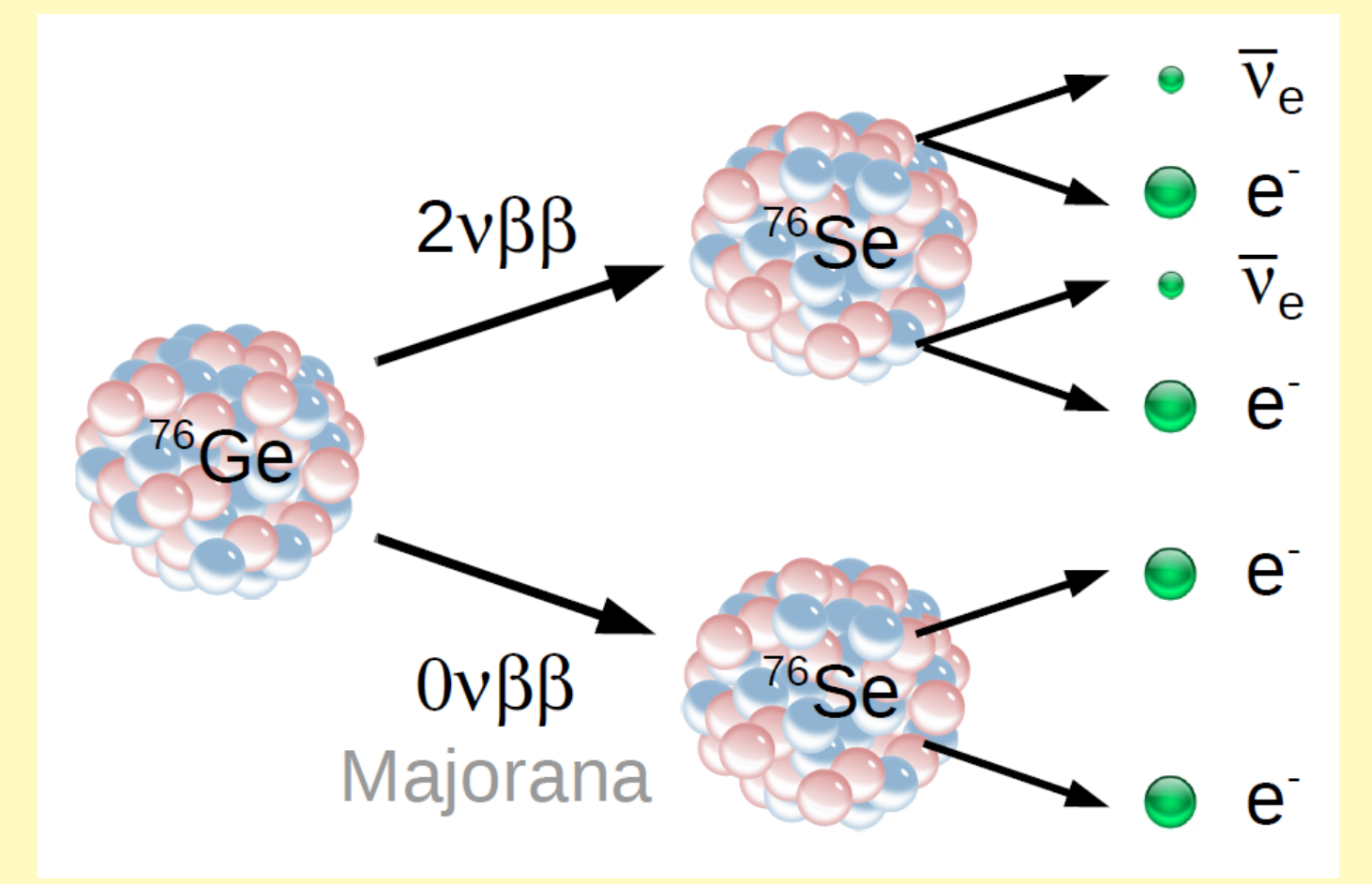
