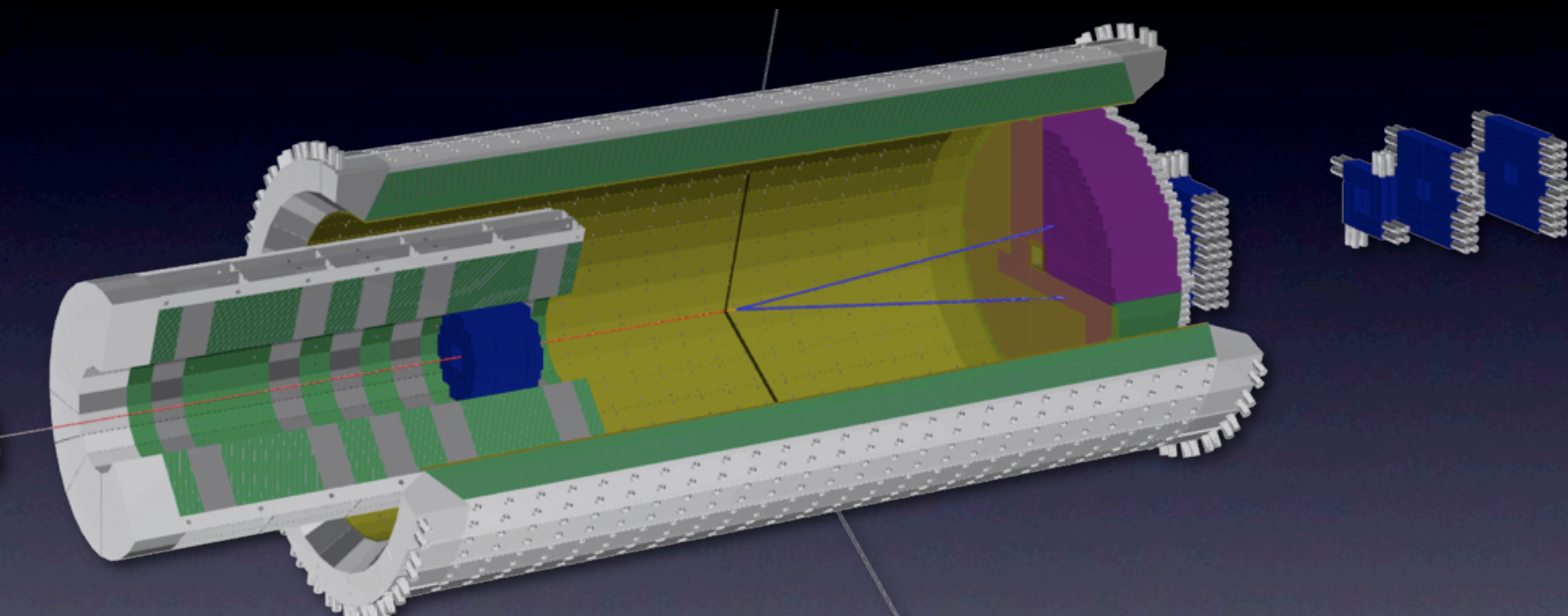
KOTO Detector status



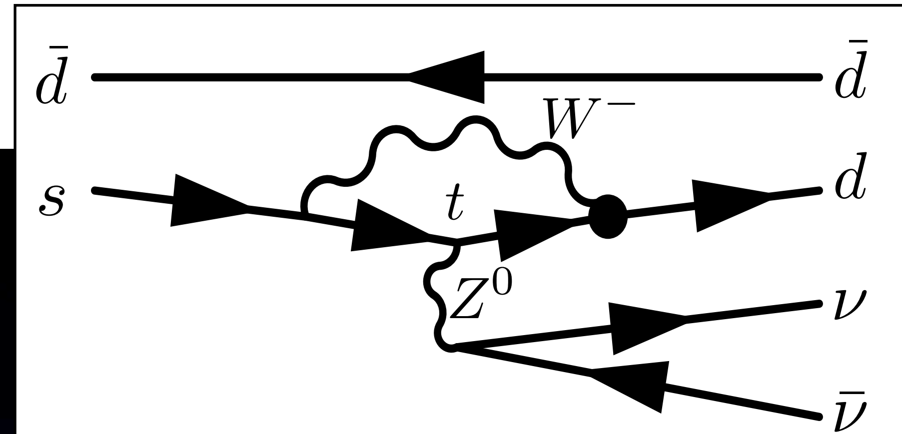
Takahiko Masuda (Kyoto Univ. JAPAN)
for the KOTO collaboration

2013.5.1 in KAON13 @ University of Michigan Ann Arbor

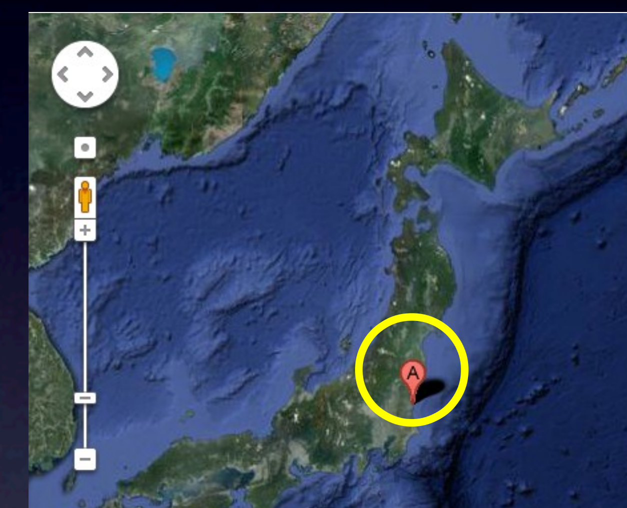
experiment

- $K_L \to \pi^0 \nu \bar{\nu}$
  - Directly breaks the CP symmetry
  - Sensitive to CPV new physics
    - Rare decay
      - SM prediction 2.4×10^{-11}
    - Loop diagrams
    - Small theoretical uncertainty (2.5%)

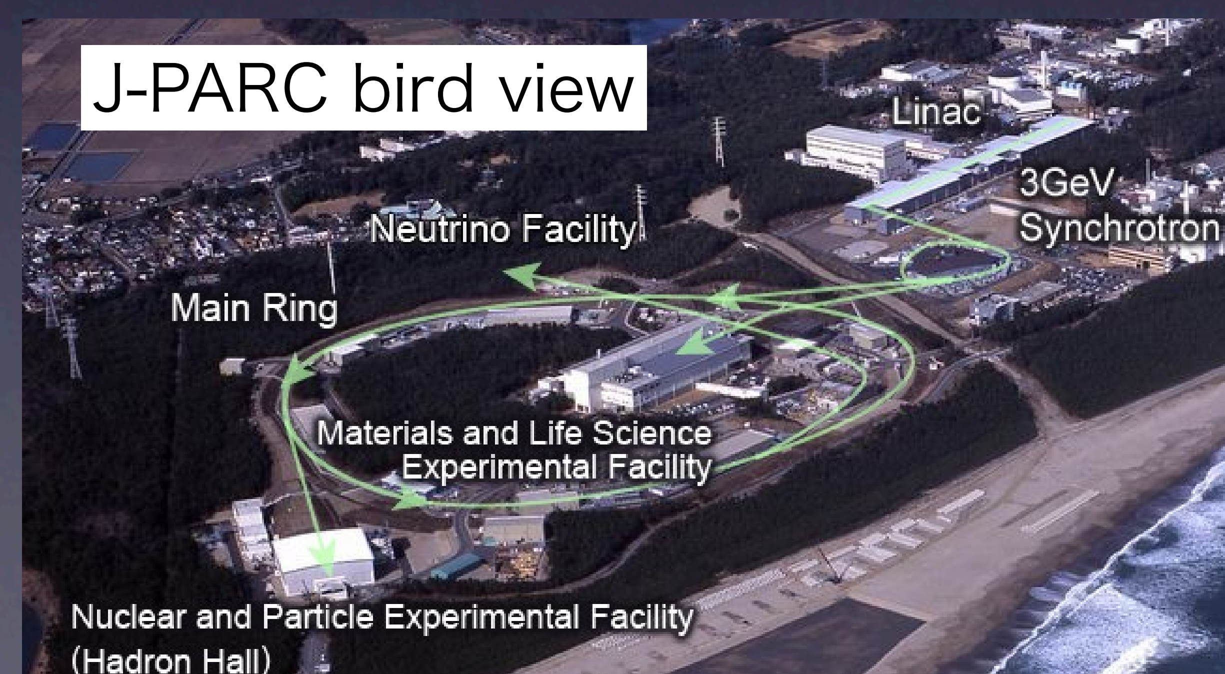
J. Brod et al., PRD **83**, 034030 (2011)



A Feynman diagram of the decay.

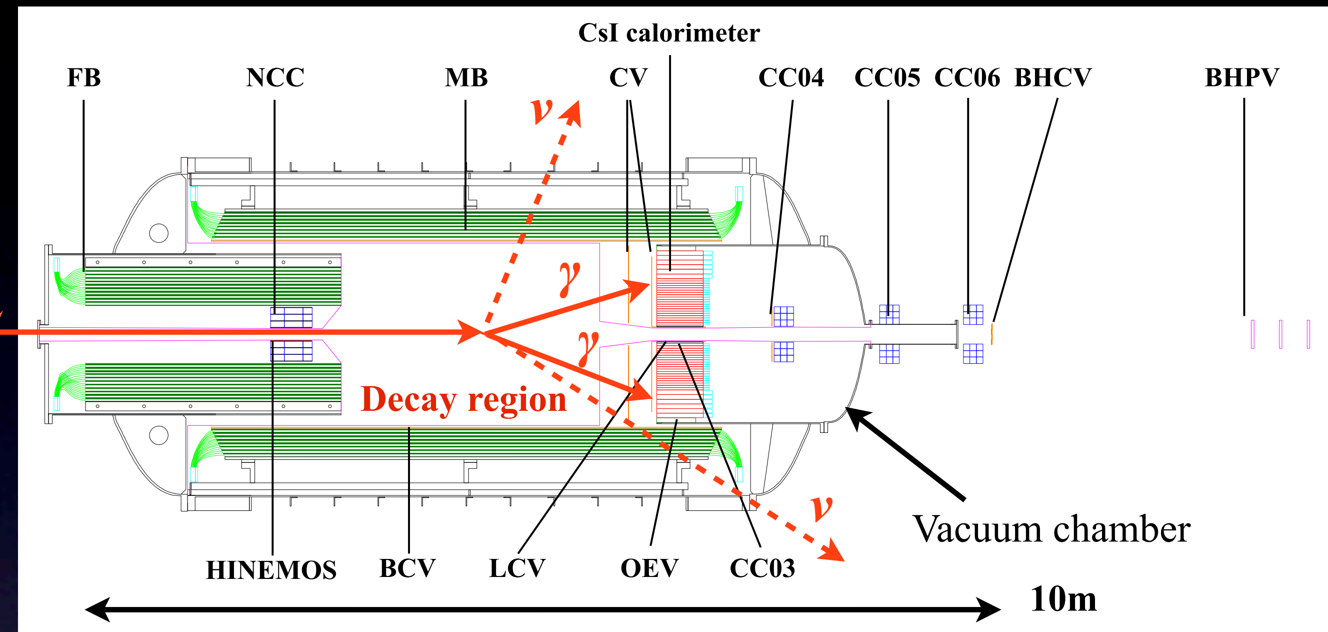

Tokai, Ibaraki, Japan

- KOTO experiment
  - K^0 at TOKAI (J-PARC)
  - Upgrade from KEK-PS E391a
  - Detector construction finished
  - will start the physics run in this month.

