MEASUREMENTS OF A_{yy}, A_{xx} AND A_y ANALYZING POWERS OF TRITON FRAGMENTATION IN d(d↑,p) REACTION AT 270 MeV

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Abstract

The final results on the polarization observables of A_{yy}, A_{xx} and A_y analyzing powers of the $d\uparrow d \rightarrow pX$ breakup reaction at 270 MeV of deuteron kinetic energy is presented. The obtained angular distributions of these polarization observables compared with data of the $d\uparrow d \rightarrow pT$ binary reaction. The analyzed data refer to the triton breakup above threshold up to 10 MeV.

Introduction

New generation of realistic NN potentials

AV18,CD Bonn, Nejm (I,II) OBE (ω, ρ, η, δ exchanges) up to 350 MeV

higher than 290 MeV π-thresold

d↑ p → p↑ d	T_{20}, k_0		Saclay, Dubna
d↑ p → p d↑	k_0, dσ/dΩ, A_y,A_{yy},A_{xx},A_{xz}	250 MeV	RIKEN
p↑ d → d↑ p	A_y (p), A_y (d)	150, 190 MeV	KVI
d↑ ^{3}He↑→p ^{4}He	C//	140, 200, 270 MeV	RIKEN

all of them are simplest processes with a large momentum transfer

↓

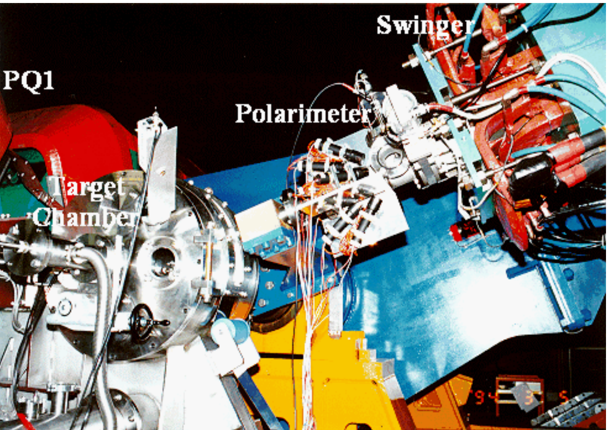
1. These reactions could be used as a tool to study the deuteron structure at short distances;
2. Polarization observables of these reactions are sensitive to the D/S wave ratio in deuteron.
3. The ONE mechanism dominates for all these reactions

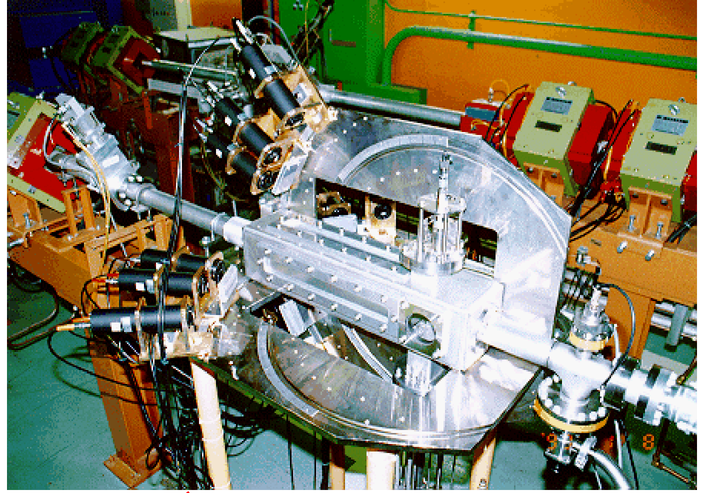
d↑ d→pT and d↑ d→pX A_y, A_{yy}, A_{xx}, A_{xz} 140, 200, 270 MeV RIKEN

In this report the data obtained in R308n experiment at RIKEN of the breakup and binary reactions are compared.

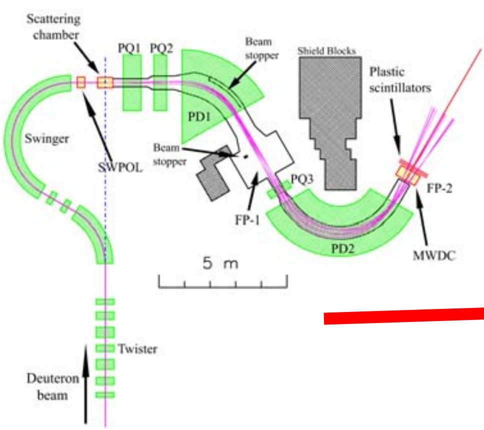
The relative momenta of nucleons in deuteron achieves ≈ 400 MeV/c at energy Ed=270MeV.

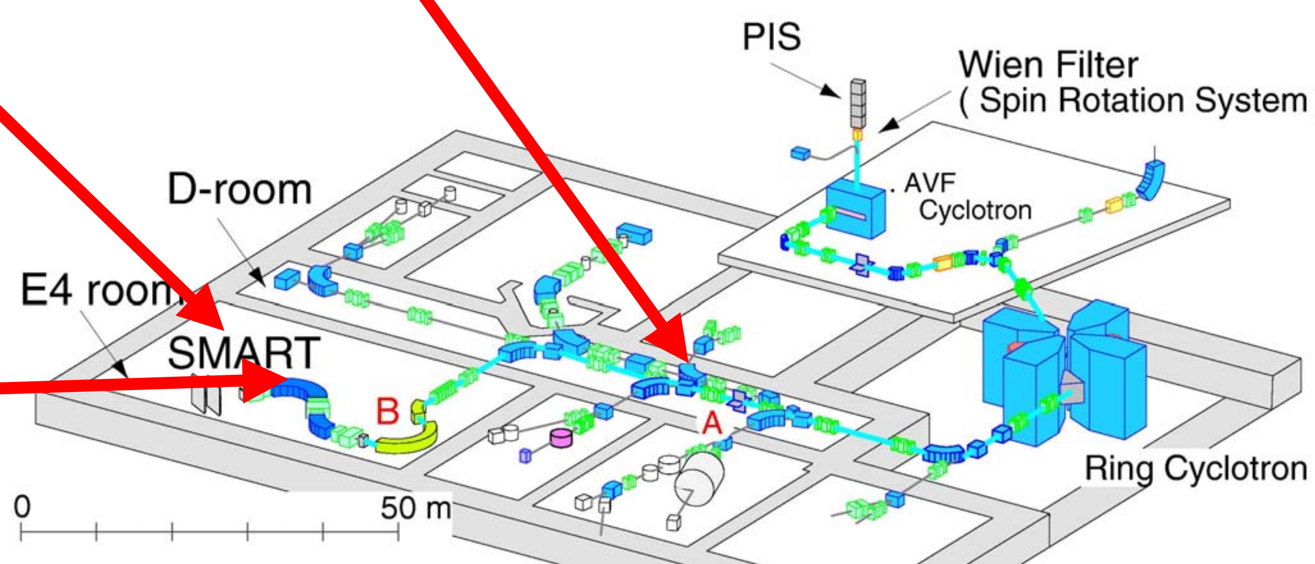
Experiment





RIKEN Accelerator Research Facility (RARF)





