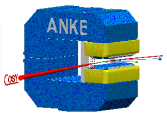
Deuteron Polarimetry at ANKE

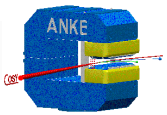
David Chiladze

for the ANKE collaboration



Outline

- Introduction
- Test measurement
- Identification of dp reactions
  - dp elastic
  - $dp\pi^0$
  - $^3He\ \pi^0$
  - (2p)n
- Deuteron polarimetry
- Polarimetry results
- Summary
- Outlook



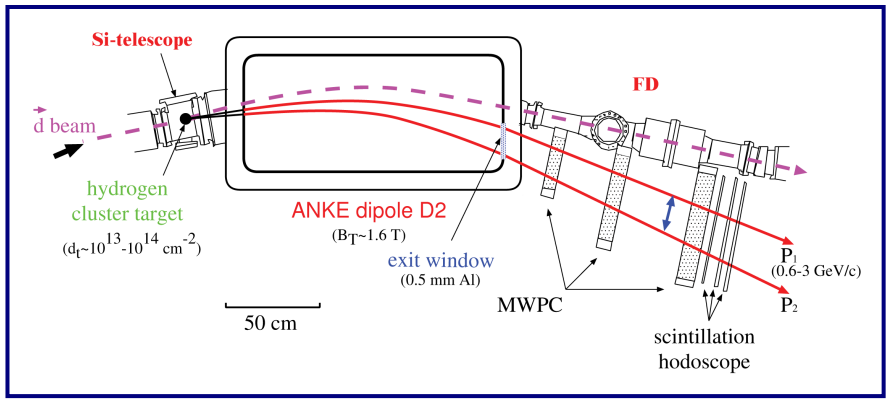
Introduction

- COSY proposal #125 (2003):
  "The Polarised Charge-Exchange Reaction $\vec{d}p \rightarrow (2p)n$"
  [Spokespersons: A.Kacharava, F.Rathmann]
- A measurement of the $\frac{d\sigma}{dt}$ and the analysing powers T_{20} & T_{22}
- Direct reconstruction of the spin-dependent np amplitudes
- First step: test measurement
- Aim: to check the feasibility of the experiment, to develop polarimetry of the COSY deuteron beam with ANKE.

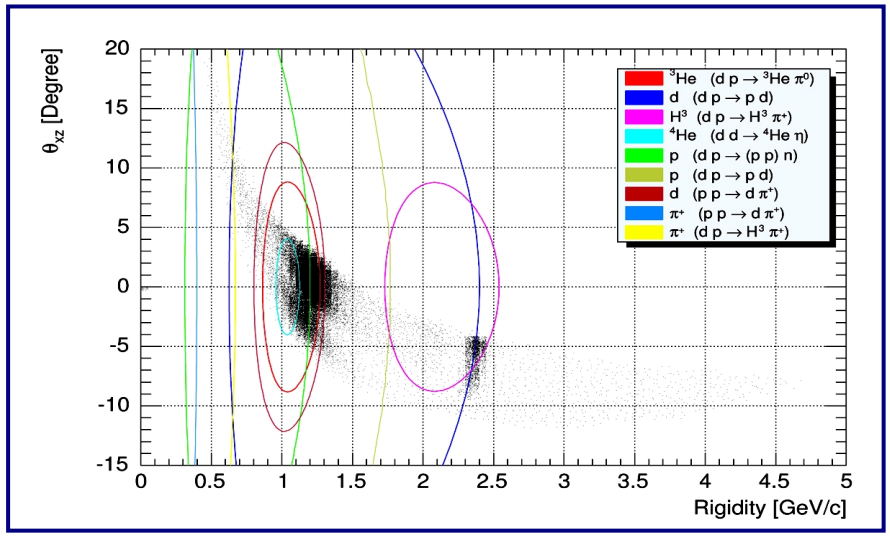
Test measurement – Set-up

Three days test measurement during machine development in November 2003.

T_d = 1170 MeV; I_0 = 3 x 10^9



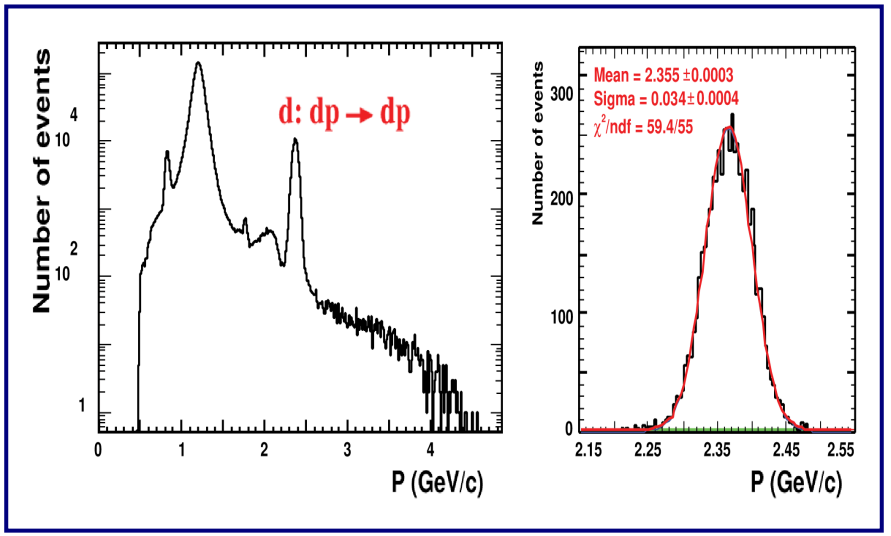
Spin Mode	P_z ideal	P_{zz} ideal	Intensity [I_0]
0	0	0	1
1	-2/3	0	1
2	+1/3	+1	1
3	-1/3	-1	1
4	+1/2	-1/2	2/3
5	-1	+1	2/3
6	+1	+1	2/3
7	-1	-1/2	2/3

