Journal of Physics: Conference Series **635** (2015) 022087 doi:10.1088/1742-6596/635/2/022087

A lepton spectrometer for studies of fundamental atomic processes at HESR at FAIR

K. E. Stiebing*[1], F. King*, P.-M. Hillenbrand†[2], S. Hagmann*,†, Yu. A. Litvinov†, S. Schippers‡, and Th. Stöhlker†,&,§

*Goethe Universität Frankfurt, Germany, †GSI Darmstadt, Germany, ‡Justus-Liebig-Universität Gießen, Germany, &Friedrich-Schiller-Universität Jena, Germany, §Helmholtz-Institut Jena, Germany

Synopsis A lepton spectrometer for the study of atomic processes in relativistic collisions of very heavy highly charged ions has been designed for experiments at the HESR storage ring at the FAIR facility.

Projectile energies of up to 5 GeV/u for very heavy highly ionized ions (up to e.g. U^{92+}) enable the study of electron-positron pair production processes in extremely strong transient electric and magnetic fields. Under these conditions, those reaction channels, where the electron of the dynamically created e^+/e^--pair is captured into the vacant K-shell of the projectile, become interesting channels of observation. For the specific case of collisions of U^{92+} on Ar, accessible at HESR, two fundamental processes can be contrasted here [1]:

(a) Bound-free pair production **(BFPP)**:

$$U^{92+} + Ar \rightarrow U^{91+} + Ar^* + e^+ \quad \text{and}$$

(b) Negative continuum dielectronic recombination **(NCDR)**:

$$U^{92+} + Ar \rightarrow U^{90+} + [Ar^+]^* + e^+.$$

While in BFPP the electron is directly captured into the projectile bound state, the *hitherto unobserved* NCDR process results in the capture of two electrons (one from the e^+/e^- pair and one from the excited target atom) into the projectile. Therefore, both processes can be separated by their ejectile's charge states. The relativistic kinematics facilitates experimental studies by essentially focusing the emitted e^+ into a small forward cone. In fig.1, the expected positron-spectrum of NCDR at an ion energy of 2,37 GeV/u is shown. The simulation bases on calculations by Artemyev et al. [2], using the argon Compton profiles of Biggs et al. [3].

A (Q-2D-Q) spectrometer, consisting of two magnetic dipole sectors (60°) combined with magnetic quadrupole singlets at the entrance and the exit has been designed and simulated by 3D-FE calculations [4] (see fig. 2). Position resolving stacks of ΔE-E scintillation detectors will be installed in the focal plane. The e^+/e^--annihilation radiation is detected in an array of photon scintillation detectors.

[1] E-mail: stiebing@em.uni-frankfurt.de
[2] E-mail: p.m.hillenbrand@gsi.de

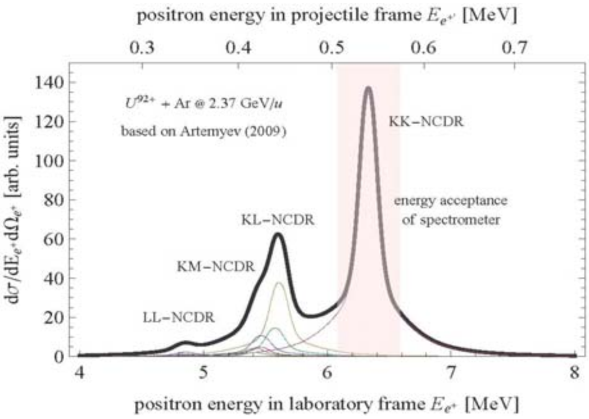

Figure 1: Simulated positron energy spectrum for NCDR emitted at an angle of **θ** = 0° for 2.37 GeV/u U^{92+}+Ar collisions.

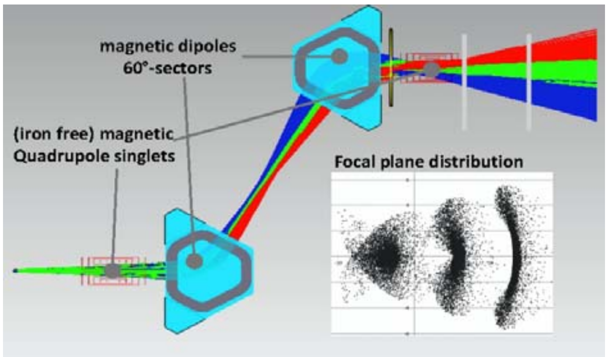

Figure 2: 3D Transport simulations [4] of leptons (three kinetic energies centered at 6.5 MeV±4%, with an emission angular spread of Δθ= 2.5°).

References

[1] P.-M. Hillenbrand *et al.*, Experimental concepts of positron spectroscopy at HESR, Phys. Scr., *submitted* (2015).
[2] Artemyev A N, Shabaev V M, Stöhlker T and Surzhykov A S; Phys. Rev. A79(3), 032713 (2009).
[3] Biggs F, Mendelsohn L and Mann J; Atomic Data Nuclear Data Tables 16(3), 201(1975).
[4]Computer simulation Technology, www.cst.com

Supported by Helmholtz-CAS Joint Research Group HCJRG-108 and by the Federal Ministry of Education and Research, FRG, (Contract No. 05P12RFFAH).