

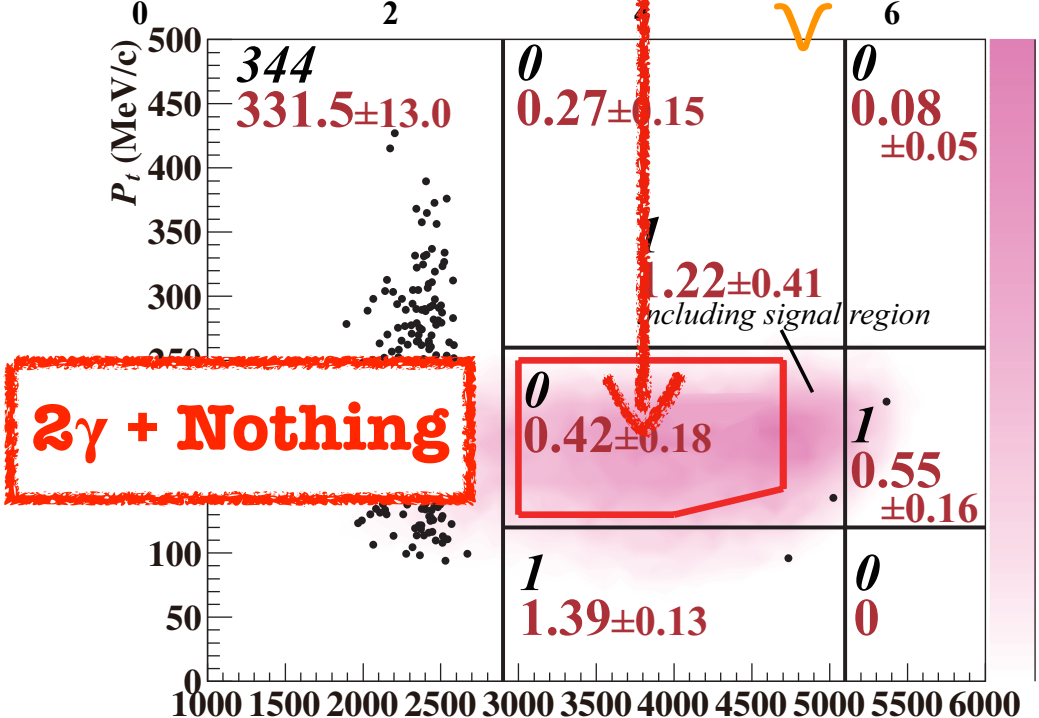
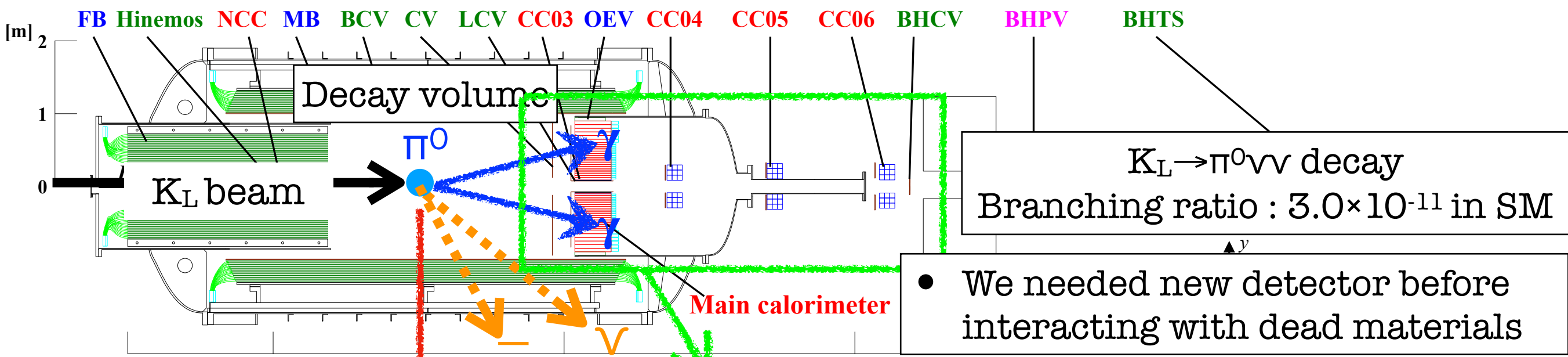


Performance check of the charged particle detector for the KOTO experimental at J-PARC.

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for the KOTO collaboration

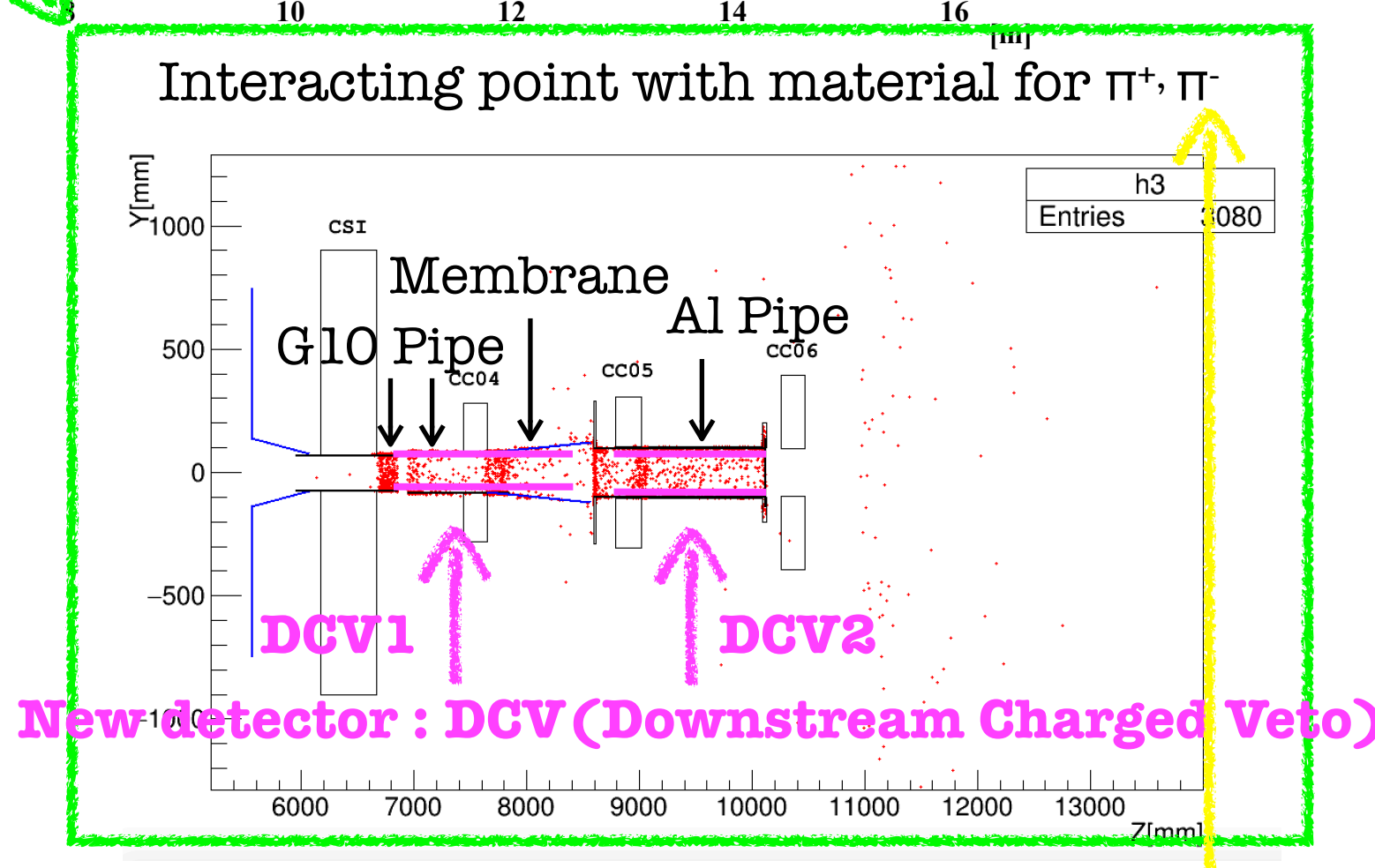
2019 KPS Fall Meeting(2019.10.25.)

