# Performance check of the charged particle detector for the KOTO experimental at J-PARC.

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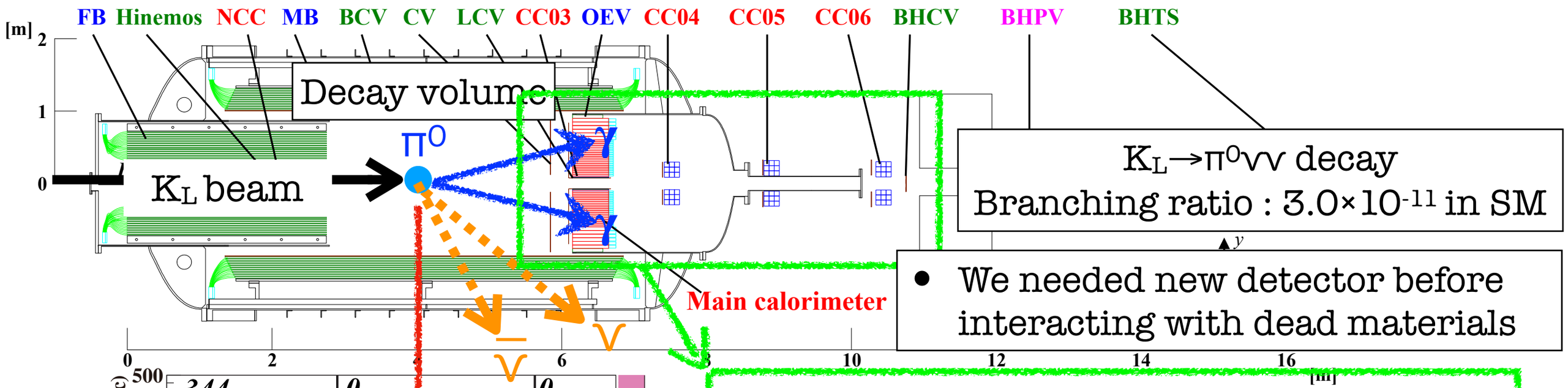
for the KOTO collaboration

2019 KPS Fall Meeting(2019.10.25.)

# The motivation of new detector(DCV)




Background Estimation
(2015 data, S.E.S = $1.3\times10^{-9}$)

| source | | Number of events |
|---|---|---|
| $K_L$ decay | $K_L \to \pi^+\pi^-\pi^0$ | 0.05 ± 0.02 |
| | $K_L \to 2\pi^0$ | 0.02 ± 0.02 |
| | other $K_L$ decays | 0.03 ± 0.01 |
| neutron-induced | hadron-cluster | 0.24 ± 0.17 |
| | upstream-$\pi^0$ | 0.04 ± 0.03 |
| | CV-$\eta$ | 0.04 ± 0.02 |
| total | | 0.42 ± 0.18 |

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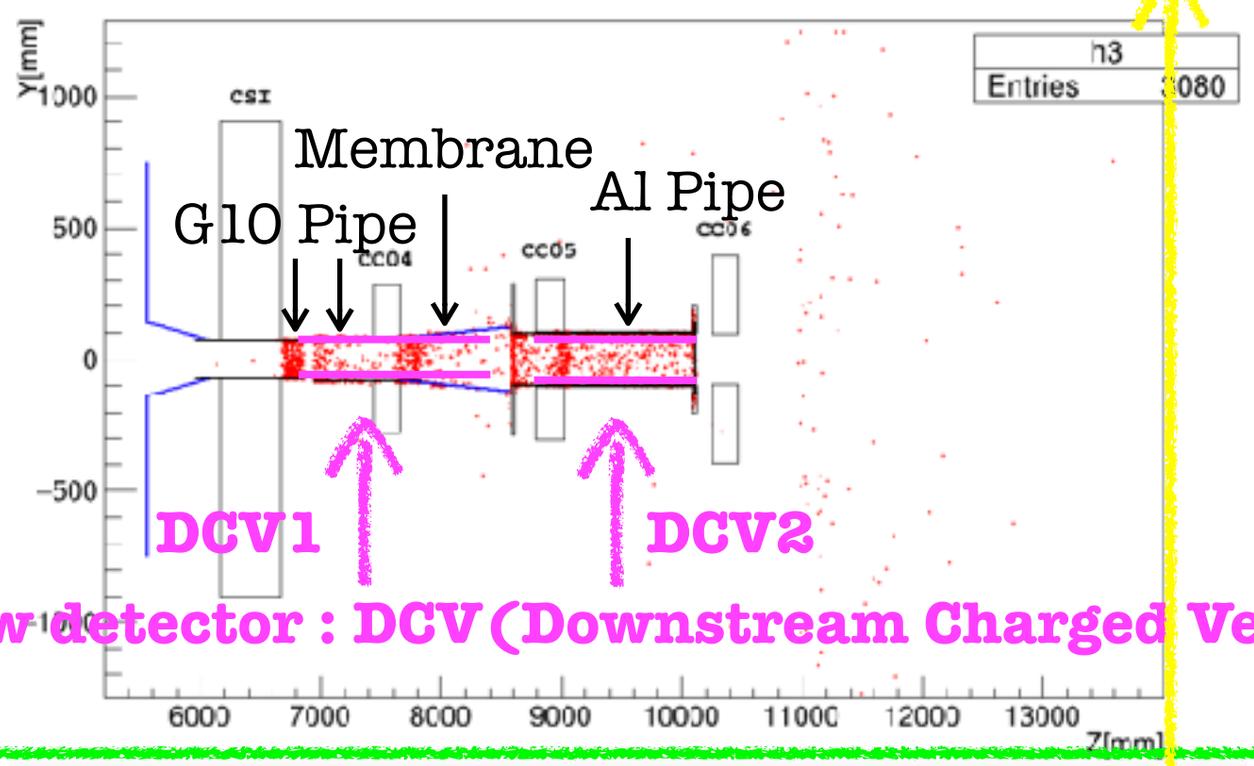
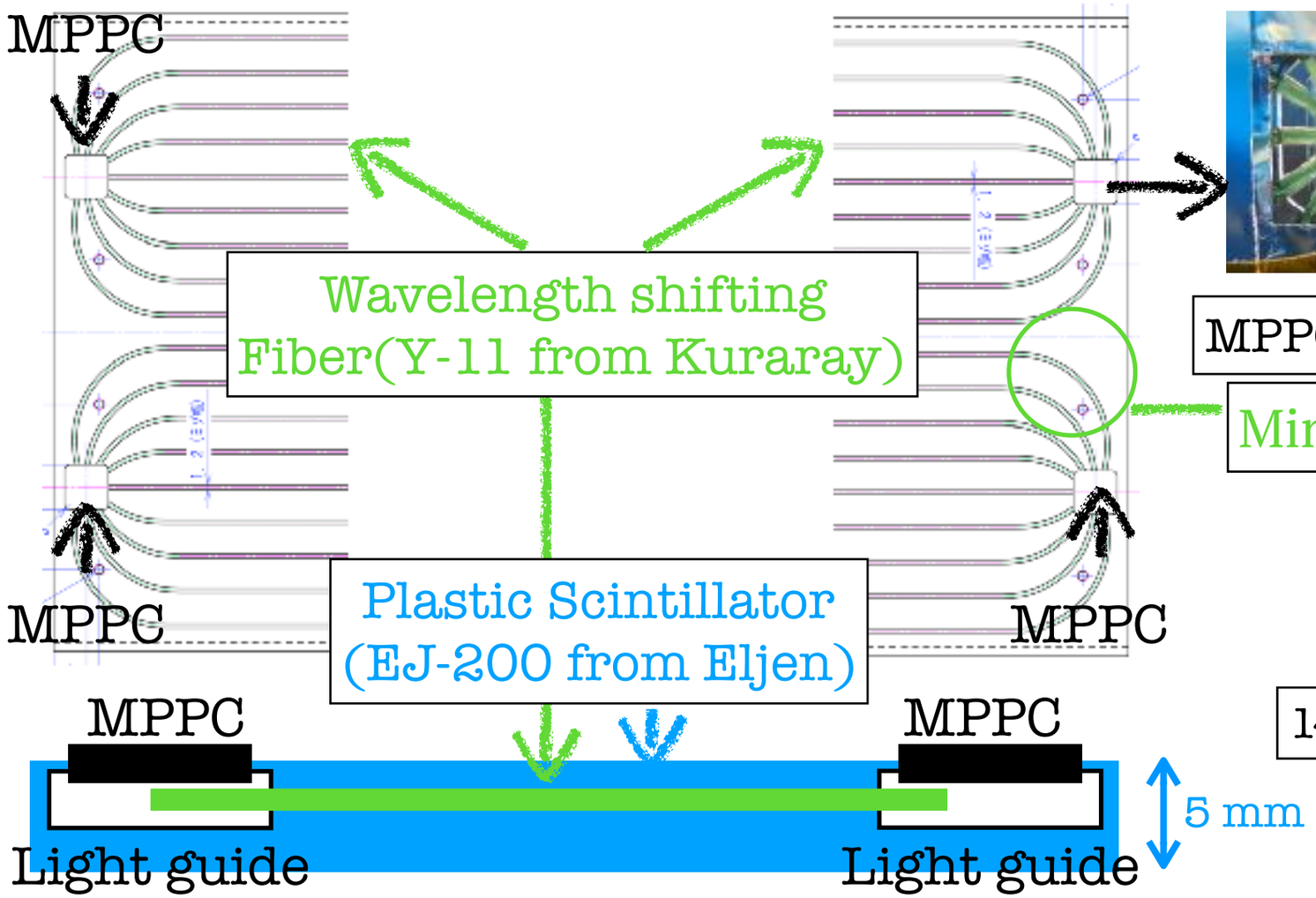
Interacting point with material for $\pi^+$, $\pi^-$

