Der Antiprotonen Decelerator Komplex (AD)

WRANGLING ANTIMATTER

Six experiments at the particle-physics lab CERN are on the hunt for subtle differences between the properties of antimatter and matter. All sit inside the Antiproton Decelerator, which slows antiprotons down to manipulable speeds. From there, the experiments further slow the particles and some combine them with positrons to make antihydrogen.

THE ANTIMATTER

ANTIPROTON

The proton's antimatter counterpart is produced in high-energy collisions and needs heavy deceleration.

POSITRON

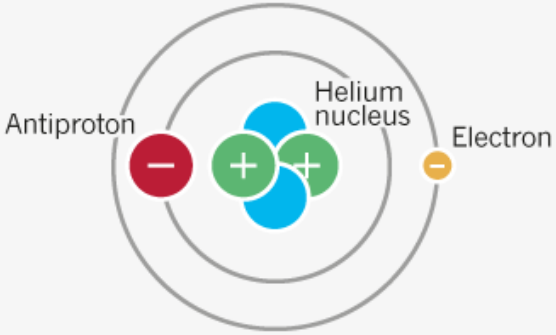
This lower-mass particle, the electron's antimatter counterpart, is produced in radioactive decays.

ANTIHYDROGEN

An antiproton and a positron can be combined to make antihydrogen, opening up opportunities to study new properties.

ANTIPROTONIC HELIUM

Researchers also build this exotic hybrid, in which an antiproton takes the place of an electron in a helium atom.



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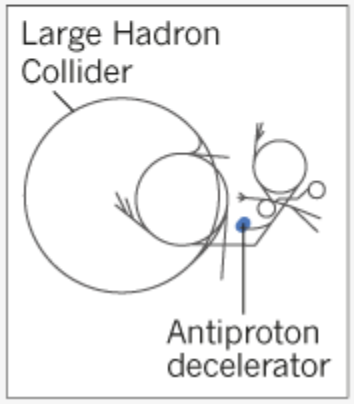
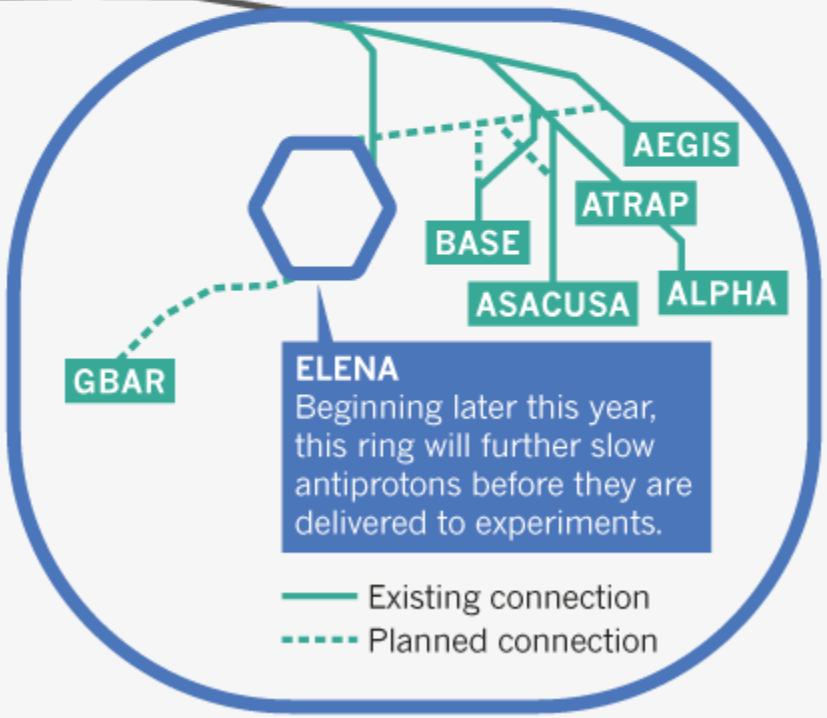
THE DECELERATORS

ANTIPROTON DECELERATOR
The 182-metre-circumference ring uses electromagnetic fields and beams of electrons to slow incoming particles to around 10% of their initial speed over 100 seconds.

ANTIPROTON PRODUCTION
Protons from the CERN accelerator complex are fired into an iridium target to create antiprotons.





