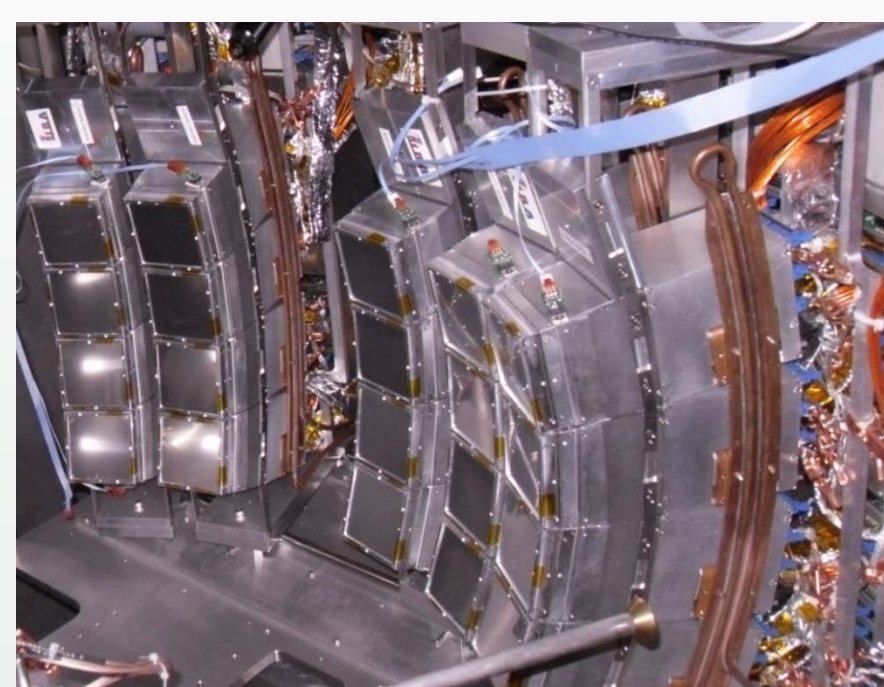


Calibration of the E Si detector in a DE-E telescope with a ^{212}Pb pin source

