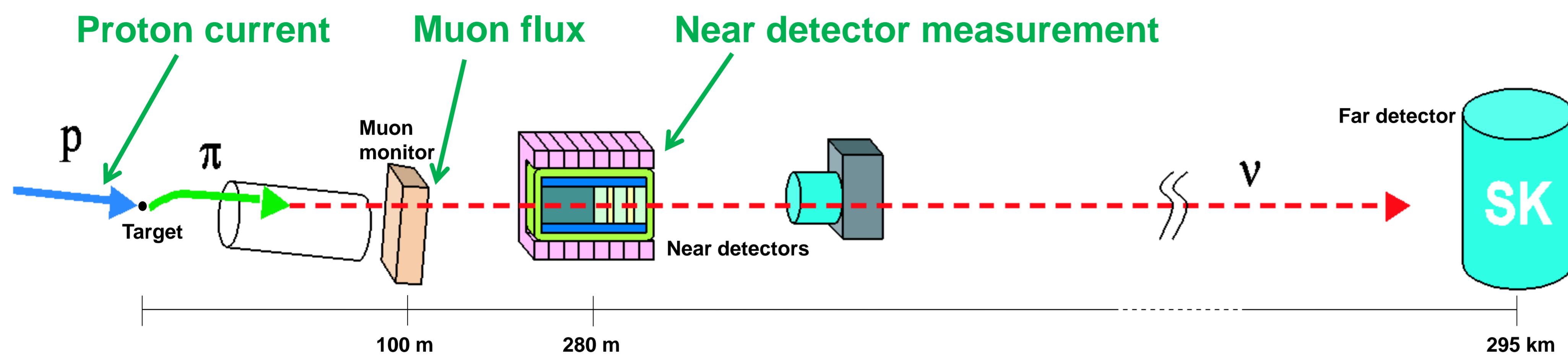


# A test experiment to measure neutrino energy spectrum at on-axis direction of J-PARC neutrino beam

Hiroshi Kaji (RCCN, ICRR, University of Tokyo)  
on behalf of the LEM collaboration

**Original  $\nu$ -flux measurement is important for the neutrino oscillation analysis.**

The flux is determined with following information at T2K experiment.



**The multilateral analysis is needed for the  $\nu$ -flux understanding.**

Each measurement is not enough to measure  $\nu$ -flux, alone.

- The estimation from proton current is affected by the model dependence on hadron productions.
- There is no sensitivity to low energy  $\nu$ -flux in the muon flux measurement.
- The  $\nu$ -beam angle covered by near detector is different from that of Super-K (and also Hyper-K).

