FOCUS

Field-guided charge Optimization and Collection Using electrostatic lensing in hybrid TPCs for rare event Searches

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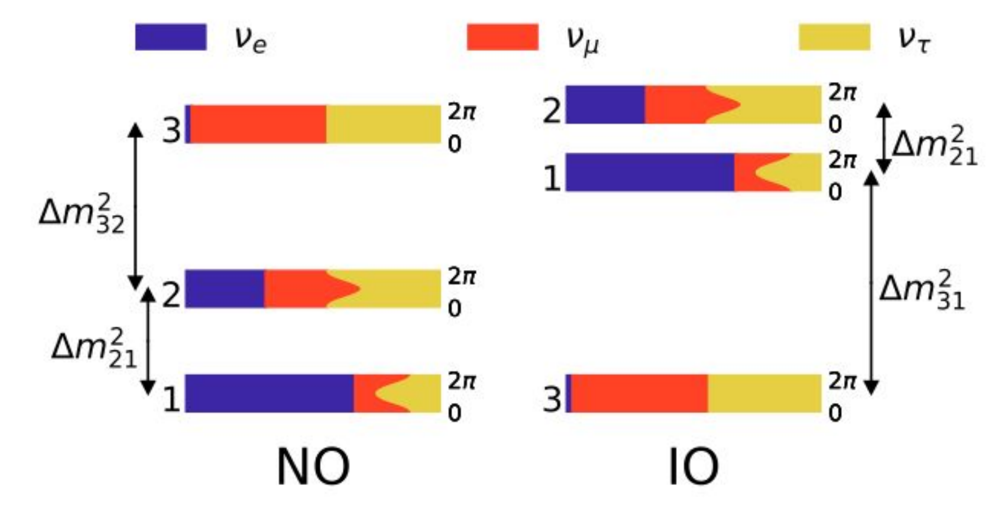
Young Astronomers Meeting 2026

ASTROCENT

Centrum Astronomiczne
im. Mikołaja Kopernika
Polskiej Akademii Nauk

The Quest for Majorana Neutrinos

Neutrinoless double-beta decay (0νββ) remains one of physics' most elusive **discoveries.** Observing this rare process would prove neutrinos are t**heir own antiparticles** and unlock the **absolute neutrino mass** scale.



Taken from [1], reproduced from [2]

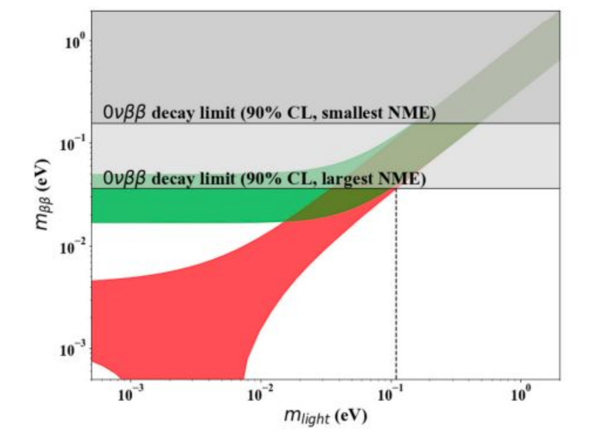
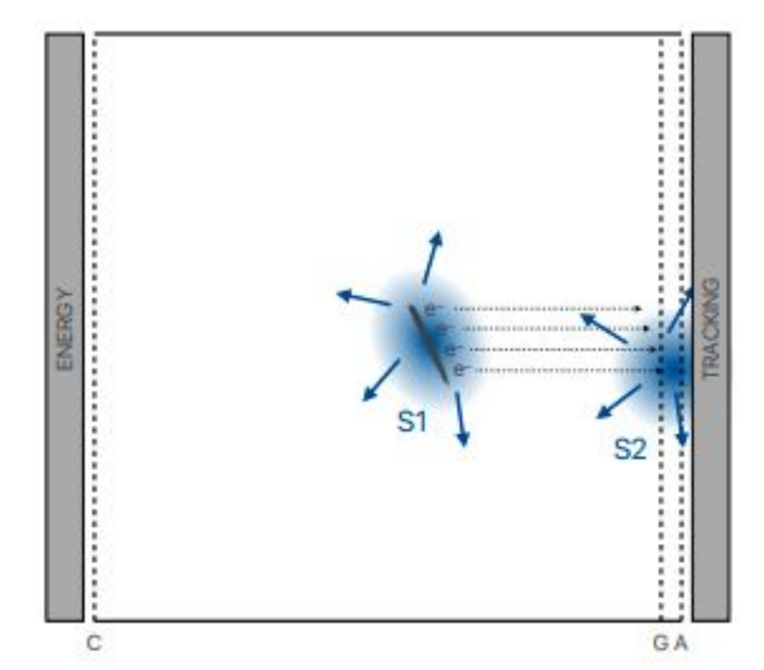


