Latest results of the R2D2 project

A future $0\nu\beta\beta$ experiment

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Introduction

- Observation of $0\nu\beta\beta$ decay would demonstrate the Majorana nature of the neutrino and point to the mass scale of new physics

Requirements for a $0\nu\beta\beta$ experiment

1. **Low background** Low rate of signal events requires as small a background as possible
2. **Large isotope mass** Limits on $0\nu\beta\beta$ half-life require large isotope masses
3. **Good energy resolution** Essential to discriminate the $0\nu\beta\beta$ signal from the $2\nu\beta\beta$ background

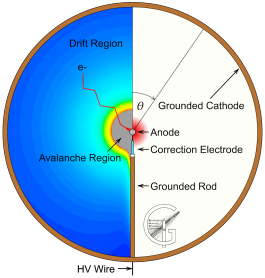
Properties of Spherical Proportional Counters

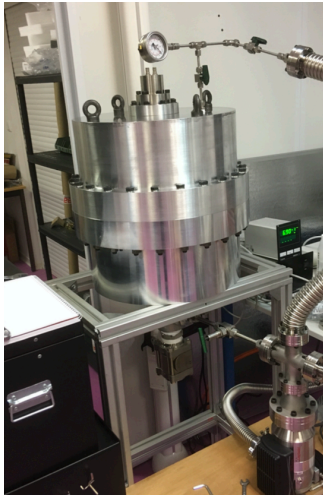
1. **Low background** a) Spherical shape has the optimal surface-to-volume ratio, b) Very low material budget c) Radial discrimination through pulse analysis
2. **Large isotope mass** Large masses of extremely pure gaseous isotopes can be achieved through high pressure operation
3. **Good energy resolution** The subject of this talk

- **SPCs good $0\nu\beta\beta$ detectors?** Conceptual design investigated in detail in JINST 13 (2018) 01, P01009

The R2D2 project

- **R2D2** (Rare decays with a radial detector) is an R&D project to investigate using a Xenon filled SPC to search for $0\nu\beta\beta$
- SPCs currently being used to search for dark matter (NEWS-G project)





The initial goal of the project is to demonstrate the required energy resolution to search for $0\nu\beta\beta$ can be achieved (1% FWHW at $Q_{\beta\beta}$ of 2.458 MeV)

Experimental setup

R2D2 spherical TPC: first energy resolution results

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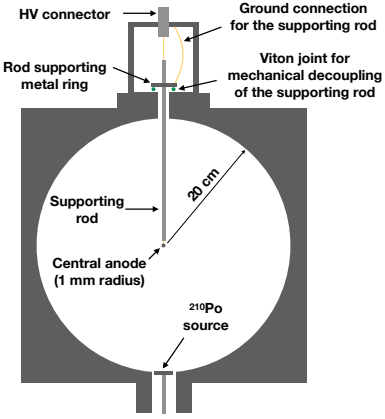
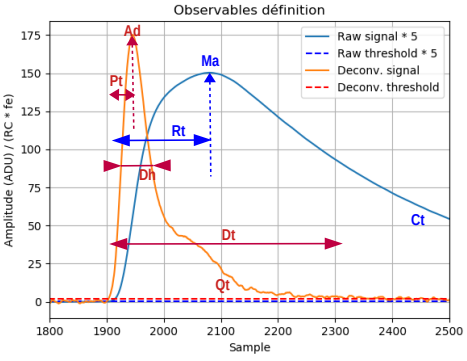
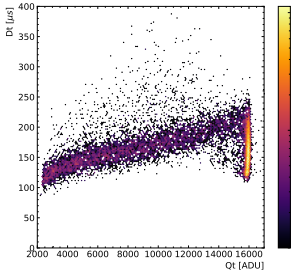
- To investigate whether the desired energy resolution can be achieved a 20 cm radius aluminium SPC has been produced and operated at CENBG in Bordeaux
- The detector was filled with a mix of Argon/CH_4 (98/2%)
- An α particle source (^{210}Po) was used, producing α particles with $E = 5.3$ MeV

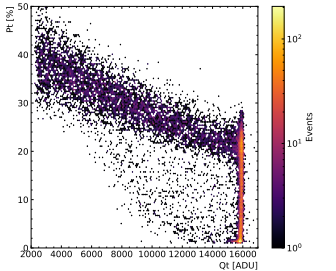


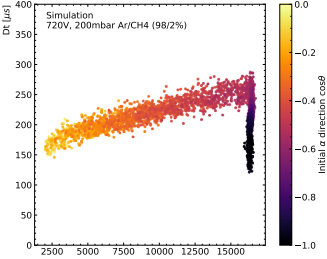
Results (i)

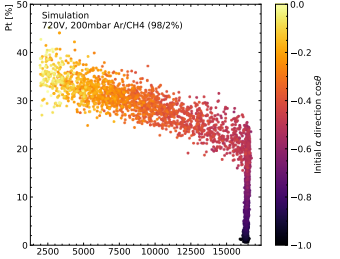
- Measured data are compared with simulation results using ▸ JINST 15 (2020) 06, C06013
- Good agreement
- Pulse properties can be used to select specific events











Results (ii)

Resolution measurement

- The energy resolution is measured to be $\approx$ 1.1% FWHM at 5.3 MeV
- Scaling to the $Q_{\beta\beta}$ of 136Xe gives a resolution of 1.6%
- Tested at two different pressures (track lengths varying from a few to 20 cm). Results independent of track length.
- Promising first results!

Coming soon

- A new detector certified to operate at 40 bar is on the way
- Will be operated with Xenon to confirm energy resolution at high pressure
- Stay tuned for new results!