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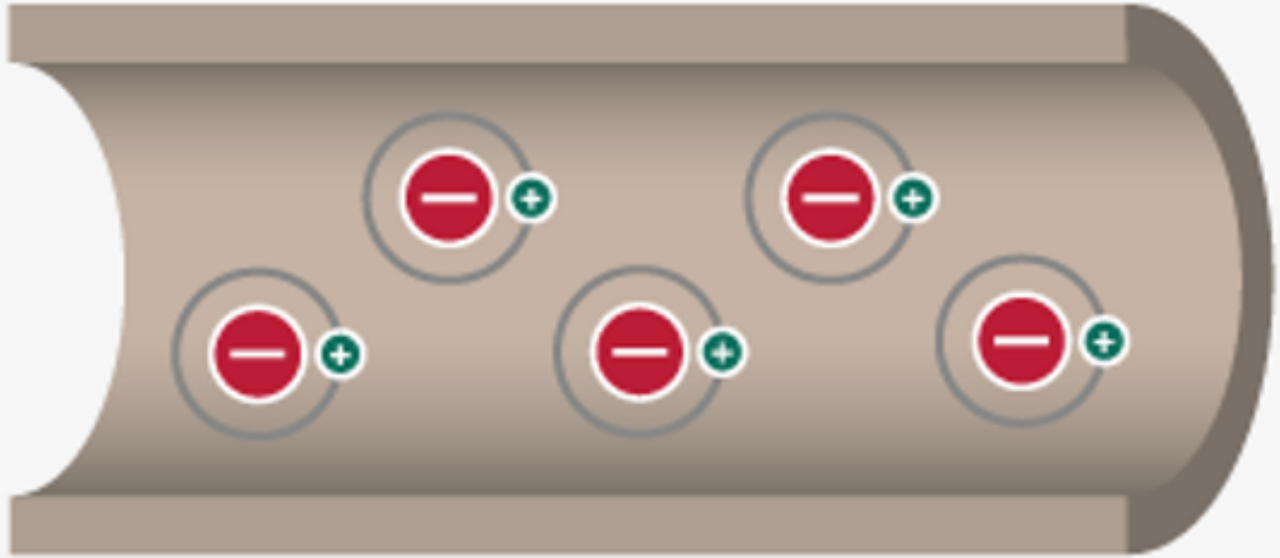
ALPHA

Started: 2005

Studies: Charge, spectroscopy and acceleration under gravity of antihydrogen.

How it works: Mixes antiprotons and positrons in a complex electromagnetic trap to create antihydrogen, which physicists probe with lasers.

