

# Status of SBS Hadron-Calorimeter (HCAL)

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SBS Collaboration Meeting  
July 2023

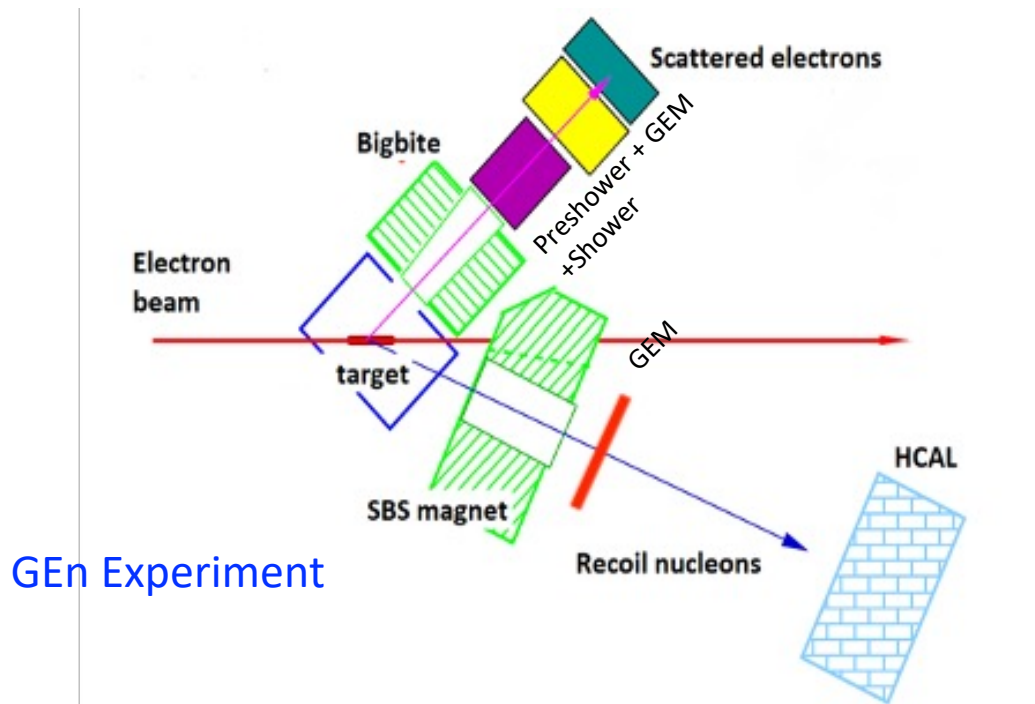
# Outline

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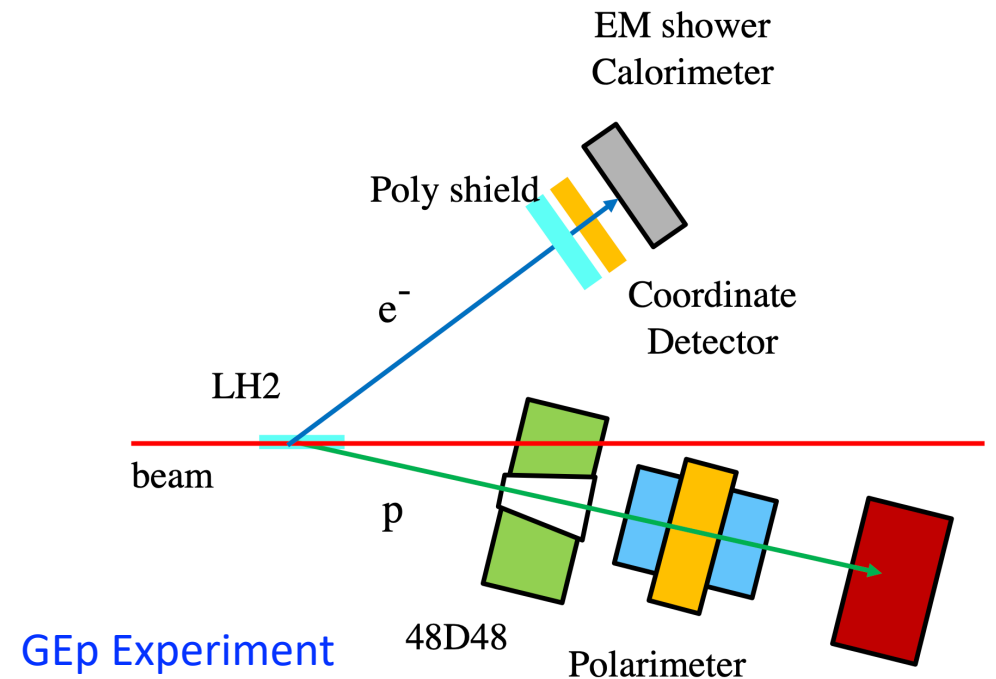
- Overview of SBS and HCAL
- HCAL during GEn
- HCAL issues and ongoing studies
- Summary and Outlook

# Overview: SBS Program

- 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 ~75% completed)
  - E12-17-004 -> GEn-RP (2024)
  - E12-07-109 -> GEp (2024)
- **Beamline, Electron Arm, Hadron Arm**

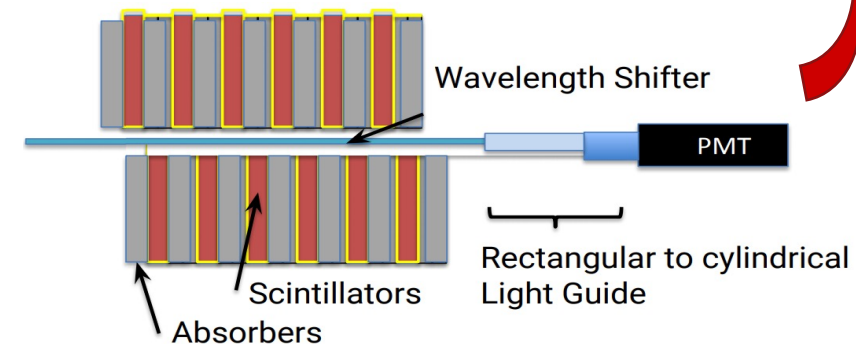
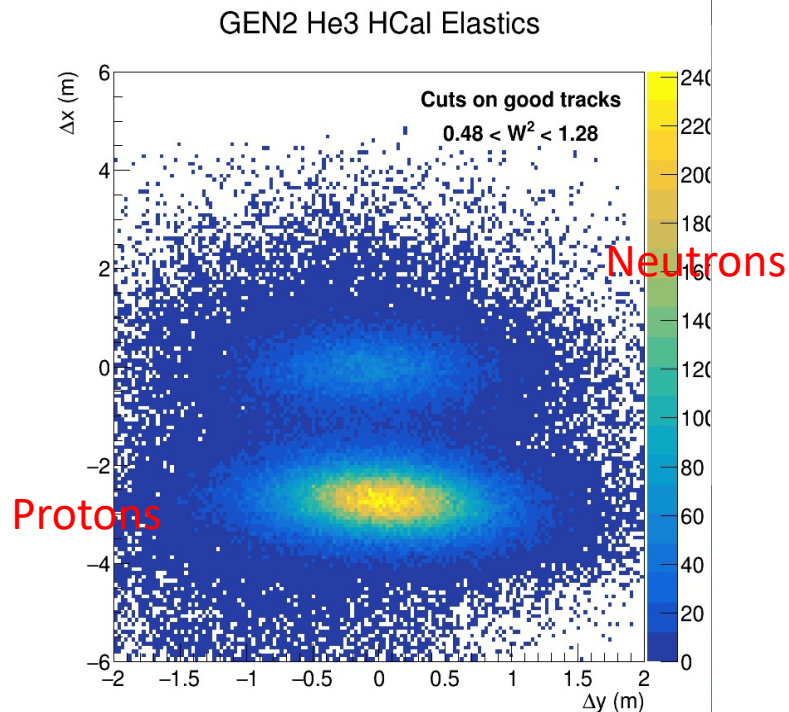
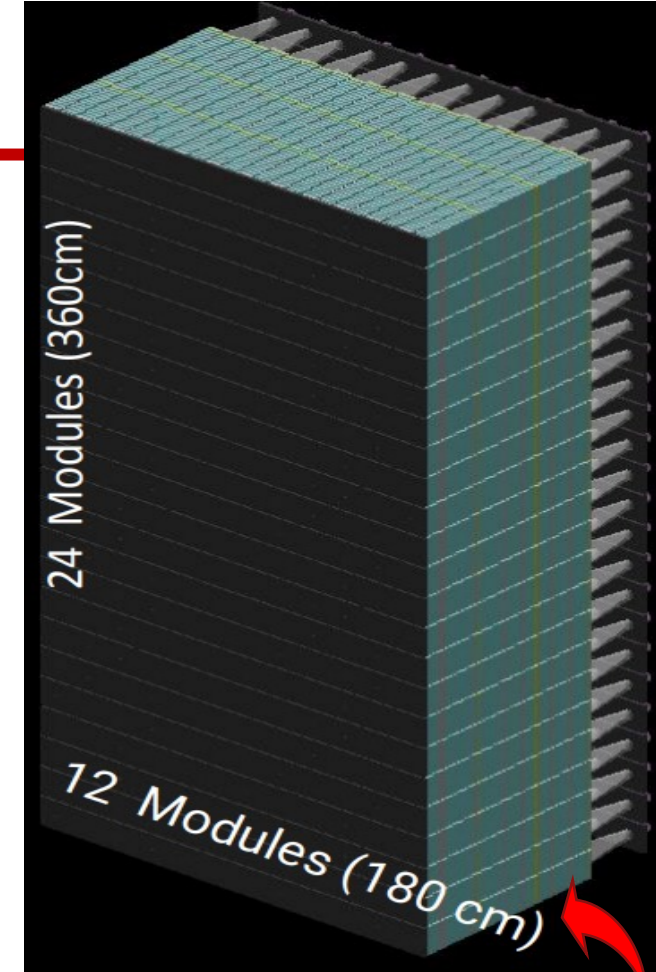


