Differential cross section measurements for pp elastic scattering at ANKE

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Motivation

- NN description requires precise data for Phase Shift Analysis.
- There are severe problems with the small angle predictions from SAID above 2.5 GeV.

In order to deduce information on np system it is necessary to have equally robust pp data in the same angular range.
Experimental Setup

- $d\sigma/d\Omega$ measurement in the angular range: $5^\circ<\theta_{cm}<30^\circ$ for the energies: $T_p = 1.0, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8\text{ GeV}$.

- Proton detection either with FD, or with STT, or with both in coincidence.

- Three Multi-wire Chambers with two layers of Scintillation hodoscopes. $(10^\circ<\theta_{cm}<30^\circ)$

- Three layers of double-sided silicon strip detectors. $(5^\circ<\theta_{cm}<15^\circ)$
Measurement Technique

- Absolute measurement of pp elastic scattering \( \frac{d\sigma}{d\Omega} \) using the Schottky technique. **COSY proposal #200 (PAC-37)**

- Cross section \( \sigma \) of given physical process is related to its event rate \( R \) by luminosity:

  \[
  \sigma = \frac{R}{L}
  \]

  Where: \( L = n_B \cdot n_T \)

- Accurate measurement of beam intensity \( n_B \) is possible via the high precision Beam Current Transformer (BCT) device.

- Effective target thickness \( n_T \) can be obtained via the measurement of the frequency shift of coasting beam using the Schottky device.

  \[
  n_T = \left( \frac{1+\gamma}{\gamma} \right) \frac{1}{(dE/dx)_m f_0^2} \frac{T_0}{\eta} \frac{df}{dt}
  \]

  Details in: Stein et al., PR ST-AB, 11, 052801
Target Density

\[ \eta = \frac{1}{\gamma^2} - \alpha \]

Mean revolution frequency shift is connected to \( \Delta B/B \) change in the bending magnets via momentum compaction factor \( \alpha \):

\[ \frac{\Delta f}{f_0} = \alpha \frac{\Delta B}{B} \]

Previous meas. Current meas.

Stein et al., PR ST-AB, 11, 052801
Luminosity

Dedicated software package determines:
- Revolution frequency
- Frequency shift
- Target density

\[ L = n_B \cdot n_T \]

With 2-3 % accuracy
Preliminary Results: Forward Detector

\( T_p = 1.0 \) GeV

\( T_p = 1.8 \) GeV

\( T_p = 2.0 \) GeV
Preliminary Results: Forward Detector

\[ T_p = 2.2 \text{ GeV} \]

\[ T_p = 2.4 \text{ GeV} \]

\[ T_p = 2.6 \text{ GeV} \]

\[ T_p = 2.8 \text{ GeV} \]

\[ \sigma / \Omega \text{ [mb/sr]} \]

\[ \theta_{\text{c.m.}} \text{ [Degree]} \]

SAID

ANKE

Preliminary
STT Analysis

- Three layers with different thickness 70 µm, 300 µm, and 5 mm allow very good particle identification
- Track and consequent vertex reconstruction
- Very accurate energy measurement for stopped particles
STT Analysis: Stopped particles

Proton missing mass [GeV/c²]

ΔE [MeV]

Mean: 0.188
Sigma: 1.219

Mean: 0.644
Sigma: 2.290

FD range

Mean: 0.188
Sigma: 1.219

David Chiladze
Absolute measurement of the differential cross section for pp elastic scattering at ANKE-COSY

JÜLICH
FORSFCHUNGZENTRUM
STT Analysis: Coincidence with FD

- There is a difference between FD and STT angle
- Energy calibration depends on energy itself
- It is necessary to consider energy dependence in the calibration procedure.

![Graph showing STT Energy Calibration](image)

- Simulation (Layer 1, Layer 2)
- Experiment (Layer 3)
STT Analysis: Efficiency

- Trigger from Forward Detector
- Efficiency of 1\textsuperscript{st} layer decreases for high energy particles as energy loss is very close to threshold

**Efficiency for individual segment**

![Graph showing efficiency vs. Tp [MeV] for different layers](image)
Summary & Outlook

• High precision luminosity determination with schottky technique has been achieved (accuracy ~ 2 – 3%)

• ANKE can provide robust pp data in energy region $T_p = 1.0 – 2.8$ GeV for c.m. angular range $10 – 30^\circ$ (uncharted territory)

• STT can provide valuable check of systematics and possible increase in angular range.

• Expected precision of differential cross section around 5% (analysis in progress).