Analysing power in deuteron breakup

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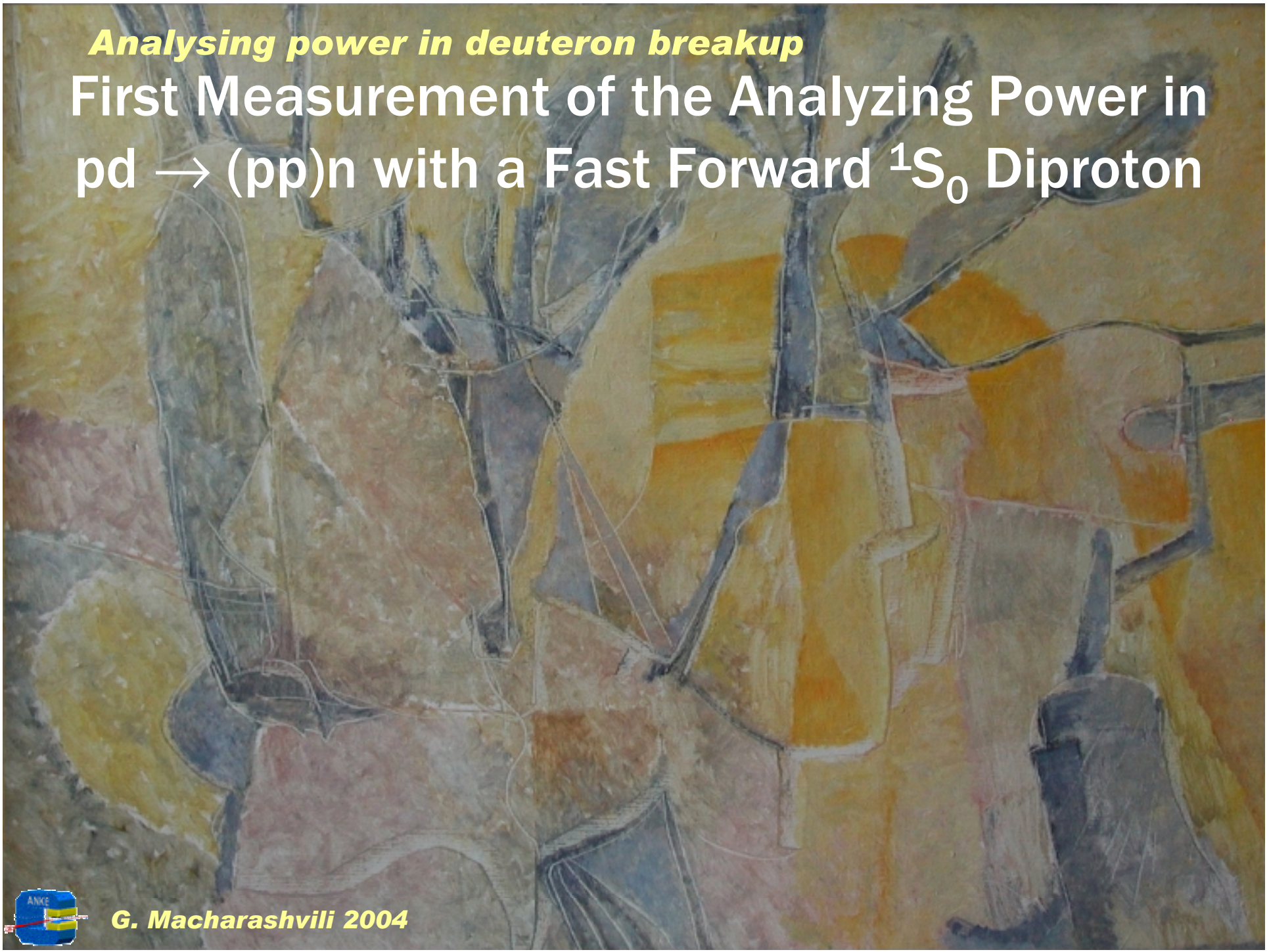
Analysing power in deuteron breakup

First Measurement of the Analyzing Power in $pd \rightarrow (pp)n$ with a Fast Forward $^1S_0$ Diproton



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First Measurement of the Analyzing Power in $pd \rightarrow (pp)n$ with a Fast Forward $^1S_0$ Diproton

S.Yaschenko[1,2], S.Dymov[2], V.Komarov[2], G.Macharashvili[2,3], F.Rathmann[4], S.Barsov[5], M.Hartmann[4], V.Hejny[4], R.Gebel[4], A.Kacharava[1,3], A.Khoukaz[6], P.Kulessa[4,7], A.Kulikov[2], V.Kurbatov[2], N.Lang[6], I.Lehmann[4], B.Lorentz[4], T.Mersmann[6], S.Merzliakov[2], S.Mikirtytchiants[5], A.Mussgiller[4], M.Nioradze[3], H.Ohm[4], D.Prasuhn[4], R.Schleichert[4], H.Seyfarth[4], E.Steffens[1], H.J.Stein[4], H.Ströher[4], Yu.Uzikov[2,8], B.Zalikhanov[2], and N.Zhuravlev[2]

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Analysing power in deuteron breakup

Physics motivation

Study of pd dynamics at high momentum transfer; Short-range structure of NN interactions;

$^1S_0$ –state of the fast forward diproton provides new features absent in the pd→dp and exclusive deuteron disintegration;

Insight on few nucleon systems at short distances;

Different Δ contribution at 0.5 and 0.8 GeV.
Δ contribution suppressed by the isospin factor 3 times at 0.8 GeV.

A number of theoretical models proposed:

L.Kondratyuk et al., Phys. Lett. B 100, 448 (1981),
Yu. Uzikov. Phys. Part. Nucl. 29 (1998) 583,
L.P.Kaptari et al., Eur. Phys. J. A19, 301 (2004), ...