Fig. 10 The effective neutrino Majorana mass $m_{\beta\beta}$ as a function of the lightest neutrino mass, m_{light}. The red (green) band corresponds to the normal (inverted) ordering, respectively, in which case m_{light} is equal to m_1 (m_3). The horizontally excluded region comes from $\beta\beta0\nu$ constraints

Taken from [1]

Taken from [3]

Current experiments like **KamLAND-Zen** and **GERDA** have set stringent limits, but next-generation detectors must achieve half-life sensitivities approaching **10^{28} years** to probe the inverted mass ordering region.



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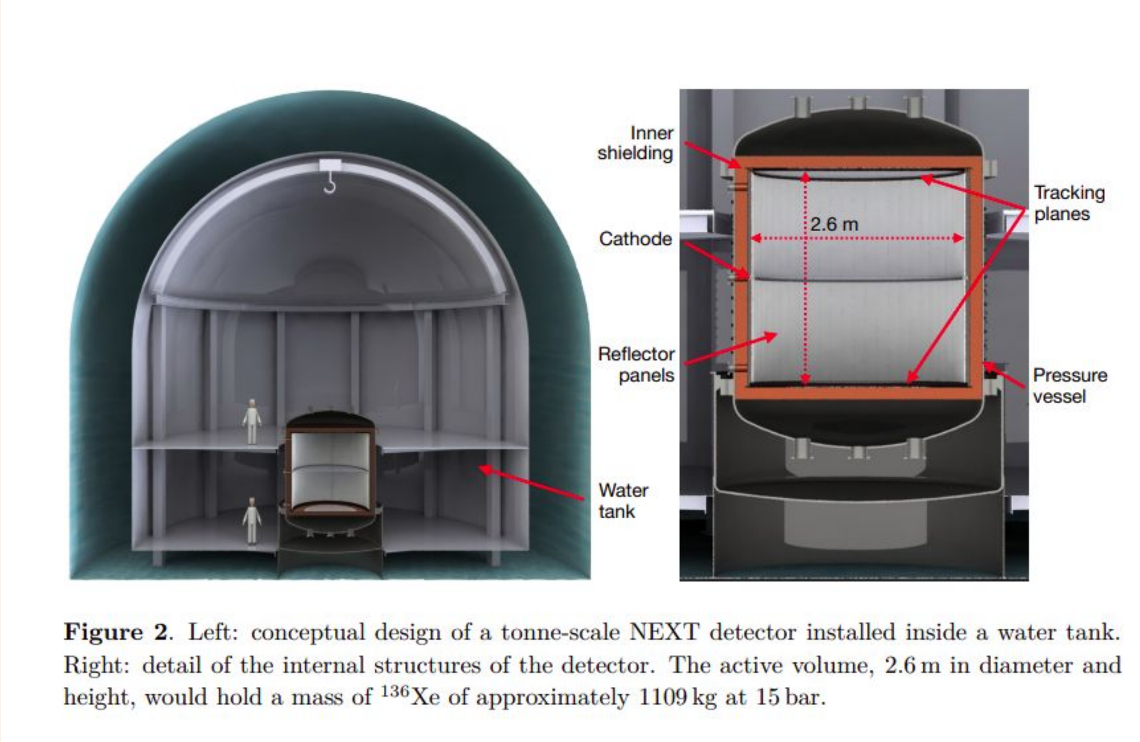


Figure 2. Left: conceptual design of a tonne-scale NEXT detector installed inside a water tank. Right: detail of the internal structures of the detector. The active volume, 2.6 m in diameter and height, would hold a mass of ^{136}Xe of approximately 1109 kg at 15 bar.

