

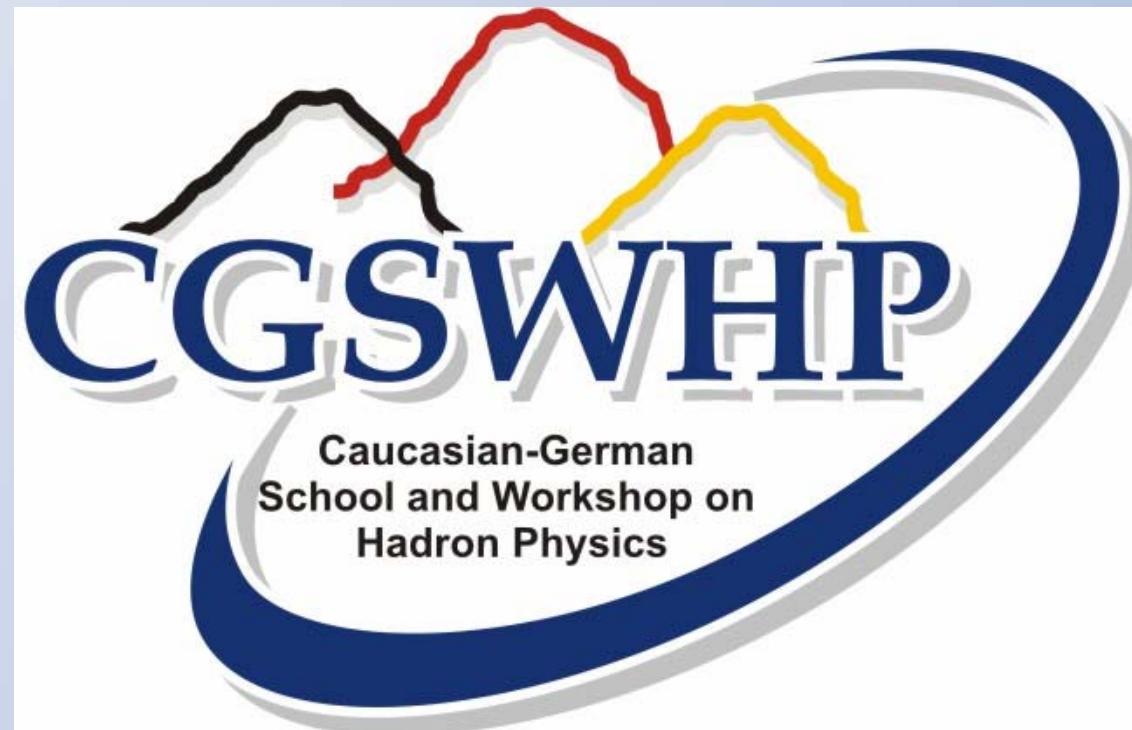


General Introductory Remarks



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CGSWHP '04:



... we will come back ... and, ... here we are !!



CGSWHP'06: „Spin in Hadron Physics“

Caucasian-German School and Workshop in Hadron An Overview Physics

- Ongoing physics program at COSY:
 - Overview talks, specialised reports
- Antiproton physics at the (to be built) FAIR:
 - Introductory talks on physics, technical aspects
 - Preparatory work at COSY
 - Effects of the Nuclear Medium
 - Non Strange and Strange Meson Production
 - Fundamental Symmetries and Symmetry Breaking
- ISTC-projects:
 - Status and progress reports
- Miscellaneous:
 - Lectures and reports on special issues
 - Spin Physics with Polarized Antiprotons - Tantalum
 - Nuclear and Hadron Physics with Stored Antiprotons
 - Quark Spectroscopy - PANDA Experiment

<http://www.fz-juelich.de/ikp/cgswhp>



The Hadron Physics Program at COSY-Jülich

Hans Ströher (IKP, FZ-Jülich, Jülich, Germany)



CGSWHP'06, Tbilisi, Spin in Hadron Physics

Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft



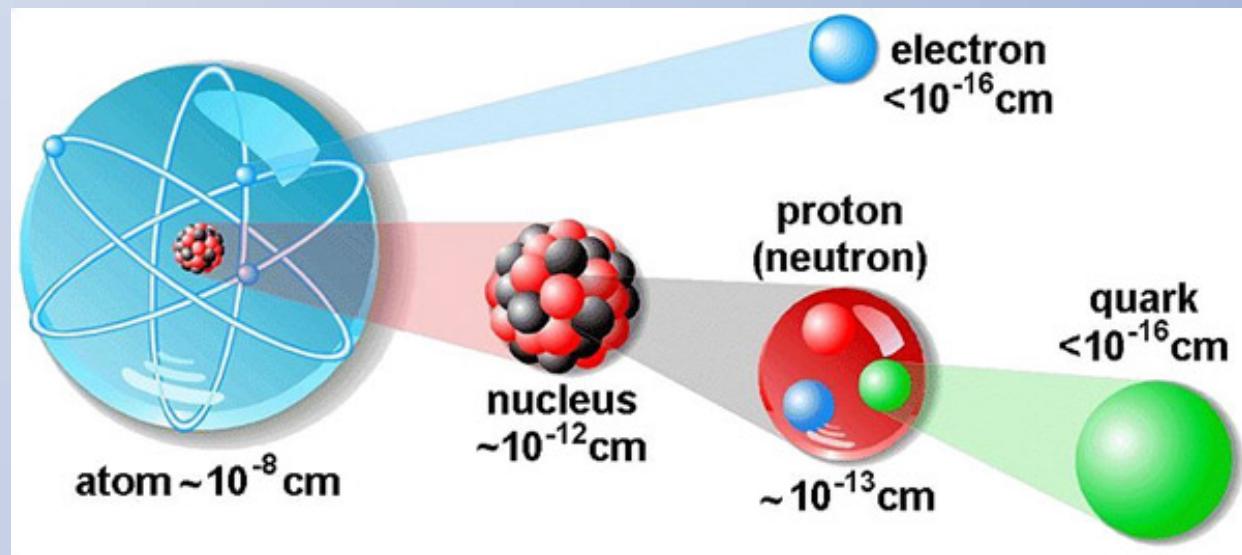
The Hadron Physics Program at COSY-Jülich

Science aims to understand Nature

→ conceive, develop, explore, test, (im-)prove or discard ... models



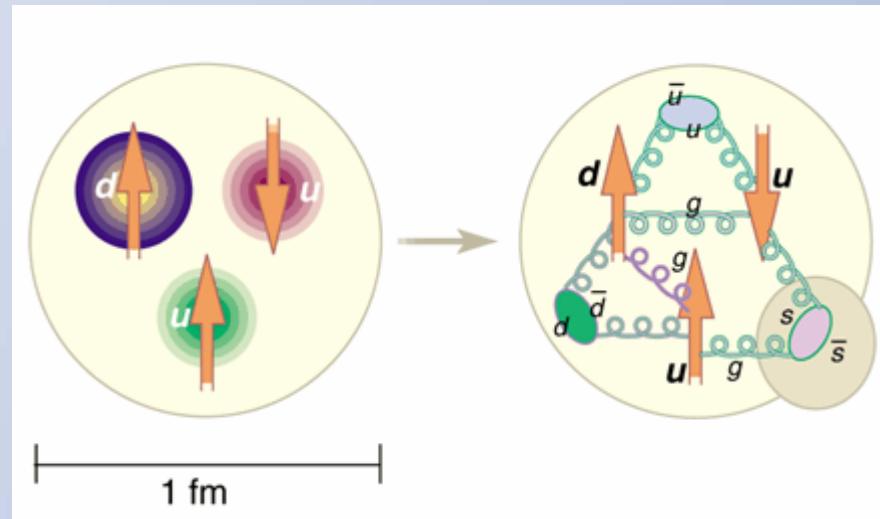
simple, but wrong



complex but not falsified yet

Hadron Physics: Understanding of all matter comprised of quarks and gluons:

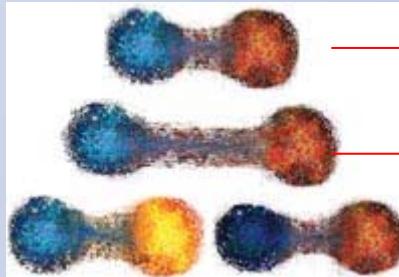
How does QCD (nature) *make* hadrons?



