

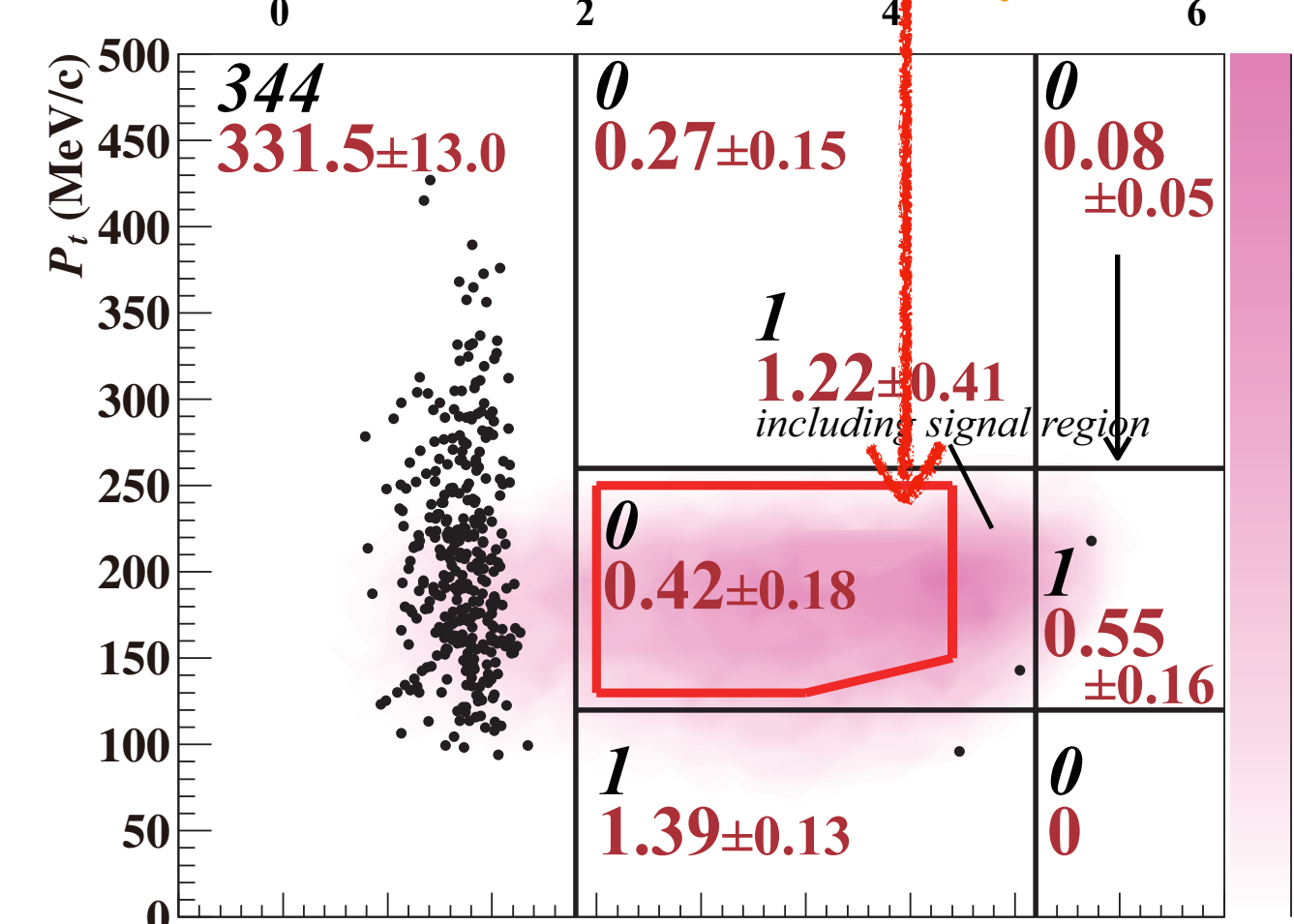
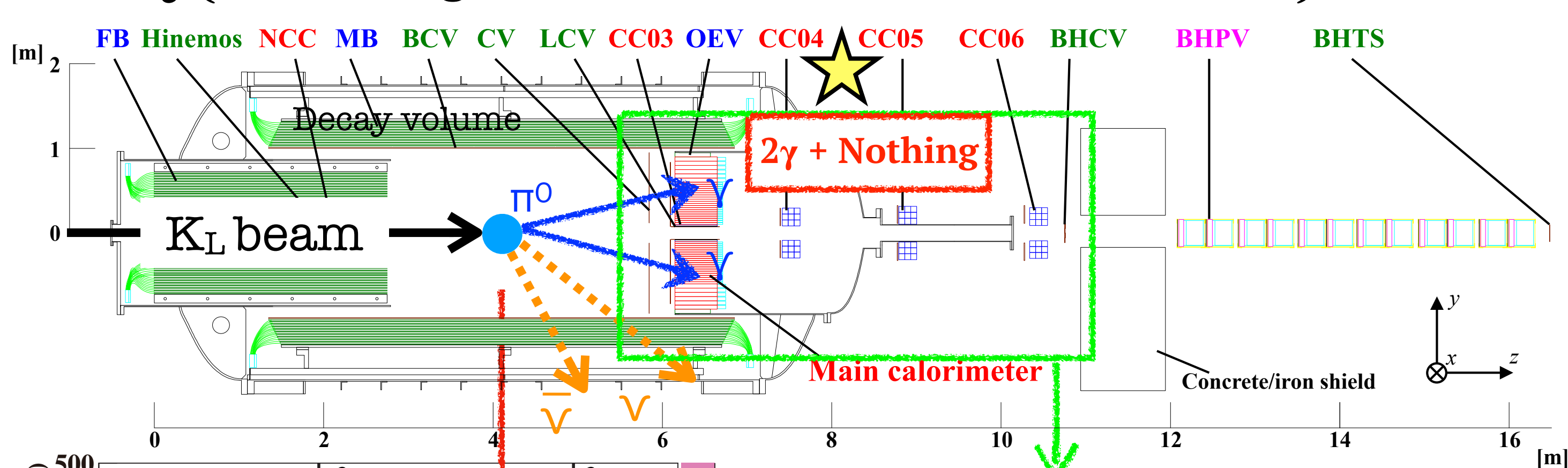
A new charged particle detector for KOTO experiment at J-PARC



