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25TH ANNIVERSARY OF LUNA

LUNA (Laboratory for Underground Nuclear Astrophysics) is an international experiment based on a small linear accelerator, the only one in the world to be installed in an underground laboratory to shelter it from the shower of particles coming from the cosmos. The experiment, whose 25th anniversary will be celebrated on 1 December next, is installed at the Gran Sasso National Laboratories, shielded by 1400 metres of rock that protect the infrastructure from cosmic rays, allowing the observation of extremely rare processes. LUNA aims to study the thermonuclear fusion reactions that take place in the core of the stars where, for billions of years, and still today, the elements that make up matter are produced. The experiment recreates in the laboratory the energy of nuclei at the centre of stars, from tens to several hundred keV, turning back the clock with its accelerator. LUNA is able to recreate the conditions of the stellar matter up to one hundred million years after the Big Bang when the first stars were formed and those processes that gave rise to the mysteries that we have not yet fully understood were triggered, such as, for example, the enormous variability in the quantity of elements in the Universe.

The core of LUNA is a small linear accelerator (terminal voltage of 400 kV), which provides hydrogen or helium beams with very high current (up to approx. $600 \,\mu$ A), sending them to a solid or a gaseous target and inducing nuclear fusion reactions. Special silicon, germanium or scintillating crystal detectors photograph the products of the collisions and identify the reaction, starting from the particles produced and the radiation emitted. To take full advantage of the peculiar conditions of the Gran Sasso Laboratories, the materials used in the experiment, in particular the detectors, are selected to have a very low internal radioactivity. Thanks to this, LUNA holds the sensitivity record in a nuclear physics experiment, having been able to observe and isolate, in a particular experiment, a single event in two months of continuous interaction between the projectile beam and the atoms of the target.

The first phase of LUNA was dedicated to the study of the fundamental reactions of the proton-proton fusion chain of the so-called "CNO" (Carbon-Nitrogen-Oxygen) reaction cycle. Subsequently, the activity



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was focused on hydrogen combustion processes in cycles that are triggered at temperatures higher than that of the Sun, such as Ne-Na (neon-sodium) and Mg-Al (magnesium-aluminium) reactions. More recently, significant results have also been obtained with regard to "primordial nucleosynthesis", i.e. the network of nuclear reactions that took place in the very first moments after the Big Bang, and which determine the abundance of hydrogen and helium in the material that extended into space starting from the initial flash.

Following the numerous successes in over 15 years of work, in 2007 the collaboration proposed the installation of LUNA-MV, a machine capable of achieving higher energies and of allowing reactions that take place in the stars at temperatures between 500 million and one billion degrees to be studied. Installation of the new accelerator, which will occupy a total area of approx. 400m², is scheduled for autumn 2018 in room B of LNGS. The accelerator will be able to provide intense proton, alpha particle and carbon ion beams in two different beam lines, one with solid targets and the other with gaseous targets. The machine and the beam lines will be housed in an 80 cm thick concrete infrastructure, which will ensure complete shielding of the accelerator from the rest of LNGS.

LUNA is an international collaboration of approx. 40 researchers including Italians, Germans, Scots and Hungarians, in wich INFN and GSSI are taking part for Italy, the Helmholtz-Zentrum Dresden-Rossendorf for Germany, the Hungarian Academy of Sciences - Institute for Nuclear Research (MTA-ATOMKI), for Hungary and the School of Physics and Astronomy of the University of Edinburgh for the UK. In Italy, the Gran Sasso National Laboratories of INFN, the INFN sections and the Universities of Bari, Genoa, Milan, Naples, Padua, Rome La Sapienza, Turin and the INAF Observatory in Teramo are collaborating in the experiment.