

DARK MATTER GROUP

PATRICK DECOWSKI



DM Group Members

- **Faculty Members:**

- Jelle Aalbers
- Auke-Pieter Colijn
- Patrick Decowski [PL]
- Tina Pollmann

- **Postdocs:**

- Maxime Pierre '23
- James Mead '23
- Jose Soto '25

- **PhDs:**

- Pravita Hallur '24 [with GRAPPA]
- Anna Hurhina '25
- Maricke Flierman '21
- Carlo Fuselli '22
- Pranati Kharbanda '23
- Saad el Morabit '23 [with Theory]
- Marjolein Troost '22 [with Neutrino Phys]
- Kelly Weerman '22

'xx → started in 20xx

- **MSc:**

- Conor Ford [RUG]
- Alejandro Guerrero Ramos [UvA/VU]
- Mathilda Lopuszanski [UvA/VU]
- Nina Oskam [UvA/VU]
- Meera Patel [UvA/VU]
- Bart Sarlemijn [UvA/VU]
- Thijs de Zeeuw [UvA/VU]

- **HBO:**

- Pieter van Toorenenburg [HvA]
- Chris Windmeijer [Haagse Hogeschool]

- **BSc:**

- Leo Sahlen [AUC]
- Magali Breur [UvA/VU]
- Mariam Sakiskaya [UvA/VU]



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Our Physics Goals:

1. Direct detection of dark matter
2. Study of rare processes such as related to neutrino properties

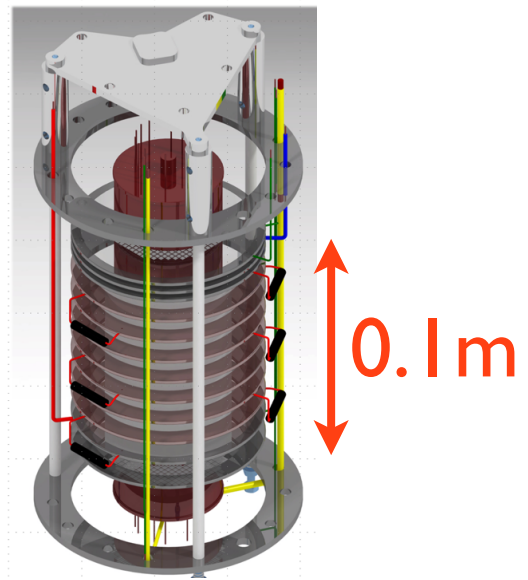


Our Activities

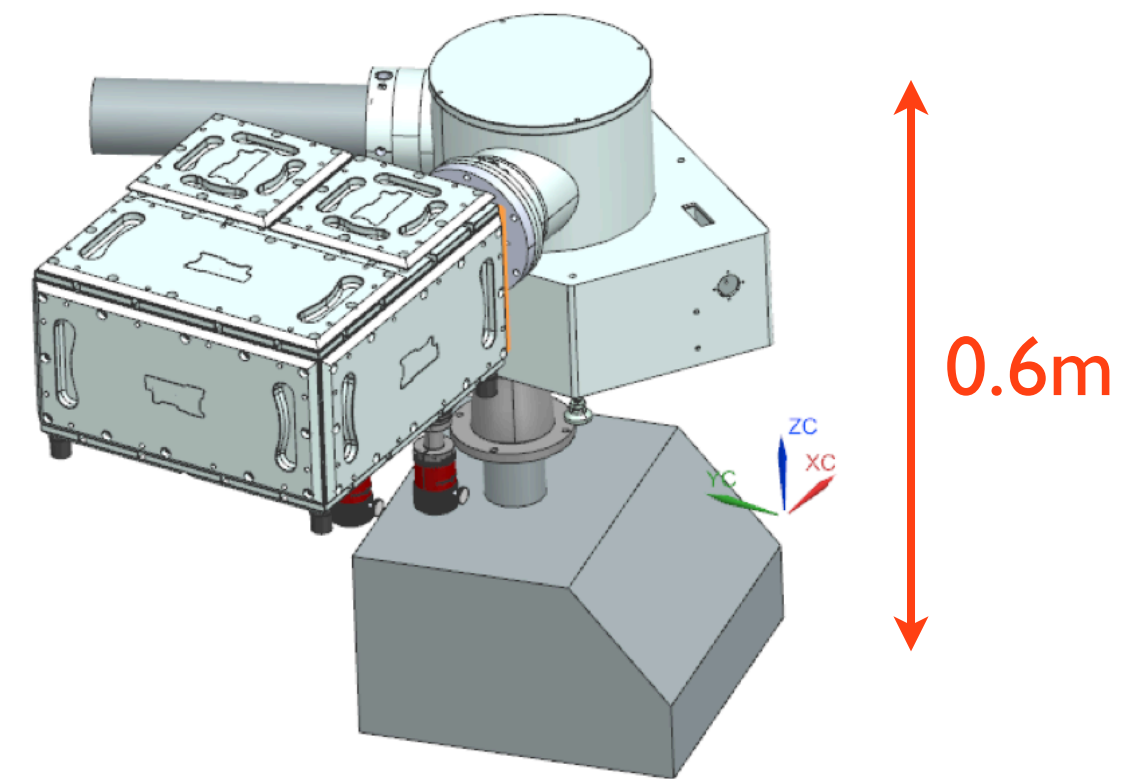
Main: liquid xenon based rare event experiments

Our R&D Lab @Nikhef

XAMS



VULCAN



Current and future experiments

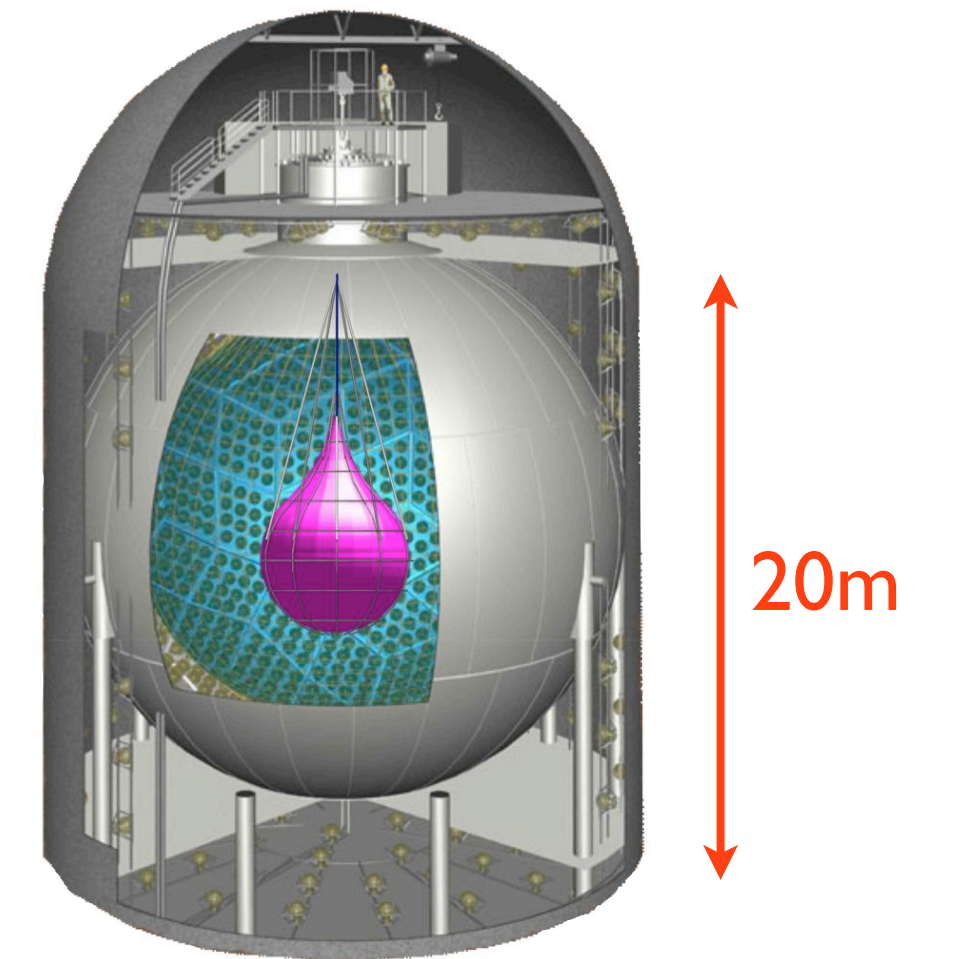
XENONnT



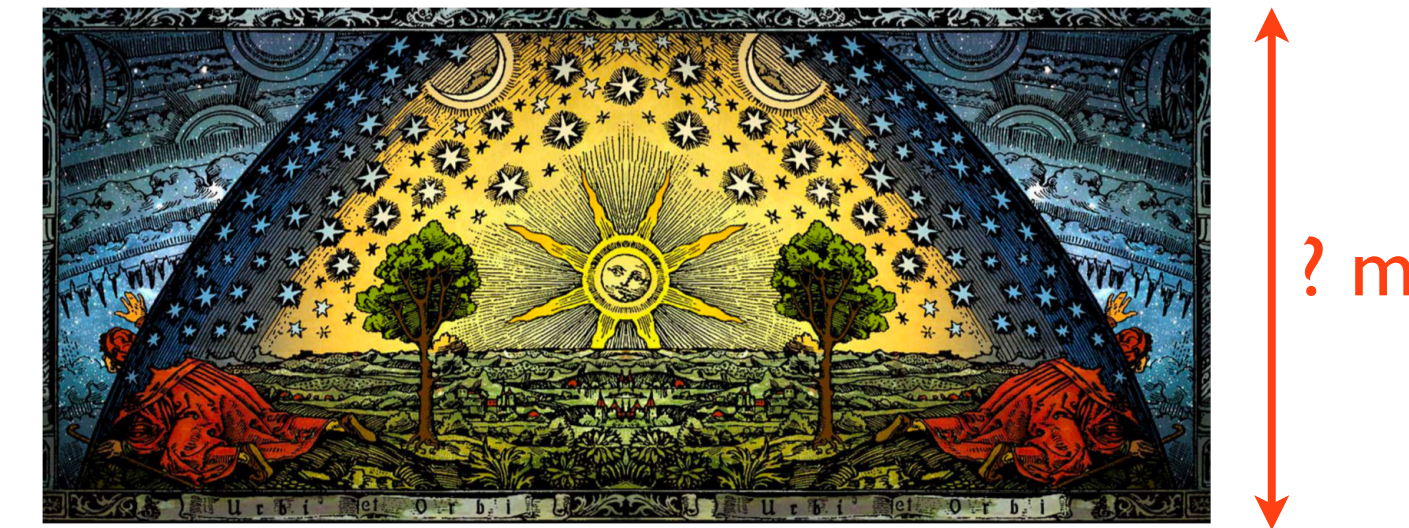
XLZD



KamLAND-Zen



PTOLEMY R&D [phasing out]



DUNE [with Neutrino Physics Group]



Our Current Roles

- **Roles in XENON**

- Auke Colijn: Technical Coordinator XENONnT
- Patrick Decowski: Chair Publication Board, Collaboration Board
- **Maxime Pierre: Physics Analysis Coordinator**

- **Roles in XLZD**

- Auke Colijn: Siting Committee, L2 co-lead Cryostat+Infra
- Patrick Decowski: Executive Board, setting up Pub Board, L2 co-lead DAQ
- Tina Pollmann → Jelle Aalbers: Work Group Leader Science & Sensitivity

- **Roles in DUNE / ND-LAr**

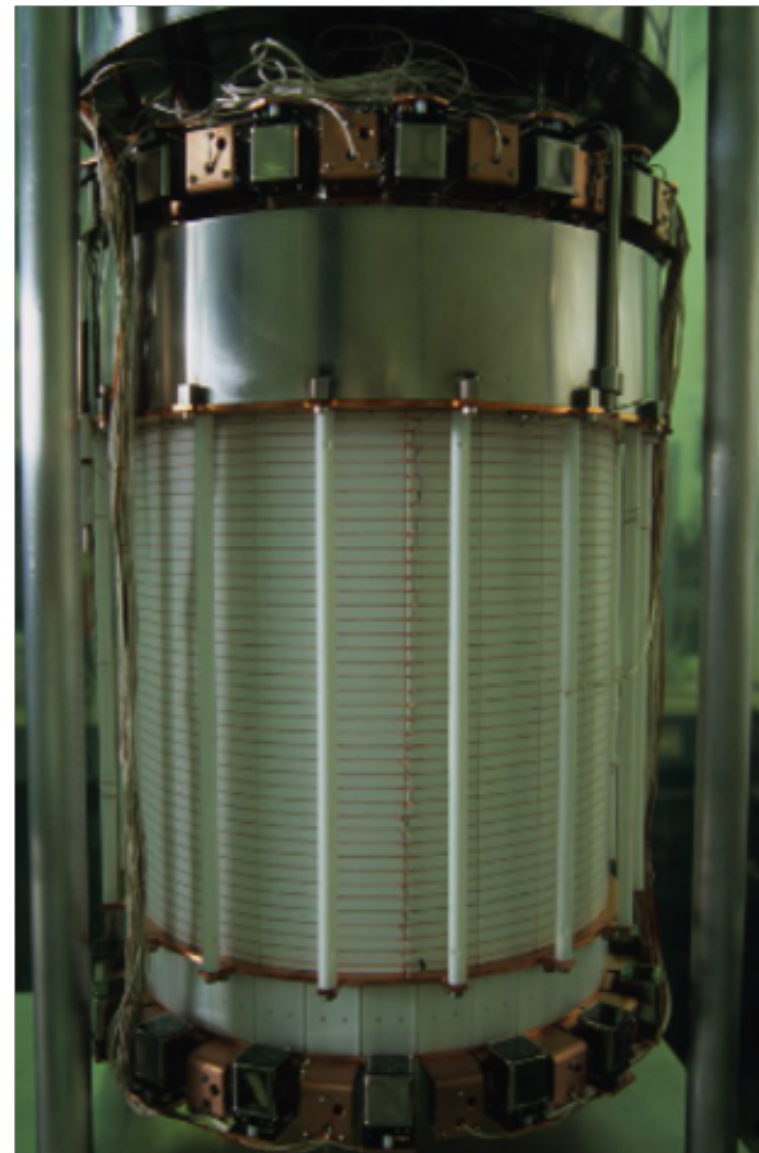
- Tina Pollmann: Light Readout System (LRS) co-convenor
- **Jose Soto: 2x2 LRS analysis convenor**
- Guido Visser [ET]: LRS lead electronics engineer

- **Roles in XENON**

- **Saad el Morabit: MC Work Group Leader**
- **Carlo Fuselli: (was) MC Work Group Leader**
- **Pranati Kharbanda: S2-Only Work Group Lead**

LXe Series of Experiments

Every few years we build more sensitive experiments, with lower radioactive backgrounds, more xenon target.
The XENON collaboration joined with our LZ competitors in the US to form the XLZD collaboration.



