# SBS Hadron-Calorimeter (HCAL) Perfomance

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Jefferson Lab

Hall A Winter Collaboration
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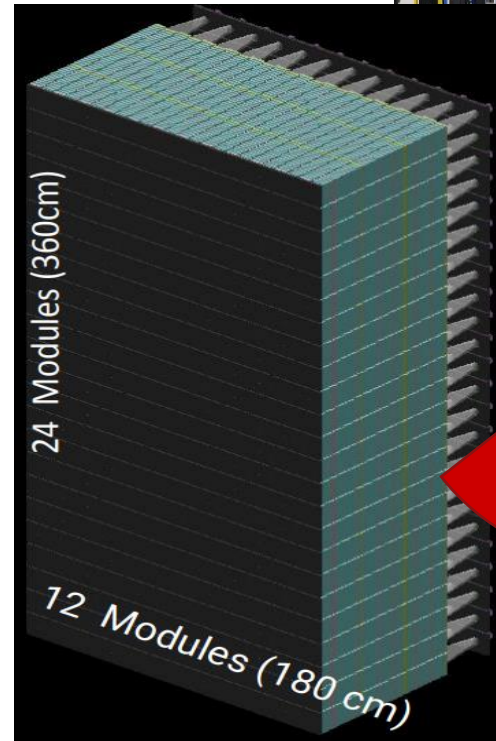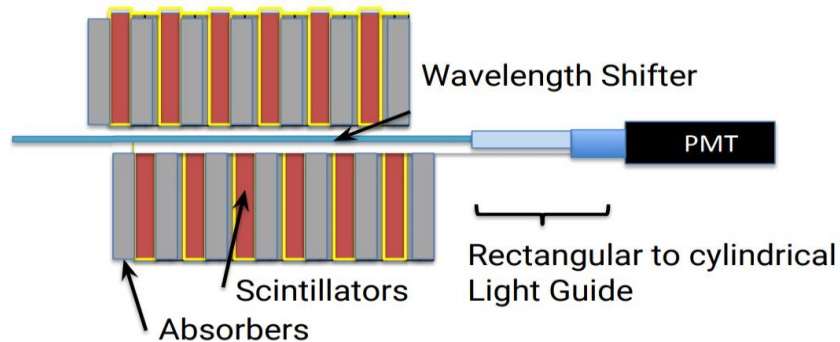
Background

- Super Big-Bite Programs: Study of nucleons form factors (G_E and G_M)
  - E12-09-019 -> GMn (data collection completed in 2020)
  - E12-09-016 -> GEn (data collection completed in 2023)
  - E12-17-004 -> GEn-RP (2024)
  - E12-07-109 -> GEp (2024)
- Hadron (protons/neutrons) Calorimeter detector for SBS Program
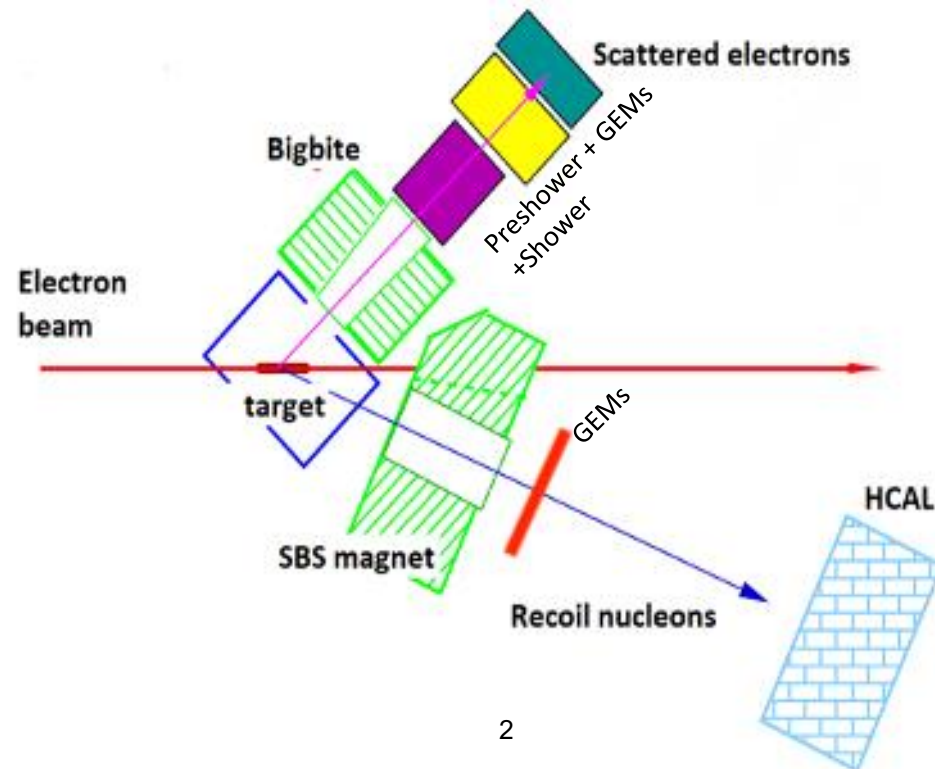
HCAL Detector

- Hadron (protons/neutrons) Calorimeter Detector

- Segmented Calorimeter to detect high energy nucleons: 288 modules (12x24 blocks of 15x15x100cm dimension)

- Each module: 40 layers of Iron absorbers alternate with scintillators, and a wavelength shifter in the middle

