Installation of a gas terminal stripper and a gas/foil post stripper system at the 5.5 MV Demokritos Tandem Van de Graaff accelerator

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Abstract

A gas stripper system was installed inside the terminal of the accelerator in addition to the existing terminal foil stripper system, while two additional post strippers (one gas and one foil) were also installed in the beam line between the analyzing and switching magnets of the Tandem. These additions are needed for the production of He-like ions used in the APAPES* project to investigate electron capture phenomena in ion-atom collisions by high resolution zero-degree Auger projectile electron spectroscopy in a dedicated experimental setup first put in operation two years ago.

Older experiments [1] have shown that for He-like ions foil stripping results in a mixed-state ($1s^2$, 1s2s) beam, while gas stripping in the terminal can produce an almost pure ground-state ($1s^2$) beam. Thus, ion-atom collision measurements using both strippers will allow for the determination of state-selective capture contributions solely from the metastable state (1s2s) of the ion observable in the associated projectile K-Auger electron spectrum. In addition, post-stripping will allow us to obtain ion charge states whose production is not possible with only one stage of stripping [2].

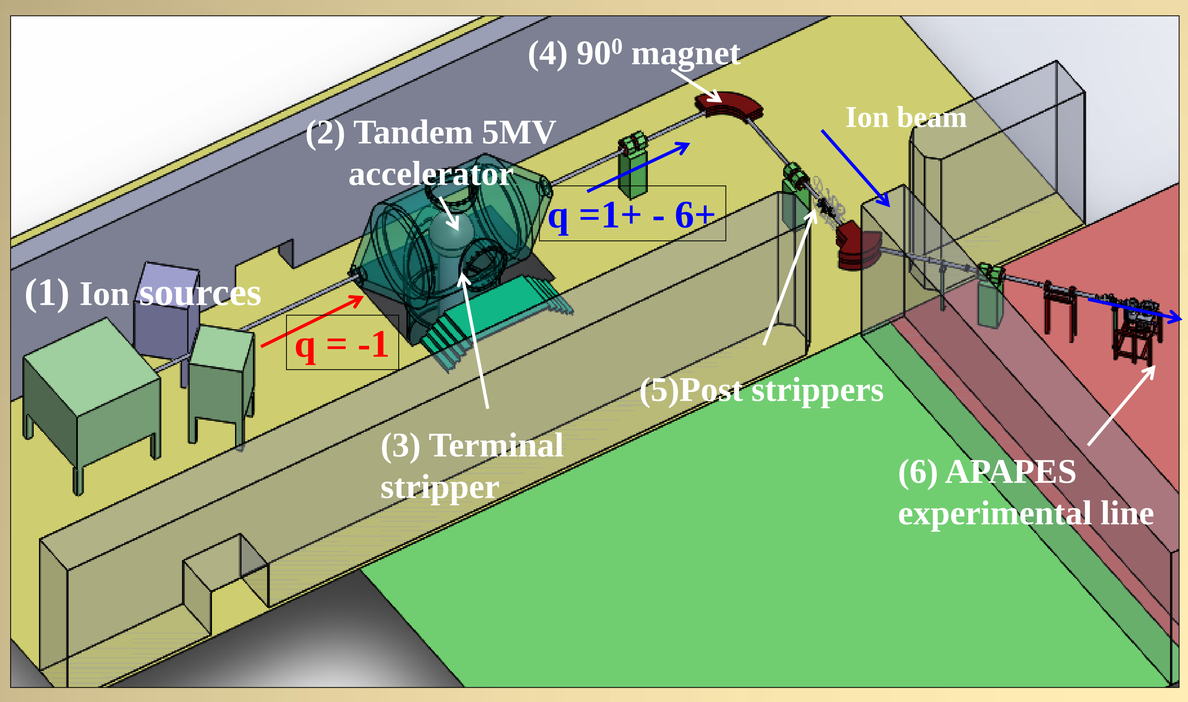

Fig. 1: The TANDEM accelerator laboratory of the NCSR "Demokritos" and the APAPES experimental station. The position of the three new strippers is indicated. The terminal strippers (foil and gas) give us the ability to produce a different fraction of a specific charge state while with the use of post strippers this ability is further expanded to charge states unavailable with only one stage of stripping.

