

PRAD COLLABORATION MEETING - HYCAL HARDWARE WORK UPDATE

BY: ERIK WRIGHTSON



MISSISSIPPI STATE
UNIVERSITY™

DEPARTMENT OF PHYSICS
AND ASTRONOMY



OUTLINE

- Final HyCal Signal Cable Tests and Repairs
- LMS Functionality
- HyCal Pb-Glass LMS Signal
- HyCal Pb-Glass Cosmic Signal Second Pass
- HyCal Single Channel DAQ Test
- Remaining Work/Other Talks
- The [PRad Logbook](#) and the [PRad Wiki](#)
- Acknowledgements

03/03/2025

3

SIGNAL CABLE TESTS AND REPAIRS

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HYCAL SIGNAL CABLE TESTS AND REPAIRS

- All 60 bundles have been converted to LEMO connectors use with the FADCs
- Since the previous PRad Collaboration meeting, the final 8 bundles were converted, tested, and re-bundled into their sub-groups (X.X.1 for cables 1-16 and X.X.2 for cables 17 – 25, 27, or 32)
- 4 of the bundles also needed their 32-pin connectors to HyCal replaced due to having bent pins or cracking.
- After testing we did a second pass of any marked cables and if they still presented issues, we marked them for repairs.
- Bundle 5.4.2 cable 17 and bundle 6.6.1 cable 8 each needed repairs and were confirmed to work afterwards.
- The final boards being converted to LEMO ends and the repairs were done by Armen Stepanyan of the Fast Electronics Group.
- This work has been fully completed.



32-Cable Bundles:

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32

27-Cable Bundles:

1	3	5	7	9	11	13	15	17	19	21	23	25			
27	2	4	8	10	12	14	16	18	20	22	24	26	6		

25-Cable Bundles:

1	3	5	7	9	11	13	15	17	19	21	23				
25	2	4	6	10	12	14	16	18	20	22	24	8			



LIGHT MONITORING SYSTEM (LMS)

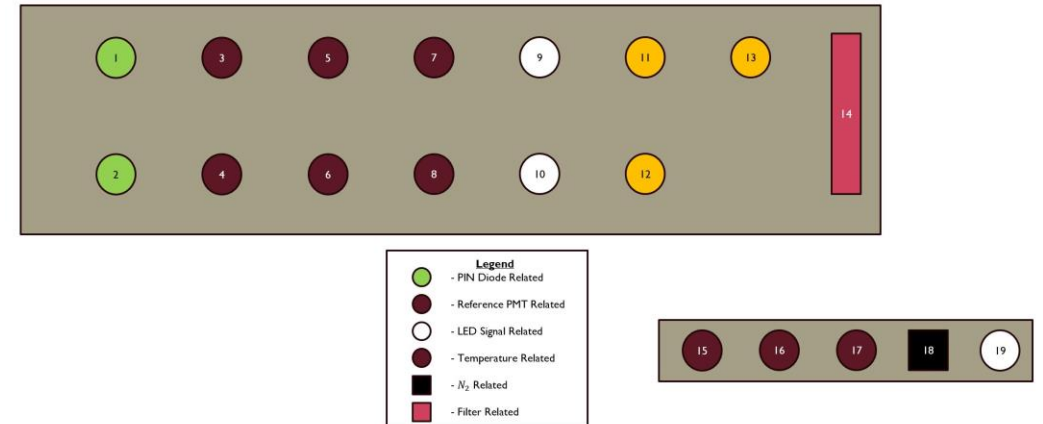
- The LMS was successfully re-started on December 12, 2024

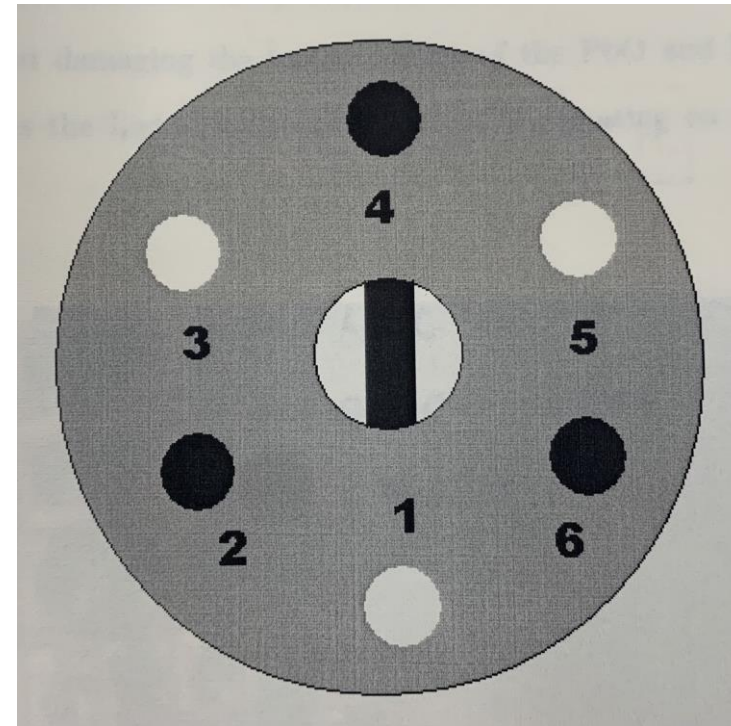
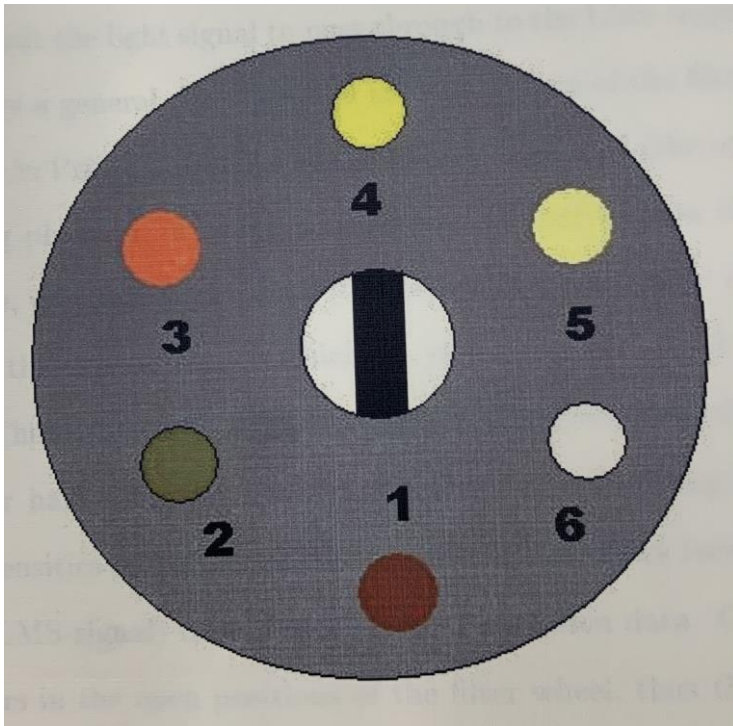
LMS PRIMARY COMPONENTS

- 31 Nichia Super-Bright Blue LEDs - arranged in Series with one another and “avalanche” transistors that allow for pulsing HV signal to light them
- Integrating Sphere – removes angular dependence of LED Signal via mixing
- PIN Photodiodes – allows for direct LED measurement on Integrating Sphere
- Light Filter – 3 settings to block the LED signal from reaching the Optic Bundle, 3 open settings for different light intensities
- Optic Bundle – carries the LED pulse to all HyCal Modules and Reference PMTs
- 3 Reference PMTs – allows for gain monitoring and signal stability monitoring using radioactive sources and LED fibers

LMS SIDE PANEL AND VOLTAGES PROVIDED DURING TESTING

- 1, 2 – Connected to Photodiodes (Electronically Connected; Port 2 is unused)
- 3, 5, 7 – Reference PMT Dynodes (#1, #2, and #3 respectively)
- 4, 6, 8 – Reference PMT Anodes (#1, #2, and #3 respectively)
- 9 – LED Pulse Input (5V, 20Hz, 100nS width)
- 10 – LED ~1V Input (No Longer Needed)
- 11, 12, 13 – Temperature Sensors for Reference PMTs
- 14 – Ribbon Cable for Filter
- 15, 16, 17 – HV Input for Reference PMTs (1000-1300V)
- 18 - N_2 Supply Input
- 19 – HV Input for LED Array (125V)