Taken from [4]

The Multi-Tonne Scaling Challenge

Background Radiation

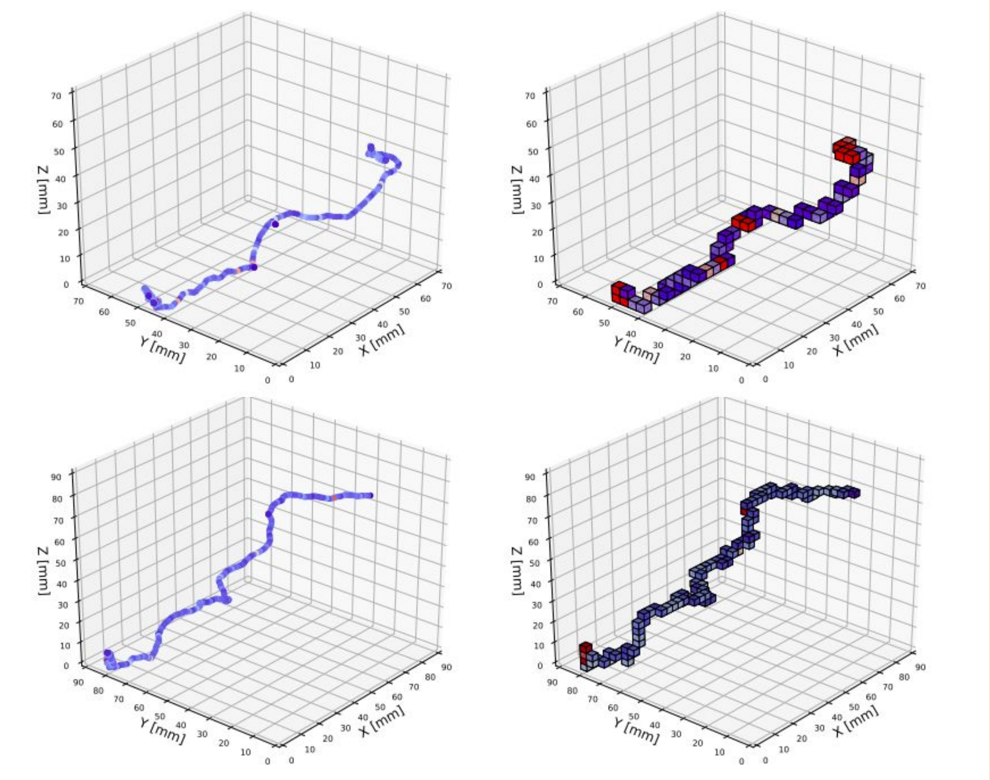
Thousands of readout channels with radioactive background from ^{238}U/^{232}Th mask the 0νββ signal

Cost Barrier

Large-area pixelated readout systems represent dominant construction costs for multi-tonne detectors

Power Requirements

High channel counts demand substantial front-end electronics power, incompatible with cryogenic operation e.g. CUORE, CUPID



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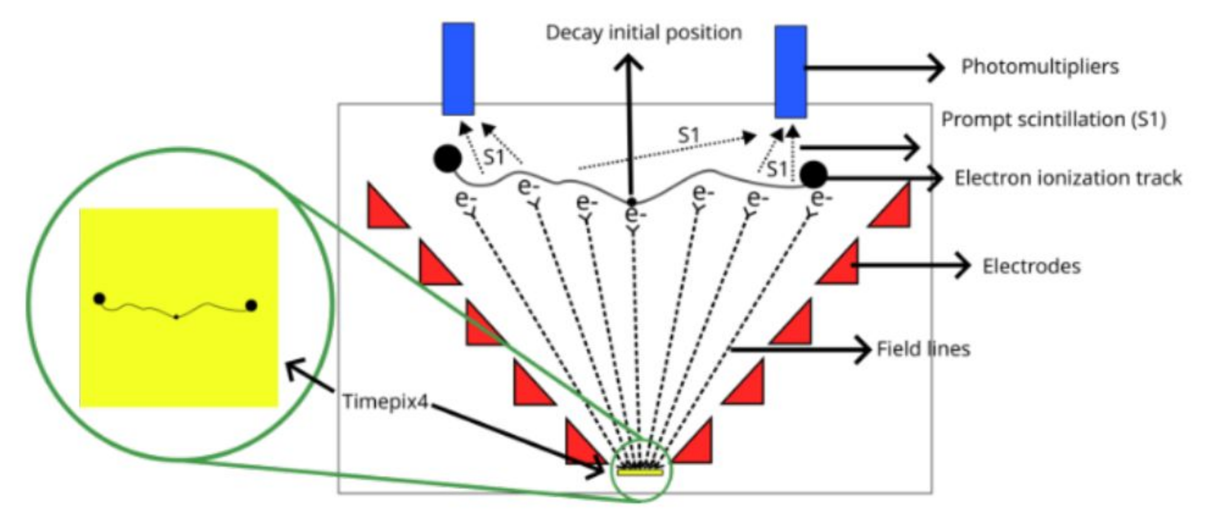


