Antimatter at CERN

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CERN

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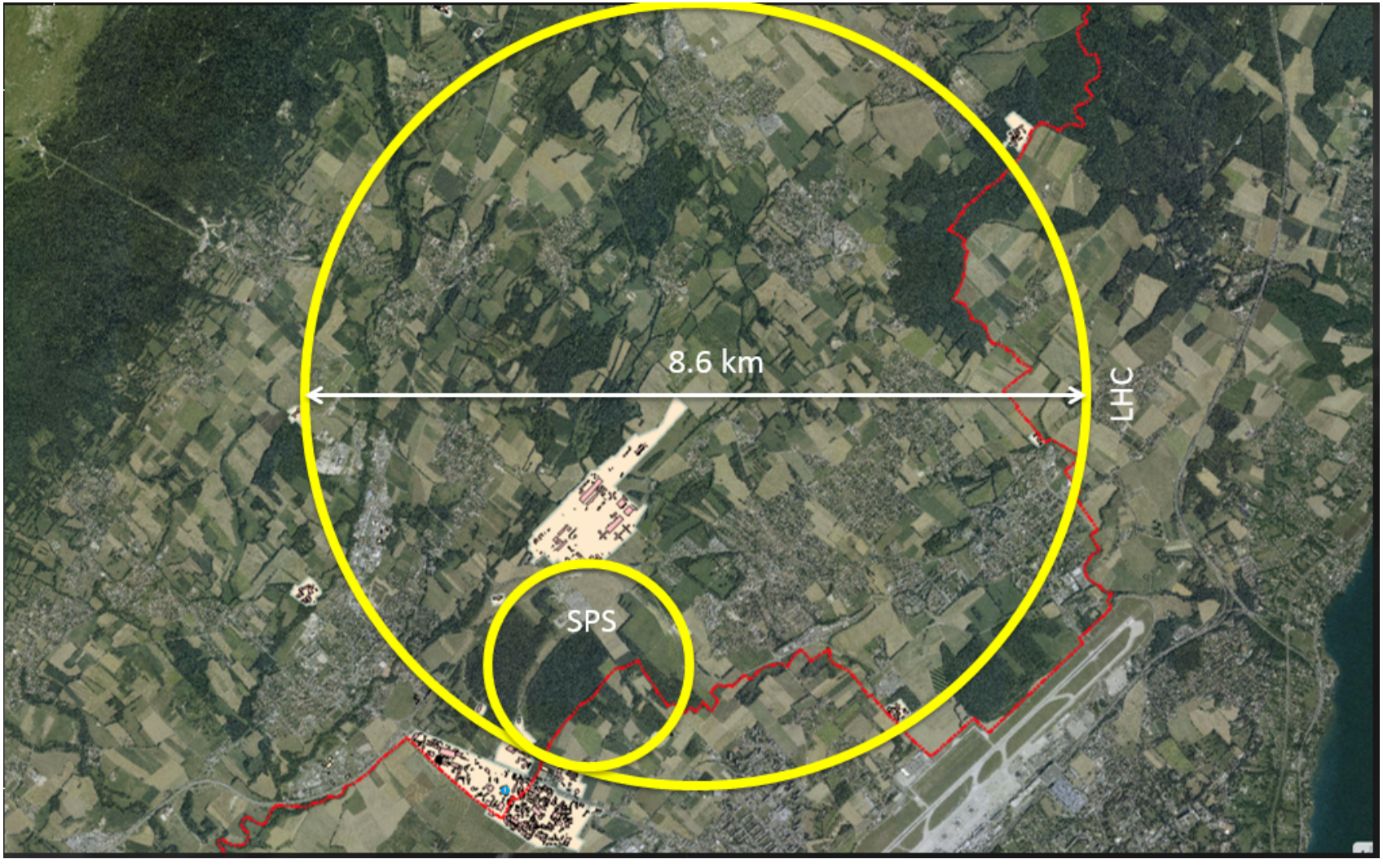
End Times | Science From Hell | The CERN Files

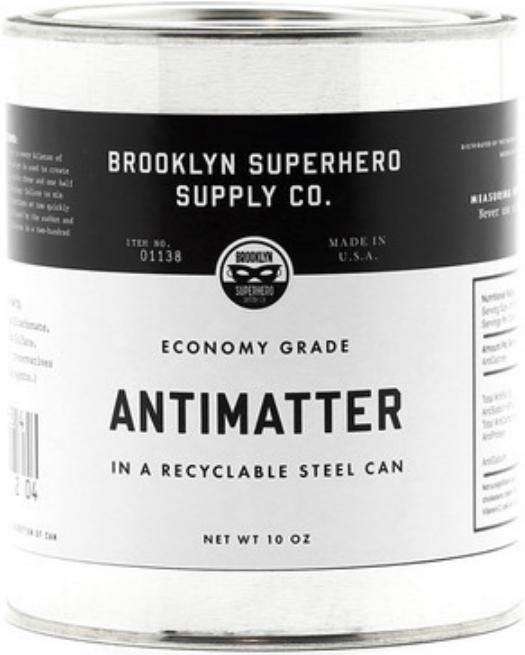
CERN Manifesting Hell on Earth with Their Darkest Finding Yet

By **Emily** - 12/21/2016 14

Up until recently, scientists were in the dark regarding the composition of antimatter, but now researchers at CERN have shined a light on it.

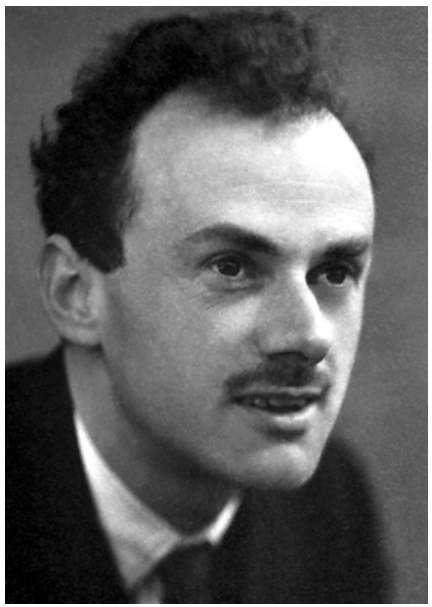

8.6 km
LHC
SPS

What is antimatter?



Anti-electron/Positron

In 1928, combined quantum mechanics with Einstein's special relativity.



$$E^2 = p^2c^2 + m_0^2c^4$$

Negative energy?

