Angular distribution of the vector A_y and tensor A_{yy}, A_{xx} analyzing powers in dp elastic scattering at the energy of 880 MeV

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Collaboration

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Three nucleon forces manifestation

- Nowadays a new generation the NN potentials(Nijmegen, CD-Bonn, AV-18 etc.) was obtained. They reproduce data on the nucleon nucleon scattering up to 350 MeV with very good accuracy.
- However, these modern NN forces fail to provide experimental binding energies of few-nucleon systems.(for the ^3H underbinding is 0.8 MeV for CD-Bonn). Moreover the data on the *dp* elastic scattering and deuteron breakup are not described.
- The incorporation of the **3NF** makes it possible to reproduce the binding energy of the three-nucleon bound systems and also data on nonpolarized of *dp* interaction.
- Nevertheless, polarization data for the reactions with participation of three and more nucleons is not reproduced neither with the inclusion of the new models of the **3NF** nor with the use of modern **NN** potentials of interaction.

dp elastic scattering at the intermediate energies

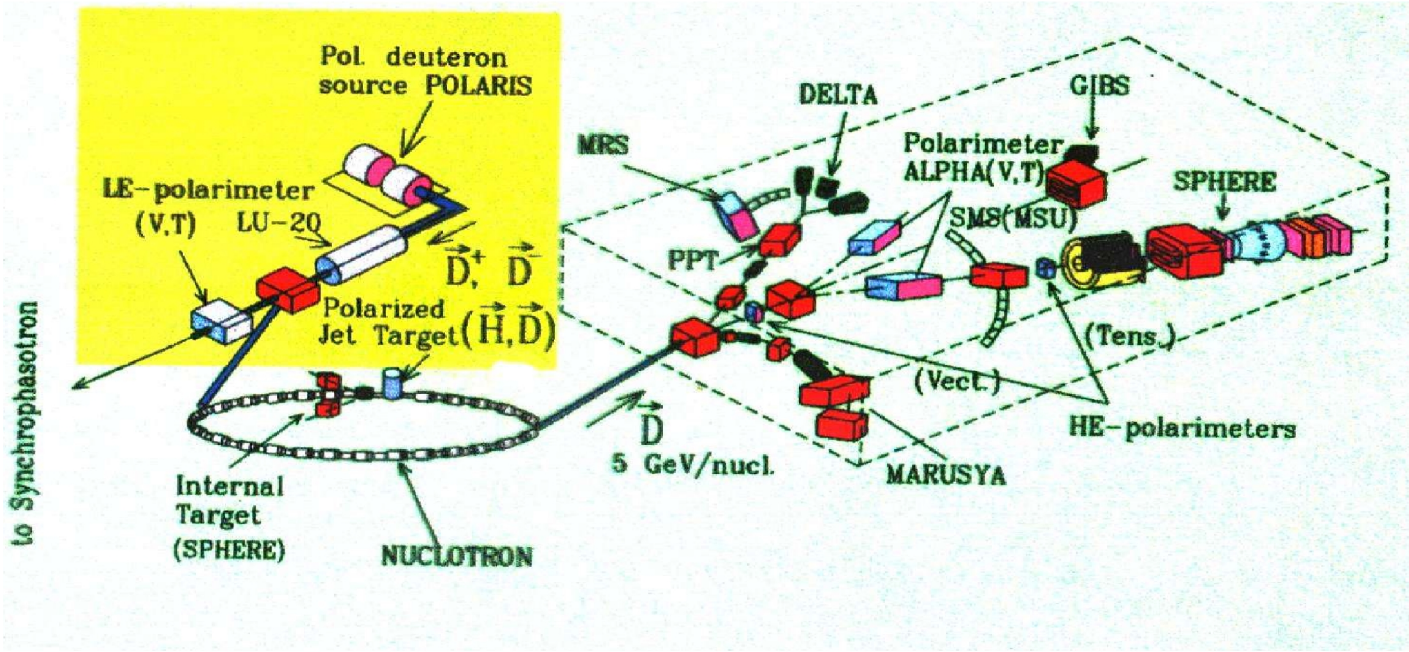
- The cross section data for the dp elastic scattering are reproduced well up to 150 MeV taking into account three-nucleon forces. However, the experimental data on polarization observables A_{yy}, A_{xx} and A_{xz} are described at this energy very poor.
- Even the cross section data are not reproduced at the energy 250 MeV. Most likely this is connected with the relativistic effects.

