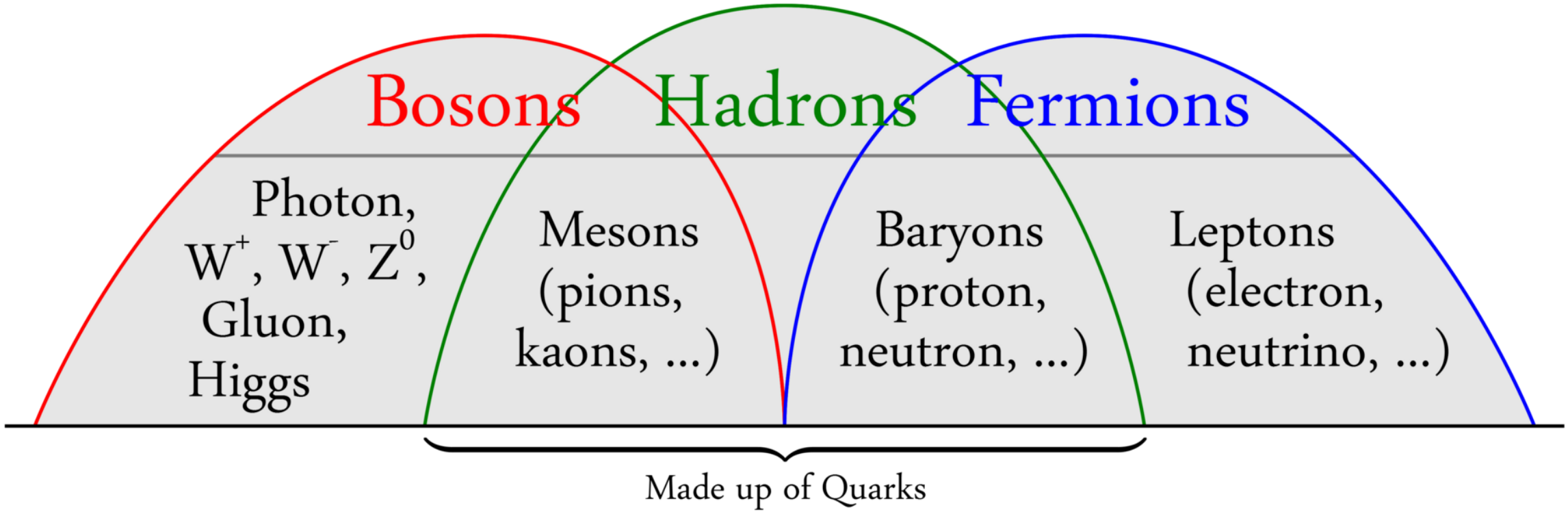
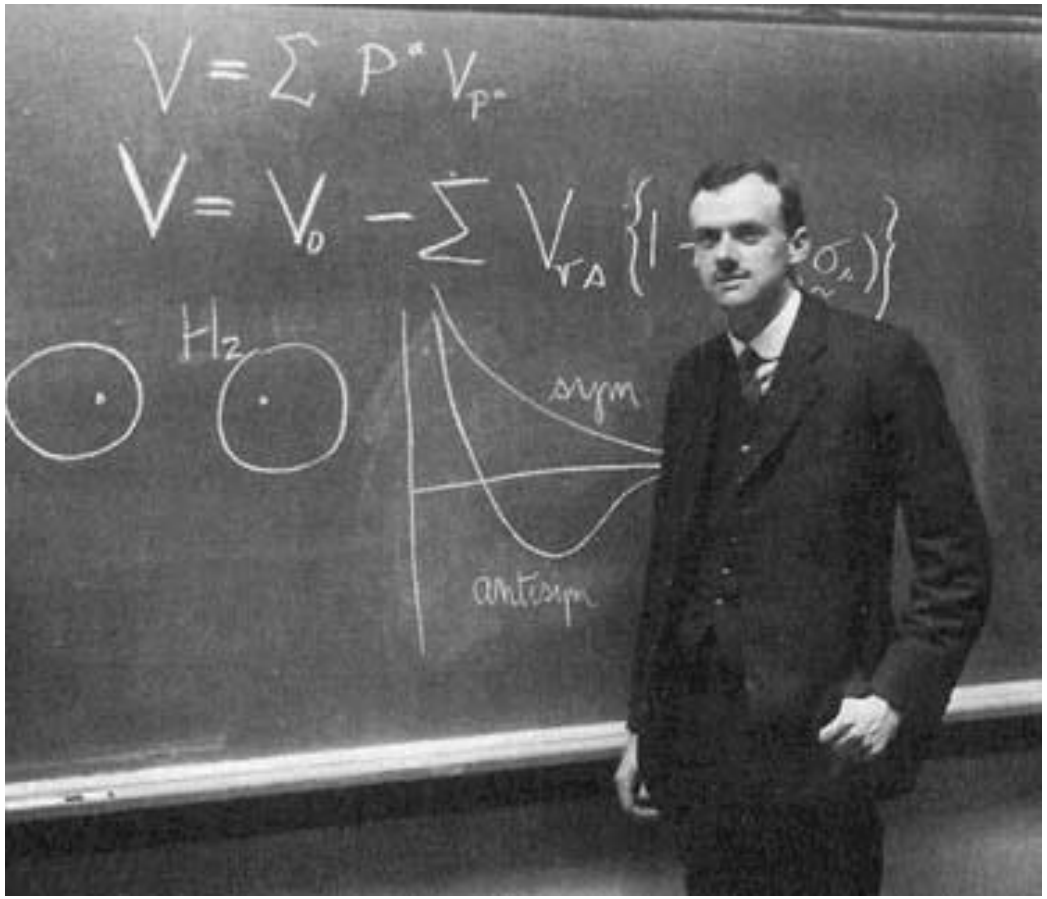
