Jefferson Lab

BIGBITE CALORIMETER (BBCAL)
- FOR THE GMN RUN

Arun Tadepalli - Jefferson Lab

BBCAL TIMELINE & MILESTONES

REFURBISHING BBCAL

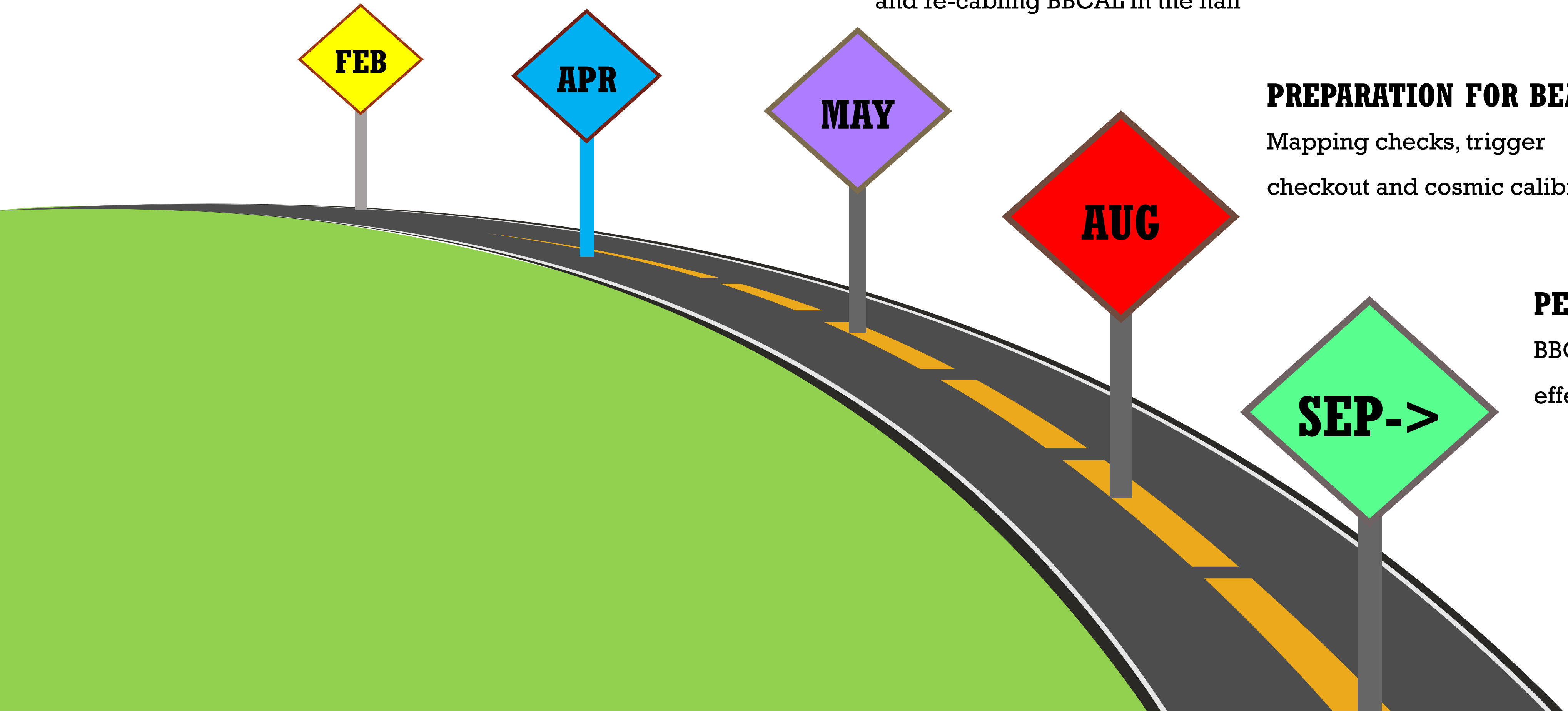
Replacing less efficient preshower and shower blocks

DEMONSTRATION AT TEDF

All connections in place, switching over to FADCs

MOVE TO HALL A

De-cabling at TEDF, successful move and re-cabling BBCAL in the hall



PREPARATION FOR BEAM

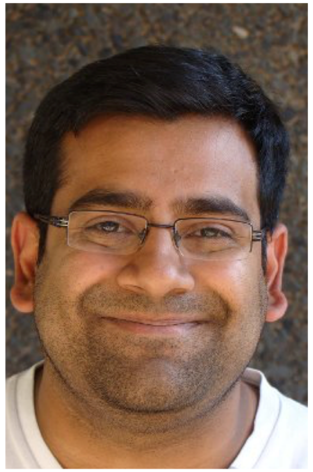
Mapping checks, trigger checkout and cosmic calibration

PERFORMANCE DURING GMN

BBCAL in-beam performance, effect of fringe fields

BBCAL TEAM

ARUN TADEPALLI - contact



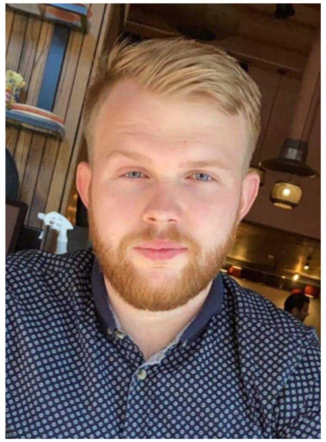
BOGDAN WOJTSEKHOWSKI

MARK JONES

WILL TIREMAN

PROVAKAR DATTA*

GARY PENMAN



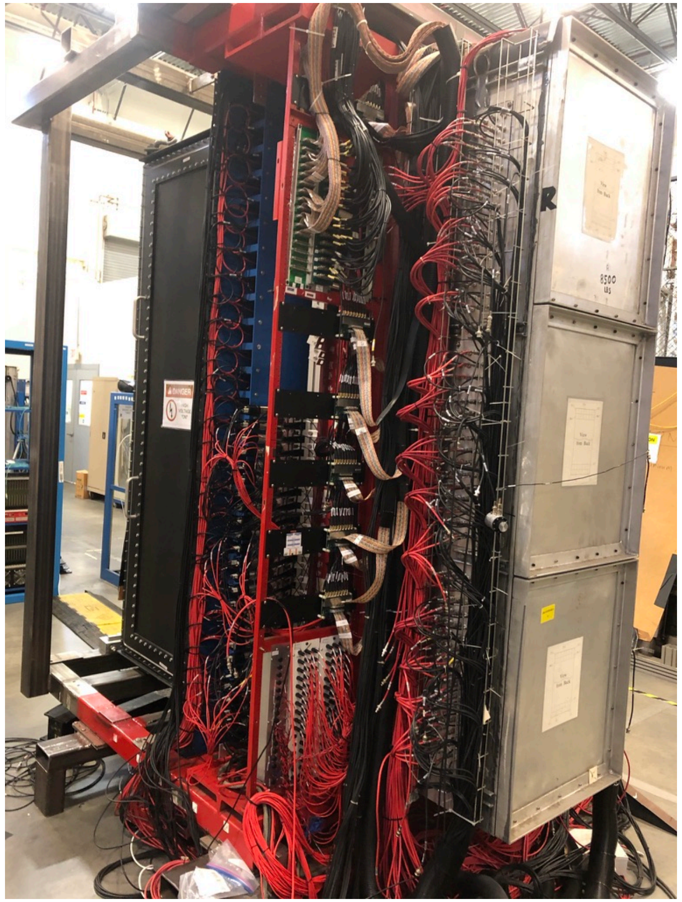
ERIC FUCHEY

Special thanks to:
Andrew Puckett – support
Dipangkar Dutta - support
Alex Camsonne - DAQ
Bryan Moffit - DAQ
Ben Raydo - DAQ
Steve Wood – HVGUI, scalers
Jessie, Robin and Jack

GENERAL DETECTOR CAPABILITIES

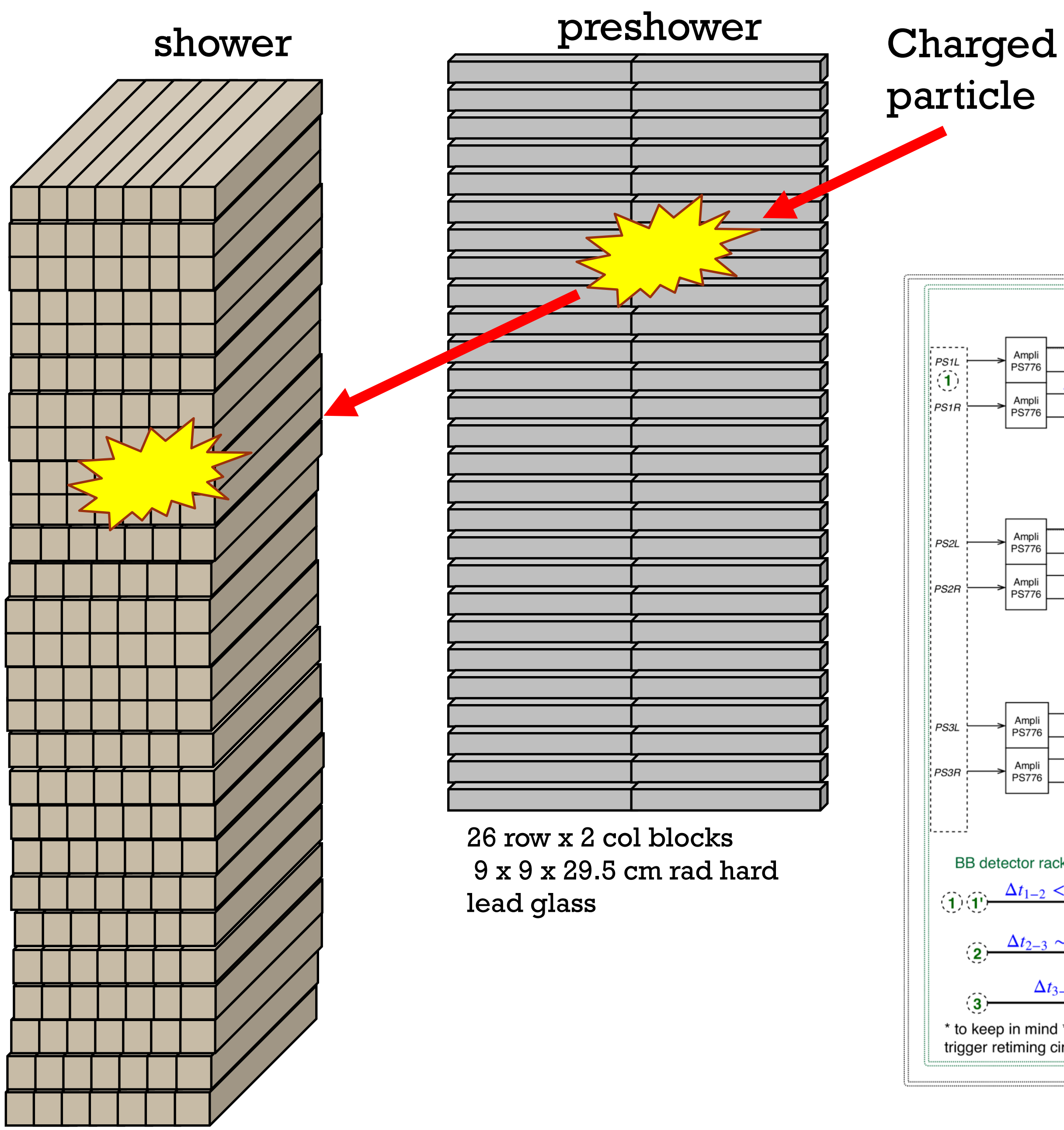
- Purpose
  - Trigger (for all experiments other than GEp)
  - Determination of energy
  - PID
  - Starting point of track reconstruction and time determination

