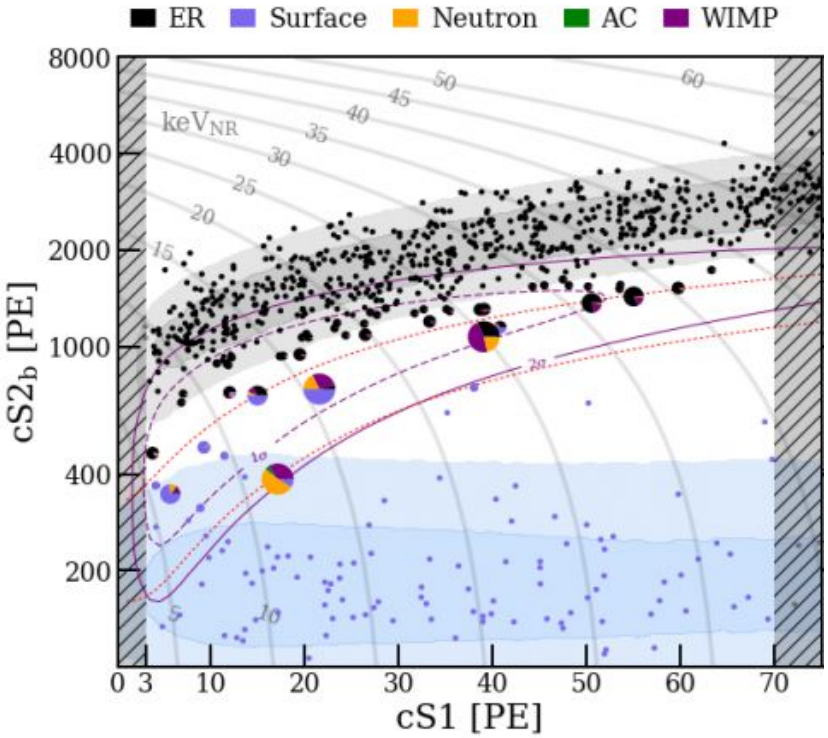
LBECA: A Low-Mass Dark Matter Search with Xenon

Michael Clark for the LBECA Collaboration

DPF Meeting 2019
August 1, 2019

Low-Energy Signals in Xenon

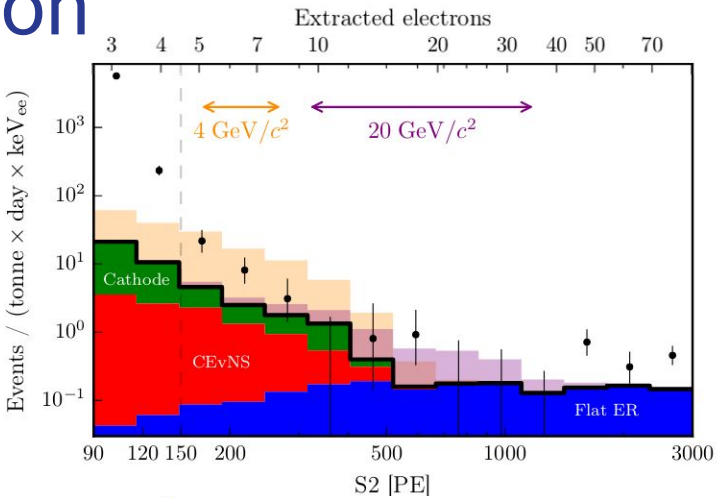
- Energy threshold dominated by detection of the scintillation (S1) signal
- Could push threshold even lower using only the ionization (S2) channel



XENON1T, 1805.12562

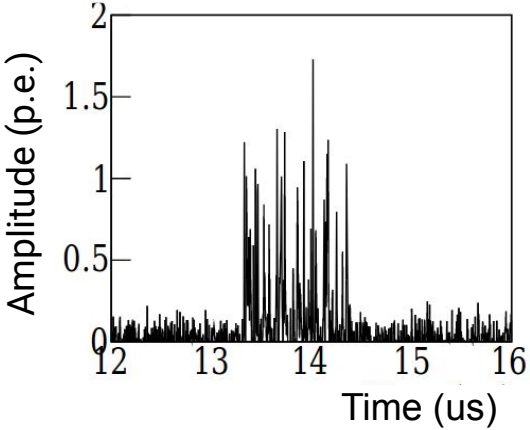
Low-Energy Signals in Xenon

- Recent results using only S2 signals in XENON1T see unexpected background at low number of electrons, ultimately limiting the threshold



