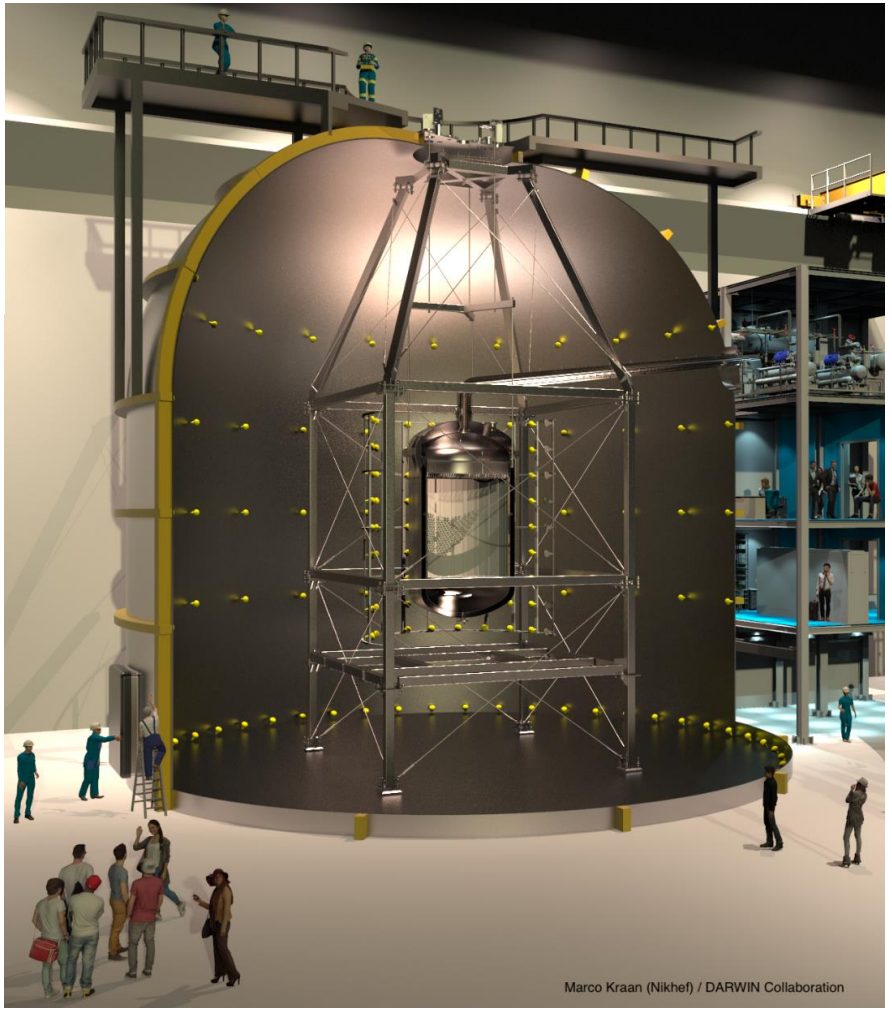
Recent developments around DARWIN

Klaus Eitel
Karlsruhe Institute of Technology
klaus.eitel@kit.edu
www.iap.kit.edu/dm
in cooperation with

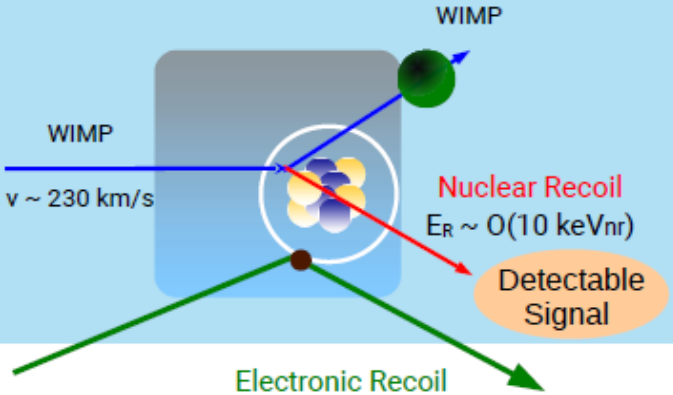
Julien Masbou

Luca Scotto Lavina

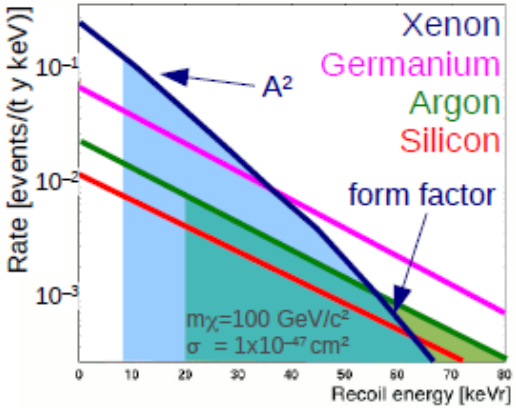


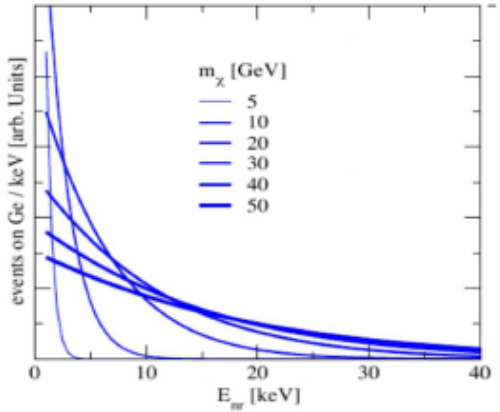
WIMP scattering principles

Elastic Scattering of
WIMPs off target nuclei
➞ nuclear recoil



Recoil Spectra:





WIMP landscape (SI scattering)