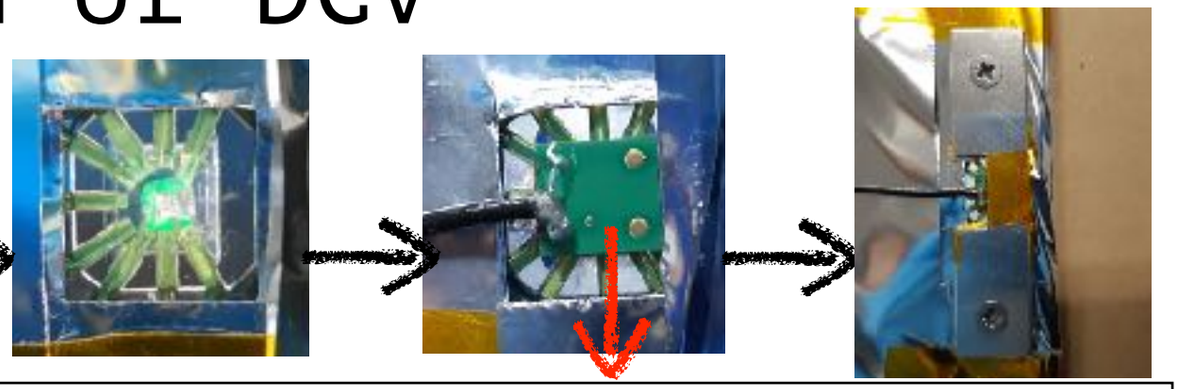



New detector : DCV (Downstream Charged Veto)

- The number of $K_L \to \pi^+\pi^-\pi^0$ events can reach approximately 2 at SM sensitivity.

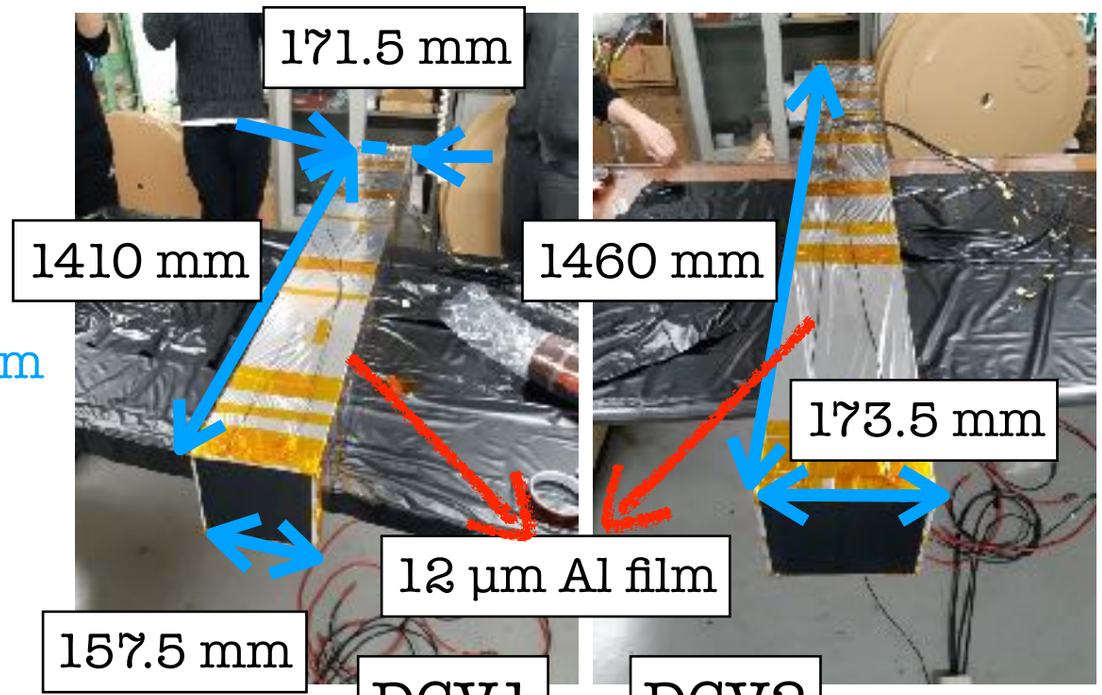
# Fabrication of DCV



MPPC : S13360-6050PE from HAMAMATSU

Minimum radius of curvature : 20 mm



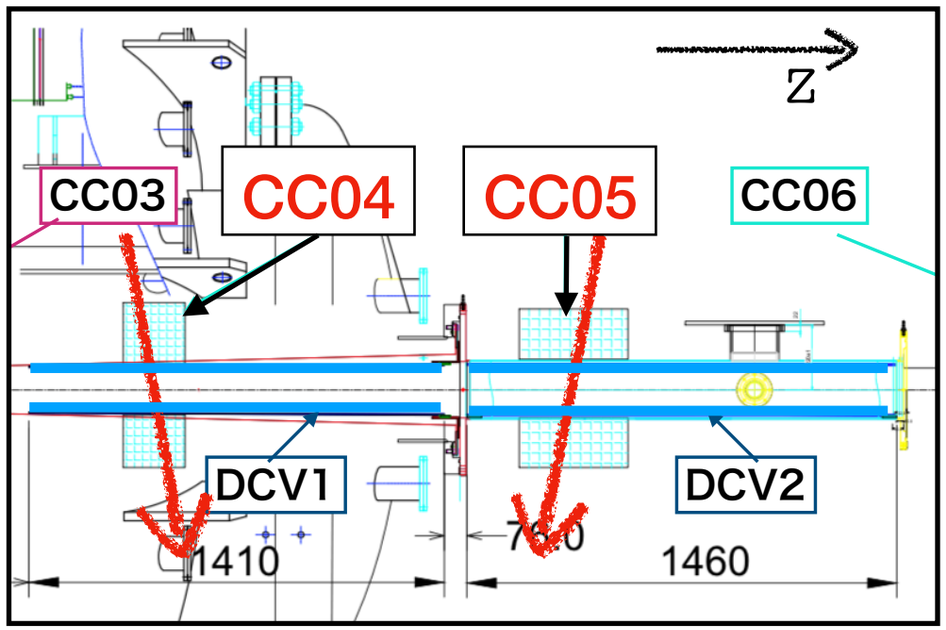

- Due to very limited space, we are trying a new scheme of light collection.

