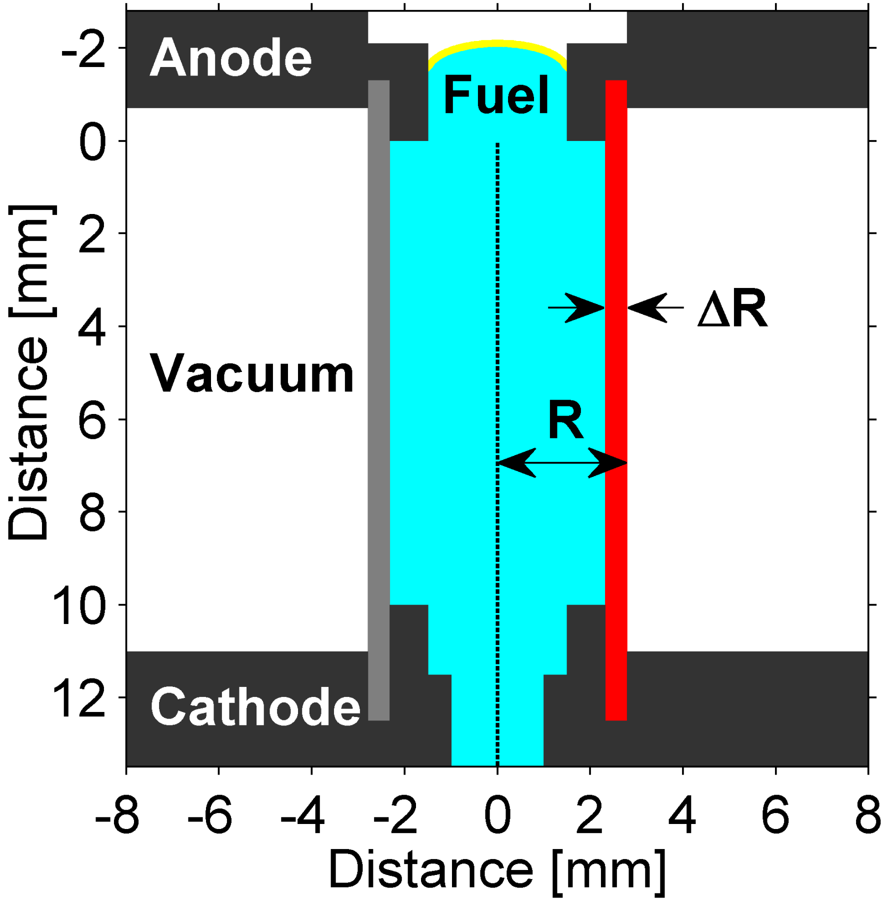
Apply axial magnetic field

Laser-heat the magnetized fuel

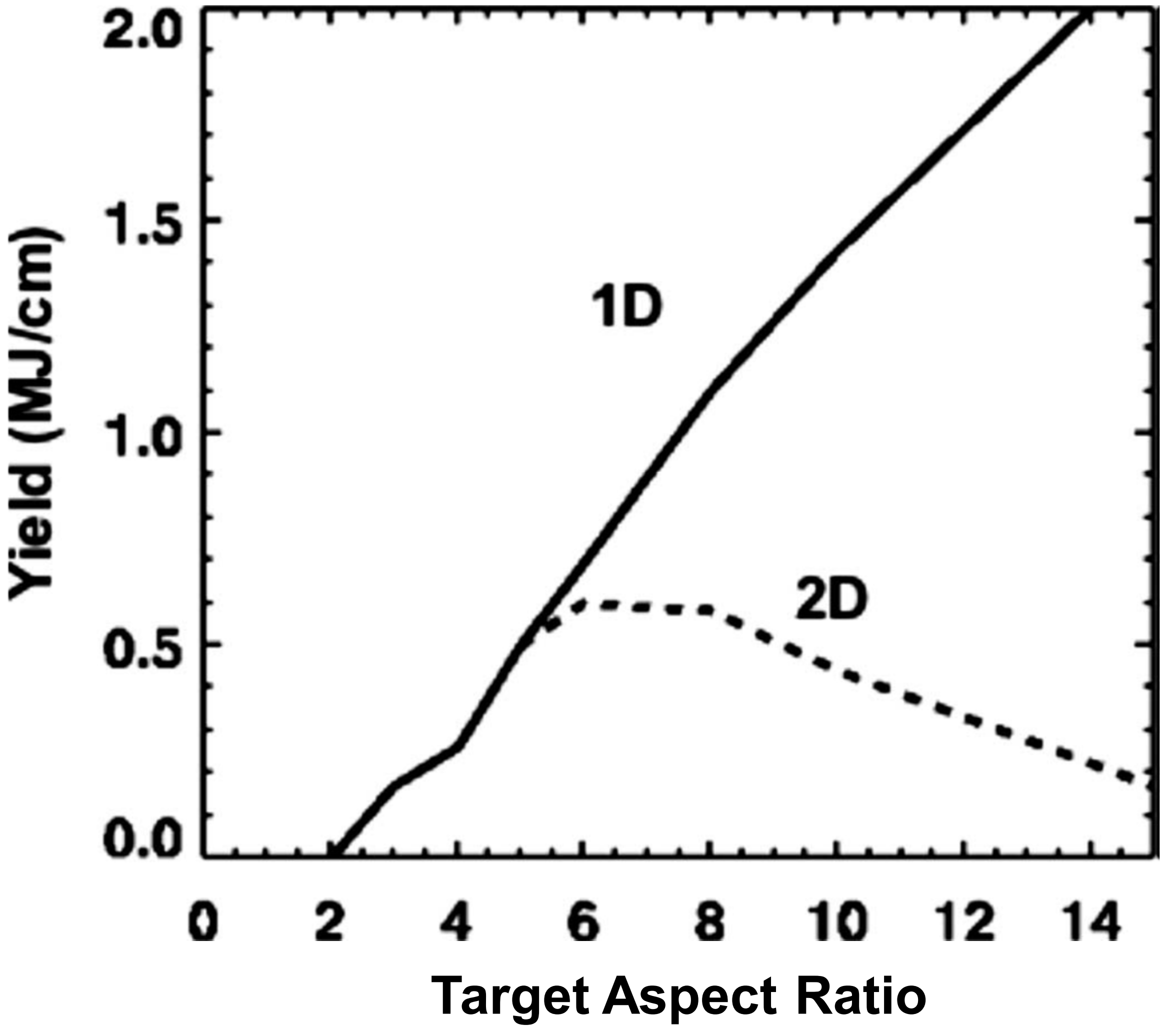
Compress the heated and magnetized fuel

S. A. Slutz, et al., Phys. Plasmas 17, 056303 (2010).

Initial simulations indicated optimized, 1D-like behavior for targets with an aspect ratio of 6