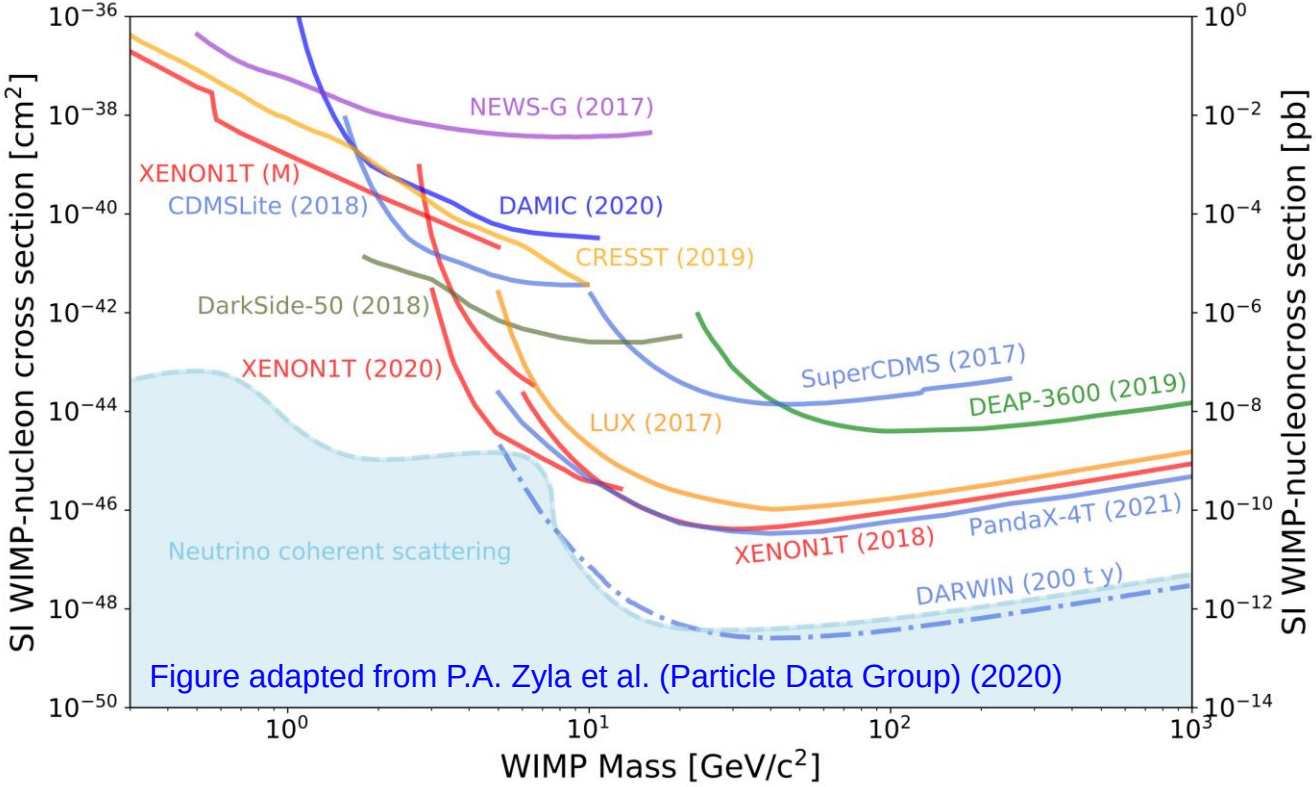
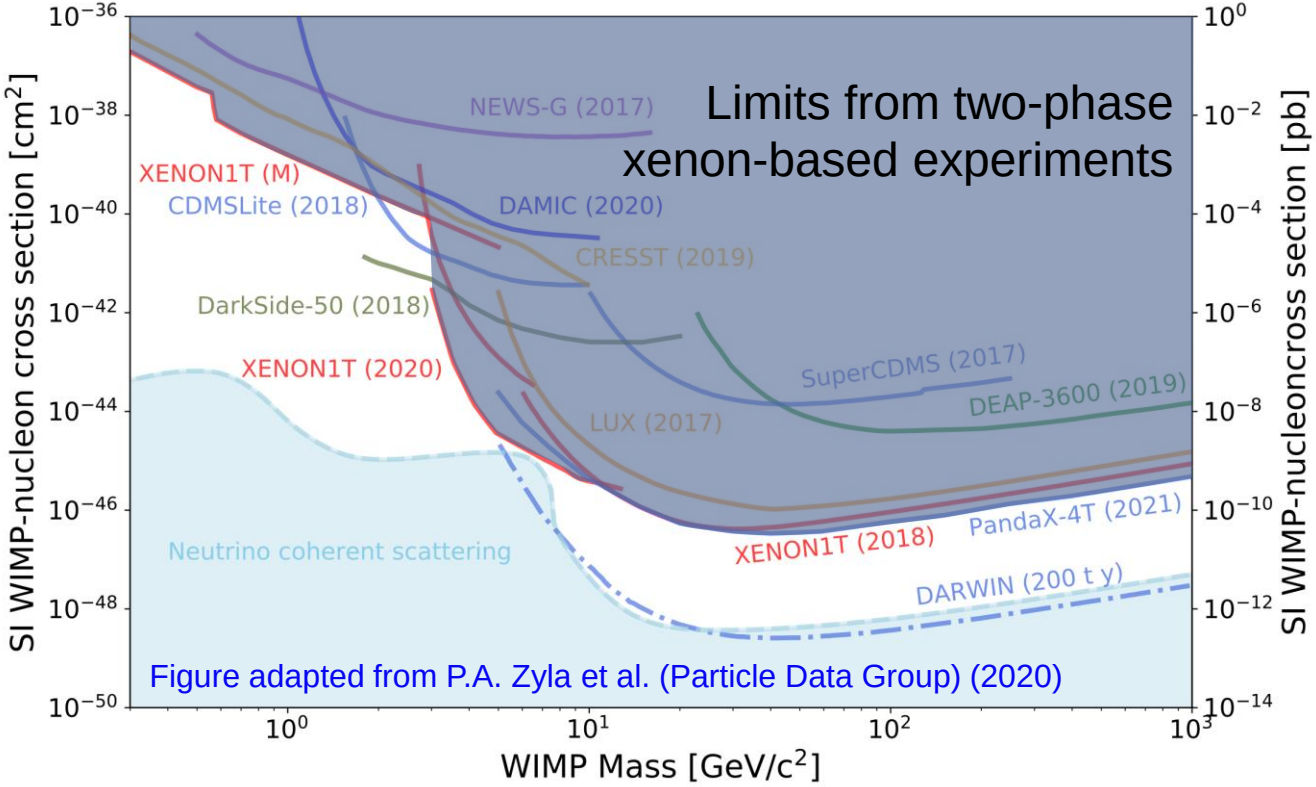


Figure adapted from P.A. Zyla et al. (Particle Data Group) (2020)

WIMP landscape (SI scattering)



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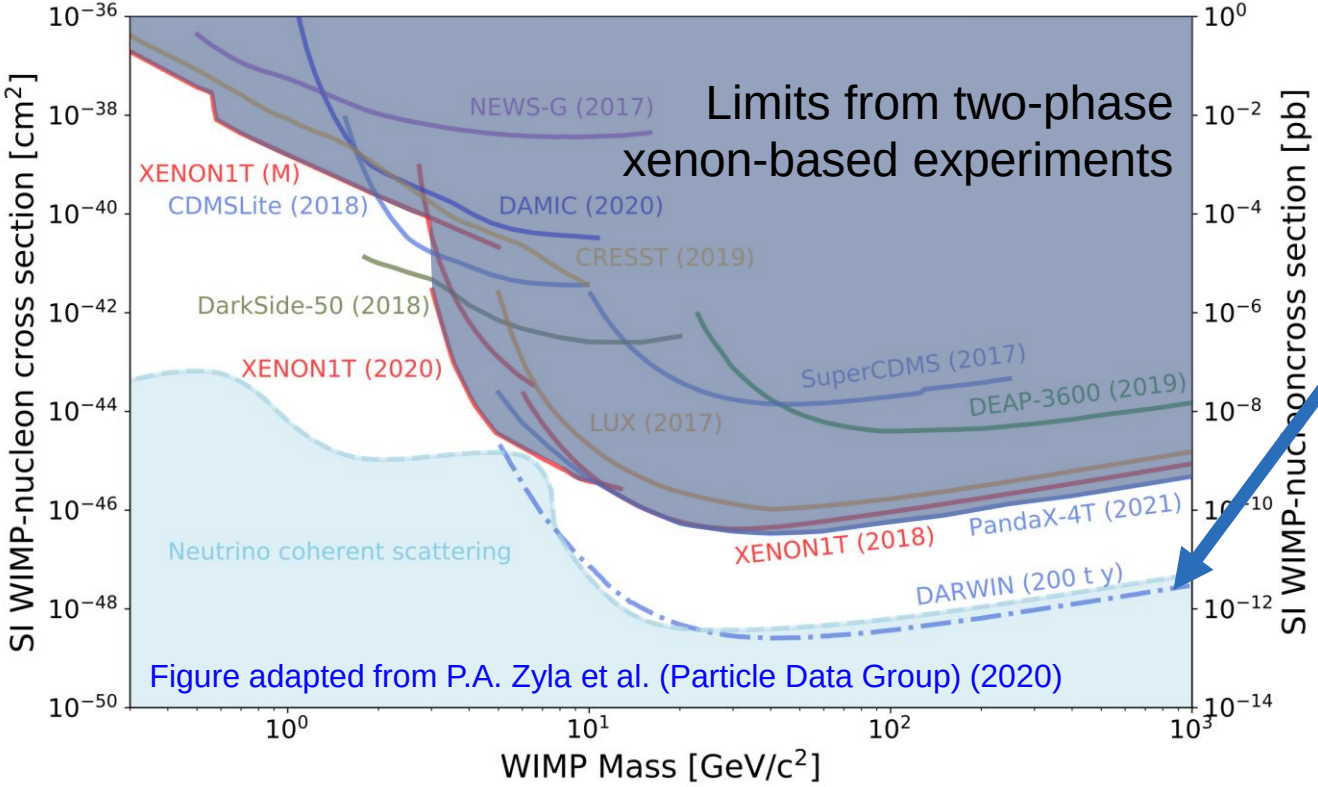