Wavelength Shifter

PMT

Rectangular to cylindrical Light Guide

Scintillators

Absorbers

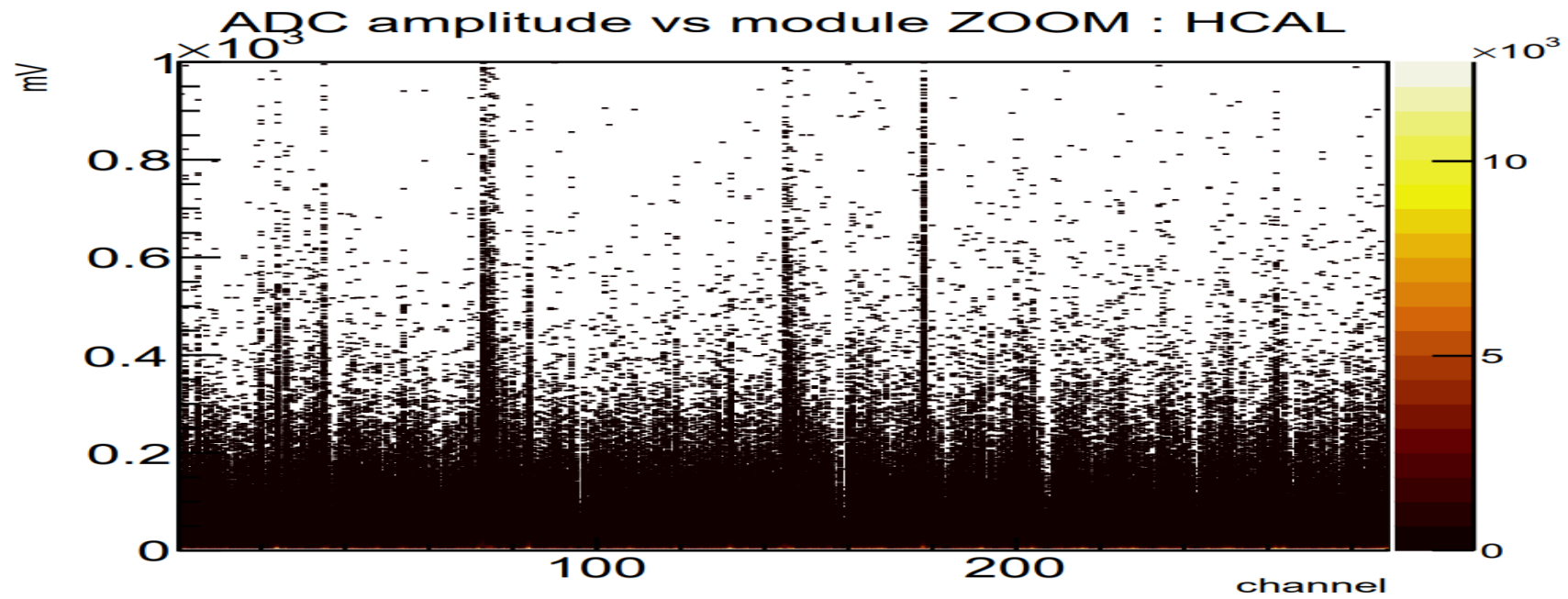24 Modules (360cm)

12 Modules (180 cm)

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HCAL System
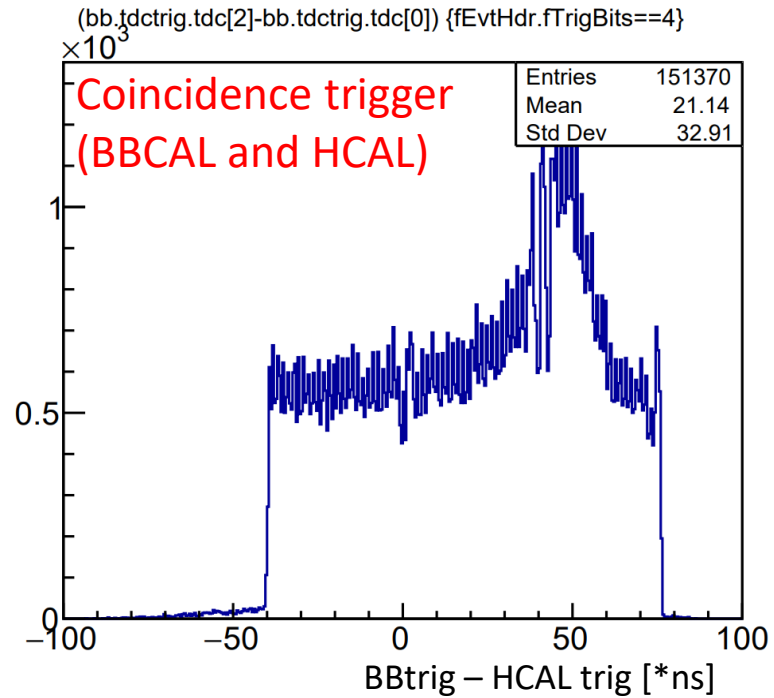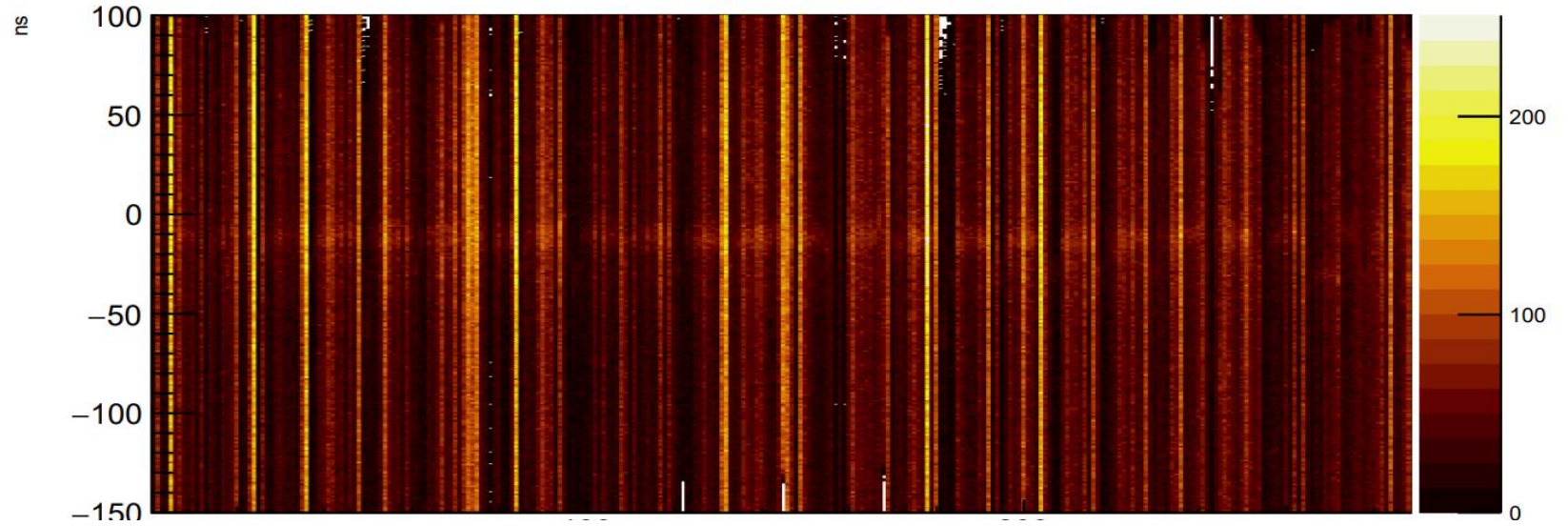
- Signals amplification (10x) at the Front end (HCAL upper platform) and readout at the back end (DAQ bunker)

