TECHNISCHE UNIVERSITÄT DRESDEN

INSTITUT FÜR KERN- UND TEILCHENPHYSIK

LEGEND

Investigation of neutron-induced γ rays from Ge-nuclides in the region of interest of LEGEND

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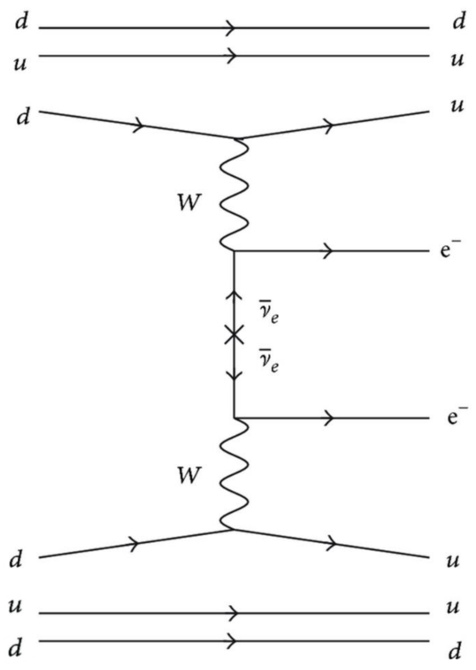
Neutrinoless double beta decay ($0\nu\beta\beta$)

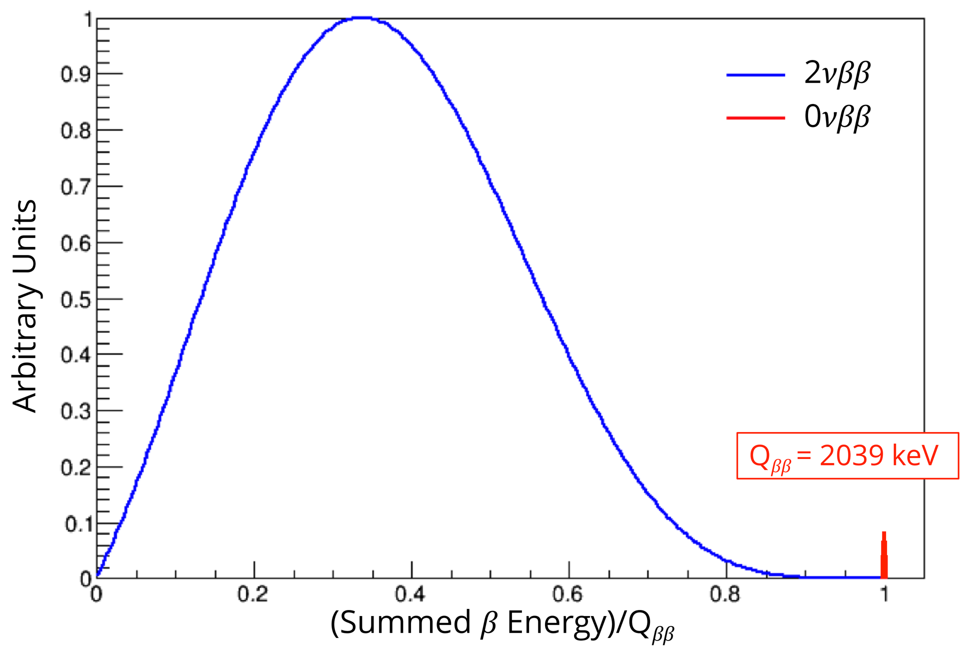
The discovery of this extremely rare process would verify the theory of **neutrinos being Majorana particles.** This process further violates the lepton number by 2 which gives rise to explanations regarding the matter-antimatter asymmetry in the universe by leptogenesis [1].