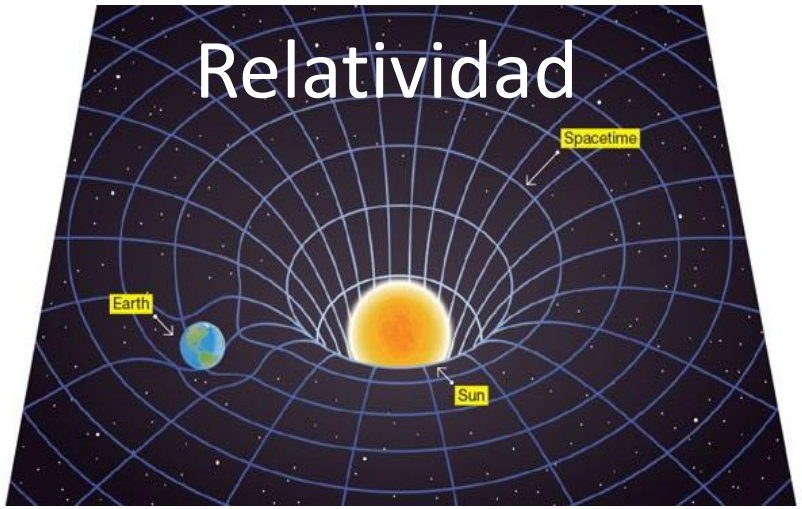
Antimateria

