FERMILAB-SLIDES-23-401-STUDENT

Light Dark Matter (E)xperiment

Mubarak Ayantayo

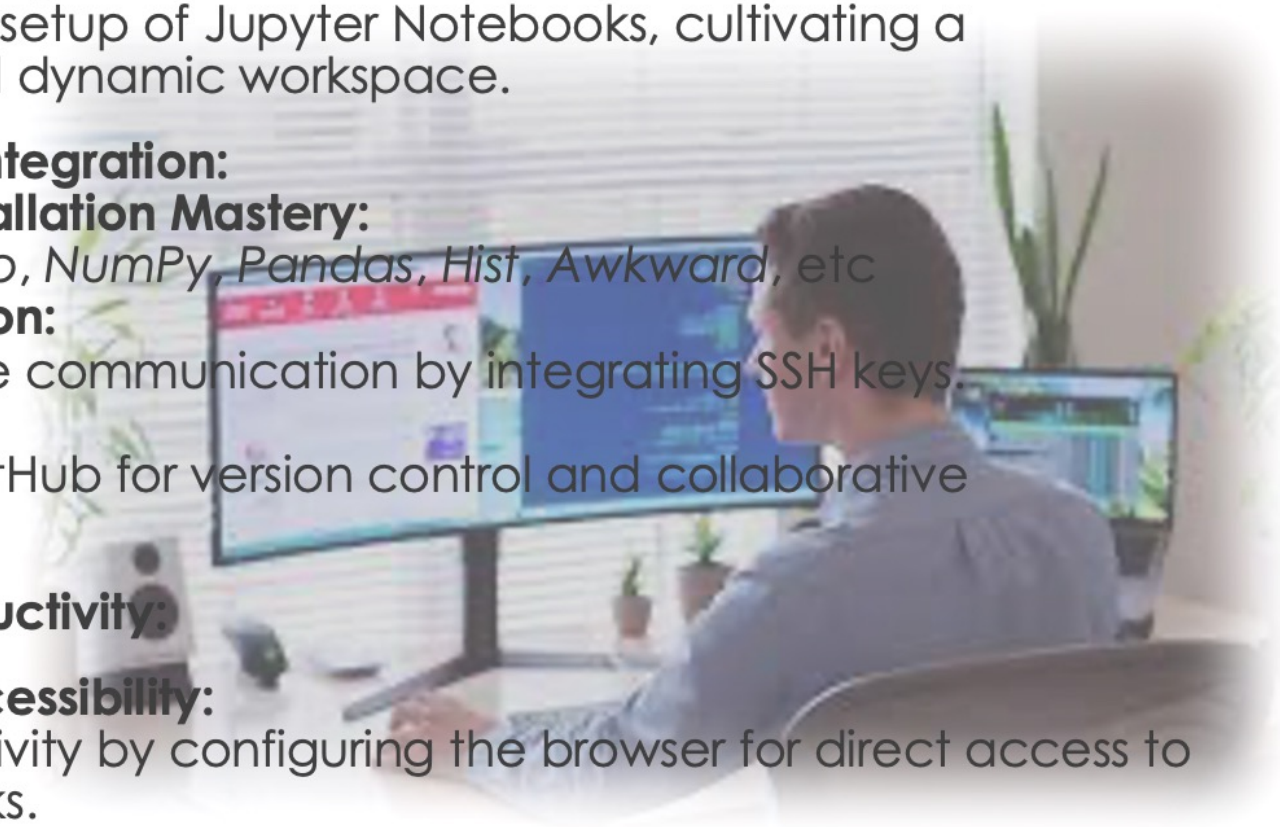
Momentum Reconstruction

Nov 28, 2023

a.This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.
b.This work was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).