A : D-room Polarimeter

B : Swinger Polarimeter

Derivation of Beam Polarization

The deuteron vector and tensor polarizations with respect to the cylindrically symmetric axis Z are defined by

$$p_Z = N_+ - N_-$$
$$p_{ZZ} = N_+ + N_- - 2N_0$$
$$N_+ + N_- + N_0 = 1$$

The differential cross section normalized by the unpolarized one is

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

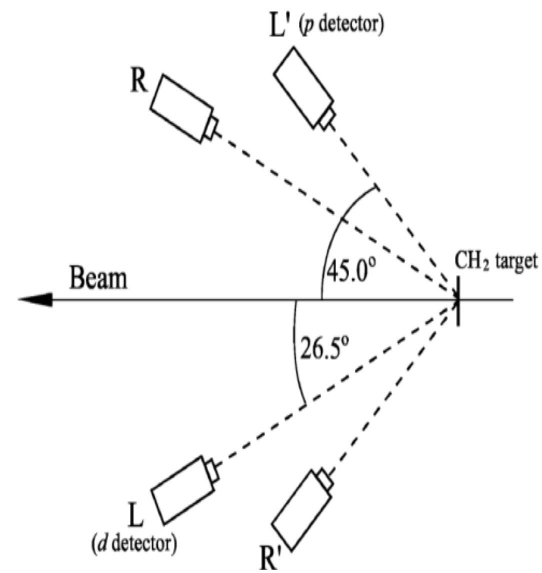
Experimentally 60-75% from ideal magnitudes:

Mode 0: $(p_Z,p_{ZZ})=(0,0)$

Mode 1: $(p_Z,p_{ZZ})=(0,-2)$

Mode 2: $(p_Z,p_{ZZ})=(-2/3,0)$

Mode 3: $(p_Z,p_{ZZ})=(1/3,1)$



Derivation of Beam Polarization

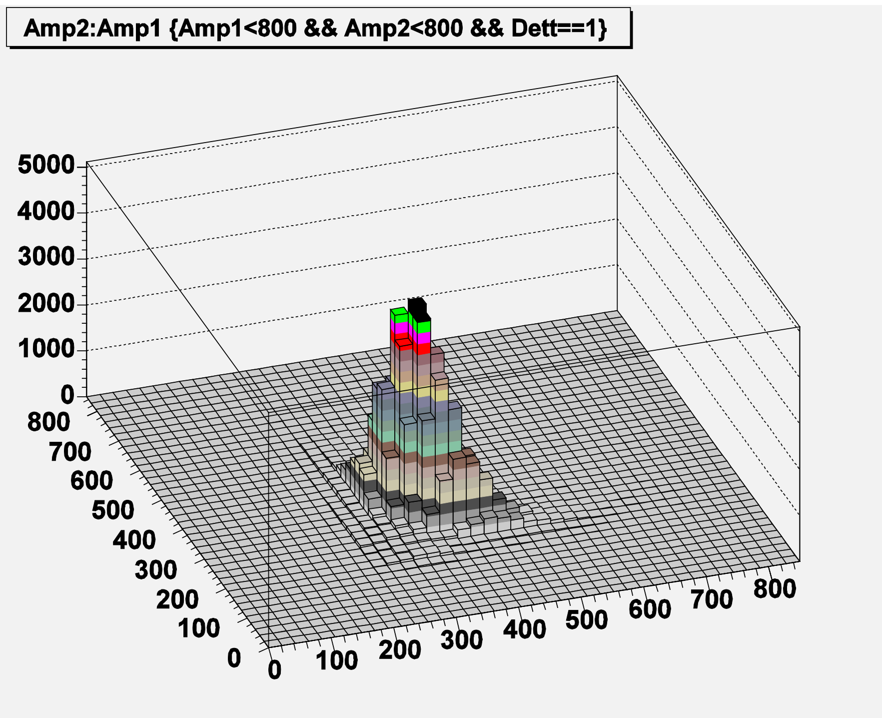
Amp1.vs.TOF1

The amplitude correlation between signals from the deuteron energy losses and RF signal of cyclotrons.

TOF1-TOF2

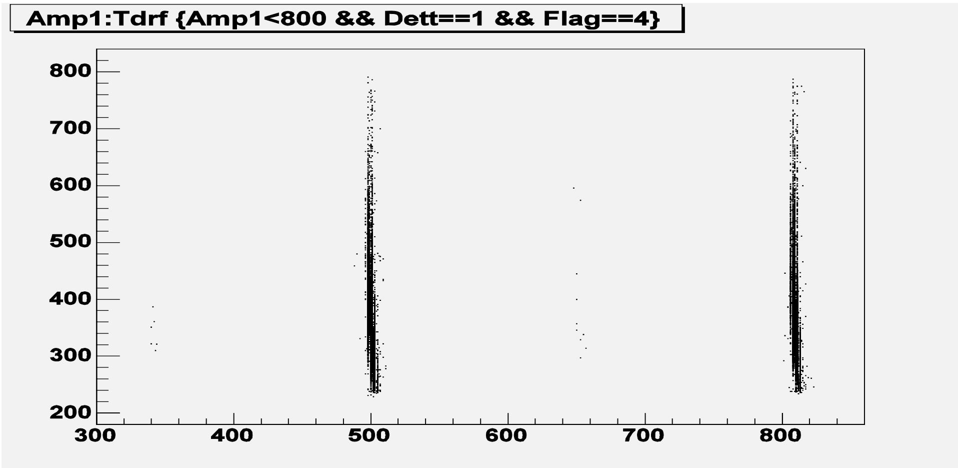
Time-of-flight coincidence for the deuteron and proton detectors.