Status of HCAL



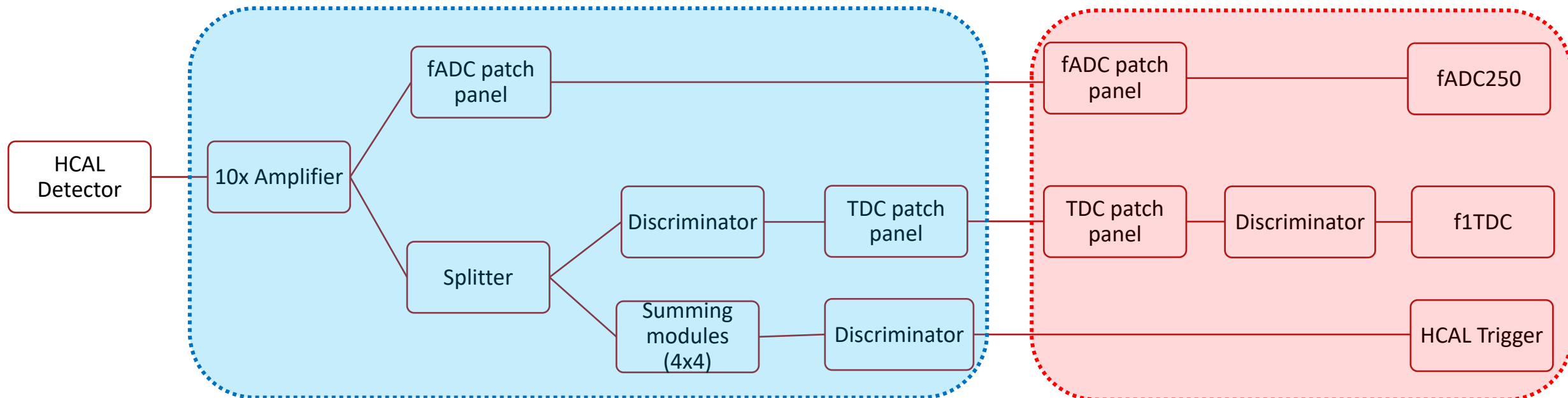
# HCAL Detector

- Hadron (protons/neutrons) Calorimeter detector
- 40 layers of Iron absorbers alternate with scintillators, and a wavelength shifter in the middle of each module
- Segmented Calorimeter to detect high energy nucleons: 288 modules (12x24 blocks of 15x15x100cm dimension)
- Proton/neutron separation due to SBS magnet



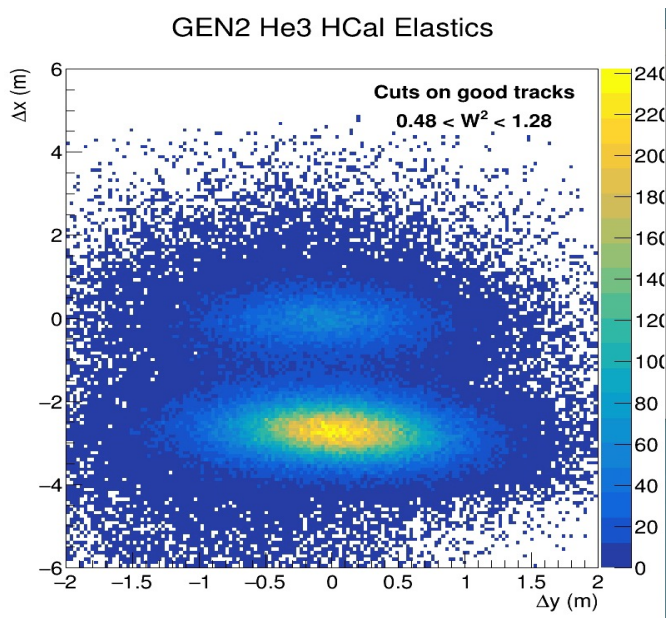
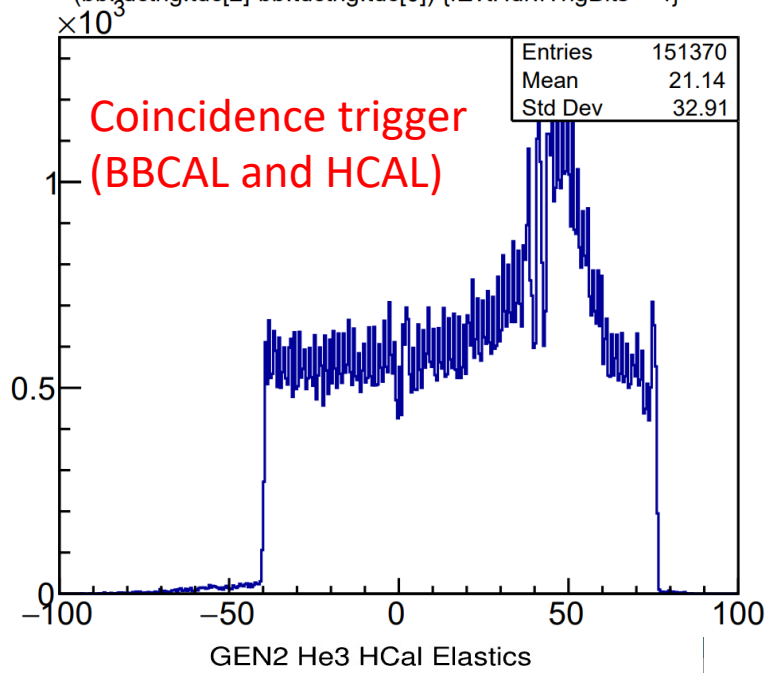
# HCAL DAQ

- Signals amplification at Front end ([HCAL upper platform](#)) and readout at back end ([DAQ bunker](#))
- Both waveform (ADCs) and timing (TDCs) information recorded from HCAL
- HCAL trigger generation after sum threshold