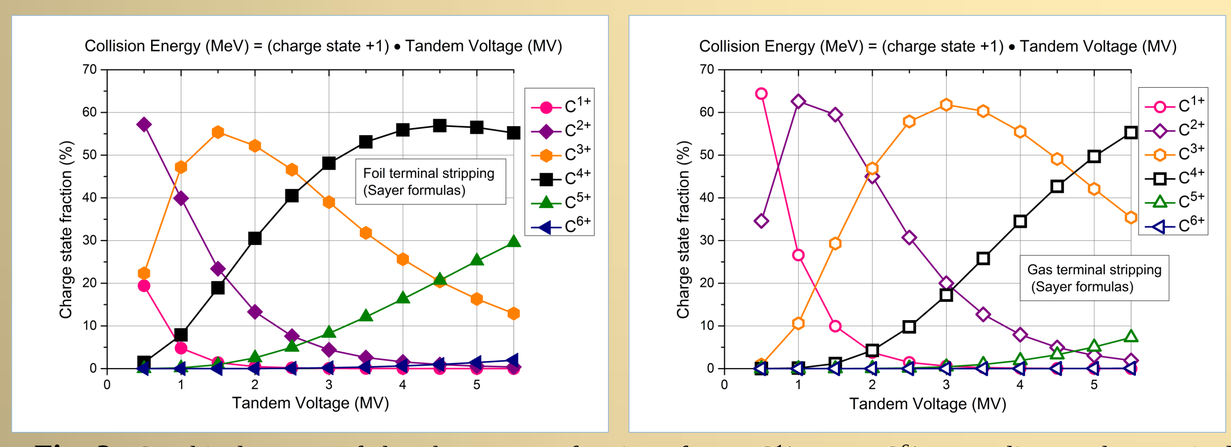

Fig. 2: Graphical output of the charge state fractions from C^{1+} up to C^{6+} according to the terminal voltage of the tandem accelerator calculated theoretically by the program TARDIS developed by the APAPES group [6]. In the case of terminal stripping the stripping energy of the ion beam is the same as the terminal voltage. Particular emphasis is given to the helium-like C^{4+} ion beam which is used in ion atom collisions for atomic physics research by APAPES group. TARDIS calculates the theoretical fraction of each charge state after stripping (terminal or post) using various models such as the semi-empirical formulas of Betz [2], Dmitriev [3], Sayer [4] and Schiwietz-Schmitt [5]. TARDIS is available at the APAPES website (http://apapes.physics.uoc.gr/)

