Investigating Electro-Nuclear Interactions in a New Dark Matter Search

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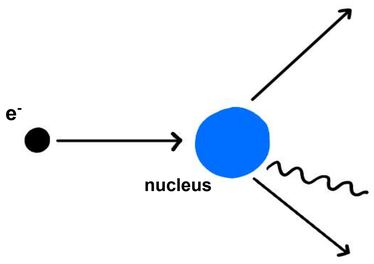
Beatrice Croteau, Mount Holyoke College | Supervisors: Cristina Mantilla Suarez and Christian Herwig

Electro-Nuclear (EN) Interactions

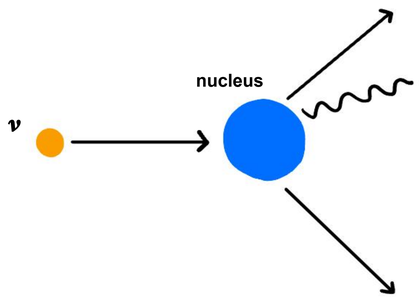
Electro-nuclear interactions are interactions in which an incident electron scatters off a nucleus, also producing byproduct particles.



Electron-nucleus interaction. The collision will scatter the electron off the nucleus and produce various other particles.

Why Study EN Interactions?

Neutrino-nucleus interaction. The collision will scatter the neutrino off the nucleus and produce various other particles.

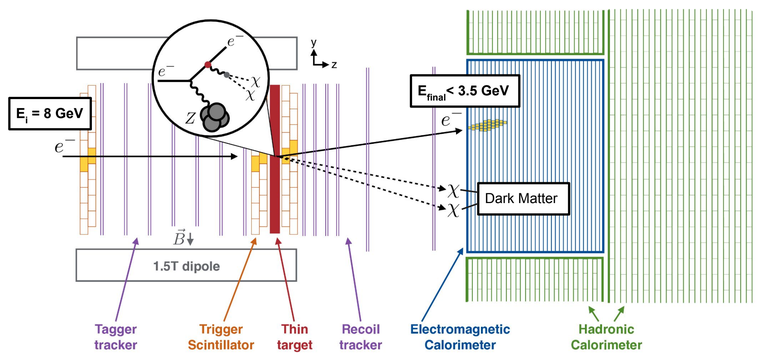


Data on EN interactions in final final states is of interest to neutrino researchers. Electro-nuclear interactions can be used to inform modelling of *neutrino*-nuclear interactions.

LDMX: An Experiment of Opportunity

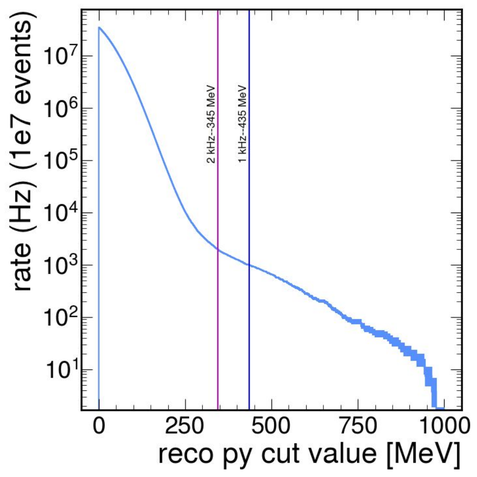
Light Dark Matter Experiment:
- small-scale
- fixed-target
- **electron beam**

LDMX presents an opportunity to study EN interactions, but it's trigger is not sufficient for EN interactions–**we need to develop an additional trigger.**

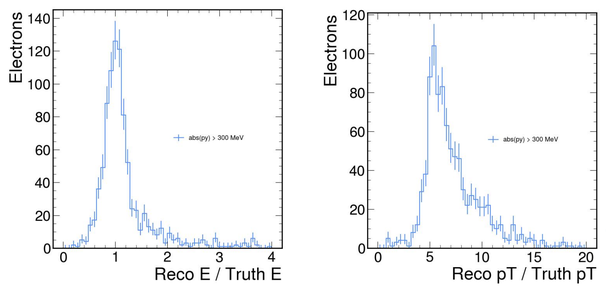


Proposed LDMX setup.