Therefore, obtaining the additional polarization data in the reaction dp interaction with the energies more than 135 MeV is very desirable for the study the spin structure of the 3NF and the relativistic effects.

Polarimetry

- We suggest to use the dp elastic scattering at backward angles ($\theta_{c.m.} > 60^{\circ}$) as a polarimetry at the energy $0.88 - 2.0$ GeV
- The calibration of polarimeter with the energies of the deuteron beam 0.88-2.0GeV was the basic aim of the experiment carried out in June 2005
- The calibration with the energies in a GeV region is necessary for the *PHe3* project at the Nuclotron. In this experiment on the measurement of the polarization observables in the ${}^{3}He(d,p)^{4}He$ reaction it is necessary to measure of the both vector and tensor polarizations of the deuteron beam.
- New facility RIBF at RIKEN will have polarized deuterons at 880 MeV.
- The problem of systematics for the experiments on the different facilities is a result of different polarization standards.

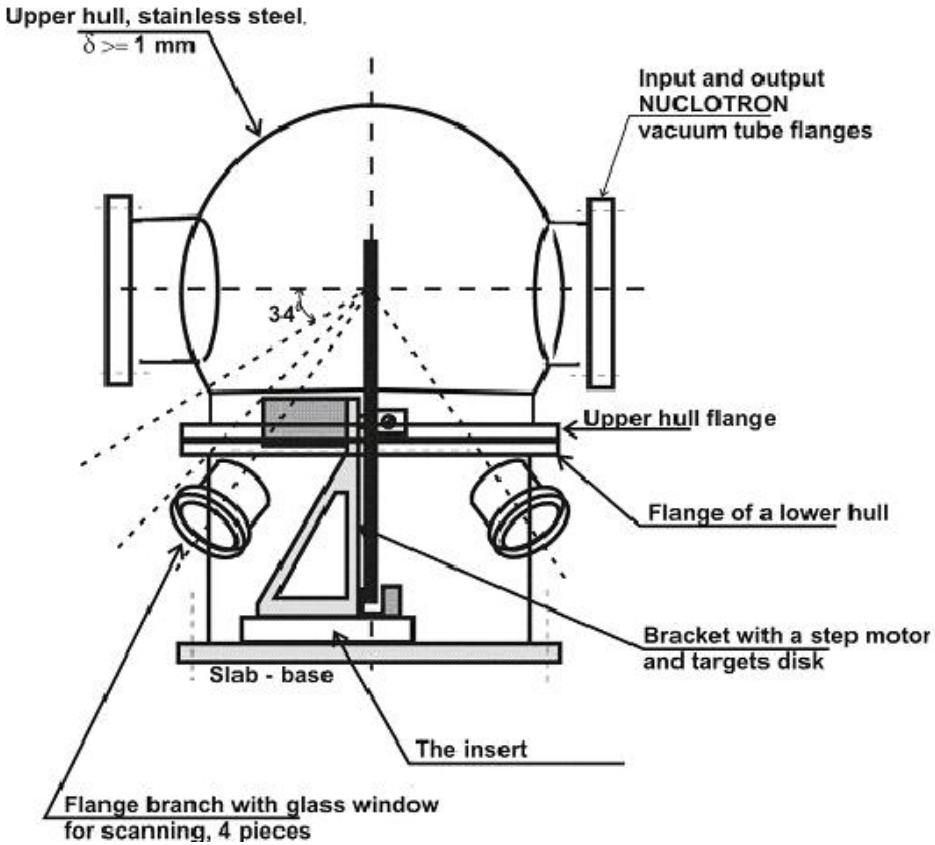
NUCLOTRON Accelerator Complex



- PIS on 360 kV terminal
- 10 MeV/A LINAC
- Tensor and vector LEPs
- Nuclotron Ring: 6 GeV/A
- ITS polarimeter
- Extraction beam line
- HE polarimeters
- Experimental setups

