KOTO status and plan

- Quick report on February run
- Plan

Tadashi Nomura

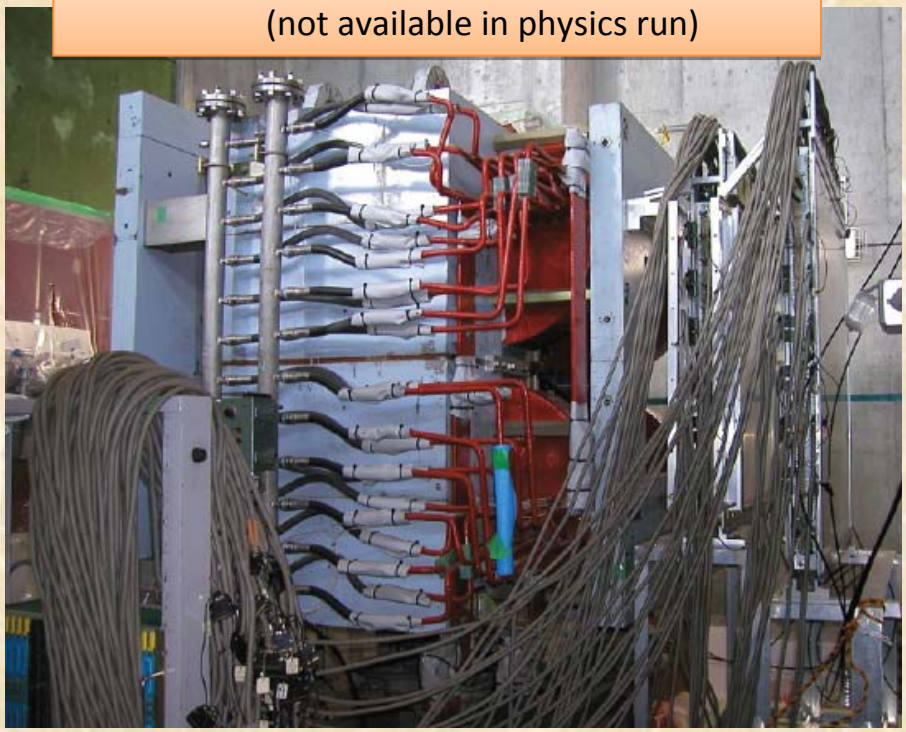
(KEK)

KOTO in February run

- Checked collimator alignment (after the earthquake)
- Studied on calorimeter calibration methods
  - Cosmic ray: MIP
  - $K_L \rightarrow \pi e \nu$: e^+/e^- with known momentum
  - $K_L \rightarrow 3\pi^0$: $M(6\gamma)=MK_L$, 3pairs of $M(2\gamma)=M\pi^0$

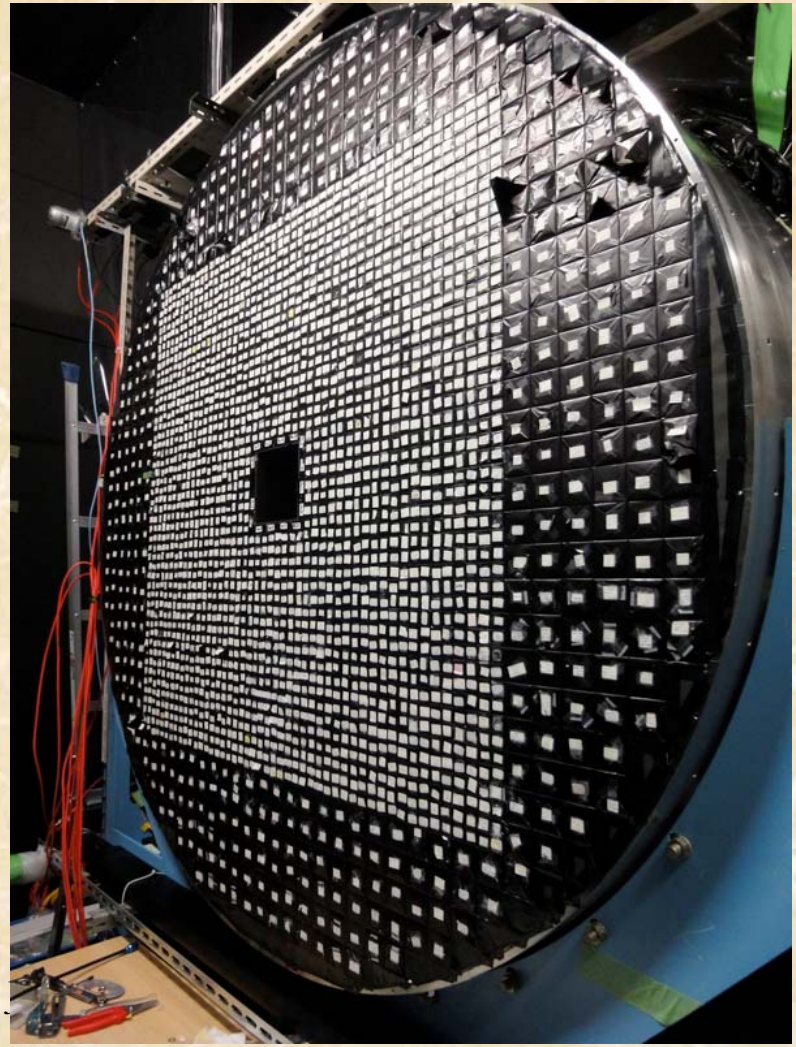
compare

Spectrometer for calibration purpose
(not available in physics run)



KL beam

KOTO CsI calorimeter

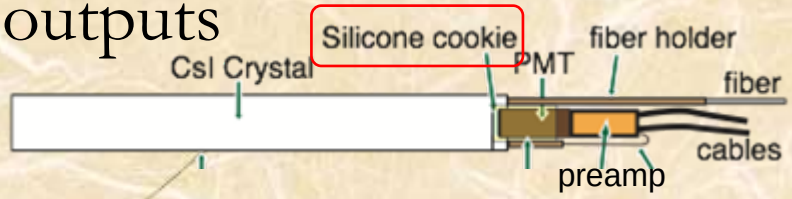


Statistics in February run

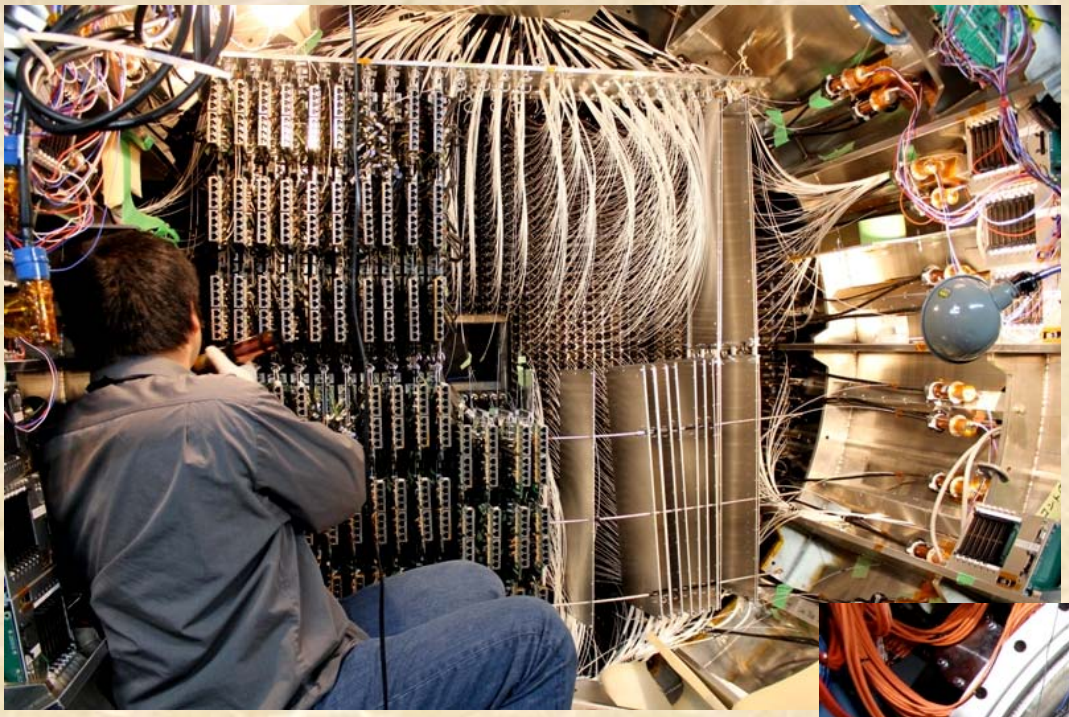
- MR beam power for users
  - 1kW for startup 5 days + 0.5*5 days (0.5 for MR study)
  - 3.3 kW for stable run ~10 days
- Allocated time for each run
  - Ke3 ~4 days + 1.5 days (1kW)
  - K3π^0 ~5 days + 0.5 days (1kW)
  - Al plate in beam ~6 hours ← π^0 production in the neutral beam
  - + Collimator alignment (during 1kW),
    trigger study, accidental activity studies, …

