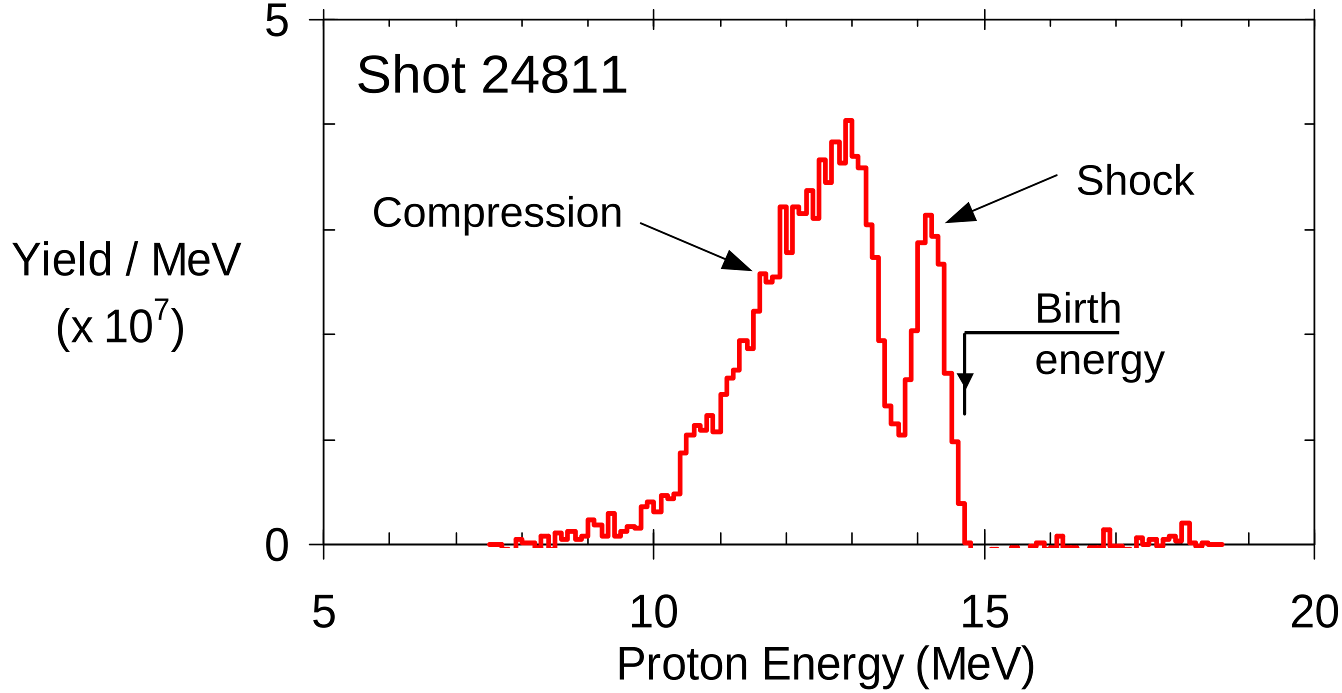
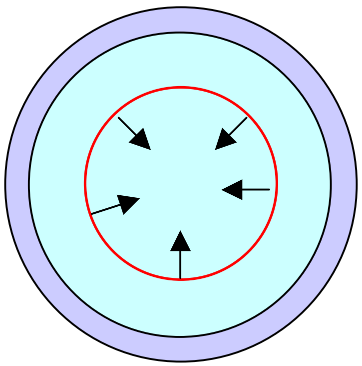
Capsule ρR nonuniformities and evolution in OMEGA D^3He implosions inferred from 14.7-MeV proton line structure



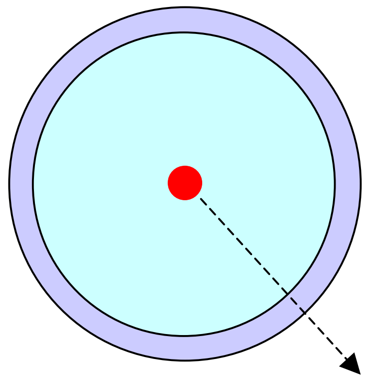
R. D. Petrasso

Shock yield and compression yield

Ingoing shock



$t \approx 1.7$ ns
Shock coalescence
at center

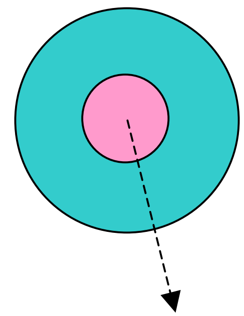


D-^{3}He protons
downshifted by

~ 0.4 MeV,

ρR ~ 13 mg/cm^2

$t \approx 2.1$ ns
Compression burn
("bang time")



D-^{3}He protons
downshifted by

~ 2 MeV ,

ρR ~ 70 mg/cm^2

Contributors

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Summary

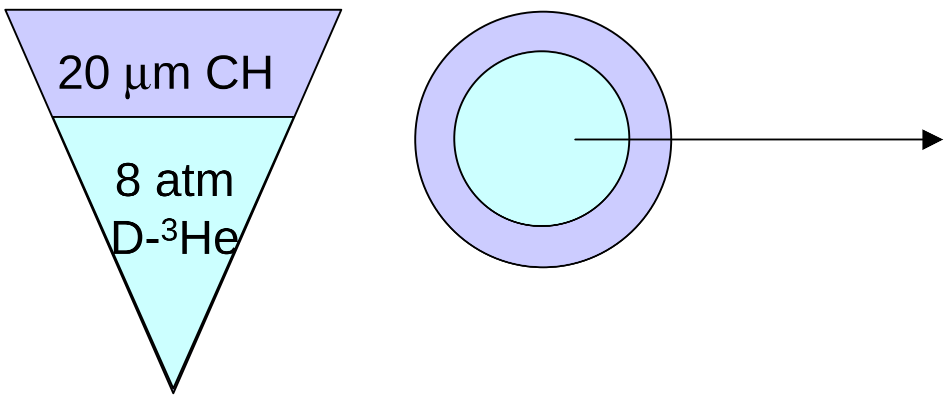
- Using D-^{3}He proton spectra, we study ρR at shock coalescence and at compression for capsules with 24-μm shells.
- At shock time, $<\rho R> \approx 13$ mg/cm^2 and $<T_i> \approx 5.5$ keV .
- At compression time, $<\rho R> \approx 70$ mg/cm^2 .
- At shock-coalescence time, ρR asymmetries are smaller than current measurement errors.
- At compression burn time, significant ρR asymmetries are seen but there is no evidence of holes in the shell.
- Could small asymmetries at shock time be precursors of the larger ones at compression? *(Future work with smaller errors)*
- Fuel-shell mix occurs by compression burn but not by shock time.