The motivation of new detector(DCV)



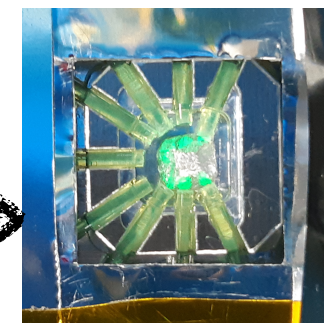
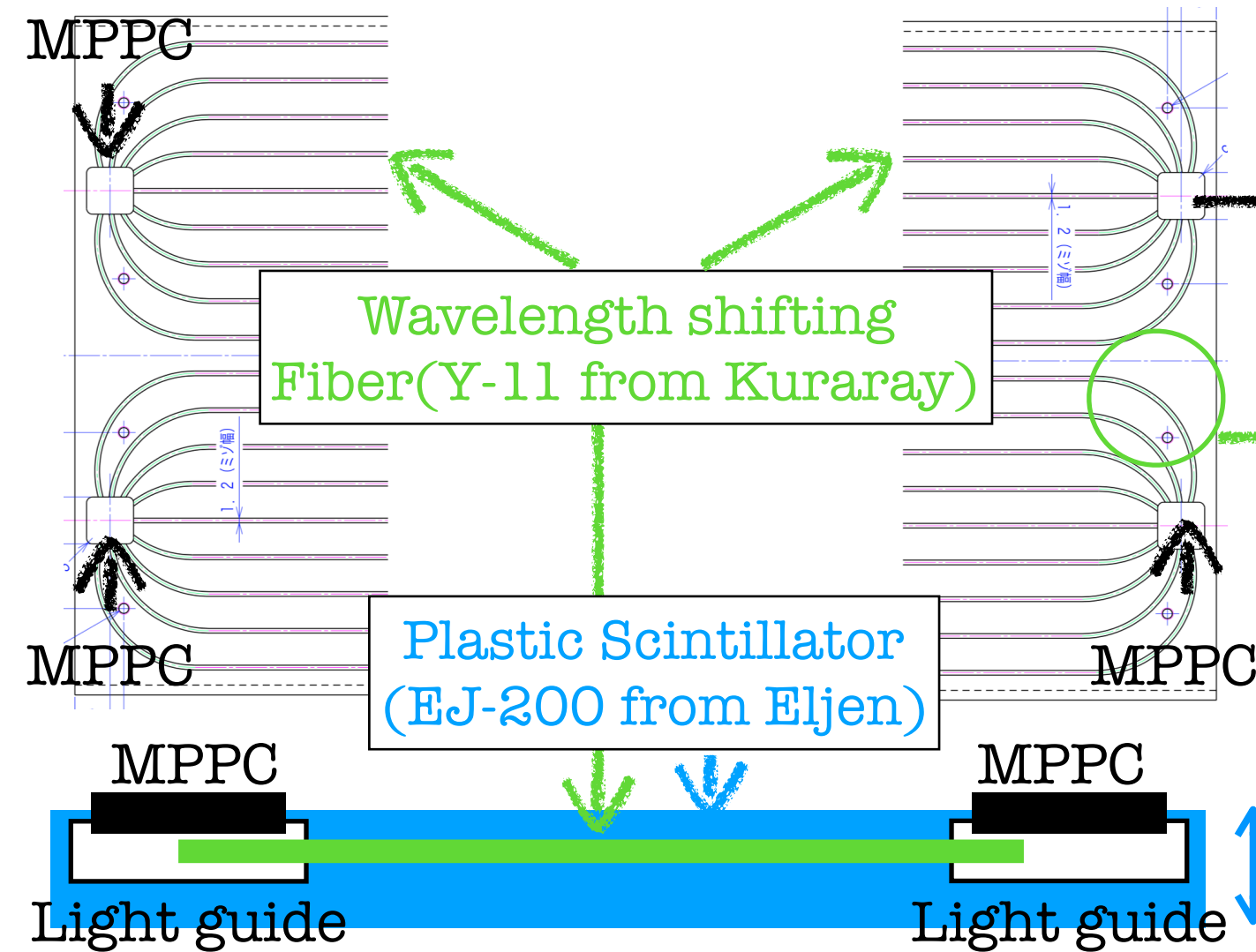
Background Estimation
(2015 data, S.E.S = 1.3×10^{-9})

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



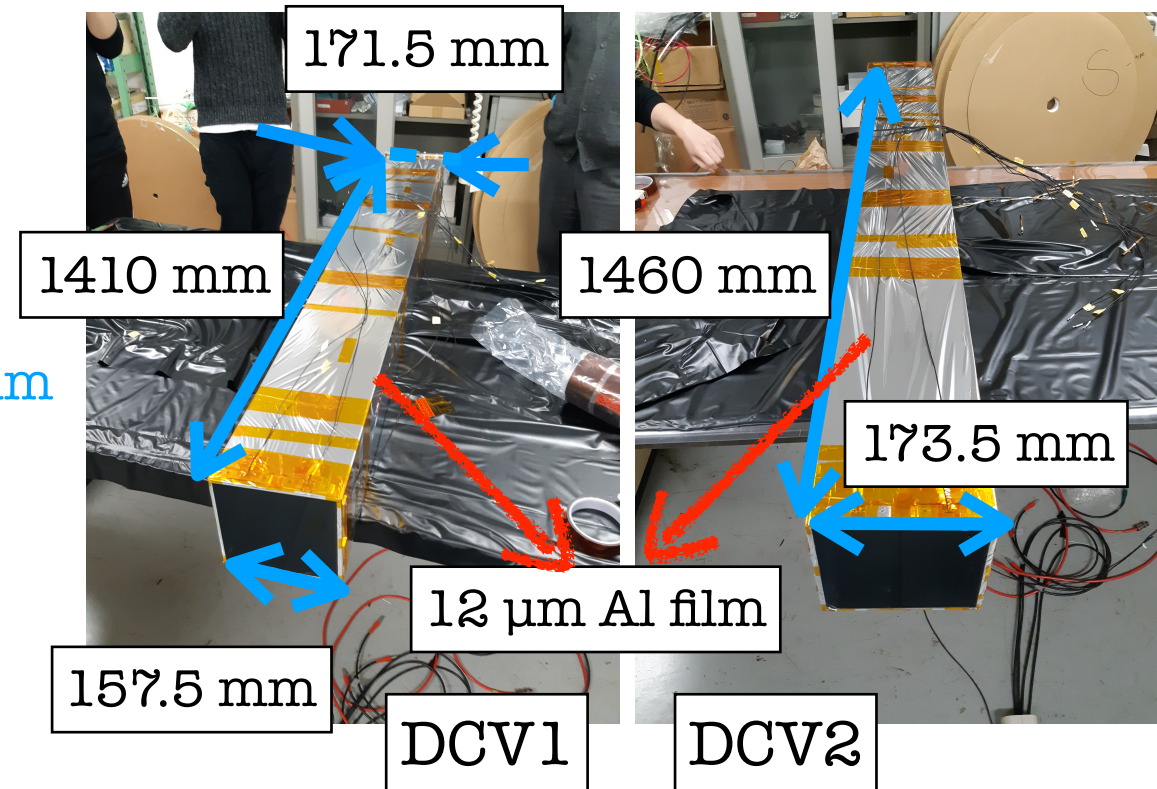
• The number of $K_L \rightarrow \pi^+ \pi^- \pi^0$ events can reach approximately 2 at SM sensitivity.