- General principles
  - Collect Cherenkov light from relativistically charged particles including primaries and secondary e+/e- shower in electromagnetic cascades
  - Long axis of preshower perpendicular to e^- or pion
  - Long axis of shower parallel to e^- or pion



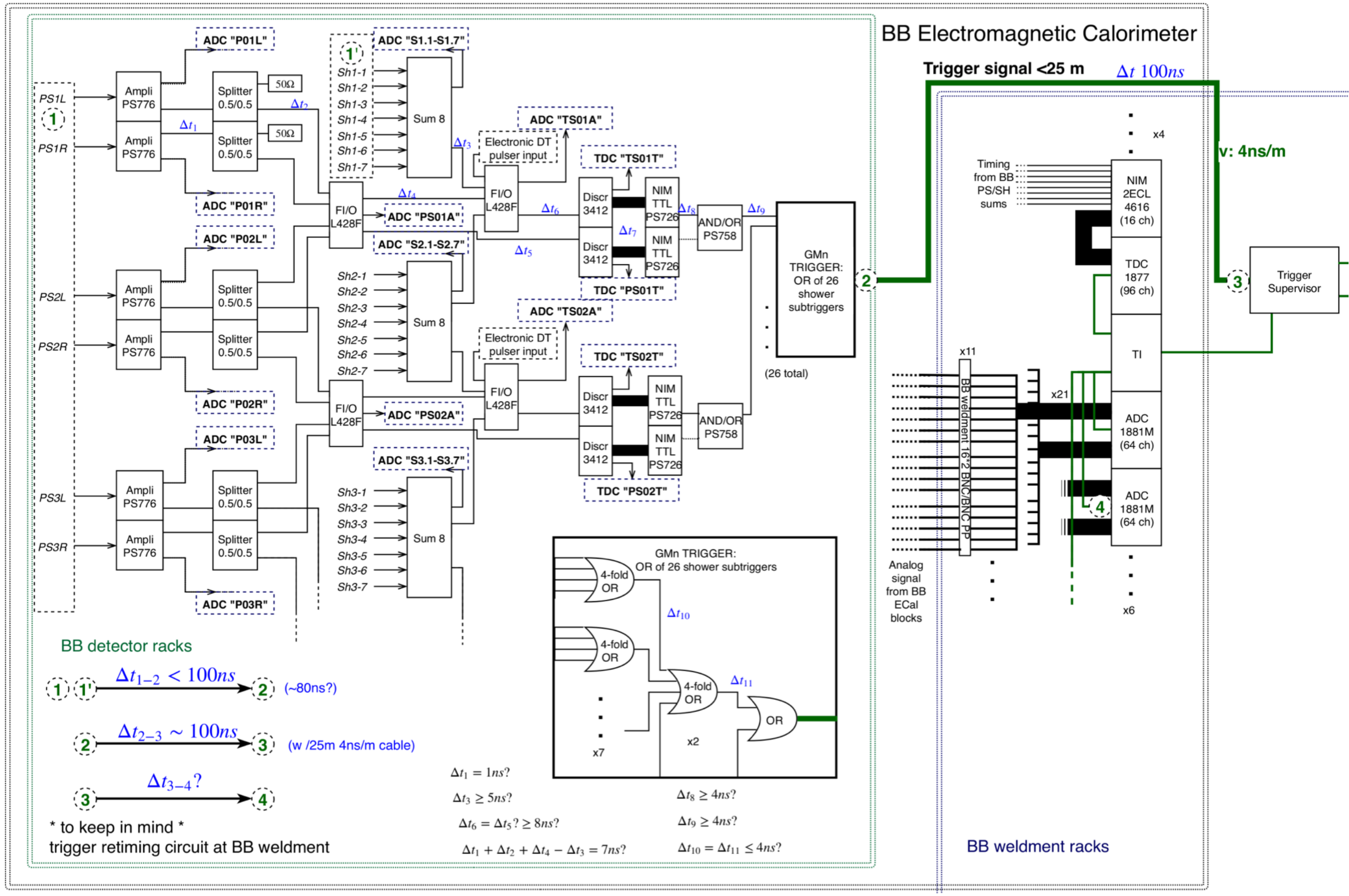
https://drive.google.com/drive/folders/1wp-CWXj9u6otH6OU8Wz1OW3F3scEEEc7?usp=sharing

TRIGGER DIAGRAM



27 row x 7 col
8.5 x 8.5 x 34 cm lead glass

26 row x 2 col blocks
9 x 9 x 29.5 cm rad hard lead glass

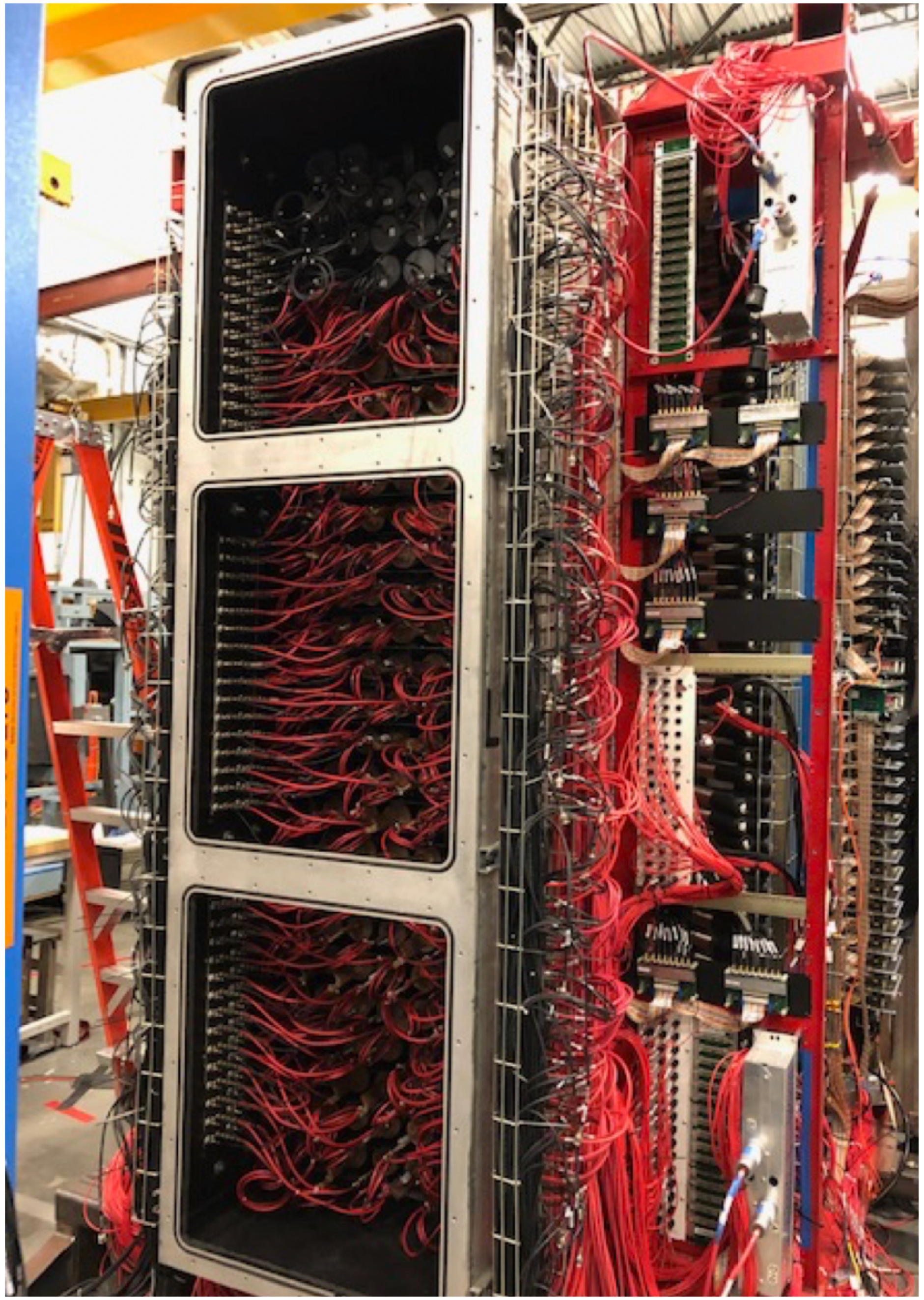


SBS Document 113-v1

Trigger concept:
PS + SH > Adjustable threshold

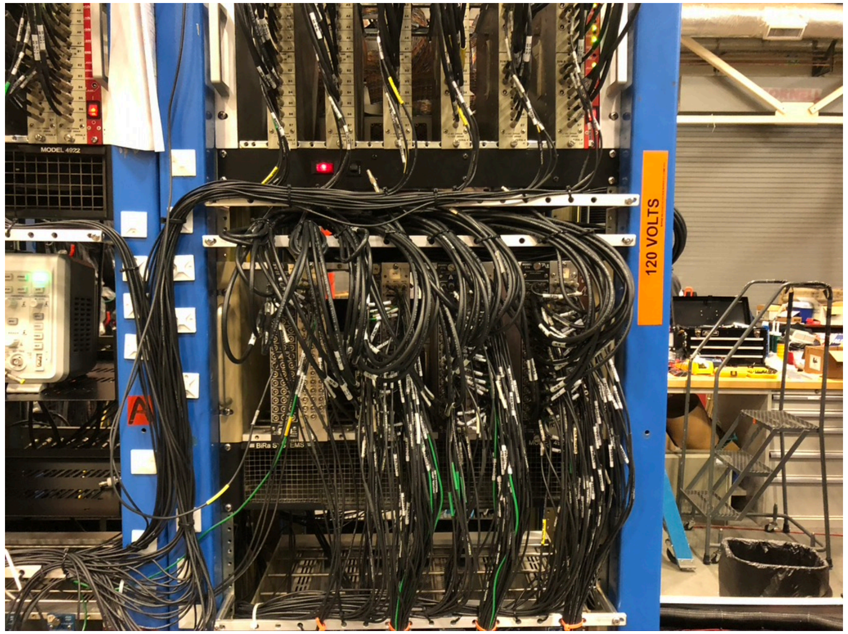
- Shower stacking with more efficient blocks and mu-metal plates

- Replaced (previously adjusted) top layers of inefficient shower blocks with good old preshower blocks

