

# The LEGEND Experiment

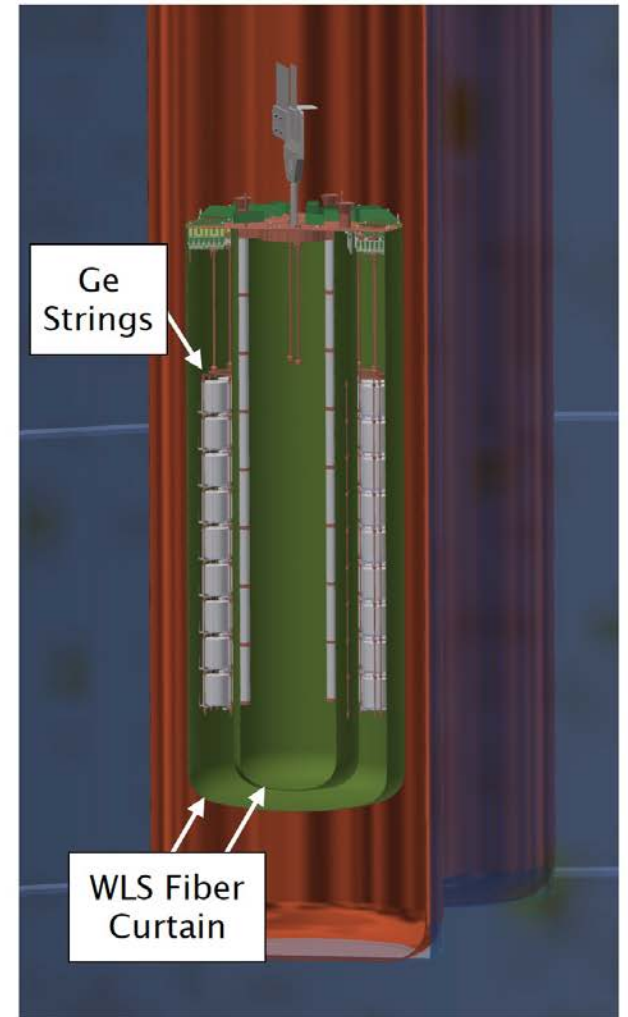
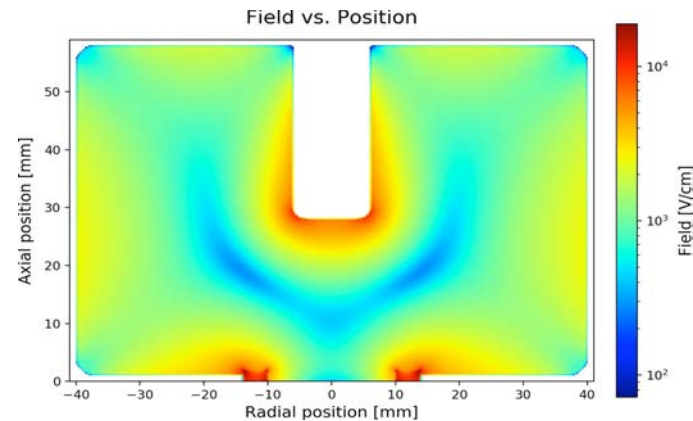
Particle Physics Annual Meeting April 2021



University of Liverpool, University College London, Lancaster  
University, University of Warwick

# Overview of the presentation

- Introduction to LEGEND and scientific motivation
- Status of the LEGEND experiment
- The UK contribution to LEGEND
- The UK funding situation and future plans