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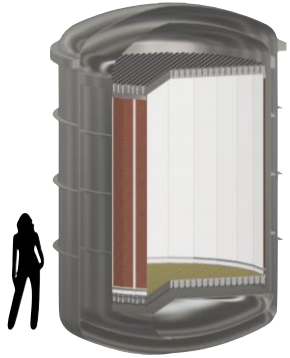
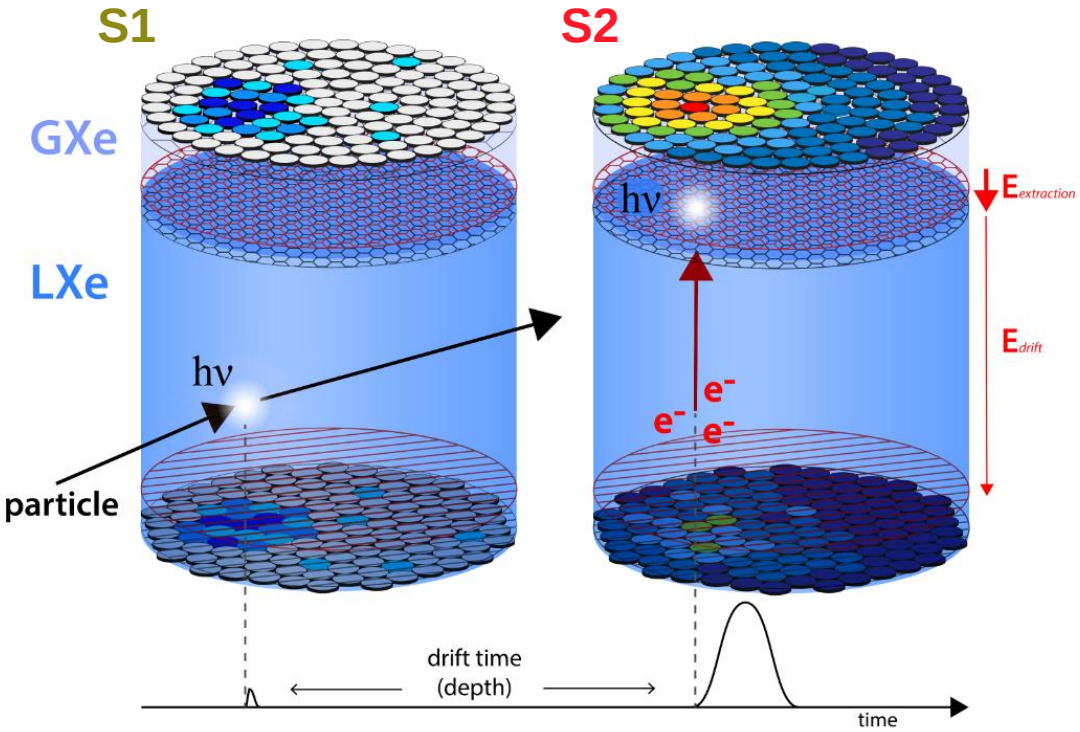
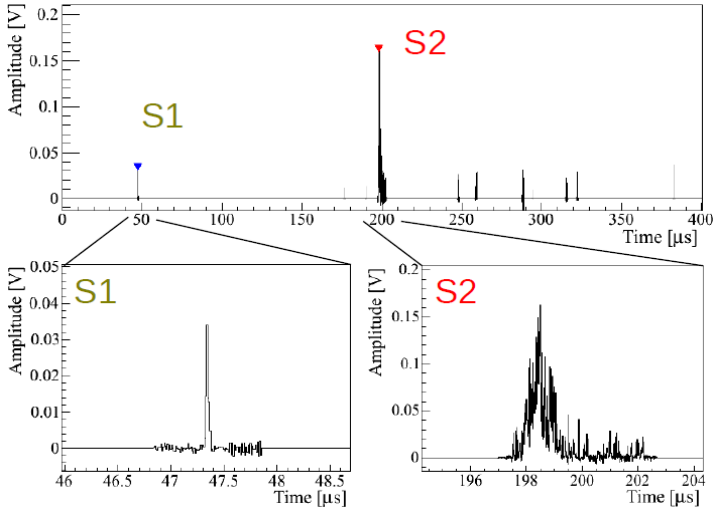
DARWIN -
the next generation



