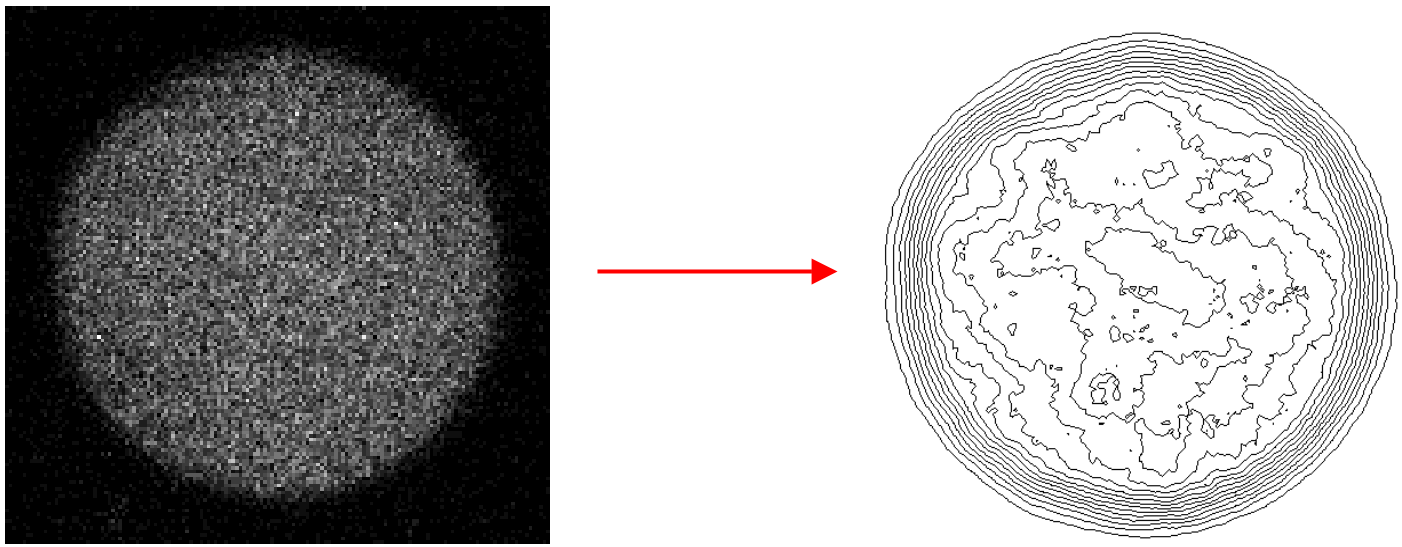
Proton Core Imaging Spectroscopy (PCIS) of OMEGA Implosions



Richard D. Petrasso, et al.
MIT - Plasma Science and Fusion Center

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

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Collaborators

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Summary

- With Proton Core Imaging Spectroscopy (PCIS), the first burn profiles of DD and D^3He reactions have been obtained of thin- and thick-shell implosions

- $T_i(r)$ and $n_i(r)$ profiles have been inferred for thin-shell implosions and compared to 1-D simulations

- Burn profiles of DD and D^3He reactions at shock coalescence and at bang time have been measured for thick shell implosions.

Outline

- Describe the principle of Proton Core Imaging Spectroscopy (PCIS).
- Illustrate PCIS with thin-shell implosion, obtaining DD and D^3He burn profiles
- Illustrate PCIS with thick-shell implosion, obtaining DD burn profile at shock flash and D^3He burn profile at bang time

PCIS details in Poster:	B. E. Schwartz, et al., KP1.147
Related talks:	F. H Seguin, et al., GO2.013 R. Rygg, et al., GO2.014 V. Smalyuk, et al., QI1.005 C. K. Li, et at., RI1.005

