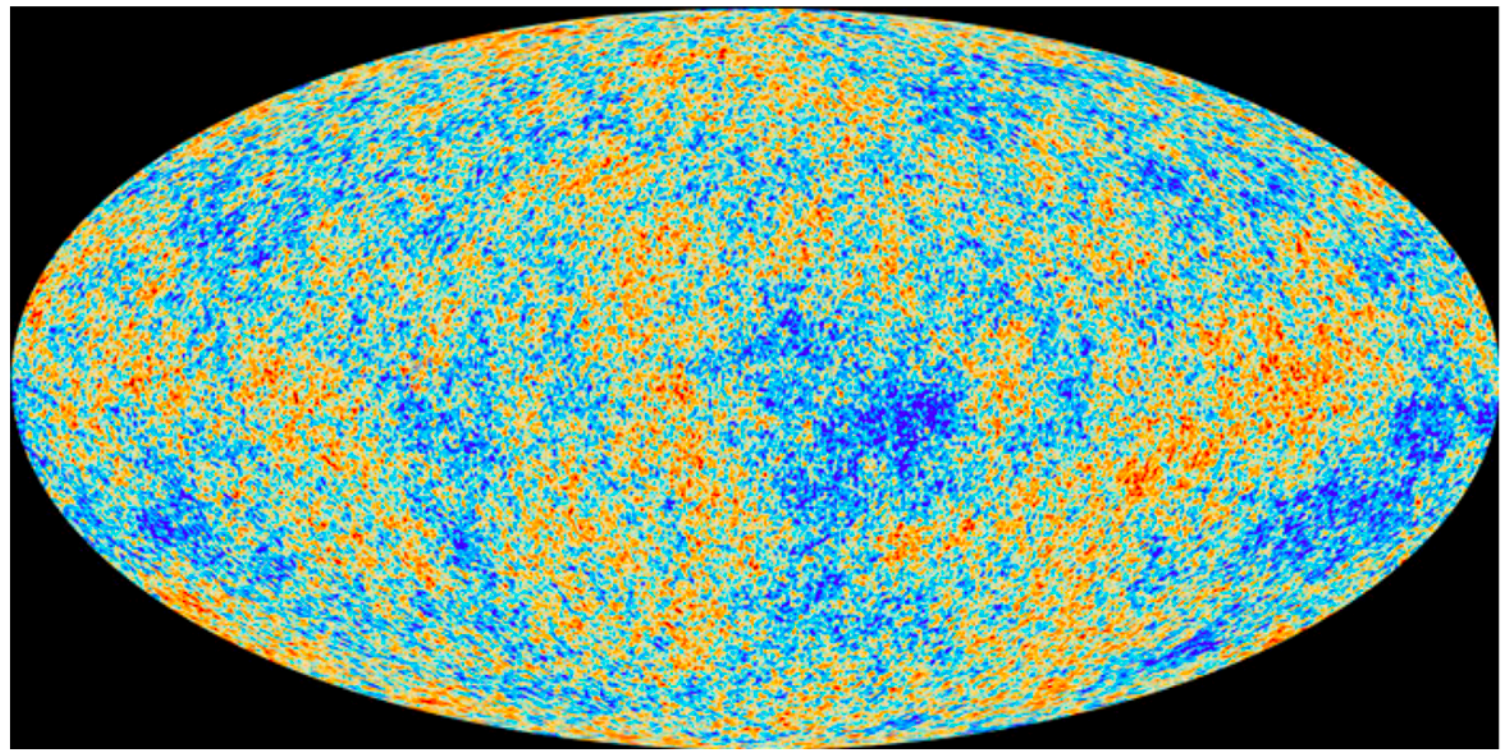
First Results from XENONnT and an outlook towards DARWIN

Jörn Mahlstedt (SU)