- Signal waveform (ADCs) and timing (TDCs) information in data stream

- Summing modules for HCAL trigger (threshold on 8x8 sum)

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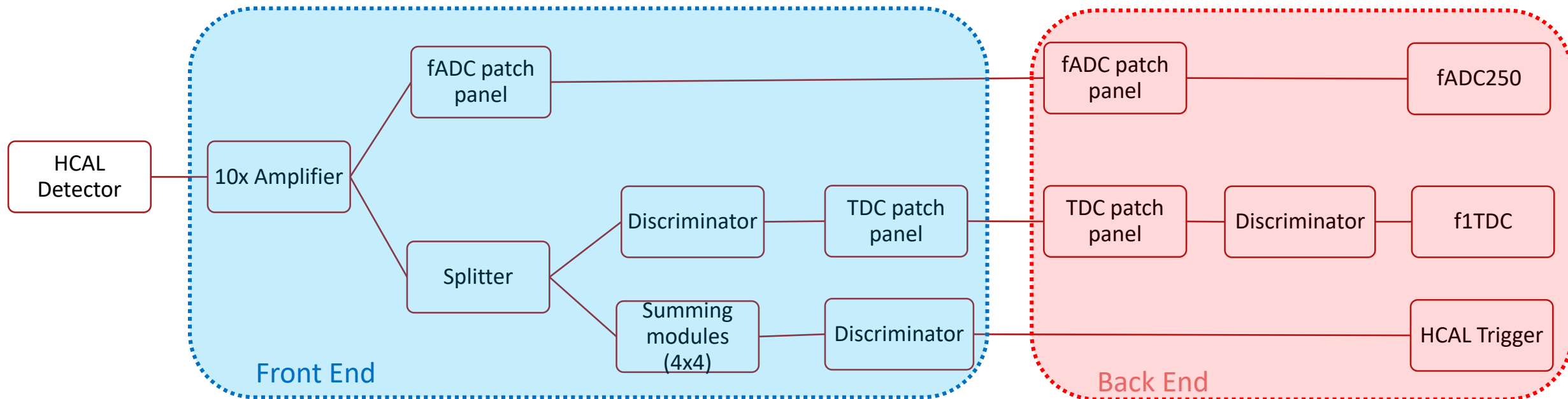
HCAL during GEn