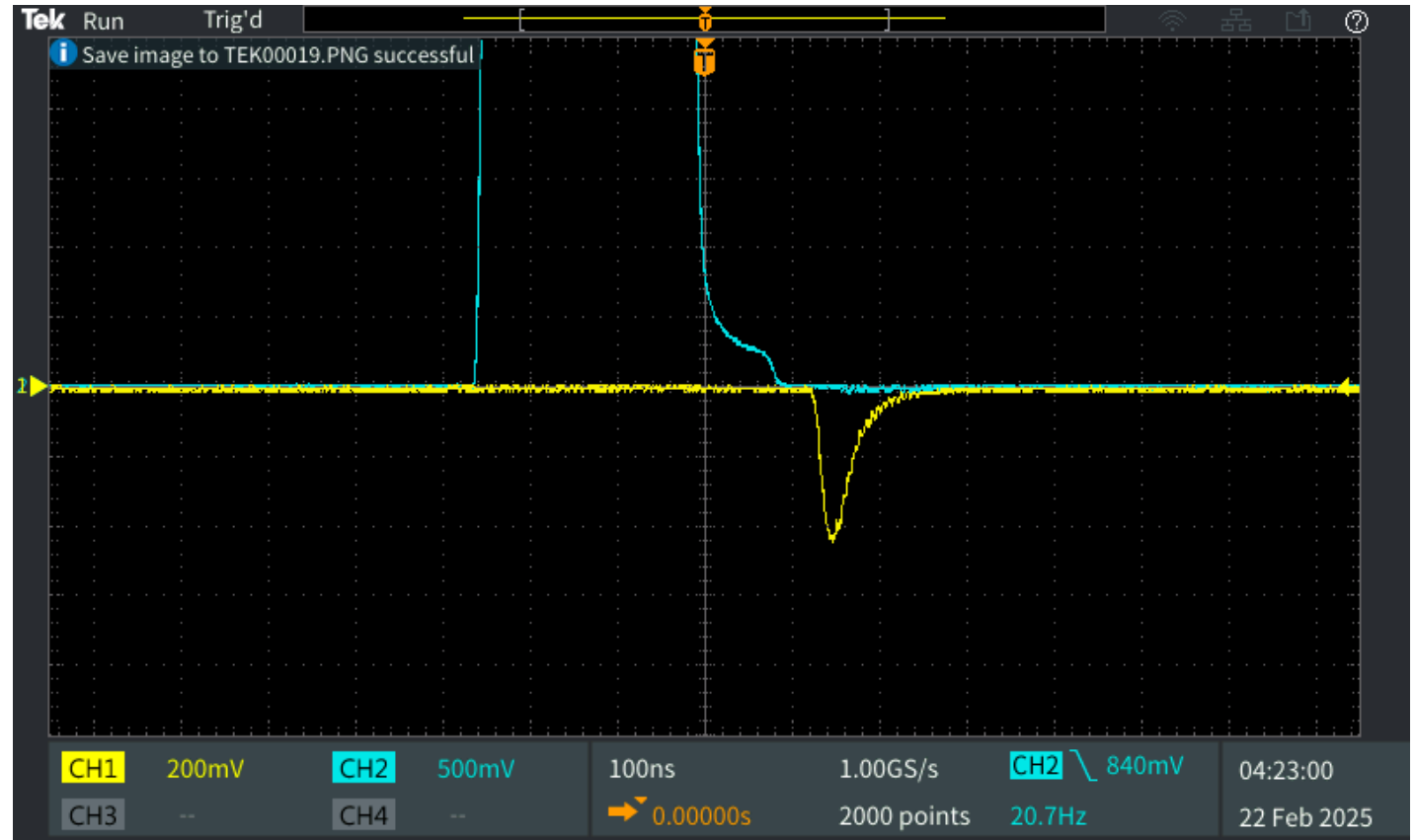


LMS FILTER WHEEL

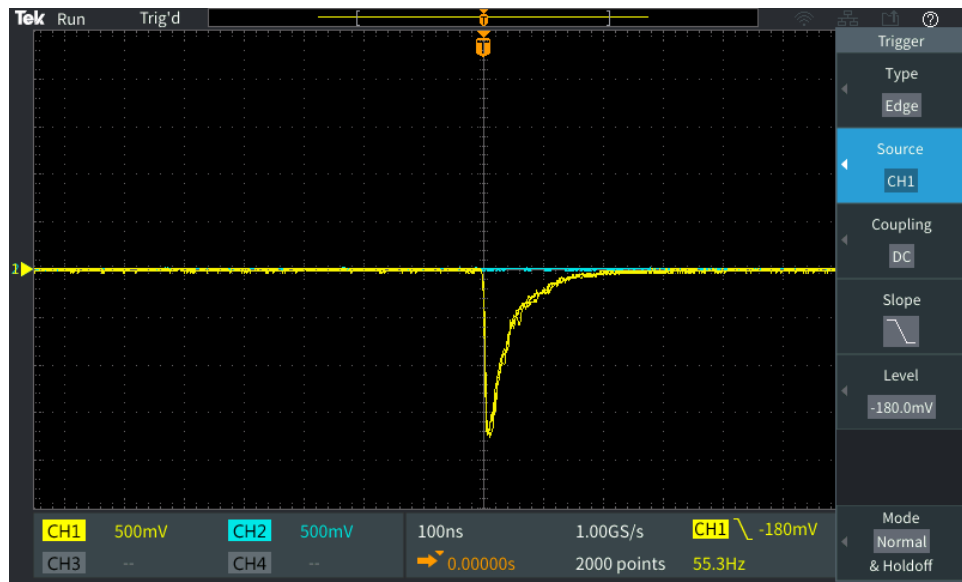
- Originally, the filter wheel allowed for 6 intensities of light to pass through (Left image).
- After modification, 3 settings were covered so that whether the HyCal modules received LMS light or not could be remotely controlled by just rotating the filter and it still allowed for 3 light intensities to be used.
- Images from the Master's thesis of Larray J. Benton from NC A&T

PIN PHOTODIODE RESPONSE

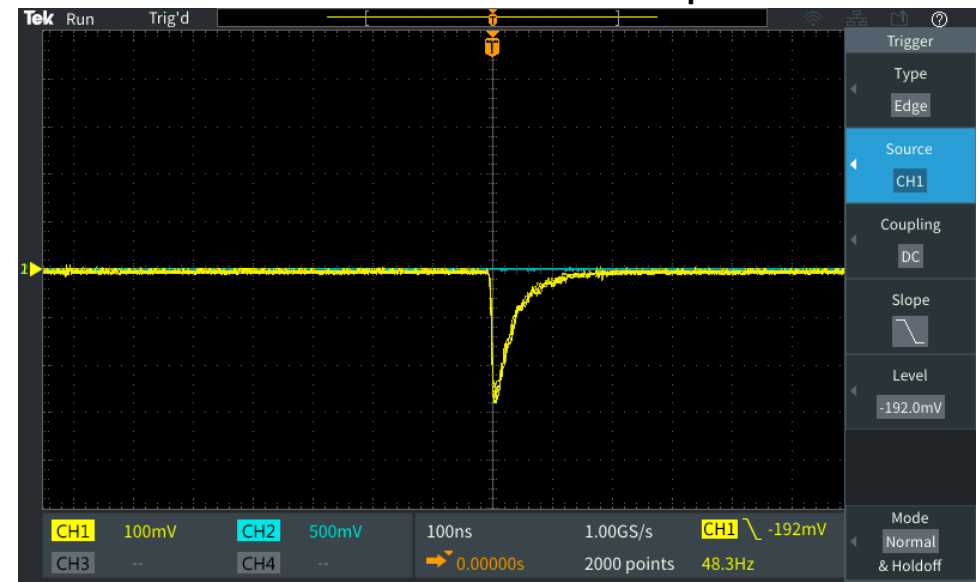
- There are two electrically connected photodiodes attached directly to the integrating sphere.
- There is a center and lower diode on the sphere.
- The blue is just the pulse trigger to ensure the signal is from the LED pulse.