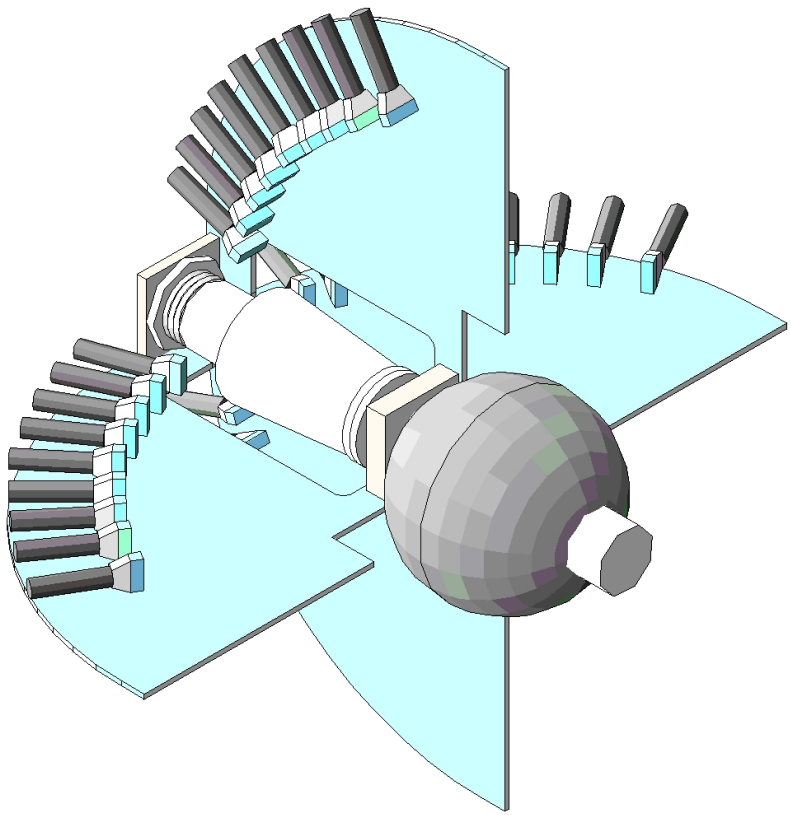
Internal Target Station

The Internal Target Station is well suited for the study reactions of the *dp* interaction at large angles in the center of mass system.



Detection system (CNS, Japan)

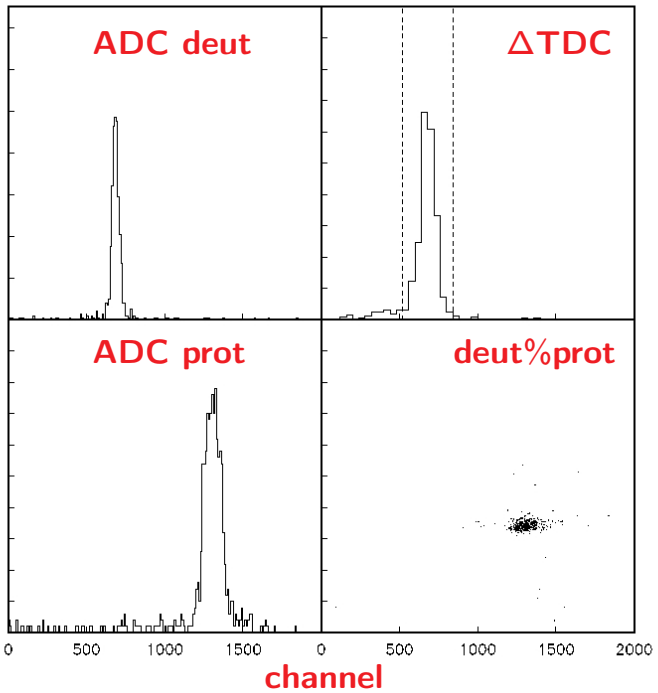
- Scintillation counters (48) based on Hamamatzu H7415 PMTs were placed on the left, right, up and down were used at the same time.
- The detectors covered the angular range $60 - 140^{\circ}$ in the center of mass.
- VME+CAMAC (FERA, FERET) DAQ was used for data taking.



