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(U*) (POS-37) State selective field ionization for reionization of optically nuclear spin polarized, low-abundance radioisotope beams

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The TRIUMF polarizer facility provides nuclear-spin-polarized radioactive isotopes via collinear optical pumping for physical and biomedical science[1]. Recently, more exotic isotopes, such as ^{32}Na and ^{230,232}Ac, with production rates below ~1000 s^{-1}, are demanded to be highly spin-polarized to study nuclear structure and develop radiopharmaceuticals for cancer treatment. The traditional fluorescence detection method is insufficiently sensitive for measuring the hyperfine structures of these isotopes required to produce spin-polarized beams.

In this work, we try to develop a more sensitive detection mechanism compatible with our existing collinear geometry. The radioisotopes will undergo a two-step resonant ionization, first to an excited state and then to a high-energy Rydberg state, and subsequently be ionized by an intense electric field. Using charge particle detection instead of photon detection will significantly improve detection efficiency. Here we compare several different approaches to ionizer designs[2,3]: a homogeneous set of electrodes that surround the atomic beam, and a heterogeneous mix of electrodes and meshes of wire grids. All designs aim to achieve low energy spread and high detection selectivity by providing an energy signature to produced ions that distinguish them from background ions.

We simulated these designs and compared the potentials and fields that the beam would experience. The plots we generated confirmed that the mesh-based design had significantly smaller radial variations in potential and field. Numerical calculations showed that the spread in electric potential on and off-axis was two-to-three orders of magnitude lower than for the other designs. Moving forward, we will build the mesh-based geometry and test its efficiency compared to the other designs, eventually deploying the best geometry in experiments to determine the hyperfine spectra of critical low-production isotopes.

[1] C. D. P. Levy et al., "A polarized beams project at ISAC", Nuclear Physics A 701, 253c-258c (2002).
[2] K. Stratmann et al., "High-resolution field ionizer for state-selective detection of Rydberg atoms in fast-beam laser spectroscopy', Rev. Sci. Instrum. 65, 1847–1852 (1994).
[3] A. R. Vernon et al., "Laser spectroscopy of indium Rydberg atom bunches by electric field ionization", Sci. Rep. 10, 12306 (2020).

Keyword-1

Field Ionization

Keyword-2

Rydberg Atom

Keyword-3

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