Hans Ströher

Status and Perspectives of Hadron Physics in Europe

Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft

Europe

We are here:

Tbilisi (Georgia)

Area	(EU 15):	~	$\pi \times 10^6$ km^2	(EU 25):	$1.25\,\pi$	(US): ~ π^2
Population	(EU 15):		378 million	(EU 25):	455	(US): 291

20 (official) languages

Status and Perspectives of Hadron Physics in Europe

Overview:

Introduction: Why Hadron Physics?

Status: Current Facilities in Europe

Future: Facilities and Challenges ahead

Summary

Outlook

Hans Ströher, Tbilisi (Georgia), Aug./Sept. 2004

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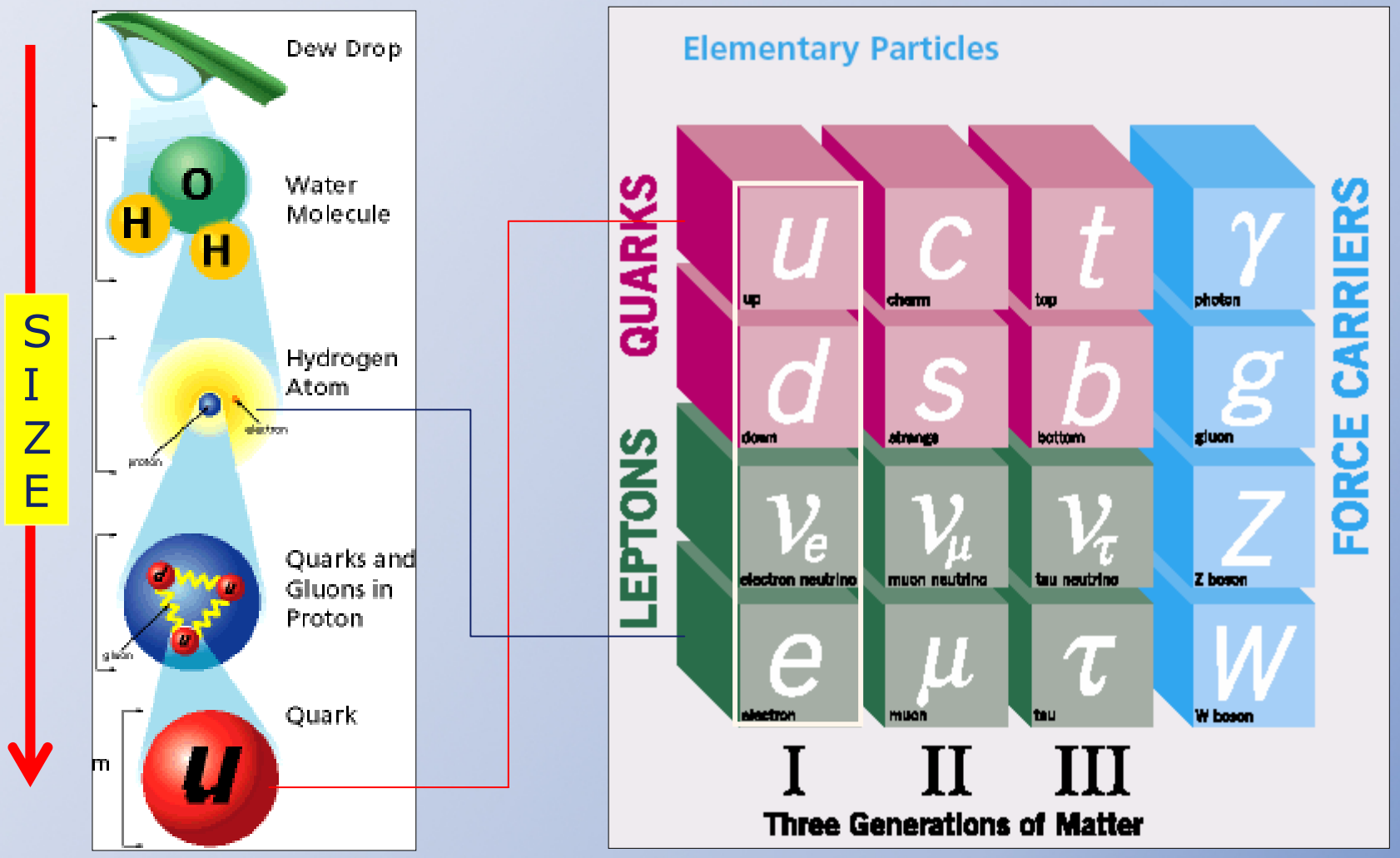
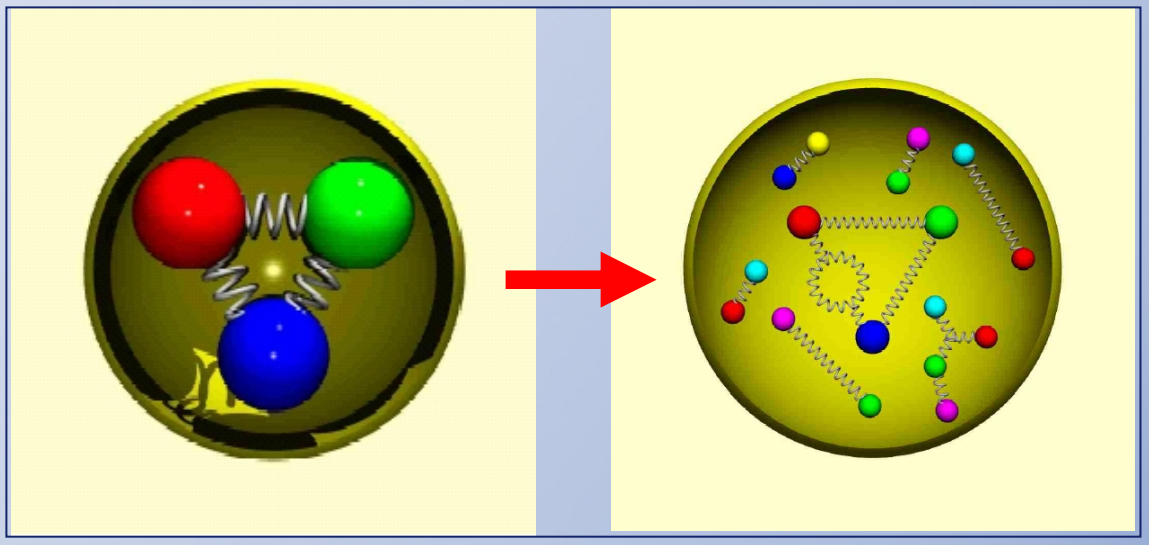
Structure of Matter: Building Blocks