Fabrication of DCV



MPPC : S13360-6050PE from HAMAMATSU

Minimum radius of curvature : 20 mm



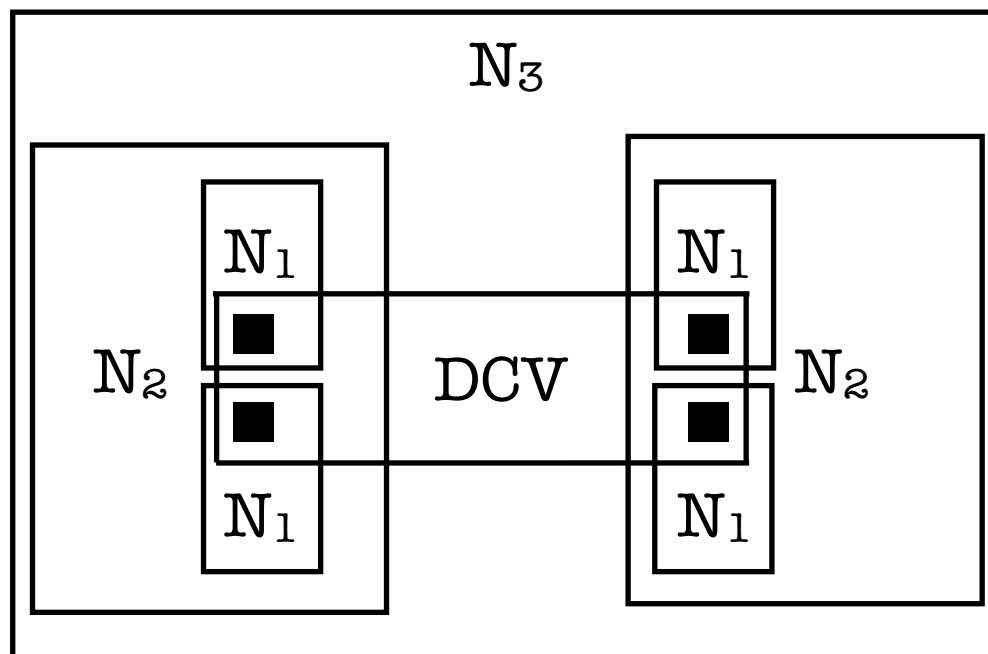
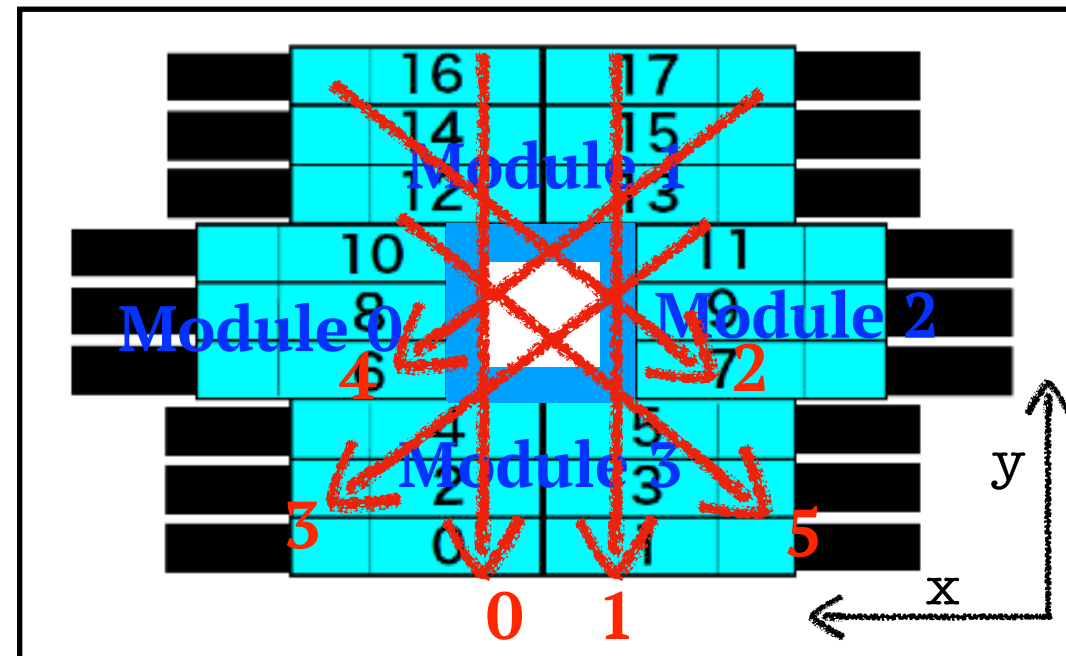
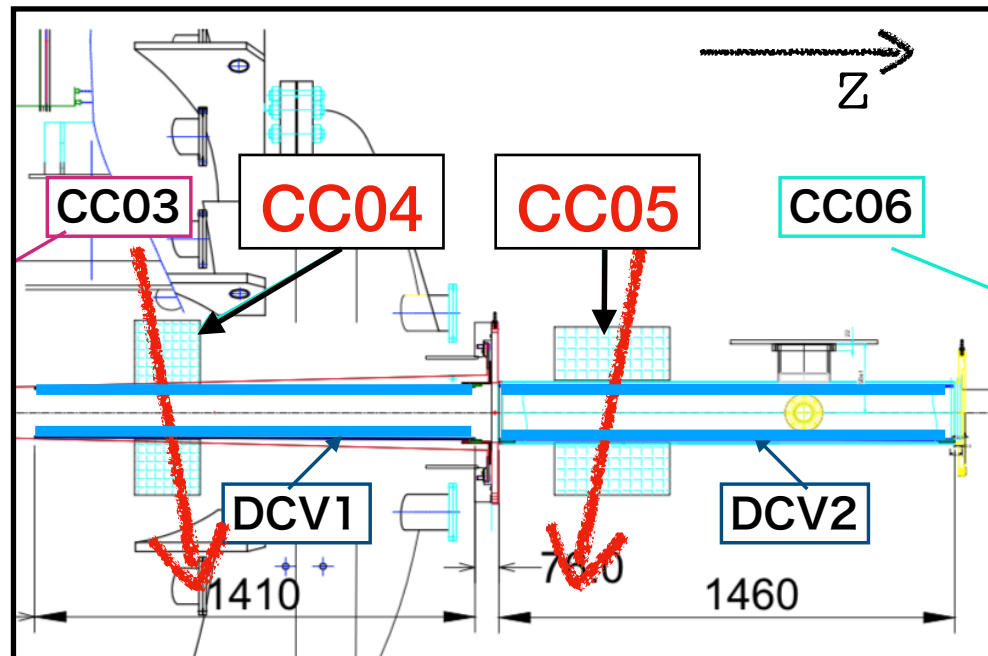
- Due to very limited space, we are trying a new scheme of light collection.

