Introduction: Hadron Physics with a Spin

From ANKE/COSY to PAX/FAIR

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ANKE-PAX Collaboration Meeting

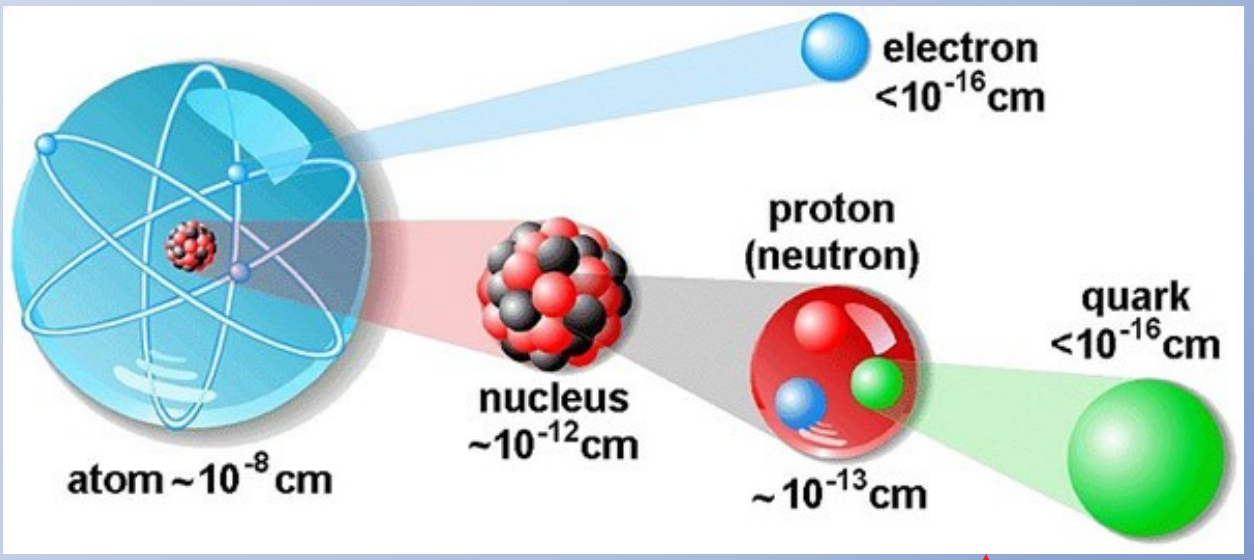
Ferrara (Italy), May/June 2007

Science: Understanding of Nature:

… conceive, develop, explore, test, (im-)prove

or discard … models:

Example: Building blocks of matter

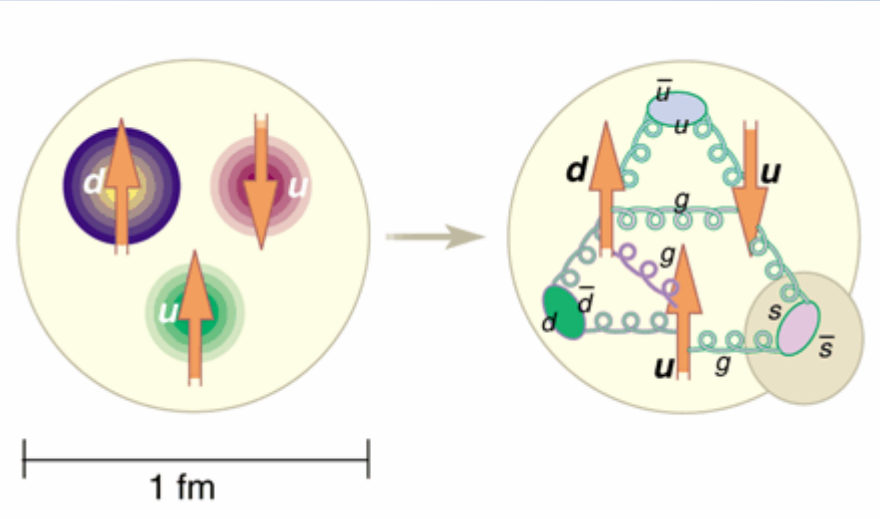


simple, but wrong

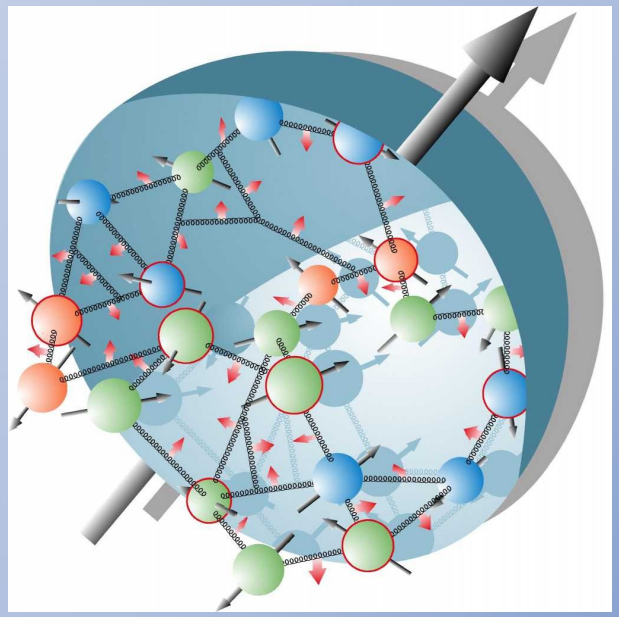
complex and not falsified yet

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

How does QCD (nature) *make* hadrons?

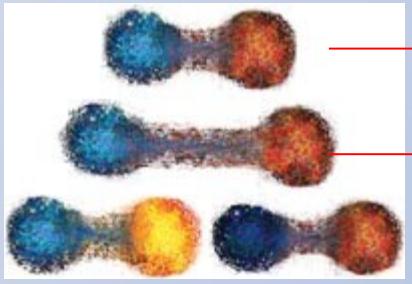


Evolution of our view of the nucleon



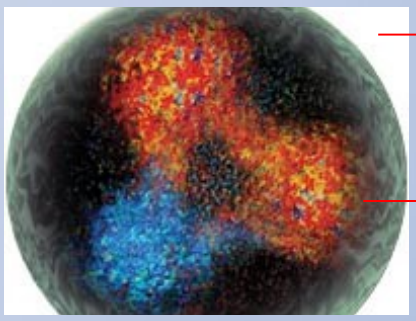
Fundamental questions (I):

- No free quarks?
  "Confinement"



Force independent of distance

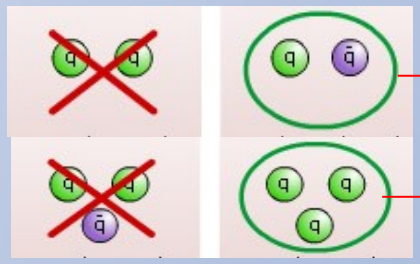
- Mass of hadrons?
  "Mass without mass"
- Changes in medium?
  "Restoration of Chiral Symmetry"



QCD vacuum

Valence quark

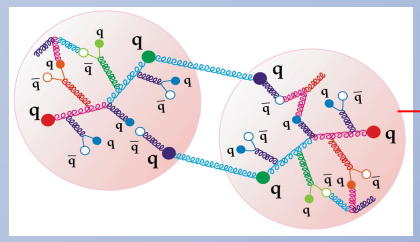
- Hadronic states?
  Spectroscopy



Meson

Baryon

- Hadronic interaction?
  Remnant of quark-quark interaction

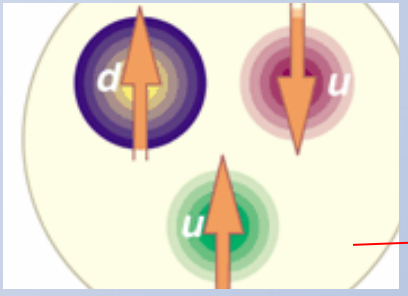


Composite nucleoon

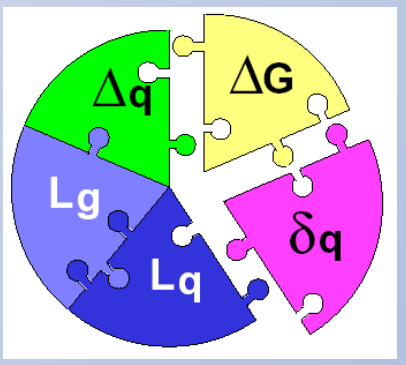
Fundamental Questions (II):

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

"Spin Crisis
Spin Puzzle"



