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

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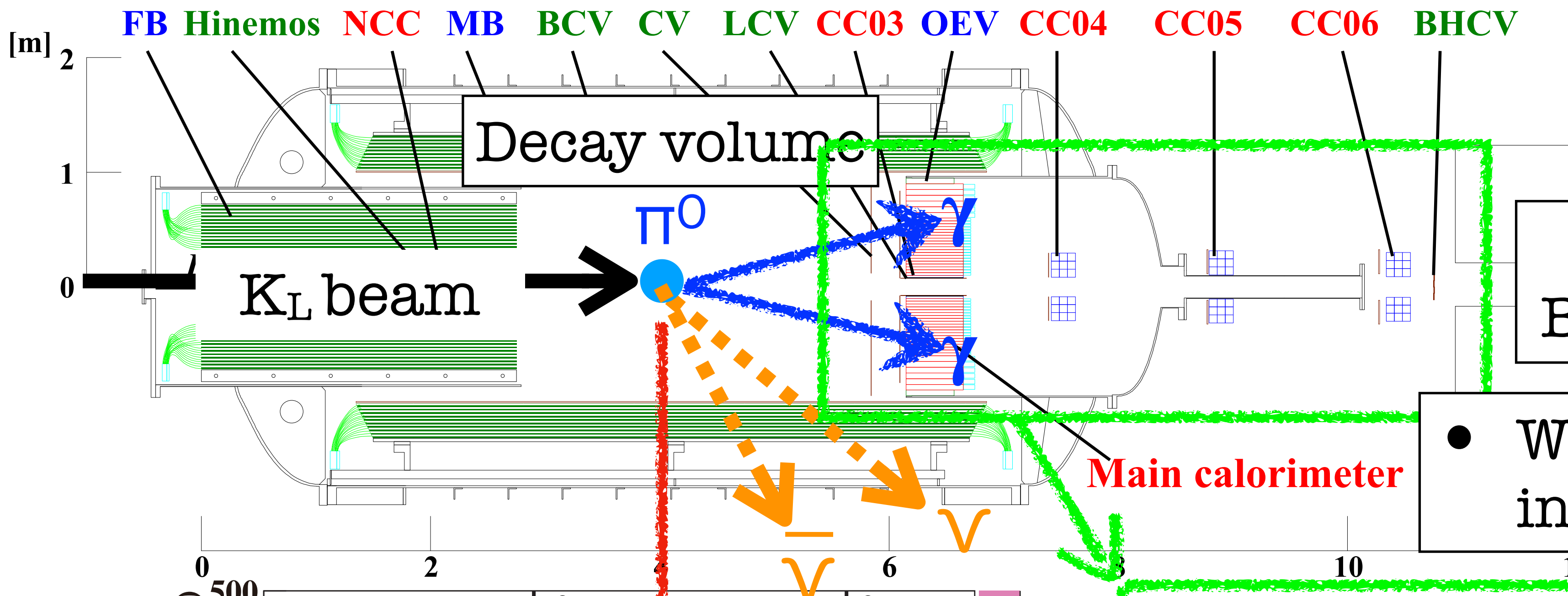
for the KOTO collaboration

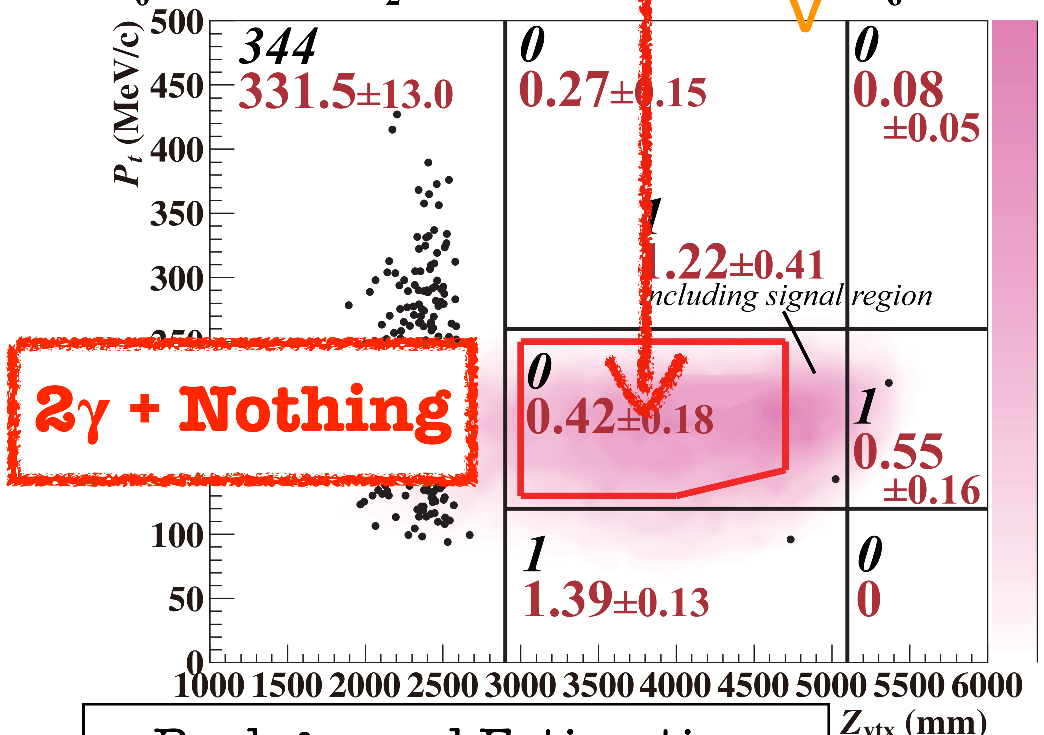
2019 KPS Fall Meeting(2019.10.25.)

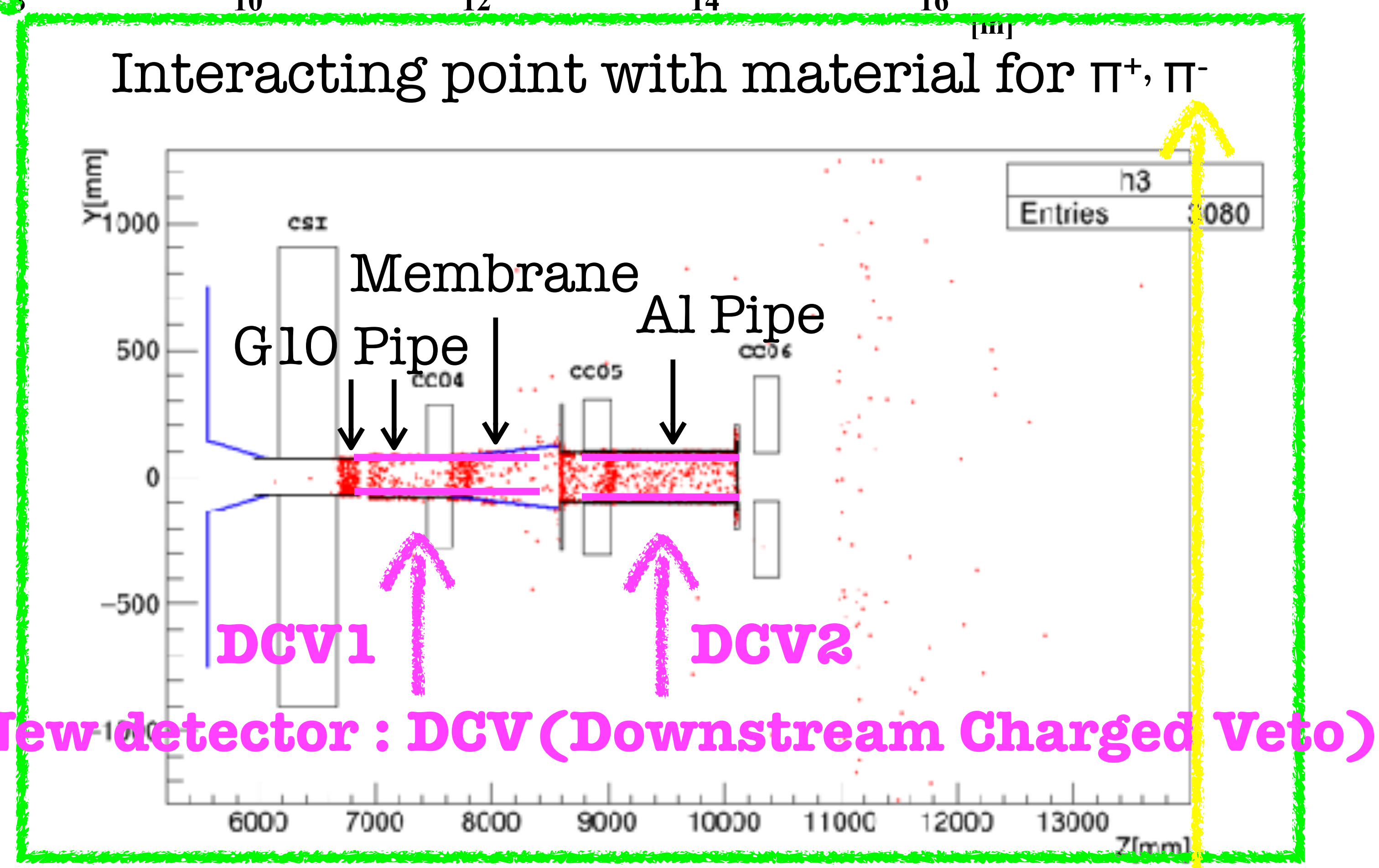
The motivation of new detector(DCV)



$K_L \to \pi^0 \nu \bar{\nu}$ decay
Branching ratio : 3.0×10^{-11} in SM

- We needed new detector before interacting with dead materials





Background Estimation
(2015 data, S.E.S = 1.3×10^{-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-π^0	0.04 ± 0.03
	CV-η	0.04 ± 0.02
total		0.42 ± 0.18