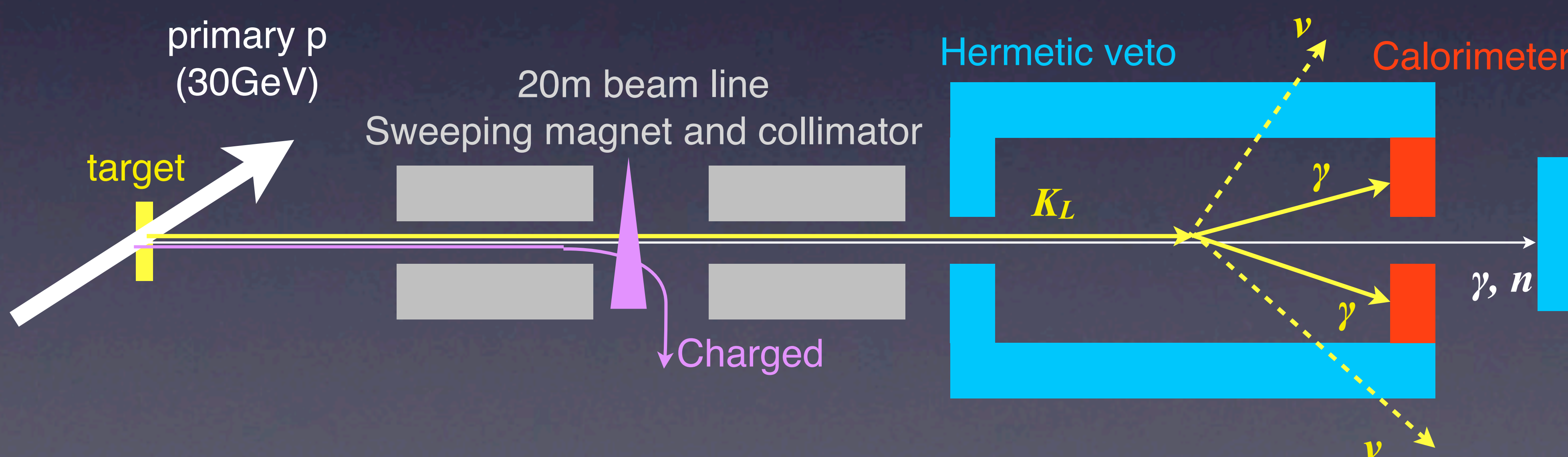


Principle

- K_L pencil beam
- 2γ + nothing
  - Calorimeter + Hermetic veto



T. Shimogawa et al.,
NIMA 623, (2010) 585



Principle

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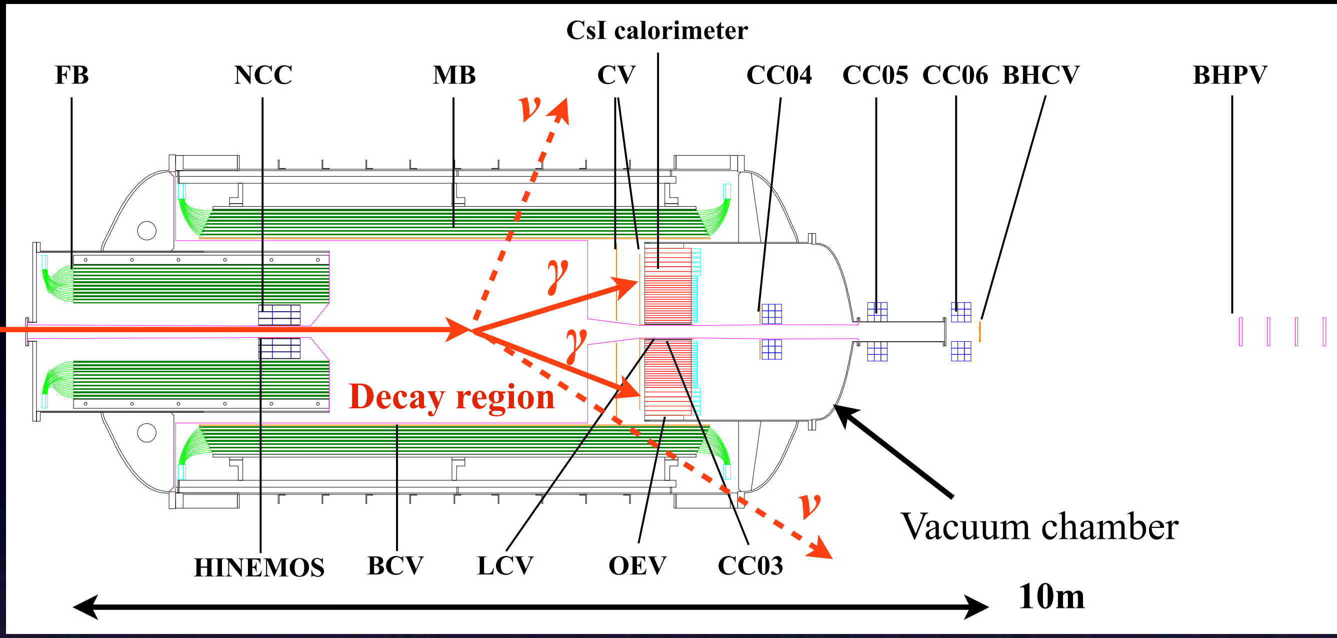
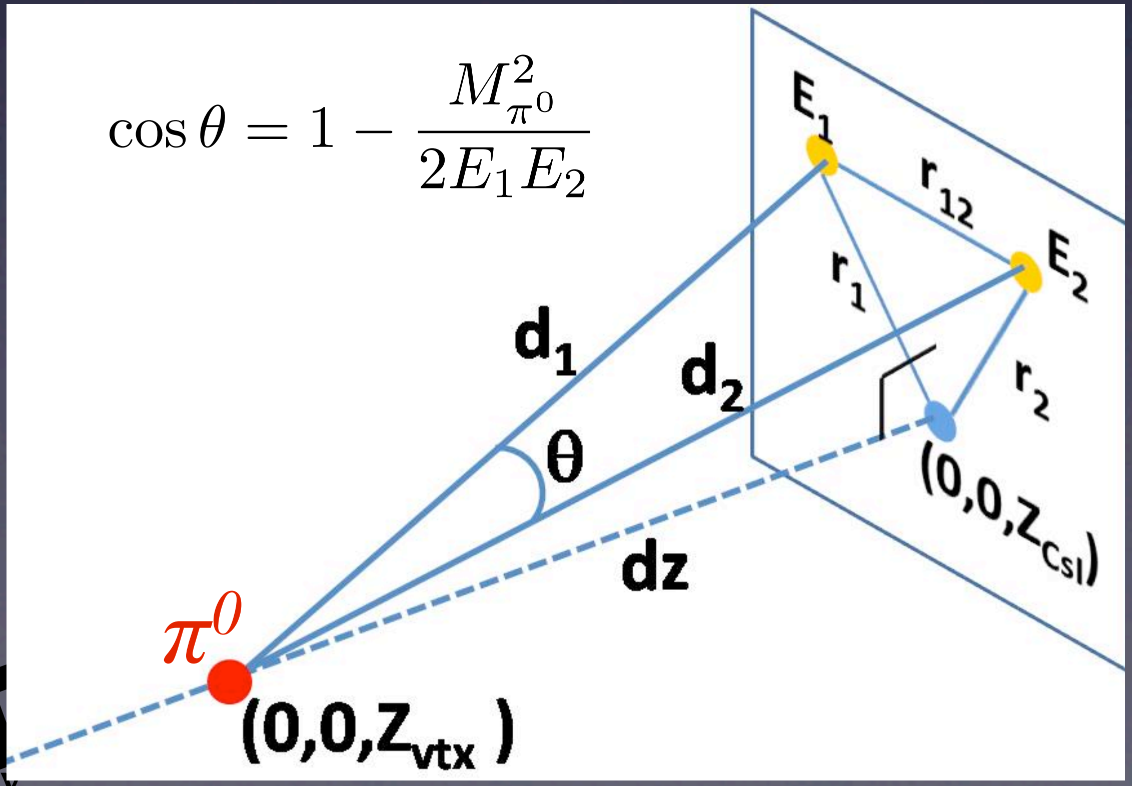
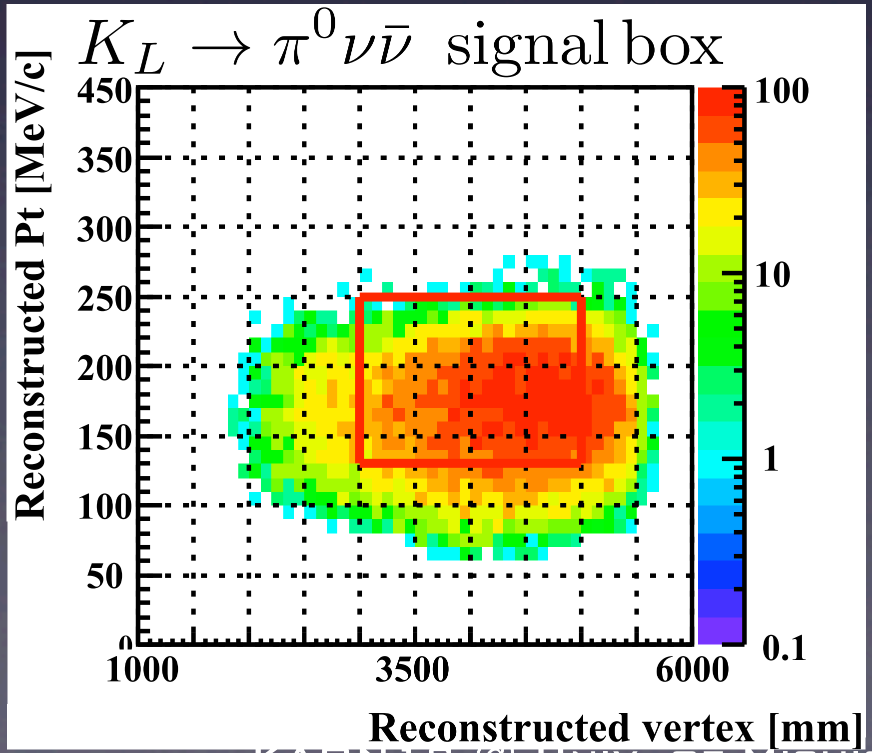
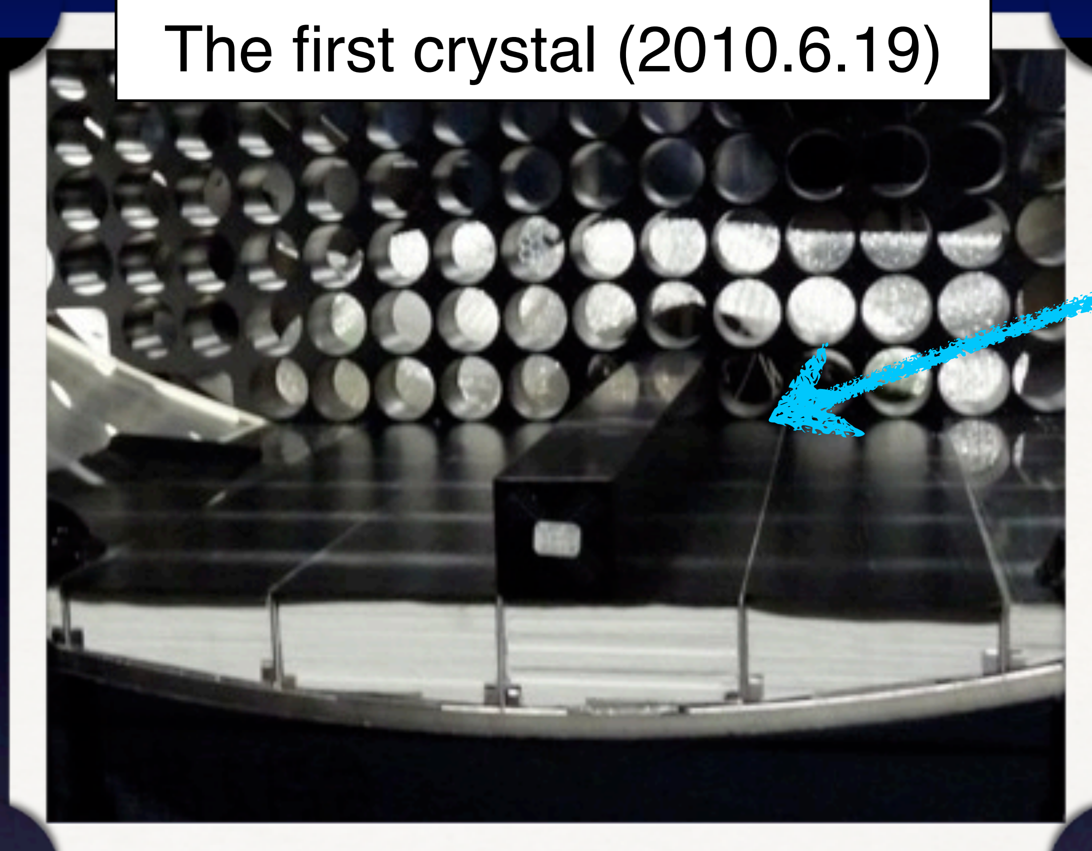


- Signal reconstruction
  - Assume 2 gammas come from π^0
  - Require large transverse momentum
  - z vertex - Pt distribution

