# Performance of the BigBite Calorimeter during $SBS\text{-}G_M^n$ Experiment

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(On behalf of the SBS Collaboration)

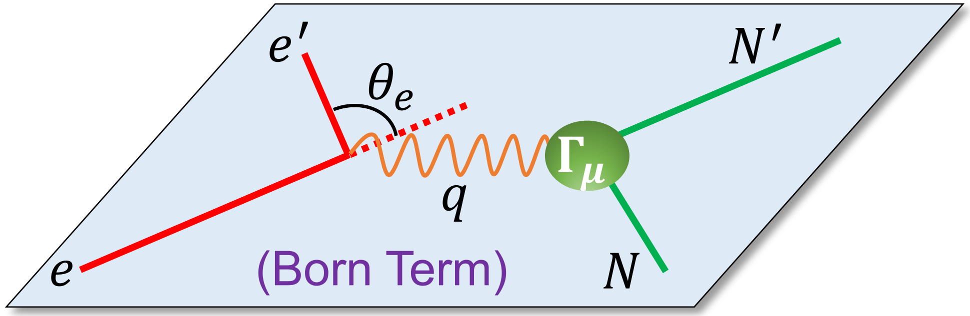
# $SBS\text{-}G_M^n$ Experiment: Theory & Motivation

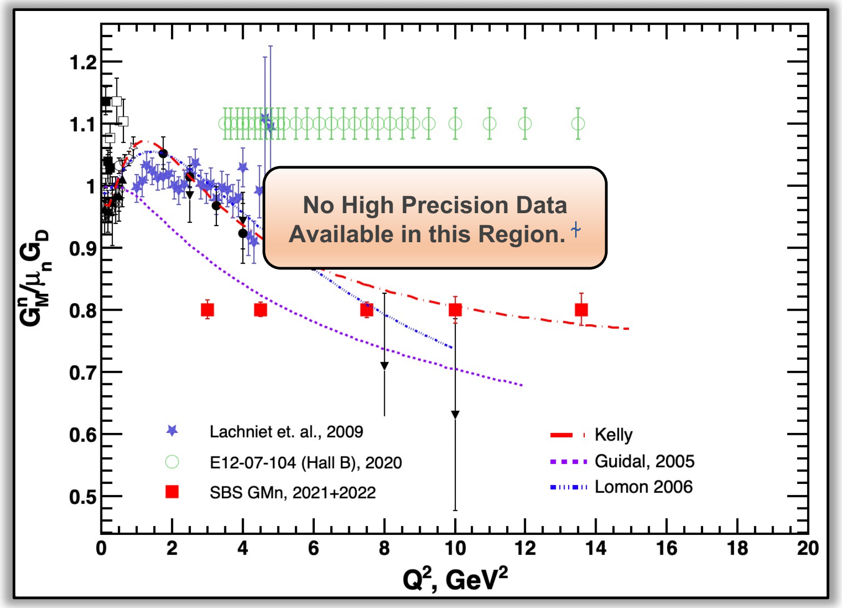
- Ran in Jefferson Lab's Experimental Hall A from Fall 2021 to February 2022.

❖ **Goal:** High precision measurement of $G_M^n$ at $Q^2$ = 3, 4.5, 7.5, 10 & 13.6 $(GeV/c)^2$.

- Nucleon vertex (elastic $e$-$N$ scattering):

$$\Gamma_\mu(q) = \gamma_\mu \underbrace{F_1(-q^2)}_{\text{Dirac FF}} + \frac{i\sigma_{\mu\nu}q^\nu}{2M_N}\underbrace{F_2(-q^2)}_{\text{Pauli FF}}$$





No High Precision Data Available in this Region. †

- Defining Sachs Form Factors (FFs): $\begin{cases} G_E(Q^2) \equiv F_1(Q^2) - \tau F_2(Q^2) \\ G_M(Q^2) \equiv F_1(Q^2) + F_2(Q^2) \end{cases}$

- $G_E$, $G_M$: Sachs Electric and Magnetic FFs, respectively.

- Differential Cross Section:

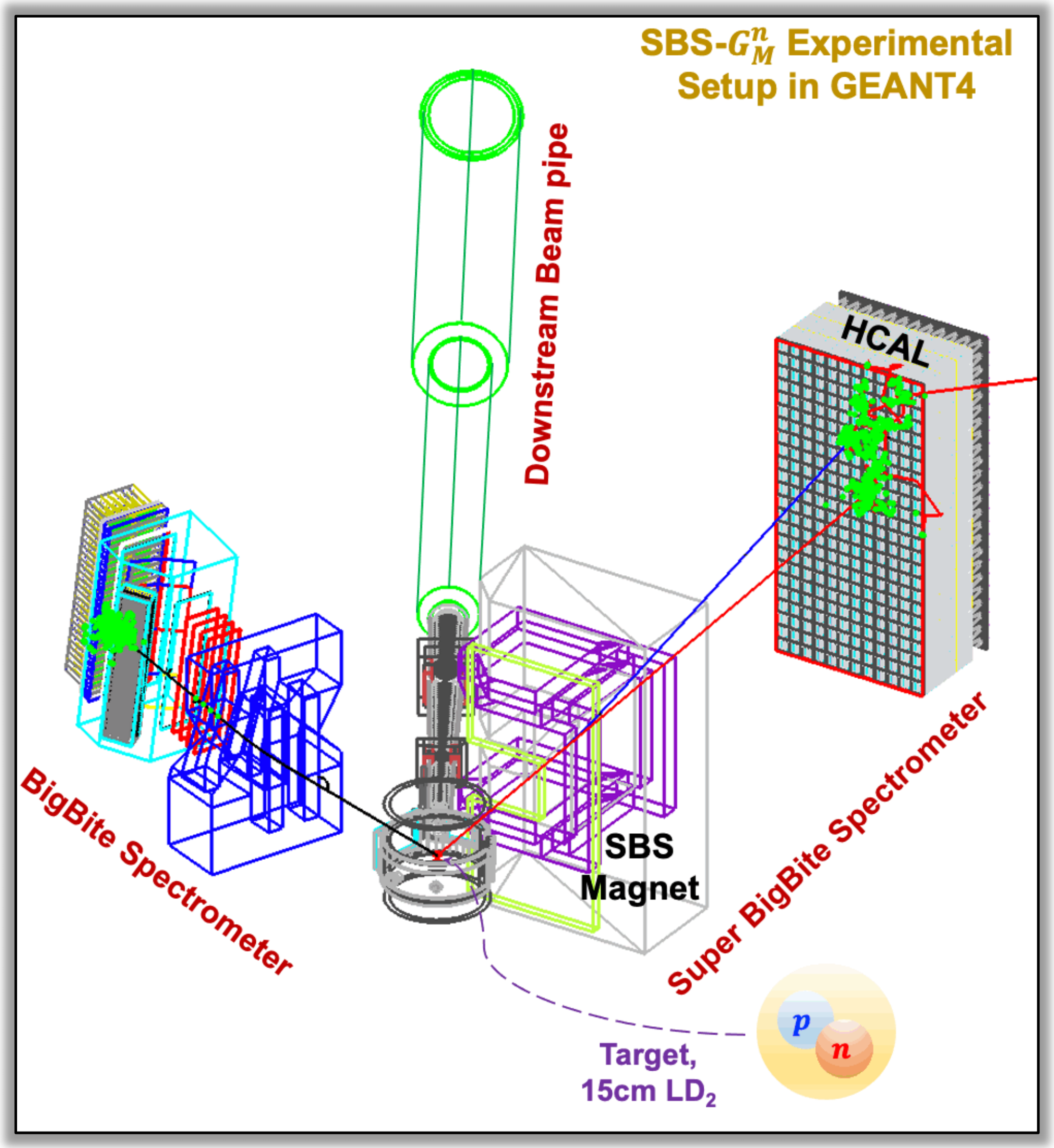
$$\frac{d\sigma}{d\Omega} = \frac{\sigma_{Mott}}{1+\tau}\left(G_E^2(Q^2) + \frac{\tau}{\epsilon}G_M^2(Q^2)\right)$$

- $Q^2 = -q^2$
- $\tau = Q^2/4M_N^2$
- $\epsilon = (1 + 2(1+\tau)tan^2(\theta_e/2))^{-1}$

❖ $Q^2$ evolution of Sachs FFs reveal nucleon's internal structure.

† CLAS12 measured $G_M^n$ up to $Q^2 = 13.5\ GeV^2$, results are yet to be published.

# $SBS\text{-}G_M^n$ Experiment: Technique



- Simultaneous detection of elastically scattered electrons and nucleons.
- 3 major steps to get $G_M^n$:

① Extracting QE cross section ratio, $R''$, directly from the experiment:

$$R'' = \frac{\frac{d\sigma}{d\Omega}\big|_{d(e,e'n)}}{\frac{d\sigma}{d\Omega}\big|_{d(e,e'p)}}$$

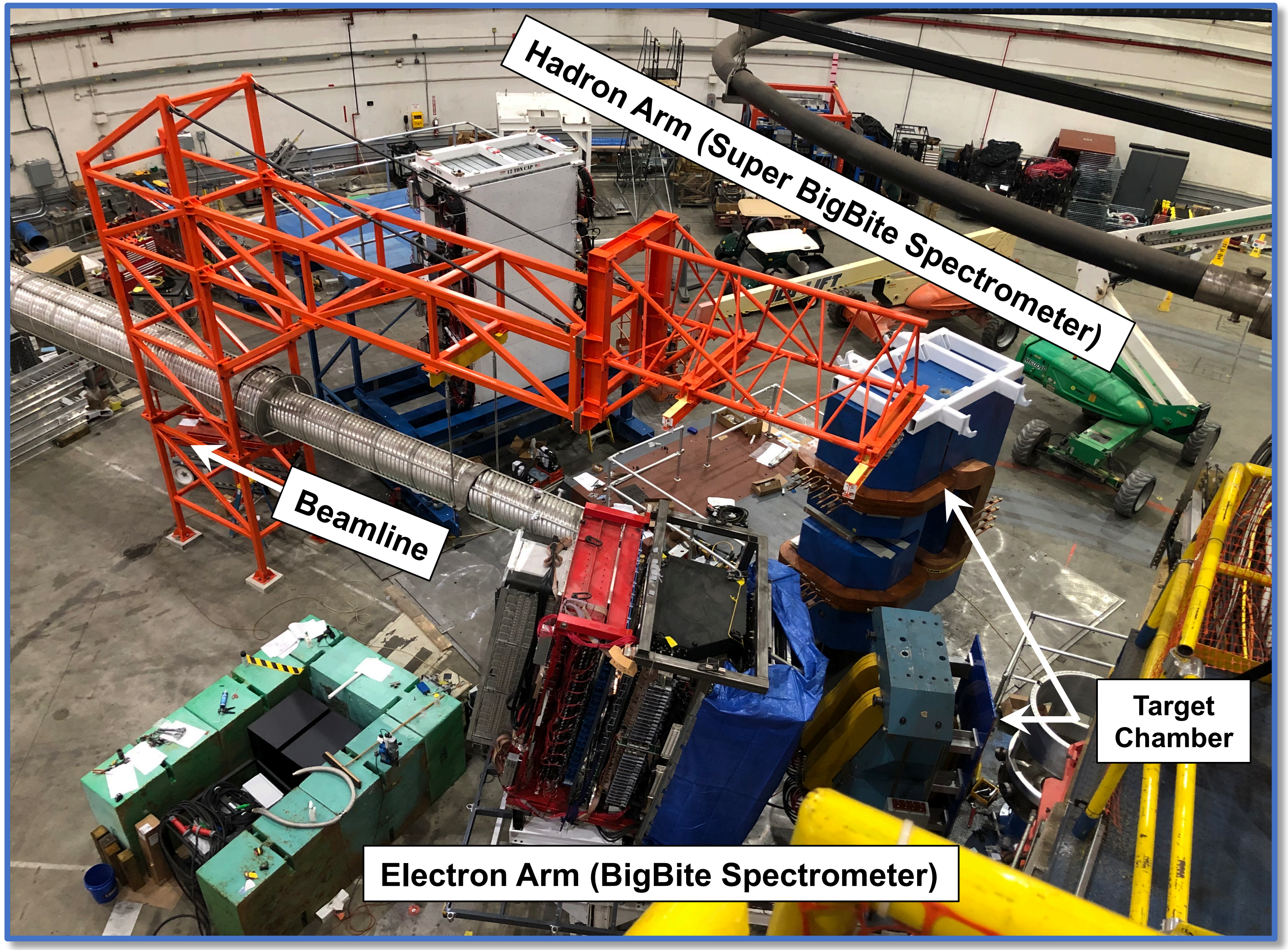
② Apply nuclear corrections to obtain:

$$R' = \frac{\frac{d\sigma}{d\Omega}\big|_{n(e,e')}}{\frac{d\sigma}{d\Omega}\big|_{p(e,e')}} \equiv \frac{\frac{\sigma_{Mott}}{1+\tau}\left({G_E^n}^2 + \frac{\tau}{\epsilon}{G_M^n}^2\right)}{\frac{d\sigma}{d\Omega}\big|_{p(e,e')}}$$

③ Finally,

$$G_M^n = -\left[\frac{1}{\tau}\frac{d\sigma}{d\Omega}\bigg|_{p(e,e')} R' - \frac{\epsilon}{\tau}{G_E^n}^2\right]^{\frac{1}{2}}$$

