Application of thin NaI(Tl) scintillator for rare decay physics

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Application of NaI for nuclear rare processes

- Double beta decay
  - Good energy resolution
  - Larger backscattering of electron
- Solar neutrino
  - ^{127}I is sensitive to low energy neutrino
  - $^{127}I + \nu \rightarrow {}^{127}Xe + e^-$ $Q_{EC} = 0.789MeV$
  - Followed by γ rays=124.75keV
- Dark matter
  - Large scattering cross section
  - Sensitive to various types of coupling

Double Beta Decay

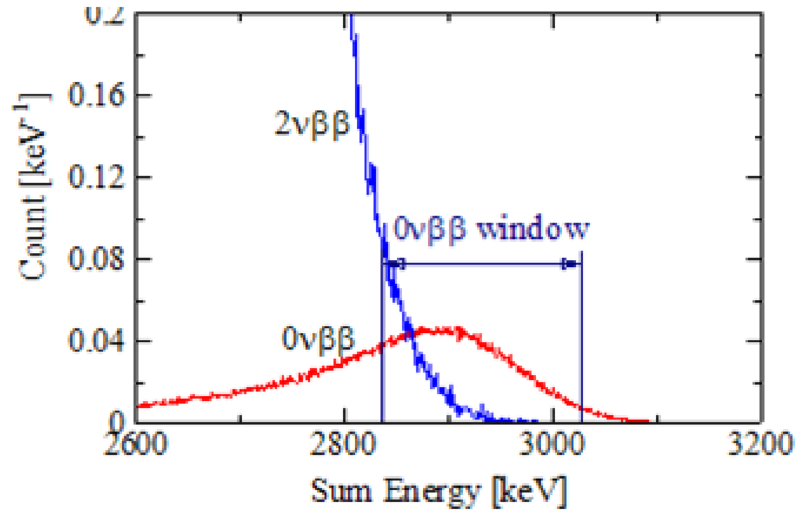
- Serious background
  - $2\nu\beta\beta$ events overlap
- Better energy resolution