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0. Motivation

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

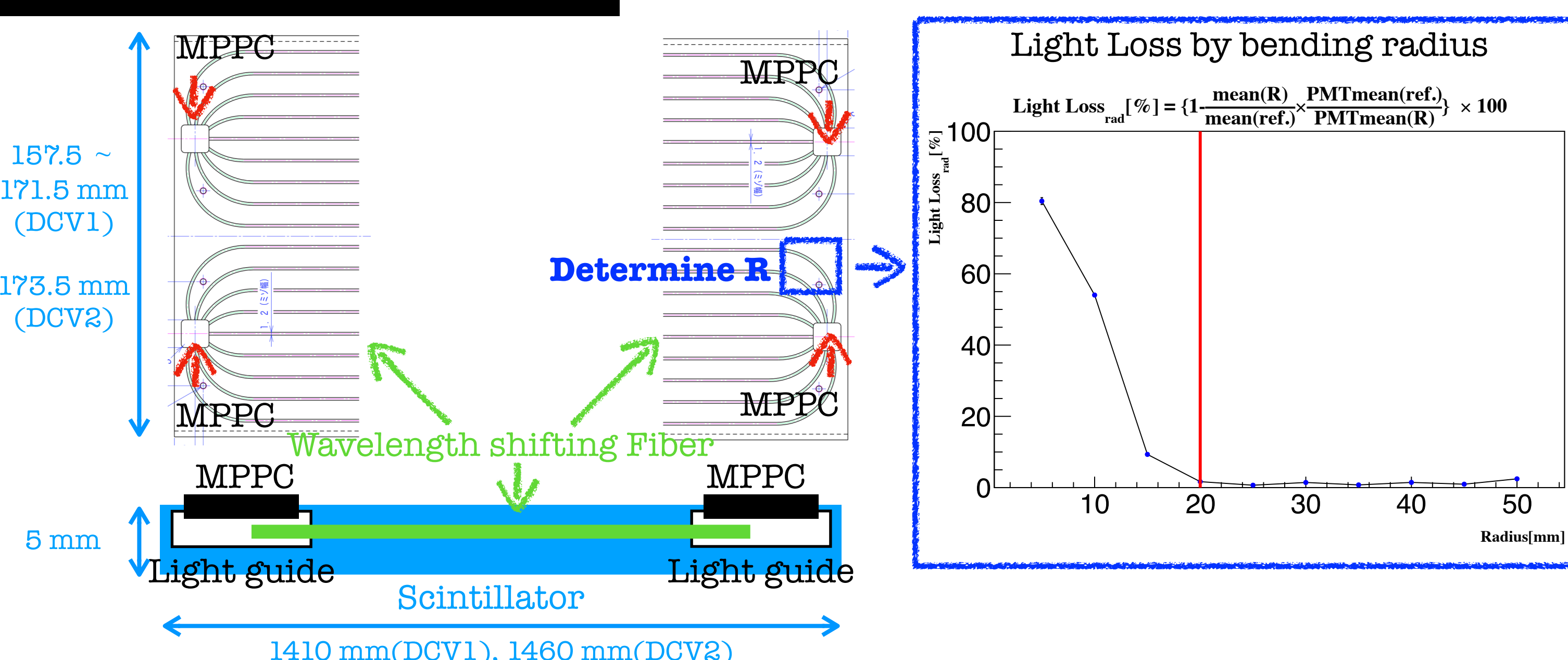


Background Estimation
(2015 data, S.E.S = 1.3×10^{-9}) PRL 122, 021802 (2019)

source		Number of events
K_L decay	$K_L \rightarrow \pi^+ \pi^- \pi^0$	0.05 ± 0.02
	$K_L \rightarrow 2\pi^0$	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

- The number of $K_L \rightarrow \pi^+ \pi^- \pi^0$ decay mode event can be reached about 2 at the S.M. sensitivity.
- A new detector to prevent charged pions from interacting with dead materials
- Due to very limited space, a new scheme of light collection has been implemented.

