PRODUCTION OF HE-LIKE ION BEAMS IN MIXED- STATE ($1s^2$, 1s2s) USING GAS AND FOIL POST-STRIPPERS FOR ZERO-DEGREE AUGER PROJECTILE ELECTRON SPECTROSCOPY

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Abstract

The research initiative APAPES has setup a new experimental station at the 5MV TANDEM of the NCSR "Demokritos" with a beam line dedicated to solely to atomic collisions physics research[1]. The experimental setup, developed for zero-degree Auger projectile spectroscopy (ZAPS), performs high resolution studies of electrons emitted at 0° with respect to the ionic beam direction during ion-atom collisions. The apparatus consists of a Hemispherical Deflector Analyzer (HDA) with a 4-element zoom lens at its entry and a 2-dimensional Position Sensitive Detector (PSD), together with a doubly-differentially pumped gas target. It is currently fully operational for performing systematic isoelectronic investigations of K-Auger spectra emitted from collisions of He-like ions excited in collisions with gas targets. Our goal is to provide a better understanding of the cascade feeding of the 1s2s2p ^4P metastable states produced by electron capture of He-like and H-like ions with gas targets [2].

The experimental measurements performed so far have been limited to electron capture to a mixed state ($1s^2$, 1s2s ^3S) 12 MeV C^{4+} ion beam generated at the terminal foil stripper. In order to perform measurements with both pure ground state as well as mixed state beams, our group has already started the installation of: i) A terminal gas stripper[3], ii) A stripping point along the beam line, hosting both foil and gas (post) strippers. This also allows us to vary the fraction of metastable 1s2s ^3S component. A schematic of the beam line in the accelerator room is displayed in Fig.1

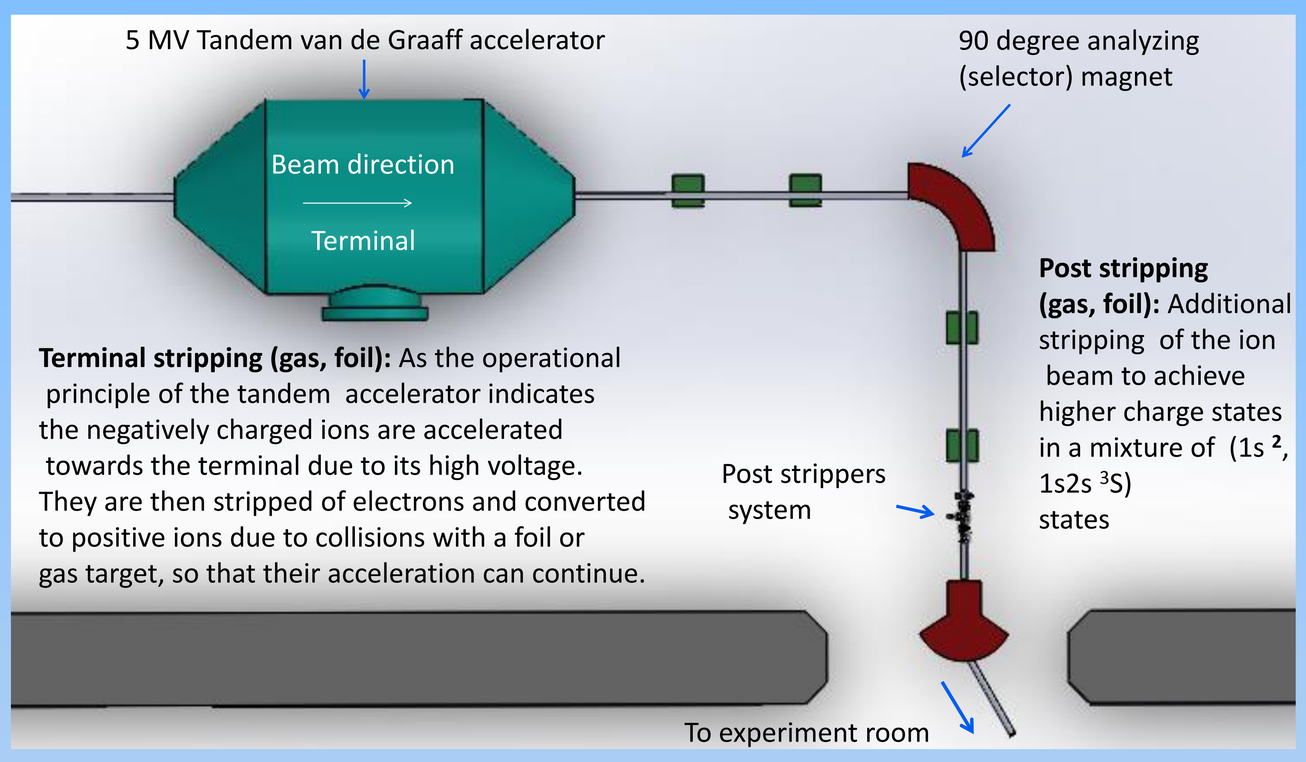

Fig. 1: 2-D view of the experimental setup inside the accelerator room. High charge states cannot always be achieved with the use of only the terminal stripper. These charge states can be achieved at a higher intensity only by using post strippers. Also, *gas* stripping in the terminal will allows us to produce pure ground-state ion beam, while foil stripping gives us a variably mixed state beam, making it possible to determine the fraction of the metastable 1s2s ^3S component.