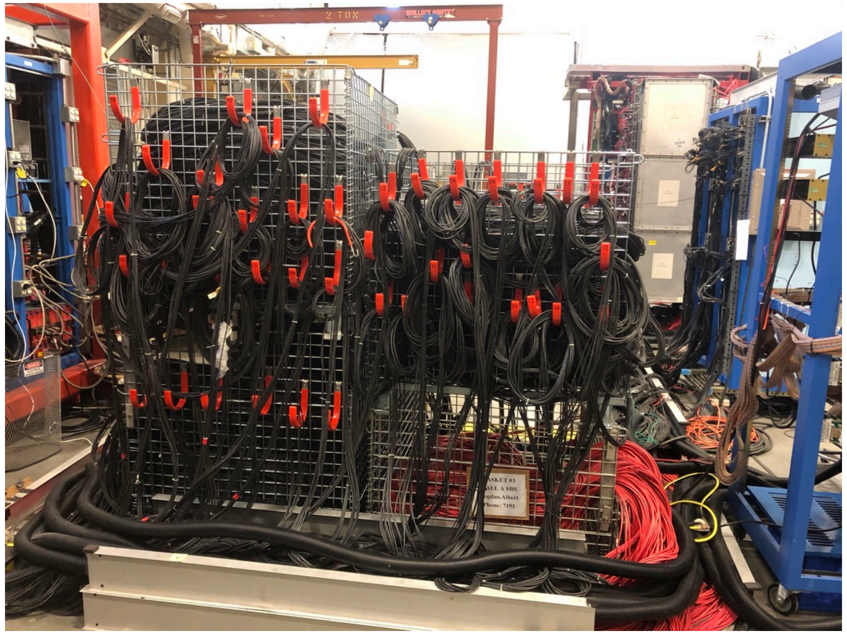


Inside the shower

Preshower stacking completed



Cabling work completed



AT TEDF…

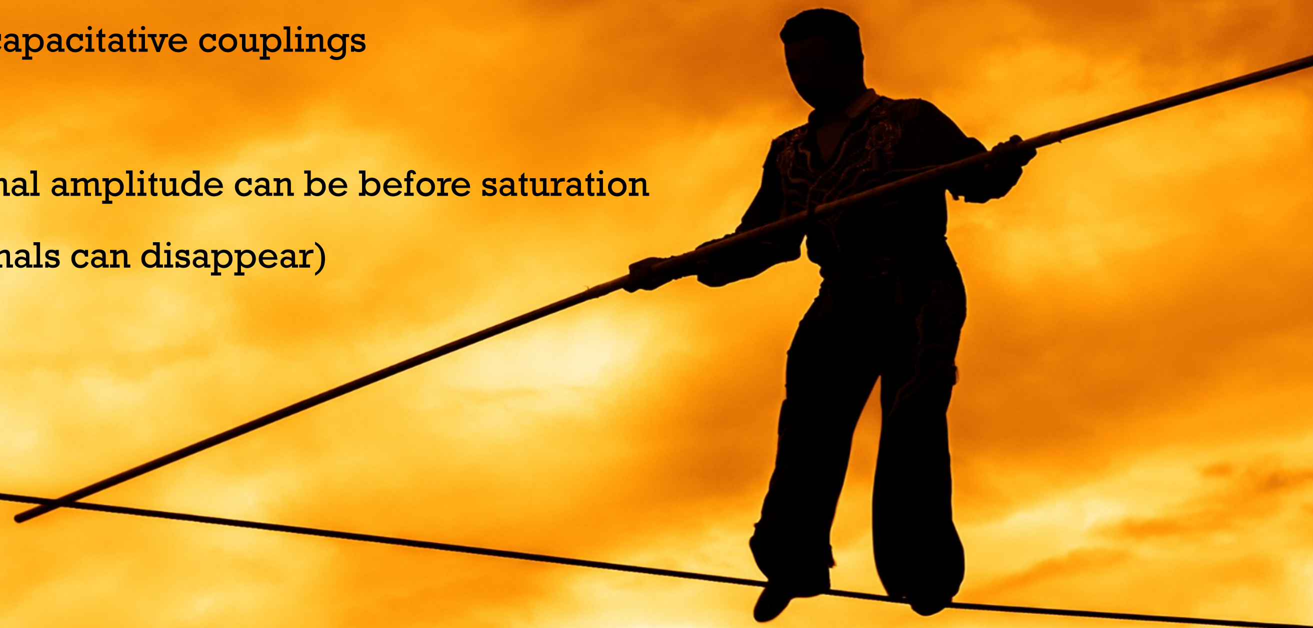
- Cabling (signal and HV) - all cables and connectors intact – completed
- Repaired broken modules in place – completed
- Light leak checks (shining flash light and checking for current on pico-ammeter) - completed
- Signals on individual channels - completed
- Looking at pedestals with HV off - completed
- Looking at the amplitude shape of the signals with HV on – completed (general noise issues pertains)
- Attaching the cosmic counter and setting up the FastBus trigger – completed
- Also set up the trigger using the sum of different layers in the shower and preshower – completed
- Checking the shape of amplitude distribution – completed
- Taking data using different HV settings for shower and preshower – completed
- Alpha studies for shower and preshower completed – completed
- Adjusting the gain and offset seen on amplifier summer modules – completed
- Checking individual channels on the discriminator – completed

For more information see BigBite calorimeter status weekly meeting updates on Sep 14th 2020, Nov 9th 2020, Jan 11th 2021

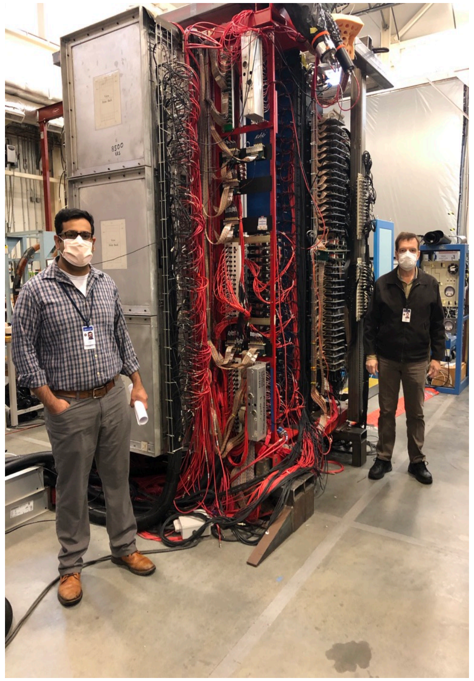
BIGBITE DETECTOR PACKAGE MOVED TO THE HALL

BBCAL TIGHTROPE

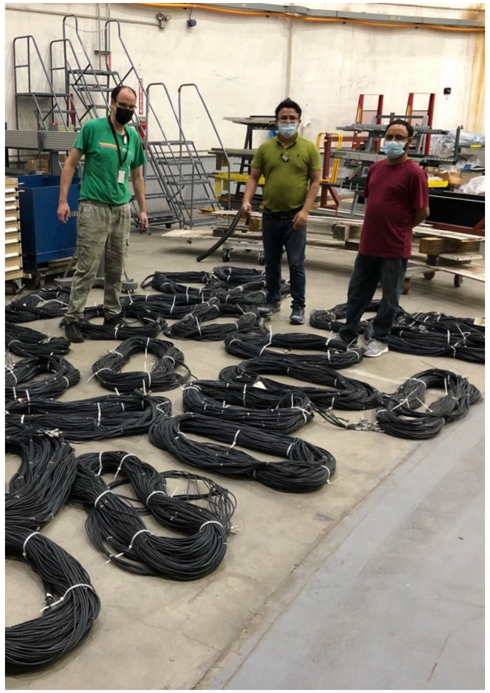
- COVID19.
- Time critical installation -> Beam start time fast approaching
- Crane issues -> Weldment (which housed all the electronics) cannot be taken into the DAQ bunker
- All the blue electronics racks had to be disconnected and reconnected in the hall
- Need to make cable extensions to go from the spectrometer to the DAQ bunker
- Cables have to be laid out so that they are not in the path of spectrometer rotations
- Avoiding baseline shifts and DC noise by installation of capacitative couplings
- Need fall training to work on the BigBite platform
- Limitation due to amplifier modules on how high the signal amplitude can be before saturation
- Strong SBS fringe fields (shower and preshower PMT signals can disappear)
- Lots of safety procedures to follow!



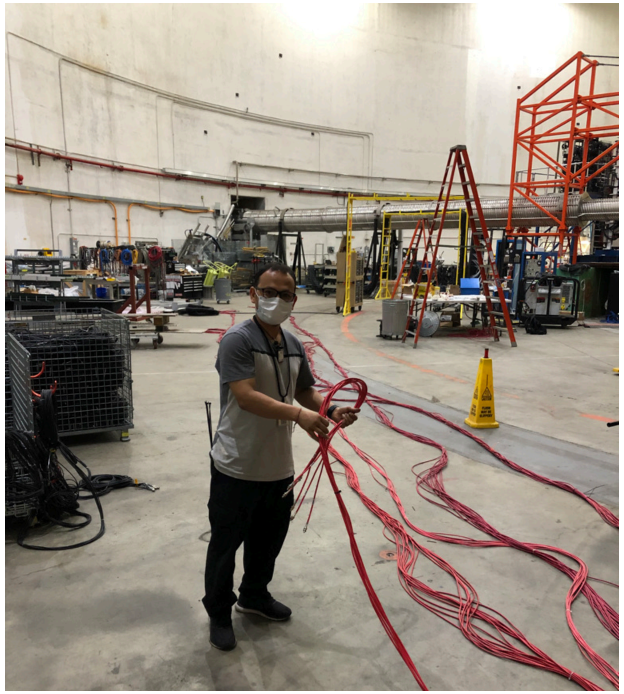
THANK YOU FOR YOUR HELP!



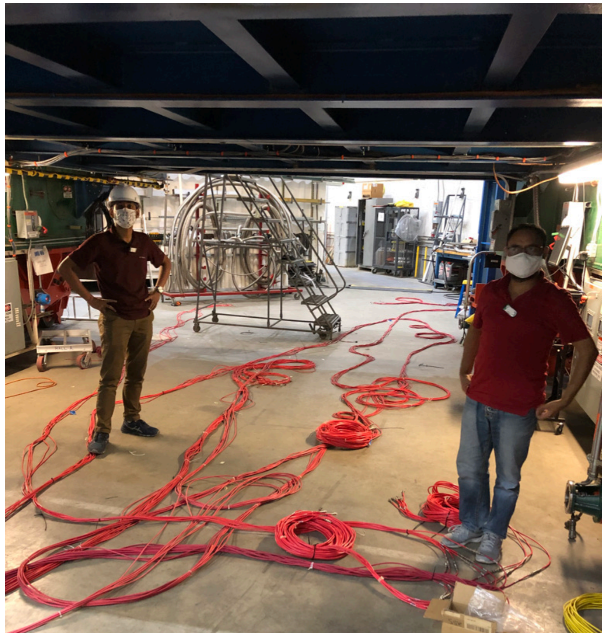
CHUCK LONG



BHESHA DEVKOTA



ABISHEK KARKI



HEM BHATT

SEBASTIAN, ZEKE

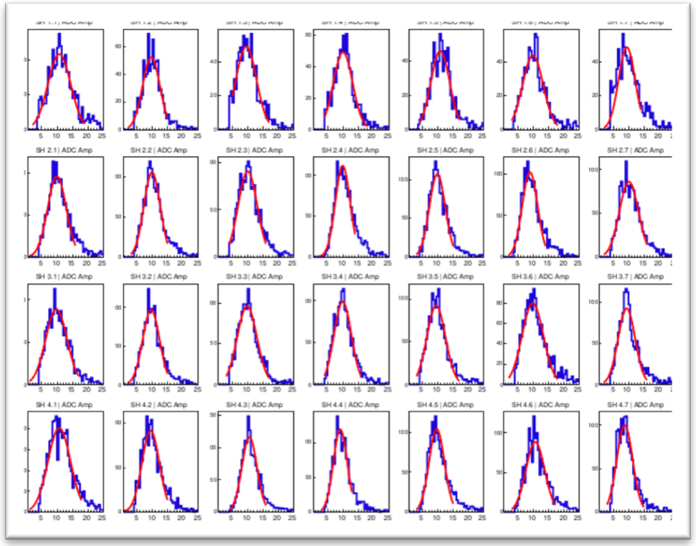
Thank you, Dipangkar!

