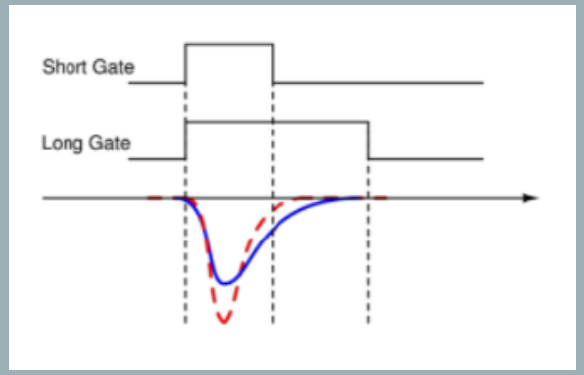
DIFFERENTIATION OF NEUTRON AND GAMMA RESPONSE FOR EJ-301 DETECTOR AT LOW ENERGIES

IDEA

- In direct dark matter search experiments, fast neutrons are prevalent in the background and can mimic WIMP signals.
- We use an Am-Be source which gives both neutron and gamma spectra. It is essential to differentiate between them.

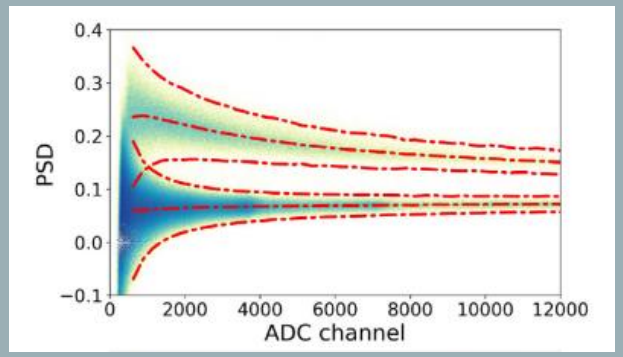
EJ-301 liquid scintillation detector and photo-multiplier tube[1]

- The EJ-301 is a liquid scintillation detector. It shows excellent pulse shape discrimination and allows differentiation of neutron and gamma spectra.



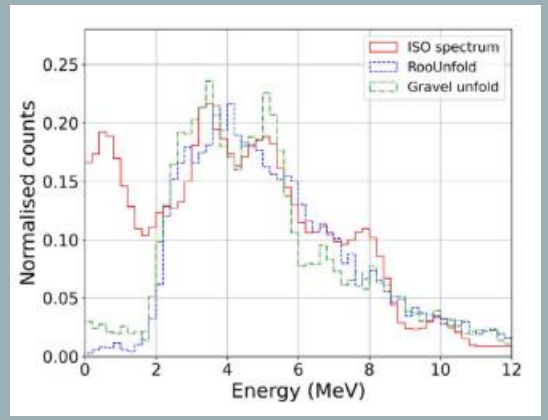
Short gate and long gate for two chosen pulses[2]

- Pulse shape discrimination is a measure of the charge accumulated in the tail of the pulse over the total charge in the pulse.
- $PSD = \frac{Q_{long} - Q_{short}}{Q_{long}}$



Pulse shape discrimination achieved for Am-Be source. The upper band corresponds to neutron, the lower to gamma[1]

- Next, we perform unfolding, wherein we reconstruct the energy spectrum by using the detector response that is measured experimentally.



Unfolded Am-Be spectrum[1]

- **Goal:** Unfolding the Am-Be spectrum and validating it against the ISO spectrum, specifically below the 740 ADC Channel cut.

BASELINES

- To gain a thorough understanding of the physical phenomenon that govern our project.
- To take additional experimental data and assemble a template of pulse shapes for different ADC Channels.
- Using tSNE to verify the possibility of classification.
- Learning and implementing appropriate ML packages for classification of scattering events.
- Unfolding the energy spectrum and validating our findings against the ISO spectrum.

- ❖ We plan on covering the first three baselines by the mid-semester examination.
- ❖ Both teammates will contribute towards all baselines since all of them are inter-dependent.
- ❖ We have access to the dataset used for PSD and unfolding used to plot the previous figures, for both neutron and gamma signals.

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RELEVANT PAPERS

- S. Das, V.K.S. Kashyap, B. Mohanty, Energy calibration of EJ-301 scintillation detector using unfolding methods for fast neutron measurement, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1042, 2022, 167405

- Chen, Y., Chen, X., Lei, J. *et al.* Unfolding the fast neutron spectra of a BC501A liquid scintillation detector using GRAVEL method. *Sci. China Phys. Mech. Astron.* 57, 2014, 1885–1890

- Laurens van der Maaten and Geoffrey Hinton. “Visualizing Data using t-SNE”. In: Journal of Machine Learning Research 9 (2008), pp. 2579–2605.

REFERENCES

[1] source: S. Das, V.K.S. Kashyap, B. Mohanty, Energy calibration of EJ-301 scintillation detector using unfolding methods for fast neutron measurement, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1042, 2022, 167405

[2] source: S. Das, Simulating the response of a liquid scintillation detector to gamma and neutrons, National Institute of Science Education and Research, Bhubaneswar, 2021