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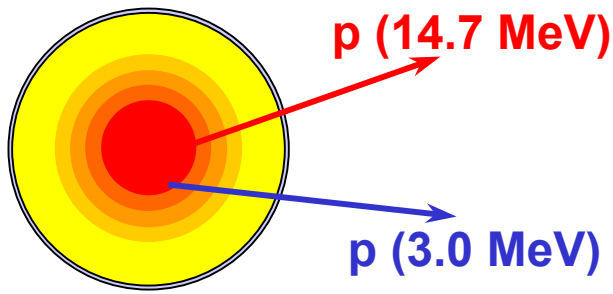
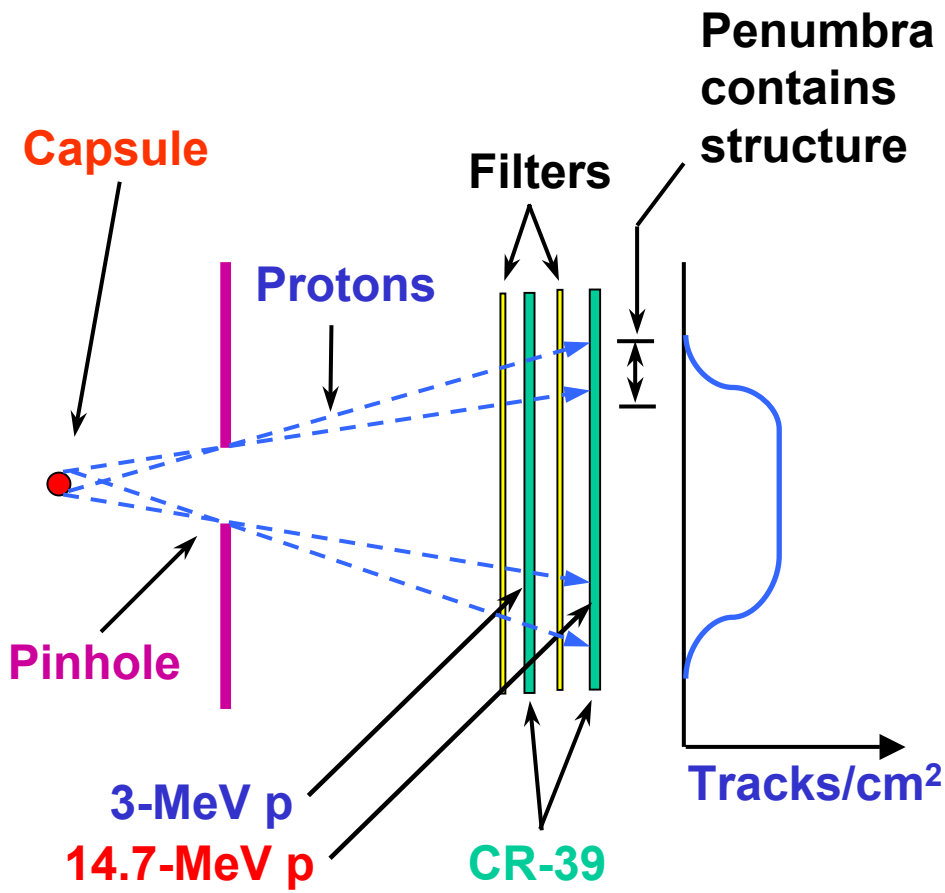
Important reactions for Proton Core Imaging Spectroscopy (PCIS)

$$D + {}^{3}He \Rightarrow p\ (14.7\ MeV) + \alpha\ (3.6\ MeV)$$

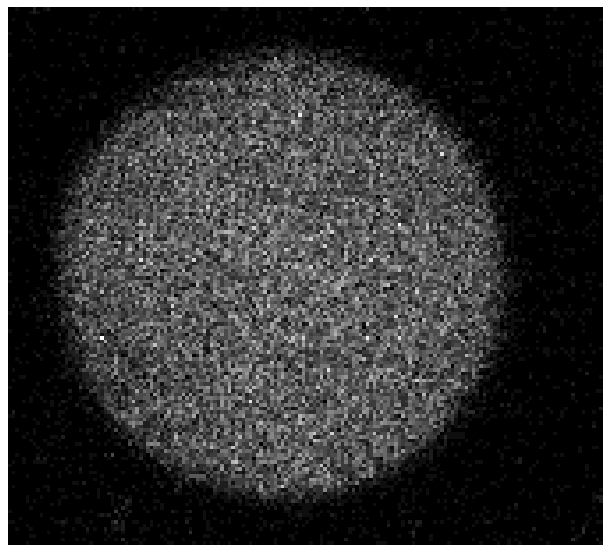
$$D + D \Rightarrow p\ (3.0\ MeV) + t\ (1.0\ MeV)$$



