

2023 CDM Annual Workshop, Adelaide



First Science Run Results

of XENONnT

Yajing Xing – Subatech | CNRS
On behalf of the XENON collaboration





XENON

France-Australia Joint Program

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023



XERD – DM – ν

XENon Time Projection Chambers: R&D for Future Generation Experiments, searching for **Dark Matter** and investigating the nature of neutrinos (ν)



Monthly Oz-France meetings organized by Theresa Fruth (Sydney)

French PI
Sara Diglio
SUBATECH/CNRS

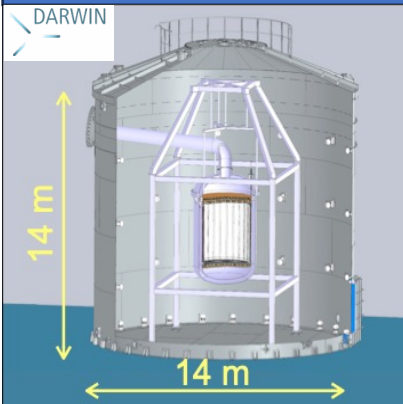
- 4 Joints PhDs SUBATECH – Melbourne
- Marina Bazyk (2021 – 2024)
 - Owen Stanley (2022 – 2025)
 - Lorenzo Principe (2022 – 2025)
 - Ananthakrishnan Ravindran (2023 – 2026)

- 2 Postdocs strongly committed
- Yajing Xing (SUBATECH)
 - Robert James (Melbourne)

Phill (Melb), Celine (Sydney), Dominique (SUBATECH), Ciaran (Sydney), Jayden (Melb), Luca (LPNHE), ...

Australian PI
Elisabetta Barberio
Melbourne

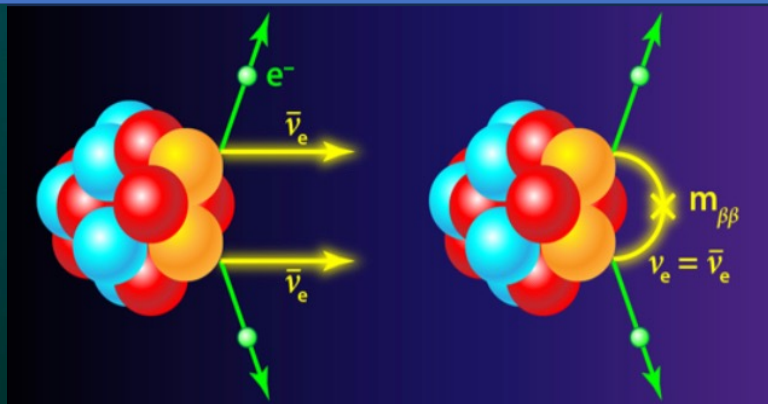
Future generation LXe experiments



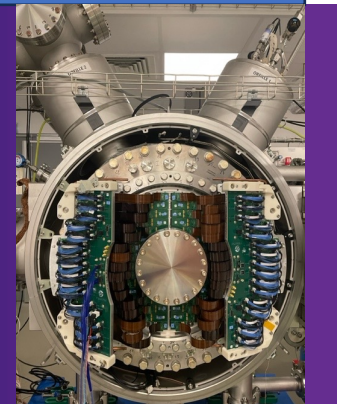
Dark Matter searches



Neutrinoless Double Beta Decay



LXe technology





XENON

France-Australia Joint Program

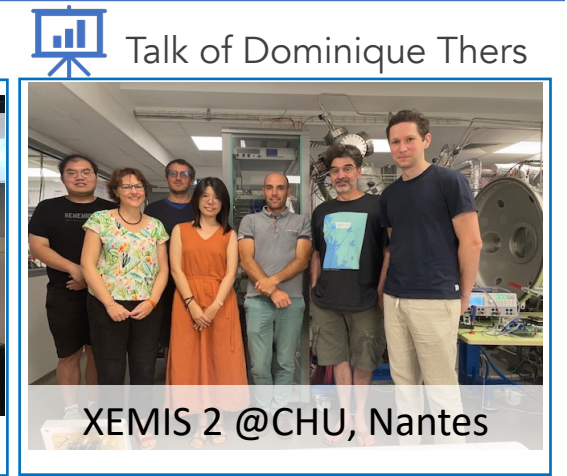


XERD – DM – ν

XEnon Time Projection Chambers: R&D for Future Generation Experiments, searching for **D**ark **M**atter and investigating the nature of neutrinos (ν)



Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023



2024 – 2028 : Willing to strenghten the collaboration around LXe technology
→ Submitted International Research Project (IRP) proposal CNRS – Australia