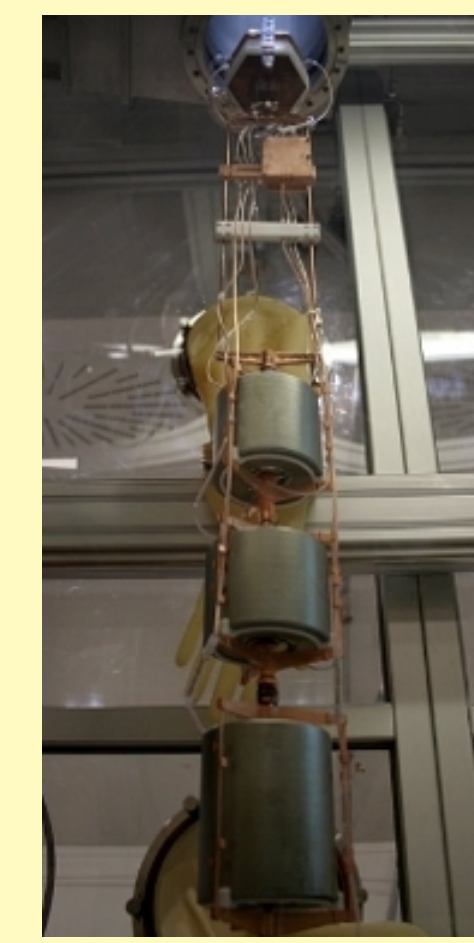
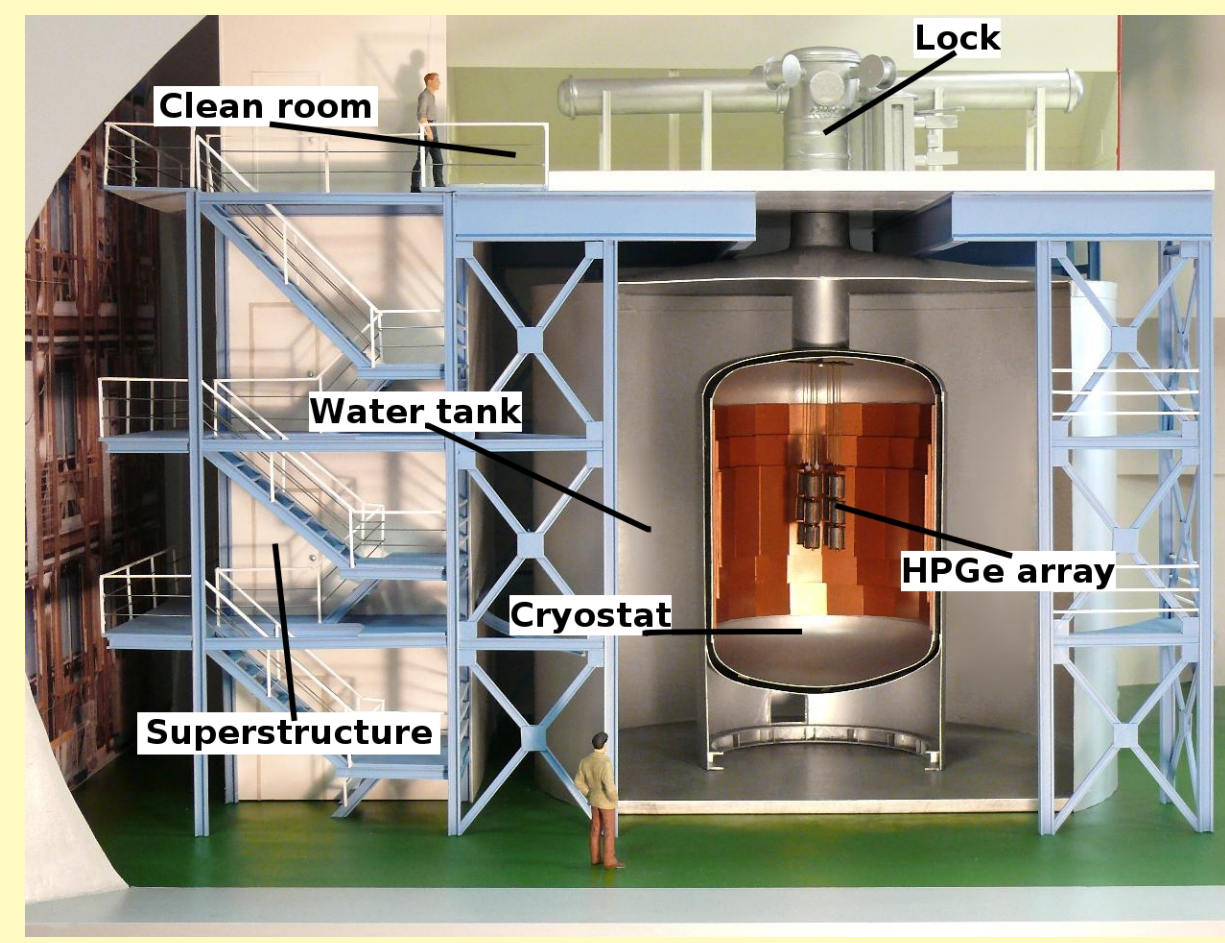
