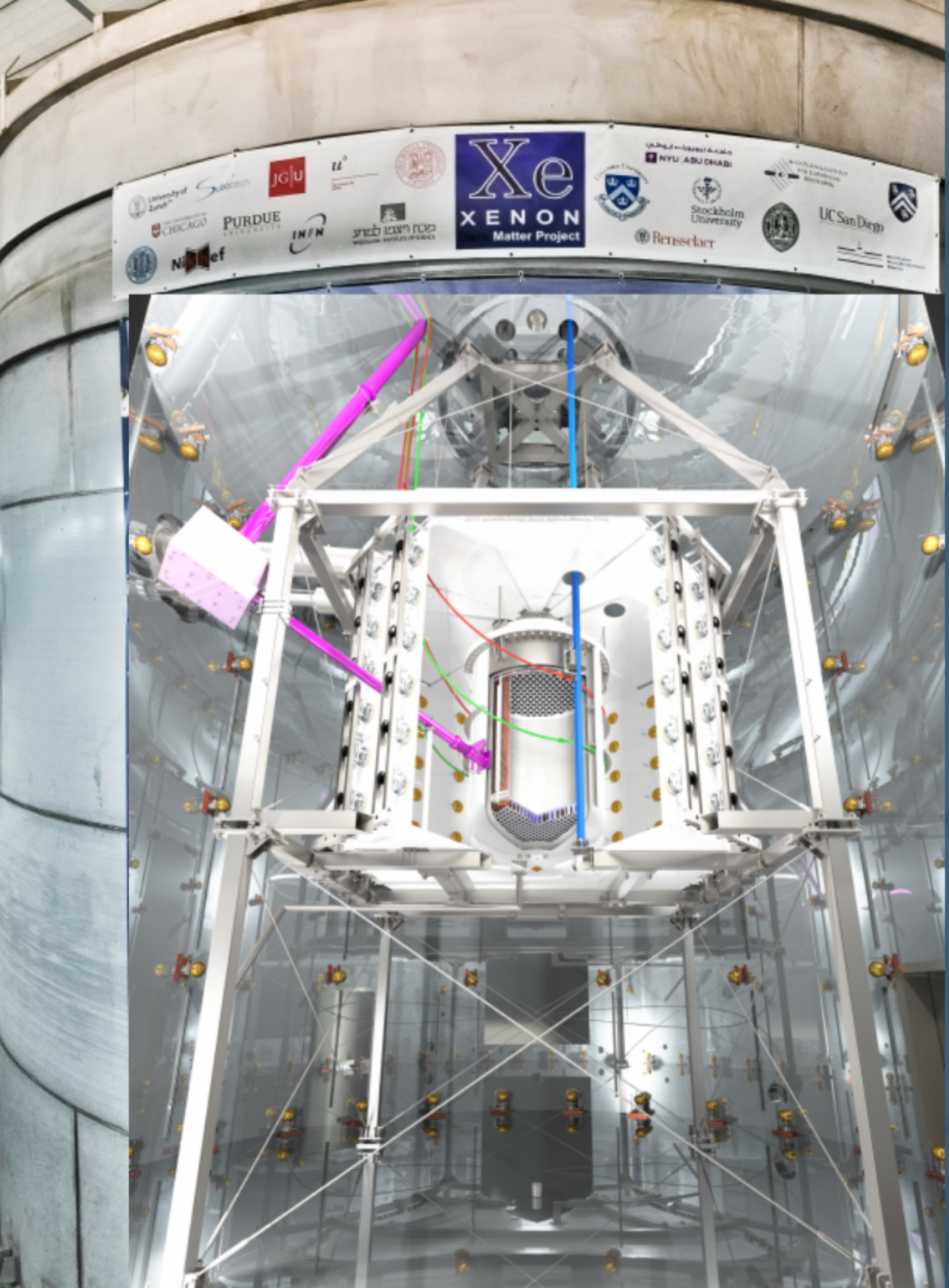


LA THUILE 2022
LES RENCONTRES DE PHYSIQUE DE LA VALLÉE D'AOSTE

Status of the XENONnT Dark Matter Experiment

INFN

ANDREA MANCUSO - UNIVERSITY & INFN BOLOGNA

The XENON Collaboration

XENON

~ 170 scientists - 27 institutes / 11 countries

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

Chicago

UCSD

Rice

Purdue

Tsinghua

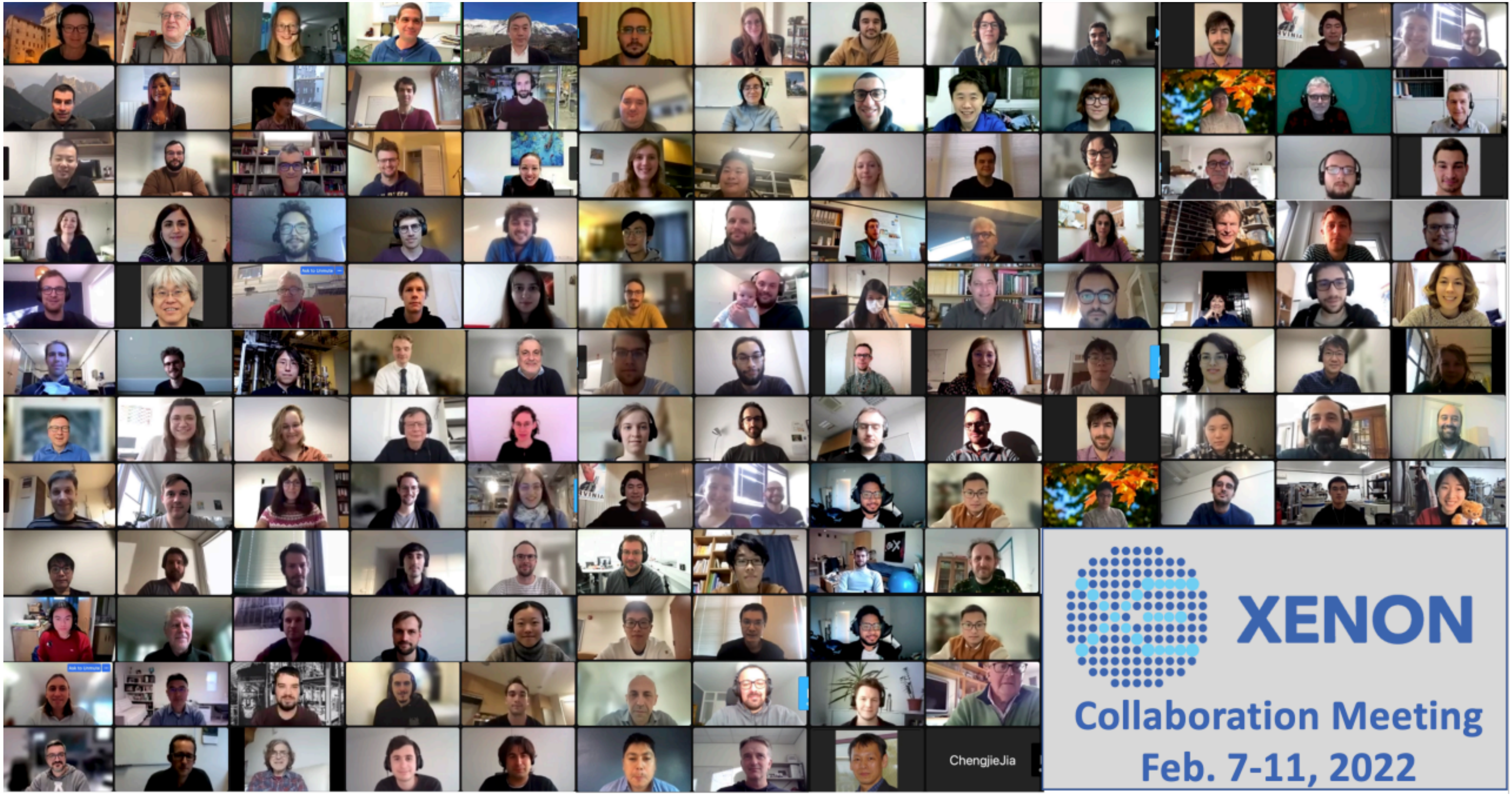
Tokyo

Nagoya

Kobe

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

The XENON Collaboration



The XENON Project

XENON

2005 - 2007

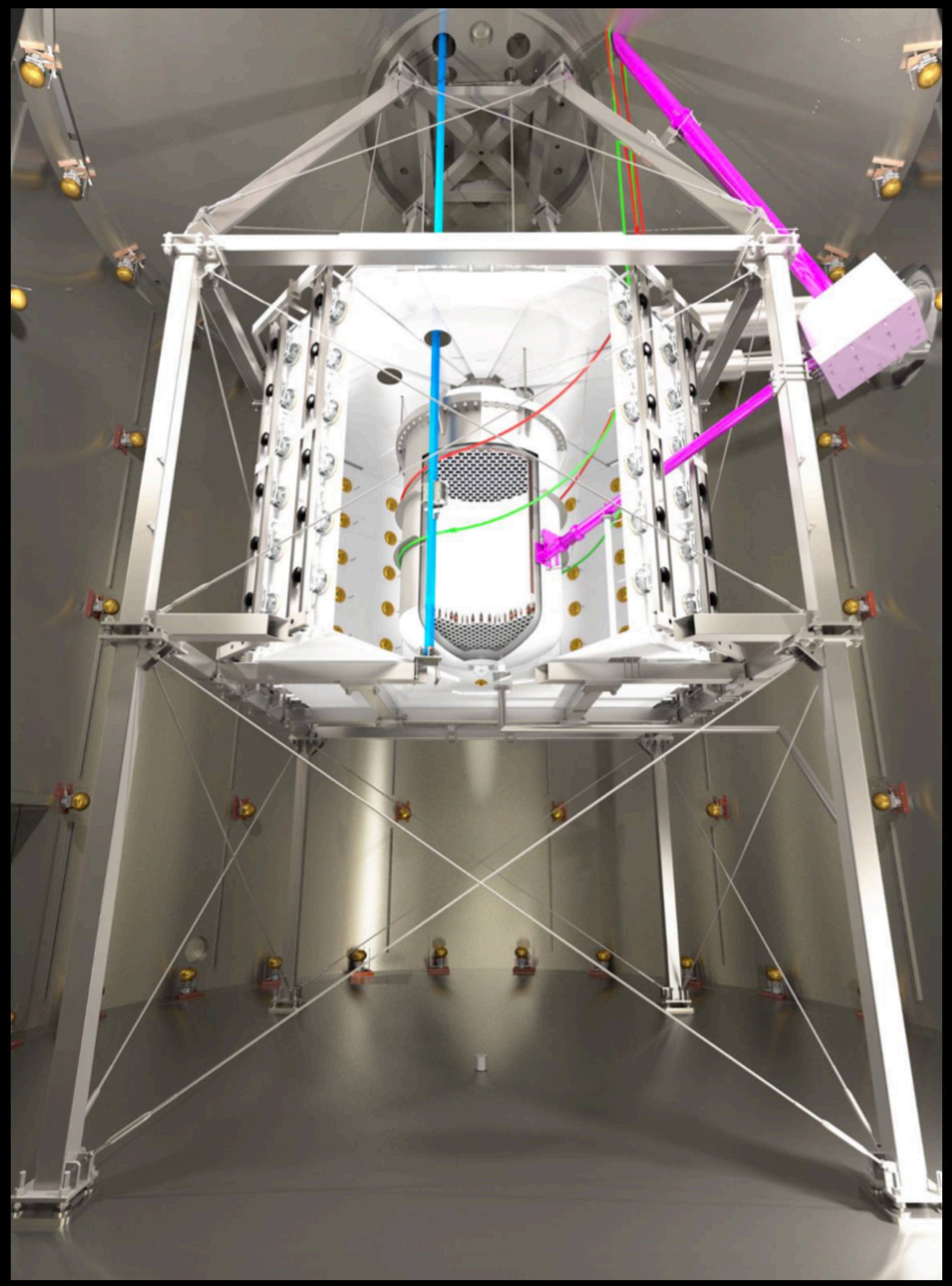
XENON10

2008 - 2016

XENON100

2012 - 2018

XENON1T



2019 - 202n

XENONnT

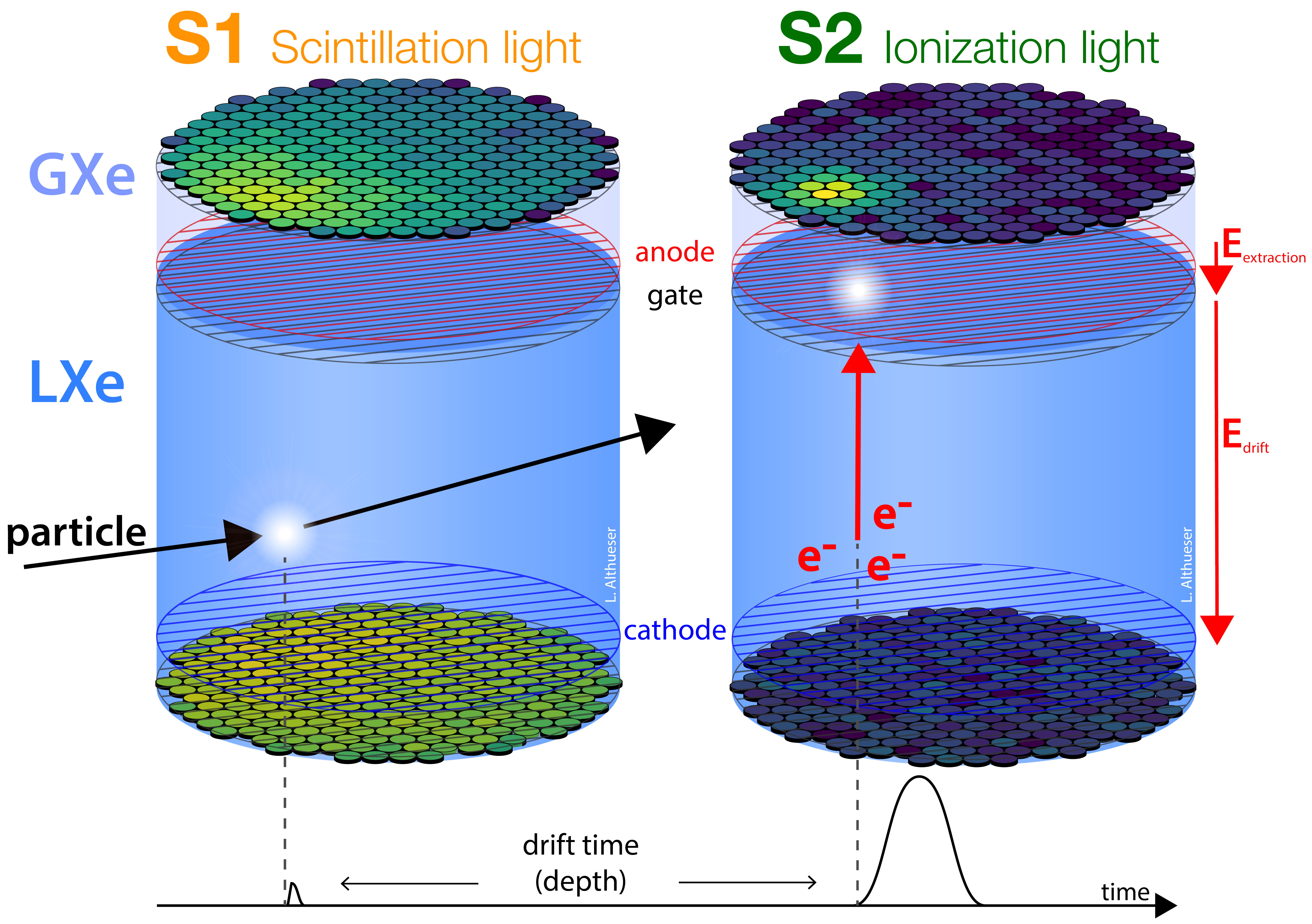
	XENON10	XENON100	XENON1T	XENONnT
Active Mass	14 kg	62 kg	2 tons	5.9 tons
Sensitivity	~10^{-43} cm^2	~10^{-45} cm^2	~10^{-47} cm^2	~10^{-48} cm^2

JCAP 04 (2016) 027

JCAP 11 (2020) 031

The Xe Dual-Phase TPC

Detection Principle

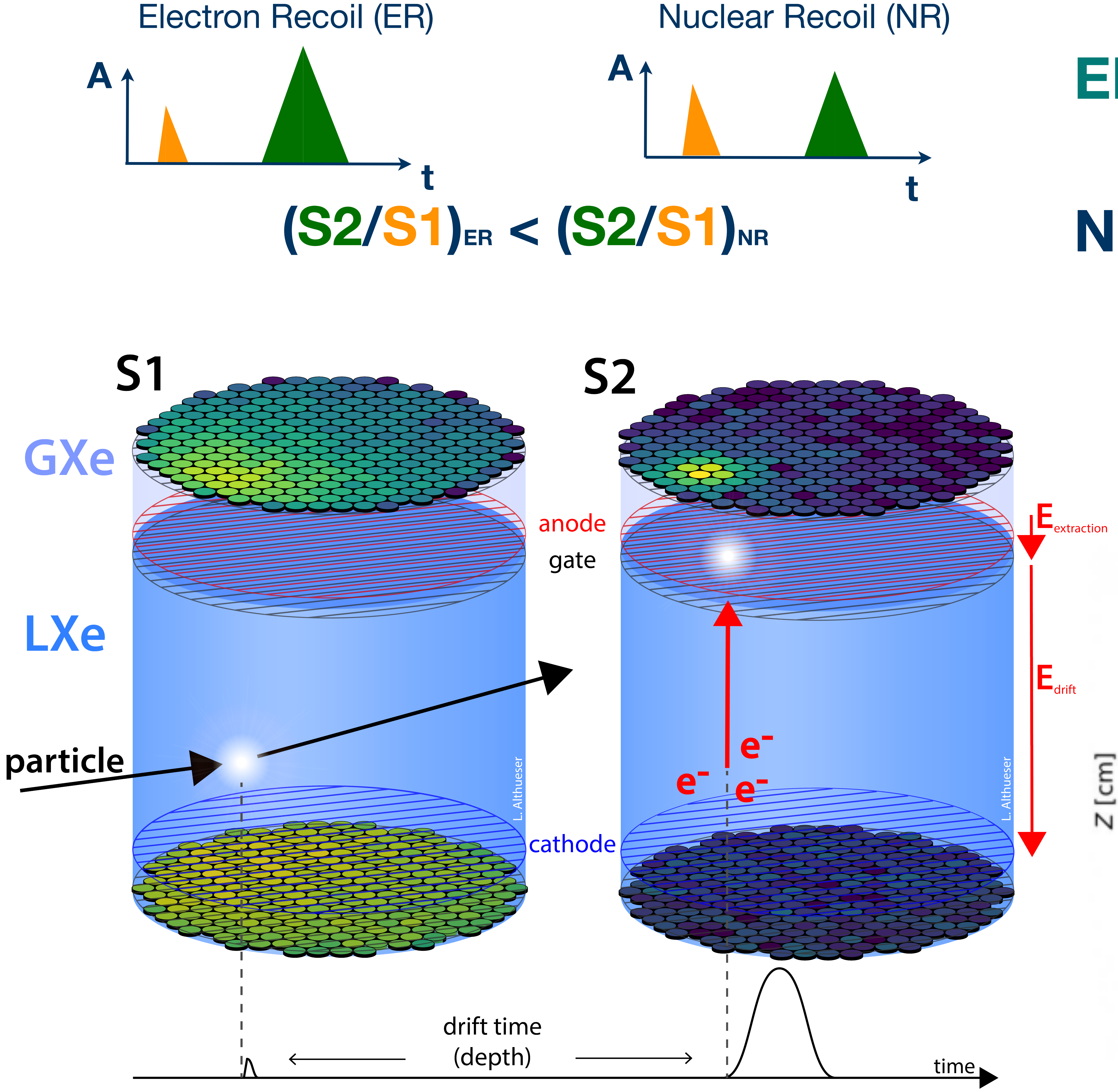


- Dual phase (LXe + GXe) Time Projection Chamber
- Energy Reconstruction $$E = W\left(\frac{S_1}{g_1} + \frac{S_2}{g_2}\right)$$
- 3D Event Reconstruction
  - (x,y) from S2
  - z from drift time
- Discrimination between Electron Recoil and Nuclear Recoil

