Neutron and Gamma Ray Session 2-Ray Leeper

- Yongho Kim-GEMS Update
- Carl Wilde-Gamma Imaging
- Christian Stoeckl-P11 nTD
- Brandon Lahmann-NIF nTD
- Hong Sio-Mag pTOF

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LA-UR-15-27669

Gamma-to-Electron Magnetic Spectrometer (GEMS) Update

Yongho Kim, Hans Herrmann, Carl Young, Justin Jorgenson, Frank Lopez, David Barlow, Michelle Espy, Mandie Gehring (LANL)

Terry Hilsabeck (GA)

Wolfgang Stoeffl, Dan Casey, Todd Clancy (LLNL)

Ken Moy (NSTec)

2015 National Diagnostic Workshop, Los Alamos, NM
October 6 - 8, 2015

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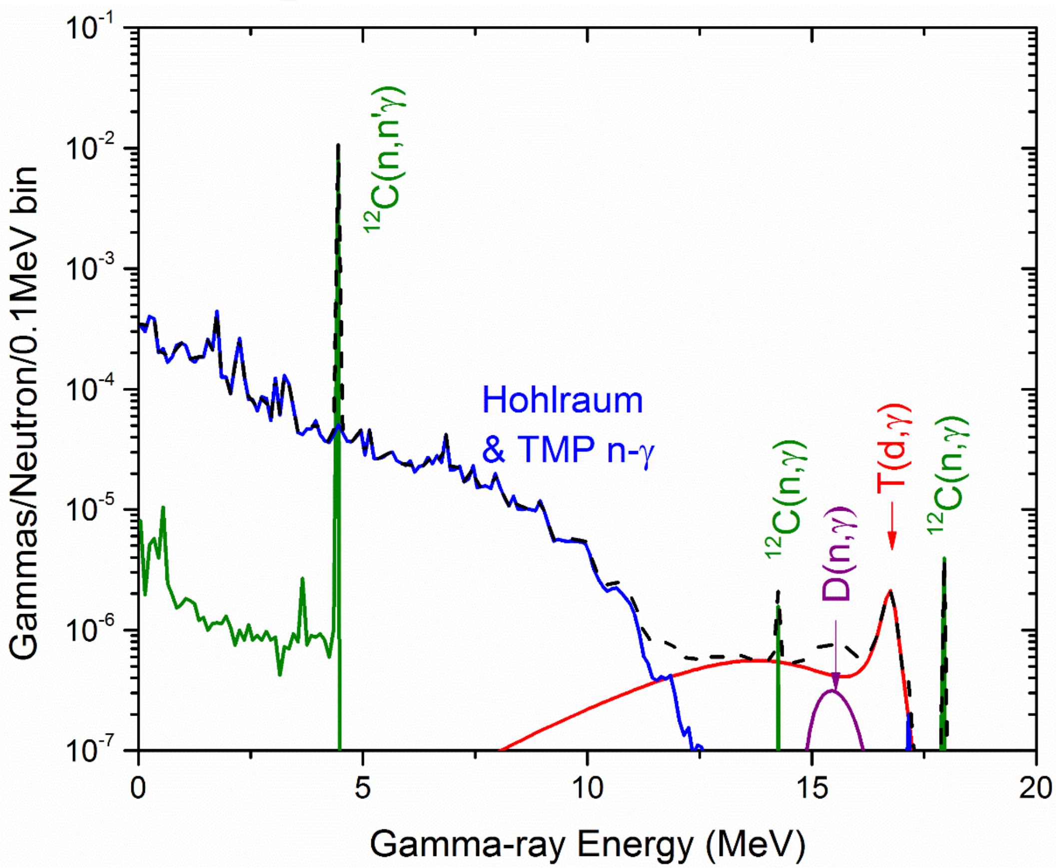
Gamma-to-Electron Magnetic Spectrometer (GEMS) will provide key burn parameters