Standard Model of Particles and Forces (EW & QCD)

Understanding of all matter comprised of quarks and gluons

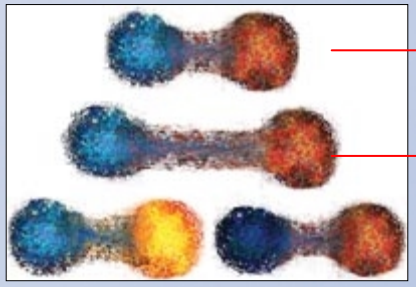
How do hadrons arise from theory (QCD)?
How does QCD – nature – *make* hadrons?



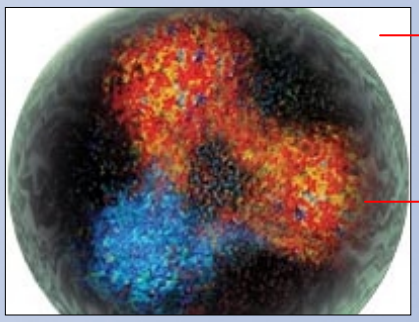
Nucleon (all hadrons) must be "color-neutral"

Fundamental questions

- No free quarks ?
  "Confinement"
- Mass of hadrons ?
  "Mass without mass"
- Changes in medium ?
  "Restoration of Chiral Symmetry"
- Hadronic states ?
  Spectroscopy
  New bound systems
- Hadronic interaction ?
  Remnant of quark-quark interaction

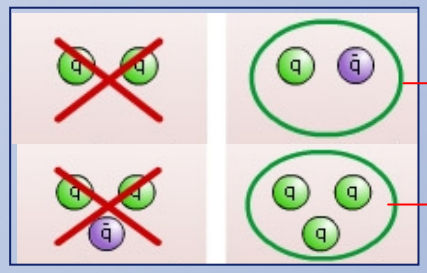


Force independent of distance



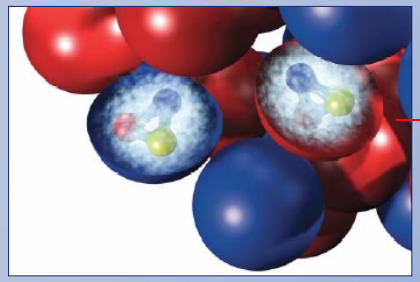
QCD vacuum

Valence quark



Meson

Baryon



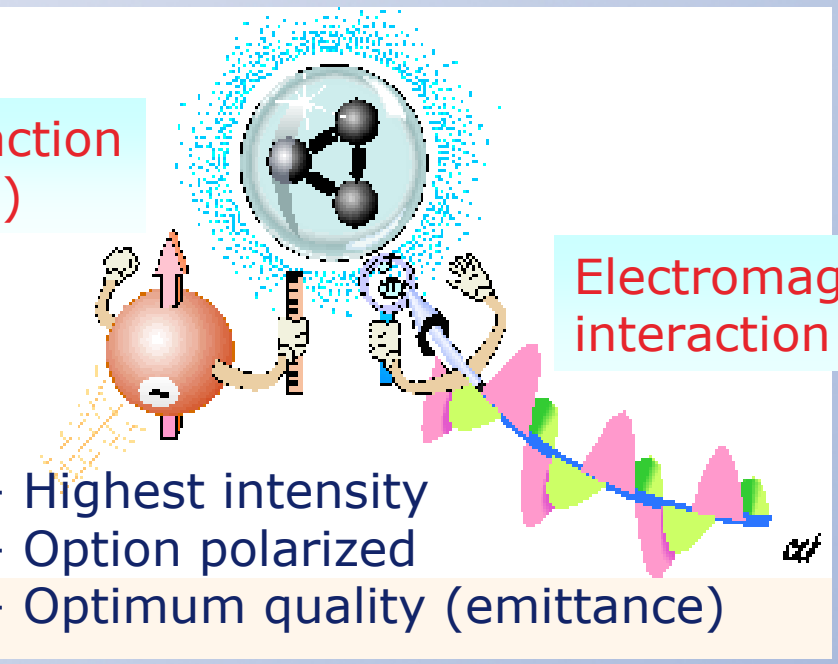
Nucleus

EXPERIMENTS

Experiments in Hadron Physics

Experimental investigation with different probes:

Hadronic interaction
(π, p, d, … K, $\bar{p}$)



Electromagnetic
interaction (e, μ, γ)

- Highest intensity
- Option polarized
- Optimum quality (emittance)

→ Frontier equipment:

- sources,
- accelerators, storage rings,
- detectors

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Equipment for Hadron Physics

Electromagnetic probes:

- MAMI (Mainz, Germany)
- ELSA (Bonn, Germany)
- DAΦNE (Frascati, Italy)

Facilities at large accelerators:

- HERMES (DESY, Germany)
- COMPASS (CERN, Switzerland)
- GRAAL (ESRF, France)

Equipment for Hadron Physics

Hadronic probes:

- CELSIUS (Uppsala, Sweden)
- COSY (Jülich, Germany)
- GSI (Darmstadt, Germany)

Facilities at large accelerators:

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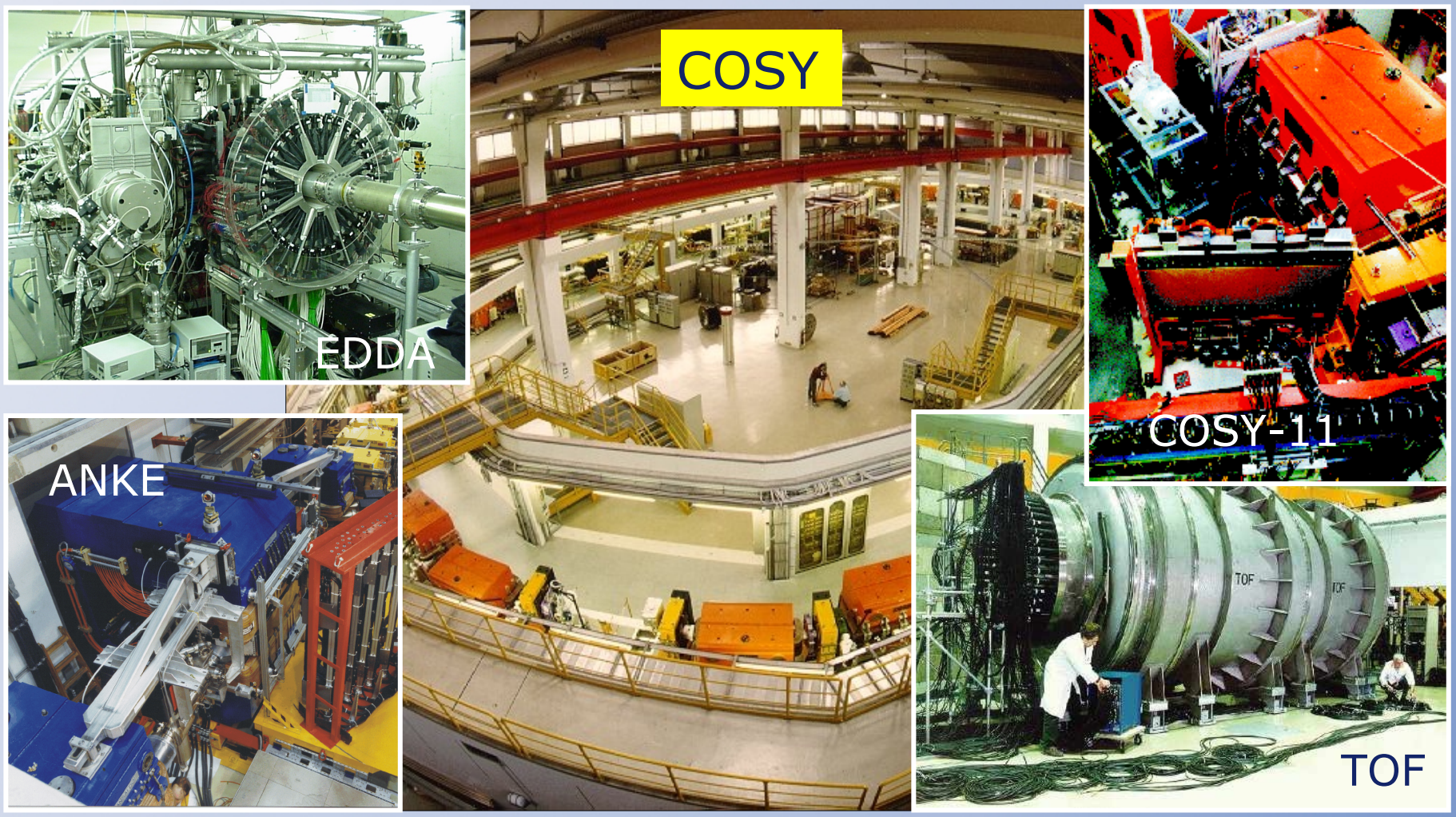
Example



Cooler Synchrotron (COSY) & Detector systems

COSY is a unique facility

- Energy range (up to 2.8 GeV)
- Cooling (2 methods: electron, stochastic)
- Polarization (proton, deuteron beams & targets)
- Beams (internal, extracted)
- Instrumentation (ANKE,COSY-11,EDDA,BIG KARL,TOF, WASA)

