

# PRAD COLLABORATION MEETING - HYCAL HV TESTS

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DEPARTMENT OF PHYSICS  
AND ASTRONOMY



# OUTLINE

- Previously discussed HyCal tests
- Setting up the HV PMT tests
- PMT testing procedures
- Testing notes
- Progress
- Overview of the signals.
- Light Monitoring System (LMS)
- Remaining/Other work
- The [PRad Logbook](#) and the [PRad Wiki](#)
- Acknowledgements

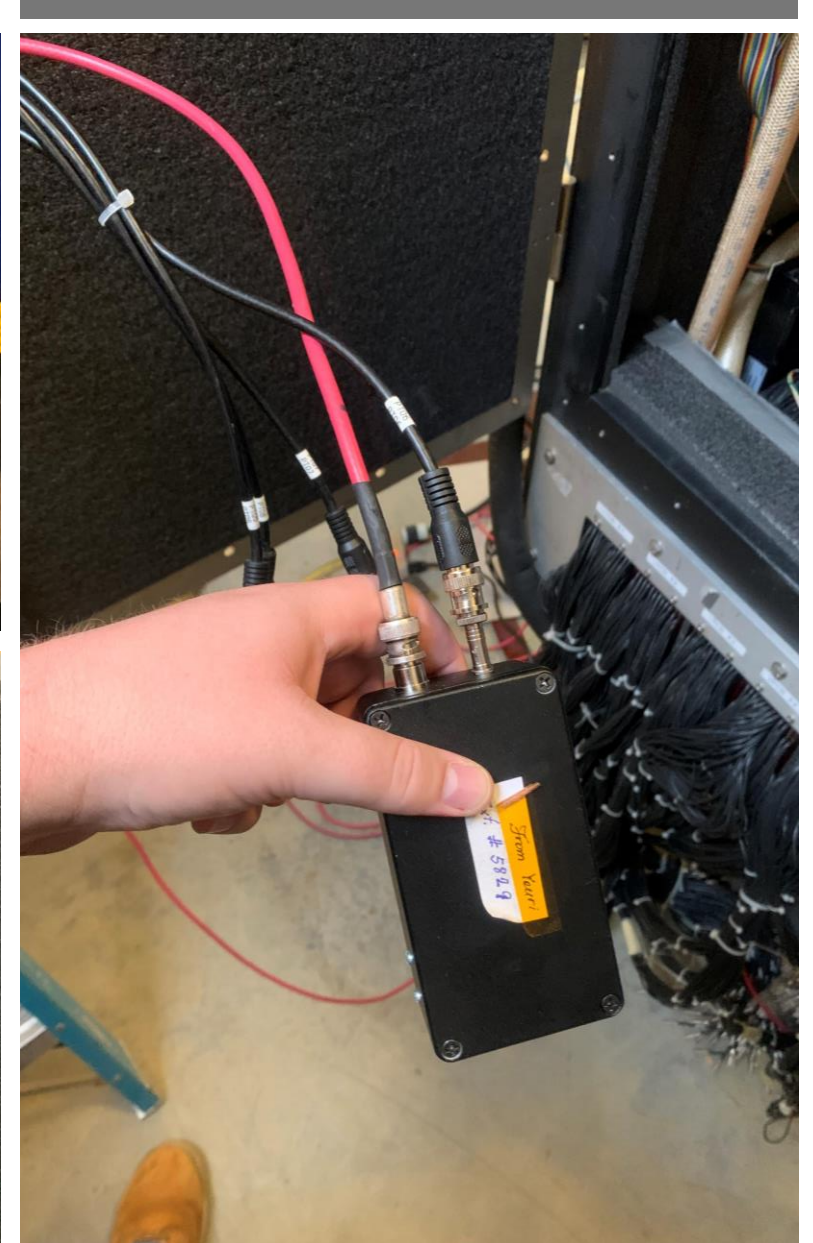
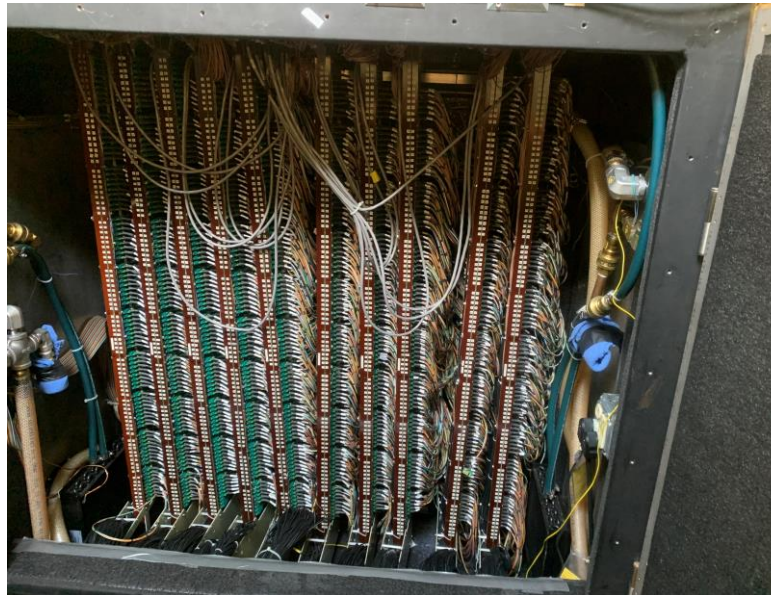


