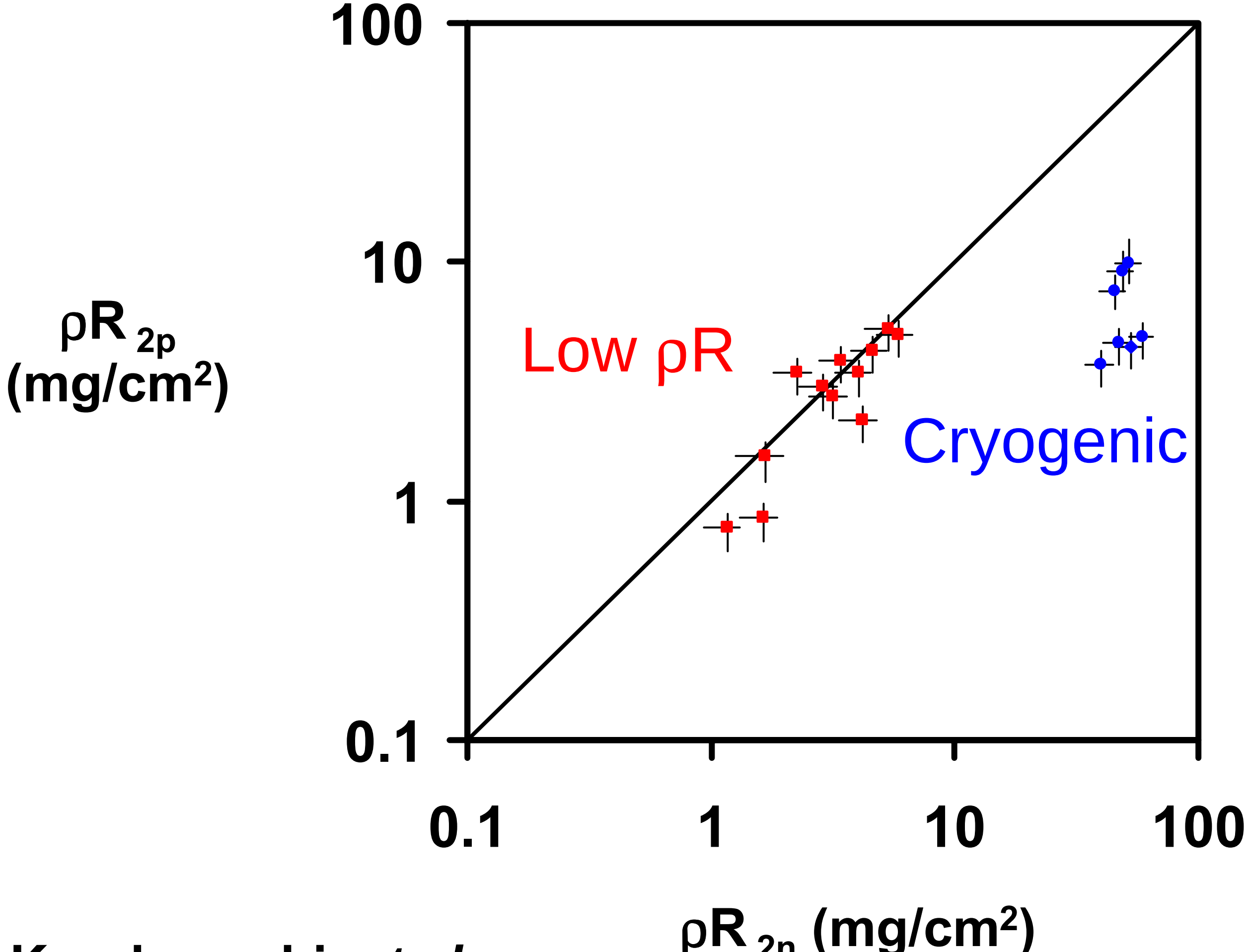
# Use of Secondary Nuclear Particles for Studying Areal Density in $D_2$-filled Inertial Confinement Implosions

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# Summary

On the basis of experiments and simulations,

- For low ρR, simple models are sufficient to infer ρR from either secondary protons or neutrons

