LBECA: Pushing Xenon TPCs to Single Electrons

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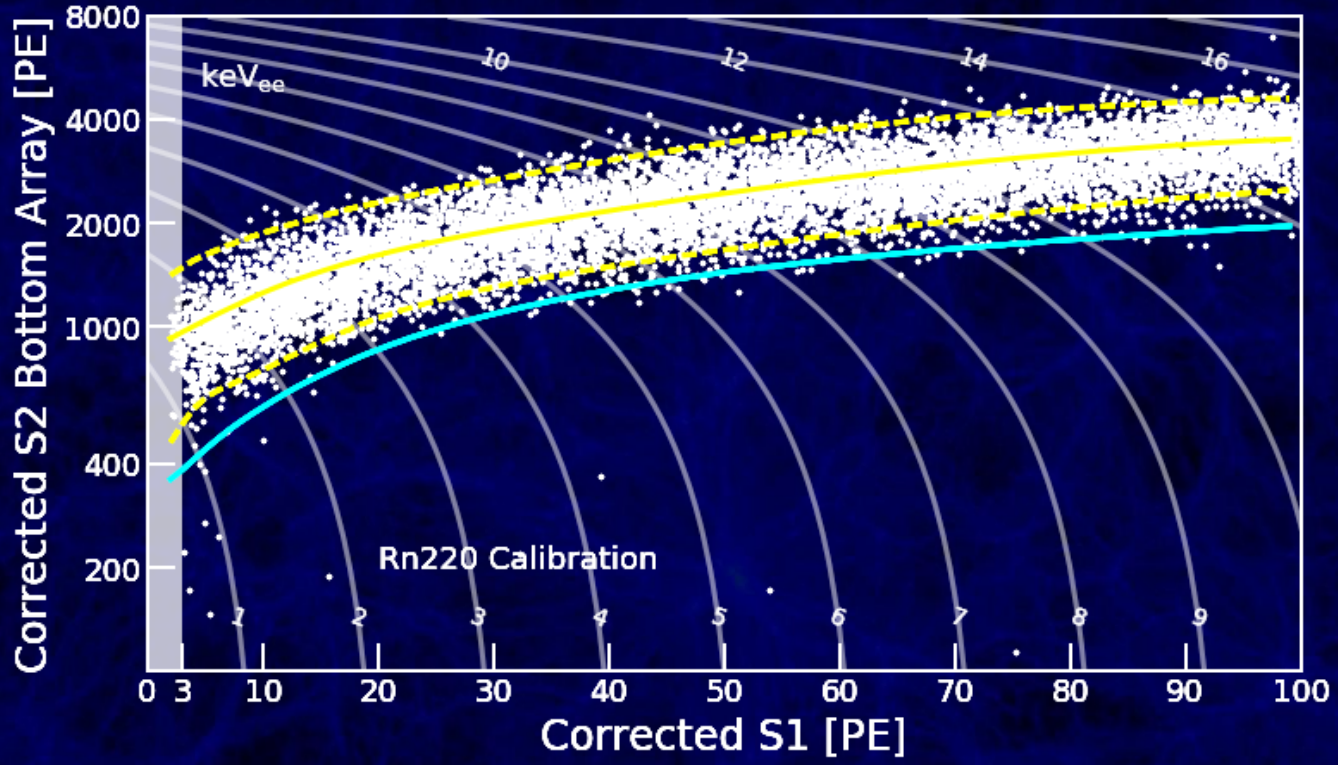
“S2 Only” Channel