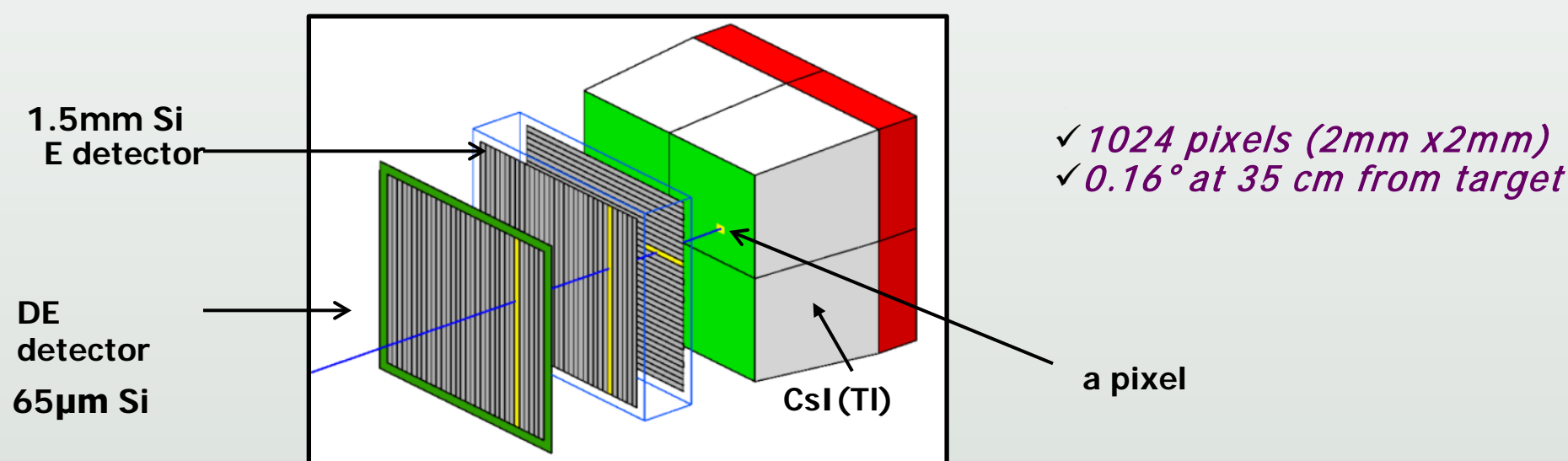
K.P. Chan

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HIRA