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Nuclear Astrophysics Underground: Status & Future

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Even more than 60 years after the groundbreaking publication by Burbidge, Burbidge, Fowler, and Hoyle, Nuclear Astrophysics is still a thriving and exciting research field at the interface of nuclear physics, astro¬physics, and particle physics. An important current topic is associated with the evolution of stars and its impact on the production of heavy elements. The most critical reactions are 12C(alpha,gamma)16O, 13C(alpha,n)16O, 22Ne(alpha,n)25Mg as well as 12C+12C fusion but other (p,gamma), (alpha,gamma), or (alpha,n) reactions may also play a role depending on the stellar environment. The study of these reactions at stellar energies has been a major goal by the community, in Europe, the US and increasingly also in China. However, the large cosmic ray induced background has been prohibitive for advancing these measurements into the stellar energy range and the present reaction rates rely on theoretical extrapolations that carry high uncertainties.
Accelerator laboratories, located deep underground offer unique conditions for measuring these reactions at low energies as demonstrated by the success of the LUNA facility at Gran Sasso, Italy. Luna showed for the case of hydrogen burning reactions that many of these kinds of extrapolations can be significantly improved. Over the past years the CASPAR (Compact Accelerator System for Performing Astrophysical Research) laboratory has been constructed and commissioned at the Sanford Underground Research Facility (SURF) at former Homestake Gold mine (Lead, South Dakota, USA) to address the further need for such facilities. CASPAR operates a 1MV, high intensity, fully refurbished Van de Graaff accelerator that can provide beam intensities of more than hundred micro-Ampere. Furthermore, the LUNA-MV facility in Gran Sasso and as well as the JUNA project in China's Jinping Underground Laboratory will be operational in the near future. Successful implementation of a science program at these facilities will offer great opportunities for significant progress in the field. The programs and the current status of the upcoming and existing underground accelerator facilities for Nuclear Astrophysics will be reviewed.

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