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TI-STAR: A new silicon tracker for direct reaction studies at ARIEL

The future ARIEL facility, under development at TIRUMF, Vancouver, BC, will produce radioactive ion beams from photofission with unprecedented purities and intensities in the mass A=100 region. The first stage of ARIEL is the $4.24M CANadian Rare Isotope Facility with Electron Beam Ion Source (CANREB), which will go online in 2019.

Within an international collaboration of the University of Guelph (Canada), TRIUMF (BC, Canada), Colorado School of Mines (USA) and the Technical University of Munich (Germany), we have designed a new auxiliary charged particle detector, to be coupled to the high-granularity TIGRESS array of HPGe detectors at TRIUMF. The new TI-STAR (TIGRESS Silicon Tracker ARray) is optimized for direct nuclear reaction studies with heavy, exotic beams at ARIEL. TI-STAR will host an extended gas target, filled with a pure 1H, 2H, 3He or 4He gas at 1 bar. For the first time, ultrathin silicon detectors (20um) will be used to track the interaction vertex event-by-event with over 4000 channels of silicon strip detectors, processed by SKIROC ASICs. The new approach of TI-STAR offers a number of benefits over active targets (rate capabilities, less background reactions, better missing mass resolution for heavy beams etc.) and will allow to couple the tracker to an array of HPGe detectors.

TI-STAR will offer a gain of up to two orders of magnitude in luminosity for direct nuclear reaction studies at ISOL facilities in comparison to experiments with loaded foils. We will discuss the opportunity to measure neutron-capture cross sections via the "Oslo" method following one-neutron transfer to key nuclei along the r-process path in the A=130 region. Thanks to the vertex reconstruction in TI-STAR, the Doppler correction of TIGRESS spectra is significantly enhanced specially at high gamma ray energies, allowing to measure momentum transfers and spectroscopic factors in the region of high level densities, like at threshold energies for critical reactions along the rp process in the A=60 region.

Using the Skyrme Hartree-Fock method it has been shown that the measurement of the energy dependence of direct nuclear reaction cross sections is a sensitive measure for the radial wavefunctions of the outermost orbitals in neutron-rich nuclei. We will discuss how TI-STAR will give access to systematic measurements of neutron halos in medium-heavy and heavy nuclei. This will allow to inspect the importance of the characteristic behavior of weakly bound orbitals with low angular momentum for a more consistent description of nuclear shell evolution. Another goal of TI-STAR is the direct measure of (alpha, p) and (p, alpha) cross sections, constraining thermonuclear reaction rates. Here, TI-STAR offers the possibility to measure the temperature dependence of S-factors in a single measurement. TI-STAR also will allow new access to the neutron-rich region north-east of 208Pb for the study of shell evolution and fission barrier heights, critical for our understanding of r-process fission re-cycling.

This presentation will concentrate on the new physics opportunities accessible through TI-STAR at ARIEL. We also will present the technical and electronics design of TI-STAR and will discuss the results from detailed GEANT4 simulations.

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