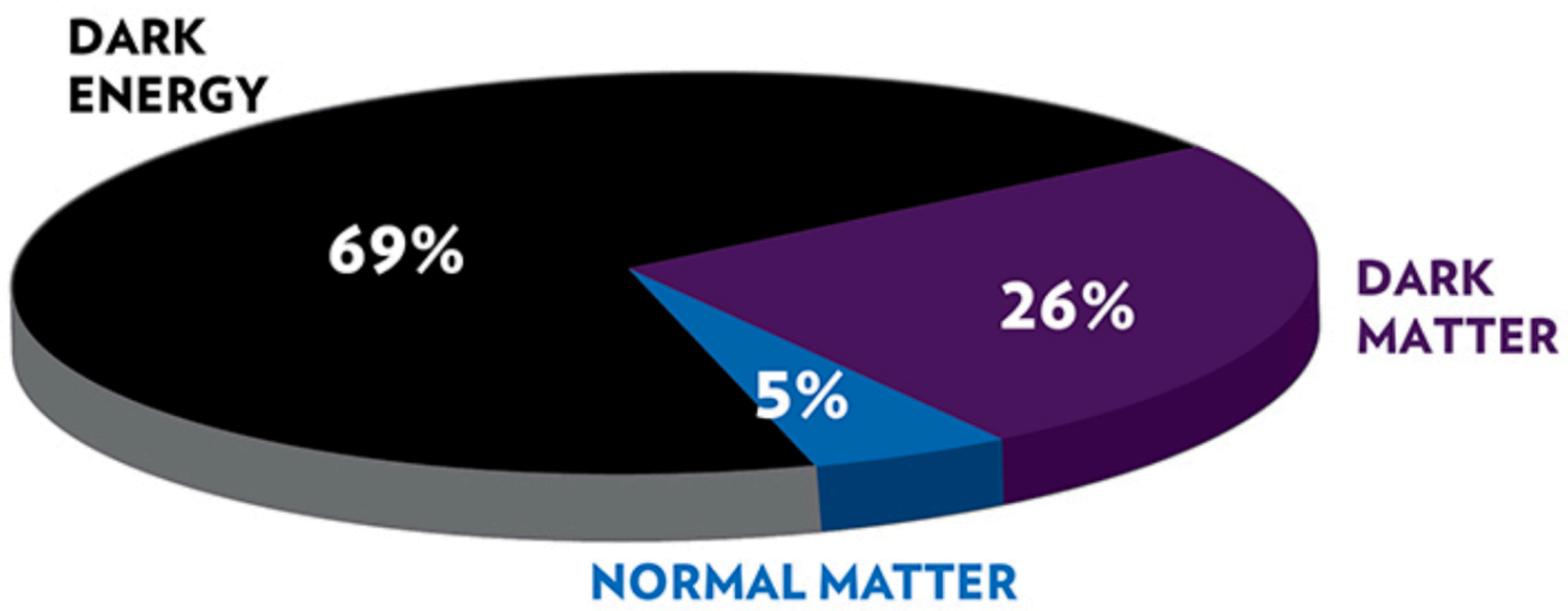
Fysikdagarna 2023
16/06/2023

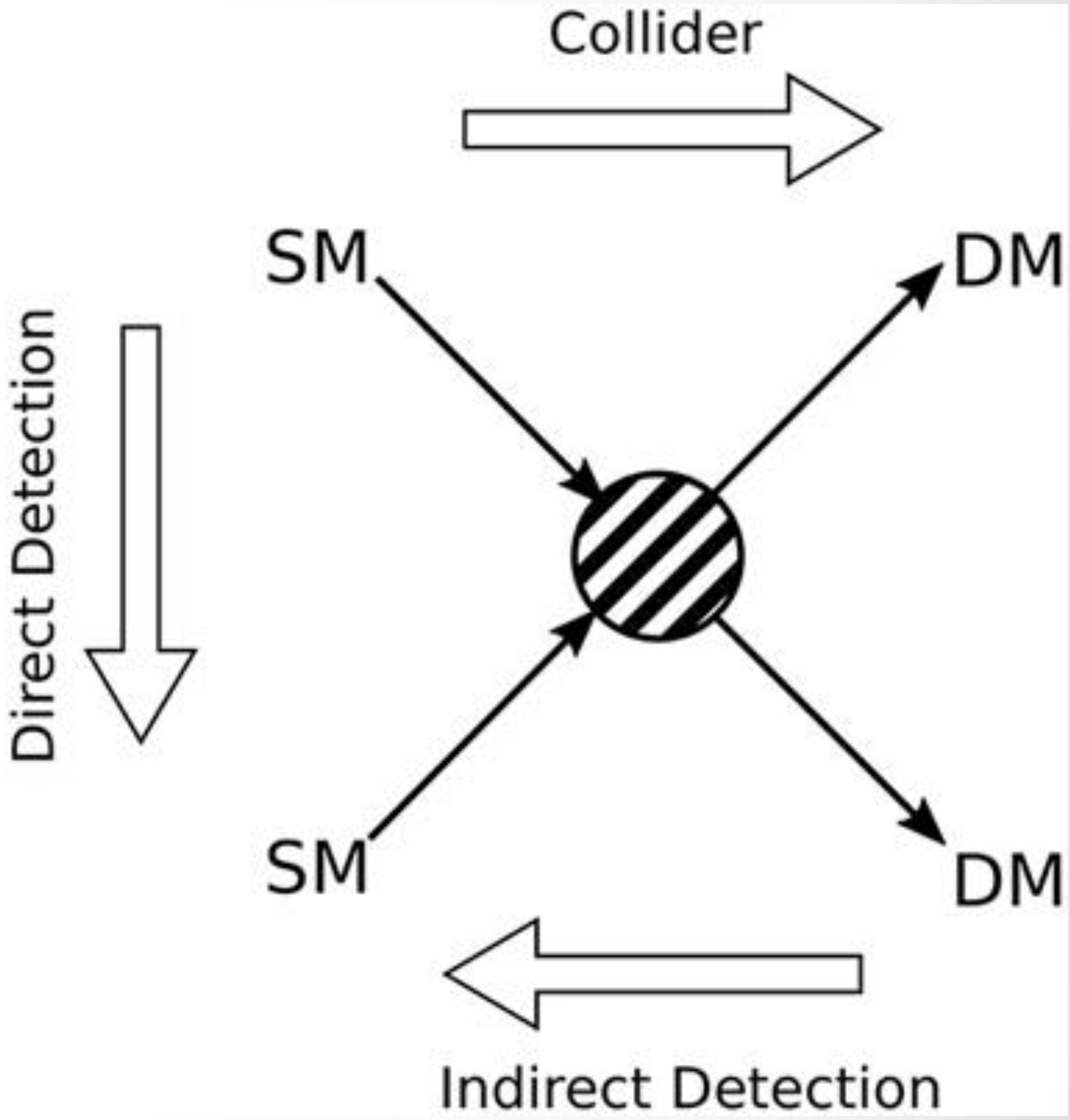
Dark Matter Direct Detection

Evidence for dark matter



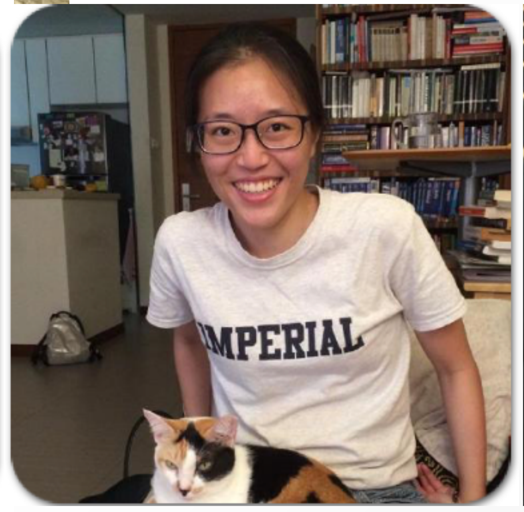
CMB



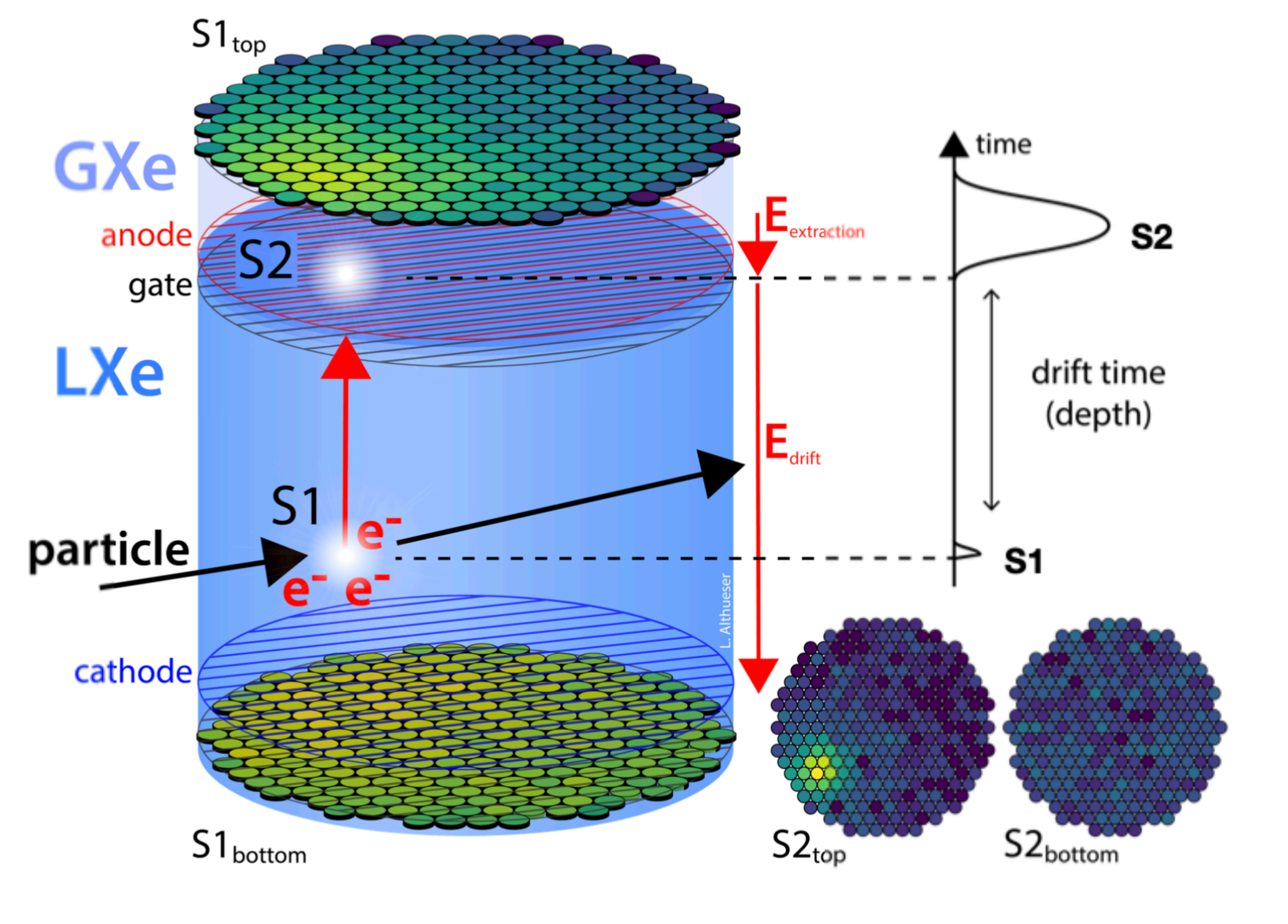


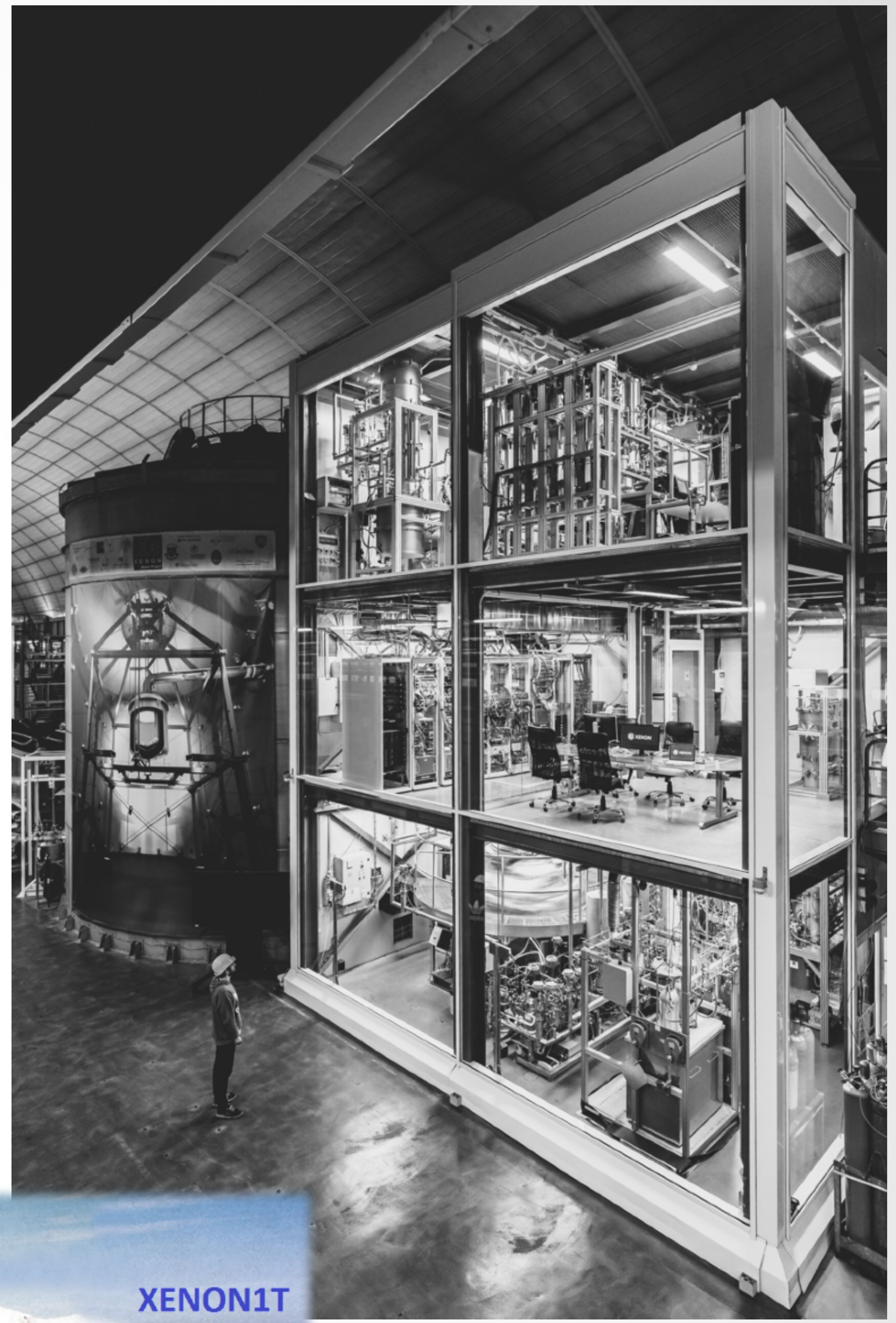
XENON collaboration

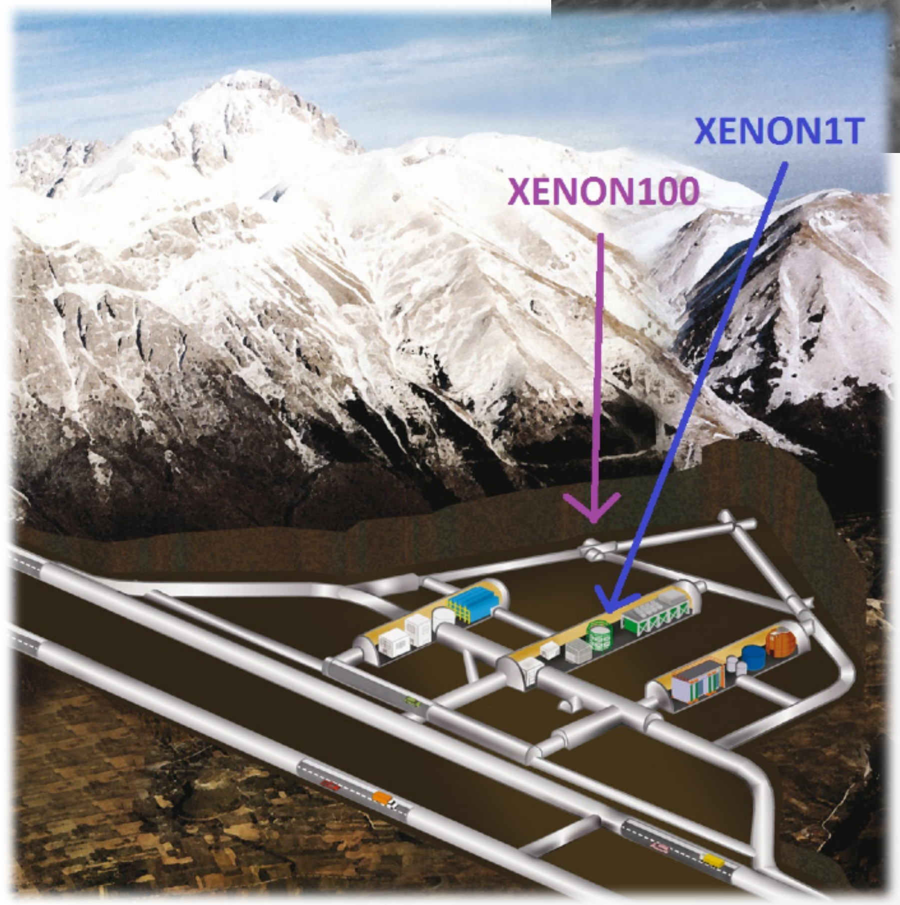
- 170 scientists
- 27 institutes
- 12 countries

XENONnT TPC

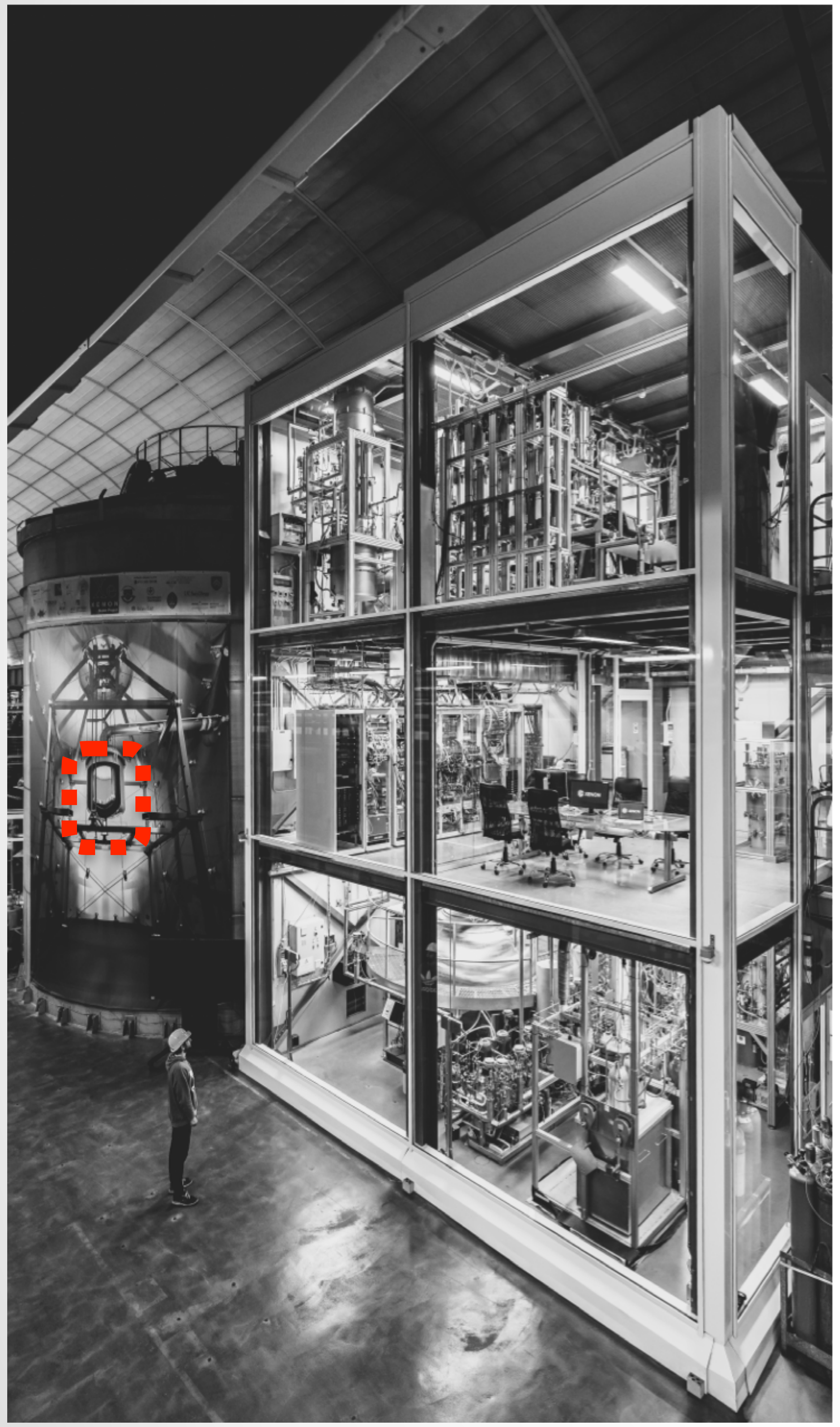




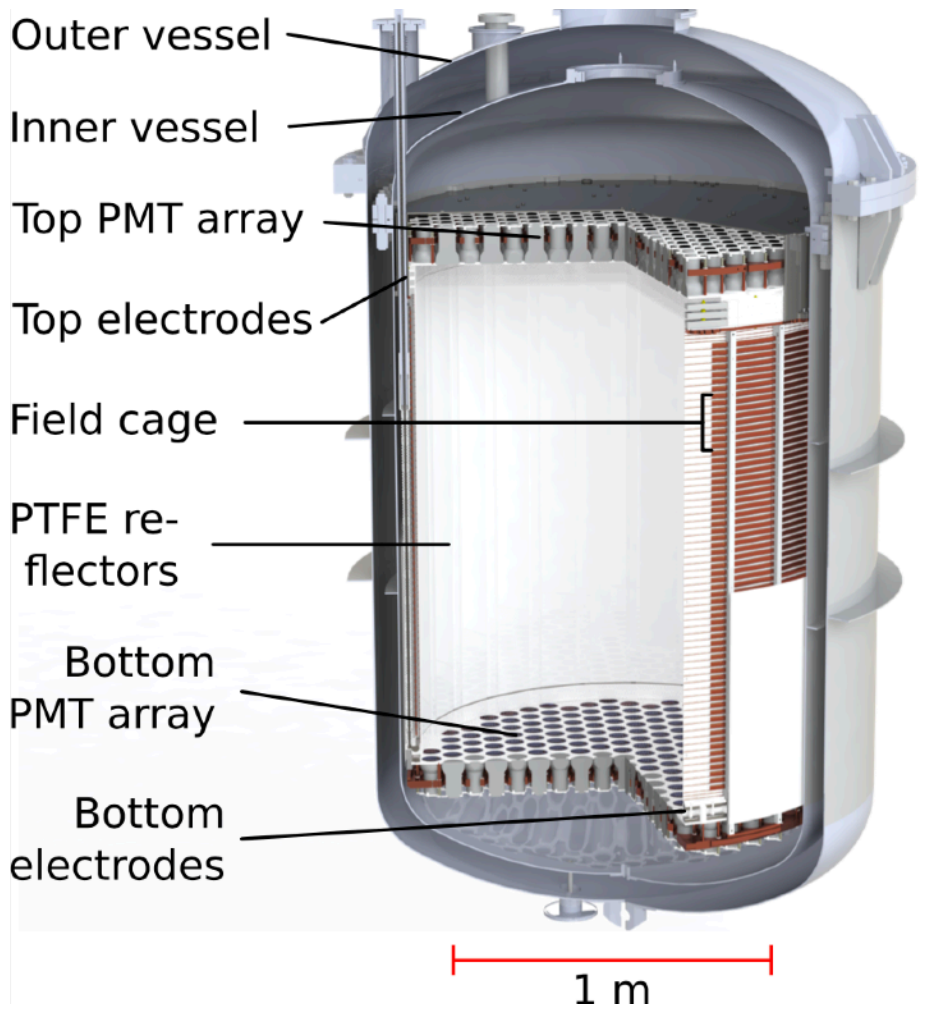


LNGS
in Italy

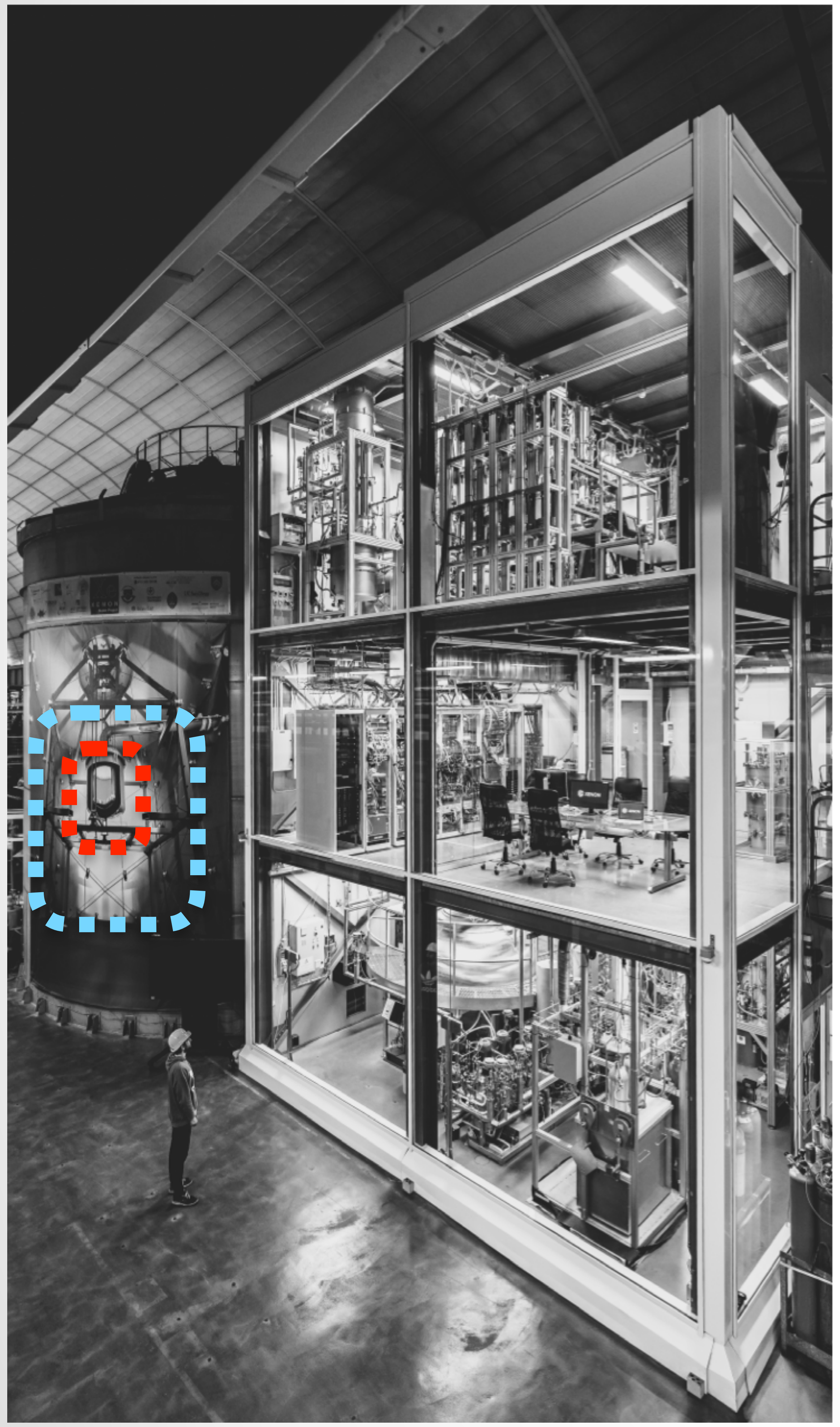
XENONnT



Time Projection Chamber (TPC)