DE-E telescope

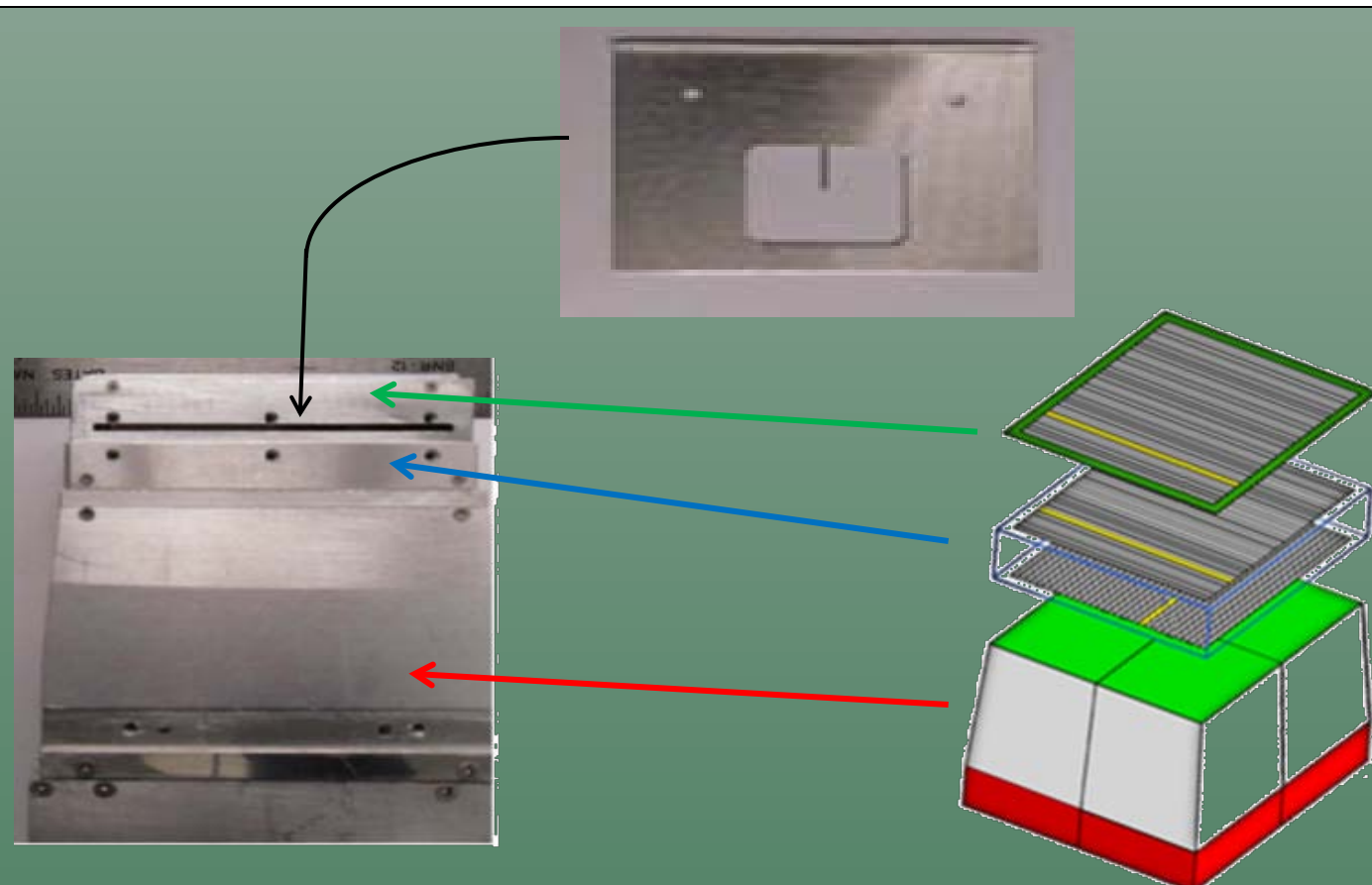
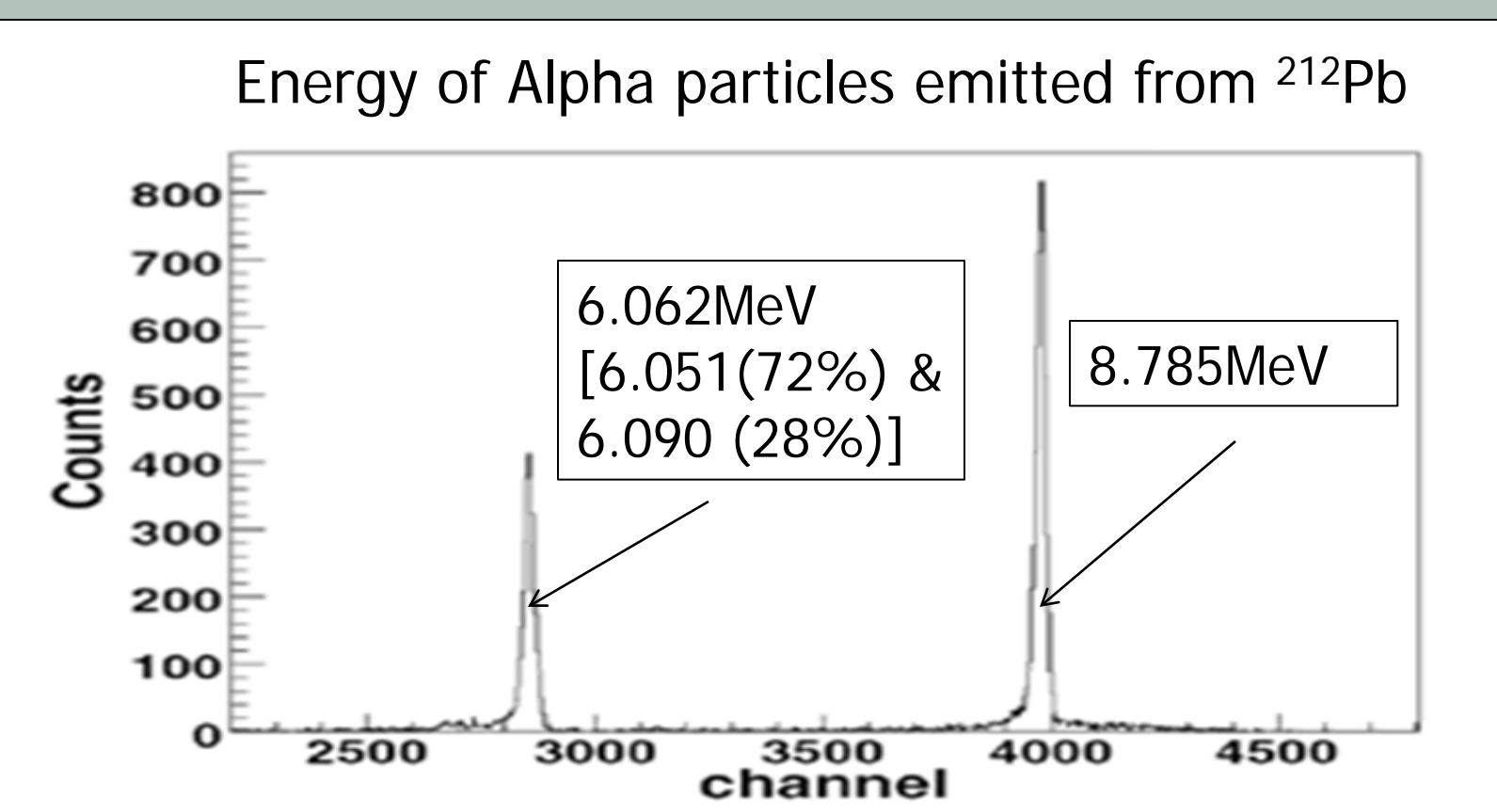


