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Overview of NN scattering studies at ANKE/COSY

August 6, 2012 | David Chiladze (HEPI, Tbilisi State University)

CGSWHP
Caucasian-German School and Workshop on Hadron Physics

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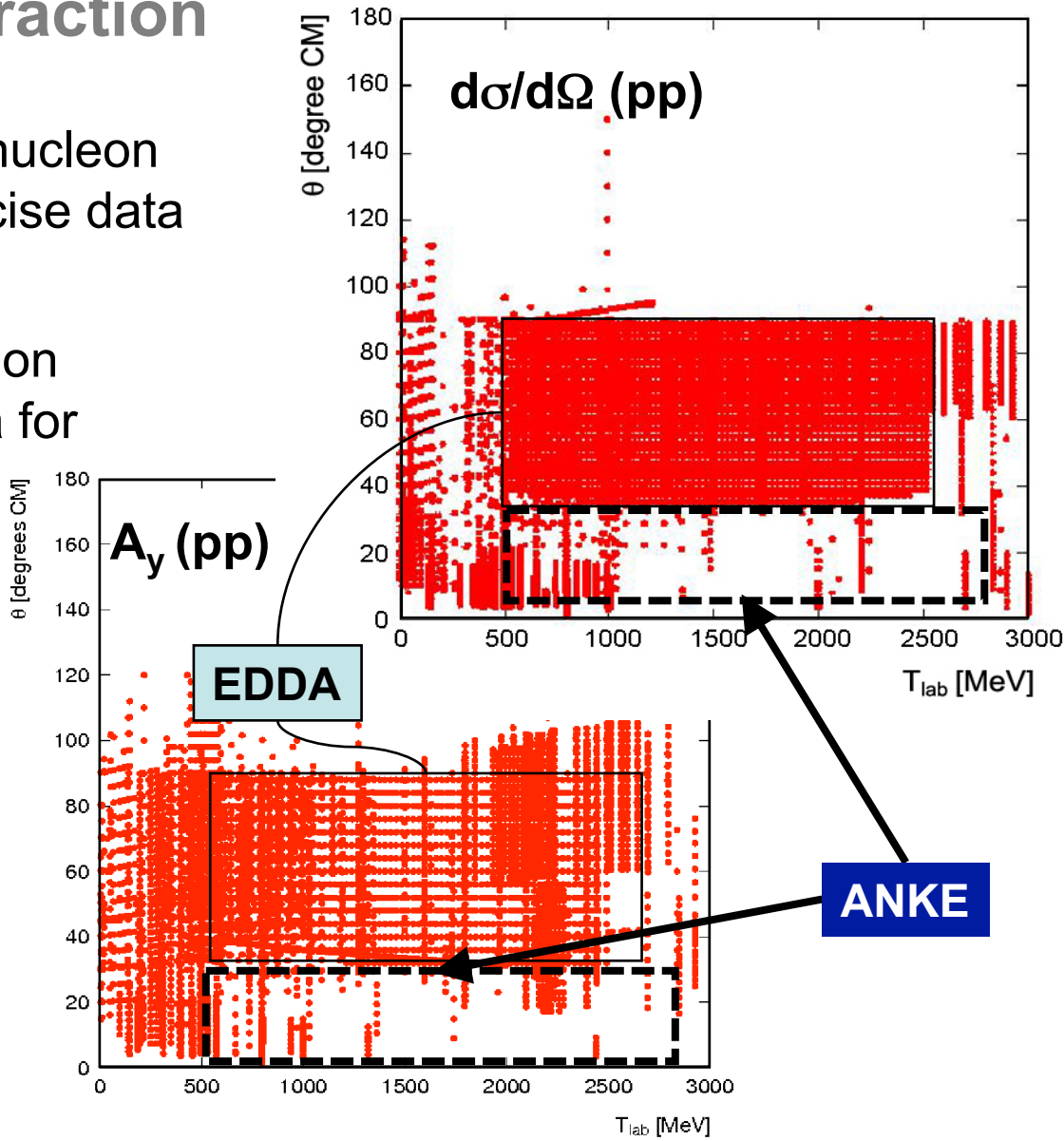
Outline

- Introduction
- Experimental tools
- Status of np and pp program
- Future steps
- Summary

