UMD characterization

Joaquín de Jesús

Hirsap meeting
2-3 Nov 2021

Outline

1. Study on crosstalk

2. Features of ADC calibration files

3. Study on fiber attenuation
   binary channel
   integrator channel

4. Study on corner-clipping muons

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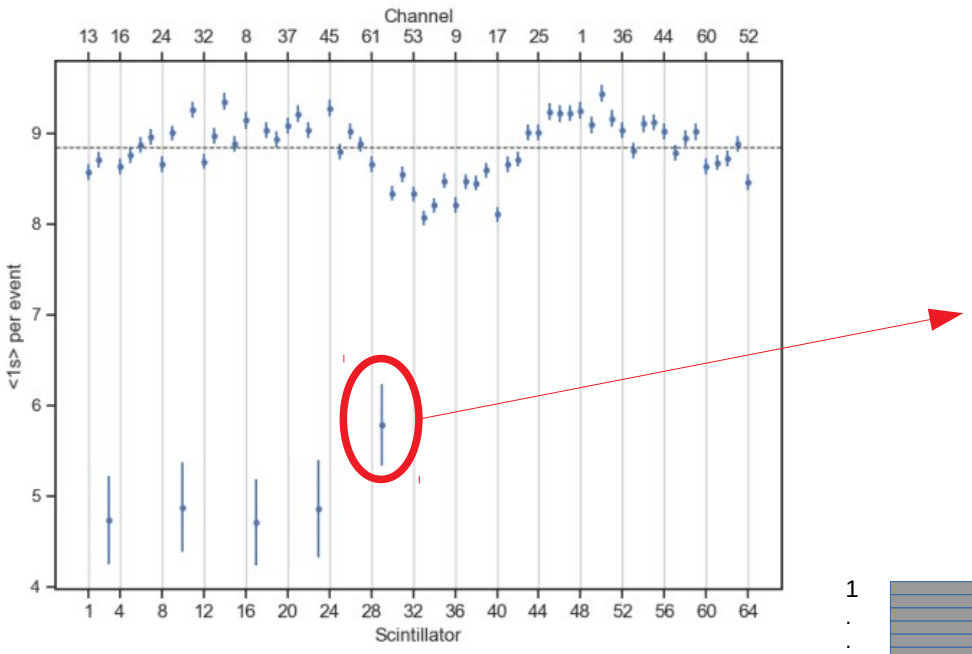
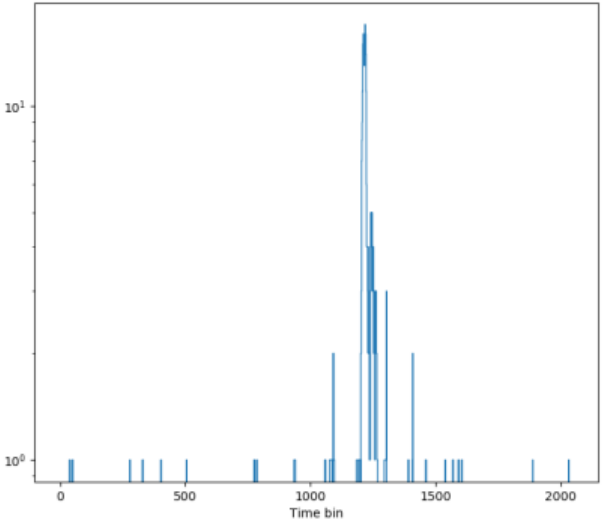
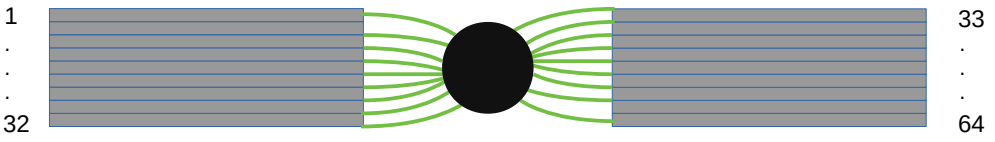
1. Study on crosstalk

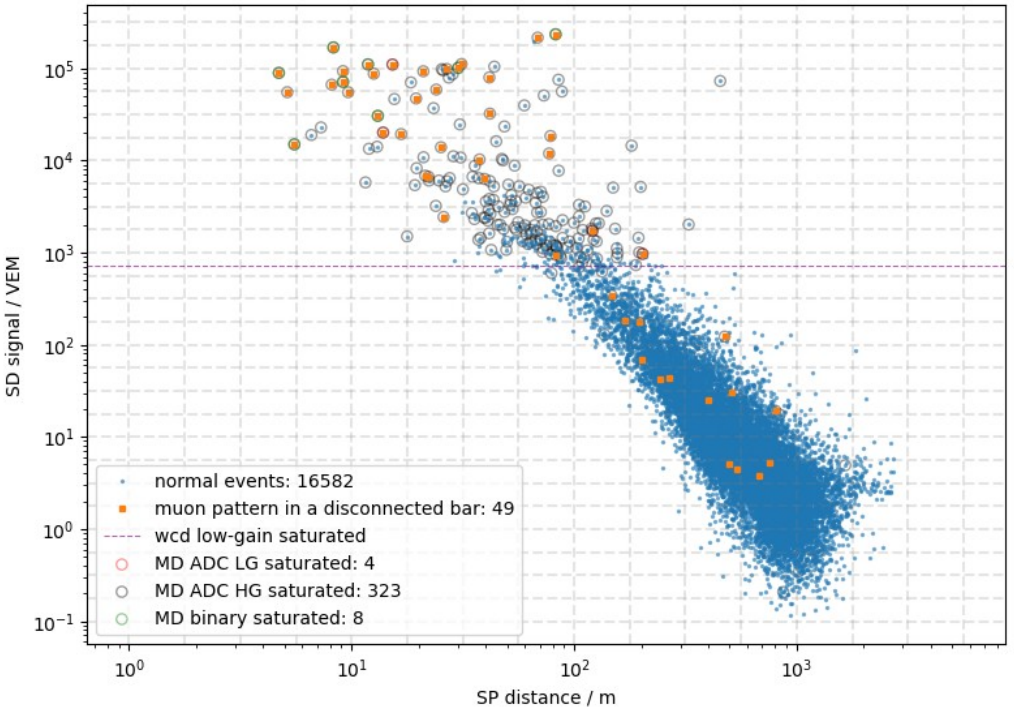
- There are 5 disconnected fibers in module 101 of counter 93
- Most signals in these bars are correlated with showers

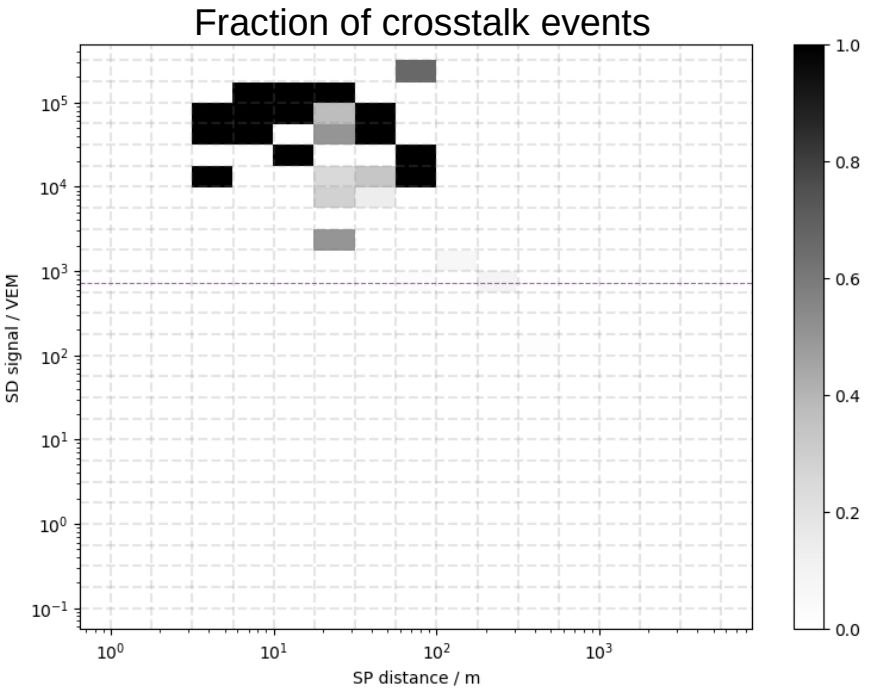






1. Study on crosstalk





- 0,3 % of crosstalk events
- Occuring when module samples high number of particles
  - Muons hitting SiPM array
  - Photons from electronic cascade of neighboring SiPMs
- ~1/3 caused by scintillator 29