# SBS $G_M^n$ Experimental Setup (JLab Hall A)

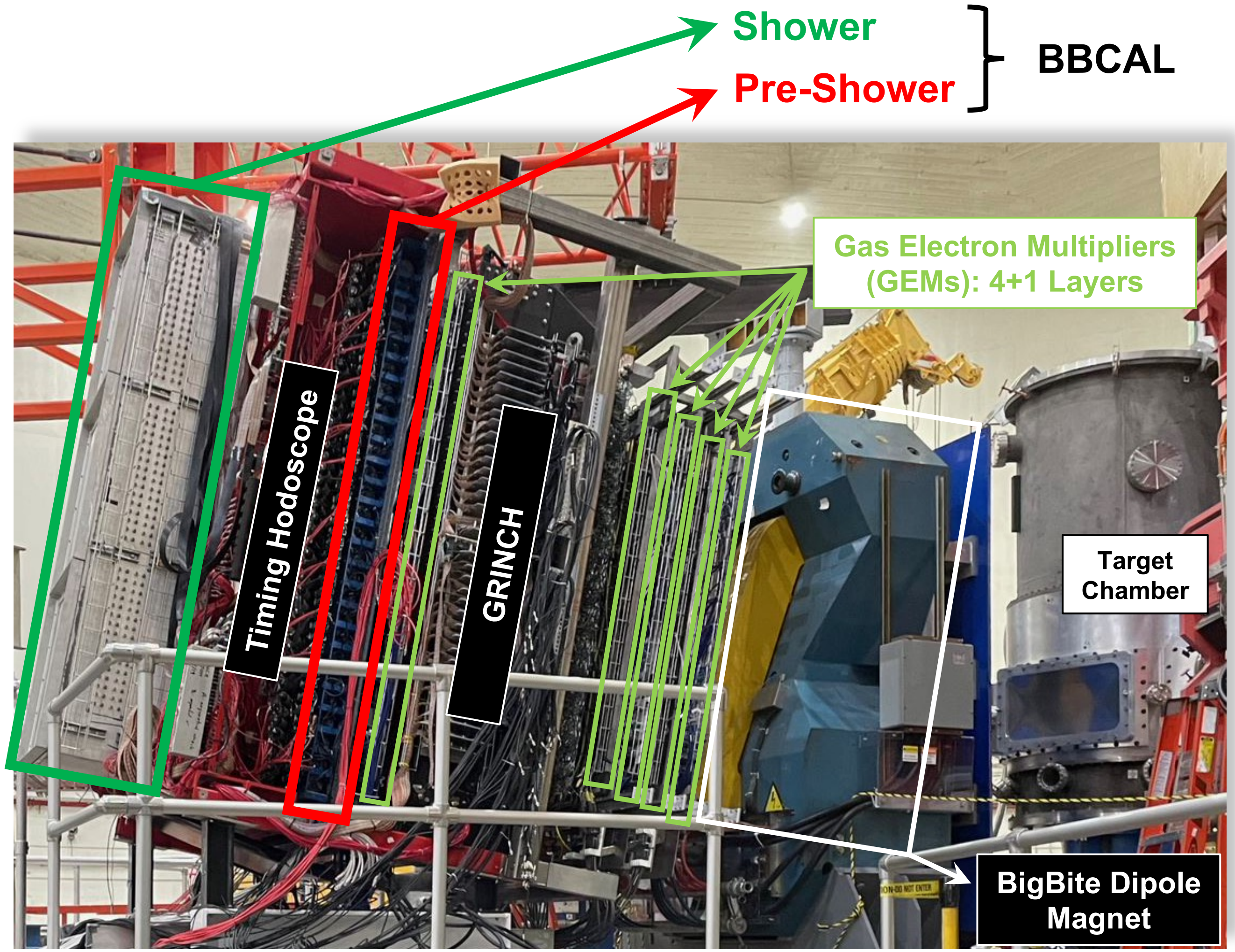


**Bird's eye view of Jefferson Lab's Experimental Hall A during SBS installation (Summer 2021).**

- Each spectrometer weigh ~ 50 Tons.
- 43,000+ detector readout channels.

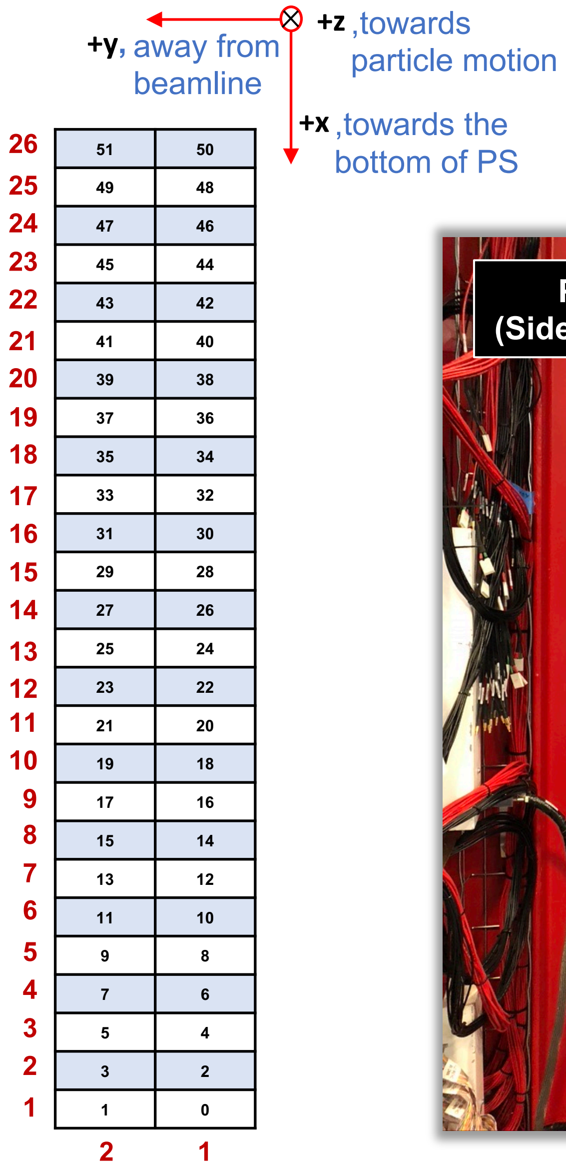
# The BigBite Calorimeter

- **The BigBite Spectrometer** was used to detect and fully characterize the kinematics of the **scattered $e^-$s**.
- **The BigBite Calorimeter** A.K.A. **BBCAL** is an integral part of it. BBCAL has two parts:
    - ○ Pre-Shower (PS) Calorimeter
    - ○ Shower (SH) Calorimeter

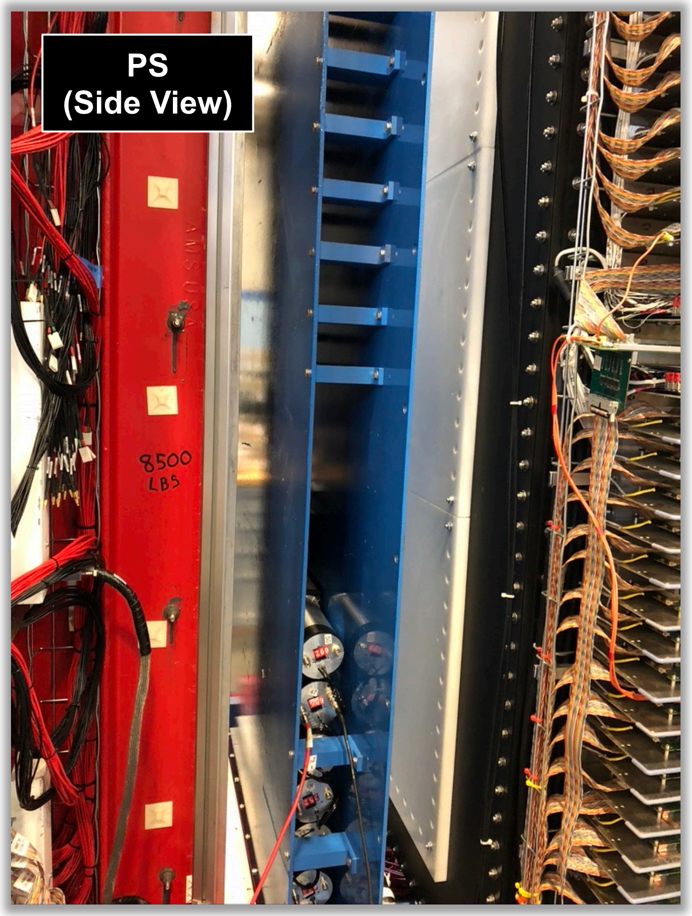


The BigBite Spectrometer in Hall A (Side View)

# Design: Pre-Shower (PS)



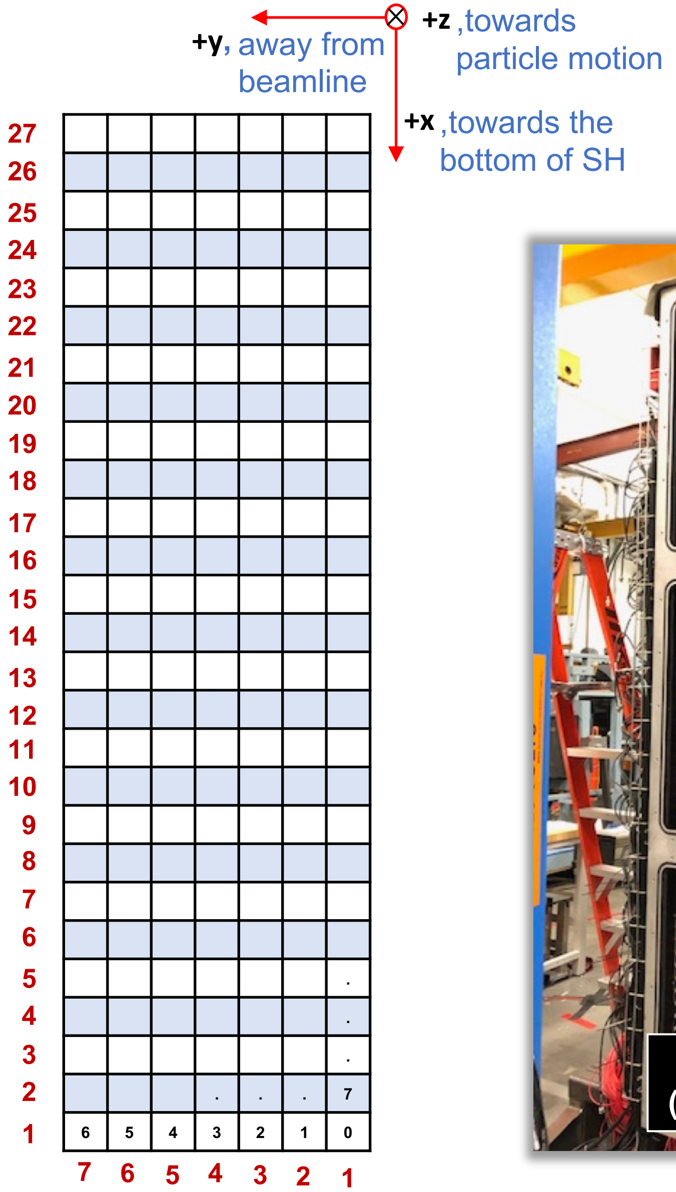
| | | |
|---|---|---|
| 26 | 51 | 50 |
| 25 | 49 | 48 |
| 24 | 47 | 46 |
| 23 | 45 | 44 |
| 22 | 43 | 42 |
| 21 | 41 | 40 |
| 20 | 39 | 38 |
| 19 | 37 | 36 |
| 18 | 35 | 34 |
| 17 | 33 | 32 |
| 16 | 31 | 30 |
| 15 | 29 | 28 |
| 14 | 27 | 26 |
| 13 | 25 | 24 |
| 12 | 23 | 22 |
| 11 | 21 | 20 |
| 10 | 19 | 18 |
| 9 | 17 | 16 |
| 8 | 15 | 14 |
| 7 | 13 | 12 |
| 6 | 11 | 10 |
| 5 | 9 | 8 |
| 4 | 7 | 6 |
| 3 | 5 | 4 |
| 2 | 3 | 2 |
| 1 | 1 | 0 |
| | 2 | 1 |

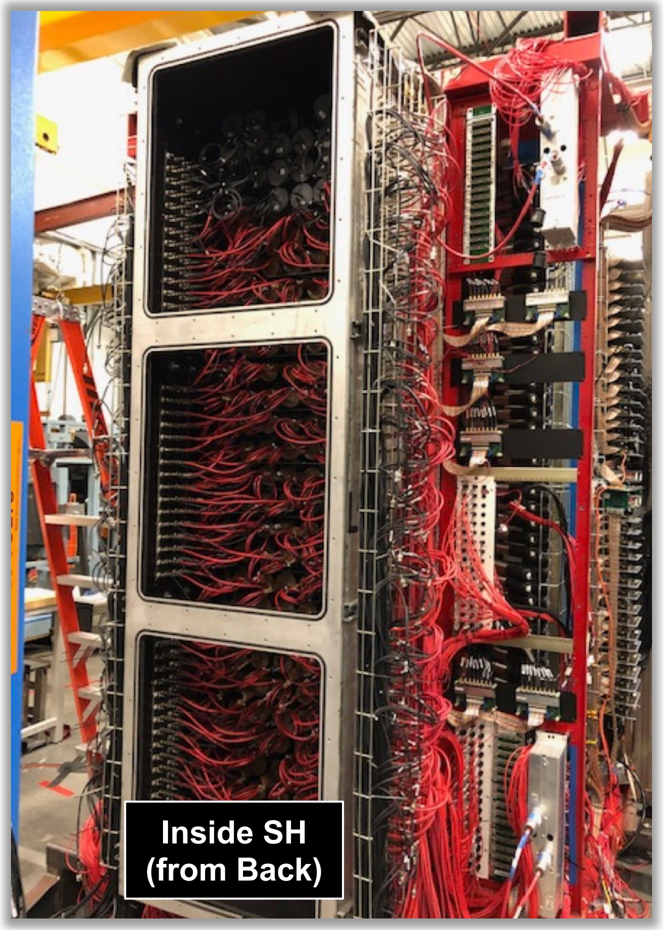

**PS (Side View)**

- PS is made of 52 rad-hard lead-glass blocks.
- Signals generated in each block are readout by a PMT.
- Block dimension: 9 x 9 x 29.5 cm$^3$
- Blocks are stacked in 26 rows of 2 columns facing each other.
- mu-metal shielding around each block.


**PS Modules**

# Design: Shower (SH)




Inside SH (from Back)

- BB Shower is made of 189 lead-glass blocks.
- Signals generated in each block are readout by a PMT.
- Block dimension: 8.5 x 8.5 x 34 $cm^3$
- Blocks are stacked in 27 rows of 7 columns facing the spectrometer axis.
- mu-metal shielding outside & between rows.


