CDEX-1B dead layer measurement

Jinglu Ma
Tsinghua University
CDEX Collaboration
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CJPL 中国锦屏地下实验室
China Jinping Underground Laboratory

Outline

- CDEX-1B dead layer measurement with ^{133}Ba source

  ----The 1kg germanium crystal diameter is 62.1mm and length is 62.3mm.

- Experimental data analysis

  ----Energy calibration, peak fitting, efficiency correction.

- Monte Carlo simulation

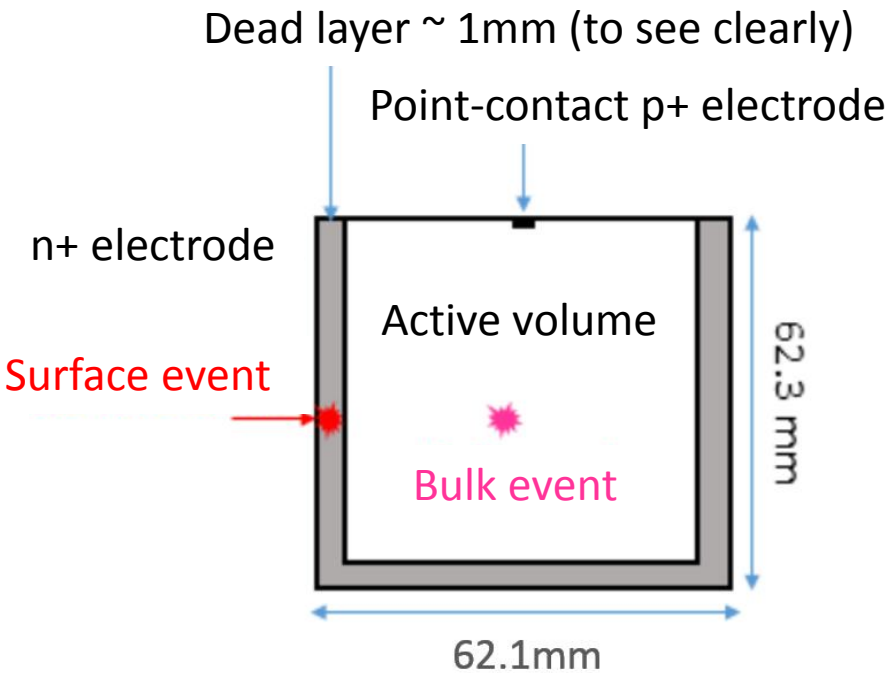
  ---- Geant4, version 4.10.00

- Dead layer measurement result

CDEX-1B detector

- **CDEX-1B : 1kg p-type point-contact Ge detector (1kg-PPCGe)**

  ----Small capacitance :
  Low electronic noise and provides ultra-low energy threshold.
  ---- ~ 1mm dead layer near n+ contact caused by lithium diffusion.
  Partial energy collection.