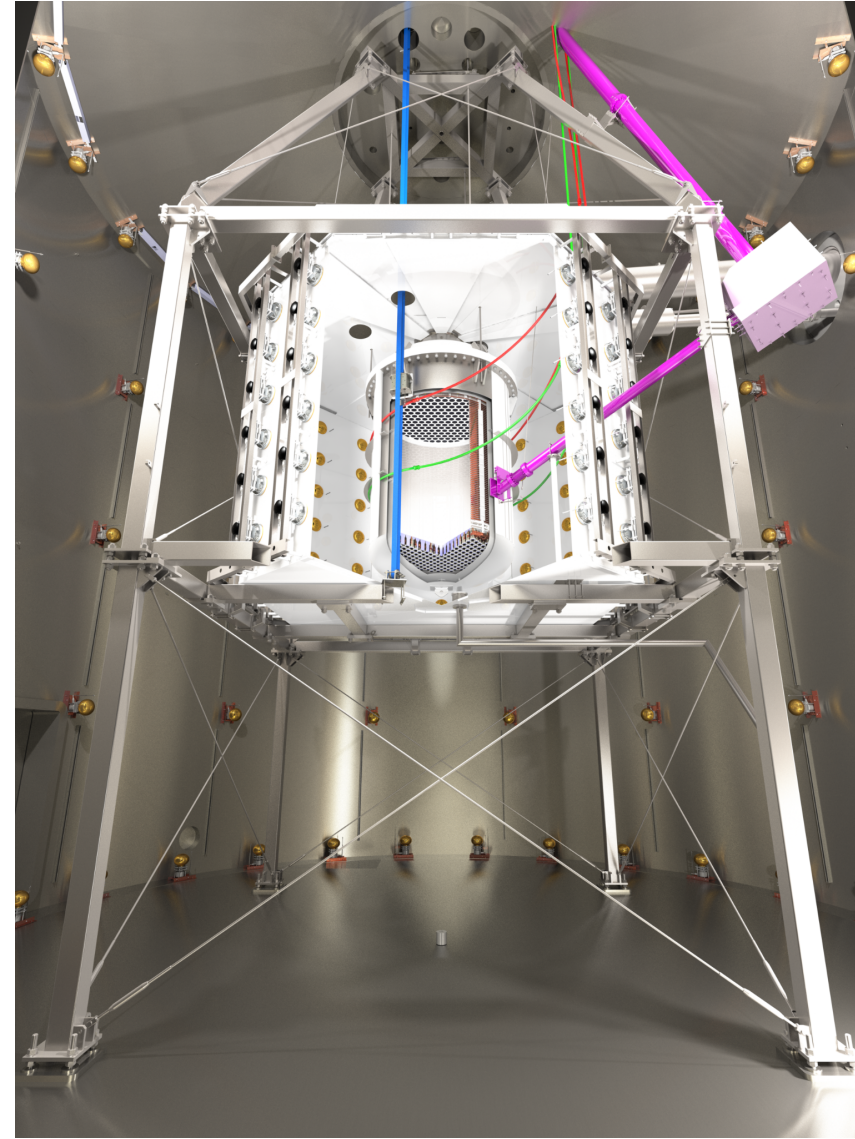
XENON100

160 kg



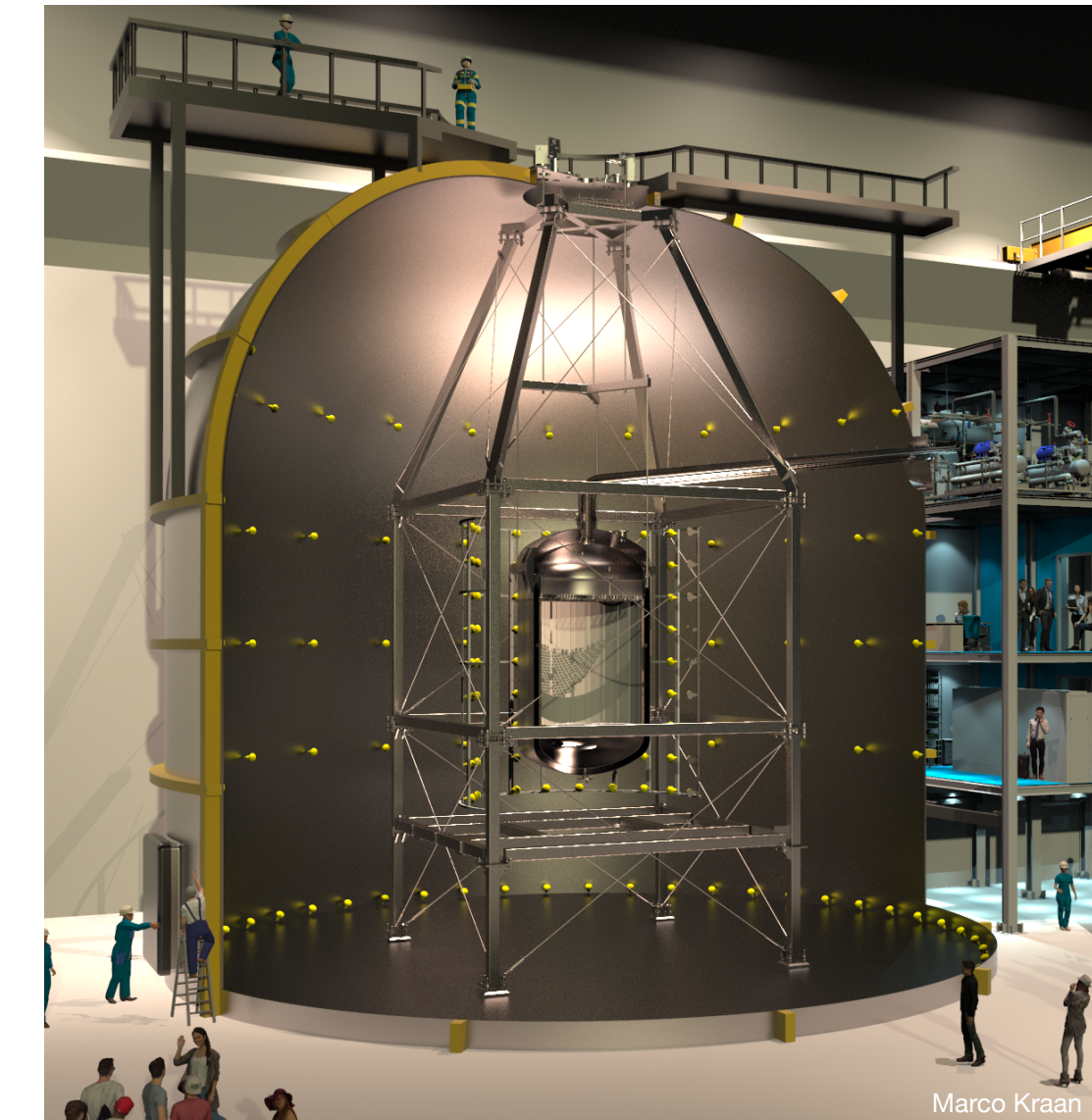
XENON1T

3.5 ton



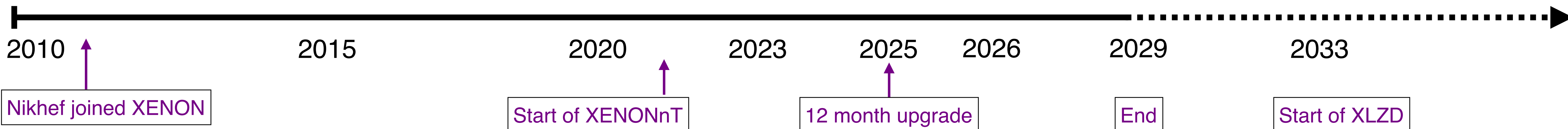
XENONnT

8.5 ton xenon



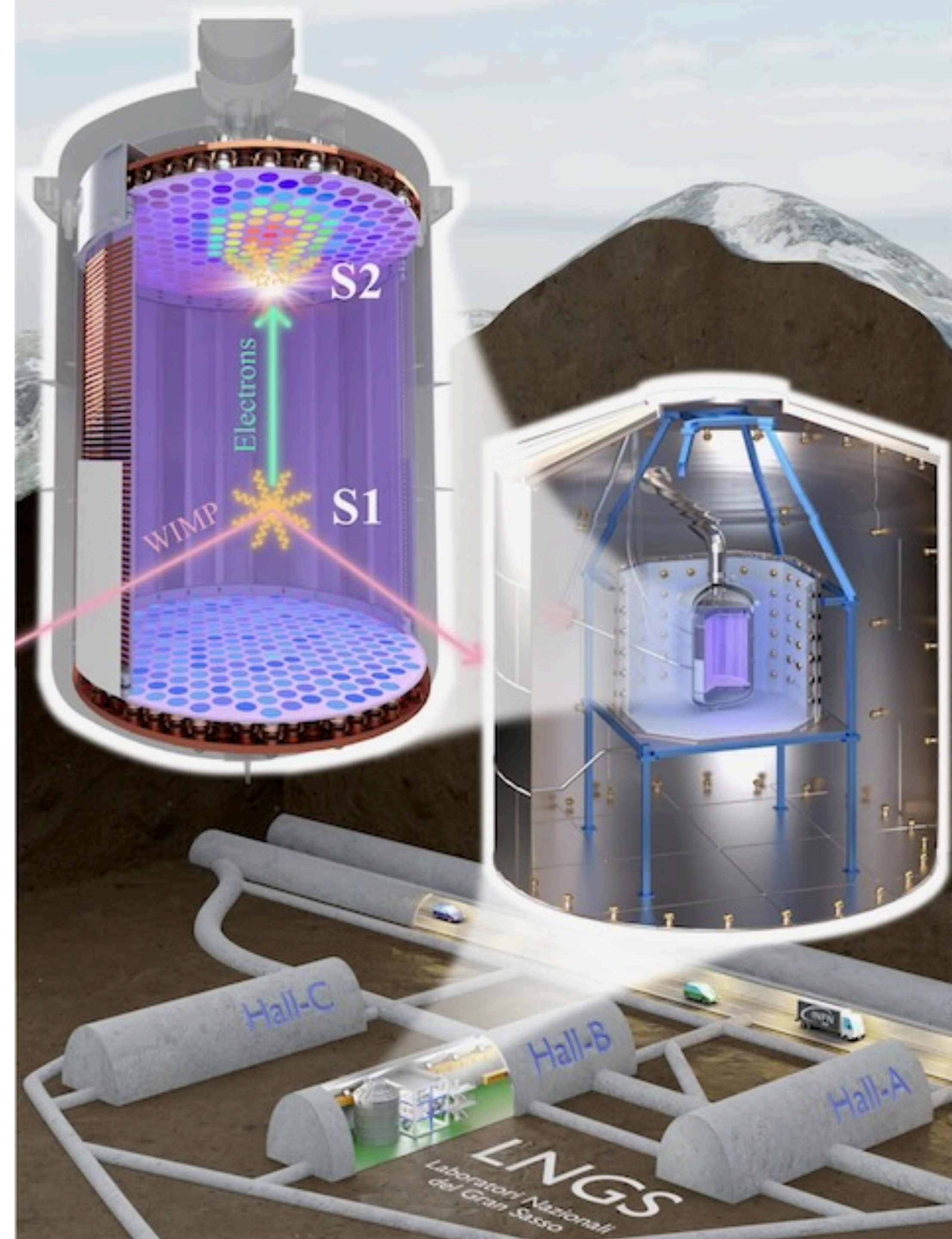
XLZD

60 ton

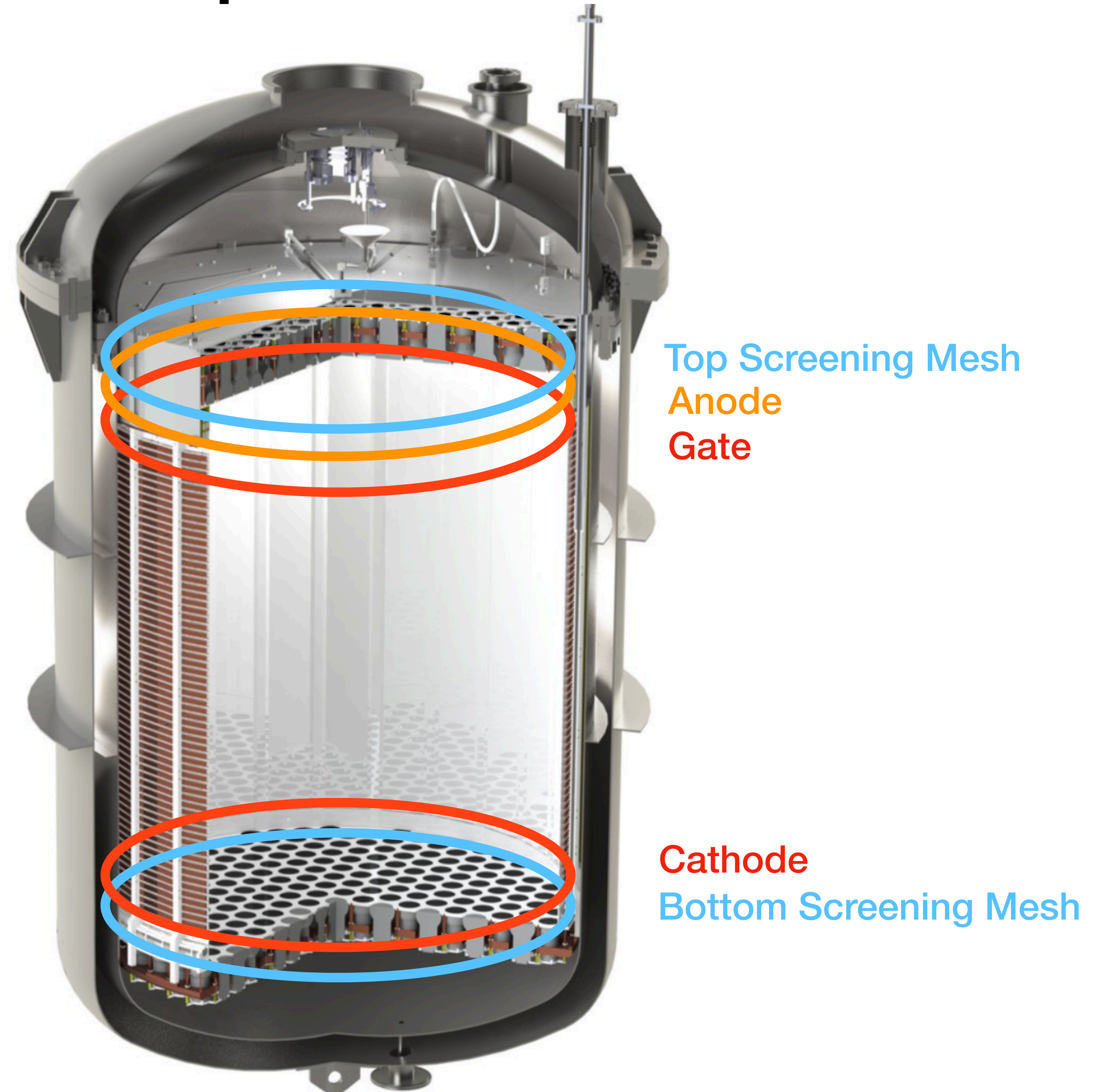
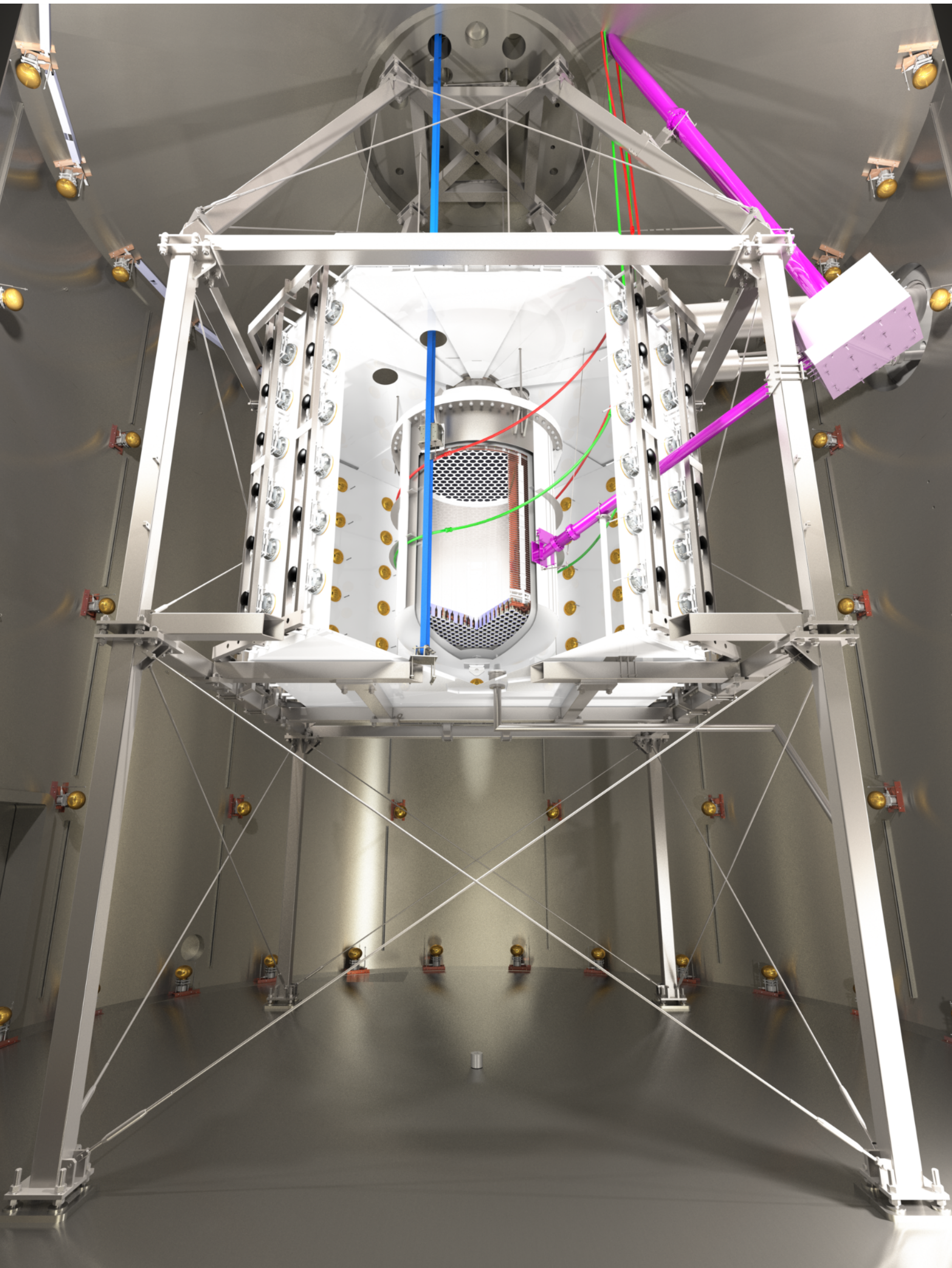


