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

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NCSP Technical Program Review
Feb. 23-25, 2021

LLNL-PRES-819436
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

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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 :

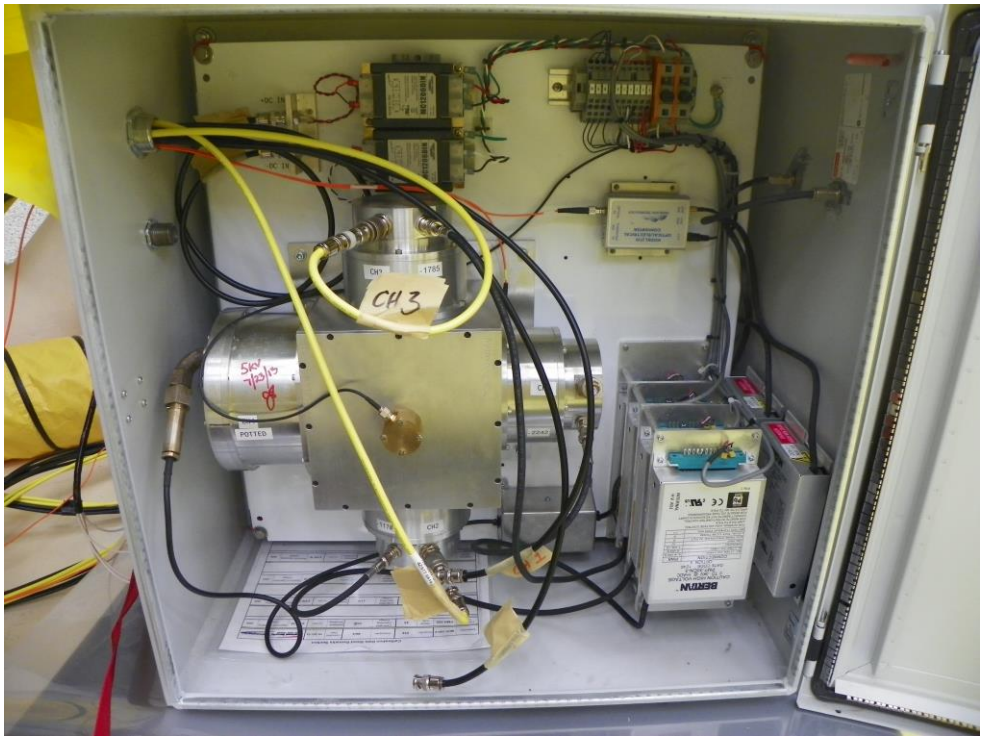
- John Scorby and Test Readiness team: Dan Bower, Mark May, Pat Lewis

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

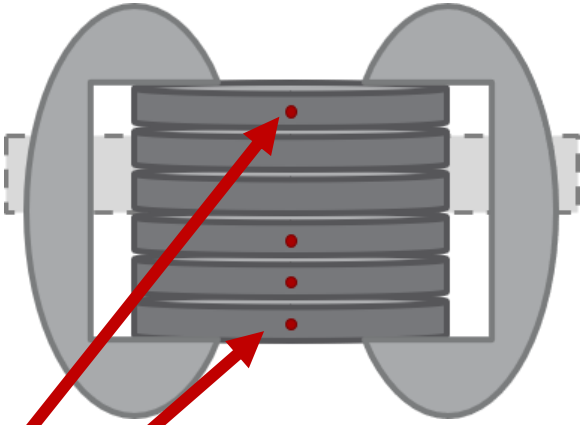
Experimental Setup: MHD-240

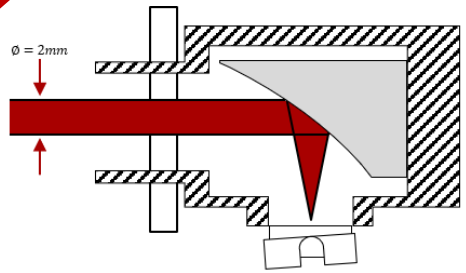
- Gamma & Neutron Calibrated
- 6" Scintillator cube with 3 PMTs and 1 PD
- Designed for a high dynamic range with a linear response over 8 orders of magnitude
- Deployed at a variety of pulse power type facilities, including a previous measurement at Godiva



