Upgraded polarized target for polarized Drell-Yan measurement at COMPASS

2016 J. Phys.: Conf. Ser. 678 012005

(http://iopscience.iop.org/1742-6596/678/1/012005)

Journal of Physics: Conference Series **678** (2016) 012005 doi:10.1088/1742-6596/678/1/012005

Upgraded polarized target for polarized Drell-Yan measurement at COMPASS

Michael Pešek

Charles University Prague, Faculty of Mathematics and Physics, Prague, Czech Republic University of Torino, Department of Physics, Torino, Italy

On behalf of the COMPASS Collaboration

Abstract

The first ever polarized Drell-Yan measurement, presently being done by the COMPASS collaboration at CERN is described. Emphasis is put on the polarized target and its upgrade.

1. Polarized Drell-Yan process at COMPASS

When parton transverse momentum is taken into account then the proton structure can be described at leading twist by eight so called Transverse Momentum Dependent parton distribution functions (TMDs). They are summarized in Tab.1. They can be measured in a variety of processes like (polarized) Semi-Inclusive Deep Inelastic Scattering (SIDIS) or Drell-Yan (DY) process. In Fig.1. the leading order Feynman graphs for these two processes are shown. There are two TMDs which are of great interest: the Sivers and Boer-Mulder functions. These are naïve T-odd and thus process dependent and are predicted to change sign when measured in SIDIS or DY process. The measurement of the sign change is the main goal of COMPASS DY programme, see Ref. [1] for details.

		Parent hadron polarization		
		Unpolarized	Longitudinal	Transverse
Quark polarization	Unpolarized	$f_1(x, k_T^2)$ Number density		$f_{1T}^{\perp}(x, k_T^2)$ Sivers
	Longitudinal		$g_1(x, k_T^2)$ Helicity	$f_1(x, k_T^2)$
	Transverse	$h_1^{\perp}(x, k_T^2)$ Boer-Mulders	$h_{1L}^{\perp}(x, k_T^2)$	$h_1(x, k_T^2)$ Transversity $h_{1T}^{\perp}(x, k_T^2)$

Table 1: Transverse Momentum Dependent parton distribution functions

The COMPASS(COmmon Muon and Proton Apparatus for Structure and Spectroscopy) collaboration runs a fixed target experiment located at the CERN North Area. It uses a secondary hadron or tertiary muon beam from SPS accelerator with momentum up to 280 GeV/*c*. The apparatus is two staged magnetic spectrometer (for measurements of

Journal of Physics: Conference Series **678** (2016) 012005 doi:10.1088/1742-6596/678/1/012005

particles scattered at large and small angles) with both hadronic and electromagnetic calorimetry and particle identification in both stages.

For the DY measurement the original COMPASS apparatus [2] required several important modifications. These include modification of the polarized target, building a hadron absorber with beam dump, scintillating fibers based vertex detector, new large drift chamber and improved calorimetry. The modifications mainly result from using high intensity negative hadron beam (10^8 hadrons/s, 97 % pions) to maximise the number of DY events as the corresponding cross-sections are low, of the order of a tenth of nanobarn. The use of hadron absorber is necessary to avoid saturating the detectors with the hadronic background. This then limits the experiment to measurement of muon pairs only.