XENONnT Status

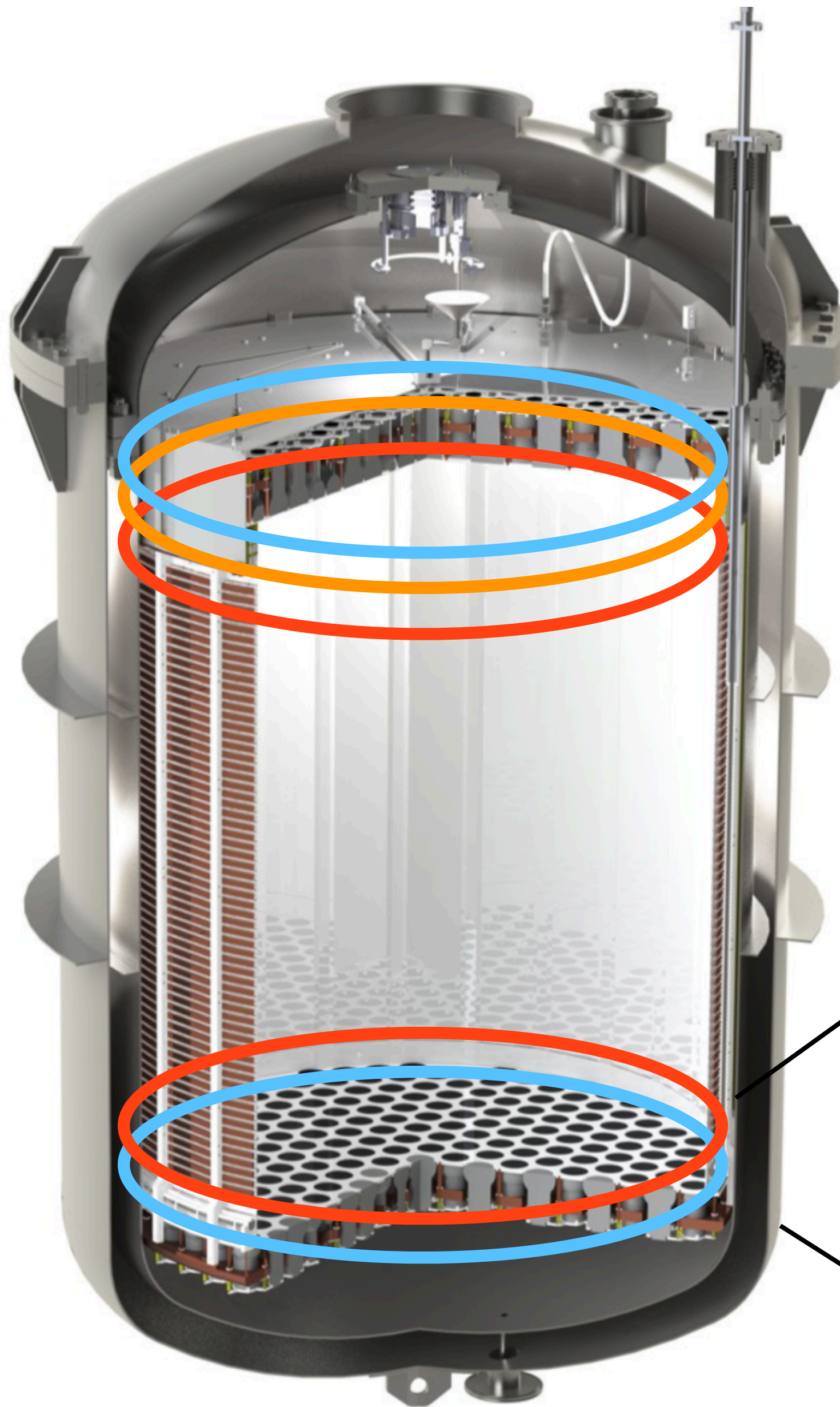
- Upgrade completed replacing electrodes to increase drift field from 23 V/cm $\rightarrow$ 100 V/cm
 - 1-year long operation: built clean-room in watertank
 - At the heart of the experiment: actual replacement took a few weeks
- Nikhef upgrade contributions:
 - Replace the DAQ machines
 - Photoluminescence inspection of the XENONnT TPC
 - Grid installation
- Current status and plans:
 - Everything back in place, 8.5 tons of LXe
 - Commissioning until July, then start of data taking

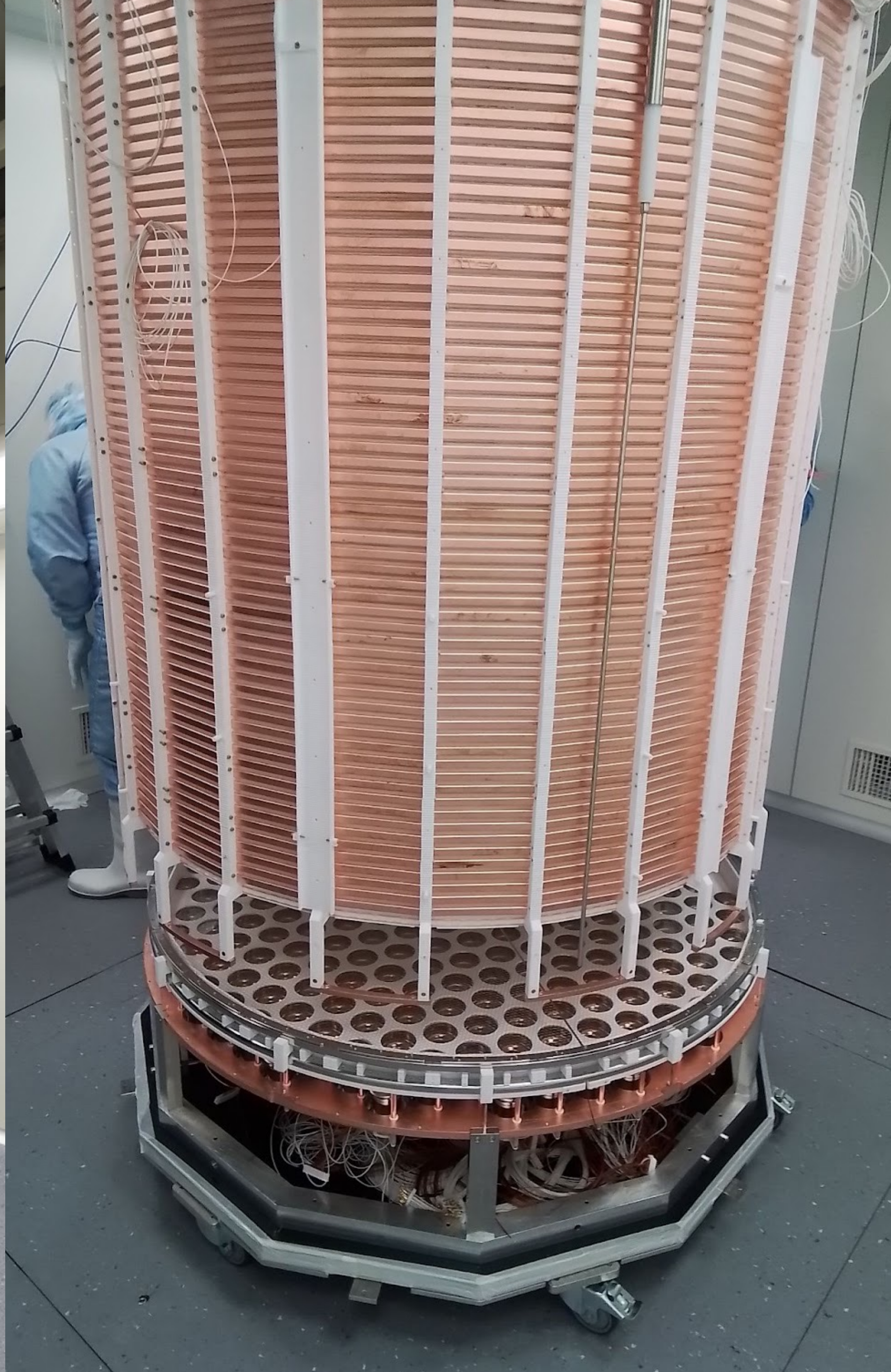


Electrode Replacement



Suspicion Confirmed











A Cleanroom Mystery

Photoluminescent Contaminations and Other Unexpected Findings

Anna Hurhina, Pranati Kharbanda
Nikhef and University of Amsterdam

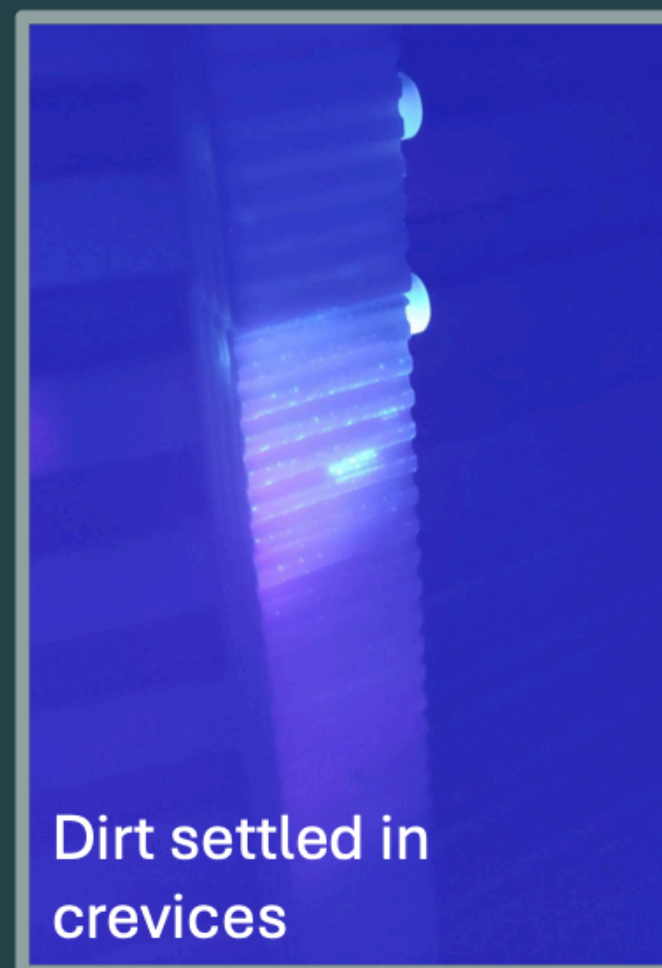
XENON Collaboration Meeting 10-12 December 2025, LNGS

Nikhef

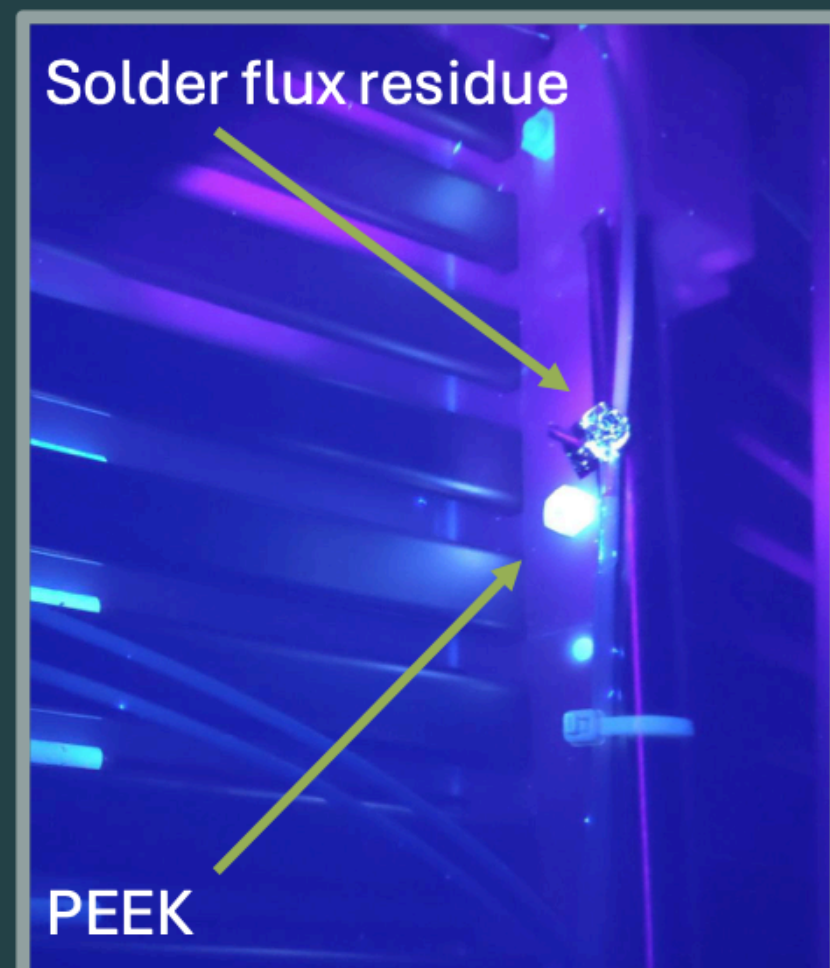


TPC UV inspection

XENONnT TPC has been inspected with a **365 nm UV source** to potentially identify presence of photoluminescent contaminations. These contaminations are hypothesized to contribute to delayed photon signal thus adding to the instrumental background. Recorded photoluminescent features were visually classified by their material, shape, size and in some cases colours.



