Recent Scientific Results from Internal Experiments at COSY: EDDA, ANKE, COSY-11

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Outline

- Experimental Program
- Achieved Results
- Summary & Outlook

Experimental Program

Goal:

New insight into strong interaction physics at intermediate energies

Tools:

- Hadronic probes (p, d)
- Double polarization (beam/target)

Priority topics:

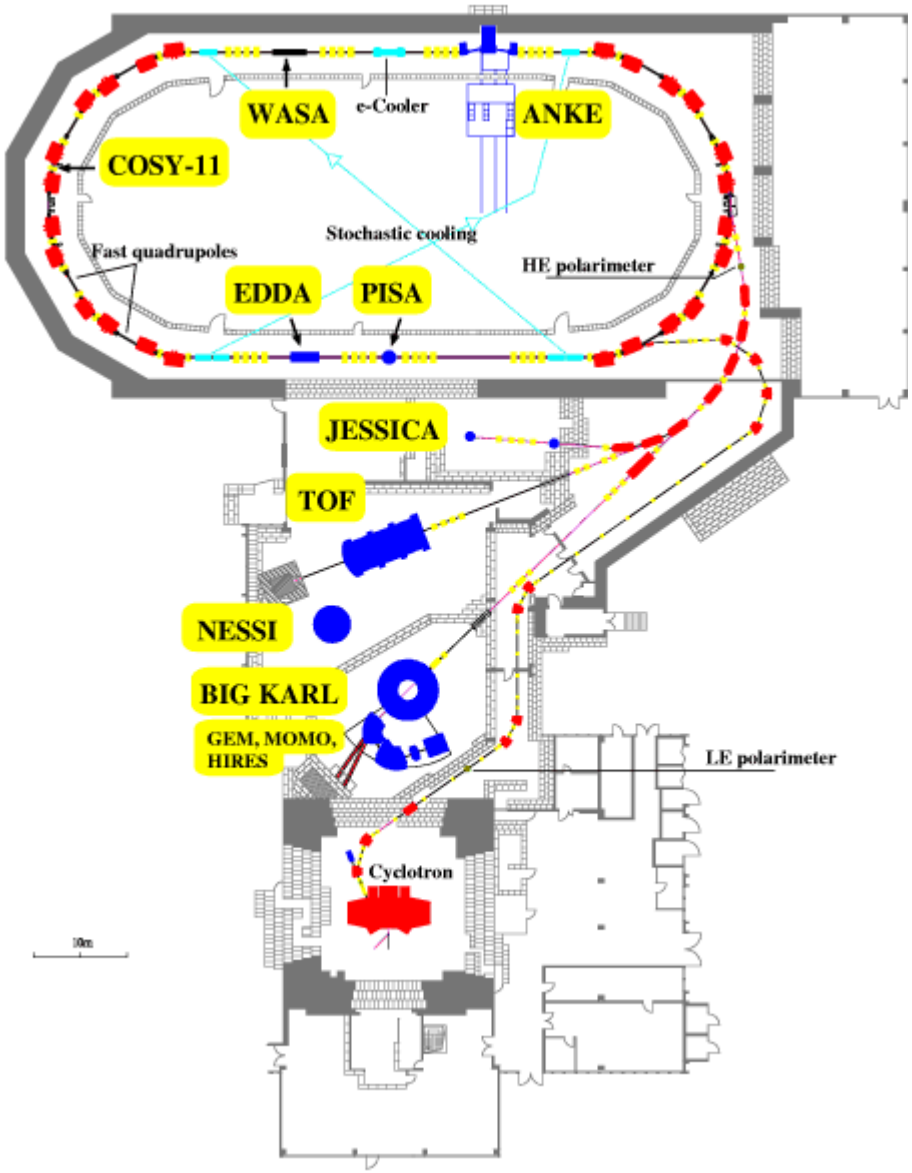
1. NN scattering	↔	**Nuclear forces**
2. Meson production	↔	**ChPT, phenomenological models, FSI**
3. Hyperon production	↔	**SU(3) symmetry**

Motivation:
Colin Wilkin

Internal Experiments at COSY

Characteristics:

- Magnetic spectrometers: **ANKE, COSY-11**
  - high resolution
  - low geometrical acceptance
- Non-magnetic spectrometer: **EDDA**
  - moderate resolution
  - large acceptance
- Energy variation (**COSY** ramping mode)
- Standard targets (foil, fiber, gas jet)
- Polarized targets
  - fast switching: **ANKE, EDDA**
  - high density storage-cell target: **ANKE**



Experimental Results I

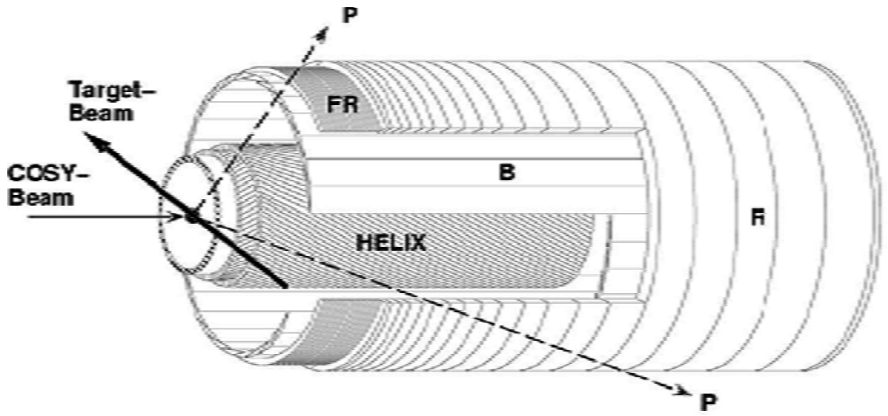
NN Scattering

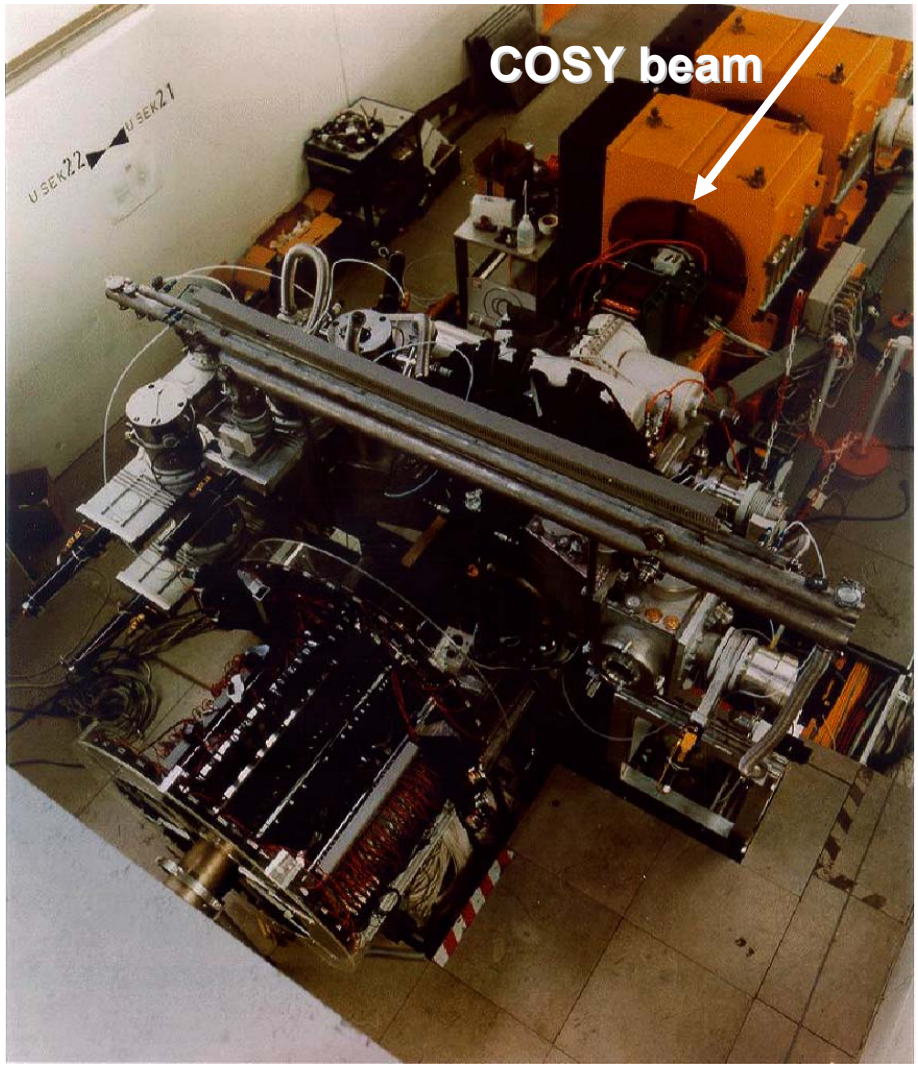
pp: A scientific summary (EDDA)

$pp \to pp$ – $d\sigma/d\Omega$ (PRL 78,1997; EPJ A22,2004)

$\vec{p}p \to pp$ – A_N (PRL 85,2000; EPJ A23, 2005)

$\vec{p}\vec{p} \to pp$ – A_{**} (PRL 90,2003; PR C71, 2005)

