MOON

MOON concept
Report on the prototype detector (MOON-1)

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MOON collaboration

NDM06 Paris

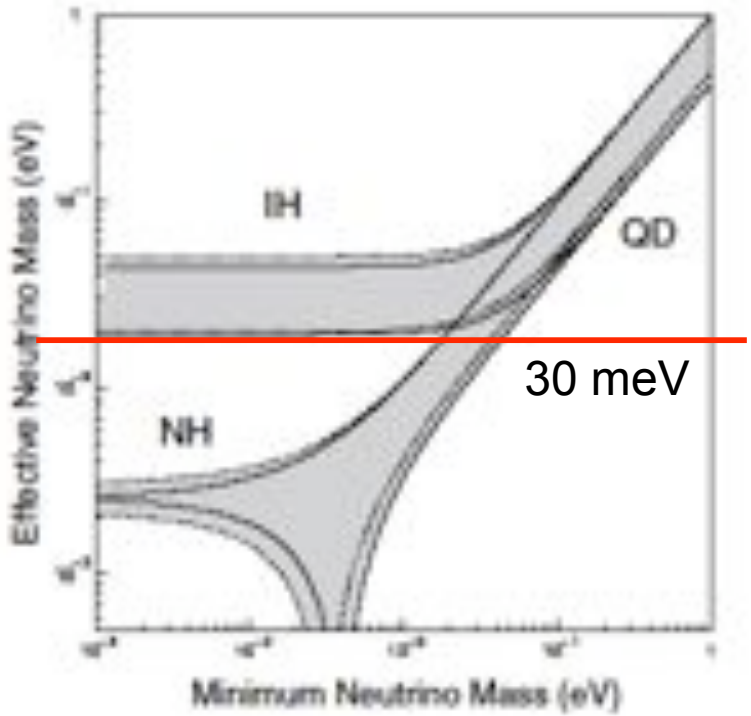
Challenge to 30 meV

- Sensitivity : 30 meV

$$T_{\frac{1}{2}} \approx 10^{27}\ years$$

- several decays / ton / year
- Require a few tons of ^{100}Mo
- 1t in 40mg/cm^2 foil