Outline

- The 14.7-MeV D^3He proton “line” as a ρR diagnostic
  - – Relationship between E_p downshift and ρR
  - – Measurement methods
  - – ρR symmetry
- The 2-component structure of the “line” for thick-shell capsules
  - – Identification with two times
  - – Comparison with neutron temporal measurements
  - – Comparison with hydrodynamic models
- Analysis of ρR at the two times
  - – $\langle \rho R \rangle$
  - – ρR asymmetries
  - – <Ti> at shock time
  - – Fuel-shell mix

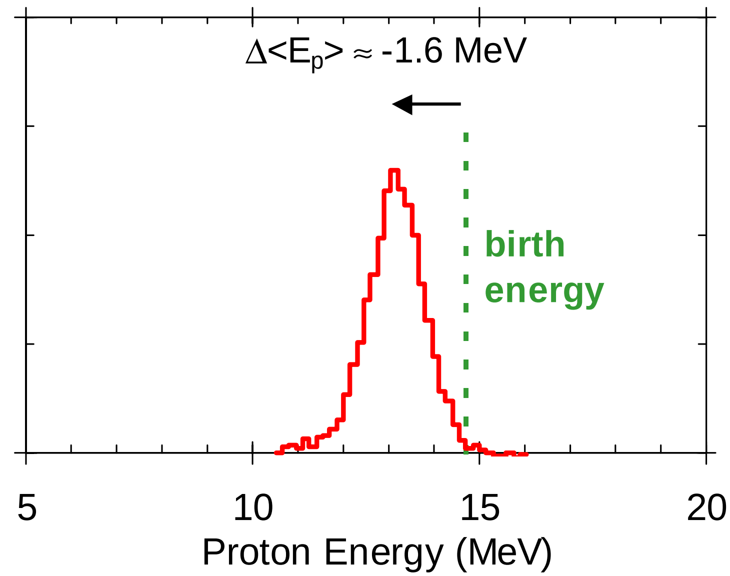
Protons lose energy in proportion to ρR_{total} while leaving a capsule

OMEGA
Shot 24690



60 laser beams
22 kJ energy
1-ns square pulse

Measured spectrum

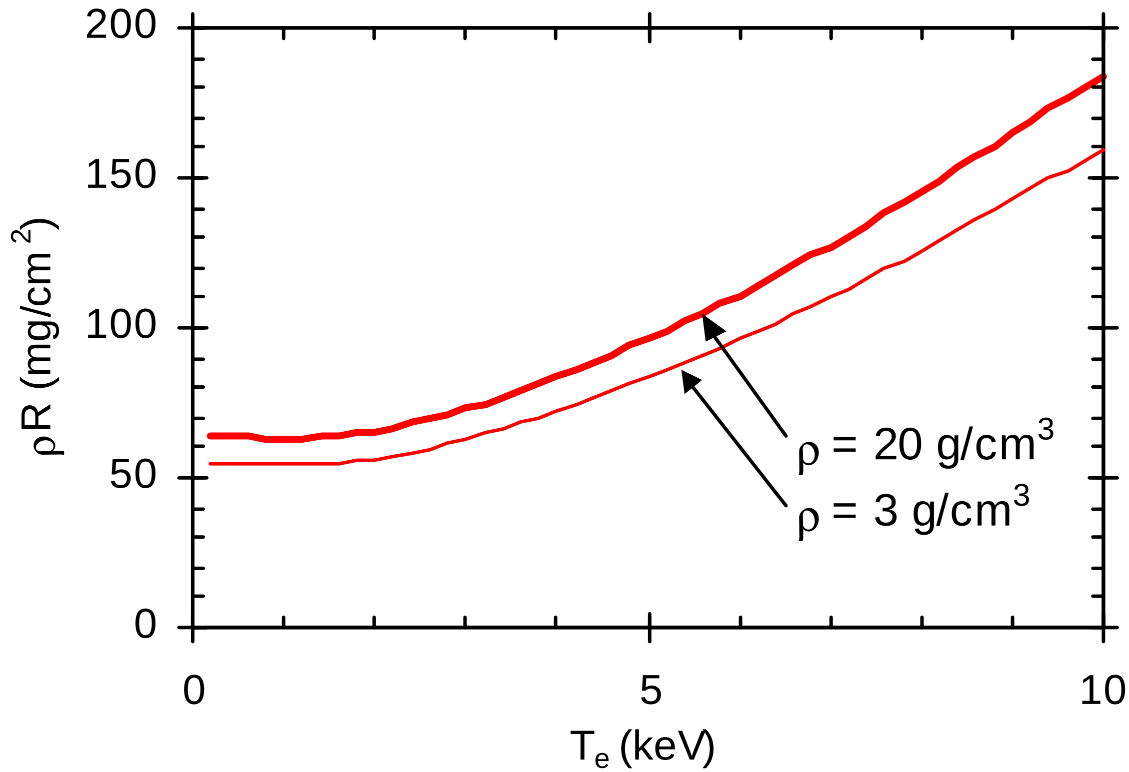


$\Delta \langle E_p \rangle \approx -1.6$ MeV $\Rightarrow \rho R \approx 52$ mg/cm^2

(insensitive to shell temperature, density, and composition)

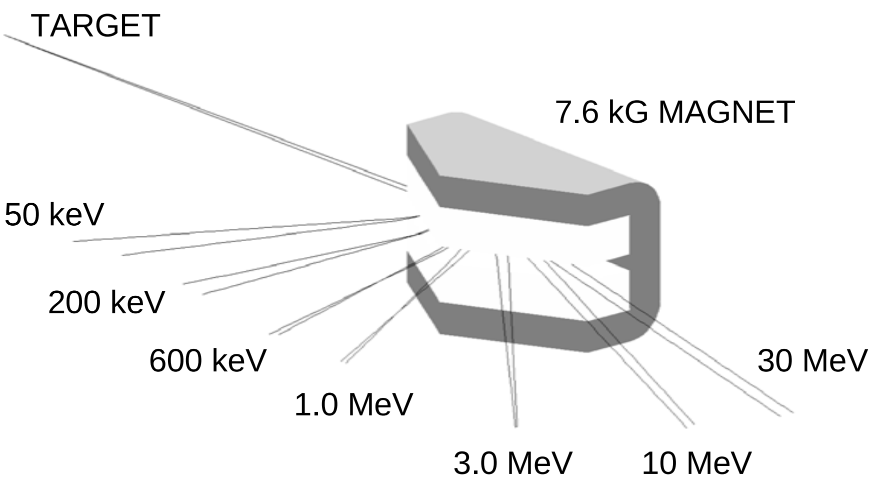
Relationship between ΔE_p and shell ρR is insensitive to T_e and ρ

Example: CH ρR required to slow 14.7-MeV protons down to 12.7 MeV



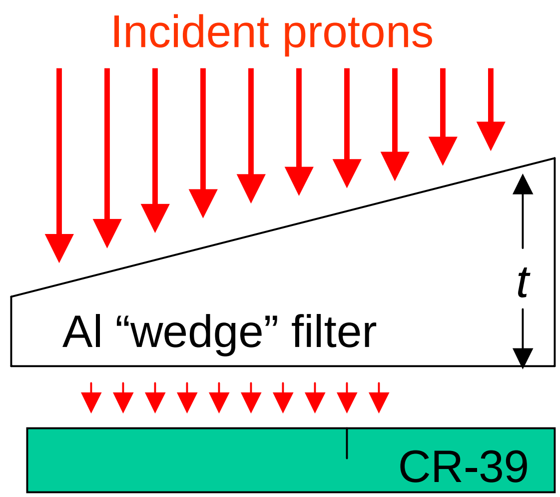
Two kinds of spectrometers* are used for protons

Magnet-based Spectrometers (CPSs)



Particle energies identified from trajectories.