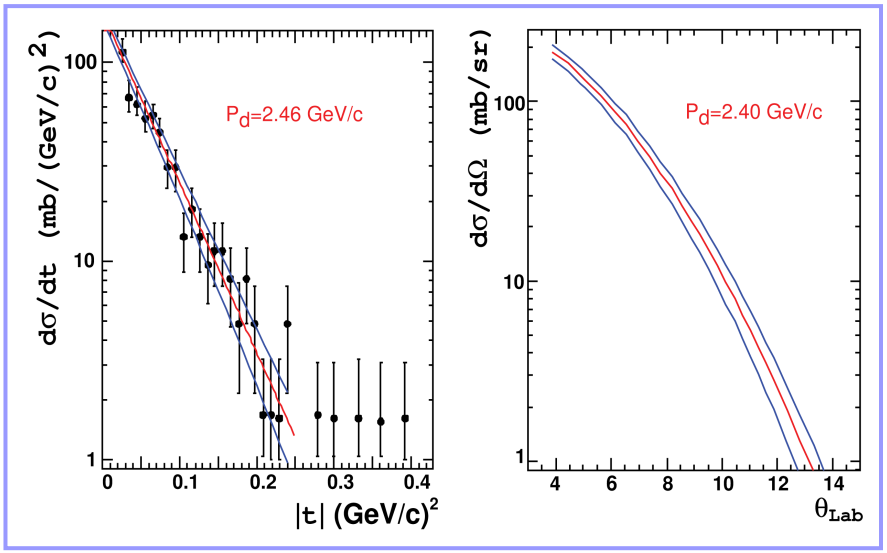


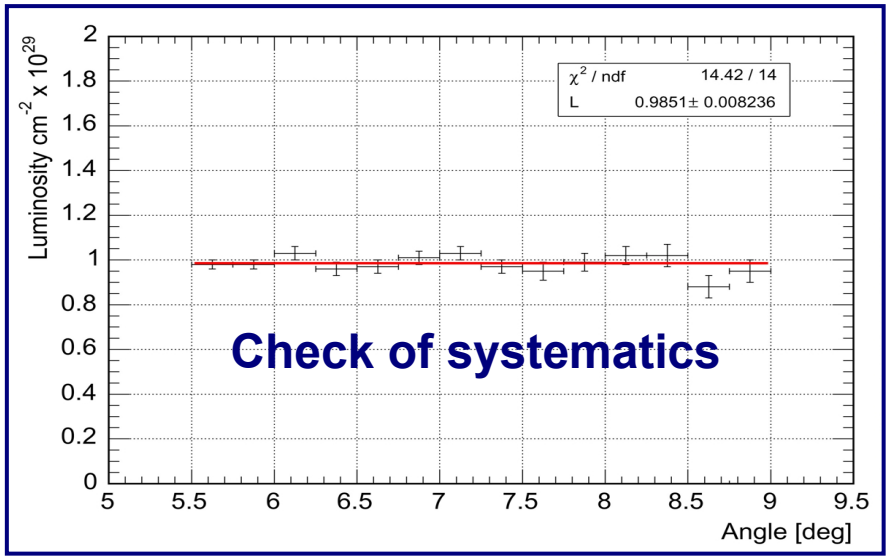
Test measurement – Identification of $\vec{d}p \to dp$

- P_z, P_{zz} measurement
- Luminosity determination

  [KEK data, NPA438 (1985),685]



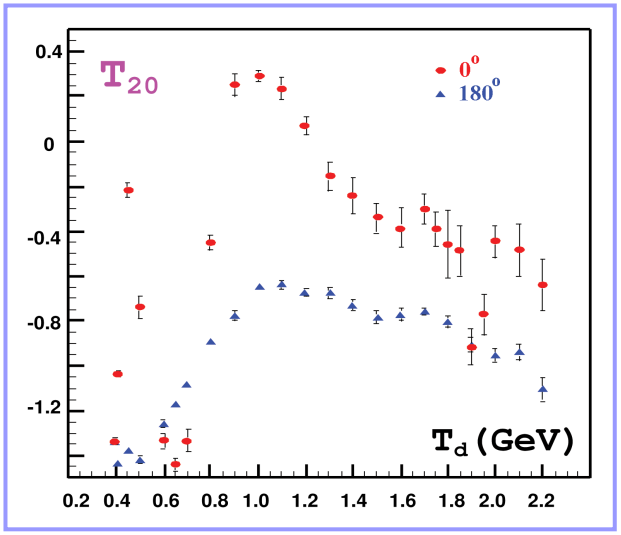


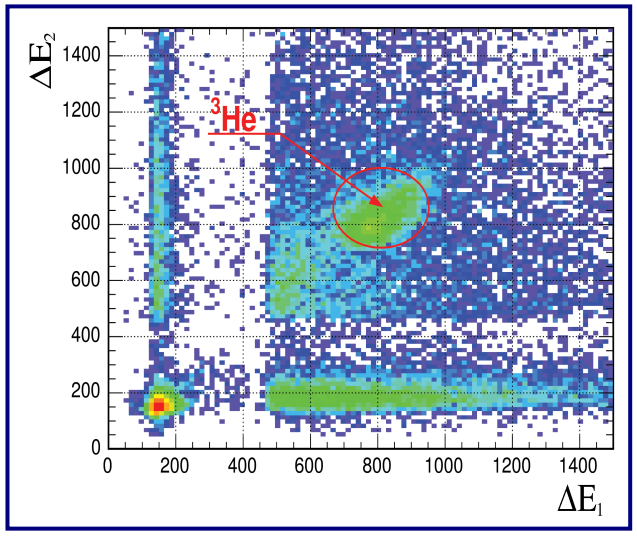


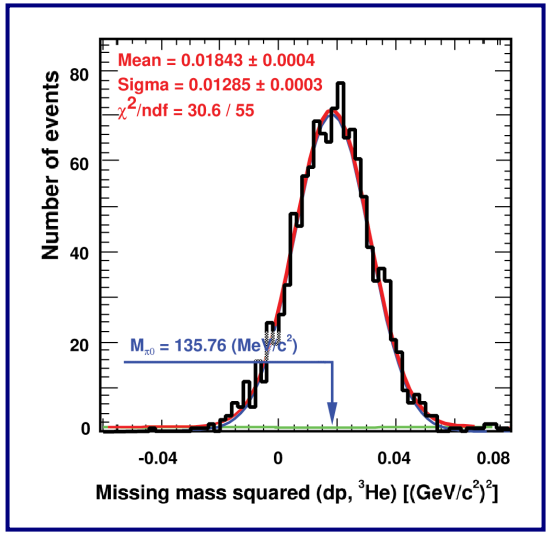
Test measurement – Identification of $\vec{d}p \rightarrow {}^3He\pi^0$

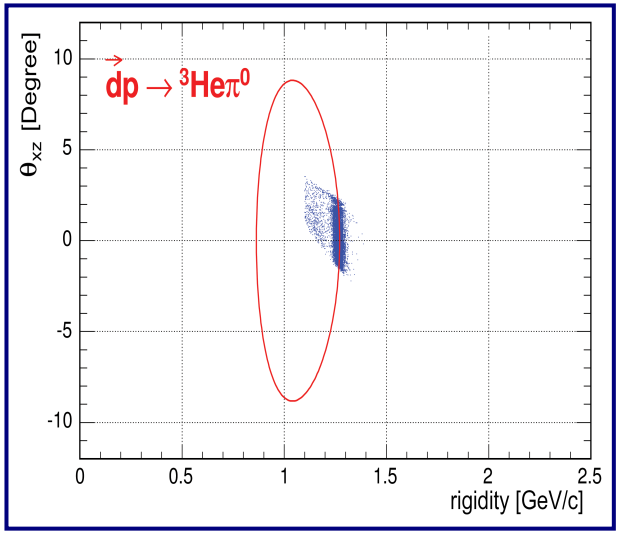
- P_{zz} Measurement (θ~0°)
- Accuracy of $A_{yy}(\theta\sim0°)\sim$ 2%