Alberto Jesús Uribe Jiménez

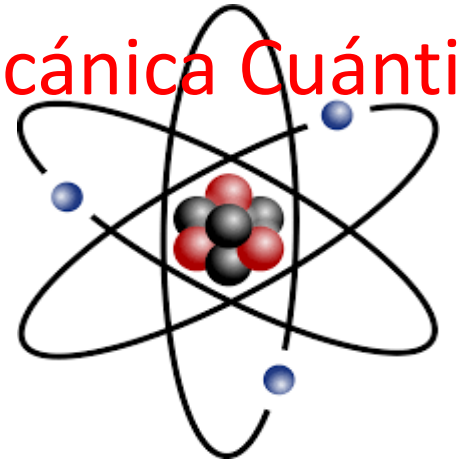
Spanish Language Teacher Programme

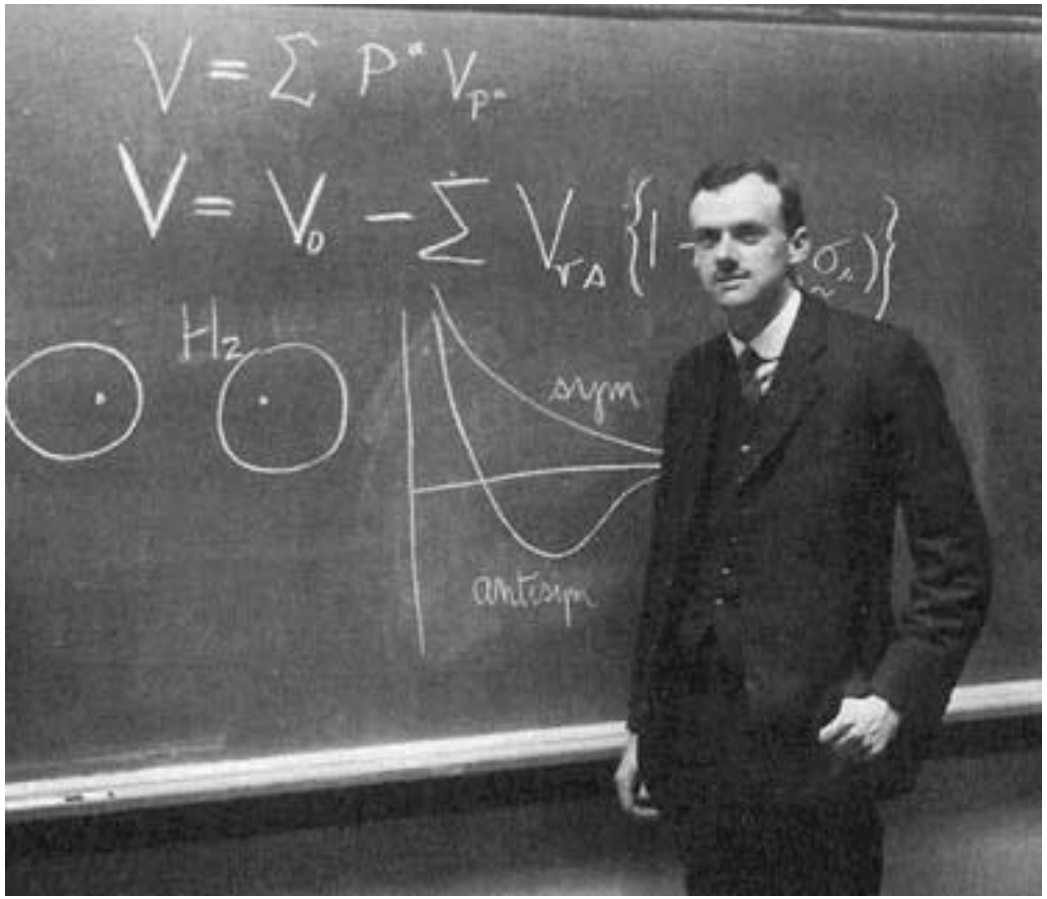

Bosons
Hadrons
Fermions
Photon,
W^+, W^-, Z^0,
Gluon,
Higgs
Mesons
(pions,
kaons, ...)
Baryons
(proton,
neutron, ...)
Leptons
(electron,
neutrino, ...)
Made up of Quarks





