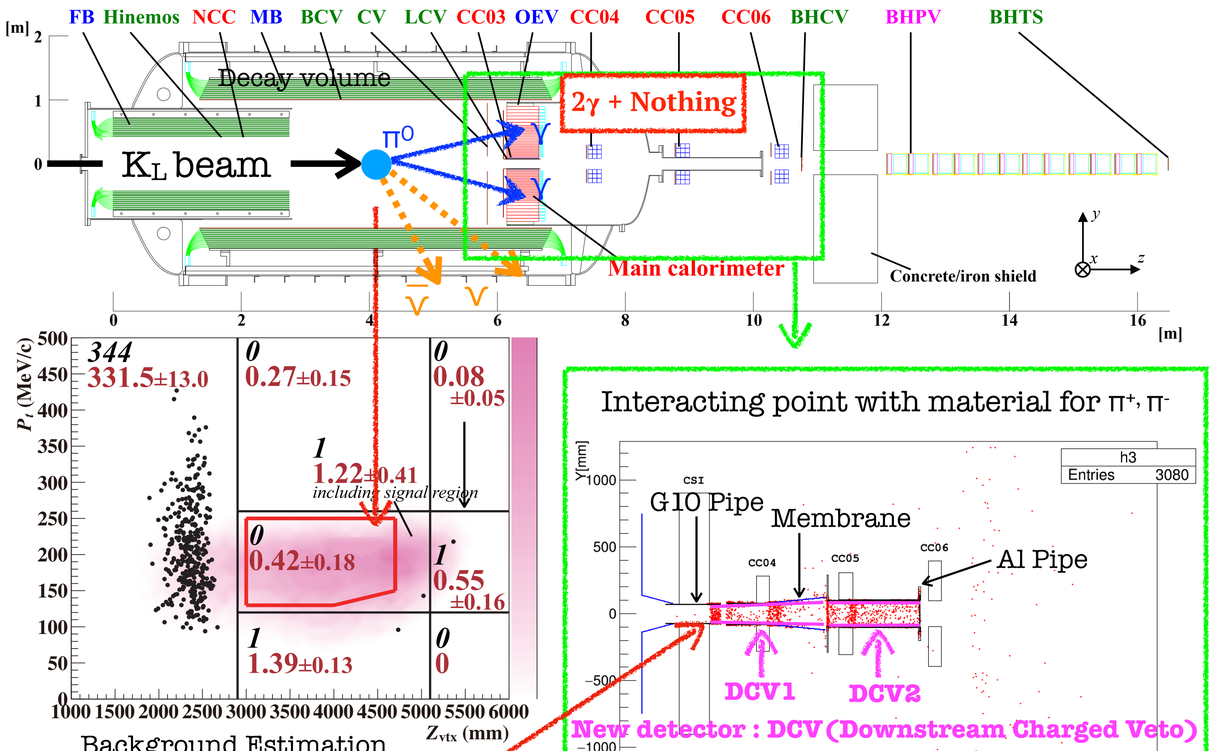
A new charged particle detector for KOTO experiment at J-PARC

HongMin KIM for the KOTO Collaboration, recenter@naver.com

0. Motivation

- The KOTO Experiment at J-PARC is searching for the $K_L \to \pi^0\nu\bar{\nu}$ decay(Branching ratio : 3.0×10^{-11} in Standard Model).



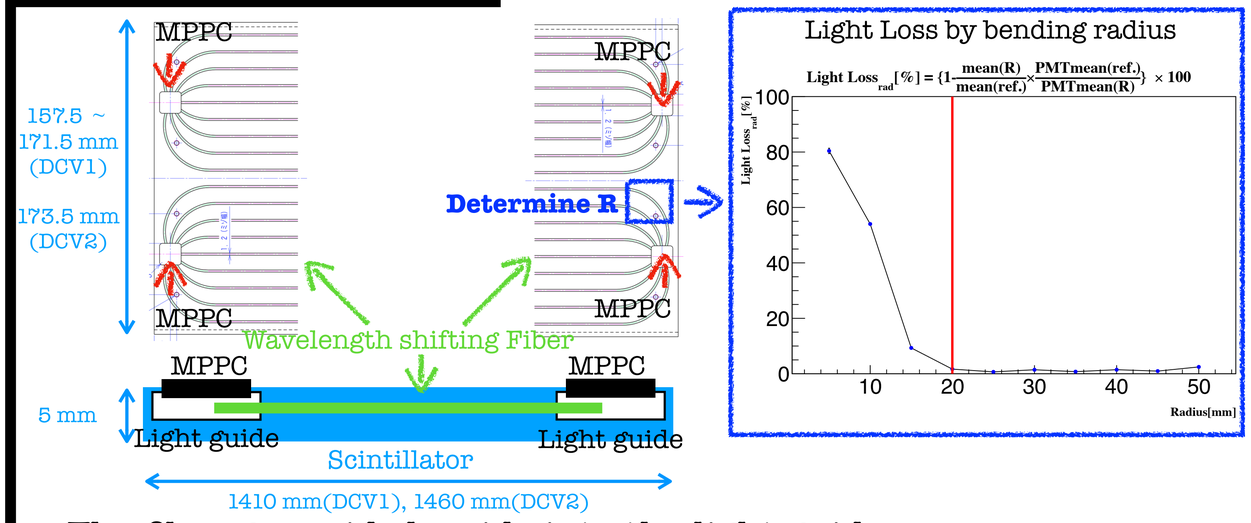
Background Estimation
(2015 data, S.E.S = 1.3×10^{-9})