The Xe Dual-Phase TPC

XENON

Detection Principle

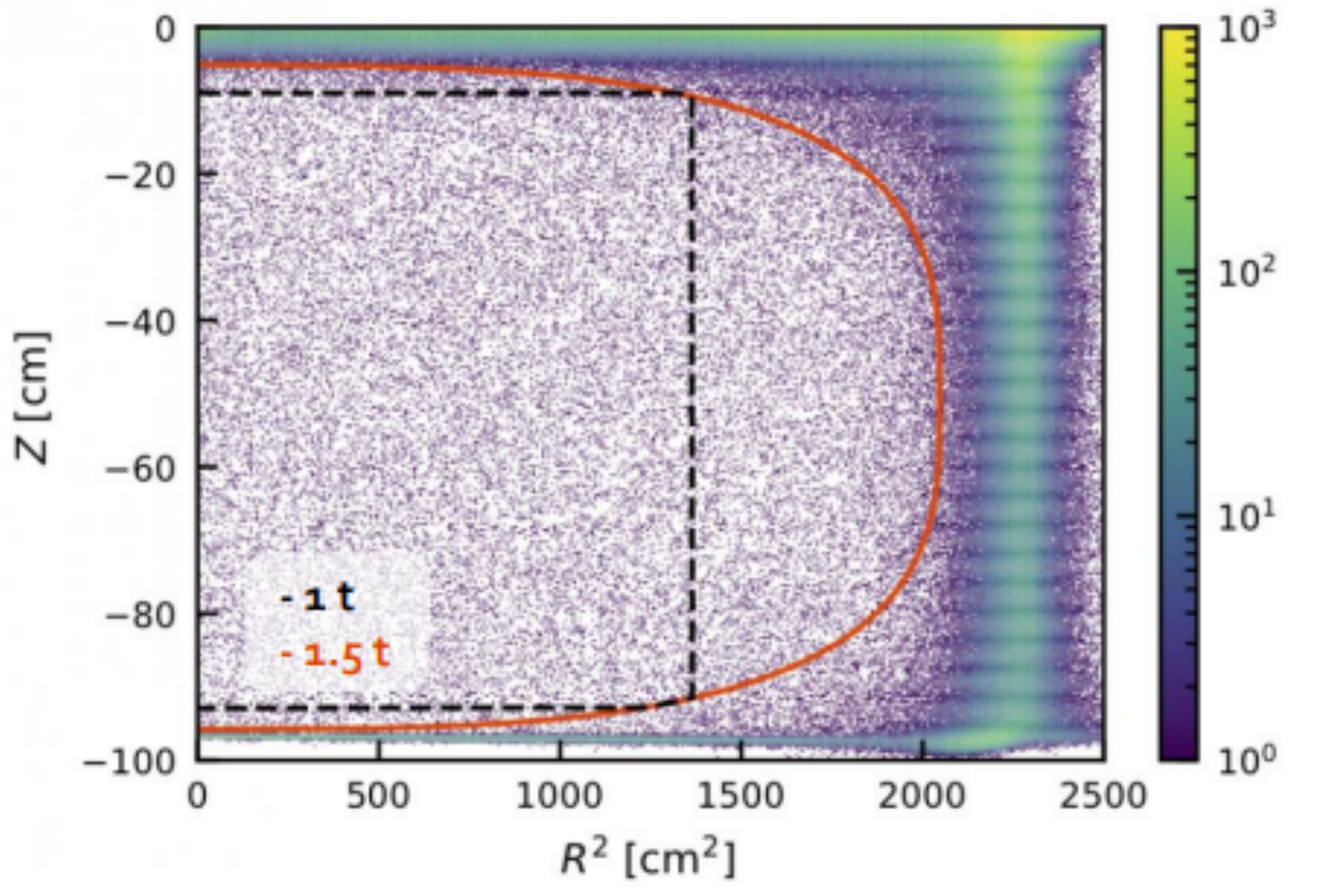


$(S2/S1)_{ER} < (S2/S1)_{NR}$

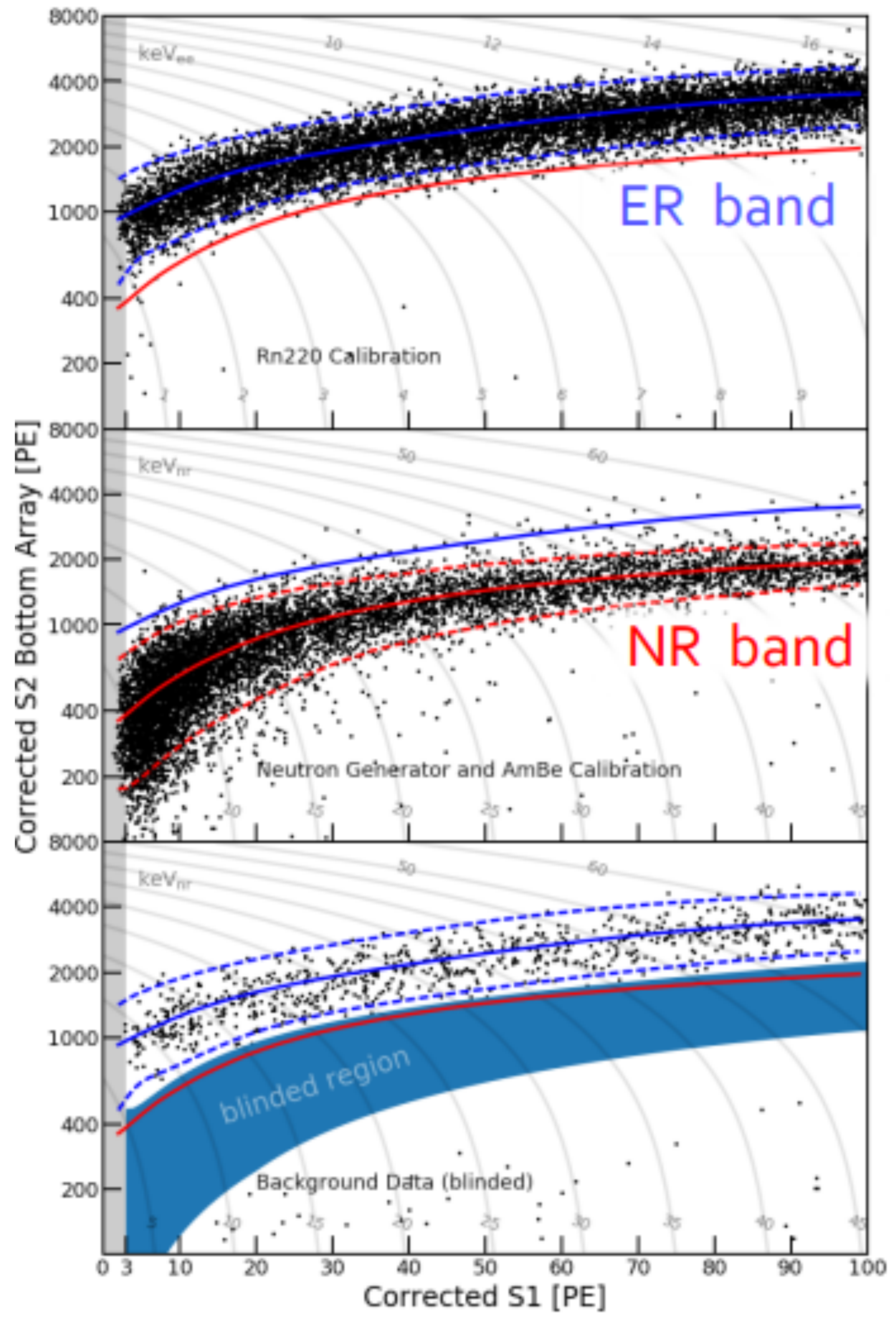
Background

ER	$\gamma, \beta, \nu\text{-}e$ interactions
NR	Neutrons, CEνNS

Fiducialization



Phys. Rev. Lett. **119**, 181302 (2017)



ER-NR discrimination

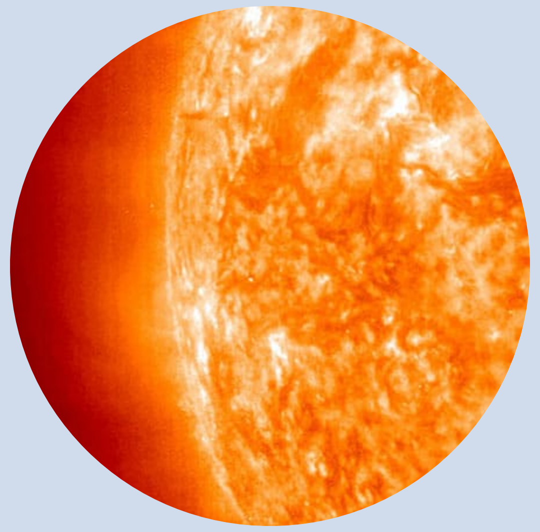
Physics Research in XENON

Dark Matter

WIMP Search
- Spin independent
- Spin dependent
- Sub-GeV

- Dark Photons
- Axion-like particles (ALP)s
- Planck mass

Neutrinos



- Double beta decay of ^{136}Xe
- Double-electron capture in ^{124}Xe
- Neutrino magnetic moment

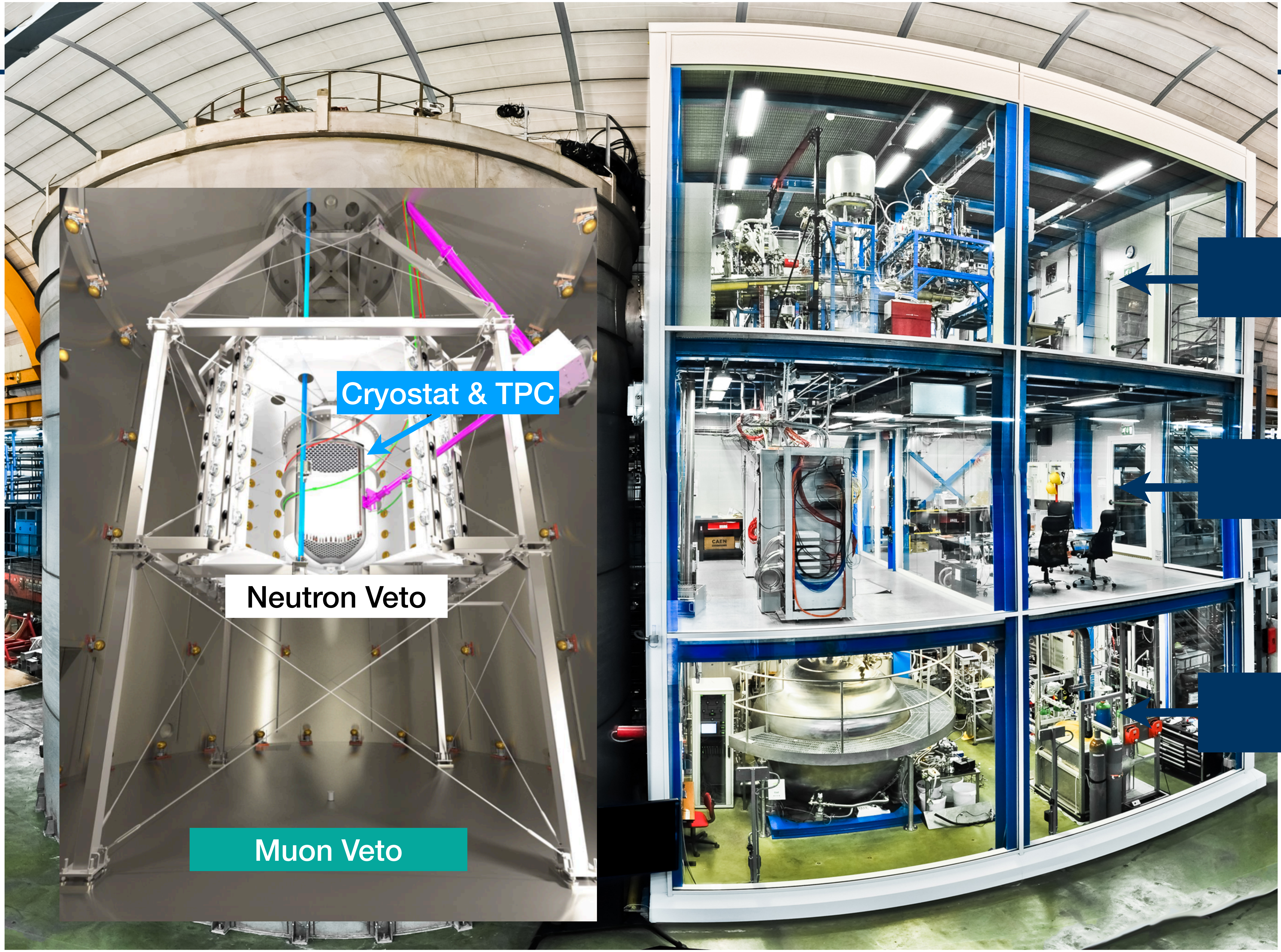
Solar Neutrinos
- Boron-8
- pp neutrinos

