DETERMINATION OF THE EFFECTIVE SOLID ANGLE OF THE 1s2s2p ^4P METASTABLE AUGER DECAY IN FAST ION-ATOM COLLISIONS USING SIMION 8.1 IN A MONTE-CARLO TYPE SIMULATION

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Abstract

Our goal is to investigate the formation mechanisms of the 1s2s2p ^4P metastable state in energetic collisions of He-like ionic projectiles with gas targets. In order to do that, we need to study the Auger decay of these states. Due to their long lifetimes (10^{-6}-10^{-9} s) their decay occurs well after the excitation region, making the determination of the detection solid angle non-trivial. An experimental setup (Fig.1), involving a Hemispherical Deflector Analyzer (HDA) equipped with 4-element injection lens and a 2-D Position Sensitive Detector (PSD), is currently located at the 5 MV TANDEM accelerator of the National Research Center "Demokritos" in Athens, as a part of the APAPES [1] research initiative. Here, we present Monte-Carlo type simulations, using the SIMION 8.1 package [2]. Random electron distributions in energy and emission angles were used to simulate the metastable Auger decay along the projectile ion trajectory, while the number of electrons detected on the PSD was recorded. Upon systematic study, the effective solid angle correction factor G_τ for the ^4P decay was accurately determined. Our results were found to have excellent agreement both with previously published data, concerning metastable ^4P and prompt Auger projectile states formed by electron capture in collisions of 25.3 MeV F^{7+} with H_2 [3], as well as with new experimental data of 12 MeV C^{4+} collisions with Ne acquired within the APAPES project [4]. These results are of great importance for the accurate evaluation of the 1s2s2p $^4P/^2P$ ratio of K-Auger cross sections, whose observed non-statistical production by electron capture into He-like ions, recently a field of interesting interpretations [5], awaits further resolution.

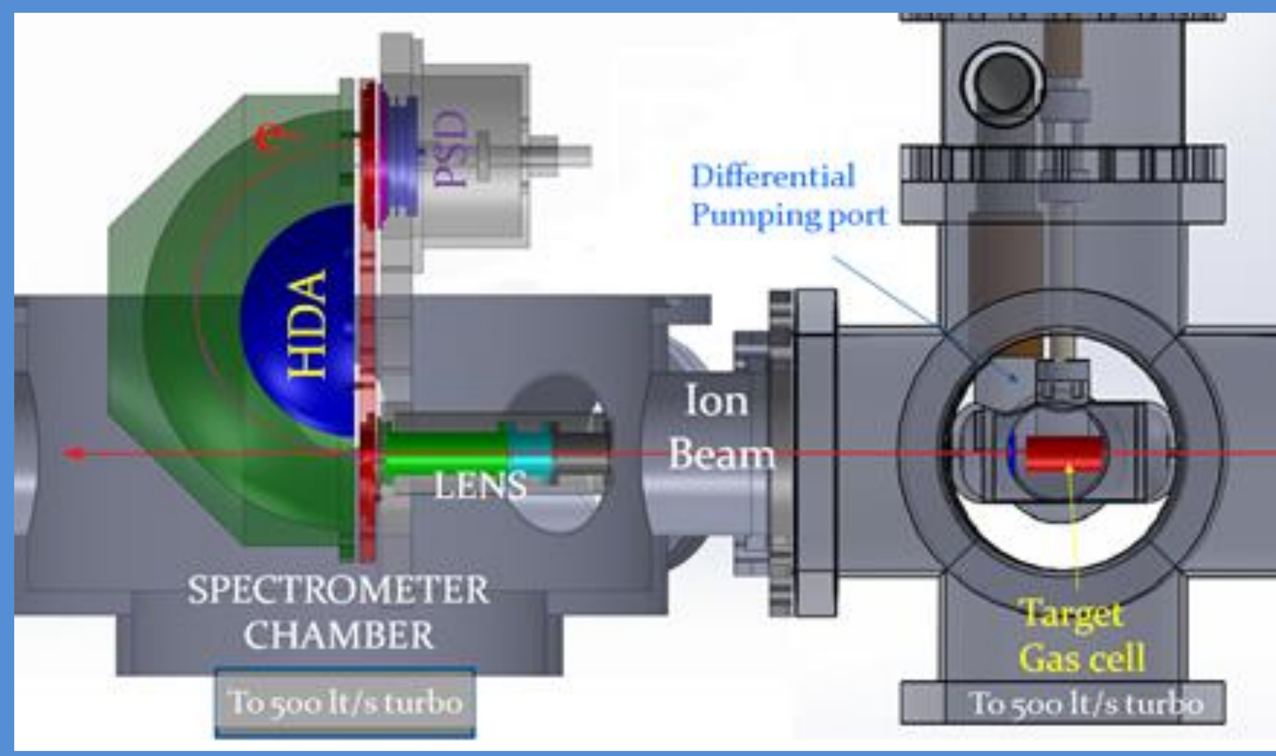

Fig. 1: Doubly Differentially pumped target gas cell, along with Paracentric Hemispherical Deflector Analyzer (HDA) with 4-element input lens and 2-D Position Sensitive Detector (PSD). Each color denotes a different voltage.