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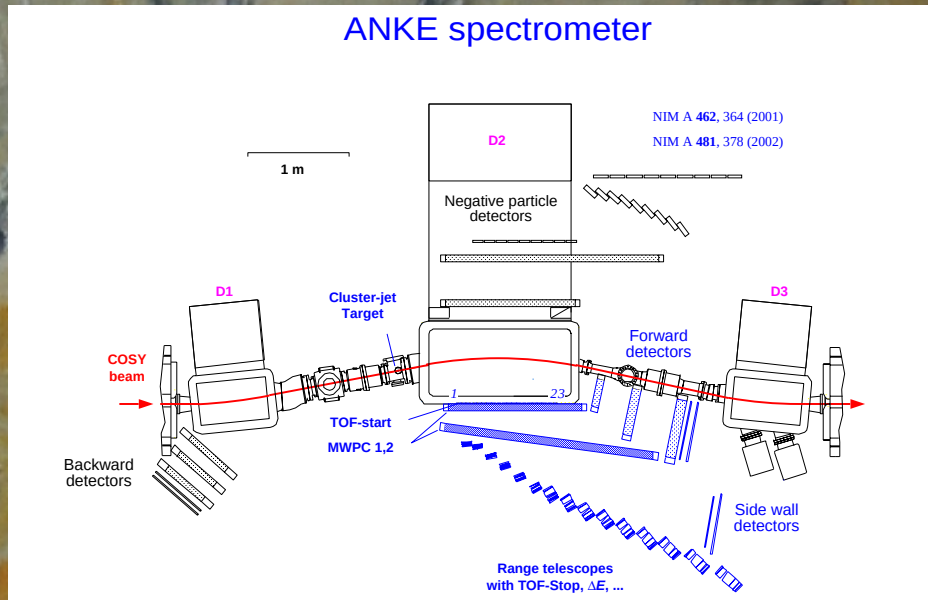
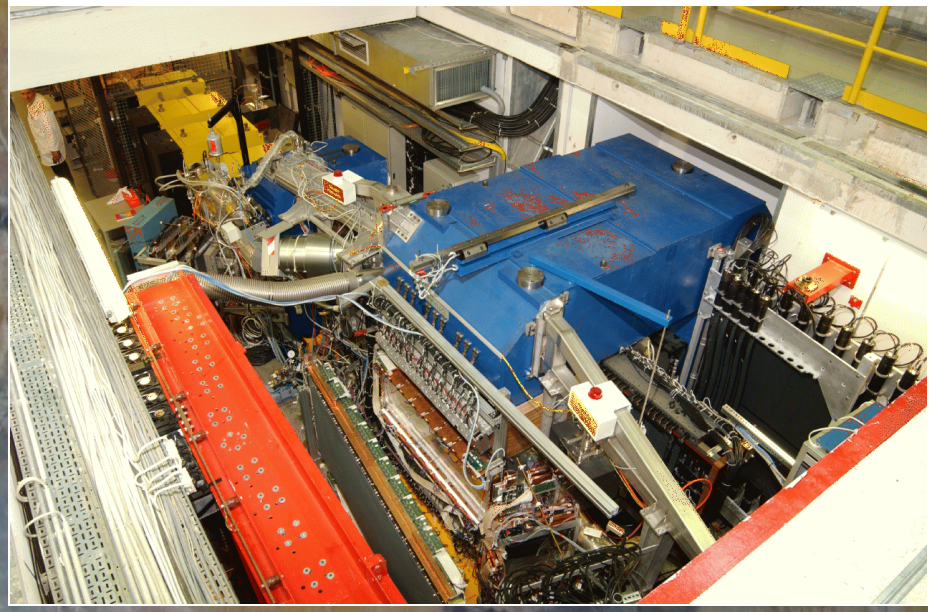
ANKE spectrometer





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Polarizaed proton beam:

stored in COSY ring $3 \cdot 10^9$

polarization $0.564 \pm 0.003^{stat} \pm 0.004^{syst}$

D_2 cluster target:

density $2 \cdot 10^{14}$ cm^{-2}

along the beam 12 mm

full width 4.5 mm

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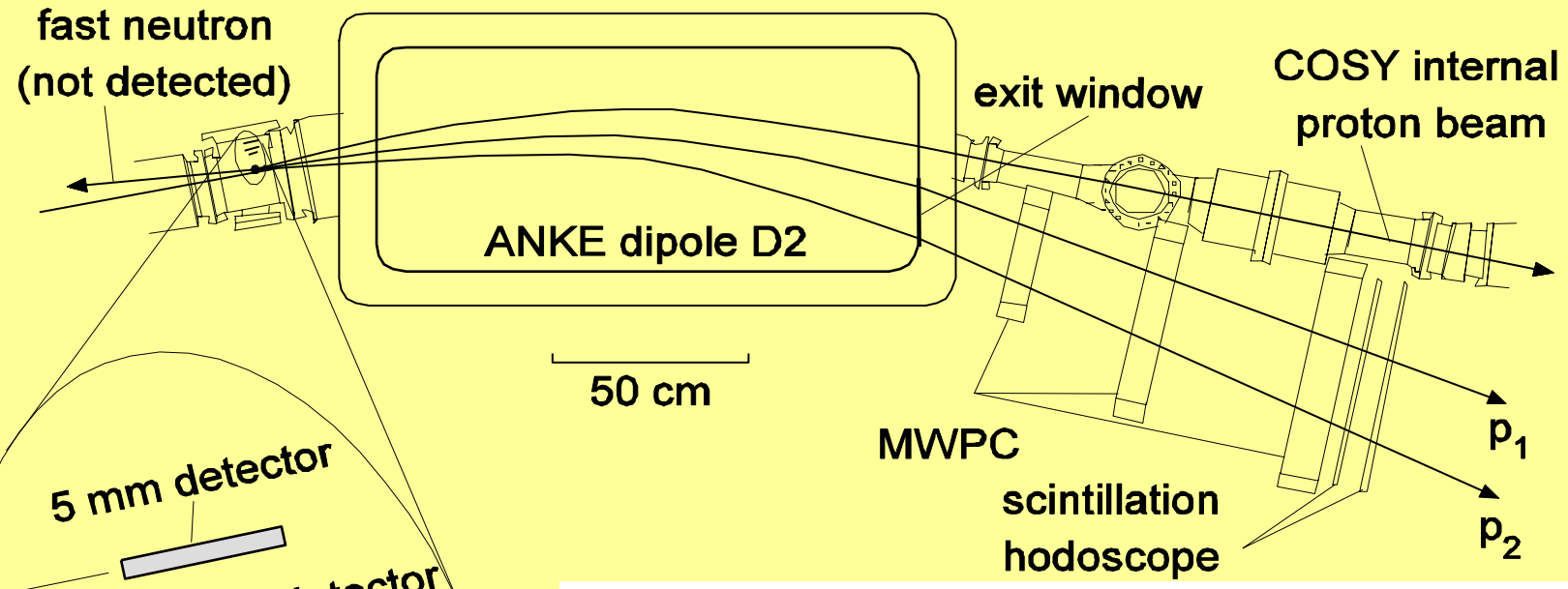