The dual-phase Xe TPC





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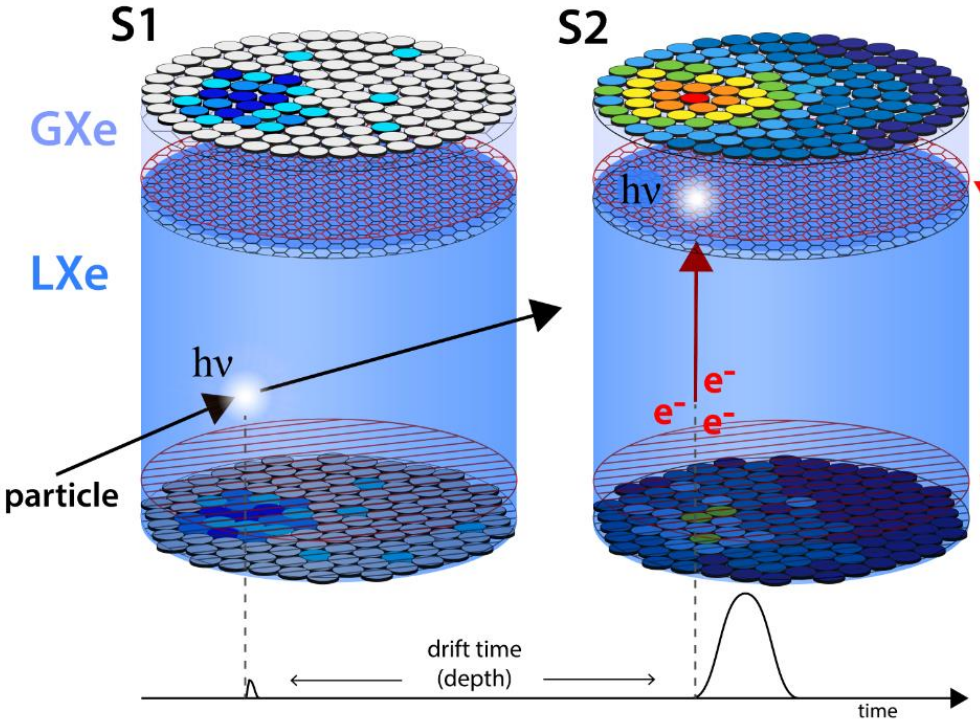
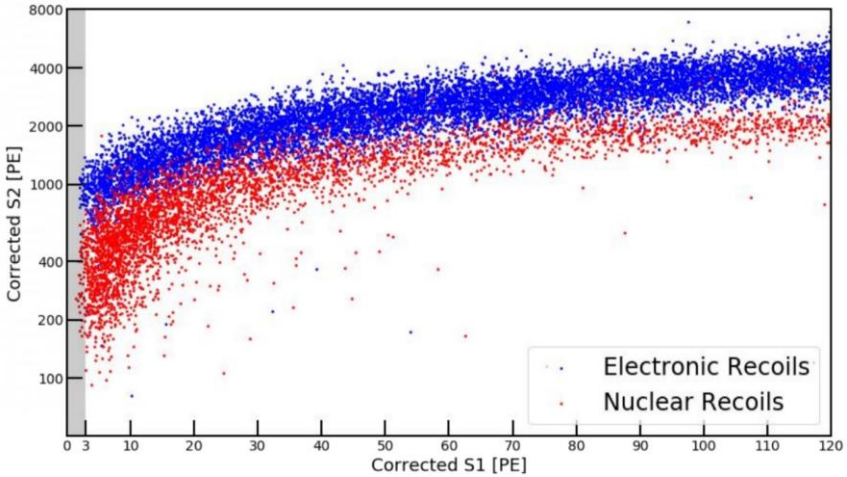


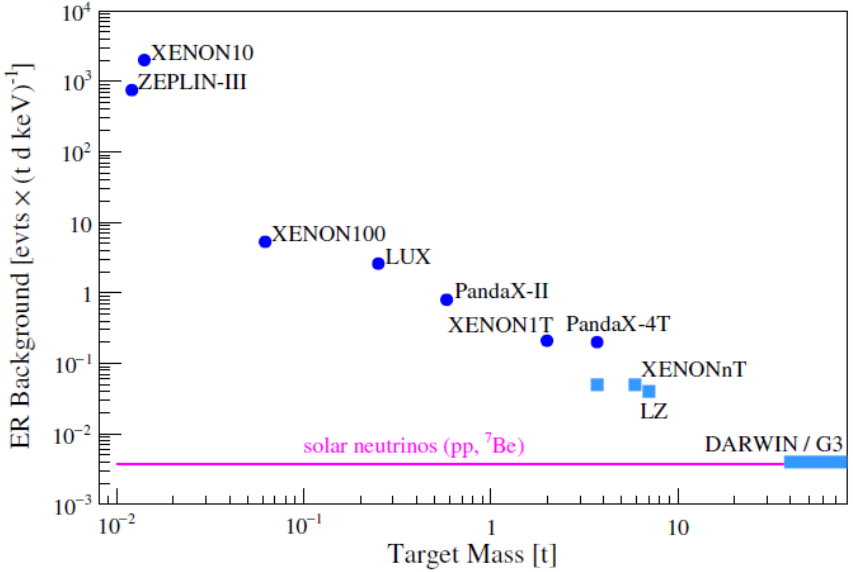
Combination of **S1** and **S2** allows for:

- 3D Position reconstruction
- Energy reconstruction
- **ER**/**NR** discrimination

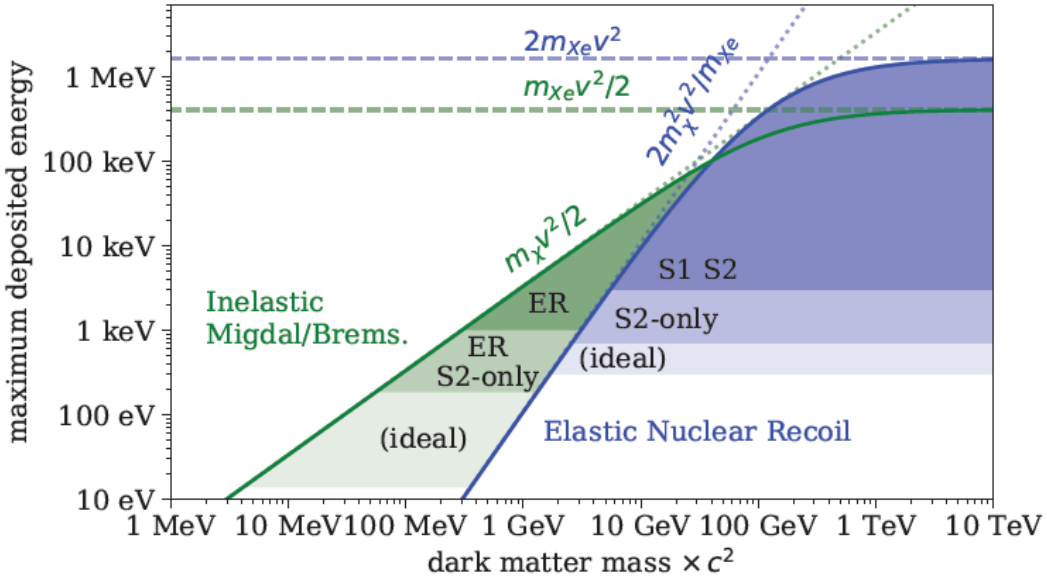


Towards higher sensitivity

Larger target mass
& lower background

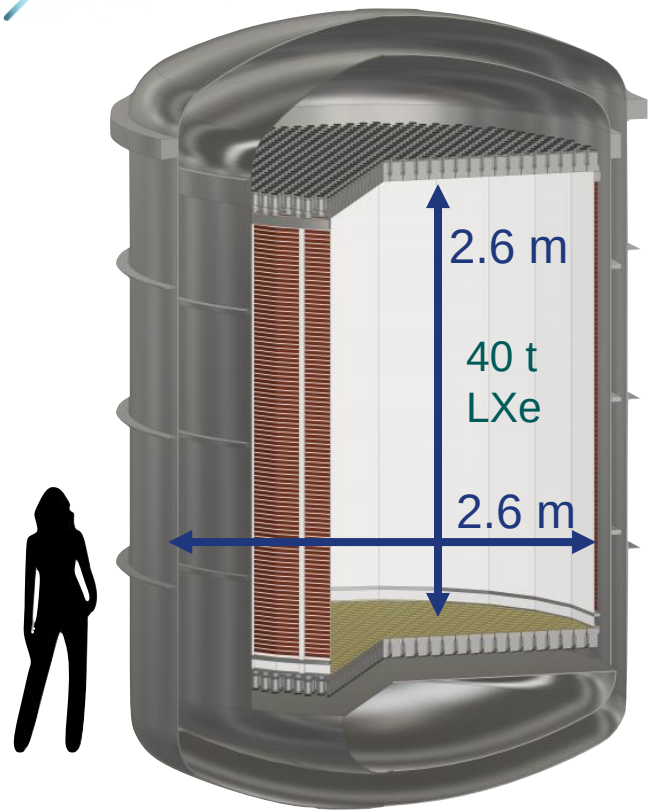


Interaction kinematics
→ lowering the threshold



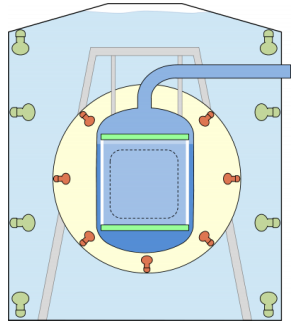
Community Whitepaper: arXiv:2203.02309 (2022)