XENONnT



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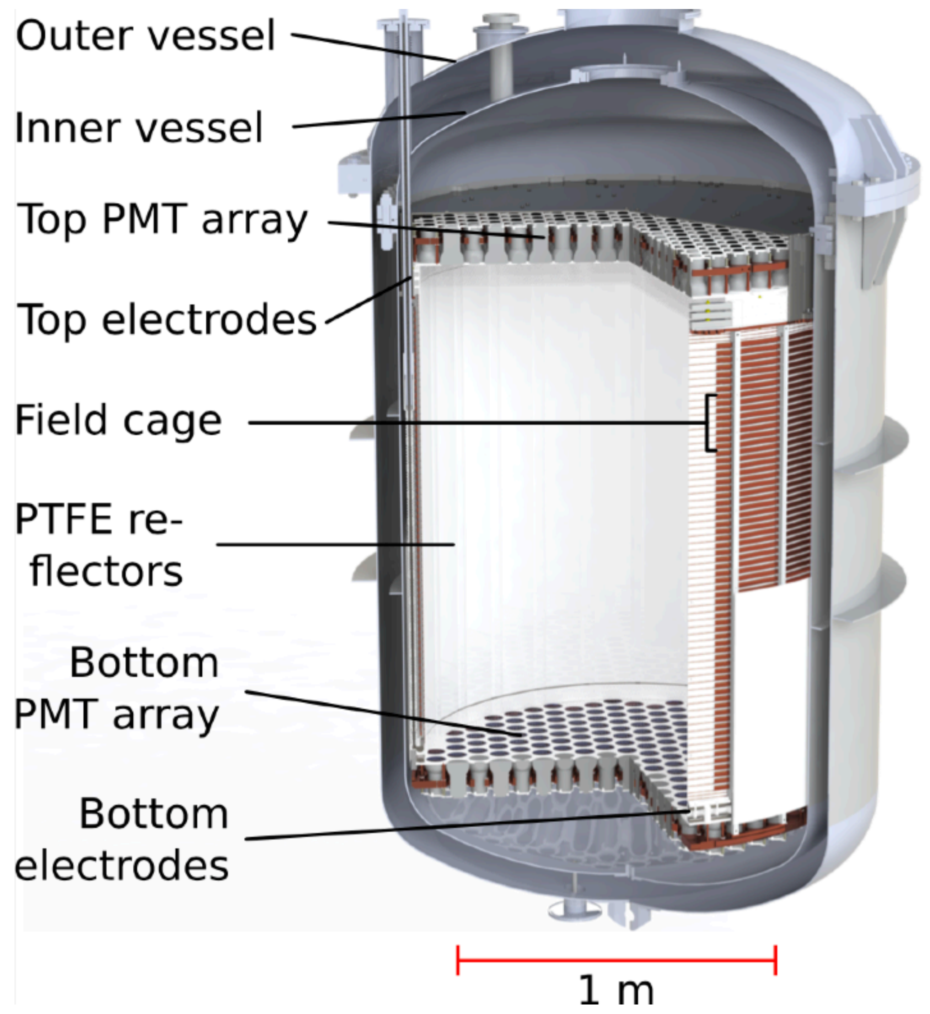
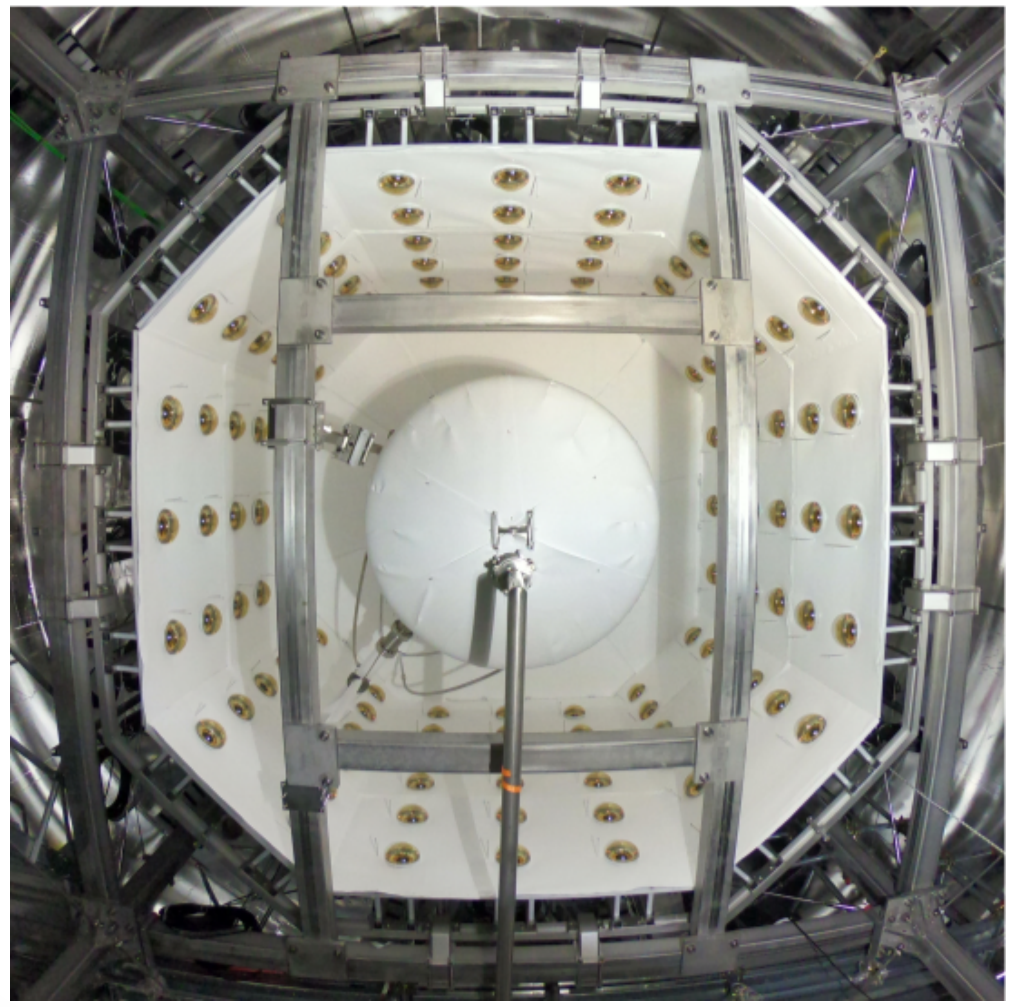
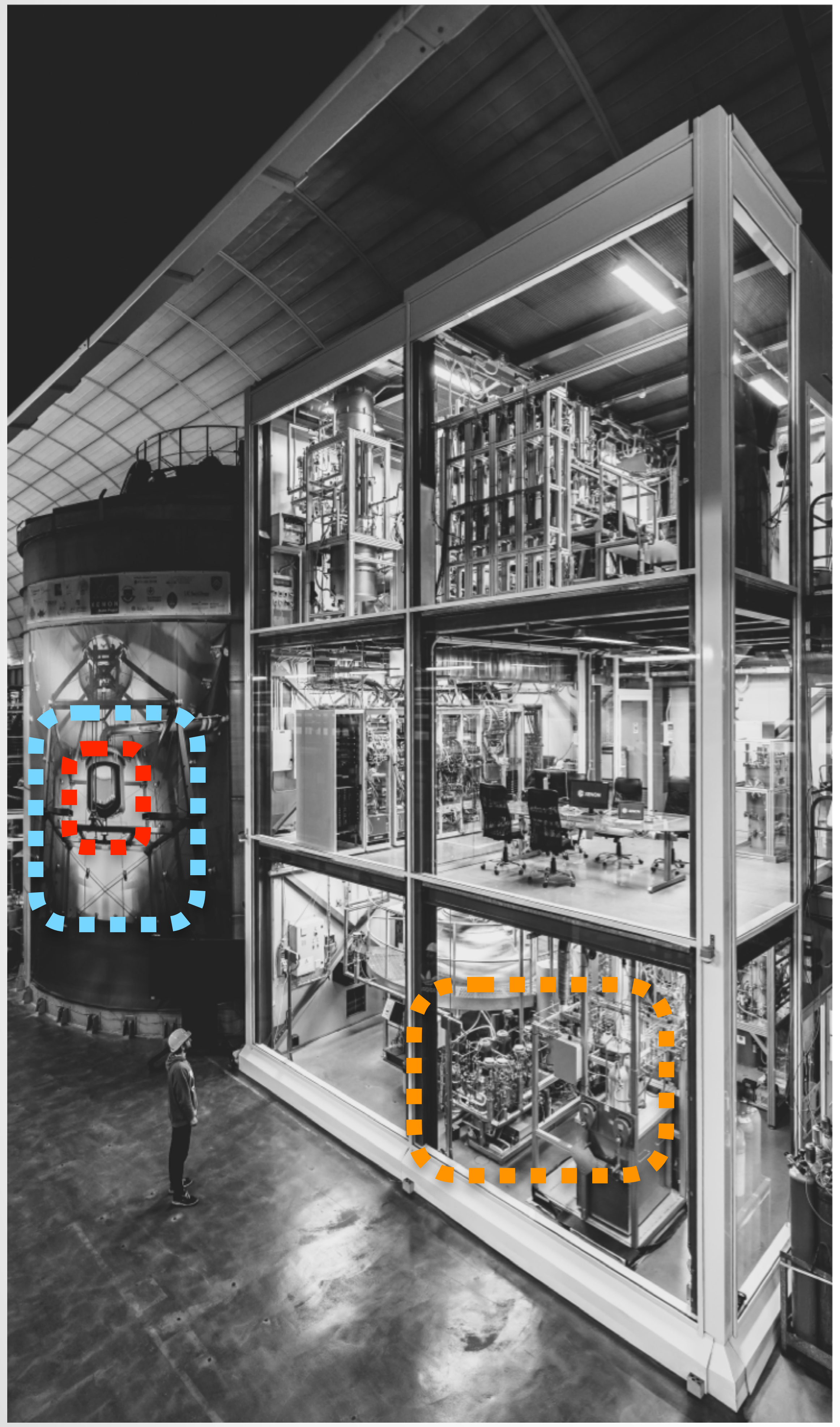


Neutron veto



XENONnT



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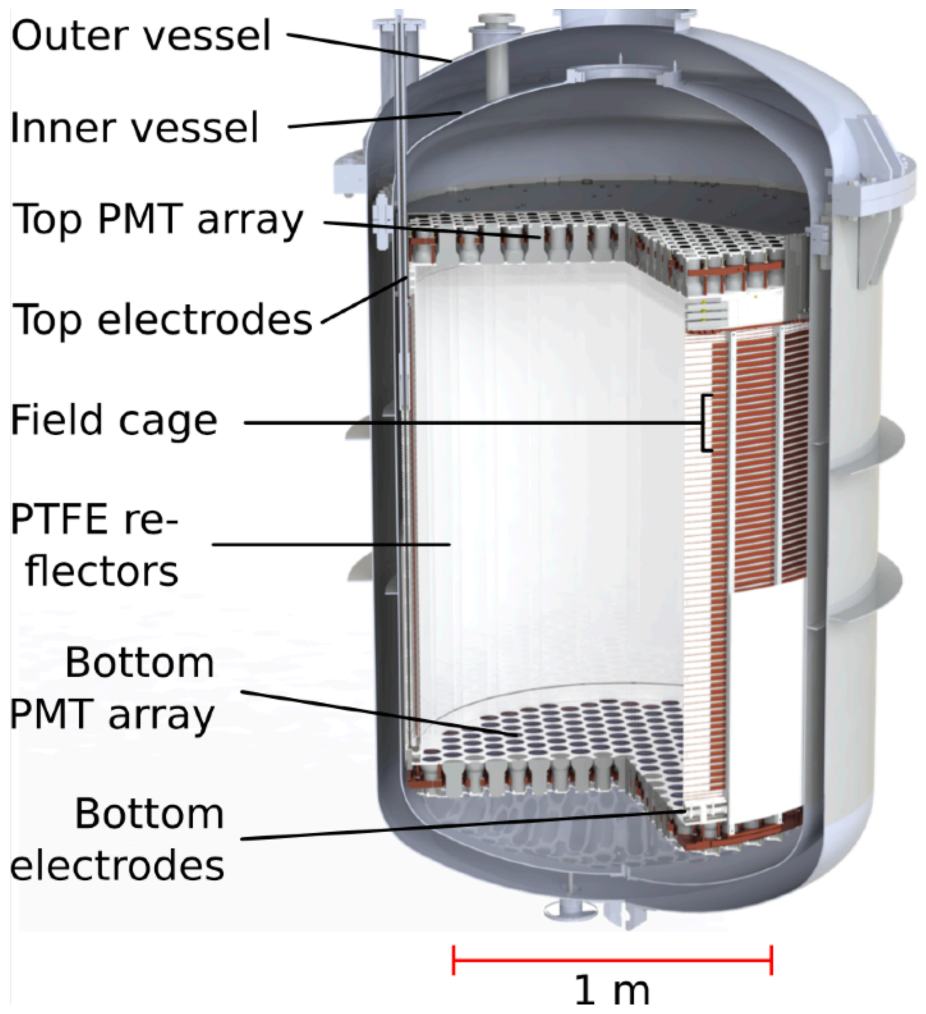
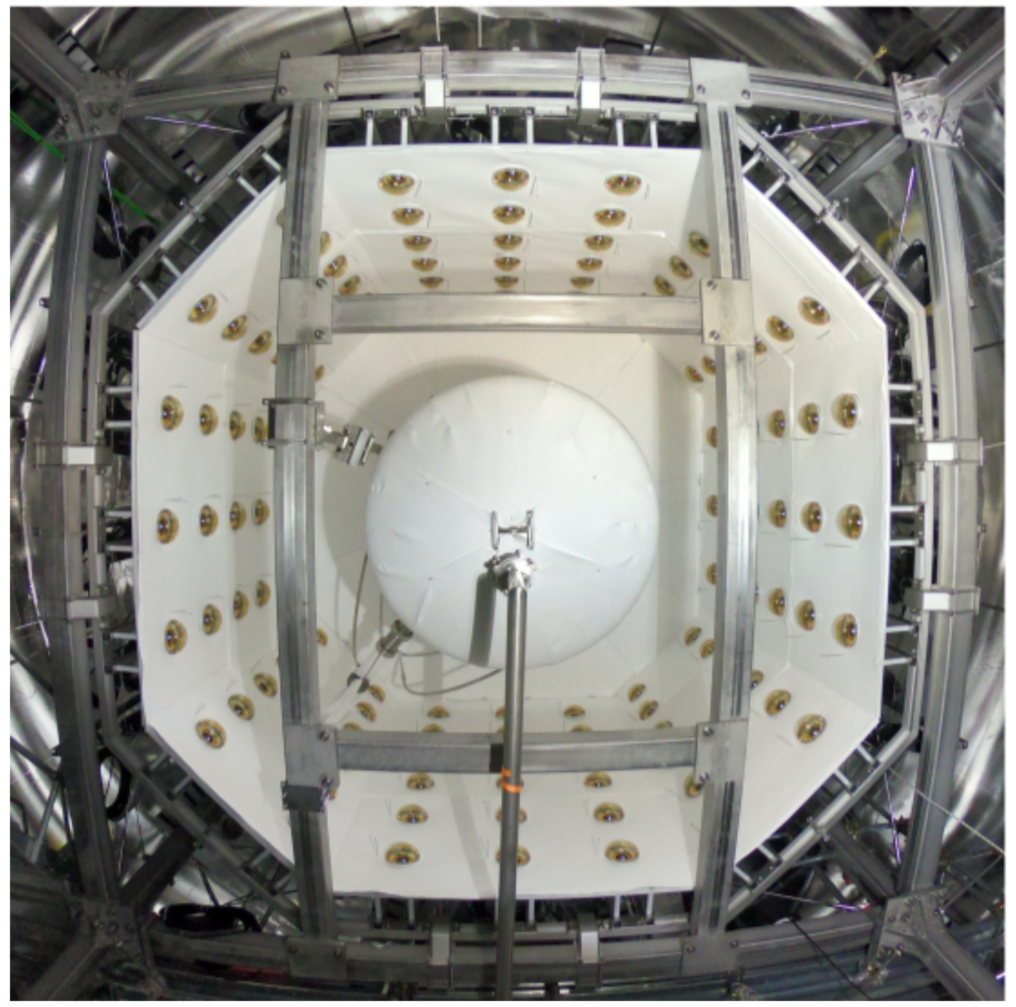
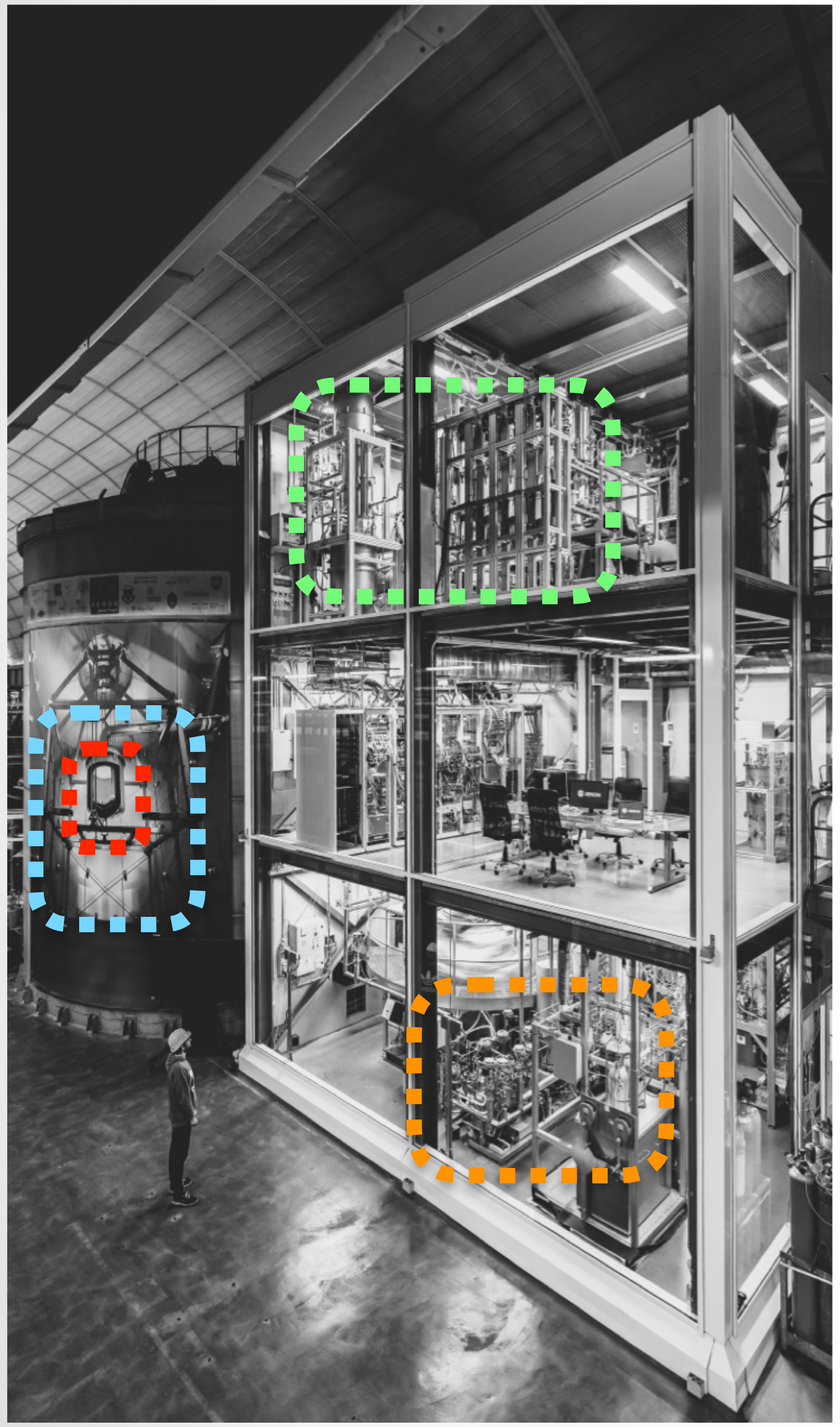


