

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

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Outline

- Experimental Program
- Achieved Results
- Summary & Outlook



Goal:

**New insight into strong interaction physics
at intermediate energies**

Tools:

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

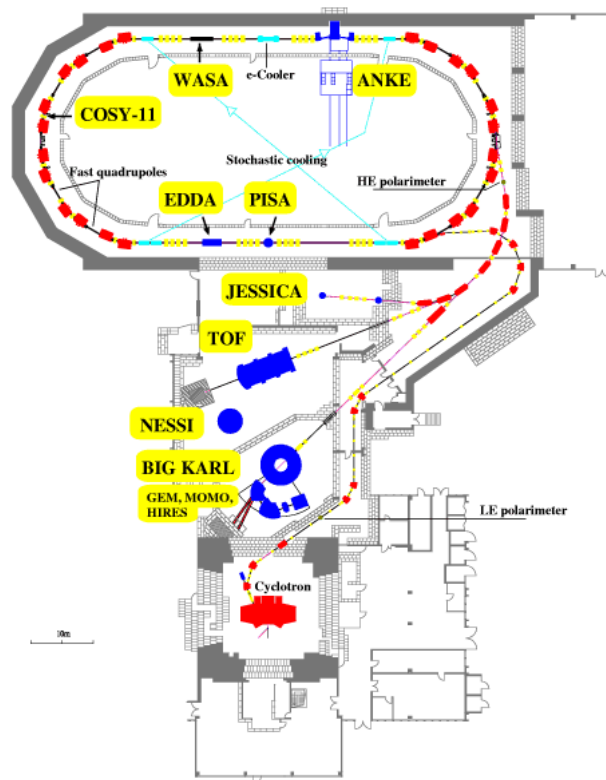
Priority topics:

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

Motivation:
Ch. Hanhart,
Ulf-G. Meißner

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**





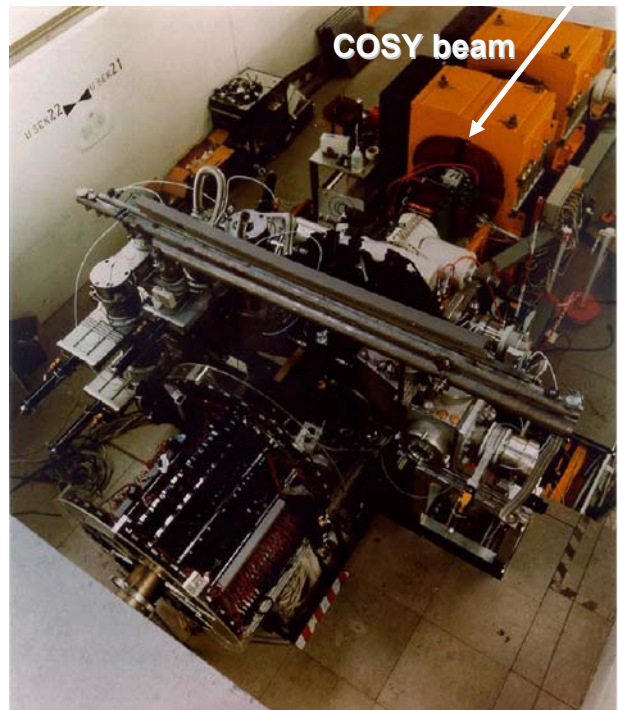
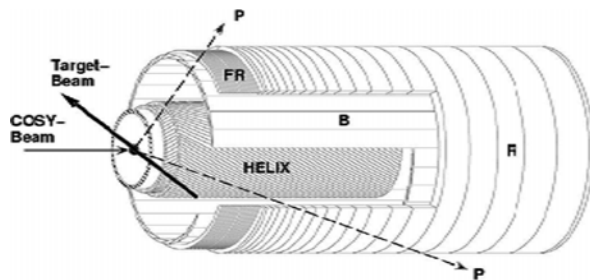
NN Scattering



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

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

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

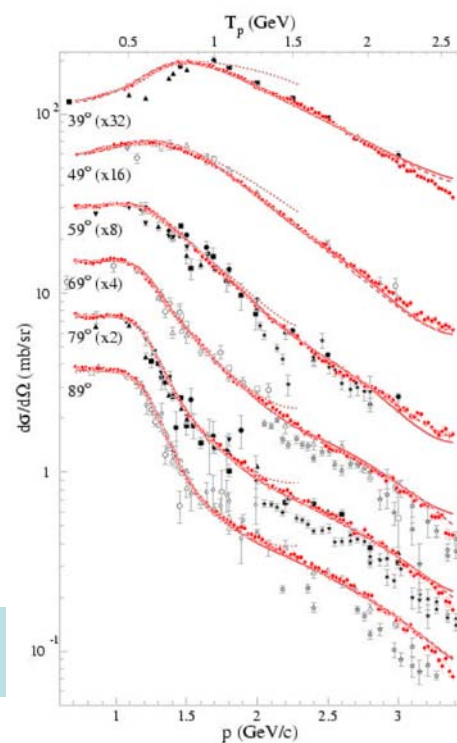


NIM, A329, 151 (1993) and A431, 385 (1999)