The principle of PCIS



Proton tracks / cm²
on CR-39



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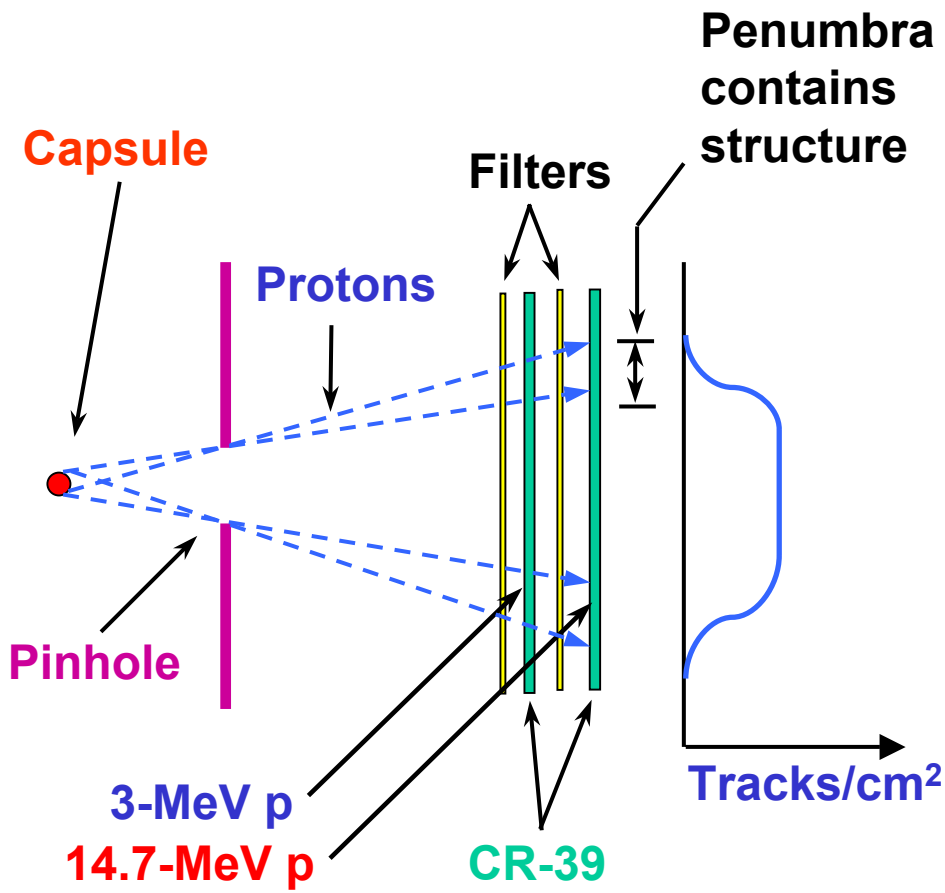
The principle of PCIS



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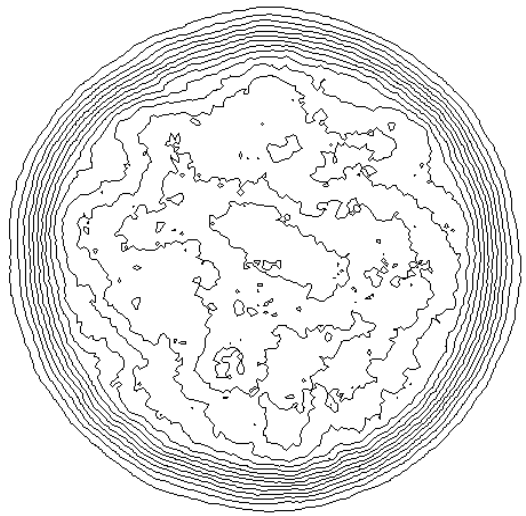