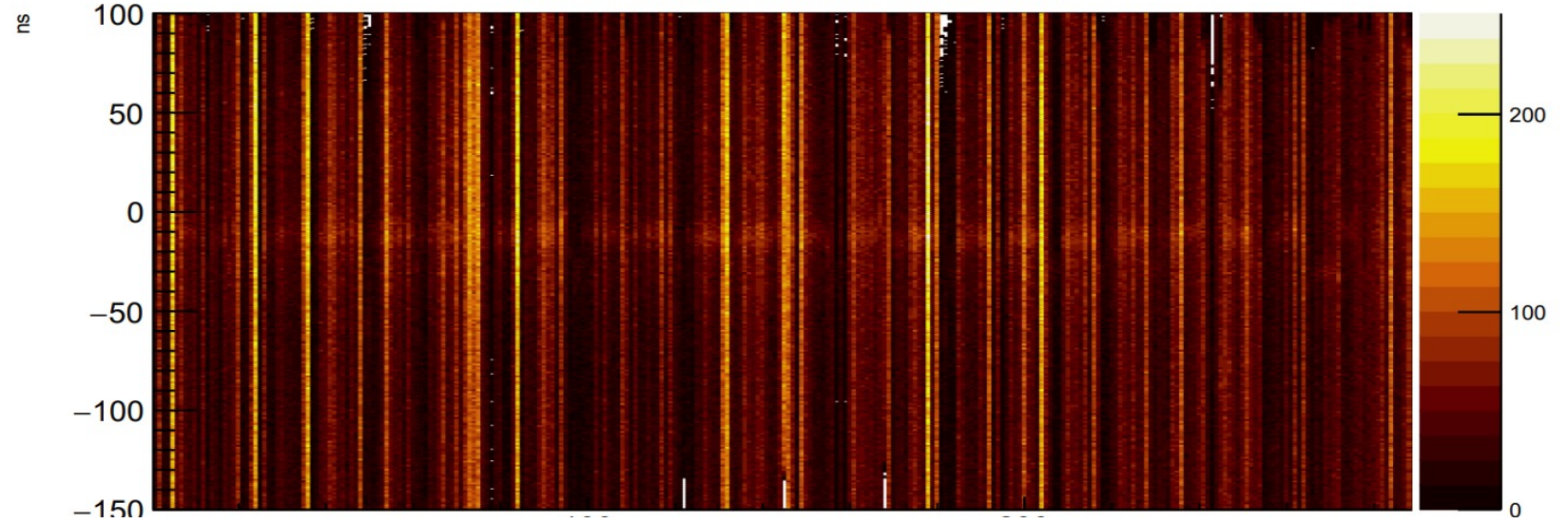


# HCAL during GEN

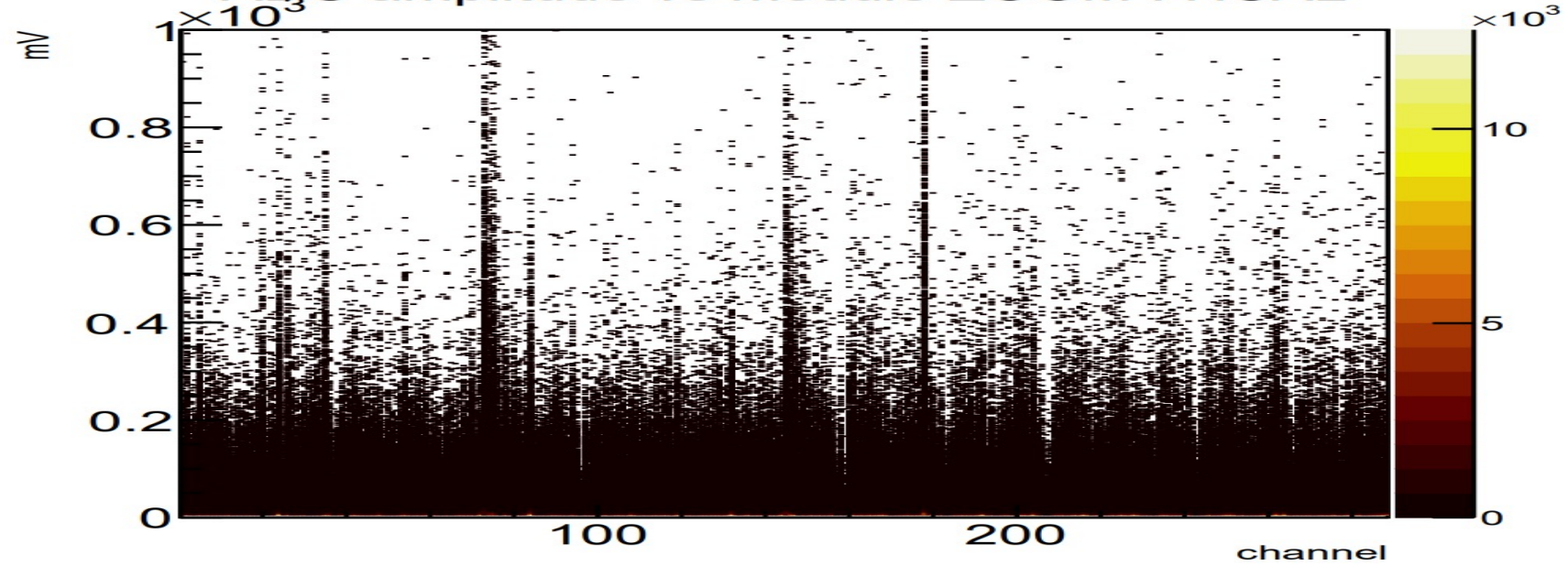
(bb.tdctrig.tdc[2]-bb.tdctrig.tdc[0]) {fEvtHdr.fTrigBits==4}