2500m^2 or 50m x 50m

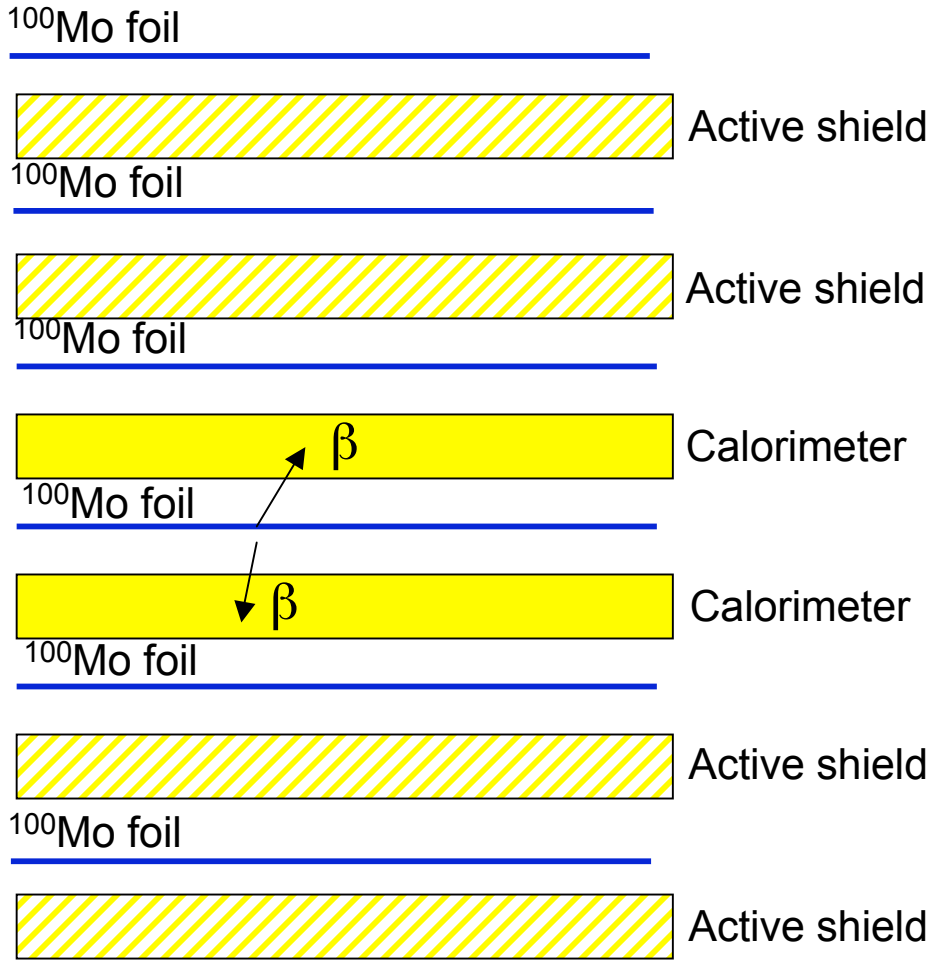


MOON Detector
source ≠detector

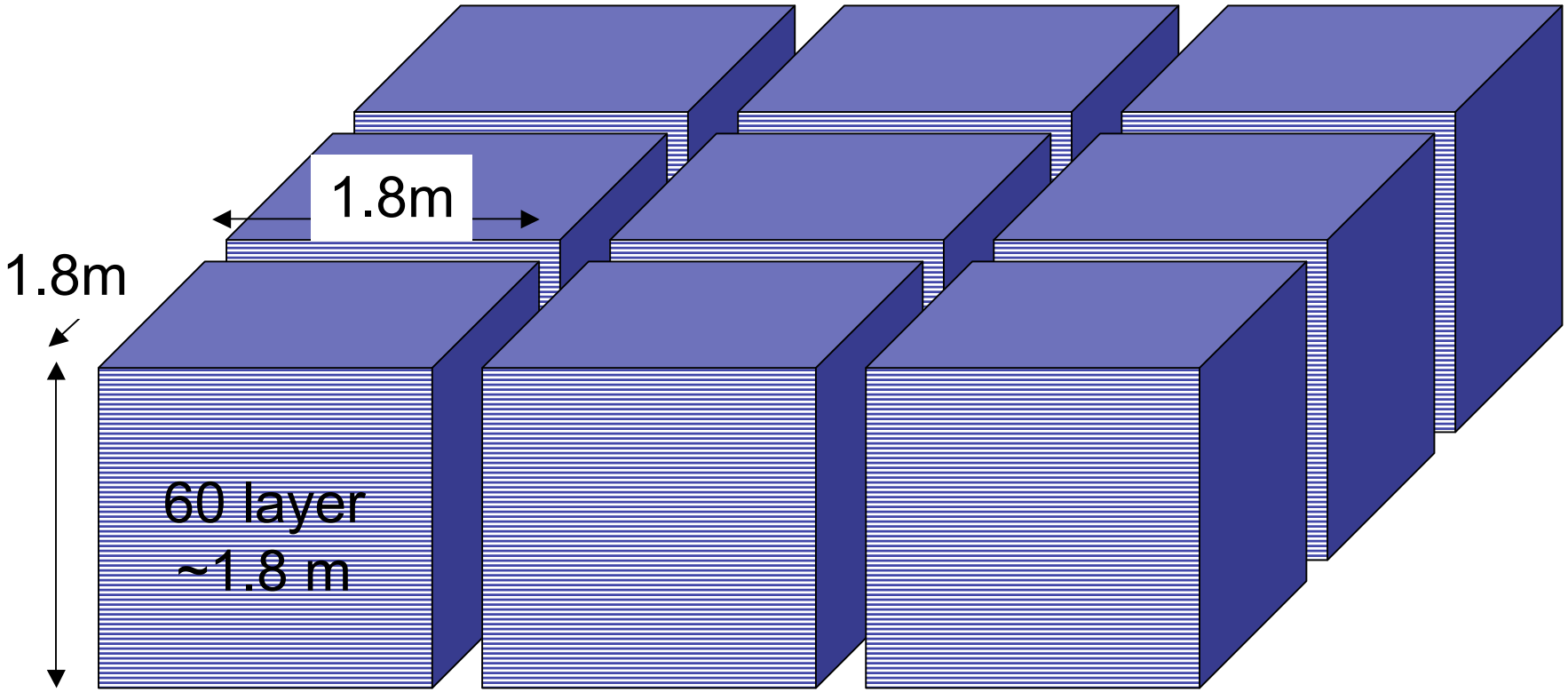
- **Multi layers module**
  - **^{100}Mo foil & Plastic scintillator**

    Mo foil is interleaved with PLs.
  - **Compact**

    PL works both as calorimeter and as active shield
  - **No TOF**
  - **Particle ID may be necessary.**
    - **Not in MOON-1 prototype detector**
    - **No tracking detector**
    - **Delta E / E telescope**
    - **No magnetic field**



MOON



22 module x 1.4m x 1.4m x 60 layer= 2577m^2

^{100}Mo 40mg/cm^2 ~1t