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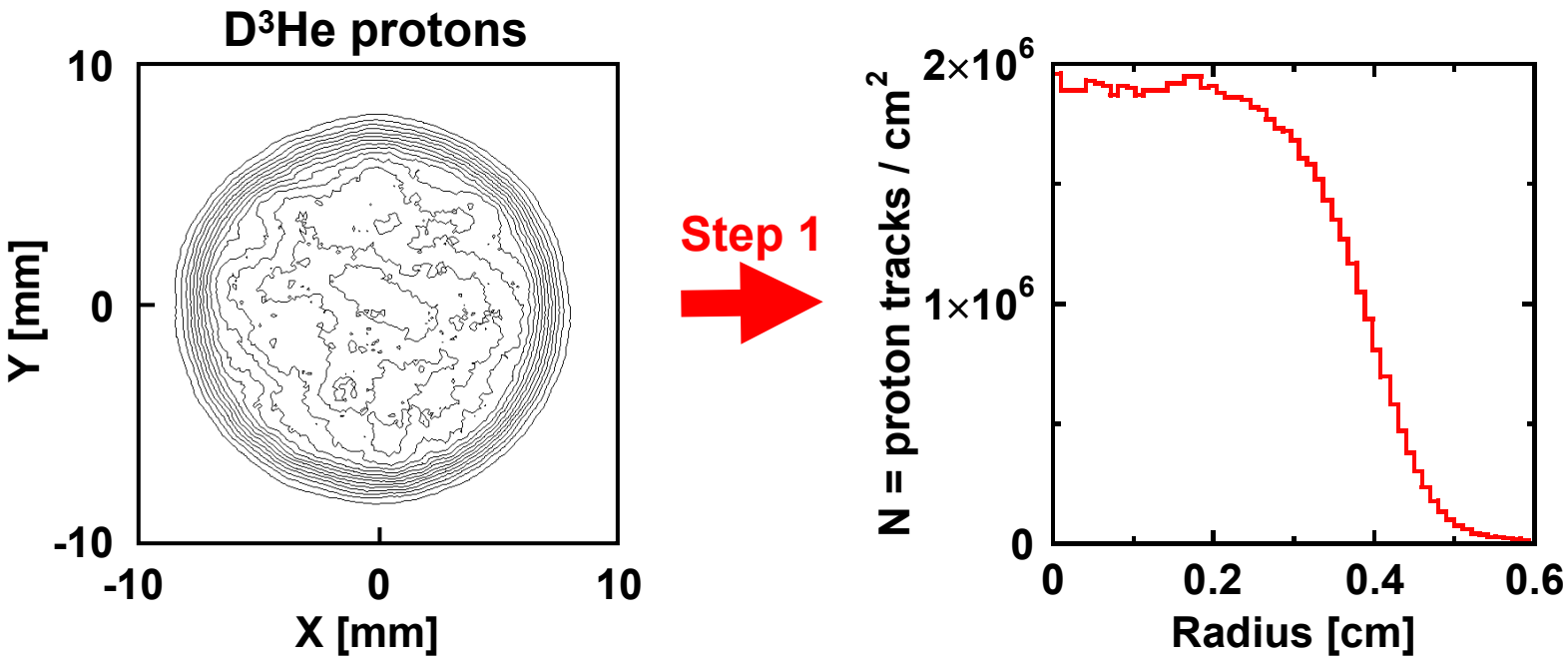
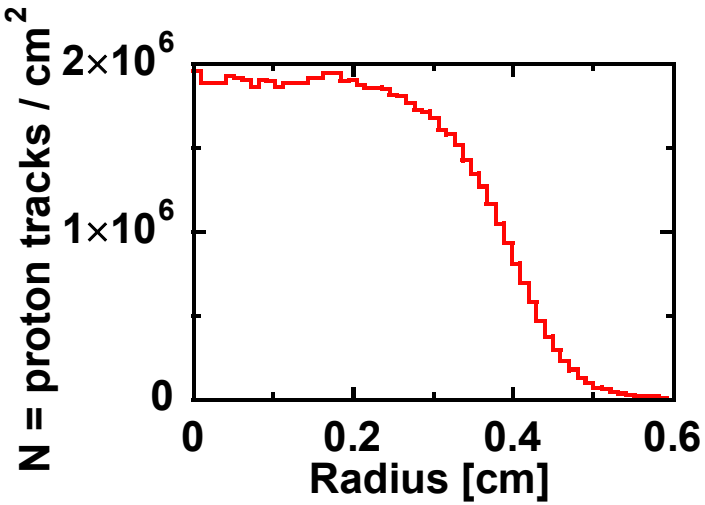
Finding the radial burn profile (part 1)



Step 1: Calculate the proton hit density (N) as a function of radius in the image plane.

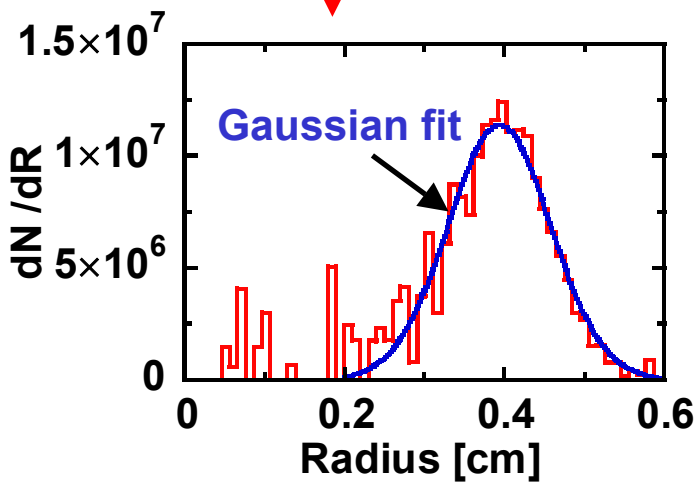
Finding the radial burn profile (part 2)