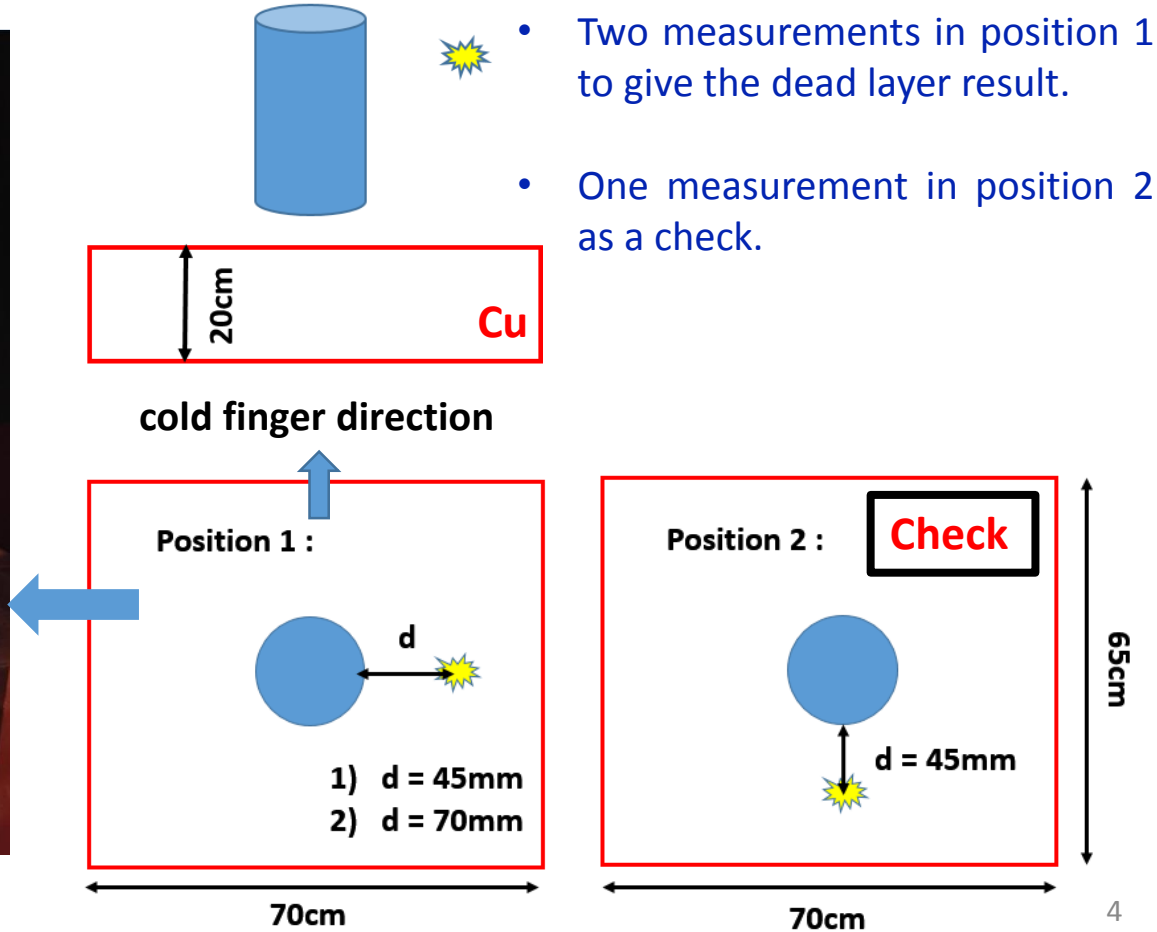


^{133}Ba Experiment layout

- **Source: ^{133}Ba** (81.0keV, 276.4keV, 302.9keV, 356.0keV)

  ----Different dead layer thickness: different attenuation.

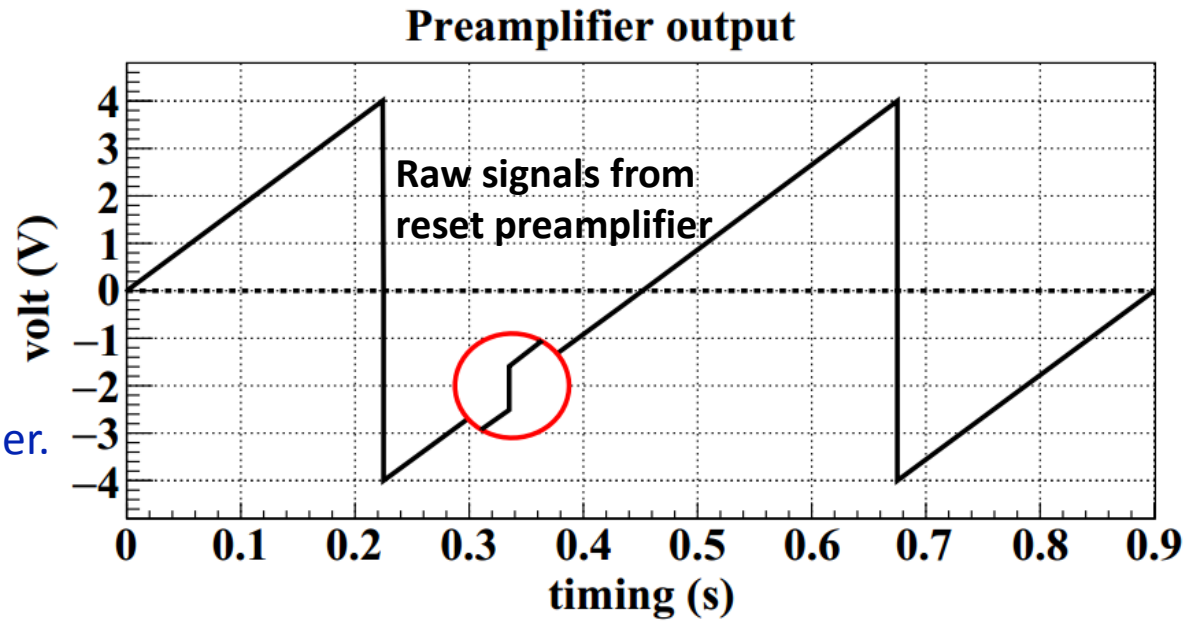
  ----Each peak ratio represents a certain dead layer thickness.



