Gruppo di Fisica Adronica
Esperimenti

PANDA

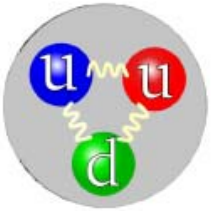
MAMBO

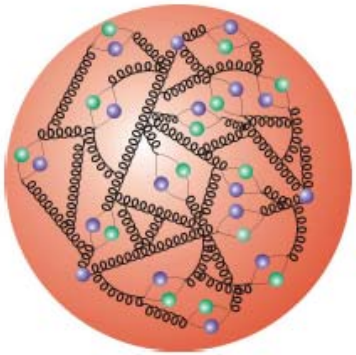
AEGIS

The proton sea

- **constituent quark model:**
  pure valence description
- **perturbative sea:** $g \rightarrow q\bar{q}$
  flavor-symmetric, $\bar{u} = \bar{d}$
- **analysis of NMC data:**

$$\int_0^1 [\bar{d}(x) - \bar{u}(x)]\ \mathrm{d}x \neq 0$$





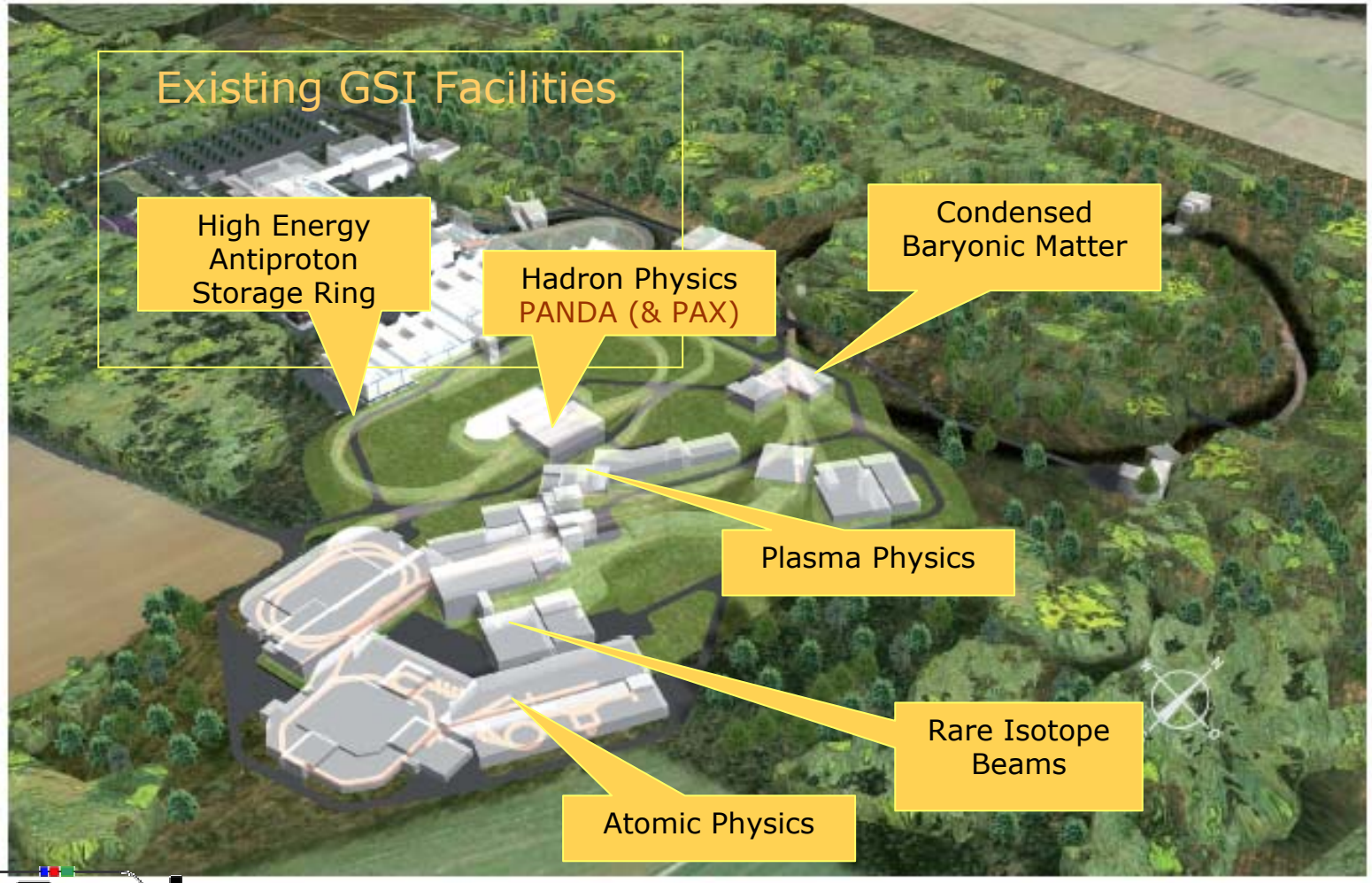
- data shows $\bar{d} > \bar{u}$ (up to 50%)
- **alternate degrees of freedom of sea**

quark: 30% dello spin, 50% del momento

1. PANDA at FAIR

THE European hadron facility

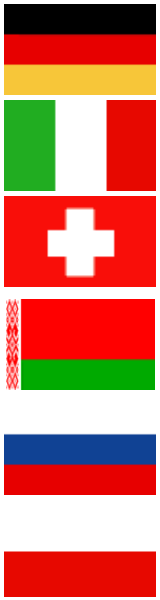
Facility for **A**ntiproton and **I**on **R**esearch



PANDA Collaboration

Gruppo di Pavia: Gianluigi Boca, Susanna Costanza, Pablo Genova, Lia Lavezzi, Paolo Montagna, Alberto Rotondi

- At present a group of **420 physicists** from 55 institutions from 17 countries



Austria – Belaruz – China – Finland – France – Germany – India – Italy – The Netherlands – Poland – Romania – Russia – Spain – Sweden – Switzerland – U.K. – U.S.A.