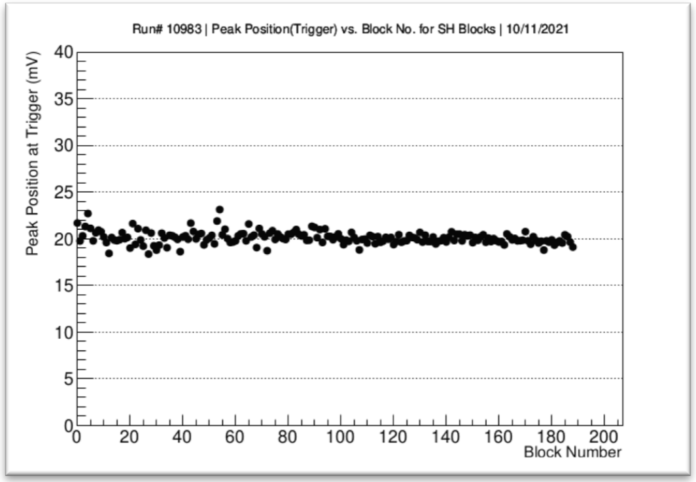
BIGBITE CALORIMETER MOVE TO THE HALL

Cabling up the calorimeter, front end electronics, and DAQ in the hall

COSMIC CALIBRATIONS IN HALL A

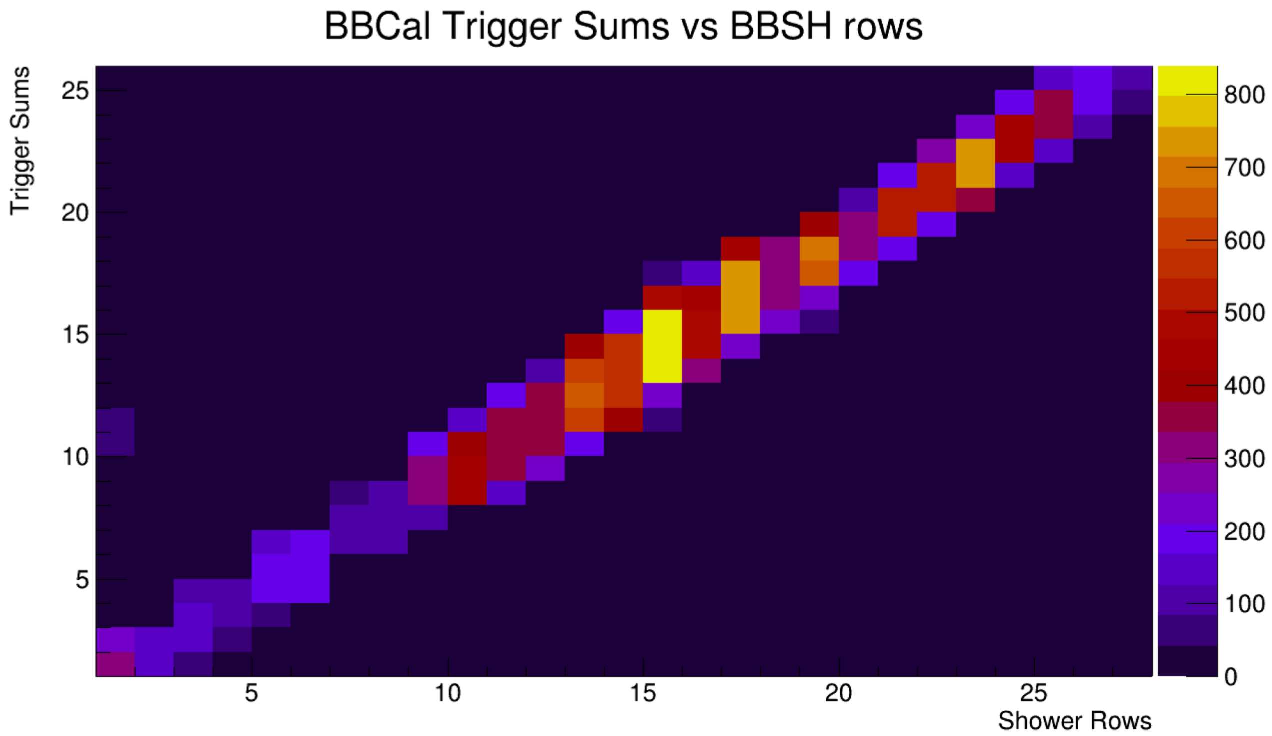
- All preshower and shower channels are working well after the detector has been fully cabled
- Cosmic calibrations of shower and preshower detectors were performed before start of the beam
- All signals were aligned at the trigger level before commissioning using a pulser





Peak amplitude at trigger

BBCAL TRIGGER WORKS AS EXPECTED



https://logbooks.jlab.org/entry/3927778

Trigger sums map

Trigger sums	Associated SH and PS Rows
SC 25-26	SH 26 + SH 27 + PS 25 + PS 26
SC 24-25	SH 25 + SH 26 + PS 24 + PS 25
SC 23-24	SH 24 + SH 25 + PS 23 + PS 24
SC 22-23	SH 23 + SH 24 + PS 22 + PS 23
SC 21-22	SH 22 + SH 23 + PS 21 + PS 22
SC 20-21	SH 21 + SH 22 + PS 20 + PS 21
SC 19-20	SH 20 + SH 21 + PS 19 + PS 20
SC 18-19	SH 18 + SH 19 + SH 20 + PS 18 + PS 19
SC 17-18	SH 17 + SH 18 + SH 19 + PS 17 + PS 18
SC 16-17	SH 16 + SH 17 + SH 18 + PS 16 + PS 17
SC 15-16	SH 15 + SH 16 + SH 17 + PS 15 + PS 16
SC 14-15	SH 14 + SH 15 + SH 16 + PS 14 + PS 15
SC 13-14	SH 13 + SH 14 + SH 15 + PS 13 + PS 14
SC 12-13	SH 12 + SH 13 + SH 14 + PS 12 + PS 13
SC 11-12	SH 11 + SH 12 + SH 13 + PS 11 + PS 12
SC 10-11	SH 10 + SH 11 + SH 12 + PS 10 + PS 11
SC 9-10	SH 9 + SH 10 + SH 11 + PS 9 + PS 10
SC 8-9	SH 8 + SH 9 + SH 10 + PS 8 + PS 9
SC 7-8	SH 7 + SH 8 + PS 7 + PS 8
SC 6-7	SH 6 + SH 7 + PS 6 + PS 7
SC 5-6	SH 5 + SH 6 + PS 5 + PS 6
SC 4-5	SH 4 + SH 5 + PS 4 + PS 5
SC 3-4	SH 3 + SH 4 + PS 3 + PS 4
SC 2-3	SH 2 + SH 3 + PS 2 + PS 3
SC 1-2	SH 1 + SH 2 + PS 1 + PS 2

- X- Axis are Shower calorimeter rows
- Y-Axis are the Trigger sums (shown on the map)
- Correlation shows that the Trigger works as expected since all the Trigger sums fire uniformly whenever individual shower rows are triggered

