

# Planning the future DARWIN/XLZD observatory - WIMP sensitivity goals and detector R&D

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TAUP 2023 (August 28 - September 1)

Vienna, Austria

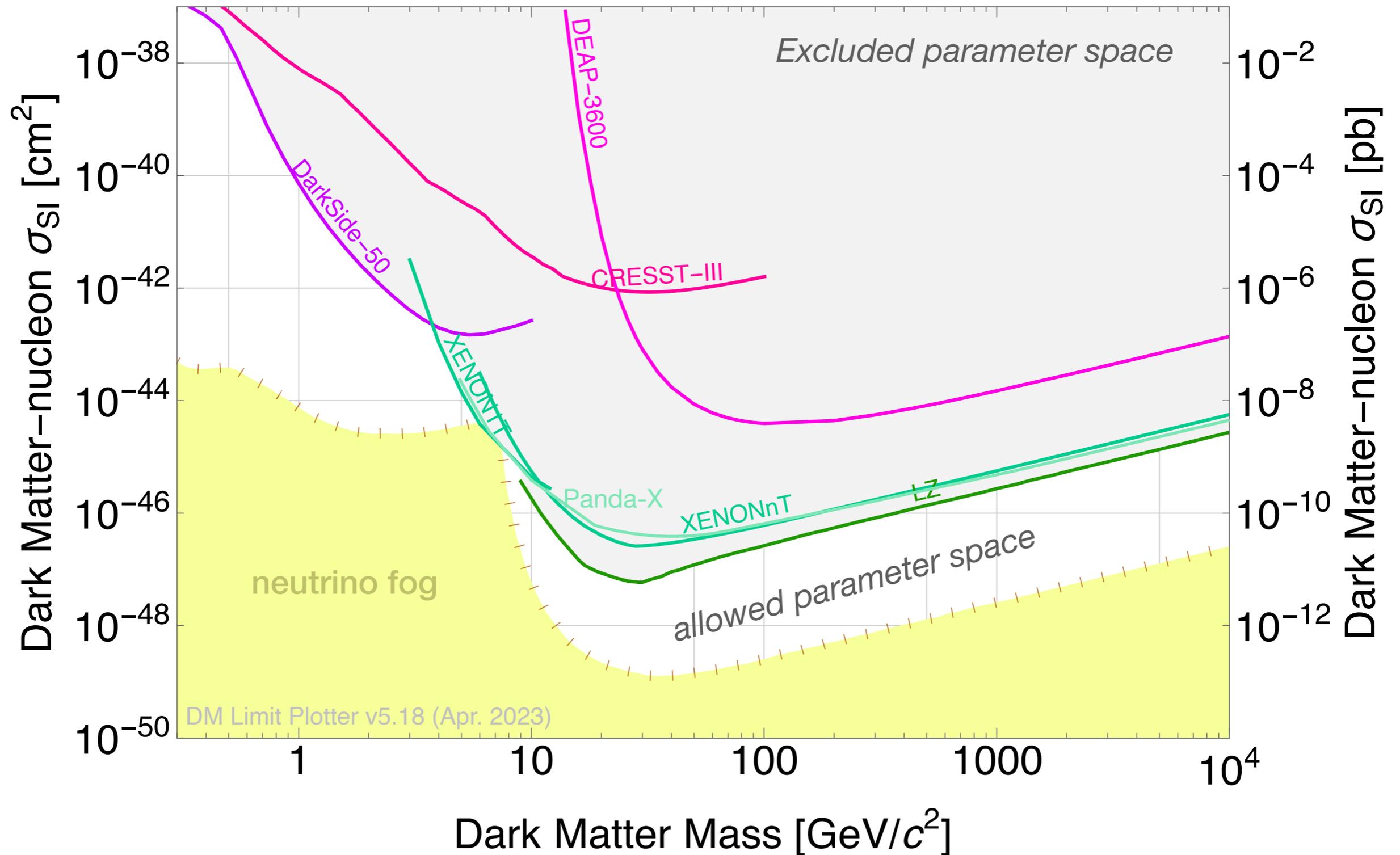
Tina Pollmann for the DARWIN collaboration and the XLZD consortium



