Los Alamos
NATIONAL LABORATORY
EST. 1943

High explosives and proton radiography

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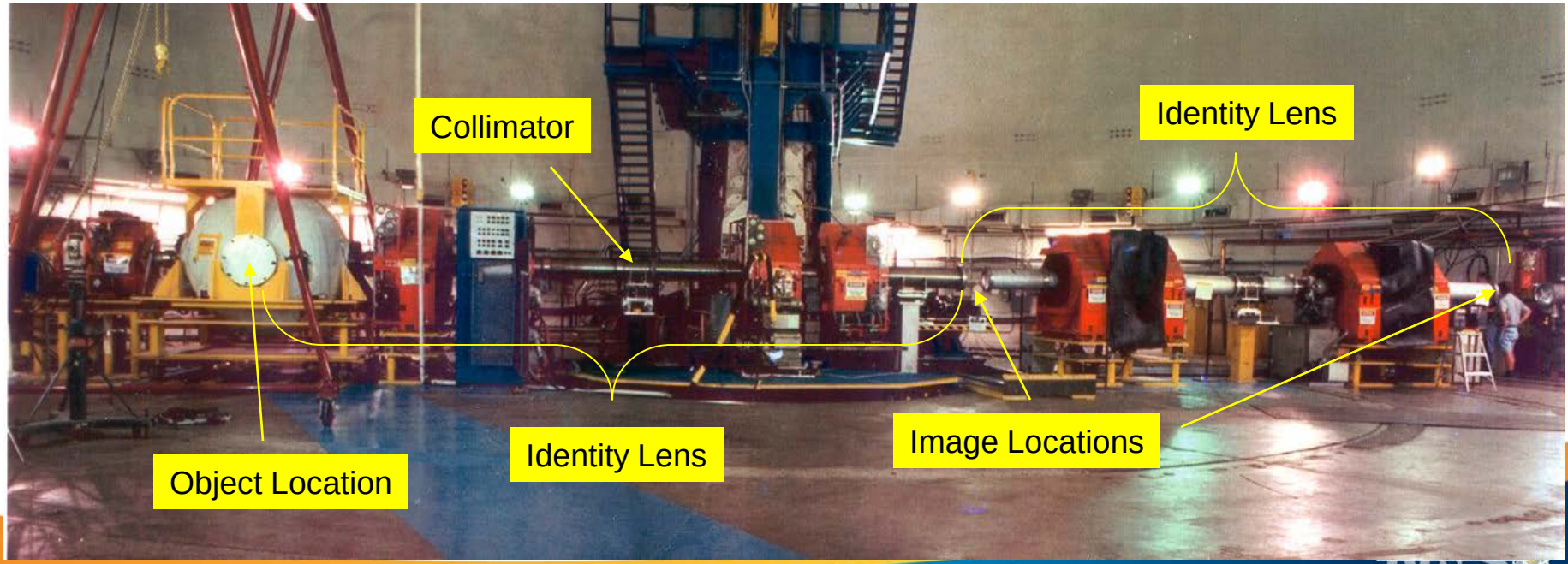
Definition of terms for this talk

- pRad – the proton radiography capability at LANL that uses 800 MeV protons, produced by the LANSCE accelerator, to provide multiple frames of flash radiography of static and dynamic configurations
- High Explosives – HEs release large amounts of energy and rapidly increase in volume; explosives can be divided into high (detonating) and low (deflagrating) explosives – HEs are often used to drive other materials

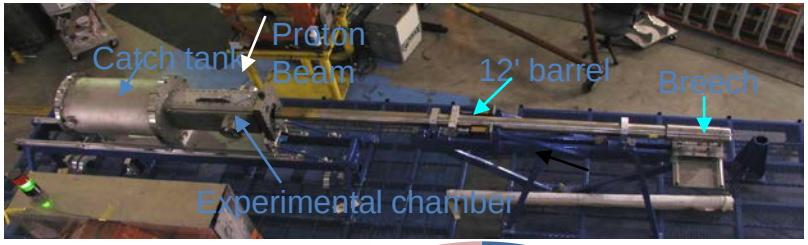
pRad capabilities at a glance

- 21 frames available
- Magnification/FOV: none/$(120mm)^2$, x3$(40mm)^2$ and x7$(17mm)^2$
- Current HE load limits: 10 lbs TNT equivalent max