Experimental Setup: PDV

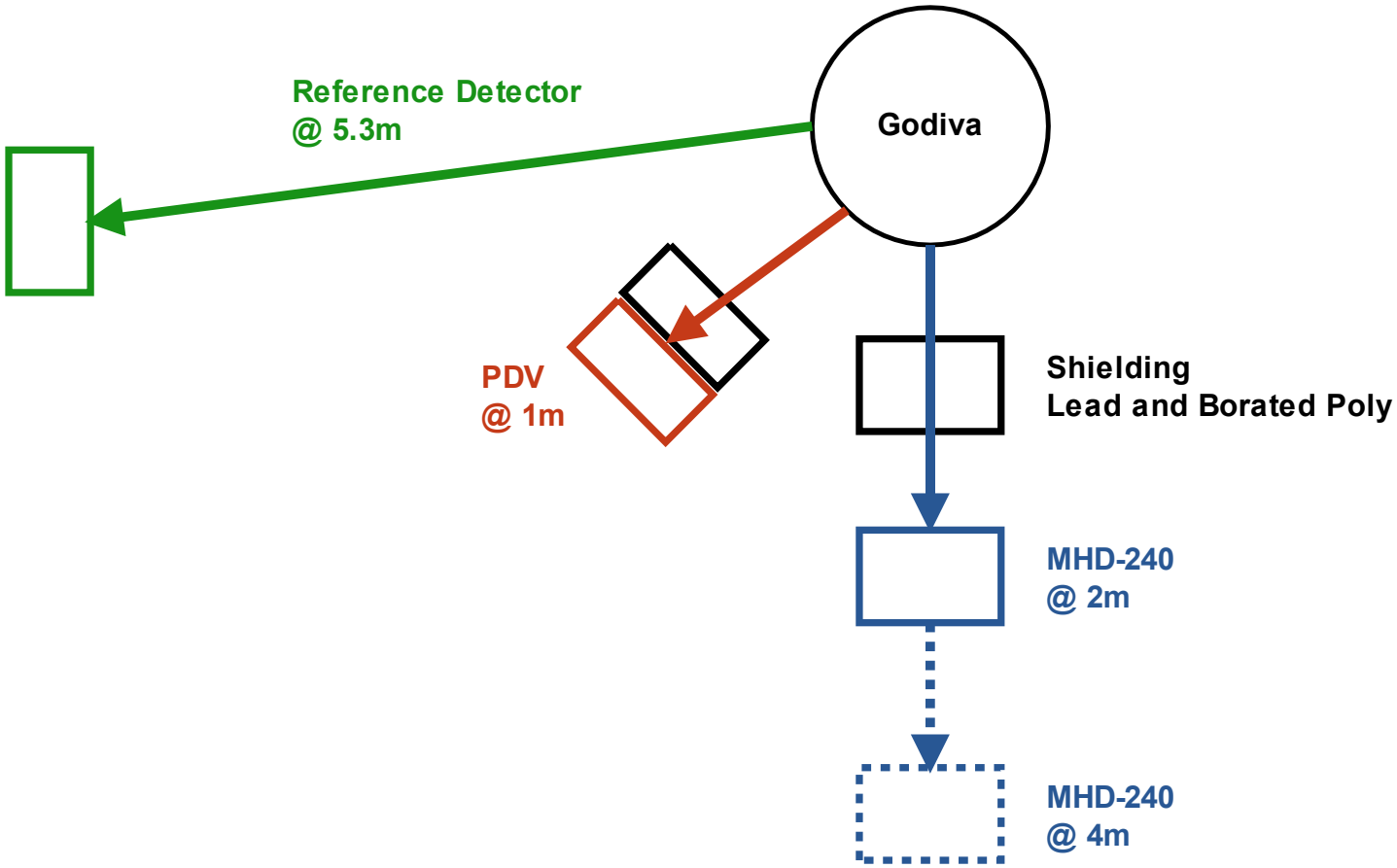
- First *successful* attempt on Godiva
- ThorLabs RC02APC-P01 – Reflector Collimator
- Mounted using ThorLabs KM05 – Kinematic Mirror Mount
- Probe point positioned on 1st, 4th, 5th, & 6th rings
- Successful data collection on the 1st and 6th





ThorLabs RC02APC-P01 based on a 90° off-axis parabolic mirror provides a collimated output using a standard FC/APC connector.