Basel, Beijing, Bochum, IIT Bombay, Bonn, Brescia, IFIN Bucharest, Catania, Cracow, IFJ PAN Cracow, Cracow UT, Dresden, Edinburgh, Erlangen, Ferrara, Frankfurt, Genova, Giessen, Glasgow, GSI, Inst. of Physics Helsinki, FZ Jülich, JINR Dubna, Katowice, KVI Groningen, Lanzhou, LNF, Lund, Mainz, Minsk, ITEP Moscow, MPEI Moscow, TU München, Münster, Northwestern, BINP Novosibirsk, IPN Orsay, Pavia, Piemonte Orientale, IHEP Protvino, PNPI St.Petersburg, KTH Stockholm, Stockholm, Dep. A. Avogadro Torino, Dep. Fis. Sperimentale Torino, Torino Politecnico, Trieste, TSL Uppsala, Tübingen, Uppsala, Valencia, SINS Warsaw, TU Warsaw, AAS Wien

http://www.gsi.de/panda

- Charmonium/open charm spectroscopy
- Exotic states
- Strange and charmed baryons
- Hadrons in the nuclear medium
- Hypernuclear physics
- Nucleon structure via e.m. processes

Racetrack shaped Ring: 574 m length

Luminosity/Intensity:

- Pbar production rate: 2×10^{7} /s
- High luminosity mode: $L = 2 \times 10^{32}$ [$cm^{-2}s^{-1}$]
- High resolution mode: $L = 10^{31}$ [$cm^{-2}s^{-1}$]

Momentum range:

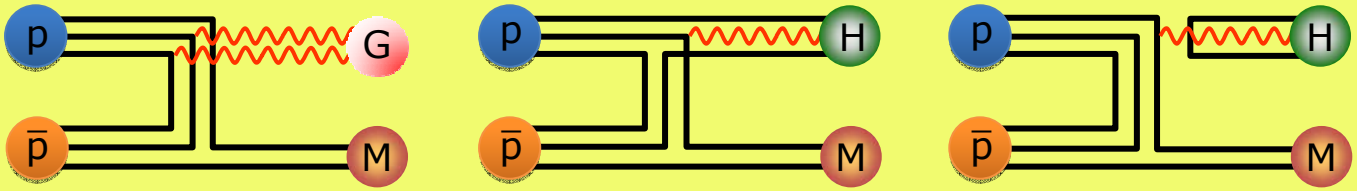
- 1.5 – 15 [GeV/c]

Momentum resolution:

- High luminosity mode: $\Delta p/p = 10^{-4}$ (stochastic cooling above 3.8 GeV/c))
- High resolution mode: $\Delta p/p = 10^{-5}$ (electron cooling)