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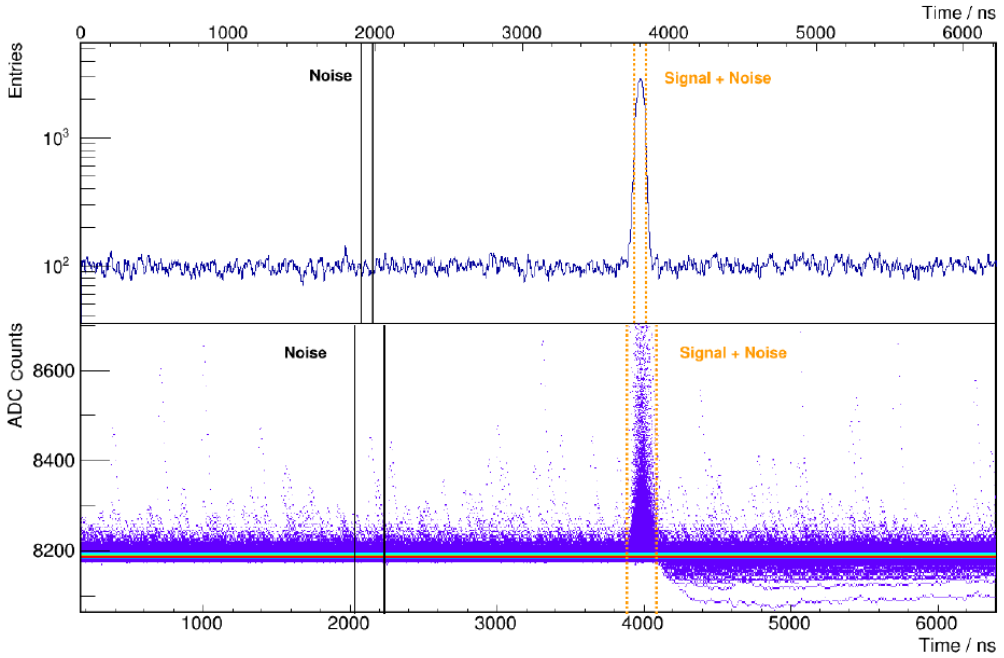
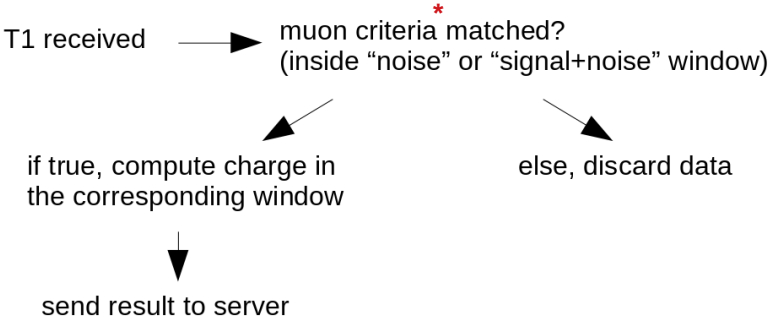
2. ADC calibration files



360000 background events (1 hour of T1 triggers)

- Idea: use background muons to obtain $\overline{Q}_\mu$
- An algorithm was implemented in the electronics to extract calibration data (runs in parallel to normal acquisition).

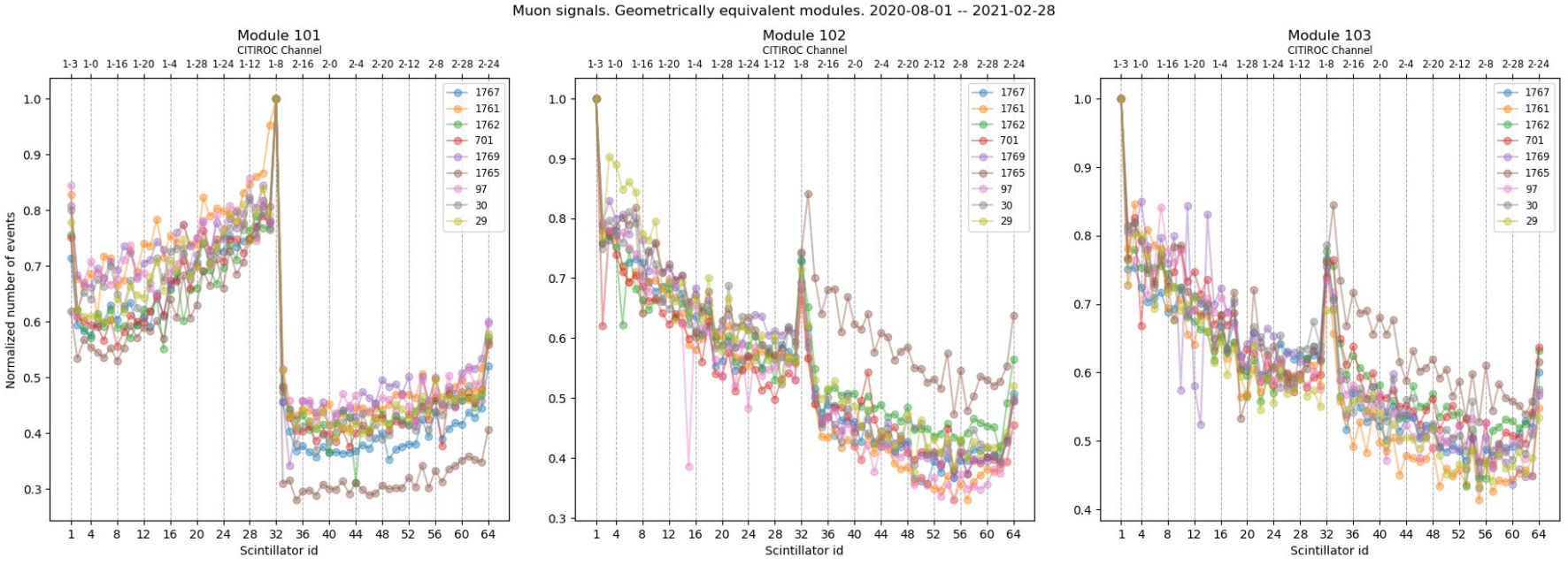


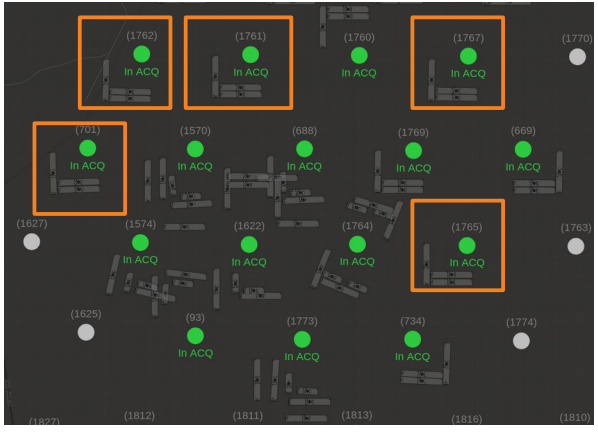
(A. Botti et al., GAP2021_015)

- One plain text per module per day with calibration data

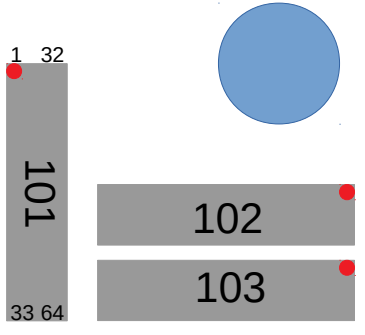
* Muon criteria: more than four 1s and less than twelve in only one strip

2. Geometrical dependence on rate



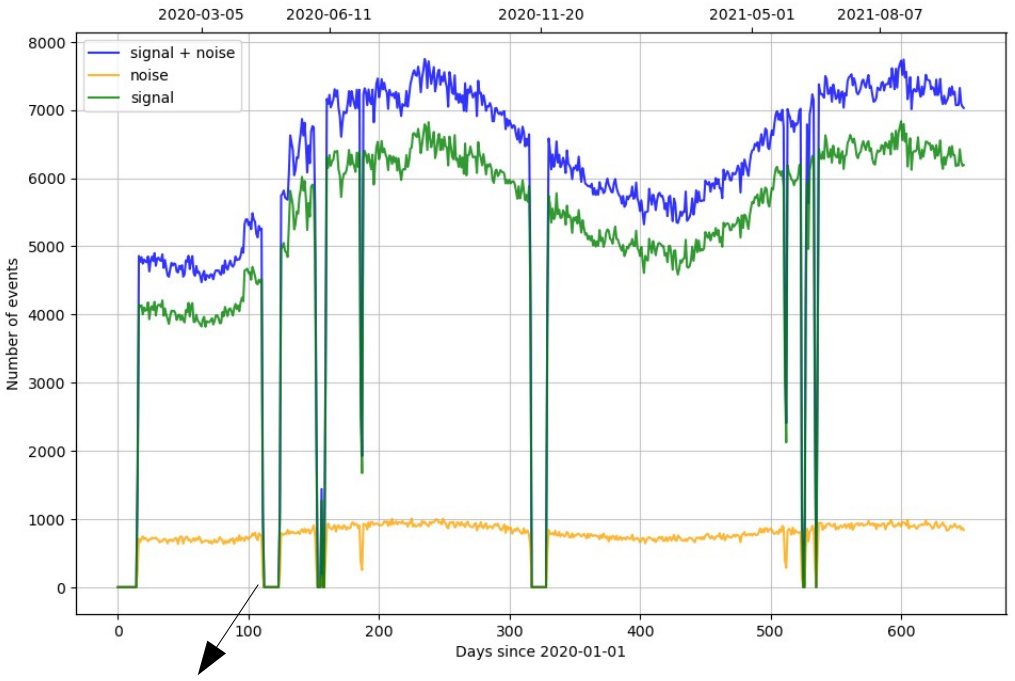


- atmospheric muons?, sub-threshold showers?
- Higher rate in lateral scintillators (1, 32, 33, 64)