SH Modules

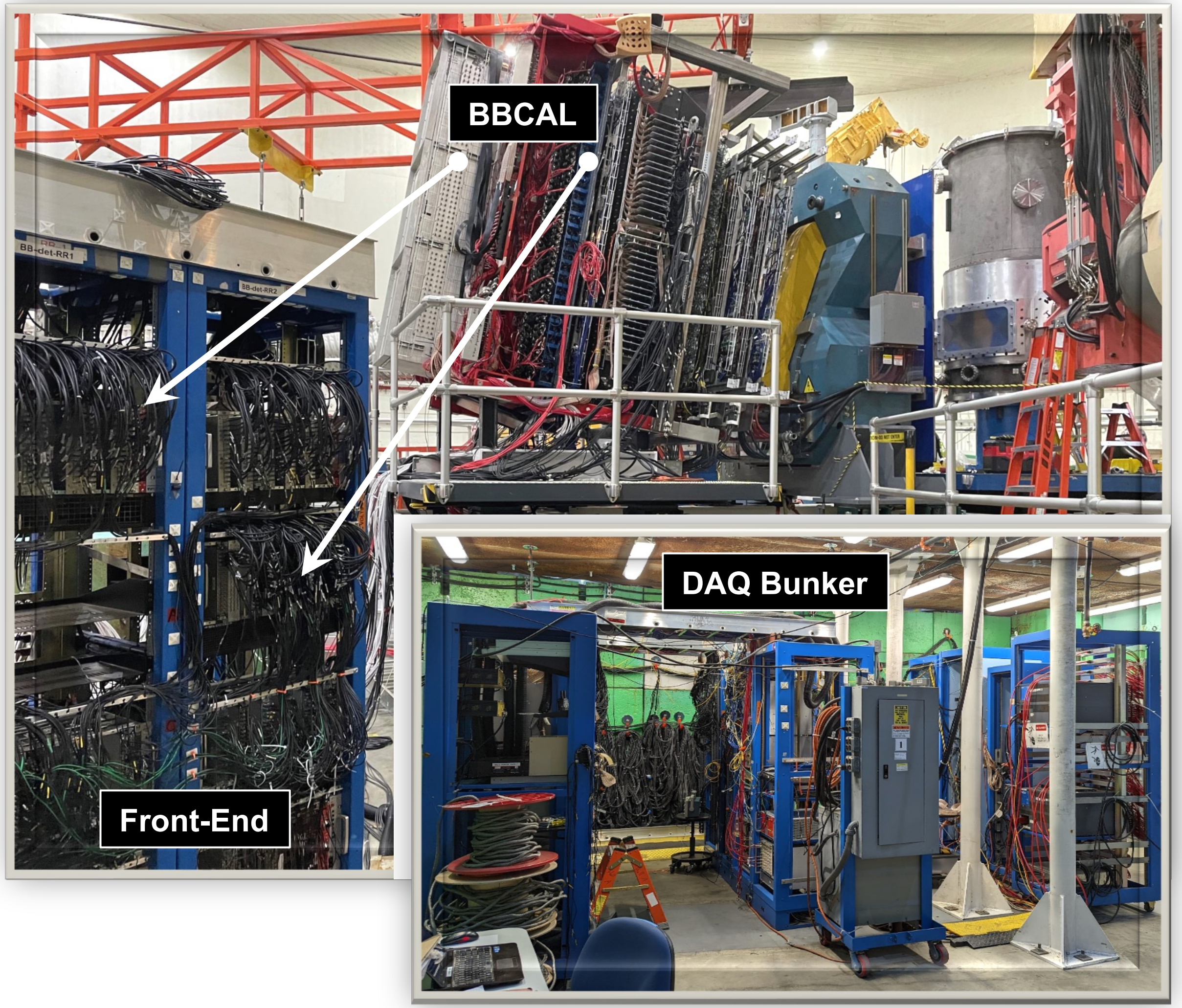
# Basic Working & Purpose

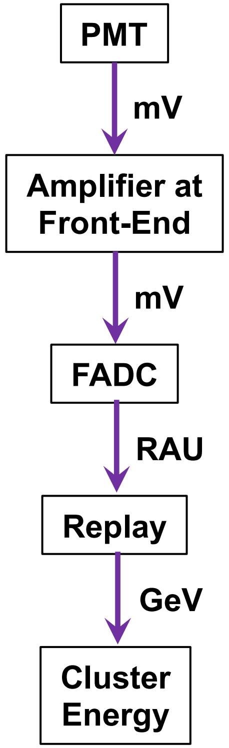
- High energy $e^-$s lose energy in lead-glass by the formation of **electromagnetic shower**.
  - PS thickness is not enough to stop them. So, $e^-$s deposit only a fraction of their energy in it.
  - SH, on the other hand, define the 'End of the road' for incoming $e^-$s by containing them fully.

- Primary uses of BBCAL:
  1. Measures the scattered $e^-$ energy and crudely determines the track position.
  2. Provides handle for pion background rejection (PS energy deposit is used for this purpose).
  3. Provides trigger for the BigBite spectrometer.
  4. Gives constraint for the track search region.

# 1. Energy Measurement

- **Detect**, **Digitize**, & **Convert** (from mV to GeV) the signal produced by EM shower in PS and SH modules.





**PMT**

**mV**

**Amplifier at Front-End**

**mV**

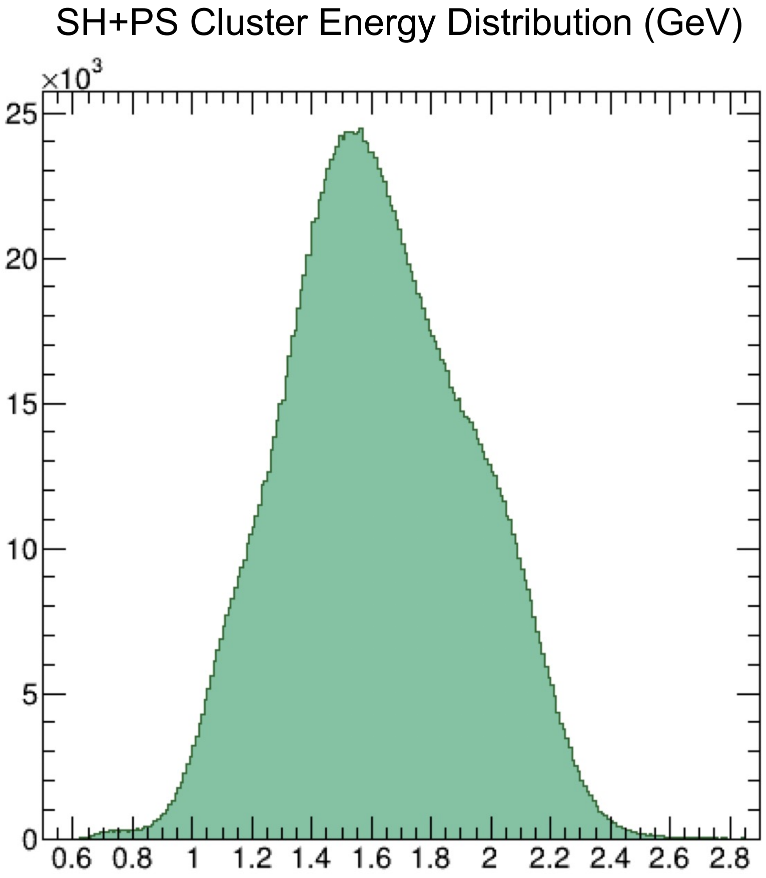
**FADC**

**RAU**

**Replay**

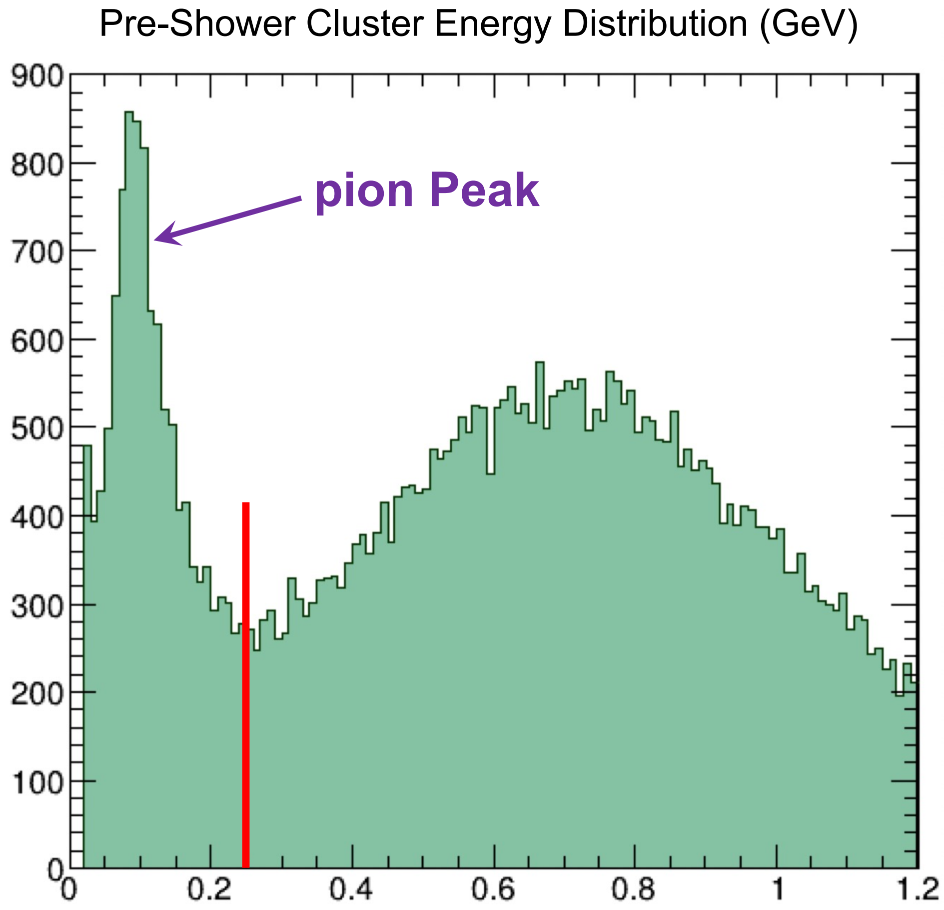
**GeV**

**Cluster Energy**


SH+PS Cluster Energy Distribution (GeV)

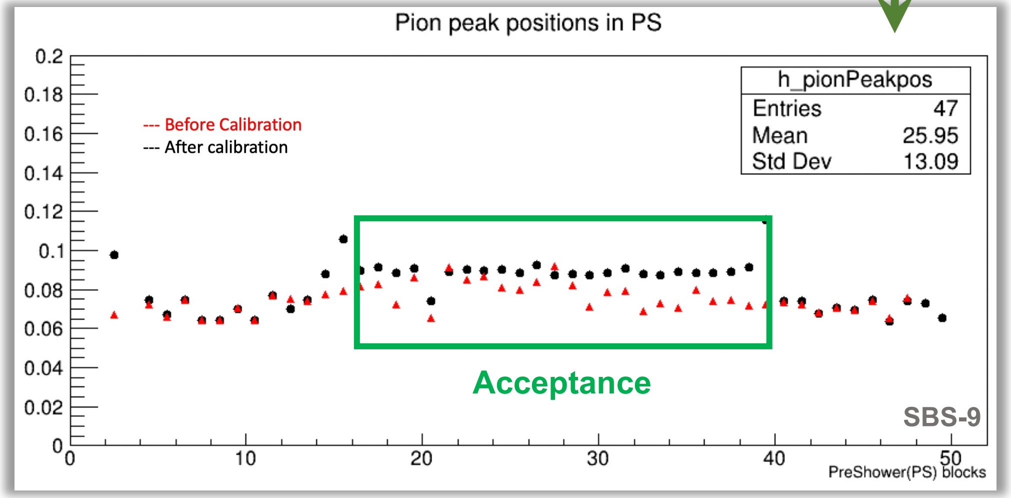
SBS-4, SBS 30% field Data

# 2. pion Background Rejection

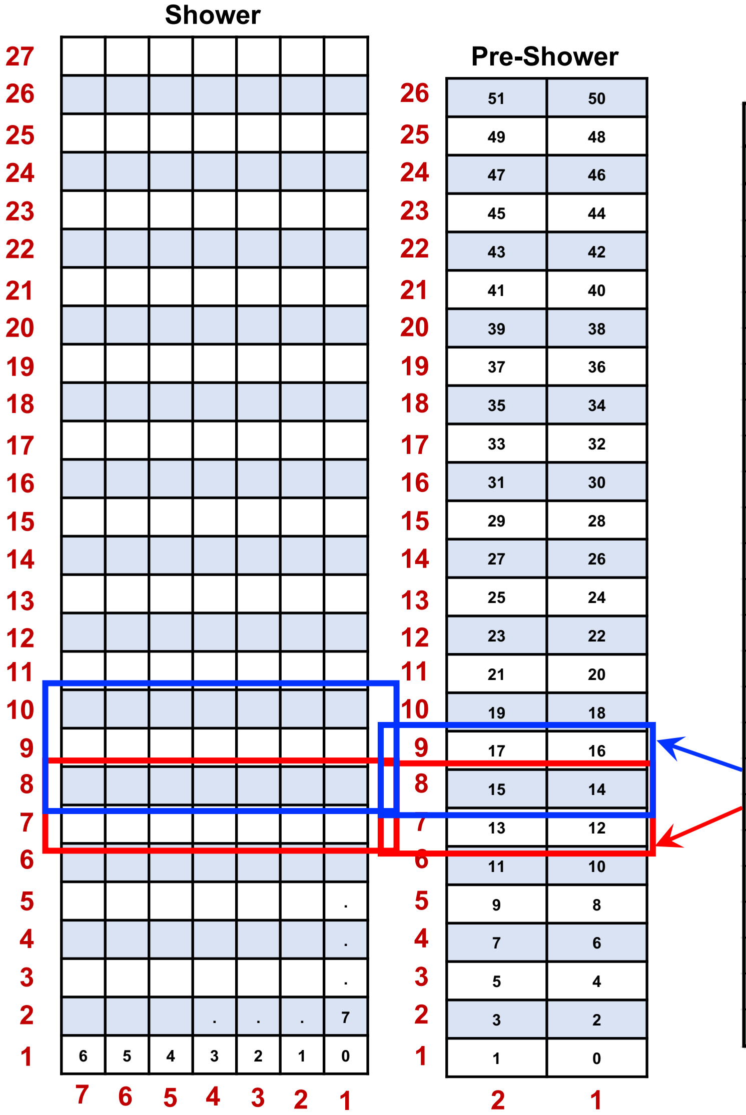


SBS-11, SBS 100% field Data

- pions produce MIP like signal in PS modules in the momentum range of interest.
- Peak due to pions is **easily distinguishable** from the $e^-$ peak.
- Hence, **a simple cut** on the PS energy can reject significant number of pions.
- One can also use pion peak positions to check the quality of PS calibration.