Dirt settled in crevices

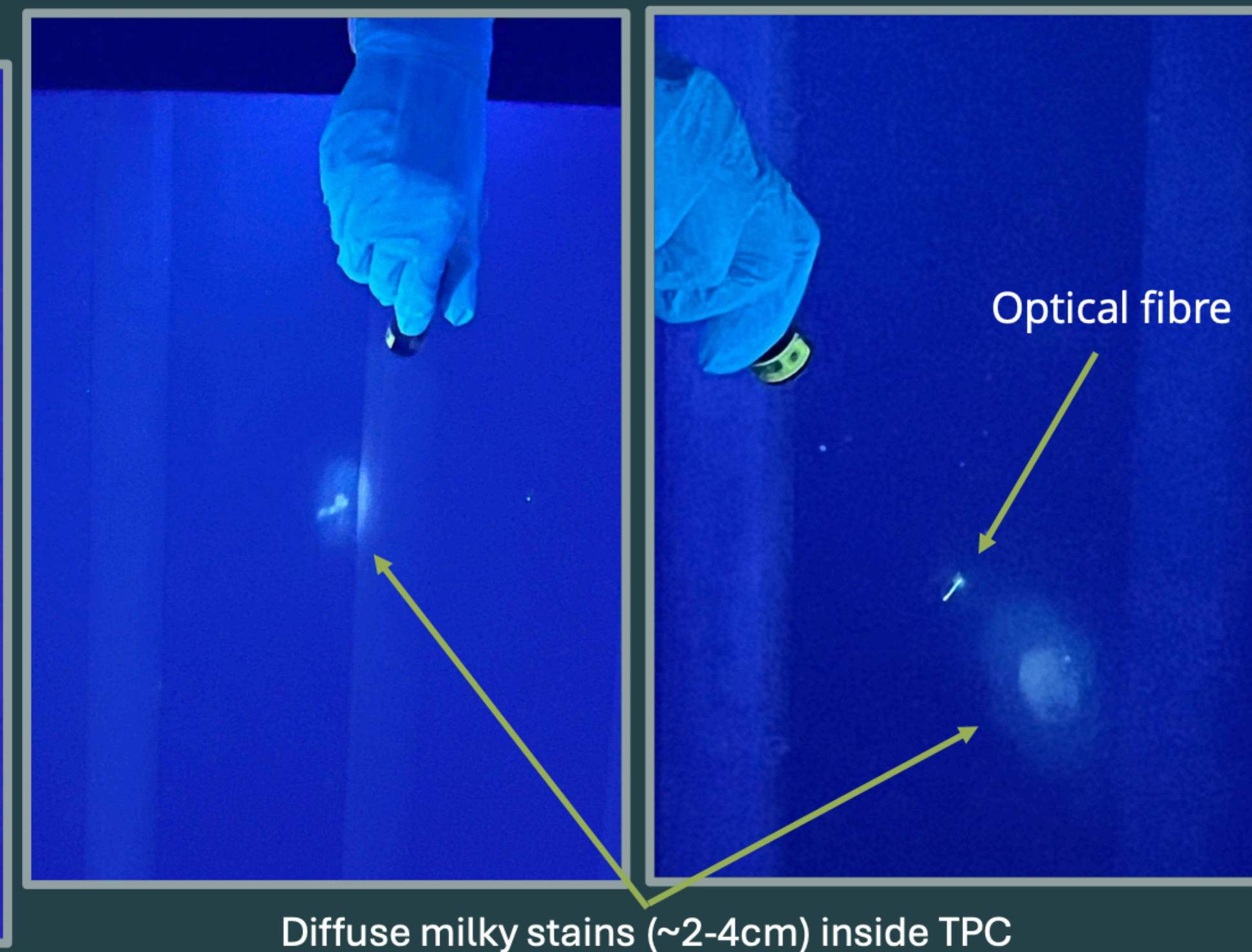


Solder flux residue

PEEK



Diffuse milky stains on PTFE pillar with dust

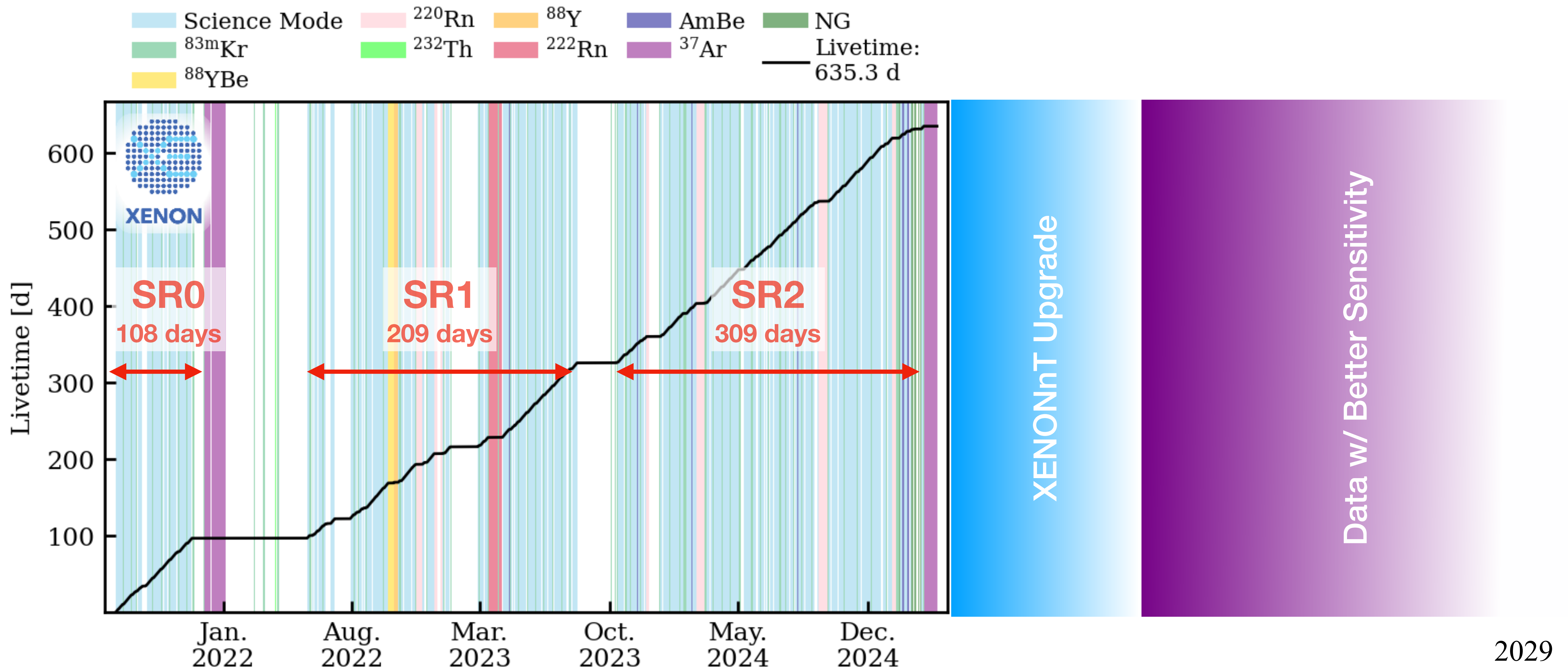


Optical fibre

Diffuse milky stains (~2-4cm) inside TPC

XENON Poster Award!

XENONnT Science Runs



For most analyses only SR0+SR1 analyzed so far: ~2x more data awaiting

Phys. Rev. Lett. 135, 221003

Accepted in Phys. Rev. D

OPEN ACCESS

WIMP Dark Matter Search Using a 3.1 Tonne-Year Exposure of the XENONnT Experiment

E. Aprile¹, J. Aalbers², K. Abe³, S. Ahmed Maouloud⁴, L. Althueser⁵, B. Andrieu⁴, E. Angelino^{6,7}, D. Antón Martín⁸, S. R. Armbruster⁹ et al. (XENON Collaboration)

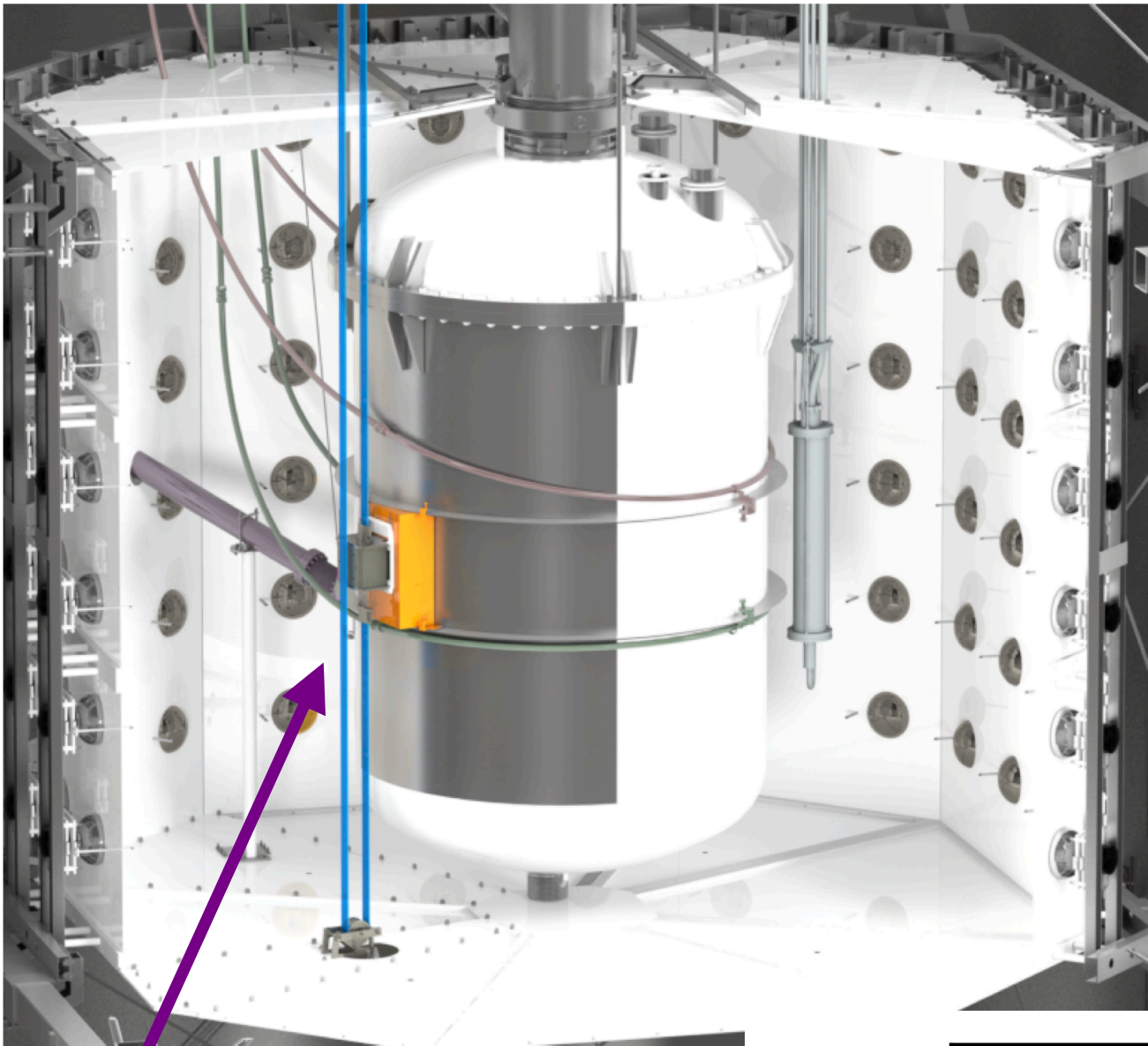
Phys. Rev. Lett. 135, 221003 – Published 24 November, 2025

