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3-DIMENSIONAL MODELING OF NESTED Al and Al on Ni-CLAD Ti WIRE ARRAY Z PINCHES

C.A.Jennings, C.A. Coverdale, D. J. Ampleford, S.B.Hansen, B. Jones, E.P.Yu, M. E. Cuneo
Sandia National Laboratories, Albuquerque

J. P. Chittenden
Blackett Laboratory, Imperial College, London

P.D. LePell
Ktech Corporation, Albuquerque, NM 87123

Y. Maron
Weizmann Institute, Israel

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Outline

Implosion and Stagnation of a Large Diameter Wire Arrays

- **Describe the implosion and stagnation of Aluminium large diameter k-shell source**
- **Outline processes responsible for high photon energy emission**

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GORGON code well suited to model discrete wires in the full array volume

GORGON – 3D Resistive MHD

Fixed square grid finite volume hydrodynamics

Single fluid – separate electron and ion temperatures

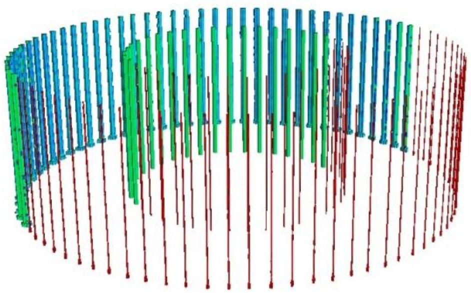
Explicit electro-magnetic field solution (wave equation in vacuum / diffusion equation in plasma)

Van Leer Advection

Constrained Transport for Magnetic Field Advection

Driven from measured voltage to account for current losses

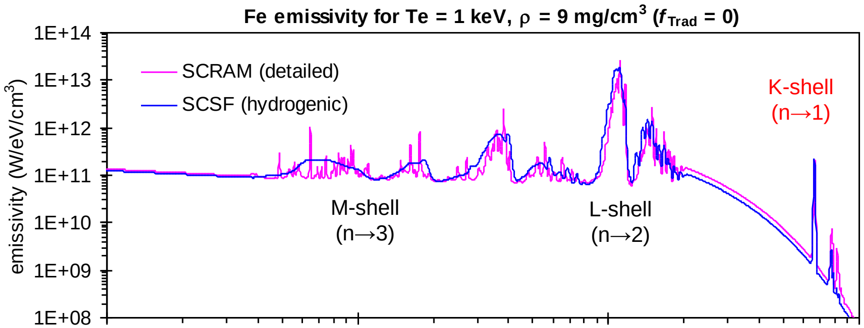
Full array modeled as discrete wires



Radiation is flux limited diffusion out of a zone then lost

Emissivity's ε and Rosseland/Planck opacities are tabulated on ρ, T_e, and f_{Trad} (T_{rad}=T_e).

Tables are based on the screened-hydrogenic/ UTA non-LTE model SCSF [1], which, like LLNL's DCA [1], compares well to more detailed atomic codes (*e.g*. SCRAM [2], [3])



[1] H. Scott and S.B. Hansen, HEDP 6, 39 (2010)

[2] S.B. Hansen *et al*., HEDP 3, 109 (2007)

[3] Brown, Hansen *et al*., PRE 77, 066406 (2008)

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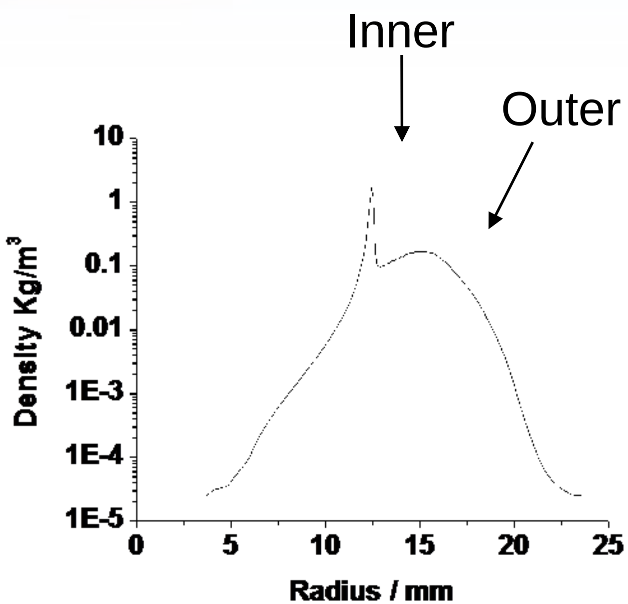
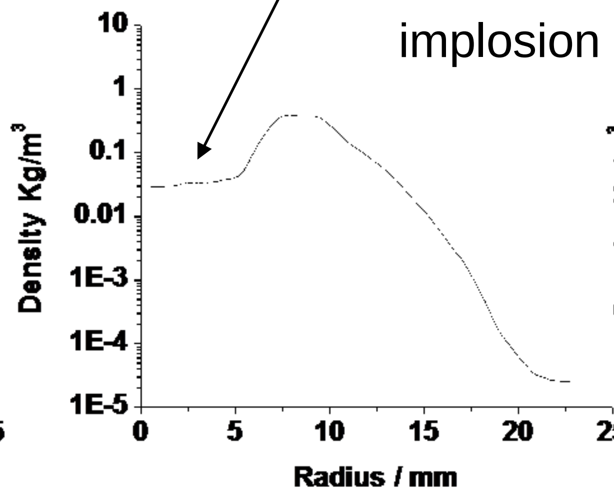
Radial Mass Distribution in Run up to Stagnation

Z2076 (50mm Al nested ~2mg)



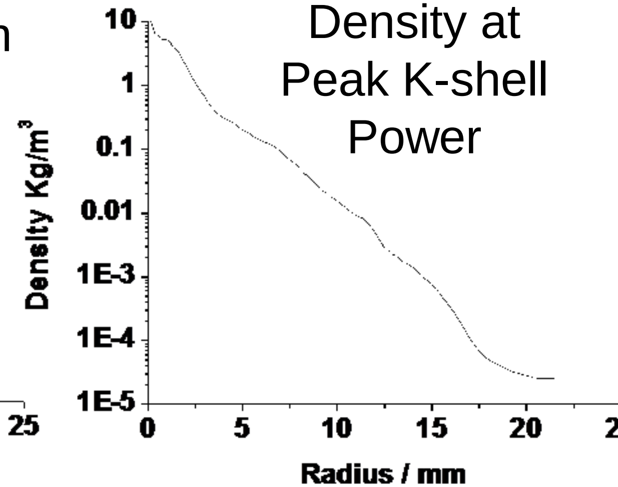
3060ns (-20ns)