Anti-electron/Positron

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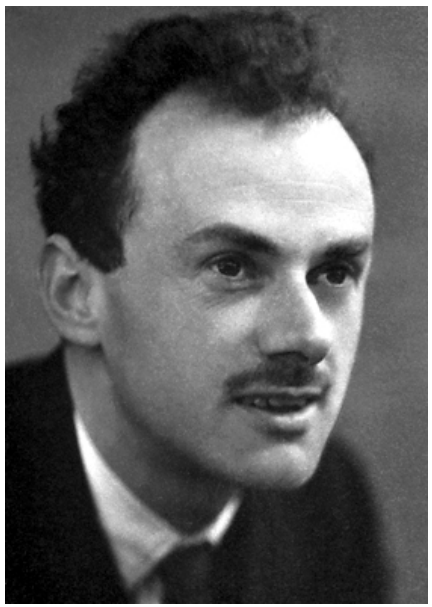
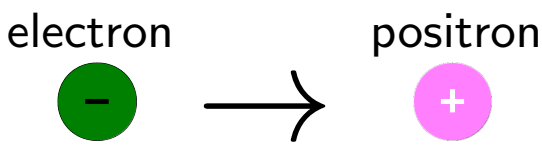
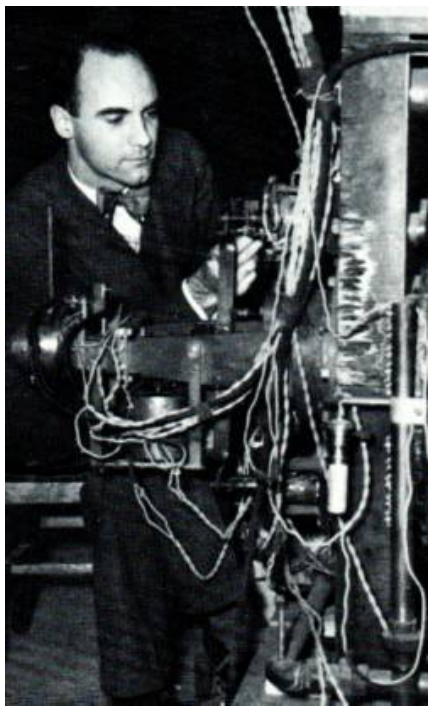
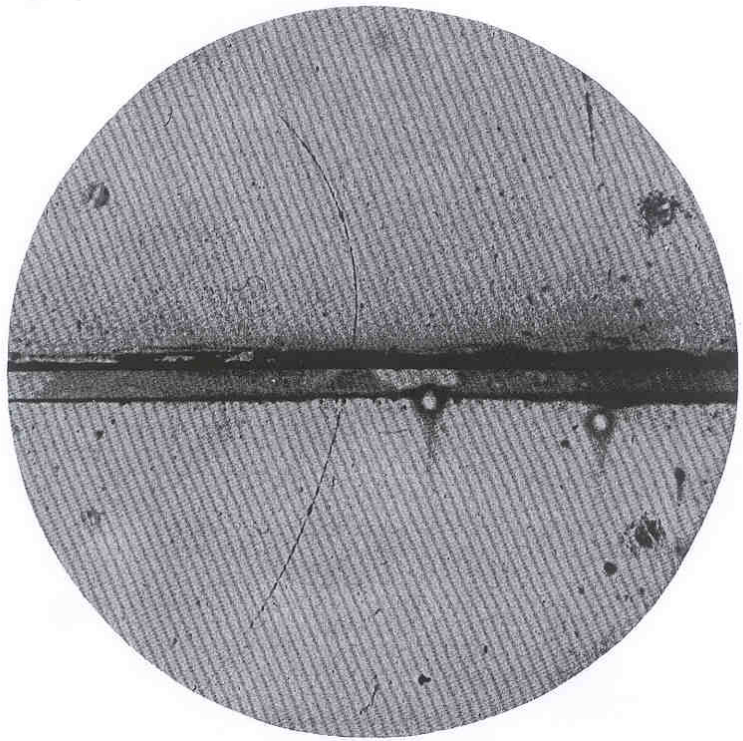




Anti-electron/Positron

Observed in 1932 by Carl Anderson.





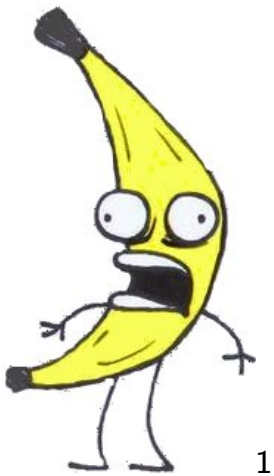
Anti-electron/Positron

1

- Bananas contain $\approx 60\ \mu$g of unstable ^{40}K isotopes.

[1] "I'm a banana" – Don Hertzfeldt

Anti-electron/Positron



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- Emits 1 positron roughly every hour.

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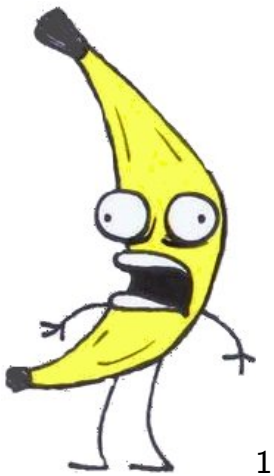
Anti-electron/Positron



[1]

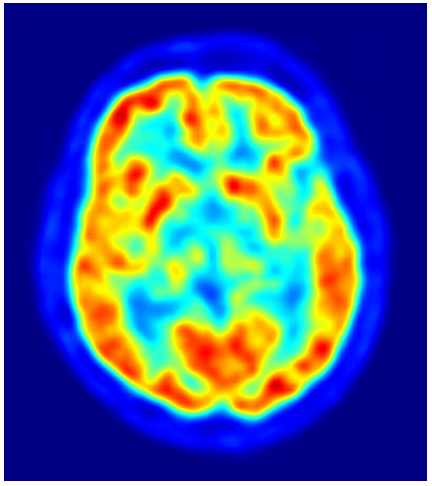
- Bananas contain $\approx 60\ \mu$g of unstable ^{40}K isotopes.
- Emits 1 positron roughly every hour.
- We use a Sodium-22 source to produce 10 M e+ per second.

$$^{22}Na \rightarrow ^{22}Ne + e^{+} + \nu_e + \gamma \qquad (1)$$

[1] "I'm a banana" – Don Hertzfeldt

Anti-electron/Positron

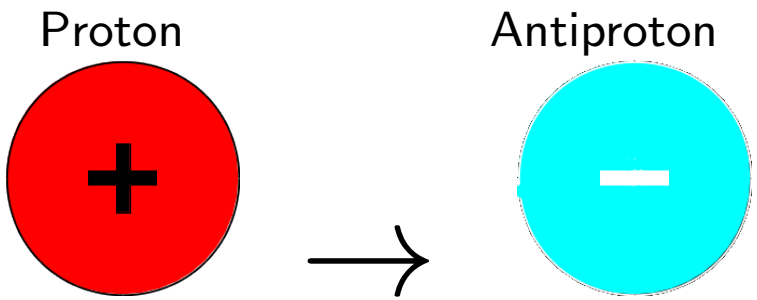
Positron Emission Tomography (PET) scans.



Antiproton

Antiproton

- Also have antiprotons. Identical (as far as we can tell) to protons but with a negative charge.



- Can be made in accelerators by slamming protons into a metal target ($E = mc^2$).
- First produced by Serge and Chamberlain in 1955.

What happens when matter and antimatter meet?

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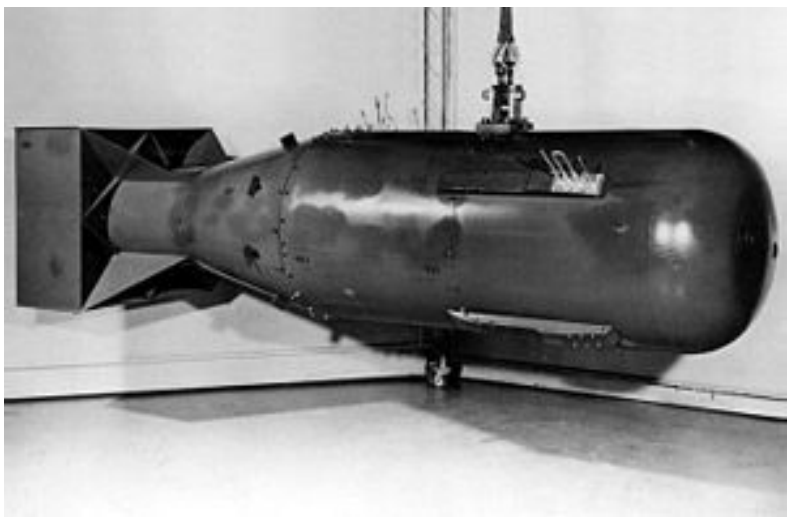
- In Angels and Demons 1/4g of antimatter is stolen from CERN.
- Equivalent to 10 grains of anti-rice. 
- If the anti-rice annihilates it would produce a 10 kiloton explosion.
- The Hiroshima bomb was about 15 kilotons and contained 64 kg of uranium.