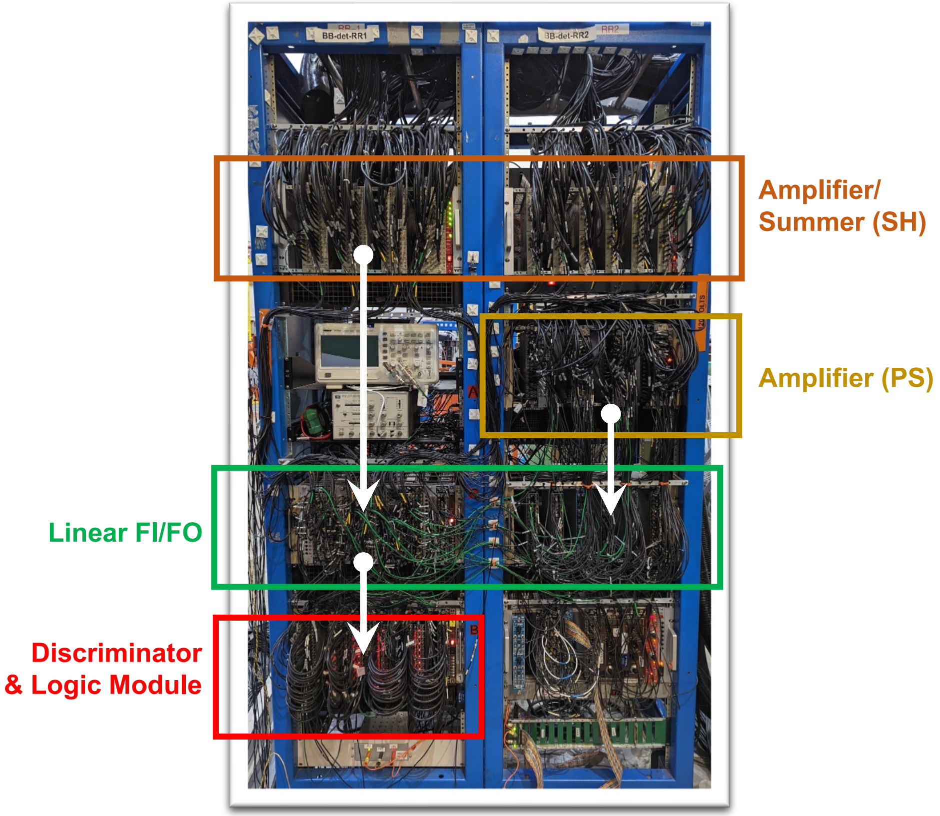


# 3. BigBite Trigger: Logic & Implementation



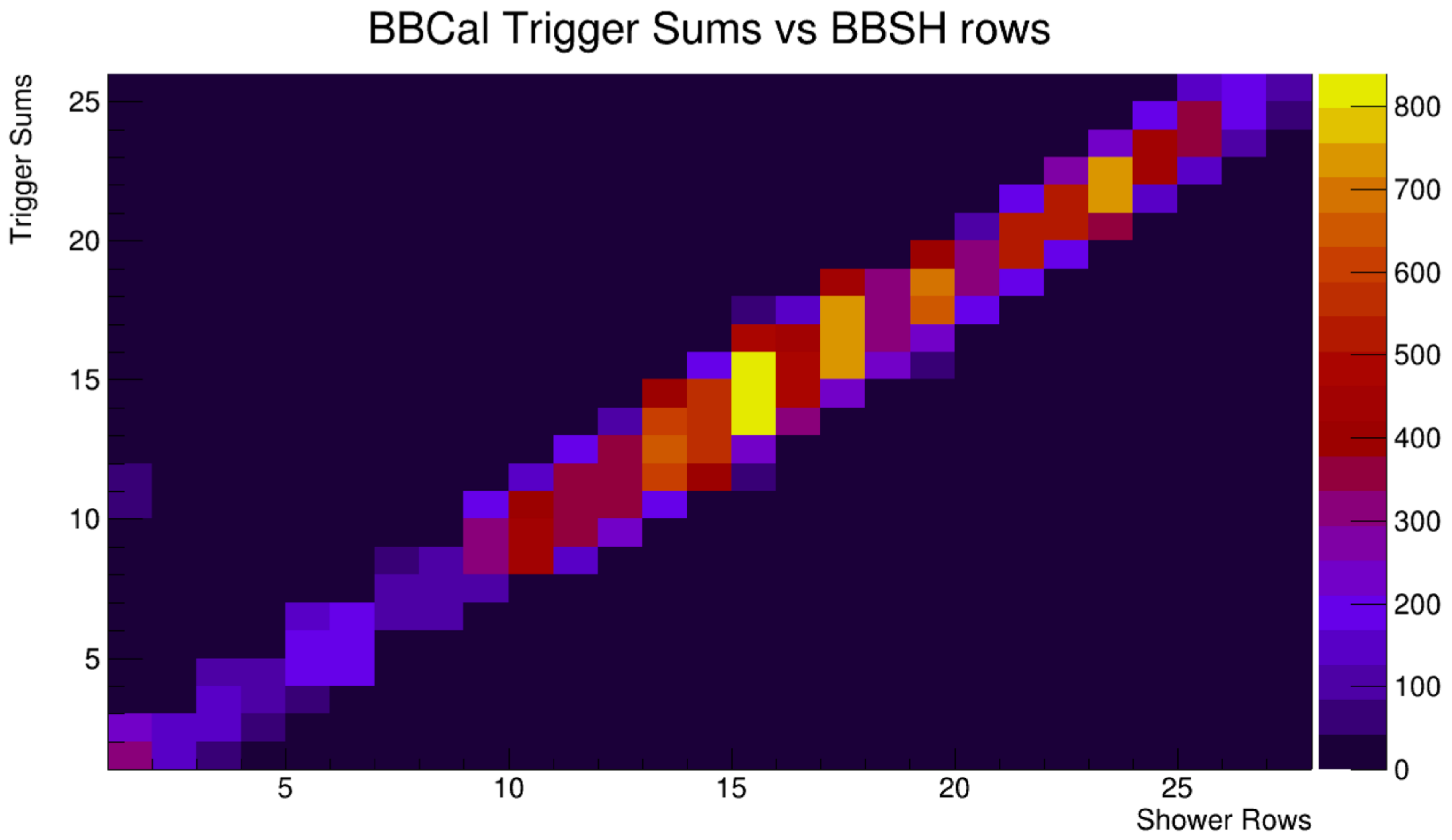
| Trigger Sums | Associated SH and PS rows |
|---|---|
| SC 25-26 | SH 26 + SH 27 + PS 25 + PS 26 |
| SC 24-25 | SH 25 + SH 26 + PS 24 + PS 25 |
| SC 23-24 | SH 24 + SH 25 + PS 23 + PS 24 |
| SC 22-23 | SH 23 + SH 24 + PS 22 + PS 23 |
| SC 21-22 | SH 22 + SH 23 + PS 21 + PS 22 |
| SC 20-21 | SH 21 + 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 |

- Overlapping SH and PS row sums constitute the trigger logic.
- Logical OR of all the discriminated sums make the final trigger.



BBCAL Front-End

# BigBite Trigger: Performance



| 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 |

**2 SH Rows**

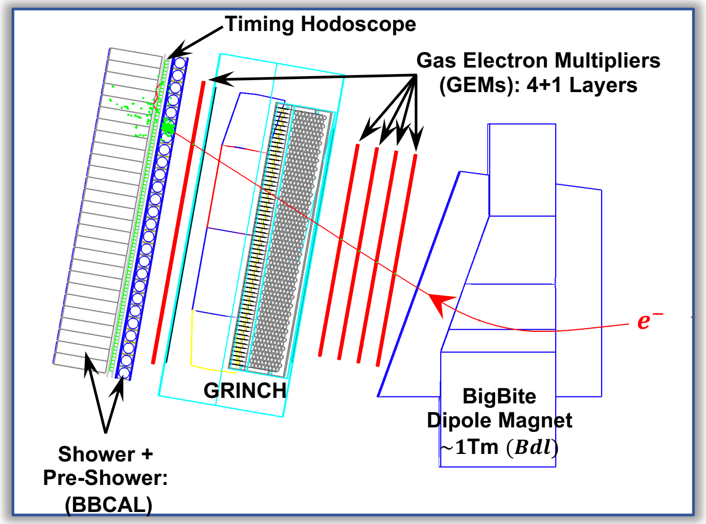
**3 SH Rows**

**2 SH Rows**

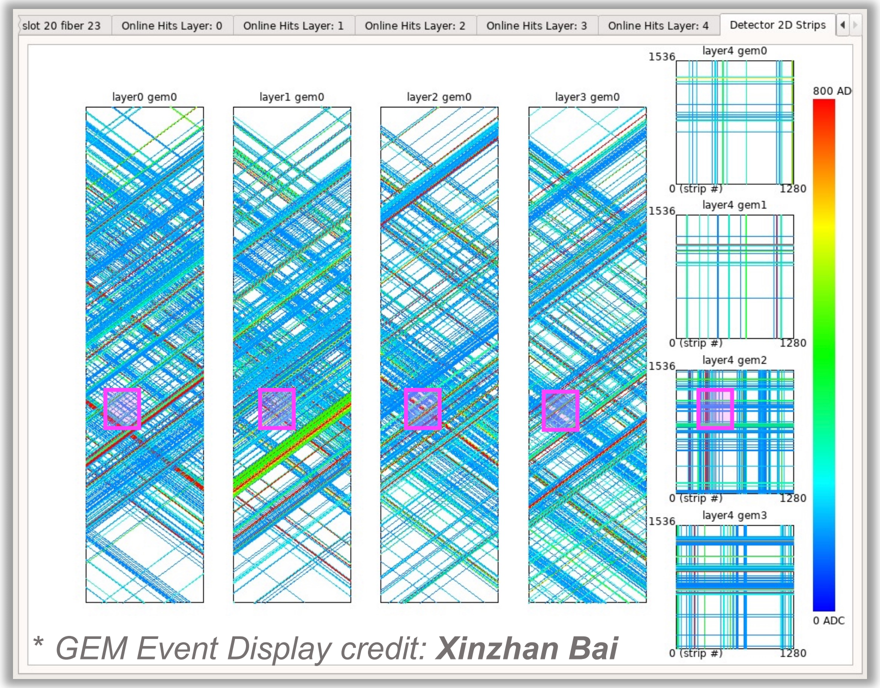
- All the trigger sums associated to same SH row, fire uniformly.

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

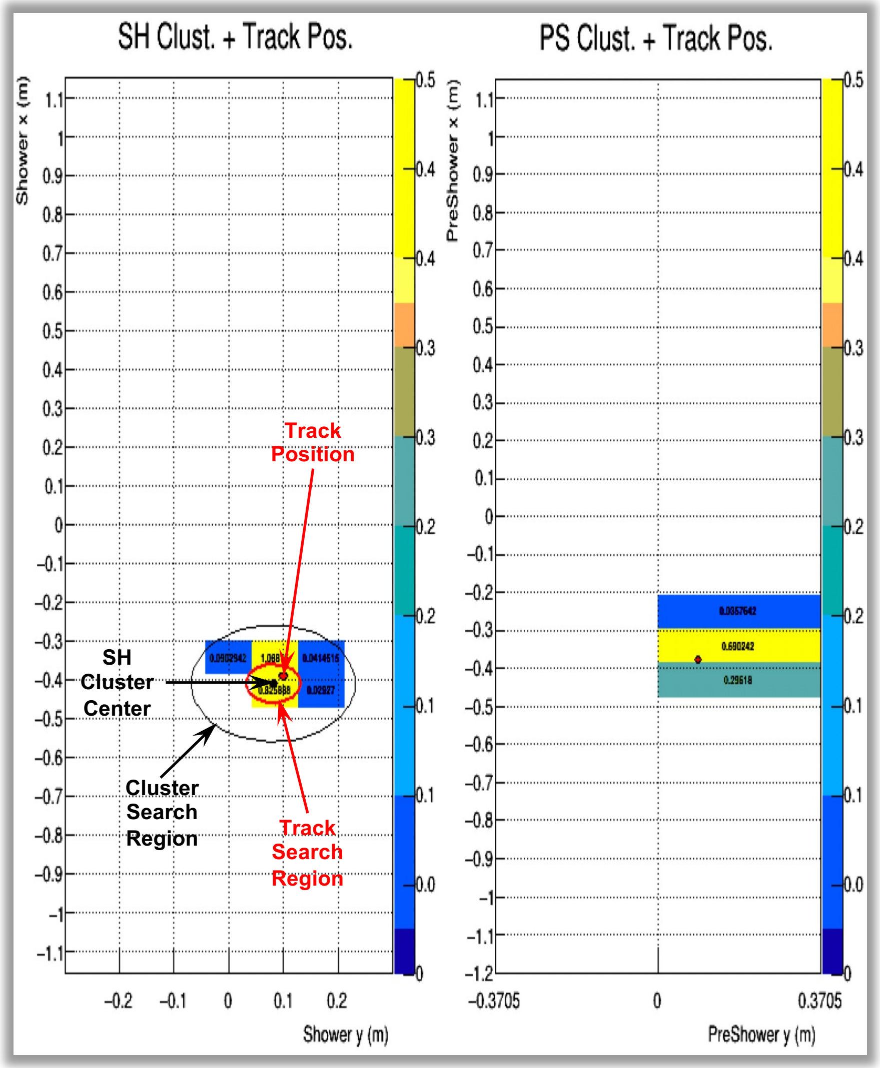
# 4. Constraint for Track Search Region



- We reconstruct scattered $e^-$ tracks in BigBite backwards.
- First, we define a search region around SH cluster position.
- Then propagate that region to all the GEM layers and search for tracks within.
- SH cluster position also gives starting vertical position and vertical angle for track search.



* GEM Event Display credit: ***Xinzhan Bai***



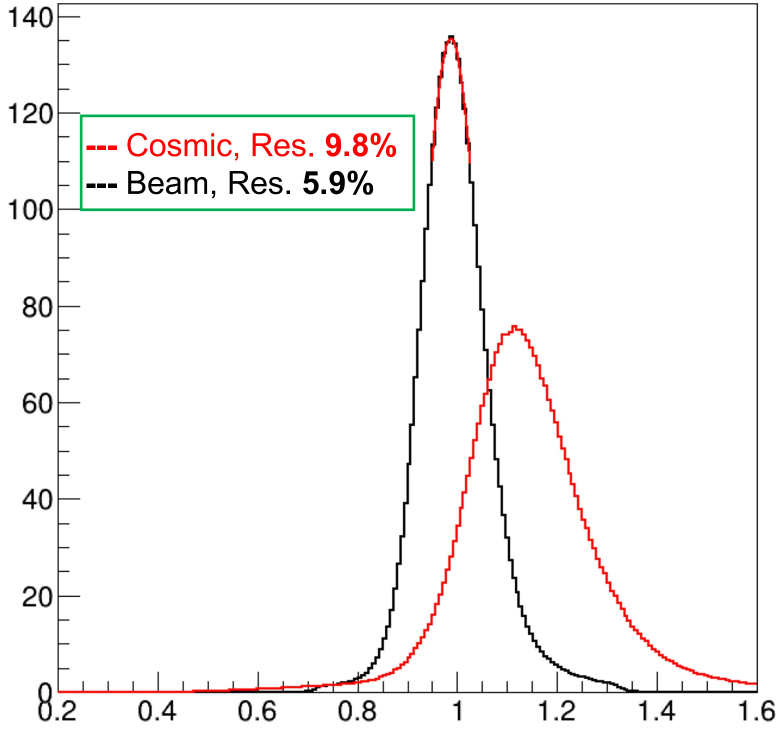
❖ This utility of BBCAL makes replay possible for SBS experiments!