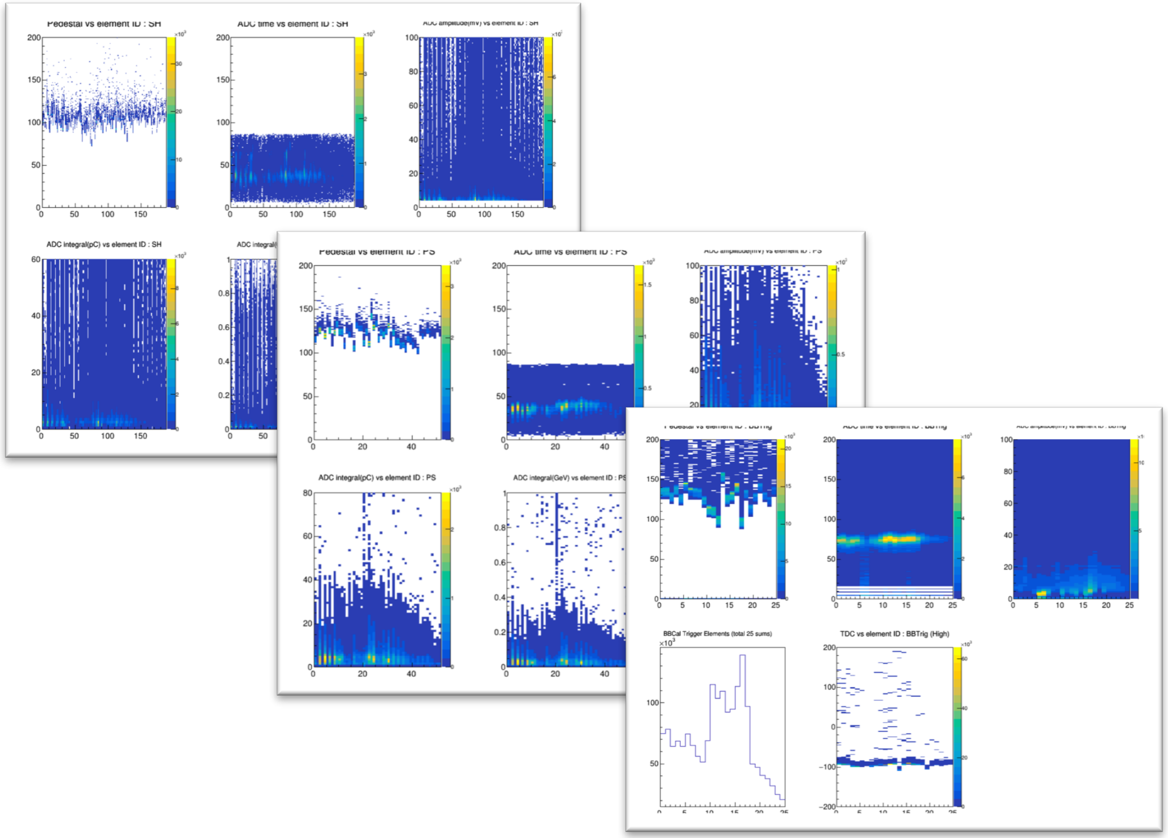
ADDITIONAL MONITORING

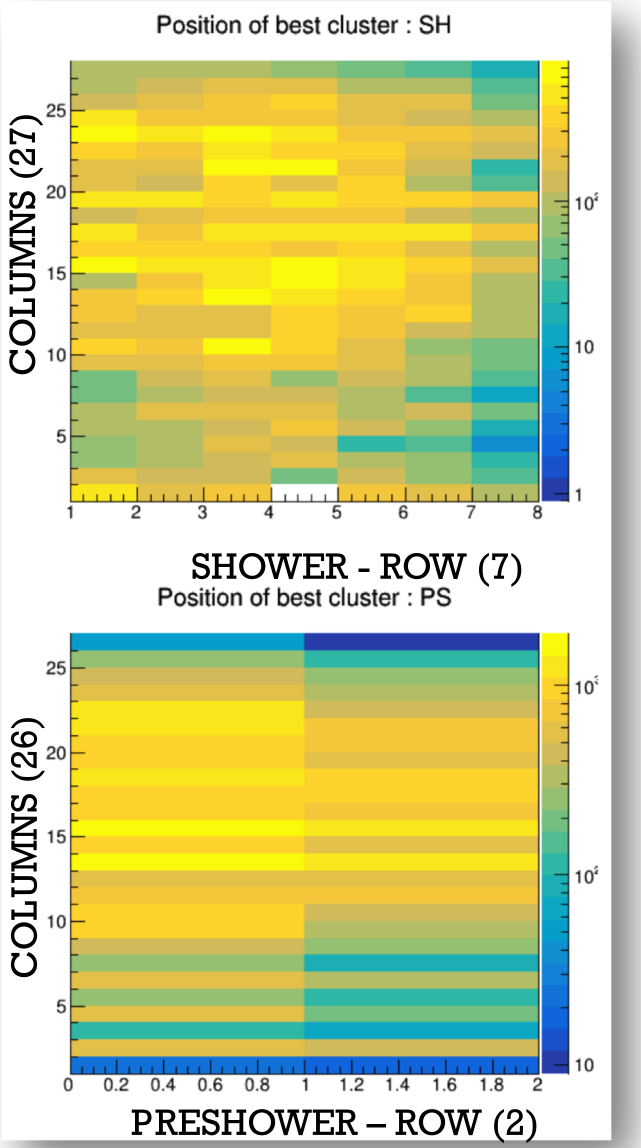
- BBCALDISCLO and HI (two sets of trigger) used for cosmics and production data
- Remotely monitorable threshold controls added
- Trigger monitor added for both the copies of discriminators
- Trigger amplitude monitor added for both the copies
- Capacitative coupling to avoid DC offset and noise
- Fans added to keep the crate cool

ONLINE MONITORING

- Online monitoring setup and BigBite calorimeter performance (ADC pedestals, time, amplitudes and integrals) being continuously monitored by shifters using diagnostic plots

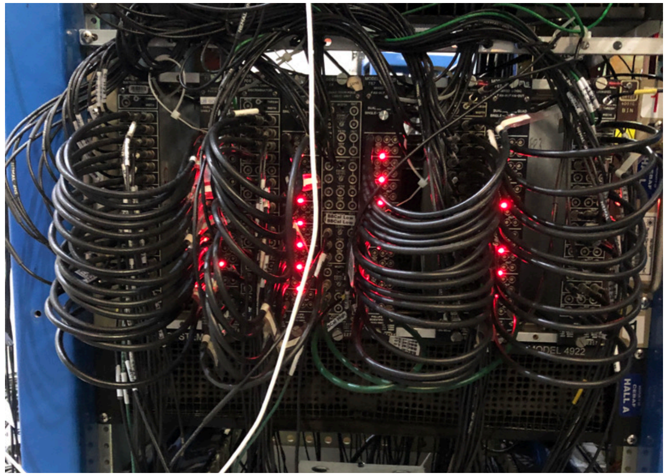
Examples of online monitoring plots run #11199





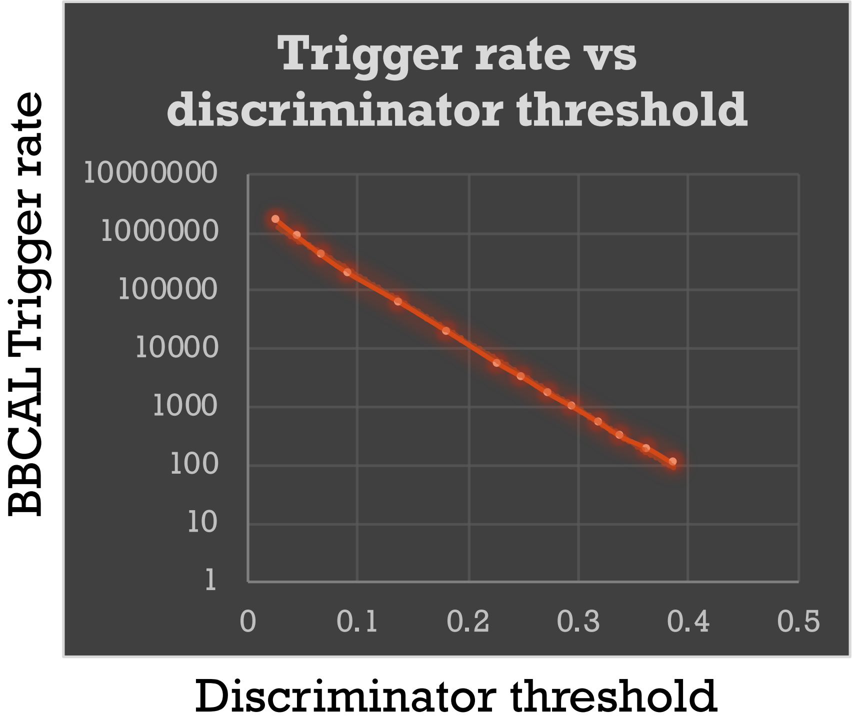
OPTIMIZING THE THRESHOLD SETTINGS

- Threshold scan performed for different discriminator threshold settings to determine the optimal value to start data collection
- Trigger rate drops exponentially as a function of discriminator threshold as expected
- BBCAL threshold adjusted during data taking to accommodate DAQ limitations



BBCAL discriminator front end setup

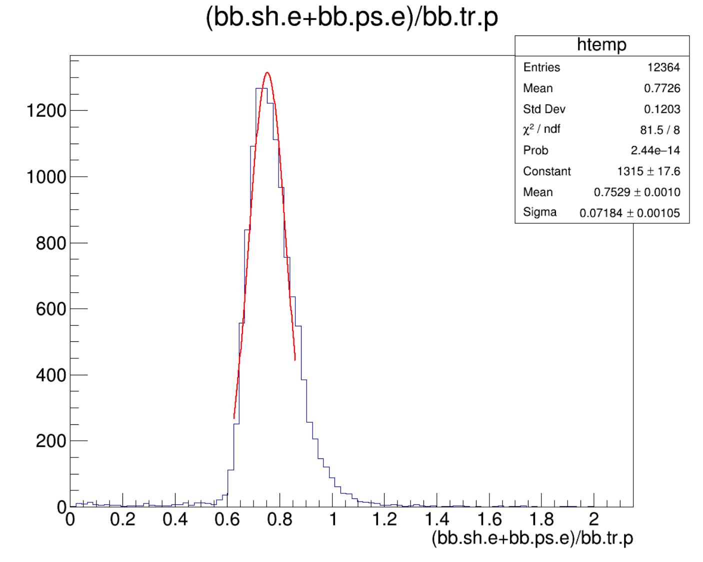
*Code written by Gary penman

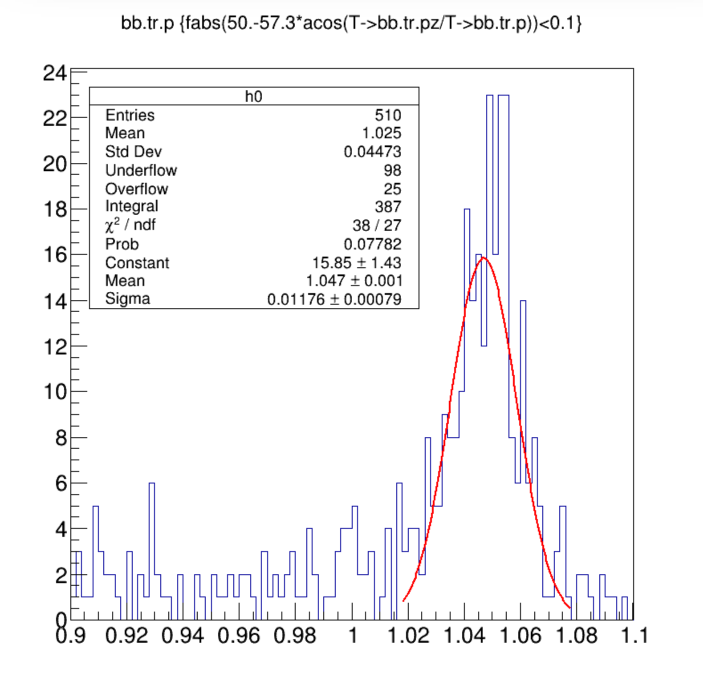


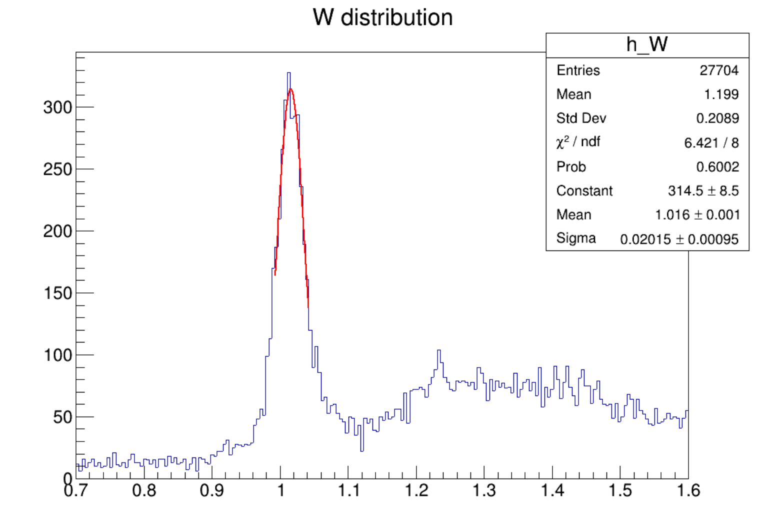
FIRST LOOK AT ELASTICS DATA

- Plots show W distribution, BigBite calorimeter resolution (~7%) and momentum resolution (~1.02%) with current optics settings which are being optimized by the collaboration

- Necessary elastics data acquired



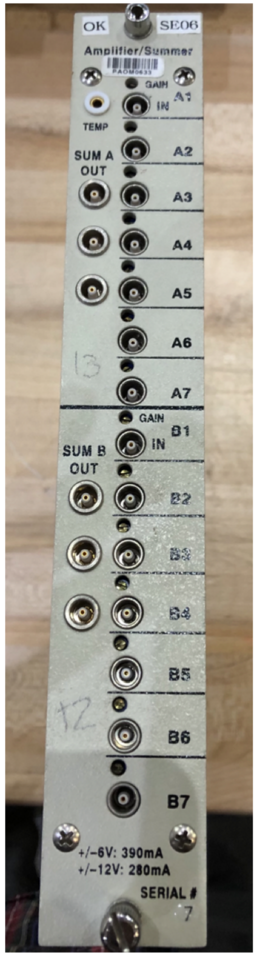




HANDLING SBS CONFIGURATIONS

Program	Q^2 $(GeV/c)^2$	E_{beam} (GeV)	θ_e	θ_N	$E_{e'}$ (GeV)
SBS-4	3	3.728	36^0	31.9^0	2.11
SBS-7	10	7.906	40^0	16.1^0	2.67
SBS-11	13.6	9.910	42^0	13.3^0	2.67
SBS-14	7.5	5.965	46.5^0	17.3^0	2.00
SBS-9	4.5	4.015	49^0	22.5^0	1.63

