## Commissioning of the polarized deuterium gas target at ANKE*

Boxing Gou[1,2] for the ANKE collaboration

In order to extend the spin programme [1] up to the highest energy at COSY, a polarized deuterium gas target has been commissioned at the ANKE spectrometer using an unpolarized proton beam of 600 MeV provided by the COoler SYnchrotron (COSY). Four polarization states (Table 1) and an unpolarized target were used in this experiment.

The reaction $p\vec{d} \to pd$ is used as a polarimetry due to its high cross section and well measured analyzing powers within the ANKE acceptance at this energy ($T_p$ = 600 MeV) [2-4]. Most of the deuterons from this reaction were detected by two STTs placed along the left and right sides of the target cell, which is confirmed by the missing mass spectrum of $pd \to dX$ showing a peak at the proton mass. The particles are identified using the information about energy deposit in different layers of STT. With the target polarization axis pointing perpendicular to the accelerator plane, the polarized differential cross section of $p\vec{d} \to pd$ is given by [5]

$$\frac{d\sigma}{d\Omega}^P(\theta,\phi) = \frac{d\sigma}{d\Omega}^0(\theta)\{1+\frac{3}{2}Q_yA_y(\theta)\cos\phi+\frac{1}{4}Q_{yy}[A_{yy}(\theta)(1+\cos2\phi)+A_{xx}(\theta)(1-\cos2\phi)]\} \quad (1)$$

where $\frac{d\sigma}{d\Omega}^0(\theta)$ is the unpolarized differential cross section, $A_y(\theta)$ and $A_{yy}(\theta)$ are the vector and tensor analyzing powers respectively. To extract the polarizations, following cross ratio is defined:

$$CR = \frac{N_L^P N_R^0 - N_R^P N_L^0}{N_L^P N_R^0 + N_R^P N_L^0} \quad (2)$$

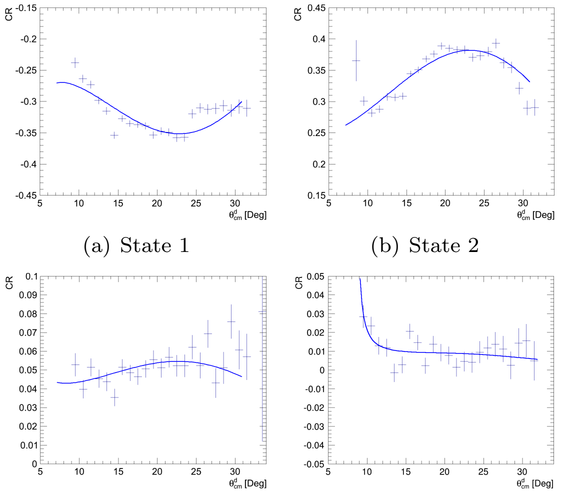
where $N_{L/R}^{P/0}$ denotes the number of events with polarized/unpolarized target and with deuterons detected in the left/right STT. Restricting $\phi$ close to 0 and $\pi$, taking into account that the ratio of the left and right STT efficiency $\frac{\varepsilon_L}{\varepsilon_R}$ does not change over the time, this cross ratio can be simplified as:

$$CR(\theta) \approx \frac{-\frac{3}{2}Q_yA_y(\theta)}{1+\frac{1}{2}Q_{yy}A_{yy}(\theta)} \quad (3)$$

It allows to extract both vector ($Q_y$) and tensor ($Q_{yy}$) polarizations in one step, unless the vector analyzing power is too small. Fig. 1 shows the results of the fits, and the polarization values are presented in Table 1. However for state 3 (0, -2) and state 4 (0, +1) the tensor polarization ($Q_{yy}$) can not be determined due to reduced signals caused by the small vector polarization ($Q_y$). On the other hand the smallness of the vector polarization allows to determine the tensor polarization ($Q_{yy}$) via a counting rate ratio between polarized and unpolarized states.

$$\frac{N^P(\theta,\phi)}{N^0(\theta)} \approx R_{Lum.}[1+\frac{1}{4}Q_{yy}A_{yy}(\theta)(1+\cos2\phi)] \quad (4)$$

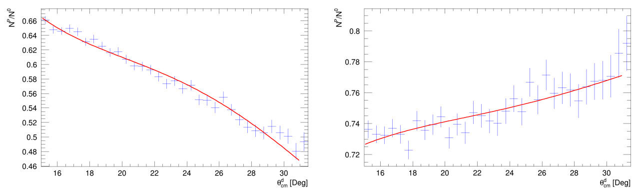
Here $R_{Lum.} = \frac{Lum.^P}{Lum.^0}$ is luminosity ratio between polarized and unpolarized states. By fitting counting rate ratio with eq. (4), following results were obtained: $R^3_{Lum.}$=0.697±0.003, $Q^3_{yy}$=-1.24±0.023 and $R^4_{Lum.}$=0.702±0.004, $Q^4_{yy}$=0.3032±0.026 (Fig. 2).



(a) State 1 (b) State 2

(c) State 3 (d) State 4

Fig. 1: Preliminary results of cross ratio (CR) as a function of deuteron scattering angle for all the four states, fitted by eq. (3).



(a) State 3 (b) State 4

Fig. 2: Preliminary results of counting rate ratio ($N^P/N^0$) as a function of deuteron scattering angle for state 3 and 4, fitted by eq. (4).

Both ideal and measured polarizations of the four polarized states are summarized in Table 1.

Table 1: Polarized target states.

| States | Ideal polarizations | | Measured polarizations | |
|---|---|---|---|---|
| | $Q_y$ | $Q_{yy}$ | $Q_y$ | $Q_{yy}$ |
| State 1 | +1 | +1 | 0.719±0.005 | 0.951±0.054 |
| State 2 | -1 | +1 | -0.716±0.007 | 0.738±0.068 |
| State 3 | 0 | -2 | -0.101±0.003 | -1.24±0.023 |
| State 4 | 0 | +1 | -0.014±0.003 | 0.3032±0.026 |

### References: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