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Investigating nuclear reactions at astrophysical energies with gamma-ray beams and an active-target TPC

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A new methodology to measure cross-sections for thermonuclear reactions that power the stars is being developed at the University of Warsaw. These reactions take place at different energies according to the respective stellar environment. Such energies are well below the Coulomb barrier and the respective cross-sections are incredibly small, often below the experimental reach. There is a lack of experimental data on cross-sections for low-energies, information that is indispensable for modelling energy production in stars. As a consequence, extrapolations are made, with their unavoidable large uncertainty. Of special interest are (p,gamma) and (alpha,gamma) reactions, in particular those, that regulate the ratio of C and O and those that burn 18O and, therefore, regulate the ratio between 16O and 18O in the Universe. One of the benchmark reactions to be investigated in this work is the 12C(alpha,gamma)16O at energies down to 1 MeV in the centre-of-mass reference frame.

We propose to use a gaseous active target detector to study (alpha,gamma) and (p,gamma) nuclear reactions of current astrophysical interest by means of studying time-inverse photo-disintegration processes induced by high energy photons. The advantage of such an approach stems from the fact that photons are not subject to the nuclear Coulomb barrier. The Extreme Light Infrastructure-Nuclear Physics facility (ELI-NP) - currently being built near Bucharest, Romania - will deliver monochromatic, high-brilliance and polarized gamma-ray beams. The charged products of photodisintegration reactions will be measured by means of a Time Projection Chamber (ELITPC) with 3-coordinate (u-v-w) planar electronic readout acting as virtual pixels. The detector will be equipped with triple-GEM structure for gas amplification and will work at lower-than-atmospheric pressure. The concept of the detector and the status of the R&D for it will be presented, as well as results from tests using a scaled demonstrator detector.

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