Solar Axions

Supernova neutrinos
Multi-messenger

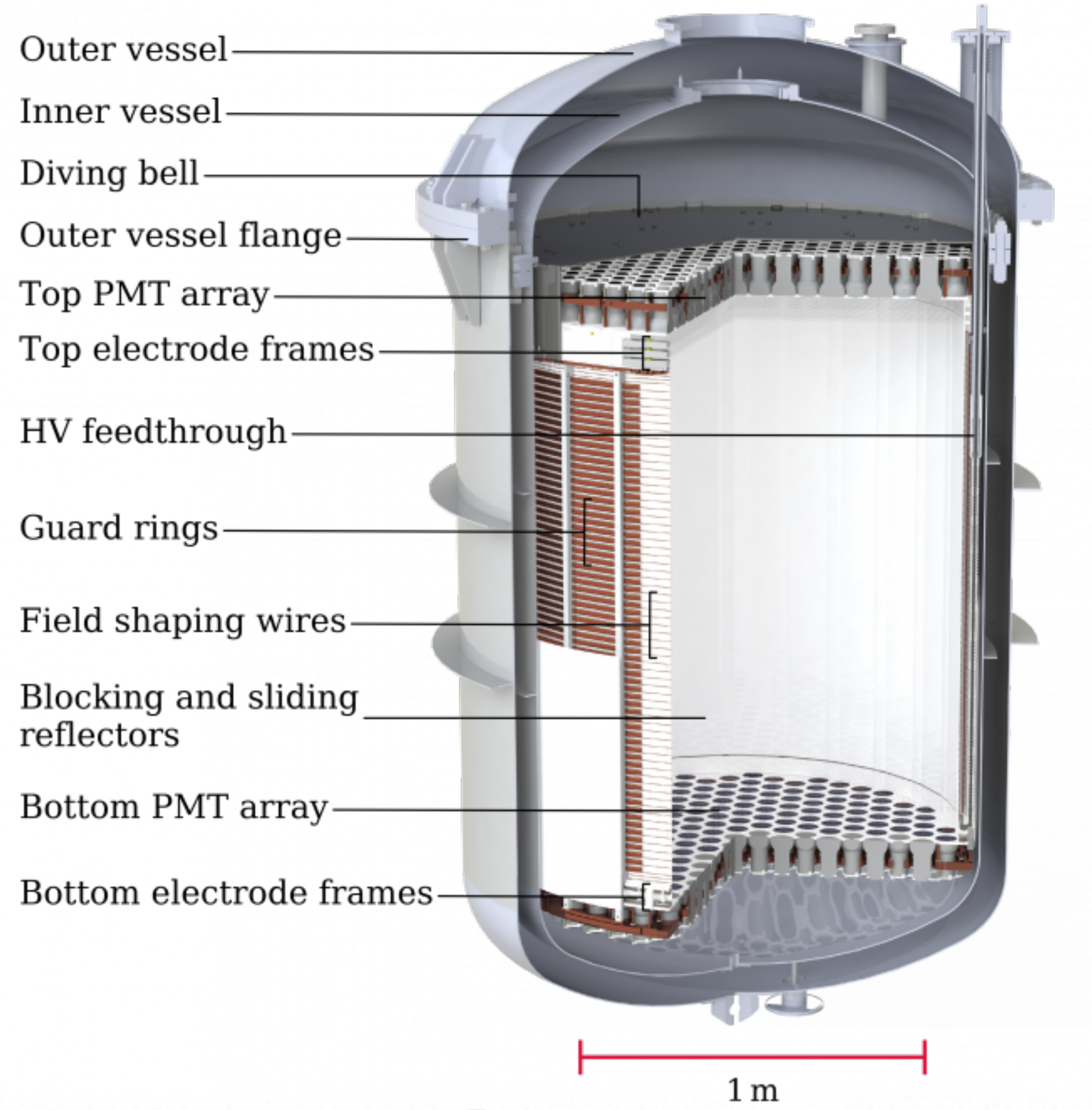
The Experiment

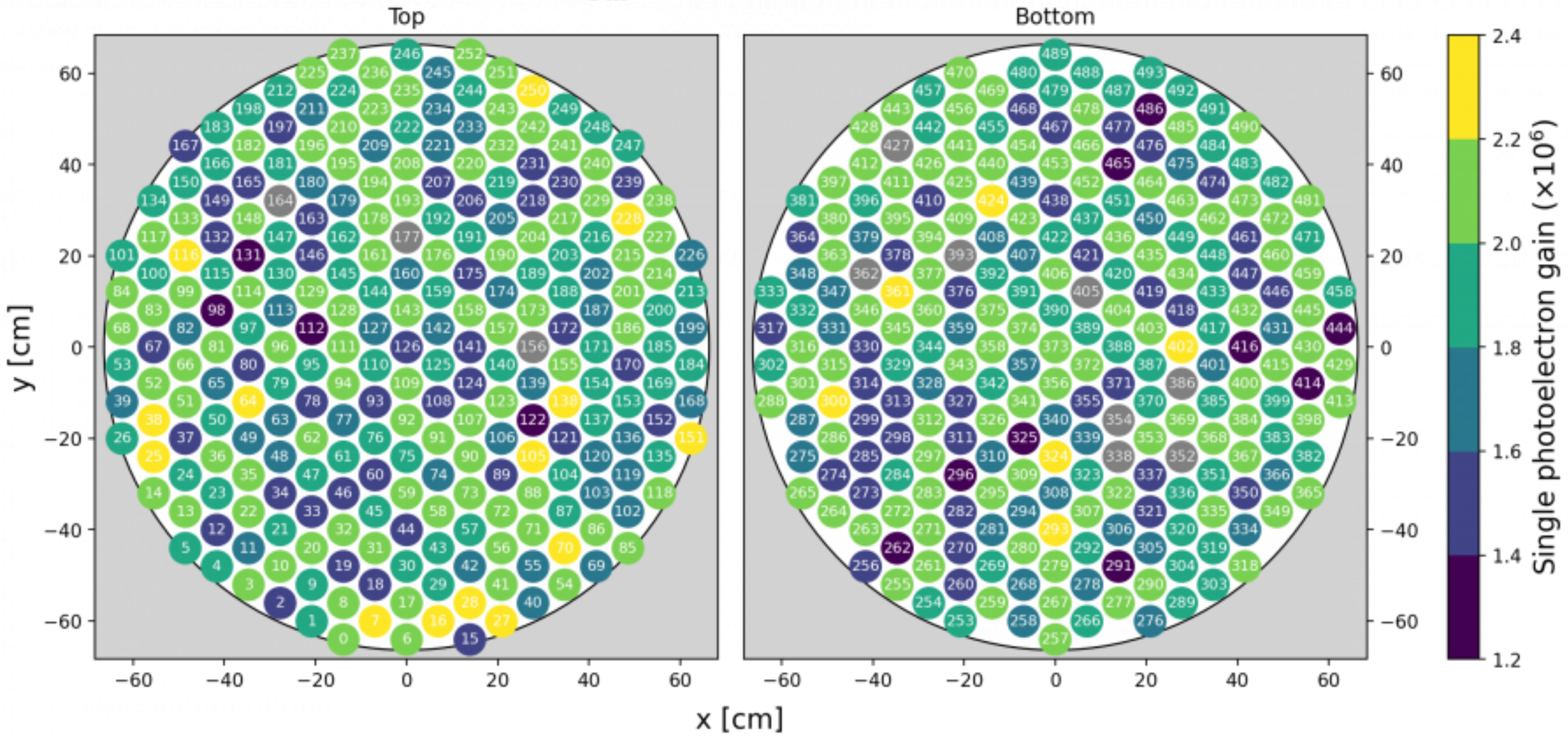
- Commissioned in 2020/21
- Currently in Science Run: data taking and analysis



The XENONnT TPC

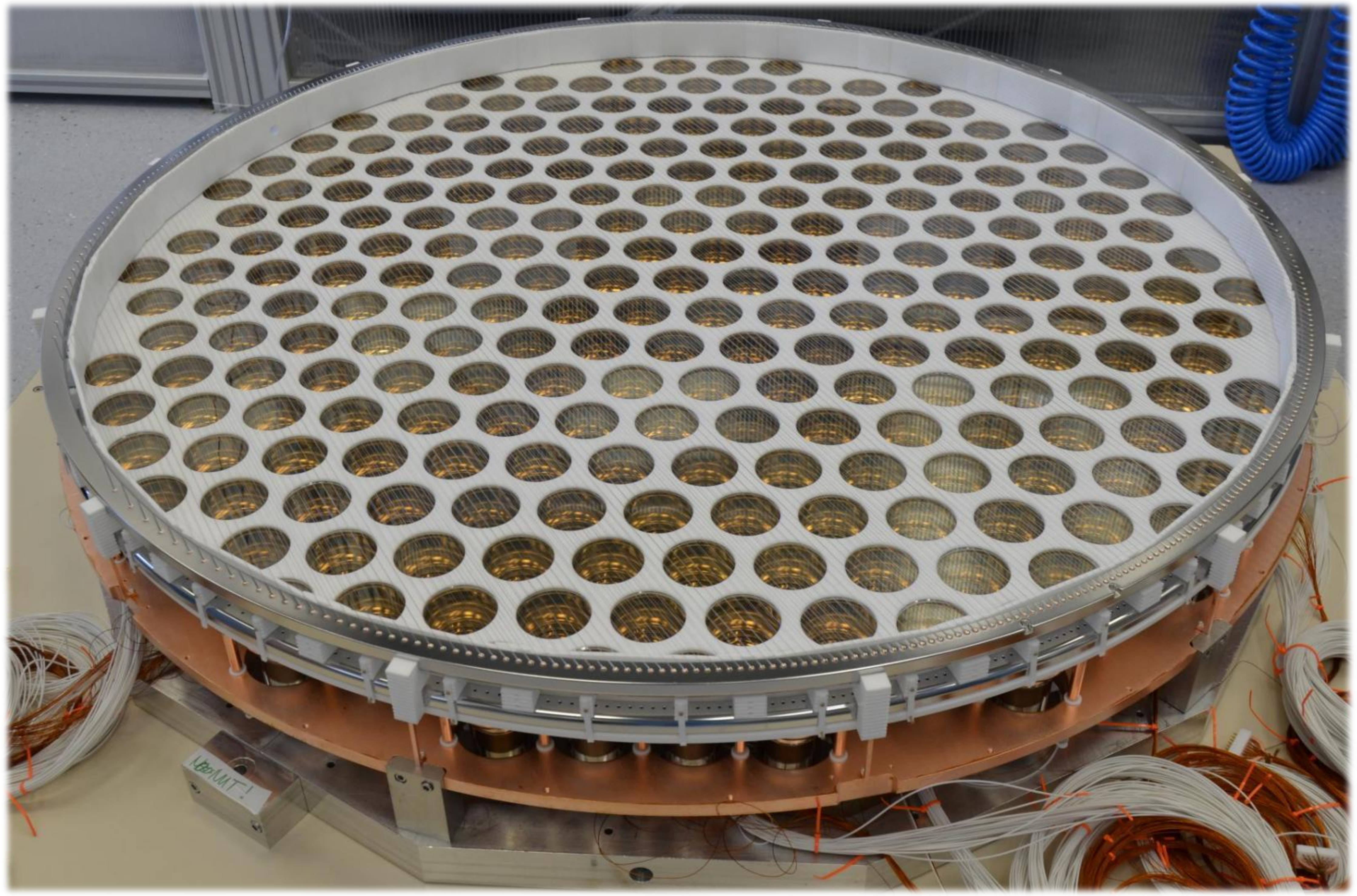
XENON

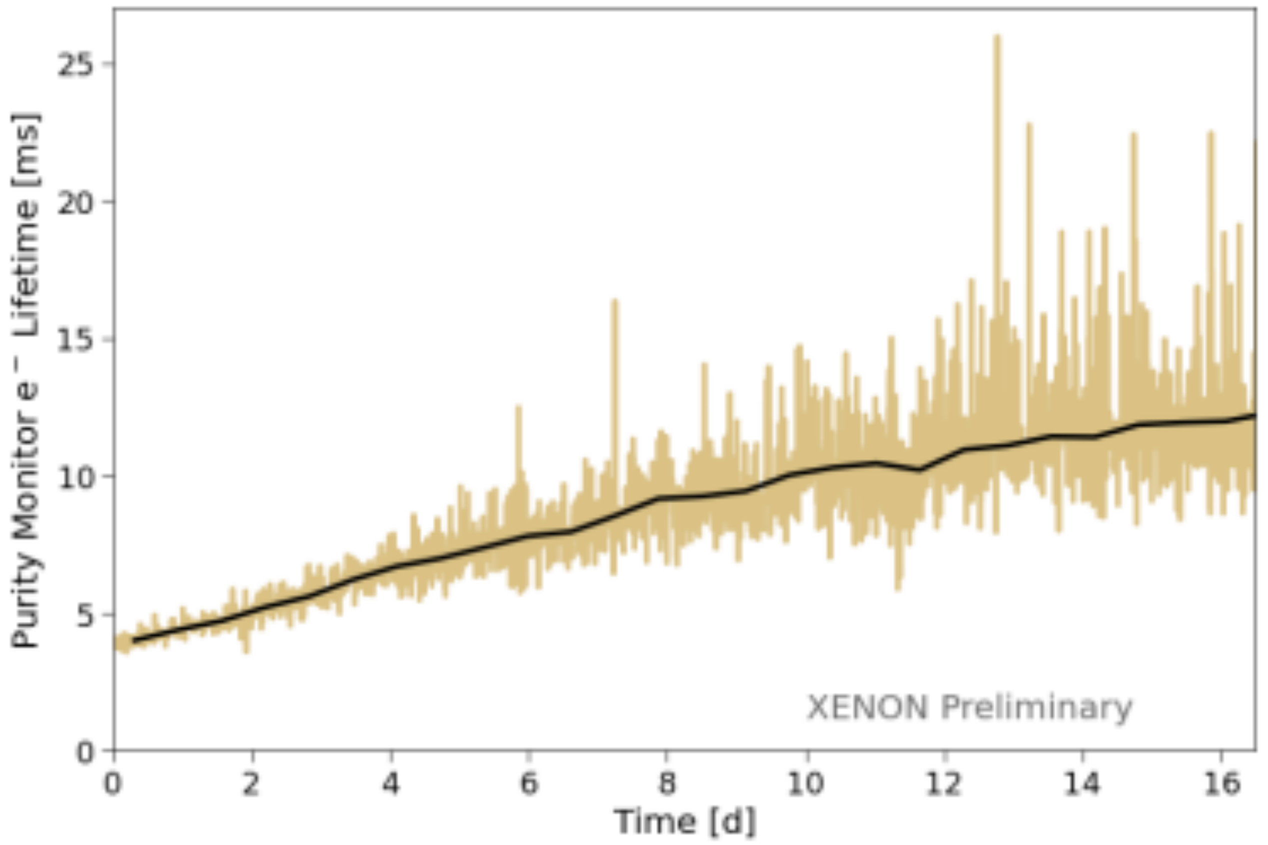




- 5.9 t active LXe (3 times XENON1T)
- 494 PMTs Hamamatsu R11410-21 3-inches
- Tunable field shaping rings chain
- Materials selection based on intense screening campaing