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

- π^+, π^- were interacting with G10 pipe, membrane, Al pipe that are not detector.

- $K_L \to \pi^+\pi^-\pi^0$ decay is the one of background.
- We needed new detector before interacting with dead materials
- Due to very limited space, we are trying a new scheme of light collection.

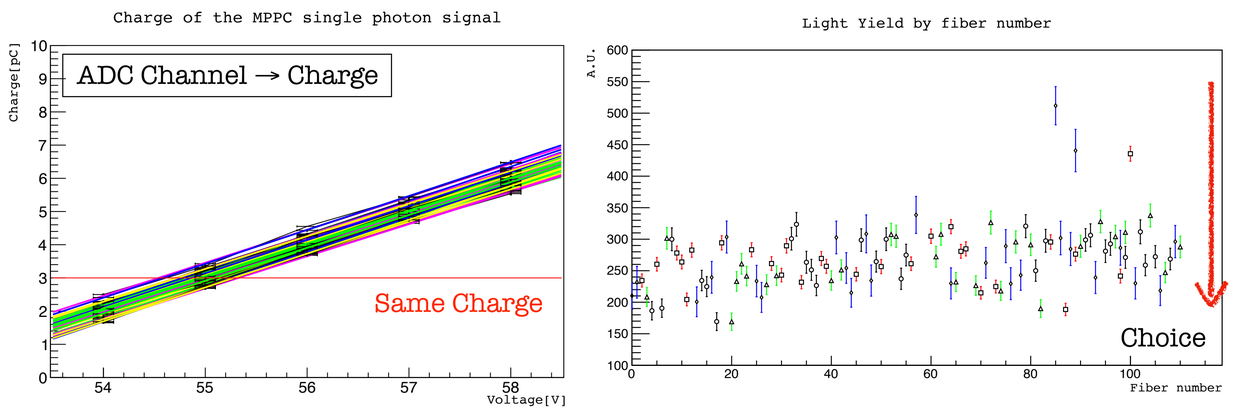
1. Scheme of DCV



- The fiber goes side by side into the light guide.
- MPPCs are attached to the surface of the scintillator.
- We could bend the fiber to a minimum radius of 20 mm.

2. Fabrication Process

- MPPC Gain Measurement & Fiber Test

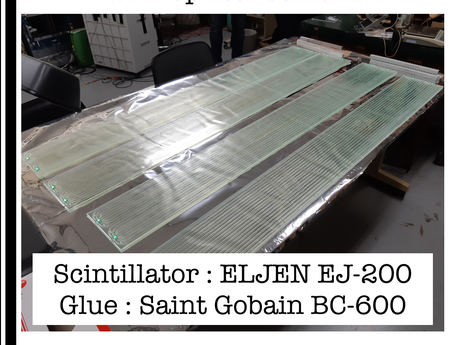


- We used the MPPCs from HAMAMATSU S13360-6050PE.
- MPPCs were each connected by U.FL Cable(1.32ϕ)
- Using 430 nm LED, we measured the MPPC single gain.
- MPPCs were grouped into four with the same operating voltage.
- We used the fiber from Kuraray Y-11(1 mm)
- It shot an LED light of 430nm from one side and measured the light yield with MPPC from the other side.
- We chosen the fiber from the highest value of light yield.