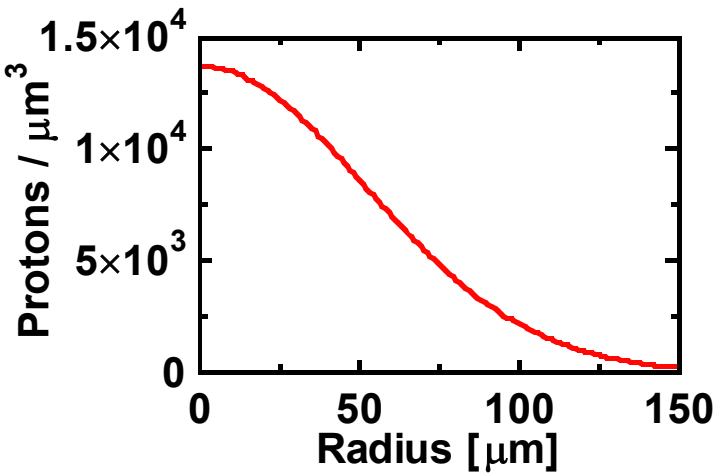
Step 2: Calculate dN/dr, which is well fit by a Gaussian.

Step 3: Use analytic inversion formula with system geometry to get radial profile of the proton emissivity.

Step 2



Step 3



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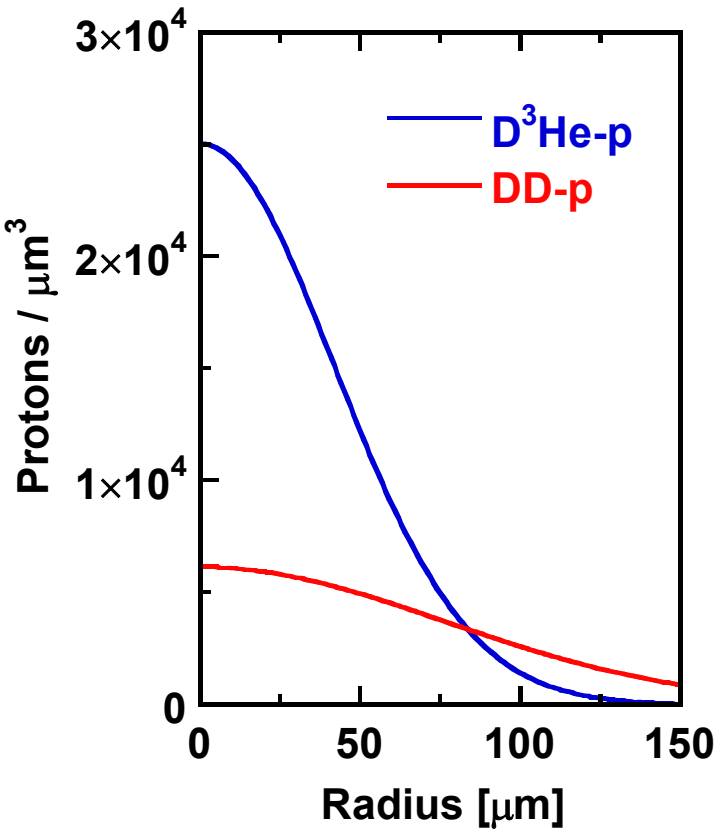
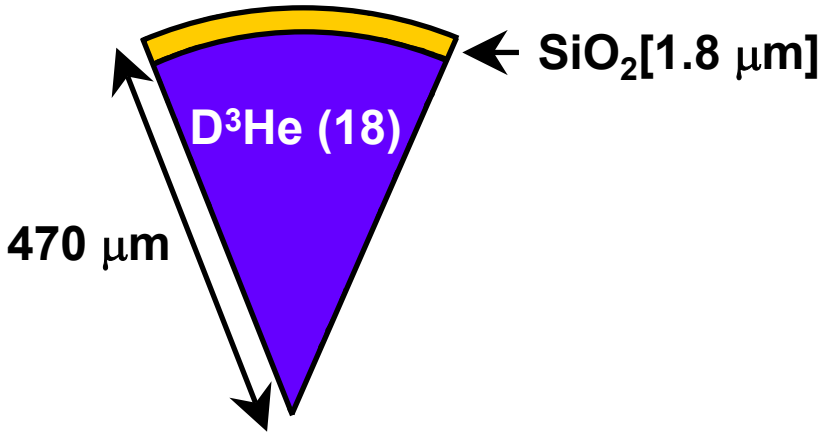
PCIS simultaneously measures burn profiles of DD and D^3He protons for thin-glass implosions