"Wedge-Range-Filter" Spectrometers (WRFs)



Particle energies identified from local thickness *t* and diameter of etched proton tracks in CR-39.

*F. H. Séguin *et al*., "Spectrometry of charged particles from inertial-confinement-fusion plasmas", Rev. Sci. Instrum. (accepted).

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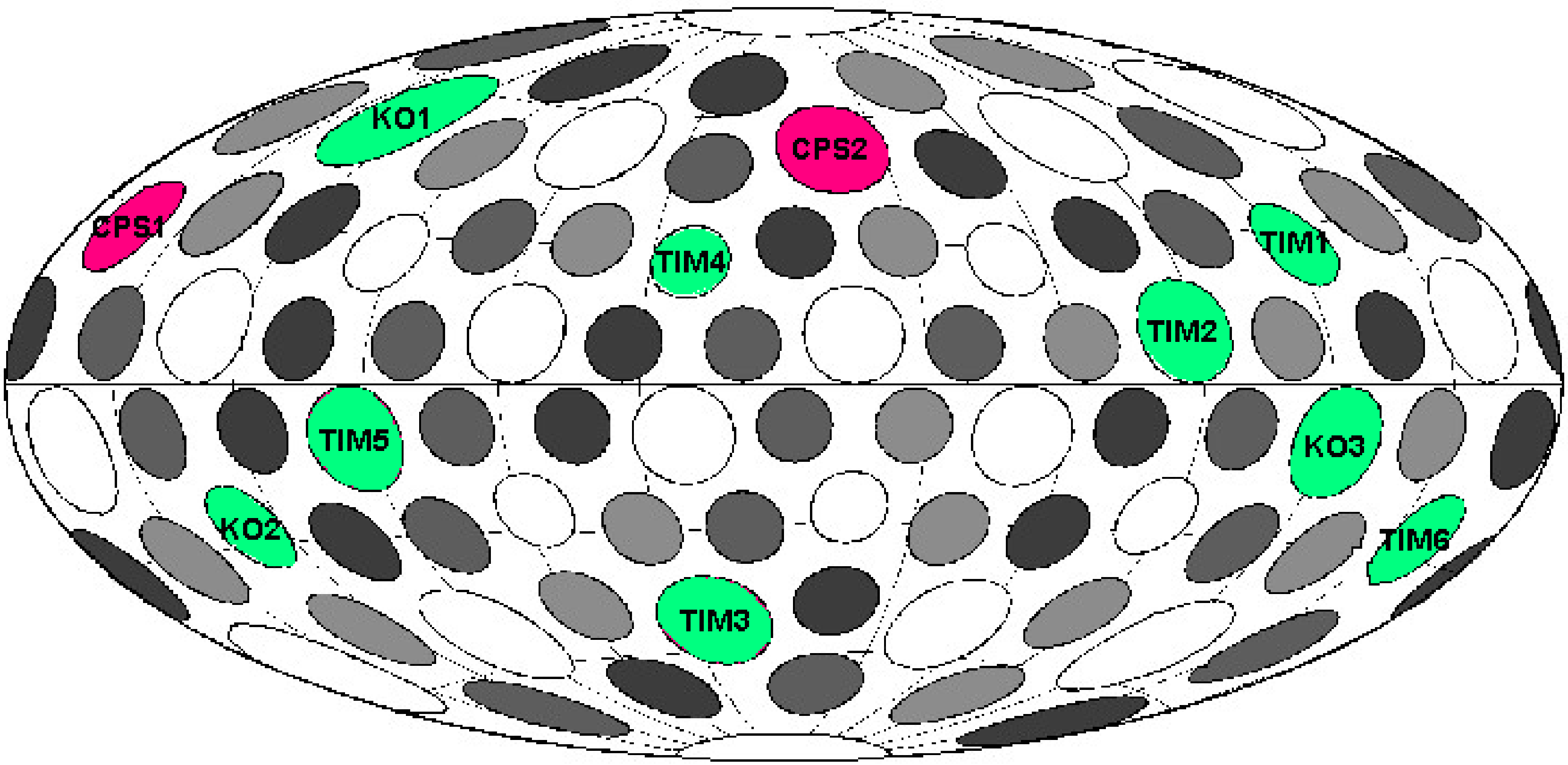
Up to 11 ports can be used for charged-particle spectrometry on the OMEGA target chamber