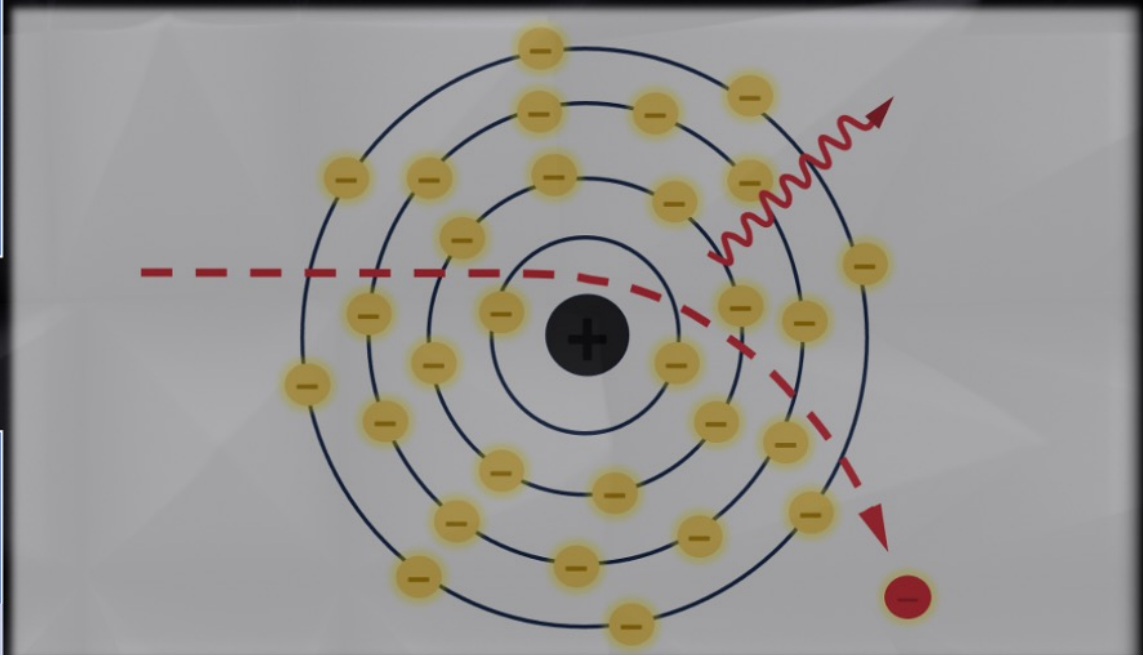
ONBOARDING AND INFRASTRUCTURE SETUP

- Embarked on the internship journey by immersing myself in the Linux environment and navigating terminal.
- **Technical Proficiency Milestones:**
- **Creating a Distinct Profile (Conda Installation):**
  - Skillfully crafted a personal profile for an optimal Linux workspace.
- **Jupyter Notebook Configuration:**
  - Orchestrated the setup of Jupyter Notebooks, cultivating a collaborative and dynamic workspace.
- **Package Ecosystem Integration:**
- **Package/libraries Installation Mastery:**
  - *Uproot , Matplotlib, NumPy, Pandas, Hist, Awkward*, etc
- **SSH Key Implementation:**
  - Implemented secure communication by integrating SSH keys.
- **GitHub Collaboration:**
  - Connection to GitHub for version control and collaborative development.
- **Browser-Enabled Productivity:**
- **Jupyter Notebook Accessibility:**
  - Elevated productivity by configuring the browser for direct access to Jupyter Notebooks.



Bremsstrahlung Radiation

Used fundamentally in the medical field and industrial applications, bremsstrahlung radiation produces X-rays that can penetrate matter and create detailed images.



WHAT HAPPENS

Some electrons are attracted to the nucleus, resulting in directional change	Bremsstrahlung radiation produces a continuous spectrum of X-rays, as the amount of energy lost by electrons can vary, resulting in X-rays with a range of wavelengths.	Lost energy is released in the form of an X-ray photon

Particle journey:

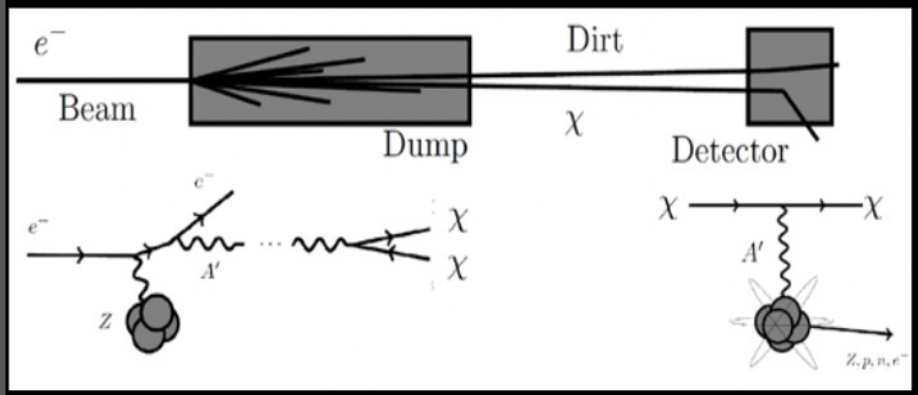
- High-energy electrons hits aluminum target (less dense nucleus)
- The journey ends at a detector (Ecal)
  Keeping Momentum in Check:
- Fundamental principle of momentum conservation.