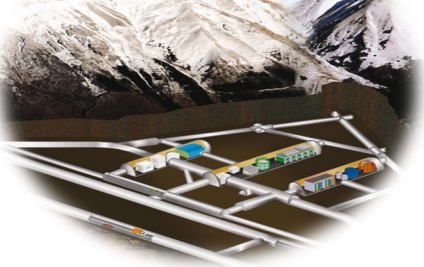
XENON

XENONnT Experiment

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023

INFN

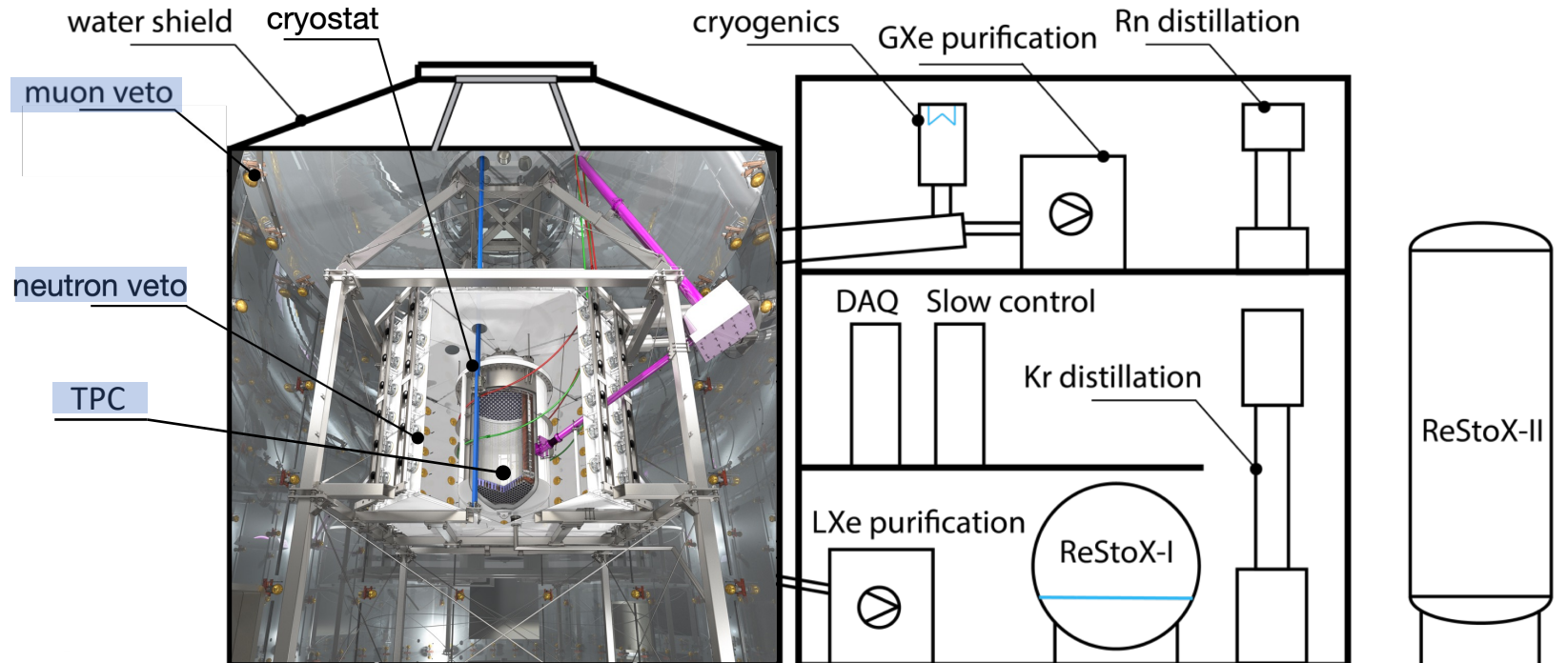
Laboratori Nazionali
del Gran Sasso



Overburden 3600 m.w.e
1 muon per m² per hour

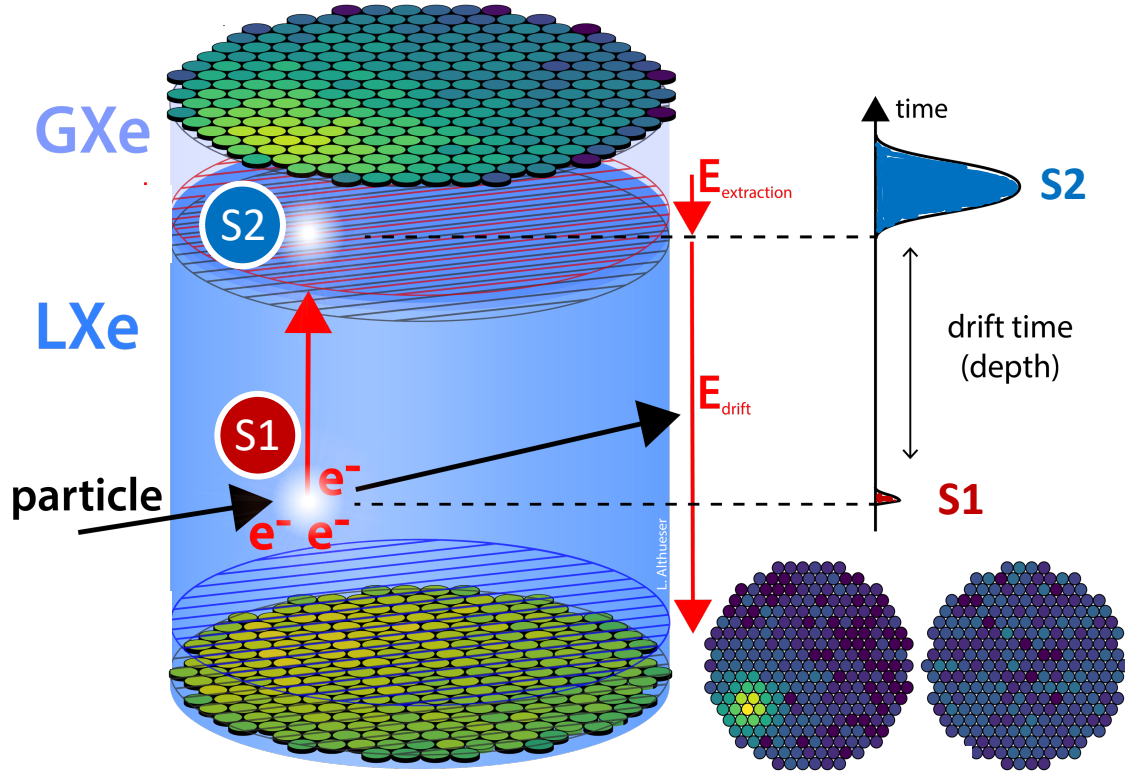
Sensitive to WIMP DM
candidates and other
new-physics channels

- Three nested detectors in a ~10 m x10 m water tank
 - muon veto, neutron veto, TPC
- Three-floor auxiliary building hosting experiment infrastructure
 - online distillation and purification systems
 - DAQ, SC and LXe storage

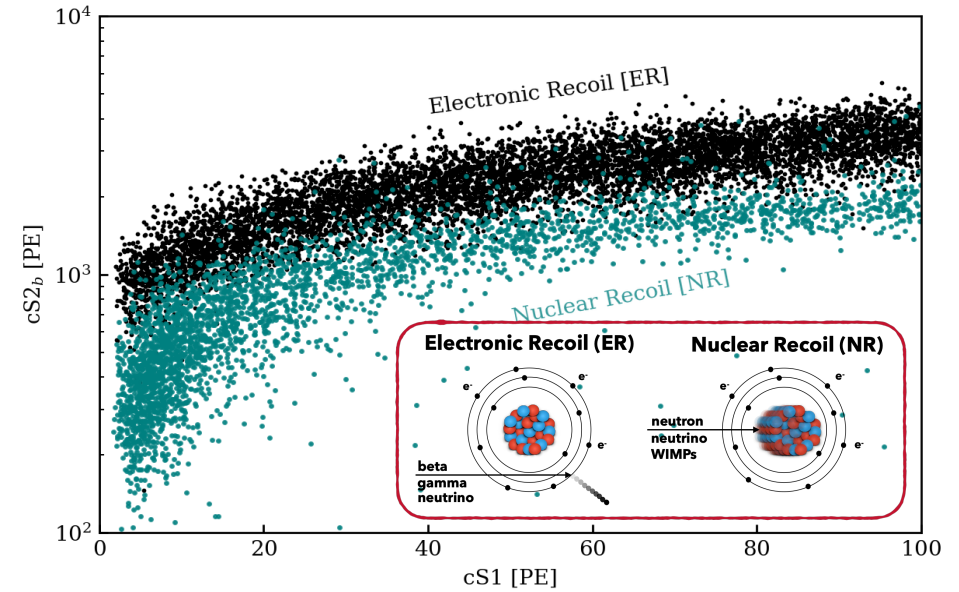


Dual-phase XENON TPC

- DETECTION** Scintillation and ionization signals:
- Prompt light (**S1**)
 - Proportional light from drifted electrons (**S2**)



- RECONST** Energy: **S1** area, **S2** area
 Position: Z (drift time), X-Y (**S2** pattern)
ER/NR Interaction type: **S2/S1** ratio



STRENGTH Particle discrimination allows for different physical process searches



XENON

Calibration - Particle discrimination]

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023

ER datasets:

^{220}Rn (^{212}Pb beta decay):

- modeling of ER-band response
- quality cuts validation
- energy threshold evaluation

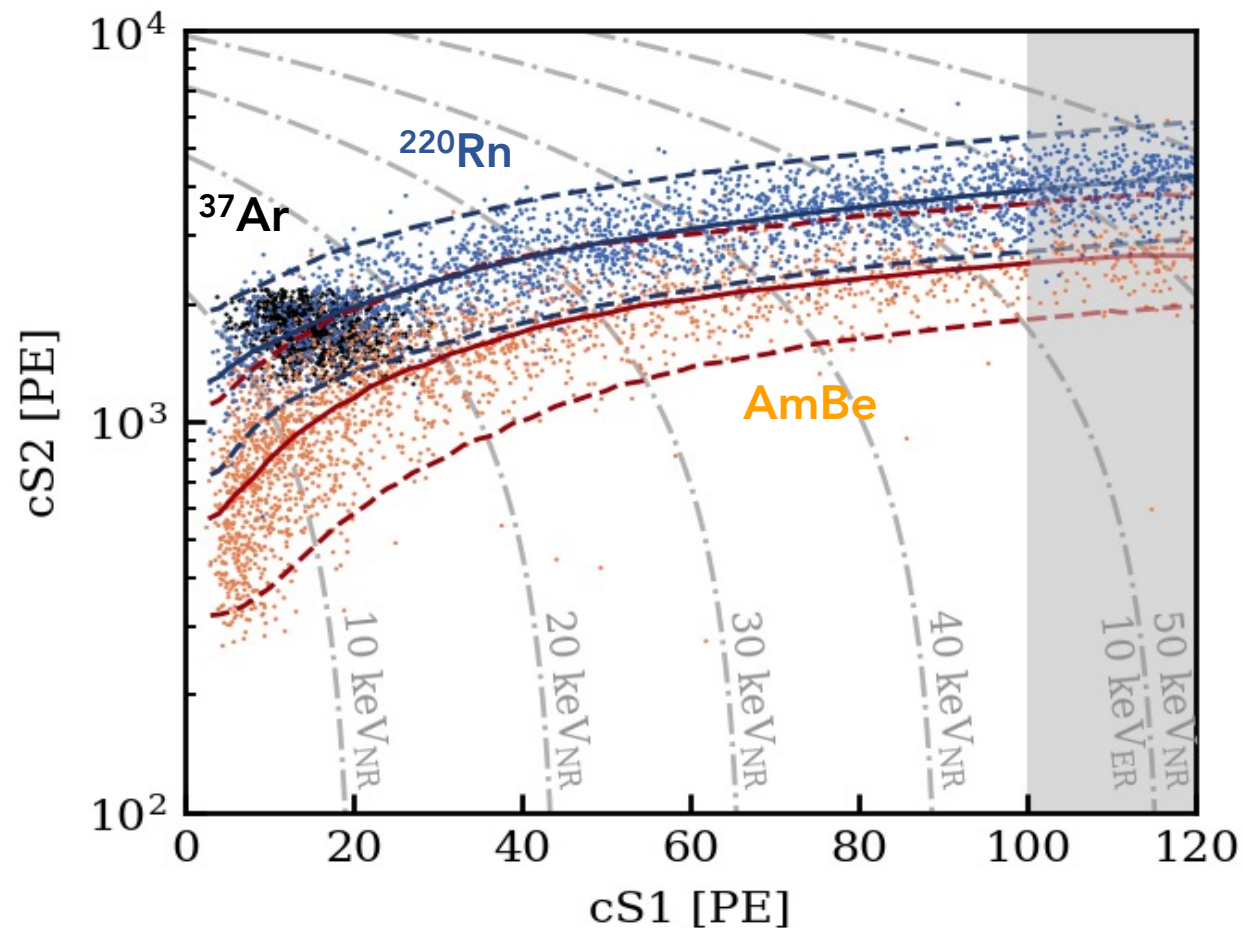
^{37}Ar :