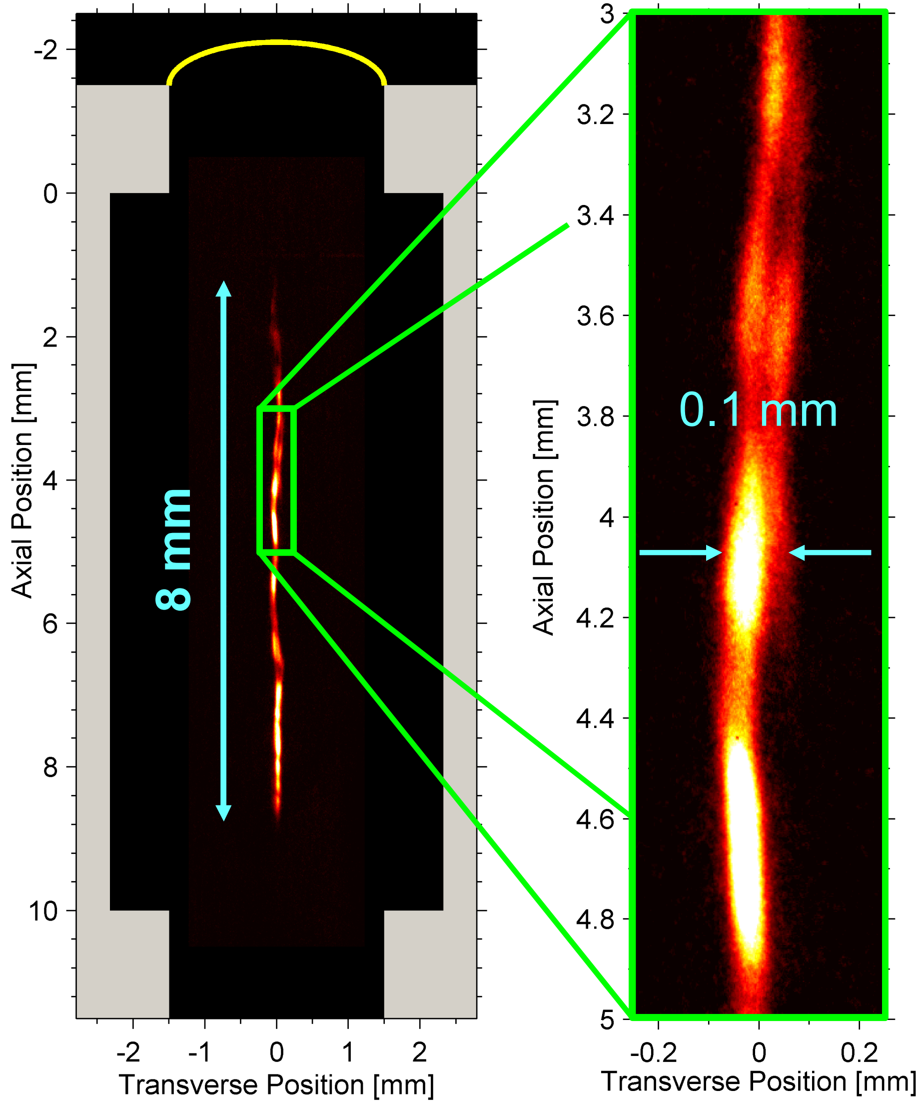


$$Aspect\ Ratio = \frac{Outer\ Radius}{Wall\ thickness} = \frac{2.79\ mm}{0.465\ mm} = 6$$



S. A. Slutz, et al., Phys. Plasmas 17, 056303 (2010).

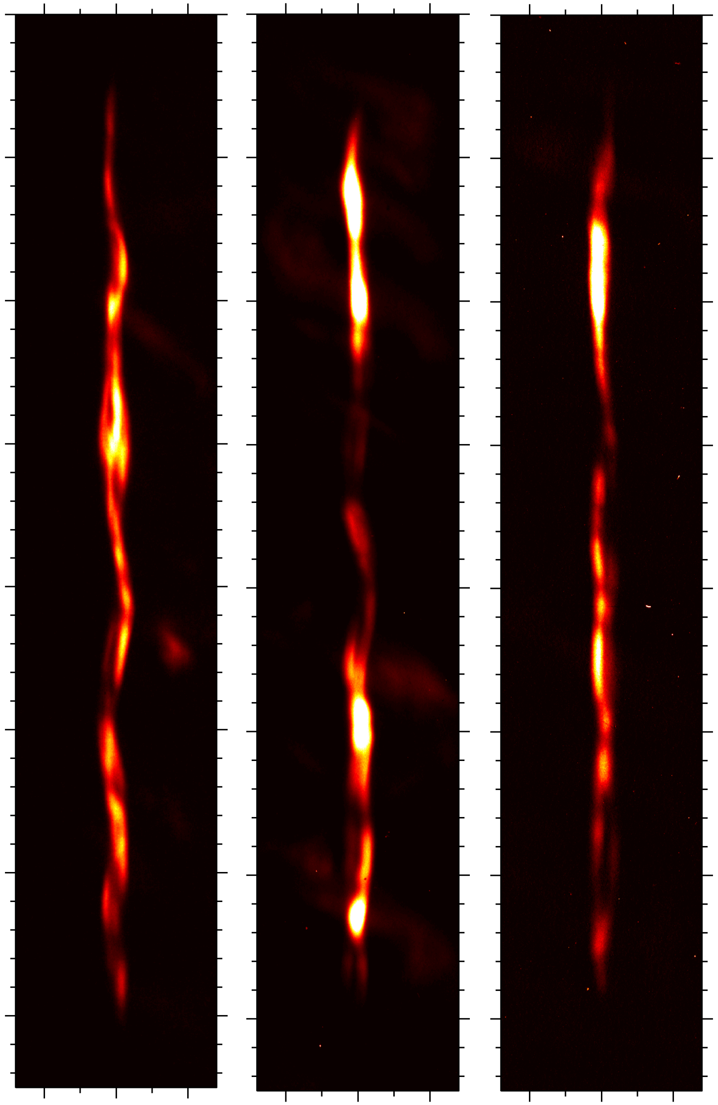
High resolution x-ray images show a high aspect ratio column at stagnation