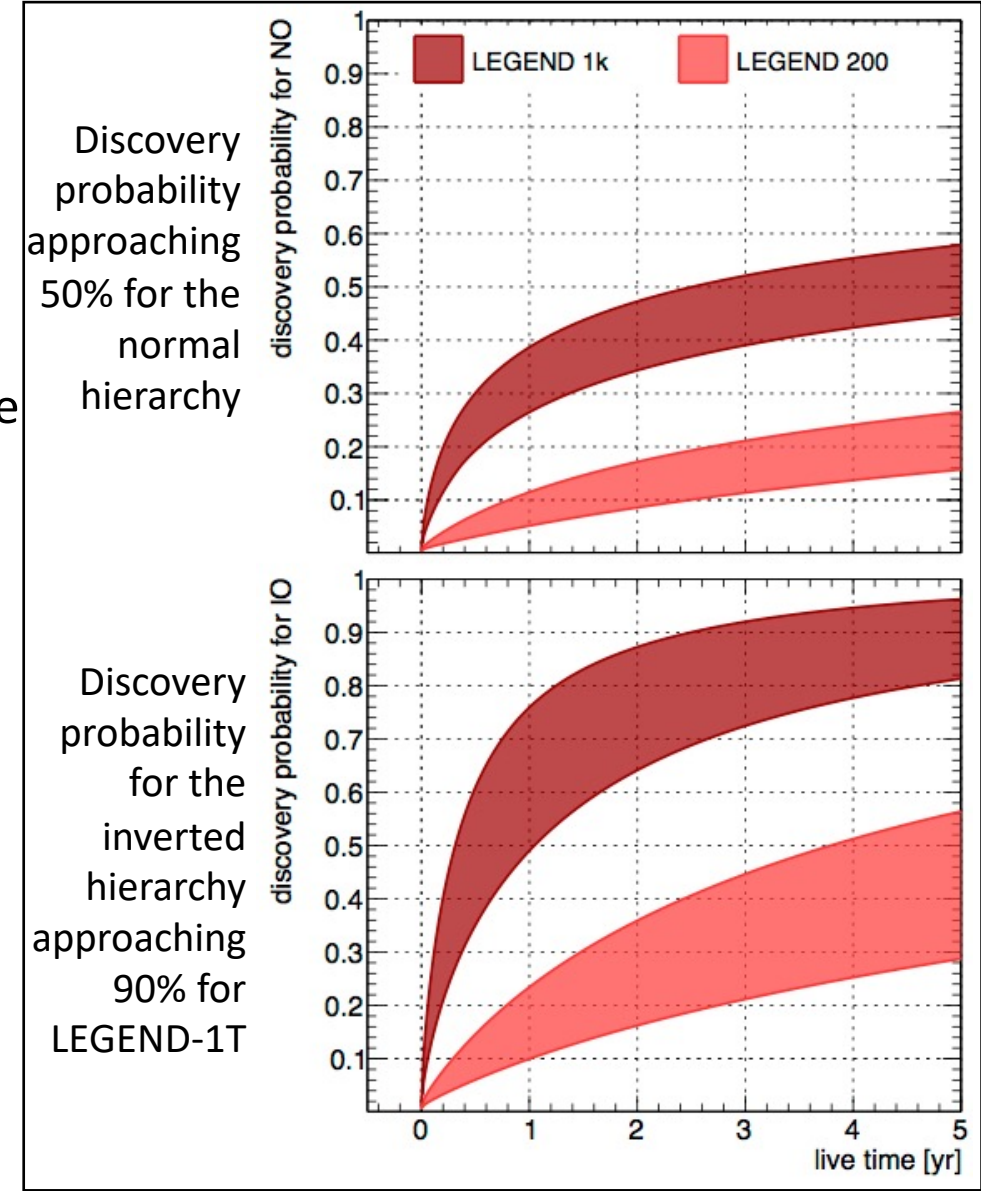
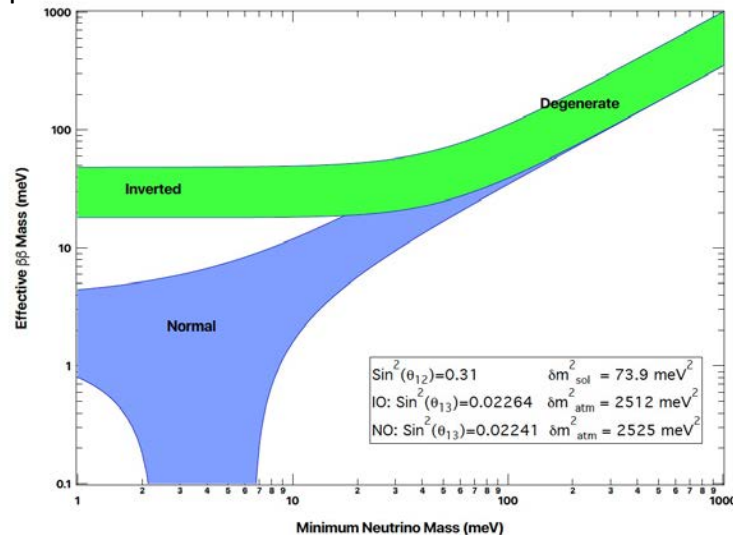


# Introduction to LEGEND

- The LEGEND collaboration proposes a  $0\nu\beta\beta$  decay search experiment, using a 1 tonne of  $^{76}\text{Ge}$  enriched detectors
- The programme follows a staged approach:
  - **LEGEND-200**: a 200 kg mass experiment, installed in the GERDA LAr cryostat at LNGS, Gran Sasso
  - It is an approved experiment at LNGS, with first commissioning foreseen to start by the end of 2021
  - **LEGEND-1000**: a 1T experiment will require a new underground infrastructure and additional R&D to further reduce backgrounds
  - LEGEND-1000 to start running later this decade