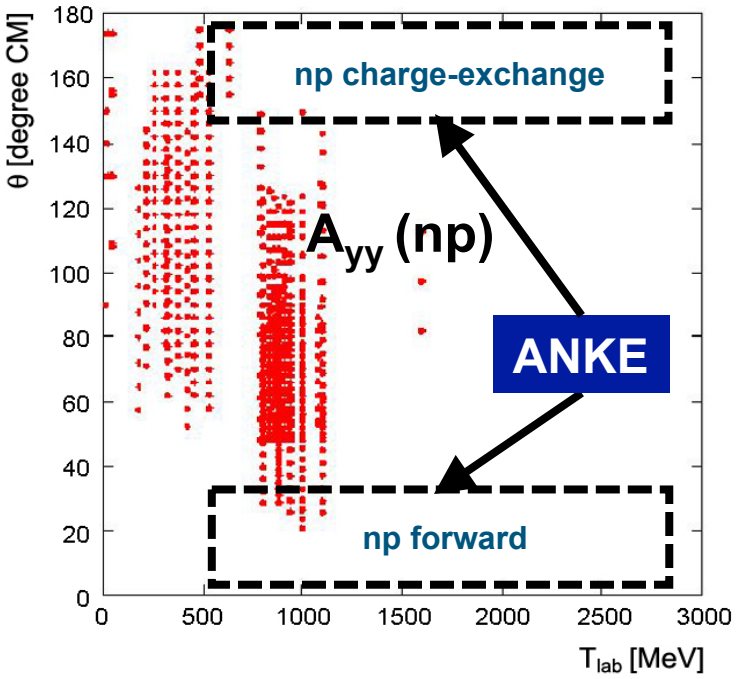
Introduction: NN interaction

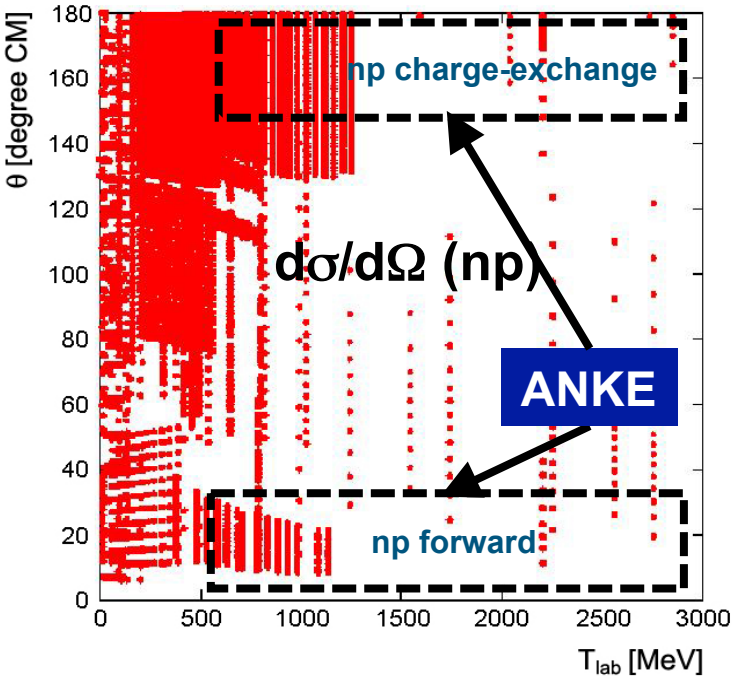
- Description of nucleon-nucleon interaction requires precise data for Phase Shift Analysis
- COSY-EDDA collaboration produced wealth of data for **pp elastic scattering**.
- There are no experimental data at low angles (θ_{cm}<30°) above 1.0 GeV energy.



Introduction: NN interaction

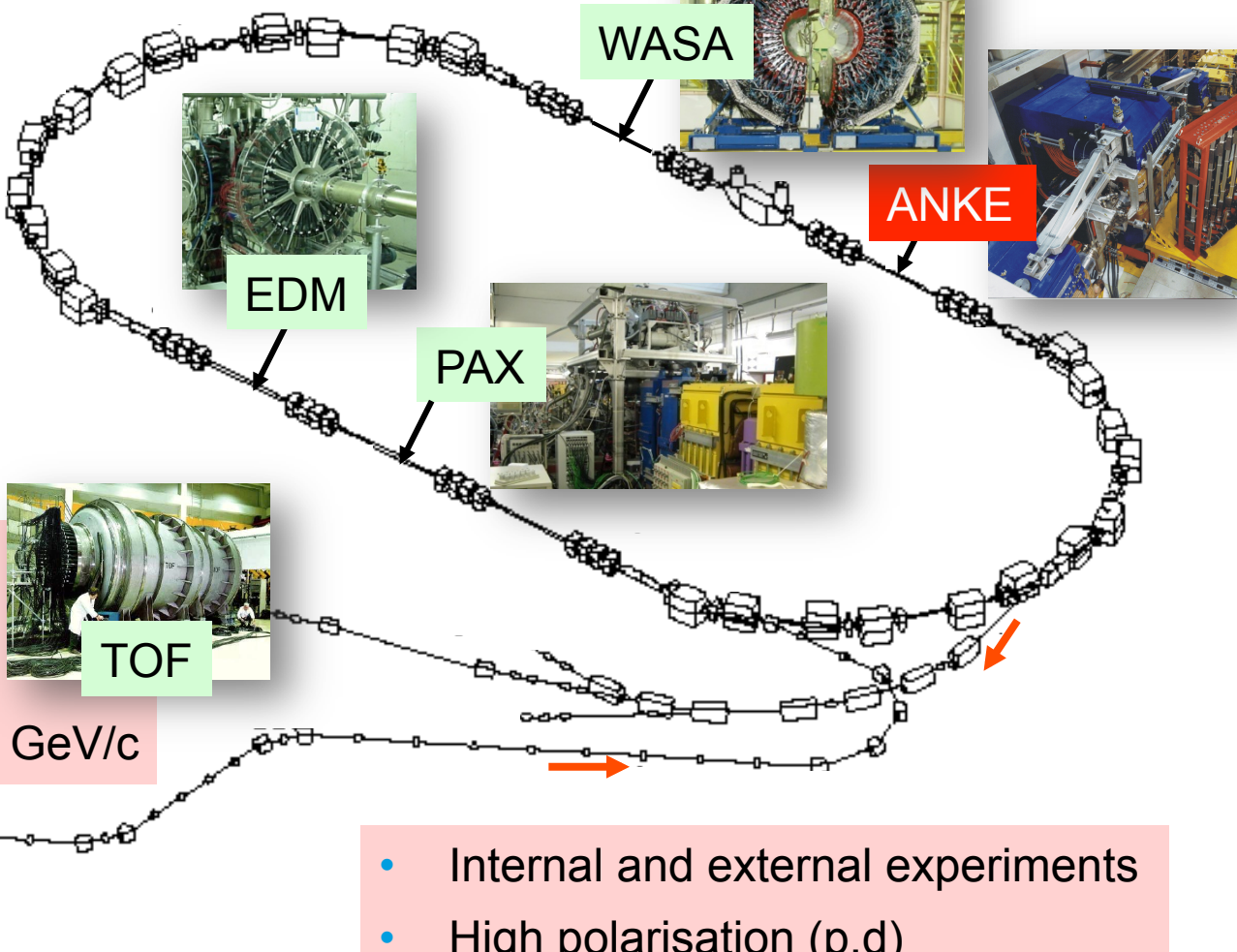
R. Arndt: *"Gross misconception within the community that np amplitudes are known up to a couple of GeV. **np data** above 800 MeV is a DESERT for experimentalists."*





