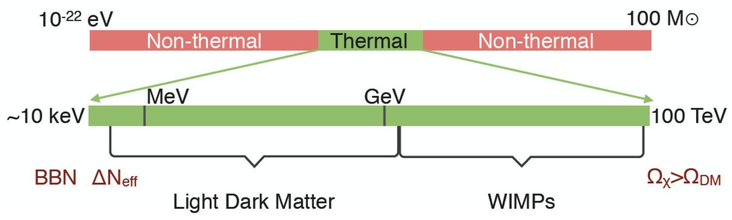
The Light Dark Matter eXperiment

Matt Solt, University of Virginia, On behalf of the LDMX Collaboration

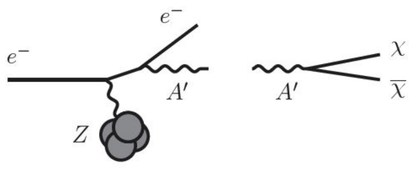
Light Dark Matter

- **Dark matter** is an unknown form of matter that is thought to account for approximately 85% of the matter in the universe.
- The mass is unknown, but "light" dark matter (LDM) is well motivated by hidden sector models.

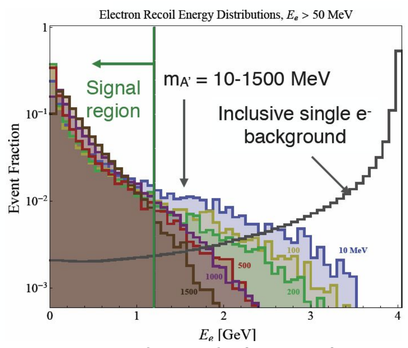


- Small-scale accelerator fixed target-experiments, like LDMX, can provide powerful probes of LDM using missing energy signatures.
- Unlike direct detection experiments, relativistic production at accelerators are nearly insensitive to DM spin and mass.

LDMX Concept & DM Kinematics

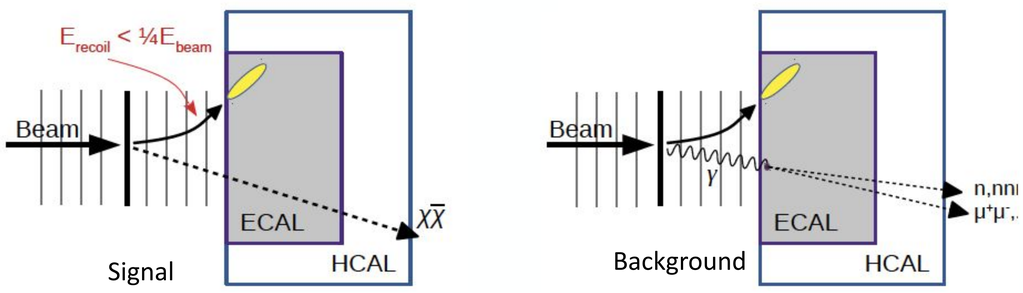


Dark photon (A') production possible on or off-shell



Dark photons couple to electric charge: produced through a process analogous to the primary background (photon bremsstrahlung), but different rates and kinematics:

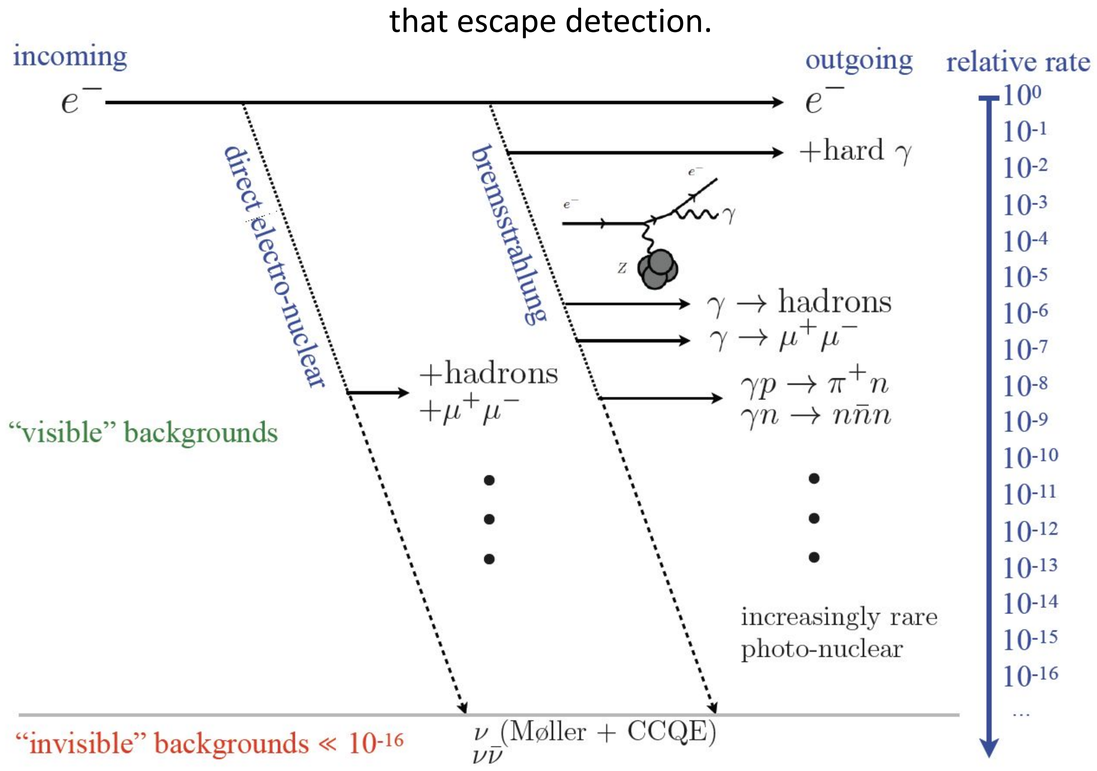
- A' takes most of the beam energy.
- Recoil electron soft, at wide angles —> large missing energy/momentum.



