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The magnetic toroidal sector: a broad-band electron-positron pair spectrometer

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Synopsis We discuss the suitability of a toroidal magnetic spectrometer for free-free pair spectroscopy.

For heavy-ion atom collisions at near-relativistic collision velocities and above, electron-positron pairs from non-nuclear, atomic processes appear as significant reaction products. The underlying production mechanisms are a central topic of QED in strong fields. Kinematically complete experiments at the future relativistic storage-ring HESR at FAIR are focussing on momentum spectroscopy of emitted electrons and positrons and corresponding recoil ions. The first experiments will investigate capture pair production and negative continuum dielectronic recombination, in both cases the electron of the generated pair is captured into a bound atomic state and the positron emitted into the continuum in a narrow cone around the beam direction will be analyzed with a forward magnetic spectrometer in coincidence with the charge changed projectile[1,2].
In the related process free-free pair production both leptons, electron and positron, are emitted into the continuum. Theoretical calculations on the vector-momentum correlation of electron positron pairs beyond the elementary back-to-back emission in the emitter frame are not available and experimental benchmark data on the vector momentum correlation of electron positron pairs are highly desirable-for better elucidation of the details of the production mechanism[3].
For enabling a simultaneous spectroscopy of both leptons we are studying the previously described toroidal sector magnetic reaction microscope[4] for application as a free-free pair spectrometer in a storage ring and for electron/positron energies up to 1 MeV.
In this context we investigate the electron-optical properties of a modified 90^0 magnetic toroidal sector configuration for electrons and positrons suitable for implementation into a storage ring with a supersonic jet target and covering a wide range of emission into the forward hemisphere. The simulation calculations are performed using the OPERA-3d 17-64 code[5]. Our calculations use the TOSCA subpackage of the OPERA code for the calculation of the magnetic fields of the toroidal coils configuration and calculation of the trajectories of electrons and positrons in the magnetic field.
For electrons and positrons mapped from the target zone onto large 2D position sensitive detectors in the focal plane the instrument exhibits a large momentum dispersion of electrons and positrons in the upper and lower half-sphere, thus enabling a simul-taneous detection of both, electron and positron from a pair, over a large solid angle of emission. In the fig it is clearly visible how for a suitably cho-sen combination of magnetic field B and lepton ki-netic energy the desired lepton energies may be fo-cused on distinct locations in the focal plane.

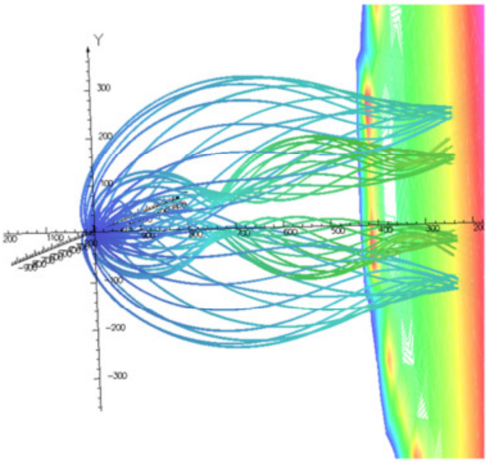

Figure 1. Trajectories of electrons (lower half-plane) and positrons (upper half-plane) of 12 keV and 50 keV energy, respectively, from the source at the jet target to the detector plane with 2D position sensitive detectors at the end of the toroidal sector.

References

[1] HESR-Techn. Design Report, GSI 2015
[2] P.M. Hillenbrand et al. Phys. Scr., submitted 2015
[3] A. Voitkiv, priv. communication, 2014
[4] X. Wang, S. Hagmann Meas. Sci. Technol. **18** (2007) 161-166
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