- For cryogenic capsules, secondary protons and neutrons are produced in the hot and cold fuel regions respectively, therefore, ρR must be interpreted correctly

# Outline

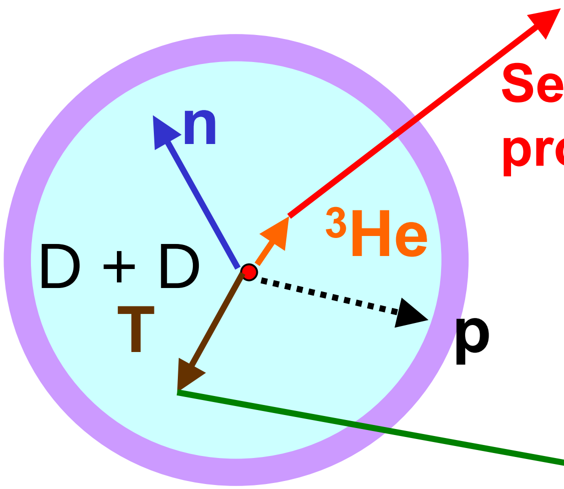
- Secondary nuclear production in ICF capsules
- Data
- Monte-Carlo code; adjust $T_i(r)$ and $\rho(r)$ to match experimental data
- Data and best model for a cryogenic implosion at OMEGA

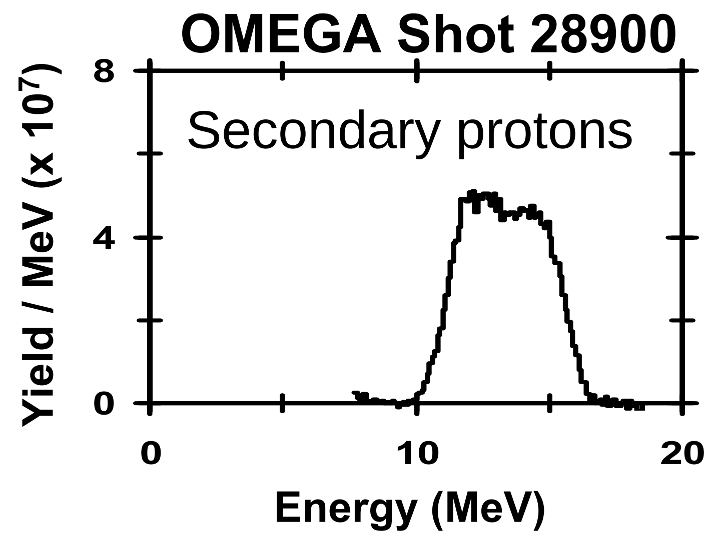
# Two secondary products are measured at OMEGA

D + D → n + $^3$He [0.82 MeV]

$^3$He [≤0.82 MeV] + D

→ α + p [12.6-17.5 MeV]




D + D → p + T [1.01 MeV]

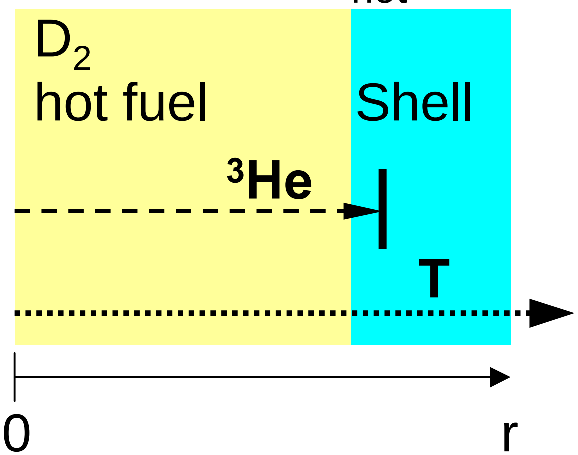
Secondary
neutrons

T [≤1.01 MeV] + D

→ α + n [11.9-17.2 MeV]