- low energy response calibration
- peak reconstruction

NR datasets:

AmBe:

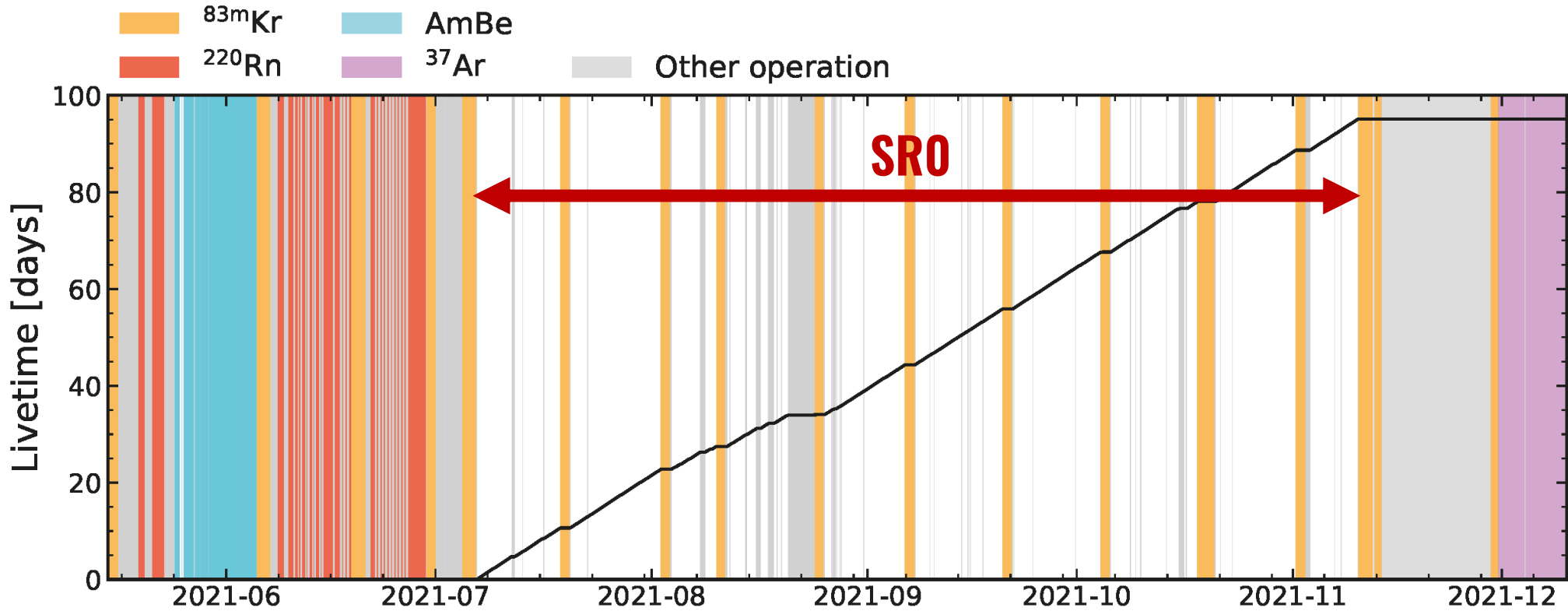
- modeling of NR-band response
- neutron veto characterization



First Science Run - SRO

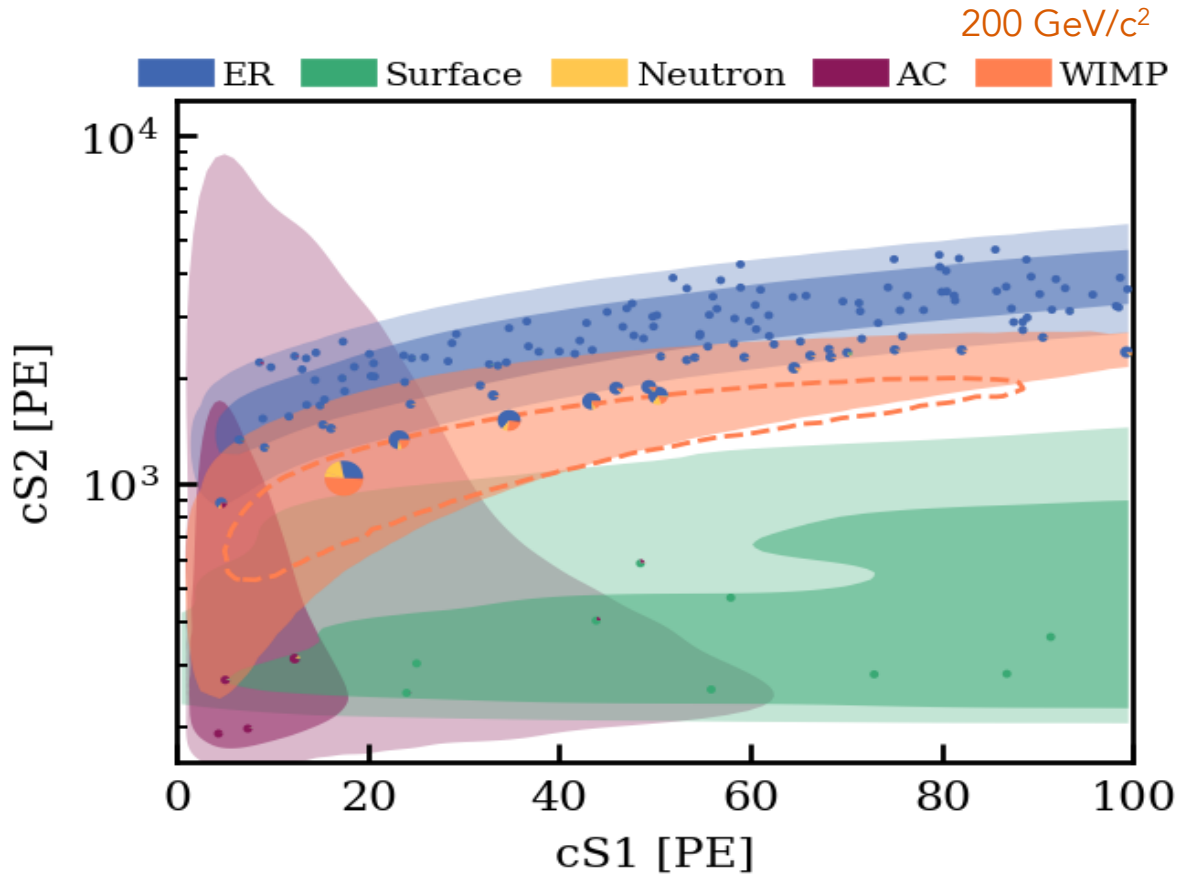
- July 6 to Nov 10, 2021 (97.1 days).
- 95.1 days lifetime corrected.
- 4.18 ± 0.13 tonnes fiducial volume.

