XENONnT

direct dark matter searches: the latest results

Cecilia Ferrari on behalf of the **XENON Collaboration**

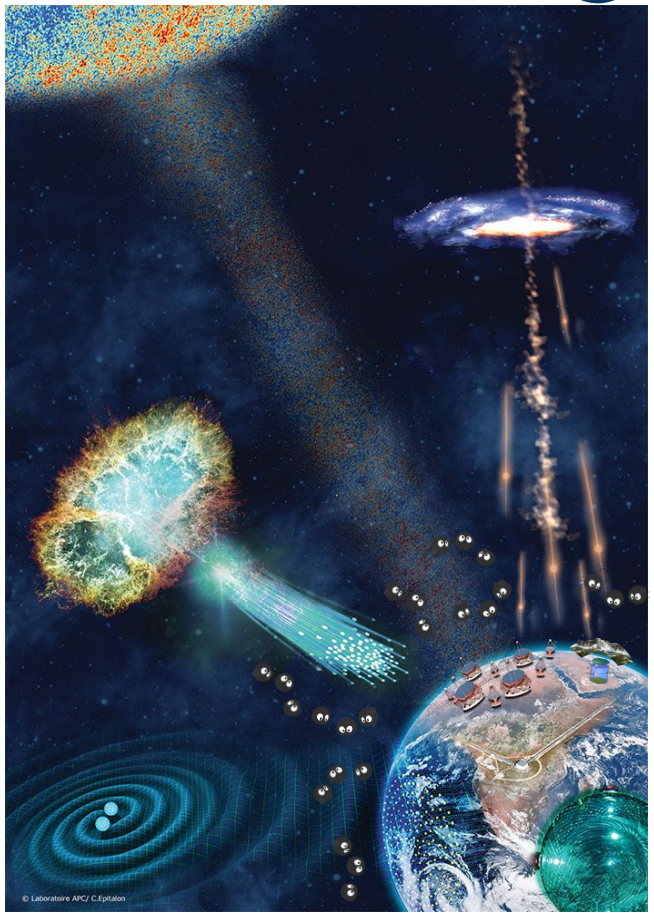
Astroparticle physics with XENONnT

Astroparticles, depending on their nature and energy, can be experimentally probed by a large variety of detectors, placed **in the sky**, **on the ground** or **underground**.

Direct Dark Matter detection, given these particles elusive nature, demand very **low-background experiments**.

For **WIMP** searches, this condition is met when the detector:

- operates **underground**
- is shielded by active/passive **vetoes**
- (optional) is equipped with **background removal systems**



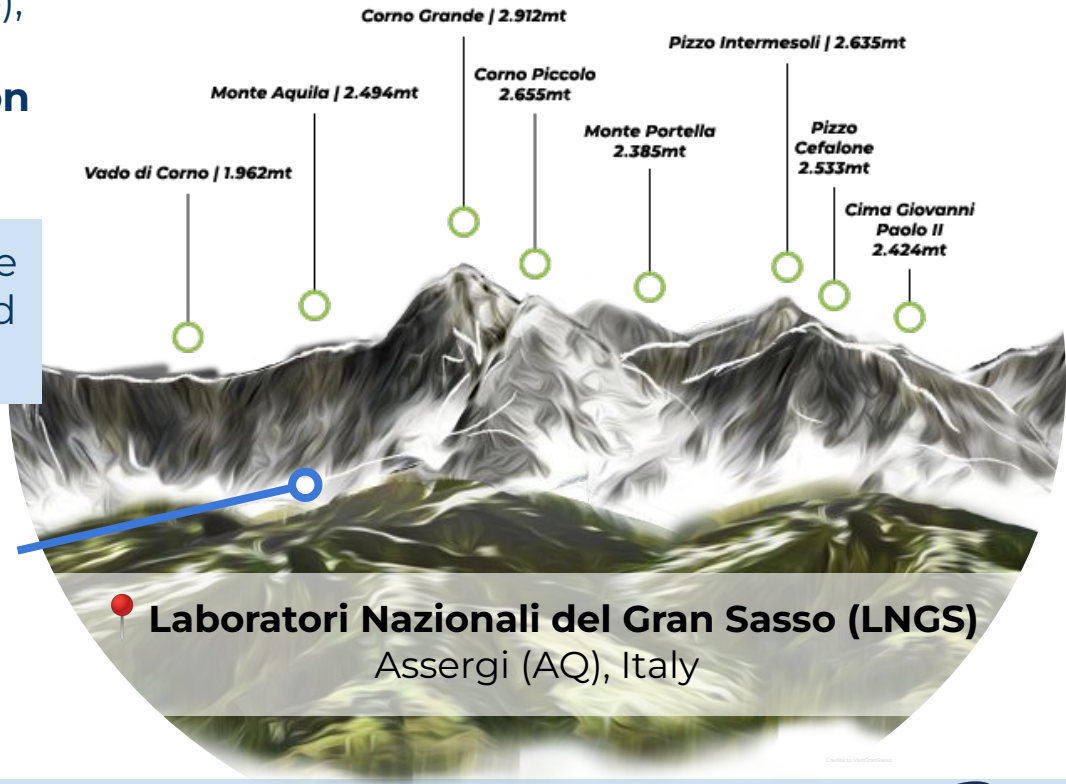
Going underground to directly detect WIMPs

Thanks to:

- LNGS rock **overburden** (**3600** m.w.e),
- **muon** and **neutron vetoes**,
- **online distillation** and **purification systems**,

the **XENONnT** experiment is sensitive to **WIMP** dark matter candidates and other **new-physics channels.**

XENONnT experiment /
overburden 3600 m.w.e
1 muon per m^2 per hour



XENONnT underground infrastructures

Same XENON1T infrastructure in the LNGS underground facility with some important **upgrades**