anti-rice

=



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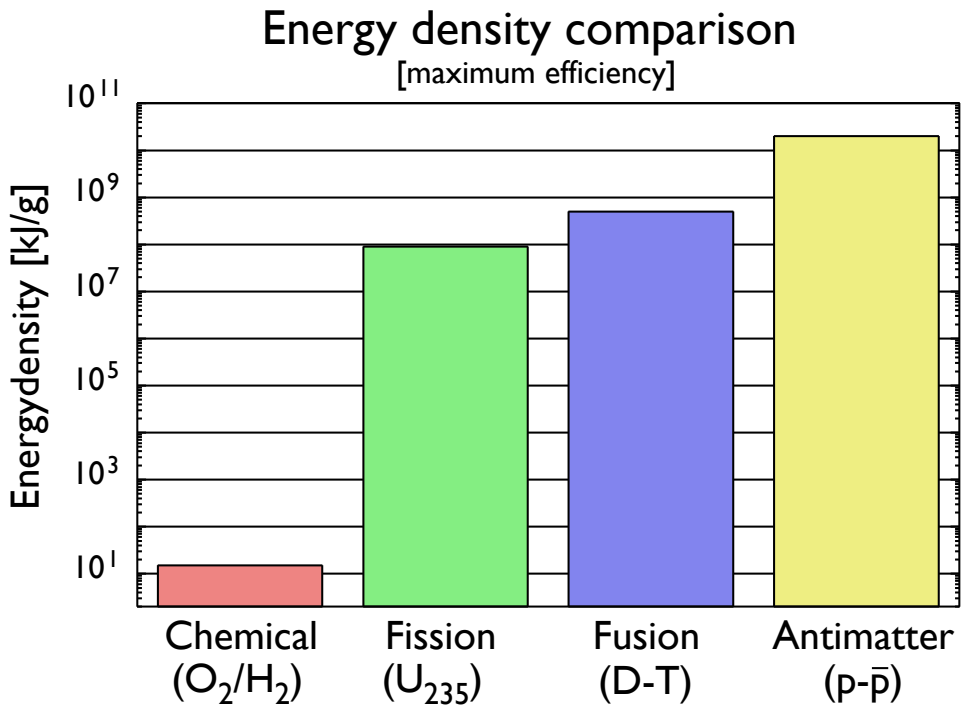


Don't Panic

or: How I learned to stop worrying and love antimatter

- To date CERN has produced less than 10 nanograms of antimatter.
- Only enough to light a 60 W light bulb for 4 hours.

Don't Panic

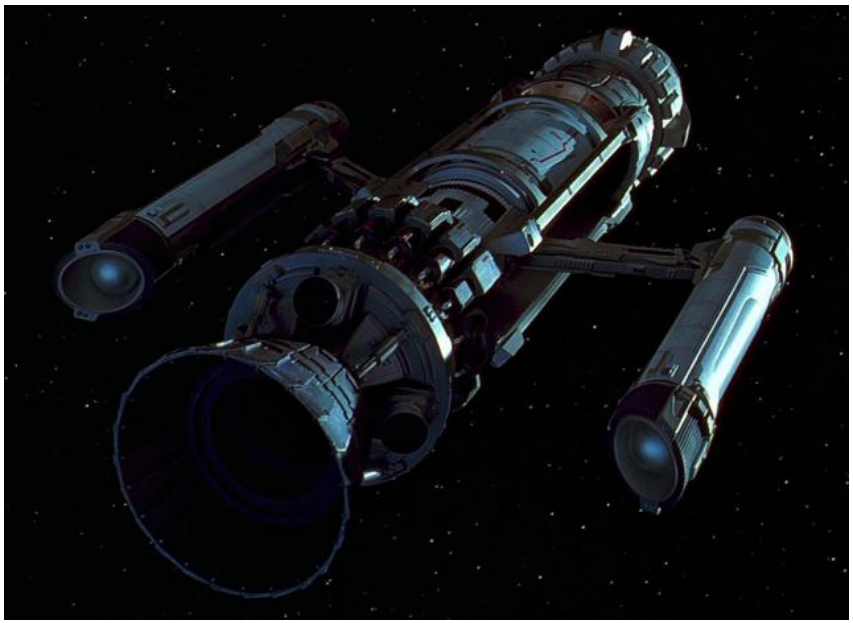
or: How I learned to stop worrying and love antimatter

- To date CERN has produced less than 10 nanograms of antimatter.
- Only enough to light a 60 W light bulb for 4 hours.
- At this rate will take 1 billion years to make 1 g of antimatter.

Don't Panic

or: How I learned to stop worrying and love antimatter

Fistful of antimatter could launch a 100 kg probe at 0.1c.



Why study antimatter?

Antimatter and Gravity

Apple

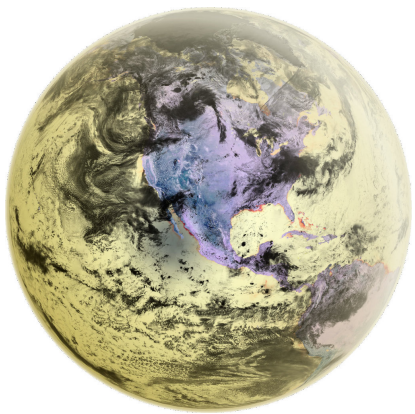
Earth

Antimatter and Gravity

Apple

Earth

Anti-Apple



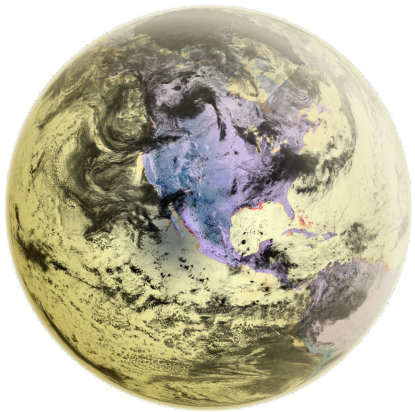
Anti-Earth

Antimatter and Gravity

Apple

Earth

Anti-Apple



Anti-Apple

? ?

? ?

Earth

Matter/Antimatter Imbalance

- Big Bang should have produced equal amounts of matter and antimatter.
- Everything should have annihilated leaving:

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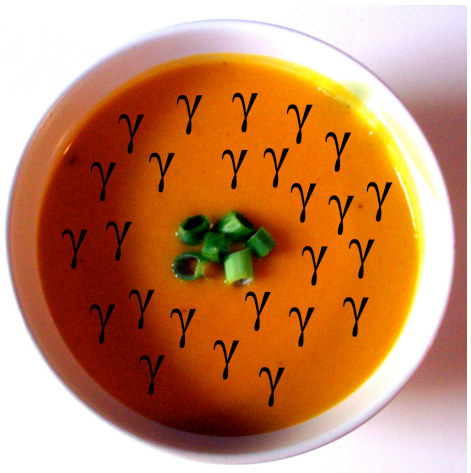
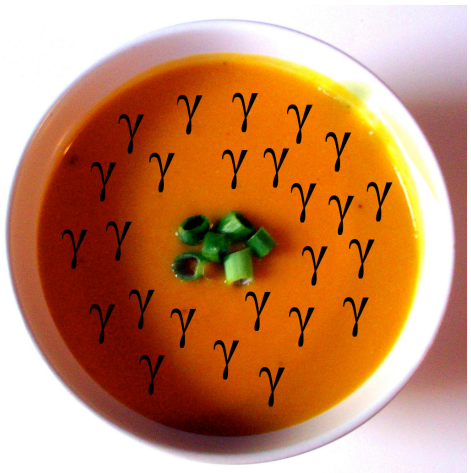


