Double Polarized pn-Experiments

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1. Polarized Neutron Target
2. Spectator Proton Detector
3. pn scattering at ANKE
4. Summary
5. Outlook

Polarized Neutron Target

$$p + d \rightarrow p_{Spectator} + p + n$$

$$p + d - p_{Spectator} \rightarrow p + n$$

Spectator Model: $\vec{N} = -\vec{p}_{Spectator}$

$N = d - p_{Spectator}$ *is a quasi free off shell neutron*

$$\vec{p} + \vec{N} \rightarrow p + n$$

What is the mass of this ‚neutron'?

What is its spin? $\vec{d} \parallel \vec{p}_{Spectator}$???

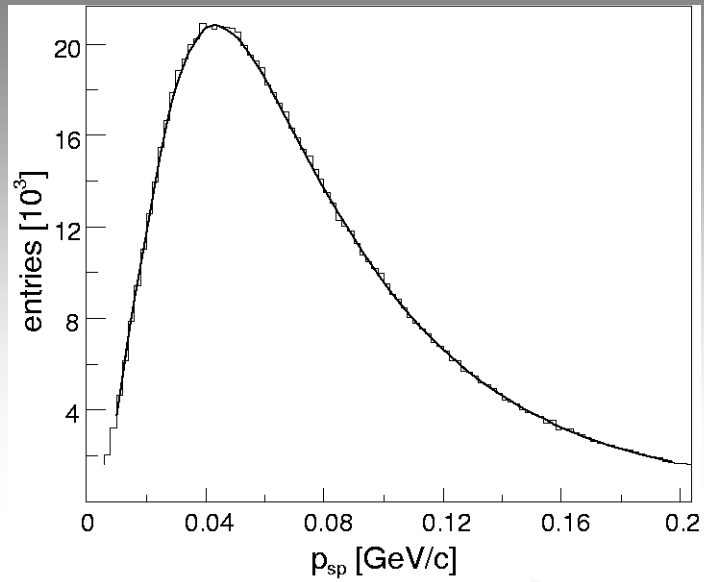
Energy/momentum conservation influences the kinematics of p+N → p+n

$$m_N = m_N^0 \sqrt{1-\frac{2\cdot m_d}{(m_N^0)^2}T_{Sp}} \approx m_N^0 \sqrt{1-4.3\cdot 10^{-3}\frac{T_{Sp}}{MeV}}$$

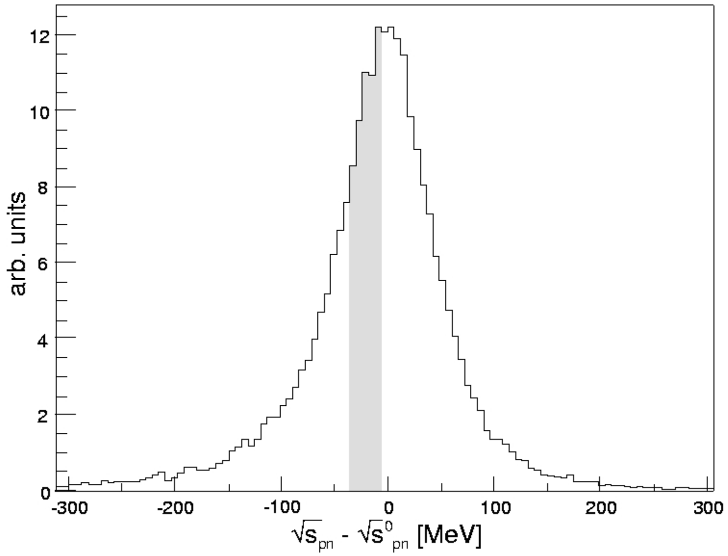
$$m_N^0 = m_d - m_p \approx 937 MeV$$

$$m_N(T_{Sp} = 10 MeV) \approx 917 MeV$$

Fermi Momentum:



At fixed beam-energy,the spectator energy and direction scans the c.m. energy:



$$s = (p_{beam} + d - p_{Sp})^2$$

$$= s(T_{Sp} = 0) + 2\cdot(\vec{p}_{beam}\vec{p}_{Sp} - E_{beam}T_{Sp})$$

First step:
Have a spectator proton detector and learn how to interpret deuterium as a polarized neutron-target.

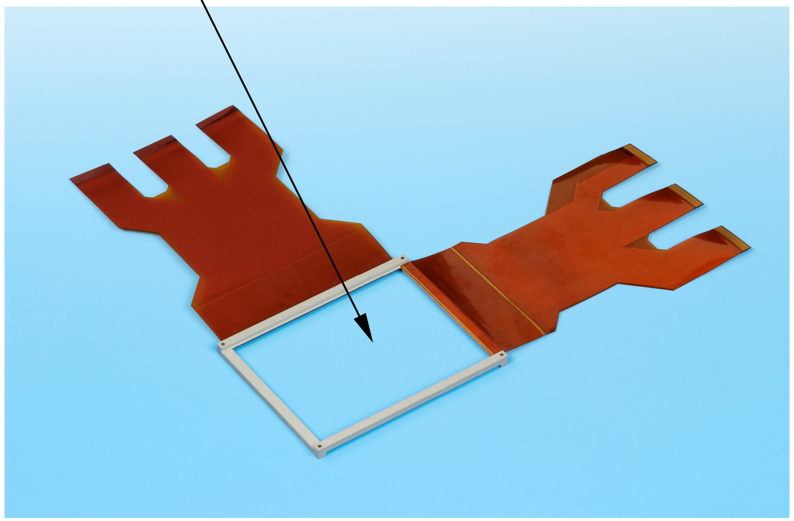
Spectator Proton Detector

Range telescopes with 3 layers of x,y silicon detectors:
ΔE/E identification plus tracking.

