

Hadron Physics – Status and Perspectives

May 2010 | Hans Ströher



What is *Hadron Physics* about?

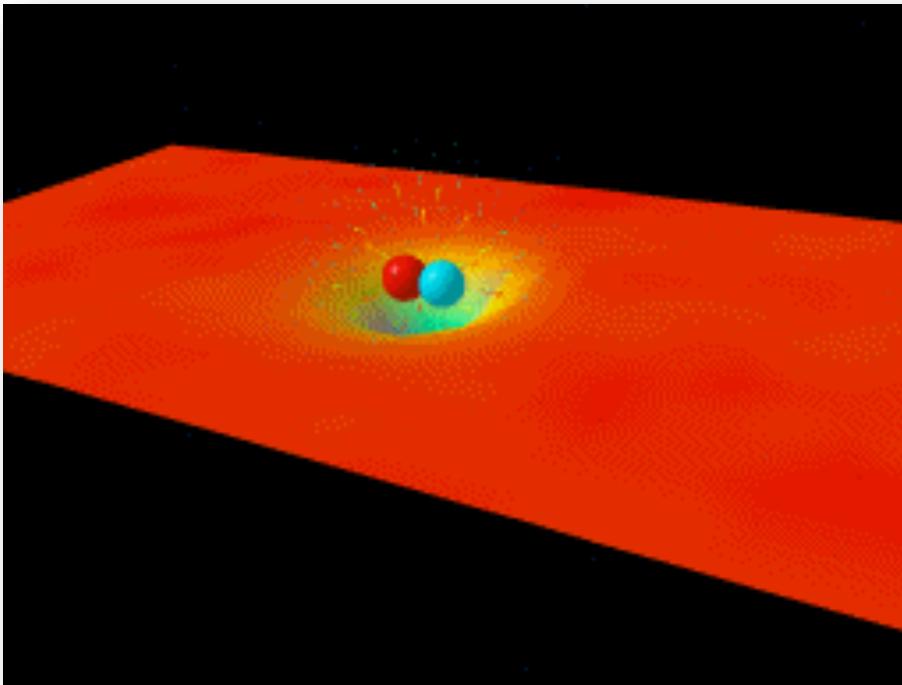
Hadron Physics – What?



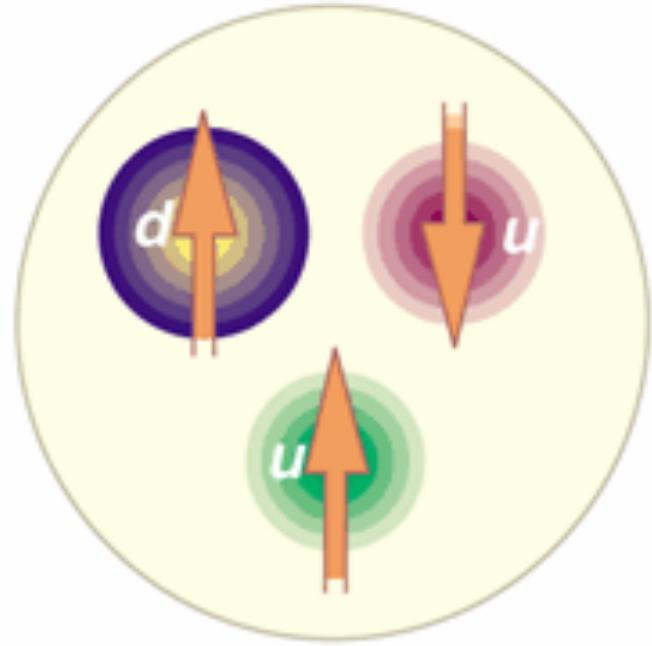
Hadron Physics – What?