[Saturne data, PLB181 (1986), 28] ⟶

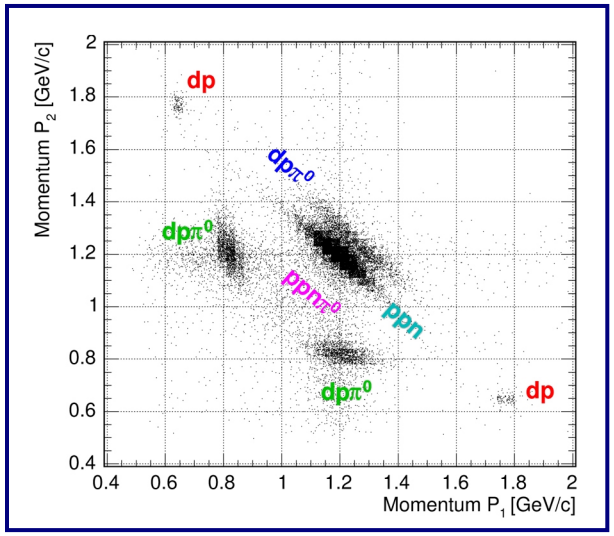


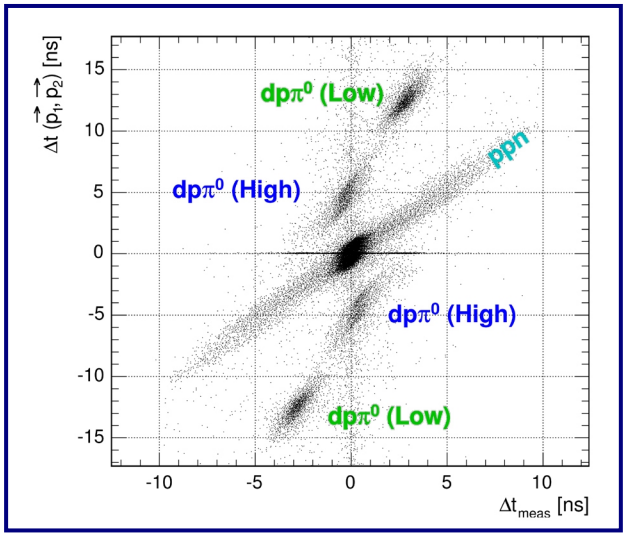


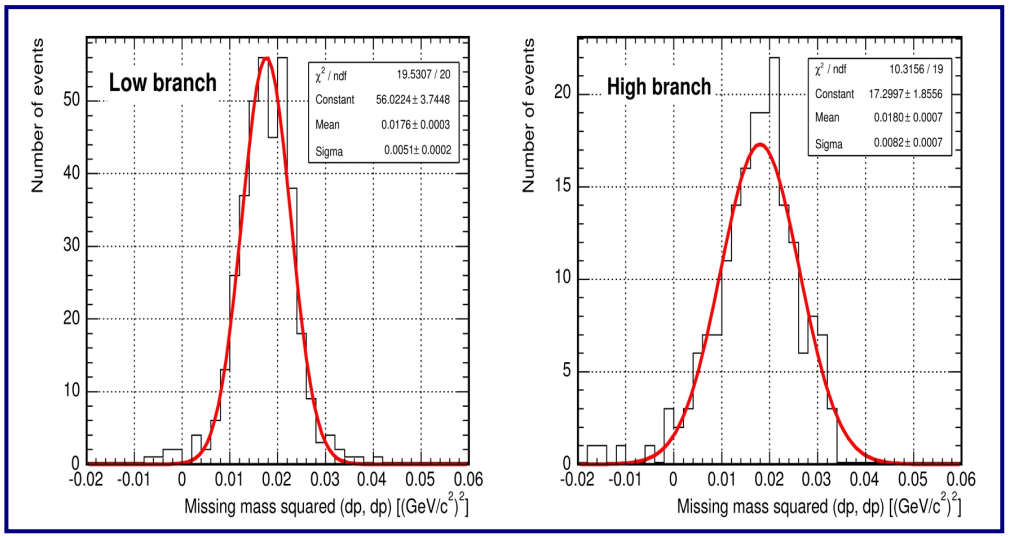


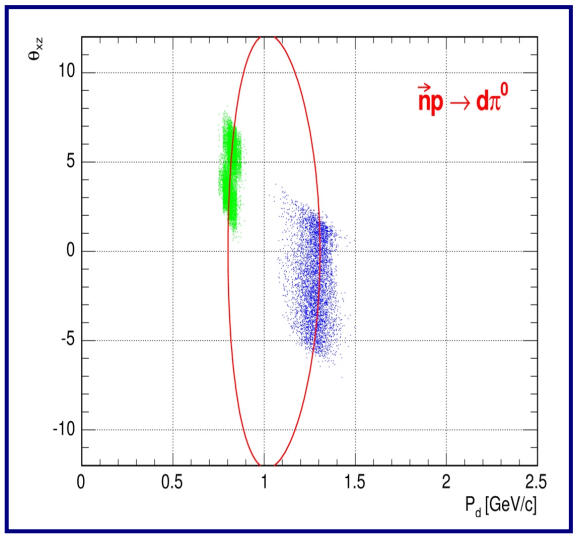


Test measurement – Identification of $\vec{d}p \to dp\pi^0$



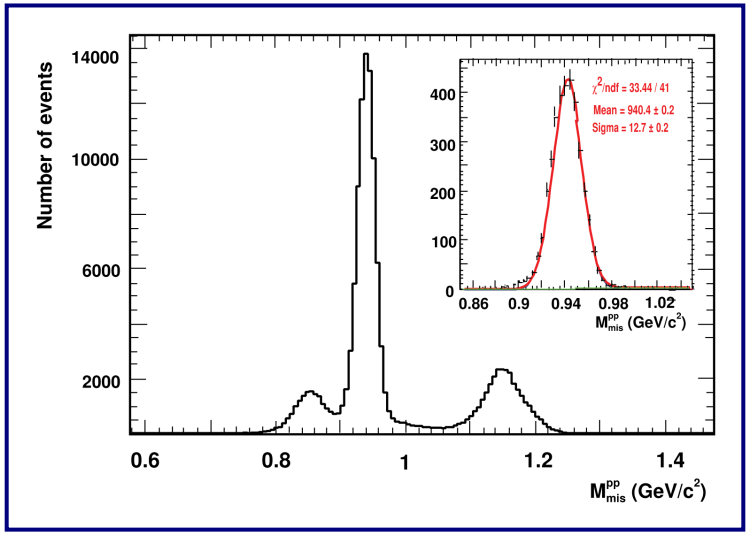


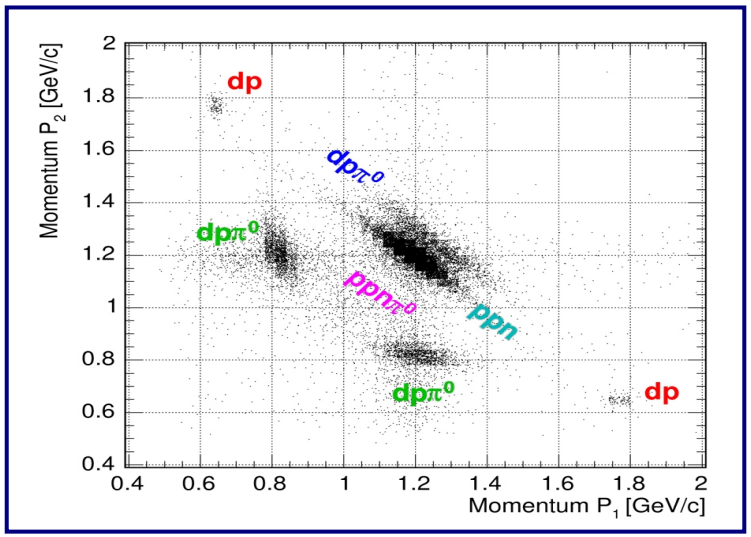


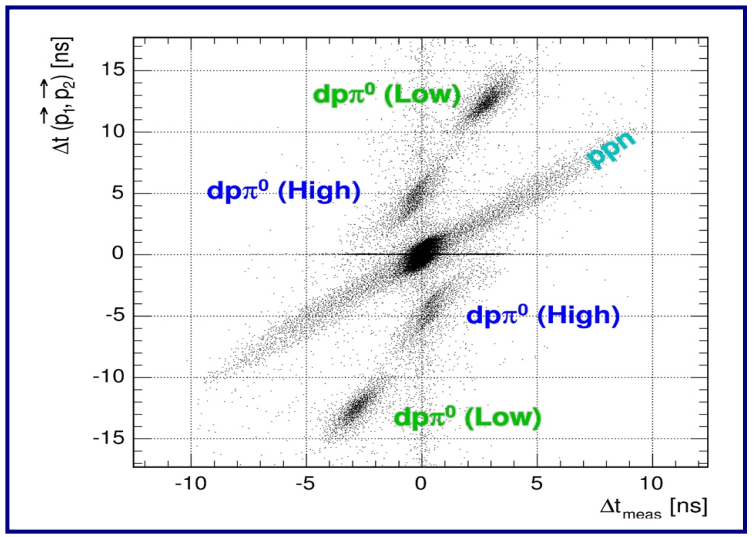


Test measurement – Identification of $\vec{d}p \rightarrow (2p)n$

