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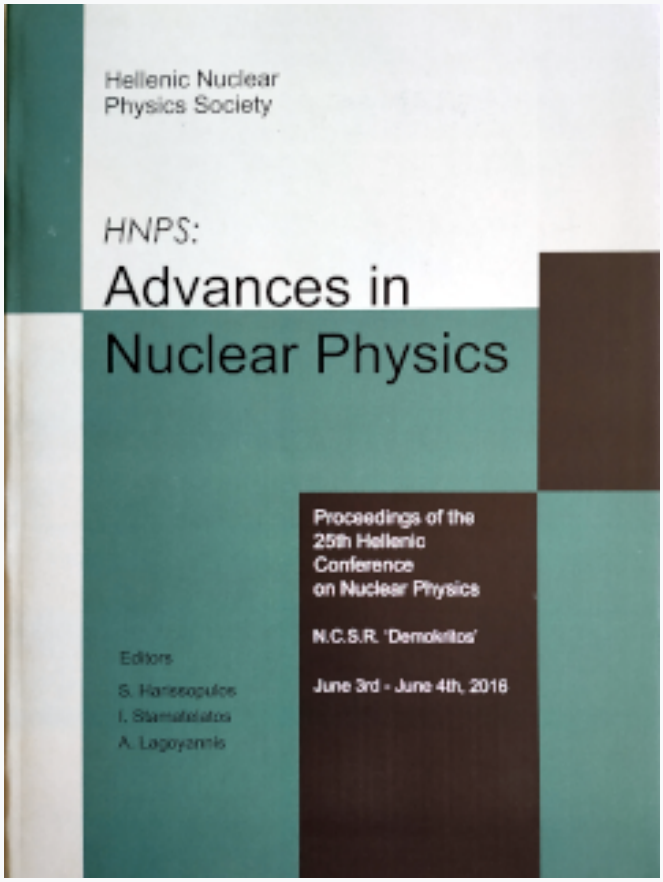


# Installation of a gas terminal stripper and a gas/foil post stripper system at the 5.5 MV Demokritos Tandem Van de Graaff accelerator

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# 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 has been installed inside the terminal of the Demokritos TANDEM accelerator, in addition to the existing 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 accelerator. These installations were necessary for the production of He-like ion beams used in the APAPES‡ project for the investigation of electron capture phenomena in ion-atom collisions using high resolution zero-degree Auger projectile electron spectroscopy in a dedicated experimental setup already in operation since two years. Older measurements have shown that for He-like ion beams foil stripping results in the production of a mixed-state beam ($1s^2$, $1s2s\ ^3S$), while gas stripping in the terminal can produce an almost pure ground-state ($1s^2$) beam [1-3]. Thus, using both strippers, collision measurements will allow for the selective determination of state-selective capture contributions from either the metastable- ($1s2s\ ^3S$) or the ground-state of the ion by judicious analysis of both associated projectile K-Auger electron spectra [4]. In addition, post-stripping will allow us to obtain ion charge states whose production is not possible with only one stage of stripping [5].

**Keywords:** ion strippers, tandem Van de Graaff accelerator, He-like beams, metastable ions

## INTRODUCTION

As part of the APAPES‡ research initiative, three new ion beam strippers have been installed in the 5.5 MV TANDEM Van de Graaff accelerator of the NCSR "Demokritos". Prior to this, no post strippers had ever been used at this accelerator. One of these strippers is a new additional terminal gas stripper which will complement the previously used foil stripper inside the accelerator terminal, while a post stripper utilizing both gas and foil stripping was also installed in the beam line section between the analyzing and switching magnets. The terminal gas stripper had been initially installed together with the foil stripper during the original purchase of the TANDEM accelerator, but was later removed due to some malfunctions regarding the vacuum inside the beam line. The newly installed foil post

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‡ APAPES: Atomic Physics with Accelerators, Projectile Electron Spectroscopy. http://apapes.physics.uoc.gr

stripper system had been previously used in the 7 MV Kansas State University tandem Van de Graaff, while the newly installed gas post stripper was a design based on original drawings also obtained from Kansas State, redesigned by the APAPES group and then built in the "Demokritos" TANDEM laboratory's machine shop. An extensive theoretical study of the ion charge state intensities produced was done prior to the installation of the strippers using the semi-empirical formulas of R. O. Sayer [6] through the TARDIS program [7]. Details of the "Demokritos" TANDEM accelerator facility showing the positions of the new stripping systems is shown in Fig.1.