COSY / FZJ

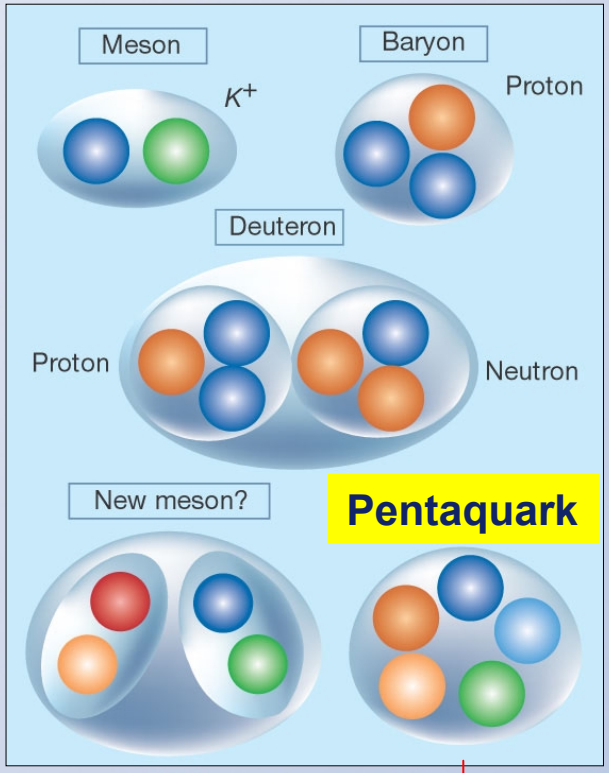
is a center for

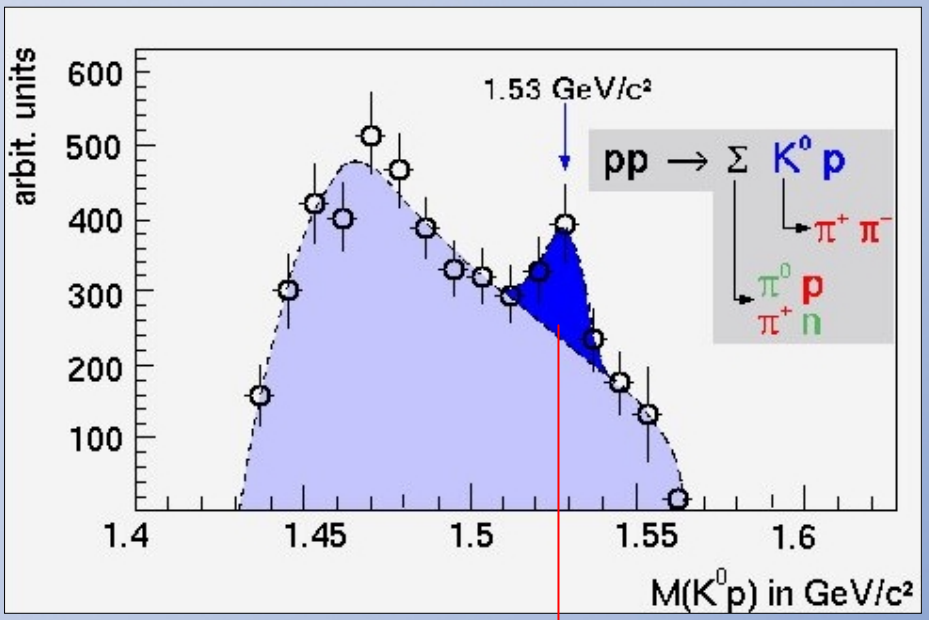
hadron physics

with hadronic probes

Hadronic bound states

- Indications for a new kind of hadron: also from COSY (*





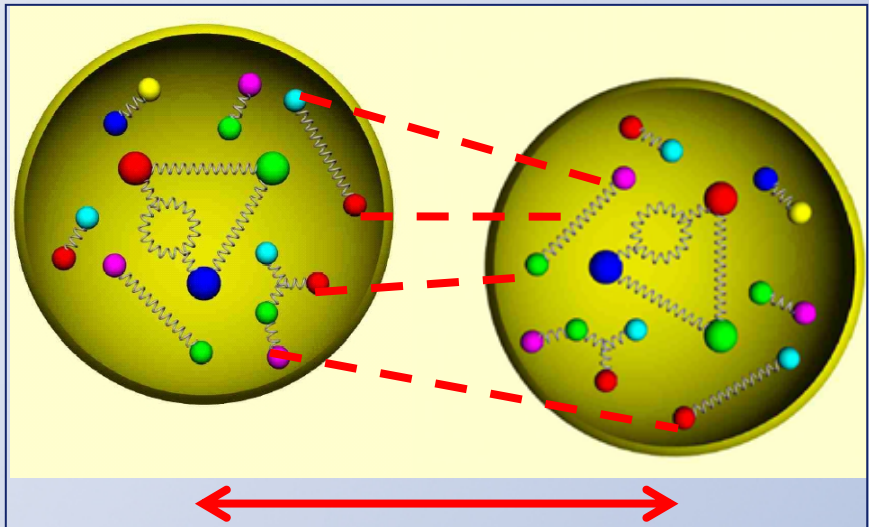
Narrow – long lived – state

"Pentaquark": existence (!) ; quantum numbers