Material assembles on axis ahead of main implosion

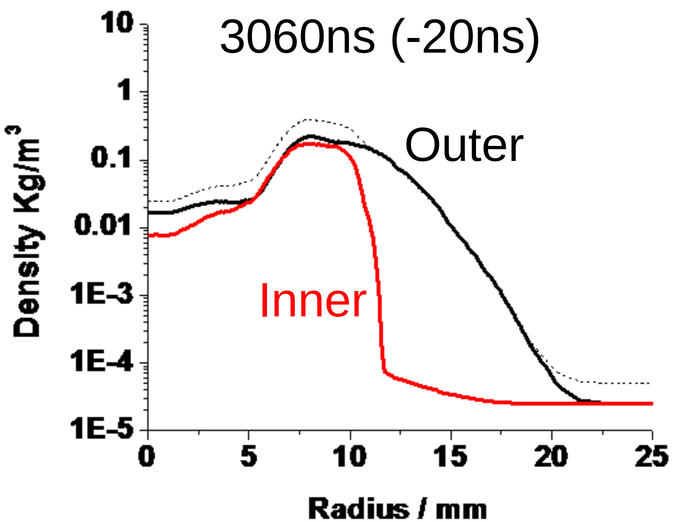


3070ns (-10ns)

Density at Peak K-shell Power



3080ns (-0ns)



Material assembled on axis comprised of both inner and outer array material

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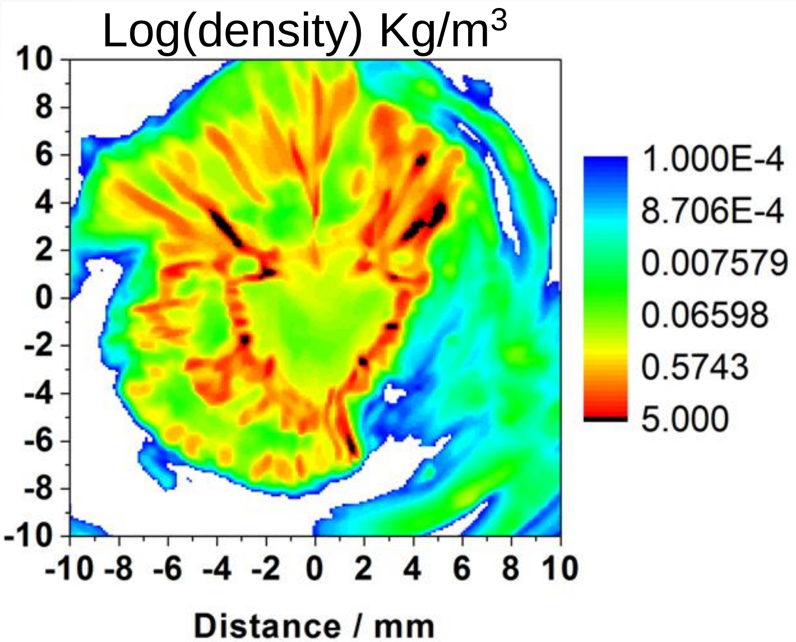
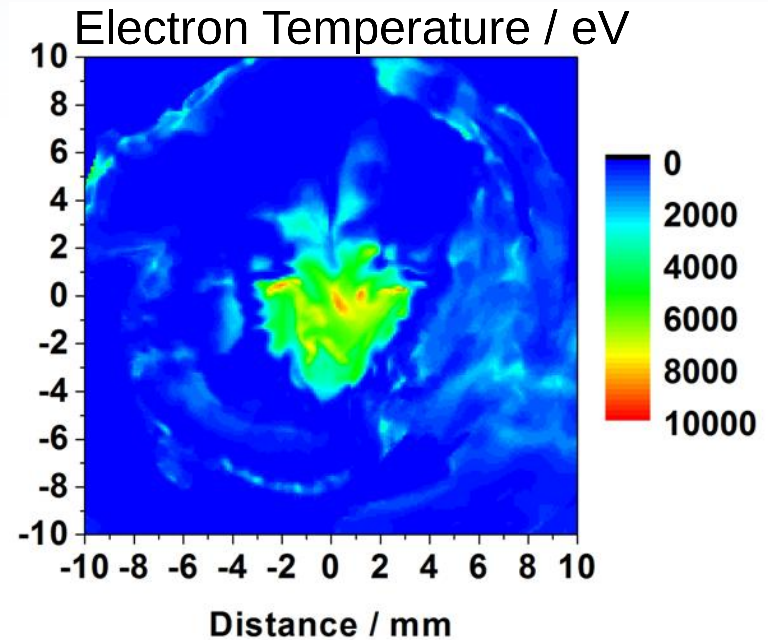
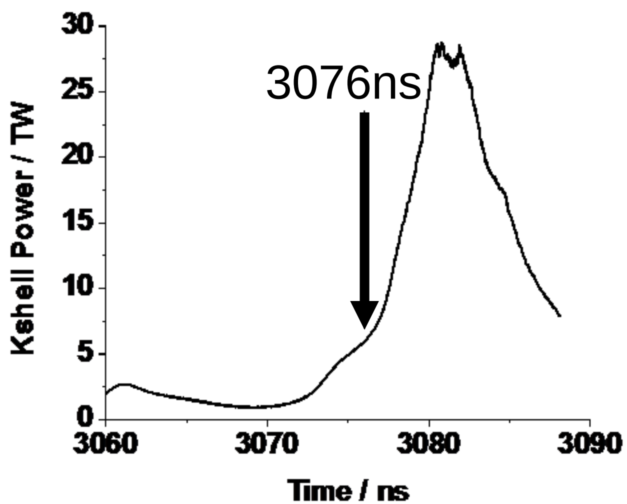
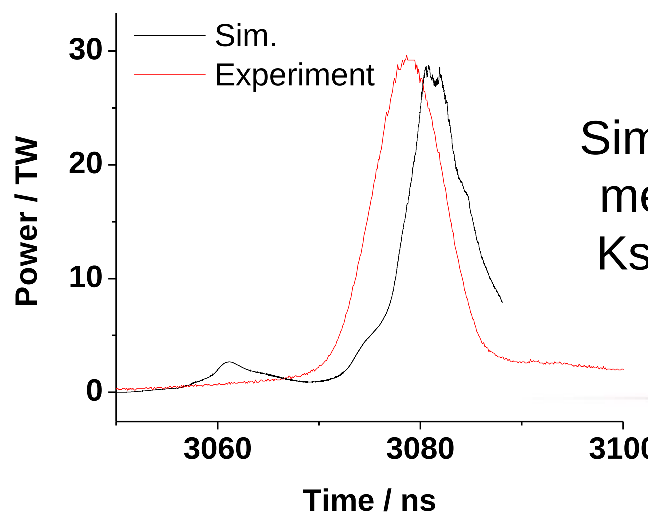
Low density material on axis is High Temperature