Condition of the June 2005 run at Nuclotron

- Polarized deuterons were provided by PIS POLARIS. Typical intensity in the Nuclotron ring was $2 \div 3 \cdot 10^7$ deuterons per spill.
- Polarization mode $(p_z, p_{zz}) = (0, 0), (+1/3, +1), (+1/3, -1)$
- The 10 μm CH_2 foil has been used as the target. Also measurements with carbon target have been performed in order to estimate the background.
- The data have been accumulated at 270, 880 and 2000 MeV. The measurement of the beam polarization has been performed at 270 MeV.

Polarization measurement at 270 MeV
(LEP measurements by L.S.Zolin & Yu.K.Pilipenko)



	Pol.	Mode 2-6	Mode 3-5
ITS	T	0.557± 0.026	-0.555± 0.022
ITS	V	0.215± 0.012	0.221± 0.015
LEP	T	0.69±0.13	-0.67± 0.16

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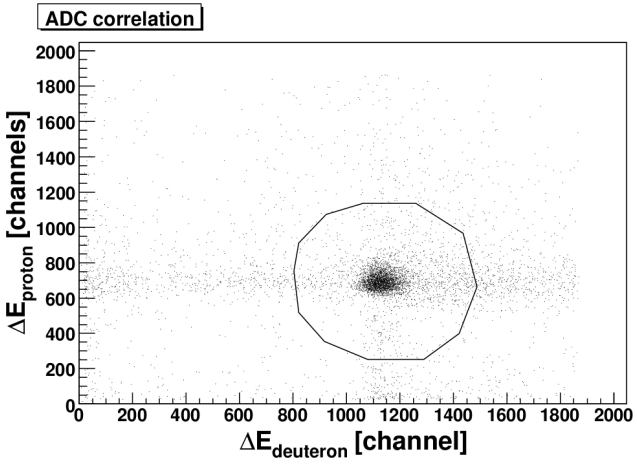
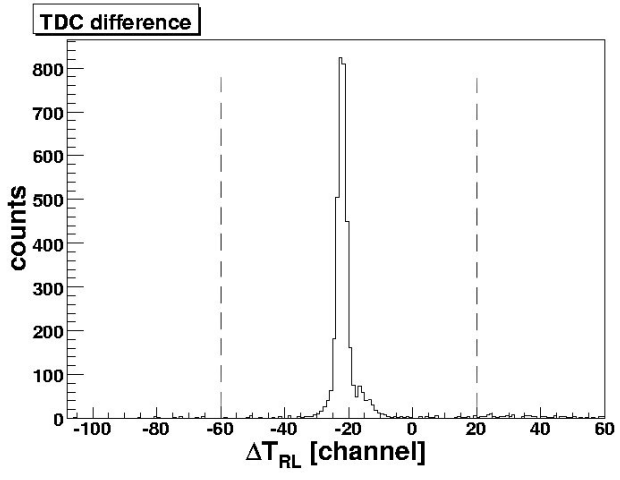
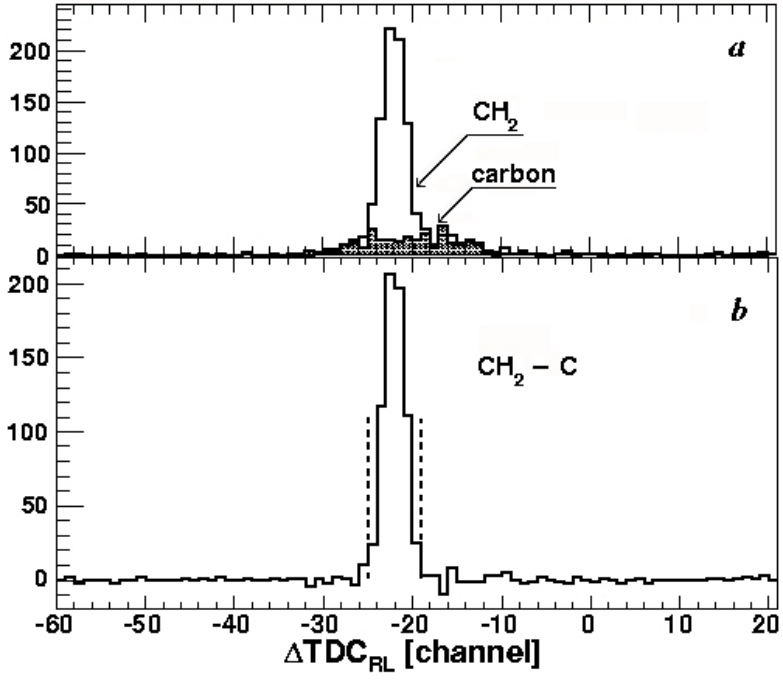
Calibration measurement of the polarimeter at 880 and 2000 MeV