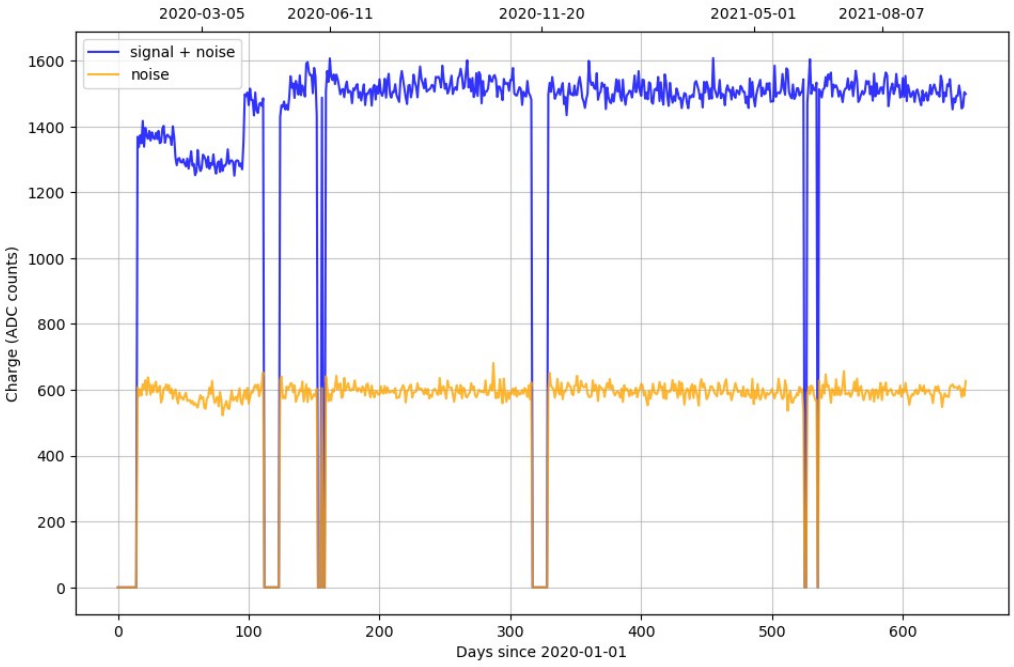


2. Seasonal modulation

Counter 93, module 101.
Jan 2020 – Oct 2021

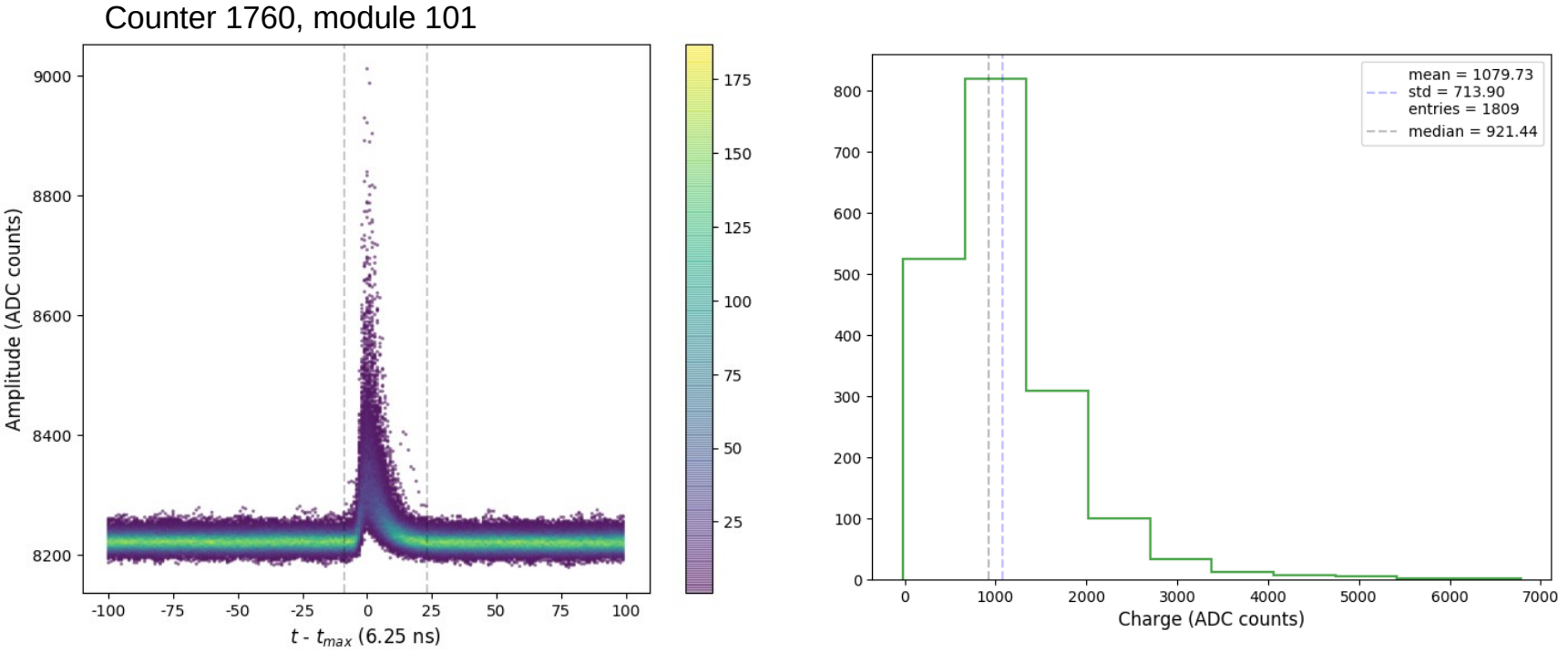


Change in firmware



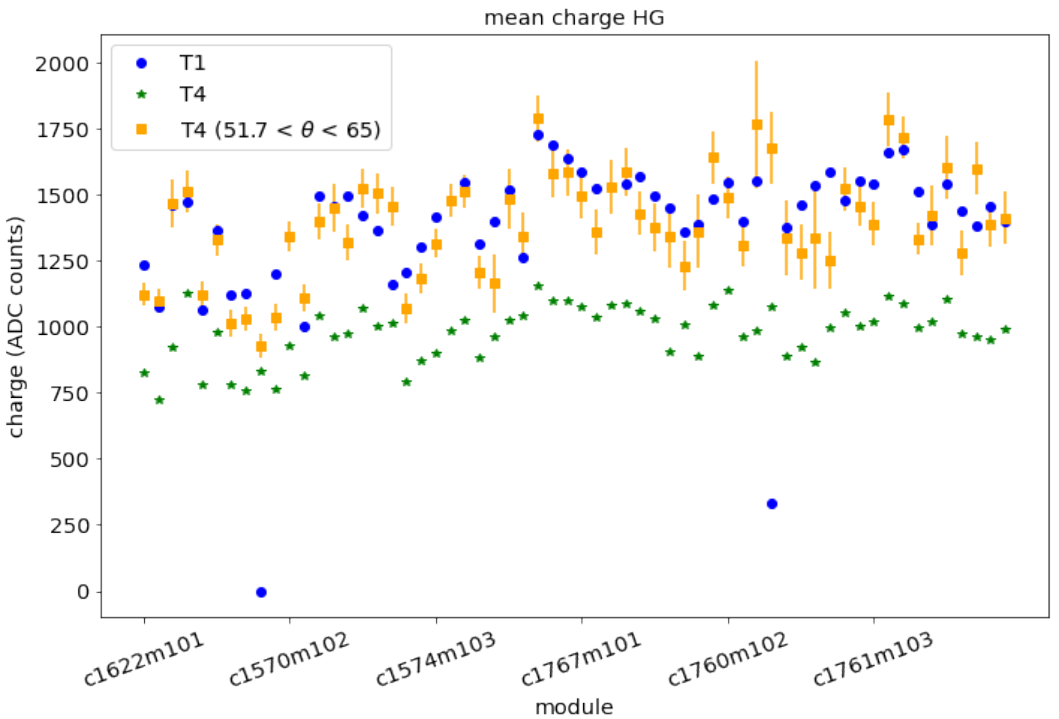
- Higher number of T1s w/ muon pattern in winter (both in “signal+noise” and “noise” windows)
- No modulation in charge

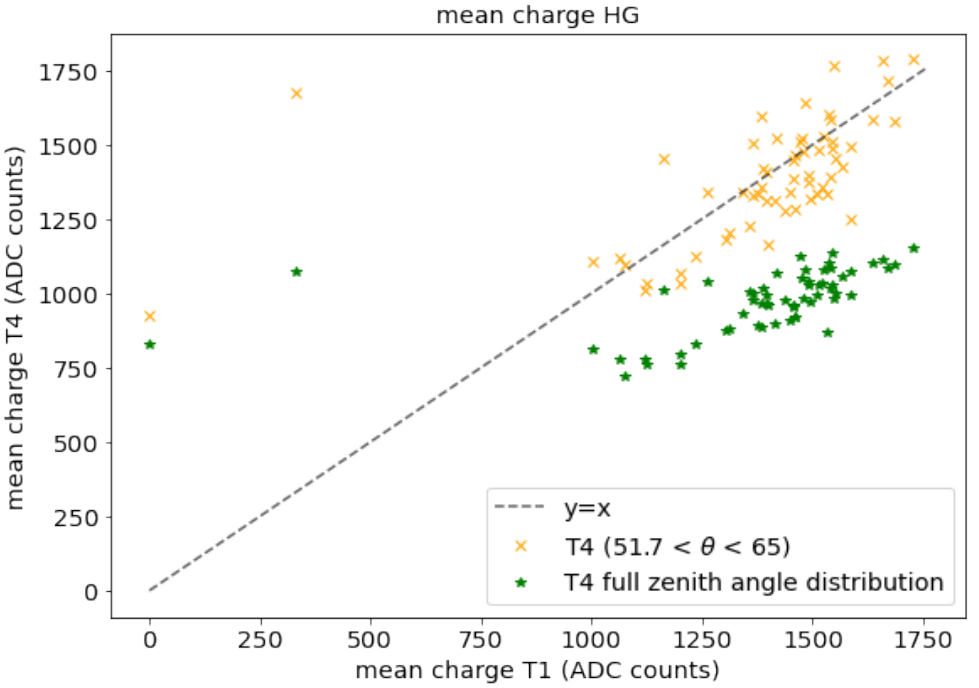
2. Comparison of $\overline{Q}_\mu$ with showers



- T4 events from Jan 2018 to Feb 2021
- Modules with only one strip with muon pattern are used

2. Comparison of $\overline{Q}_\mu$ with showers





$\overline{Q}_\mu$ obtained in ADC calibration files (T1) are systematically higher (~45%)