PMT Top Array



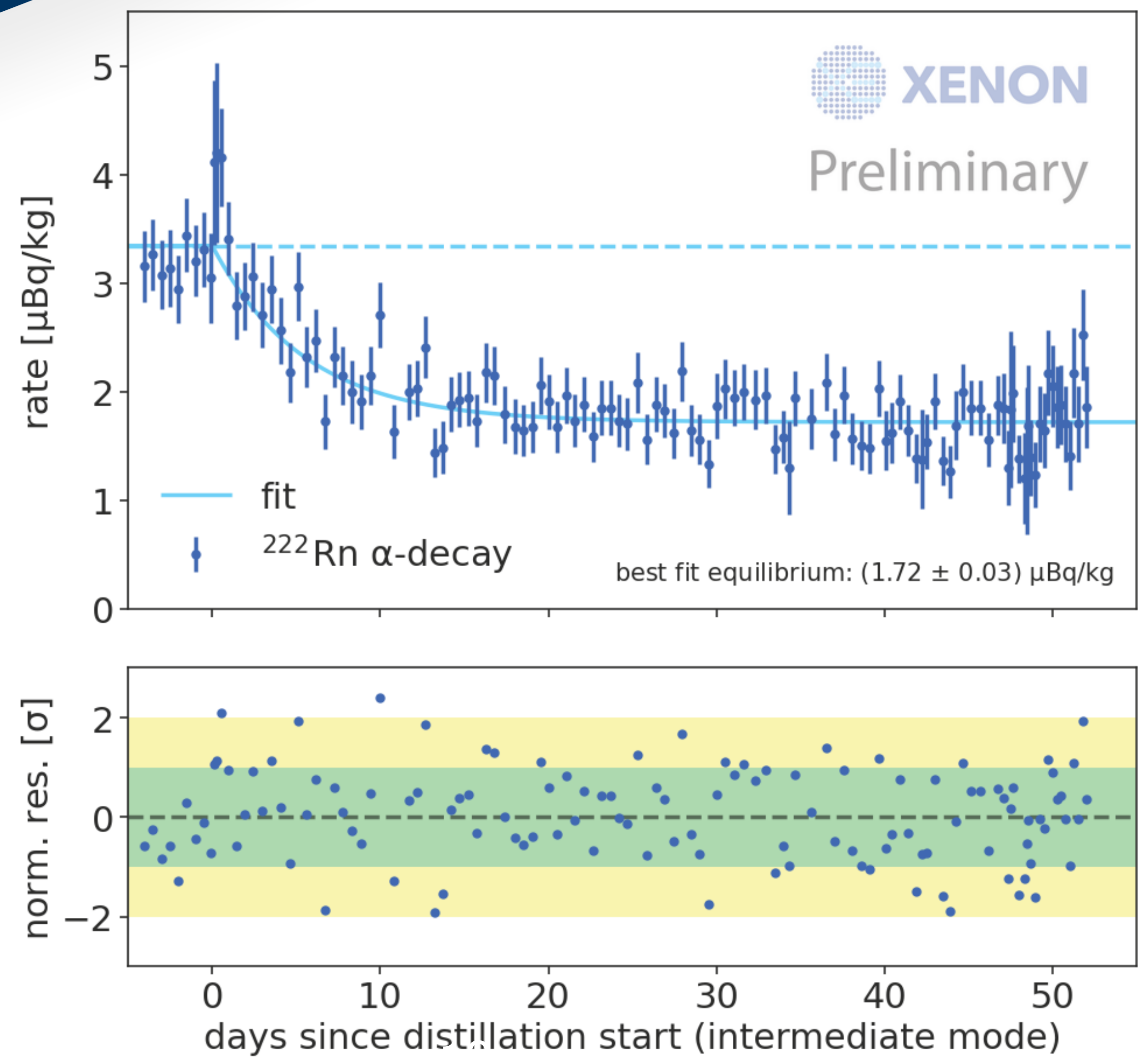


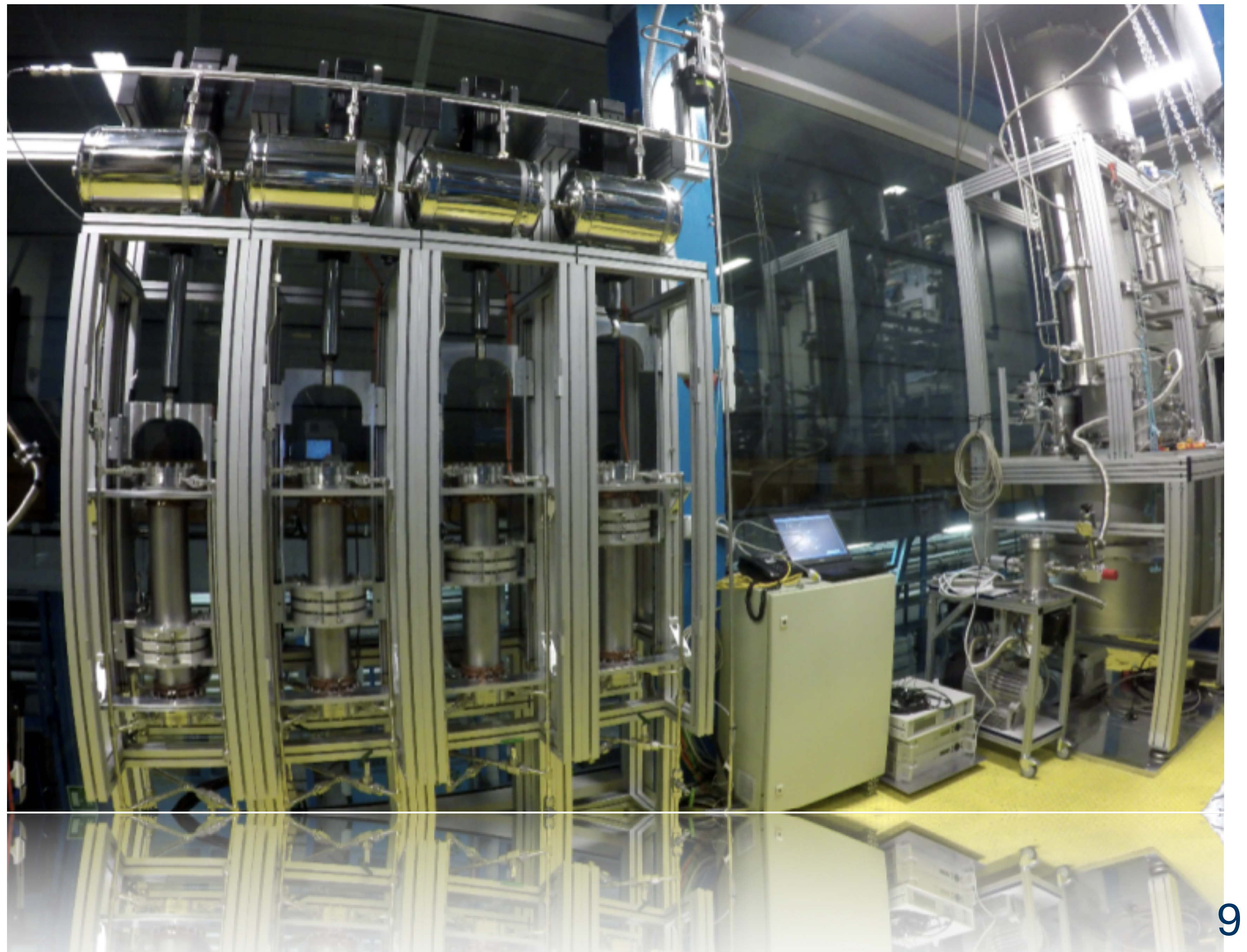
XENON

- Electron lifetime >10 ms
- Ultra-low radon emanation

Rn Distillation Column

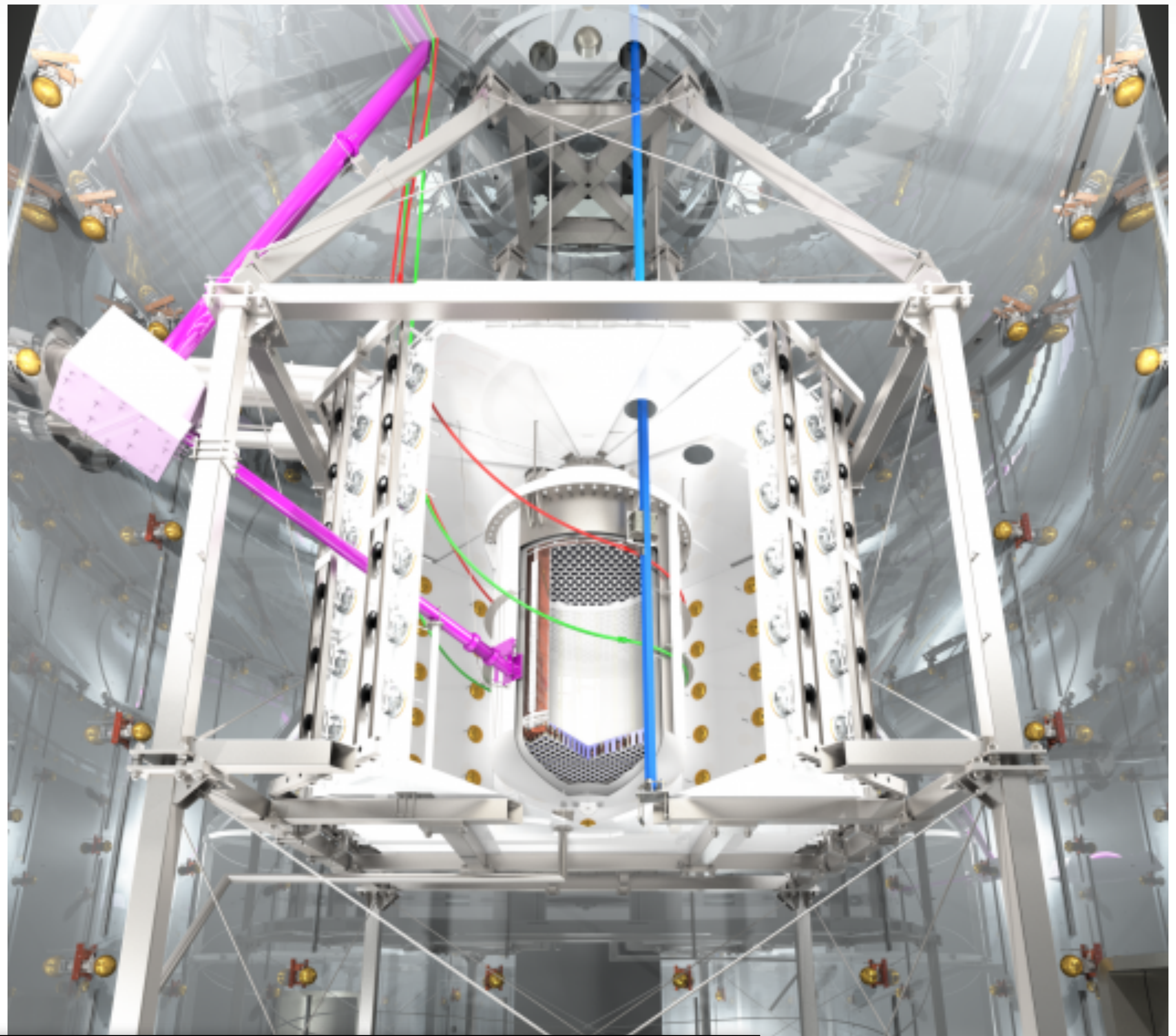
Liquid Xe Purification





- Achieved result: < 2 µBq/kg ^{222}Rn achieved
- Goal: 1 µBq/kg - Extra factor of 2 reduction possible

Neutron & Muon Veto



MV

Water Cherenkov Detector instrumented with 84 PMTs

Passive water shield

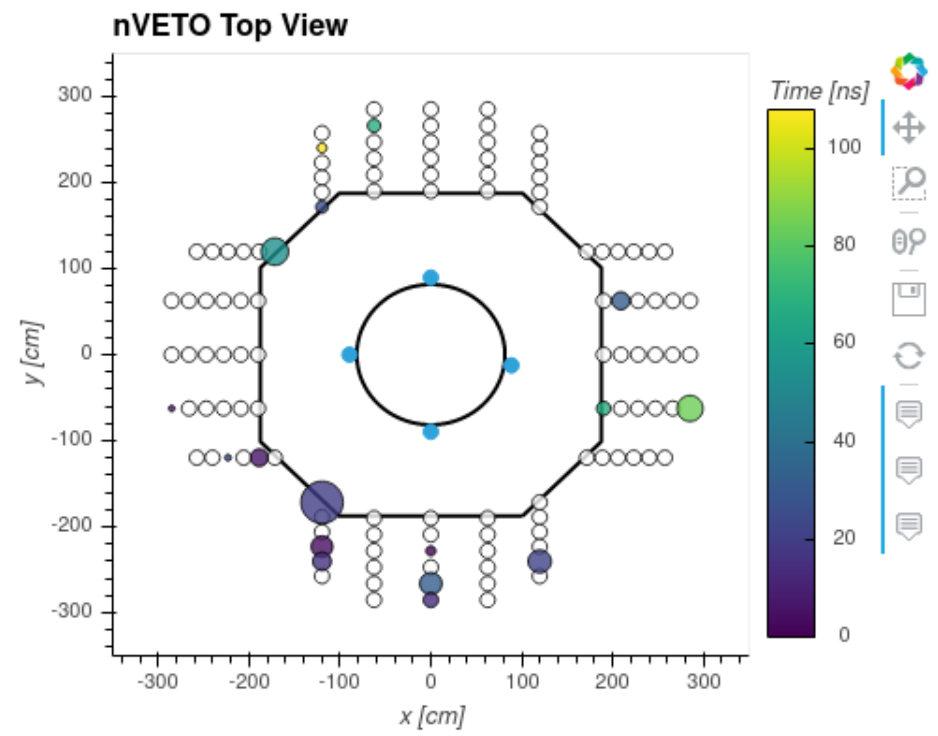
NV

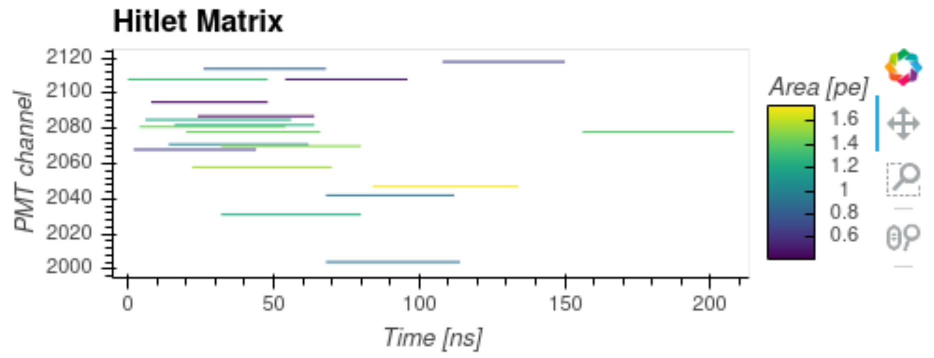
Water Cherenkov detector, currently operated with demi-water. In the next phase we will dope with 0.5% Gd-sulphate.

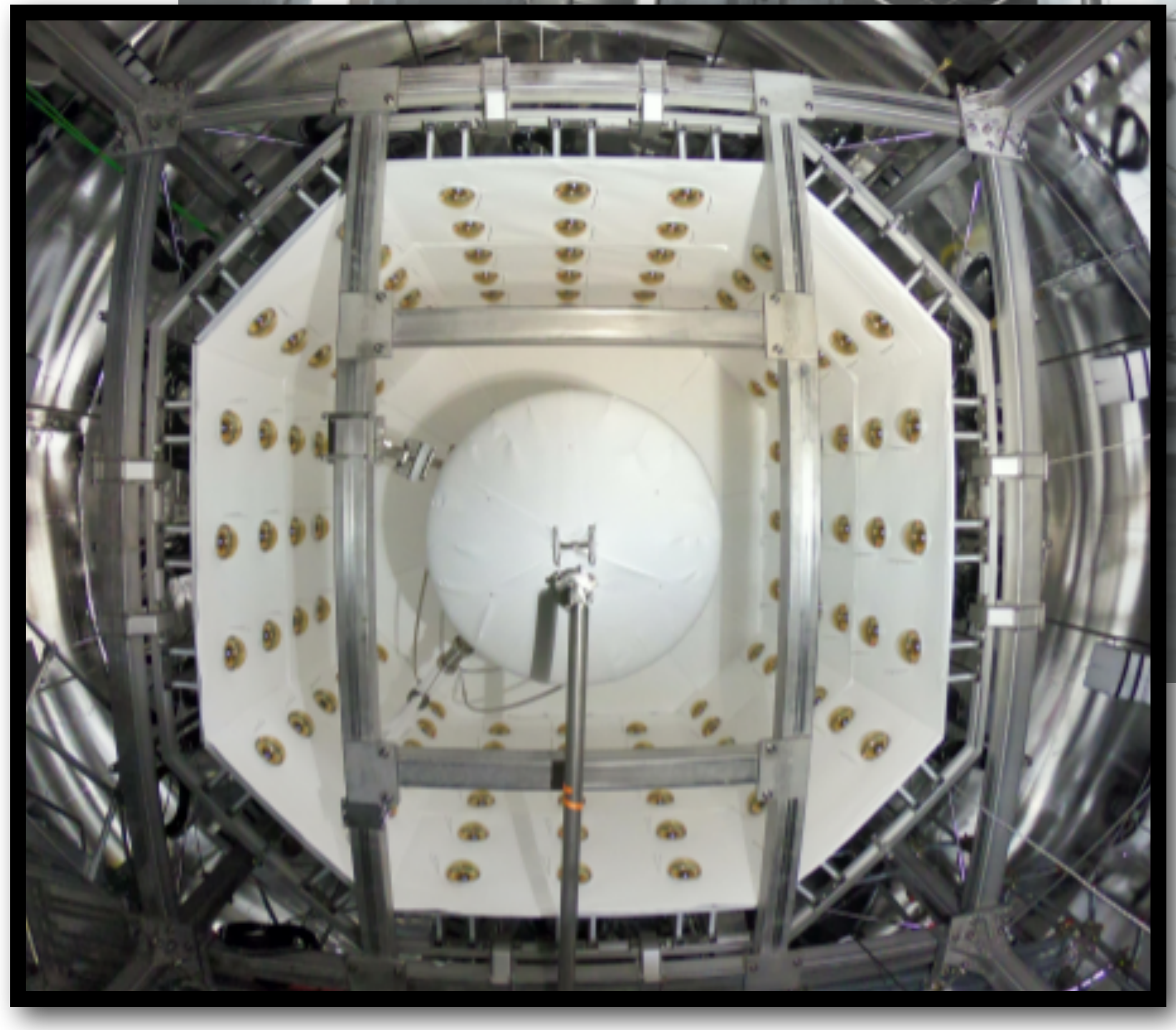
Inner region optically separated from the MV through high reflectivity ePTFE panels,

Instrumented with 120 low-radioactivity, high-QE PMTs

Aims to reduce the background of radiogenic neutrons coming from the detector materials

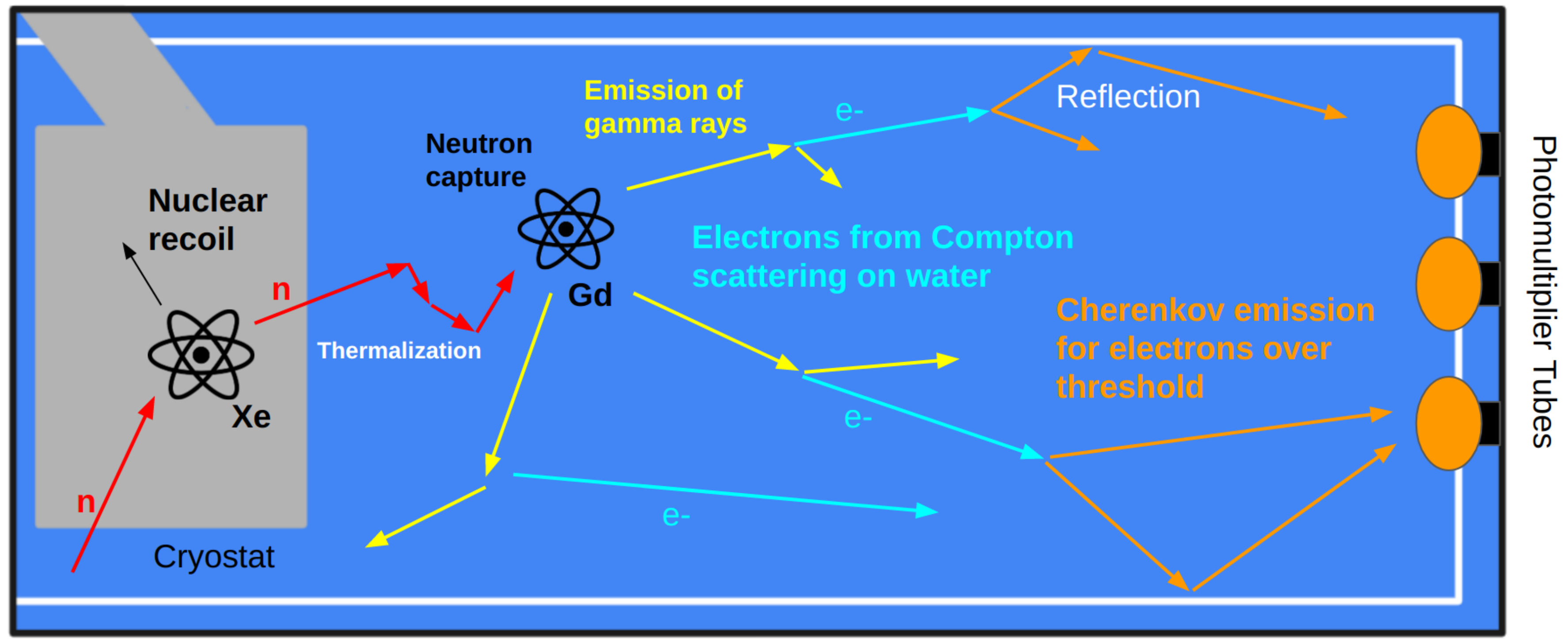






Gd-Water Purification Plant

(In commissioning at LNGS)



- Expected tagging efficiency with Gd: 87 % - with water: 65%
- Goal: <1 neutron events / (20 tonne year)