Spectroscopy with antiprotons

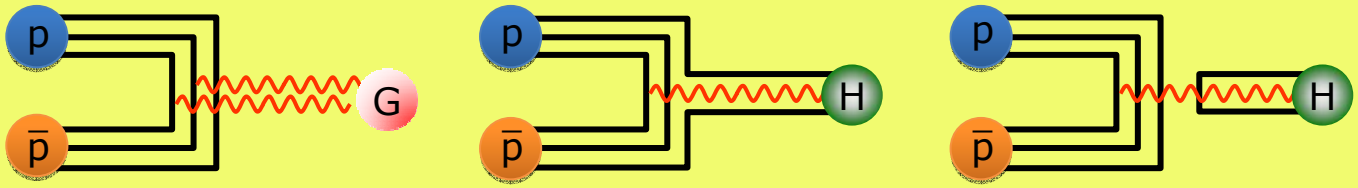
Production

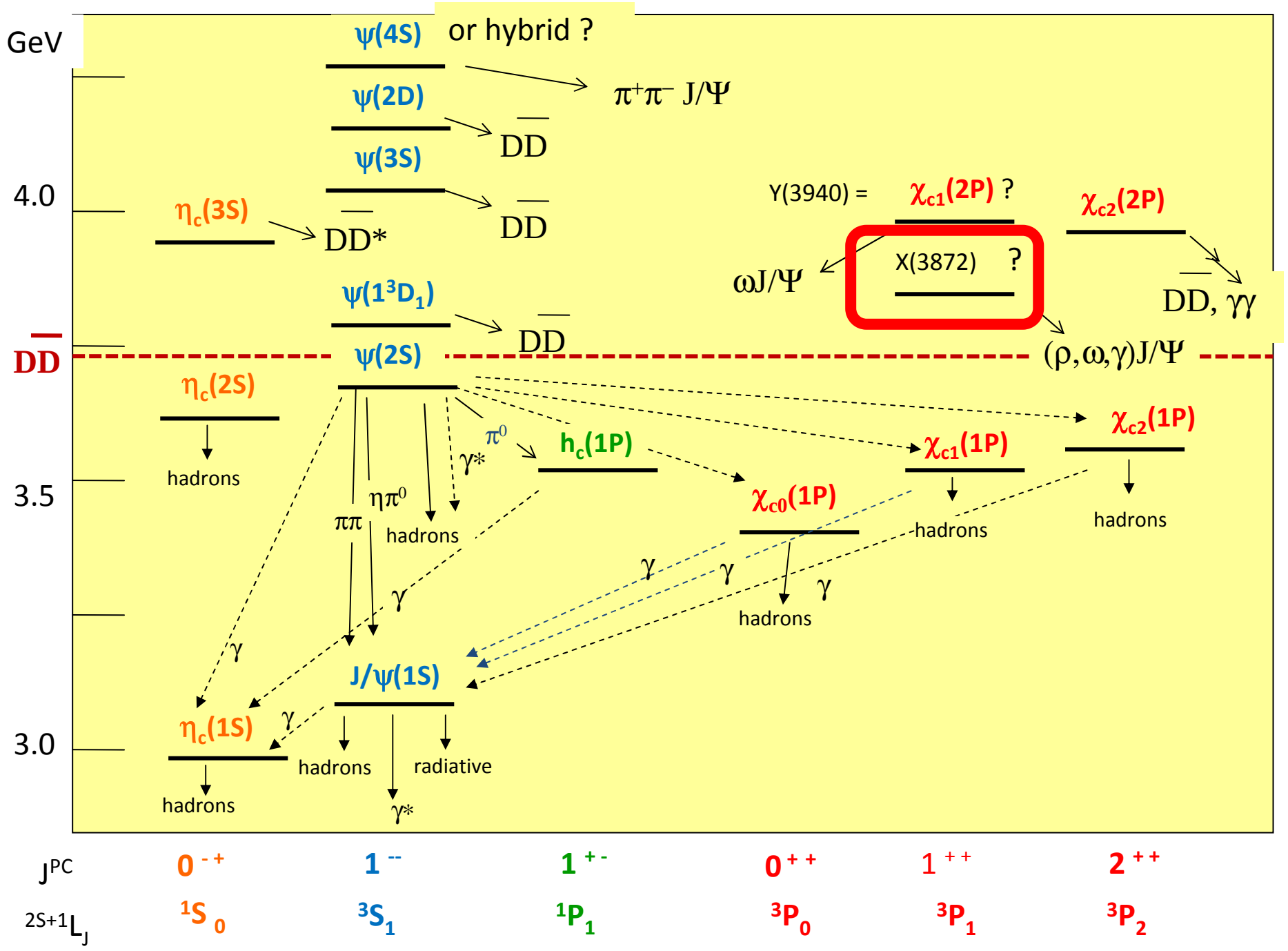


Even exotic quantum numbers can be reached σ ~100 pb

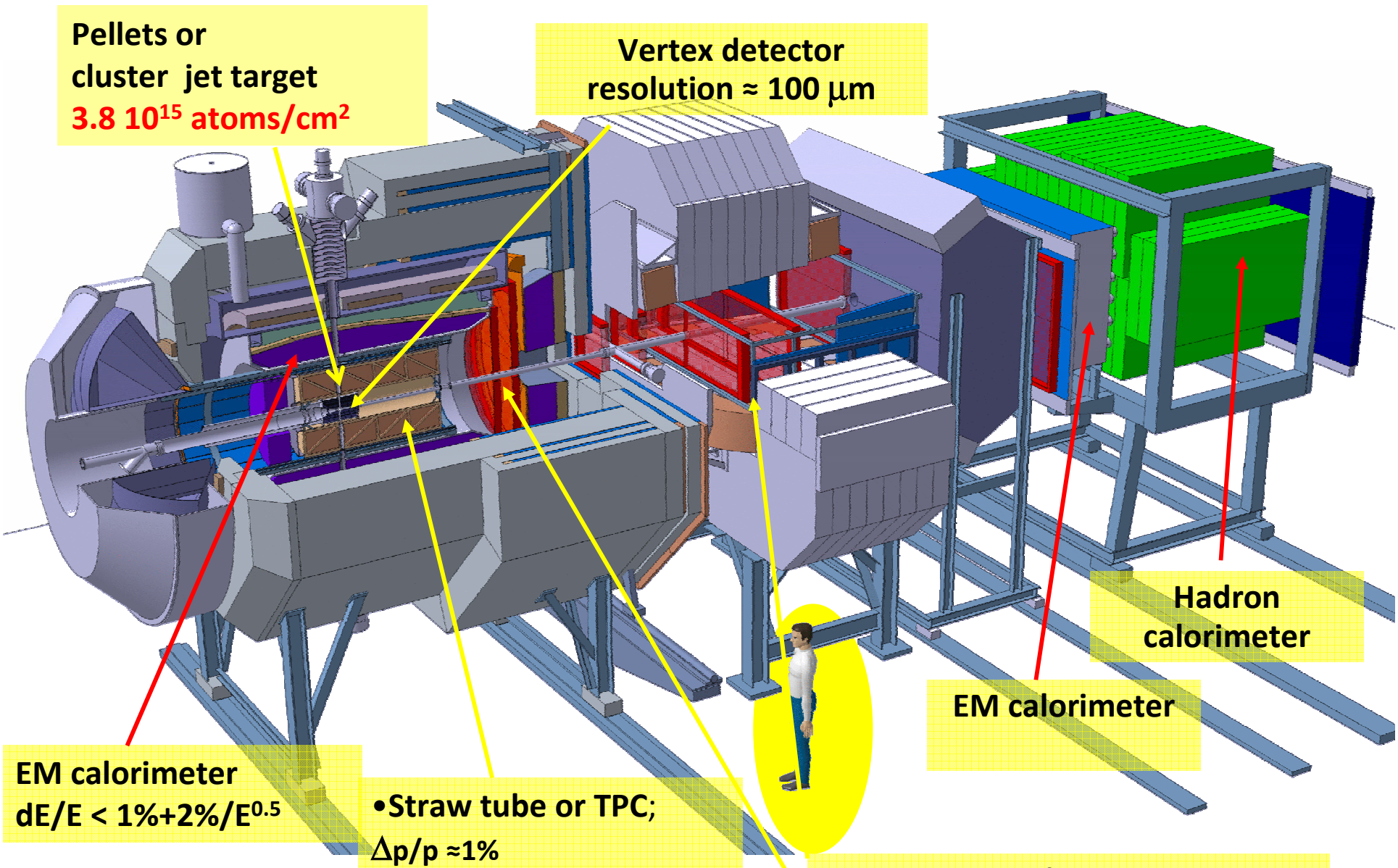
All ordinary quantum numbers can be reached σ ~1 μb

Formation




GeV
4.0
3.5
3.0
DD
ψ(4S)
or hybrid ?
ψ(2D)
ψ(3S)
ψ(1³D₁)
ψ(2S)
J/ψ(1S)
π⁺π⁻ J/Ψ
DD
DD*
ηc(3S)
Y(3940) =
χc1(2P) ?
X(3872) ?
χc2(2P)
ωJ/Ψ
DD, γγ
(ρ,ω,γ)J/Ψ
ηc(2S)
hadrons
π⁰
hc(1P)
γ*
χc1(1P)
χc2(1P)
ππ
ηπ⁰
χc0(1P)
γ
ηc(1S)
radiative
JPC
0 -+
1 --
1 +-
0 ++
1 ++
2 ++
2S+1LJ
1S 0
3S1
1P1
3P0
3P1
3P2

The PANDA detector (tracking)



PANDA; disponibilità di tesi sperimentali di Fisica Nucleare

- Studio delle prestazioni dell'apparato
- Nuovi metodi di analisi di reazioni su dati simulati
- Partecipazione alle misure di calibrazione presso i centri di Julich e di FAIR (Darmstadt)

2. MAMBO: Studio sperimentale dello

Spin (e di altre proprietà) del protone (neutrone)

utilizzando fasci di fotoni di alta energia
(50 MeV $\leq E_\gamma \leq$ 3000 MeV) prodotti presso i laboratori MAMI di Mainz (Germania) ed ELSA di Bonn (Germania)