- 4 and 8 GeV e- beam, low-current with high repetition rate.
- Missing-energy ECal-based trigger to select events with large energy lost from the electron.
- Use tagging tracker to confirm beam energy and recoil tracker to confirm energy of recoil electron after target interaction.
- Calorimeters veto additional activity beyond the electron in the event.
- Equipped for e/γ particle ID

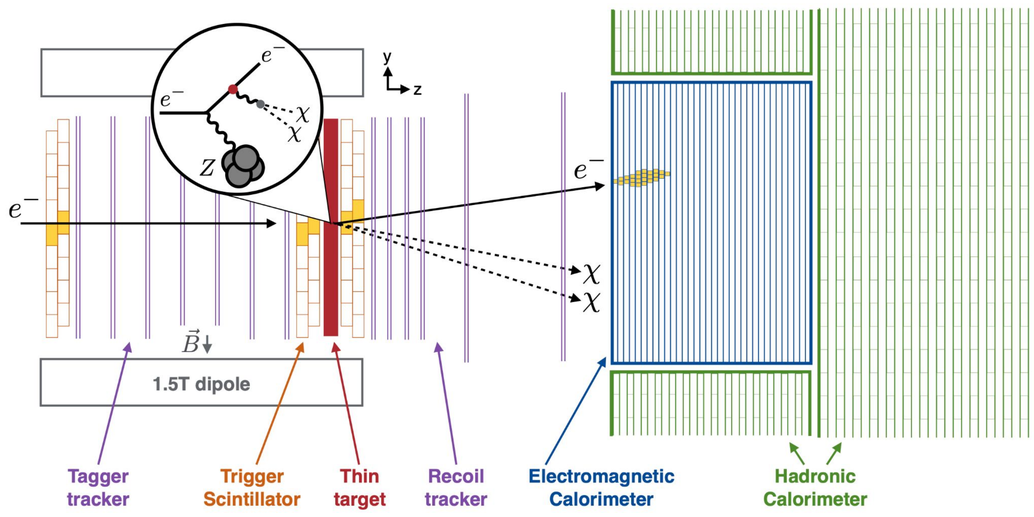
Background Relative Production Rates

Primary backgrounds from hard bremsstrahlung followed by muon conversion, photonuclear interactions, or electronuclear interactions which produce particles that escape detection.



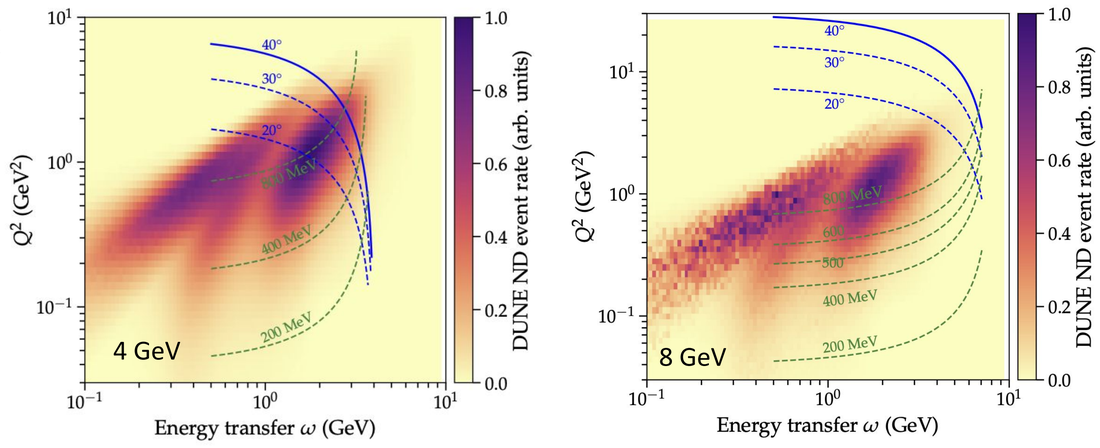
Recoil e- kinematics enable background rejection and signal selection.