- Detectors were also located symmetrically in the directions of azimutal angles.
- The analyzing powers A_y and A_{yy} were extracted from the counts of the left and right pairs detectors.
- The analyzing power A_{xx} were extracted from the counts of the up and down pairs detectors.
- One pair of counters was used for pp quasi-elastic scattering.

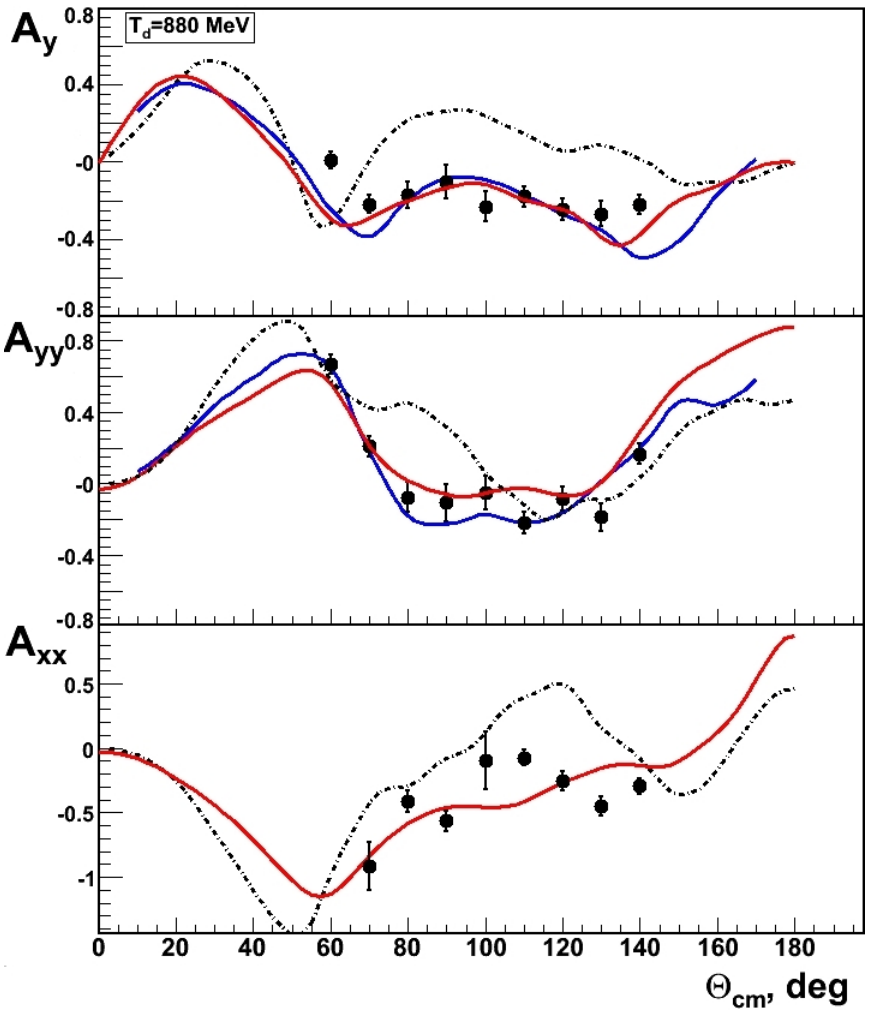
Selection of the *dp* elastic events at 880 MeV







