Evaluation of the inefficiency of a charged particle detector for KOTO experiment

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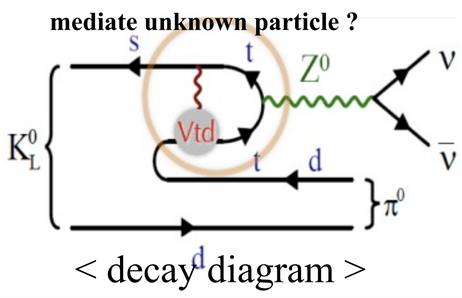
Introduction to the KOTO experiment

Started in May 2013, at J-PARC(TOKAI, JAPAN).
Goal of the KOTO experiment.

- ○**Discovery of the KL → $\pi^0\nu\bar{\nu}$ decay.**
- ○**Search for physics beyond the SM.**



< decay diagram >

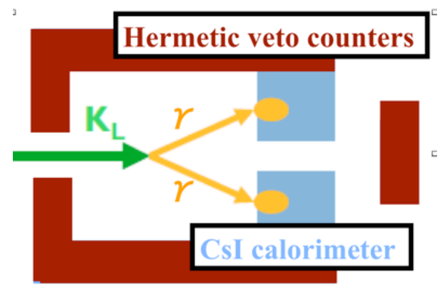
○small theoretical uncertainty(～2%) .

○suppress in the SM(Br～2.4×10^{-11}).

→**sensitive to new physics.**

signal event @ KOTO

$K_L \rightarrow \pi^0 \nu\nu$ ← undetected
$\pi^0 \rightarrow 2\gamma$
2γ + **nothing**



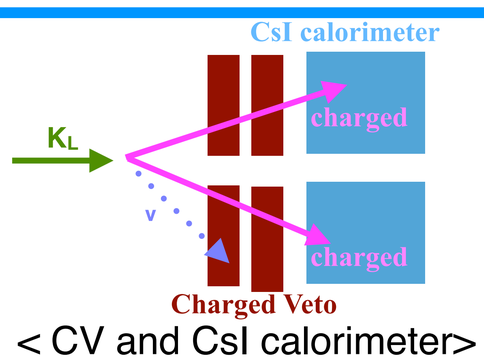
< conceptual diagram of the KOTO detector >

- $2\gamma(\pi^0 \rightarrow 2\gamma)$ is measured with the CsI calorimeter.
  - ○Energy
  - ○Positions

  calculate → ○Vertex position ○Transverse momentum (Cut value)
- Hermetic veto counters surrounding the decay volume.
  →Ensures nothing else.

Introduction to Charged veto

○Charged particle counters in front of the CsI calorimeter.
○reject Kaon decays including charged particle below one-10^{10}th.
->need **10^{-3} inefficiency** against a charged particle which penetrates CV toward the calorimeter at 100 keV threshold .



