THE LIGHT DARK MATTER EXPERIMENT, LDMX

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Motivations

Recent phenomenological advances in accelerator searches for "hidden sector" dark matter (DM) models arise from the realization that the existence of *sub-GeV* thermal relic DM requires a new force [3]. The benchmark model envisions LDM to be charged under a new U(1)' gauge boson (the vector mediator. dark/heavy photon, A') that kinetically mixes with standard model photons [1].

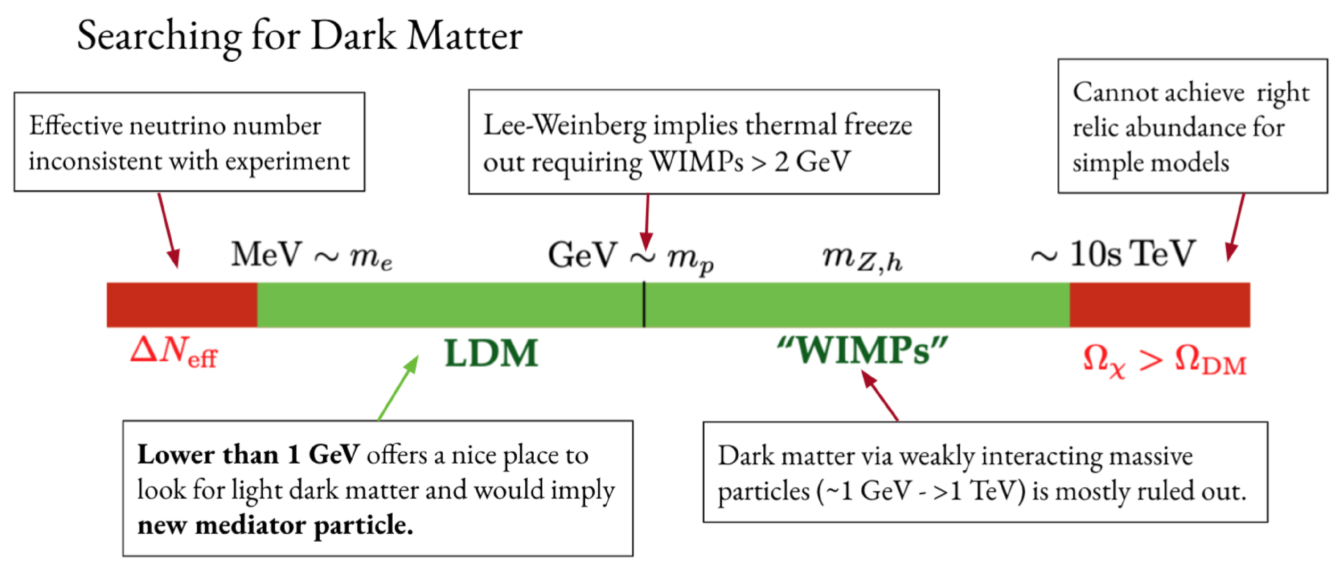


Fig. 1: A visualization for the range of allowable dark matter.

The **Light Dark Matter eXperiment (LDMX)** is a planned electron-beam fixed-target missing-momentum experiment that has unique sensitivity to light DM in the sub-GeV range. The production process in electron fixed-target experiments is closely analogous to Bremsstrahlung, where instead of a typical photon emitted by the deceleration of the electron, a heavy or "dark" photon is emitted, hence "dark bremsstrahlung."