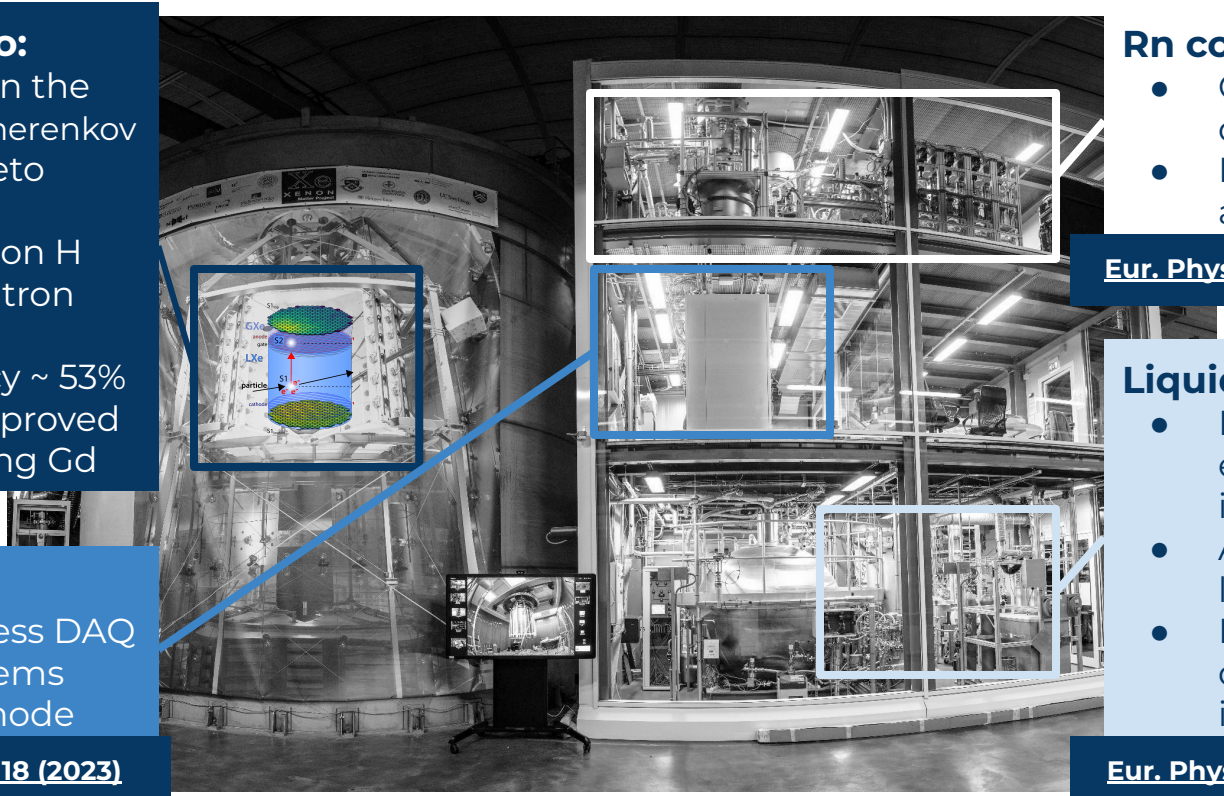
Neutron veto:

- Hosted in the water Cherenkov muon veto
- Neutron capture on H
- SR0 neutron tagging efficiency ~ 53%
- Soon improved by loading Gd

nT DAQ:

- Triggerless DAQ
- Subsystems linked mode

JINST 18 (2023)



Rn column:

- Continuous Rn distillation
- Lowest ^{222}Rn bkg ever achieved: 1.8 μBq/kg

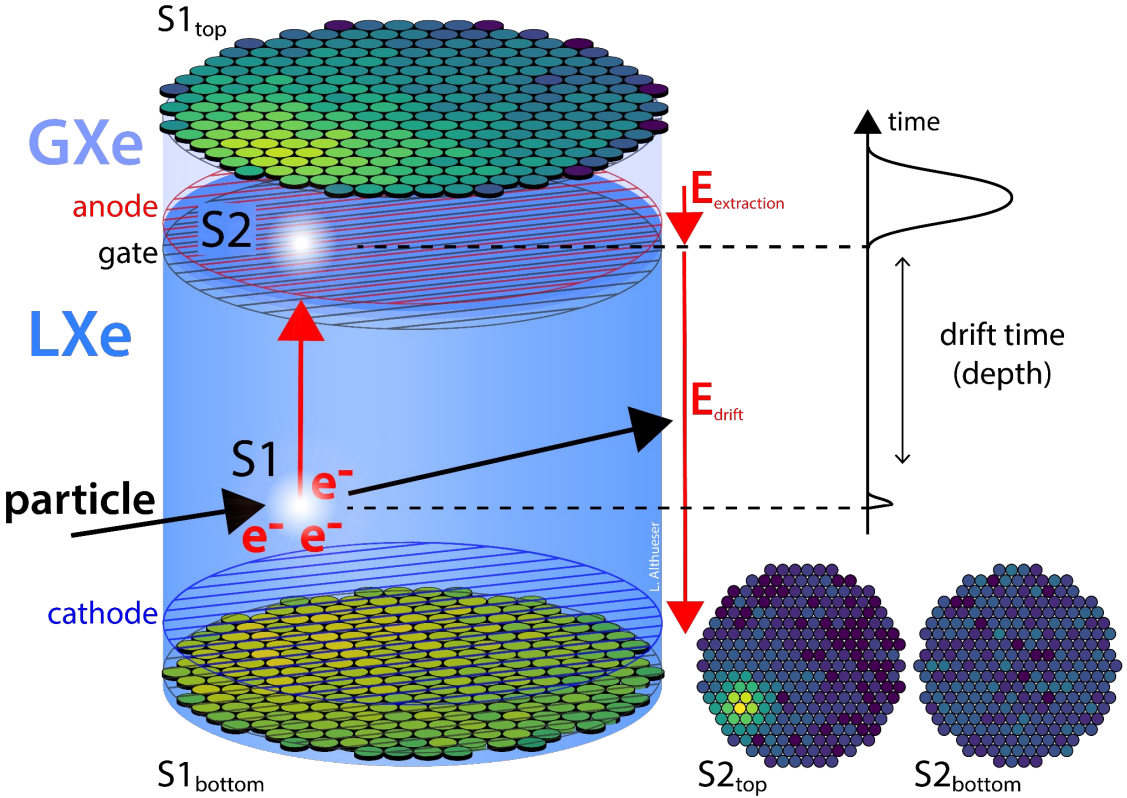
Eur. Phys. J. C 82, 1104 (2022)

Liquid Purification:

- Removes electronegative impurities (O_2 and H_2O)
- Average electron lifetime 1.5 ms
- Reduces S2 z dependences and improves S1 LCE