Reference PMT #3 – YAP Response



Reference PMT #2 – YAP Response

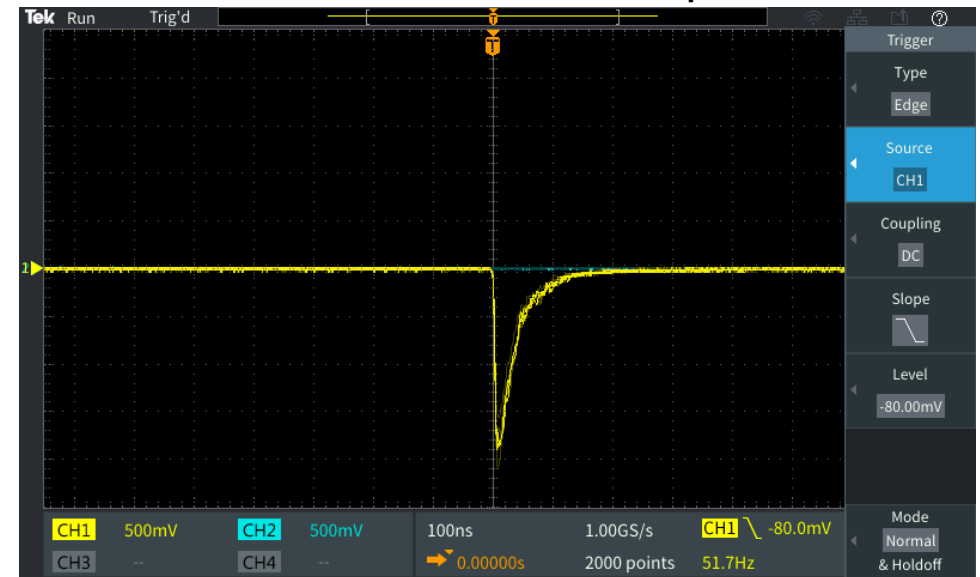


03/03/2025

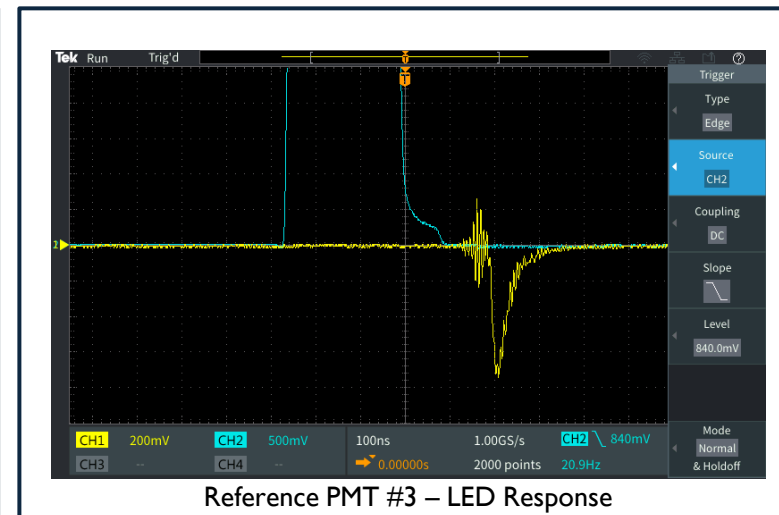
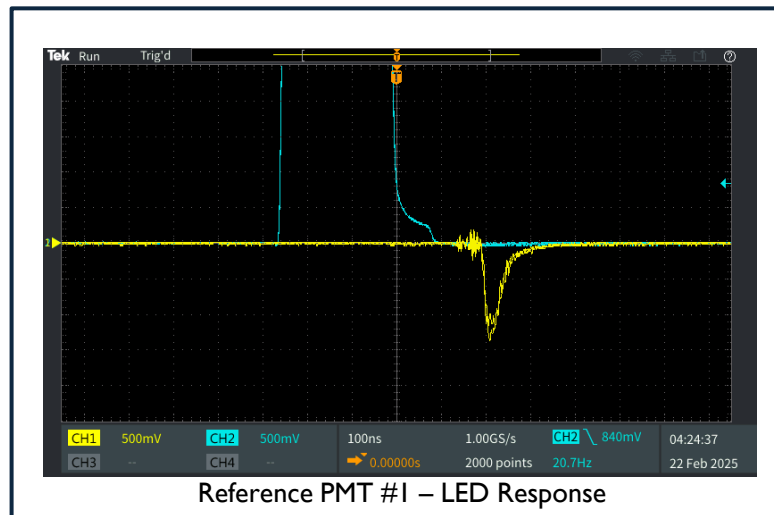
REFERENCE PMTS – YAP (Am^{241}) CRYSTAL α -SOURCE

- Allows for a randomly timed known signal for checking stability and calibration.
- Allows for a known signal to normalize to.

Reference PMT #1 – YAP Response



REFERENCE PMTS – LMS LED- SOURCE



- Good linearity with HV supplied for the reference PMTs.

$$\text{Stability} = \frac{\text{LED Response \#1} * \text{YAP Response \#3}}{\text{YAP Response \#1} * \text{LED Response \#3}}$$

$$E = E_e - \sum_{i=1}^n \frac{Q_i g_i(t_0)}{\alpha_i g_i(t)} = E_e - \sum_{i=1}^n \frac{Q_i}{\alpha_i} g_i^{LMS}$$

- If the response in the LMS is stable and the calibration constants (α_i) are well known for each HyCal module via periodic calibration, then we can get the energy deposited with very good resolution.
- Equations are originally from the master's theses of Jarreas C. Underwood, and Larray J. Benton from NC A&T
- For more detailed information please see the LMS Overview document that I will send out soon prior to putting it up on the Wiki.

TESTING HYCAL

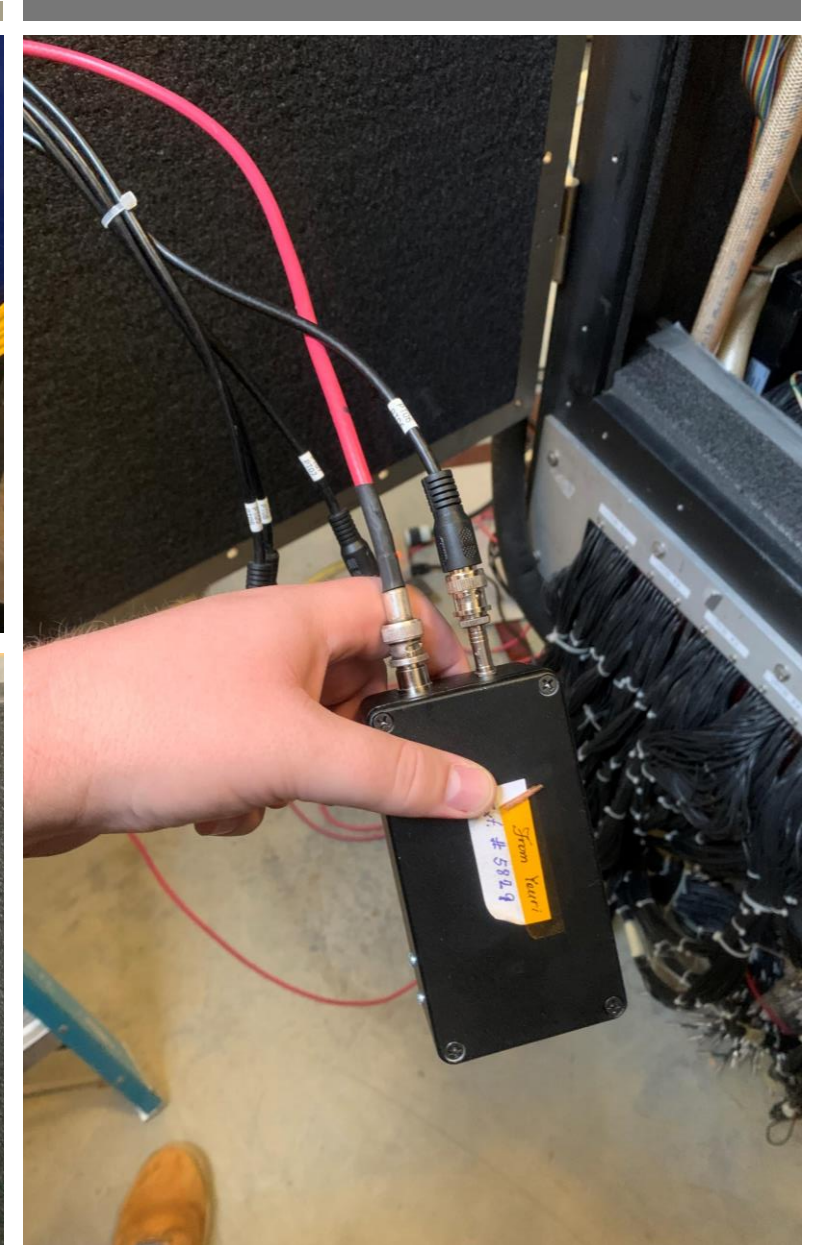
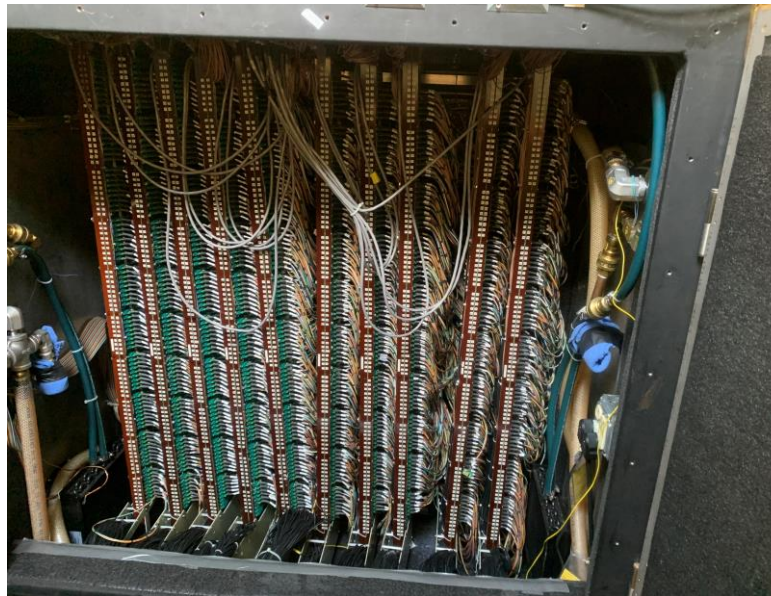
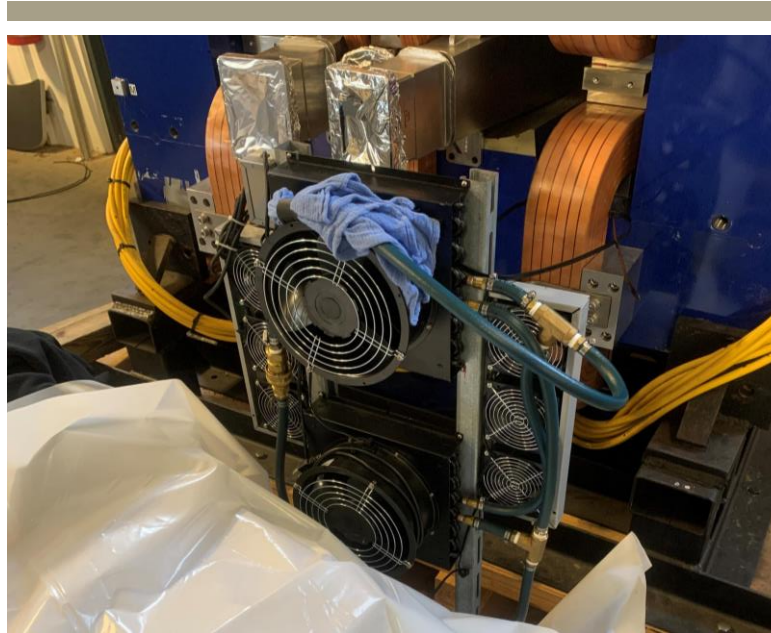
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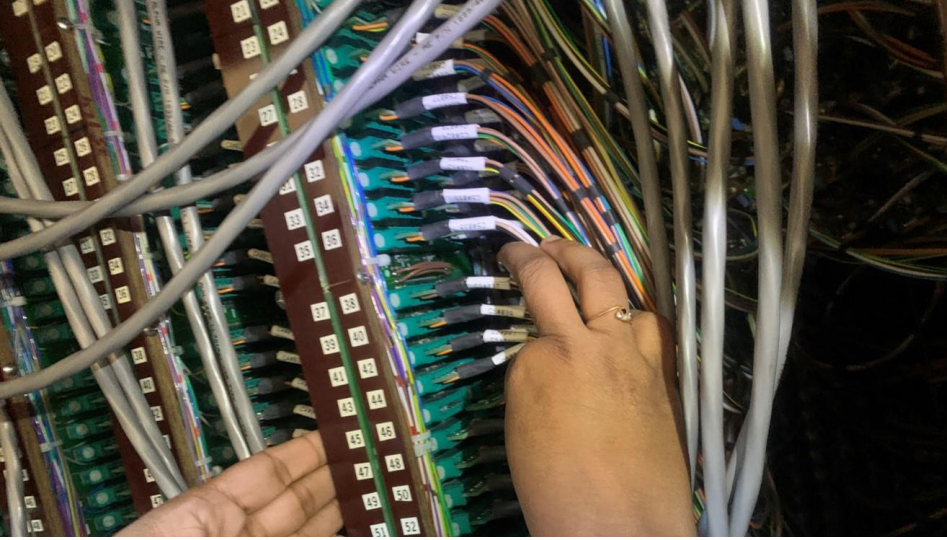
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13

