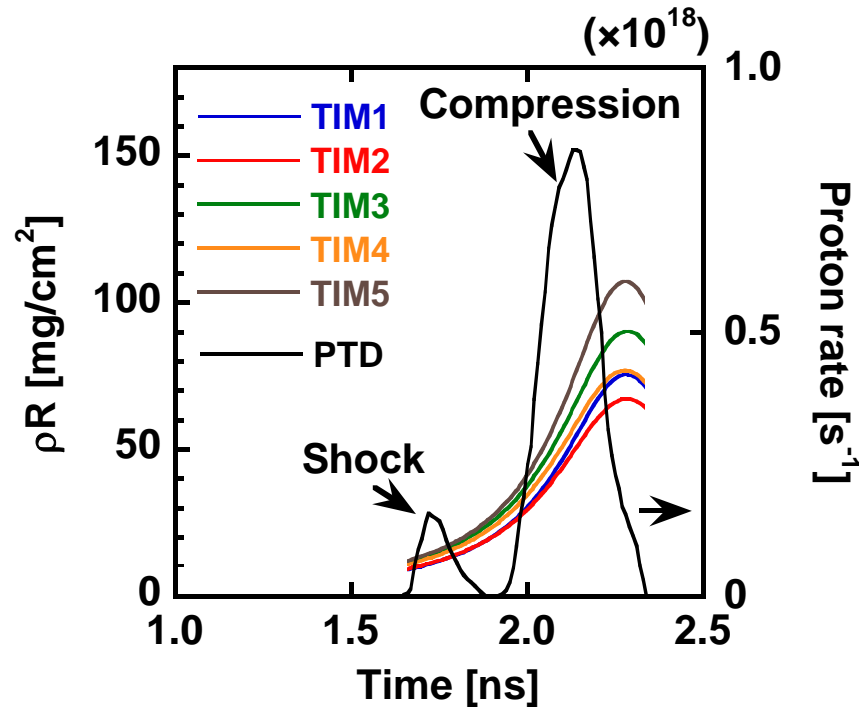
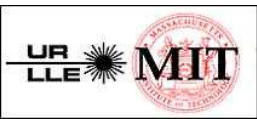


# Measurement of shock-coalescence timing and $\rho R$ evolution of D<sup>3</sup>He implosions at OMEGA



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3<sup>rd</sup> International  
Conference on Inertial Fusion  
Science and Applications  
Monterey, CA  
September 7-12, 2003



## Collaborators

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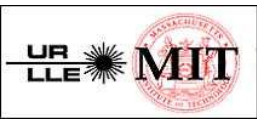
**C. K. Li, F. H. Séguin, J. DeCiantis, J. R. Rygg, S. Kurebayashi,  
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**\* Visiting senior scientist at LLE**



## Summary

# Shock-coalescence timing and $\rho R$ evolution of $D^3He$ implosions have been measured at OMEGA

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- A series of 18-atm  $D^3He$  filled CH capsules with thickness varying from 20 to 27  $\mu m$  were imploded using 1-ns square laser pulses delivering 23 kJ.
- $D^3He$ -reaction rate and  $\rho R$  evolution were determined using a proton temporal diagnostic (PTD) in combination with several  $D^3He$ -proton spectrometers.
- First results show that the  $D^3He$  proton production history contains a unique shock component in addition to a compression history similar to that of DD neutrons as measured by a neutron temporal diagnostic (NTD).
- Unique results from the PTD such as  $T_i(t)$ , shock-coalescence time and shock-burn duration have been obtained and compared with 1-D calculations.
- Preliminary analysis suggests that low-mode  $\rho R$  asymmetries at shock time are mirrored at bang time.