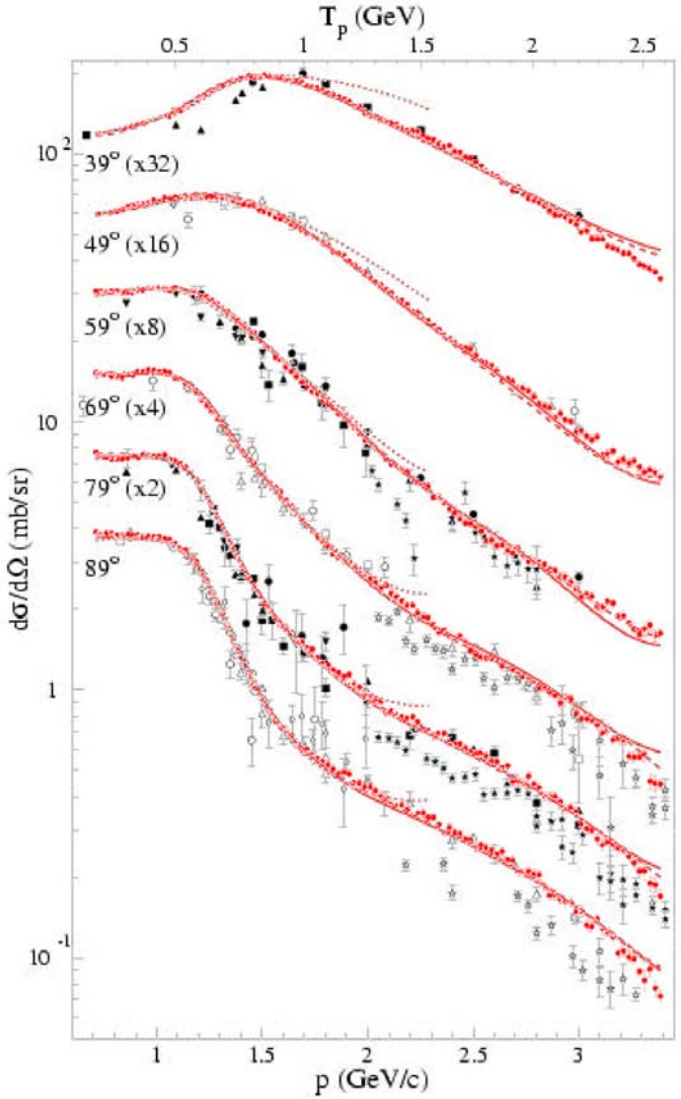




NIM, A329, 151 (1993) and A431, 385 (1999)

pp: Spin-averaged dσ/dΩ (p_{lab}, θ_{cm}) (EDDA)

- Excitation functions, angular distributions
- Continuous measurements during acceleration (ramping mode)
- Wide energy and angular range
- High precision and internal consistency in normalization

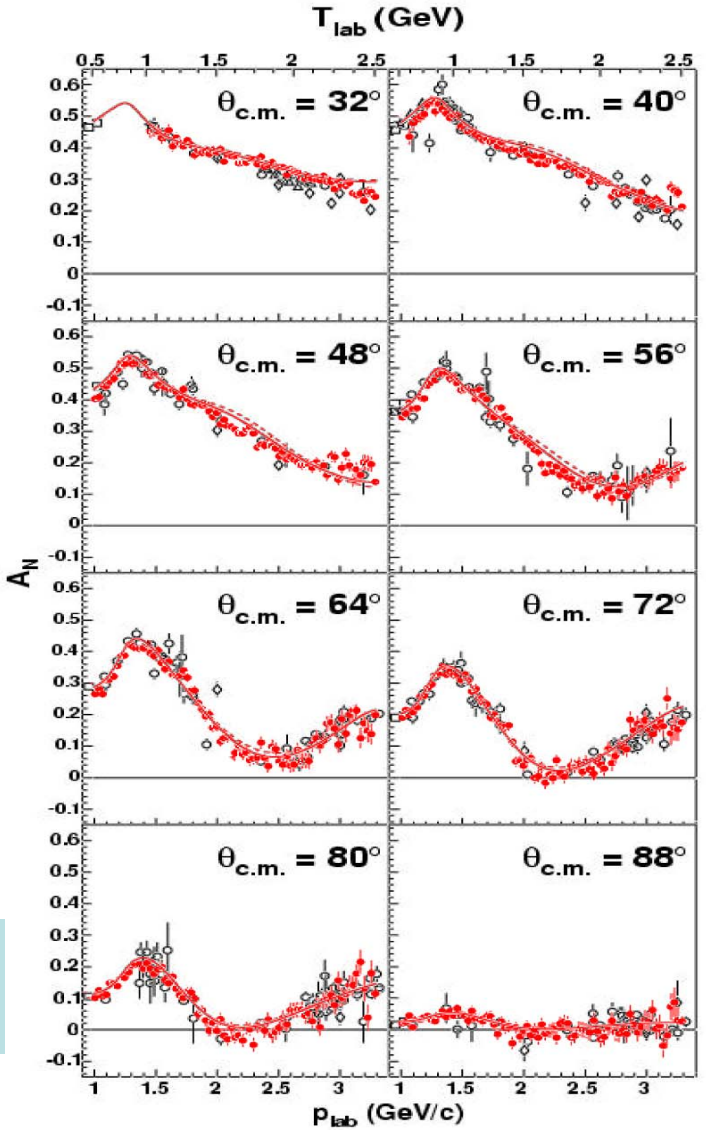


pre EDDA
EDDA

D. Albers et al., Eur. Phys. J. A22, 125 (2004)

pp: Analysing power $A_N(p_{lab}, \theta_{cm})$ (EDDA)

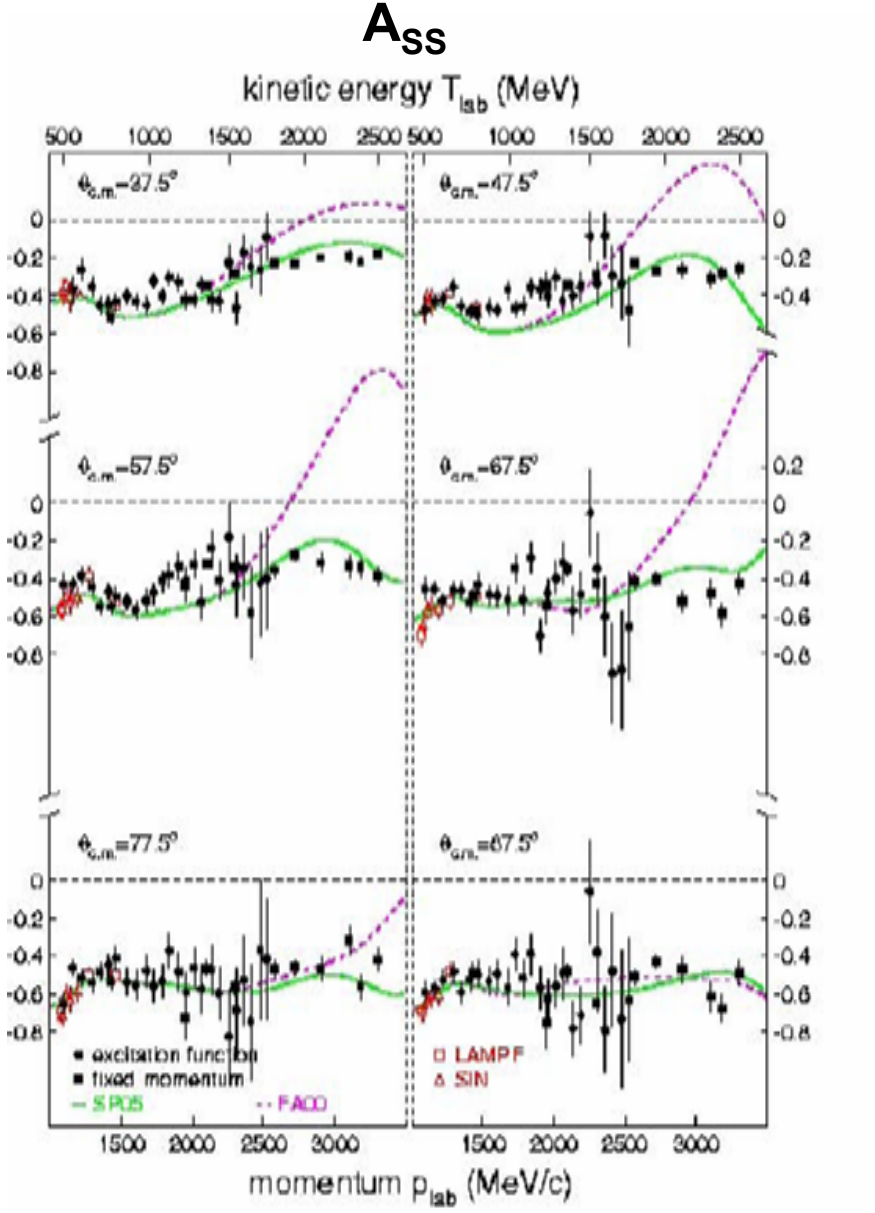
- Excitation functions and angular distributions
- Ramping mode
- High precision and internal consistency



pre EDDA
EDDA

M. Altmeier et al., Eur. Phys. J. A23, 351 (2005)

pp: Spin correlations $A_{**}(p_{lab}, \theta_{cm})$ (EDDA)