ANKE is able to provide the experimental data both for **pp and np systems** and improve our understanding of NN interaction

Experimental tools: COSY



- Energy range:
  0.045 – 2.8 GeV (p)
  0.023 – 2.3 GeV (d)
- Max. momentum ~ 3.7 GeV/c

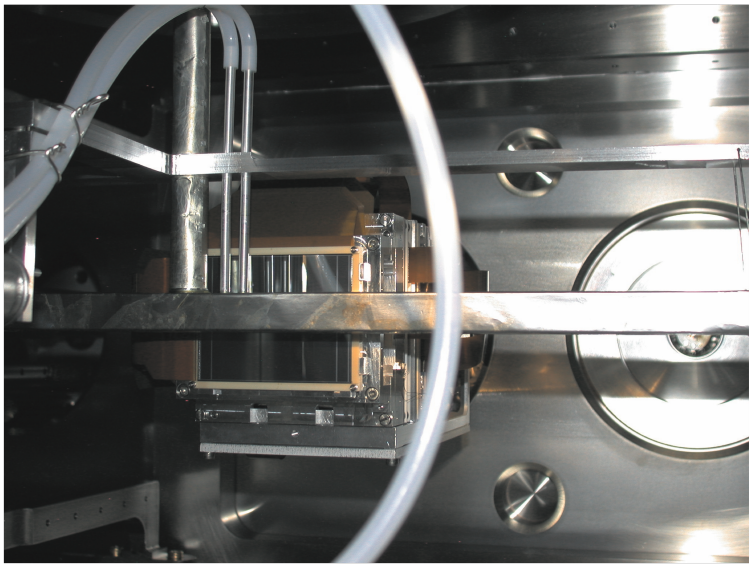
- Energy variation (ramping mode)
- Electron and Stochastic cooling

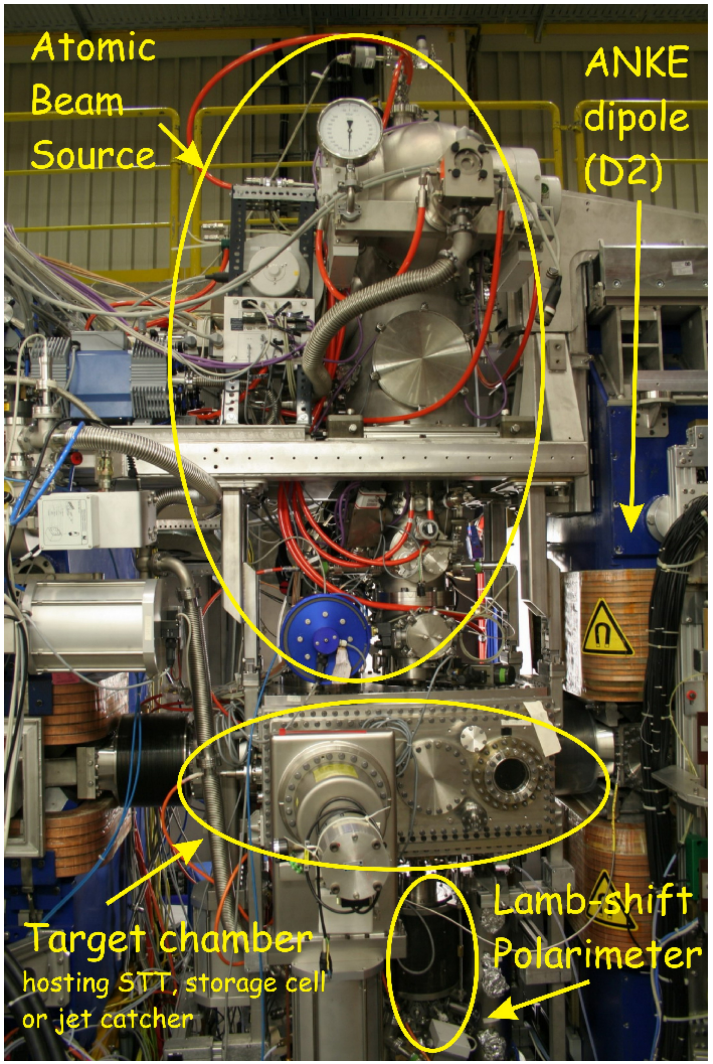
- Internal and external experiments
- High polarisation (p,d)
- Spin manipulation

Experimental tools: Polarised Internal Target

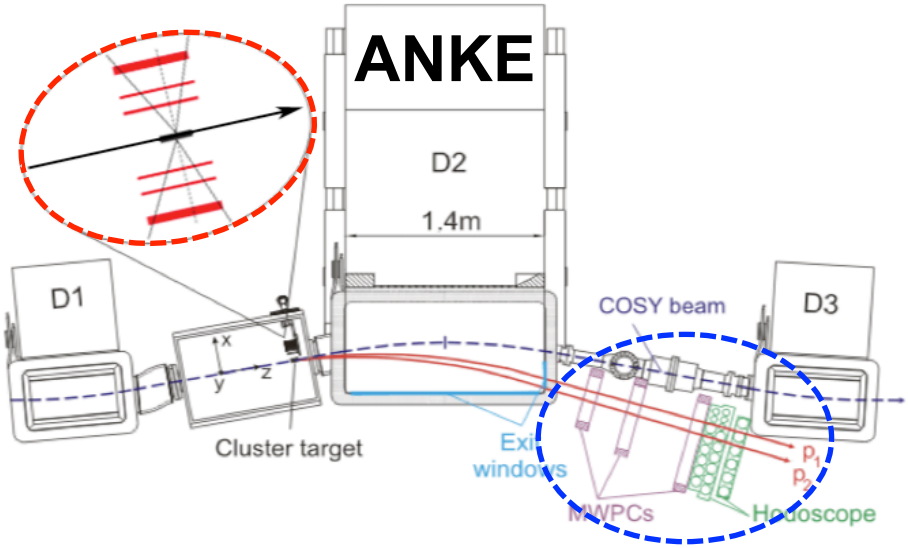
Atomic Beam Source (ABS) provides polarised