Neutron veto

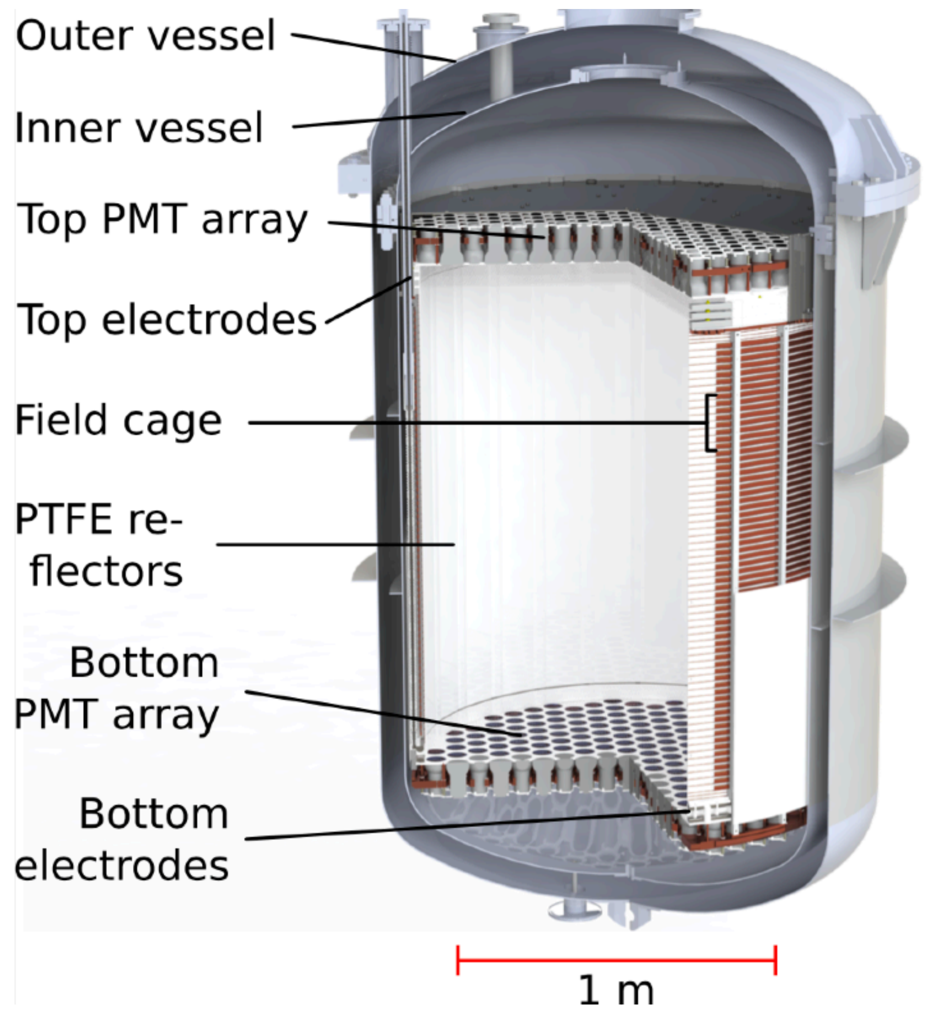


Liquid xenon purification

XENONnT

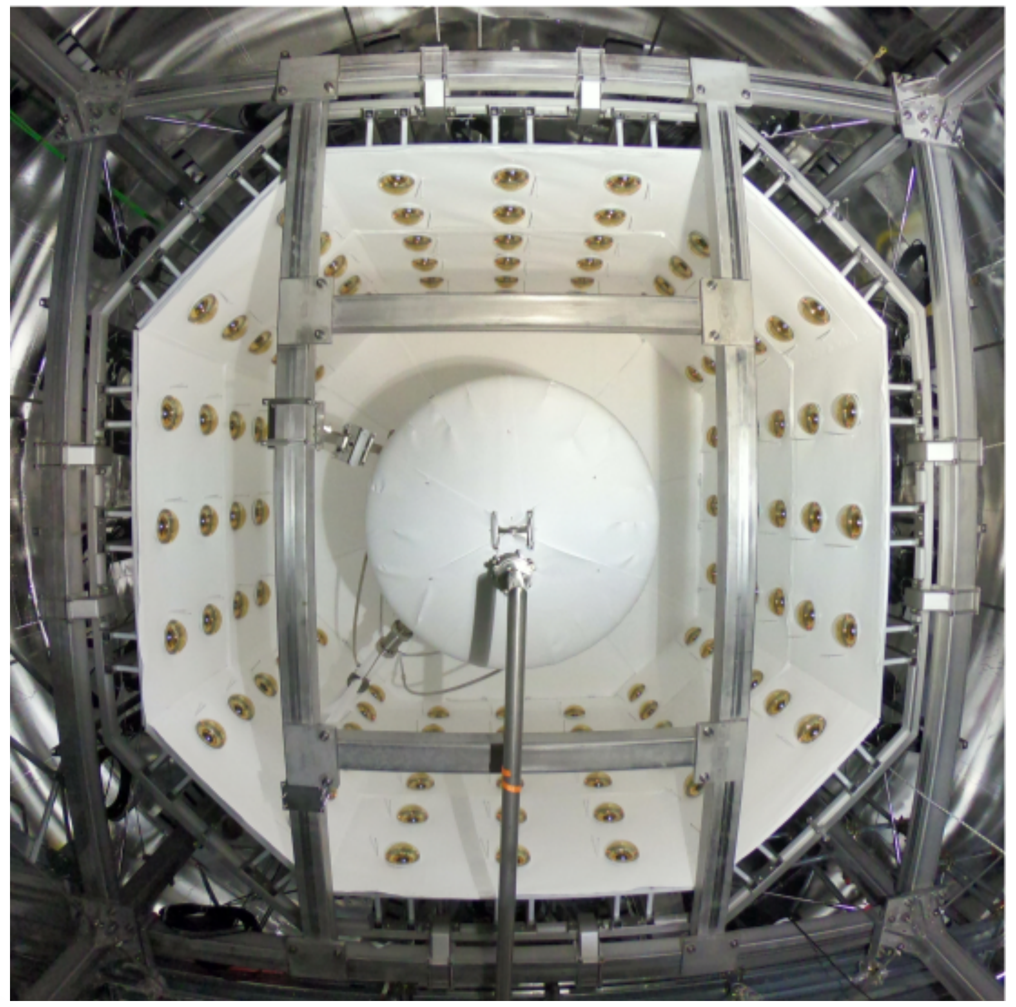


Time Projection Chamber (TPC)