2. Fabrication Process

- Making the scintillator pipe

Fiber gluing with optical cement



Scintillator : ELJEN EJ-200
Glue : Saint Gobain BC-600

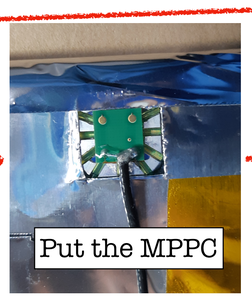
Evacuation by vacuum chamber

Less than 1 pa.
Over the 48 hr
Extracting outgas

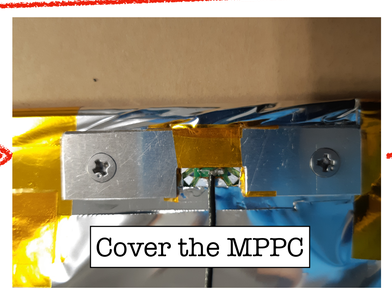
Wrapping with aluminized film

Thickness of film : 12 μm

Light guide



Put the MPPC

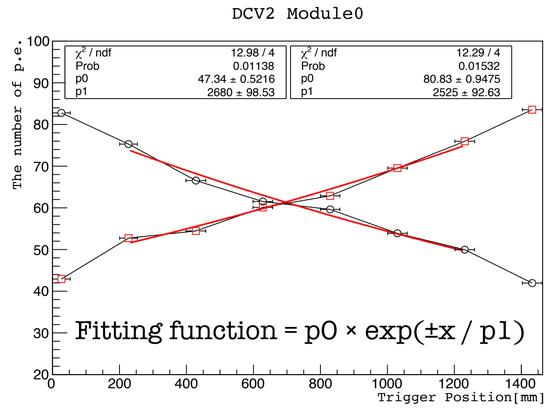


Cover the MPPC

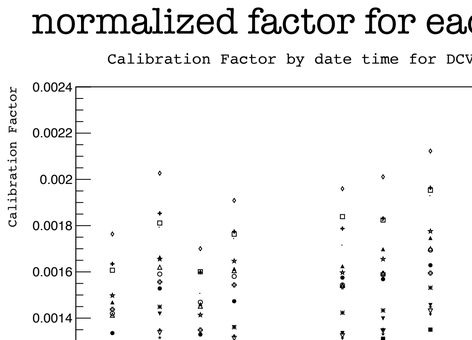
Making the pipes

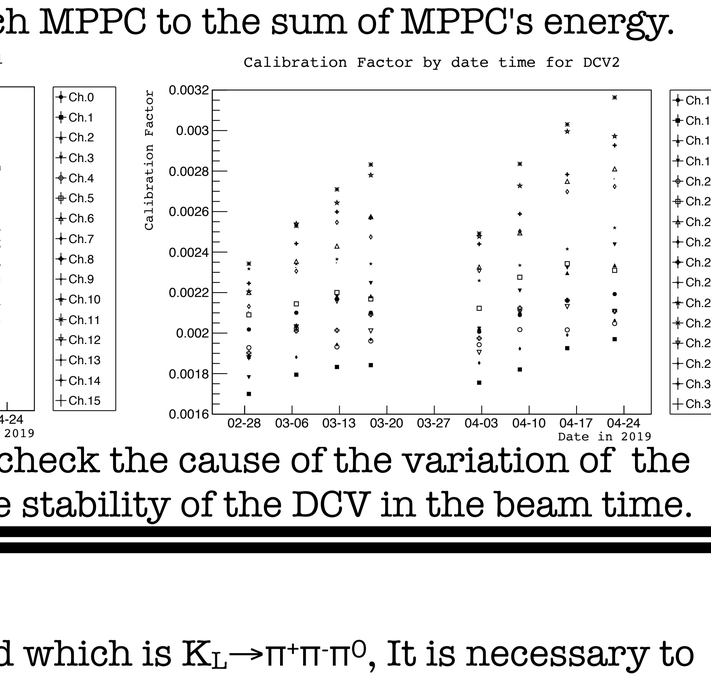
- Cosmic ray test

- We mesurement the P.E. by cosmic ray at 8 trigger position.
- P.E. for 1 MeV
  36.98(Min.) ~ 85.08(Max.)
- Attenuation length
  2469 mm(DCV1)
  2567 mm(DCV2)

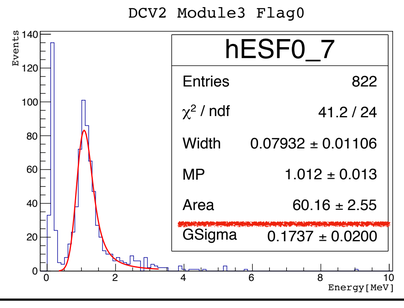


3. Beam Commissioning





Fitting function : Landau convoluted with gaussian



Calibration factor = Attenuation factor / (f1 × f2 × f3 × Path length correction factor)

- CC04, CC05(surrounding DCV) were used as trigger to calibrate with cosmicray.
- Energy calibration was performed from the calculation of normalized factor for each MPPC to the sum of MPPC's energy.

- Analysis is underway to check the cause of the variation of the calibration factor and the stability of the DCV in the beam time.

4. Summary

- To reduce the background which is $K_L \to \pi^+\pi^-\pi^0$, It is necessary to install the new scintillator detectors(DCV) inside the beam pipe.
- Due to limit space, a new type of light collection is adapted.
- The result of cosmic ray data, DCV got 40 ~ 80 p.e.
- DCV was well installed at KOTO beam line.
- The calibration of DCV was completed by using the cosmic ray data.
- Analysis for stability of performance is ongoing.

@International Conference on Kaon Physics 2019, University of Perugia(Italy)