XENONnT Commissioning

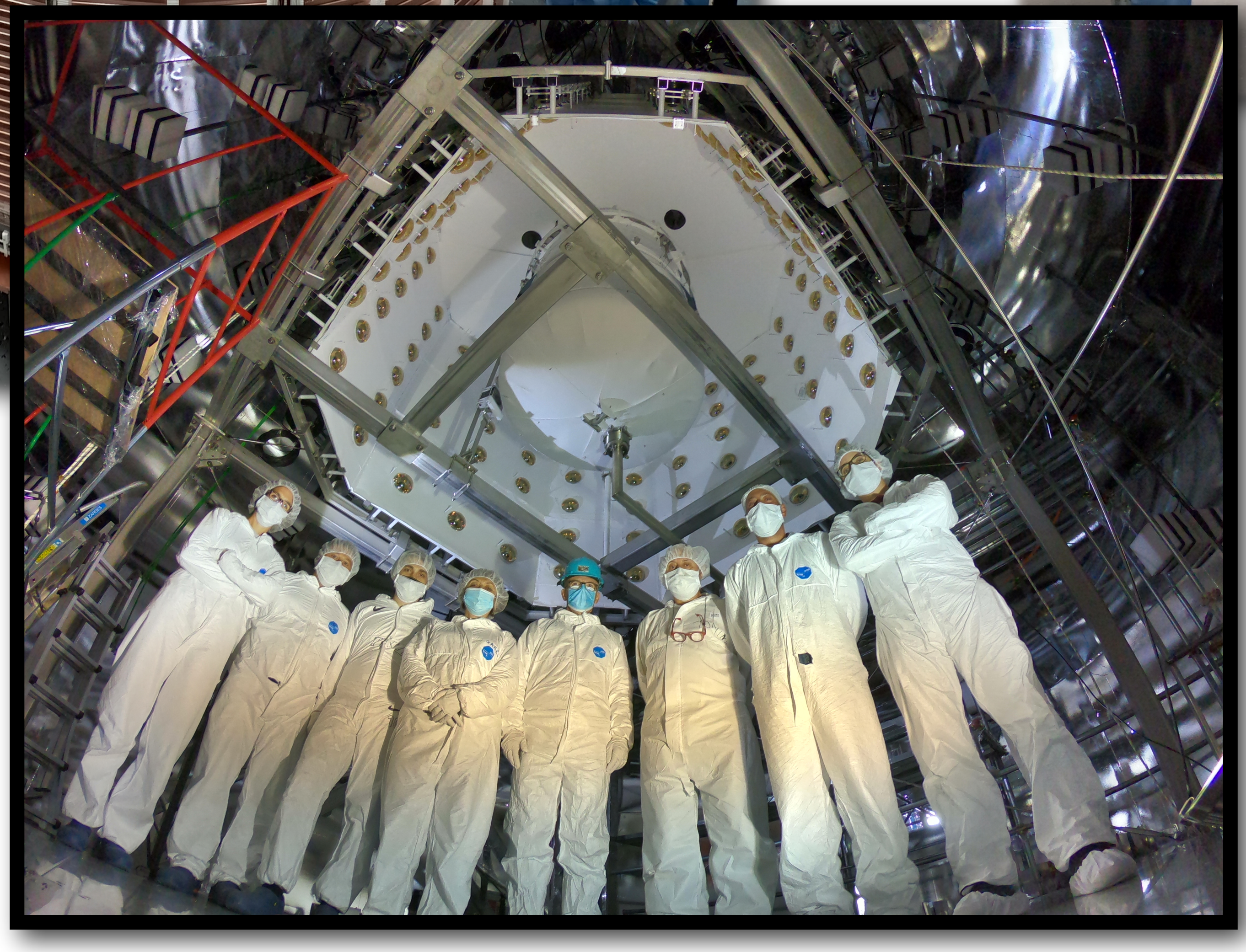
Spring 2020
- **TPC Installation**

Summer 2020
- **NV Installation**

December 2020
- **Water Tank filled**

First months 2021
- **Test of all the subsystems and TPC commissioning**

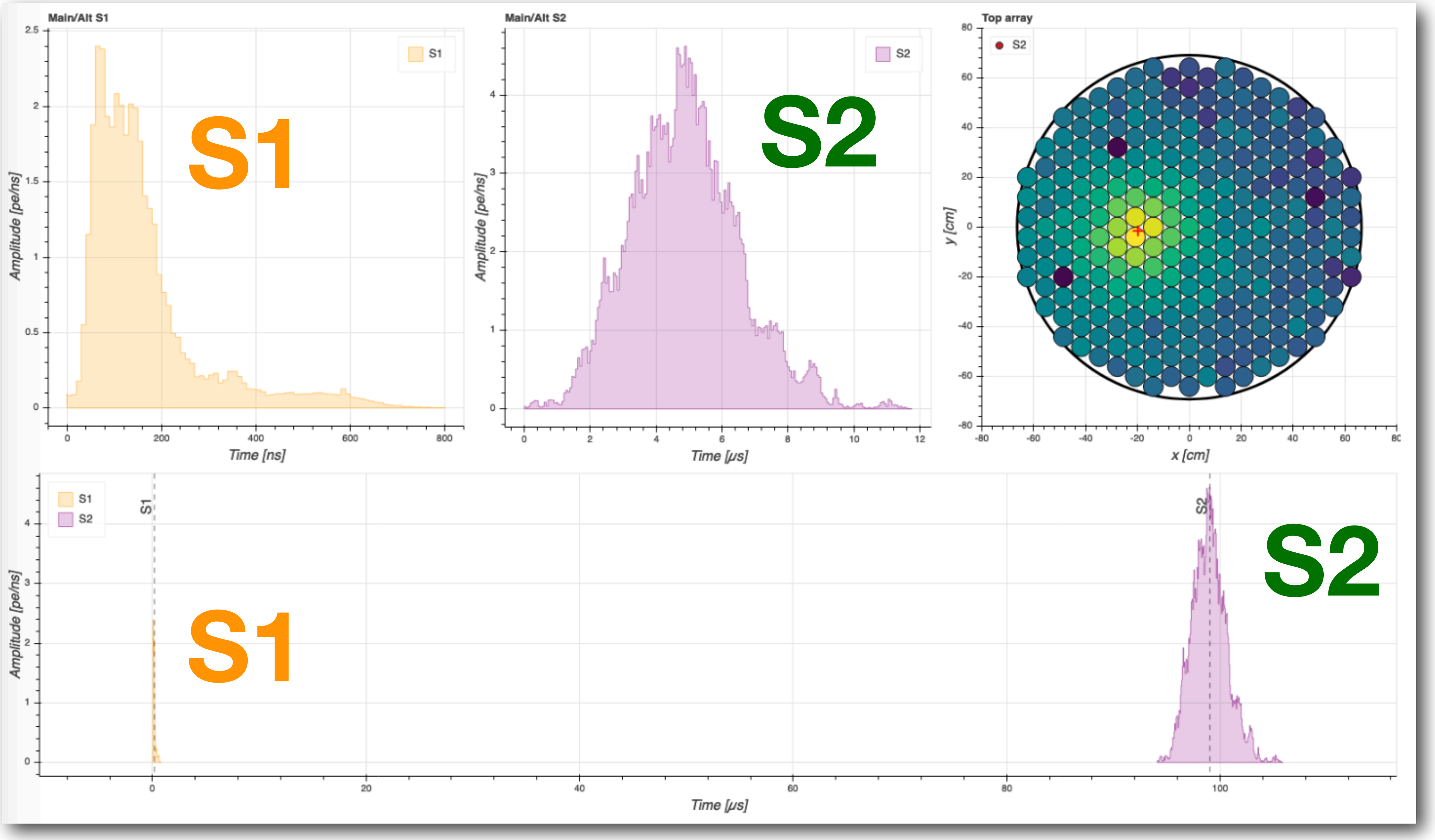
Now
- **Science Run**



XENONnT First Science Run

First XENONnT Science Run ongoing

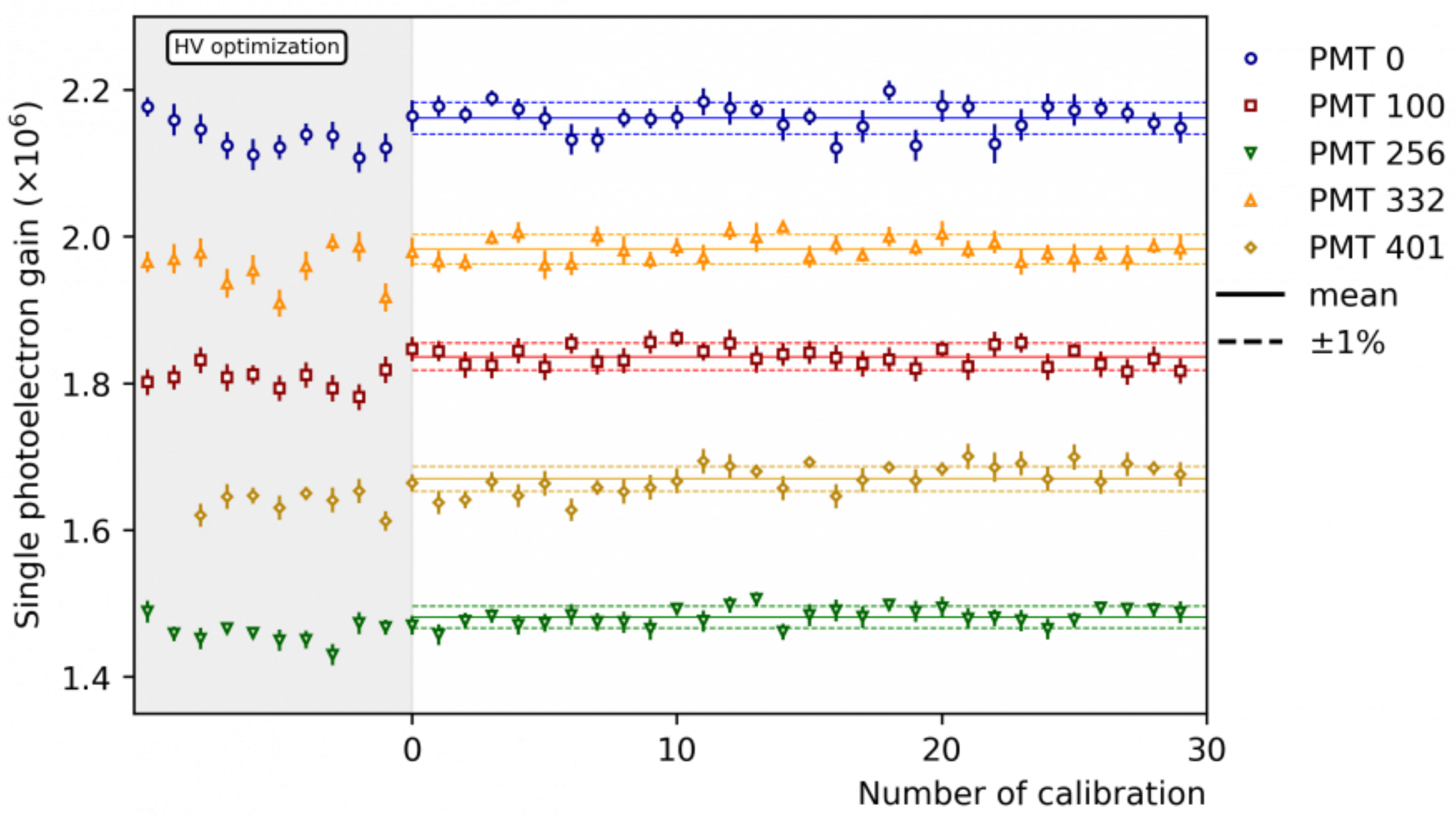
- Focused on WIMP search
- Investigation of the low-energy ER events

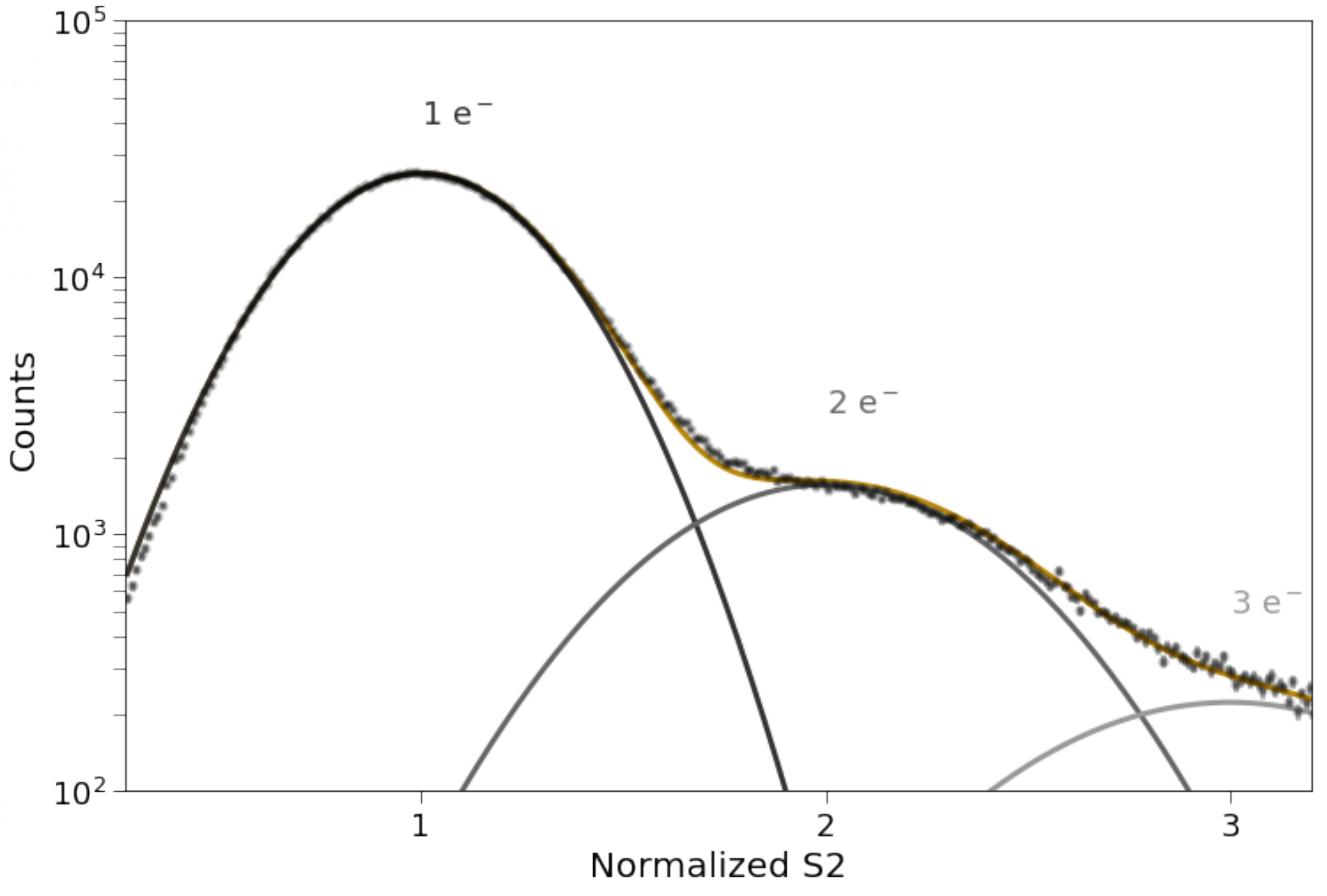


Initial XENONnT Perfomance

- **Light Collection** : ~17%
- **SPE Resolution** : ~27%
- **Excellent PMTs performance**

