PROCEEDINGS OF SCIENCE

Concluding Remarks

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1. Introduction

The workshop PSTP 2013 on Polarized Sources, Targets and Polarimetry was conducted at the University of Virginia in Charlottesville (VA) from Sept. 9 to 13, 2013 and organized by Donald Crabb (UVA), Matthew Poelker (JLab) and a local organizing committee. There were 81 registered participants. Two Russian and two Chinese participants did not arrive because of visa problems, their talks were presented in absence by others. From the 77 remaining participants a large majority of 60 came from US Institutions, 16 from EU incl. CH, and one participant was from Japan. The distribution reflects the influence of geographical proximity and political trends, and indicates the accumulation of new or active Spin physics projects in a few areas in the world.

In the following, the origin of the series of these workshops and its tasks are discussed. Then the main topics are reviewed and my personal view of this meeting is presented.

2. Series of PST(P) Workshops

The present workshop is called the 15th of this series. PST means "Polarized Sources and Targets". From the 2007 meeting at BNL on, another P was added for "Polarimetry", reflecting the growing importance of a precise knowledge of the polarization, needed for high precision experiments (see the talk of Elke Aschenauer, these proceedings). Let me remind you of what I – as one of the veterans in polarization – know about its origin. You may find more about it in Richard Milner's paper 'History of Spin' in these proceedings.

2.1 Early meetings

3.The first meeting on tools used in spin physics which is known to me is the International Conference on Polarized Targets and Ion Sources at Saclay 1966, chaired by A. Abragam. The program reflects the status of development at that time, including solid proton targets polarized by means of DNP[1] (Jeffries, Borghini, Saclay group,…), application of solid polarized targets for neutron physics (first experiment on 'Spin Filtering' by Shapiro at Dubna), a nice overview by Beurty (Saclay) on Lamb Shift and Atomic Beam polarized ion sources, and more. A second conference of this type on polarized targets took place at Berkeley in 1971, chaired by O. Chamberlain (Nobel Prize 1959 for the discovery of the antiproton), a former member of the Spin Committee.

4.Work on tools used in spin physics was also discussed at the Polarization Symposia[2] conducted every five years (!), a series with main focus on the physics results. At Basel in 1960, the first results on an accelerated deuteron beam from a polarized ion source were discussed. At the second symposium 1965 in Karlsruhe, the idea of a 'Colliding Beam source' (CBS) was presented by Haeberli. This type of source is in operation at the COSY injector cyclotron (FZ Jülich). A highlight at the Madison meeting in 1970 was 'Achromatic Focusing' by means of a compressor sextupole, reported by Glavish. In Zürich 1975, the first meeting I attended, the first

[1] Dynamical Nuclear Polarization
[2] International Symposia on Polarization Phenomena in Nuclear Reactions

results on polarized electrons from a GaAs cathode were presented by Müller/IBM-Lab Zürich. At Santa Fe in 1980, the first experimental demonstration of the CBS[3] and and the first test of a storage cell polarized gas target were presented by the Madison group. – Similar work has been discussed at the biennial Symposia on High Energy Spin Physics, initiated by A. Krisch and starting in 1974.

2.2 Topical workshops, initiated mostly by the High Energy community

Two workshops were organized in preparation of a polarized proton beam for the AGS at Brookhaven (BNL), at Ann Arbor in 1981, and at Vancouver in 1983, entitled "High Intensity Polarized Proton Sources". The solid polarized target community had a series of meetings "Polarized Target Materials and Techniques" in Abingdon 1981, BNL 1982, and Bad Honnef 1983. In 1985, a workshop on "Polarized Antiprotons" was conducted at Bodega Bay, north of San Francisco, organized by O. Chamberlain and A. Krisch. The aim was brain-storming on possible ways to produce beams of polarized antiprotons, predominantly beams stored in a ring in order to make optimum use of these precious particles. The most obvious way, to polarize them in a scattering process, did not produce enough intensity. It should be noted that today – 28 years later – this goal has still not been met.

A first "combined" workshop on "Polarized Sources and Targets" took place in 1986 at Montana in Switzerland, organized by Jaccard and Mango (SIN, now Paul-Scherrer-Institut PSI), Grüebler (ETHZ) and Niinikoski (CERN). As stated in the Foreword, *it was the idea of Prof. A. Krisch to have a joint* – sources and targets – *meeting this year, so as to give to the two communities an opportunity to compare ideas and share technologies…* The workshop in the Swiss Alps had more than 50 participants from all over the world and has set standards for the meetings to follow.