Exposure: 1.1 tonne-year of scientific data



* 83mKr internal source: TPC response monitoring and characterization

1.1 t × yr of exposure - Blinded Analysis



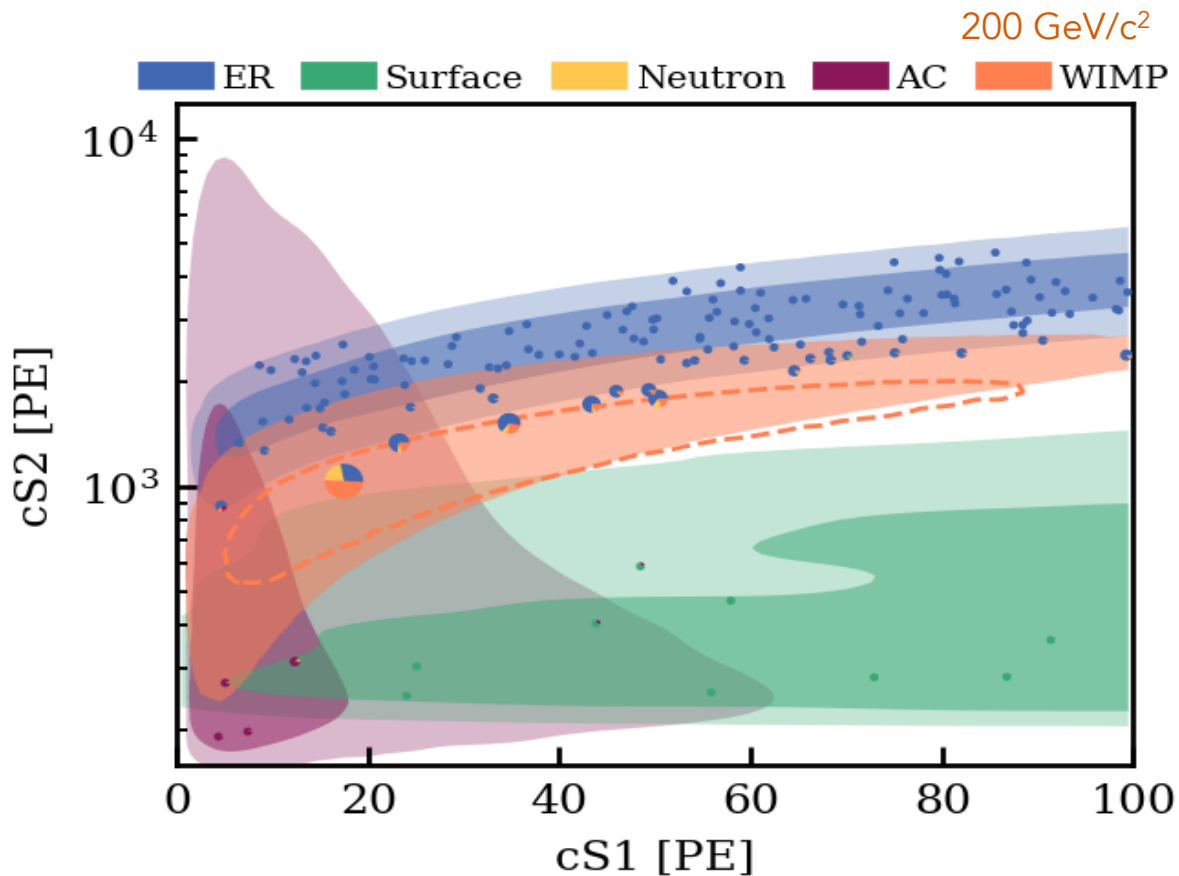
WIMP ROI backgrounds

- **ER:** dominated by ^{214}Pb from ^{222}Rn
- **Surface/Wall:** ^{210}Pb from PTFE panels
- **AC:** randomly paired S1s and S2s
- **NR:** radiogenic neutrons and ^8B CEvNS

	Nominal		Best fit	
	ROI		Signal-like	
ER	134	135^{+12}_{-11}	0.92 ± 0.08	
Neutrons	$1.1^{+0.6}_{-0.5}$	1.1 ± 0.4	0.42 ± 0.16	
CEvNS	0.23 ± 0.06	0.23 ± 0.06	0.022 ± 0.006	
AC	4.3 ± 0.9	$4.4^{+0.9}_{-0.8}$	0.32 ± 0.06	
Surface	14 ± 3	12 ± 2	0.35 ± 0.07	
Total background	154	152 ± 12	$2.03^{+0.17}_{-0.15}$	
WIMP	...	2.6	1.3	
Observed	...	152	3	