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)
- I will primarily discuss the Pb-Glass testing. For the crystal tests, please see Aruni's talk.
- Hall B techs (and Ashot) removed the HyCal fan system, so we had room to work.
- 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)





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TESTING HYCAL PB-GLASS WITH THE LMS

- No LMS responses in the Pb-Glass modules so far.
- We have cycled through the various filter settings with no luck.
- Modules have been tested using cosmic signal information.
- We intend to fix this soon.



HyCal Layout (Module ID Notation) [Front View - Pb Glass ONLY]

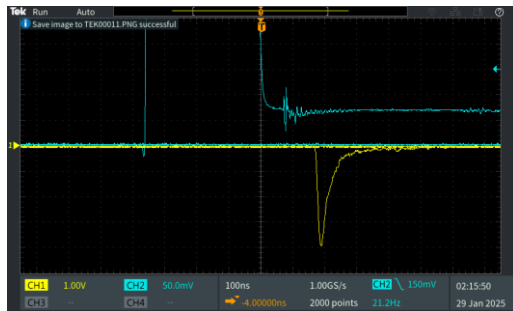
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151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
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391	392	393	394	395	396																			415	416	417	418	419	420
421	422	423	424	425	426																			445	446	447	448	449	450
451	452	453	454	455	456																			475	476	477	478	479	480
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661	662	663	664	665	666																			685	686	687	688	689	690
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841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870
871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900

Legend	
Red	Bad
Yellow	Issue
Green	Good

TESTING HYCAL PB-GLASS WITH COSMIC DATA

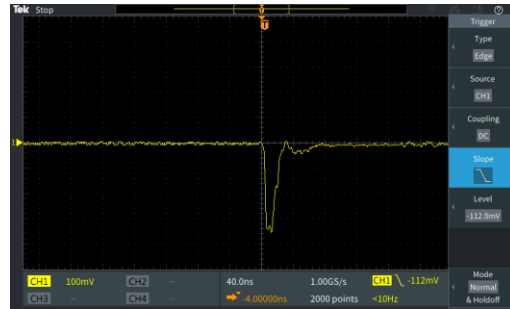
- With Bo's help we were able to do a second pass of the marked modules from the last collaboration meeting.
- 7 previously marked modules ended up being moved to "Good"
- 17 modules marked "Bad" for lack of response
- 3 modules marked "Issue" for oddly low response

DAQ SINGLE CHANNEL TEST

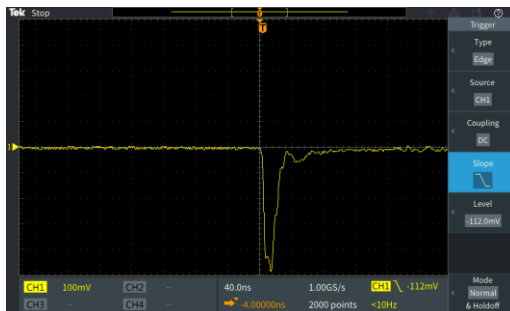


Channel W445 LMS Response

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Channel W445 Cosmic Response Sample #1



Channel W445 Cosmic Response Sample #2

- With the guidance of Chao Peng, we took a 20-minute LMS run, and a day long cosmic run on 01/28-01/29.
- Used module W445 which is on VPC board 09 and in channel 81.
- The signals were also captured on the oscilloscope to ensure check the signals prior to the run.
- Chao was able to confirm the results and well-characterizable behavior.



REMAINING WORK/OTHER TALKS

- Finish work on Veto Scintillator (see Buddhiman's talk)
- Finish work on $PbWO_4$ Crystal Section Repairs (14 total modules) (see Aruni's Talk)
- Get Pb-Glass responses to LMS signals.
- Do chiller tests with old chiller
 - Electronics have been set up in ESB for this test to occur when ready
- Test 16 channels at once to be able to more thoroughly test DAQ
- Overall, we have been making steady progress with some hiccups throughout, but we will continue prepping everything as we are able



AS ALWAYS, FIND
DAILY UPDATES ON
THE PRAD
LOGBOOK.

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



ACKNOWLEDGEMENTS

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Office of Science

- US Dept. Of Energy under contract #DE-FG02-07ER41528
- 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, and processed the data for the DAQ single channel test]
- Dr. Youri Sharabian, JLab [Designed the testing box]
- Dr. Jingyi Zhou, Duke University
- Bo Yu, Duke University
- Current and Future PRad Collaborators
- Armen Stepanyan, Mark Taylor, and all the Fast Electronics Group, JLab



QUESTIONS?

HYCAL TESTS AND STATES

BY: ARUNI NADEESHANI

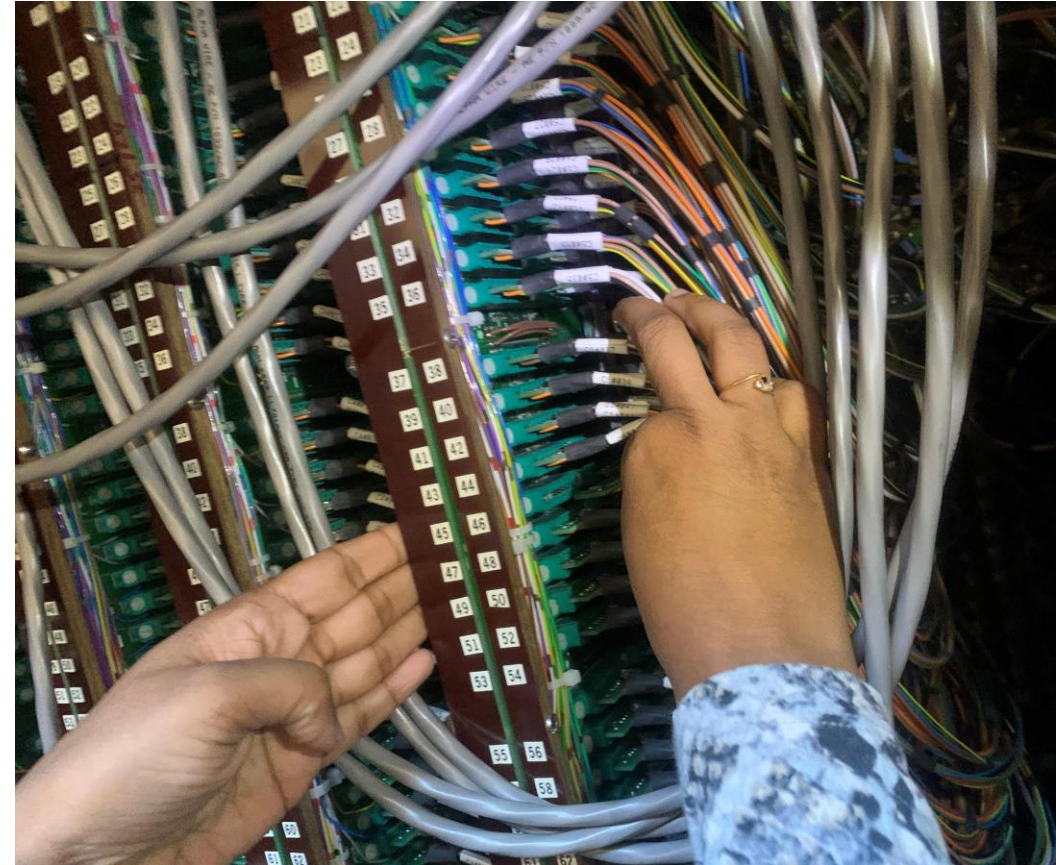


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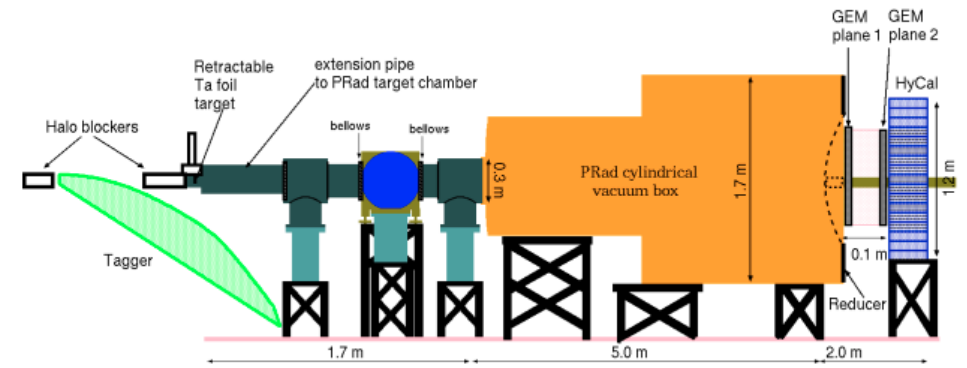
OUTLINE