Experimental Setup



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

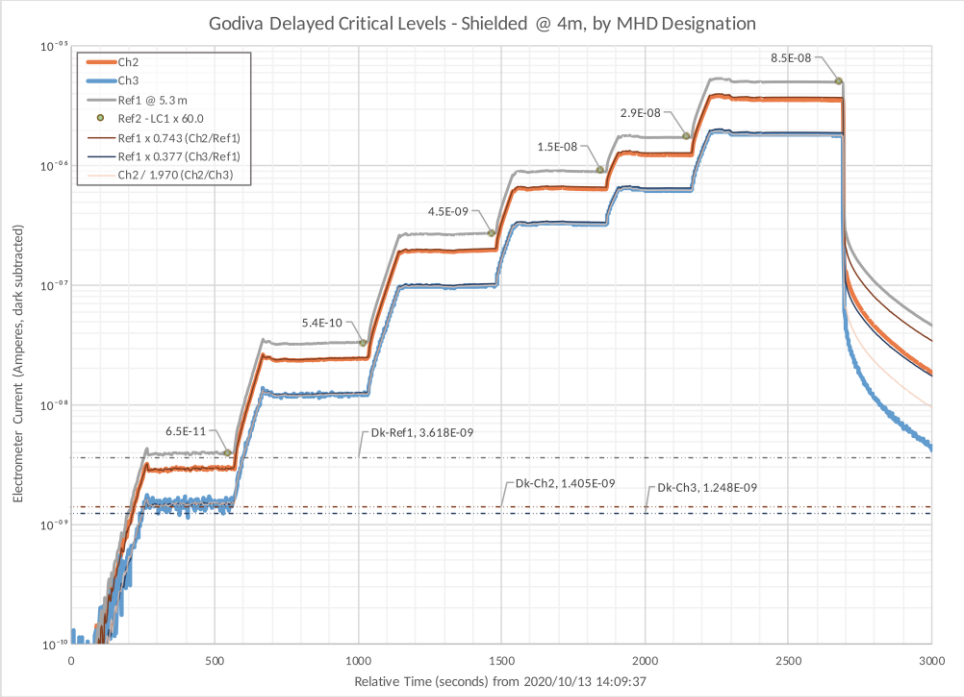


Figure 2. Shielded flux measurement data at 4 meters.

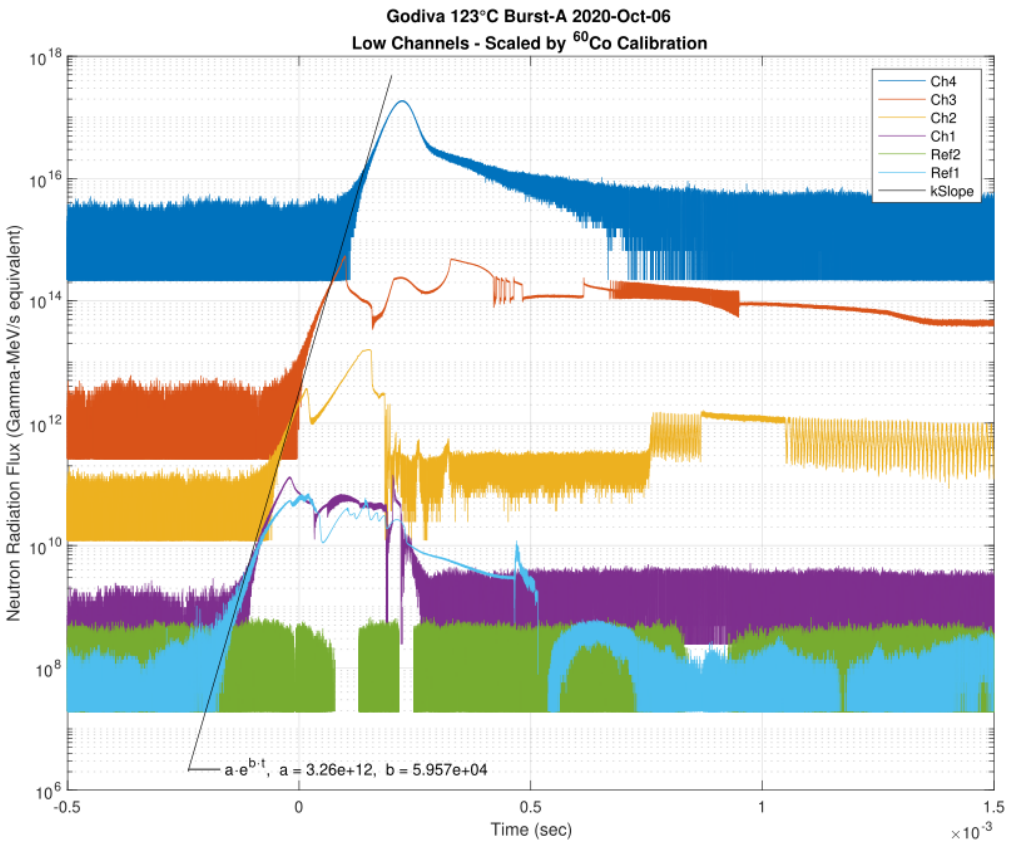
Delayed Critical Measurement To Determine Room Return