## Related work

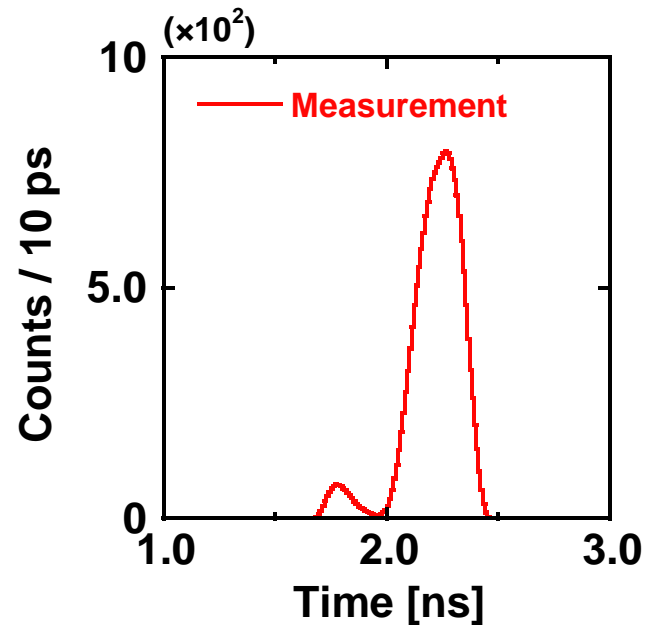
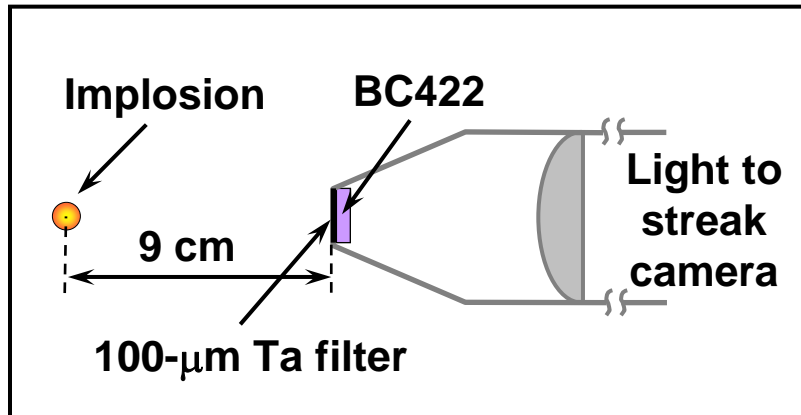
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### Recent related papers:

R. D. Petrasso et al., **Phys. Rev. Letters 90 (2003) 095002.**

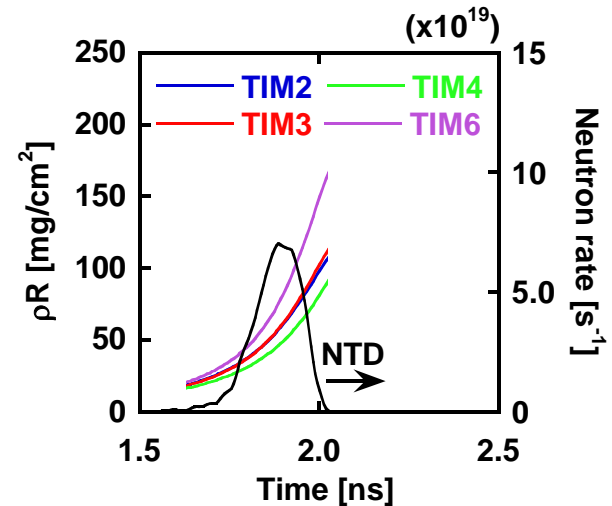
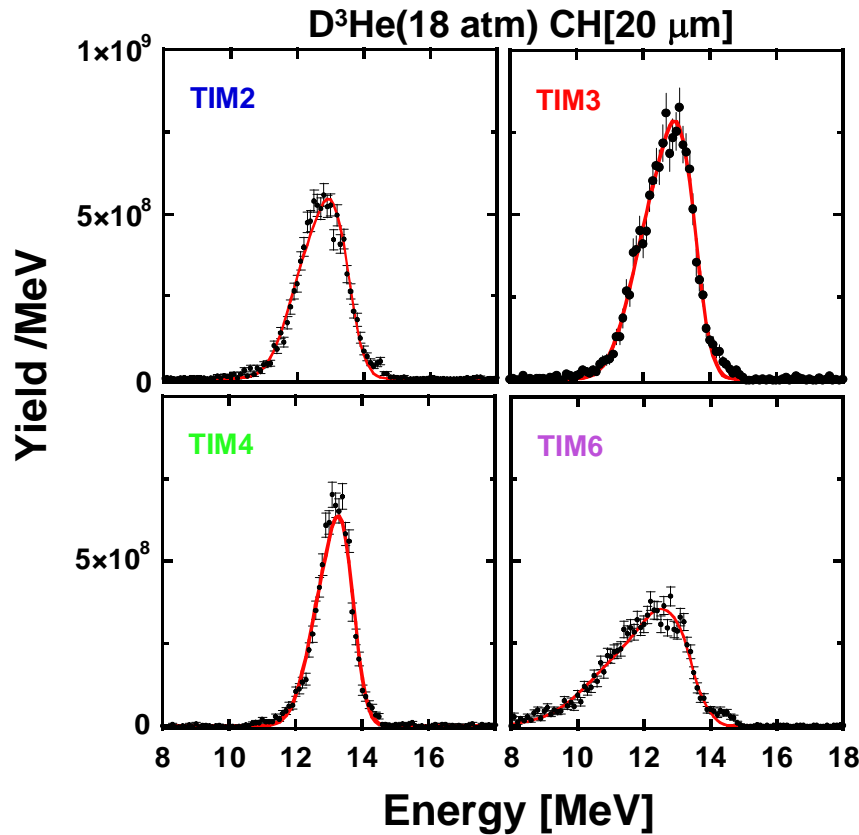
V. A. Smalyuk et al., **Phys. Rev. Letters 90 (2003) 135002.**