- Introduction to HyCal Calorimeter
 - Experimental setup
 - Design of HyCal
- HyCal tests
 - HyCal cabling.-Erik
 - Hycal optical fiber and connection repair (summary)
 - HyCal HV test with cosmics and LMS
- Summary and future work



INTRODUCTION : EXPERIMENTAL SETUP

- GEMs- A pair of GEM detector planes, separated by about 40 cm.(From UVA group)
- Target: Windowless hydrogen gas flow target (reduced backgrounds)
- High resolution HyBrid PbWO_4 crystal and Pb-Glass calorimeter (the PbWO_4 crystals) with fADC based readout. (HyCal repairs: MSU , NC A&T State University and JLab)
- Vacuum chamber, one thin window, large area GEM chambers (better resolution)



PRIMEX HYCAL CALORIMETER

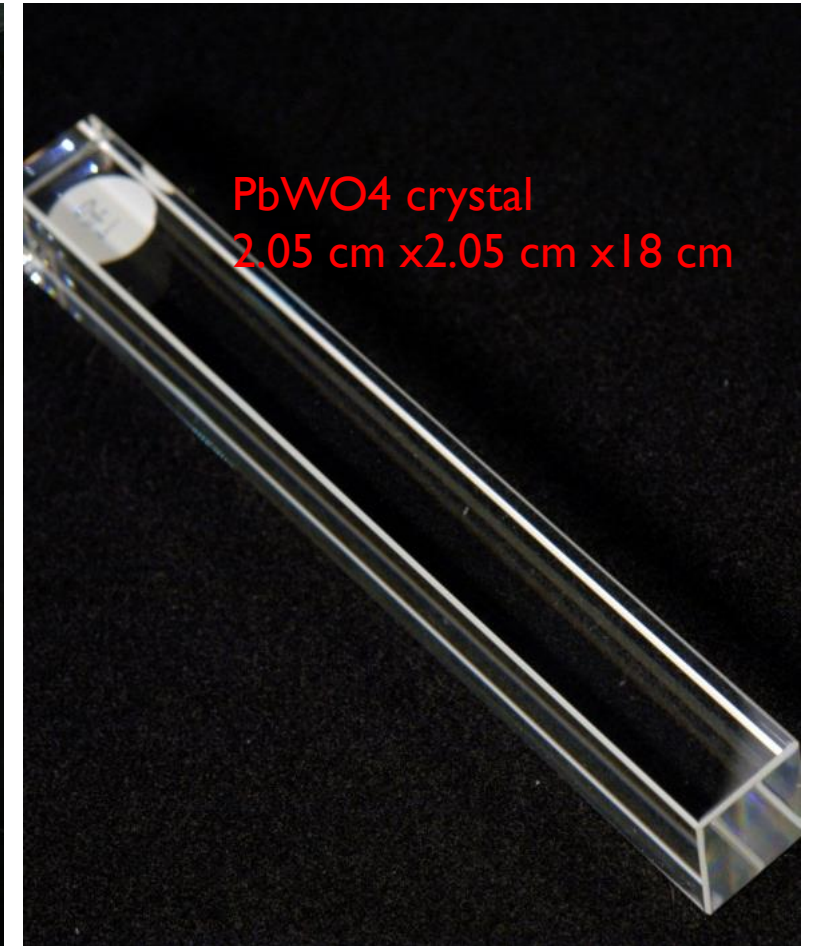
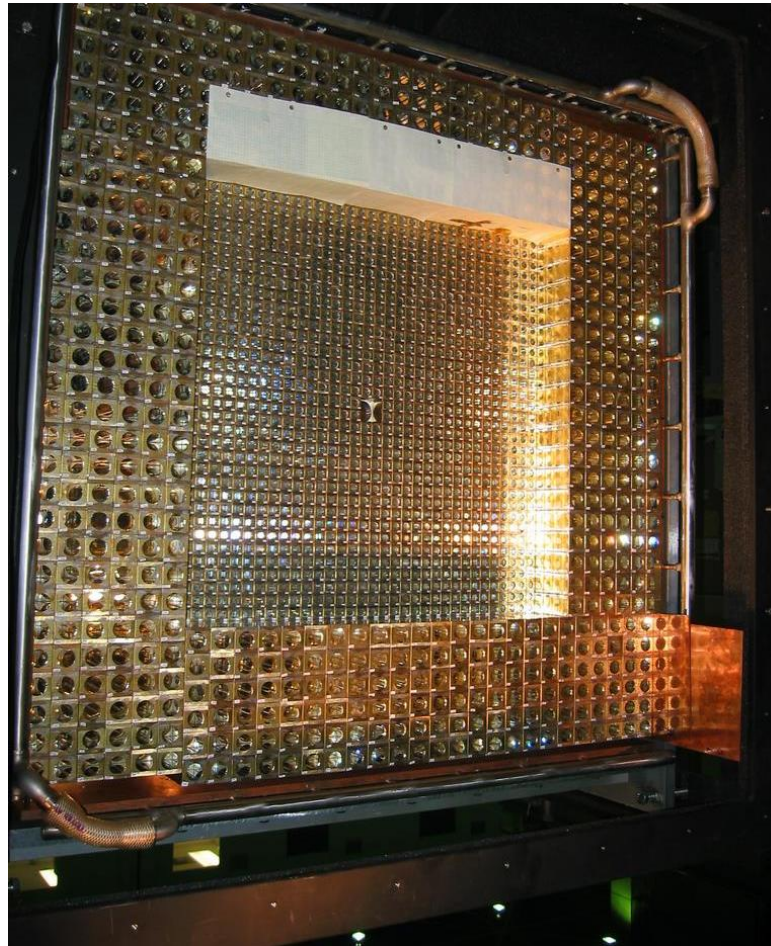
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- Combination of PbWO_4 and Pb-glass detectors ($118 * 118 \text{ cm}^2$)
- $34 * 34$ matrix of $2.05 \times 2.05 \times 18 \text{ cm}^3$ PbWO_4
- 576 Pb-glass detectors $3.82 \times 3.82 \text{ cm}^2$ x 45 cm.
- Allows coverage of extreme forward angle ($0.7^\circ - 7.5^\circ$) in a single setting and complete azimuthal angle coverage.
- HyCal reused for PRAD experiment.
- The first experiment to use a magnetic spectrometer free method to measure

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PRAD COLLABORATION MEETING

4/15



03/03/2025

5/15

HYCAL TESTS

- HyCal optical fiber and connection repairs
- HyCal cabling- Erik W.
- HyCal HV test with cosmics
- HyCal HV test with LMS

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PRAD COLLABORATION MEETING



HYCAL OPTICAL FIBER AND CONNECTION REPAIR








- The optical fibers, plexiglass connectors, and light blocking coverings necessary for the Light Monitoring System (LMS) to send control signals to the HyCal modules required repairs to have all ~2000 modules in proper working order.
- These fibers can be used to test the various modules as well as be used as a control signal during experiment and calibration.
- HyCal is in the ESB at JLab where an ePAS approval needed to be filed for the work as it involved clear UV-activated glue for securing the optical components to each module.