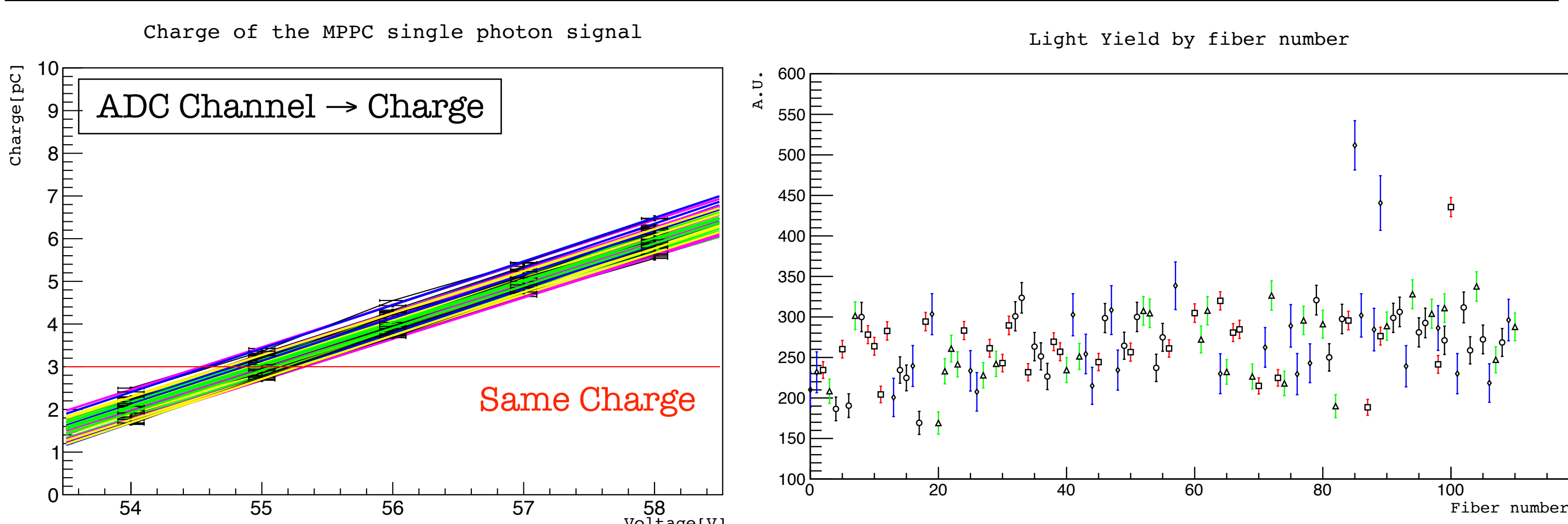
1. Scheme of DCV



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

2. Fabrication Process

