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DIANA: nuclear astrophysics with a deep underground accelerator facility

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Current stellar model simulations are at a level of precision such that nuclear reaction rates represent a major source of uncertainty for theoretical predictions and for the analysis of observational signatures [1]. To address several open questions in cosmology, astrophysics, and non-Standard-Model neutrino physics, new high precision measurements of direct-capture nuclear fusion cross sections are essential [1]. Experimental studies of nuclear reaction of astrophysical interest are hampered by the exponential drop of the cross-section [2]. The extremely low value of $\sigma(E)$ within the Gamow peak prevents measurement in a laboratory at the earth surface. The signal to noise ratio would be too small, even with the highest beam intensities presently available from industrial accelerators, because of the cosmic ray interactions with the detectors and surrounding materials. An excellent solution is to install an accelerator facility deep underground where the cosmic rays background into detectors is reduced by several order of magnitude [3], allowing the measurements to be pushed to far lower energies than presently possible. This has been clearly demonstrated at the Laboratory for Underground Nuclear Astrophysics (LUNA) [4] by the successful studies of critical reactions in the pp-chains [5] and first reaction studies in the CNO cycles [6]. However many critical reactions still need high precision measurements [1], and next generation facilities, capable of very high beam currents over a wide energy range and state of the art target and detection technology, are highly desirable. The DIANA accelerator facility is being designed to achieve large laboratory reaction rates by delivering high ion beam currents (up to 100 mA [7]) to a high density (up to 10^{18} atoms/cm^2), super-sonic jet-gas target as well as to a solid target. DIANA will consist of two accelerators, 50-400 kV and 0.4-3 MV, that will cover a wide range of ion beam intensities, with sufficient energy overlap to consistently connect the results to measurements above-ground. In the present work the status of the US DIANA project [7], for underground nuclear astrophysics will be presented.

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