Photon Soup

Matter/Antimatter Imbalance

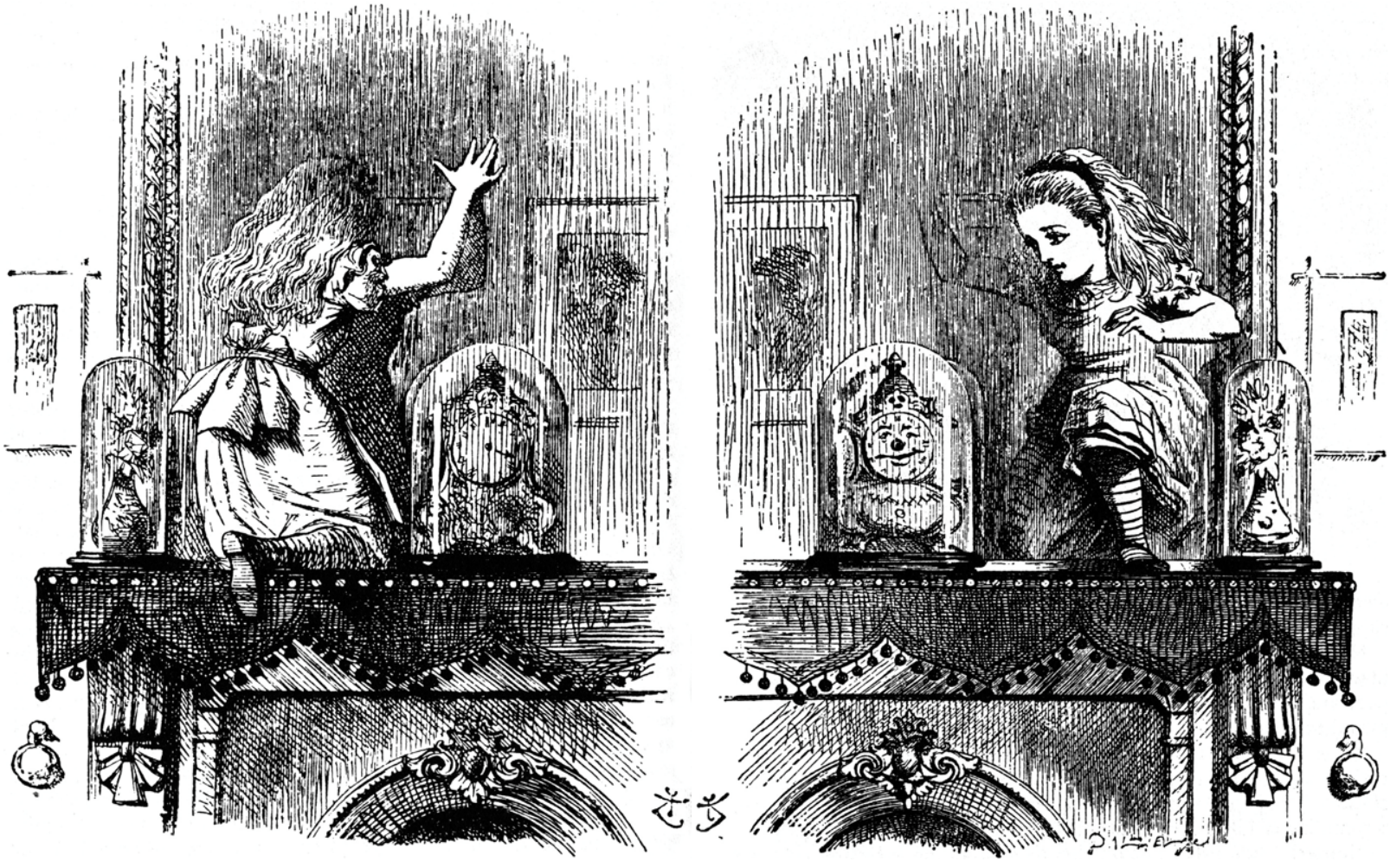
- Big Bang should have produced equal amounts of matter and antimatter.
- Everything should have annihilated leaving:



Photon Soup

- Must have been an imbalance.
- 1,000,000,001 particles vs 1,000,000,000 antiparticles?
- But why?

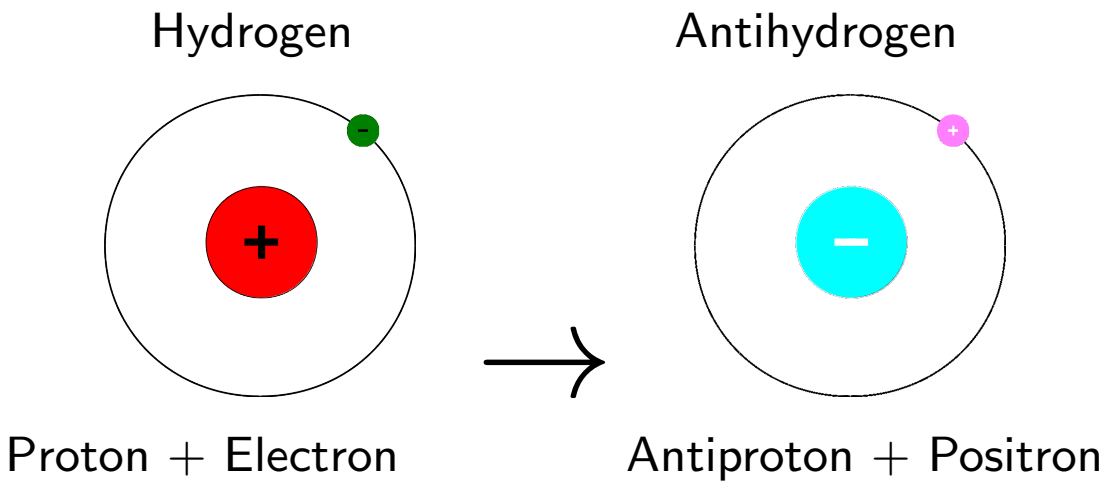
Perfect mirror?



Antihydrogen

Antihydrogen

- Hydrogen is the simplest atomic system
- One of the best studied systems in physics.

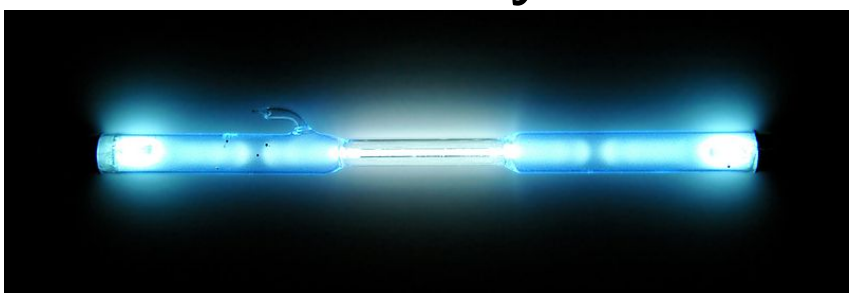


Antihydrogen spectroscopy

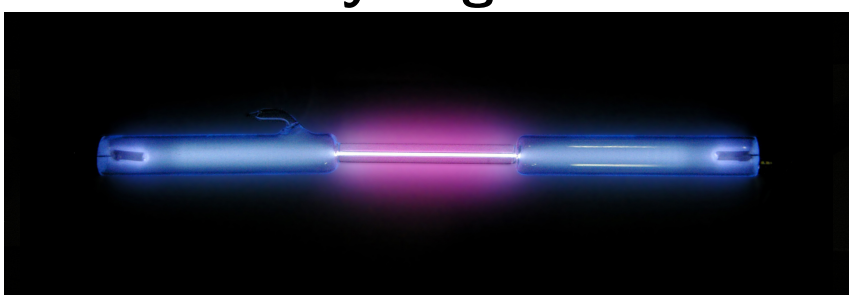
Atoms absorb and emit light with characteristic colours (spectra).