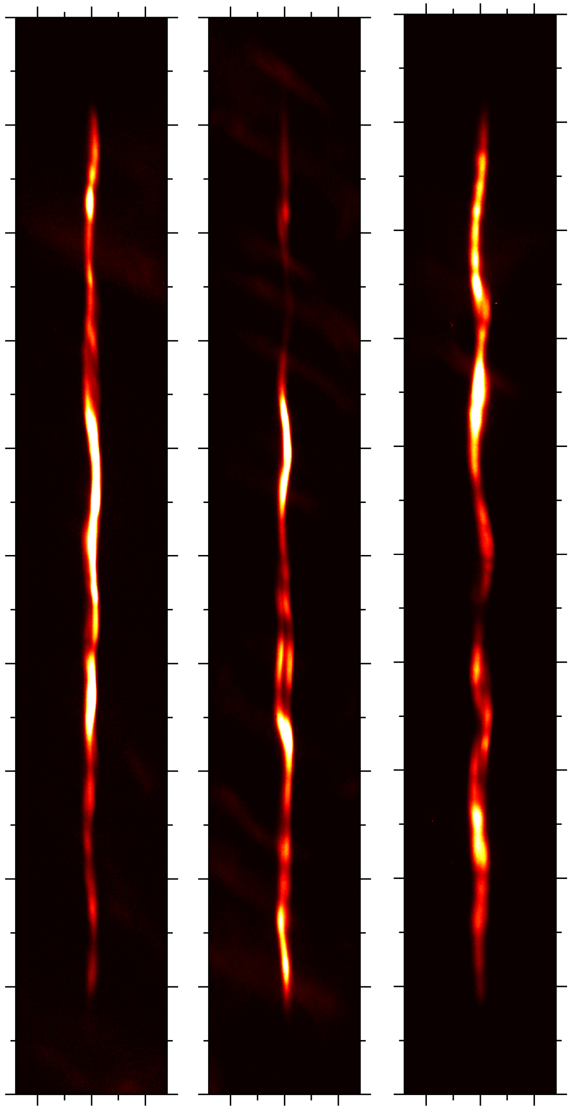
- Emission from stagnation column is roughly 80% of the initial target height
- Emission is generally continuous over the height of the target
- Emission width is roughly 1/45 of the initial target diameter
  - Very high convergence?

M. R. Gomez, et al., Phys. Rev. Lett. 113, 155003 (2014).

Intensity variations and noticeable helicity indicate instabilities may be impacting performance

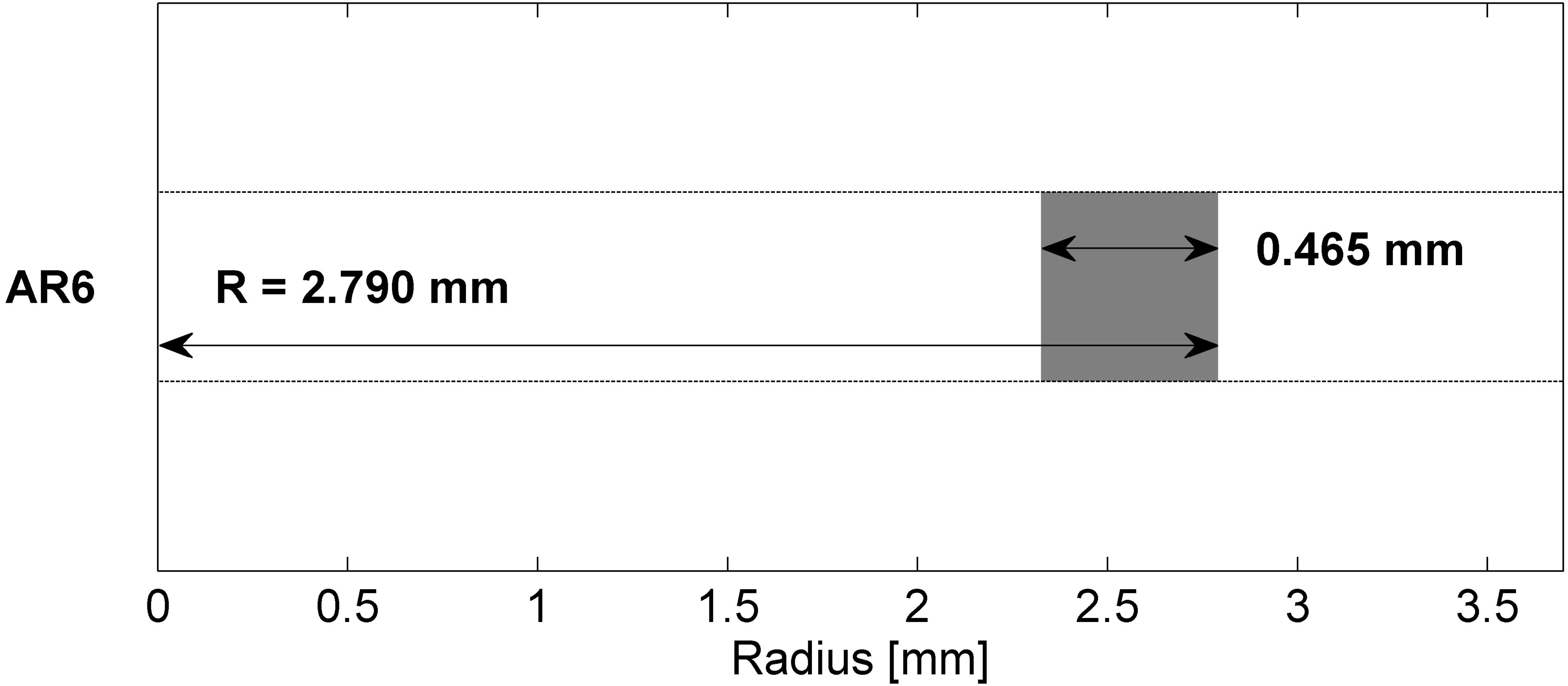


- Intensity variations are likely a combination of changes in fuel pressure as well as changes in liner rho-R
- Helical structure could be a sign of feedthrough of instabilities from the exterior of the liner
- Bifurcation could be an indication of m ≥ 2 modes



M. R. Gomez, et al., Phys. Plasmas 22, 056306 (2015).

We both increased and decreased the aspect ratio to investigate the impact on stability