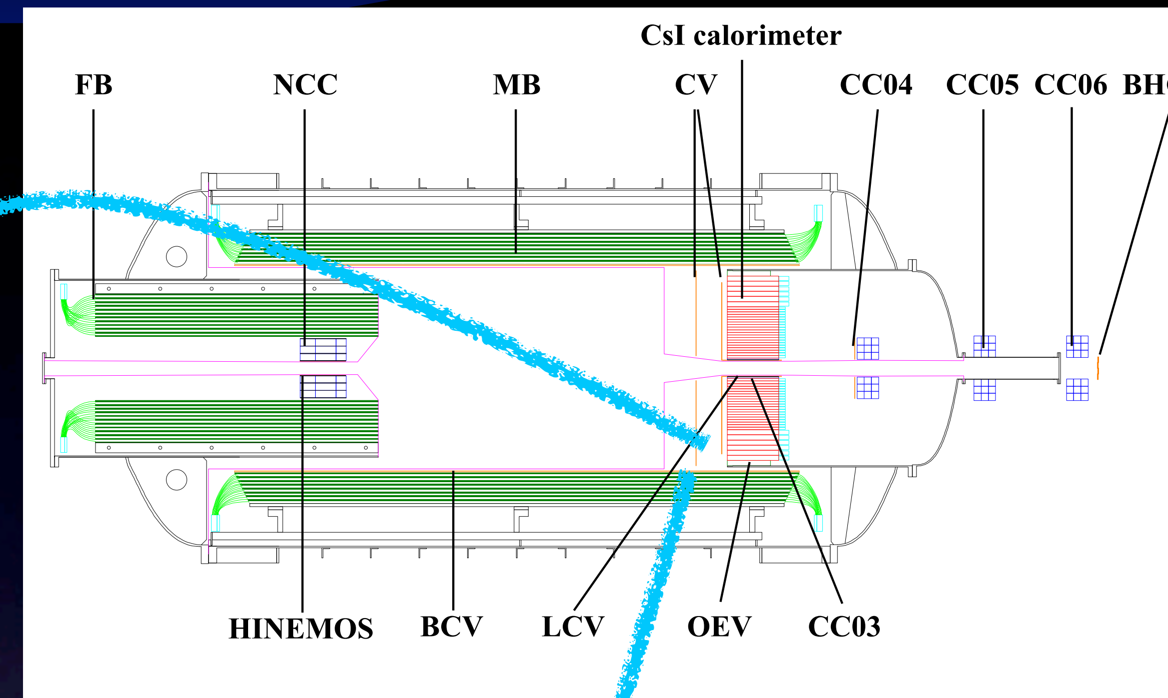




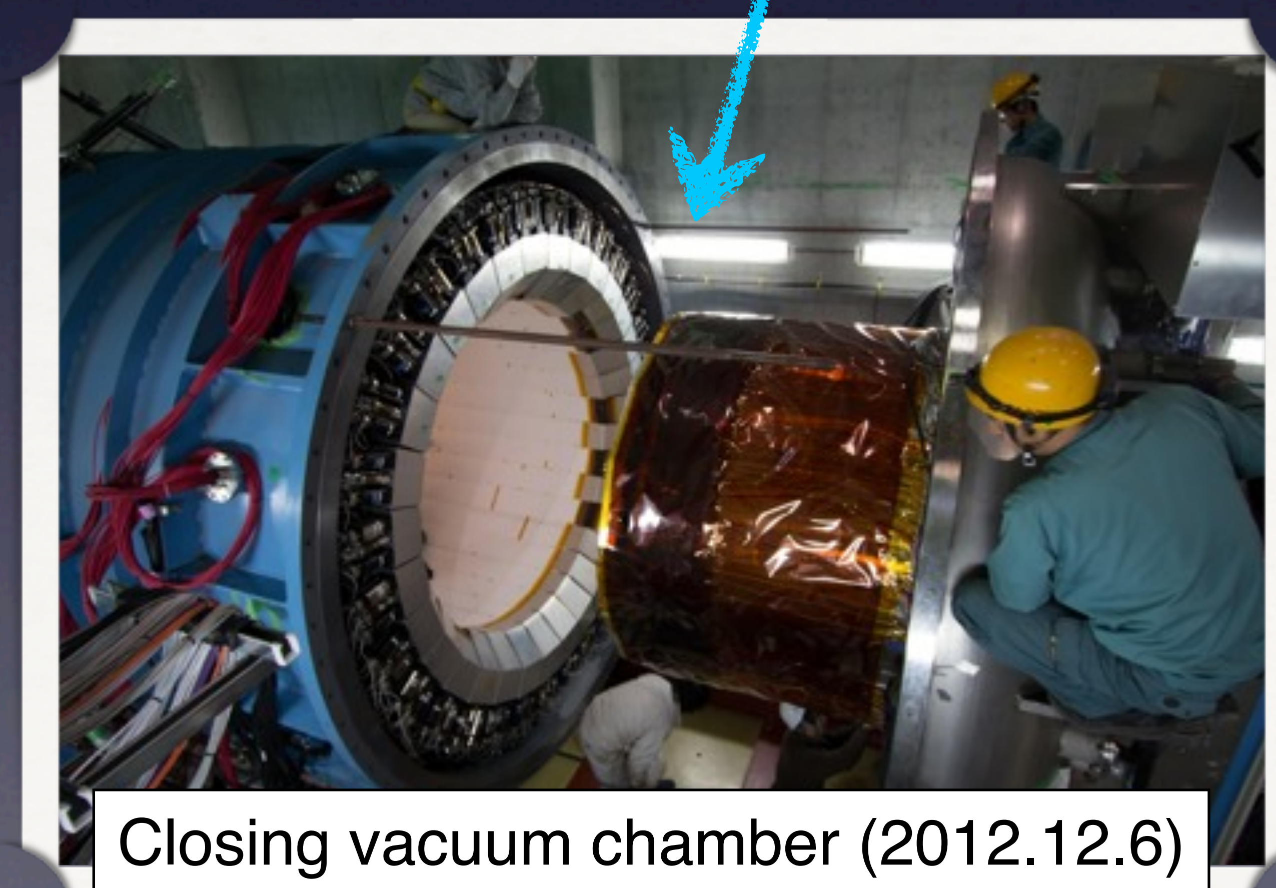
Detector construction



The first crystal (2010.6.19)

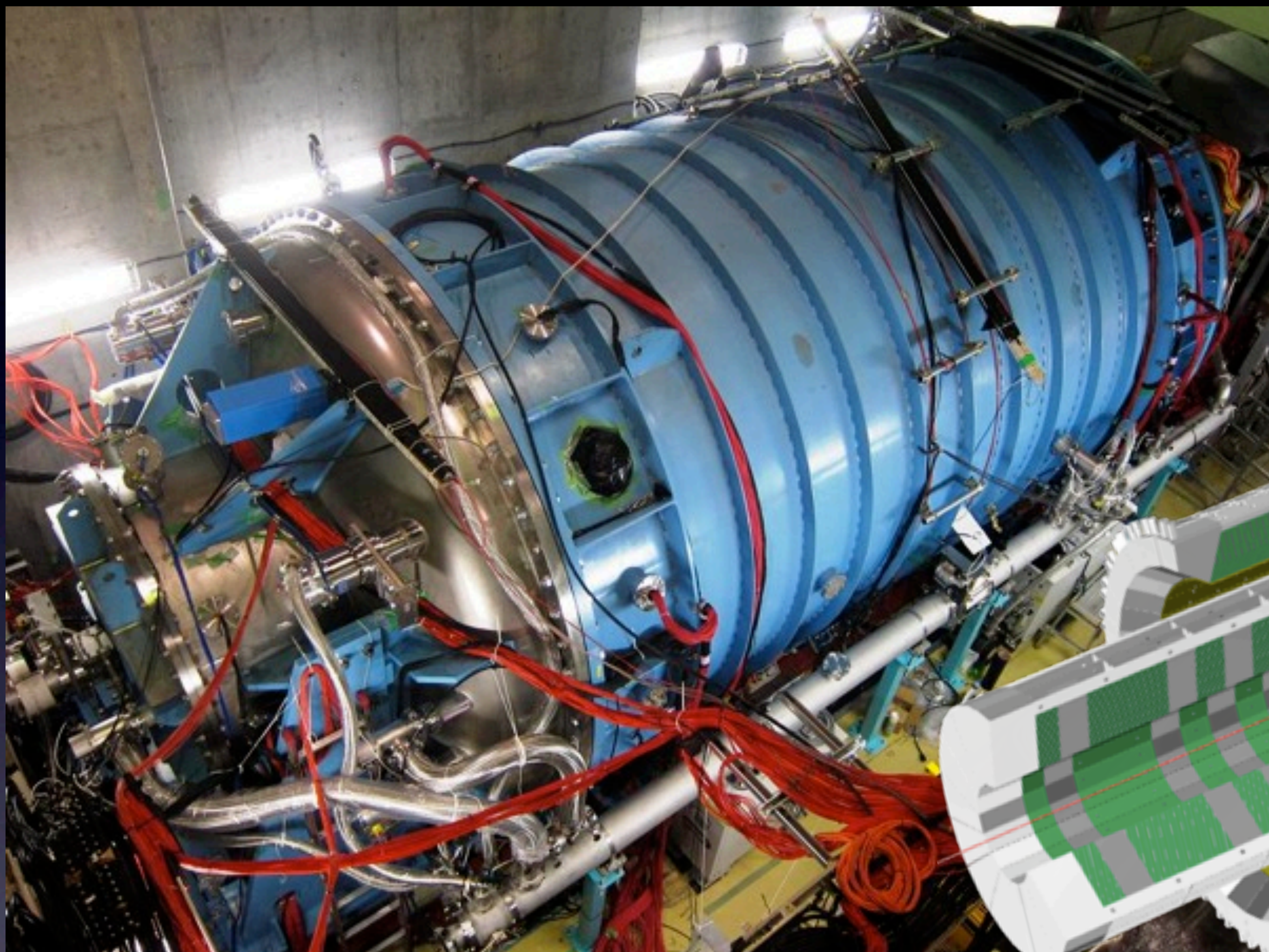


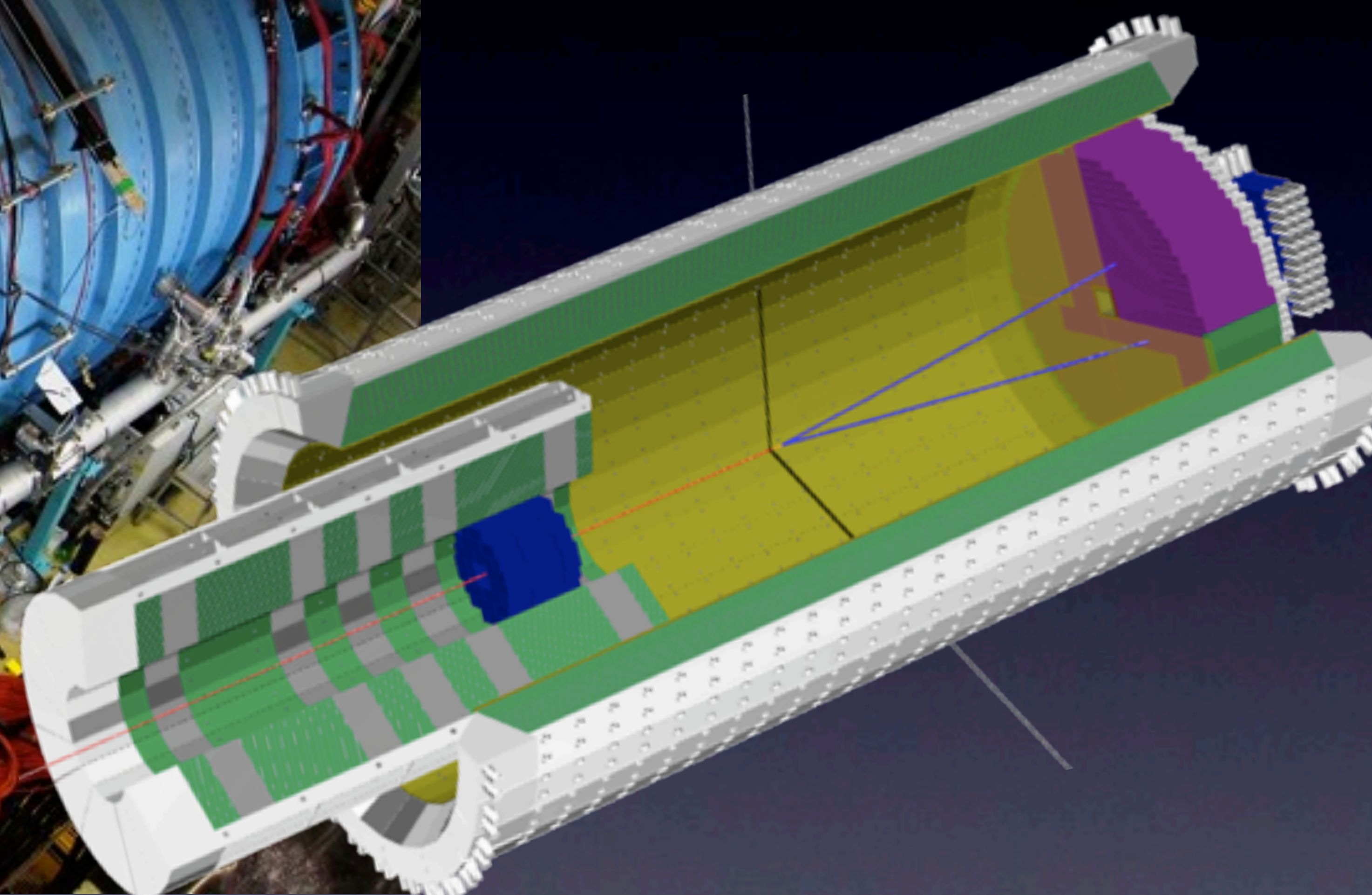
Earthquake (2011.3.11)



Closing vacuum chamber (2012.12.6)

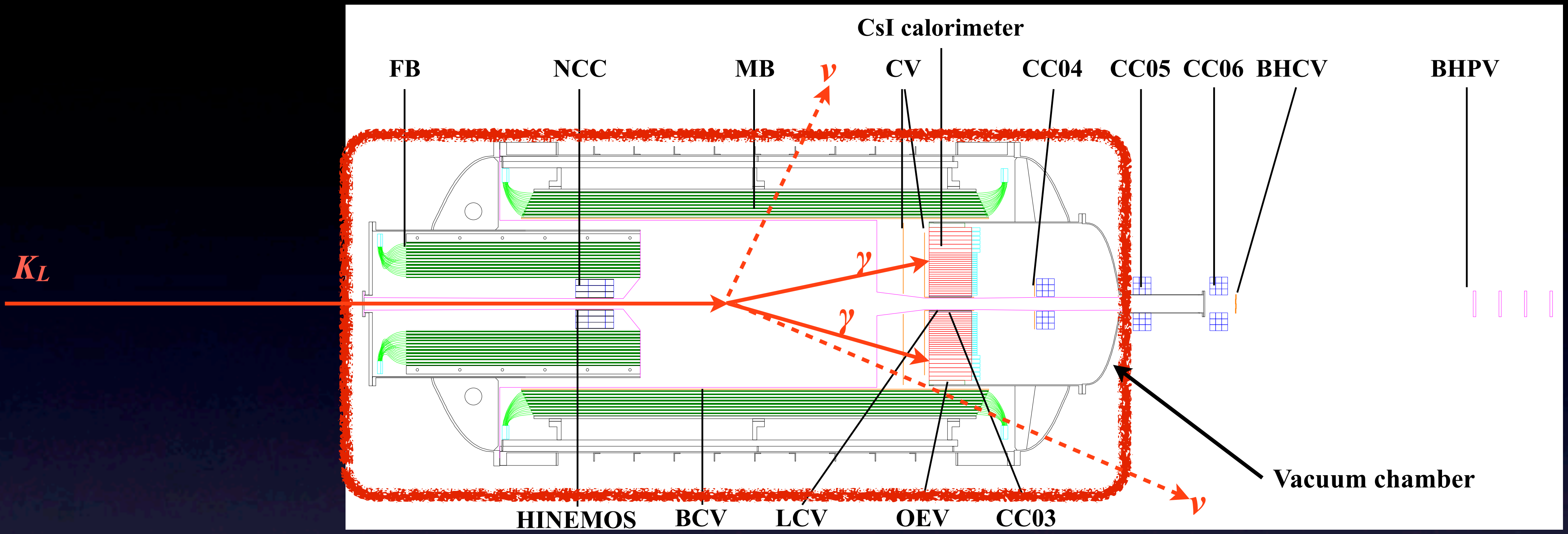
Detector construction





- To reduce the interaction between the beam particles and the residual gas, the evacuation started from 2013-Jan-4.
  - The current vacuum level of the decay region is 7×10^{-5}Pa.