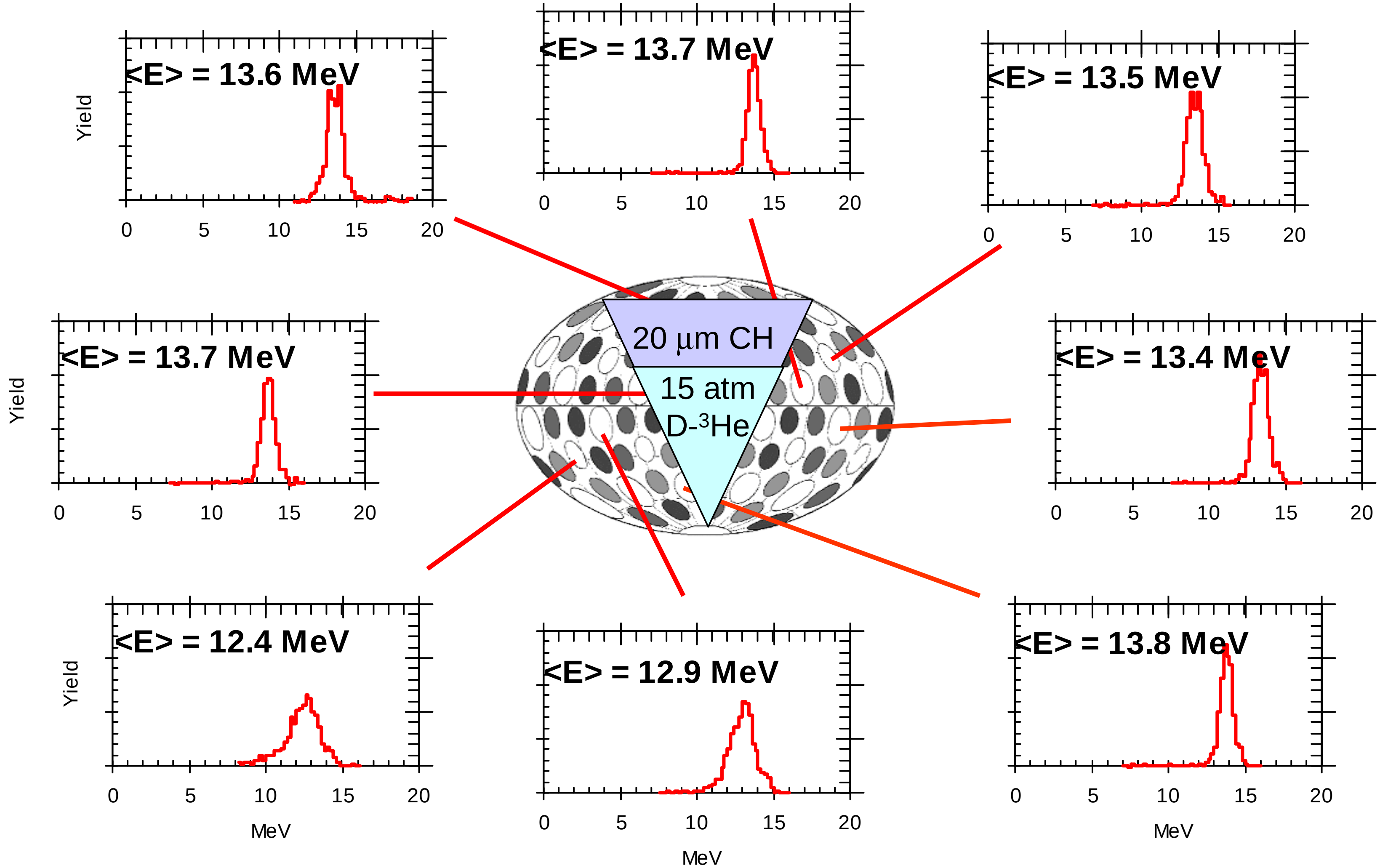
Magnet-based CPSs

WRF spectrometers

OMEGA target chamber

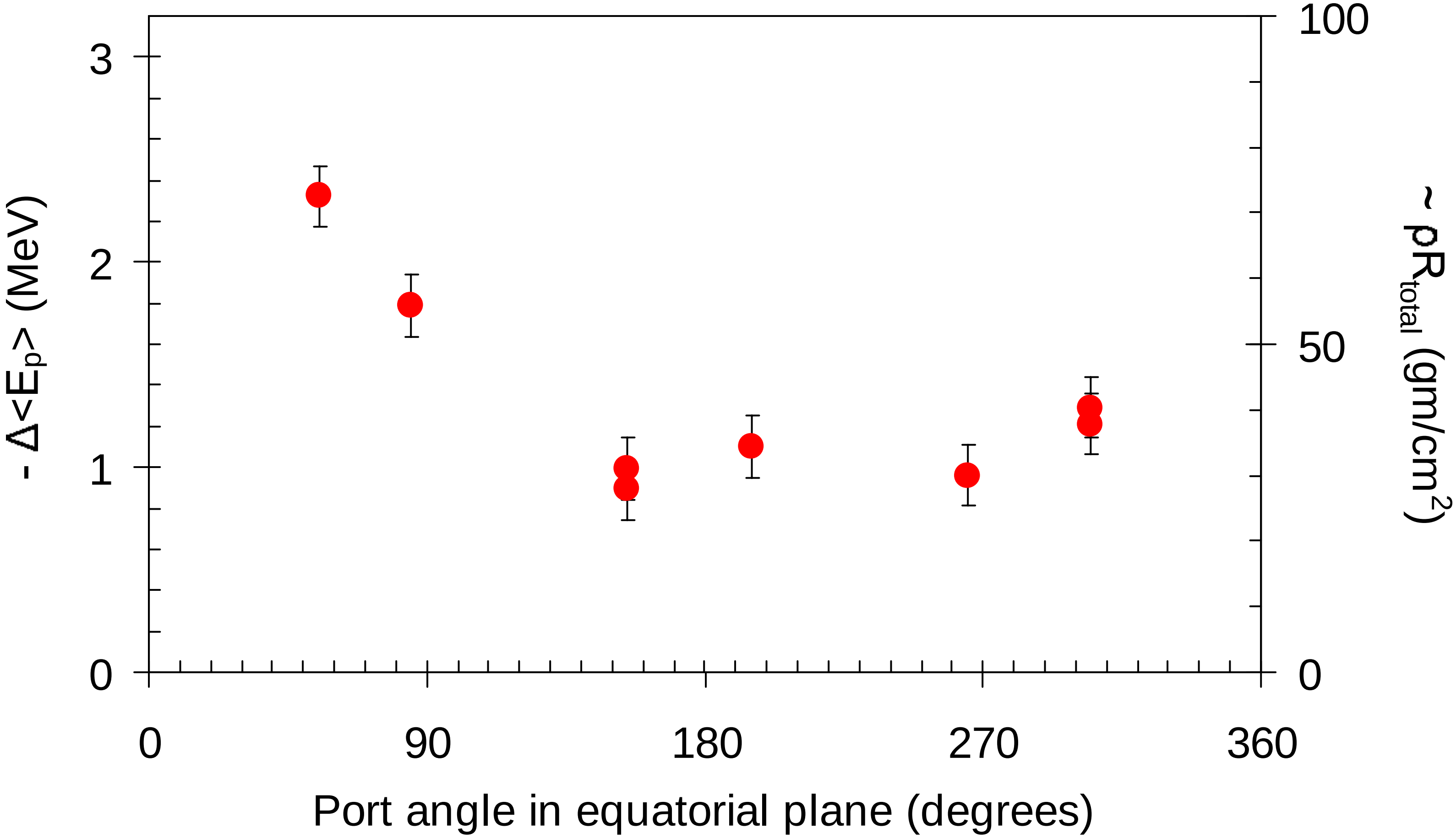
There are often substantial energy asymmetries that reflect ρR asymmetries*

