The BDX-MINI detector for Light Dark Matter search @ JLAB

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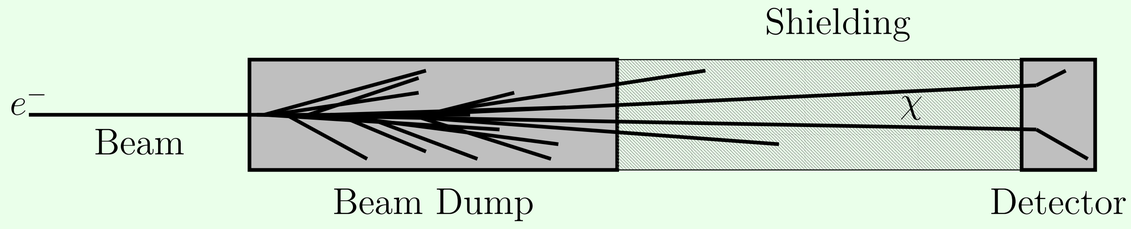
Light Dark Matter

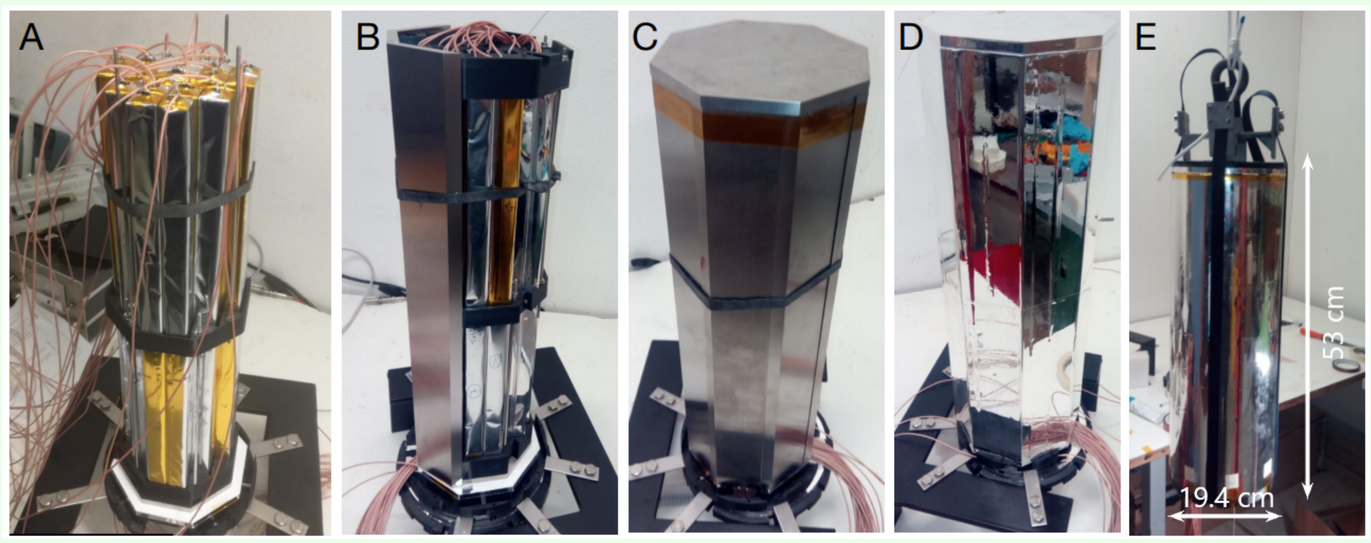
- Light Dark Matter (LDM) is a new compelling hypothesis that identifies Dark Matter with new sub-GeV states interacting with ordinary matter through a new force. This interaction can be mediated by a massive vector boson called "Dark Photon".
- In beam dump experiments, a high intensity beam impinges on a thick material (beam dump), producing a forward focused secondary LDM beam
- A sizable shielding located downstream the dump absorbs all SM particles except neutrinos
- LDM particles are detected through their scattering in a downstream detector. BDX-MINI aims at detecting $\chi - e$ elastic scattering in an electromagnetic calorimeter



BDX-MINI Detector

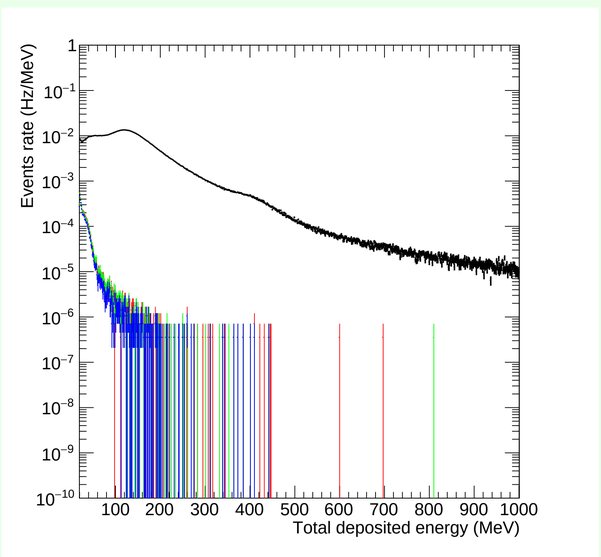
BDX-MINI detector is composed of an ECal surrounded by a multi layer veto:

- ECal is made up of 44 $PbWO_4$ crystals for a total active volume of 4 dm^3 (A)
  - 32 ($15 \times 15 \times 200$ mm^3) spare CLAS-12 FT crystals glued in pairs
  - 28 ($20 \times 20 \times 200$ mm^3) spare PANDA ECal crystals
  - Readout: 6×6 mm^2 Hamamatsu MPPCs (S13360-6025PE)
  - LY: 1 p.e. / MeV
- The veto is composed of three layers:
  - Innermost layer: passive tungsten shielding 0.8 cm thick (B, C)
  - Middle (D) and Outer (E) layer made by 0.8 cm thick plastic scintillator read with WLS fibers and 3×3 Hamamatsu S13360-3075CS SiPMs
    - Octagonal Inner Veto composed by 8 paddles coupled with optical glue
    - Cylindrical Outer Veto composed by a single cylindrical tube
    - Number of readout channels for each active veto: 10 (8 for lateral, 2 for bases)
- Data acquisition:
  - Bias voltage provided by a custom designed board
  - SiPMs connected to front-end electronics via 8 m long coaxial cable (low noise)
  - Custom transimpedence amplifier with different gains for ECal and Veto channels
  - CAEN FPGA v1495 used for custom trigger logic
  - Digitalization with CAEN (v1730 and v1725) Flash ADC converter



Veto Performance

- High rejection capability combining the information from the two veto systems: at the MIP peak, counting rate suppressed of a factor 3800
- Veto rejection efficiency is similar for both vetoes independently of the veto shape
- Redundant readout compensates the potential inefficiency of the single SiPM
- The anti-coincidence requirement has a negligible effect on the signal detection efficiency

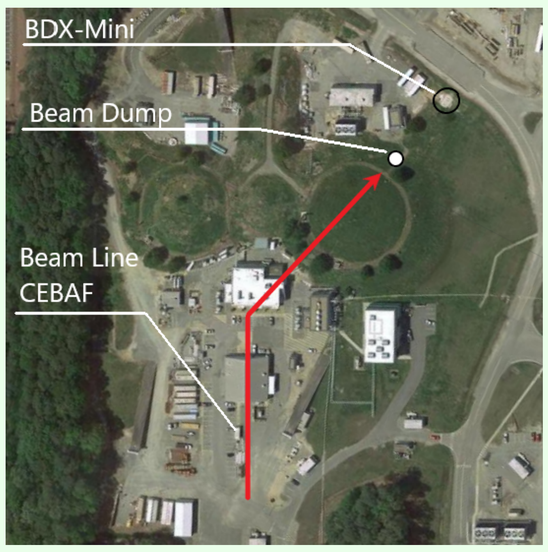


BDX-MINI Experiment

BDX-MINI experiment is a Beam Dump eXperiment running at Jefferson Lab. It aims to search for DM produced by the CEBAF high intensity e^--beam impinging on the experimental Hall-A beam dump:

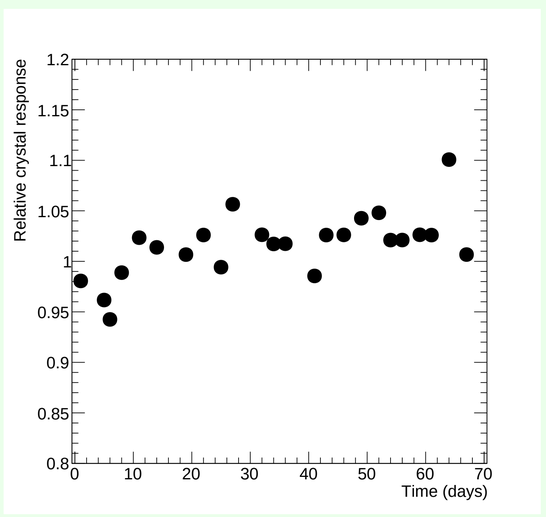
- e^- beam with $E_{beam} = 2.176$ GeV, current up to 150 μA
- Hall-A beam dump: 3 m Al + water cooling system
- detector positioned in a well 26 m downstream of the dump at beamline height
- Entire experimental setup situated within a sturdy field tent

BDX-MINI ran for 6 months in spring-summer 2020, collecting about 2.56×10^{21} EOT.



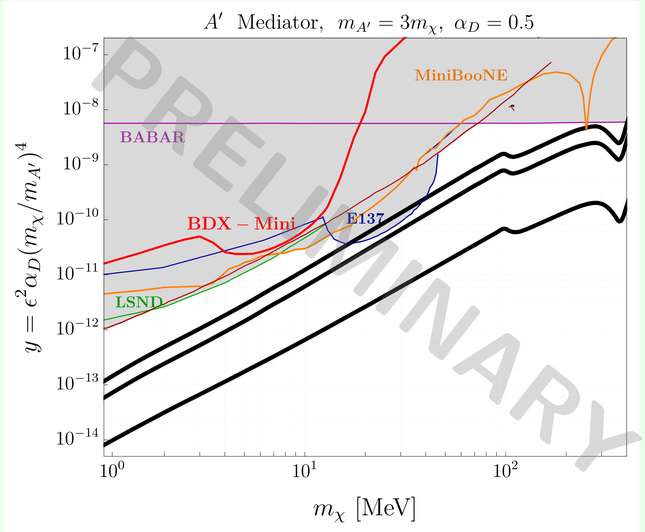
ECal Performance

- ECal calibration with special 10 GeV run
- Stability checked using cosmic muons
- Detector stable within $\sim 10\%$



Physics Results

Evaluation of exclusion limit (90% C.L.) in the LDM parameter space



References

[1] Battaglieri M. et al arXiv:1707.04591
[2] Battaglieri M. et al. Eur. Phys. J. C (2021) 81: 164