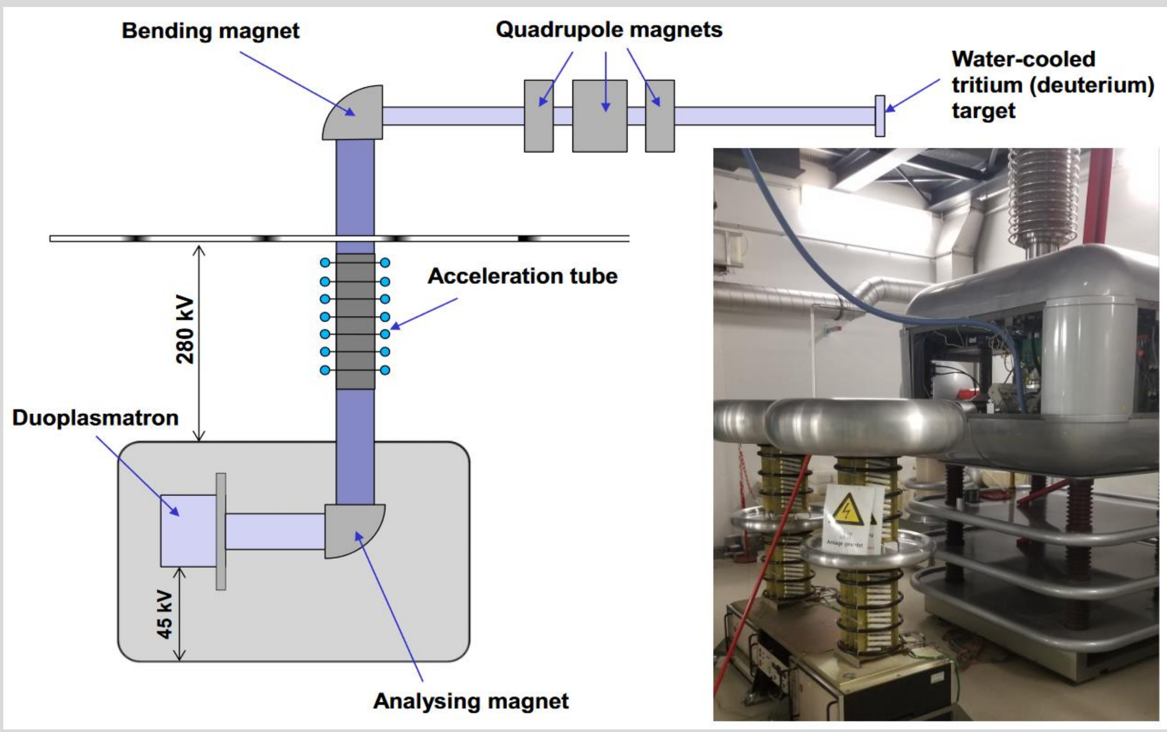
LEGEND

LEGEND – **the Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay** – is one of the most promising experiments in the search for the still undetected $0\nu\beta\beta$ decay of ^{76}Ge. The signal corresponds to a single peak at the energy of the $Q_{\beta\beta}$ value (**2039 keV**).

The setup consists of bare germanium detectors enriched in ^{76}Ge, which are operated in liquid argon. Everything is further surrounded by a water Cherenkov veto.