Shot 21240

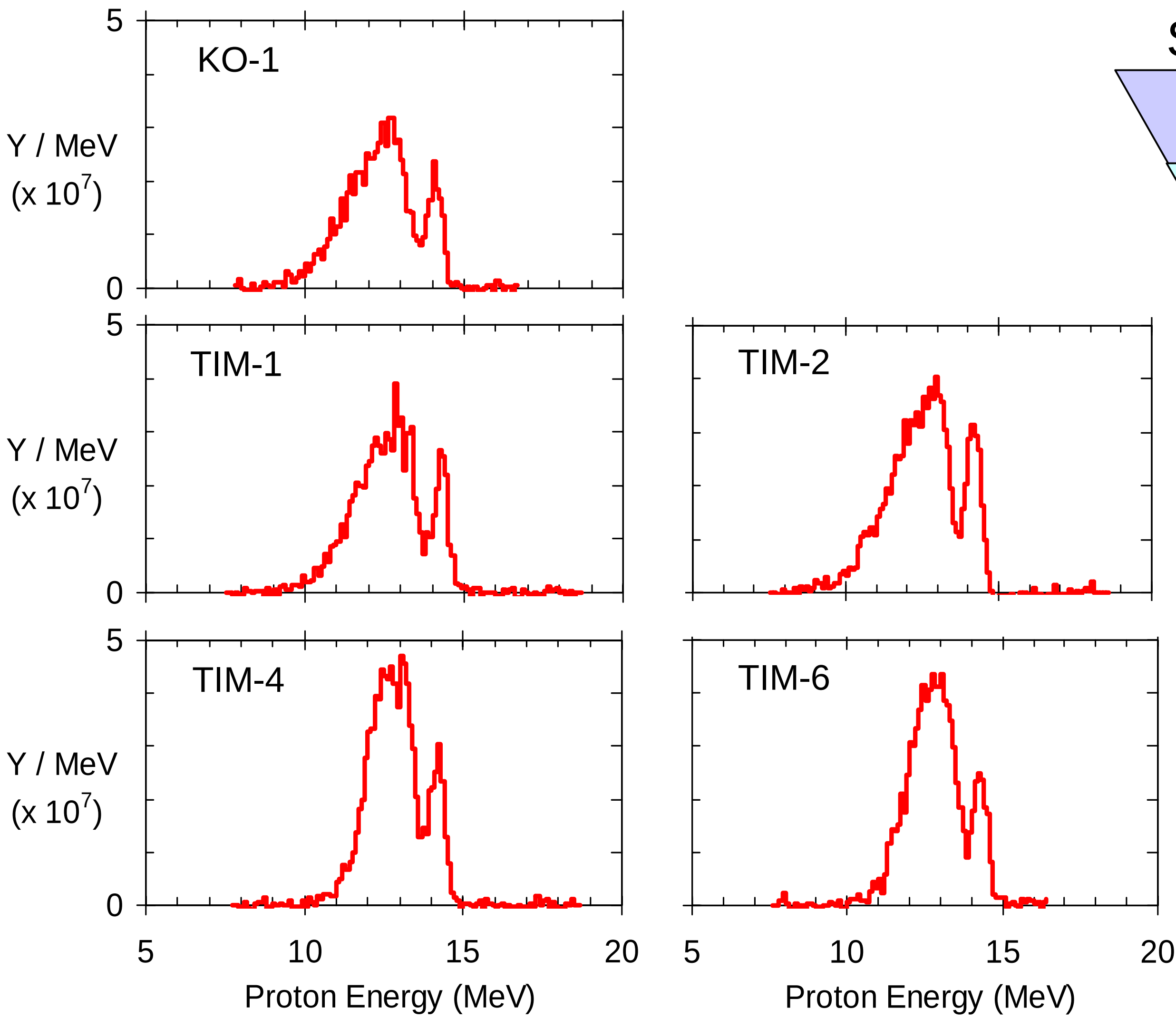


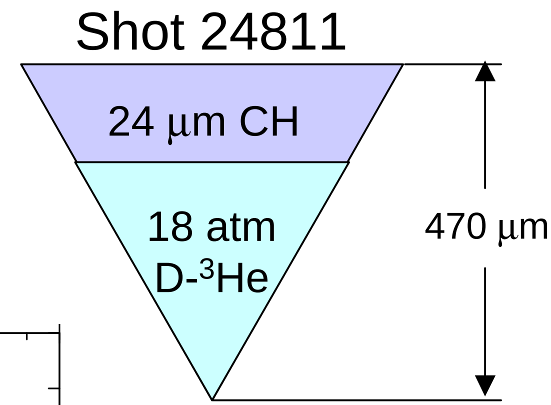
*F. H. Séguin *et al*., Phys. Plasmas (August 2002).

Angular energy variations can be related to angular ρR variations

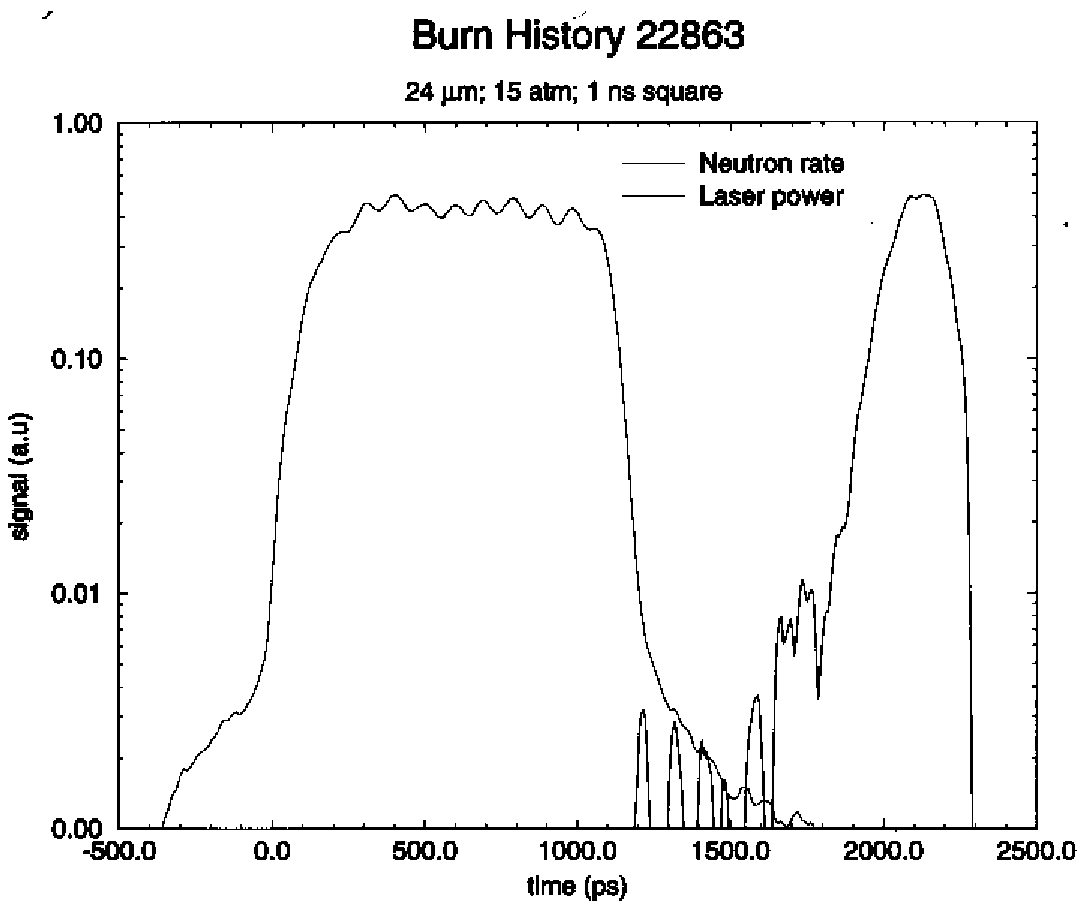


Capsules with thicker shells produce spectra with two “lines” which represent two times