INFN –Sezione di Pavia: S.Costanza, A. Braghieri, P.Pedroni,

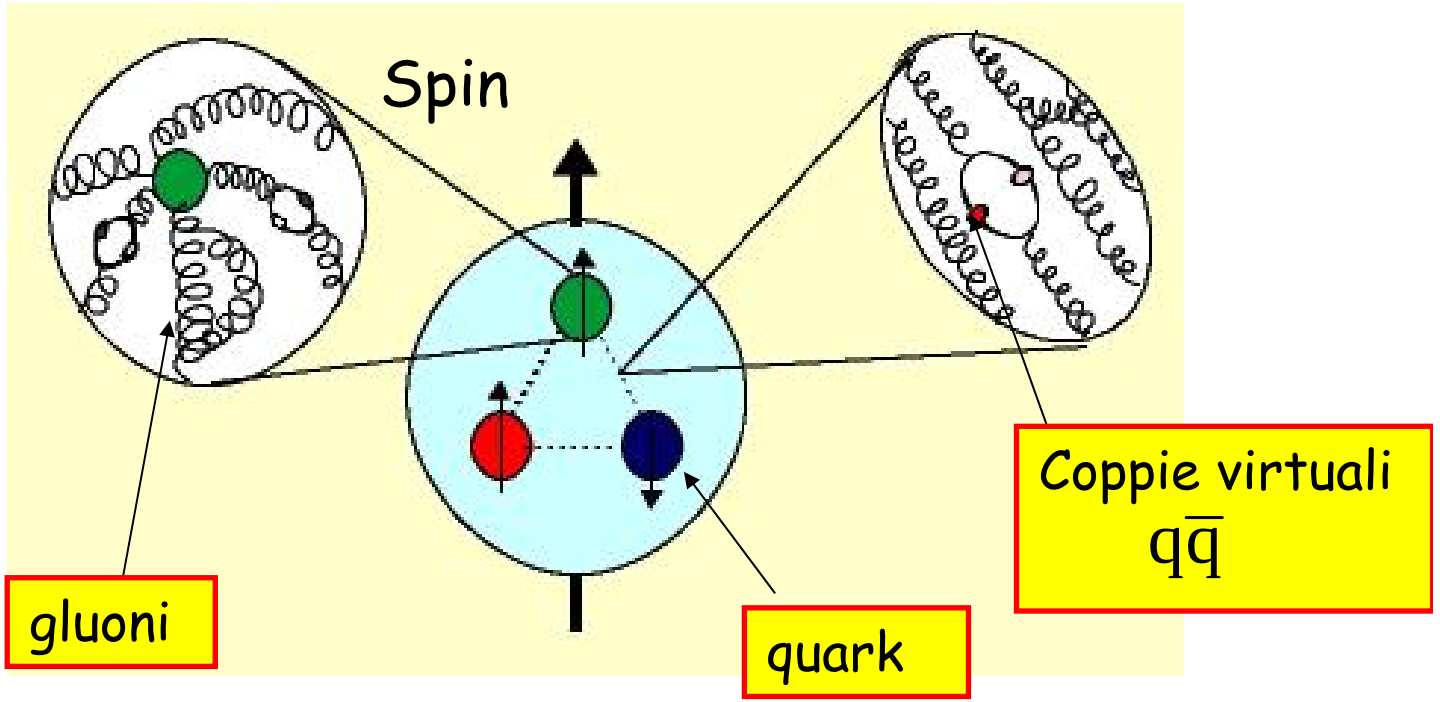
Università di Mainz, Bonn, Glasgow, Edimburgo, Bochum, Giessen, Basilea, Washington, Los Angeles, Kent (USA), Sackville (CAN), Tomsk (Russia)

INR-Mosca, RBI-Zagabria, NPI-Gatchina (Russia)

Perché il protone (neutrone) è dotato di spin ?

Quarks spin = 1/2		
Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.003	2/3
d down	0.006	−1/3
c charm	1.3	2/3
s strange	0.1	−1/3

Strong (color) spin = 1		
Name	Mass GeV/c^2	Electric charge
g gluon	0	0



- Modello "naif" Spin = $\frac{1}{2}$ = $\sum Spin_{quark}$
- QCD perturbativa Spin = $\frac{1}{2}$ = $\sum Spin_{quark} + L_{quark} + \Delta gluoni + \Delta q\bar{q}$

$\sum Spin_{quark} \cong$ 80% dello Spin

- **Esperimenti: $\sum Spin_{quark} \cong$ 20-30% dello Spin (!)**

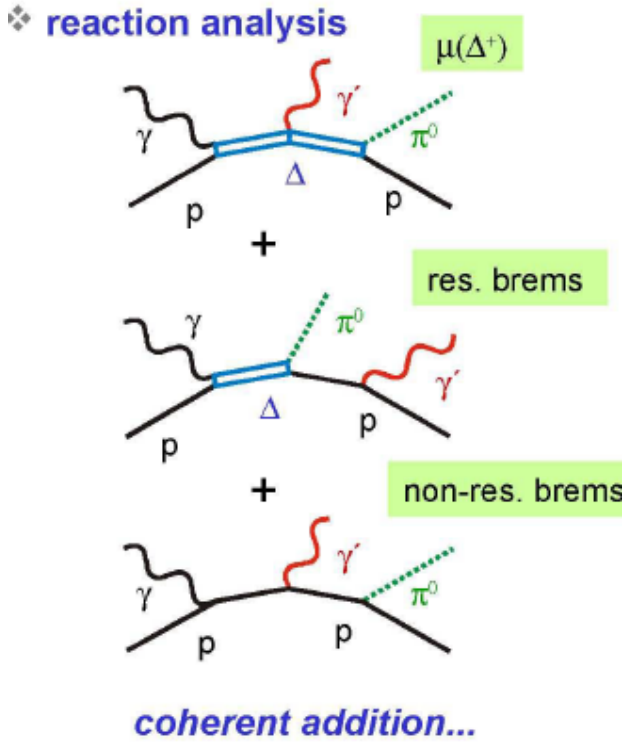
Attività in corso e prevista

- Misure di proprietà fondamentali del protone/neutrone e dei loro stati risonanti (informazioni necessarie anche per risolvere il problema dello spin)

- Verifica di principi quantistici fondamentali (conservazione carica, CP, ...) attraverso lo studio dei decadimenti rari dei mesoni η ed η'

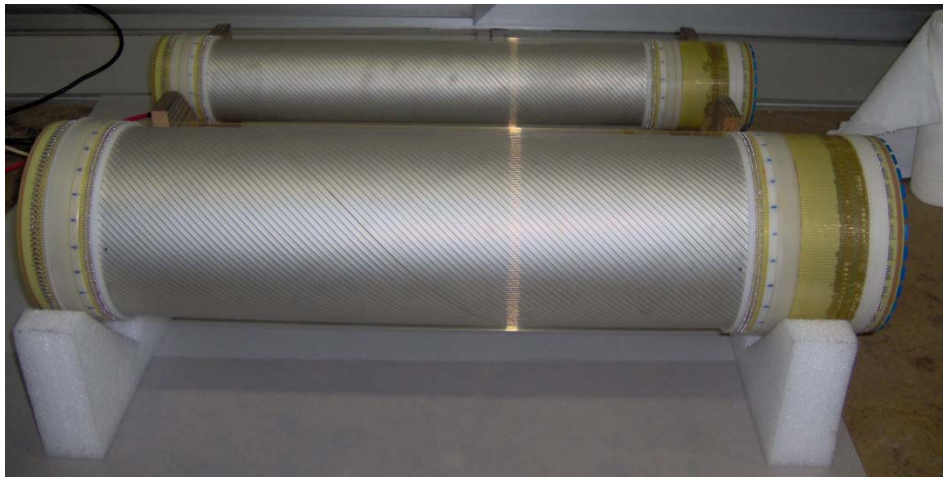
- Modifiche delle proprietà fondamentali del protone/neutrone all'interno dei nuclei atomici

$$\gamma p \rightarrow p \pi^0 \gamma'$$



Ruoli del gruppo di Pavia

- Costruzione, test e commissioning delle camere a fili cilindriche usate sia a Mainz che a Bonn per determinare le traiettorie delle particelle cariche emesse nelle reazioni indotte da fotoni.