1968: SLAC u up quark	1974: Brookhaven & SLAC c charm quark	1995: Fermilab t top quark	1979: DESY g gluon
1968: SLAC d down quark	1947: Manchester University s strange quark	1977: Fermilab b bottom quark	1923: Washington University* γ photon
1956: Savannah River Plant ν_e electron neutrino	1962: Brookhaven ν_μ muon neutrino	2000: Fermilab ν_τ tau neutrino	1983: CERN W W boson
1897: Cavendish Laboratory e electron	1937: Caltech and Harvard μ muon	1976: SLAC τ tau	1983: CERN Z Z boson

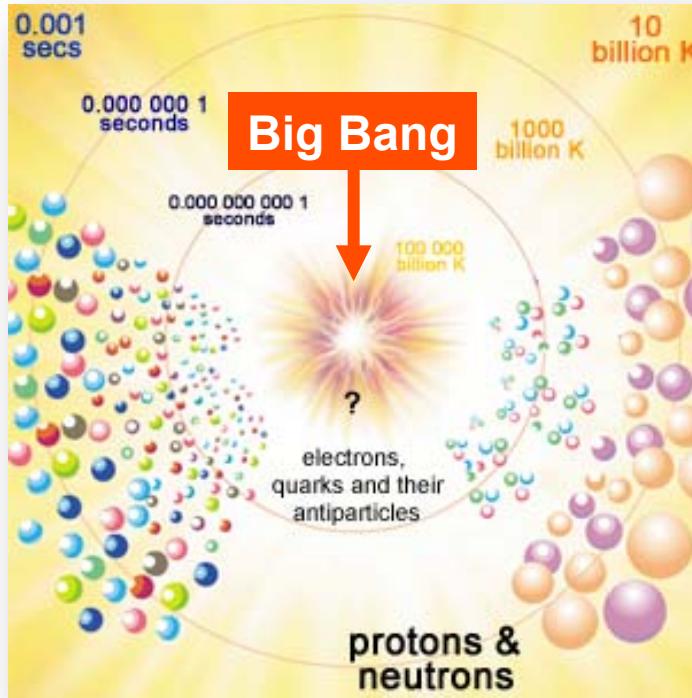
Fundamental constituents



Quarks cannot be isolated
(„confinement“)



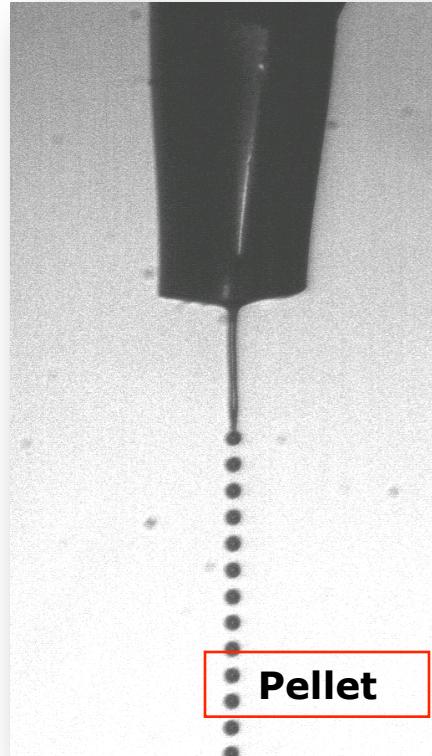
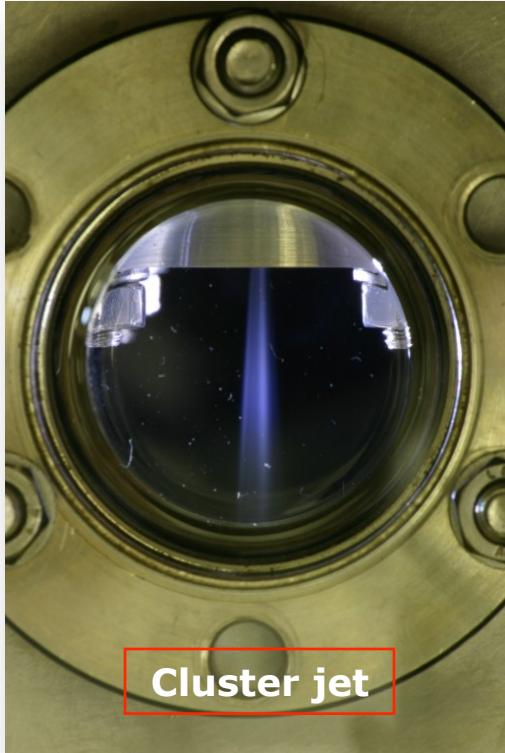
Hadrons – irrevocably
bound quark systems