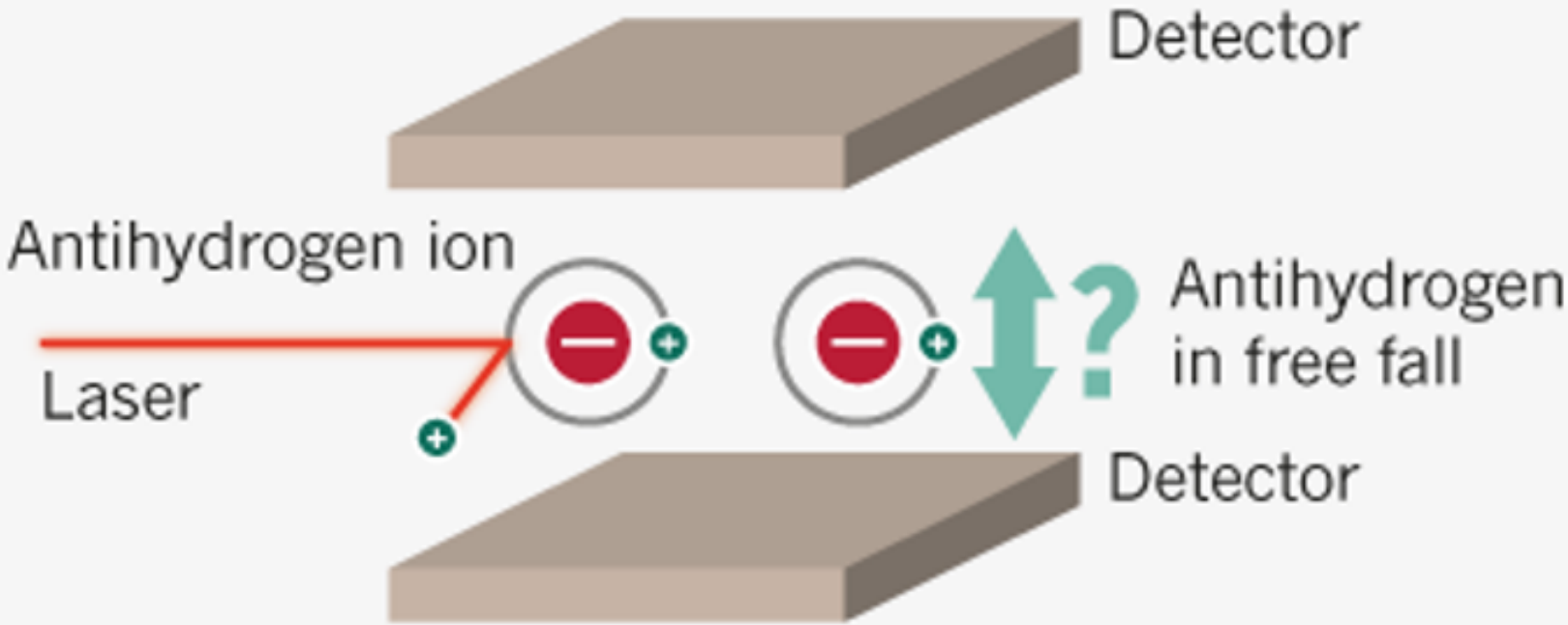


GBAR

Starting: 2017

Studies: Gravitational acceleration of antihydrogen atoms.

How it works: Laser-cooled beryllium ions chill antihydrogen ions containing two positrons. A