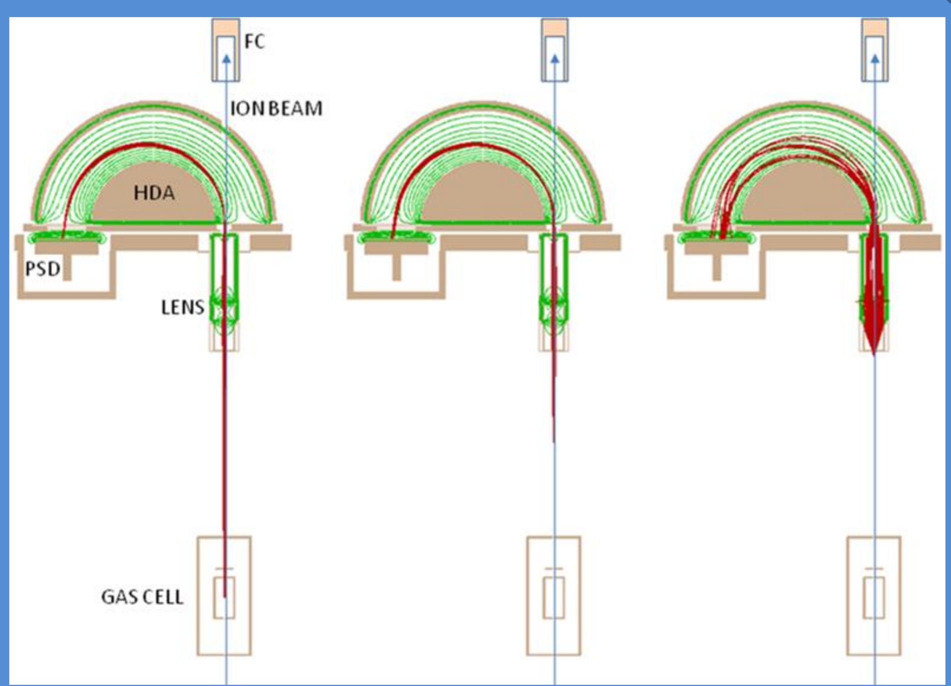

Fig.2: 2-D view of the experimental setup. The ionic projectile beam interacts with the atoms at the gas cell, whose Auger decay occurs along the beam path all along to and through the spectrometer. Electrons emitted from the excited ions are focused by the lens at the entry of the HDA to be detected at the PSD. The ions continue their way through the spectrometer and are finally collected by a Faraday cup (FC). Three different cases of the ionic states Auger de-excitation are illustrated: [*Left*] At the center of the gas cell. [*Middle*] At the mid-distance between the center of the gas cell and the lens entry. [*Right*] At the neighborhood of lens entry, where the solid angle effects become considerable.