Engineering run

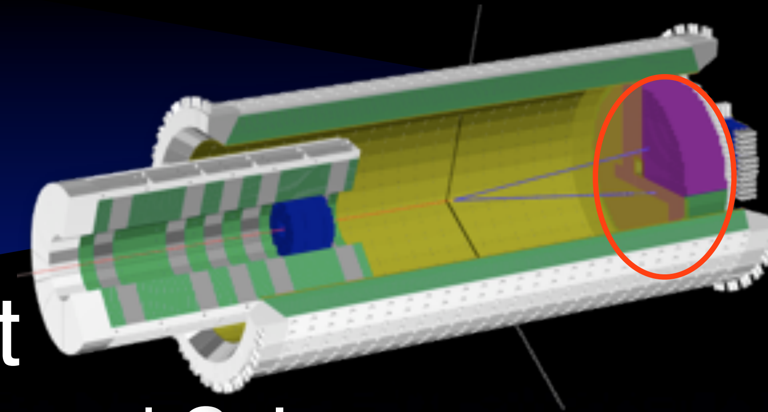


- We performed engineering runs in Dec. 2012 - Jan. 2013
- **Major milestones.**
  - Stable operation of all the detectors in vacuum
    → We operated the whole detectors during run.
  - Confirmation of the DAQ / Slow control system
    → We took many types of data.
  - Confirmation of the detector calibration methods
    → Established.
  - Check the performance of the whole detector system in situ
    → The main topics of this talk.

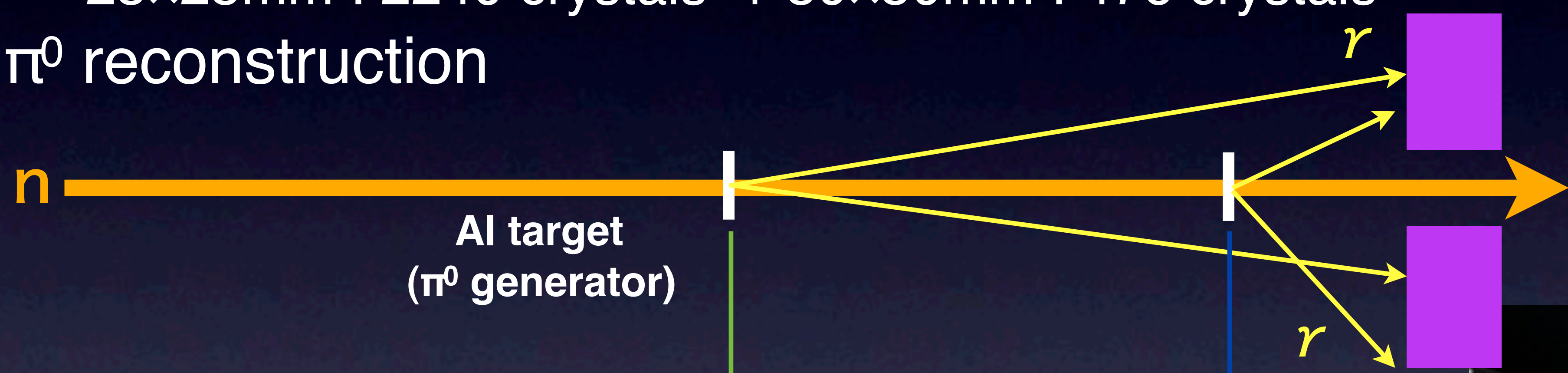
- Detector introduction. (some parts of all)
    - CsI calorimeter
    - Charged Veto
    - Main barrel

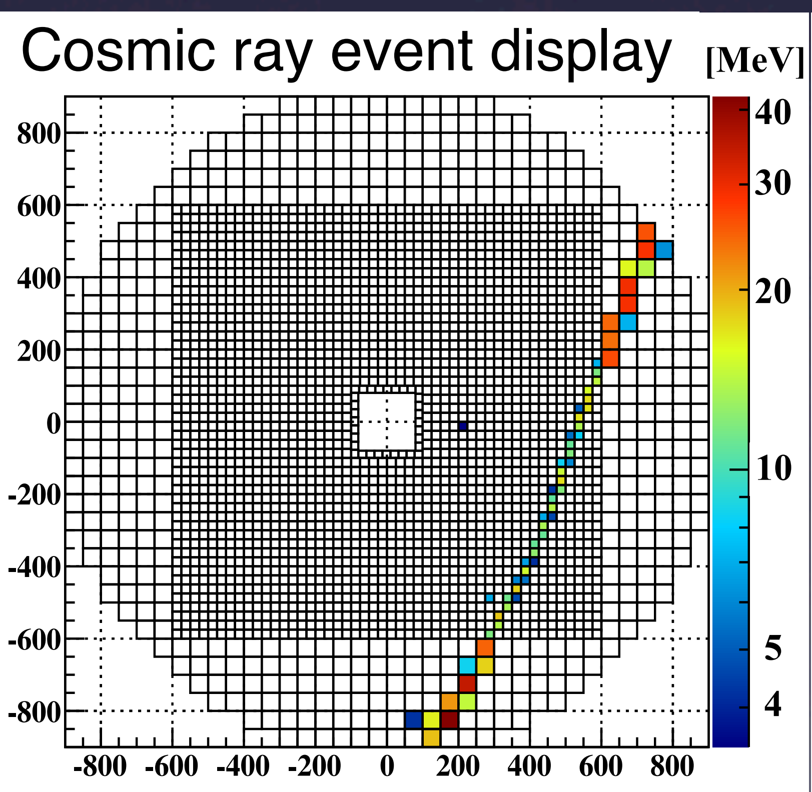
- Some plots from the engineering run

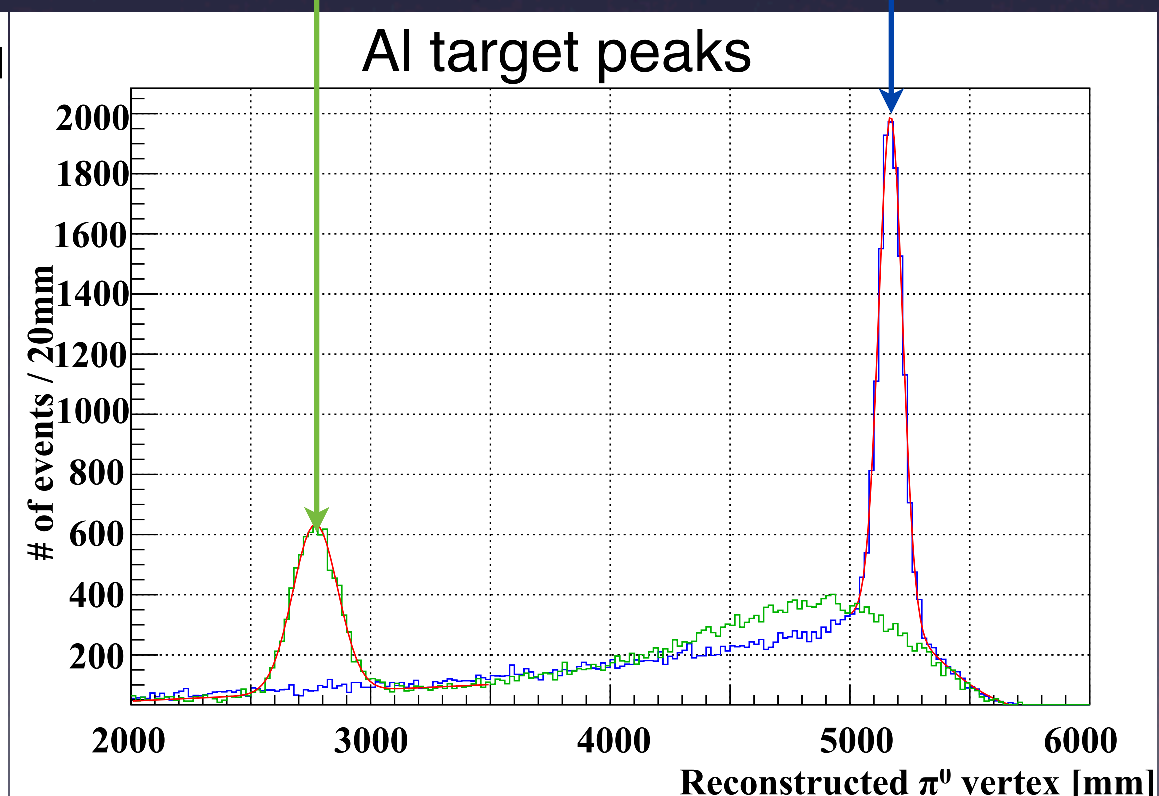
CsI calorimeter

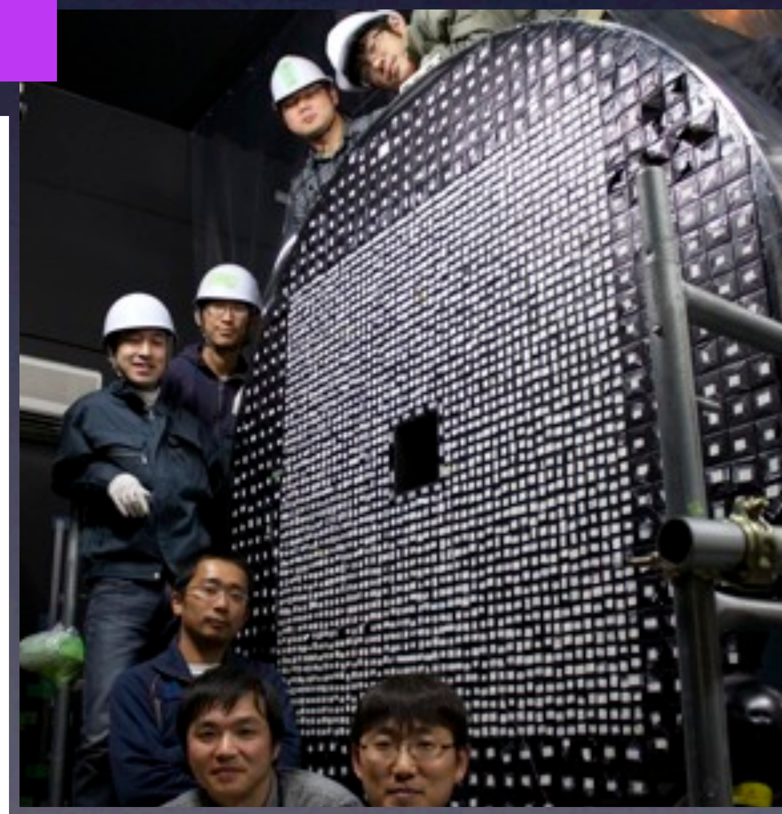


- The main detector of KOTO experiment
  - 2m diameter 500mm ($27X_0$) long full active undoped CsI
  - Originally made for FNAL KTeV
  - Fine granularity (2716 crystals)
    - 25×25mm : 2240 crystals + 50×50mm : 476 crystals
  - π^0 reconstruction