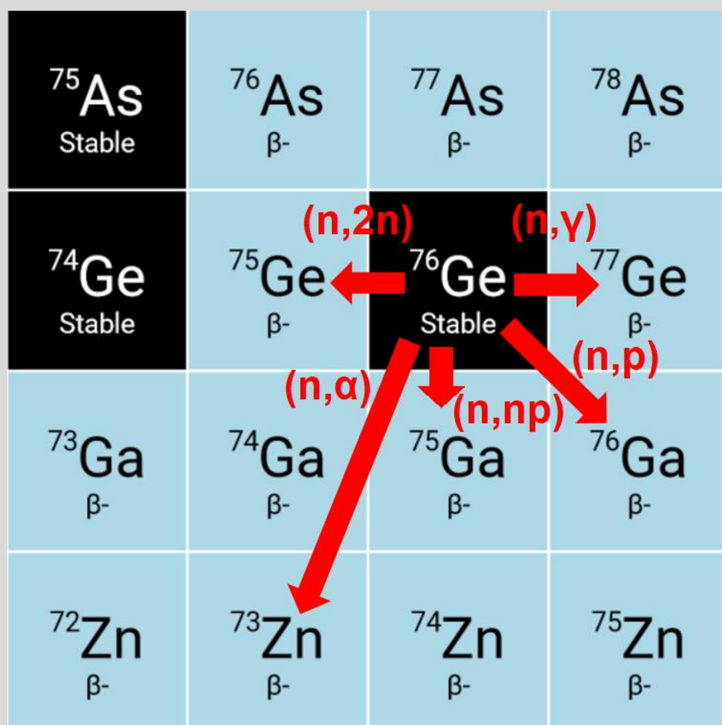
Muon-induced neutrons can enter the setup unnoticed and could lead to background events in the spectrum near 2039 keV [2].



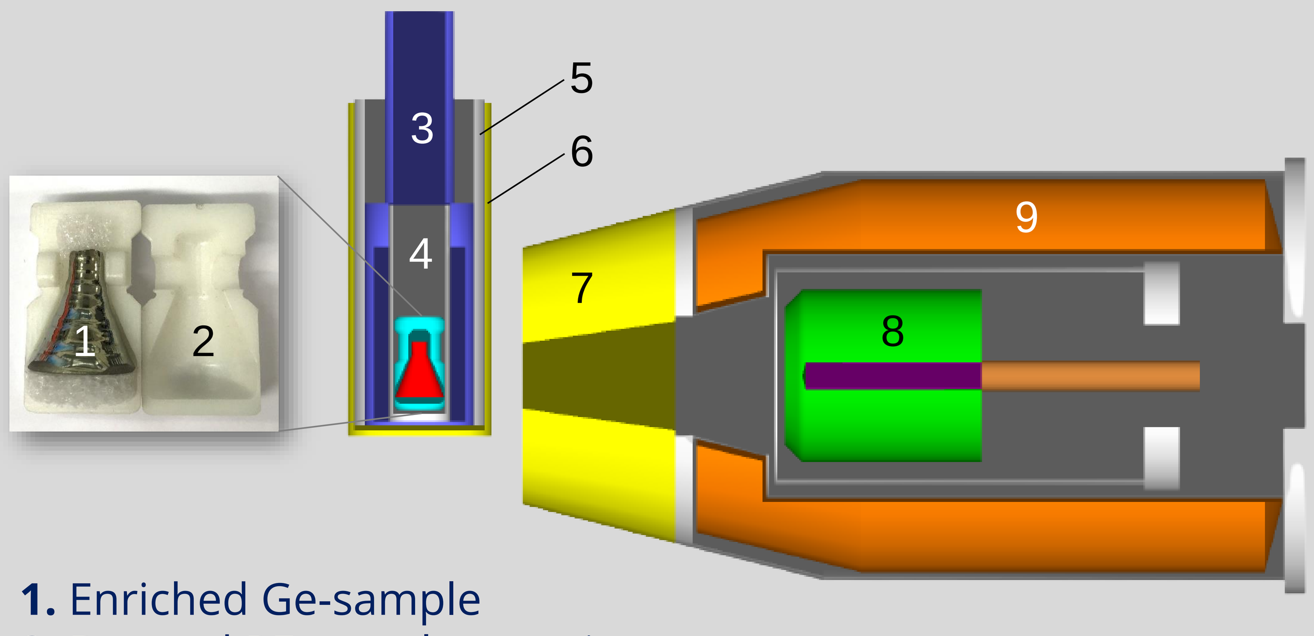
DT generator

An enriched ^{76}Ge sample is irradiated by **monoenergetic neutrons** of 14.1 MeV, provided by one of the strongest deuterium tritium (DT) generators in the world with a flux up to 10^{12} neutrons per second [3].