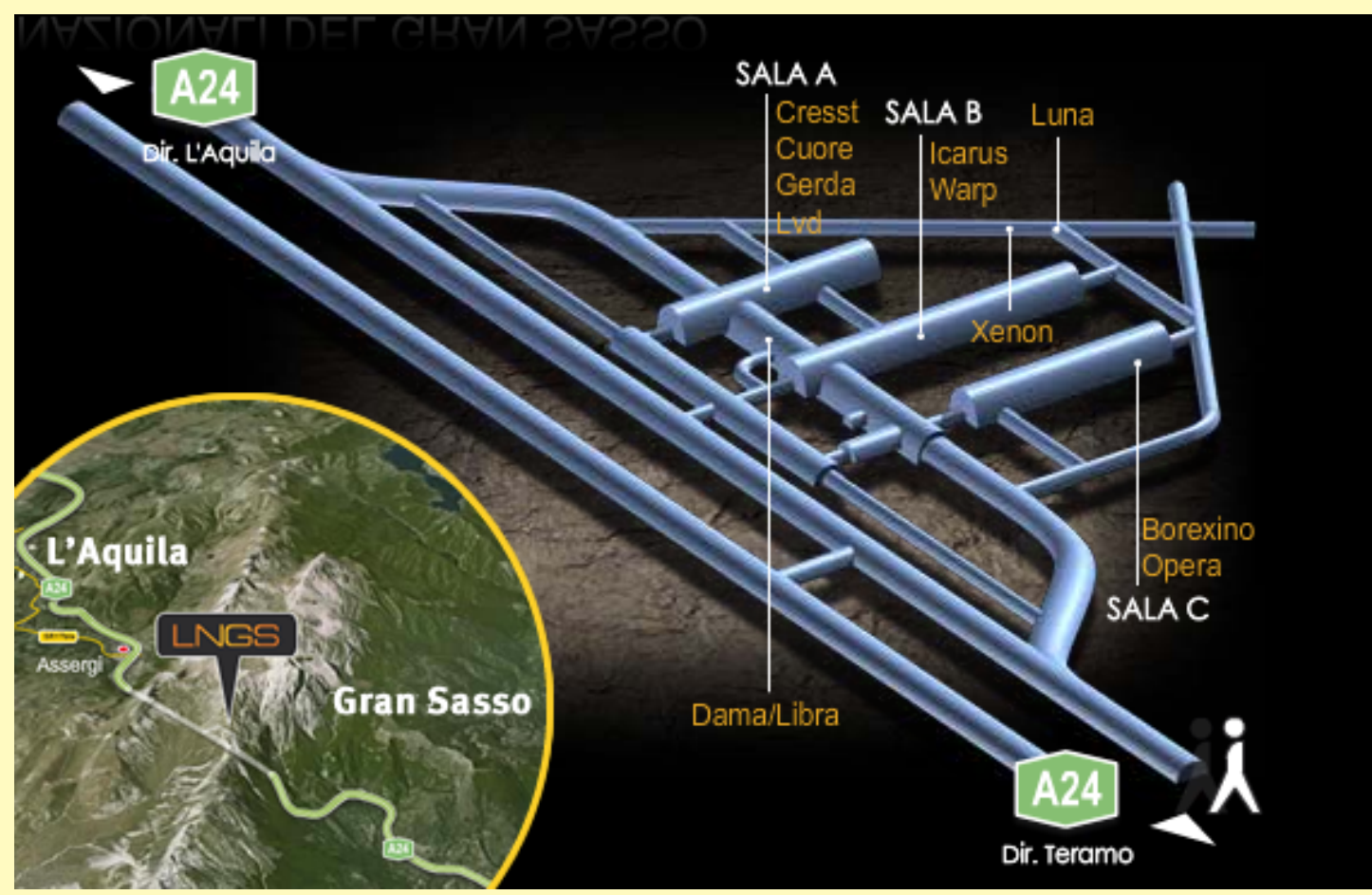