TDC vs Module : HCAL

(bb.tdctrig.tdc[2]-bb.tdctrig.tdc[0]) {fEvtHdr.fTrigBits==4}

Entries	151370
Mean	21.14
Std Dev	32.91

Coincidence trigger
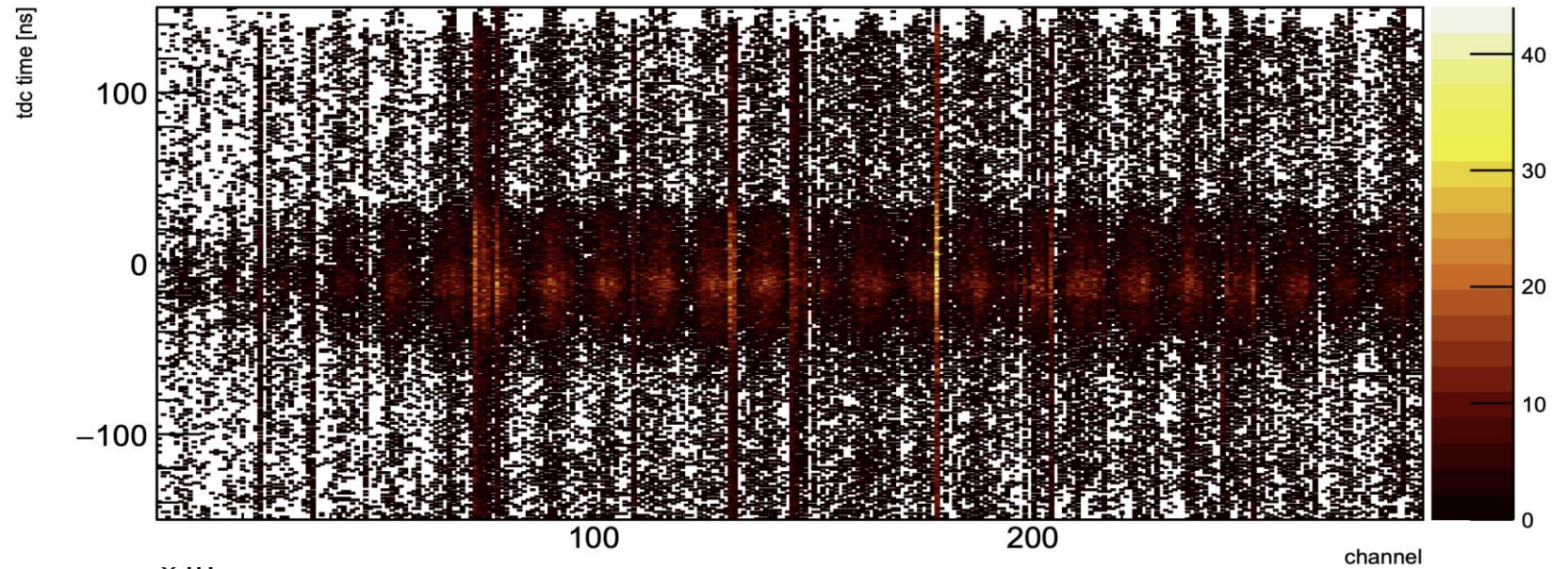(BBCAL and HCAL)

BBtrig − HCAL trig [*ns]

ADC amplitude vs module ZOOM : HCAL
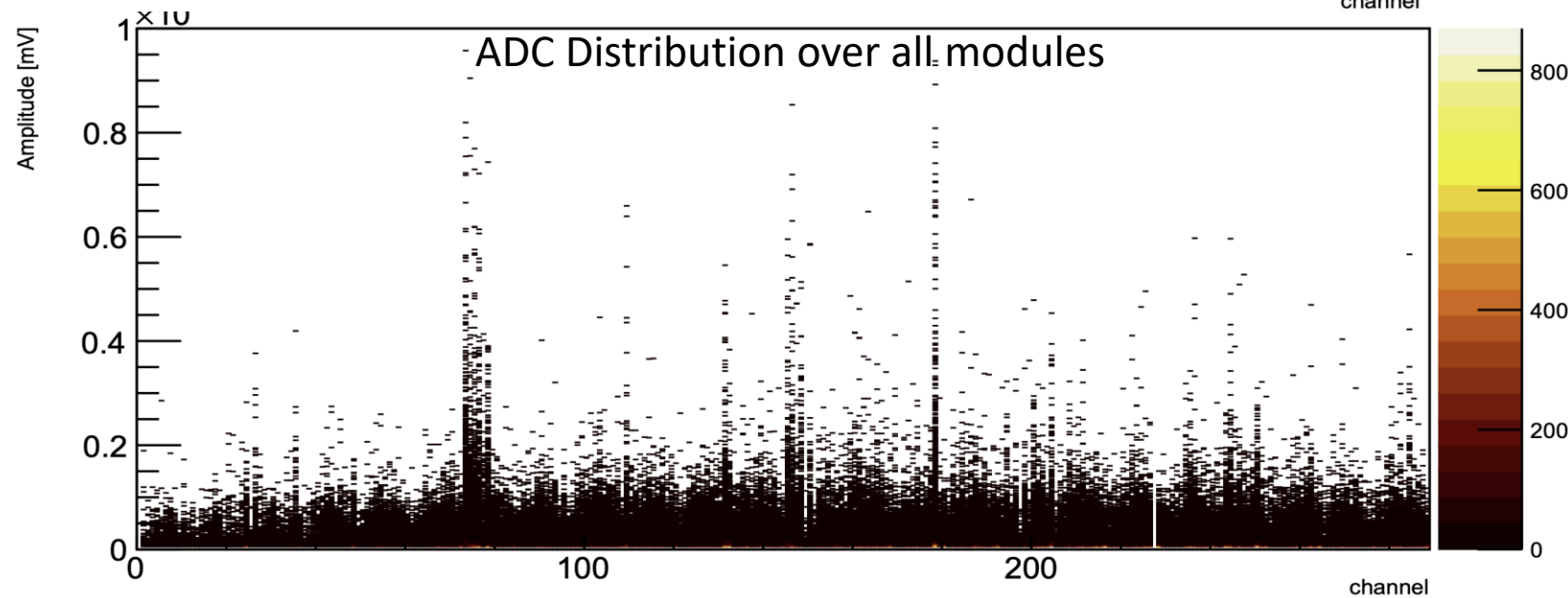
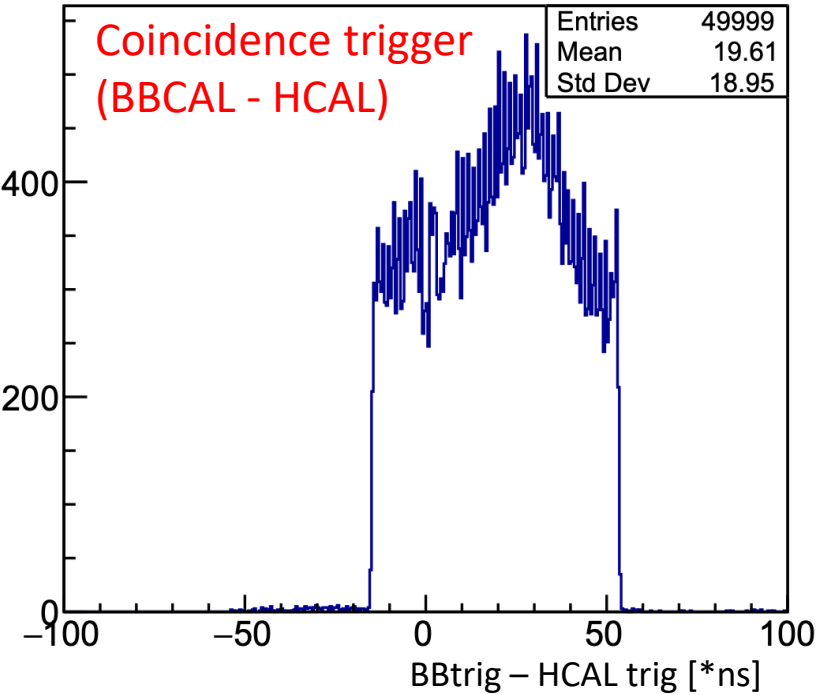Status of HCAL

