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An Event Display for the Light Dark Matter eXperiment

Anmol Sandhu, University of Virginia - SULI

Introduction

The Light Dark Matter eXperiment (LDMX) is a proposed experiment to detect dark matter in the sub-GeV mass range, using both a missing momentum search for dark matter production and a search for long-lived visibly decaying dark photons. The experiment works by firing a beam of high energy electrons through taggers, recoil trackers, a trigger scintillator, and a magnet into an electromagnetic calorimeter and a hadronic calorimeter. The goal of this project was to create an interactive event display of the entire experiment as to allow someone to get a full view of the setup and to run simulations of event data in that display.

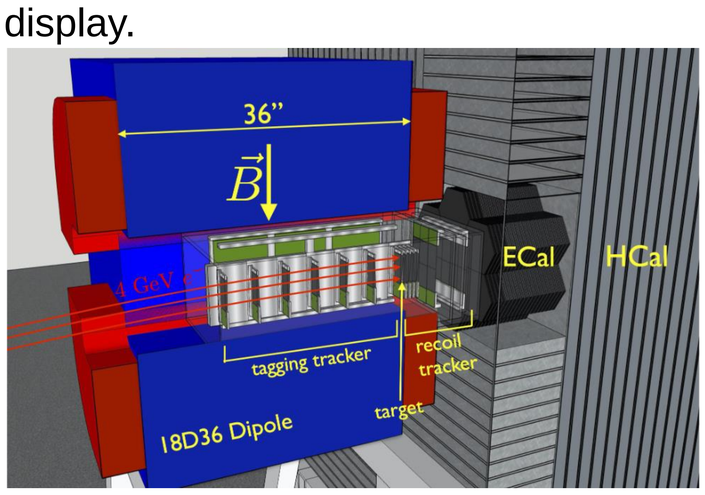

Fig. 1: The intended setup of the experiment

The event display was created using Phoenix, an open-source modeling software specifically designed for high energy physics. The first part of the project was to take the .gdml files that contained the experimental setup and converting them to .gltf files which are compatible with Phoenix. This was done by converting to .root files as an intermediate step, before converting to .gltf.. After the geometry of the experiment was put into Phoenix, the next step was to get the data from the experiment into a usable format for Phoenix. The data was stored in .root files. To be input in Phoenix, it had to be converted into a JSON format as described in the Phoenix documentation.

Fig. 2: Tagging Tracker – identify incoming electrons and measure momentum

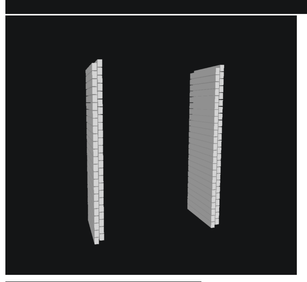

Fig. 3: Trigger Scintillator – provides count of number of electrons in beam bunch

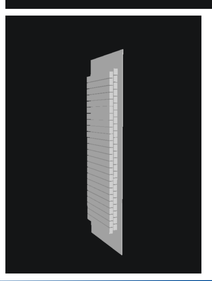

Fig. 4: Target – As an electron passes through it, the electron is deflected, a dark photon (A’) is produced and decays to a dark matter particle

Fig. 5: Recoil Tracker – identify low momentum recoil electrons and measure momentum

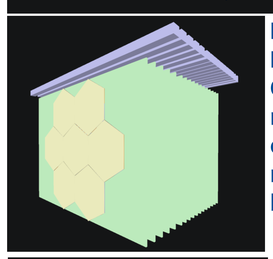

Fig. 6: Electromagnetic Calorimeter – measures energy of the trigger and rejects background

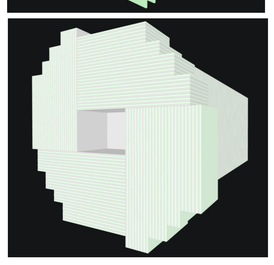

Fig. 7: Hadronic Calorimeter – detects neutral hadrons and muons, senses electromagnetic showers that escape the ECal

Results and Discussion

Experimenters will be able to use this display to visualize both signals and background events, not as histograms or in .root files, but as it would have appeared in the experiment as shown in Fig. 9 and Fig. 10. Each part of the event display has different opacities to make it as easy as possible to see the event data. These opacities can be easily changed in the code. There are 2 types of objects to be displayed from the events: Hits and Tracks. Hits are points where the detectors sensed particles and Tracks are the path certain particles took. These tracks are truth tracks which means they represent the true trajectory of a particle.