Numerical data access:
http://kaa.desy.de/edda/Edda.html

pp: Spin correlations $A_{**}(p_{lab}, \theta_{cm})$ (EDDA)

Scientific impact:

- **New Phase Shift Analysis including all EDDA results:**

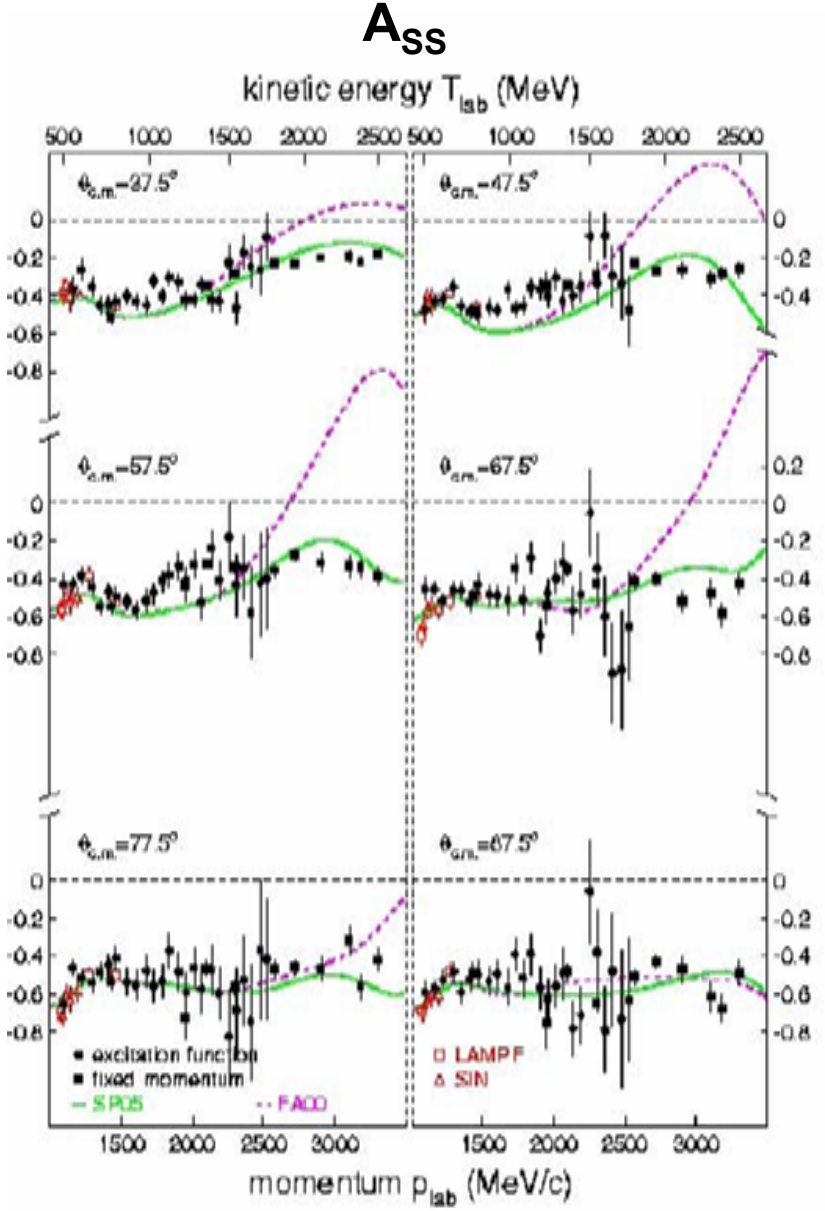
  ----- FA 00

  ——— SP 05

- **Modification of NN OBE models**

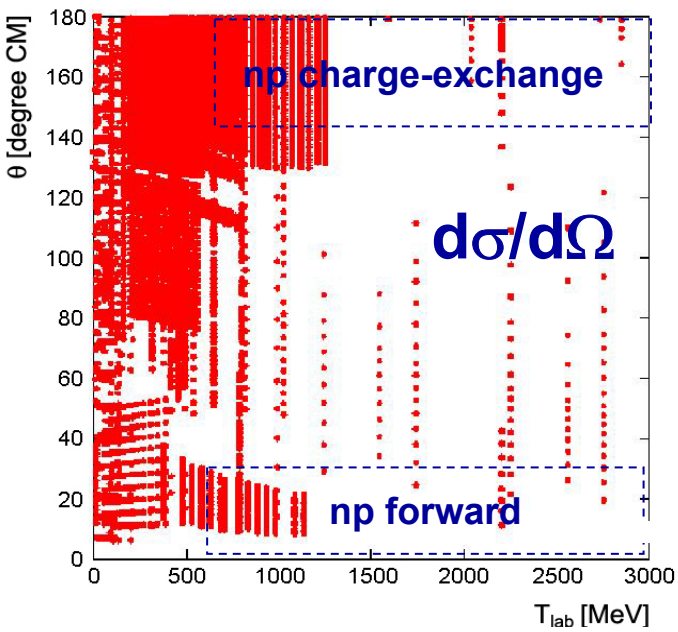
- **Exclusion limits on narrow dibaryon resonances**

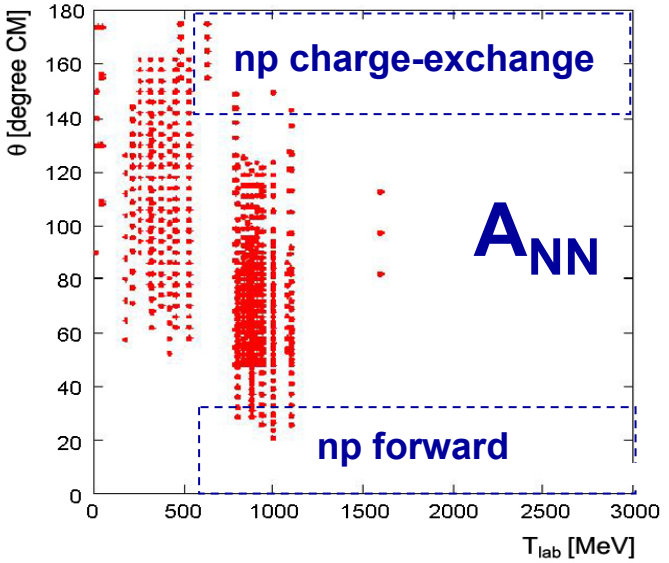
Numerical data access:
http://kaa.desy.de/edda/Edda.html



np: Different isospin channel (ANKE)

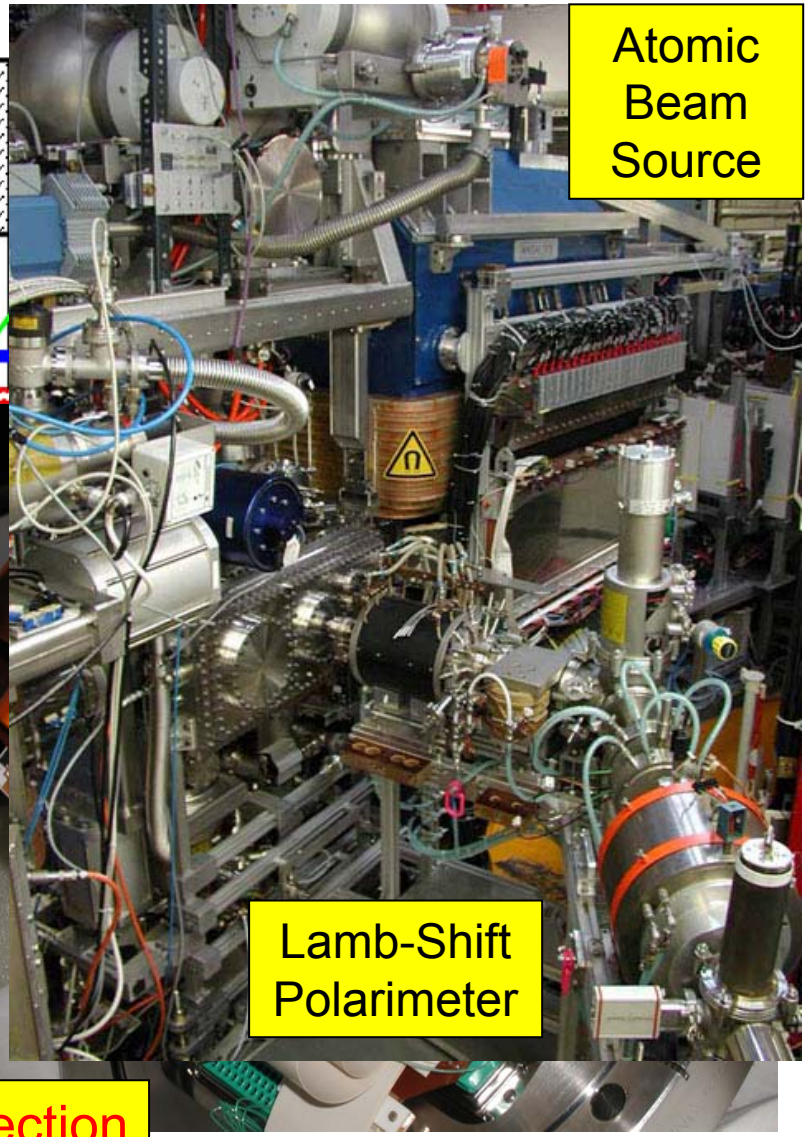
- Status of data base: poor
- Method: polarized deuteron (beam or target) as a neutron source
- ANKE: high-quality np data in forward / backward region