At the High Energy Spin Symposia Spin1998 in Minneapolis and Spin1990 in Bonn, there were several satellite workshops on polarization techniques. Also in 1990, there was a workshop at KEK (Tsukuba, Japan) on "Polarized Ion Sources and Gas Targets", organized by Mori. After 1990, the PST workshops were predominantly in the uneven years between the Spin Symposia, starting with Heidelberg 1991 (restricted to polarized gas targets), Madison 1993, Köln/Cologne 1995, Urbana (IL) 1997, Erlangen 1999, Nashville (IL) 2001, Novosibirsk 2003, Tokyo 2005, Brookhaven 2007, Ferrara 2009, and St. Petersburg (2011). This year, PSTP2013, the 15th workshop in this series is being conducted in Charlottesville (Virginia), a wonderful historical location and the home of a very active spin physics group, and in close proximity to Jefferson Lab, one of the big centers active in our field.

3. Tasks of Workshops on Spin Tools

Spin workshops may be initiated on experimental or theoretical subjects essential for the scientific goals of spin physics, i.e. the study of spin effects in nuclear and particle physics and neighboring fields. They are approved by the Spin Physics Committee[4] and should support

- the development of new methods,

[3] Colliding Beam Source
[4] International Spin Physics Committee (ISPC), present Chair: R. Milner (MIT)

- formation of a community,
- initiatives for new collaborations and experiments.

4. Distribution of Topics and Speakers at PSTP 2013

Distribution of Topics and Speakers at PSTP 2013If we look at the number of presentations by subject we get the following picture:

Polarized targets	about	17	presentations
Polarized sources		24	
Polarimetry		15	
Facilities		7	
General & new methods		8	

The three main subjects Sources, Targets and Polarimetry are covered nearly equally. Compared with previous meetings, polarimetry has gained in importance because of the need for higher precision.

The number of presentations by labs and/or area is shown in the following:

JLab and collaborators	about	36	presentations
BNL		12	
Other US labs		5	
Europe		8	
Russia (incl. Dudnikov Fest)		5	
Japan		1	

As we all know, new projects or upgrades of larger projects tend to initiate new developments. As a matter of fact, we loose important chances if we miss these opportunities. New projects are driving the progress in our field. This is strongly reflected in the number of talks from the various places, predominated by groups working at JLab and RHIC-BNL. The general trend seems to continue that experimental work on spin physics is concentrated in North-America, of course with significant international collaboration.

For a stable future of our field it is important that polarization is implemented at other existing or future facilities, like eRHIC/EIC (secured) or FAIR (uncertain). New ideas are required, but they do not come out of the blue. Are the PSTP workshops sufficiently innovation-friendly? Let us try altogether not to forget this aspect at future workshops.

5. Workshop Impressions

It is not my aim to summarize in detail all the more than 60 talks presented at PSTP 2013. Instead, let me try to give you my personal perspective of the different topics of the program.

Polarized Solid Targets: Targets based on solids placed in a high magnetic field at low temperature were the early workhorses in Spin physics. They enabled polarization measurements with one spin in the entrance channel polarized, and they produced many data, predominantly at medium and high energy machines where the target heating can be kept sufficiently low. Such targets using DNP as a polarizing mechanism are in use in experiments at ELSA, MAMI, Jefferson Lab and COMPASS/CERN. The high level of such targets was

demonstrated in two sessions where results were presented by groups from Bochum, Mainz, PSI, and CERN. As an alternative to DNP, HD ice targets polarized by the Brute-Force method have entered the testing phase at several experiments with photons or electrons, with the promise to improve in purity.

Polarized Gas Targets: Two types have been discussed at this meeting. One was the polarized storage cell target for storage rings used for the ANKE and PAX experiments at COSY (FZ Jülich) which is under study as an antiproton polarizer for the FAIR project. The other was the high-pressure ^{3}He gas cell polarized by optical pumping which is employed as very efficient neutron polarizer.

Polarized Electron Sources: The high level of such sources based on GaAs cathodes is the result of 40 years of development at various labs including SLAC and JLab. A key feature is the optimum photocathode produced by specialized groups e.g. the Nagoya group, supplying the community. The sources include an ultra-clean UHV system with load locks and conditioning devices in order to optimize quantum efficiency and running time. For future applications, like the ILC[5] or the EIC[6], studies at MIT and elsewhere are in progress to develop a High Intensity polarized electron gun for high bunch charge and intensity.