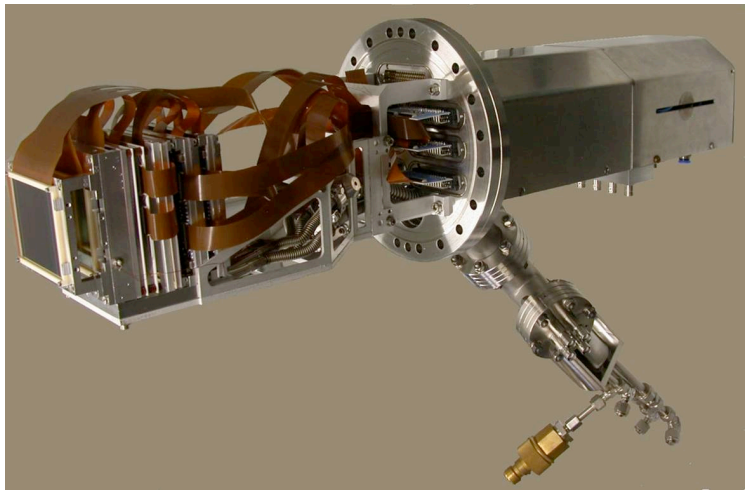
- H or D in the cell.
- Density ≤ 10^{13} cm^{-2}
- Fixed cell (20 x 15 x 390 mm^3)
- Openable cell (11 x 15 x 390 mm^3)
- Lamb-shift Polarimetry





Experimental tools: ANKE spectrometer



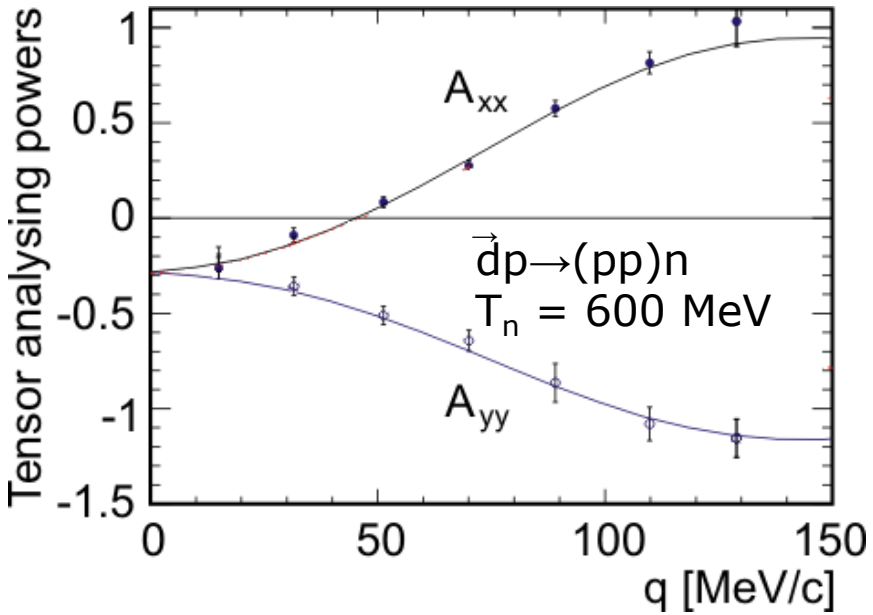


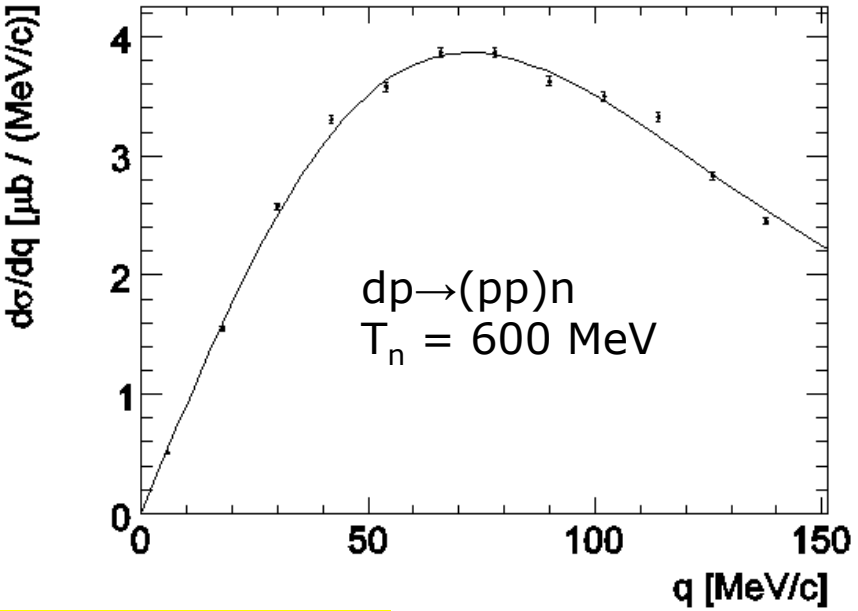
- **FD:** Three Multi-wire Chambers with three layers of Scintillation hodoscopes.
- **STT:** Three layers of double-sided silicon strip detectors.
- High precision luminosity determination via the Schottky technique.