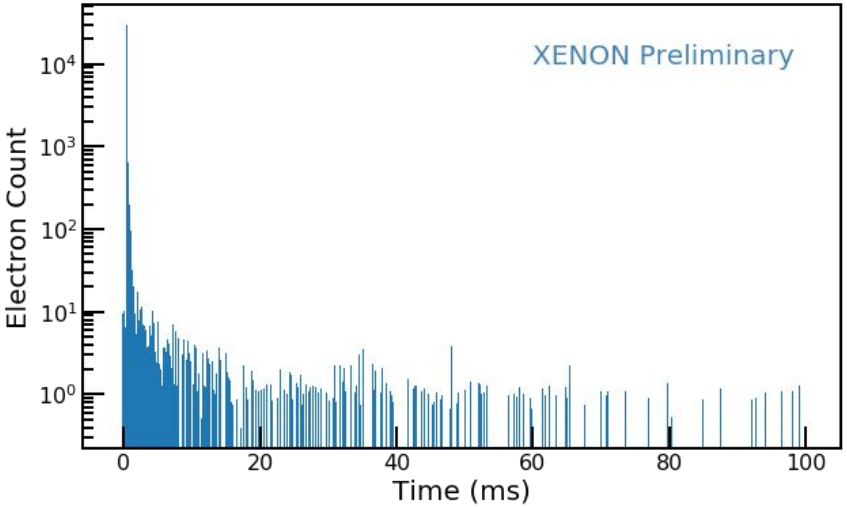
XENON1T, 1907.11485

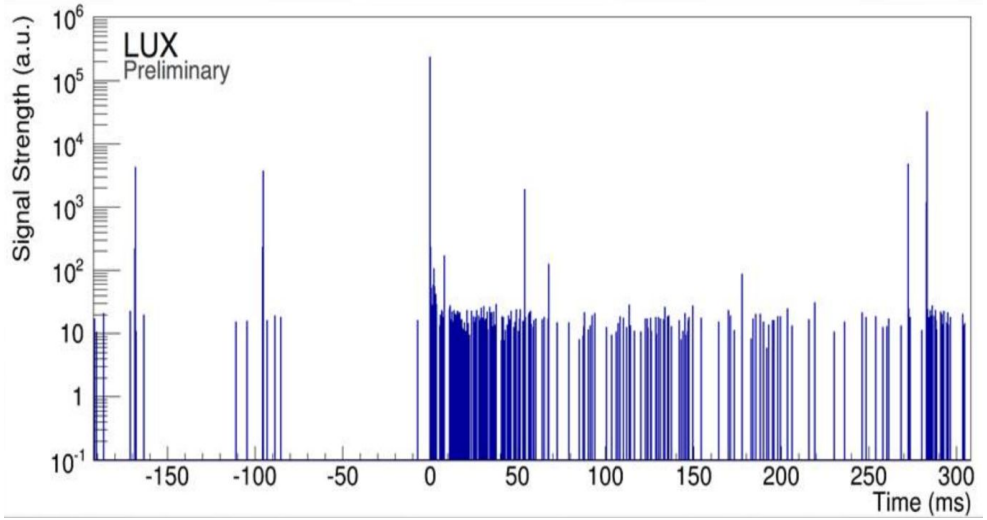
- Single electrons produce a clear signal, should be able to trigger on such signals, if backgrounds are understood



Xu et al., 1904.02885

Single Electron Backgrounds after Large Signals





After large energy deposits, single electron signals are observed over several hundreds of milliseconds

Where do these single electrons come from?

- Photo-ionization of metal surfaces or impurities
- Delayed extraction of ionization electrons...
  - ...at the liquid-gas interface
  - ...trapped on electronegative impurities