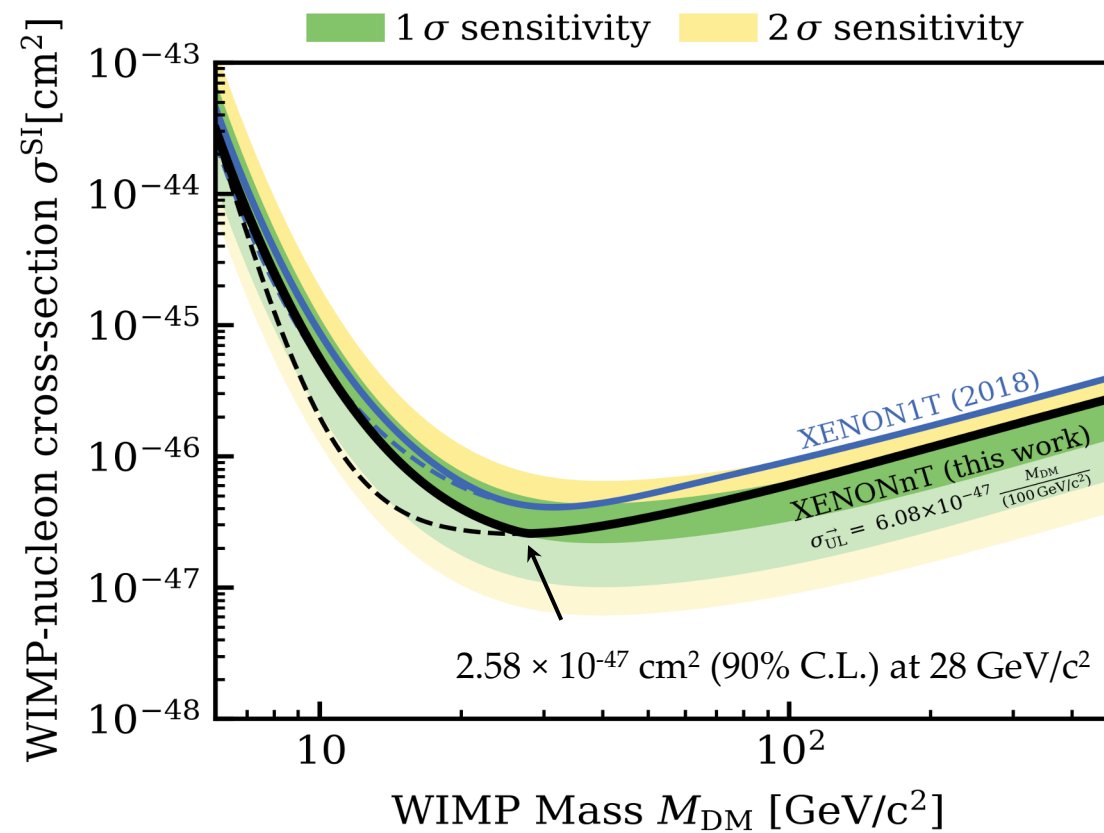
152 events in ROI, 16 in blinded region

1.1 t × yr of exposure - Blinded Analysis



No significant excess

New upper limit with 90% CL on SI



1.6× improvement from XENON1T



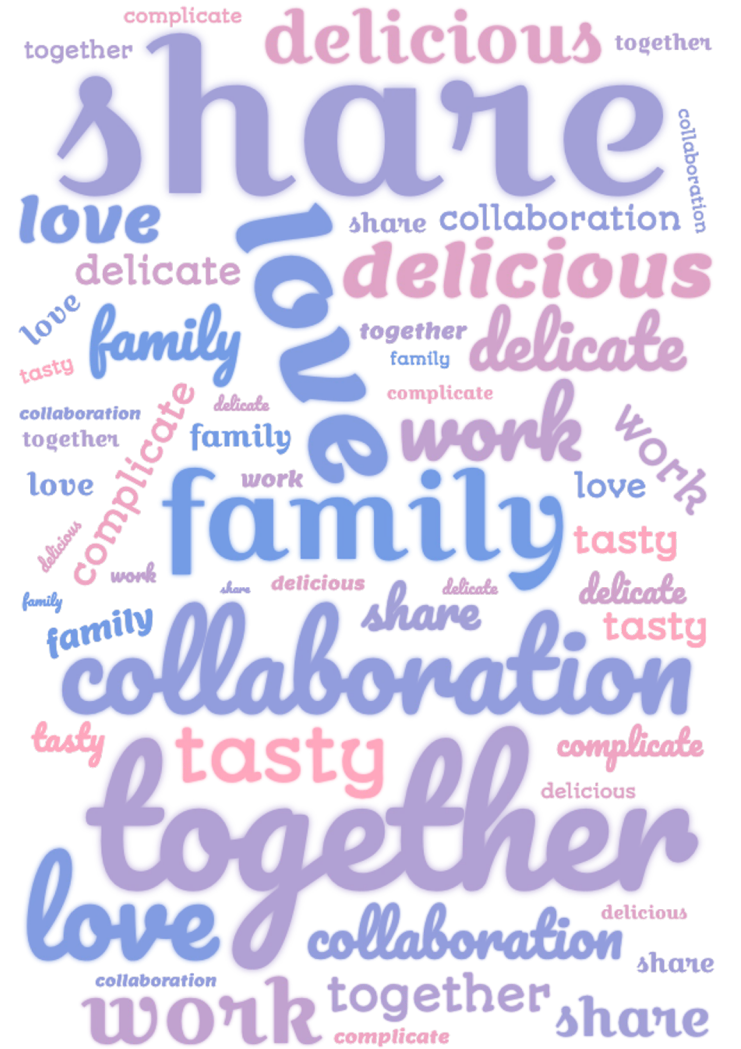
How did we get there?!



XENON

Fish Dumplings? Family!]