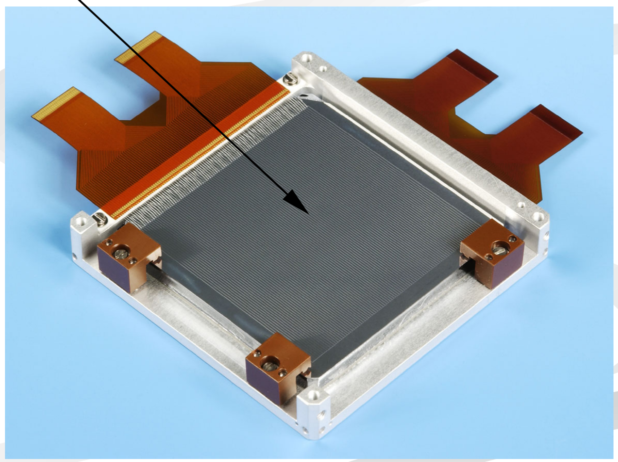
detectors:

$$69\mu m,\ \Delta E < 2.5MeV,\ 66\cdot 52mm^2,\ \sim 0.4mm\ pitch$$
$$300\mu m,\ \Delta E < 6.2MeV,\ 66\cdot 52mm^2,\ \sim 0.4mm\ pitch$$
$$500\mu m,\ \Delta E < 6.2MeV,\ 66\cdot 52mm^2,\ \sim 0.4mm\ pitch$$
$$5500\mu m,\ \Delta E < 40MeV,\ 64\cdot 64mm^2,\ \sim 0.7mm\ pitch$$