LDMX Simulation Reconstruction and Rates



Event rate as a function of the electron py for the full set of electron-on-target events

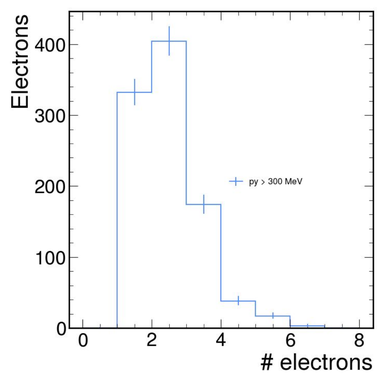


Ratio plots comparing reconstructed values to truth values.

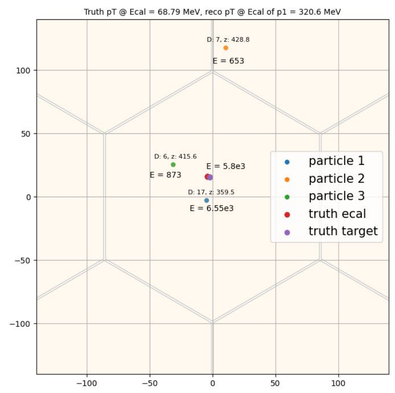
Trigger development begins with a rate plot. The events saved by a given trigger can be studied for **reconstruction accuracy**.

Mis-reconstruction of Electron Momentum

Momentum reconstruction was poor for events with large py. It was observed that most events with large py are reconstructed as having **multiple particles per event.** Such events were studied using event displays.

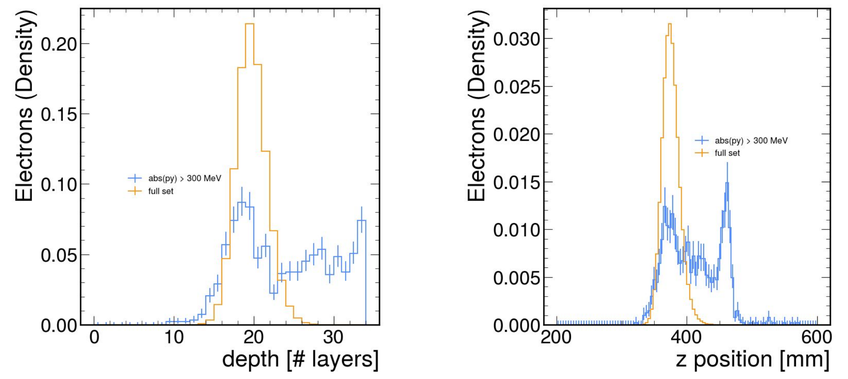


The number of particles per event for events with |py| > 300 MeV.



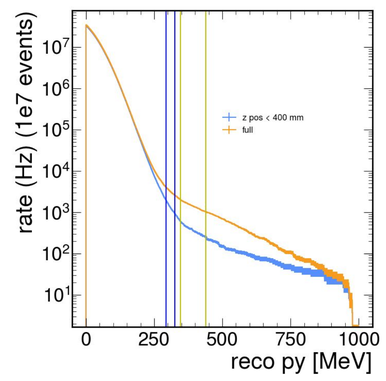
Example event plot: shows x, y, z position, energy, and depth of all particles in an event.

Conclusions

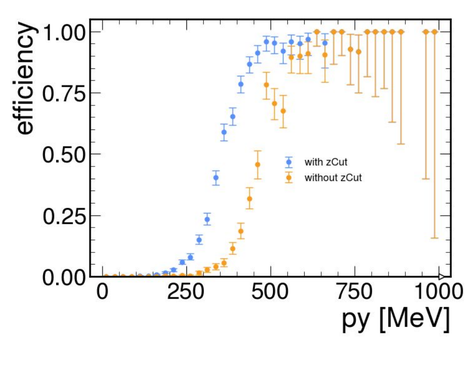


Comparisons of z-position and depth of electrons in EM calorimeter for the full set of EOT and those with large py.

We observed that **large py events are biased towards large depth and large z-position** in the electromagnetic calorimeter.



Rate plot comparing data with and without a z-position cut applied. Green lines represent rates without the cut, blue lines represent rates with the cut.



Efficiency plot displaying how efficiently EN events will be recorded based on principal electron y-momentum.

py

1 kHz: 435 MeV → 325 MeV | 2 kHz: 345 MeV → 293 MeV

We introduced a quality cut on the z-position of the electron, which lowered the trigger threshold for rates of 1 and 2 kHz. Creating an efficiency plot using this trigger on a sample of EN events reveals the **improvement provided by the z-position cut** and the performance of the EN trigger overall.

The z-position quality cut will be applied in tandem with the trigger value identified within this study to actual data collected on the LDMX experiment, allowing for the collection of EN interaction events.

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