Separation and solid angle correction of the metastable 1s2s2p ^4P Auger yield produced in ion-atom collisions using the biased gas cell technique: A tool for the determination of the population mechanisms

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We demonstrate an experimental approach to the solid angle correction needed for the metastable 1s2s2p ^4P state obtained in ion-atom collisions with gaseous targets. By applying a small bias voltage V_{GC} on the target gas cell, the ^4P contributions are separated into two peaks one arising from inside (which is shifted by $e \cdot V_{GC}$) and the other outside the gas cell which is unshifted. Using SIMION we compute the correction in each case and perform a consistency check on our approach.

A persisting problem in the analysis of Auger spectra obtained in collisions of He-like ions with gaseous targets using zero-degree Auger projectile spectroscopy is the determination of the correct contributions from the 1s2s2p $^4P_{1/2,3/2,5/2}$ metastable states to the measured total ^4P Auger electron yield. Their inherent long lifetime (>10^{-9}s) results in their decay all along the projectile path towards (and through) the spectrometer. Thus, the overall electron detection solid angle varies with the position of electron emission and therefore a considerable correction to the ^4P_J electron yields is needed. In the literature this correction has been treated either geometrically [1] or by SIMION simulations [2](See Figure 1).

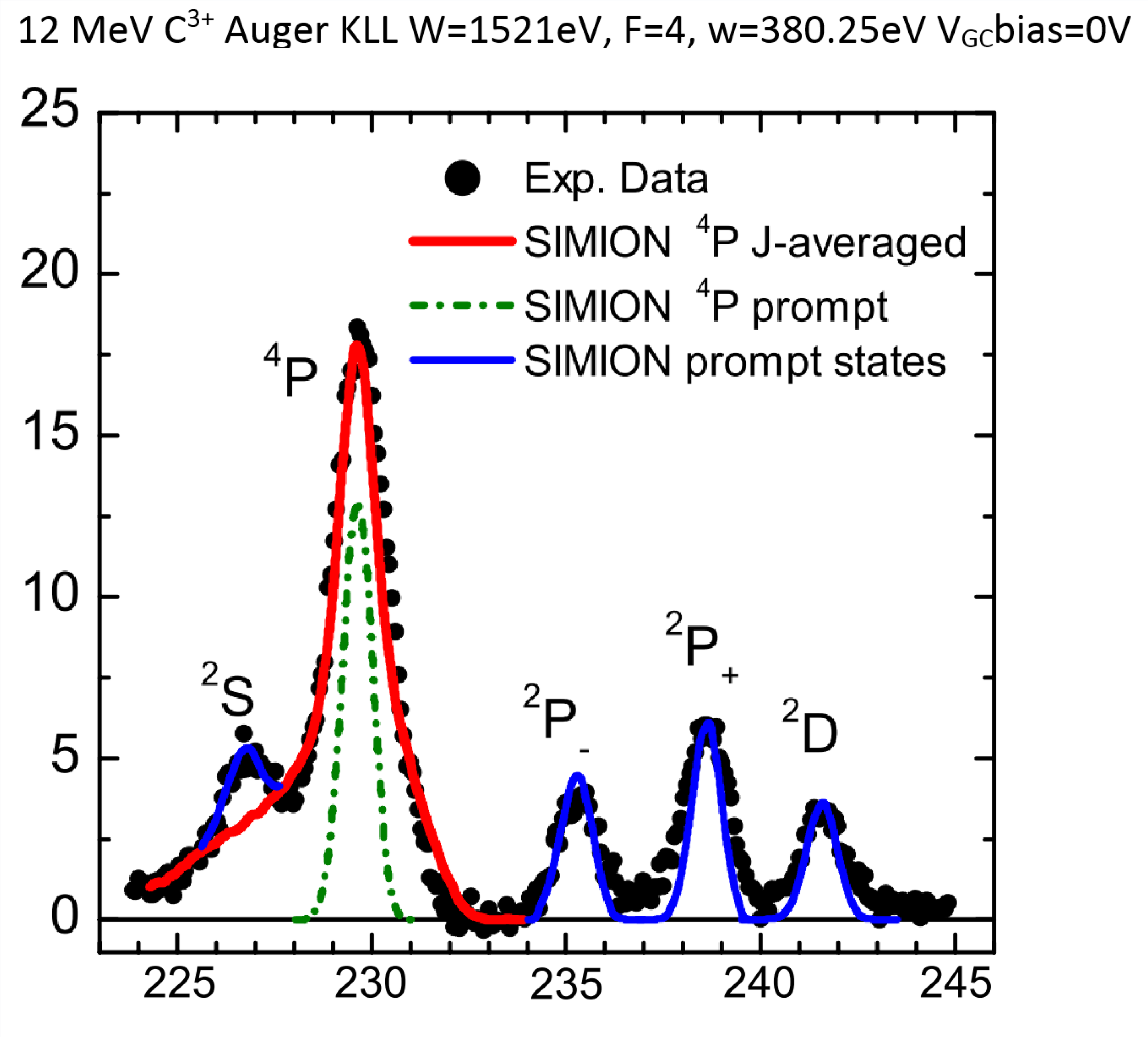

Figure 1. SIMION simulations over experimental spectra with a non-biased gas-cell in the rest frame. The ^4P line is decaying along the beam path due to the various lifetimes, which results to a non-constant detection angle and a non-analytical correction for electrons emitted inside the lens[2].