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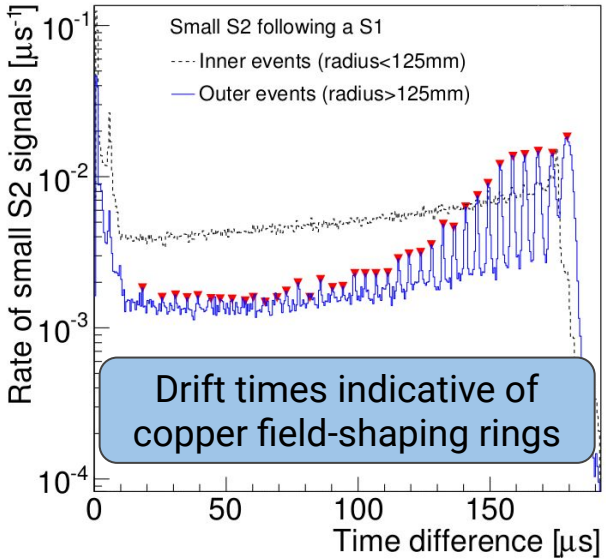
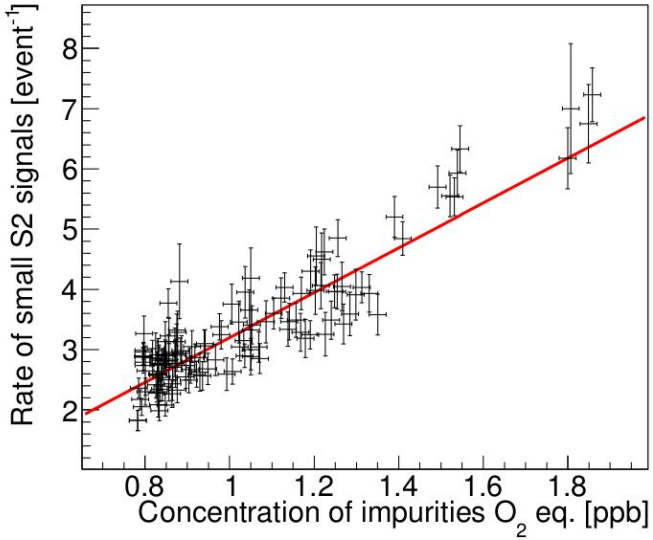
Signals will be limited to within a maximum drift-time of initial excitation





XENON100, 1311.1088

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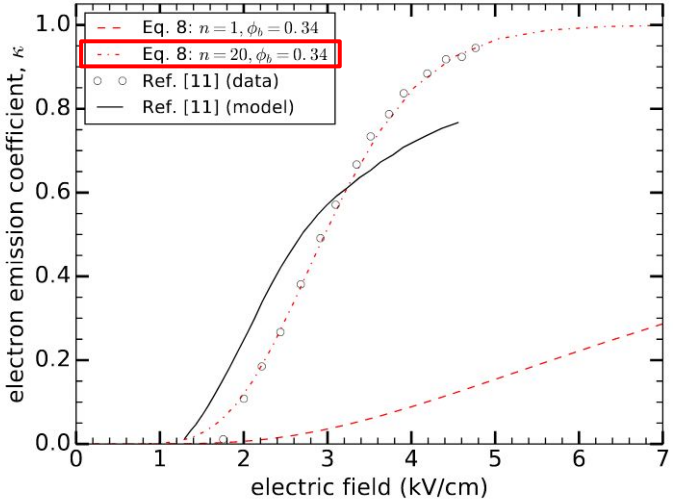
Electron extraction could be stimulated with an external energy source to quench extraction time