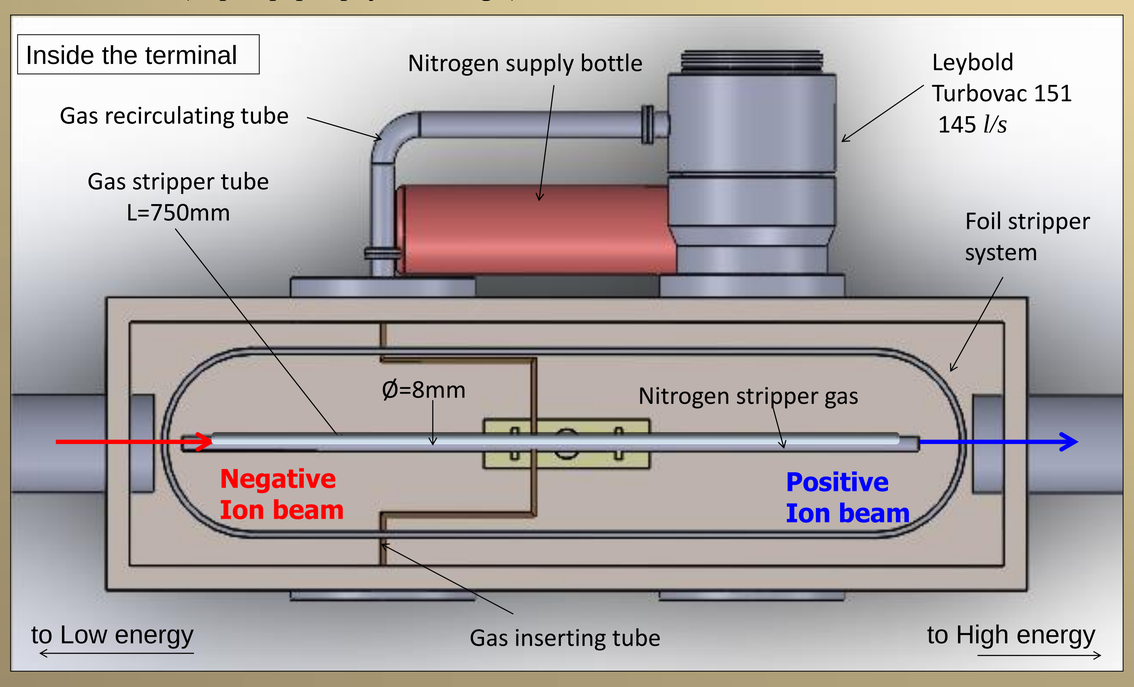

Fig. 2: 3-D view of the apparatus of the ion strippers installed in "Demokritos" 5MV Tandem Van de Graaff accelerator terminal. The addition to the existing foil stripper system is a gas stripper with a recirculating gas system to save on gas consumption. Lower energy gas stripping in the terminal will allow us to produce pure ground-state ion beam ($1s^2$) [6], while foil stripping gives us a variably mixed state beam ($1s^2$, 1s2s ^3S), making it possible to determine the fraction of the metastable 1s2s ^3S component.

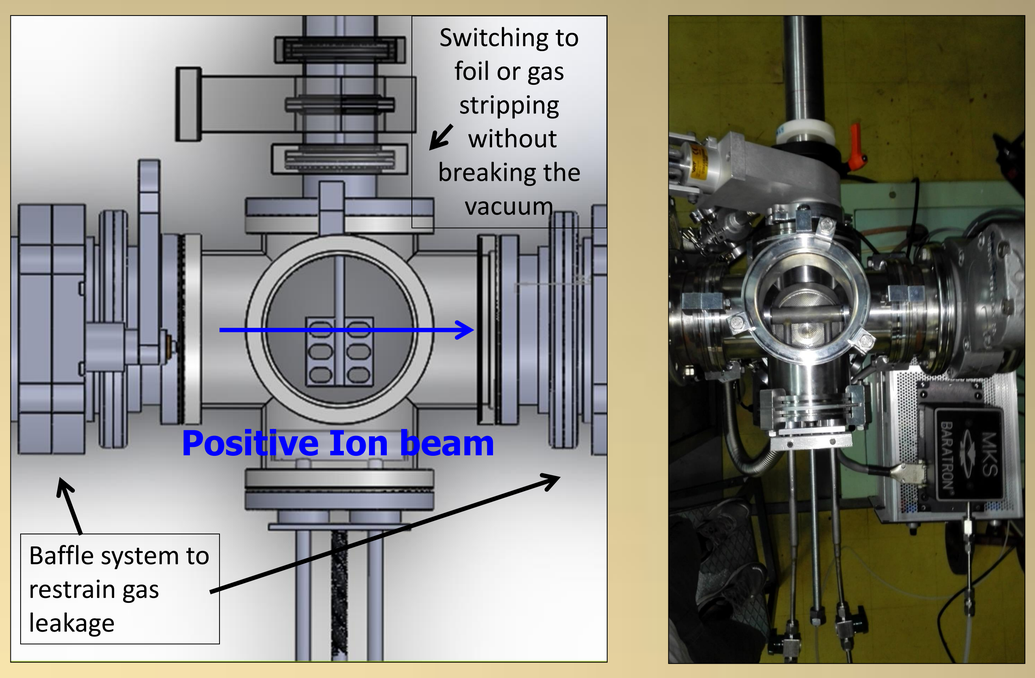

Fig. 4: 3-D design of the post stripping point in higher detail (left). Both strippers are placed in a 6-way cross that has already been installed in the Tandem beam line (right). The whole project was designed by APAPES group, and constructed at the Tandem's laboratory machine shop.