Calorimeter in February run

- In the middle of works to fix problems
  that we found in the vacuum test in September 2011
  - A half of modules still had damaged cookies.
    → They have smaller light outputs



  - PMTs for large crystals in top and bottom regions were not installed.
    → small crystals: all 2240 blocks were read out.
    large crystals: 236 of 476 blocks were read out.



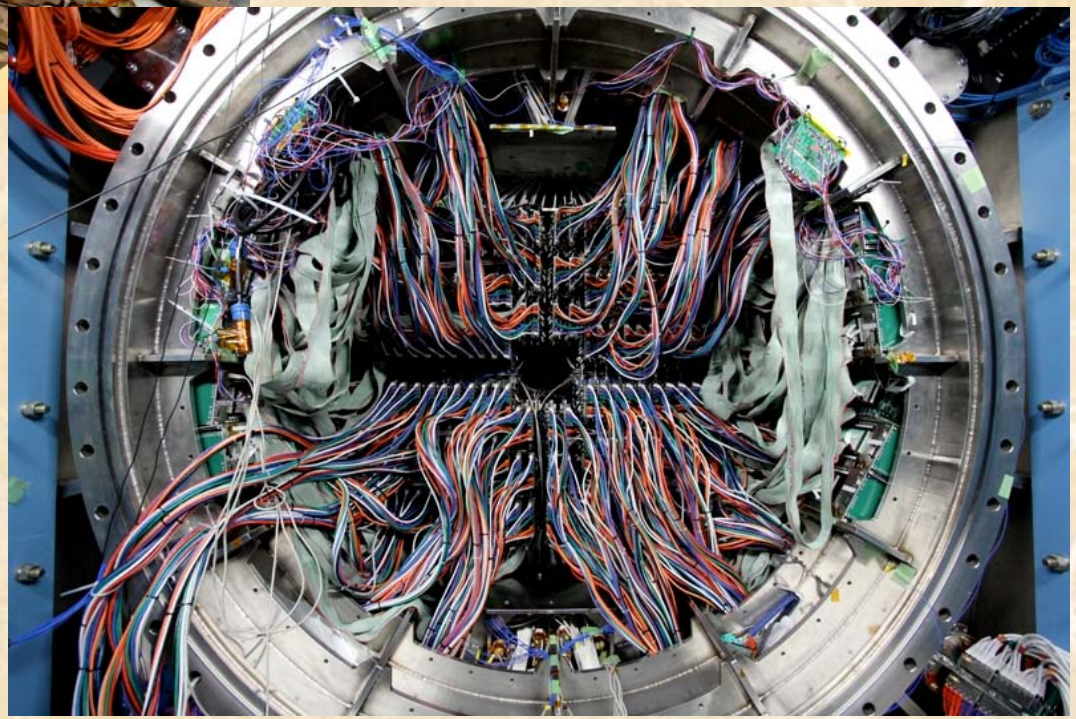
End of Dec 2011

- A part of PMTs was unmounted
- Items were being cleaned up

During January,

- Optical cookies were partially replaced
- Most of PMTs were re-installed →

Just before Feb 2012 run



Calorimeter in February run

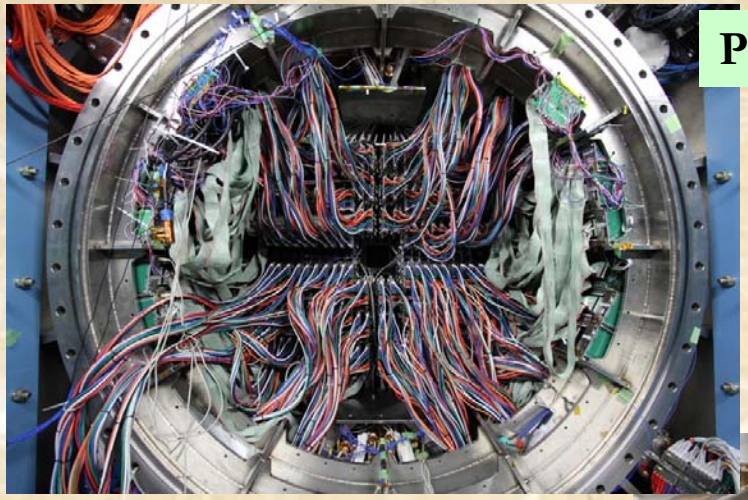
- Trigger
  - Level 1 trigger system was implemented
    (We use this system in the physics run)

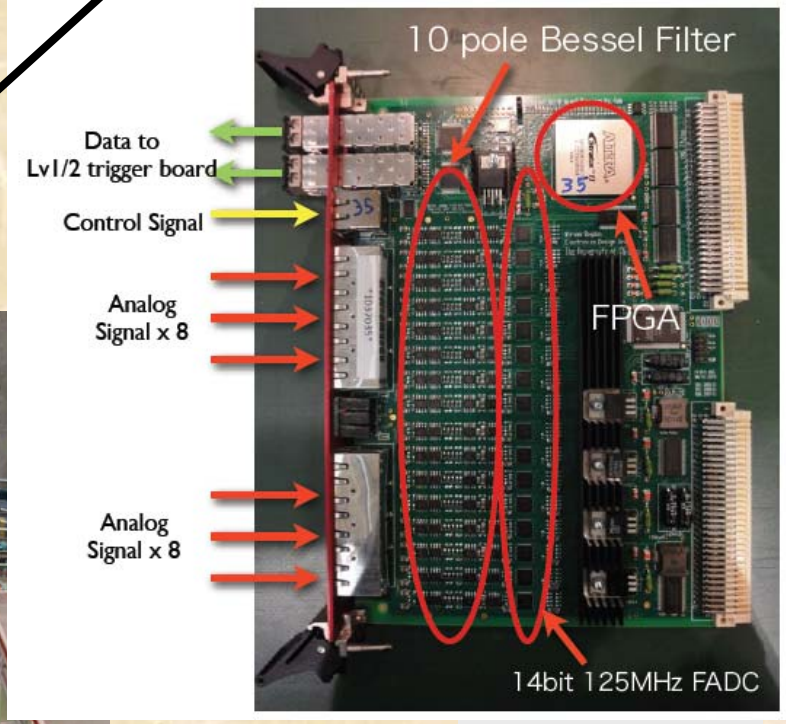
This enabled us to develop better trigger logic for K3π^0 run
→ We could collect K3π^0 much faster than we estimated.