< CV and CsI calorimeter>

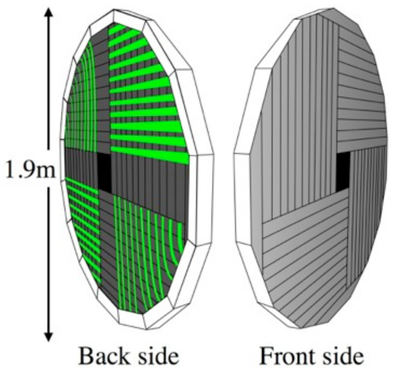


<photo of CV>

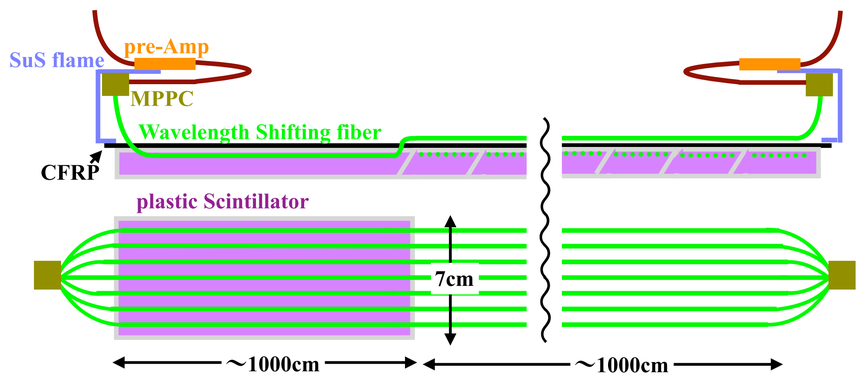
～design of CV～

○two plastic scintillator planes (48strips + 44strips).
○make overlap of scintillator strips to reduce the gap.
  groove wavelength shifting fibers.
  use MPPC for the both-end readout of the fibers.

to achieve high light-yield and efficiency over the whole area.



<CV over view>



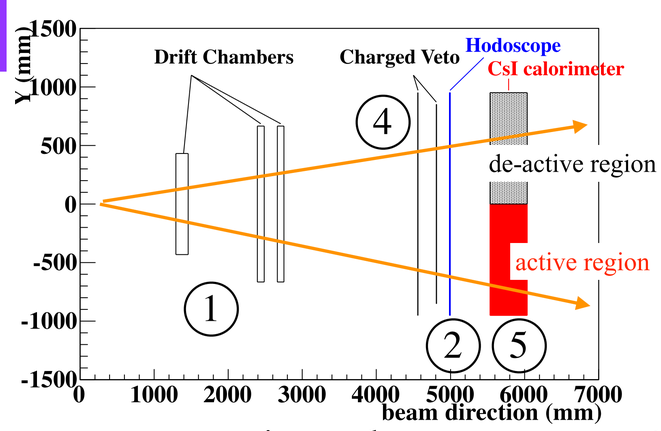
<each module design>

Evaluation of the inefficiency of a Charged veto

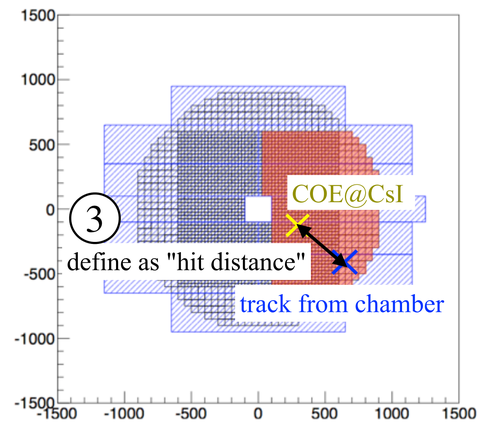
○measured in June, 2012, at the Koto beam line.
○environment of the experimental area：air(beam power:6kW)
○tracking：Drift chambers + Hodoscopes(require 2 tracks)

analysis flow

①②④ ensure track reconstruction
⑤ ensure charged-particle hit position



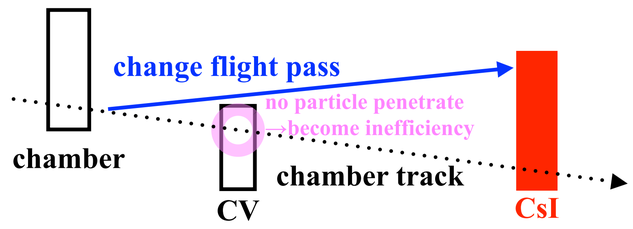
<experimental set up >



<hodoscope (blue) and CsI active region(red) >

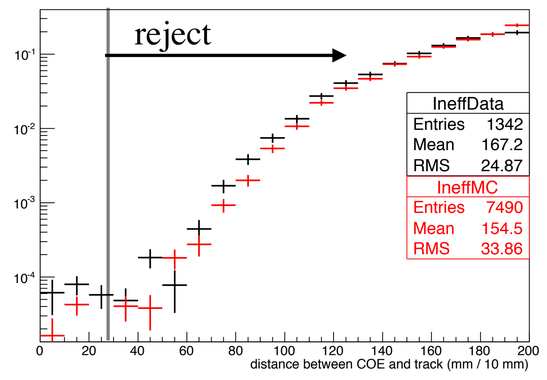
① reconstruct XY of 2tracks by the drift chambers
② matching of hodoscope hit and track
③ calculate hit position on CsI
  track far from the CsI hit
  track near the CsI hit
④ matching of CV hit and the track
⑤ reject unqualified track
⑥ check energy deposit of CV