$$\langle m_\nu \rangle \propto \left(\frac{b\Delta E}{Mt_{live}} \right)$$

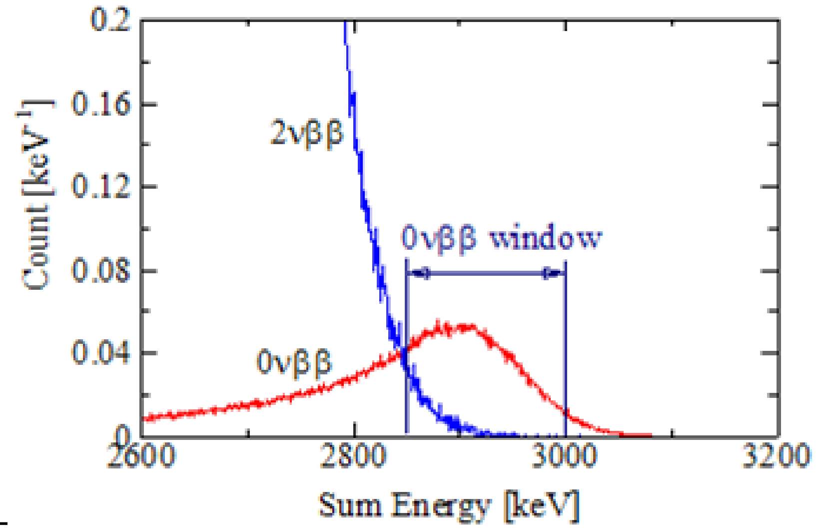
0.6 t y 72 meV

$Y^{0\nu} \sim 20/2$ ty

$\sigma = 2.2$ %



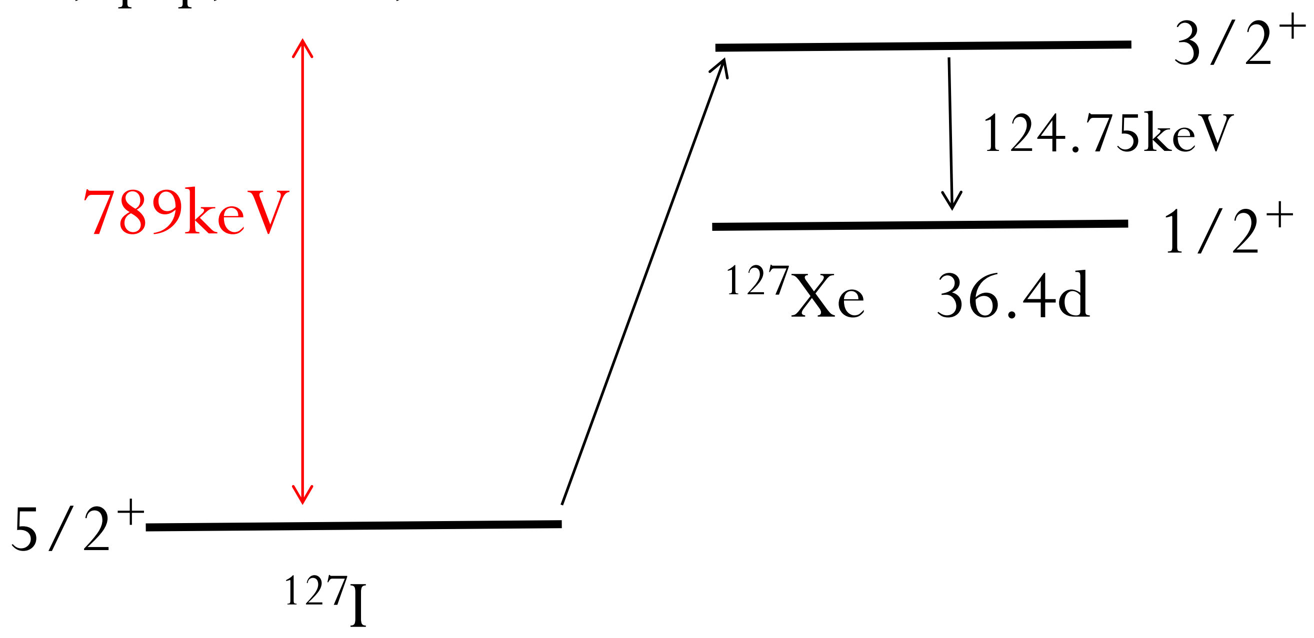
$\sigma = 1.7$ %



Low energy Solar Neutrino

- $^{127}I+\nu_e \rightarrow {}^{127}Xe^{*}+e^{-}$
- $^{127}Xe^{*} \rightarrow {}^{127}Xe+\gamma$
- Coincidence measurement of e^{-} and γ
- ^{7}Be, pep, CNO, ^{8}B

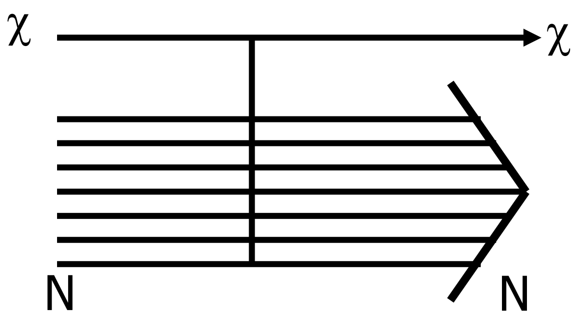
W.C.Haxton, PRL68(1988)768
J.Engel et al., PRC 50 (1994) 1702



Interactions between WIMPs and nucleus

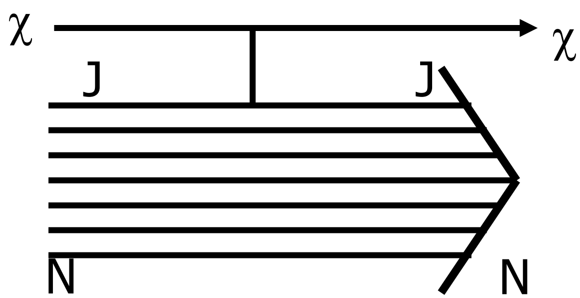
H.Ejiri K.Fushimi and H.Ohsumii, Phys. Lett B317(1993)14

SI



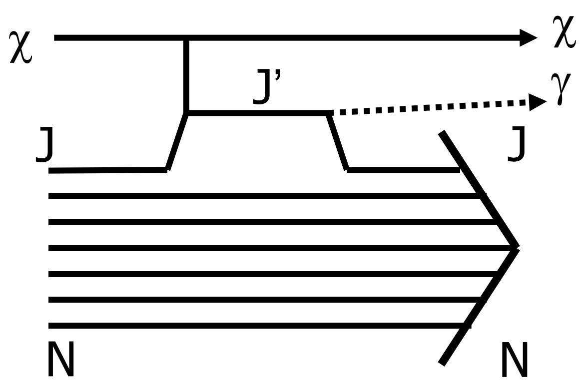
$$\sigma \propto A^2$$

SD



$$\sigma \propto C\lambda^2 J(J+1)$$

EX



$$\sigma \propto \sqrt{\frac{2J'+1}{2J+1}}\frac{1}{g_M}\langle A|M1|A^*\rangle$$

We planned to study all the types of interaction!!

