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THE PAX EXPERIMENT AT FAIR

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Abstract

Polarized antiprotons, by spin filtering with an internal polarized gas target, provide access to a wealth of single- and double-spin observables. This includes a first direct measurement of the transversity distribution of the valence quarks in the proton and a first measurement of the moduli and the relative phase of the time-like Electric and Magnetic Form Factors (EMFF) $G_{E,M}$ of the proton. The PAX (Polarized Antiproton eXperiments) collaboration [1] is developing a viable experimental set-up [2] which can be realized within the FAIR (Facility for Antiproton and Ion Research, GSI - Darmstadt) [3] project for a large european hadron facility, where a low-energy antiproton polarizer ring is used to yield an antiproton beam with sizeable polarization. After acceleration, the polarized antiproton beam can be used to collide with a polarized internal hydrogen target (fixed target mode) or with a beam of polarized protons (collider mode). The detector concept for a large angle apparatus optimized for the detection of lepton pairs of large invariant mass is anticipated.

1 Physics Case

The physics program of the polarized antiproton facility proposed by PAX would extend to a new domain the studies of the nucleon structure performed in unpolarized and polarized Deep Inelastic Scattering (DIS), which have been at the center of high energy physics during the past four decades. The polarized antiproton-proton interactions at HESR (High Energy Storage Ring, GSI - Darmstadt) will allow a unique access to a number of new fundamental physics observables, which can be studied neither at other facilities nor at HESR without transverse polarization of protons and/or antiprotons. In order to exploit all the planned measurements, the physic has been divided into two phases: Phase-I and Phase-II both in the CSR (Cooled Storage Ring, at FAIR).

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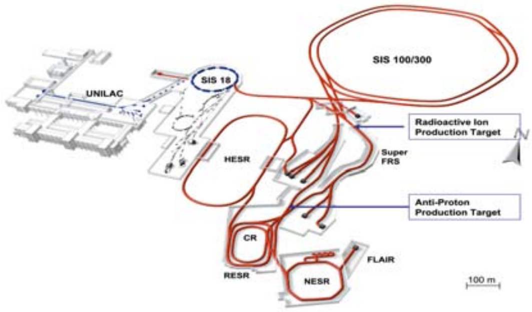

Figure 1: FAIR accelerator layout (future facilities)

1.1 Phase-I

Phase-I (fixed-Âtarget) concentrates on the time-like proton form factors and hard elastic scattering measurements. The simple and over-constraint kinematics of these events puts less stringent requirements on the detector performance. The measurements can start even before the detector is completed and can be used to test and optimize each of the sub-systems. In this phase, a polarized/unpolarized pbar beam of momentum up to 4 GeV/c will strike on fixed hydrogen atoms, accumulated in a storage cell. Atomic hydrogen will be produced by a conventional ABS (Atomic Beam Source). This phase is completely independent from HESR, so it does not interfer with the PANDA [4] experiment. At the CSR energies, the outgoing particles have an

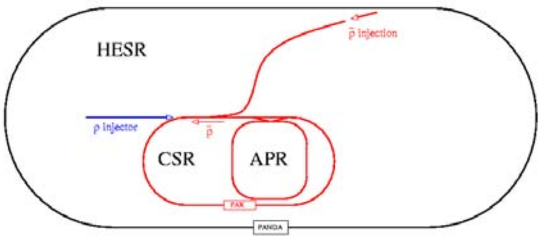

Figure 2: Phase I accelerator setup

almost isotropic distribution and a momentum between 0.5 and 1.5 GeV/c. The expected luminosity is $2.7 \cdot 10^{31} cm^{-2} s^{-1}$. Measurements will take from few hours to few weeks.

1.2 Phase-II

Phase-II (asymmetricÂ-collider mode) concentrates on the h_1 measurement (Transversity Distribution). In this phase a polarized proton beam circulating in HESR (p=15GeV/c) will strike, had-on, on a polarized antiproton beam circulating in CSR (p=3.5 GeV/c). The resulting CM (Center of Mass) energy will be 15 GeV. The inclusive $pp \rightarrow e^+e^-$ X Drell-Yan (DY) process

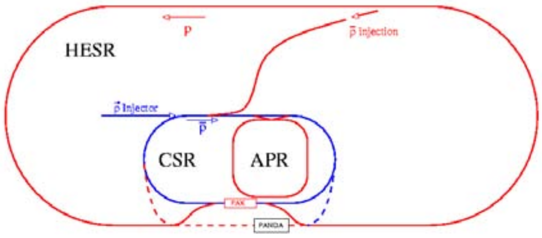

Figure 3: Phase II accelerator setup

has poor kinematic constraints. A rejection factor of 10^3 against background events is required to reduce the rate from few MHz to kHz levels. The trigger asks for two tracks in opposite hemispheres above the Cerenkov threshold. To reduce low-energetic combinatorial background, a cut on the dilepton invariant mass is applied using the deposited energy and the impact point at the calorimeter. The first layer of silicon is used to veto gamma conversions. The expected luminosity [5] is $5 \cdot 10^{31} cm^{-2} s^{-1}$. With a polarization of 20%, after one year of datataking, a precision of 10% in the measured h_{1u} in the valence region is expected.

2 Detector

The detector has a barrel geometry (fig. 4) that covers large θ_{lab} angle ($20^o - 120^o$). It's simmetric in ϕ in order to measure asymmetries of h_1 in ϕ. It has been designed to identify DY events in a large hadronic background (one DY event on 10^7 interactions). It will use five different types of detectors:

- Silicon Tracking Telescopes (two layers @ 5 and 22 cm from the beam axis, inside vacuum)
- Drift chambers (@ 65 and 135 cm from the beam axis)
- Cerenkov (between drift chambers)
- Scintillation odoscopes (in the forward region)

- Electromagnetic calorimeter (16·X_0, up to 5 GeV showers)

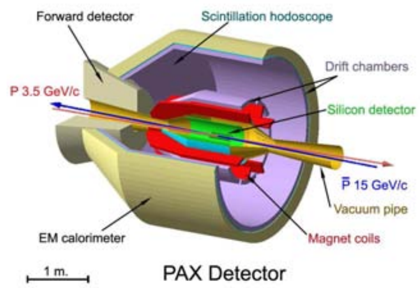

Figure 4: Artists view of PAX detector, produced by GEANT

In order to be compatible (no fringe field) with Cerenkov detector and with transversly polarized target, the chosen magnet design is a superconducting toroid. It's composed of eight separate coils.

3 Summary

PAX project has an innovative spin physics program to explore transversity/SSA (in collider mode) and EMFF/hard p-pbar scatterings (in fixed-target mode). It will open a way to obtain a polarized antiproton beam and will provide at FAIR a fexible second IP (Interaction Point) that really matches the physics items.

References

[1] http://www.fz-juelich.de/ikp/pax/

[2] PAX Technical Proposal

[3] http://www.gsi.de/fair/

[4] http://www-panda.gsi.de/

[5] Y. Shatunov et al. (2005)