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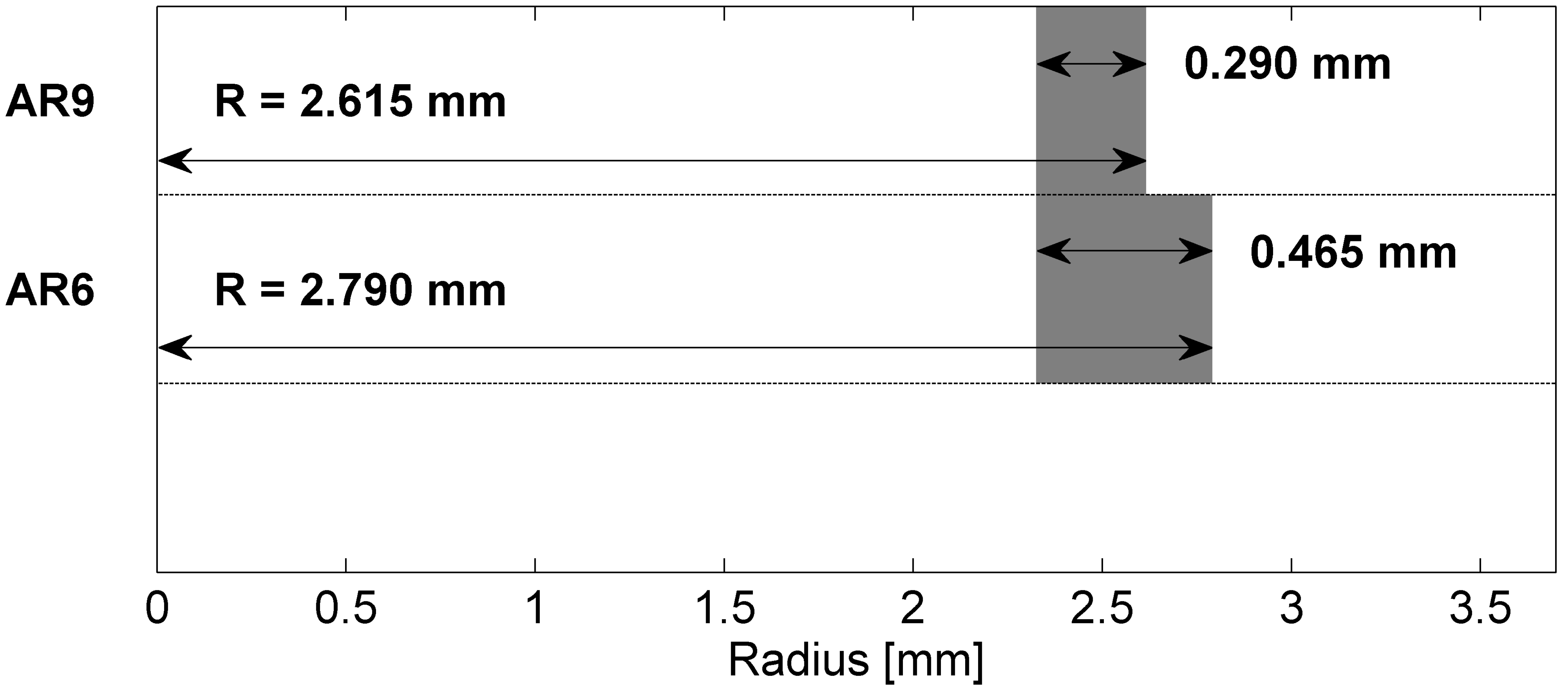