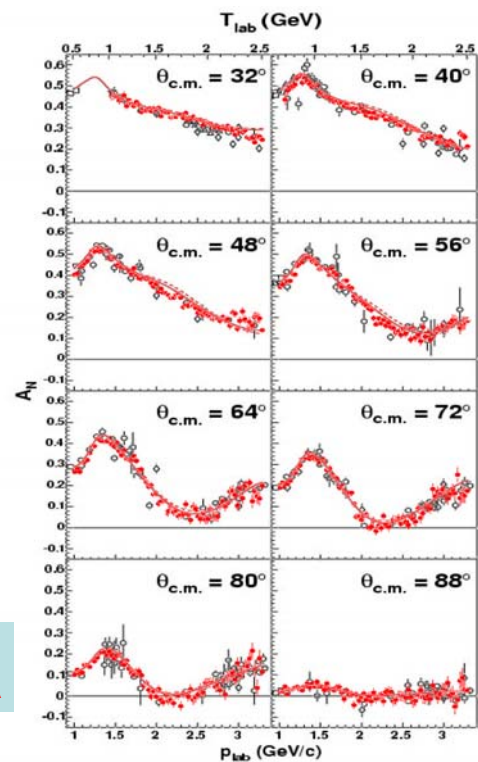
- Excitation functions, angular distributions
- Continuous measurements during acceleration (ramping mode)
- Wide energy and angular range
- High precision and internal consistency in normalization

pre EDDA
EDDA



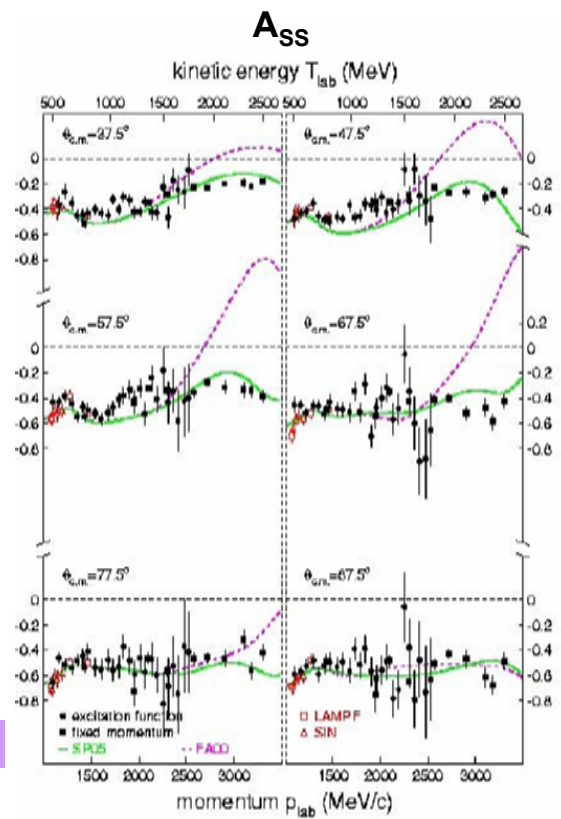
D. Albers et al., Eur. Phys. J. A22, 125 (2004)

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



pre EDDA
EDDA

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



F.Bauer et al., Phys. Rev. C 71, 054002 (2005)

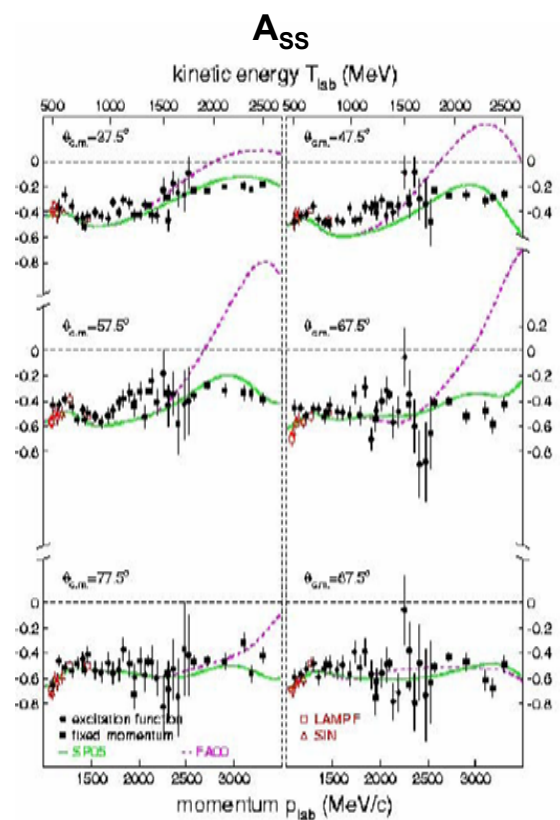
Scientific impact:

- ▶ New Phase Shift Analysis including all EDDA results:

--- FA 00
— SP 05

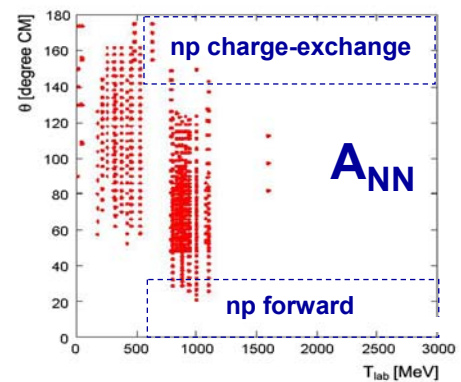
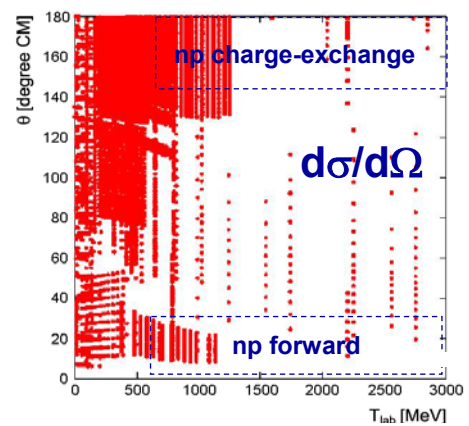
- ▶ Important step to develop NN OBE models
- ▶ Exclusion limits on narrow dibaryon resonances