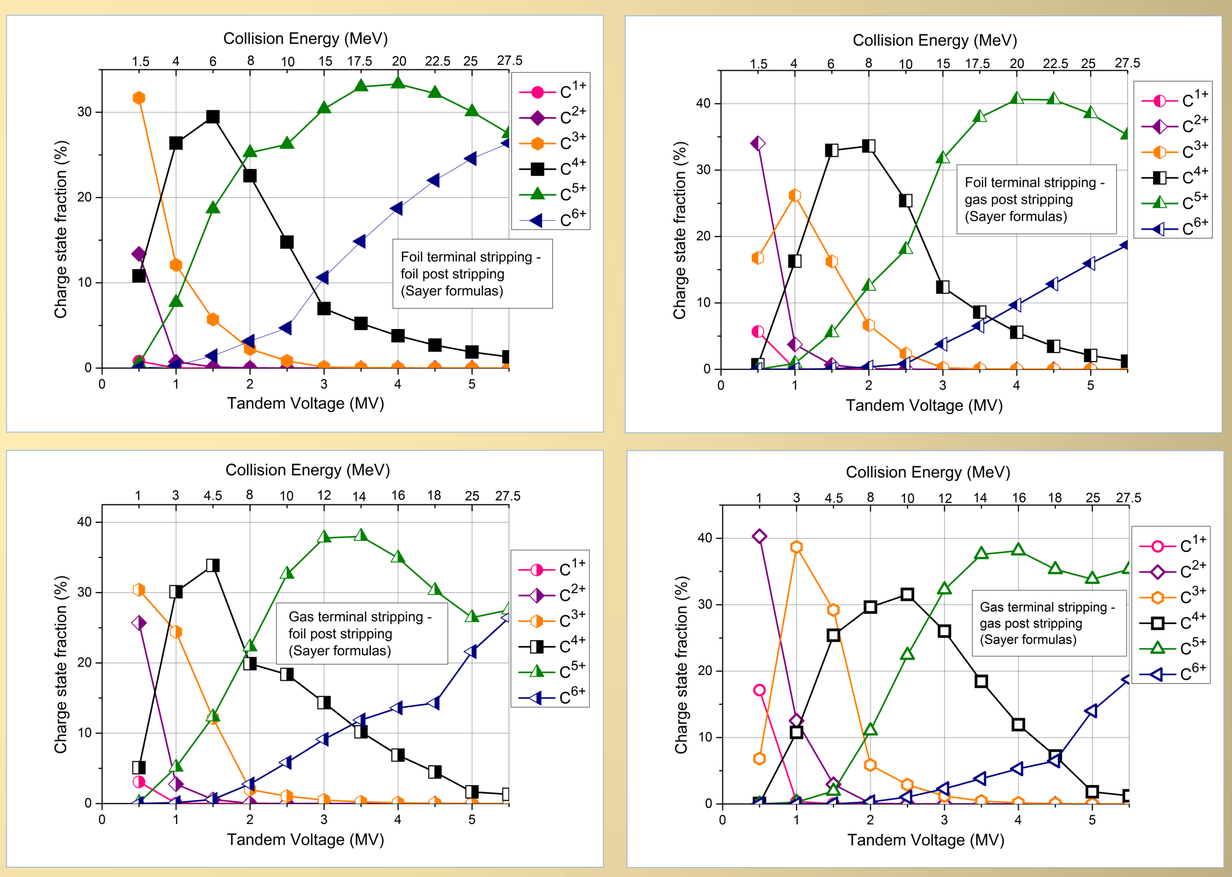

Fig. 5: Graphical output of the charge state fractions of C^{1+} up to C^{6+} according to the stripping energy as calculated theoretically by the program TARDIS developed by the APAPES group [7]. The addition of the two post strippers (gas and foil) gives the ability to produce enough fraction of charge states that would be impossible with only one stage of stripping.

Conclusion and future work:

- Post strippers have been installed and first spectra have been obtained with their use.
- The terminal gas stripper with the gas recirculating system has been installed and tests for its proper operation are in progress.
- Stripping energy dependence of ($1s^2$, 1s2s ^3S) measurements will be possible once the terminal gas stripper is fully operational.
- In the near future, with both terminal gas and post gas/foil strippers operational we will be able to produce both pure ground state ion beam ($1s^2$) and mixed ($1s^2$, 1s2s ^3S) state beams and determine the available metastable (1s2s ^3S) fraction. [1]
- Highly charged ions will be available in the near future also at lower collision energies.
- The fraction $^4P/(^2P_+ + {}^2P_-)$ can then be determined at the lower collision energies [6]
- The whole project is a brand new addition to the 'Demokritos' Tandem accelerator laboratory as neither post stripping nor terminal gas stripping has ever been used.

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