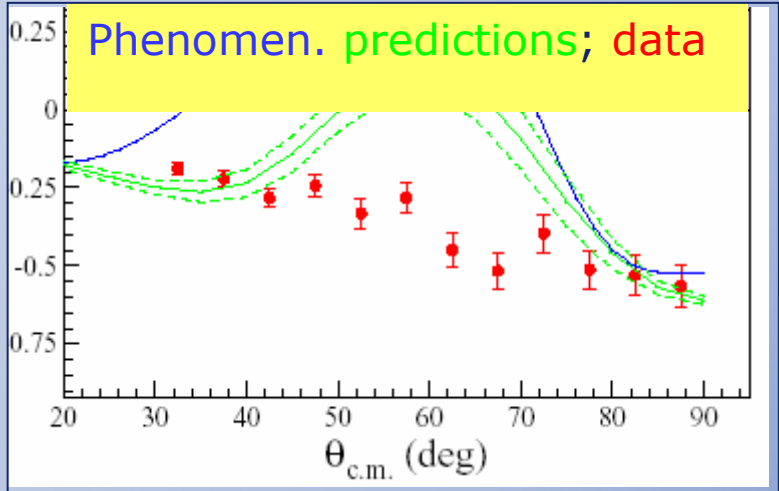
(* COSY-TOF collaboration; published in Physics Letters

Hadronic interaction

- Origin of nucleon-nucleon interaction:



Repulsive short-distance part (< 1 fm)



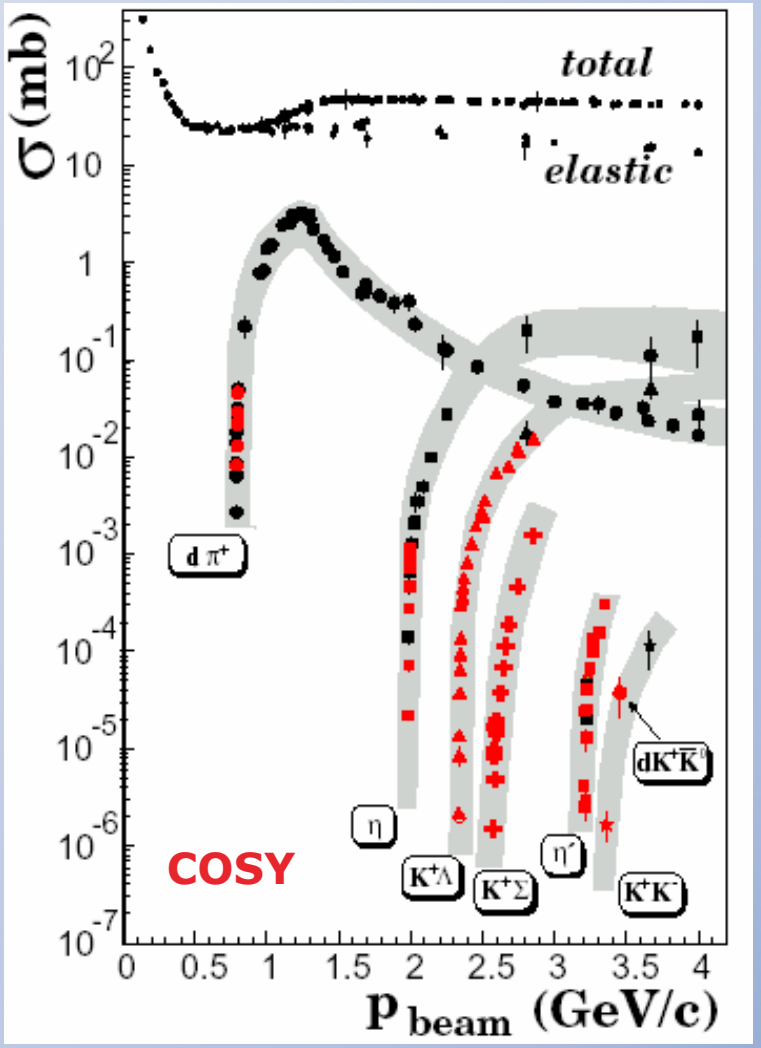
Spin dependence (A_{ss}) (*

Proton-proton interaction: characterization, but no understanding at high energies; no 6 quark-states

