Measurement of luminosity using p-p elastic scattering at T_{lab} = 1400 MeV with WASA-at-COSY

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Introduction

Luminosity, one of the most important parameter of any experiment, is the number of particles per unit area per unit time times the opacity of the target, expressed in $b^{-1}s^{-1}$. The integrated luminosity is the integral of the luminosity with respect to time and characterizes the experiment. The advantage is that once the integrated luminosity is known then the cross section for a particular process can be calculated by the relation

$$\sigma = \frac{N_{exp}}{\epsilon L}, \quad (1)$$

where N_{exp} is the number of events measured in the experiment for chosen reaction, ϵ is the overall detector efficiency and L is the time integrated luminosity.

In this paper we report the luminosity, for the WASA-at-COSY collaboration, of the experimental run in April 2007. Generally binary reactions are selected for measurement of luminosity. Here we have two possibilities: proton-proton elastic scattering and pion deuteron production (pp$\rightarrow \pi^+ d$). We are using proton-proton elastic scattering for measurement of luminosity. All the kinematical and dynamical properties of the p-p elastic scattering are well known. It has been measured in several experiments at COSY, the IUCF or SATURNE. The available data set for elastic scattering of protons is compiled in a database called SAID database([1]) and can be accessed via world-wide web.

For luminosity measurement one can ensure the following physical constraints, for an elastic collision between two particles of equal mass:

$$|\phi_1 - \phi_2| = \pi \quad (2)$$

$$tan\Theta_{1,lab} * tan\Theta_{2,lab} = \frac{1}{{\gamma_{cm}}^2} \quad (3)$$

Equation (2) is the co-planarity condition and equation (3) is known as kinematical correlation. The Lorentz factor γ_{cm} describes the movement of the laboratory system with respect to the center of mass system and can be written as

$$\gamma_{cm} = \sqrt{1 + \frac{T_{lab}}{2m}} \quad (4)$$

where T_{lab} is the kinetic energy of the incident beam and m is the rest mass of the beam particle.

Experimental setup

The Wide Angle Shower Apparatus (WASA) is installed at the COSY accelerator in Jülich, Germany. The COSY accelerator delivers phase space cooled beam of protons and deuterons in the momentum range between 0.3-3.7 GeV/c. WASA is a fixed target experiment with a pellet target system, which provides the target of hydrogen or deuterium of thickness 35μm. The forward part is designed to measure scattered particles. The central part is designed to measure decay products of the η-meson, like $\pi^{\pm}$, $e^{\pm}$ and photon.

Analysis

The Monte Carlo data for p-p elastic scattering are generated using Pluto event generator at T_{lab} = 1400 MeV and passed through

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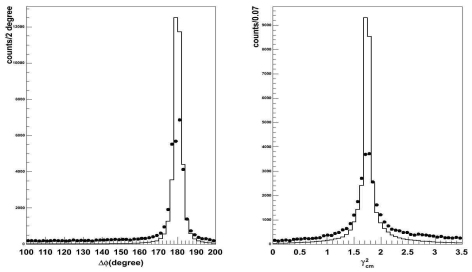

FIG. 1: (a) Phi difference and (b) Square of Lorentz factor for MC and data. Cricles are data points and solid line is MC.

detector. For selection of events we search for one charged track in forward detector and one charged track in central detector. The planarity distribution and square of Lorentz factor are plotted in FIG. 1 for MC and for the data taken in April 2007. We select the events by applying a cut on three sigma of planarity on Lorentz factor in center of mass frame. The square of Lorentz factor distribution is fitted by assuming signal to be a Gaussian and background to be a fourth order polynomial(FIG. 2). The signal to background ratio is 10.32%. After subtraction of background, integration of Lorentz factor distribution in center of mass frame within three sigma gives us total number of elastic events. Assuming elastic scattering cross-section 21.52 mb at T_{lab}=1400 MeV and using equation (1), we get time integrated luminosity $(2331.6\pm2.4_{stat})nb^{-1}$ for 62 hours of data.

Now to verify that the measured integrated luminosity is correct, we tried to compare the angular distribution for p-p elastic scattering from our data to angular distribution from the SAID database. The efficiency corrected and background subtracted angular distribution is plotted in FIG. 3, where circles shows our data point and triangles are data points from SAID database. The distribution deviates from the SAID data in the angular range 11.5-14.5 but it agrees well in range 15.5-17.5.

The luminosity measurement for the data taken in April 2007 is done using proton-proton elastic scattering. The preliminary result of luminosity for 62 hours of data is presented here. The analysis for estimation of systematic error is in process.

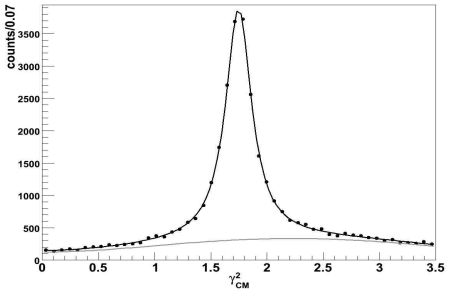

FIG. 2: Square of Lorentz factor for data. The Lorentz factor is fitted by assuming signal to be Gaussian and background to be polynomial of order four. Circles are data points.

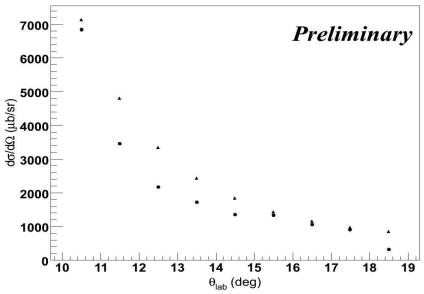

FIG. 3: Comparison for angular distribution of proton in laboratory frame of WASA-at-COSY data with SAID data. Triangles are SAID data and cirlces are data from WASA-at-COSY.

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References

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