The R2D2 Radial Time Projection Chamber for ββ0ν Decay

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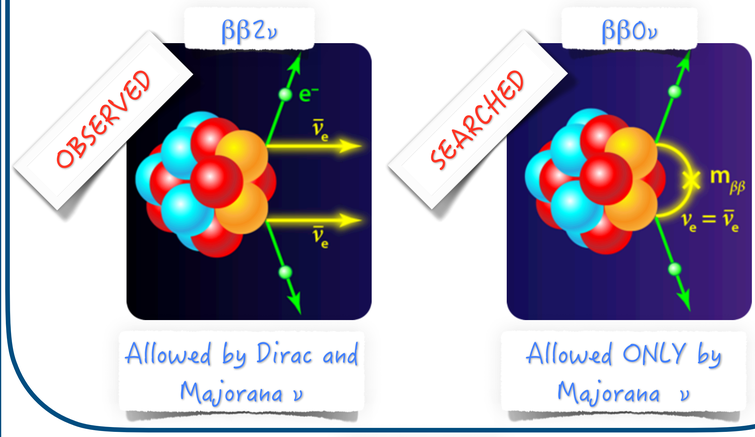
Physics Case

The observation of neutrinoless double beta decay (ββ0ν) is fundamental to determine the nature of neutrino.

Dirac ($\nu \neq \bar{\nu}$)
Majorana ($\nu = \bar{\nu}$)



Allowed by Dirac and Majorana ν

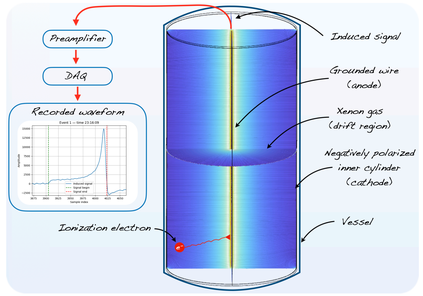
Allowed ONLY by Majorana ν

Concept

R2D2 (Rare Decays with Radial Detector), started as R&D in 2017 [1], aims to develop a detector meeting all requirements for ββ0ν searches.

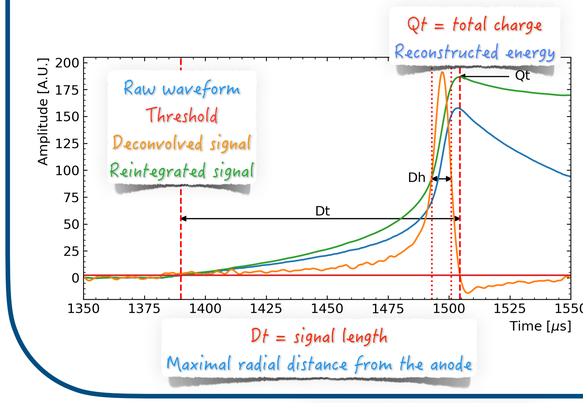
- Excellent energy resolution
- Low background
- Large masses of isotopes
- Electron tracks identification

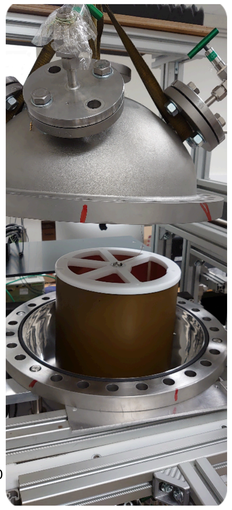
→ Goal of R2D2 (Rare Decays with Radial Detector) → Using a radial high pressure xenon TPC



Prototype

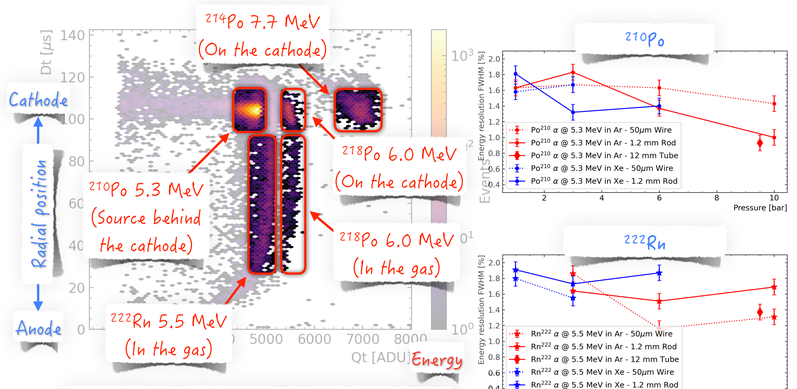
Several prototypes were built and operated in ionization mode to avoid gain fluctuations and directly relate the signal length to the radial position of the deposited energy [2].





Results

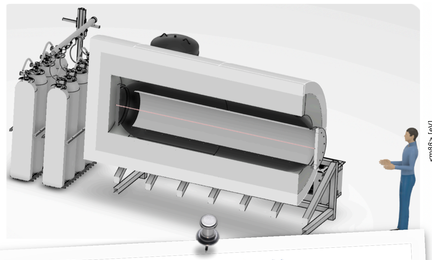
The different alpha sources are well identified. The energy resolution at the per-cent level is independent of gas type, pressure, and source position [3].



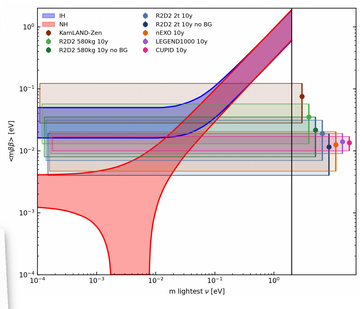
Data for xenon at 3 bar, anode of 1.2 mm diameter, and -3000 V applied to the cathode

Sensitivity

Detailed background simulations show that the sensitivity of an R2D2-based detector is comparable to that of other projects [4].

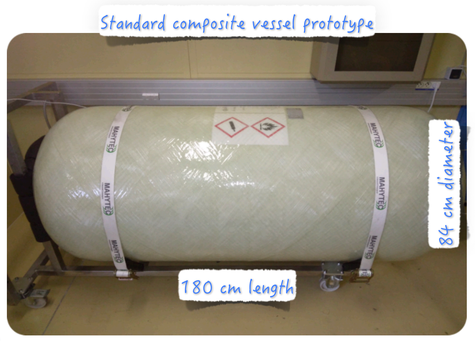


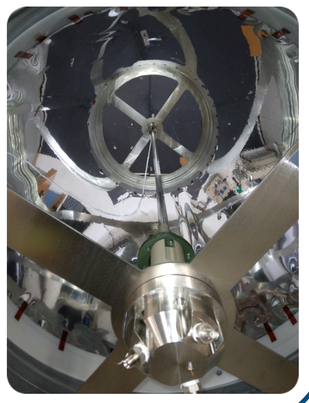
580 kg of active Xenon
Footprint 50 m²
Detector cost (including shielding and utilities) is about 3 Millions (Enriched Xe cost excluded)



Next Steps

The remaining step towards a full-scale experiment is to validate a low-radioactivity composite pressure vessel and demonstrate the feasibility of an almost zero-background detector at the ton scale.





[1] A. Meregaglia et al. [R2D2 Collaboration] *JINST* 13 (2018) 01, P01009
[2] R. Bouet et al. [R2D2 collaboration] *JINST* 18 (2023) 10, T10001
[3] R. Bouet et al. [R2D2 collaboration] *Eur.Phys.J.C* 84 (2024) 5, 512
[4] R. Bouet et al. [R2D2 collaboration] *Eur.Phys.J.C* 85 (2025) 7, 732

R2D2 Collaboration

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