HCAL during A_LL

TDC Distribution over all modules

(bb.tdctrig.tdc[2]-bb.tdctrig.tdc[0]) {fEvtHdr.fTrigBits==4}
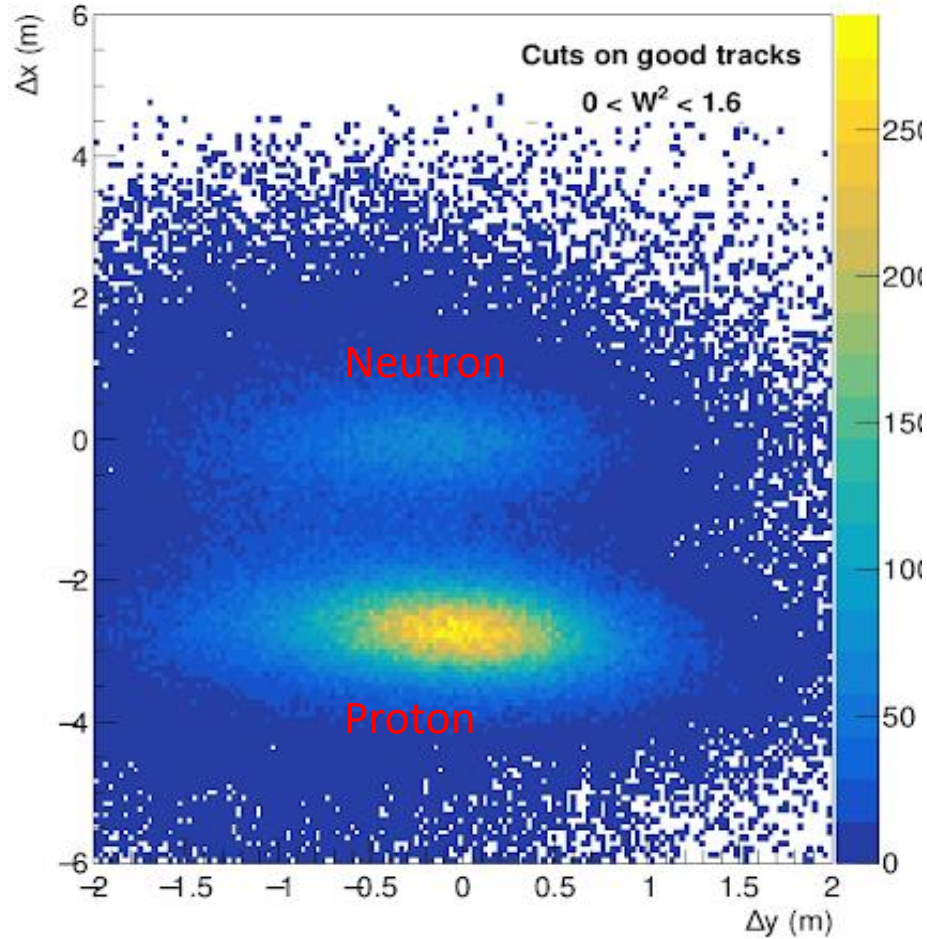
Coincidence trigger
(BBCAL - HCAL)