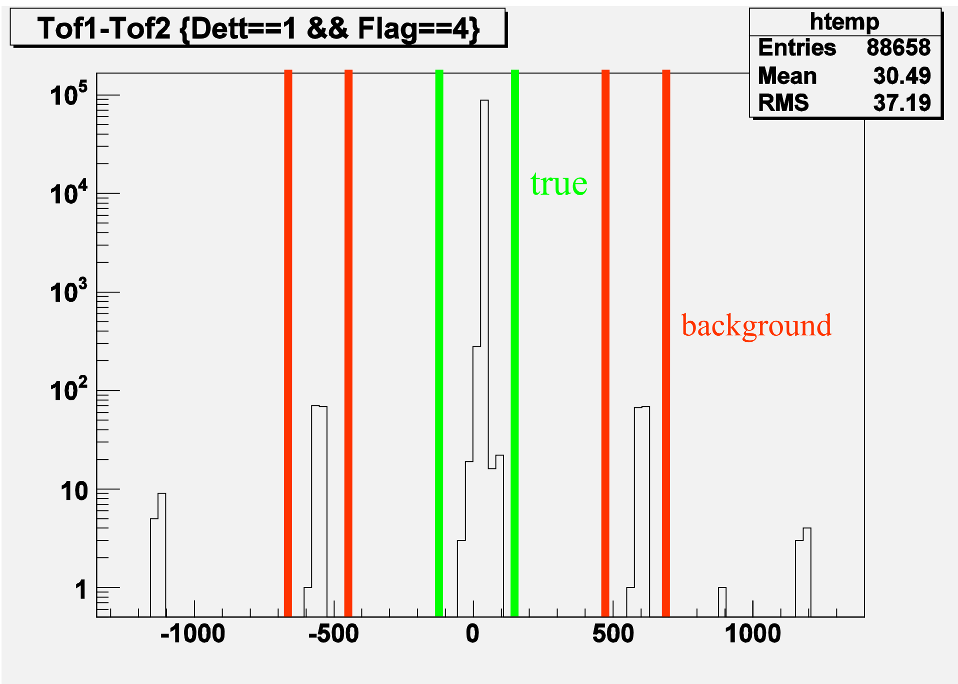
Amp1.vs.Amp2



Amp1.vs.TDRF

Deuteron energy losses versus RF signal synchronization with a Trigger





Derivation of Beam Polarization

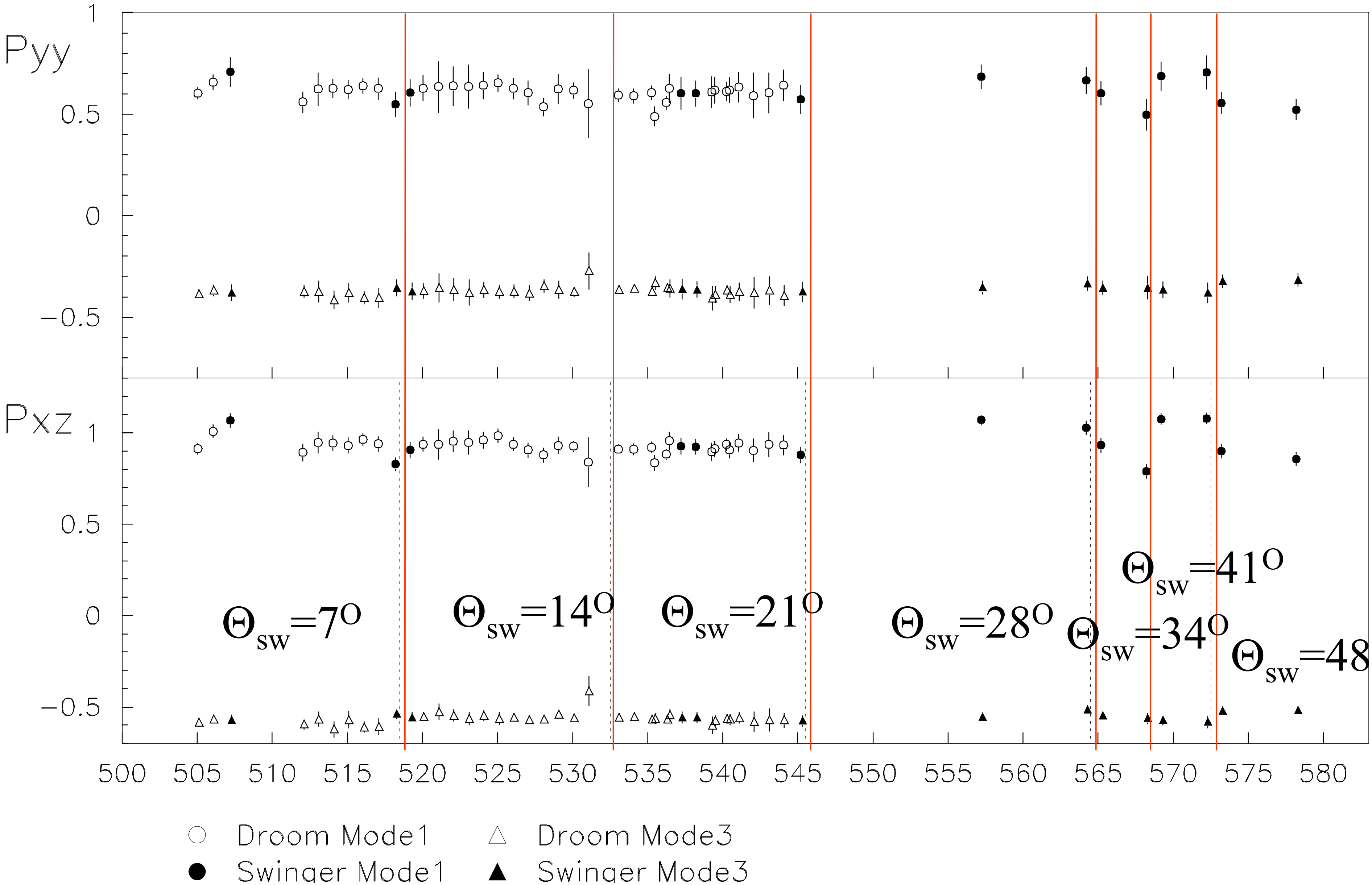
The cross section asymmetries:

$$N_{exp}^{M} = \frac{Y_{L,R,U,D}^{M}/(Q_{L,R,U,D}^{M}\epsilon_{L,R,U,D}^{M})}{Y_{L,R,U,D}^{M=0}/(Q_{L,R,U,D}^{M=0}\epsilon_{L,R,U,D}^{M=0})},$$

$$\chi^2(p_Z^{M=1,2,3}, p_{ZZ}^{M=1,2,3}; \beta, \phi) =$$

$$= \sum_{M=1,2,3}\sum_{A=L,R,U,D}\left(\frac{N_A(p_Z^M, p_{ZZ}^M; \beta, \phi) - N_{expA}^M}{\Delta N_{expA}^M}\right)^2$$

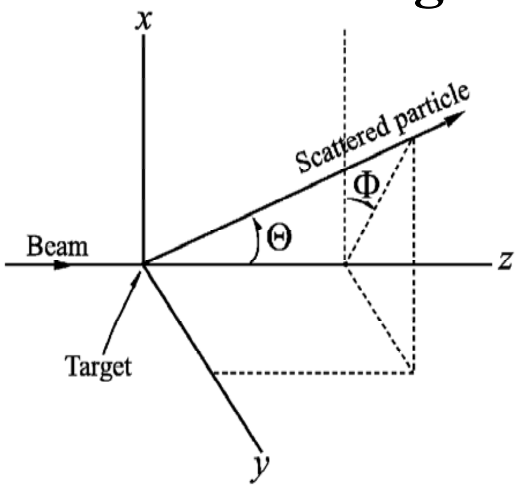
The tensor Pyy and Pxz polarization elements for A_{xz} data at 270 MeV.