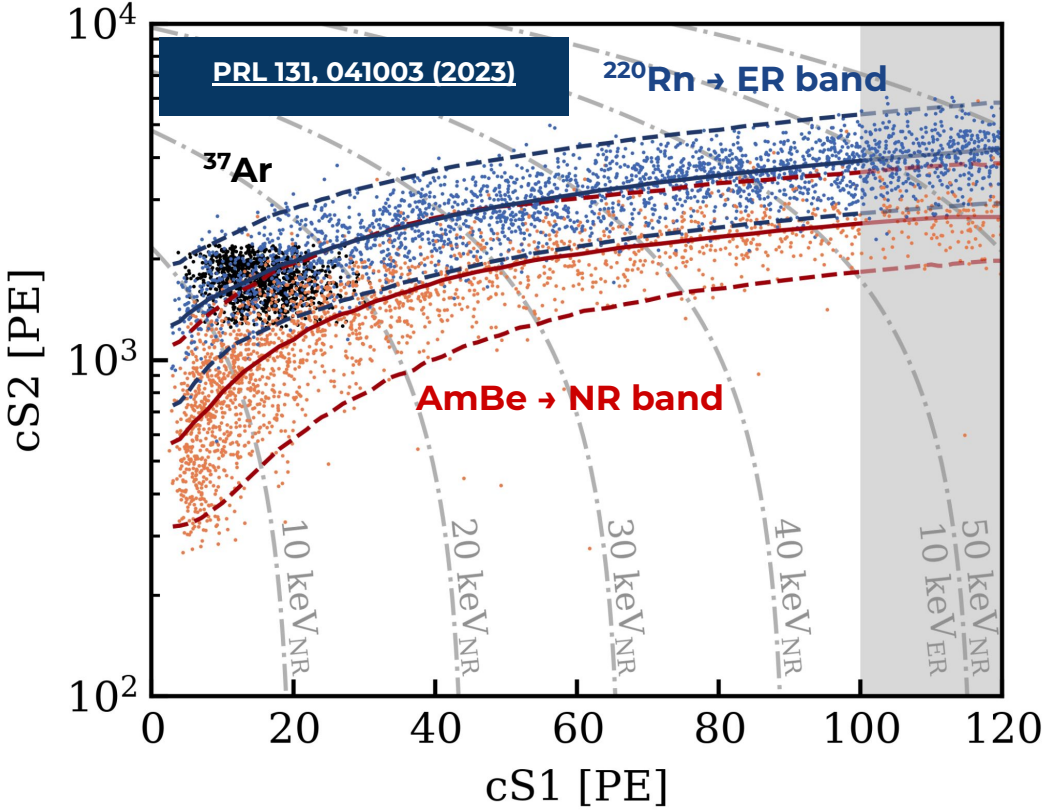
Eur. Phys. J. C 82, 860 (2022)

XENONnT detector working principle



- **5.9 t LXe** instrumented with a **cylindrical TPC:**
  - drift field of 23 V/cm
  - r=66.4cm, h=150cm
- **Detection** via **prompt scintillation** light (**S1**) and **delayed ionization** signal (**S2**)
- **Event position reconstruction:**
  - (x,y) from S2 top PMTs pattern
  - z from drift time
- **Particle discrimination** in (cS1, cS2)

XENONnT TPC calibration



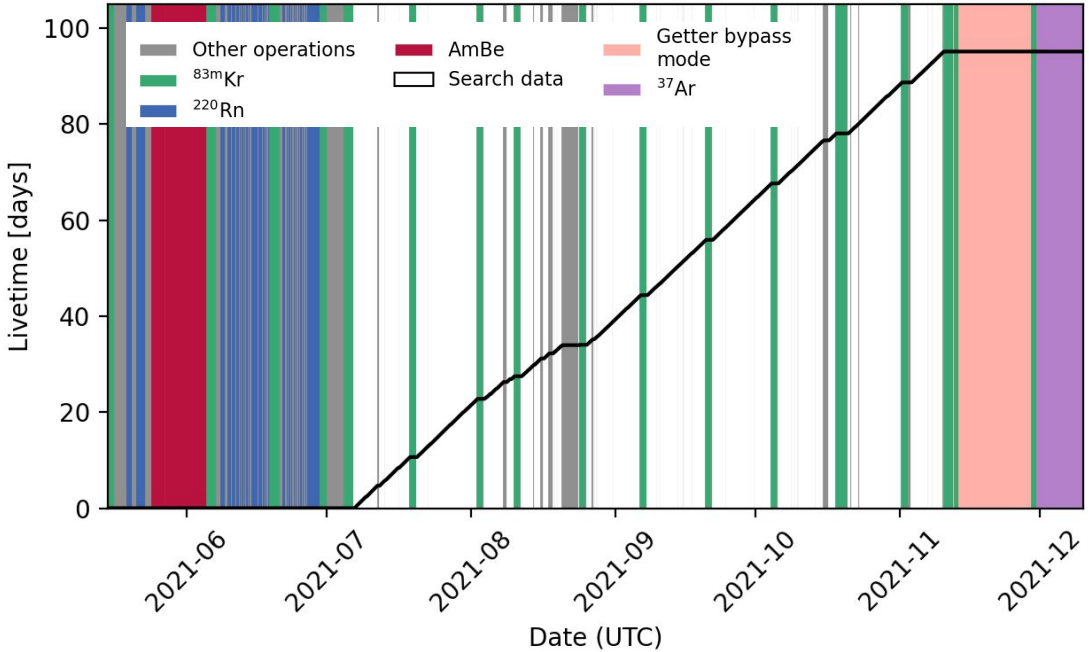
Particle discrimination in (cS1, cS2)

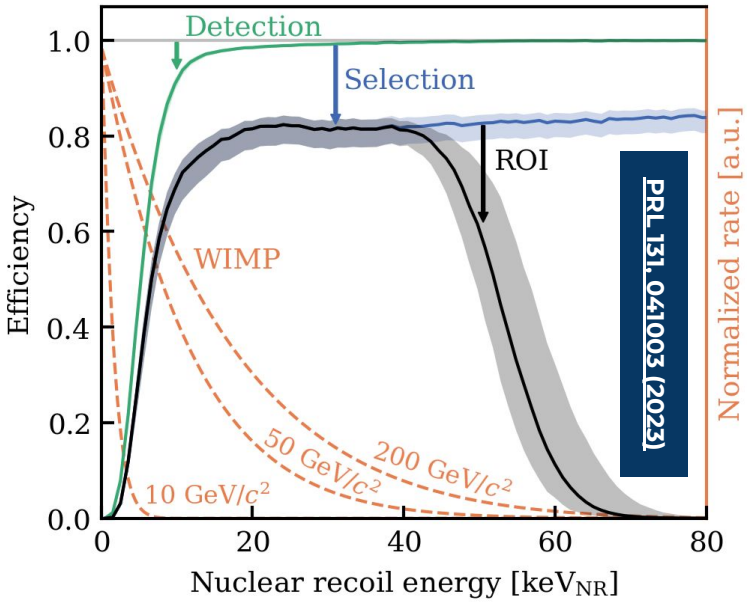
- **^{220}Rn** (^{212}Pb beta decay):
  - modeling of ER response
  - quality cuts validation
  - energy threshold evaluation
- **^{37}AR**:
  - low energy response calibration
  - peak reconstruction
- **AmBe**:
  - modeling of NR response
  - neutron veto characterization
- **^{83m}Kr** (not in the plot):
  - TPC response characterization