Burn-averaged observables

- **Total Y_{DT}**
  - $Y_{DT} = B_{\gamma/n}\ Y_{DT\gamma}$
  - No Total Yield measurement currently exists
- **Total Down Scattering Fraction (TDSF)** when combined with primary Yn
  - TDSF = $1 - (Y_{n(13\text{-}15)}/Y_{DT\text{-}\gamma})$
- **Cold fuel ρR**
  - D(n,γ)
  - Current fuel ρR depends line-of-sight
- **Ablator ρR**
  - 12C(n,n'γ)
  - 12C(n,γ)
  - Reduced uncertainty relative to GRH

Direct, individual measurement of total ρR, fuel ρR, and ablator ρR

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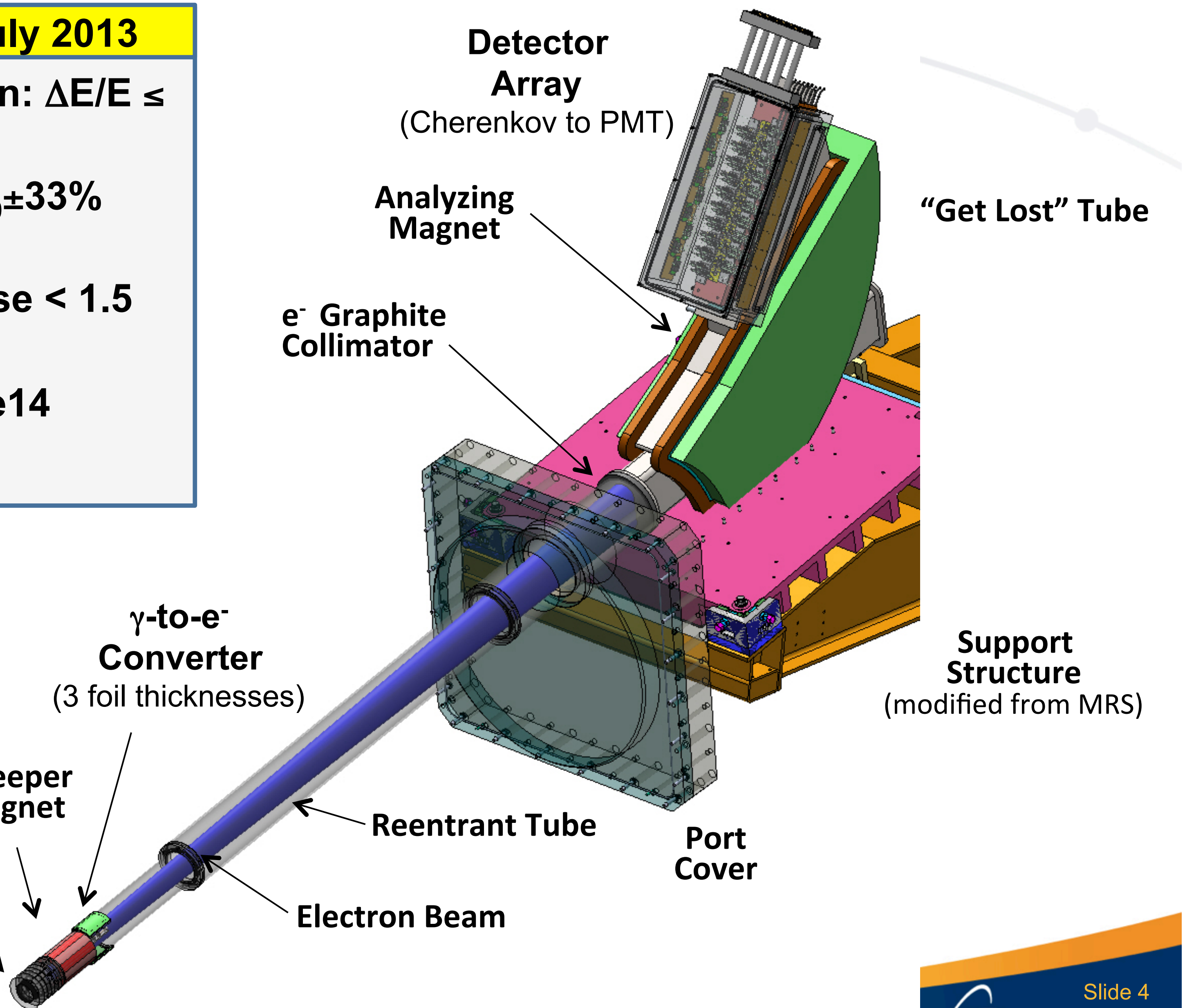
NIF CDR held in July 2013