- 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

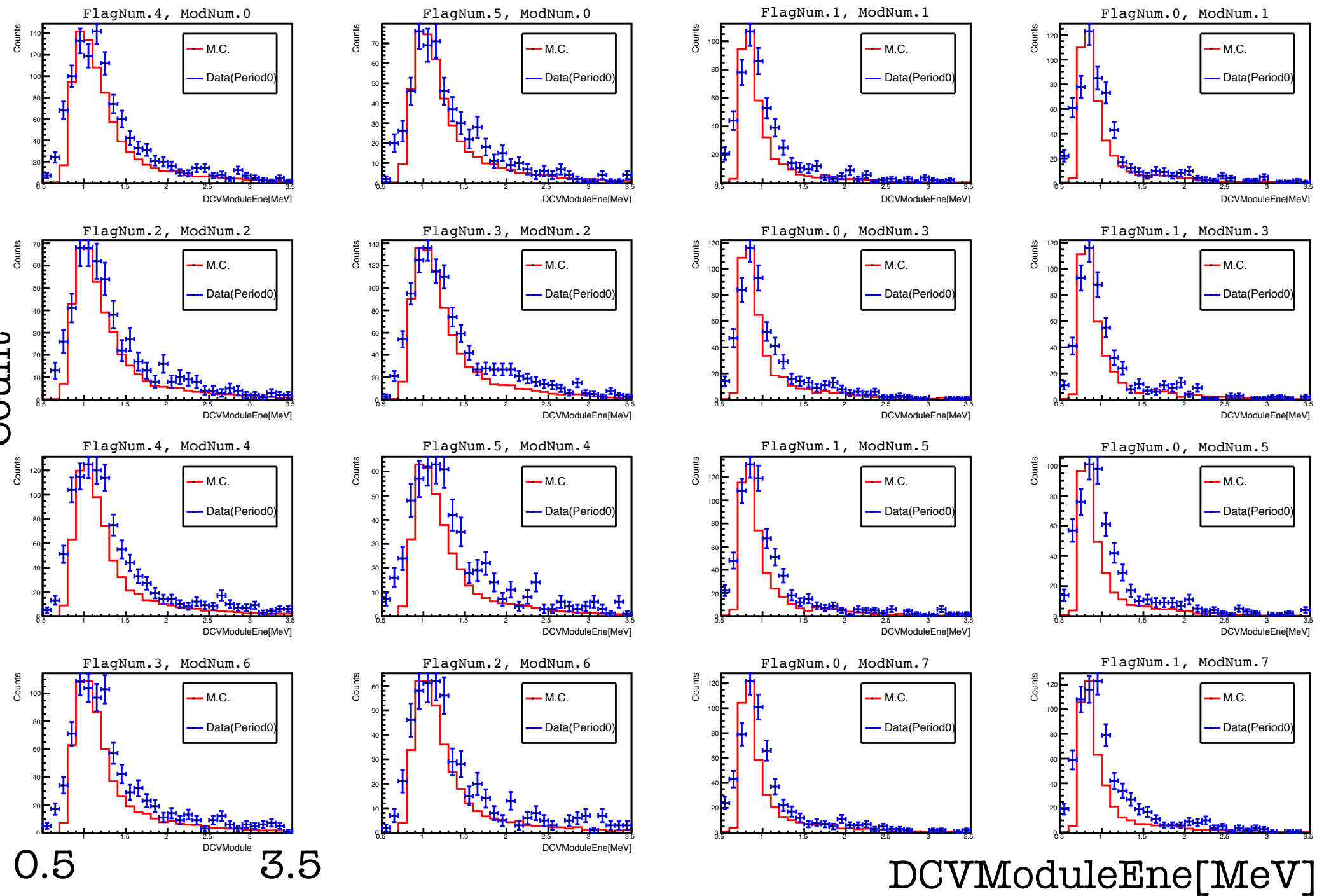
Cosmic-ray tracking



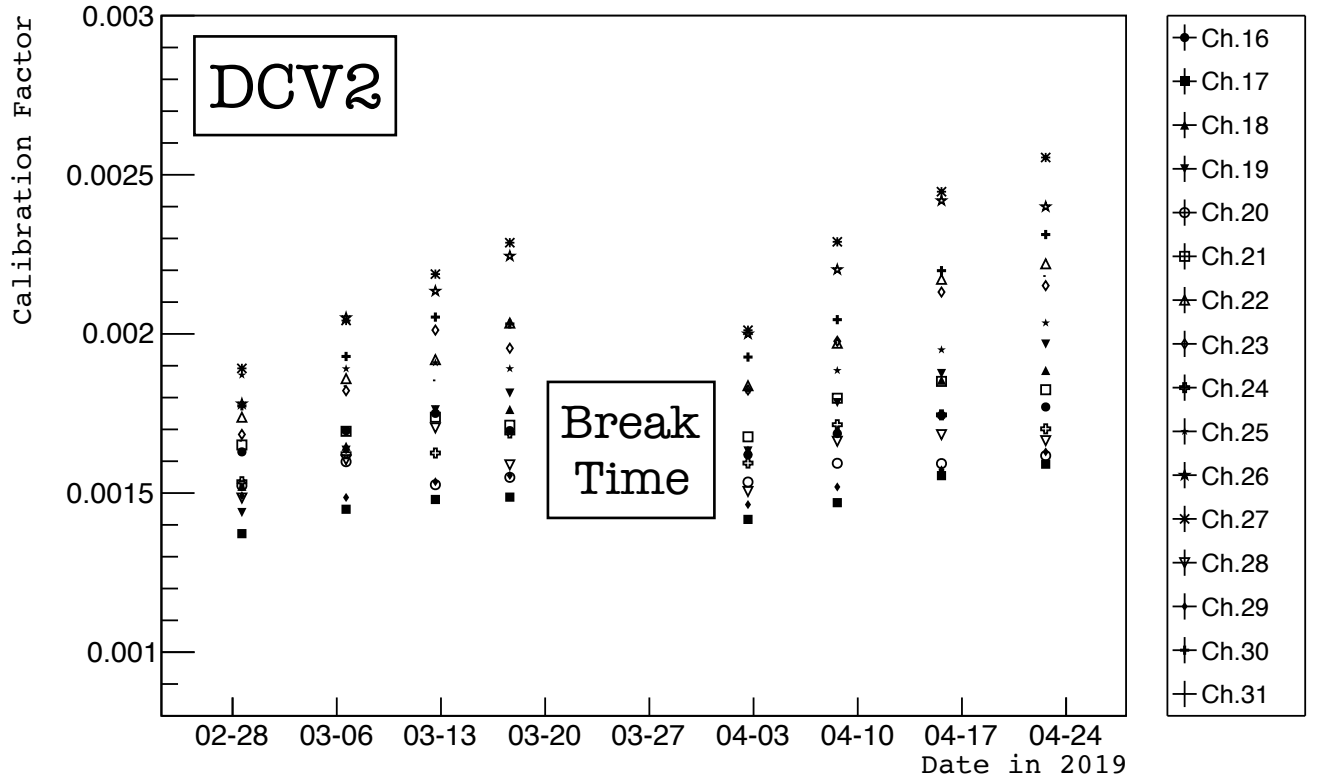
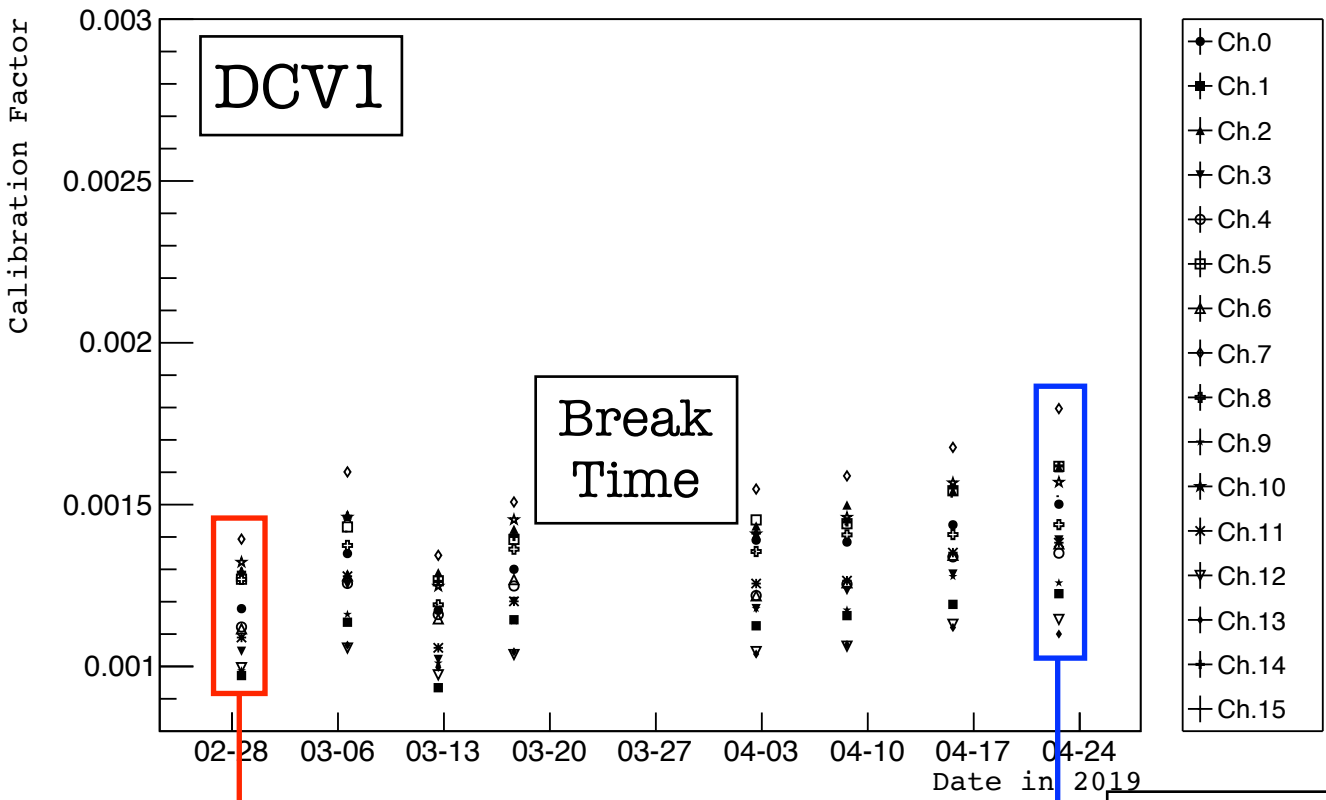
N_1 : Normalization Factor for each MPFC.
 N_2 : Normalization Factor for a pair of MPFC at Upstream(Downstream)
 N_3 : Normalization Factor for 4 MPFC.

