SimLUNA: a new simulation tool based on Geant4 for LUNA experiment

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on behalf of LUNA Collaboration

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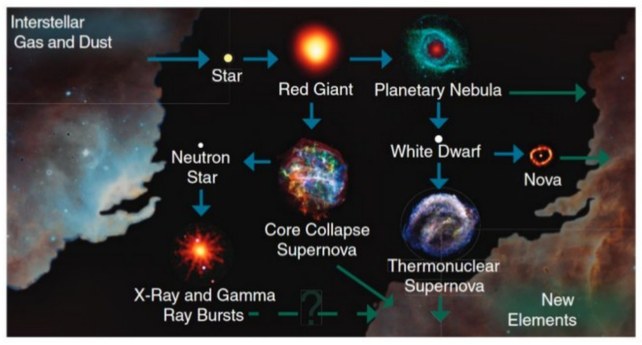
THE LUNA COLLABORATION

http://luna.lngs.infn.it

LUNA Laboratory for Underground Nuclear Astrophysics



The thermonuclear reactions are responsible for powering the stellar engine and for the synthesis of the chemical elements. At astrophysical energies, the cross section of nuclear processes is extremely small and the cosmogenic background prevents their measurement at stellar energies on Earth surface.

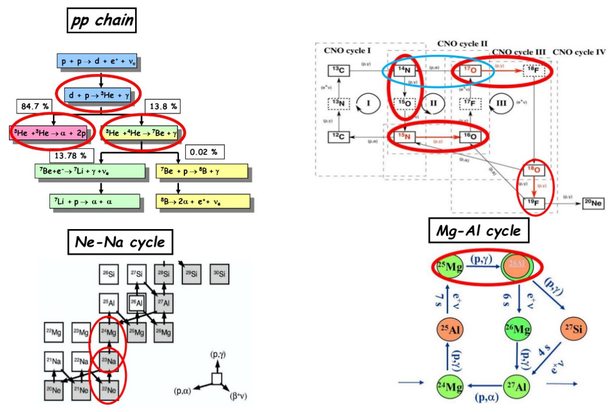
Deep underground in the Gran Sasso Laboratory, several crucial reactions involved in hydrogen burning have been measured directly at astrophysical energies by the LUNA (Laboratory for Underground Nuclear Astrophysics) Collaboration with both the LUNA-50kV and the LUNA-400kV accelerators.

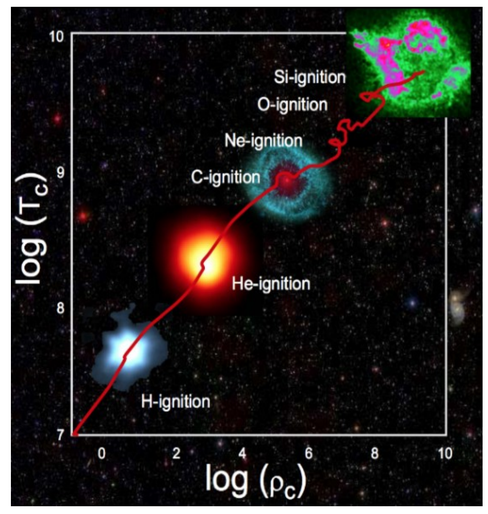
Some reaction during the H-burning and BBN measured @ LUNA are illustrated. →

A picture of the accelerator and the 2 beam lines equipped with gas and solid targets is shown →

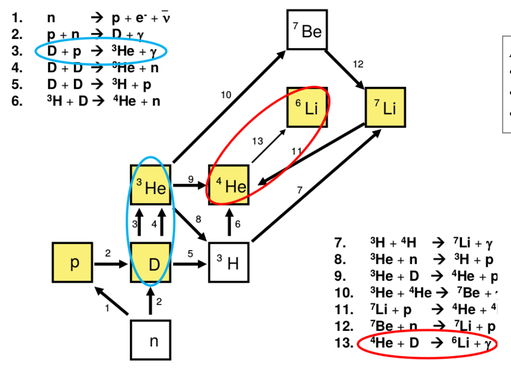
Here, 1400 meters of rocks act as a natural shield against cosmic radiation, suppressing the background by orders of magnitude.