DOI: <https://doi.org/10.1103/msw4-t342>

WIMP Results for SR0+SR1
SR2 analysis ongoing

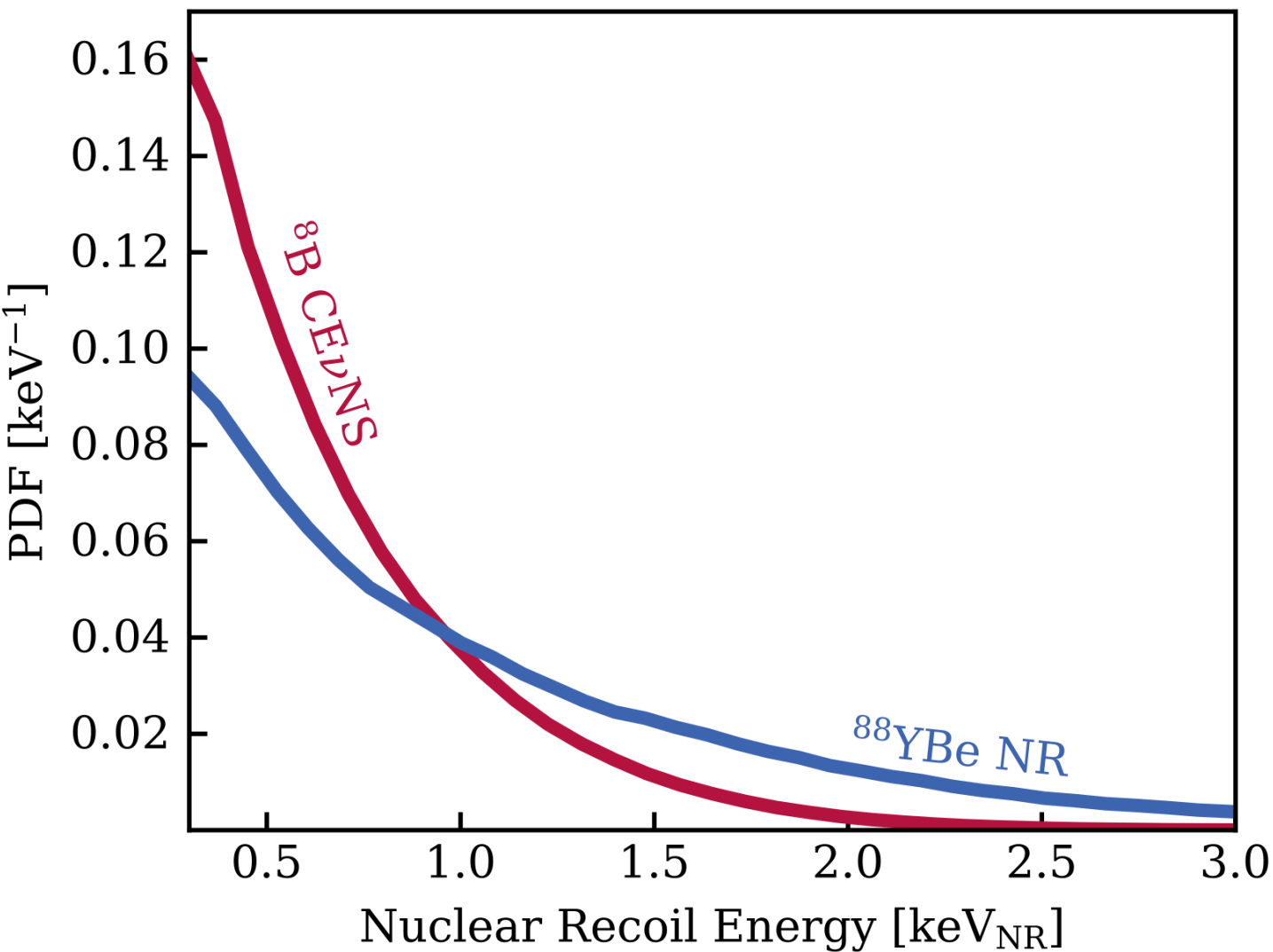
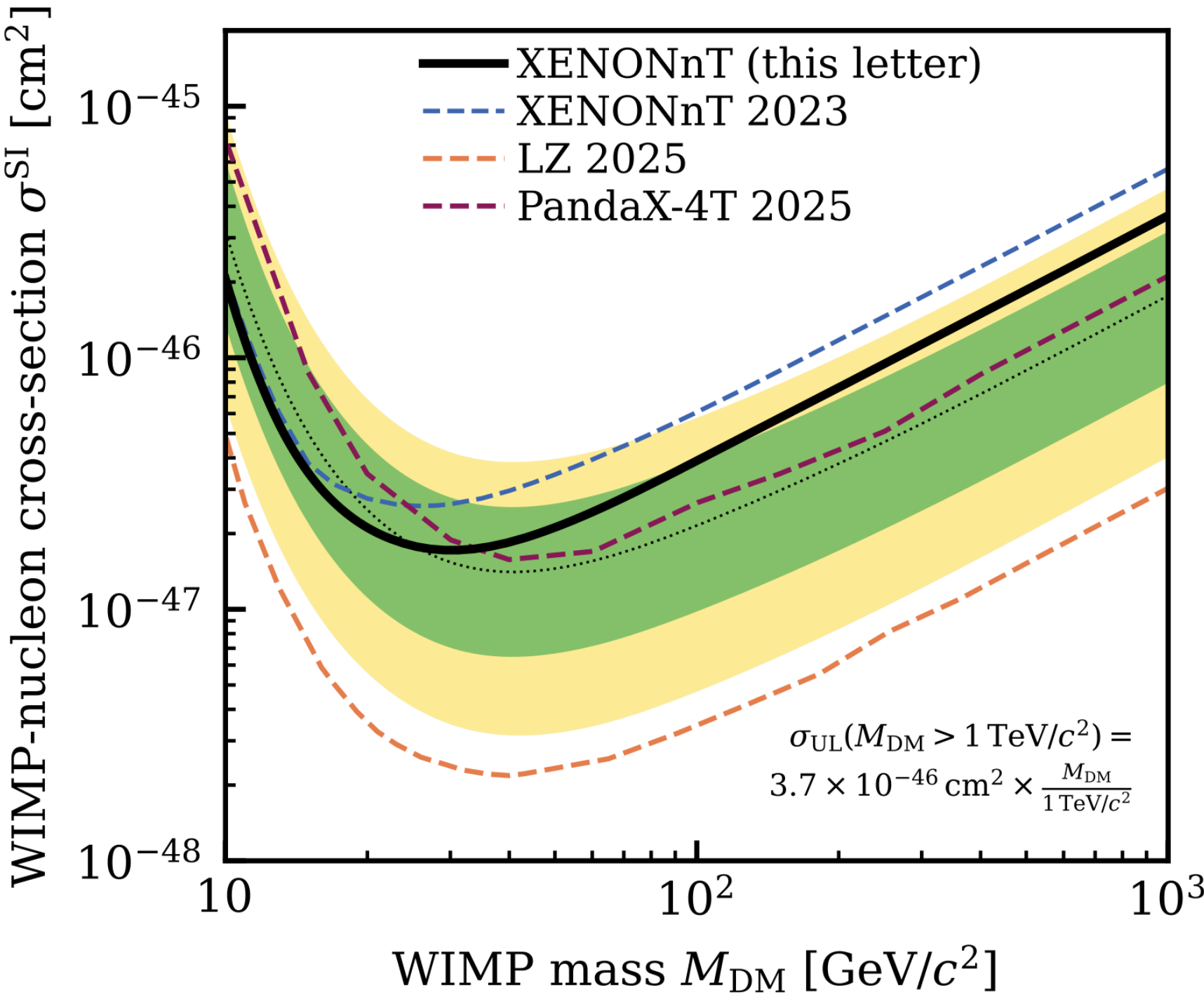
ACCEPTED PAPER

Low-energy nuclear recoil calibration of XENONnT with a ⁸⁸YBe photoneutron source



YBe produce 152 keV neutrons, XENONnT used it to calibrate very low energy NR

Nikhef



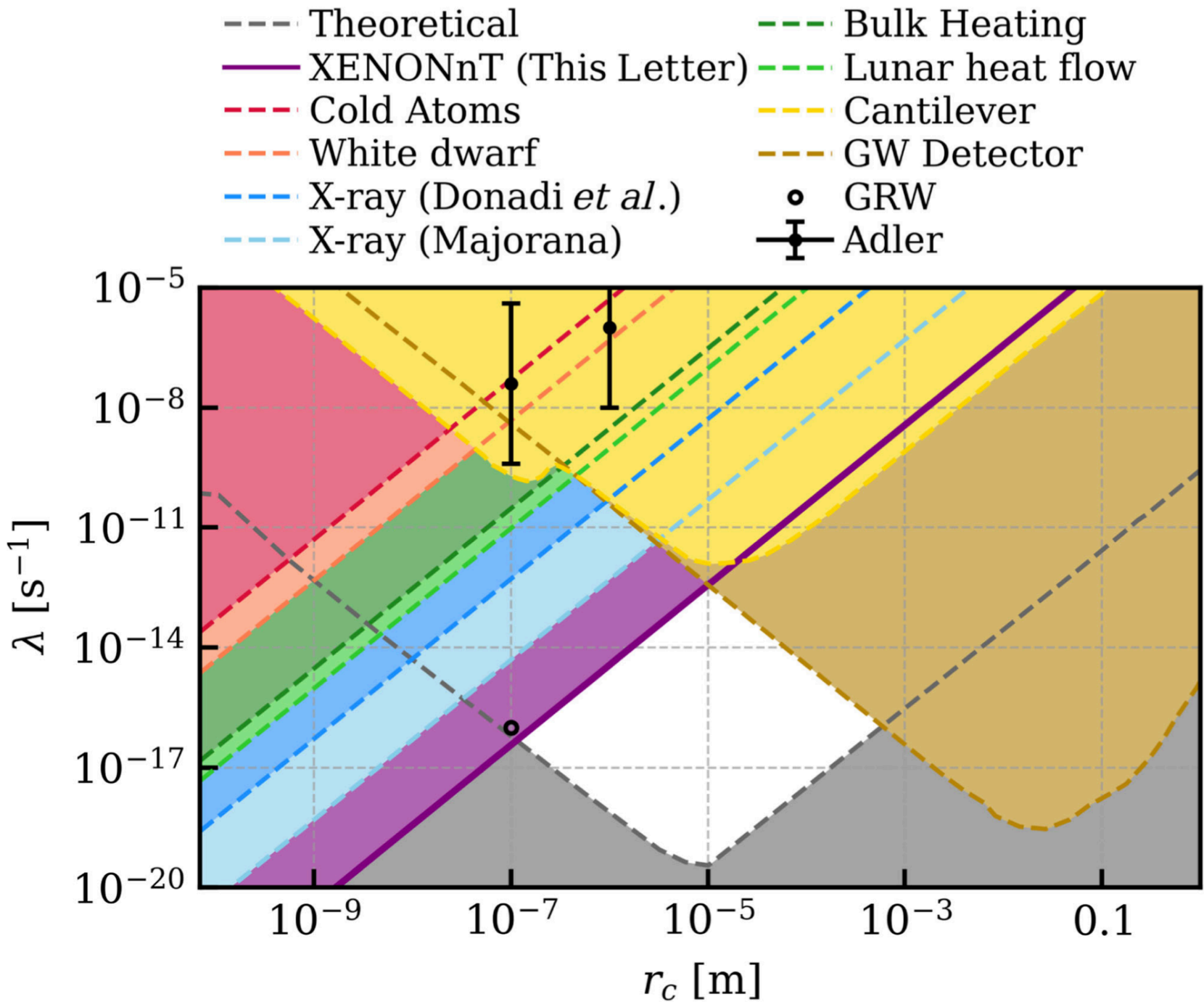
Phys. Rev. Lett. 136, 1202201

EDITORS' SUGGESTION | OPEN ACCESS

Challenging Spontaneous Quantum Collapse with the XENONnT Dark Matter Detector

E. Aprile¹, J. Aalbers², K. Abe³, S. Ahmed Maouloud⁴, L. Althueser⁵, B. Andrieu⁴, E. Angelino^{6,7}, D. Antón Martín⁸, S.R. Armbruster⁹ et al. (XENON Collaboration[¶])

Use spontaneous X-ray emission in low-energy electronic recoil data to set world-leading limits on the CSL and Diósi-Penrose collapse models — improving prior constraints by up to two orders of magnitude experimentally excluding the originally proposed CSL parameter ranges.