The reaction of interest is **^{76}Ge(n,p)^{76}Ga**, which leads to radioactive ^{76}Ga-nuclei with a relatively short half-life of only $T_{1/2}$ = 32.6 s. The Ge-sample also contains ^{74}Ge, which is activated as well via **^{74}Ge(n,p)^{74}Ga** reactions to ^{74}Ga with a half-life of $T_{1/2}$ = 8.12 min.



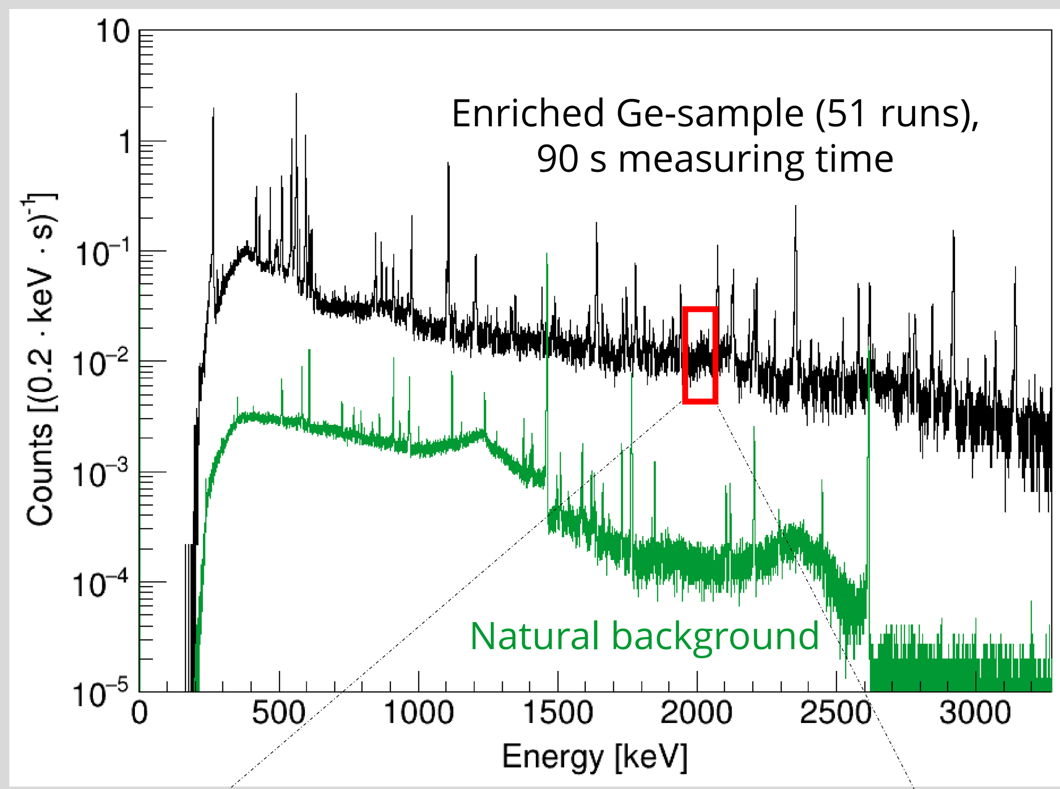
The sample is transported within a **pneumatic tube system**



1. Enriched Ge-sample
2. Borated PE sample container
3. + 4. End piece of the pneumatic tube system
5. Aluminium shielding (5 mm)
6. Lead shielding (3 mm)
7. Lead collimator
8. HPGe detector
9. BGO detector

Detection setup

The radiation emitted by the sample is recorded with a **HPGe detector** with 110% rel. efficiency, which is surrounded by a **bismuth germanate (BGO) detector**. The BGO acts as an active Compton suppression shield.
Furthermore, the **shielding is optimized** with the help of Geant4 simulations of the detection setup. In order to reduce bremsstrahlung in the γ-ray spectrum, electrons emitted during the β^- decays are stopped by a 5 mm thick aluminum cylinder. Since the two most intensive γ lines in the spectrum are low energetic, a second shielding layer consisting of a 3 mm lead foil is further arranged around the sample. This efficiently shields against low energetic photons while γ rays of more than 2 MeV remain nearly unaffected.