- **Cracking the Momentum Code:**

We don't have a straightforward way to calculate the electron's momentum.

Why It Matters:

Solving the mystery of reconstructing momentum helps us understand the Light Dark Matter experiment and opens doors to grasp the basics of how particles interact with each other.



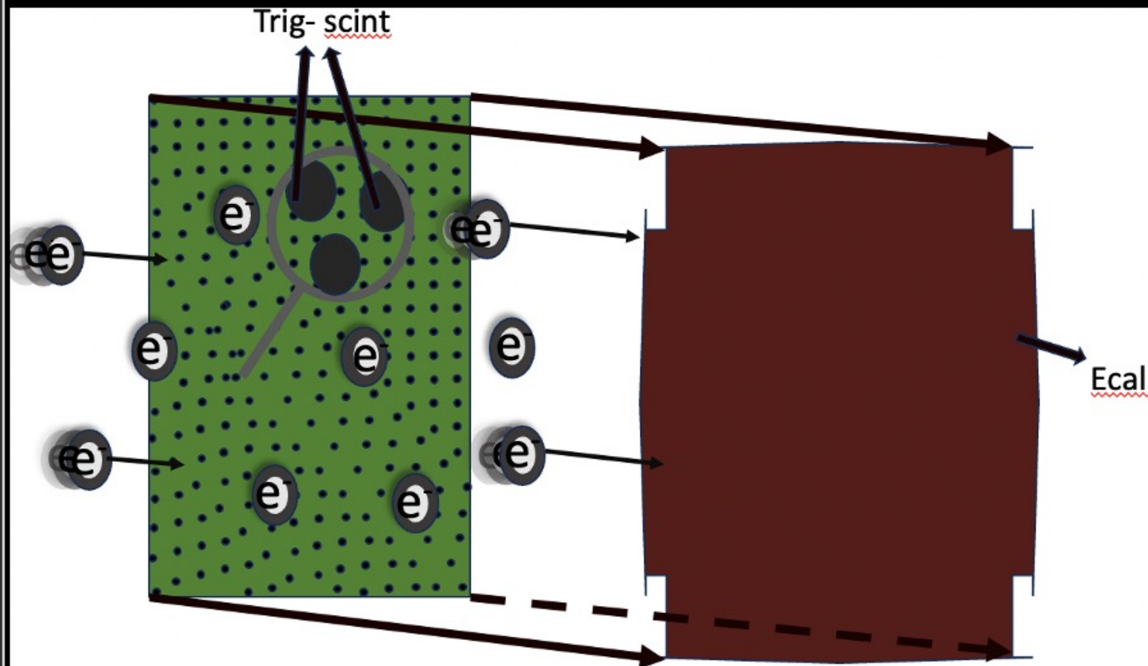
$\sigma \sim \alpha_D \varepsilon^4$

Probe dark sector coupling

Fermilab

Why can't we track the momentum?

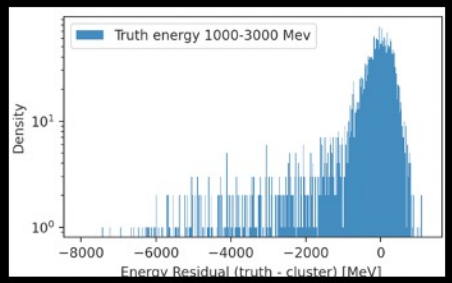
1) High frequency of electron events and the need for rapid decision-making in the System
2) compromise between the need for rapid decision-making and the desire for detailed particle trajectory information in the experiment.
3) The key attributes considered in the limited data scenario are the position displacement and the energy (scintillator and Ecal)