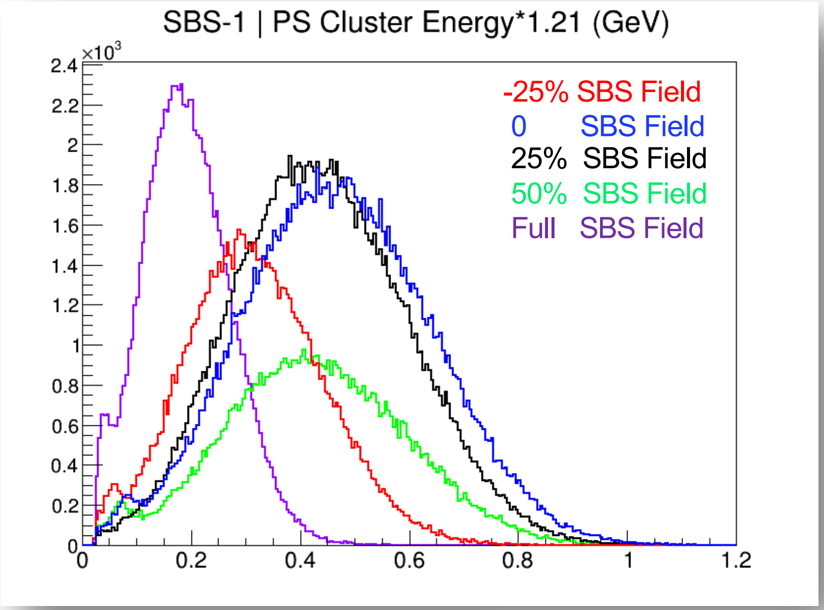
Set the HV so that the e' energy is accommodated by S/A module without saturation



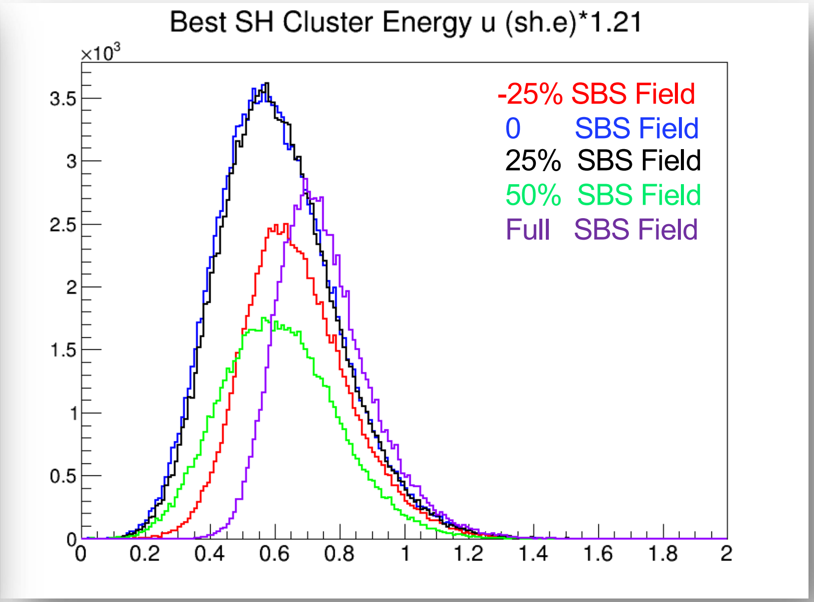
The outputs on the back of S/A modules saturate when the input crosses 200 mV

Study of the Linear Region of Operation for all the Electronic Modules involved in BigBite Calorimeter Circuit - SBS Document 118-v1 – Datta, Jones, Tadepalli

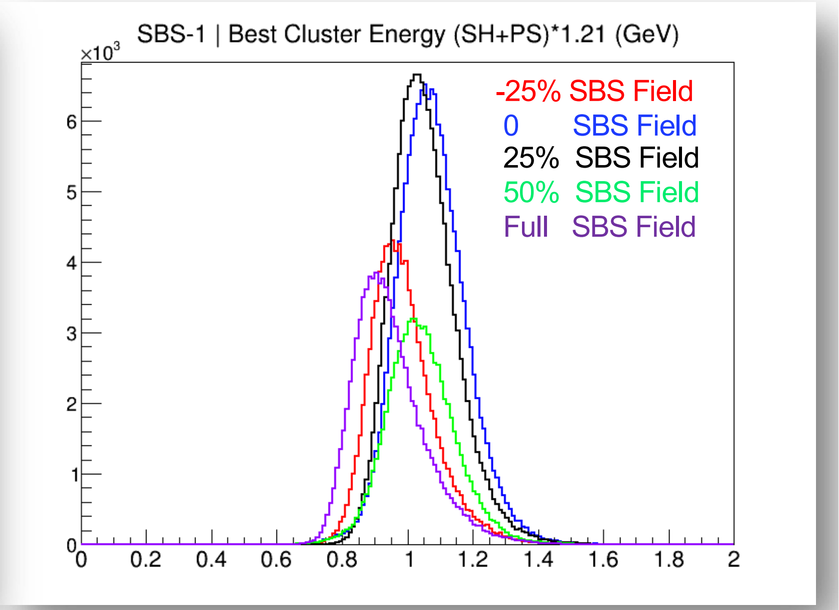
PS cluster energy



SH cluster energy



PS+SH cluster energy



8.8 Environmental Factors 187

8.8.2 Magnetic Fields

Magnetic fields are one of the more important influences on the operation of PM's. It is easy to see, in fact, that a small magnetic field is enough to deviate the electron cascade from its optimum trajectory in a PM and thereby affect its efficiency. By far the most sensitive part of the PM to magnetic fields is the electron collection system. Here electrons may be so deviated that they may never reach the first dynode at all. As well, the orientation of the tube with respect to the field is clearly a determining factor as well as its symmetry with respect to its axis. Figure 8.17 illustrates the effect of a magnetic field on a PM oriented along three orthogonal axes. In general, the following conclusions can be made:

1) the anode current decreases as magnetic flux increases,
2) the influence of the field is least when oriented along the axis of the PM.

It is common practice to shield PM's with a mu-metal screen which fits around the PM tube. These are available commercially or can be made easily. Generally it is sufficient to shield only the area around the tube; however tests have shown that better results are obtained if the screen is extended pass the tube somewhat. Figure 8.18 shows this difference by comparing the effects of a magnetic field versus the positions and lengths of the mu-metal screen. For strong magnetic fields, it may also be necessary to use a further soft iron shield about the mu-metal. In such cases, care should be taken that parts of the PM do not become magnetized as well. More recently, new designs using a *close proximity focusing* scheme [8.12] have made their appearance on the com-

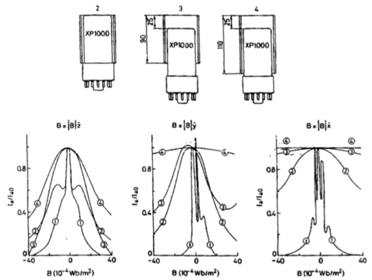


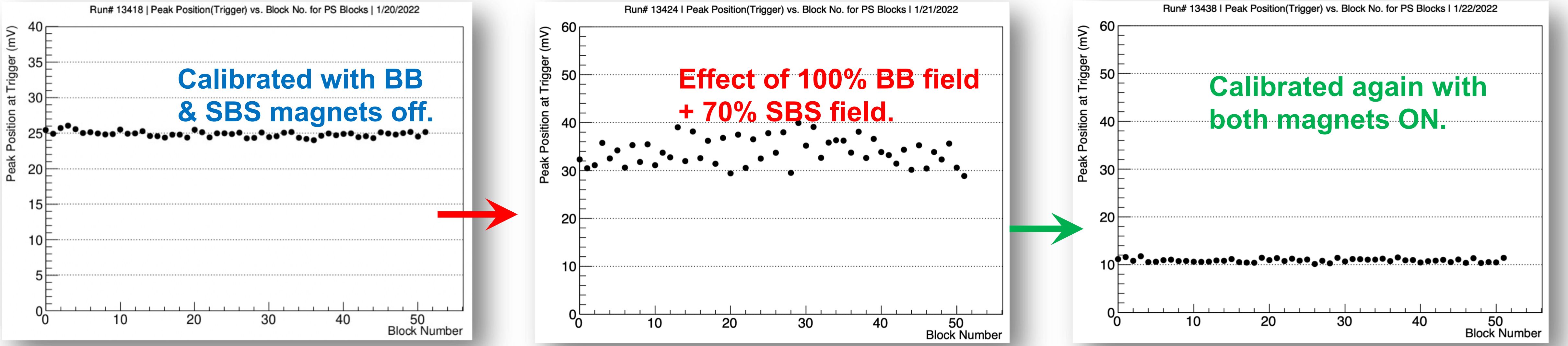
Fig. 8.18. Shielding effect of different mu-metal configurations (from Schonkeren [8.1])

Experimental nuclear physics, Leo pg 187

- Non-negligible effect on the PS and SH cluster energies due to the strong SBS fringe fields
- Problem mitigated by taking cosmics before production running and gain matching the PMTs to align at the trigger level

*pointed out by Provakar Datta

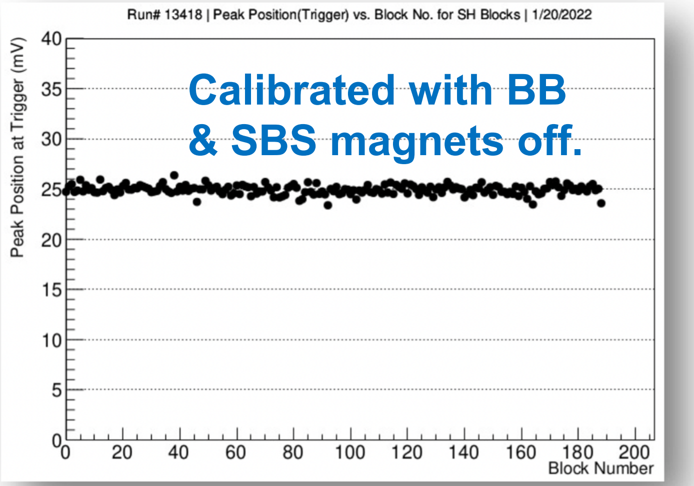
MITIGATION OF FRINGE FIELD EFFECT ON BBCAL SHOWER PMTS (SBS-8)