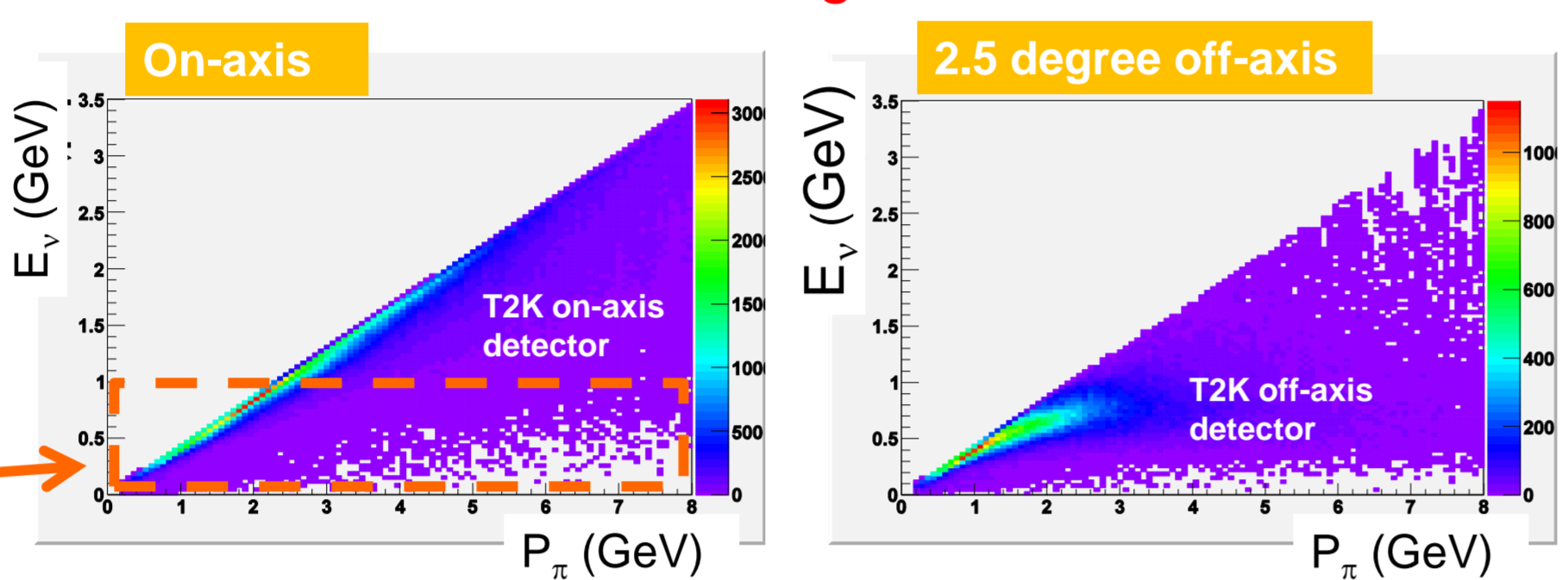
**Our experiment also provide input for this analysis.**

**The  $\nu$  flux and spectrum measurement in  $E_\nu < 1\text{GeV}$  and on-axis direction**

There is good correlation between  $\nu$  energy and hadron momentum in on-axis direction. Measurement in on-axis is important information for understanding the  $\nu$  beam.

- However ...
- No energy spectrum measurement in the on-axis of J-PARC  $\nu$ -beam.
  - No sensitivity in  $E_\nu < 1\text{GeV}$  region by T2K on-axis detector.