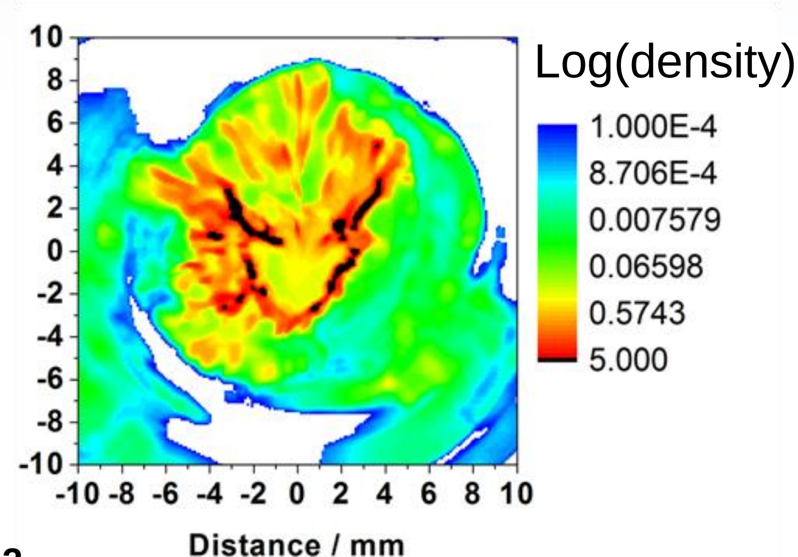




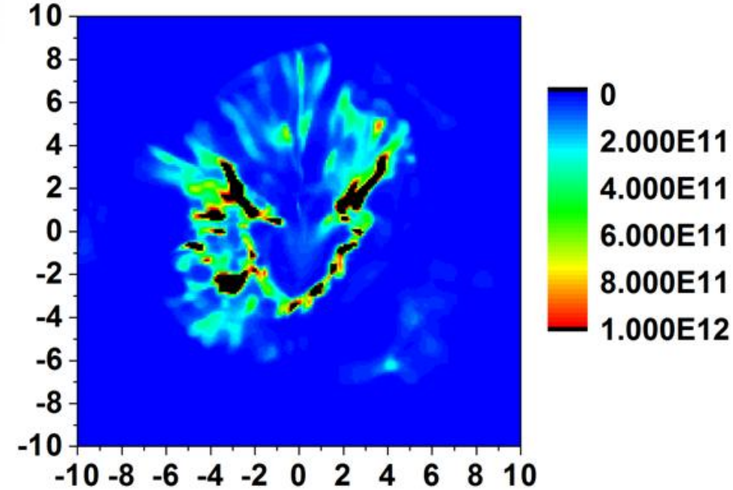


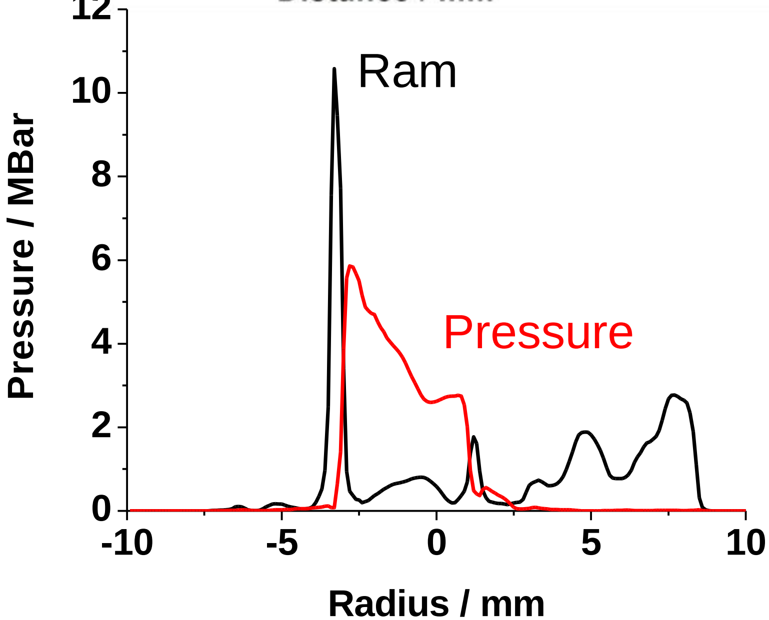
Simulated and measured Al Kshell power

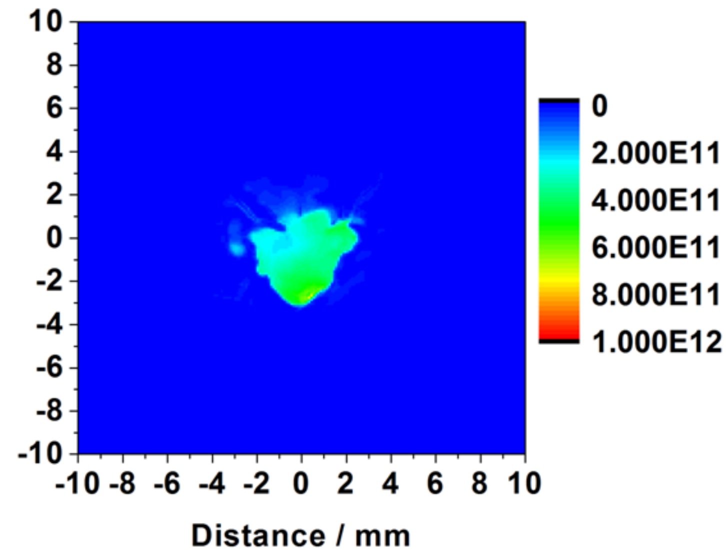
Ram Pressure exceeds material pressure. Stagnation is not in pressure balance but continues to collapse