## PREVIOUSLY COVERED HYCAL TESTS AND UPGRADES

- As previously seen, in Aruni and Buddhiman's talks HyCal is:
  - Undergoing a DAQ upgrade to fADCs
  - Having all its cables in Hall B tested and upgraded to LEMO
  - Having all its optical fiber connections tested and repaired
- HyCal Consists of:
  - 1152  $PbWO_4$  crystals in the center region ( $2.05 \times 2.05 \text{ cm}^2$  face, 18 cm long)
  - 576 Pb-glass blocks ( $3.82 \times 3.82 \text{ cm}^2$  face, 45 cm long)

# HYCAL HIGH VOLTAGE PMT TESTS

- Each module must be individually tested using both cosmic information and our Light Monitoring System (LMS) using the black box (see right image)
- For this meeting we wanted to make sure we tested every crystal at least.
- Hall B techs (and Ashot) removed the HyCal fan system, so we had room to work.



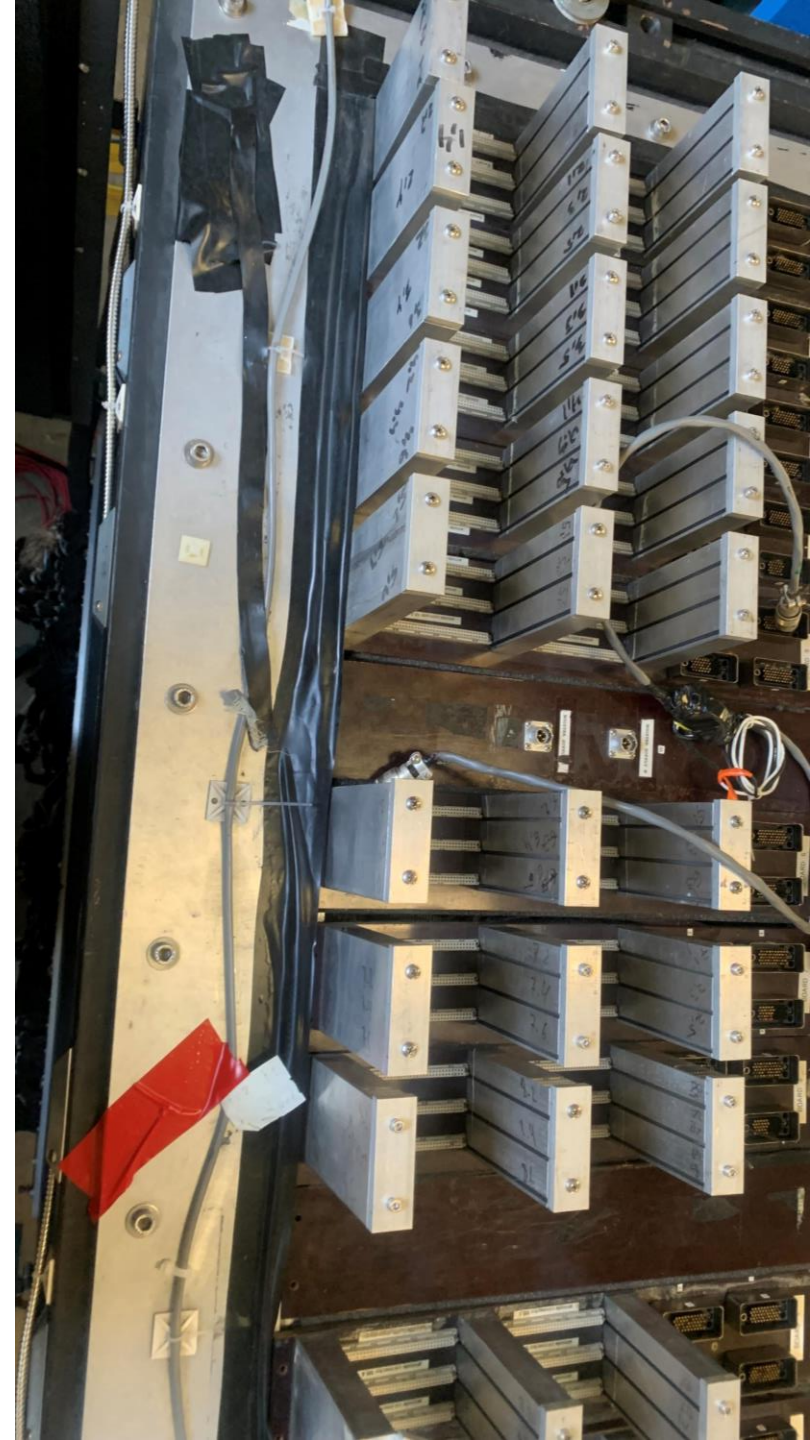
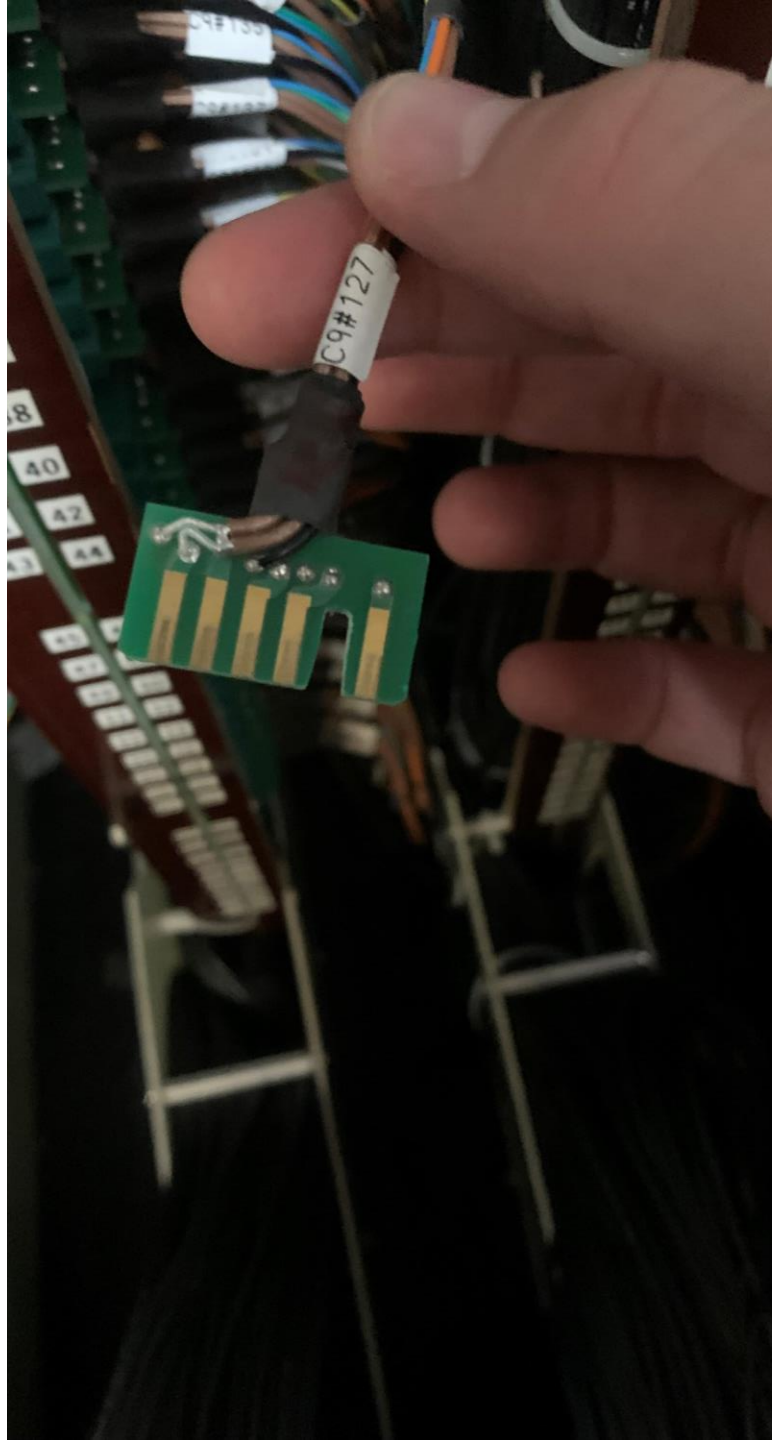