# PTD data must be corrected for time dispersion caused by source and shell geometry, $\rho R$ evolution, Doppler broadening and PTD response



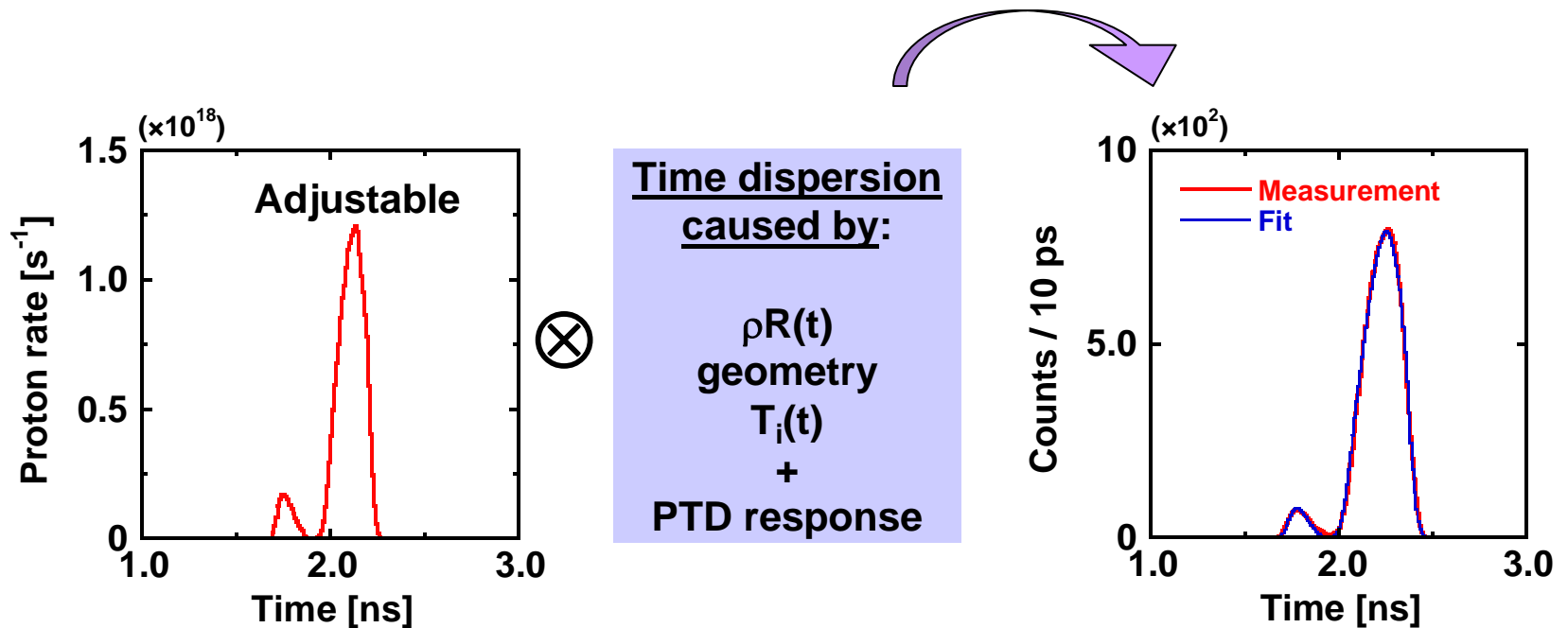
- Source and shell geometry: From Proton Core Imaging data and X-ray imaging data.
- Doppler broadening from  $T_i(t)$ : From calculations.
- PTD response: From Monte-Carlo simulations.
- $\rho R$  evolution: Needs to be determined.