Introduction



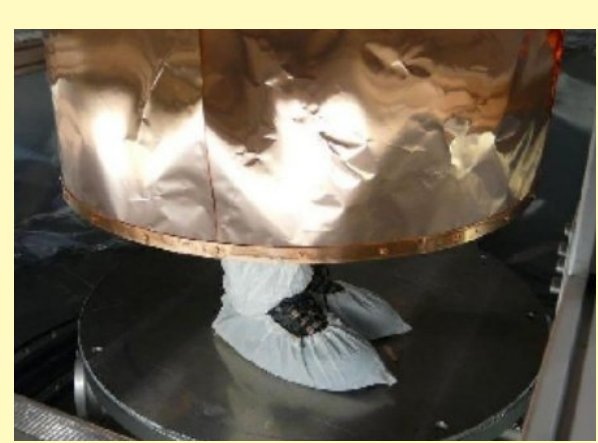
The Laboratori Nazionali del Gran Sasso (LNGS), in a highway tunnels close to L'Aquila in the Abruzzo mountains, have an overburden of about 3800 m w.e.

The GERDA setup with its main components and the 3-detector string used during the commissioning phase

Double beta decay in ^{76}Ge with two neutrinos (top) and without neutrinos (bottom)

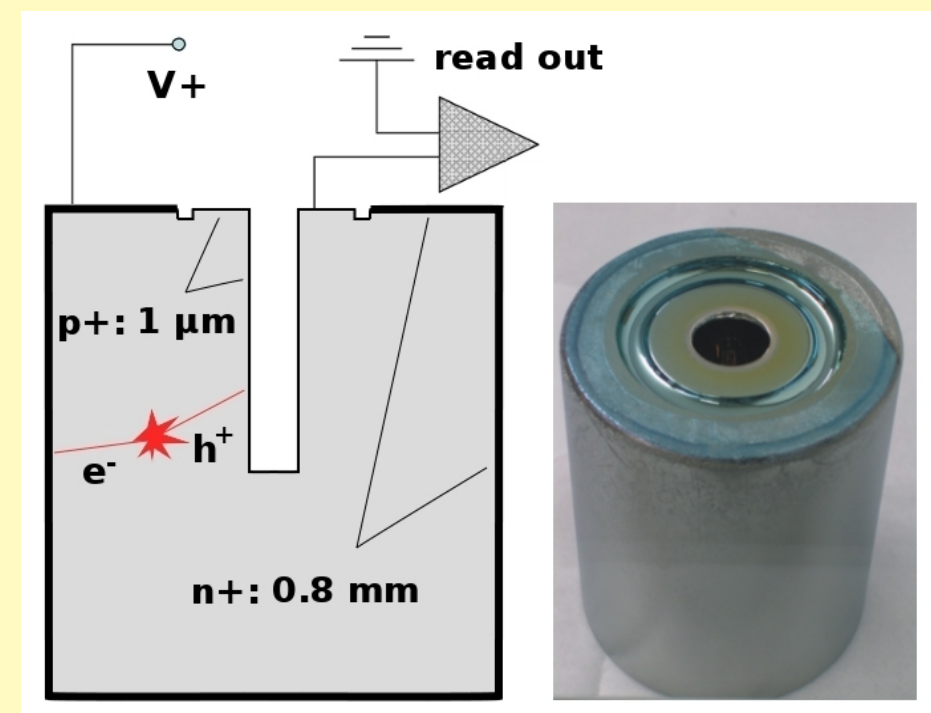
GERmanium Detector Array

The GERDA experiment is constructed in an onion-layered geometry to reduce outside background contributions; the outside layer is a 650 m^3 **water tank** (bottom left) which serves as shielding and a μ -veto. The inner layer is a **cryostat** with 90 t of liquid argon (LAR) for further shielding as well as detector cooling. The operation of naked Ge detectors inside the LAR is one of the GERDA novelties. A class 10,000 **clean room** with a gas controlled glove box (bottom right) and **the lock** prevents the entrance of impurities.



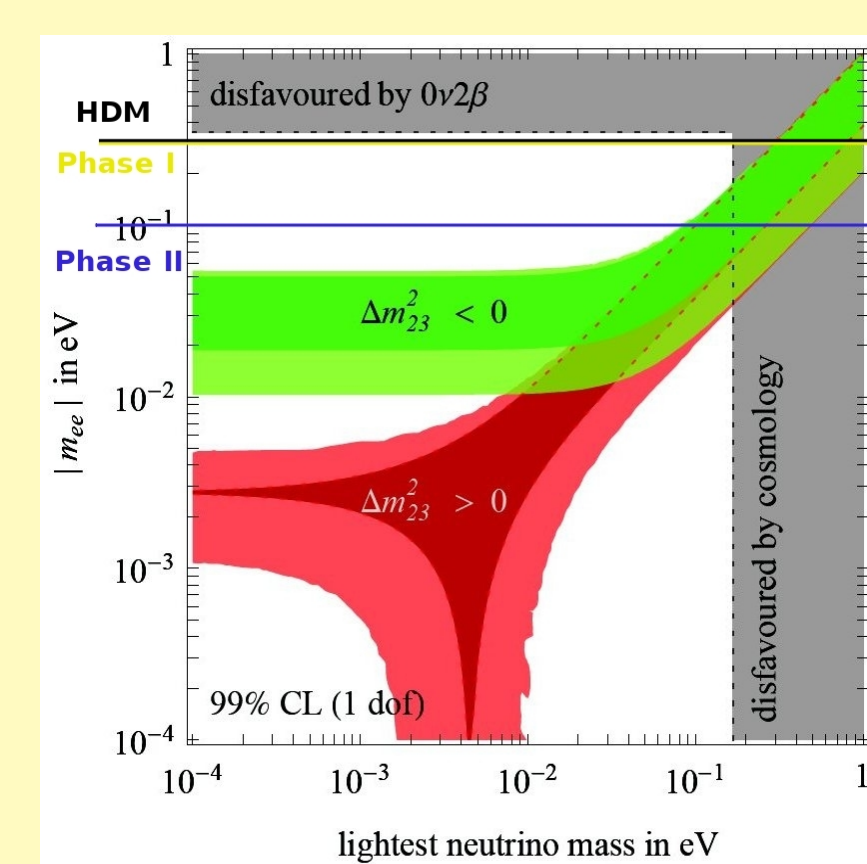
Inside the cryostat is a $R = 76\text{ cm}$ cylindrical copper foil around the detectors - the **Rn-shroud**. It prevents convection of LAR, contaminated by Rn from the wall, to reach the detector array.

The **detector array** consists of enriched (86% ^{76}Ge) detectors refurbished from HDM and IGEX for **Phase I** and newly built enriched BEGe detectors for **Phase II**. In the **commissioning phase** three non-enriched (7.6% ^{76}Ge) detectors from the GENIUS test facility were used. A HPGe detector schematic is shown on the left.



Neutrinoless Double Beta Decay

Neutrino properties are manifold and include three mass eigenstates, three mixing angles, one CP-violating phase and, if they are Majorana particles, two Majorana phases.



$0\nu\beta\beta$ experiments are the only experimental approach to determine the possible Majorana nature of neutrinos which will be accomplished by discovering the decay. Subsequently, one can determine the effective Majorana neutrino mass

$$|m_{ee}| = \left| \sum_i m_i U_{ei}^2 \right|,$$

and possibly identify the mass hierarchy structure.

