PST 2009: XIII International Workshop on Polarized Sources
Targets and Polarimetry

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Abstract. The workshops on polarized sources, targets, and polarimetry are held every two years. In 2009 the meeting took place in Ferrara, Italy, and was organized by the University of Ferrara and INFN. Sessions on Polarized Proton and Deuterium Sources, Polarized Electron Sources, Polarimetry, Polarized Solid Targets, and Polarized Internal Targets, highlighted topics, recent developments, and progress in the field. A session dedicated to Future Facilities provided an overview of a number of new activities in the spin-physics sector at facilities that are currently in the planning stage. Besides presenting a broad overview of polarized ion sources, electron sources, solid and gaseous targets, and their neighbouring fields, the workshop also addressed the application of polarized atoms in applied sciences and medicine that is becoming increasingly important.

1. Introduction
The workshop was part of a series of workshops on techniques required for experiments in nuclear and particle physics, to measure spin-dependent observables in the scattering of energetic particles. About 80 participants registered for the workshop, which reflected all relevant areas where polarized beams and targets are presently employed, or are likely to be employed in the future. Although dedicated meetings exist for some of the fields covered, the aim of Workshop was to give a general, but comprehensive view of the technology involved in the polarization experiments and applications and to encourage discussions and exchange of information between the different fields. The various sessions included presentations (number in brackets) on:

- Electron/Positrons sources and Polarimetry (16)
- Atomic and Ions Sources and Polarimetry (16)
- Solid Polarized Targets and Polarimetry (12)
- Future Facilities (4)

In addition, there was one introductory talk given by E. Steffens, which presented a brief history of the workshops in this series, and one summary talk given by F. Rathmann. In total, there were about 50 presentations scheduled at the meeting.

The present summary is aimed at highlighting some issues freely selected by the Author among the presentations given in the various sessions. Interested reader are invited to refer to the Proceedings, published by World Scientific, for a more complete overview of the covered topics.

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2. Electron and positron sources and polarimetry

2.1. A look to the past: 10 years of HERA polarized running
Longitudinal polarization of the lepton beams was a key ingredient in the success of the world’s unique $e^\pm-p$ ring collider HERA, as reported in the presentation of B. Sobloher. The beam polarization in HERA was produced via radiative polarization, which has been first described theoretically by Sokolov and Ternov. The beam polarization was measured routinely with two polarimeters, using polarization-dependent Compton scattering. The Transverse POLarimeter (TPOL) detected the tiny up-down asymmetries associated with the vertical polarization, while the Longitudinal POLarimeter LPOL utilized the energy asymmetry caused by the longitudinal polarization. The preliminary estimation of the systematical uncertainties for TPOL amounts to about 2.9 % and for LPOL to 2 %. The two polarimeters show a varying behaviour over time which is not yet understood. A third option to measure the beam polarization using a high finesse Fabry-Perot cavity has been established at HERA, successfully operating with increasing data-taking frequency towards the end of the HERA running period.

2.2. A new challenge: the Gatling gun photocathode for MeRHIC
I. Ben-Zvi reported on the planning for the electron-ion collider eRHIC at BNL, where as a first stage MeRHIC (medium energy eRHIC) is envisioned. The polarized electron beams for these facilities will be provided by either a DC or RF gun, and then accelerated by a multi-pass superconducting energy recovery linac to collide with polarized protons provided by RHIC. MeRHIC requires a polarized electron beam current of 50 mA, while eRHIC may require as much as 260 mA. In order to test the feasibility of a high-current polarized electron source, an R&D program together with MIT/Bates and JLab is carried out, focusing on:
• demonstration of the feasibility of a polarized electron cathode in a superconducting RF gun, and
• development of a 50 mA polarized electron gun based on a funnel scheme of multiple low-current photocathodes in a “Gatling gun” scheme.

3. Atomic beam and ions sources and polarimetry

3.1. An impressive achievement: the RHIC polarized source
Polarized hydrogen and deuterium sources are mainly used to either inject electrically-charged polarized projectiles into an accelerator, or to feed a polarized target. Progress from BNL was reported by A. Zelensky. The polarized beam intensity for the relativistic heavy ion collider (RHIC) at BNL, which is produced in an optically-pumped polarized $H^-$ ion source, is intensive enough so that the polarized proton beam intensity in the high-energy accelerator is not limited any longer by the intensity of the polarized source. The RHIC spin program benefits strongly from developments in the polarized ion source and polarized target technology.