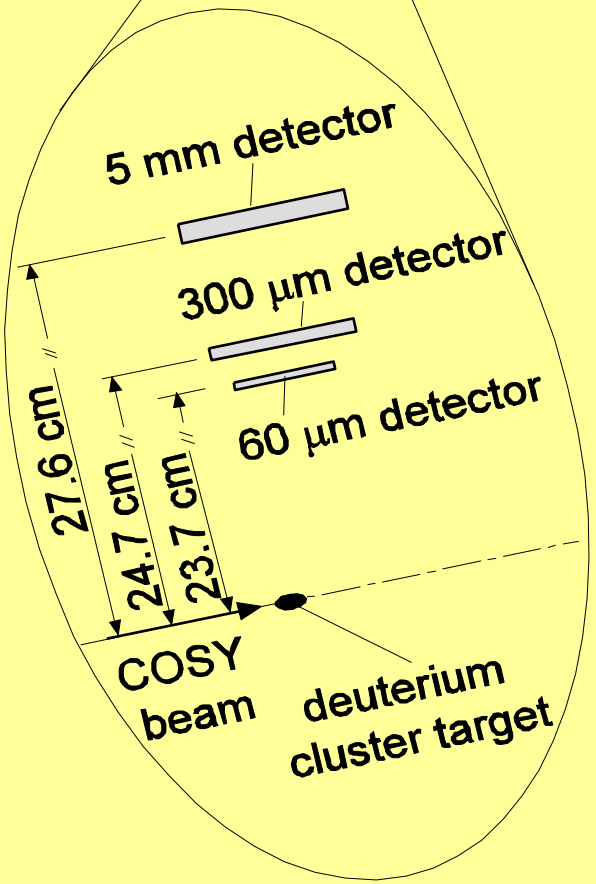

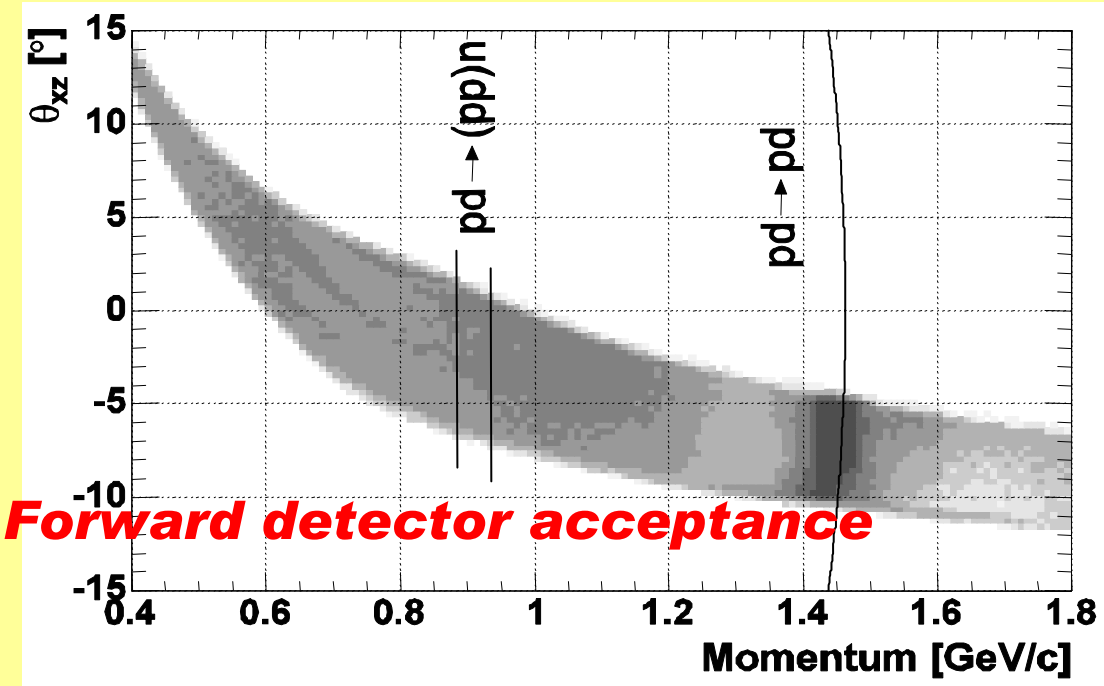

Forward detector acceptance

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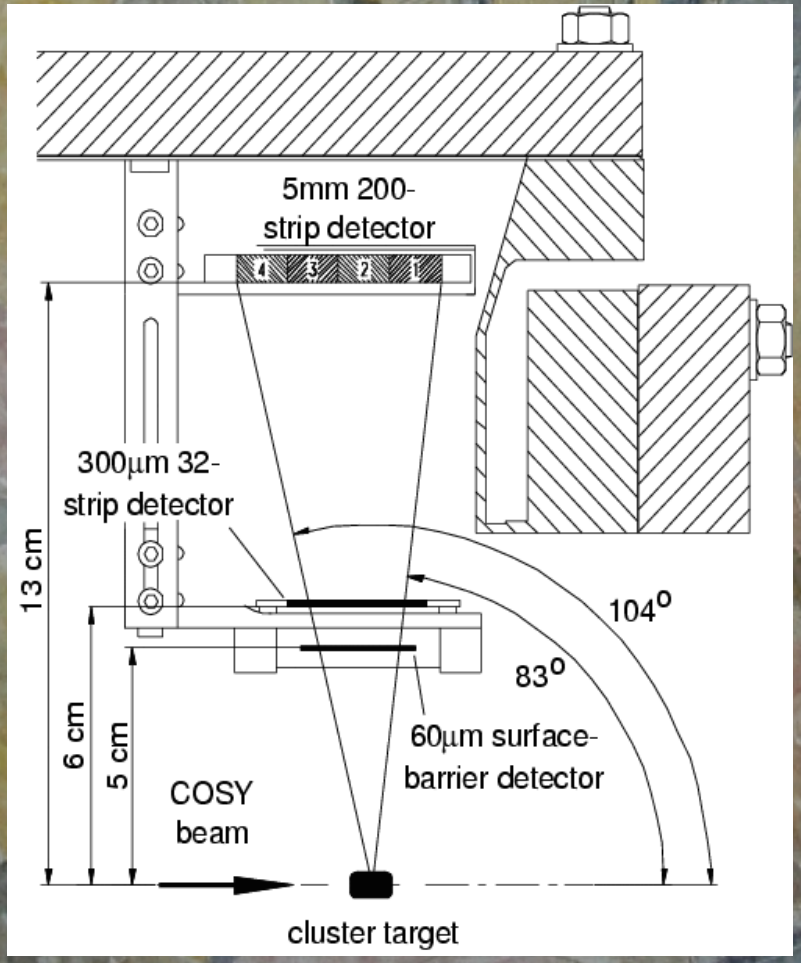
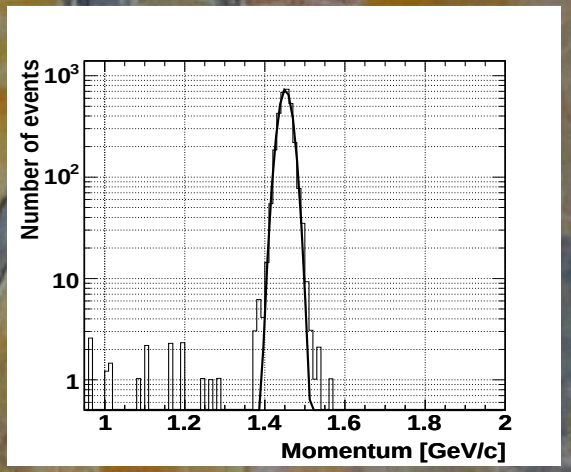
Spectator detector (SDT). Energy resolution 300 keV.