- **Energy Resolution: $\Delta E/E \leq$ 5%**
- **Energy Range: $E_0 \pm 33\%$ within 2-25 MeV**
- **Temporal response < 1.5 ns**
- **Viable at $Y_{DTn} \geq$ 5e14**



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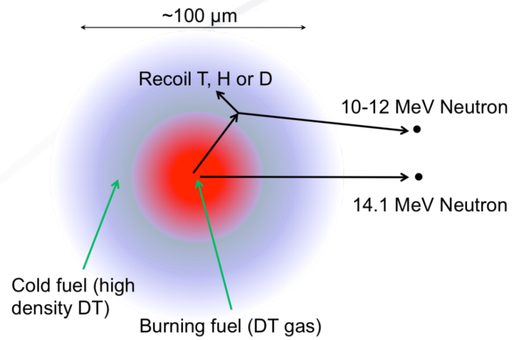
Gamma Component of Al on 90-315 LOS at NIF (or GNXI)

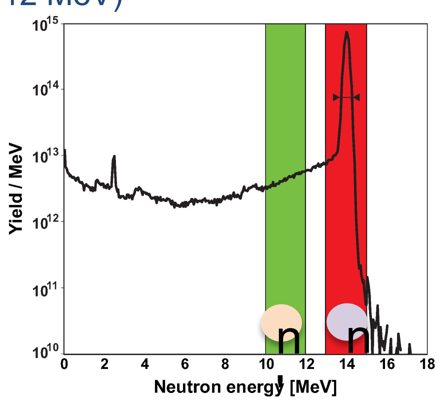
Carl Wilde, C. Danly, F. Merrill, R. Simpson, P. Volegov

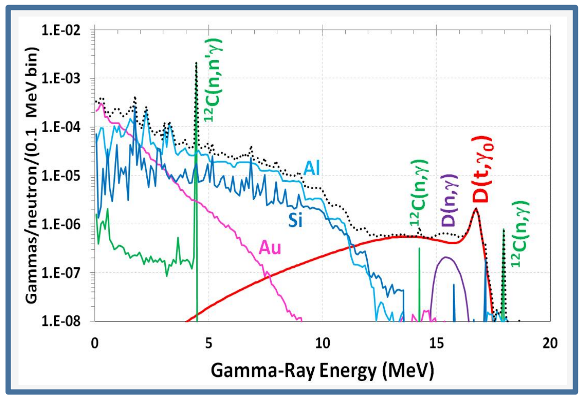
Building on the work of many (Gary Grim, Daniel Lemieux, Nobuhiko Izumi….)

Neutron images provide the shape and size of the imploded fuel at stagnation. Gamma imaging can measure the ablator location.

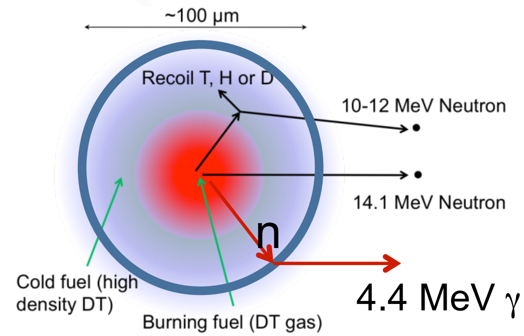


Neutron images are used to diagnose NIF implosions. Temporal separation of neutrons after 28 m drift results in ability to collect two neutron images: Primary (13-17 MeV), Down-Scattered (10-12 MeV)