Status of np program: Proof of principle

To check the feasibility of the program first experimental data was taken with deuterium beam at T_n = 600 MeV to compare with tested theoretical predictions.

$$\vec{d}p \rightarrow (pp)_{^1S_0} n$$





D. Chiladze et al., PRST-AB 9, 050101 (2006)

D. Chiladze et al., PLB 637, 170 (2006)

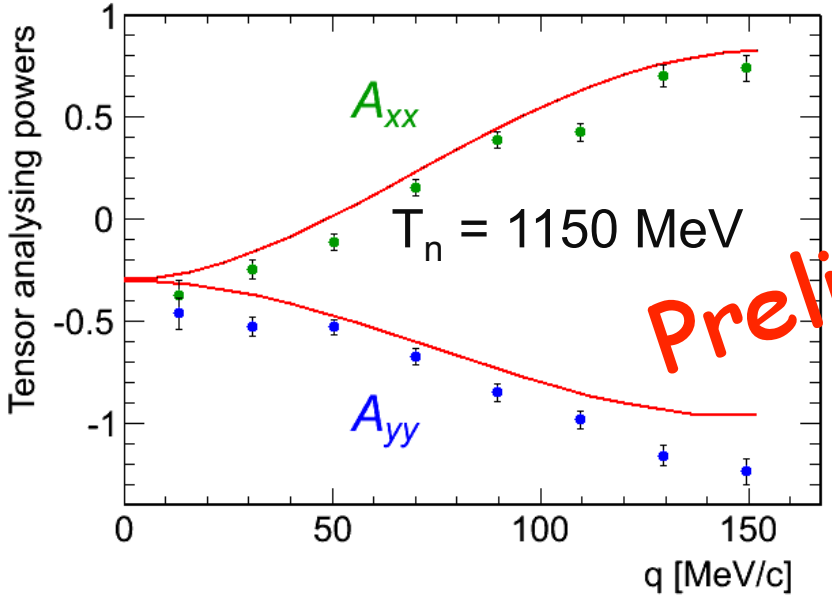
D. Chiladze et al., EPJ. A 40 (2009)

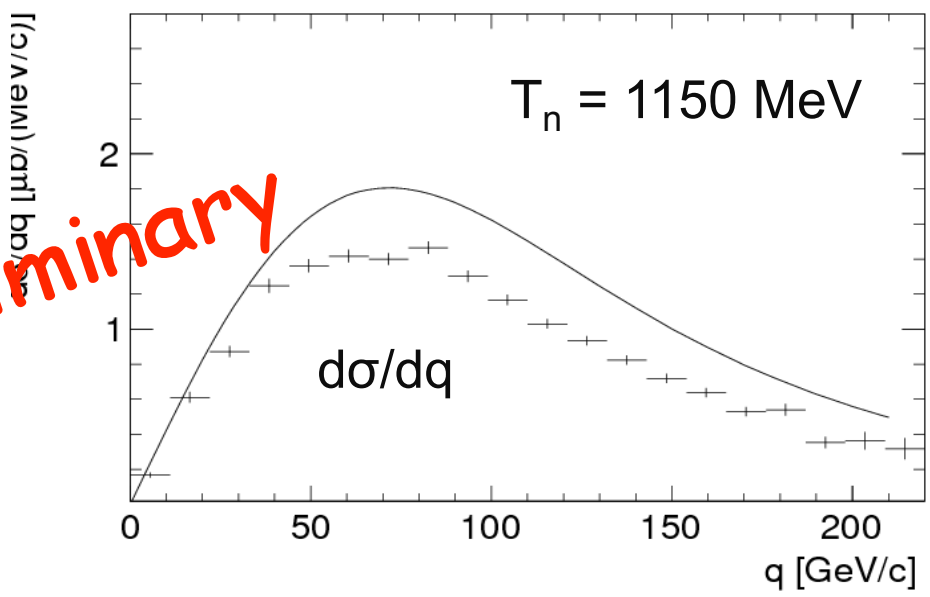
Status of np program: Single polarised experiments

$\vec{d}p \to (pp)_{^1S_0} n$

Analysing power and Cross section measurements at 800, 900 and 1150 MeV

Results differ from theory at $\mathbf{T_n = 1150\ MeV}$.