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023





XENON

XENON Collaboration

Main Goal: Direct detection of WIMP dark matter candidate

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023



Columbia



KIT



Nikhef



Muenster



Stockholm



Mainz



MPIK, Heidelberg



Freiburg



University of Zurich
Zurich



Chicago



UCSD



Rice



Purdue



Subatech



Coimbra



LPNHE



Torino



Bologna



L'Aquila



LNGS



Napoli



Weizmann



Tsinghua



Tokyo



NAGOYA UNIVERSITY
Nagoya



Kobe



NYUAD

Collaboration Meeting @ Paris, September 2023



~180 scientists

28 institutions

12 countries



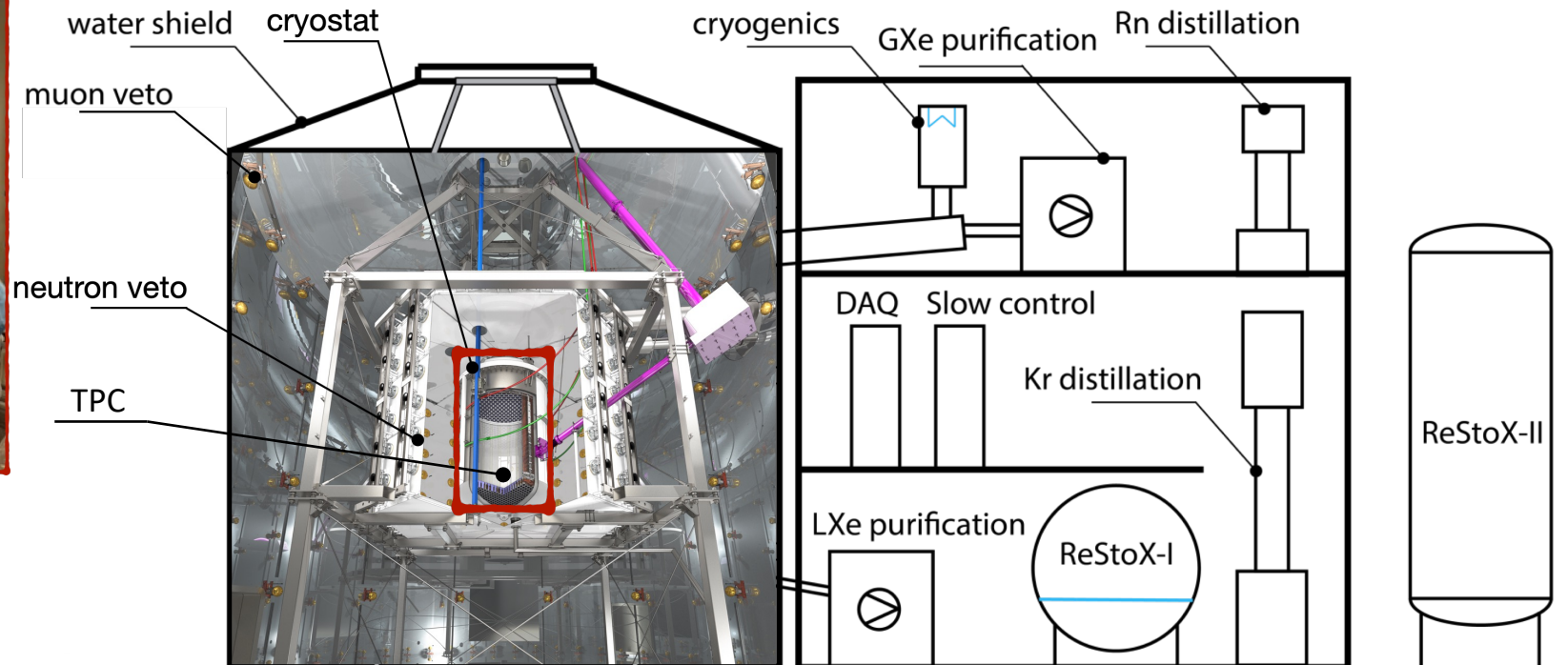
XENON

From XENON1T to XENONnT

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023

UPGRADES

x3 larger TPC
8.5 t LXe
494 PMTs



From XENON1T to XENONnT

UPGRADES

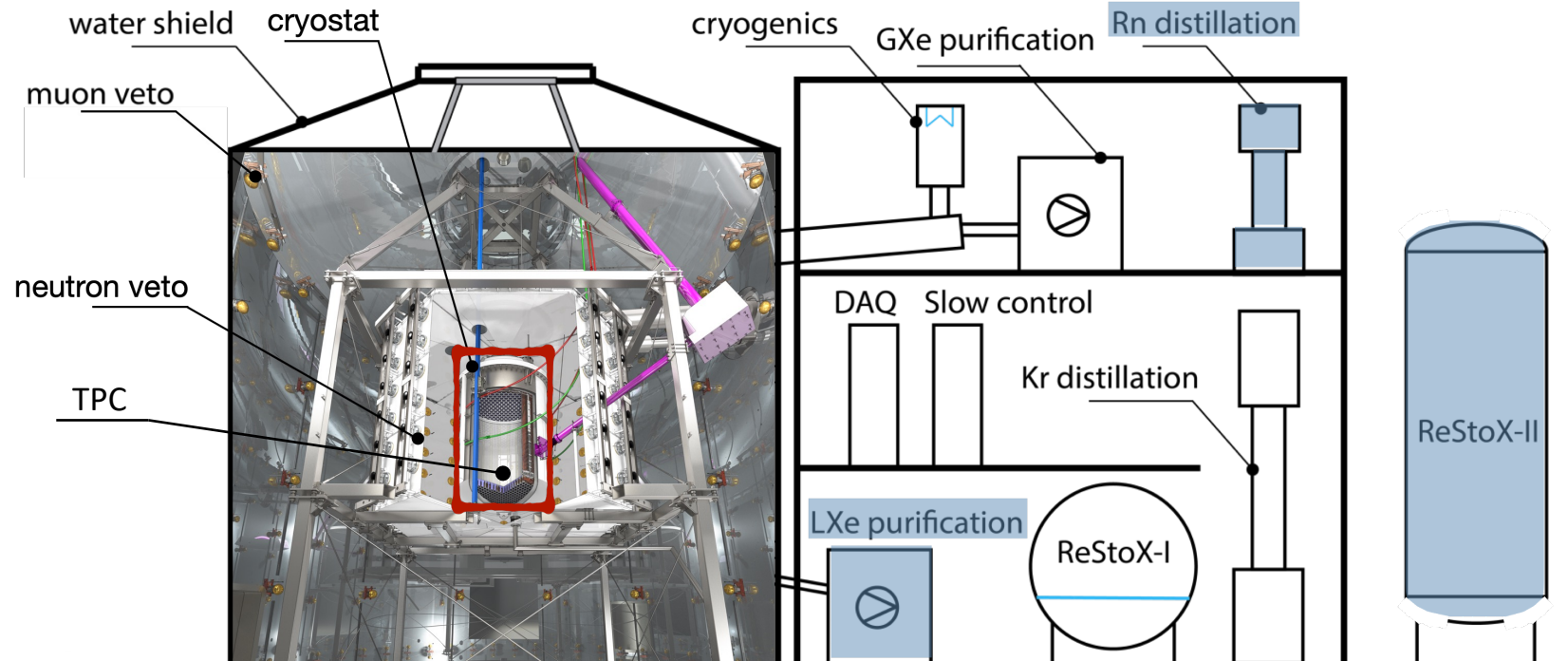
x3 larger TPC
8.5 t LXe
494 PMTs

Xenon handling
New purification
& ER bkg. reduction
New recovery/storage

x10 better purity -> Electron lifetime > 10 ms
x7 ²²²Rn reduction -> 1.8 μBq/kg

Rn distillation: Eur. Phys. J. C 82, 1104 (2022)
LXe purification: Eur. Phys. J. C 82, 860 (2022)

ReStoX-II
100% French
contribution



Designed and funded by
Subatech and LPNHE (+ LAL)



XENON

From XENON1T to XENONnT

Yajing Xing, 2023 CDM Annual Workshop, 29 Nov 2023

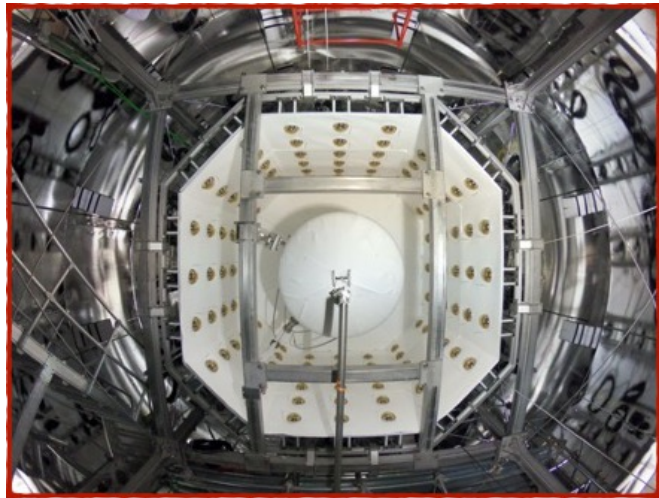
UPGRADES

x3 larger TPC
8.5 t LXe
494 PMTs

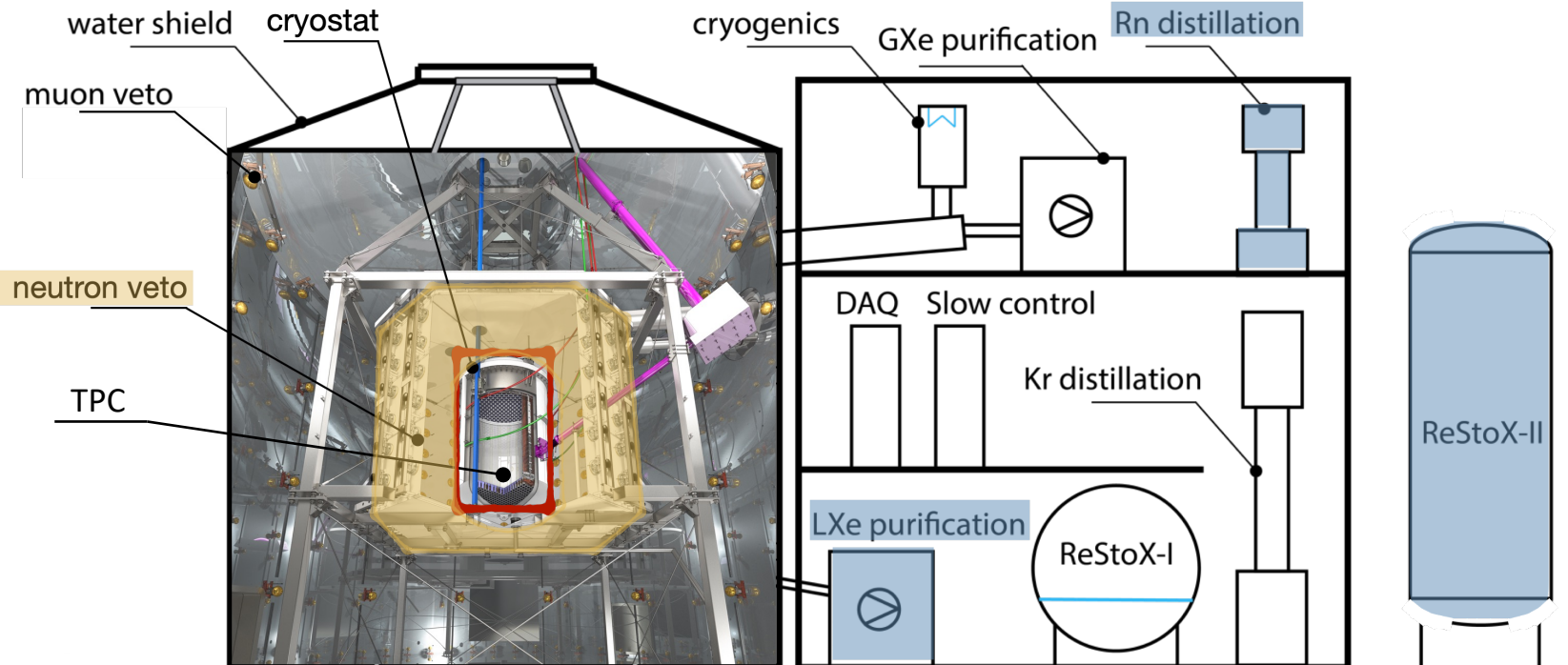
Xenon handling
New purification
& ER bkg. reduction
New recovery/storage

**Water Cherenkov
Neutron Veto**
Gd-doping in
preparation

Rn distillation: Eur. Phys. J. C 82, 1104 (2022)
LXe purification: Eur. Phys. J. C 82, 860 (2022)