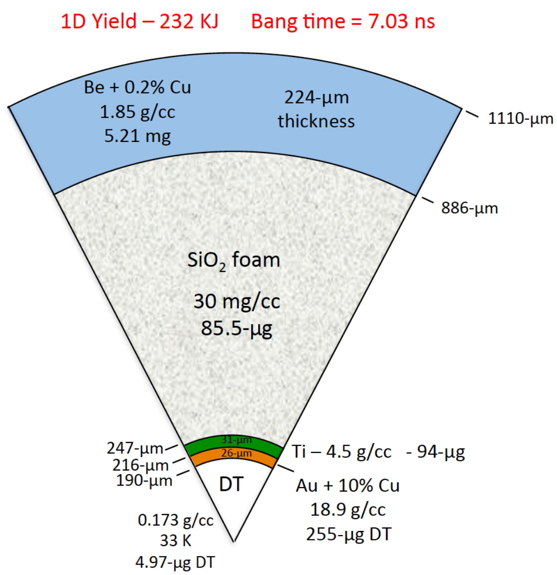
Courtesy of H. Herrmann et.al.

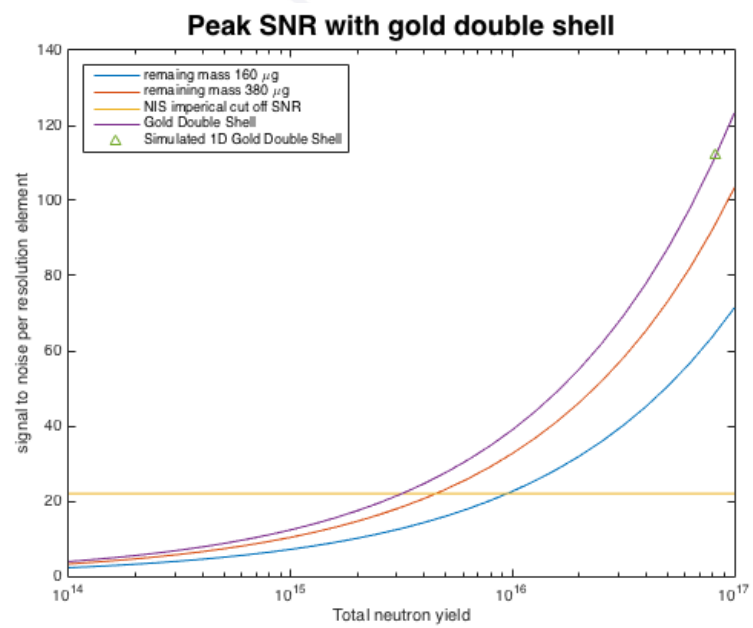


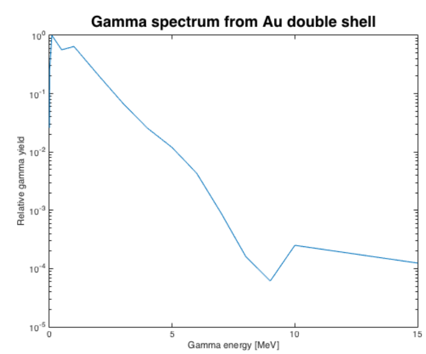
<u>Gamma Ray Imaging</u>

At yields $>10^{16}$ neutrons and sufficient remaining ablator mass there should be enough (n,γ) reactions to form images of the ablator location.

Simulations indicate that NIF double shell experiments can be imaged with GRI







Stagnation Conditions:
Neutron Yield: 8E16
Inner gold shell radius: 20 microns
Gold shell thickness: 35 microns
Mass averaged gold density: 2200 g/cc

Conclusions / future work

- Imaging of $^{12}C(n,n'\gamma)^{12}C$ gamma rays is possible with neutron yields O(1E16)
- GRI of gold double shell experiments should be even easier
- Modest modifications to the 90-315 NIS can enable this
- Need to design and measure noise in detector
- Can apply NIS full system model to study effect of aperture on features of interest etc.