⑤ main source of unqualified track



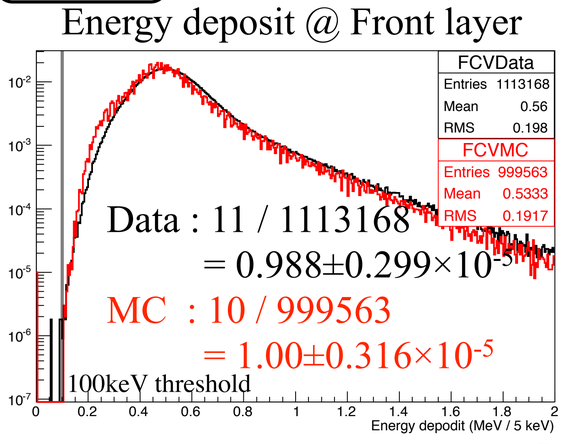
○the effect of multiple scatter and hard scatter .
○π→μdecay in flight.

dependence between CV inefficiency and hit distance



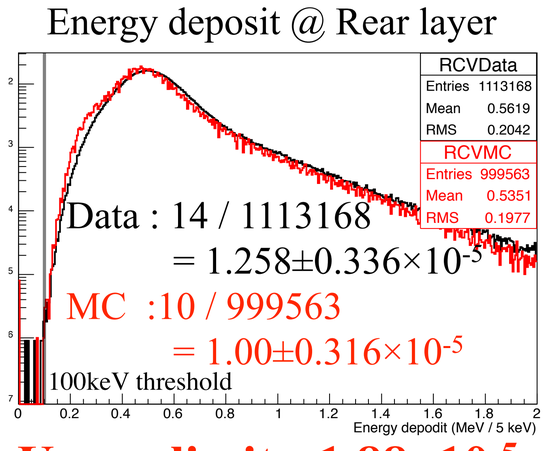
Result

Energy deposit @ Front layer



Upper limit : 1.58×10^{-5} @90%.C.L.

Energy deposit @ Rear layer

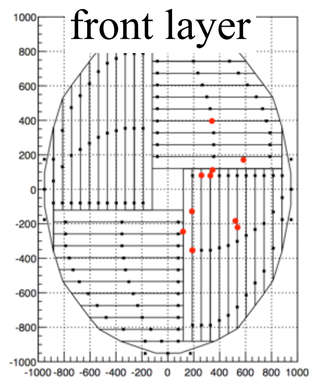


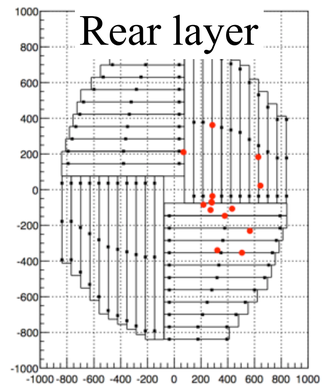
Upper limit : 1.88×10^{-5} @90%.C.L.

○main systematic uncertainties.
→due to accidental hit (3%).
→due to contamination of unqualified track(1.7±0.14%).

the track position of inefficiency event

○Black square (0.6×0.6mm²) : hole for fixing scintillator.
○most inefficiency event penetrate the hole or bounds of scintillators.





conclusion

○We designed and constructed, evaluated CV performance.
○CV requires 10^{-3} inefficiency for rejection of background.
○**CV achieves ～2×10^{-5} inefficiency**.