½ =

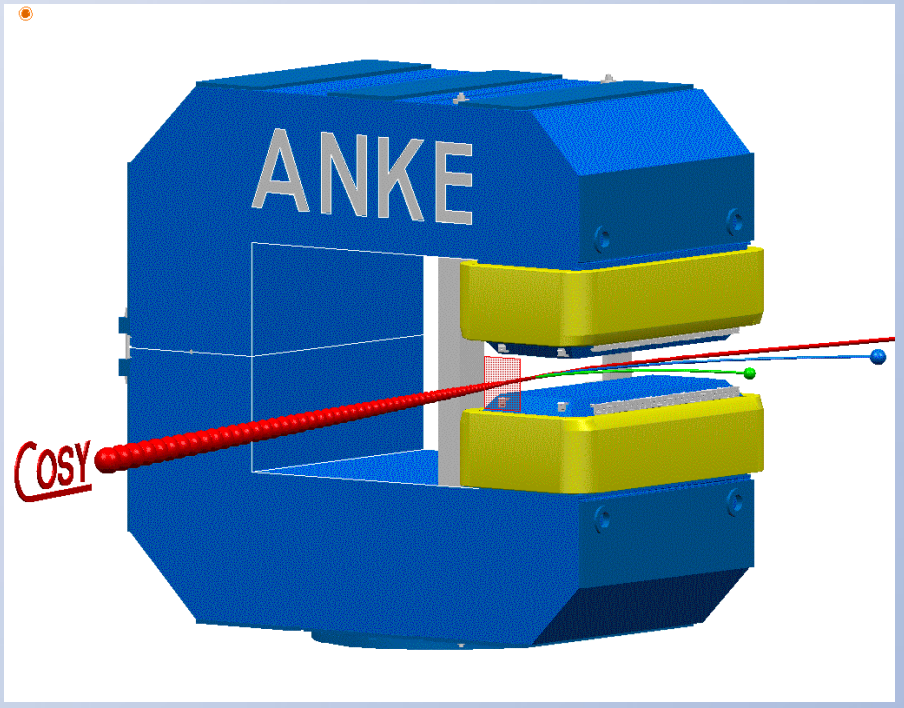


quarks + antiquarks + gluons + orbital angular momentum

→ Realm of HEP – but also medium energy (~ GeV) physics

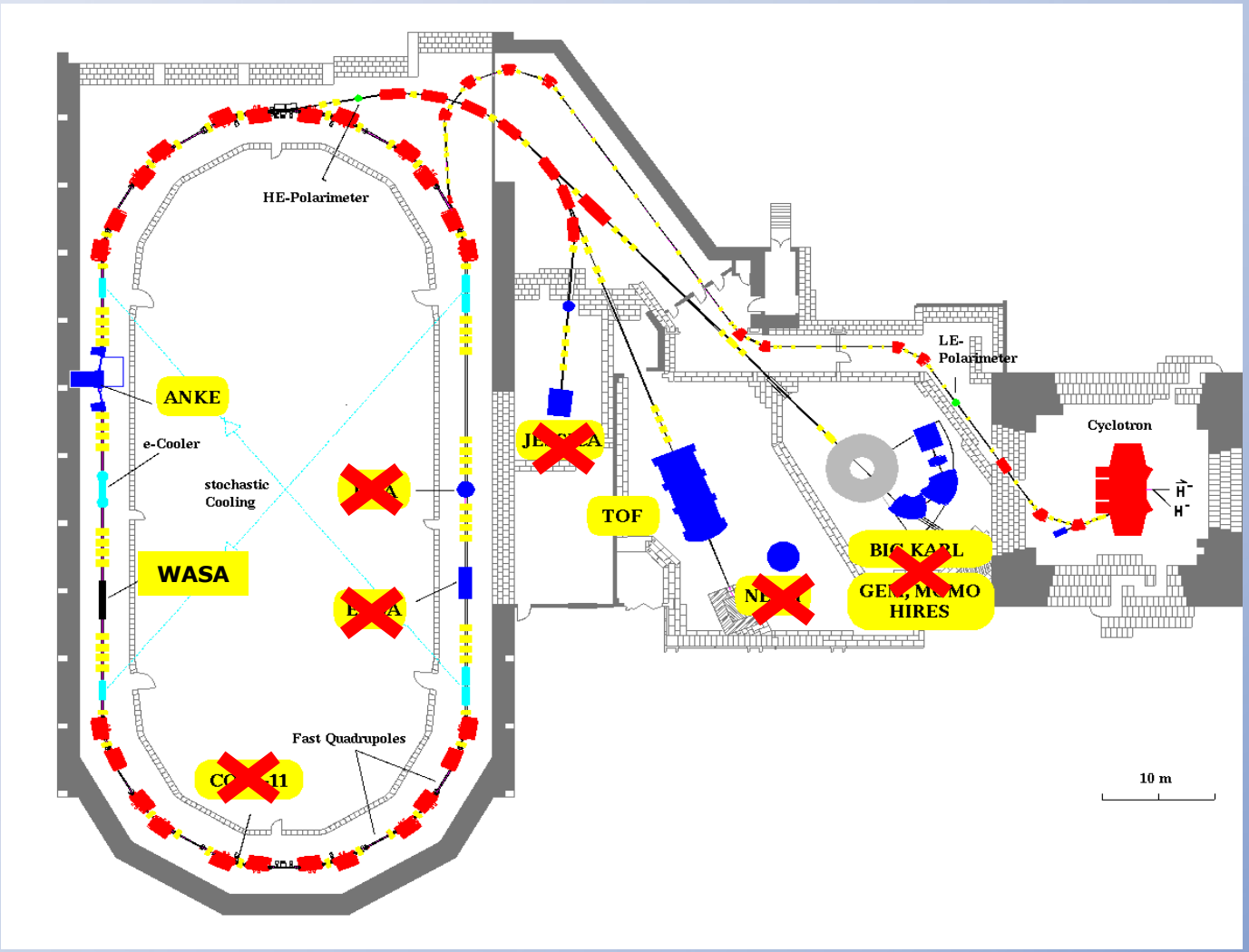
→ Present: e.g. ANKE at COSY Jülich

→ Future: e.g. PAX at FAIR GSI (Darmstadt)



Central ANKE Spectrometer Dipole

ANKE: An internal magnetic spectrometer at COSY

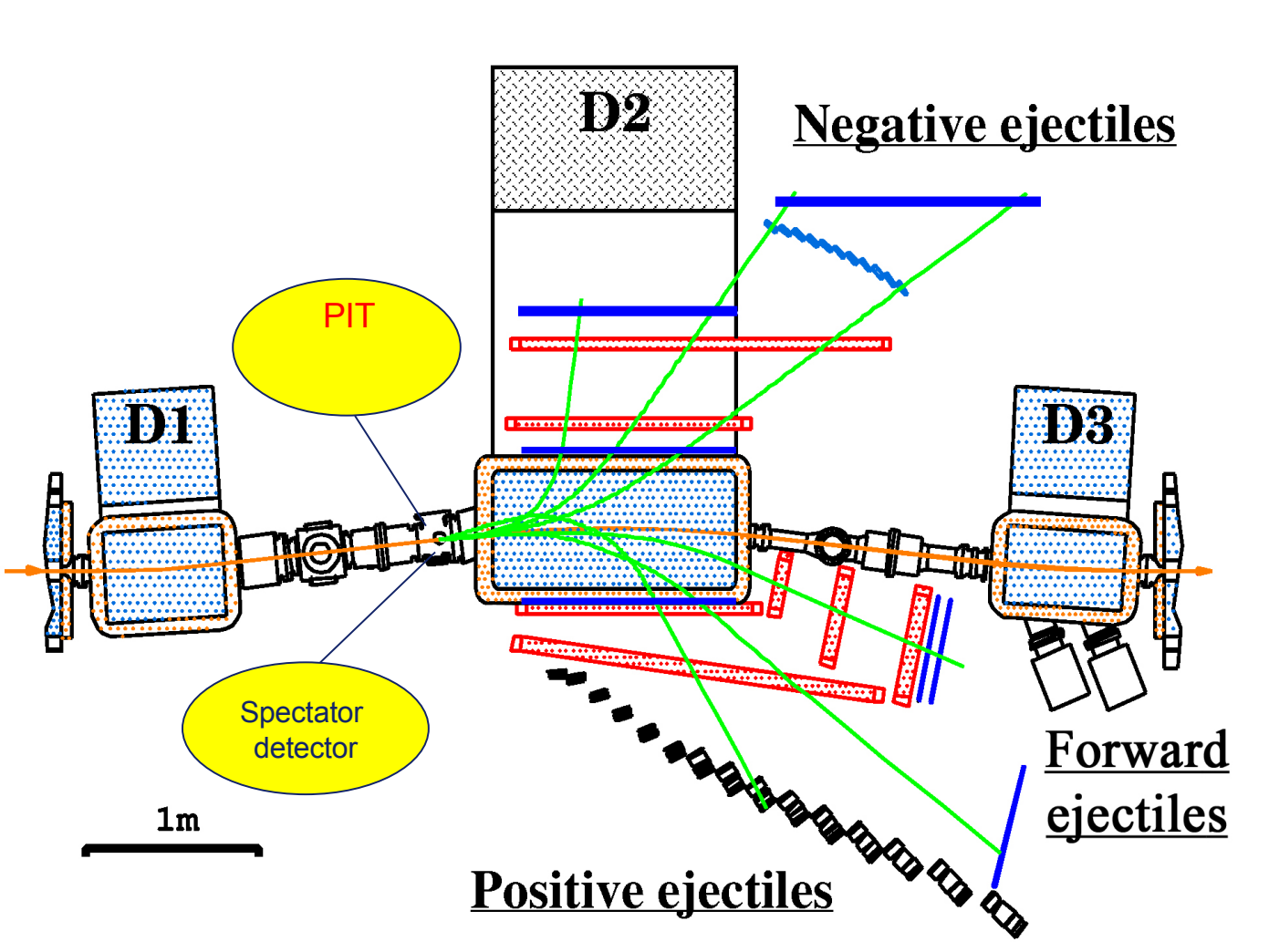


Schematic overview COSY Facility (FZ-Jülich)