Proton momentum in FD for detected in SDT deuterons. No background ...



These elastic events were used for beam polarimetry

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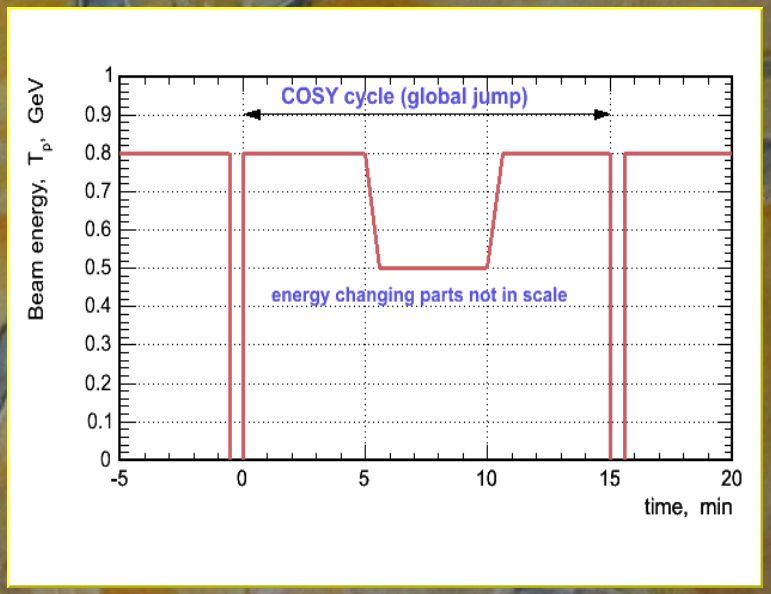
Polarization export

-Spin flip occures at 631.8 MeV
(the 2nd improper resonanse)
-depolarization caused by:
magnetic field errors;
misalignment of magnets;
vertical focussing magnets;
-Polarization loss is less than 1 %

A.Lehrach et al., Spin-2002, p.153



No loss of the beam polarization
during the polarization export

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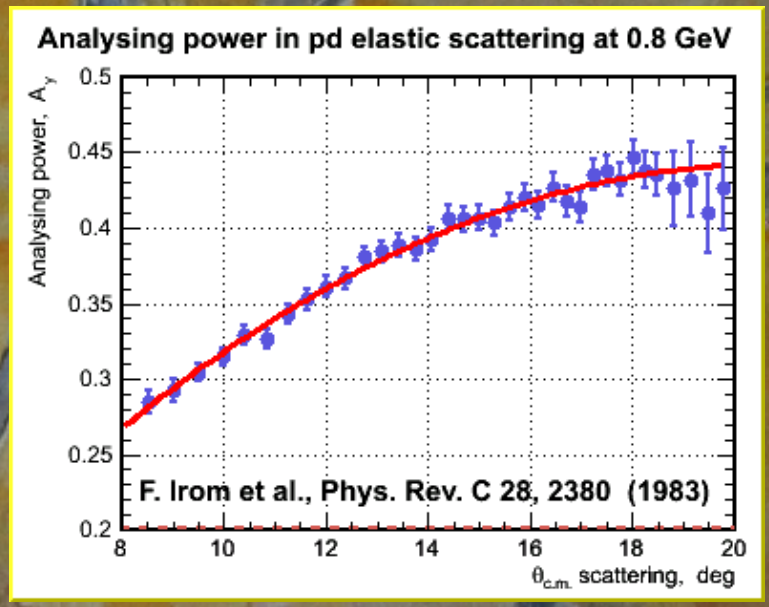
Beam polarimetry at 0.8 GeV

Analysing power in pd elastic scattering is used for the beam polarization measurement in the 1st and the 3rd flattops. The Polarization value is exported to the 2nd flattop at 0.5 GeV.



Exp. data from:
F.Irom et al., Phys.Rev.C 28, 2380 (1983)

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Analysis procedure

- **Double-track events are filtered for proton-pair selection;**
- **The efficiency of double-proton identification is checked by ΔE and TOF difference methods;**
- **Two proton phase space was checked;**
- **Left/Right scattered events were accumulated**