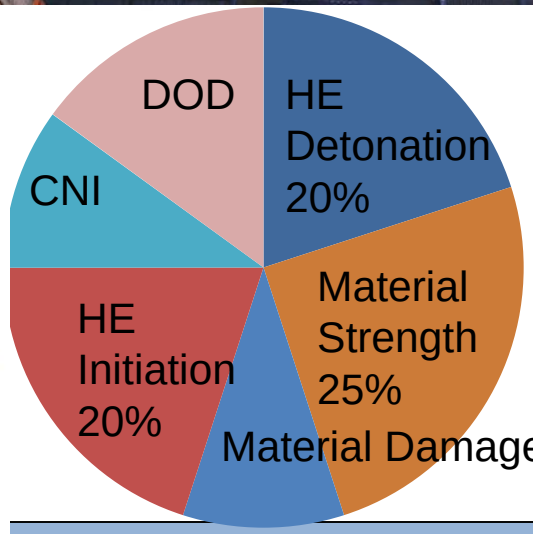


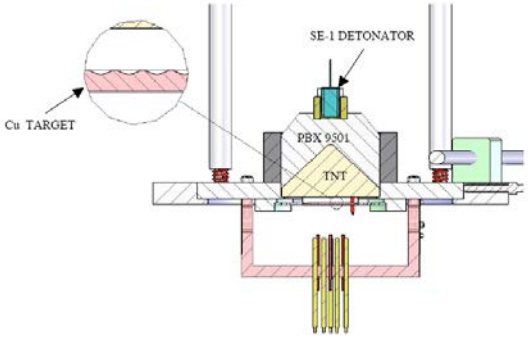
HE is both a driver and an object of study

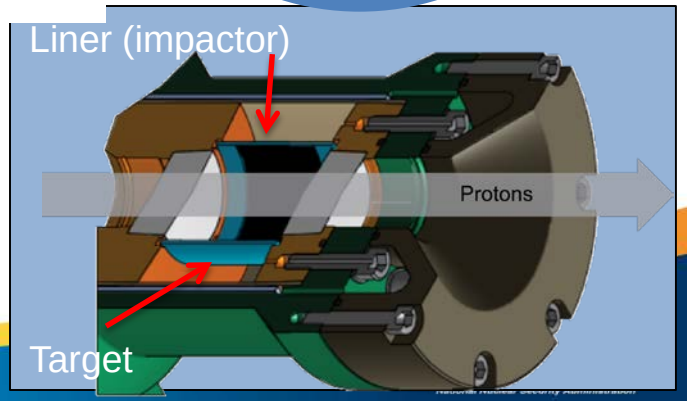
- Available dynamic drive options
  - HE-driven
  - Gas-gun driven
  - PHELIX (pulsed power)
- The behavior of HE itself is also of interest and pRad is very good at capturing HE behavior