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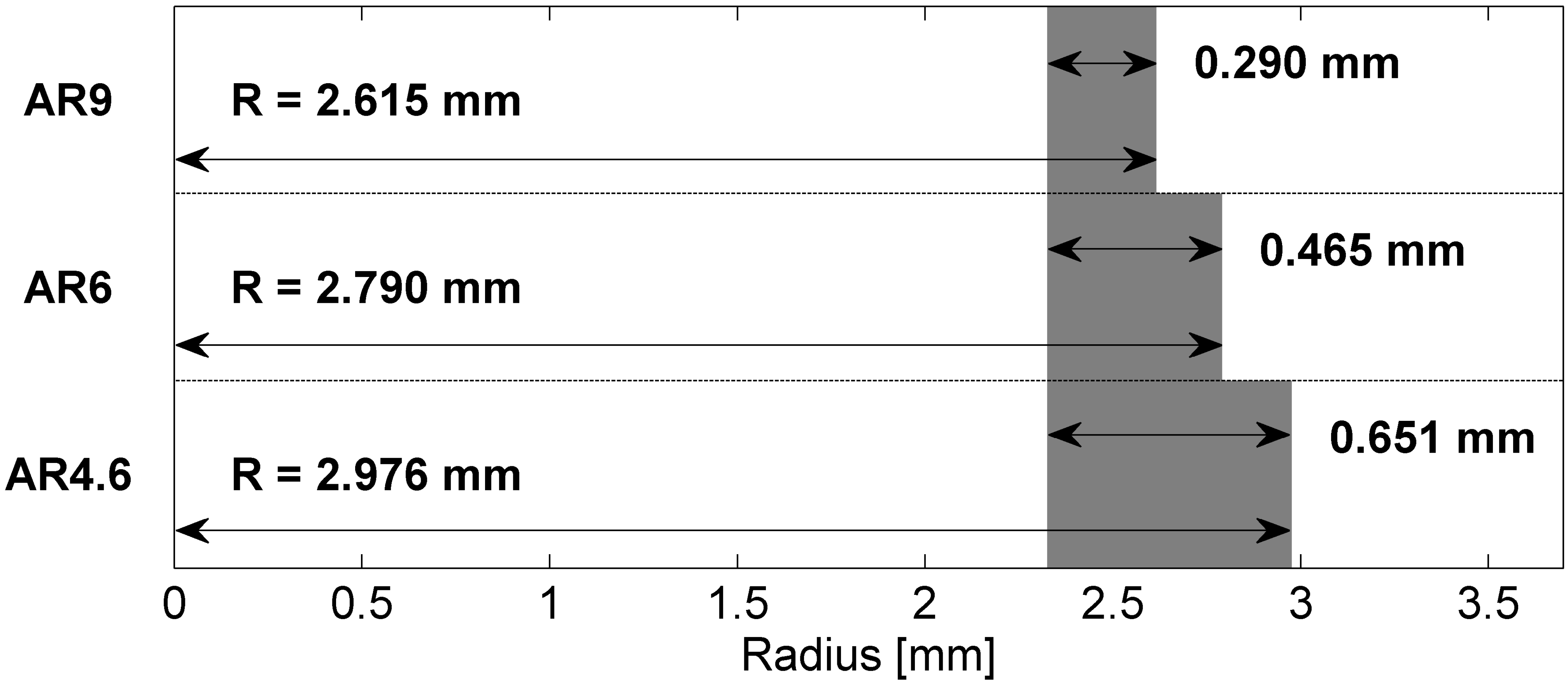
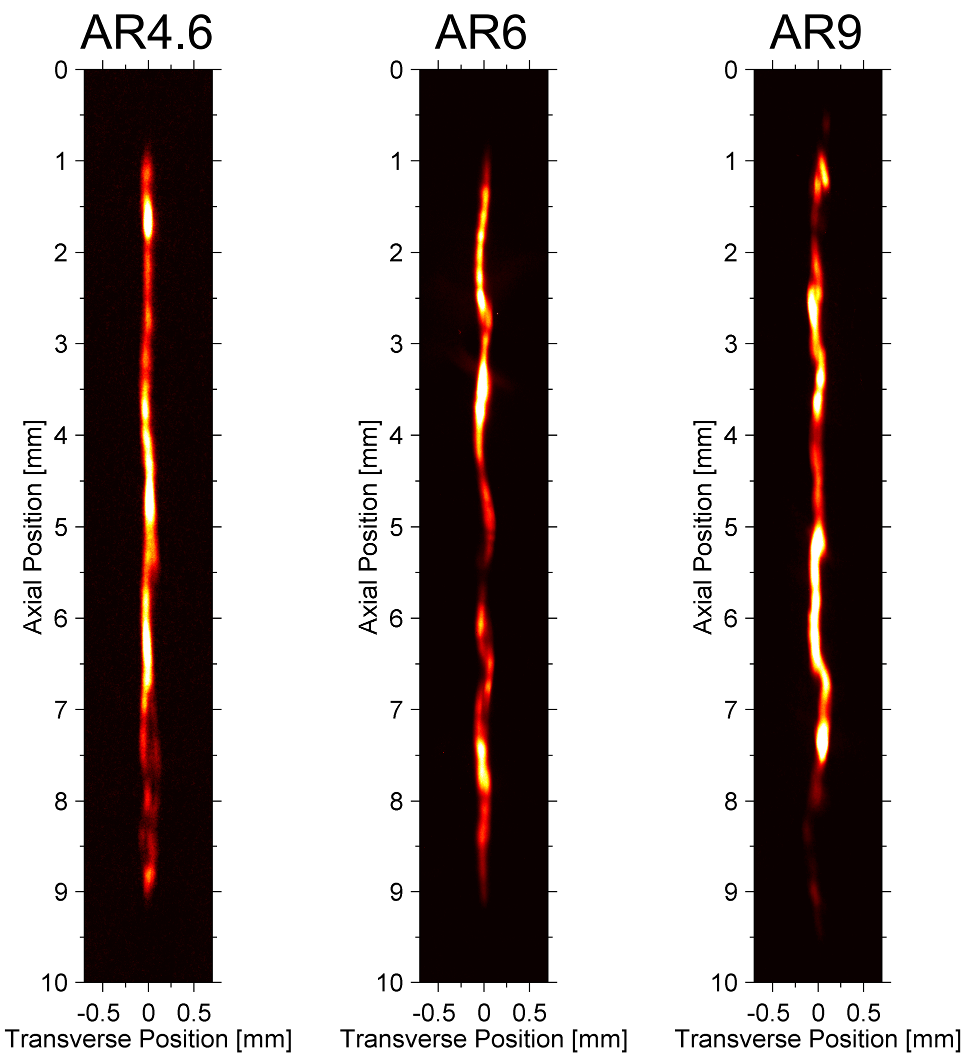


Stagnation appears to be more stable for targets with thicker walls

- Lower aspect ratio = more stable stagnation column and higher aspect ratio = less stable stagnation column
- Indicates stagnation stability is impacted by feedthrough from the exterior of the target
- Neutron yield is not improved in more stable case and is not significantly degraded in less stable case
  - Could be related to the change in implosion time due to the change in mass