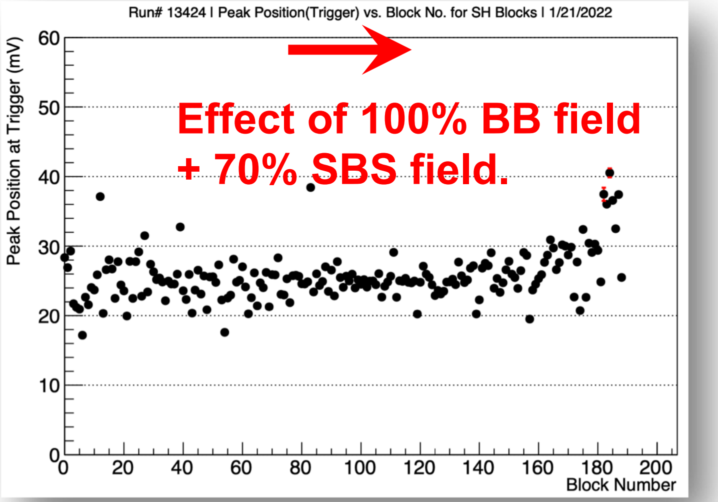


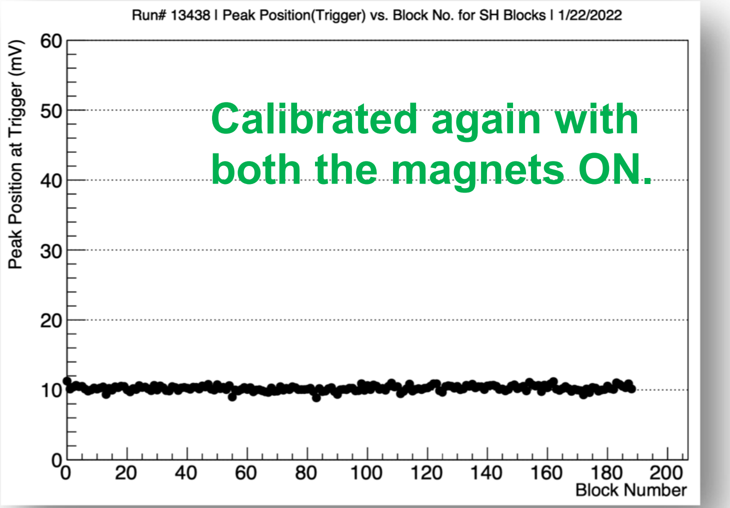
- Use a known calibrated setting with cosmics (BB and SBS fields OFF)
- Turn on the magnets
- Recalibrate taking the effect of the fields into account
- Do this for all kinematics and field settings
- Procedure worked really well!

*calibration by Provakar Datta

MITIGATION OF FRINGE FIELD EFFECT ON BBCAL SHOWER PMTS (SBS-8)







- Use a known calibrated setting with cosmics (BB and SBS fields OFF)
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- Recalibrate taking the effect of the fields into account
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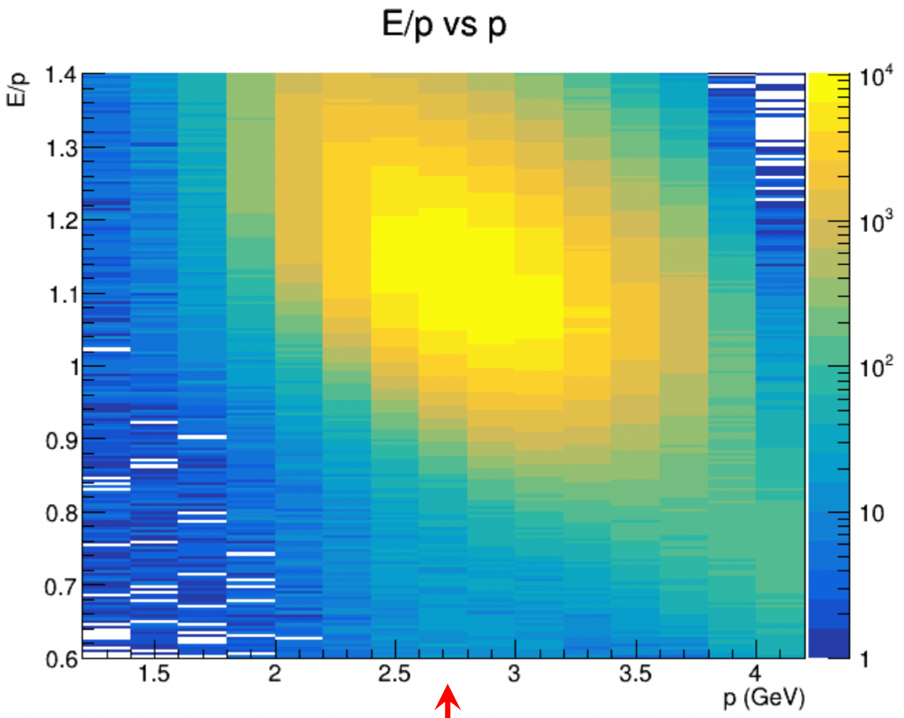
*calibration by Provakar Datta

SUMMARY

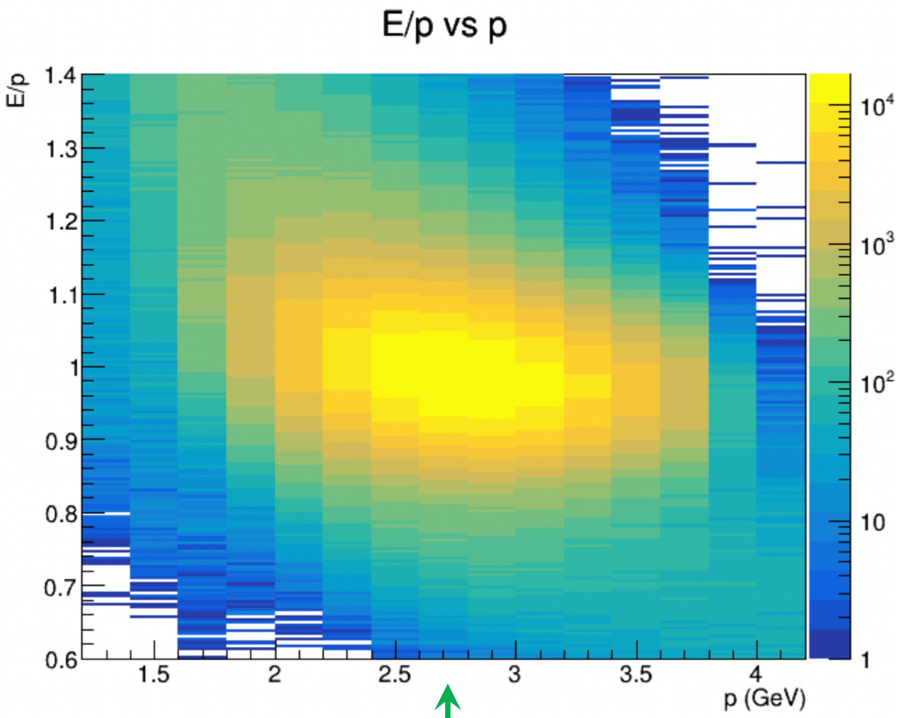
- BBCAL refurbished, tested at TEDF and moved to the hall successfully
- Re-cabling, trigger checkout and cosmic calibration were performed and BBCAL was prepared for beam
- Good quality data taken with BBCAL at all the settings
- Calibration is in progress
- BigBite calorimeter supports many other high-impact experiments such as GEn, SIDIS, KLL, ALL, GEn-RP!

THANK YOU

E/p vs p before and after calibration with beam (SBS-8, SBS70%)



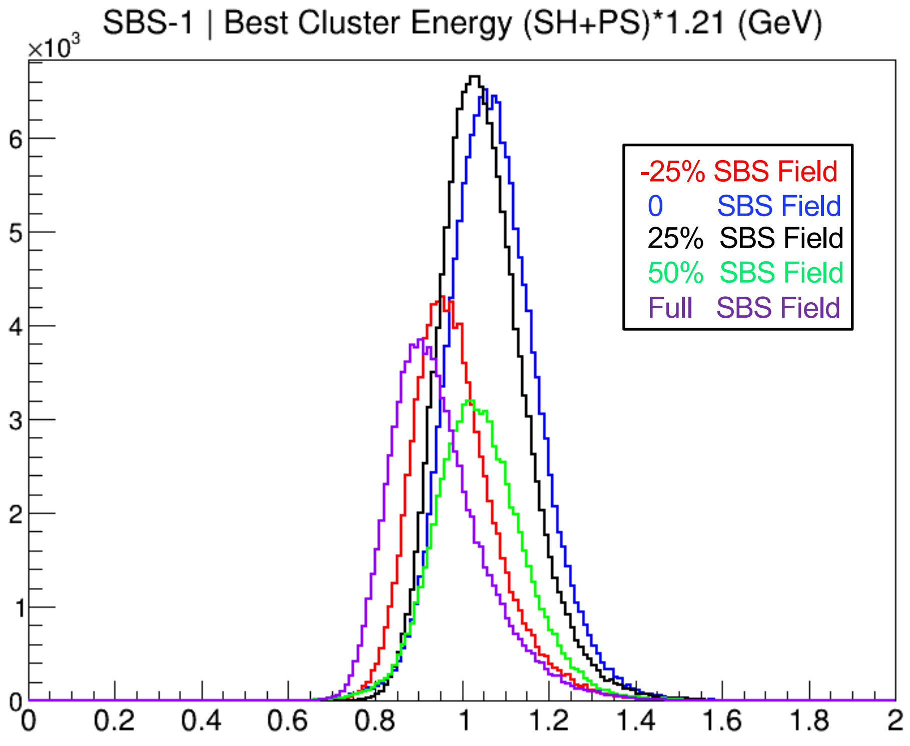
Cosmic Calibration



Calibration with Beam (LH2)

- Before calibration, we see a strong negative correlation between E/p and p which almost disappears with just 1st round of calibration with LH2 data.

SBS FRINGE FIELD EFFECT ON BBCAL

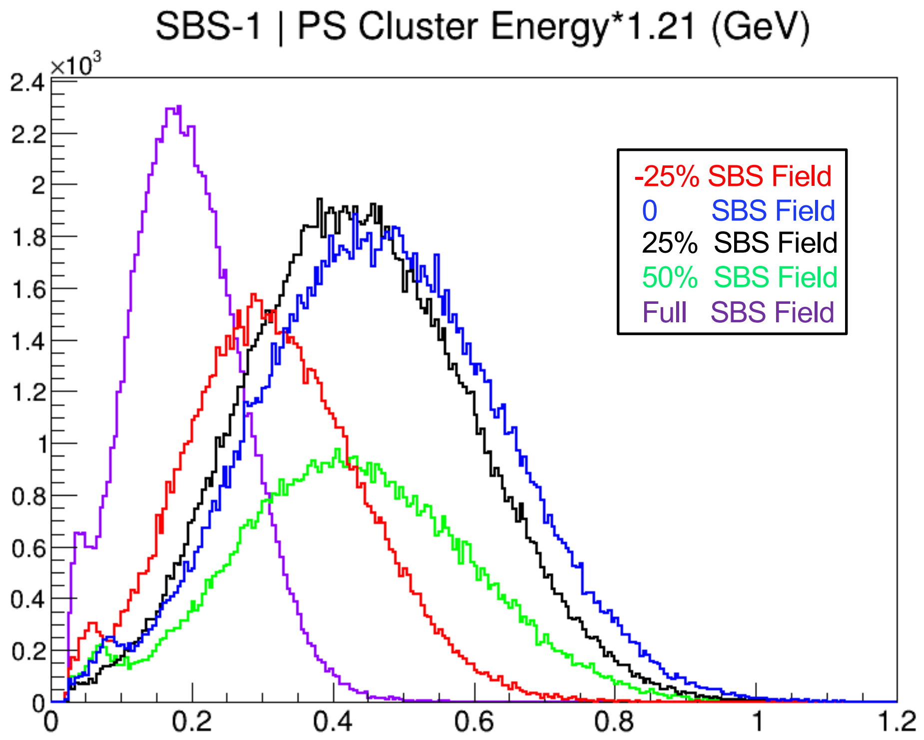


SBS Field (%)	Mean (GeV)	Sigma (GeV)	Change w.r.t. 0 field (%)
-25	0.9606	0.0831	9.5
0	1.0612	0.0954	0
25	1.0323	0.0894	2.7
50	1.0295	0.0948	3.0
100	0.9091	0.0834	14.3

- Configuration: SBS-1
- Target: LH2
- Events selected: Elastic (Tight cut on W)

- Above plots show the distribution of total BBCal cluster energy at different SBS field settings.
- Analysis of SBS 0 field data shows that the energy calibration of BBCal with cosmics was 21% off. In order to compensate for that discrepancy we have multiplied the total cluster energy with a constant factor of 1.21.
- Preliminary results show, SBS fringe field has non-negligible effect on BBCal cluster energy in SBS-1 configuration.

