Event Rate Estimates for the Spin Filtering Experiment at the AD–ring of CERN*

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The PAX collaboration [1] suggests to study the polarization buildup in an antiproton beam at the AD–ring (CERN) in the energy range of 50–200 MeV [2]. The experimental basis for predicting the polarization buildup in a stored antiproton beam is practically non–existent. The polarization buildup, by spin filtering of stored antiprotons by multiple passage through a polarized internal hydrogen gas target, gives a direct access to the spin dependence of the antiproton–proton total cross section. Once the experimental data base will be made available by the AD experiments, the final design of a dedicated Antiproton Polarizer Ring (APR) [3] can be targeted.

In this report we present results of the event rate estimates for $\bar{p}p$ elastic scattering process in the energy range of 20–250 MeV. For the analysis, a model for the nucleon–antinucleon interaction [4] based on the meson–baryon dynamics, has been used. The model enables a simultaneous description of nucleon–antinucleon scattering and annihilation phenomena with fair quality. We decided to use the calculated results of the differential cross section $\mathrm{d}\sigma/\mathrm{d}\Omega$ and of the analysing power $\mathrm{A_y}(\theta)$ from this model in the following analysis.

For each fixed beam energy, the Figure of Merit ($\mathrm{FoM}(\theta) = \mathrm{A_y^2}(\theta) \cdot \mathrm{d}\sigma/\Omega)$ *vs* antiproton polar angle (θ) was calculated and the value of the maximum FoM was determined. In Fig.1 the angular dependence of the differential cross section (upper row), analyzing power (middle), and FoM (lower row) at three different antiproton beam energies ($\mathrm{T_{Pbar}}$), are shown.

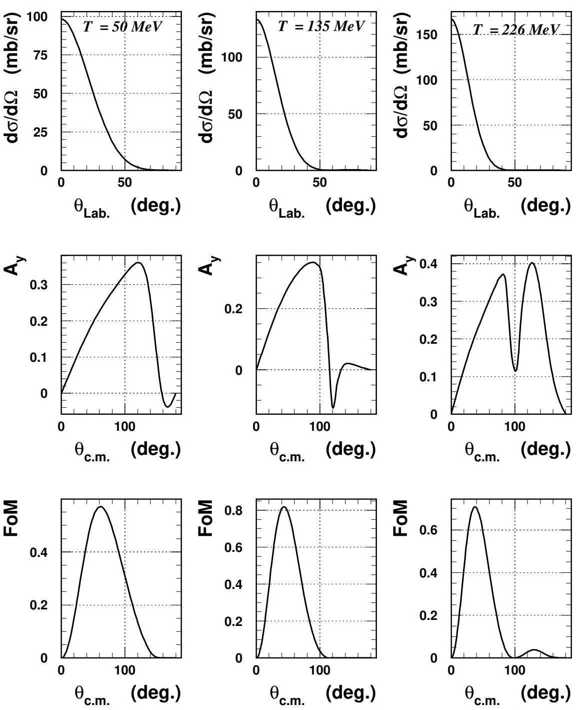

Fig. 1: The angular dependence of the differential cross section (upper row), analyzing power (middle), and FoM (lower row).

The maximum of FoM moves towards smaller forward angles with increasing beam energy, where the differential cross section is dominant.

To estimate of the $\bar{p}p \rightarrow \bar{p}p$ elastic count rates, we have considered a scenario with detection of both particles. To detect recoil protons we suppose to use a similar detector system as it is presently used at ANKE, a so–called Silicon Tracking Telescope (STT) [5]. Recoil protons can be identified via the ΔE/E method over an energy range from 2.5 MeV to 30 MeV with the resolution of 150–250 keV. In this kinematics, the forwarde antiproton is the fast particle and by using the STT, it is possible to determine the flight direction, which is sufficient, in combination with the recoil proton, to reconstruct the vertex position in the storage cell of the Polarised Internal Target [6].

Based on the features shown in Fig.1, we assumed that for each beam energy the *forward* telescope system will cover laboratory polar angles $\theta = 15^\circ - 30^\circ$, which is possible with the present STT detector design.

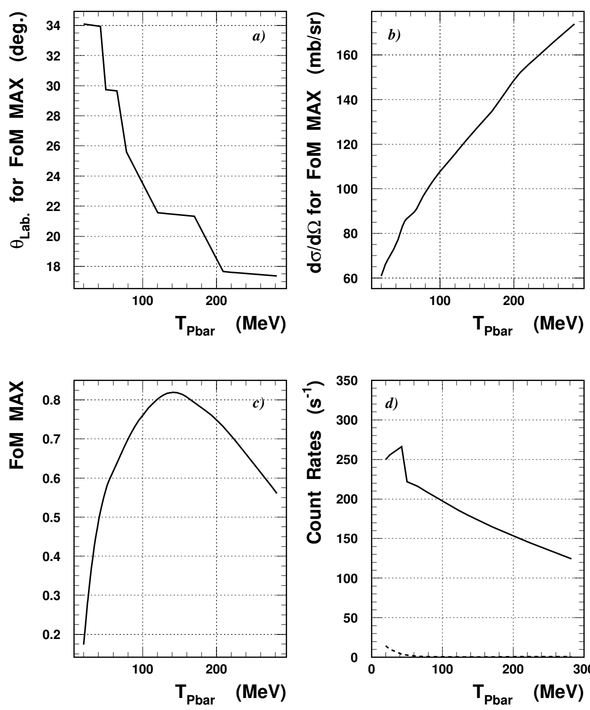

Fig. 2: The energy dependence of: a) the antiproton polar angle θ corresponding to the maximum FoM, b) the differencial cross section corresponding to the maximum FoM, c) maximum FoM, and d) the count rates. Dashed line on the fig.1.d corresponds to the background due to misidentification of antiprotons.

In these estimates, a luminosity of $\mathrm{L} = 10^{27}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ has been used, which is based on the following assumptions: The AD provides about 3×10^7 stored antiprotons. Through stacking, one may be able to increase the number of stored antiprotons by about a factor of five, wherefrom also the other experiments at the AD would benefit. With a beam current corresponding to about 10^8 stored antiprotons, a luminosity of $L = N_{\bar{p}} \cdot f \cdot d_t = 10^8 \cdot 10^6\,\mathrm{s}^{-1} \cdot 10^{14}\,\mathrm{atoms/cm}^2 = 10^{28}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ may be achievable. To provide a larger number of stored antiprotons in the AD in the first place is important, because after spin filtering for a few beam lifetimes one wants to be left with a substantial beam intensity to carry out the beam polarization measurements. In our calculations, a detection efficiency of 100 % was assumed, and dead–time correction factor of 1. Under these conditions, the estimated antiproton–proton elastic rates are about 120–250 s^{-1} (see Fig. 2.d).

Based on these rough estimations, we plan to do more precise calculations with Monte Carlo simulation, using the GEANT4 program developed for ANKE. This will include the real sizes of the ANKE target chamber, disposition of two STT systems around the long (40 cm) storage cell target, and the density distribution of the PIT target. It will then be possible to address the other issues concerning the experimental conditions, like resolution and backgound estimates made more accurately.

References:

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