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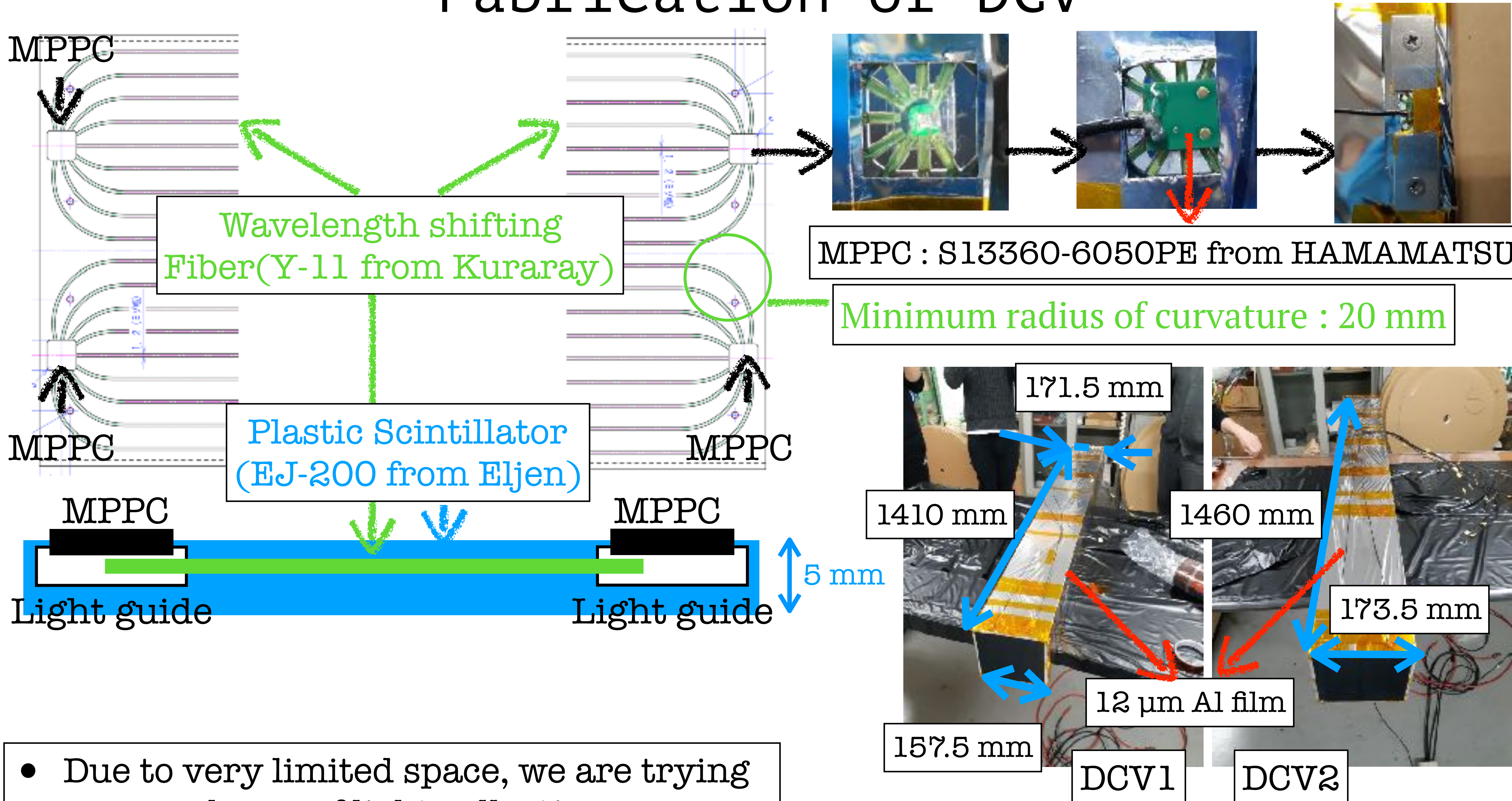
- The number of $K_L \to \pi^+\pi^-\pi^0$ events can reach approximately 2 at SM sensitivity.

Fabrication of DCV



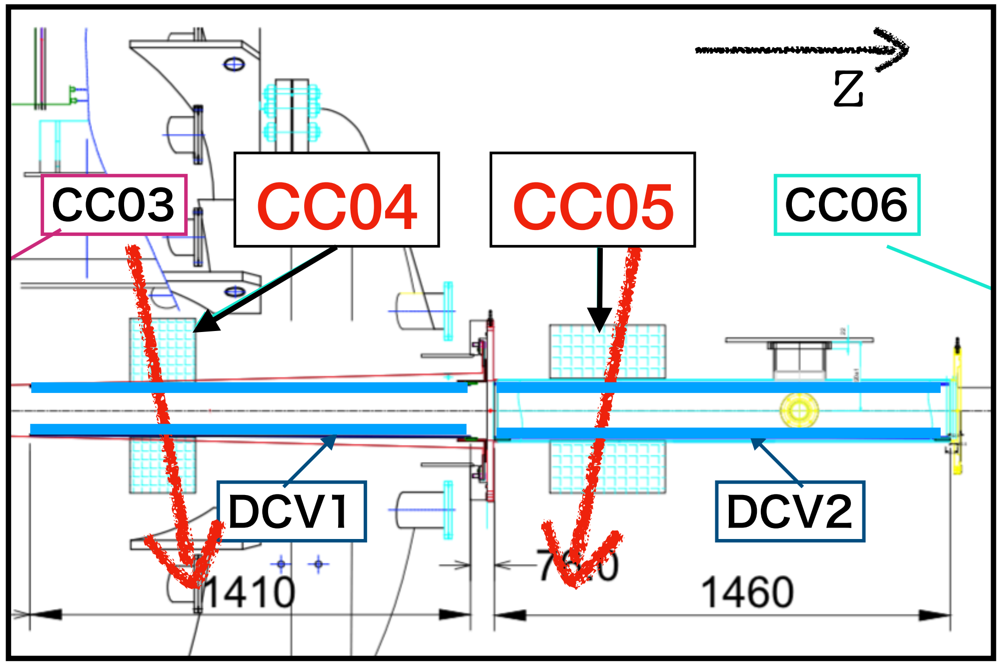
- Due to very limited space, we are trying a new scheme of light collection.

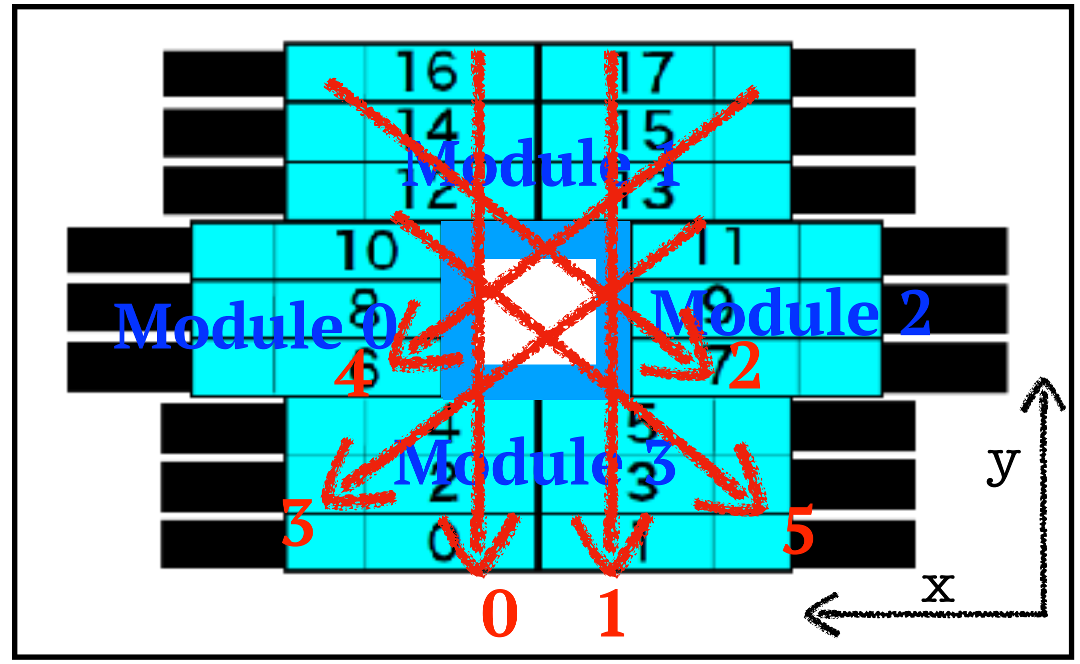
- MPPC Gain Measurement(Grouping) > Fiber Light Yield Test(Selection) > Gluing > Evacuation > Wrapping > Cosmic-ray Test > Installation > First Beam Commissioning

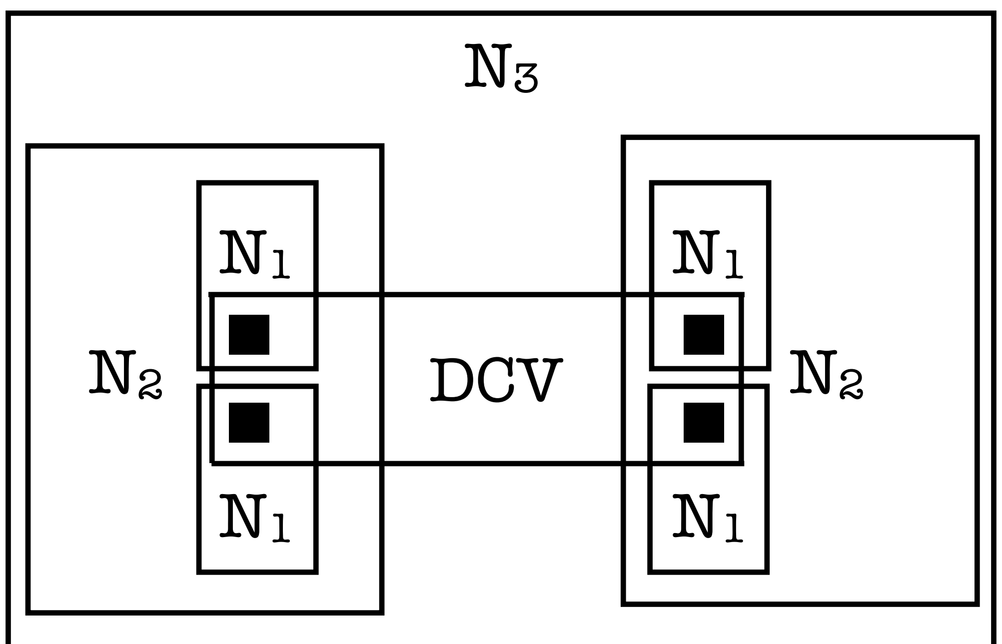
- From the Cosmic-ray test, we got 60 p.e. at the center of DCV.