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Conceptual Design of The Neutron Temporal Diagnostic (NTD) for Measuring DD or DT Burn Histories at the NIF

Brandon Lahmann

Diagnostic Workshop - LANL

Oct. 6-8, 2015

Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

The time-resolution requirement of 30 ps sets strict restrictions on the NTD scintillator geometry and position

- Time dispersion creates an uncertainty that scales with and stand-off distance
  - Max ~ 2 cm for 4keV DDn
  - Max ~ 12 cm for 4keV DTn

$$\Delta t_{dispersion} \propto \sqrt{T_{ion}} \left(\ell_{standoff} / E_{neutron} \right)$$

- The detector thickness creates an uncertainty in neutron-interaction time
  - Max ~   650 microns for DDn
  - Max ~ 1500 microns for DTn

$$\Delta t_{thickness} \propto \left(w_{thick} / \sqrt{E_{neutron}} \right)$$

- Detector diameter can contributes to the uncertainty in the interaction time if it's comparable to the standoff distance
  - Max ~ 0.8 cm for DDn
  - Max ~ 2.8 cm for DTn

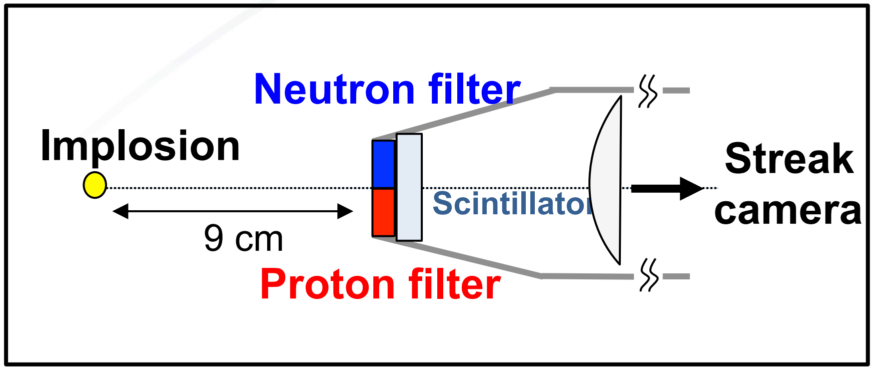
$$\Delta t_{diameter} \propto \left(d/\ell_{standoff} \right) \left(d/\sqrt{E_{neutron}} \right)$$

An NTD has been conceptually designed to measure DD or DT burn histories with a time-resolution of <30 ps at the NIF

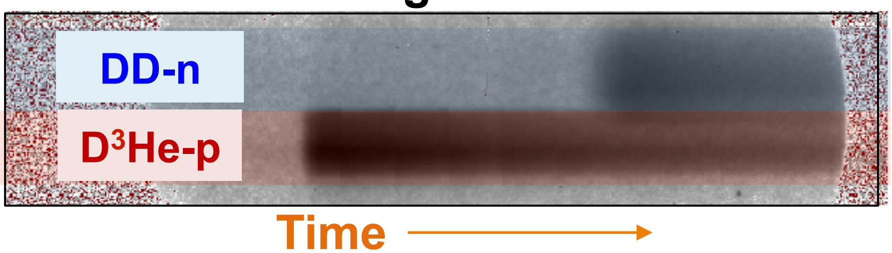
- **The front end of the NTD consists of a 100 micron thick, 5 mm diameter scintillator positioned 18 mm (DD) and 100 mm (DT) away from TCC.**
- **The NTD will compliment the existing GRH and future MRSt for measurement of DT-burn histories. It will also measure DD-burn histories.**
- **MCNPX was used to assess signal to background from NIF implosions**
- **For DD, on the basis of NVH implosion data and estimates of ambient backgrounds levels, burns widths and bang times can be determined with an accuracy of 45 ps and 30 ps respectively for yields greater than $5x10^{10}$**
- **The NTD can also be used to measure burn widths and bang times of DT implosions with an accuracy of 45 ps and 30 ps for yields greater than 10^{13}**

Measurements of multiple nuclear bang times and burn histories toprobe implosion dynamics and kinetic effects at OMEGA and the NIF