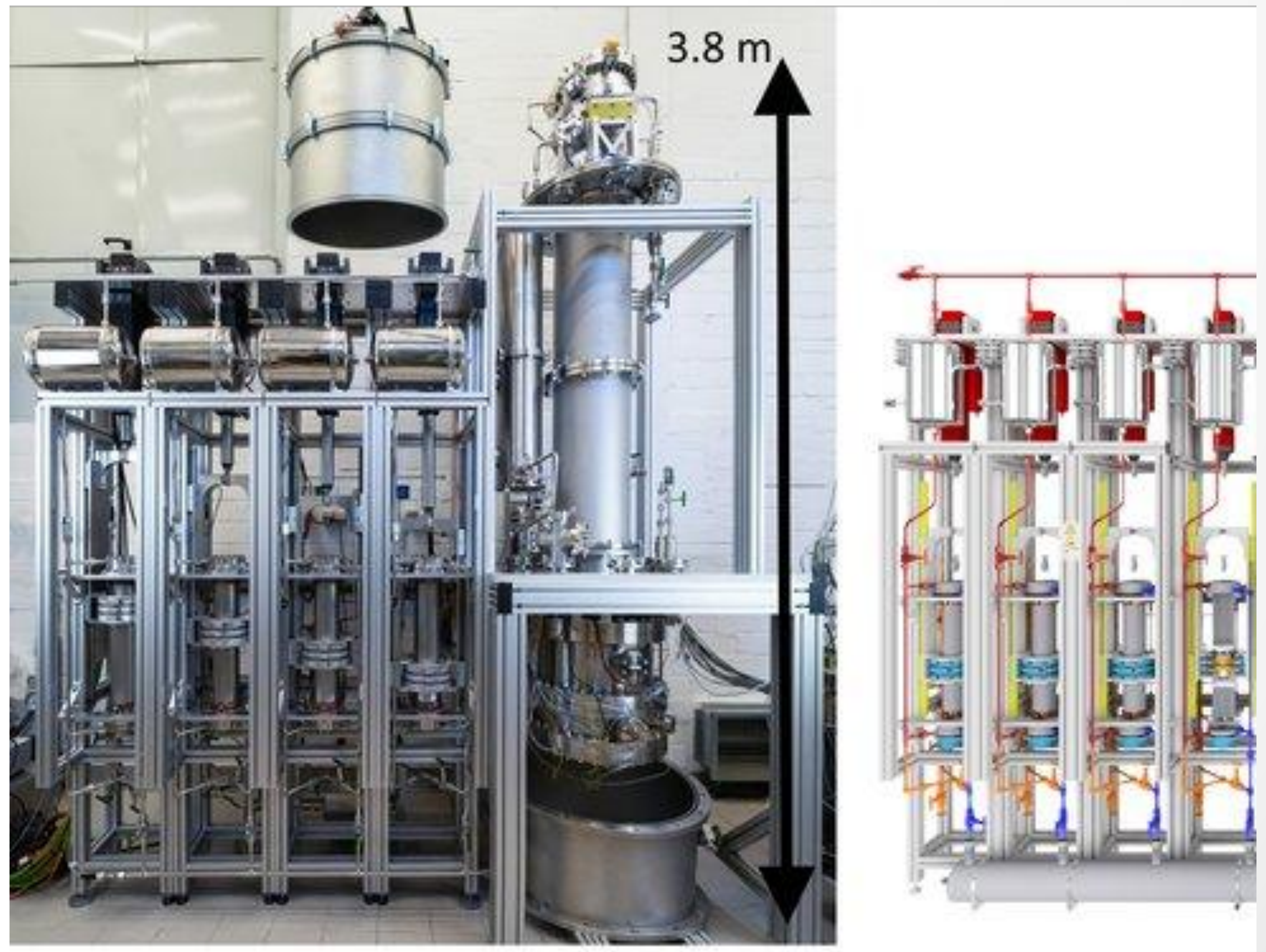


Liquid xenon purification

Neutron veto



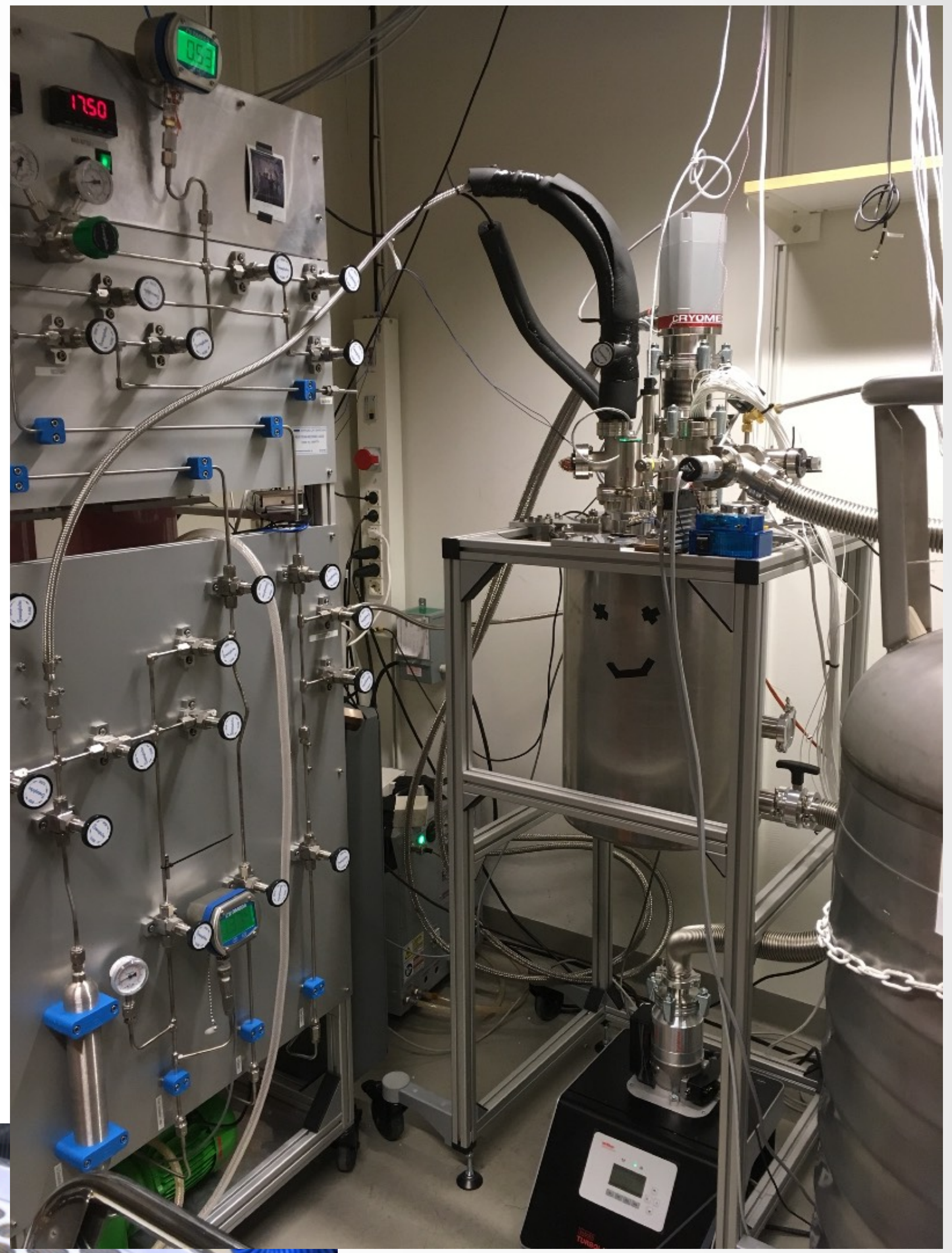
Radon destillation

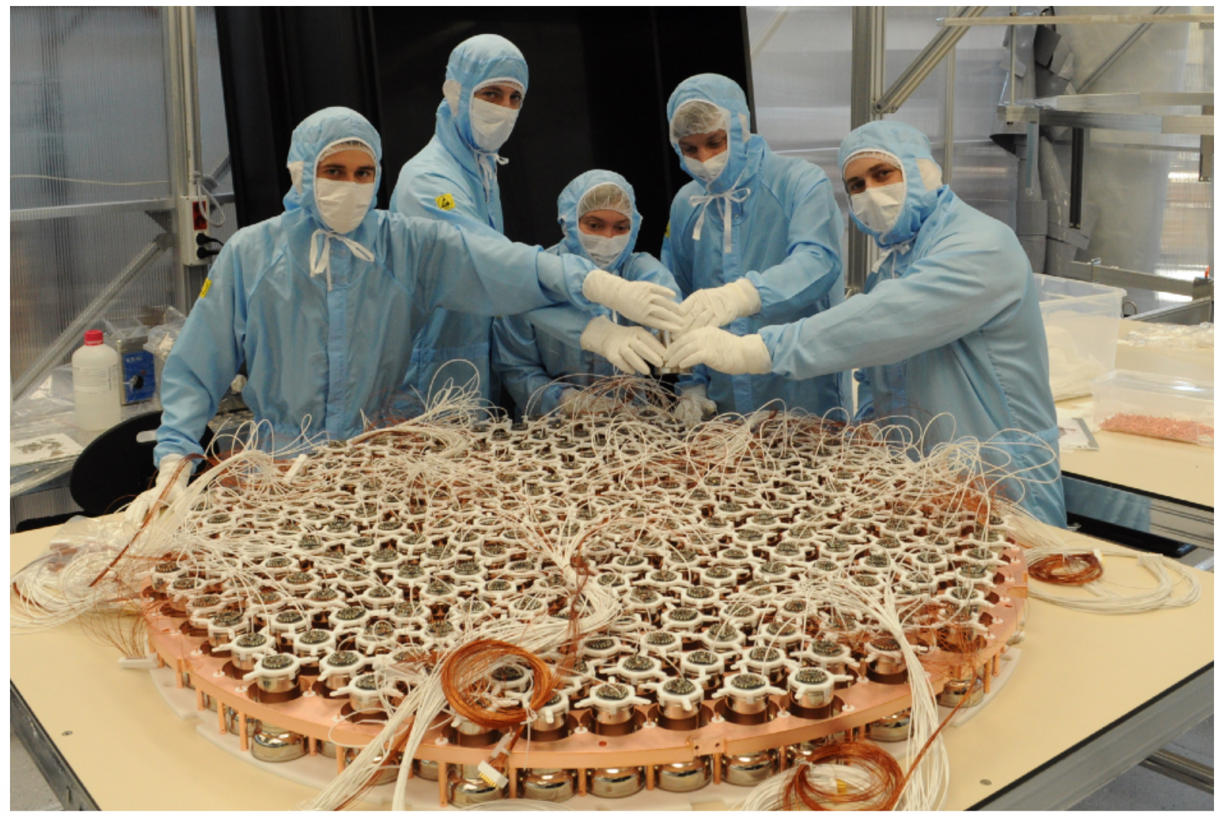


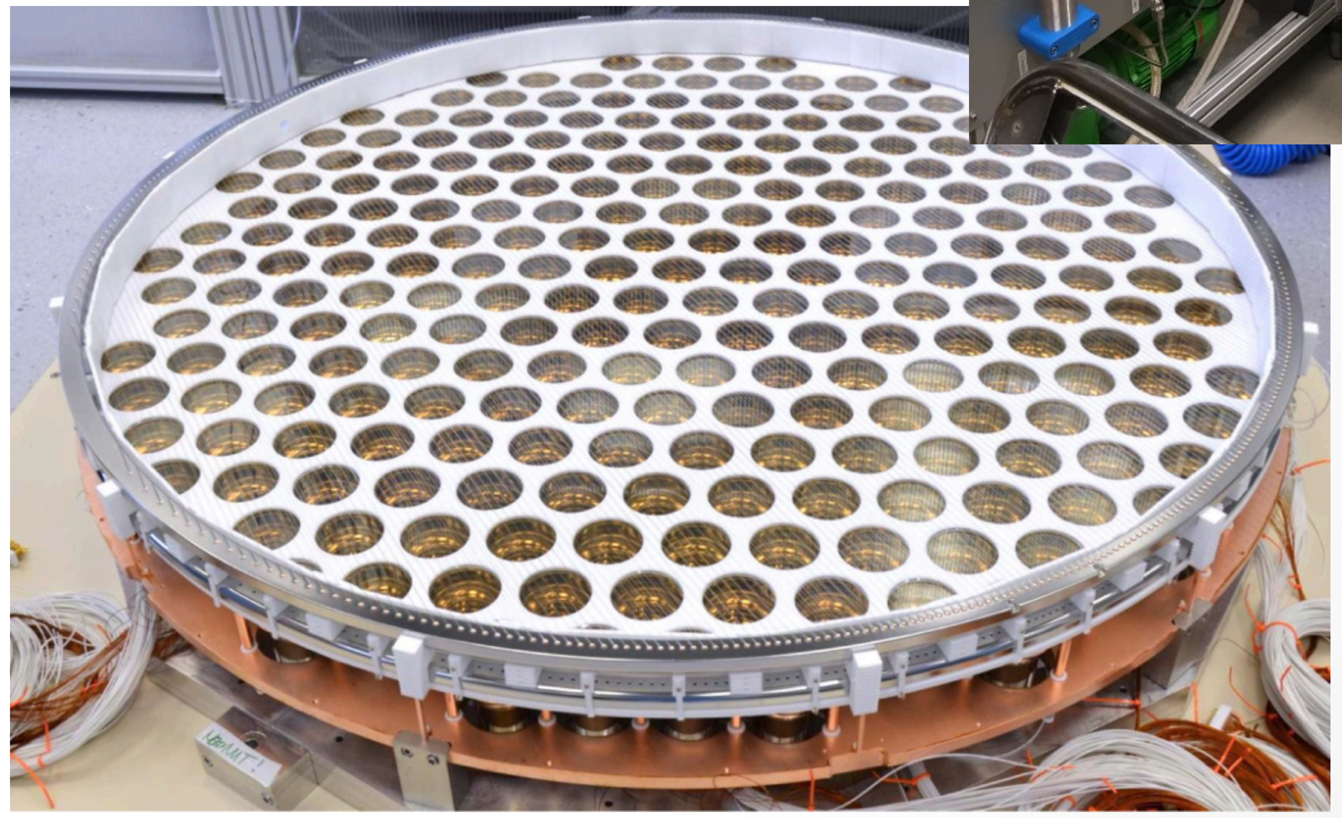
SU PMT Tests and Assembly of XENONnT

- 494 Photomultiplier tubes (PMTs) are used in XENONnT
  - PMTs were tested in liquid xenon at SU
  - Assembly of the XENONnT arrays in 2019 lead by SU
  - Commissioning of the XENONnT detector in 2020/21
  - Taking science data since 2021
  - Status today, after 3 years: 97% of all PMTs still operational

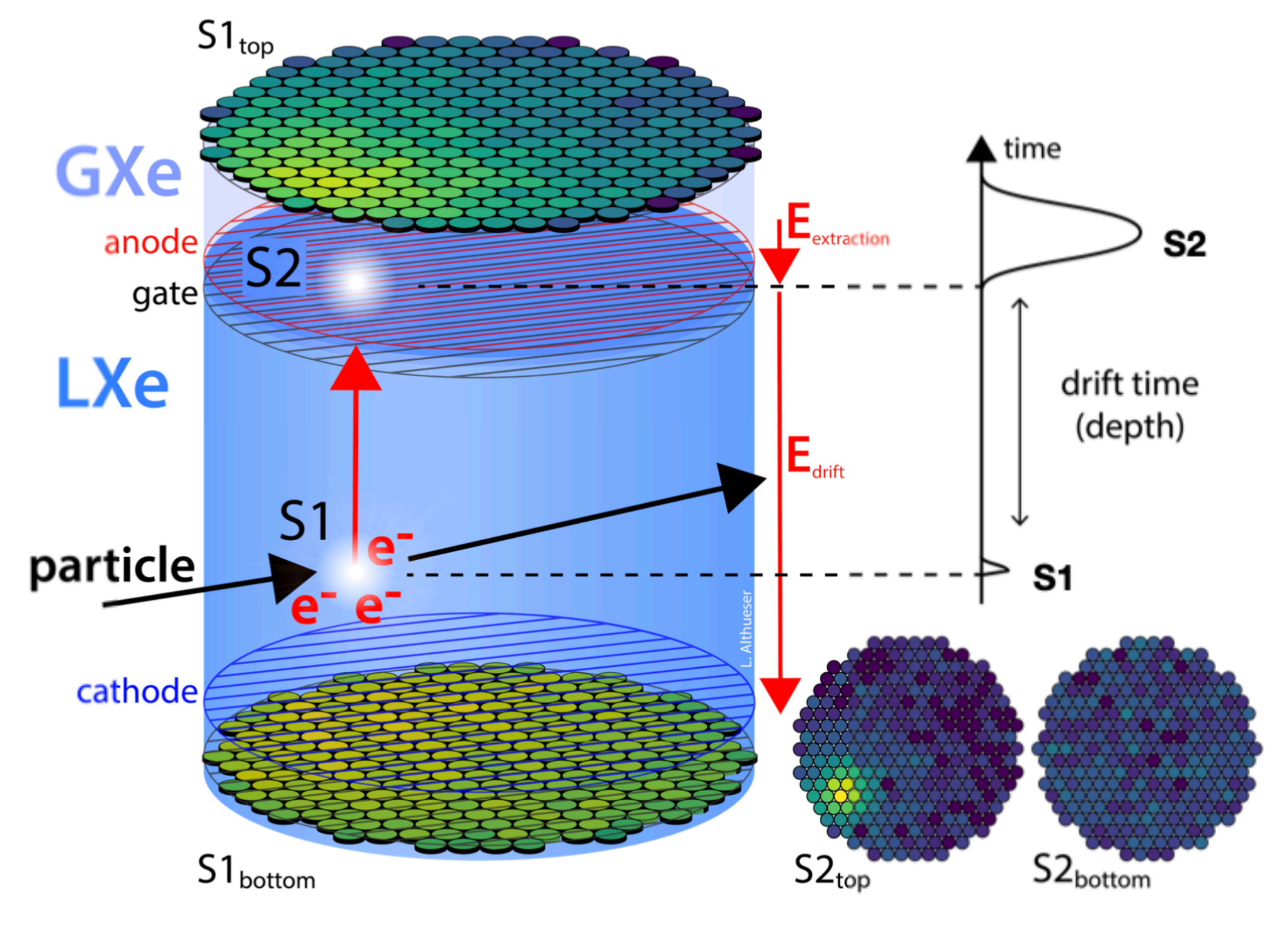
SU test facility







Backgrounds for WIMP search



Electronic recoils (ER)

- Dominated by ^{214}Pb (from ^{222}Rn)
- Suppressed by ER/NR separation

Accidental coincidences (AC)

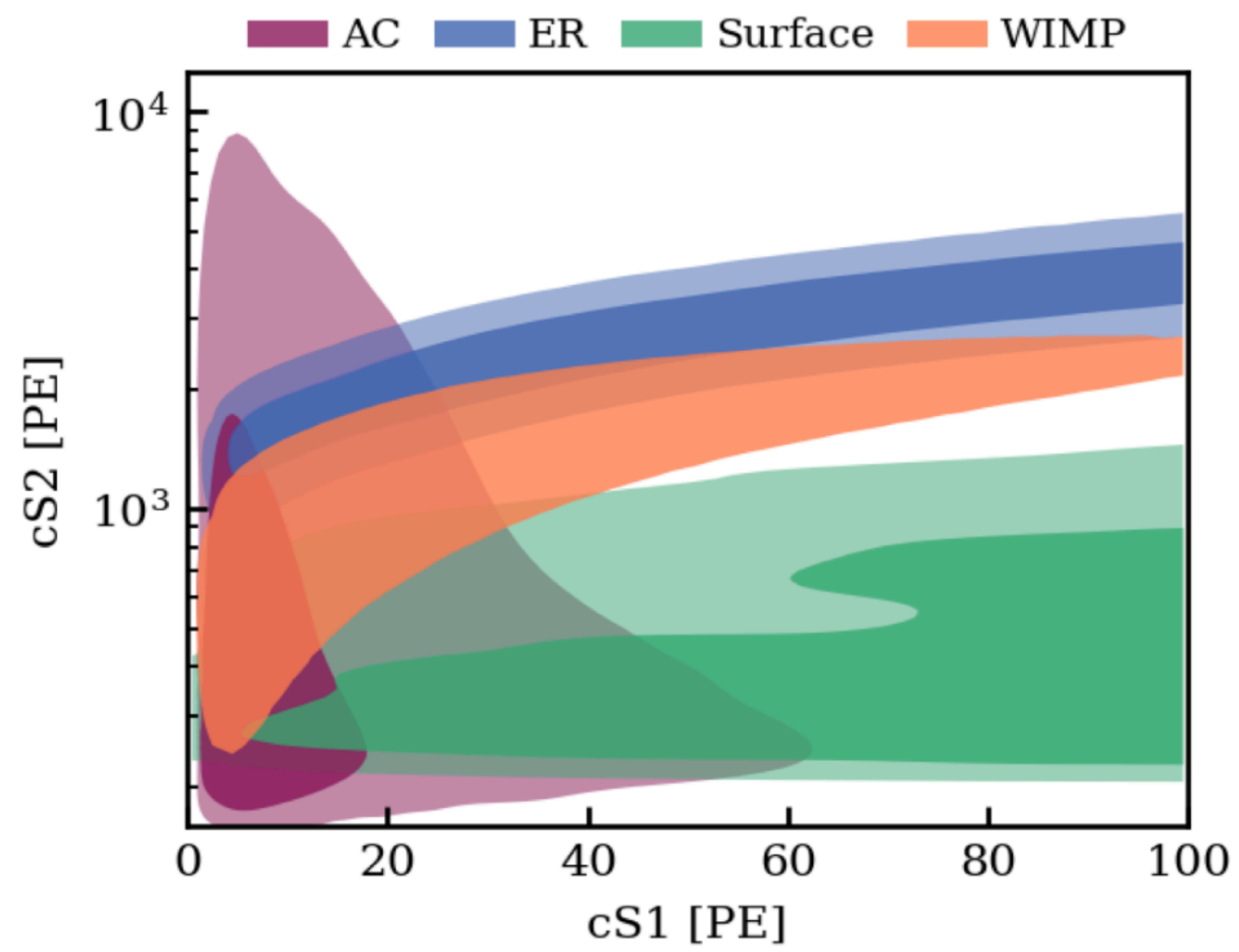
- Random pairing of isolated S1/S2
- Suppressed by analysis cuts

Surface

- ^{210}Pb plate-out during construction
- Radial selection

Nuclear recoils (NR)

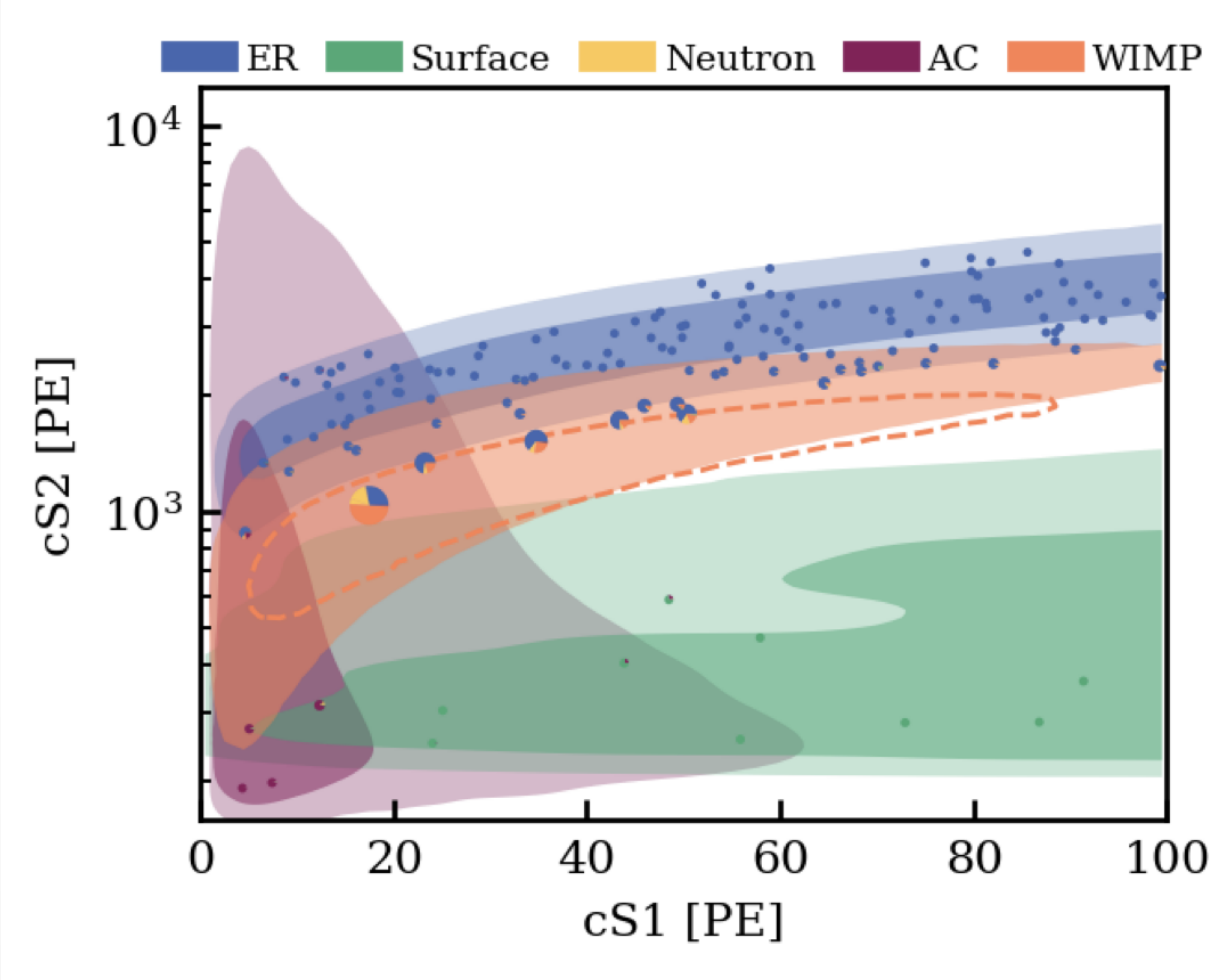
- Radiogenic neutrons: fission & (α, n)
- CEνNS: Solar & atmospheric neutrinos



Expected Background events:

ER	AC	Surface
134	4.3 ± 0.2	14 ± 3
Neutrons	**CEνNS**	**Total**
$1.1^{+0.6}_{-0.5}$	0.23 ± 0.06	154

WIMP result for SR0 (95.1 days)



