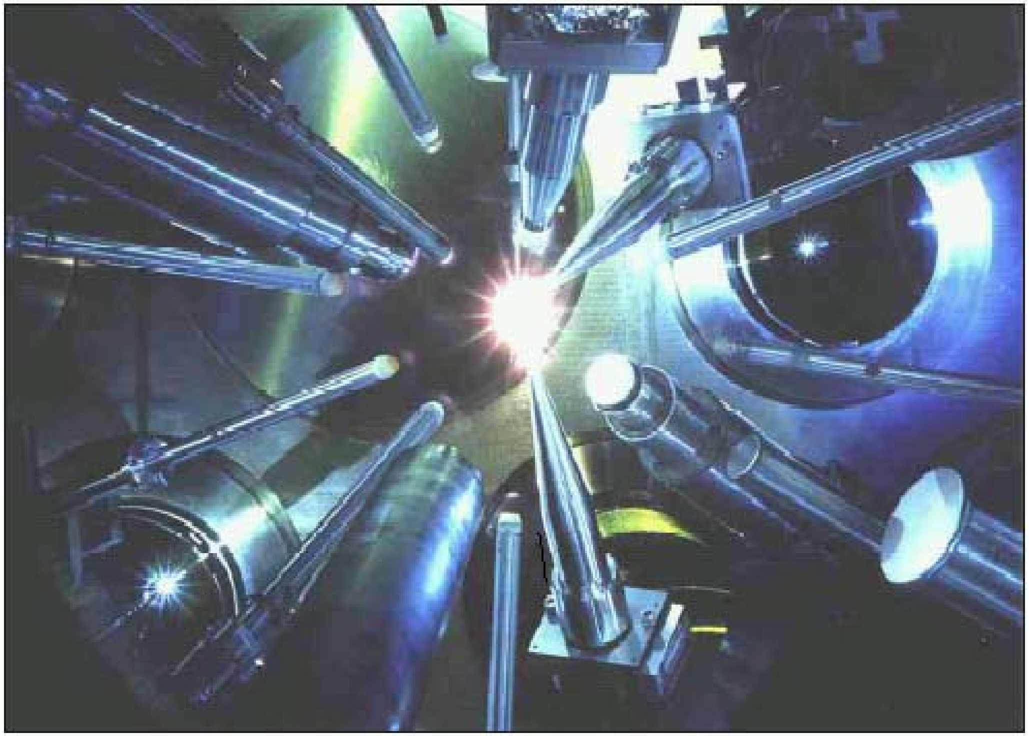
Capsule areal density asymmetries and time evolution inferred from 14.7-MeV protons in OMEGA implosions



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44th Annual Meeting of the
America Physics Society
Division of Plasma Physics
Orlando, FL
November 11-15, 2002

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Summary

Charged-particle spectra are used to study capsule areal density (ρR) asymmetry and time evolution

- Charged-particle spectra are measured simultaneously from different directions during individual OMEGA implosions
- Experiments demonstrate the presence of low ℓ- mode ρR asymmetry in direct-drive capsule implosions
- No single source of low ℓ-mode has been identified to dominate measurements of ρR asymmetry
- Data indicate time evolution of ρR and ρR asymmetry between shock coalescence and compression burn
- The first proton core imaging provide burn profiles at the times of shock coalescence and compression burn

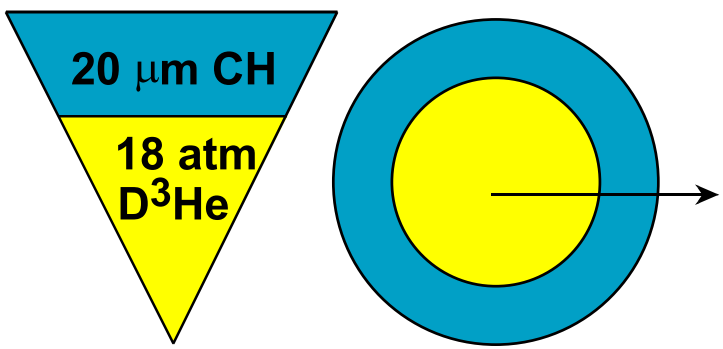
Related talks in this conference

- **F. J. Marshall *et al*., GO2.007**
- **P. W. Mckenty *et al*., GO2.008**
- **R. D. Petrasso *et al*., GO2.015**
- **P. B. Radha *et al*., FO2.003**
- **R. Rygg *et al*., GO2.014**
- **T. C. Sangster *et al*., RI1.006**
- **B. Schwartz *et al*., KP1.147**
- **F. H. Seguin, *et al*., GO2.013**
- **V. A. Smalyuk *et al*., QI1.005**
- **J. M. Soures *et al*., GO2.005**

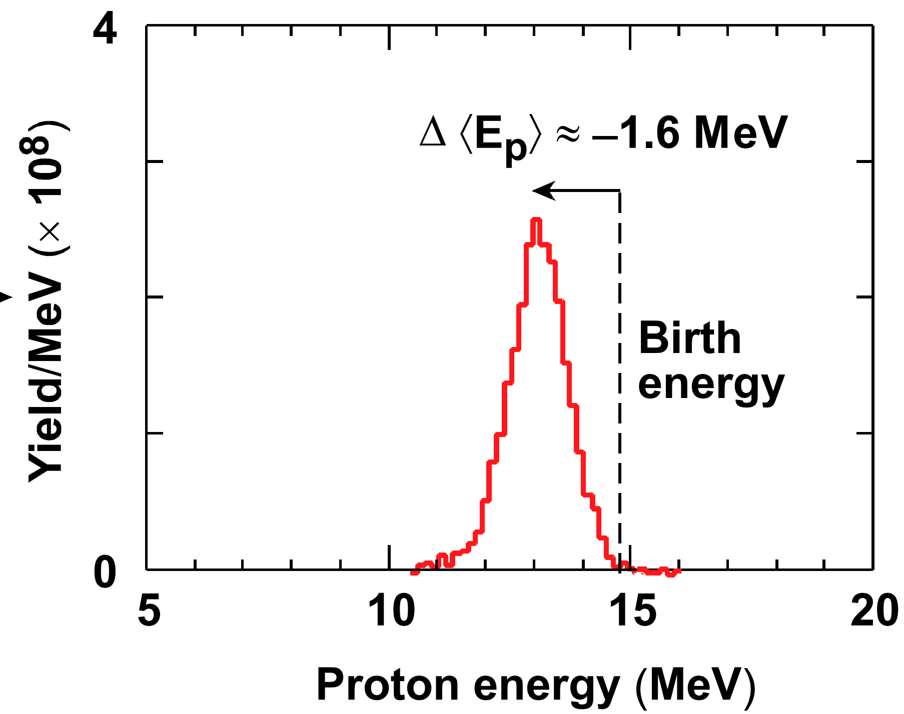
Outline

- Charged-particle spectroscopy on OMEGA
- Measurements of ρR asymmetry
- Possible sources of ρR asymmetry
- Evolution of ρR and ρR asymmetry

To study ρR asymmetry, we measure energy loss of 14.7-MeV D^{3}He protons



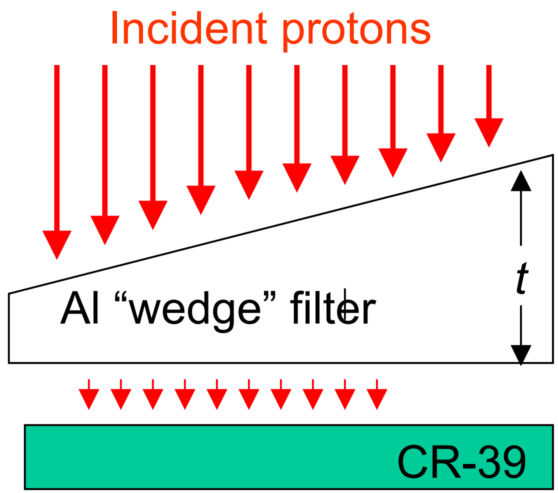
60 laser beams
22-kJ energy
1-ns square pulse



D + ^{3}He → α + p (14.7 MeV)