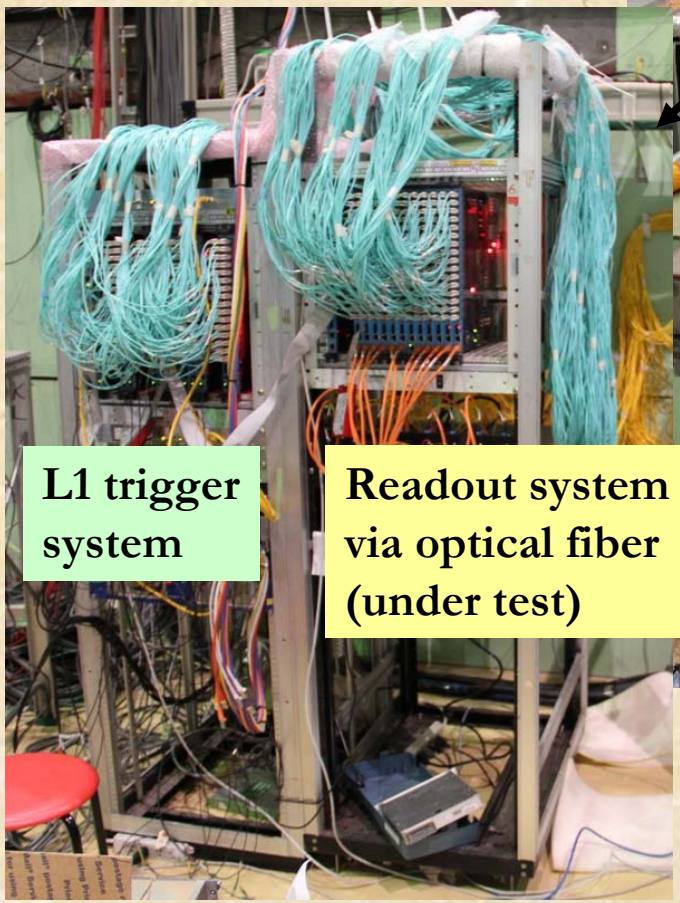
- DAQ
  - Readout via VME-bus was used
    (instead of KOTO readout via optical fibers)

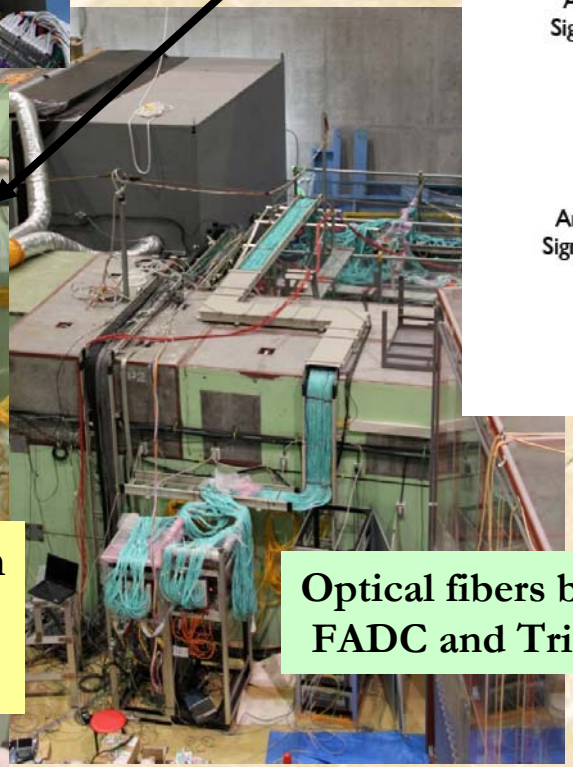
    → This limited the DAQ rate to ~500Hz

PMT + preamp → Flash ADC









L1 trigger system

Readout system via optical fiber (under test)