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

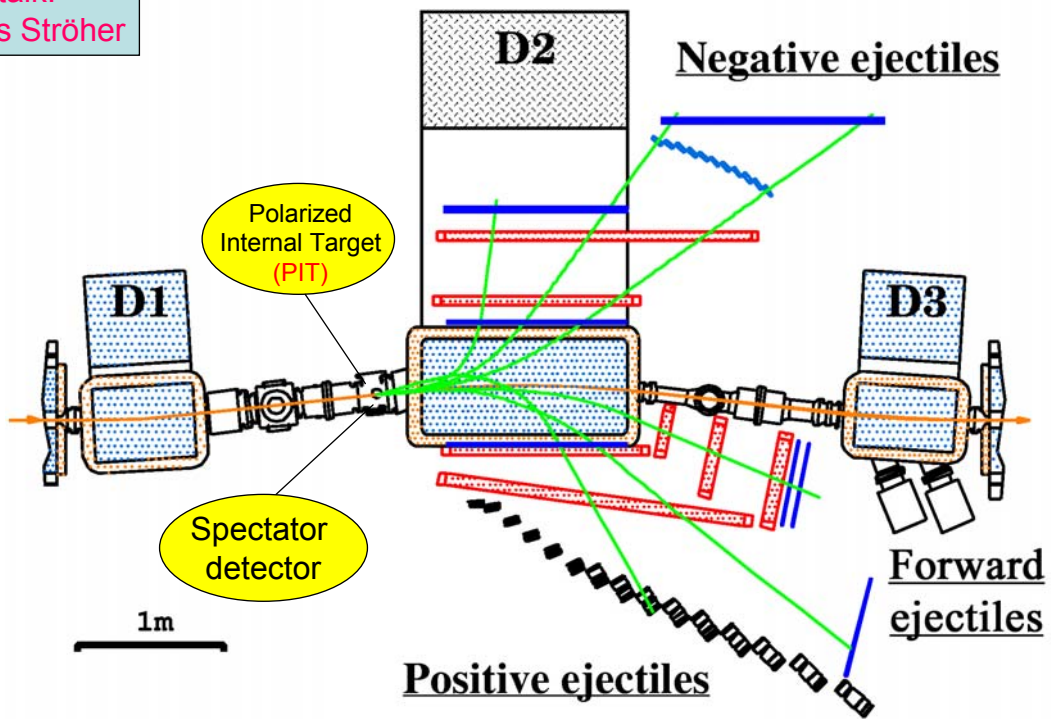




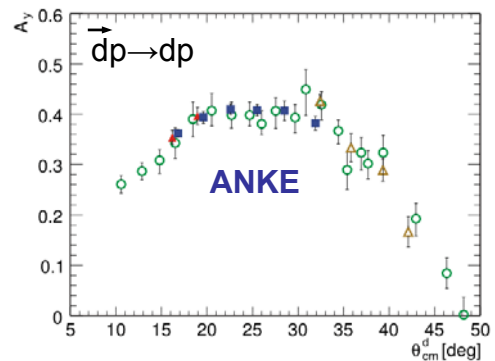
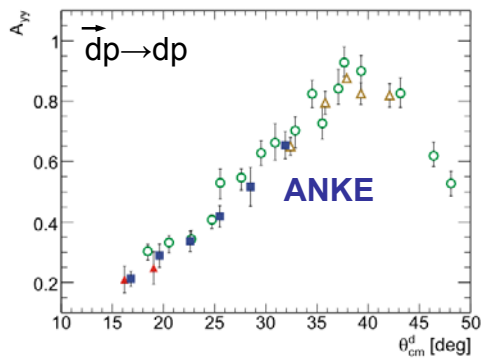
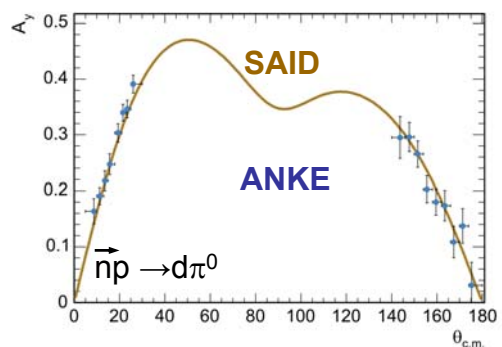
- Status of data base: limited
- Method: polarized deuteron (beam or target) as a neutron source
- **ANKE**: high-quality np data in forward / backward region



see talk:
Hans Ströher



- Calibration energy: $T_d = 1170$ MeV
 1. $\vec{d}p$ elastic (A_y, A_{yy})
 2. $\vec{d}p \rightarrow {}^3\text{He}\pi^0$ (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;* nucl-ex/0511052; Accepted by Phys. Rev. ST-AB, April (2006)



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

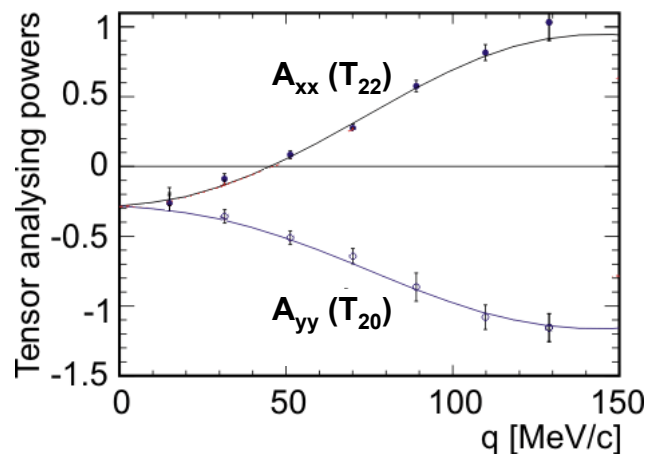
Obtain np elementary spin-dependent
amplitudes:

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

Results:

- ▶ Method works at $T_n = 585$ MeV
- ▶ Application to “uncharted territory”

$T_d = 1170$ MeV



D. Chiladze et al., *Vector and tensor analyzing powers in dp-breakup reactions at intermediate energies*; nucl-ex/0601038; Accepted by PLB, April (2006)