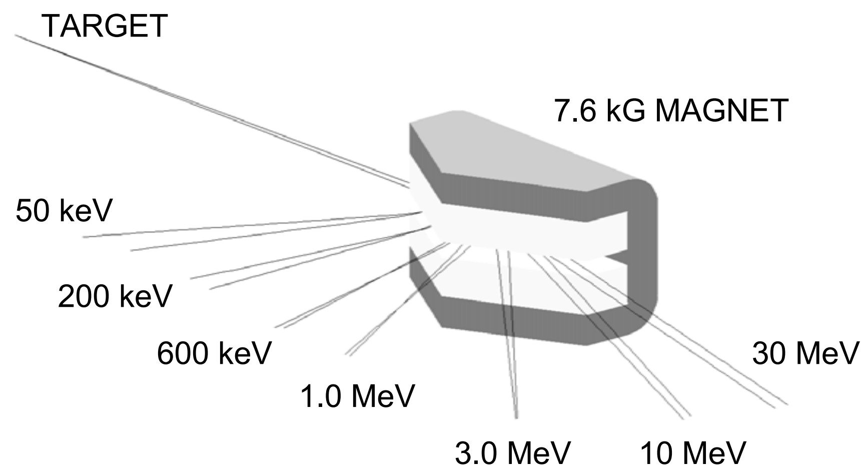
Two kinds of charged-particle spectrometers are used to study ρR asymmetry and time evolution

"Wedge-Range-Filter" spectrometer (WRF)



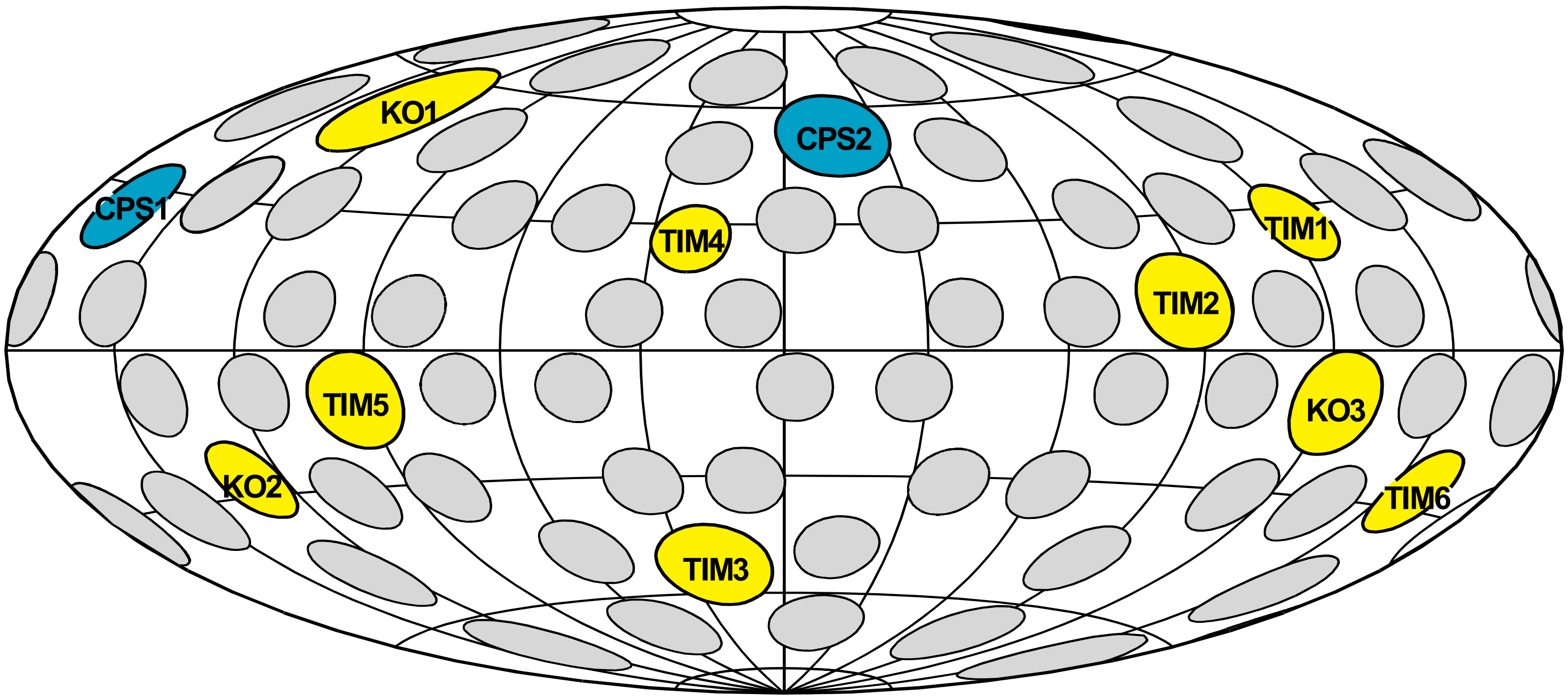
Particle energies identified from local thickness *t* and diameter of etched proton tracks in CR-39.

Magnet-based spectrometers (CPS)



Particle energies identified from trajectories.

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



= WRF spectrometers
= Magnet-based CPS's

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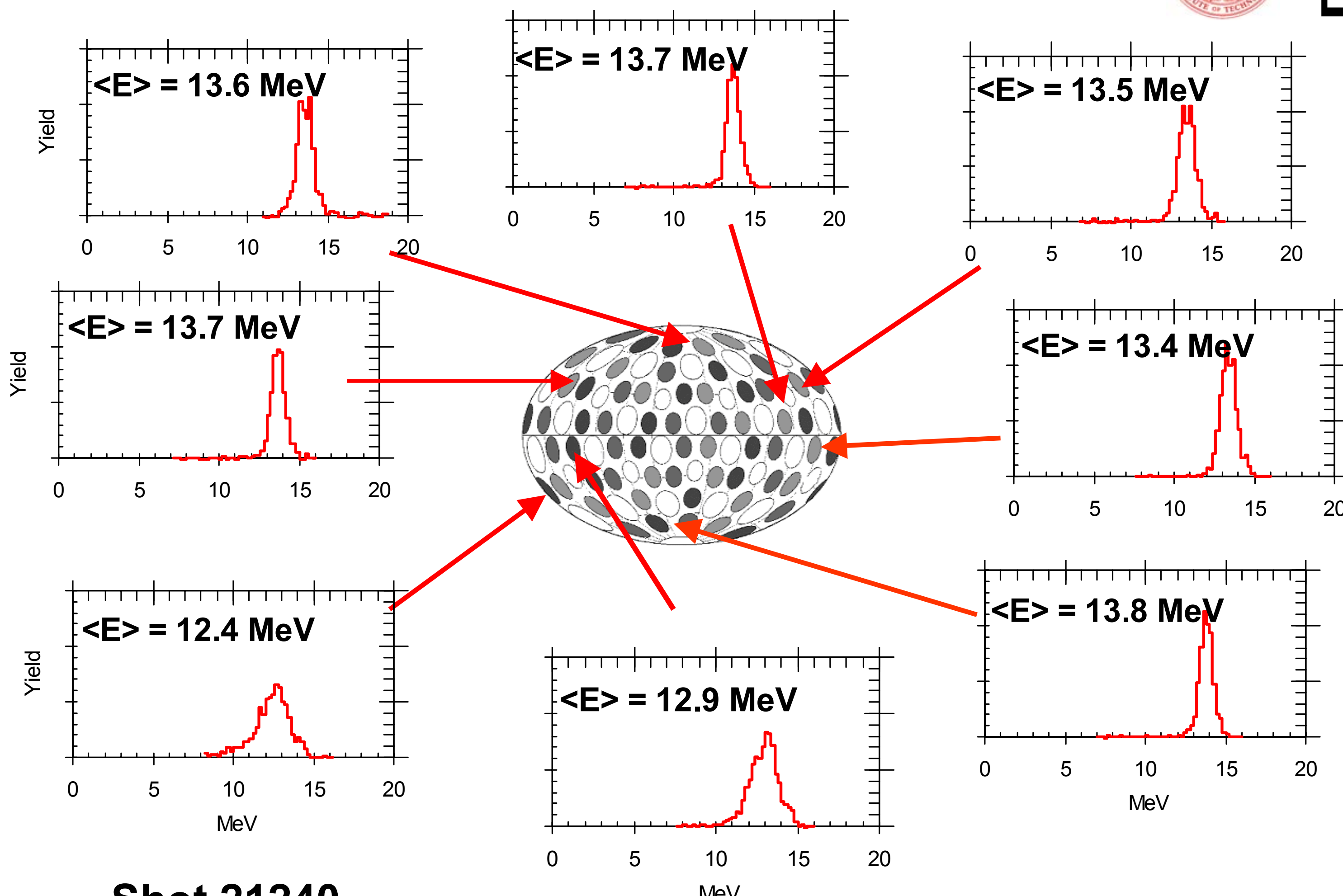
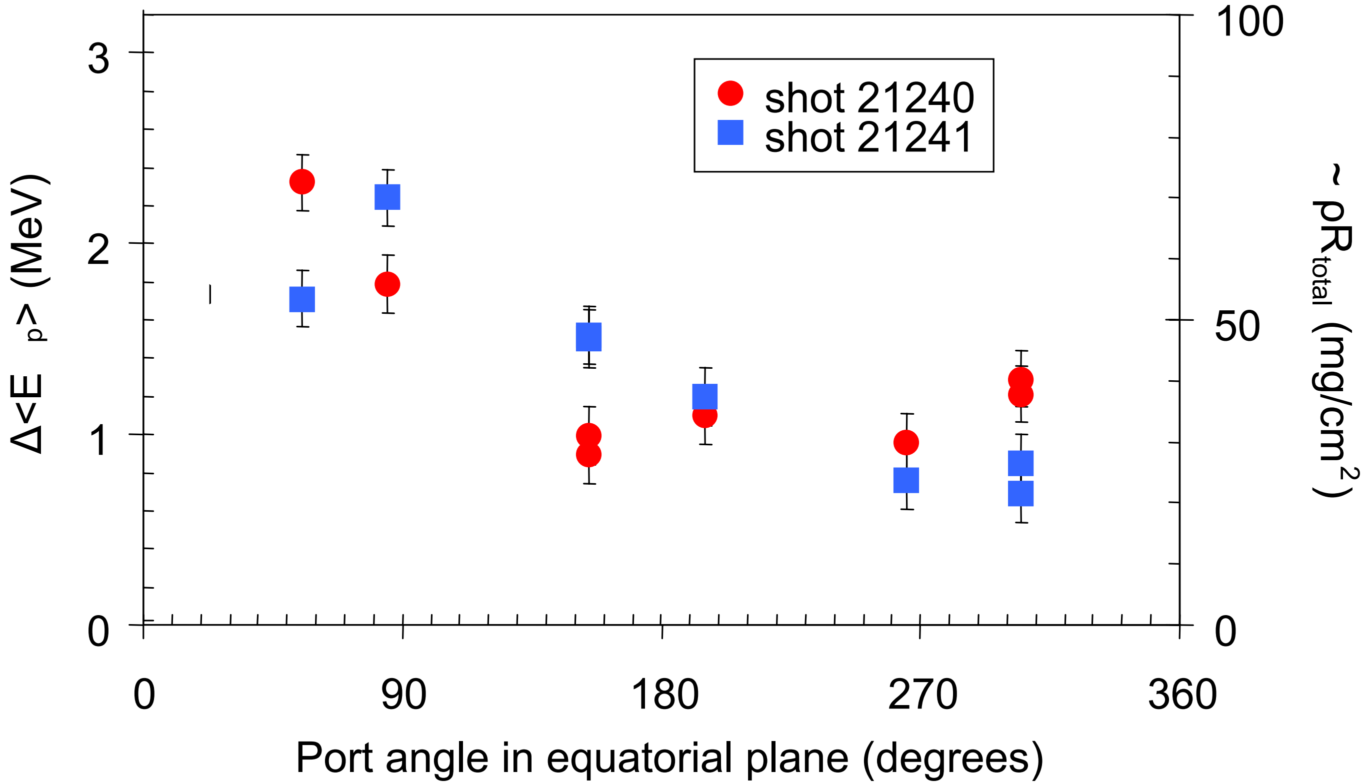
Charged-particle spectra are measured simultaneously from different directions during an individual OMEGA implosion