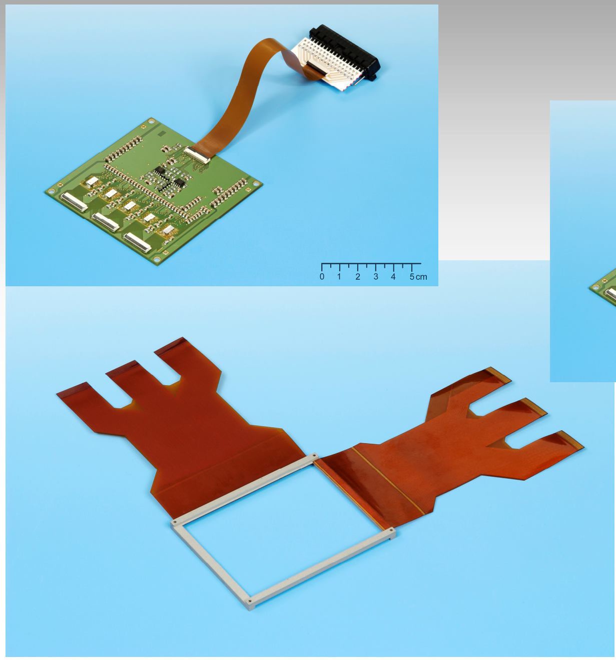
69/300/500 µm Si-detector

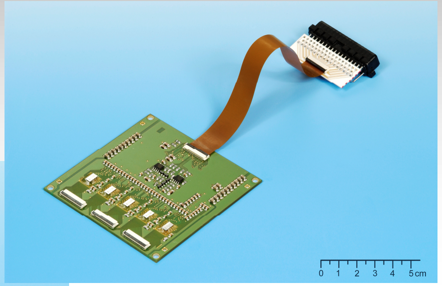


5100µm thick Si(Li) detector

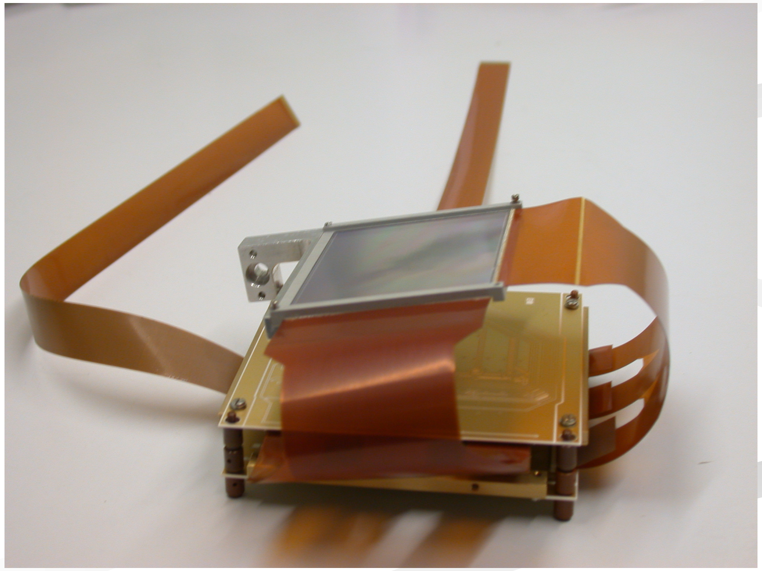


UHV-Vacuum Assembly



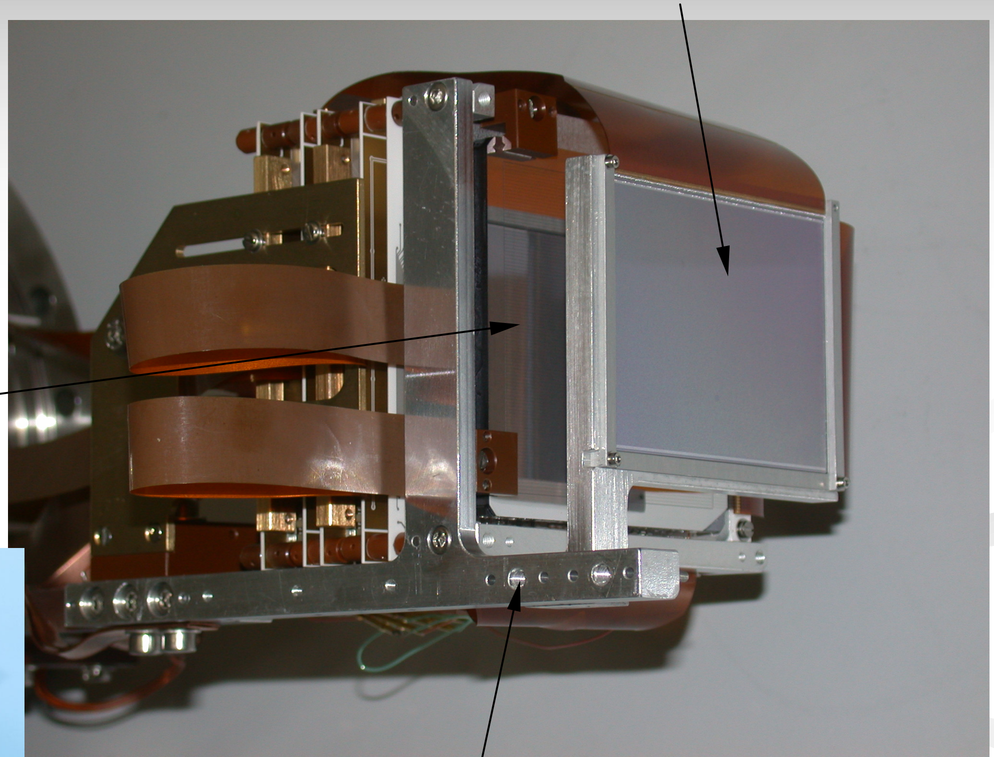


- 160 channels preamplifiers
- Dynamic range: 1-100 MIPs
- self-triggering
- 5(10) MHz read-out

