Calibration of the E Si detector in a DE-E telescope with a ^{212}Pb pin source

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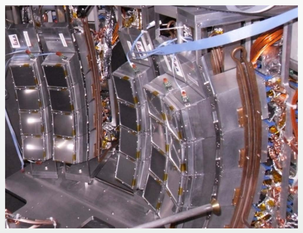
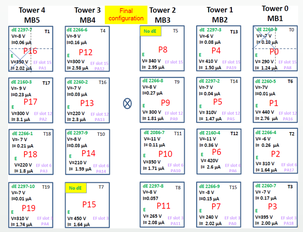
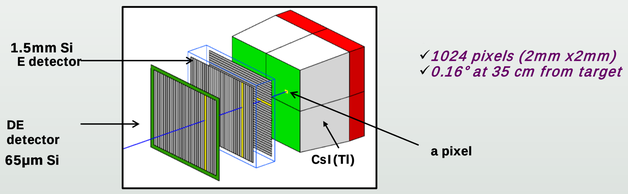
HiRA DE-E telescope



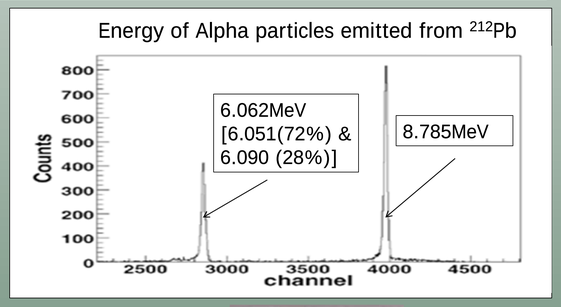


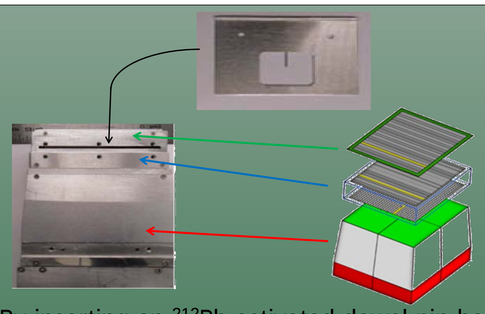


✓*1024 pixels (2mm x2mm)*
✓*0.16° at 35 cm from target*

- excellent energy resolution and linear energy response over a large dynamic range.
- "DE" is used to measure the energy loss of the particle passing through it.
- "E" (two sided strip detector) is used to measure position and energy loss of the particle.
- The energy measured in DE or E are used for particle identification.

Pin source of HiRA telescope



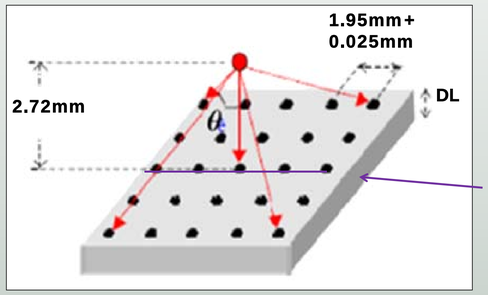


- By inserting an ^{212}Pb activated dowel pin between the DE and E detectors, we can calibrate and determine the front dead layer thickness of the E detector without dismounting the DE detector which may damage the detectors and disturb the stability of the electronics.

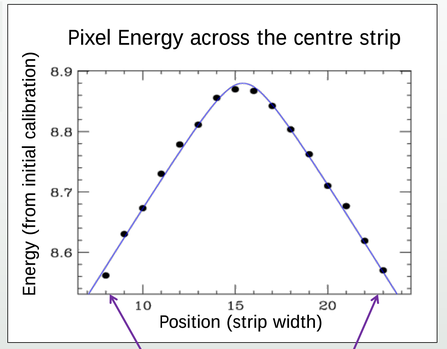
Dead-layer thickness determination

- Dead-layer is the non-depleted region and metallic electrodes on the surface of a silicon detector.
- The energy of alpha particles lost in the dead-layer can not be measured.
- However, the energy loss in the dead-layer varies with on the entrance angles.