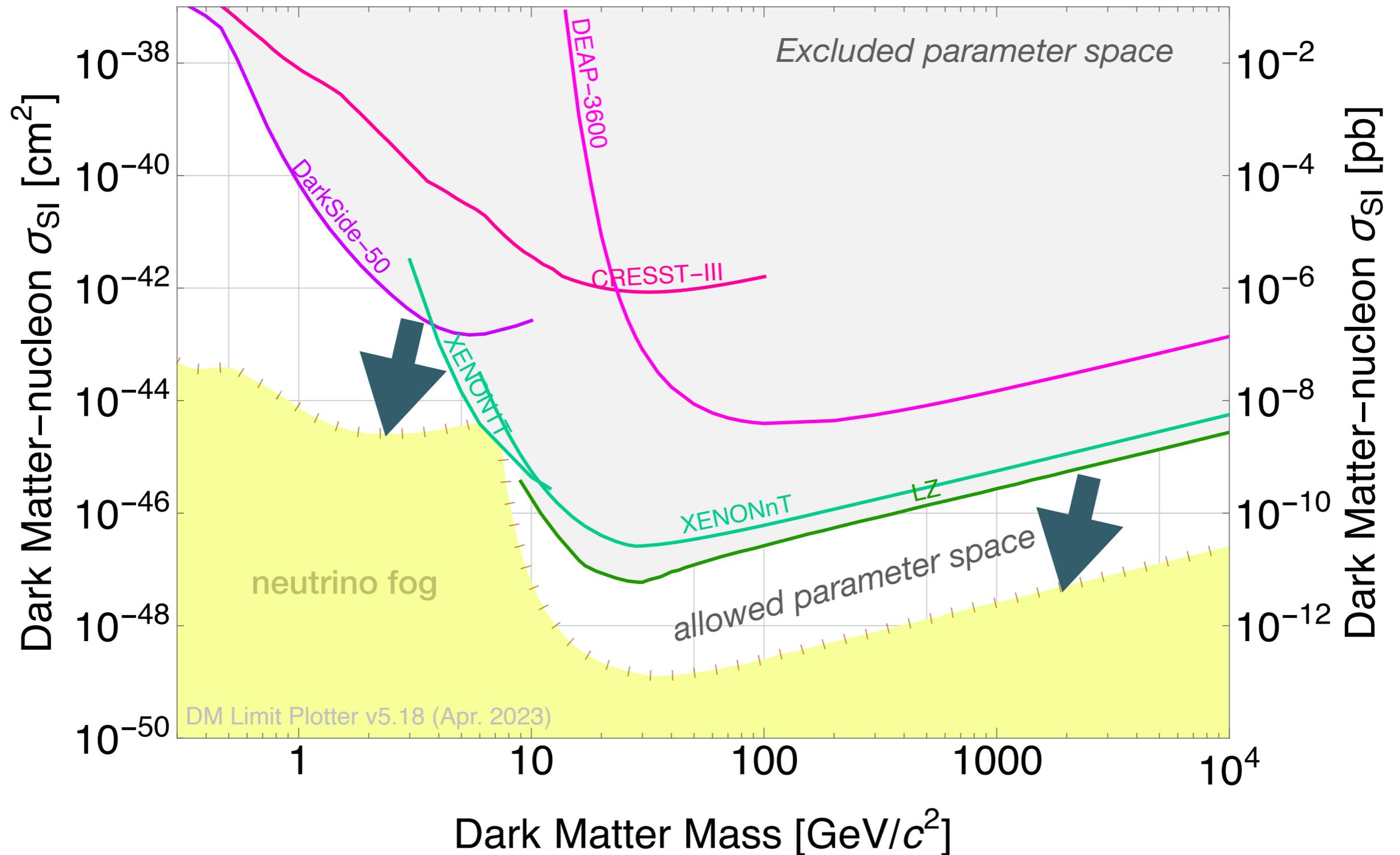
DARWIN



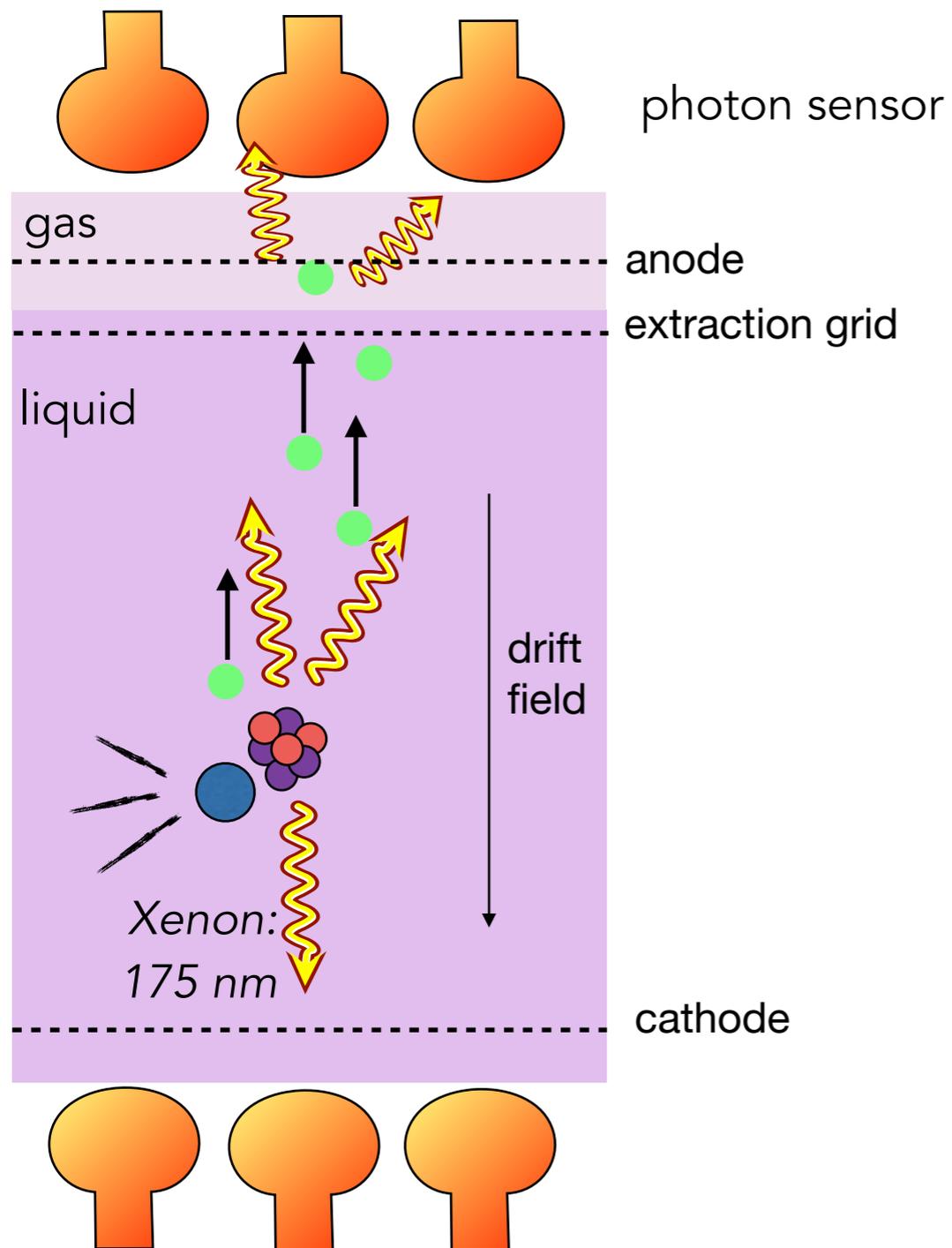
Direct detection of WIMP dark matter is led by noble liquid detectors.



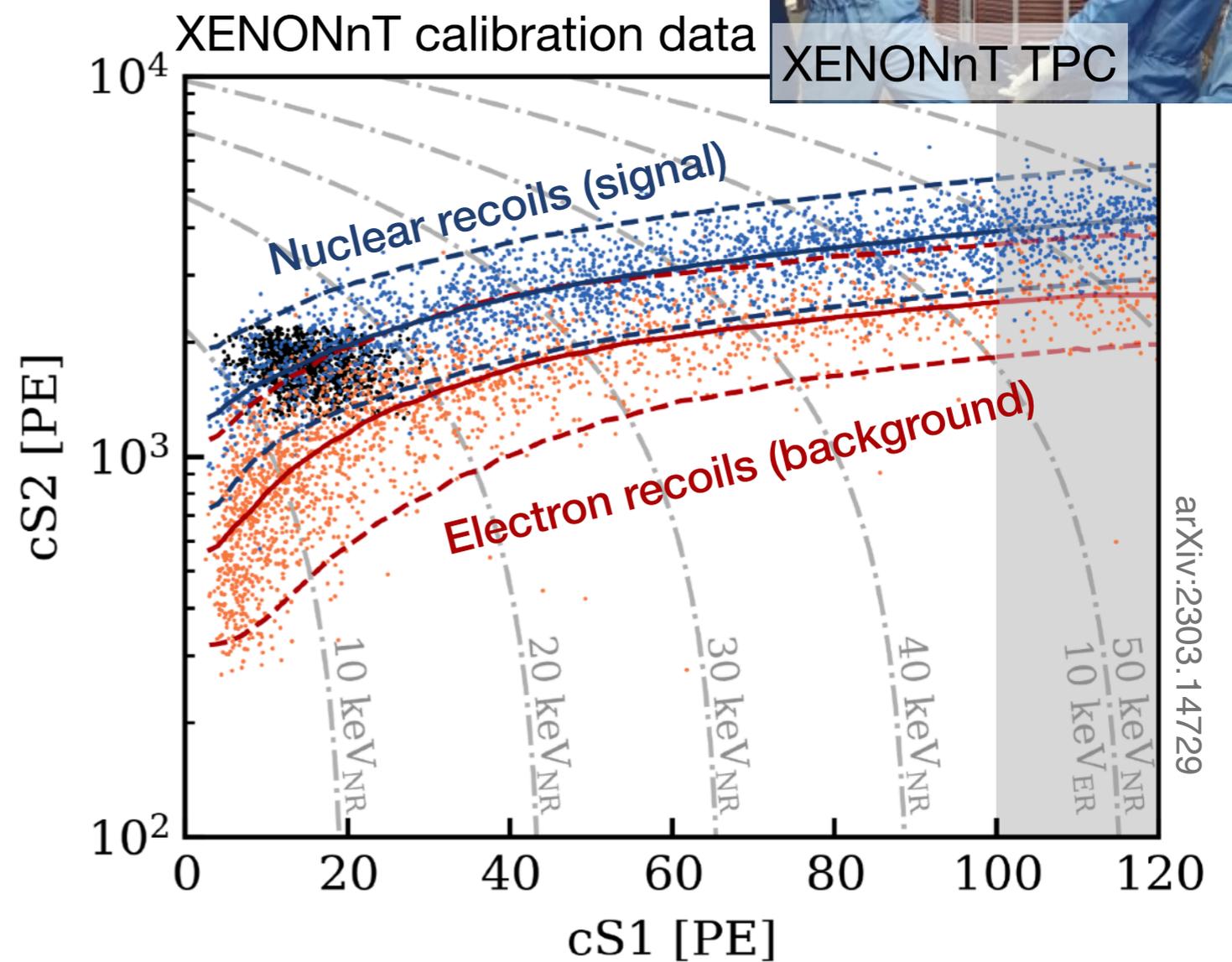
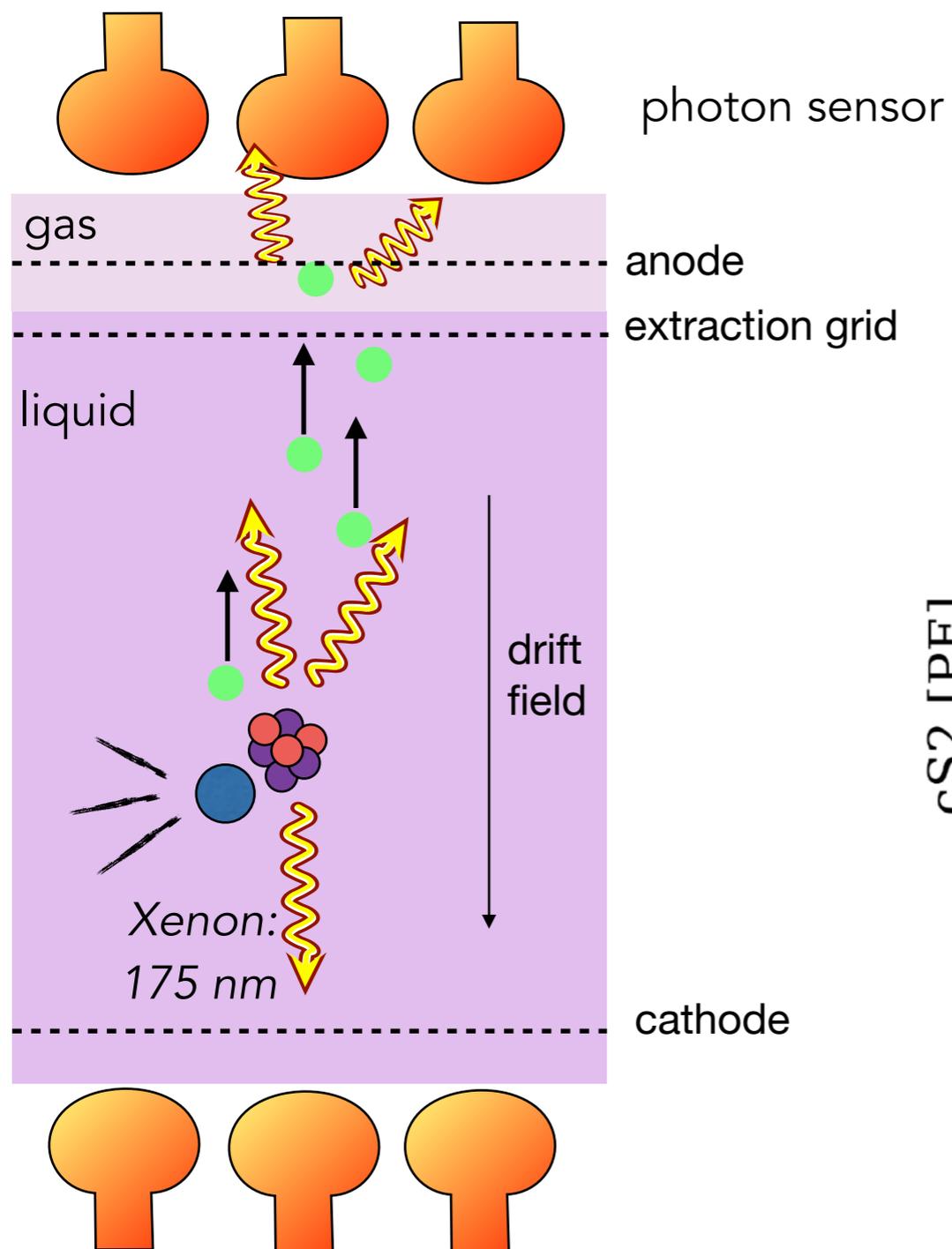
We want to extend the sensitivity of the detectors into the neutrino fog.