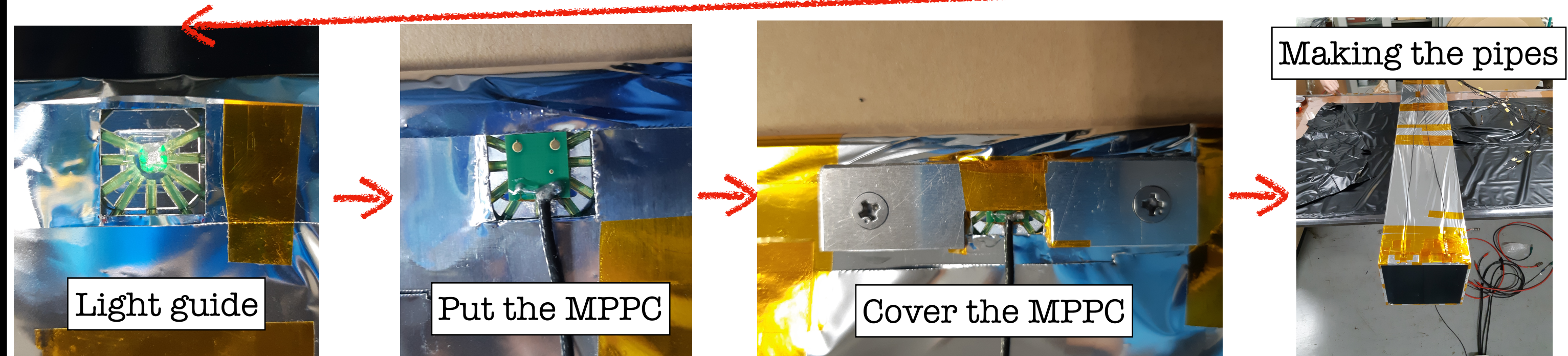
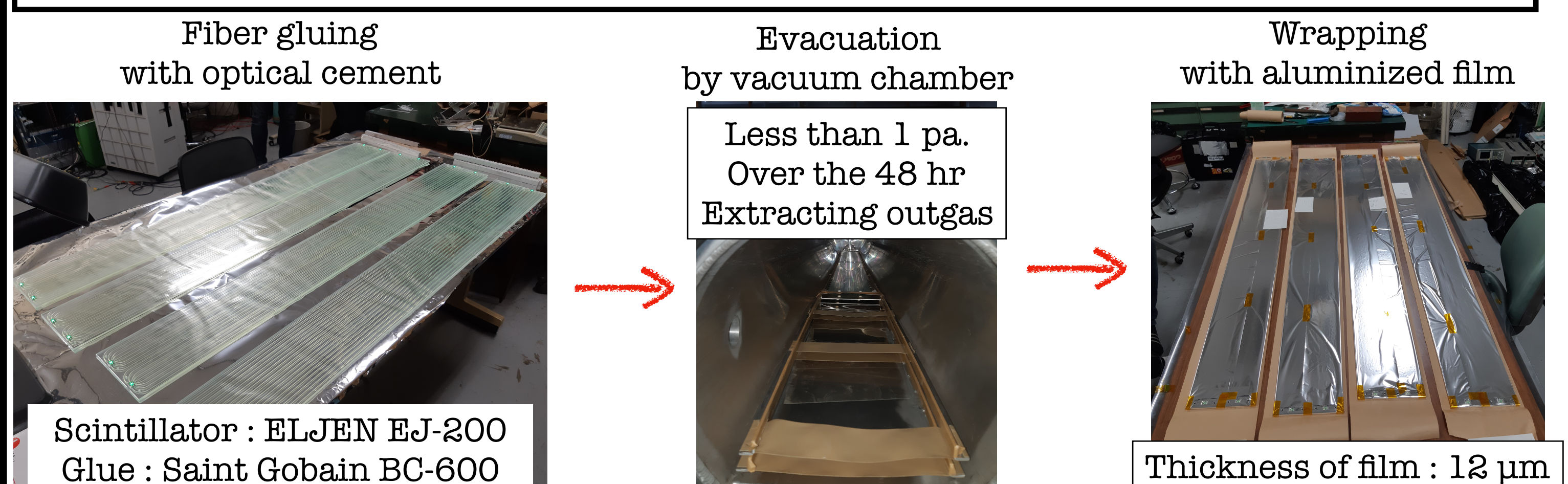
- MPPC Gain Measurement & Fiber Test