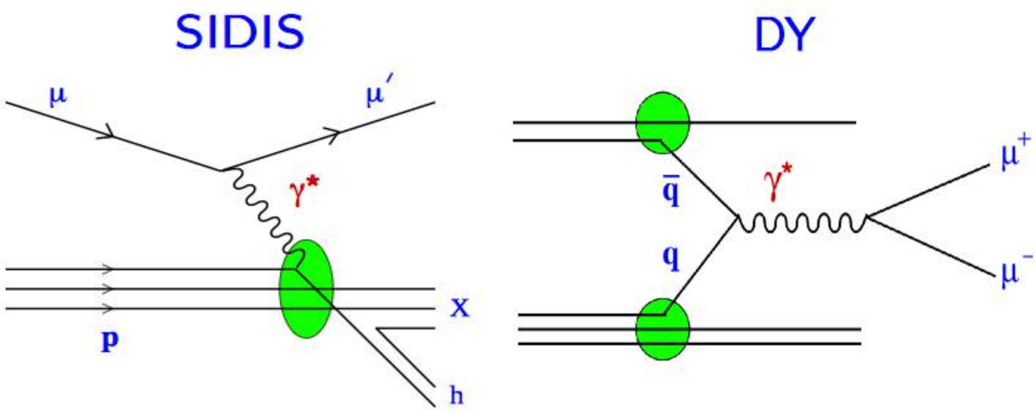

Figure 1: Leading order Feynman graphs for Semi Inclusive Deep Inelastic Scattering ($\mu+p\rightarrow\mu'+h+X$) and for Drell-Yan processes ($q+\bar{q}\rightarrow\mu^{+}+\mu^{-}$)

2. COMPASS polarized target

The polarized target [3] is the key component of the experiment. Building of the polarization needs microwave system (microwave cavity and a pair of microwave generators) for inducing the polarization via the Dynamic Nuclear Polarization mechanism [4] while sustaining the polarization needs low temperature and high magnetic field.

The target has two cells of 55 cm length and 4 cm diameter containing about 700 ml of solid ammonia each. The cells are separated by a 20 cm gap to ensure a proper vertex assignment to each cell. After reaching the high polarization, about 75-90%, in the solenoid field of 2.5 T and temperature about 300 mK the material is cooled down to about 60 mK, and the field is switched to that of a dipole of 0.64 T. The low temperature is obtained by a powerful dilution refrigerator with a cooling power of 5 mW at 75 mK. At these low temperatures the spin-lattice relaxation time for protons is of the order of 1 000 hours which is sufficient for the measurement.

During the buildup the polarization is measured through a continuous Nuclear Magnetic Resonance by five coils in each cell where three of them are mounted outside a cell and two inside it. Cells are polarized in opposite direction to minimise the systematic errors.

The target original design in 2010 and 2011 consisted of three cells of 30-60-30 cm lengths and 4 cm diameter and of ten NMR coils which were all mounted outside the cells. A different design was chosen for DY to cope with higher thermal input form the high intensity hadron beam and to allow a proper assignment of interaction vertex to a target cell. This leads to a

Journal of Physics: Conference Series **678** (2016) 012005 doi:10.1088/1742-6596/678/1/012005

modification of the microwave cavity i.e. a change of microwave stoppers which prevent microwaves to leak from one cell to another. A new layout is shown in Fig.2.

The target requires constant monitoring of all its parameters; it is done by about 30 thermometers, 10 pressure gauges and flow meters. Because of the high radiation dose expected in the experimental hall, it was decided to change the set up the remote control of the whole experiment. This mean abbandoning the LabView system for target monitoring and to develop a new one. The new system called *ptread* has been developed using the C++ language. It is an open-source modular software which allows for many connected measuring devices and several outputs. Most important is a possibility to communicate with COMPASS centralized Detector Control System. Fig.3 shows the structure diagram of the *ptread*.

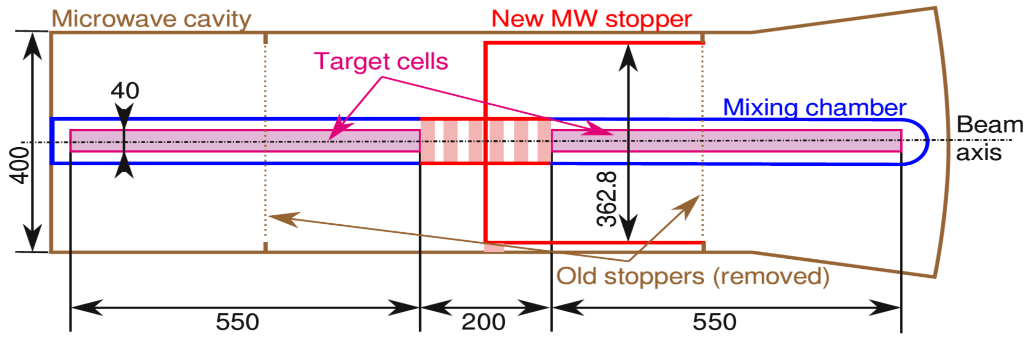

Figure 2: Modified microwave cavity. Numbers denote dimensions in mm.

