Gamma and Neutron Counter made of undoped CsI crystals with WLS fiber readout for KOTO experiment

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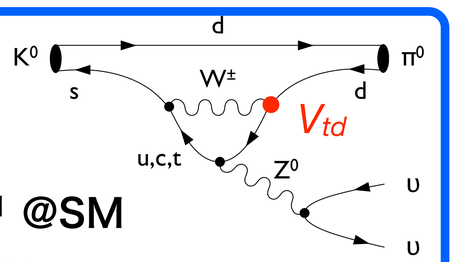
$K_L \to \pi^0 \nu \bar{\nu}$



- $K_L \to \pi^0 \nu \bar{\nu}$ decay
  - **rare decay :Br=2.4x10^{-11} @SM**
  - "direct" CP violating process
  - measure η in CKM matrix : Br($K_L \to \pi^0 \nu \bar{\nu}$)$\propto \eta^2$
  - small theoretical uncertainty (1~2%)

→ **good probe for New Physics**

KOTO experiment

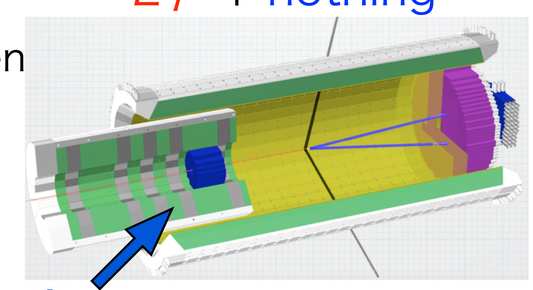
$K_L \to \pi^0 \nu\bar{\nu}$

→ 2γ → cannot detect

"2γ + nothing"

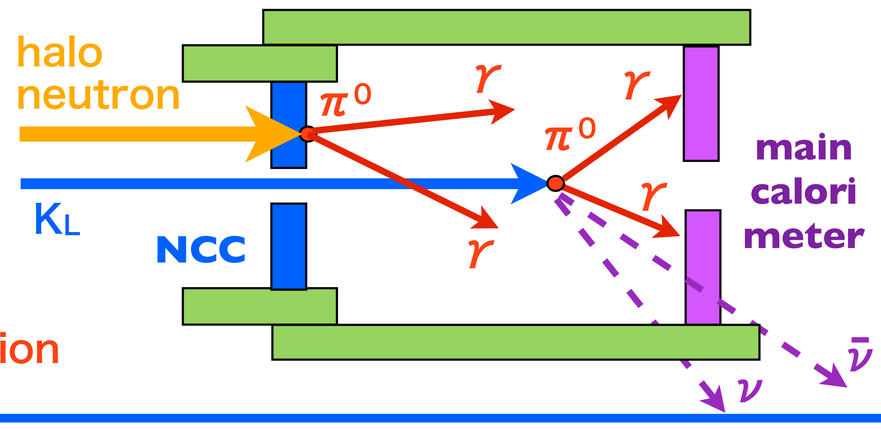
- dedicated experiment for this decay mode
  - Uses high inteisity K_L beam @ J-PARC
  - Detectors upgraded from E391a experimen
- To identify signal event
  - 2γ → CsI calorimeter
  - nothing → hermetic Veto detectors

→ **NCC : upstream veto near the beam**



Halo neutron background

- Neutrons existing around the KL beam(**halo neutron**)interact with NCC , generate π^0s , and $\pi^0 \to 2\gamma$ events become background
- countermeasures for halo neutron BG
  - detect π^0 generated event and veto → **background reduction**
  - measure the amount of halo-n & energy spectrum → **background estimation**

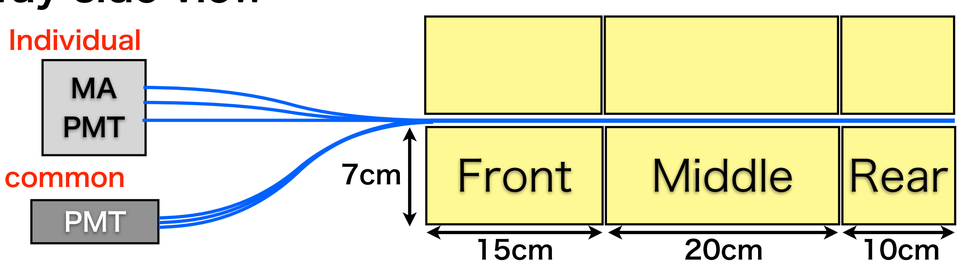


Concept of Neutron Collar Counter(NCC)

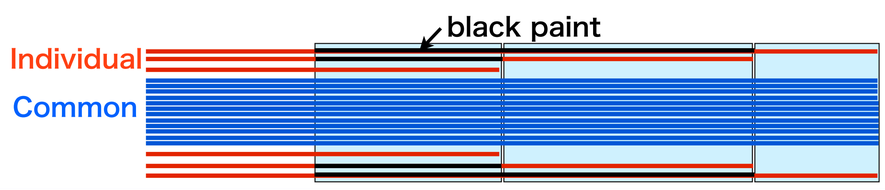
Neutron Collar Counter(NCC) is a fully active detector made of undoped CsI with WLS fiber readout