Ram Pressure / Mbar







Pressure / MBar

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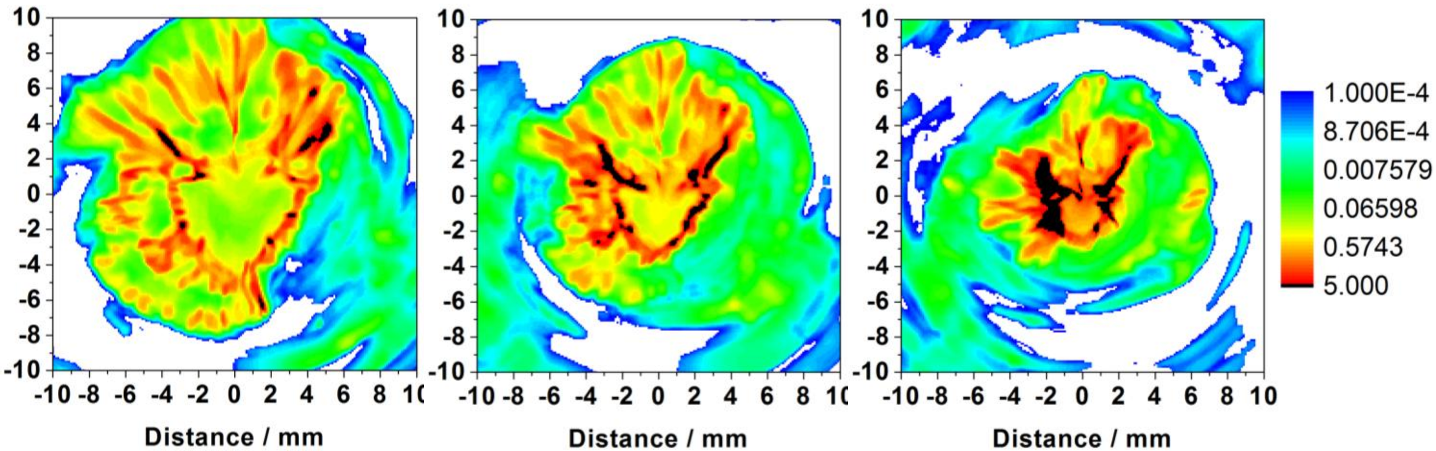
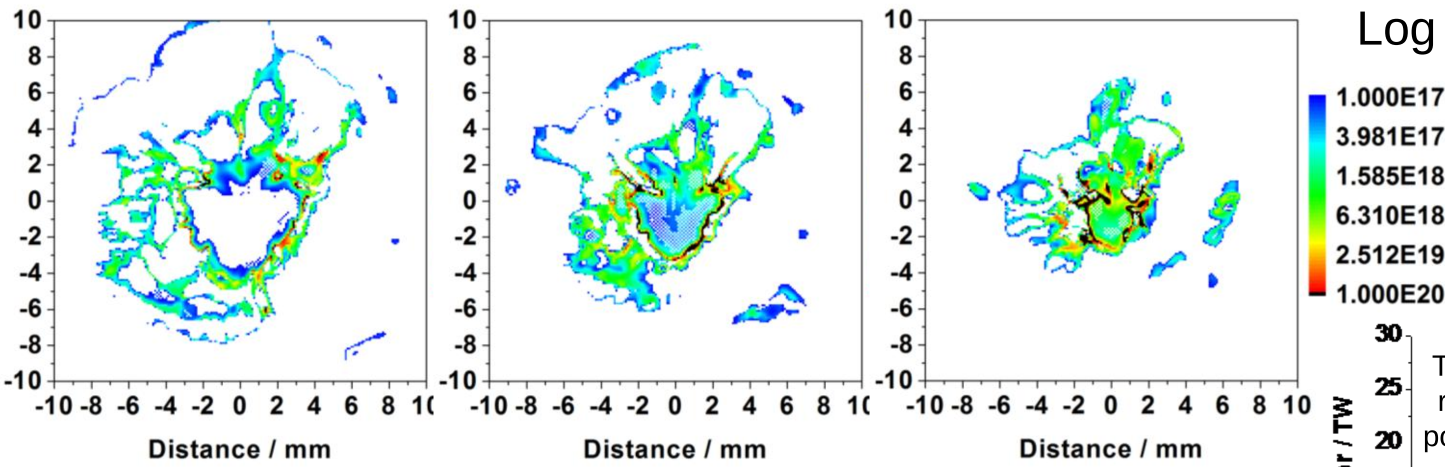
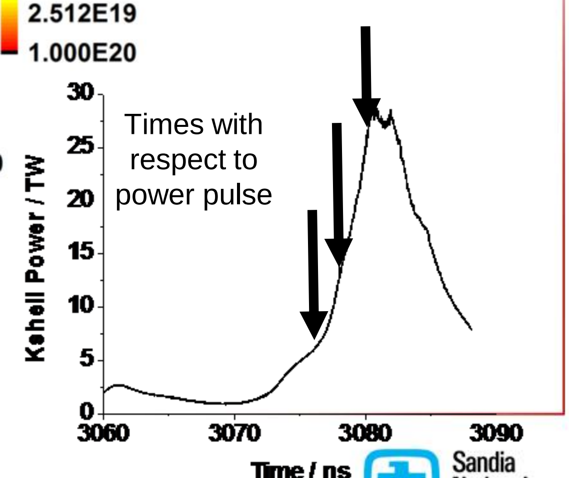
Kshell Emission comes predominantly from leading edge of imploding shell



Log (density) Kgm^{-3}

Log (kshell power) Wm^{-3}





Source of High photon energy emission appears to be like snow plough radiation from the leading edge of imploding "shell"

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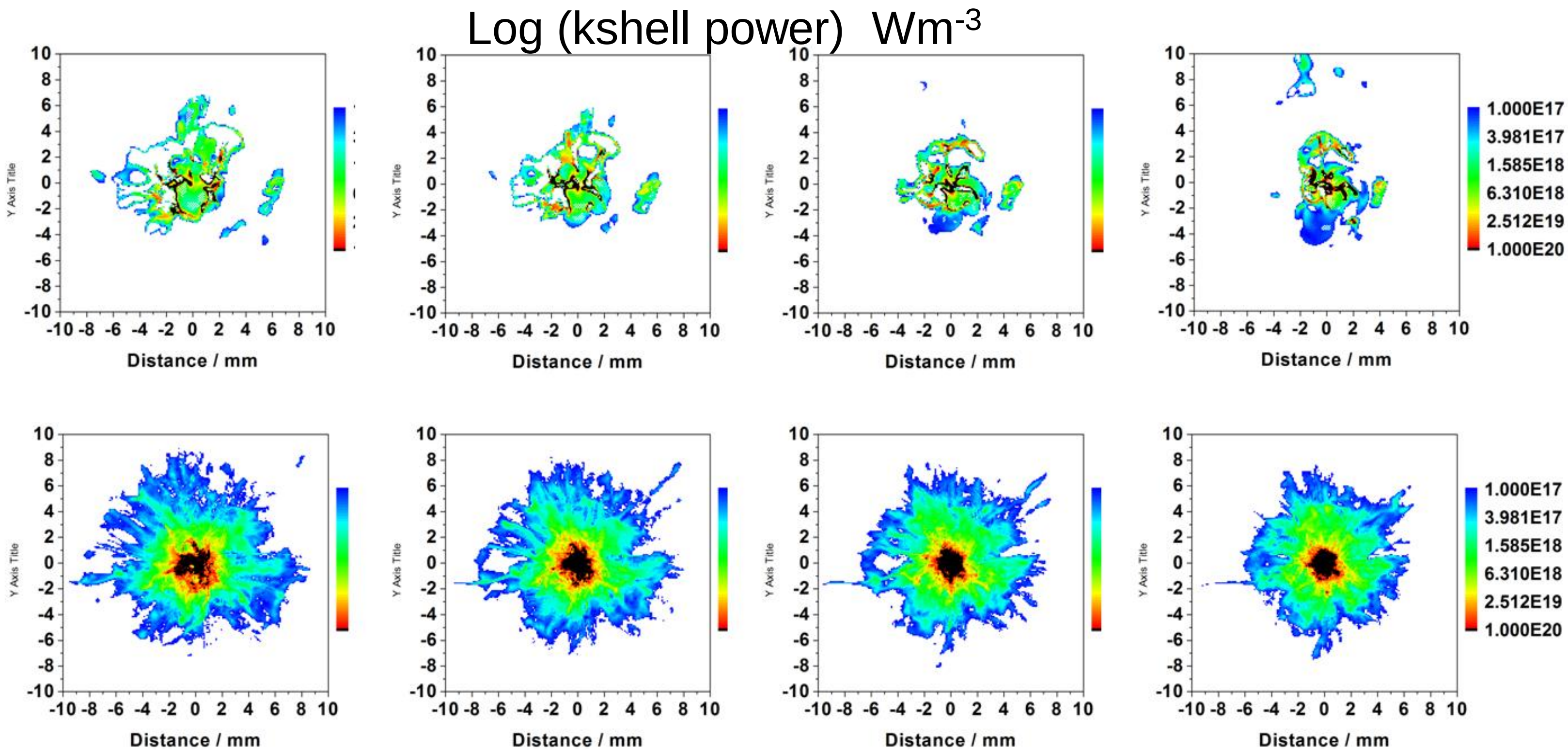
Dissasembly of pinch looks like finite pinch size when integrated along axis