- 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

	Unshielded-4m	Shielded - 4m	Unshielded-2m	Shielded - 2m
MHD-ch2/Ref1	1.099	0.743	2.092	0.895
MHD-ch3/Ref1	0.458	0.377	0.685	0.423

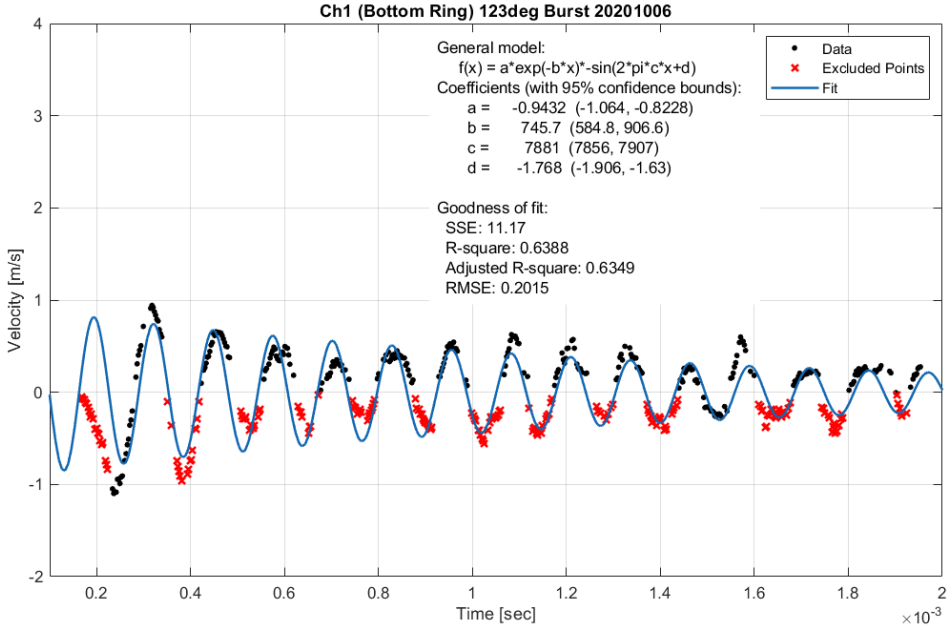
MHD-240 Burst Measurement for Total Fission Yield and Alpha

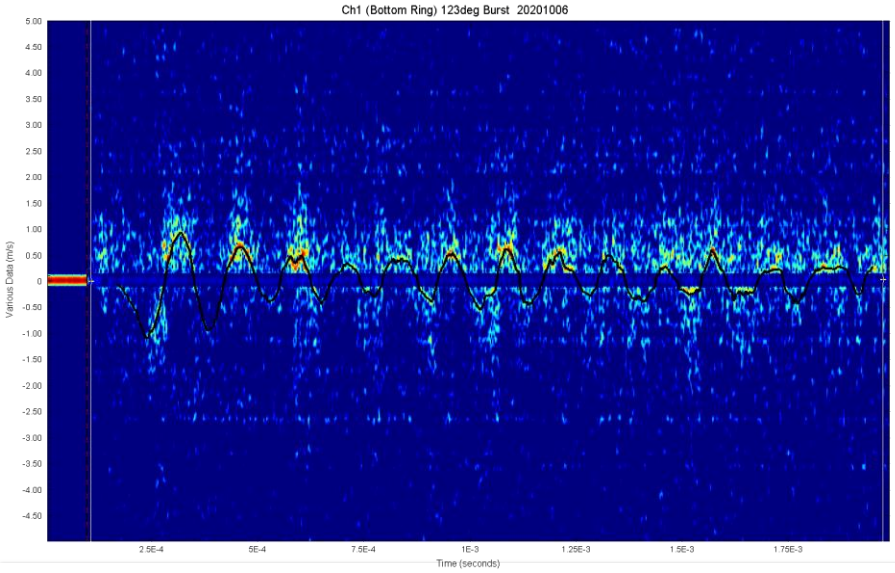
- Calibrated Gamma (Co-60) and neutron (Ohio Edwards Accelerator) sensitivity
- 4 channels (8 orders of mag.) split on two scopes (different gains)
- With some assumptions about fission gamma & neutron yield and a room return correction the total fission yield will be extracted