PMT Performance





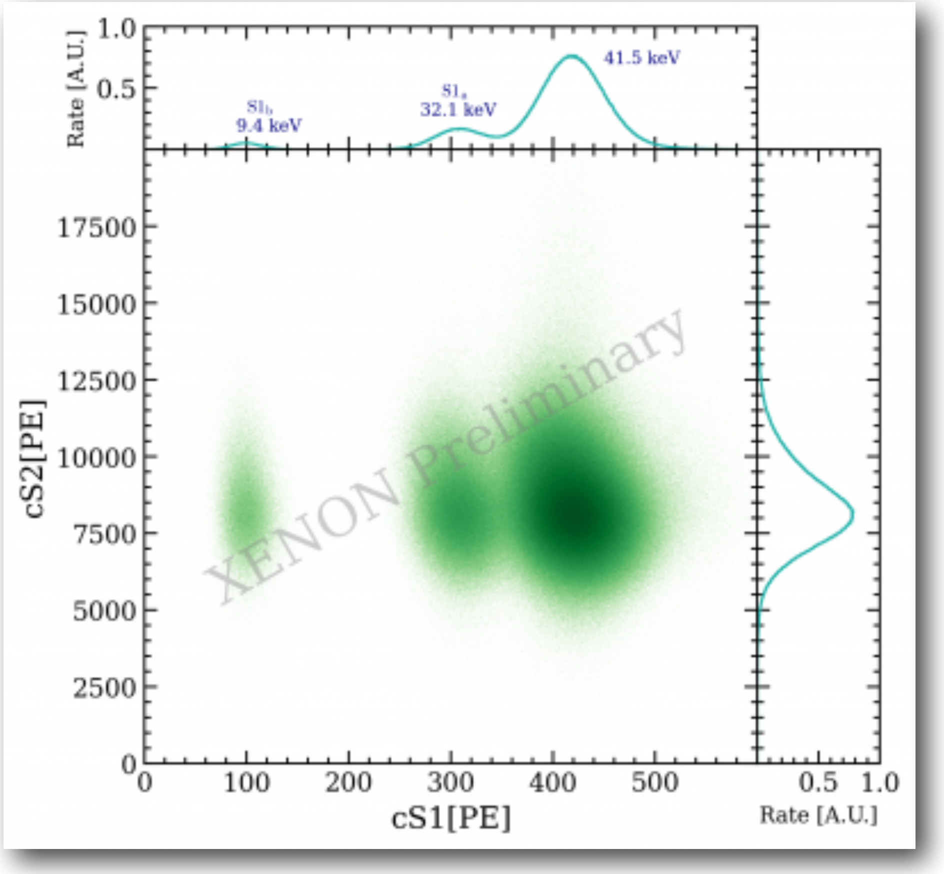
XENONnT First Science Run

Calibrations

^{83m}Kr

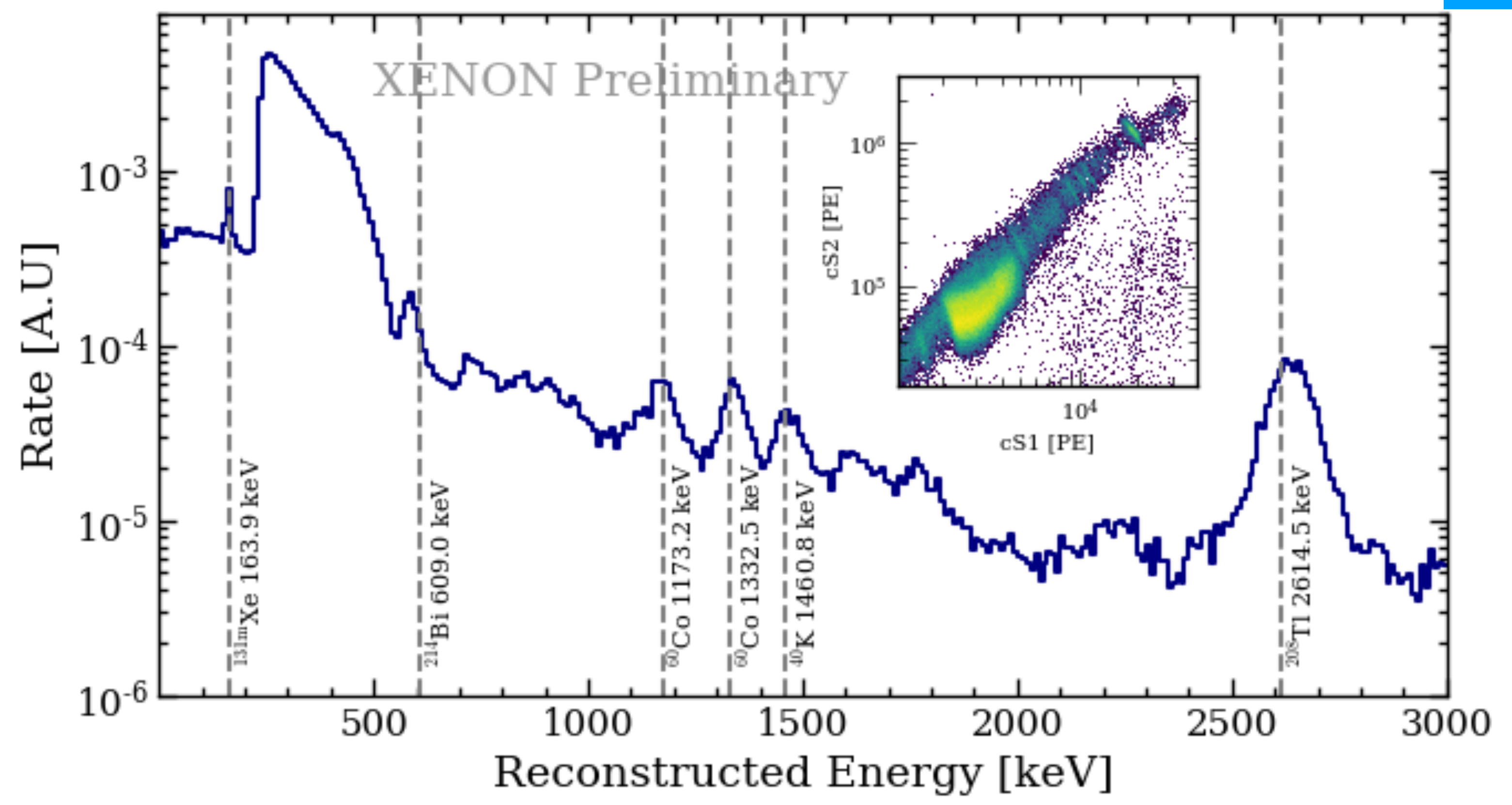
Detector effects and energy resolution

- 7.6% energy resolution at 41.5 keV



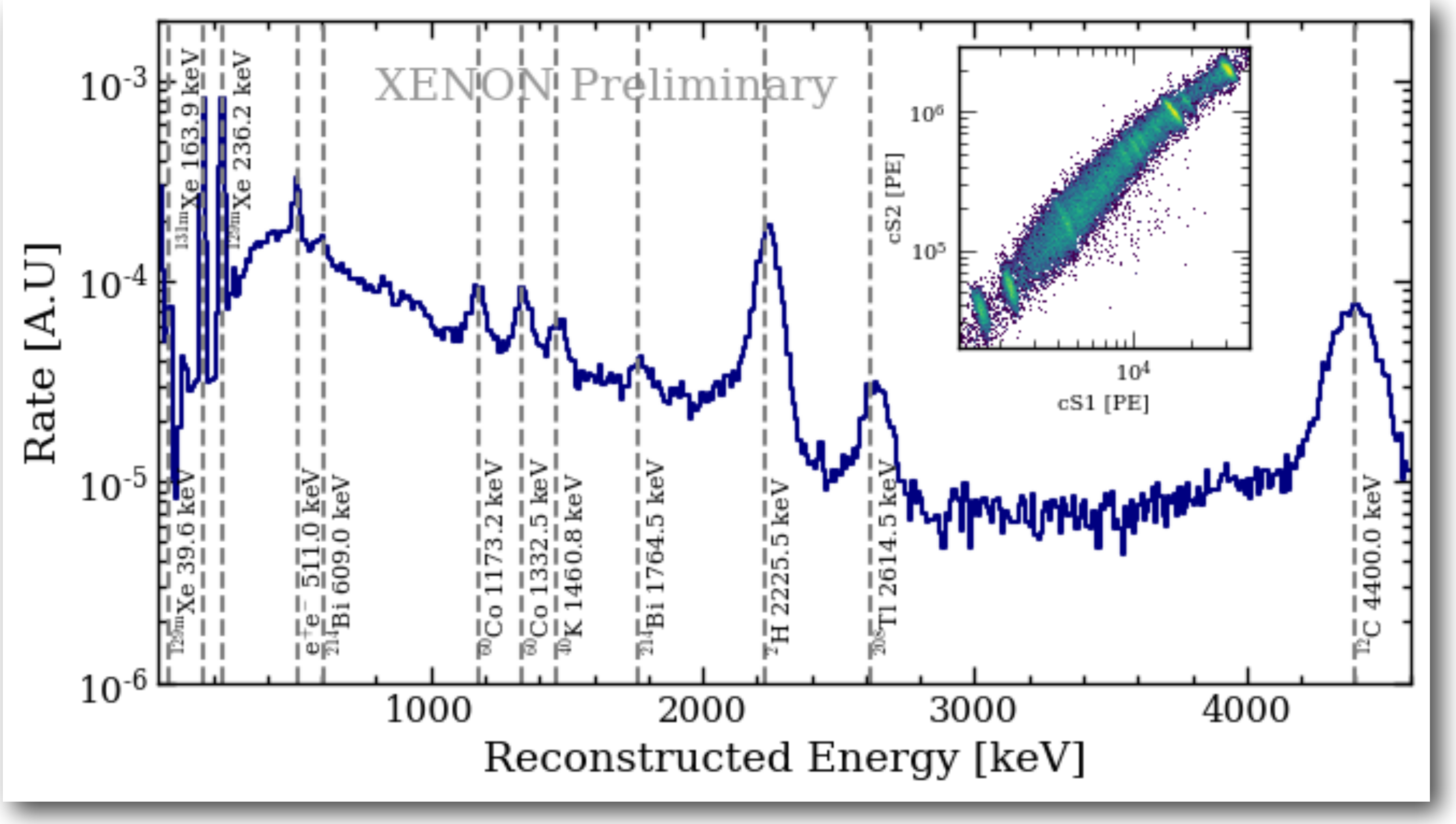
^{220}Rn

Electron Recoil band

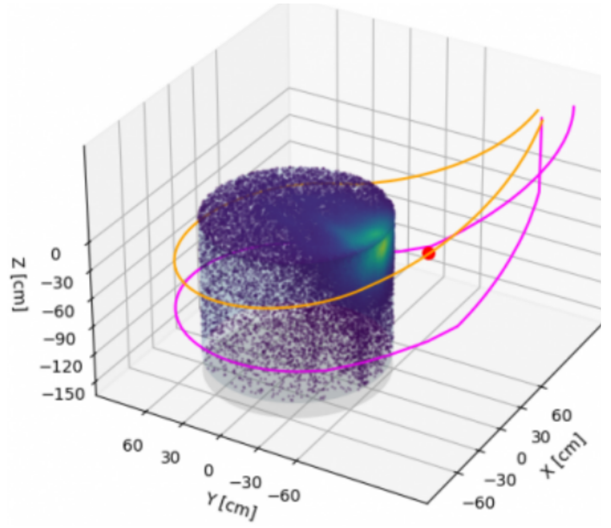


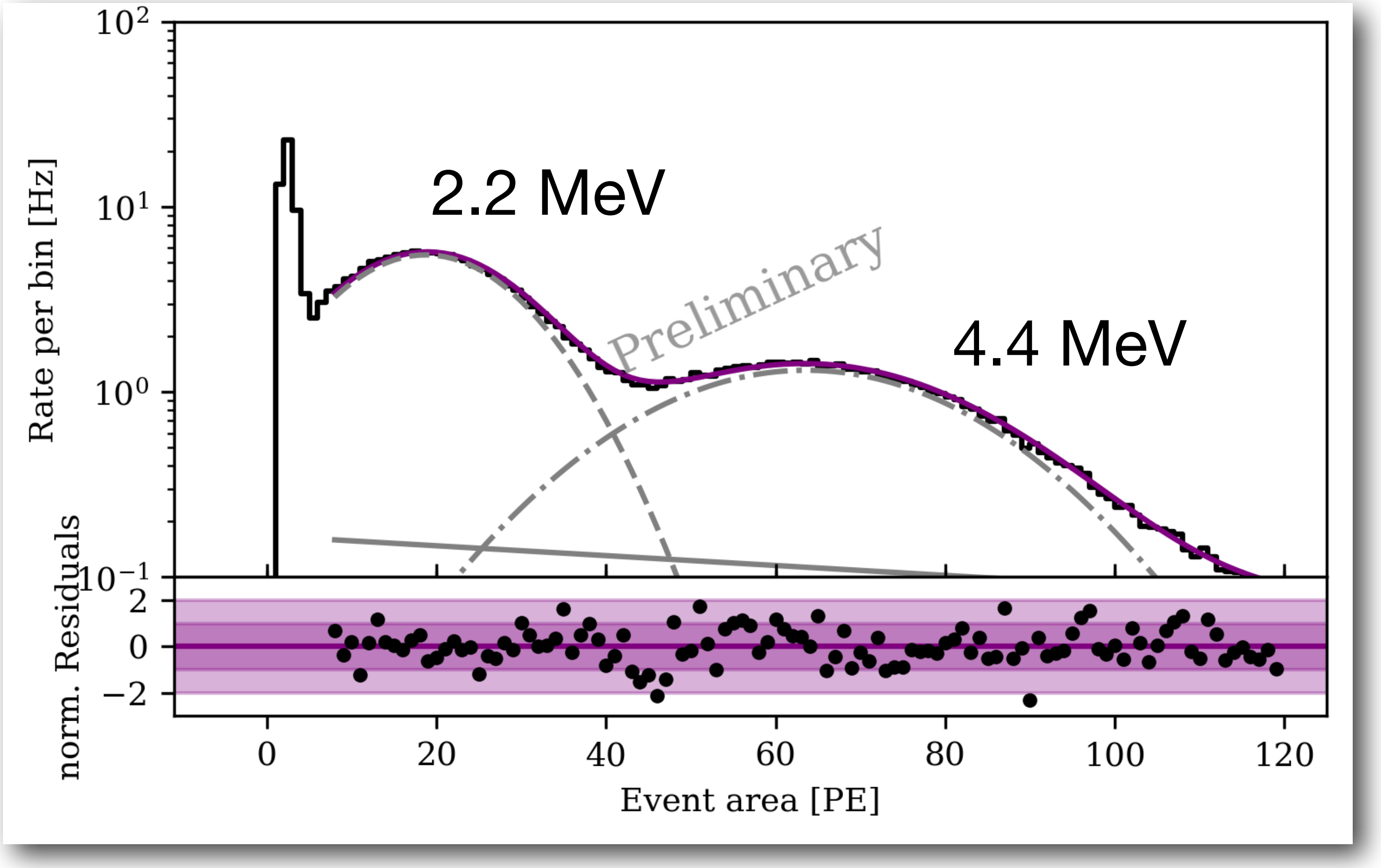
AmBe

Nuclear Recoil band



NV Tagging Efficiency





XENONnT First Science Run

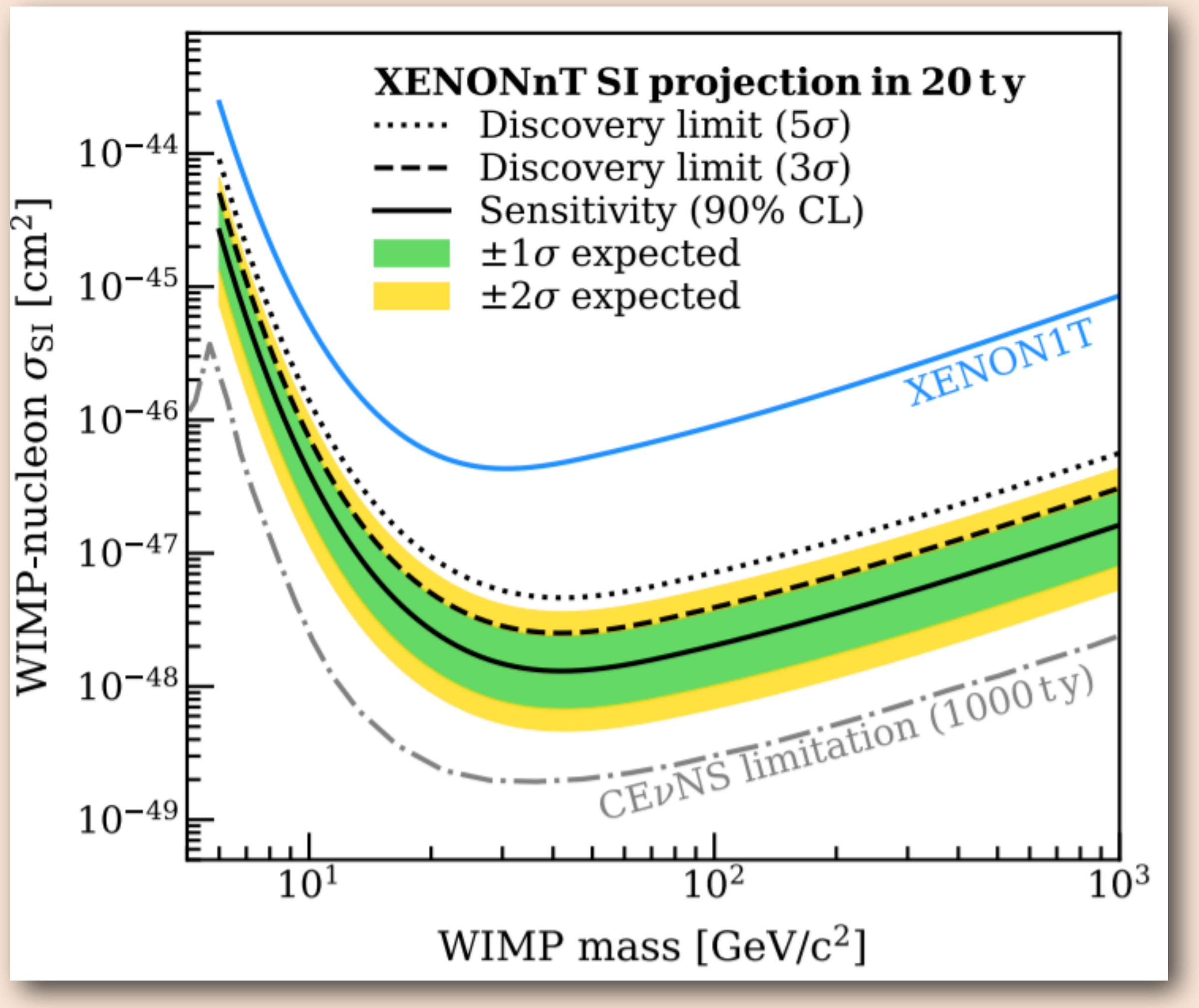
XENON

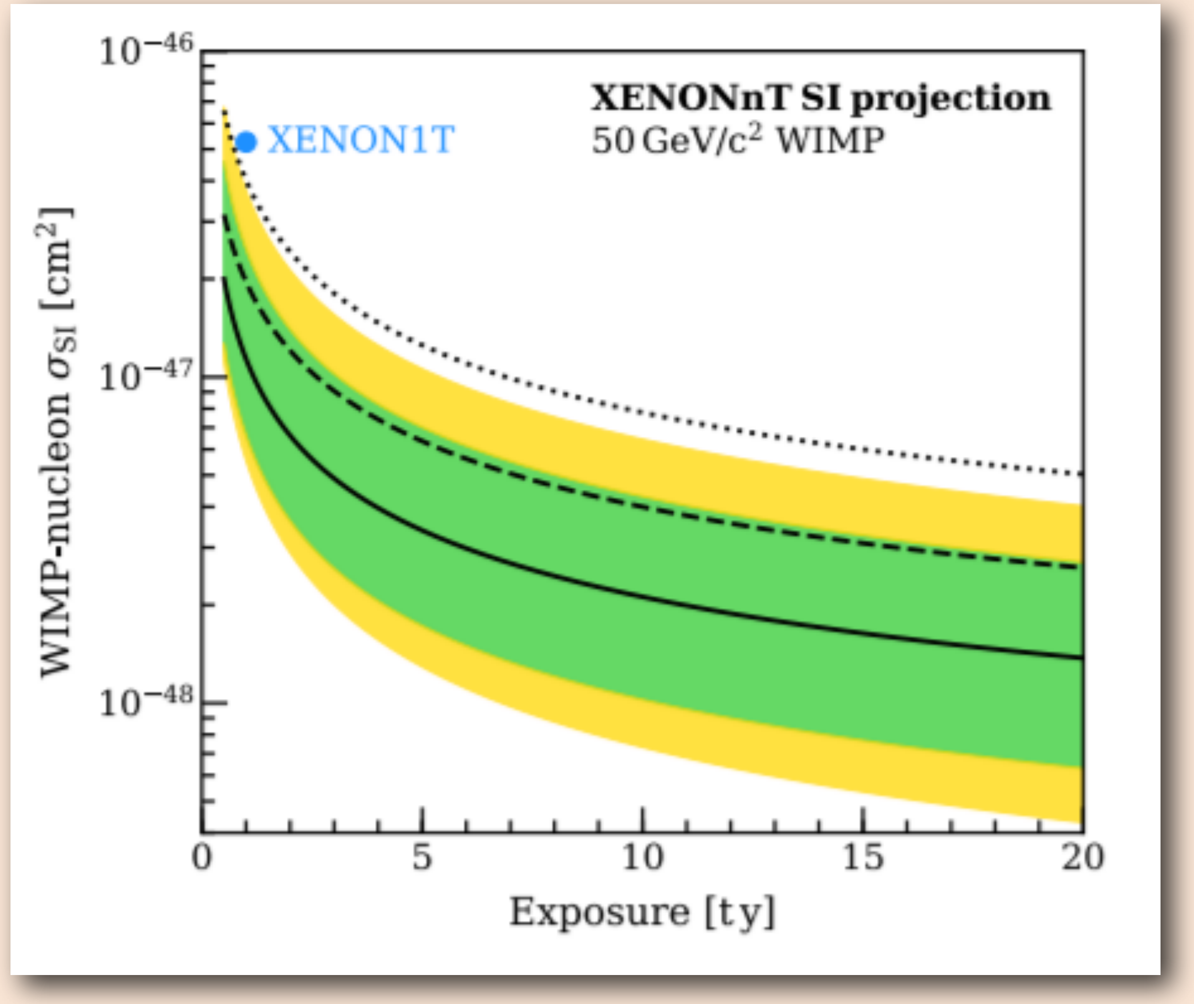
Projections

Expected WIMP-nucleon cross section

- Exposure Goal : 20 t x yr

$$\sigma_{SI} \sim 1.4 \times 10^{-48}\mathrm{cm}^2 \text{ at } 50\mathrm{GeV/c}^2$$