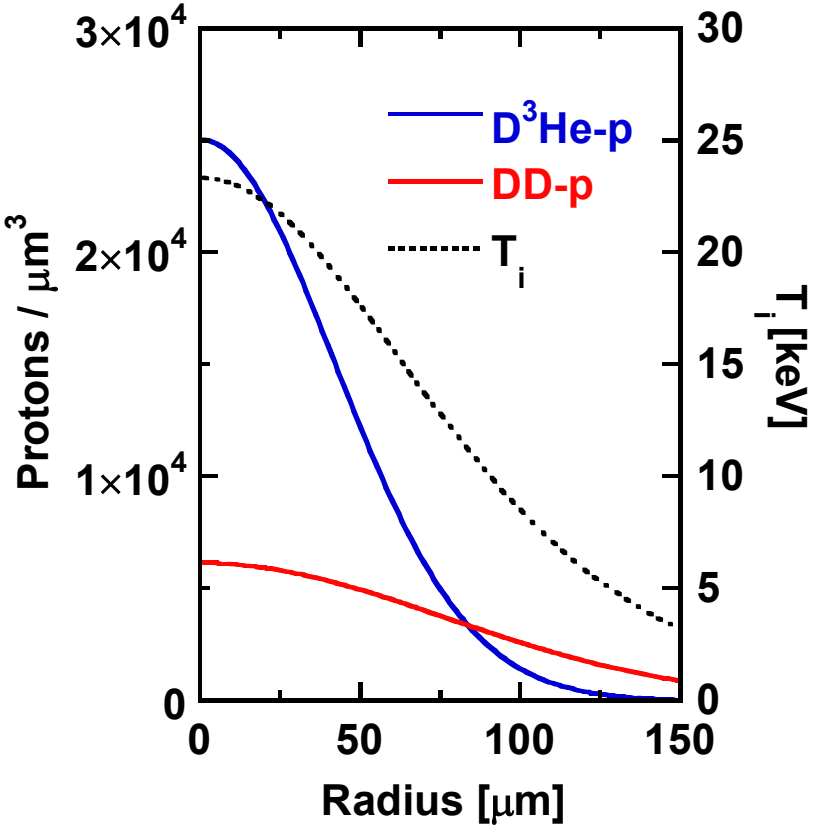
Shot 27456





The 1/e points are at radii 60 and 110 μm

Temperature $T_i(r)$ is inferred from the DD and D^3He burn profiles (Shot 27456)