HyCal Layout (Row Column) (Front View - PbWO4 ONLY)																																
1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34
2.02	2.03	2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12	2.13	2.14	2.15	2.16	2.17	2.18	2.19	2.20	2.21	2.22	2.23	2.24	2.25	2.26	2.27	2.28	2.29	2.30	2.31	2.32	2.33	2.34
3.02	3.03	3.04	3.05	3.06	3.07	3.08	3.09	3.10	3.11	3.12	3.13	3.14	3.15	3.16	3.17	3.18	3.19	3.20	3.21	3.22	3.23	3.24	3.25	3.26	3.27	3.28	3.29	3.30	3.31	3.32	3.33	3.34
4.02	4.03	4.04	4.05	4.06	4.07	4.08	4.09	4.10	4.11	4.12	4.13	4.14	4.15	4.16	4.17	4.18	4.19	4.20	4.21	4.22	4.23	4.24	4.25	4.26	4.27	4.28	4.29	4.30	4.31	4.32	4.33	4.34
5.02	5.03	5.04	5.05	5.06	5.07	5.08	5.09	5.10	5.11	5.12	5.13	5.14	5.15	5.16	5.17	5.18	5.19	5.20	5.21	5.22	5.23	5.24	5.25	5.26	5.27	5.28	5.29	5.30	5.31	5.32	5.33	5.34
6.02	6.03	6.04	6.05	6.06	6.07	6.08	6.09	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.17	6.18	6.19	6.20	6.21	6.22	6.23	6.24	6.25	6.26	6.27	6.28	6.29	6.30	6.31	6.32	6.33	6.34
7.02	7.03	7.04	7.05	7.06	7.07	7.08	7.09	7.10	7.11	7.12	7.13	7.14	7.15	7.16	7.17	7.18	7.19	7.20	7.21	7.22	7.23	7.24	7.25	7.26	7.27	7.28	7.29	7.30	7.31	7.32	7.33	7.34
8.02	8.03	8.04	8.05	8.06	8.07	8.08	8.09	8.10	8.11	8.12	8.13	8.14	8.15	8.16	8.17	8.18	8.19	8.20	8.21	8.22	8.23	8.24	8.25	8.26	8.27	8.28	8.29	8.30	8.31	8.32	8.33	8.34
9.02	9.03	9.04	9.05	9.06	9.07	9.08	9.09	9.10	9.11	9.12	9.13	9.14	9.15	9.16	9.17	9.18	9.19	9.20	9.21	9.22	9.23	9.24	9.25	9.26	9.27	9.28	9.29	9.30	9.31	9.32	9.33	9.34
10.02	10.03	10.04	10.05	10.06	10.07	10.08	10.09	10.10	10.11	10.12	10.13	10.14	10.15	10.16	10.17	10.18	10.19	10.20	10.21	10.22	10.23	10.24	10.25	10.26	10.27	10.28	10.29	10.30	10.31	10.32	10.33	10.34
11.02	11.03	11.04	11.05	11.06	11.07	11.08	11.09	11.10	11.11	11.12	11.13	11.14	11.15	11.16	11.17	11.18	11.19	11.20	11.21	11.22	11.23	11.24	11.25	11.26	11.27	11.28	11.29	11.30	11.31	11.32	11.33	11.34
12.02	12.03	12.04	12.05	12.06	12.07	12.08	12.09	12.10	12.11	12.12	12.13	12.14	12.15	12.16	12.17	12.18	12.19	12.20	12.21	12.22	12.23	12.24	12.25	12.26	12.27	12.28	12.29	12.30	12.31	12.32	12.33	12.34
13.02	13.03	13.04	13.05	13.06	13.07	13.08	13.09	13.10	13.11	13.12	13.13	13.14	13.15	13.16	13.17	13.18	13.19	13.20	13.21	13.22	13.23	13.24	13.25	13.26	13.27	13.28	13.29	13.30	13.31	13.32	13.33	13.34
14.02	14.03	14.04	14.05	14.06	14.07	14.08	14.09	14.10	14.11	14.12	14.13	14.14	14.15	14.16	14.17	14.18	14.19	14.20	14.21	14.22	14.23	14.24	14.25	14.26	14.27	14.28	14.29	14.30	14.31	14.32	14.33	14.34
15.02	15.03	15.04	15.05	15.06	15.07	15.08	15.09	15.10	15.11	15.12	15.13	15.14	15.15	15.16	15.17	15.18	15.19	15.20	15.21	15.22	15.23	15.24	15.25	15.26	15.27	15.28	15.29	15.30	15.31	15.32	15.33	15.34
16.02	16.03	16.04	16.05	16.06	16.07	16.08	16.09	16.10	16.11	16.12	16.13	16.14	16.15	16.16	16.17	16.18	16.19	16.20	16.21	16.22	16.23	16.24	16.25	16.26	16.27	16.28	16.29	16.30	16.31	16.32	16.33	16.34
17.02	17.03	17.04	17.05	17.06	17.07	17.08	17.09	17.10	17.11	17.12	17.13	17.14	17.15	17.16	17.17	17.18	17.19	17.20	17.21	17.22	17.23	17.24	17.25	17.26	17.27	17.28	17.29	17.30	17.31	17.32	17.33	17.34
18.02	18.03	18.04	18.05	18.06	18.07	18.08	18.09	18.10	18.11	18.12	18.13	18.14	18.15	18.16	18.17	18.18	18.19	18.20	18.21	18.22	18.23	18.24	18.25	18.26	18.27	18.28	18.29	18.30	18.31	18.32	18.33	18.34
19.02	19.03	19.04	19.05	19.06	19.07	19.08	19.09	19.10	19.11	19.12	19.13	19.14	19.15	19.16	19.17	19.18	19.19	19.20	19.21	19.22	19.23	19.24	19.25	19.26	19.27	19.28	19.29	19.30	19.31	19.32	19.33	19.34
20.02	20.03	20.04	20.05	20.06	20.07	20.08	20.09	20.10	20.11	20.12	20.13	20.14	20.15	20.16	20.17	20.18	20.19	20.20	20.21	20.22	20.23	20.24	20.25	20.26	20.27	20.28	20.29	20.30	20.31	20.32	20.33	20.34
21.02	21.03	21.04	21.05	21.06	21.07	21.08	21.09	21.10	21.11	21.12	21.13	21.14	21.15	21.16	21.17	21.18	21.19	21.20	21.21	21.22	21.23	21.24	21.25	21.26	21.27	21.28	21.29	21.30	21.31	21.32	21.33	21.34
22.02	22.03	22.04	22.05	22.06	22.07	22.08	22.09	22.10	22.11	22.12	22.13	22.14	22.15	22.16	22.17	22.18	22.19	22.20	22.21	22.22	22.23	22.24	22.25	22.26	22.27	22.28	22.29	22.30	22.31	22.32	22.33	22.34
23.02	23.03	23.04	23.05	23.06	23.07	23.08	23.09	23.10	23.11	23.12	23.13	23.14	23.15	23.16	23.17	23.18	23.19	23.20	23.21	23.22	23.23	23.24	23.25	23.26	23.27	23.28	23.29	23.30	23.31	23.32	23.33	23.34
24.02	24.03	24.04	24.05	24.06	24.07	24.08	24.09	24.10	24.11	24.12	24.13	24.14	24.15	24.16	24.17	24.18	24.19	24.20	24.21	24.22	24.23	24.24	24.25	24.26	24.27	24.28	24.29	24.30	24.31	24.32	24.33	24.34
25.02	25.03	25.04	25.05	25.06	25.07	25.08	25.09	25.10	25.11	25.12	25.13	25.14	25.15	25.16	25.17	25.18	25.19	25.20	25.21	25.22	25.23	25.24	25.25	25.26	25.27	25.28	25.29	25.30	25.31	25.32	25.33	25.34
26.02	26.03	26.04	26.05	26.06	26.07	26.08	26.09	26.10	26.11	26.12	26.13	26.14	26.15	26.16	26.17	26.18	26.19	26.20	26.21	26.22	26.23	26.24	26.25	26.26	26.27	26.28	26.29	26.30	26.31	26.32	26.33	26.34
27.02	27.03	27.04	27.05	27.06	27.07	27.08	27.09	27.10	27.11	27.12	27.13	27.14	27.15	27.16	27.17	27.18	27.19	27.20	27.21	27.22	27.23	27.24	27.25	27.26	27.27	27.28	27.29	27.30	27.31	27.32	27.33	27.34
28.02	28.03	28.04	28.05	28.06	28.07	28.08	28.09	28.10	28.11	28.12	28.13	28.14	28.15	28.16	28.17	28.18	28.19	28.20	28.21	28.22	28.23	28.24	28.25	28.26	28.27	28.28	28.29	28.30	28.31	28.32	28.33	28.34
29.02	29.03	29.04	29.05	29.06	29.07	29.08	29.09	29.10	29.11	29.12	29.13	29.14	29.15	29.16	29.17	29.18	29.19	29.20	29.21	29.22	29.23	29.24	29.25	29.26	29.27	29.28	29.29	29.30	29.31	29.32	29.33	29.34
30.02	30.03	30.04	30.05	30.06	30.07	30.08	30.09	30.10	30.11	30.12	30.13	30.14	30.15	30.16	30.17	30.18	30.19	30.20	30.21	30.22	30.23	30.24	30.25	30.26	30.27	30.28	30.29	30.30	30.31	30.32	30.33	30.34
31.02	31.03	31.04	31.05	31.06	31.07	31.08	31.09	31.10	31.11	31.12	31.13	31.14	31.15	31.16	31.17	31.18	31.19	31.20	31.21	31.22	31.23	31.24	31.25	31.26	31.27	31.28	31.29	31.30	31.31	31.32	31.33	31.34
32.02	32.03	32.04	32.05	32.06	32.07	32.08	32.09	32.10	32.11	32.12	32.13	32.14	32.15	32.16	32.17	32.18	32.19	32.20	32.21	32.22	32.23	32.24	32.25	32.26	32.27	32.28	32.29	32.30	32.31	32.32	32.33	32.34
33.02	33.03	33.04	33.05	33.06	33.07	33.08	33.09	33.10	33.11	33.12	33.13	33.14	33.15	33.16	33.17	33.18	33.19	33.20	33.21	33.22	33.23	33.24	33.25	33.26	33.27	33.28	33.29	33.30	33.31	33.32	33.33	33.34
34.02	34.03	34.04	34.05	34.06	34.07	34.08	34.09	34.10	34.11	34.12	34.13	34.14	34.15	34.16	34.17	34.18	34.19	34.20	34.21	34.22	34.23	34.24	34.25	34.26	34.27	34.28	34.29	34.30	34.31	34.32	34.33	34.34