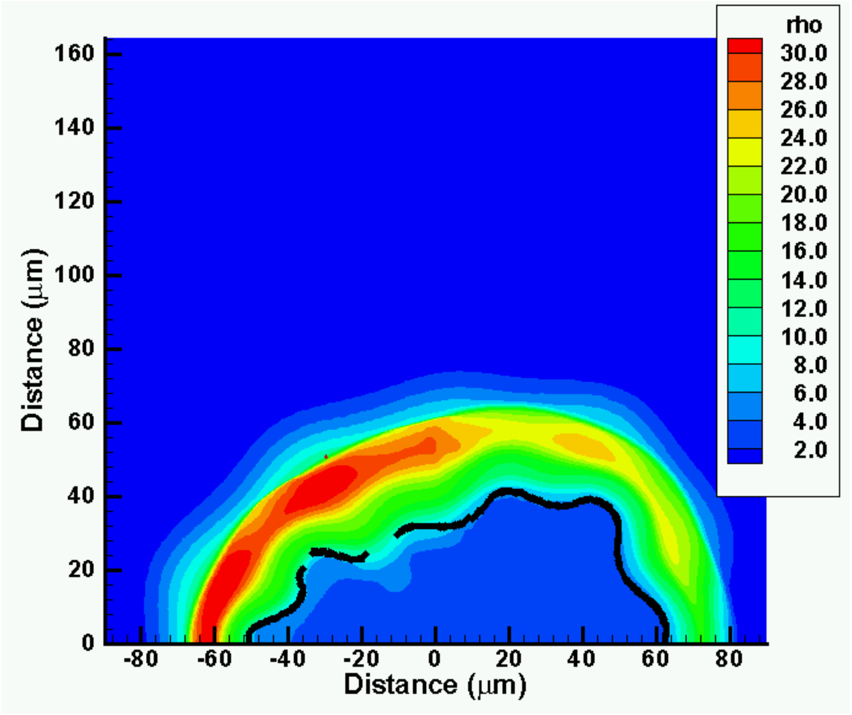
Shot 21240

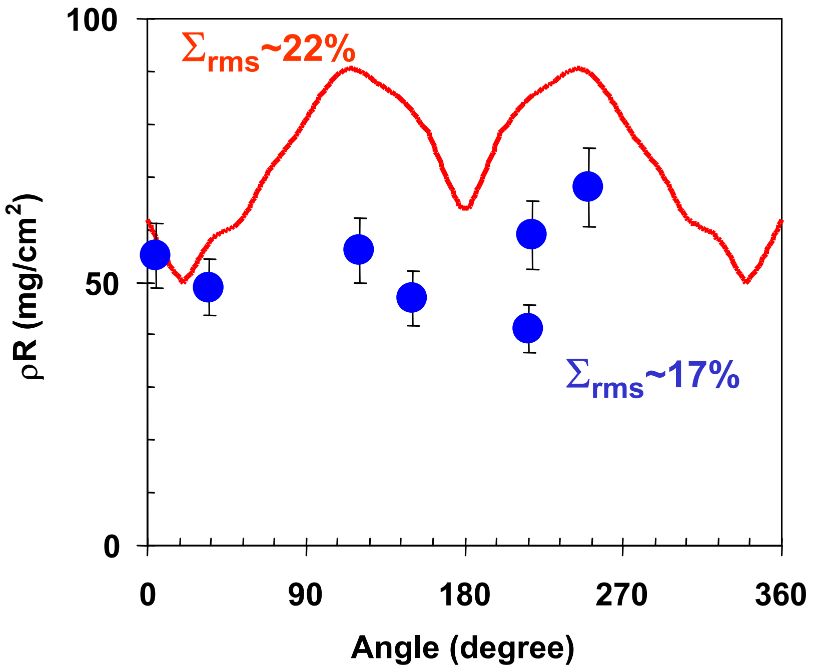
F. Seguin, et al., Phys. Plasmas, 9 3558 (2002)

Experiments demonstrate low ℓ- mode ρR asymmetry



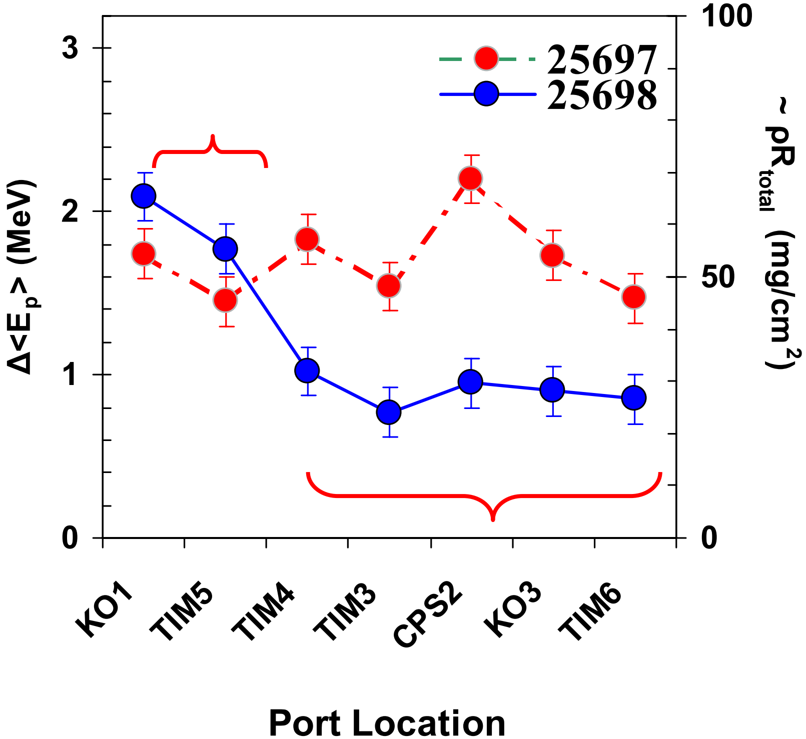
2D DRACO simulation indicates the low ℓ- mode ρR asymmetry at the time near peak burn