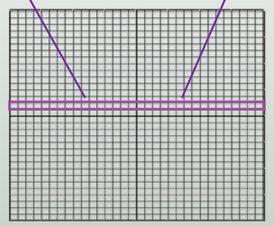
$$E = E' - \frac{dE}{dx}\frac{DL}{Cos\theta}$$ [Jenny Lee, thesis, 2010]



Schematic geometry of pin source calibration



EF_{18} of tele 13 as an example



Fitting method

$$E = \text{Pin source energy} - (\text{stopping power} * DL) * \frac{1}{Cos\theta}$$

$$E = C1 - C2 * \sqrt{1 + \left(\frac{d}{h}\right)^2}$$

$$E = C1 - C2 * \sqrt{1 + k * (x - C3)^2}$$

$$k = \frac{\text{Strip width}^2}{h^2} = \frac{(1.95 + 0.025)^2}{2.72^2} = 0.527$$

Using Mathematica to do the fitting,
{C1 → 8.948, C2 → 0.068, C3 → 15.41}

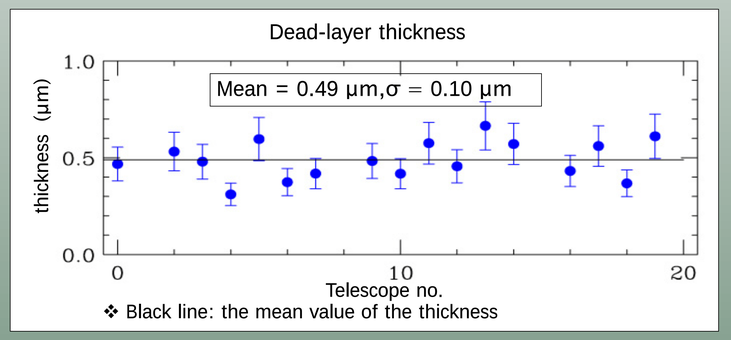
Position of the pin in unit of strip

If stopping power of the dead-layer is known, DL can be found

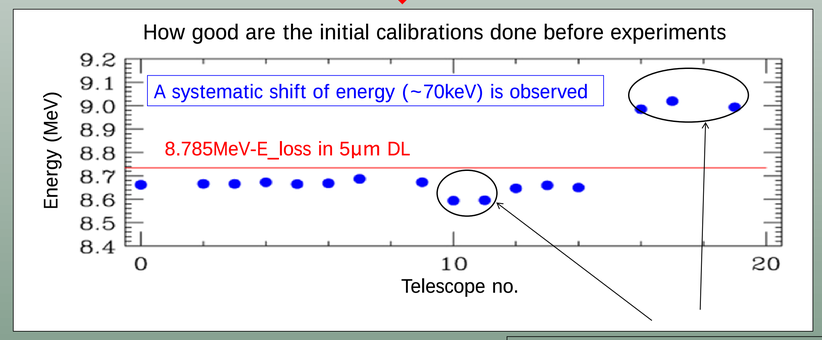
Pin source energy =8.785 – energy loss in DL
→initial calibration is slightly off
Assume a linear correction:
$E_{real} = A \times E_{detected} + B$

The alpha peaks from the pin source can be used to provide calibrations of the E detectors and compared to initial alpha source calibrations before the experiments.

Results



❖ Black line: the mean value of the thickness



The electronic configuration was changed

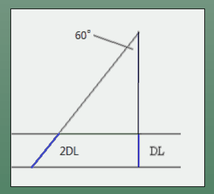
Calculation

Based on the energy of all telescopes, assume |A-1|<0.05.

$$E_{loss} = C2 \times \left(\frac{1}{\cos 0^\circ} - \frac{1}{\cos 60^\circ}\right) = C2$$

C2: stopping power × DL

$$E_{loss} = [A \times E(0^\circ) + B] - [A \times E(60^\circ) + B]$$
$$= A \times [E(0^\circ) - E(60^\circ)] \approx [E(0^\circ) - E(60^\circ)]$$



C2 = stopping power x DL , DL can be calculated with LISE++
As the 8.785MeV peak is always sharper and the energy is more accurate, it gives more weight to the determination of DL

$$DL_{corr} = 0.7 \times DL(8.785MeV) + 0.3 \times DL(6.062MeV)$$

Conclusion

- A pin source is relatively easy to make and convenient to use. It provides accurate calibrations to the E Si detectors placed behind a thin DE detector with minimum disturbance to the mechanical and electronic setup in nuclear physics experiments.
- By placing a pin source close (~2.5 mm) to a two sided 2mm pitch Si strip detector, the deadlayer thickness of the Si detector is determined to be about 0.5 ±0.10 μm.
- In the example we studied, the pin source was used to both check and correct the initial calibrations of the HiRA detectors. This is particular useful in experiments that run for a long time.

Acknowledgement

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