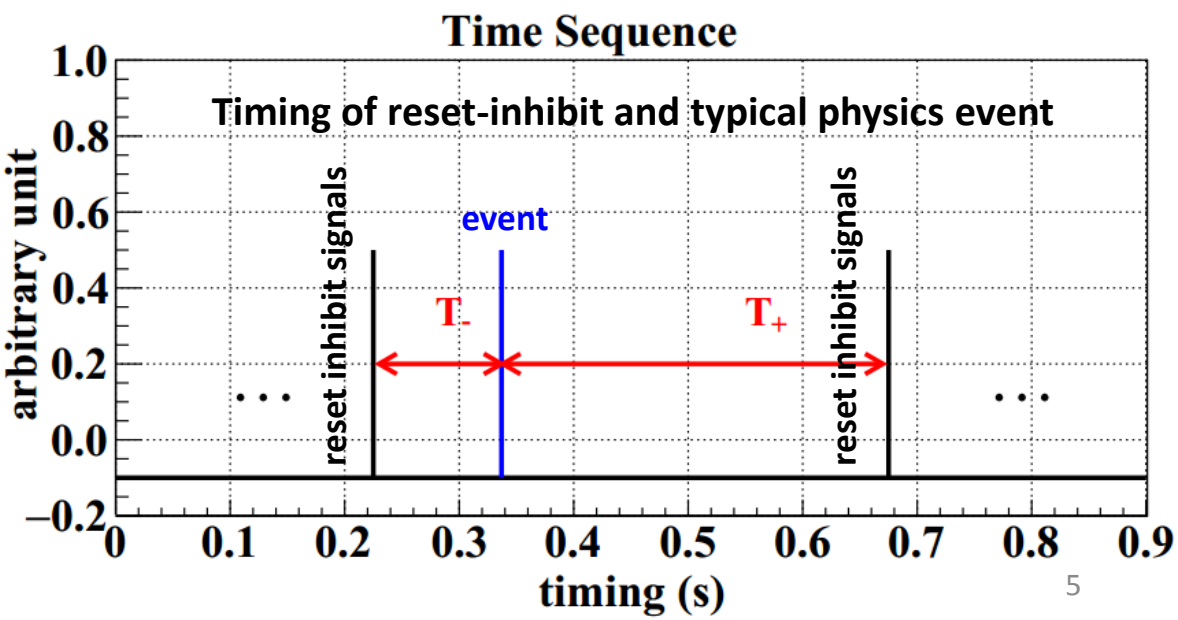
- Two measurements in position 1 to give the dead layer result.
- One measurement in position 2 as a check.

Experimental data analysis

- The charge and discharge procedure of the preamplifier.



- T_- : time interval between the event and its nearest prior-inhibit signal.