Tower 4	Tower 3	Tower 2	Tower 1	Tower 0
MB5	MB4	MB3	MB2	MB1
P16	P17	P18	P19	P20
P17	P18	P19	P20	P21
P18	P19	P20	P21	P22
P19	P20	P21	P22	P23
P20	P21	P22	P23	P24
P21	P22	P23	P24	P25
P22	P23	P24	P25	P26
P23	P24	P25	P26	P27
P24	P25	P26	P27	P28
P25	P26	P27	P28	P29
P26	P27	P28	P29	P30
P27	P28	P29	P30	P31
P28	P29	P30	P31	P32
P29	P30	P31	P32	P33
P30	P31	P32	P33	P34
P31	P32	P33	P34	P35
P32	P33	P34	P35	P36
P33	P34	P35	P36	P37
P34	P35	P36	P37	P38
P35	P36	P37	P38	P39
P36	P37	P38	P39	P40
P37	P38	P39	P40	P41
P38	P39	P40	P41	P42
P39	P40	P41	P42	P43
P40	P41	P42	P43	P44
P41	P42	P43	P44	P45
P42	P43	P44	P45	P46
P43	P44	P45	P46	P47
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P51	P52	P53	P54	P55
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P53	P54	P55	P56	P57
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P56	P57	P58	P59	P60
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P61	P62	P63	P64	P65
P62	P63	P64	P65	P66
P63	P64	P65	P66	P67
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P66	P67	P68	P69	P70
P67	P68	P69	P70	P71
P68	P69	P70	P71	P72
P69	P70	P71	P72	P73
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P71	P72	P73	P74	P75
P72	P73	P74	P75	P76
P73	P74	P75	P76	P77
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P76	P77	P78	P79	P80
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P81	P82	P83	P84	P85
P82	P83	P84	P85	P86
P83	P84	P85	P86	P87
P84	P85	P86	P87	P88
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P86	P87	P88	P89	P90
P87	P88	P89	P90	P91
P88	P89	P90	P91	P92
P89	P90	P91	P92	P93
P90	P91	P92	P93	P94
P91	P92	P93	P94	P95
P92	P93	P94	P95	P96
P93	P94	P95	P96	P97
P94	P95	P96	P97	P98
P95	P96	P97	P98	P99
P96	P97	P98	P99	P100