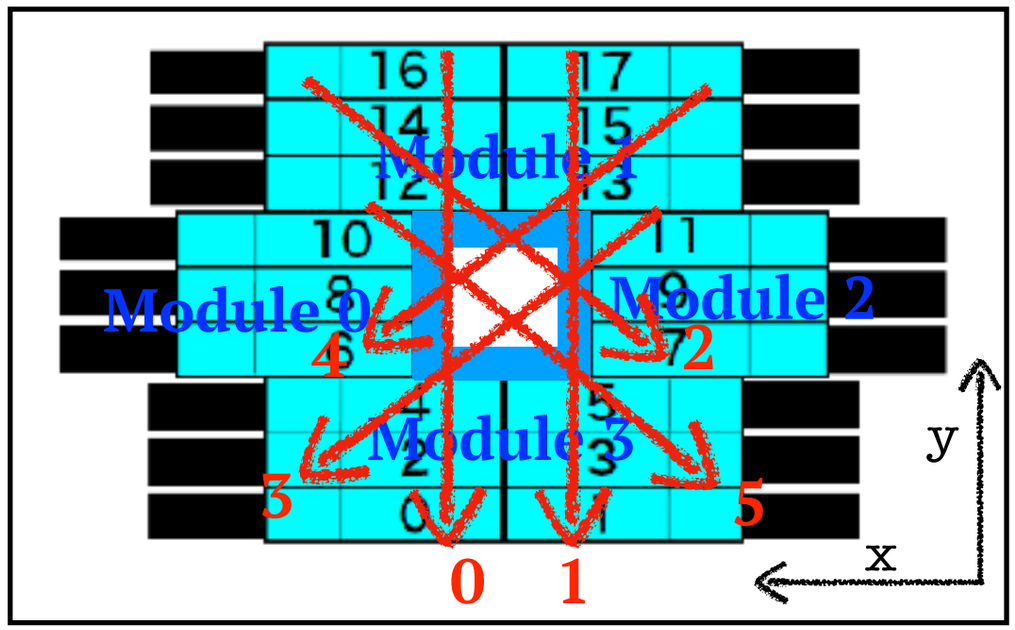
- MPPC Gain Measurement(Grouping) > Fiber Light Yield Test(Selection) > Gluing > Evacuation > Wrapping > Cosmic-ray Test > Installation > First Beam Commissioning

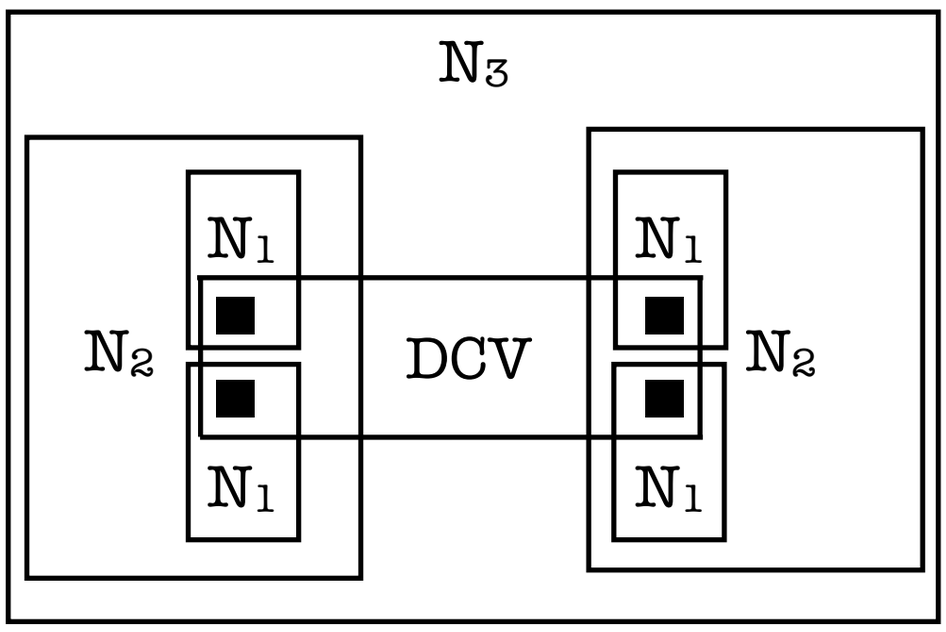
- From the Cosmic-ray test, we got 60 p.e. at the center of DCV.

# How to do Energy Calibration of DCV

Cosmic-ray tracking



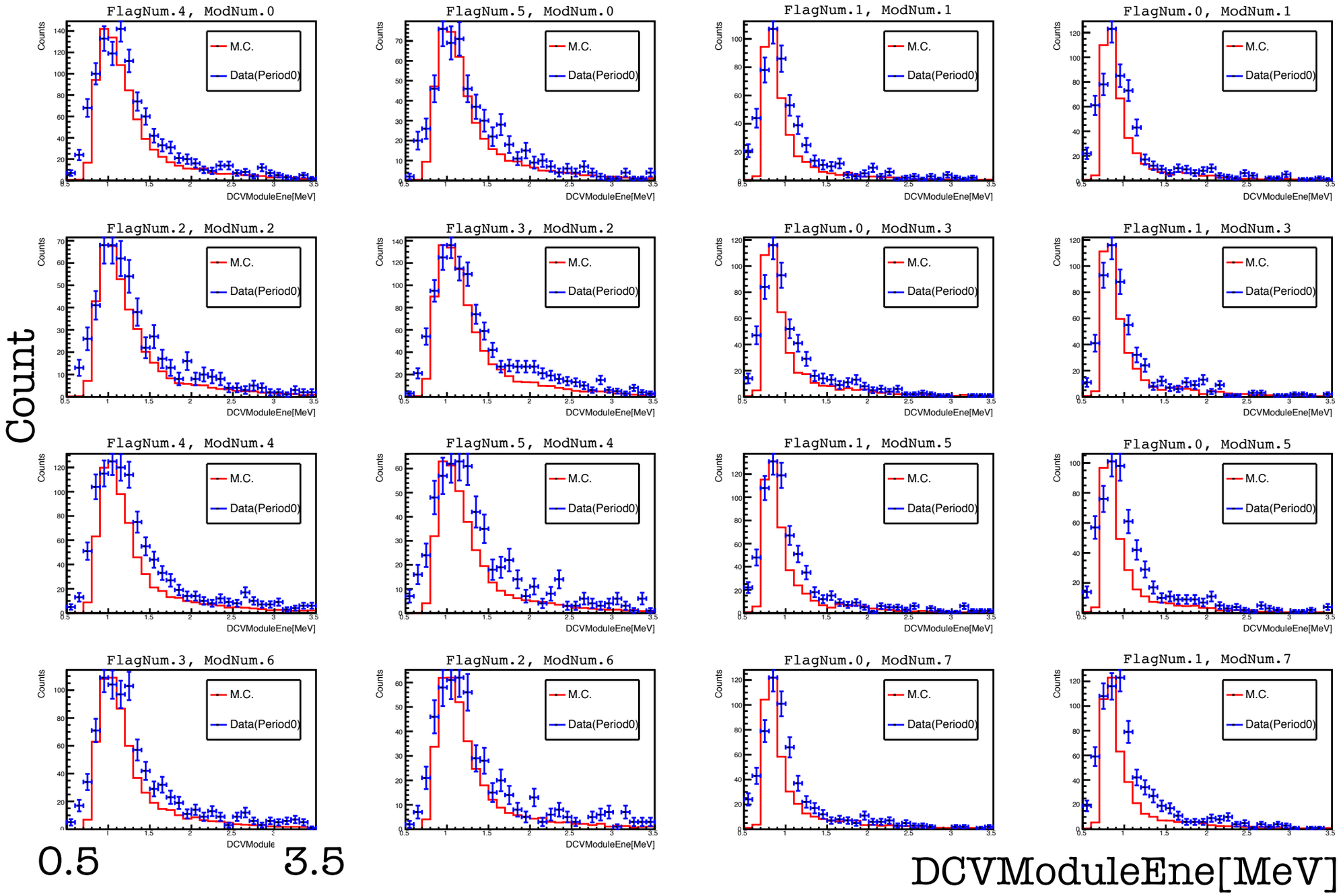




$N_1$ : Normalization Factor for each MPPC.
$N_2$ : Normalization Factor for a pair of MPPC at Upstream(Downstream)
$N_3$ : Normalization Factor for 4 MPPC.