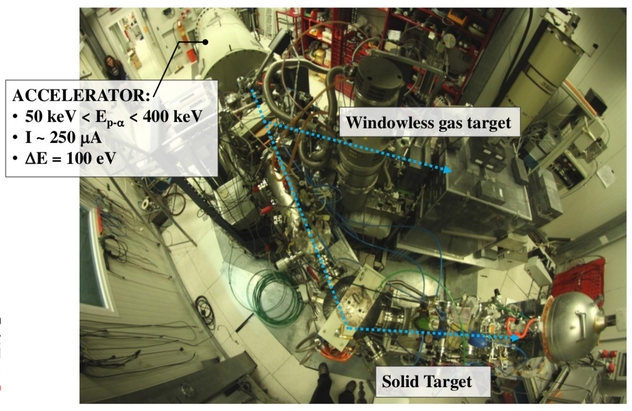
Hydrogen burning reactions



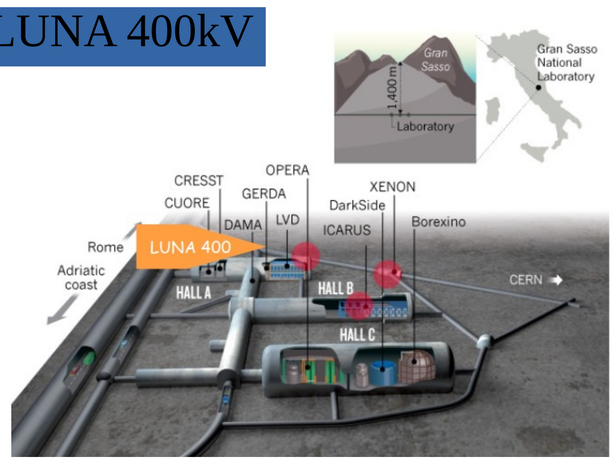


Big bang nucleosynthesis

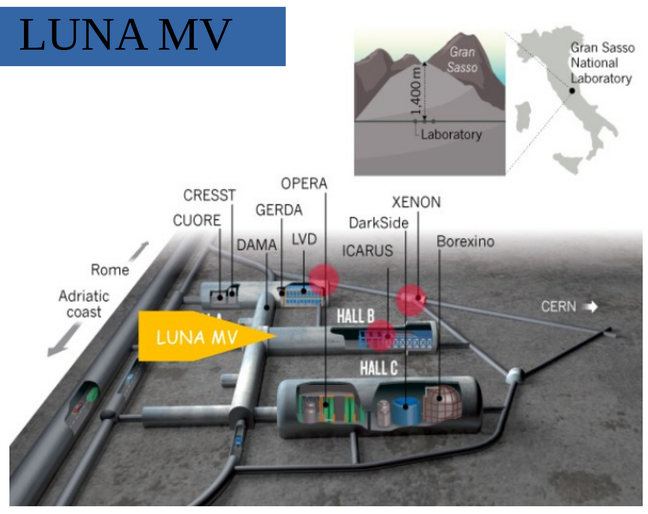




LUNA 400kV



LUNA MV



This research activity will continue with the installation of a new LUNA-MV machine able to provide hydrogen, helium and carbon high current beams, allowing to explore the helium and carbon burning processes. For the LUNA-MV project, High Voltage Engineering has developed a 3.5 MV linear single-ended DC accelerator The in-line Singletron will provide intense beams of H^+, $^4He^+$, $^{12}C^+$ and $^{12}C^{2+}$ The accelerator tube with voltage gradient design to allow high current beam transport with minimal transmission losses over the entire terminal voltage range of 300 kV–3.5 MV. →