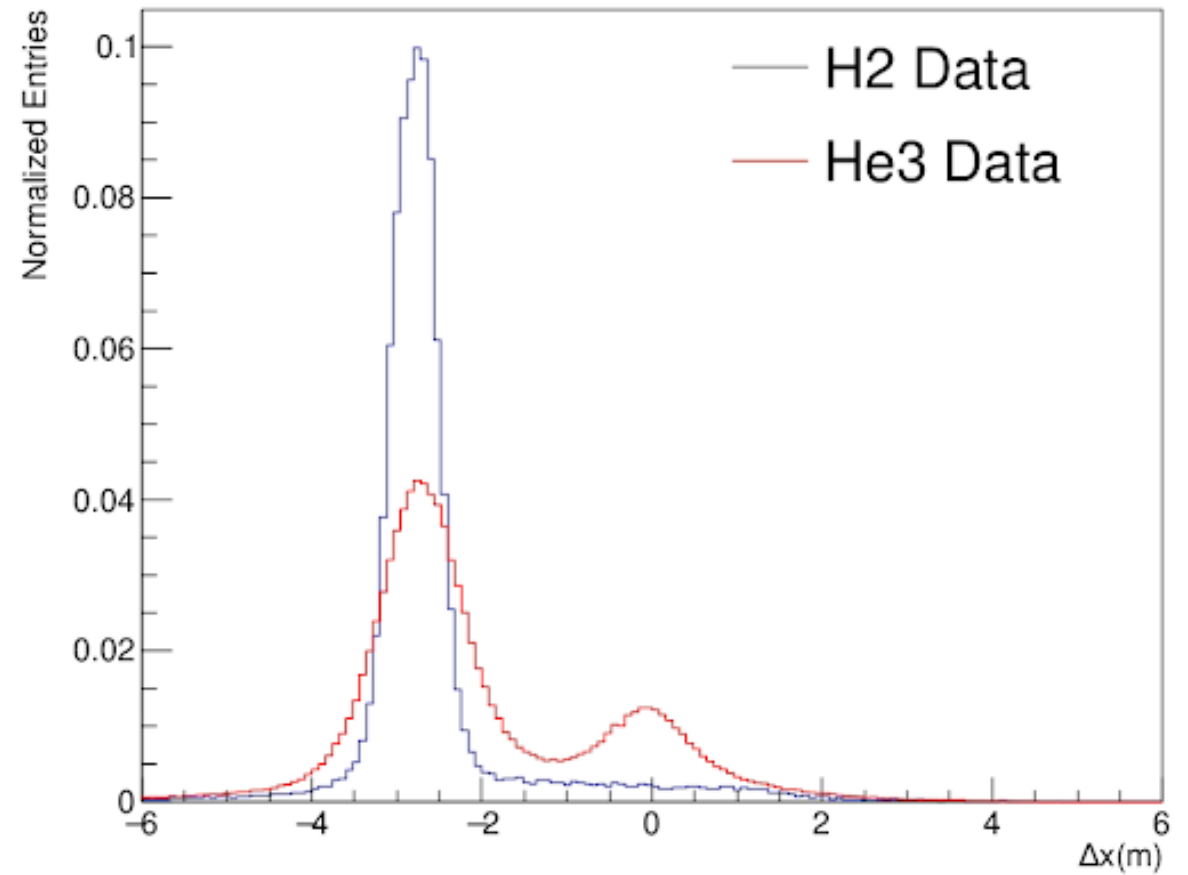| Entries	49999
Mean	19.61
Std Dev	18.95

BBtrig − HCAL trig [*ns]