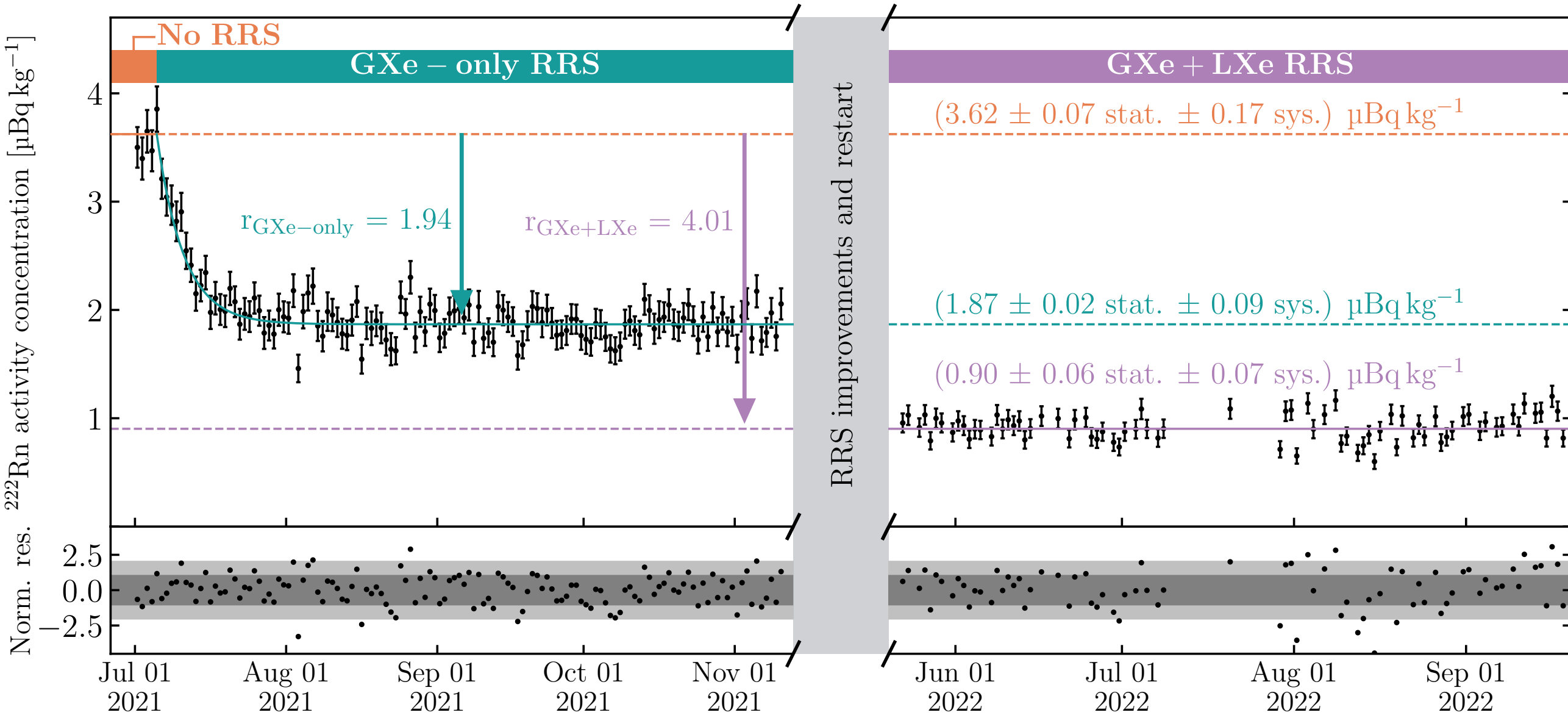
Phys. Rev. X 15, 031079

FEATURED IN PHYSICS | OPEN ACCESS

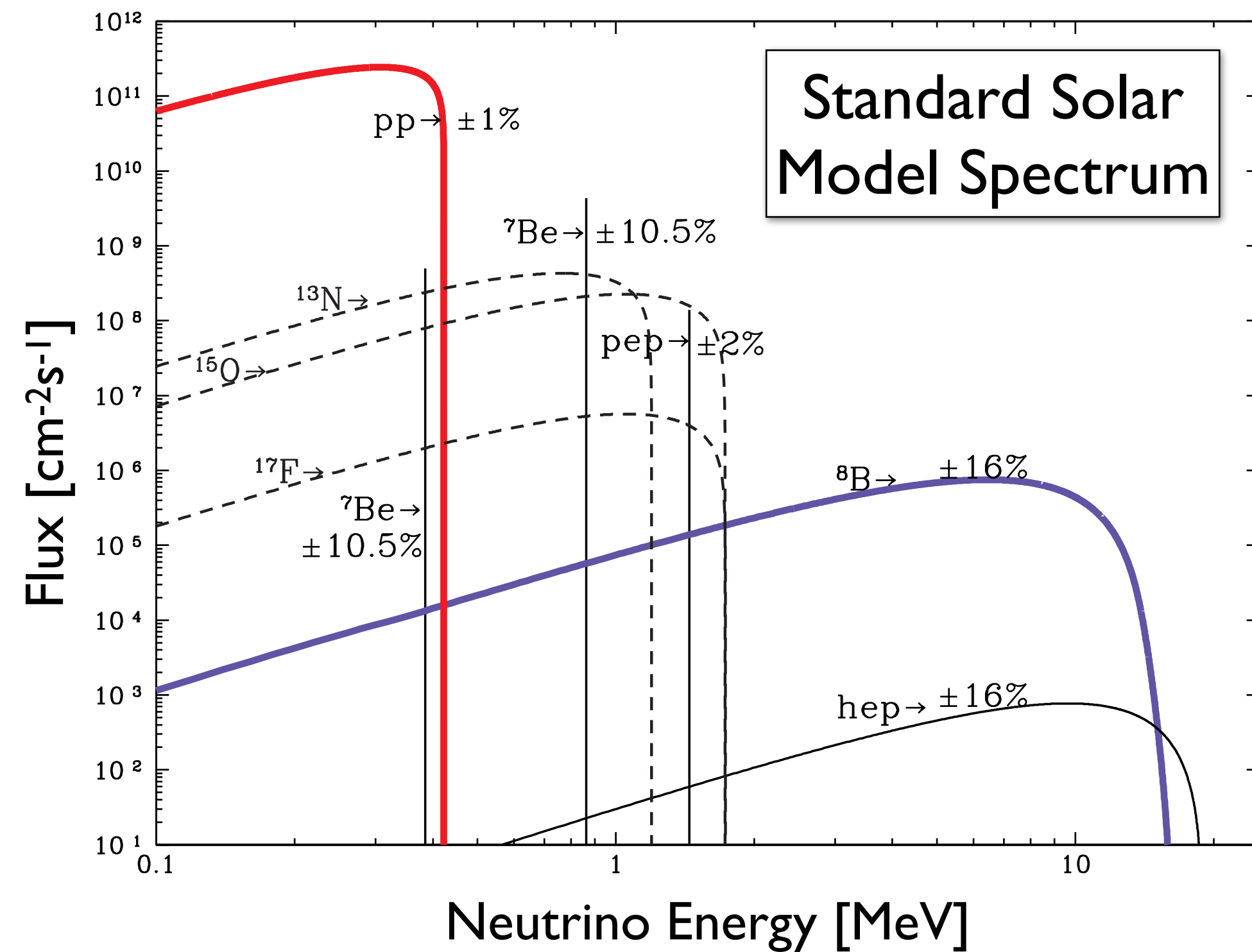
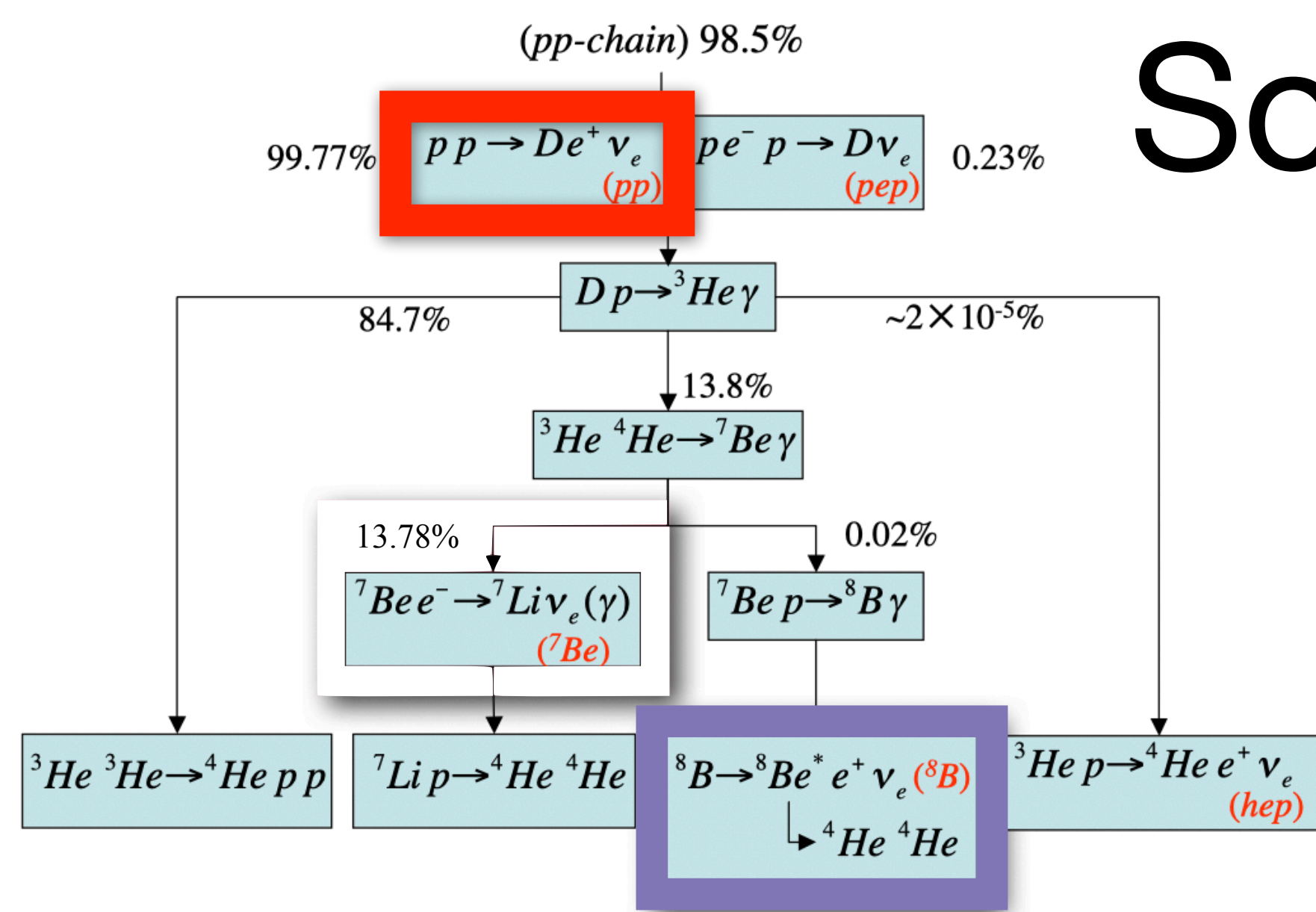
Radon Removal in XENONnT down to the Solar Neutrino Level

E. Aprile¹, J. Aalbers², K. Abe³, S. Ahmed Maouloud⁴, L. Althueser⁵, B. Andrieu⁴, E. Angelino^{6,7}, D. Antón Martín⁸, F. Arneodo⁹ et al. (XENON Collaboration)

XENONnT achieved a concentration of about 430 radon atoms per ton of liquid xenon, only 1 billionth of the radioactivity found in a human body and lower than the neutrino background from the sun.

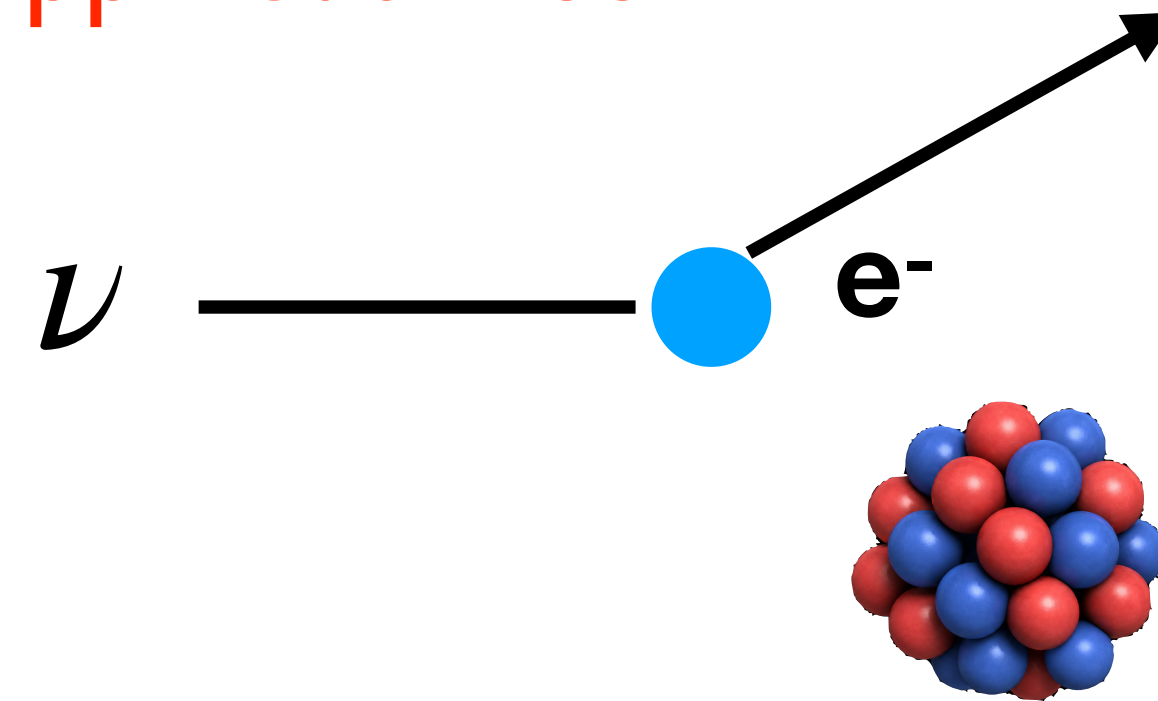


Solar Neutrinos



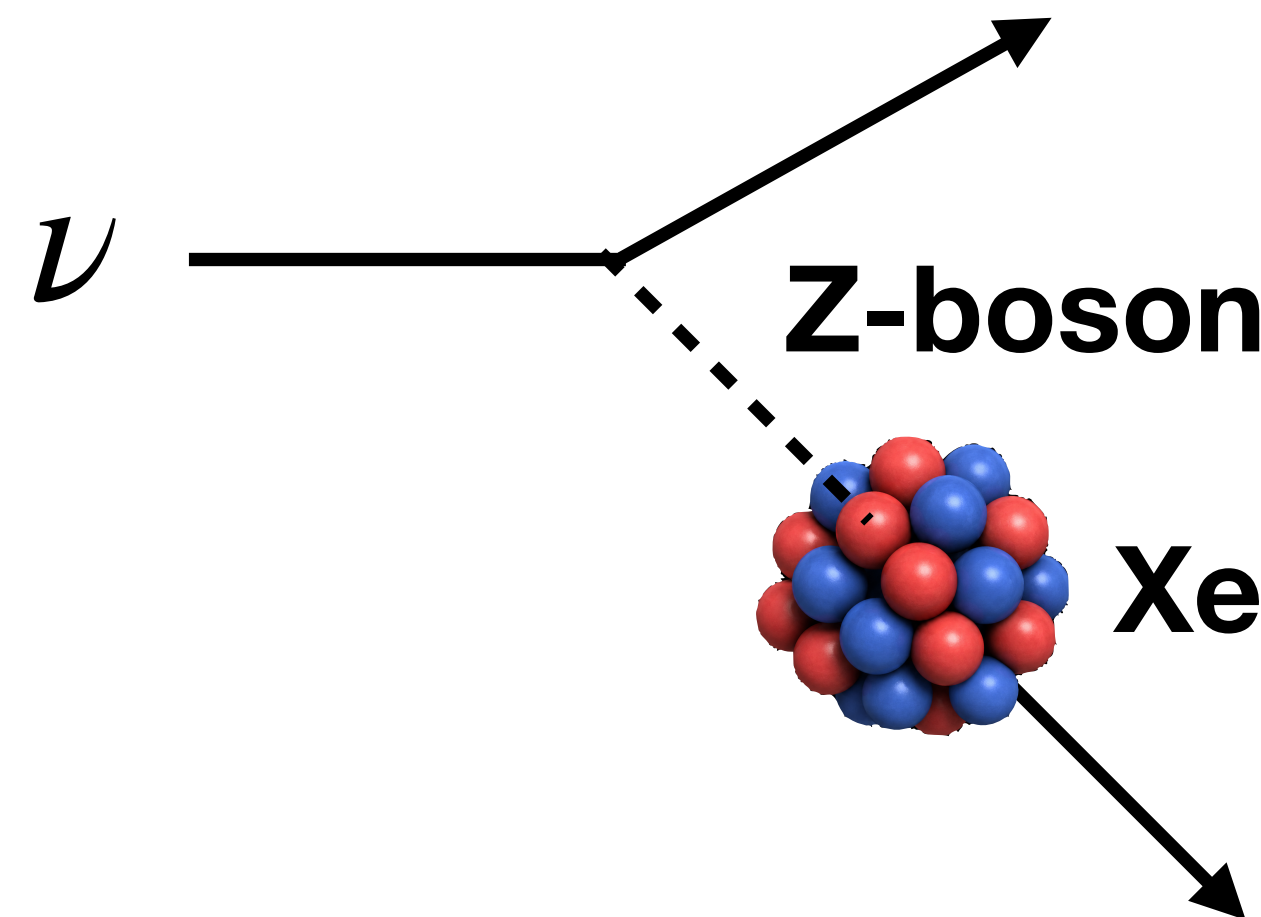
XENONnT can probe solar ν :

pp-neutrinos



Electronic Recoil

${}^8\text{B}$ -neutrinos



Nuclear Recoil

Coherent Elastic Nucleus Neutrino Scattering (CEvNS)

Probing the Solar ⁸B Neutrino Fog with XENONnT

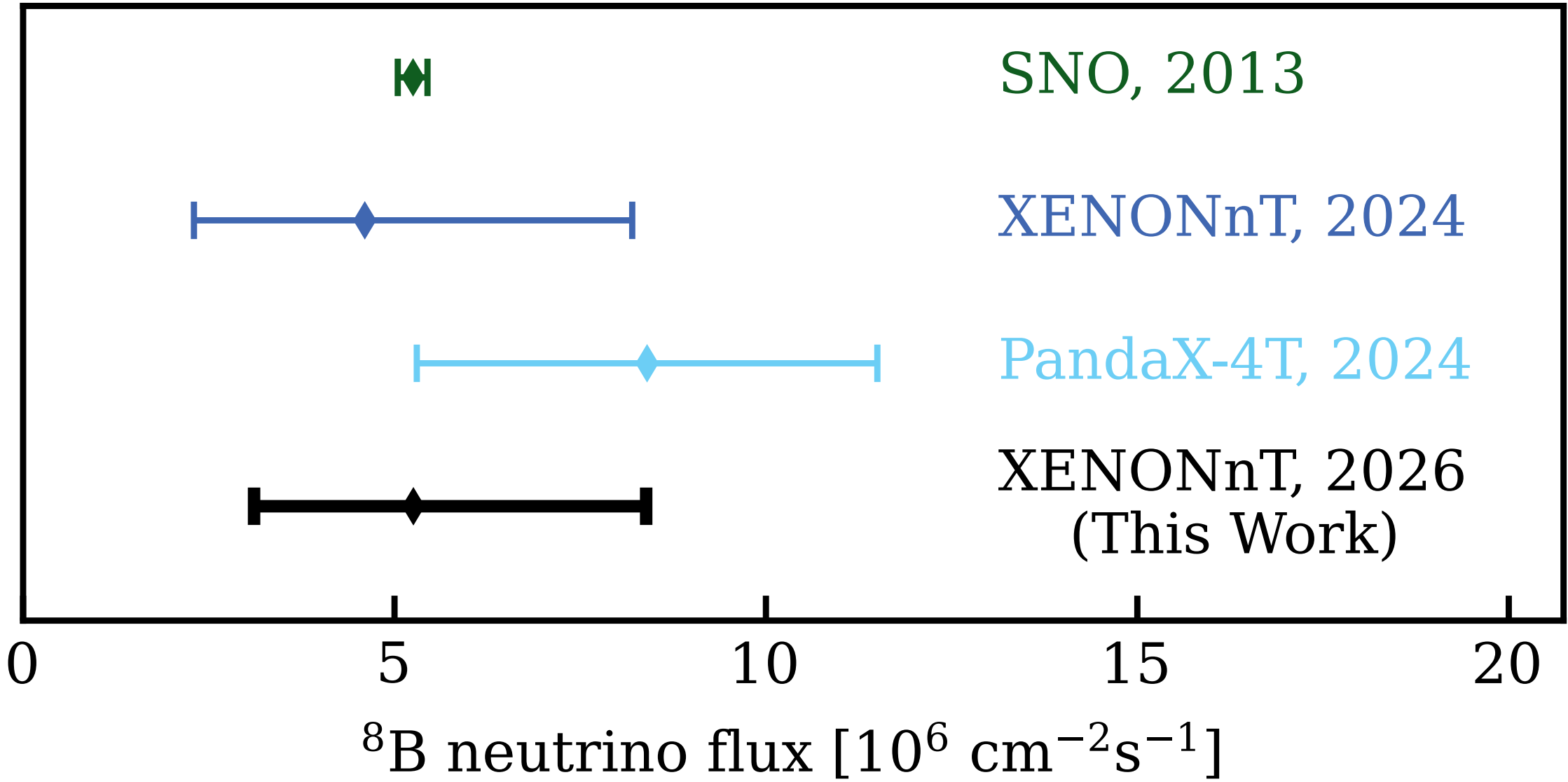
E. Aprile, J. Aalbers, K. Abe, M. M. Abu Rmeileh, M. Adrover, S. Ahmed Maouloud, L. Althueser, B. Andrieu, E. Angelino, D. Antón Martin, S. R. Armbruster, F. Arneodo, L. Baudis, M. Bazyk, V. Beligotti, L. Bellagamba, R. Biondi, A. Bismark, K. Boese, R. M. Braun, G. Bruni, R. Budnik, C. Cai, C. Capelli, J. M. R. Cardoso, A. P. Cimental Chávez, A. P. Colijn, J. Conrad, J. J. Cuenca–García, V. D'Andrea, L. C. Daniel Garcia, M. P. Decowski, A. Deisting, C. Di Donato, P. Di Gangi, S. Diglio, K. Eitel, S. el Morabit, R. Elleboro, A. Elykov, A. D. Ferella, C. Ferrari, H. Fischer, T. Flehmke, M. Flierman, R. Frankel, D. Fuchs, W. Fulgione, C. Fuselli, F. Gao, R. Giacomobono, F. Girard, R. Glade–Beucke, L. Grandi, J. Grigat, H. Guan, M. Guida, P. Gyorgy, R. Hammann, C. Hils, L. Hoetzsch, N. F. Hood, M. Iacovacci, Y. Itow, J. Jakob, F. Joerg, Y. Kaminaga, M. Kara, S. Kazama, P. Kharbanda, M. Kobayashi, D. Koke, K. Kooshkjalali, A. Kopec, E Kozlova, H. Landsman, R. F. Lang, L. Levinson, A. Li, H. Li, I. Li, S. Li, S. Liang, Z. Liang, Y.–T. Lin, S. Lindemann, M. Lindner, K. Liu, M. Liu, F. Lombardi, J. A. M. Lopes, G. M. Lucchetti, T. Luce, Y. Ma, C. Macolino, G. C. Madduri, J. Mahlstedt, F. Marignetti, T. Marrodán Undagoitia, K. Martens et al. (79 additional authors not shown)

We report a $3.3\,\sigma$ measurement of coherent elastic neutrino–nucleus scattering from solar ⁸B neutrinos using a 6.77 tXyr exposure from the XENONnT experiment, inferring a solar ⁸B neutrino flux of $(5^{+3}_{-2}) \times 10^6\,\text{cm}^{-2}\text{s}^{-1}$, consistent with previous measurements. In the presence of the ⁸B "neutrino fog", we find no evidence for light dark matter, and observe diminishing returns in sensitivity with increasing exposure. A 93% increase in exposure from the previous search improves the median sensitivity to $5\,\text{GeV}/c^2$ weakly interacting massive particles–nucleon cross section by 10%. The dataset was also used to measure the weak mixing angle at $\sim 0.02\,\text{GeV}/c$ momentum transfer and constrain physics beyond the Standard Model.