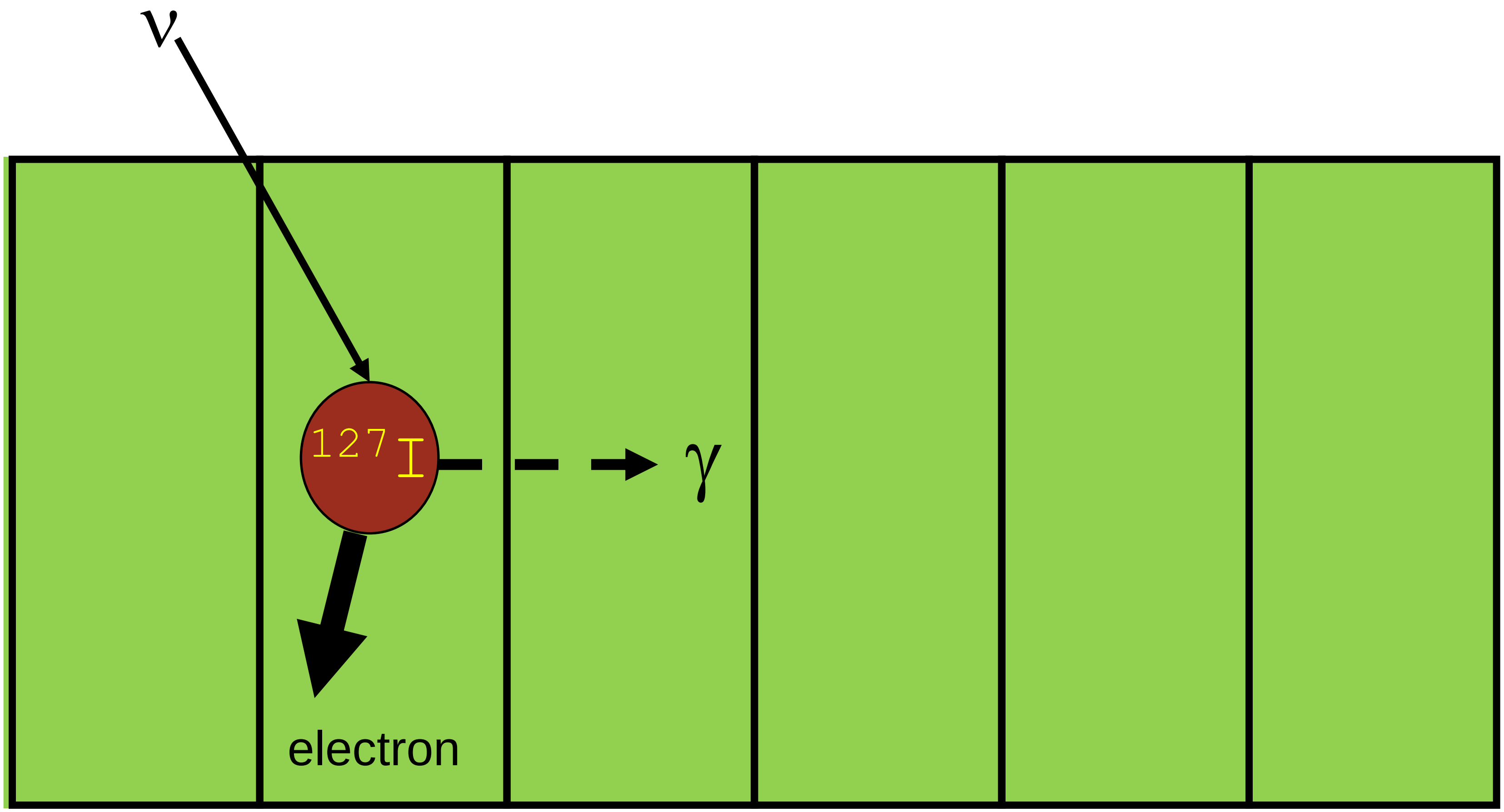
PICO-LON/MOON Project

- Planar Inorganic Crystal Observatory for LOw-background Neutr(al)ino
- Molybdenum/Majorana Observatory Of Neutrino
- Aim
  - Search for dark matter
  - Search for double beta decay
- Detector
  - Thin NaI(Tl)
  - Thin Plastic scintillator
  - Their Complex

Signal selection by Spatial and Timing Correlation (SSSTC)