Optical fibers between FADC and Trigger boards

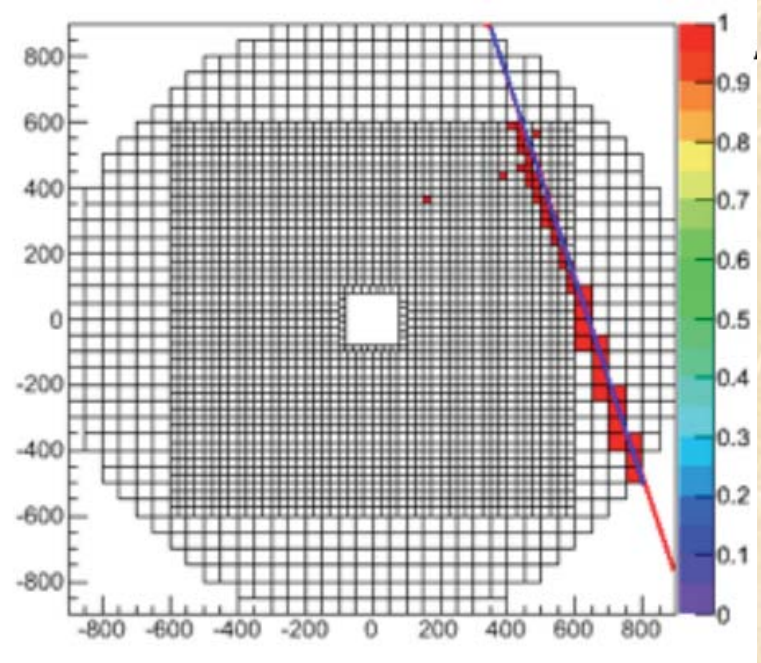
Readout via VME bus

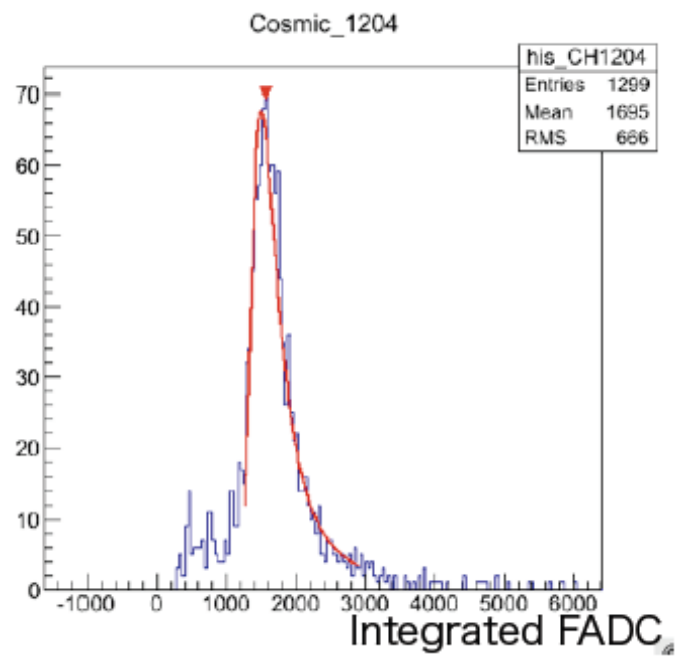
PC cluster

KEK computing center

Calibration 1: with cosmic rays

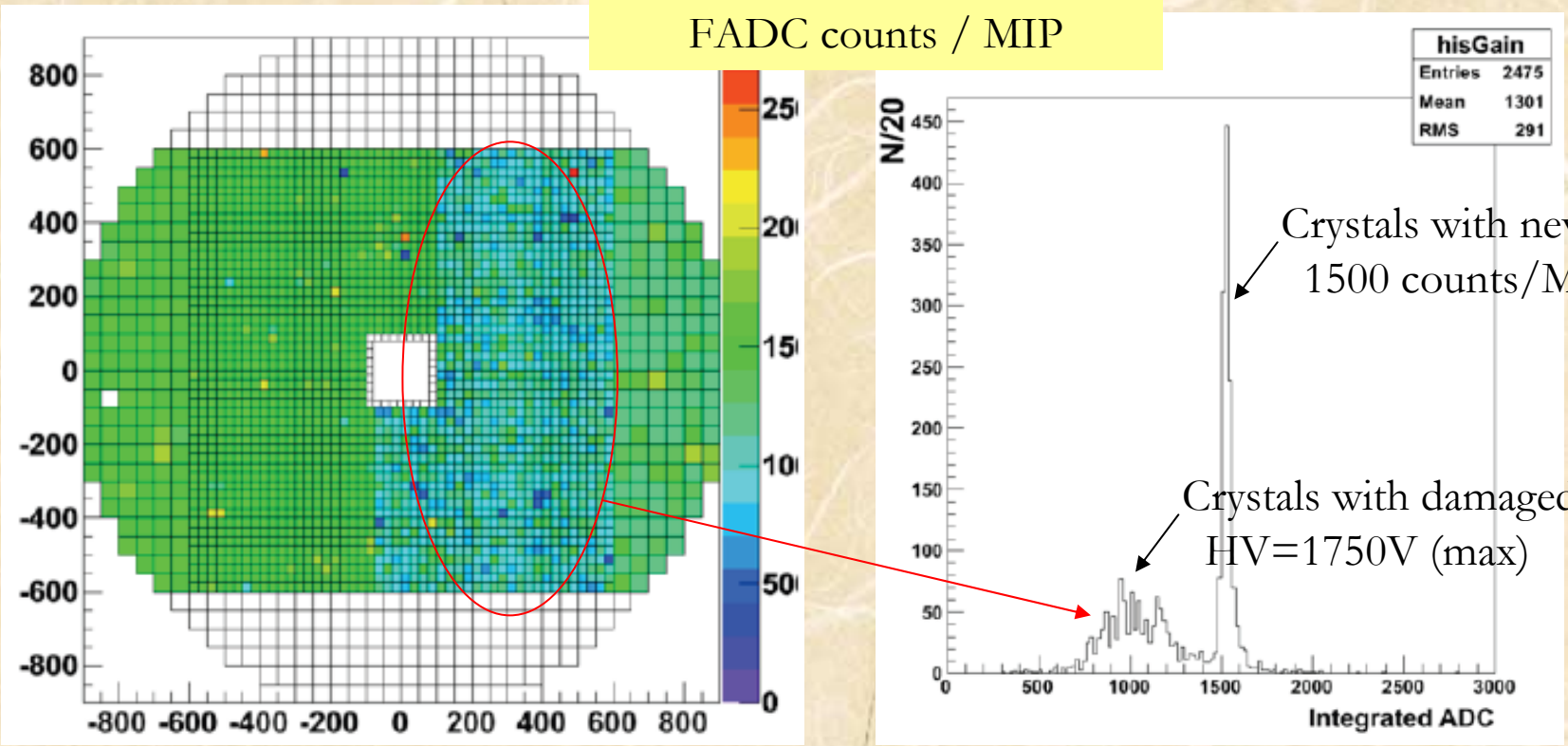
- Tracking by pattern recognition
  - Confirm path length in a crystal
- Obtain the peak for MIP





Calibration 1: with cosmic rays

- Gains were mostly adjusted before the beam time

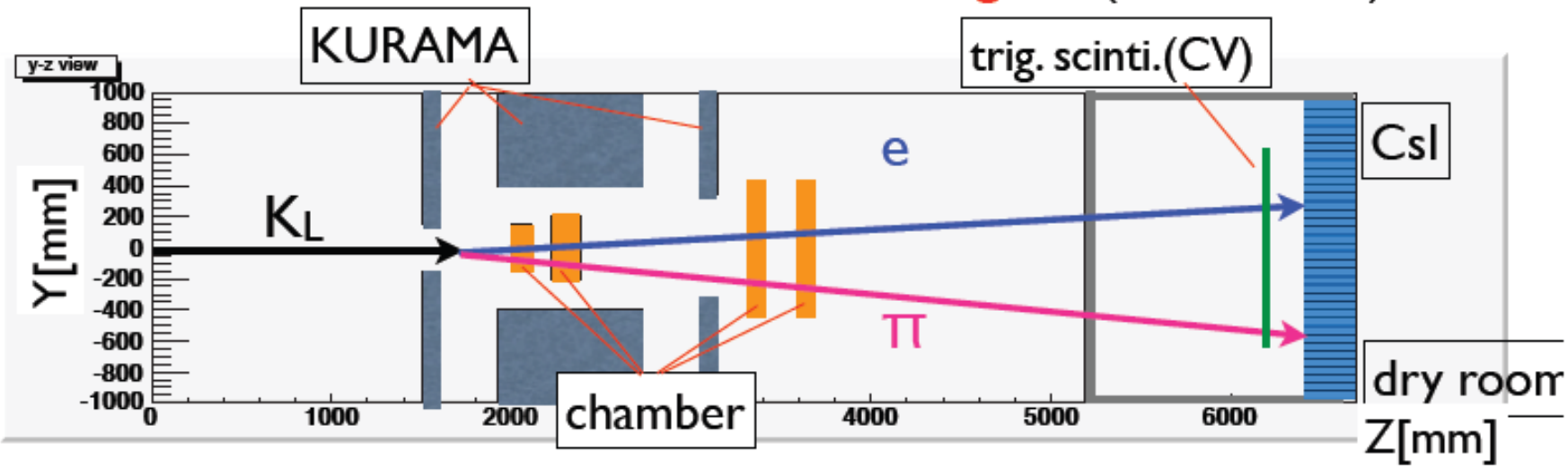


Calibration 2: with Ke3

method, setup

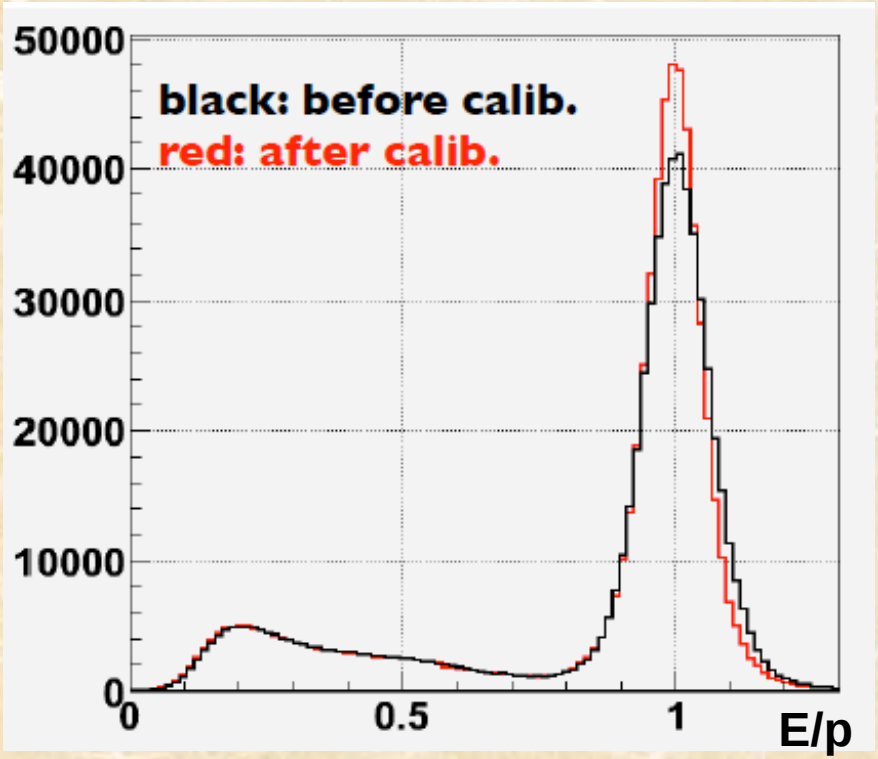
★track e and π by 4 chambers

★P_e and P_π are measured with 0.7 T magnet (KURAMA)

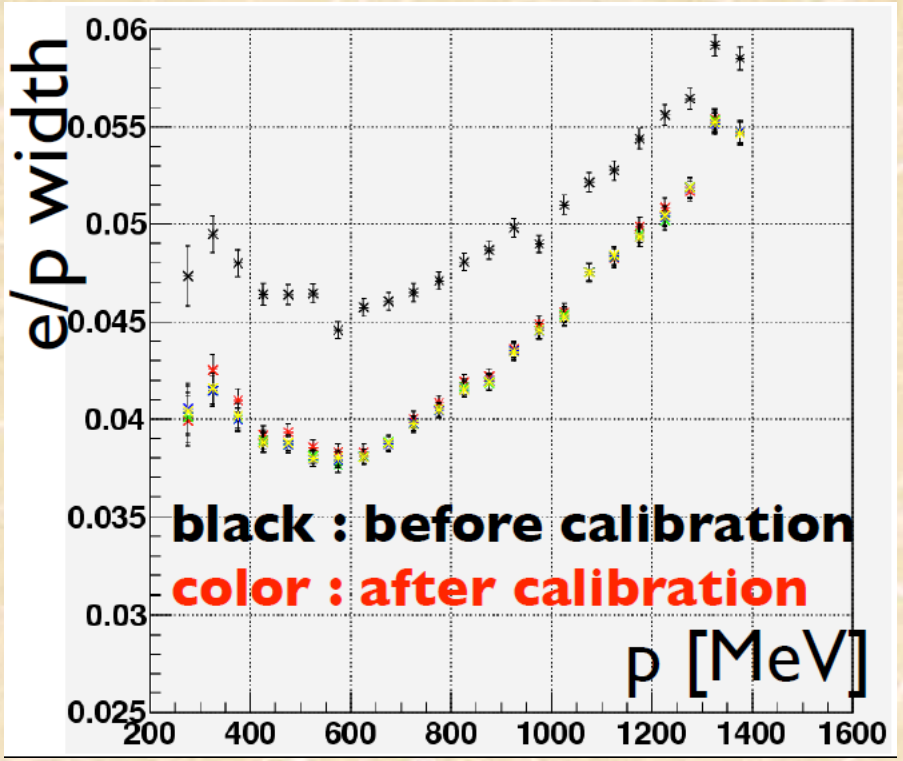


Calibration 2: with Ke3

Gain factors of crystals were obtained by aligning E/p to 1



(after selection cuts for electron)