Un-blinding SR0 NR data

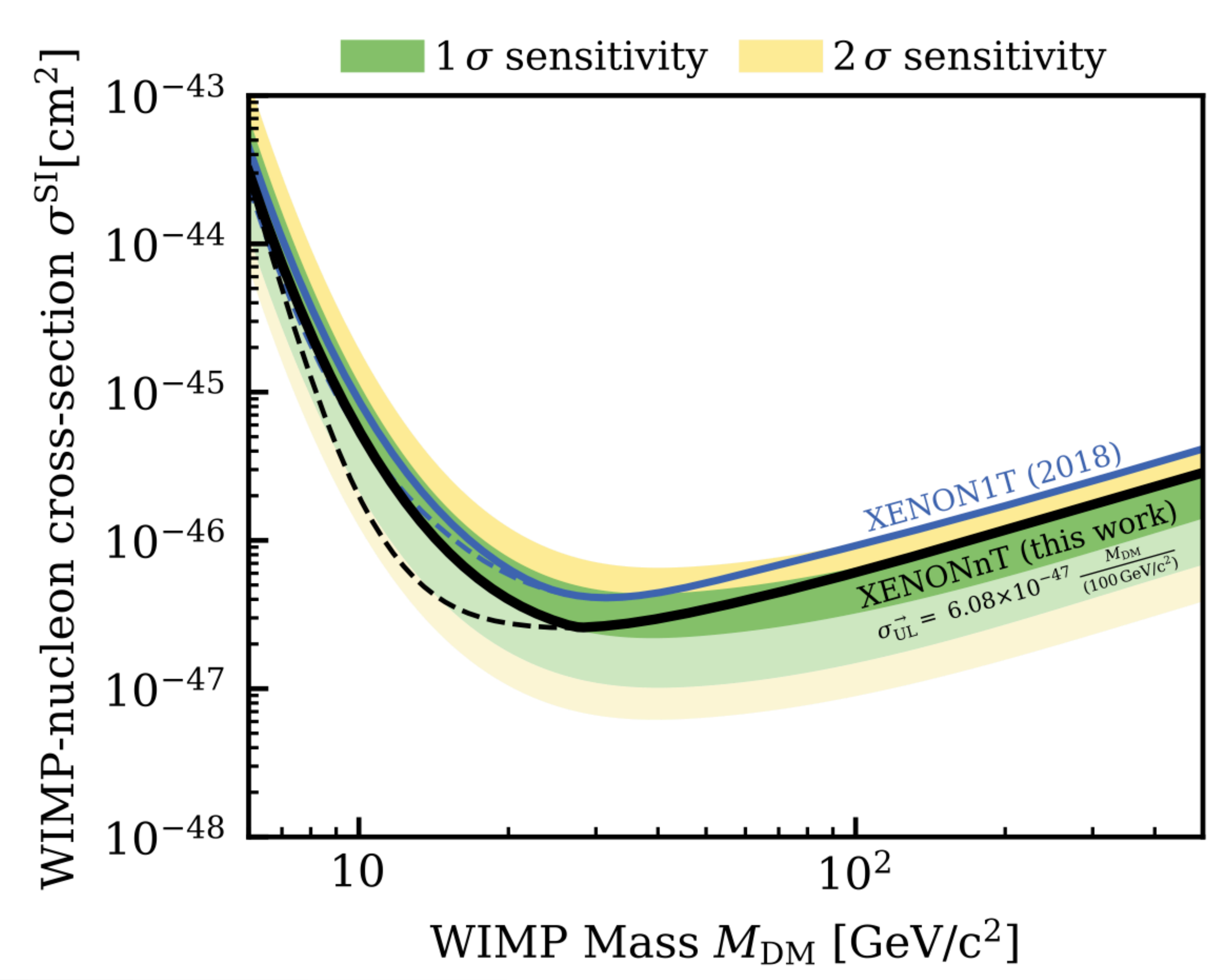
200 GeV/c²

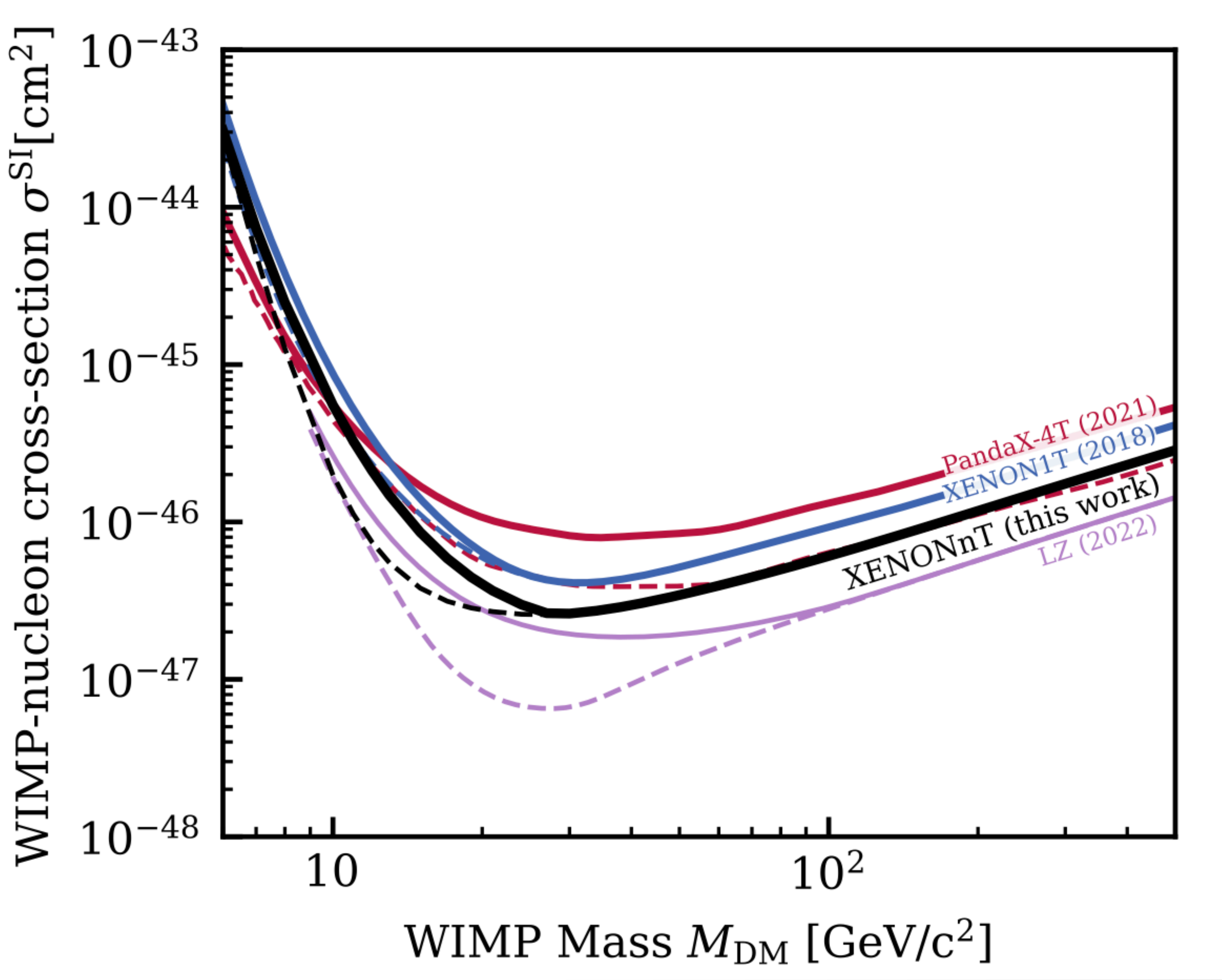
	Nominal	Best Fit
ER	134	135 (+12) (-11)
Neutrons	1.1 (+0.6) (-0.5)	1.1 ± 0.4
CEvNS	0.23 ± 0.06	0.23 ± 0.06
AC	4.3 ± 0.2	4.32 ± 0.15
Surface	14 ± 3	12 (+0) (-4)
Total Background	**154**	**152 ± 12**
WIMP	-	2.6
Observed	-	**152**

→ Best fit indicates **no significant excess!**

arXiv: [2303.14729v1](2303.14729v1)

Setting limits on WIMP DM



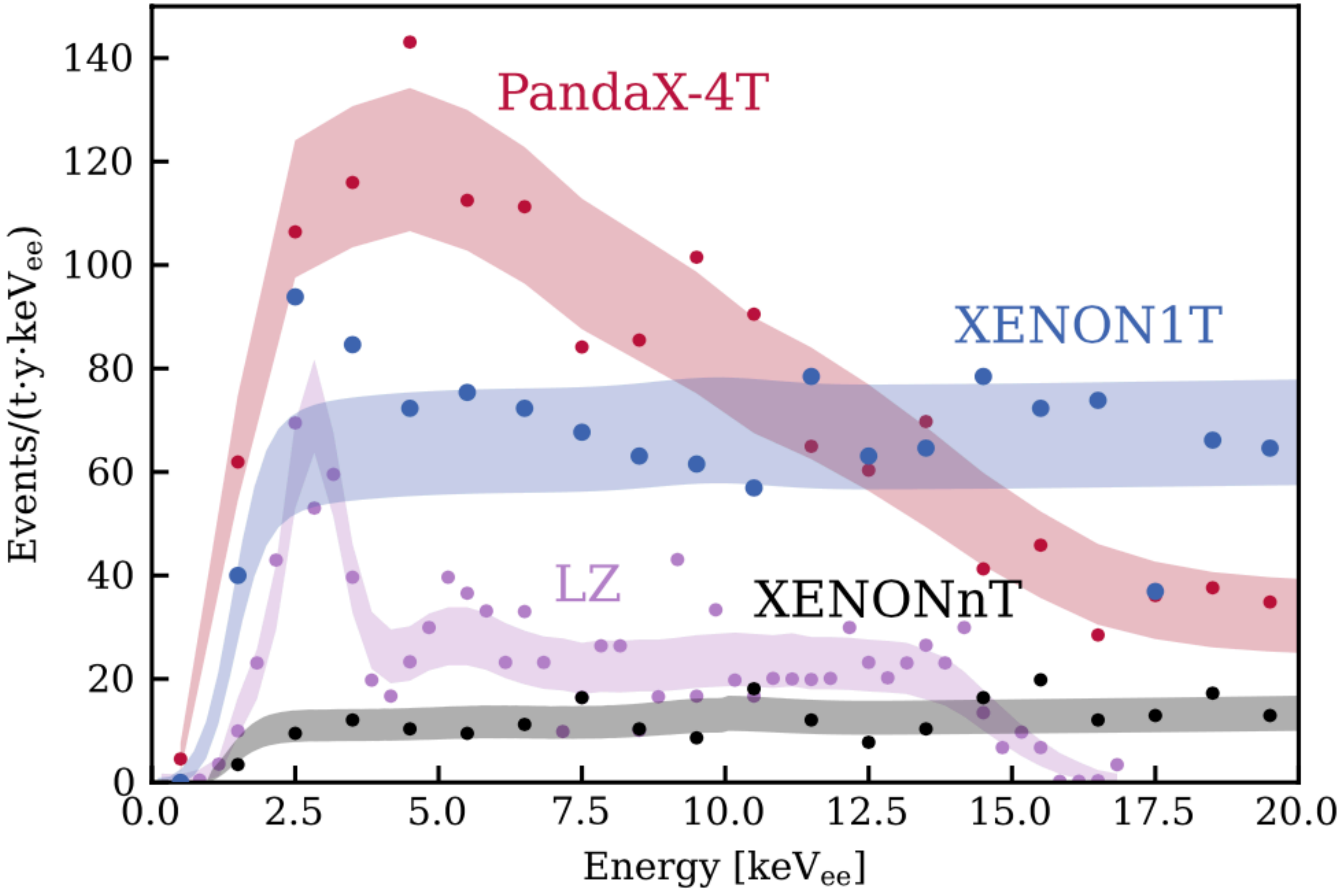


SU: coordination of statistics sub group

arXiv: 2303.14729v1

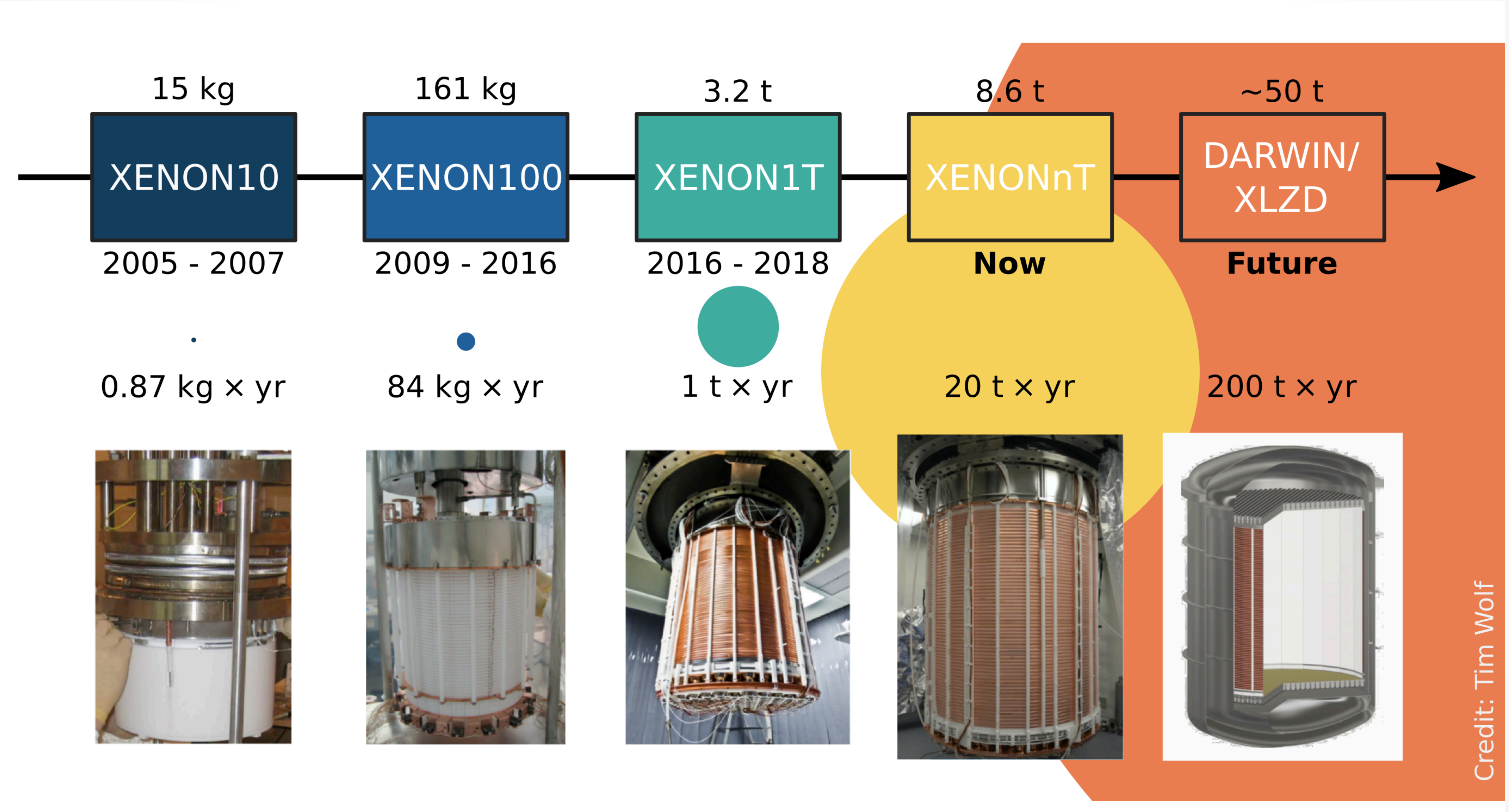
Low ER search and future of XENONnT

PRL 129, 161804 (2022)
PRD 102, 072004 (2020)
arXiv: 2207.03764 (2022)
PRL 129, 161805 (2022)

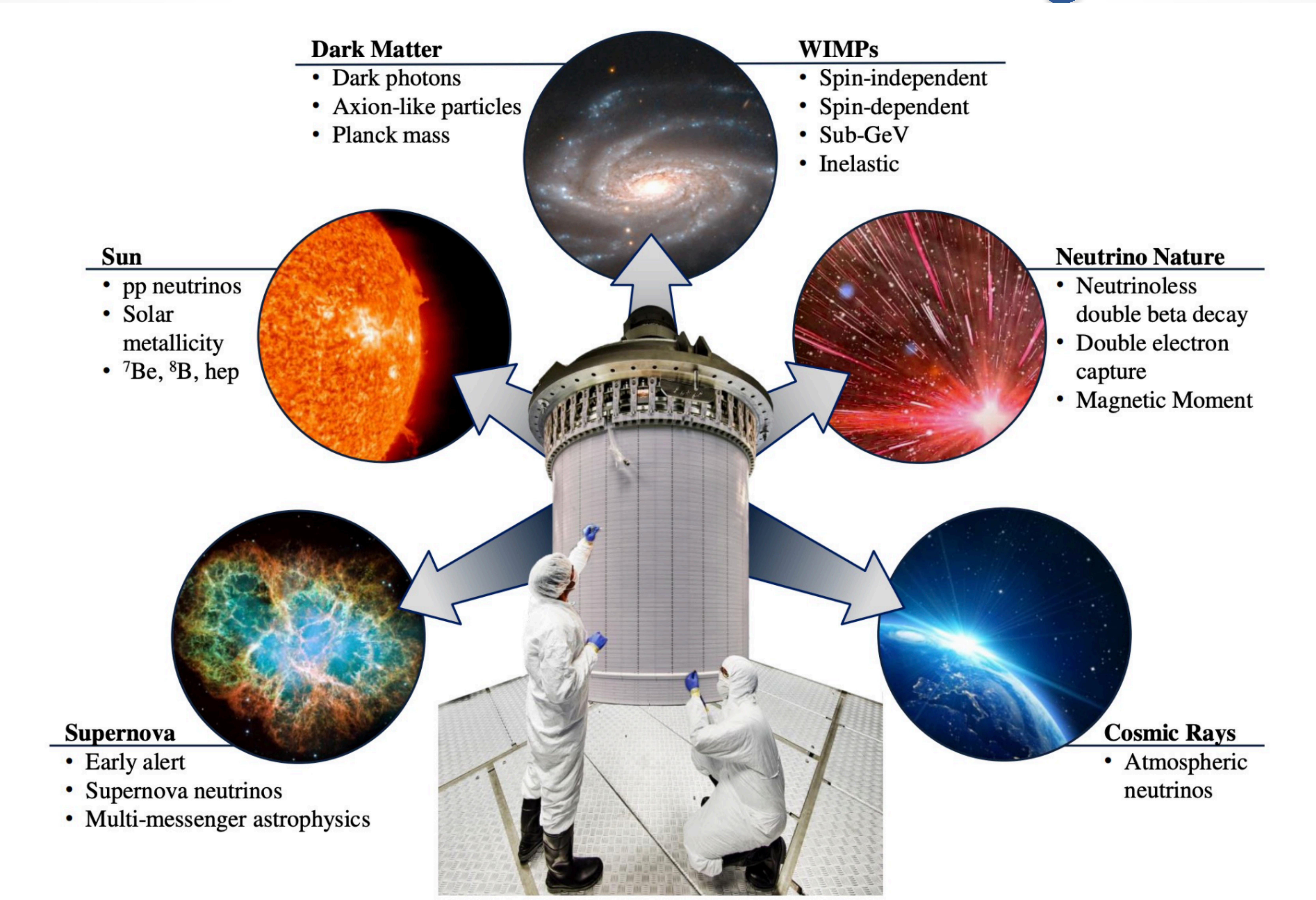


- No excesses found in electronic/nuclear recoil region in XENONnT
- Factor 5 reduction in ER background XENON1T ⇒ XENONnT
- Further reduction is possible (^{222}Rn distillation using LXe & GXe) in SR1
- Taking blinded data since 2022 (SR1) ⇒ stay tuned

