Forward-electron Spectroscopy in the ESR

S.Hagmann[1], Th. Stoehlker[1,2], R. Moshammer[3] , J. Ullrich[3] , R.Doerner[1], Ch. Kozhuharov[2], F. Bosch[2], H. Rothard[4], H.Schmidt-Boecking[1], M. Steck[2], P. Beller[2], F. Nolden[2], R.Steiner[2], P. Spiller[2], M.Nofal[1], R. Mann,[2]

[1]Inst.f. Kernphysik, Univ. Frankfurt, [2]GSI-Darmstadt, [3]MPI f. Kernphysik, Heidelberg, [4]CIRIL,GANIL, Caen, France

We present first results for electron loss to continuum (ELC) Cusp and Binary Encounter 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 haven 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.

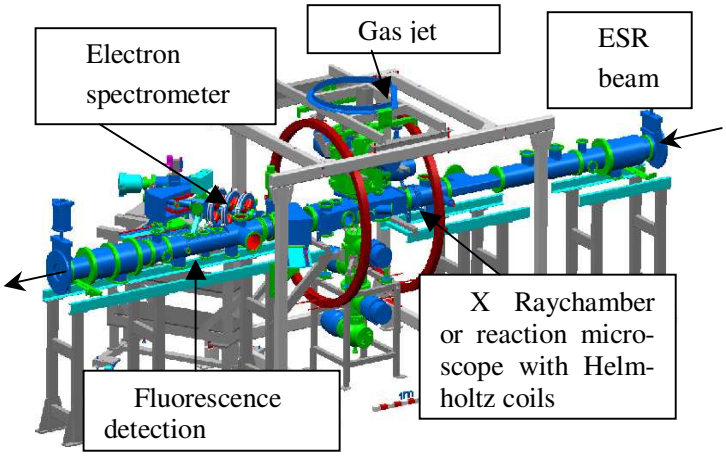

Fig.1: Set-up of spectrometers in supersonic jet target zone of the ESR

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, resulting in a dipole-quadrupole triplet-dipole configuration combined with a 2D position sensitive detector following momentum defining slits in the focus of the 2. dipole. During commissioning 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 binary encounter electron spectrum for 0^0 emission angle is displayed for the same detector configuration as above.

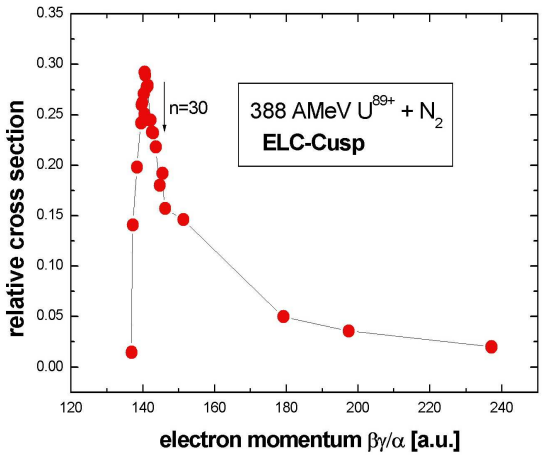

Fig.2: Electron Loss to Continuum Cusp for 388AMeV U^{89+} ($1s^2 2s$) + N_2

The peak maximum is found at p= 174 a.u in close agreement with p= 173 a.u. found from relativistic kinematics. The experimental 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. With momentum defining slits and the 2D position sensitive detector the calculated momentum resolution of better than 10^{-3} will allow predicted asymmetries in the Cusp and autoionizing Rydberg states to be investigated.

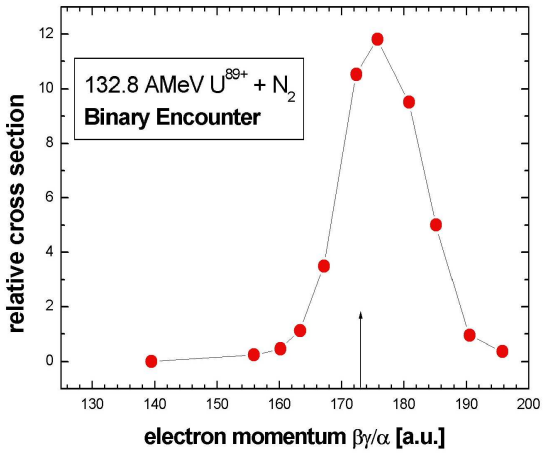

Fig.3: 0^0 Binary Encounter Electrons for 132.8AMeV U^{89+} + N_2 collisions

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. Burgdoerfer, Lecture Notes in Physics 213(1984) 32
2. S.Hagmann et al., NIM B(2003) in print
3. D. Jakubassa-Amundsen, private communication 2002 and subm. to J.Phys. B (2003)