## TDC vs Module : HCAL



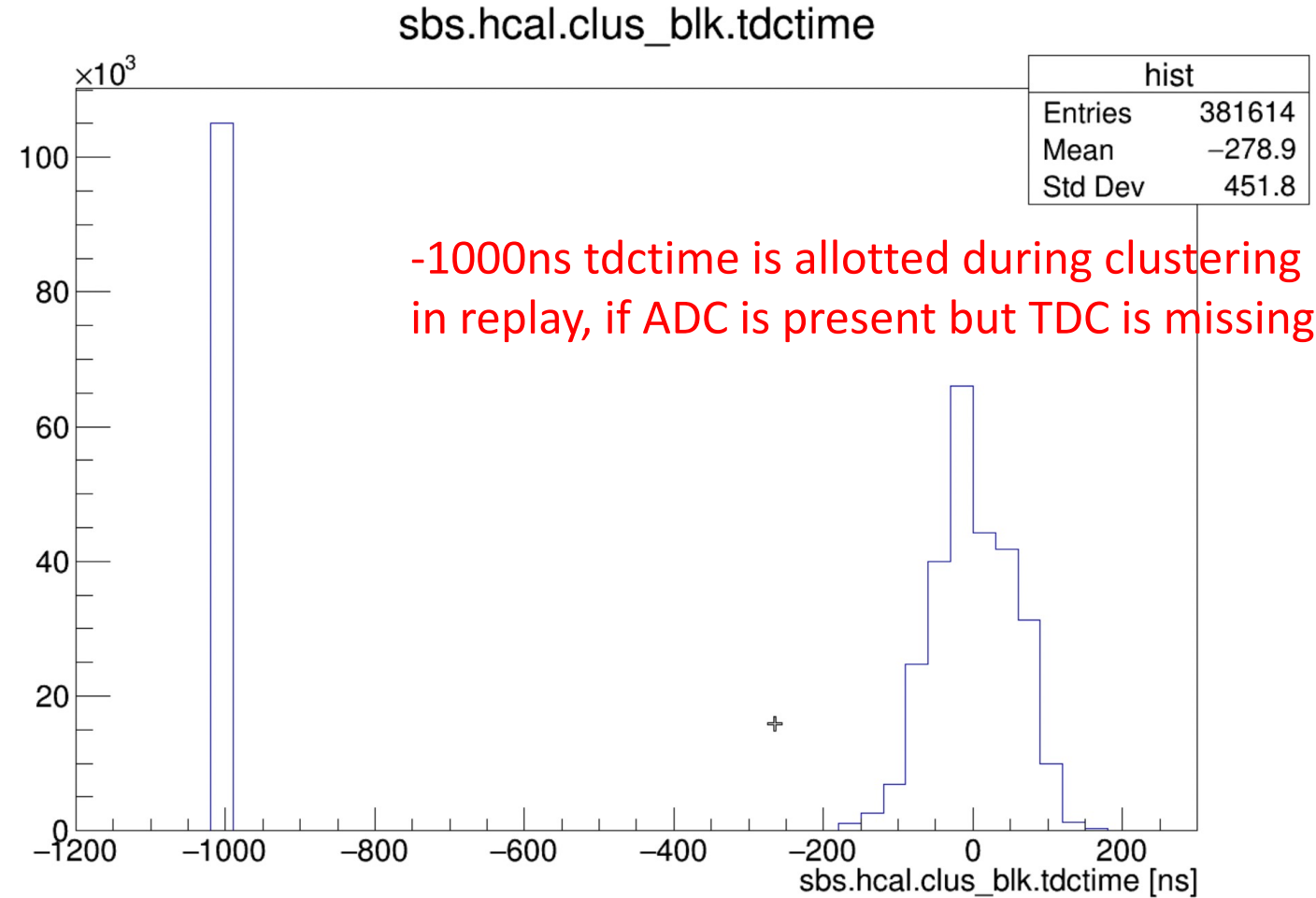
## ADC amplitude vs module ZOOM : HCAL



# HCAL Issues

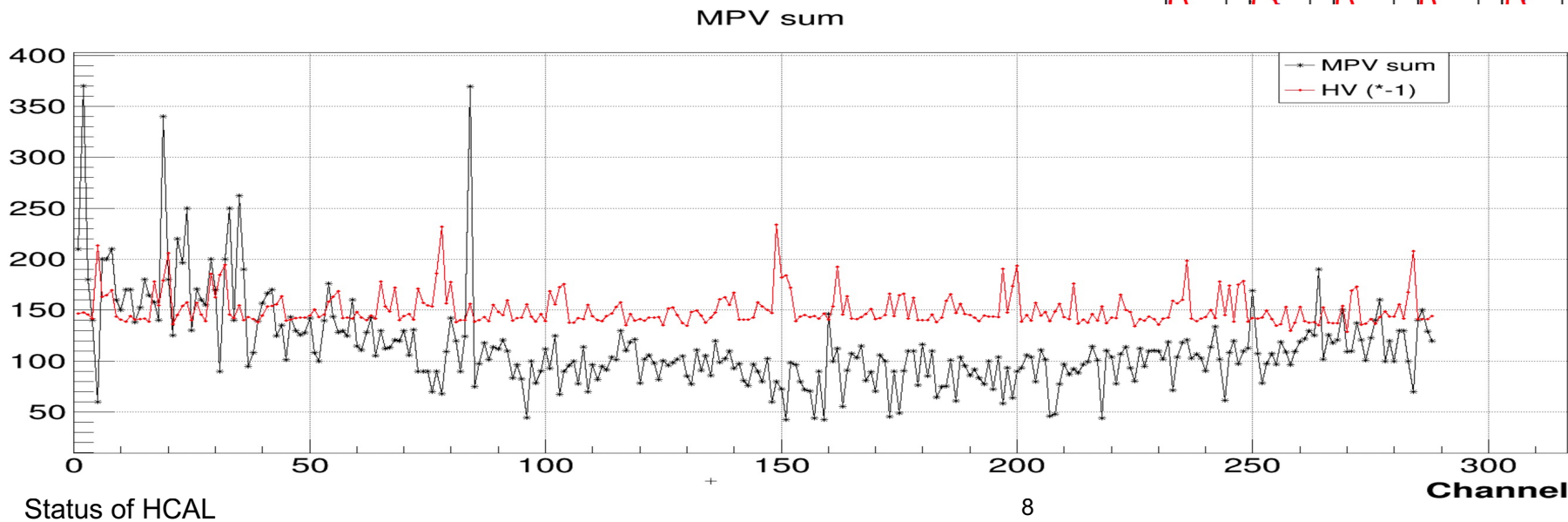
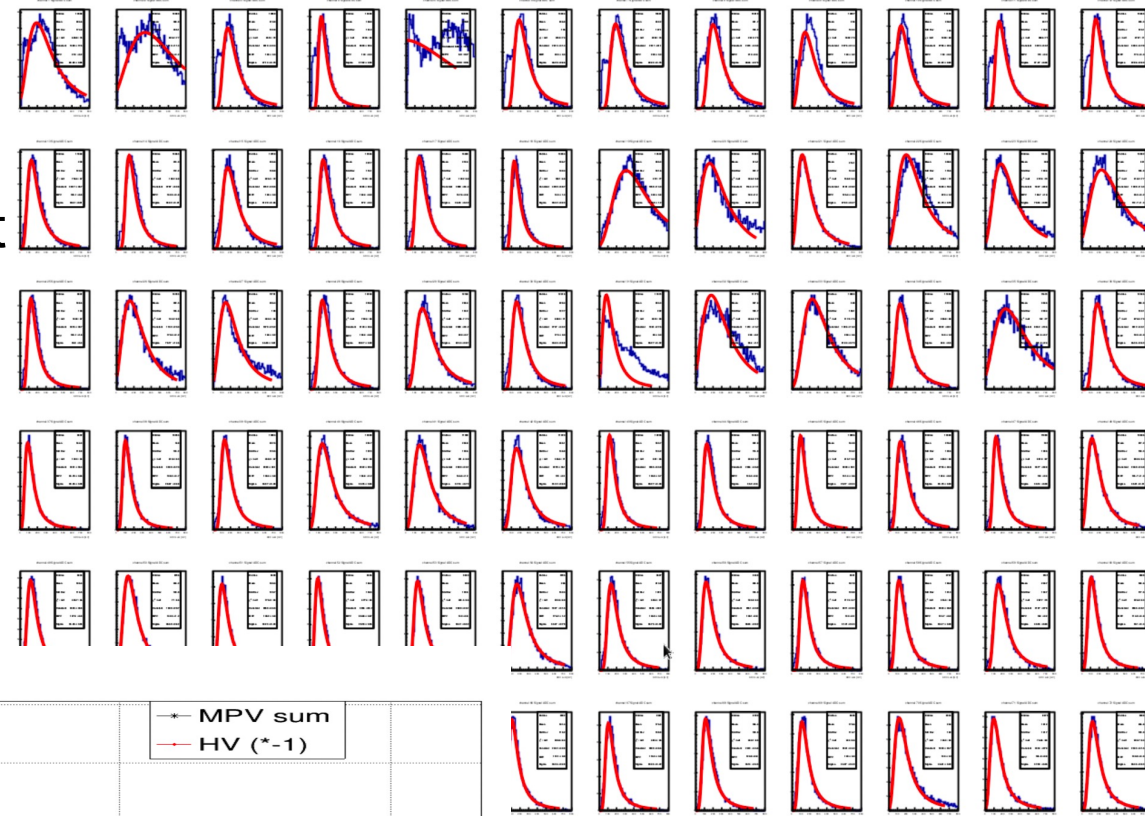
- Noisy channels in TDC and ADC spectrum
- Gain matching and HV adjustment
- Missing TDC values in f1TDC

These issues affect HCAL calibration and triggering => compromised performance and efficiency



# Ongoing Studies: noisy channels (1)

- Distribution of ADC-integral per channel with cosmic run
- Landau fit works in most of the channels except some
- Very narrow vs wide distributions (?)
- No clear separation of peak
- Long tail in some channels (?)

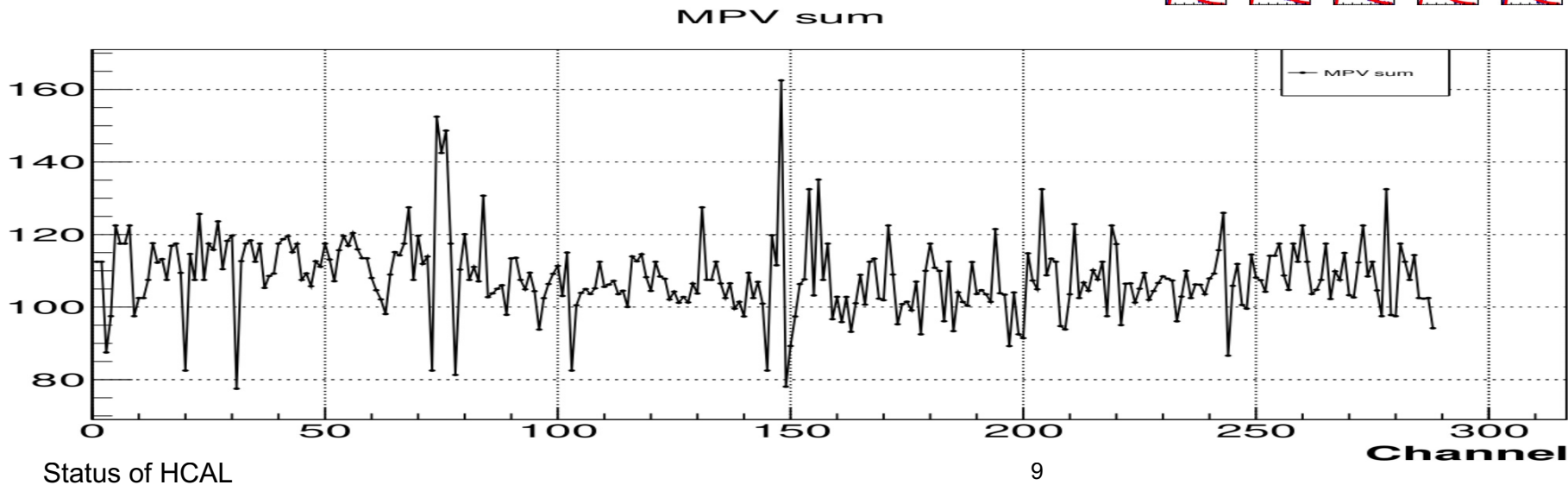


Landau fit of adc-integral  
and the most probable  
value (MPV) from fit



## Ongoing Studies: noisy channels (2)

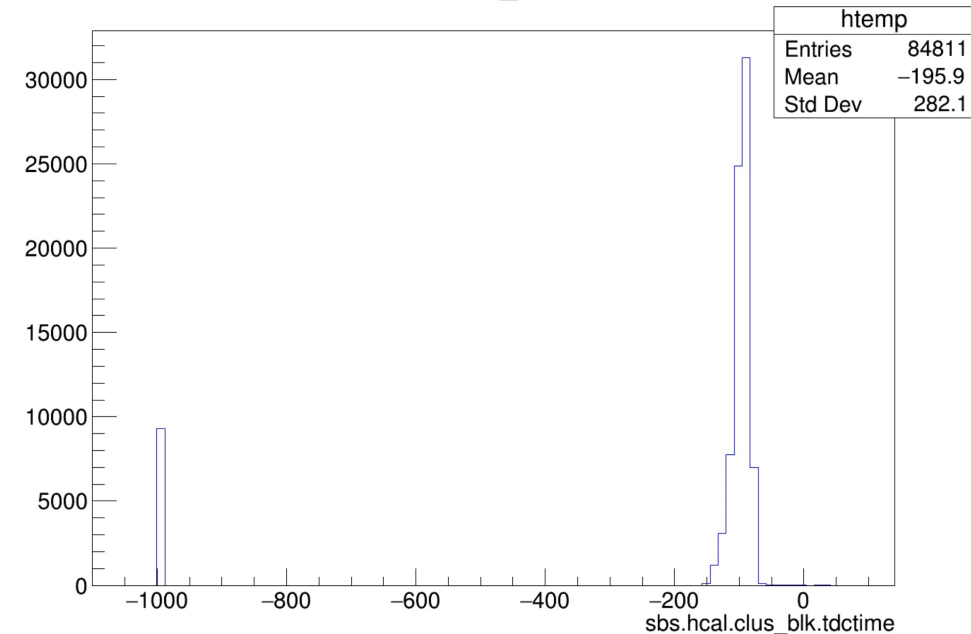
- Adjusted HV comparing signals with adjacent (top/bottom) channels in scope first, then using DAQ
- Improvement in some channels, but some other still have issues (long tail/ no clear peak separation)
- Paused work in the hall due to crane repair