Our Innovative Solution

A system of field-shaping conducting rings progressively decreases aperture to guide and focus drifting electron clouds from large sensitive volumes onto compact pixelated readout chips.

10×

Lensing Factor

Signal focused from 30 cm diameter to 3×3 cm sensor area

70%

Collection Efficiency

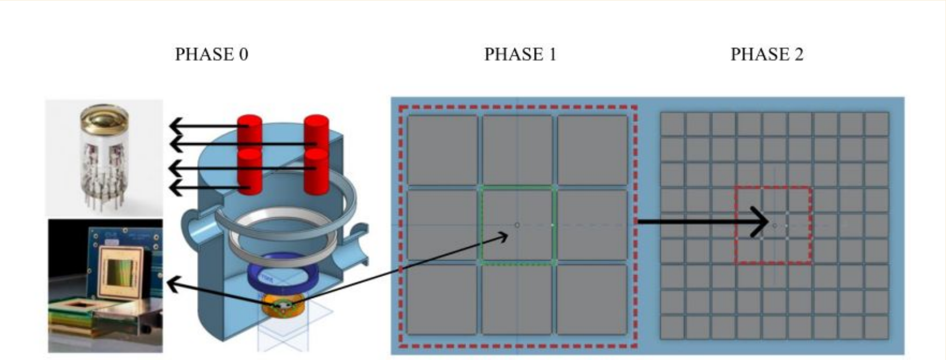
Target electron collection without signal degradation

~1%

Energy Resolution

FWHM at 2458 keV Q-value

Research Questions



1

Collection Efficiency

Can electrostatic lensing achieve ≥70% collection efficiency from large drift volumes without degrading energy or position resolution?

2

Optimal Geometry

What ring configuration maximizes collection while maintaining field uniformity for <1% FWHM energy resolution?

3

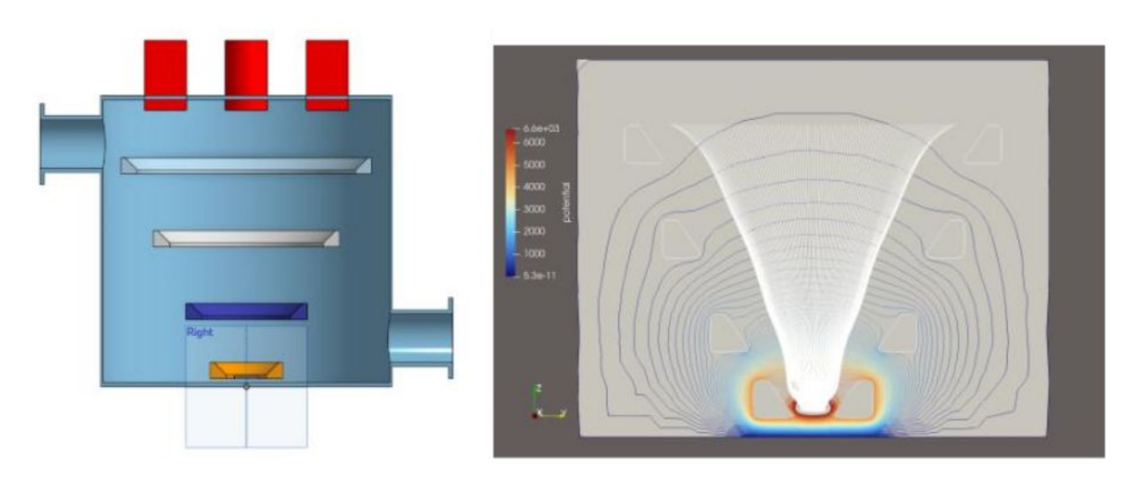
Parameter Scaling

How does efficiency scale with drift field (100-300 V/cm), pressure (3-15 bar), and initial electron position?