**The LEM detector takes care of this part.**

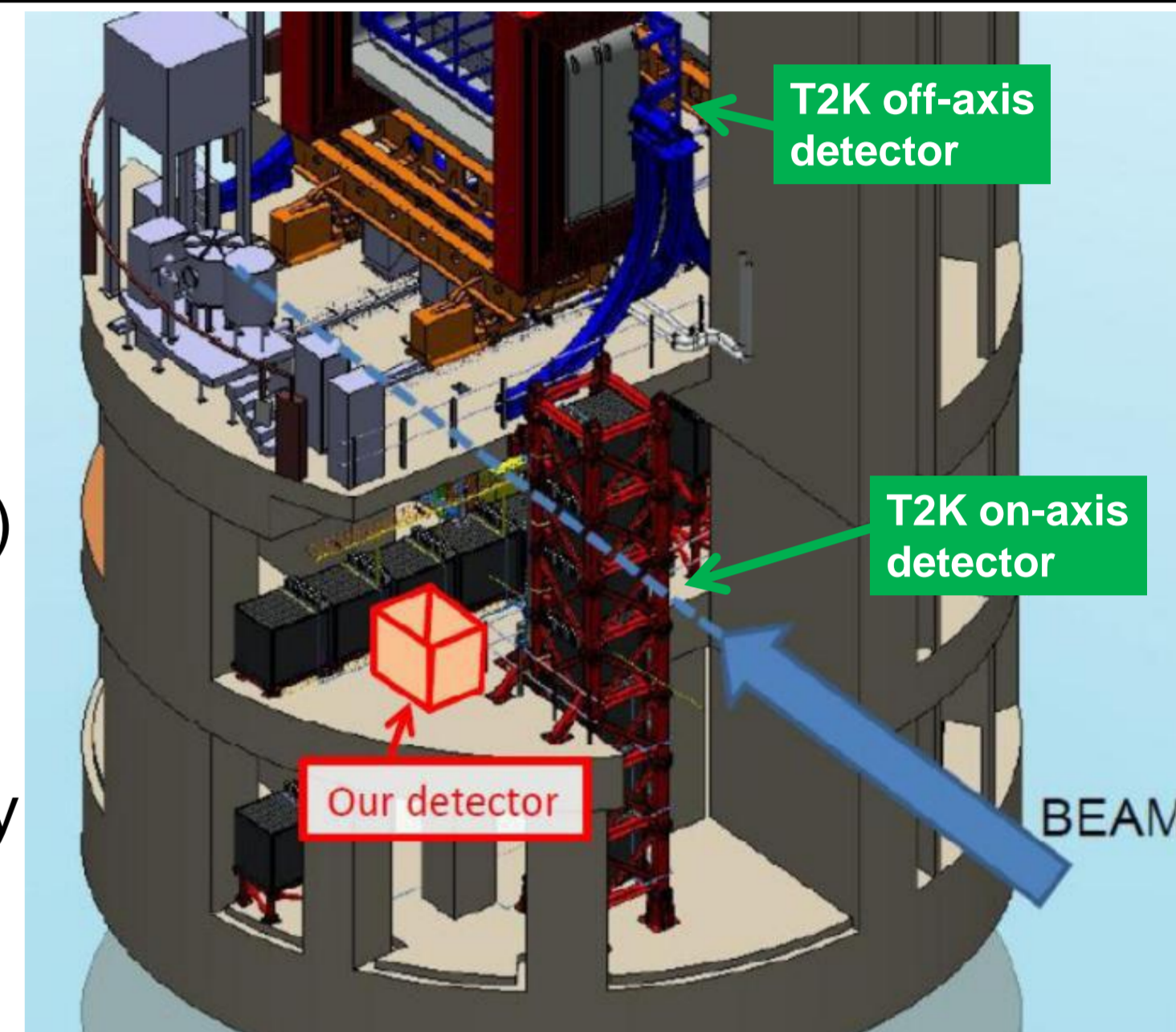


**Install new detector at the ND280 hall**

The LEM detector is placed on the landing space of SS-floor. (The same floor as T2K's on-axis detector.)

The installation in 2011 summer is approved by J-PARC PAC and KEK.

The measured direction is 0.5 degree away from beam center, however, still good correlation is expected.



**The LEM detector (Low Energy Module)**

**120x120x120 cm<sup>3</sup> size module. Iron and scintillator plates are placed alternately.**

**The scintillator is divided into horizontally or vertically to obtain hit position information. The scintillating lights are collected by wave length shifting fibers.**

**The  $\nu$  flux is determined by counting  $\nu$  interaction.**

Charged Current Quasi-Elastic (CC QE) Scattering

**The scattered  $\mu$  is detected by this module.**

**Readout system**

**64ch PMT (H8804-200)**  
QE : 25% at 500nm  
3layer/PMT

**clear fiber**

**20 clear fibers**

**60**

**64ch MaPMT**

**DAQ board**

**Computer**

**GPS**

**Computer**

**Ether net connection to Computer**

**NIM type DAQ board (OPERA-ROC system)**  
xxx MHz clock  
⇒ Timing resolution: ~10 ns  
8 bit ADC  
Power supply for PMT  
Operated by Inner/outer triggers  
LED for gain calibration