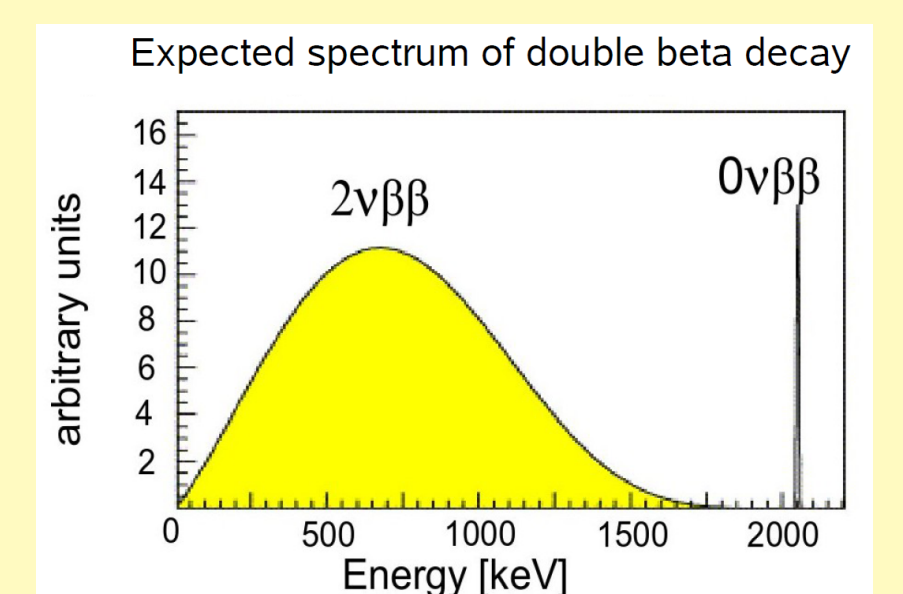
There is a pending claim with $T_{1/2} = 1.2 \cdot 10^{25}\text{ yr}$ or $|m_{ee}| = 300\text{-}530\text{ meV}$ by a subset of the **HDM collaboration**. **Phase I** of GERDA aims at testing this claim within one year of data taking and **Phase II** aims at probing down to 90 meV.

The experimental signature are the two final state e^- that carry the total decay energy. For ^{76}Ge the monoenergetic peak is at 2039 keV.

With the detected events in the signal peak one can determine the half-life of the $0\nu\beta\beta$ ^{76}Ge decay. This half-life is connected to $|m_{ee}|$ by

$$\left[T_{1/2}^{0\nu} \right]^{-1} = F^{0\nu} \cdot |\mathcal{M}^{0\nu}|^2 \cdot |m_{ee}|^2,$$

where $F^{0\nu}$ is the phase space factor and $\mathcal{M}^{0\nu}$ the nuclear matrix element. The determination of $\mathcal{M}^{0\nu}$ is model dependent and one of the major theoretical challenges today.

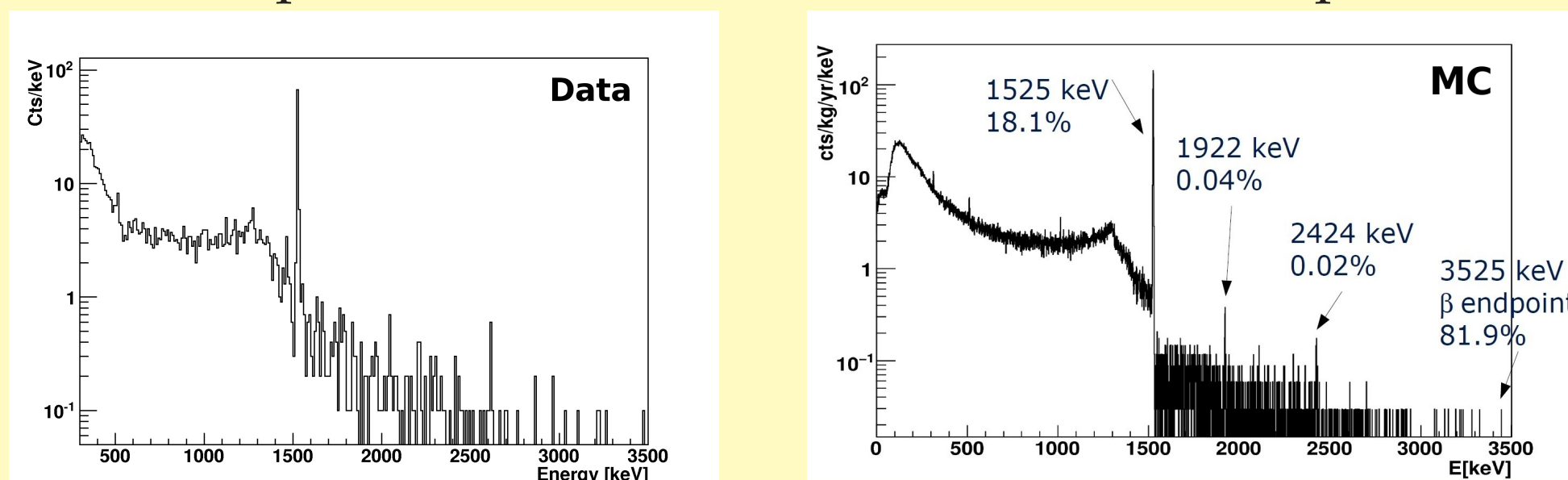


Commissioning Runs from July 2010 - April 2011

Run 1: Discovery of prominent ^{42}K 1525 keV γ -line in the background spectrum and ^{42}Ar investigation:

Decay chain: $^{42}\text{Ar}(32.9\text{ yr}) \rightarrow ^{42}\text{K}(12.36\text{ h}) \rightarrow ^{42}\text{Ca}$