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

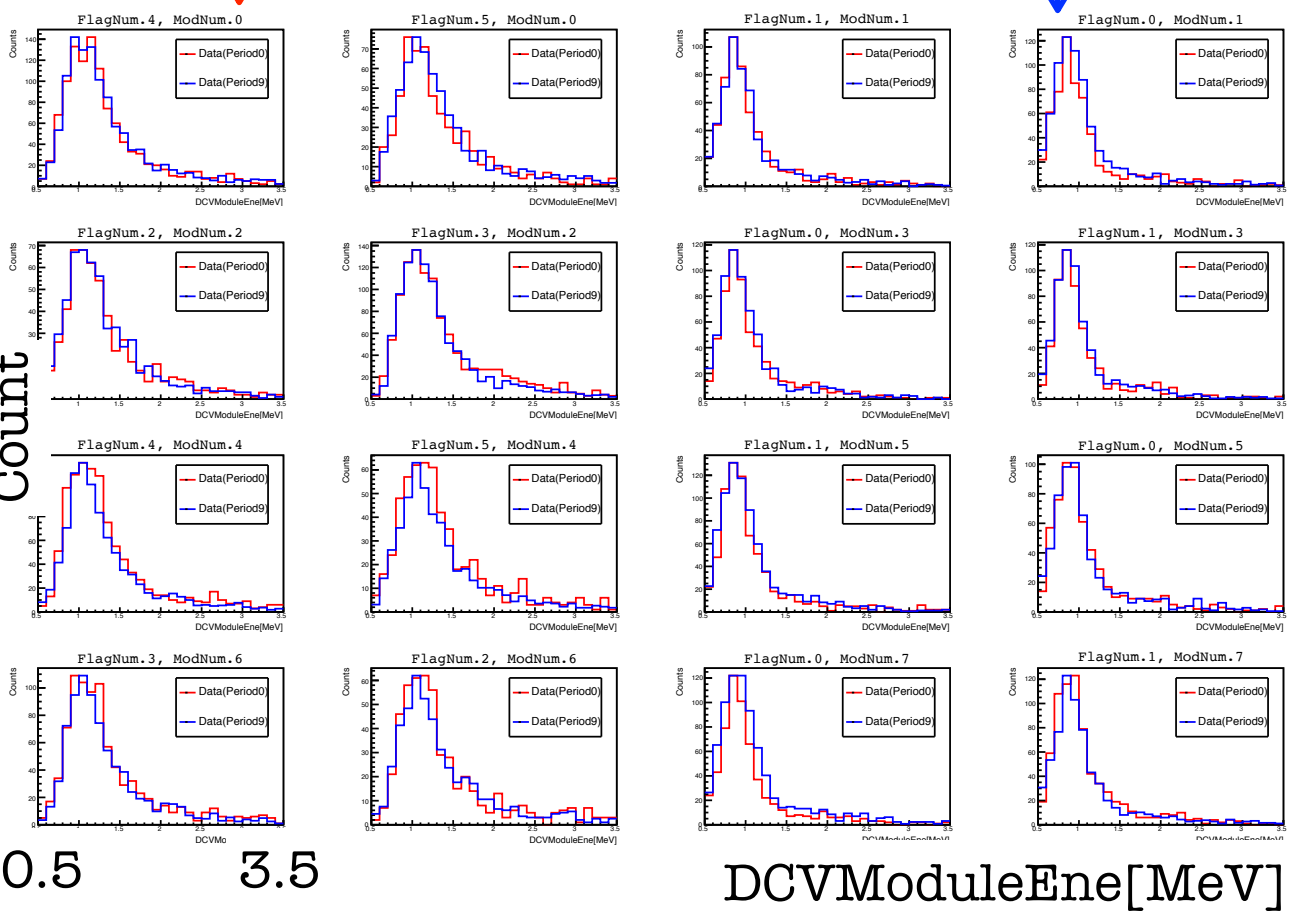
Count



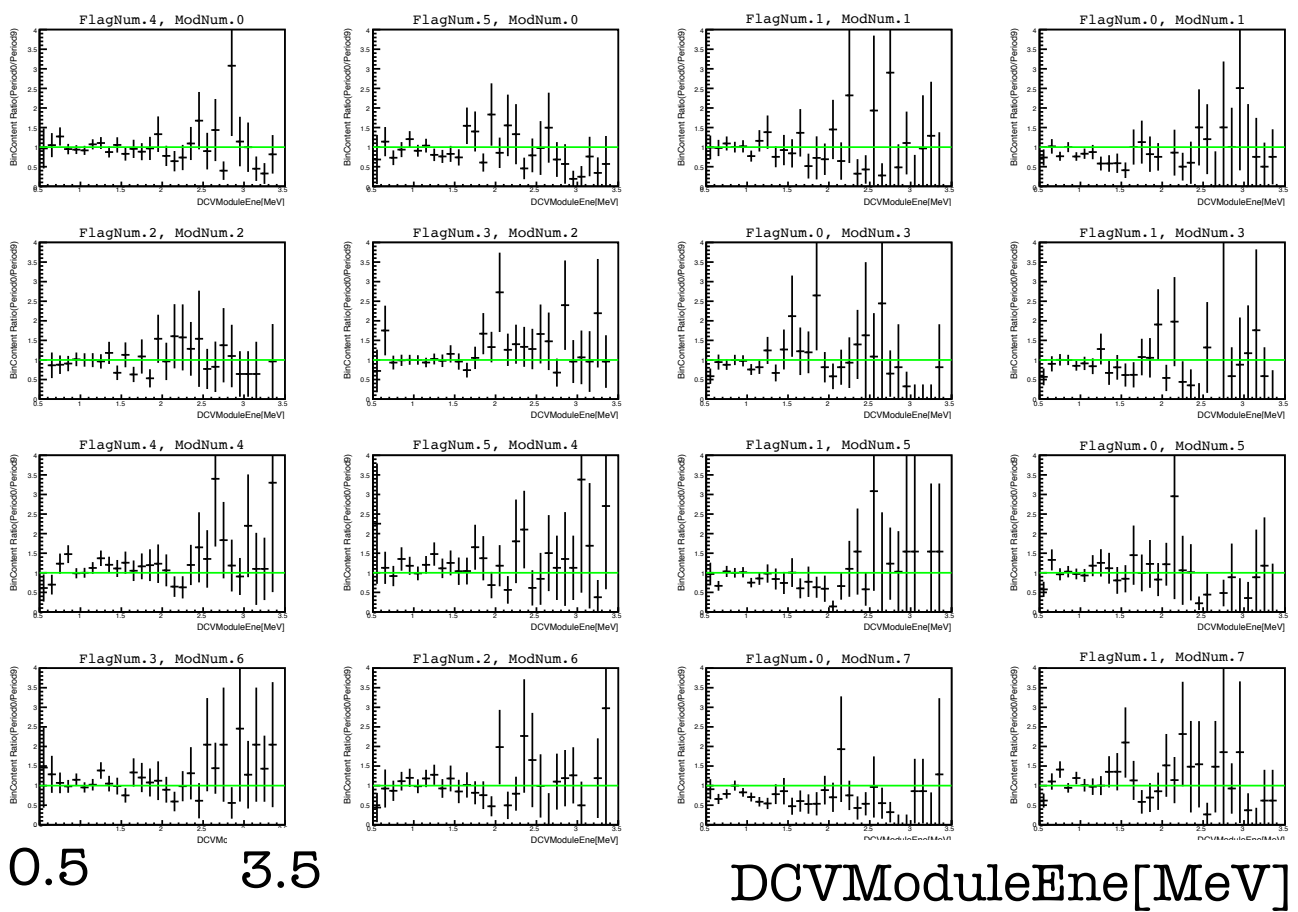
Calibration Factor during Beam Time



● Calibration Factors tend to increase over time



BinContent Ratio(Period0/Period9)

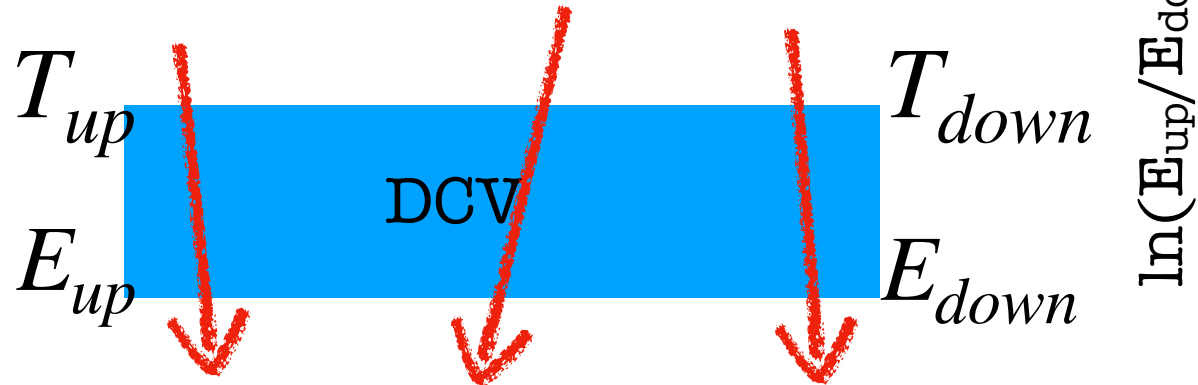


Attenuation Length

- Trigger : DCV Self(Cosmic-ray)