The DARWIN baseline design



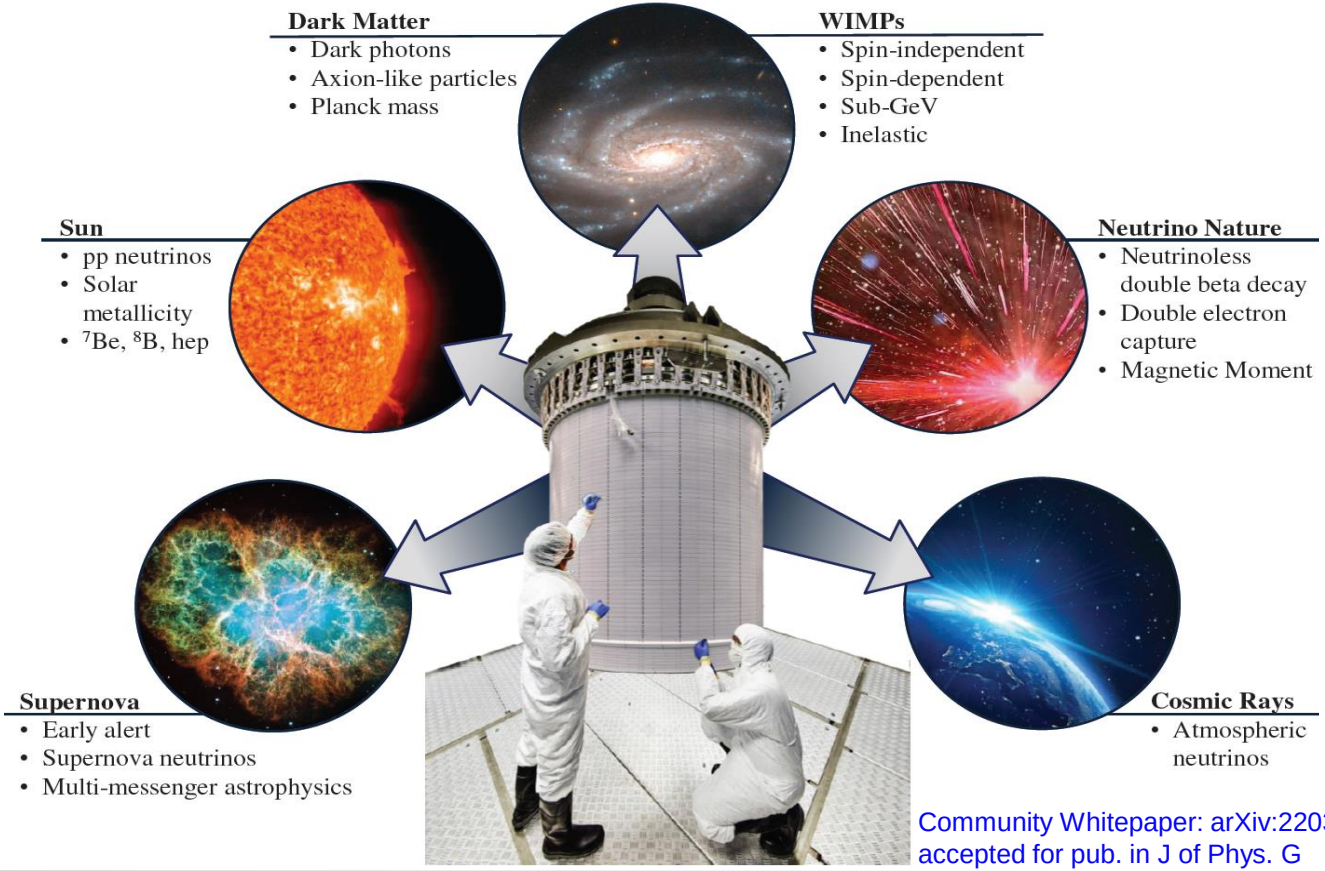
DARk matter **WI**mp search with liquid xeno**N**

- Two-phase LXe/GXe TPC; aspect ratio 1 (Ø=h)
- 50 t total LXe (40 t active target)
- Top and bottom photosensors (~1800 3” XENON PMTs)
- PTFE reflectors and Cu field-shaping rings
- In-situ purification plus krypton and radon distillation (background mitigation)
- Veto detectors: water Cerenkov for muons with Gd doping for neutrons