2014-15 run cycle

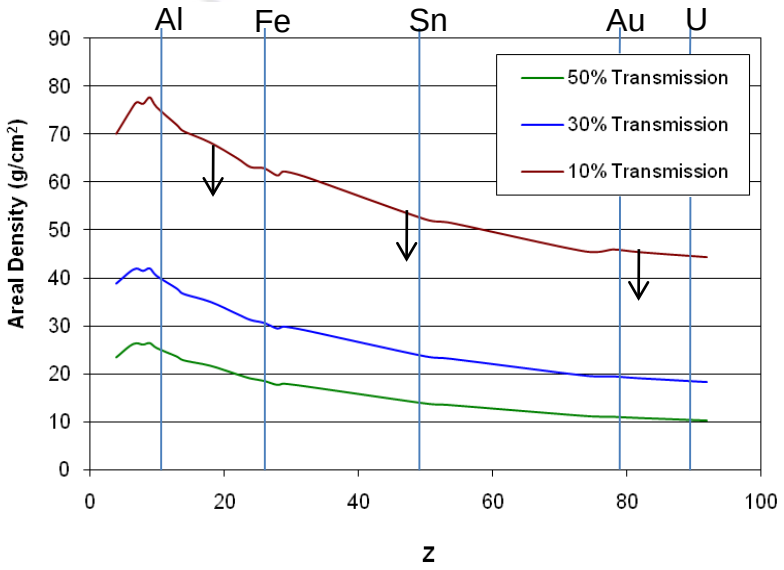






Why do pRad and HE work so well together?

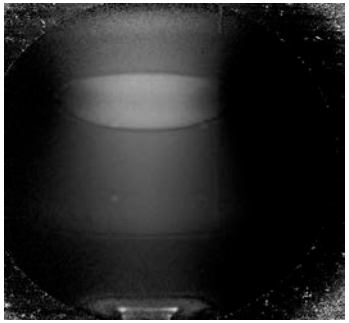
- Standard field of view (~10 cm) and resolution (~200 micron) of pRad coordinate well with HE needs
- Can distinguish regions of higher density in HE
- Can clearly distinguish shock/ detonation fronts

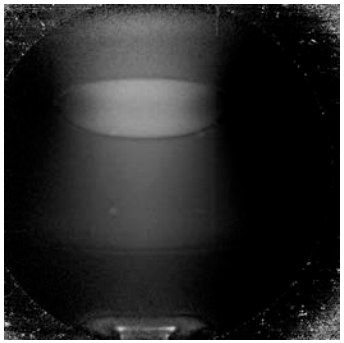


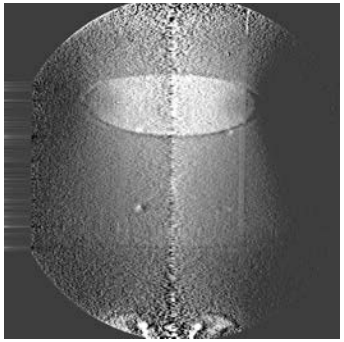
- pRad can image the shock/detonation waves **inside** the HE – that's a very unique capability

We can look at the data in various ways

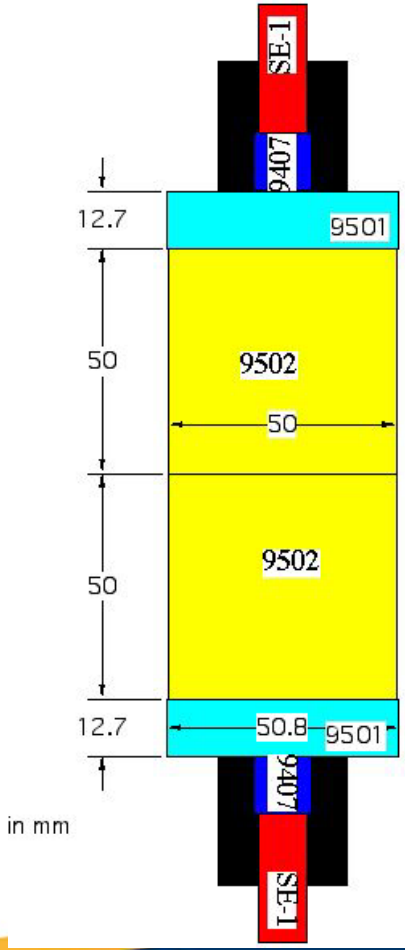
- Some ways that have been used to look at data:
  - Flattened
  - Areal density
  - Volume density