# Scientific Motivation

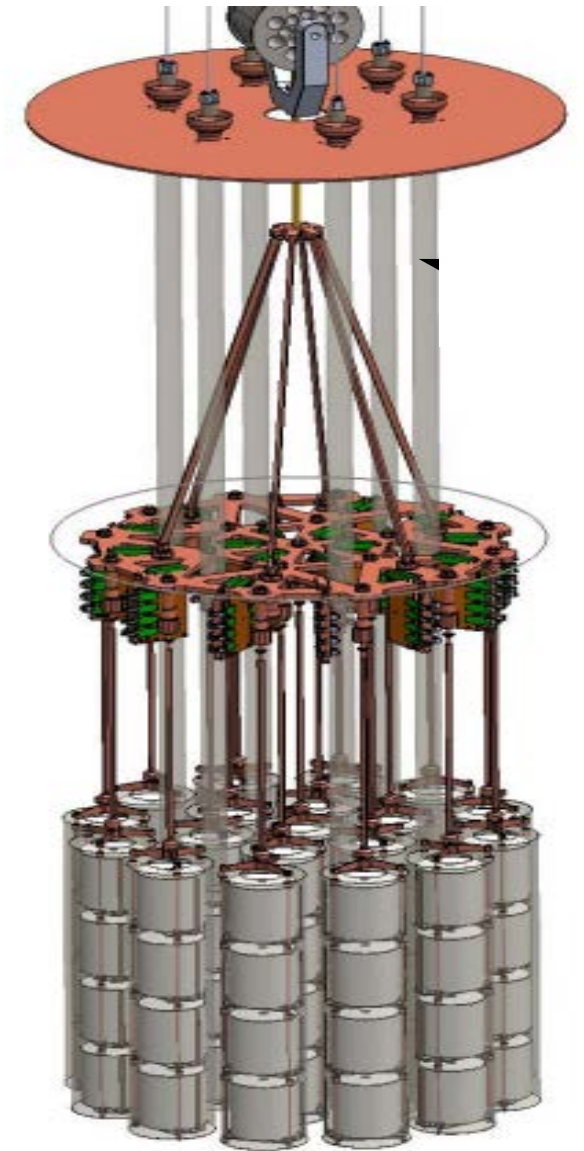
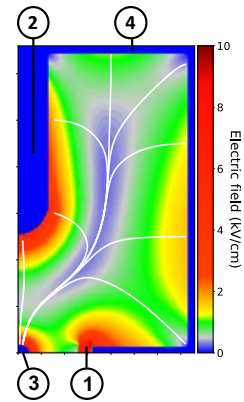
- Addresses the fundamental nature of the neutrino by pursuing a next-generation **neutrinoless double-beta decay** experiment with **high discovery potential**.
- The target for the next generation of experiments is a discovery potential for effective neutrino masses ( $m_{\beta\beta}$ ) above **18 meV**
- LEGEND 200 will have a  $3\sigma$  discovery potential for the  $0\nu\beta\beta$  half-life of  $10^{27}$  yr corresponding to  $m_{\beta\beta} \sim 28\text{-}57$  meV by 2026
- LEGEND-1000 will have a  $3\sigma$  discovery potential of  $\sim 10^{28}$  yr, corresponding to  $m_{\beta\beta} \approx 9\text{-}18$  meV in 10 years of running.