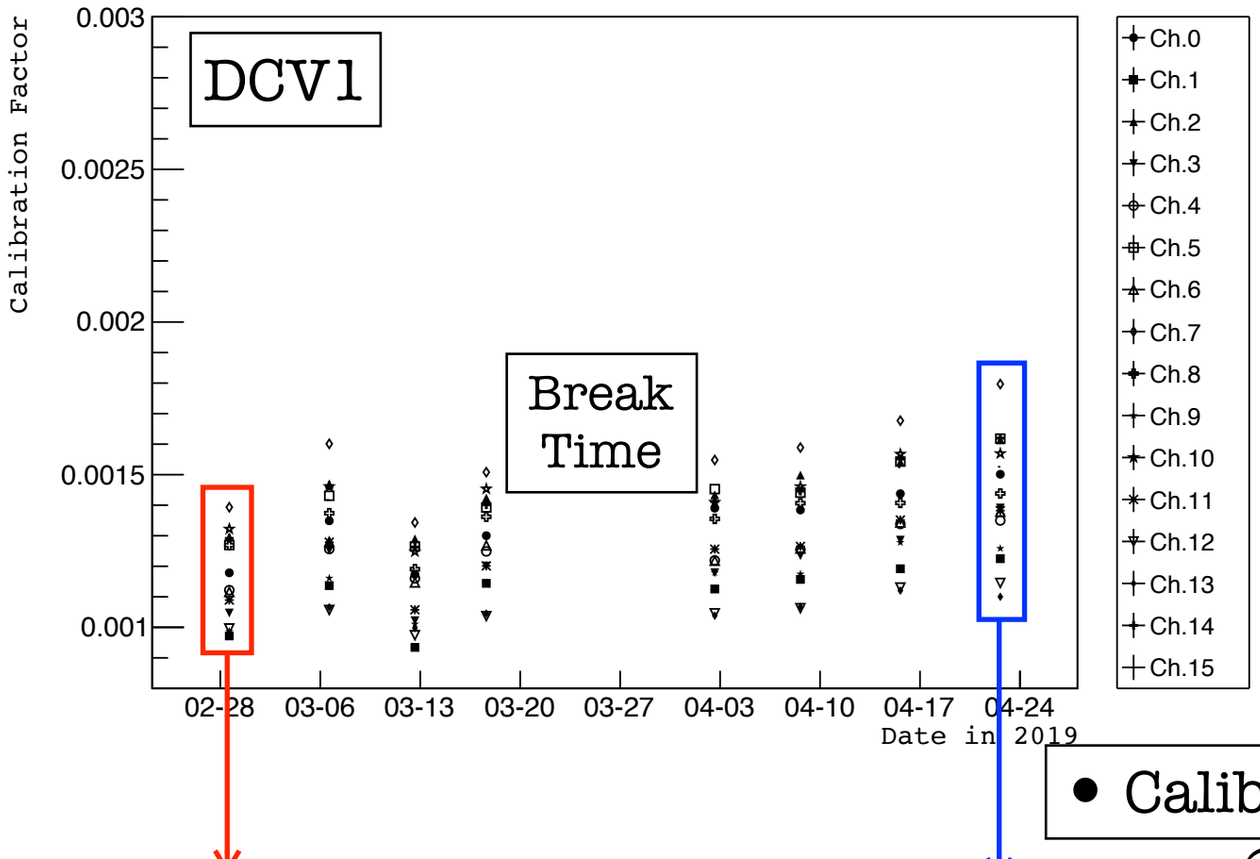
$$Calibration\ Factor = \frac{Attenuation\ Factor}{N_1 \times N_2 \times N_3 \times PathLengthFactor} \times M.C.CorrectionFactor$$

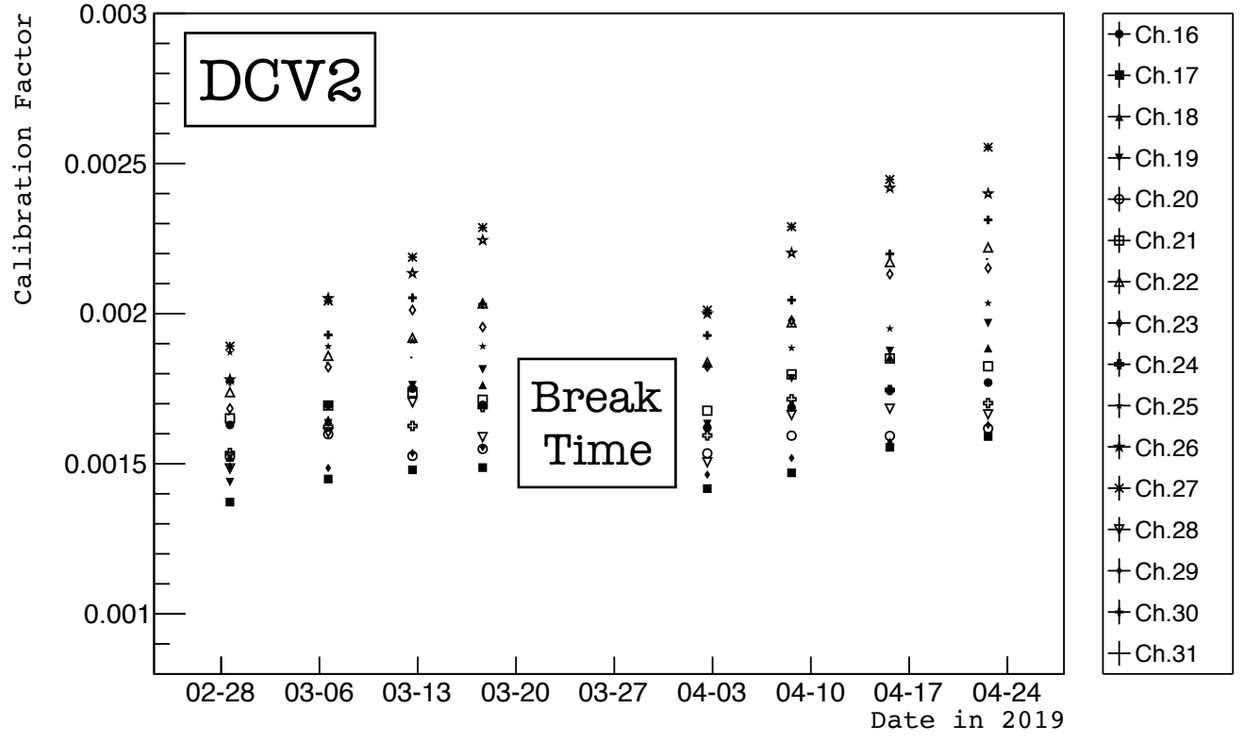
# Data vs M.C.