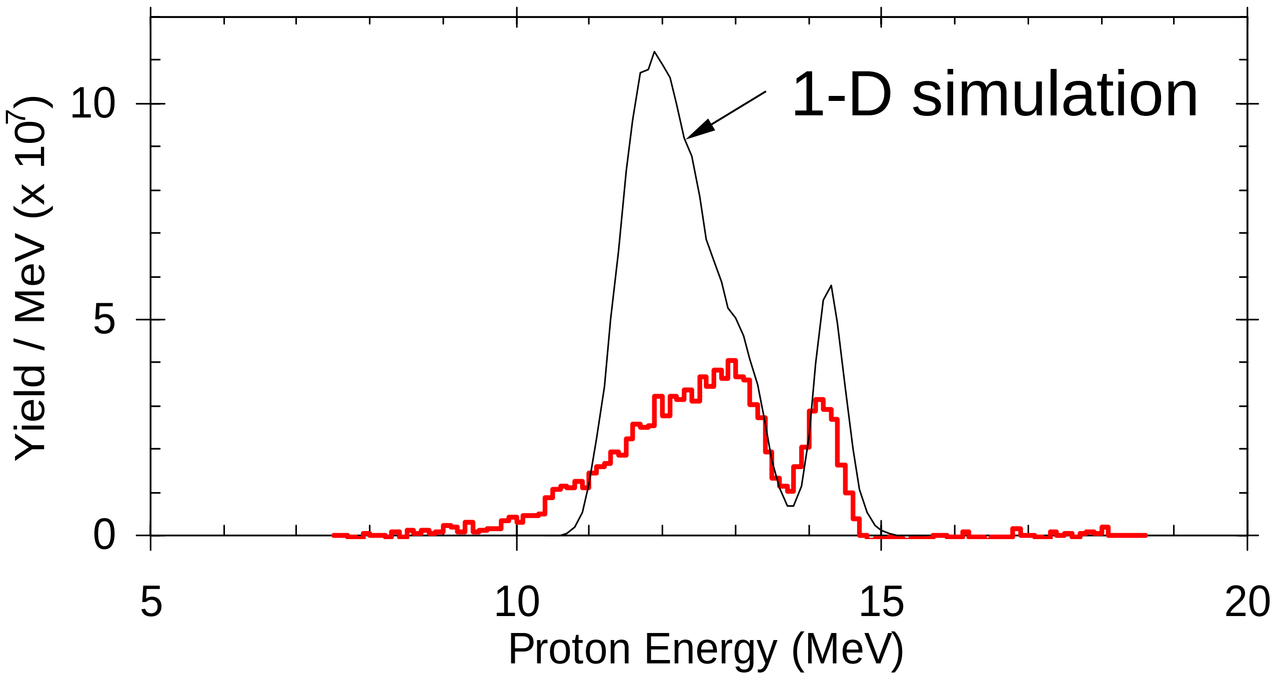


Neutron temporal measurements show that shock burn occurs ~400 ps before compression burn