DARWIN Collaboration, JCAP 1611 (2016) 017

Science channels for DARWIN



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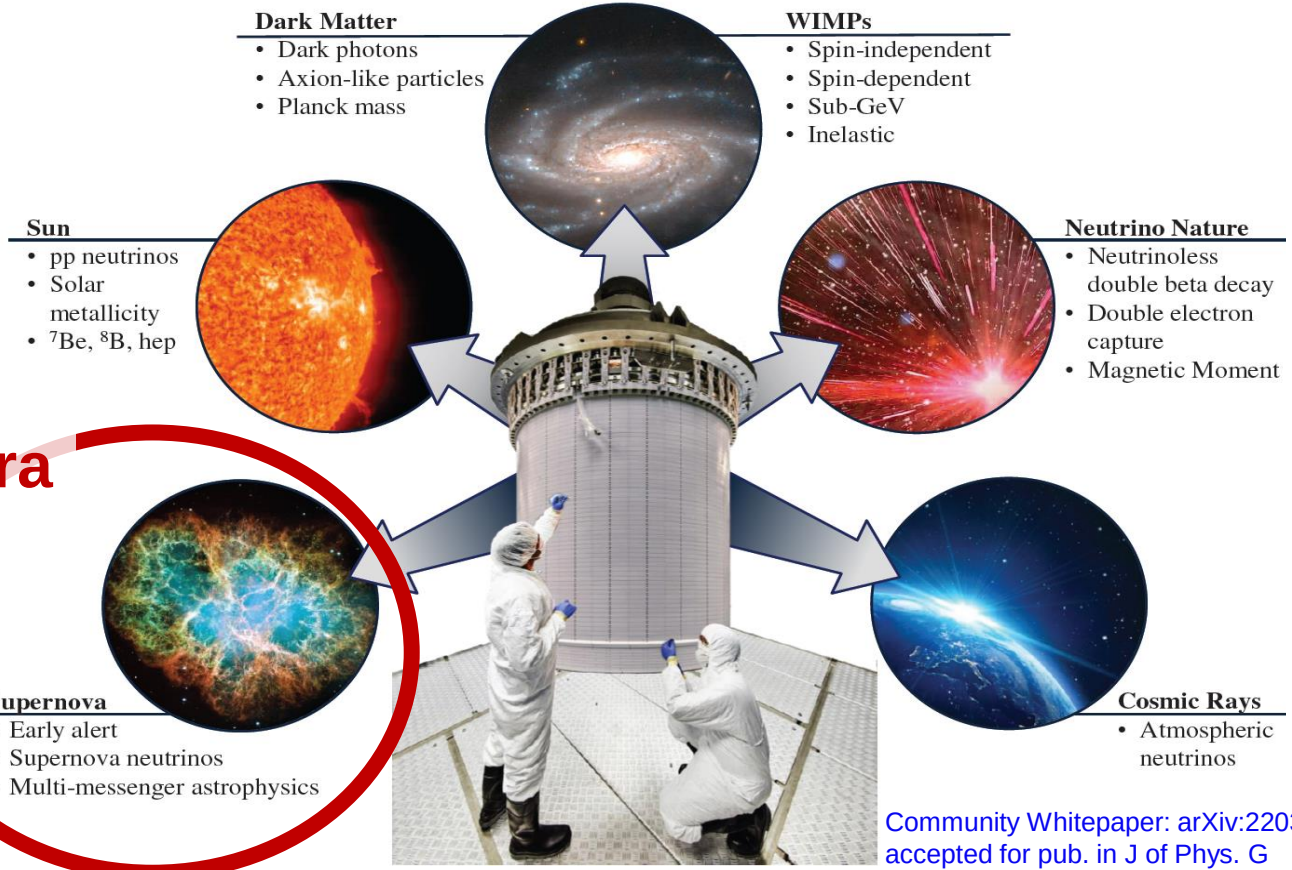

Melih Kara

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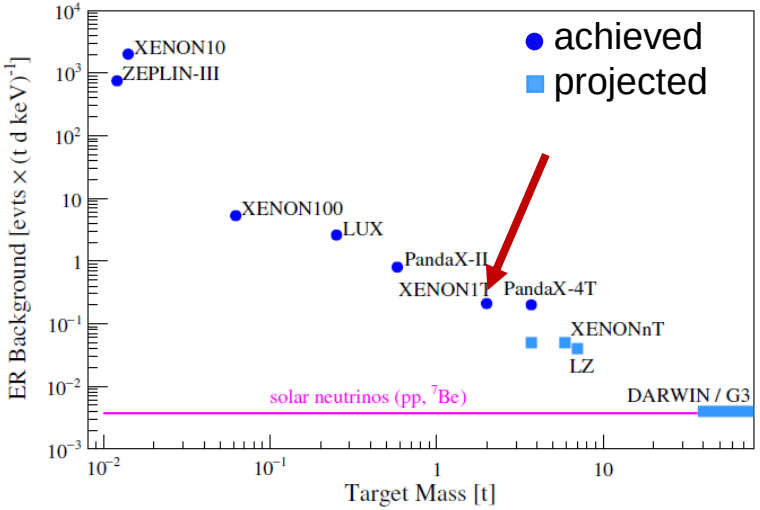
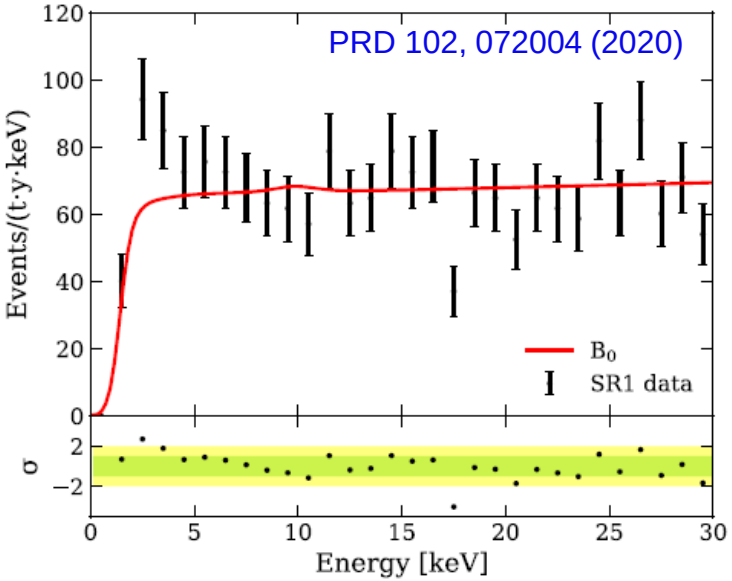
Recent Developments (I)

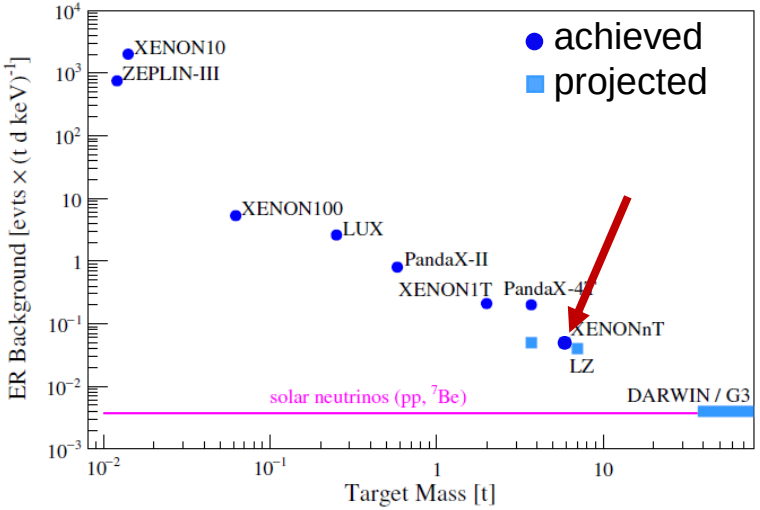


Low ER excess in XENON1T

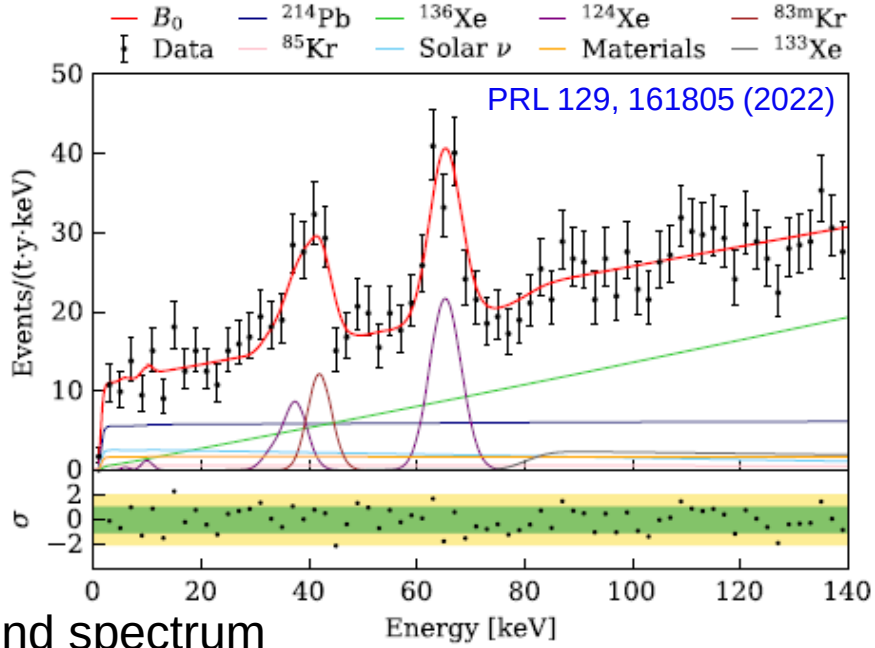


- solar axions?
- bosonic DM?
- neutrino magnetic moment?
- tritium?