Experimental data analysis

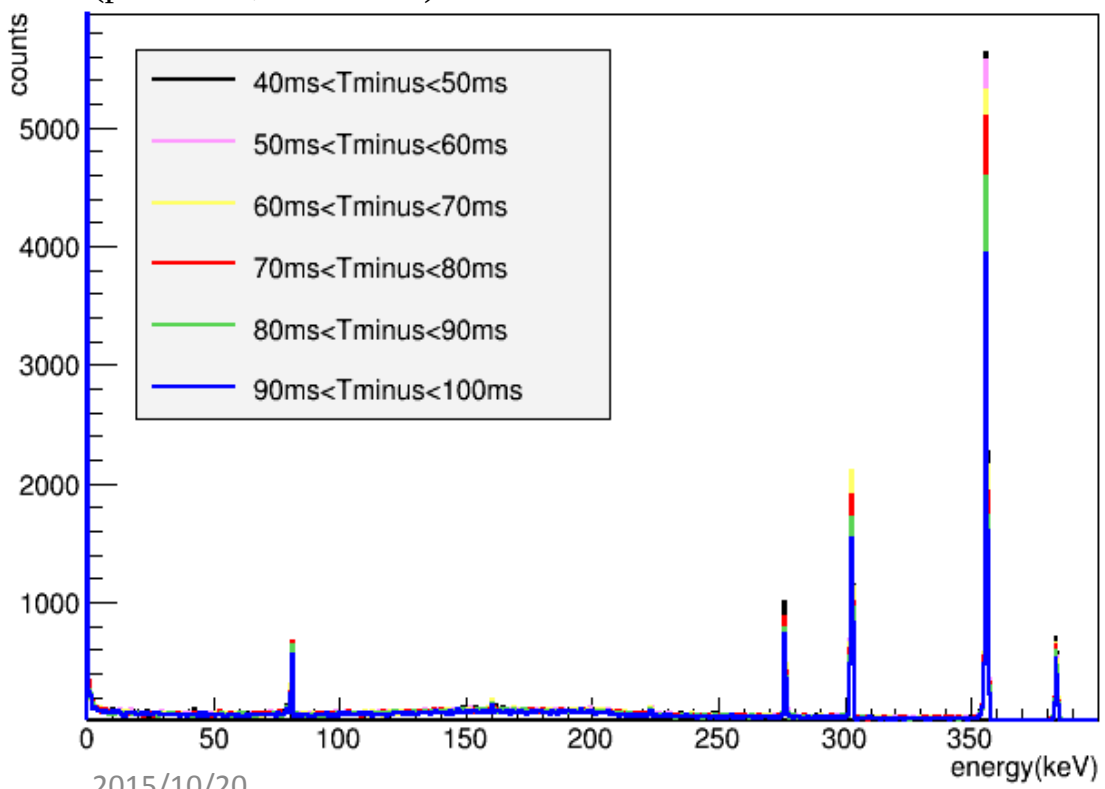
- **^{133}Ba energy spectrum in every 10ms T- interval**

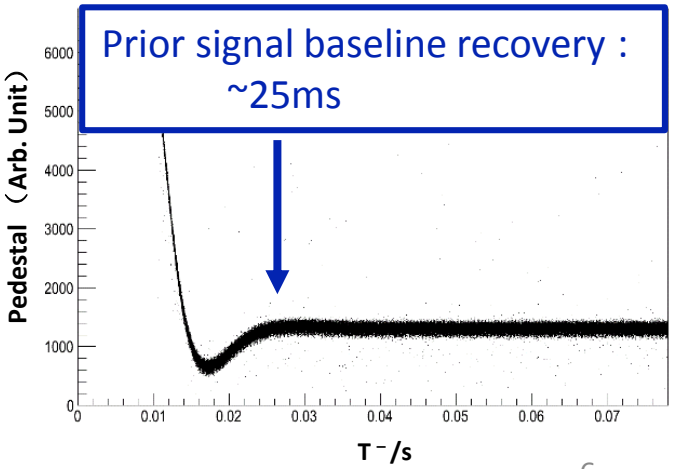
----Fit the peak and calculate the counts of 81.0keV, 276.4keV, 302.9keV, 356.0keV.

----The peak-count within 10ms drops apparently as T⁻ increases.