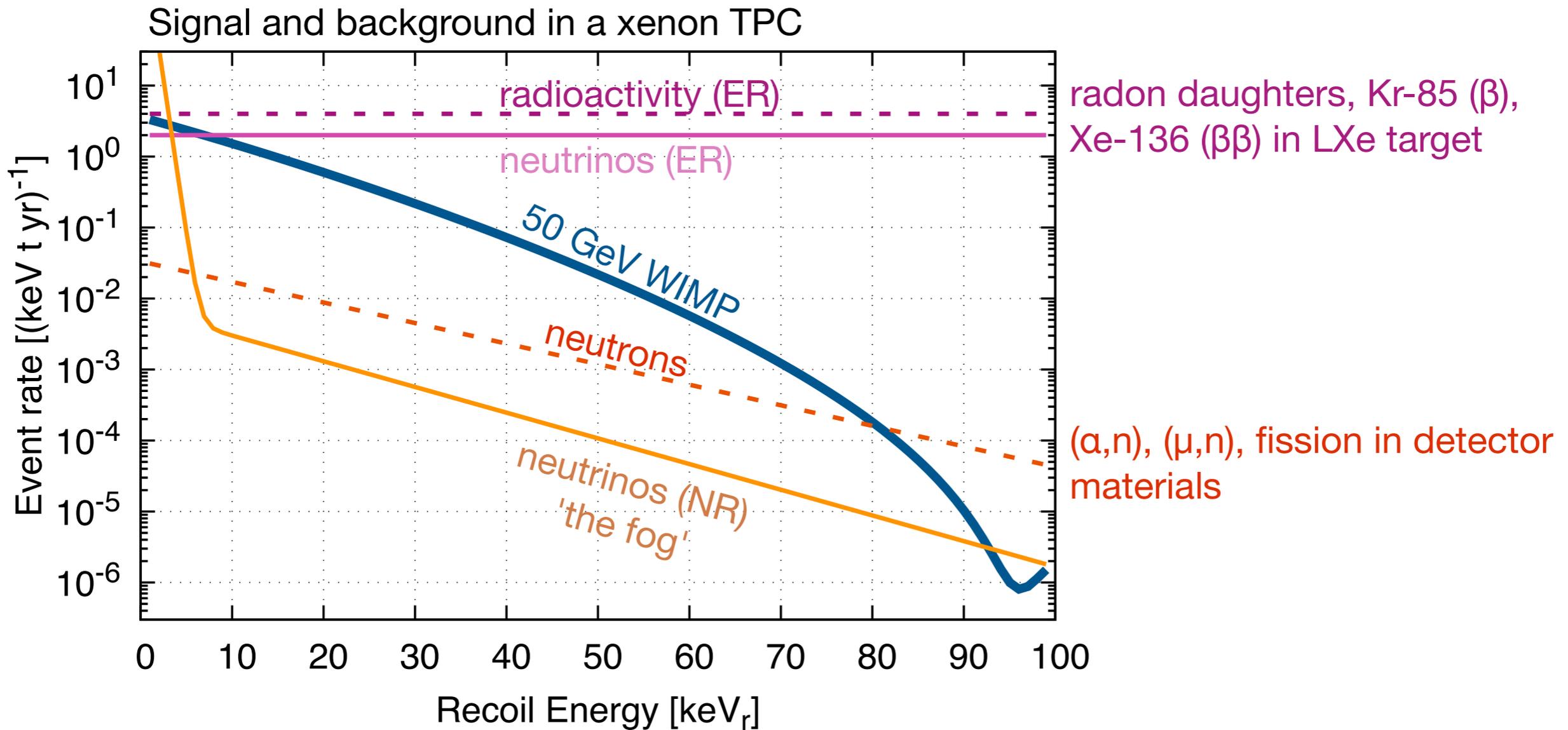
Particles interacting in a noble liquid Time Projection Chamber (TPC) create scintillation photons (S1) and ionisation electrons (S2).



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To increase sensitivity down to the neutrino fog, detectors have to become **bigger**, and **quieter**