(with temperature correction)

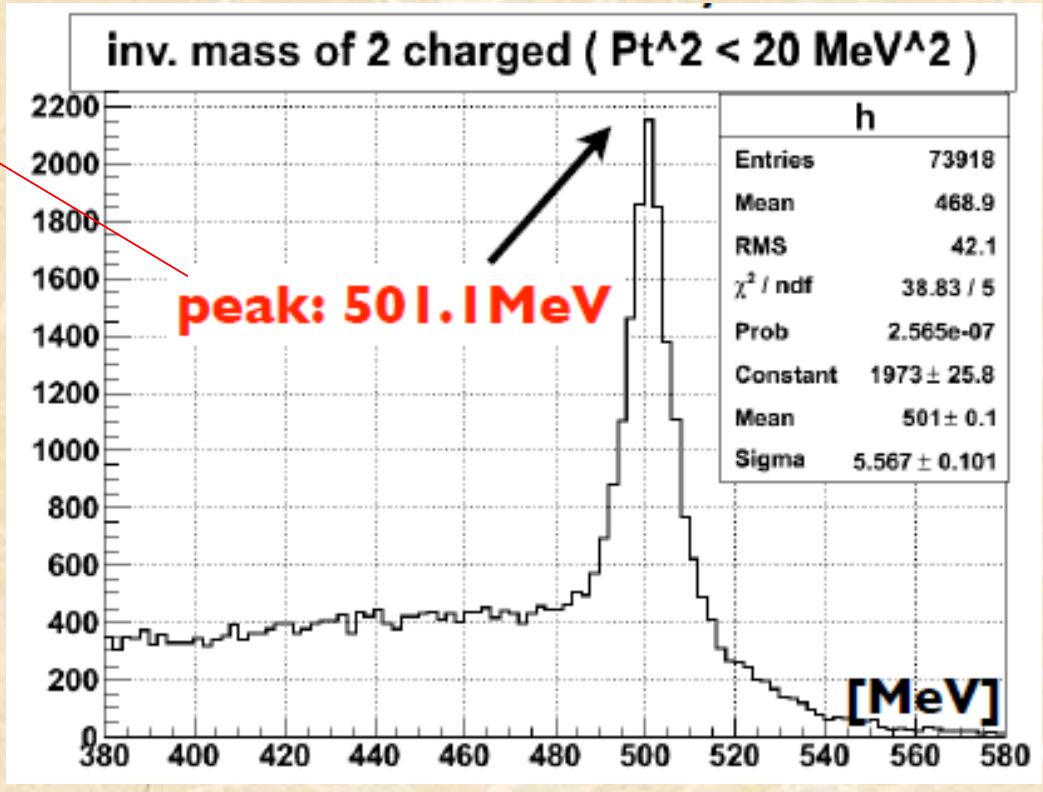
- Collected ~500K electrons.
- Detailed analysis is in progress.
  (subtract contribution of momentum resolution (next slide), etc…)

Calibration 2: with Ke3

Evaluate spectrometer performance with $K \rightarrow \pi^+\pi^-$

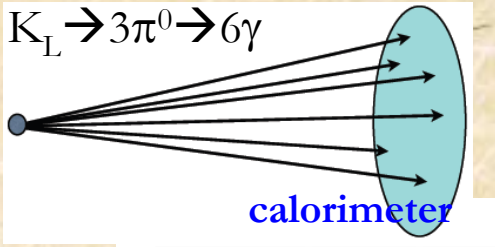
- Accumulated ~7.5×10^3 $K_L \rightarrow \pi^+\pi^-$ candidates

This corresponds to …
momentum scale was 1.1% high
→ Scale correction
(already applied in E/p plot)

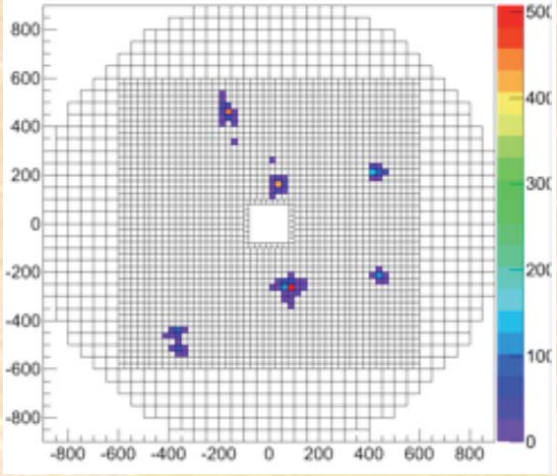


The width, contributed from momentum resolution, is now being evaluated.

Calibration 3: with $K_L \rightarrow 3\pi^0$

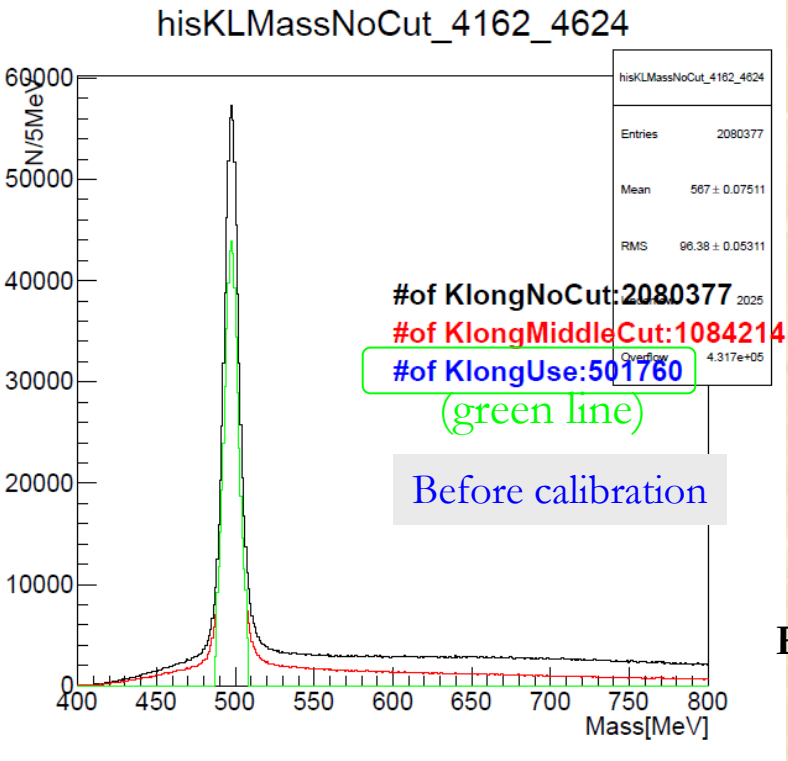


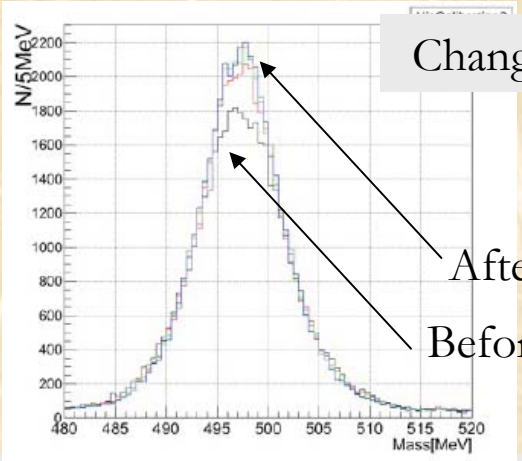
- Calibration by using constrained fit
  - 18 observables (Eγ, x, y of 6 photons)
  - 3 unknown parameters (vertex x,y,z)
  - Constraints:
    - 3 pairs of photons which have π^0 mass
    - Mass of 6 photons equals to K_L mass
    - Momentum balance
  - When being calibrated,
    one of 6 Eγ-s is considered as a parameter and required gain correction factor to give the best fit is searched.