# Using NTD data as initial input, $\rho R(t)$ was initially inferred from a fit to measured $D^3He$ -proton spectrum



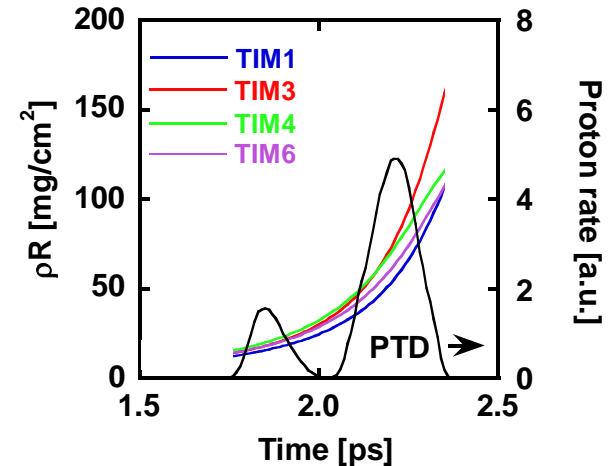
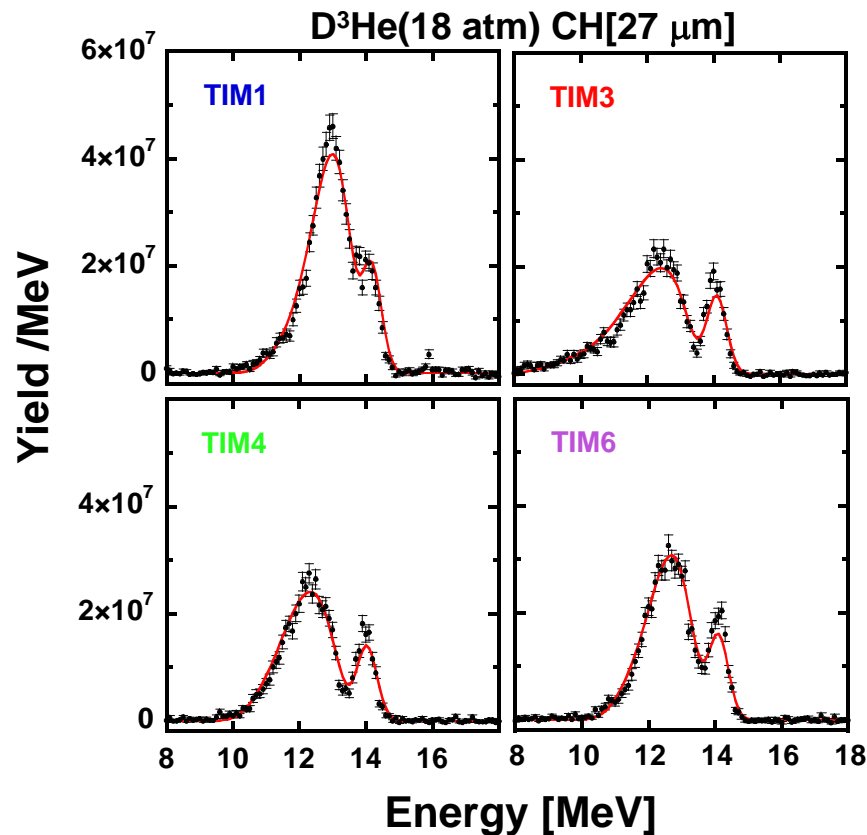
A Lorentzian function and/or a fourth-order polynomial was used as a  $\rho R(t)$  function in the fitting procedure.

# A convolution of $D^3He$ production history and components causing time dispersion are used to fit measured PTD data



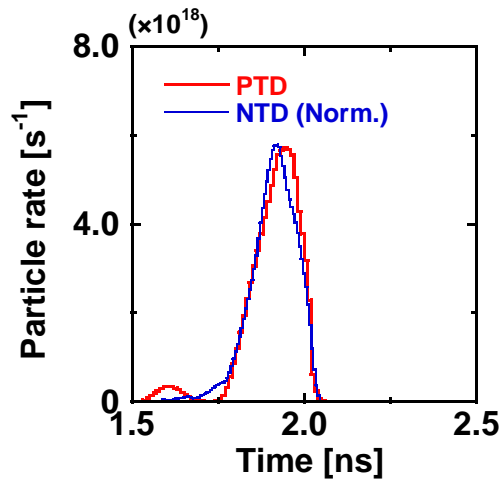
Number of free parameters used in fitting are equal to number of time bins with data.

# Using unfolded $D^3He$ production history, $\rho R(t)$ was finally determined from a fit to measured $D^3He$ -proton spectrum

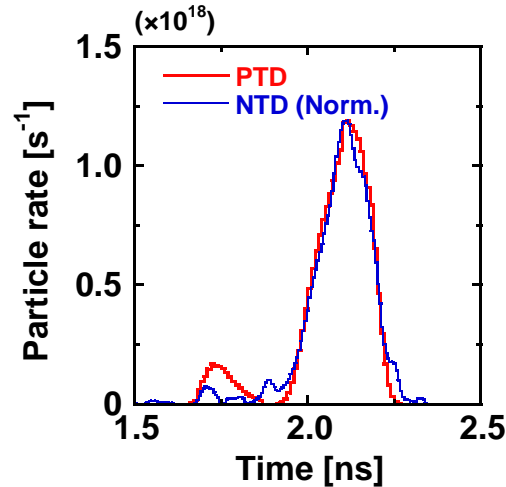


# First results show that the $D^3He$ proton production history contains a unique shock component in addition to a compression history similar to that of the DD neutrons