# Sometimes secondary particle yields ($Y_2$) can be used to infer hot fuel $\rho R$

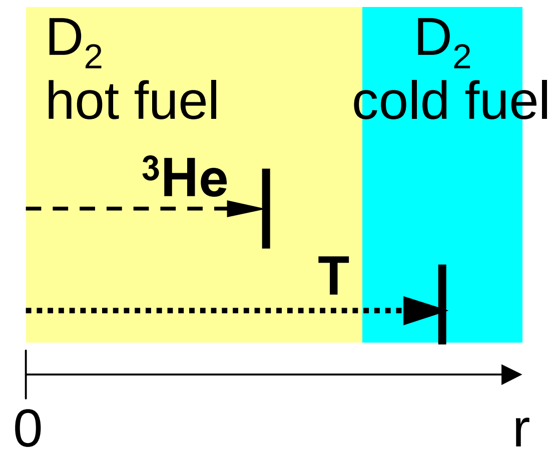
Small $\rho R_{hot}$




$\rho R^*_{2p} = \rho R_{hot}$

$\rho R^*_{2n} = \rho R_{hot}$

Large $\rho R_{hot}$ Cryo



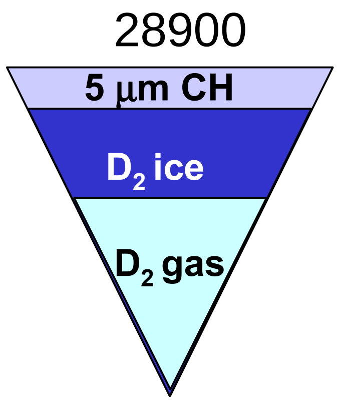

$\rho R^*_{2p} < \rho R_{hot}$

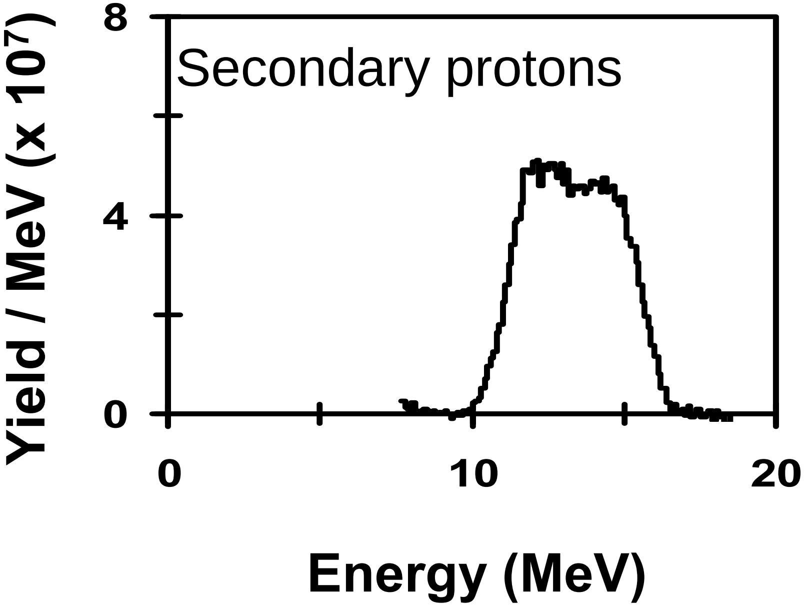
$\rho R_{hot} < \rho R^*_{2n} < \rho R_{total}$