- 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

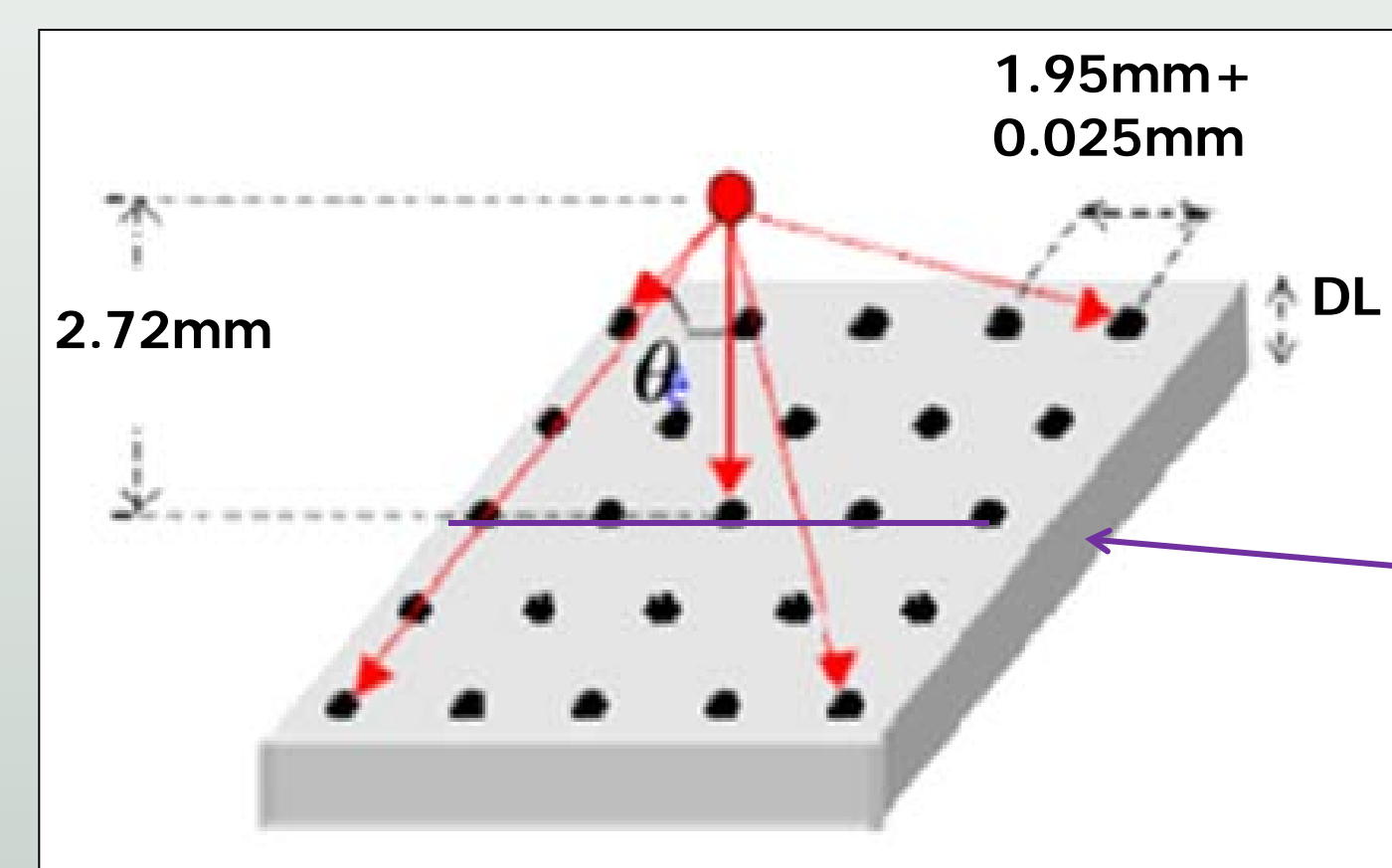


- By inserting an ^{212}Pb activated dowel pin between the DE and E detectors, we can calibrate and determine the front dead layer thickness of the E detector without dismounting the DE detector which may damage the detectors and disturb the stability of the electronics.

