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Underground Nuclear Astrophysics: pushing direct cross section measurements toward the Gamow window

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Nuclear fusion reactions are at the heart of nuclear astrophysics as they control the energy production in stars and determine the synthesis of the elements in our Universe. Most cross sections are too small to be directly measured in a laboratory at the stellar energies. They are extrapolated by means
of phenomenological nuclear models anchored to available high energy data. Cosmic rays, environmental radioactivity and beam-induced background reactions on target impurities, all represent a major limitation to the measurement of thermonuclear cross sections at stellar energies.

The LUNA collaboration (https://luna.lngs.infn.it) was the first to propose a new approach to nuclear astrophysics, by exploiting the extremely low background inside the Laboratori Nazionali del Gran Sasso (LNGS), which is part of the Italian Istituto Nazionale di Fisica Nucleare. In over 30 years of activity, LUNA has achieved extremely important results with major implications not only in nuclear astrophysics but also in cosmology and particle physics, using the LUNA 400 kV machine, a Singletron accelerator which has been operational since 2001.
The LNGS-INFN is currently expanding the accelerator laboratory having installed a 3.5 MV Singletron machine designed and built by High Voltage Engineering Europe (HVEE) . The 3.5 MV machine can deliver intense proton, helium, and carbon beams with well-defined energy resolution and stability.
A first experimental proposal for the use the new 3.5 MV machine, presented by the LUNA-Collaboration, focuses on measurements of the reactions:
• 14N(p,g)15O, which influences stellar evolution and nucleosynthesis, and specifically the "metallicity"of the solar core;
• 12C + 12C, which affects the final fate of intermediate-mass and massive stars and the associated nucleosythesis;
• 22Ne(a,n)25Mg, which provide the source of neutrons in stellar interiors.
During my talk I will report about some recent results and the future program of LUNA.

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