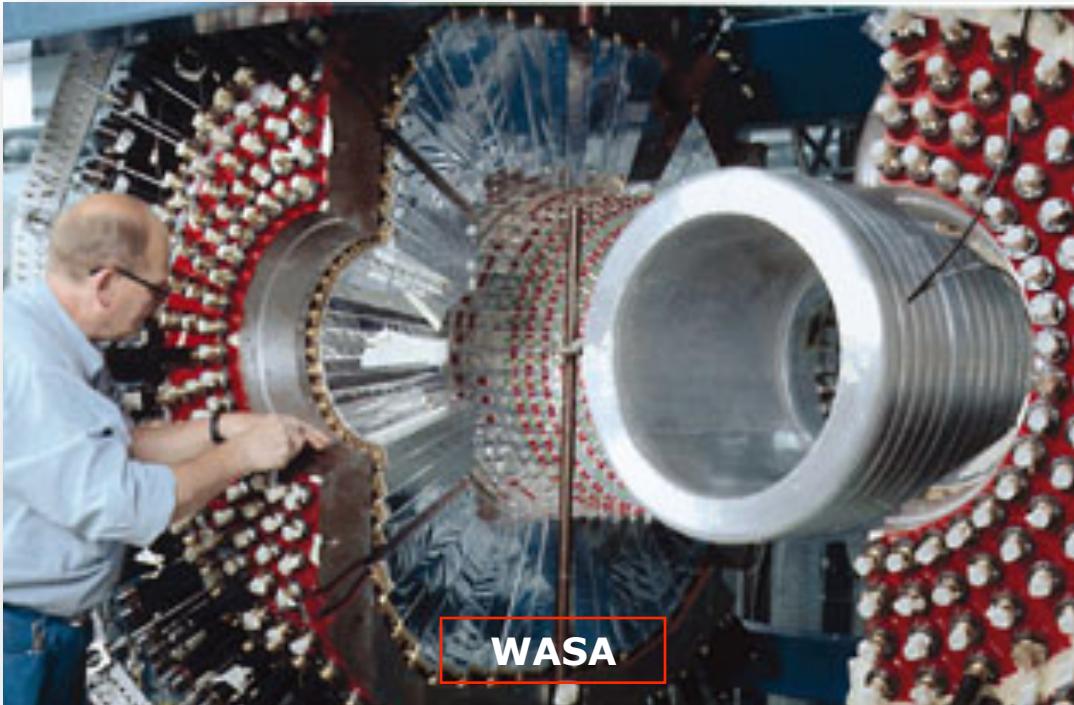
How did/does
Nature *make* hadrons?



Tools: accelerators → beams



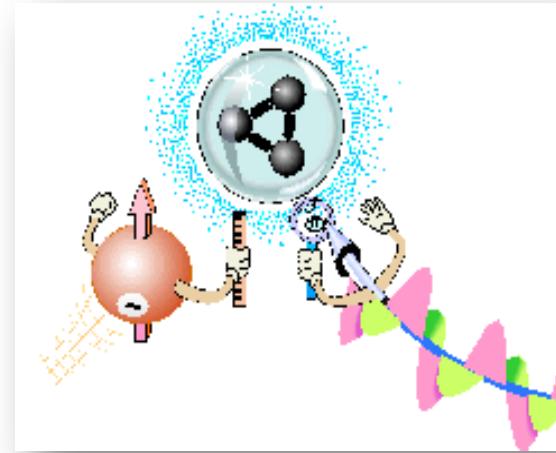
Tools: targets



Tools: detectors

Electron Accelerator Facilities

MAXLab Lund
Darmstadt Linac
Mainz Microtron
Stretcher Bonn
Daφne Frascati
Compass CERN



BEPC (China)
JLab (USA)