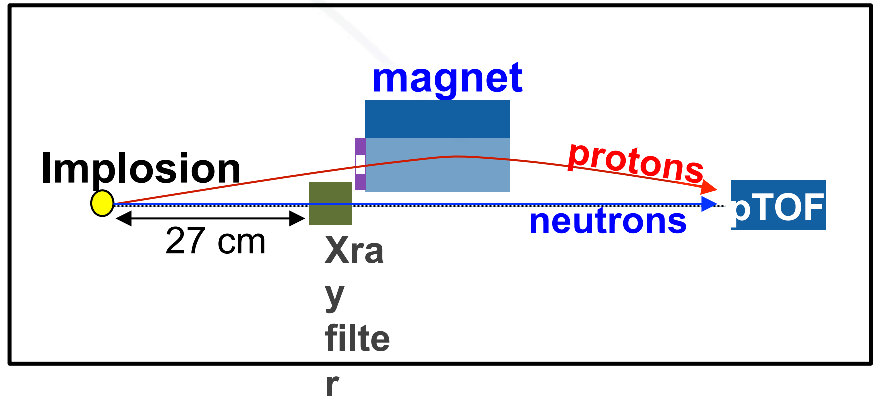
multiPTD on OMEGA

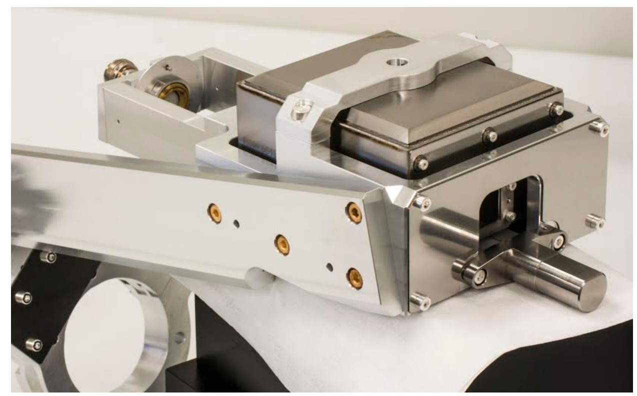


Scintillator signal on streak camera



magPTOF on NIF



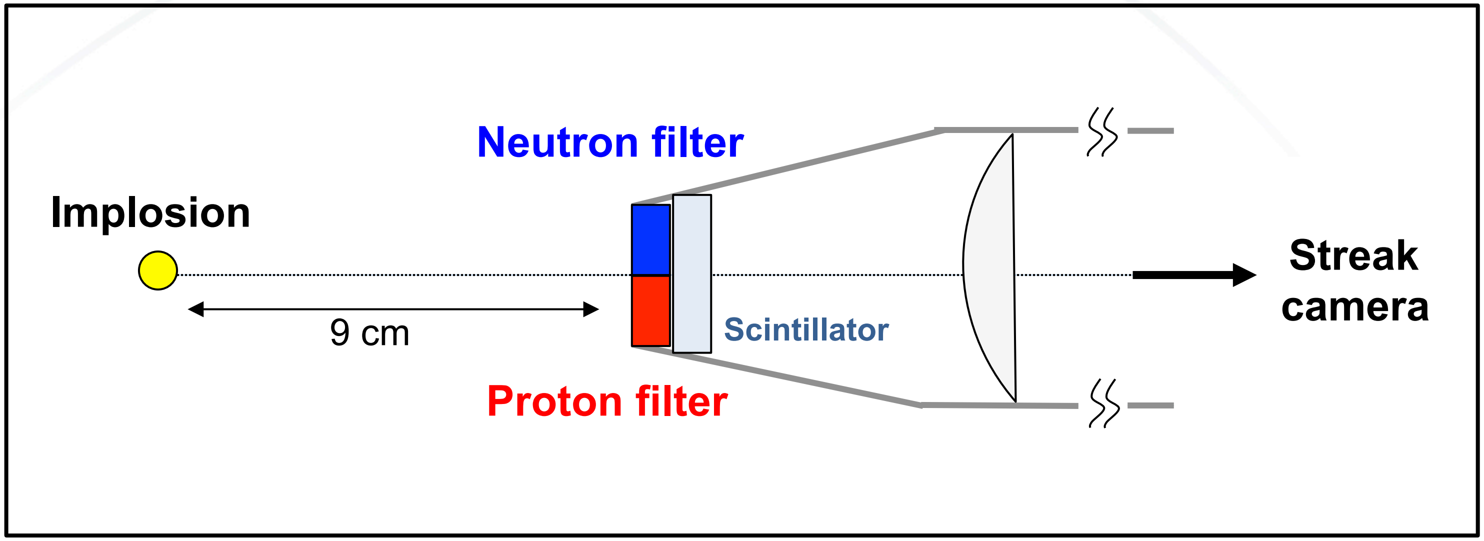


@ MIT PSFC

Hong Sio, MIT

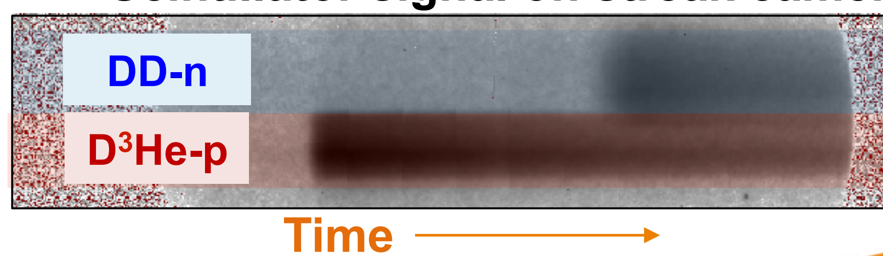
October 6th, 2015, Los Alamos, NM