Model potential barrier at liquid gas interface due to mirror charges

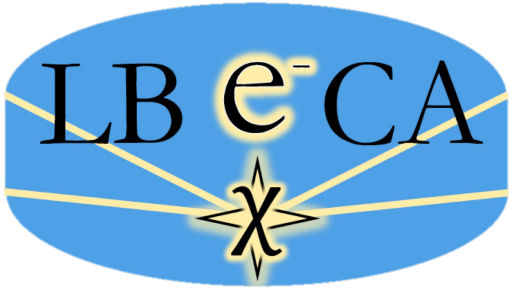
0.34 eV potential



Sorensen, 1702.04805

LBECA: Low Background Electron Counting Apparatus

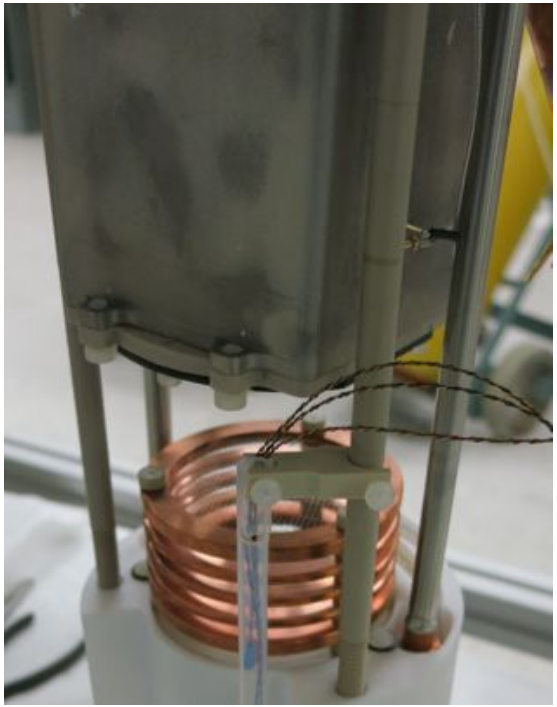
1. Investigate these hypotheses using several R&D testbeds and XENON1T+LUX data
2. Develop technology in parallel to mitigate backgrounds
3. Make accurate calculations and modeling of expected low-energy signals
4. Build a dedicated xenon TPC incorporating the new technology for low-mass dark matter search

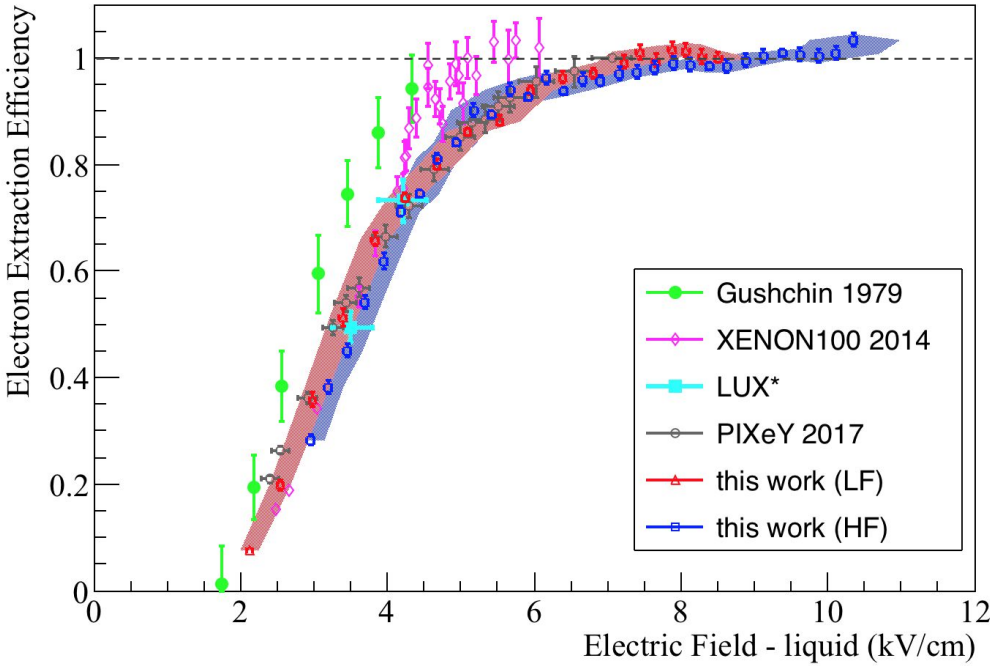


<u>Collaboration</u>
LBNL: P. Sorenson
LLNL: A. Bernstein, J. Xu, S. Pereverzev
Purdue: R. Lang, M. Clark, A. Kopec
Stony Brook: R. Essig, M. Fernandez-Serraj, C. Zhen
UCSD: K. Ni, J. Long, J. Ye