- MWPC information
- Timing information





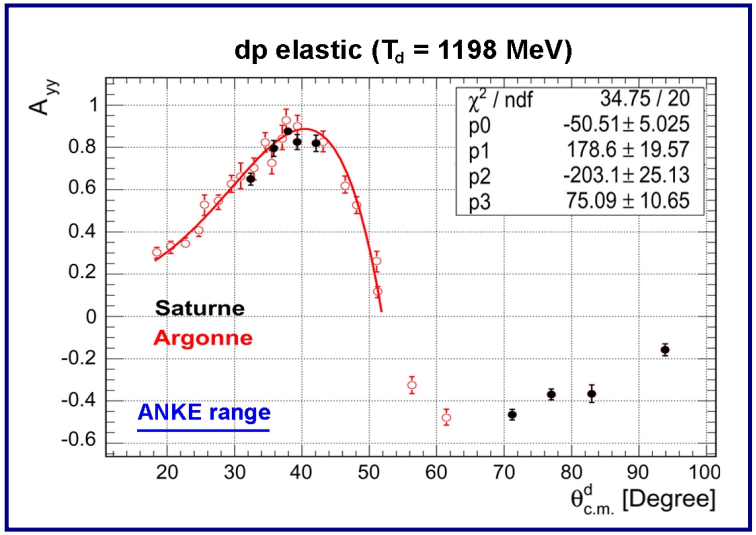


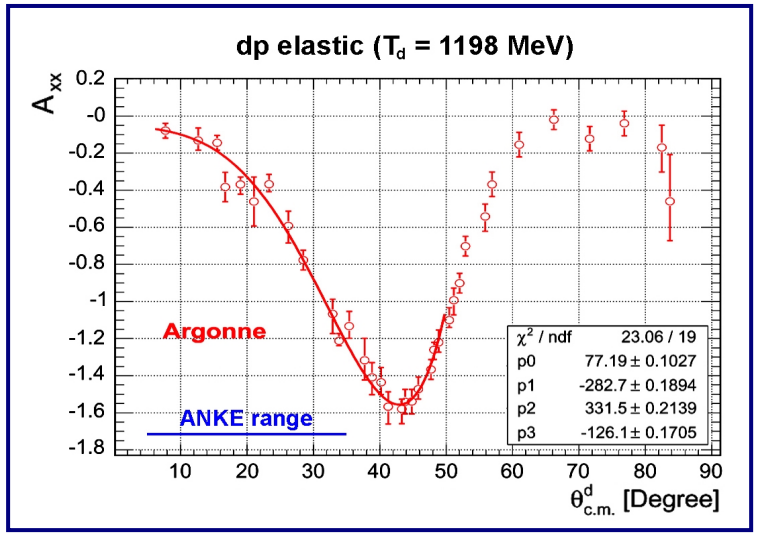
Deuteron polarimetry – Polarimetry reactions

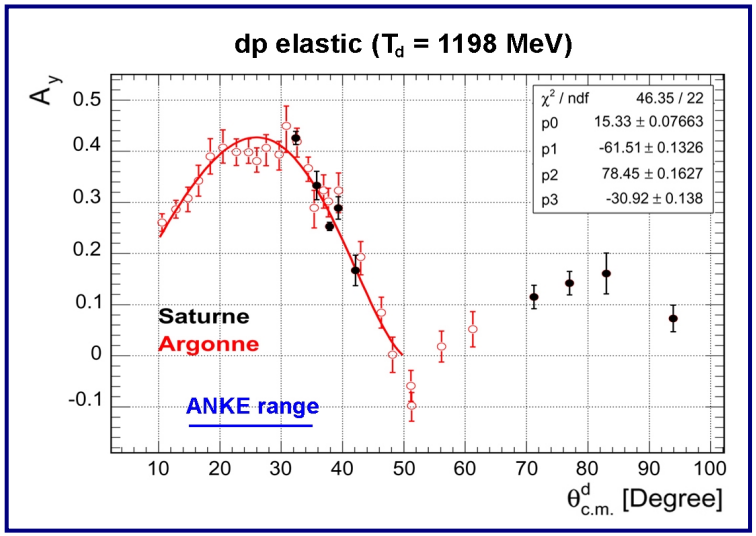
$$\sigma^{\uparrow}(\theta,\phi)=\sigma^{0}(\theta)\left(1+\frac{3}{2}P_z A_y(\theta)\cos\phi+\frac{1}{4}P_{zz}\left[A_{yy}(\theta)(1+\cos 2\phi)+A_{xx}(\theta)(1-\cos 2\phi)\right]\right)$$