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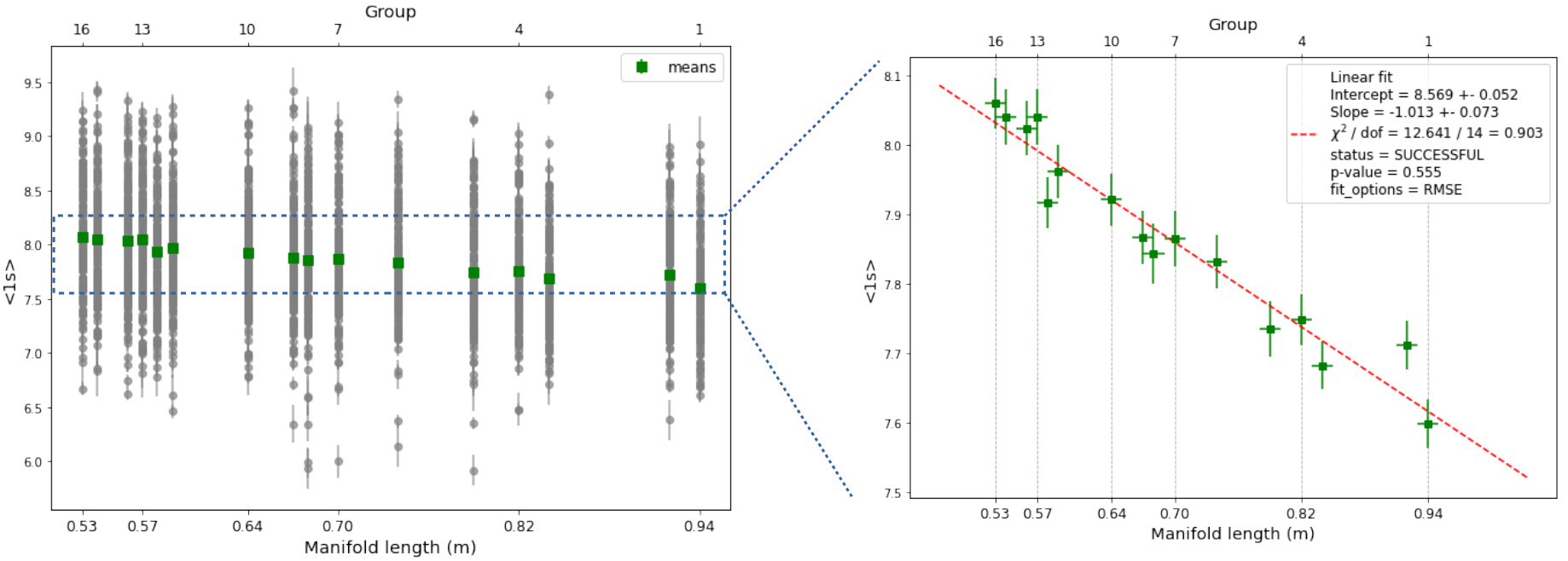
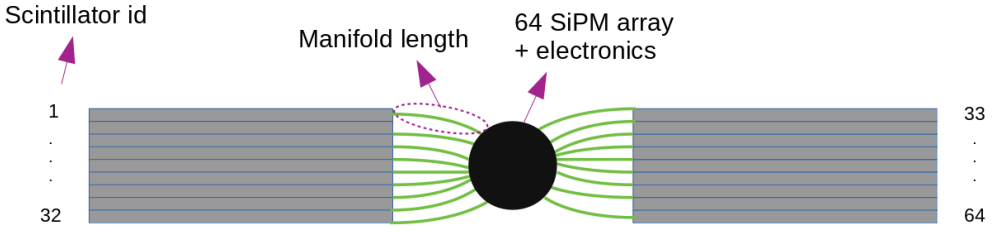
   binary channel
   integrator channel

4. Study on corner-clipping muons

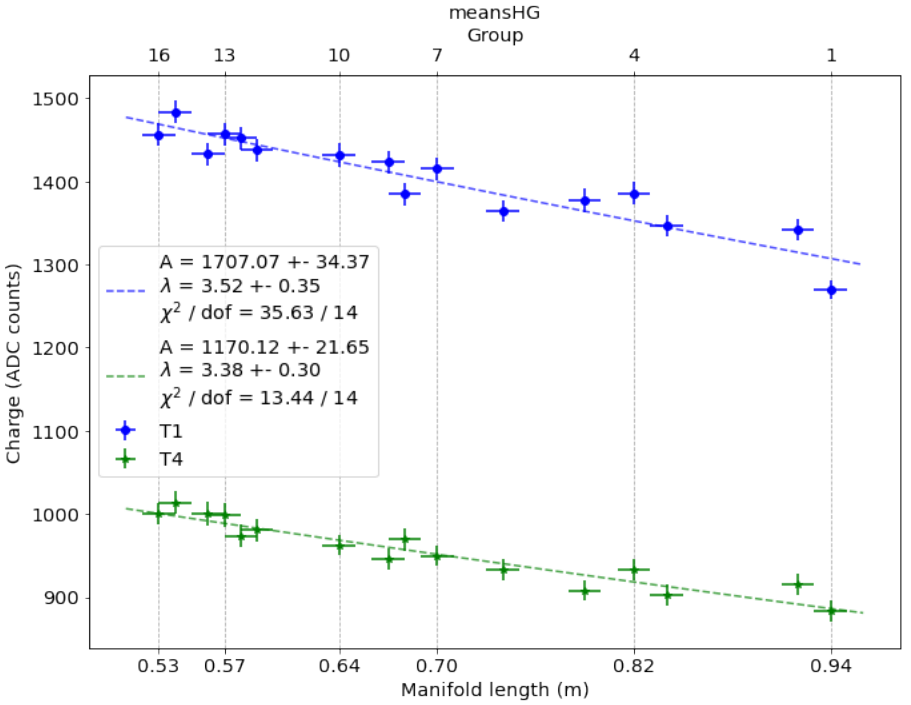
3. Study on fiber attenuation: binary channel

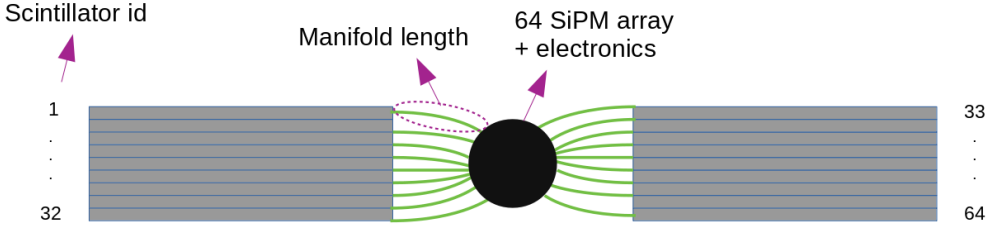




- Fiber attenuation: anti correlation of <1s> with fiber length
- GAP2021_034

3. Study on fiber attenuation: ADC channel





- Fiber attenuation: anti correlation of $<Q_\mu>$ with fiber length
- Fit with A*exp(-x/λ)
- λ values are consistent with T1s and T4s
- GAP2021_052

Outline

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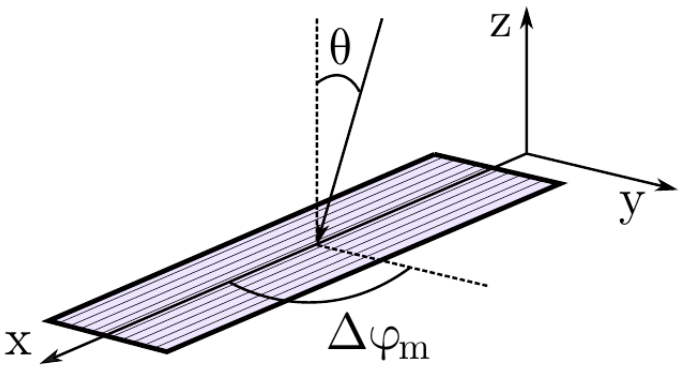
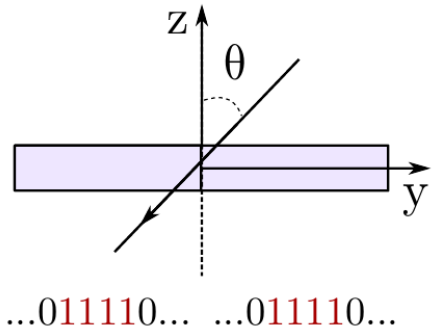
4. Corner-clipping muons

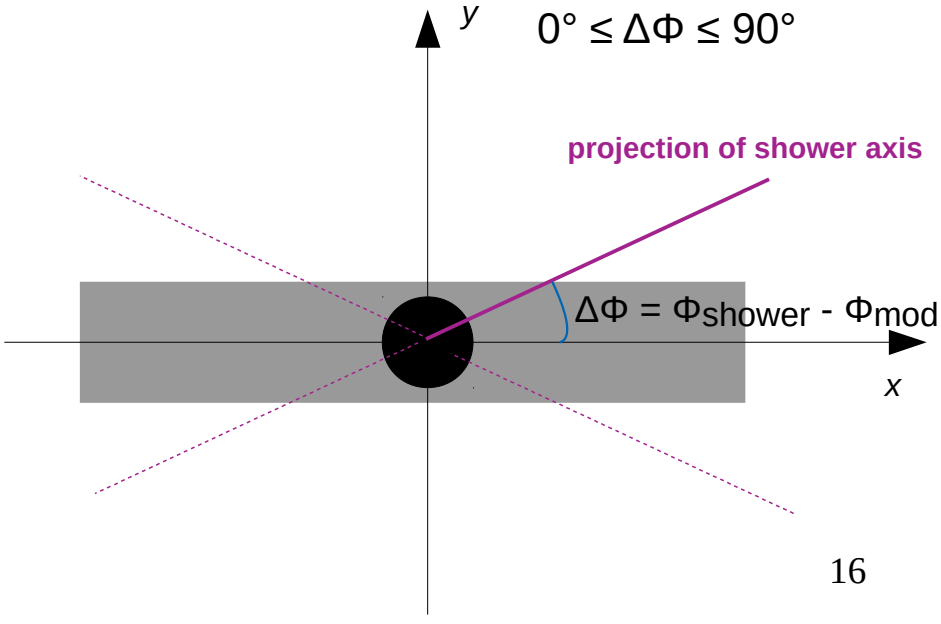




Over-counting in the binary channel

<u>Idea:</u> 1 muon can activate 1 (N_{1bar}) or 2 bars (N_{CC}).
Probability of corner-clipping:

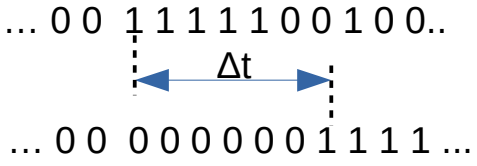
$$p_{CC}(\theta, \Delta\phi) = \frac{N_{CC}(\theta, \Delta\phi)}{N_{CC}(\theta, \Delta\phi) + N_{1bar}(\theta, \Delta\phi)}$$

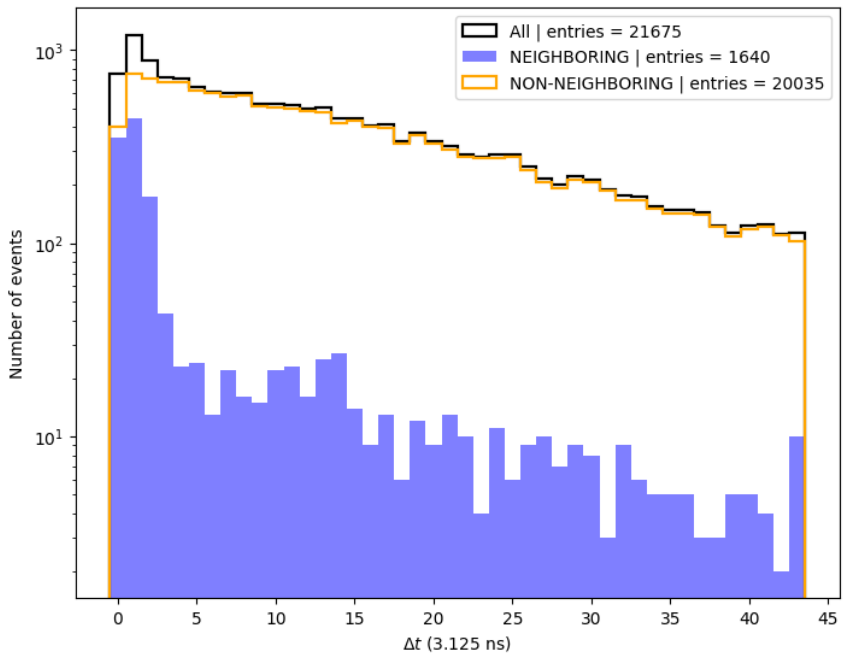


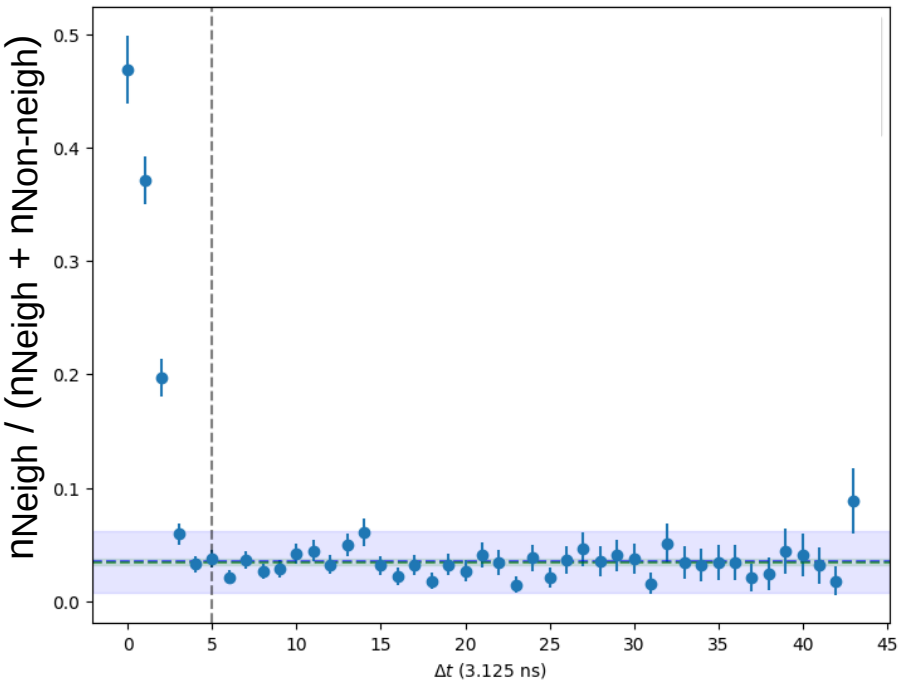
For each module:

- Events with only one strip activated in bins of (θ, ΔΦ)
- Events with only two strips activated in bins of (θ, ΔΦ)

4. Determining $N_{CC}(\theta, \Delta\Phi)$



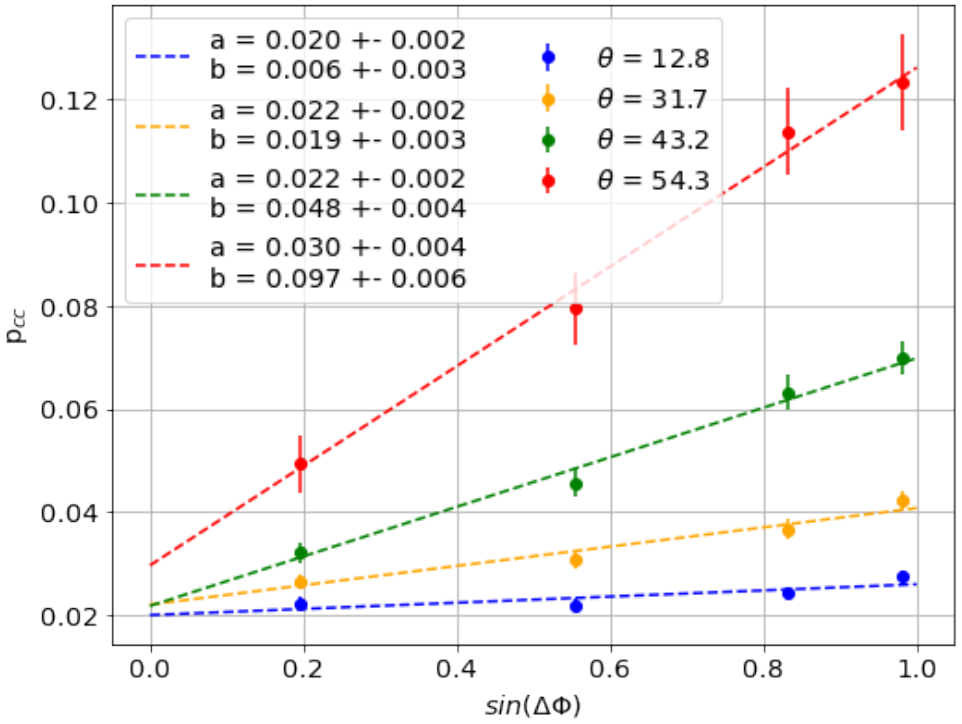




$$N_{\mathrm{CC}}(\theta, \Delta\phi) = \sum_{\Delta t=0}^{\Delta t=3} f_{\Delta t}(\theta, \Delta\phi) * N_{\Delta t}(\theta, \Delta\phi)$$

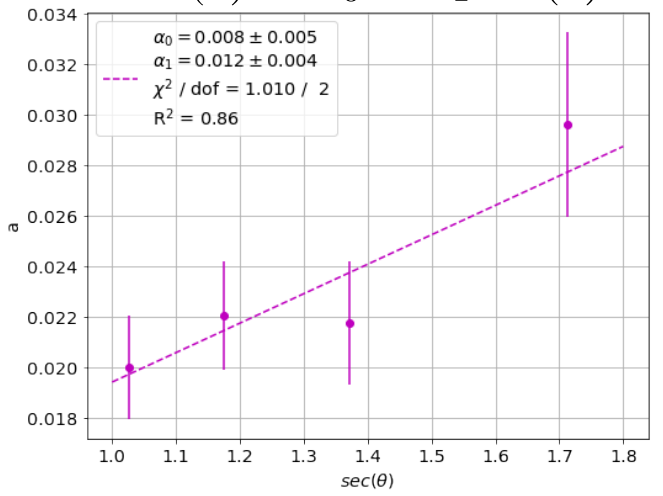
$$p_{\mathrm{CC}}(\theta, \Delta\phi) = \frac{N_{CC}(\theta, \Delta\phi)}{N_{CC}(\theta, \Delta\phi) + N_{1bar}(\theta, \Delta\phi)}$$

4. pCC(θ, ΔΦ)

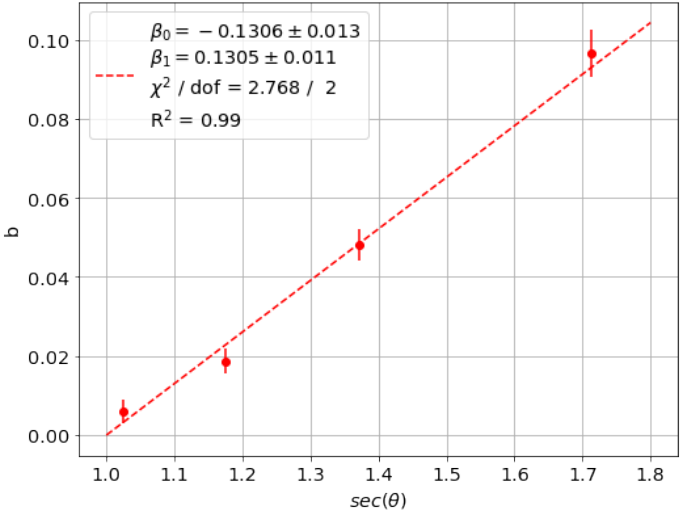


$$p_{\mathrm{CC}}(\theta, \Delta\phi) = a(\theta) + b(\theta)\sin(\Delta\Phi)$$

$$a(\theta) = \alpha_0 + \alpha_1 \sec(\theta)$$



$$b(\theta) = \beta_0 + \beta_1 \sec(\theta)$$



Validate with simulations
How is p_{CC} related to the bias?
Data-driven corner-clipping correction?