MOON-1 Detector

MOON prototype detector (MOON-1) was developed

to study the energy resolution and multilayer performance.

- **Plastic scintillator (PL)** BC408. equivalent **53x53x1cm^3 , 6 layers**
- **142g ^{100}Mo(94.5% enrich), 40mg/cm^2 3 layers**

  Mo foils are interleaved with two PLs.

  – Aluminized Mylar films are used to support Mo foil and to suppress the light cross talk between layers.
- **56 PMTs (^{40}K Free 0.7Bq/PMT)**

  HAMAMATSU, R6236-01 K-MOD

  Silicon cookie for the optical contact.

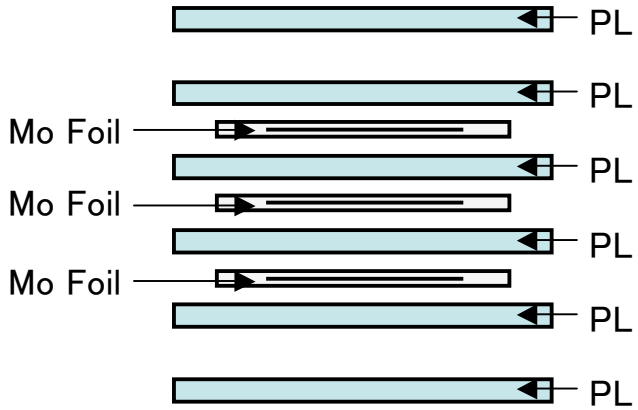
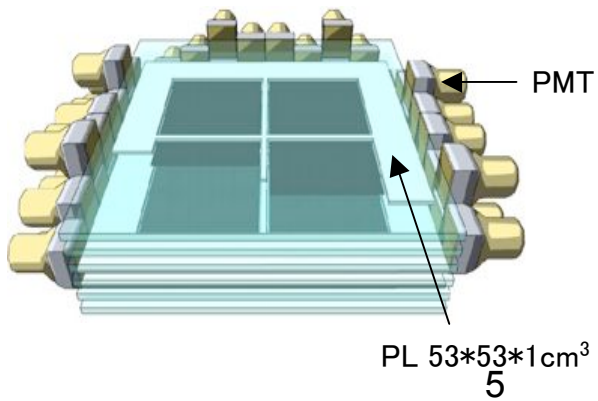