How to do Energy Calibration of DCV

Cosmic-ray tracking





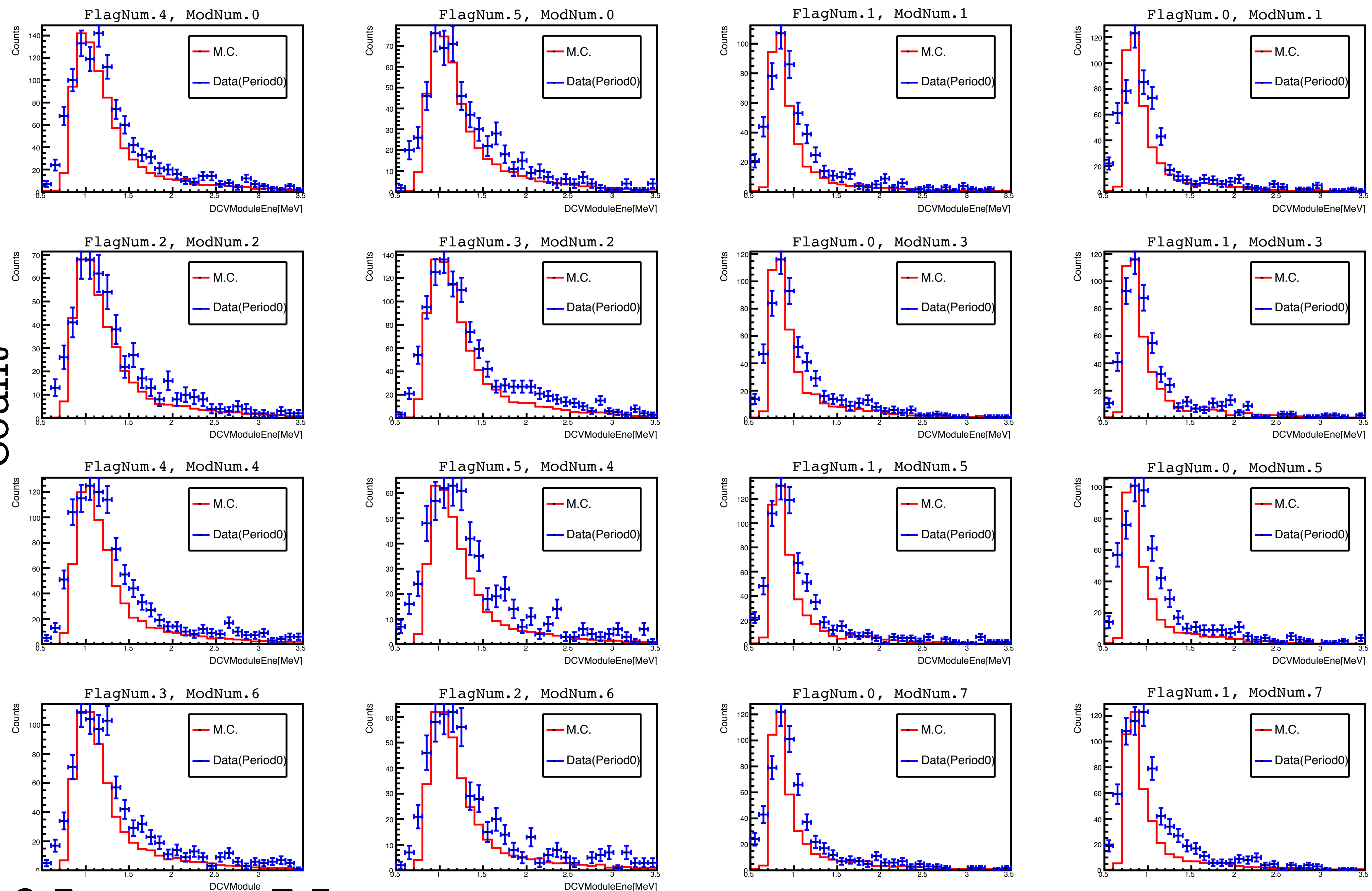


N_1 : Normalization Factor for each MPPC.
N_2 : Normalization Factor for a pair of MPPC at Upstream(Downstream)
N_3 : Normalization Factor for 4 MPPC.

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

Data vs M.C.

DCVModuleEnergy distribution for each Cosmic-ray track.