Tminus(ms) \ Energy(keV)	81.0	276.4	302.9	356.0
40-50	100%	100%	100%	100%
50-60	99.8%	99.9%	99.7%	98.9%
60-70	97.7%	96.2%	98.7%	94.2%
70-80	96.2%	89.9%	90.7%	90.1%
80-90	92.0%	83.7%	83.5%	80.2%
90-100	81.9%	77.9%	75.3%	71.9%

(position 1, d = 45mm)





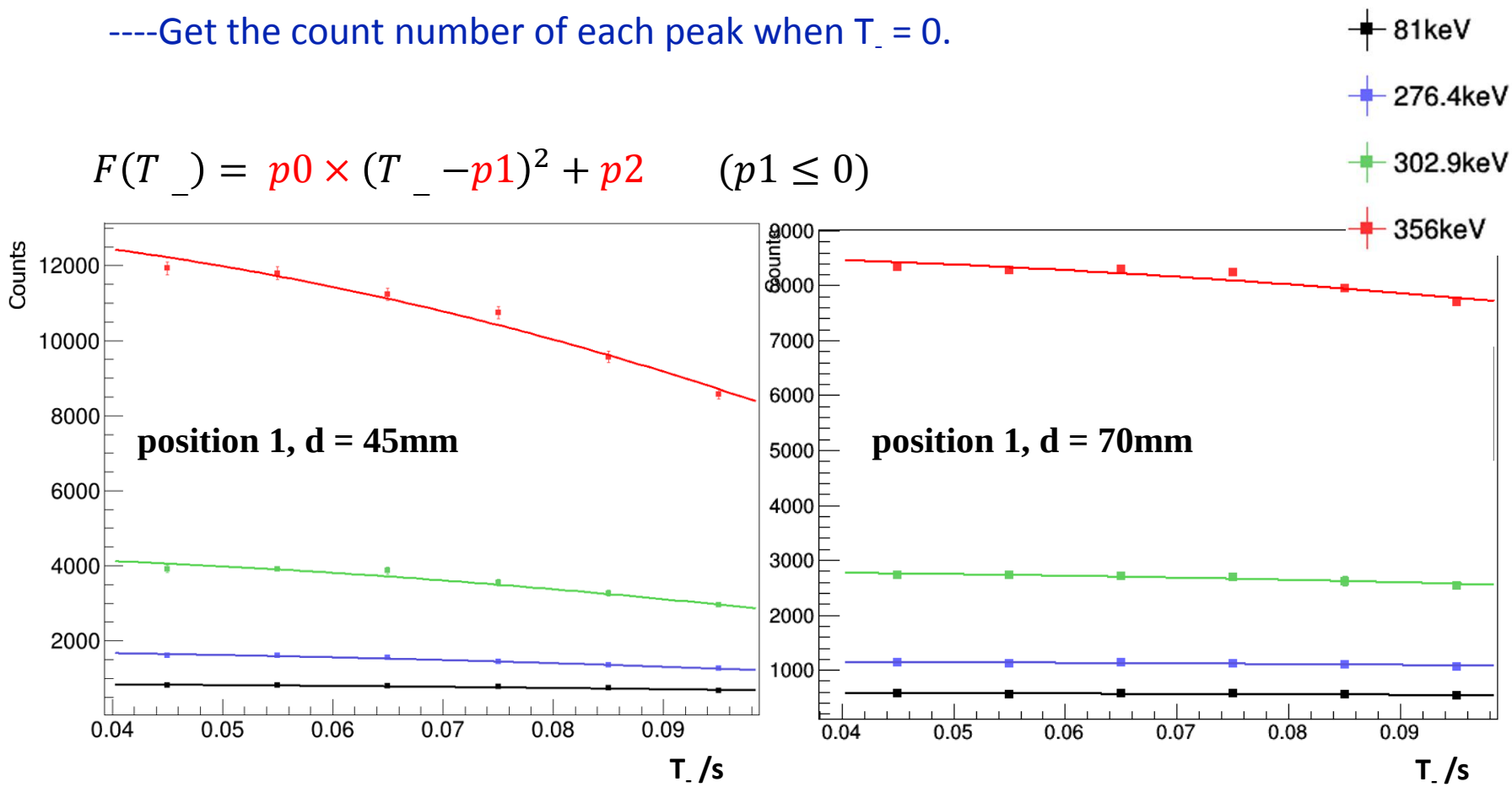
Experimental data analysis

- **Efficiency correction**

----Fit the peak-count in each 10ms T- interval with the quadratic function F(T_).