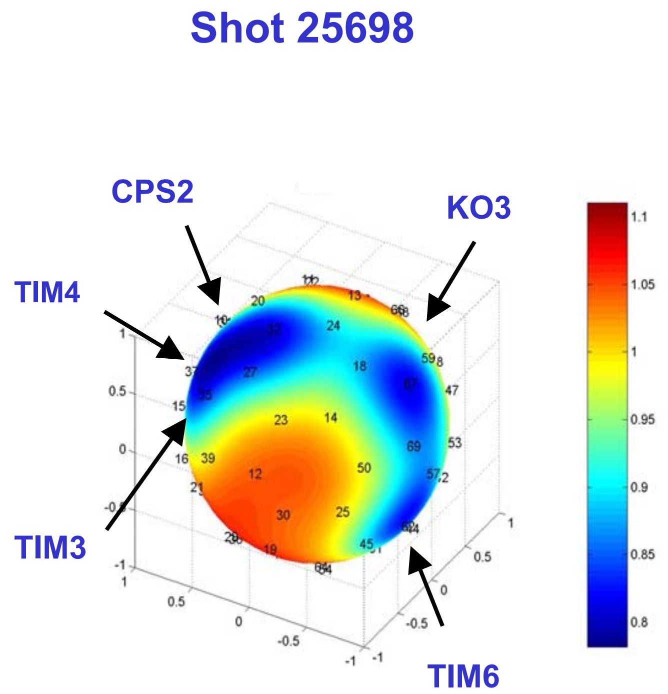




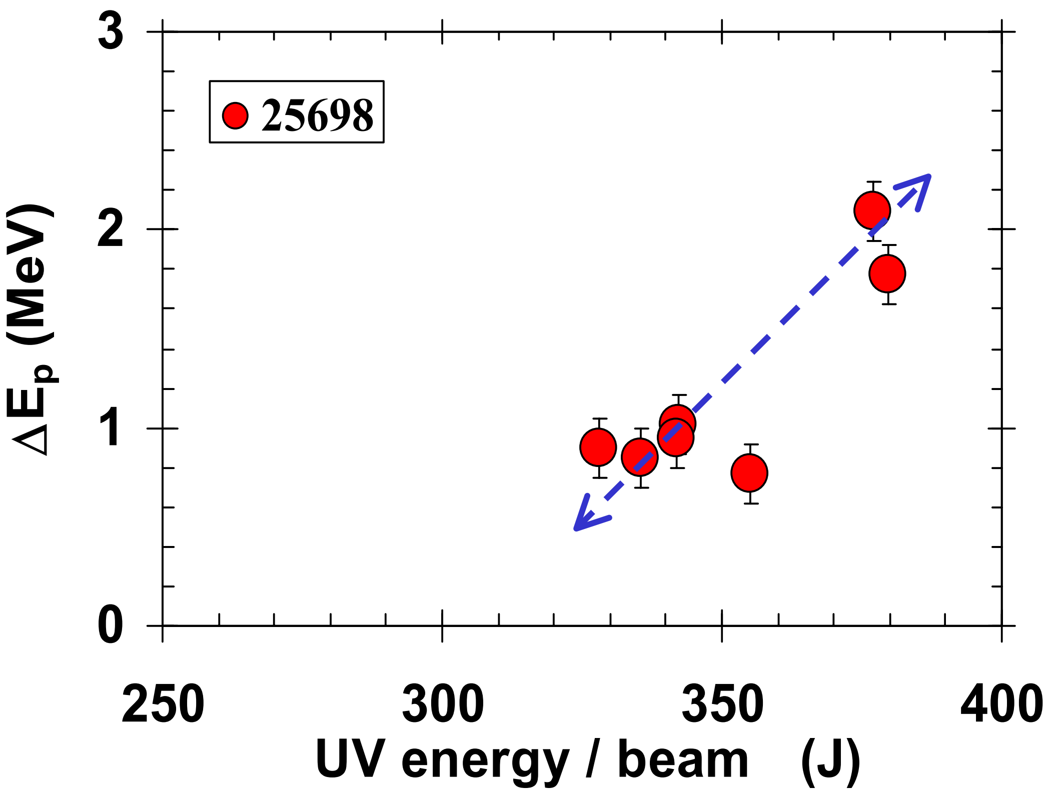
Shot 25697
1-ns square, 23 kJ
beam imbalance ~6% rms

Measured ρR asymmetry is correlated with beam energy imbalance when it is ~ 25% rms (σ_{rms} ~ 9% after beam overlap)





ρR asymmetry is correlated with energy imbalance when this imbalance is ~25% rms

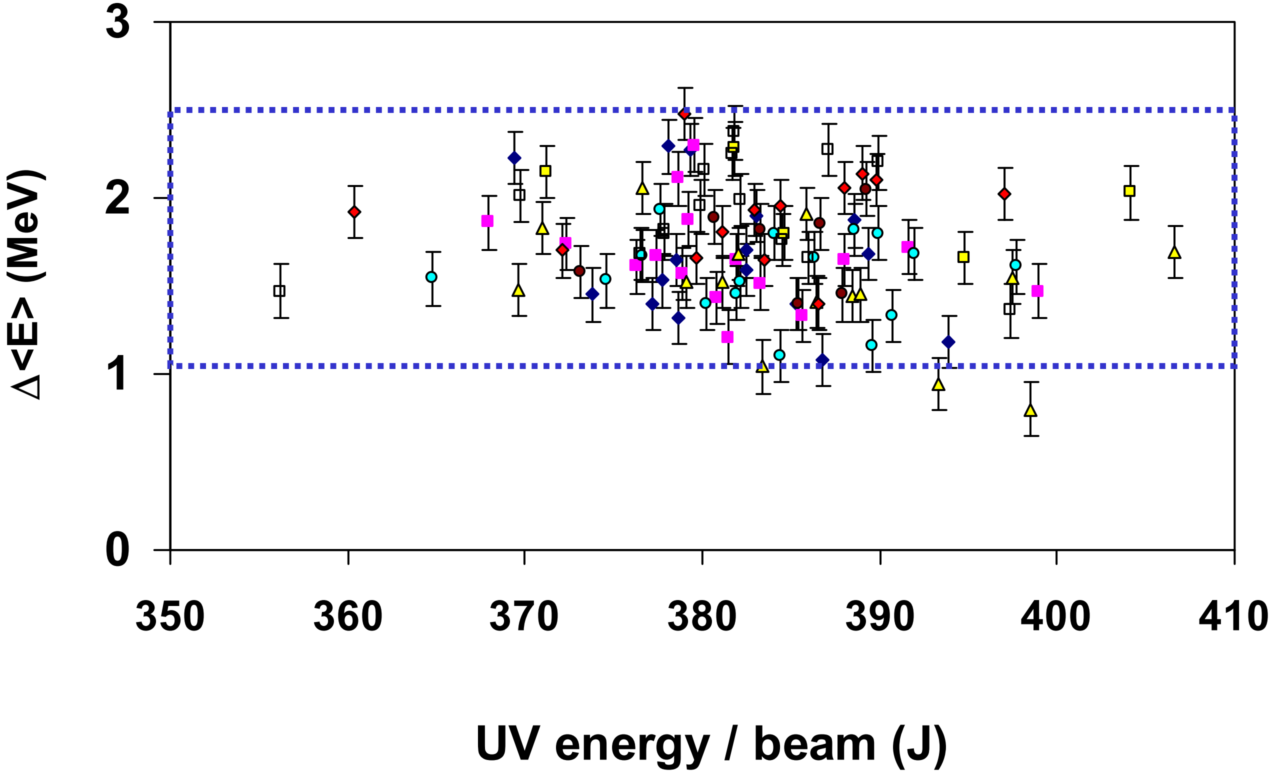


Under current OMEGA experimental conditions, possible sources of low-mode number ρR asymmetry include:

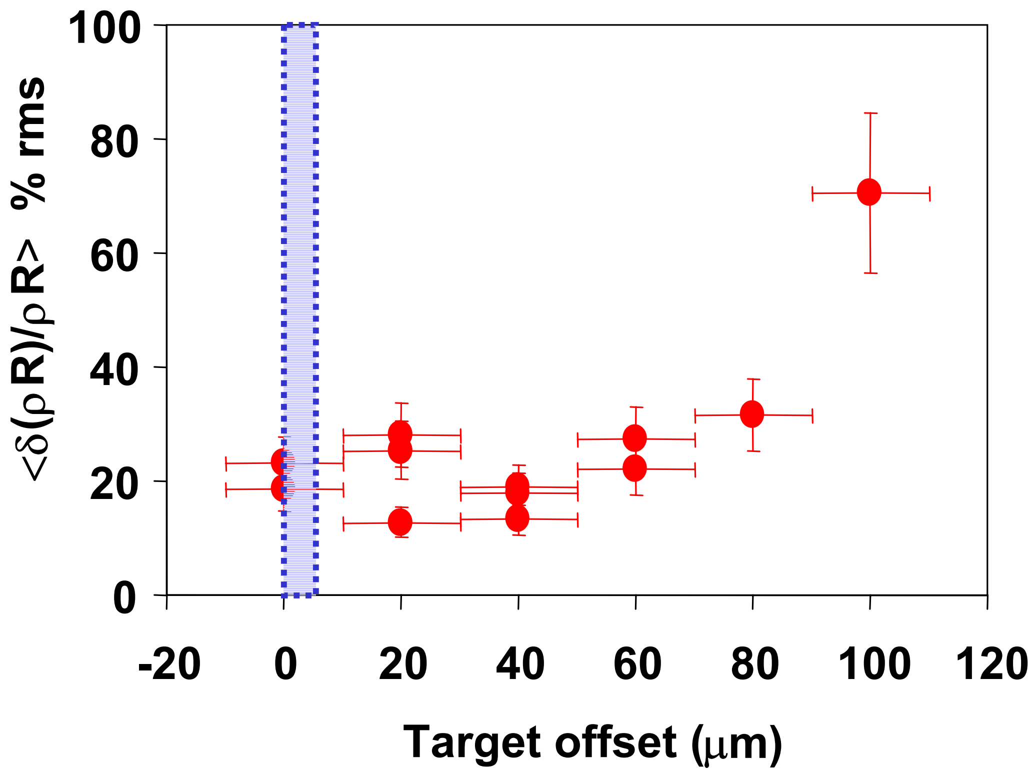
- Irradiation non-uniformity *
  - Beam energy/power imbalance ≤ 5% rms
    (σ_{rms} = 1-2% after beam overlap)
  - Capsule offset from TCC ≤ 5 μm (σ_{rms} ≤1%)
  - Beam mispointing ≤ 20 μm (σ_{rms} ~ 1.9 %)
  - Beam mistiming ≤ 10 ps (σ_{rms} ~1%)
  - Beam shape (σ_{rms} ~1.1%)
- Capsule imperfections

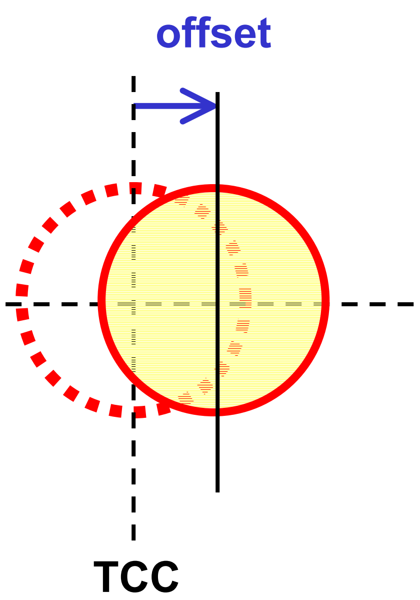
* F. J. Marshall *et al*., GO2.007 in this conference

When beam energy imbalance is ~5% rms (σ_{rms} ~1-2%), ρR asymmetry is uncorrelated with this imbalance



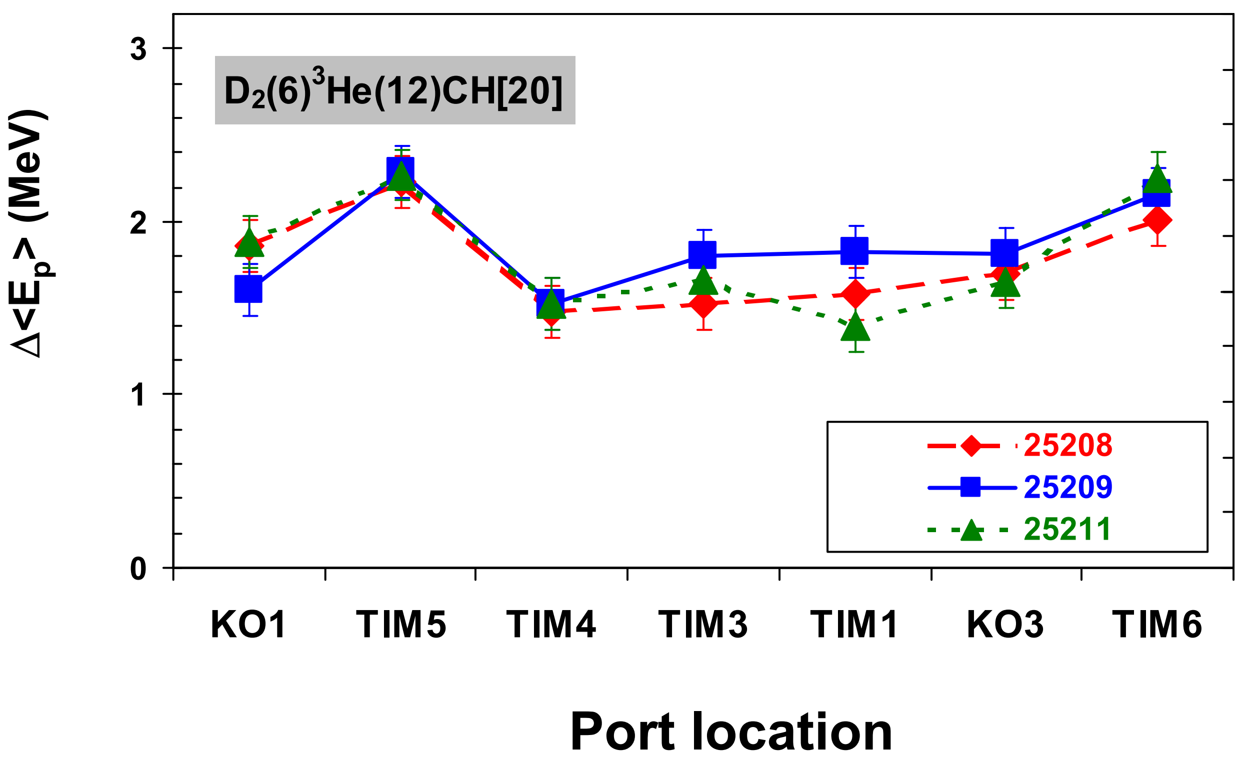
Measured ρR asymmetry is uncorrelated with offset of the capsule from the target chamber center (TCC) when this offset is ≤ 80 μm