- **Combined energy scale:**
  E[keV] ∝ (cS1/g1+cS2/g2)
  where g1 , g2 from calibration peaks

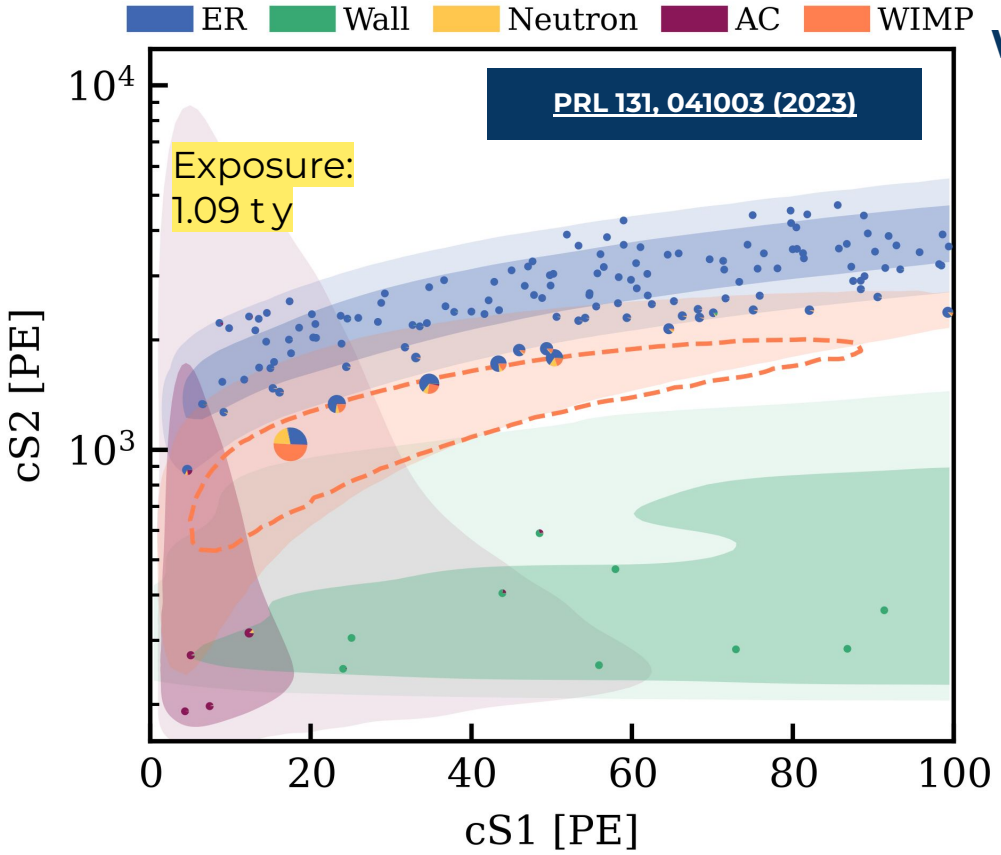
XENONnT WIMP searches - SR0

- **WIMP** searches with XENONnT **SR0** background data: **95.1 days of live time**
- Data **selection acceptance ~80%** in WIMP ROI:
  - Fiducial volume pre-cut to reduce surface/wall background: **4.18 t**
  - Agreement between simulation and data driven acceptance curves





XENONnT WIMP searches - results



WIMP ROI backgrounds

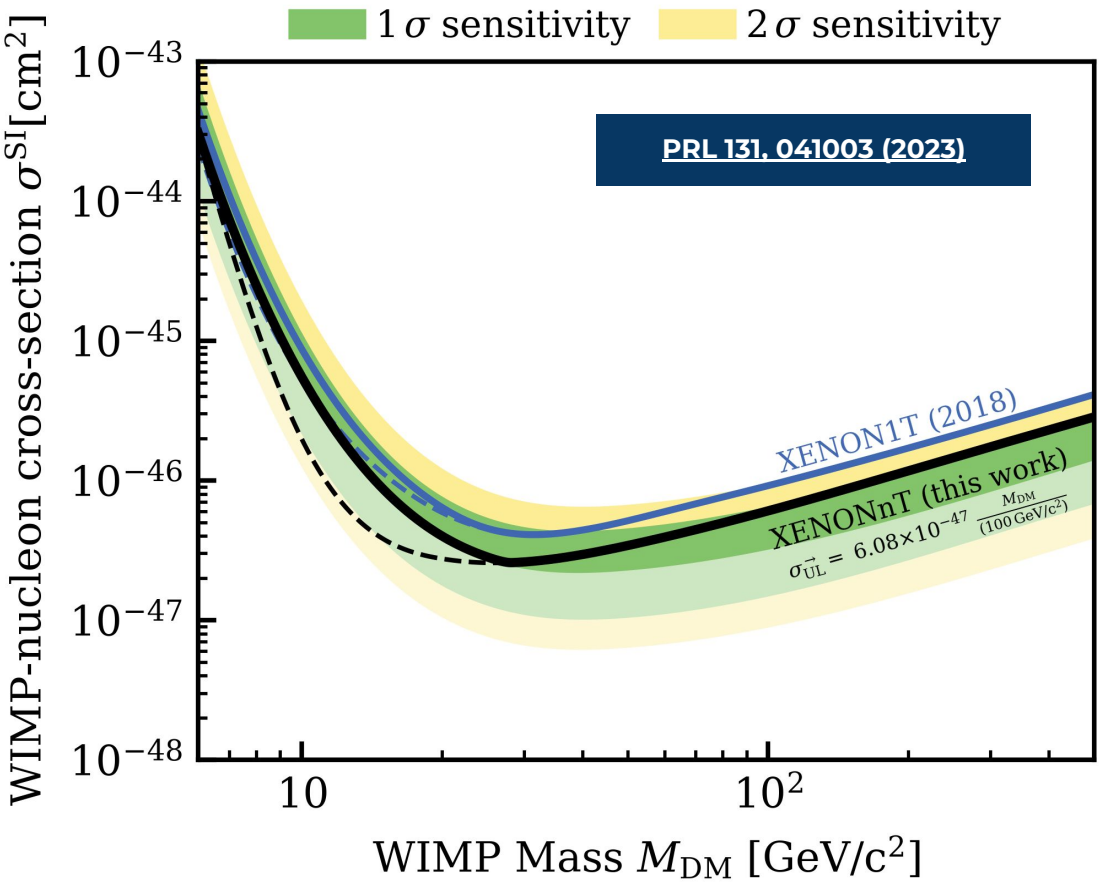
- **ER**: dominated by ^{214}Pb from ^{222}Rn
- **Surface/Wall**: ^{210}Pb from PTFE panels
- **AC**: randomly paired S1s and S2s