Evolution of our view of the nucleon

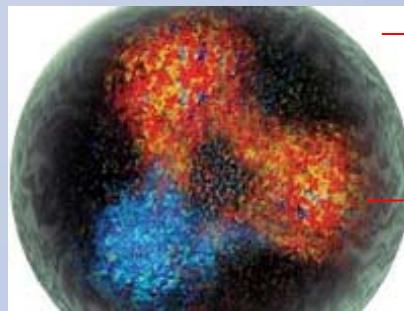
Fundamental questions (I):

- No free quarks?
"Confinement"



qq-interaction;
force independent
of distance

- Mass of hadrons?
"Mass without mass"
- Changes in medium?
"Restoration of
Chiral Symmetry"



QCD vacuum

Valence quark

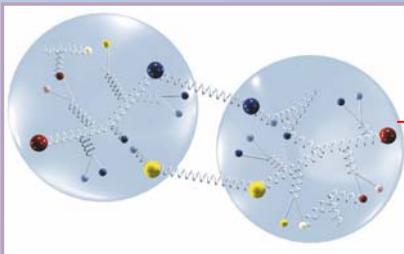
- Hadronic states?
Spectroscopy



Meson

Baryon

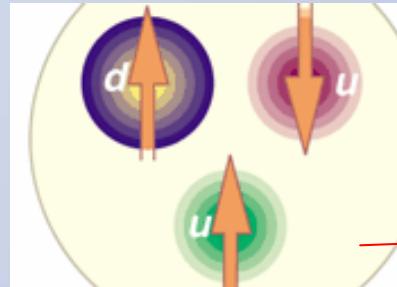
- Hadronic interaction?
Remnant of
quark-quark
interaction



Composite
nucleon

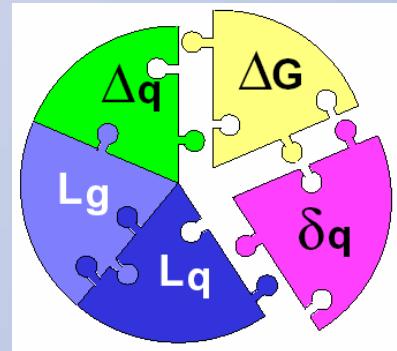
Fundamental Questions (II):

- Spin of composite particles (e.g. proton)?
“Spin Puzzle”