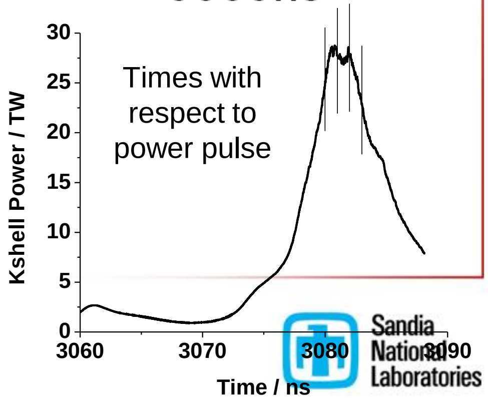
Slice through mid-plane

Integrated along axis



3080ns 3081ns 3082ns 3083ns

Unstable disassembly of pinch, when viewed in emission and integrated along axis appears like a stable pinch in pressure balance, but the finite pinch size is not maintained by pressure balance, but by a failure to geometrically converge



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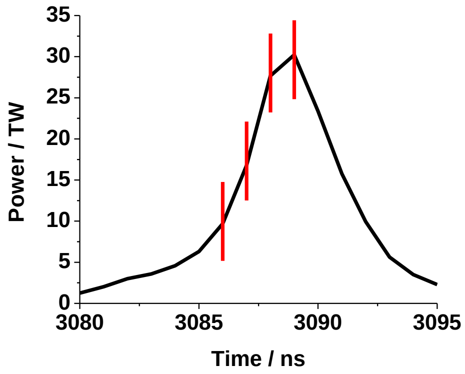
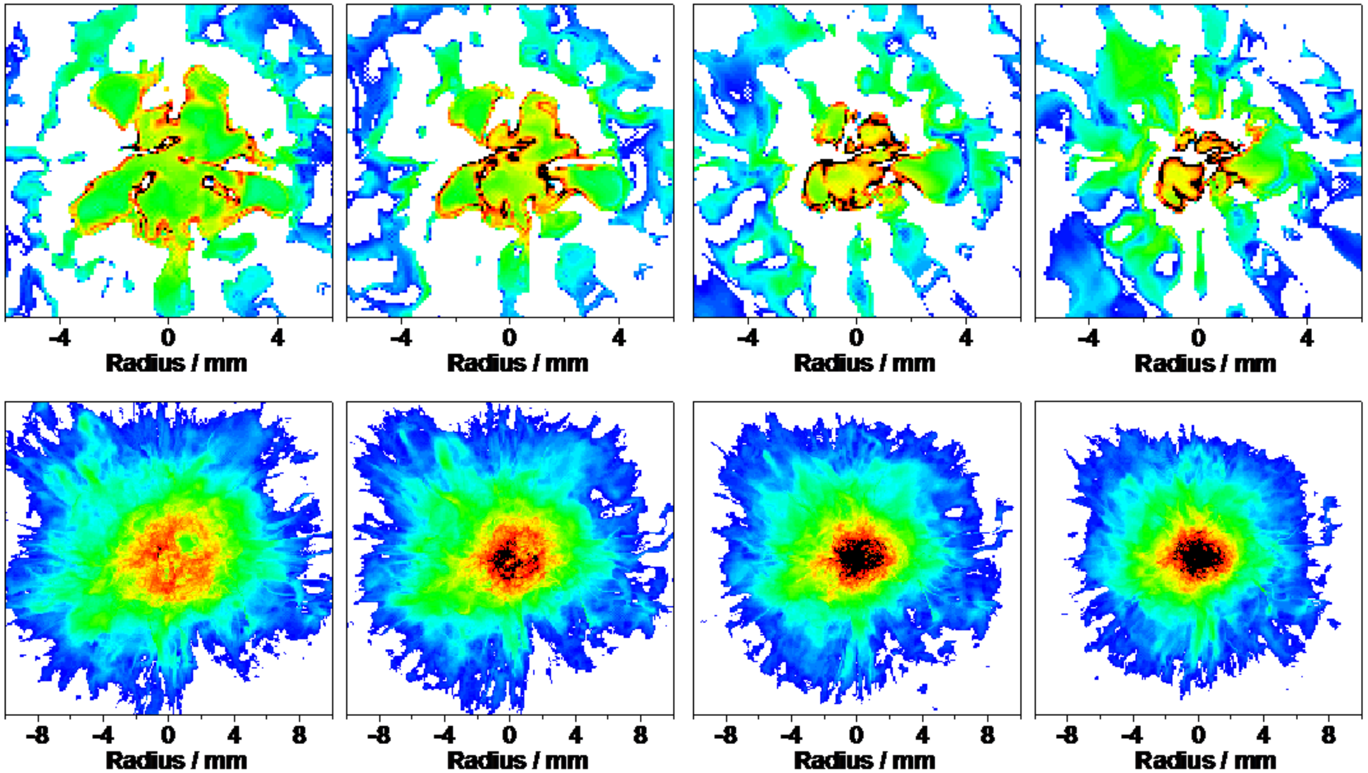
Same behavior observed in large diameter stainless steel implosions

