Simulations of Luminosity monitor for PANDA experiment

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Introduction

The Panda experiment at the future GSI facility FAIR (Facility of Antiprotons Research) is designed to address broad physics programs in hadron physics using the antiproton beam. The physics program includes, among other things, the study of charmonium spectrum and open charm states with high precision and search of exotic hybrids and glueballs in the charmonium mass region [1, 2]. While in some measurements, such as, the resonance scans to determine the resonance widths and mass, only a relative measurement of luminosity may be sufficient, the measurement of the time integrated luminosity at the interaction point is essential in most of the cases to determine the cross section for physical processes. A luminosity monitor based on Si-strip detectors is planned for the PANDA experiment. In the present work, we report initial simulation studies that have been started at NPD, BARC on the design and optimization of the Si-strip based luminosity monitor for the PANDA experiment.

Luminosity Measurement

The principle of measuring the luminosity in the PANDA experiment is based on the measurement of elastically scattered antiprotons in the region of Coulomb-nuclear interference. Elastic scattered particles are needed to be measured with high precision and at extreme forward angle. The rate of elastic scattering is linked to the total interaction rate through the optical theorem. According to it, the total cross section is directly proportional to the imaginary part of the forward elastic scattering amplitude extrapolated to zero momentum transfer squared $-t$ (at small values of $-t$, $-t = (p\theta)^2$, with the beam momentum p and the forward scattering angle θ):

$$\sigma_{tot} = 4\pi\Im[f_{el}(0)] \quad (1)$$

The aim is to measure elastic scattering down to such small t-values that the cross section becomes sensitive to the electromagnetic amplitude via the Coulomb-nuclear interference term. Since the electromagnetic amplitude can be precisely calculated, it allows both the luminosity and total cross section to be determined without measuring the inelastic rate

$$\begin{aligned}\frac{dN}{dt} &= L\pi(f_C + f_N)^2 \\ &= L\pi(\frac{-2a_{EM}}{|t|} + \frac{\sigma_{tot}}{4\pi}(i+\rho)e^{-b\frac{|t|}{2}})^2 \quad (2)\end{aligned}$$

This expression for the measured rate is fitted for the luminosity L to determine it along with the other parameters ρ, σ_{tot} and the slope parameter b from the fit.

Simulation of PANDA Luminosity Monitor

The luminosity monitor is designed to reconstruct the angle of the scattered antiprotons and thereby reconstruct the 4-momentum transfer variable t in the polar angle range of 3-8 mrad with respect to beam axis. For this purpose, four planes of Si-strip detectors located far from the interaction point but very close to the beam axis is proposed. The silicon wafers are located inside a vacuum chamber to minimize scattering of the antiprotons before traversing the 4 tracking planes Two such geometrical designs consisting of eight and four trapezoidal Si wafers in four planes as shown in Fig. 1 have been considered for simulation.

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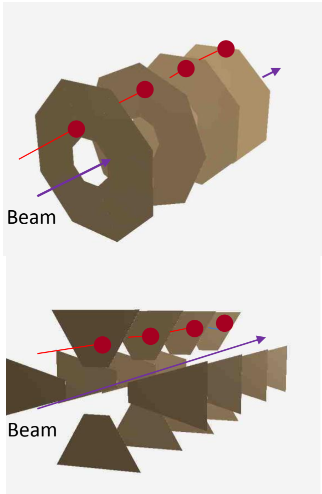

FIG. 1: Two different geometries of Si strips in 4 planes used for the simulations.

The Si sensors have 300 micron thickness and 50 micron pitch and are they are located 3-8 cm from the centre. The first plane is located at 10 m downstream the interaction point and the subsequent planes are separated by 20 cm, along the beam direction.

Initial simulation studies have been performed for studying the performance of the PANDA luminosity monitor using the Pandaroot software. The main goal is to study how well the proposed design can be used to reconstruct the momentum (angle) with very good precision. 10000 antiprotons at 6.2 GeV/c momentum have been simulated for the disk geometry (as shown in upper part of Fig. 1). We have used all steps of digitization, Reconstruction, track finding and fitting in the simulation. The results of simulation are shown in terms of the pull distributions for the polar and azimuthal angles using the reconstructed and Montecarlo distributions. Further simulations are in progress to optimize the design geometry.

Acknowledgments

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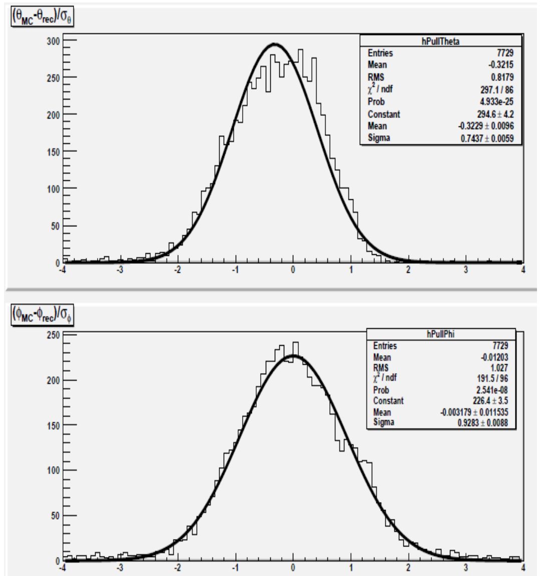

FIG. 2: Pull distributions of the reconstructed polar and azimuthal angle with respect to the Monte Carlo generated events.

References

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