Mecánica Cuántica





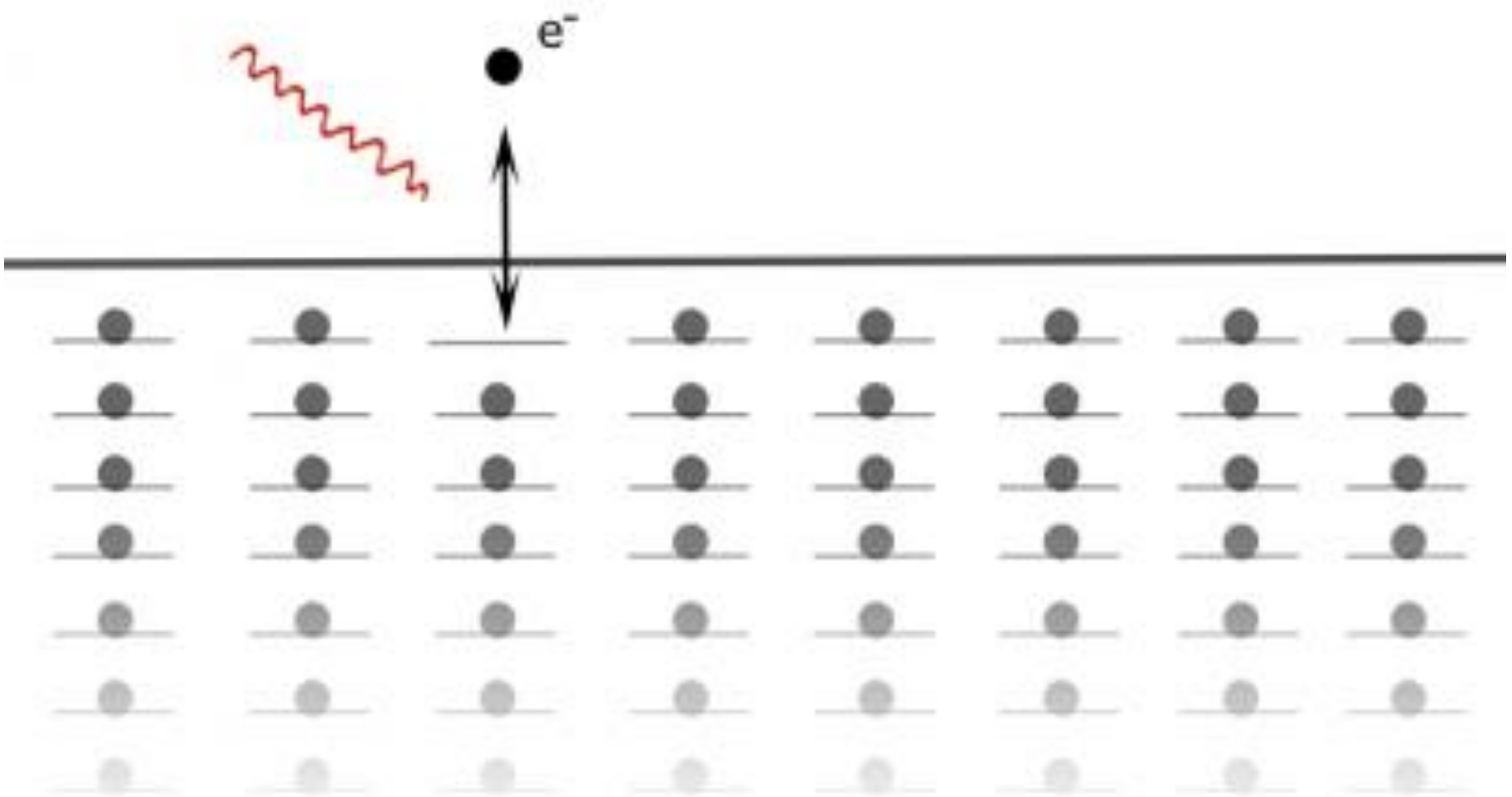
Relatividad + Mecánica cuántica

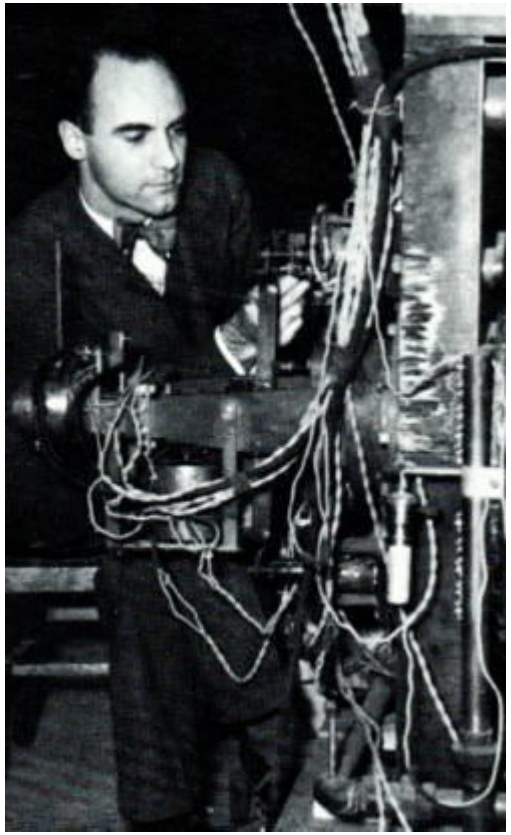
Dirac equation *(original)* Nobel 1933

$$\left(\beta mc^2 + c\left(\sum_{n=1}^{3} \alpha_n p_n\right)\right)\psi(x,t) = i\hbar\frac{\partial\psi(x,t)}{\partial t}$$

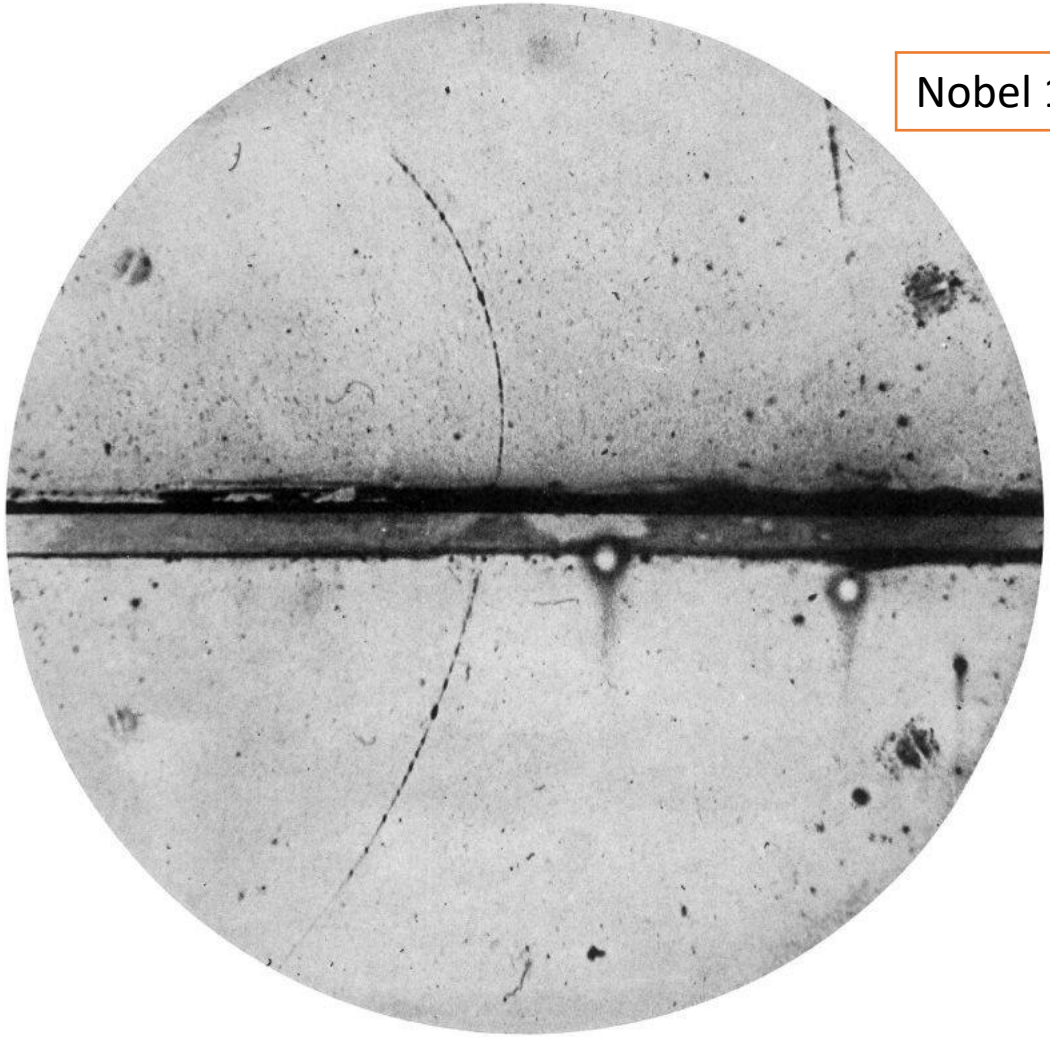
Particle	Year	Discovered	Technique
e^-	1897	Thomson	Discharge in gases
p	1919	Rutherford	Radioactivity
n	1932	Chadwik	Radioactivity
e^+	1933	Anderson	Cosmic-rays
$\mu^{+/-}$	1937	Neddermeyer, Anderson	Cosmic-rays
$\pi^{+/-}$	1947	Powell, Occhialini, Lattes	Cosmic-rays
$K^{+/-}$	1947	Rochester, Butler	Cosmic-rays
π^0	1949	Bjorklund	Accelerator
K^0	1951	Armenteros	Cosmic-rays
Λ^0	1950	Hopper	Cosmic-rays
anything else	1955 $\rightarrow$ today	various groups	Accelerators