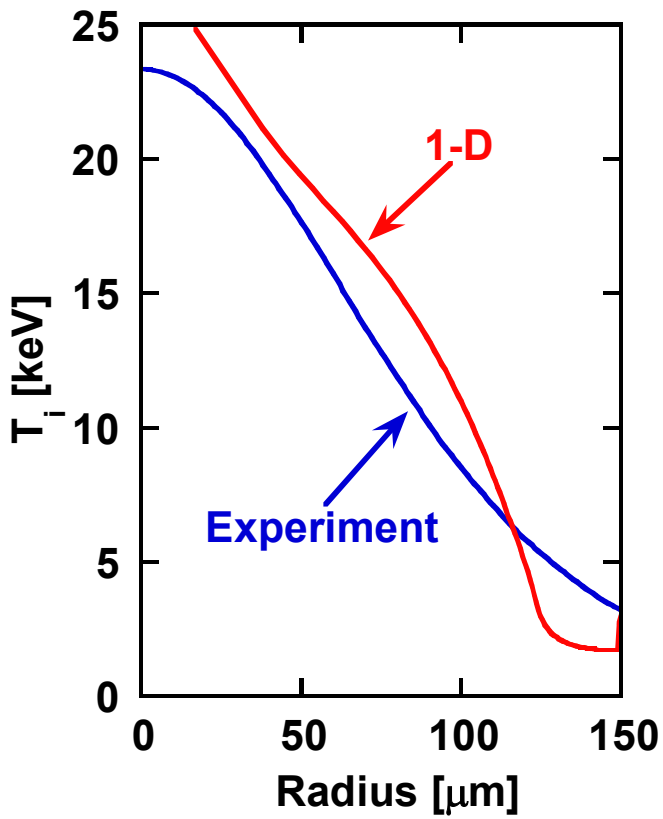


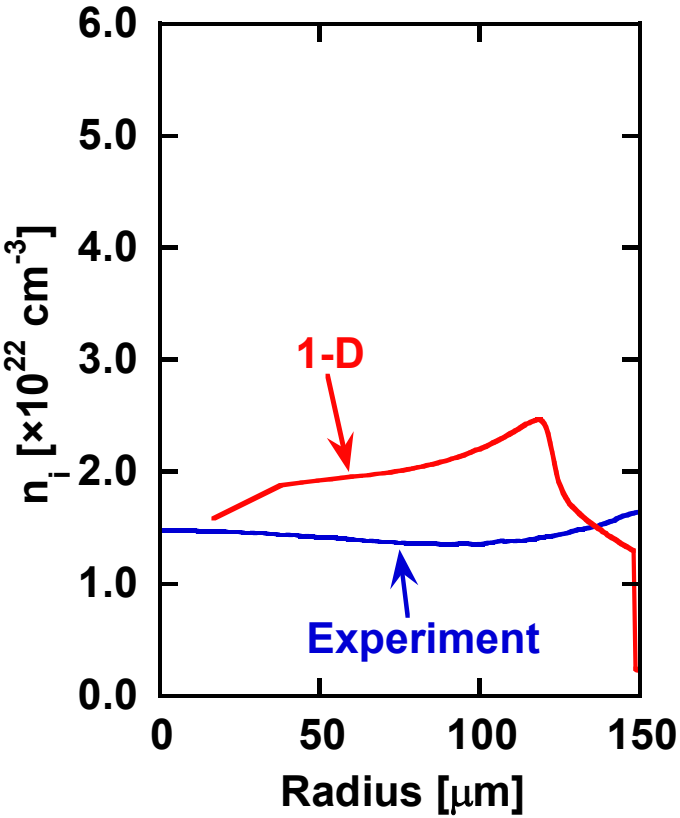
Diag.	$\langle T_i \rangle_{D3He}$ [keV]	$\langle T_i \rangle_{DD}$ [keV]
PCIS	~ 15	~ 8
WRF	~ 14	-
nTOF	-	~ 10

The 1/e points are at radii 60 and 110 μm

Comparison of T_i and n_i profiles to 1-D calculations

Shot 27456





PCIS measures burn profiles of DD and D^3He reactions for thick-shell implosions at shock and bang time

$$D + {}^3He \Rightarrow p\ (14.7\ MeV) + \alpha\ (3.6\ MeV)$$

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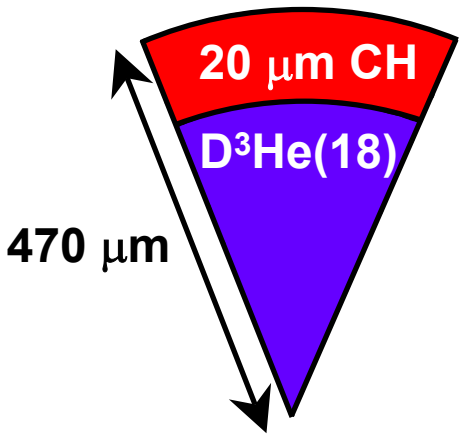