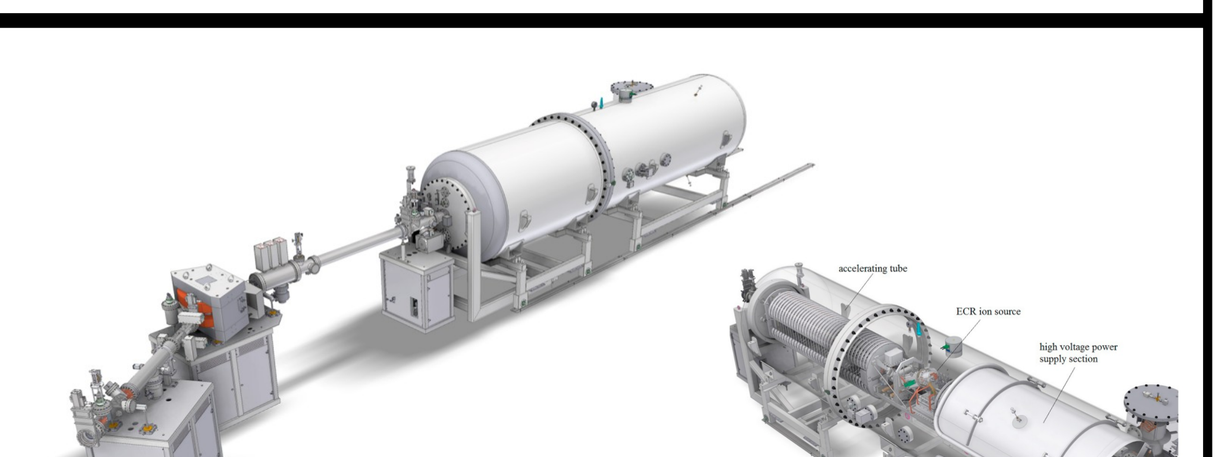
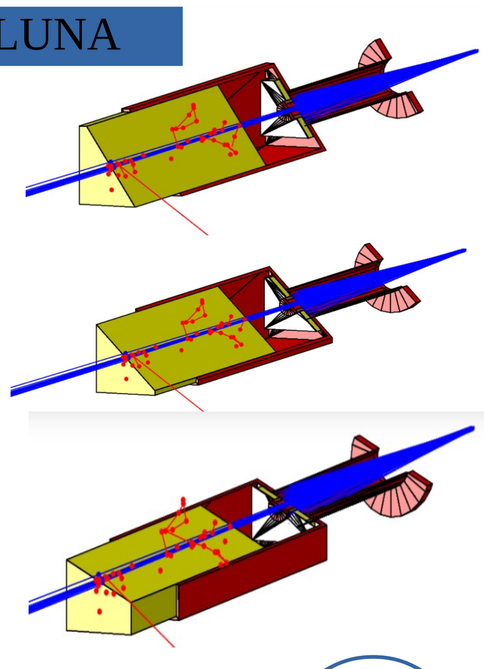
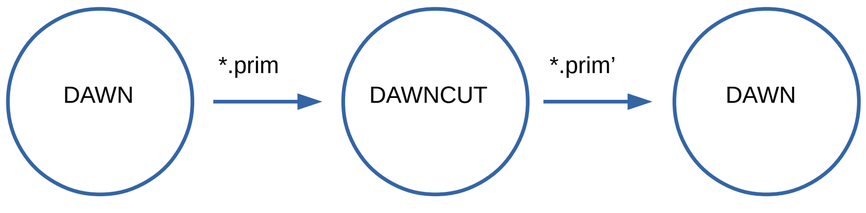


Fig. 1. 3D-CAD layout of the LUNA-MV Singletron system.

SimLUNA



SimLUNA is a new tool on LNGS clusters to run Monte Carlo (based on Geant4) for LUNA 400 kV and LUNA MV. Several advantages: have one "trusted" version of the software, where validated esperimental setups (reaction chamber / shielding / detectors) in released versions are available to the collaboration. Also, the user not need to download and build the software on his laptop since the software running on LNGS. The user can modify settings via external scripts. Massive MC production using LNGS clusters is possible. SimLUNA will be also a "repository" of all the MC studies carried out @ LUNA.
For visualization, we use Dawn + DawnCut to produce cut views of the geometry. ←



Implementation of a case-study: $^{20}Ne(p,\gamma)^{21}Na$. This is the first reaction of the NeNa cycle and having the slowest reaction rate, it controls the speed at which the entire cycle proceeds. Proton capture on ^{20}Ne nuclei may occur in different stellar scenarios such as red giants stars (during H shell-burning), asymptotic giant branch stars, novae, and massive stars. This reaction can proceed in these environments if the temperature reaches T = 0.05 GK. The software running quinte well and preliminary results are presented.