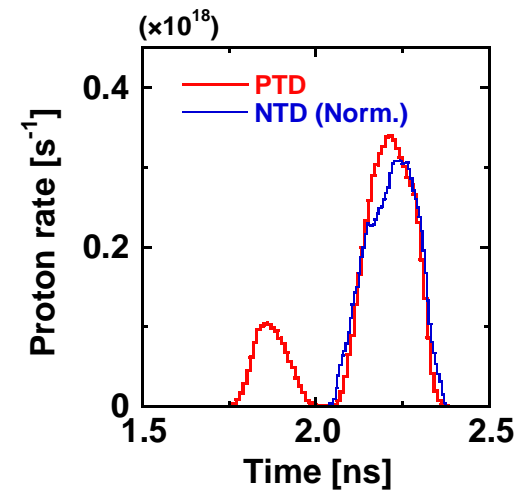
CH[20  $\mu\text{m}$ ]



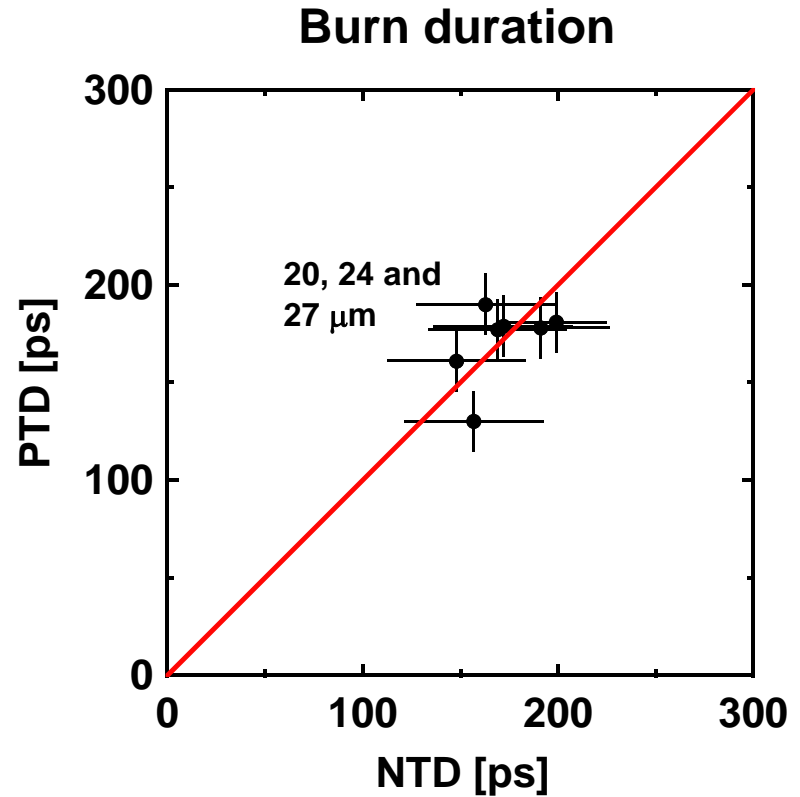
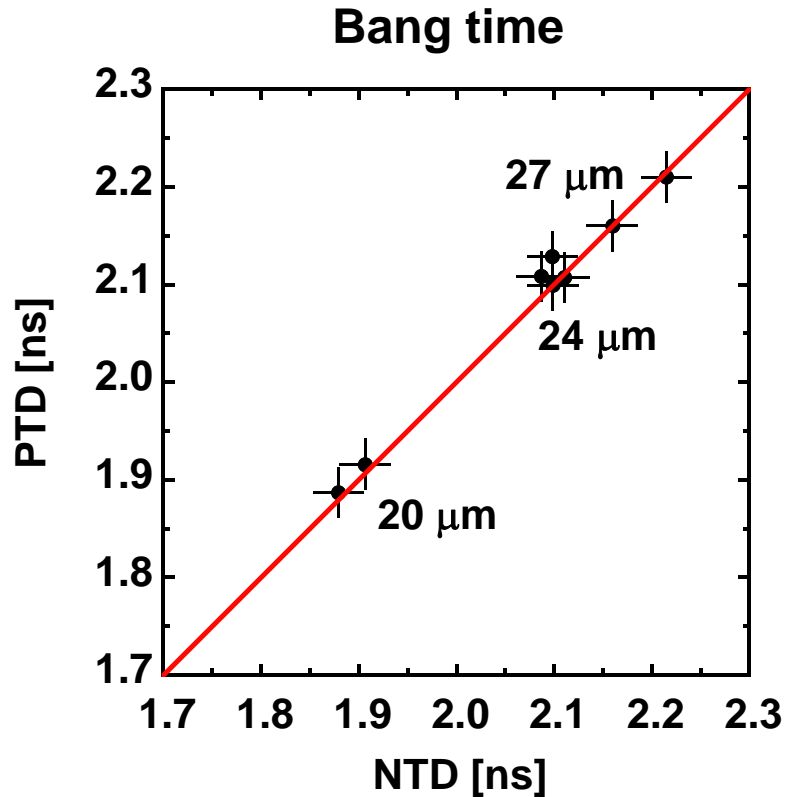
CH[24  $\mu\text{m}$ ]