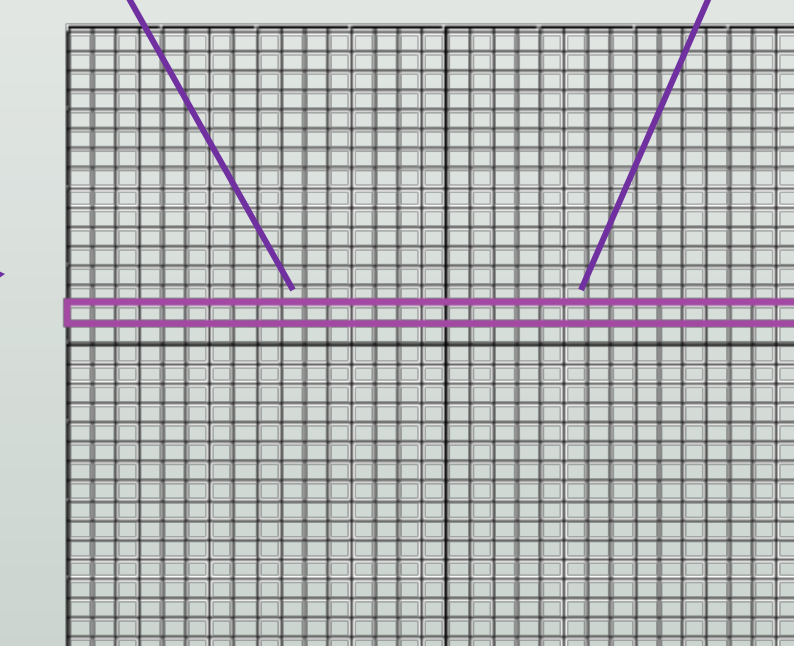
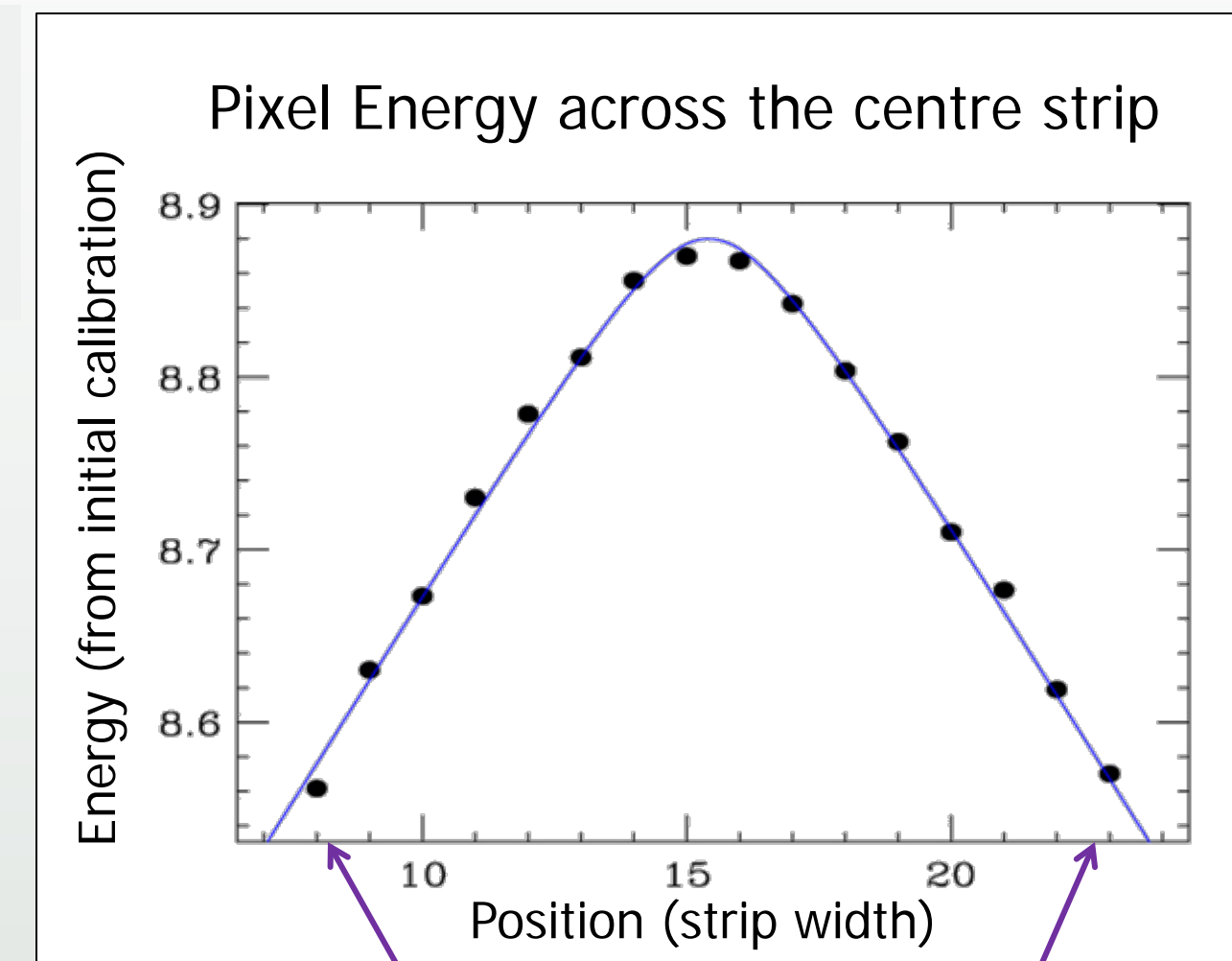
Dead-layer thickness determination

- 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.