- Hit Condition

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



$$R_E = \frac{E_{up}}{E_{down}}$$

$$\Delta T = T_{down} - T_{up}$$

$$\ln R_E = \frac{v}{\lambda} \Delta T$$

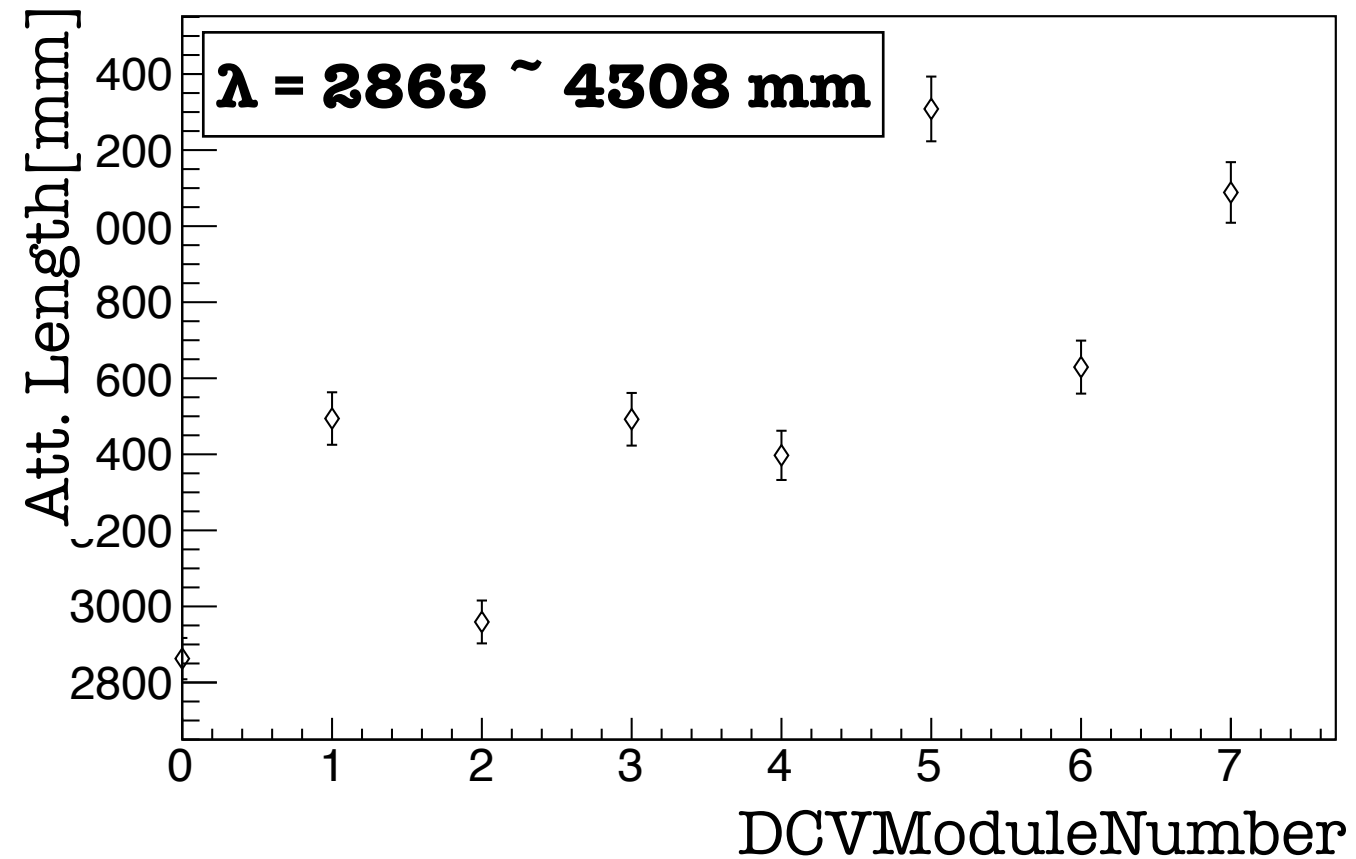
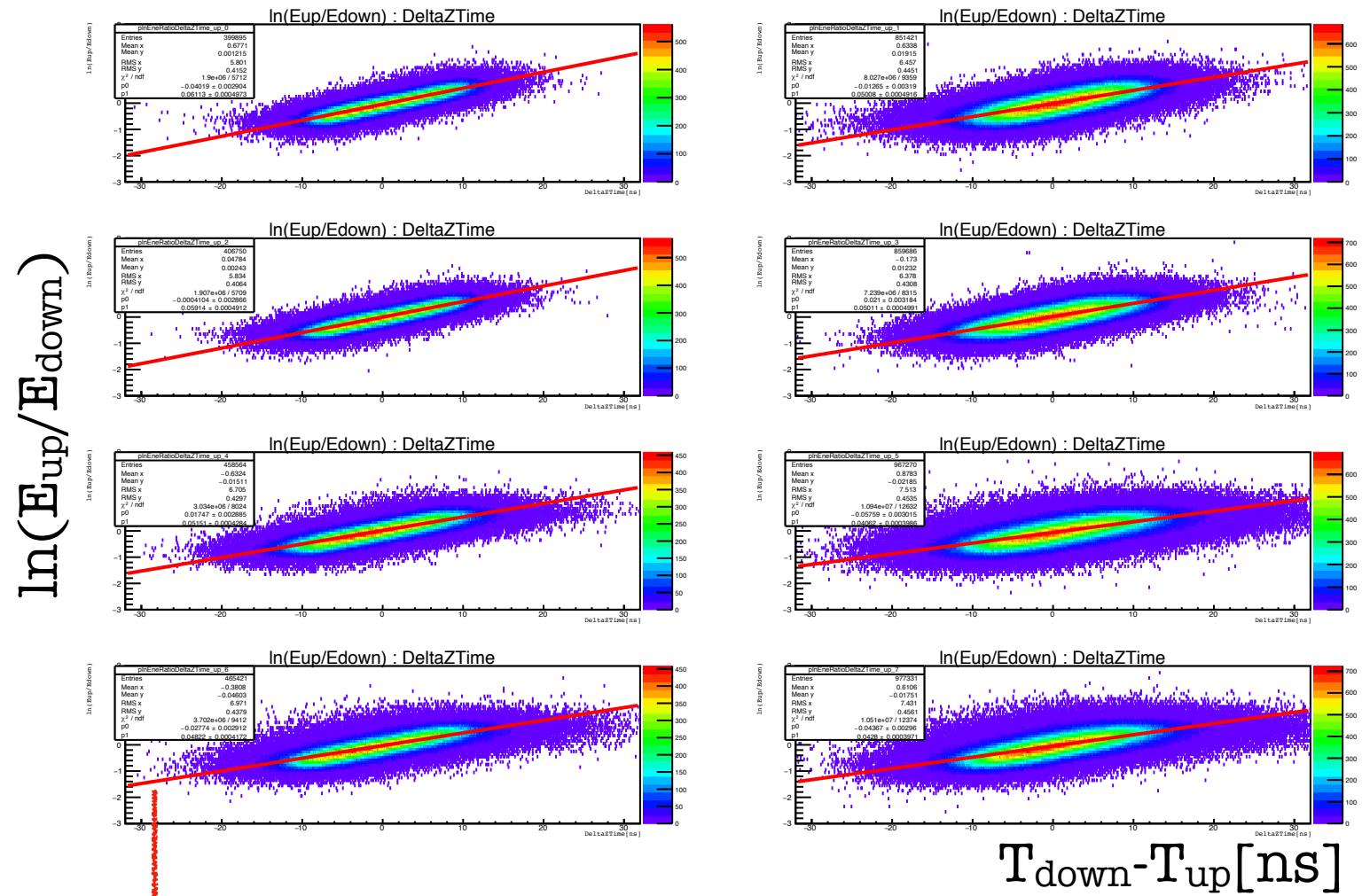
λ = Attenuation Length
 v = Propagation Velocity

$$y = p_1 x + p_0$$

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

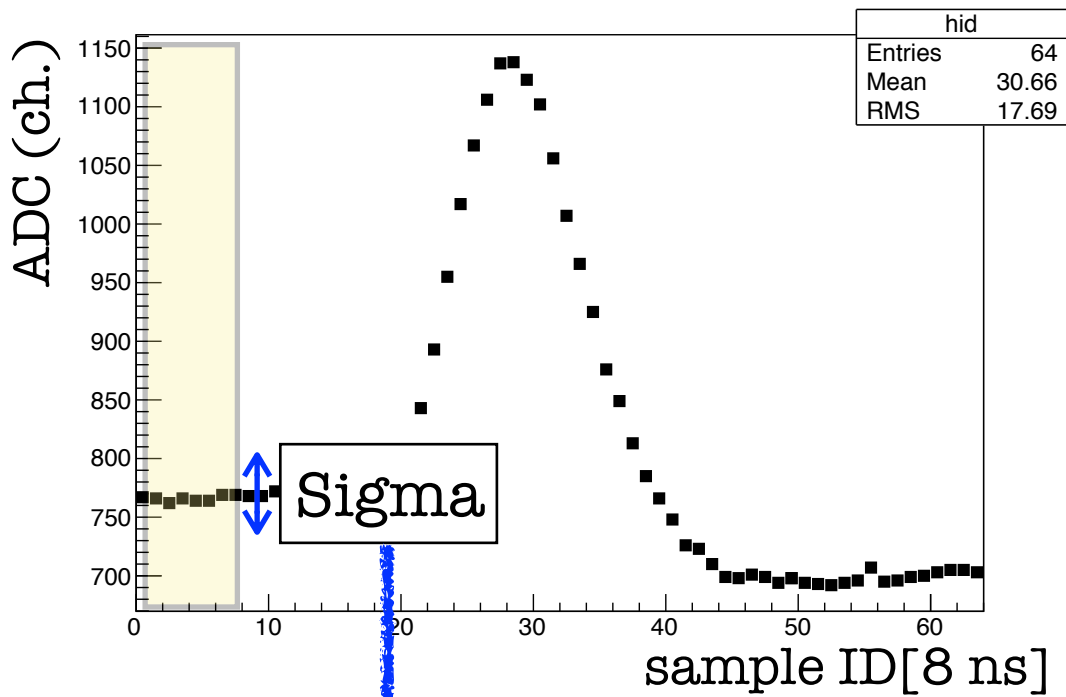
$v = 175 \pm 3 \text{ mm/ns}$
 (From E391a Barrel Photon Detector)