Results of SR0 **blinded** analysis

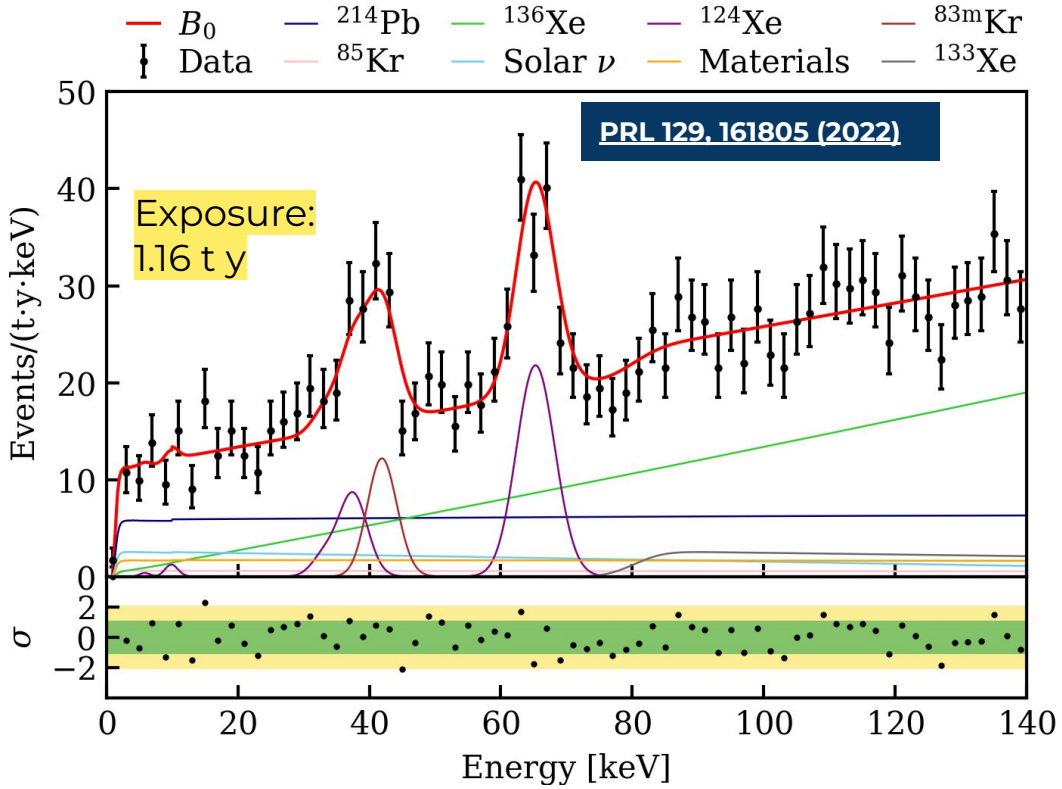
	Nominal	Best fit	
	ROI		Signal-like
ER	134	135^{+12}_{-11}	0.92 ± 0.08
Neutrons	$1.1^{+0.6}_{-0.5}$	1.1 ± 0.4	0.42 ± 0.16
CEνNS	0.23 ± 0.06	0.23 ± 0.06	0.022 ± 0.006
AC	4.3 ± 0.9	$4.4^{+0.9}_{-0.8}$	0.32 ± 0.06
Surface	14 ± 3	12 ± 2	0.35 ± 0.07
Total background	154	152 ± 12	$2.03^{+0.17}_{-0.15}$
WIMP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

XENONnT WIMP searches - results

- **No** significant **excess observed**
- New **upper limit with 90% CL** on **SI** WIMP-nucleon interaction **cross section** limited at median sensitivity