Hadron Accelerator Facilities

COSY Jülich

GSI Darmstadt

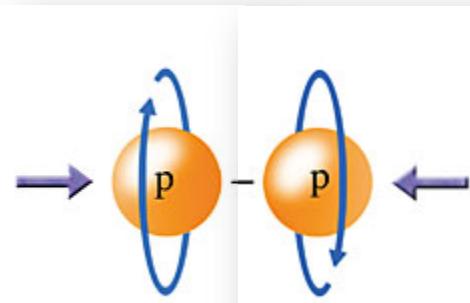
Compass CERN

FAIR Darmstadt

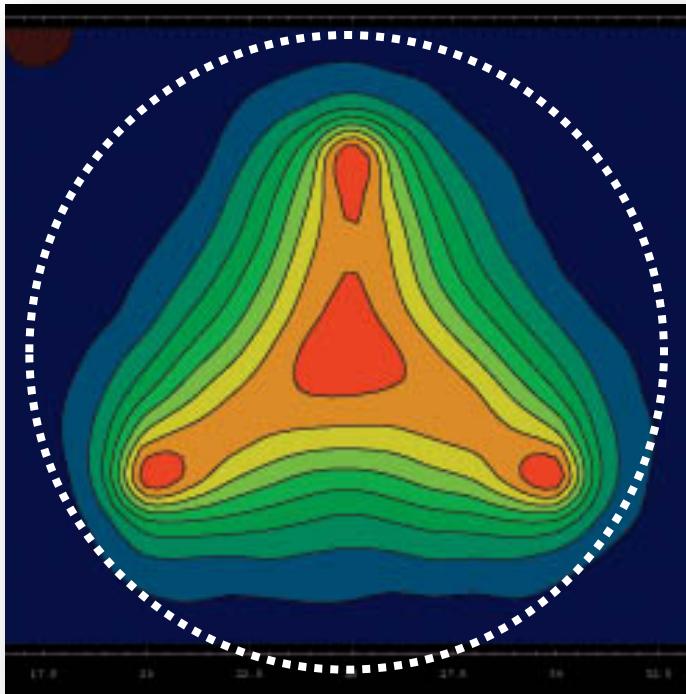
CSRm,e (China)

J-PARC (Japan)

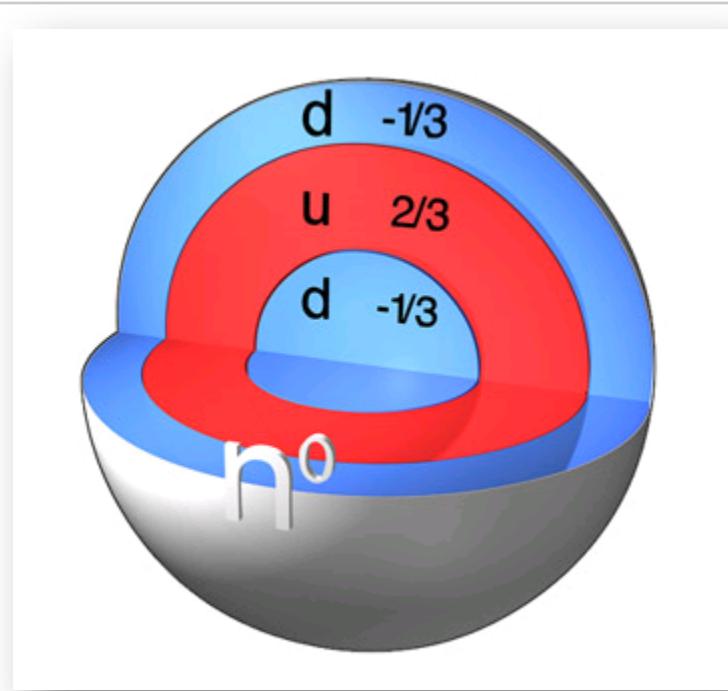
RHIC (USA)



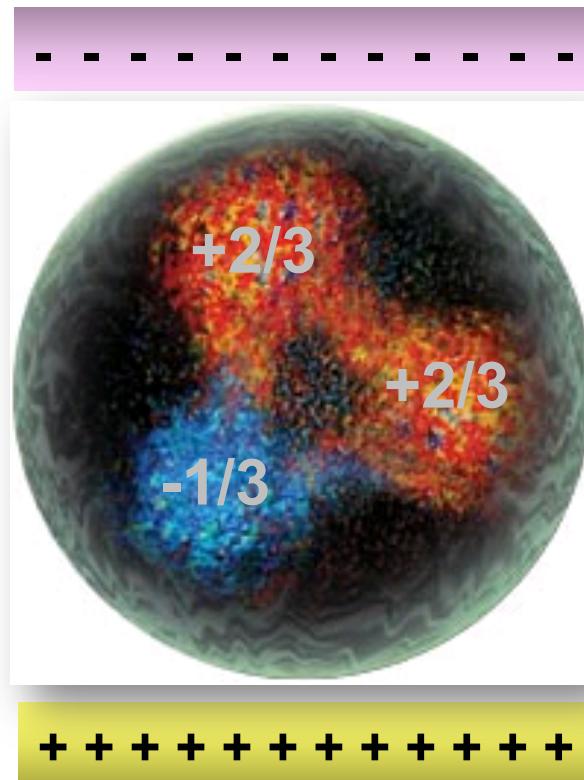
There are things
we know that **we know** ...