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



Schematic geometry of pin source calibration



EF₁₈ 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,

$$(C1 \rightarrow 8.948, C2 \rightarrow 0.068, C3 \rightarrow 15.41)$$

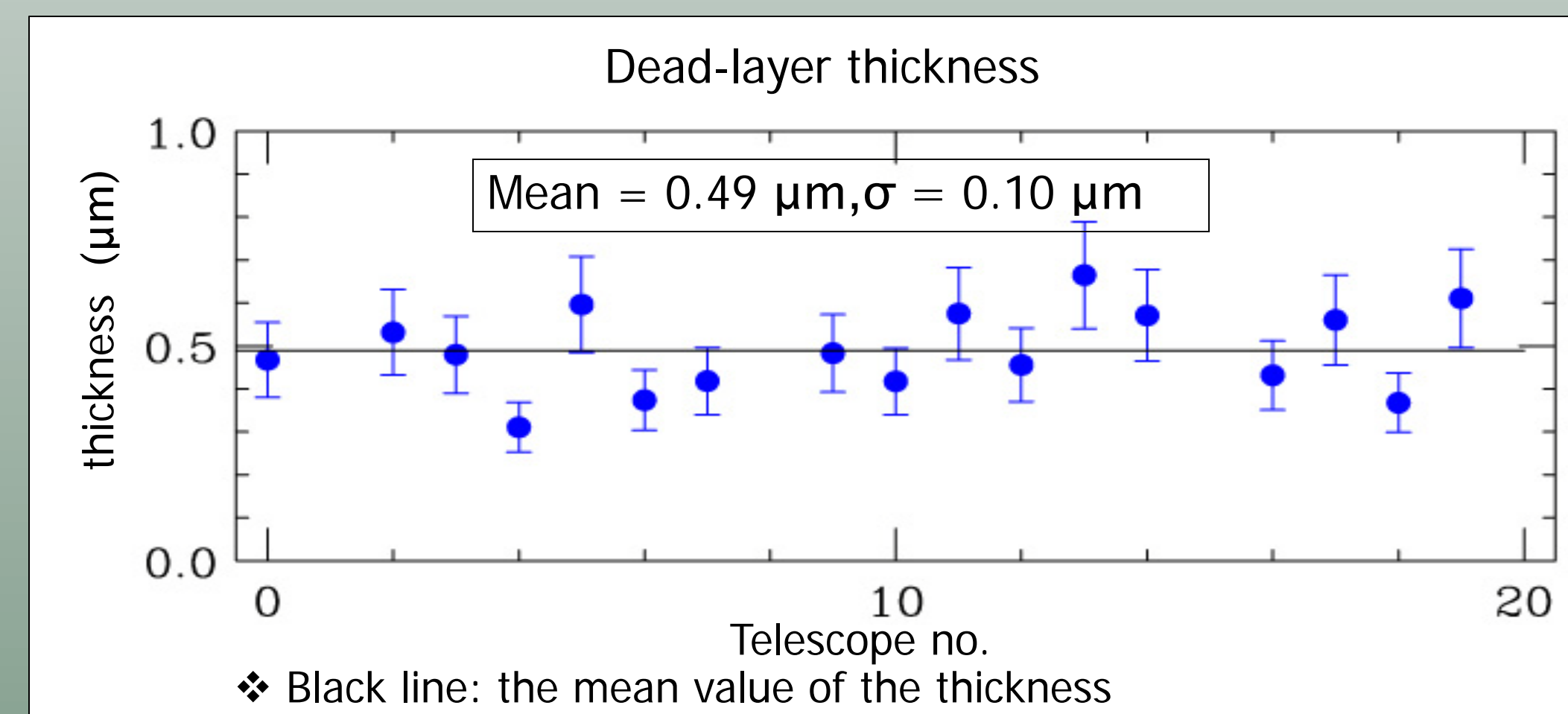
Position of the pin in unit of strip

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

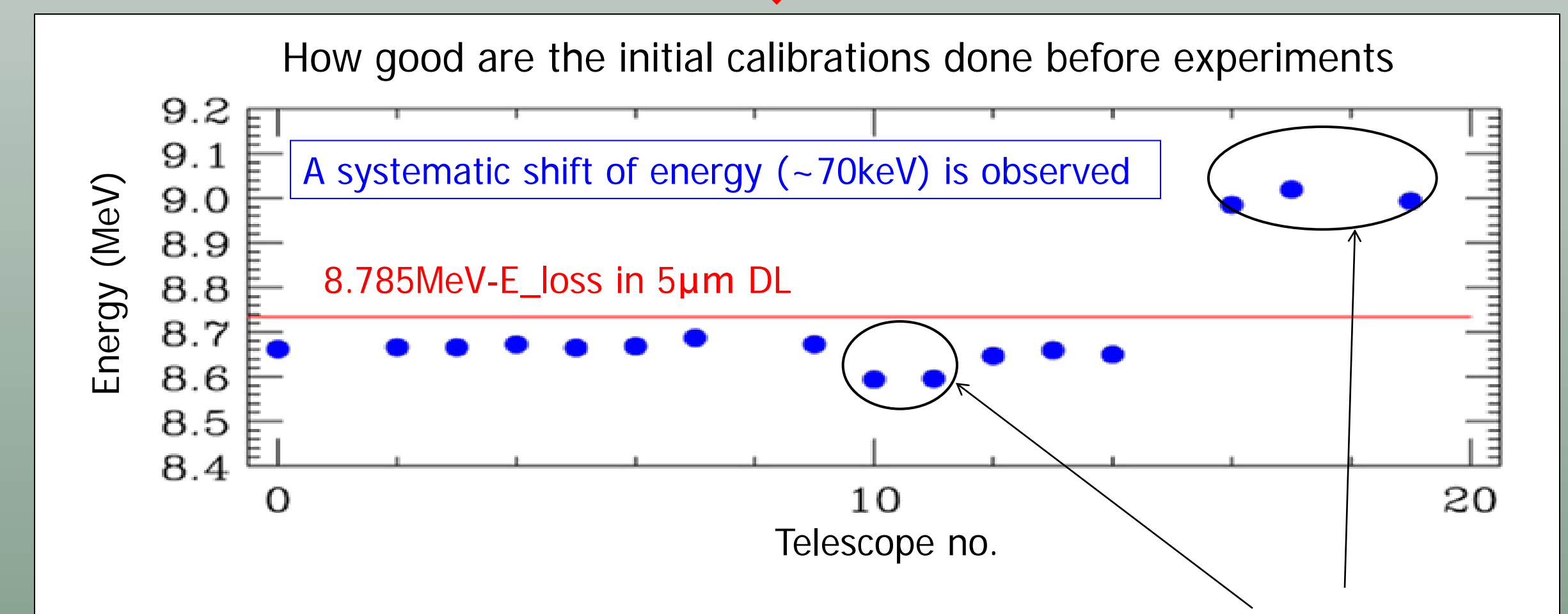
Pin source energy = 8.785 - energy loss in DL
→ initial calibration is slightly off
Assume a linear correction:
 $E_{\text{real}} = A \times E_{\text{detected}} + B$

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