(* COSY-EDDA collaboration; published in Physical Review Letters

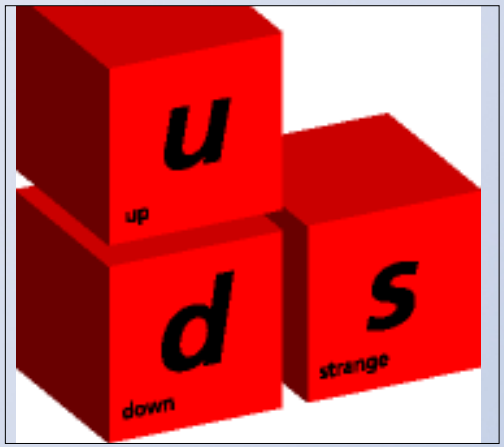
Hadronic reactions

- Summary of COSY-results: pp → BaryonBaryonMeson

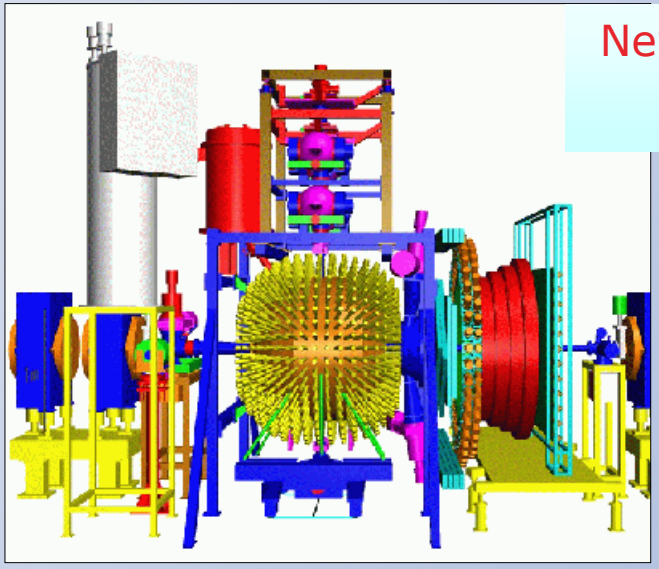


Strategy for the future

- Exploit COSY for hadron physics in the "light quark sector":

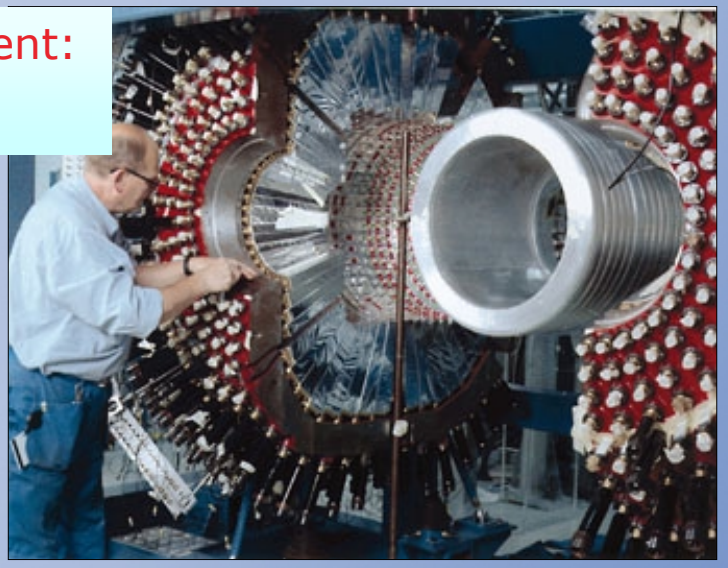


- Symmetry and –breaking (ISB, …)
- Hadronic states spectroscopy (Θ^+, …)
- Baryon-baryon interaction (np, YN)
- Hadronic medium effects (Kaon mass)



New equipment:

WASA



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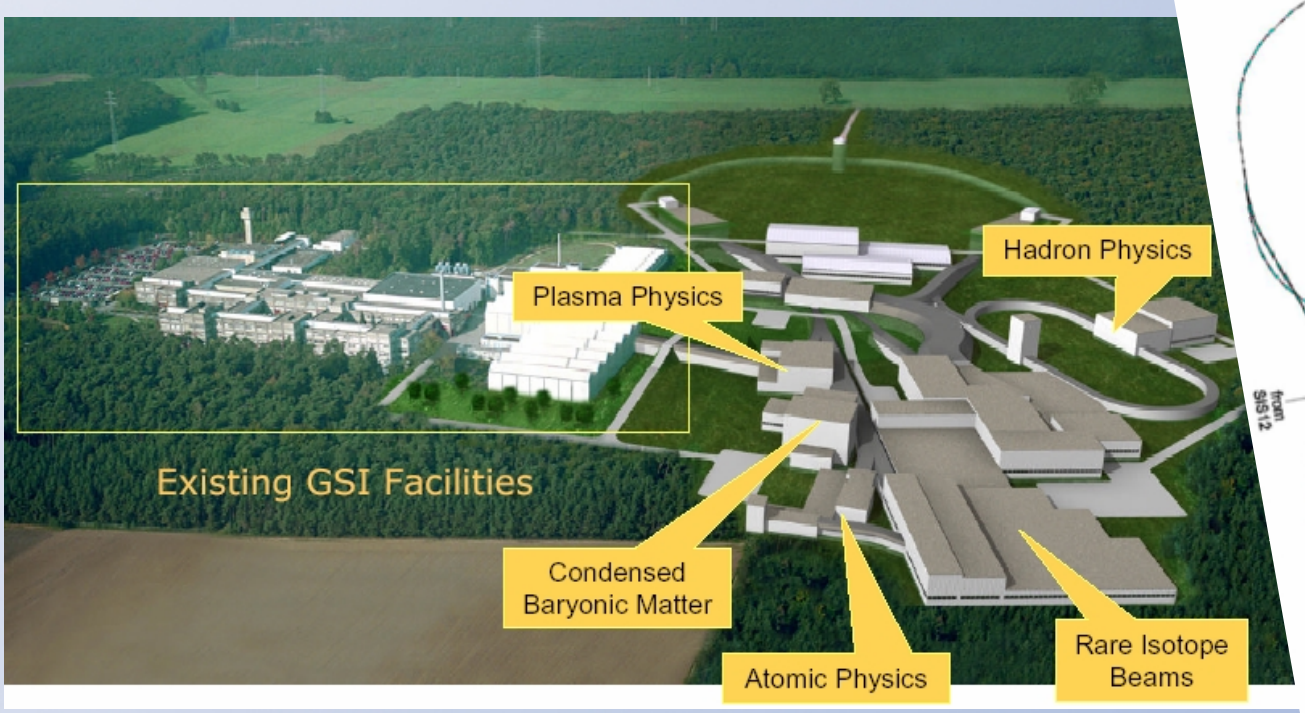
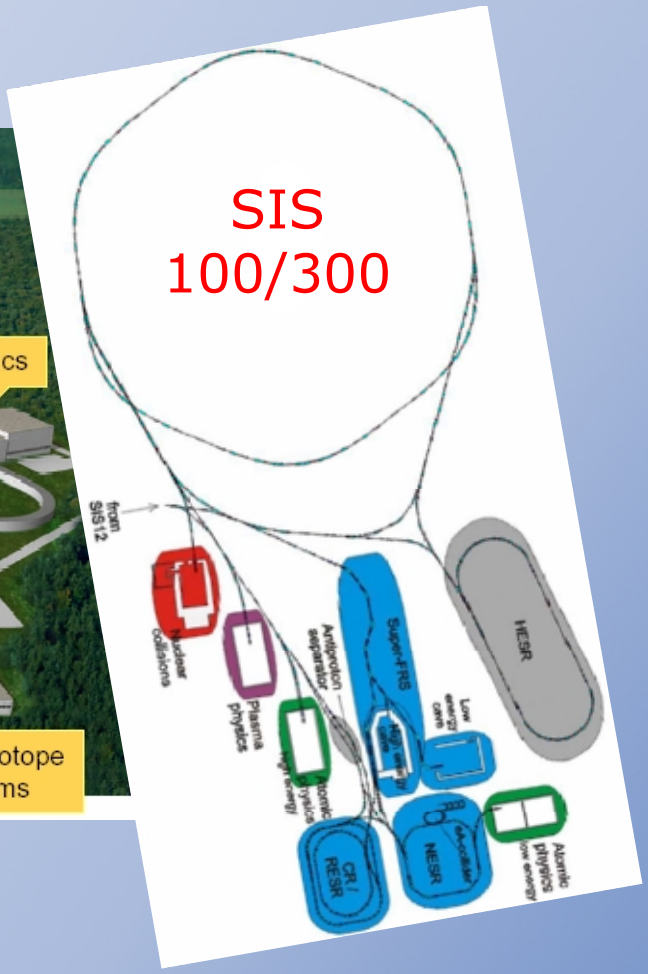
The NEW Facility