Summary

1. Crosstalk
   - 0,3 % of crosstalk events
   - occuring when module samples high number of particles
2. ADC calibration files
   - rate distribution depends on module orientation
   - seasonal modulation in rate
   - $\overline{Q}_{\mu}$ consistent with those obtained in inclined showers
3. Study on fiber attenuation
   - anti-correlation of <1s> with fiber length
   - anti-correlation of $\overline{Q}_{\mu}$ with fiber length
4. Study on corner-clipping muons
   - $p_{CC}(\theta, \Delta\Phi)$ obtained and fitted with $a(\theta) + b(\theta)\sin(\Delta\Phi)$
   - $a(\theta)$, $b(\theta)$ fitted with $\alpha_0 + \alpha_1 \sec(\theta)$
   - next steps:
     Validate method with simulations
     Strategy for a corner-clipping correction

Summary

1. Crosstalk
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   - occuring when module samples high number of particles
2. ADC calibration files
   - rate distribution depends on module orientation
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   - $\overline{Q}_{\mu}$ consistent with those obtained in inclined showers

ADC reconstruction

3. Study on fiber attenuation
   - anti-correlation of <1s> with fiber length
   - anti-correlation of $\overline{Q}_{\mu}$ with fiber length
4. Study on corner-clipping muons
   - $p_{CC}(\theta, \Delta\Phi)$ obtained and fitted with $a(\theta) + b(\theta)\sin(\Delta\Phi)$
   - $a(\theta)$, $b(\theta)$ fitted with $\alpha_0 + \alpha_1 \sec(\theta)$
   - next steps:
     - Validate method with simulations
     - Strategy for a corner-clipping correction

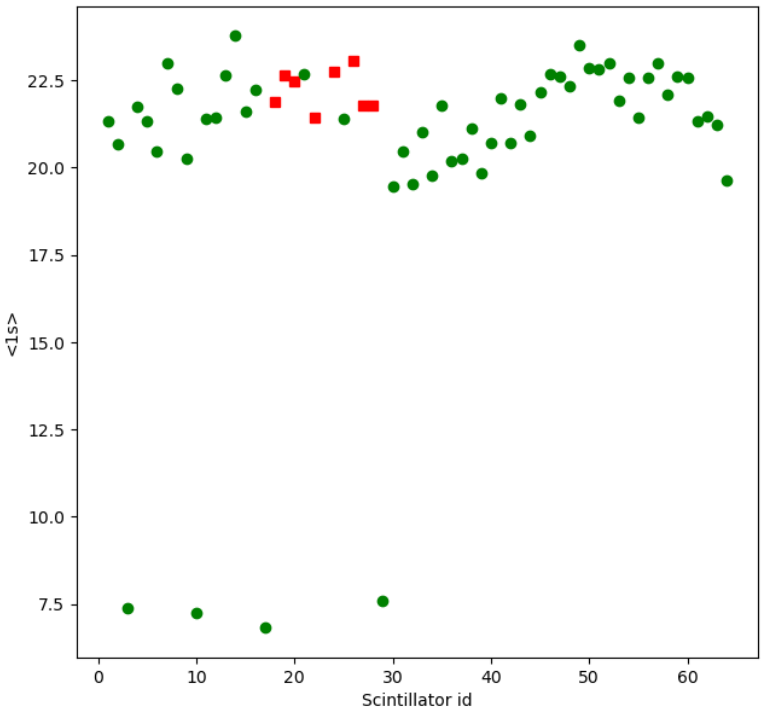
Binary reconstruction

Back up

1. Study on crosstalk

- Are photons leaking from neighboring fibers?

Events with scintillator 23 w/ muon pattern

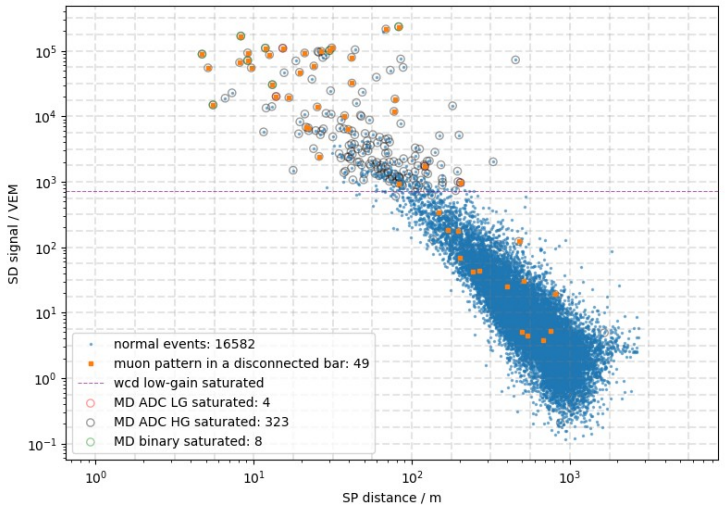


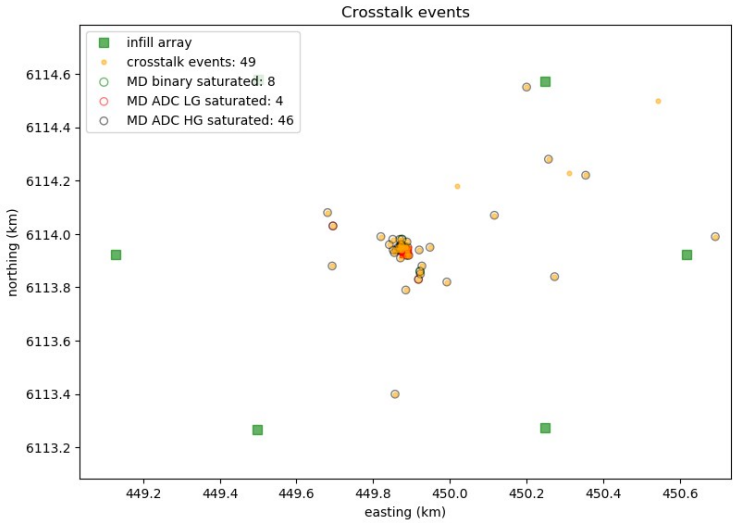
Scintillators fibers in SiPM array

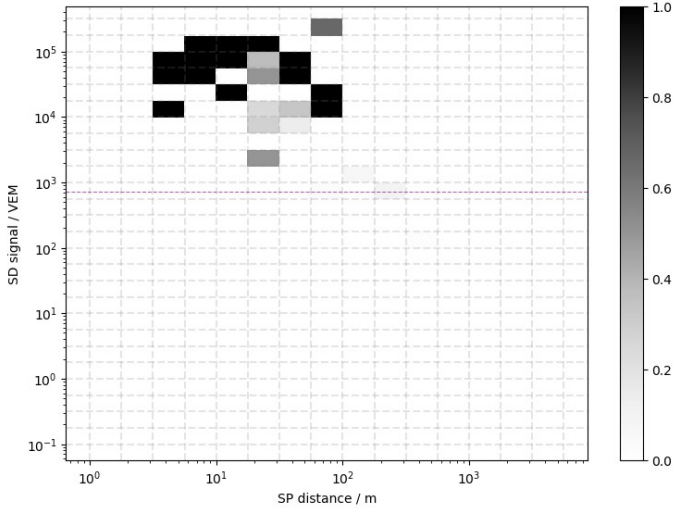
29	25	21	17	16	12	8	4
30	26	22	18	15	11	7	3
31	27	23	19	14	10	6	2
32	28	24	20	13	9	5	1
64	60	56	52	45	41	37	33
63	59	55	51	46	42	38	34
62	58	54	50	47	43	39	35
61	57	53	49	48	44	40	36