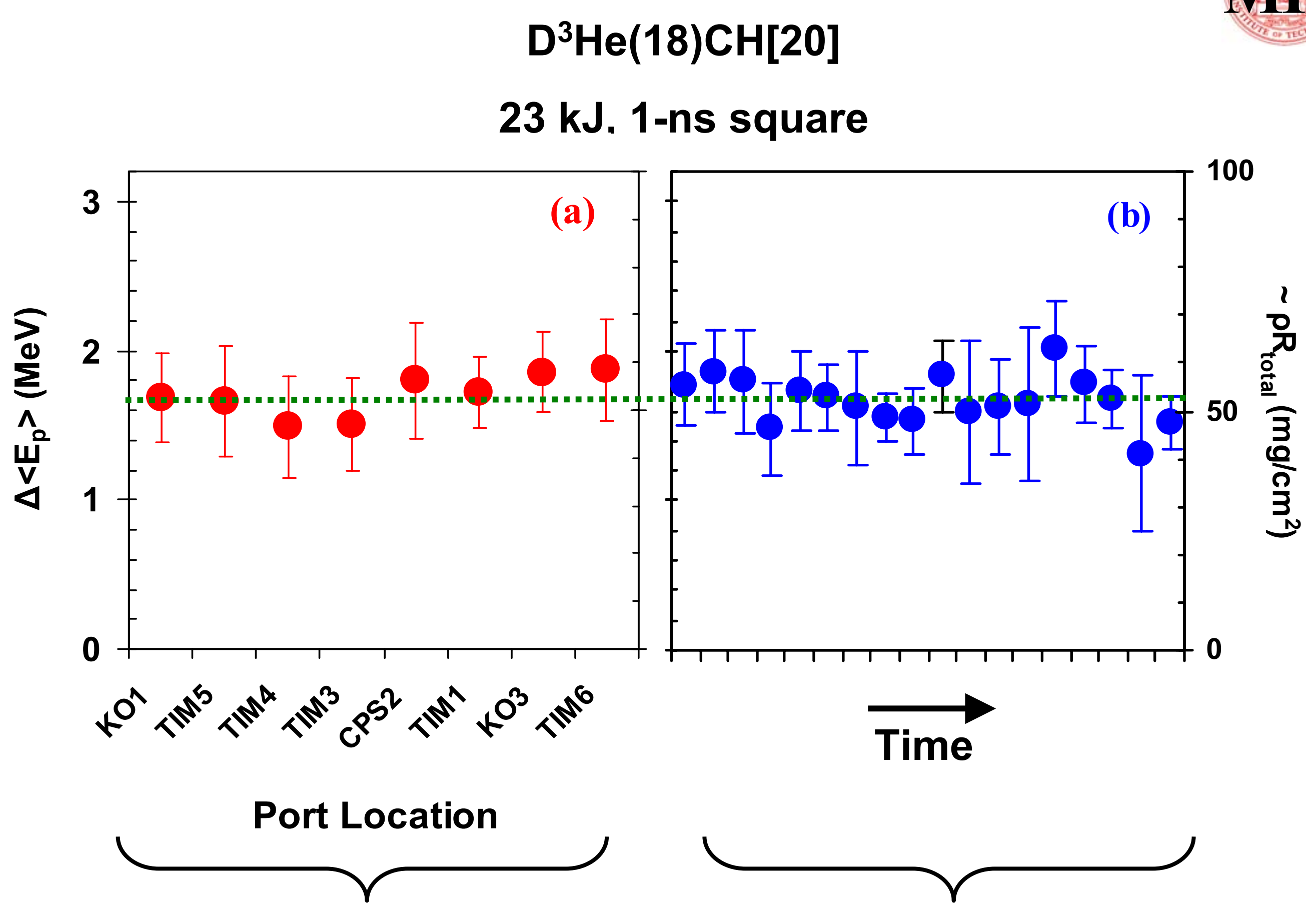


*J. M. Soures *et al*., GO2.005 in this conference

For contiguous shots, similarities in asymmetries suggest that ρR asymmetry is uncorrelated with capsule imperfections



During a two-week interval, ρR asymmetries are randomly distributed over space and time



Each port averaged over 18 shots

Each shot averaged over 7 ports

No single source of low-order ℓ modes has been identified to to dominate the measured ρR asymmetry

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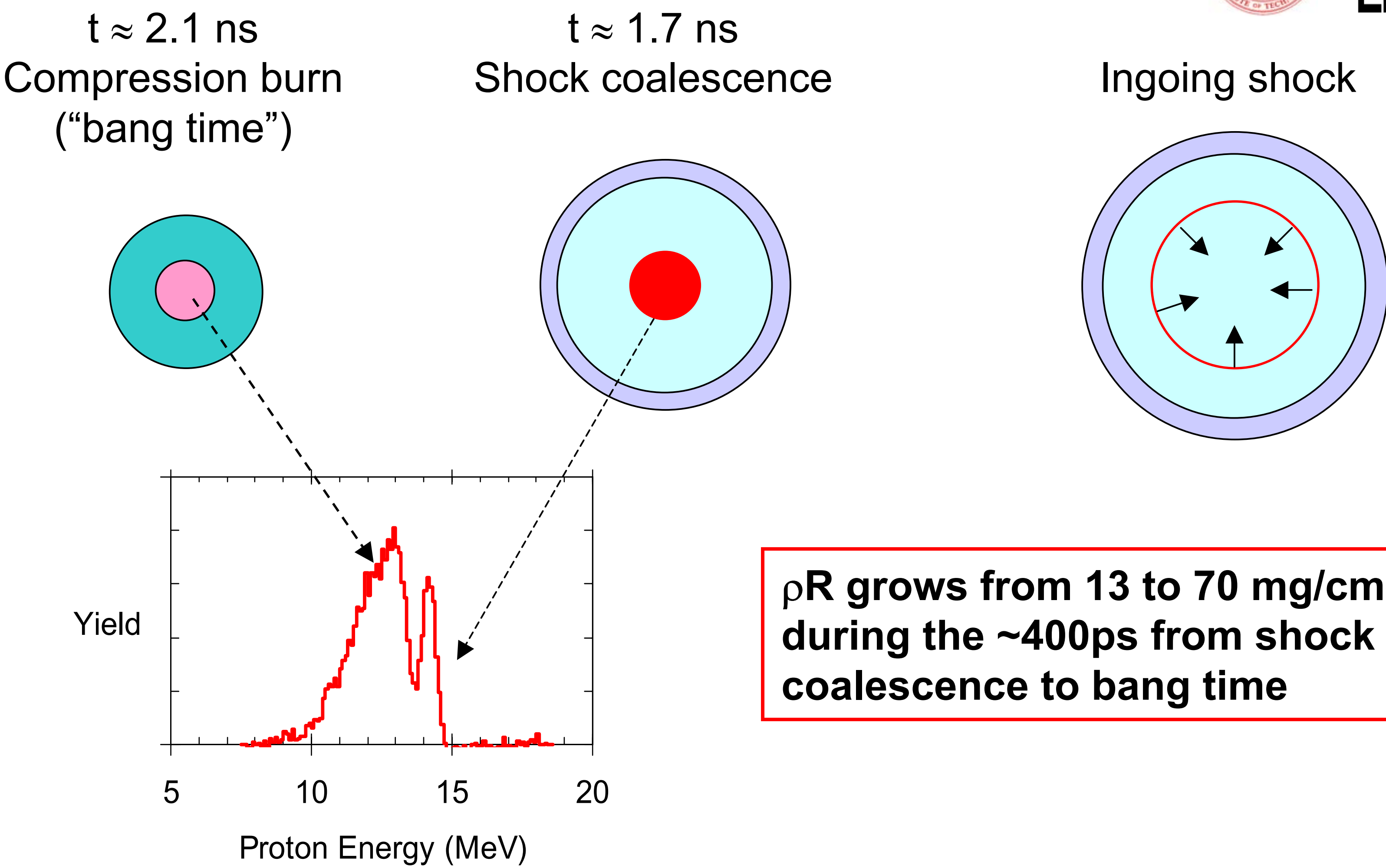
Next questions

- How do ρR and ρR asymmetries evolve with time?
- How much are these asymmetries amplified over time?