68% efficiency now
87% expected with Gd



From XENON1T to XENONnT

UPGRADES

x3 larger TPC
8.5 t LXe
494 PMTs

Xenon handling
New purification
& ER bkg. reduction
New recovery/storage

**Water Cherenkov
Neutron Veto**
Gd-doping in
preparation

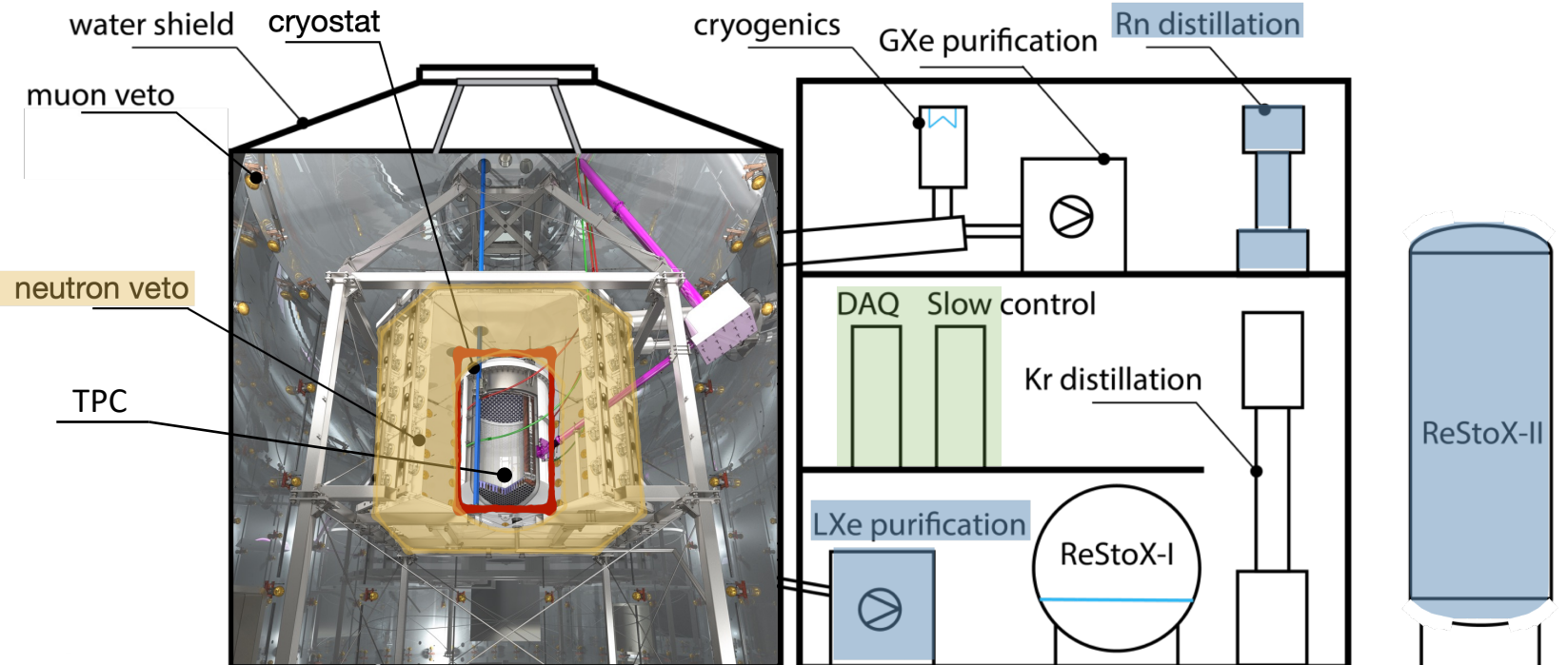
DAQ & SC
Triggerless acquisition
Double gain Top PMT
Live monitoring

Rn distillation: Eur. Phys. J. C 82, 1104 (2022)
LXe purification: Eur. Phys. J. C 82, 860 (2022)

nT DAQ: JINST 18 (2023)

GOAL

More target mass
Lower background level
Higher efficiency



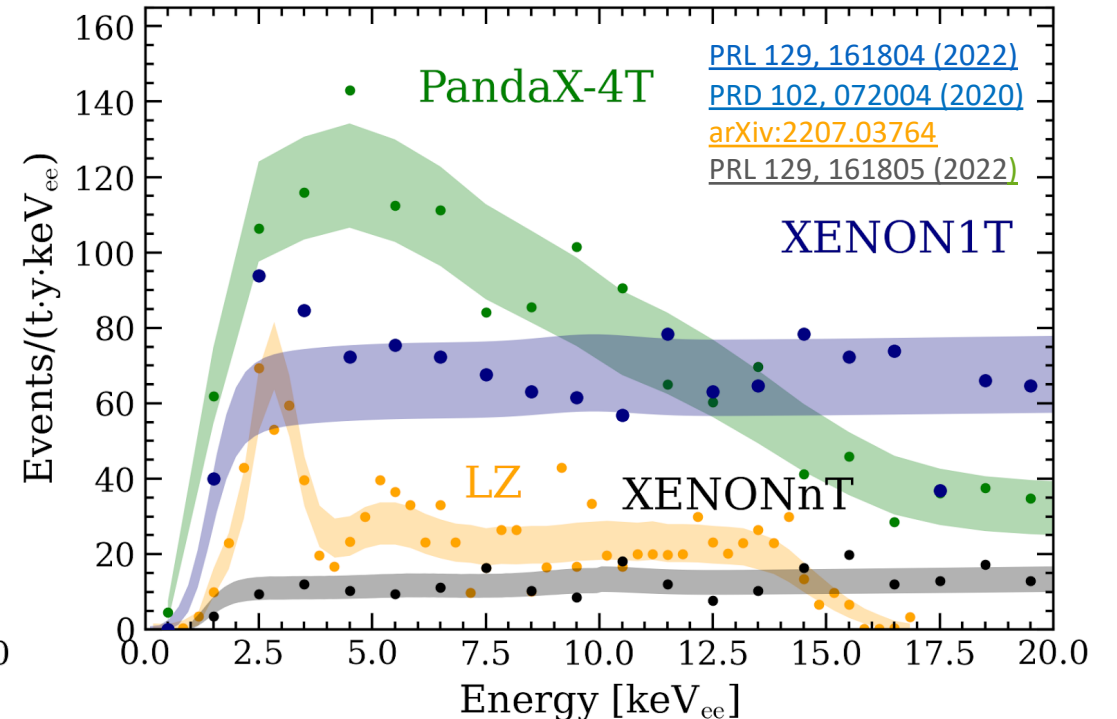
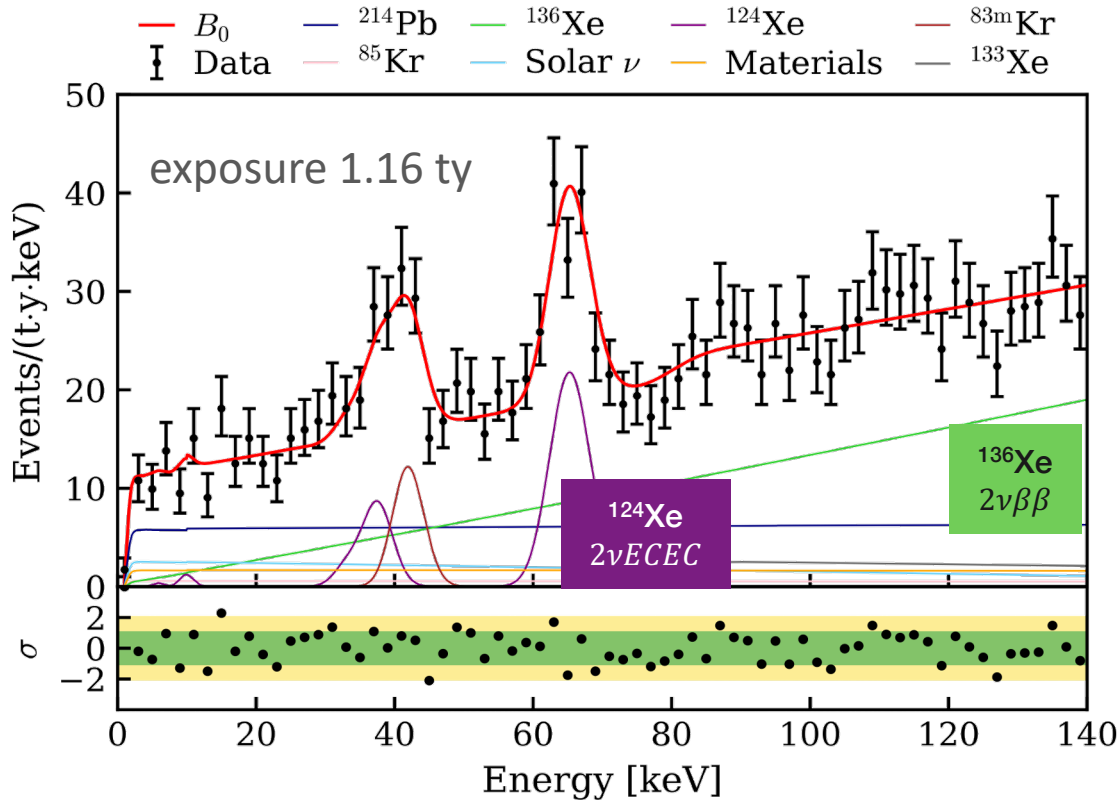


XENON

Low-energy ER Searches

- Outstanding 5× reduction compared to XENON1T → (16.1 ± 1.3) events/(t x yr x keV).
- Lowest ER background rate ever achieved with such detector.
- Limited by second-order weak processes (^{124}Xe , ^{136}Xe) for energies greater than ~ 35 keV.