4

Simulation Framework

Can full-physics simulations reliably predict lensing system performance for full-scale detector scaling?



What you will do:

1

Validated Simulation Framework

Elmer-FEM electric field maps, Garfield++ electron transport, Geant4 detector response benchmarked to <10% uncertainty

2

Proof-of-Concept Demonstrator

Collection efficiency ≥70% with lensing factor 3-10, 3D track reconstruction, competitive energy and spatial resolution

3

Full Benchmarking

Agreement between simulation and experiment validated, extrapolation to xenon and tonne-scale detectors

4

Feasibility Report

Design basis, performance projections, cost analysis for 100 kg-1 tonne scale NEXT-HD integration

Research Team Excellence

Dr. Pedro Silva, PI

PhD in Physics Engineering, 10+ years gas detector R&D, NEXT collaboration contributor, extensive simulation expertise

Diego Rodas Rodríguez

Doctoral researcher, FAT-GEM development, simulation framework lead, data analysis specialist

Dr. Miroslav Macko

13 years 0νββ experience, QRPA nuclear matrix calculations, SuperNEMO Physics Coordinator

Dr. André Cortez

Assistant Professor, noble gas charge transport, SONATA-19 PI, NEXT/CYGNO/DarkSide collaborations

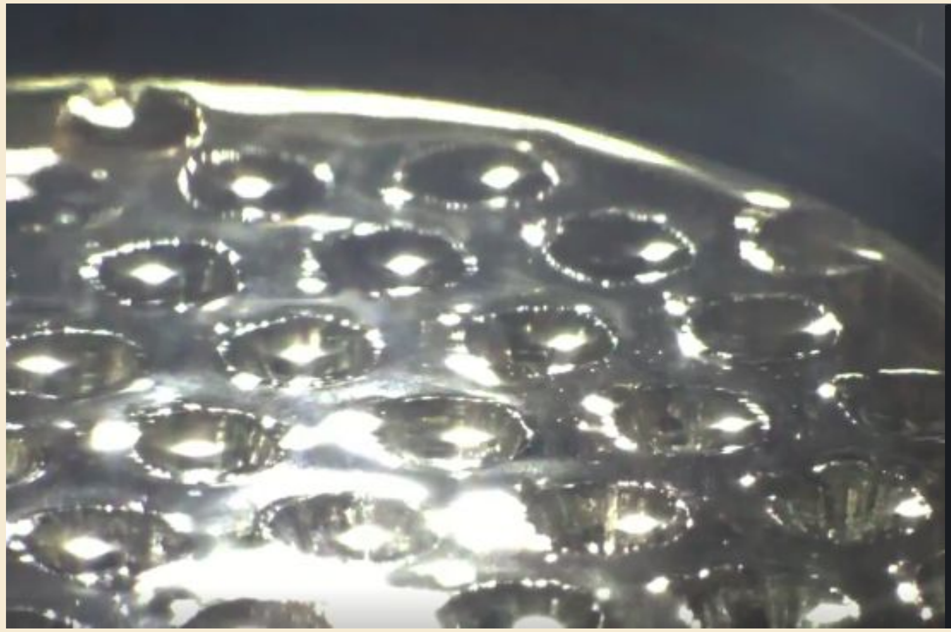
Dr. Hugo Natal da Luz

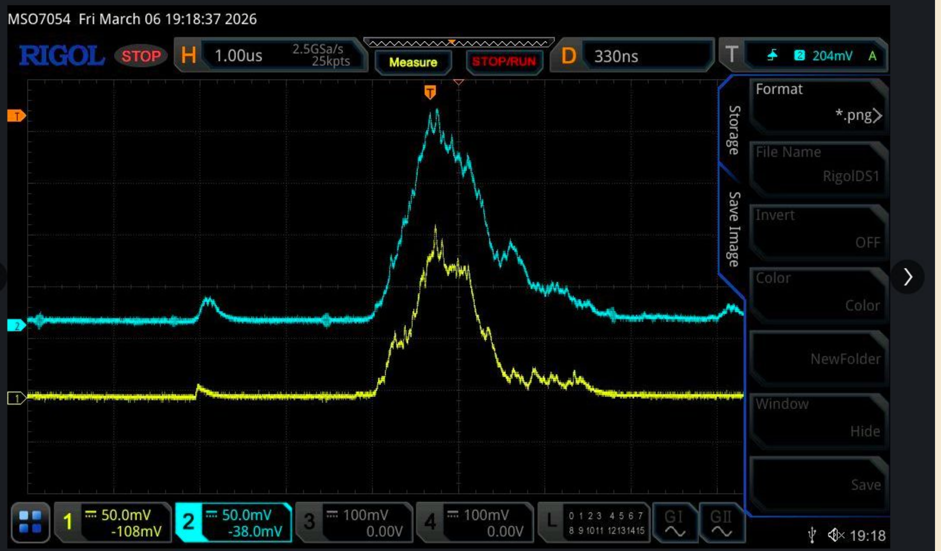
IEAP CTU Prague

Timepix4 ecosystem expert, Medipix Collaboration, early ASIC access and integration expertise

YOU?

Transforming particle and radiation detection





GAS FUNDAMENTAL PARAMETERS;
3D PRINTING, ETC

PhD Position

Exploring Spectral Dynamics of Argon Scintillation

From Scintillation Threshold to Breakdown Voltage in MPGD Structures

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Open PhD position · 4-year funded scholarship

Application deadline: April 12th, 2026

DRD1 Collaboration · WG3

ASTROCENT / CAMK PAN

Warsaw, Poland

Supervisors
Dr. Marcin Kuźniak
Dr. André Filipe Cortez

phdstudies@camk.edu.pl · https://geoplanetschool.erk24.pl

Project Overview

Motivation