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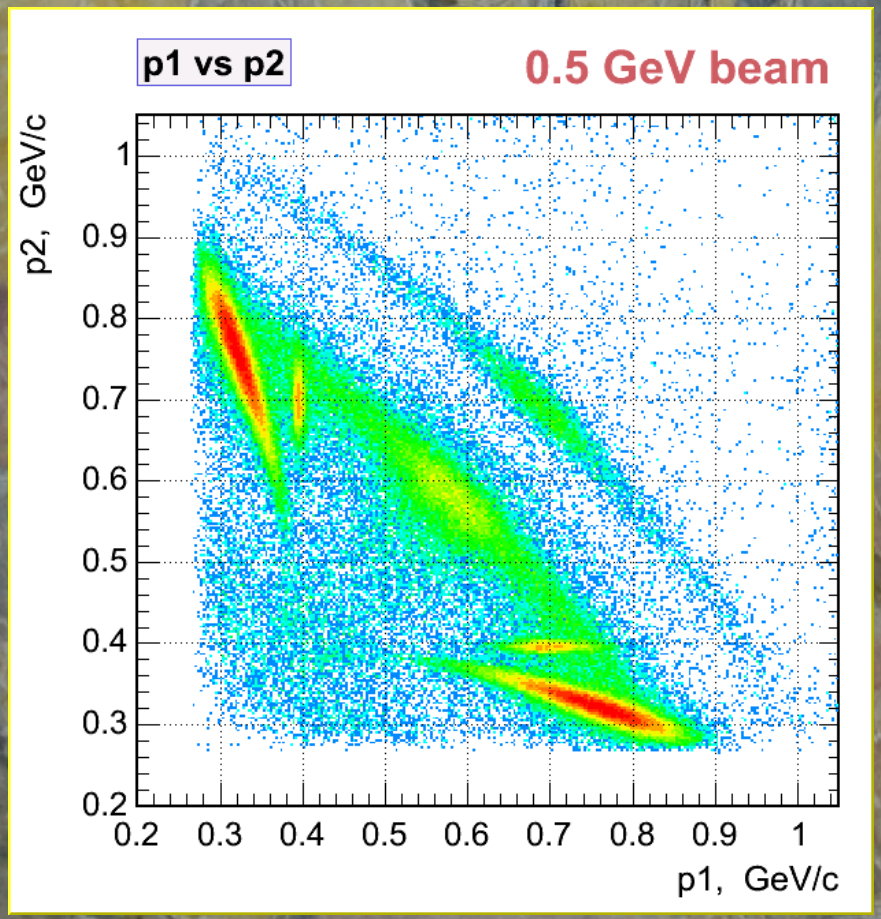
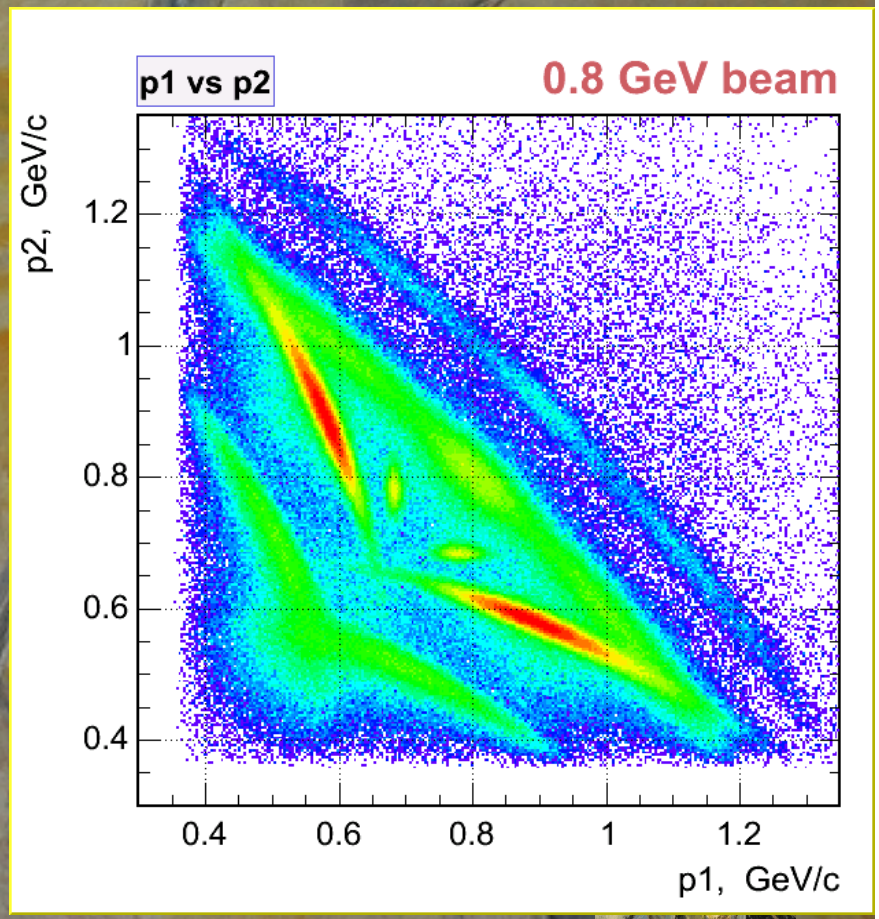
Two particle momentum correlation.

Break-up events are concentrated at the outer arc center.





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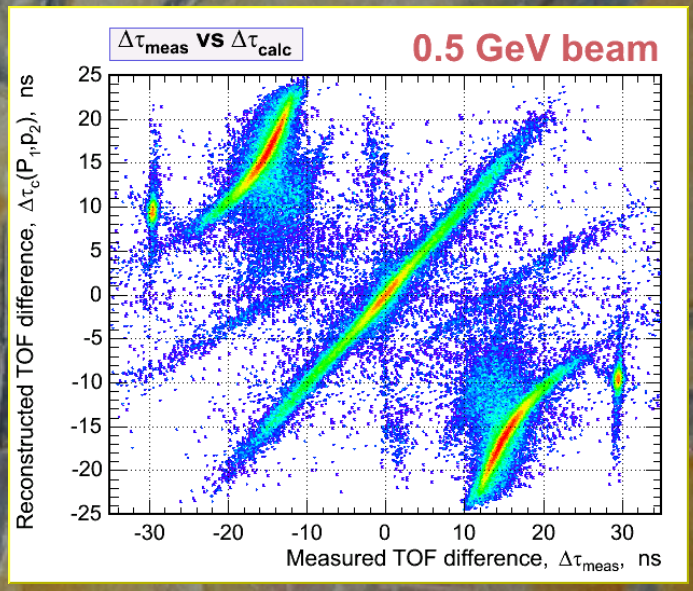
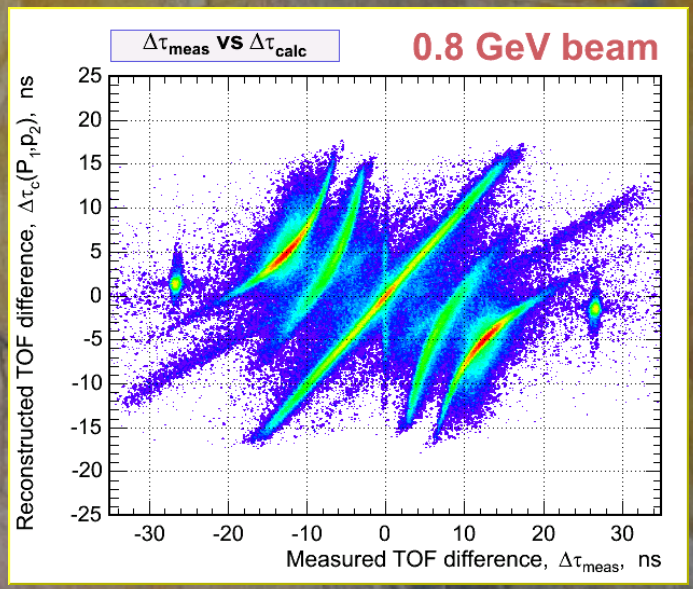
Two particle TOF differences (measured versus calculated)