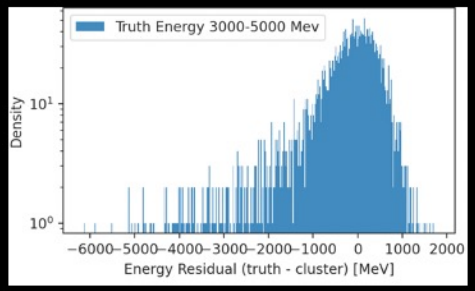


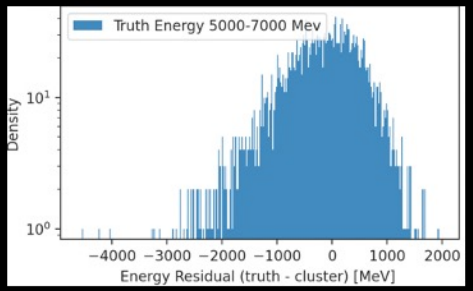
Goal: Reconstruct momentum information at the Ecal using displacement and energy.

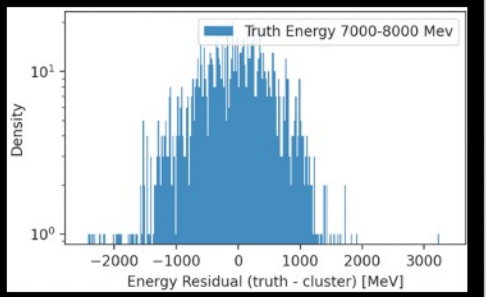
Ecal-Cluster Energy resolution

Expectations: We anticipate observing a high-quality energy resolution, reflecting our capability to accurately reconstruct the energy deposited in the Ecal.

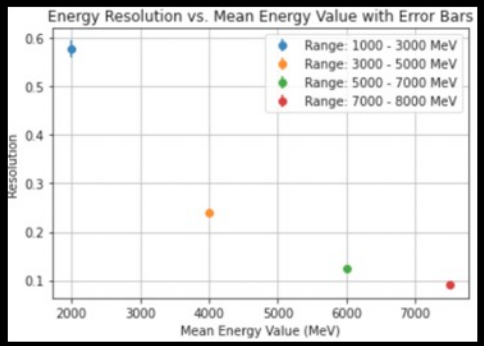








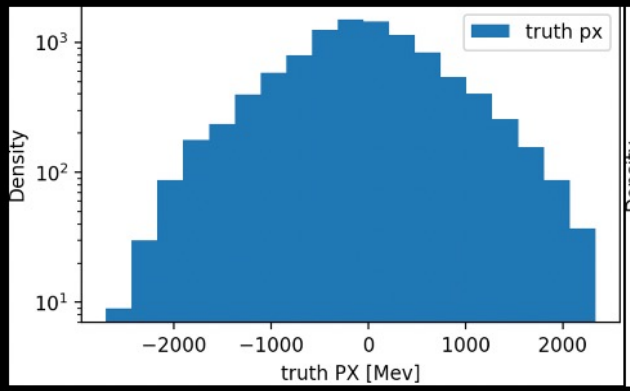
Visualizing the Ranges with Error bars: introducing error bars to gauge the precision of our calculations.