Quark-gluon structure
of nucleon (proton, neutron)



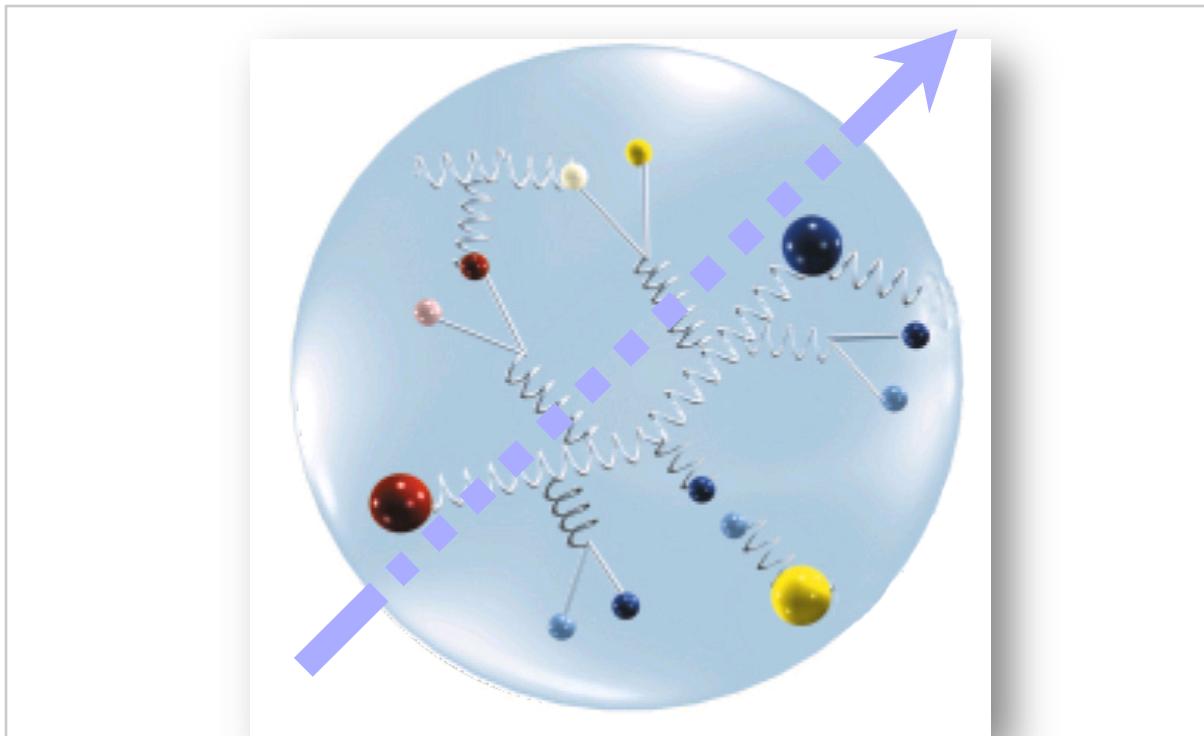
Charge distribution
of neutron



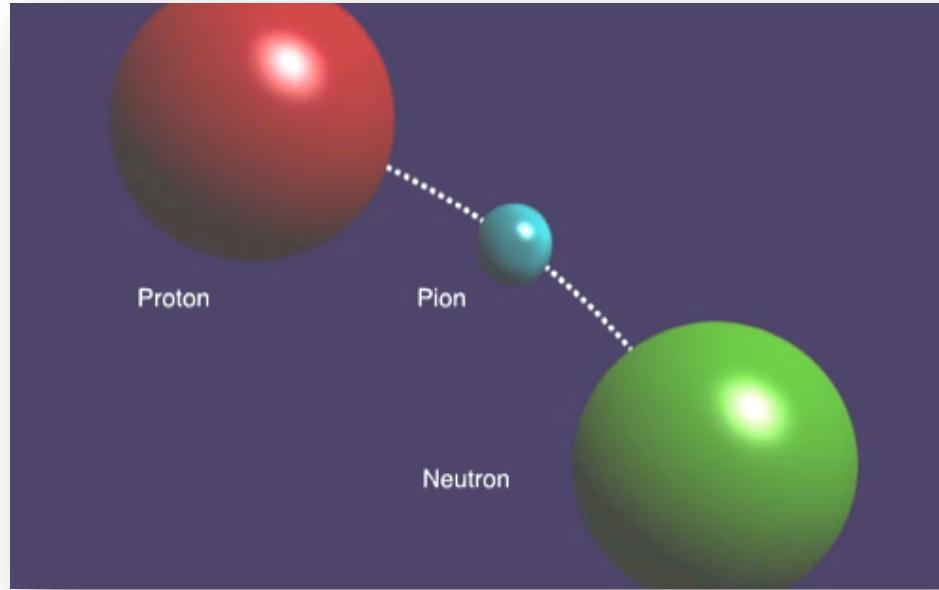
Nucleon polarizabilities