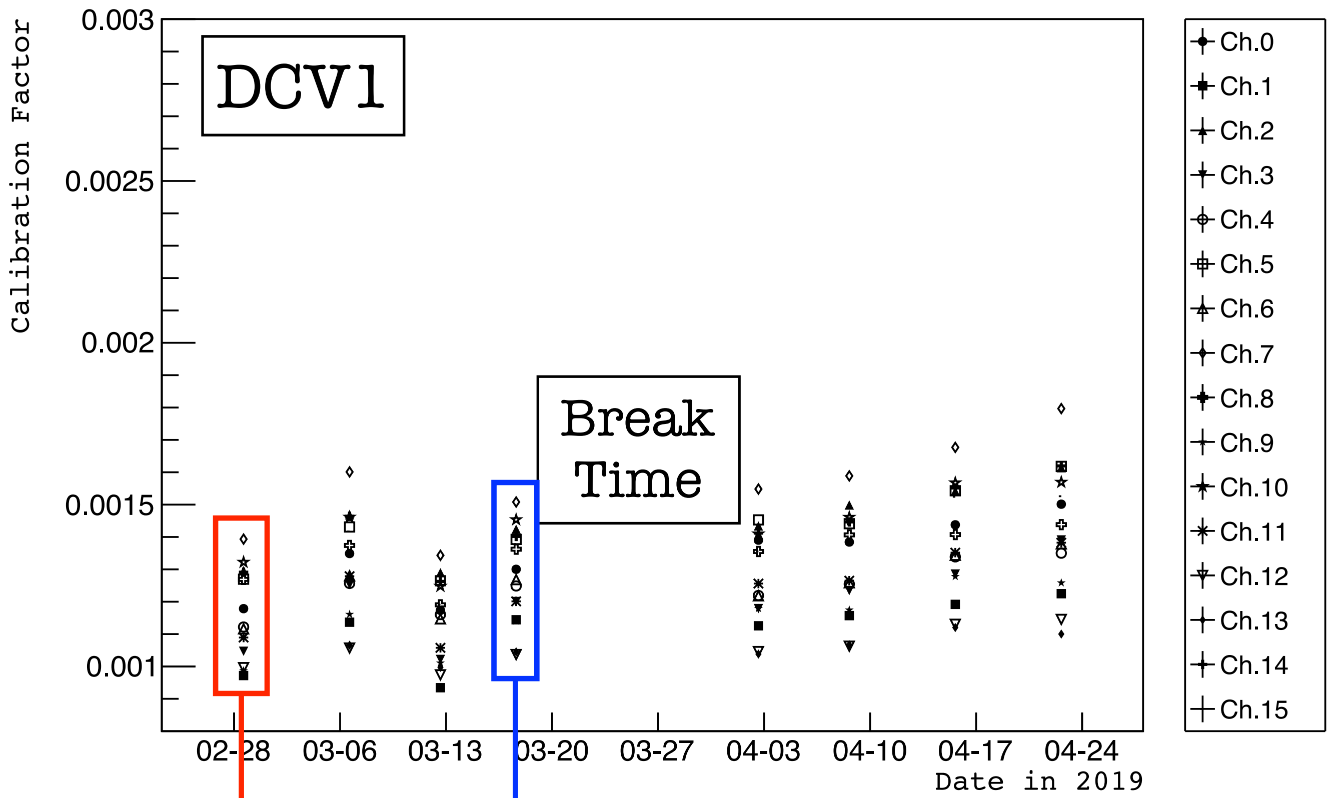


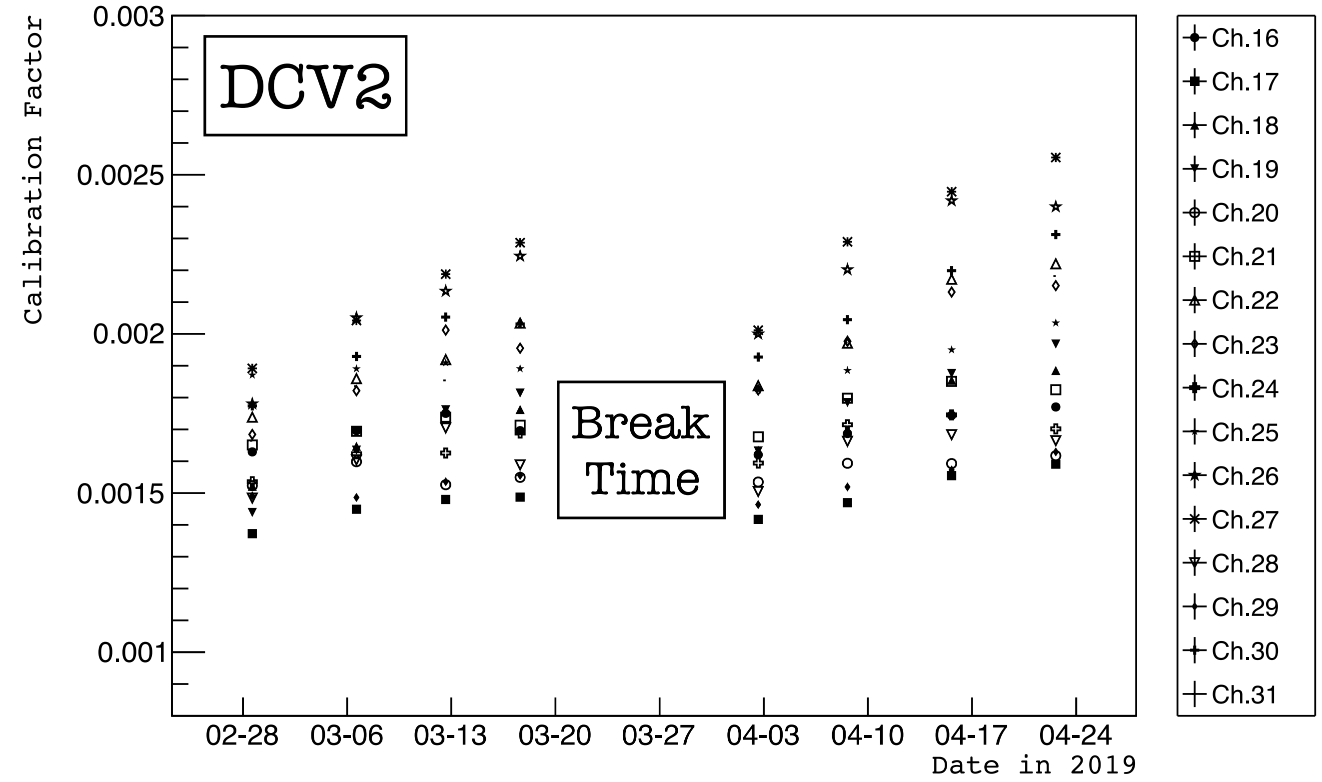
Count

0.5 3.5

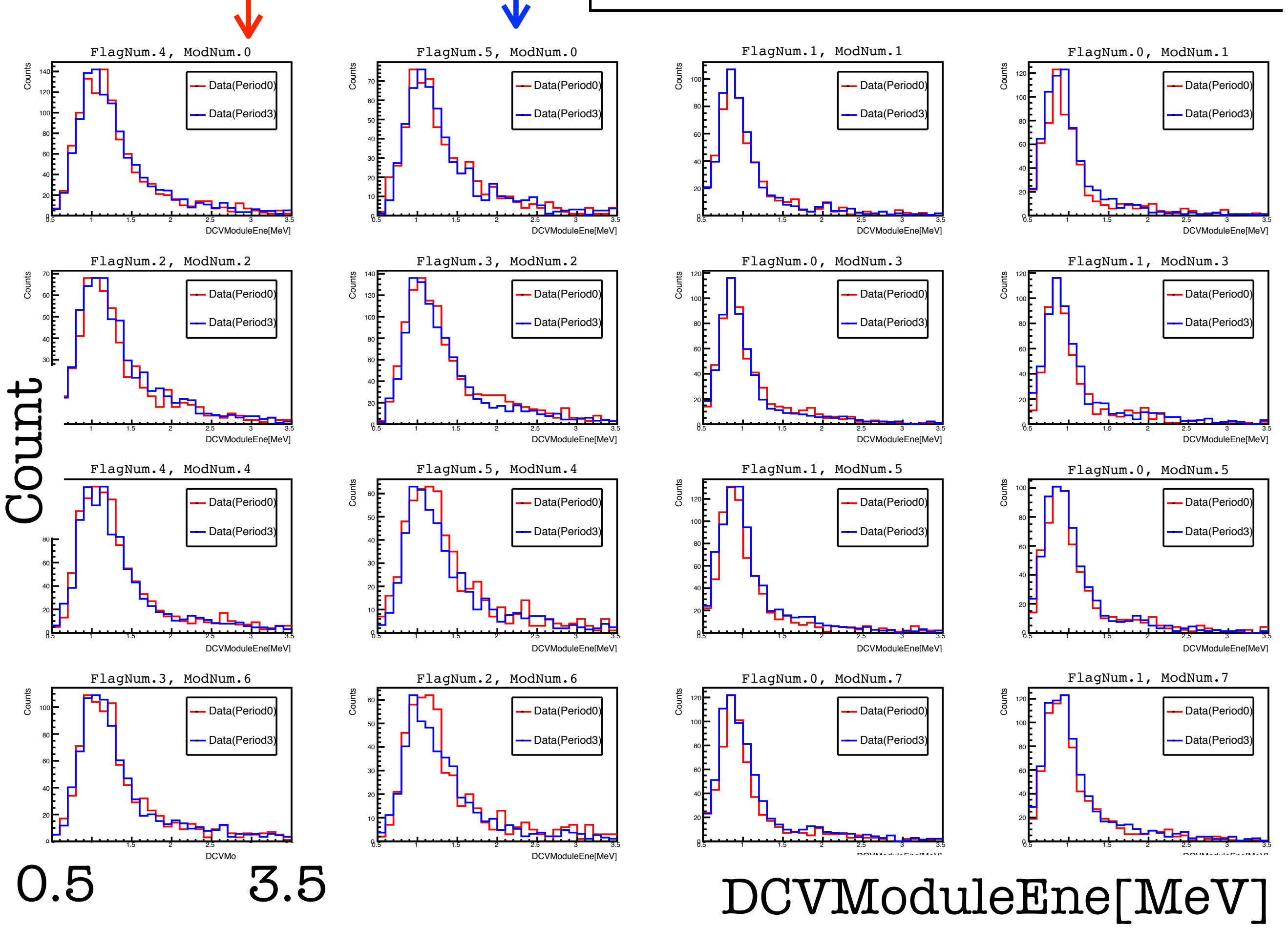
DCVModuleEne[MeV]