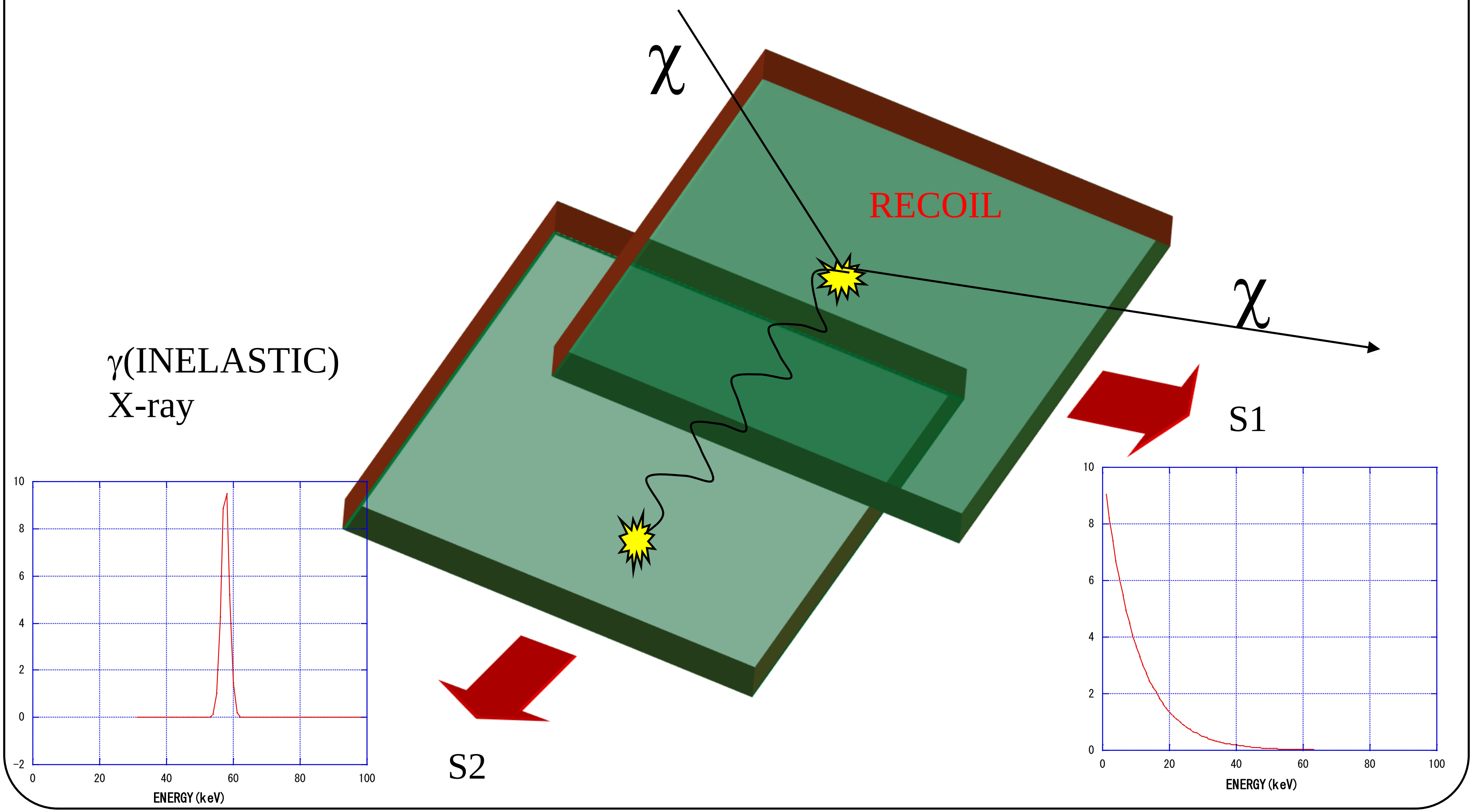
- Signal Selection by Spatial Correlation
  - Signal → 57.6keV γ + Low energy recoil
  - Localized event in space and time
  - Background → U,Th chain, ^{40}K etc.
  - Diffused event in space and time
- Signal Selection by Timing Correlation
  - Signal → No following events
  - Baclground → Time-correlated events by decay chain