11/11/2024

# PMT ELECTRICAL TEST PROCEDURES

- Connect the PMT divider to the black box.
- Close HyCal
- Provide HV
- Check for signal in scope (adjust HV as needed)
- Record results
- Repeat ~1200 times (so far)
- See our ePAS for comprehensive procedures.

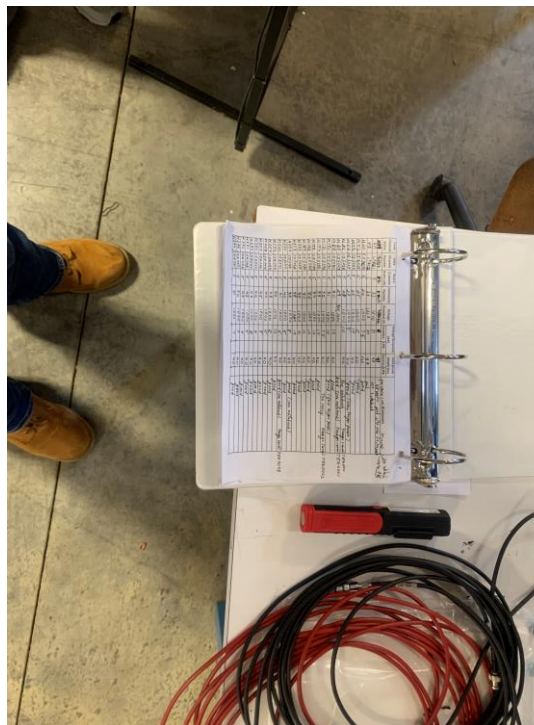
E. WRIGHTSON



Front Channel Name	Back Channel Number	Board Column (from Left)	Connecto #Number	Voltage Provided (V)	Voltage Response (mV)	Time (Peak Width) (ns)	Comments	Status	Image?
W183 (1183)	C074055	7	55	1000	10	40		Good	
W184 (1184)	C074056	7	56	1000	10	32		Good	
G721 (721)	C104145	10	145	1000	20	20		Good	
G722 (722)	C104146	10	146	1000	20	20		Good	
G726 (726)	C104149	10	149				No Response at 1-1.2k, Spike at 1.4k then no signal	Bad	
G726 (726)	C104150	10	150	1400	15	20		Good	
W19 (1019)	C054023	5	23	1000	10	40	Issue with occasional low frequency spark, added 50 Ohm terminator. This is okay for now.	Issue	10.22.24
W18 (1018)	C054022	5	22	1000	20	40		Good	2
W20 (1020)	C054024	5	24	1000	7.5	40		Good	3
W52 (1052)	C054025	5	25	1000	5	40		Good	4
W53 (1053)	C054026	5	26	1000	10	40		Good	5
W54 (1054)	C054027	5	27	1000	5	40	Some larger peaks (See image)	Good	Yes 6
W86 (1086)	C054028	5	28	1000	10	40	large peak, worked fine at 900V and 950V (See image)	Good	Yes 7
W87 (1087)	C054029	5	29	1000	10	40	Signal all over the place, many sparks (See image)	Bad	Yes 8
W88 (1088)	C054030	5	30	1000	10	40		Good	9
W120 (1120)	C054031	5	31	1000	10	40	Some larger peaks	Good	10
W121 (1121)	C054032	5	32	1000	7.5	40	(See image)	Good	Yes 11
W154 (1154)	C054033	5	33	1000	10	40		Good	12
W155 (1155)	C054034	5	34	1000	10	40		Good	13
W186 (1186)	C054035	5	35	1000	10	40		Good	14
W189 (1189)	C054036	5	36	1000	10	40		Good	15
W222 (1222)	C054037	5	37	1000	10	40		Good	16
W223 (1223)	C054038	5	38	1000	10	40		Good	17
W224 (1224)	C054039	5	39	1000	8	40	Was too noisy initially, but ramped down to 900V and then back up to 1000V made it stable	Good	18
W225 (1225)	C054040	5	40	1000	5	40		Good	19
W226 (1226)	C054041	5	41	1000	5	40	Some larger peaks (See image)	Good	Yes 20
W256 (1256)	C054042	5	42	1000	10	40		Good	21
W257 (1257)	C054043	5	43	1000	8	40		Good	22
W258 (1258)	C054044	5	44	1000	5	40		Good	23

Front Channel Name	Back Channel Number	Board Column (from Left)	Connecto #Number	Voltage Provided (V)	Voltage Response (mV)	Time (Peak Width) (ns)	Comments	Status	Image?
W259 (1259)	C054045	5	45	1000	5	40		Good	24
W260 (1260)	C054046	5	46	1000	5	40		Good	25
W290 (1290)	C054047	5	47	1000	6	40		Good	26
W291 (1291)	C054048	5	48	1000	5	40		Good	27
W292 (1292)	C054049	5	49	1000	5	40		Good	28
W293 (1293)	C054050	5	50	1000	7	40		Good	29
W294 (1294)	C054051	5	51	1000	7	40		Good	30
W324 (1324)	C054052	5	52	1000	10	40		Good	31
W325 (1325)	C054053	5	53	1000	10	40		Good	32
W326 (1326)	C054054	5	54	1000	10	40		Good	33