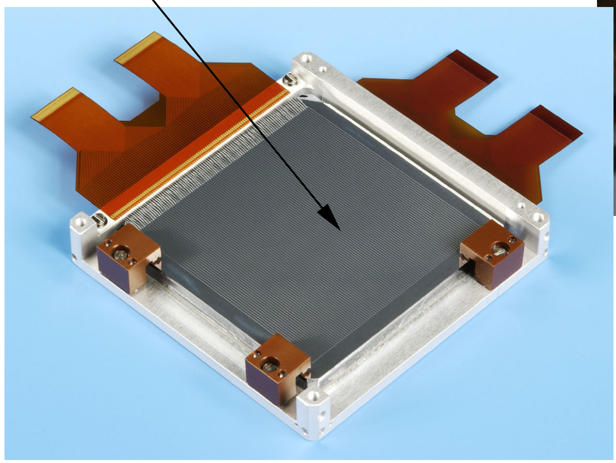


Silicon Tracking Telescope

69 µm Si Detektor

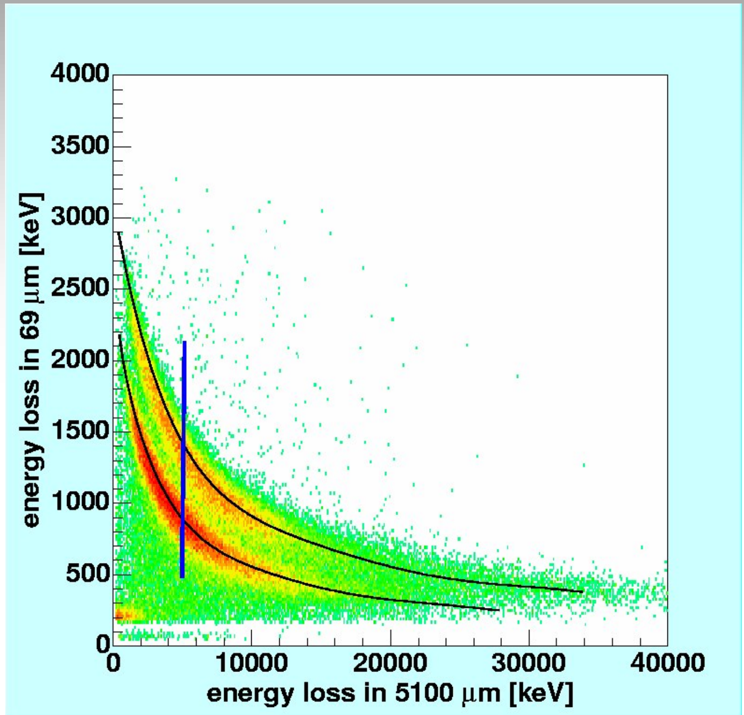


5100µm thick Si(Li) detector

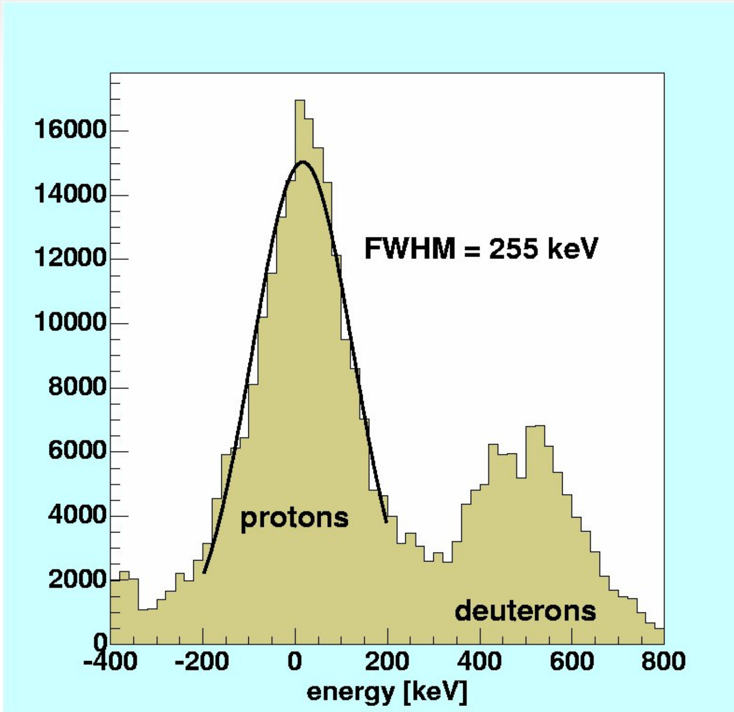


300 µm Si detector (is missing here)