CH[27  $\mu\text{m}$ ]

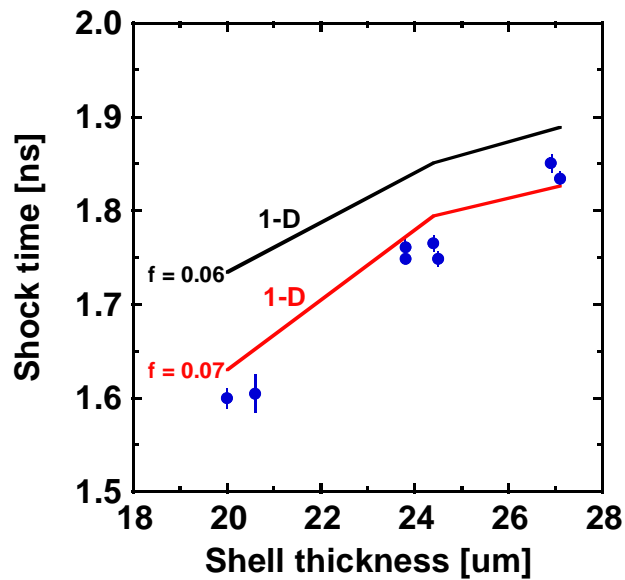


# Similar bang time and burn duration are inferred from $D^3He$ proton and DD neutron production histories

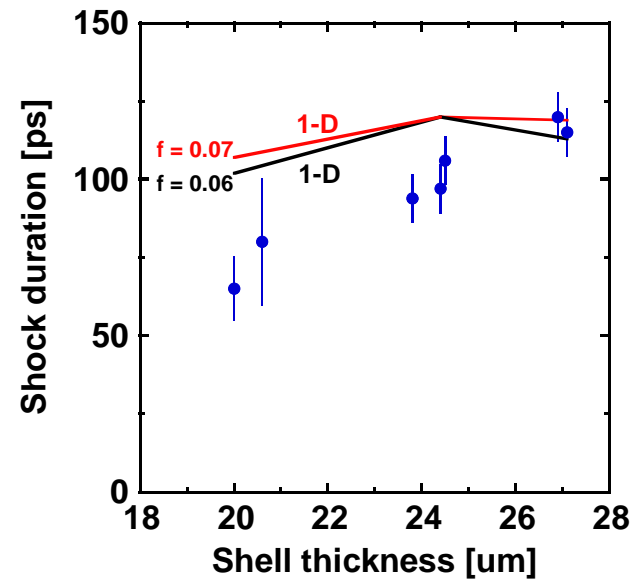


# Unique results from the PTD such as shock time and shock-burn duration have been obtained and compared with 1-D calculations