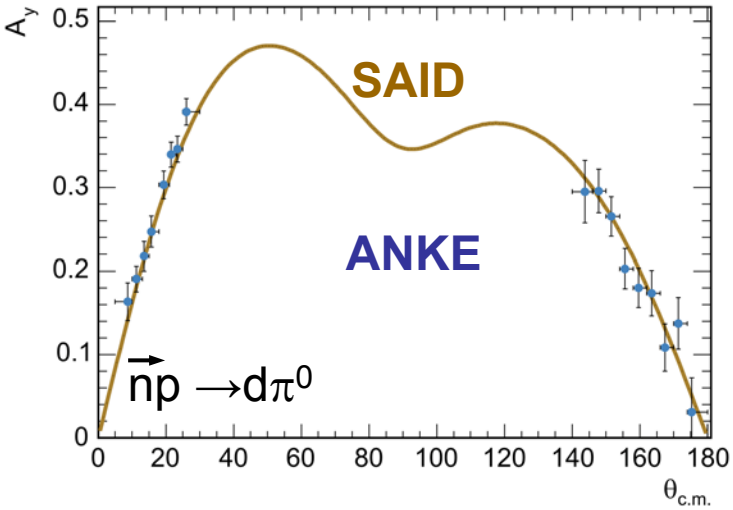
np: ANKE set-up

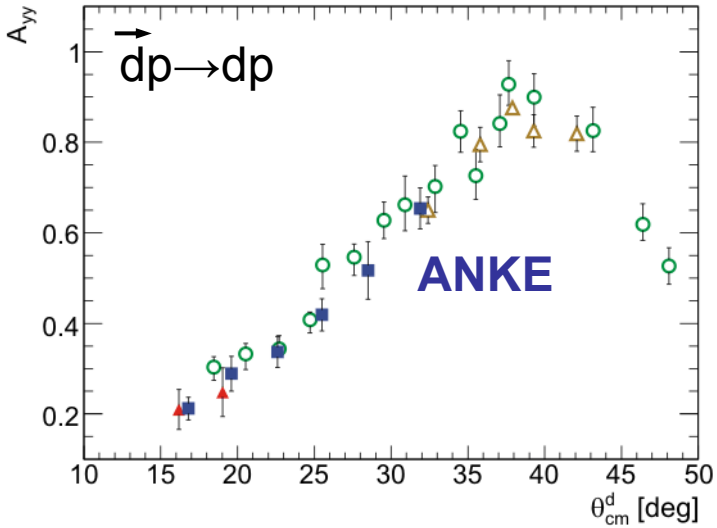
see talks:
Ralf Engels,
Sergey Dymov

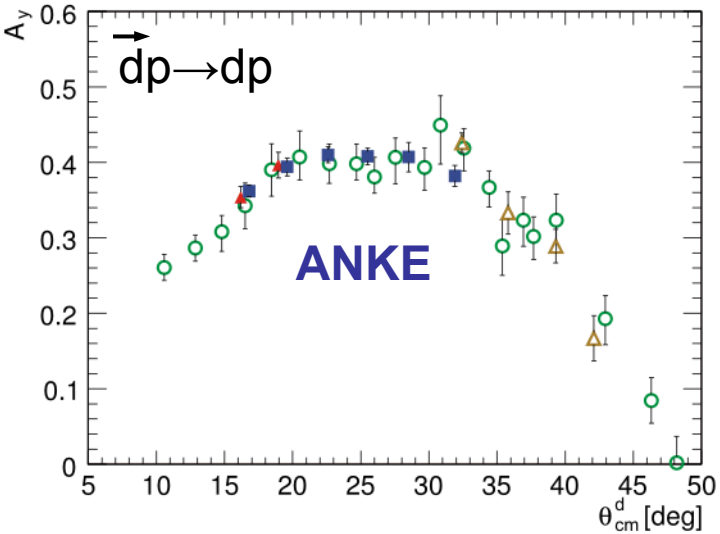


np: Deuteron beam polarimetry (ANKE)

- Calibration energy: T_d = 1170 MeV
  1. $\vec{d}p$ elastic (A_y, A_{yy})
  2. $\vec{d}p \rightarrow {}^3He\pi^0$ (A_{yy})
  3. quasi-free $\vec{n}p \rightarrow d\pi^0$ (A_y)
- Results:
  - polarization standard established
  - no depolarization during acceleration







D. Chiladze et al., *Determination of Deuteron Beam Polarization at COSY*;
Phys. Rev. ST-AB, 9, 0511052 (2006)

np: Charge-exchange reaction (ANKE)

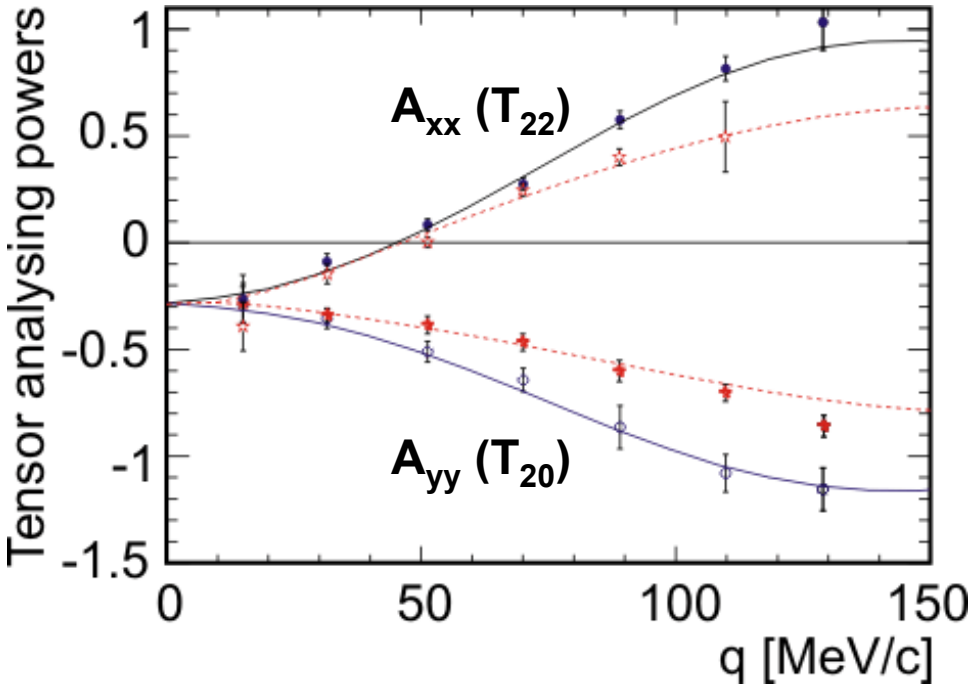
$\vec{d}p \rightarrow (pp)_{^1S_0}\, n$

T_d = 1170 MeV

Transition from deuteron to $(pp)_{^1S_0}$:
pn → np spin flip

Obtain np elementary spin-dependent amplitudes:

$$\frac{d\sigma}{dq}, T_{20}, T_{22} \Rightarrow |\gamma|^2 + |\beta|^2, |\delta|^2, |\varepsilon|^2$$



Results:

- Method works at T_n = 585 MeV
- Application to "uncharted territory"

Next step:

- Double polarized→ $C_{y,y}$, $C_{x,x}$

D. Chiladze et al., *Vector and tensor analyzing powers in dp-breakup reactions at intermediate energies*; PLB, 637,170 (2006)

see talk:
David Chiladze

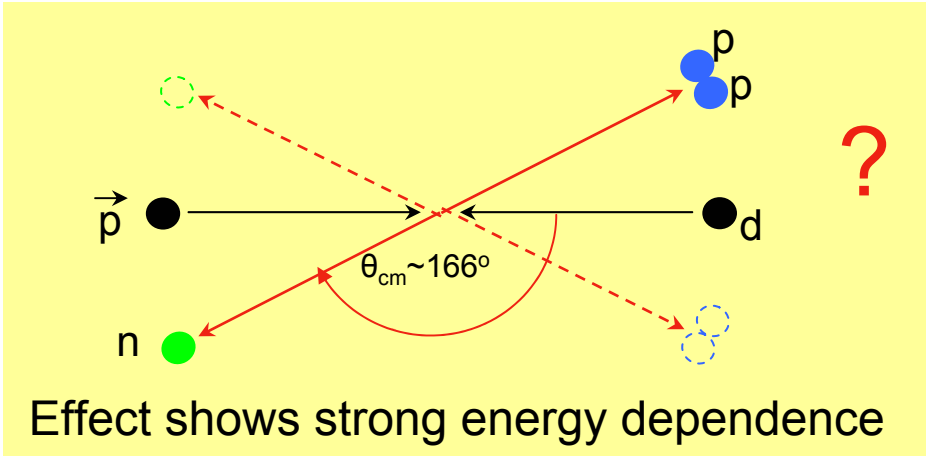
NN: pd dynamics (ANKE)

pd dynamics at high momentum transfer

- pd → $(pp)_s$ n
- Kinematics like pd backward elastic
  - → S-wave pp-pairs
  - → Suppression of Δ