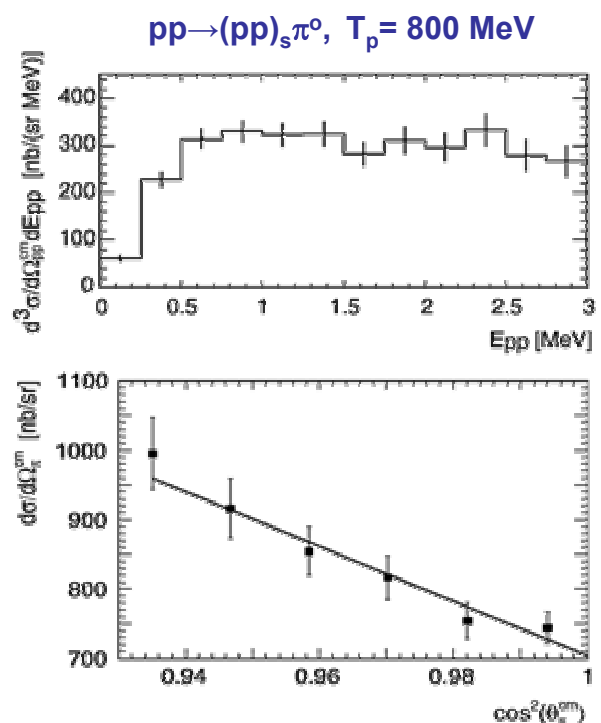


Meson Production

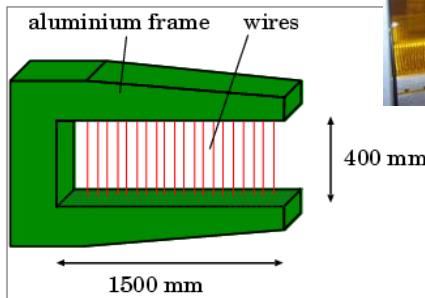
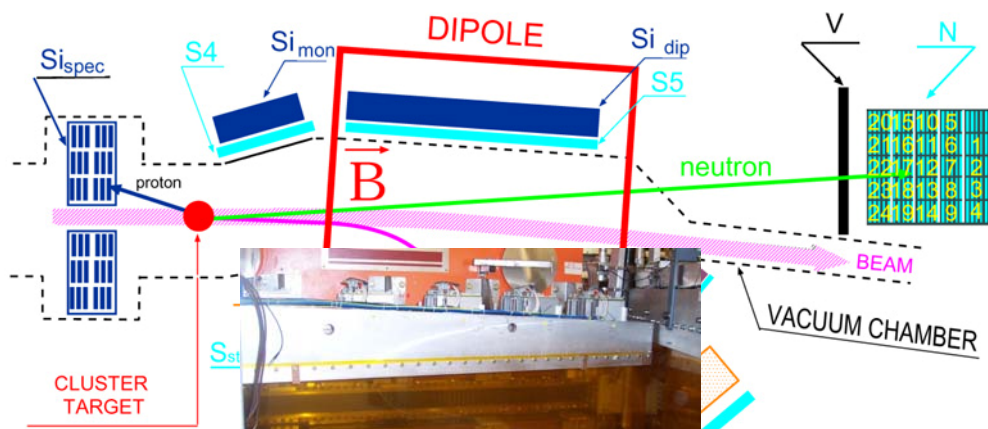
- $pp \rightarrow (pp)_s \pi^0$ $T_p = 350 \dots 950$ MeV
- $pn \rightarrow (pp)_s \pi^-$ $T_p = 350$ MeV
- low energy:
provide data of relevance for ChPT studies
- higher energies:
crucial extra test of pion production dynamics

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)**



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

April 27, 2006



Results:

- ▶ η/η' mesons: pp FSI
- ▶ η meson: in addition ηp FSI
- ▶ strong η NN interaction

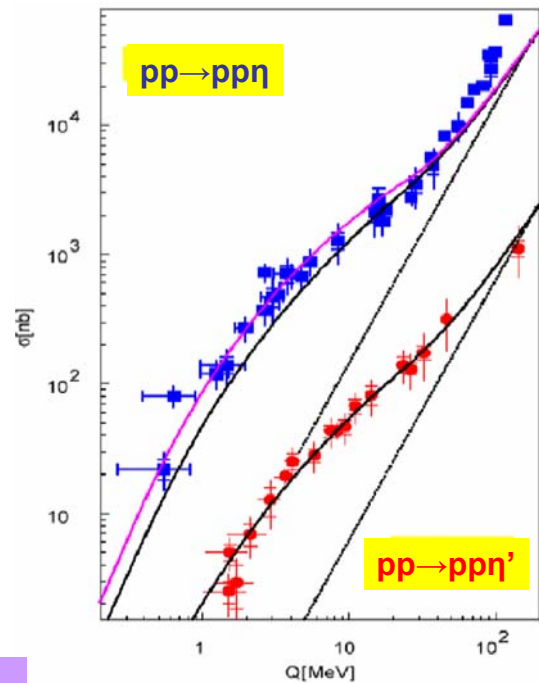
Next:

Isospin dependence:

$p n \rightarrow p n \eta, d\eta$

$p n \rightarrow p n \eta', d\eta'$

(Analysis in progress)

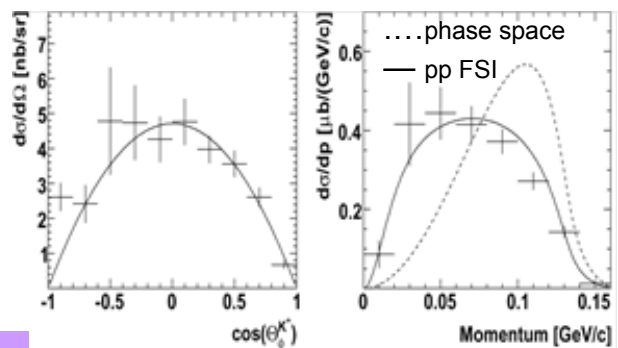
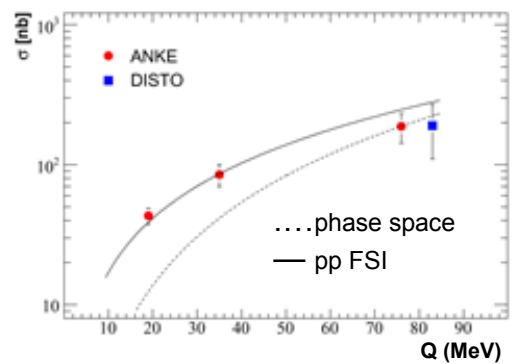


P.Moskal et al., Phys. Rev. C 69 (2004) 025203
A.Khoukaz et al., Eur. Phys. J. A 20 (2004) 345