New physics searches in Electron Recoil band



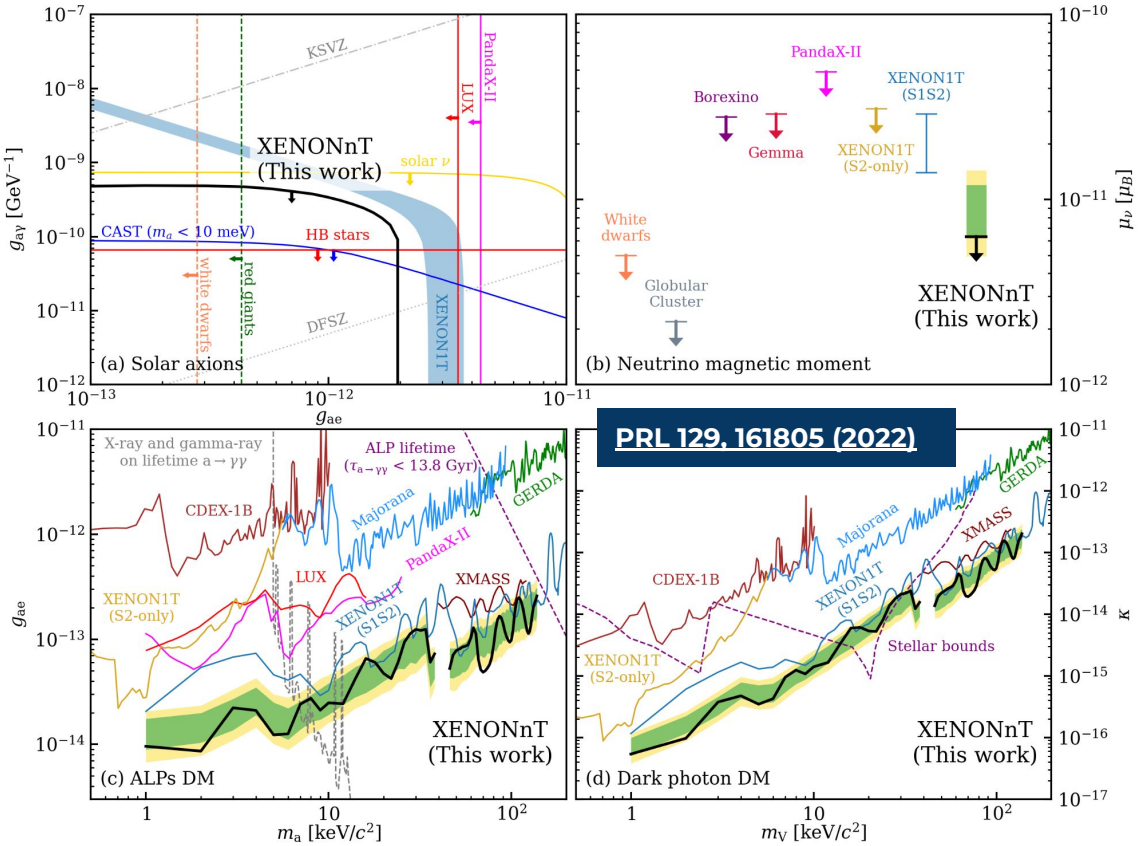
Not only WIMP searches: studies in ER band can **probe new physics channels**

- **Lowest** ER **background** ever achieved in a direct dark matter experiment.
- Limited by **second-order weak processes** (^{124}Xe, ^{136}Xe) for energies greater than ~35 keV

Results - updated new-physics limits

Solar axions

ν magnetic moment

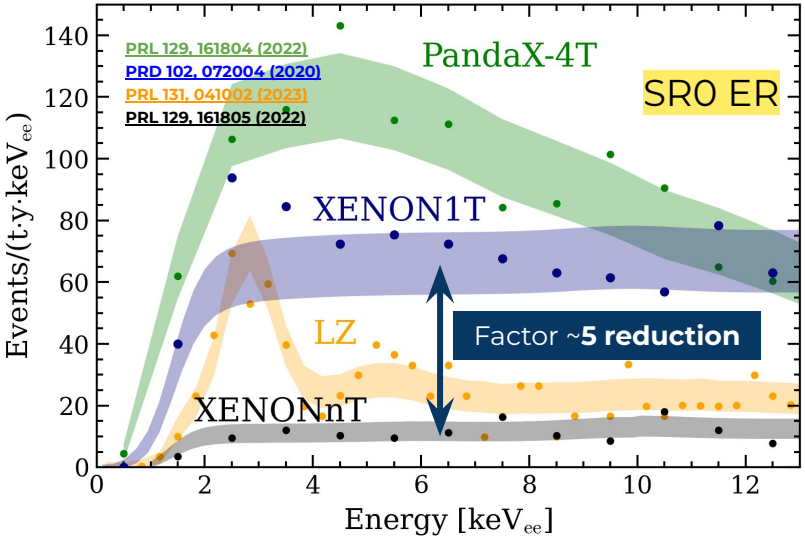


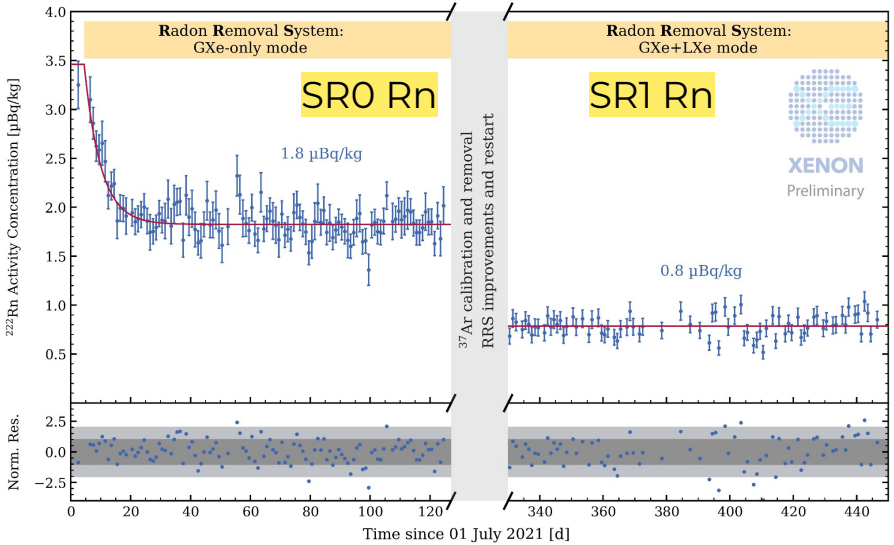
ALPs

Dark photon

Prospects

- **XENONnT** is currently taking a new run of background data (**SR1**).
- Thanks to the **radon removal system in LXe** mode the **^{222}Rn** contribution to the background budget has been **reduced by a factor greater than 2**.
- **Expected increased neutron tagging efficiency** in NV Gd-loaded phase
- Soon new improved results





Thank you for your attention!

Columbia · KIT · Nikhef · Muenster · Stockholm · Mainz · MPIK, Heidelberg · Freiburg · Zurich