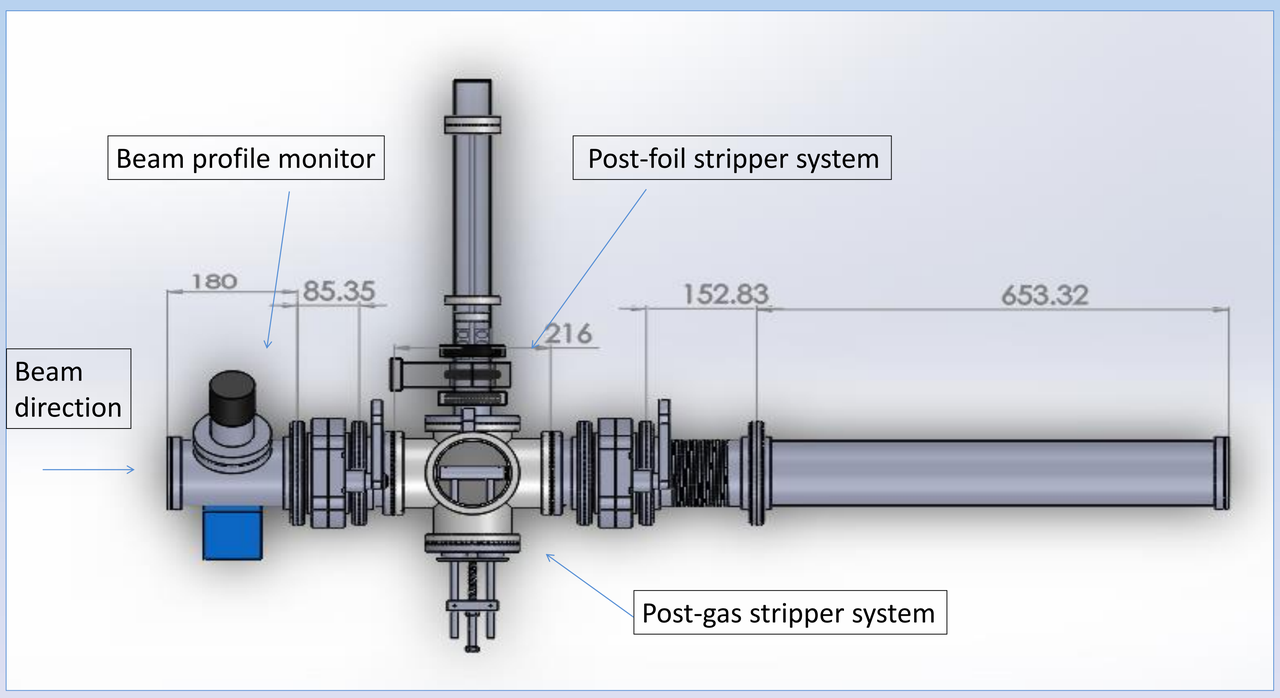

Fig. 2: 3-D view of the apparatus of the ion strippers installed in 'Demokritos' 5MV van de Graaff tandem accelerator room. The gas post stripper was fully designed by our group and built in the NCSR 'Demokritos' TANDEM accelerator machine shop, while the foil stripper has been used before in Kansas State University. In order to achieve a differential pumping of the inserted gas, a set of two baffles were placed before and after the gas stripper in the form of beam line valves. By this addition, and the support of a turbo pump placed exactly under the gas stripper, gas diffusion into the beam line is much reduced. All dimensions are in mm.