Effect of SBS fringe field on Pre-Shower cluster energy

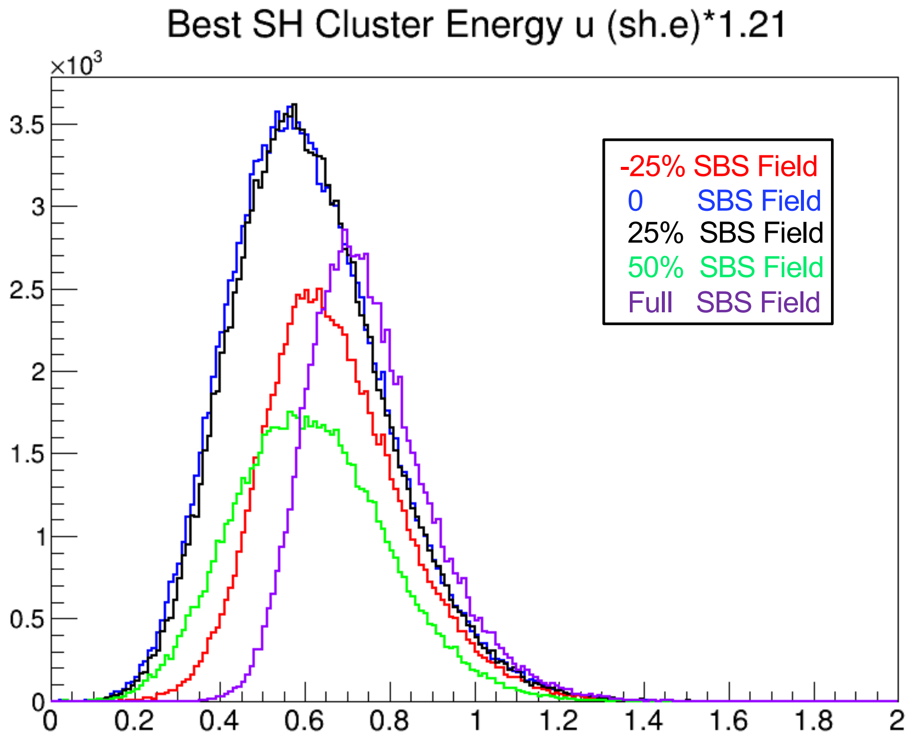


SBS Field (%)	Mean (GeV)	Sigma (GeV)	Change w.r.t. 0 field (%)
-25	0.3019	0.1237	34.1
0	0.4585	0.1780	0
25	0.4233	0.1658	7.7
50	0.4132	0.1667	9.9
100	0.1803	0.0782	60.7

- Configuration: SBS-1
- Target: LH2
- Events selected: Elastic (Tight cut on W)

- Above plots show the distribution of total pre-shower(PS) cluster energy at different SBS field settings.
- From the plots above it can be clearly seen that SBS fringe field had significant effect on PS cluster energy in SBS-1 configuration, which strongly implies that SBS fringe field did affect the gains of PS PMTs.
- The shift in peak position between 0 field and full field settings is about **61%**!

Effect of SBS fringe field on Shower cluster energy

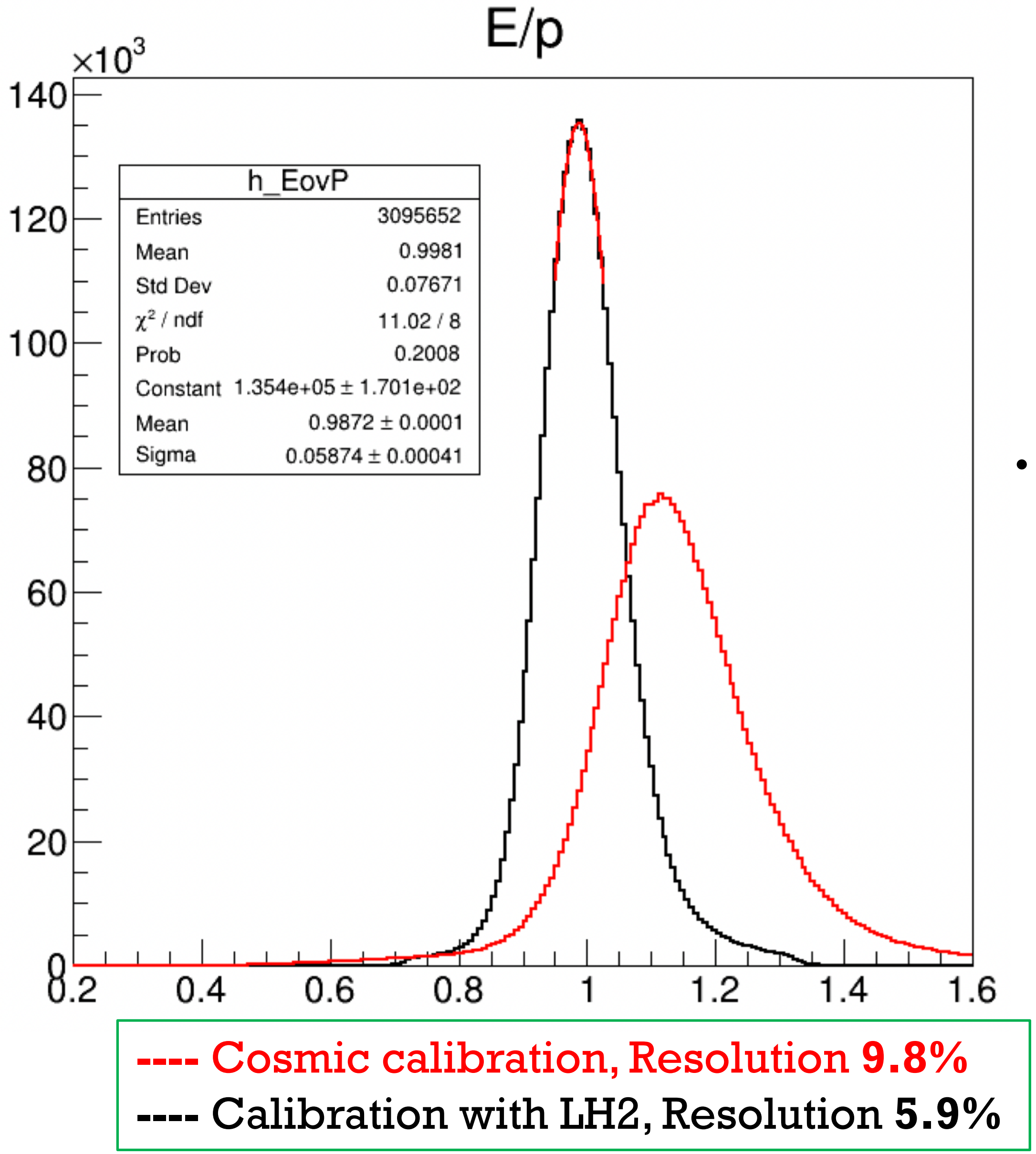


SBS Field (%)	Mean (GeV)	Sigma (GeV)	Change w.r.t. 0 field (%)
-25	0.6297	0.1427	19.5
0	0.5671	0.1780	0
25	0.5772	0.1704	1.8
50	0.5943	0.1862	4.8
100	0.7087	0.1220	25.0

- Configuration: SBS-1
- Target: LH2
- Events selected: Elastic (Tight cut on W)

- Above plots show the distribution of total shower(SH) cluster energy at different SBS field settings.
- Like PS PMTs, SH PMTs also got affected by the SBS fringe field even if the magnitude was lower.
- Unlike PS PMTs, SH PMTs show a higher gain with higher SBS field! NOTE: SH and PS PMTs are oriented perpendicular to each other.

BBCal resolution before and after calibration with beam (SBS-8, SBS70%)

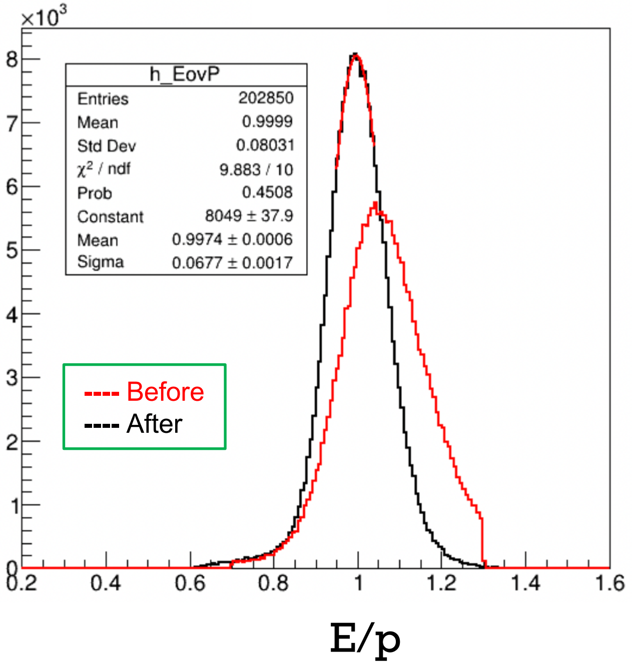


- BBCal resolution improves from **9.8%** to **5.9%** after calibration with LH2 data.

CALIBRATION IN PROGRESS

Configuration	E_{beam} (GeV)	$E_{e'}$ (GeV)	Magnet Current (A)		BBCal Resolution (%)	
			BB	SBS	Before Calib.	After Calib.
SBS-4	3.728	2.11	750	0	8.9	**6.5**
			750	630	8.6	**6.6**
			750	1050	9.5	**6.6**
SBS-7	7.906	2.67	750	1785	9.4	**6.8**
SBS-8	5.965	3.59	750	0	9.8	**6.0**
			750	1050	9.8	**5.8**
			750	1470	9.8	**5.9**
			750	2100	9.8	**5.9**
SBS-9	4.015	1.63	750	1470	9.7	**7.8**

BBCal Calibration Result for SBS-7



- 2. First pass mass replay and analysis – *Scripts to do mass replay on the farm is in place.*