## DCVModuleEnergy distribution for each Cosmic-ray track.

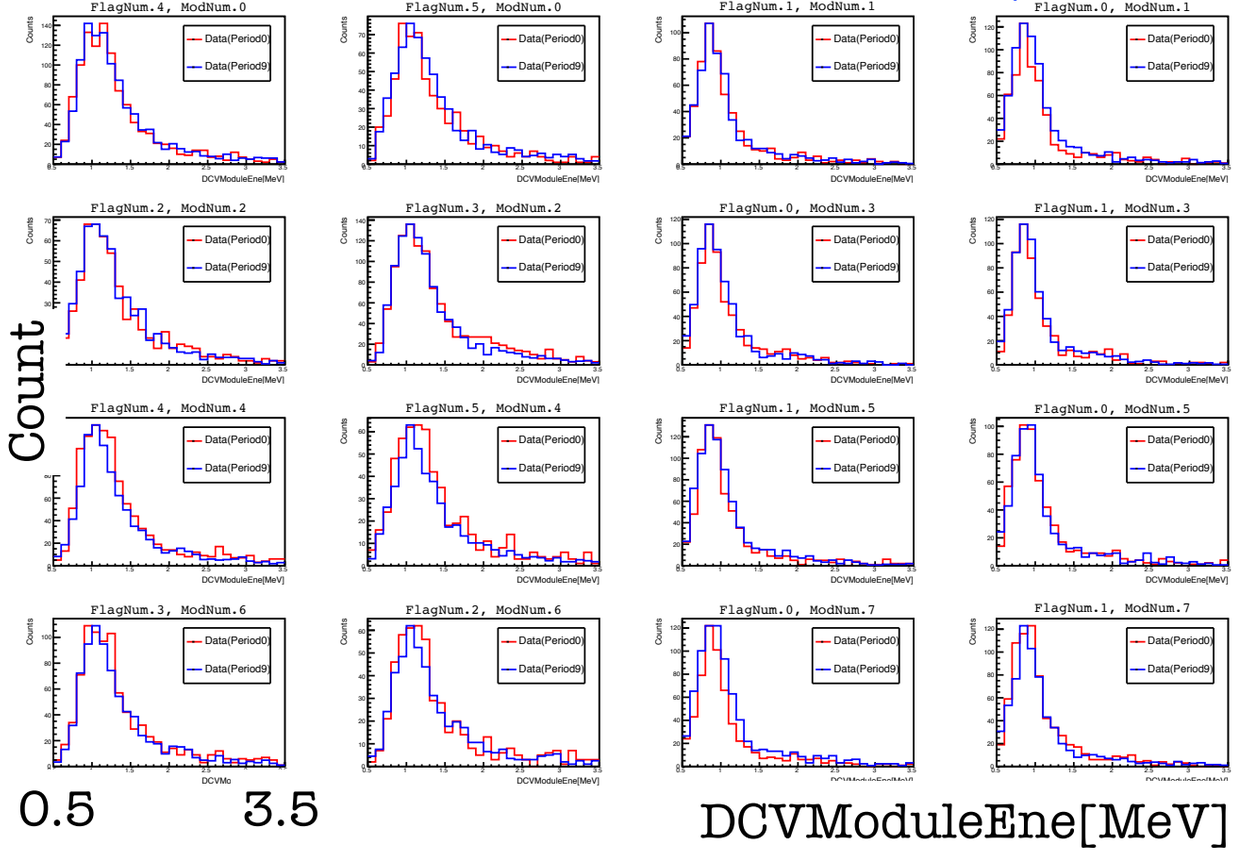


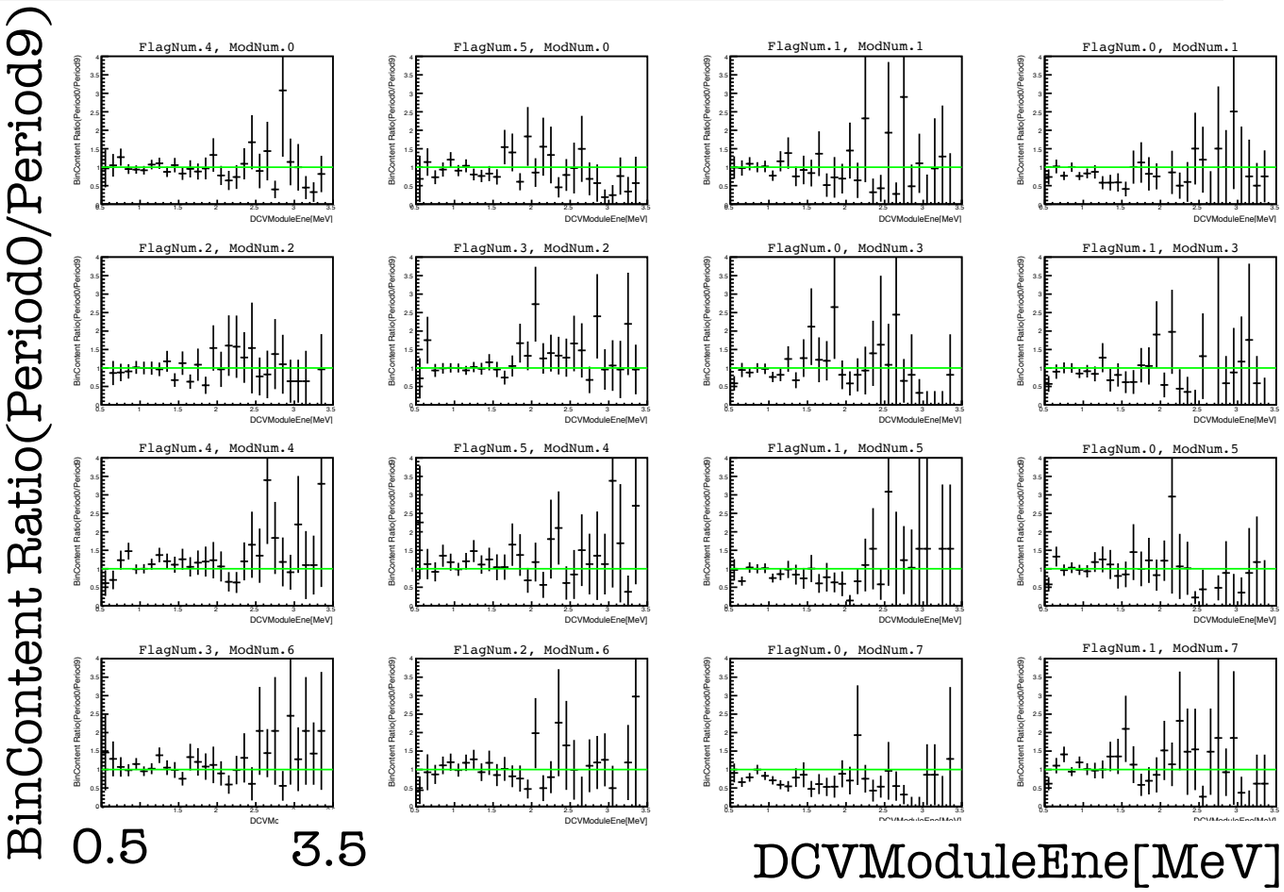
# Calibration Factor during Beam Time




- Calibration Factors tend to increase over time

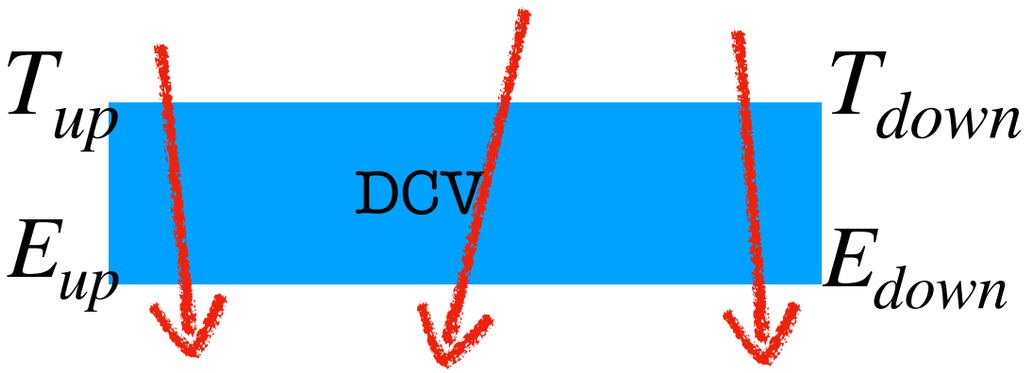


# Attenuation Length

- Trigger : DCV Self(Cosmic-ray)
- Hit Condition

1) Hit Module Number = 2