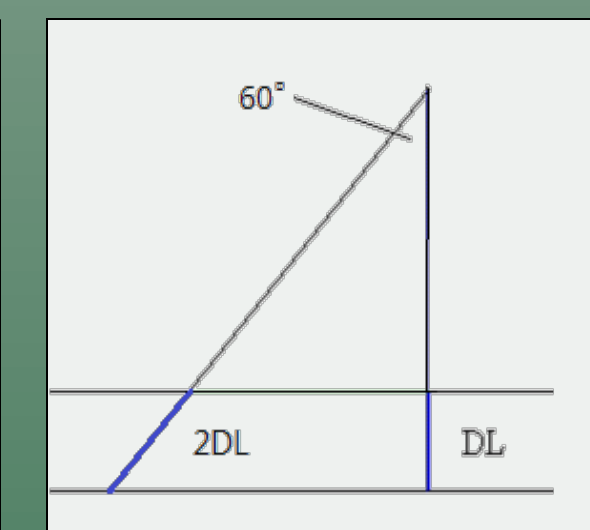
Based on the energy of all telescopes, assume $|A-1| < 0.05$.

$$E_{1088} = C2 * \left(\frac{1}{\cos 0^\circ} - \frac{1}{\cos 60^\circ} \right) = C2$$

C2: stopping power * DL

$$E_{1088} = [A * E(0^\circ) + B] - [A * E(60^\circ) + B]$$

$$= A * [E(0^\circ) - E(60^\circ)] \approx [E(0^\circ) - E(60^\circ)]$$



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

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

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 $0.5 \pm 0.10 \mu\text{m}$.
- 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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