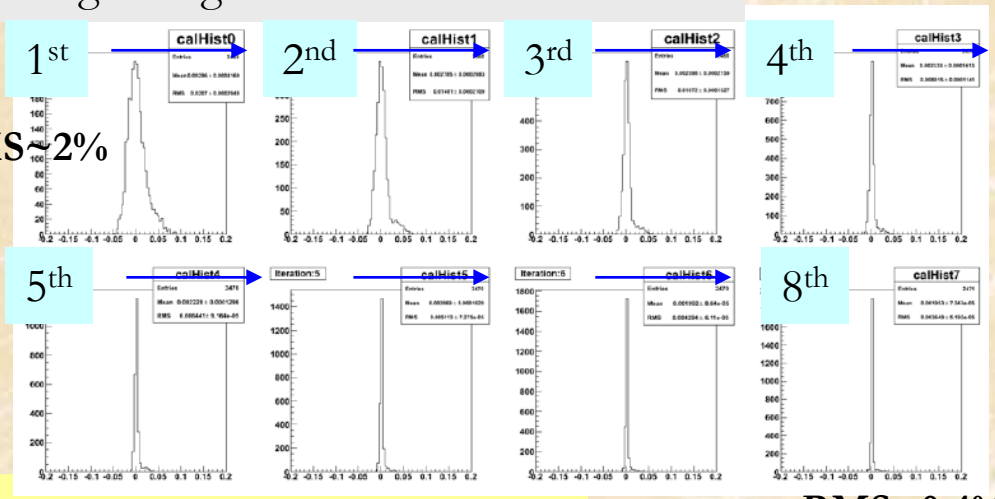
We used the same method used in KEK E391a experiment,
which developed for larger crystals (7cm2 x 30cm);
We've not optimized the method for KOTO crystals, so far.

Calibration 3: with $K_L \rightarrow 3\pi^0$





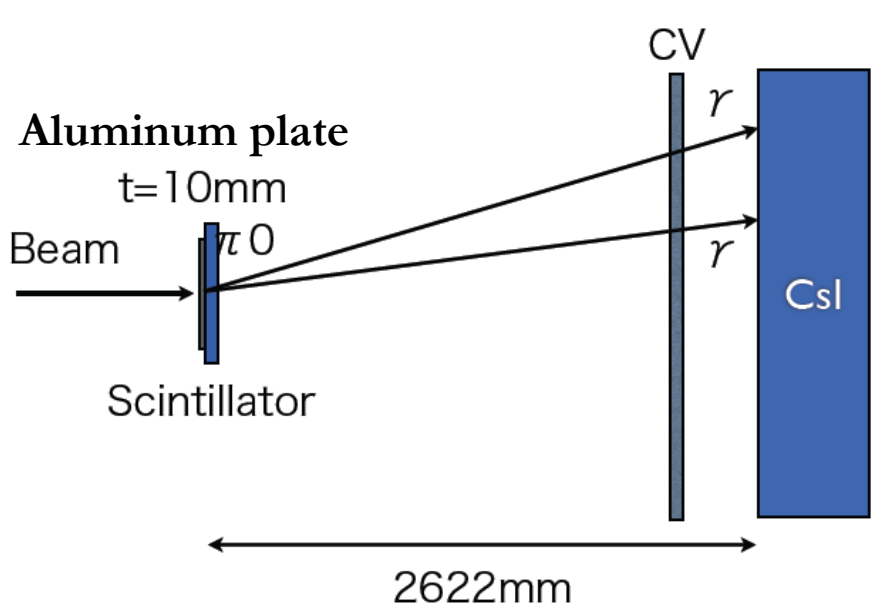
Changes of gain factors in each iteration

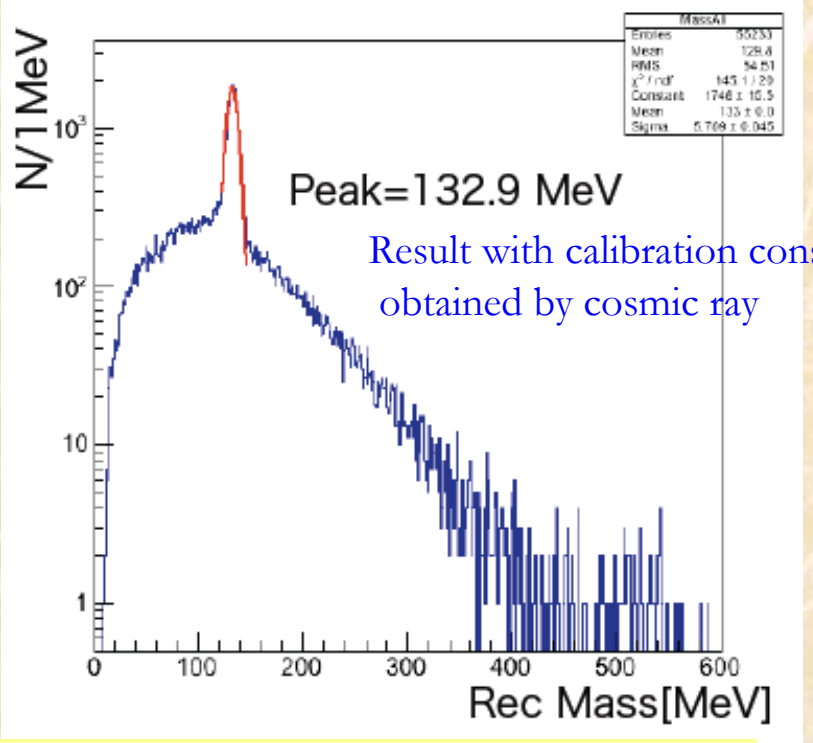


- Collected ~500K $K_L \rightarrow 3\pi^0$ candidates.
- Calibration method is being evaluated and optimized.

