A High-Brightness Source for Neutral Polarized p and d Beams ◇

K. El Abiary, R. Hertenberger, A. Metz, P. Schiemenz, S. Trieb, and G. Graw

The concept of a new Stern-Gerlach type polarized ion source for high intensity negative $\vec{p}$ and $\vec{d}$ beams at the Munich tandem laboratory is given in refs. [1,2]. We report here on its Atomic Beam part (ABS) [3], i.e. the performance of the neutral atomic $\vec{p}$ beam and compare with the HERMES and MADISON ABS sources [4,5], which are used in experiments with internal storage targets.

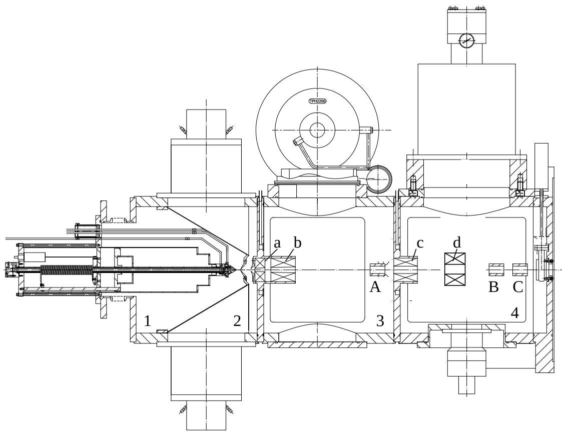

Fig. 1: Vertical section of the ABS: All active components are contained in four vacuum vessels. The turbo-molecular pump of chamber 1 (equal to the pump of chamber 3) is not shown. The four sextupole magnets (FeNdB permanent magnets) are labeled by a...d, the three adiabatic high frequency transitions by A,B and C. The new high flux dissociator [3] is indicated on the left side. A compression-tube detector (not shown) can be installed at the right hand side of the source.

A thermal atomic beam is produced in a rf-dissociation and expands with a $(\cos\theta)^{2.25}$ angular distribution [6] through the cooled (80K) aluminum nozzle. Nuclear polarization is achieved by a combination of four Stern-Gerlach permanent sextupole magnets (FeNdB) for electron spin separation and two (for deuterium three) adiabatic rf-transitions for the interchange of the different hyperfine substate populations. A compression-tube detector (length of the tube: 100 mm, diameter: 10 mm [3]) is installed at the downstream end of the ABS for beam diagnostics.

The upper part of fig. 2 shows the atomic H_1 flux into the compression-tube as a function of the molecular H_2 flux to be dissociated. The curve saturates at H_2 flow rates of about 2.1 mbarl/sec indicating beam losses due to absorption or incomplete dissociation. To disentangle these two contributions, we compare with the intensity of molecular H_2 flux into the compression-tube in the lower part of fig. 2. The absorption becomes directly measurable, as dissociation is switched off.

Ignoring losses due to beam absorption and incomplete dissociation (only H_1), the $H_{1/2}$ fluxes into the compression-tube (straight solid lines in fig. 2) are given by:

$$Flux_{H_{1_{stau}}} = Flux_{H_2} \times P_{H_1} \times \Omega_S \times T \qquad (1)$$

$$Flux_{H_{2_{stau}}} = Flux_{H_2} \times P_{H_2} \times \Omega_C \qquad (2)$$

with $P_{H_{1/2}}$: peaking factor under the assumption of a $(\cos\theta)^{2.25}$ expansion, T: transmission of the atomic beam through the sextupole system (calculated in a Monte Carlo simulation) and $\Omega_{S/C}$: opening angles normalized to π for the sextupole system (s) and the compression-tube (c).

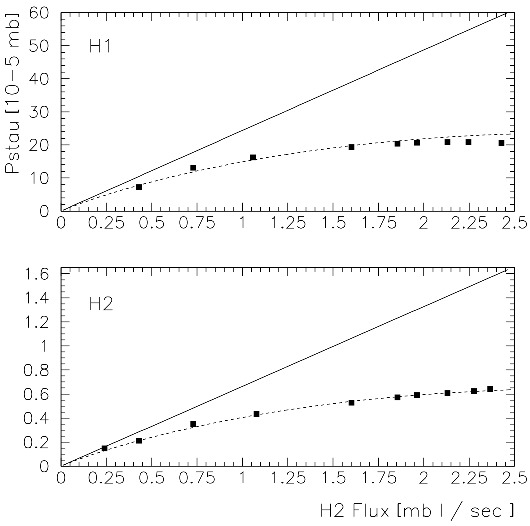

Fig. 2: Intensity of the beam into the compression-tube detector against the molecular H_2 flux through the dissociator:
upper part: atomic hydrogen, lower part: molecular hydrogen
in units of the pressure in the compression tube [P_{stau} 10^{-5}mbar].

A molecular hydrogen beam is unaffected in the sextupole system. Only the peaking factor of the expansion at the nozzle and the opening angle of the compression-tube enter into the theoretical description (equ. (2)). The comparison between data points and solid line in the lower part of fig. 2 gives directly the beam absorption. It is parametrized by the dashed curve. In case of equality between the absorption of atomic and molecular hydrogen and in case of equality between P_{H_1} and P_{H_2}, we can apply this parametrization to the data of H_1 (dashed curve in the upper part of fig. 2). It fits the data points. At our present understanding, this is in agreement with a high degree of dissociation being constant over the whole parameter space. To resolve remaining ambiguities of this multi-parameter problem, further tests are necessary.

The maximum H_1 flux achieved so far (22×10^{-5} mbar in the upper part of fig. 2) corresponds to $5.9 \pm 0.6 \times 10^{16} atoms/sec$ at a molecular H_2 flux of 2.1 mbarl/sec. The HERMES and MADISON ABS sources saturate at H_2 fluxes of about 1.7 mbarl/sec with maximum rates of $6.8 \times 10^{16} atoms/sec.$ Tests to increase the performance of our sextupole magnetic system by increasing its opening angle Ω_S are ongoing.

References

[1] R. Hertenberger et al., Rev.Sci.Instrum. **67 (2)** (1996)
[2] K. El Abiary et al., Jahresbericht 1994, p. 239
[3] K. El Abiary, diploma thesis, LMU München, 1996
[4] F. Stock et a., Nucl.Instr.Meth. **A 343** (1994)
[5] T. Wise et al., Nucl.Instr.Meth. **A 336** (1993)
[6] B. Lorentz, diploma thesis, MPI Heidelberg, 1993

◇Supported in part by BMBF and DFG.