The Polarized Target for COSY-TOF

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1st Meeting
Polarized Nucleon Targets for Europe
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Setup of a polarized solid target system for the measurement of the Pentaquark $\Theta^+(?)$ parity at COSY-TOF
Indication of the existence of the Pentaquark $\Theta^+(1540)$
… and unsuccessful search
A Method to Determine the Parity of the $\Theta^+$ Pentaquark


$\Theta^+$ production in the threshold region:
- Fermi statistics of the two nucleons and threshold kinematics
- Conservation of total angular momentum, parity and isospin in the strong interaction

$$\bar{p} + p \rightarrow \Sigma^+ + \Theta^+$$

IF $\Theta^+$ has positive parity $\Rightarrow$ pp spins anti-aligned ($^1S_0$)

IF $\Theta^+$ has negative parity $\Rightarrow$ pp spins aligned ($^3P_{0,1}$)
How to measure the parity of the $\Theta^+$ in $pp$ collisions


Spin correlation coefficients: project on individual initial spin states

$$^1\sigma_0 = \sigma_0 (1 - A_{xx} - A_{yy} - A_{zz}),$$

$$^3\sigma_0 = \sigma_0 (1 + A_{xx} + A_{yy} - A_{zz}),$$

$$^3\sigma_1 = \sigma_0 (1 + A_{zz}),$$

$$^3\sigma_\Sigma = \frac{1}{2} (^3\sigma_0 + ^3\sigma_1) = \frac{1}{2} \sigma_0 (2 + A_{xx} + A_{yy}).$$

Positive parity: $A_{xx}$ and $A_{yy}$ go to -1

Sign of $A_{xx}$ is opposite to parity near threshold
COSY Facility

The COSY-TOF Detector
Accurate determination of the interaction point:

- highly collimated beam
- detection of \( \Sigma^+ \) (c\(\tau\)≈2.4cm)

- Mechanical accuracy
- Challenge on the PT
Straw - Driftkammer PM COSY - Beam Flüssig Helium Vorrat Kryostat PM PM Polarisations Magnet Frozen - Spin - Target Veto Detektor Segmentierter Halbleiterzähler Szintillator Hodoskop lichtdichte Abdeckung

vorhandener Teil des TOF - Spektrometers
eu zu entwickeln bzw. im Bau

T O F - Detektor mit Frozen - Spin - Target
(N.Paul, IKP-Jülich)
Is it possible to run the COSY PT in frozen spin mode?

1 mm², $10^7$ particles/s beam:

• Radiation resistance
• Relaxation time
• Polarization measurements

• Estimate Kapitza resistance
• Estimate temperature profile within the target
• Choose suitable geometry and size
• Select target material
Typical relaxation times in Butanol

![Graph showing relaxation times vs. temperature for different months: Mainz '98, Bonn 'Sep.01', Bonn 'Jun.01', Bonn 'Jan.01'.]
Temperature profile in the target material (1)
Temperature profile in the target material (2)
Temperature on target border vs. target thickness

\[ T_R \leq 90 \text{ mK} \quad dx \approx 0.02 \text{ cm} \]
Vertical Target System for PS 185/3 @ LEAR

- Target region with Butanol target
- Acceptance: $\pm 32^\circ$
- Target dimensions: $l = 9\text{mm}$, $\varnothing = 6\text{mm}$
- $P_{\text{max}}$ (butanol): $p \sim 80\%$
The dilution cryostat is currently being renewed, reassembled and leak checked.

New:
• tubing
• needle valves
• thermometers (AB)
• radiation shields
• PS185/3 setup will be used for the measurement of the $\Theta^+$ parity
• test of the target material by the Bochum PT group
• installation of the components in the Bonn PT lab
• test of the complete system in summer 2005
• installation of the polarized system at TOF
• measurements start in fall 2005