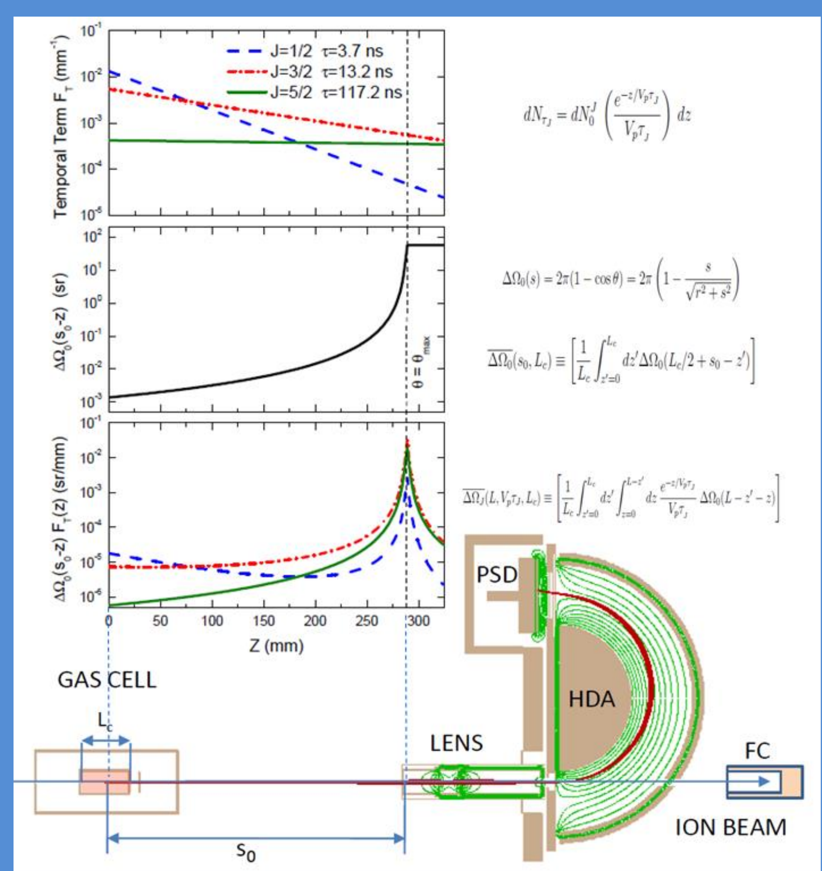

Fig 3: Z-dependence along the ion trajectory for the probability decay density (top), the point source solid angle $\Delta\Omega_0(z)$ (middle) and their product (bottom) as calculated for the 1s2s2p ^4P_J states in the case of a 12.0 MeV C^{4+} ionic beam. At the very bottom drawn to scale is the experimental geometry showing the gas cell, the lens and the HDA.