# PMT HV TEST NOTES

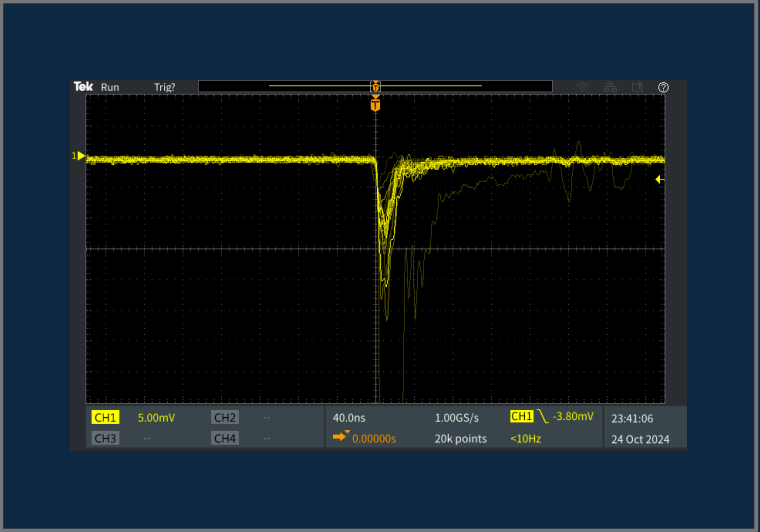
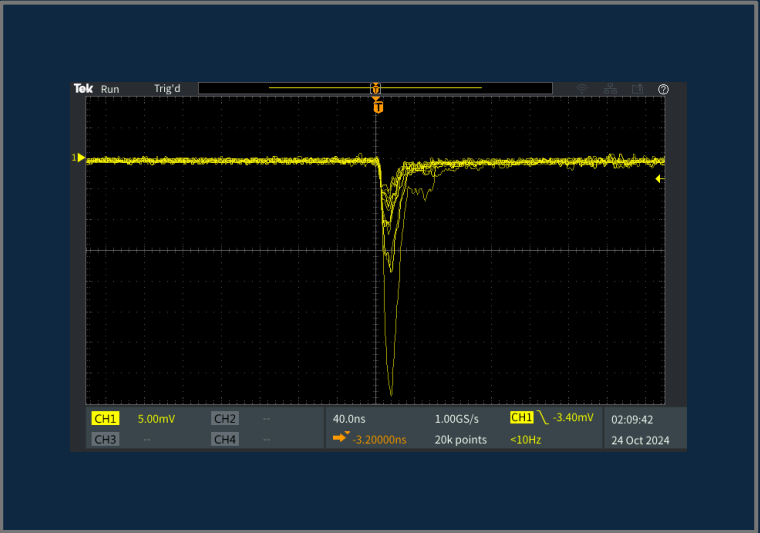
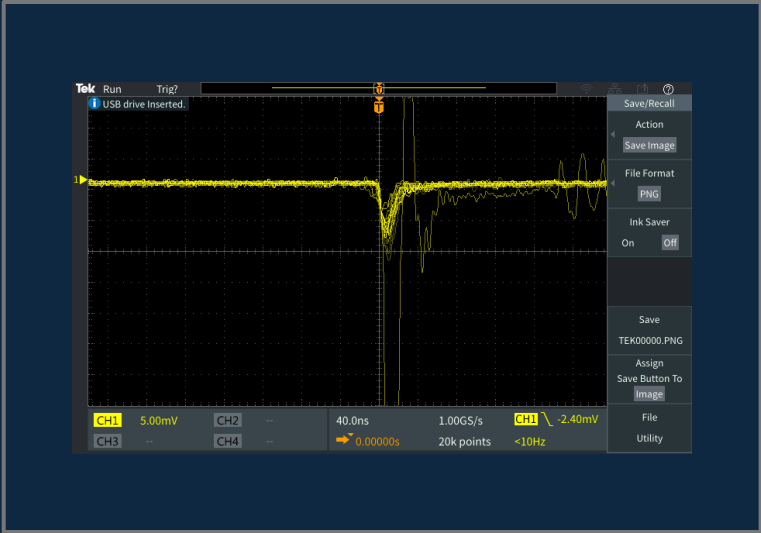
- All notes were recorded by hand and digitally.
- 3 possible statuses: Good, Issue, and Bad (with notes to elaborate)
- Each night we setup a connection to take comic data for spectrum analysis by Chao Peng (when available).

# CURRENT PROGRESS

- All 1152  $PbWO_4$  crystals have been tested
- Average responses: 5-20 mV, ~40ns width
- This was done in 2 passes.
  - 1<sup>st</sup> pass: Check each module in 1-3 minutes record status, move on.
    - 10/22 – 37 tested [3 noted], 10/23 – 71 tested [4 noted], 10/24 – 106 tested [2 noted], 10/25 – 110 tested [3 noted], 10/28 – 90 tested [1 noted], 10/29 – 130 tested, 10/30 – 105 tested, 10/31 – 141 tested, 11/01 – 116 tested, 11/04 – 152 tested, 11/05 – 94 tested [1 noted]
  - 2<sup>nd</sup> pass: Re-check any “issue” or “bad” modules and check with voltages from previous experiment and spend more time.
    - 15 modules were rechecked
    - 13 were able to settle into producing reliable good signals.
    - 2 bad modules remain
      - One module was unresponsive completely
      - One module was continually giving 2 wide/unpredictable signals for every 1 good signal at any responsive voltage.