3.2. A cute idea: an inexpensive source of polarized deuterons
The effect of nuclear spin dichroism, predicted by theoretical studies as the appearance of tensor polarization in initially unpolarized beams behind unpolarized or spinless targets, has been studied at the Cologne tandem accelerator using 9.5 to 18.7 MeV unpolarized deuteron beams, impinging on graphite targets of areal densities ranging from 36 to 188 mg/cm$^2$. As reported by H. Seyfarth, distinct deviations from the predicted weak effects were observed, with a maximum value of $p_{zz} = -(0.28 \pm 0.03)$ measured behind a 129 mg/cm$^2$ carbon target at 14.8 MeV initial beam energy. One implication of this finding is that it will allow one to produce tensorpolarized deuteron beams with $p_{zz}$ about $-0.30$ or $+0.25$ from an initially unpolarized deuteron beam using a graphite target of appropriate thickness.
3.3. *A breakthrough in Storage ring technology: the openable storage cell of the PAX experiment*

C. Barschel presented an overview of the target section for spin-filtering studies at COSY and CERN/AD, an experiment pursued by the PAX collaboration (Polarized Antiproton eXperiment) that aims to polarize a stored antiproton beam by spin-filtering. The setup requires a cell as a Polarized Internal Target (PIT), which is fed by the Atomic Beam Source (ABS) previously used at the HERMES experiment at HERA/DESY. The target cell is surrounded by silicon detectors. The working principle of the Breit-Rabi Polarimeter (BRP), including the calibration procedure, and first results of the analysis of the recorded BRP signals were presented. First tests with an openable storage cell with 5μm Teflon walls have been shown. The cell can be opened at injection when the uncooled beam covers the whole machine acceptance and closed after the beam has been cooled. This cell of new conception, does not limit the machine acceptance at injection and opens the way to a new generation of storage ring experiments with internal polarized targets.

3.4. *A spinoff of polarized atomic sources: Magnetic Resonance Imaging with polarized $^3$He*

S. Karpuk discussed the status of spin-polarized $^3$He, from basic research to medical application. Techniques and practices for gas production and delivery include a central polarized $^3$He production facility, capable of providing ~60–70 bar liters/day with a polarization of $P = 0.6$. The main technical problems of storage and transport ($T_1 > 100$ h), polarimetry, gas administration, and the recovery of expensive $^3$He are solved. In a clinical study during 2002–2004, 116 patients and 37 volunteers were treated. The technology is applied in morphological magnetic resonance imaging (MRI) studies and dynamic imaging of lung functions. The clinical infrastructure includes a standard (1.5 T) MR scanner and a low-field (0.1–0.5T) scanner, transmitter/receiver coils, a gas administration unit, and suitable software for the implementation of $^3$He imaging sequences.

4. *Solid polarized targets and polarimetry*

4.1. *Great expectations: the HD-ICE target at JLAB*

X. Wei, in his presentation on HDIce (the frozen-spin solid HD target for CLAS at Jefferson Lab), explained that the HD target has many proven advantages for nuclear spin physics experiments with a photon beam:

- Low holding field and relatively high temperature.
- Low background, and small dilution factor, providing a short running time.
- The portable production facility can be separated from the experimental site.

The HD target facility has been relocated from BNL to JLab for use with the CLAS detector, where a target lab is currently under construction. A new in-beam cryostat is being designed. The major unknown for using the target with an electron beam is the radiation damage. A test of the target is scheduled for spring 2011. If this test is passed, the e$^+$HD run will start in the winter of 2011.

5. *New facilities*

5.1. *The quest for a new tool: polarized antiprotons*

Polarized antiprotons provide access to a wealth of single- and double-spin observables, thereby opening a window to physics uniquely accessible with the HESR at FAIR. The most promising approach to provide a beam of polarized antiprotons, adopted by the PAX collaboration, is based on spin-filtering using an internal polarized hydrogen gas target - a method that has been shown to work with stored protons. The necessary studies will be carried out at COSY/Jülich and AD/CERN, as discussed by F. Rathmann. A program at COSY is underway to test and commission the equipment required for the spin-filtering experiments at the AD, i.e. the polarized internal target and the new low-β section, efficient polarimeters to determine target and beam polarizations, and a Siberian snake to maintain the longitudinal beam polarization.
6. Open discussion

6.1 Development of new intense polarized atomic sources
There is a prevailing demand for the development of more intense ABSs, in particular for the feeding of internal targets in future generation experiments. In a round table discussion, organized by A. Nass, this issue was addressed from two different perspectives: i) understanding of existing sources, and ii) the development of new ideas. The known factors presently limiting the intensity of existing sources are beam attenuation due to collisions with the residual gas, and intrabeam scattering. An additional influence might be attributed to the characteristics of the beam formation system. The most intense source presently operating is the ABS used for the H-jet polarimeter at RHIC. Despite its performance, this source is presently not well characterized, therefore dedicated measurements to investigate the above mentioned effects in this particular source should be performed. At Ferrara, a parallel program is being developed to study these effects using a test bench setup. The question of whether superconducting sextupole magnets should be used instead of permanent magnets is still an unanswered one. The development of new techniques should be pursued: direct simulation Monte Carlo codes could provide the capability to also include the magnetic forces on the atoms, and thus lead to a better understanding of the underlying limitations in the present sources. Storage cells trapping the polarized atoms more efficiently should be explored as well.

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