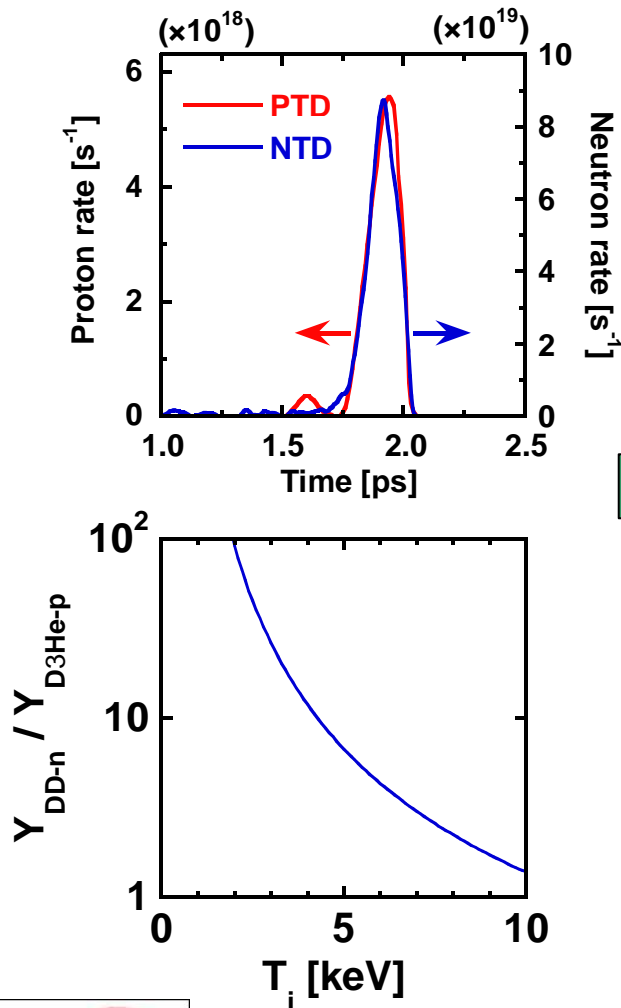
## Shock time



## Shock-burn duration



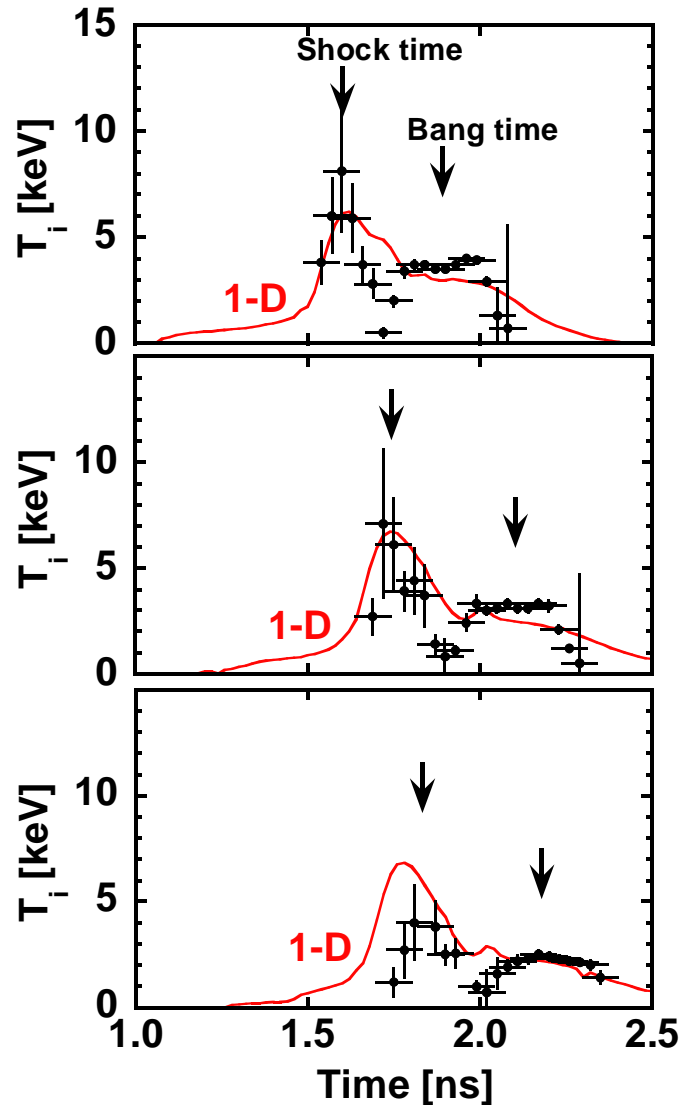
# Time resolved $T_i$ has been inferred from $D^3He$ proton and DD neutron production histories, and compared with 1-D calculations using a flux limiter of 0.07



CH[20  $\mu m$ ]

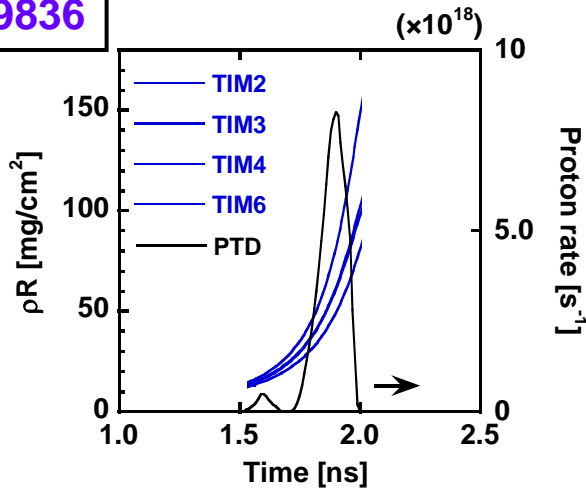
CH[24  $\mu m$ ]

CH[27  $\mu m$ ]