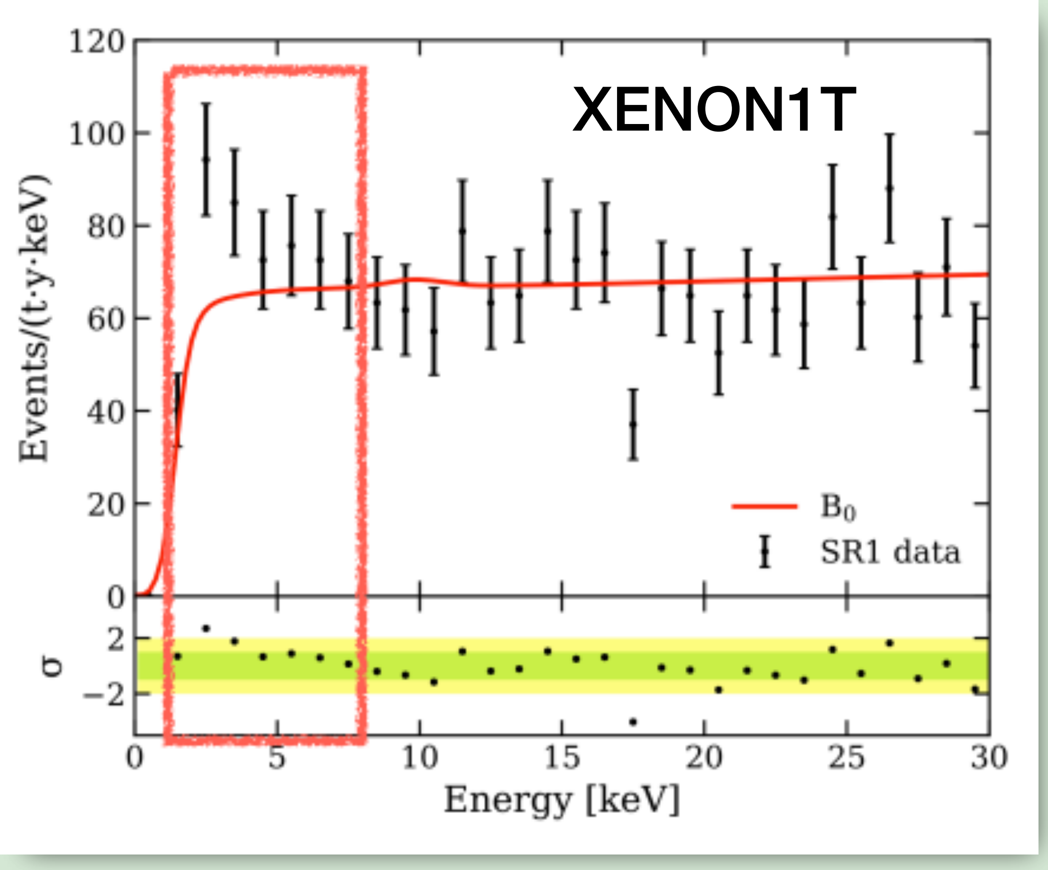


JCAP 11 (2020) 031

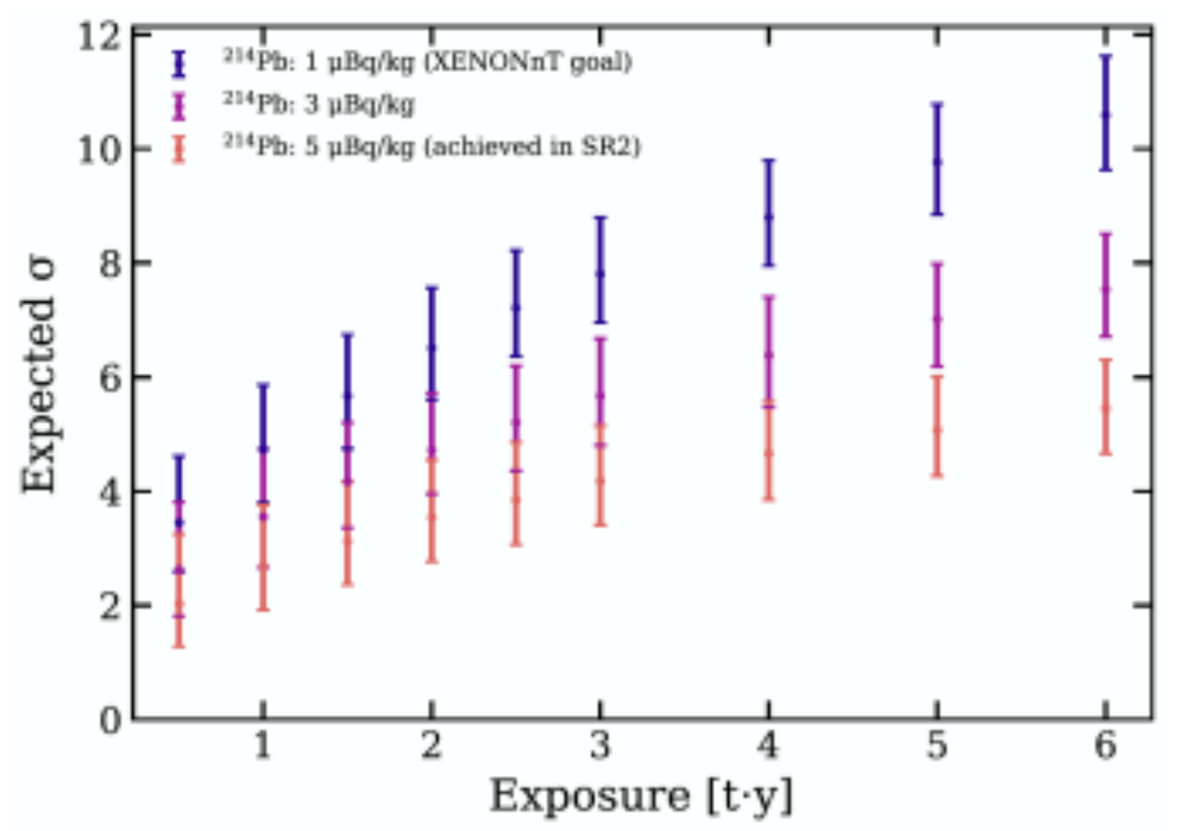
Low-Energy ER excess

- XENON1T observed an excess in the low-ER region
- XENONnT will be able to study this excess:

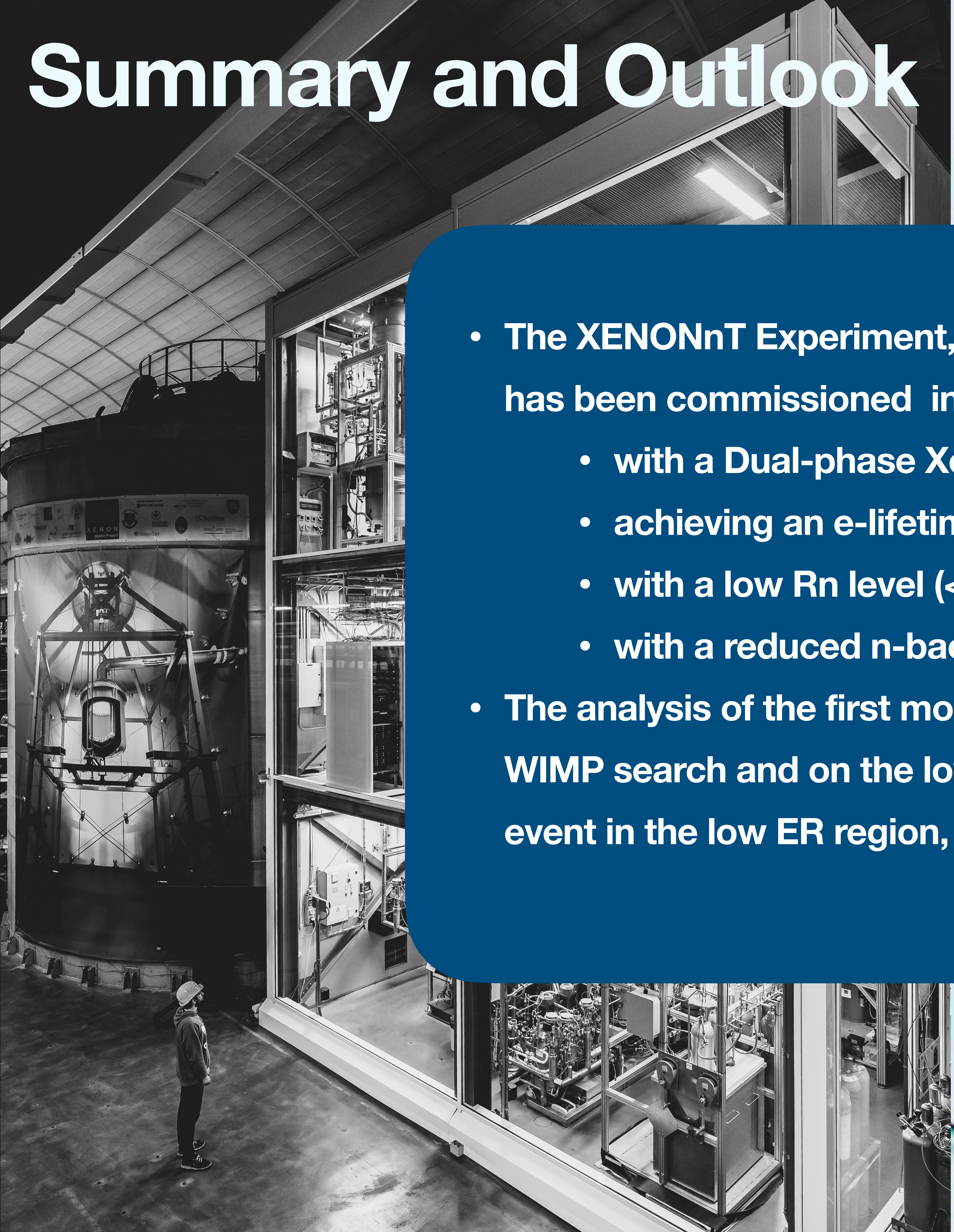
After few months of XENONnT data the various hypothesis to explain this excess can be discriminated at the 5σ level

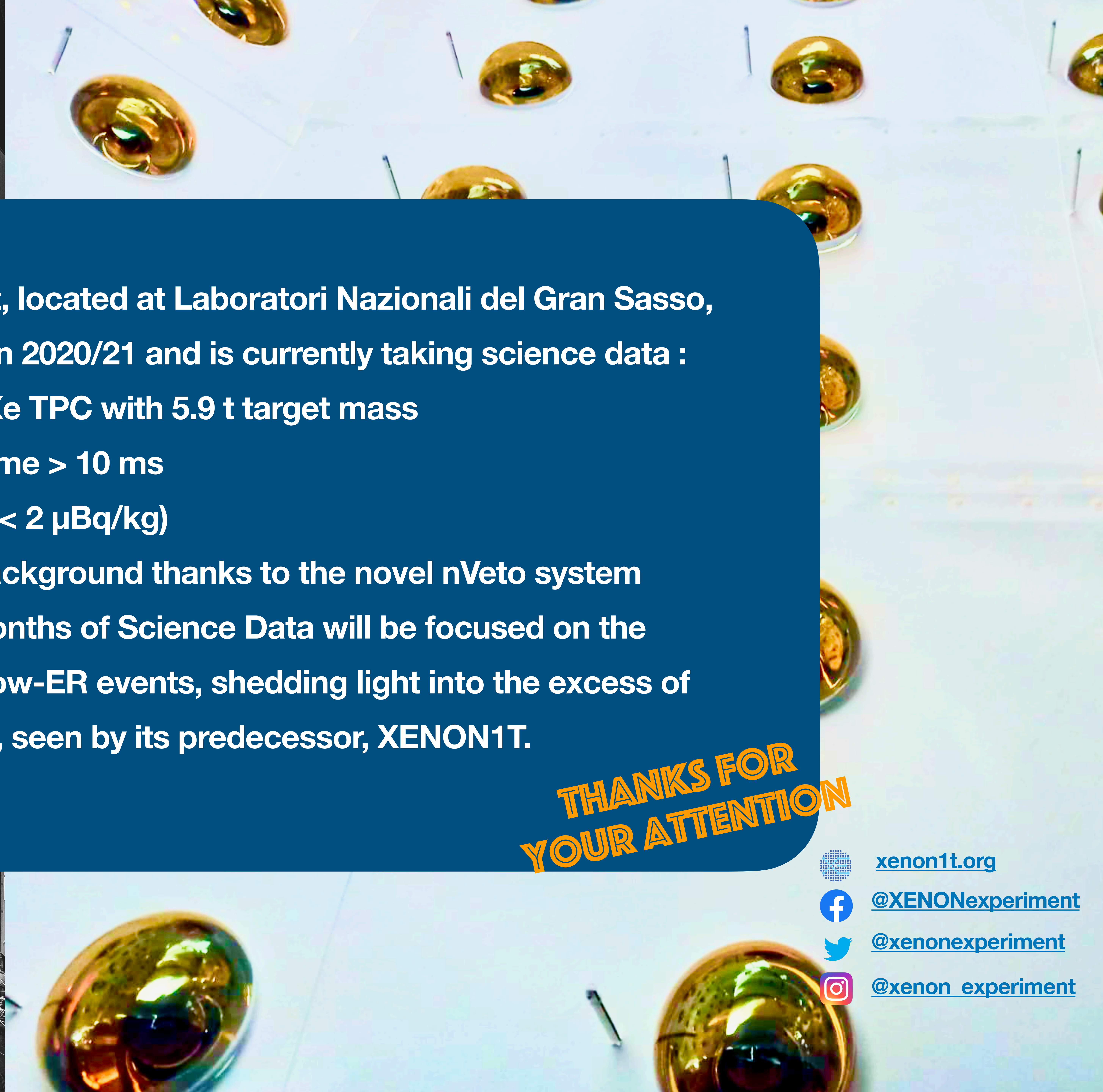


Phys. Rev. D 102, 072004 (2020)



Summary and Outlook





- The XENONnT Experiment, located at Laboratori Nazionali del Gran Sasso, has been commissioned in 2020/21 and is currently taking science data :
    - with a Dual-phase Xe TPC with 5.9 t target mass
    - achieving an e-lifetime > 10 ms
    - with a low Rn level (< 2 μBq/kg)
    - with a reduced n-background thanks to the novel nVeto system
- The analysis of the first months of Science Data will be focused on the WIMP search and on the low-ER events, shedding light into the excess of event in the low ER region, seen by its predecessor, XENON1T.