The target superconducting magnet underwent heavy refurbishment in 2012-2014. The cryogenic part (thermal shielding) was greatly improved. Also huge improvement to superconducting circuitry, mainly the trim coils which homogenize the magnetic field. A new Magnet Safety System and Magnet Control System were designed by the PH-DT group [6] at CERN.

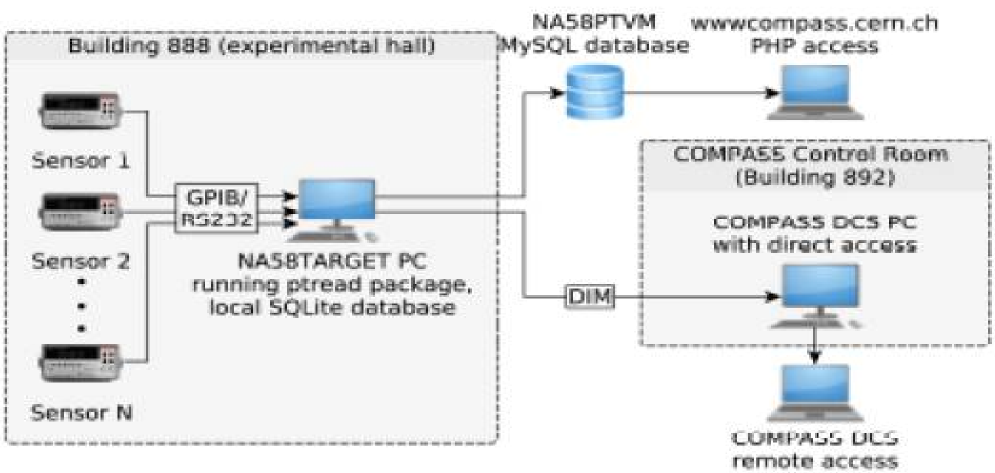

Figure 3: Diagram of *ptread* communication. The Linux computer with *ptread* package reads sensors. Data can be stored locally in SQLite database, sent to MySQL database and published by a DIM server [5] for the COMPASS DCS.

3. Present status

The year 2014 allowed for a short two-months pilot DY run. The majority of the target systems were commissioned except the superconducting magnet. The magnet was fully commissioned in April 2015 and the target is fully operational since then. Data-taking is ongoing.

4. Conclusion

Year 2015 is devoted to the first ever polarized Drell-Yan measurement using negative pion beam and transversely polarised proton target at COMPASS. Data should allow to verify the predicted sign change of the Sivers and Boer-Mulders TMDs. This goal required heavy modifications of the apparatus, mainly the polarized target which underwent modifications concerning the target cells, microwave cavity and superconducting magnet. The new design of the target cells allows for better distribution of the heat load caused by the high intensity hadron beam, thus he target provides high degree of proton polarization (around 80 %) with sufficient relaxation time (>1000 h). The new design also allow to separate well enough the vertices of interaction originating from the different cells. This would be very difficult with the old design as the hadron absorber does not allow any tracking for more than 2 m after the target.

5. Acknowledgements

The author acknowledges the support by the LG13031 MEYS Czech Republic grant.

6. References

[1] COMPASS Collaboration, COMPASS-II Proposal, CERN-SPSC, CERN-SPSC 2010-014, SPSC-P-340, http://wwwcompass.cern.ch/compass/publications/#proposal

[2] COMPASS Collaboration, P. Abbon et al., Nucl. Instr. and Meth. A577 (2007) 455.

[3] J. Koivuniemi et al., Journal of Physics: Conference Series 150 (2009) 012023

[4] A. Abragam, M. Goldman, Rep. Prog. Phys. 41 (1978) 395.

[5] C. Gaspar et al., Distributed information management system, http://dim.web.cern.ch/dim/

[6] CERN Detector Technologies group, http://ph-dep-dt.web.cern.ch