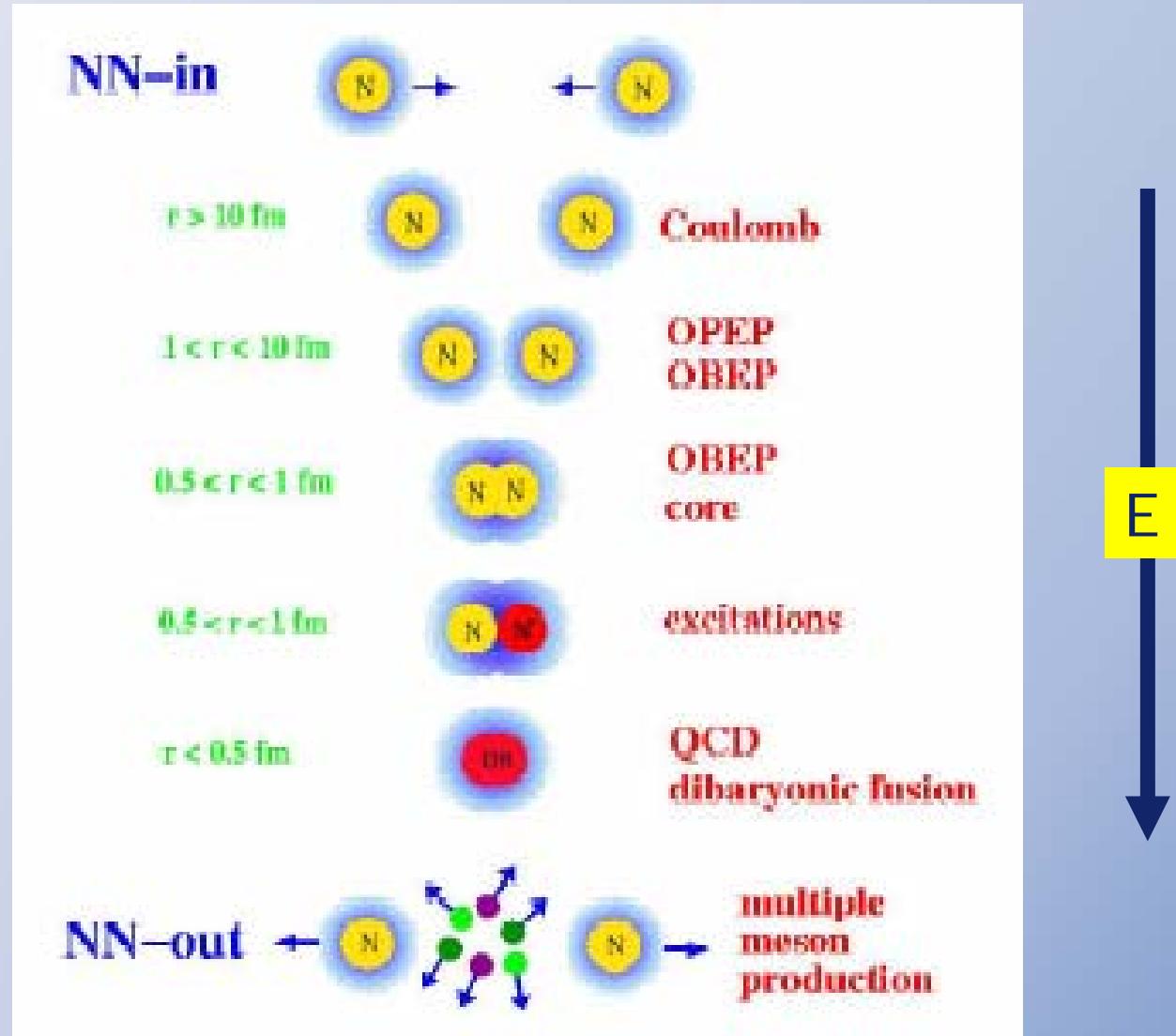
$$\gamma_2 =$$

quarks +
antiquarks +
gluons + orb.
ang. momentum

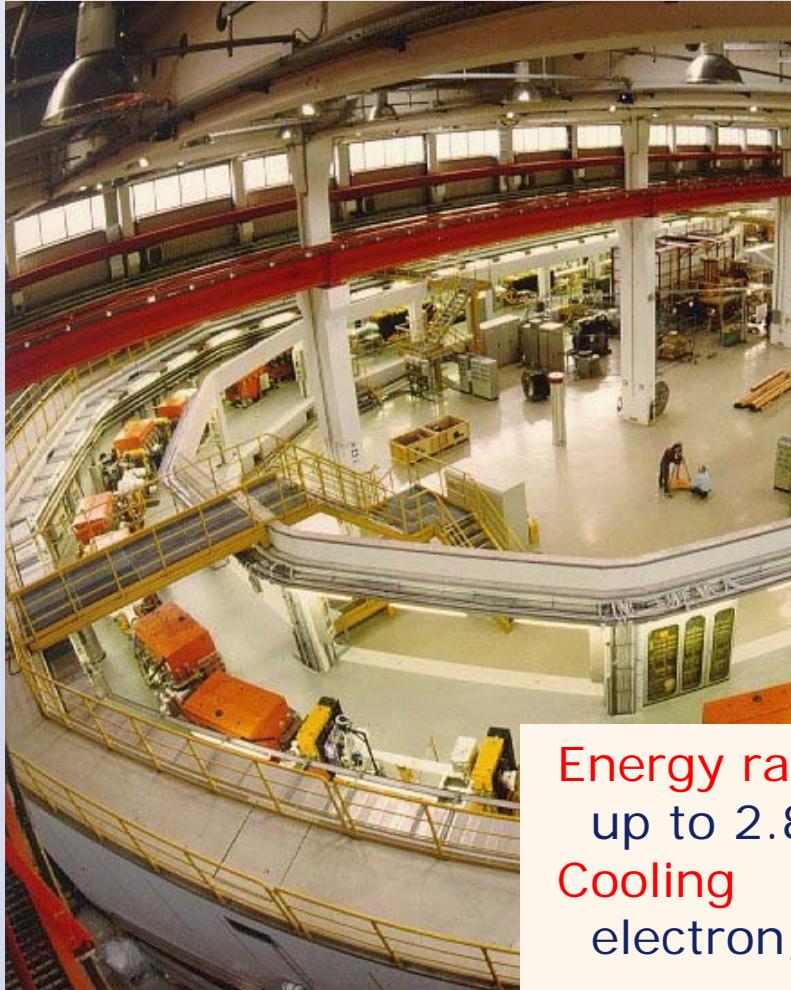


→ Experiments:
em and hadronic probes

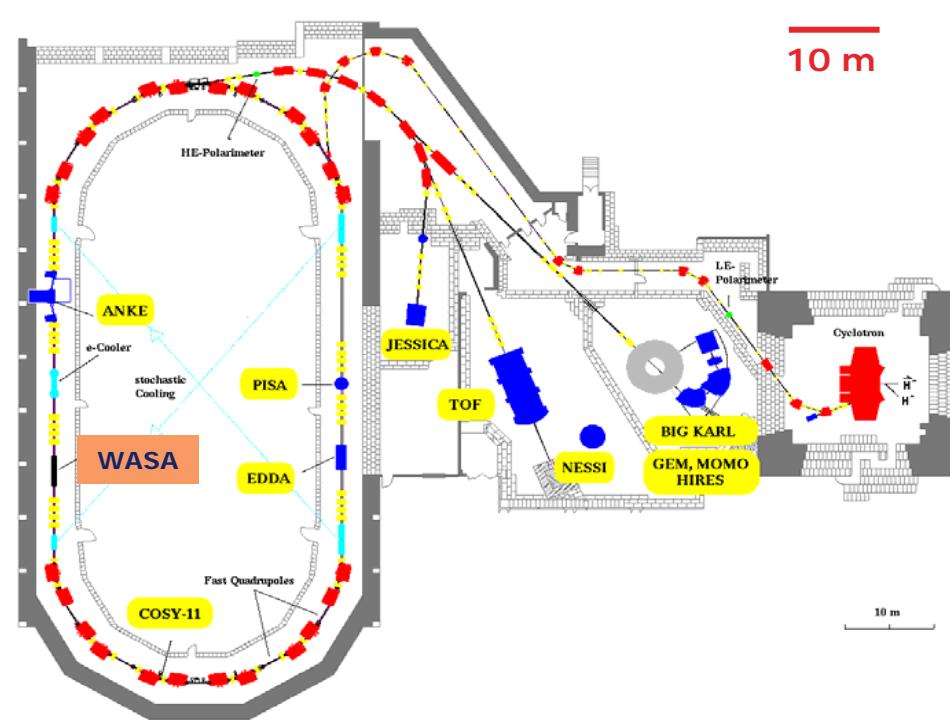
Research at COSY: An Overview



Experimental tools (I): Accelerator



Energy range
up to 2.83 GeV
Cooling
electron, stochastic



Polarization
p, d beams & targets
Beams
internal, extracted

Cooler Synchrotron (COSY)

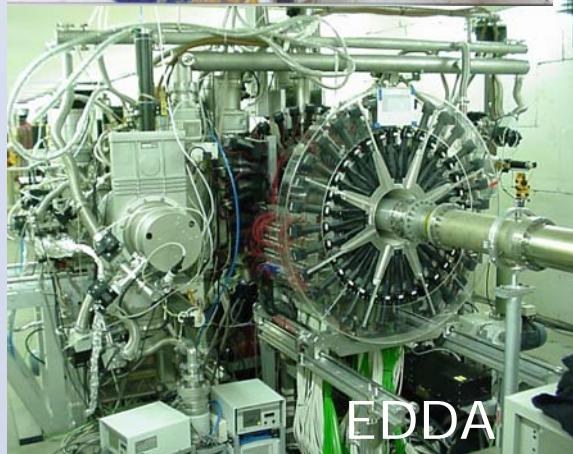
Experimental tools (II): Detectors; Status 2006



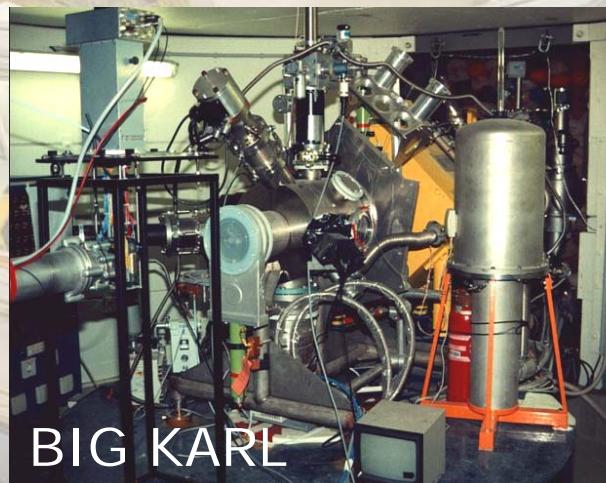
ANKE



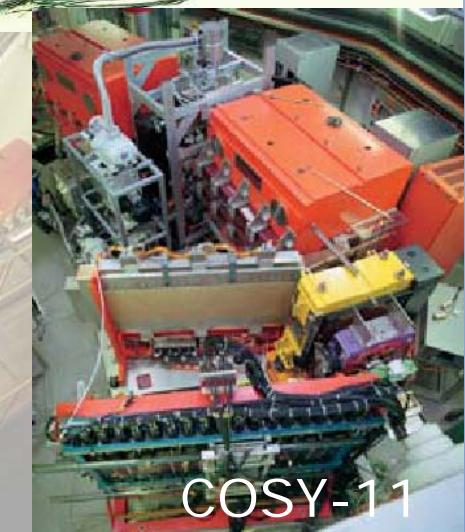
COSY



EDDA



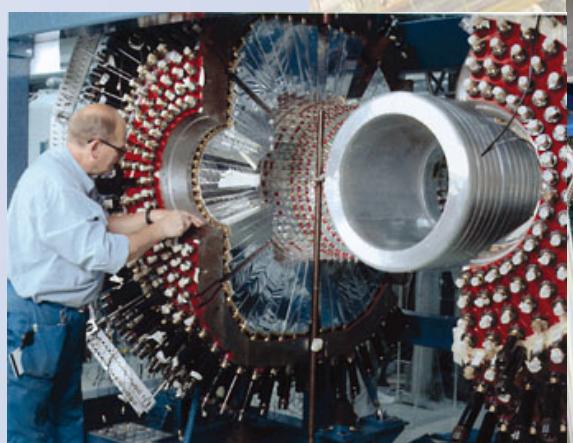
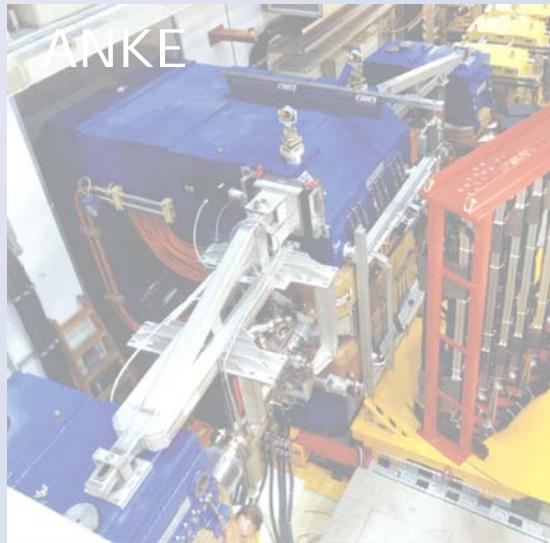
BIG KARL