Mar de Dirac



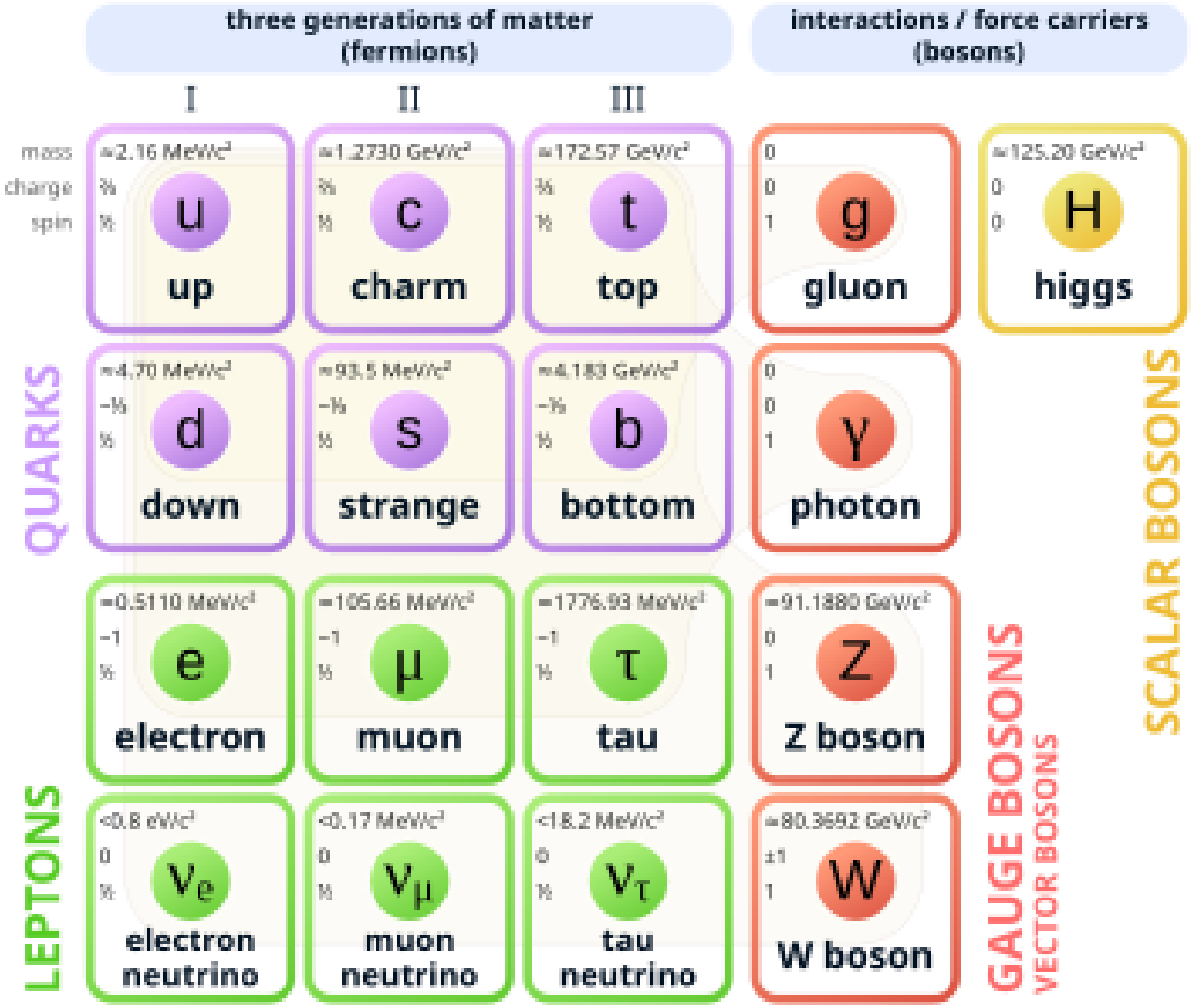


Carl Anderson

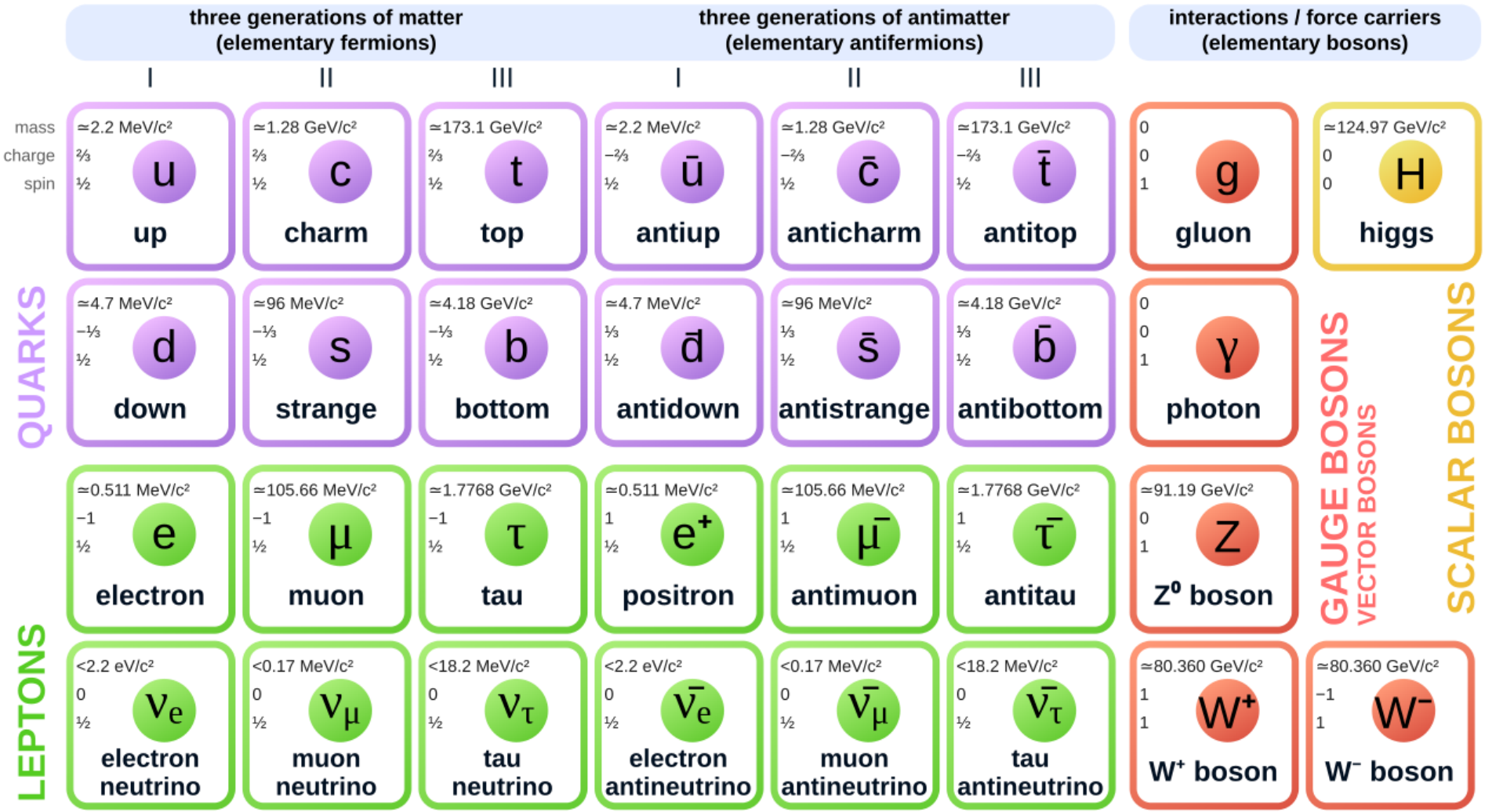


