HIGH-INTENSITY OPTICALLY PUMPED POLARIZED H^- ION SOURCE DEVELOPMENT FOR RHIC AND HERA

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Abstract

A status of polarized H^- ion source development for RHIC and HERA is presented.

1 Introduction

Collider experiments with polarized proton beams, approved at RHIC [1] and under consideration at HERA [2], will provide fundamental tests of QCD and the electroweak interaction. Polarized beams should allow better identification of new objects produced in proton-proton collisions, and will expand the limits of searches for possible manifestations of New Physics beyond the Standard Model. Such experiments will require the maximum available luminosity, and therefore polarization must be obtained without sacrificing intensity.

2 OPPIS INJECTOR FOR RHIC

The polarization facilities at RHIC will provide 70% polarized proton-proton collisions at energies up to $\sqrt{S}$=500 GeV and a luminosity of 2×10^{32} cm $^{-2}$ s^{-1} (see ref. [1]). The polarized injector must produce in excess of 0.5 mA H^- ion current during the 300 μs pulse, or current $\times$ duration >150 mA μs, within a normalized emittance of less than 2π mm mrad. This is an ideal application for the TRIUMF-type OPPIS, where a 1.64 mA current was obtained in dc mode. The required pulsed operation will greatly simplify and reduce the cost of the laser system, while providing the best source performance due to ample optical pumping laser power.

The first ECR-type OPPIS was constructed at KEK. Polarized beam is not presently required at KEK, and the KEK OPPIS is on loan to BNL to supply polarized H^- for RHIC. The source is at present being upgraded at TRIUMF to meet the RHIC requirements. It will be delivered to BNL in the first half of 1999, and design of the matching optics between the source and the RFQ has begun.

The existing TRIUMF OPPIS meets the RHIC requirements even with CW laser pumping. However, 100 μs pulse durations with peak currents of 1.5 mA would be preferred, since that would improve injection efficiency. The preference for the higher current, combined with the relatively low cost of pulsed lasers dictates the use of pulsed optical pumping. In previous tests at TRIUMF, near 100% Rb polarization was measured in a 2 cm diameter Rb cell having a vapour thickness of 1×10^{14} atoms cm^{-2} and a length of 30 cm, using a pulsed Ti:sapphire laser.

The KEK OPPIS as delivered to TRIUMF used a pulsed 18 GHz ECR proton source and CW laser pumping. At TRIUMF the KEK OPPIS is being optimized using a DC 28 GHz ECR proton source. Preliminary results give 520 μA of H^- DC current, using a 121-aperture extraction electrode with an overall diameter of 13 mm. This already satisfies the minimum RHIC beam current requirements, and a 199-aperture system will do proportionally better.

A new Na-jet negative-ionizer target is being developed, which has some advantages over the original canal and condensation chambers arrangement. A jet target can be shorter and the beam apertures larger, since Na vapour is more effectively confined. The condensed Na is recycled. Large apertures reduce secondary electron emission caused by the intense polarized atomic hydrogen beam striking the cell, and therefore may allow biasing the Na cell up to 32 kV. If so, a 35 keV beam from the source will be injected into an RFQ, without requiring that the whole source be placed on a high voltage platform.

3 PULSED OPPIS FOR HERA

Studies of the hadron spin structure functions in collisions of polarized electrons with polarized helium-3, hydrogen and deuterium internal targets are in progress at DESY (HERMES experiment). The proposal to significantly expand the kinematic range of these studies and measure the gluon contribution to the proton spin in collisions of an 800 GeV polarized proton beam with a 30 GeV polarized electron beam was recently examined.