The multiple Particle Temporal Diagnostic (multiPTD) is a streak-based burn-history diagnostic that has been implemented and used on OMEGA



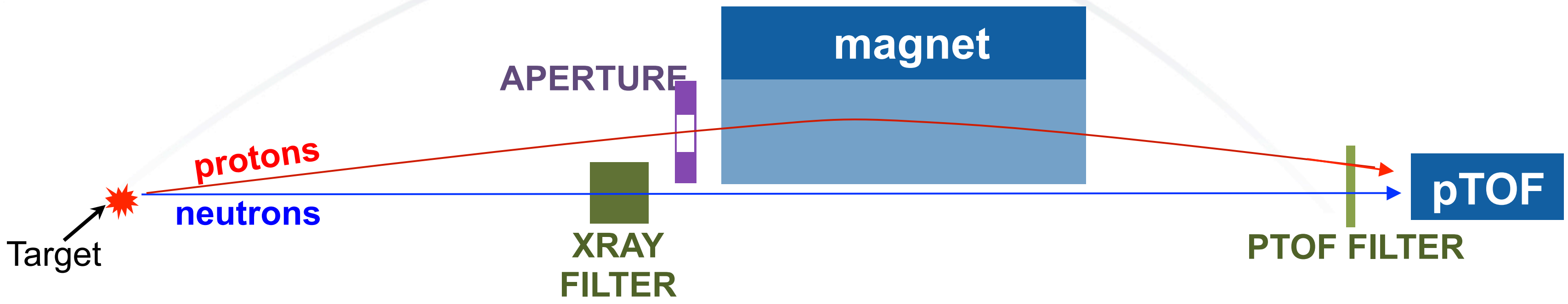
Simultaneous measurements of multiple nuclear burn histories on the **same** diagnostic is critical for timing accuracy