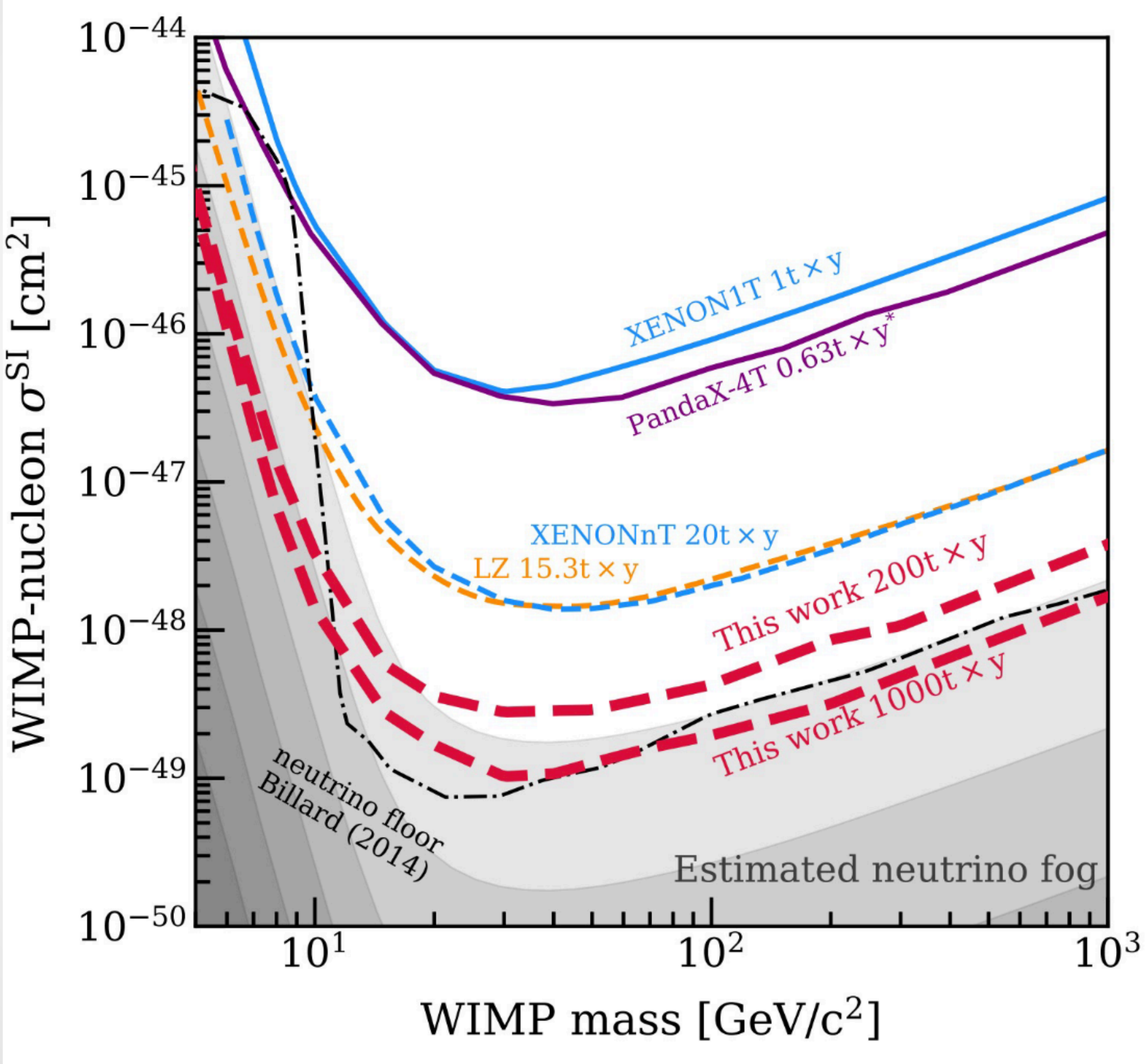
Future: DARWIN



DARWIN: Rich Science Program

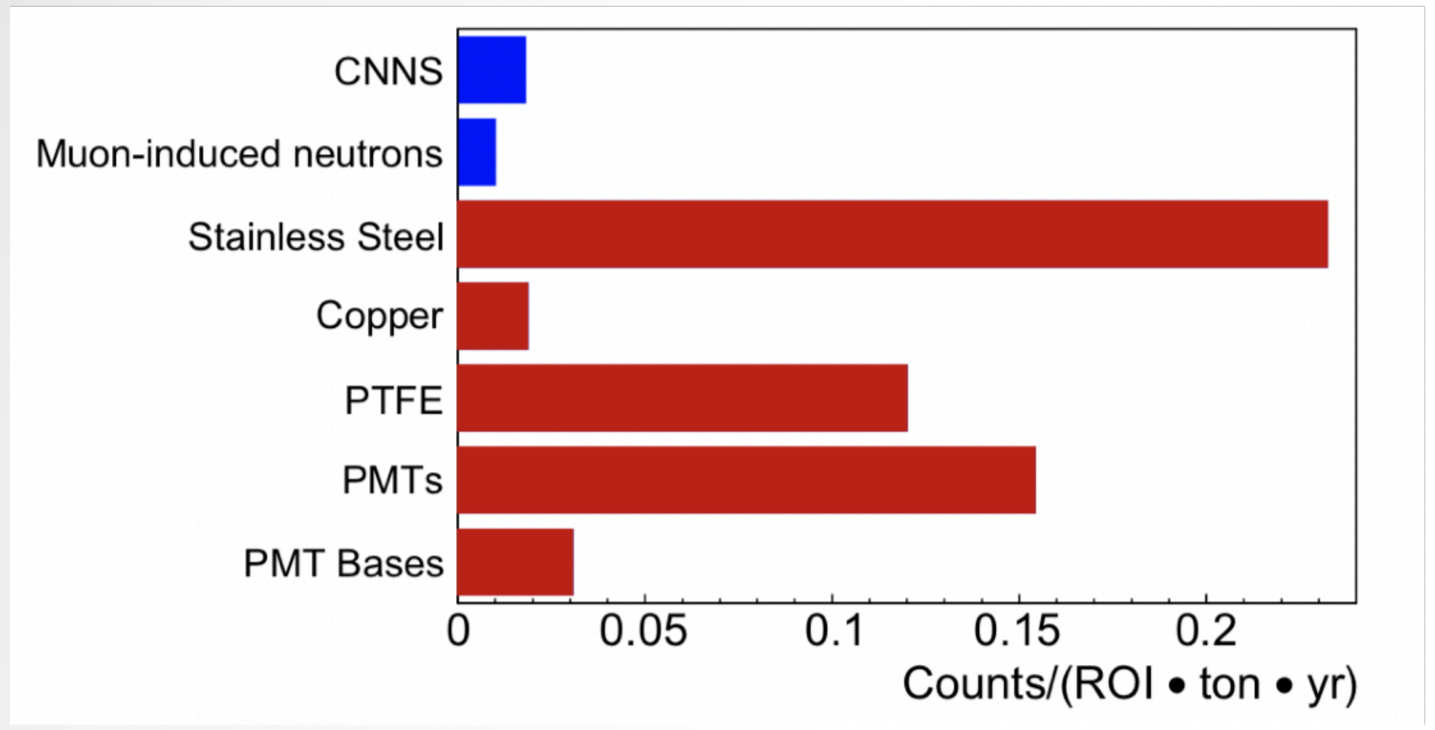


Sensitivity in WIMP region



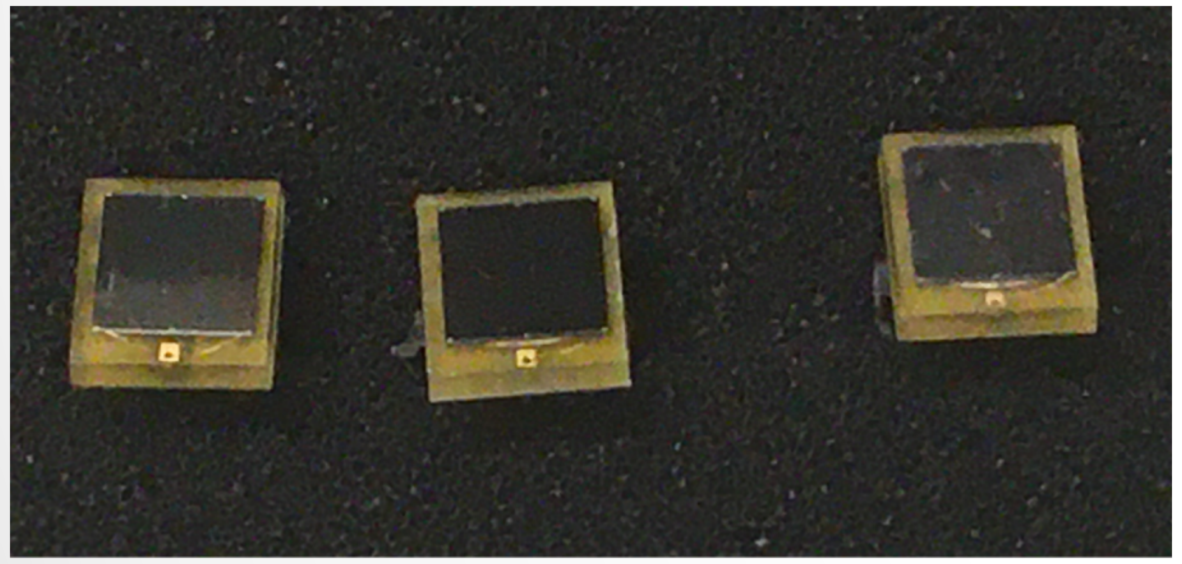
Covering all the remaining WIMP space until reaching the neutrino floor -> fog

SU contribution to DARWIN R&D

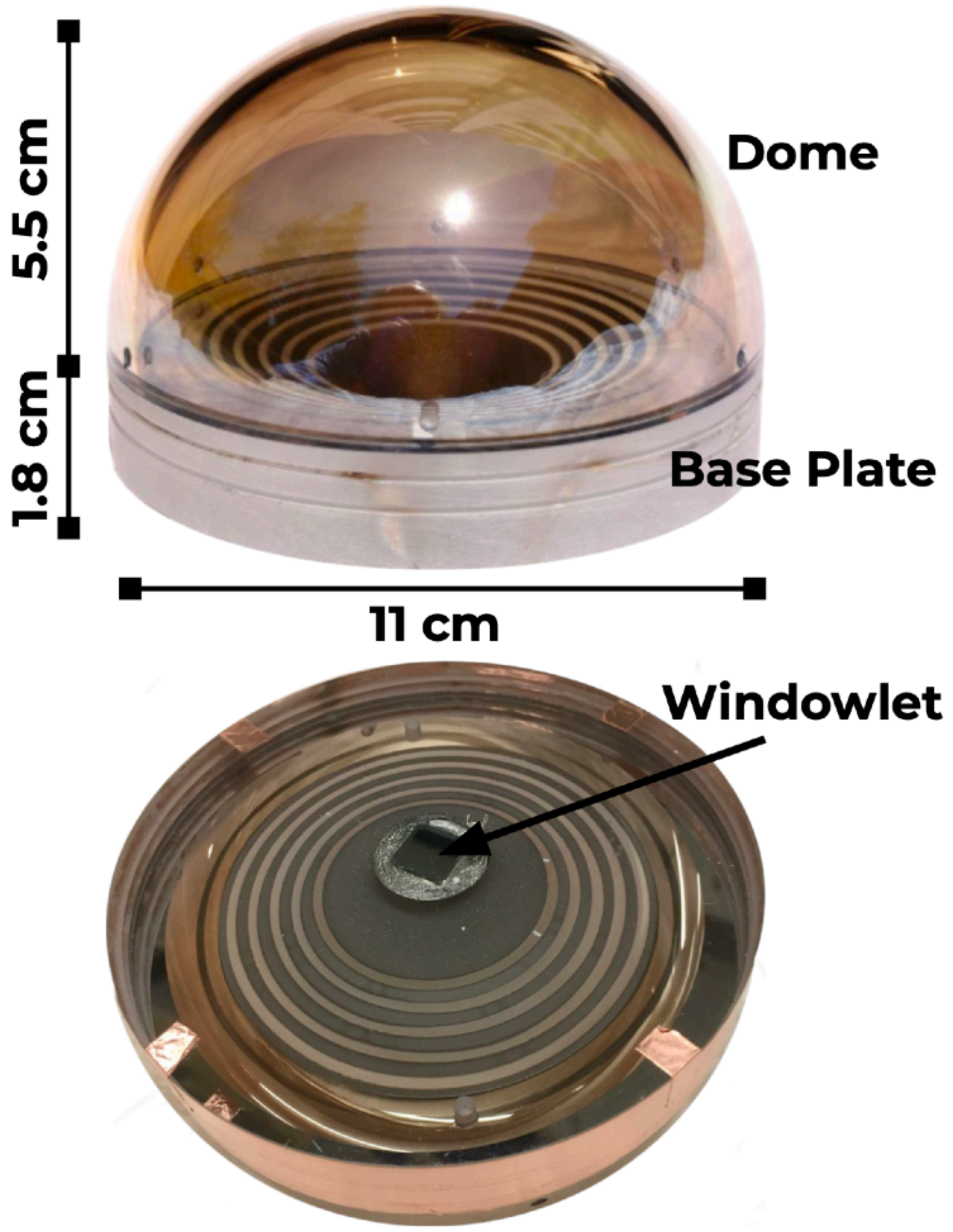


PMTs contribute to 1/3 of the total nuclear recoil background

Alternative Photosensors

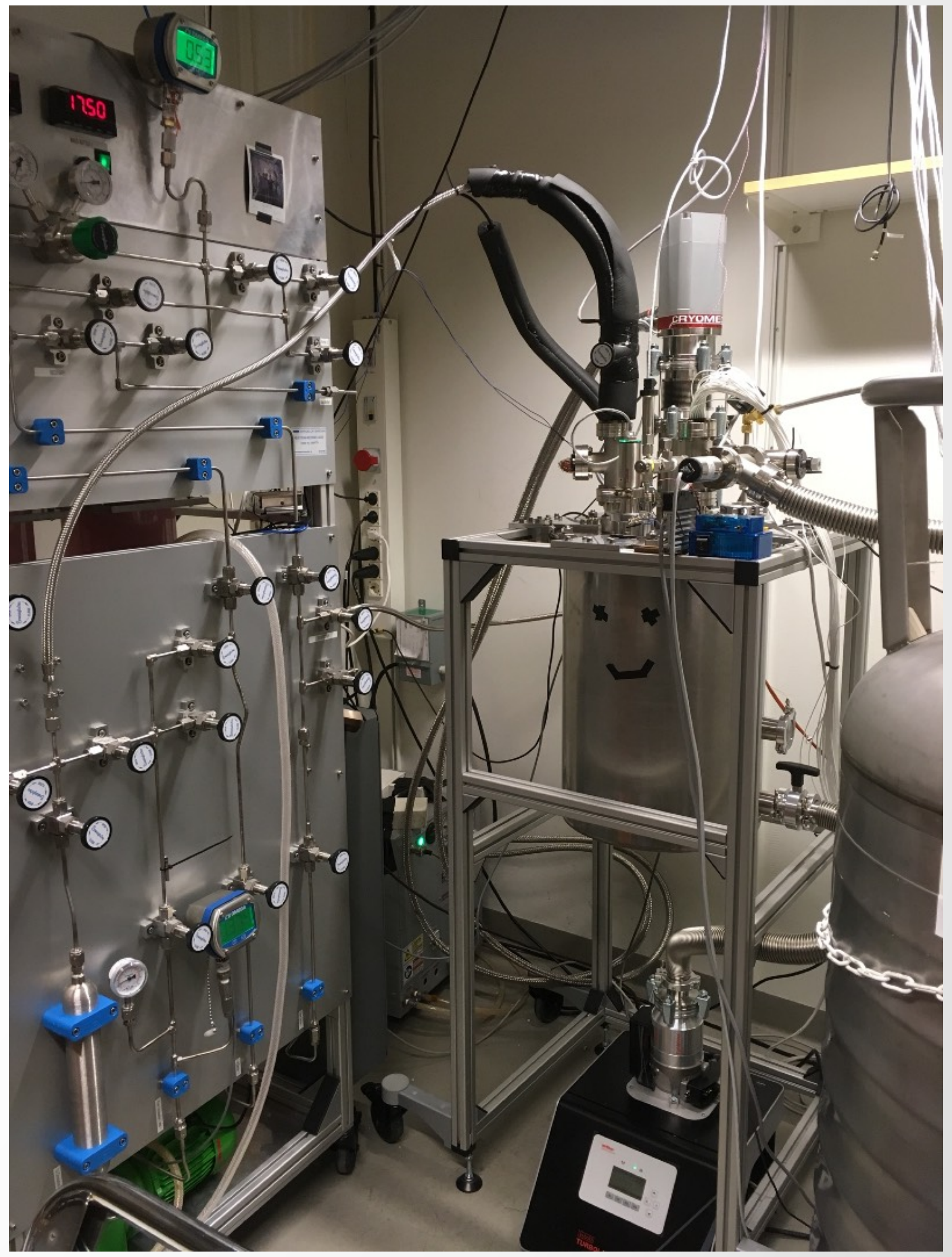


SiPMs (disadvantage: high dark count rate)