- 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)
- LED light (430 nm) was injected from one side and the light yield was measured with MPPC from the other side.
- We chosen the fiber from the highest value of light yield.

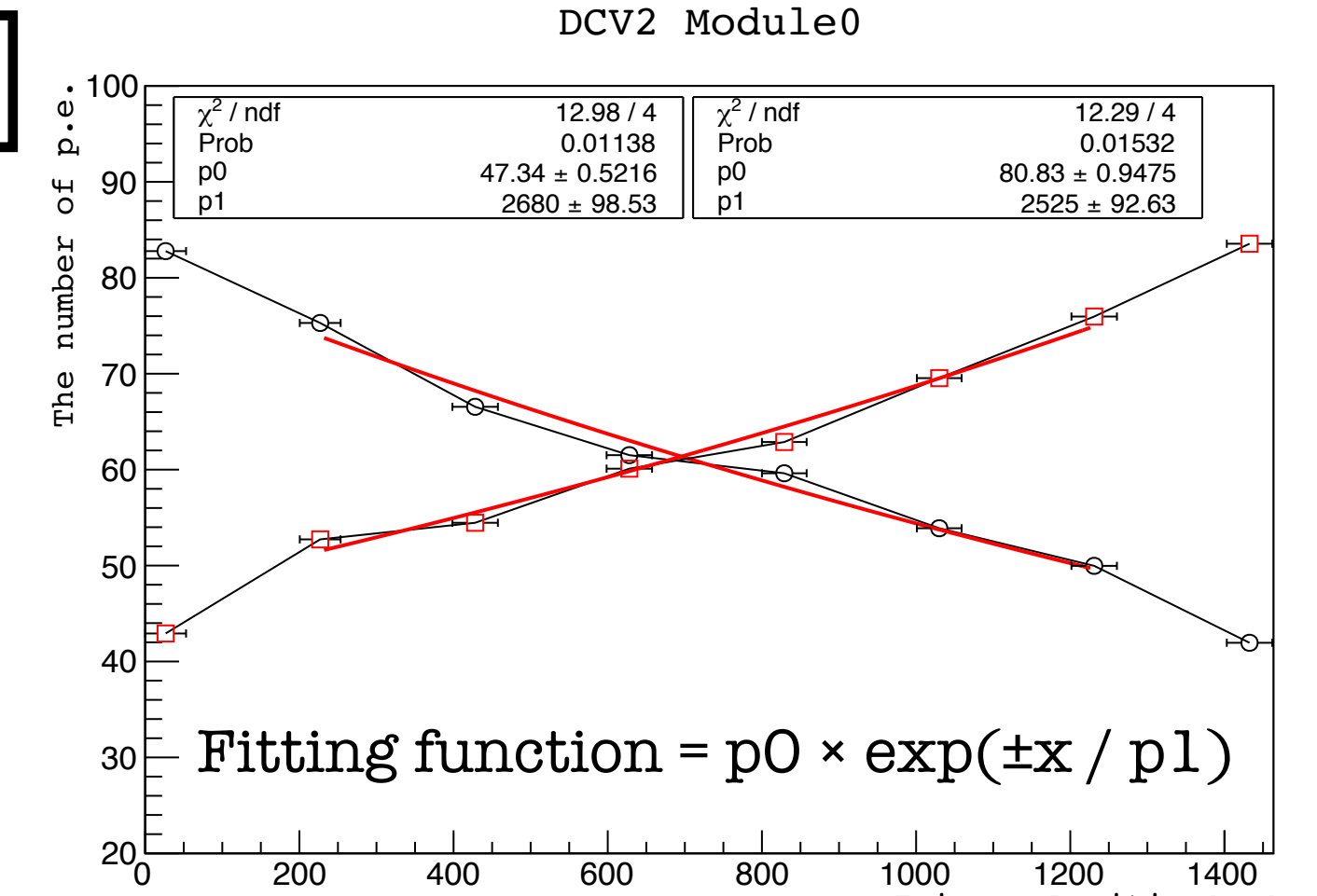
2. Fabrication Process

- Making the scintillator pipe

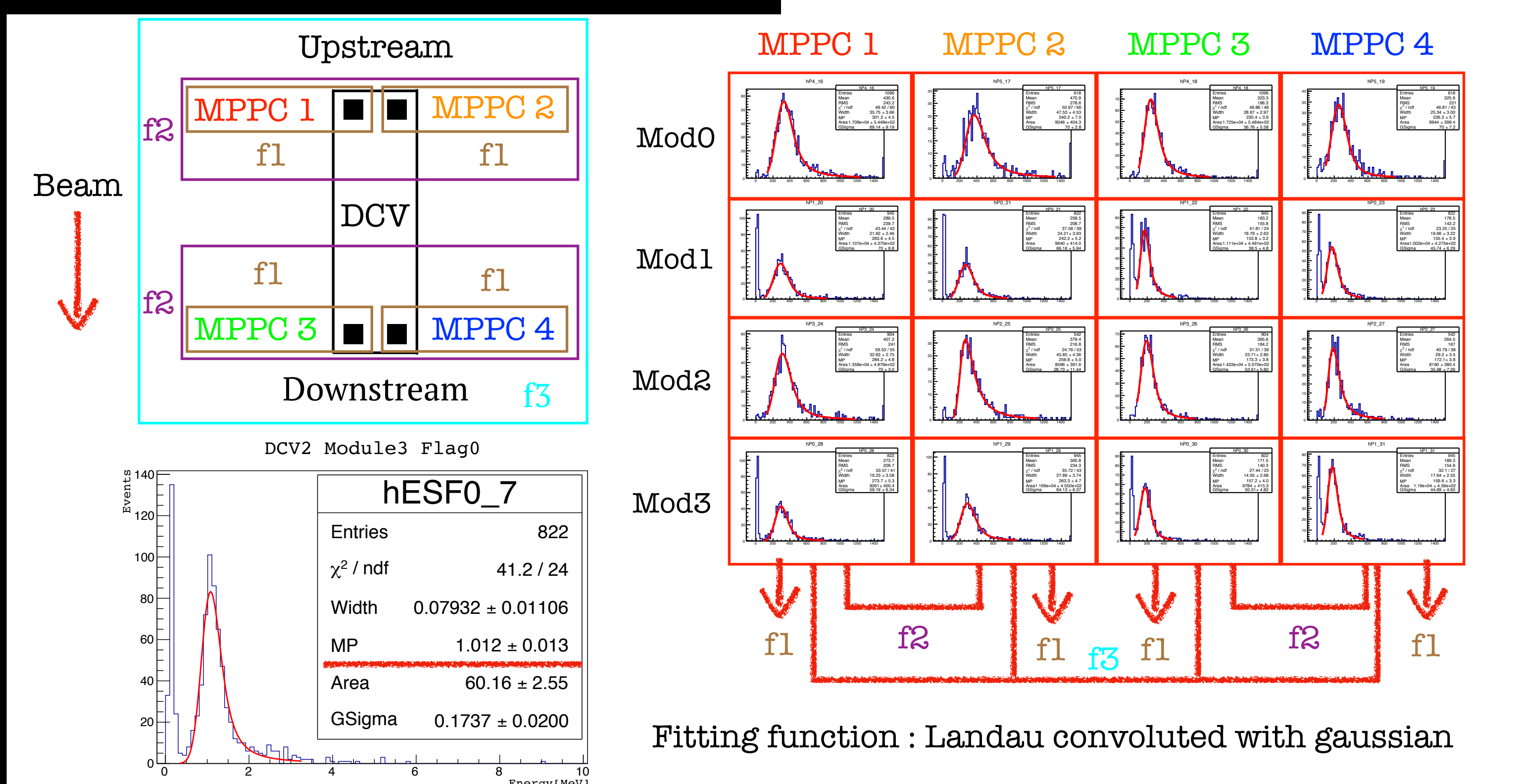


- Cosmic ray test