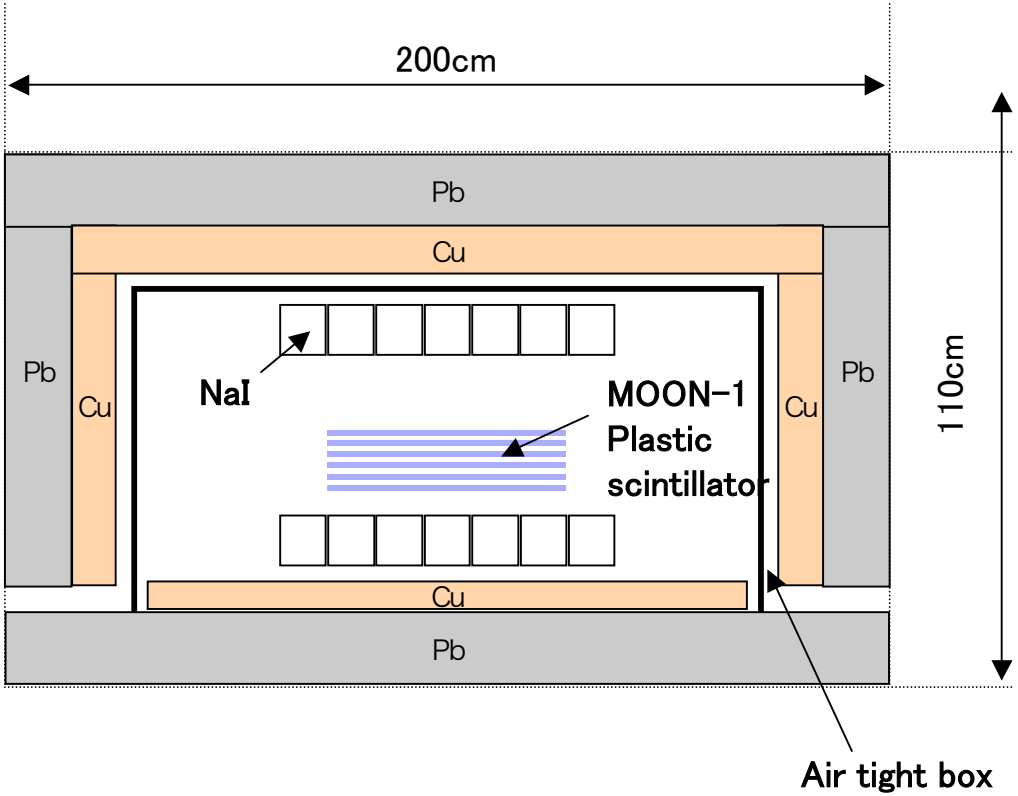
Fig. Cross section view of MOON−1



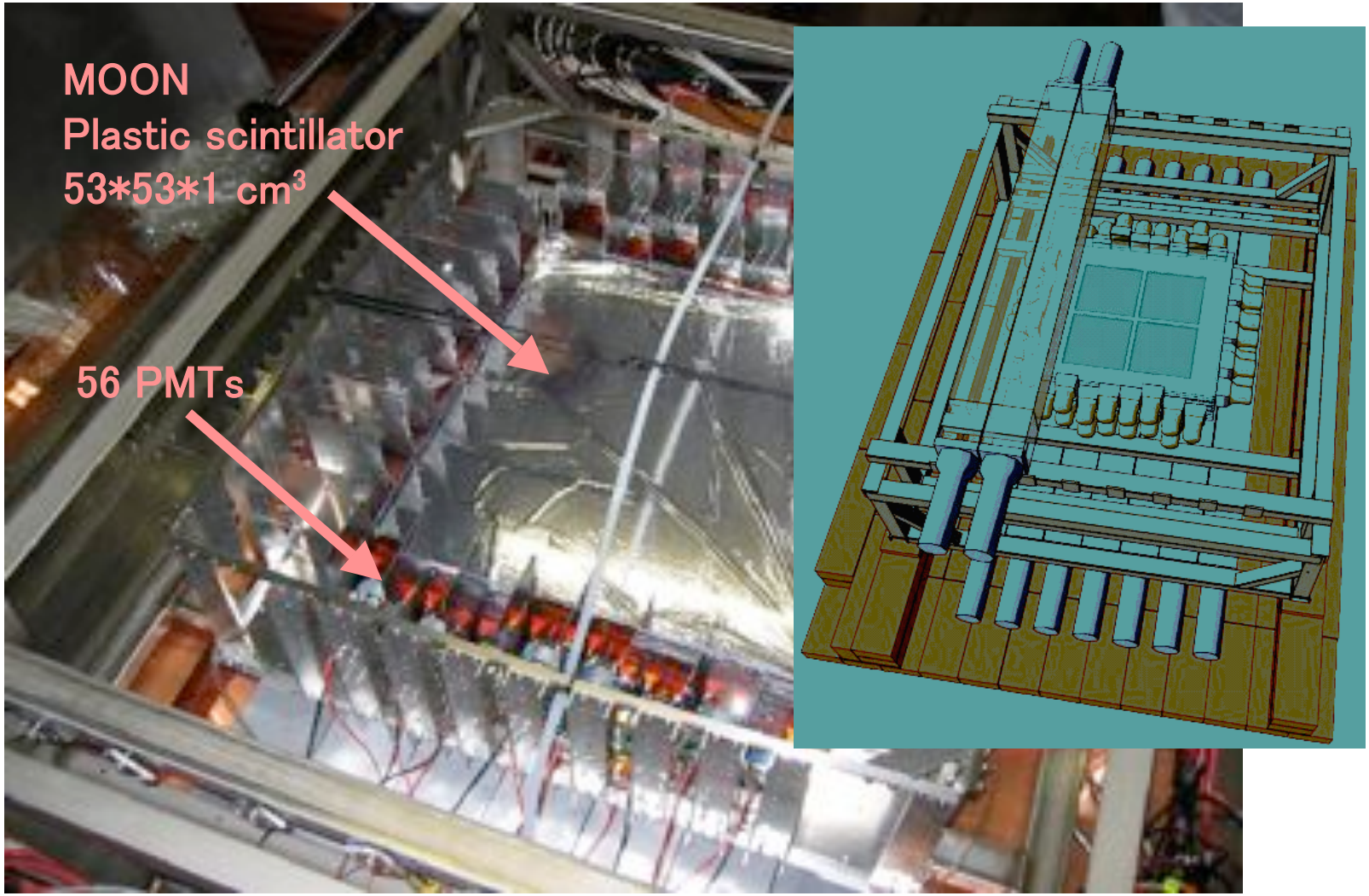
setup

MOON-1 is placed in active/passive shield of ELEGANT-V.

- NaI(Tl) detector
  14 of NaI(Tl) detectors are above and below MOON-1 detector for gamma ray active shield
- Air tight box
  To keep Rn concentration low, N_2 gas was flushing.
  Rn concentration was 125mBq/m^3.
- Lead & Copper passive shield
  The outside of the air tight box is covered with 10cm Cu, 15cm Pb as passive shield.