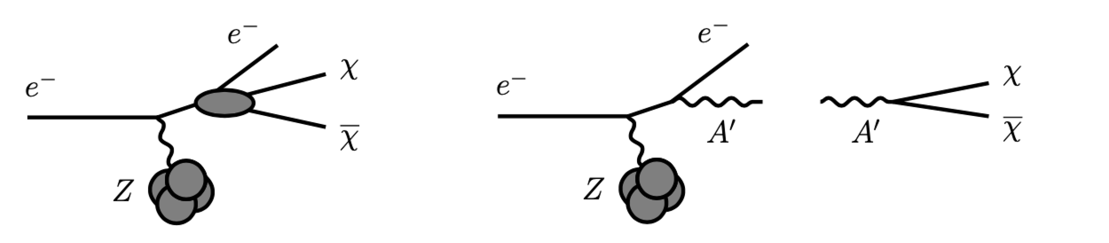


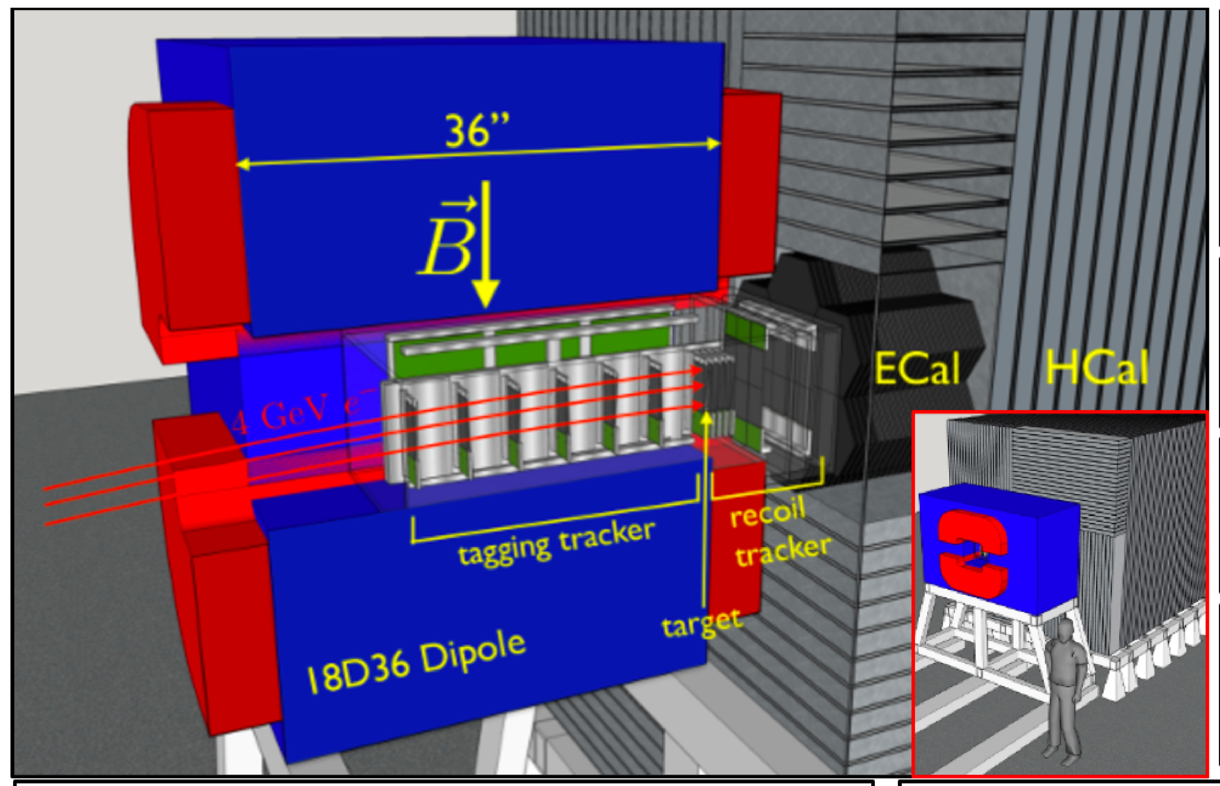
Fig. 2: Two possible invisible primary decay modes as a consequence of kinetic mixing. Left: Direct DM production. Right: Mediator particle, or heavy photon, production via "Dark Bremsstrahlung."

Missing Momentum Search

A **silicon tagging tracker**, housed in a **1.5T dipole magnet**, tags incoming electrons from the high rate **SLAC LCLS-II 4 GeV Electron Beam** incident on a **tungsten target**. A **silicon recoil tracker** and electromagnetic calorimeter (ECAL) selects electrons with approximate $E_{e^-_{recoil}} < \frac{E_{beam}}{4}$. A **hadronic calorimeter** (HCAL) is further downstream and vetos events on other particles that could have carried away momentum from the production reaction. A **trigger scintillator** subsystem counts the number of incoming electrons and significantly reduces typical beam particle arrival rate.