laser knocks off one positron, and the antihydrogen atom free-falls under gravity.



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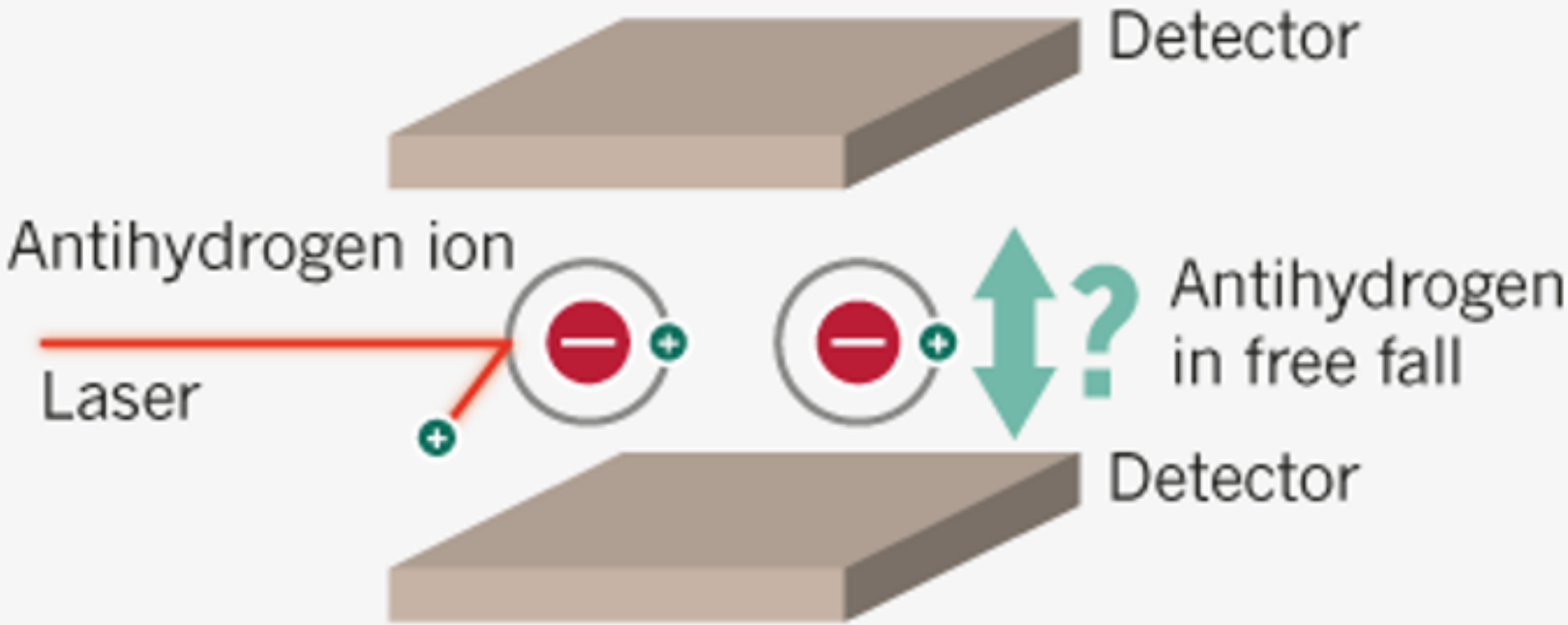
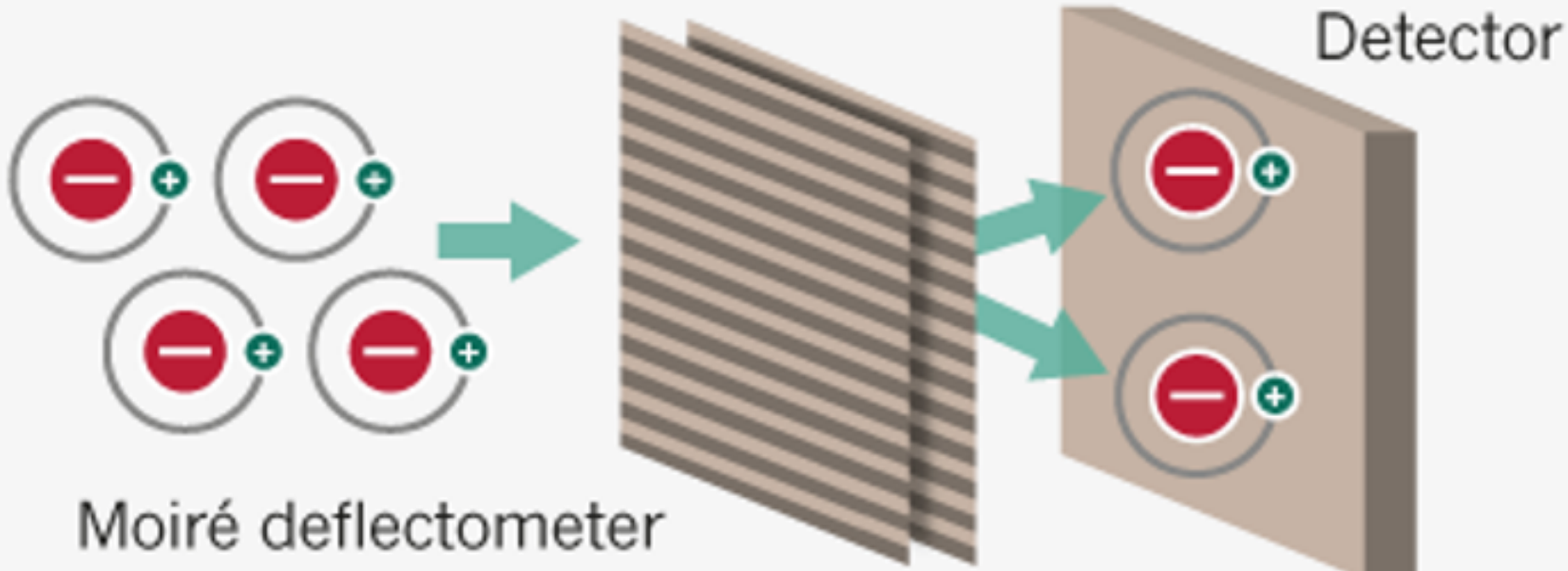