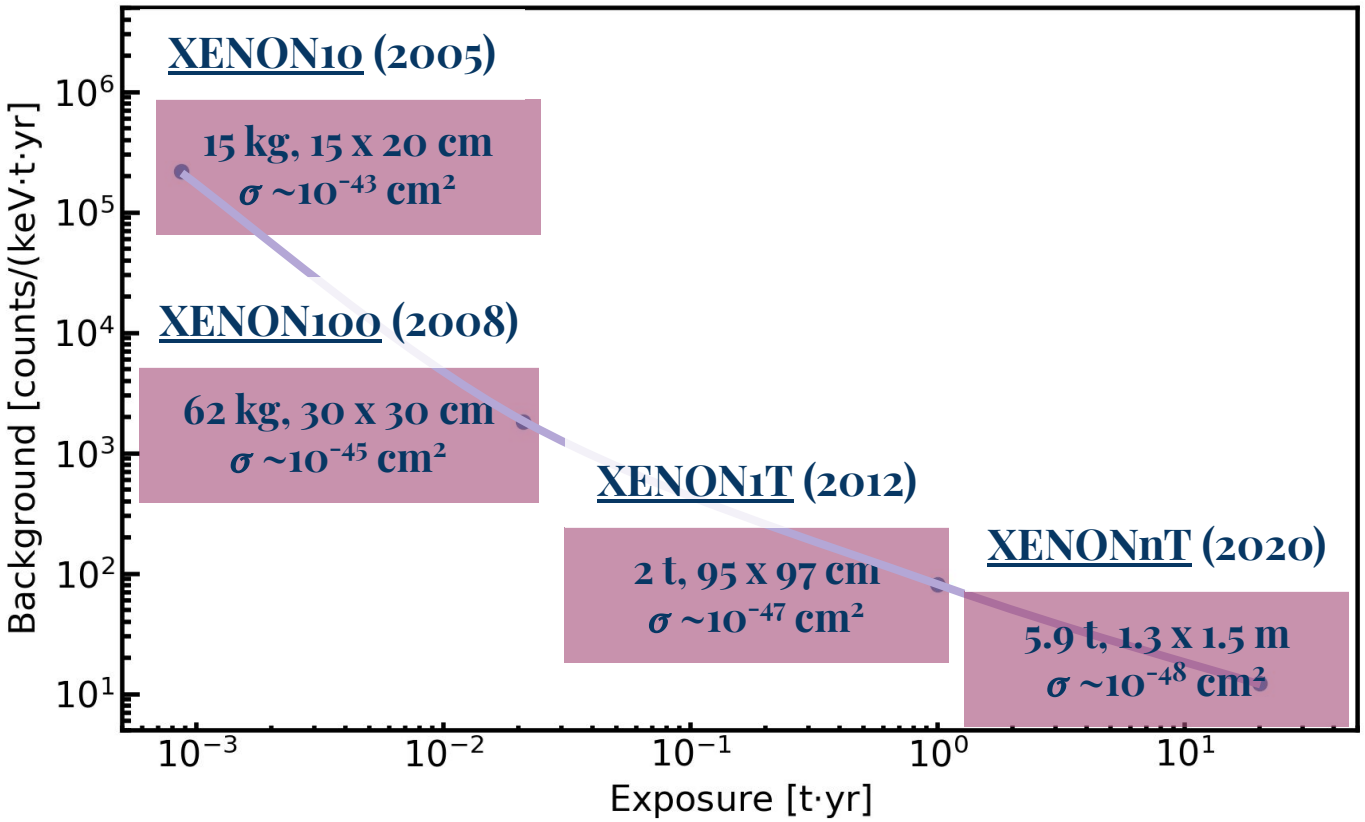
XENON Collaboration: 27 institutions and ~180 scientists

Chicago · UCSD · Rice · Purdue · Tsinghua · Tokyo · Nagoya · Kobe

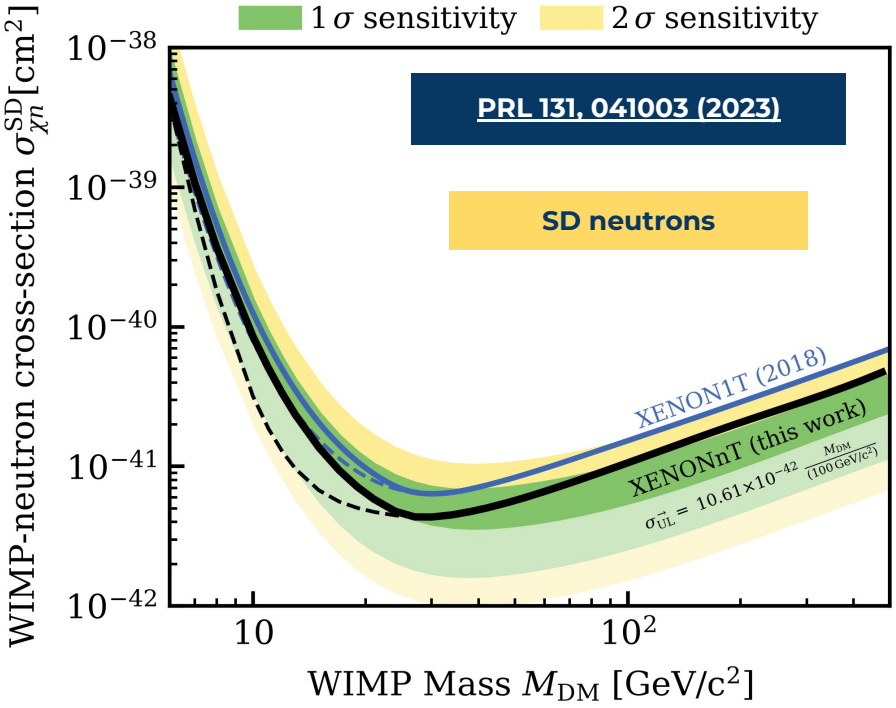
Subatech · Coimbra · LPNHE · Torino · Bologna · L'Aquila · LNGS · Napoli · Weizmann · NYUAD