ABALONE photosensor:

- Low radioactivity
- Low dark count rate
- Tests at SU in xenon at cryogenic temperatures



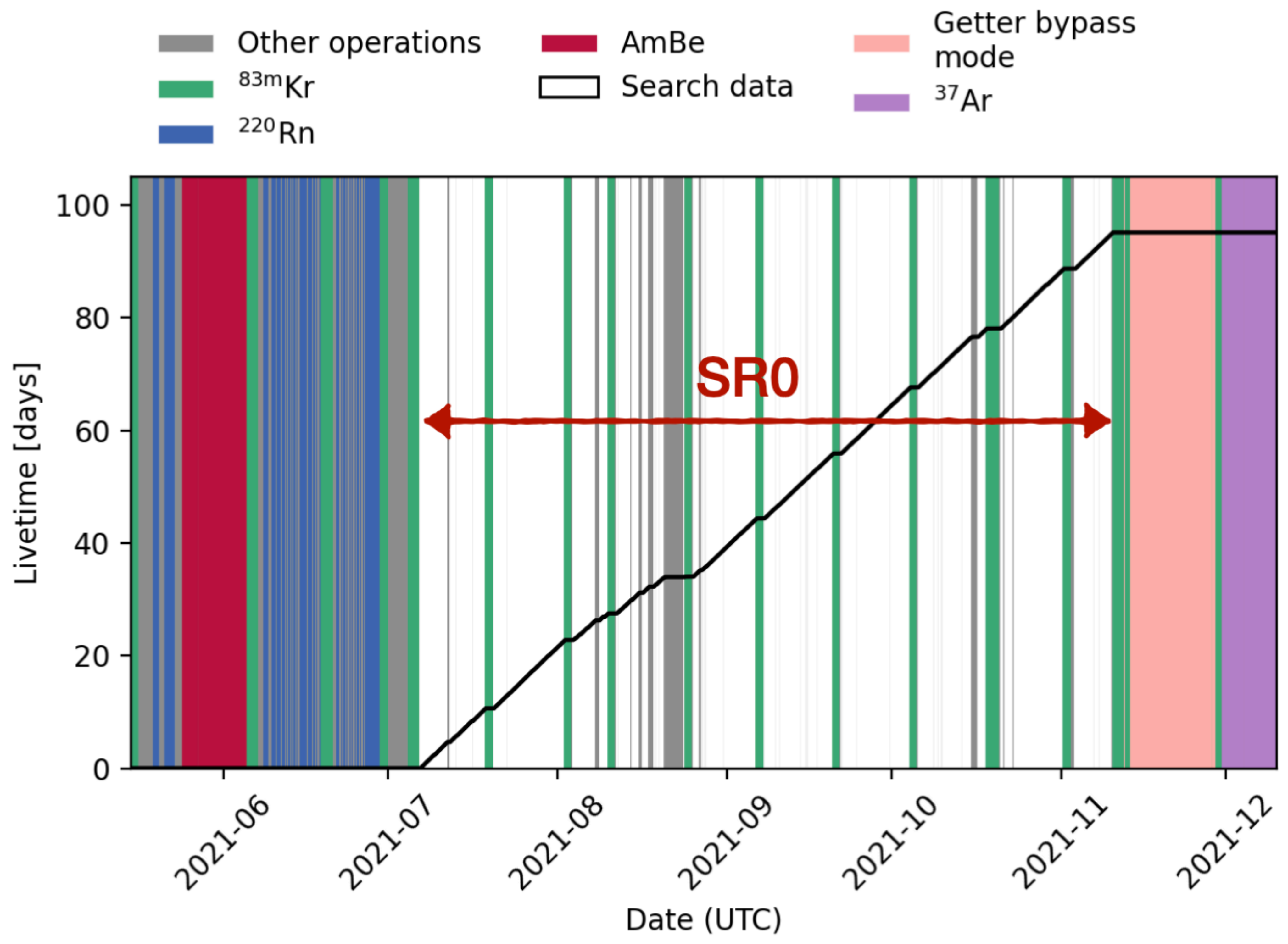
XLZD consortium

Thank you!

Backup

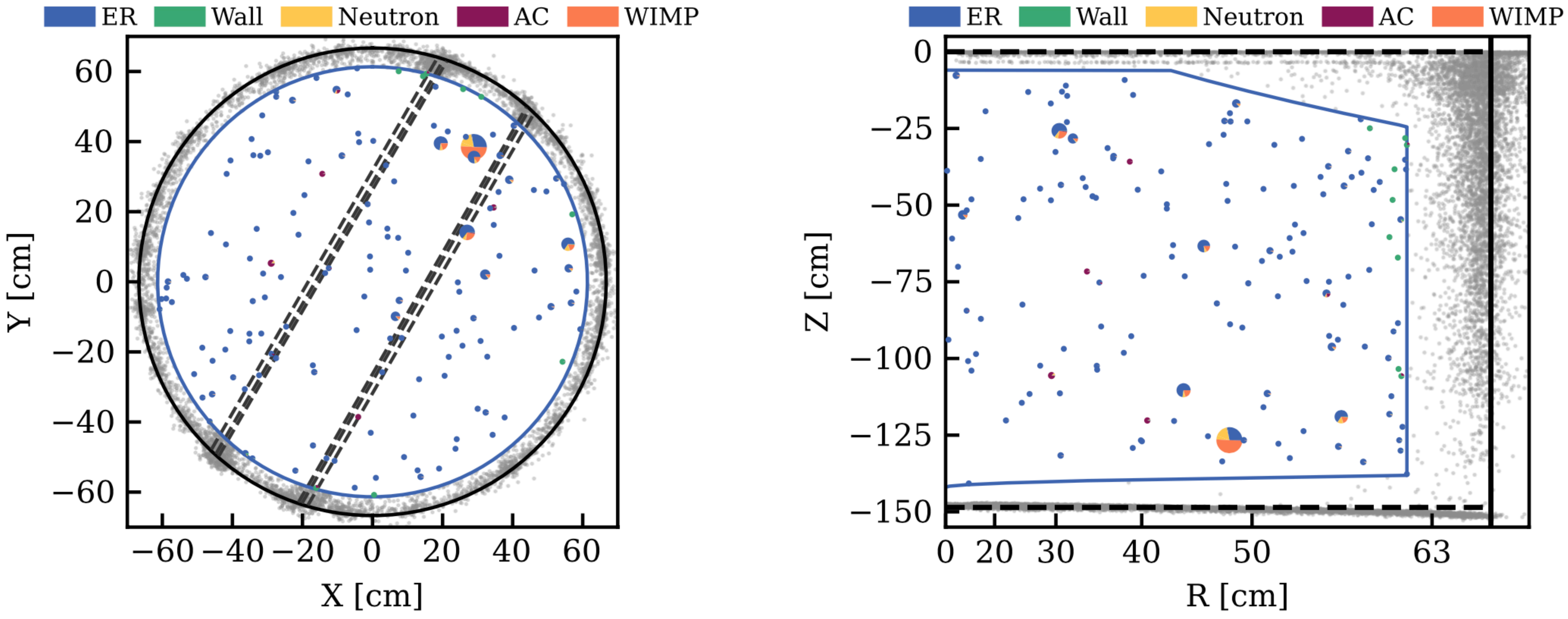
SR0

SR0 Nuclear Recoil search data



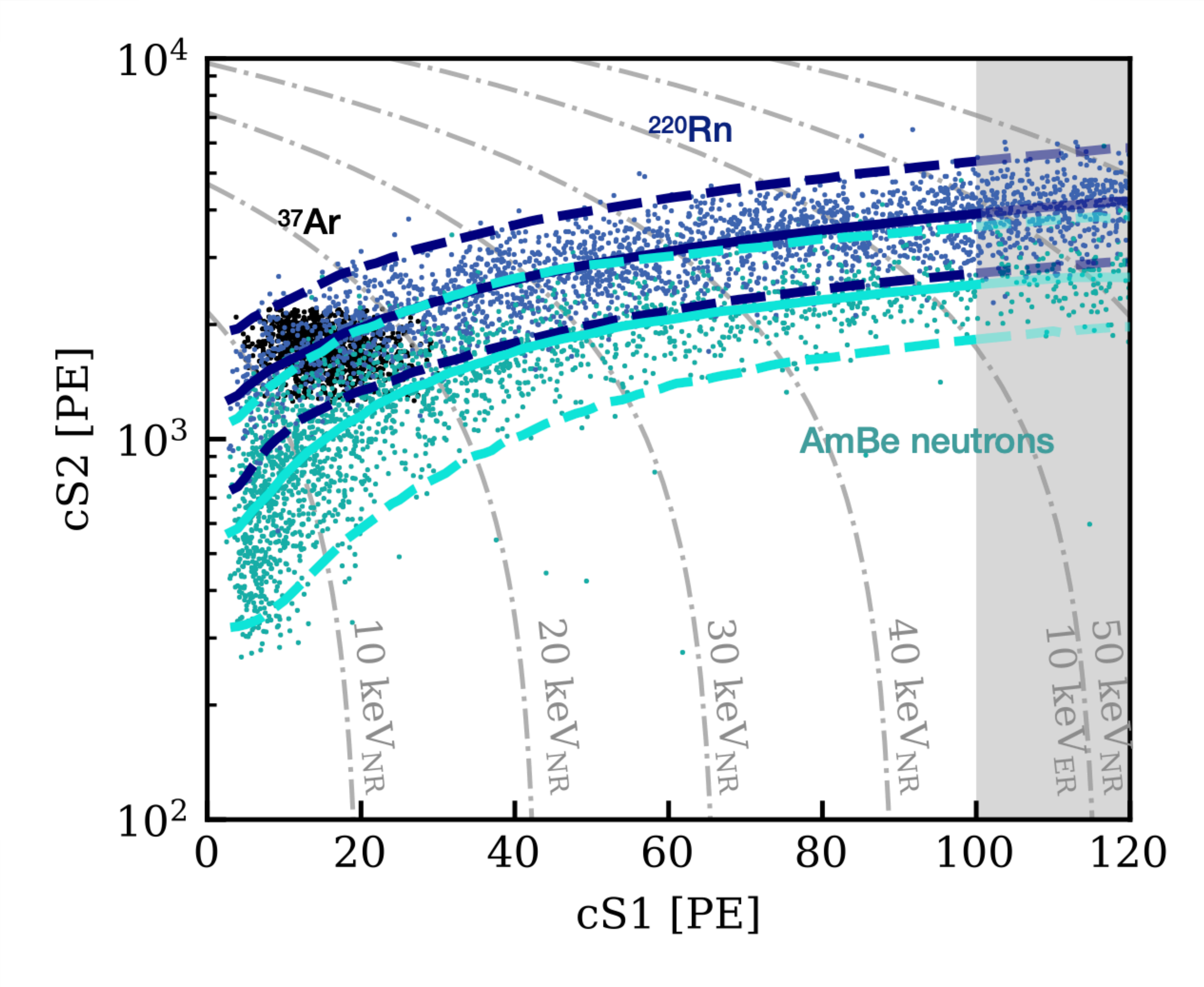
- Extensive calibration periods before (and after) the search data period
- July 6 – Nov 10, 2021 (97.1 real time days)
- 95.1 days lifetime corrected
- **(4.18 ± 0.13) tonnes** fiducial volume
- Exposure of **1.1 tonne x years**
- **Blinded analysis**

Event distribution

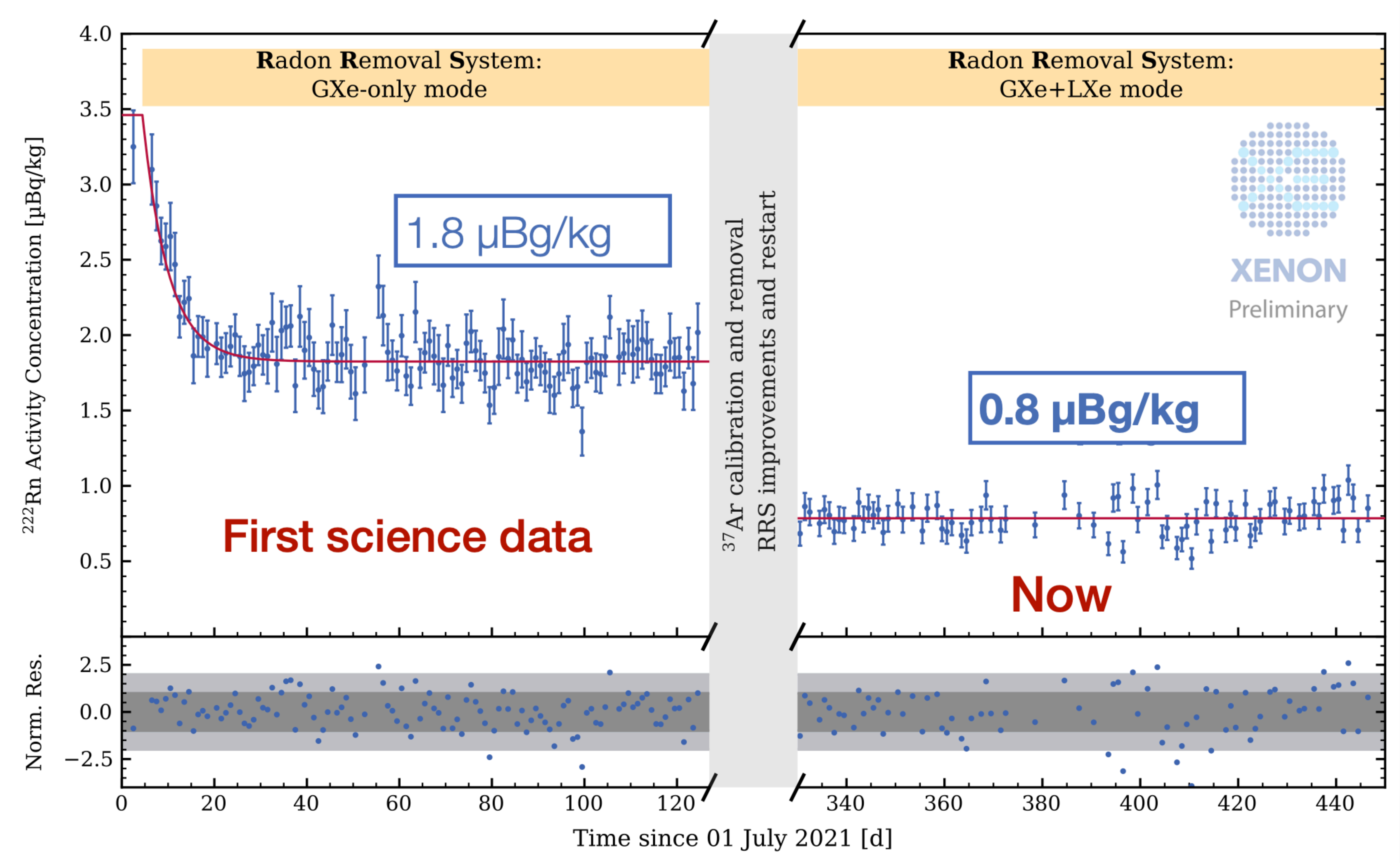


- XY asymmetry in unblinded data
- Not observed in corrections, quality selection or calibration data

Calibration



Rn removal



Radon Removal System:
GXe-only mode
Radon Removal System:
GXe+LXe mode
1.8 μBg/kg
0.8 μBg/kg
First science data
Now
XENON
Preliminary
^{37}Ar calibration and removal
RRS improvements and restart
^{222}Rn Activity Concentration [μBq/kg]
Norm. Res.
Time since 01 July 2021 [d]