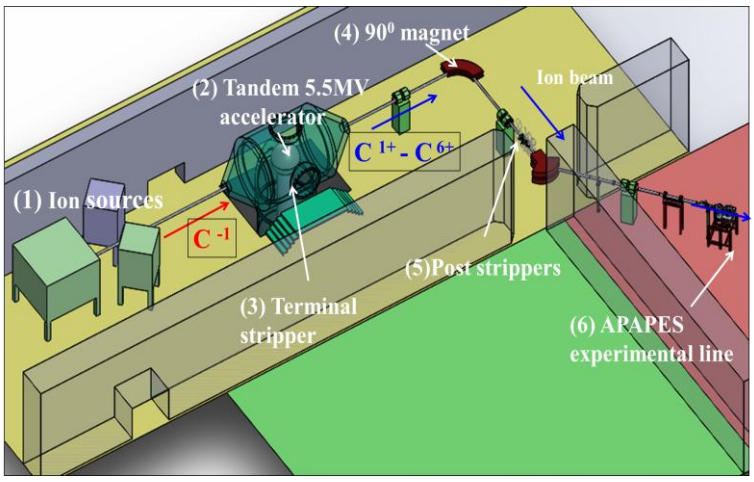


**Fig. 1.** The TANDEM accelerator laboratory of the NCSR "Demokritos" and the APAPES experimental station on the L30 beam line. The position of the three new strippers is indicated along the path of a carbon ion beam.

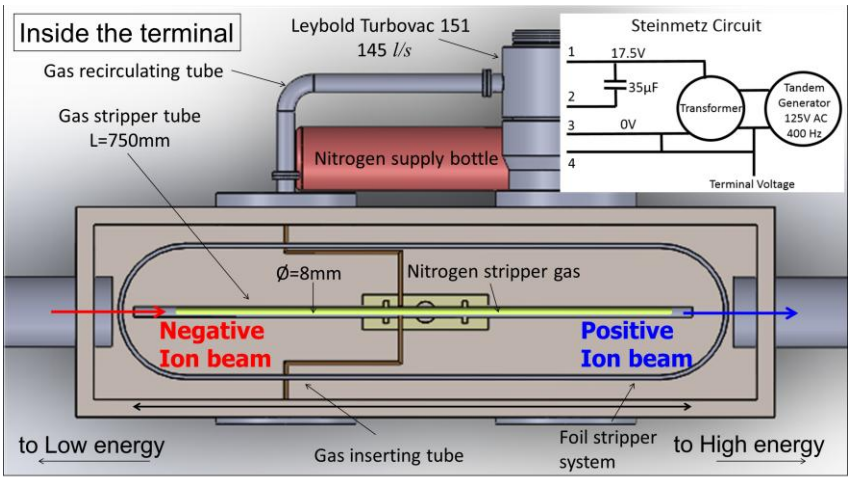


**Fig. 2.** Schematics of the gas and foil stripper systems inside the terminal of the TANDEM. Insert: The Steinmetz circuitry used to power the recirculating turbo pump from the belt generator.

## EXPERIMENTAL DETAILS

The installation of the terminal gas stripper, which allows for the production of low

metastable ($1s2s\ ^3S$) content beams, is shown in Fig. 2. The installation of the gas/foil post stripper system is shown in Fig. 3. This, aside from the ability to provide variable metastable beam content, also allows for the production of higher charge states at more intense beam currents than what was possible with only the single stripping inside the TANDEM tank.

A challenging task in the above designs was to maintain the pressure inside the beam line below $10^{-6}$ Torr while supplying enough gas pressure for ion stripping. This was achieved at the terminal gas stripper using a Leybold TM151 turbo pump to recirculate the excess stripping gas back into the stripper canal as shown in Fig. 2. The turbo pump was powered by a simple Steinmetz circuit used with a toroidal transformer to convert the single phase 400 Hz 125V AC belt generator terminal output to the three-phase 17.5V AC used by the pump. It was found that the TANDEM vacuum would effectively adjust, albeit quite slowly, to the changes in the stripping pressure securing proper operating conditions. At the post stripping area, both strippers were mounted on a 6-way cross, as shown in Fig. 3, which was pumped by a 250lt/s turbo pump. A system of two removable baffles mounted at the entry and exit of the ion beam path through the 6-way cross was used to create a doubly differentially pumped area restraining the gas from polluting the rest of the beam line. The removable baffles were built after modifying two spare gate valves. The gas pressure inside the gas post stripper was efficiently controlled utilizing a needle valve with a capacitive manometer coupled to an electronic feedback controller.