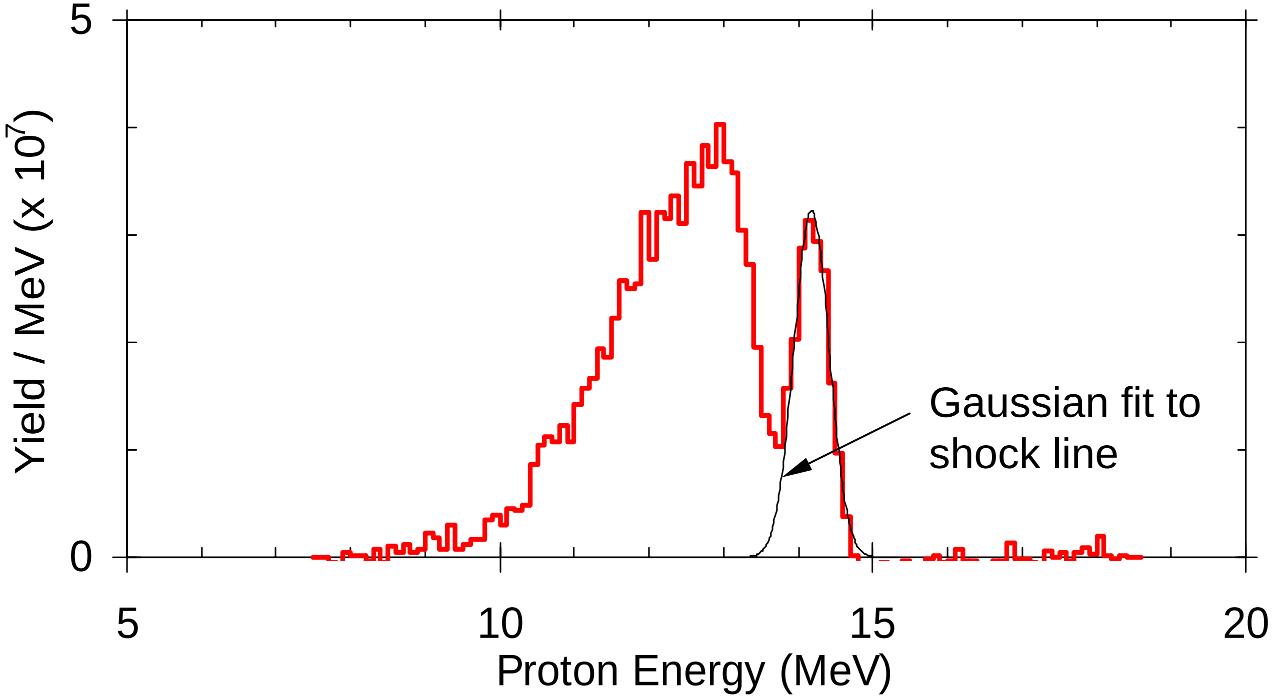


Different shot

Hydrodynamic simulations show that this interpretation is reasonable

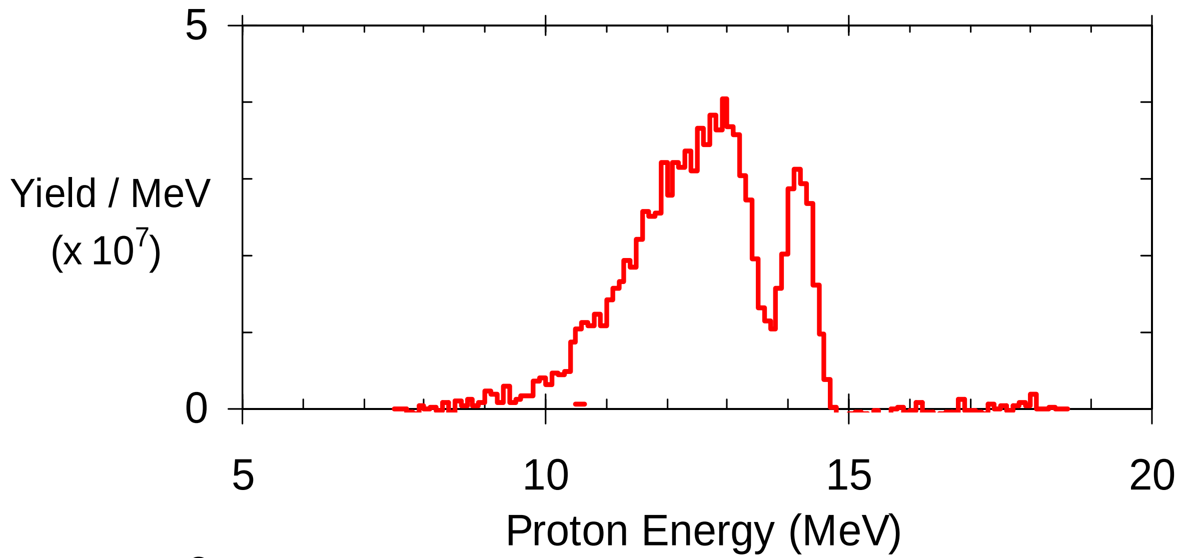


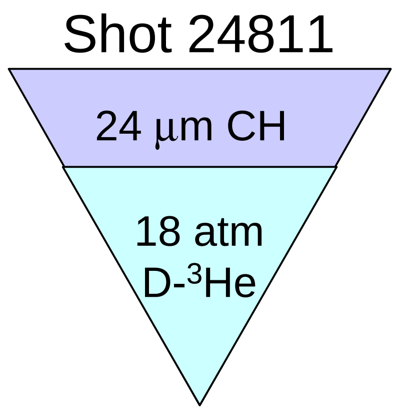
Yield-weighted <T_i> at shock coalescence can be estimated from the line width

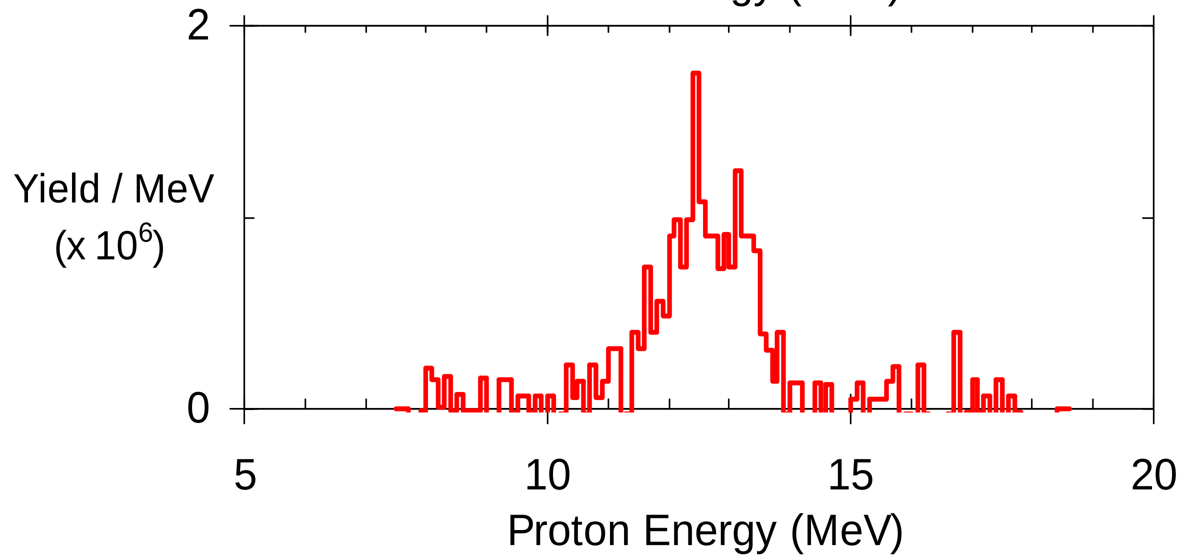


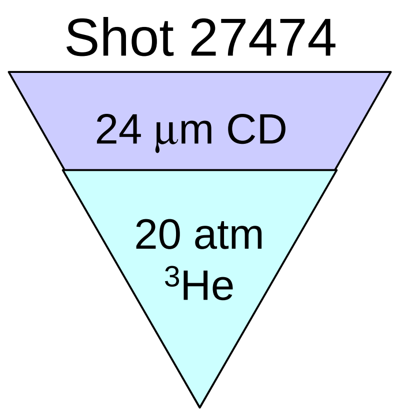
$\langle T_i \rangle_{shock} = (5.5 \pm 0.6)$ keV