$\Delta E/E$ p, d-Identification

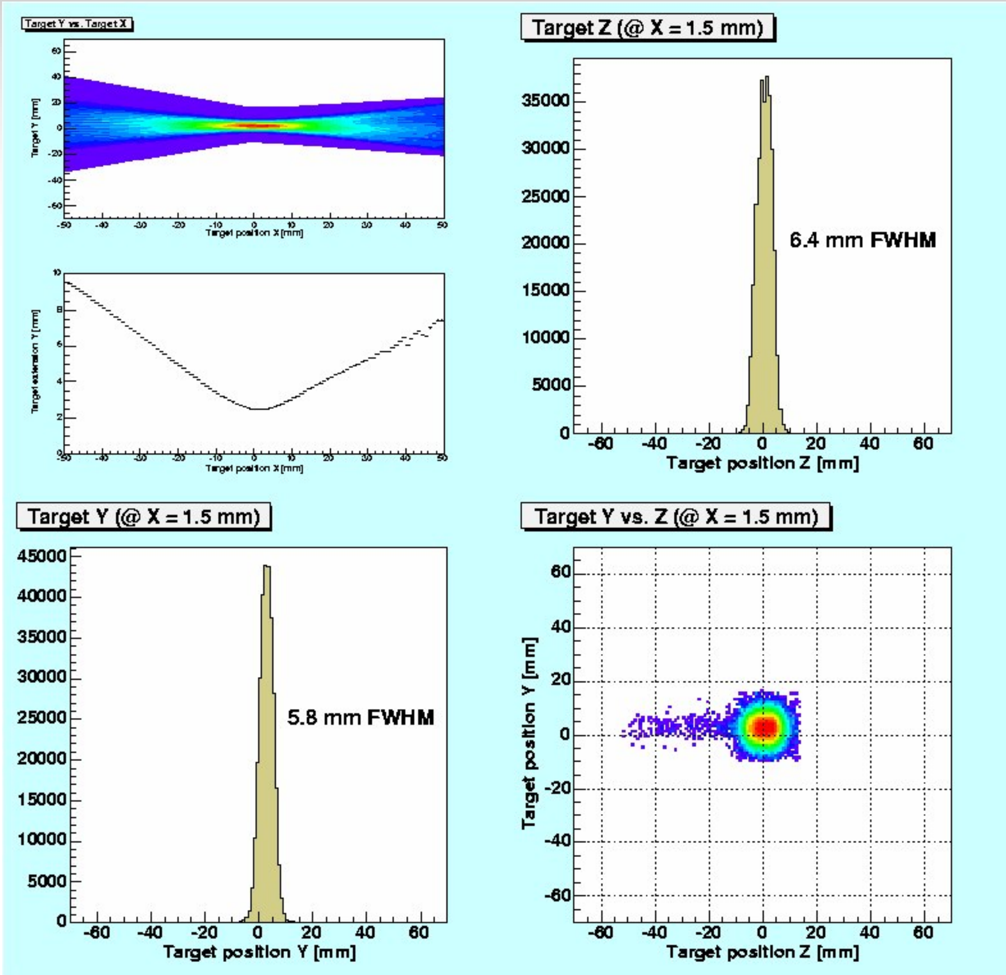


Proton identification: 2.5-35 MeV



Particle Tracking

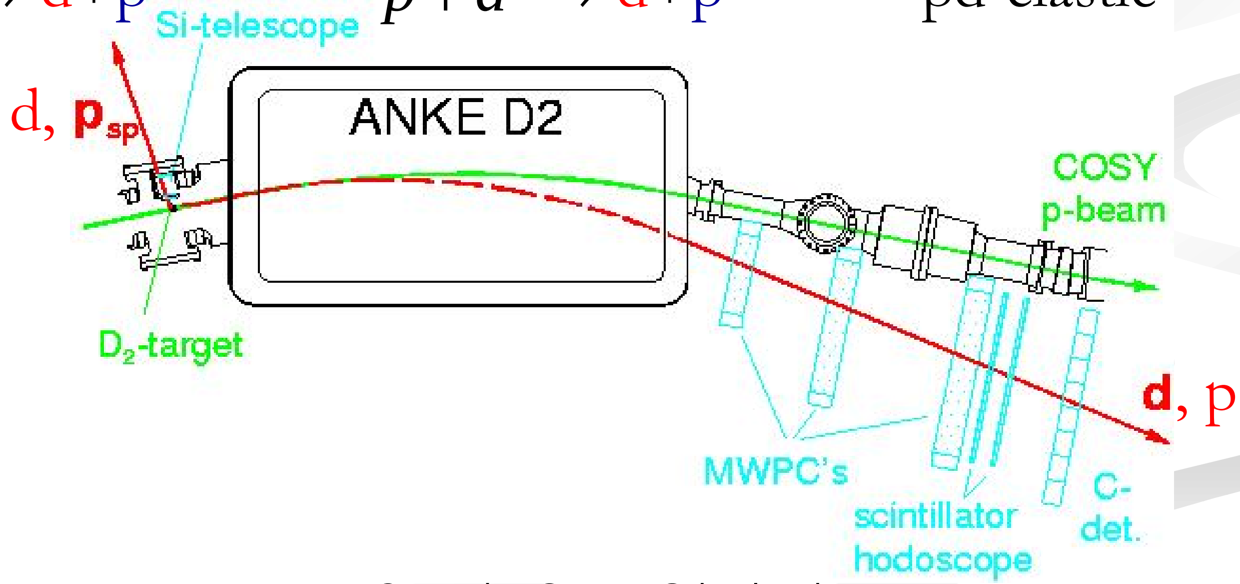
Overlap of the COSY beam with the ANKE deuteron cluster target



PIT & Spectator & ANKE

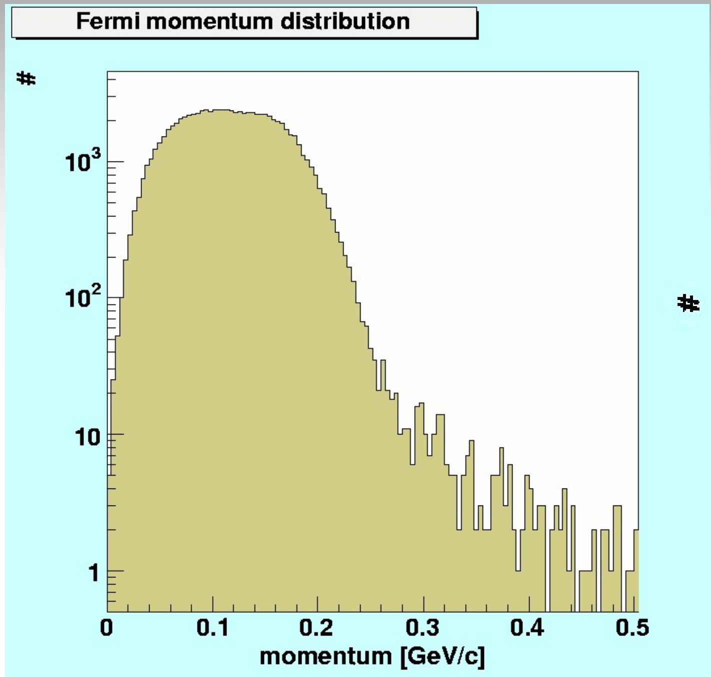
The polarized internal target at ANKE plus
near target proton, deuteron identification ***and*** tracking.

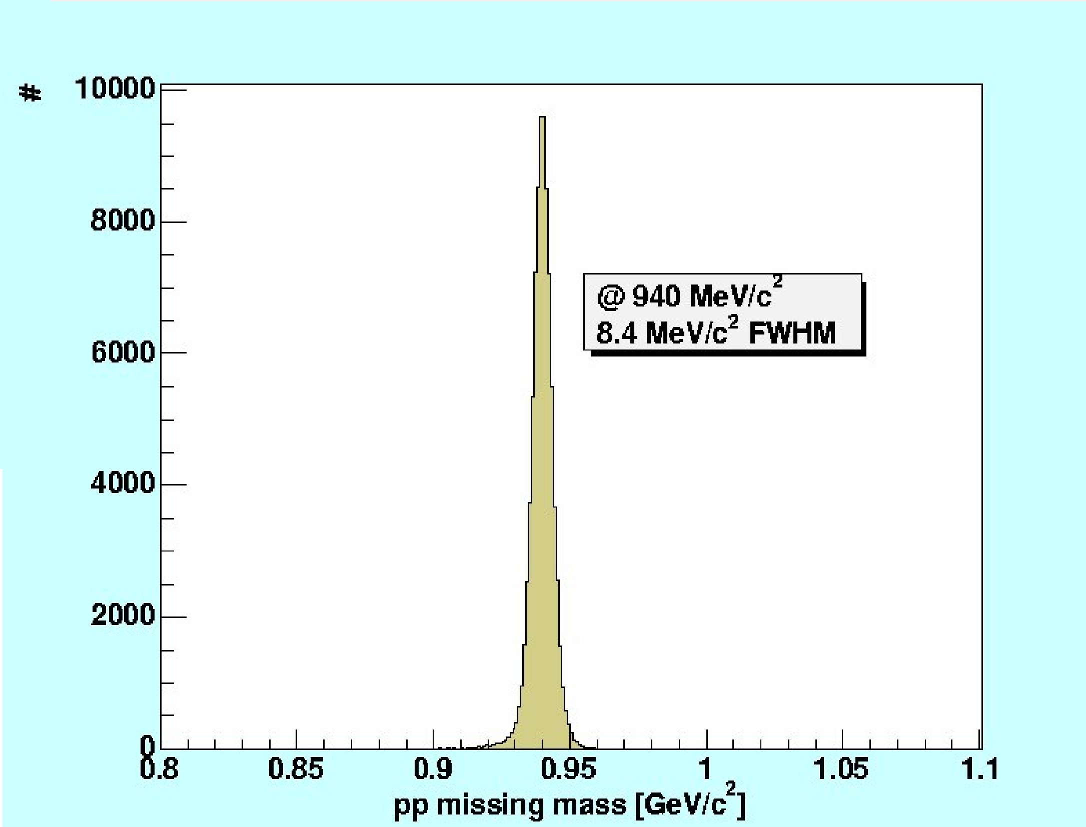
$\vec{p}+\vec{d} \rightarrow p_{Sp}+p+n$	$\vec{p}+\vec{N} \rightarrow p+n$	pN-quasi elastic
$\vec{p}+\vec{d} \rightarrow p+p+n_{Sp}$	$\vec{p}+\vec{P} \rightarrow p+p$	pP-quasi elastic
$\vec{p}+\vec{d} \rightarrow p+d$	$\vec{p}+\vec{d} \rightarrow p+d$	pd-elastic
$\vec{p}+\vec{d} \rightarrow d+p$	$\vec{p}+\vec{d} \rightarrow d+p$	pd-elastic