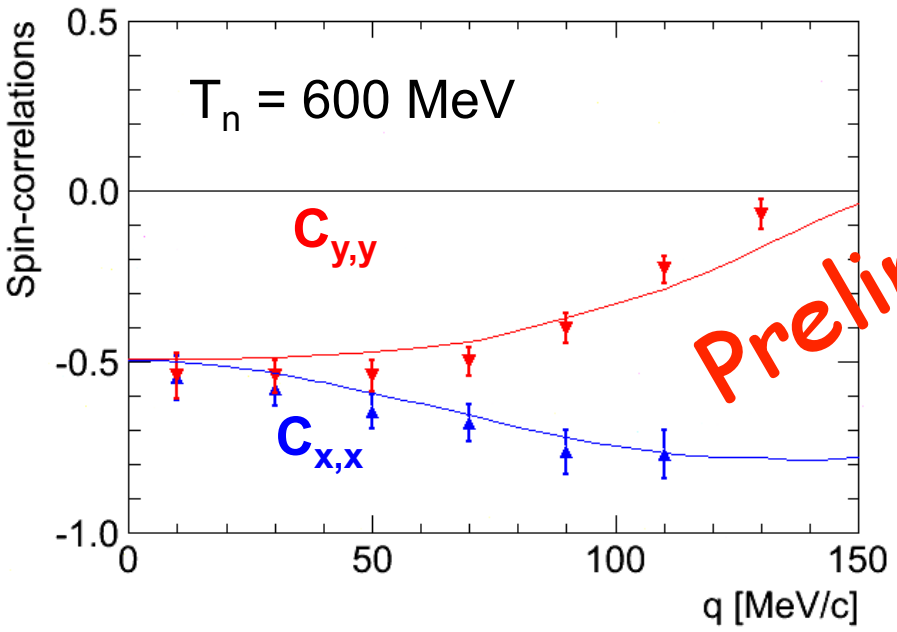
See talk by David Mchedlishvili

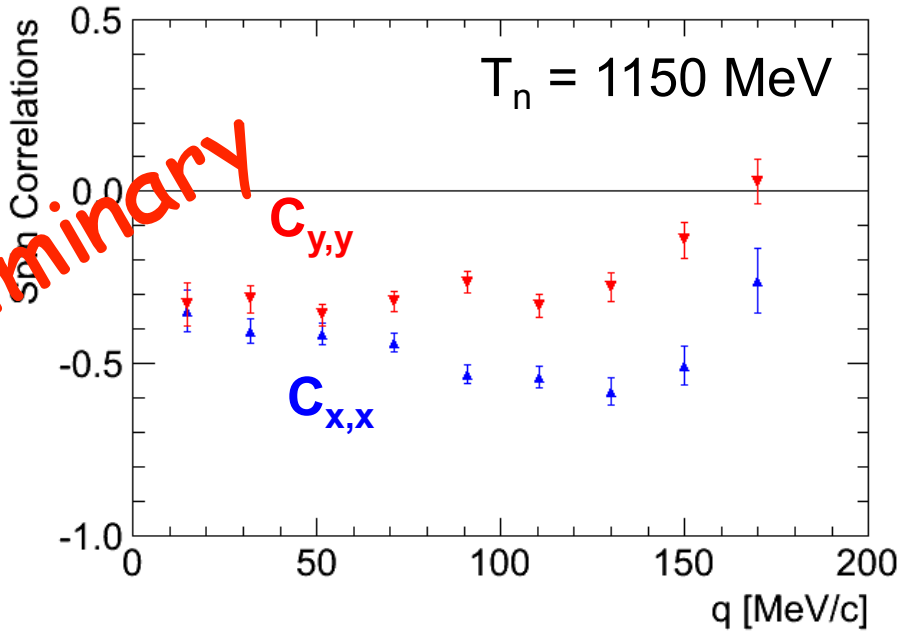
Status of np program: Double polarised experiments

$\vec{d}\vec{p} \rightarrow (pp)_{^1S_0} n$

Spin correlation parameters

Relative phases between the amplitudes





Preliminary

See talk by David Mchedlishvili

Status of pp program: Measurement technique

- Absolute measurement of pp elastic scattering (dσ/dΩ) using the Schottky technique in the angular range: 5°< θ_{cm}<30° for the energies: T_p = 1.0, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8 GeV.
- Cross section σ of given physical process is related to its event R rate by luminosity:

$$\sigma = \frac{R}{L}$$

Accuracy 2-3%

Where: $L = n_B \cdot n_T$

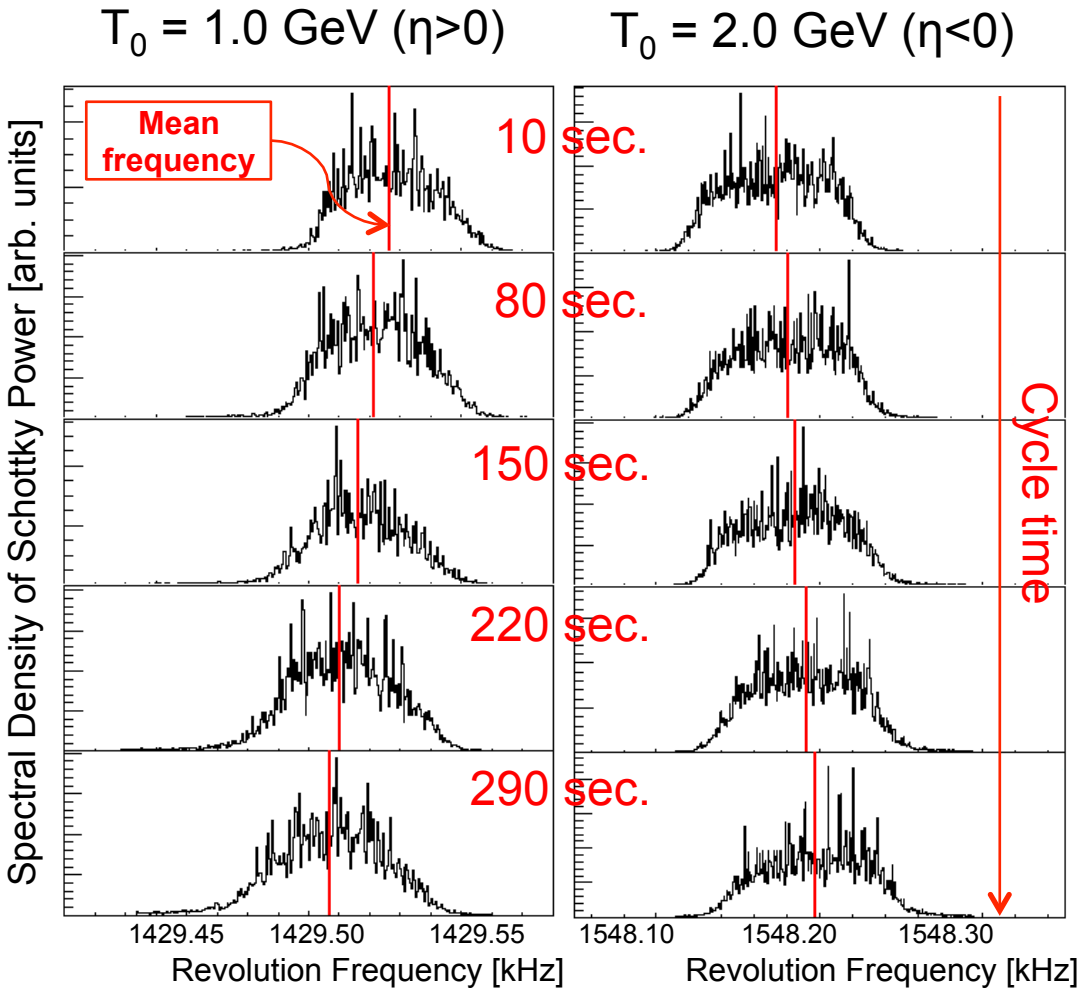
  - Accurate measurement of beam intensity n_B is possible via the high precision Beam Current Transformer (BCT) device.
  - Effective target thickness n_T can be obtained via the measurement of the frequency shift of coasting beam using the Schottky device.