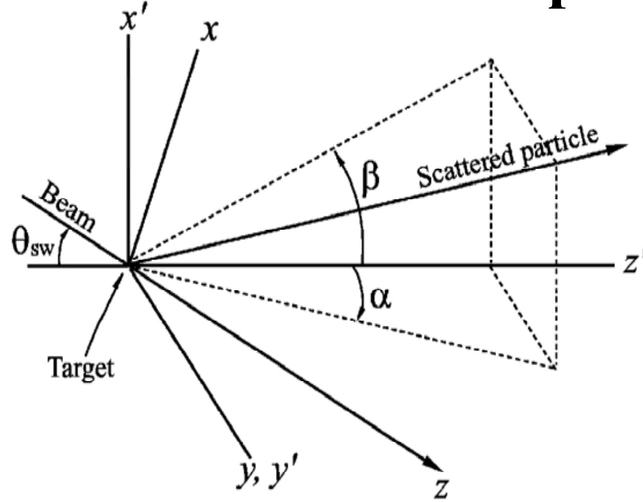
Derivation of Analyzing Powers

Definition of the scattering angles and the coordinates:

at the target



at the spectrometer

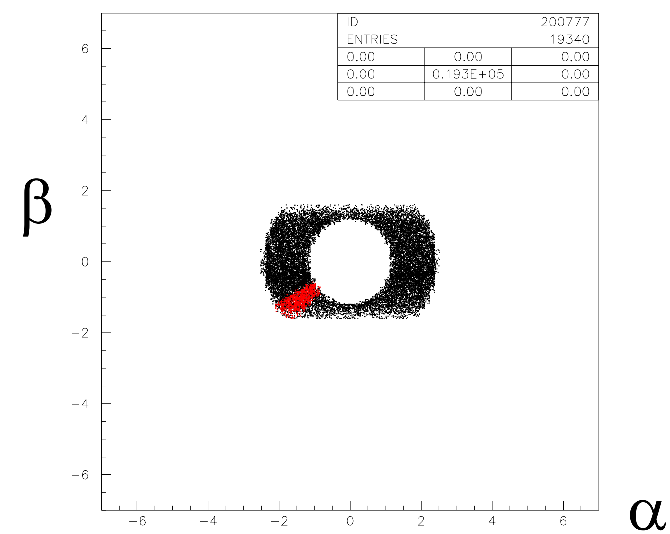


The relations between Θ, Φ and α, β:

$$cos\Theta = \frac{cos(\beta + \Theta_{sw})}{\sqrt{1 + tan^2\alpha cos^2\beta}}$$

$$cos\Phi = \frac{sin(\beta + \Theta_{sw})}{\sqrt{sin^2(\beta + \Theta_{sw}) + tan^2\alpha cos^2\beta}}$$

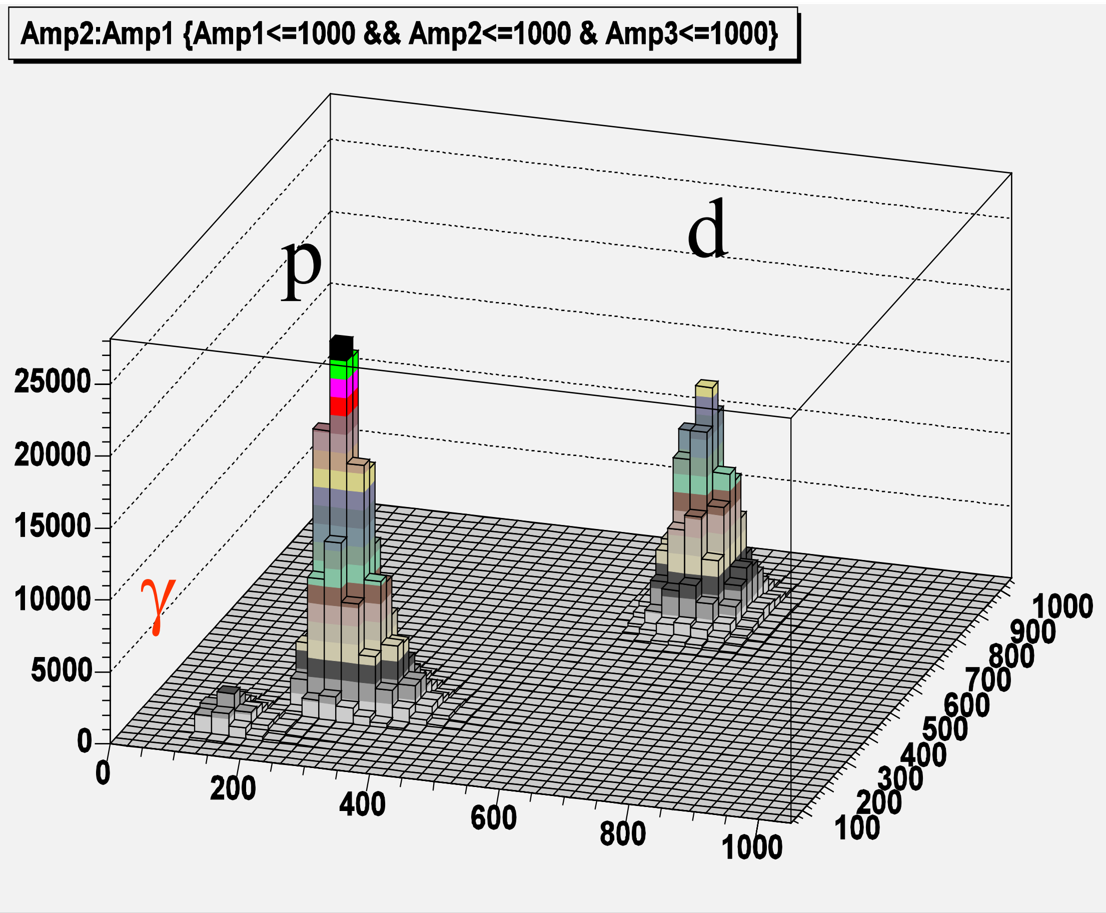
MWDC profile



Derivation of Analyzing Powers

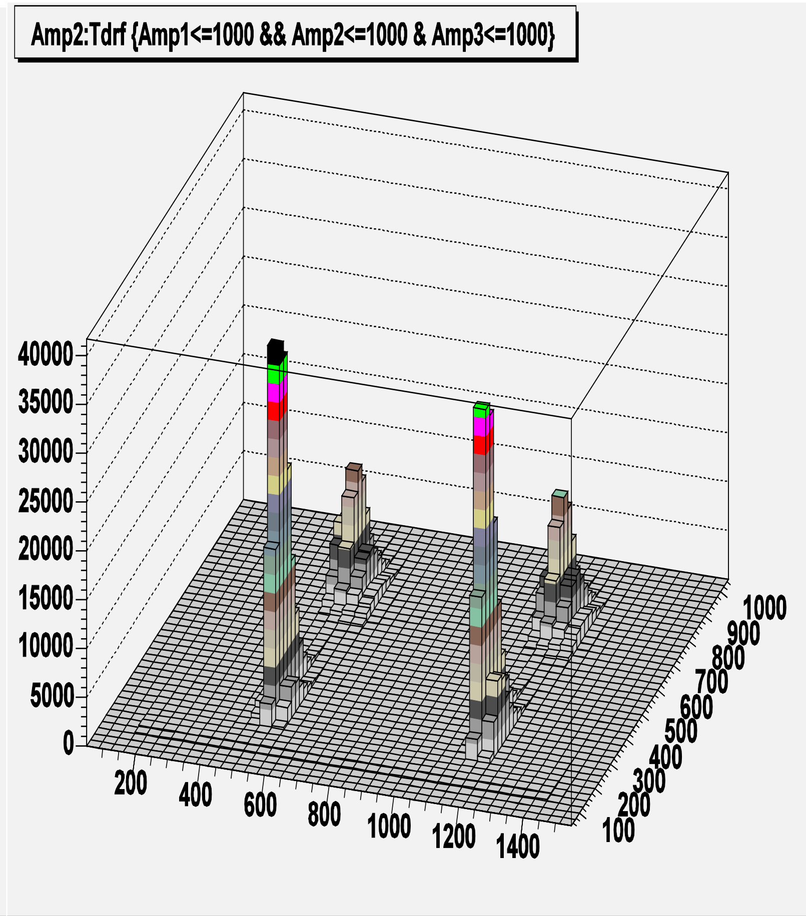
Amp1.vs.Amp2

The amplitude correlation between the energy losses from the first and the second plastic scintillators.