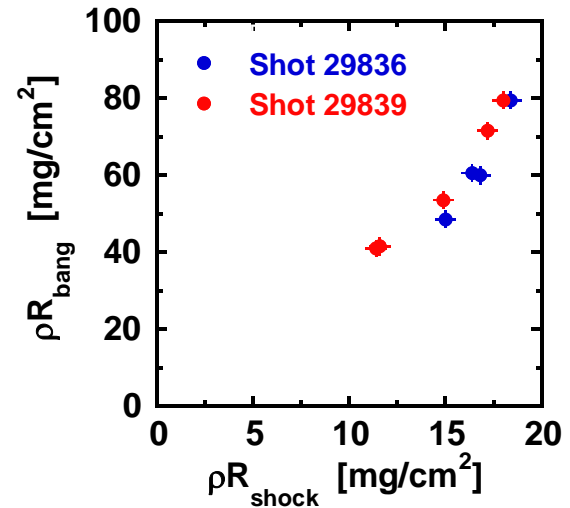
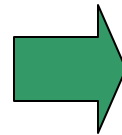
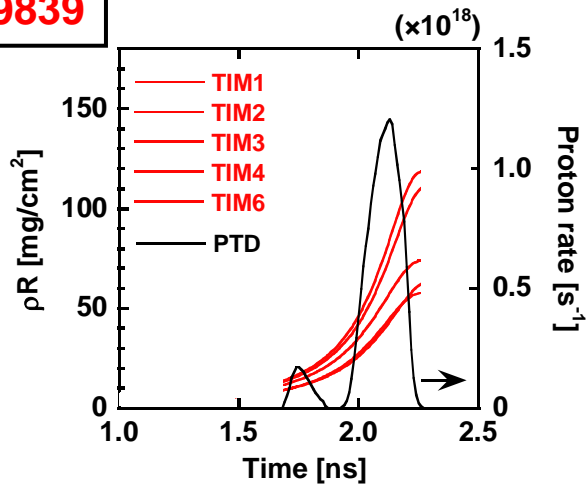


# Preliminary analysis suggests that low-mode $\rho R$ asymmetries at shock time are mirrored at bang time

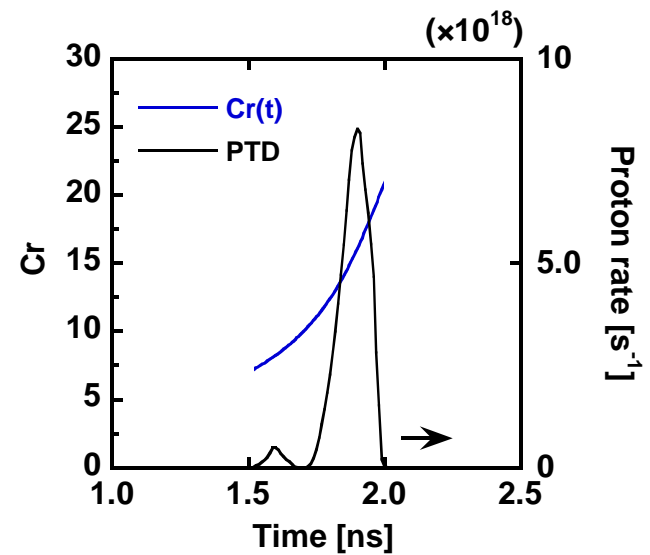
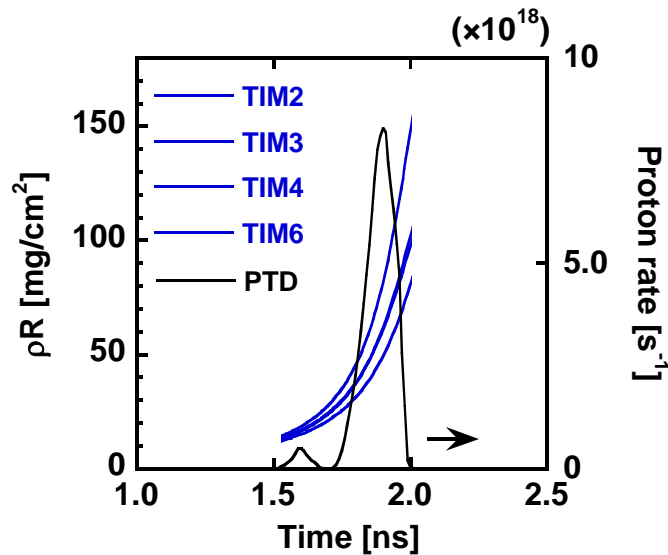
**Shot 29836**



**Shot 29839**



# Evolution of convergence ratio has been inferred from D<sup>3</sup>He proton production history and energy spectra



$$Cr(t) = \sqrt{\frac{\langle \rho R(t) \rangle}{f \times \rho R_{initial}}}$$

f = fraction of initial shell not ablated away

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## Future work

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- Compare experimental data with more elaborate modeling and calculations.
- Time-resolved studies, using the PTD, of fuel-shell mix of  $^3\text{He}$ -filled CD capsules.
- Feasibility study of shock-coalescence timing measurements of  $^3\text{He}$ -seeded cryogenic  $\text{D}_2$  implosions.