PbWO4 - NOTES
6.11 - Fiber is disconnected
32.04 - Fiber is disconnected
21.10 - Fixed Black Tape
17.10 - Fiber is disconnected
13.18 - - Fiber is disconnected
14.18 - Fiber is disconnected
14.19 - Fiber is disconnected
16.20 - Fiber is disconnected
17.20 - Fiber is disconnected
18.20 - Fiber is disconnected
19.20 - Fiber is disconnected
16.26 - Fiber is loose
6.27 - Fiber is disconnected
9.29 - Fiber is disconnected
5.30 - Fiber is loose
6.31 - Fiber is loose
28.33 - Fiber is loose
23.31 - Black tape needs to be fixed

Temperature Sensors	Simulator Notation	Module ID
11.01	W341	1341
24.09	W791	1791
11.10	W350	1350
18.13	W591	1591
17.20	W566	1566
25.24	W840	1840
24.34	W816	1816
11.25	W365	1365

Key	
	Temperature Sensor
	Issue
	Empty
	Under Tungsten Absorber
	Issue/Temperature Sensor
	Repaired/Found to be good
	Repaired/Under Tungsten Absorber

HyCal optical fiber repair mapping spreadsheet for PbWO

1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30
2.01	2.02	2.03	2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12	2.13	2.14	2.15	2.16	2.17	2.18	2.19	2.20	2.21	2.22	2.23	2.24	2.25	2.26	2.27	2.28	2.29	2.30
3.01	3.02	3.03	3.04	3.05	3.06	3.07	3.08	3.09	3.10	3.11	3.12	3.13	3.14	3.15	3.16	3.17	3.18	3.19	3.20	3.21	3.22	3.23	3.24	3.25	3.26	3.27	3.28	3.29	3.30
4.01	4.02	4.03	4.04	4.05	4.06	4.07	4.08	4.09	4.10	4.11	4.12	4.13	4.14	4.15	4.16	4.17	4.18	4.19	4.20	4.21	4.22	4.23	4.24	4.25	4.26	4.27	4.28	4.29	4.30
5.01	5.02	5.03	5.04	5.05	5.06	5.07	5.08	5.09	5.10	5.11	5.12	5.13	5.14	5.15	5.16	5.17	5.18	5.19	5.20	5.21	5.22	5.23	5.24	5.25	5.26	5.27	5.28	5.29	5.30
6.01	6.02	6.03	6.04	6.05	6.06	6.07	6.08	6.09	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.17	6.18	6.19	6.20	6.21	6.22	6.23	6.24	6.25	6.26	6.27	6.28	6.29	6.30
7.01	7.02	7.03	7.04	7.05	7.06																			7.25	7.26	7.27	7.28	7.29	7.30
8.01	8.02	8.03	8.04	8.05	8.06																			8.25	8.26	8.27	8.28	8.29	8.30
9.01	9.02	9.03	9.04	9.05	9.06																			9.25	9.26	9.27	9.28	9.29	9.30
10.01	10.02	10.03	10.04	10.05	10.06																			10.25	10.26	10.27	10.28	10.29	10.30
11.01	11.02	11.03	11.04	11.05	11.06																			11.25	11.26	11.27	11.28	11.29	11.30
12.01	12.02	12.03	12.04	12.05	12.06																			12.25	12.26	12.27	12.28	12.29	12.30
13.01	13.02	13.03	13.04	13.05	13.06																			13.25	13.26	13.27	13.28	13.29	13.30
14.01	14.02	14.03	14.04	14.05	14.06																			14.25	14.26	14.27	14.28	14.29	14.30
15.01	15.02	15.03	15.04	15.05	15.06																			15.25	15.26	15.27	15.28	15.29	15.30
16.01	16.02	16.03	16.04	16.05	16.06																			16.25	16.26	16.27	16.28	16.29	16.30
17.01	17.02	17.03	17.04	17.05	17.06																			17.25	17.26	17.27	17.28	17.29	17.30
18.01	18.02	18.03	18.04	18.05	18.06																			18.25	18.26	18.27	18.28	18.29	18.30
19.01	19.02	19.03	19.04	19.05	19.06																			19.25	19.26	19.27	19.28	19.29	19.30
20.01	20.02	20.03	20.04	20.05	20.06																			20.25	20.26	20.27	20.28	20.29	20.30
21.01	21.02	21.03	21.04	21.05	21.06																			21.25	21.26	21.27	21.28	21.29	21.30
22.01	22.02	22.03	22.04	22.05	22.06																			22.25	22.26	22.27	22.28	22.29	22.30
23.01	23.02	23.03	23.04	23.05	23.06																			23.25	23.26	23.27	23.28	23.29	23.30
24.01	24.02	24.03	24.04	24.05	24.06																			24.25	24.26	24.27	24.28	24.29	24.30
25.01	25.02	25.03	25.04	25.05	25.06	25.07	25.08	25.09	25.10	25.11	25.12	25.13	25.14	25.15	25.16	25.17	25.18	25.19	25.20	25.21	25.22	25.23	25.24	25.25	25.26	25.27	25.28	25.29	25.30
26.01	26.02	26.03	26.04	26.05	26.06	26.07	26.08	26.09	26.10	26.11	26.12	26.13	26.14	26.15	26.16	26.17	26.18	26.19	26.20	26.21	26.22	26.23	26.24	26.25	26.26	26.27	26.28	26.29	26.30
27.01	27.02	27.03	27.04	27.05	27.06	27.07	27.08	27.09	27.10	27.11	27.12	27.13	27.14	27.15	27.16	27.17	27.18	27.19	27.20	27.21	27.22	27.23	27.24	27.25	27.26	27.27	27.28	27.29	27.30
28.01	28.02	28.03	28.04	28.05	28.06	28.07	28.08	28.09	28.10	28.11	28.12	28.13	28.14	28.15	28.16	28.17	28.18	28.19	28.20	28.21	28.22	28.23	28.24	28.25	28.26	28.27	28.28	28.29	28.30
29.01	29.02	29.03	29.04	29.05	29.06	29.07	29.08	29.09	29.10	29.11	29.12	29.13	29.14	29.15	29.16	29.17	29.18	29.19	29.20	29.21	29.22	29.23	29.24	29.25	29.26	29.27	29.28	29.29	29.30
30.01	30.02	30.03	30.04	30.05	30.06	30.07	30.08	30.09	30.10	30.11	30.12	30.13	30.14	30.15	30.16	30.17	30.18	30.19	30.20	30.21	30.22	30.23	30.24	30.25	30.26	30.27	30.28	30.29	30.30

PbGlass - NOTES	
2.01 - Fiber is loose	
20.03 - Fiber is loose	
20.04 - Fiber is loose	
30.01 - Fiber is loose	
27.04 - Fiber is disconnected	
3.25 - loose	
6.20 - loose connection	
1.09 - Fix tape	
2.09 - Fix tape	
5.21 - Fiber is loose	
25.08 - Fiber is loose	
27.08 - Fiber is loose	
3.29,20.01 - Fiber disconnected	
16.28 - Fiber is loose	
20.25 - Fiber is loose	
25.27 - Fiber is loose	
25.28 - Fiber is loose	
26.28 - Fiber is loose	
30.30 - Fiber is loose	
30.24 - Fiber is loose	
25.24 - Fiber is loose	
27.22 - Fiber is loose	
29.10 - Fiber is loose	
18.04 - Fiber disconnected	

Temperature Sensors	Simulator Notation	Module ID
6.13	G30	30
1.30	G163	163
18.06	G259	259
13.25	G318	318
25.18	G414	414

Key	
Orange	Temperature Sensor
Red	Issue
Black	Empty
Yellow	
Pink	Missing Plexiglass Covering (These have been fixed with Black Tape)
Red/White Striped	Issue/Temperature Sensor
Green	Repaired