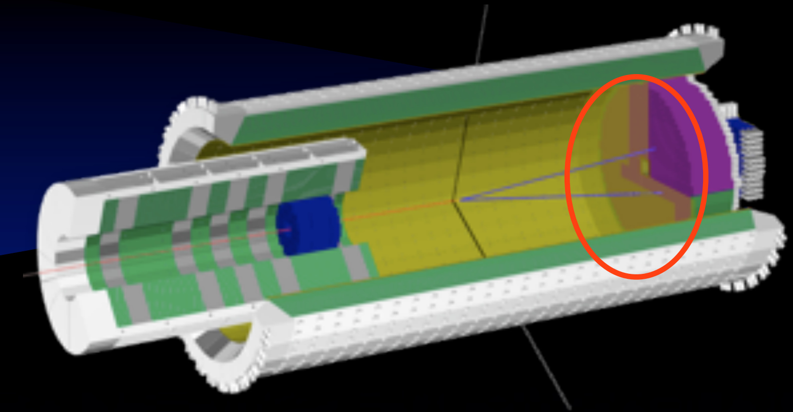




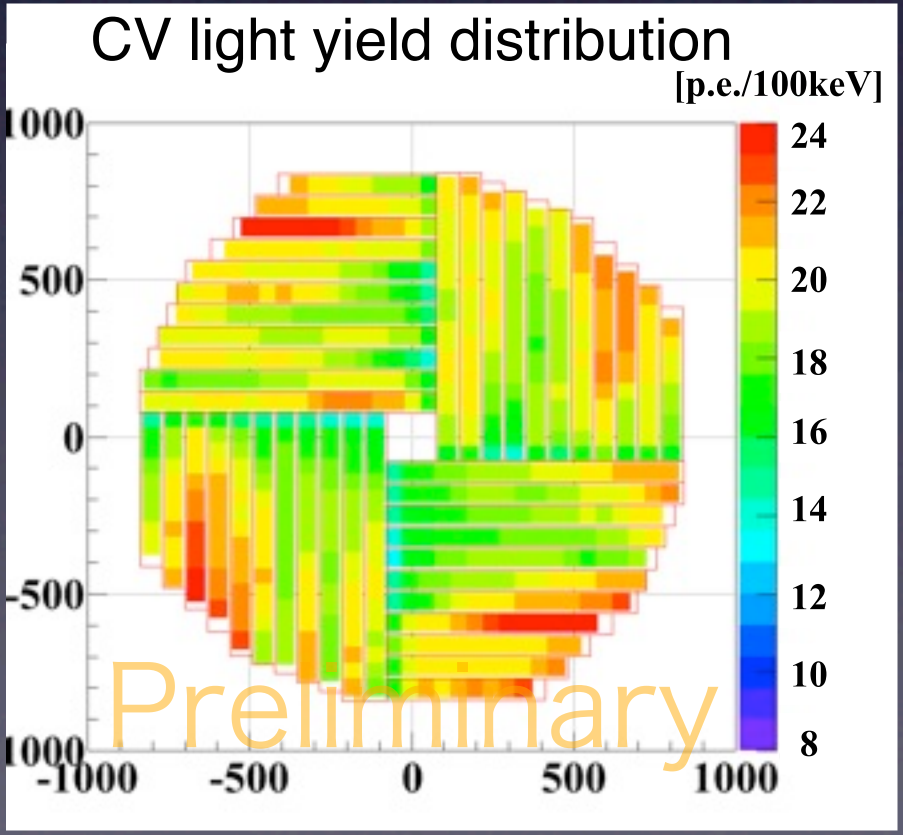




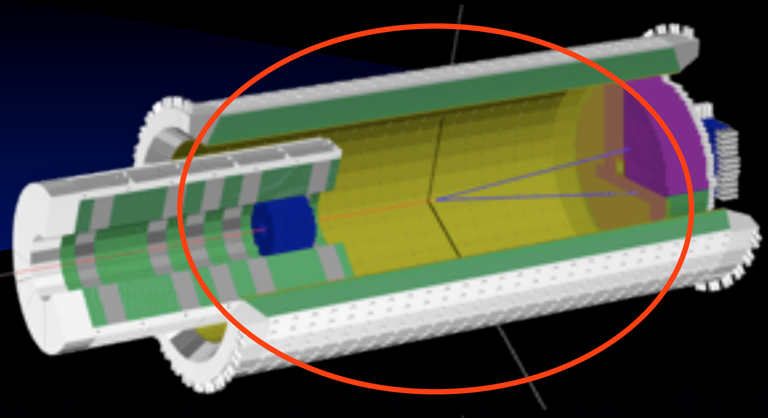
Charged Veto (CV)



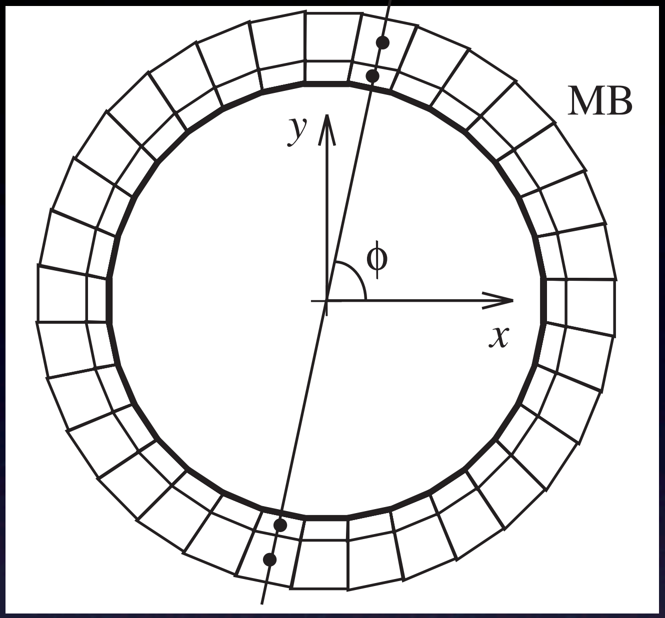
- Charged veto
  - Fully new detector
  - Located in front of the CsI calorimeter
  - Two planes of 2m diameter 3mm thick plastic scintillators
  - WLS fibers, and MPPCs on both ends
  - < 10^{-6} inefficiency is required (10p.e./100keV)
- The performance is well understood
  - Enough light yield is achieved in whole veto region



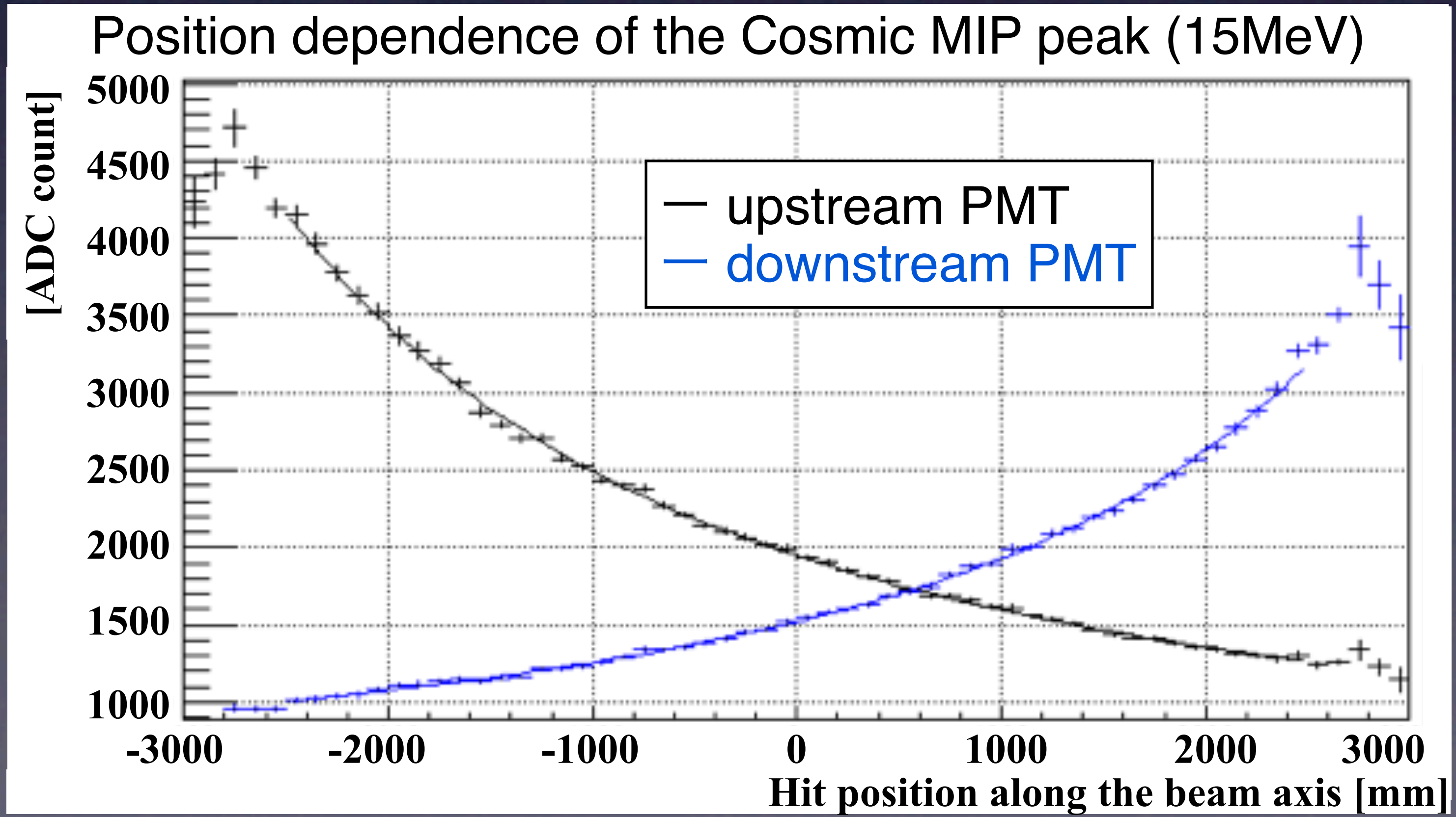
Main barrel (MB)



- Large area photon veto detector
  - Same as E391a
  - 64 segmented modules (right figure)
  - 5.5 m long sandwich
    of the plastic scintillator and lead sheet ($14X_0$)
  - WLS fiber, and PMTs on both ends



- Need to veto 1MeV in whole region
  - Determine the hit position based on the time difference between both ends.
  - Correct energy and timing.



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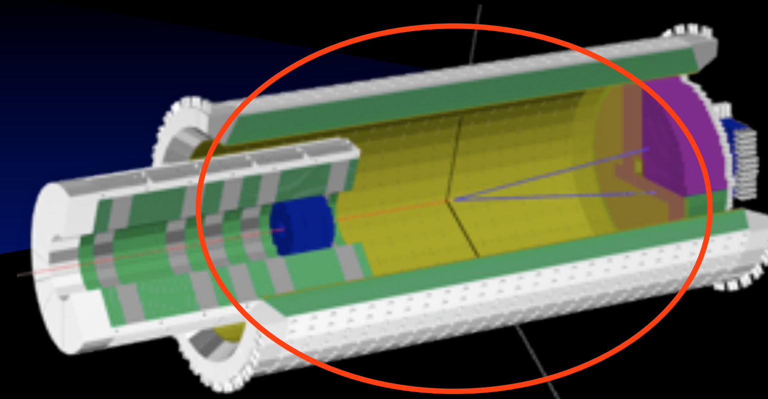