MOON-1 detector

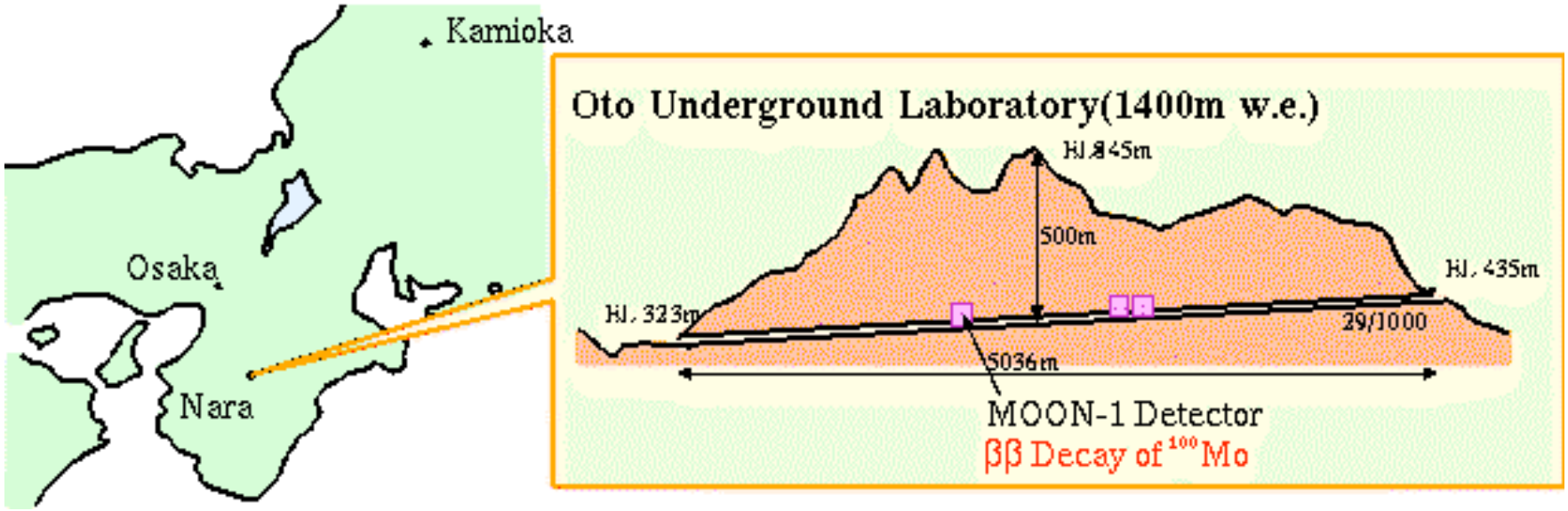


Oto underground Laboratory

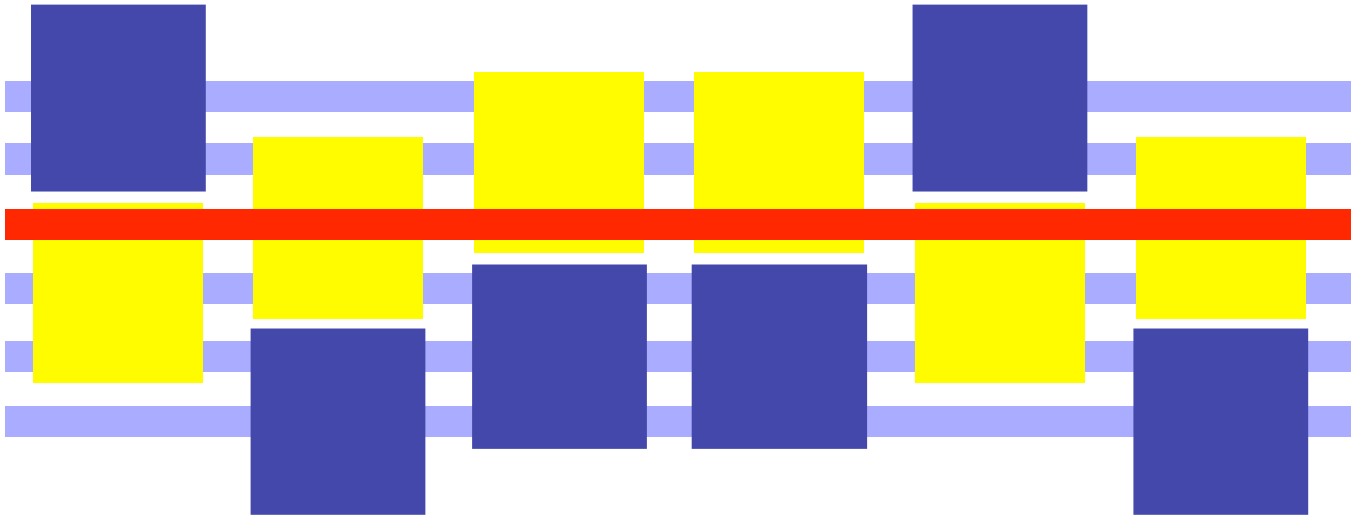
- **Depth**
  the lab is placed at 1,300m w.e.

- **BG level**
  The BG level were measured by ELEGANT group[2].
  - **Cosmic Ray: $4 \times 10^{-7}/cm^2/sec$**
  - **Neutron Flux: $4 \times 10^{-5}/cm^2/sec$**
  - **Rn: $10 Bq/m^3$**

  [2] Nucl. Instr. and Meth. A459(2001)177-181



Single layer Hit events



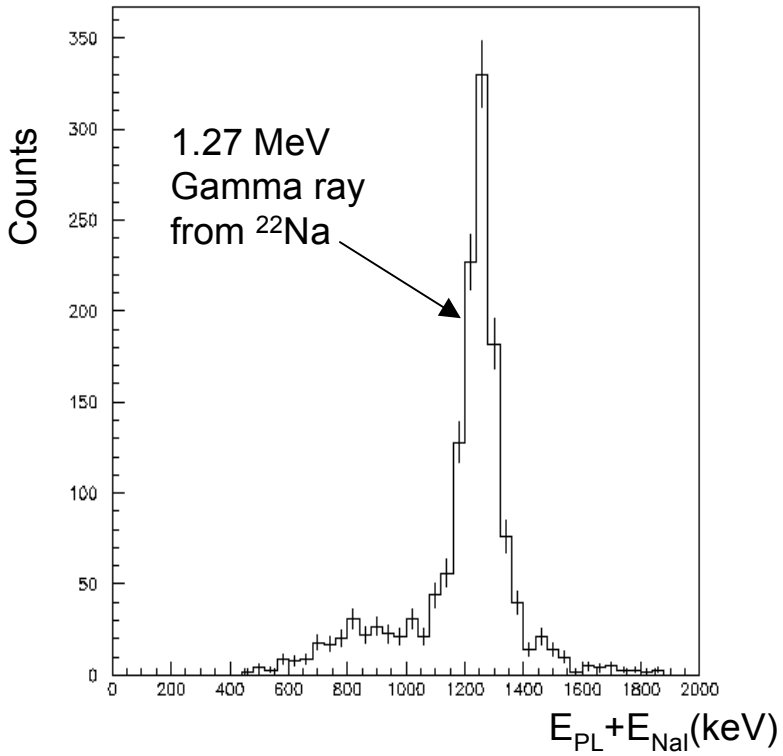
A PMT is attached to the 3 plastic scintillators in zigzags
To reduce the number of PMT