Polarized Proton and Ion Sources: As ions heavier than protons, deuterons and ^{3}He ions are important for high energy experiments. The highest intensity for protons is produced by the OPPIS[7] source injecting into RHIC up to the the space charge limit. There are very strong demands on stability of intensity and polarization imposed by the needs of the Collider experiments. As part of the eRHIC project, measurements of the neutron spin structure are planned by colliding polarized $^3He^{++}$ ions stored in one of the RHIC rings with polarized electrons from a different machine, e.g. an ERL[8] linac with bending magnets, located in the RHIC tunnel. A source for polarized fully-stripped ^{3}He ions is under study, based on optically-pumped polarized ^{3}He atoms injected into an EBIS ionizer[9].

If polarized protons and deuterons are required, a versatile ABS[10] with suitable ionizer is an alternative to the OPPIS source. Such a source of the CBS-type[3] is working at the COSY injector cyclotron. A similar project based on the former IUCF source is being prepared for the NICA injector in cooperation between JINR Dubna and INR Moscow.

Polarimetry: In general, both for electron and ion polarimetry, there is a variety of methods depending on the beam energy, the need for a relative or absolute polarization result, and the required precision. Four sessions were devoted to electron and ion polarimetry. The precise determination of the polarization of electron beams plays a central role at Jefferson Lab, employing all the different methods and pushing them to the experimental limit, with errors well below 1%. A comparison of results from different polarimeters at injection and in the various halls, an effort called 'Spin Dance', has revealed a very good overall agreement and no unexpected spin precession on the way to the experiments. The next challenge is commissioning of the polarimeters for operation at up to 12 GeV beam energy.

[5] International Linear (e+ e-) Collider
[6] Electron-Ion Collider, e.g. eRHIC at BNL, or mEIC at JLab
[7] Optically Pumped Polarized Ion Source
[8] Energy Recovery Linac, recovering the beam energy by slowing down the beam
[9] Electron Beam Ion Source
[10] Atomic Beam Source for a polarized atomic beam with a flexible polarization scheme

For the Spin program at RHIC, the determination of the proton polarization at all stages of acceleration and storage is essential for setting up and running the accelerator complex, and for achieving the optimum precision. Several relative polarimeters allow for an optimization, and an polarimeter based on a polarized hydrogen jet target provides the absolute calibration. A detailed understanding of this device is mandatory for the final precision of the physics results. For future studies of a polarized ^{3}He beam stored in RHIC first ideas of a polarimeter based on electromagnetic interference with calculable analyzing power were presented. Another challenge is part of the measurement of the EDM[11] of ions proposed by the FZ Jülich, which requires polarimetry of stored ions like deuterons with an unprecedented accuracy.

New Facilities and Application of Spin: There were several progress reports discussed at this workshop dealing with the JLab 12 GeV upgrade, or with major extensions of existing labs, like the electron-ion collider projects being worked out at BNL and JLAb, or the NICA ion collider facility at JINR (Dubna). Polarized protons in the Fermilab Main Injector were also a point of discussion. The measurement of the EDM of ions was another hot topic which may enable using our spin tools to contribute to very fundamental questions of particle physics and cosmology. Other presentations were about the opportunities of Spintronics, about the far-fetched proposal to use polarized fuel in future fusion reactors, or about a high-energy gamma ray source under construction at TUNL based on Compton back scattering.

6. Conclusions

The 15th International Workshop on Polarized Sources, Targets and Polarimetry, PSTP 2013, has been run very smoothly by the two Chairs Don and Matt, the UVA group and the Local Committee. They succeeded to set up a broad and inspiring program. The speakers contributed to the success by presenting very interesting talks. There was enough room for discussions between the talks and during lunch. The workshop dinner at Morven Farms brought participants and accompanying persons together, providing a nice atmosphere for sociable conversations. In conclusion, the workshop was a memorable event, which gave our community a positive momentum. I am sure that all participants enjoyed the meeting as I did, leaving it with a feeling of gratitude to the organizers.

7. Acknowledgements

I would like to thank the organizers of PSTP 2013 for their huge effort in preparing this event. Special thanks are due to Willy Haeberli for valuable comments on the written version.

[11] Electric Dipole Moment