- Coordinamento del programma di fisica che utilizza fasci di fotoni linearmente polarizzati e bersagli di protoni/neutroni polarizzati

- Analisi off-line dei dati sperimentali raccolti

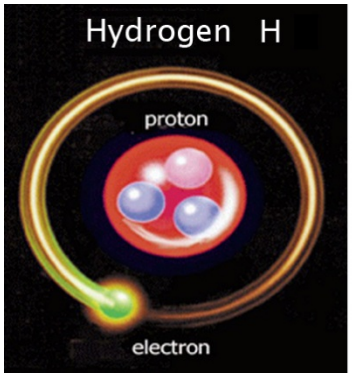
Ampia disponibilità di tesi sperimentali di Fisica Nucleare

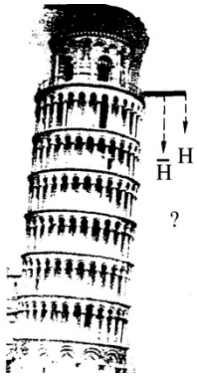
- Test e calibrazione delle nuove camere a fili presso il laboratorio di Pavia e l'acceleratore di Bonn
- Sviluppo e test dell'elettronica di front-end per la nuove camere a fili
- Partecipazione alle misure presso gli acceleratori di Mainz e Bonn con analisi off-line dei dati raccolti

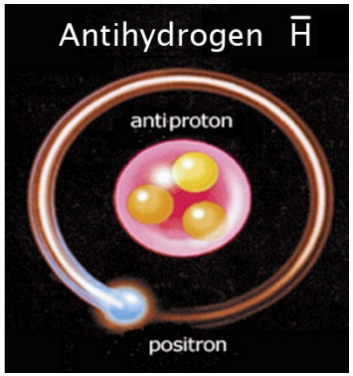
3. AEGIS

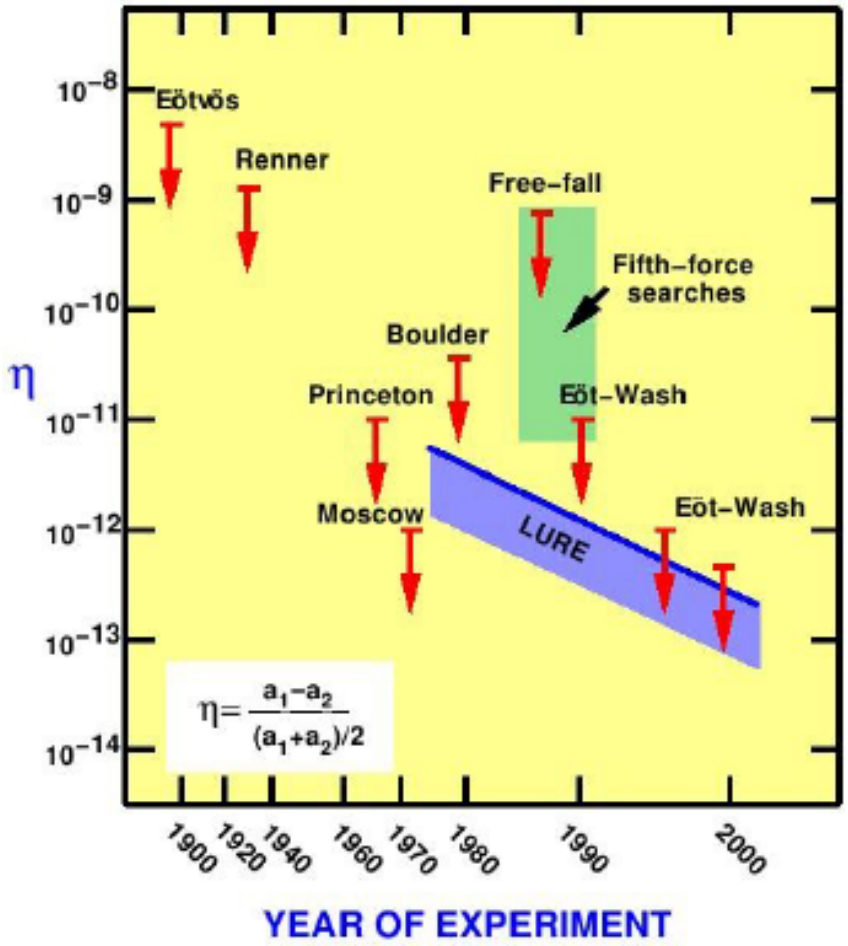
Antimatter Experiment: Gravity, Interferometry, Spectroscopy