$$\vec{p} + d \longrightarrow p + p + n$$

Spectator ANKE





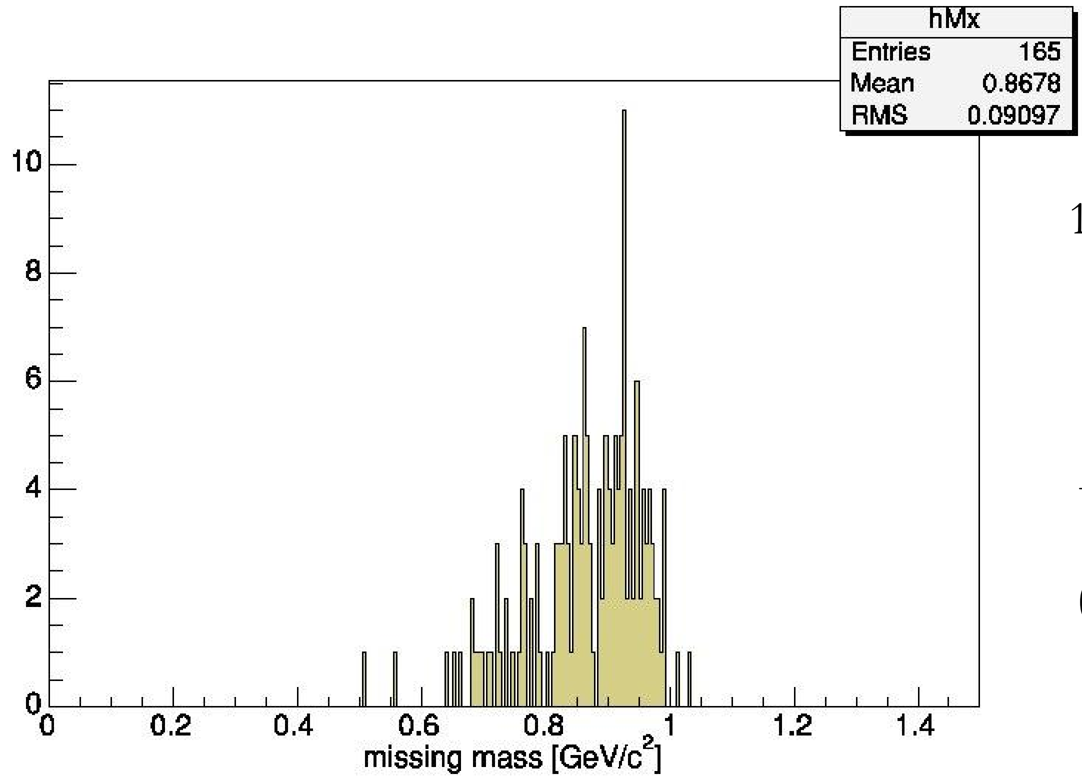
⇒ analysis by Andreas Mussgiller, study pp-quasi free kinematics...

$p + d \rightarrow p + p + n$

Spectator ANKE

Both protons in a single Teleskop placed at 90°:

Study **deuteron break-up** with 2 low energy protons (← Colin Wilkin)



165 from 220000 Events,

⇒ analysis by Andreas Mussgiller

$$\frac{165}{220000} = 7.5 \cdot 10^{-4}$$

$$(4 \ \textit{telescopes} \approx 10^{-2})$$

pn scattering at ANKE

What ANKE can contribute:

1. Spectrometer & Polarized d-Target & Spectator Detector
2. Provide data for $\vec{p} + \vec{d} \rightarrow p_{Spectator} + p + n$ up to 2.65GeV beam energy and 30° c.m. angles.
3. A_y and A_{yy}

*What ANKE can **not** contribute at least not without major effort:*

1. A complete characterisation of NN scattering.
2. Detect the neutron or measure the polarisation of the outgoing particles.
3. A_{xx}, A_{xz}
   (needs an additional coil system around the target).
4. A_{zz} which needs longitudinal beam polarization
   (Sibirian Snake)