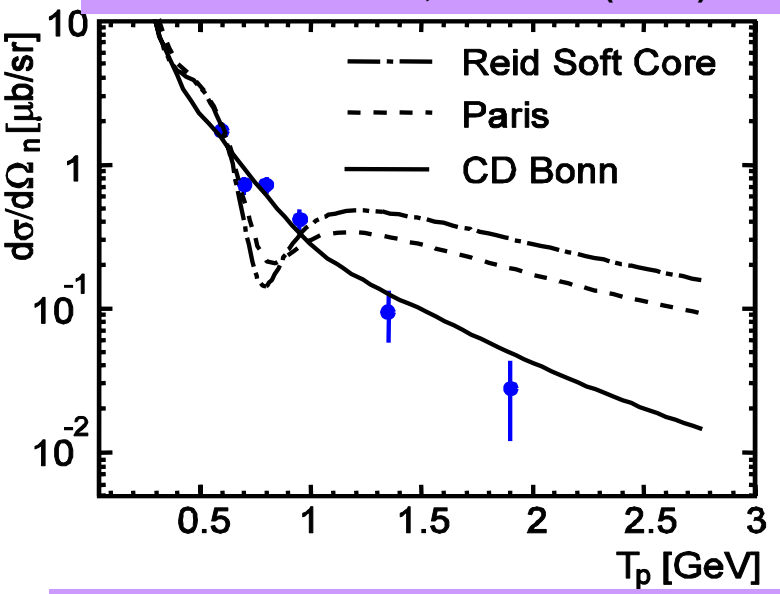
– Status

- Cross sections (✓)
- Analyzing power A_y^p (✓)
- **Next: Double polarized**
  - Analyzing power T_{20}
  - Spin-Correlation parameters

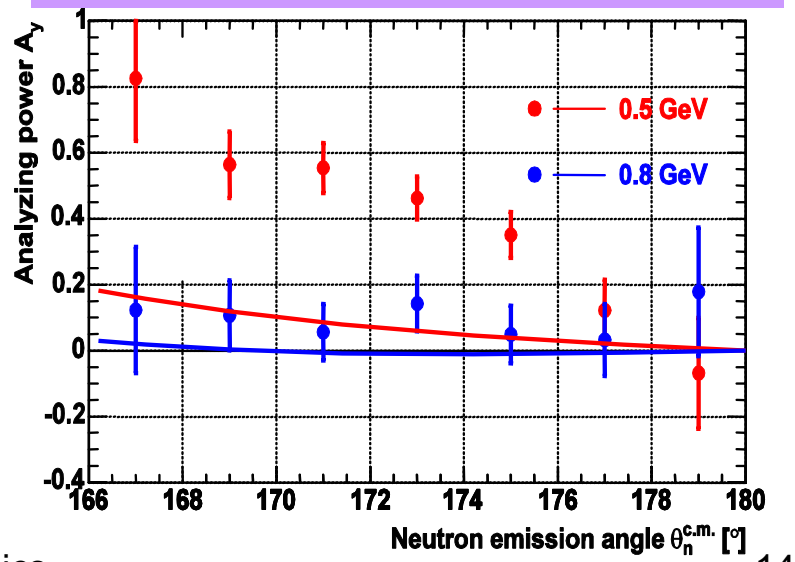


Effect shows strong energy dependence

V.Komarov et al., PLB 553 (2003) 179



S.Yaschenko et al., PRL 94 (2005) 07234



Meson Production

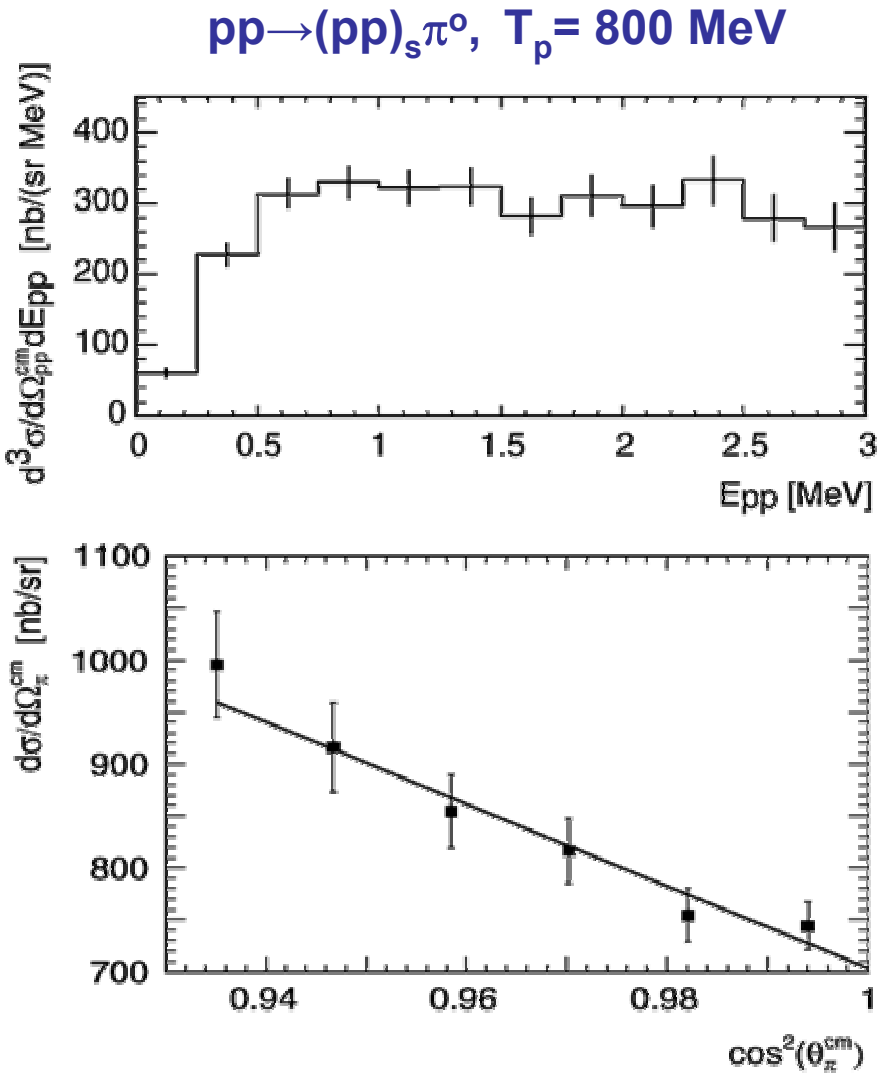
π production: First result (ANKE)

- $pp \rightarrow (pp)_s \pi^o$ T_p= 350 … 950 MeV
- $pn \rightarrow (pp)_s \pi^-$ T_p= 350 MeV

- low energy:
  provide data of relevance for ChPT studies
- higher energies:
  crucial extra test of pion production models

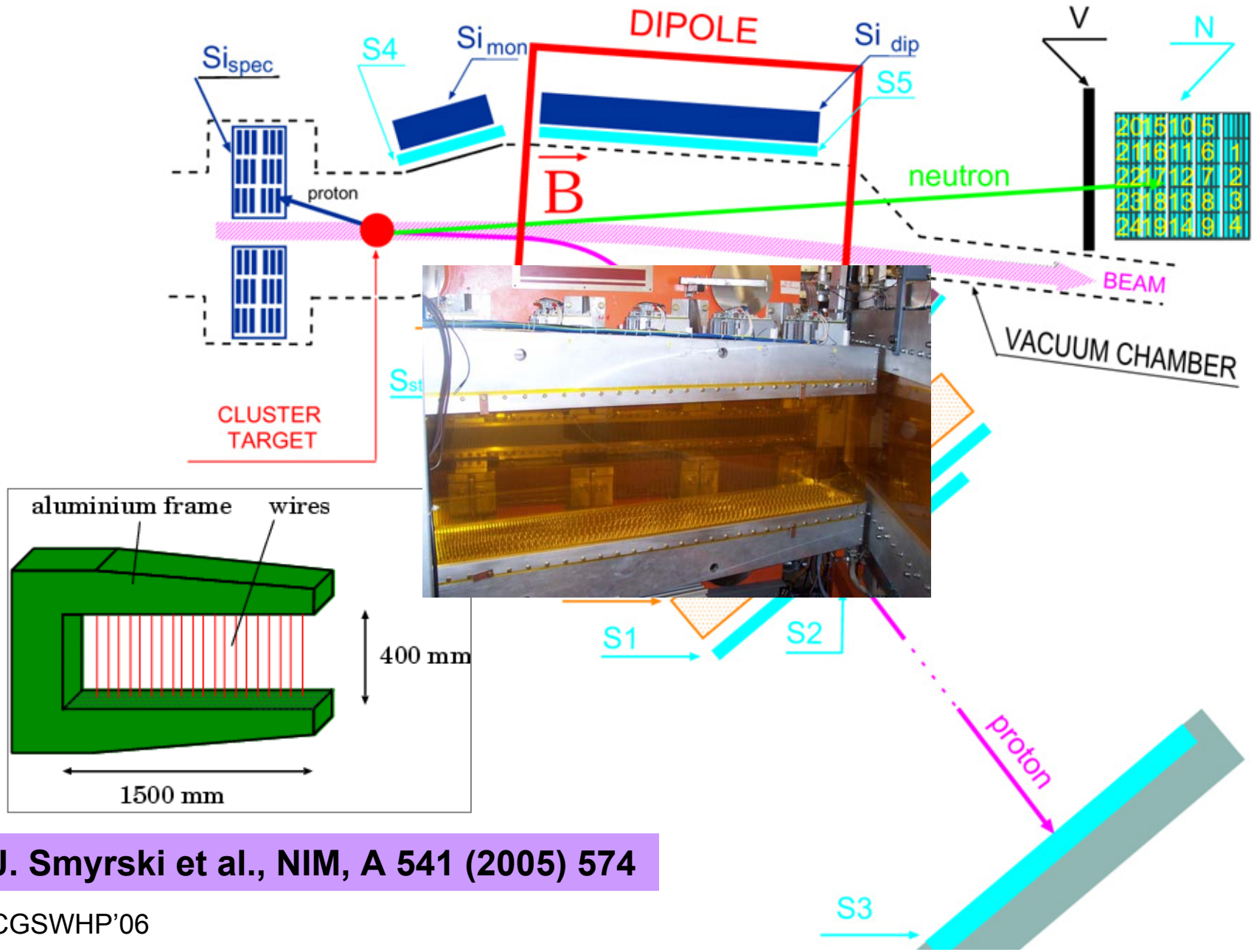
Result:

- ► unexpectedly large slope



S.Dymov et al., *Production of the $^1S_0$ diproton in the $pp \rightarrow (pp)\pi^0$ reaction at 0.8 GeV*; PLB 635, 270 (2006)

η/η' mesons: COSY-11 set-up



J. Smyrski et al., NIM, A 541 (2005) 574

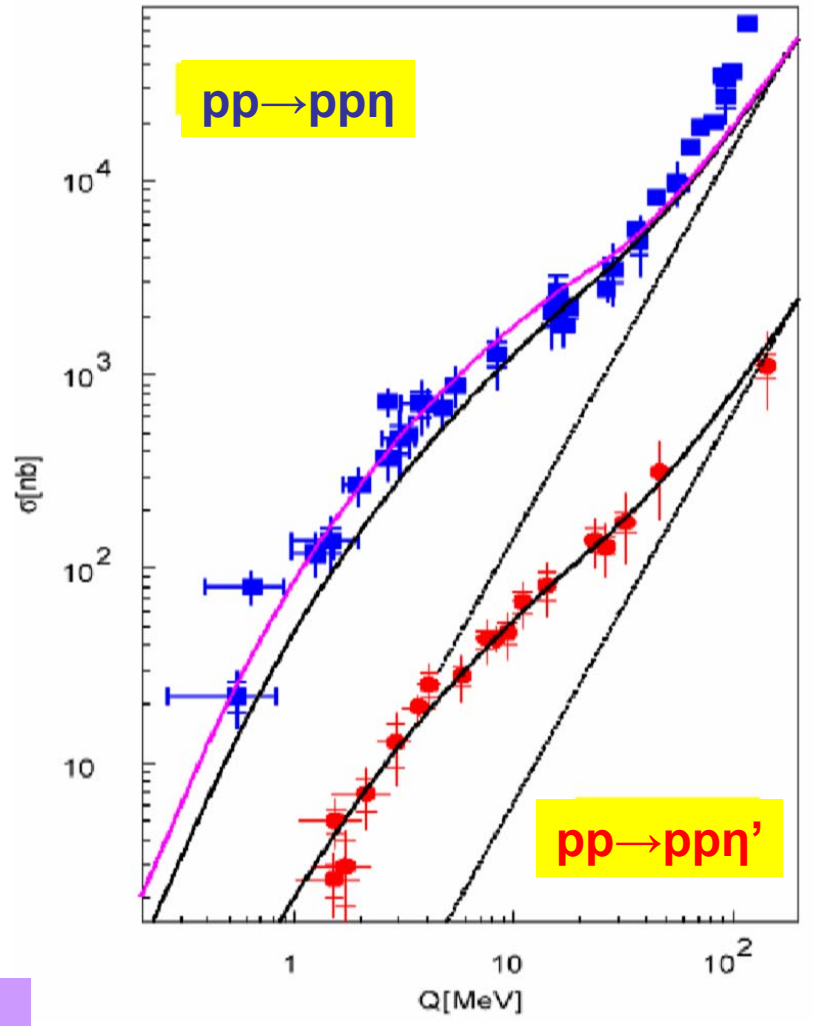
η/η' mesons: σ_{tot} (COSY-11)

Results:

- η/η' mesons: pp FSI
- η meson: in addition ηp FSI
- ηN interaction: coupling to N*

Next:

Isospin dependence:
p n → p n η, dη
p n → p n η', dη'
(Analysis in progress)



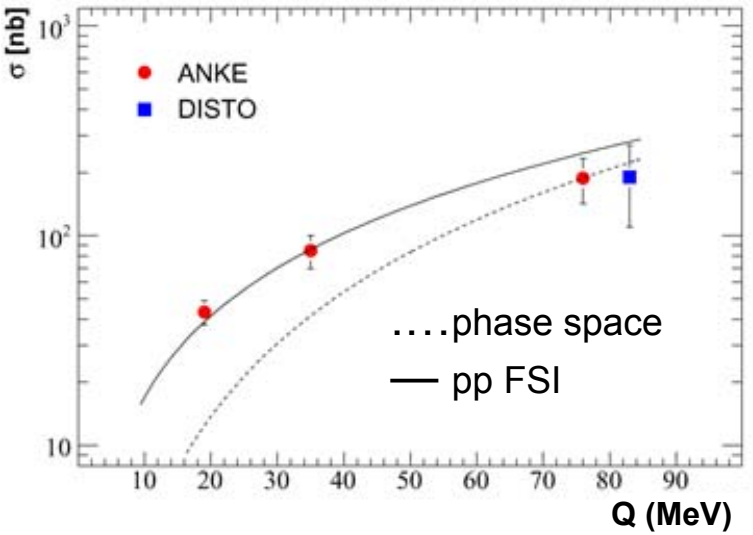
P.Moskal et al., Phys. Rev. C 69 (2004) 025203
A.Khoukaz et al., Eur. Phys. J. A 20 (2004) 345

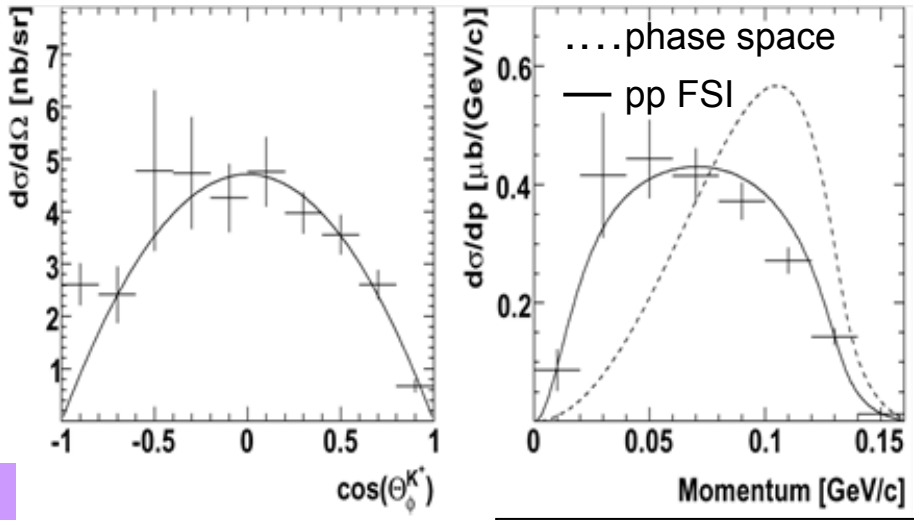
Φ production: σ_{tot}, dσ/dΩ (ANKE)

- pp→ppΦ near threshold (three excess energies)

Results:

- S-wave dominance
- Significant FSI
- OZI rule





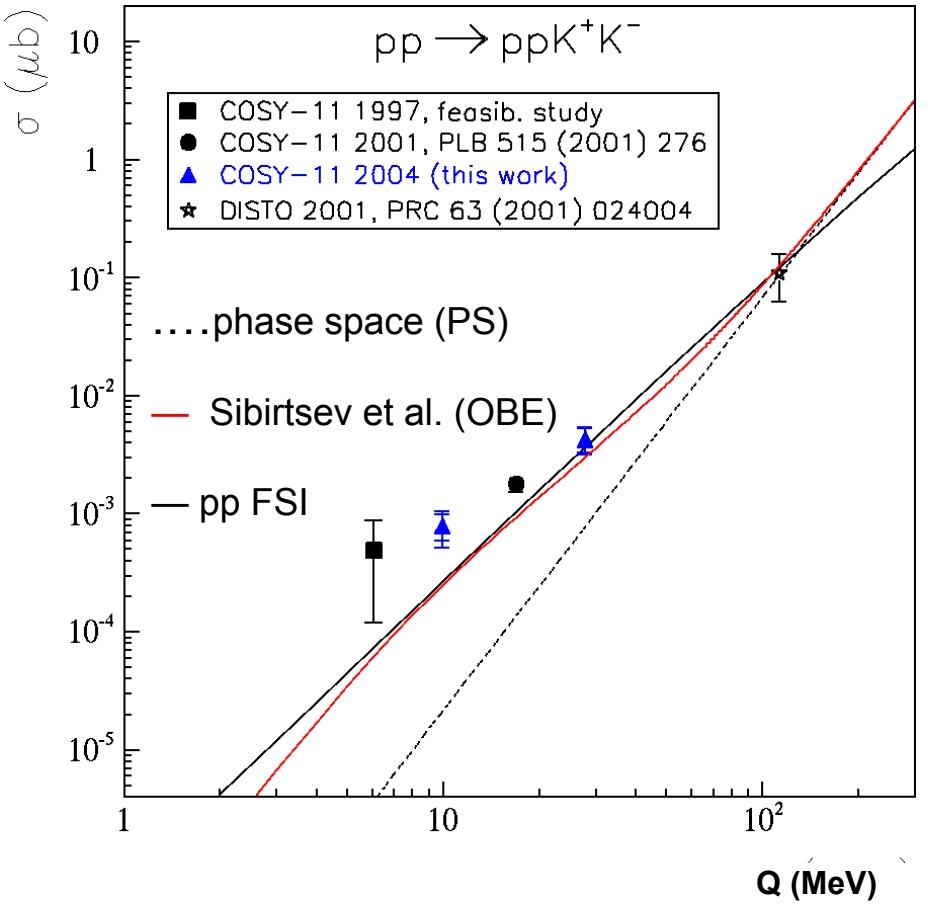
M.Hartmann et al., *The Near-Threshold Production of Φ Mesons in the pp Collisions*;
PRL, 96, 242301 (2006)

see talk:
Irakli Keshelashvili

K^+K^- production: σ_{tot} (COSY-11)

- K^+K^- close to threshold

- Results:
  - pure PS
  - with pp FSI
  - boson exchange model



P. Winter et al., PLB 635 (2006) 23

K^+K^- production: σ_{tot} (ANKE)

Resonant:

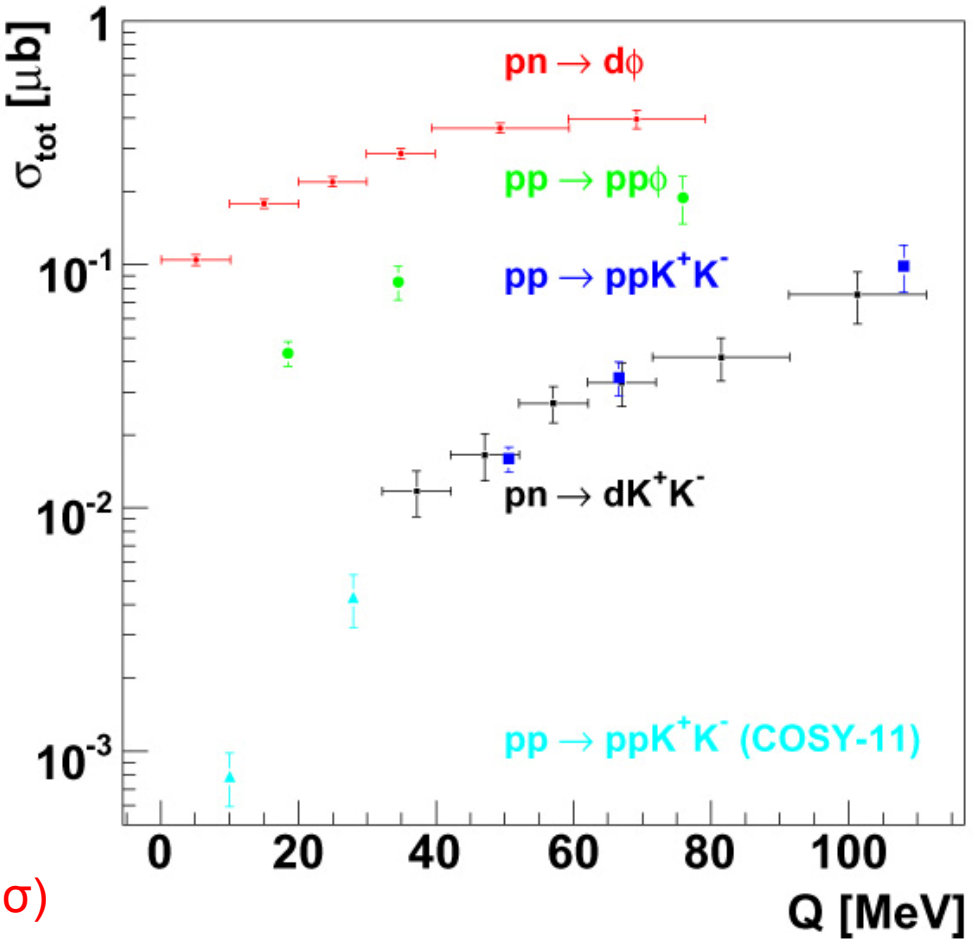
$\sigma_{tot}(pp \to pp\phi) = \sigma_T$

$\sigma_{tot}(pn \to d\phi) = \sigma_S{}^d$

Non-resonant:

$\sigma_{tot}(pp \to ppK^+K^-)$

$\sigma_{tot}(pn \to dK^+K^-)$



- Result:
  - ▶ "pp" ≈ "pn" (same non-resonant σ)
  - ▶ Implication for models

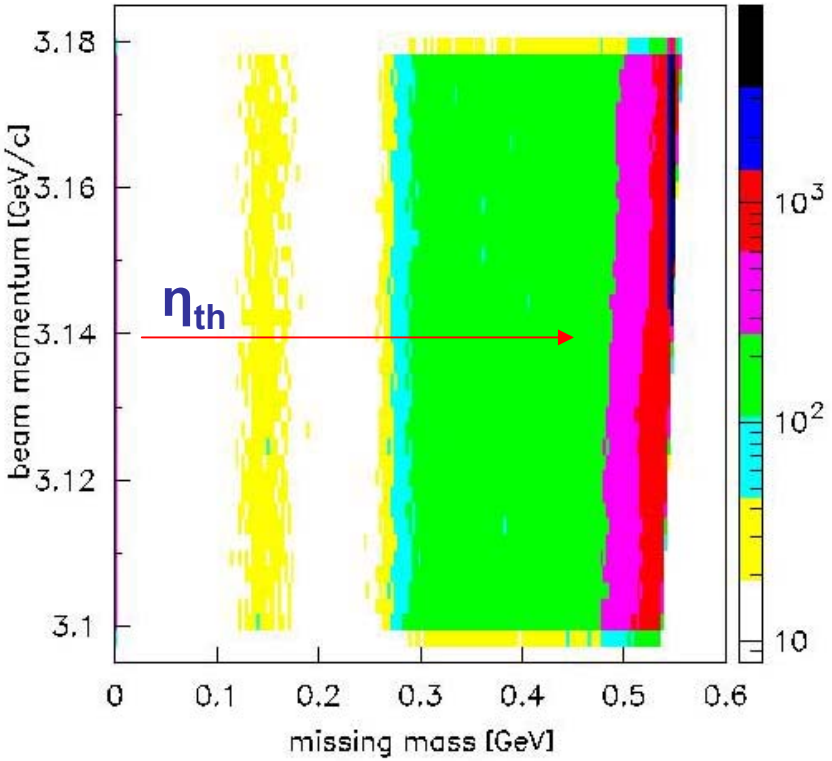
Y. Maeda et al., *Φ Meson Production in pn Collisions*;
Accepted by PRL (2006): nucl-ex/0607001.

see talks:
Irakli Keshelashvili,
Alexey Dzyuba

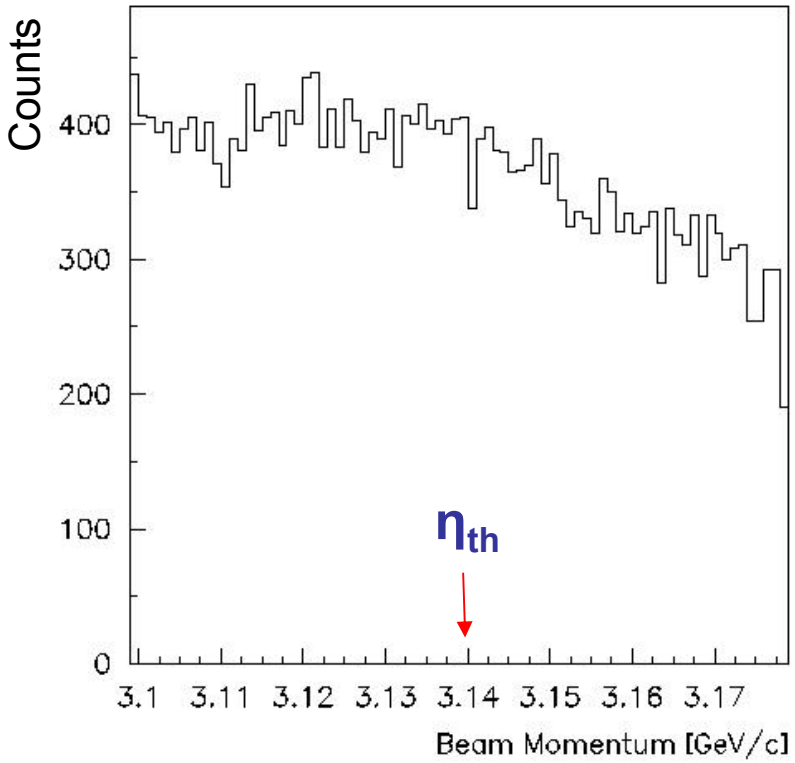
Nuclear-Meson Production

^{3}Heη: Bound state (COSY-11)