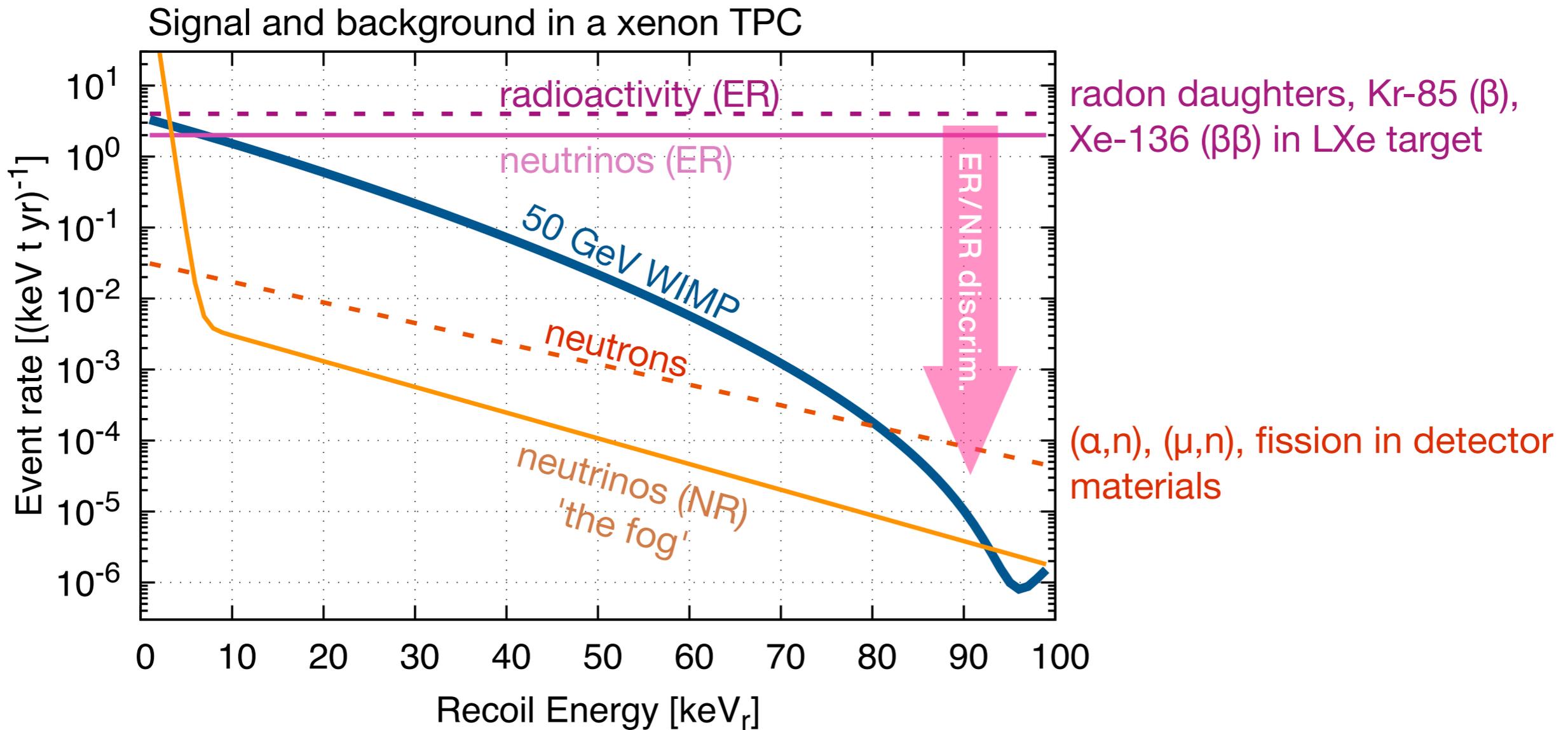


$$\sigma_{\text{WIMP-nucleon}} = 1e-10 \text{ pb}$$

Background rates approximate expectation for XENONnT, only fiducial volume cut

based on: arXiv:2007.08796 and arXiv:1802.06039

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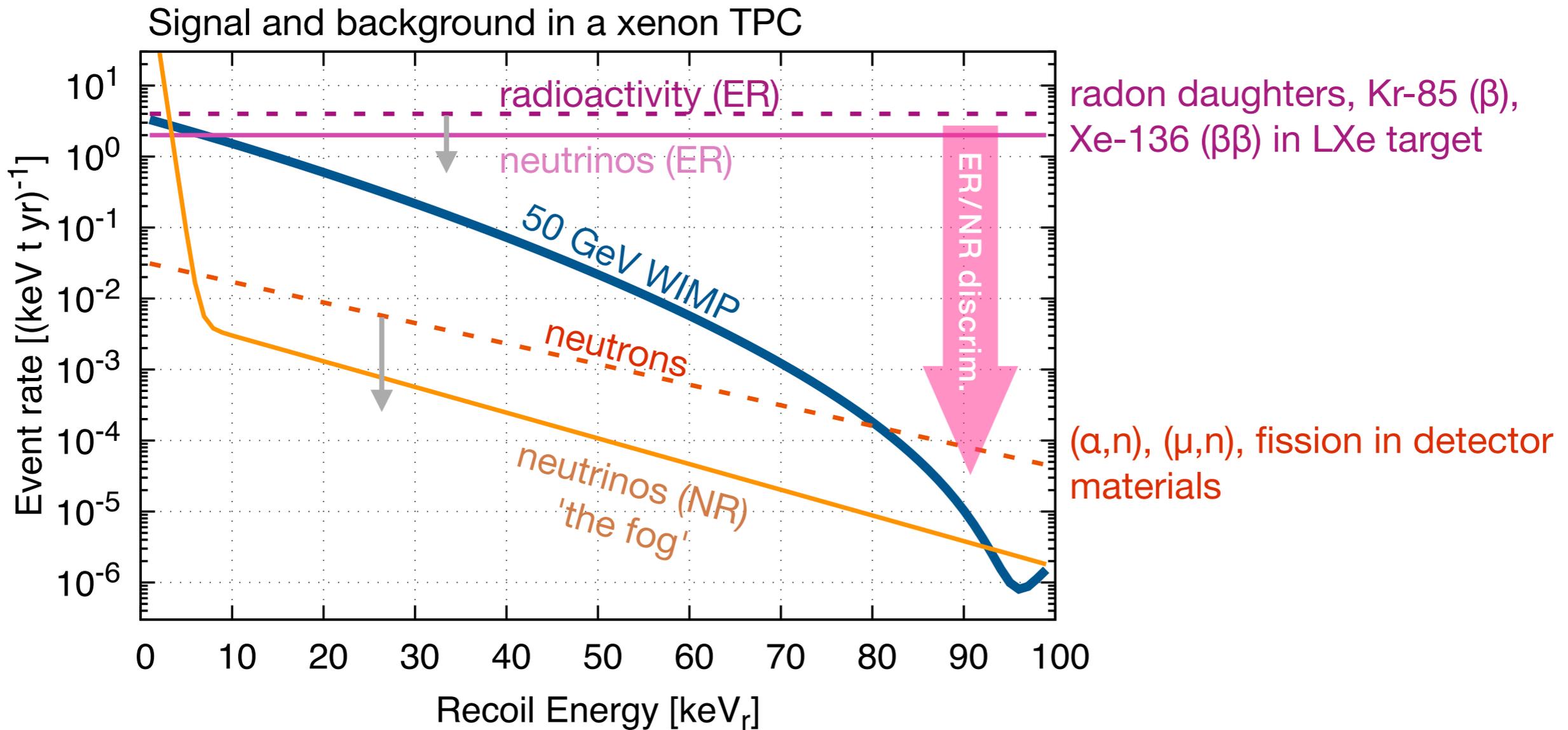