# LEGEND 200 Overview

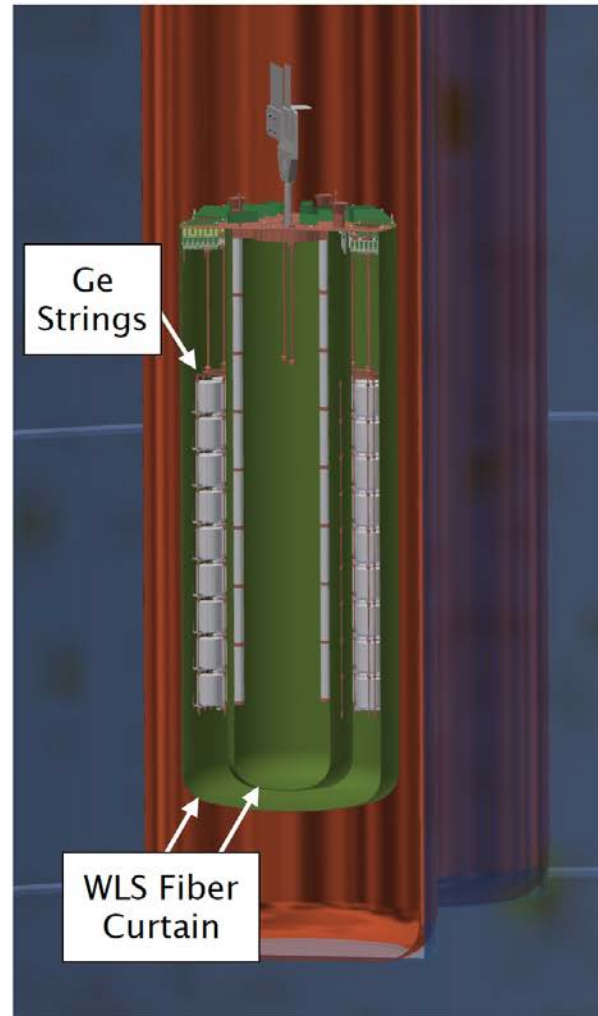
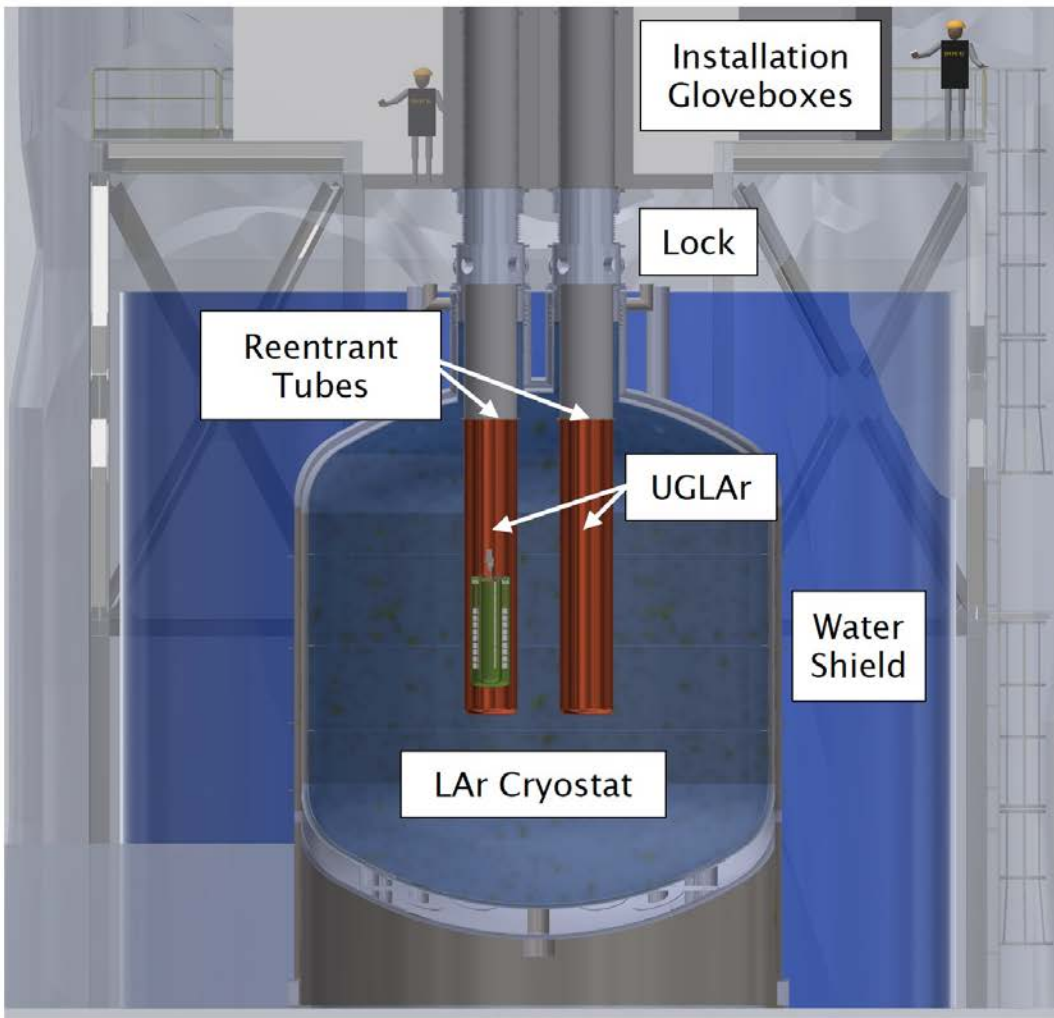
- A merger of the GERDA and MJD demonstrators @LNGS
- Re-use GERDA LAr cryostat: optimise geometry
- Low-background MJD front-end electronics, further from detectors
- Refinements to:
  - Veto system
  - Calibration systems
  - DAQ
- Trial PEN
- Installation in progress

