Forward-electron Spectroscopy in the ESR

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We present first results for electron loss to continuum (ELC) Cusp and Binary Encounter (BE) measurements during commissioning of the new forward electron spectrometer in the ESR storage ring.

Zero degree electron spectroscopy in relativistic heavy ion-atom collisions is a powerful tool to study fundamental aspects of the dynamics of collisions processes as electrons carry the most direct information about shape and orientation of excited and continuum states [1]. For this reason ELC and electron capture to continuum (ECC) Cusp structures, particularly multiply excited autoionizing projectile Rydberg states have been in the focus of interest for quite some time. The high velocity of ions in the ESR will permit corresponding studies now to be performed for very heavy highly charged ions in unprecedented resolution.

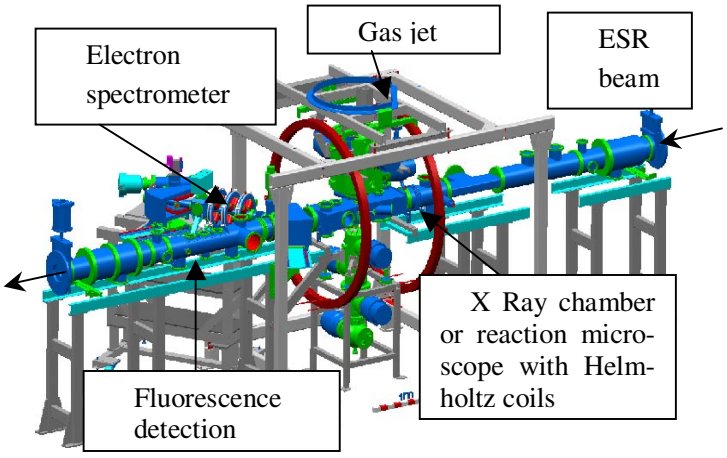

Fig.1: Set-up of spectrometers in the jet target zone of the ESR

The determining factor in the design of the forward spectrometer has been the task of reconstructing the initial vector momenta of fast, $v_e \sim v_{proj}$, electrons emitted near 0^0 while assuring a minimum interference with the circulating ESR beam. We chose a dipole-quadrupole triplet-dipole configuration (see fig.1) followed by a 2D position sensitive detector behind momentum defining slits in the focus of the 2. dipole. During commissioning using U^{89+} an almost background free identification of Cusp electrons could be established via energy analysis in a Si(Li) following momentum analysis. Almost all electrons appear in coincidence with U^{90+} [2]. In fig.2 an ELC Cusp spectrum for 388AMeV U^{89+} + N_2 is shown. The spectrometer is stepped through a range of Bρ values corresponding to a transmission of electrons with energies around the Cusp energy E_0 = 213keV. In the present configuration with a Si(Li) detector in the focus of the second dipole the measured width is dominated by the low instrumental resolution set to Δp/p=4.2%. This corresponds to transitions in autoionizing Rydberg levels already with n<30 to fall outside the FWHM. The calculated location of transitions involving n=30 is indicated in fig.2. In fig.3 a BE electron spectrum for 0^0 – emission angle is displayed for the same detector configuration as above.

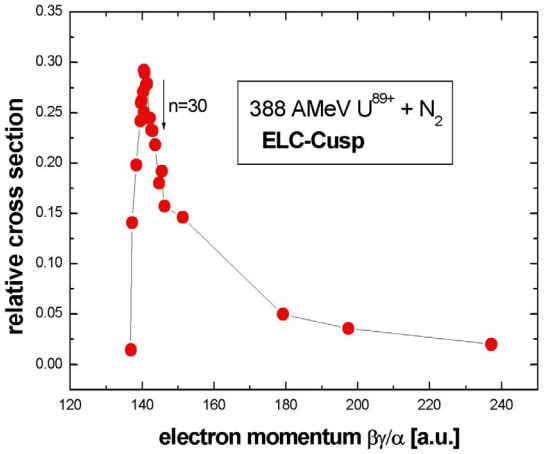

Fig.2: ELC - Cusp for 388AMeV U^{89+} ($1s^2 2s$) + N_2

The peak maximum is slightly below p=173 a.u. found from free 2-body relativistic kinematics due to binding energy corrections. The width of the peak of Δp/p =7% is, too, dominated by the set instrumental width; a preliminary width of the intrinsic electron momentum profile of ±4.5a.u is derived, possibly indicating strong inner shell contributions.

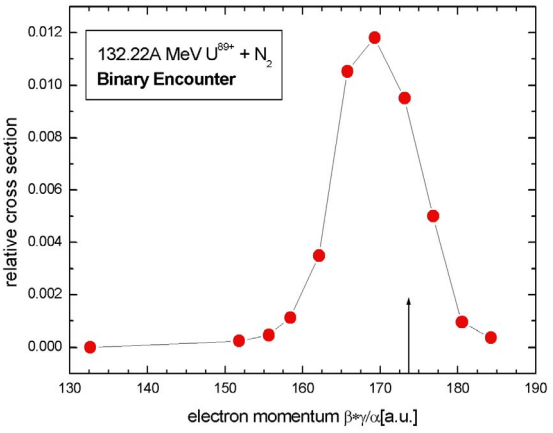

Fig.3: 0^0- Binary Encounter Electrons for 132.2AMeV U^{89+} + N_2

Next, with momentum defining slits and the 2D position sensitive detector in location the calculated momentum resolution of better than 10^{-3} will allow predicted asymmetries in the Cusp and autoionizing Rydberg states to be investigated. A recently predicted very strong anisotropy of ECC Cusp electron emission in the radiative ionisation (RI) process [3] will be accessible for the first time via measurements of 0^0 – Cusp RI-X ray coincidences. We also note that the combination of the forward electron spectrometer with the new reaction microscope allows for the first time to study kinematically complete (e,2e) reactions with high Z highly charged ions.

[1] J. Burgdörfer, Lecture Notes in Physics 213(1984) 32

[2] S. Hagmann et al., NIM B(2003) in print

[3] D. Jakubaßa-Amundsen, priv. comm.(2002) subm. J.Phys. B(2003)