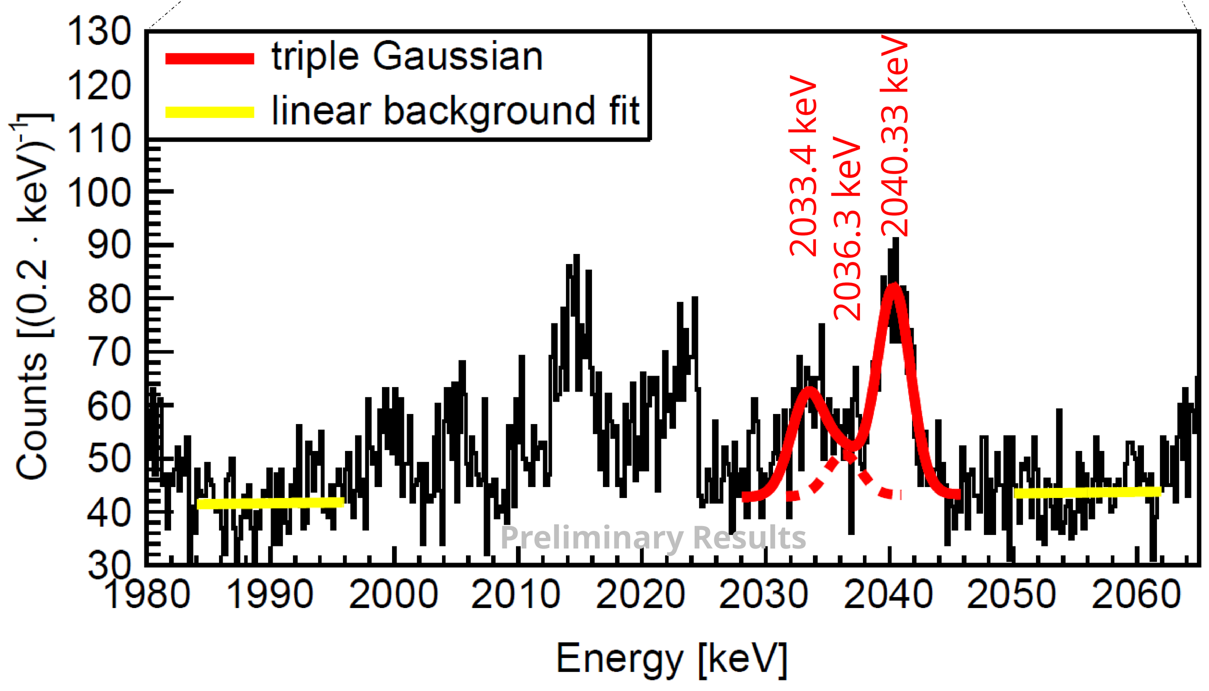


Analysis of the ROI

With this experimental procedure 51 irradiation cycles are performed using the enriched Ge-sample. The summed-up spectrum shows three peaks near the region of interest (ROI) of LEGEND:

- (**2033.4** ± 0.3) keV from ^{76}Ga
- (**2036.3** ± 0.4) keV from ^{74}Ga [4][5][6]
- (**2040.33** ± 0.12) keV from ^{76}Ga [7]

Half a century after its first observation the existence of the 2040 keV γ-line could be confirmed and even a new γ line at 2033 keV was observed during the decay of ^{76}Ga. **This means that germanium itself can potentially contribute to the background in all ^{76}Ge $0\nu\beta\beta$ decay experiments such as LEGEND.**



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References
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