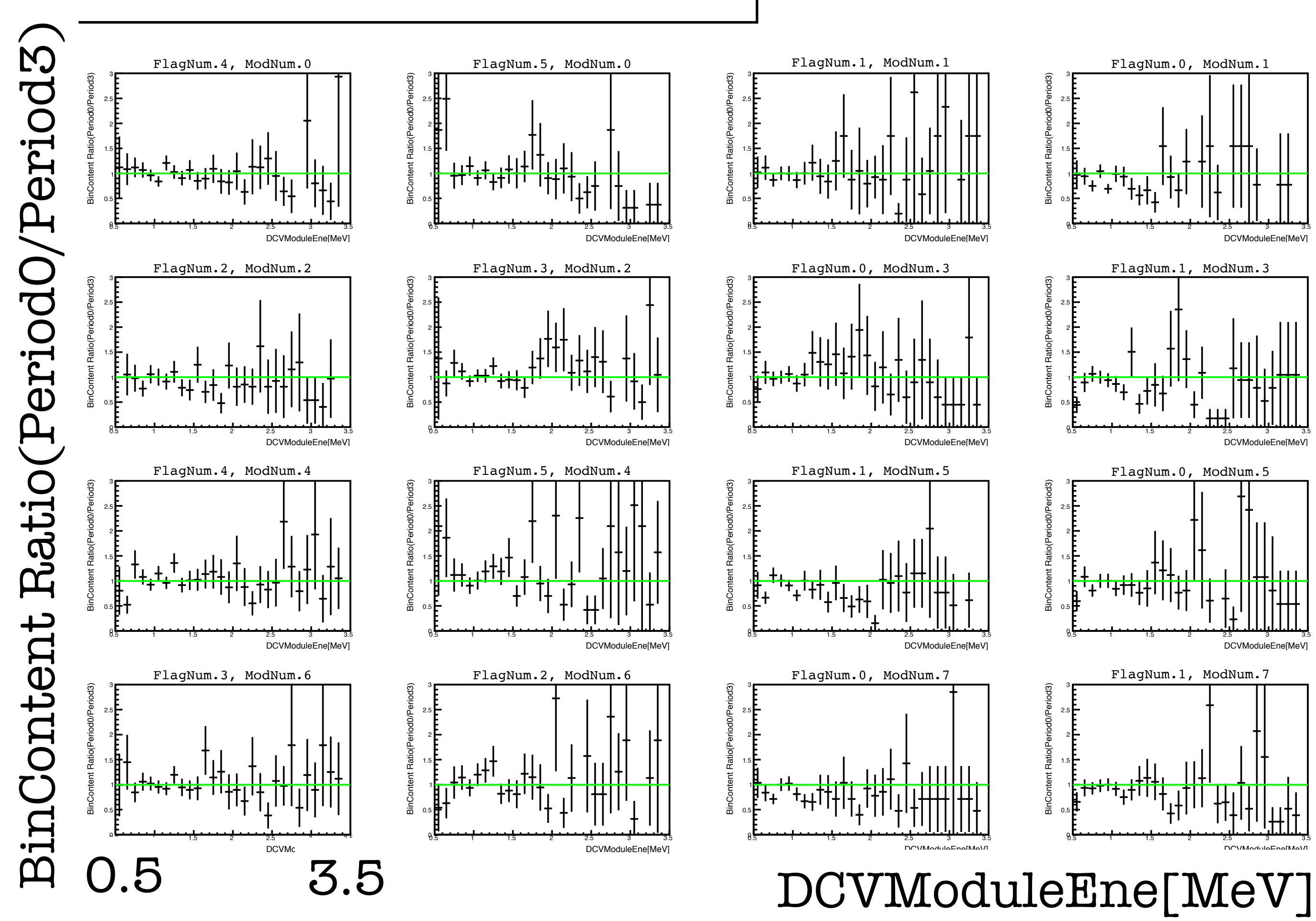
Calibration Factor during Beam Time





- Calibration Factors tend to increase over time

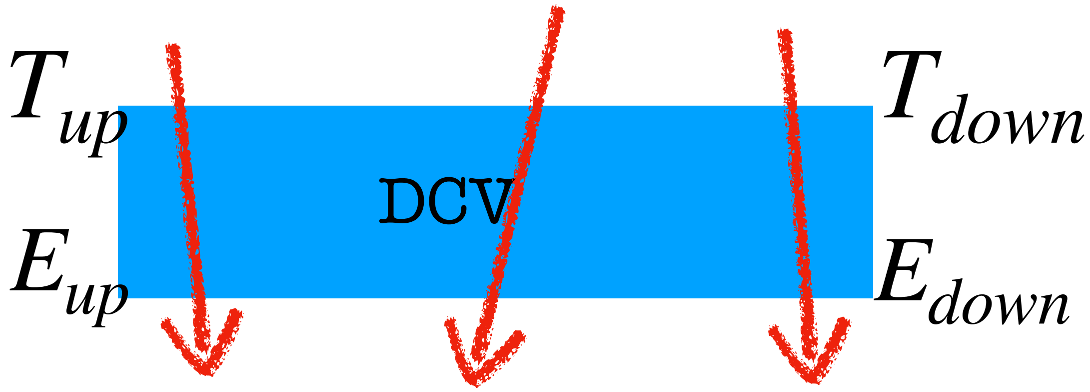




Attenuation Length

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

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



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

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

λ = *Attenuation Length*

v = *Propagation Velocity*

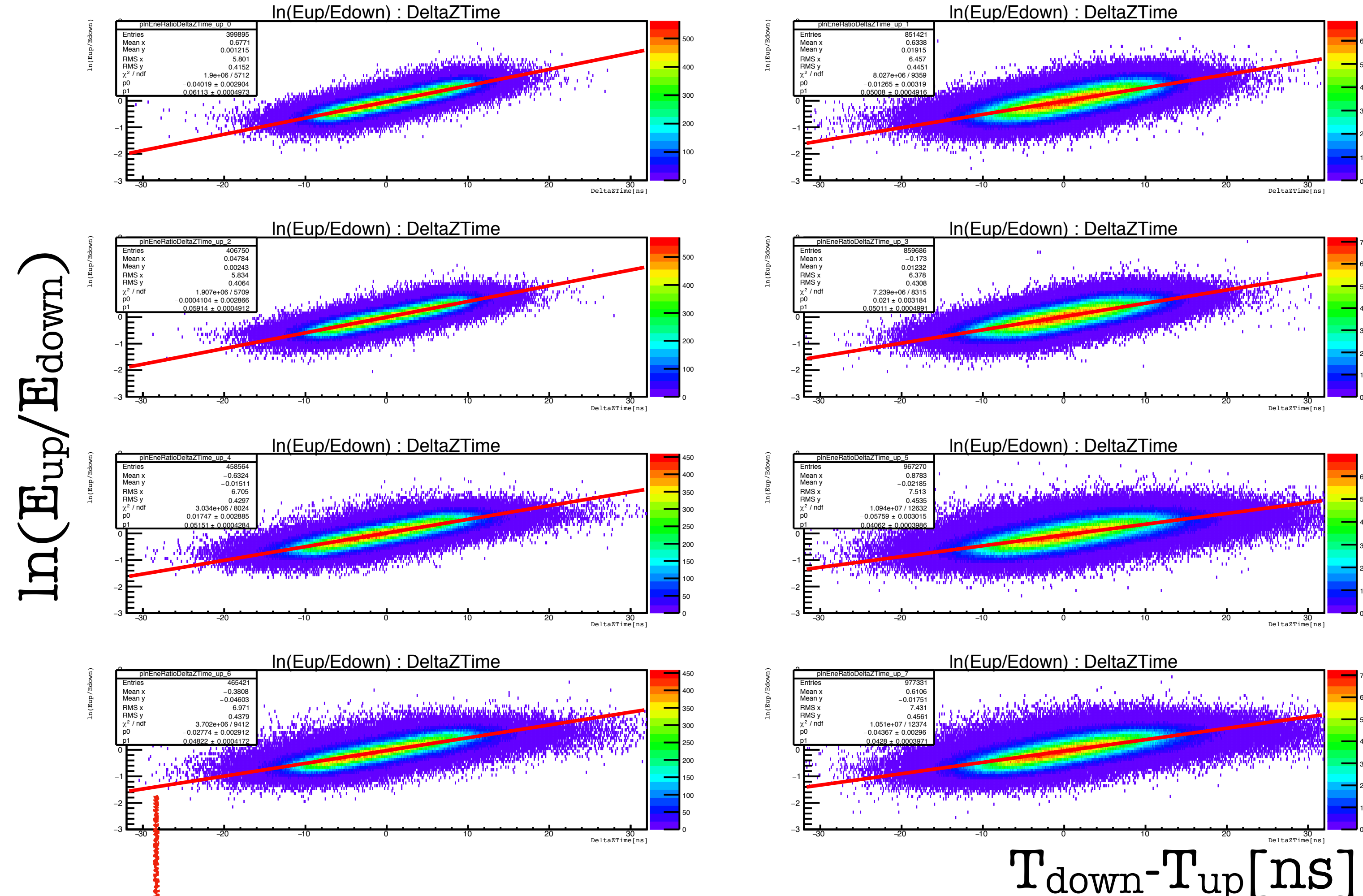
$$y = p_1 x + p_0$$

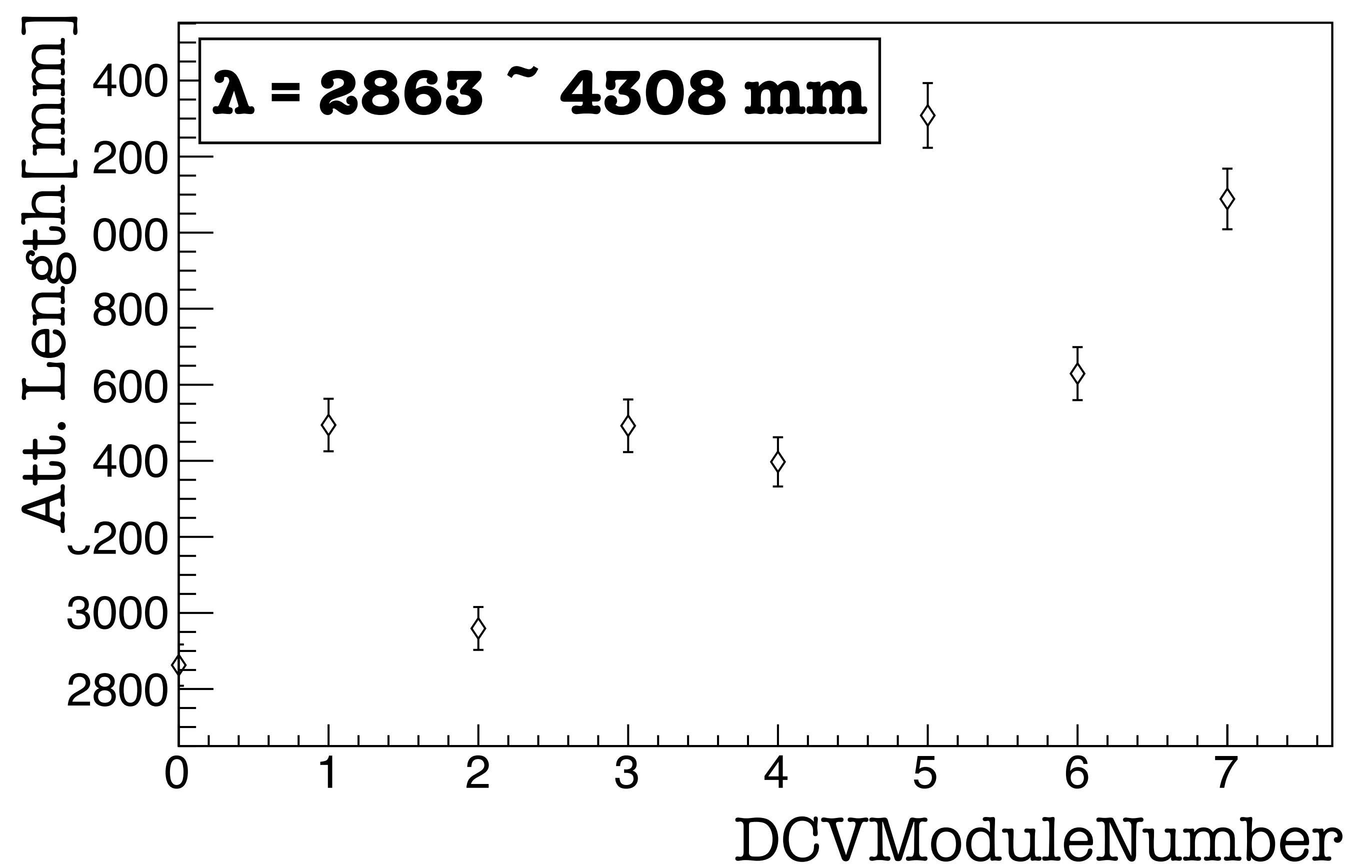
$$\lambda = \frac{v}{p_1}$$

$v = 175 \pm 3$ mm/ns

(From E391a Barrel Photon Detector)