Slice through High Photon Energy Emission



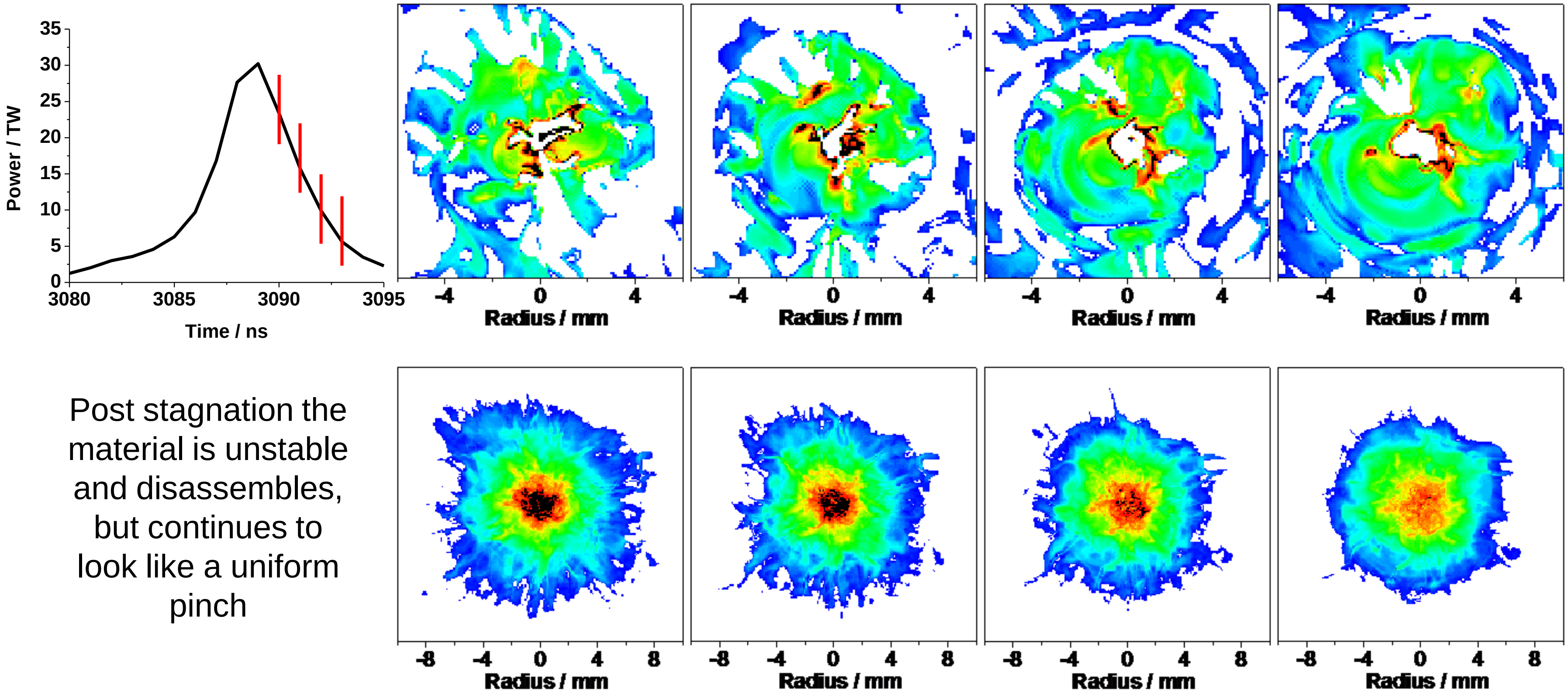


Emission Integrated Along Axis

Rise of K-shell x-ray pulse is more like snow plough radiation as pinch collapses.

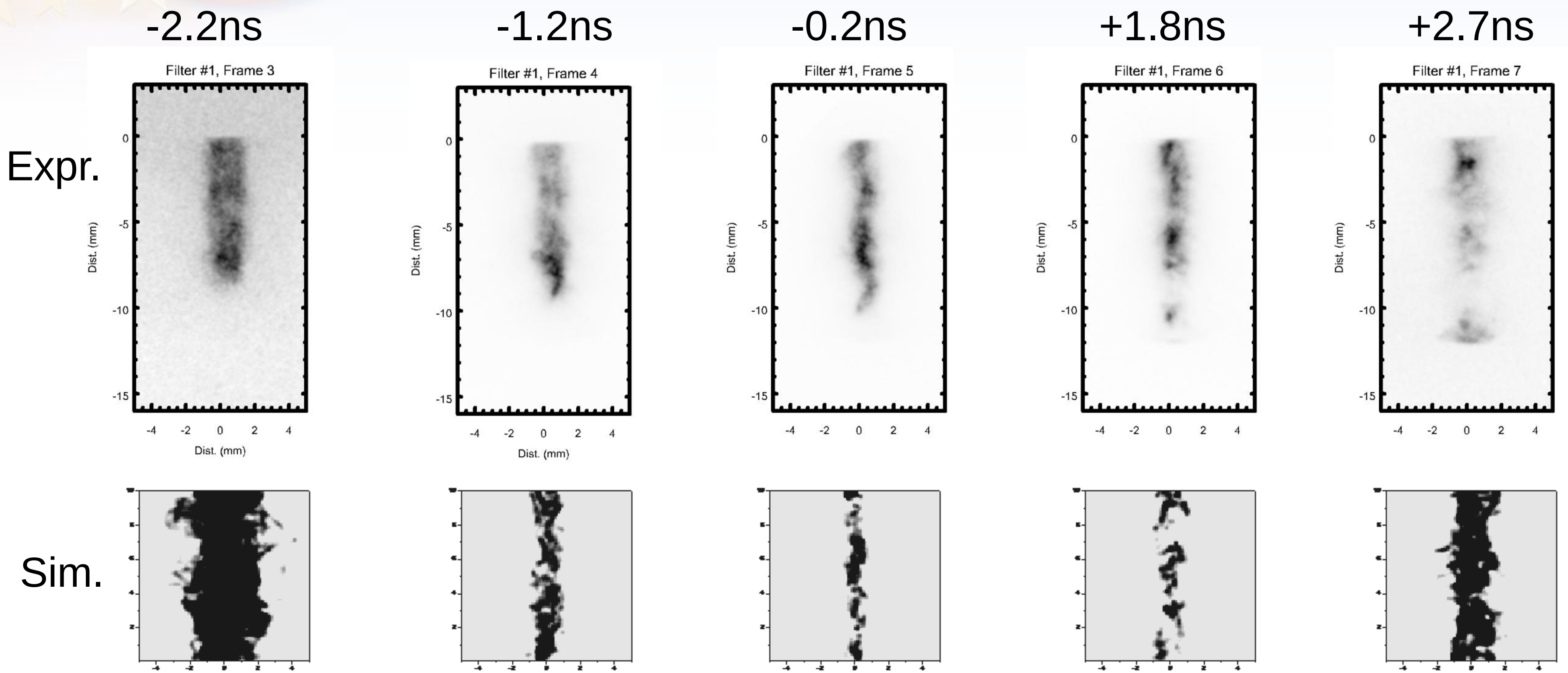
From the outside world this can look like a uniform pinch