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Now

Future

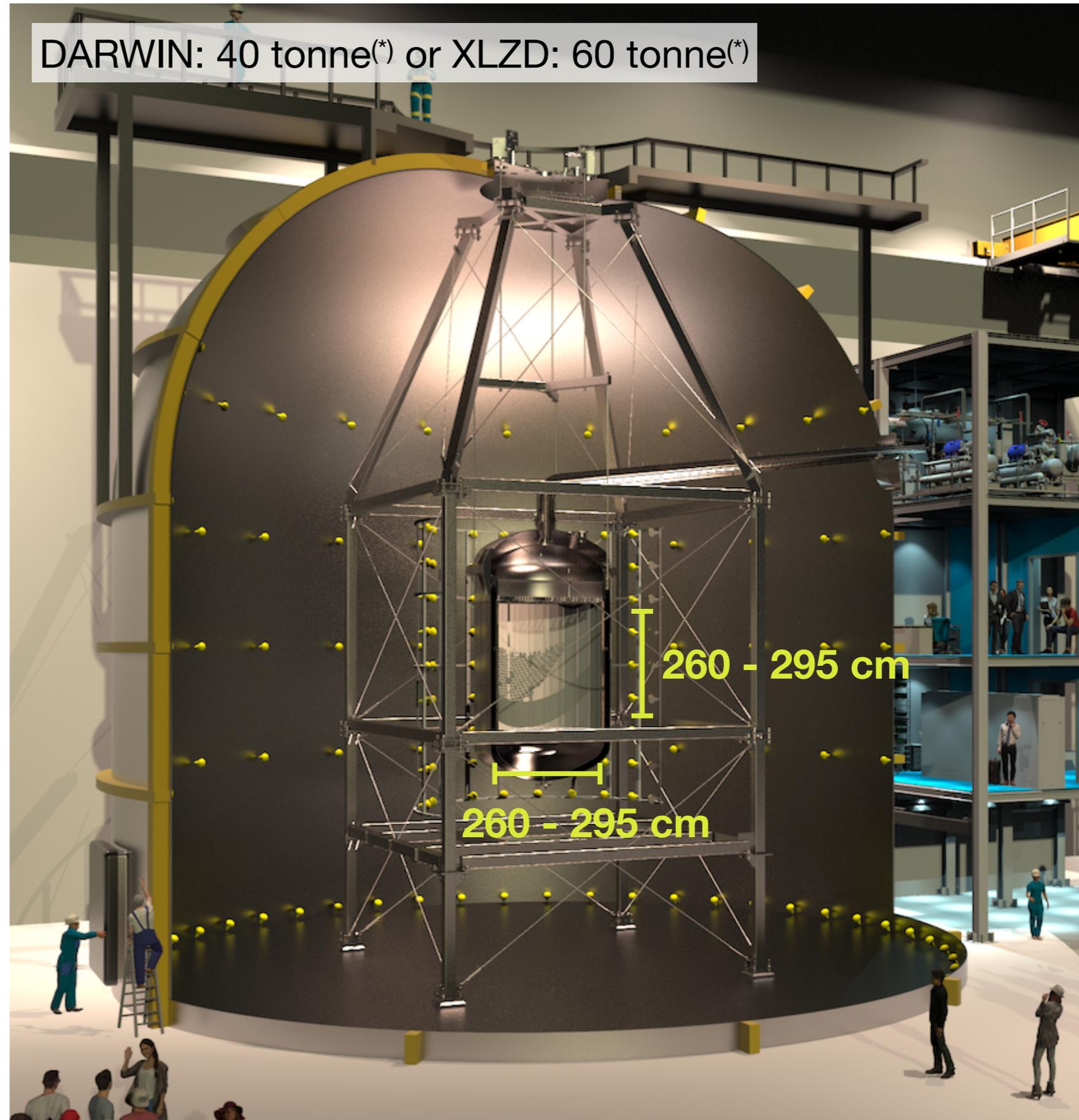
LZ: 7 tonne, d=150 cm

XENONnT: 6 tonne, d=133 cm

PandaX: 3.7 tonne, d=118 cm

(\*) active volume (inside TPC)

DARWIN: 40 tonne(\*) or XLZD: 60 tonne(\*)



# The DARWIN collaboration

~200 members from 38 institutions



# The XLZD consortium

104 PIs signed MoU, July 2021

**XENON + LZ + DARWIN**



Los Angeles, 2023

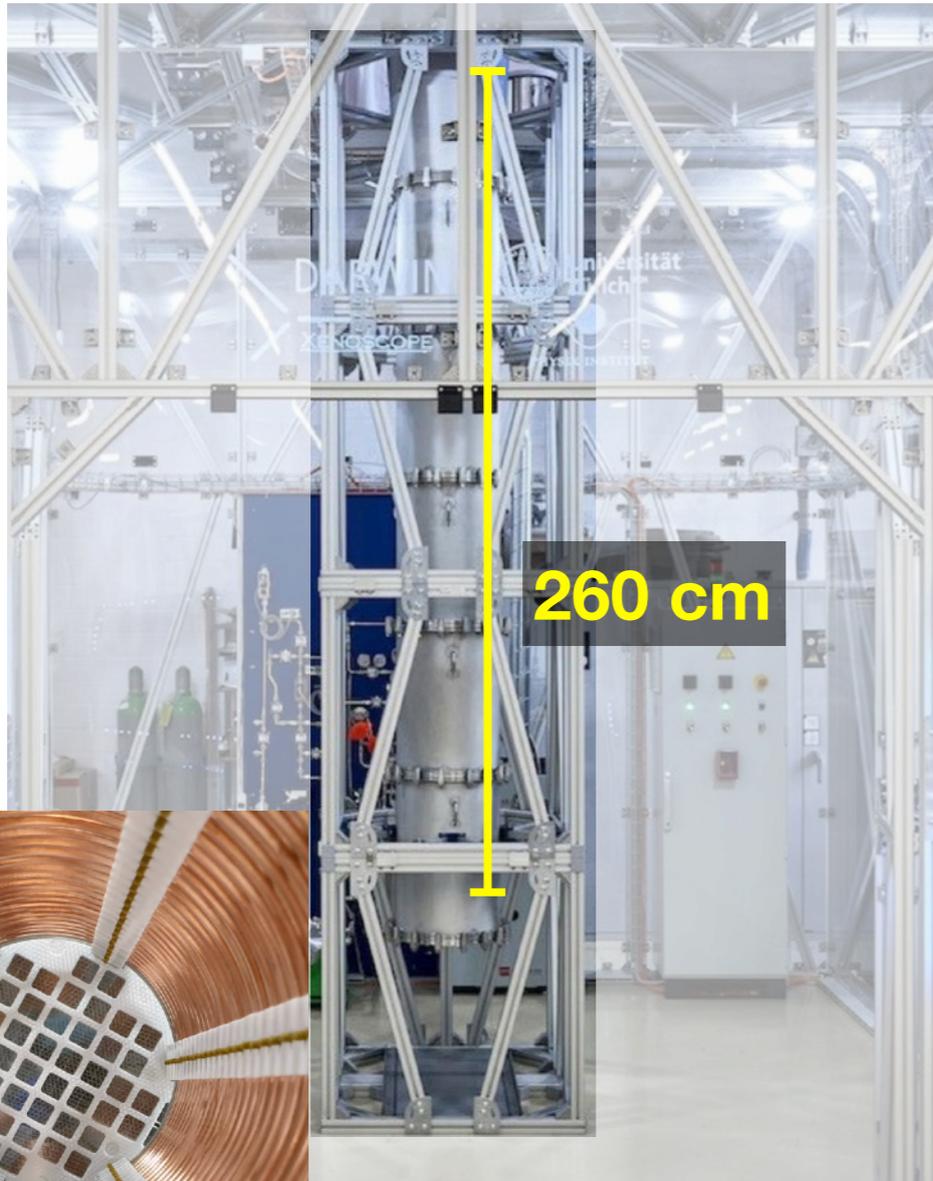
Community white-paper  
arXiv:2203.02309



Karlsruhe, 2022

# Scaling up: full size demonstrators to test components

Xenoscope (Zurich)