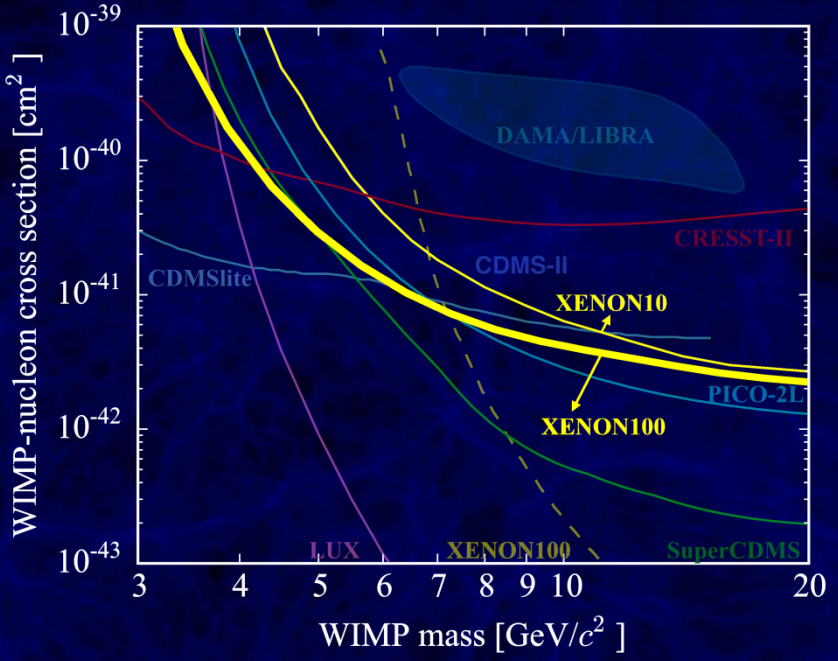


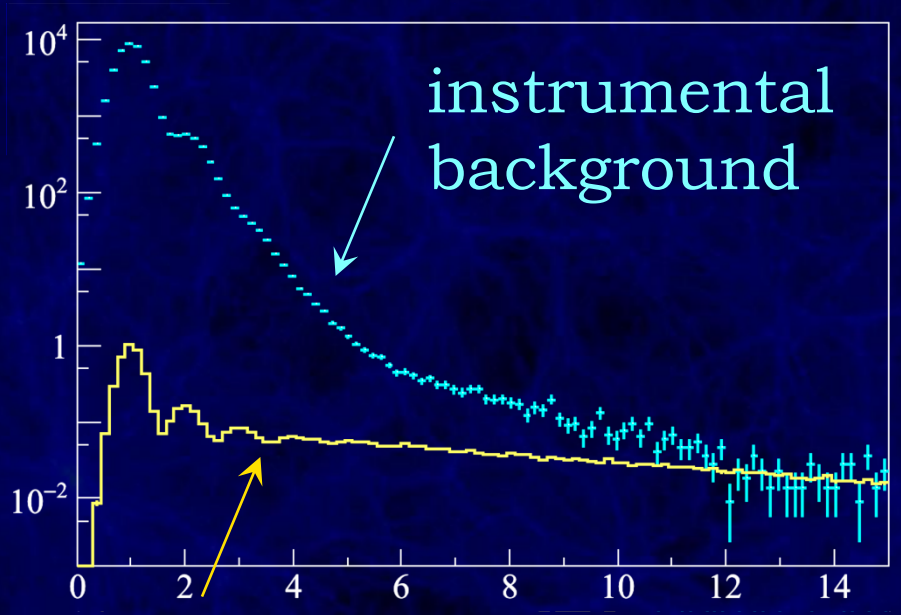
XENON1T

Exploit built-in amplification (proportional scintillation)

Limited by Instrumental Background

XENON100 1605.0626

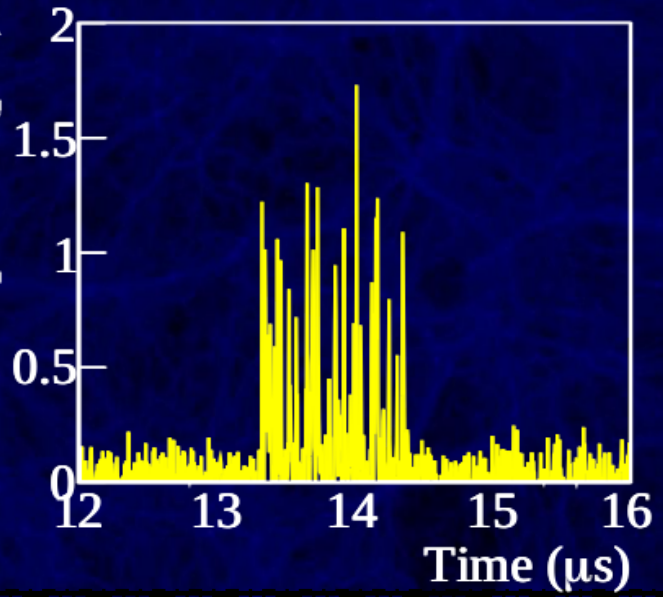




J.Xu

Why Push LXe to Single e^-

- Scalable to tons
- Whopping signal:

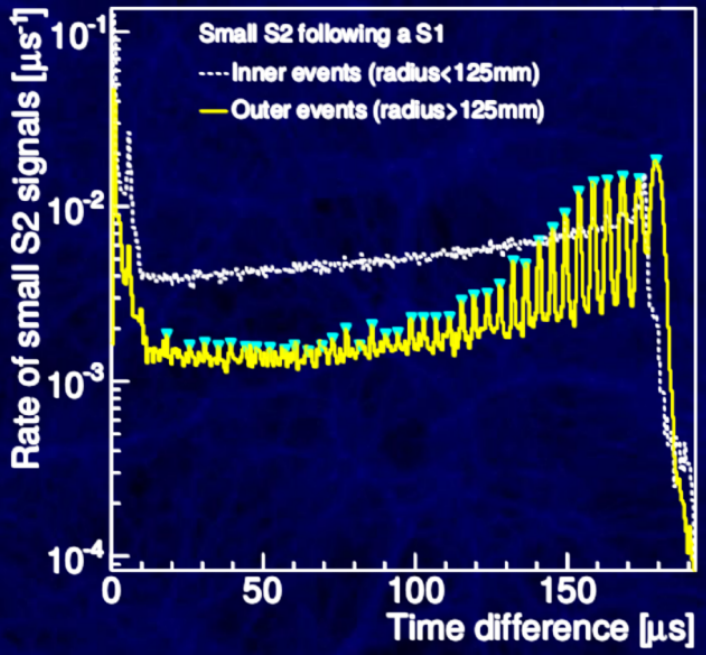


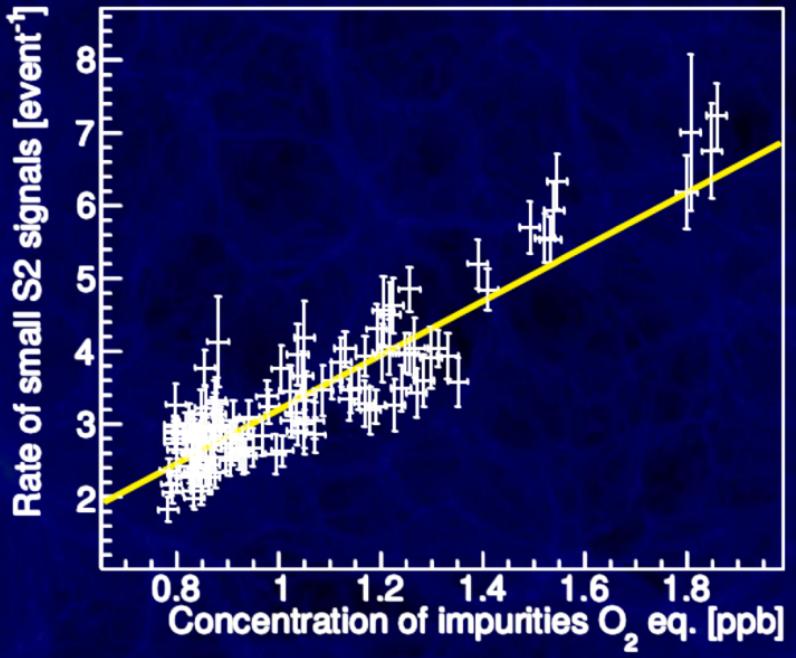
Xu+ 1904.02885

- Xenon is radio-clean
- Excellent self-shielding
- Ionization energy only ~9 eV → Large χ-e^- scattering rate
- Easily ionize additional atoms (only ~14 eV_{ee}) → produce multiple e^- → less background