New detectors for LEGEND:  
P-type Inverted-Coaxial Point Contact  
Larger mass : > 2 kg/detector

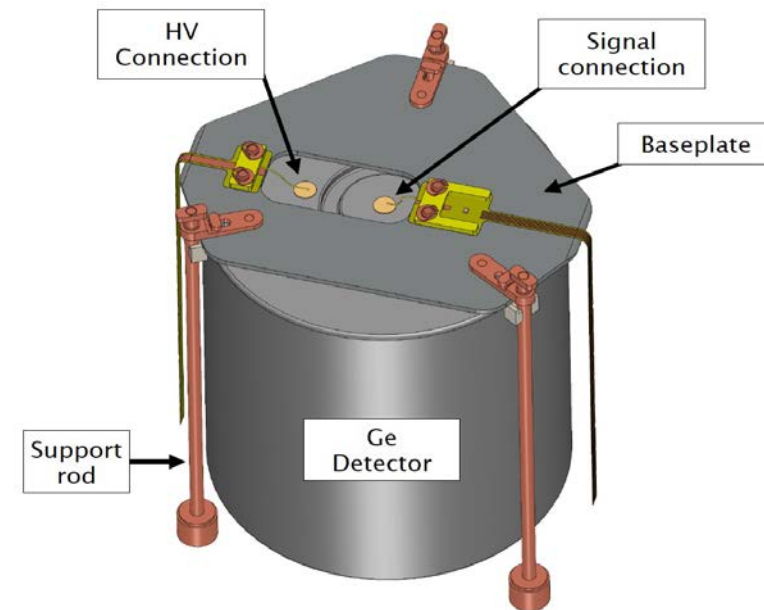




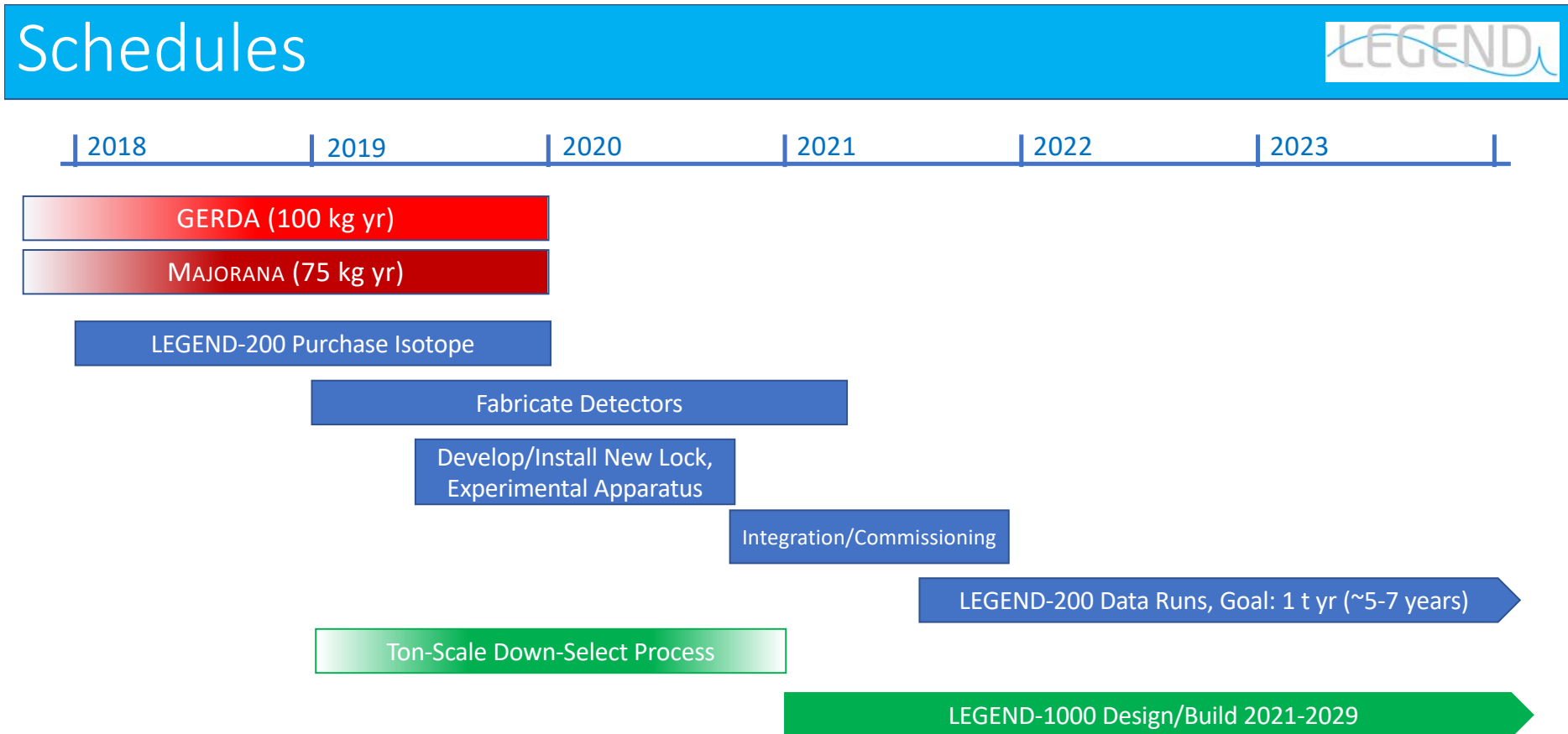
# LEGEND 1000 Overview



Site possibilities  
LNGS, SNOLab,  
SURF



# Status of the LEGEND-200 experiment

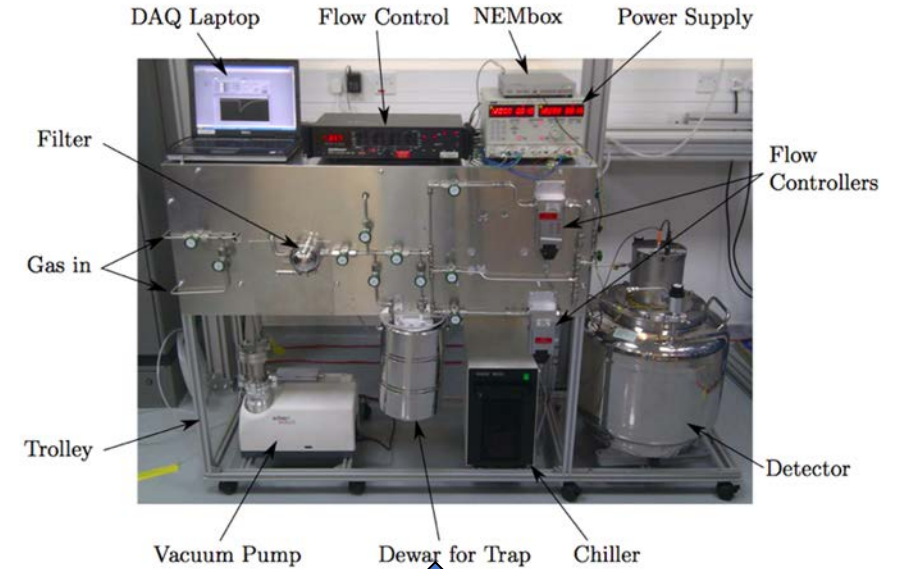


Original plan -> COVID-19 delays add 1 year

Earliest LEGEND-1000 Data Start 2025/6

# LEGEND the UK contribution

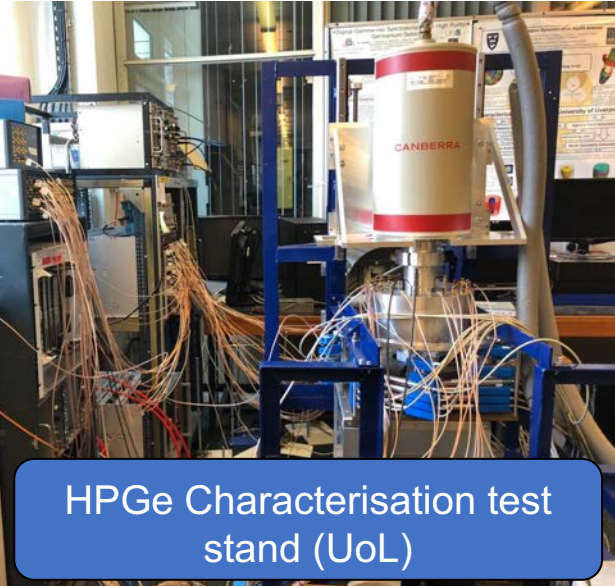
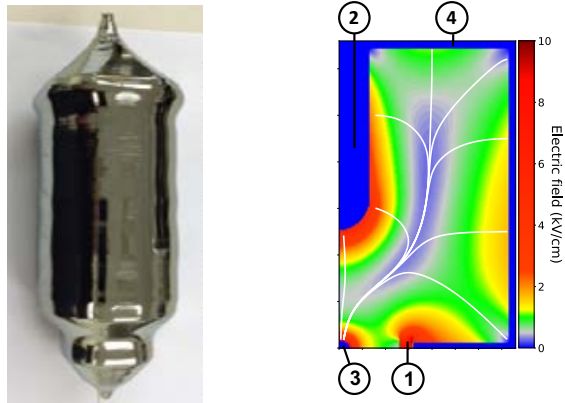
- Funded through an STFC PPRP Opportunities project (Q1 2020 – Q4 2021):
  - WP1 HPGe Characterisation and Technology Development
  - WP2 Simulation Studies for Tonne-Scale  $0\nu\beta\beta$  Experiments
  - WP3 Radio-purity Assay Campaign for LEGEND
  - WP4 Novel Scintillating Material Development for LEGEND
- LEGEND-design HPGe detectors have a broad range of applications (environmental monitoring,  $^{210}\text{Pb}$  dating, nuclear decommissioning)  
Working in collaboration with Mirion Technologies