PDV: 123°C Burst – Bottom Ring

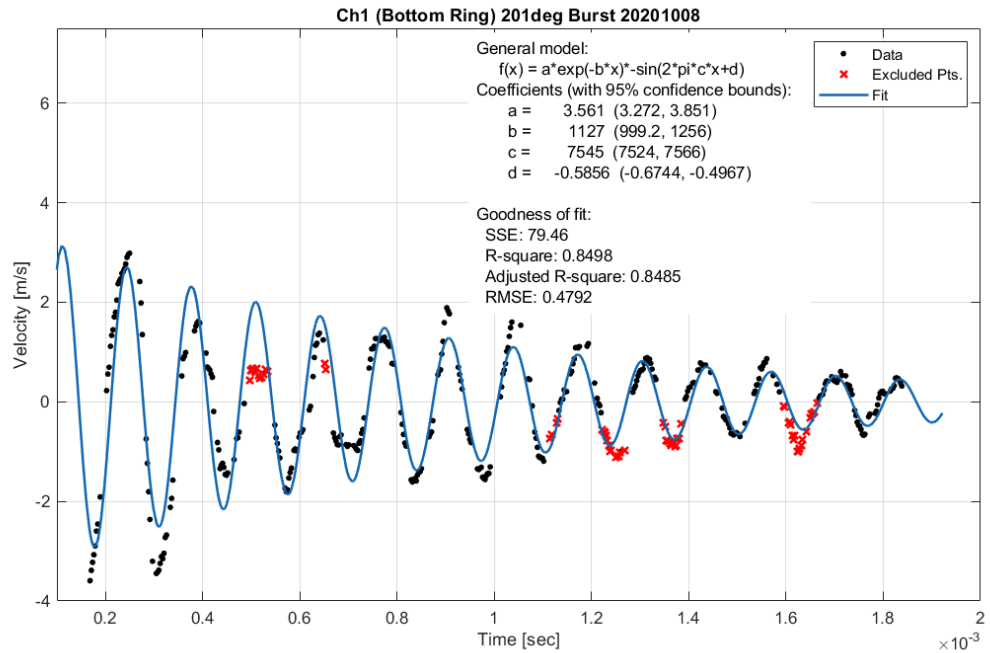
- 7881 Hz
- 95% confident band: 7856 – 7907 Hz

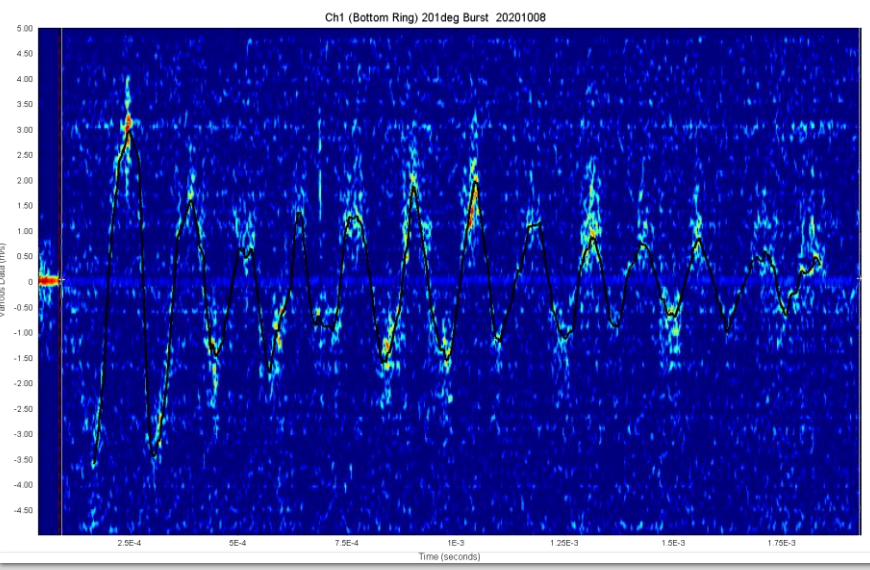




PDV: 201°C Burst – Bottom Ring

- 7545 Hz
- 95% confident band: 7524 – 7566 Hz





Summary of PDV Frequency Measurements

Temp ° C	Location	Freq. Hz	95% Hz
123	Bottom	7881	7856-7907
123	Top	7729	7716-7742
201	Bottom	7545	7524-7566
201	Top	7317	7261-7372

- 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**
- **This work was funded by the United States Department of Energy's Nuclear Criticality Safety Program (NA-511)**