The MAJORANA DEMONSTRATOR

The MAJORANA DEMONSTRATOR is a near-surface, low-background experiment in the Sanford Underground Research Facility in Lead, SD to test the feasibility of building modular arrays of Ge detectors.

The goals of the MAJORANA DEMONSTRATOR are:
1. Demonstrate background levels low enough to justify building a tonne-scale experiment
2. Establish the feasibility of constructing & fielding modular arrays of Ge detectors
3. Search for additional physics beyond the Standard Model, such as solar axions and dark matter

String Building

Cleanliness protocols

The low-background aim of the MAJORANA DEMONSTRATOR mandates that great care be taken to avoid introducing any radiocontaminants to the detectors. Of particular concern is radon, which is gaseous and present in the lab air. To address this concern, cleanliness protocols are followed as described by Benassi et al. To mitigate cosmogenic activation in strings, detectors are kept underground in (a) a glovebox maintained as a Class 10 cleanroom and purged with liquid nitrogen boil-off. Detector unit construction

Detector construction

The collaboration received detection units from a vendor cryostat. After acceptance measurements are made, the detector is (a) dehydrated in the glovebox. The detector is then (b) mounted into a detector unit made of electroformed copper. Detector materials are chosen to be ultra-pure and minimal mass. Each detector has a unique HV connection and (c) signal read-out cable which is fed to a preamplifier outside of vacuum via a Vespel connector.

Modular Approach: Detector, String, Cryostat

Construction of the MAJORANA DEMONSTRATOR follows a modular approach, which allows for scalability and rapid deployment.

String construction and testing

Strings are built by (a) stacking detector units along three copper rods, threading HV and signal cables through copper guides. The string is then (b) inserted into a String Test Cryostat (STC), a vessel for operating and testing individual strings. The collaboration can operate up to seven STCs simultaneously. Once testing is complete, the string is mounted, along with six other strings, into a module cryostat, forming a full MAJORANA module.

String characterization measurements

The STC is used to verify that the detector & strings behave as expected before their insertion into a module cryostat. Characterization data taken in the STC includes:

- Source measurements to look for cross-talk between detectors
- Coincidence measurements to measure relative timing
- Noise and microphonics characterization
- Pulse shape analysis performance for background discrimination
- Threshold determination

String Characterization

Energy resolution

A series of source measurements are taken in the STC to confirm the detector resolution matches values taken during acceptance testing, as well as to optimize the performance of the digitizer. Data shown at left are for a natural Ge detector manufactured by ORTEC.

Source scanning measurements

An automated e-scanner (a) with a $^{133}$Xe source is used to measure the insensitive dead layer at the outer surface of the detector. A rotating scanning table (b) will be used to determine crystal axys, which facilitates a solar axion program.

Room background measurement & modeling

To ensure each string has been constructed without introducing contamination, background data were taken with the string in an unshielded String Test Cryostat. Monte Carlo simulations of the STC and surrounding rock provide an expected background spectrum for each detector. Simulation and data can be compared to measured data to check for unexpected features.

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