2) ModuleEne > Ene threshold




$$R_E = \frac{E_{up}}{E_{down}} \qquad \Delta T = T_{down} - T_{up}$$

$$lnR_E = \frac{v}{\lambda}\Delta T$$

$\lambda = Attenuation\ Length$

$v = Propagation\ Velocity$

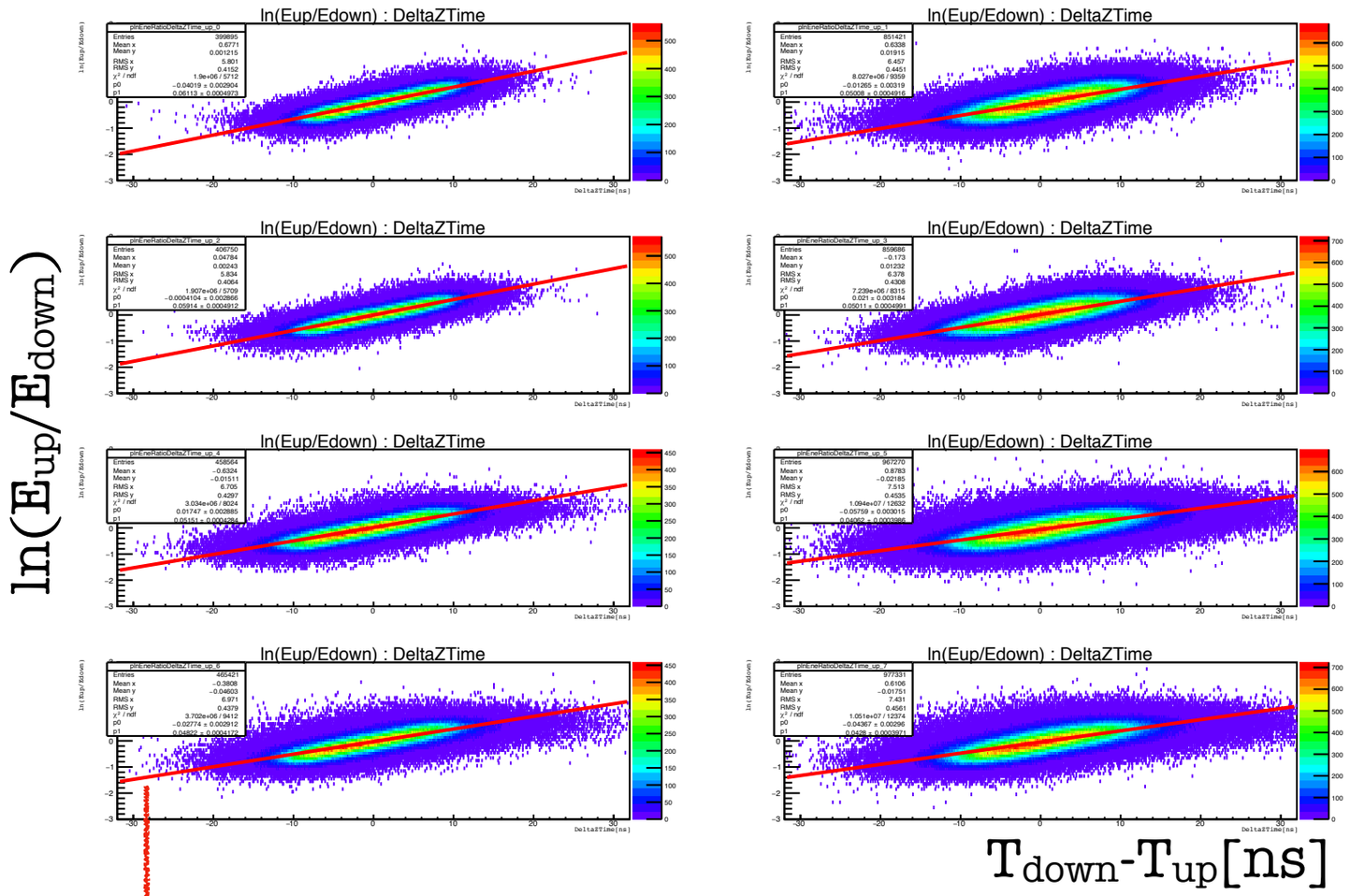
$$y = p_1 x + p_0$$

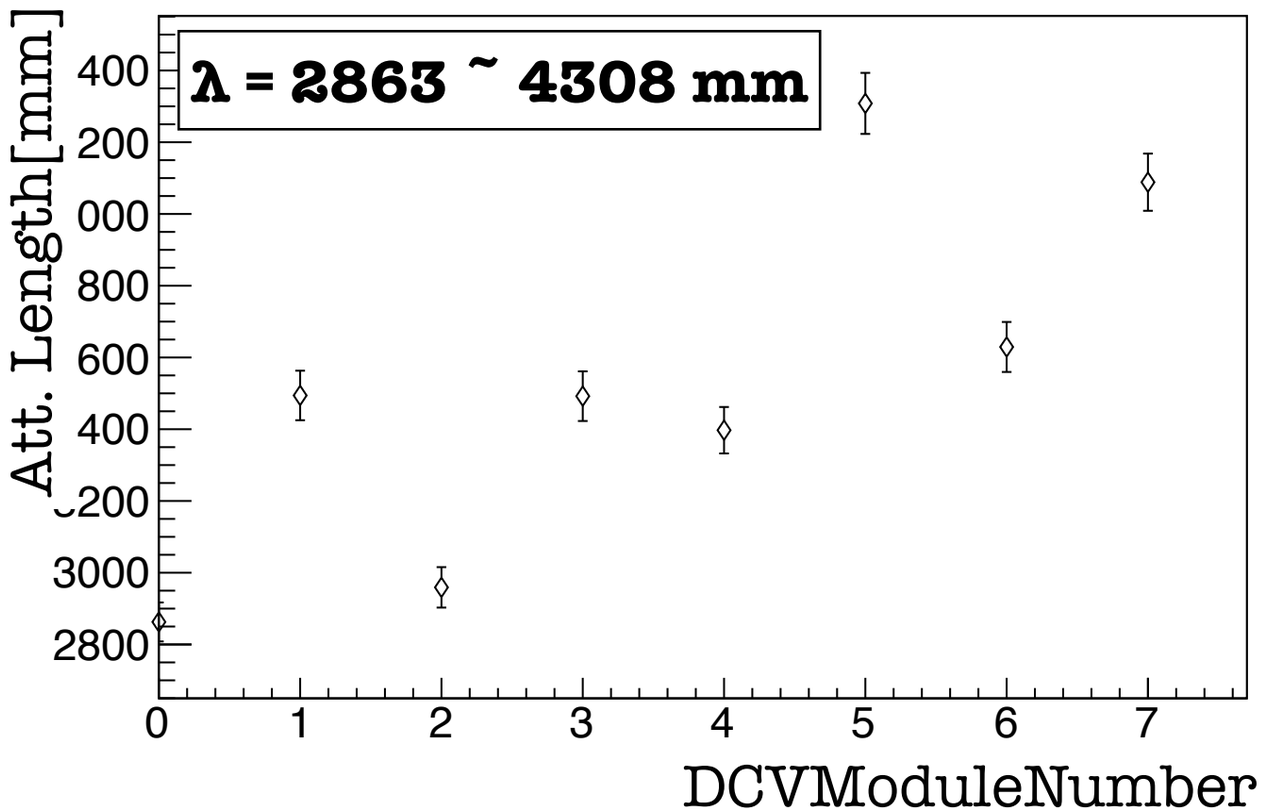
$$\lambda = \frac{v}{p_1}$$

$v = 175 \pm 3$ mm/ns

(From E391a Barrel Photon Detector)