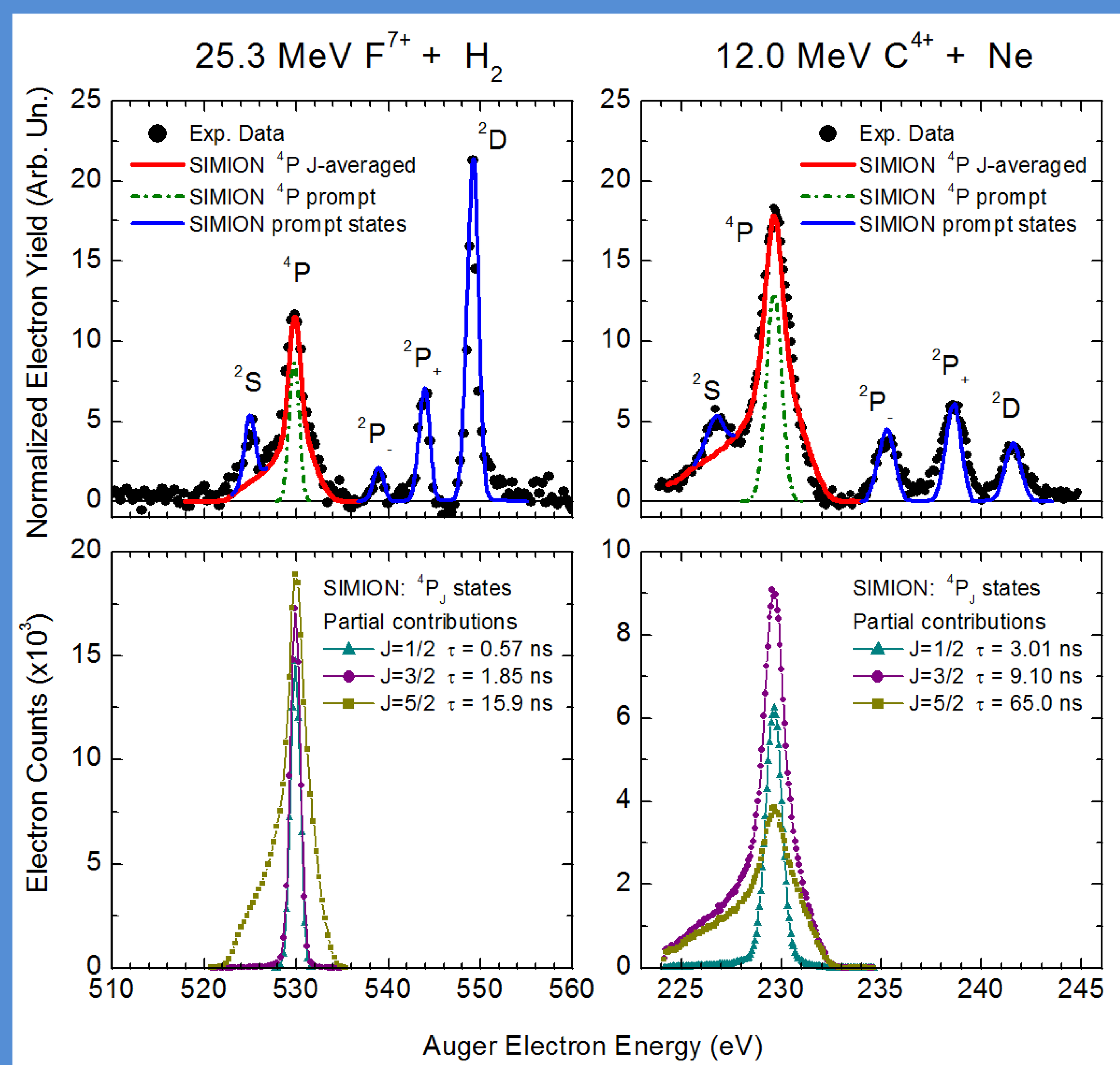

Fig.4: [Top] Presentation of SIMION Monte Carlo type calculations of the line shape of the Auger electron yields from metastable and prompt states in comparison to experimental data. [Bottom] Individual contributions of the J states to the ^4P state. [4]

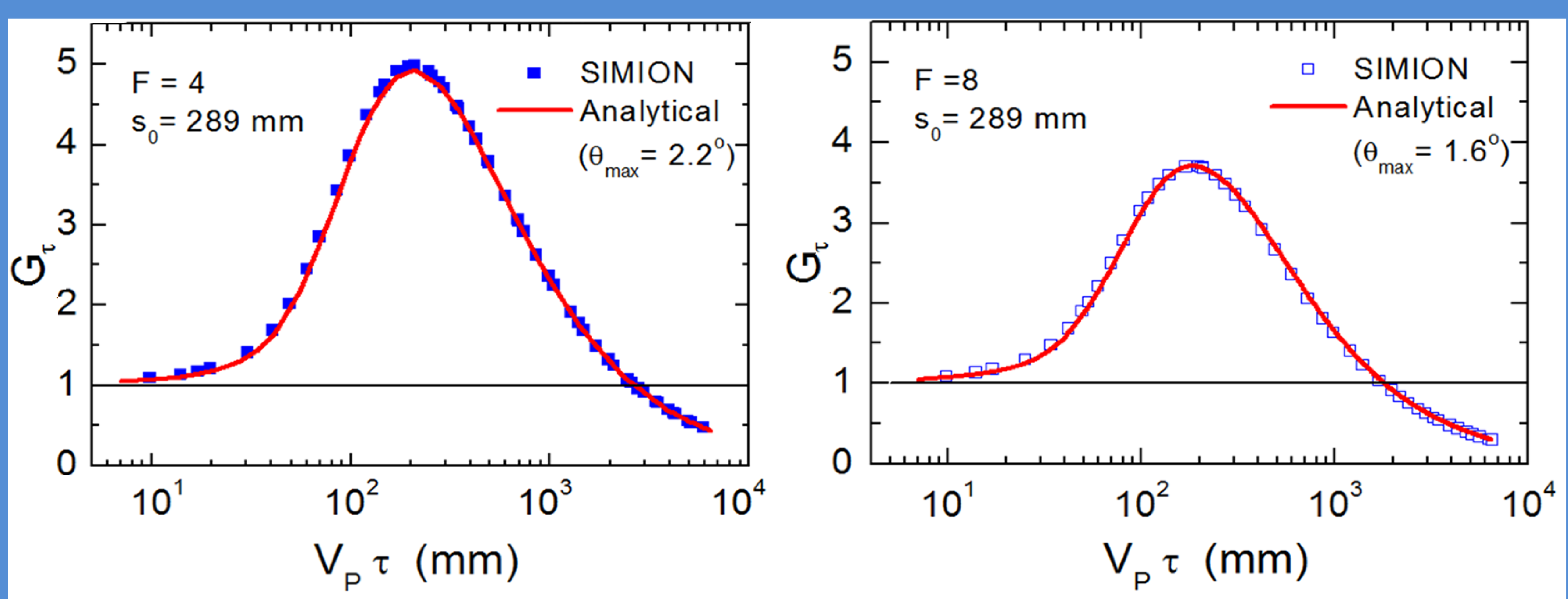

Fig.5: The effective solid angle correction factor G_τ as a function of the universal parameter $V_p\tau$, where V_p is the projectile velocity and τ the lifetime of the state. [Left] Case of gas deceleration factor F = 4. [Right] Case of gas deceleration factor F = 8. The solid lines represent analytical calculations terminated at maximum angles 2.2◦ for F = 4 and 1.6◦ for F = 8 in order to fit the SIMION results.

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