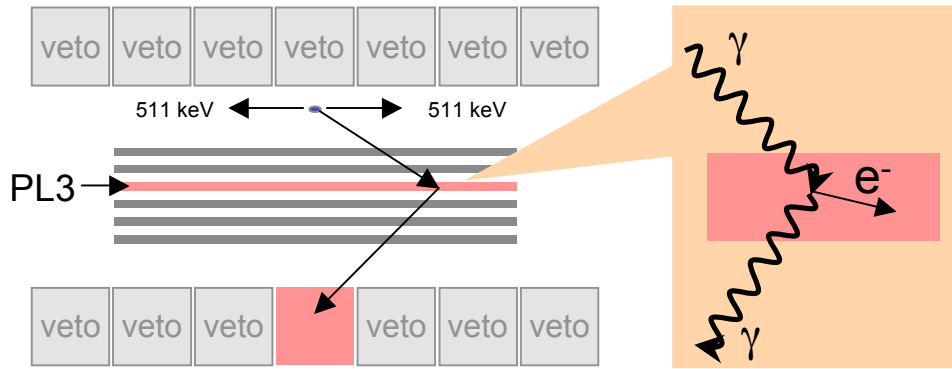
- Threshold Level -

Yellow PMT: 200keV
Blue PMT: 200keV

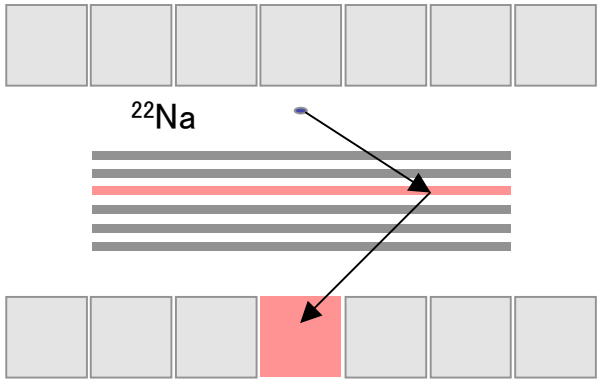
Energy reconstruction

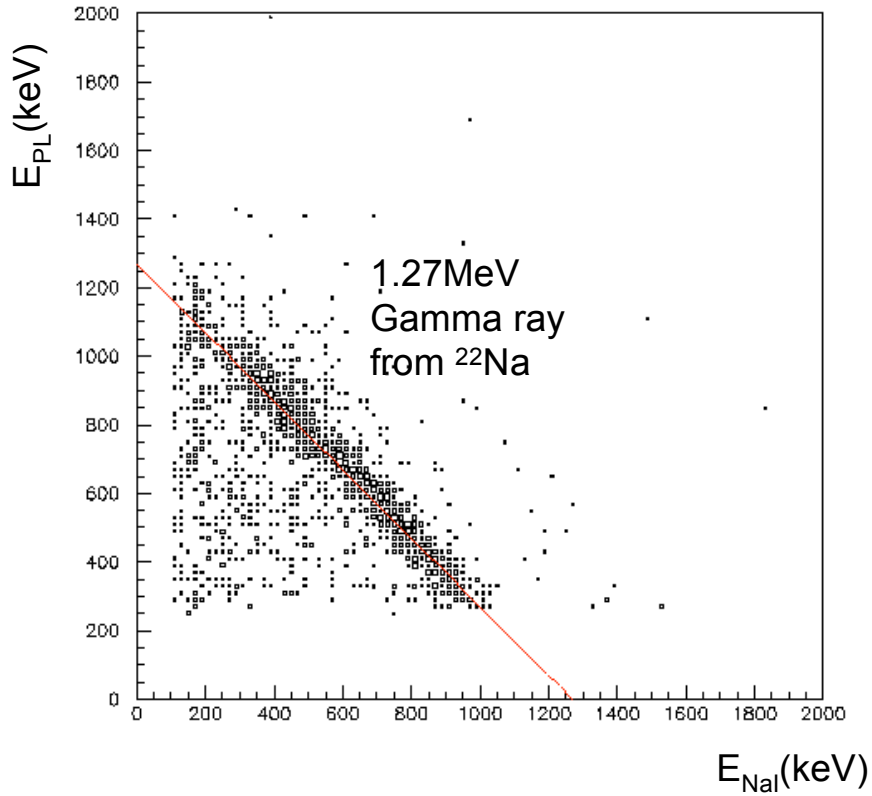
$$E_{\gamma} = E_{electron} + E_{gamma} = E_{PL} + E_{NaI}$$





Energy calibration



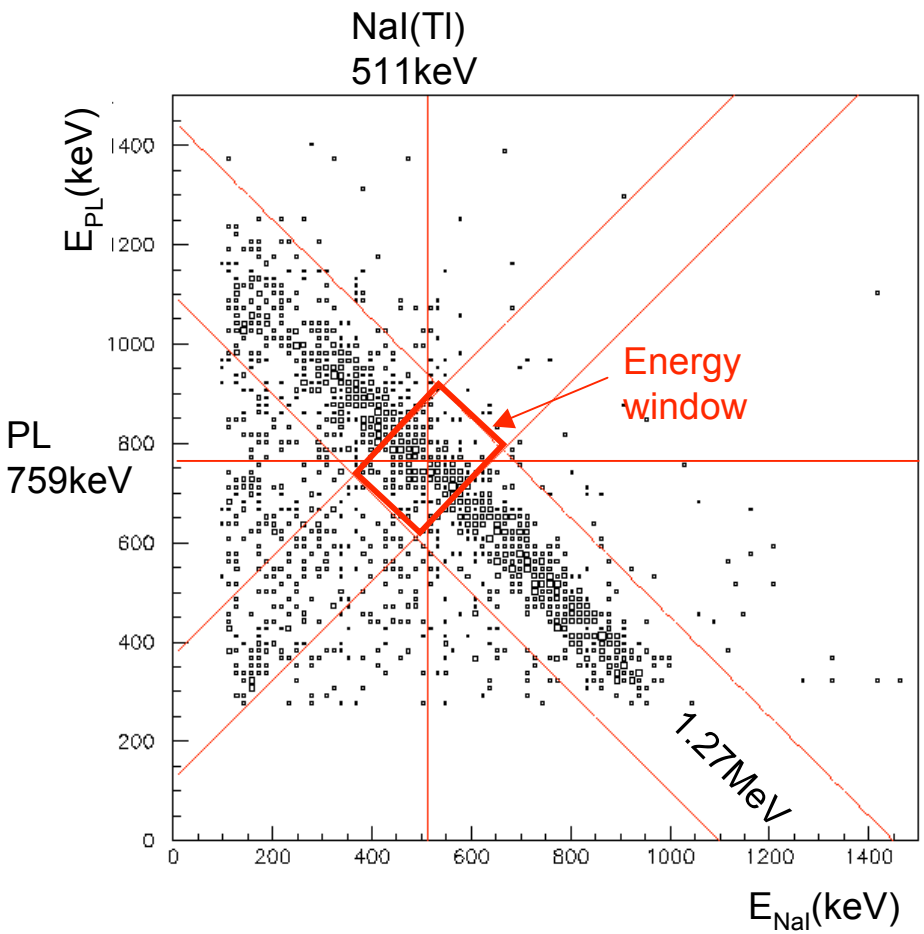


511keV is vetoed by Upper NaI(Tl)s.