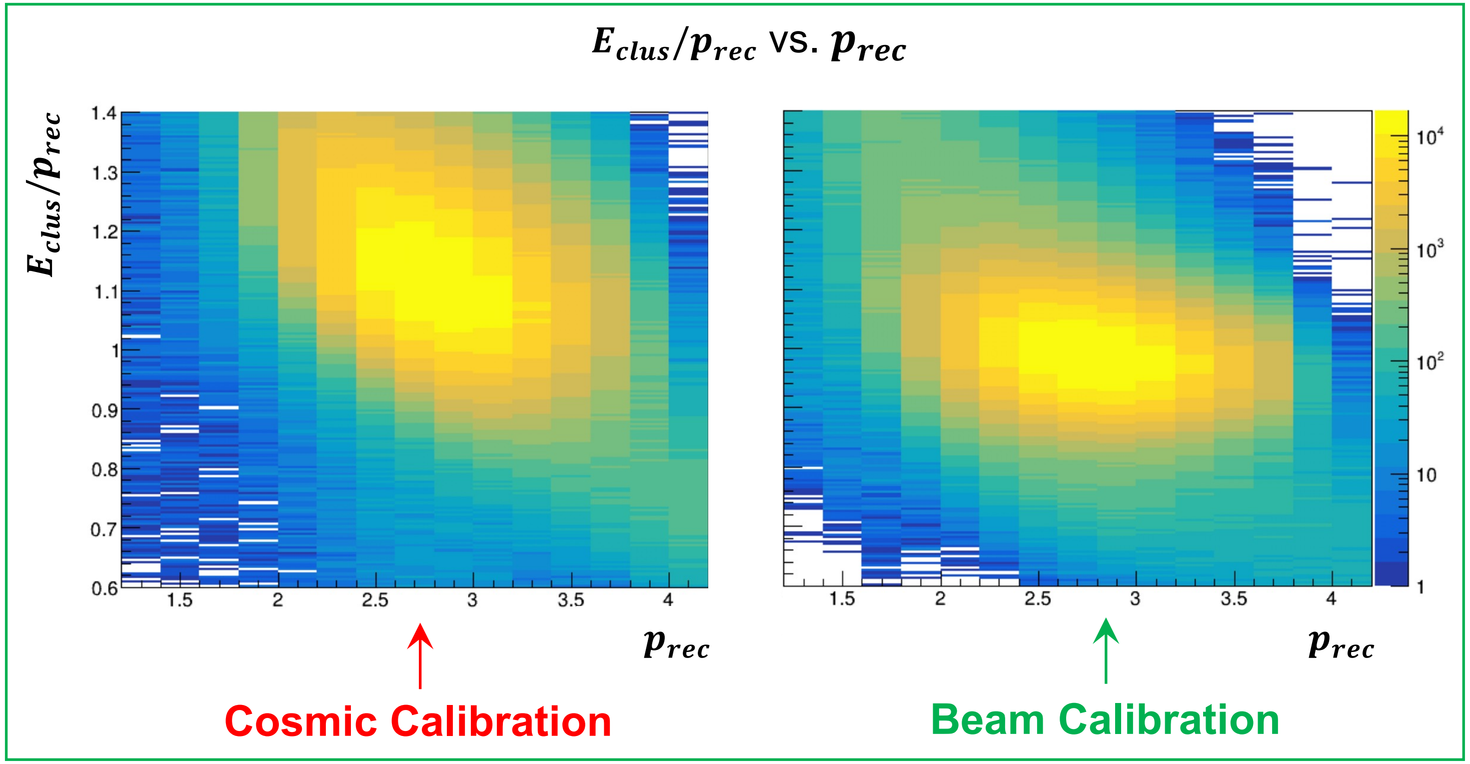
- The constraint reduces the search region to **2-3%** of the entire GEM active area.
- Good BBCAL energy calibration is necessary to use this feature.

❖ Better calibration lets us optimize the search region which in turn improves the reconstruction efficiency significantly.

# Energy Resolution: Preliminary Results

$E_{clus}/p_{rec}$ Distribution





**Cosmic Calibration**

**Beam Calibration**

- Initially we see a strong negative correlation between $E_{clus}/p_{rec}$ and $p_{rec}$ which almost disappears with just 1st round of calibration with beam.
- Energy resolution improves drastically with beam calibration.

SBS-8, SBS 70% field Data

# Energy & Time Resolutions: Preliminary Results contd.

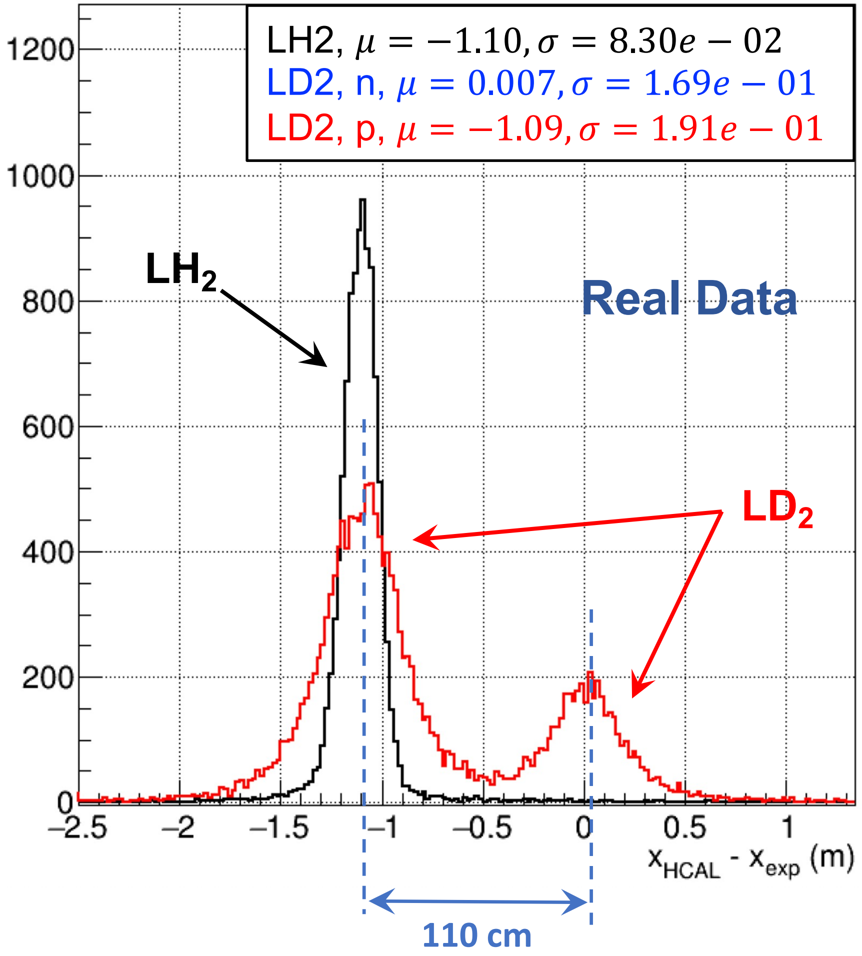
Table I: **BBCAL energy resolution before and after calibration for all SBS configurations.**

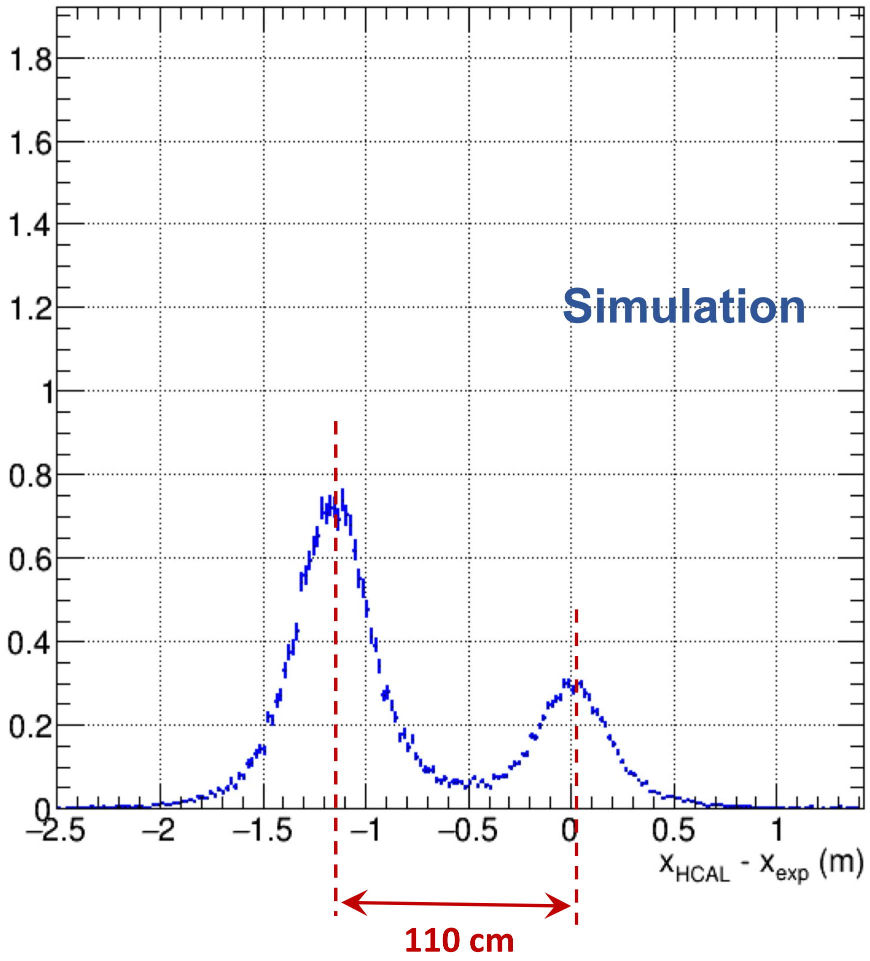
| Configuration | $E_{beam}$ (GeV) | $E_{e'}$ (GeV) | Magnet Current (A) | | BBCAL Resolution (%) | |
|---|---|---|---|---|---|---|
| | | | BB | SBS | Before Calib. | After Calib. |
| SBS-4 | 3.728 | 2.11 | 750 | 0 | 8.9 | **6.5** |
| | | | 750 | 630 | 8.6 | **6.6** |
| | | | 750 | 1050 | 9.5 | **6.6** |
| SBS-7 | 7.906 | 2.67 | 750 | 1785 | 9.4 | **6.8** |
| SBS-11 | 9.91 | 2.67 | 750 | 0 | 12.3 | **7.8** |
| | | | 750 | 2100 | 12.2 | **7.9** |
| SBS-14 | 5.965 | 2.00 | 750 | 0 | 10.5 | **7.8** |
| | | | 750 | 1470 | 10.7 | **7.3** |
| 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** |

- Completed **initial** calibration of all 13 different settings across 6 SBS configurations.
- Achieved 5.9% **energy resolution at 3.6 GeV** scattered $e^-$ energy.
- Work in progress for the most challenging setting (SBS-11).

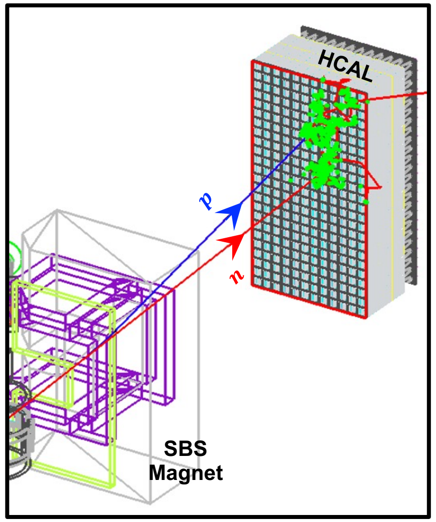
❖ Apart from energy resolution, we also could achieve ~ 2.5 ns time resolution.

# First Look at Production Data $[Q^2 = 3\ (GeV/c)^2]$





- Primary Cuts:
  1. No. of tracks per event = 1
  2. No. of GEM layers that had hit > 3
  3. $|(\text{vertex})_z| < 0.08$ m
  4. PS cluster energy > 0.2 GeV
  5. SH + PS cluster energy > 1.7 GeV
  6. |E/p - 0.92| < 0.2
  7. HCAL cluster energy > 0.02 GeV
  8. |HCAL-BBCAL coin – 510| < 10 ns
- Choosing only elastic (LH2) or QE (LD2) events: $0.7 < W < 1.12$.



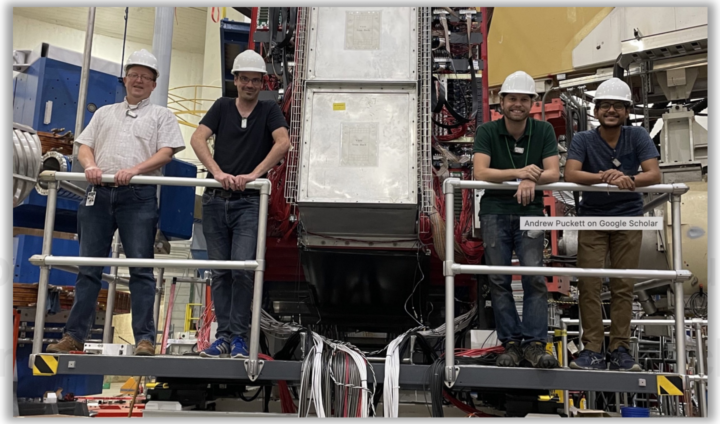
❖ Ensures the detections of both $d(e,e'n)$ & $d(e,e'p)$ events.

$$R'' = \frac{\frac{d\sigma}{d\Omega}\Big|_{d(e,e'n)}}{\frac{d\sigma}{d\Omega}\Big|_{d(e,e'p)}}$$

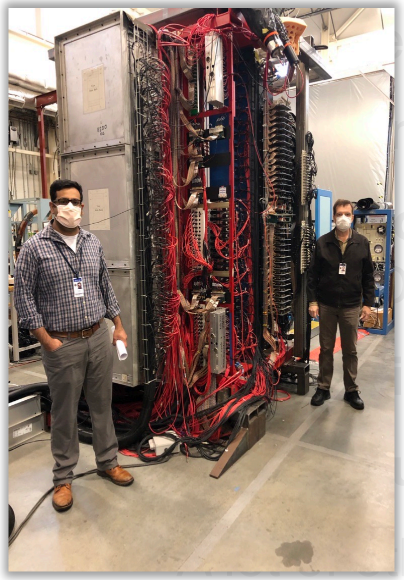
# Summary

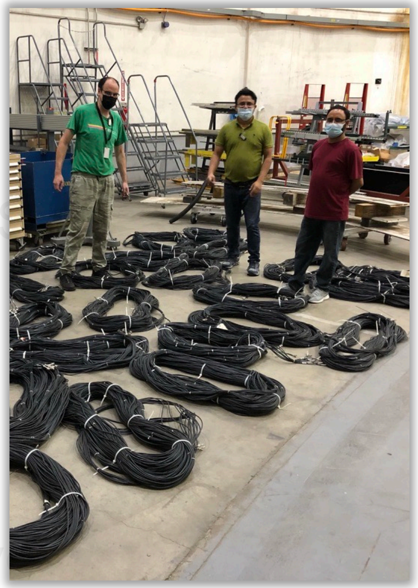
- SBS $G_M^n$ installation and running had a lot of challenges:
  - Failure of Hall A overhead crane.
  - Limited manpower due to COVID.
  - Several configuration changes during run. [Configuration change means moving and aligning $\sim 50$ Ton spectrometers in a very short amount of time!]
  - Largest installation of GEMs in the country till date had massive DAQ, hardware, and software related challenges associated with it.
  - et cetera..
- But we could overcome all these challenges by working as a team. Thanks to the tireless work of Hall A technicians, Graduate students, Post Docs, JLab Staff Scientists, and Professors.
- We are currently calibrating our detectors. Performance of all the detector subsystems look very good even with very preliminary calibration. E.g., for BBCAL, we could achieve **5.9%** energy resolution (at 3.6 GeV $e^-$ energy) and **2.6 ns** time resolution.
- A significant effort of data analysis is ongoing. Preliminary results look promising.
- Results of SBS $G_M^n$ i.e., high precision values of $G_M^n$ at unexplored $Q^2$ regime will **guide GPD formalism**, **benchmark LQCD**, and provide more insight into **nucleon quark flavor decomposition**.