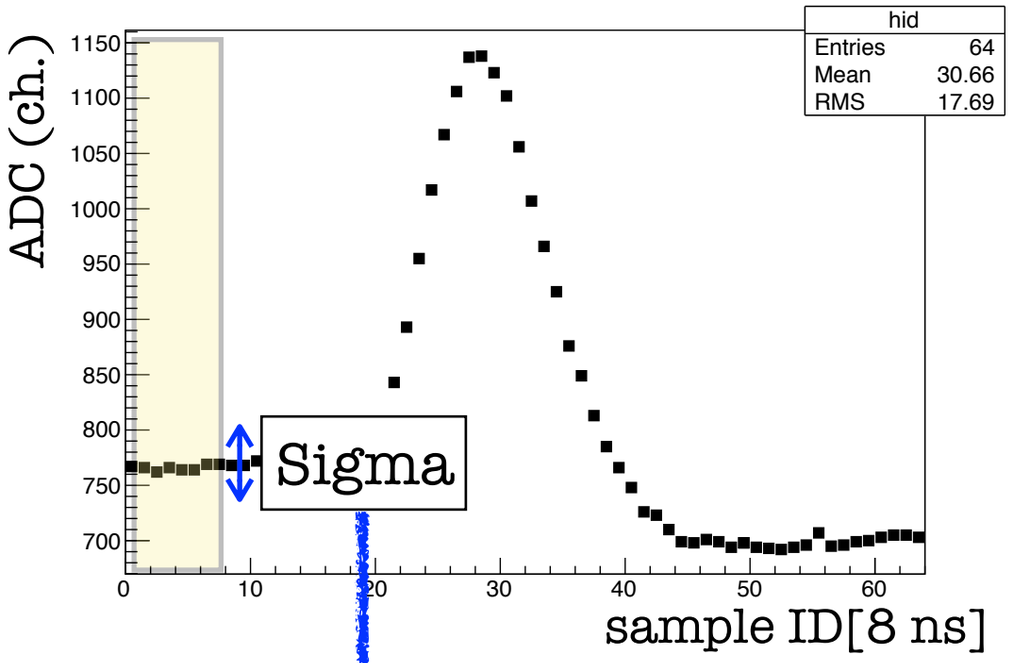
(Y-11(Kuraray) Att. Length > 3500 mm)