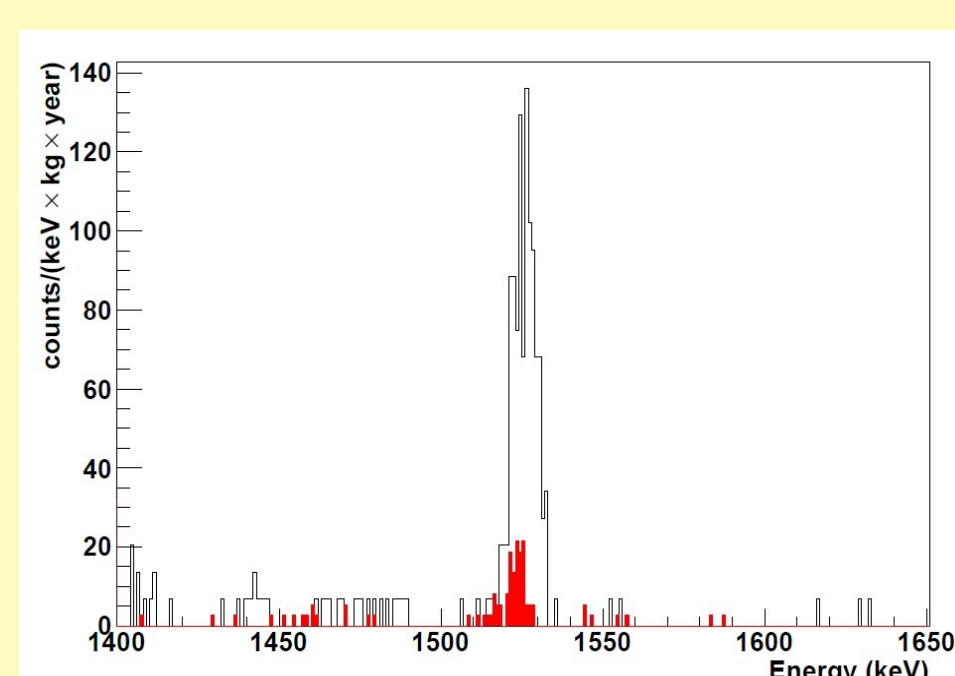
Measured spectrum of first 91.7 d (left), ^{42}K MC spectrum (right)



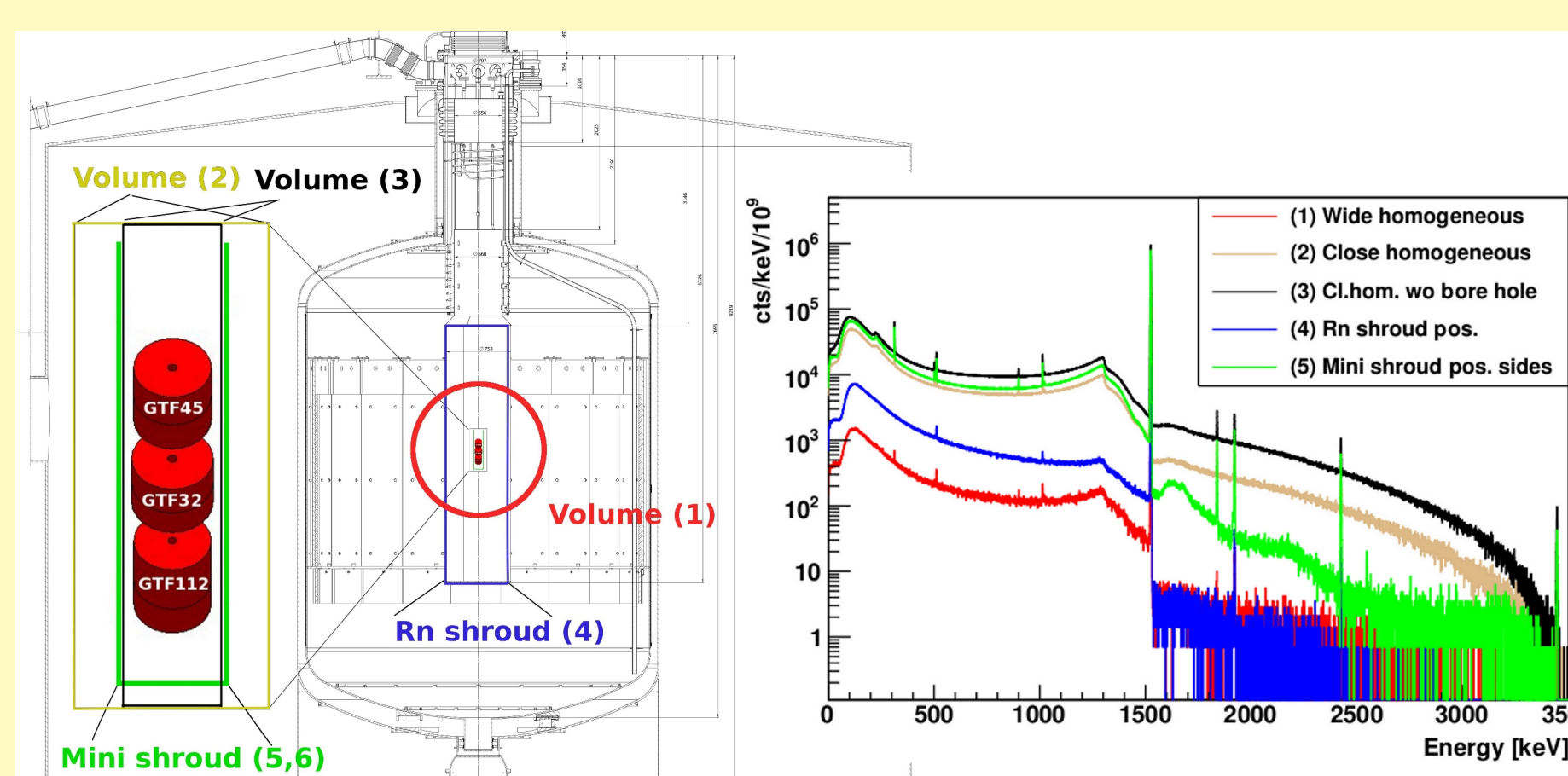
Run 2-3: Assumption: charge collection of ^{42}K ; negative HV on Rn-shroud to pull charged $^{42}\text{K}^+$ ions from the detector array