AEGIS

Started: 2015

Studies: Gravitational acceleration of antihydrogen atoms.

How it works: Observes the pattern produced by parallel beams of excited low-energy antihydrogen atoms as they pass through a grating.

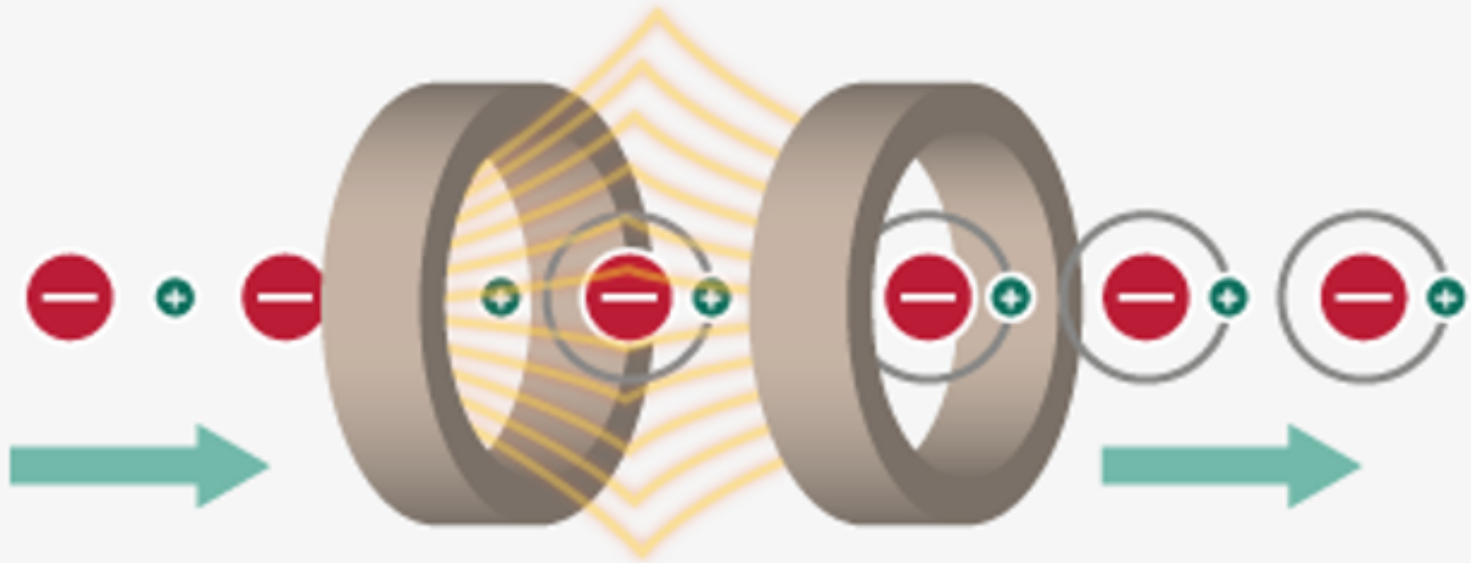


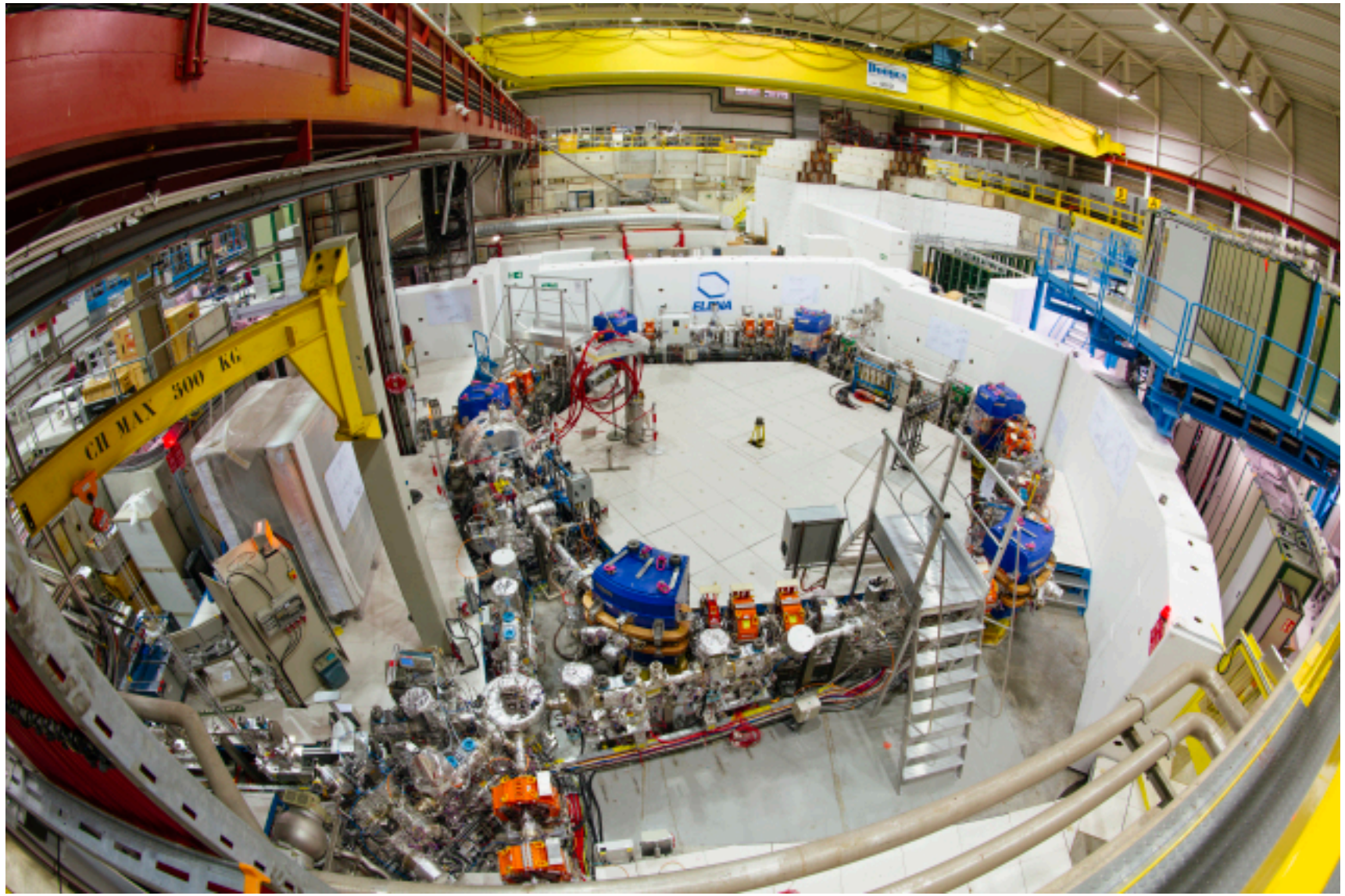
ASACUSA

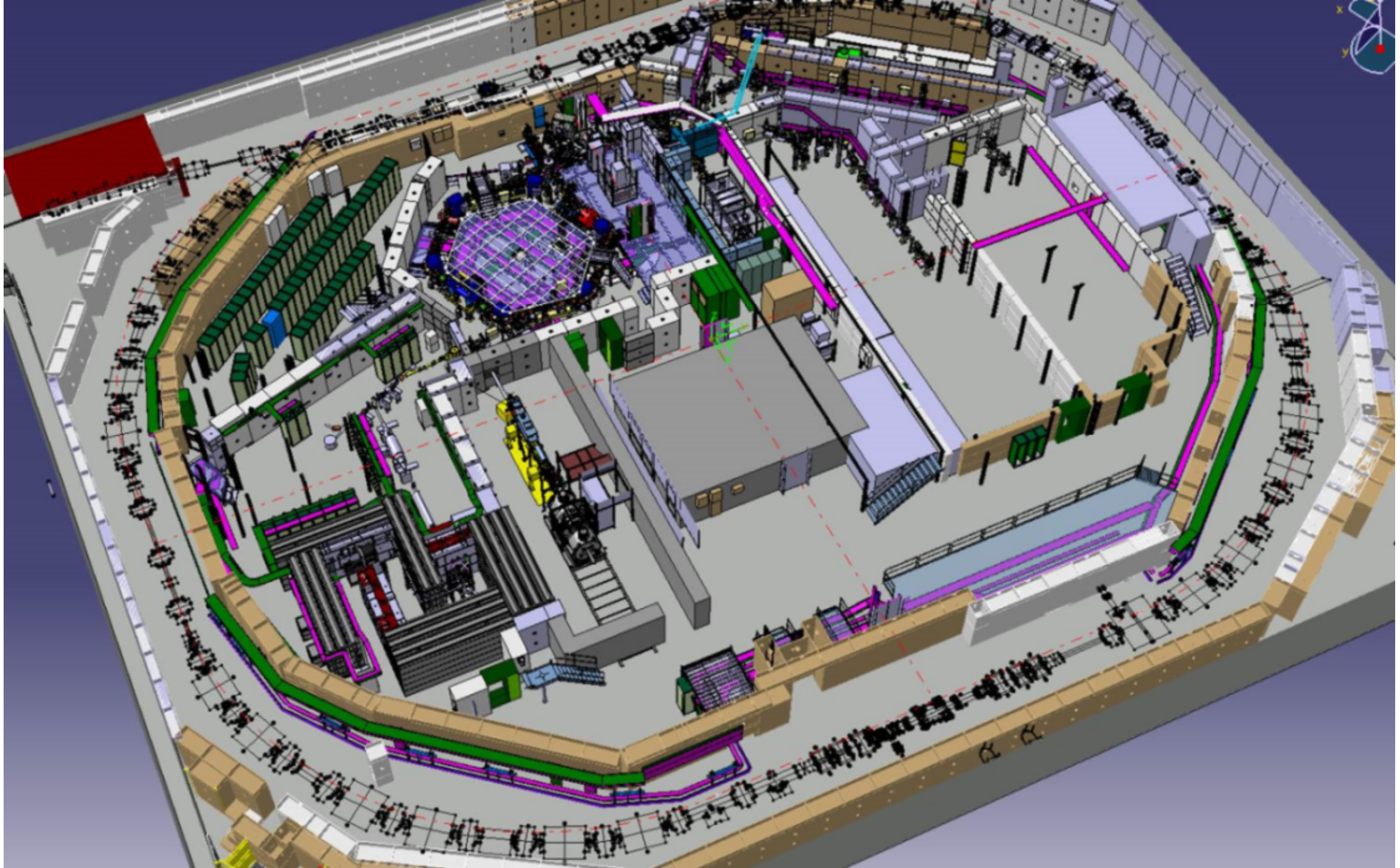
