Beam-Diagnostics for the New Polarized Hydrogen Source ◇

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The thermal atomic hydrogen beam from our Stern-Gerlach source [1–3] has an intensity of 6×10^{16} atoms/sec or 10 particle-mA and a nuclear polarisation of P > 95 %. To form negative ions we follow the two-step charge exchange scheme from ref. [4]. The beam is ionized in an electron cyclotron resonance (ECR) plasma, transported over a distance of 60 cm and focussed into the middle of the cesium gas target [5]. There, the efficiency for double electron pickup is up to 30 % at a beam energy of 500 eV/n and a gas density of 10^{15} cs-atoms/cm^2.
Fig. 1 shows a vertical section of the vacuum housing, the ECR-ionizer and the electrostatic lens system.

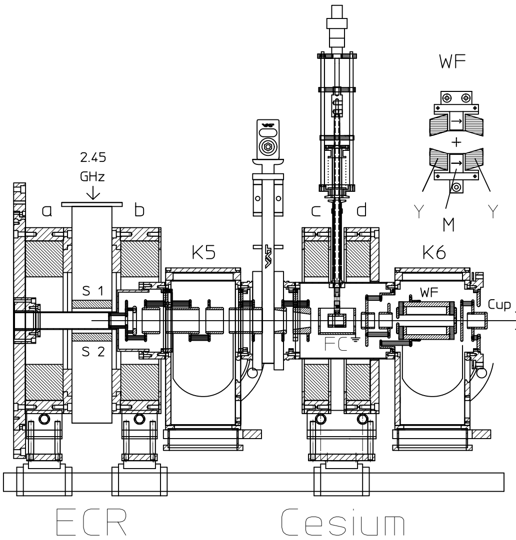

Fig. 1: Vertical section of ECR ionizer, electrostatic lens system, moveable Faradaycup (FC) and Wien filter. The Faradaycup replaces the cesium gas target and the Wien filter separates the different ion species for beam analysis. The coils for the axial mirror field of the ECR ionizer are denoted by a and b, c and d mark the coils for the axial holding field for the conservation of the nuclear spin polarization during double electron pickup. S1 and S2 are two of the six permanent magnets creating the radial sixtupole field for the electron cyclotron resonance surface. The vacuum chambers K5 and K6 are each pumped by one 500 l/s turbomolecular and one 1500 l/s kryo pump. The basic vacuum in both chambers is 3×10^{-8} mbar.

Fig. 2 shows a ray tracing simulation for positive hydrogen beam with an intensity of 0.5 mA. Space charge effects are included. A genetic algorithm was used to optimize the geometry of the electrostatic lenses and the applied voltages. They are close to the voltages we experienced under similar conditions in the beam transport system of our Lamb shift polarized ion source.

For beam analysis of the positive ion beam and for determination of the efficiency of the ECR ionizer a moveable Faradaycup or a wire scanner will be installed at the place of the cesium gas target. A Wien-filter is foreseen to analyze the beam according to its different ion species. Its section (WF) is given in the upper sub-picture of fig. 1. Two permanent magnets (M) together with the shaded steel yokes (Y) create a horizontal magnetic field of 0.15 T. Both halfes are also used as electrodes for the vertical electric field. The distance of separation is 28 mm. The inhomogenity of the magnetic field in the central area of 4mm radius is about 7 %. Fig. 3 shows a ray tracing calculation. H^+ ions are transmitted, H_2^+ ions deflected. The inhomogenity of the magnetic field requests the bent H^+ trajectory. It is created by a slightly stronger electric field than defined by the equality between Lorentz-force and Coulomb-force. The particles are deflected by the surplus electric field into the increased magnetic field and are refocussed to the exit of the Wien filter.

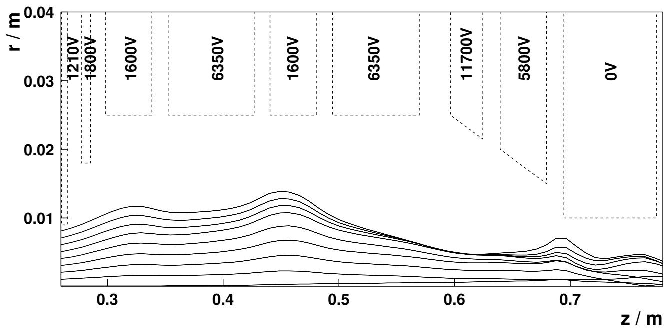

Fig. 2: Beam trajectory calculation for positive hydrogen beam including space charge effects. The electrostatic lenses are indicated by the shaded lines. The extraction electrode is not shown. All voltages have negative sign. The cesium gas target is grounded.

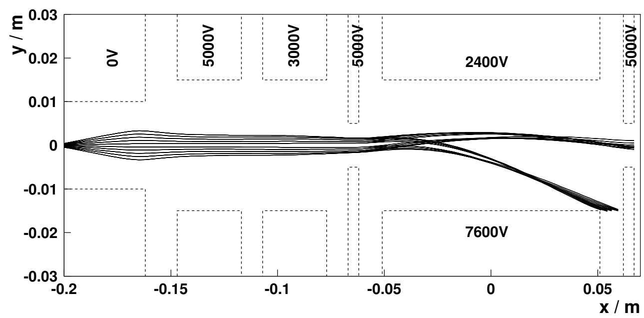

Fig. 3: Beam trajectory calculation for the Wien filter. The throughgoing particles are 6 keV protons, the deflected particles are 6 keV H2 molecular ions. The grounded dashed area is one half of the cs gas target. The ions have here a kinetic energy of 1 keV. The Wien filter is kept on 5 kV. All voltages have negative sign.

The measurements are ongoing. First tests with unpolarized hydrogen were successfull. Intensities of about 0.5 mA of positve ions were observed.

References

[1] R. Hertenberger *et al.*, Rev. Sci. Instrum. **67**(3) (1996) 1354
[2] K. El Abiary, diploma thesis, LMU München, 1996
[3] K. El Abiary *et al.*, Jahresbericht 1995, p. 110
[4] T. B. Clegg *et al.*, Nucl. Instr. Meth. **A357** (1995)
[5] A. Metz *et al.*, Jahresbericht 1996, p. 109

◇ Supported in part by BMBF, DFG and BL-Munich.