Run 4: Installation of the **mini shroud** (left) to restrict $^{42}\text{K}^+$ movement and for additional repelling potential: negative HV on Rn-shroud and positive HV on mini shroud

Run 5: Reversing E-field to collect $^{42}\text{K}^+$ close to the detectors (black) and verify assumption of charge collection compared to run 4 (red)



Run 6-7: Additional E-field variations for charge collection studies accompanied with MC simulations (below)

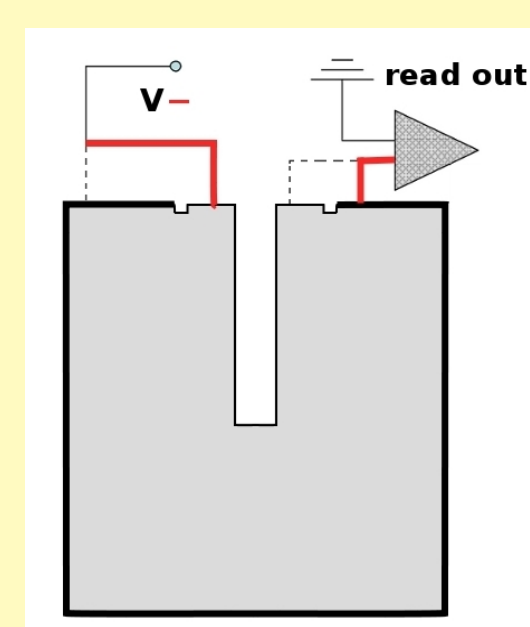


Run 8-9: Encapsulation of top detector to prevent β -penetration; exchange of bottom detector with BEGe

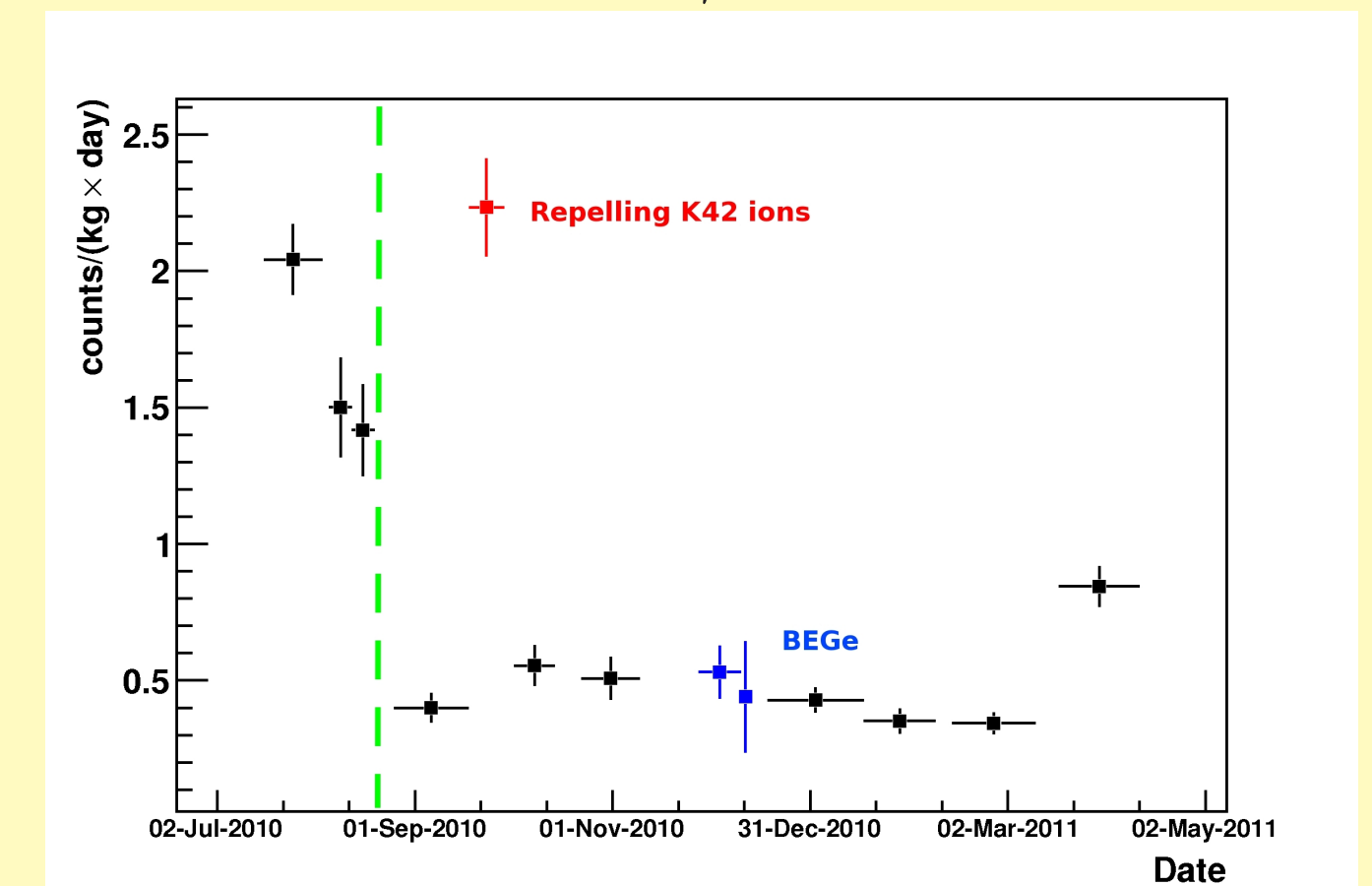
Run 10-11: Back to standard string but top and bottom detector encapsulated with different materials