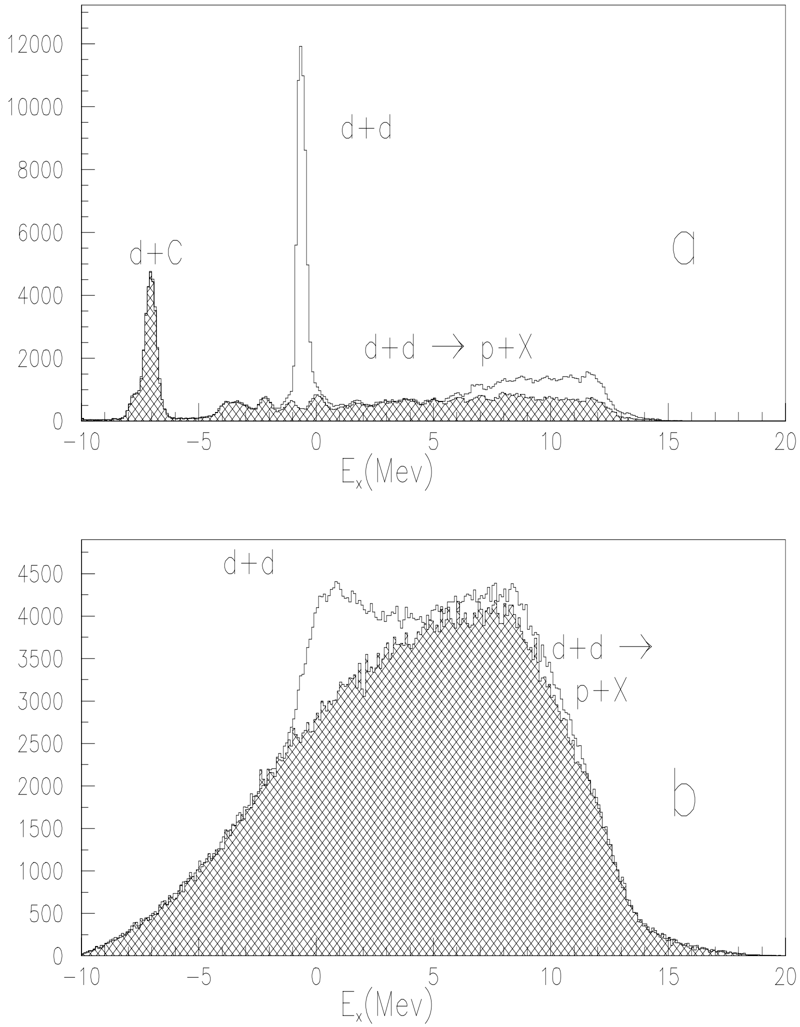
Amp1.vs.TDRF

The amplitude correlation between the signals from the first plastic scintillator and TDRF (Trigger-RF).

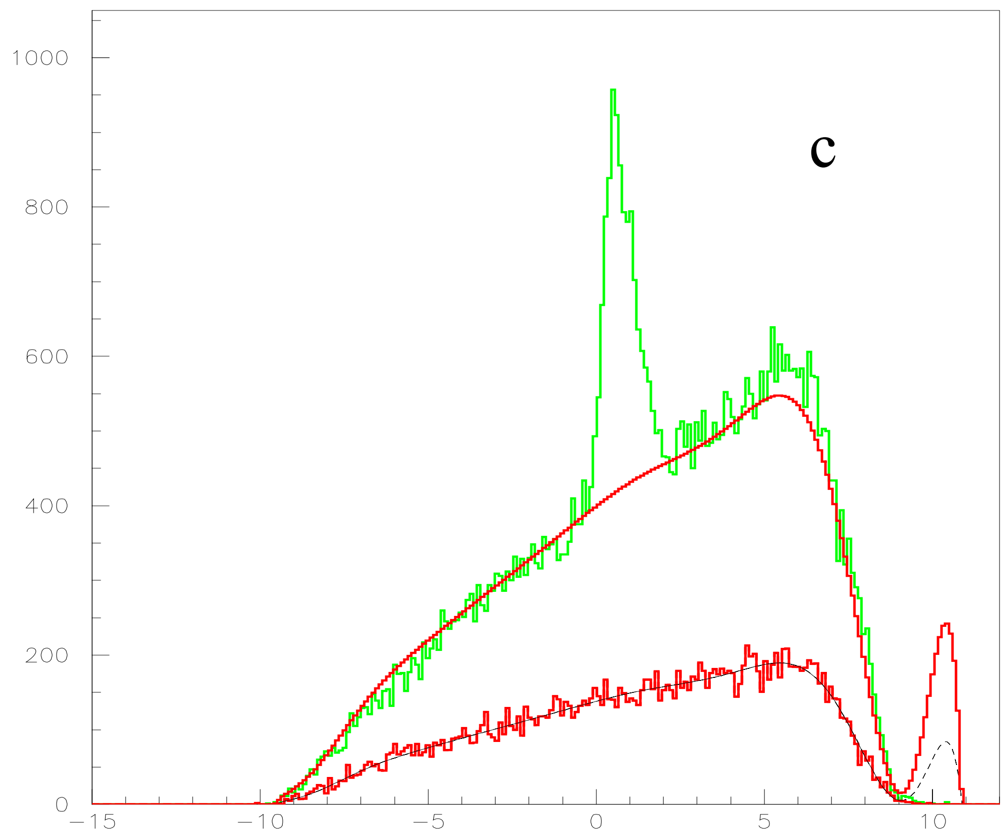


Derivation of Analyzing Powers

Typical example of the obtained energy spectra of d↑ d→pT d↑ and d→pX reactions at emission angles Θcm=175 (a) and 103 (b) and Carbon fit(c).



$$E_X = \sqrt{(E_0 - E_S)^2 - p_L^{\,2}} - M_L$$



Derivation of Analyzing Powers

The normalized cross section for the spin mode M (M=1,2,3) are defined as:

$$N^{M}_{exp} = \left(\frac{d\sigma}{d\Omega}\right)^{M} / \left(\frac{d\sigma}{d\Omega}\right)^{M=0} = \frac{Q^0 \epsilon^0 Y^M}{Q^M \epsilon^M Y^0}$$

The set of linear equations for A_{yy} and A_y. The solution obtained by the least square method gives A_{yy} and A_y.