Background: Photoionization

Xenon light 175nm=7eV photoionizes metals & impurities

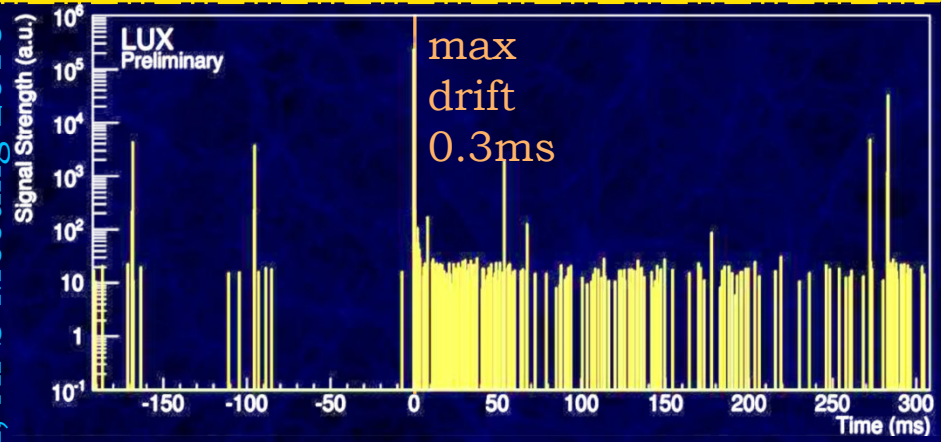




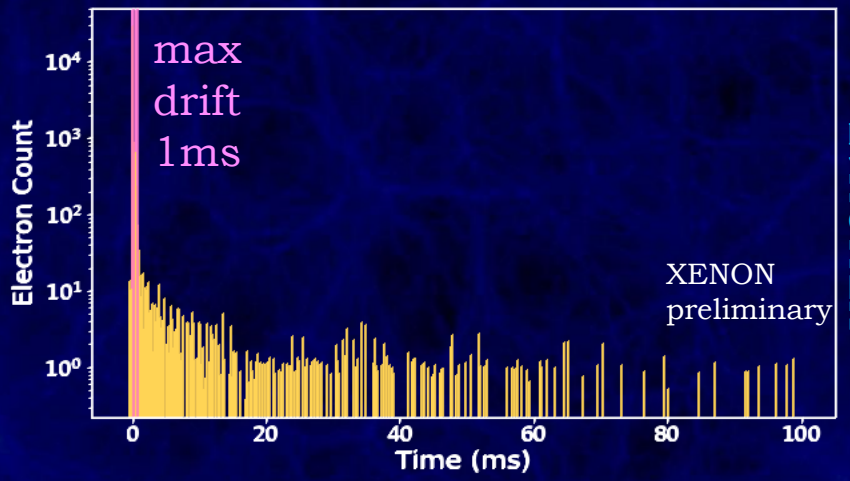
XENON100 1311.1088

Not a huge worry: simply veto away

Background: Long Timescales



J.Xu/LUX, APS Meeting 2016



XENON1T

- Long-lived impurity states?
  Sorensen&Kamdin 1711.07025
- Delayed extraction?
  Sorensen 1702.04805
- Self-Organized Criticality?
  Pereverzev in prep.

The LBECA Project

U.S. DEPARTMENT OF ENERGY

Office of Science

…in three easy steps:

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

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

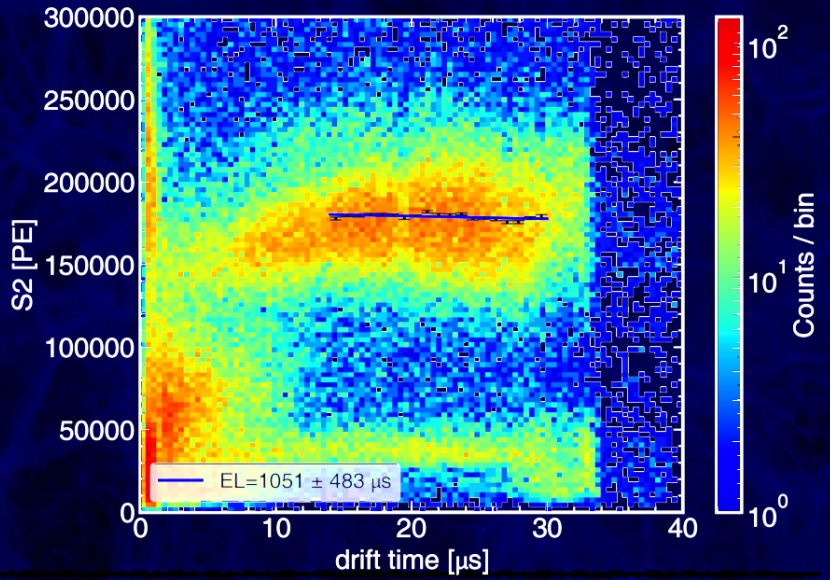
2) Mitigate backgrounds
   ongoing at Purdue, UCSD & LLNL (2019/2020)