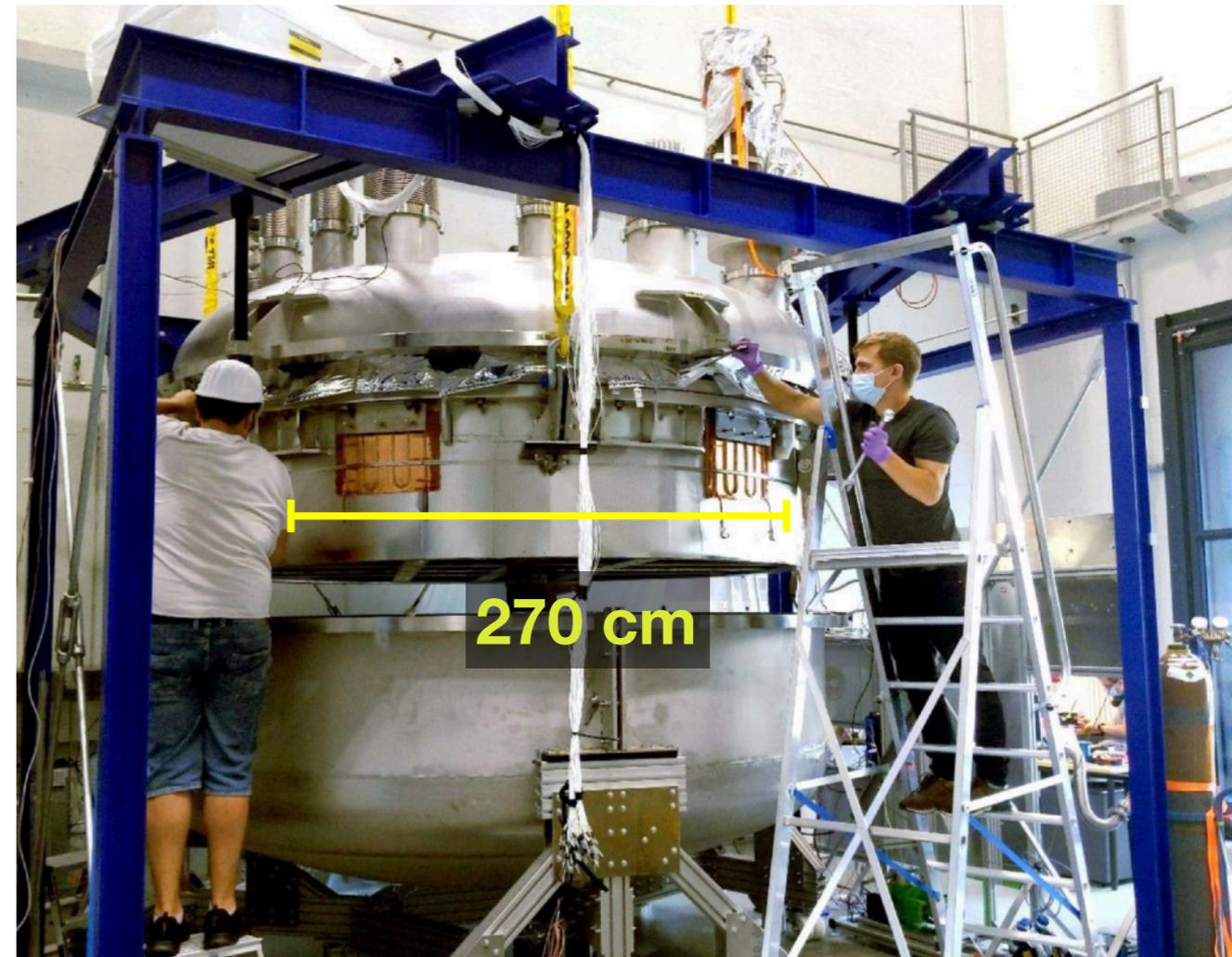


DOI:10.1140/epjc/s10052-023-11823-1

To study: electron drift

Status: first LXe run starting now

Pancake (Freiburg)



electrode design/stability

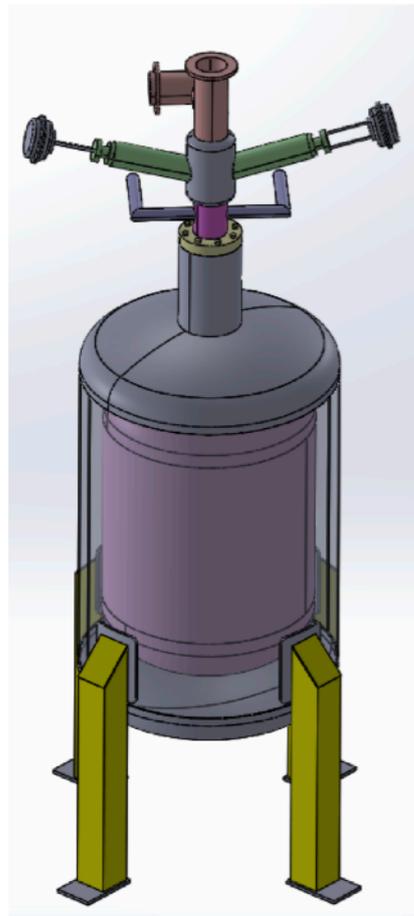
Xe liquefaction/fill system commissioned

# Scaling up: bigger detector infrastructure is not trivial

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Showcase:

MiniRestoX (Paris)



Large volume xenon purification, liquefaction, recovery, storage

Electrodes (Karlsruhe/Freiburg/Alabama)

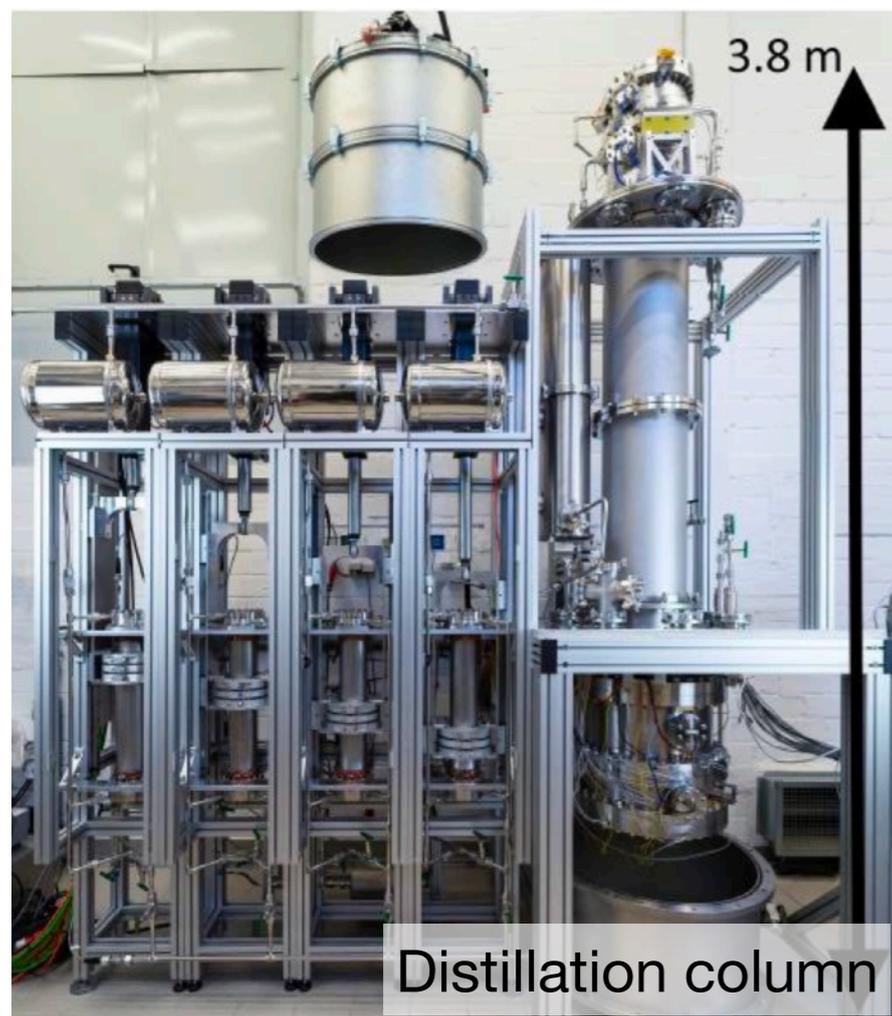


Sagging, stability, defects/QA, transparency, electron emission, ...

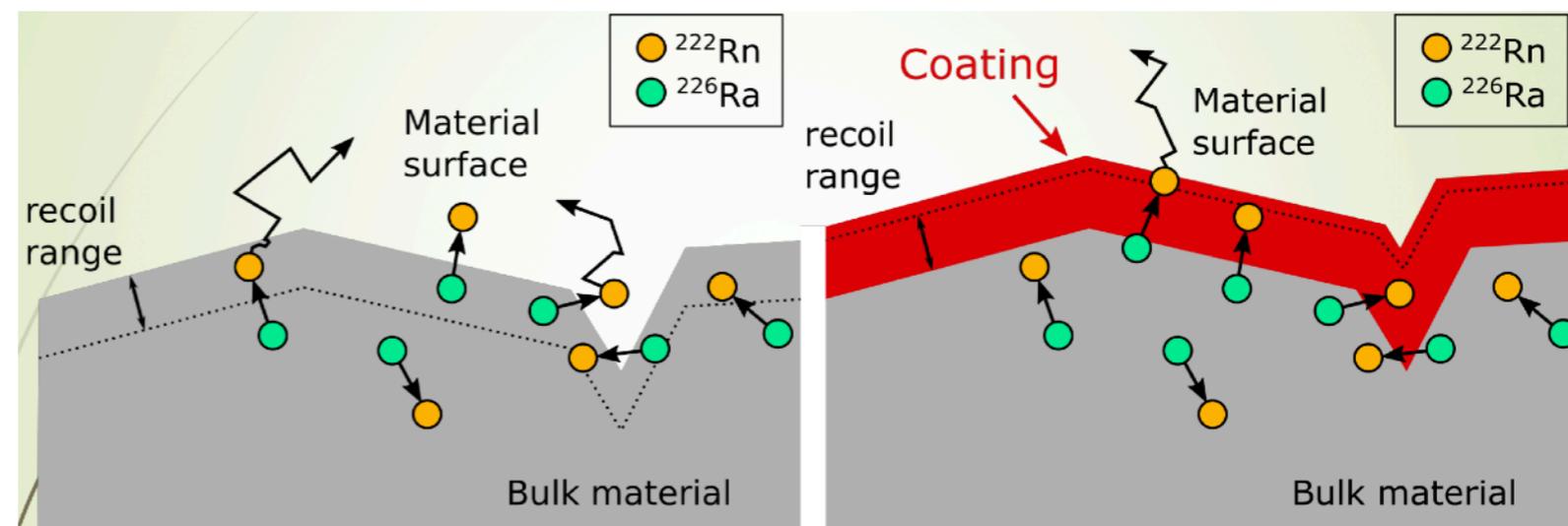
# Quieter: Radon and krypton reduction with aim to reach 10x lower specific activity than in XENONnT