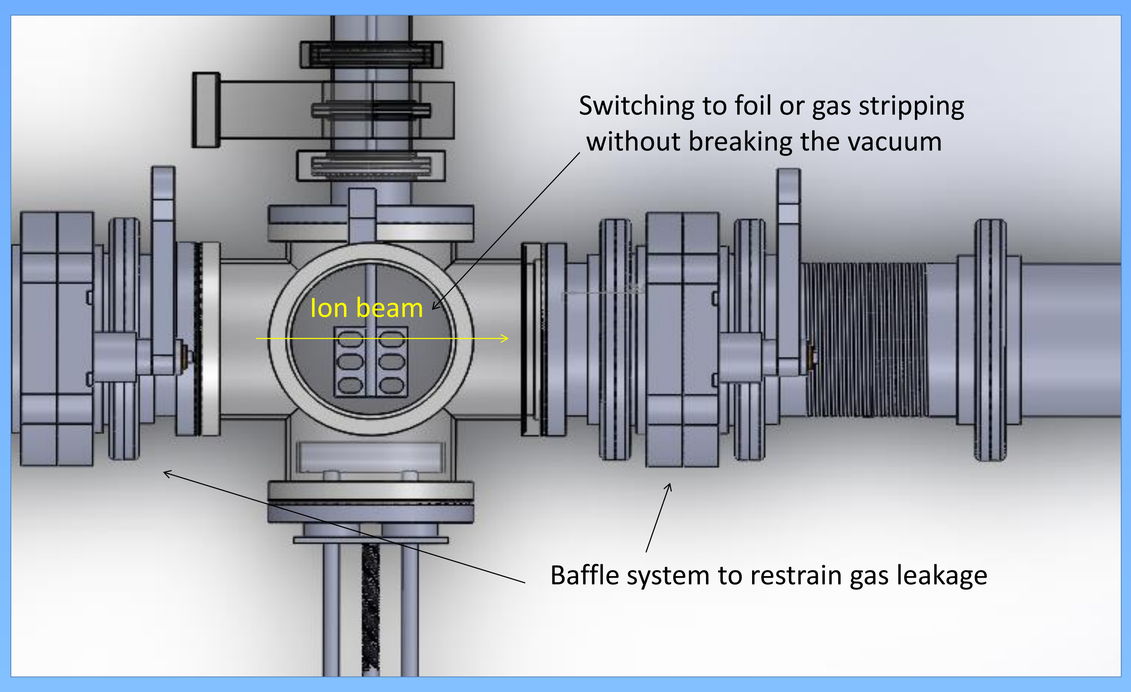

Fig. 3: The post stripping point in higher detail. Both strippers are placed in a 6-way cross that has already been installed in the tandem beam line.

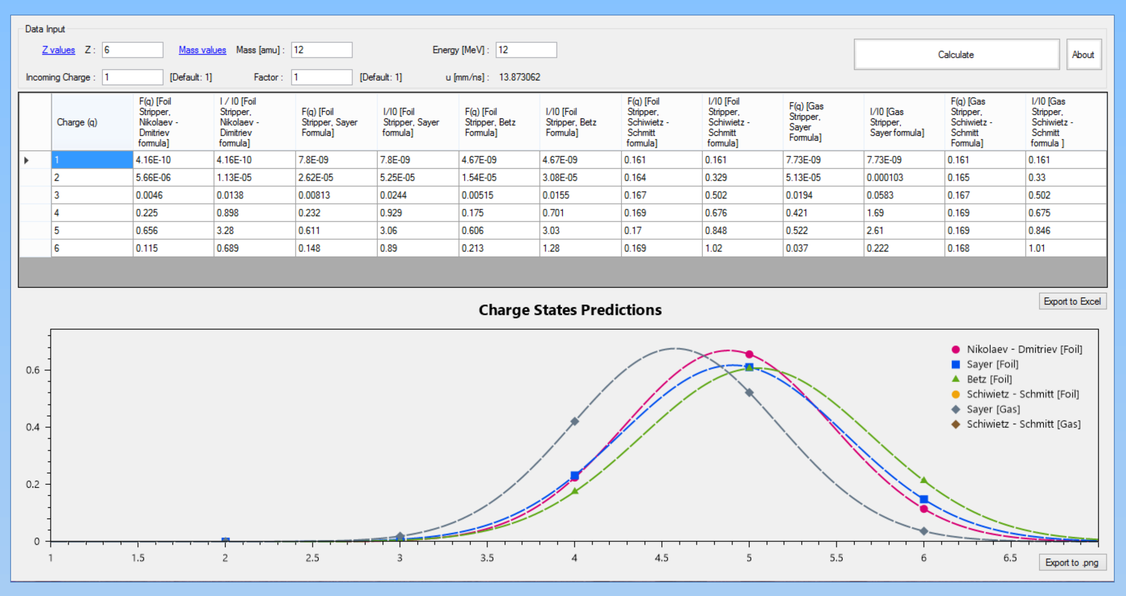

Fig. 4: Graphical output of the charge distribution by the program TARDIS developed by the APAPES group. TARDIS calculates the theoretical intensity of each charge state after stripping using various models such as the semi-empirical formulas of Nikolaev, Sayer, Betz and Schiwietz-Schmitt. TARDIS is available at the APAPES website (http://apapes.physics.uoc.gr/)

TANDEM Voltage (foil stripping) for C^{4+} ions production	5MV	4MV	3MV	2MV	1MV
Gas post stripping probability	0.14%	4.9%	15.3%	32.9%	16.1%
Foil post stripping probability	0.79%	2.6%	8.1%	21.7%	26.4%

Table 1: A short investigation using TARDIS program can give us valuable information about the optimal voltages of the tandem accelerator in order to have the highest intensity of a desired charge state. In this example the intensity of C^{4+} ion was examined with the use of a foil terminal stripper and a gas or foil post stripper. Note that for each method of post stripping the accelerator must be switched to a different energy.

Conclusion and future work:

- Post strippers have already been installed and are being tested
- The installation of a terminal gas stripper is in progress.
- In the near future, with both terminal gas and both post strippers operational we will be able to produce both pure ground state ion beam ($1s^2$) and mixed of (1s ², 1s2s ³S)state beams from which we can determine the available metastable (1s2s ³S) fraction. [3]
- The whole project is a brand new addition to the 'Demokritos' tandem accelerator laboratory as post stripping has never been used before.

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