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COMPASS Polarized Target for Pion-induced Drell–Yan Experiment

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Abstract

The first ever polarized Drell–Yan (DY) measurement is under preparation at COMPASS experiment at CERN. One of the key parts is the low-temperature polarized target. Modifications are required to cope with the intense pion beam that will be used. Solid NH_3 will serve as a transversely-polarized target. Polarization is expected to be up to 90%. Two 55 cm long target cells give the target volume of about 690 cm^3. The data taking is expected to start on fall 2014 and to continue in 2015 (approximately 180 days). Current status of the target, the modifications and future plans are presented.

Keywords: , polarized target, Drell–Yan

1. Introduction

COMPASS [1] is a fixed-target experiment situated at CERN Super Proton Synchrotron (SPS) North Area. For physics data taking it uses either hadron or muon beams[1]. Either normal or polarized targets are used. COMPASS detector is a universal spectrometer with good particle tracking and identification capability.

COMPASS physics program focuses on spin structure studies and hadron spectroscopy [2]. Among other experiments the first ever measurement of a single-polarized Drell–Yan (DY) process using a pion beam and a transversely-polarized proton target was proposed by the COMPASS Collaboration [3]. Its goal is to test some crucial predictions of QCD, namely a change of sign of the Sivers and Boer–Mulders TMDs when measured in Semi-Inclusive Deep-Inelastic Scattering (SIDIS) and in DY processes.

As the DY cross section is small, the luminosity should be as high as possible. In the case of COMPASS this corresponds to the beam intensity of about 10^8 pions/s. That is the highest hadron beam intensity COMPASS has used so far, which leads to several challenges for the detection, data acquisition and the polarized target.

[1]Produced by proton beam from the SPS hitting a Be target. The beam has momentum up to 280 GeV/c and can be either positive or negative. Muons are naturally longitudinally polarized.

2. Drell–Yan program at COMPASS

The Feynman graph on Fig. 1 shows the Drell–Yan (DY) process, which has lately attracted much attention as a tool for polarized hadron structure studies. The reason is that the cross section does not involve any fragmentation function, but only convolution of structure functions of both hadrons. That is an advantage with respect to SIDIS.

The disadvantage of the DY process is a small cross section. To acquire a reasonable statistics an intense beam[2] will be used resulting in a large flux of secondary-hadrons. To avoid a spectrometer flooding-up a hadron absorber was designed [3]. The non-interacting beam and all secondary particles except

[2]Intensity up to 10^8 pions/s.

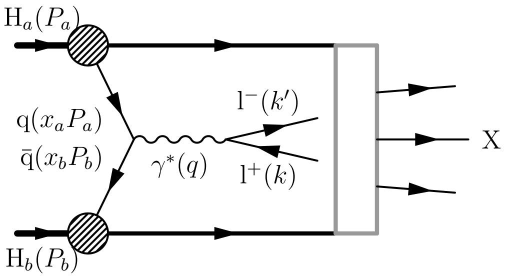

Figure 1: The Drell–Yan process. A quark-antiquark pair from the two hadrons annihilate, producing a lepton-antilepon pair in final state. The grey box denotes hadronization.

muons will be stopped inside. It is made of stainless steel and alumina, with a tungsten beam plug in the centre.

The high intensity pion beam together with the hadron absorber will cause slightly higher radiation dose in the experimental building than in previous runs. Because of that the control room will be moved to another building.

3. Polarized target

The low-temperature polarized target [1, 4] is an essential tool for COMPASS spin structure studies. It is one of the biggest polarized targets in the world. The target material occupies a cylindrical space that is about 120 cm long and has about 4 cm in diameter. The degree of polarization exceeds 80% in the case of H in NH_3 and 50% in the case of D in ^{6}LiD [5].

Polarization of the target material is reached using Dynamic Nuclear Polarization (DNP) method [6] at about 0.5 K. During the physics runs the target is kept in a *frozen spin* mode: The material is cooled down to about 50 mK, when a spin-lattice relaxation time is very long (in order of 10^3 hours) allowing reasonably efficient experiment. Two microwave systems for DNP allow to have target cells with opposite polarization. That helps to reduce systematic errors in measured asymmetries.

The degree of polarization is measured by a continuous-wave NMR. The cooling is provided by a dilution refrigerator, which has a power of about 5 mW at 75 mK [7]. A large-aperture superconducting magnet provides a field up to 2.5 T parallel and 0.64 T perpendicular to the beam axis. Homogeneity of the longitudinal field, which is important for DNP, is about 10^{-5} T. Combination of the two magnetic fields allows measurement with transverse polarization and polarization rotation.

4. Modifications of the target for the DY program

The intense hadron beam and the presence of the absorber brought need for modification of the target. New target cells were made. There are two of them (4 cm in diameter, 55 cm long) with 20 cm long microwave stopper in between[3]. The gap between the oppositely-polarized cells ensures proper assignment of events to them. The gap is wider than in the SIDIS runs, since the hadron absorber introduces significant multiple scattering worsening the vertex resolution.

The NMR system for polarization measurement has 10 coils. Three coils are placed outside of each cell and are oriented for measurement in the longitudinal field. Two coils are placed inside each cell near the ends and serve for polarization homogeneity monitoring.