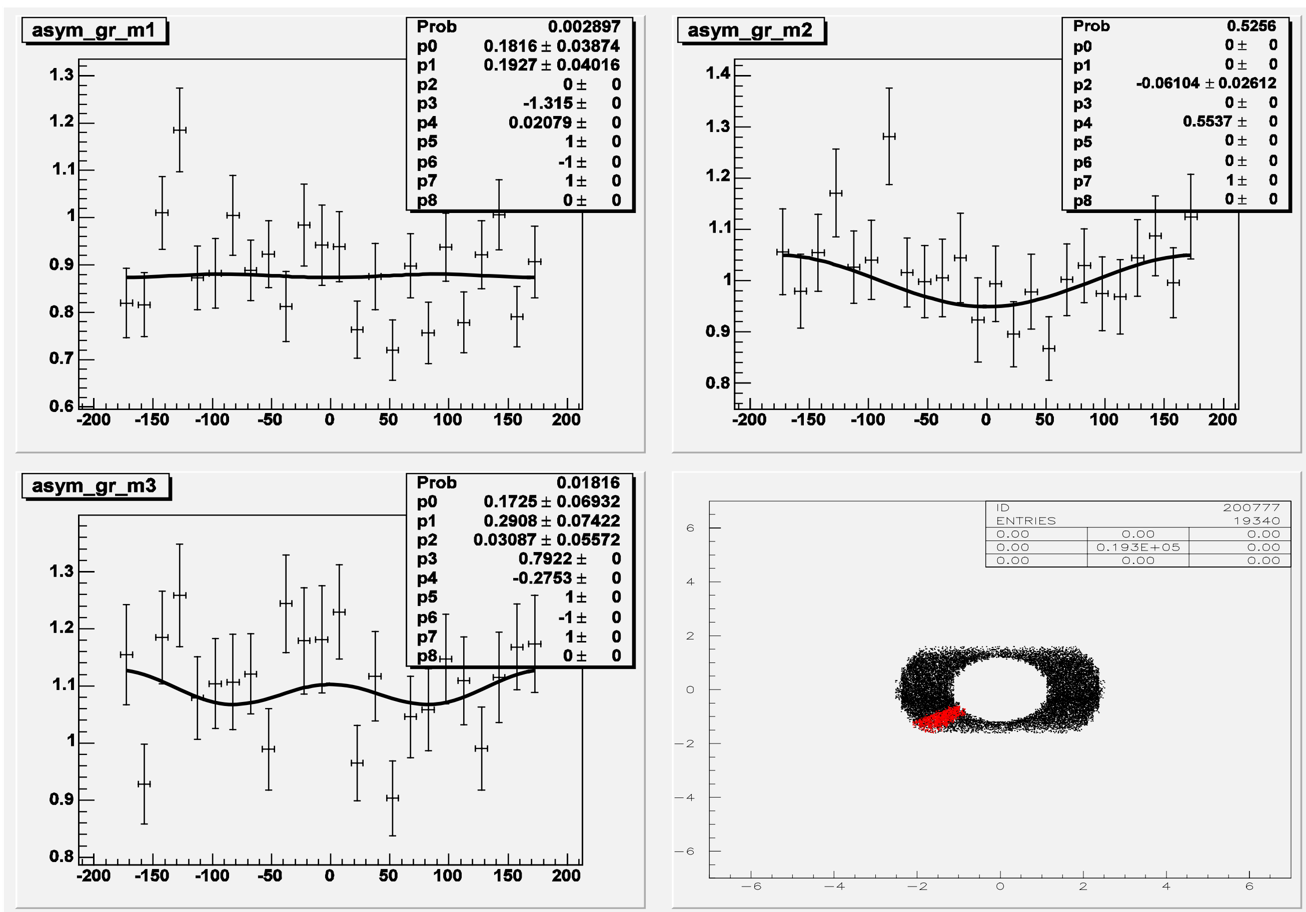
$$\begin{cases} N^1_{exp}(\Theta_{cm}) &= 1 + \frac{1}{2} p^1_{yy} A_{yy}(\Theta_{cm}) \\ N^2_{exp}(\Theta_{cm}) &= 1 + \frac{3}{2} p^2_{y} A_{y}(\Theta_{cm}) \\ N^3_{exp}(\Theta_{cm}) &= 1 + \frac{3}{2} p^3_{y} A_{y}(\Theta_{cm}) + \frac{1}{2} p^3_{yy} A_{yy}(\Theta_{cm}) \end{cases}$$

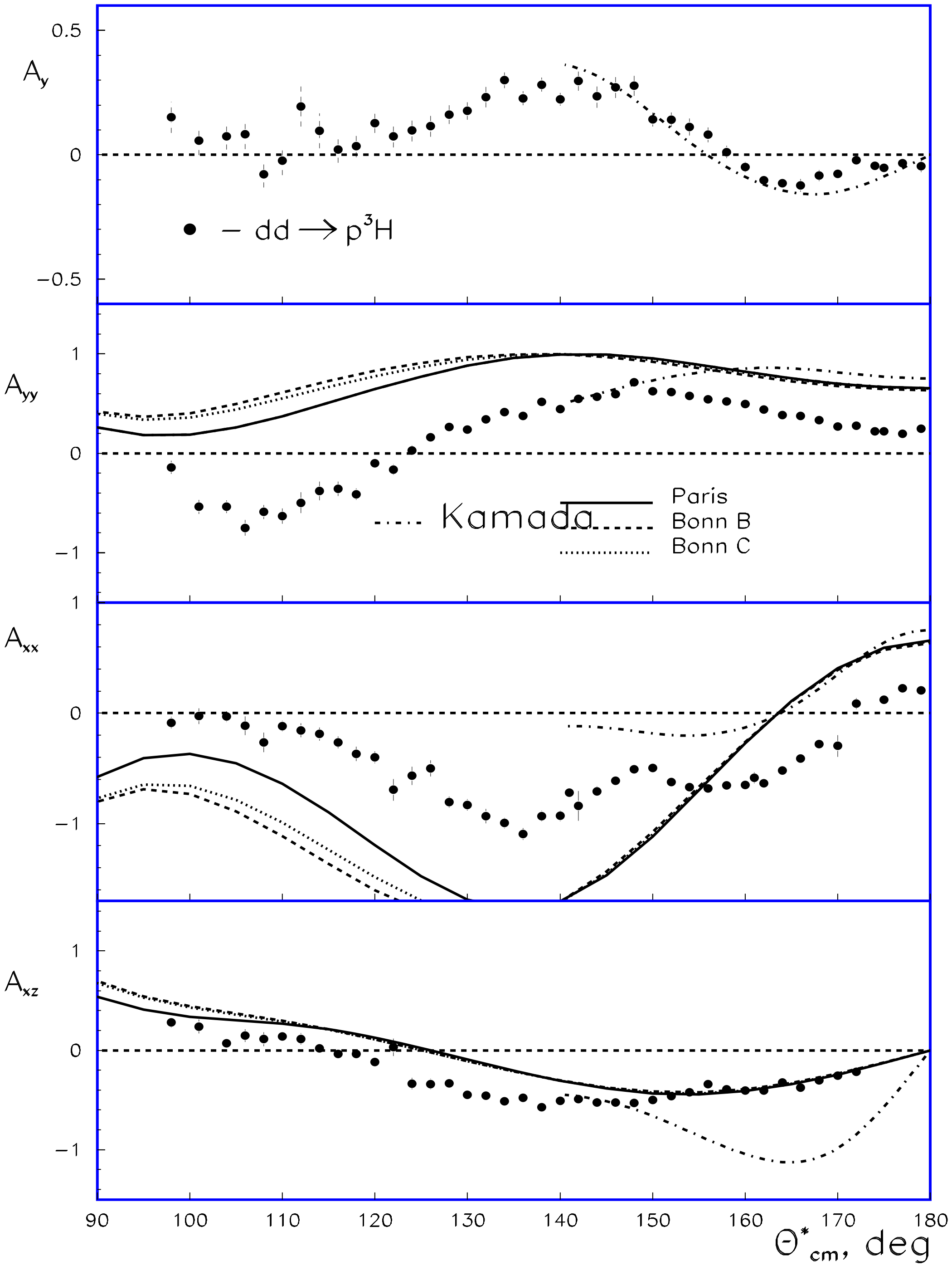
At emission angles $\Theta<7^{o}$ lab. Φ-dependence of beam polarization must be considered.