# MOST SIGNALS ARE GOOD

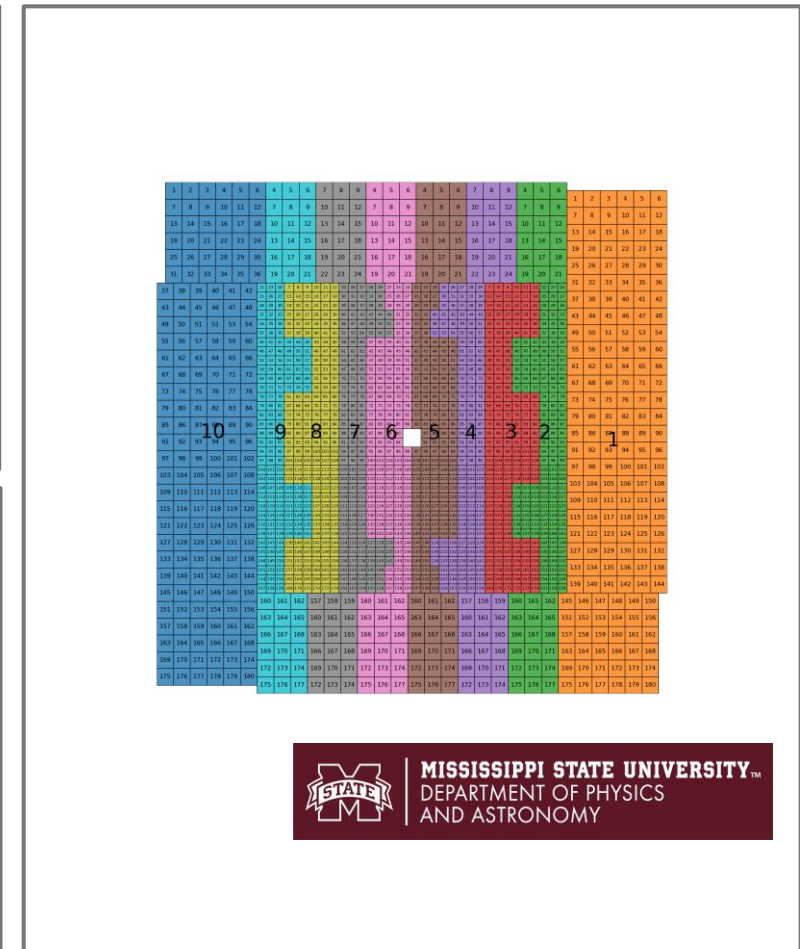
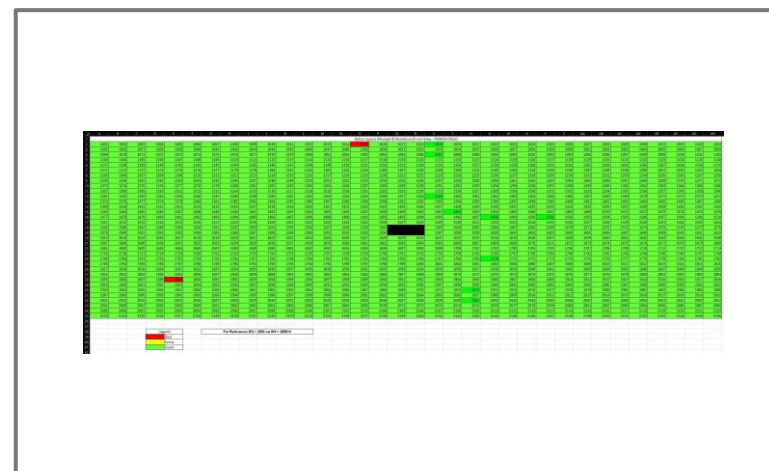
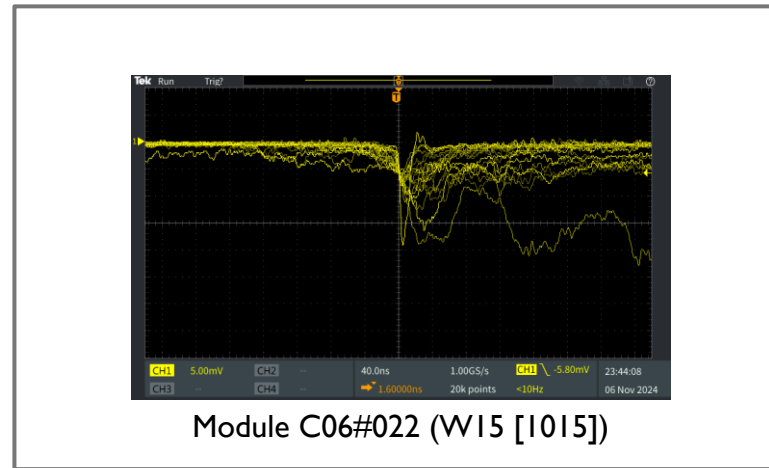