dp → ^{3}He X



dp → ^{3}He π^0



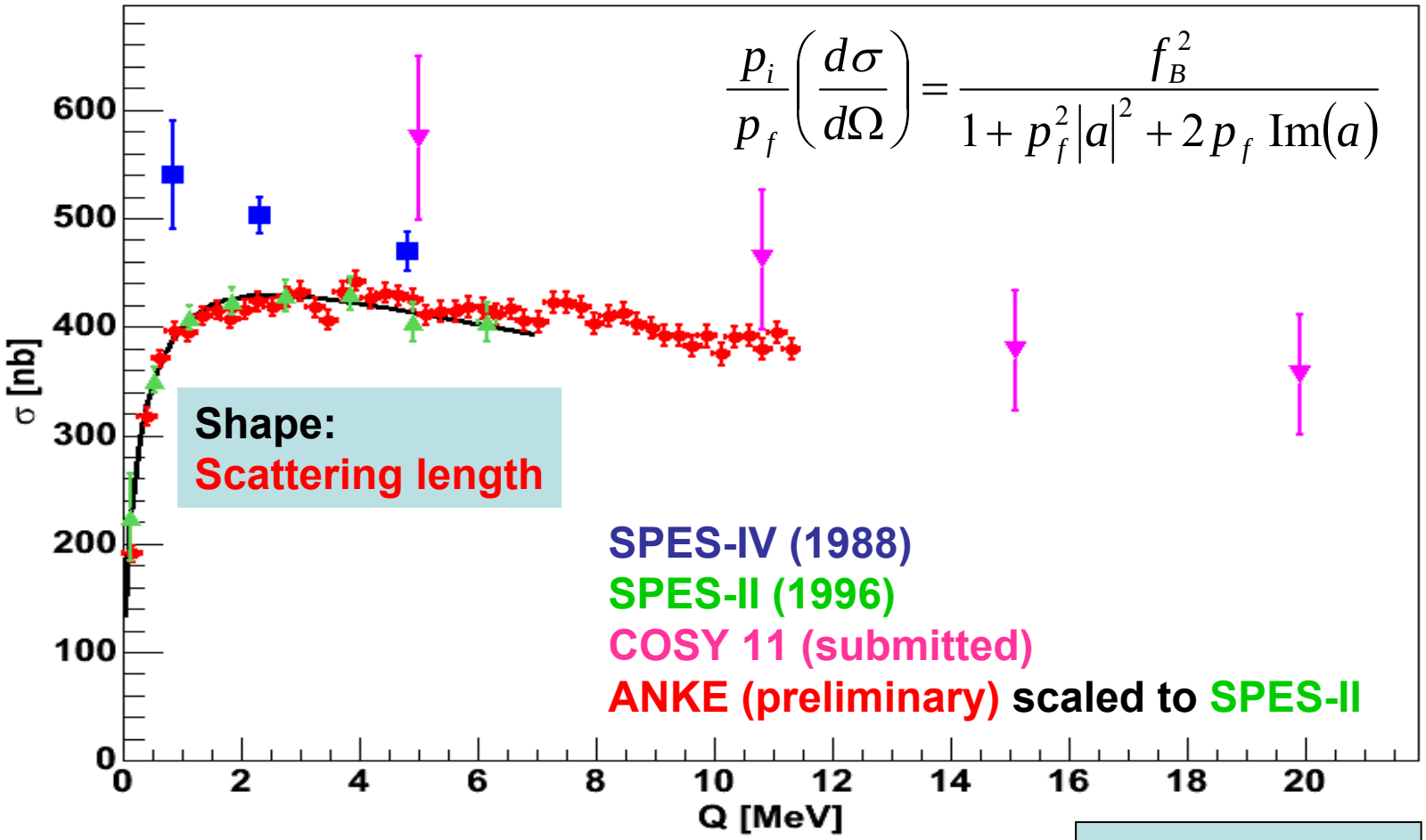
Preliminary result:

- **no indication for ^{3}Heη bound state**

J.Smyrski et al., nucl-ex/0603023

^{3}Heη: Scattering length (ANKE)

$$\frac{p_i}{p_f}\left(\frac{d\sigma}{d\Omega}\right) = \frac{f_B^2}{1 + p_f^2|a|^2 + 2p_f\,\mathrm{Im}(a)}$$



see talk:
Timo Mersmann

Hyperon Production

Hyperon production: σ_{tot} (COSY-11)

$pp \rightarrow pK^+\Lambda$

$pp \rightarrow pK^+\Sigma^0$

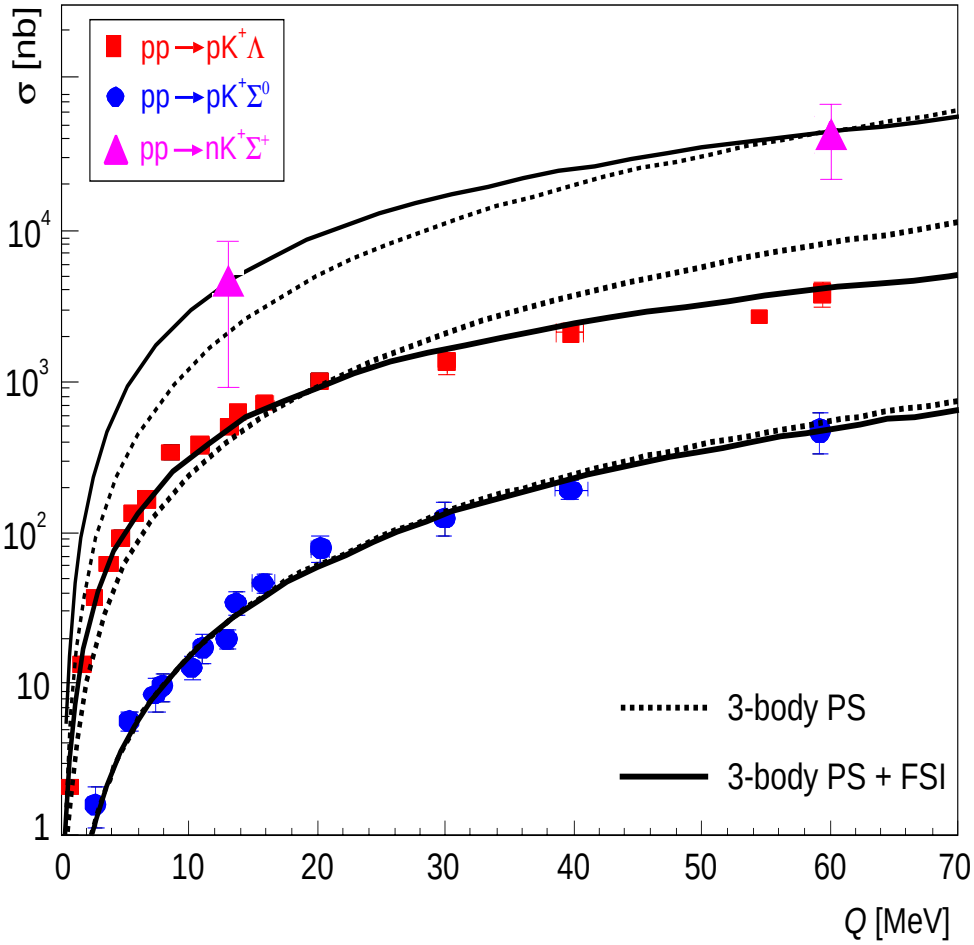
$pp \rightarrow nK^+\Sigma^+$

Results:

- Importance of NY FSI
- Surprisingly large σ for $nK^+\Sigma^+$

- Hyperon production at ANKE

see talk:
Izabella Zychor



T. Rozek et al., Accepted by PLB (2006)
P. Kowina et al., Eur. Phys. J. A 22, 293 (2004)

Hyperon production: Double Polarization

Spin/isospin dependence of $pN \to (N\Lambda)\, K^+$

- Both needed:

  $\vec{p}\vec{p} \to (p\Lambda)\, K^+$ TOF

  $\vec{p}\vec{n} \to (n\Lambda)\, K^+$ ANKE $\Rightarrow$ via spectator detection

- ANKE is well equipped to provide:

I_0	–	unpolarized cross section
A_{yy}	–	transverse spin-correlation
D_{yy}	–	spin-transfer parameter

- $N\Lambda$ triplet final state can be isolated unambiguously from ~ $d\sigma(\uparrow\uparrow)/dm^2_{N\Lambda}$

  A. Gasparyan et al., PRC 69 (2004) 034006

Summary & Outlook

- EDDA experiment successfully completed
- COSY-11 experiment will soon complete data taking to finalize physics program
- ANKE will continue with double-polarized spin physics program (*COSY proposal #152, 2005*):
  "Spin Physics from COSY to FAIR" (arXiv:nucl-ex: 0511028)