Analyzing powers in *dp* elastic scattering at 880 MeV

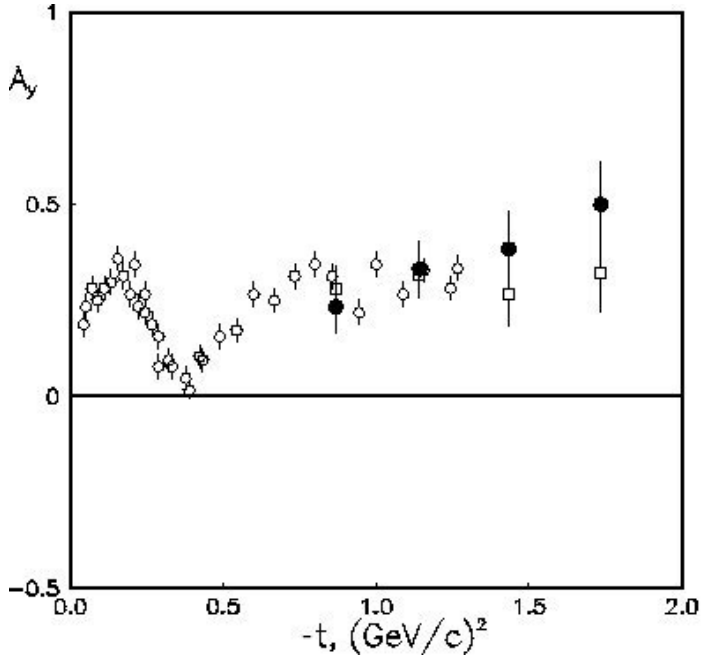


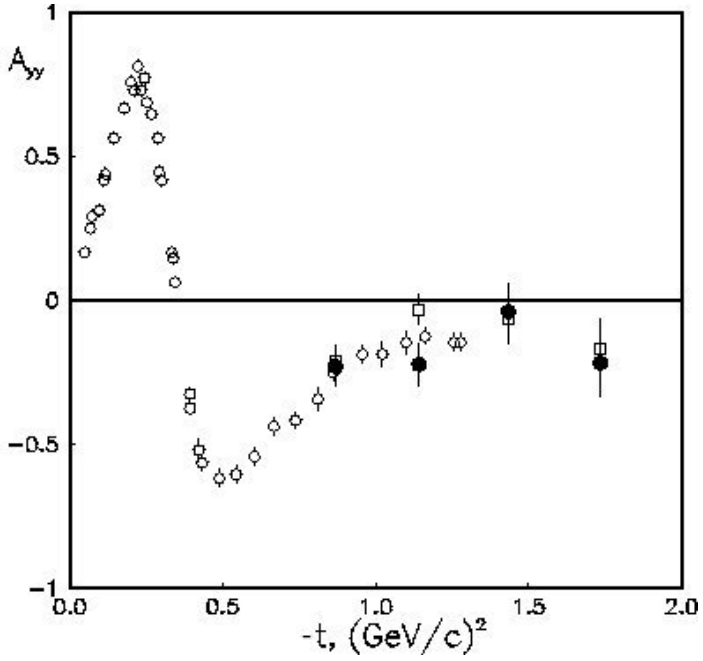
N.B. Ladygina (arXiv:0705.3149)