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

Improved Purity

Sealed acrylic TPC realized at UCSD

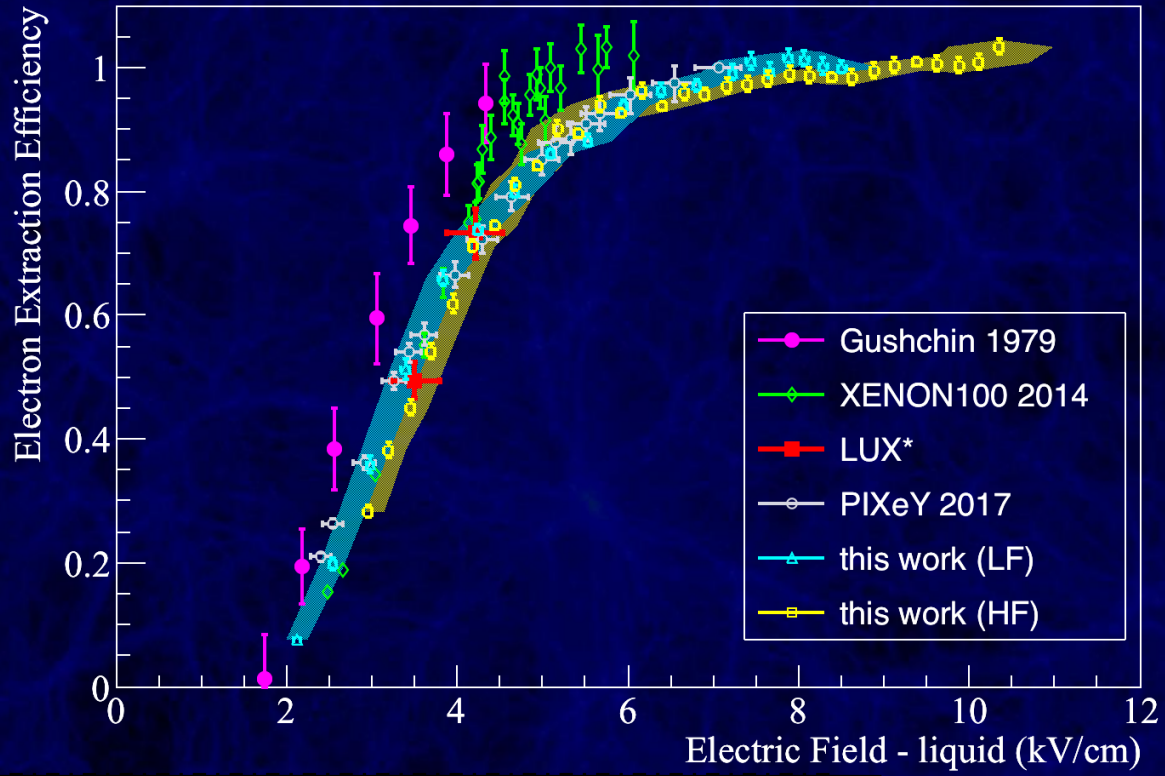
K.Ni



graphene-coated
fused silica electrode

Improved Extraction

Saturated extraction realized at LLNL