Probe new physics channels [PRL 129 161805 \(2022\)](#)

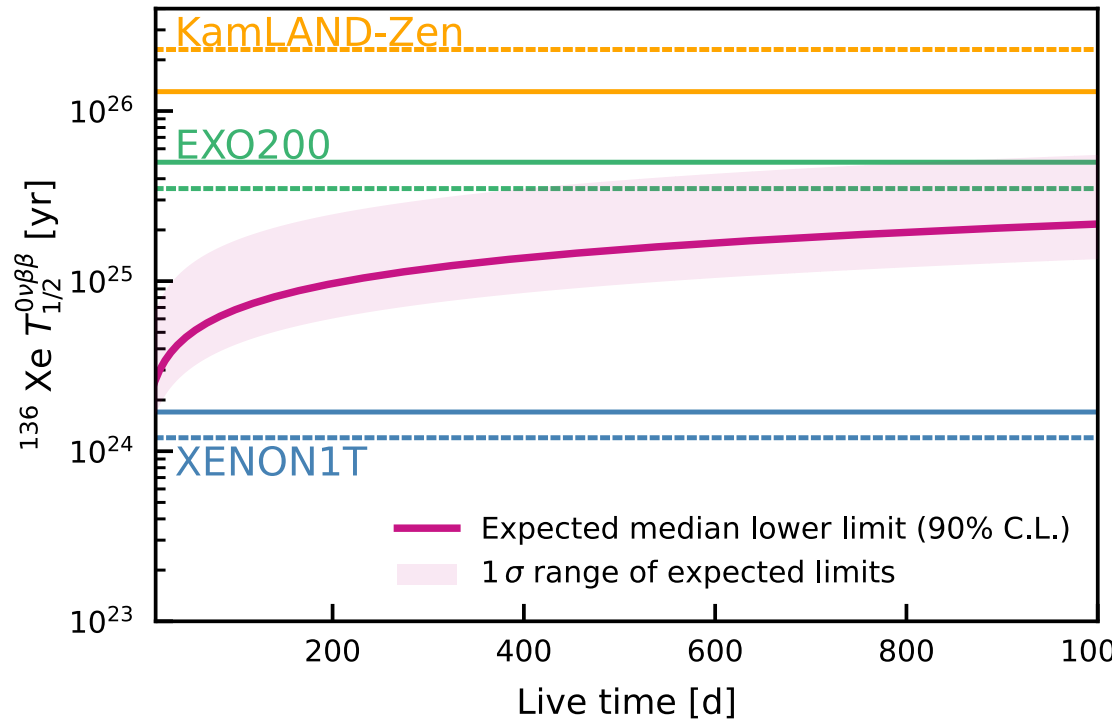


XENONnT Projection for $0\nu\beta\beta$

Simultaneous search for DM and $0\nu\beta\beta$ decay in a single detector

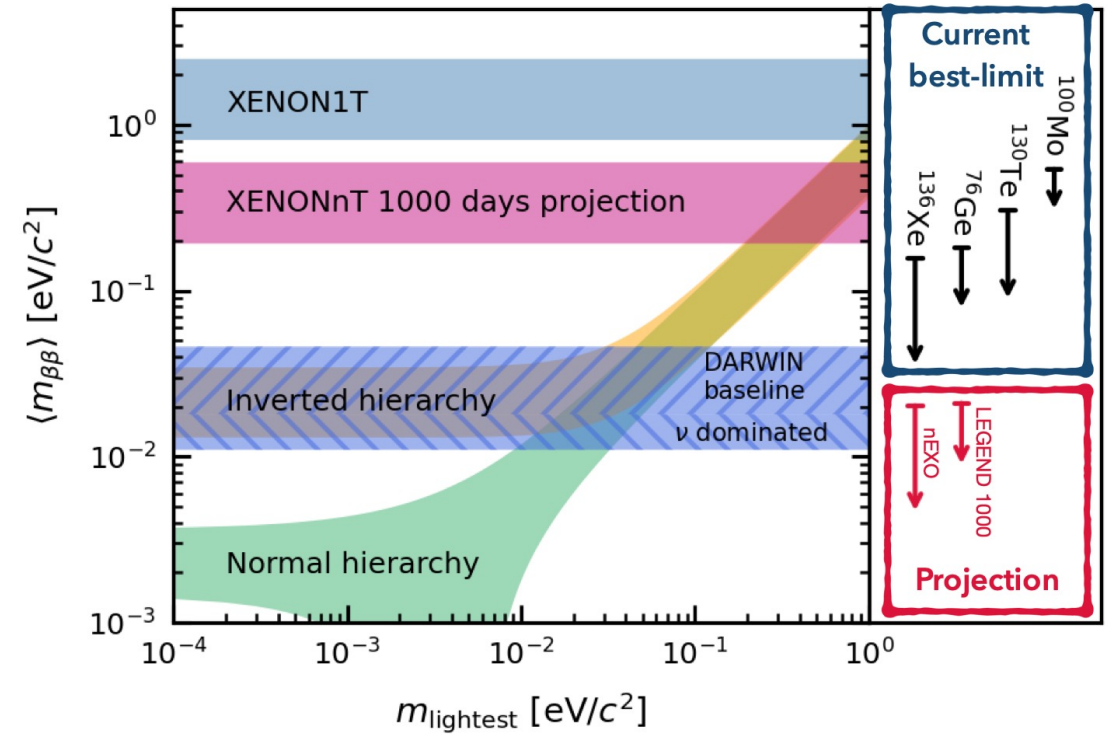
Not yet competitive with dedicated experiments:

- Non-enriched target.
- Materials optimization for DM search (SS Cryostat).



Potential for future xenon DM experiments:

- DARWIN/XLZD can approach the sensitivity of dedicated $0\nu\beta\beta$ experiments.



Summary and Prospects

- XENONnT first science run completed
- No evidence of new physics from SR0 data
- Unprecedented lowER background
- XENONnT continues taking data


WIMP Results: [PRL 131, 041003 \(2023\)](#)
 LowER Results: [PRL 129 161805 \(2022\)](#)

White Paper: [arXiv:2203.02309](#)


Towards a multi-ton scale xenon observatory



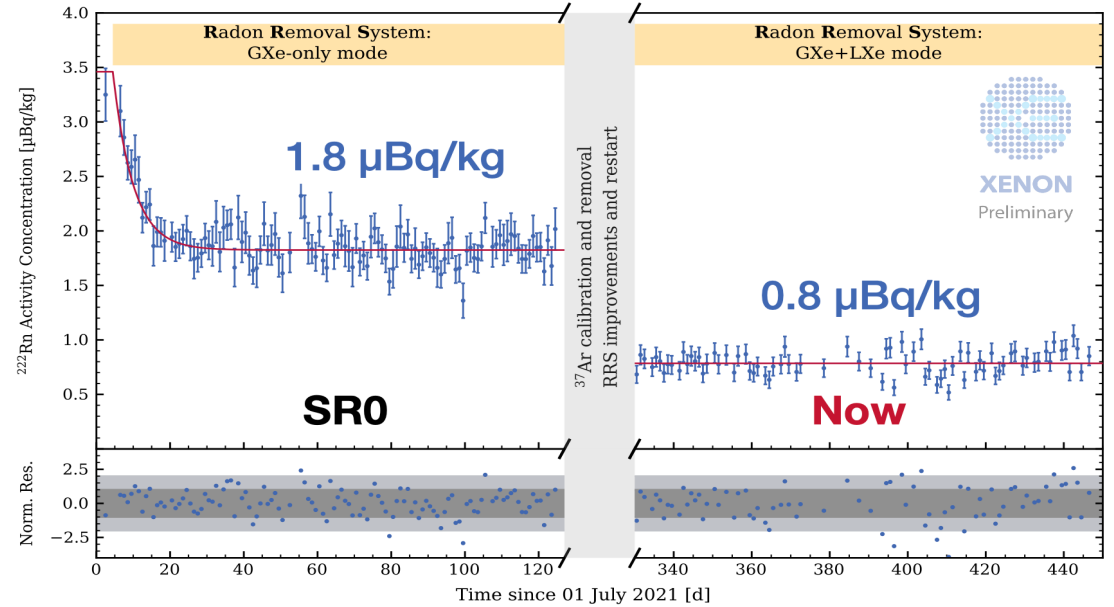
XENON
 Currently operating with 8.5 tonnes of liquid Xenon at Gran Sasso in Italy



LUX-ZEPLIN
 Currently operating with 10 tonnes of liquid Xenon at SURF in South Dakota



DARWIN
 Leading many R&D projects designing a future 50 tonnes liquid Xenon detector




Talk of Marc Schumann

Talk of Robert James