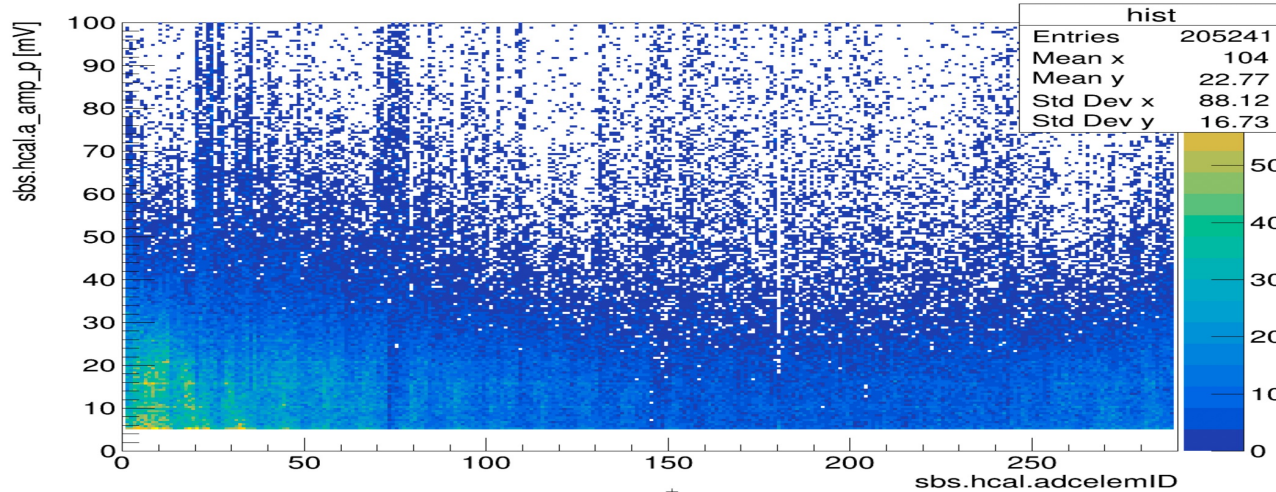
# Ongoing Studies: missing TDC (1)

- Similar TDC distribution for **cosmic data**
- Major contribution due to low amplitude signals
  - Only half of amplified signal goes to TDC discriminator after splitter
  - TDC discriminator threshold 9.48 – 10.49 mV
  - 8mV in fADC  $\approx$  10 mV to discriminator
  - Pedestals not fixed from (average of 3 bin contents)
- One channel needs further study (**high amp. missing**)

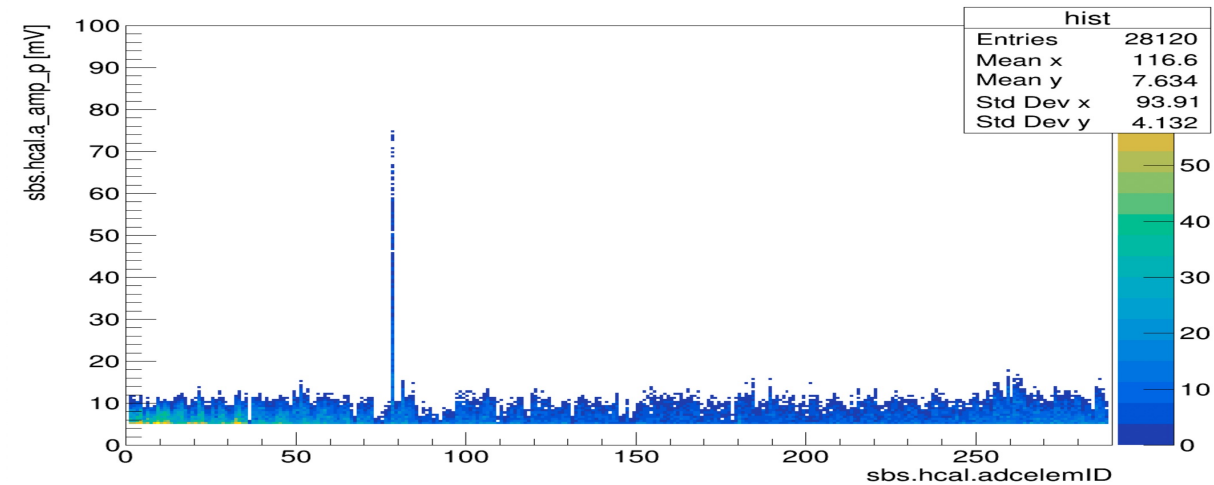
sbs.hcal.clus\_blk.tdctime



sbs.hcal.a\_amp\_p:sbs.hcal.adcelemID {sbs.hcal.a\_time>0}



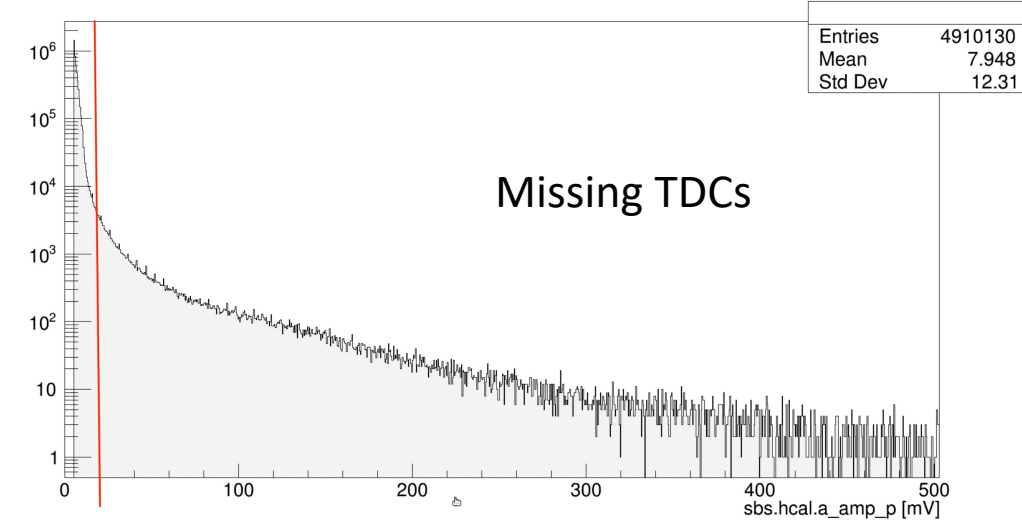
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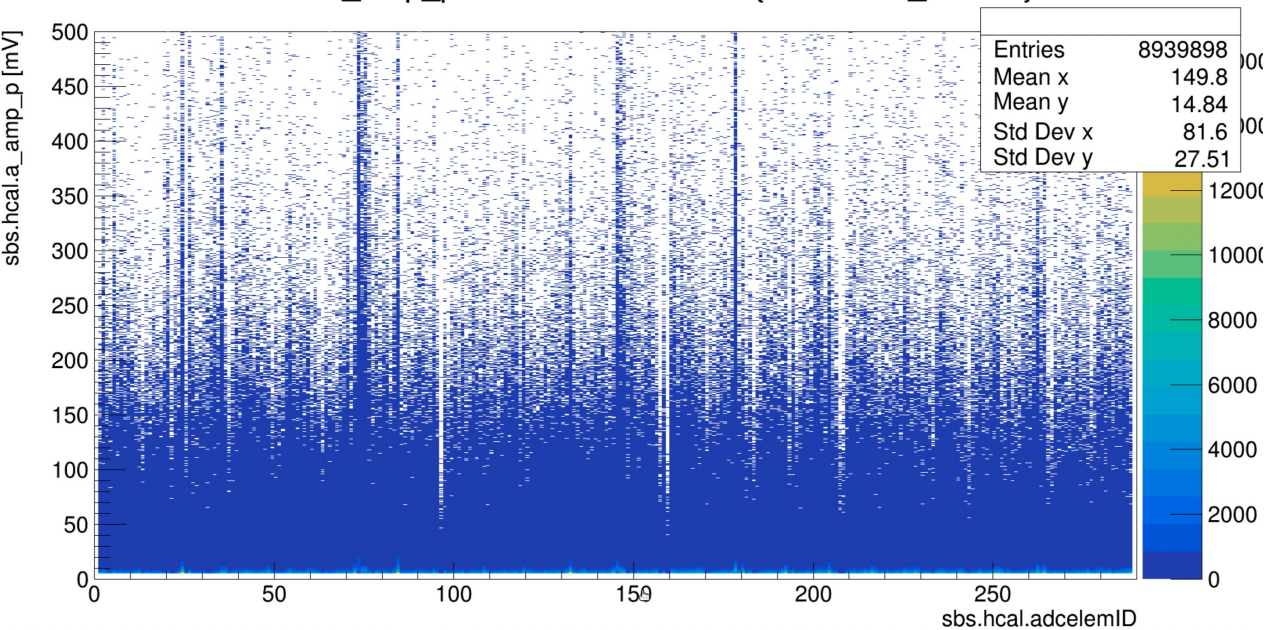
# Ongoing Studies: missing TDC (2)

- Higher amplitude signals missing in **Production data**
- Large fraction of missing tdc have low amplitude
- Channels lose tdc at higher amplitude as well
  - Noisy channels
  - High rate at production (?)
  - Electronics (amplifier, discriminator, f1tdc) (?)
  - Decoding and clustering software