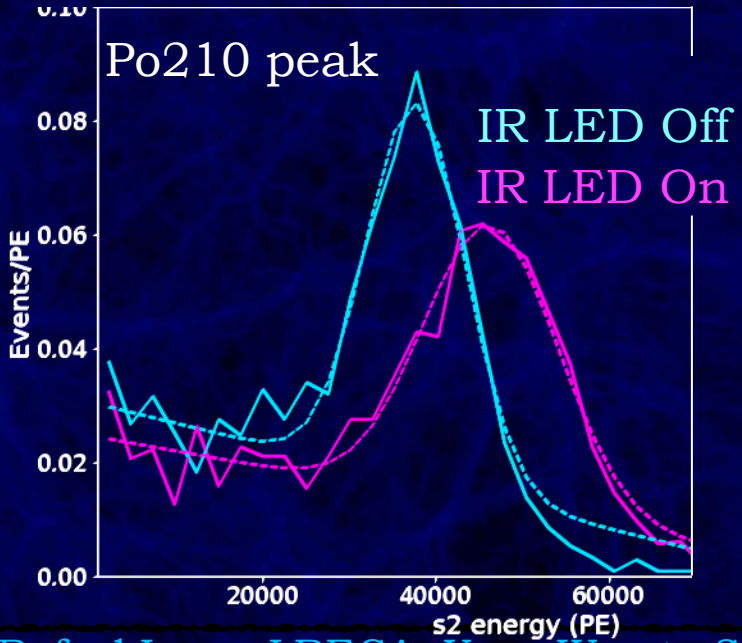


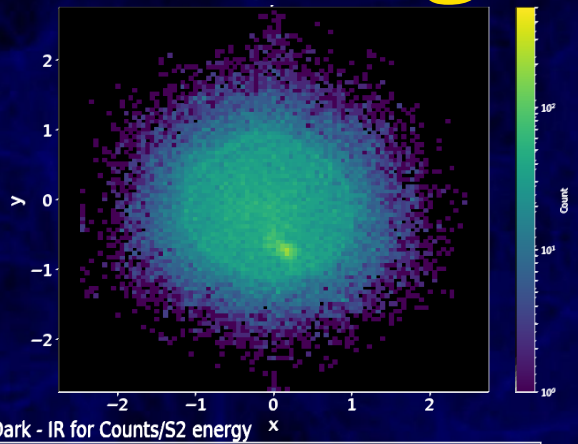
Xu+ 1904.02885

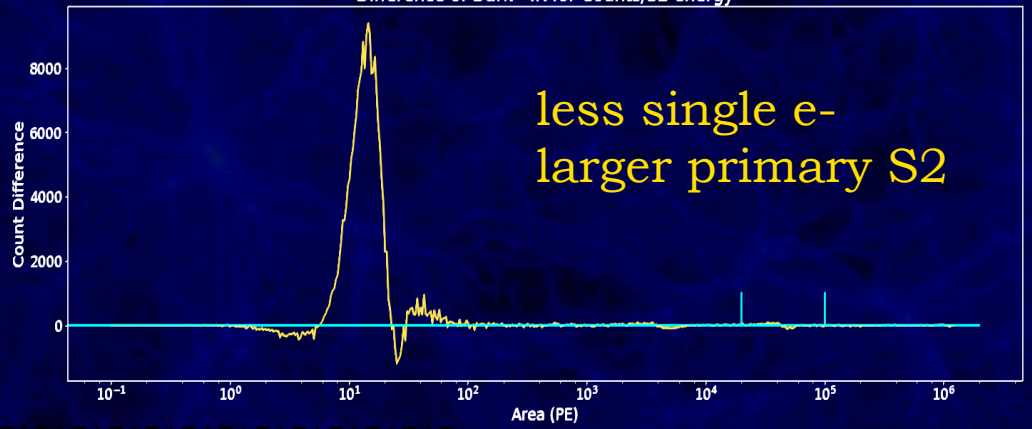
Stimulated Emission/Quenching

LXe IR setup at Purdue

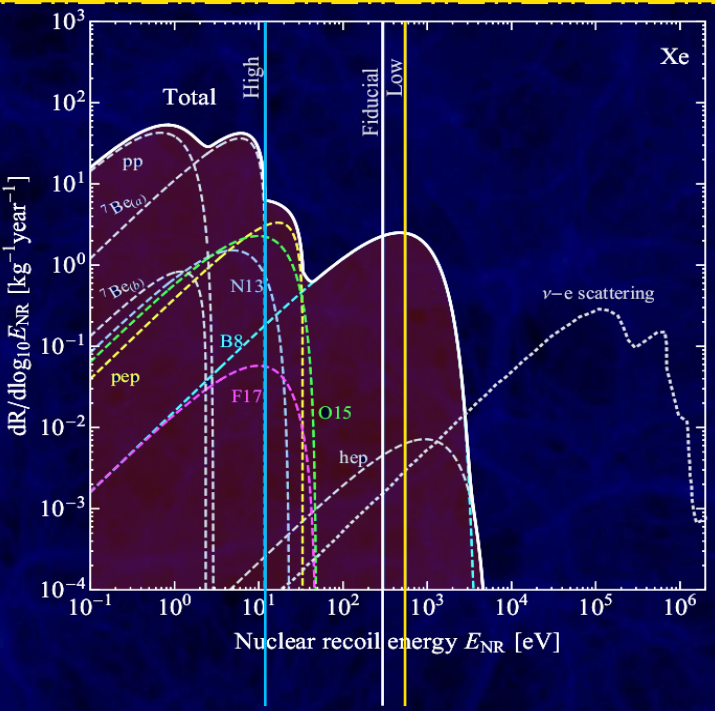
This just in: IR light really helps