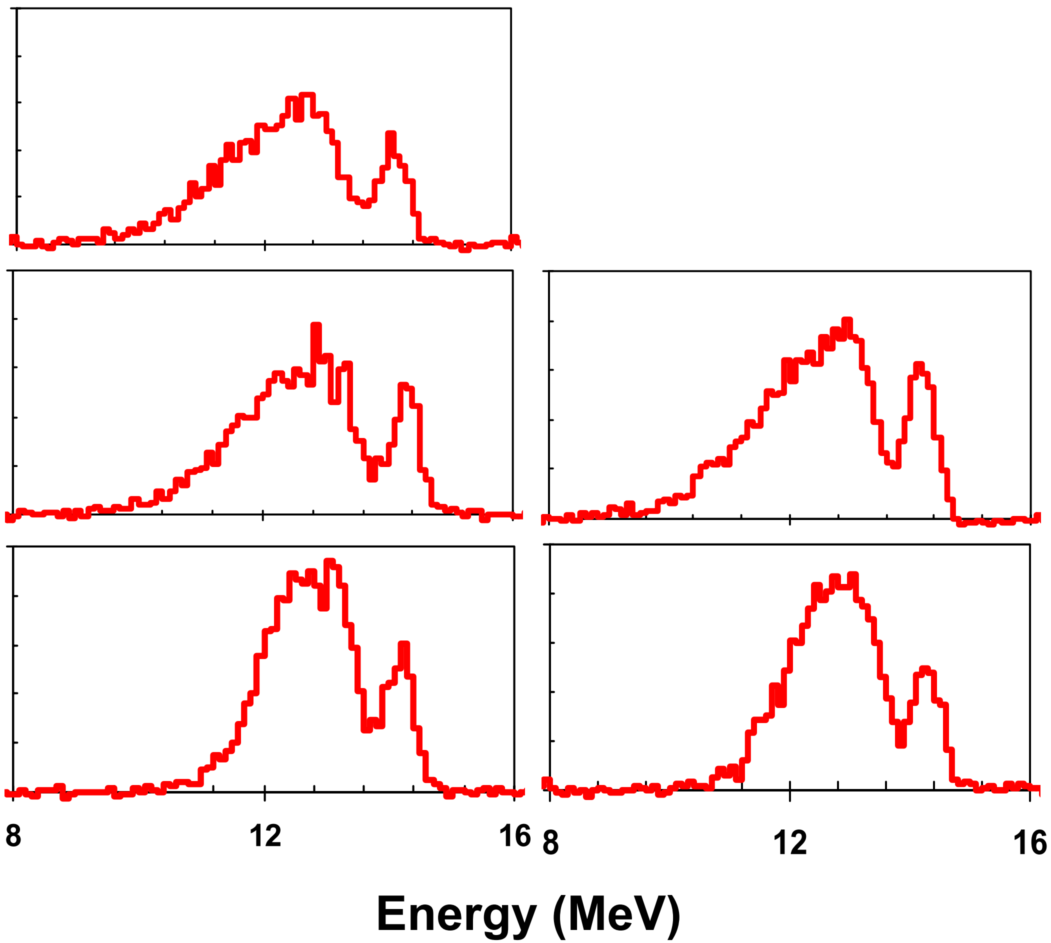
Evolution of ρR has been studied at the time of shock-coalescence and ~400 ps later, at the time of compression burn



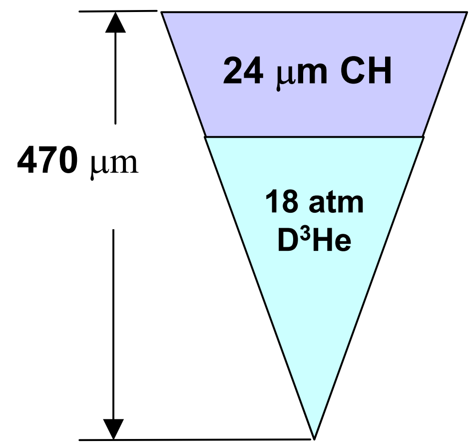
ρR grows from 13 to 70 mg/cm² during the ~400ps from shock coalescence to bang time

R. D. Petrasso *et al.*, to be published in Phys. Rev. Lett. (2002)

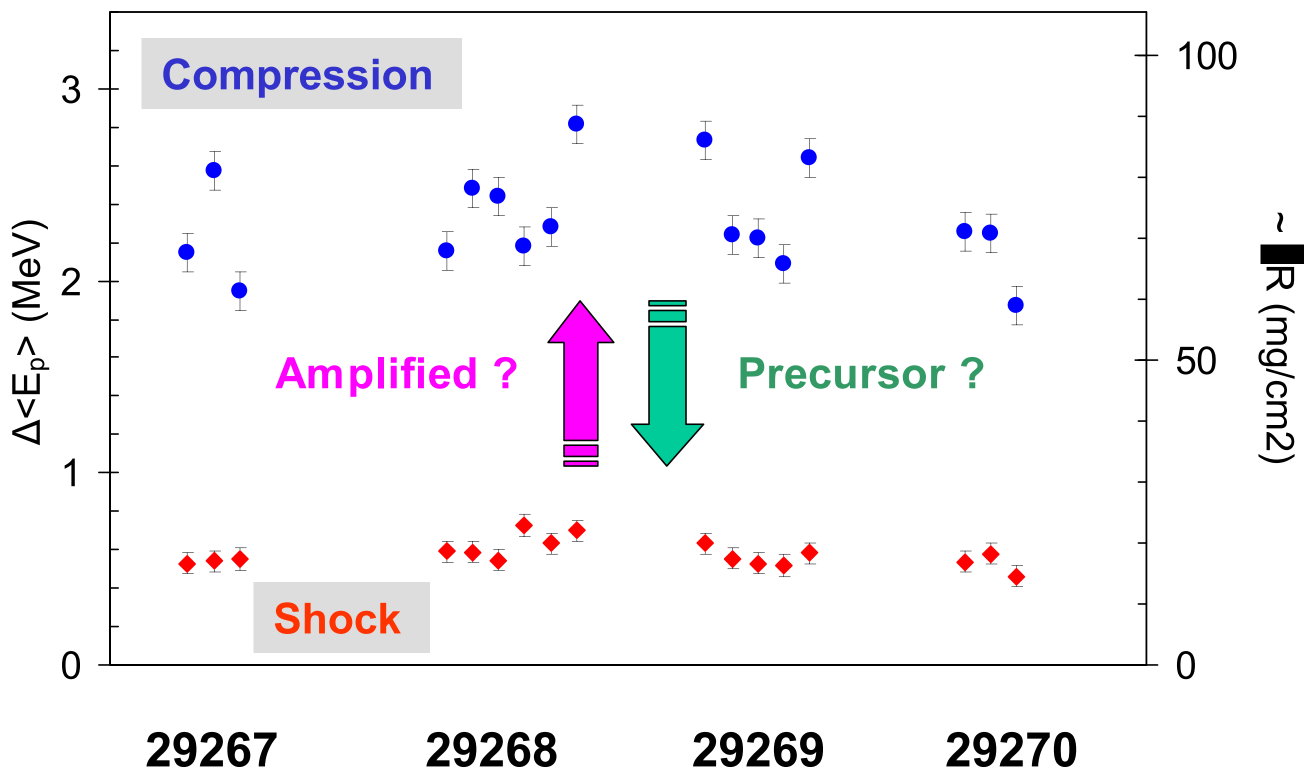
Are there any correlations in ρR asymmetry between shock-coalescence time and compression burn time?



Shot 24811
1 ns square, 23kJ

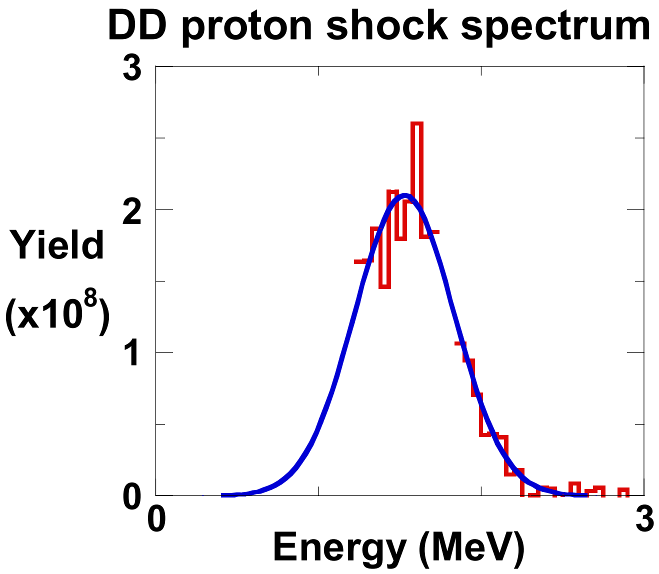


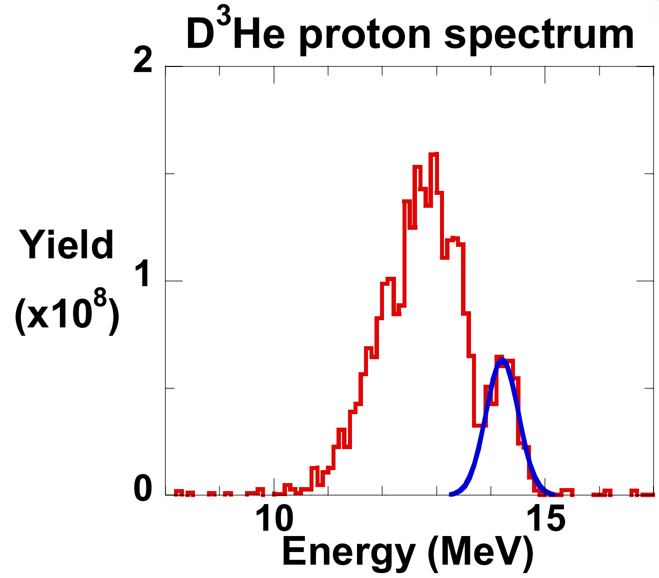
Does the asymmetry seen at compression burn amplify from the time of shock coalescence?