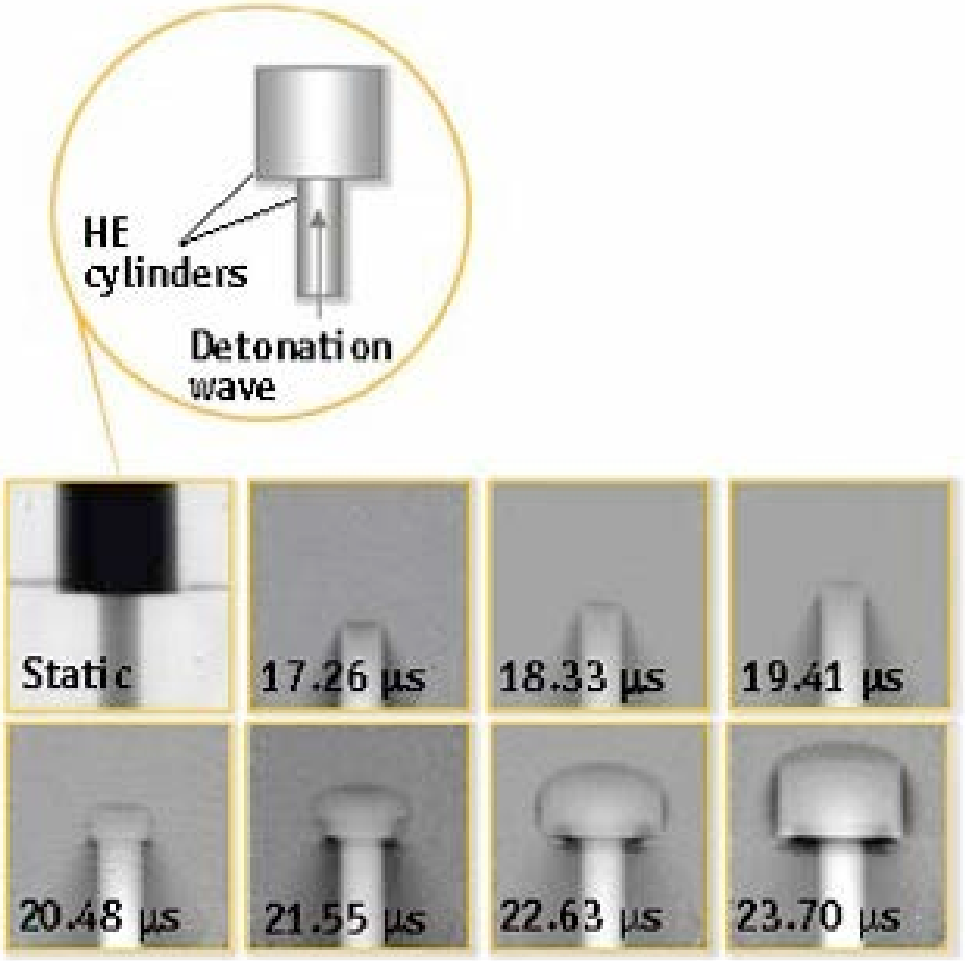




Colliding waves

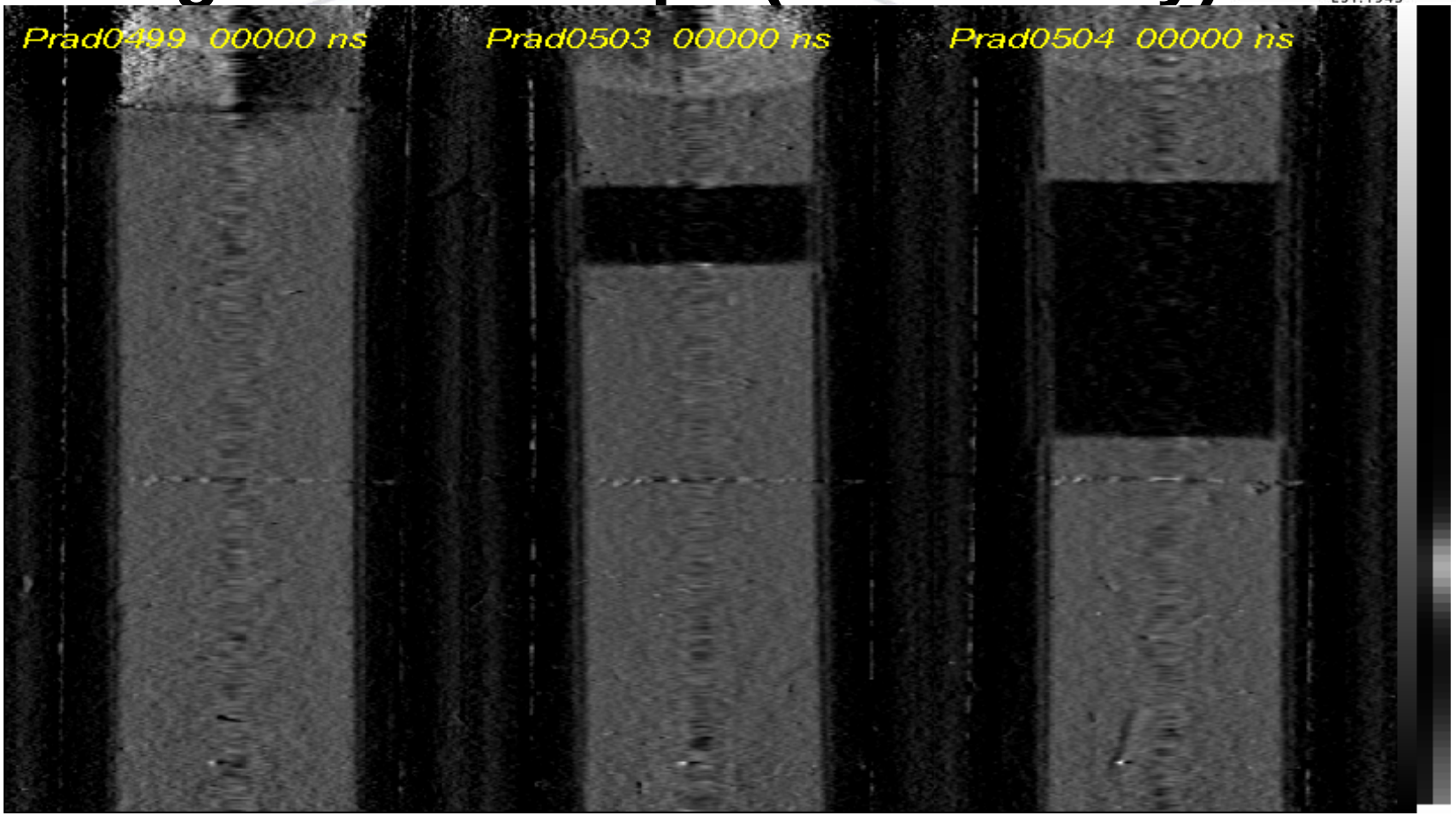


Early pRad history with HE – corners