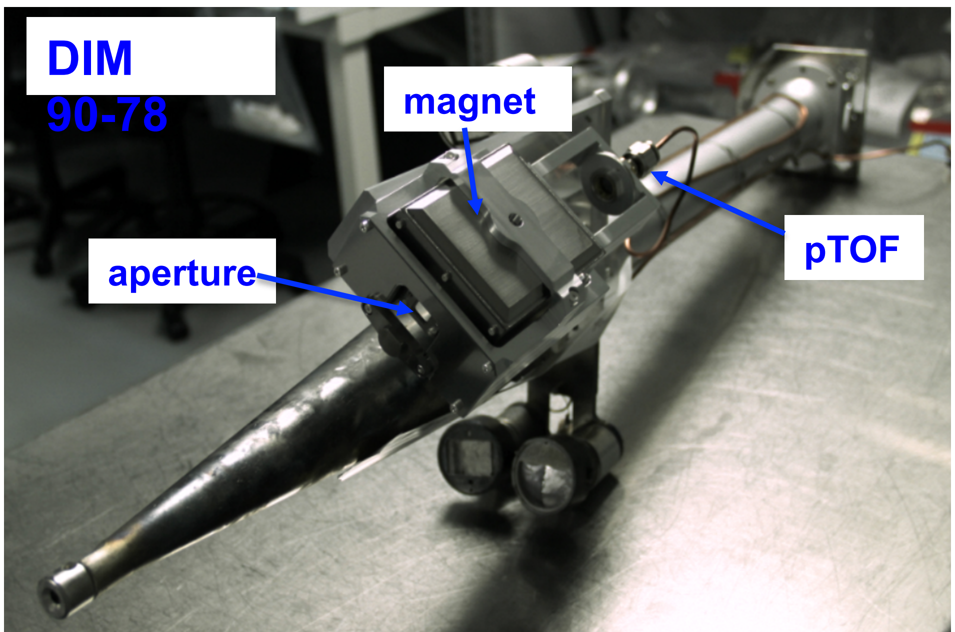
Scintillator signal on streak camera



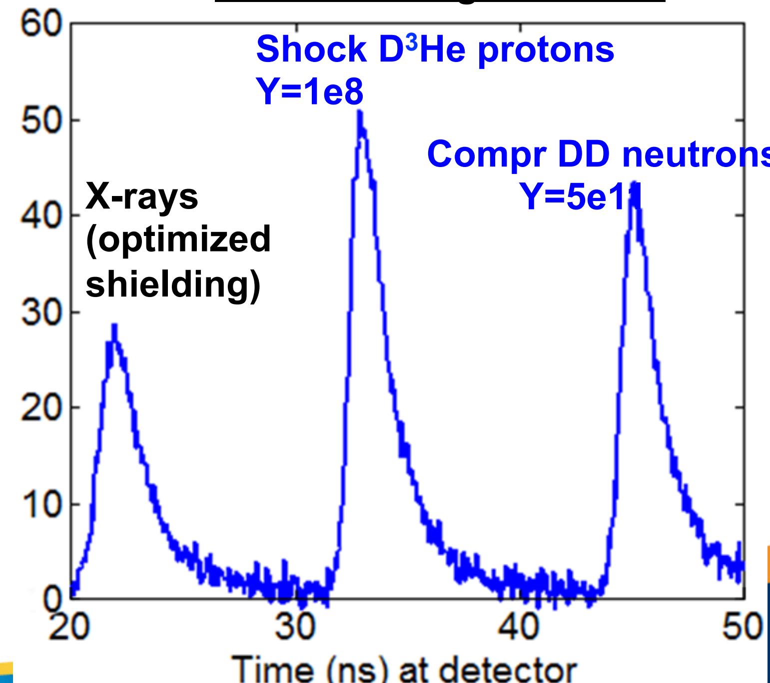
Stoeckl *et al.*, Rev. Sci. Instrum. **74**, 1713 (2003)

In the magPTOF upgrade, magnet and x-ray shielding allow x-ray, proton and neutron signals to be measured with similar amplitudes





Simulated MagPTOF data



Summary

Kinetic effects and shock dynamics are studied in ICF plasmas on OMEGA and the NIF using burn history and bang-time diagnostics

- multiPTD is a streak diagnostic for measuring multiple nuclear burn histories to probe kinetic / multi-ion effects on OMEGA
  - Moving closer to TCC will improve relative timing of burn histories to ~ 10 – 20 ps
  - New filtering will be used to measure nuclear-burn and x-ray emission simultaneously

- magPTOF is a bang-time diagnostic for measuring shock and compression nuclear bang-times to study shock dynamics on the NIF
  - Improved positioning and larger x-ray shielding will reduce x-ray background to acceptable level
  - can also function as a low-energy charged-particles spectrometer for diagnosing various basic science and ICF experiments