AR4.6	AR6	AR9
6.0×10^{11}	3.2×10^{12}	2.2×10^{12}
1.6 keV	2.5 keV	2.5 keV

Data courtesy of Dave Ampleford, Chris Jennings, and Pat Knapp

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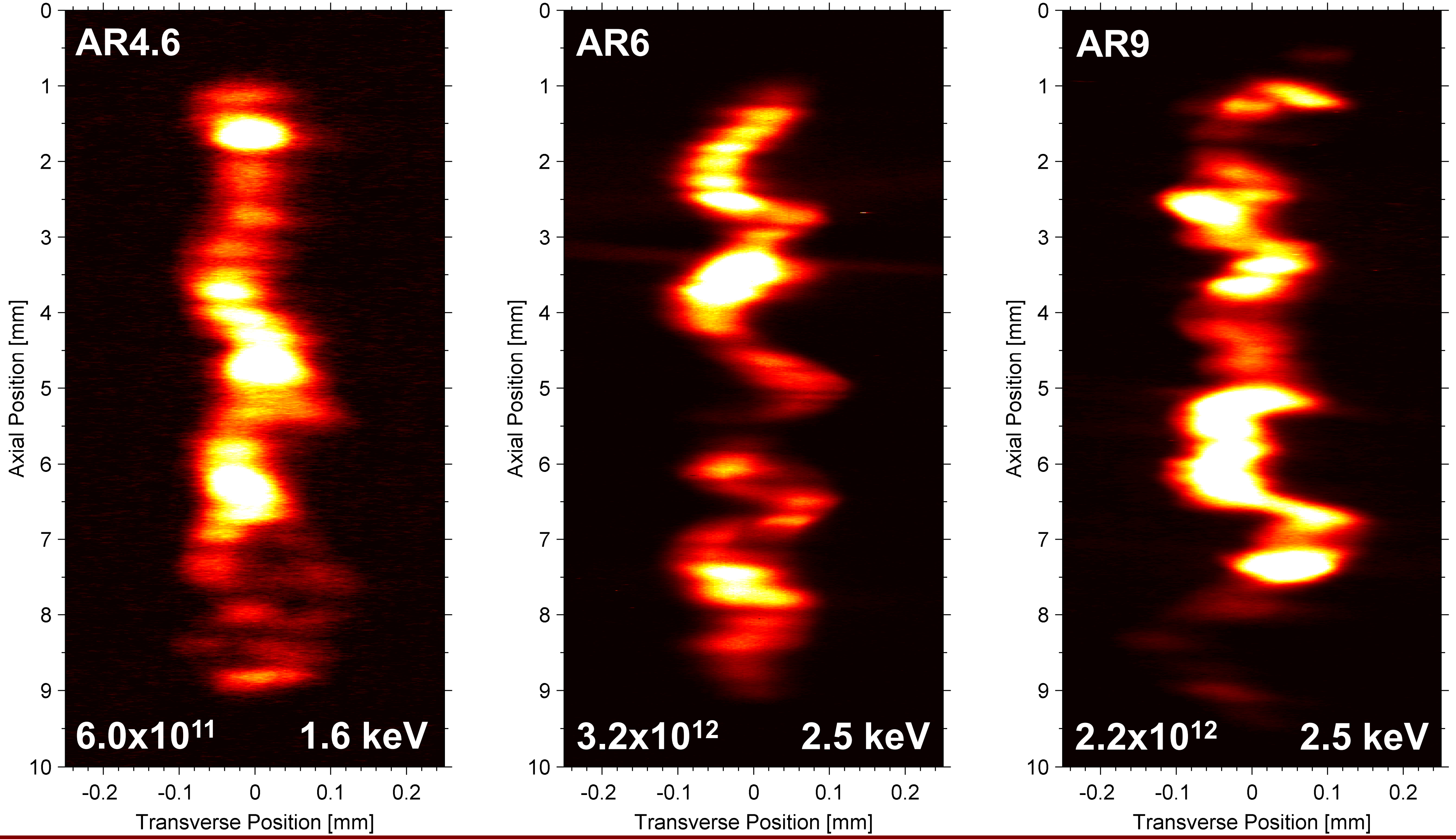
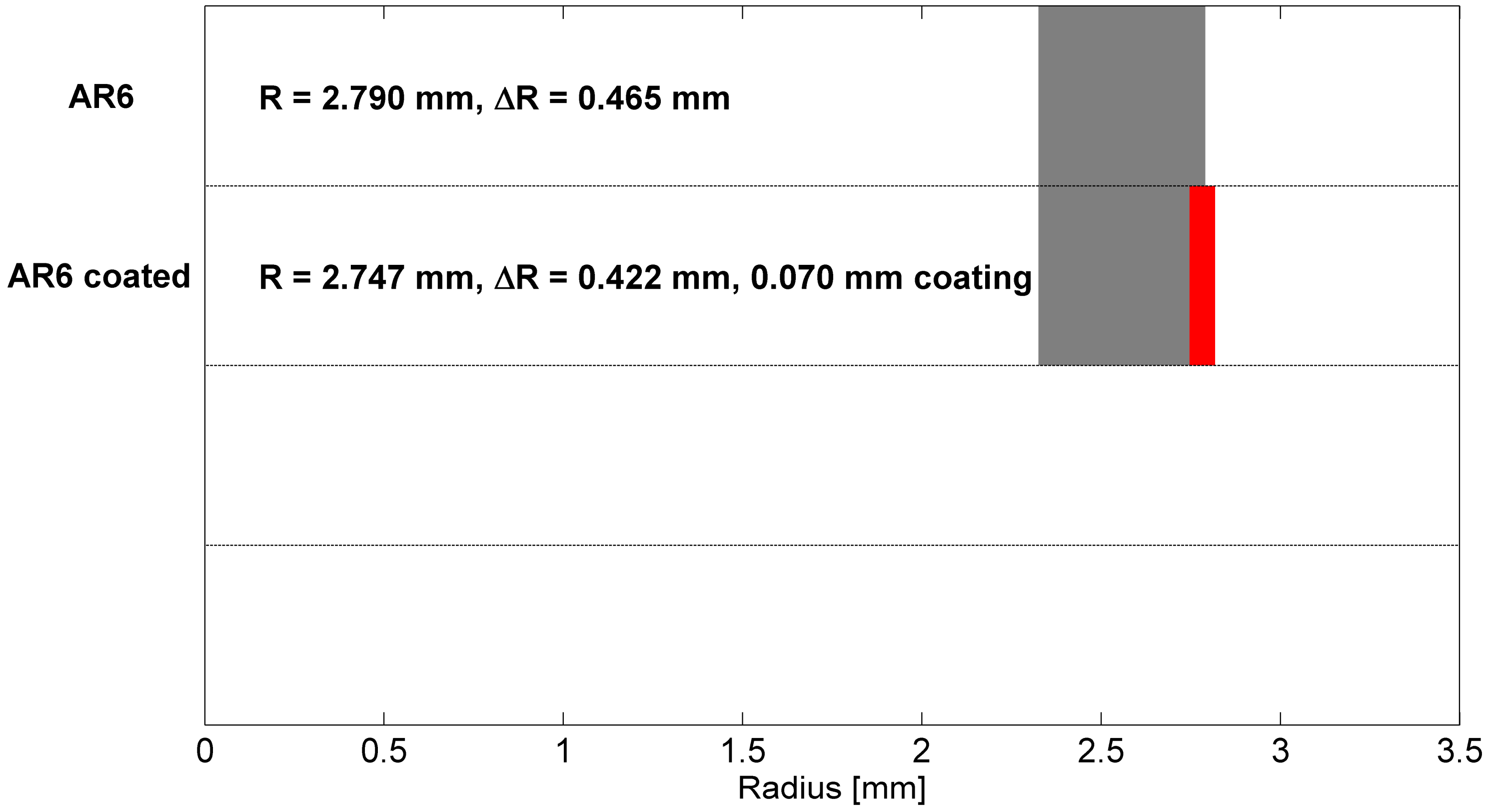


- Images stretched 10x in horizontal direction
- Subtle helical mode in AR4.6
- Distinct helical mode in AR6
- Many modes in AR9

Data courtesy of Dave Ampleford, Chris Jennings, and Pat Knapp

Stability was improved without changing implosion time via a dielectric coating

The dielectric coating tamps early-time non-uniform expansion due to the electrothermal instability, which reduces the seed for the magneto-Rayleigh-Taylor instability



- Targets are mass-matched to maintain the same implosion times
  - Be density is 1.85 g/cm^3
  - Epon density is 1.13 g/cm^3
- Coated targets have reduced beryllium thickness but increased overall thickness