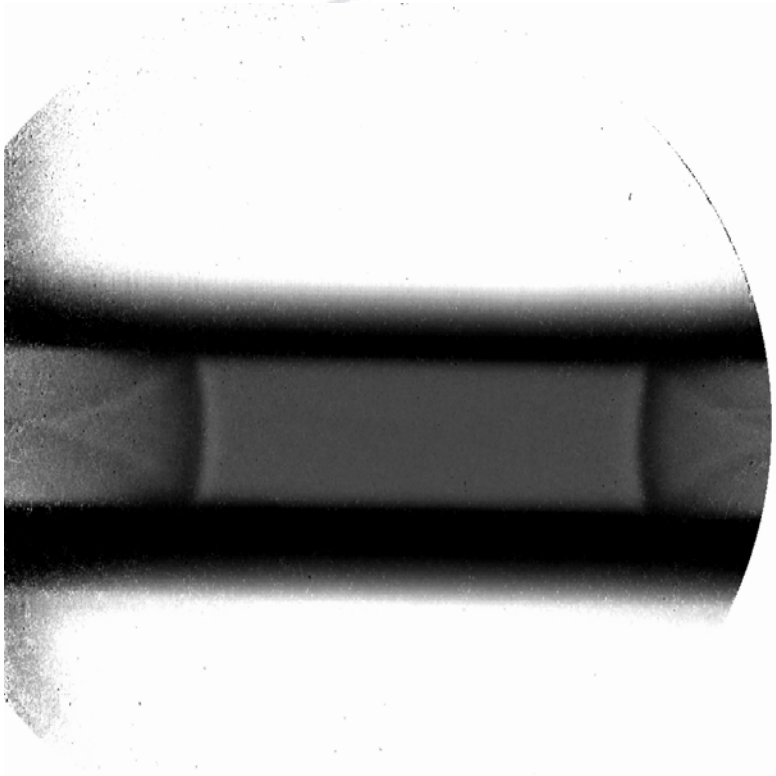
These early pRad HE experiments were looking at the progression of a detonation wave from the smaller cylinder into the larger one – dark regions indicate that the detonation has difficulties “turning the corner”

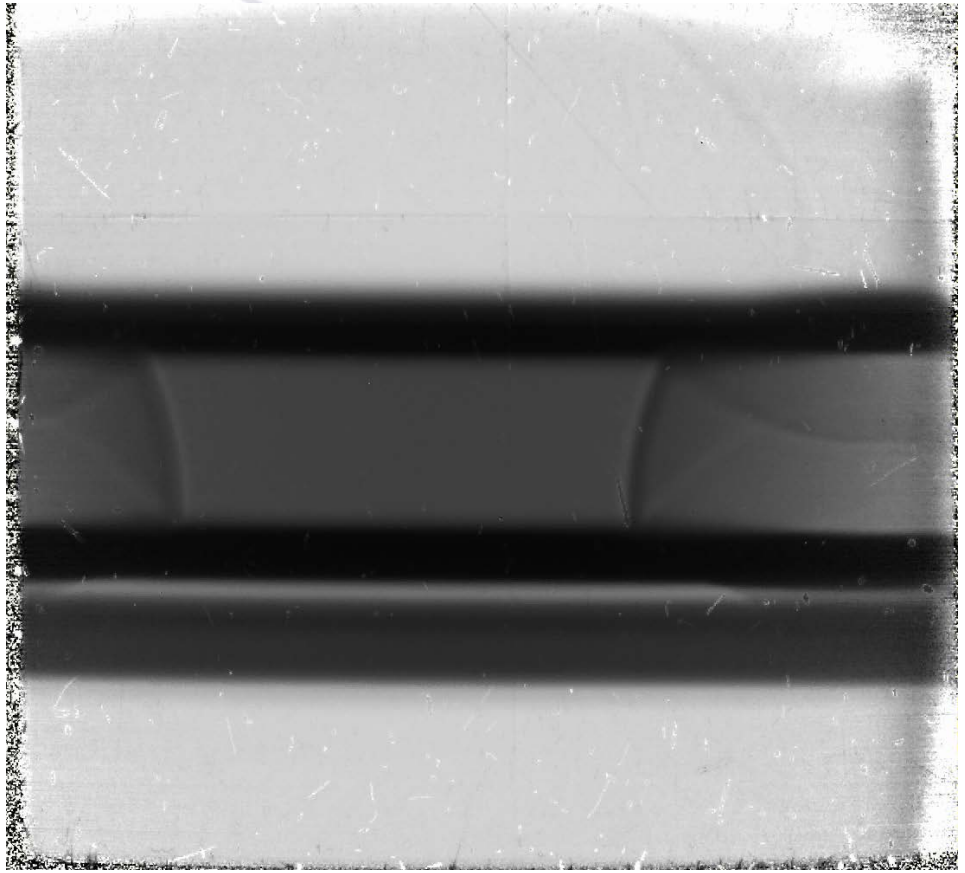
Crossing Vacuum Gaps (vol. density)