Recent Developments (I)

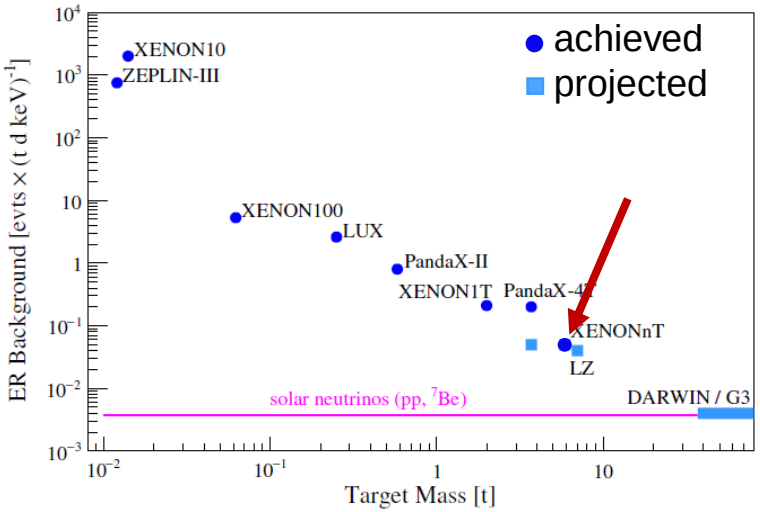


Low ER in XENONnT



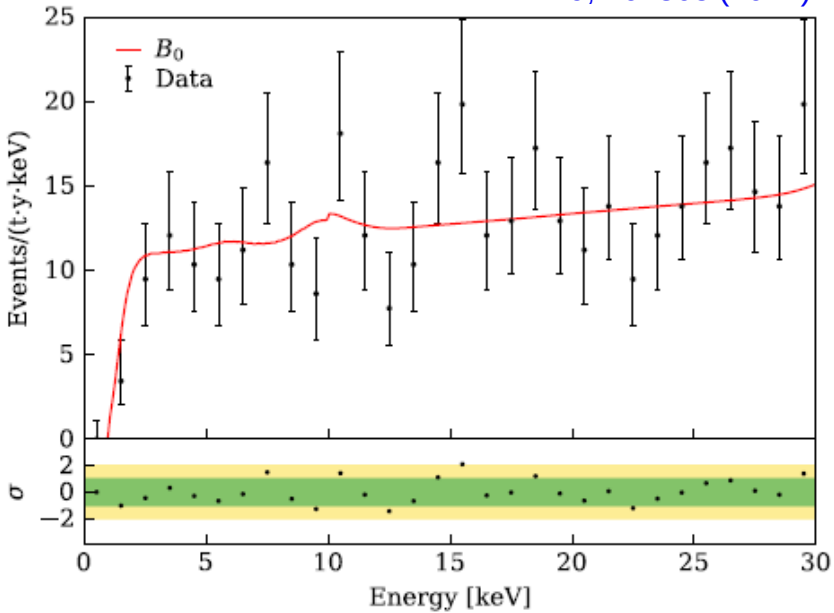
For the first time, shape of low-E background spectrum dominated by **second order weak decays** (2νββ of ^{136}Xe, 2νECEC of ^{124}Xe)

Recent Developments (I)



Low ER in XENONnT

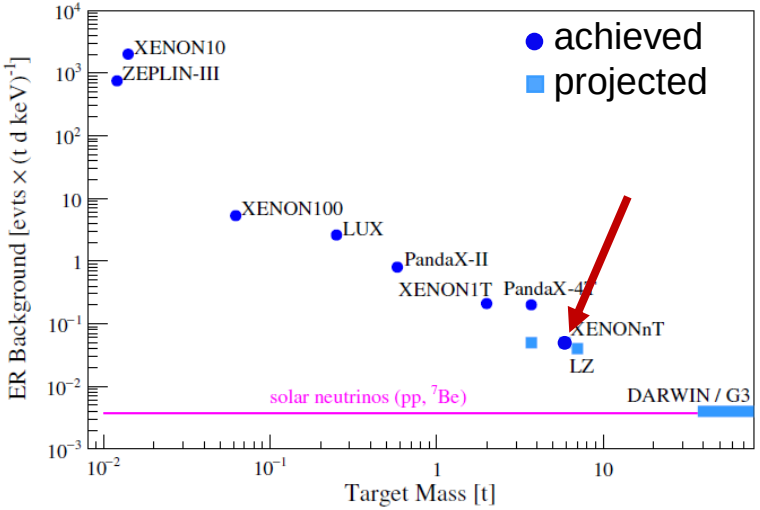
PRL 129, 161805 (2022)



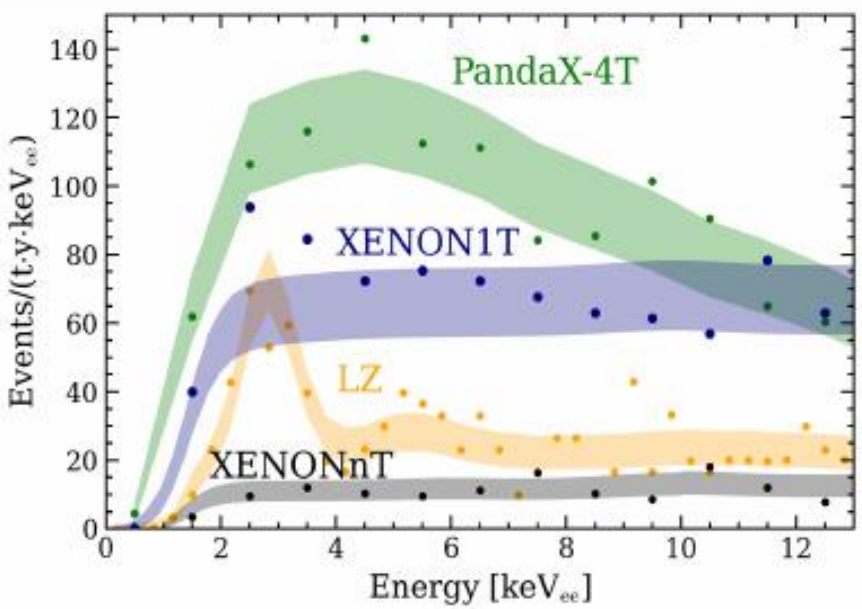
No excess above background observed

→ XENON1T excess not from new physics

Recent Developments (I)