Started: 2000

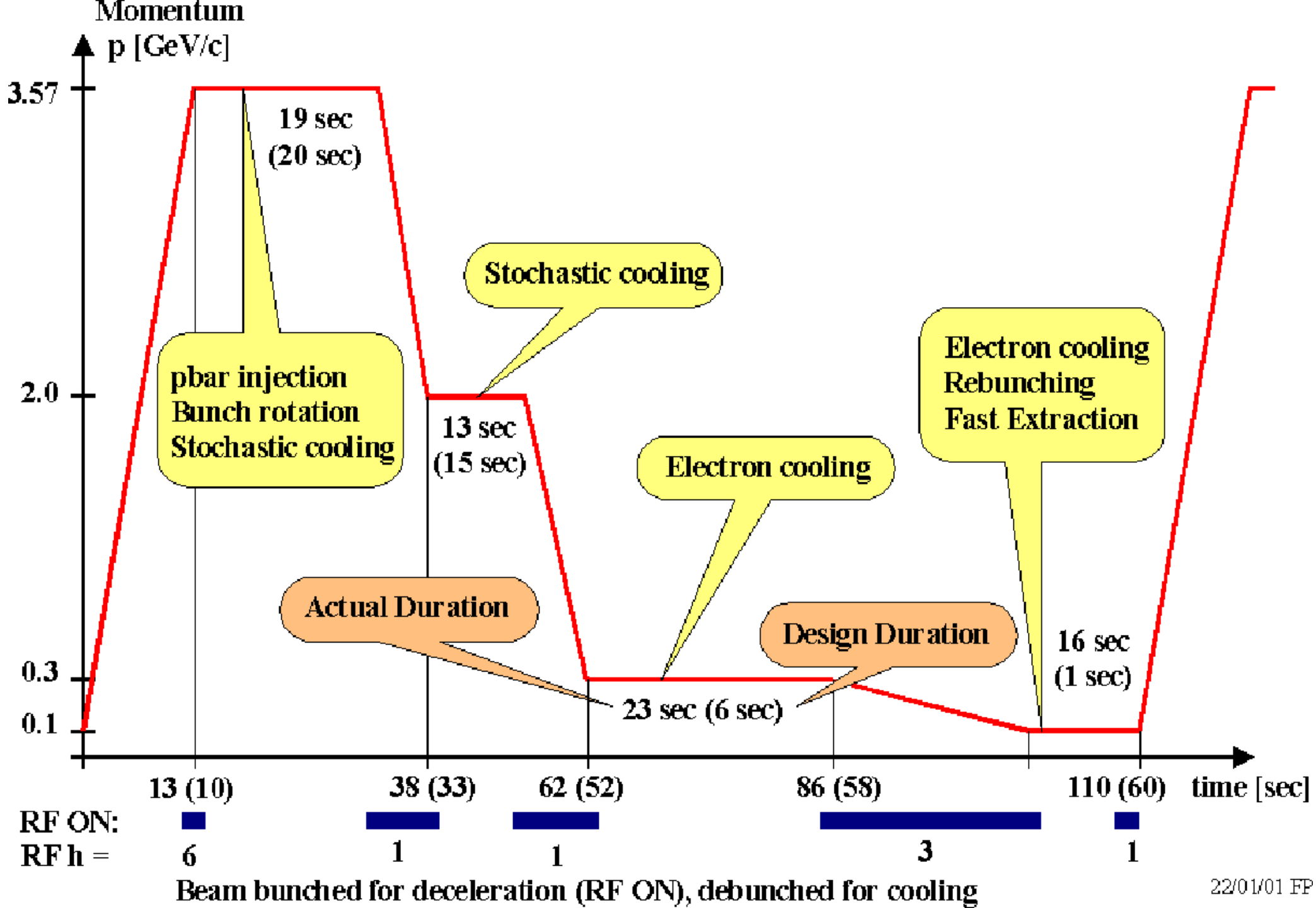
Studies: Mass of antiproton (relative to the electron), spectroscopy of antihydrogen and antiprotonic helium.