----Get the count number of each peak when T_ = 0.

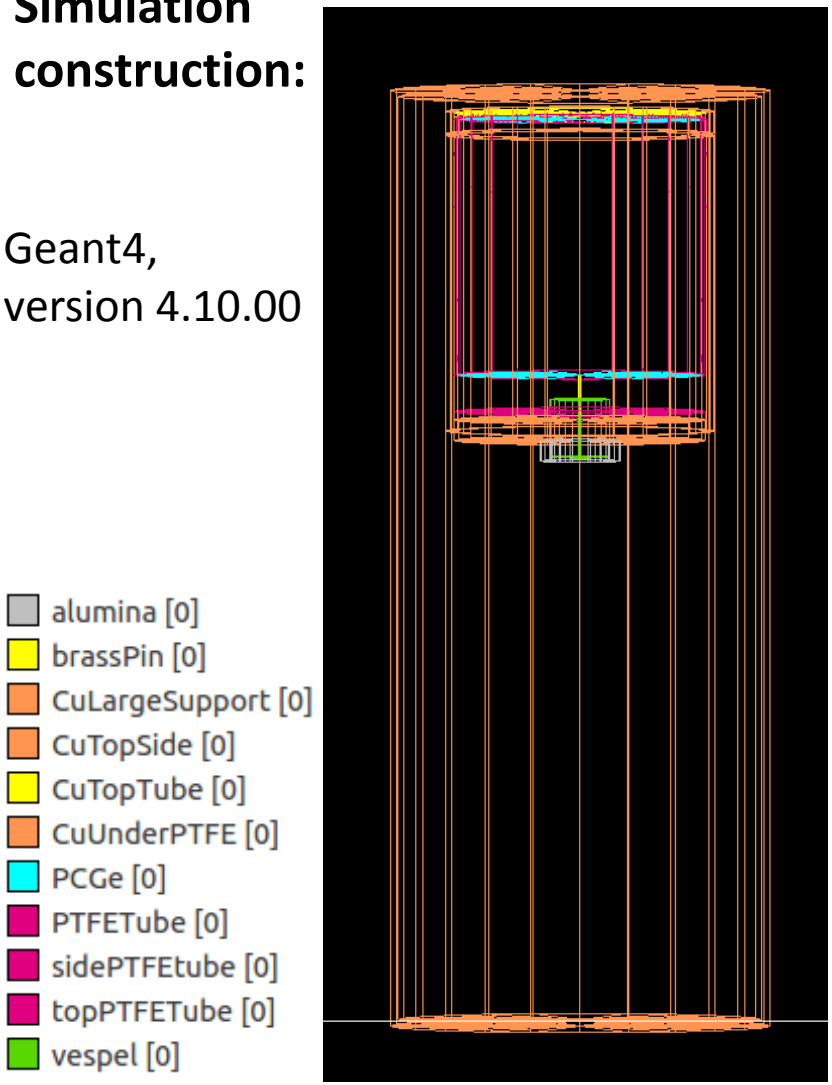
$$F(T\_) = p0 \times (T\_ - p1)^2 + p2 \qquad (p1 \leq 0)$$