*LowRad*  
Kr and Rn distillation (Münster)

Demonstration in XENONnT<sup>(1)</sup>:  
 $^{222}\text{Rn} < 1 \mu\text{Bq/kg}$   
 $^{85}\text{Kr} < \text{ppt}$



Surface coating to suppress  $^{222}\text{Rn}$  emanation (Heidelberg)



➔ *H. Simgen's talk yesterday 18:15*

(1) Eur. Phys. J. C 82, 1104 (2022), Eur. Phys. J. C 77 (2017)

# Beyond the baseline design: Photon detectors with lower radioactivity, lower cost, or enabling higher light yield

Baseline:

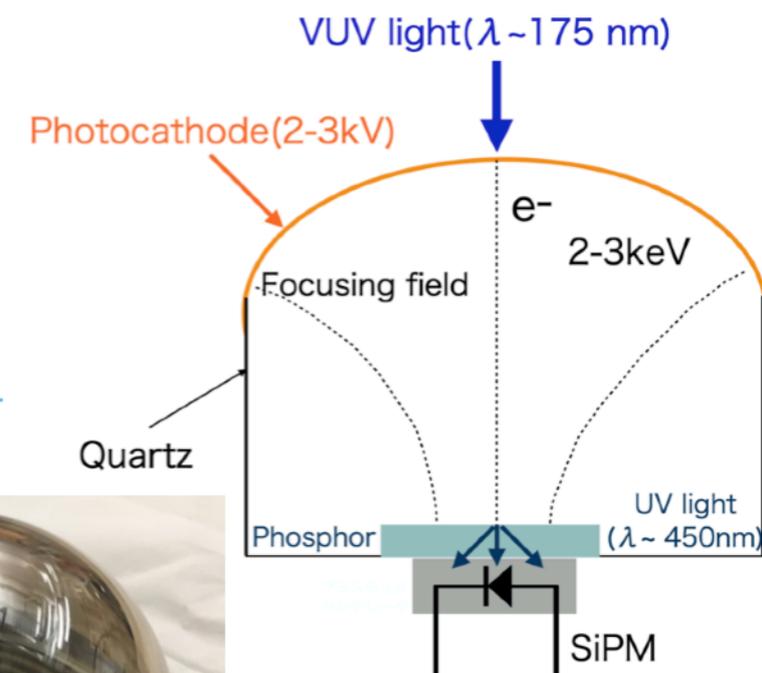
3" Hamamatsu R11410 PMT; same as XENONnT/LZ/PandaX



R&D:

Many groups on sensor development (Nagoya, Zurich, Heidelberg, Stockholm, LNGS ...)

- alternate PMT models
- bigger/more radiopure R11410
- (digital) SiPMs
- PMT/SiPM hybrids



JINST 18 C03027 (2023)

JINST 17 C01038 (2022)

# Beyond the baseline design: A variety of R&D LXe TPCs to study improved charge and light collection methods

Showcase:

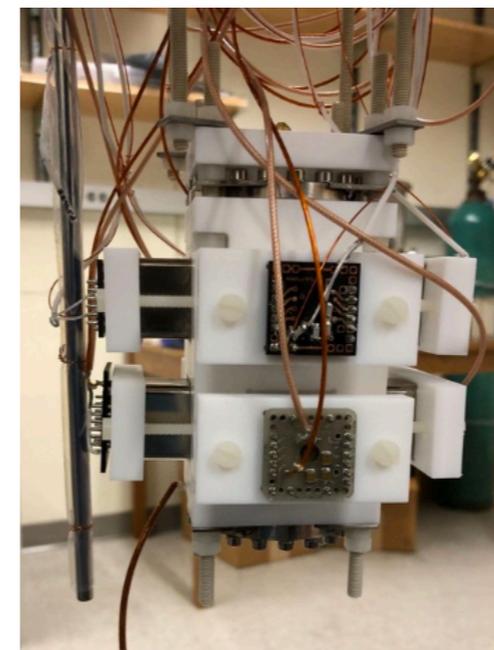
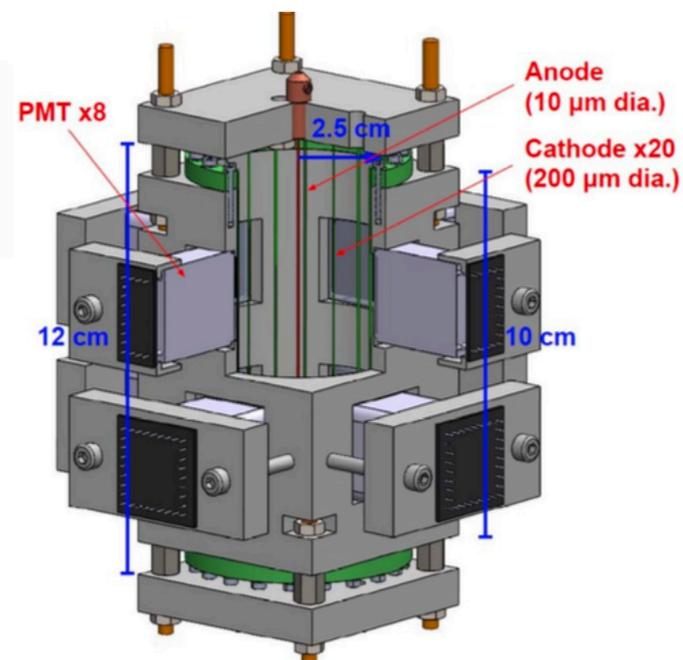
Single-phase TPC (Freiburg)



XAMS (Amsterdam)



SanDix, single-phase radial TPC (San Diego)



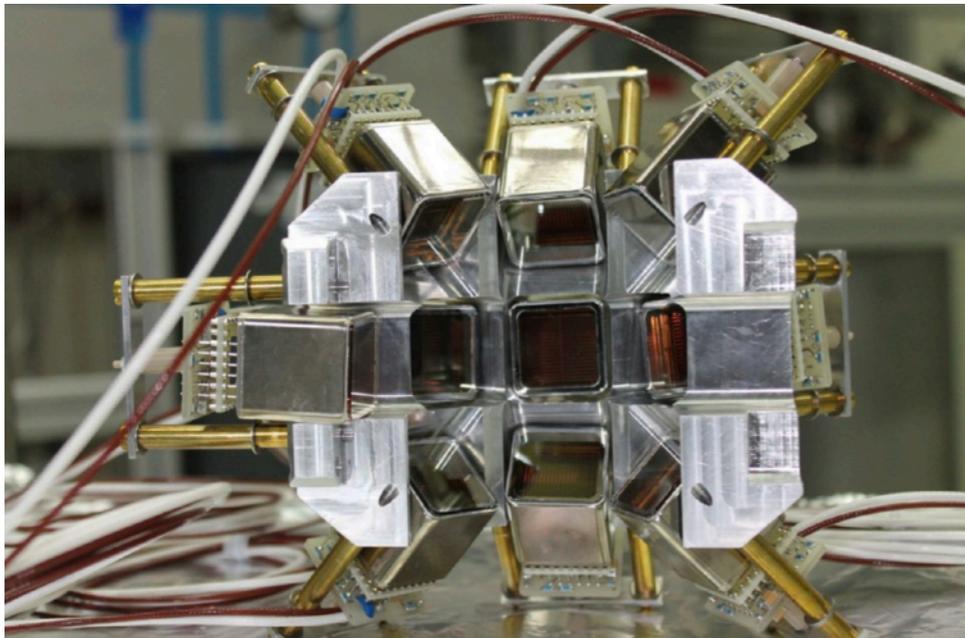
Phys. J. C 83, 9 (2023)