LLNL - XeNu

High electric field to improve electron extraction efficiency

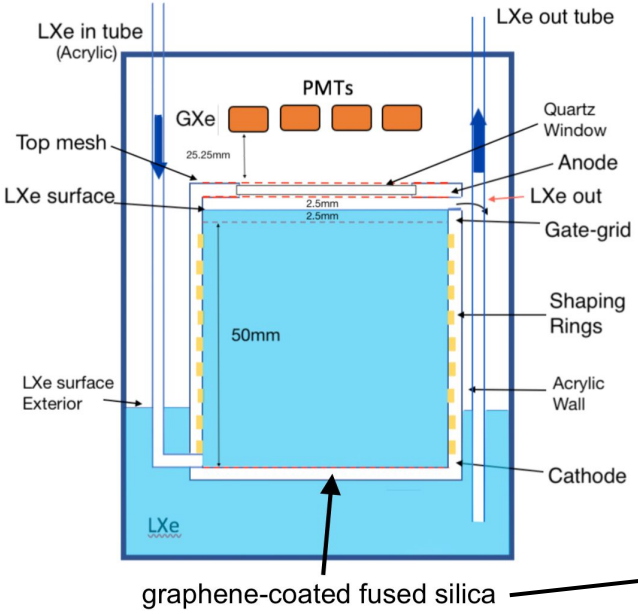


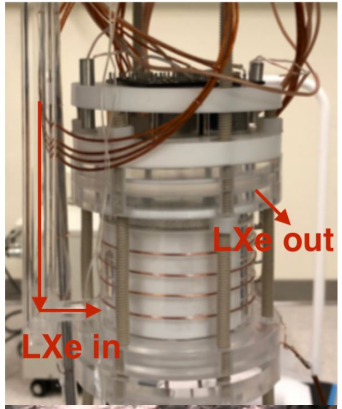


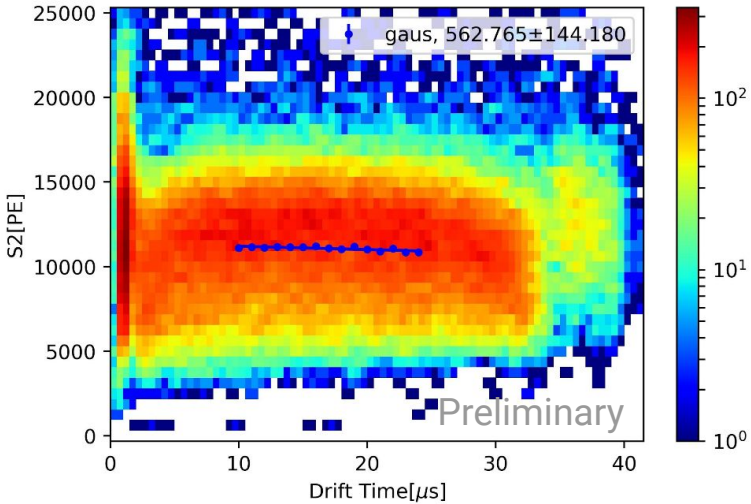
Xu et al. 1904.02885

USCD - SanDiX Sealed TPC

Reduction in metal surfaces and plastics to reduce photo-ionization and impurities in the liquid xenon