$$n_T = \left(\frac{1+\gamma}{\gamma}\right) \frac{1}{(dE/dx)m} \frac{T_0}{f_0^2} \frac{1}{\eta} \frac{df}{dt}$$

Details in: Stein et al., PR ST-AB, 11, 052801

Status of pp program: Frequency shift

- Beam-target interaction gives energy loss that changes the machine frequency.
- Frequency change depends on η parameter
- Schottky distribution was recorded in every 10 sec. throughout the 300 sec. cycle.



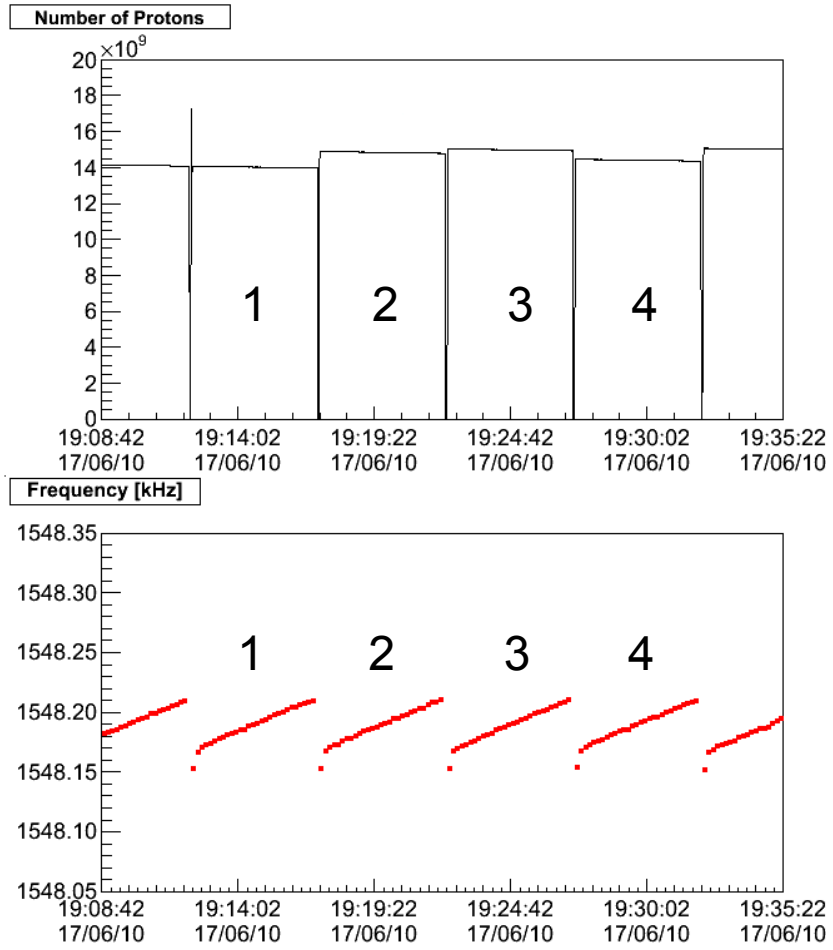
Status of pp program: Luminosity

$$n_T = \left(\frac{1+\gamma}{\gamma}\right)\frac{1}{(dE/dx)m}\frac{T_0}{f_0^2}\;\frac{1}{\eta}\;\frac{df}{dt}$$