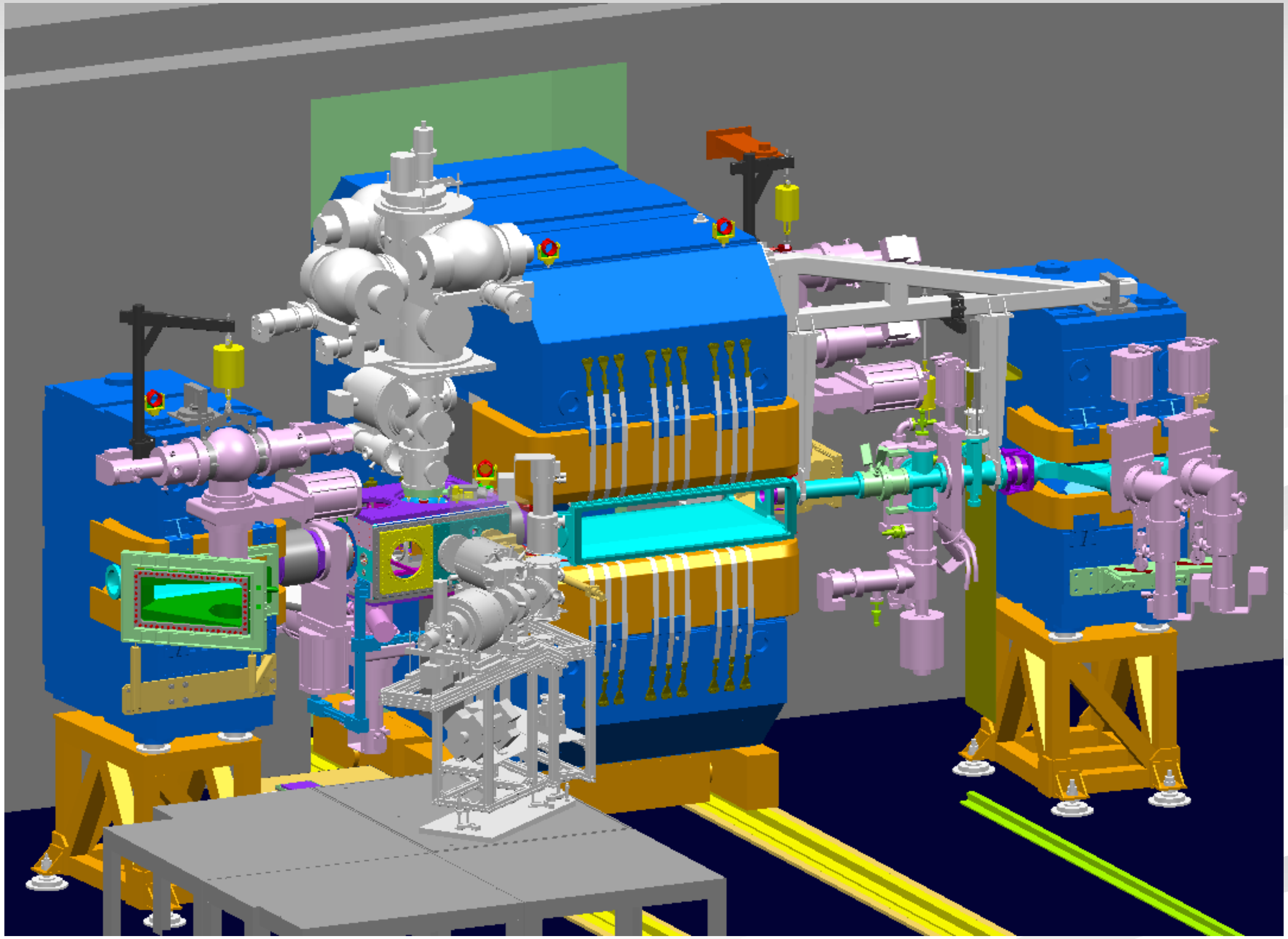
Summary…

1. Deuterium is a tricky neutron target.
2. Use pP and pN-quasi elastic and pd-elastic in comparison to study kinematics and polarization.
3. pd→ppn with 2 low energy 'spectator' protons 'survives a storage cell' by vertex reconstruction, good test!
4. Very limited characterisation of NN scattering at ANKE.
5. A_y and A_{yy} in $\vec{p}\vec{d} \rightarrow p_{Spectator}\, pn$ possible may be even without a storage cell ($L \sim 10^{28} cm^{-2} s^{-1}$).

…and outlook?