COSY-11

No photon detection

Experimental tools (II): Detectors; Future



ANKE, TOF and WASA

Research at COSY: An Overview

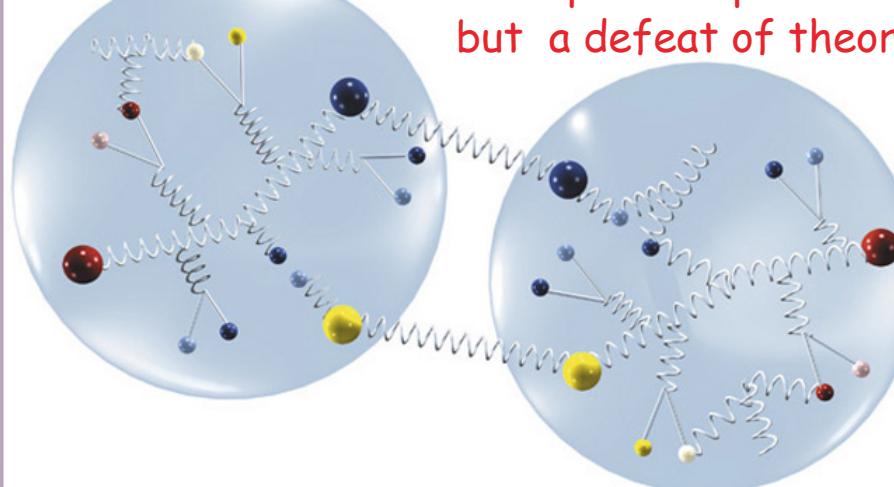
Spectroscopy, Spin, Symmetry

- Nuclear Forces Hadronic Spectroscopy (N^* 's, Exotics)
- Strangeness Role of s-Quark (OZI)
- Symmetries Symmetries and Symmetry Breaking
(ChS, P, C, IS)
- In-medium Final State Interactions (Bound States)
Modifications

...

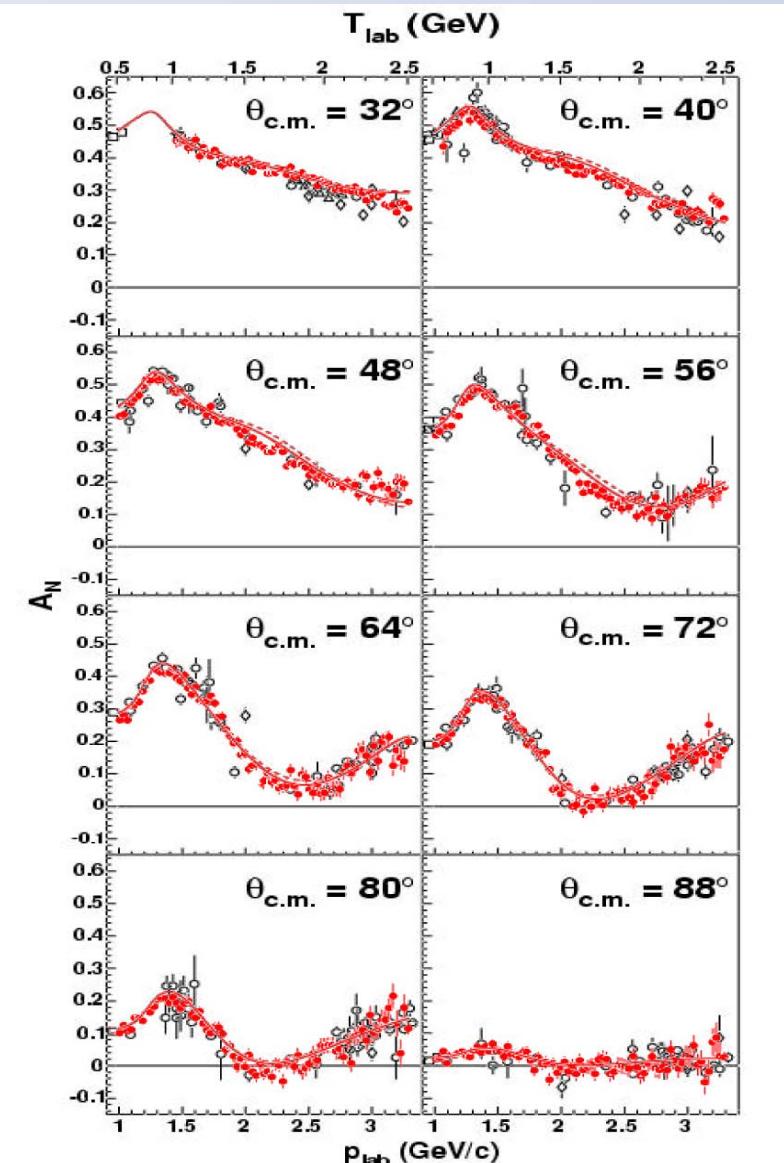
- use of isospin and polarization (beams, targets) as tools!
- exploit (final state) photons as a probe (WASA)!

R. Machleidt: A triumph of experiment,
but a defeat of theory



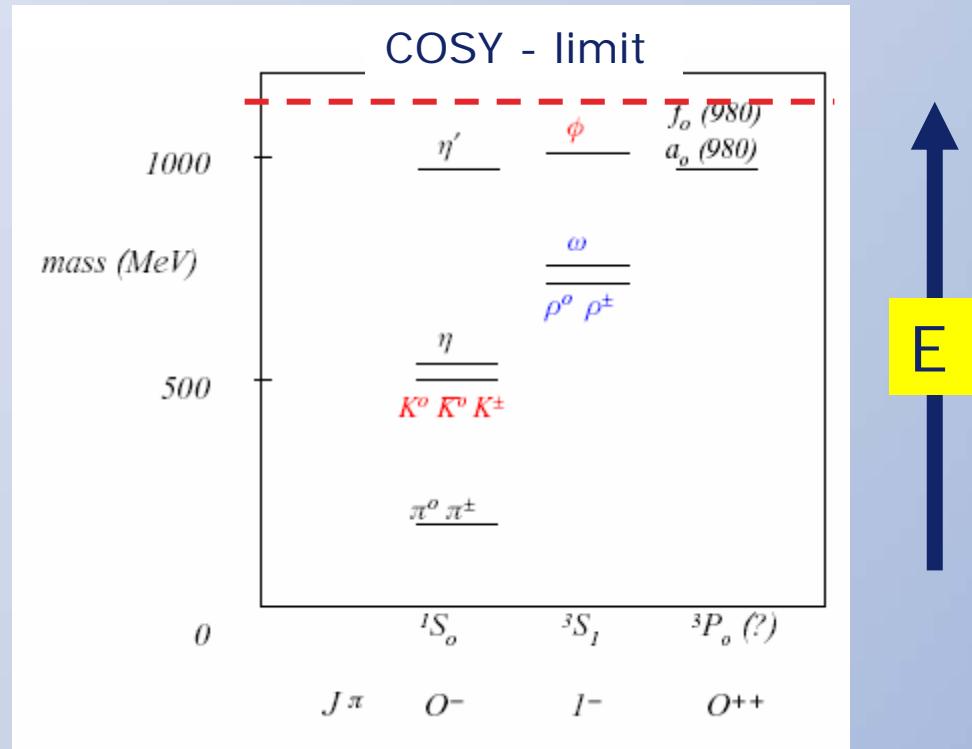
(1) NN-Interaction

NN-Interaction – The EDDA Legacy



- 8 (of 15) angular distributions:
 - high precision
 - internal consistency
- in addition: unpolarized (σ) and double polarized (A_{NN} , A_{SS} , A_{SL}) data
- significant impact on PSA
(i.p. spin triplet phase shift)
- no evidence for narrow resonances (dibaryons)