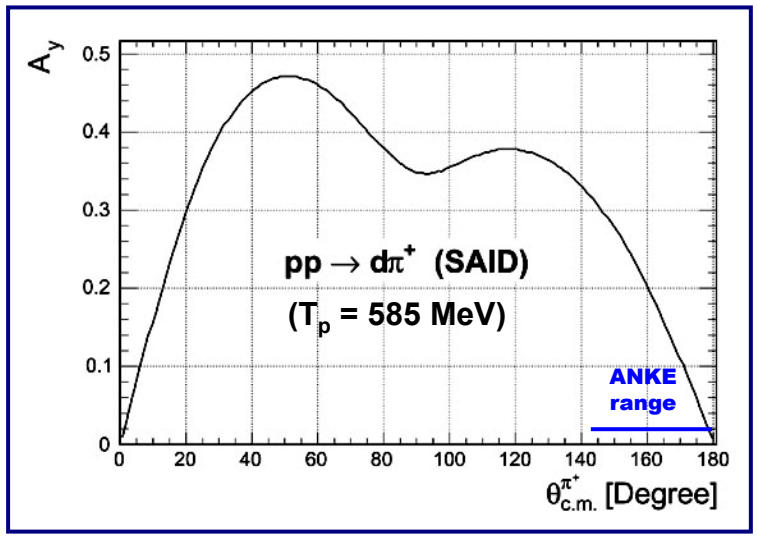
Reactions for P_z measurements	Reactions for P_{zz} measurements
$\vec{d}p \to dp$	$\vec{d}p \to dp$
$\vec{n}p \to d\pi^0$ *(quasi-free)*	$\vec{d}p \to {}^3\mathrm{He}\pi^0$
$\vec{p}p \to pp$ *(quasi-free)*	$\vec{d}p \to (2p)n$

Deuteron polarimetry – Analysing powers





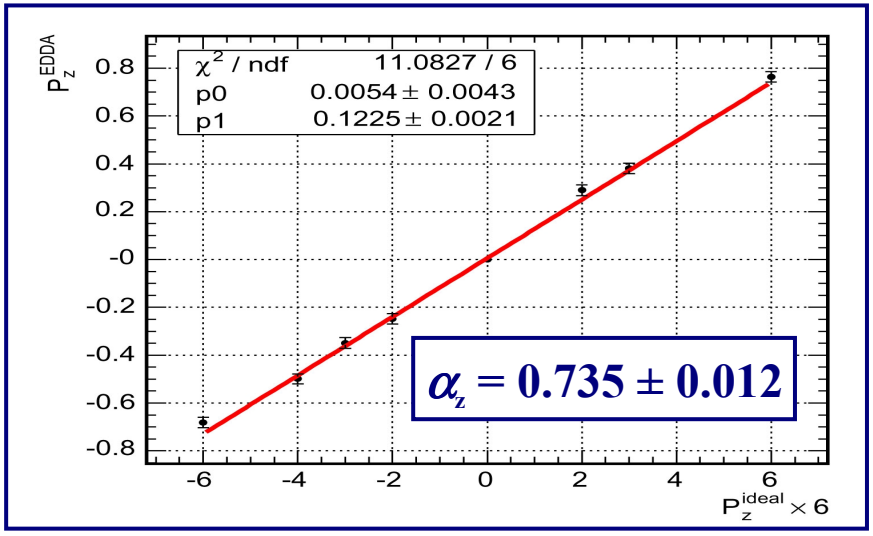


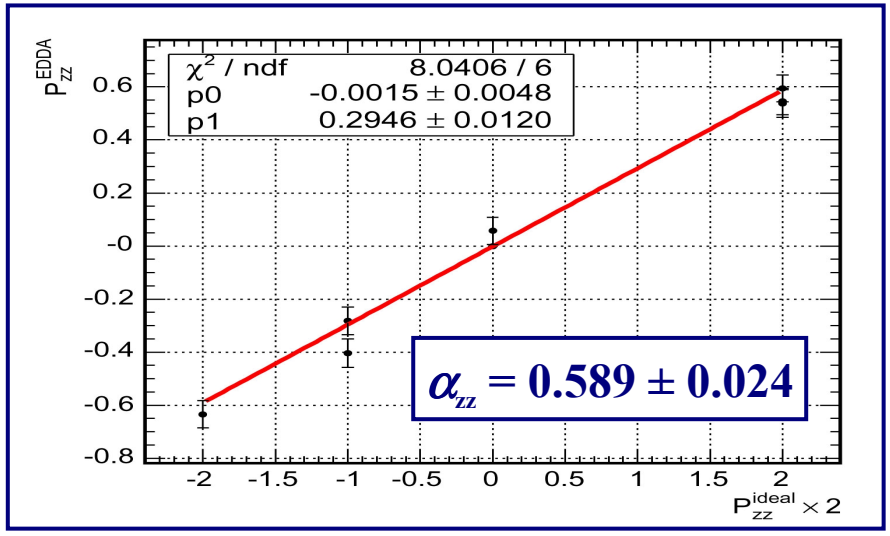


Polarimetry results – EDDA *(dp elastic)*

- T_d = 270 MeV
- $N_0 = 10^7$
- A_y (RIKEN data)
  [Phys.Rev. C 65, 034003 (2002)]
- $\theta_{c.m.} = 65° – 95°$
- $P_i = \alpha_i \cdot P_i^{ideal}$

Spin mode	P_z EDDA	P_z ideal	P_{zz} EDDA	P_{zz} ideal
0	0± 0.0	0	0± 0.0	0
1	-0.499± 0.021	-2/3	0.057± 0.051	0
2	0.290± 0.023	+1/3	0.594± 0.050	+1
3	-0.248± 0.021	-1/3	-0.634± 0.051	-1
4	0.381± 0.022	+1/2	-0.282± 0.052	-1/2
5	-0.682± 0.022	-1	0.537± 0.052	+1
6	0.764± 0.022	+1	0.545± 0.050	+1
7	-0.349± 0.022	-1/2	-0.404± 0.053	-1/2

