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Reaction studies with neutron-rich light nuclei at the upgraded SEC Device : (Testinting the parity inversion in 11,3Li))

The term halo nucleus was coined to describe a group of nuclei with an unusually large spatial extension, diverging from the standard $r = roA^{1/3}$. The first empirical observation of this behavior came from scattering experiments of Lithium isotopes [1,2], intended to measure the interaction cross-section of neutron-rich nuclei. As we move closer to the neutron dripline and jump from ${}^{9}_{3}Li$ to ${}^{11}_{3}Li$ the cross-section drastically increases, pointing toward a nuclear radius larger than the theoretical prediction. This discovery was interpreted as a new type of nuclear system [3], formed by a compact core and an external set of nucleons (one neutron for ${}^{11}_{4}Be$ and two neutrons for ${}^{11}_{3}Li$. A few years later [4], the ${}^{9}_{3}Li$ momentum distribution obtained from ${}^{11}_{3}Li$ break-up experiments confirmed this hypothesis. Further research has proven that halo nuclei are relatively abundant in the regions close to the neutron drip lines. Halo nuclei have proven to be more complex than what the nuclear physics community initially expected and currently this continues to be an active field of research.
Our object of study is the ${}^{11}_{3}Li$ isotope which can be considered the archetype of the two neutron halo. Most of the research done indicates that ${}^{11}_{3}Li$ is a three-body system formed by two weekly correlated neutrons linked to a ${}^{9}_{3}Li$ core in its ground state (instead of the initially proposed dineutron-${}^{9}_{3}Li$ system) [5].The structure of the ${}^{11}_{3}Li$ ground state is well established with a mixture of p(59(1)%) + s (35(4)%) + d(6(4)%) waves [6]. However, the knowledge of the excite energy levels of ${}^{11}_{3}Li$ is confusing. Different reactions identified different excited levels. Most of these studies start from ${}^{11}_{3}Li$ so we consider a different approach starting from a simpler ground state,that of ${}^{9}_{3}Li$ and using (t,p) reactions in inverse kinematics to explore the excited states of ${}^{11}_{3}Li$ [7].
The experiment will be performed at the Scattering Experiment Chamber (SEC) at ISOLDE-CERN (Switzerland) in the spring of 2023. We will employ HIE-ISOLDE to accelerate the ${}^{9}_{3}Li$ Beam with an energy of 7 MeV/nucleon on a tritium target to populate the excited states of ${}^{11}_{3}Li$. We will gain information on the ${}^{11}_{3}Li$ structure from the residual proton, the emitted gamma particles, and the break-up products. Our team has prepared a state of-the-art setup: including a system of 5 telescopes (PAD+DSSD) forming a pentagon around the target to cover laboratory angles between 40-80°. The forward and backward angles, we will use CD-silicon disks, an S3 in the back and an S3-S5 telescope on the front. To maximize angular coverage the data will be processed by a new DAQ using integrated digitizer cards.
In this contribution, we present the Geant4-MC simulations of the set-up and discuss the current status of the setup, which is almost completed.

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