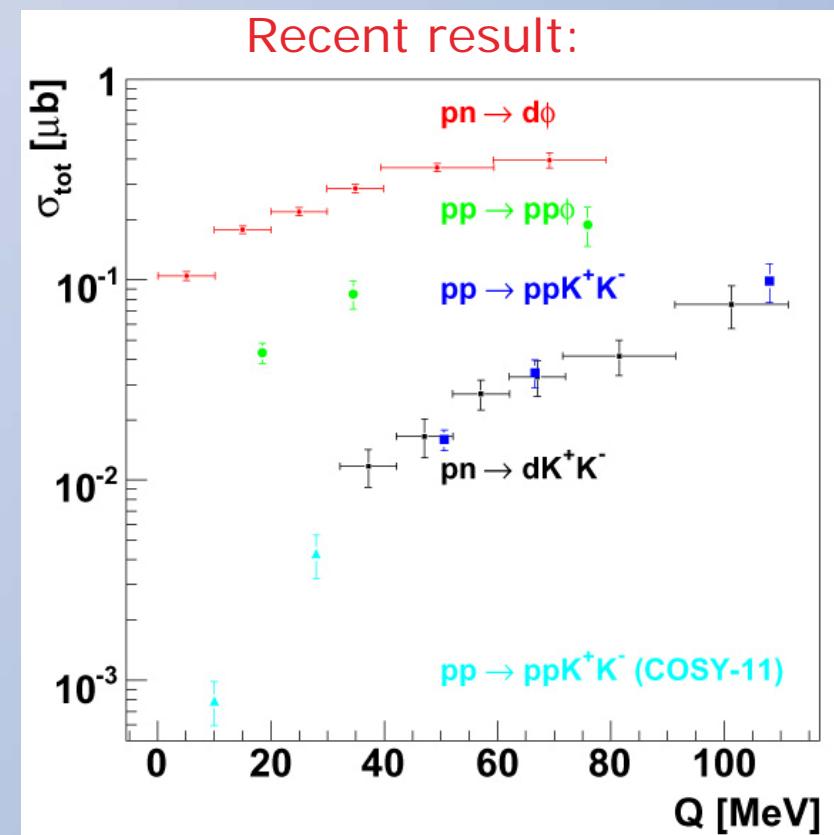
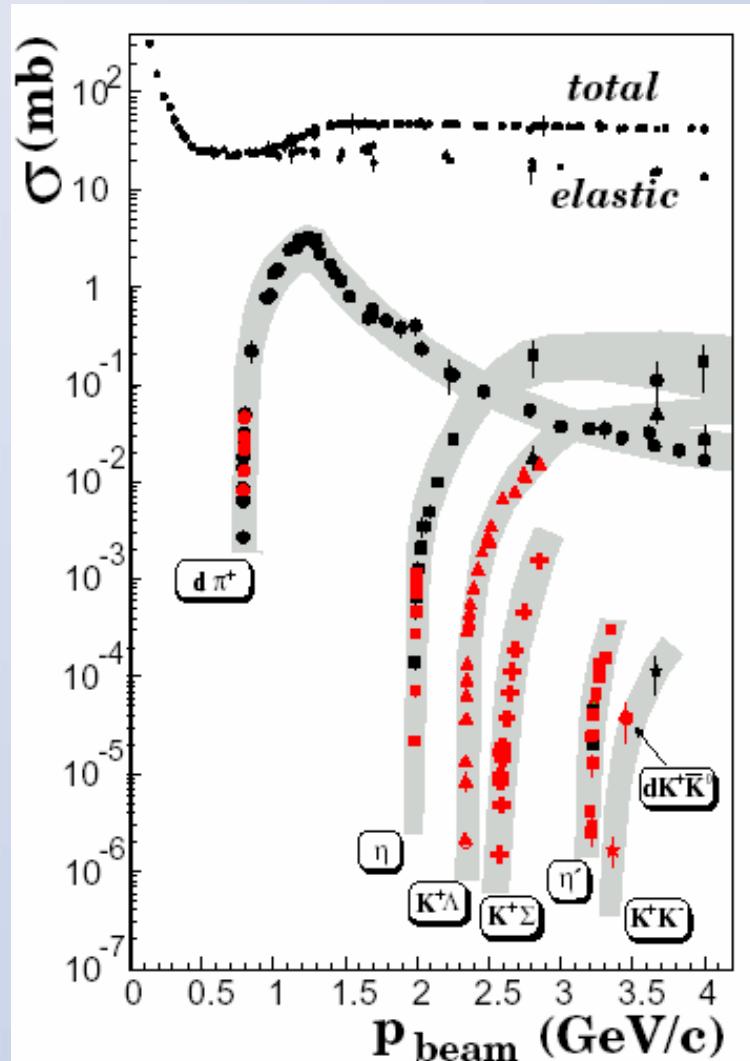
M. Altmeier et al., EPJ A 23, 351 (2005)



(2) Meson Production

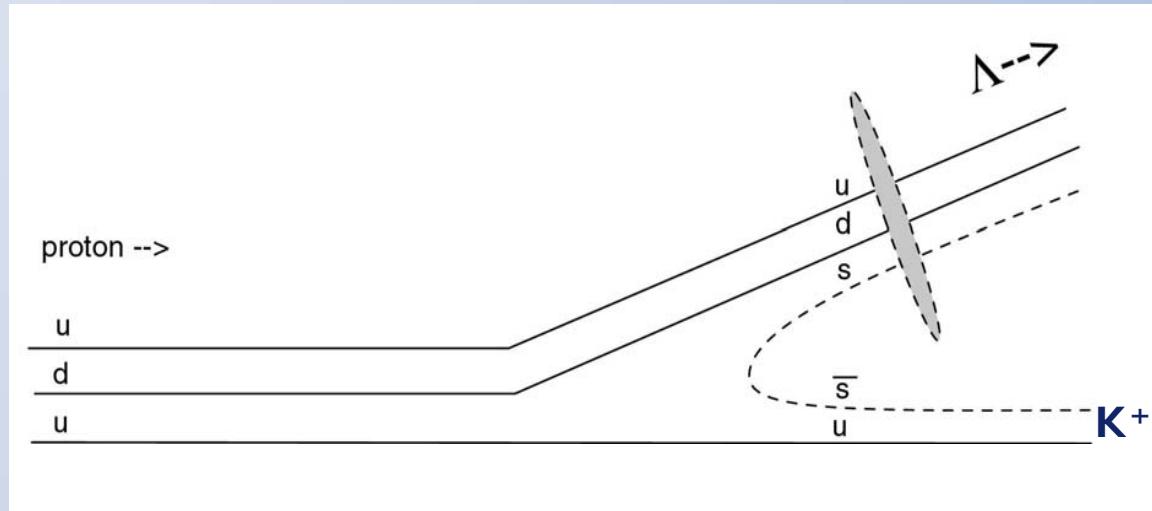
Meson Production: From Pions to the Phi

- Near Threshold Meson Production in Storage Rings:



M. H. et al., PRL 96, 242301 (2006)
Y. Maeda et al., accept. PRL (2006)

P. Winter et al., PL B 635, 23 (2006)



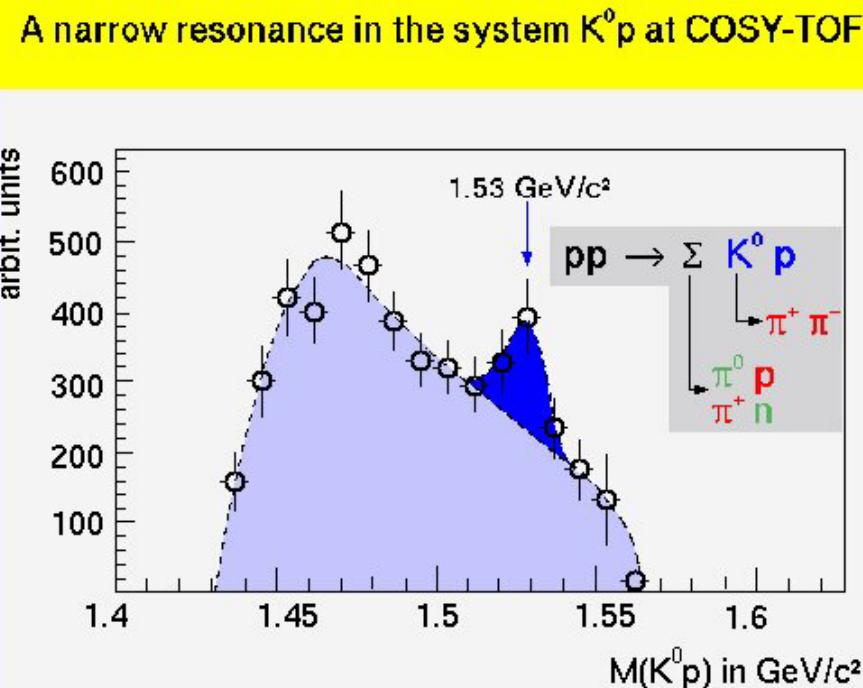
(3) Strangeness Production

Strangeness Production: To be or not ...

- Indications for exotic states:

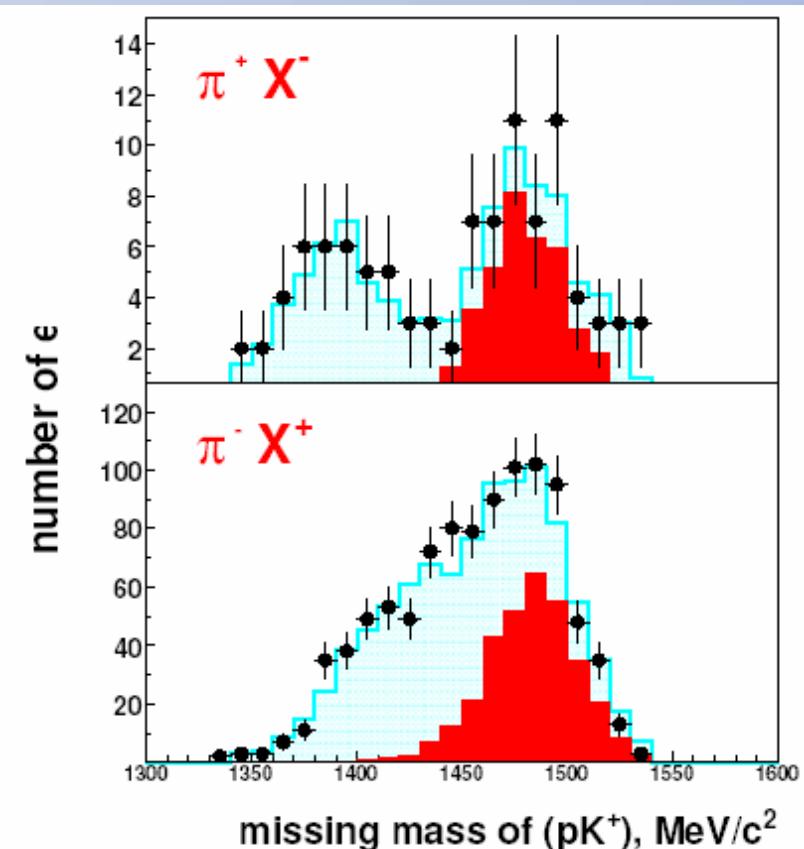
COSY contribution to

“The Tale of the Pentaquark”



M. Abdel-Bary et al., PL B 595, 127 (2004)

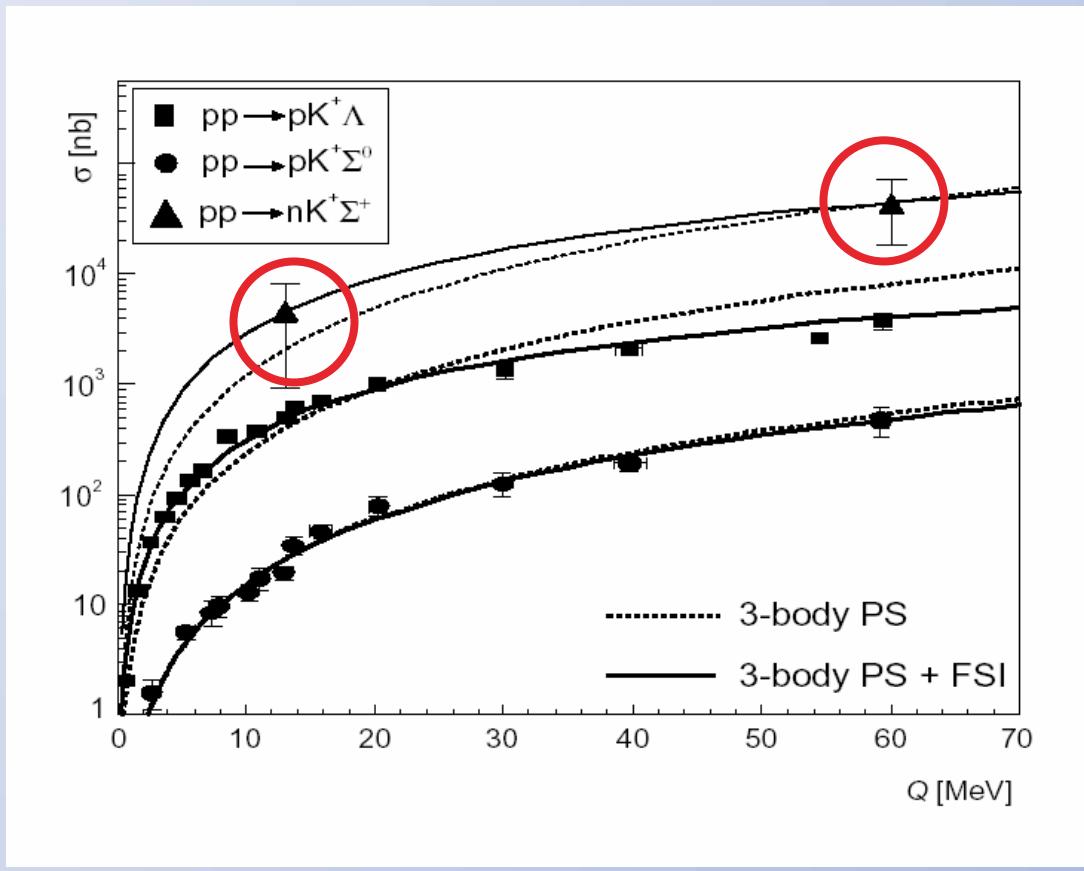
New experiment
(→ ongoing analysis)



I. Zychor et al., PRL 96, 012002 (2006)

Strangeness Production: To be or not ...

