Improving sensitivity to low-mass dark matter in LUX using a novel electrode background mitigation technique

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On behalf of the LUX collaboration

Detection Technique



Fiducialization

- Xe is "self shielding"
- Edge event rate is 3-4 orders of magnitude > center rate

- - Fiducial volume



Spin-independent WIMP-nucleon Limit



- LUX 33.5 tonne-day
 - WS2013 (95 live days) +
 WS2014-16 (332 live days)
 - lowest 90% CL exclusion = 0.11 zb at 40 GeV/c
 - PRL, 118, 021303, 2017
- Moved on to physics searches in different energy ranges, and analyses that would benefit near-future LUX-ZEPLIN (LZ)
- Low-mass (sub-GeV) dark matter

Very Low Energy Recoils in Xe Detectors



- Electron Detection Efficiency 50-100%
- Photon Detection Efficiency ~10%
- Yield turns in favor of electrons

Electrode Backgrounds





Cut Events in Non-uniform E-field



Boosted Decision Tree (BDT)



Parameters that quantify the S2 shape

- Time to 10%, 25%, 50%, 75%, 95%, 90% of the full pulse area
- Maximum pulse height
- Time of the maximum pulse height
- Time at which the rising and falling edges of the pulse reach 0 phd/sample

Boosted Decision Tree (BDT)

Training/testing dataset

- Background data: Low-energy background events with S1 and drift time corresponding to gate or cathode
- Signal data: Tritium beta decay calibration source



Receiver Operator Characteristic



Acceptance/Rejection



Spectrum



7 events/tonne/day/e⁻ at threshold

Charge Yield



- NR cutoff = 0.3 keV
- ER cutoff = 0.186 keV

Result

- Yellin's p-max test statistic
- WS2013 5 tonne day exposure



Training+Testing Data



WS2013 Waveforms



Background-like (Cathode-like by eye)

WS2013 Waveforms



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BDT with only Half Width



Conclusion

- Developed a technique for mitigating grid electrode backgrounds based on S2 pulse shape
- Demonstrated technique can improve Poisson limits by a factor of 2-7
- Using a LUX, 5 tonne day exposure set competitive limits on low-mass dark matter
- Suggest refining technique for near future experiments like LZ



Sanford Underground Research Facility

LUX Fully Constructed

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03

4850 ft Underground

LZ Construction in Progress

Data Selection Criteria

Large Event Veto

Skew-gaussian Fits to S2 Pulses

BDT with only Half Width