T. J. Awe, et al., Phys. Rev. Lett. 116, 065001 (2016).

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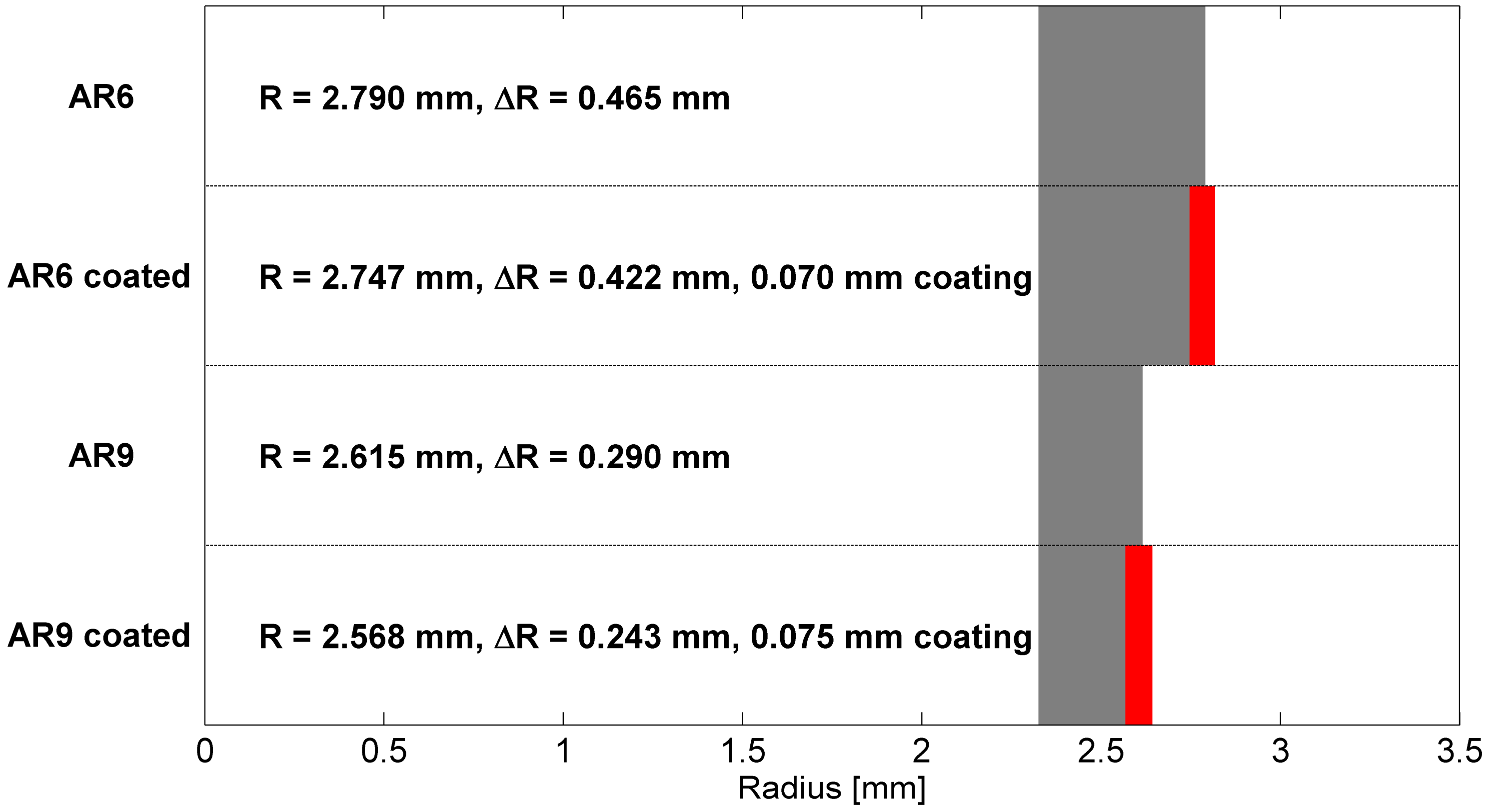
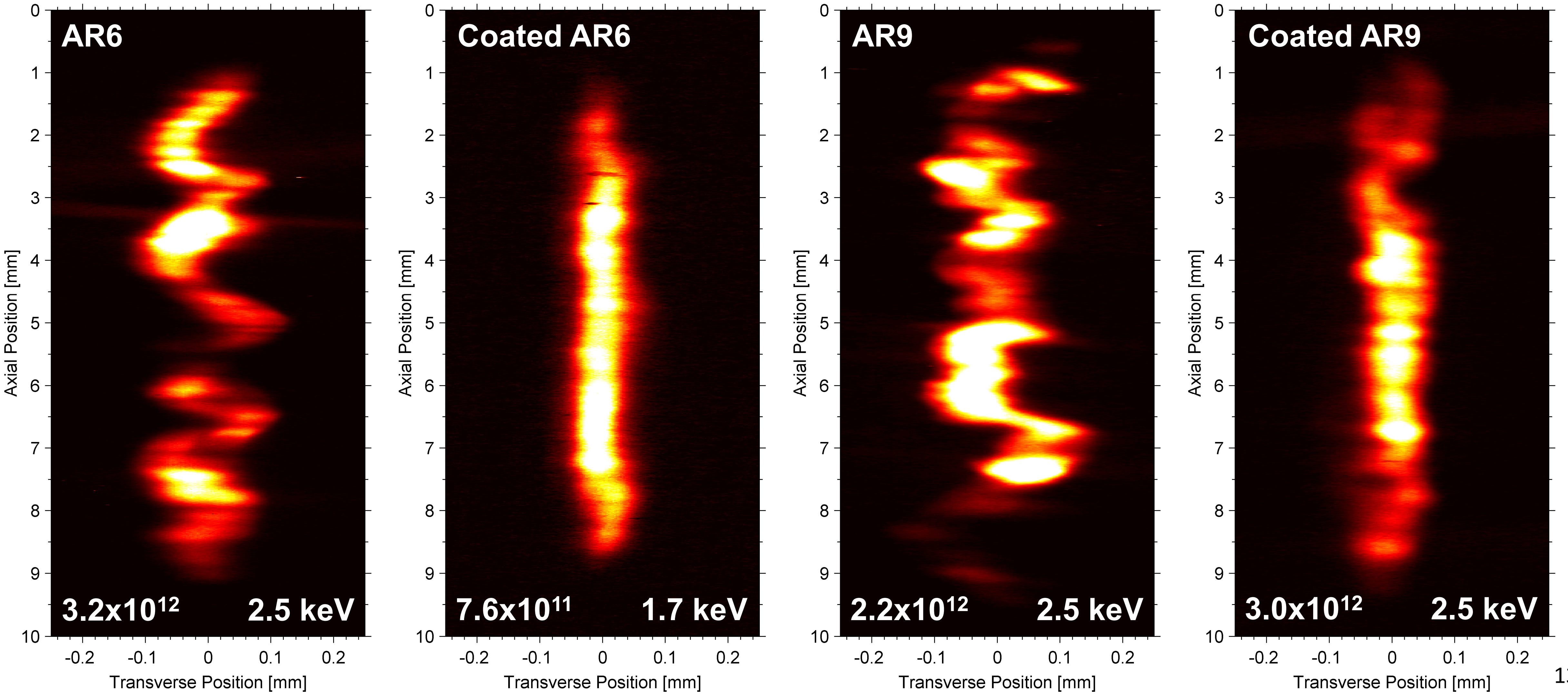