M.A. Shikhalev (arXiV:nucl-th/0612108)

H. Witala (private communicarion)

Analyzing powers in *dp* elastic scattering at 2000 MeV





Vector A_y and tensor A_{yy} analyzing powers versus $-t$ for the *dp* elastic scattering at $T_d = 2.0$ GeV ($\circ$) by ANL group and ($\square - CH_2$, $\bullet - H_2$) by Dubna group.

Conclusion

- The preliminary data on the measurement of the analyzing powers A_y, A_{yy} and A_{xx} at 880MeV are obtained.
- Obtained data are described quite good the faddeev calculations based on the CD-Bonn NN model without the inclusion of 3NF.
- The large values of the analyzing powers in some angular region are suitable for conducting the polarimetry at this energy.
- The reaction of the dp elastic scattering can be used for the polarimetry of high energy deuteron.
- Data at the energy 2000 MeV are in progress. The preliminary data on the measurement of the analyzing powers A_y, A_{yy} are show on the possibility to provide of the polarimetry at this energy.

Thank you for the attention!!!

Calculation of the analyzing powers

$$N(\theta;\beta,\phi) = 1 + \frac{3}{2}p_y(\beta,\phi)A_y(\theta) + \frac{2}{3}p_{xz}(\beta,\phi)A_{xz} + \frac{1}{2}p_{zz}(\beta,\phi)A_{zz} + \frac{1}{6}[p_{xx}(\beta,\phi) - p_{yy}(\beta,\phi)][A_{xx}(\theta) - A_{yy}(\theta)]$$

$$N_L(\theta;\beta,\phi) = N(\theta;\frac{\pi}{2},0), \quad N_R(\theta;\beta,\phi) = N(\theta;\frac{\pi}{2},\pi)$$

$$N_U(\theta;\beta,\phi) = N(\theta;\frac{\pi}{2},\frac{3\pi}{2}), \quad N_D(\theta;\beta,\phi) = N(\theta;\frac{\pi}{2},\frac{\pi}{2})$$

$$\begin{aligned} p_y(\beta,\ \phi) &= p_Z \sin\beta\cos\phi \\ p_{yy}(\beta,\ \phi) &= 1/2 p_{ZZ}(3\sin^2\beta\cos^2\phi - 1) \\ p_{xx}(\beta,\ \phi) &= 1/2 p_{ZZ}(3\sin^2\beta\sin^2\phi - 1) \\ p_{xz}(\beta,\ \phi) &= -3/2 p_{ZZ}\sin\beta\cos\beta\sin\phi \\ p_{zz}(\beta,\ \phi) &= -1/2 p_{ZZ}(3\cos^2\beta - 1) \end{aligned}$$

p_Z – the vector polarisation

p_{ZZ} – the tensor polarisation

β, ϕ – the direction of polarization vector

Calculation of the analyzing powers

$$N_R^{\pm} = N_R^0(1 - \frac{3}{2}p_z^{\pm}A_y + \frac{1}{2}p_{zz}^{\pm}A_{yy}) \tag{1}$$

$$N_L^{\pm} = N_L^0(1 + \frac{3}{2}p_z^{\pm}A_y + \frac{1}{2}p_{zz}^{\pm}A_{yy}) \tag{2}$$

$$N_{U,D}^{\pm} = N_{U,D}^0(1 + \frac{1}{2}p_{zz}^{\pm}A_{xx}) \tag{3}$$

$$A_y = \frac{2}{3}\frac{p_{zz}^-(N_L^+/N_L^0 - 1) - p_{zz}^+(N_L^-/N_L^0 - 1)}{p_z^+p_{zz}^- - p_z^-p_{zz}^+} \tag{4}$$

$$A_y = \frac{2}{3}\frac{p_{zz}^-(N_R^+/N_R^0 - 1) - p_{zz}^+(N_R^-/N_R^0 - 1)}{-p_z^+p_{zz}^- + p_z^-p_{zz}^+} \tag{5}$$