Neon

Mercury

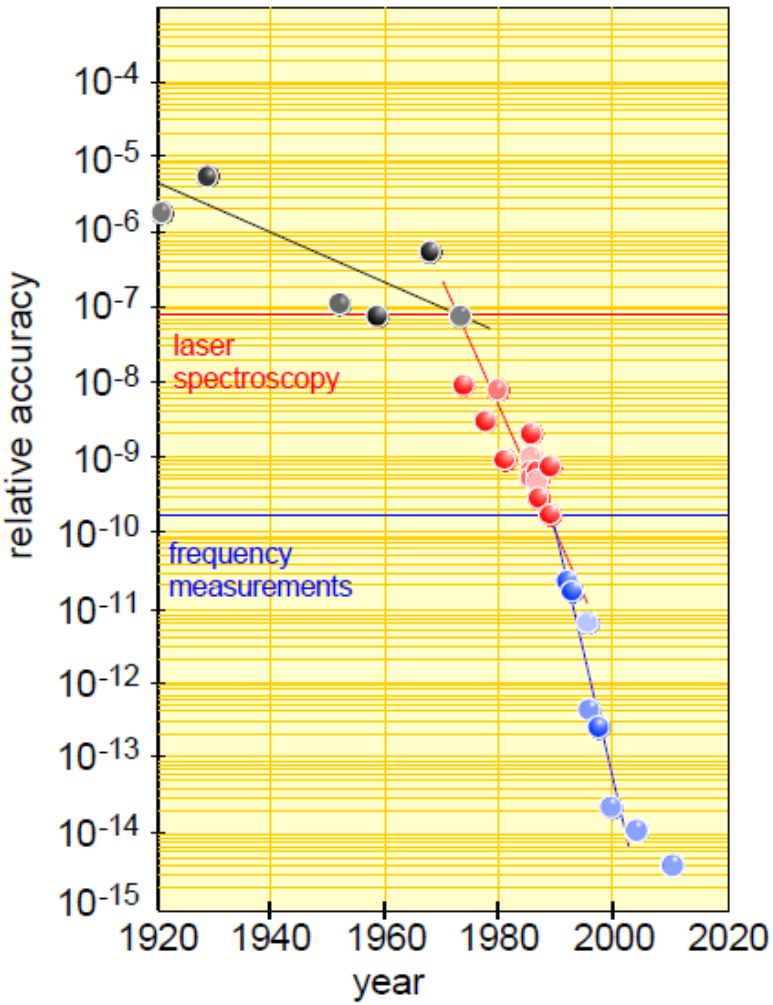


Hydrogen



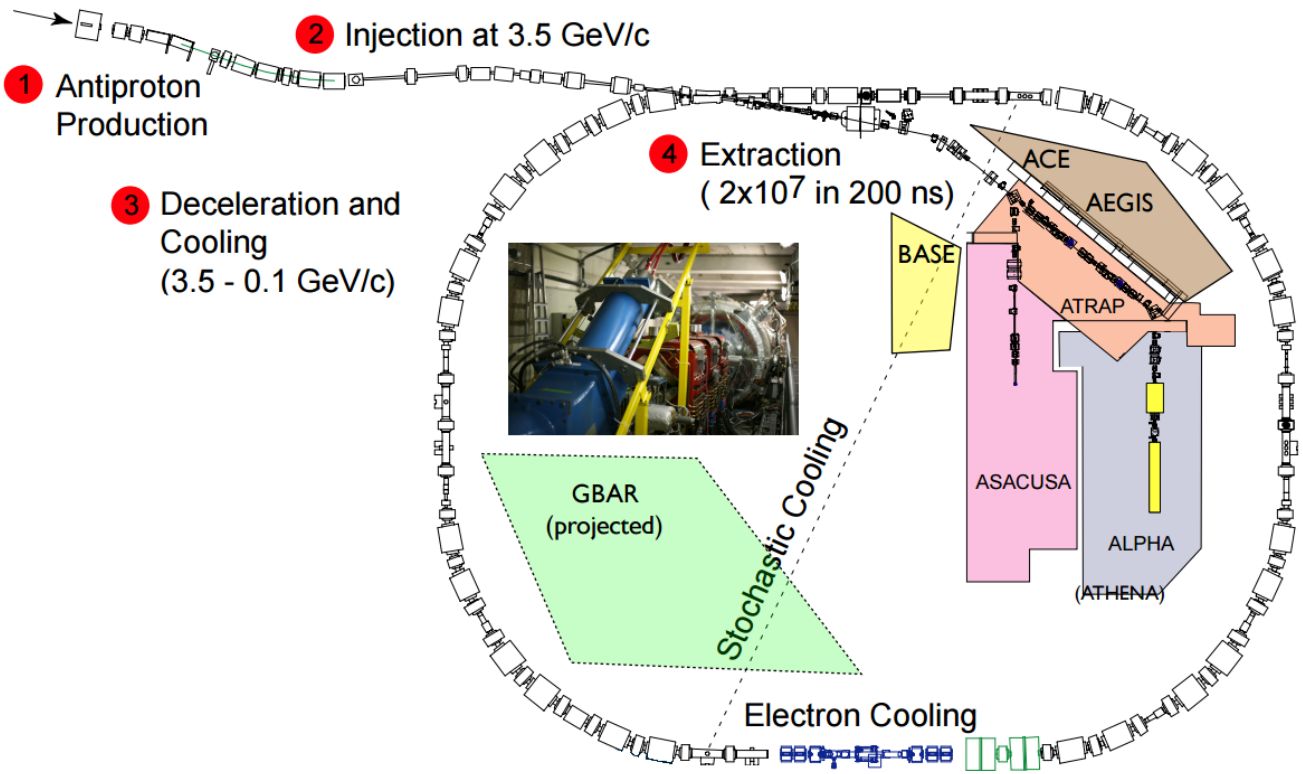
Antihydrogen spectroscopy

Are the spectra of hydrogen and antihydrogen identical?

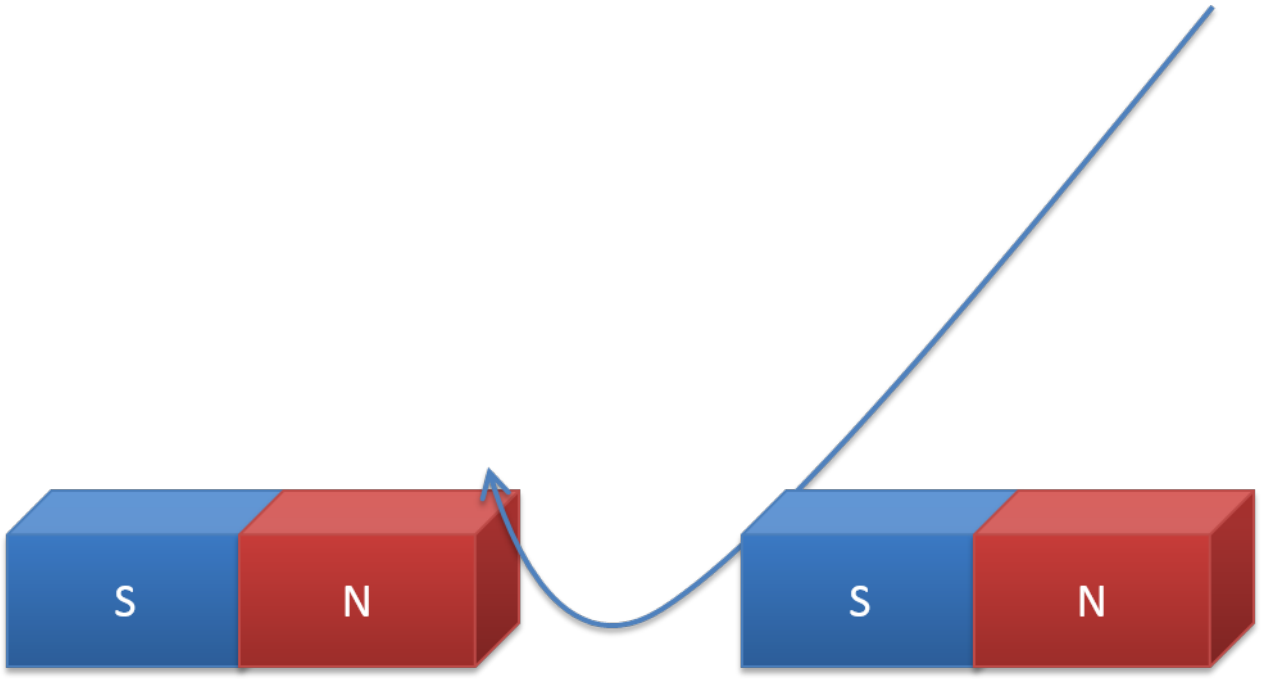


Making antimatter

- Positrons from radioactive sodium-22. "Easy".
- Antiproton production requires a facility like the Antiproton Decelerator.