For the calculation two-proton hypothesis was used.

(pp) – on the diagonal
(dπ⁺) (dp) (pπ⁺) (tπ+) identified

TOF measurement uncertainty (the diagonal profile RMS):
200 ps at 0.5 GeV
180 ps at 0.8 GeV





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Missing-mass spectra.

Proton-pair selection criteria

$E_{pp} < 3$ MeV

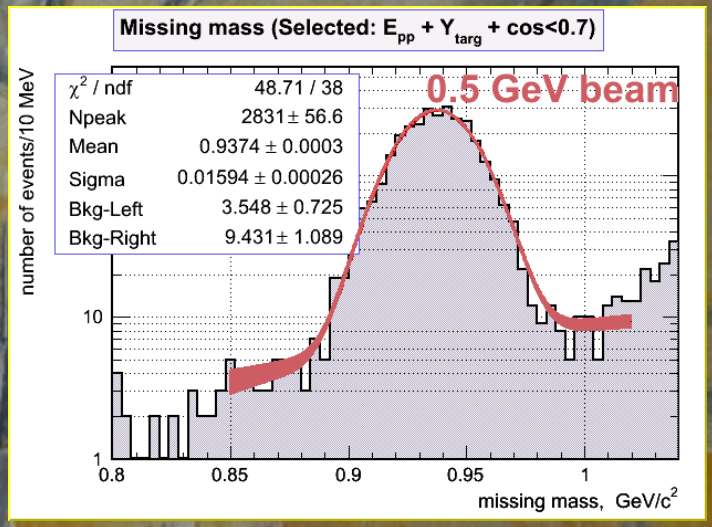
$\cos\varphi > 0.7$

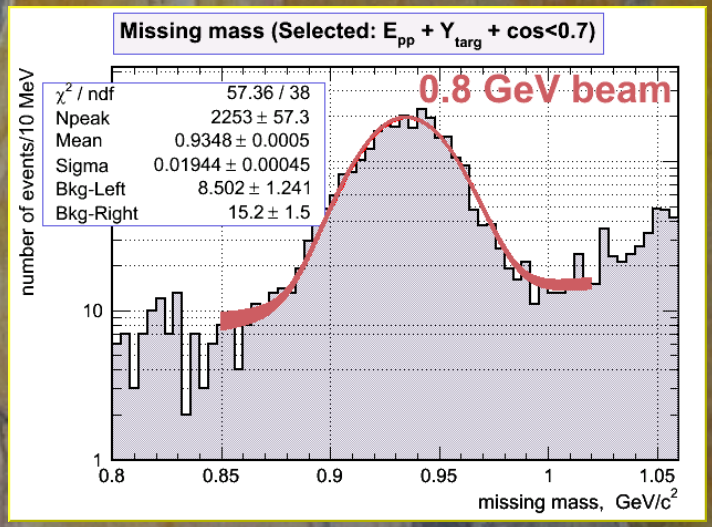
$|Y_{target}| < 2.2$ cm

Background in $\pm 3\sigma$ interval:

0.5 GeV 5 %

0.8 GeV 13 %





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Analysing power in deuteron breakup

A_y calculation and statistical uncertainties.

Left/right counts of the break-up events were accumulated in each θ bin:

$$L(\theta) \sim X_+ (1 + A_y(\theta) P_+ \langle\cos\varphi\rangle)$$
$$R(\theta) \sim X_- (1 - A_y(\theta) P_- \langle\cos\varphi\rangle)$$

Measured asymmetry:

$$\varepsilon(\theta) = (L(\theta) - f R(\theta)) / (L(\theta) + f R(\theta)) ;$$

Where f is the relative luminosity correction factor $f = X_+/X_- ;$

Statistical uncertainty:

$$\delta\varepsilon = (L + fR)^{-1} [(1 - \varepsilon^2)L + (1 + \varepsilon^2)(f^2R + \delta_f^2R^2)]^{1/2}$$

Finally, the analysing power is defined as:

$$A_y(\theta) = \varepsilon(\theta) / P \langle\cos\varphi\rangle_\theta ; \quad P = 0.5 (P_+ + P_-)$$

Analysing power in deuteron breakup

Systematic uncertainties

Difference of the beam polarization

$$P = 0.5\,(P_+ + P_-)$$

$$\Delta P = 0.5\,(P_+ - P_-)$$

leads to the change of analysing power:

$$A_y \rightarrow A'_y = A_y\,(1 + \Delta P \cdot A_y)^{-1}$$

Relative luminosity correction factor $f = L_+/L_-$

if $f \rightarrow f' = f\,(1 + \xi)$

$$A_y \rightarrow A'_y < A_y - \xi/2P$$

Systematic uncertainties are negligible in comparison with statistical ones **(≤ 0.02)**

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Realtive luminosity monitoring

For relative luminosity monitoring the polarization independent count rates used:

Single protons counted at polar angles close to zero $\theta_{cm} < 1^{o}$

Single protons counted at azimuthal angles

$85^{o} < \varphi < 95^{o}$ or $265^{o} < \varphi < 275^{o}$

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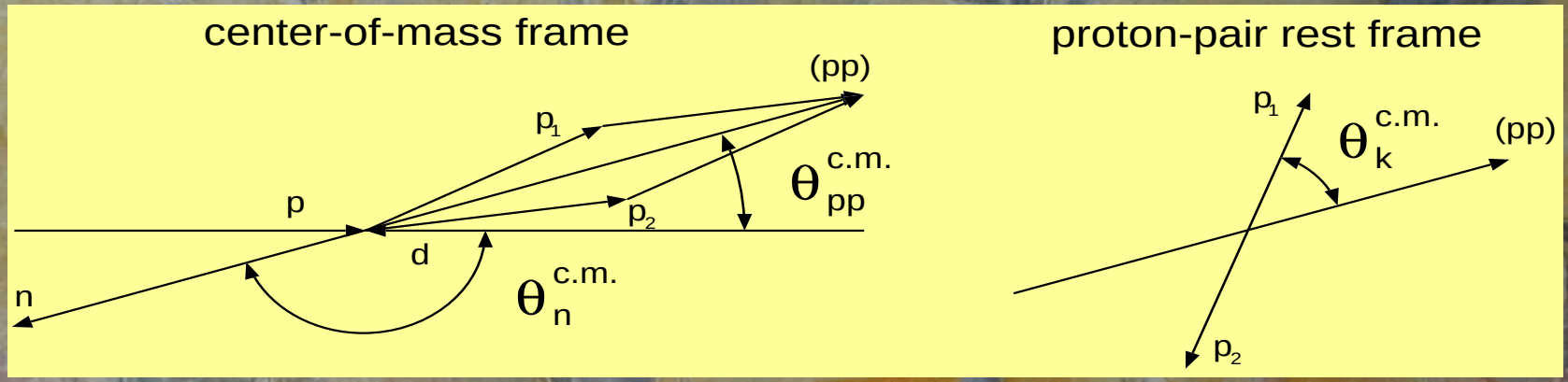
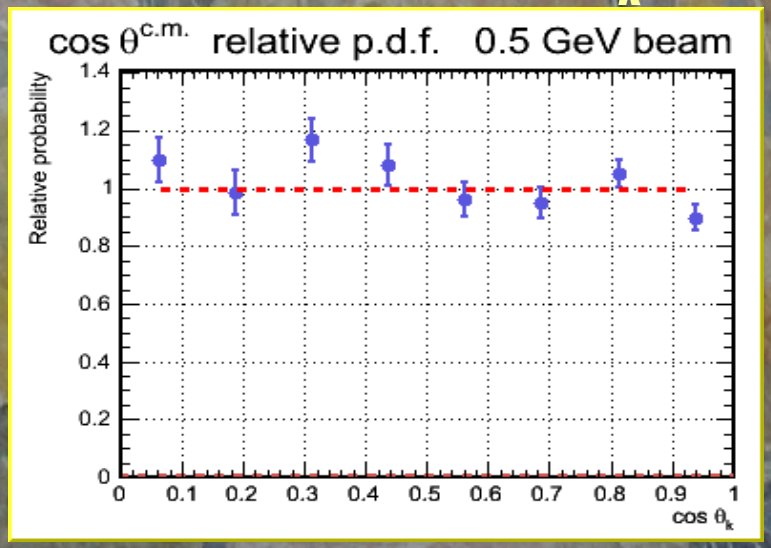
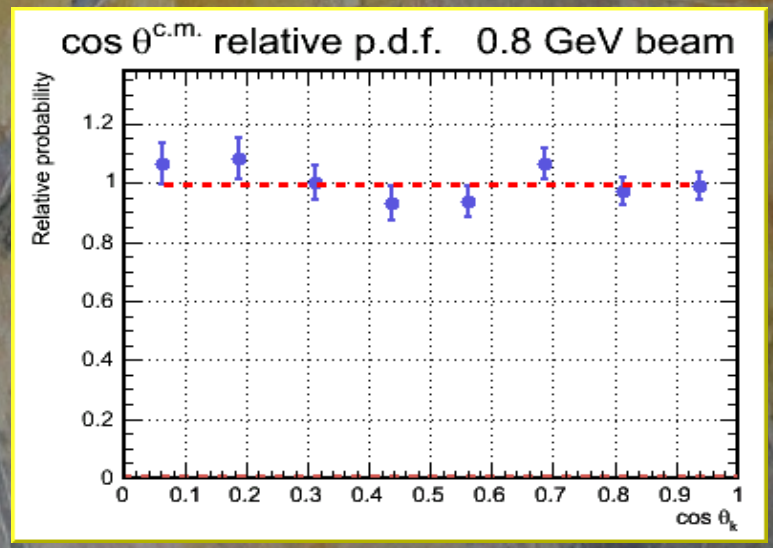
S – wave dominance



Selected event $\cos\theta_k^{cm}$ distributions.





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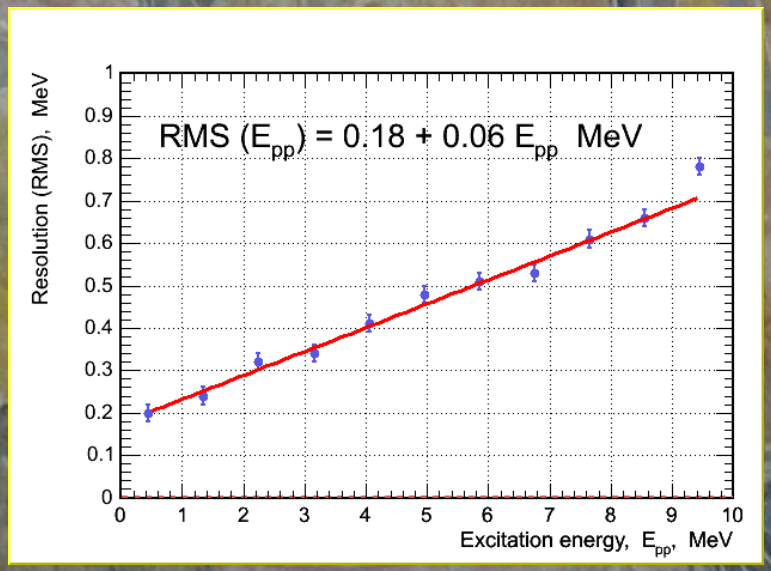
Analysing power in deuteron breakup