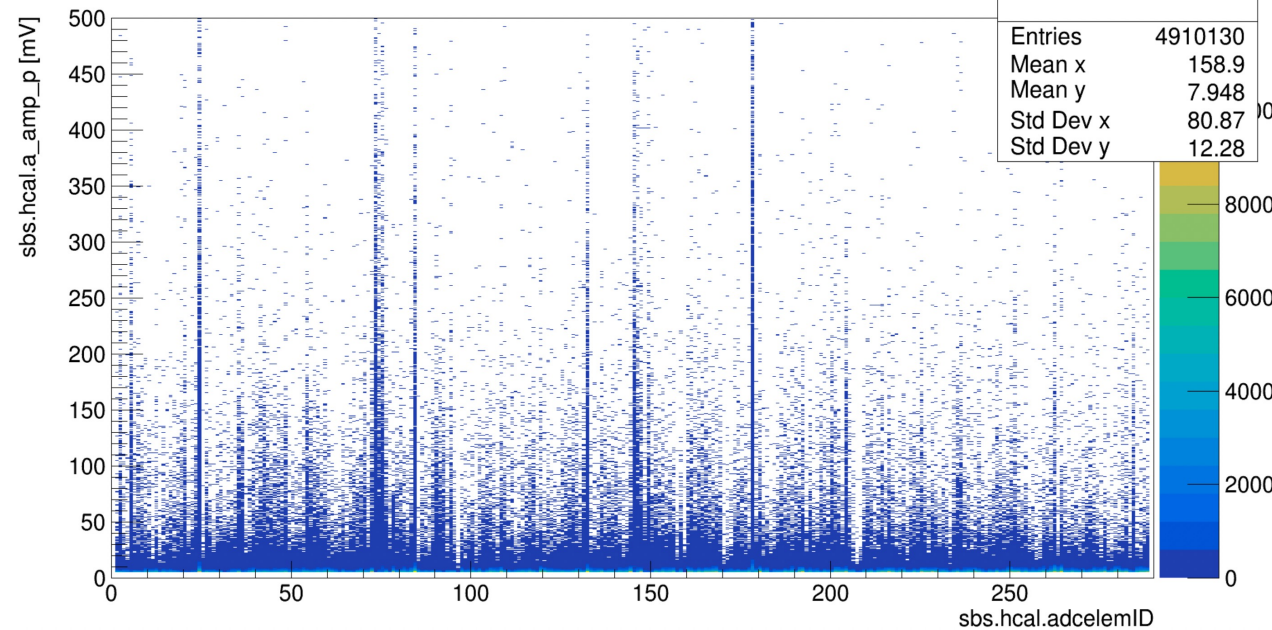
sbs.hcal.a\_amp\_p {sbs.hcal.a\_time>0&&sbs.hcal.tdc==1e38}



sbs.hcal.a\_amp\_p:sbs.hcal.adcelemID {sbs.hcal.a\_time>0&&sbs.hcal.tdc==1e38}

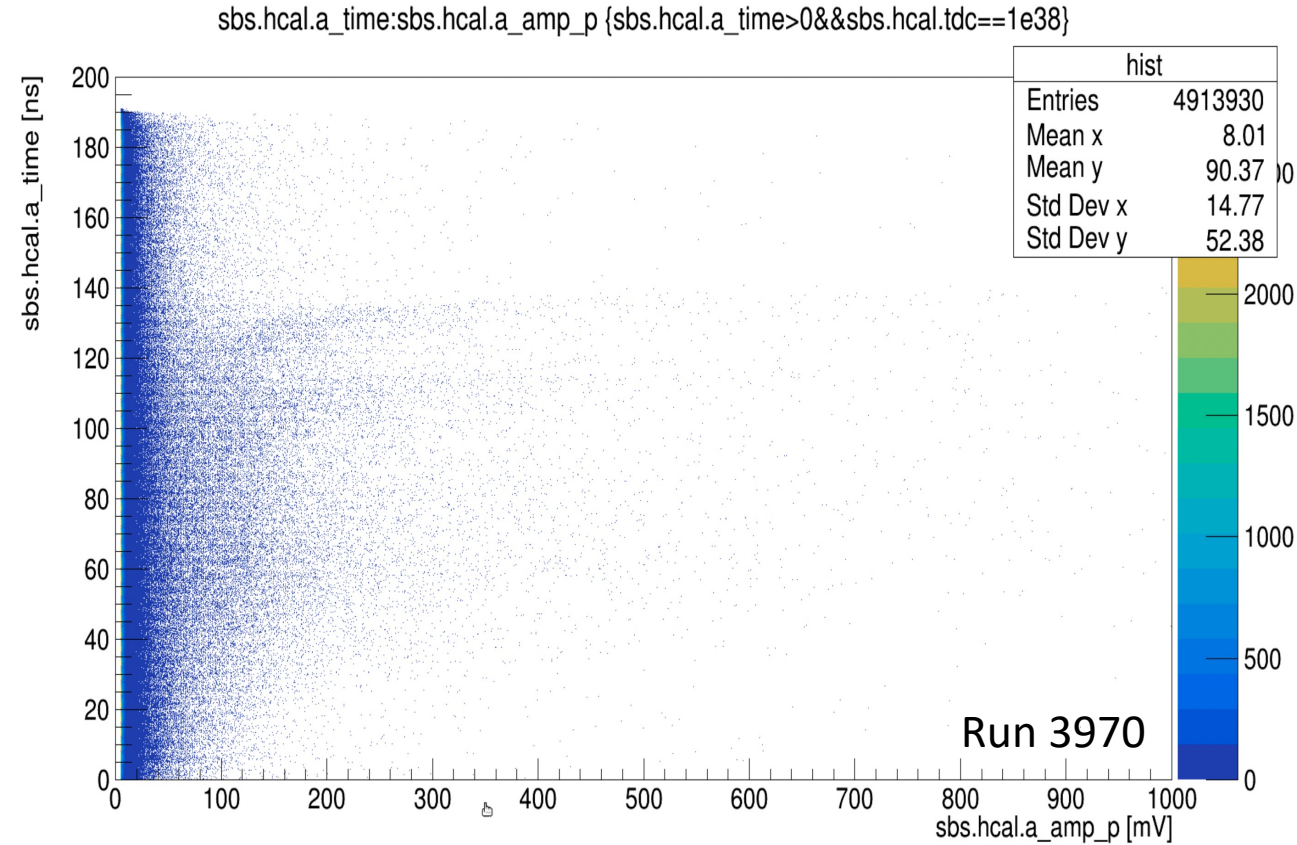
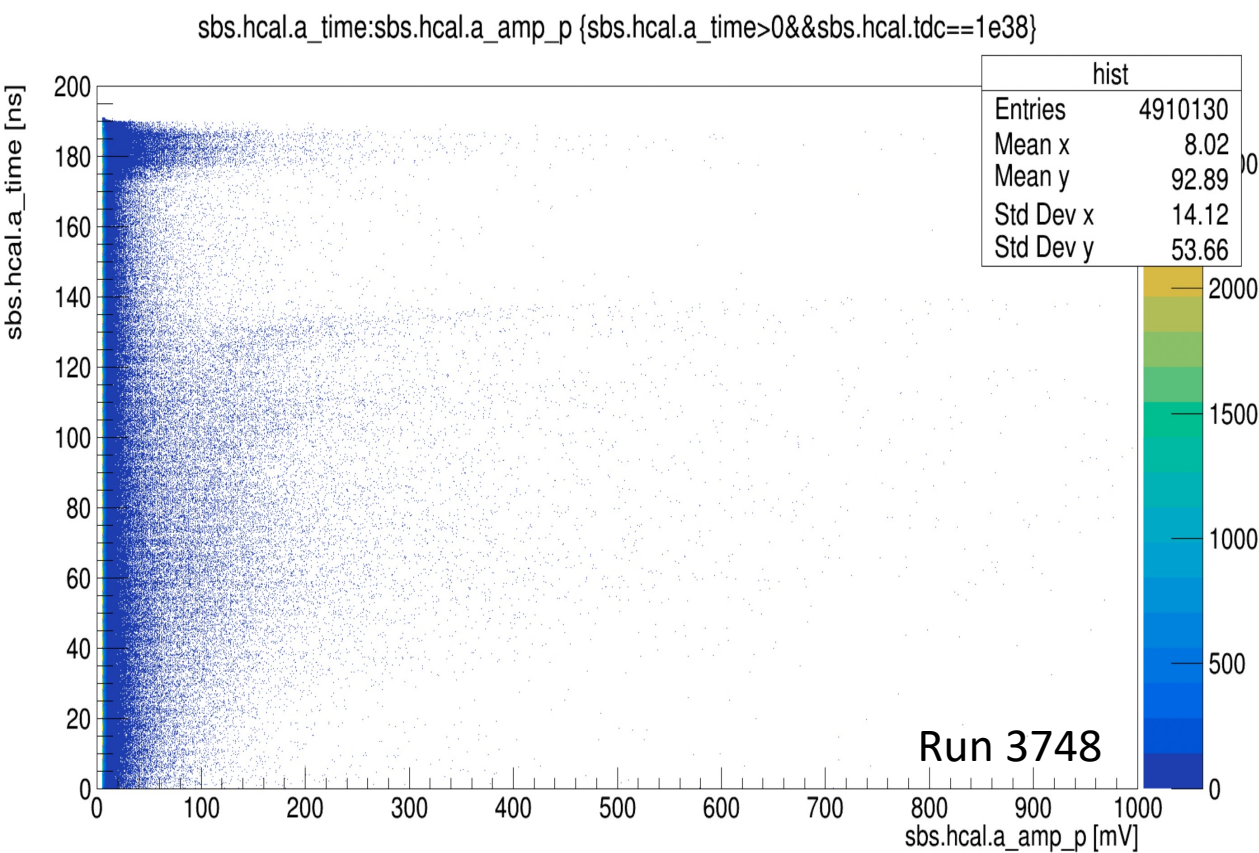


Status of HCAL



# Ongoing Studies: missing TDC (3)

- Window mismatch of fADC and f1TDC readout => changed the f1TDC latency to keep fADC window (200ns) within f1TDC window (300ns)
- Run 3748 (before the change) compared with run 3970 (after the change) during GEN