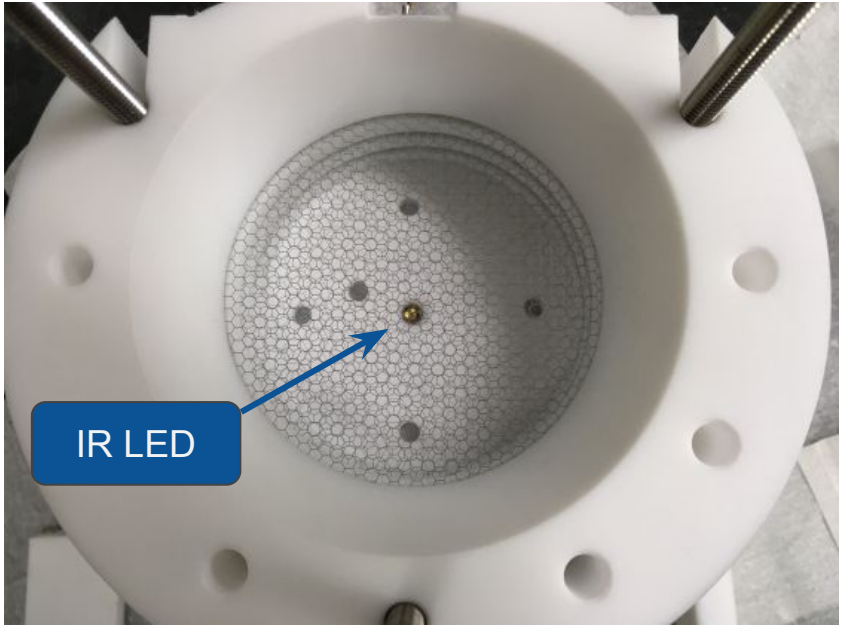


Measured electron lifetime of >500us after 1 day of circulation

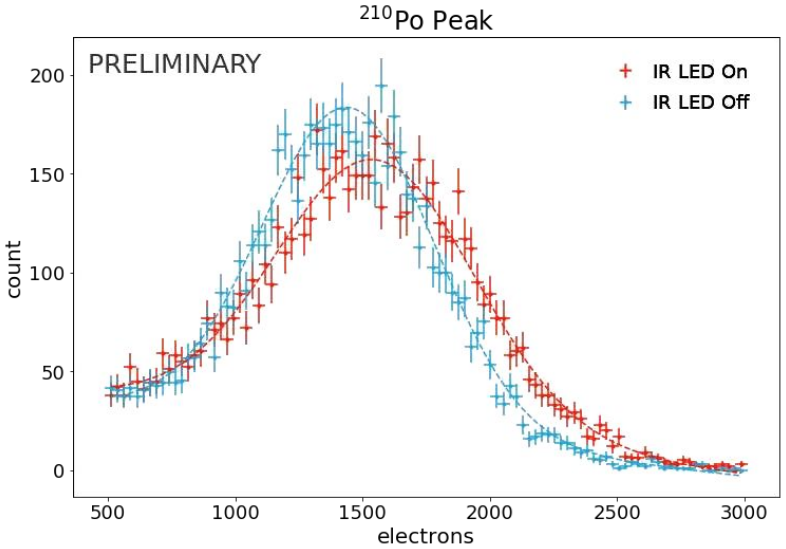
Purdue - ASTERiX

Quenching time-scales of trapped electrons using infrared light

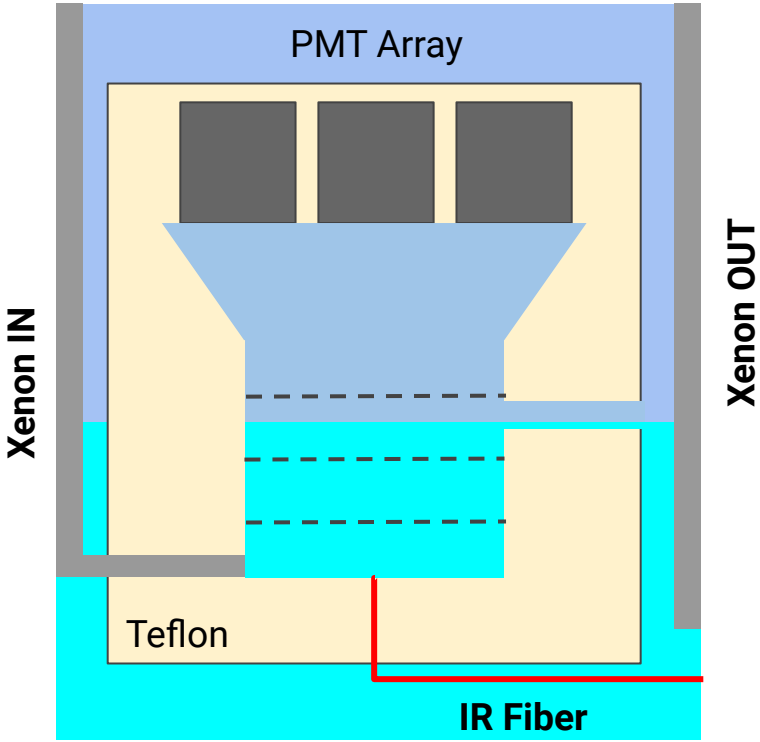
Top View



IR light increases signal of alpha events, but the current effect is small



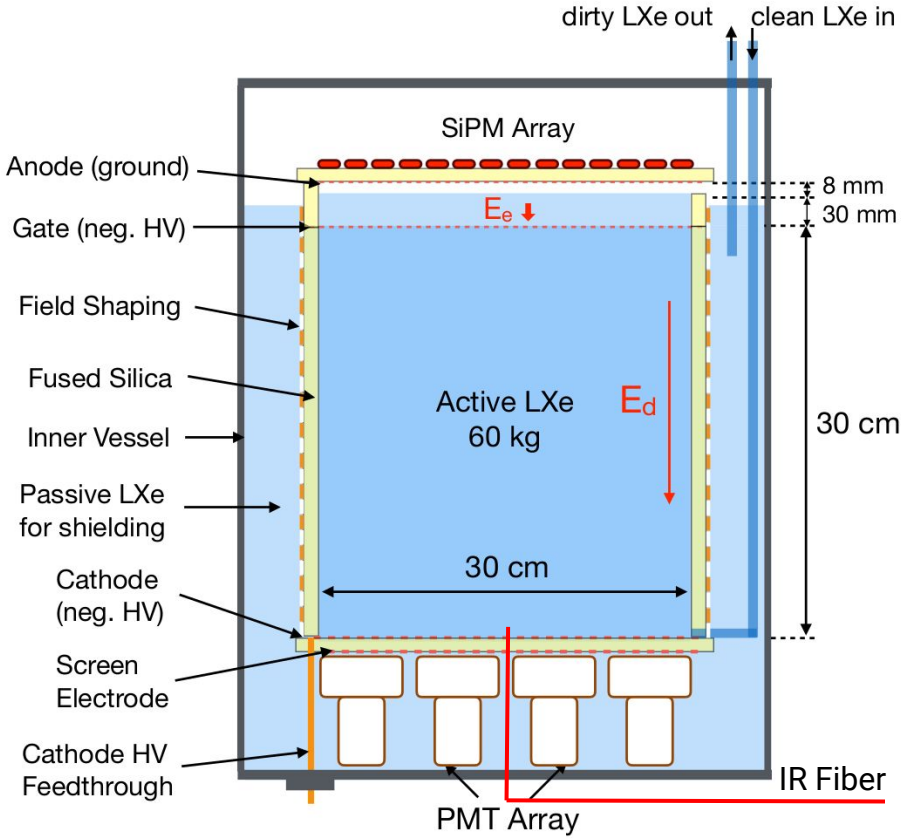
Purdue - ASTERiX



Planned Upgrades to ASTERiX:

- Increase IR Flux by using external laser coupled to optical fibers
- Improve xenon circulation to control impurities faster and increase stability

LBECA Preliminary Design



Integrates cleanliness, extraction field, and electron quenching from R&D detectors