Ar & Xe detectors are central to **Dark Matter searches** and neutrino experiments, yet VUV scintillation mechanisms — wavelength spectra, photon yield, and timing — remain **incompletely understood.**

Our Approach

Time- & wavelength-resolved spectroscopy of Ar scintillation at 0.5–4 bar using MPGD structures (GEM, THGEM, FAT-GEM), probing emission from threshold to breakdown voltage — including the unexplored **third continuum.**

DarkSide

Dark Matter search
(Gran Sasso, Italy)

ARIADNE

Liquid Ar TPC for
neutrino physics

GANESS

Noble gas detector
R&D programme

Your Role & What We Offer

Your Tasks

- Detector instrumentation & apparatus assembly
- Time- & wavelength-resolved scintillation studies
- Monte Carlo simulation (Geant4) development
- Optical amplification characterisation with monochromators
- Data analysis & result validation (ROOT)
- Data-taking campaigns within DarkSide collaboration

Desired skills: C++/Python · Radiation detector principles · Geant4 & ROOT (desirable)

What We Offer

4-year funded scholarship

Years 1–2: ~3,077 PLN/month net

Years 3–4: ~4,740 PLN/month net

- Research stays at Gran Sasso National Laboratory (LNGS), Italy
- World-class lab infrastructure & international scientific network
- International conference presentations & networking

Apply by April 12, 2026 · geoplanetschool.erk24.pl

Bibliography

[1] - Gómez-Cadenas, J. J., Martín-Albo, J., Menéndez, J., Mezzetto, M., Monrabal, F., & Sorel, M. (2024). The search for neutrinoless double-beta decay. *La Rivista del Nuovo Cimento*, *46*, 619–692. https://doi.org/10.1007/s40766-023-00049-2

[2] - P.F. De Salas, S. Gariazzo, O.Mena, C.A. Ternes,M. Tórtola, Neutrino mass ordering from oscillations and beyond: 2018 status and future prospects. Front. Astron. Space Sci. 5, 36 (2018). https://doi.org/ 10.3389/fspas.2018.00036. arXiv:1806.11051 [hep-ph]

[3] - Gallery of Ettore Majorana, https://prabook.com/web/ettore.majorana/3757343.

[4] - C. Adams et al. (NEXT Collaboration), "Sensitivity of a tonne-scale NEXT detector for neutrinoless double beta decay searches," JHEP 2021(08), 164 (2021). https://doi.org/10.1007/JHEP08(2021)164