Study of pp elastic scattering with an internal COSY experiment

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ABSTRACT

The internal target experiment EDDA at COSY aims at a precision measurement of excitation functions for proton-proton elastic scattering cross sections and polarization observables in the energy range 250–2500 MeV. The detector setup required for spin-averaged measurements has been completed, and results of test runs at 793 MeV are reported.

1. Introduction

Proton-proton elastic scattering is a fundamental strong interaction process at intermediate energies. Its investigation has greatly contributed to the development of modern meson-exchange nucleon-nucleon potentials and the extraction of amplitudes by phase-shift analysis. Yet, the database for both differential cross sections and polarization observables has remained sparse and inconsistent for projectile kinetic energies $T_p > 1.2$ GeV.

The EDDA experiment is designed to fill this gap by measurement of excitation functions in small energy steps between 0.25 and 2.5 GeV for a wide range of scattering angles. It will also be sensitive to possible contributions of intermediate dibaryonic states, which have been predicted[3] but not unambiguously identified in experiments[4]. The experiment uses the beam of the Cooler Synchrotron COSY on an internal target during the acceleration of the beam. At present, a thin polypropylene (CH_2) fiber target is employed for spin averaged cross sections. When a polarized COSY beam becomes available it will be replaced by a polarized atomic beam target to measure spin correlation observables – indispensable for both phase shift analysis and the clean identification of possible resonant contributions.

2. Detector Concept

The main components of the EDDA detector are shown schematically in Fig. 1. It consists of a segmented, double-layered scintillator structure of cylindrical symmetry, centered around the COSY beam. It provides a coverage of 90% of 4π for pp elastic scattering. The outer layer is comprised of scintillator slabs (S in Fig. 1) parallel and scintillator semirings (R) perpendicular to the beam. The semirings closest

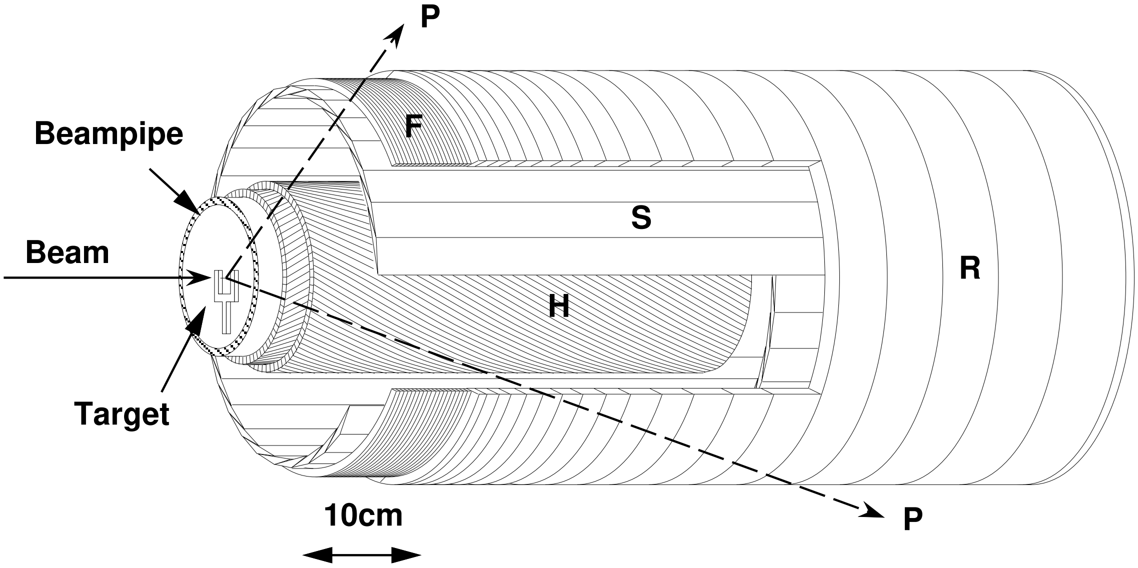

Figure 1: Schematic cut-away view of the EDDA detector

to the target are constructed from scintillating fibers (F). The detector elements of each layer overlap and yield an angular resolution far better than that given by the granularity of the detector (see Ref. 5). In conjunction with the inner layer (H), made up by two helices of scintillating fibers with opposite slope, reconstruction of the scattering vertex will be possible.

A fast trigger on pp-elastic events is generated by the outer layer requiring a kinematic coincidence of the two protons. By virtue of elastic scattering kinematics these are coplanar with the beam, i.e. $|\phi_1 - \phi_2| = \pi$, and the scattering angles in the laboratory are correlated via

$$\tan\theta_1 \tan\theta_2 = 1/\gamma_{c.m.}^2.$$

Here, $\gamma_{c.m.}$ is the Lorentz-γ of the center–of–mass motion in the laboratory.