Trapping charged antimatter



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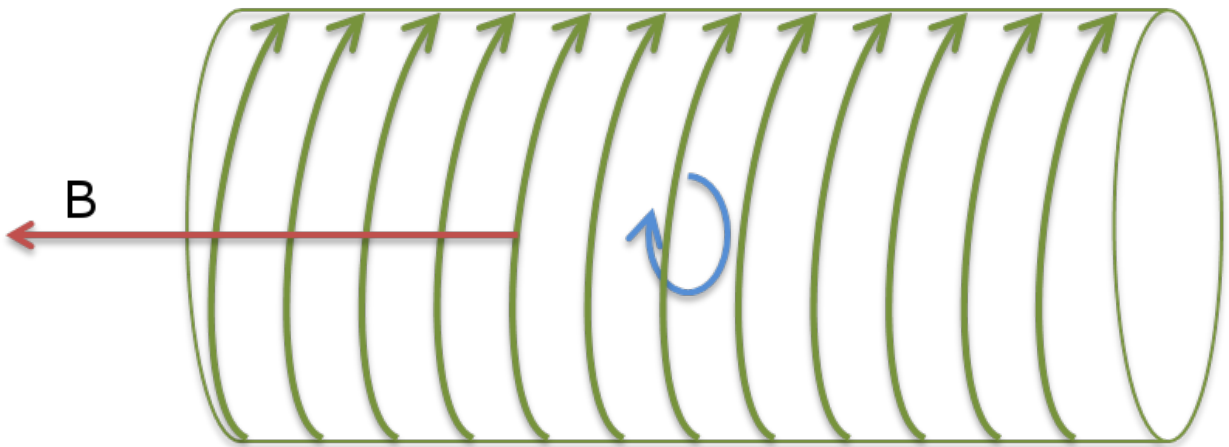

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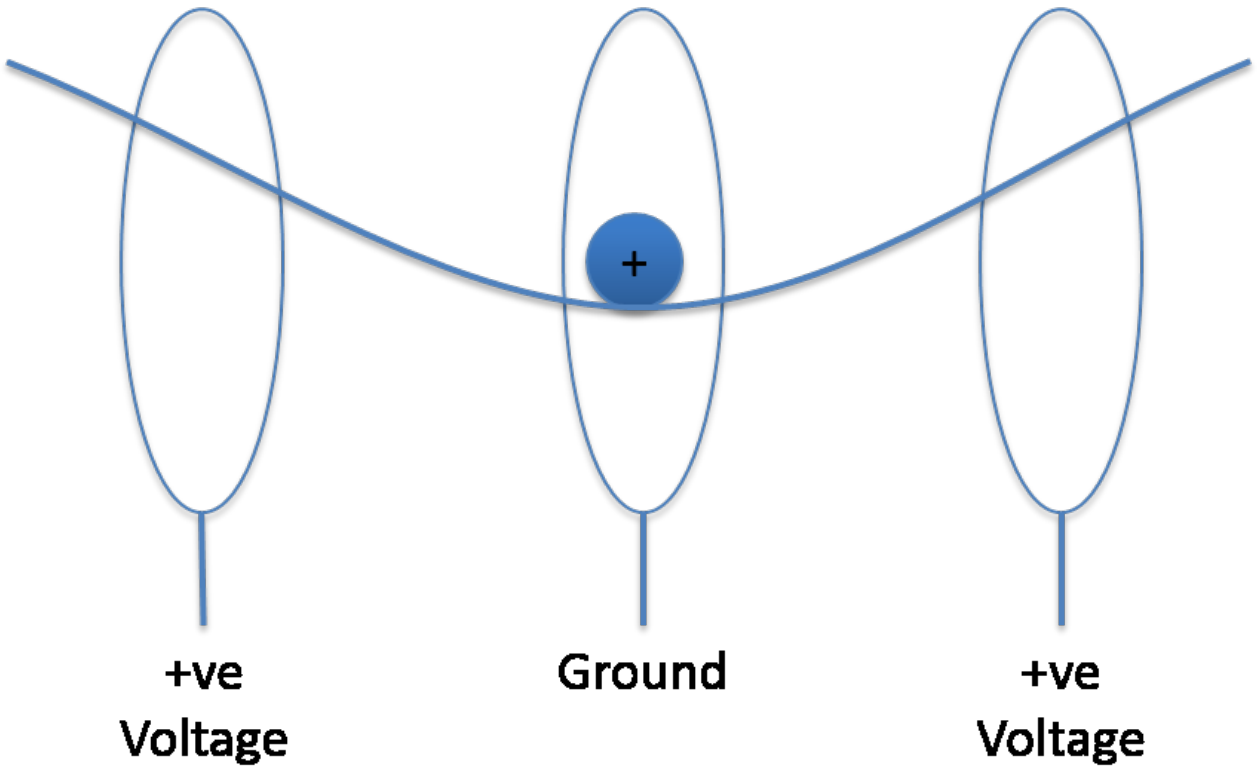
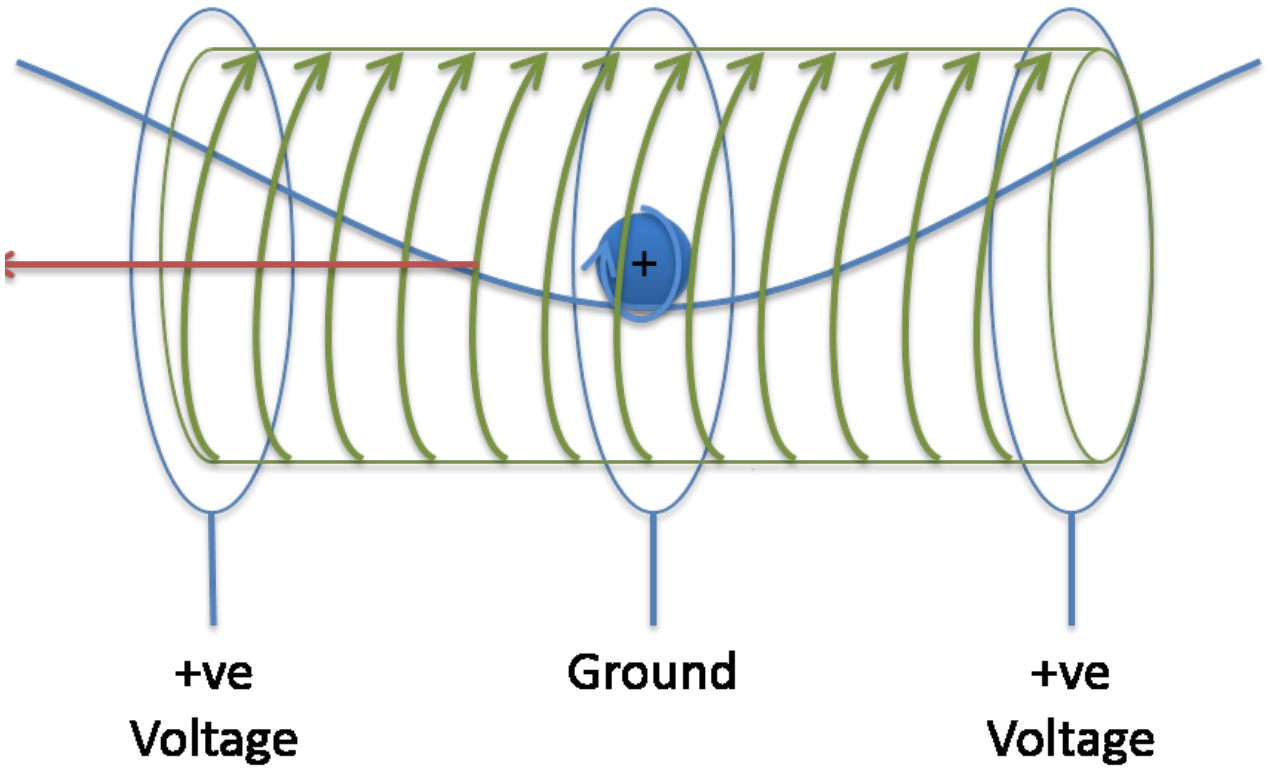
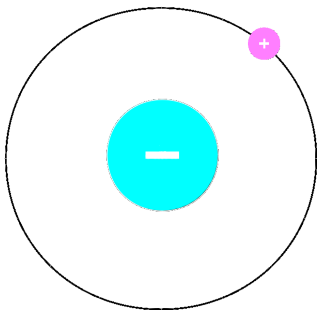