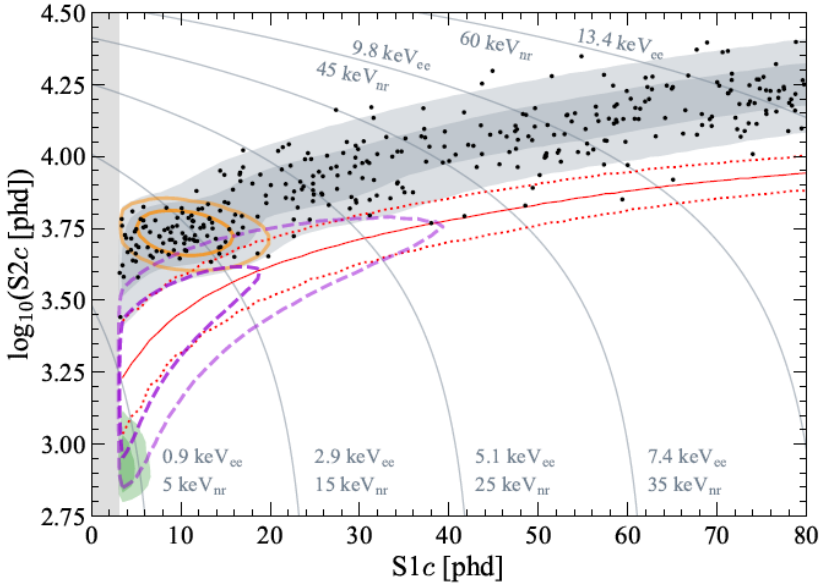
Low ER in XENONnT



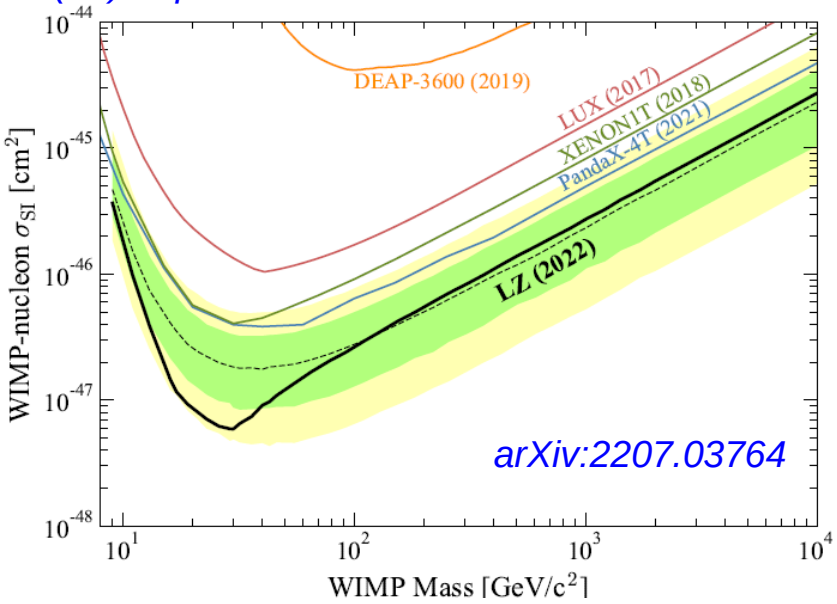
world-record **low ER background** level: (15.8+-1.3) evts/(t×yr×keV)

Recent Developments (II)

First Dark Matter Search Results from the LUX-ZEPLIN (LZ) Experiment



1σ/2σ contours of
best fit ER background model
^{37}Ar background component
30 GeV/c^2 WIMP model
^{8}B solar neutrinos
NR band (10%/90% quantiles)



Non-Blind analysis
of 0.90 t×y data
→ fiducial volume of 5.5t
→ very large downward fluctuation of background

Recent Developments (III)

Same technology – Different detectors

apart from different TPC design choices…
different cryostats, LXe/neutron vetoes,
LXe purification, Kr and Rn removal,
calibration methods, DAQ paradigms, etc etc

XENON LZ DARWIN → XLZD

- Memorandum of Understanding signed July 6, 2021 by 106 research group leaders from 16 countries
- Intnl consortium w/ complementary areas of expertise
- 1st joint meeting April 26-27, 2021 online
- 2nd meeting June 27-29, 2022 at KIT

Recent Developments (IV)

A Next-Generation Liquid Xenon Observatory for Dark Matter and Neutrino Physics

J. Aalbers,[1,2] K. Abe,[3,4] V. Aerne,[5] F. Agostini,[6] S. Ahmed Maouloud,[7] D.S. Akerib,[1,2] D.Yu. Akimov,[
A.K. Al Musalhi,[10] F. Alder,[11] S.K. Alsum,[12] L. Althueser,[13] C.S. Amarasinghe,[14] F.D. Amaro,[15] A.
T.J. Anderson,[1,2] B. Andrieu,[7] N. Angelides,[16] E. Angelino,[17] J. Angevaare,[18] V.C. Antochi,[19] D. Ant

[39] SUBATECH, IMT Atlantique, Université de Nantes, CNRS/IN2P3, Nantes 44307, France
[40] Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
[41] Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany
[42] Vatican Observatory, Castel Gandolfo, V-00120, Vatican City State

The nature of dark matter and properties of neutrinos are among the most pressing issues in contemporary particle physics. The dual-phase xenon time-projection chamber is the leading technology to cover the available parameter space for Weakly Interacting Massive Particles (WIMPs), while featuring extensive sensitivity to many alternative dark matter candidates. These detectors can also study neutrinos through neutrinoless double-beta decay and through a variety of astrophysical sources. A next-generation xenon-based detector will therefore be a true multi-purpose observatory to significantly advance particle physics, nuclear physics, astrophysics, solar physics, and cosmology. This review article presents the science cases for such a detector.

>600 authors from XLZD + theory

>100 institutions

Community Whitepaper:
arXiv:2203.02309
accepted for pub. in J Phys. G

1] S. Ritz et al., *Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context*, https://science.energy.gov/~/media/hep/hepap/pdf/May-2014/FINAL_P5_Report_Interactive_060214.pdf (2014).
C. Zeitnitz, *Particle Physics Strategy in Germany*, https://indico.desy.de/indico/event/20166/contribution/6/material/slides/0.pdf (2018).

[1258] N. Tyurin, *PARTICLE PHYSICS IN RUSSIA* (2012).
[1259] T. Nakada et al., *The European Strategy for Particle Physics Update 2013* (2013).
[1260] C. Bai et al., *Neutrinoless Double Beta Decay: A Study of Strategic Development by Chinese Academy of Sciences, in Chinese* (2020).
[1261] P. J. W. Faulkner et al. (GridPP), J. Phys. G **32**, N1 (2006).
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D. Supernova Neutrinos (NR)
1. Galactic Supernova Neutrinos
2. Pre-Supernova Neutrinos
3. Supernova Early Warning System
4. Diffuse Supernova Neutrinos

→ Melih Kara

The natu... contem-
porary pa... chnology
to cover ... s), while
featuring ... tors can
also stud...
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to significantly advance particle physics, nuclear physics, astrophysics, solar physics, and cosmology.
This review article presents the science cases for such a detector.

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