3. Fiber Target and Luminosity Monitors

In the first (unpolarized) phase of the experiment, a thin polypropylene fiber target is used. It is aluminum-coated and connected to the ground via a sensitive amperemeter, which measures the total rate of electrons emanating from the target as it is hit by the COSY beam and serves as a *relative* luminosity monitor. In addition, energetic δ electrons are detected by an array of PIN diodes at 40° (lab). Lifetimes of the beam on target are in the order of 1–3 s.

4. First Results

First measurements were carried out at a fixed energy of T_p=793 MeV in order to compare the data taken to a recent precision experiment at LAMPF[6]. The COSY

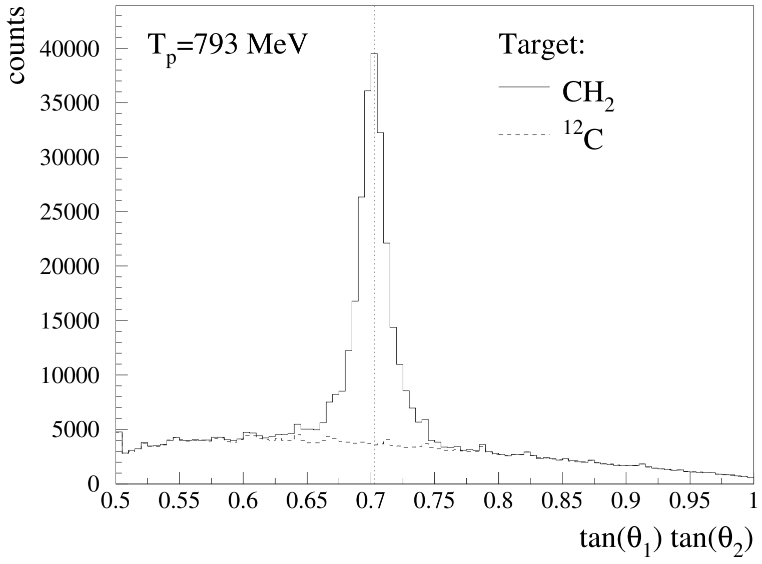

Figure 2: Distribution of the angular correlation $\tan\theta_1 \tan\theta_2$ for 2-prong events, measured with a polypropylene (CH_2, solid line) and a carbon (dashed line) fiber target at 793 MeV beam energy. The vertical line indicates the value $1/\gamma^2_{c.m.} = 0.703$ required by p-p elastic scattering kinematics.

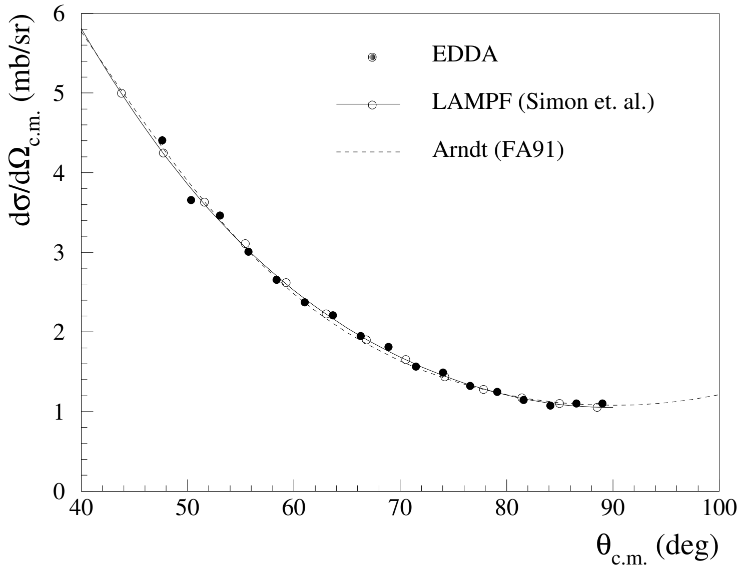

Figure 3: Differential pp-scattering cross section in the center-of-mass. The results of the EDDA experiment (filled symbols) at $T_p = 793$MeV have been normalized to the data of Ref. 6 (open symbols) and the parametrization (solid line) given therein. The dashed line is the result of a recent phase-shift analysis by Arndt[7] (solution FA91). Statistical errors are about as large as the symbols.

beam turned out to be exceedingly clean. Background unrelated to the target was not observed. Fig. 2 shows the distribution of the angular correlation $\tan\theta_1 \tan\theta_2$ for binary events obtained with a CH_2 fiber target (solid line). The background from quasi elastic $^{12}C(p,pp)X$ scattering is deduced from data acquired with a carbon target (dashed line, normalized to the same luminosity) and can be cleanly subtracted. The angular distribution of the pp-elastic scattering events is in agreement with recent measurements at LAMPF and phase-shift analysis (cf. Fig 3).

Measurements during synchrotron acceleration have been pursued with 300–900 MeV energy range. It could be demonstrated that the COSY beam stays stable during acceleration and presents no obstacle to multi-pass excitation function measurements. Additional background as compared to measurements at a fixed energy is not observed.

Target, luminosity monitors, data acquisition and the detector have been operated successfully and reliably. The EDDA experimental program has started and will be extended to higher COSY beam energies as soon as they are available.

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