- We measured the P.E. using cosmic ray at 8 trigger positions.
- P.E. for 1 MeV at center point. 60.15(DCV1), 58.62(DCV2)
- Attenuation length 2469.12±660.37 mm(DCV1) 2566.62±664.16 mm(DCV2)

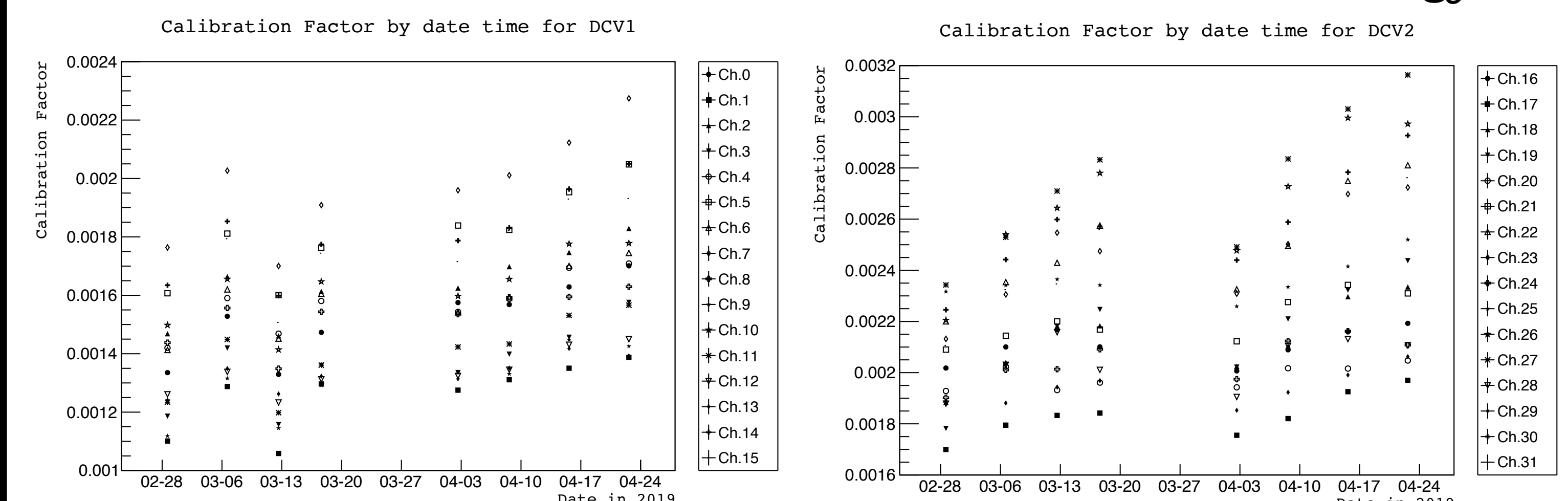


3. Beam Commissioning



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

- CC04 and CC05 (surrounding DCV) were used as trigger counter to calibrate with cosmic ray.
- 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 during the beam time.

4. 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.
- The result of cosmic ray analysis showed DCV got about 60 p.e.
- DCV has been successfully installed at KOTO.
- The calibration of DCV was completed using the cosmic ray.
- Analysis for stability of DCV performance is ongoing.