High-performance plastic for cutting-edge measurement technology

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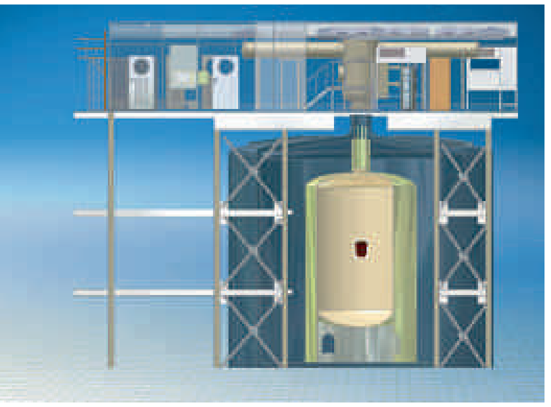
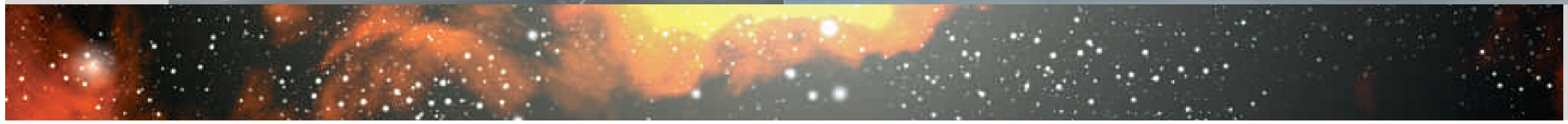
The Max Planck Institute for Nuclear Physics in Heidelberg, Germany, is collaborating on the GERDA (GERmanium Detector Array) research project, which aims to provide experimental proof of a special theorized type of radioactive decay of germanium-76. Highly sensitive measuring equipment is used for the challenging experiments being conducted at the Gran Sasso National Laboratory in Italy. The equipment includes a tank filled with argon that houses the germanium detectors. The high-performance plastic TORLON® from Angst+Pfister's APSOplast® product range is used for balanced and vibration-free mounting of the tank.



Schematic diagram of experiment setup: GERmanium Detector Array (GERDA)

TORLON® supports assembly, with and without protective covering



GERDA – an ambitious experiment

The Max Planck Institute (MPI) for Nuclear Physics is one of a total of 78 research institutes of the internationally renowned Max Planck Society. It conducts fundamental research in the fields of astroparticle physics and quantum dynamics. The activities of the Max Plank Society are largely financed by public funds; its annual budget for 2007 totaled approximately 1.4 billion euros.

The first experiments of the GERDA research project are currently being performed in an underground laboratory in the Gran Sasso massif in the Abruzzo region of central Italy. The so-called neutrinoless double beta decay of germanium-76 is being researched. With a half-life of up to 10^{25} years, the germanium-76 isotope takes an extremely long time to decay.

The project can be described in simple terms as follows: During the form of radioactive decay known as beta-plus decay, an elementary particle called a neutrino is emitted. In the theorized neutrinoless double beta decay process, the emitted neutrino is simultaneously reabsorbed back into the nucleus in a second beta decay. In order for this to occur, the neutrino must be its own antiparticle. In the experiment, the researchers measure the energy of the released electrons. The neutrinos themselves cannot be directly detected; they contribute, however, to the reaction energy. Provided that the energy of the electrons released during decay is measured with high accuracy, the neutrinoless double beta decay can be differentiated from the neutrino-accompanied double beta decay. If neutrinoless double beta decay can be experimentally proven, this means that the neutrino would indeed have to be its own antiparticle. With this proof, neutrinos can be better understood – their mass can be determined, for example. Since neutrinos play a fundamental role in understanding our universe, the experiment is of enormous scientific interest.

Inner container with aluminum foil casing

Cutting-edge measuring technology

To prove the existence of neutrinoless double beta decay, high-precision measurements must be made while blocking out the background noise of radioactive and cosmic radiation. To do that, the germanium detectors are inserted into a double-walled tank with a diameter of four meters that is filled with argon. The space between the walls is evacuated for thermal insulation and covered on the inside with multiple layers of reflective foil and cooled to approximately –190°C. The tank filled with argon is in turn encased in a water tank with a diameter of approximately ten meters. Both casings work together to shield against interfering radiation.

The argon tank is stood on eight hollow cylindrical supports made of TORLON® 4503. The TORLON® supports serve as spacers and provide thermal insulation between the inner and outer walls of the tank. The walls of the supports are subjected to a continual temperature difference ranging from approximately –190°C at one end to approximately +20°C at the other end. The hollow cylindrical supports have an exterior diameter of 174.6 mm, an interior diameter of 101.6 mm and are 100 mm long. During assembly, eight weighing cells ensured that the total load was evenly distributed on the TORLON® supports by means of disc springs. The TORLON® cylinders at one end are fitted into steel shoes.

Unusual specification profile

The MPI for Nuclear Physics initially assigned Angst+Pfister the task of finding a semifinished stock made of a material that – in accordance with the original specification profile – can bear a load of 160 tons over a period of ten years while being subjected to a continual temperature span ranging from –196°C to +20°C. Together with the project staff at the MPI, Angst+Pfister set about defining the specifications that the material and geometry of the semifinished stock had to meet for the application at hand:

- resistance to temperatures down to –196°C;
- high load-bearing capacity with minimal deformation under load;
- low creep tendency;
- no embrittlement;
- maximum retention of impact resistance;
- minimal thermal conductivity;
- no or extremely minimal radioactive radiation.

TORLON® 4503 PAI – an ideal material

TORLON® 4503 PAI, a polyamideimide combined with TiO_2 and PTFE, optimally meets this set of specifications, also from an economic standpoint. At both high and even the lowest temperatures, the material exhibits excellent properties: high mechanical stability and rigidity, good impact resistance, and very minimal creeping tendency.

To rule out every risk, the MPI commissioned the TüV NORD Group to perform low-temperature pressure tests on suitable test specimens. At temperatures as low as –190°C, the specimens were subjected to a load of 10 kN – much more than the load expected in the actual project application. The test results matched the expectations: the tension values remained within the permitted limits, the material negligibly embrittled and, after removal of the load, the deformed specimens returned to their original shape.

"I felt that I was well advised by Angst+Pfister's application technology specialists," concludes Dr. Bernhard Schwingenheuer, the project leader at the MPI for Nuclear Physics, about the successful teamwork. We at Angst+Pfister are proud to have been able to make a small contribution to this important research project.

Angst+Pfister's newly launched APSOplast® range of plastics offers you a broad selection of products and solutions for an even wider spectrum of applications. Order our APSOplast® overview brochure!

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