F. H. Seguin, *et al.*, GO2.013 in this conference

Charged-particle spectroscopy could be used to study high ℓ-mode ρR modulations at the time of shock coalescence.



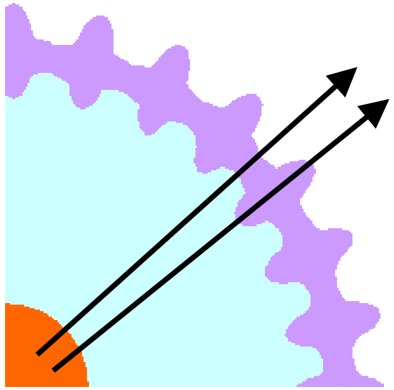


Width of shock yield (D^3He proton) → T_i

Ratio of DDp yield to D^3Hep yield → T_i

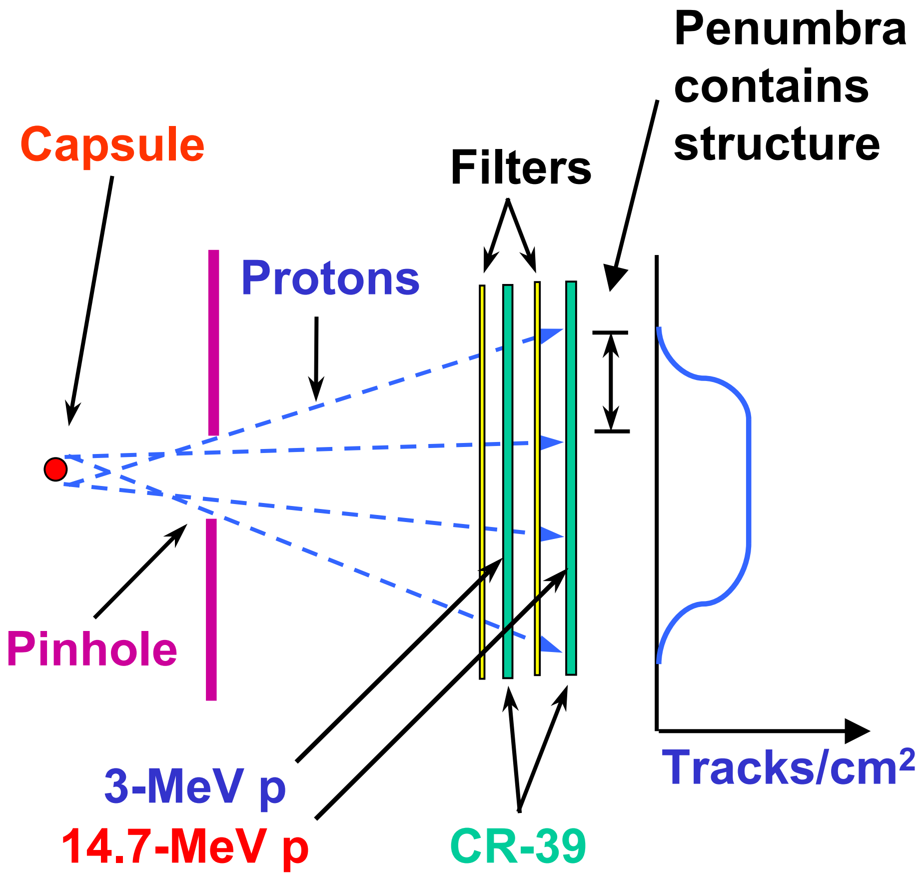
} difference

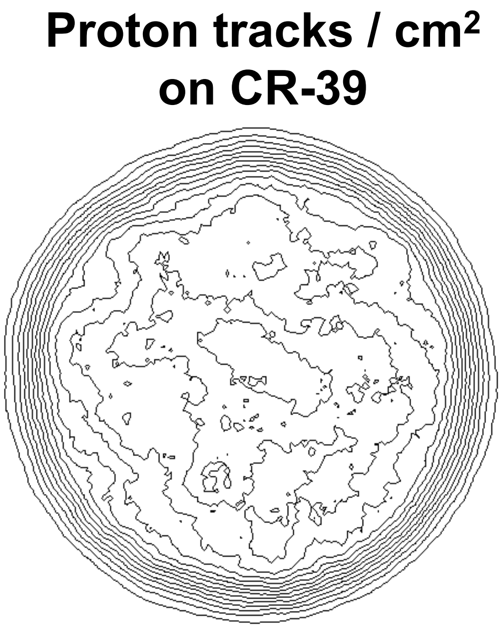
High-mode ρR modulations



R. Rygg *et al.*, GO2.014 in this conference

Proton-core-image-spectroscopy (PCIS) potentially provides a method for studying ρR evolution

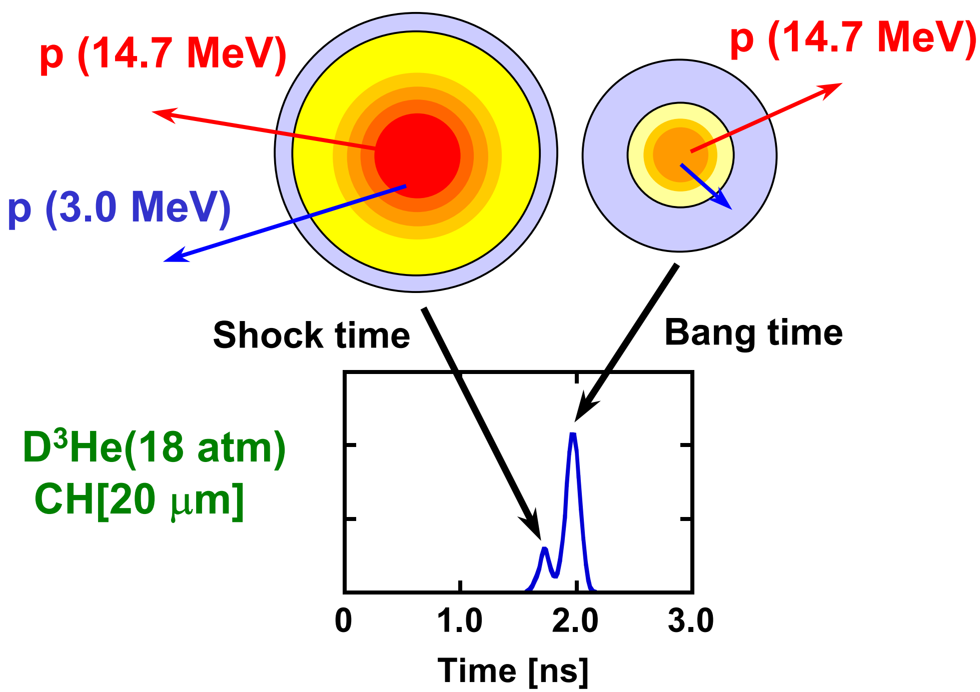




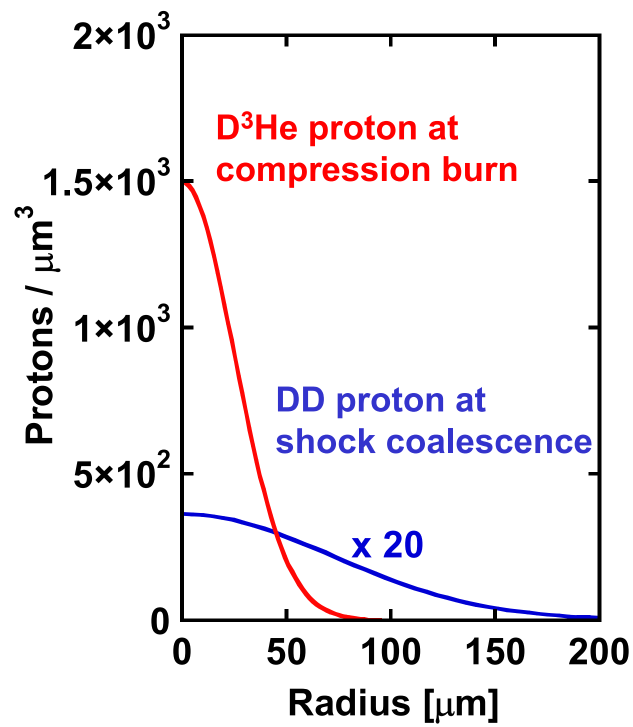
Measured proton core images at the time of shock coalescence and ~400 ps later, at compression burn

D + ^{3}He ⇒ p (14.7 MeV) + α (3.6 MeV)

D + D ⇒ p (3.0 MeV) + t (1.0 MeV)



Measured fusion burn profiles for Shot 27806



Summary/Conclusions

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