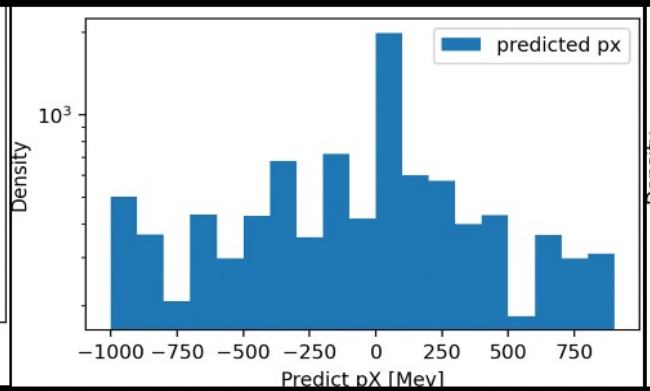


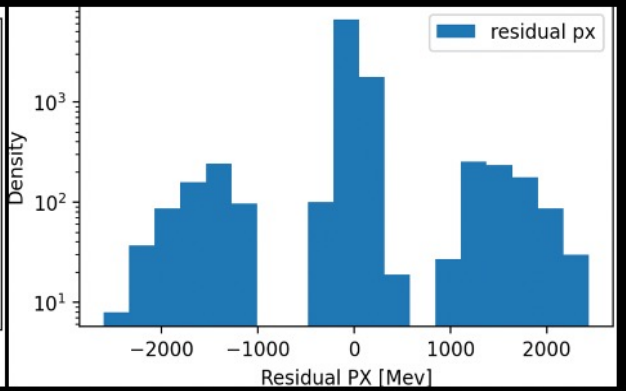
Fermilab

Closure Test

Attributes display a strong dependency on each other
– We can reconstruct the momentum



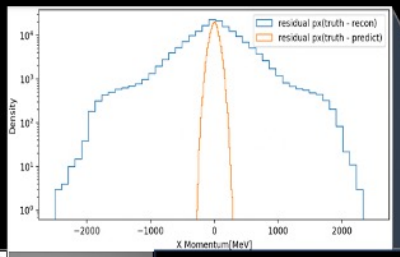


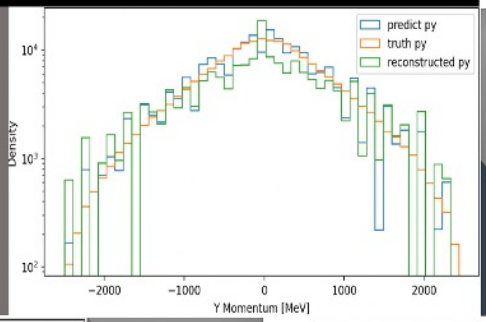


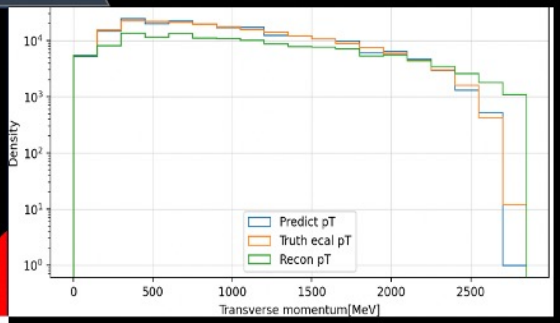
Method failed significantly! What went wrong?

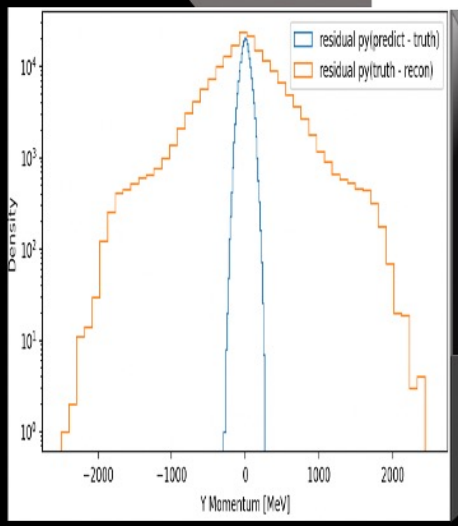
Suggestion: Is it possible that the data selection employed for representing the data is inaccurately portrayed? Could there be issues with the binning or potential faults in the methodology?

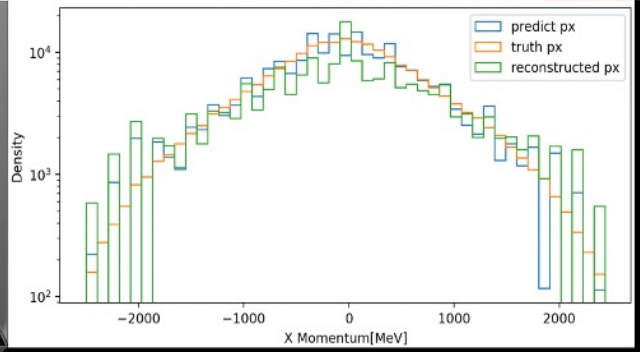
Reconstructing momentum











conclusion: We've been able to successfully predict the momentum of the simulation at almost 1:1 even with less events as the actual experiment. Results will only be more promising with more files but is already great!

Fermilab