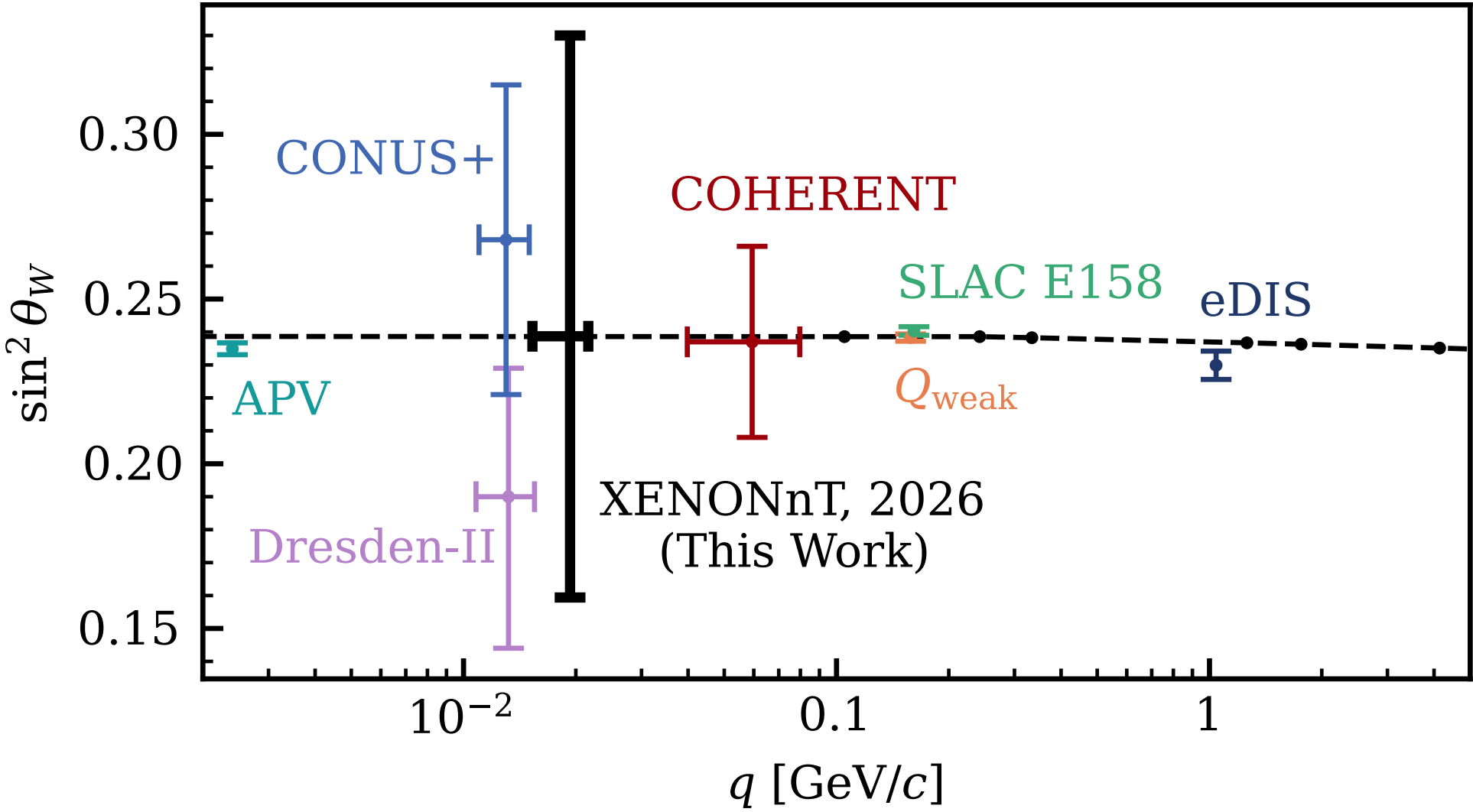
SR0+SR1+SR2

3.3σ observation of ⁸B ν

Neutrino Flux



$\sin^2 \theta_w$ @ $q \sim 0.02\,\text{GeV}$



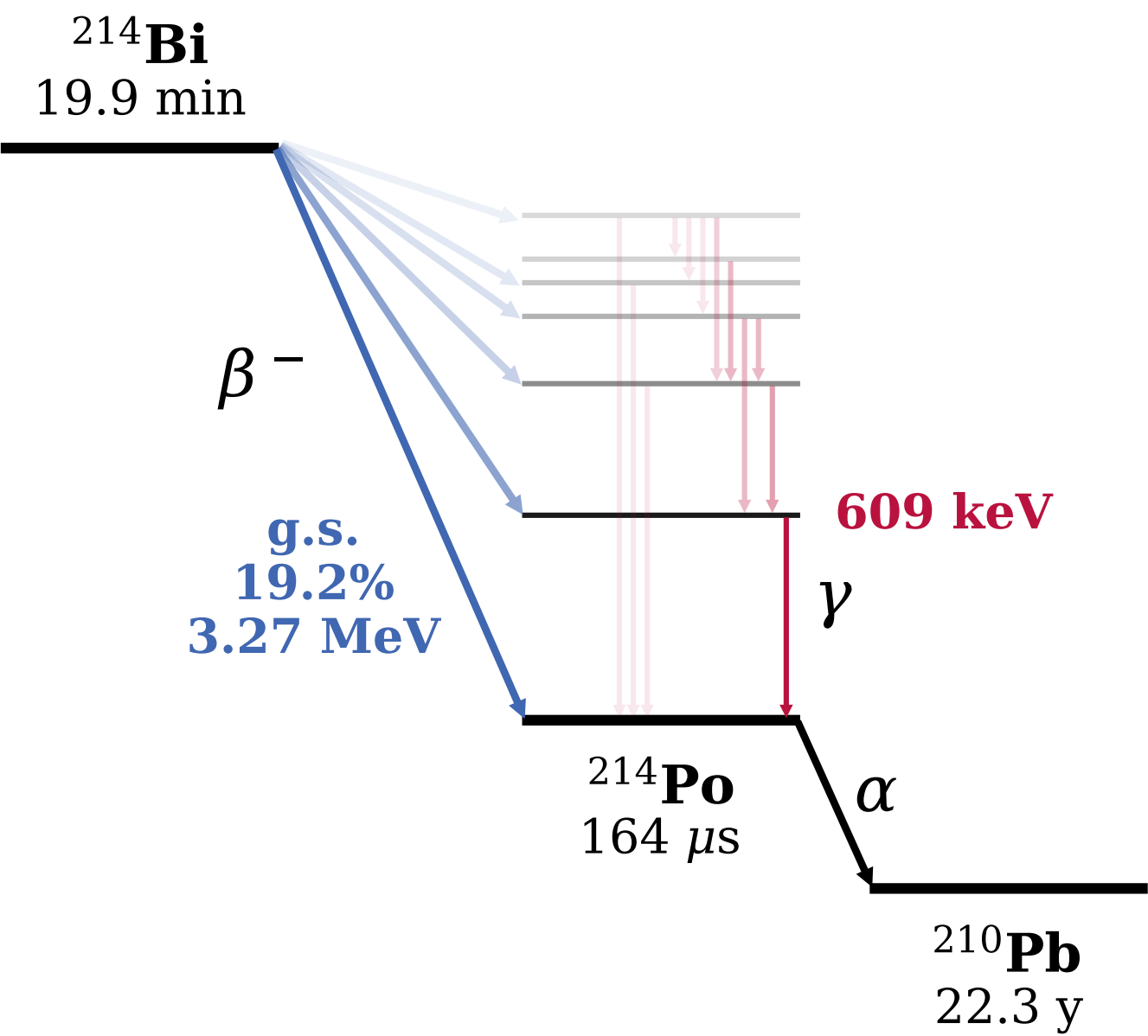
Phys. Rev. C **113**, 044303 (2026)

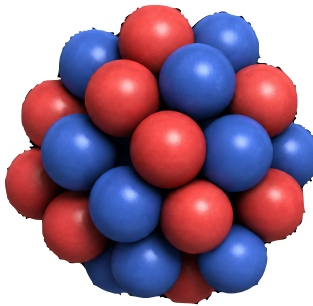
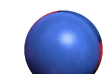
OPEN ACCESS

Spectral measurement of the ^{214}Bi β decay to the ^{214}Po ground state with the XENONnT Experiment

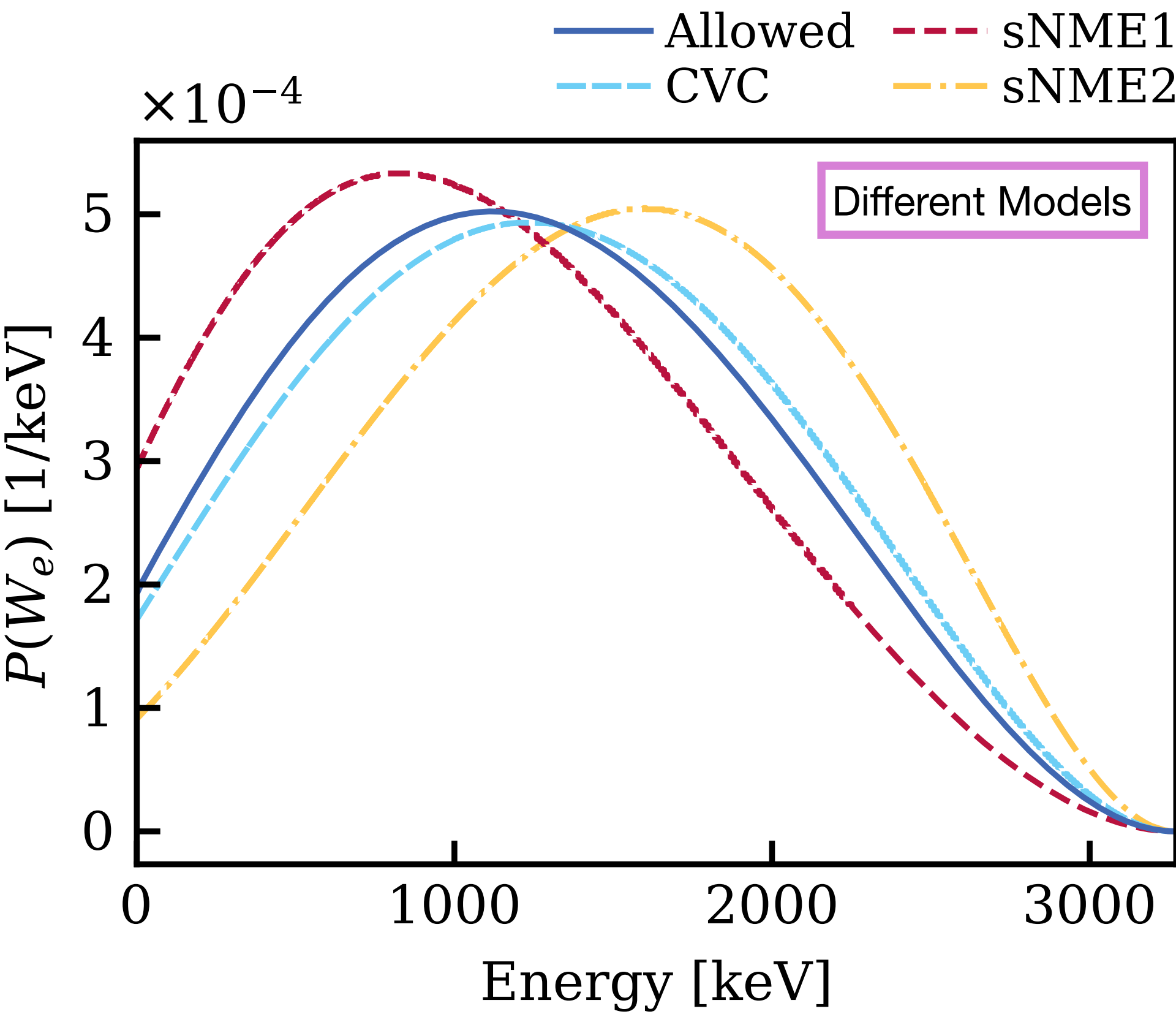
[E. Aprile](#)¹, [J. Aalbers](#)², [K. Abe](#)³, [M. Adrover](#)⁴, [S. Ahmed Maouloud](#)⁵, [L. Althueser](#)⁶, [B. Andrieu](#)⁵, [E. Angelino](#)⁷, [D. Antón Martín](#)⁸ *et al.* (XENON Collaboration[¶])