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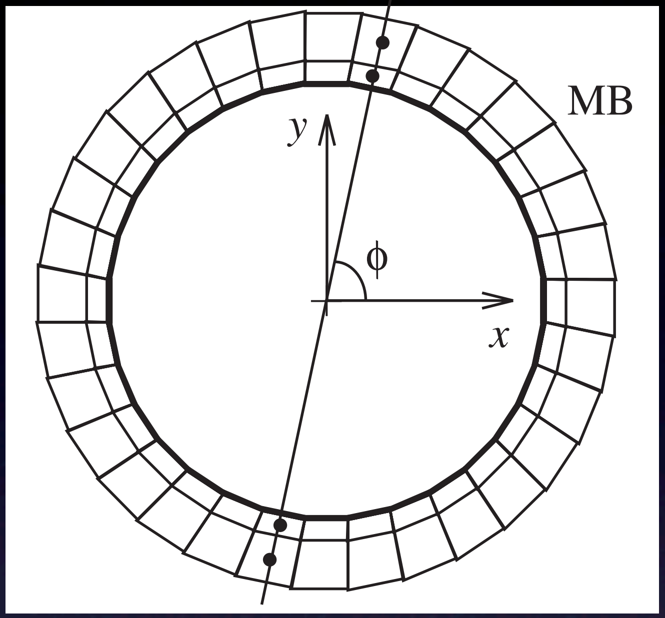
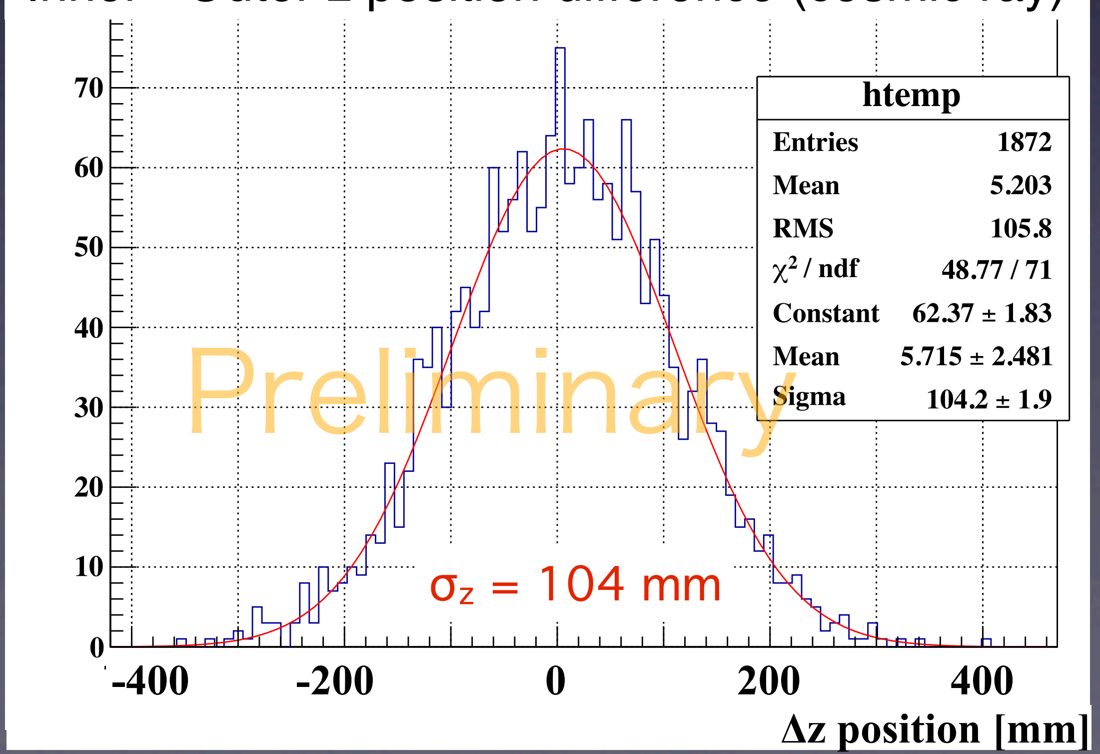
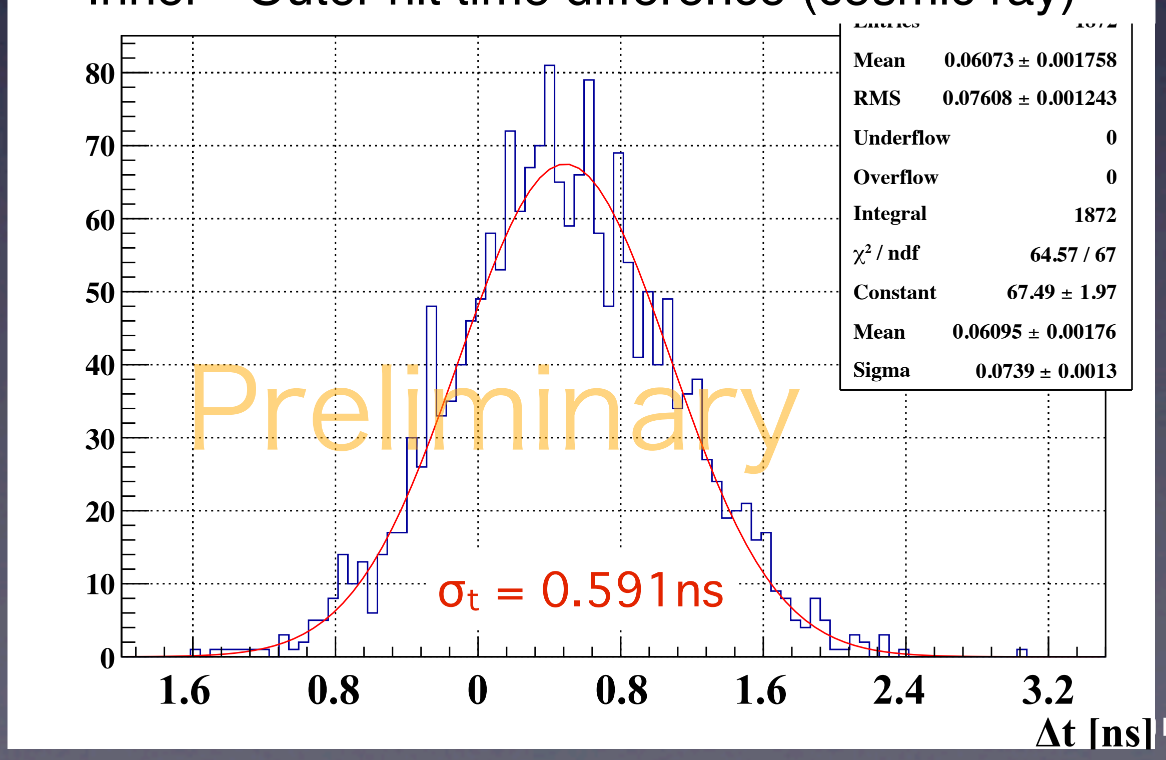


- We can achieve less than 100mm position resolution and sub ns timing resolution.

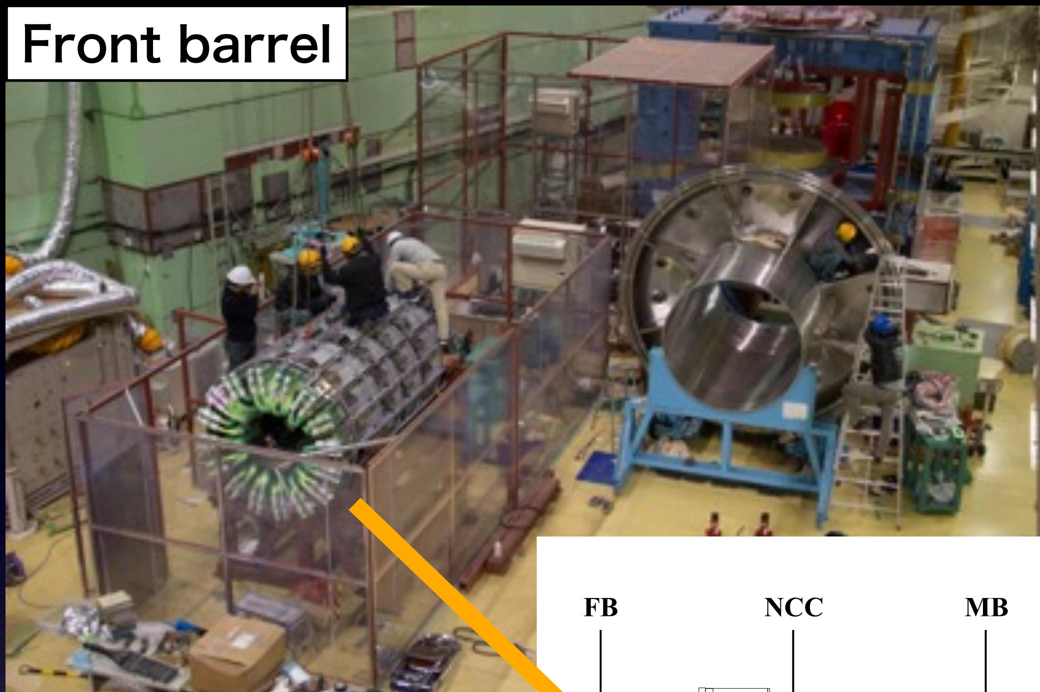
Inner - Outer z position difference (cosmic ray)

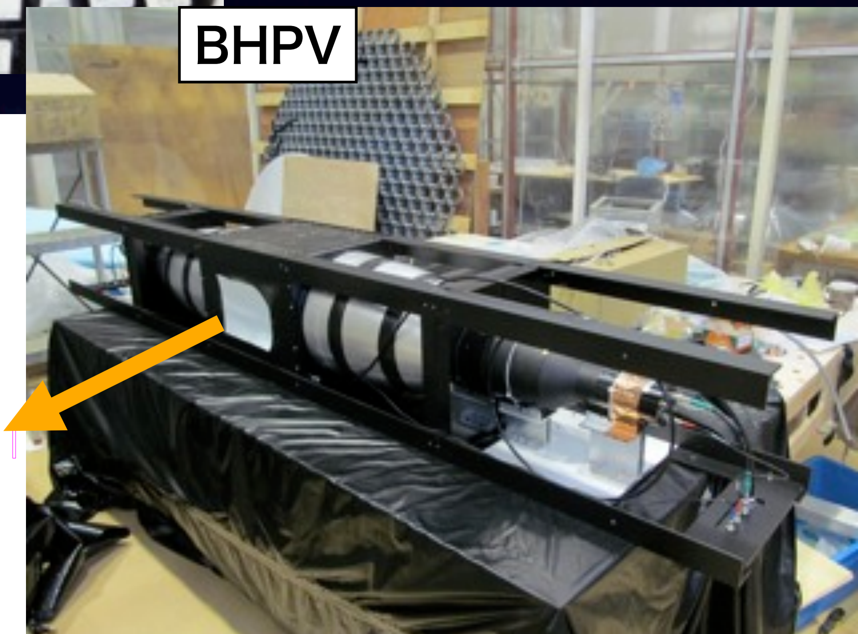


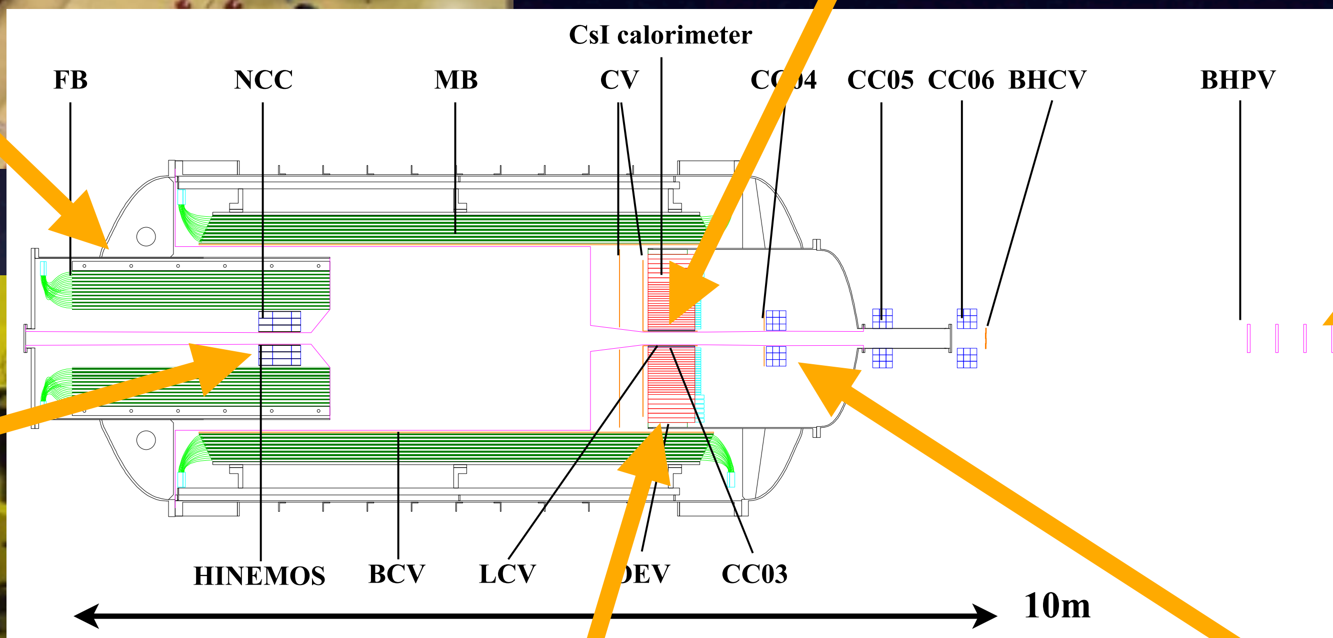
Inner - Outer hit time difference (cosmic ray)