- FAIR (GSI, Darmstadt, Germany)





- Proton linac (injector)
- 2 synchrotons (30 GeV p)
- A number of storage rings

→ Parallel beams operation

FAIR – Prospects and Challenges

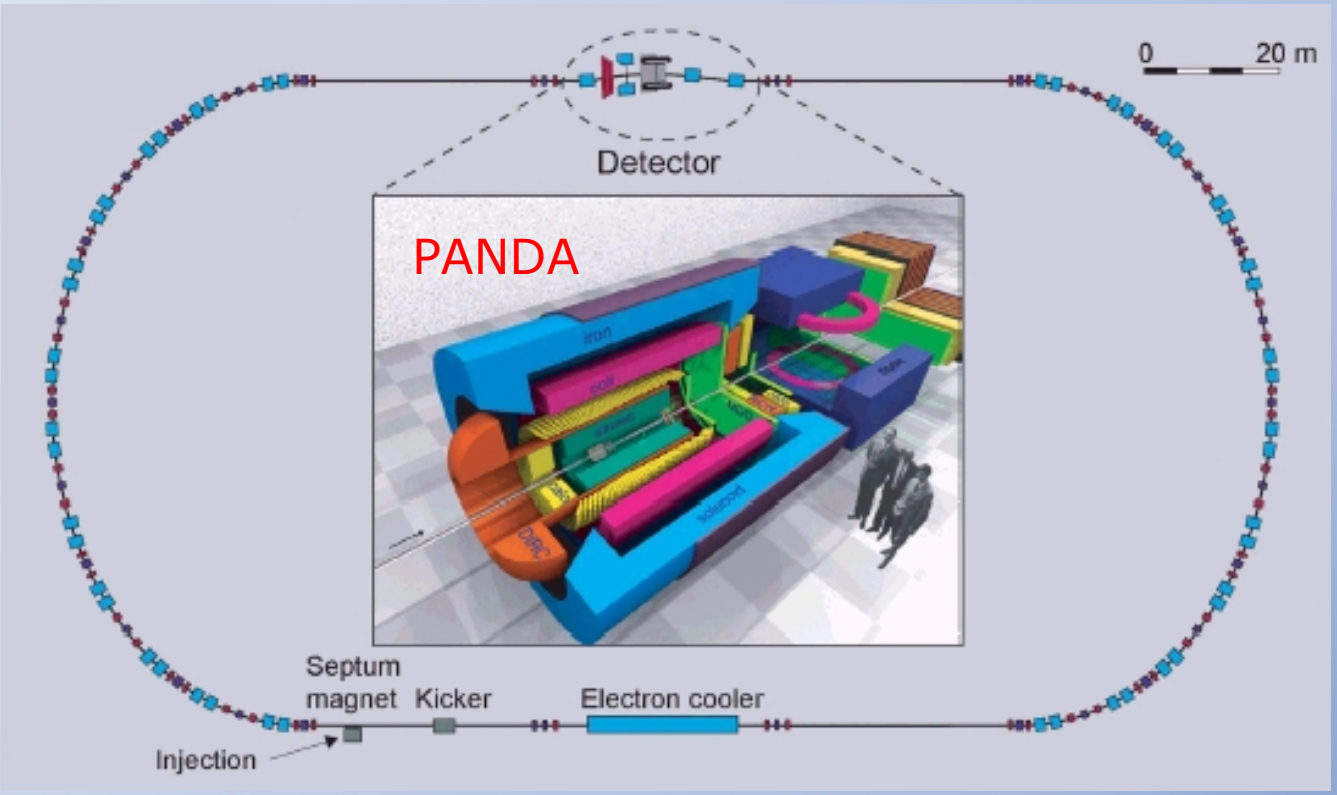
- FAIR is a facility, which will serve a large part of the nuclear physics community (and beyond):
  - Nuclear structure ←→ Radioactive beams
  - Dense Matter ←→ Relativistic ion beams
  - Hadronic Matter ←→ Antiprotons, (polarized)
  - Atomic physics
  - Plasma physics
- FAIR will need a significant fraction of the available man-power and money in the years to come:

  1 G€ ←→ 10 000 man-years = 100 "man" for 100 years

  or (1000 x 10)
- FAIR will have a long lead-time (construction, no physics) → staging (3 phases)

FAIR-Part for Hadron Physics

HESR (and PANDA): Antiproton beams



Momentum range: p = 1.5 – 15 GeV/c

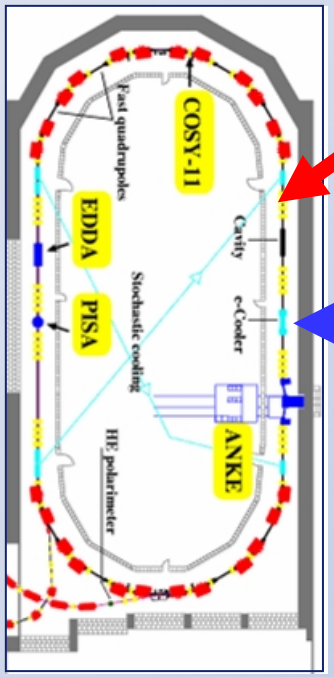
5×10^{10} stored antiprotons

Our long-term strategy

- Commitment of FZJ: essential contributions to FAIR:

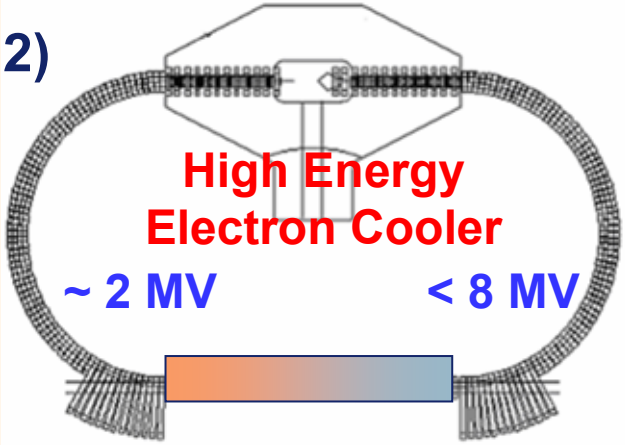
COSY

HESR at GSI

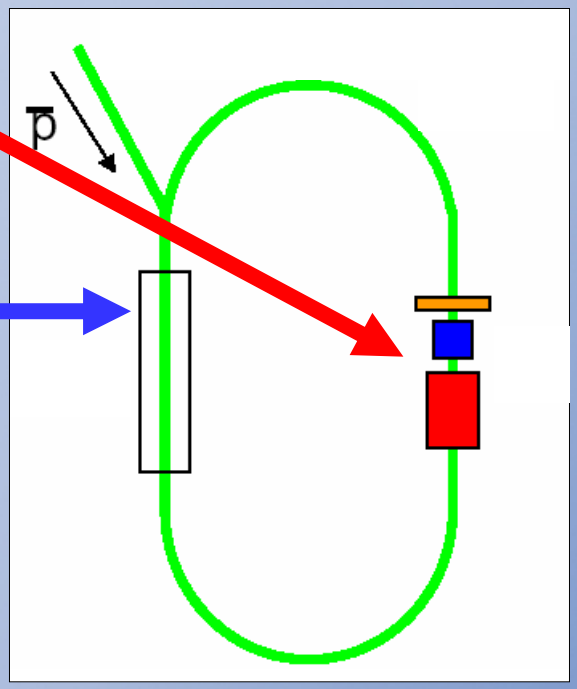


1) **Internal Detectors**
(WASA → PANDA)

2)



3) **Polarized beams**



Now

> 2014

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Summary

Hadron (and nuclear) physics in the past had, and it still has, a strong basis in Europe

Currently operated facilities will enable frontier physics to be done for the next decade –
they (and in particular COSY) will also be essential for education and training of the forthcoming generation of hadron physicists

The future project (FAIR at GSI, …) will extend the experimental part of *this kind of physics* well into the 21 century

Outlook

(Most probably) no facility for electromagnetic probes

Concentration process (large scale facilities, huge collaborations);

- Small facilities will (have to) be decommissioned
- European (or even world) facilities (e.g. FAIR)

Challenges:

- Cutting edge technology
- Educated and experienced personnel
- Hadron physics at FAIR is far away

Theory (not discussed here) is essential for real progress

→ Science:

The End