$$\rho R^* \equiv \int_L \rho_D \, dr = \frac{1}{const} \frac{Y_2}{Y_1}$$

# Experimental data from a cryogenic implosion are used to constrain the Monte-Carlo calculation

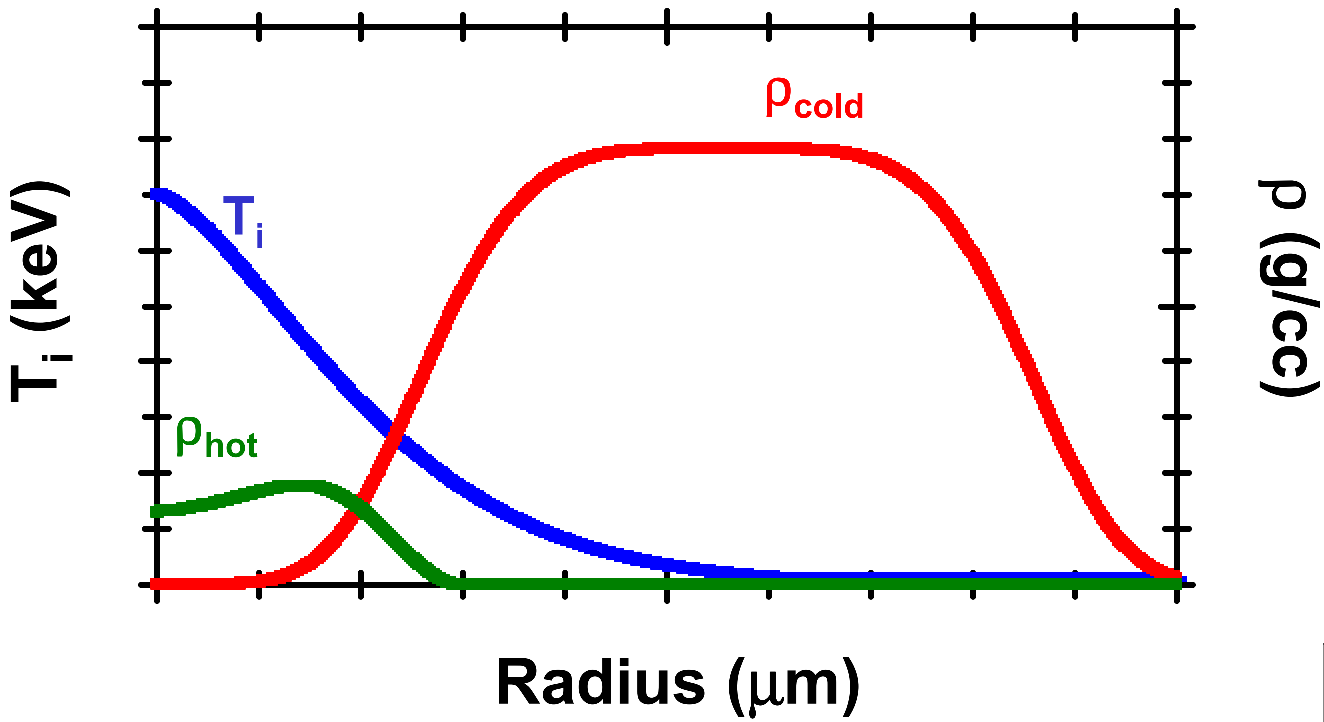
- $Y_{1n}$: 1.24E+11
- $Y_{2n}$: 1.17E+9
- Secondary proton spectra
  - $Y_{2p}$: 2.25E+8
  - $\langle E_{2p} \rangle$: 13.3 MeV
- $\langle T_i \rangle$: 3.6 keV