- **undoped CsI**
  - **relatively large interaction length (λ_I=39cm)& short radiation length (X_0 =1.9cm)**
    → **suppress π^0 generation by halo neutron & convert 2γ from π^0 decay**
  - fast (τ ~ 20ns) → can operate in high-rate condition (~ 1 MHz)
- **each module consists of 3 crystals with 2 types of WLS fiber readout**
  - Individual readout : 4 fibers read singals from each crystal individually
    → **distinguish neutron from γ using shower shape difference**
  - Common Readout : common 28 fibers for 3 crystals
    → **good light collection to achieve <1MeV background veto threshold**

cutaway side view

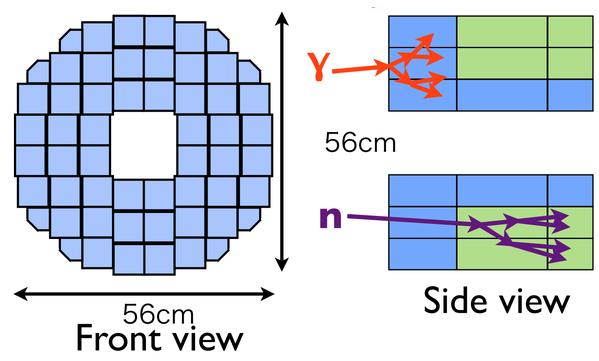


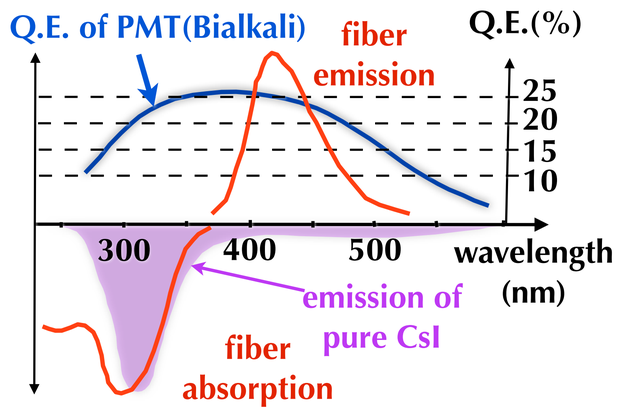
top view



- Front, Middle, and Rear crystals are optically separated with aluminum mirrors
- Modules are optically separated with Teflon wrapping
- Fiber masking with black paint for optical separation

Concept of n/γ discrimination





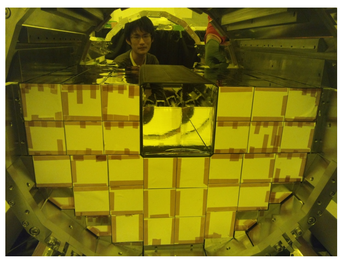
Kuraray PMP fiber matches CsI emission spectrum & Q.E. of PMT

construction

detector construction : from Apr. 2012 to Nov. 2012 @ Kyoto Univ.

module production

install into KOTO detector



module stacking

Detector installed @ J-PARC Dec. 2012

→ **successfully finished**

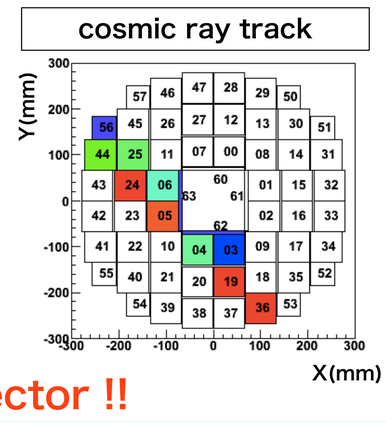
(All channels are working well !!)

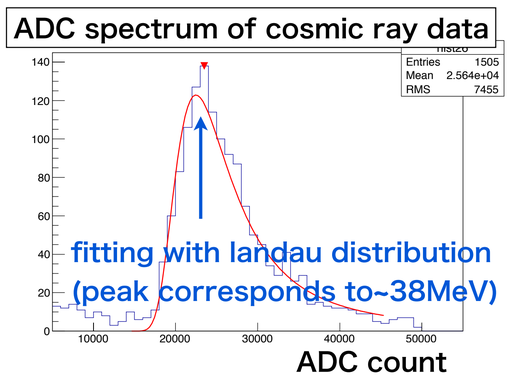
Current status and prospect

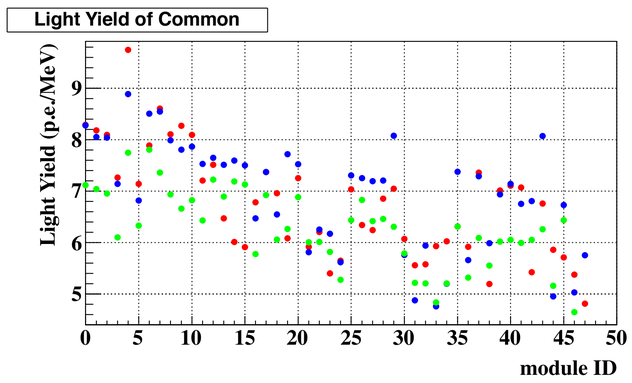
detector calibration & performance check have beed done with cosmic ray data

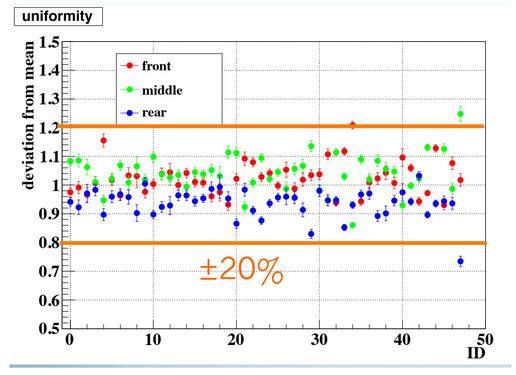
- light yield for common: **> 4.5 p.e./MeV**
- light yield uniformity of common readout between Front,Middle,and Rear : **< 20%**
- cross talk of individual readout between Front , Middle , and Rear : **<< 1%**
- energy calibration : **< 1% error**

→ **good performance as a photon veto detector !!**









First trial data for halo neutron measurement were taken in January.

Analysis is ongoing