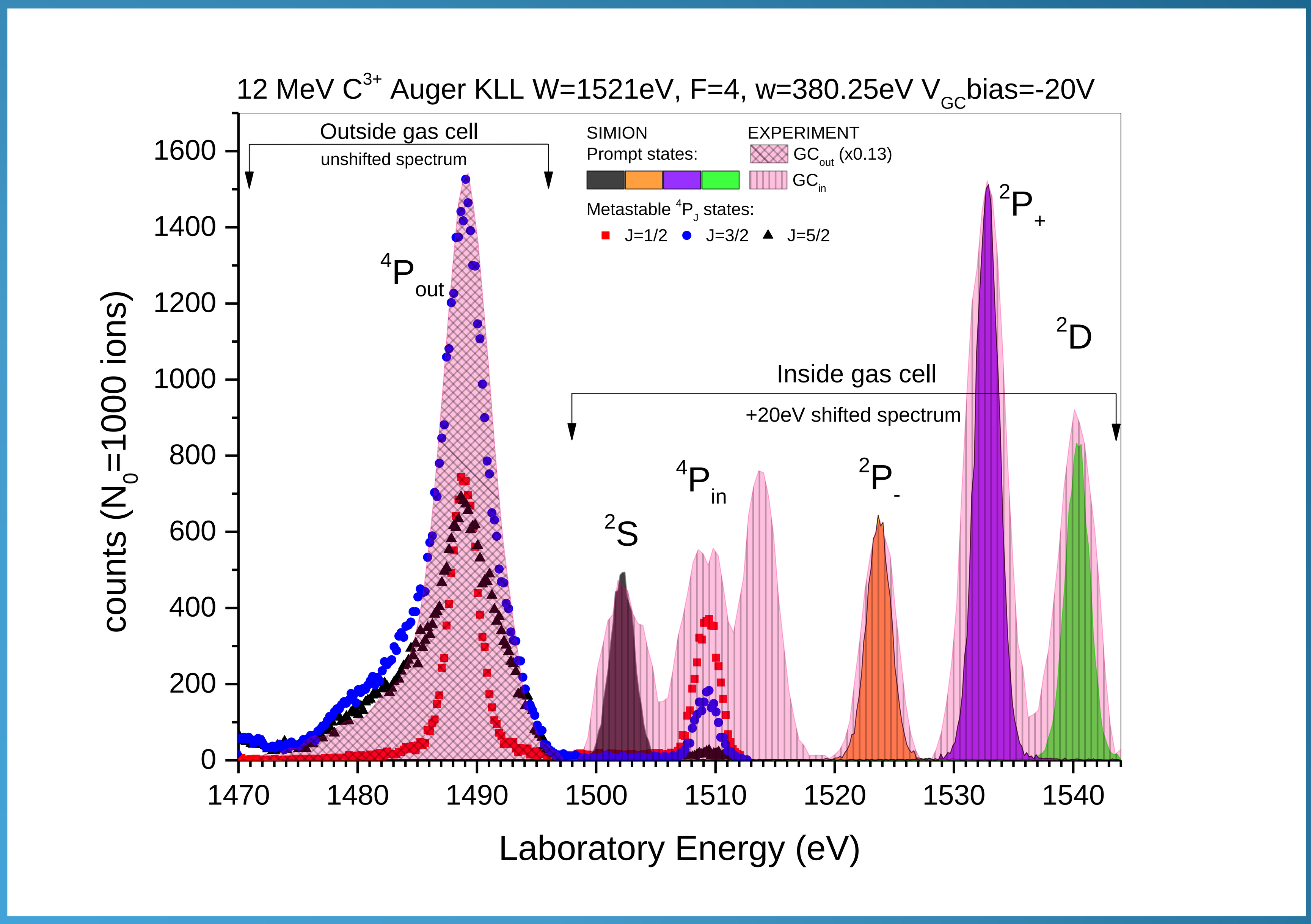

Figure 2. Comparison of SIMION simulations to experimental spectra. In both cases, the ^4P line is seen to be broken into two separate components, the unshifted line from electrons emitted outside the gas cell and the shifted line from electrons produced from inside the gas cell which is biased at $V_{GC}=-20$ V. SIMION results (scaled to the experimental spectrum) are seen to nicely reproduce the line shapes of both the metastable ^4P state and the prompt doublet states.

Another existing approach, which however has not been given sufficient attention, is adopted here. The separation of the ^4P_J yields produced inside and outside the target can be accomplished experimentally by applying a relatively small voltage (e.g. -20 V) to the gas cell [3]. Thus, the ^4P line now breaks in the spectrum into two separate components, i.e. one produced inside and the one produced outside the gas cell, as seen in Figure 2. The one produced inside the gas cell can be straightforwardly used with minimal correction in the determination of the ratio $R={}^4P/{}^2P$ of production cross sections. This ratio, has been of recent interest as large departures from the expected statistical value of R=2 have been reported lending themselves to various explanations as to the possible mechanisms involved [4-5].

Here we present results of the application of this method in collisions of 12 MeV C^{4+} with gaseous targets (H_2, He, N_2, Ne). The ratio R is then estimated, details of which will be provided. These results are part of the APAPES research initiative [6]

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