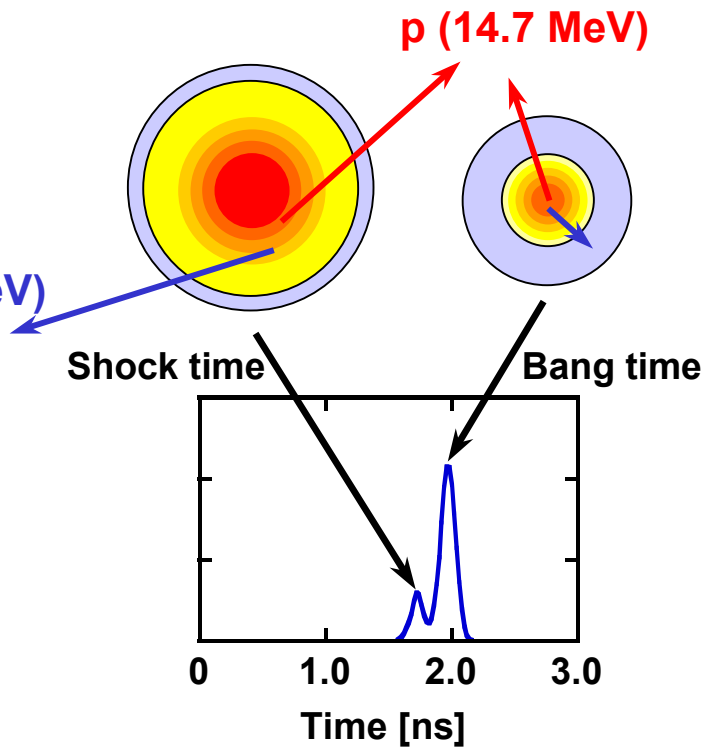

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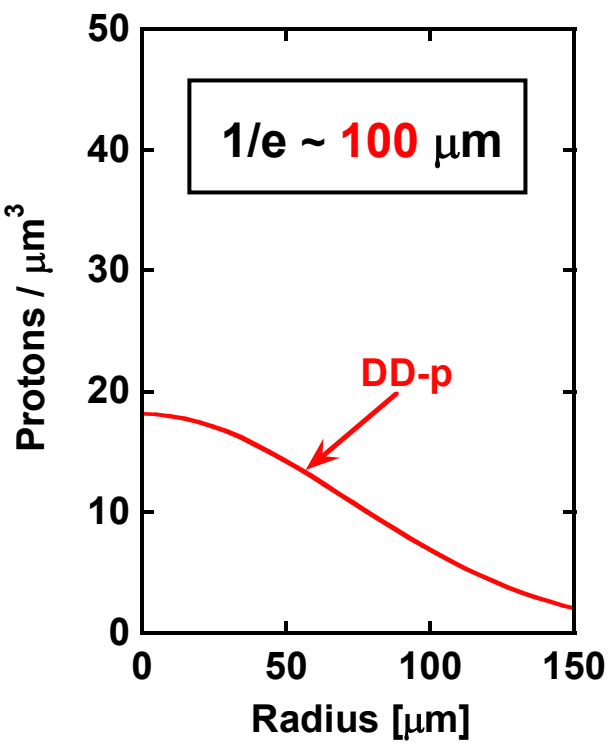
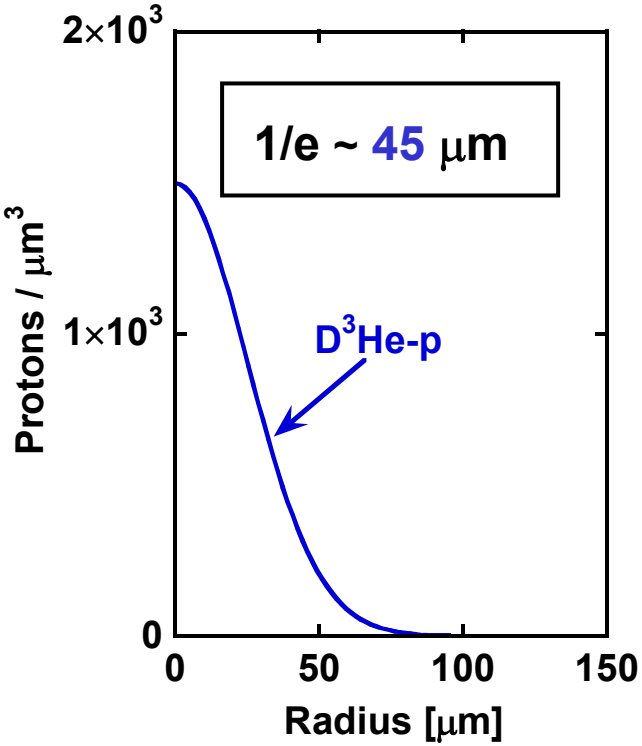
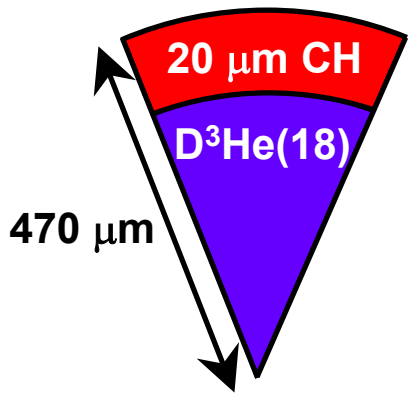
PCIS measures burn profiles of DD protons at shock time and D^3He protons at bang time (Shot 27806)







shock time

bang time

Summary

- With Proton Core Imaging Spectroscopy (PCIS), the first burn profiles of DD and D^3He reactions have been obtained of thin- and thick-shell implosions

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- Burn profiles of DD and D^3He reactions at shock coalescence and at bang time have been measured for thick shell implosions.

Future Work

- **Optimize PCIS instrumentation.**
- **Begin to build up a data base of images, and establish the range of PCIS applicability.**
- **Compare PCIS to x-ray and neutron images.**
- **Compare PCIS to 1- and 2-D simulated images.**
- **Investigate asymmetries in burn region, and develop algorithms to treat asymmetries.**
- **Obtain orthogonal images.**

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