Progress report::
NTOF-extracted C rhoR for gas symcap shots

J. Caggiano

November 14, 2013

APS
Denver, CO, United States
November 11, 2013 through November 15, 2013
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Measuring Ablator Areal Density using Neutron Time-of-Flight at the National Ignition Facility


V. Glebov, J. Knauer, LLE

For the NIF NTOF team
Outline

• Motivation
• Features in spectrum
• Fits to data
• Comparison to other carbon rho.R measurements and simulations
• Conclude
The motivation is to measure how much carbon (ablator) is left and to compare to simulations and other measurements

- Initially motivated by seeing what features we could extract from the neutron spectrum as measured by NIF NTOF detectors

- The remaining mass of CH ablator is much larger than in simulations - ~15% range vs. a few percent in simulations
  - Energy not being coupled into ablator as expected

- Measuring this quantity with the NTOF gives a LOS-dependent determination to compare to
  - GRH which is 4pi averaged
  - Ross Pair filters which have different directionality

2D Symcap simulation (B. Spears) shows shell structure
Methodology: Fitting carbon-specific features in the neutron spectrum determine the carbon rho.R

• Two approaches:
  — Fit single scatter cross sections
    - Not preferred because of multiple scattering from higher rho.R shots
  — Fit simulations to data
    - Preferred because simulations include
      - Multiple scattering

• General procedure:
  — Try to fit the data in a region of interest (the \(^{12}\text{C}^*\) [4.44 MeV] edge), with several simulated spectra assuming golf ball geometry
  — Minimize chi-square parameter in ROI
  — Report CH rho.R
  — Convert to C rho.R by ASSUMING C:H 1:1.38
Methodology: A simple MCNP (neutron transport) model is used to determine spectra to fit to data

- **MCNP model:**
  - Spherical onion model
  - P0 50 um (25 for cryo)
  - Dense ablator 50-60um
  - DT rho.R 100 mg/cm^2
    - (given amount of gas and shell volume(from sims) this is about right)
  - Inside hohlraum and TMP
  - Temperature = 2.7 keV
    - To match N130505
  - E0 = E0(Tion) (Ballabio)

- Transform through IRF (sensitivity corrected) and fit to the data
How do these features in energy map to features in neutron Time of Flight?

Transformation made for SP LOS
Flight path = 18m

Fitting these features determine remaining CH rho.R
NTOF diagnostics and NIF Symcap Data
Neutron Time-Of-Flight detectors at NIF measure several implosion variables on many different LOS.

New spectral JacBlac/Bibenzyl detectors fielded on the NIF are providing excellent nToF data.
Different classes of shots show measurable levels of CH ablator remaining.
Simulations overlaid on data show a clear sensitivity to the carbon features.
Method 1: Fitting the simulations to a small ROI produce a good measure of the CH ablator areal density

CH rho.R inferred from NTOF SpecSP is 718±71 mg/cm^2
Method 2: Using the single scattering cross sections to fit the data produce similar fits and results.

![Graph showing signal vs. scope time (ns)](updated IRF includes reflections)
Other LOS (alcove) data shows lower CH rho.R than the south pole on all shots
Carbon $\rho R$ results are larger on the south pole but average agrees with other diagnostics and simulations

<table>
<thead>
<tr>
<th>Carbon $\rho R$</th>
<th>SpecSP ±10%sys</th>
<th>SpecA</th>
<th>SpecE</th>
<th>LOS avg</th>
<th>GRH</th>
<th>Simulations</th>
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<tbody>
<tr>
<td>N130503*</td>
<td>&lt;200</td>
<td>&lt;300</td>
<td>&lt;300</td>
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<tr>
<td>N130505</td>
<td>660±70</td>
<td>380(50)</td>
<td>450(300)</td>
<td>497(~100)</td>
<td>520(120)</td>
<td>485</td>
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<td>N130507</td>
<td>670±70</td>
<td>380(50)</td>
<td>450(300)</td>
<td>500(~100)</td>
<td>580(120)</td>
<td>495</td>
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<tr>
<td>N130625</td>
<td>500±60</td>
<td>300(50)</td>
<td>450(300)</td>
<td>417(~100)</td>
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<tr>
<td>N130628</td>
<td>760±80</td>
<td>270(100)</td>
<td>450(300)</td>
<td>493(~100)</td>
<td>~600</td>
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</table>

DSR, defined as $N(10-12)/N(13-15)$ is consistent with this picture

<table>
<thead>
<tr>
<th>DSR</th>
<th>SpecSP</th>
<th>SpecA</th>
<th>SpecE</th>
<th>Simulations</th>
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<td>N130503</td>
<td>0.2(2)</td>
<td>0.2(1)</td>
<td>0.45(30)</td>
<td>0.010 / 0.096 / 0.096</td>
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<tr>
<td>N130505</td>
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<td>1.0(3)</td>
<td>1.1(4)</td>
<td>1.04 / 1.01 / 1.00</td>
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<td>1.3(3)</td>
<td>1.1(3)</td>
<td>1.3(4)</td>
<td>1.15 / 1.12 / 1.12</td>
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<tr>
<td>N130625</td>
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<td>0.8(3)</td>
<td>1.1(3)</td>
<td>--</td>
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<td>N130628</td>
<td>1.45(30)</td>
<td>0.7(3)</td>
<td>0.7(3)</td>
<td>0.69 / 0.68 / 0.69</td>
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</table>
Summary and Future plans

- Carbon rho.R’s extracted are in good agreement with GRH
  - Systematic errors of geometry and DT rho.R up to 20%

- Next implement better burn profiles, including a mixed DT/CH region:

D. Casey, S. Weber

B. Spears, S. Weber
Backup slides
Carbon $^{12}\text{C}(n,n')^{12}\text{C}^*[4.44\text{MeV}]$ feature observed in N121125 and N130510

Compare with N130505 DT symcap where there is very little TT (CH $\rho \cdot R = 720 \text{ mg/cm}^2$ (10%stat, 20%sys))