LBECA: Pushing Xenon TPCs to Single Electrons

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“S2 Only” Channel

Exploit built-in amplification (proportional scintillation)

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Limited by Instrumental Background

![Graph showing WIMP-nucleon cross section vs WIMP mass and radioactive background vs mass.]

- Instrumental background
- Radioactive background
Why Push LXe to Single e⁻

- Scalable to tons
- Whopping signal:

- Xenon is radio-clean
- Excellent self-shielding
- Ionization energy only \(\sim 9 \text{ eV} \rightarrow \text{Large } \chi\text{-e}^-\text{-scattering rate}
- Easily ionize additional atoms (only \(\sim 14 \text{ eV}_{\text{ee}}\)) \(\rightarrow\) produce multiple e⁻ \(\rightarrow\) less background
Background: Photoionization

Xenon light 175nm=7eV photoionizes metals & impurities

Not a huge worry: simply veto away

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Background: Long Timescales

- Long-lived impurity states?
  Sorensen & Kamlon 1711.07025
- Delayed extraction?
  Sorensen 1702.04805
- Self-Organized Criticality?
  Pereverzev in prep.
The LBECA Project

...in three easy steps:

1) Characterize backgrounds ongoing using R&D setups and XENON1T & LUX data

2) Mitigate backgrounds ongoing at Purdue, UCSD & LLNL (2019/2020)

3) Build a dedicated LXe TPC detector 2021/2022, design proposal submitted

LLNL: J.Xu, A.Bernstein, S.Pereverzev; LBNL: P.Sorensen; UCSD: K.Ni; Stony Brook: R.Essig, M.Fernandez-Serra; Purdue: Rafael
Improved Purity

Sealed acrylic TPC realized at UCSD

graphene-coated fused silica electrode

S2 [PE]

Counts / bin

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Improved Extraction

Saturated extraction realized at LLNL

Electron Extraction Efficiency vs. Electric Field - liquid (kV/cm)

- Gushchin 1979
- XENON100 2014
- LUX*
- PIXeY 2017
- this work (LF)
- this work (HF)
Stimulated Emission/Quenching

LXe IR setup at Purdue
This just in: IR light really helps

Po210 peak
IR LED Off
IR LED On

less single e-
larger primary S2
CEνNS in liquid xenon

Expected rate uncertain: need dedicated calibration (already in progress)
CEvNS in liquid xenon

14 – 6 events/kg/year
with 2e\textsuperscript{-} threshold

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LBECA Draft Design & Reach

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