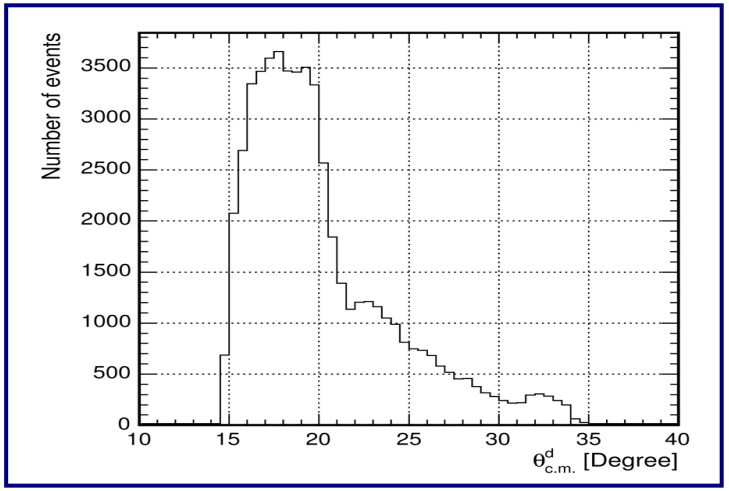


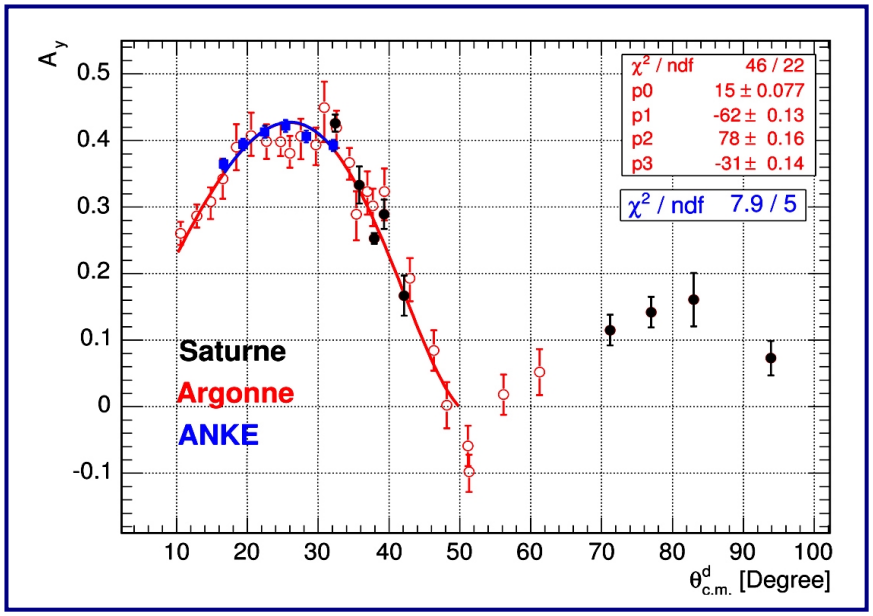


Polarimetry results – ANKE: $\vec{d}p \rightarrow dp$ (P_z)

- $N^{\uparrow} = N_0\left[1 + \beta_z P_z^{ideal} + \beta_{zz} P_{zz}^{ideal}\right]$
- $\theta_{c.m.} = 15° - 35°$
- $\beta_z = \frac{3}{2}\alpha_z A_y < \cos\phi >$

$$\alpha_z^{ANKE} = 0.73 \pm 0.02$$

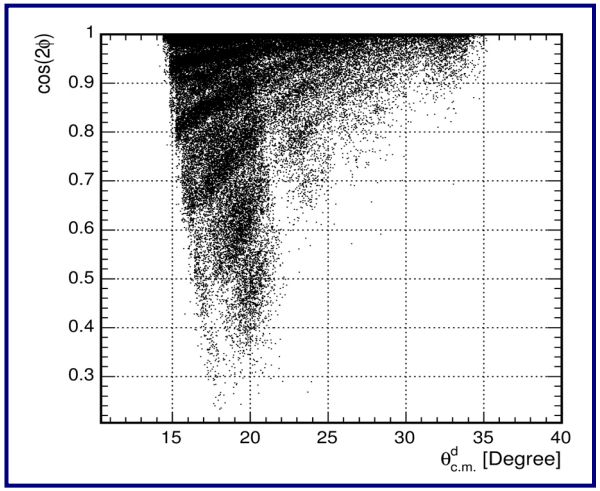




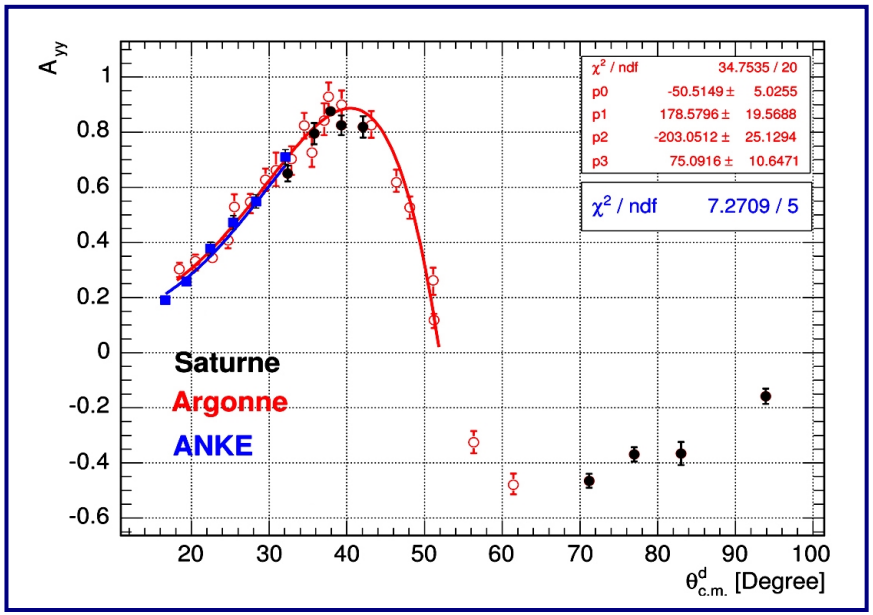
Range	$<\theta^*>$	$<\cos\phi>$	β_z
15-18°	16.7°	-0.968	-0.382 ± 0.006
18-21°	19.4°	-0.952	-0.406 ± 0.007
21-24°	22.5°	-0.976	-0.436 ± 0.012
24-27°	25.4°	-0.985	-0.449 ± 0.014
27-30°	28.3°	-0.989	-0.434 ± 0.014
30-35°	32.1°	-0.956	-0.421 ± 0.014

Polarimetry results – ANKE: $\vec{d}p \to dp$ (P_{zz})

- $N^{\uparrow} = N_0\left[1 + \beta_z P_z^{ideal} + \beta_{zz} P_{zz}^{ideal}\right]$
- $\beta_{zz} = \alpha_{zz} A_{yy} / 2 \cdot CF$
- $CF = 2A_{yy} / A_{yy}\left(1 + <\cos 2\varphi>\right) + A_{xx}\left(1 - <\cos 2\varphi>\right)$