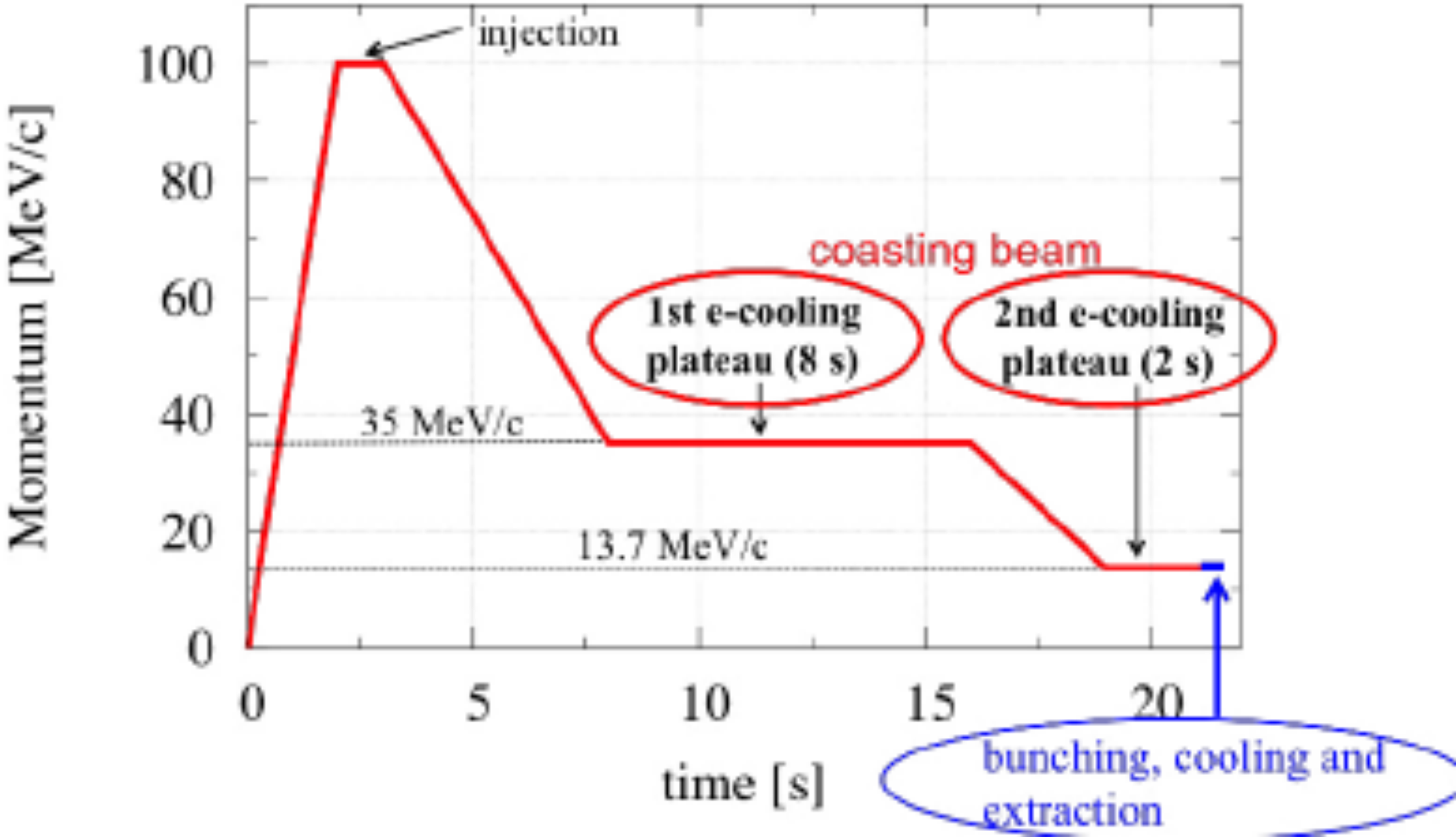
How it works: Traps antiatoms then turns them into a polarized beam, which can be probed with microwave radiation or lasers.




CH MAX 500 KG




Momentum
p [GeV/c]
3.57
2.0
0.3
0.1
19 sec
(20 sec)
pbar injection
Bunch rotation
Stochastic cooling
Stochastic cooling
13 sec
(15 sec)
Electron cooling
Actual Duration
Design Duration
23 sec (6 sec)
Electron cooling
Rebunching
Fast Extraction
16 sec
(1 sec)
13 (10)
38 (33)
62 (52)
86 (58)
110 (60)
time [sec]
RF ON:
RF h =
6
1
1
3
1
Beam bunched for deceleration (RF ON), debunched for cooling
22/01/01 FP


injection
100
80
60
40
20
0
Momentum [MeV/c]
coasting beam
1st e-cooling
plateau (8 s)
2nd e-cooling
plateau (2 s)
35 MeV/c
13.7 MeV/c
0
5
10
15
20
time [s]
bunching, cooling and
extraction