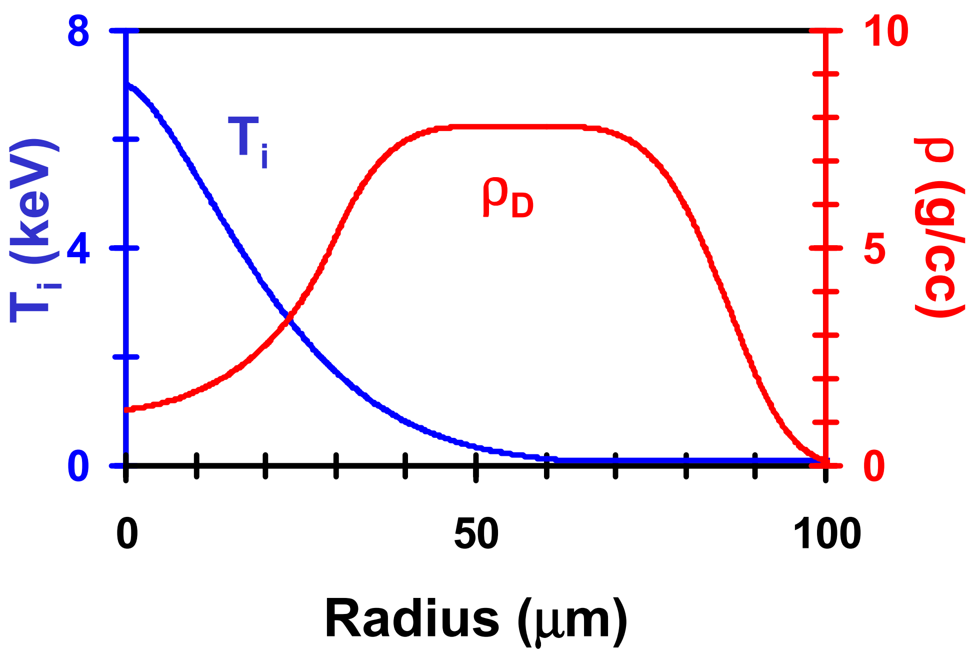



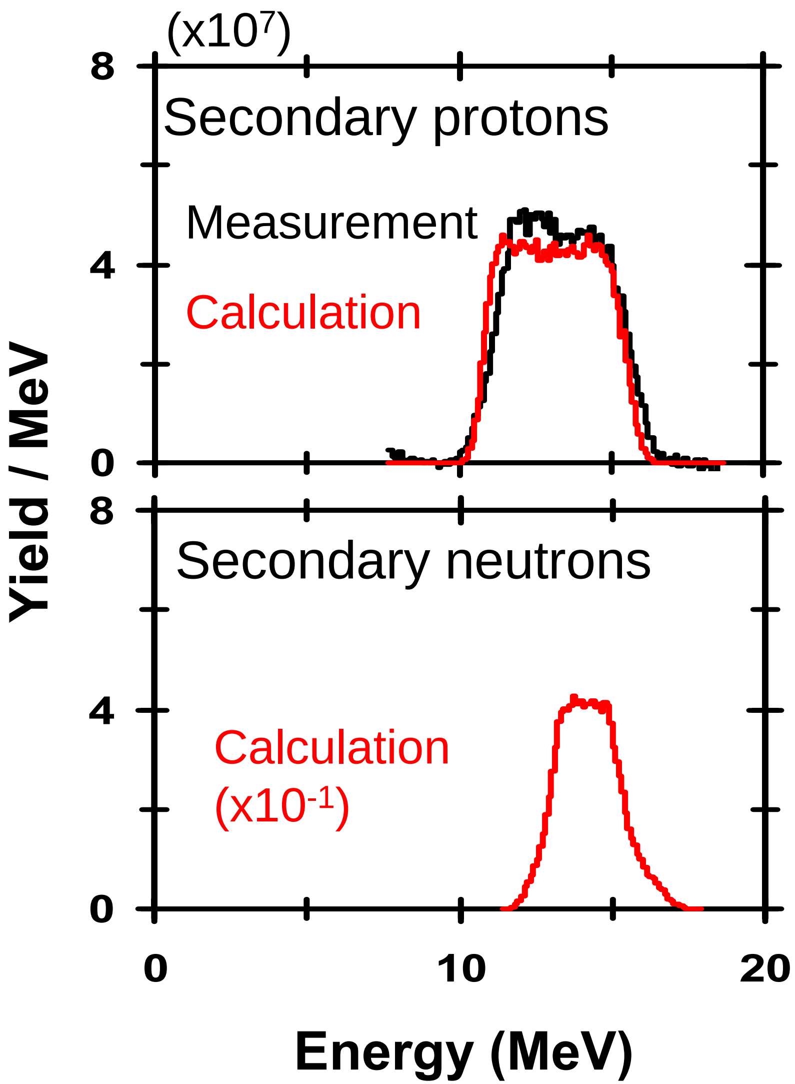
# The Monte-Carlo code assumes the $T_i(r)$ and cold $\rho(r)$ have super/sub Gaussian profiles