$$T_p = 2.0\,\mathrm{GeV}$$

$$\eta = -0.07$$

$$f_0 = 1548.15\,\mathrm{kHz}$$

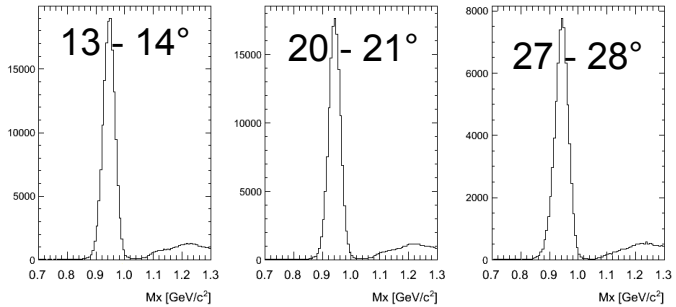


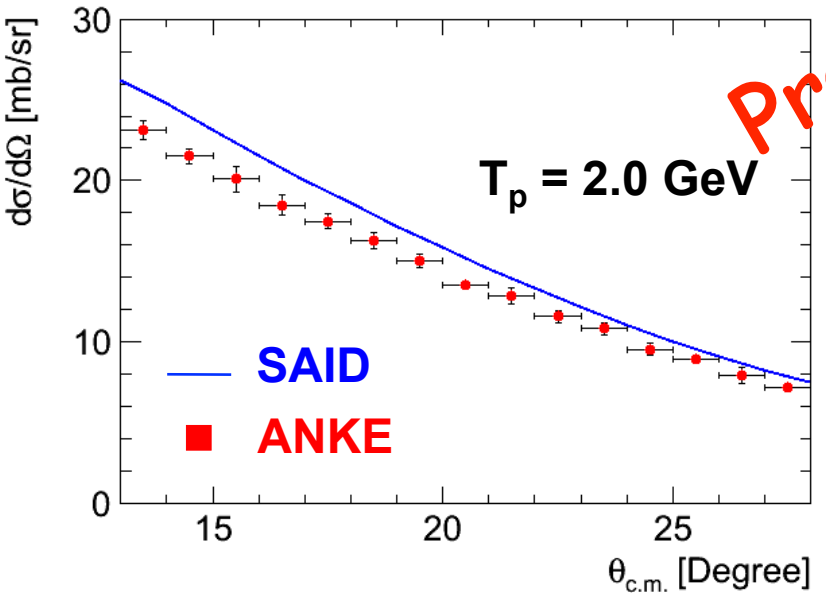
Cycle	df/dt	Target Density	Integrated Luminosity
1	0.152	2.75e+14	1.67e+33
2	0.151	2.74e+14	1.76e+33
3	0.154	2.79e+14	1.81e+33
4	0.149	2.70e+14	1.68e+33

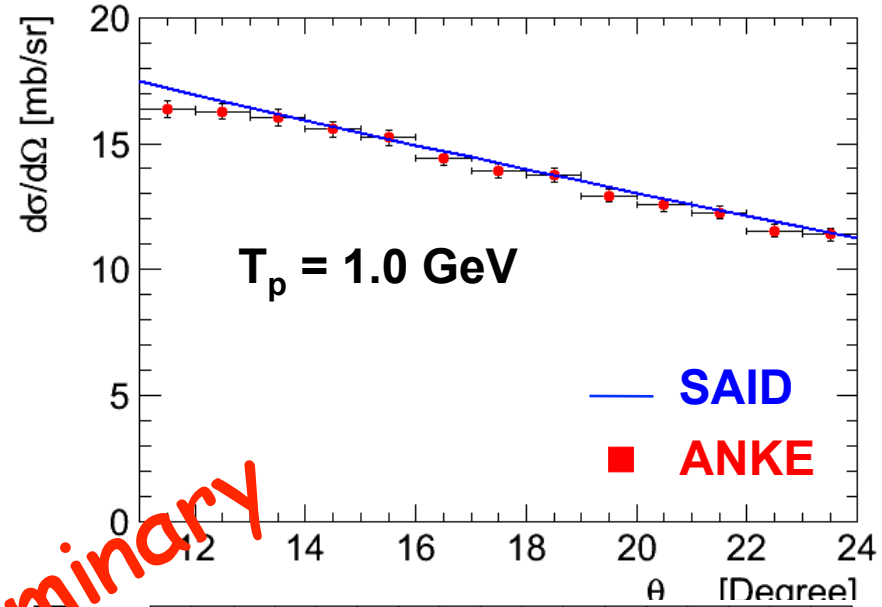
With 2-3 % accuracy

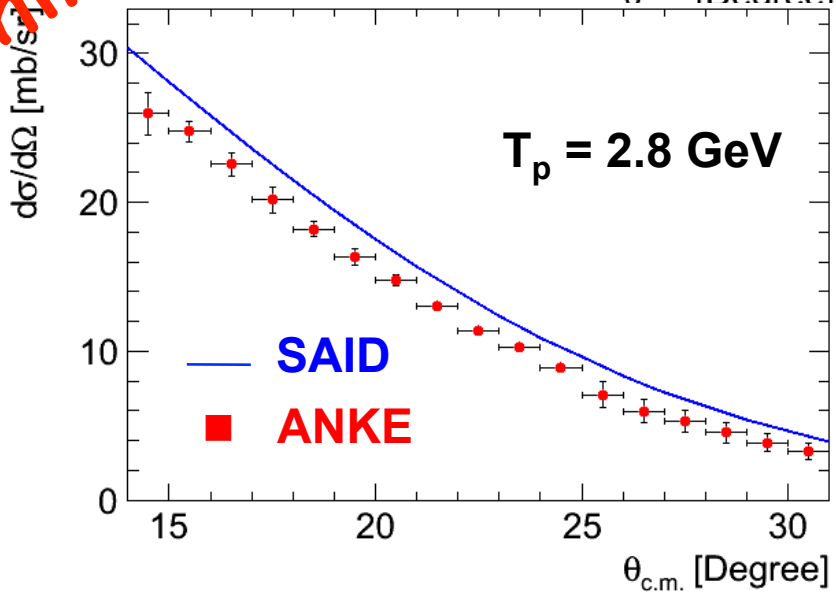
Status of pp program: Cross section

- Only FD system is used.
- Reconstructed missing mass of the proton ≈ 938 ± 18 MeV.









Preliminary

NN scattering: Future steps

- We aim to conduct experiment with polarised proton beam at the energies: T_p = 0.796, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8 GeV (approved beam time).

- By using deuterium and hydrogen cluster target we can provide

  - For **np** system: Differential cross-section (**dσ/dΩ**) and analysing power (**A_y**) in the angular range 5°< θ_{cm}< 40°.

  - For **pp** system**:** Analysing power (**A_y**) in the angular range 5°< θ_{cm}< 30°.

- After these measurements are completed we intend to perform double polarised experiment with polarised proton beam and polarised deuterium target.

Summary

- ANKE can provide robust np and pp data in energy region Tp = 1.0 – 2.8 GeV for c.m. angular range 5 – 30° (uncharted territory)
- High precision luminosity determination with Schottky technique (accuracy ~ 2 – 3%)
- Single and double polarised measurements for the determination of spin observables