ANKE: An internal magnetic spectrometer at COSY

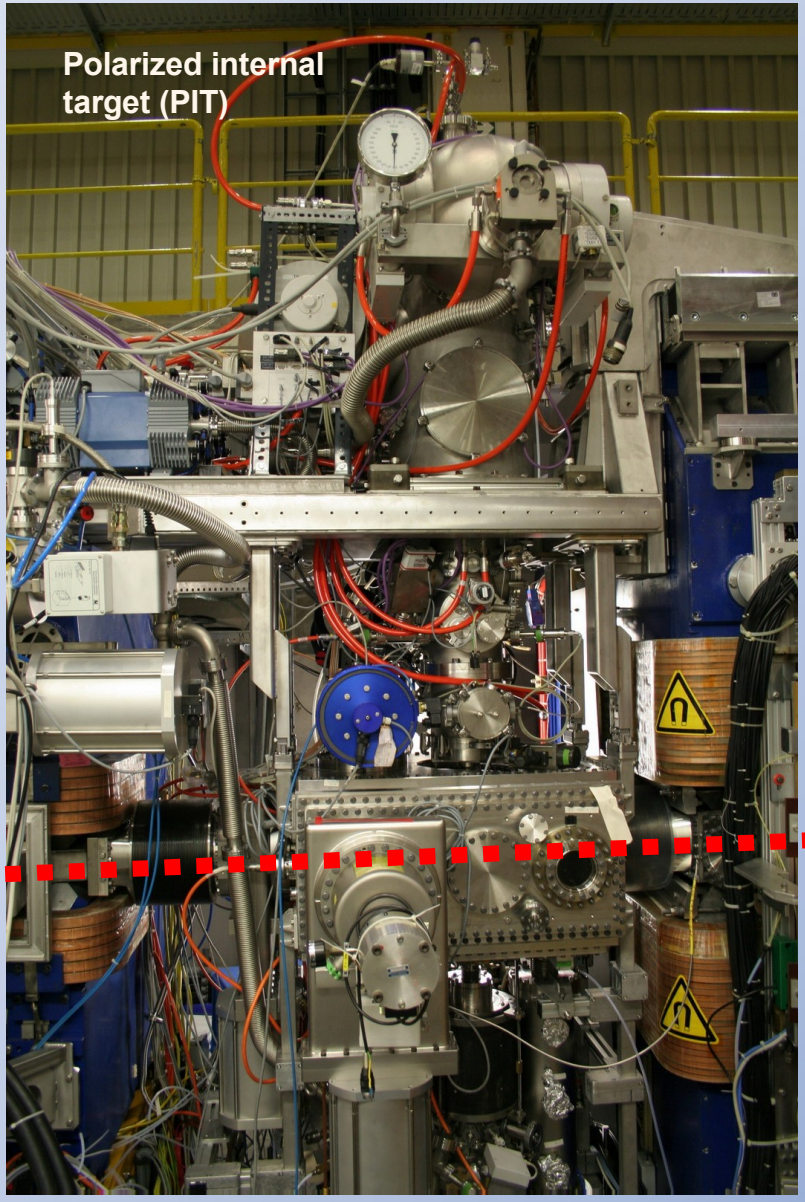
Early Picture COSY Facility (FZ-Jülich)

ANKE: An internal magnetic spectrometer at COSY

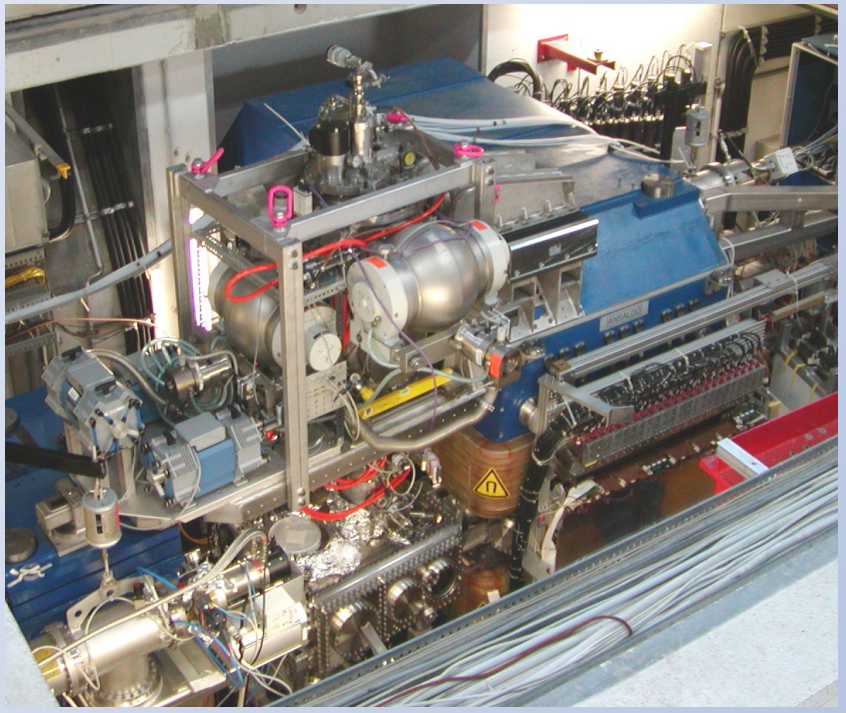


Schematic overview ANKE Facility at COSY

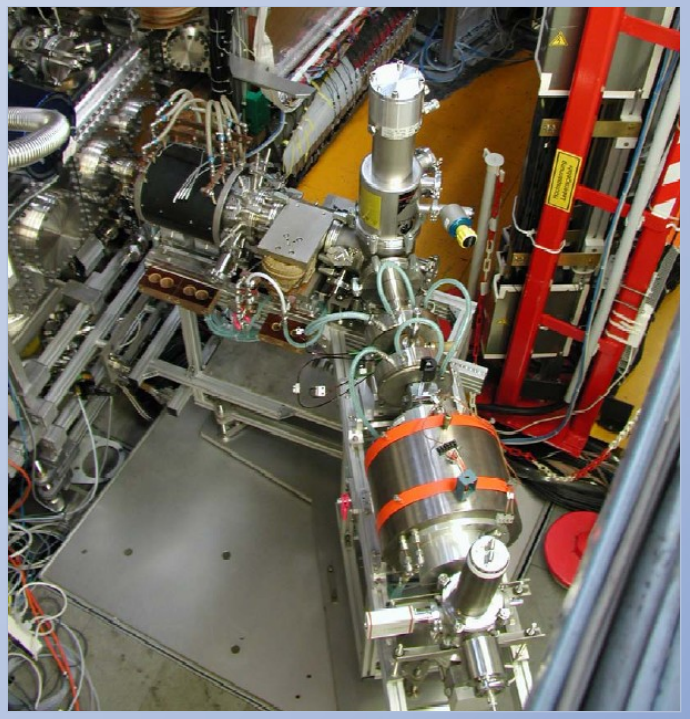
ANKE: An internal magnetic spectrometer at COSY



ANKE: An internal magnetic spectrometer at COSY



PIT (ABS)