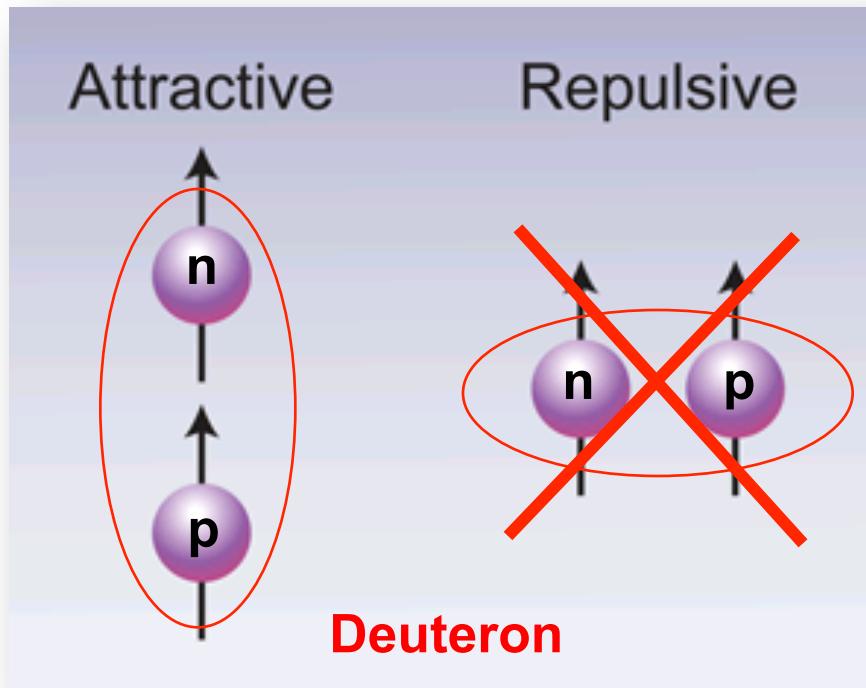
Excited states of nucleon
(H-atom → QED-theory)



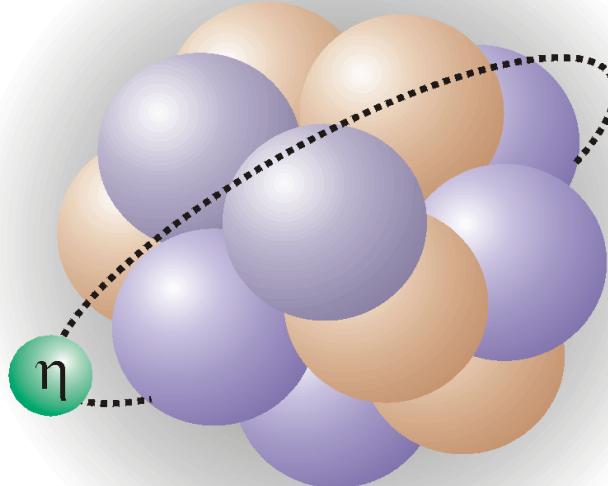
Nucleon (multiple constituents)
is very complicated (so is QCD)