THANKS FOR YOUR ATTENTION

xenon1t.org

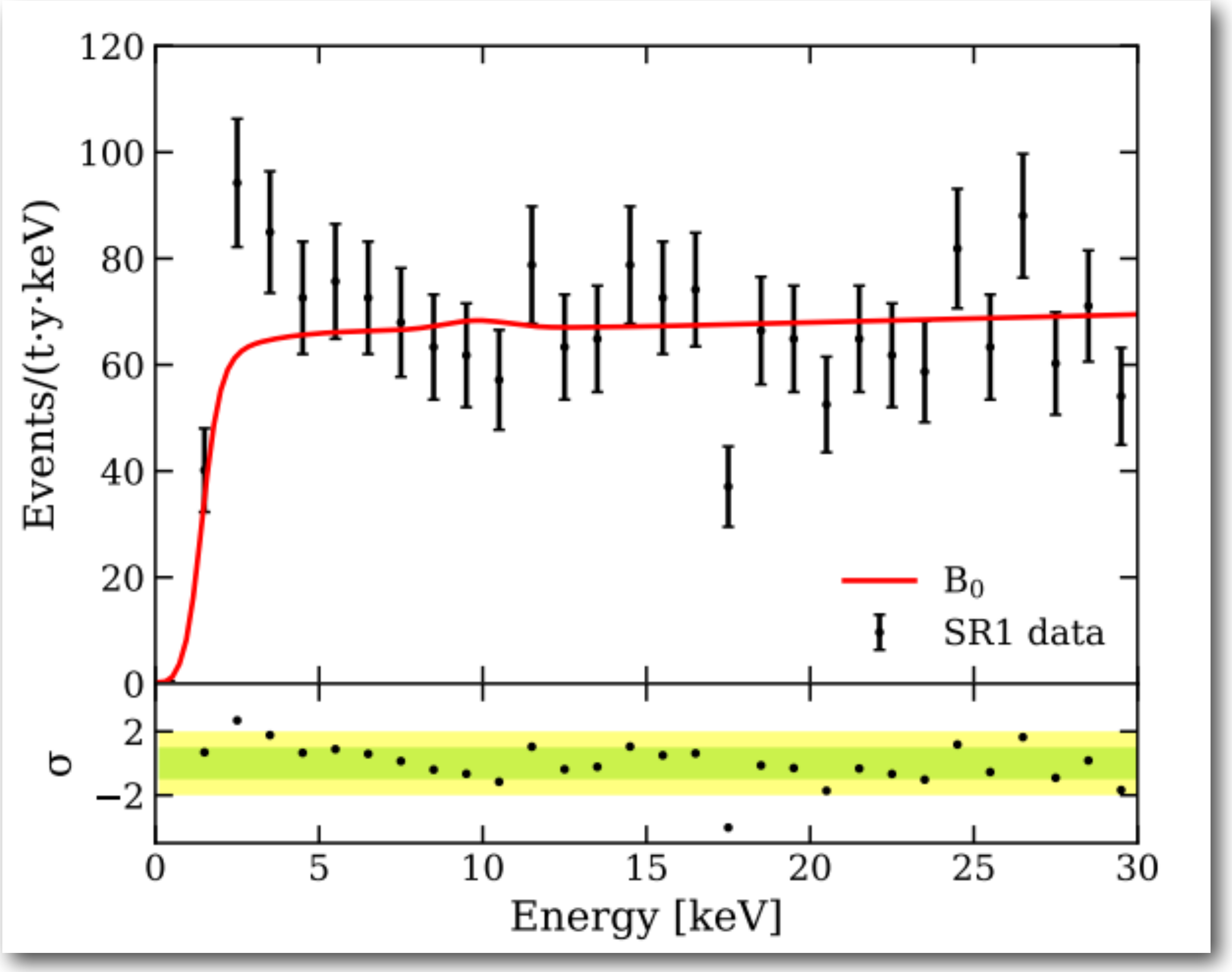
@XENONexperiment

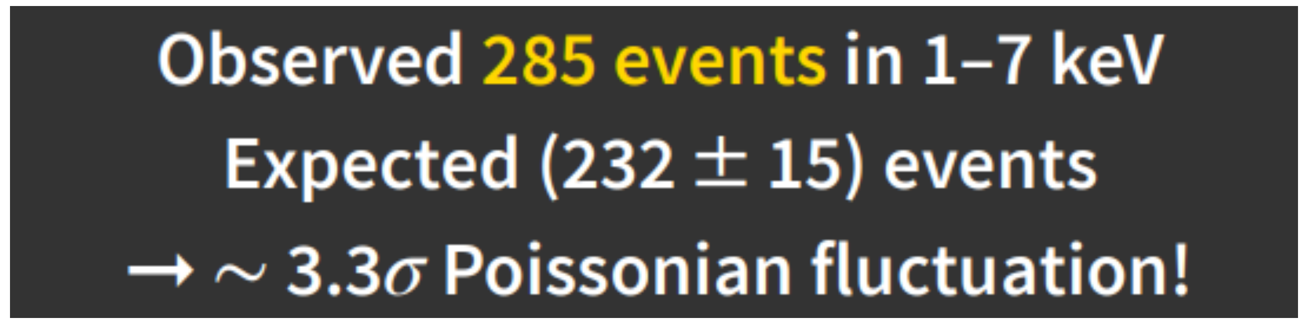
@xenonexperiment

@xenon_experiment

Backup Slides

XENON1T Low ER excess

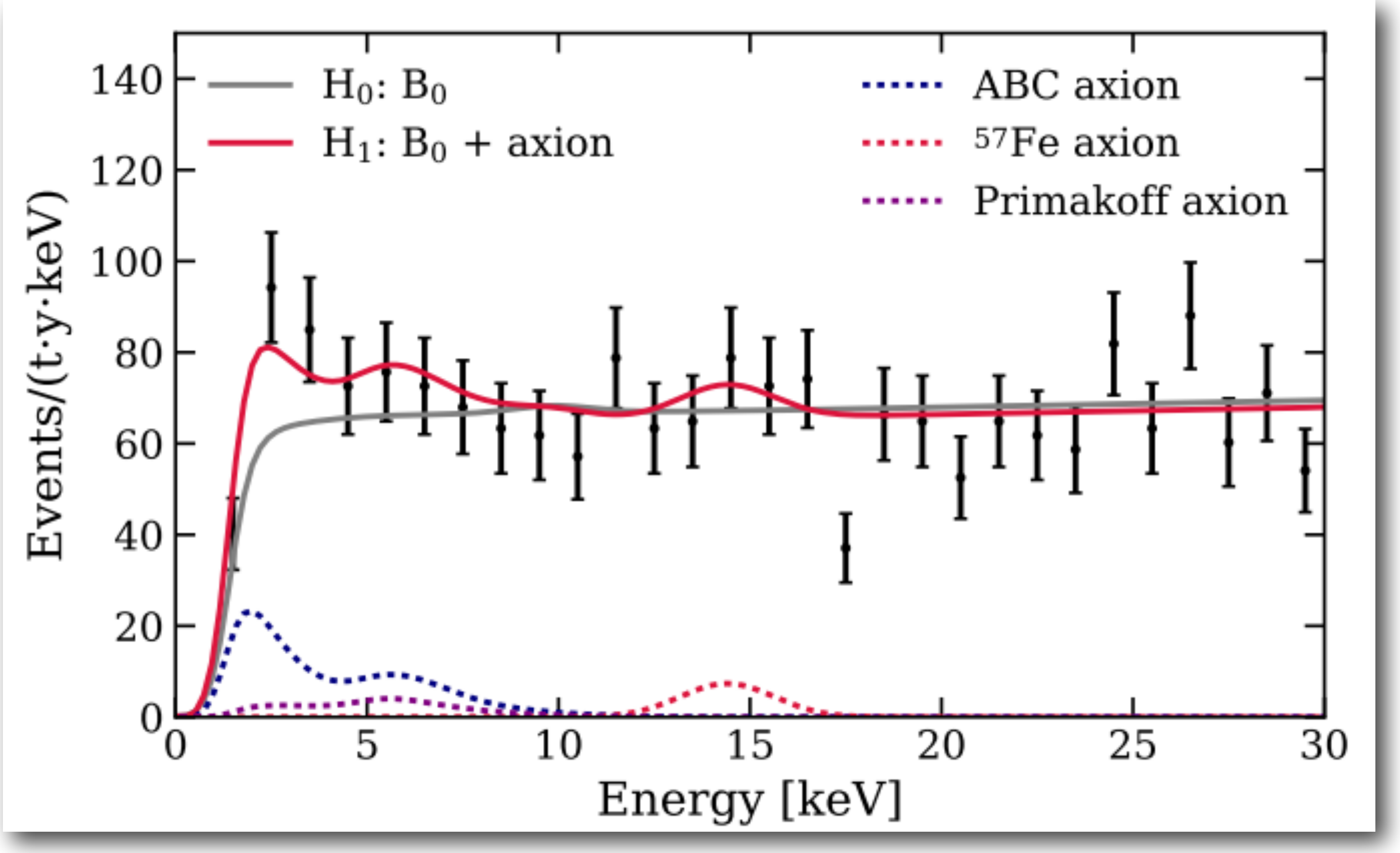




Excess observed at low energy Electron Recoil

- The signal is compatible with solar axions and the best fit on this hypothesis has 3.4 σ
- Other possibilities: e.g. Tritium (3.2 σ)

More data needed...



... more data expected from XENONnT

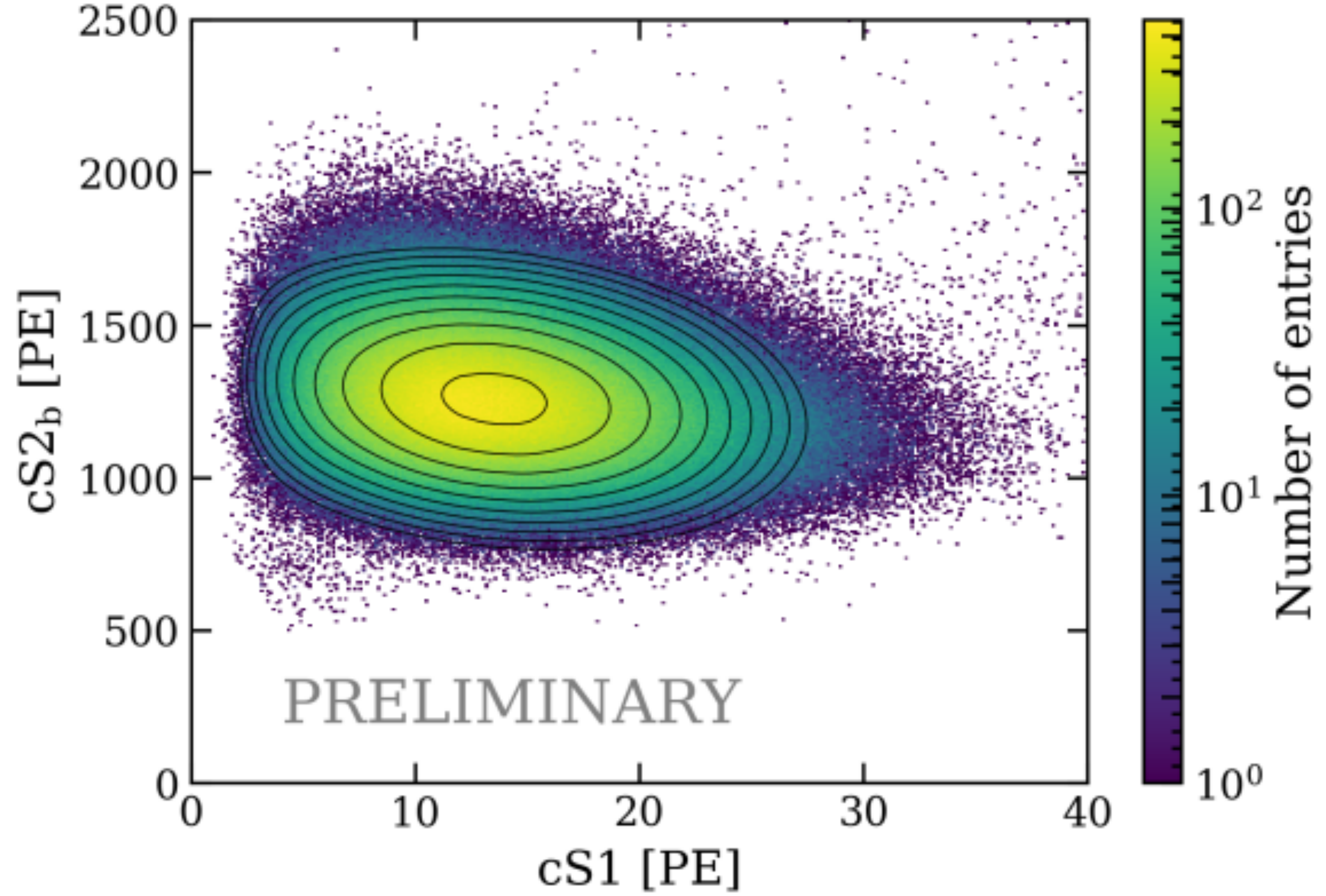
XENON1T

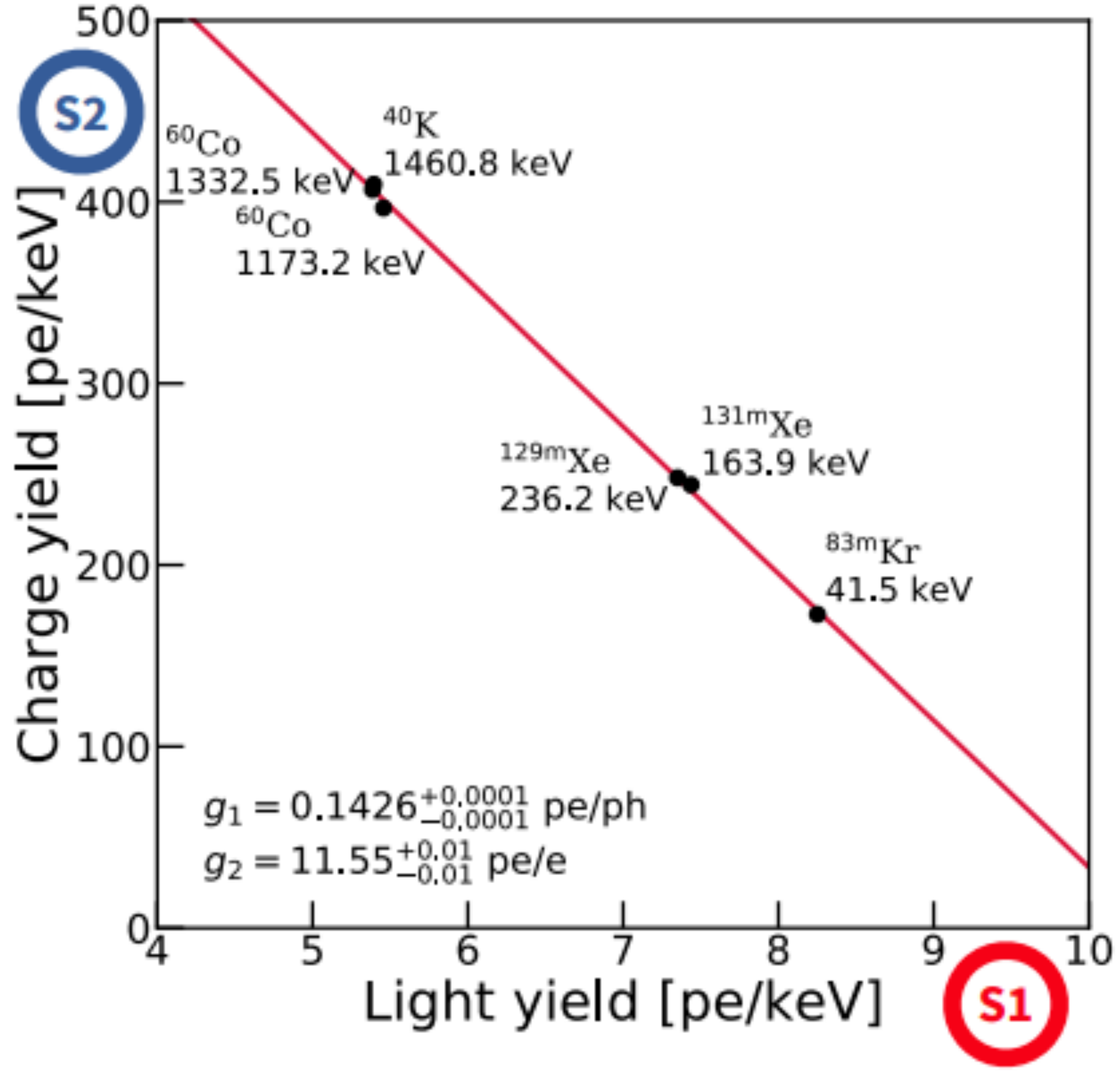
Cryogenics & Xenon Purification

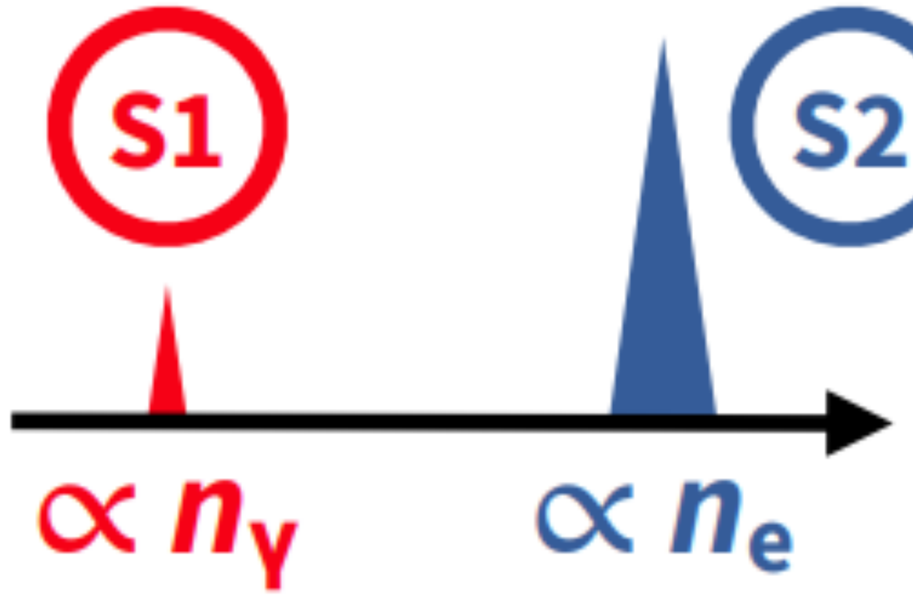
Electronics, Data Acquisition & Slow Control

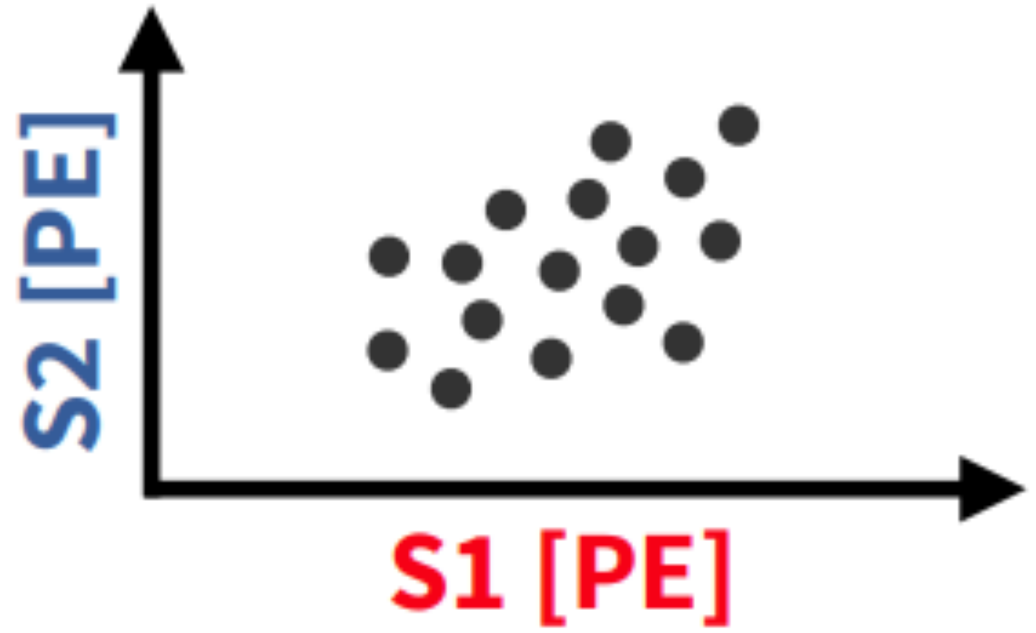
Xenon Storage, Recovery & Distillation

Reconstructing energy

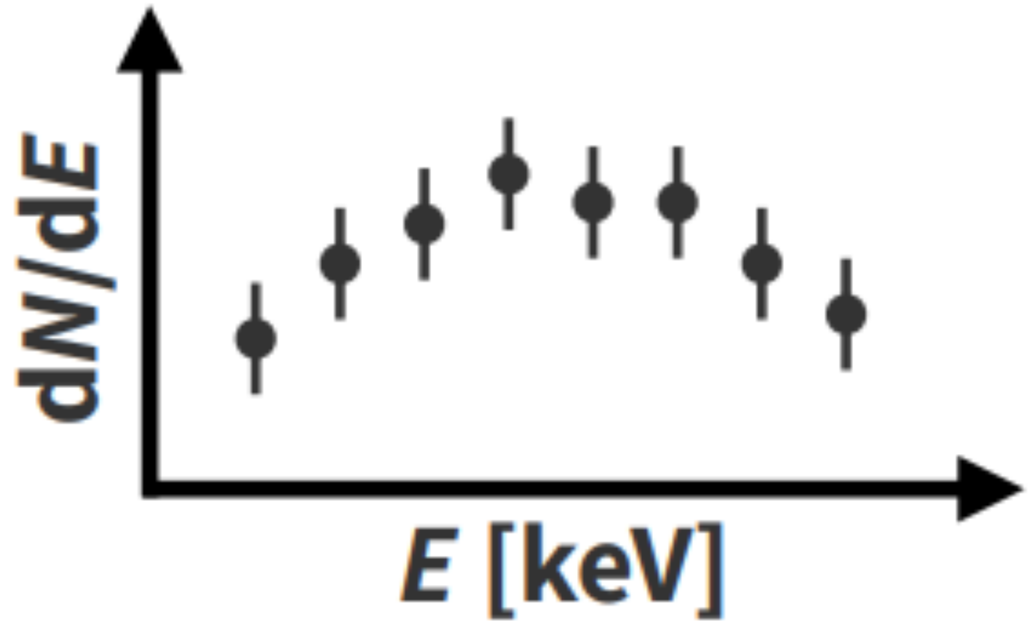








$$E = W(n_\gamma + n_e) = W\left(\frac{S1}{g_1} + \frac{S2}{g_2}\right)$$



Erwann Masson, “From XENON1T to XENONnT: Latest Results and First Light”, 32e Rencontres de Blois, 17–22 October