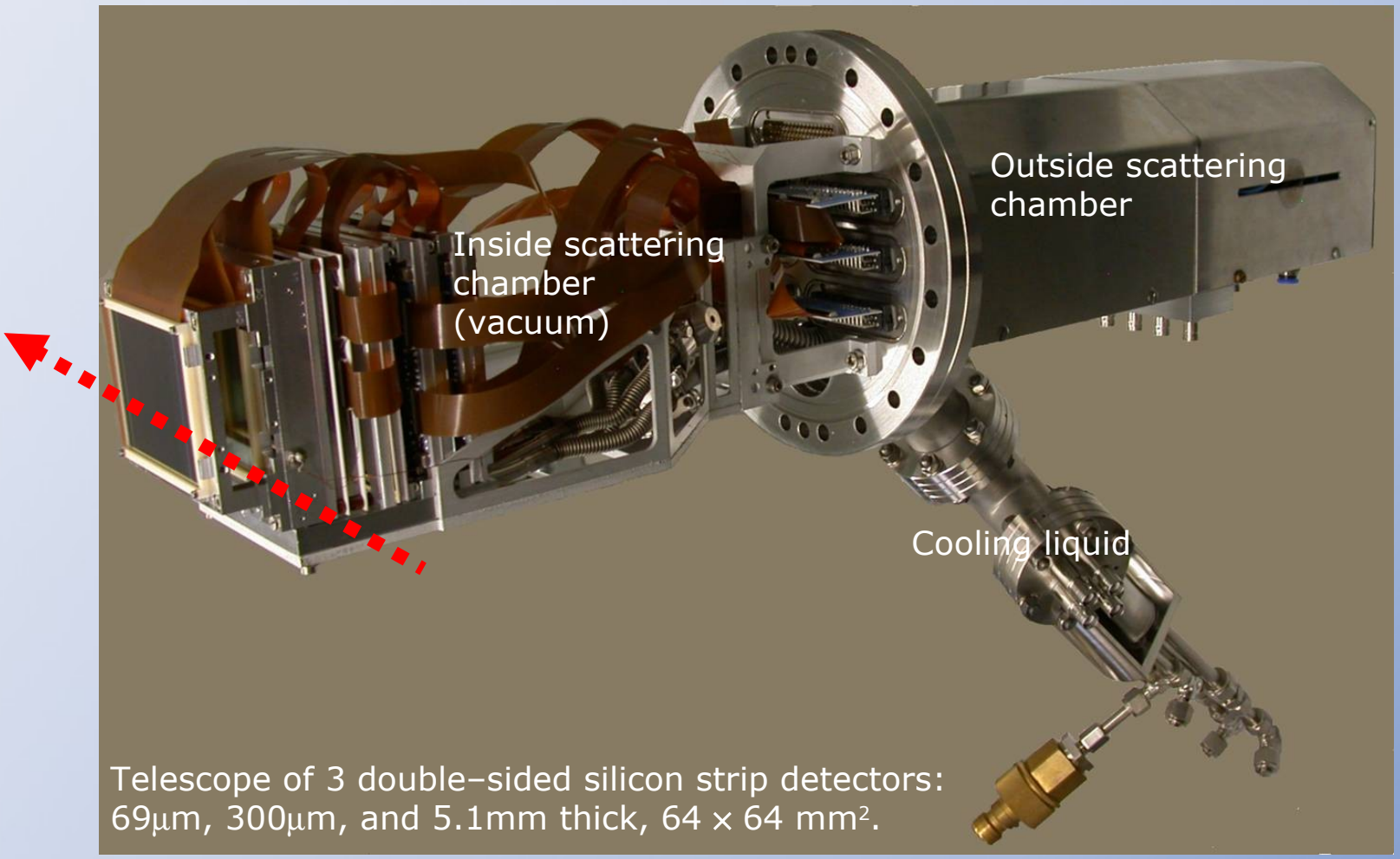


LSP

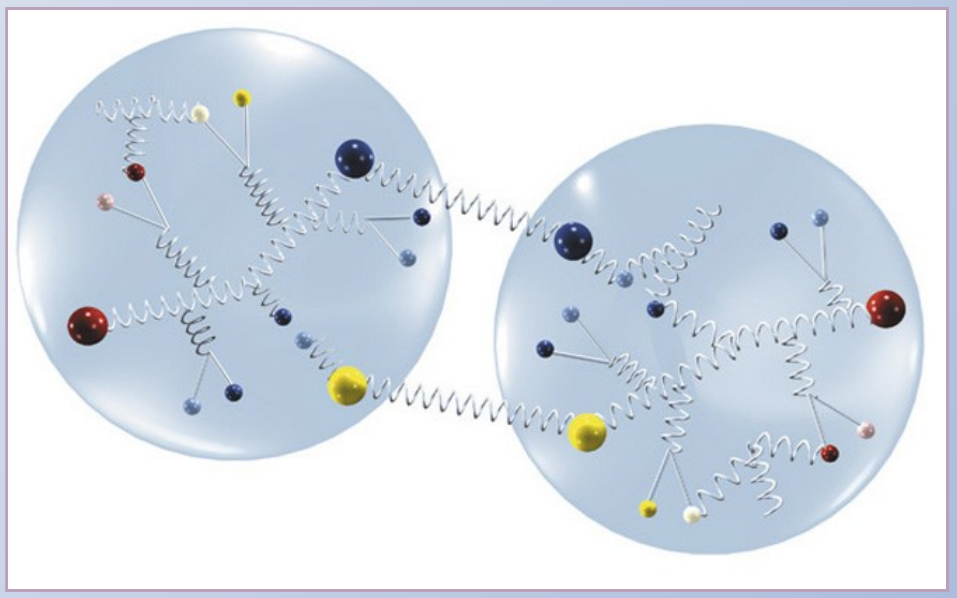
→ ready to do (double) polarized experiments !

(started with $\vec{d}\vec{p}$ → ppn in January 2007)

ANKE: An internal magnetic spectrometer at COSY



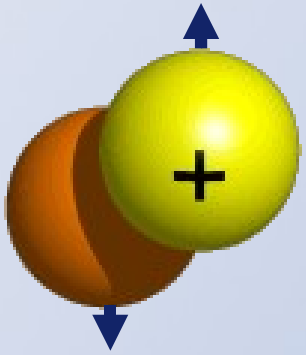
Silicon Tracking Telescope (STT)

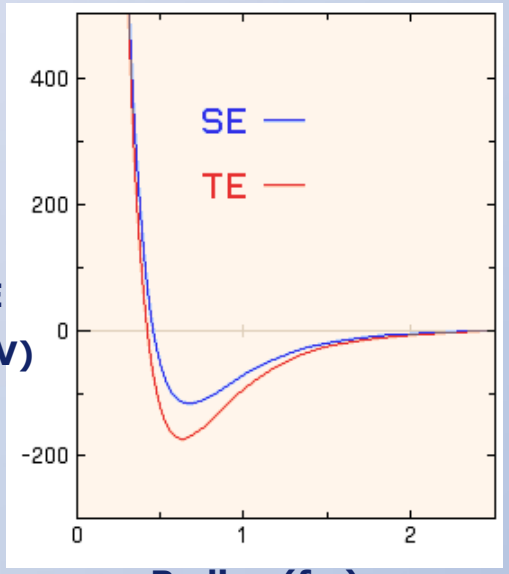


Results: (1) Nucleons

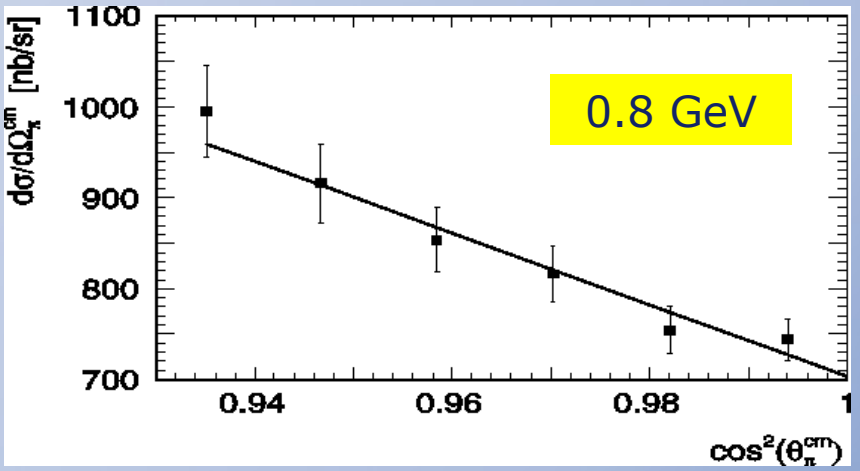
ANKE: Di-Proton System

Di-Proton $^1S_0$, studied in e.g. pp → $(pp)_s$ π°





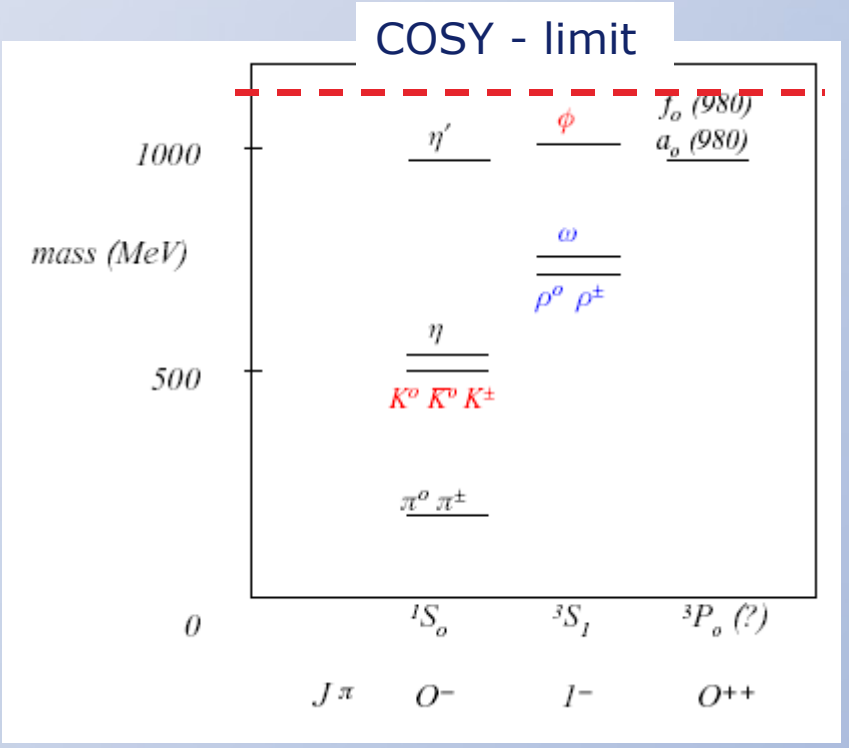
i) Unpolarized case:



(1.1 , 1.4 and 2.0 GeV to come!)