Hadronic (NN-) interaction: Phenomenology



Bound nucleon states:
multitude of nuclei

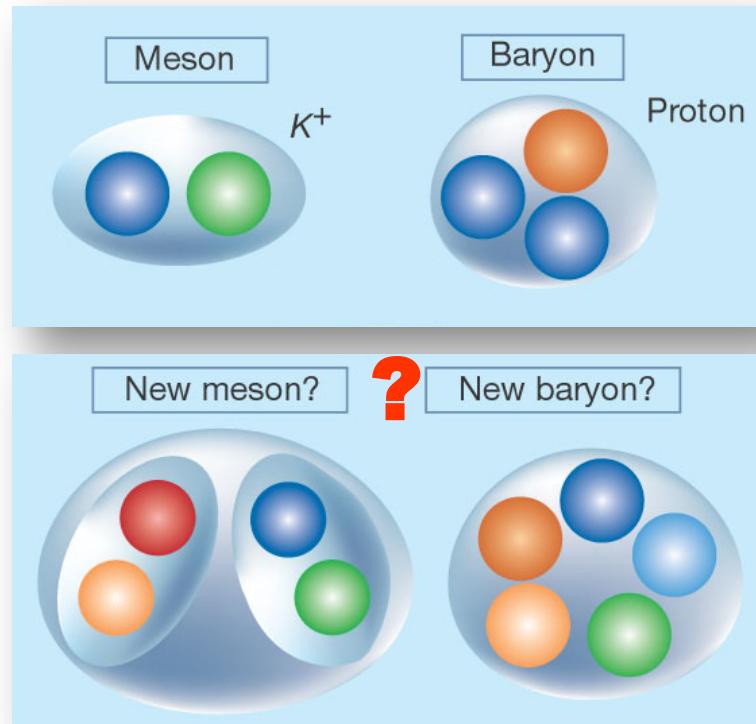


Hadronic bound states
(e.g. **η -mesic** nuclei)

... much much more, **but** ...

There are things
we know that we know,
there are things
we know
that we don't know ...