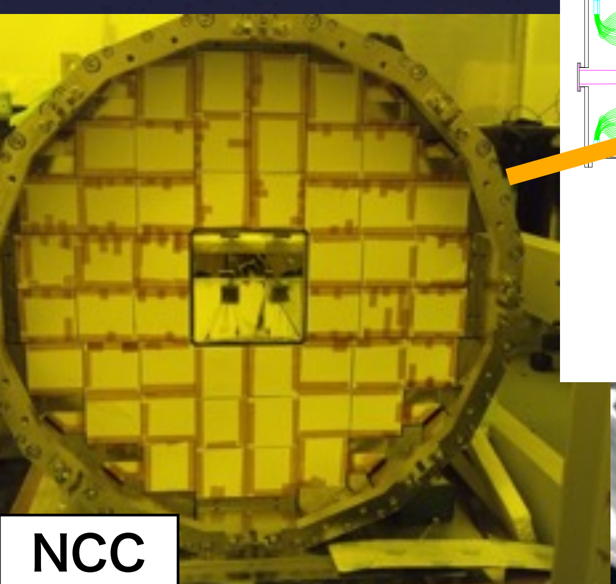


Others

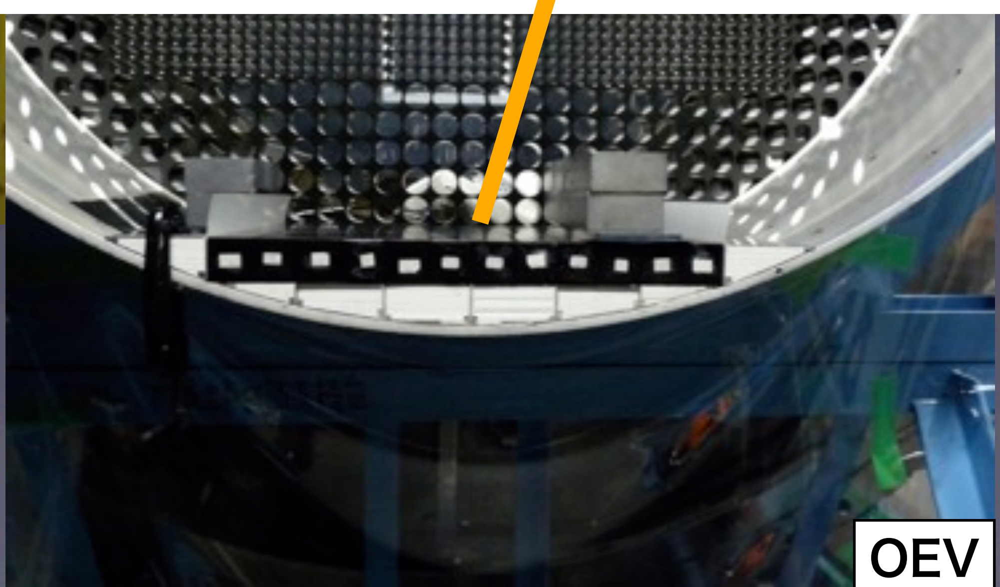


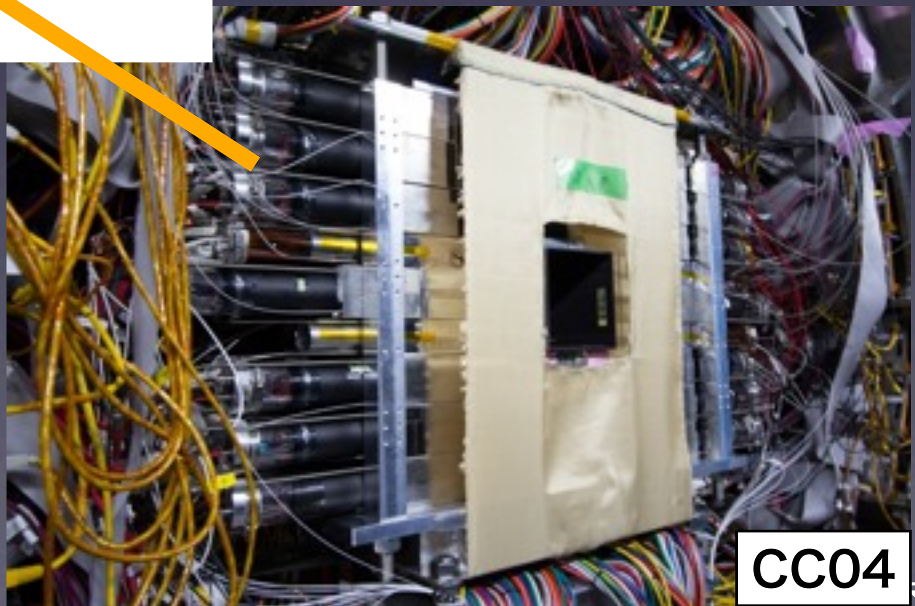






For NCC,
See poster
by N. Kawasaki



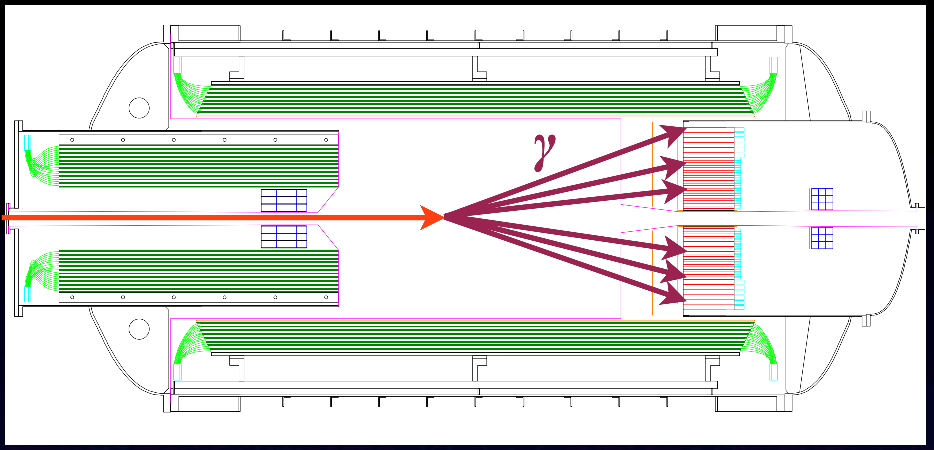


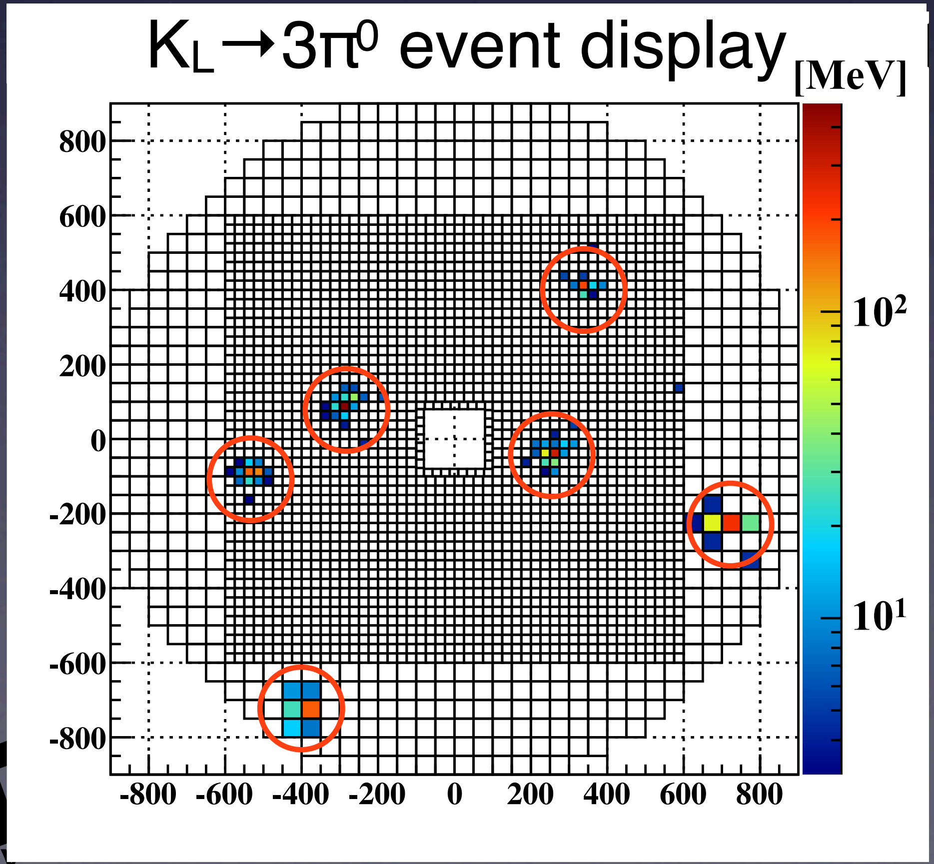
- Highlights from the engineering runs

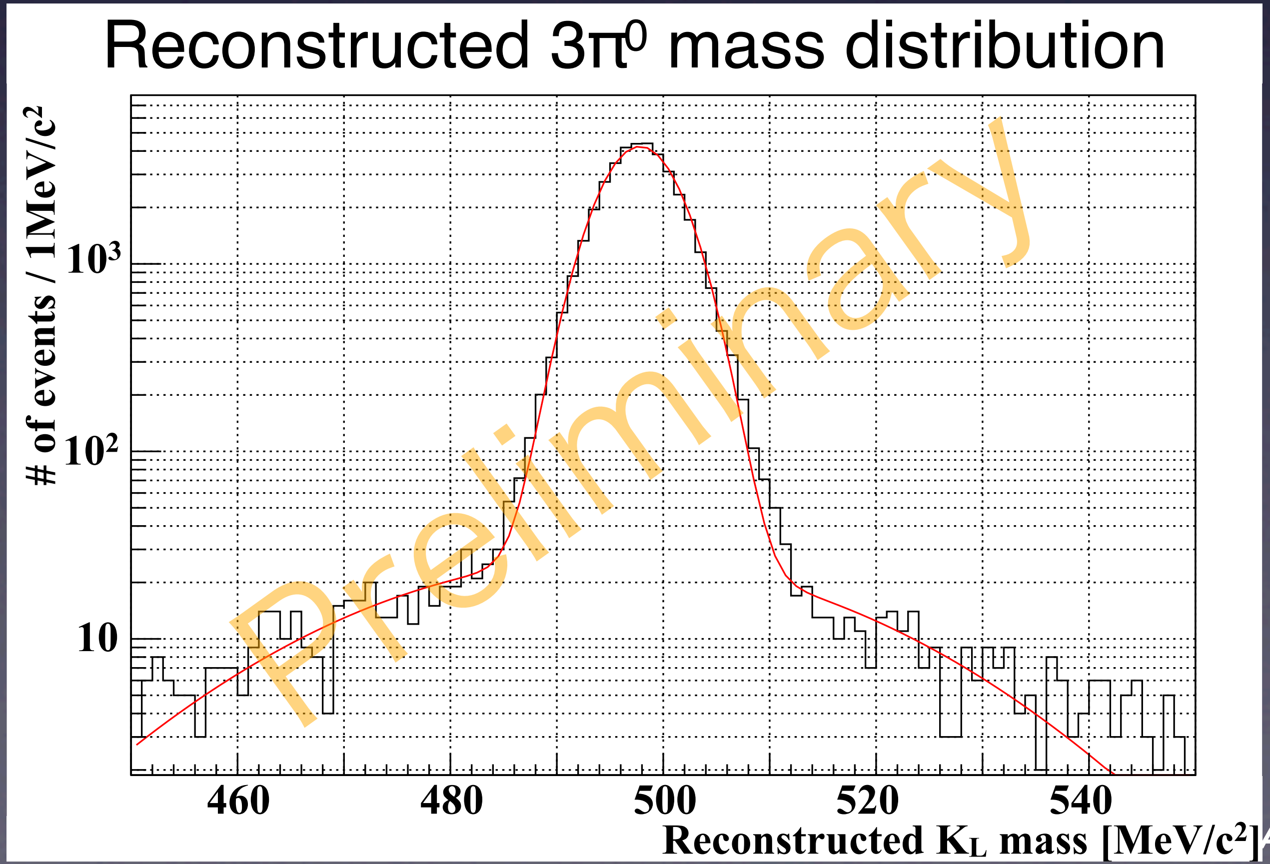
K_L neutral decay modes(1)

- $K_L \to 3\pi^0$
  - 6 gammas in CsI calorimeter
  - High statistics (Br($3\pi^0$) : 19.5%)
  - Good sample to check the CsI calorimeter performance.

Signal ($K_L \to 3\pi^0$, Br : 19.5%)



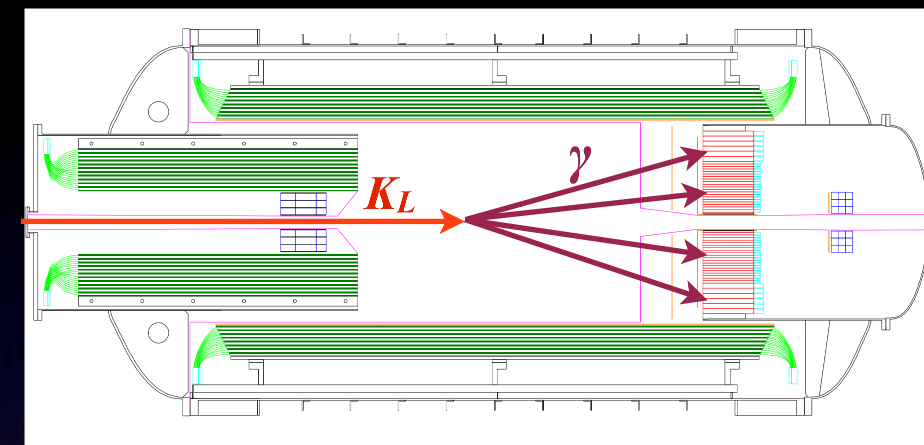




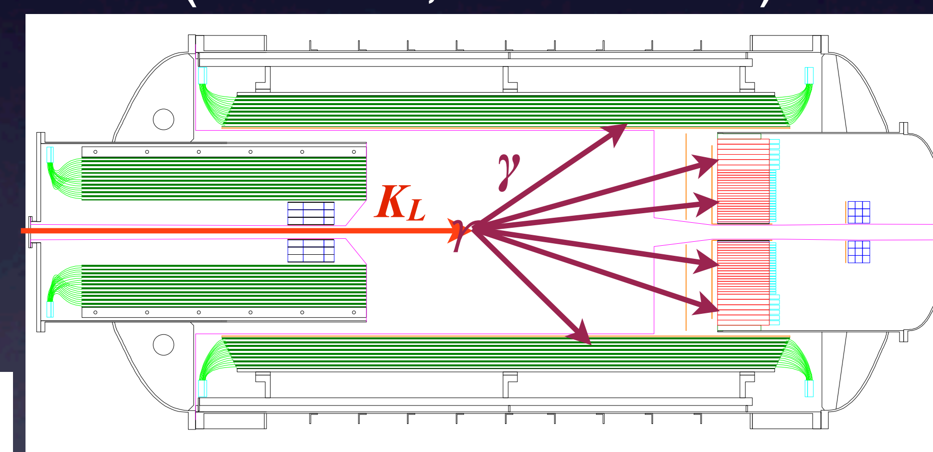
K_L neutral decay modes(2)

- $K_L \to 2\pi^0$
  - 4 gammas in CsI calorimeter
  - Backgrounds : $3\pi^0$, $\pi^+\pi^-\pi^0$
  - Good samples to check the hermetic veto performance