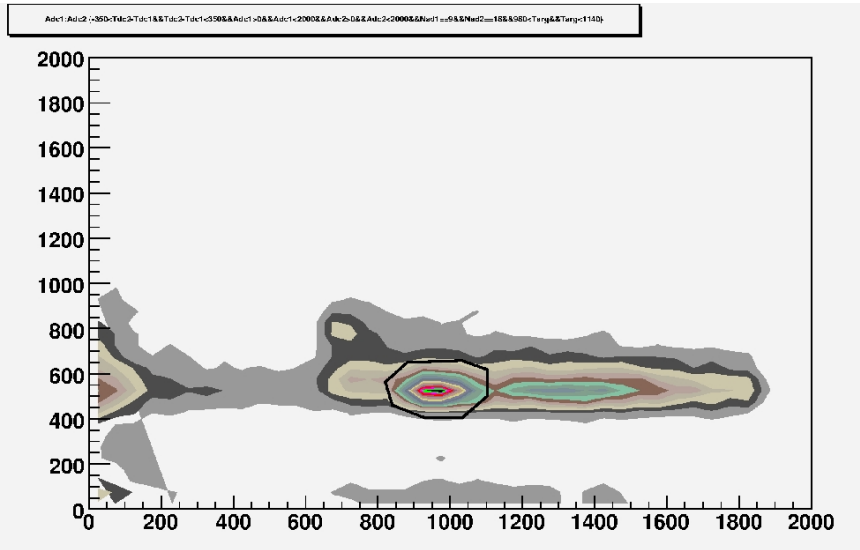
Calculation of the analyzing powers

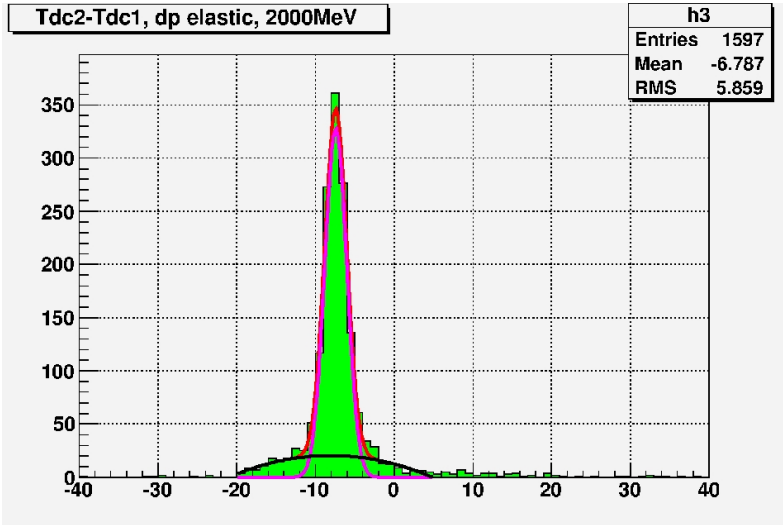
$$A_{yy} = 2\frac{p_z^+(N_L^-/N_L^0 - 1) - p_z^-(N_L^+/N_L^0 - 1)}{p_z^+ p_{zz}^- - p_z^- p_{zz}^+} \tag{6}$$

$$A_{yy} = 2\frac{p_z^-(N_R^+/N_R^0 - 1) - p_z^+(N_R^-/N_R^0 - 1)}{-p_z^+ p_{zz}^- + p_z^- p_{zz}^+} \tag{7}$$

$$A_{xx} = \frac{2}{p_{zz}^\pm}(N_{U,D}^\pm/N_{U,D}^0 - 1) \tag{8}$$

Selection of the *dp* elastic events at 2000 MeV





The contribution of the carbon at 2000 MeV depends on the detection angle

Carbon contribution at 2000 MeV