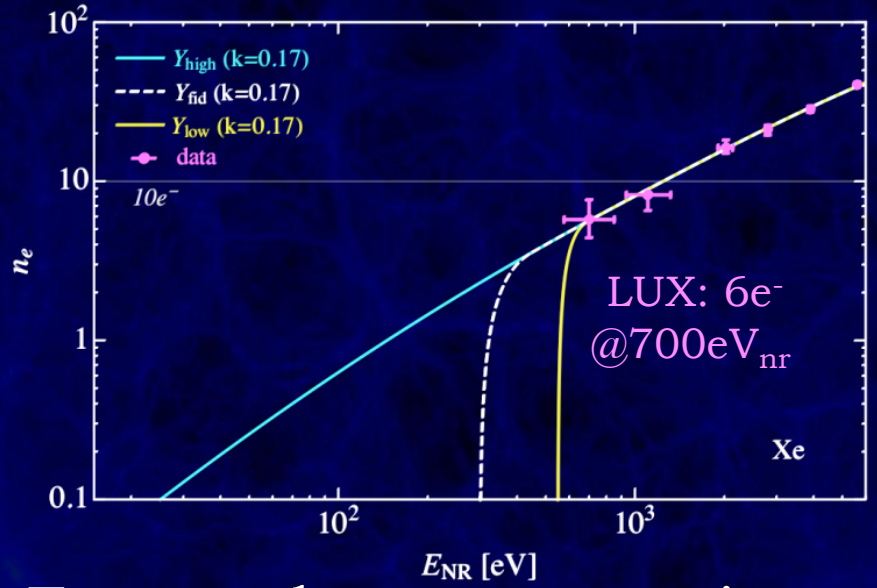


CEνNS in liquid xenon



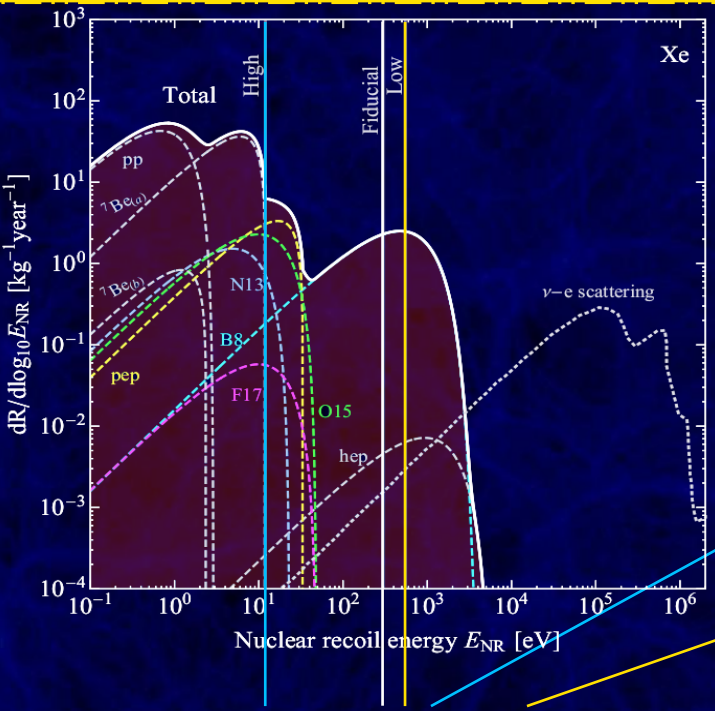
high/fid/low

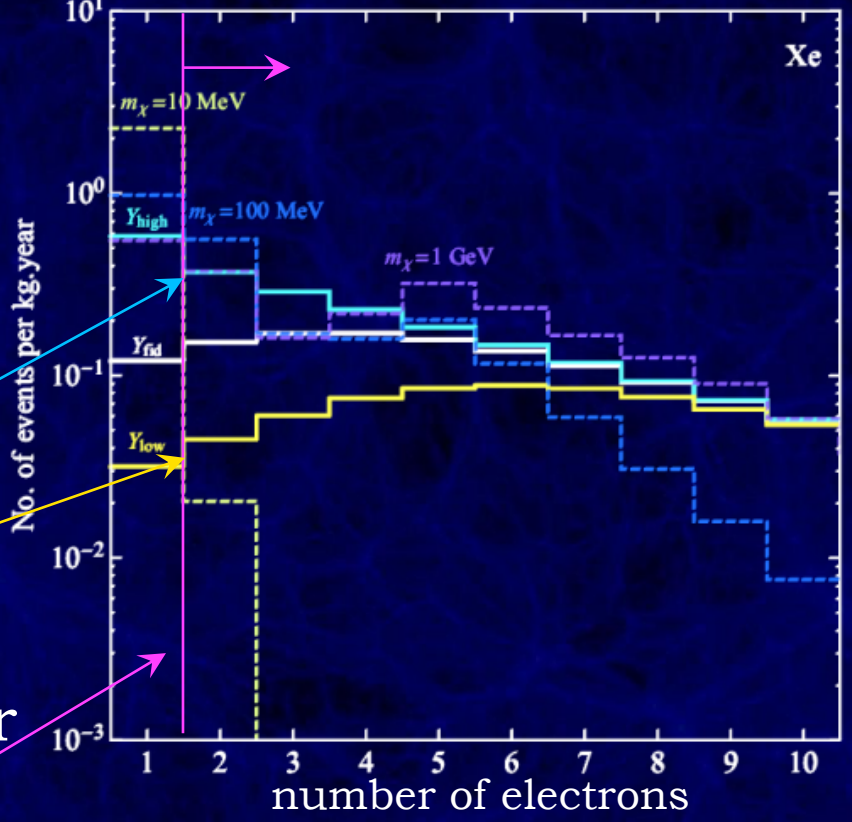
Essig, Sholapurkar, Yu 1801.10159



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

CEνNS in liquid xenon