0.25 mm 10 mm 32 mm

Confined colliding detonations





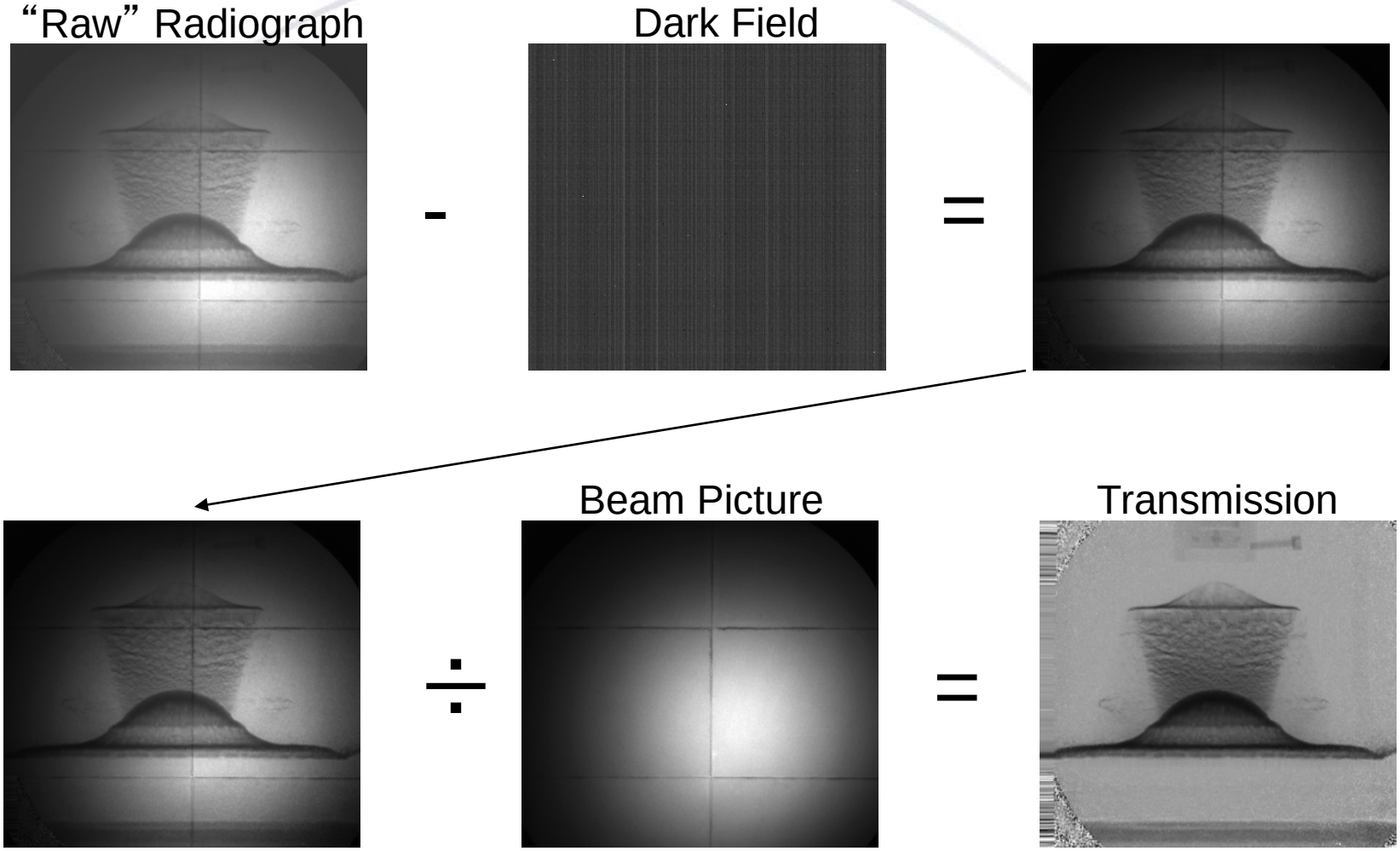
Line initiators near bottom plate

HE/pRad future needs

- pRad is uniquely well-suited to HE needs, so most things fall in the new/better/bigger category:
- A long, reliable run cycle (11 of 36 proposed shots scheduled for current run cycle)
- 10-frame cameras (in the works)
- Additional diagnostics that could provide useful HE information
  - thermal imaging and/or pyrometry
  - Embedded fibers could be used to measure burn fronts within HE samples.
