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The Gran Sasso National Laboratory and its future scientific programme

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ABSTRACT

The Gran Sasso underground laboratory is one of the four national laboratories run by the INFN (Istituto Nazionale di Fisica Nucleare). It is located under the Gran Sasso mountain, in central Italy, and it is the largest underground laboratory in the world, serving the largest and most international scientific community.
The underground facilities are located on a side of the 10-km long freeway tunnel crossing the Gran Sasso mountain and are directly accessible by car or van. The excavation of the laboratory started in 1982, in coincidence with the freeway tunnel, and was completed in 1987. The total volume underground is about 180000 m^3. The laboratory encompasses three main halls (named A, B and C), each about $100\times20\times18$ m^3, plus several ancillary tunnels, for a total available underground area of about 17800 m^2. The average 1400 m rock coverage gives a reduction factor of one million in the cosmic ray flux, down to $(2.87\pm0.03)\cdot10^{-4}$ $\mu/(m^2\cdot s)$. The measured thermal and fast neutron fluxes are $2.93\cdot10^{-2}$ $n/(m^2\cdot s)$ below 1 keV and $0.86\cdot10^{-2}$ $n/(m^2\cdot s)$ above 1 keV, respectively, namely a factor of a thousand less than on the surface. The ventilation system of the laboratory provides a flow of about 60000 m^3/h and allows reducing the ^{222}Rn content in air down to 20-80 Bq/m^3.

The scientific program at LNGS is focused on astroparticle, particle and nuclear physics. The laboratory presently hosts 16 experiments (as well as several R&D activities) dedicated to these topics, including world-leading ones in the fields of solar neutrinos, accelerator neutrinos (CNGS neutrino beam from CERN to Gran Sasso), dark matter, neutrinoless double beta decay and nuclear cross section of astrophysical interest. The laboratory is operated as an international science facility and hosts also non-INFN physics experiments, whose scientific merit is assessed by an international advisory Scientific Committee.

The world-wide scientific excellence of the LNGS will be preserved in the next 5-10 years by a broad and extensive physics program, encompassing the running of approved experiments which are presently in construction phase as well as the upgrade of ongoing experiments, to further scale in mass and sensitivity.
The double beta decay research program will rely upon the complementary experiments GERDA and CUORE, that are in commissioning and construction phase, respectively. The experiments will look for neutrinoless double beta decay using two different isotopes and techniques. CUORE is expected to be among the firsts able to probe the inverted hierarchy region of the neutrino mass pattern.
The LNGS will maintain a leading role in dark matter searches by hosting Xenon1T (the scaled version of Xenon100, which is currently running) and the upgraded version of DAMA/Libra, as well as by further pursuing the technology based on liquid argon (WArP and the recent R&D initiative Dark Side). The laboratory is also the site of the CRESST experiment, which is one precursor of the next-generation dark matter project EURECA.
The neutrino physics program will be carried on in the next years by Borexino (solar and geo-neutrinos) and by OPERA and ICARUS (CNGS neutrino beam). In particular the Borexino and ICARUS Collaborations are designing dedicated experimental activities to probe the theoretical models predicting sterile neutrinos, which have been discussed in the recent literature.
The LNGS plans to host the new 3 MV accelerator, which is the upgrade of the present LUNA 400 kV machine. The new accelerator is designed to study nuclear reactions of astrophysical interest involving He and C burning. The underground location of the new accelerator has been identified; feasibility studies are ongoing to finalize the design of the neutron shielding and to prepare the refurbishment of the underground area.
Still, the laboratory will remain open to proposals for new experiments - even of large scale - since the underground space presently occupied by OPERA and ICARUS could be made available after the completion of the CNGS program in 2013-2015.