The LDM signature would have sufficiently **large transverse momentum** as dictated by the mediator mass. The trackers would be able to resolve this and reconstruct the mass of a mediator for potential signals.

Subsystems of the Experiment



SLAC LCLS-2 4 GeV Electron Beam
- High repetition rate (~ 37.5 MHz)
- Large Beam Size (>1cm^2)
- Incident on **Tungsten** target
- EOT Phase I yield of ~10^{14}

Trigger Scintillator
- Reduces beam particle arrival rate to 5 kHz for processing/analysis

Silicon Tagging Tracker
- 6 double sided CMS APV25 based modules inside dipole

Silicon Recoil Tracker
- Measure (50 MeV – 1.2 GeV) recoil e⁻ to resolve momentum transfer

Forward Electromagnetic Calorimeter
- CMS HGC inspired SiW Sampling Calorimeter
- High photon/e⁻ efficiency and energy resolution

Hadronic Veto Calorimeter
- Photoelectron signal via SiPM based scintillator scheme
- Characterizes showers that escape ECAL / neutral hadrons

Physics Reach Estimates

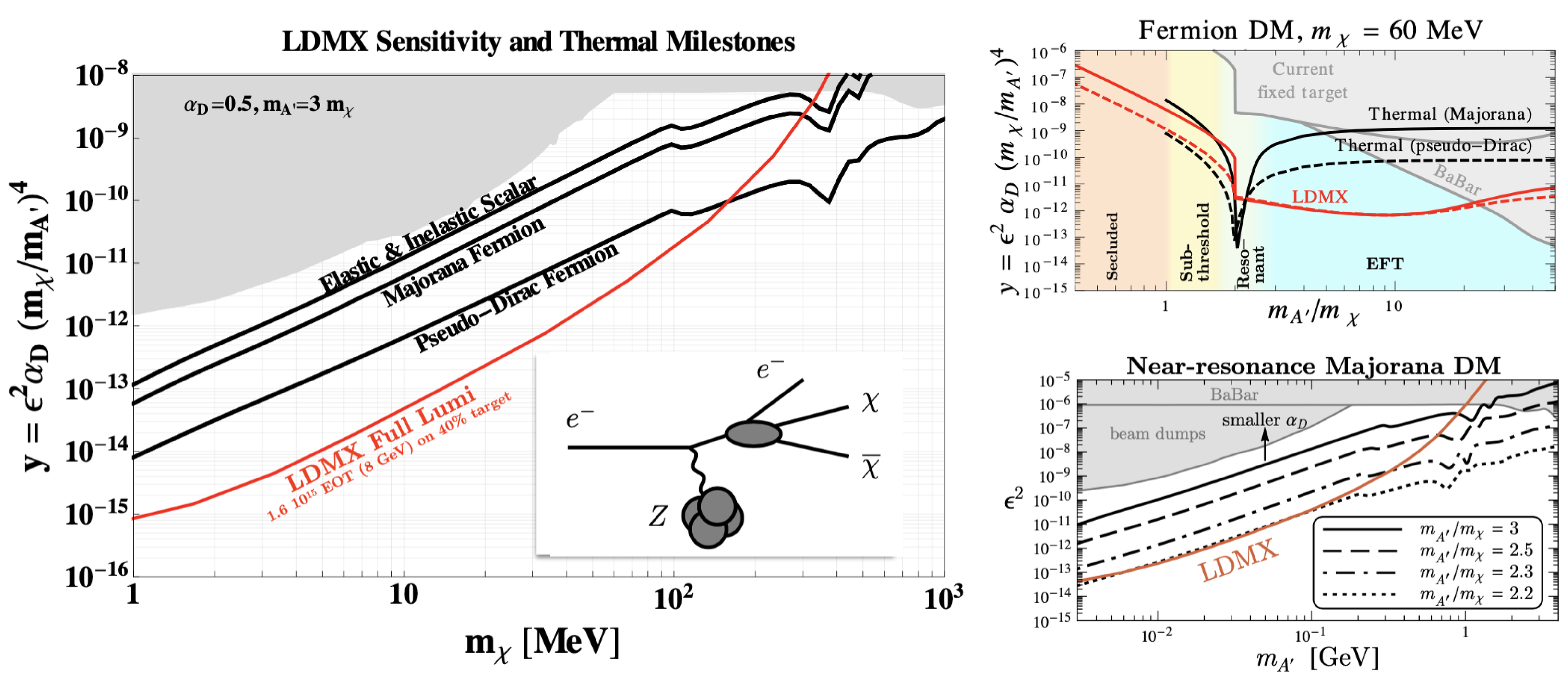


Fig. 4: **Left:** Projected full luminosity LDMX sensitivity where the experiment is able to probe three orders of magnitude lower than existing searches. **Top Right:** Here DM is assumed to have a mass of 60 MeV and LDMX explores both Majorana and Pseudo-Dirac DM. **Bottom Right:** LDMX sensitivity to various ratios of near-resonance Majorana DM as calculated in [3].

References

[1] T. Akesson, A. Berlin, and N. Blinov. "Light Dark Matter eXperiment (LDMX)". In: *arXiv* (Aug. 2018).
[2] Torsten Åkesson et al. *A High Efficiency Photon Veto for the Light Dark Matter eXperiment*. 2019. arXiv: 1912.05535 [physics.ins-det].
[3] Asher Berlin et al. "Dark matter, millicharges, axion and scalar particles, gauge bosons, and other new physics with LDMX". In: *Physical Review D* 99.7 (Apr. 2019). ISSN: 2470-0029. DOI: 10.1103/physrevd.99.075001. URL: http://dx.doi.org/10.1103/PhysRevD.99.075001.