  - Chirped fiber Bragg grating to track burn fronts.

Backup slides

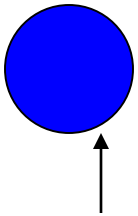
Radiographic Analysis



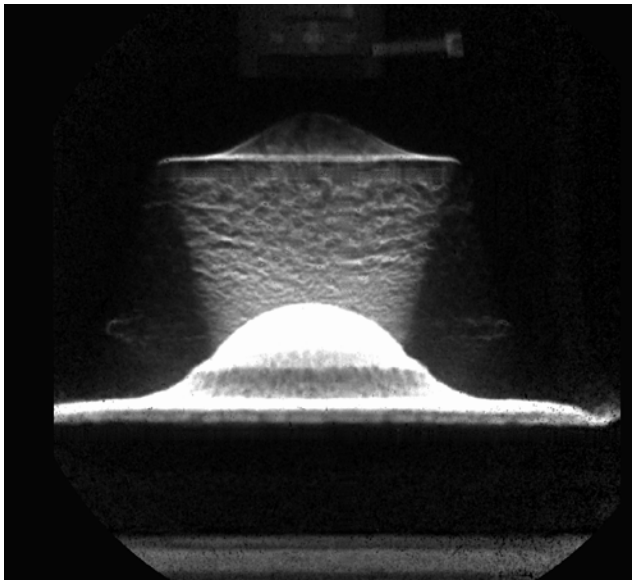
Density Reconstruction

Invert to calculate Areal Density

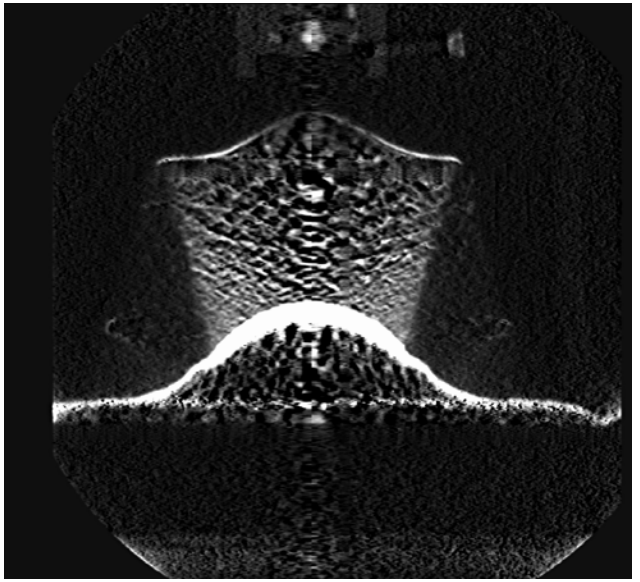
$$T = e^{-x/\lambda}\left(1 - e^{-\left(\frac{\theta_c p\beta}{14.1MeV}\right)^2 \frac{x_o}{2x}}\right)$$



Use assumption of cylindrical symmetry to determine volume density (Abel inversion)



Areal Density (g/cm^2)



Volume Density (g/cm^3)

Crossing Al Gaps (vol. density)