LDMX Detector



- **Tracker:** silicon vertex tracker adapted technology of of HPS at Jlab.
  - Removes background from low-energy electron beam contamination.
- **ECAL:** Si/W sampling calorimeter which draws on technology of High Granularity Calorimeter upgrade for CMS.
  - Resolution and particle ID sufficient to remove photon bremsstrahlung events.
  - Shower shape, MIP tracking, and other observables useful to remove some rare photonuclear (PN) events.
- **HCAL:** scintillator/steel sampling calorimeter with WLS fiber readout similar to Mu2e Cosmic Ray Veto system.
  - Optimized for hadrons produced via photonuclear interactions, and works well for muon conversions.

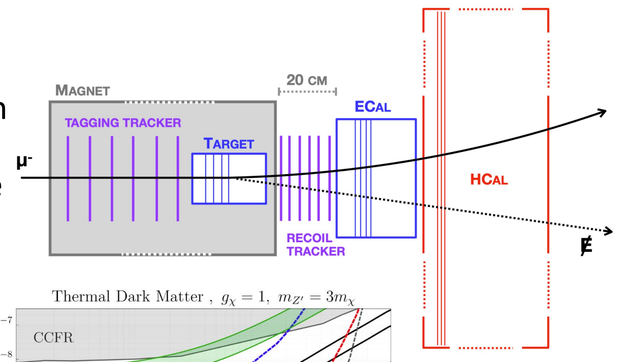
Electro-nuclear Measurements

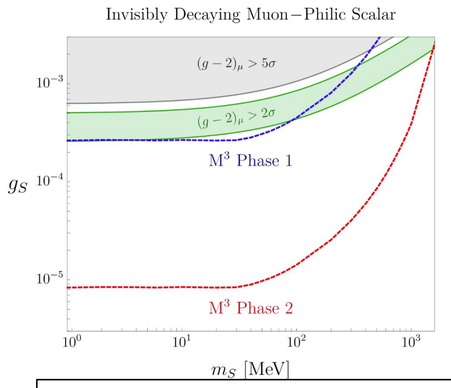


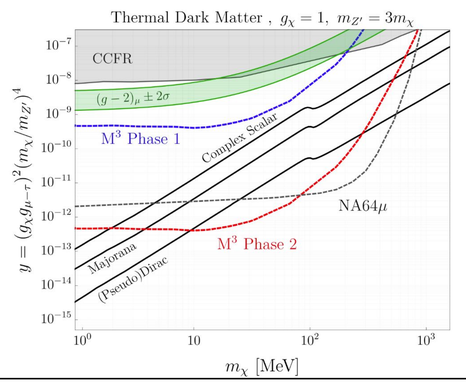
Small angle acceptance and individual particle reconstruction allows for electro-nuclear measurements of interest to neutrino experiments (such as DUNE).

Missing Momentum Muon Experiment

- M³ is a proposed LDMX-like experiment with a muon beam.
- Probes muon-philic forces through missing momentum.
- Major difference with LDMX is the thick active target made with the Ecal material from LDMX.





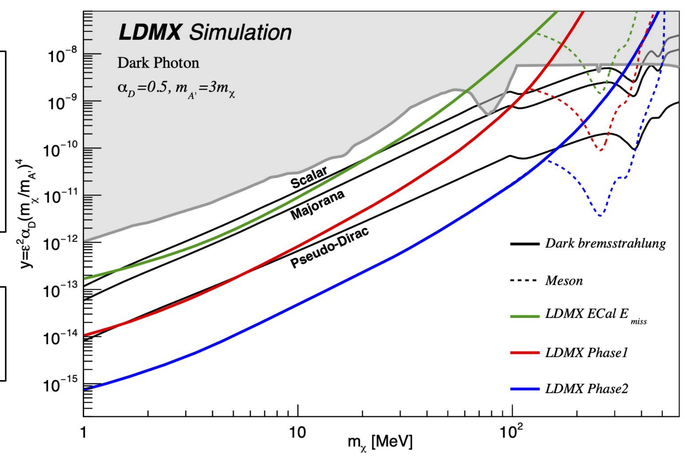


Phase I - 15 GeV and 1e10 MoT (motivated by g-2 result)
Phase II - 15 GeV and 1e13 MoT (motivated by thermal dark matter)

Conclusion

Total background expected to be less than 1 event at goal of 4×10^{14} electrons on target with a 4 GeV beam.

Phase I - 4 GeV and 1e14 EoT
Phase II - 8 GeV and 1e16 EoT



The LDMX Collaboration

Caltech · Fermilab · Lunds Universitet · University of Minnesota · UCSB University of California Santa Barbara · SLAC National Accelerator Laboratory · Stanford University · Texas Tech University · University of Virginia