Energy resolution

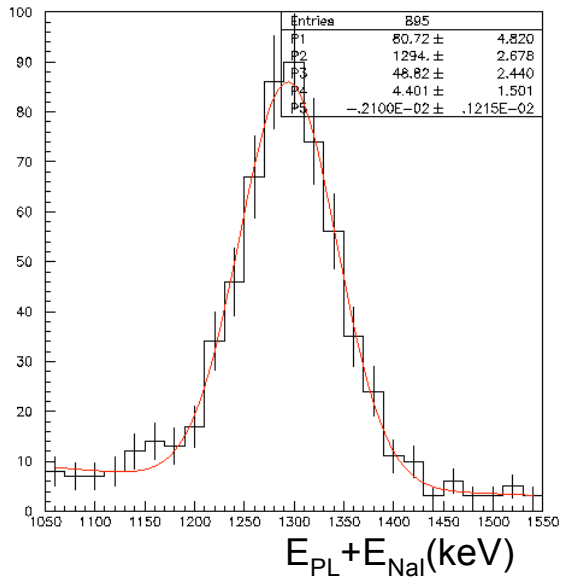
$$E_{\Sigma} = E_{PL} + E_{NaI}$$

$$\sigma_{\Sigma}^{2} = \sigma_{PL}^{2} + \sigma_{NaI}^{2}$$



$$\sigma_{PL}(E_{\gamma} - 511keV) = \sqrt{\sigma_{PL+NaI}^{2}(E_{\gamma}keV) - \sigma_{NaI}^{2}(511keV)}$$