Run 12: All detectors without encapsulation; reversing bias: HV contact inside to achieve "field-free" configuration without ^{42}K attraction

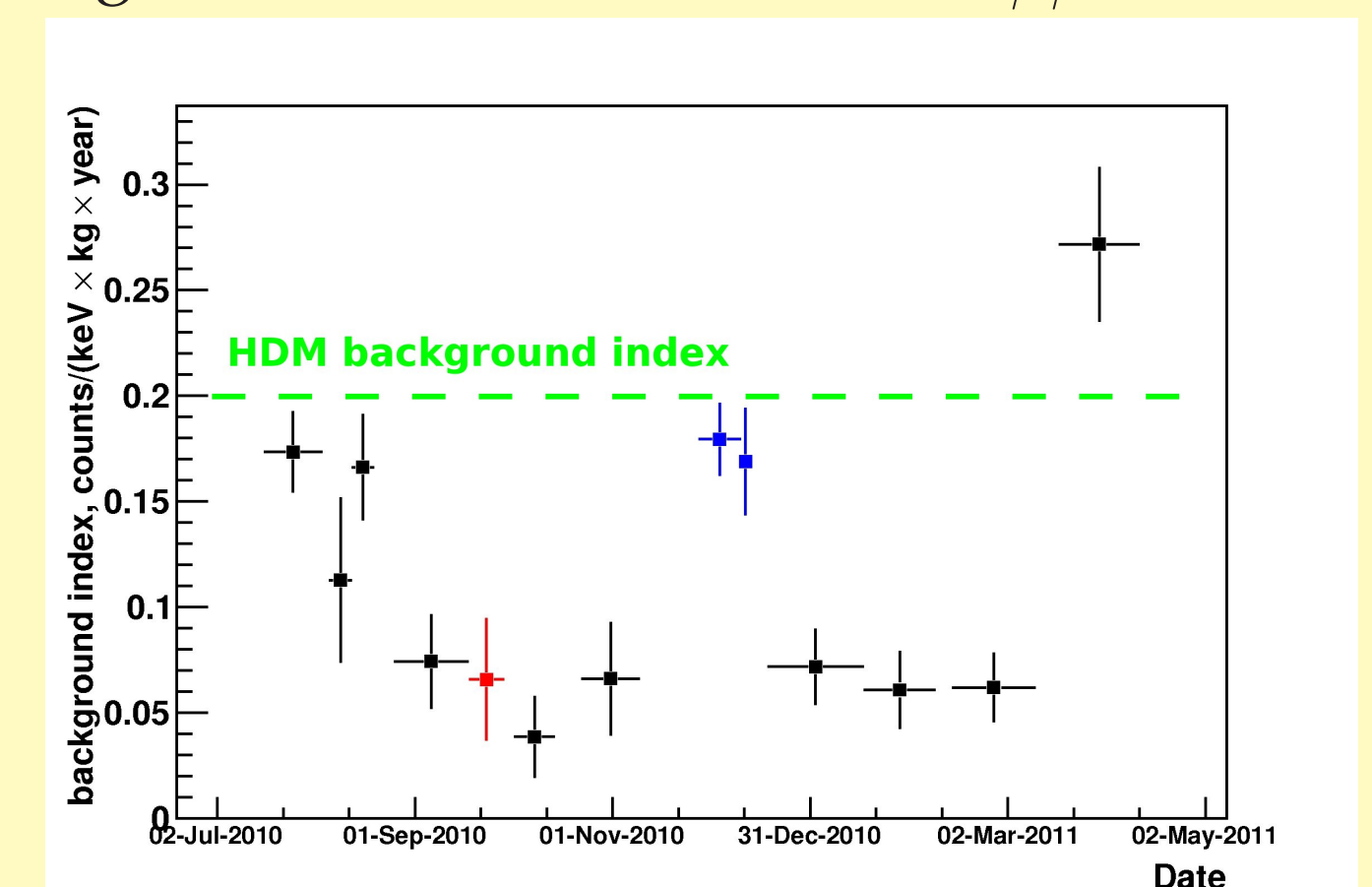
Run 13: Same as run 12 but without mini shroud



Count rate in 1525 keV γ -line of ^{42}K for all runs



Background index $\pm 200\text{ keV}$ of $Q_{\beta\beta}$ for all runs



Conclusion:

- ^{42}K charge collection confirmed
- Different approaches countering ^{42}K still under investigation (mini shroud, encapsulation, reversed bias)
- Background index larger than expected but below HDM (improvements are expected with enriched detectors which are currently deployed)