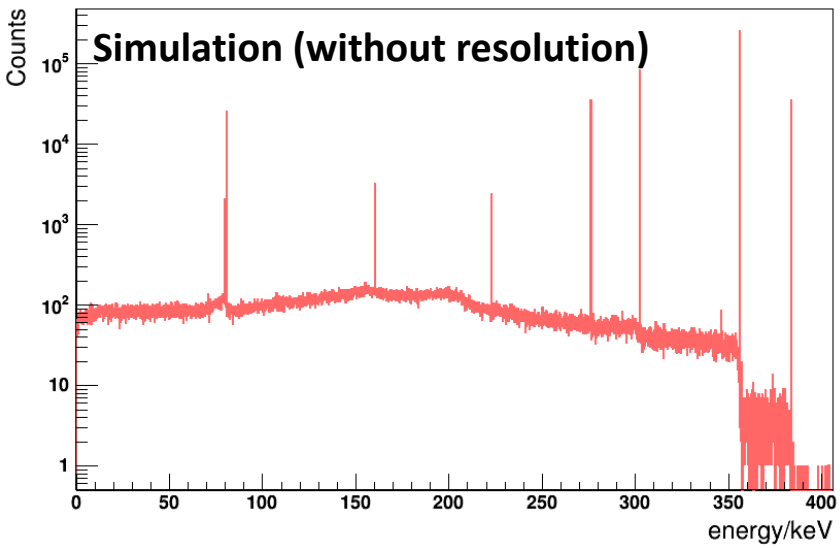
Dead layer simulation

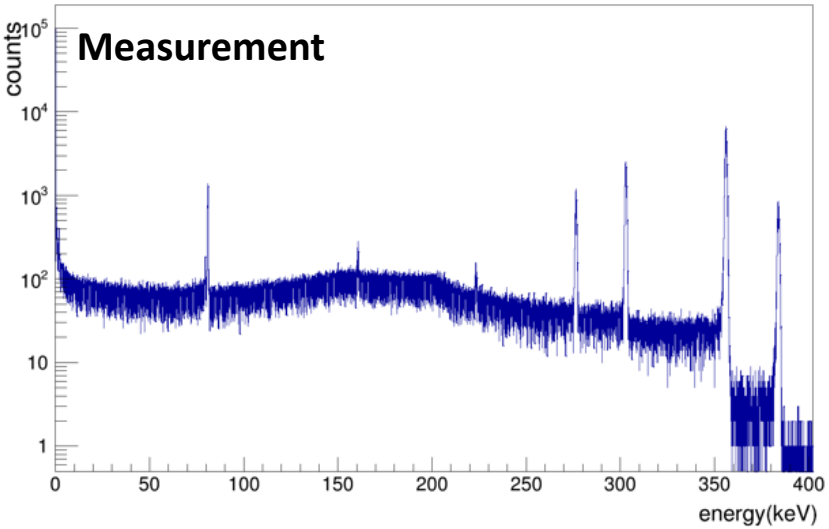
- **Simulation construction:**

Geant4, version 4.10.00



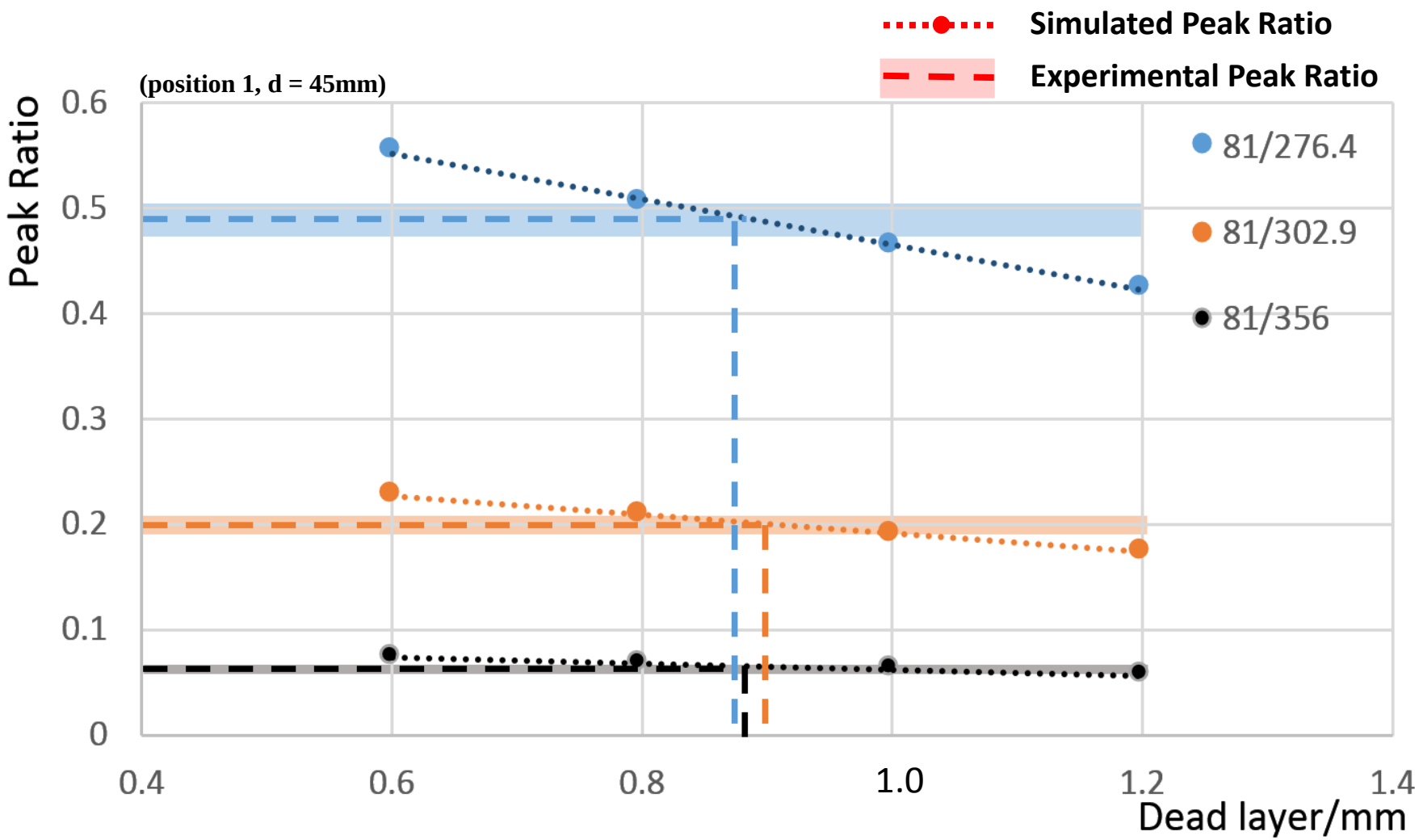
^{133}Ba spectrum





Dead layer measurement results

- **Compare the experimental peak ratio to the simulated peak ratio**



Dead layer measurement results

Position1：

Distance / Peak ratio	45mm Thickness /mm	45mm Statistical Uncertainty/mm	70mm Thickness /mm	70mm Statistical Uncertainty/mm
81/276.4	0.86	0.11	0.89	0.12
81/302.9	0.90	0.09	0.88	0.10
81/356	0.87	0.08	0.87	0.10
	0.88	0.05	0.88	0.06

Origin	source position	source distance measurement (1mm)	copper thickness (0.1mm)
Systematic Uncertainty/mm	0.01	0.01	0.10

$$Statisticql\ uncertainty = \sqrt{\frac{0.05^2 + 0.06^2}{2}} = 0.06mm$$

$$total\ uncertainty = \sqrt{0.01^2 + 0.01^2 + 0.10^2 + 0.06^2} = 0.12mm$$

$$total\ dead\ layer = 0.88 \pm 0.12mm$$

Dead layer measurement results

Position2：

- check measurement

Distance / Peak ratio	45mm Thickness /mm	45mm Statistical Uncertainty/mm
81/276.4	0.92	0.13
81/302.9	0.88	0.12
81/356	0.90	0.11
	0.90	0.07

Origin	source distance measurement (1mm)	copper thickness (0.1mm)
Systematic Uncertainty/mm	0.02	0.12

$$Statisticql\ uncertainty = 0.07mm$$

$$total\ uncertainty = 0.14mm$$

$$total\ dead\ layer = 0.90 \pm 0.14mm$$

- In agreement with the measurement result in position1 within the margin of error.

Summary

- The dead layer thickness of 0.88±0.12mm is adopted by CDEX-1B.
- This result gives rise to a fiducial mass of 0.930kg with an uncertainty of 1%.

Thank you

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