- **Hot fuel region is isobaric**



# $T_i(r)$ and $\rho(r)$ are adjusted to find the best fit to shot 28900



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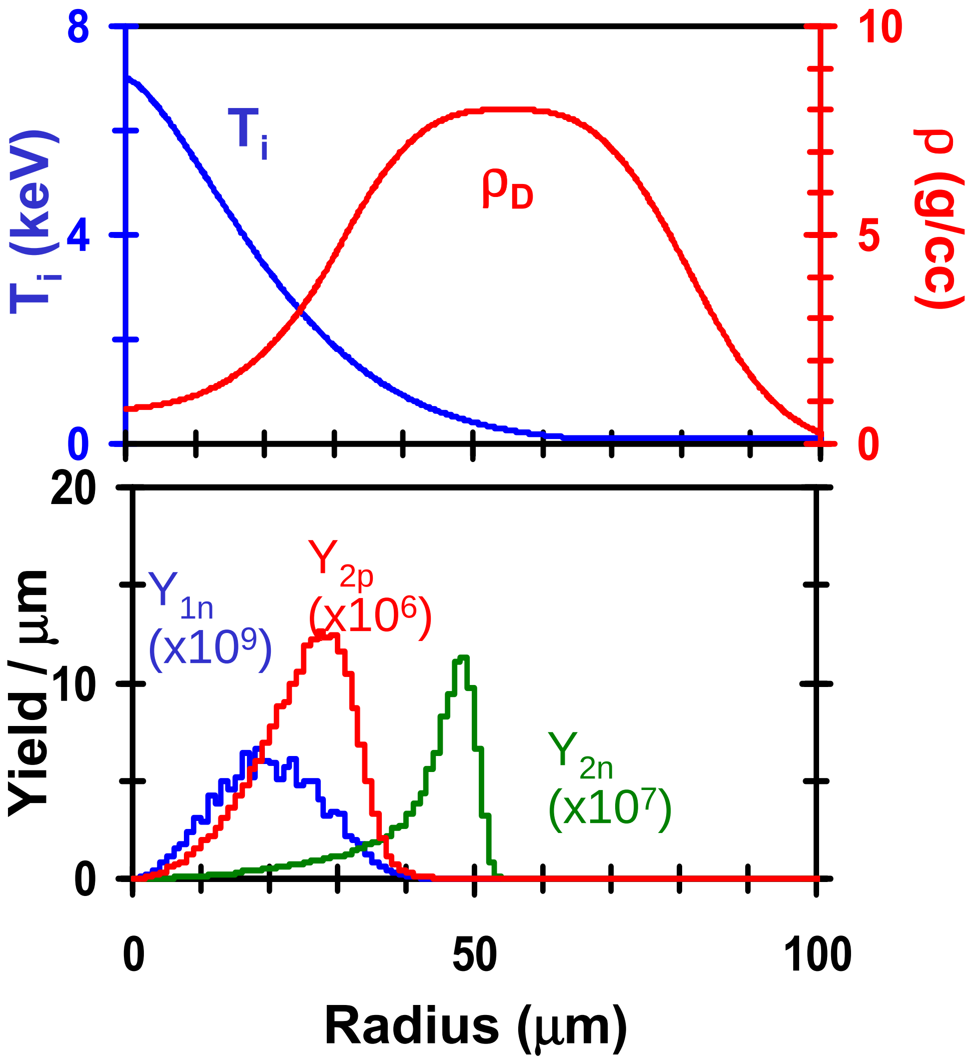


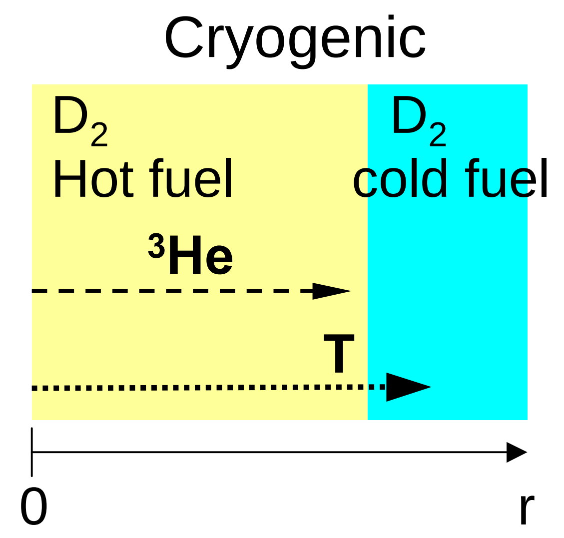


$$\rho R^*_{2p} \sim \rho R_{hot}$$

$$\rho R_{hot} < \rho R^*_{2n} < \rho R_{total}$$

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