$$\alpha_{zz}^{ANKE} = 0.49 \pm 0.02$$

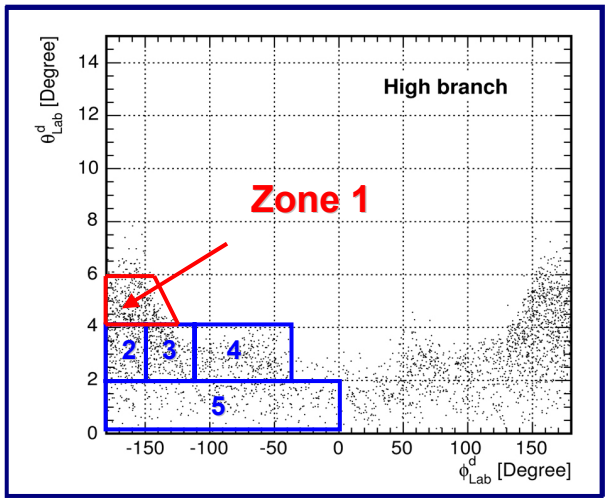


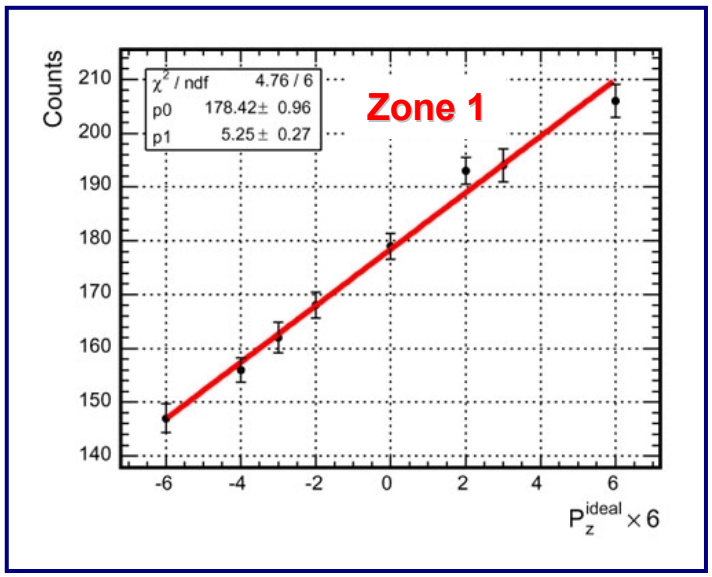
Range	$<\theta^*>$	$<\cos 2\phi>$	CF	β_{zz}
15-18°	16.7°	0.878	1.16	0.040± 0.006
18-21°	19.4°	0.818	1.27	0.050 ± 0.006
21-24°	22.5°	0.909	1.12	0.081 ± 0.010
24-27°	25.4°	0.942	1.08	0.105 ± 0.011
27-30°	28.3°	0.956	1.06	0.124 ± 0.011
30-35°	32.1°	0.971	1.04	0.163 ± 0.012

Polarimetry results – ANKE: $\vec{n}p \to d\pi^0$ (P_z)

- $A_y(pp \to d\pi^+)$ from SAID
- $P_z^n = (1 - 3/2 \cdot P_d) P_z^d$; $N^{\uparrow} = N_0 [1 + \beta_z P_z^{ideal}]$
- $\beta_z = 3/2 \cdot \alpha_z A_y < \cos\phi >$; $\beta_{zz} = 0.003 \pm 0.007$

$$\alpha_z^{ANKE} = 0.70 \pm 0.03$$



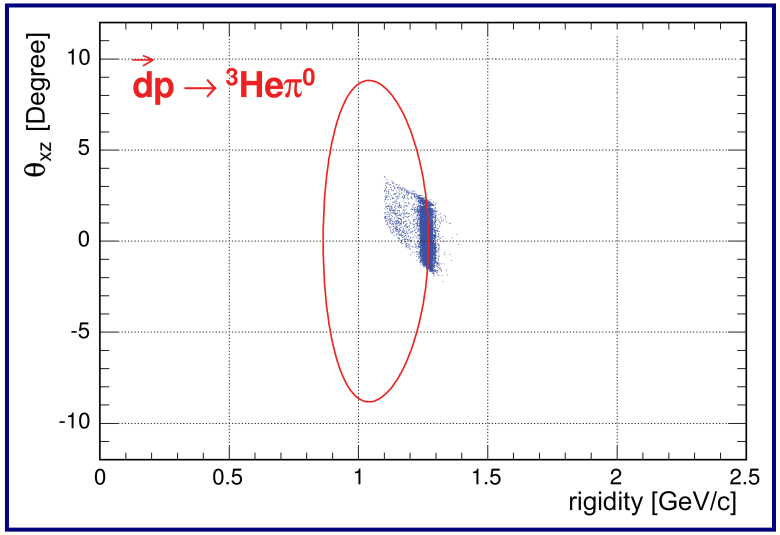


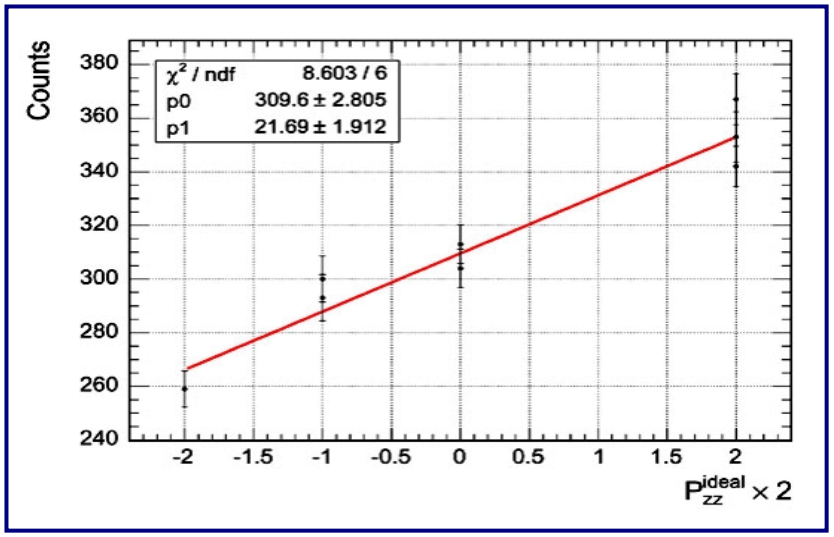
Zone	θ_{lab}	$\lvert\phi\rvert$	β_z^{ANKE}	α_z^{ANKE}
1	4 - 6°	all	0.177 ± 0.009	0.717 ± 0.024
2	2 - 4°	150 - 180°	0.139 ± 0.012	0.720 ± 0.066
3	2 - 4°	120 - 150°	0.071 ± 0.001	0.537 ± 0.091
4	2 - 4°	60 - 120°	-0.028 ± 0.011	-
5	0 - 2°	all	0.015 ± 0.09	-

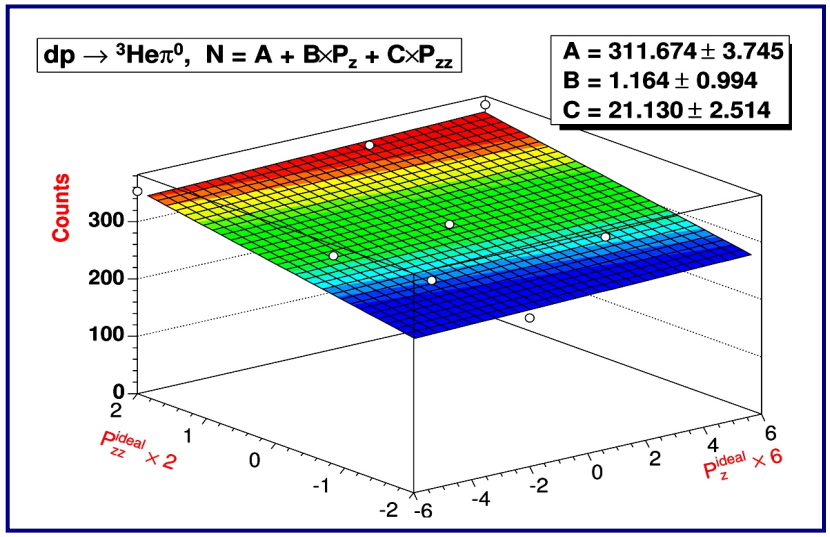
Polarimetry results – ANKE: $\vec{d}p \to {}^3He\pi^0$ (P_{zz})