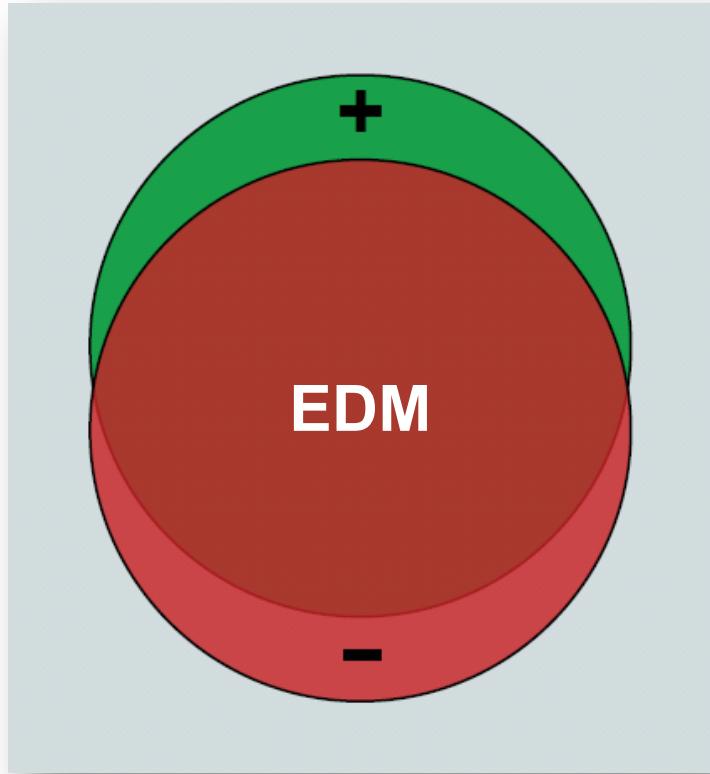
Hadron Physics – We don't know yet



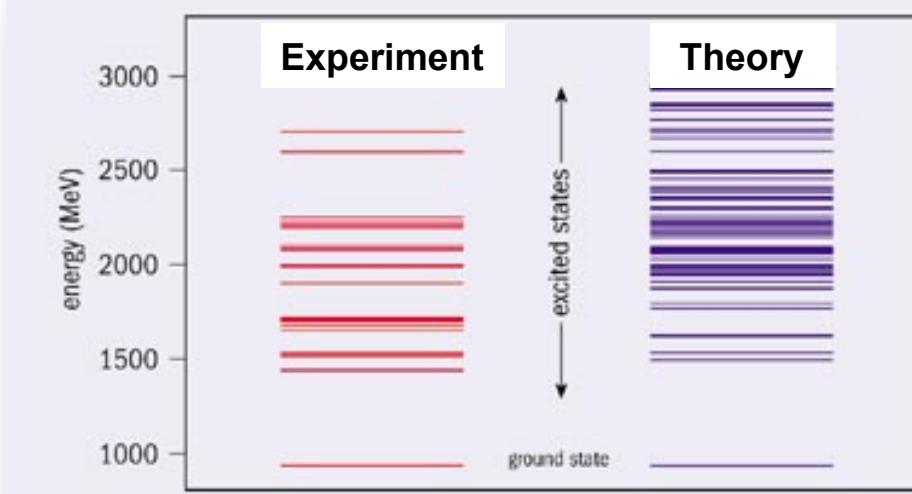
Quark bound states,
hybrids, glueballs

Symmetry

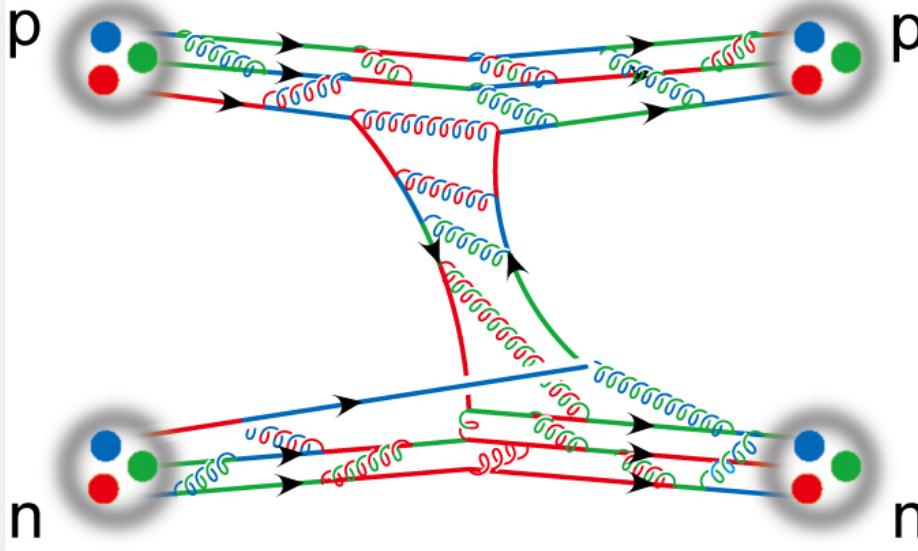
Physics is **study of symmetry**
Weak Force: ~~X~~, ~~CP~~
→ CP violated for quarks?



Charge center separation



Full spectrum
of excited N*-states

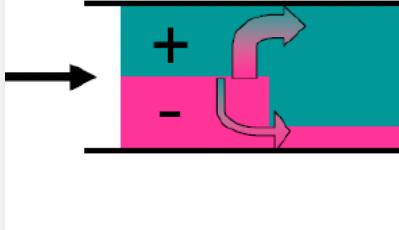


Nucleon-nucleon interaction
(residual qq-force)

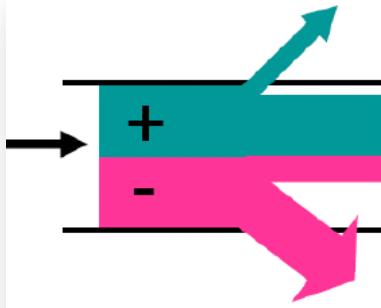
... the answer
to many more questions –
so ...



New facilities: **FAIR**



selective flip



selective loss

COSY expt.:
Does NOT work !

Works for
protons !

New tools: polarized \bar{p} -beam

Hadron Physics – We need ...



Mitglied der Helmholtz-Gemeinschaft

Seeking Excellent Young Scientists
Opportunities for Brilliant Minds



New young researchers !!

There are things
we know that we know,
there are things
we know
that we don't know,
...and then
there are things
we don't know
that we don't know !

D.H. Rumsfeld



So: be prepared for surprises



Caspar David Friedrich (1818):
Wanderer above the Sea of Fog

Thank you very much for your attention!