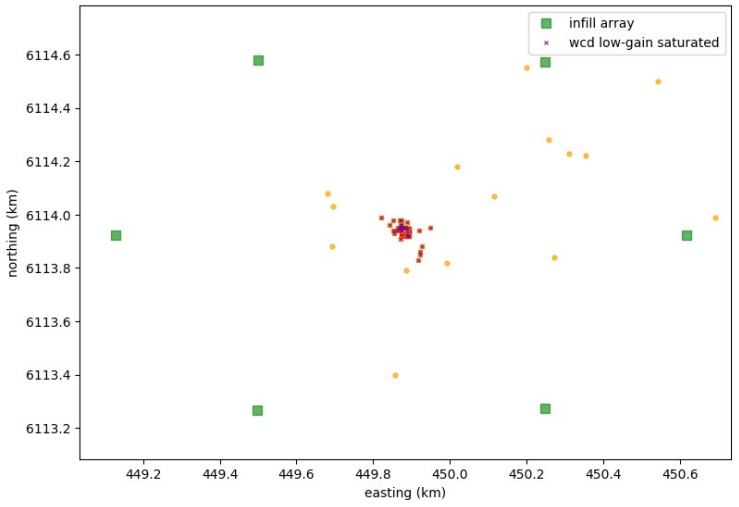
- Neighboring fibers in SiPM array

1. Study on crosstalk





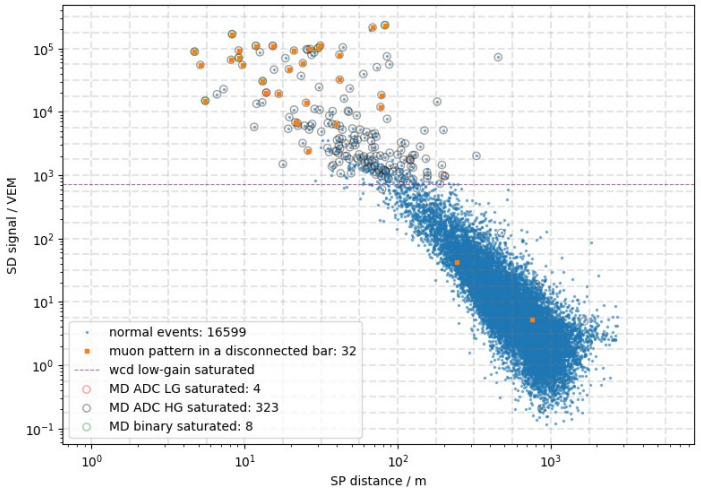


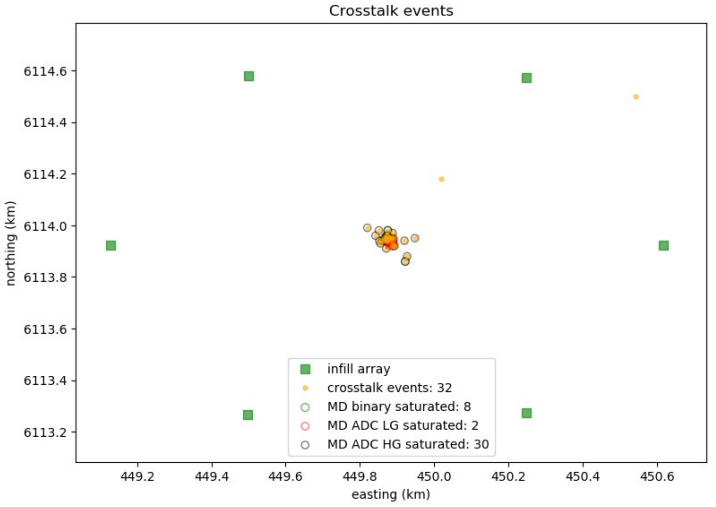


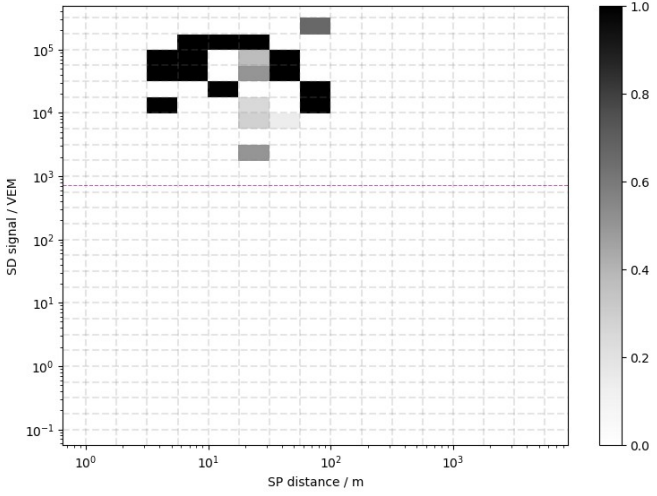
- 0,3 % of crosstalk events
- Occuring when module samples high number of particles
- ~1/3 caused by scintillator 29

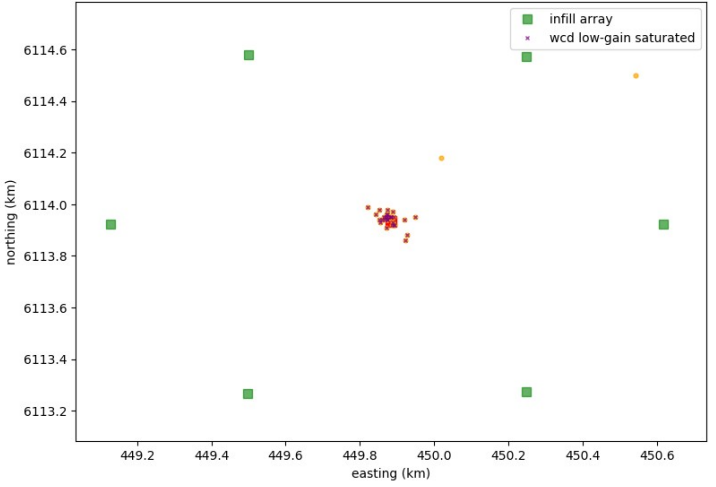
1. Study on crosstalk

Removing scintillator 29









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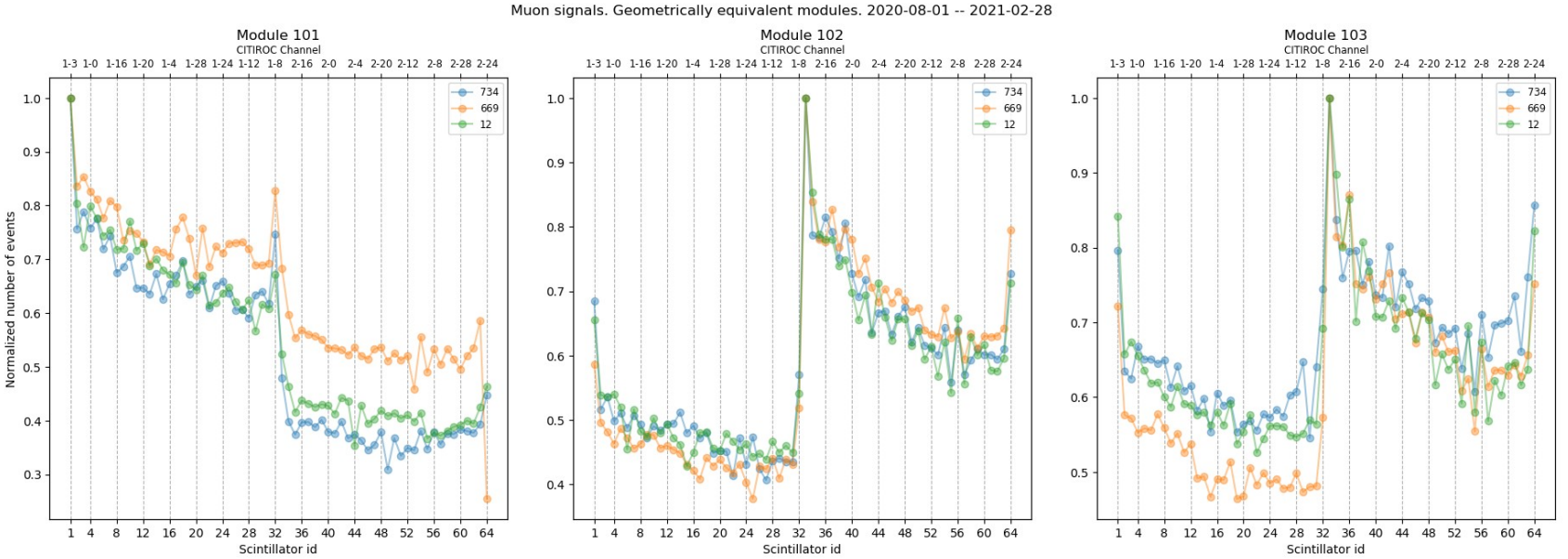
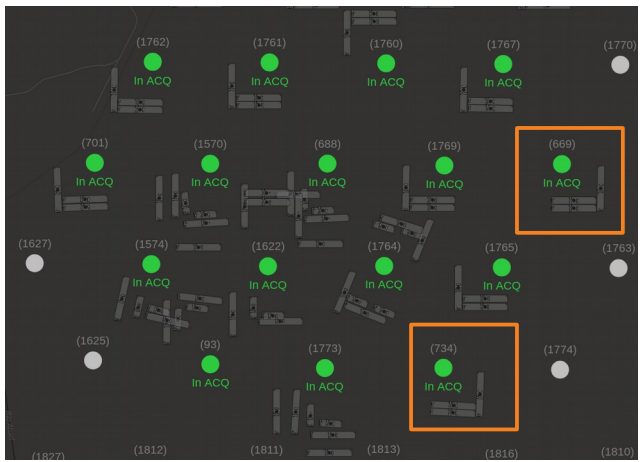
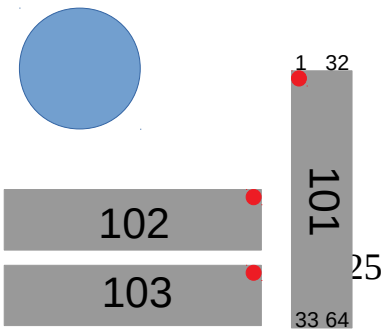
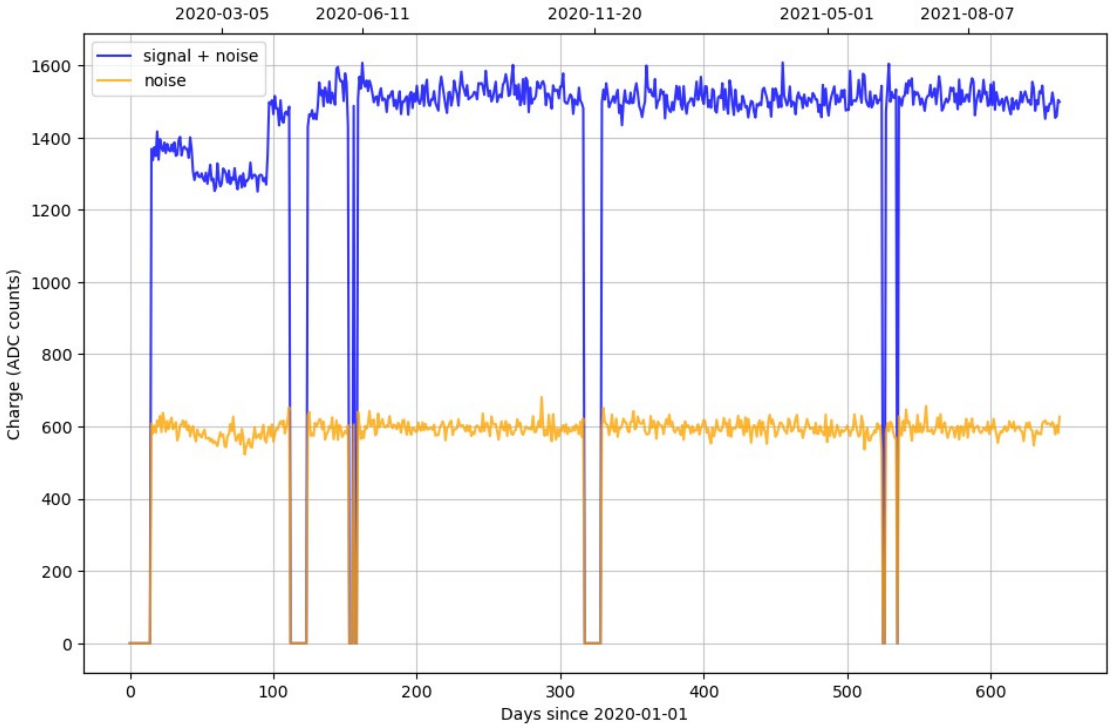






