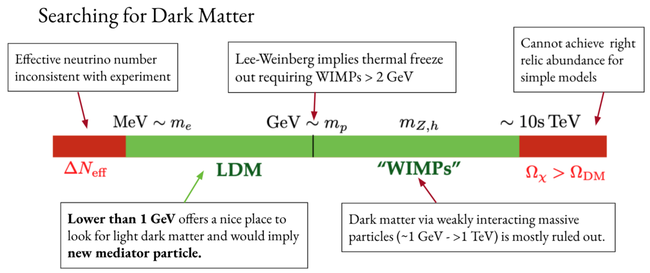
The Light Dark Matter eXperiment

Emrys Peets[a,b] on behalf of the LDMX Collaboration

Stanford University[a], SLAC[b], Fermilab, Lund University, University of California at Santa Barbara, Caltech, University of Minnesota, Texas Tech University, University of Virginia

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].



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."

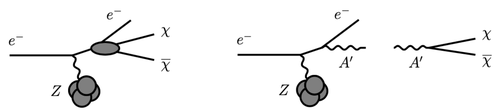
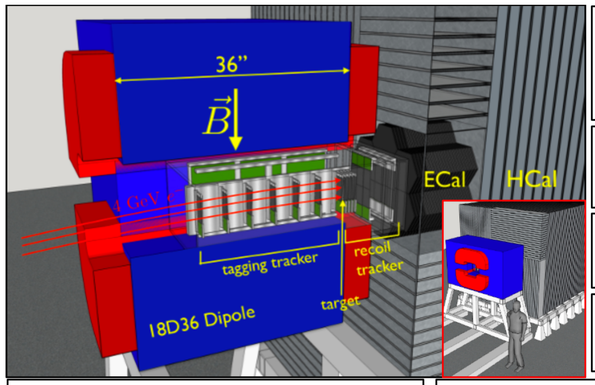


Fig. 2: Two possible invisible primary decay modes as a consequence of kinetic mixing. Left: Direct DM production. Right: Mediator particle, or heavy photon, production via "Dark Bremsstrahlung."

Missing Momentum Search

A **silicon tagging tracker**, housed in a **1.5T dipole magnet**, tags incoming electrons via the sector 30 transfer line from the high rate **SLAC LCLS-II 4 GeV Electron Beam** and 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 **large missing transverse momentum** dependent on the mediator mass. The trackers would be able to resolve this momentum and be sensitive to the mediator mass with a large sample of signal events.

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

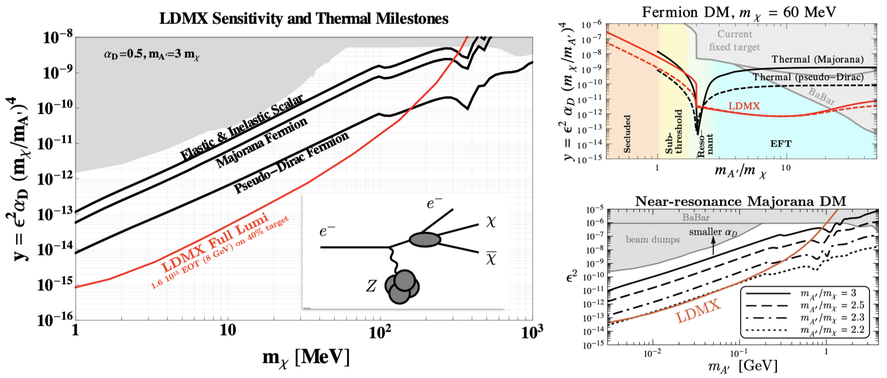
Silicon Tagging Tracker
- 6 double sided CMS APV25 based modules inside dipole

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



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].

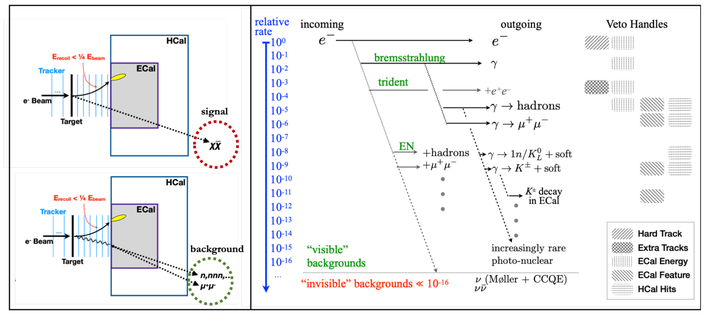
References

[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].

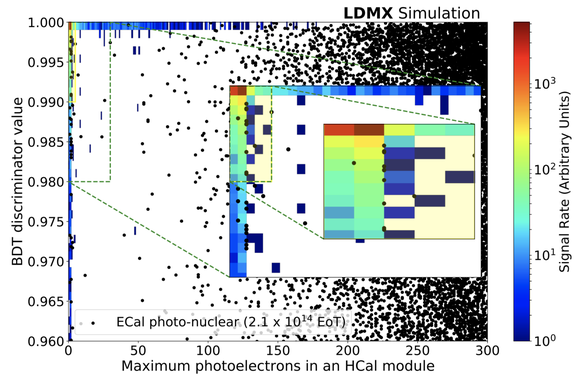
[3] Asher Berlin et al. "Dark matter, millicharges, axion and scalar particles, gauge bosons, and other new physics with LDMX". In: *Physical Review D* 99.7 (Apr. 2019). ISSN: 2470-0029. DOI: 10.1103/physrevd.99.075001. URL: http://dx.doi.org/10.1103/PhysRevD.99.075001.

Primary Background Processes



Top Left: Simple illustration representing direct LDM production. **Bottom Left:** Background illustration of hard Bremsstrahlung in target with a photonuclear reaction. **Right:** Primary background modes and rates. Veto handles show which subsystems can detect and reject the corresponding background process. [2]

Using BDT/HCAL to reject background for A' Production



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

Acknowledgements and Resources

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LDMX Website

https://confluence.slac.stanford.edu/display/MME/Light+Dark+Matter+Experiment