ADC Distribution over all modules

HCAL Performance

Nucleons in HCAL

He3 HCal Elastics

Cuts on good tracks
$0 < W^2 < 1.6$

Neutron

Proton

HCal p/n Spots
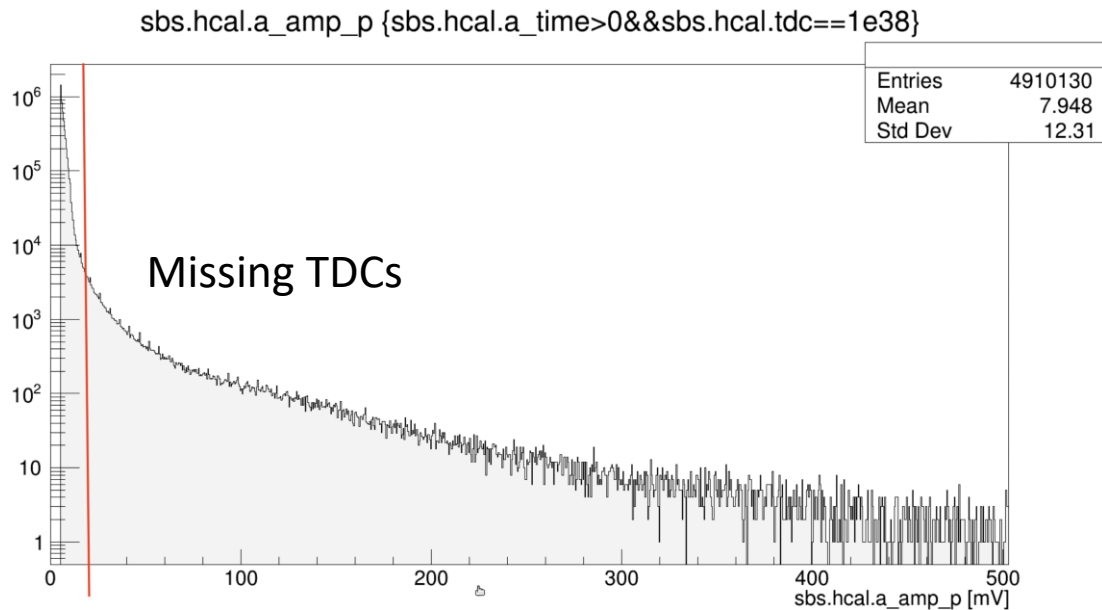
— H2 Data
— He3 Data

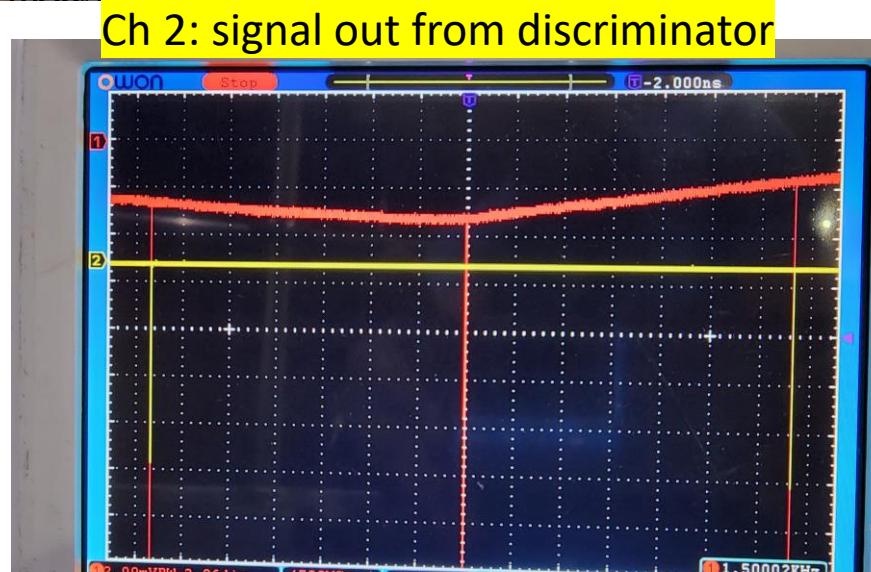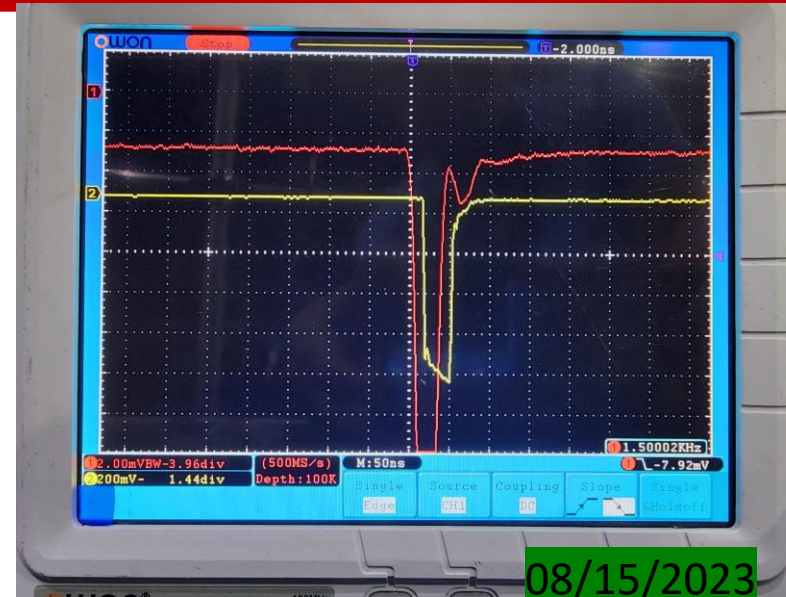Courtesy of Sean Jeffas

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Issue with HCAL Data

- Higher amplitude signals missing TDC hits in Production

- Large fraction of missing tdc have low amplitude

- Channels lose tdc at higher amplitude as well
  - discriminator behaving weird

sbs.hcal.a_amp_p {sbs.hcal.a_time>0&&sbs.hcal.tdc==1e38}

Entries	4910130
Mean	7.948
Std Dev	12.31

Missing TDCs

sbs.hcal.a_amp_p:sbs.hcal.adcelemID {sbs.hcal.a_time>0&&sbs.hcal.tdc==1e38}

Entries	4910130
Mean x	158.9
Mean y	7.948
Std Dev x	80.87
Std Dev y	12.28

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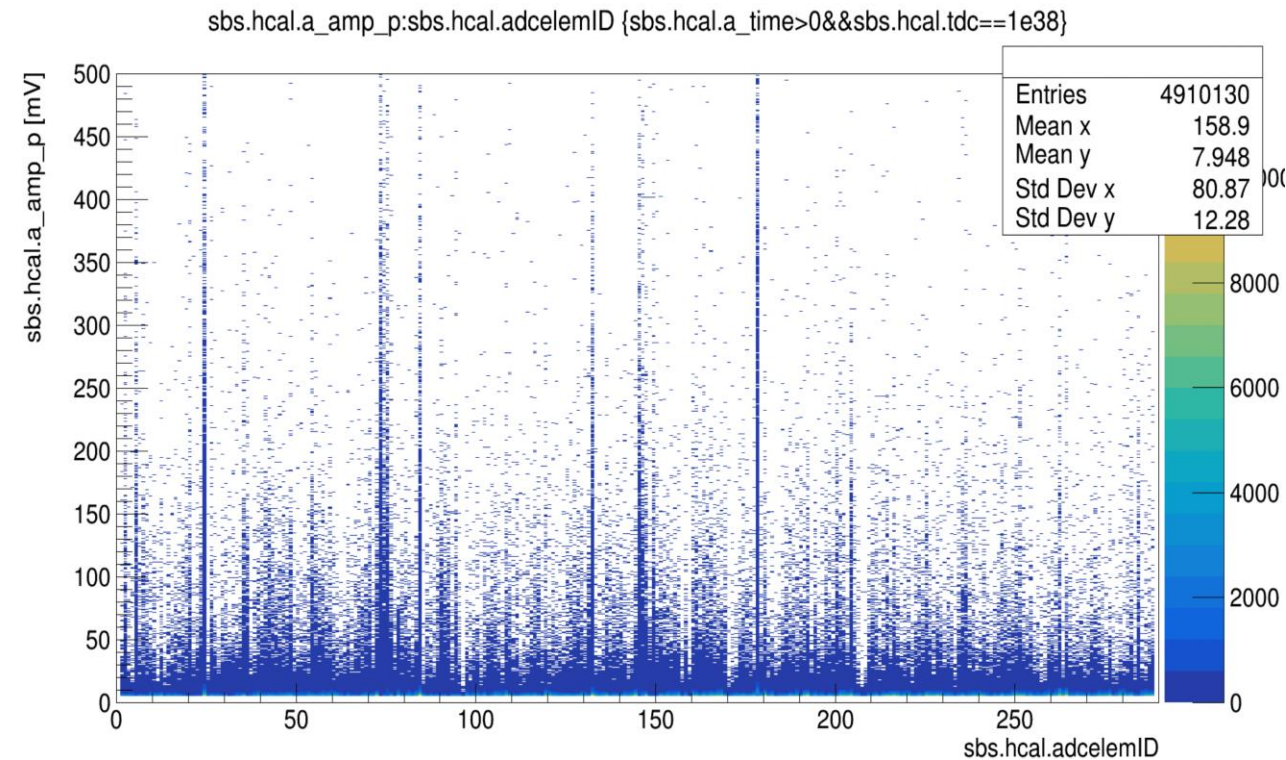
Issue with HCAL data: pulser signal in scope