- Total cross sections for: $pp \rightarrow NKY$ (mostly COSY-11 data)

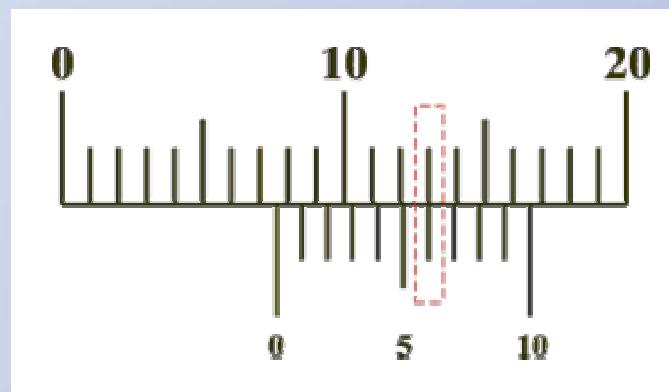


Why is Σ^+ cross section larger than Σ^0 (and even Λ) ?

... or is it ???

See analysis by
Yu. Valdau

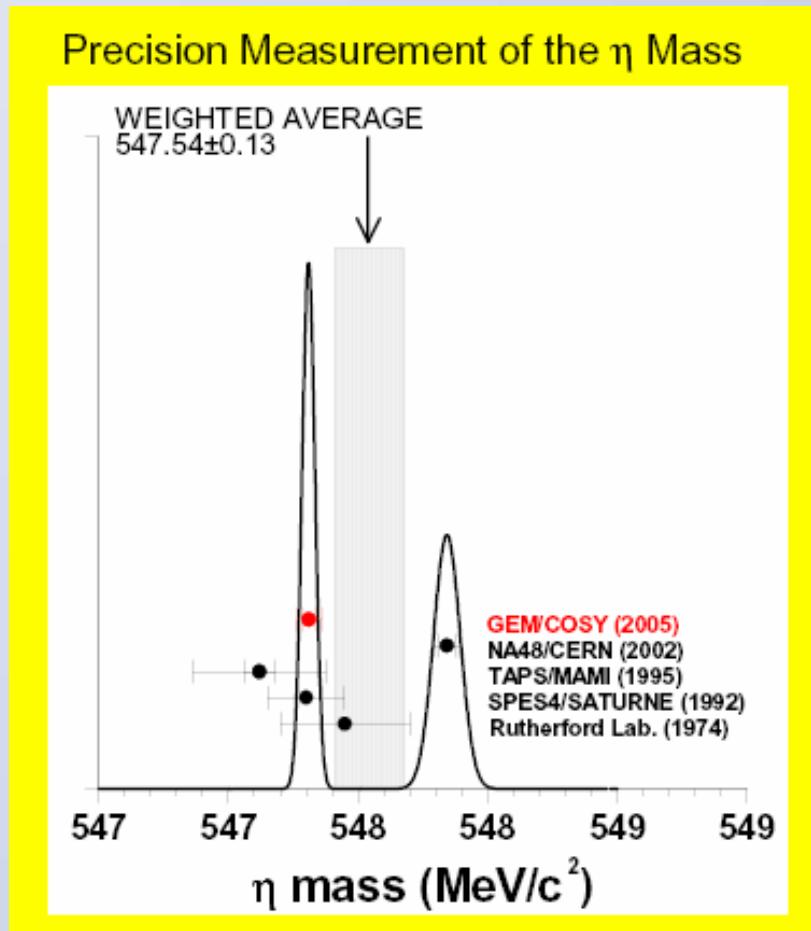
T. Rozek et al., PL B (2006), in print



(4) Precision Measurements

Precision Mass Measurements

- Mass of the η -meson:



- precision measurement (BIG KARL) \leftrightarrow missing mass
 $\rightarrow 547311 \pm 28 \pm 32 \text{ keV}/c^2$
- NA48 \leftrightarrow η decay into $3\pi^\circ$
 $\rightarrow 547834 \pm 30 \pm 41 \text{ keV}/c^2$
- KLOE \leftrightarrow η decay into $\gamma\gamma$
 $\rightarrow 547822 \pm 5 \pm 69 \text{ keV}/c^2$

~ 8σ discrepancy !!

M. Abdel-Bary et al., PL B 619, 281 (2005)

Precision Tool: Photons

- „Seeing the light“ with WASA:

Well known (QED) electromagnetic probe –

often used in: initial state

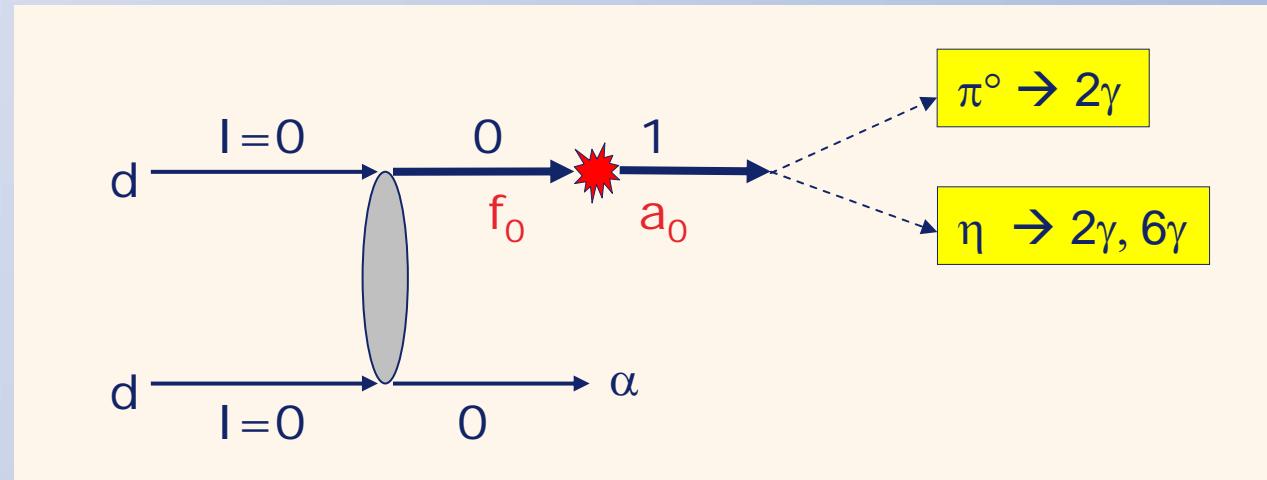


now: final state



→ Use $\sim 4\pi$ em calorimeter and reconstruct invariant mass

Physics: symmetries – just one example: $d + d \rightarrow \alpha + f_0 / a_0$



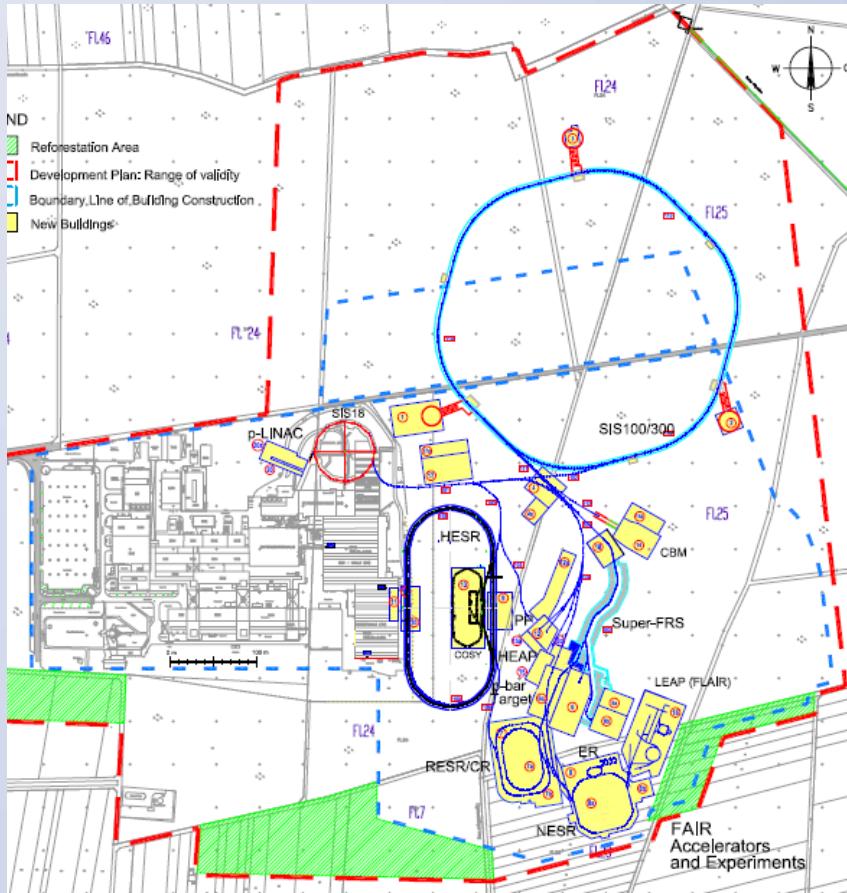
↔ structure, nature of scalar mesons $a(980)$ and $f(980)$



(5) R&D Projects

Preparing for the Future: FAIR at GSI-Darmstadt

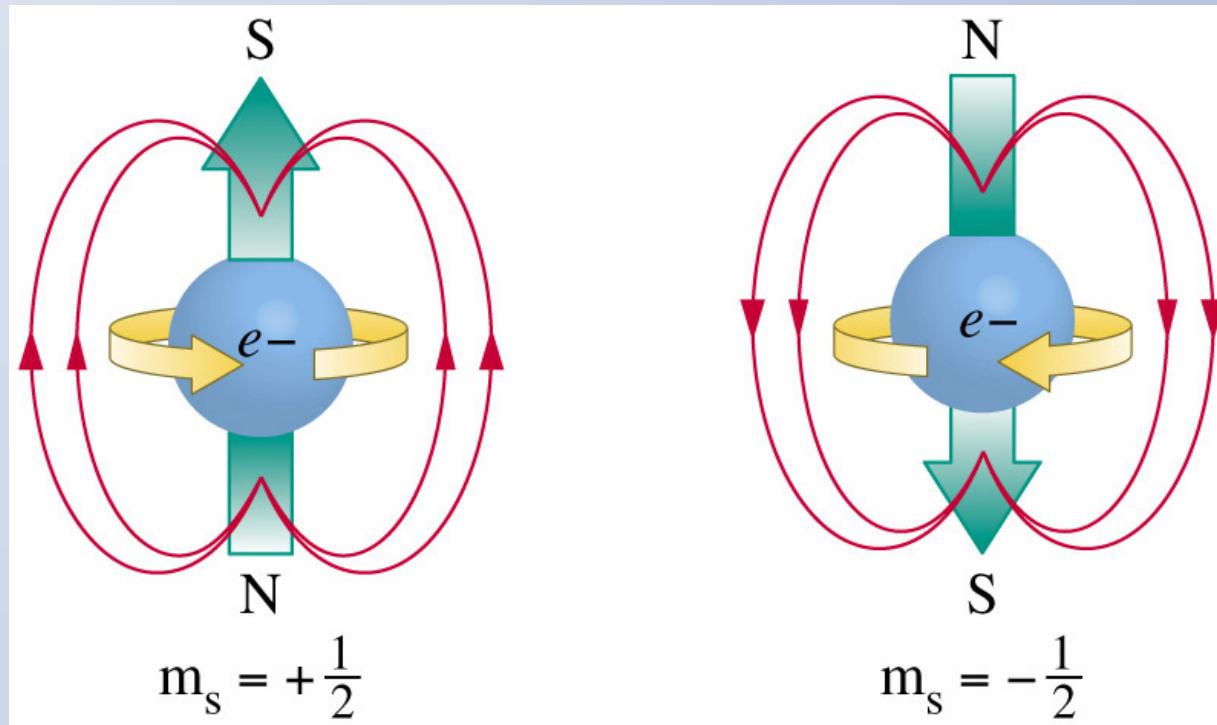
- IKP is heavily involved in the FAIR-project:



- HESR – the synchrotron and storage ring for antiprotons – is being designed, constructed and built by an international consortium, lead by Jülich
- Future upgrade option:
→ POLARIZED anti-protons
↔ HOW ?

Polarization of Anti-Protons

- Method (fast, efficient ...) to select one of the 2 possible states (for spin- $\frac{1}{2}$ particles):

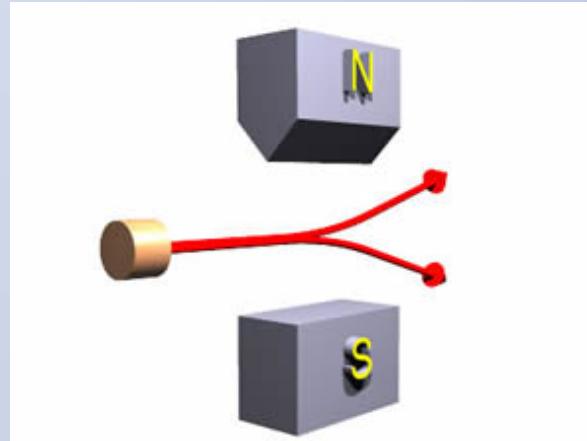


... “easy” for electrons (γ_{circ} on GaAs) and protons (ABS)

... “very difficult” for anti-protons; annihilation on contact w/ matter

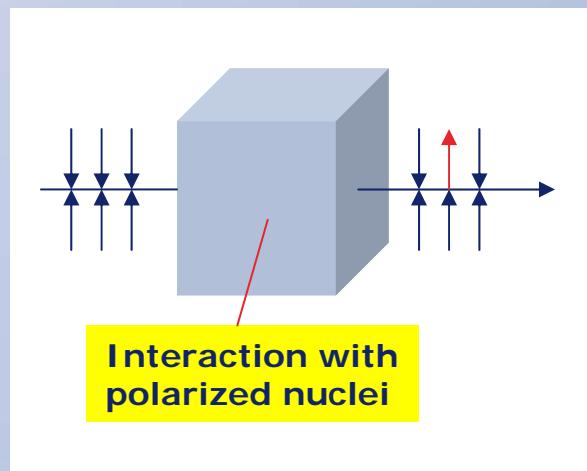
Polarization of Anti-Protons

- Anti- Λ decay, Anti-proton scattering off $\text{LH}_2 \rightarrow$ not efficient
- Stern-Gerlach separation:



→ never tested

- „Spin-filtering“:



selection by
different
probabilities for



& accumulation

Finally: Summary and Outlook

- COSY is an **indispensable facility** for hadron physics with hadronic probes
 - at least until HESR at FAIR becomes operational ~2014
- COSY provides (**cooled, polarized**) proton and deuteron **beams** up to 3.7 GeV/c to internal and external target positions
- 3 major experimental facilities – **ANKE, TOF, and WASA (new)** – are covering many of the most challenging issues in current hadron physics
- IKP (and COSY) will provide crucial input and contributions for **FAIR**

→ For all activities, we need partners!!

The Hadron Physics Program at COSY-Jülich

Many new and exciting results, plans, ideas during CGSWHP'06

Have fun !

&

Thank you very much
for your attention