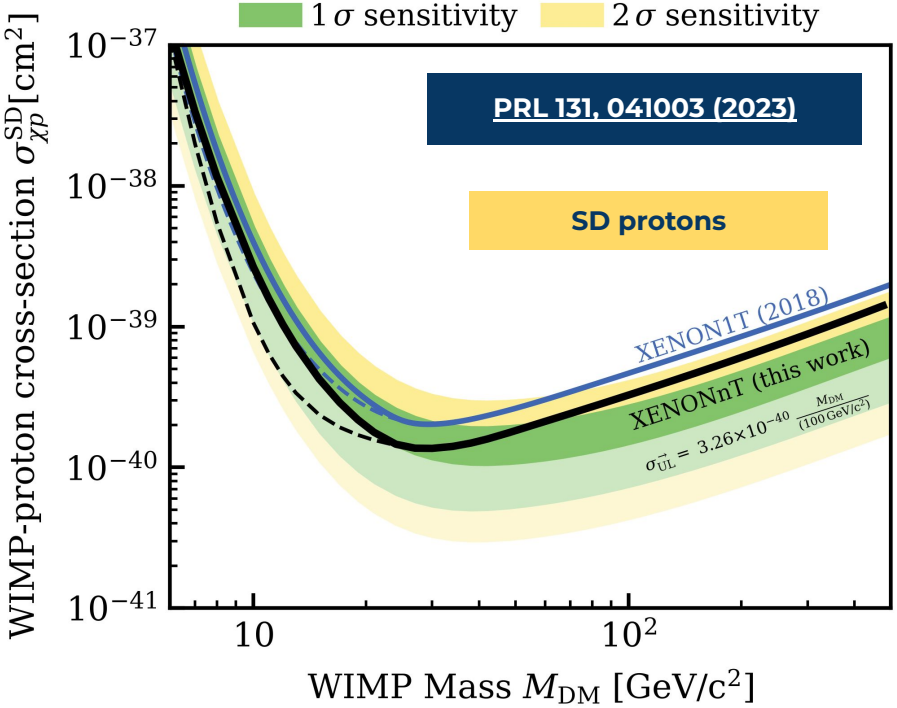
BACKUP

XENON experiments timeline

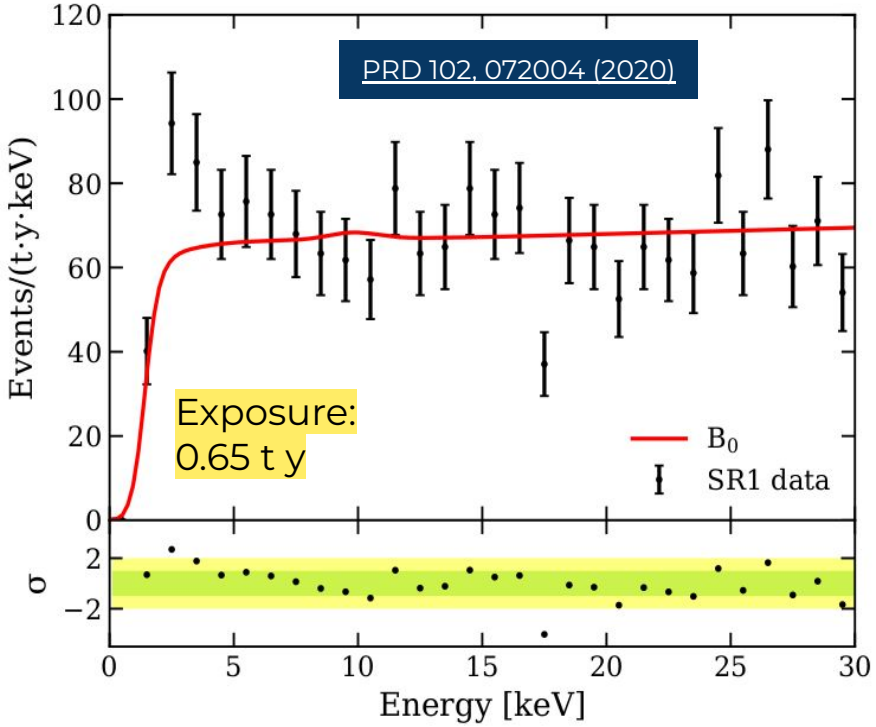


Updated SD WIMP exclusion plots





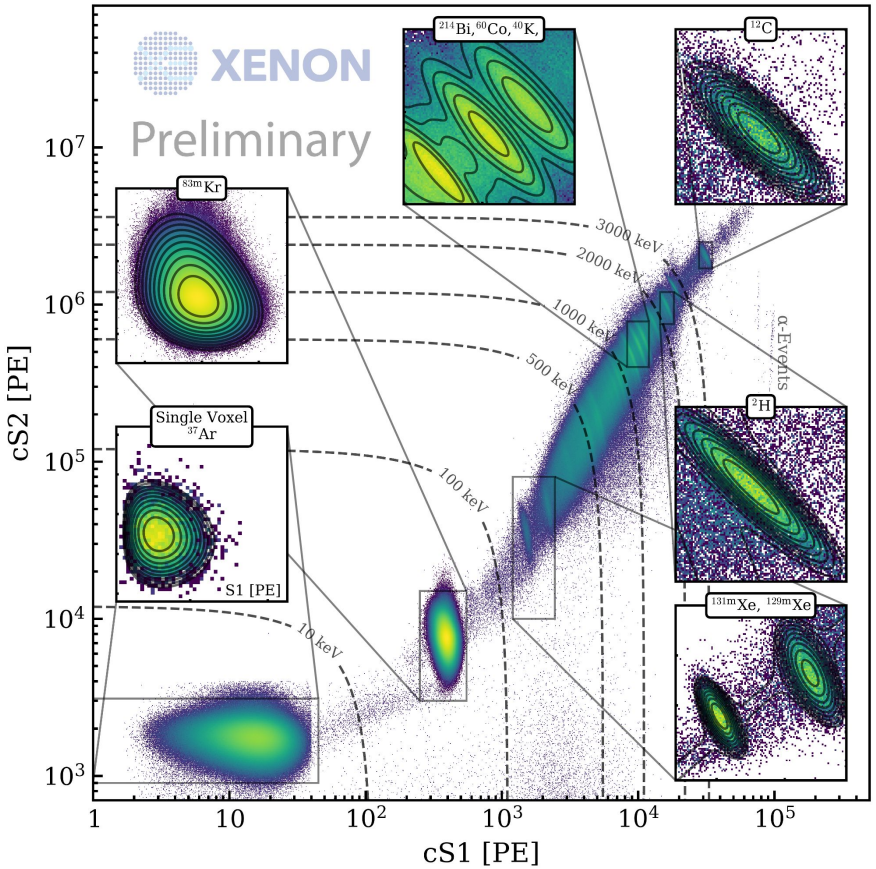
XENON1T excess



- **electron recoil** search < 30 keV
- **285 events** observed, 232 ± 15 expected (3.3σ fluctuation)
- compatible with **^{3}H contamination** at 3.2 σ with concentration (6.2 ± 2.0) × 10−25 mol/mol
- compatible with beyond-SM (**solar axions, enhanced neutrino magnetic moment, ALPs, dark photons** …)

Excluded by XENONnT results

Combined energy scale: (g1,g2) determination



- From **monoenergetic calibration sources** and **activation peaks** in cs1, cs2
- To the **Doke plot**: determination of g1,g2
- The **combined energy scale**:

  E = W x (cS1/g1+cS2/g2)