Typical distribution of asymmetries for each 15^{o} sectors at small scattering angles for M=1,2 and 3 deuteron beam spin modes.

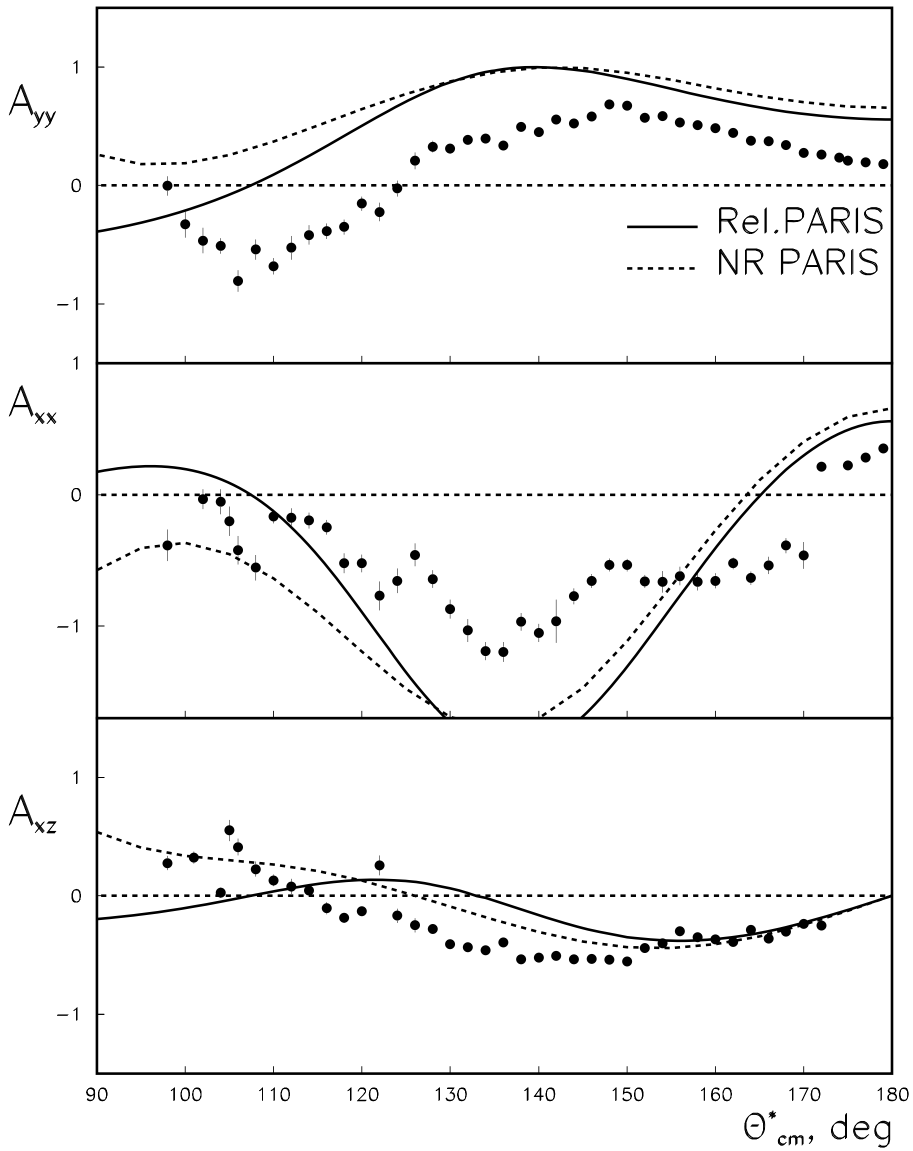
$$N(\theta;\ \beta,\phi) \ = \ 1+\frac{3}{2}p_y(\beta,\phi)A_y(\theta)+\frac{2}{3}p_{xz}(\beta,\phi)A_{xz}(\theta)+\frac{1}{2}p_{zz}(\beta,\phi)A_{zz}(\theta) + \frac{1}{6}\left\{p_{xx}(\beta,\phi)-p_{yy}(\beta,\phi)\right\}\left\{A_{xx}(\theta)-A_{yy}(\theta)\right\},$$