HyCal optical fiber repair mapping spreadsheet for Pb-glass

HYCAL HV TEST WITH COSMICS

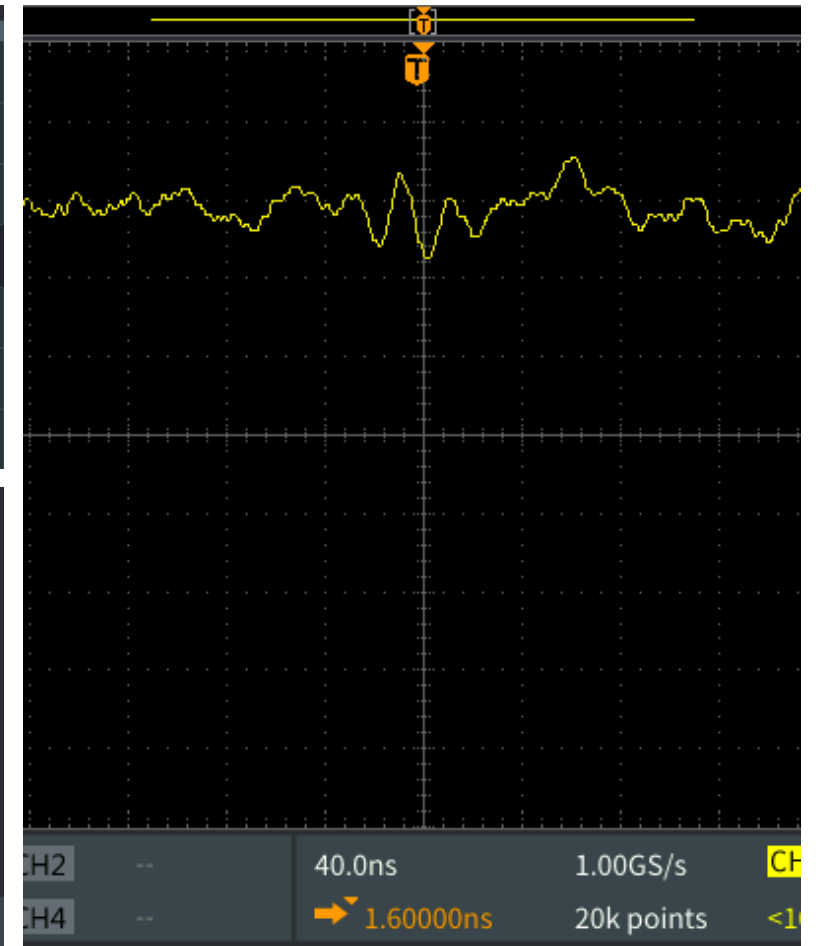
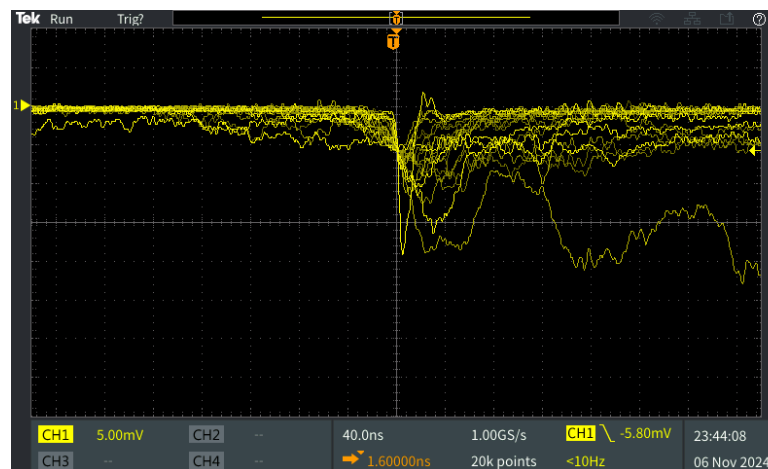
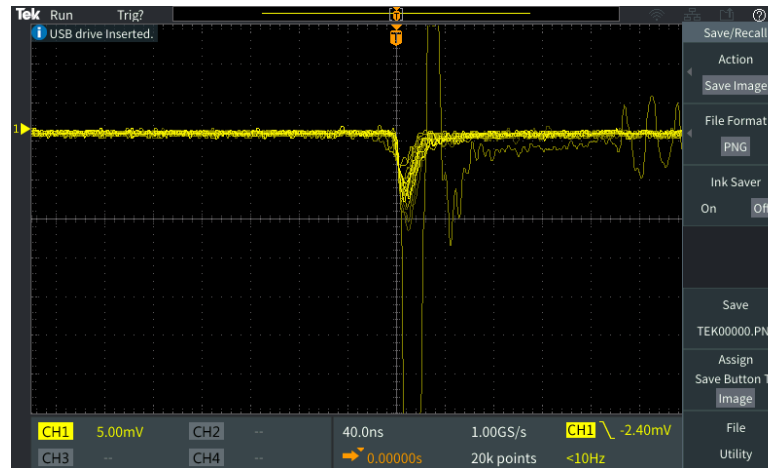
03/03/2025

- Checked all PbWO_4 modules and Pb-glass modules.
 - Average responses: 5-20 mV, ~40ns width
 - Most signals are good.
 - This was done in 2 passes.
 - Two have been labeled with PbWO_4 bad so far.
- One module was unresponsive completely.
- One module was continually giving 2 wide signals for every 1 good signal at any voltage.

PRoton
Radius

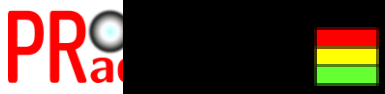
ARUNI NADEESHANI.
PRAD COLLABORATION MEETING

9/15



SUMMARY OF THE $PbWO_4$ MODULE RESPONSE MAPPING FOR COSMIC RUNS

2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975	2976	2977	2978	2979	2980	2981	2982	2983	2984	2985	2986	2987	2988	2989	2990	2991	2992	2993	2994	2995	2996	2997	2998	2999	3000
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HYCAL HV TEST WITH LMS

- Checked all PbWO_4 modules.
- Average responses : 300 mV-1200 mV,~100ns width
- Most signals are good.
- This was done by two passes.
- The blue signal: from the pulse generator used to capture any signal from the PMT that are in coincidence with the pulse.
- Yellow signal: the PMT's response to the LED pulse.
- 3 modules did not give any signal (mark as bad) and 10 channels identified as still having low voltage signal.



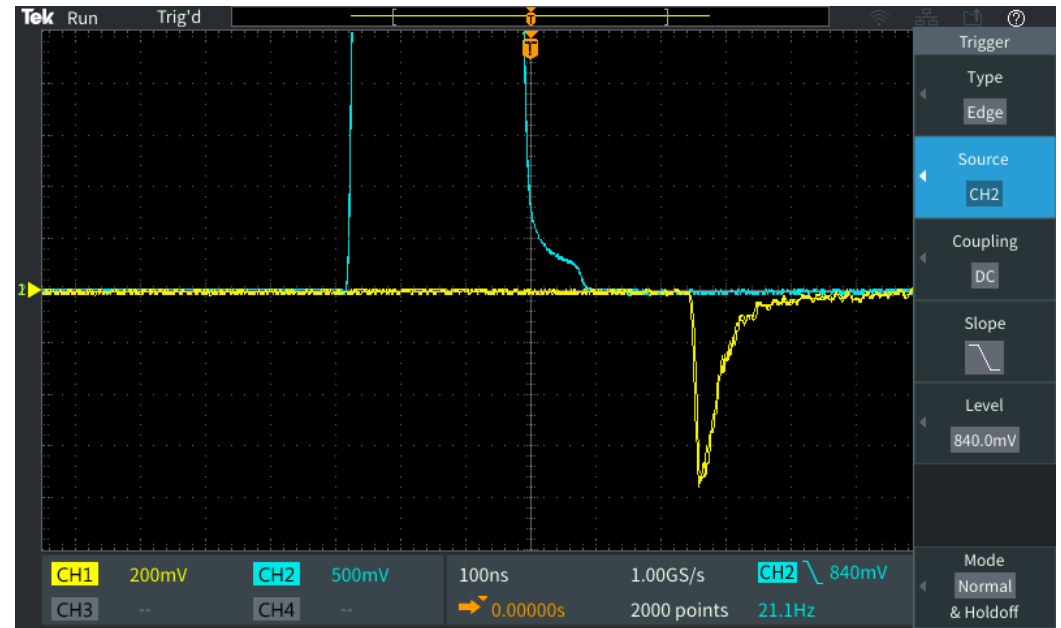
HYCAL MODULE RESPONSE MAPPING SPREADSHEET FOR PbWO₄

1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040			
1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078		
1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116		
1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154		
1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	
1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	
1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264	1265	1266	1267	1268	1269	1270	1271	
1272	1273	1274	1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	
1311	1312	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	
1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	
1389	1390	1391	1392	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424	1425	1426	1427	
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1467	1468	1469	1470	1471	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487	1488	1489	1490	1491	1492	1493	1494	1495	1496	1497	1498	1499	1500	1501	1502	1503	1504	1505	
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1584	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599	1600	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616	1617	1618	1619	1620	1621	1622	
1623	1624	1625	1626	1627	1628	1629	1630	1631	1632	1633	1634	1635	1636	1637	1638	1639	1640	1641	1642	1643	1644	1645	1646	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1661	1662
1663	1664	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679	1680	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695	1696	1697	1698	1699	1700	1701	1702
1703	1704	1705	1706	1707	1708	1709	1710	1711	1712	1713	1714	1715	1716	1717	1718	1719	1720	1721	1722	1723	1724	1725	1726	1727	1728	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739	1740	1741	1742
1743	1744	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759	1760	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775	1776	1777	1778	1779	1780	1781	1782
1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799	1800	1801	1802	1803	1804	1805	1806	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822
1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859	1860	1861	1862
1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062



HYCAL REPAIRS AFTER LMS AND COSMIC RUNS

- There are few conclusions from the LMS and cosmic runs. They are:
 - If cosmic signal present and not LMS signal : fiber disconnections.
 - If cosmic signal and LMS signal both are not working, either there is a PMT base disconnection or the PMT need to be replaced
 - If cosmic works great with lower signal for LMS : Need to connect fiber properly to the surface.
- Repairs: W392 (c05#062) which is giving consistently good cosmic responses but would not respond to LMS signal.
 - conclude that as fiber disconnection and start repair the fiber entrance.
 - After attached the fiber using new optical donuts we were able to get LMS signal. For 1000 V supply output 300 mV, 100ns and for 1150 V output is ~800 mV.



SUMMARY AND FUTURE WORK

- HyCal HV Testing:
 - All PbWO_4 modules checked with cosmics and just two module identified as bad modules (later corrected to 1).
 - Pb-Glass module checked with cosmics; identified 17 bad modules and 3 modules with some issues..
 - All PbWO_4 modules checked with cosmics; identified 3 bad modules and 10 modules need to repair fiber entrance due to low response .
- HyCal optical fiber and connection repairs:
 - All fibers identified from mechanical test were repaired. After HV test with LMS, we have more fibers which need to be repaired. Now we are working on these repairs.
- Finish Veto scintillator tests within this week .

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QUESTIONS?

ARUNI NADEESHANI.
PRAD COLLABORATION MEETING