Fuel-shell mix occurs by compression burn but not by shock coalescence

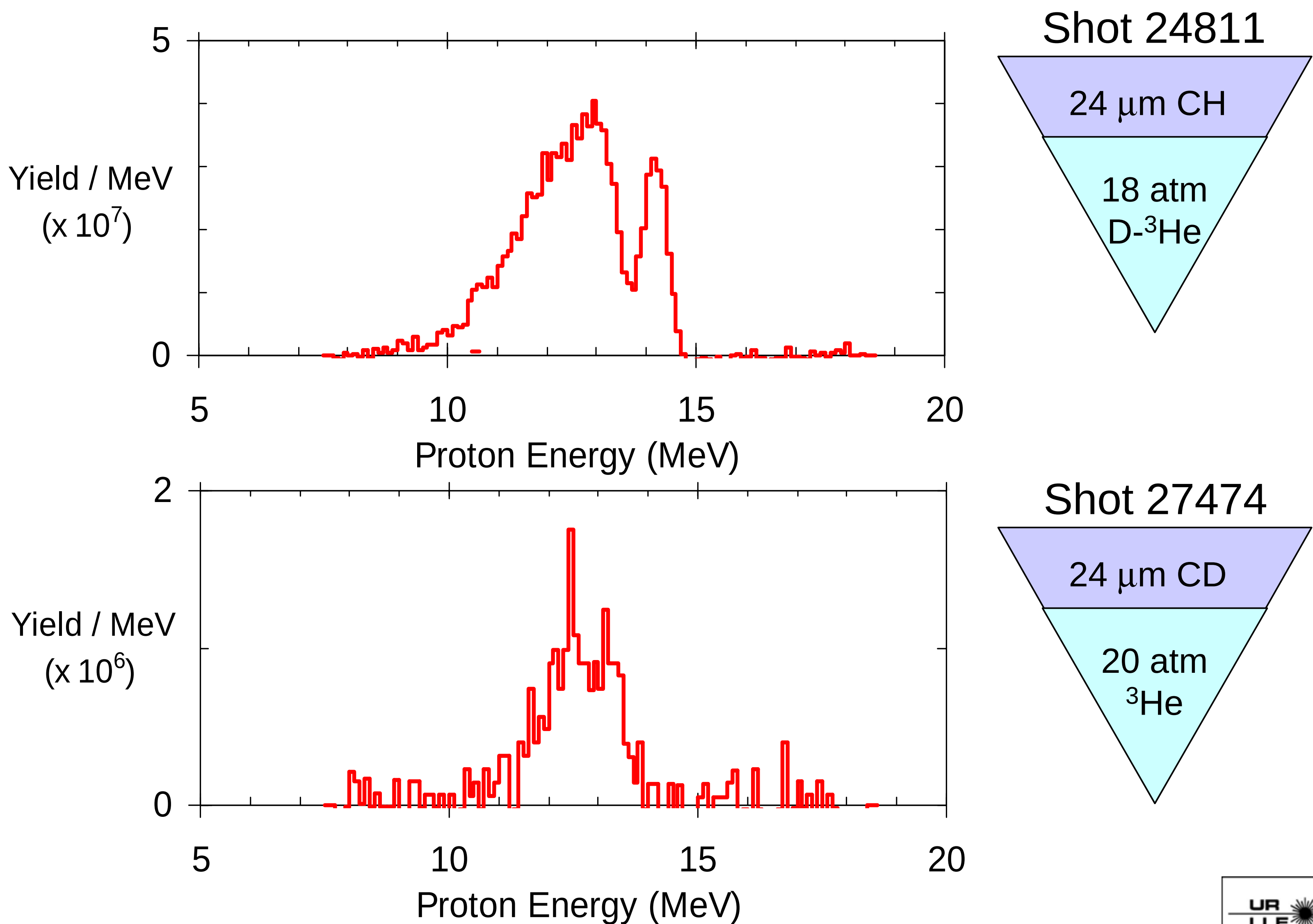




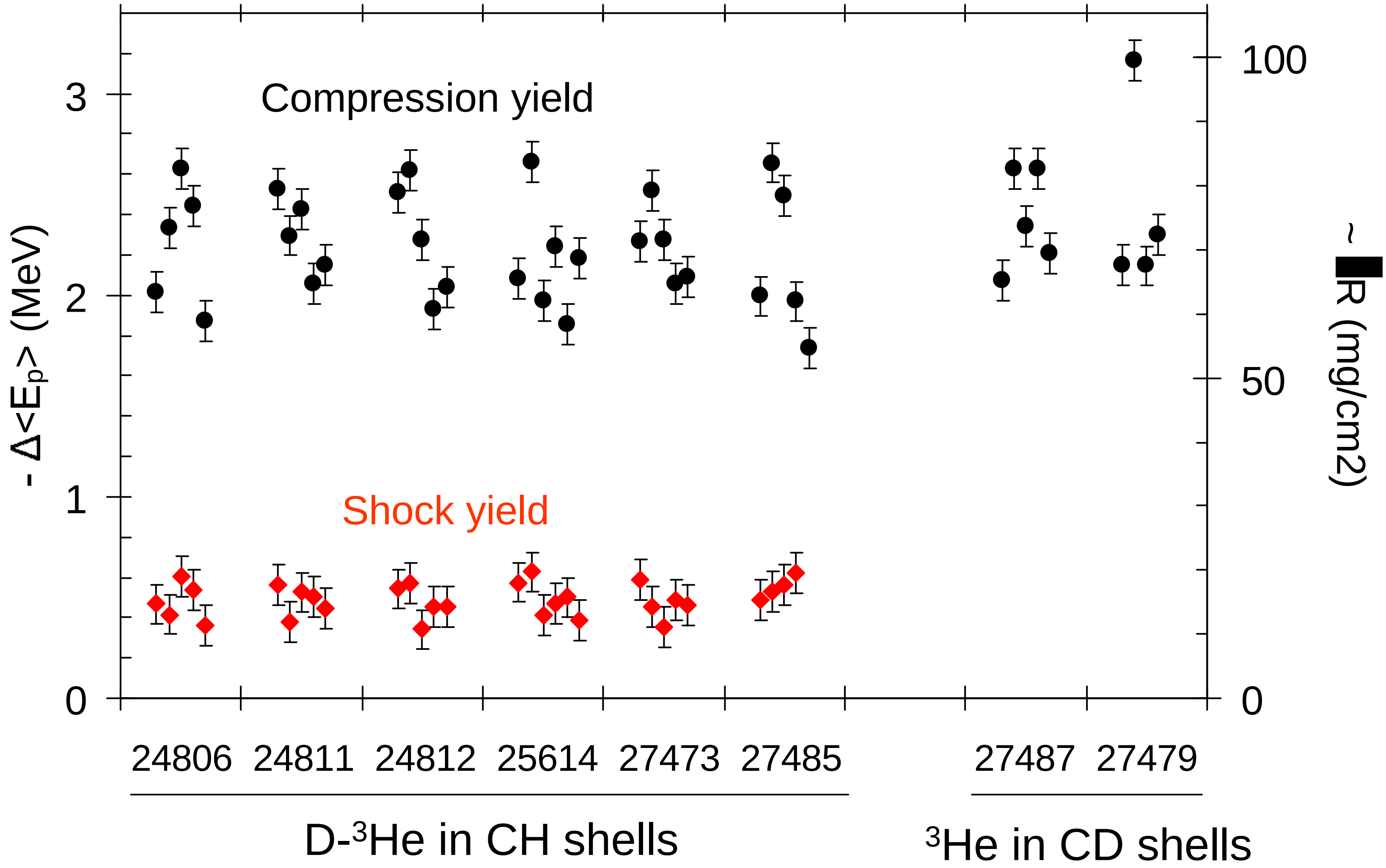




The absence of shock burn for ^{3}He-filled capsule validates this shock burn model



ρR measurements for various implosions



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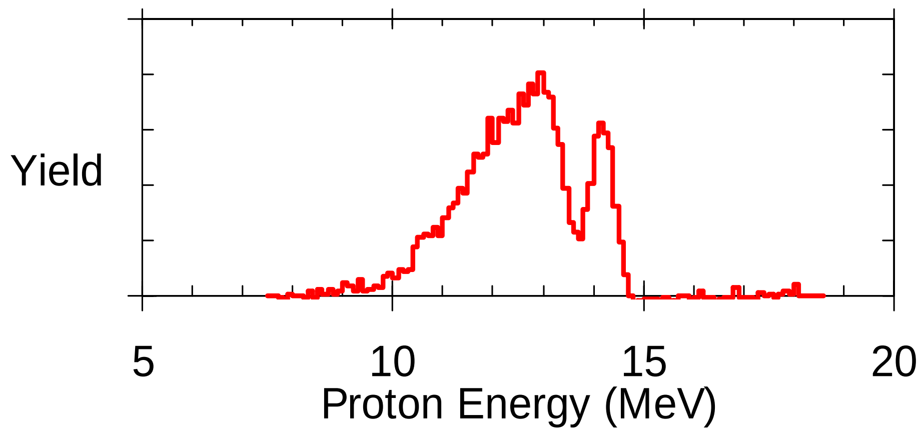

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