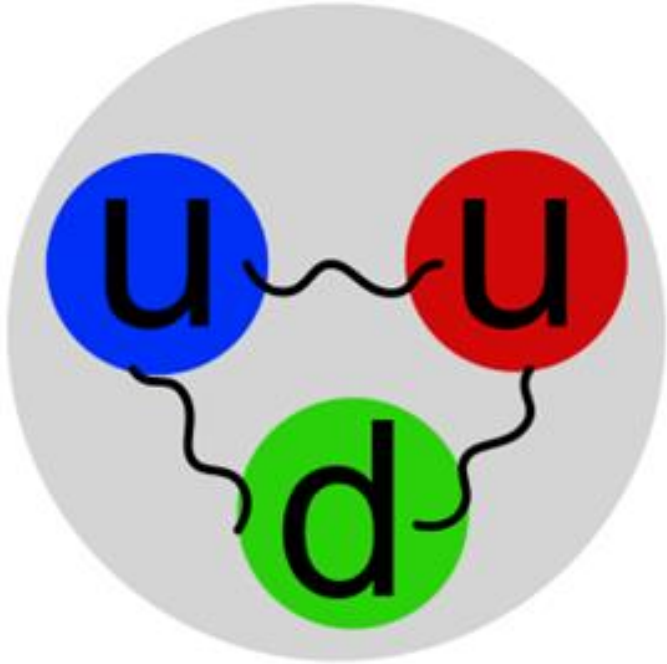
Nobel 1936

Standard Model of Elementary Particles