$p0=A_{xx}$
$p1=A_{yy}$
$p2=A_y$



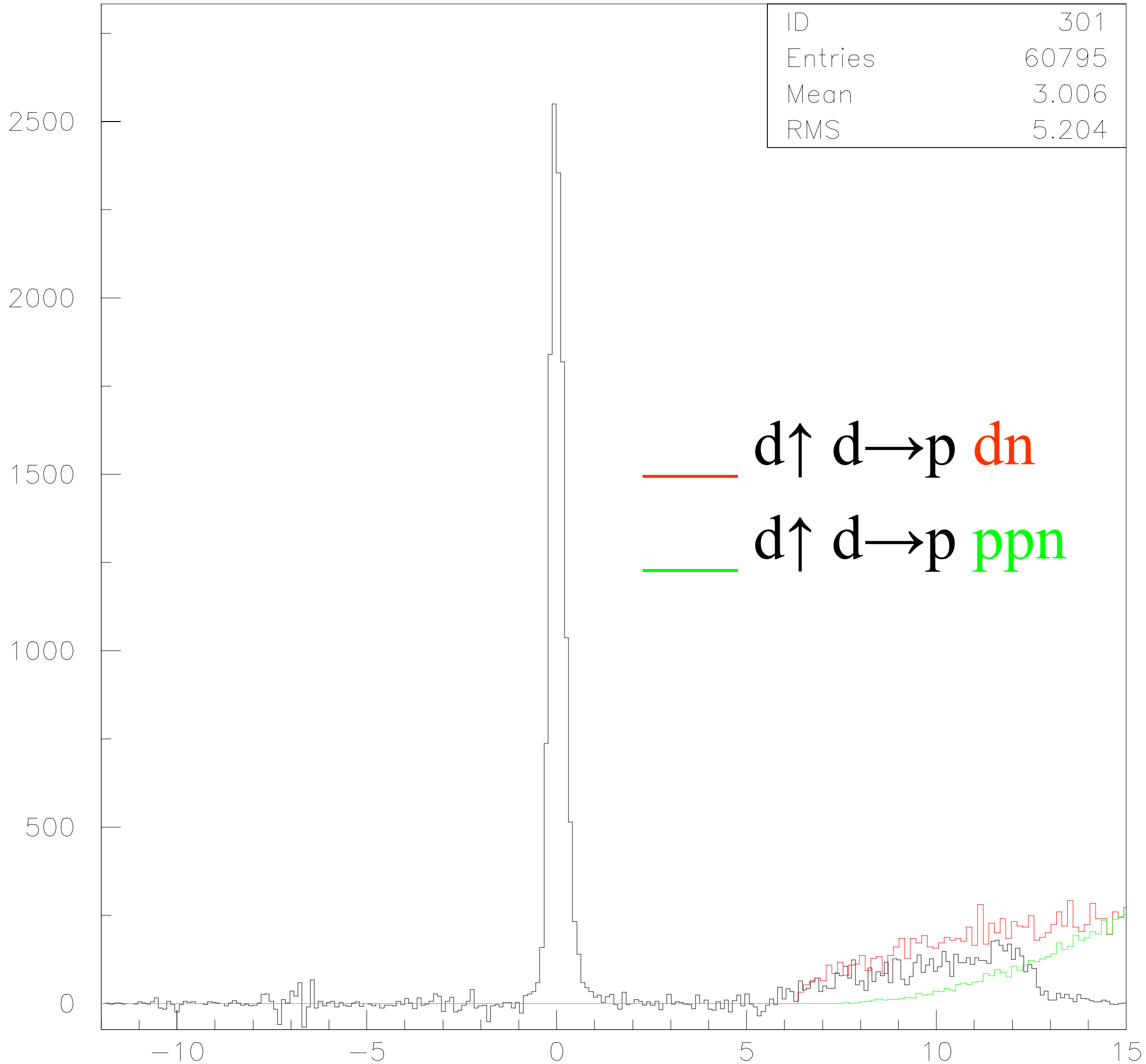


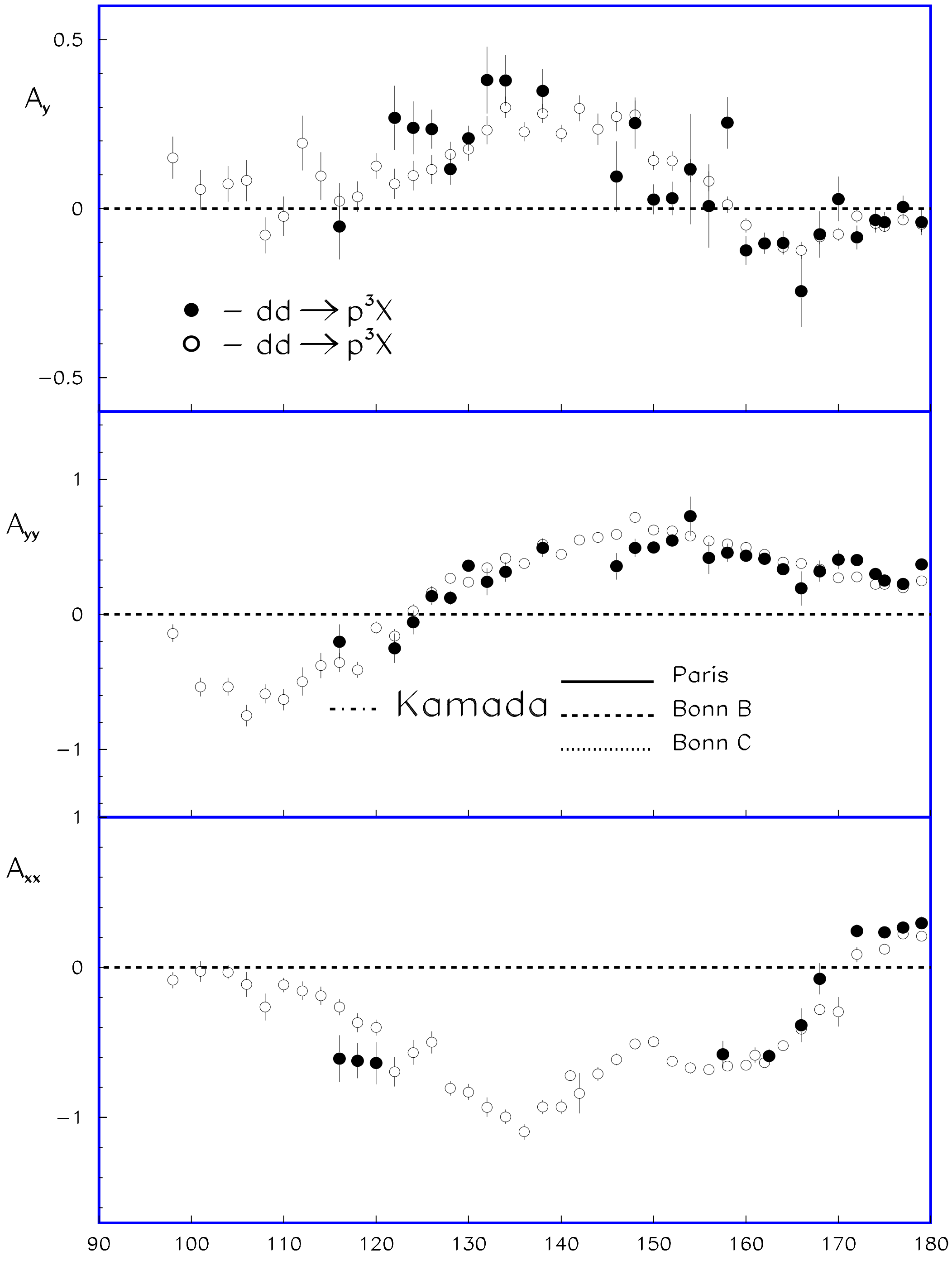
The experimental results on A_y, A_{yy}, A_{xx} and A_{xz} analyzing powers of $d\uparrow d \rightarrow pT$ reaction at E_d 270 MeV.



The experimental results on
Ay, Ayy, Axx and Axz
analyzing powers of
d↑ d→pT reaction
at Ed 270 MeV.

Typical example of the obtained excitation energy spectra after Ex(d+CD2) - k*Ex(d+C) subtraction at Θ_{cm}=8 c.m.s.





The experimental results on A_y, A_{yy} and A_{xx} analyzing powers of d↑ d→pX reaction at E_d 270 MeV.

Summary

1. The experimental data on the tensor and vector analyzing powers A_{yy}, A_{xx}, A_{xz} and A_y for $d{\uparrow}d \rightarrow pT$ are obtained at Ed=270 MeV in angular range of 90^0-180^0 in the c.m.s.

2. The experimental data on tensor analyzing powers of this reaction show sensitivity to the spin structure of deuteron.

3. The angular distribution of A_y indicates the necessity of description of thr reaction mechanism beyond the ONE.

4. The experimental data of the tensor and vector analyzing powers A_{yy}, A_{xx} and Ay for $d{\uparrow}d \rightarrow pX$ breakup reaction are obtained.

5. The experimental data on A_{yy}, A_{xx} for this reaction also show the sensitivity to
   the spin structure of deuteron.

6. The angular distribution of A_y, A_{yy} and A_{xx} of breakup reaction is the same as for the binary one within achieved experimental errors.

7. The interpretation of the obtained experimental data needs further development in theoretical approaches either to adequative description of the light nuclei structure at short distances or taking