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



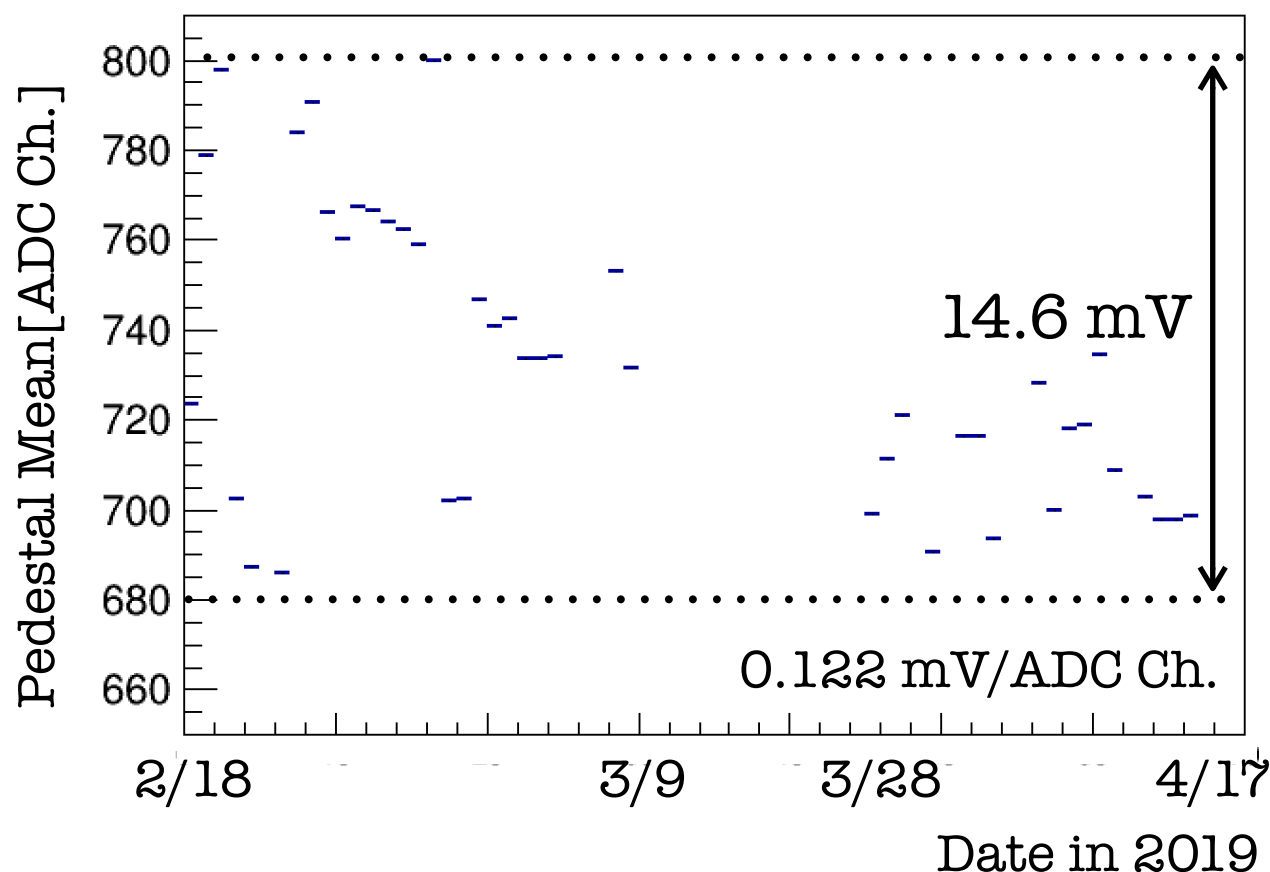
Pedestal Stability

Pulse Shape

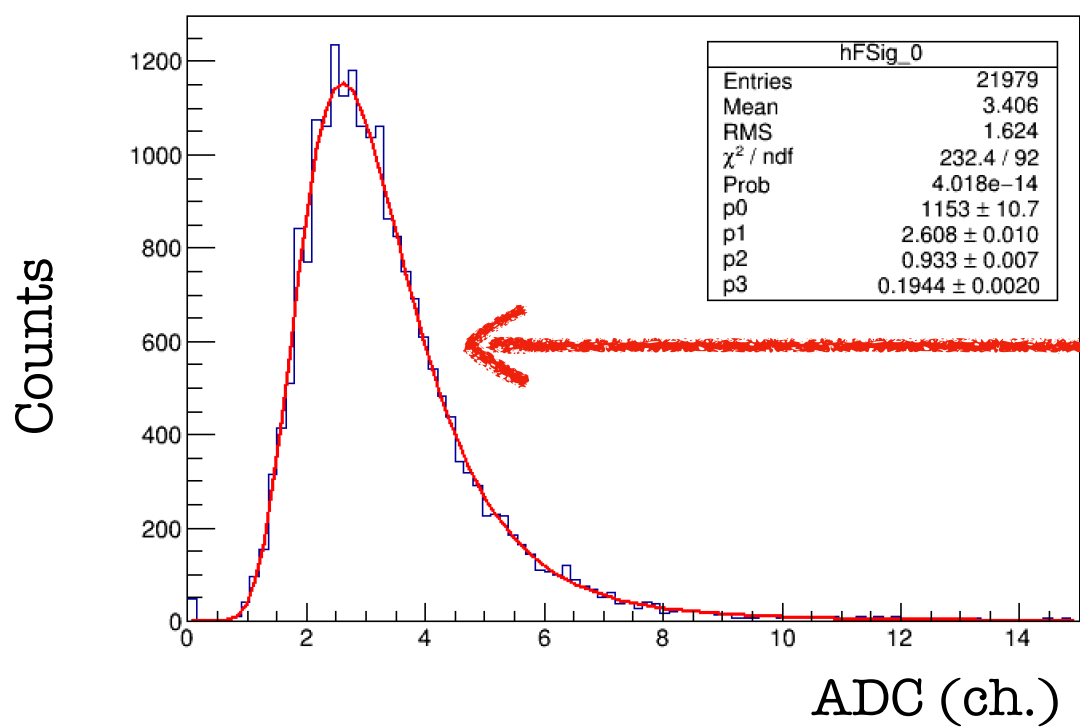


Pedestal : Mean value of ADC for Sample ID 1 ~ 9

Trend of Pedestal Mean



Pedestal Sigma Distribution. for a physics run.