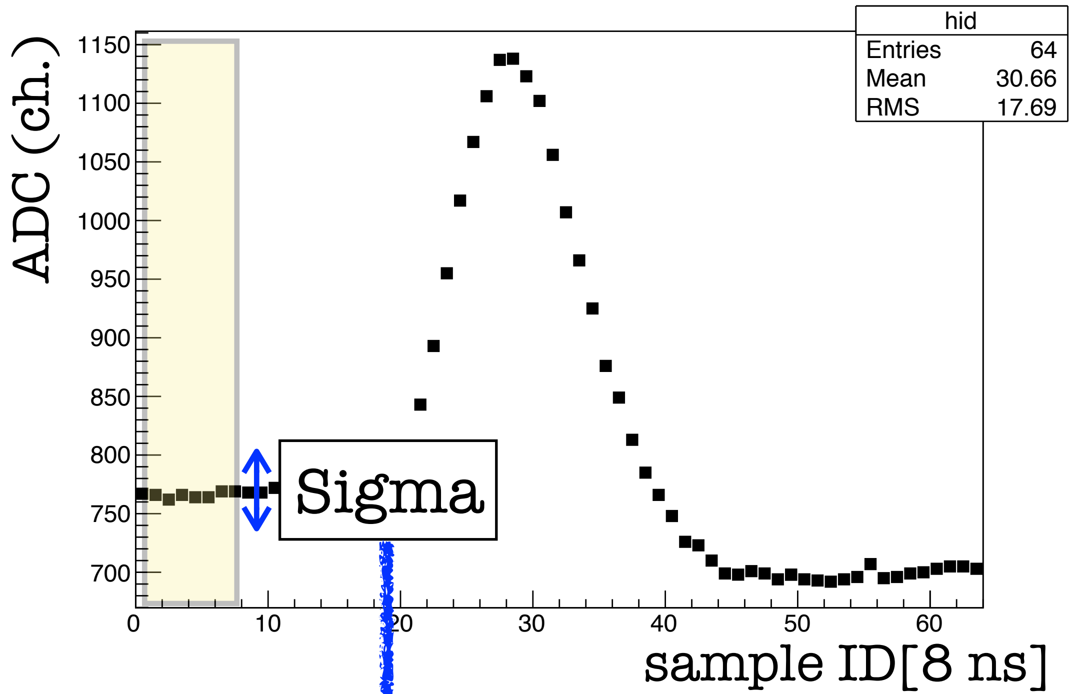
(Y-11(Kuraray) Att. Length > 3500 mm)





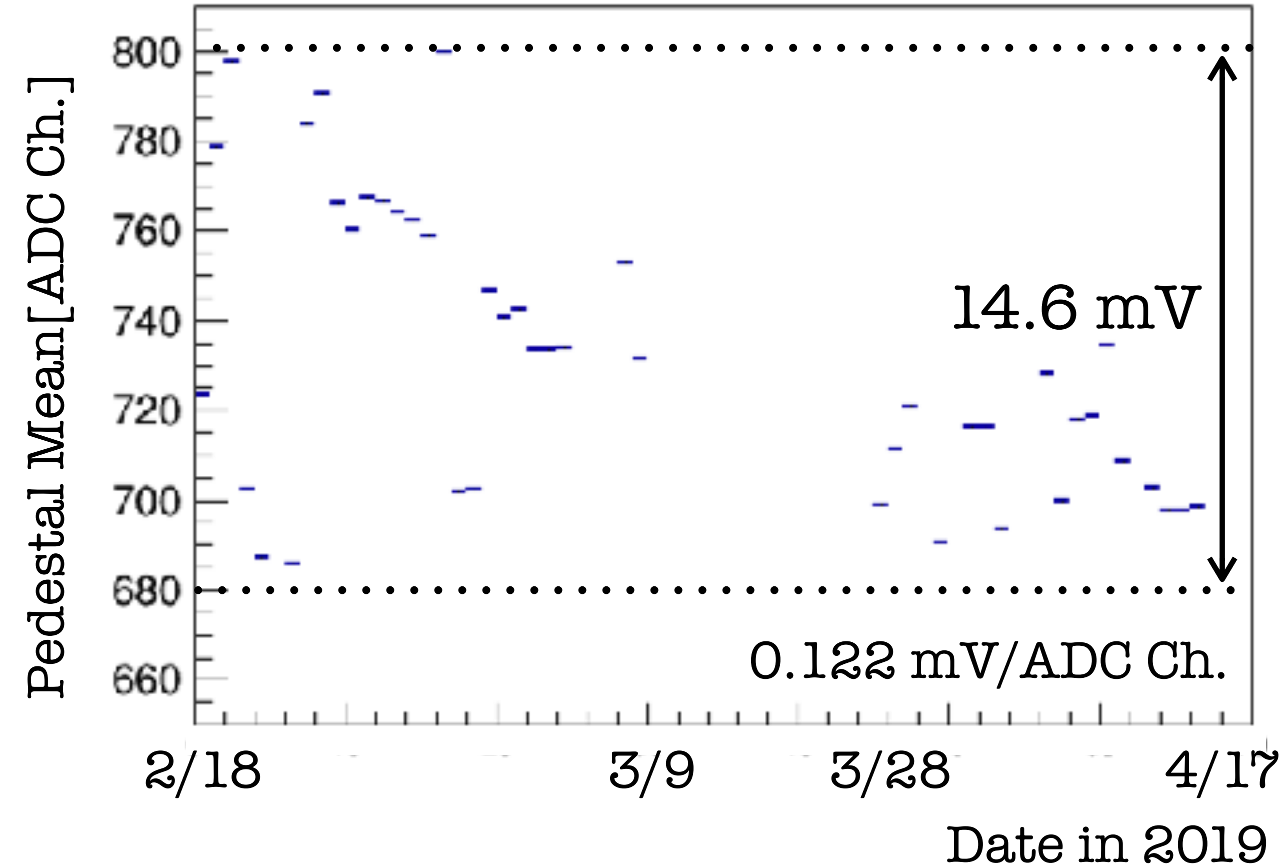
Pedestal Stability

Pulse Shape

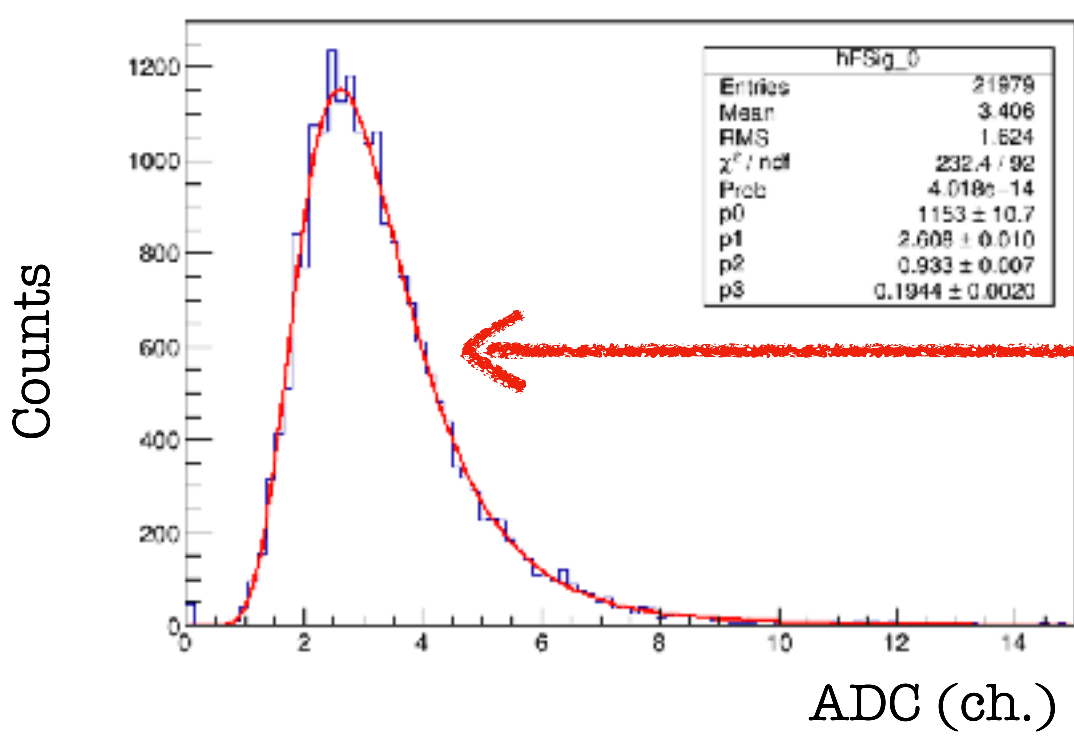


Pedestal : Mean value of ADC for Sample ID 1 ~ 9

Trend of Pedestal Mean



Pedestal Sigma Distribution. for a physics run.