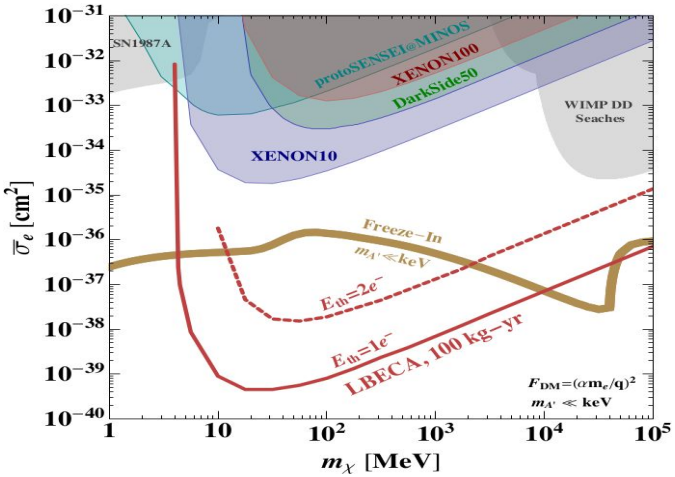
Proposed SiPM array to increase xy-position resolution, and reduce nearby radioactive material

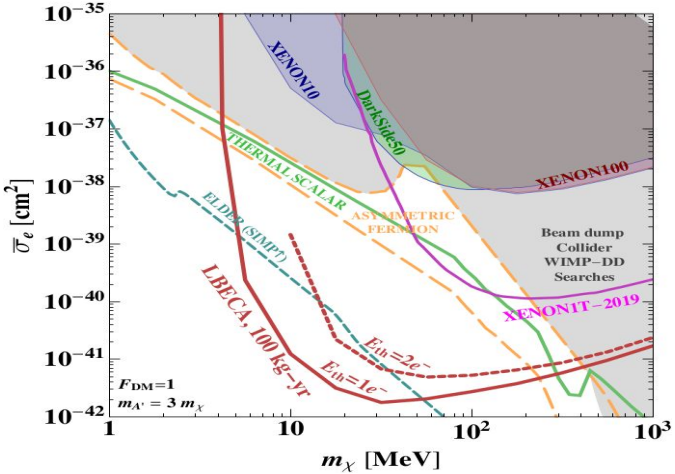
To be operated as a low-background detector for low-mass WIMPs

Outlook and Conclusions

- LBECA will be able to set limits on new parameter space for low-mass dark matter interactions
- Strong R&D program being performed in parallel at dedicated setups
  - Improved extraction efficiency
  - Improved cleanliness
  - Infrared light to quench time-scales
  - Accurate modeling of electron signals
- Design proposal for final LBECA detector submitted and under review

For more information, see A.Kopec at poster session tonight





See also: Essig, Sholapurkar, Yu 1801.10159