Radon Concentration Line & ICP-MS facility (UCL)



Proposed new detectors for LEGEND:  
P-type Inverted-Coaxial Point Contact  
Larger mass : > 2 kg/detector

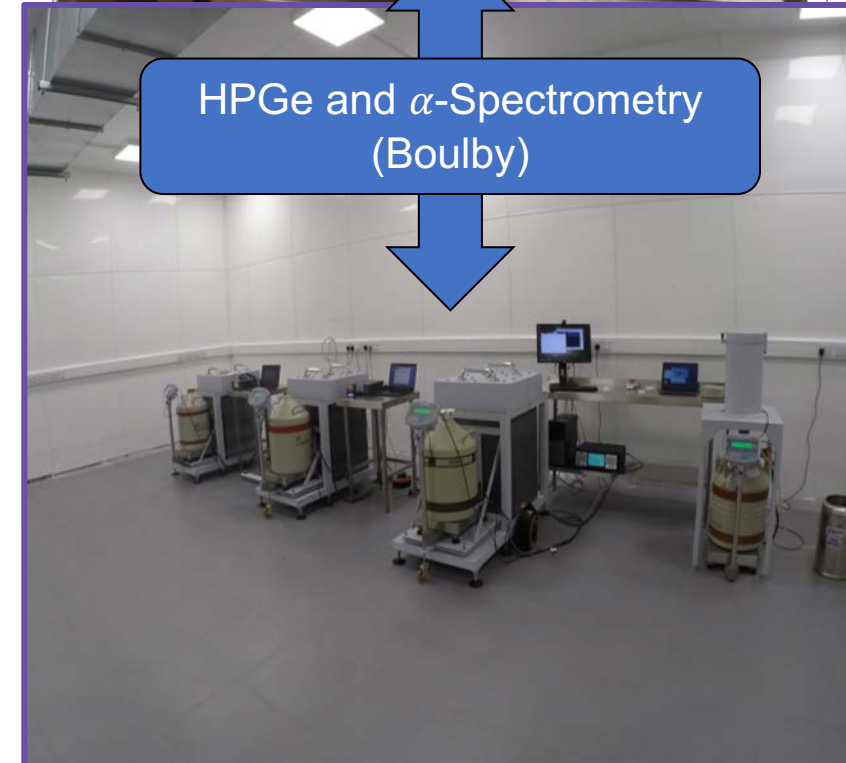
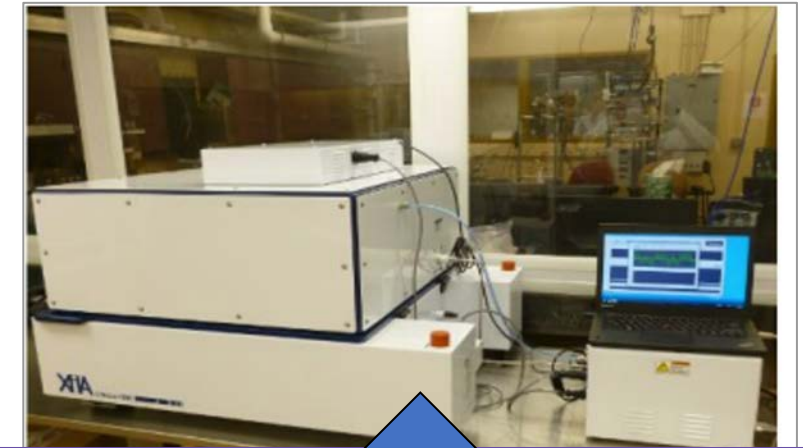
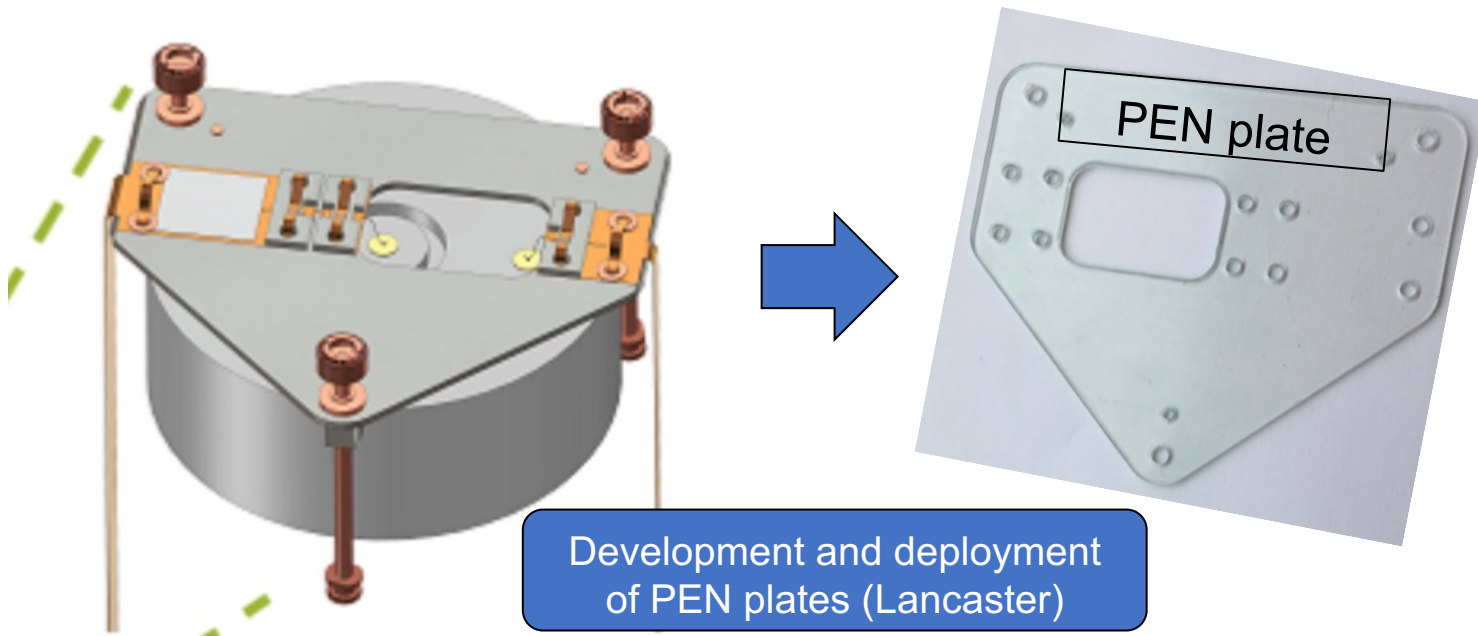


