Study of an alternative design of Luminosity Monitor Detector for $\bar{\text{P}}$ANDA at FAIR - GSI

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Introduction

The $\bar{P}$ANDA experiment will investigate antiproton annihilations with an almost 4π acceptance from two sequent spectrometer in the momentum range from 1.5 GeV/c to 15 GeV/c. An antiproton beam with intensity up to 2×10^7 $\bar{p}$/s will interact with an internal target, either a hydrogen cluster jet or a high frequency frozen hydrogen pellet target to reach a luminosity of up to 2×10^{32} $\text{cm}^{-2}s^{-1}$ [1]. The differential cross section $\frac{d\sigma_{el}}{dt}$ is dominated by Coulomb scattering at very low values of |t|. Since the electromagnetic amplitude can be precisely calculated, Coulomb elastic scattering allows both the luminosity and total cross section to be determined without measuring the inelastic rate.

$$\frac{dN}{dt} = L \cdot \sigma \qquad (1)$$

In this abstract we present the simulation work for Radiation Hard Diamond used as Luminosity Monitor Detector (LMD)

Luminosity Monitor Detector

The basic objective of the luminosity monitor is to reconstruct the angle (thus t) of the scattered antiprotons in the polar angle range of 3-8 mrad with respect to the beam axis. As one needs three points in space and to have an additional point it is proposed that the luminosity monitor will consist of a sequence of four planes of double sided Silicon/Diamond strip detectors located as far downstream and as close to the beam axis as possible. The planes are separated by 10 cm along the beam direction. Each plane consists of 4 sensors arranged radially to the beam axis. Four planes are required for sufficient redundancy and background suppression. The use of 4 sensors in each plane allows systematic errors to be strongly suppressed.

The proposed sensors are Trapezoidal in shape with dimension (3.3471 cm $\times$ 7.8099 cm) $\times$ 7 cm. It is proposed that each of these sensors will be double sided strip detectors with a thickness of 150 μm and pitch of 50 μm. Strips are oriented parallel to side walls of trapezoids and the overlapping of front side strips with strips on back side form a diamond shape structure. Fig 1 shows geometry of luminosity sensor and graphical 3D-view of detector.

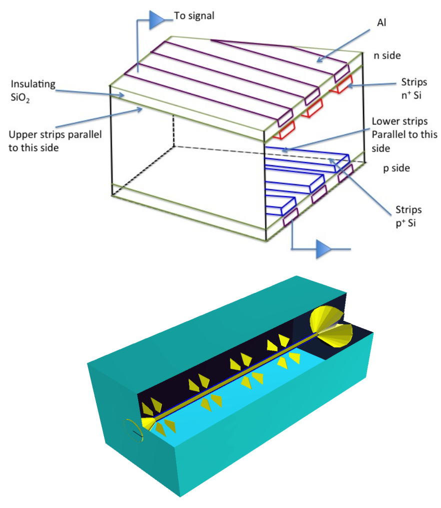

FIG. 1: (a) Sensor Geometry (b) Graphical view of LMD

Simulation and Analysis

The Monte Carlo simulation is done for forward going antiproton with energy 8.9 GeV in PandaRoot and single particle event generator is used to create events. Digitization which models the signals of the individual

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detectors and their processing in the front-end-electronics (APV25) provides detector response of interaction with incident particle.

We have done simulation for both Silicon as well as Diamond sensors. In this section we compared simulation results for both materials. The Energy Deposited in silicon is 48 KeV where as in Diamond it is 74 KeV shown in Fig 2 and Hit resolution along x and y direction of individual LMD measurements is shown in Fig 3 which is approximately same for both sensors ($\approx 11\mu$m). Fig 4 shows delta Theta for reconstructed events which is marginally better in Diamond sensors . Fig 5 shows the effect of solenoid field on particle propagation, for Anti-proton of momentum 3.5 GeV/c, at fixed theta 5.2 mrad.

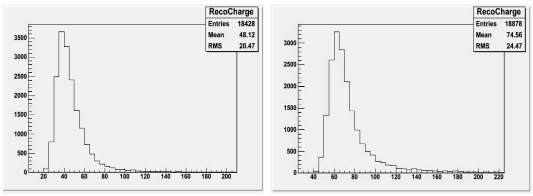

FIG. 2: simulation result for Charge deposition in (a) Silicon and (b) Diamond

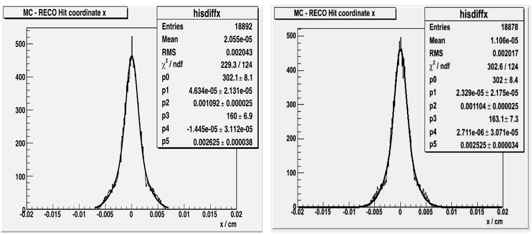

FIG. 3: simulation result for Position Reconstruction error in (a) Silicon (10.92 μm) and (b) Diamond (11.04 μm)

Diamond detectors

Simulation result shows that we can implement Diamond sensors as Radiation Hard alternative to a traditional Silicon material which provides same reliability as silicon. The detectors can be fabricated from poly-crystalline diamond substrates grown using the microwave plasma-chemical vapor deposition technique (MW-CVD) from a mixture of methane and hydrogen. We are in process of

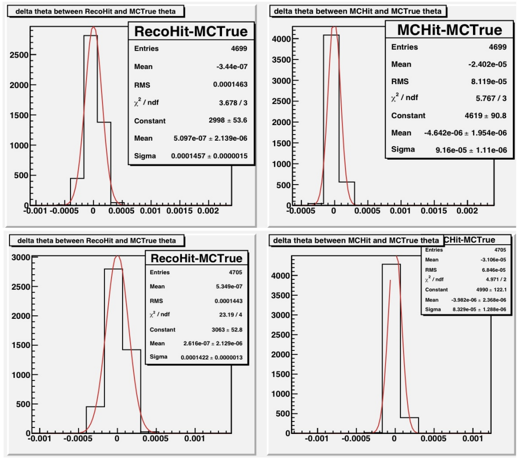

FIG. 4: simulation result for dTheta in (up) Silicon (0.1457 mrad) and (down) Diamond (0.1422 mrad)

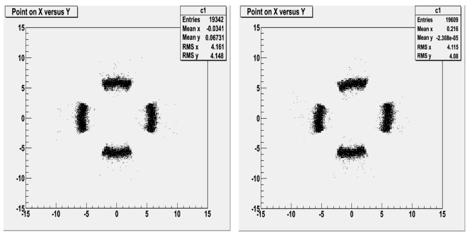

FIG. 5: Effect of solenoid field when it is (a) off (b) on

making detector from 30 μm-thick CVD diamond samples with an area of 1cm$\times$1cm. Charge collection efficiency (CCE) measurements will be presented with 5.5-MeV alpha particles from a ^{241}Am source. The exact value of the particle energy will be measured with a silicon surface barrier detector as reference detector.

Acknowledgments

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References

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[2] G. Schepers for the PANDA Collab., GS14-110427 LEAP11-proceedings-GS, PANDA at FAIR Physics and Detector.