Purpose: to search for WEP violations on antihydrogen with an accuracy of 1%





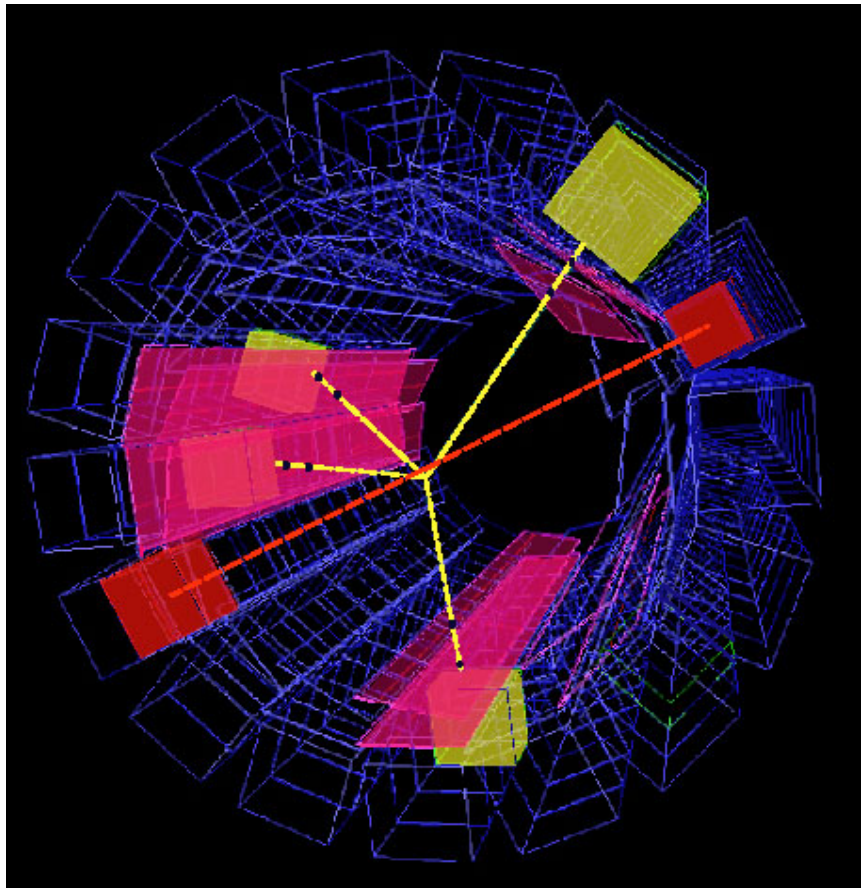




ATHENA

Study of the Anti-hydrogen production mechanisms

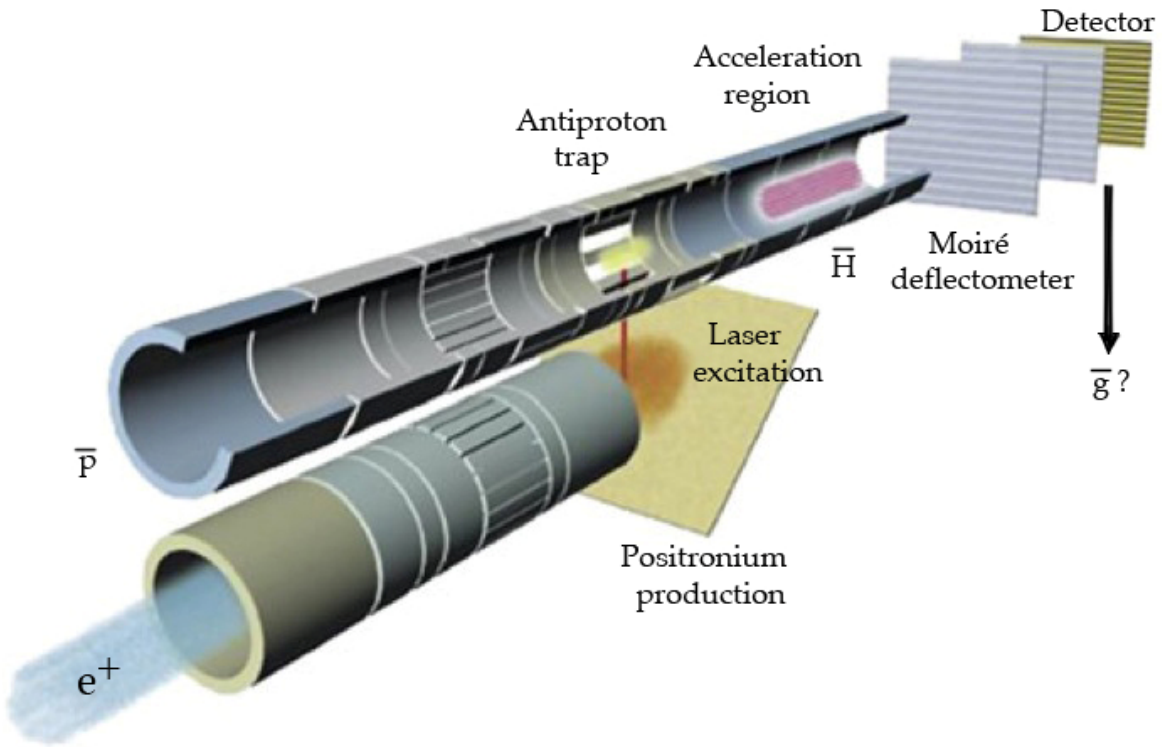
(CERN september 2002)