Post Peak X-ray Pinch Disassembles

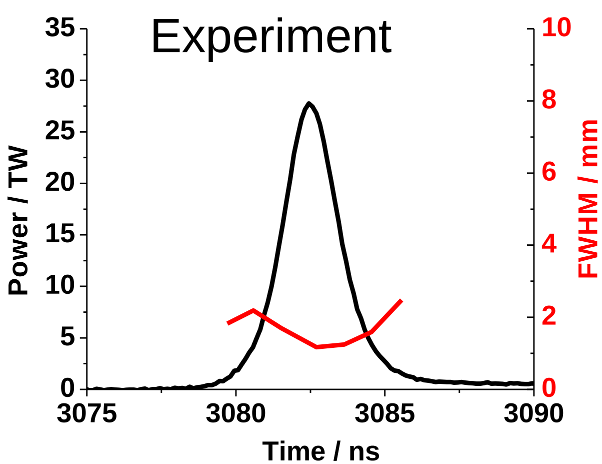


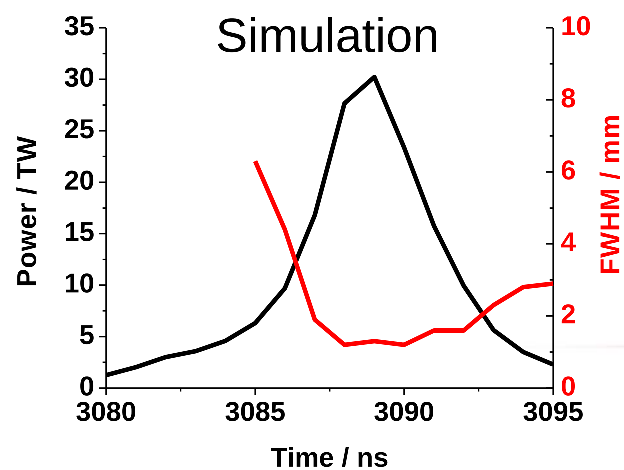
Post stagnation the material is unstable and disassembles, but continues to look like a uniform pinch

Comparison of actual and Synthetic Pinhole images

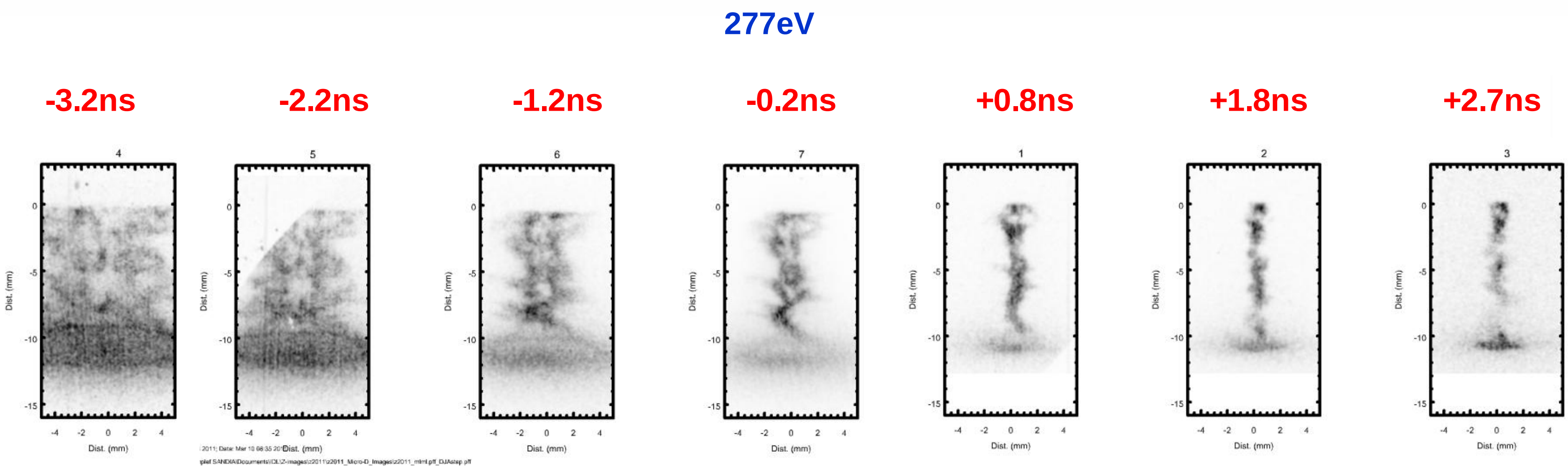


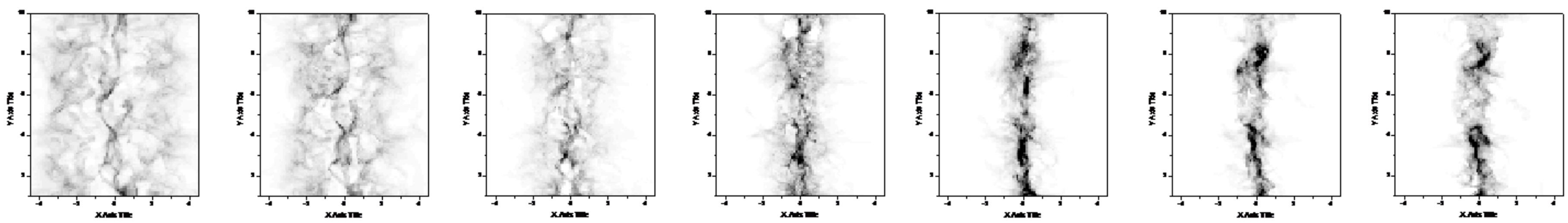
Calculated K-shell FWHM agrees with experiment