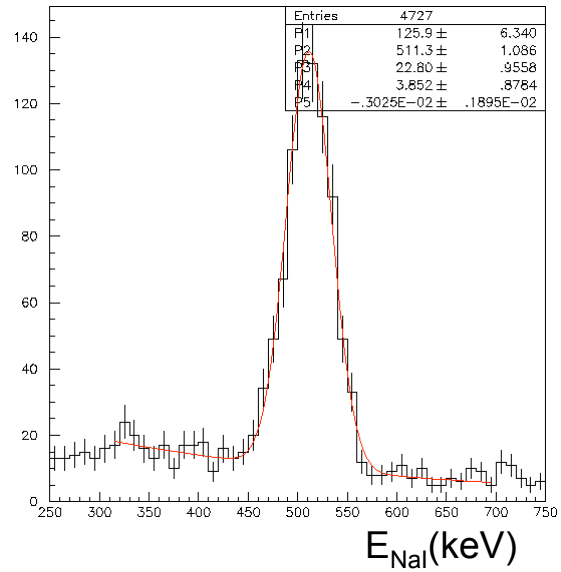
Reconstructed peak



^{22}Na 1.27 MeV

σ_{Σ}=48.8±2.4 keV

NaI(Tl) peak

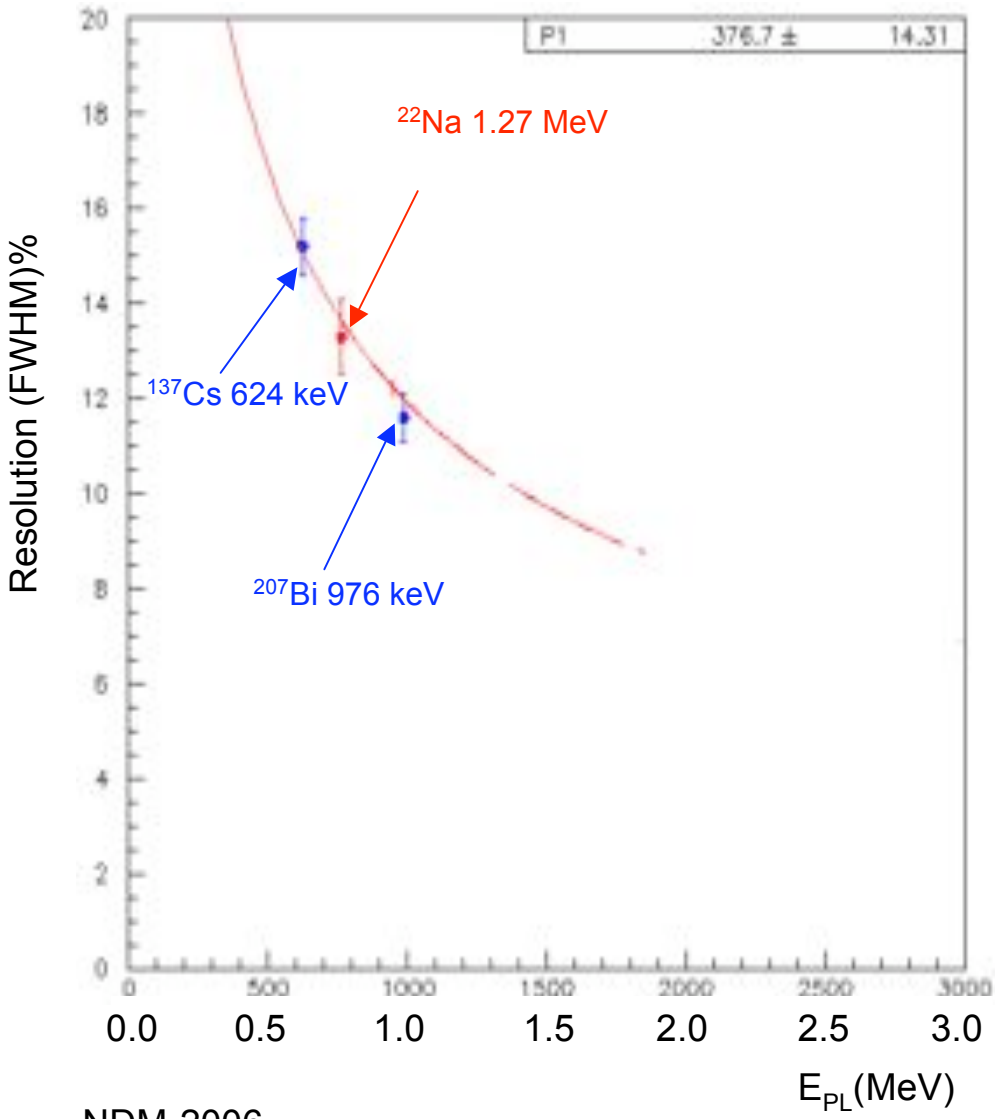


^{22}Na 511 keV

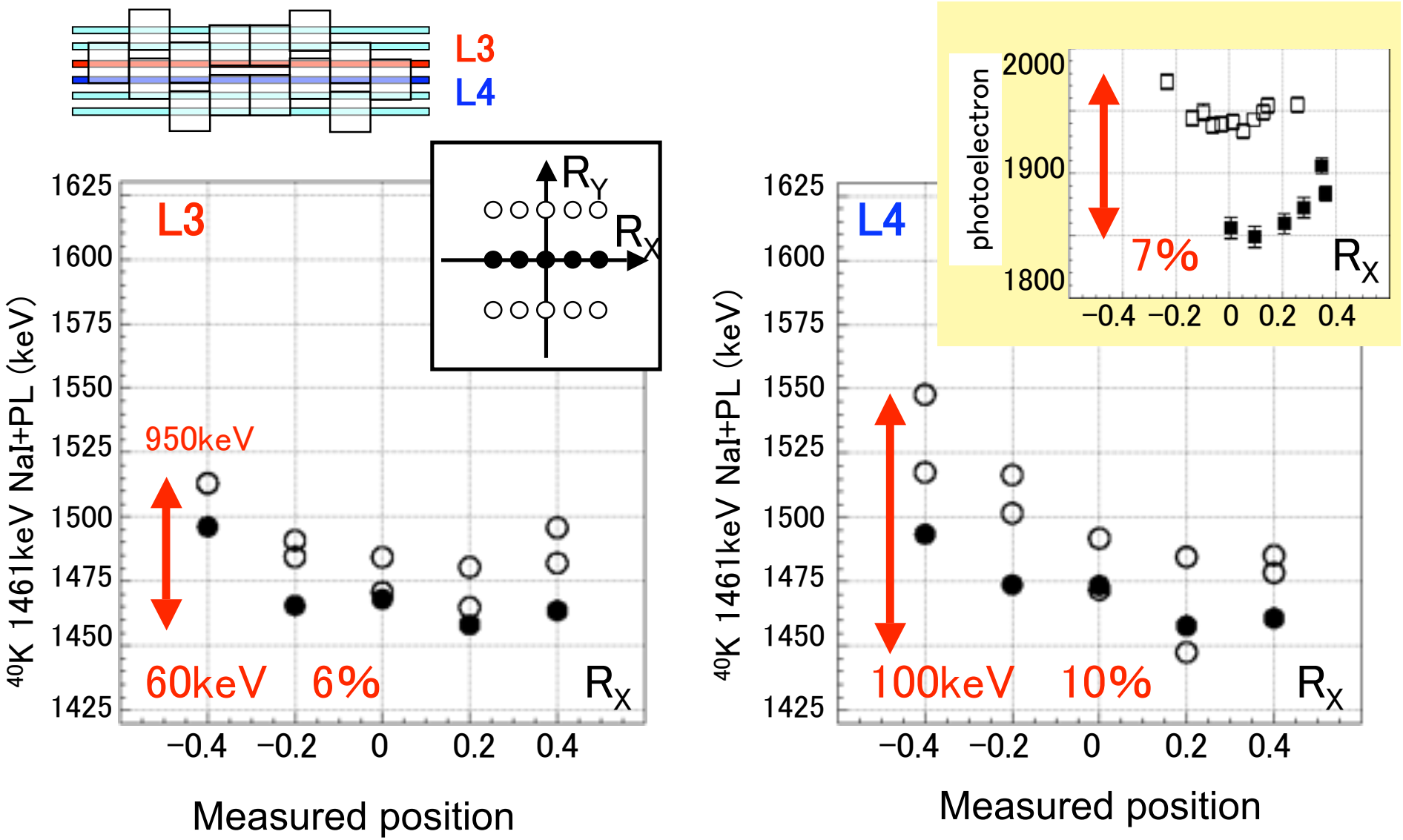
$\sigma_{N\alpha I}$=22.8±0.9 keV

MOON-1 Energy resolution

$$R(FWHM) = \frac{(11.9 \pm 0.5)}{\sqrt{E(MeV)}}\%$$



Position dependence



Summary

- MOON is multi-layer detector
- MOON-1 is proto-type detector
  - Good energy resolution in large PL plate
  - 11.9%(FWHM) at 1MeV for 53cm x 53cm
  - Small (compensation is possible) position dependence < 3%
- MOON-1 Sensitivity will be reported soon.