08/14/2023

08/15/2023

Ch 1: signal going to discriminator
Ch 2: signal out from discriminator

Status of HCAL

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Issue with HCAL data

- After changing the discriminator threshold to ~ 20 mV (from 10 mV)

Before the Change

After the Change

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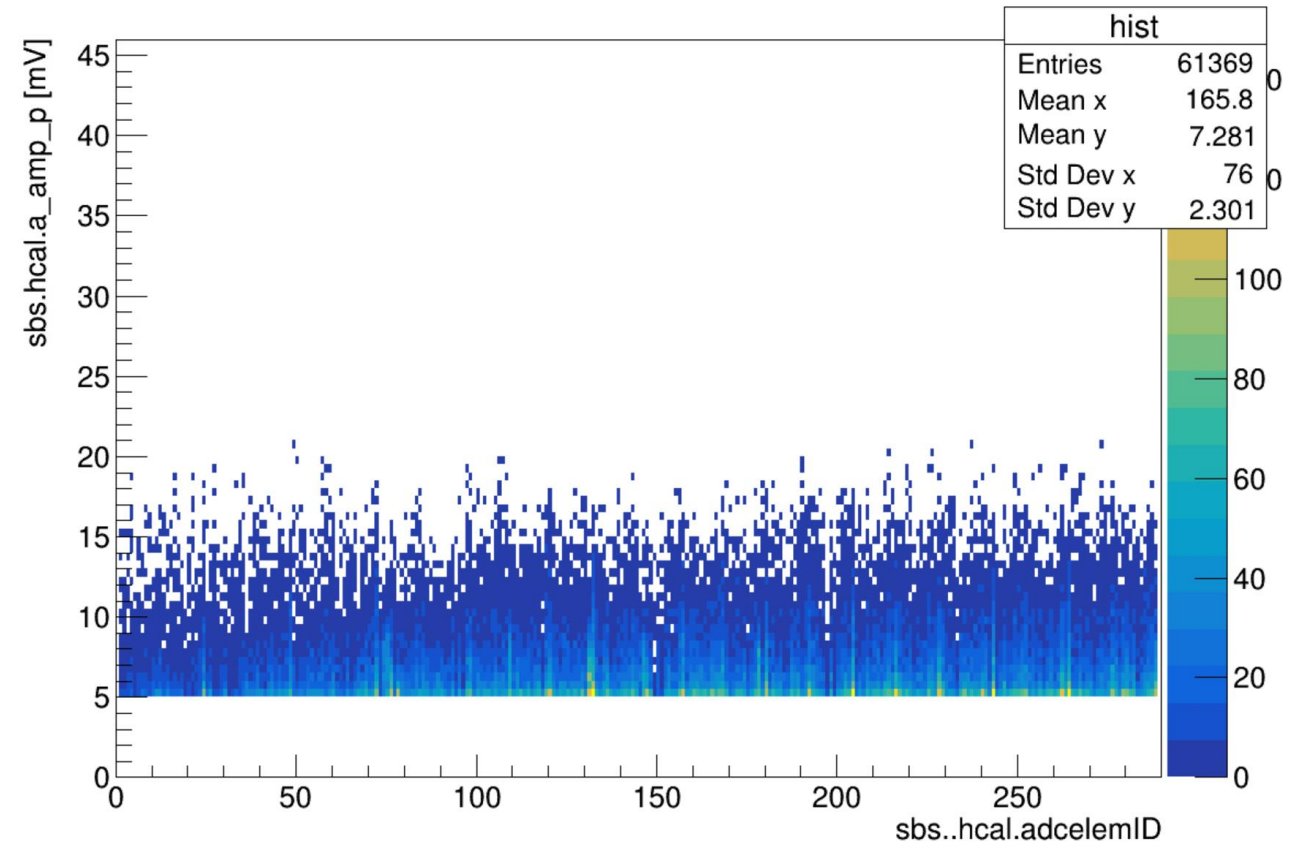
Summary

- All HCAL modules are working fine except few noisy

- Missing TDCs for larger amplitude signals is fixed

- Analog HCAL trigger is in use currently => VTP triggering from fADCs in future

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HCAL during GEn