❖ **Acknowledgement:** This work is supported by the US Department of Energy Office of Science, Office of Nuclear Physics, Award ID DE-SC0021200.



- **Core Group** … n Ta … a, Eric Fuchey.
- **Software/An** … kett … Penman.





x Camsonne, Bryan Moffit, Ben Raydo.

**ntrol:** Steve Woods.

**on:** Je … & his team, Robin & her team, Jack, Ellen, Sebastian

Devkota, Hem Bhatt, Zeke Wertz, Abishek Karki.

# Thank You for Your Attention!

## Questions? Comments?

**ics & Hardware Support:** JLab Electronics group, Chuck Long.

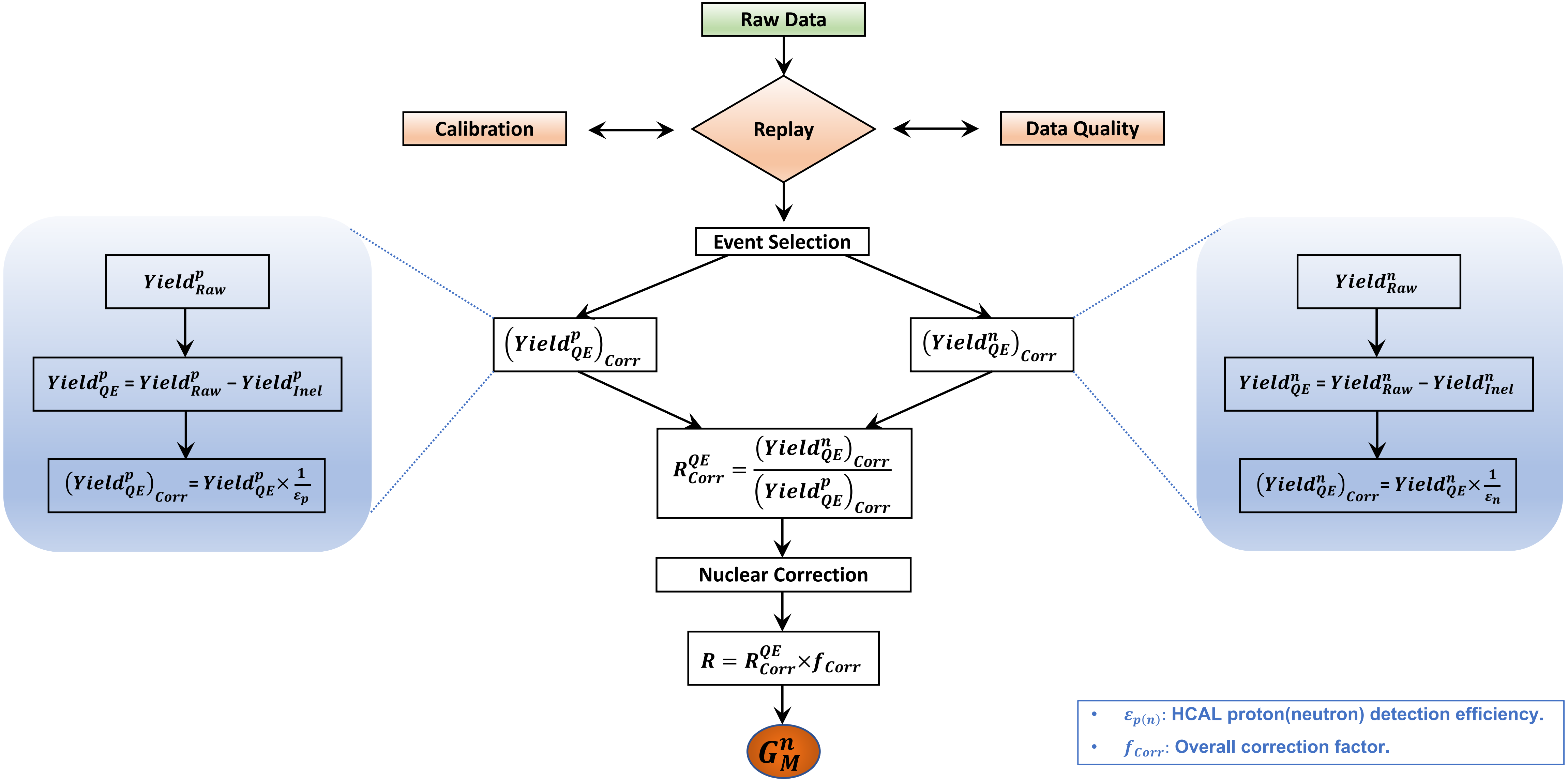
**uggestions:** Brad Sawatzky.

her people whose name I cannot recall at the moment. **Thank y**

- This work is supp … nt o … e, Office of Nuclear Physics, A

# Backup Slides

# Analysis Flowchart



Raw Data

Replay

Calibration

Data Quality

Event Selection

$\left(Yield_{QE}^{p}\right)_{Corr}$

$\left(Yield_{QE}^{n}\right)_{Corr}$

$Yield_{Raw}^{p}$

$Yield_{QE}^{p} = Yield_{Raw}^{p} - Yield_{Inel}^{p}$

$\left(Yield_{QE}^{p}\right)_{Corr} = Yield_{QE}^{p} \times \frac{1}{\varepsilon_p}$

$Yield_{Raw}^{n}$

$Yield_{QE}^{n} = Yield_{Raw}^{n} - Yield_{Inel}^{n}$

$\left(Yield_{QE}^{n}\right)_{Corr} = Yield_{QE}^{n} \times \frac{1}{\varepsilon_n}$

$$R_{Corr}^{QE} = \frac{\left(Yield_{QE}^{n}\right)_{Corr}}{\left(Yield_{QE}^{p}\right)_{Corr}}$$

Nuclear Correction

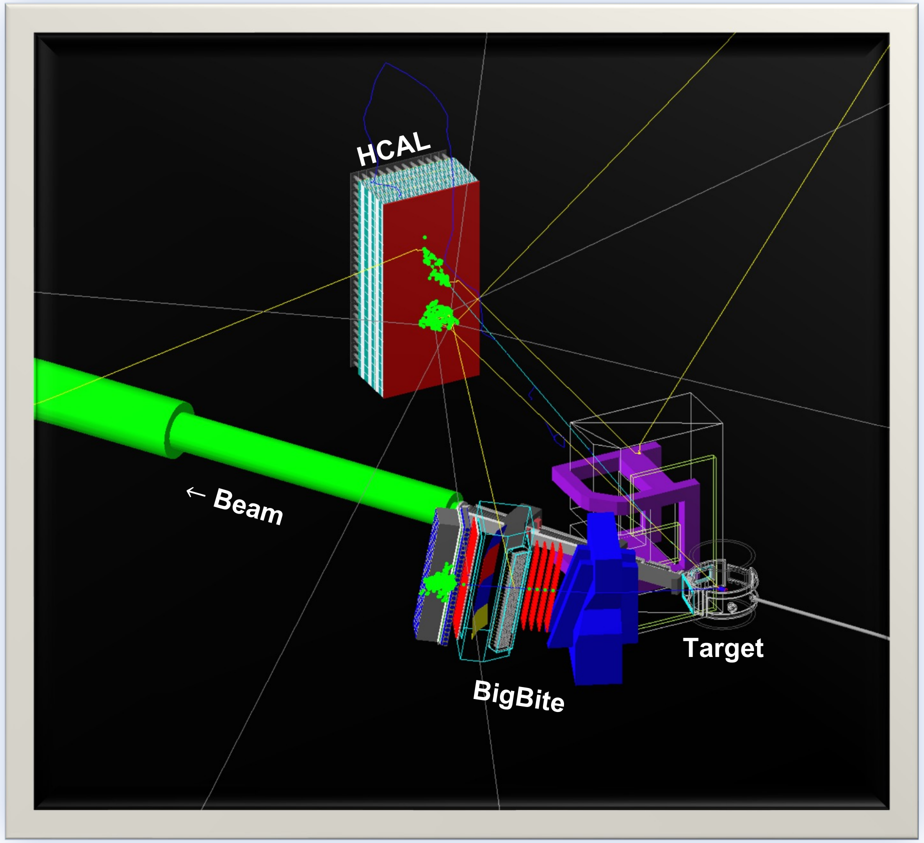
$$R = R_{Corr}^{QE} \times f_{Corr}$$

$G_M^n$

- $\varepsilon_{p(n)}$: HCAL proton(neutron) detection efficiency.
- $f_{Corr}$: Overall correction factor.

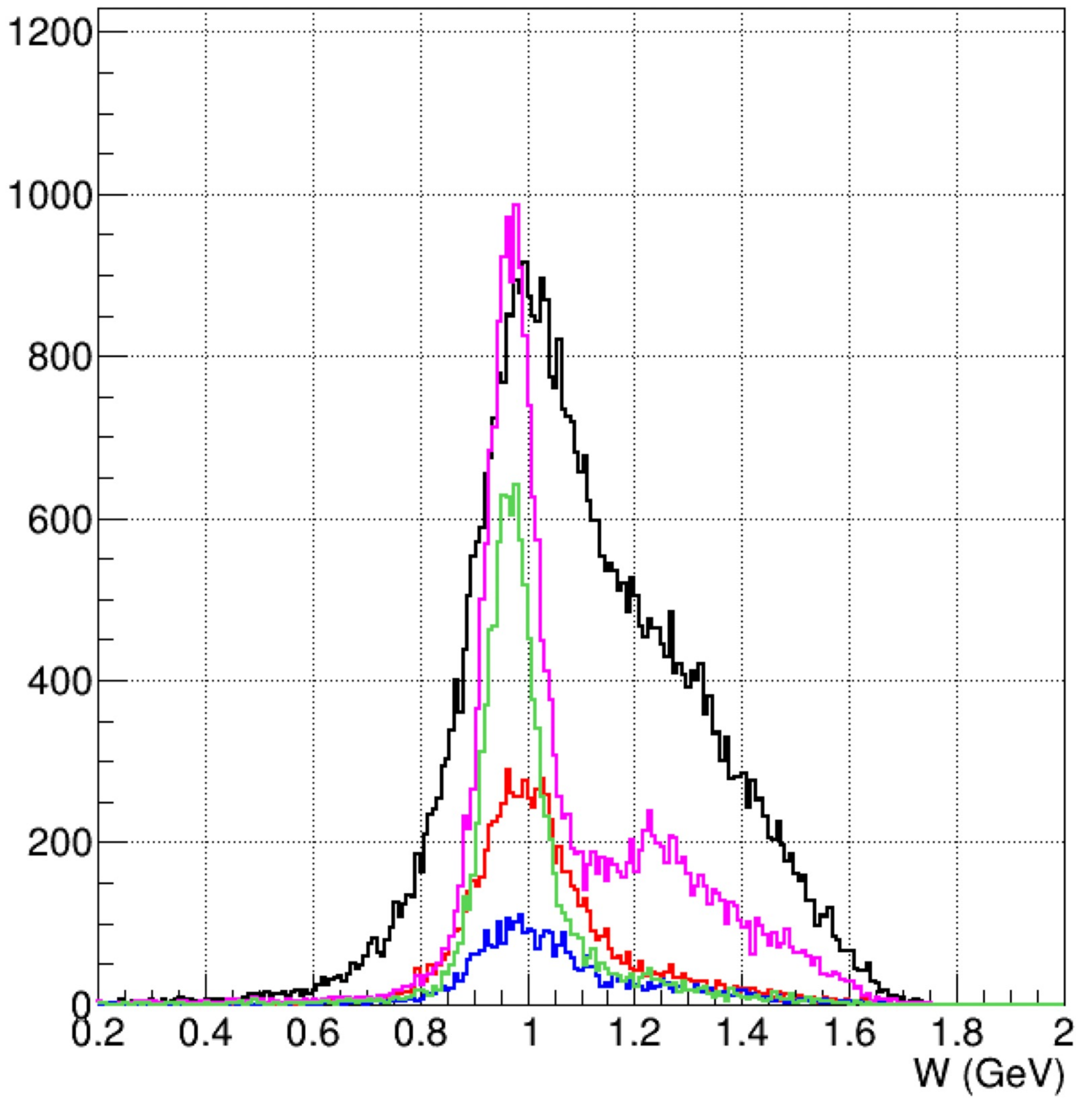
# Kinematic Parameters for $Q^2 = 3\ (GeV/c)^2$

- **Magnet Settings:**
  - BB 750A
  - SBS 0A, 630A (30%) & 1050A (50%)
- **Kinematic parameters:**
  - Beam energy: 3.7278 GeV
  - Beam current: 1.75 $\mu$A
  - BB angle: 36 deg
  - SBS angle: 31.9 deg
  - BB magnet distance: 1.80 m
  - HCAL distance: 11 m
- **Runs Used:** All SBS 30% & 50% LD2 runs for SBS4 listed in the good run list.