Signal identification by segmentation

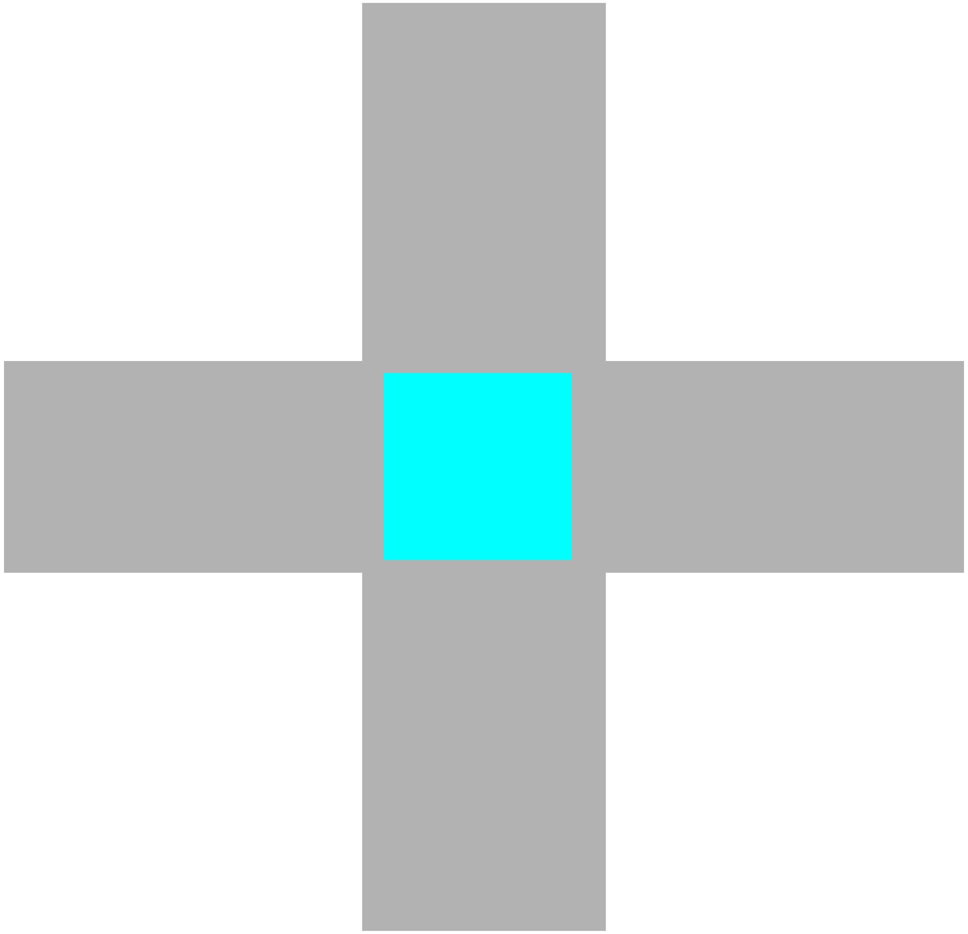


Signal Identification by Segmentation

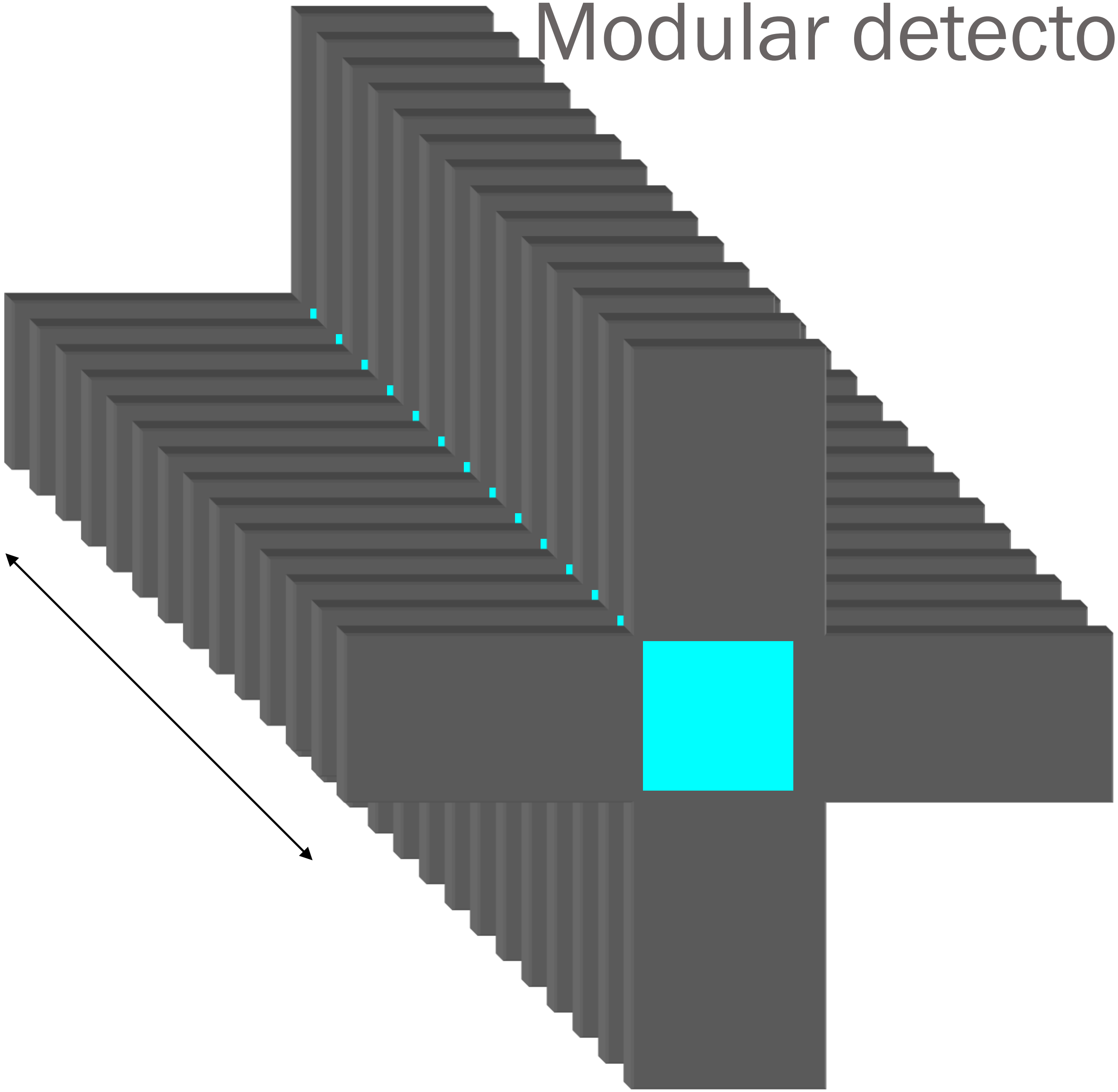
K.Fushimi et al., JPSJ74(2005)3117
H. Ejiri, Ch. C. Moustakidis, J.D. Vergados,
PL. B639, 06, 218, arXiv hep-ph/0510042 2005.