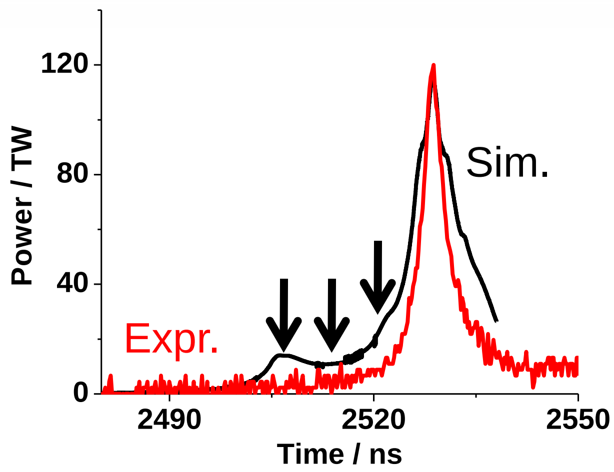


Lower Photon Energy 277eV MLM Camera shows similar structures

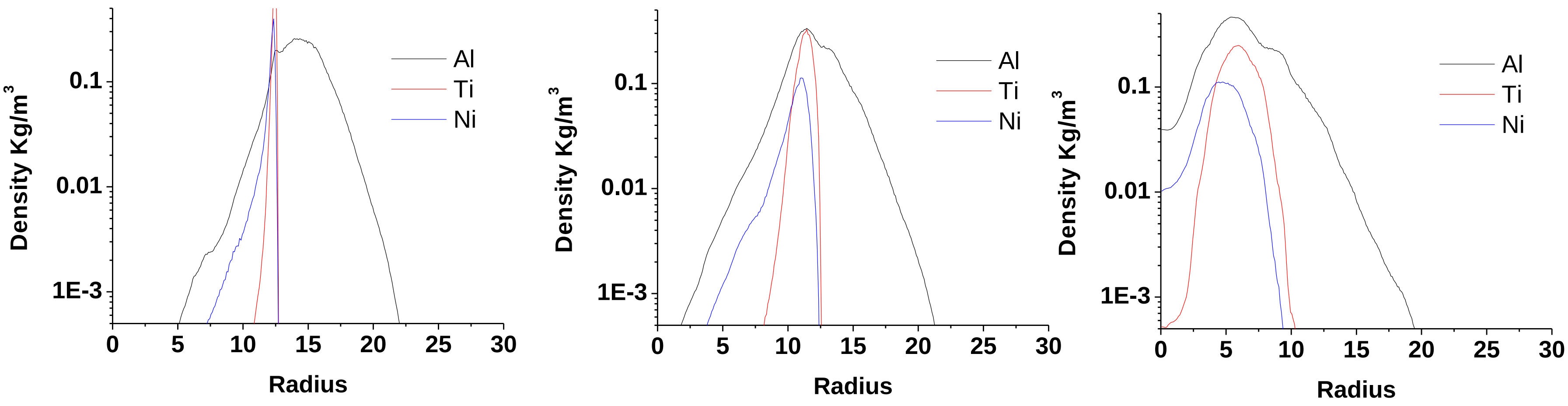




Al on Ni-clad Ti arrays show Ni cladding of inner array collected first by imploding outer



Z shot 785
Al on Ni-clad Ti
50mm on 25mm diameter
nested array

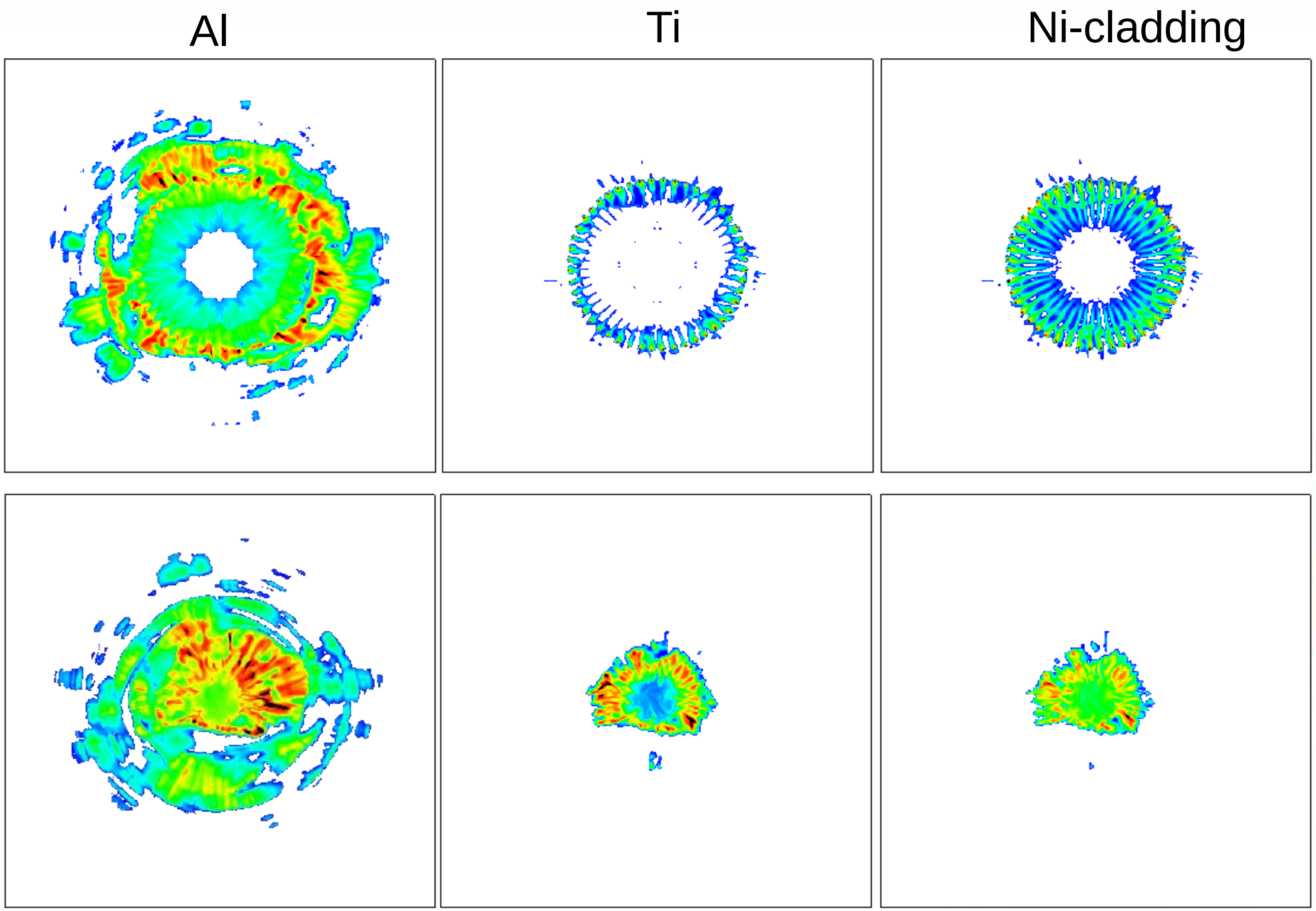


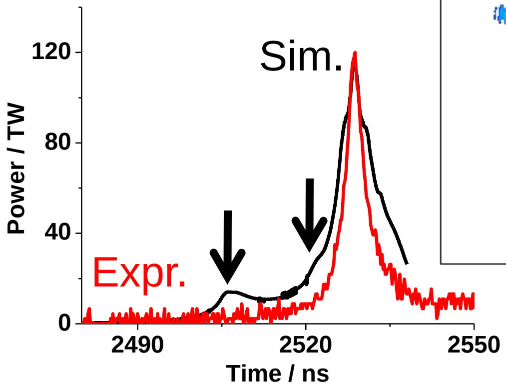
Inner material preferentially towards front of imploding mass

Model can now be employed on mixed material loads to better assess structures in the imploding and stagnating plasma

<u>Shot 785</u>
Al outer array
Ni-clad Ti inner array

Imploding Al shell first picks up Ni cladding from inner wires





Summary

- K-shell emission predominantly comes from the inside surface of an imploding shell impacting hot, low density material assembled on axis
- Pinch is highly structured at stagnation, but integrated diagnostics do not necessarily represent this
- Capability to model mixed material loads is being developed, and will greatly aid the understanding of these complicated, but diagnostically rich plasmas.