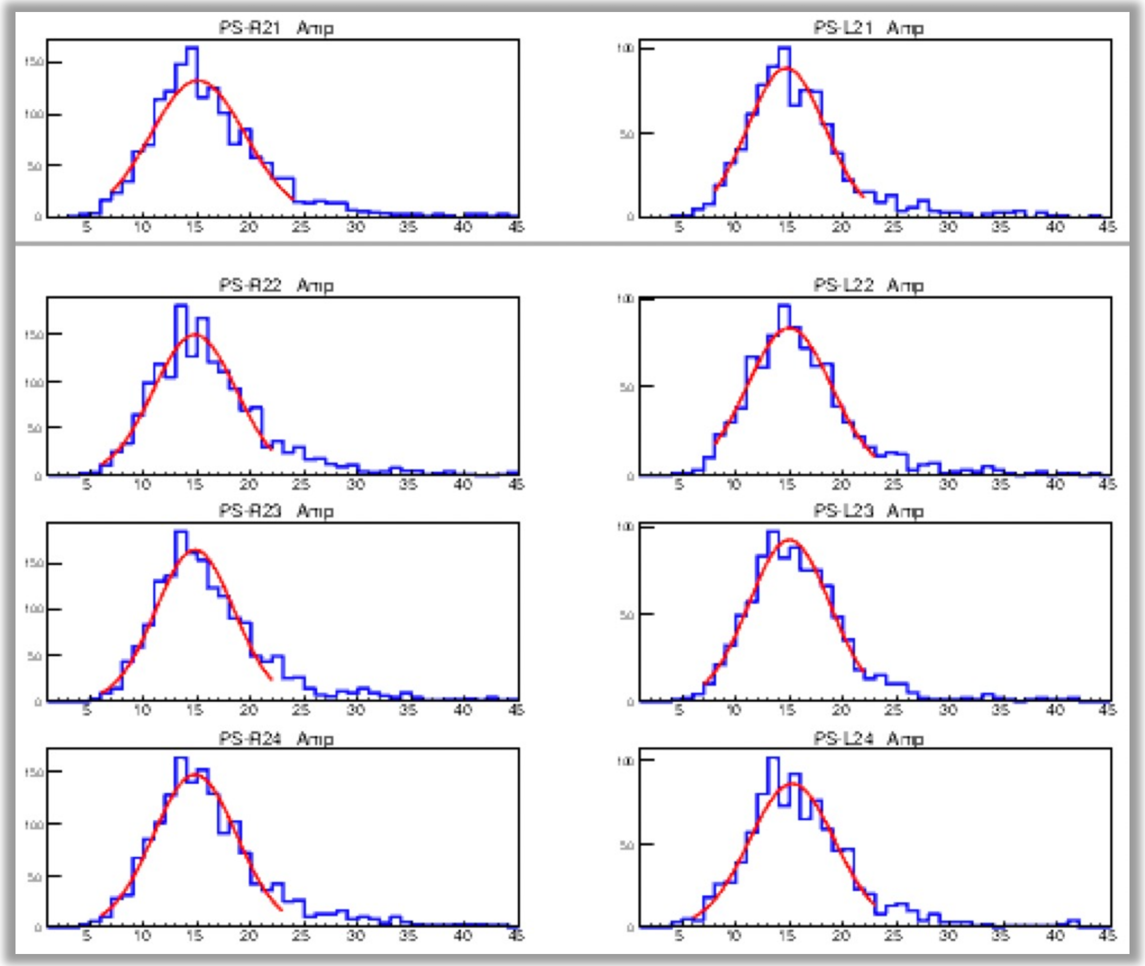


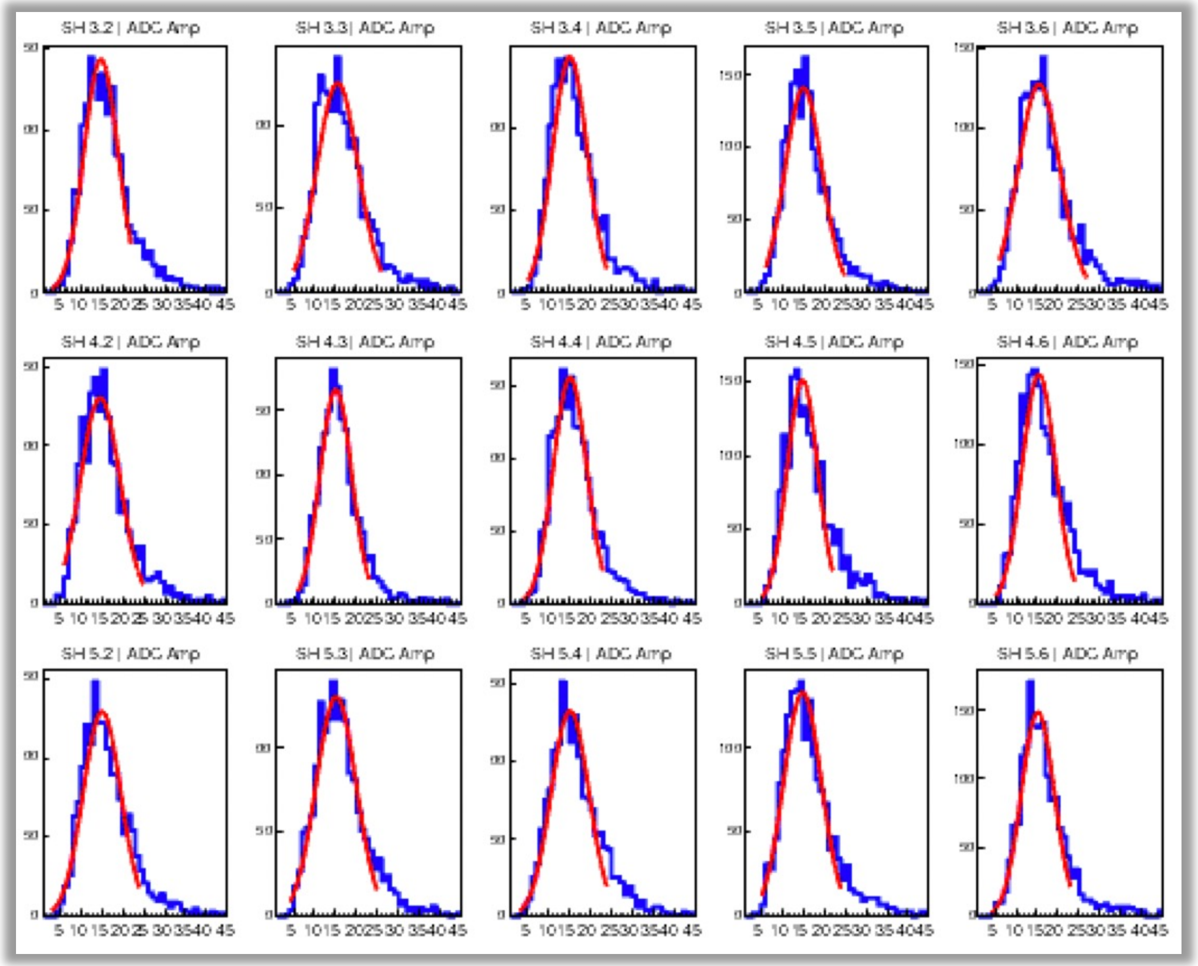
GEANT4 simulation of SBS4 configuration using g4sbs.

# Invariant Mass Distributions in Comparison



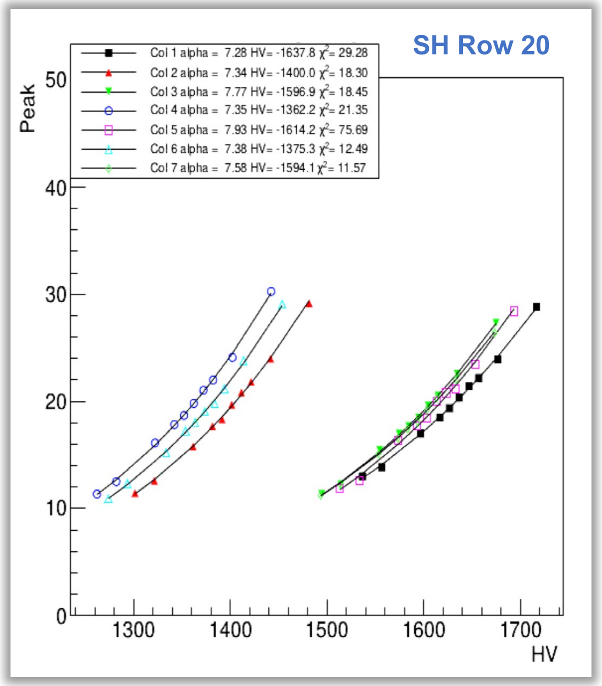
# Cosmic Peaks – PS and SH





# Cosmic Calibration

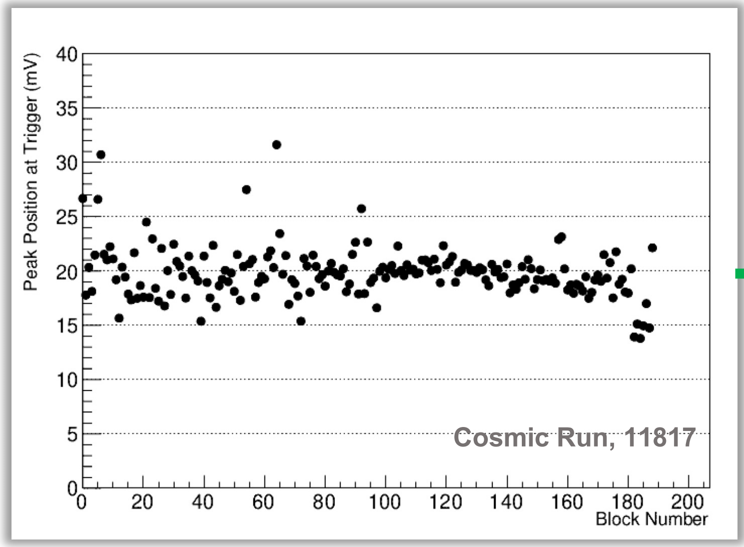
- Two primary methos of calibration – 1. Cosmic Calibration & 2. Beam Calibration (using $LH_2$)

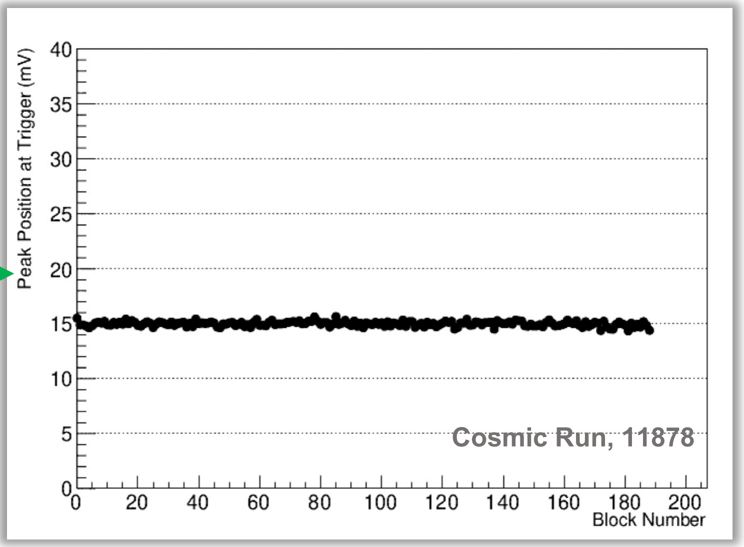


- Perform HV scan over a broad range.
- Get $\alpha$ by fitting Peak Position vs. HV plot, using: $\text{Peak Pos.} = \text{const} \times \text{HV}^{\alpha}$

❖ Only need to do this once since $\alpha$ value for a PMT should be stable.

- We then follow **2 simple steps** to perform cosmic calibration:





①

- Take a cosmic run with enough events.
- Fit the ADC amplitude distributions and extract peak positions for individual SH and PS blocks.

②

- Generate new HV settings that align Peak positions at the trigger to target ADC amplitude, using:

$$\text{HV}_{\text{new}} = \text{HV}_{\text{old}} \left[ \frac{\text{Target ADC Amp.}}{\text{Current ADC Amp.}} \right]^{\frac{1}{\alpha}}$$

# Beam Calibration: Procedure

- **Method**:
  - $\chi^2$ minimization:

$$\chi^2 = \sum_{i=1}^{N}\left(E_e^i - \sum_{k=0}^{M} C_k A_k^i\right)^2 ,$$
$$= \sum_{i=1}^{N}\left(\left(E_e^i\right)^2 + \left(\sum_{k=0}^{M} C_k A_k^i\right)^2 - 2E_e^i \sum_{k=0}^{M} C_k A_k^i\right)$$

  - Minimizing $\chi^2$ with respect to the coefficients:

$$\frac{\partial \chi^2}{\partial C_j} = 0 \Rightarrow \sum_{i=1}^{N}\sum_{k,j=0}^{M}\left(\underset{\substack{\downarrow\\ B}}{A_j} - \underset{\substack{\downarrow\\ C}}{C_k}\underbrace{\frac{A_k A_j}{E_e}}_{M}\right)_i = 0$$

  - Solving $M$ linear equations to get the $C_j$s:

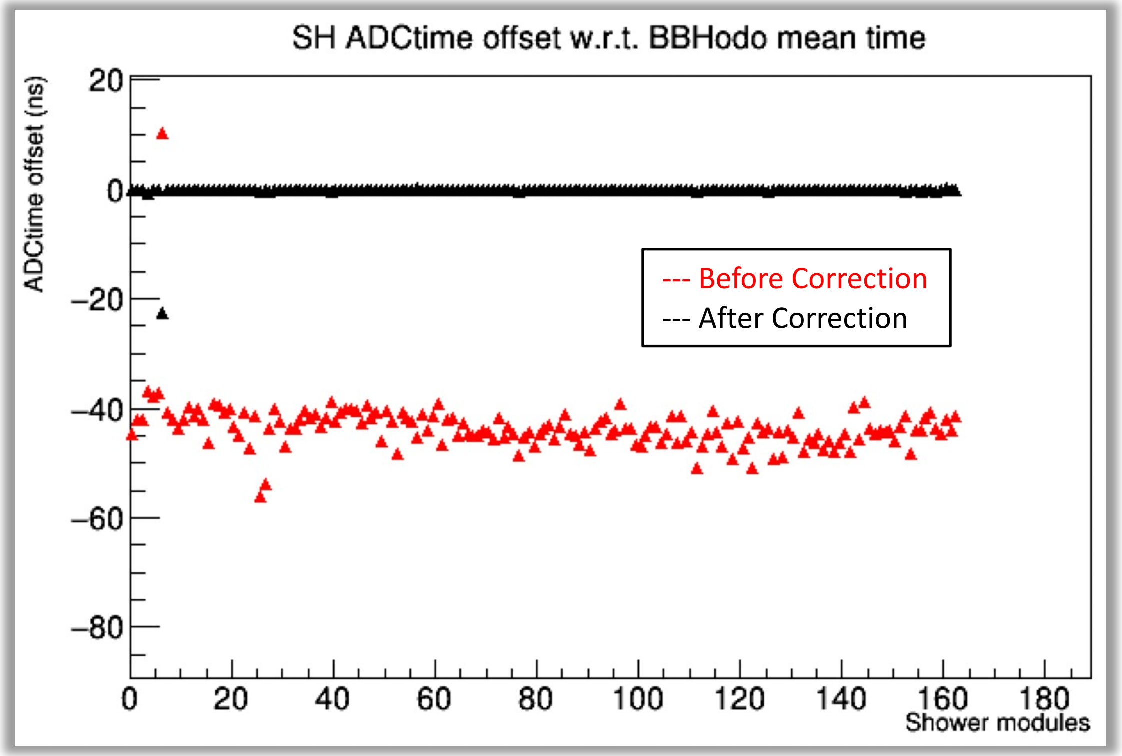
$$\boxed{C = M^{-1}B}$$

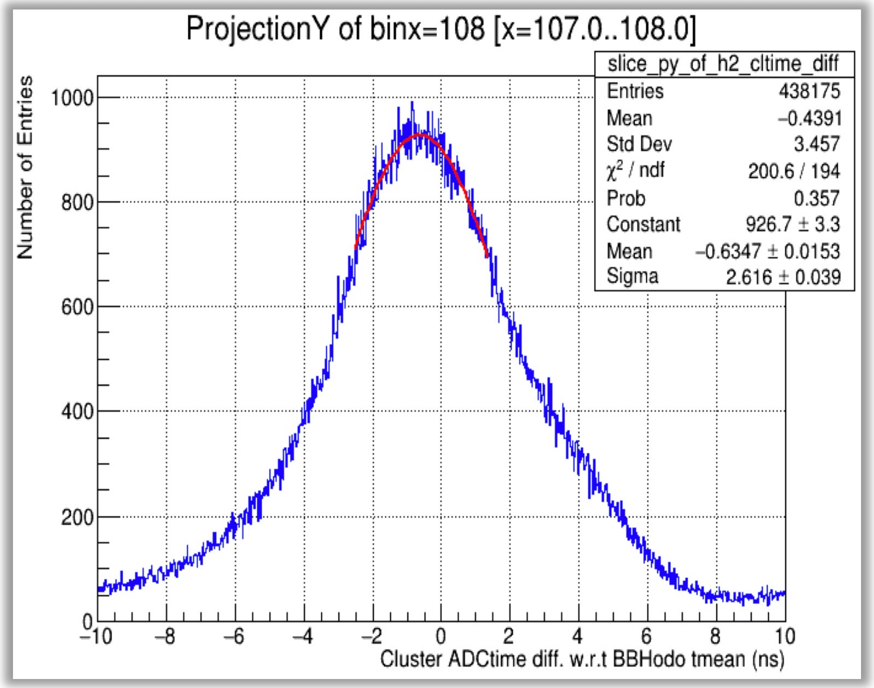
- $E_e^i$: Track momentum at $i^{th}$ event.
- $A_e^i$: Energy deposited in $k^{th}$ block at $i^{th}$ event.
- $C_k$: Gain coefficients.
- $N$: Number of events.
- $M$: Number of Shower blocks.

## ❖ Primary Cuts

1. No. of tracks per event = 1
2. No. of GEM planes that had hit > 3
3. $|(\text{vertex})_z| < 0.08$ m
4. HCAL cluster energy > 0.025 GeV
5. PS cluster energy > 0.2 GeV
6. SH + PS cluster energy > 1.9 GeV
7. $|E/p - 1| < 0.3$
8. $2.1 < p_{rec} < 3.0$ (GeV)

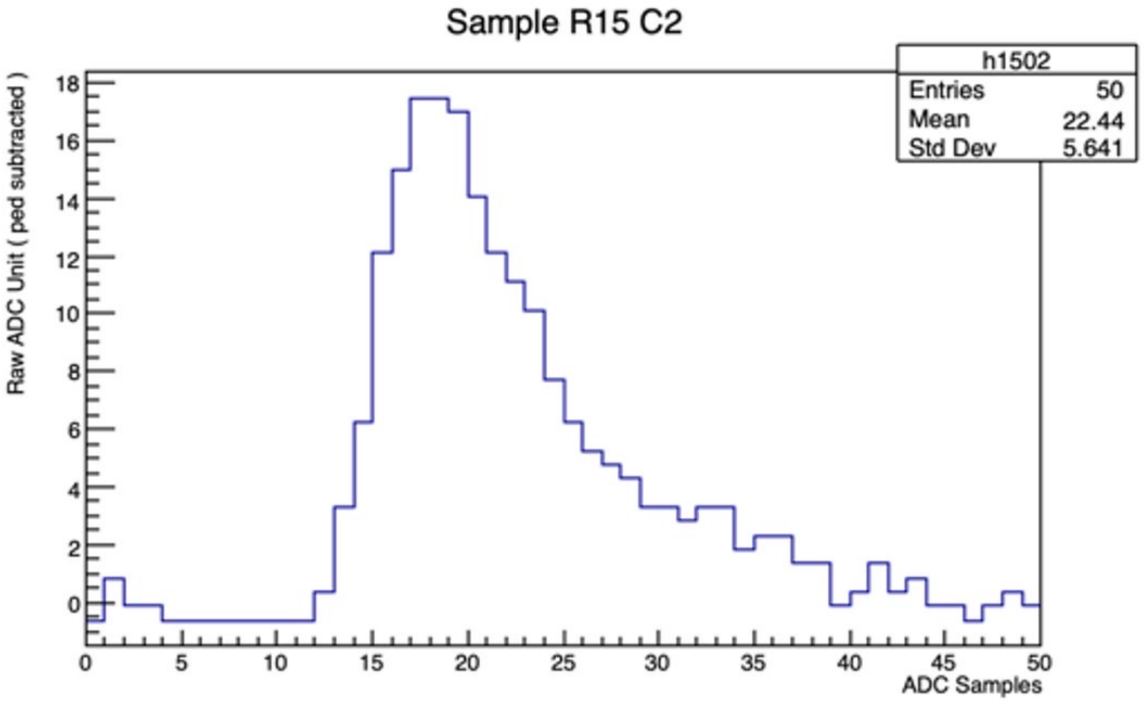
# ADC Time Resolution: Preliminary Results





- **Left Plot:** Shows results of ADC time offset correction for individual shower blocks w.r.t BBHodo cluster mean time. Similar results were achieved for Pre-Shower modules as well.
- **Right Plot:** Shows the distribution of the difference between BBHodo cluster mean time and ADC time of all blocks of the corresponding SH cluster. Resolution achieved: **2.62 ns** (Preliminary).
- Time walk corrections are yet to be implemented.

# ADC time calculation

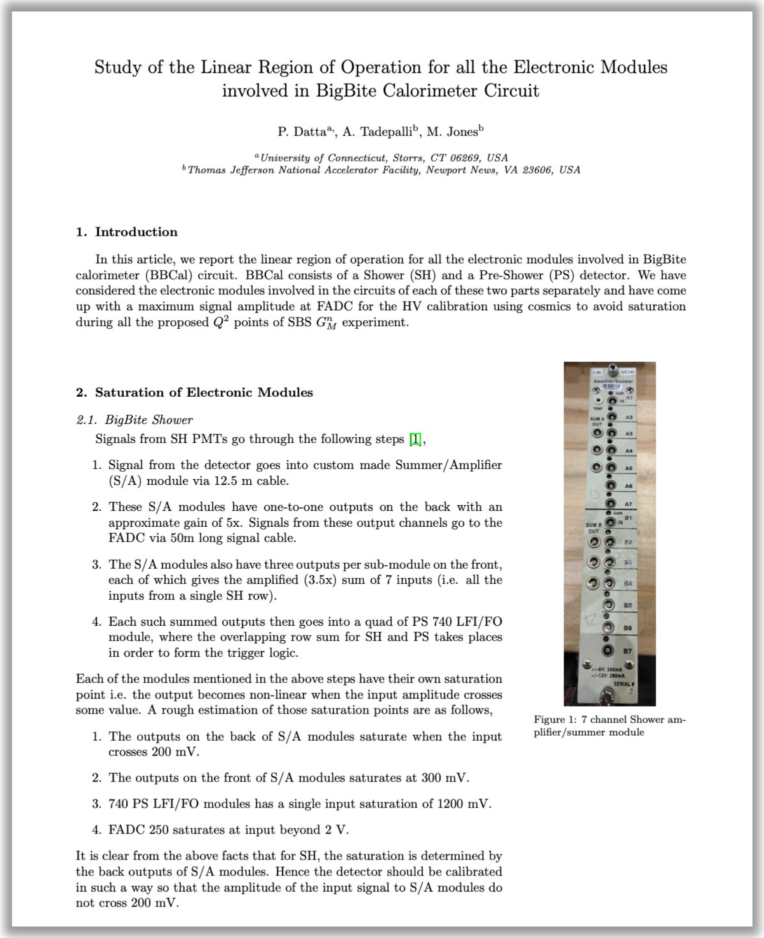


$$FADC_{time} = 4ns * [i + \frac{V_{Mid} - V_i}{V_{i+1} - V_i}]$$

here, $$V_{Mid} = \frac{(V_{peak} + pedestal)}{2}$$

- "*i*" is the sample which has value greater than $V_{Mid}$ and the next sample, "*i+1*", is less than $V_{Mid}$.

# Resources



## Study of the Linear Region of Operation for all the Electronic Modules involved in BigBite Calorimeter Circuit

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### 1. Introduction

In this article, we report the linear region of operation for all the electronic modules involved in BigBite calorimeter (BBCal) circuit. BBCal consists of a Shower (SH) and a Pre-Shower (PS) detector. We have considered the electronic modules involved in the circuits of each of these two parts separately and have come up with a maximum signal amplitude at FADC for the HV calibration using cosmics to avoid saturation during all the proposed $Q^2$ points of SBS $G_M^n$ experiment.

### 2. Saturation of Electronic Modules

*2.1. BigBite Shower*

Signals from SH PMTs go through the following steps [1],

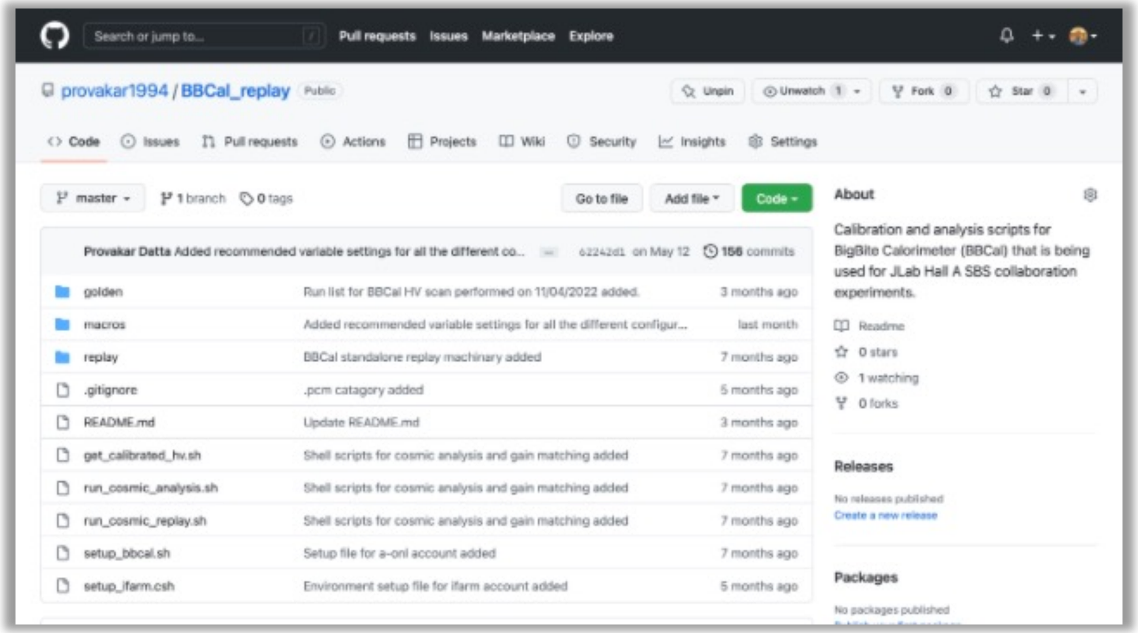
1. Signal from the detector goes into custom made Summer/Amplifier (S/A) module via 12.5 m cable.
2. These S/A modules have one-to-one outputs on the back with an approximate gain of 5x. Signals from these output channels go to the FADC via 50m long signal cable.
3. The S/A modules also have three outputs per sub-module on the front, each of which gives the amplified (3.5x) sum of 7 inputs (i.e. all the inputs from a single SH row).
4. Each such summed outputs then goes into a quad of PS 740 LFI/FO module, where the overlapping row sum for SH and PS takes places in order to form the trigger logic.

Each of the modules mentioned in the above steps have their own saturation point i.e. the output becomes non-linear when the input amplitude crosses some value. A rough estimation of those saturation points are as follows,

1. The outputs on the back of S/A modules saturate when the input crosses 200 mV.
2. The outputs on the front of S/A modules saturates at 300 mV.
3. 740 PS LFI/FO modules has a single input saturation of 1200 mV.
4. FADC 250 saturates at input beyond 2 V.

It is clear from the above facts that for SH, the saturation is determined by the back outputs of S/A modules. Hence the detector should be calibrated in such a way so that the amplitude of the input signal to S/A modules do not cross 200 mV.

Figure 1: 7 channel Shower amplifier/summer module



provakar1994 / BBCal_replay

Provakar Datta Added recommended variable settings for all the different co... 62242d1 on May 12 156 commits

| | | |
|---|---|---|
| golden | Run list for BBCal HV scan performed on 11/04/2022 added. | 3 months ago |
| macros | Added recommended variable settings for all the different configur... | last month |
| replay | BBCal standalone replay machinary added | 7 months ago |
| .gitignore | .pcm catagory added | 5 months ago |
| README.md | Update README.md | 3 months ago |
| get_calibrated_hv.sh | Shell scripts for cosmic analysis and gain matching added | 7 months ago |
| run_cosmic_analysis.sh | Shell scripts for cosmic analysis and gain matching added | 7 months ago |
| run_cosmic_replay.sh | Shell scripts for cosmic analysis and gain matching added | 7 months ago |
| setup_bbcal.sh | Setup file for a-onl account added | 7 months ago |
| setup_ifarm.csh | Environment setup file for ifarm account added | 5 months ago |

About

Calibration and analysis scripts for BigBite Calorimeter (BBCal) that is being used for JLab Hall A SBS collaboration experiments.

Readme
0 stars
1 watching
0 forks

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Create a new release

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[https://sbs.jlab.org/DocDB/0001/000118/001/BBCal_sig_circuit_saturation.pdf](https://sbs.jlab.org/DocDB/0001/000118/001/BBCal_sig_circuit_saturation.pdf)

[https://github.com/provakar1994/BBCal_replay](https://github.com/provakar1994/BBCal_replay)