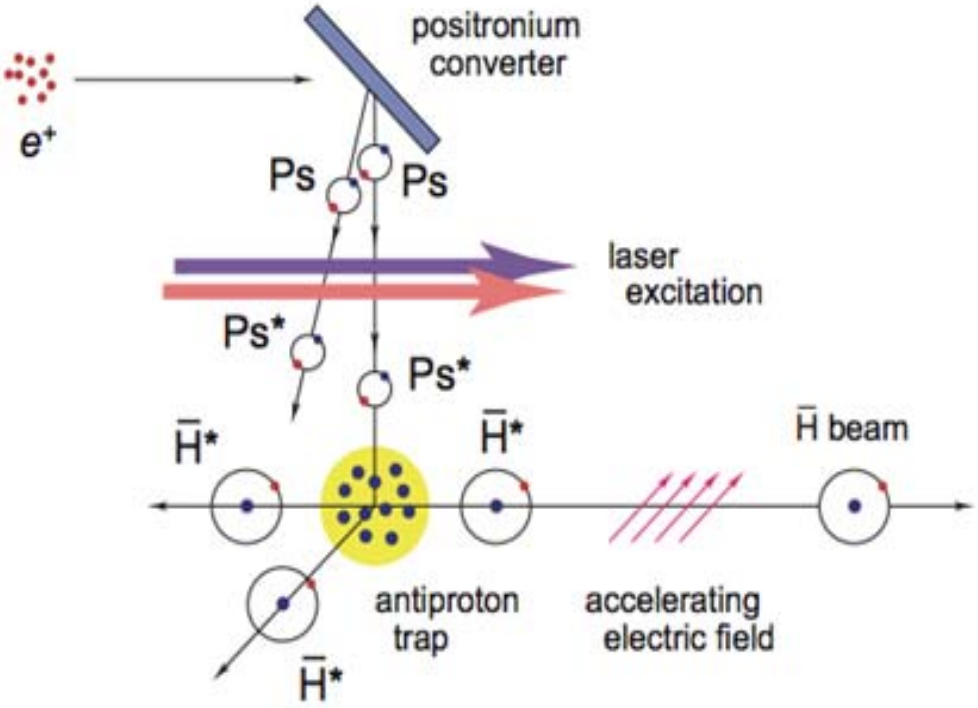
Description of the experiment

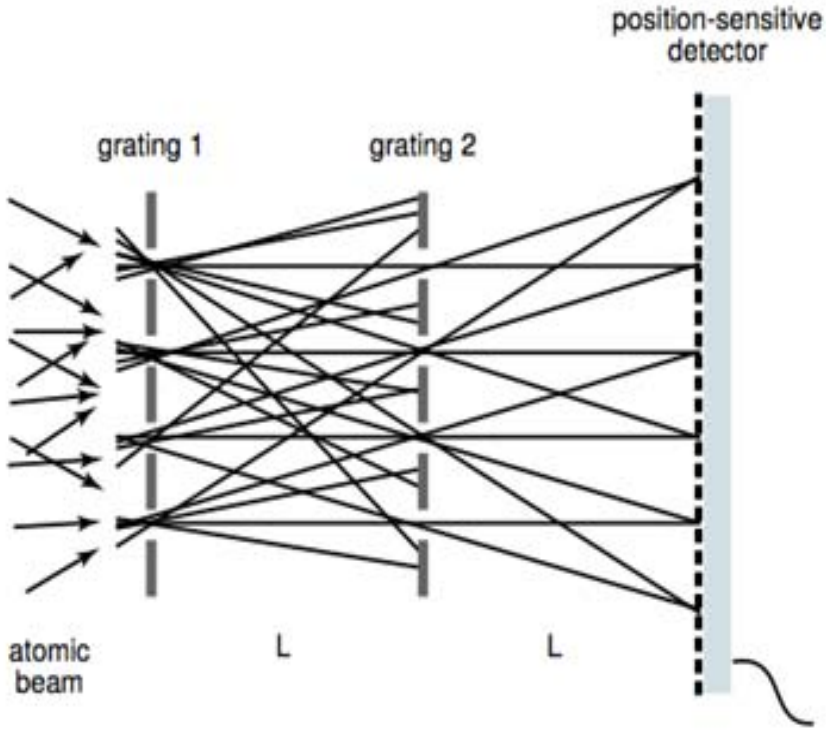
The goal of the AEgIS experiment is a first direct measurement of the earth's gravitational acceleration with the simplest form of electrically neutral antimatter, namely antihydrogen. Antihydrogen was produced in great quantities by ATHENA in 2002 and trapped by ALPHA in 2012 and is now routinely produced at CERN.

In the first phase of AEgIS a measurement of the gravity force with 1% precision will be carried out by sending an antihydrogen beam lauched horizontally in a vacuum tube and by measuring the gravitational sag with a Moiré deflectometer and a position sensitive detector.



Principles of the experiment





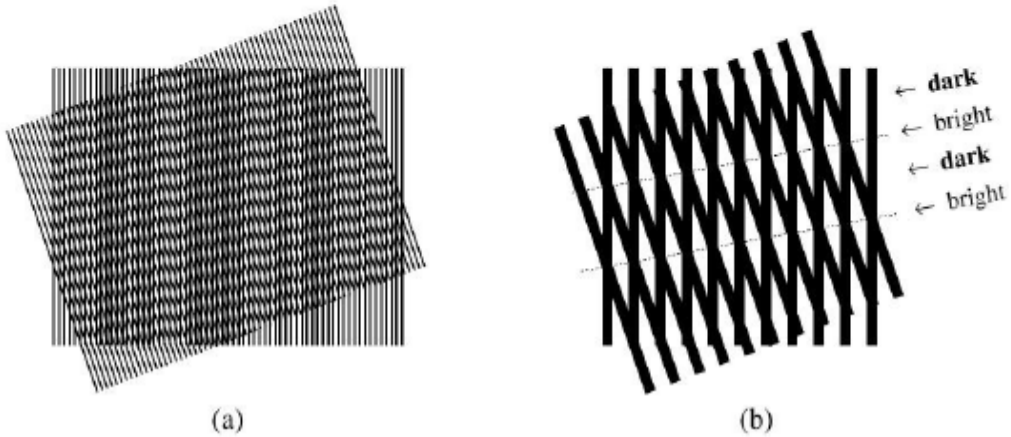
- The Moire deflectometer. Consider a beam of antihydrogen which falls freely in the Earth's gravitational eld. Given AEgIS realistic numbers, ight path length of 1 m, horizontal velocity of about 500 m/s, the vertical displacement of an antihydrogen atom due to gravity, assuming g 10 m/s, would be about 20 μ.

v[m/s]	λ_{dB}[m]	$x_c[\mu$m]	p[eV/c]
300	1.32e-09	22.98	938.9
400	9.90e-10	19.90	1251.9
500	7.92e-10	17.80	1564.9
600	6.60e-10	16.25	1877.8
700	5.66e-10	15.05	2190.8
800	4.95e-10	14.07	2503.8

L'effetto moiré

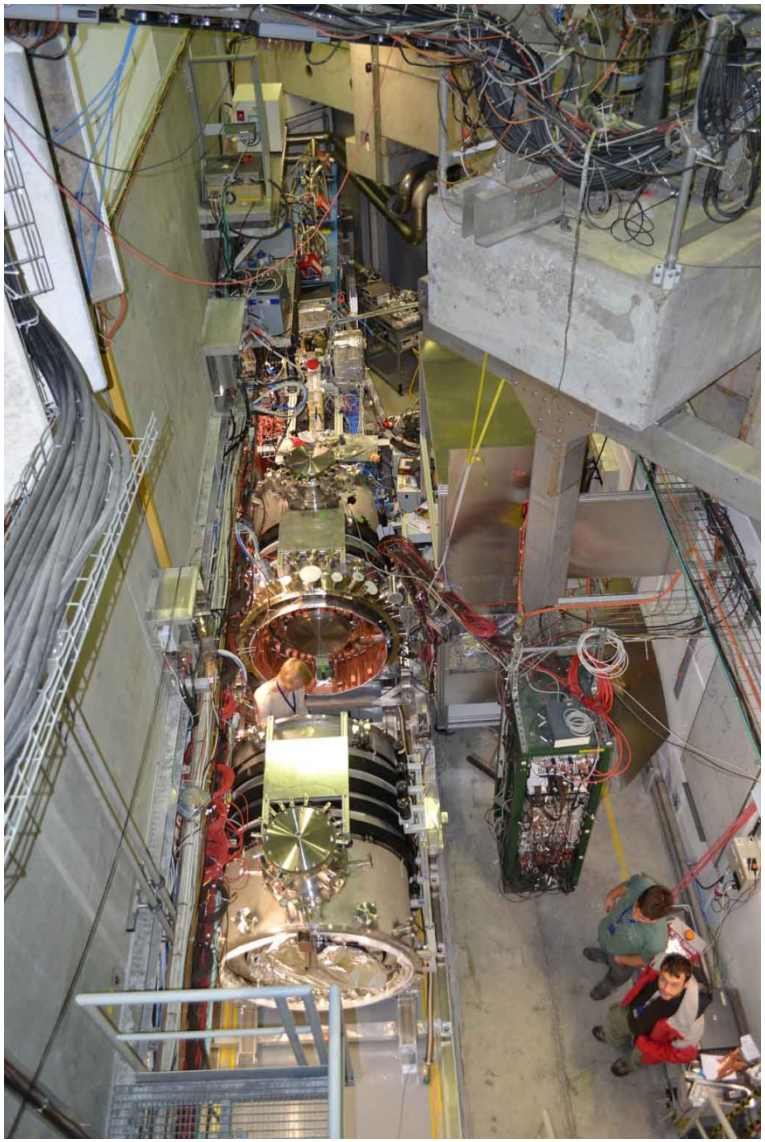
- Sovrapposizione strutture periodiche: appare nuova struttura periodica