# Summary and Outlook

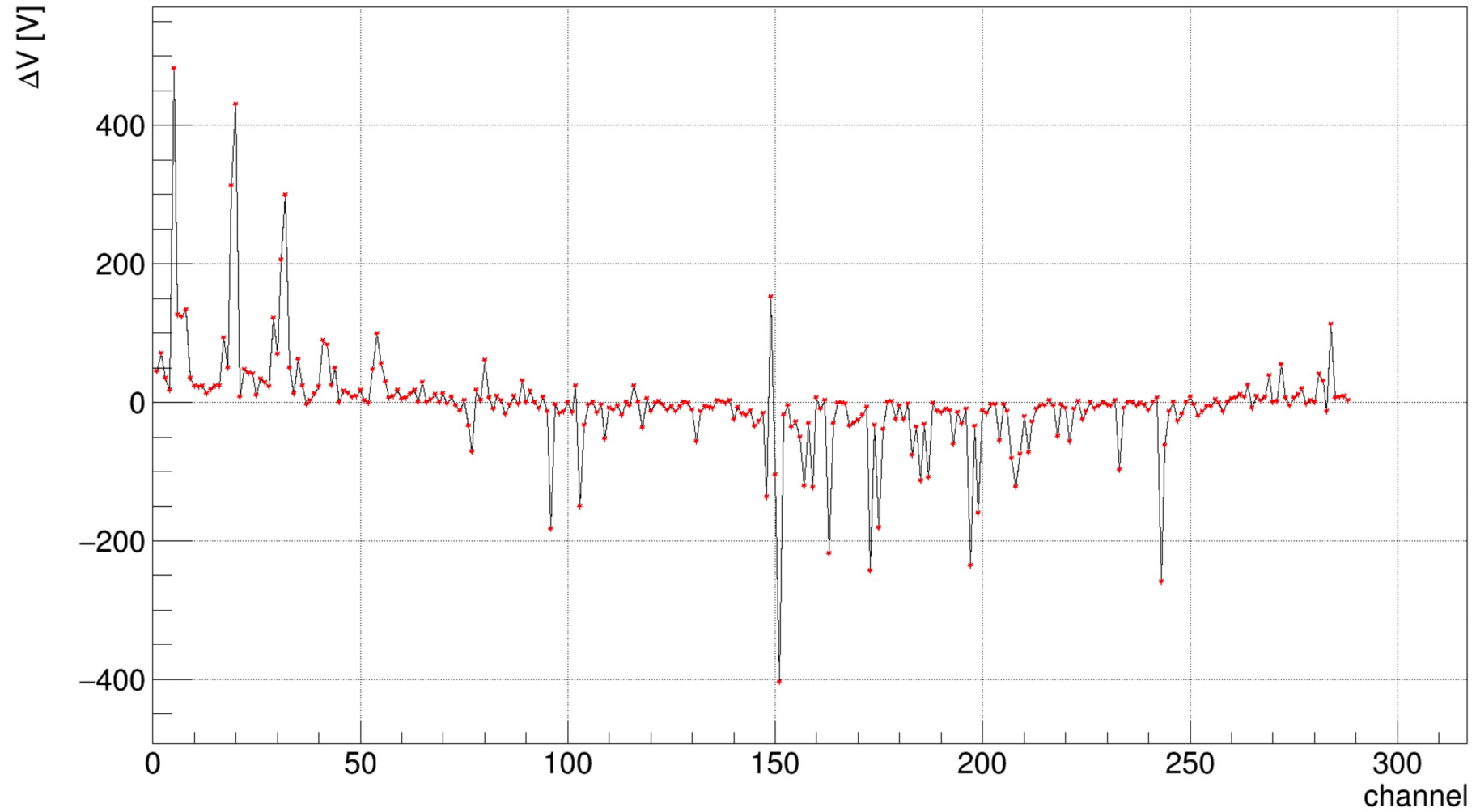
- All HCAL modules are working but few noisy => ongoing work to have better performance (continue work in hall after Crane repair, and work restart approval)
- Missing TDCs => ongoing study to resolve this issue (continue work in hall after Crane repair and work restart approval)
- HCAL trigger (analog) is currently in use => test VTP trigger from fADCs as in NPS (3x3 or 5x5 blocks clustering)



# Backup

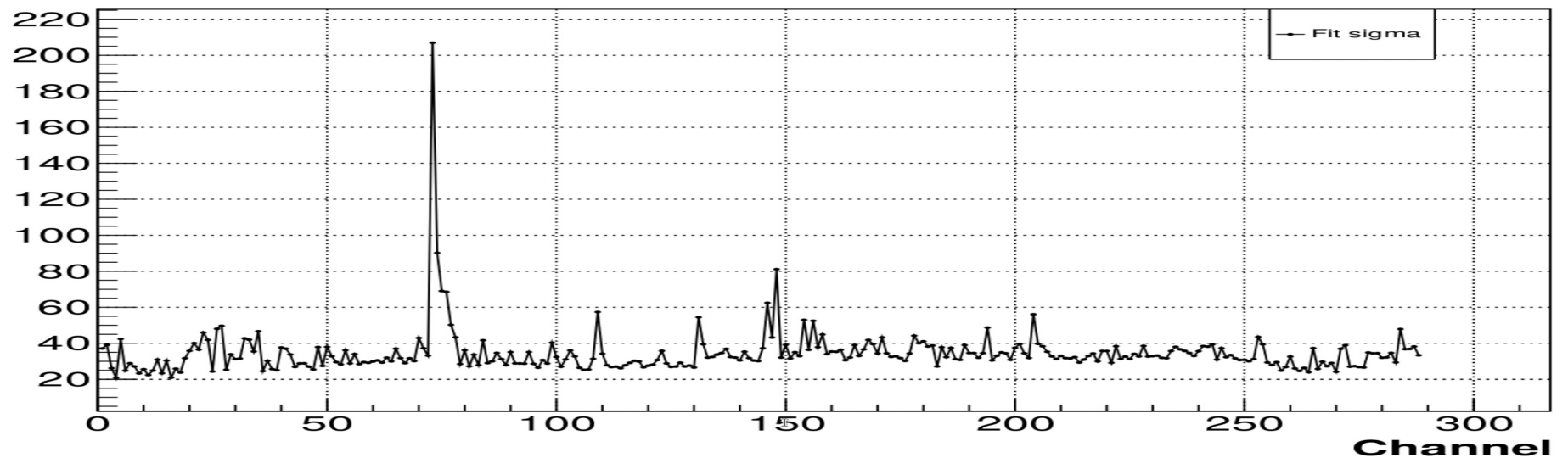
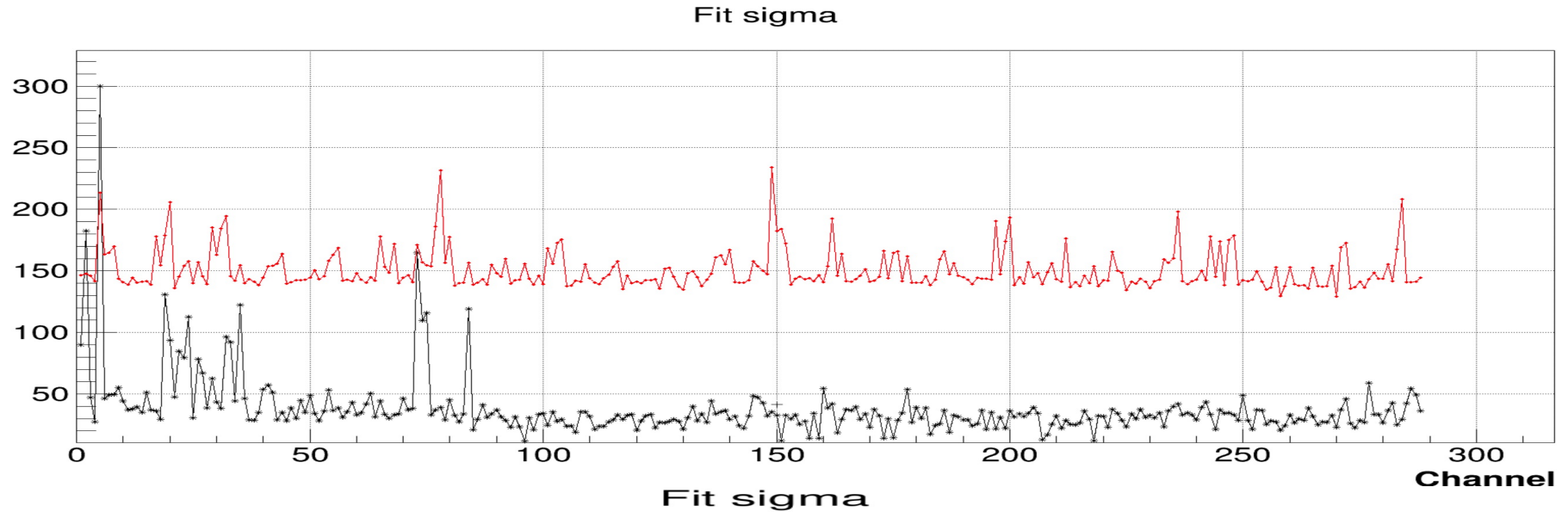
- Adjusted HV

PMT HV diff (New:test 28 - Old:prod\_set2)