PenningTrap



Making Antihydrogen

1. Trap 10k antiprotons.
2. Trap 3M positrons.
3. Cool ingredients to 30 Kelvin.
4. Mix.



Trapping Antihydrogen

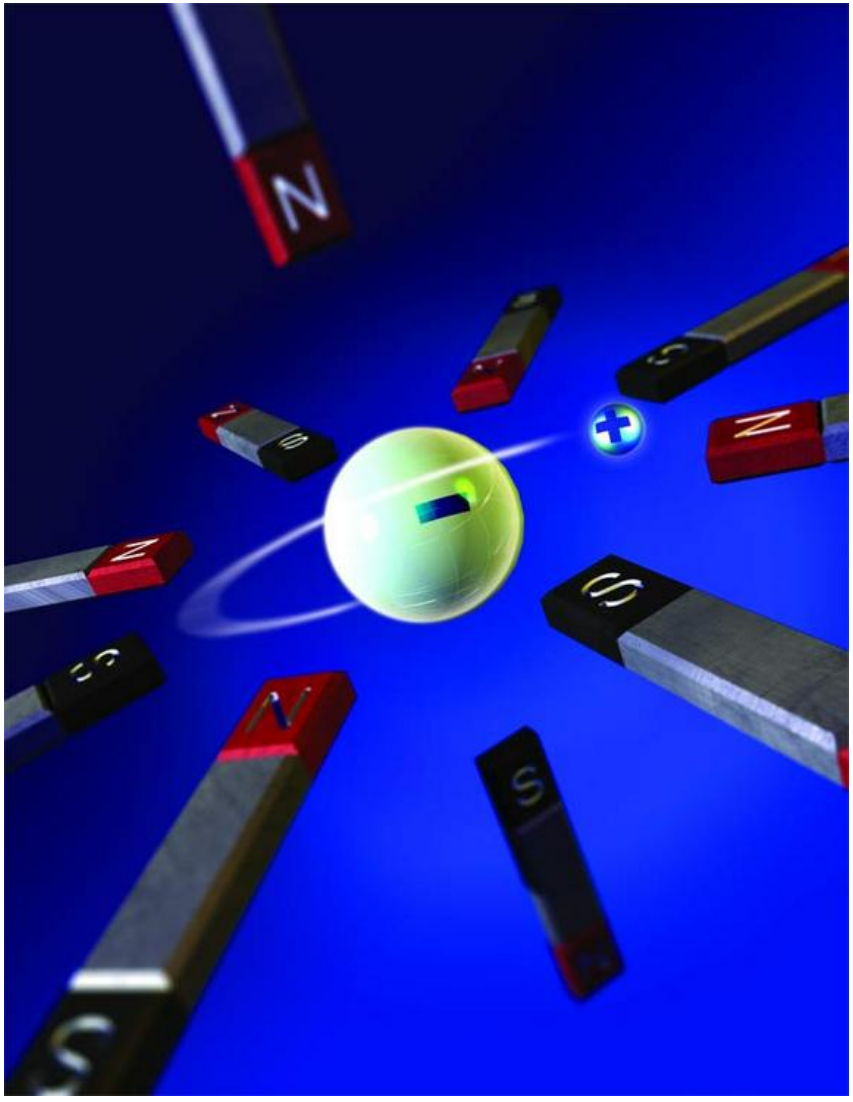
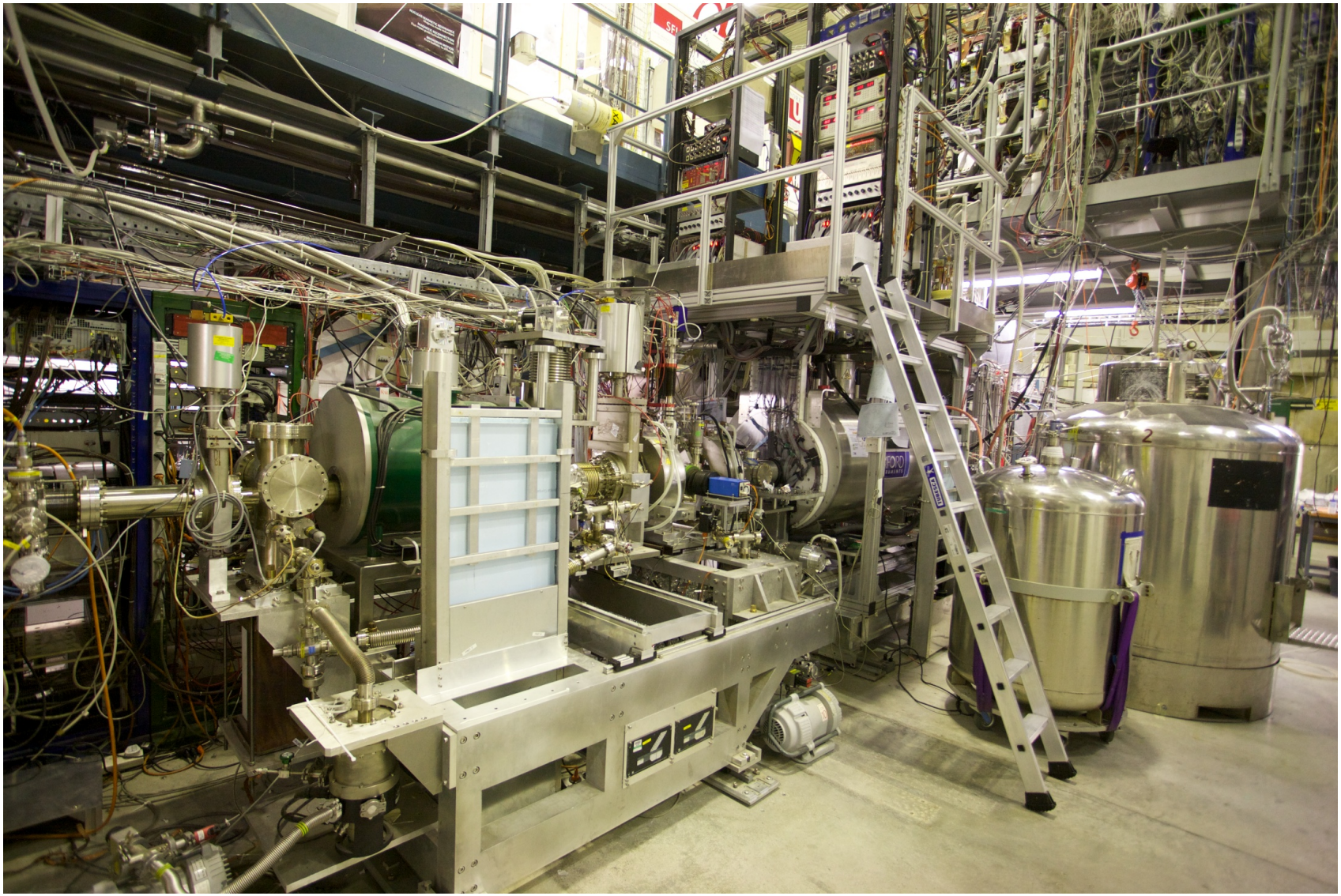
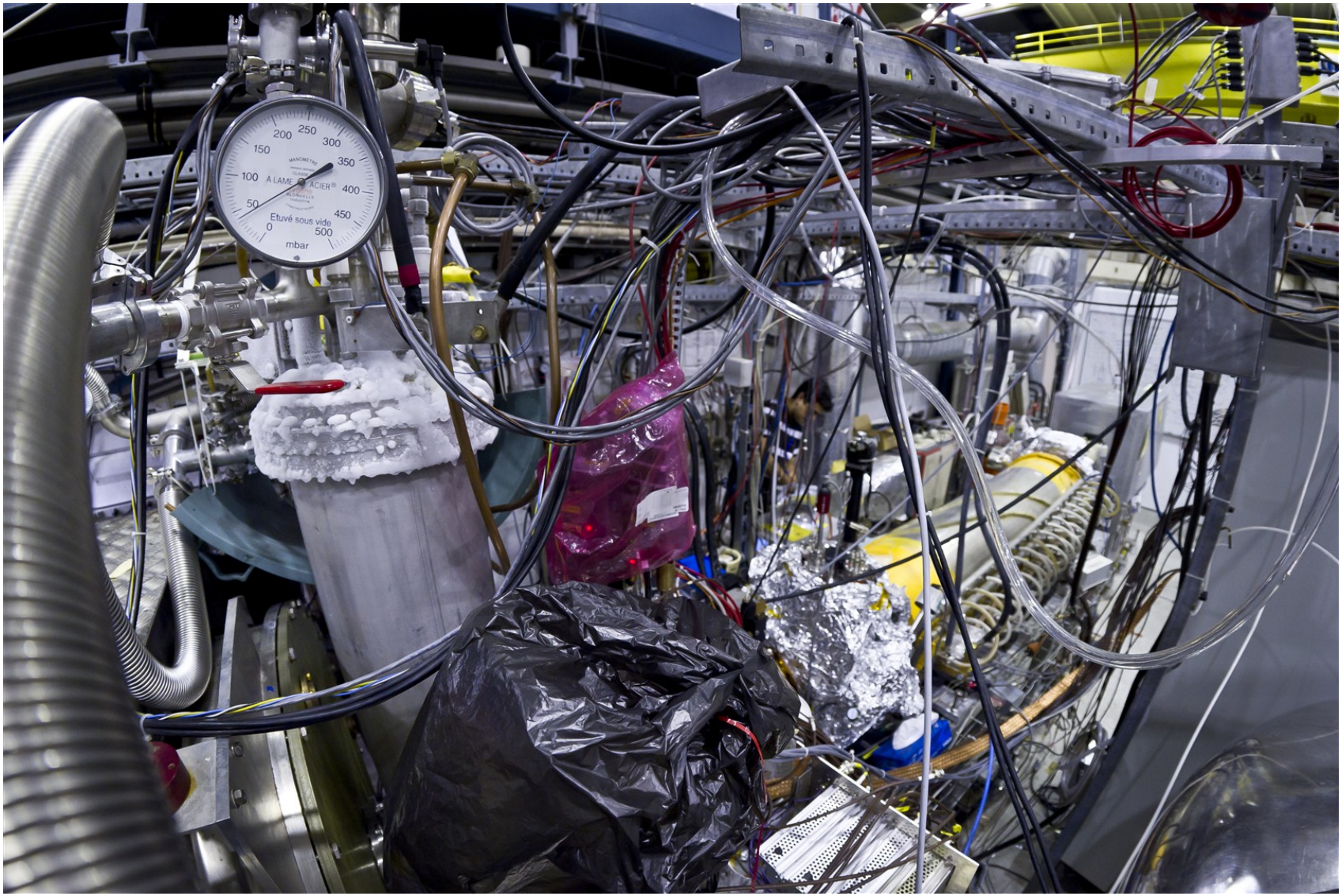