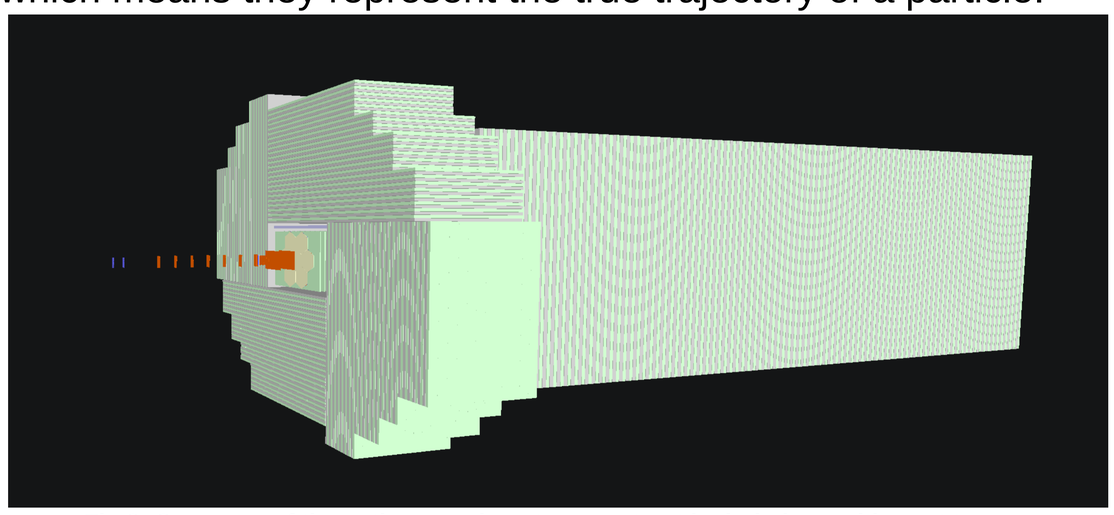

Fig 8: Geometry of the entire experiment, magnet not included, opacities set to max

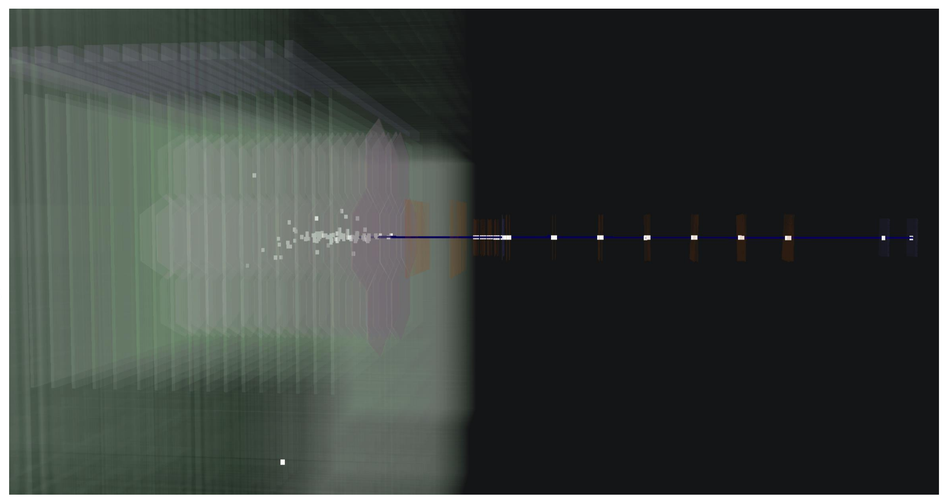

Fig 9: Hits (white) and Tracks (dark blue) from simulated experimental data of a Photonuclear event overlaying the geometry of the experiment, modified opacities

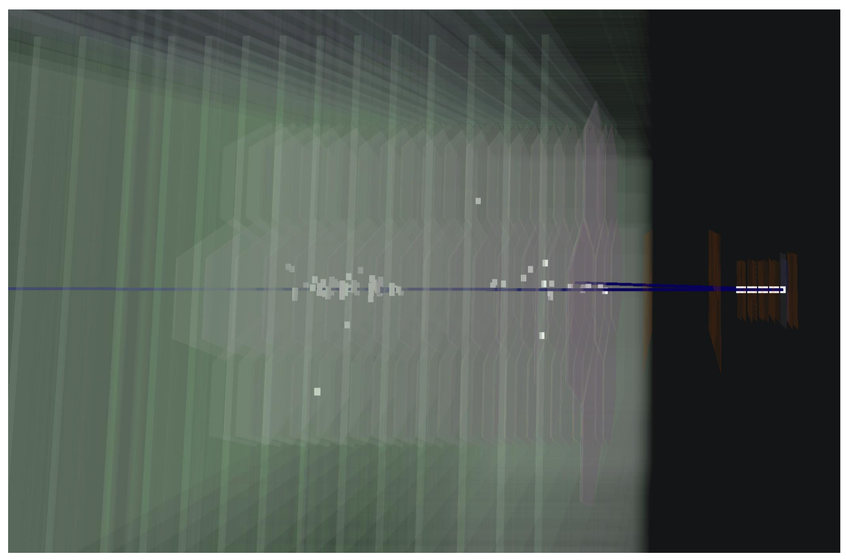

Fig. 10: A simulation of what firing electrons would look like. The short blue line is the recoil electron, and the longer blue line is the trajectory of the A’ particle. The A’ will decay to $e^+ + e^-$ pairs which can be seen in the back of the ECal.

Conclusion

The event display will let experimenters see the results of their experiments in a reconstruction of the actual LDMX setup. This will allow for greater understanding of the results and for more analysis to be done on the data. There are several improvements that could be done for this display in the future. The largest would be finding a way for ROOT to work with parametrizations or finding a way to go directly from .gdml to .gltf, so that unnesting loops is no longer required. There is also the matter of fixing the color display in Phoenix. For now, though, the event display works as intended and will improve analysis of experimental data.

Acknowledgements and Reference

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