The target superconducting magnet was refurbished by CERN magnet group. In addition to the fixed trim coils it got various upgrades, e. g. better thermal insulation and new control and safety system.

Since the control room was moved from the experimental building, a remote control is necessary. COMPASS uses a centralised Detector Control System (DCS) for monitoring (*slow control*) of most systems. The dilution refrigerator was, however, only partly monitored by it. It was decided to abandon the old LabVIEW™ system [8] for refrigerator monitoring and to develop a new, more robust, Linux-based software package called *ptread* instead. Its main advantage is that it is modular and easily adjustable. The goal to enable remote monitoring was met. The *ptread* can communicate with the DCS using DIM library [9] and insert data into MySQL and SQLite databases. Figure 2 shows how various subsystems of the target (including the refrigerator) are monitored.

In addition to the *ptread* PC there is a Programmable Logic Controller (PLC) that monitors the most important parameters of the refrigerator [8]. It is powered from a source insensitive to power failures.

5. Conclusion

The magnet was refurbished and is being cooled down and commissioned. Dilution refrigerator was tested and mounted in place. Its sensors are connected to the new Linux-based monitoring system *ptread*. The new target cells are ready. The target will be prepared

[3]The SIDIS design was three cells (30-60-30 cm long, 4 cm in diameter) with 5 cm long stoppers. A special adapter was designed for the microwave cavity to accommodate two cells with one stopper instead of two.

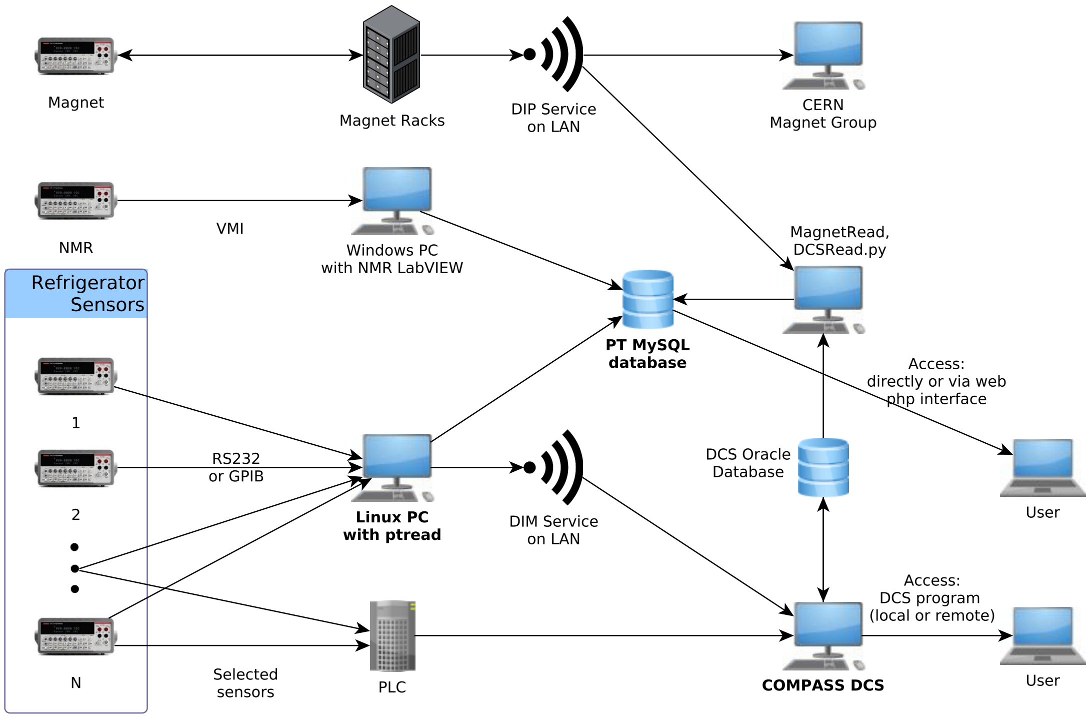

Figure 2: Diagram of target monitoring. The Linux computer with ptread package reads refrigerator sensors. Data can be stored locally in SQLite database, sent to MySQL database and published by DIM server for COMPASS DCS. The magnet is monitored by CERN experts and NMR by a LabVIEW^{TM} program.

for the physics data taking, that is scheduled from the beginning of November 2014. Second run is planned for 2015. In total there should be about 180 days of data taking.

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References

[1] P. Abbon *et al.*, NIM **A 577** 455 (2007).
[2] The COMPASS Collaboration, *List of COMPASS publications*, http://wwwcompass.cern.ch/compass/publications/
[3] The COMPASS Collaboration, *COMPASS-II Proposal*, CERN SPSC **014** 340 (2010).
[4] J. H. Koivuniemi *et al.*, JPCS **150** 012023 (2009).
[5] K. Kondo *et al.*, NIM **A 526** 70 (2004).
[6] A. Abragam, M. Goldman, Rep. Prog. Phys. **41** 395 (1978).
[7] N. Doshita *et al.*, NIM **A 526** 138 (2004).
[8] F. Gautheron *et al.*, NIM **A 526** 147 (2004).
[9] C. Gaspar *et al.*, *Distributed information management system*, http://dim.web.cern.ch/dim/.