Primary Background Processes

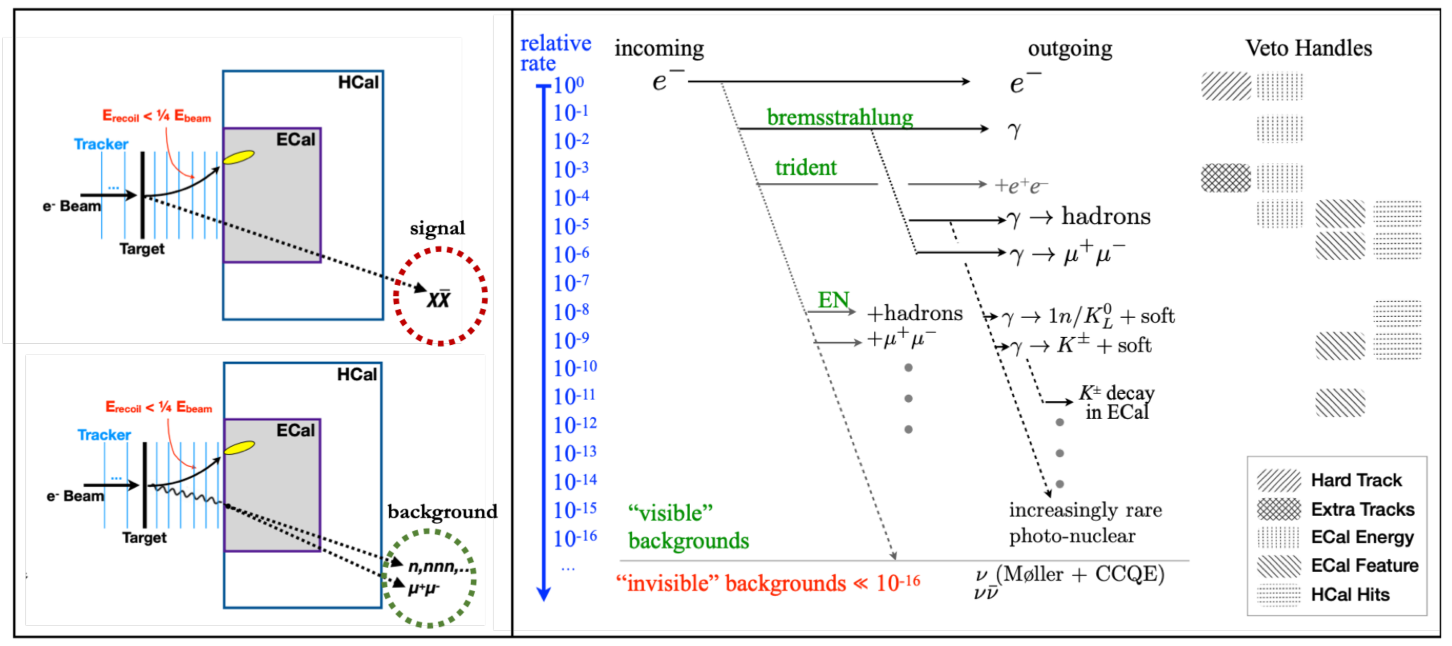


Fig. 5: **Top Left:** Simple LDMX illustration representing direct LDM production. **Bottom Left:** Background illustration of hard Bremsstrahlung process in target and photonuclear reaction in calorimeter. **Right:** Primary background modes and rates. Veto handles describe which subsystem detects and rejects corresponding background process. [2]

Event Selection

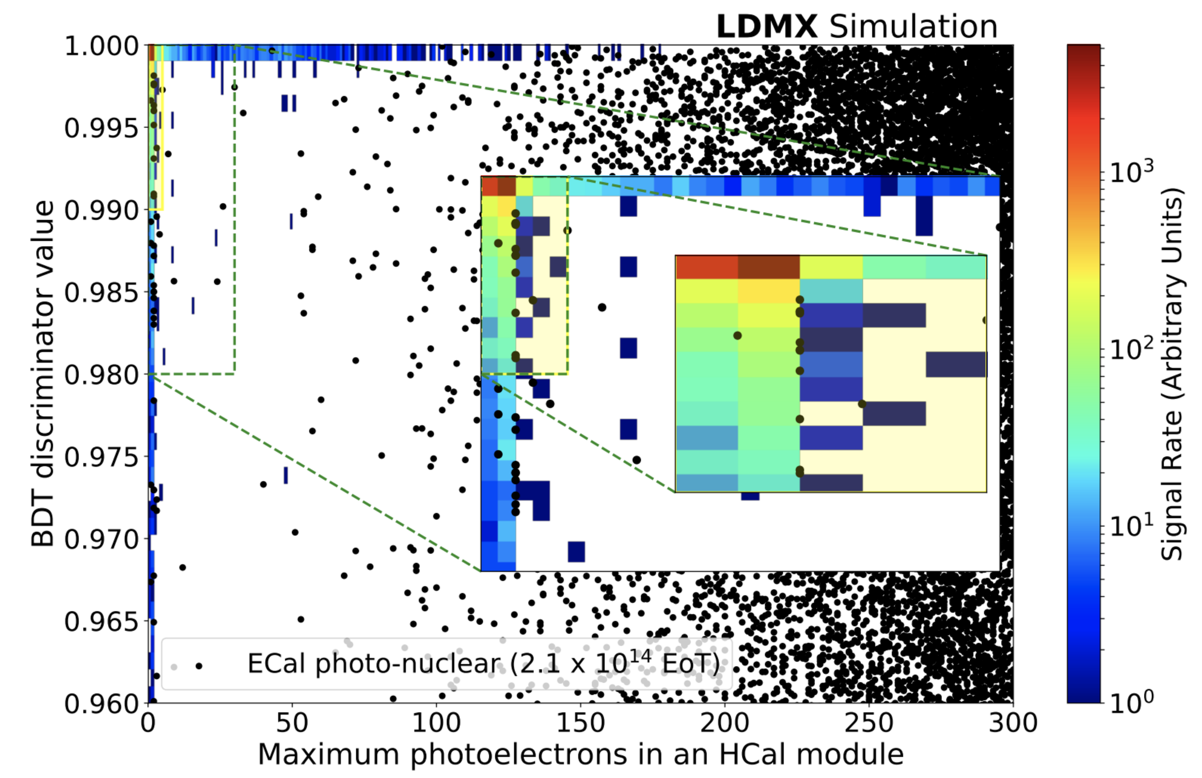


Fig. 6: Distribution of ECAL Boosted Decision Tree (BDT) Discriminator value vs maximum number of photoelectrons in HCAL module. The black points represents a 2.1×10^{14} EoT background. The heat map represents a 100 MeV A' signal sample. The signal region is defined by a BDT score of < 0.99 and PE # < 5. Background events in this region are rejected by track requirements of recoil tracker and ECAL [2].

Acknowledgements

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