IER 268: PDV and Gamma/Neutron Yield Measurements of Godiva Critical Assembly

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Acknowledgements

Combined effort of NNSS, LANL, and LLNL

MSTS PDV Team:
• Michael Peña, et al.

MSTS MHD-240 deployment and data analysis:
• Robert Buckles, et al.

Godiva Operations:
• Joetta Goda, et al.

LLNL:
• John Scorby and Test Readiness team: Dan Bower, Mark May, Pat Lewis
Objectives

• Provide data for a dynamic benchmark

• Measure total combined neutron/photon flux to determine total fission yield and alpha throughout a burst and shutdown sequence using calibrated MHD-240 detector (high dynamic range scintillator)

• Shielded and unshielded delayed critical runs used to determine background room return component

• Measure surface motion/vibrations using Photon Doppler Velocimetry (PDV)

• Data will be used to tune multiphysics simulations
Experimental Setup: MHD-240

- Gamma & Neutron Calibrated
- 6" Scintillator cube with 3 PMTs and 1 PD
- Designed for a high dynamic range with a linear response over 8 orders of magnitude
- Deployed at a variety of pulse power type facilities, including a previous measurement at Godiva
Experimental Setup: PDV

• First *successful* attempt on Godiva

• ThorLabs RC02APC-P01 – Reflector Collimator

• Mounted using ThorLabs KM05 – Kinematic Mirror Mount

• Probe point positioned on 1st, 4th, 5th, & 6th rings

• Successful data collection on the 1st and 6th
Experimental Setup

Reference Detector @ 5.3m

Godiva

PDV @ 1m

Shielding Lead and Borated Poly

MHD-240 @ 2m

MHD-240 @ 4m
Delayed Critical Measurement To Determine Room Return

• Measurements made with MHD-240 at 2 & 4m, shielded and unshielded

• Two reference detectors were used as monitors for varied reactivity, MHD-241 and LC1

• Concluded that a soft radial dependence to room return

![Graph showing Godiva Delayed Critical Levels - Shielded @ 4m, by MHD Designation](image-url)
Two reference detectors (different technology) were found to be very consistent, having good linearity over all levels of power, providing an unbiased reference for the absolute flux.

Flux ratios show expected decrease when MHD-240 is shielded but fraction remains higher than would be for a central source assuming no room return.

Room return is substantial, which is to be expected for the Godiva configuration.

Supposition of $1/r^2$ does not precisely hold, initial analysis indicates a component of room return from opposite wall and floor/ceiling or an "inward" and "outward" component.

<table>
<thead>
<tr>
<th></th>
<th>Unshielded-4m</th>
<th>Shielded-4m</th>
<th>Unshielded-2m</th>
<th>Shielded-2m</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHD-ch2/Ref1</td>
<td>1.099</td>
<td>0.743</td>
<td>2.092</td>
<td>0.895</td>
</tr>
<tr>
<td>MHD-ch3/Ref1</td>
<td>0.458</td>
<td>0.377</td>
<td>0.685</td>
<td>0.423</td>
</tr>
</tbody>
</table>
MHD-240 Burst Measurement for Total Fission Yield and Alpha

- Calibrated Gamma (Co-60) and neutron (Ohio Edwards Accelerator) sensitivity
- 4 channels (8 orders of mag.) split on two scopes (different gains)

With some assumptions about fission gamma & neutron yield and a room return correction the total fission yield will be extracted
PDV: 123°C Burst – Bottom Ring

- 7881 Hz
- 95% confident band: 7856 – 7907 Hz
PDV: 201°C Burst – Bottom Ring

- 7545 Hz
- 95% confident band: 7524 – 7566 Hz
# Summary of PDV Frequency Measurements

<table>
<thead>
<tr>
<th>Temp °C</th>
<th>Location</th>
<th>Freq. Hz</th>
<th>95% Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>Bottom</td>
<td>7881</td>
<td>7856-7907</td>
</tr>
<tr>
<td>123</td>
<td>Top</td>
<td>7729</td>
<td>7716-7742</td>
</tr>
<tr>
<td>201</td>
<td>Bottom</td>
<td>7545</td>
<td>7524-7566</td>
</tr>
<tr>
<td>201</td>
<td>Top</td>
<td>7317</td>
<td>7261-7372</td>
</tr>
</tbody>
</table>

- Lower temp has higher frequency
- Top ring consistently lower than bottom ring
- Bulk material properties, hotter does not necessarily mean higher frequency
Conclusions and Next Steps

• Measured the gamma/neutron emission from several bursts

• Measurements made that will help determine room return contributions to the burst measurements

• Measured the vibrational frequency of several bursts

• Determine the room return fraction for each prompt burst
  • Consider room eccentricity and asymmetry, compare to simulation

• Consider re-calibration MHD-240 with Co-60 source

• Detailed MHD-240 burst data analysis

• Comparisons to simulation: Geant4, MCNP, COG, & Multiphysics

• Thanks again to the teams at MSTS and LANL for the hard work

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