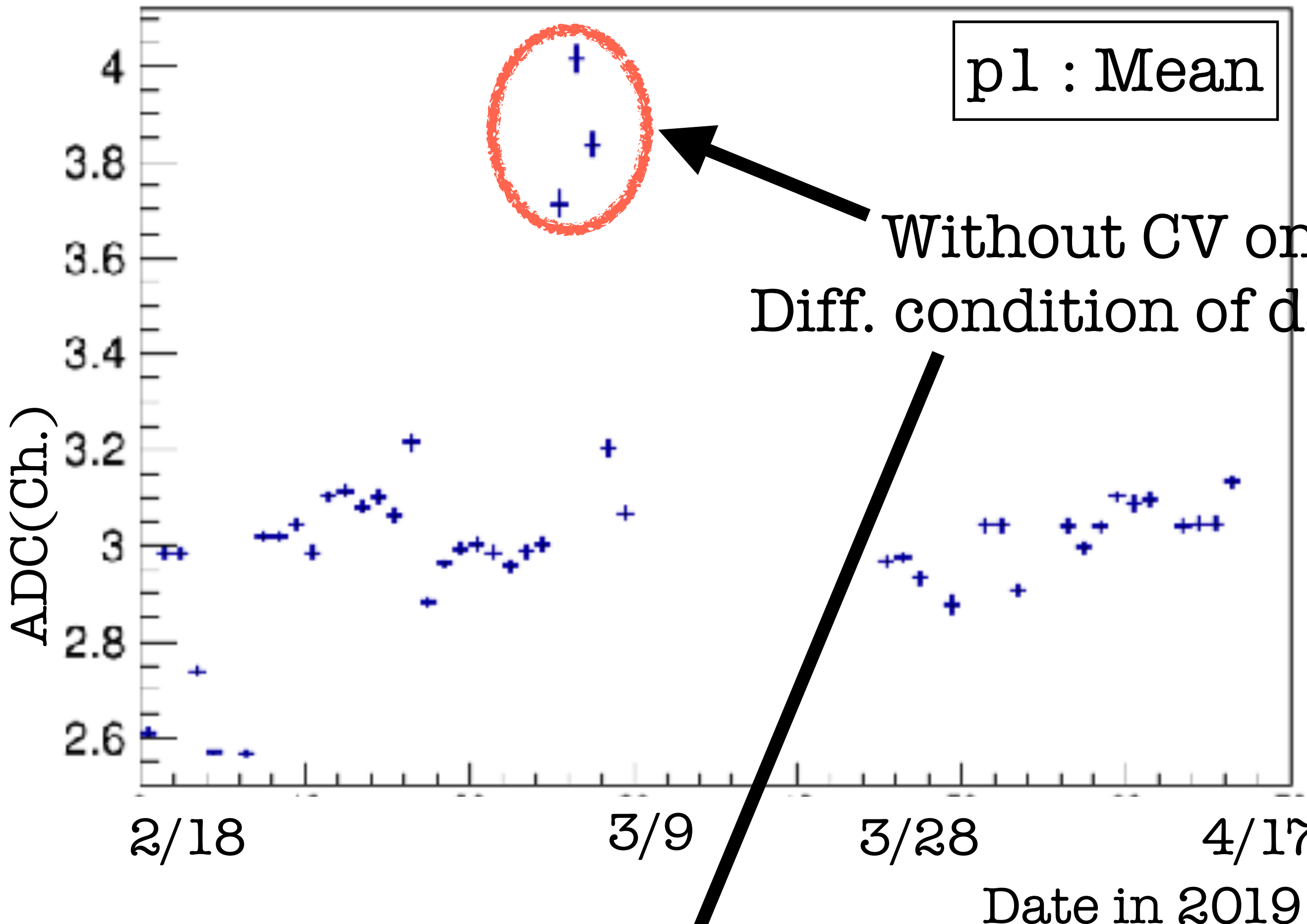


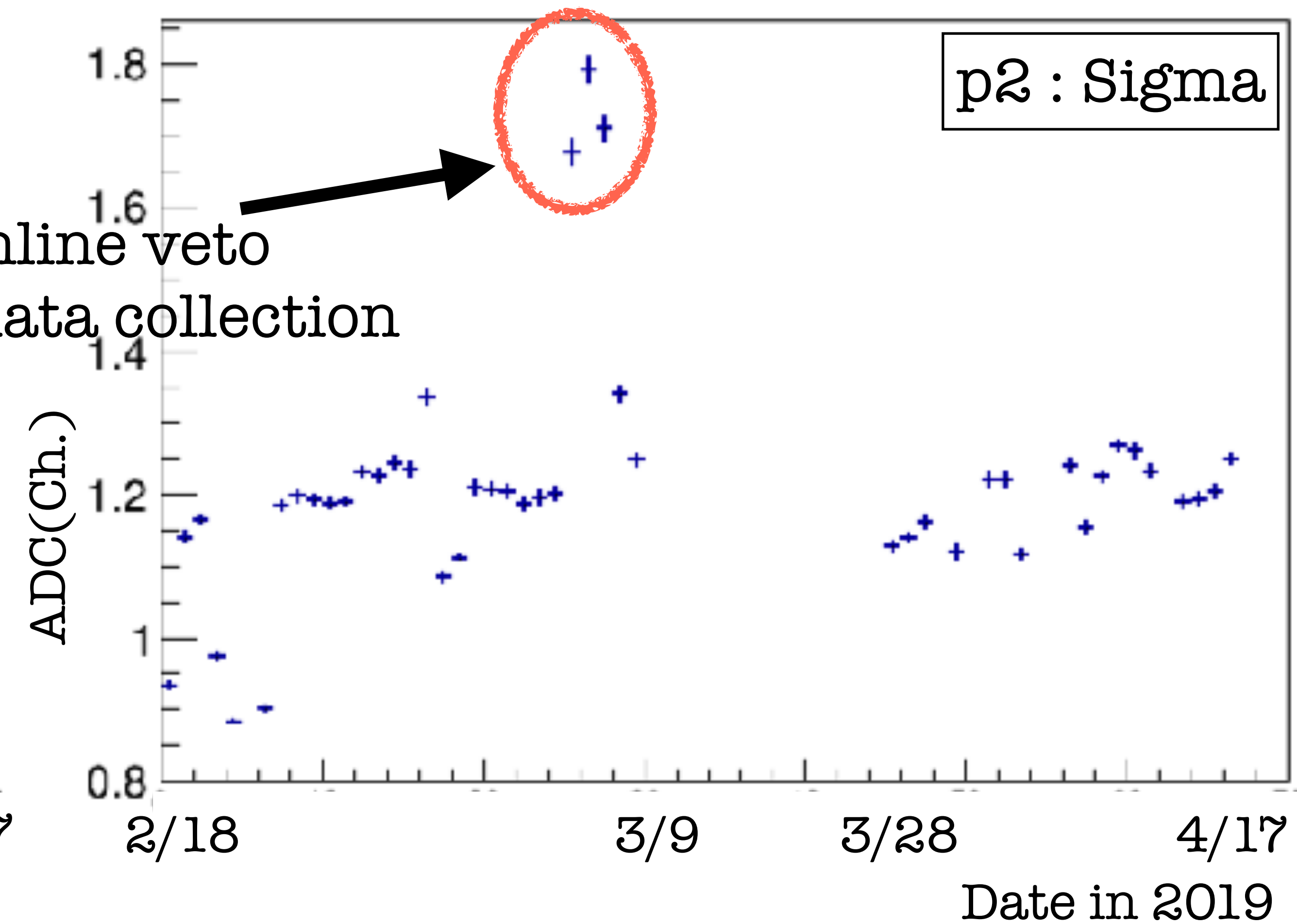
Asymmetric Gaussian Function

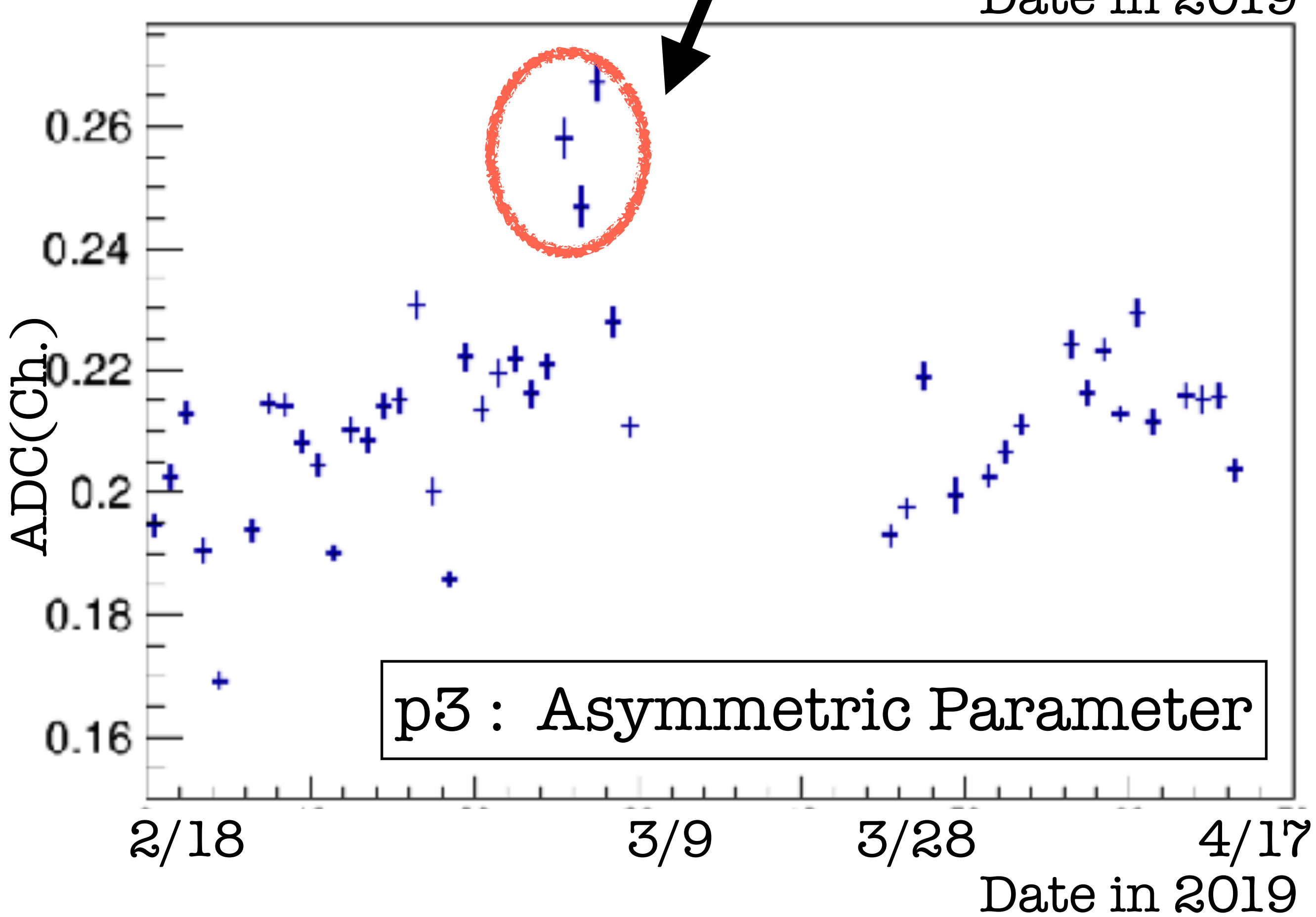
$$f(x) = P_0 exp[-\frac{(x-P_1)^2}{2(P_2+P_3(x-P_1))^2}]$$