ii) Polarized beam: approved BT

scheduled for Autumn 2007

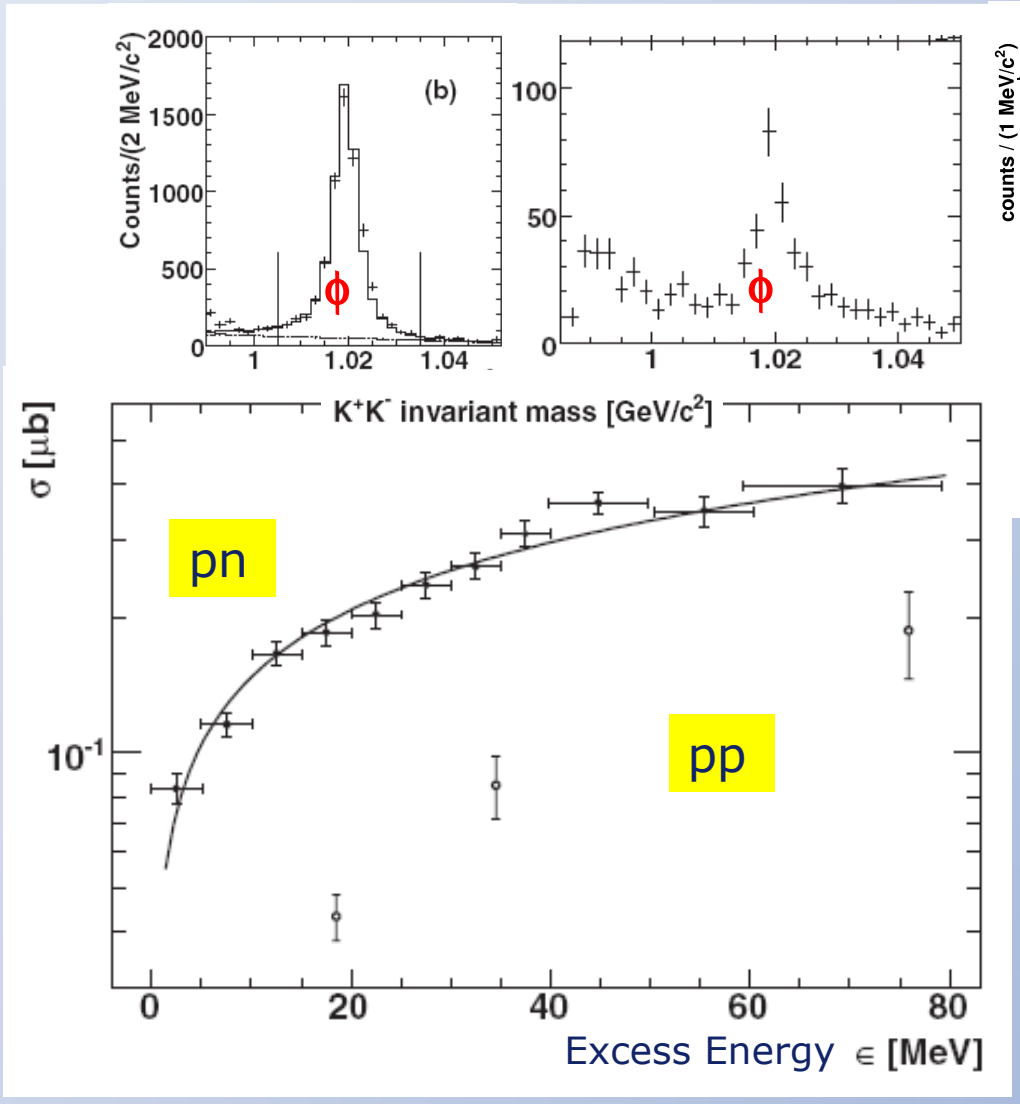


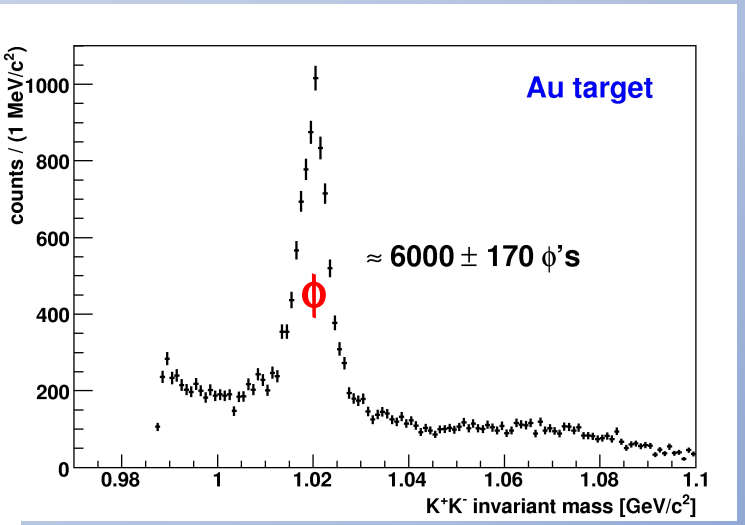
Results:

(2) Mesons

ANKE: ϕ-Meson Production

Elementary and nuclear reactions:





4 targets:

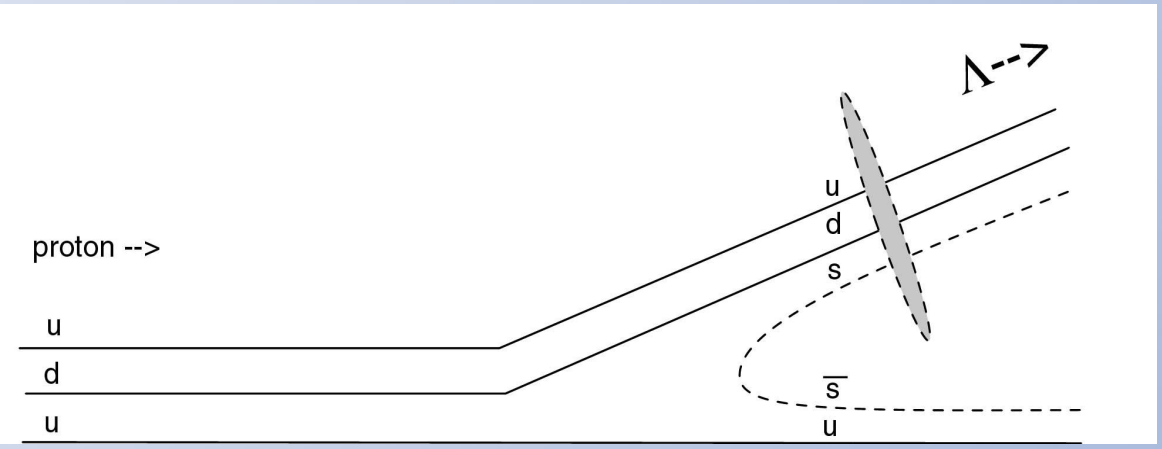
C : ≈ 6700 Φ's

Cu: ≈ 5000 Φ's

Ag: ≈ 5000 Φ's

Au: ≈ 6000 Φ's

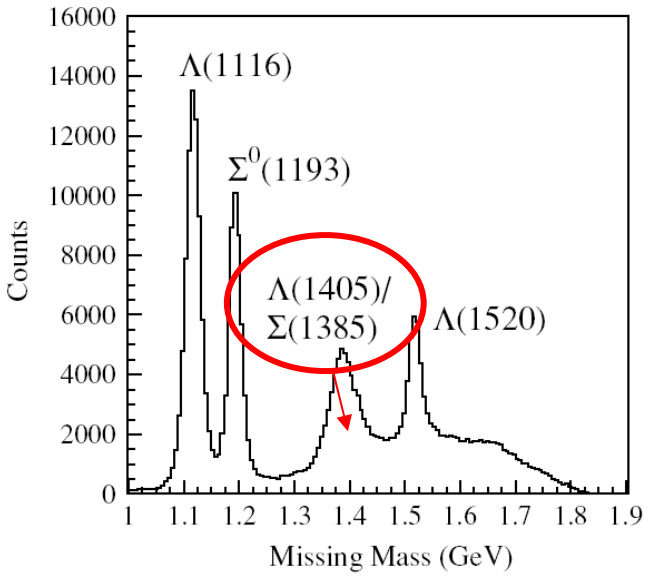
Analysis ongoing !



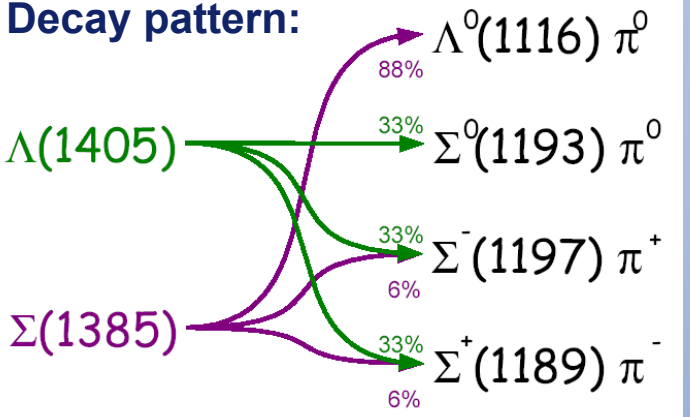
Results: (3) Strangeness

ANKE: Hyperon Production

Discrimination between Σ(1385) and Λ(1405):



Decay pattern:

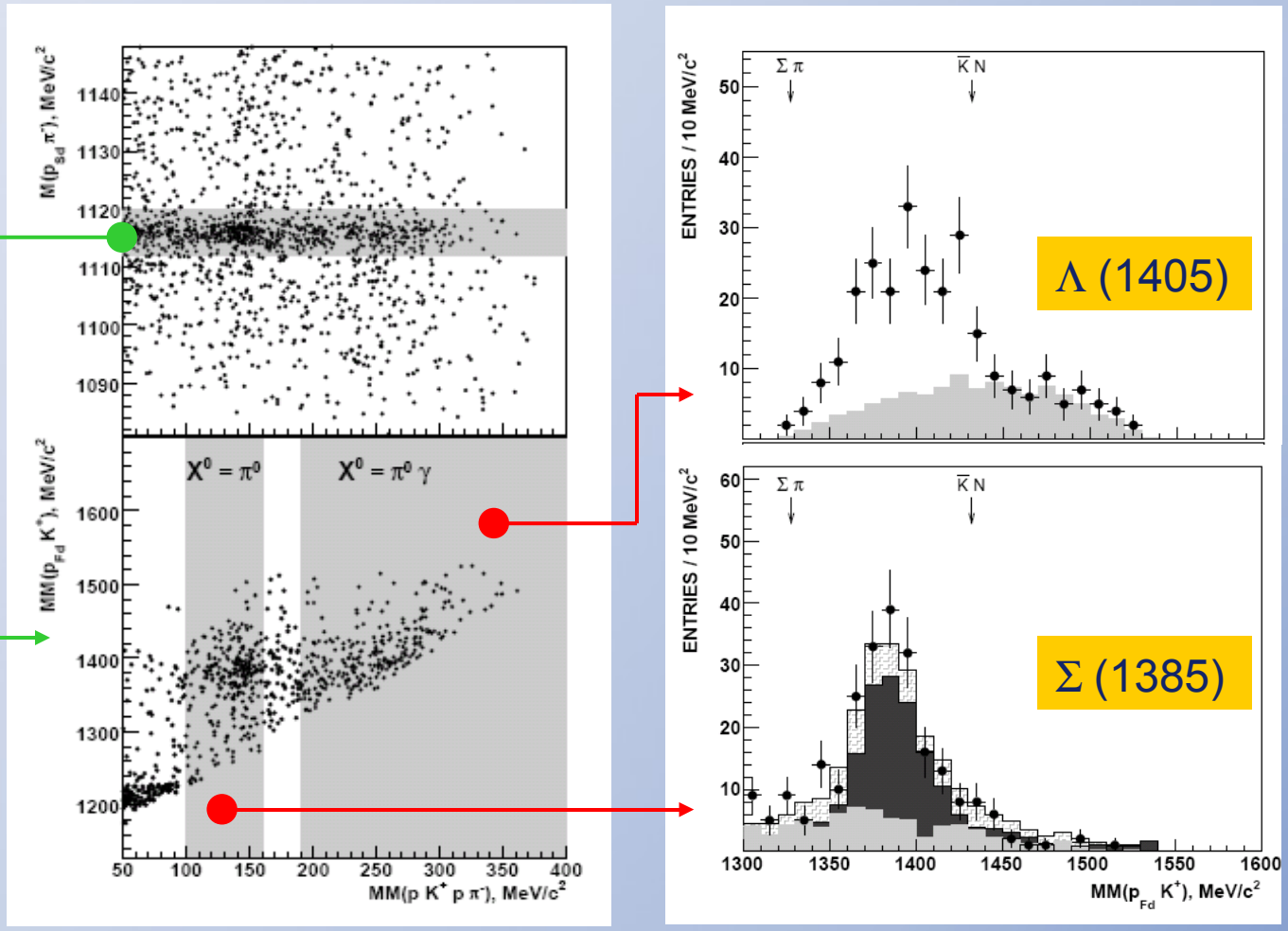


→ → pπ⁻ π°

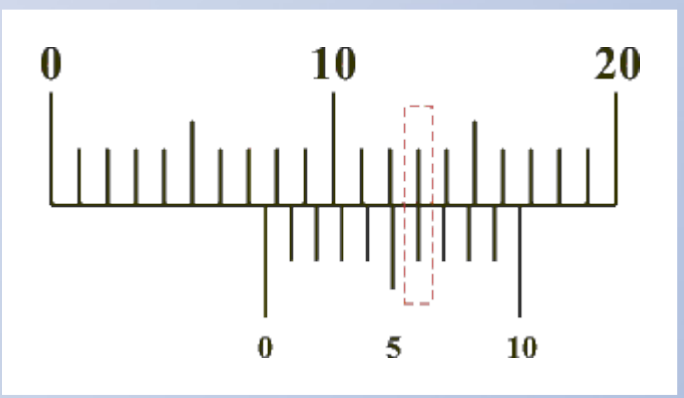
→ Λγ π° → pπ⁻ γ π°

ANKE: Hyperon Production

Discrimination between Σ(1385) and Λ(1405): pp → pK⁺ pπ⁻ X



I. Zychor et al., submitted PRL (May 2007)

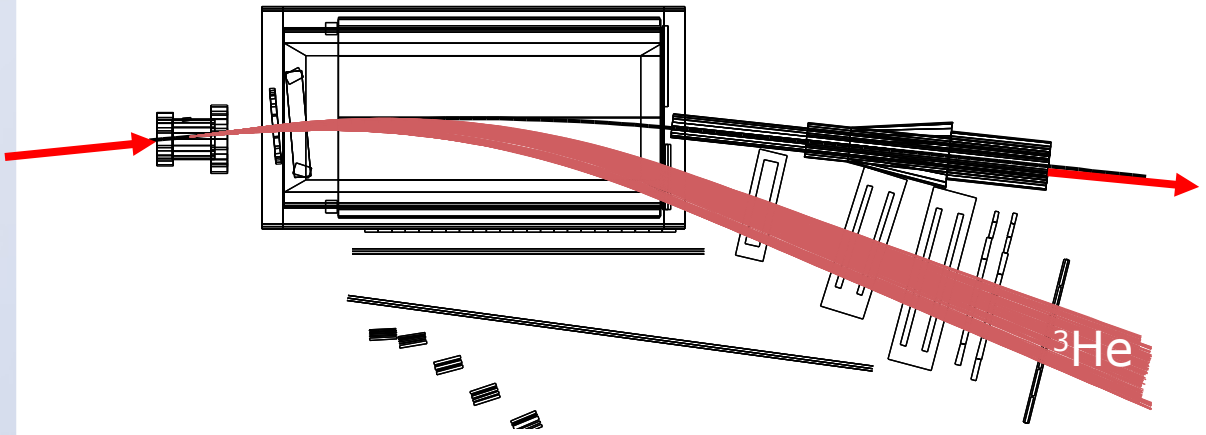


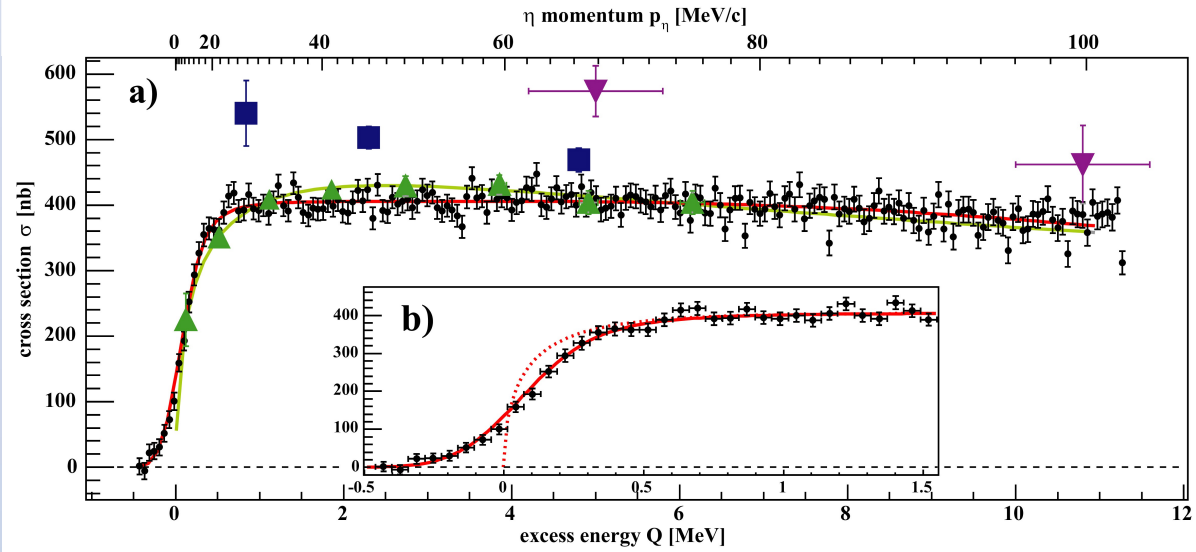
Results:

(4) Precision

ANKE: η ^{3}He Interaction

(Quasi-)bound state of η-meson and ^{3}He-nucleus: dp → η ^{3}He

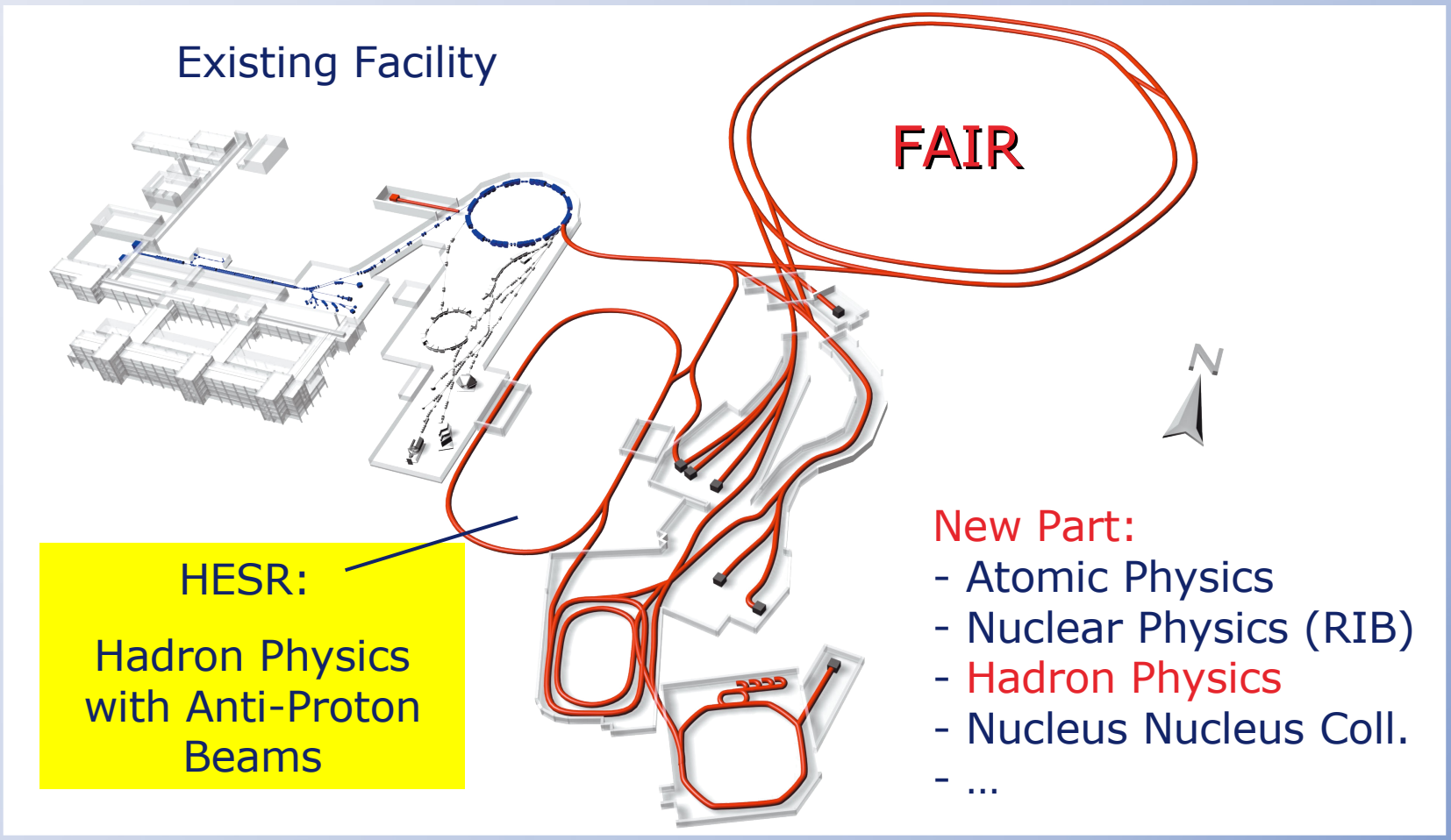




Continuous beam ramping through η–threshold (-5 … + 11 MeV)

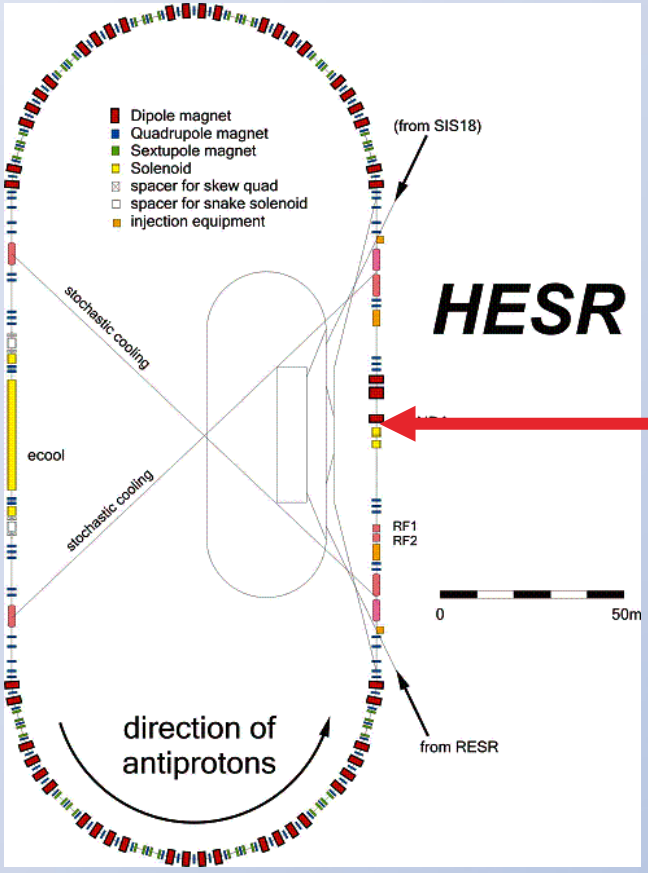
(Quasi-)bound state within < 1MeV of threshold

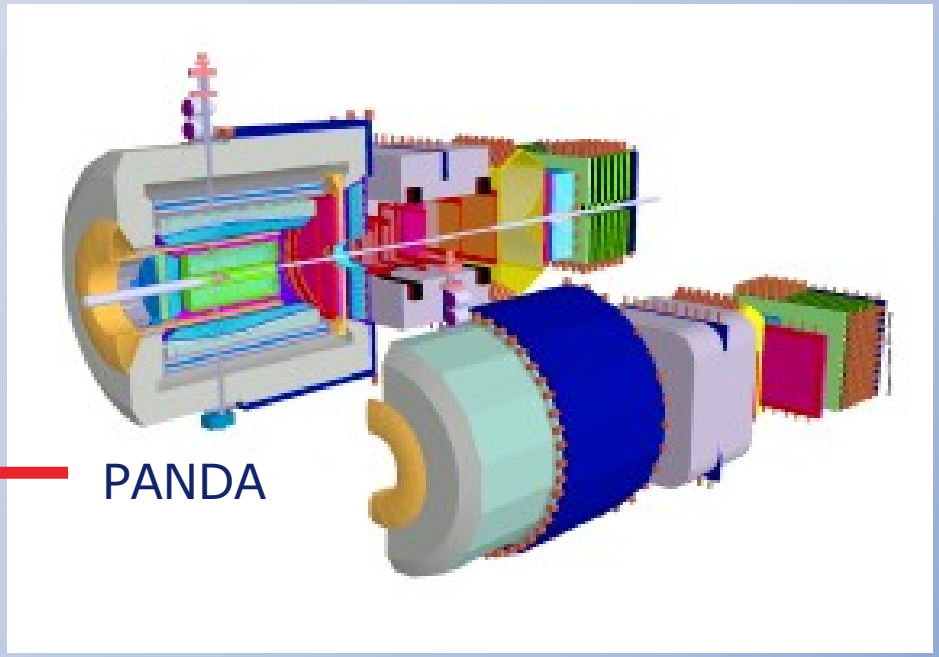
T. Mersmann et al., in print PRL (May 2007)



Floor Plan FAIR-Facility at GSI (Darmstadt), Germany

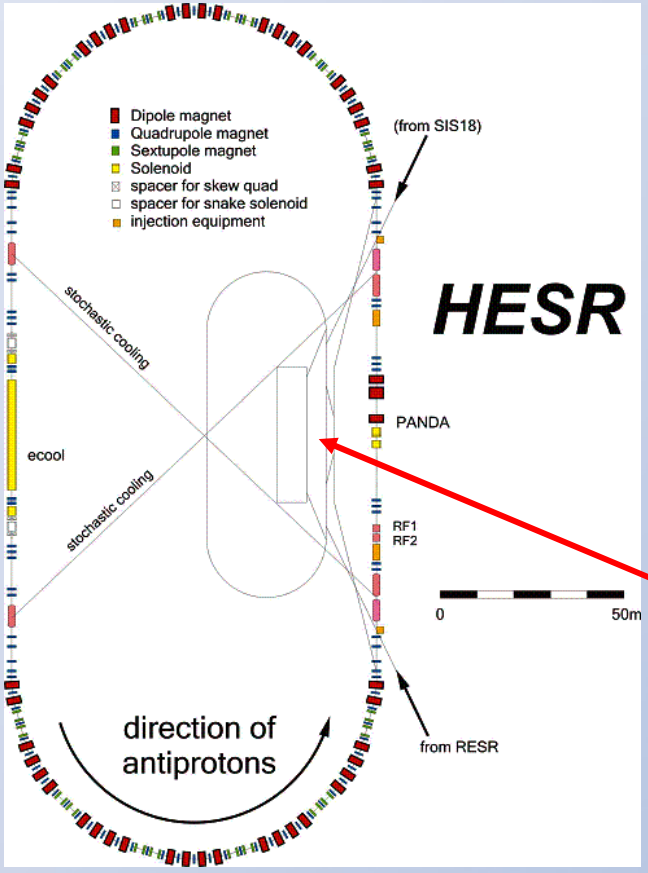
HESR (and PANDA) at FAIR

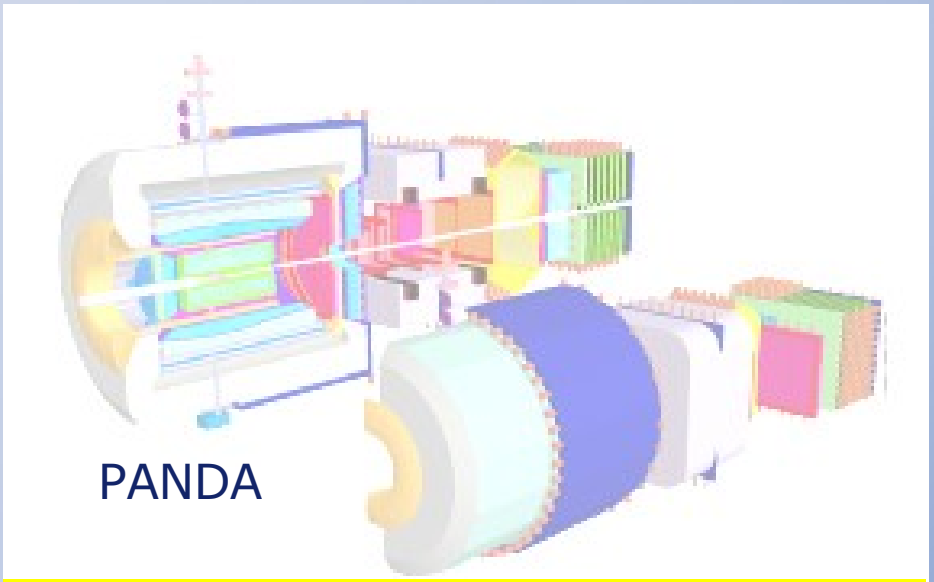




Floor Plan High Energy Storage Ring (HESR) & PANDA

HESR (and PANDA) at FAIR





Future upgrade option:

Polarized anti-protons, collider

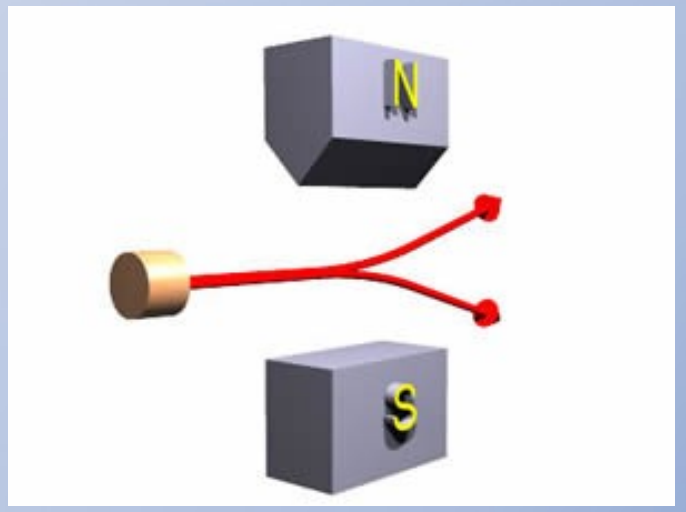
"PAX"

Floor Plan High Energy Storage Ring (HESR) & PANDA

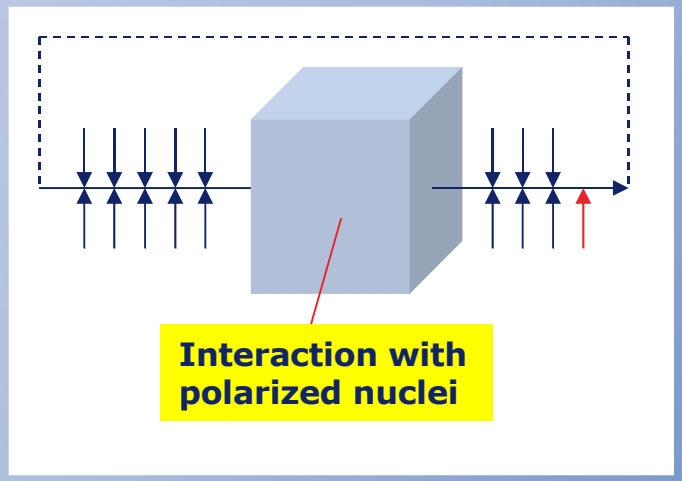
Polarization of Anti-Protons

Possible methods:

- Anti-Λ decay: $\bar{\Lambda} \rightarrow \bar{p}\,\pi^+$

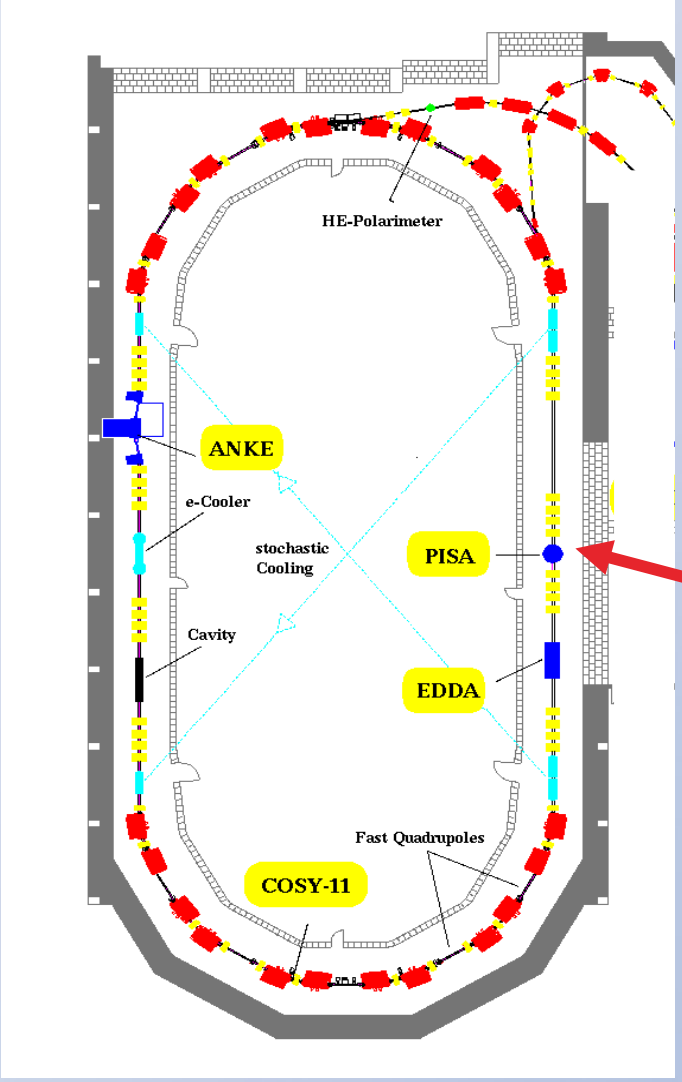


- Stern-Gerlach separation:
  (spacial or energy separation)



- „Spin-filtering“:

Preparatory Measurements at COSY

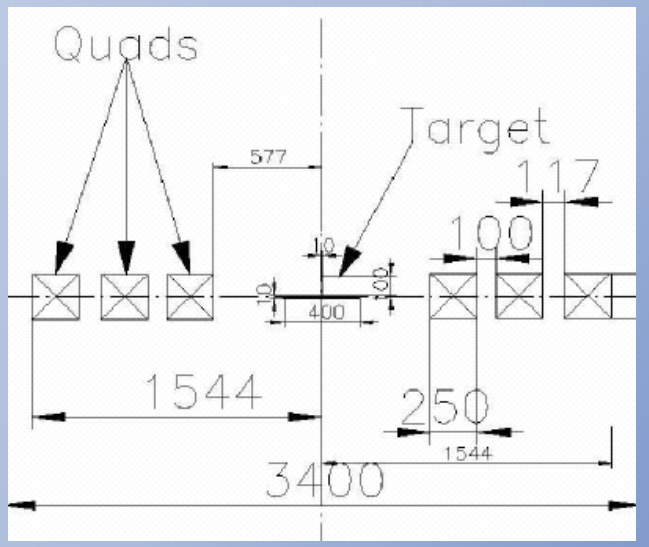


"Depolarization" test w/ p´s

→ performed at ANKE

"Spin-Filtering" test w/ p´s

→ dedicated "low-β section":

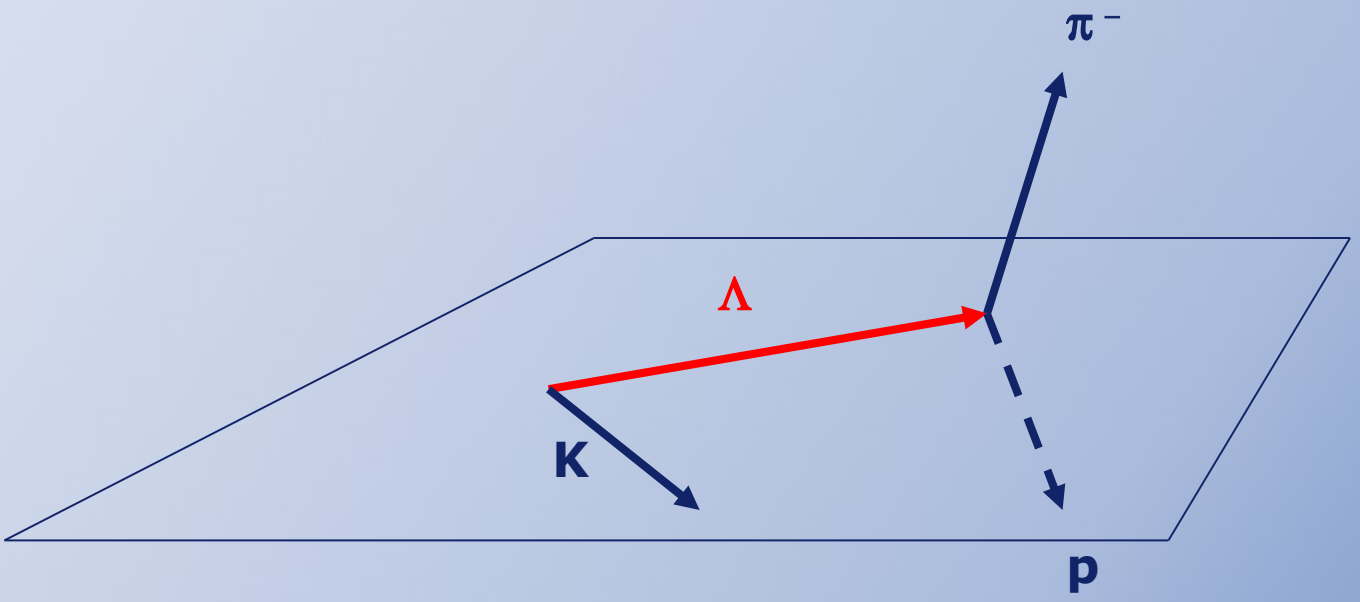


The End

-

… looking forward

to a successful meeting !


π⁻
Λ
K
p