Modular detector system

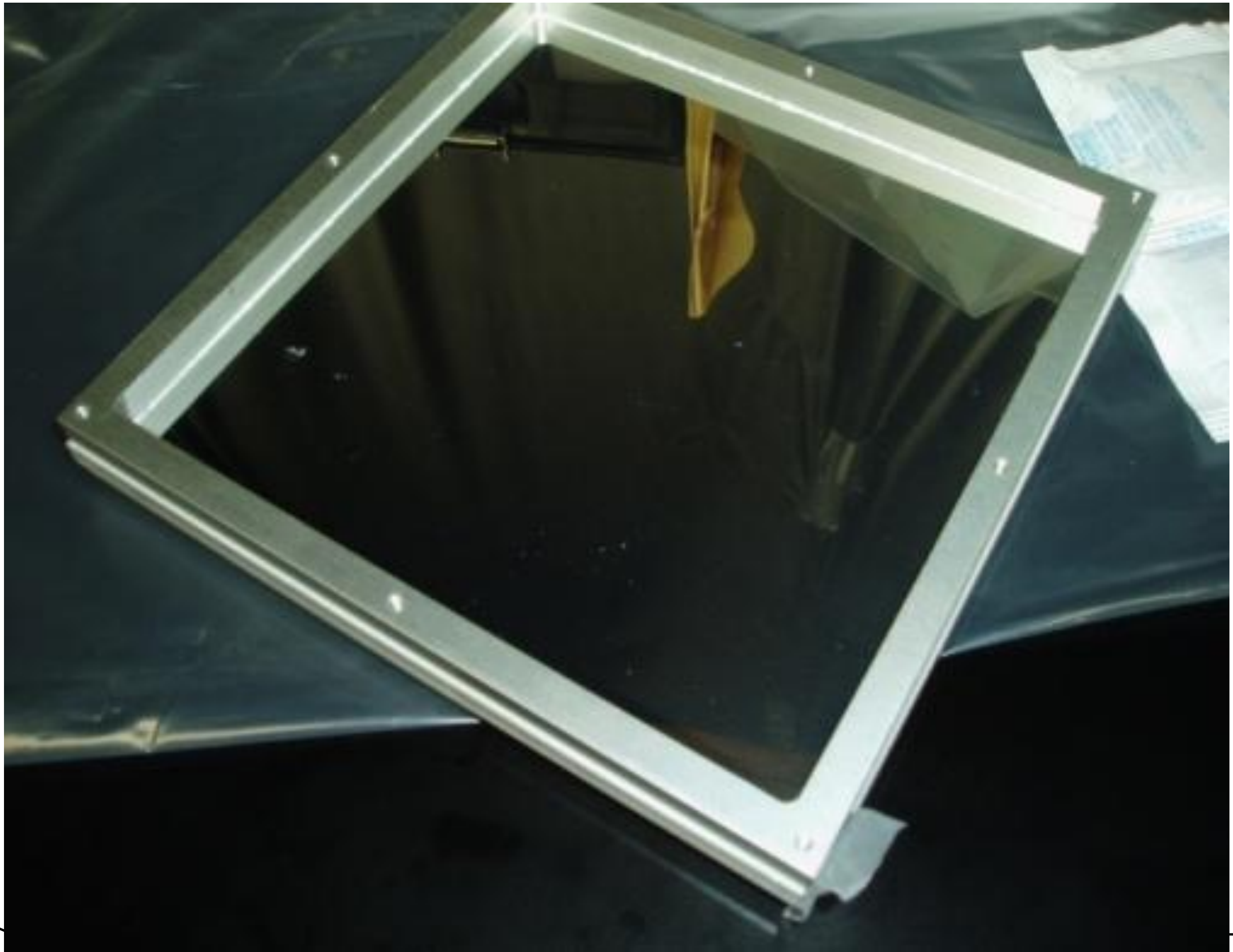


Modular detector system

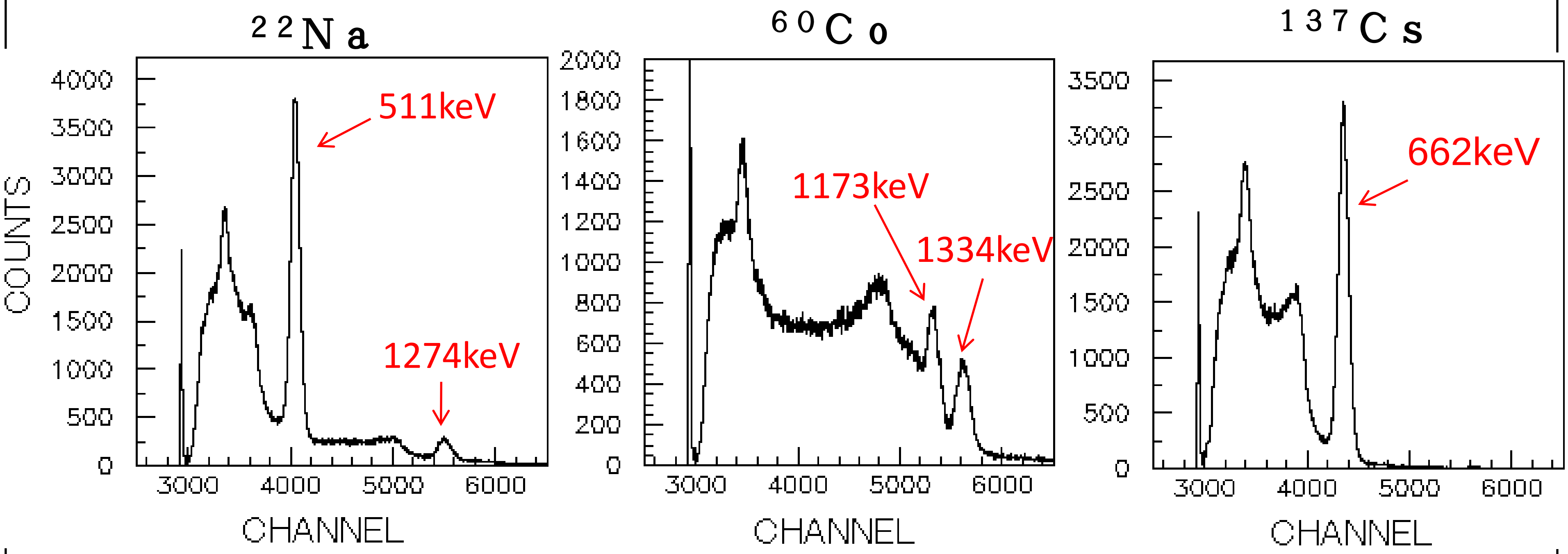


Thin NaI(Tl) plate for performance test

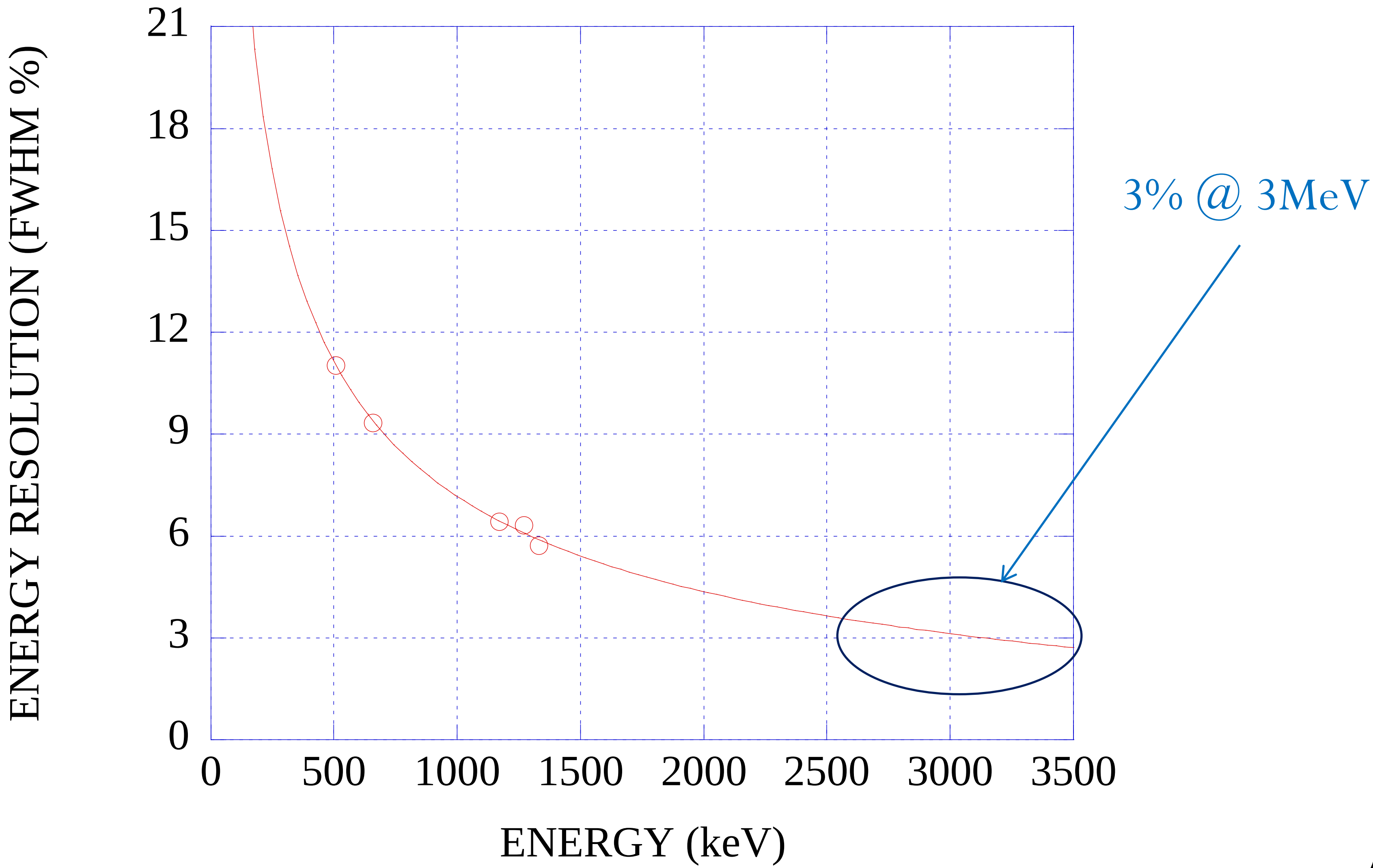