**A counter plane**

**WLS fiber**

**20 scintillator bars in an aluminum box**

**Intermediate cookie box for 3 counters**

**This system is well established by the OPERA experiment.**

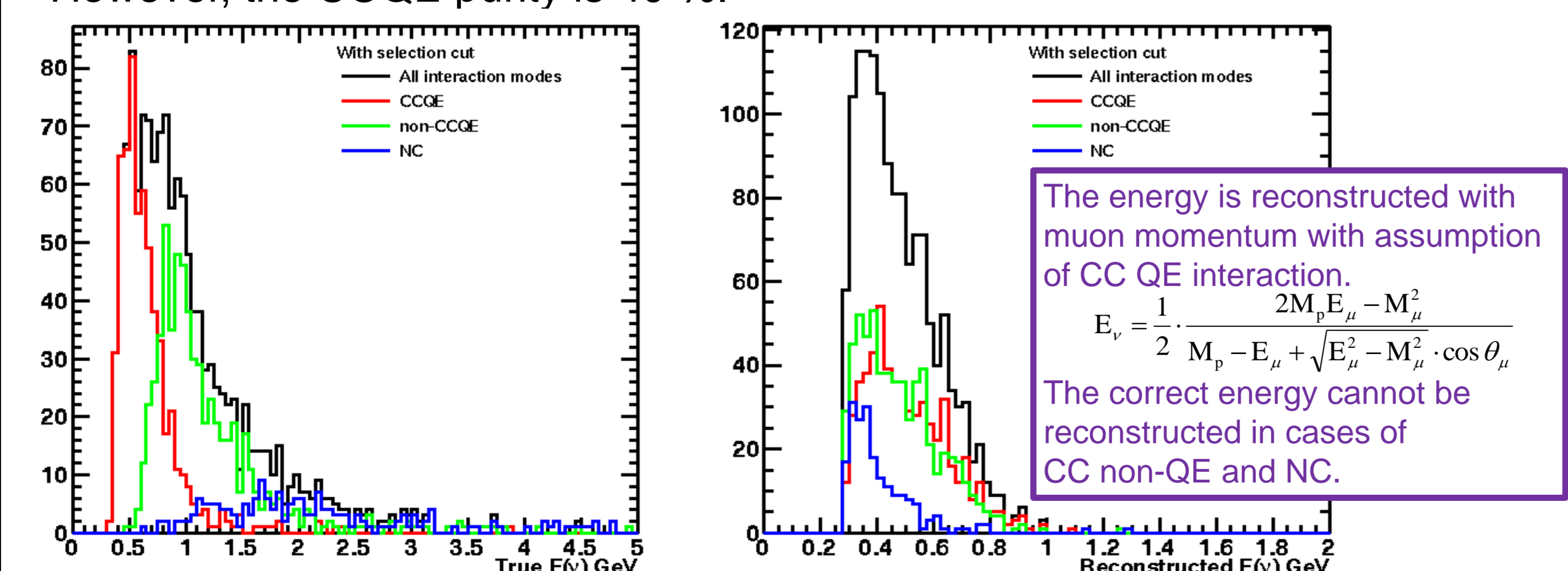
**Experiment schedule**

- Prepare all materials until the end of March 2011.
- Iron planes and support structures of detector (ICRR)
- Scintillator planes (Bern)
- DAQ boards (Lyon)
- Detector assemble during April – June 2011.**
- Installation during July – September 2011.**
- The experiment starts from October 2011.**
- The  $1.5 \times 10^7$  sec (6 month) operation is planned.**

**Expected data sample**

This estimation is assumed the p-beam power in the J-PARC's 2010 operation (50kW). The beam power will be improved in next year.

- The 2600 events after selection is expected.
- However, the CCQE purity is 40 %.



**The CC QE distribution is needed for energy spectrum measurement.**

**Statistical evaluation of CC QE distribution**

(example of offline analysis)

Following function is fitted to data and the CC QE contribution,  $P_1$ , is determined.

$$F(\text{PE}_{\text{tail}}, \cos \theta_\mu) = N_{\text{obs}} \cdot (P_1 \cdot F_{\text{CCQE}}(\text{PE}_{\text{tail}}, \cos \theta_\mu) + P_2 \cdot F_{\text{nonCCQE}}(\text{PE}_{\text{tail}}, \cos \theta_\mu) + (1 - P_1 - P_2) \cdot F_{\text{NC}}(\text{PE}_{\text{tail}}, \cos \theta_\mu))$$

The 2D function for  $\text{PE}_{\text{tail}}$  and  $\cos \theta_\mu$  distributions is made by MC sample. The fitting is implemented to each energy region to extract energy distribution.