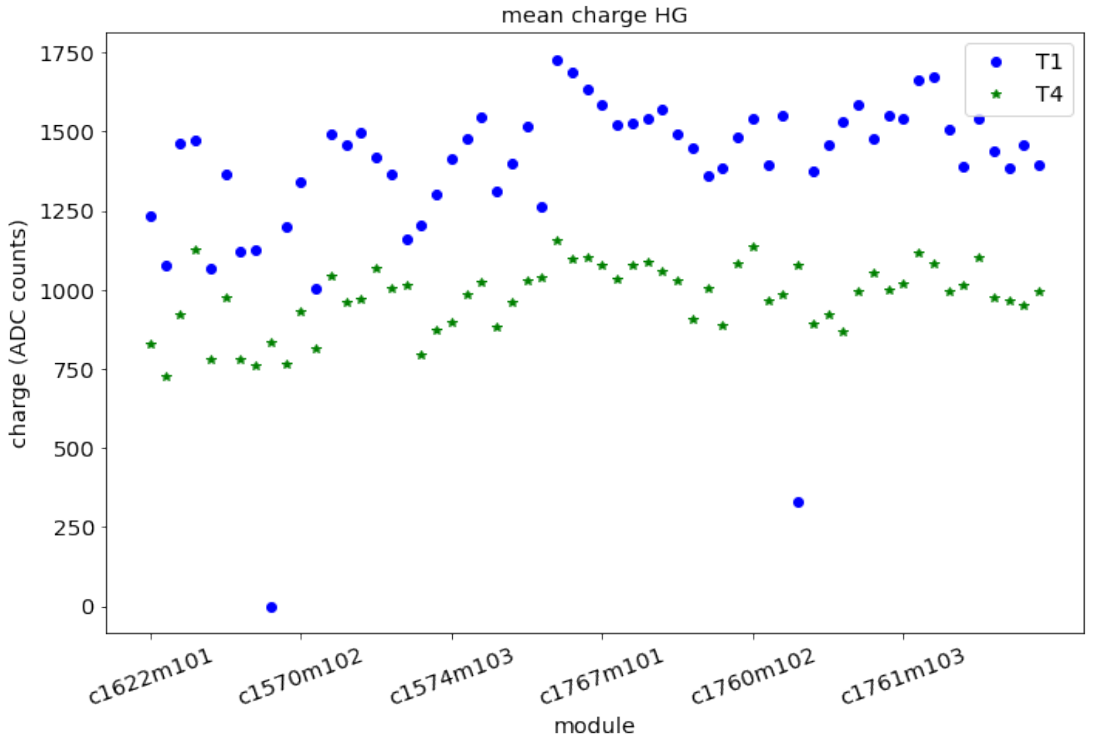
2. Seasonal modulation

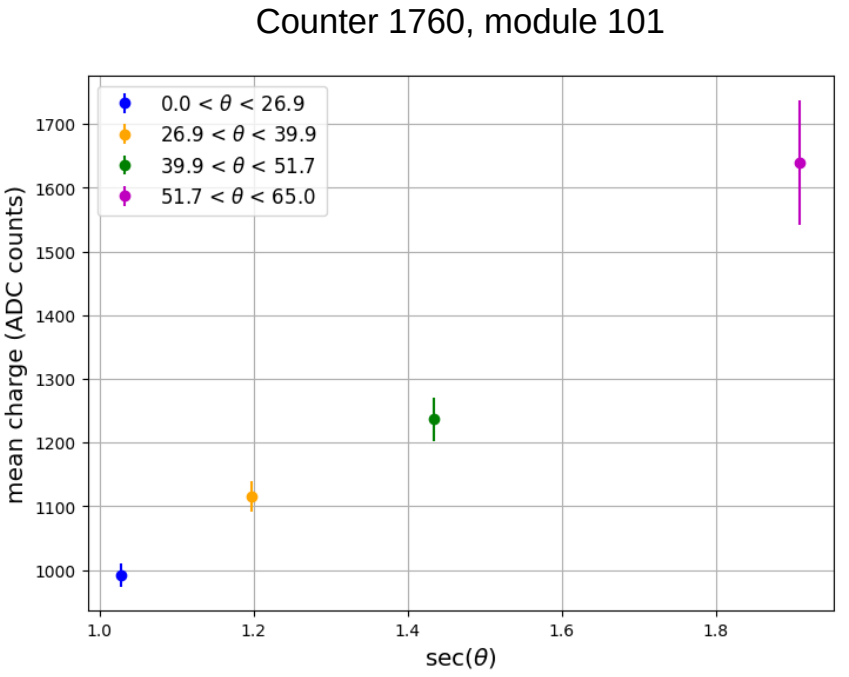
Counter 93, module 101.
Jan 2020 – Oct 2021
Daily mean charge (HG)



- No modulation in charge

2. Comparison of $\overline{Q}_\mu$ with showers

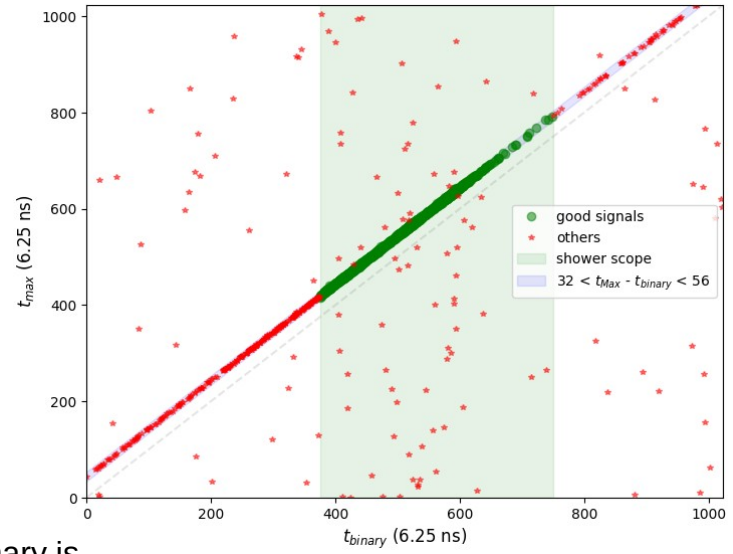


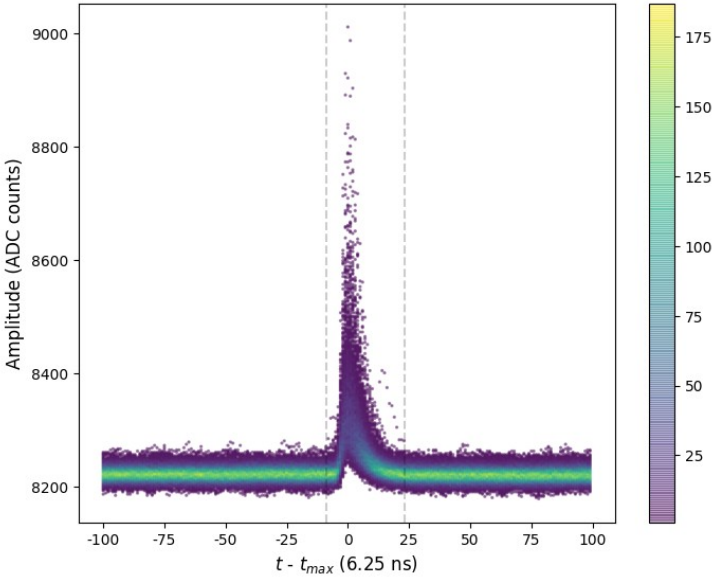


$\overline{Q}_\mu$ obtained in ADC calibration files (T1) are systematically higher (~45%)

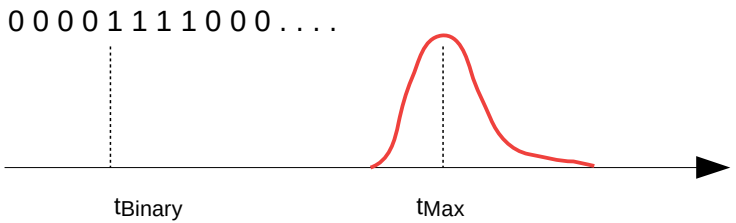
2. Comparison of $\overline{Q}_\mu$ with showers

- T4 events from Jan 2018 to Feb 2021
- Modules with only one strip with muon pattern are used

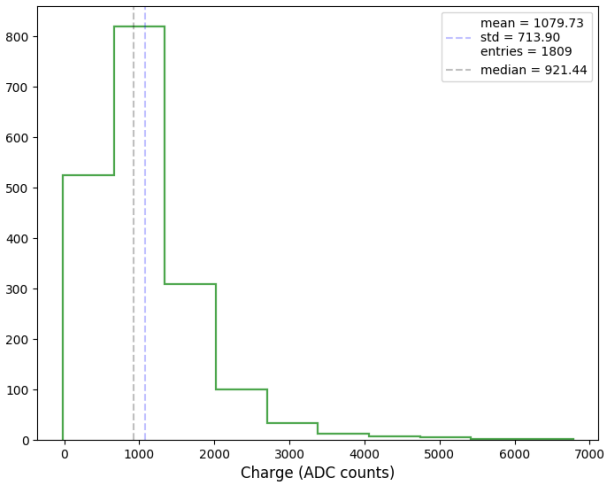




1) Check that start time of pattern in binary is in ‘shower scope’
2) Check that start time of binary is consistent with t_{Max} from ADC



3) Compute the charge in an integration window of 32 ADC samples (200 ns)



4. Determining $N_{CC}(\theta, \Delta\Phi)$

Events with only two strips activated: neighboring bars and Δt