NaI(Tl) 18cmX18cmX0.5cm



Energy resolution

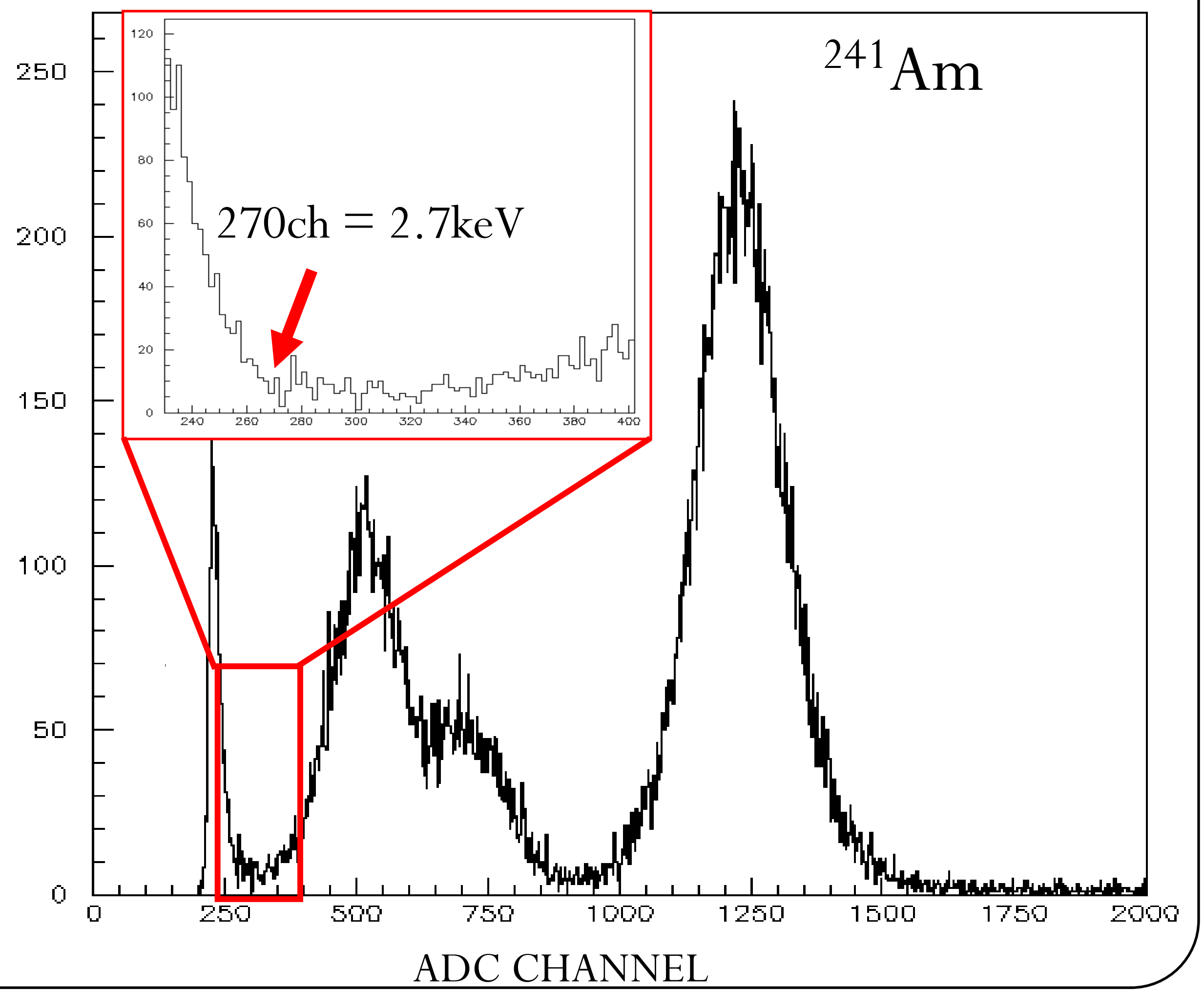


Energy resolution of thin NaI(Tl)



Low energy threshold

- Important Feature for DM search
  - Less than 5keV
- Energy calibration by low energy γ and X rays



Conclusion

- Thin NaI(Tl) plate has great advantages for
- DBD
  - Good energy resolution 3% FWHM @ 3MeV
- SN
  - Low Q_{EC} value
- DM
  - Low energy threshold
  - Study various types of interaction