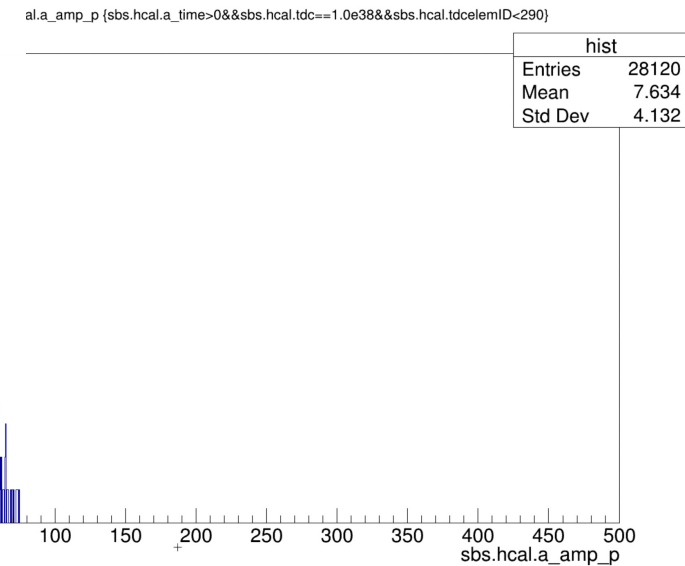
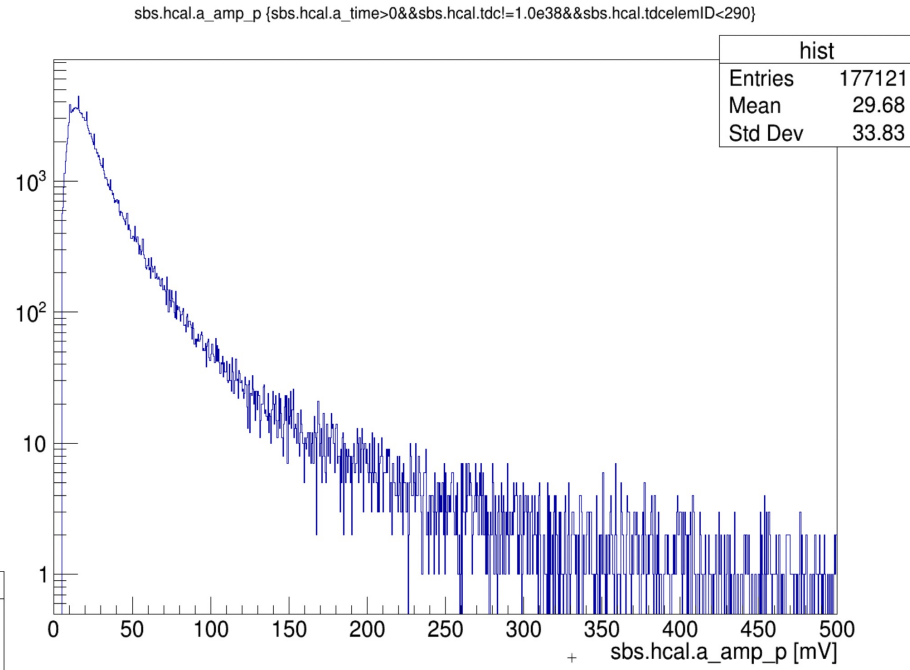
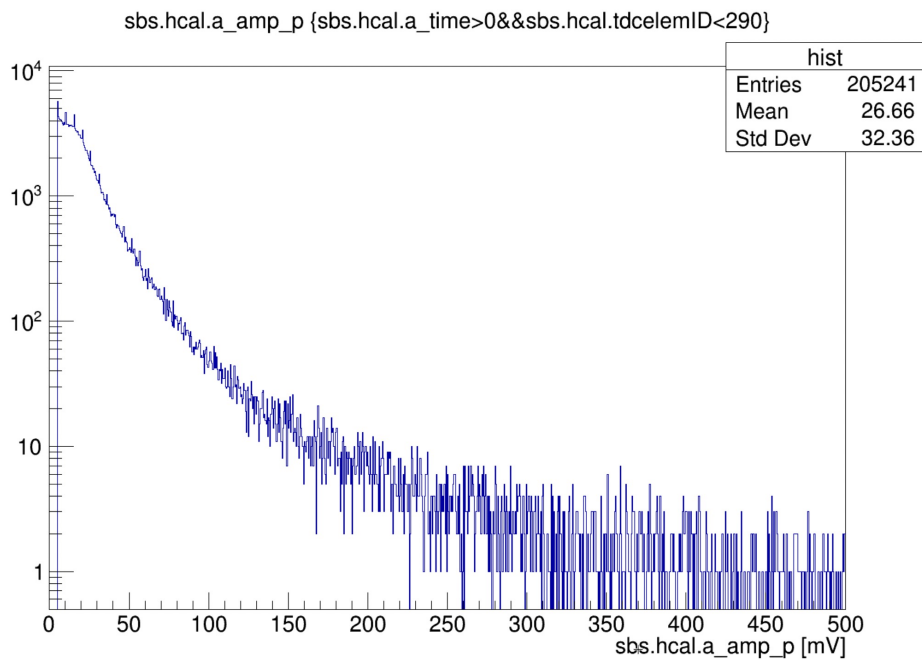
# Backup

- Sigma of Landau fit before and after HV adjustment



# Backup

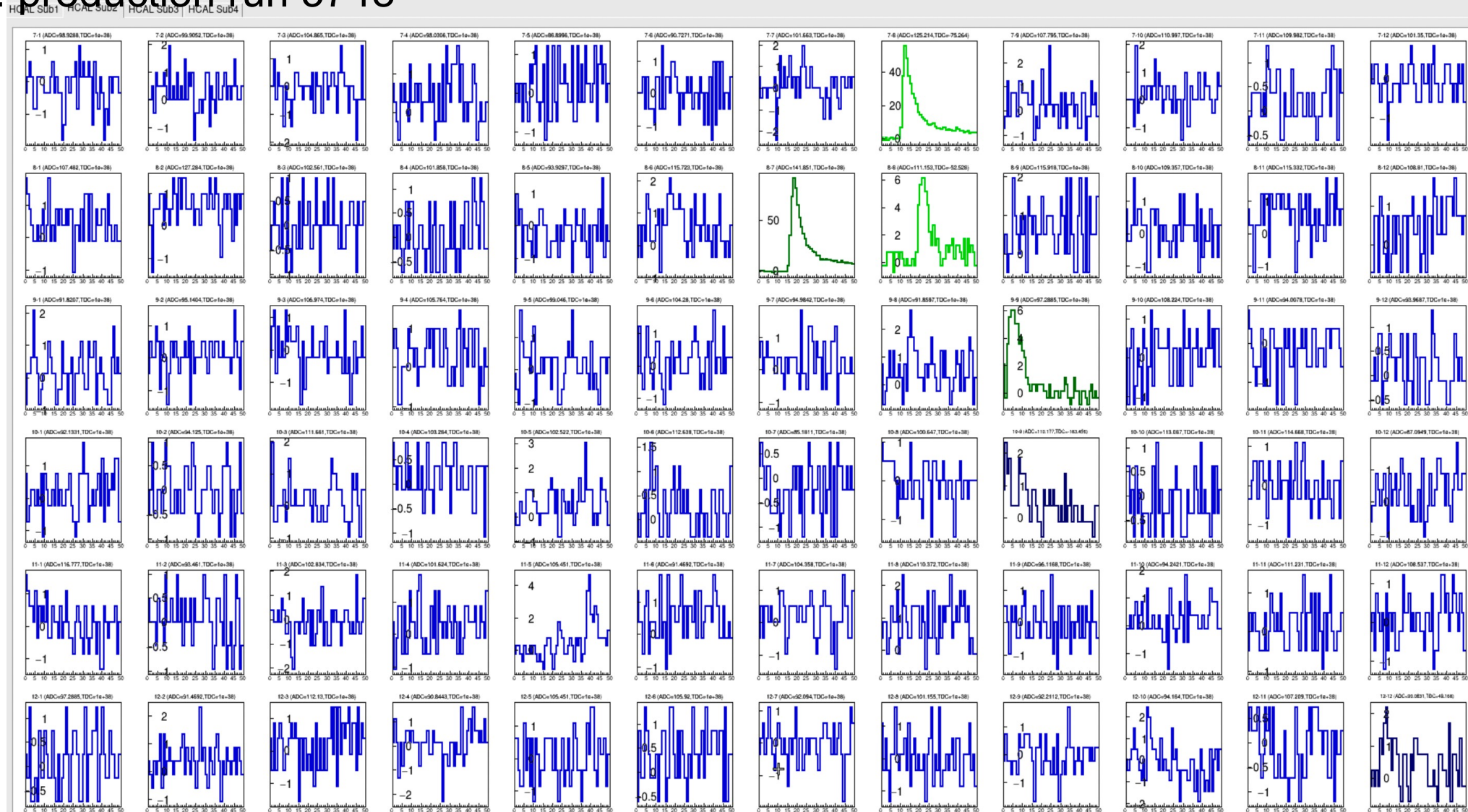
- Cosmic A\_amp 1D





# Backup

- Event display: production run 3748



- Blue: no atime and tdc data
- Dark Blue: no atime, but tdc
- Light green: signal with both atime and tdc data
- Dark green: atime, but no tdc data

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