^{214}Bi : beta delayed-alpha decay



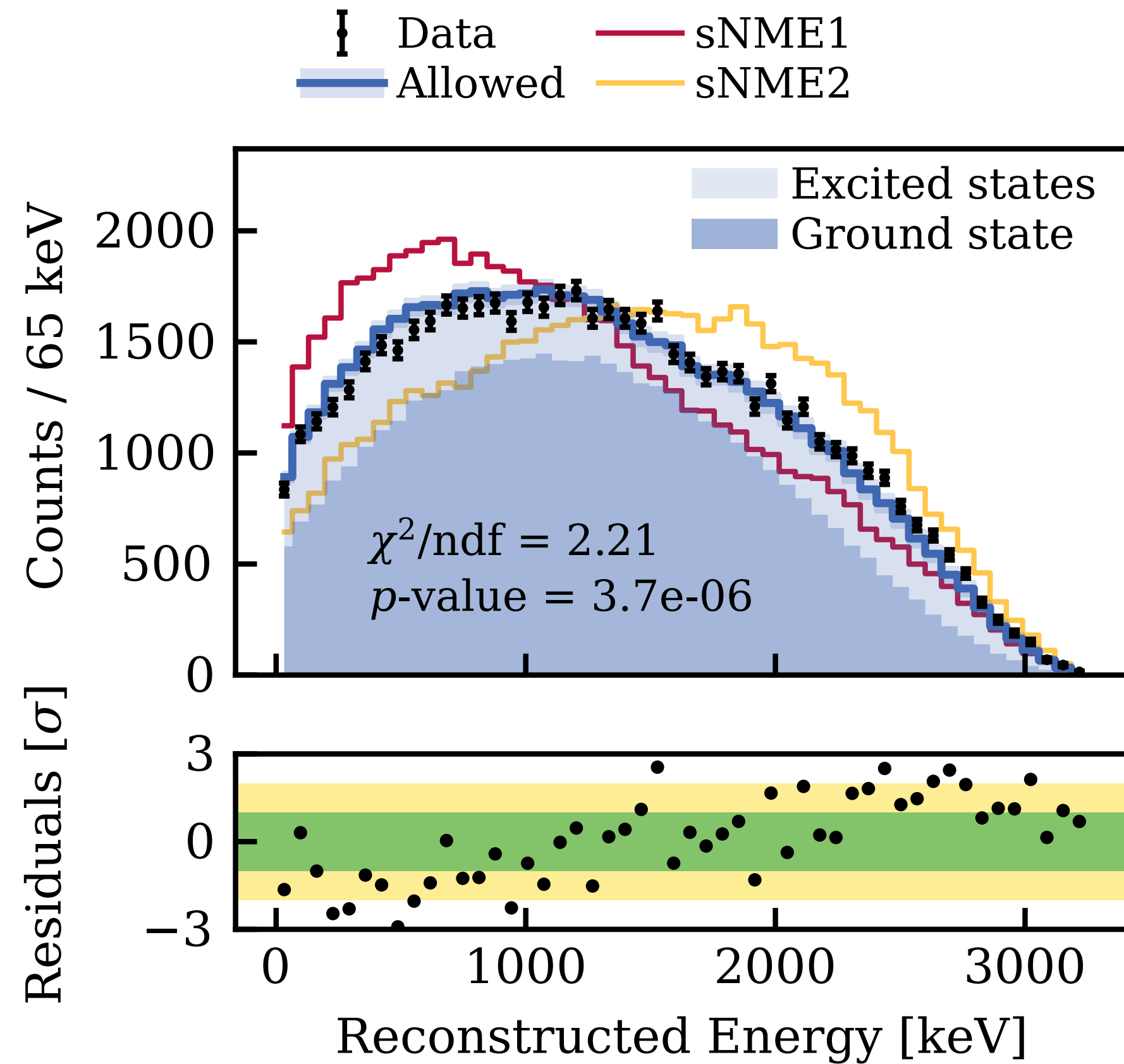
 $\neq$ **83x**  **+ 131x** 

G.S. ^{214}Bi to G.S. ^{214}Po beta-decay spectrum:
First-forbidden non-unique ($L = 1, \Delta J = 1$)

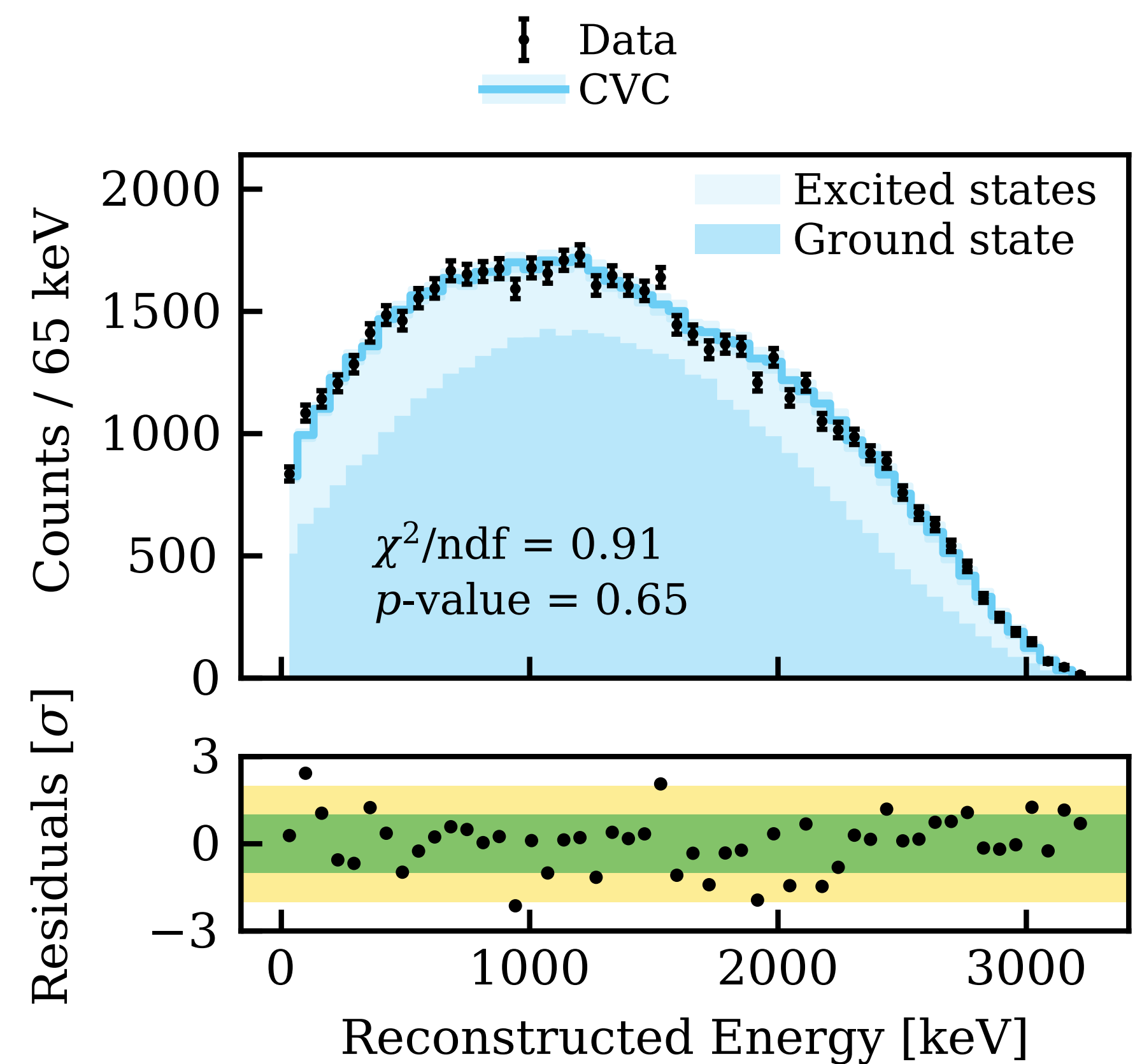


Goal is to improve nuclear models for heavy nuclei $\rightarrow$ NMEs for $0\nu 2\beta$ etc.

Results for ^{214}Bi to ^{214}Po



Detailed microphysics sim package
to model gamma-ray leakage



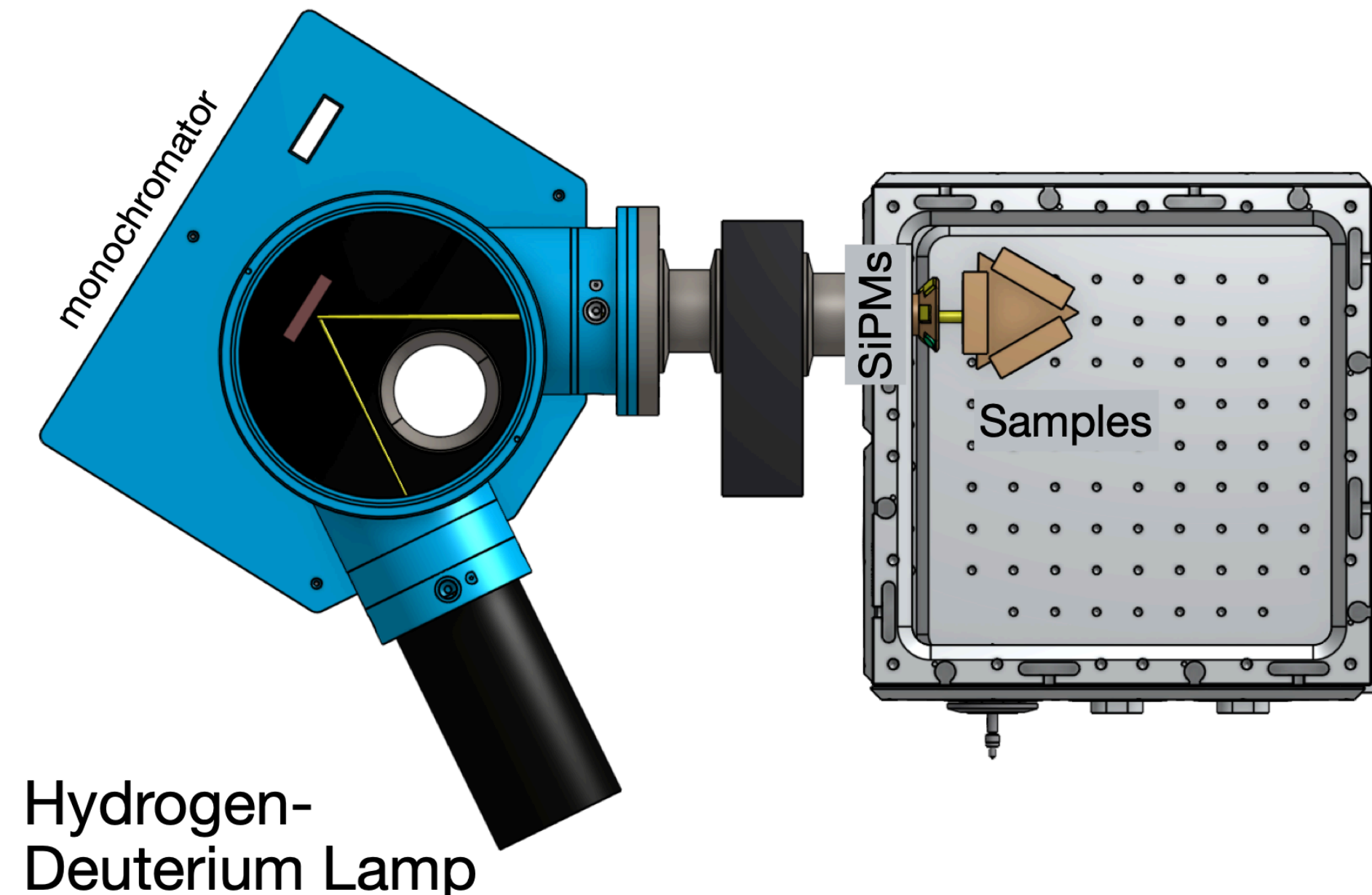
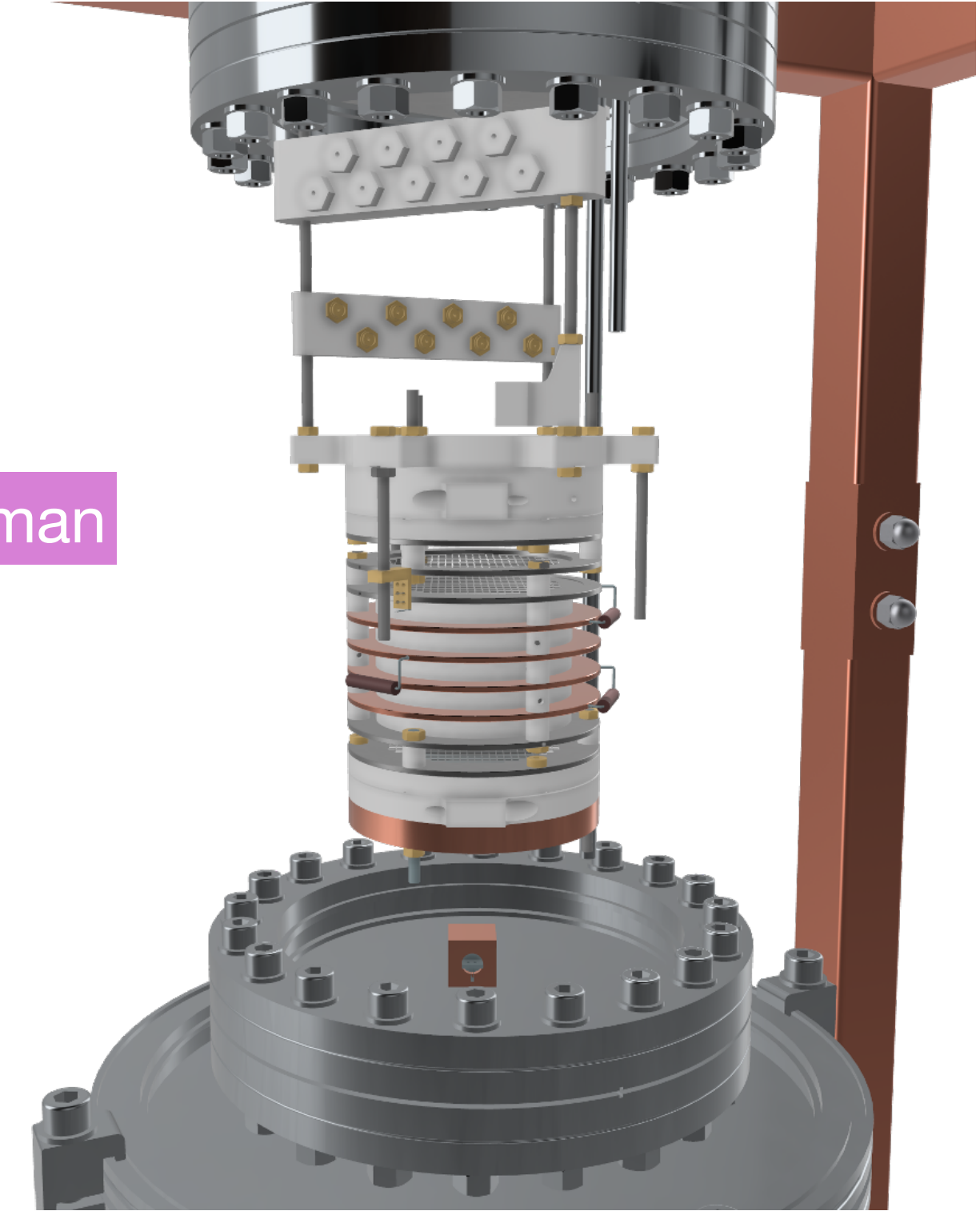
CVC model strongly favored

Local R&D - XAMS & VULCAN

- Technology development & testing for XLZD
 - e.g. “Characterization of the Hamamatsu R12699-406-M4 photomultiplier tube in cold xenon environments” recently published in JINST
- Investigation of accidental coincidence signals. Potential limiting factor for XLZD sensitivity
 - Paper on fluorescence about to be submitted
- VUV material transmission/reflection studies
- Testbed for XENON DAQ
- Training facility for Nikhef-XENON collaborators

• PhD Maricke Flierman

• PhD Anna Hurhina
• PhD Marjolein Troost



Summary

- XENONnT remains the scientific focus for the next years. Nikhef group continues to play key roles
- XLZD is a fantastic opportunity for a low background multipurpose detector
 - Several important steps in forming collaboration and initial detector design, towards CDR
- Big thanks to our Technology Departments:
 - **ET**: ND-LAr Light Readout System + Support in DM Lab
 - **MT**: XENON Photoluminescence Setup + Support in DM Lab
 - **CT**: XENON DAQ Update