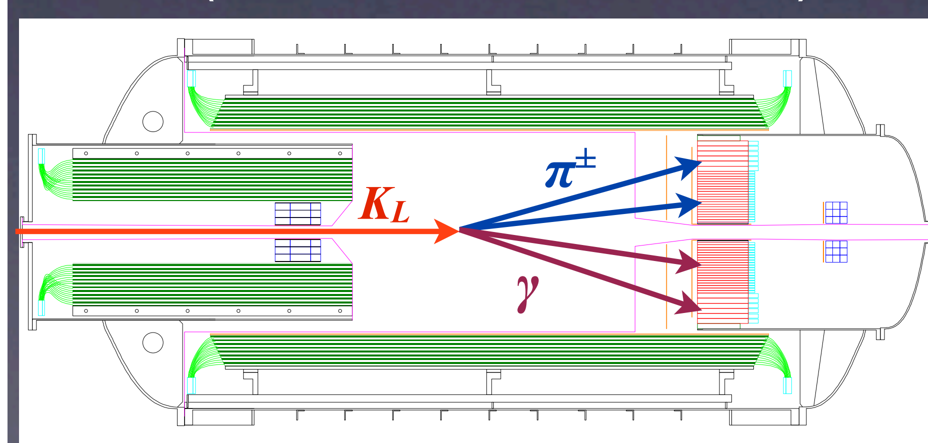
Signal ($K_L \to 2\pi^0$, Br : 8.7E-4)



B.G. ($K_L \to 3\pi^0$, Br : 19.5%)

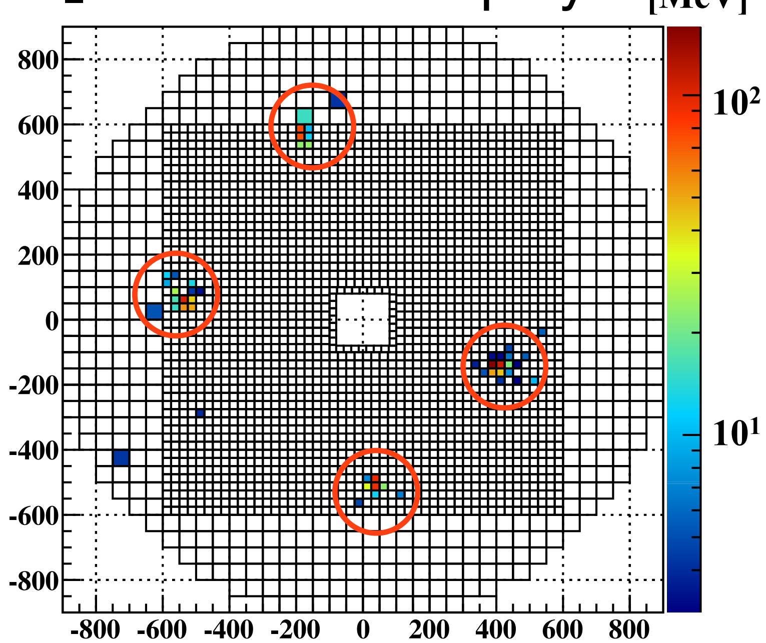


B.G. ($K_L \to \pi^+\pi^-\pi^0$, Br : 12%)

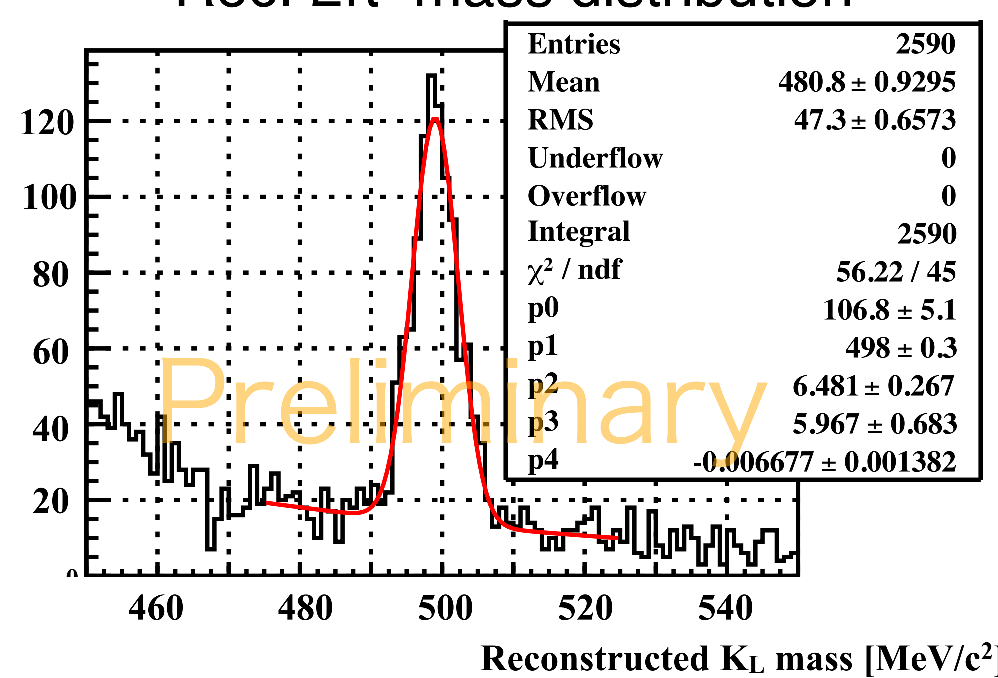


Apply only CV & MB veto

$K_L \to 2\pi^0$ event display



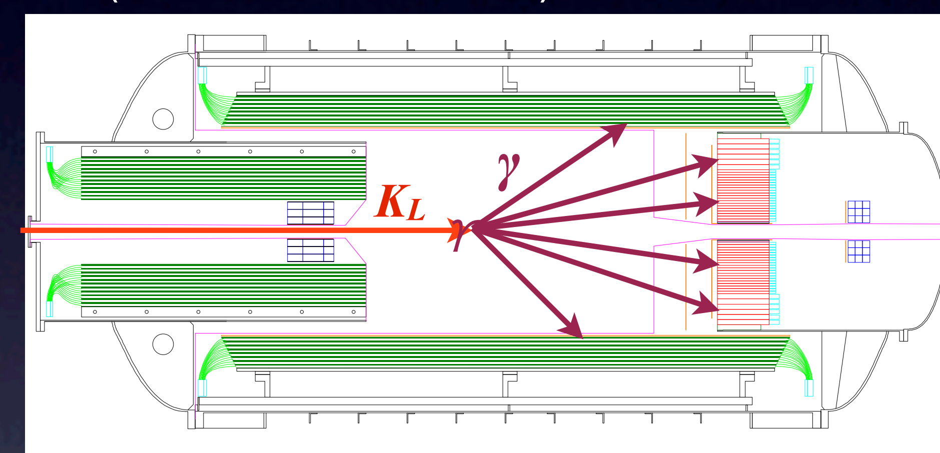
Rec. $2\pi^0$ mass distribution



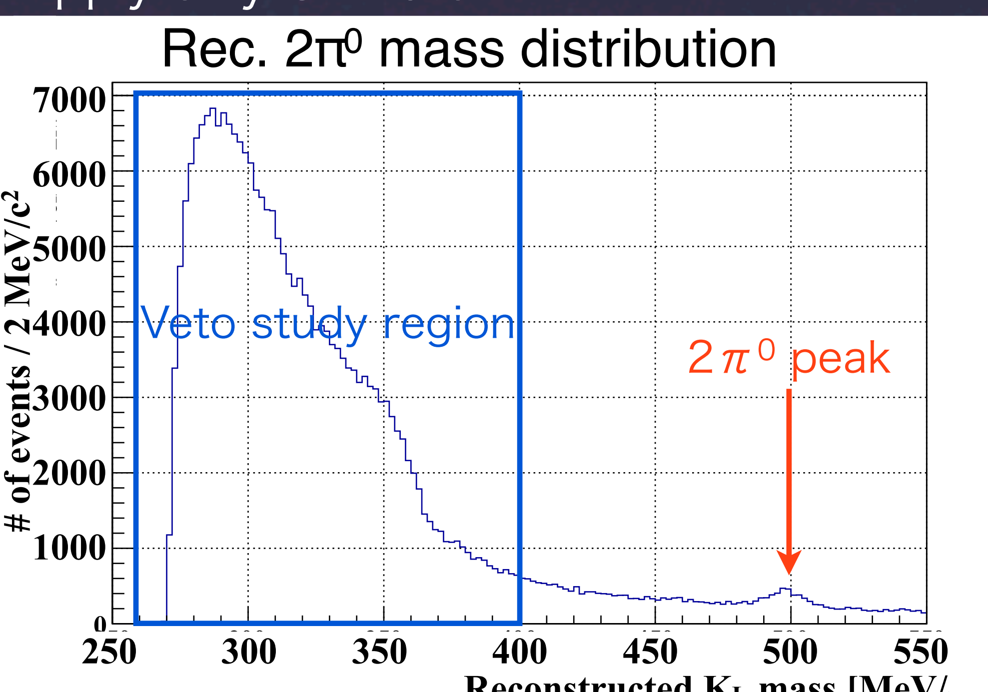
Veto performance

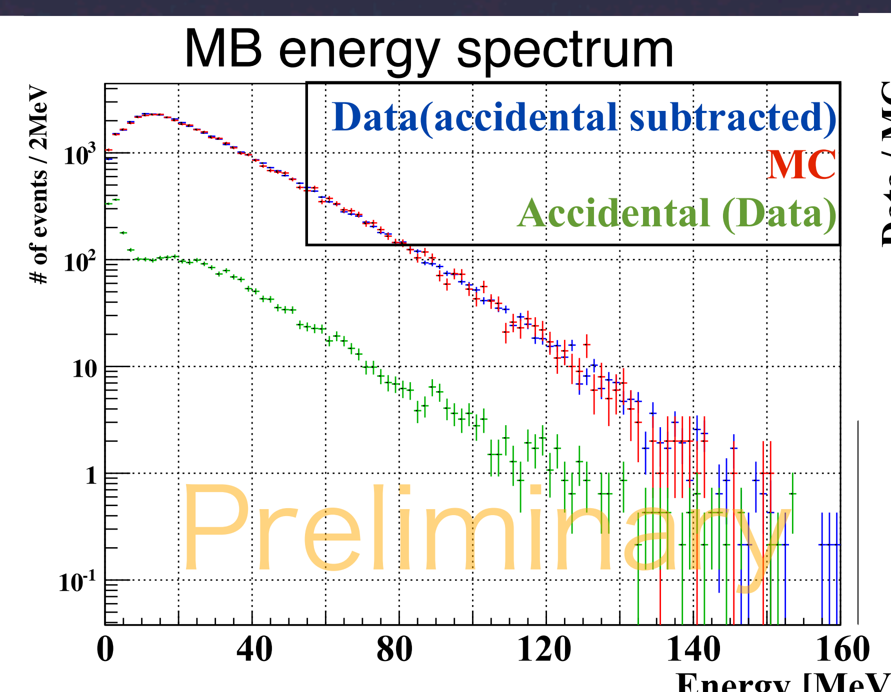
- Preliminary results.
  - Using the back ground of $2\pi^0$ reconstructed events, the MB spectra in the data and the simulation are almost consistent.
    The veto performance is well understood.

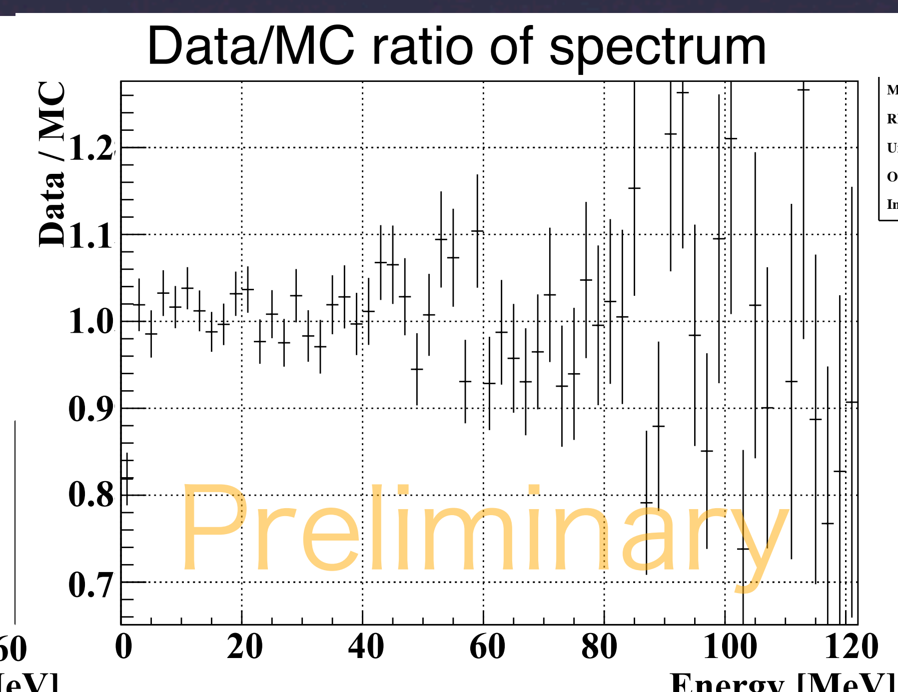
B.G. ($K_L \to 3\pi^0$, Br : 19.5%)



Apply only CV veto







Summary

- KOTO experiment aims to detect $K_L \to \pi^0 \nu \bar{\nu}$
- Detector construction almost finished and engineering runs were performed in 2012.12-2013.1
  - The whole detector system works well.
- KOTO is ready to start the physics run to investigate the new-physics region
- The physics prospects, future schedule and plan will be presented by Dr. Togawa in the next talk.