HPGe Characterisation test stand (UoL)



# LEGEND the UK contribution

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# LEGEND UK Leadership and Liverpool contribution

- LEGEND Collaboration formed in 2016
  - A. Boston co-detector coordinator 2017-2018, UK PI
  - D. Waters/R. Saakyan IB chair
  - M. Agostini analysis coordinator (current)
  - D. Muenstermann PEN-Veto coordinator (current)
- Liverpool
  - Germanium detector characterisation
  - Detector calibration/data quality enhancement
  - Data taking in LEGEND-200
  - Detector procurement and characterisation for LEGEND-1000

# The LEGEND STFC Experiment Submission

- First submission
- UK M&O tasks to support LEGEND-200
  - Software maintenance and development (M01)
  - Data monitoring and data quality (M02)
  - Detector calibrations (M03)
  - Data-taking shifts (M04)
- M&O common fund
- Liverpool request for Boston, Rose, 50% RA
- Liverpool support from Judson (no financial request)

# LEGEND International Context

- LEGEND 1000 pre-CDR fully drafted by the collaboration
- US portfolio review process
  - Select projects include nEXO ( $^{136}\text{Xe}$ ), CUPID ( $^{100}\text{Mo} \rightarrow \text{Li}_2\text{MoO}_4$ ), LEGEND 1k
  - Documents by 1 June 2021
  - Review 13 – 16 July 2021
- APPEC North American / European summit on double beta decay
  - 29th September – 1st October
- Candidate sites LNGS, SNOLab, SURF

# LEGEND UK future plans

- UK collaboration meeting summer 2021
- SOI for LEGEND 1000 construction 2021
- Request to PPRP 2022
- Ideal project start date in 2023
- For the future project Liverpool will:
  - Design and deliver a detector characterisation stand
  - Characterise inverted coaxial germanium detectors
  - Optimise the analysis algorithms and analyse the characterization data