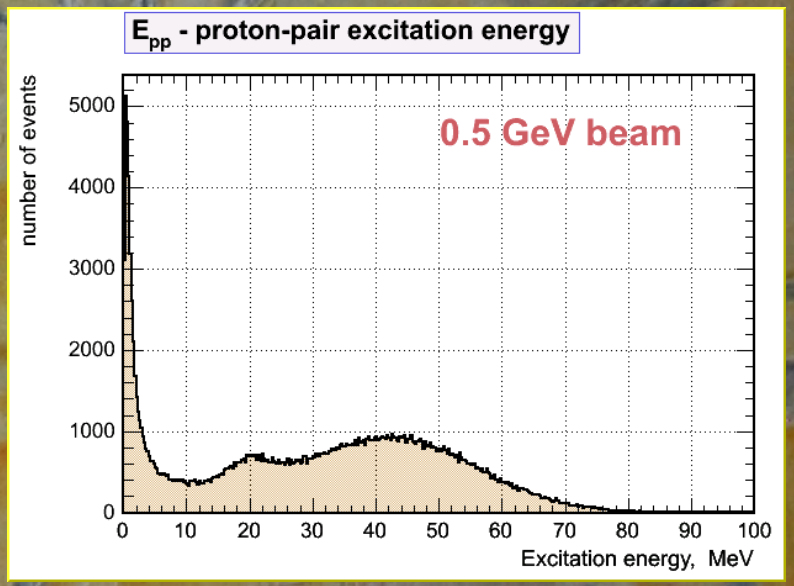
S – wave dominance

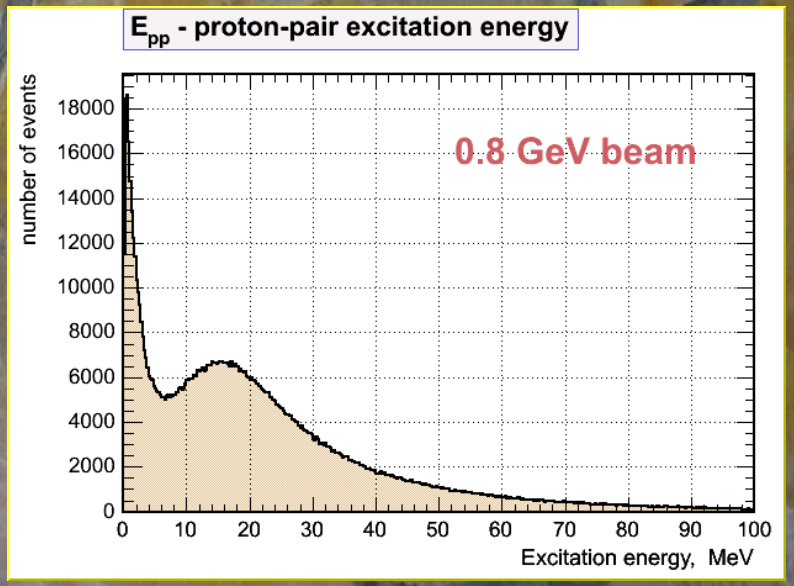
Excitation energy spectra

Events accepted if
E_{pp} < 3 MeV and
$\cos\varphi$ > 0.7

E_{pp} uncertainty (RMS)







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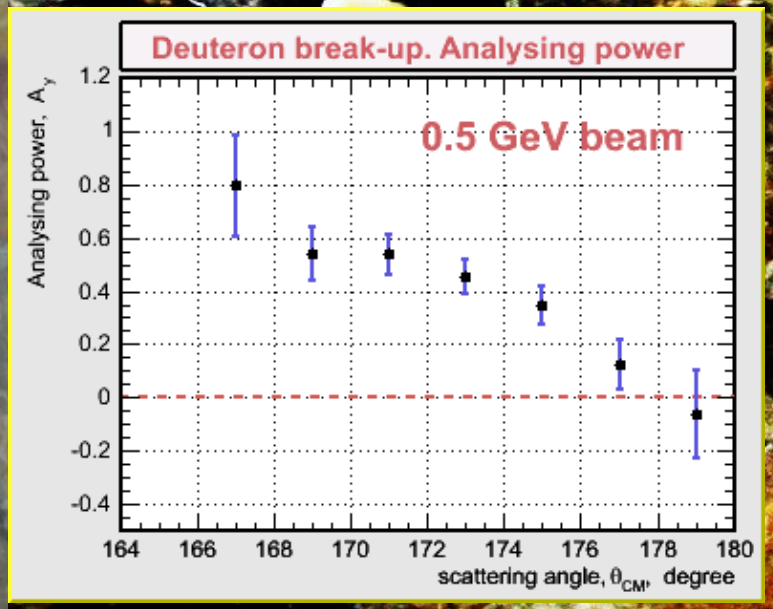
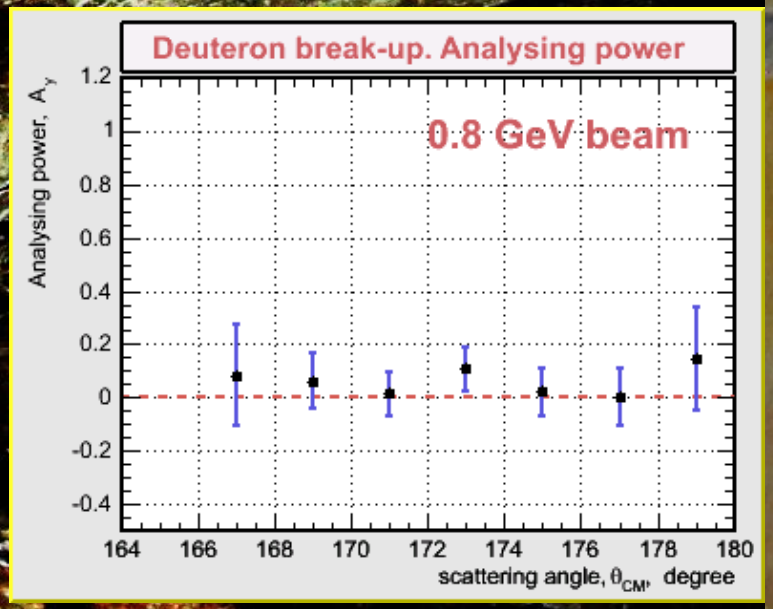
Angular dependence of the analysing power A_y as a function of back-scattered neutron c.m. angle

About 2800 and 2200 break-up events were collected at 0.5 and 0.8 GeV respectively.





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Summary

The analysing power in the deuteron break-up was measured at two beam energies of 0.5 and 0.8 GeV, at proton-pair sacttering angles $0^o < \theta_{cm} < 14^o$.

The model accounting ONE, SS, and Δ excitation describes well the unpolarized break-up cross section [V.Komarov et al., Phys.Lett. B 553, 179 (2003)].

The model fails to reproduce large A_y at 0.5 GeV.

New approach is required.

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