Calibration 4: Al plate in the beam

- Confirm a mass peak of π^0s
  which came from known interaction position

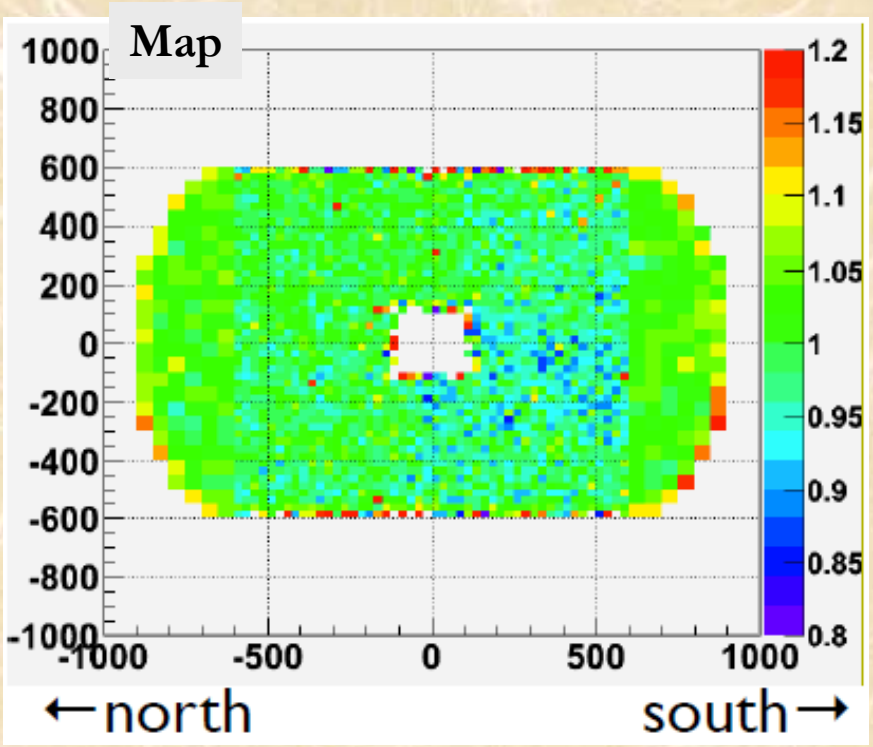


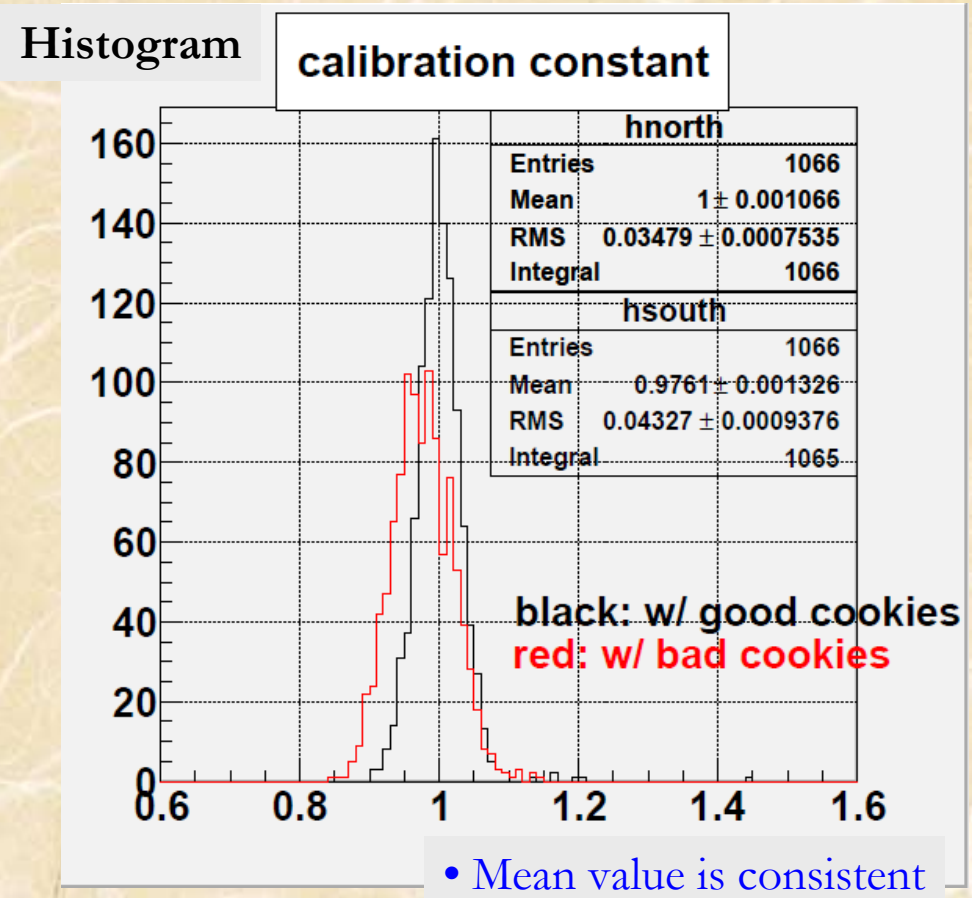


~40K π^0 candidates were accumulated. Detailed check is on going.

Comparison between Ke3 and cosmic rays

Ratio of Ke3 and cosmic ray results: C(cosmic)=1



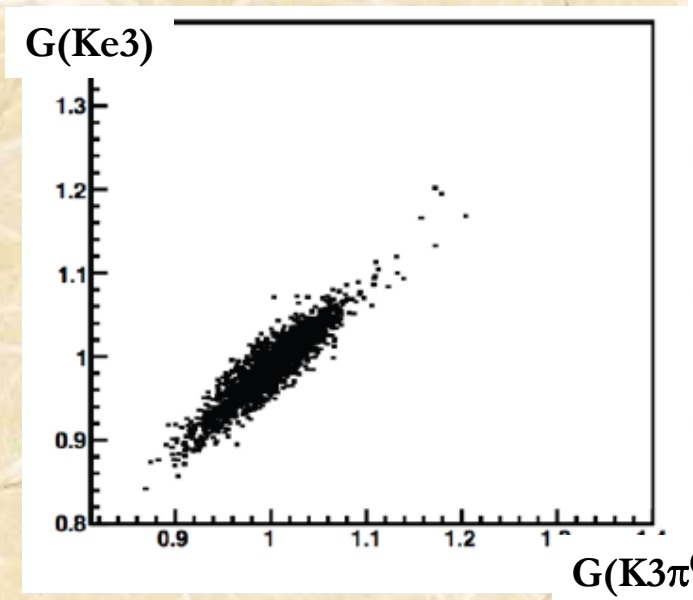


- Mean value is consistent
- RMS ~ 3.5%

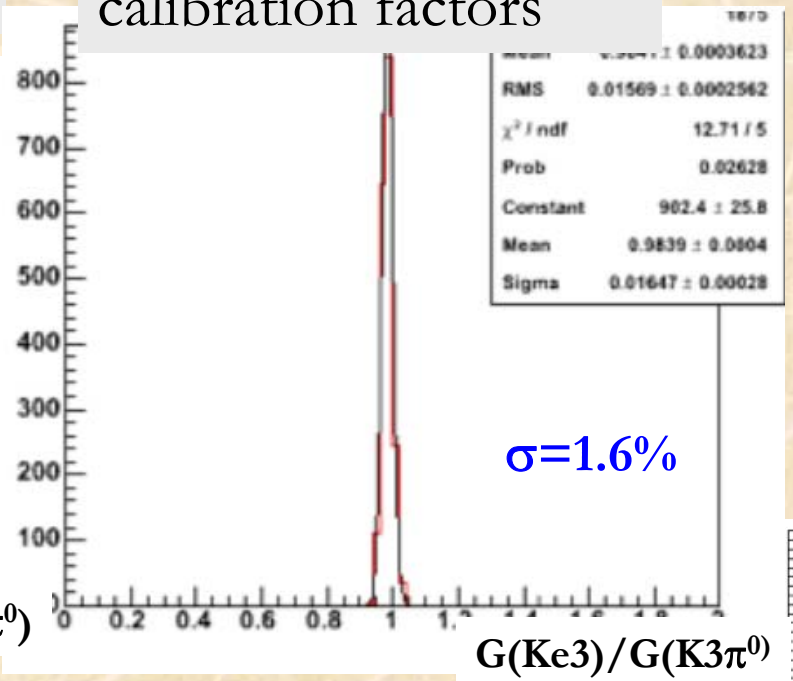
Absolute value with cosmic rays and Ke3 agreed well

Comparison between Ke3 and $K_L \rightarrow 3\pi^0$

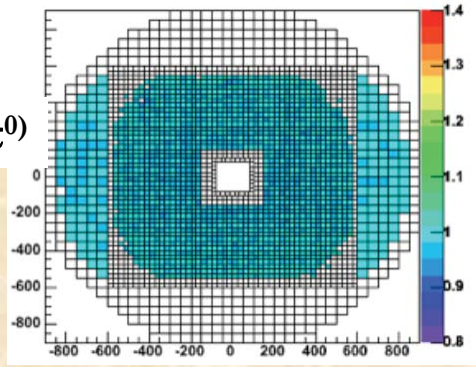
Calibration factors (G) obtained with Ke3 and $3\pi^0$