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

Pedestal Sigma Stability







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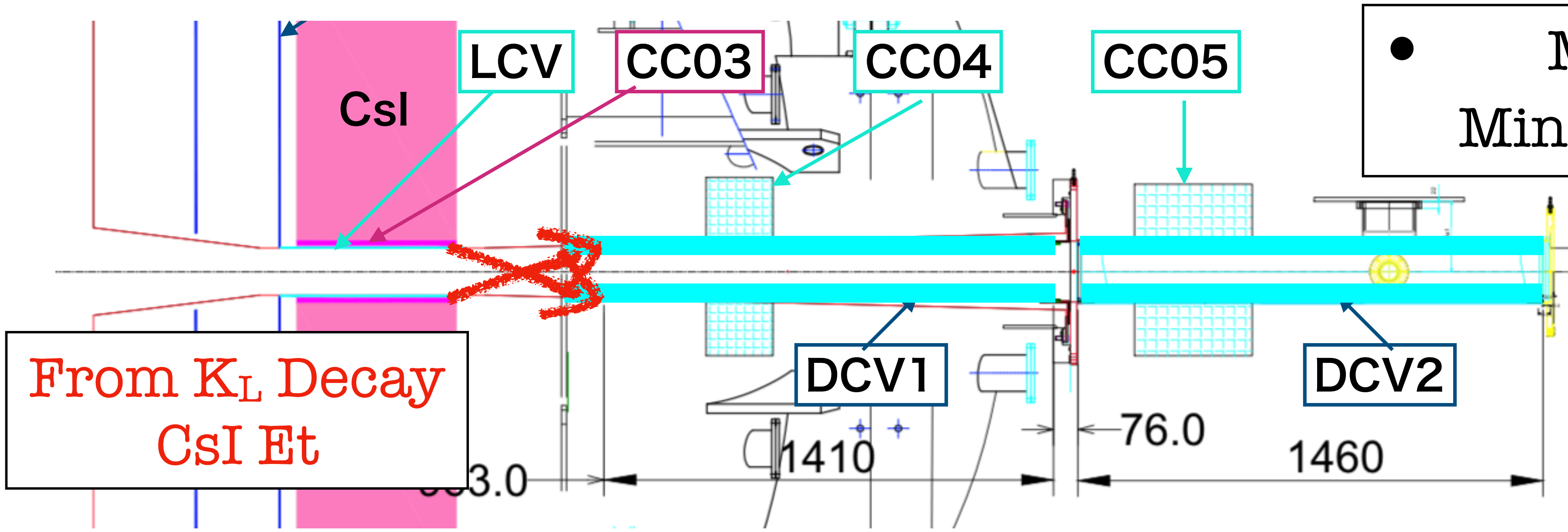
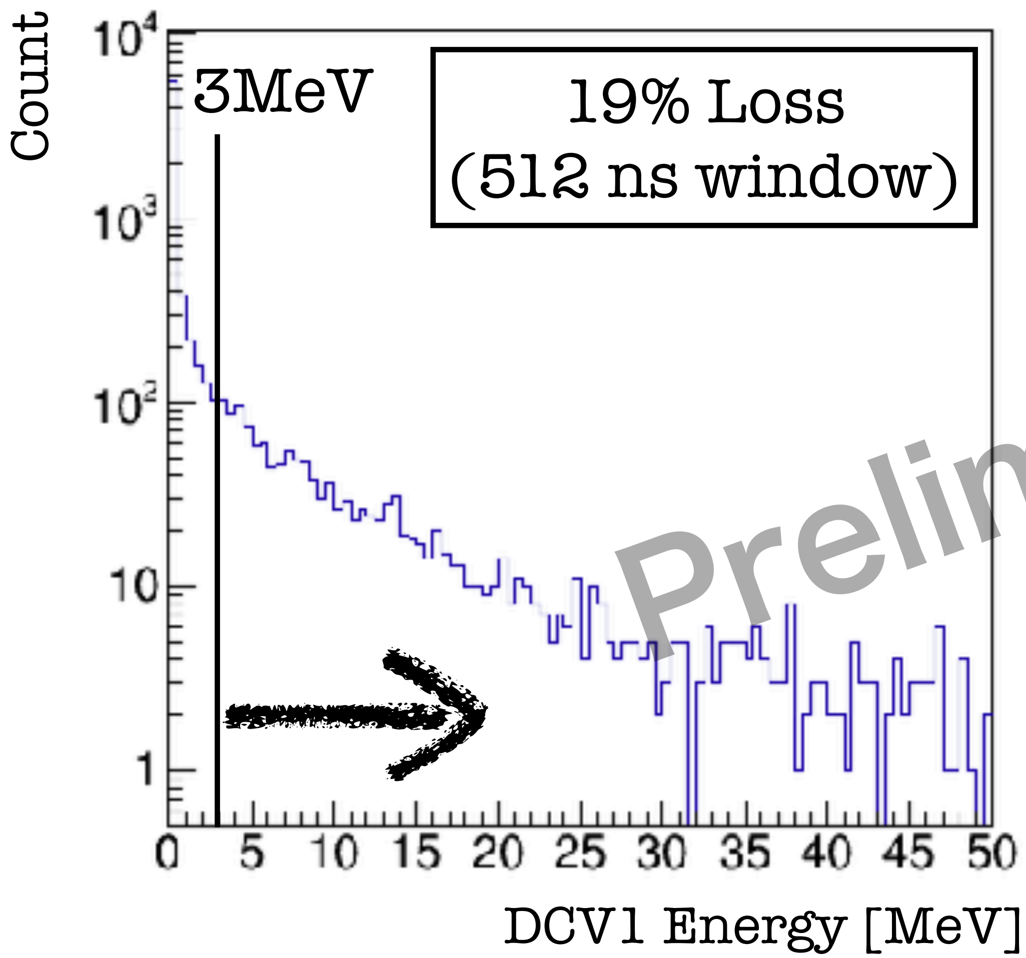
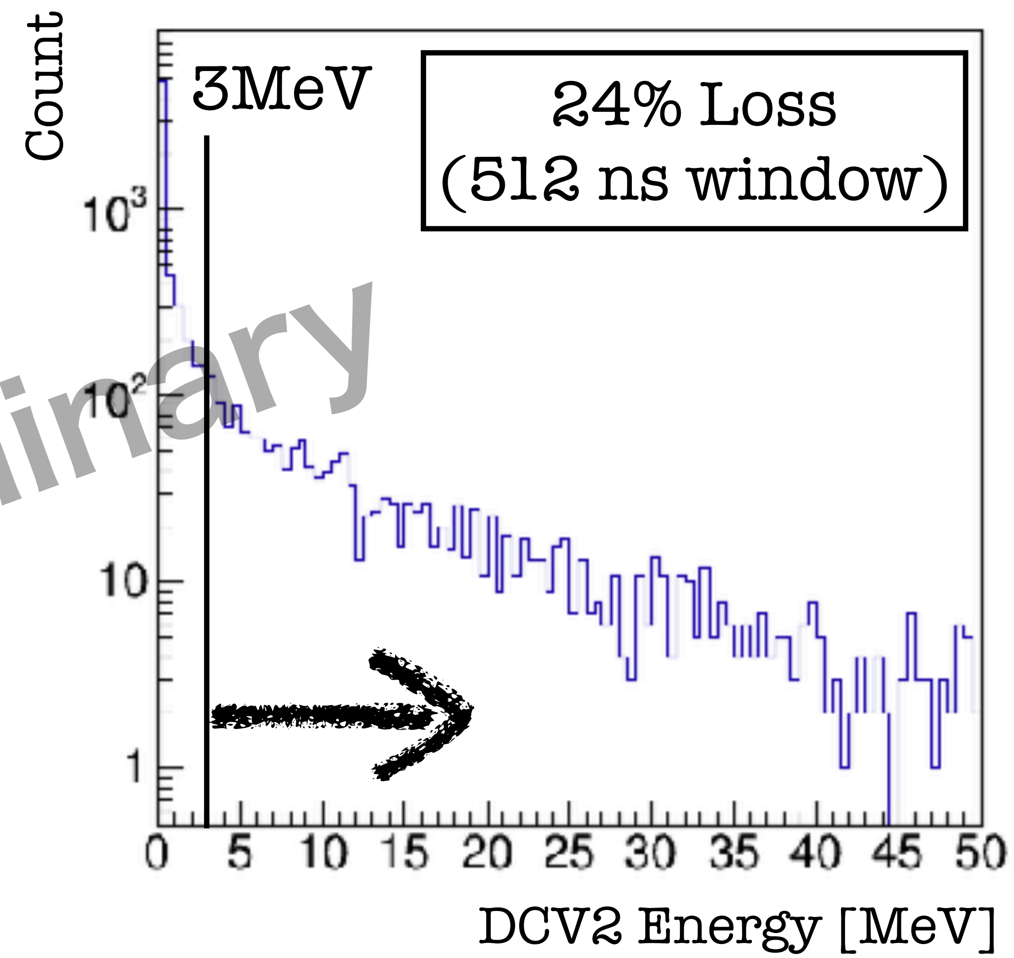
- Pedestal Sigma seem to be stable for entire period.

Accidental Loss



- Maximum Incident Angle → Minimum Path Length ~ 15.5 mm
- Energy Threshold ~ 3MeV
- Trigger : Target Monitor





- 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