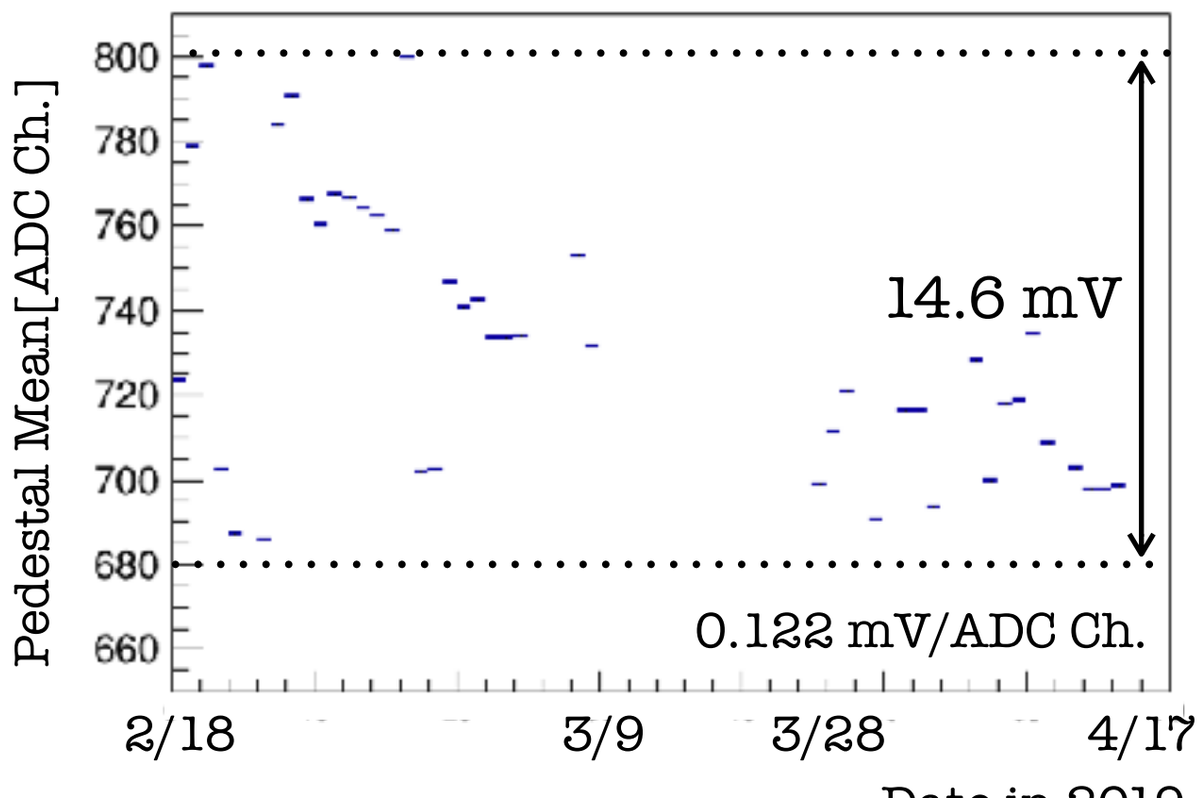
# Pedestal Stability

## Pulse Shape

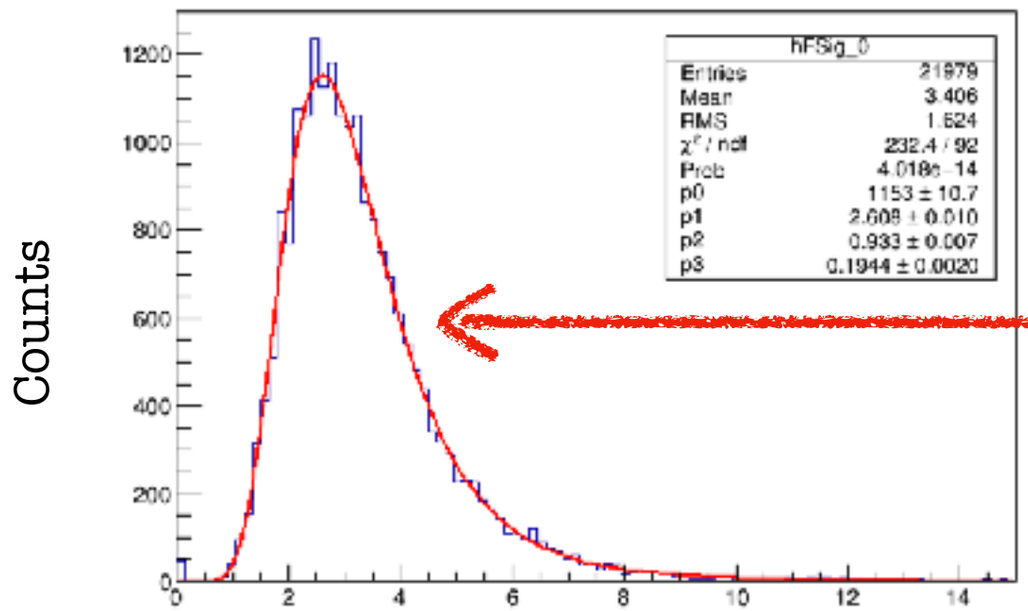



Pedestal : Mean value of ADC for Sample ID 1 ~ 9

## Trend of Pedestal Mean




## Pedestal Sigma Distribution. for a physics run.

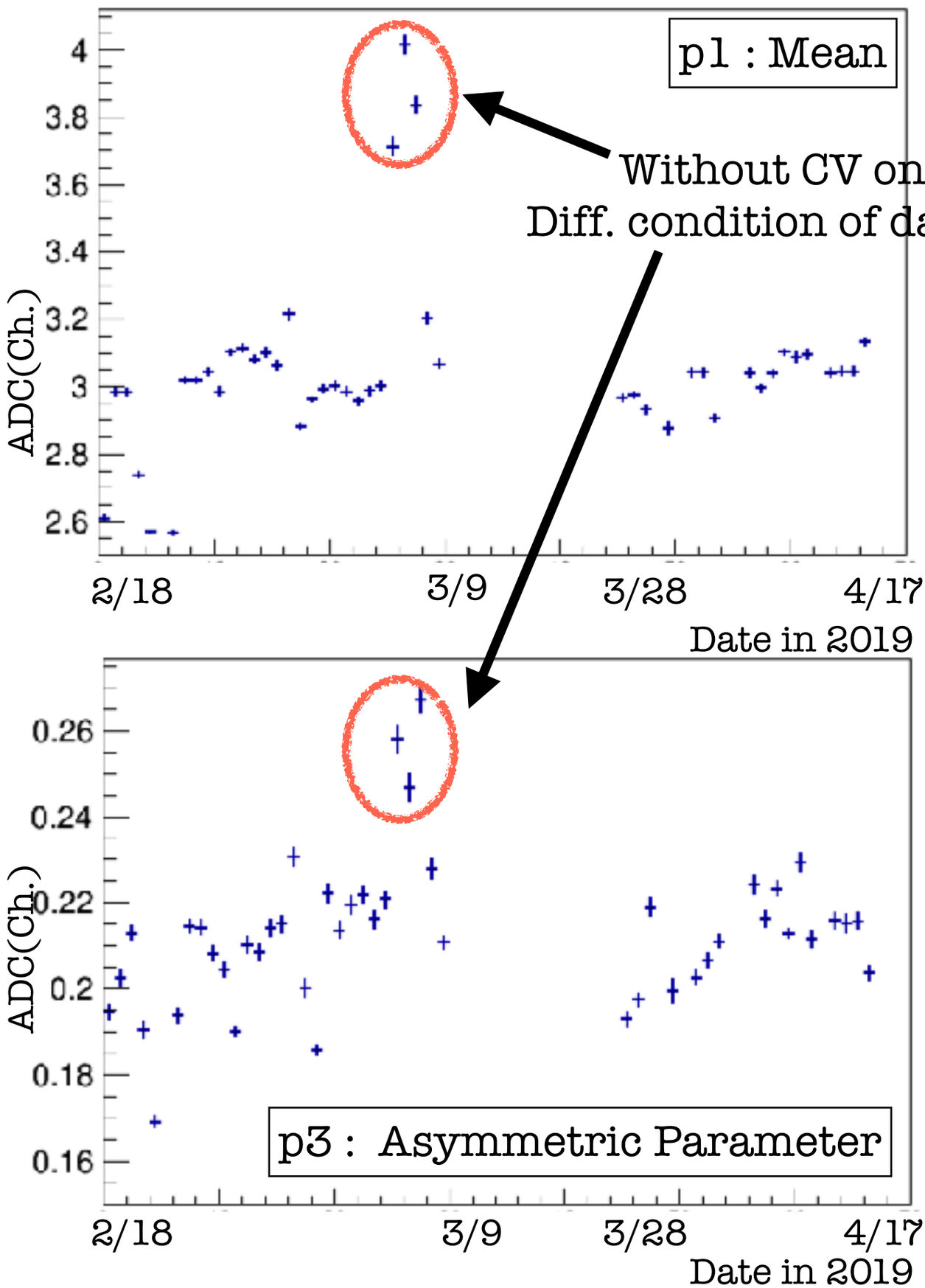



### Asymmetric Gaussian Function

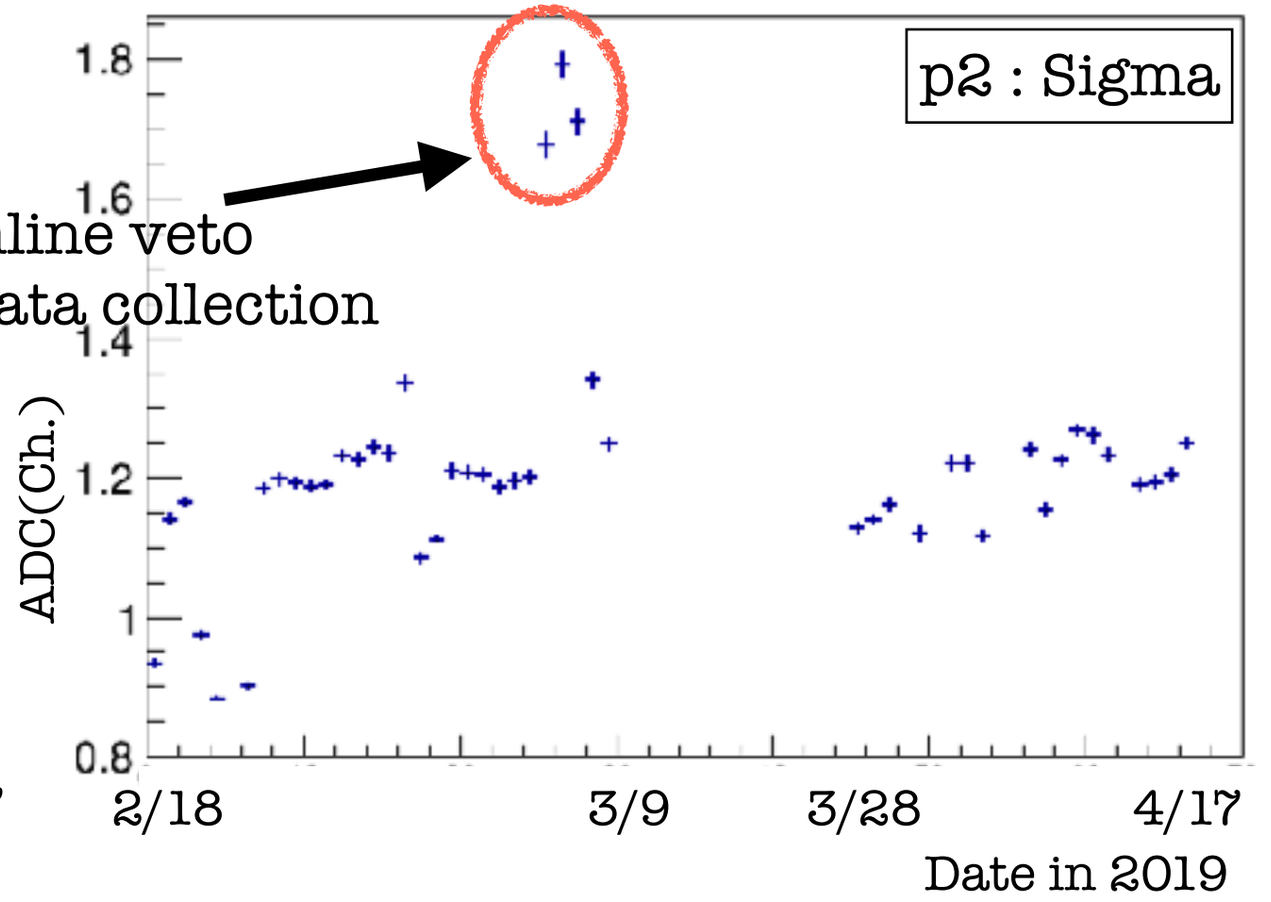
$$f(x) = P_0 exp[-\frac{(x-P_1)^2}{2(P_2+P_3(x-P_1))^2}]$$

$P_0$ : Normalization factor, $P_1$ : Mean
$P_2$ : Sigma, $P_3$ : Asymmetric parameter

# Pedestal Sigma Stability




Without CV online veto
Diff. condition of data collection




## Asymmetric Gaussian Function

$$f(x) = P_0 exp[-\frac{(x-P_1)^2}{2(P_2+P_3(x-P_1))^2}]$$

$P_0$ : Normalization factor, $P_1$ : Mean
$P_2$ : Sigma, $P_3$ : Asymmetric parameter

- Pedestal Sigma seem to be stable for entire period.

# Summary

- To reduce the $K_L \rightarrow \pi^+\pi^-\pi^0$ background, it is necessary to install a new scintillator detectors(DCV) inside the beam pipe.
- Due to limited space, a new type of light collection is adapted.
- Fabrication and Installation was finished on Feb. 2019
- Energy calibration was done with cosmic rays tagged by surrounding detectors.
- The stability of DCV is being checked.
  - Pedestal Sigma seem to be stable for entire period.
  - Attenuation length is reasonable.