- $N^{\uparrow} = N_0\left[1 + \beta_{zz} P_{zz}^{ideal}\right] \quad (\theta < 1^{\circ})$
- $A_{yy} = 0.467 \pm 0.011$ (Saturne)
- $\alpha_{zz} = 2\beta_{zz} / A_{yy}$;
- $\beta_{zz} = 0.136 \pm 0.012; \ \beta_z = 0.004 \pm 0.009$

$$\alpha_{zz}^{ANKE} = 0.58 \pm 0.05$$



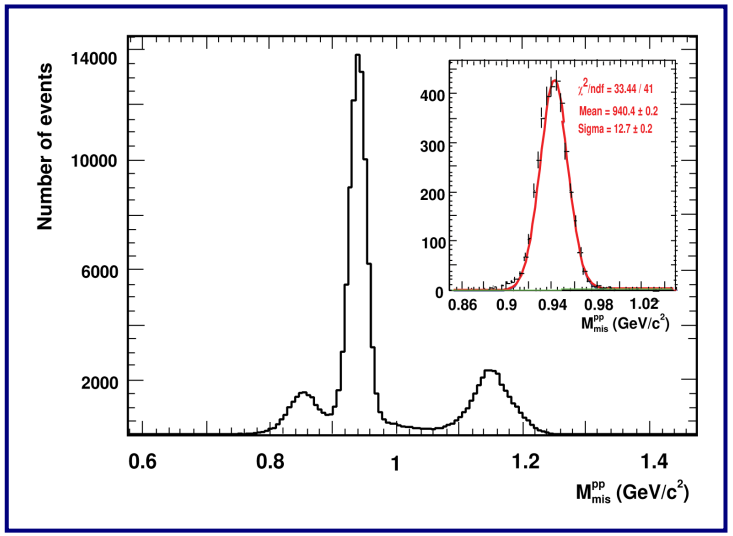


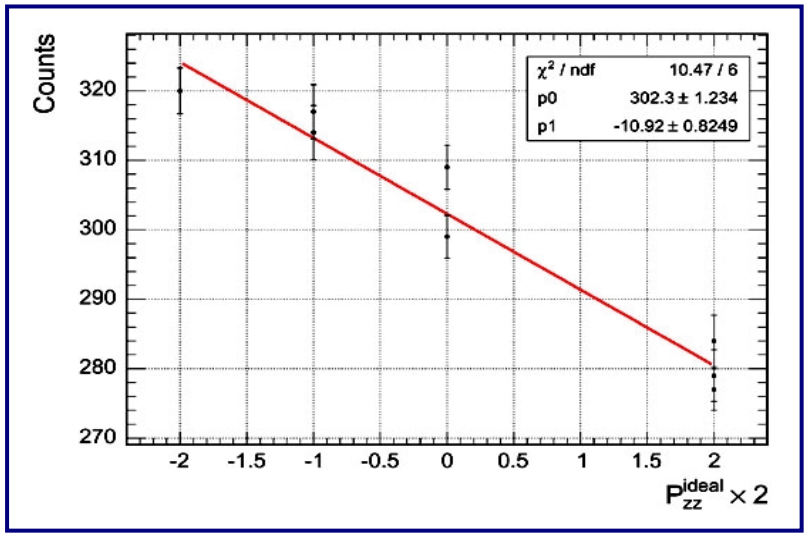


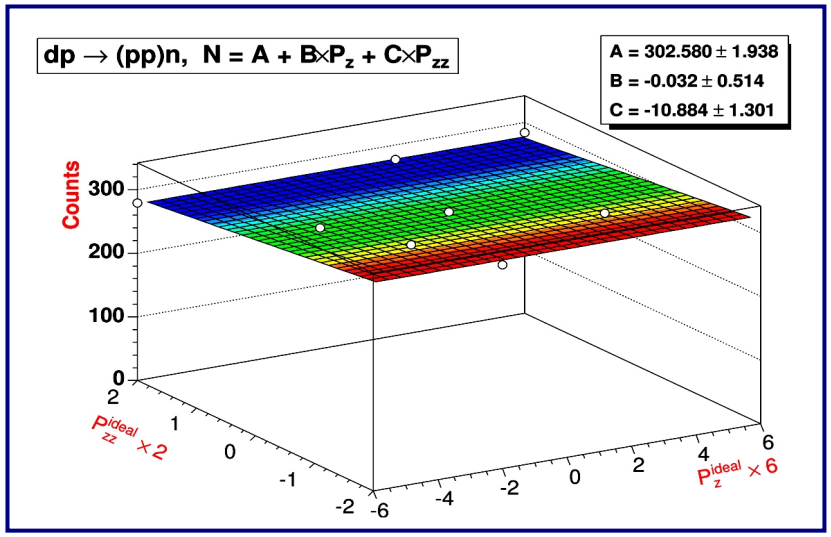
Polarimetry results – ANKE: $\vec{d}p \to (pp)n$ (P_{zz})

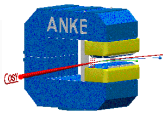
- $N^{\uparrow} = N_0\left[1 + \beta_{zz} P_{zz}^{ideal}\right] \quad \left(\theta_{pp} < 0.5^{\circ}\right)$
- $A_{yy} = -0.30 \pm 7\%$ Bugg & Wilkin
- $\alpha_{zz} = 2\beta_{zz} / A_{yy}$
- $\beta_{zz} = -0.072 \pm 0.005; \;\; \beta_z = -0.001 \pm 0.010$

$$\alpha_{zz}^{ANKE} = 0.48 \pm 0.05$$





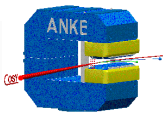




Summary

Reaction	Facility	α_z	α_{zz}
$dp \rightarrow dp$	EDDA	0.74 ± 0.01	0.59 ± 0.02
$dp \rightarrow dp$	ANKE	0.73 ± 0.02	0.49 ± 0.04
$dp \rightarrow dp\pi^0$	ANKE	0.70 ± 0.03	-
$dp \rightarrow {}^3\mathrm{He}\pi^0$	ANKE	-	0.58 ± 0.05
$dp \rightarrow (pp)n$	ANKE	-	0.48± 0.05

Polarisation	ANKE	EDDA
α_z	0.72 ± 0.02	0.74 ± 0.01
α_{zz}	0.52 ± 0.03	0.59 ± 0.02



Outlook

- Analysis:
  - $\vec{d}p \rightarrow dp$ (P_{zz}, ϕ cuts)
  - $\vec{n}p \rightarrow d\pi^0$ (low branch)
  - quasi-free $\vec{p}p$ (silicon telescope)
  - systematic effects
- Coming beam time (2005)
  - online polarimetry – $\vec{d}p$ elastic
  - polarimetry energy T_d = 1198 MeV
  - polarisation export
  - few well chosen transitions

Test measurement – Identification of $\vec{d}p \rightarrow dp\pi^0$