$$a \gg \sqrt{\lambda_{dB} L}$$

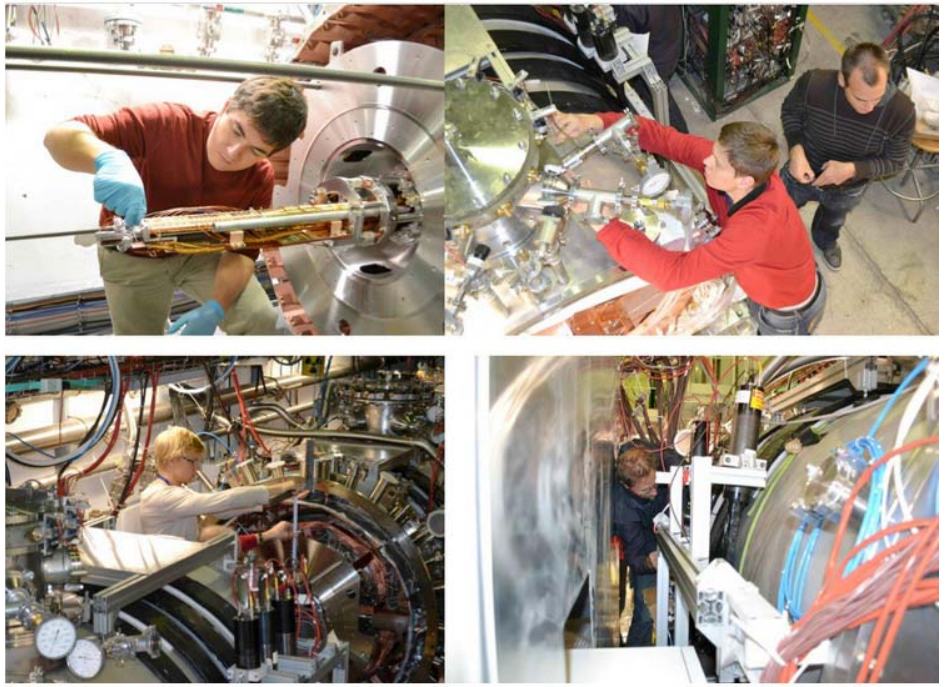


Status of the experiment

The experiment is almost completely installed and under commissioning.



- 2012: few weeks run has demonstrated antiproton capture and allowed detectors calibrations.
- 2013-2014: no beam from CERN.
  Positrons runs/proton source.
- 2015: beam will be back!
  Antihydrogen formation and beam studies

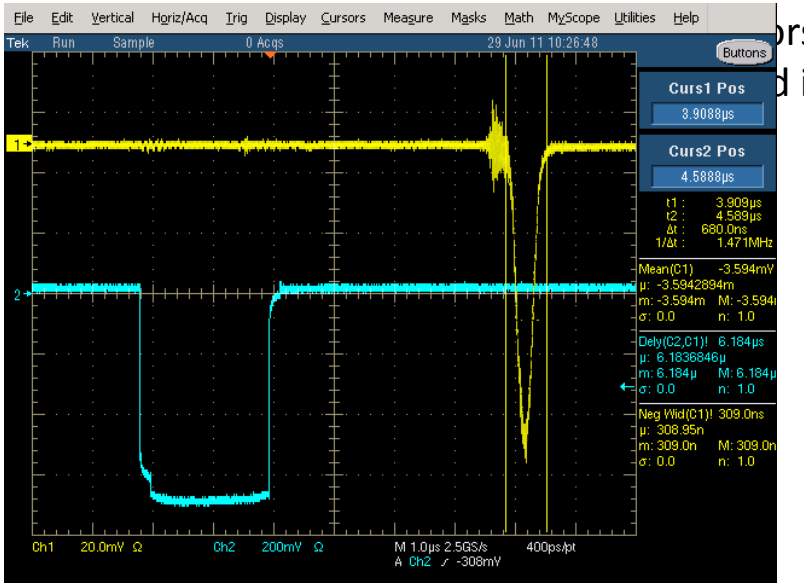


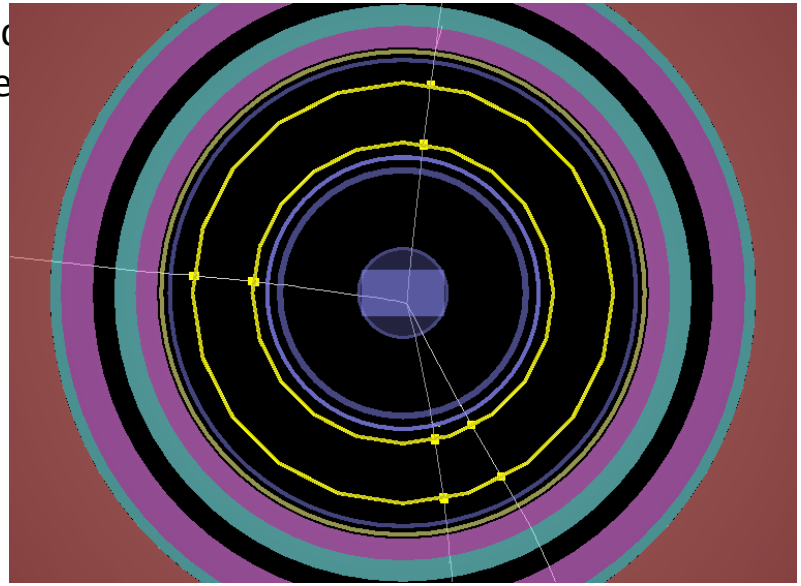
AEgIS activities in Pavia

Contact: Andrea Fontana, Pablo Genova, Cristina Riccardi, Alberto Rotondi.

The activities of the Aegis group of the INFN unit and of the University of Pavia are:

- detectors for beam monitoring (HPD);
- external scintillators and PMTs;





For further information please visit the experiment website: http://aegis.web.cern.ch/aegis/

Aegis: disponibilità di tesi sperimentali

- Studi sulle prestazioni dell'apparato
- Partecipazione al progetto, al montaggio finale e alla calibrazione dell'apparato