arXiv:2301.12296

# Beyond the baseline design: A variety of R&D detectors to study LXe scintillation physics for better ER/NR separation

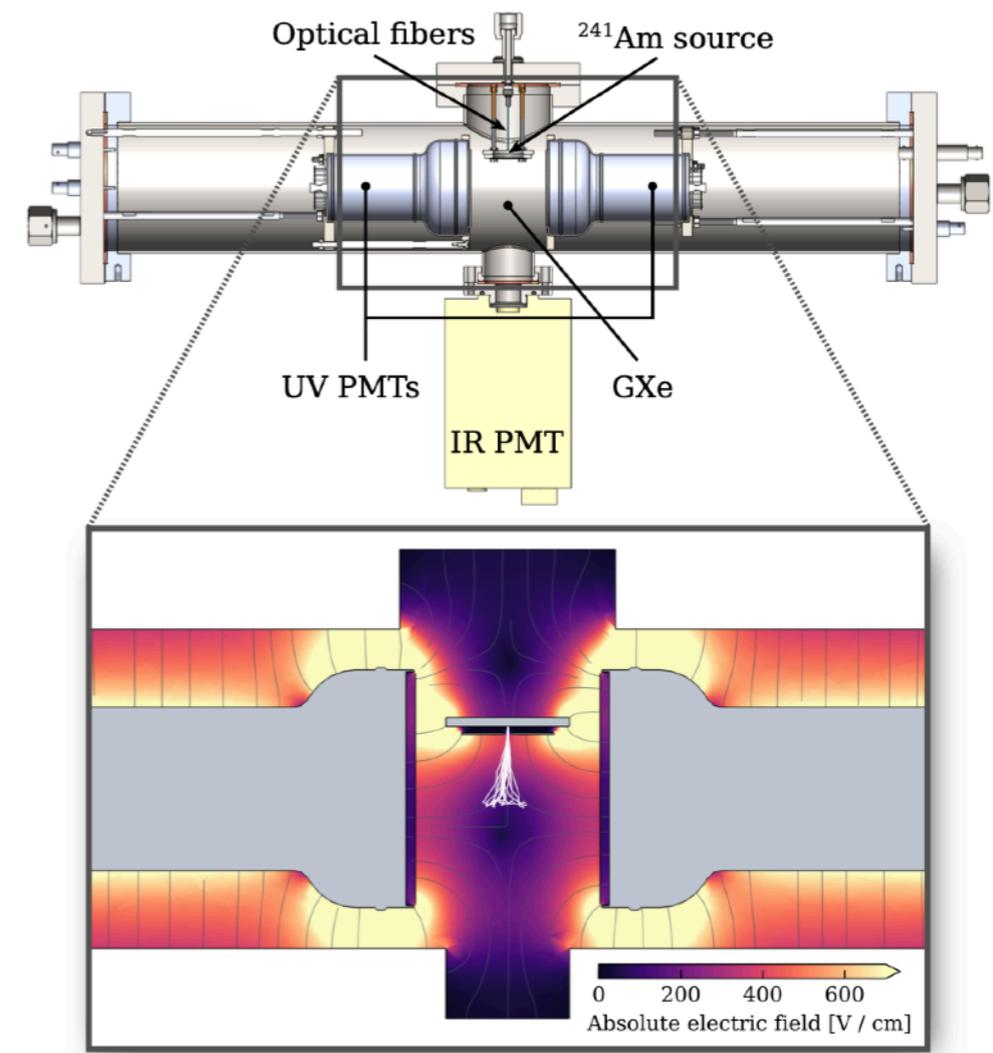
Showcase:

DireXeno (Tel Aviv)



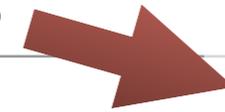
arXiv:1909.08197

VUV/IR light emission (Heidelberg)

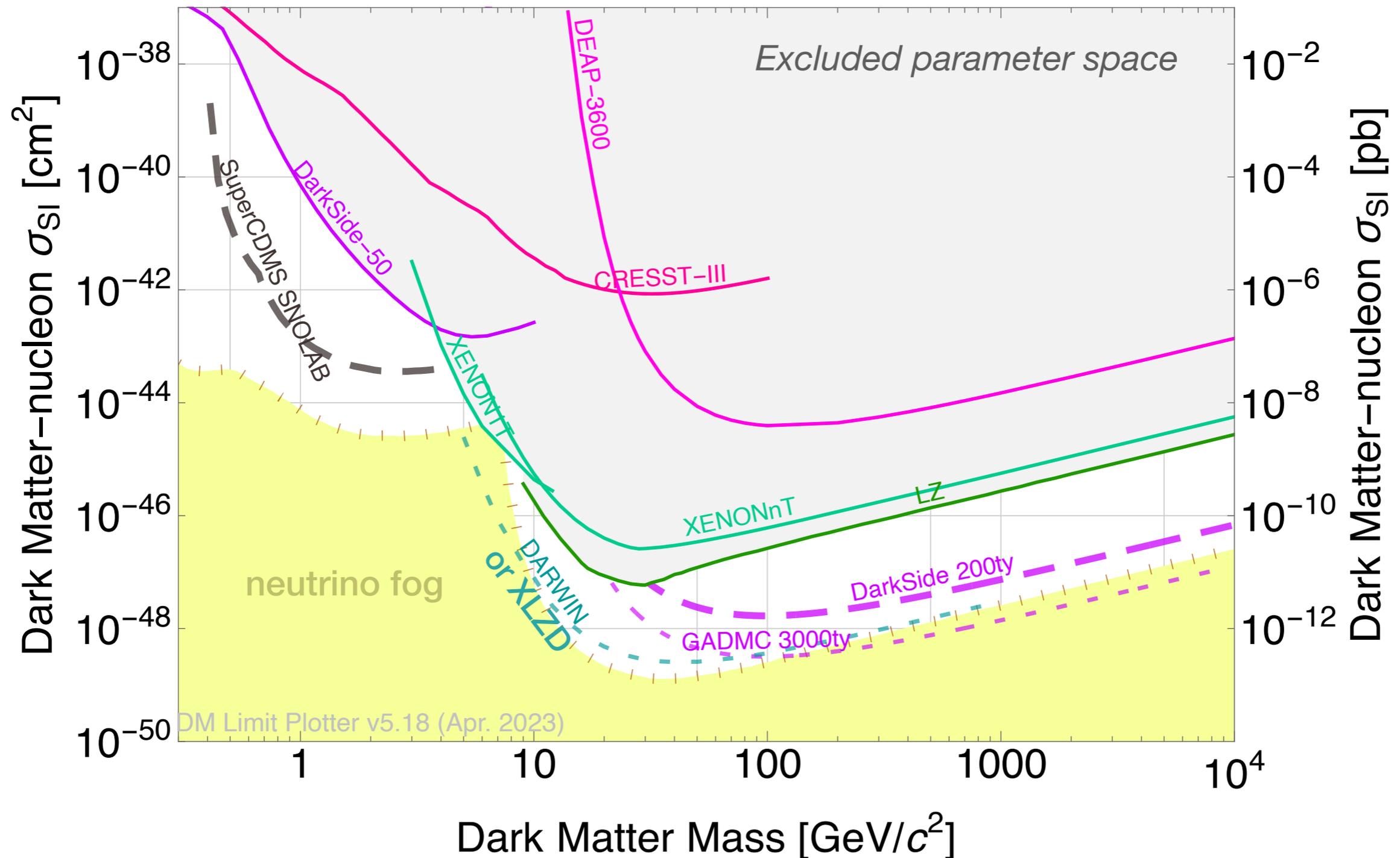


arXiv:2303.09344

DARWIN (or XLZD) will probe heavy WIMPs down to the neutrino fog, and enable a number of additional science channels



K. Palladino's  
talk today 15:15



# Summary

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- A 40 tonne to 60 tonne (active volume) G3 liquid xenon TPC will probe high-mass WIMPs to the neutrino floor, and enable a rich physics programme including neutrinos and alternate DM candidates
- DARWIN has been leading the R&D for a G3 liquid-xenon-based dark matter detector with a 40-tonne baseline design
- Crucial detector subsystems are being actively developed in several working groups.
- If funding can be secured, DARWIN+LZ+XENON will form XLZD, which would enable a 60-tonne detector (instead of the 40 tonne option)

XENONnT operation

XLZD construction

XLZD operation