- $pp \rightarrow pp\Phi$ near threshold
(three excess energies)

Results:

- ▶ S-wave dominance
- ▶ significant FSI
- ▶ new insight into OZI rule



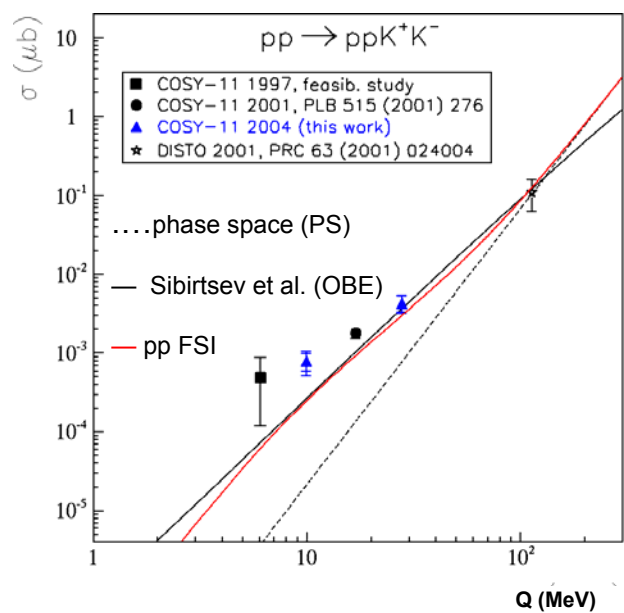
M.Hartmann et al., *The Near-Threshold Production of Φ Mesons in the pp Collisions*; nucl-ex/0604010, Submitted to PRL, 2006 (two positive reports)



- K⁺K⁻ close to threshold

- Results:

- ▶ pure PS
- ▶ with pp FSI
- ▶ reaction mechanism



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

Resonant:

$$\sigma_{\text{tot}}(pp \rightarrow pp\phi) = \sigma_{\text{T}}$$

$$\sigma_{\text{tot}}(pn \rightarrow d\phi) = \sigma_{\text{S}}^{\text{d}}$$

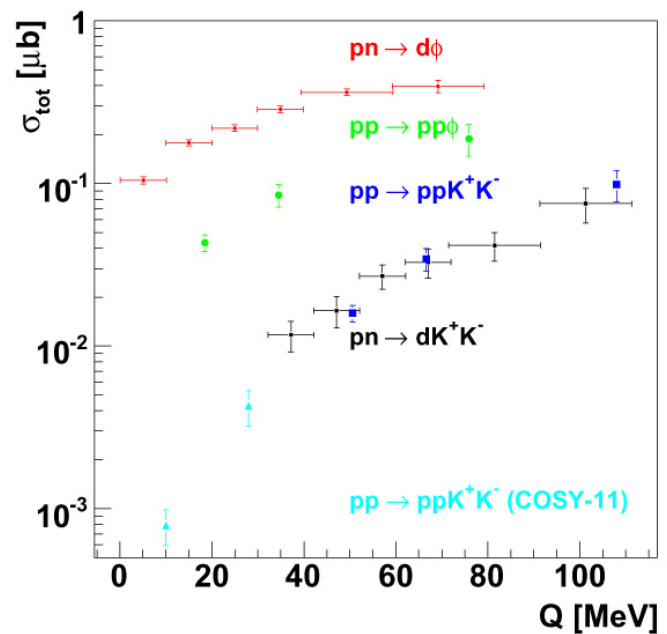
Non-resonant:

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

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

Preliminary result:

► Unusual pattern

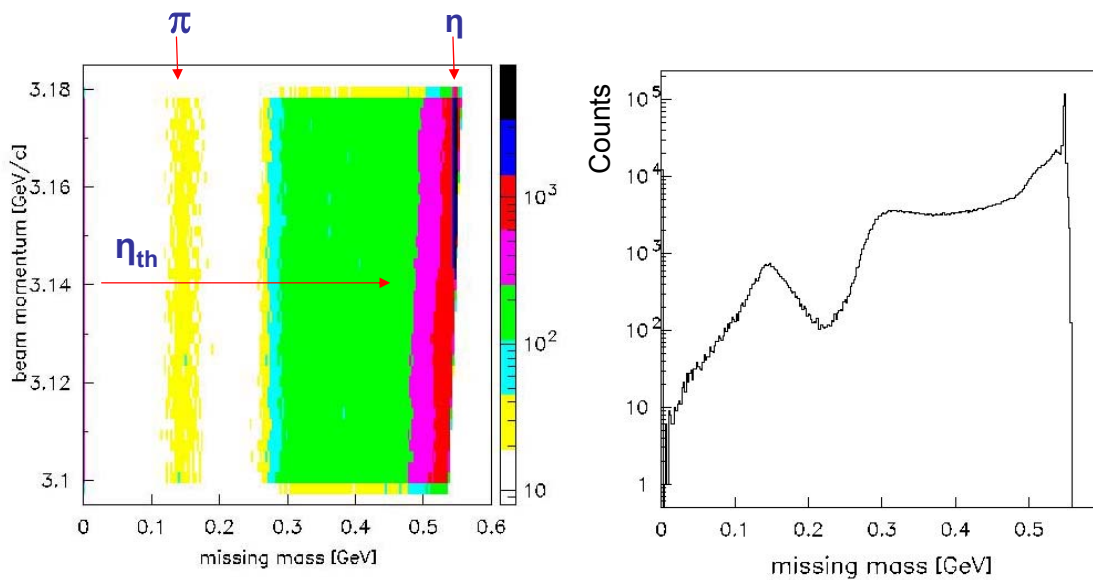


Y. Maeda et al., ϕ Meson Production in pn Collisions;
(paper in preparation)

Nuclear-Meson Production



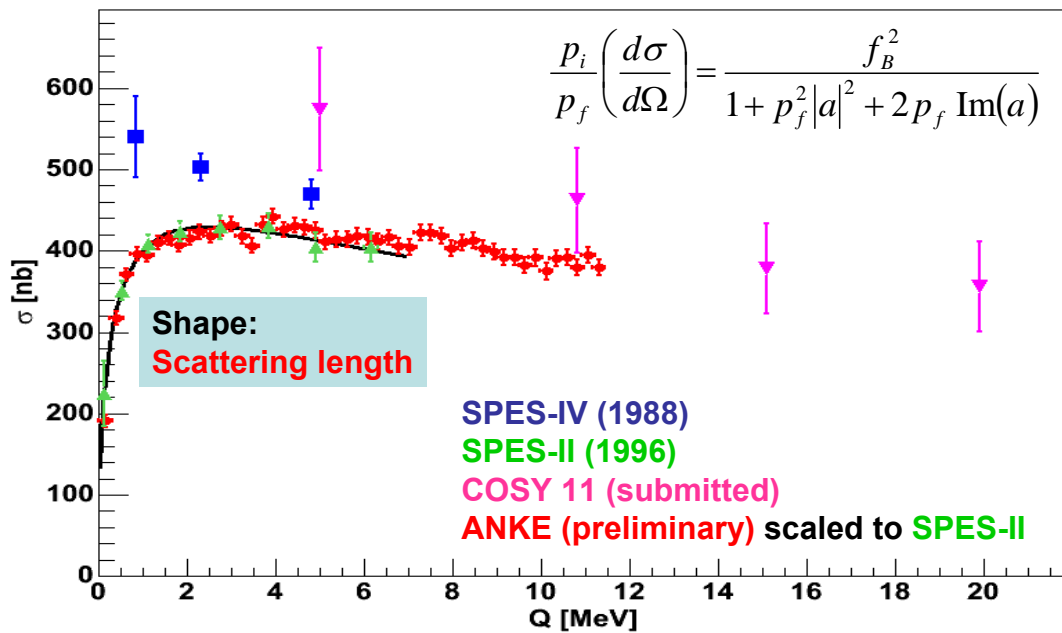
$d p \rightarrow ^3\text{He} X \text{ (} X = \pi^0, \eta \text{)}$



Preliminary result:

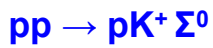
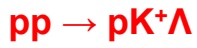
► High quality data, analysis in progress

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



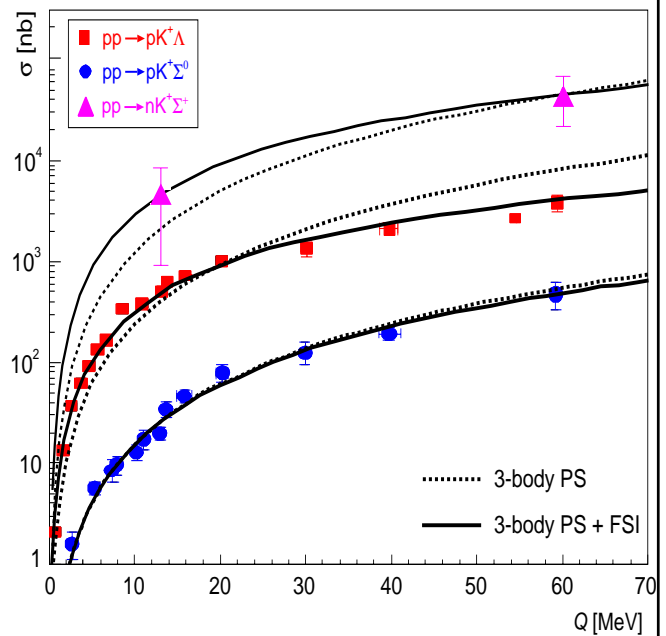
T. Mersmann, Münster university, March (2006)

Hyperon Production



Results:

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



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

- **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)



Publications list (2004-2006)

- | | |
|--|---------|
| 1. A. Khoukaz et al., Eur. Phys. J. A 20, 345 (2004) | COSY-11 |
| 2. S. Barsov et al., Eur. Phys. J. A 21, 521 (2004) | ANKE |
| 3. V. Grishina et al., Eur. Phys. J. A 21, 507 (2004) | ANKE |
| 4. D. Albers et al., Eur. Phys. J. A 22, 125 (2004) | EDDA |
| 5. P. Kowina et al., Eur. Phys. J. A 22, 293 (2004) | COSY-11 |
| 6. M. Büscher et al., et al., Eur. Phys. J. A 22, 301 (2004) | ANKE |
| 7. D. Altmeier et al., Eur. Phys. J. A 23, 351 (2004) | EDDA |
| 8. P. Moskal et al., Phys. Rev. C 69, 025203 (2004) | COSY-11 |
| 9. I. Lehmann et al., NIM, A 530, 275 (2004) | ANKE |
| 10. A. Wrońska et al., Eur. Phys. J. A 26, 421 (2005) | ANKE |
| 11. F. Rauer et al., Phys. Rev. C 71, 054002 (2005) | EDDA |
| 12. S. Yaschenko et al., Phys. Rev. Lett. 94, 072304 (2005) | ANKE |
| 13. R. Engels et al., Rev. Scient. Instr. 76, 053305 (2005) | ANKE |
| 14. J. Smyrski et al., NIM, A 541, 574 (2005) | COSY-11 |
| 15. P. Moskal et al., J. Phys. G 32, 629 (2006) | COSY-11 |
| 16. P. Winter et al., Phys. Lett. B 635, 23 (2006) | COSY-11 |
| 17. P. Fedorets, et al., Yad. Fiz. 69, 306 (2006) | ANKE |
| 18. S. Dymov et al., Phys. Lett. B 635, 270 (2006) | ANKE |
| 19. I. Zychor et al., Phys. Rev. Lett. 96, 0123002 (2006) | ANKE |

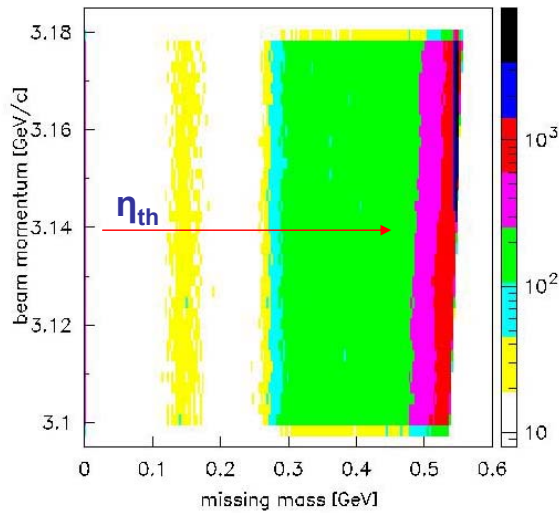


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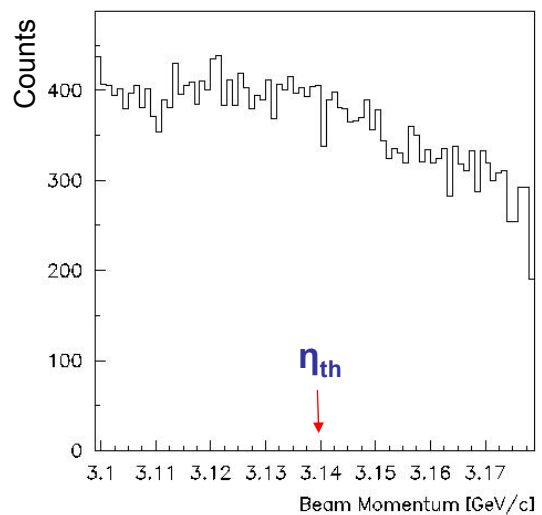
- | | | |
|-----|--|---------|
| 20. | H. Kleines et al., Accepted by NIM A (in print) (2006) | ANKE |
| 21. | D. Chiladze et al., Accepted by Phys. Lett. B (April, 2006) | ANKE |
| 22. | D. Chiladze et al., Accepted by Phys. Rev. ST-AB (April, 2006) | ANKE |
| 23. | M. Hartmann et al., Accepted by Phys. Rev. Lett. (April, 2006) | ANKE |
| 24. | T. Rožek et al., Submitted to Phys. Lett. B (2006) | COSY-11 |
| 25. | H.-H. Adam et al., Submitted to Phys. Rev. C (2006) | COSY-11 |



$dp \rightarrow {}^3\text{He} X$ ($X = \pi^0, \eta$)



$dp \rightarrow {}^3\text{He} \pi^0$



Preliminary result:

► High quality data, analysis in progress

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