The TRIUMF task is the development of a high intensity polarized H^- ion source. A polarized H^- ion current of 10–20 mA is required to provide sufficient polarized beam luminosity for the above experiments. The feasibility of producing 10 mA of polarized H^- ion current in the INR-type pulsed OPPIS was demonstrated in experiments with an atomic H injector at BINP, Novosibirsk and experiments at TRIUMF on optical pumping of high density Rb vapour in the presence of a high intensity proton beam [3]. A current of 20–30 mA may be feasible in the "combined" polarization scheme, where space charge compensation is easier to achieve. The development of a pulsed OPPIS is in

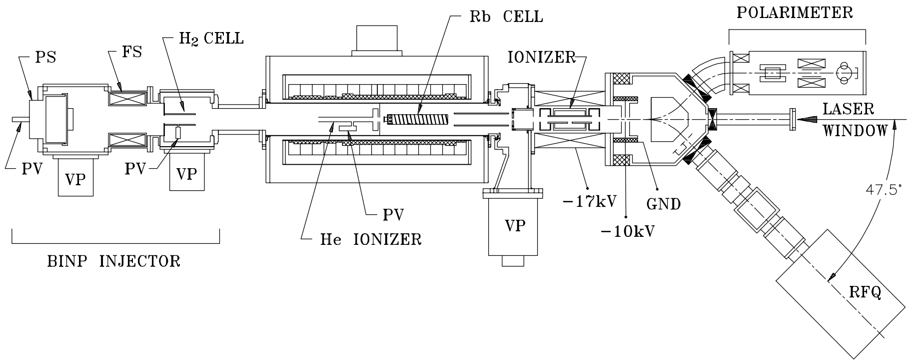

Figure 1: Pulsed OPPIS layout, PV-pulsed valves

progress at TRIUMF. The atomic H injector is being constructed and tested on a test bench. The primary proton beam is produced in a pulsed source (PS) (Fig. 1), then focussed by a solenoidal magnetic lens FS, and converted to a high intensity, converging atomic hydrogen beam in a pulsed gaseous hydrogen cell with neutralization efficiency about 95%. A unique feature of the proton source is the efficient plasma cooling during expansion between the plasma generator and the extraction system; the plasma temperature drops to about 0.2 eV at a distance of 10 cm from the generator, where the extraction system is situated. A four grid multiwire accel-decel extraction system was used in experiments at low beam energy (less than 5 keV).

A very high H^- ion current of 28 mA was obtained at 4.0 keV beam energy, which is ideal for use with the spin transfer polarization technique [4], whereby most of this current can be polarized to greater than 80% (see. Fig. 2).

Following the test stand measurements, the test stand was dismantled and the operational TRIUMF OPPIS ECR-proton source was removed and replaced by the neutral injector, for further pulsed source development between scheduled polarized beam runs at TRIUMF. Use of the full TRIUMF OPPIS as a development stand will in future permit testing of the entire INR-type OPPIS, using the superconducting solenoid to generate a fairly flat 1.2 T field over a length of 70 cm. The resulting polarization will be limited in that case to about 60% due to the relatively low field. (The superconducting solenoid at TRIUMF can produce 2.5 T only over a length of 30 cm).

The BNL-KEK-TRIUMF collaboration to develop new polarization facilities at RHIC is proceeding, and the OPPIS upgrade is on schedule. The development work on a 10–20 mA pulsed H^- OPPIS for HERA shows great

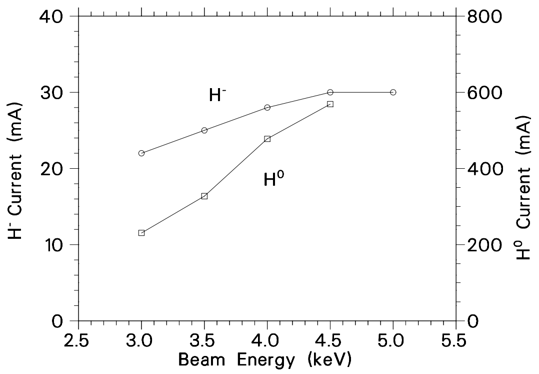

Figure 2: H^- ion current and H^0 beam intensity within the ionizer acceptance as functions of the beam energy.

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References

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