Ratio of Ke3 and $3\pi^0$ calibration factors



Only for crystals in fiducial region and with enough statistics →



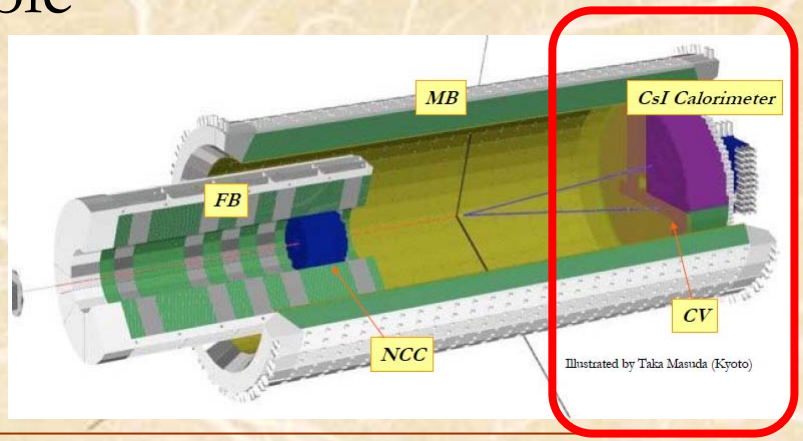
Quick comparison between Ke3 and $K3\pi^0$ showed good agreement

Plan in June, in 2012, and to early physics run

Snapshot in June

Inside KL area

- Spectrometer + KOTO end-cap part
  - Calorimeter : partially available
    - Works to fix "problems" continue
    - Full DAQ scheme will be ready
  - <u>CV : will be installed</u>



Outside of area

- "MB" photon-veto installation in progress
  parallel to beam use

Beam plan in June

(What we presented in PAC January 2012)

- February
  - 2~3 days to check beam shape and startup
  - 2 weeks for Ke3 (assuming 500/spill VME readout)

- ~~March or~~ June
  - 2 weeks for 3pi0 + Ke3
  - 1 week for pi0s produced run
  - 1 week for startup + CV tuning

Partially done or completed?
→ Need detailed analysis

and inefficiency study with chamber system

At this moment, we cannot show concrete requests…
→ trying to make it clear by mid April

Impact of June run on total schedule

- If we already have enough Ke3/K3π^0, and will turn on only specific region of the calorimeter
  → Full detectors are ready in November
- If we need more Ke3/K3π^0, and will turn on all the calorimeter modules
  → Full detectors are ready in December
- (If there is no beam in June
  → Full detectors are ready in November)

Further plan: early physics run

- Nov/Dec of 2012~ (10kW)
  - >2weeks: Engineering Run in air
  - >2weeks: Engineering Run in vacuum
- Spring 2013 : Commissioning & Physics run (beyond E391a)
- May~June, 2013 (~4weeks+): Physics run for the G.N. limit
- Summer: linac upgrade

No change
from PAC in January

10kW (and more) SX
in 2012 autumn - 2013 summer
is the key for KOTO.

We'd like ask to perform accelerator studies for SX in a timely manner.

(For instance, 5kW in June, 10kW in Oct-Dec, further in Jan-Mar 2013)

Preparation status of other detectors

Fabrication of CV scintillator + WLS fiber (Kyoto U)

Installation scheduled in May

Preparation status of other detectors

Transportation of middle section of vacuum chamber

(3.8m-diameter, 6m-long, 20-ton)

from KEK/Tsukuba to J-PARC/Tokai

Summary

- In February run, KOTO successfully accumulated
  - ~500K electrons (Ke3)
  - ~500K $K_L \rightarrow 3\pi^0$
  - ~40K π^0 candidates in Al-target run

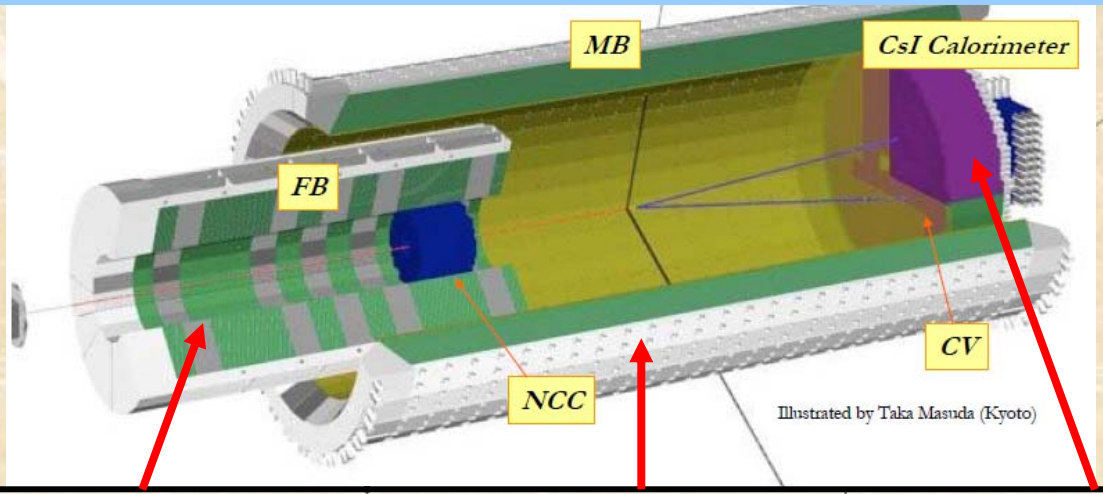
  ← Sufficient amount to play with, for now.

  ← Quick analysis showed the calibration with $K3\pi^0$ and cosmic rays seem to work.
- Plan in June depends on detailed analysis results

  ← We are trying to make it clear by mid April

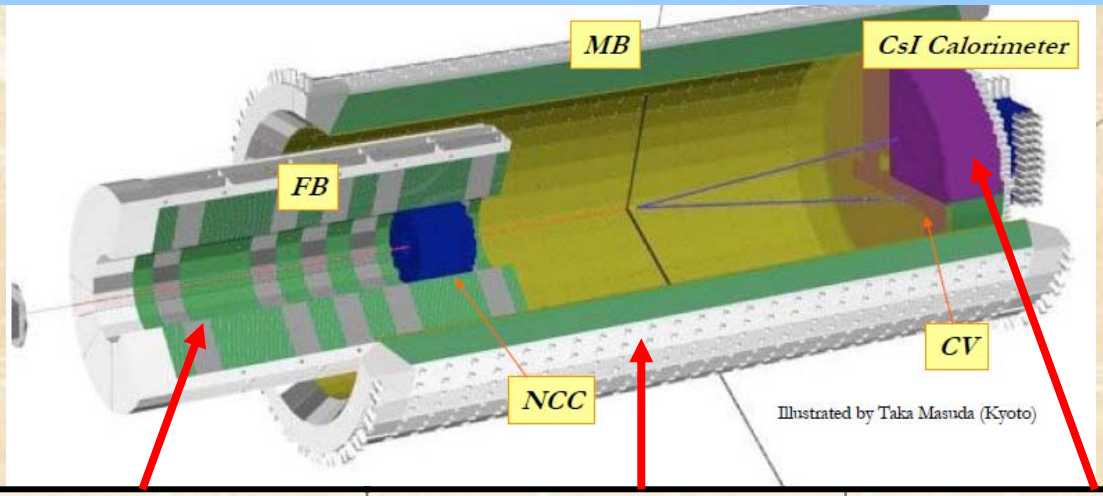
backup

If we have enough Ke3 and K3π^0 data and will turn on only specific region of the calorimeter in June



	Upstream/FB, NCC	Middle/MB	Downstream/CsI,CV	
3	NCC Fabrication	Check mechanics	Replace cookie, preamp	CV Fabrication
4				
5		Installation 1st		Install
6			SX beam	
7	Mount & check @ Kyoto	Installation 2nd (in KL area)	Replace …	
8			Re-install + check	
9	NCC & FB Installation		Vaccum test	
10	Combine 3 sections			
11	Engineering run with full detector			
12				

If we need to take Ke3 and K3π^0 further and will turn on all the calorimeter modules in June



	Upstream/FB, NCC	Middle/MB	Downstream/CsI,CV	
3	NCC Fabrication	Check mechanics	Replace cookie, preamp	CV Fabrication
4				
5		Installation 1st	Preparation	Install
6			SX beam	
7	Mount & check @ Kyoto	Installation 2nd (in KL area)	Replace cookie, preamp	
8				
9	NCC & FB Installation		Re-install + check	
10				
11	Combine 3 sections		Vaccum test	
12	Engineering run with full detector			