Image credit: Katie Bertsche



ALPHA

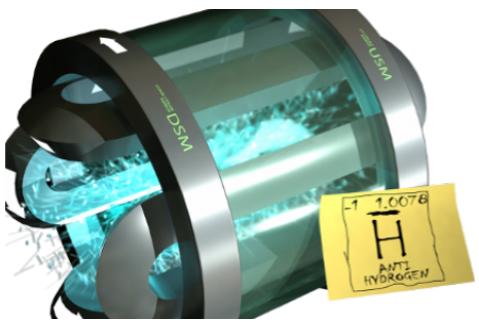


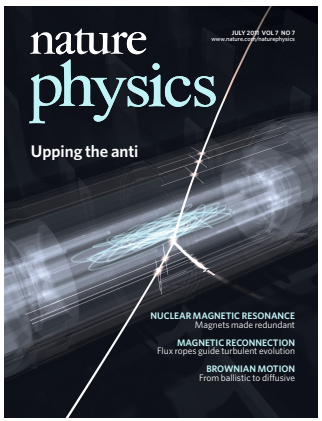
Antihydrogen progress

- **1996**: 9 antihydrogen atoms produced by LEAR and later 99 at Fermi lab.
  - Produced at 90% of the speed of light.
- **2002**: 'slow' antihydrogen atoms produced at CERN.
  - Still too energetic to be captured.

Antihydrogen progress

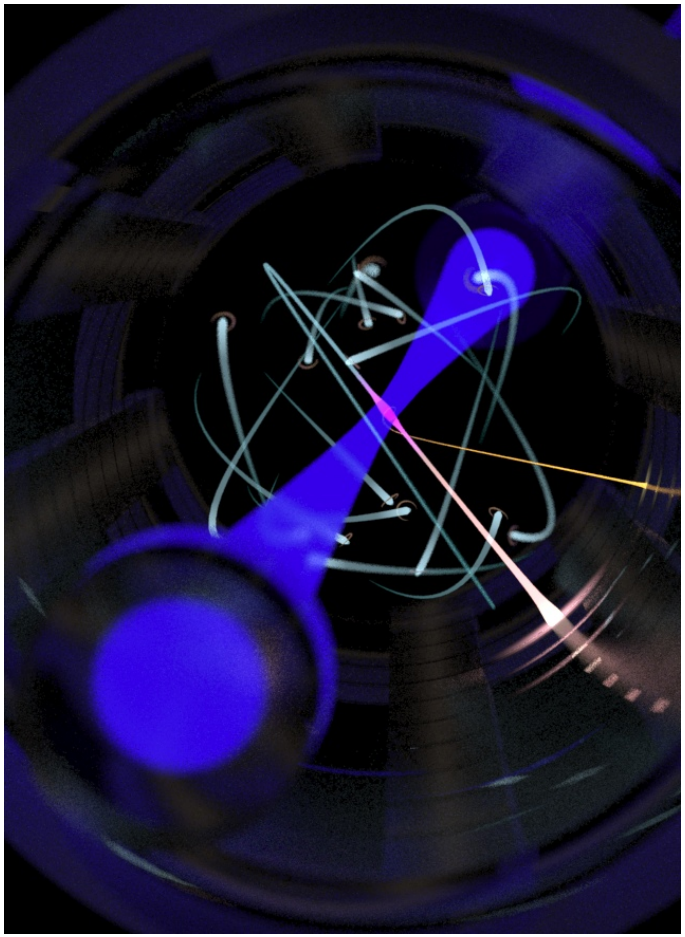
- **2010**: ALPHA traps 38 antihydrogen atoms for 172 milliseconds (one at a time).
  - Named: Physics World #1 Physics Breakthrough of 2010!
- **2011**: ALPHA traps antihydrogen for 15 minutes.
- **2011**: ALPHA performs first spectroscopic measurement on antihydrogen with microwaves.





Antihydrogen progress

- **2016**: ALPHA excites optical transition of antihydrogen (1S – 2S) for the first time!



Antihydrogen progress

"The measurement of antimatter on the optical spectrum was one of CERNs most significant findings in 2016. Get ready for a chaotic 2017 as they use what they found to manipulate our world."