# HOW TO ADDRESS PROBLEM PMTS?

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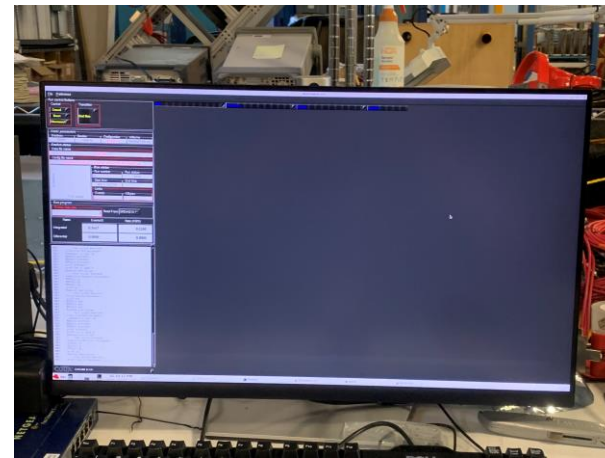
- See the remaining bad signal module (top left), and the final crystal map (bottom left).
- We will be looking first to see if we can find fault with the PMT divider and then possibly try replacing the PMT if necessary.
- This will not be done until after also checking the lead glass modules.



# LMS WORK SO FAR

- There is a lack of documentation on the LMS.
  - We plan to remedy this over the course of these tests.
- LMS does not have an easily swappable setup for putting in a different light module.
  - It would require removing the LMS (without damaging the fiber bundle that goes into HyCal).
    - This is a last resort.
- We attempted to see if we could get any signal from using the present pulse generator.
  - It does not reach a high enough voltage for even weak pulsing.
- We have confirmed that the filter can still move between its preset positions.
- We checked one of the LMS PMTs with its attached  $\alpha$  – radiation source and that gives a good consistent signal.

# WHAT TO DO NEXT (FOR HYCAL)?



- Test each of the Pb-glass modules.
- Get the LMS running and complete the testing with that.
- Make necessary repairs.
- Continue collection of cosmic data to test the DAQ and various modules.
- There are 14 PMTdividers (so far) that need new labels.
  - We will address this at the end of testing.
- Write LMS documentation.

# REMAINING/OTHER WORK?

- HyCal:
  - Test HV cables in Hall B
  - Complete signal cable testing in Hall B
  - Repair any problem modules
  - Test with the LMS
  - Test Pb-glass modules
  - Collect more cosmic data that Chao needs for the DAQ
- Other:
  - Complete X17 analysis of original PRad data
  - Complete work towards potential extended vertex analysis for the X17 experiment with Tyler Hague

AS ALWAYS, FIND  
DAILY UPDATES ON  
THE PRAD  
LOGBOOK.

I UPDATE THE PRAD  
MODULE TEST MAPS  
EACH DAY ON THE  
PRAD WIKI.



## ACKNOWLEDGEMENTS

**PR**oton  
**Rad**ius



U.S. DEPARTMENT OF  
**ENERGY**

Office of Science

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- My Advisor: Dr. Dipangkar Dutta, Mississippi State
- Dr. Aruni Naadeshani, Mississippi State [conducted all testing]
- Buddhiman Tamang, Mississippi State [conducted all testing]
- Dr. Ashot Gasparian - North Carolina A&T State University [helped with LMS and general testing]
- Dr. Eugene Pasyuk, JLab [Oversaw our work]
- Dr. Chao Peng, ANL [Provided documentation]
- Dr. Youri Sharabian, JLab [Designed the testing box]
- Dr. Jingyi Zhou, Duke University
- Current and Future PRad Collaborators



QUESTIONS?