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A ROMAN SHIELD FOR THE CUORE EXPERIMENT

In October work began on assembling the shield of the cryostat of the CUORE (Cryogenic Underground Observatory for Rare Events) experiment at the Gran Sasso National Laboratory (LNGS). CUORE is an experiment designed to study the properties of neutrinos and, specifically, to look at a rare process called neutrino-less double-beta decay. This process has never been observed before and requires an extraordinary low level of radioactivity in order to be successful. To protect the CUORE experiment, researchers have come up with a truly original solution, which was proposed by Ettore Fiorini, carried on by the University and the INFN division of Milano Bicocca and realized under the supervision of LNGS. Ancient Roman lead ingots salvaged from a shipwreck that occurred more than 2000 years ago off the coast of Sardinia have been melted down to create a shield. The use of this shielding material will protect the detectors used in the experiment against environmental radioactivity. Lead is a very dense material with a high atomic number, which makes it ideal for shielding. "Ordinary" lead contains a radioactive isotope (lead-210), which has a half-life of about 22 years: thus, the Roman lead, produced 2000 years ago, does not contain lead-210 anymore.
The Gran Sasso National Laboratory and the Sovrintendenza ai Beni Culturali (Cultural Heritage Authority) in Cagliari worked in collaboration to recover the lead ingots from the bottom of the sea. They were then studied in Cagliari and taken to the LNGS to be preserved and prepared. As agreed upon with the Cultural Heritage Authority, the parts of archaeological interest, namely the inscriptions on the top of each ingot, were removed and taken back to Cagliari for preservation. The 230 ingots were then cryoblasted to remove all surface contamination. This process, which causes no radioactive contamination, consists of bombarding the surfaces with a pressurised stream of dry ice. The ingots were then melted down to obtain the segments and panels required to assemble the shield for the experiment. This work, which was carried out at the German MTH Metall-Technik Halsbrücke GmbH & Co KG took more than two months. The shielding of the CUORE experiment will be

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cup-shaped and comprise 26 rings plus a base disk assembled within a copper supporting structure. Each ring is composed of 6 segments and the base disk is divided into 20 panels. This lead shielding will be 6 centimetres thick and weigh 5 tonnes. It will be cooled to a temperature of approximately 4 kelvin (-269 °C).
This original solution for the shielding of the experiment was dictated by the fact that the scientific goals of CUORE are really ambitious. Neutrinoless double-beta decay is an extremely rare event, so rare that it has never been detected before. If researchers are able to observe and thus demonstrate the existence of this process, they will be able to measure the mass of neutrinos, and also determine whether or not they are Majorana particles, thus offering a possible interpretation of the prevalence of matter over antimatter in the Universe. Double-beta decay is a process by which two neutrons in a nucleus are converted into two protons, emitting two electrons and two antineutrinos. In neutrinoless double-beta decay no neutrinos are emitted, because one of the antineutrinos is converted, in the nucleus, into a neutrino. According to the Standard Model, neutrinos are not involved in this transformation. However if, according to the model proposed in the 1930s by Italian physicist Ettore Majorana, neutrinos are actually their own antiparticles, like the two faces of a coin, the transition between matter and antimatter would be possible. This event, though extremely rare, may have occurred frequently in the primordial Universe immediately after the Big Bang and determined the prevalence of matter over antimatter. CUORE is an international collaboration involving some 157 scientists from thirty organisations in Italy, the USA, China, Spain and France. The INFN is taking part through its Milan-Bicocca, Bologna, Genoa, Padua and Rome La Sapienza divisions, and its Gran Sasso, Frascati and Legnaro National Laboratories. ■