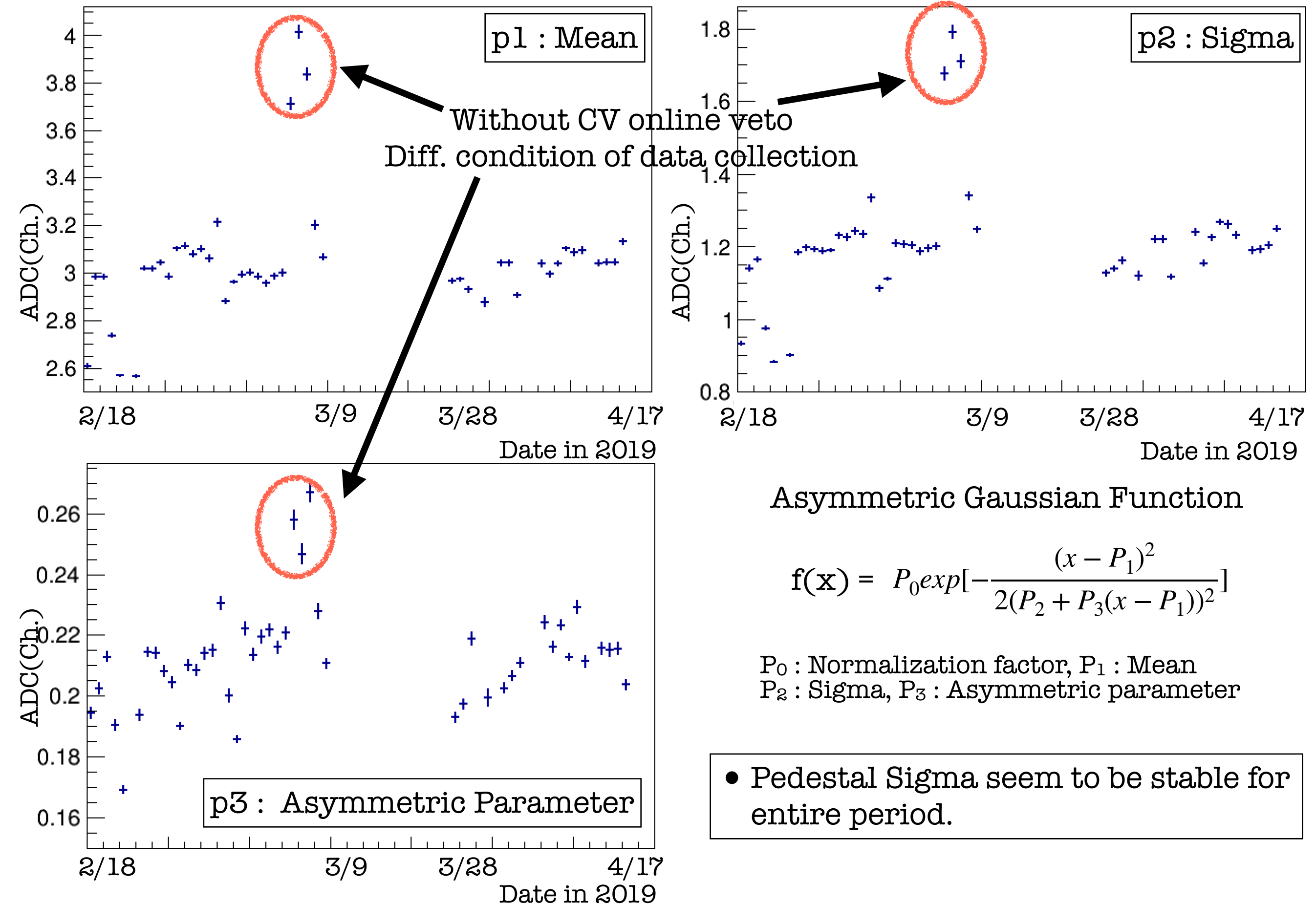


Asymmetric Gaussian Function

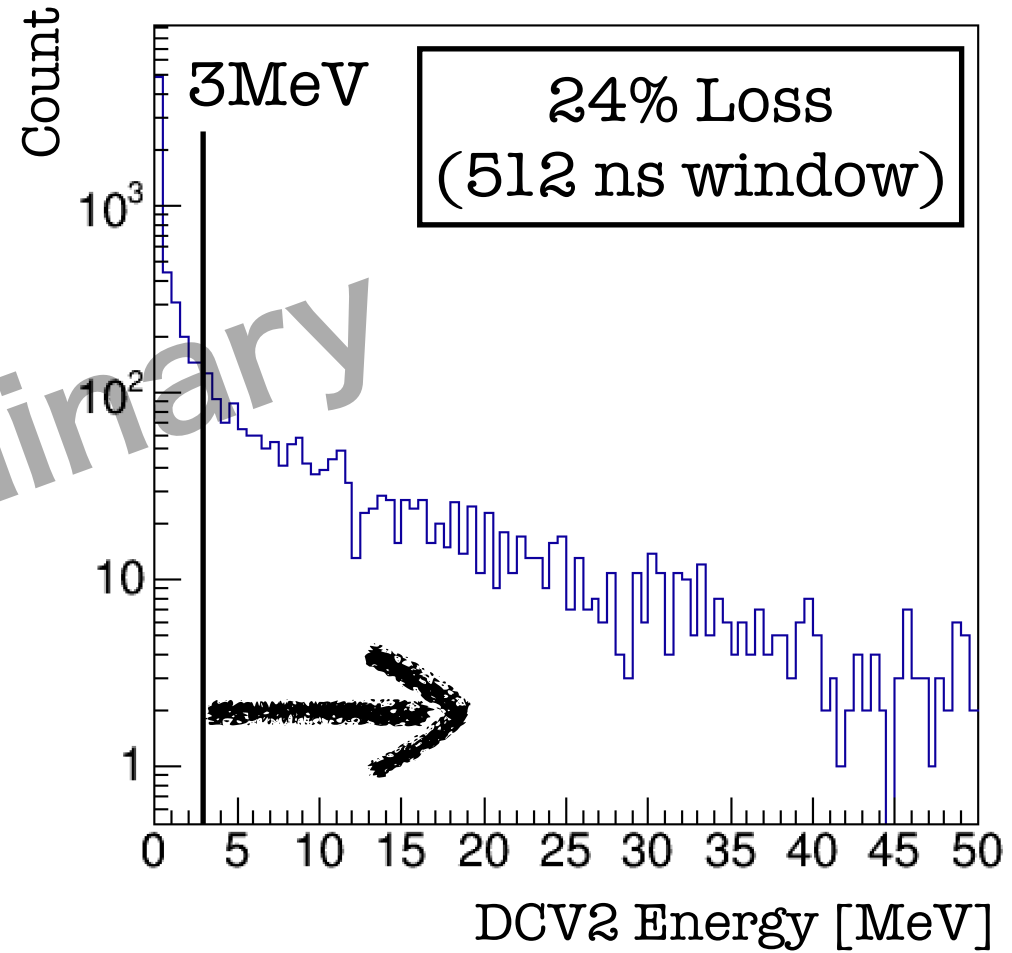
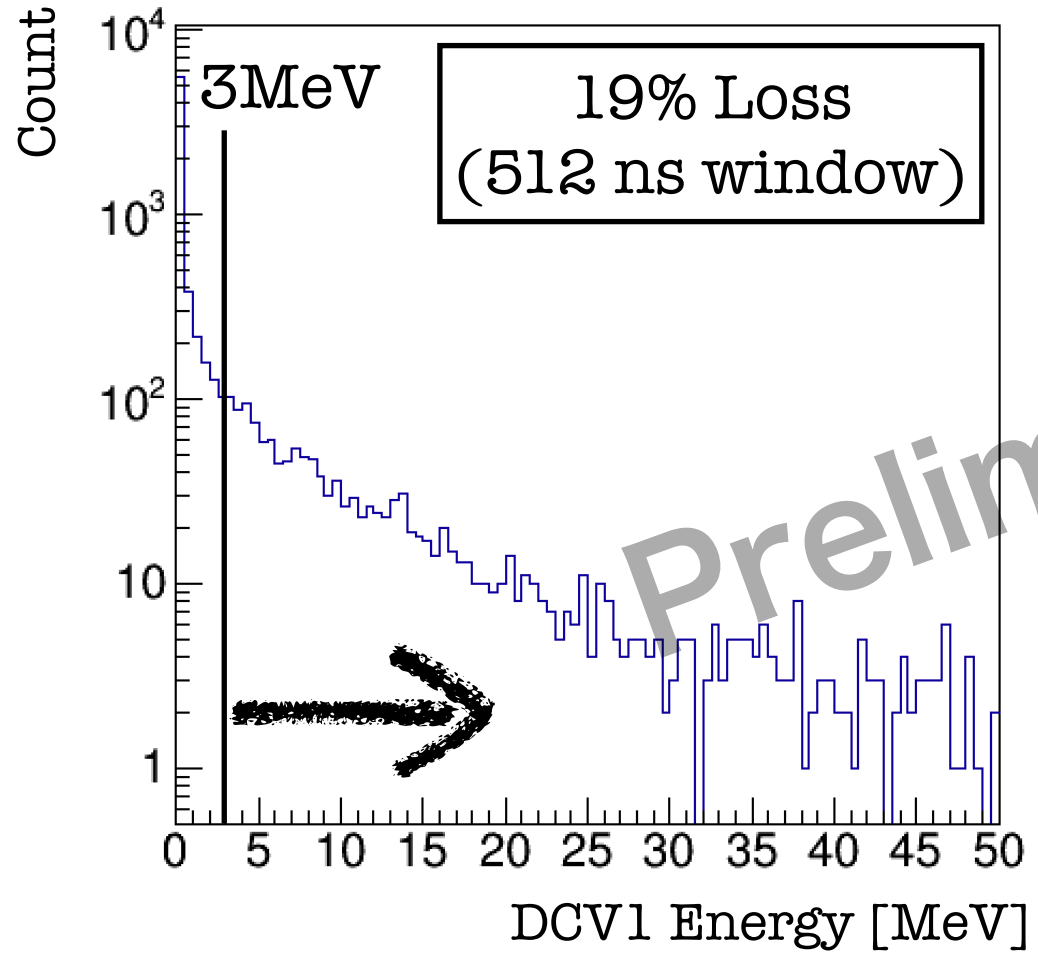
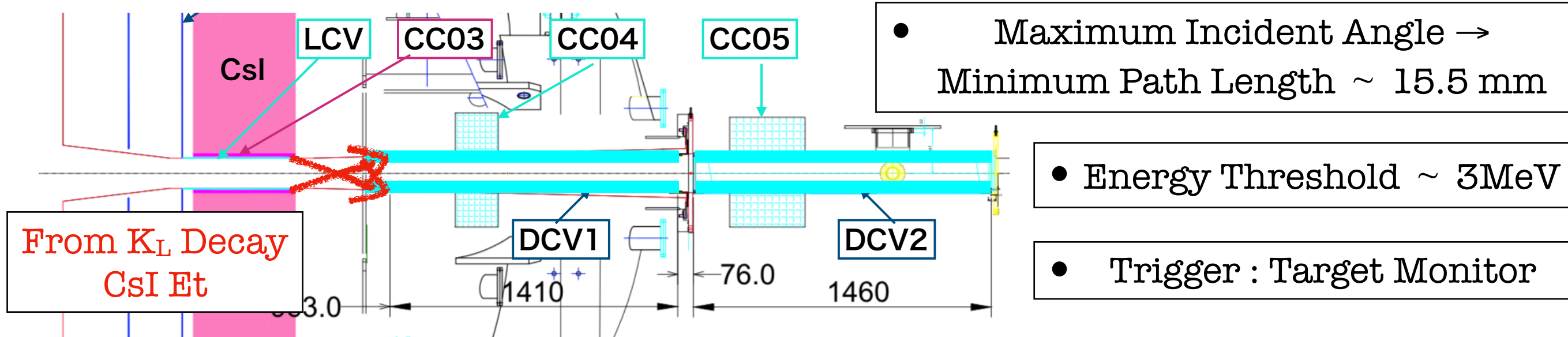
$$f(x) = P_0 \exp\left[-\frac{(x - P_1)^2}{2(P_2 + P_3(x - P_1))^2}\right]$$

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

Pedestal Sigma Stability



Accidental Loss



- We expect acceptance loss as 3.4 % due to DCV cut(veto window 50ns)
- Detailed study is under going

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.
- Acceptance loss is expected approximately 3.4 % due to DCV cut