- Targets are mass-matched to maintain the same implosion times
  - Be density is 1.85 g/cm^3
  - Epon density is 1.13 g/cm^3
- Coated targets have reduced beryllium thickness but increased overall thickness
- Applied technique to AR6 and AR9 targets

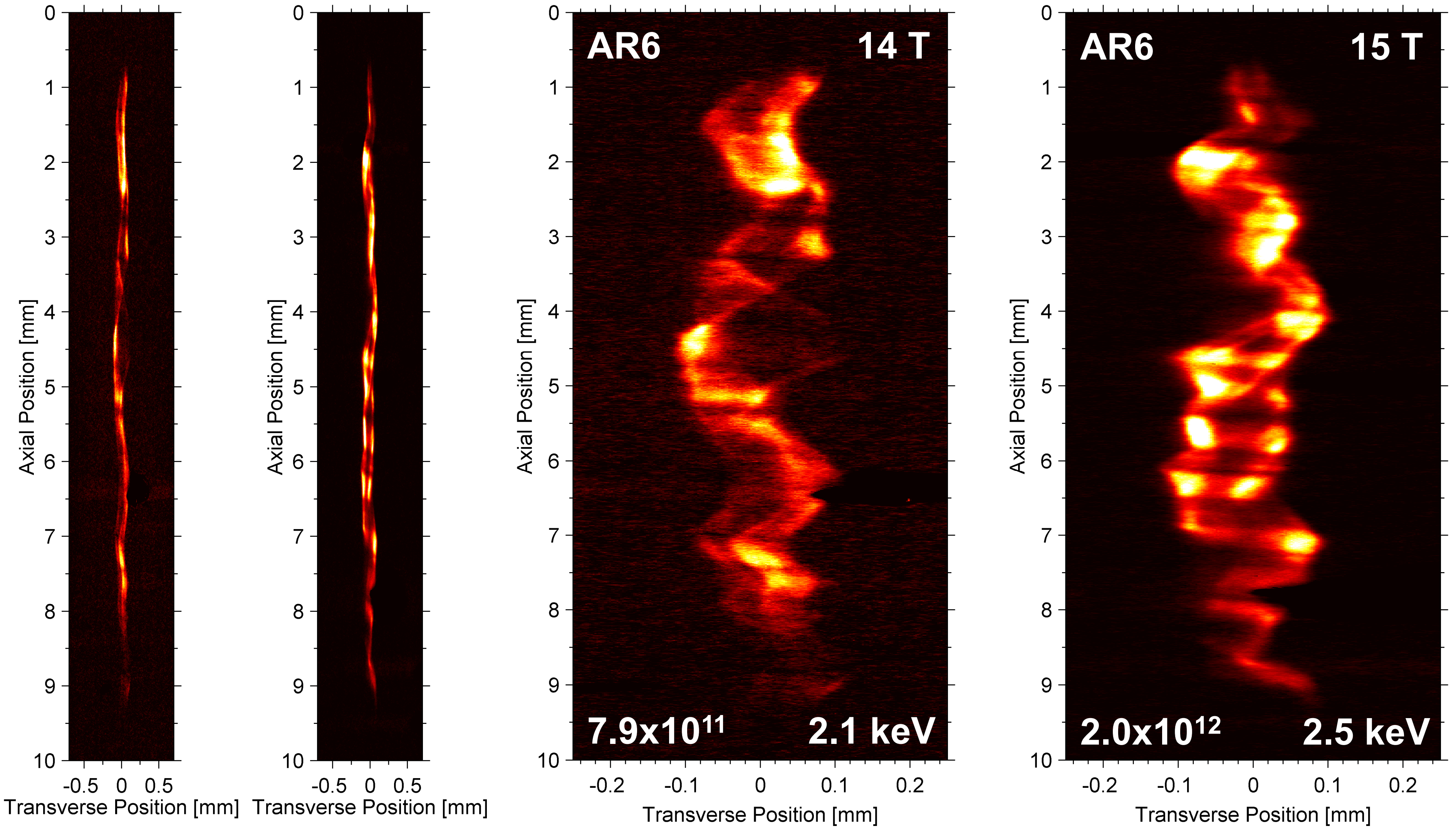
T. J. Awe, et al., Phys. Rev. Lett. 116, 065001 (2016).

Stability was improved without changing implosion time via a dielectric coating



Data courtesy of Dave Ampleford and Chris Jennings

We recently developed a higher-resolution version of the stagnation imaging diagnostic



- We are also developing:
- A time-resolved x-ray imager
- The capability to record orthogonal x-ray images
- A 1D neutron imager

Diagnostic design by Eric Harding

We've observed significant changes at stagnation through target geometry modifications

- Increasing the target wall thickness leads to a more stable stagnation
  - Measurable reduction in neutron yield and plasma temperature
  - Additional mass delays stagnation timing, maybe resulting in decreased liner confinement?
- Decreasing the wall thickness leads to a less stable implosion
  - Insignificant change in neutron yield and plasma temperature
  - Could be consistent with hot-spots dominating overall target performance?
- Reducing the seed for the magneto-Rayleigh-Taylor instability leads to a more stable stagnation
  - Coated AR6 underperforms, maybe trailing mass results in decreased current driving the liner?
  - Coated AR9 performance is extremely stable and slightly better than uncoated case
- Instability feedthrough impacts stagnation morphology but does not significantly impact yield or temperature in a negative way for our present conditions
  - Stability will be more critical at higher currents