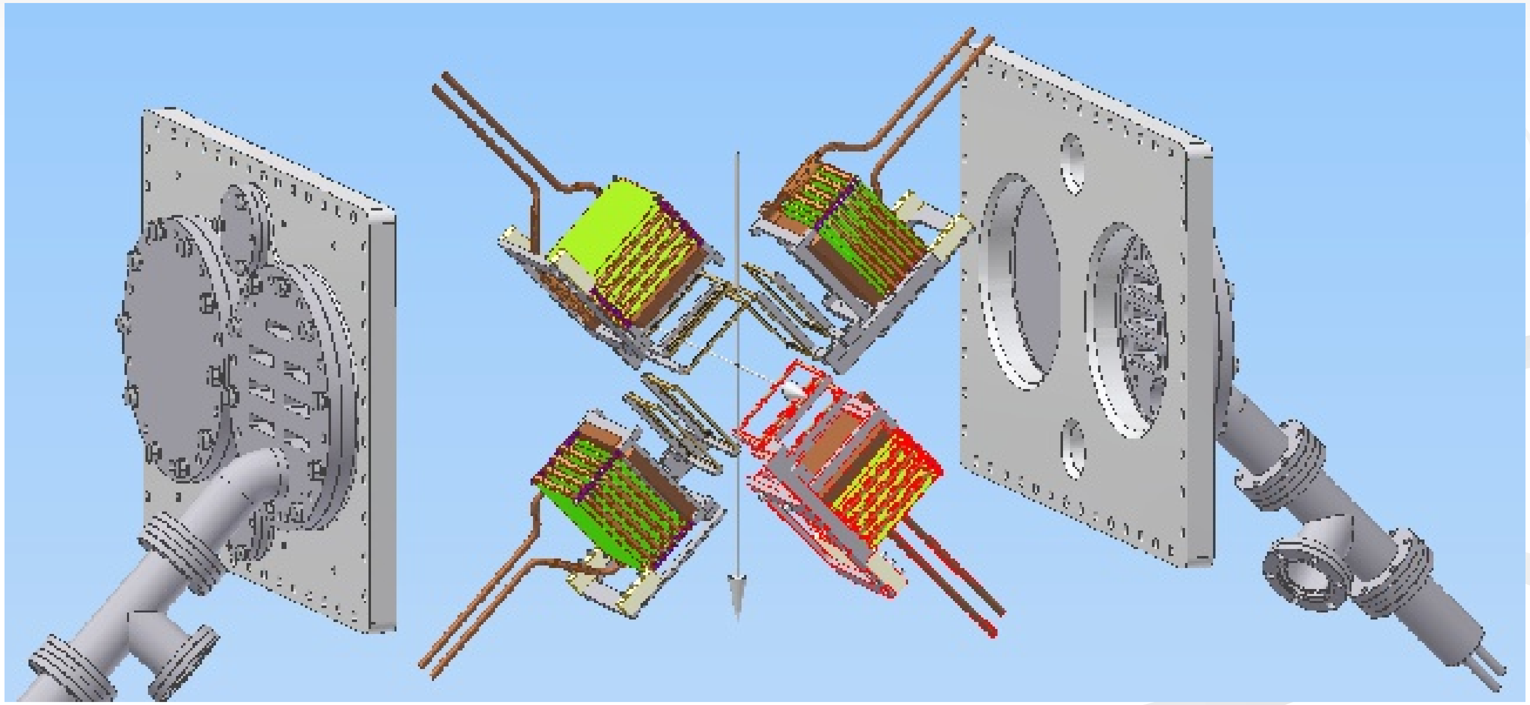
Outlook

Polarized Target Installation Spring 2005



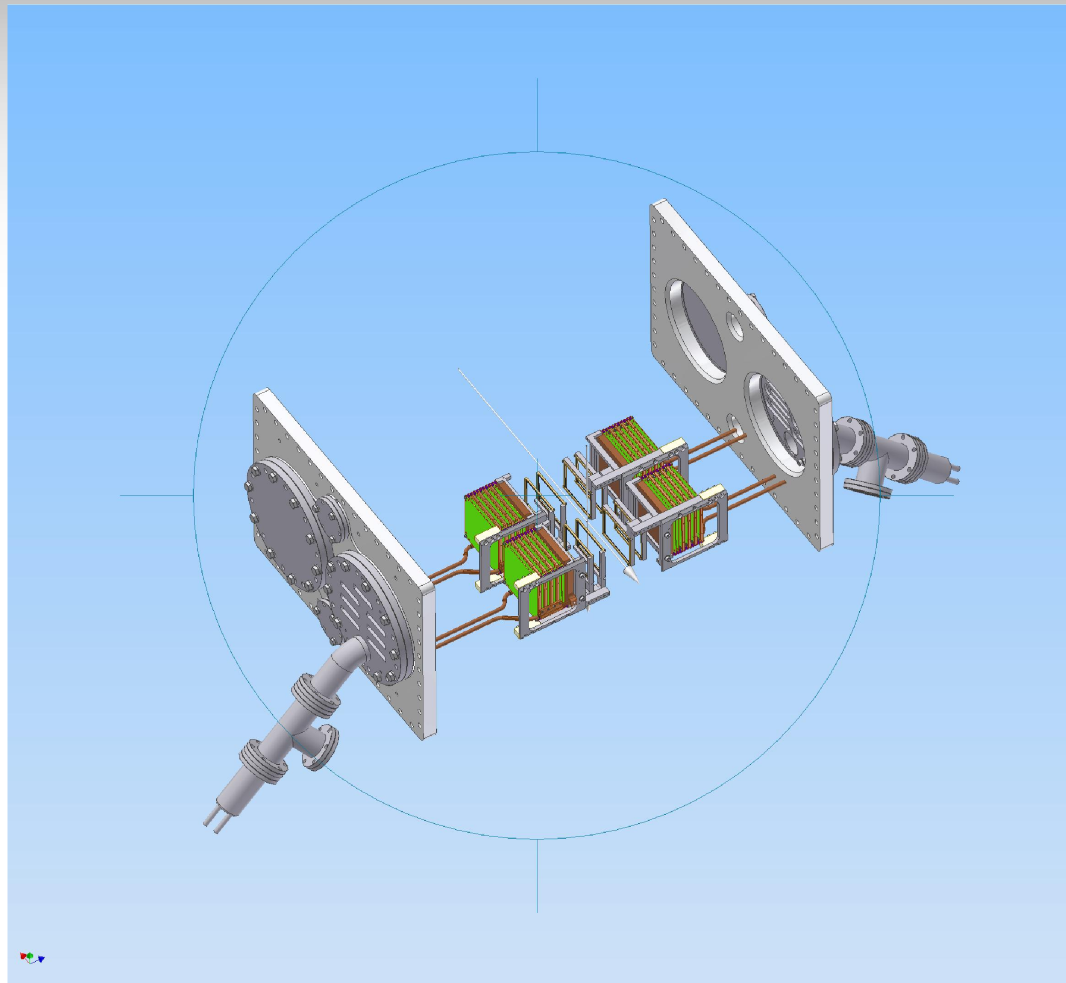
PIT & Spectator

$\sim 2\pi$ coverage for the cluster target, $L \sim 10^{31}$ $cm^{-2}s^{-1}$ feasable, 'pp, pn-overlap region'



PIT & Spectator

Less acceptance, easier to install



PIT & Spectator

Study pp versus pn