14 – 6 events/kg/year
with 2e$^-$ threshold

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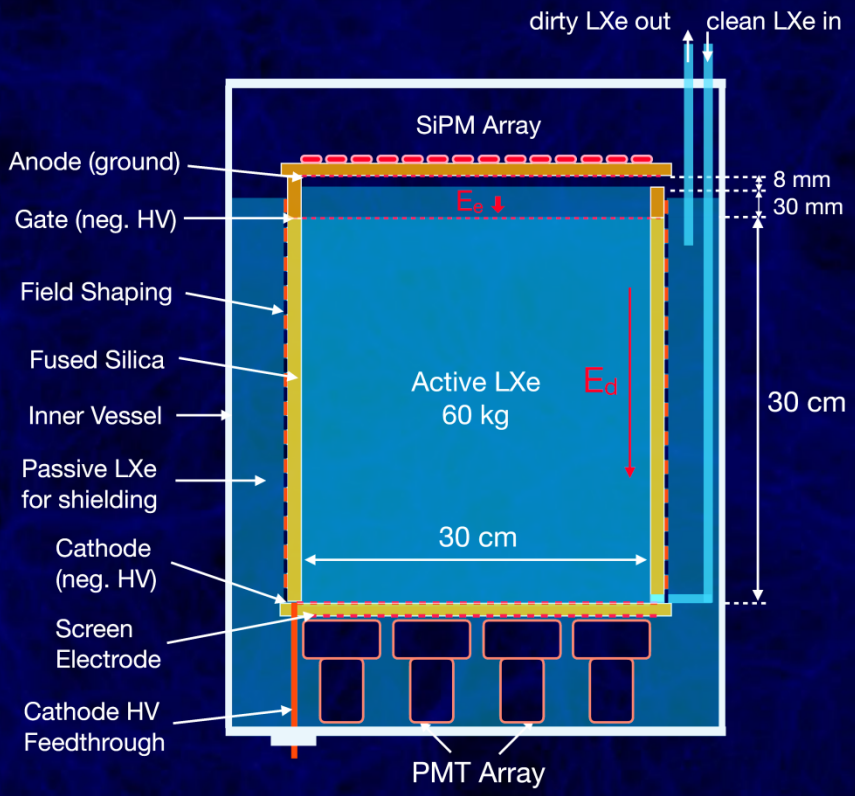
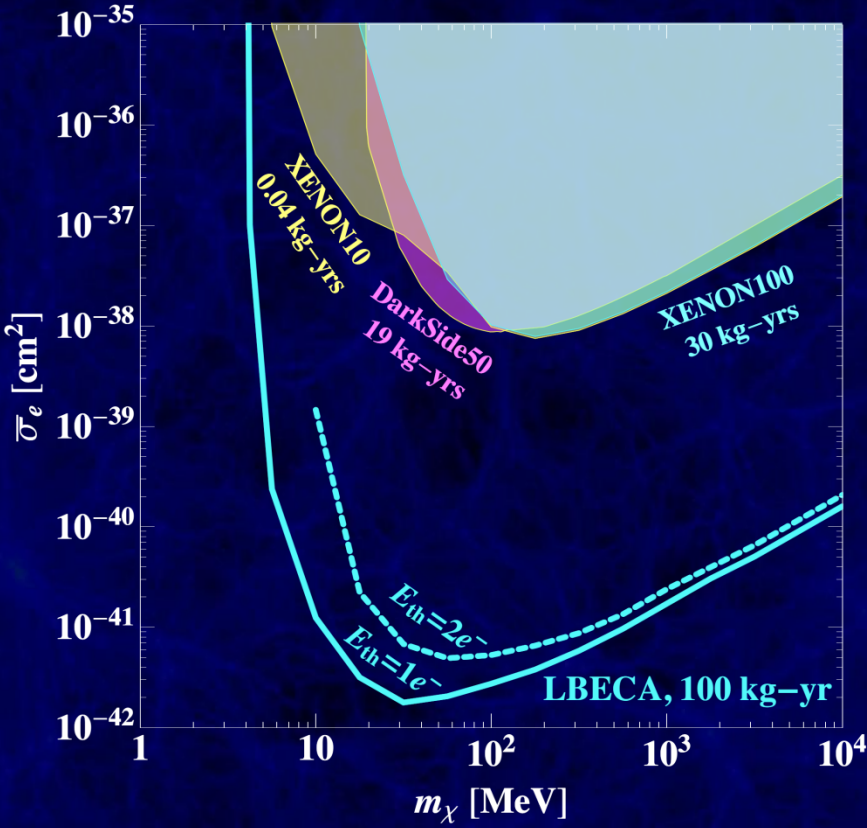
LBECA Draft Design & Reach





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