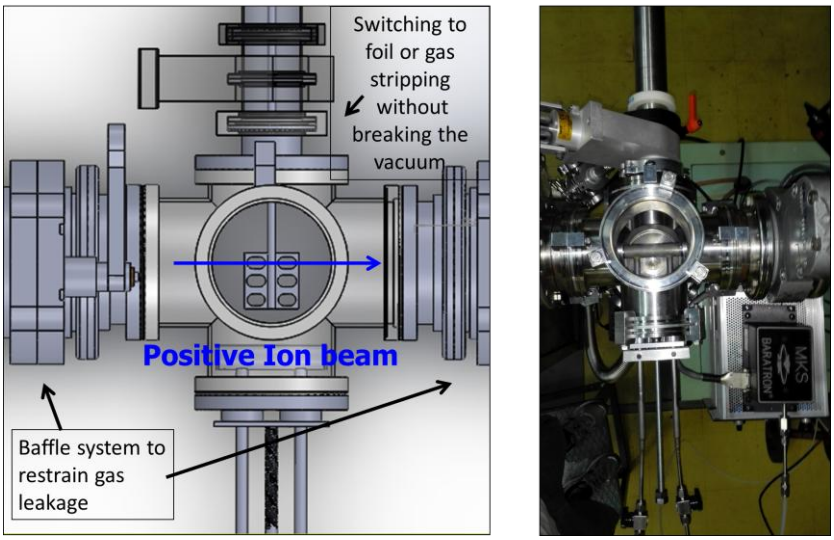


**Fig. 3:** Left: 3-D detail design of the post stripping area. Right: Both post strippers shown placed in a 6-way cross installed in the TANDEM beam line a bit before the switching magnet.

## RESULTS AND DISCUSSION

One of the major goals of the APAPES project is the reduction of the experimental Auger spectra so as to study only the isolated contributions from *just* the metastable beam component ($1s2s\ ^3S$) normally found in He-like beams as a 20-30% admixture to the ground state ($1s^2\ ^1S$). As recently shown, this requires two measurements with mixed ($1s^2\ ^1S$, $1s2s\ ^3S$)

state beams having appreciably different metastable beam content [4]. These conditions are met when producing the ions with both foil stripping and gas stripping (either terminal or post stripping) making necessary the above described strippers for such measurements.

The terminal gas stripper and the foil/gas post strippers have been experimentally tested during a few beam times and proved to be operational. Especially, the post stripping setup has provided some promising preliminary data on $C^{4+}$ beams, although further study is needed with possibly better differential pumping conditions which are already planned. The terminal gas stripper provided us with more concrete results on projectile Auger spectra with much lower metastable fraction compared to those obtained using only the terminal foil stripper. Currently, we are in the process of better understanding the dependence of the beam fraction on the pressure of the gas stripper. Both strippers provided us with enough beam even at lower collision energies of the $C^{4+}$ charge states necessary for our measuring conditions. Soon, we hope to complete our measurements for the carbon He-like ions and then extend them to similar isoelectronic studies of other low-Z ions.

## CONCLUSIONS

A terminal gas stripper along with both gas and foil post strippers have been installed in the TANDEM of the NCSR "Demokritos" as part of the APAPES research initiative. The ion strippers are expected to provide the accelerator with the ability to produce He-like ions of variable metastable ($1s2s\ ^3S$) content necessary for the APAPES measurements. Preliminary tests with $C^{4+}$ charge states obtained both with gas/foil stripping and gas/foil post stripping have shown that both strippers are now operational. We expect in the near future to have better control of both the beam current and its metastable content using a judicious selection of terminal and post stripper combinations. The new stripping systems will of course be available to all users, allowing for the use of ion beams at energies and charge-states not previously possible.

## ACNOWLEDGEMENTS

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