Standard Model of Elementary Particles

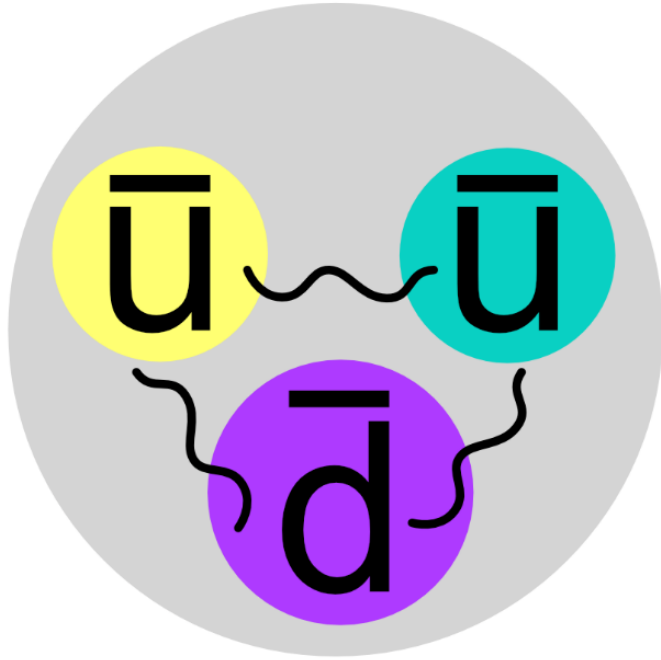




Proton

ū Anti-Up Quark

d̄ Anti-Down Quark

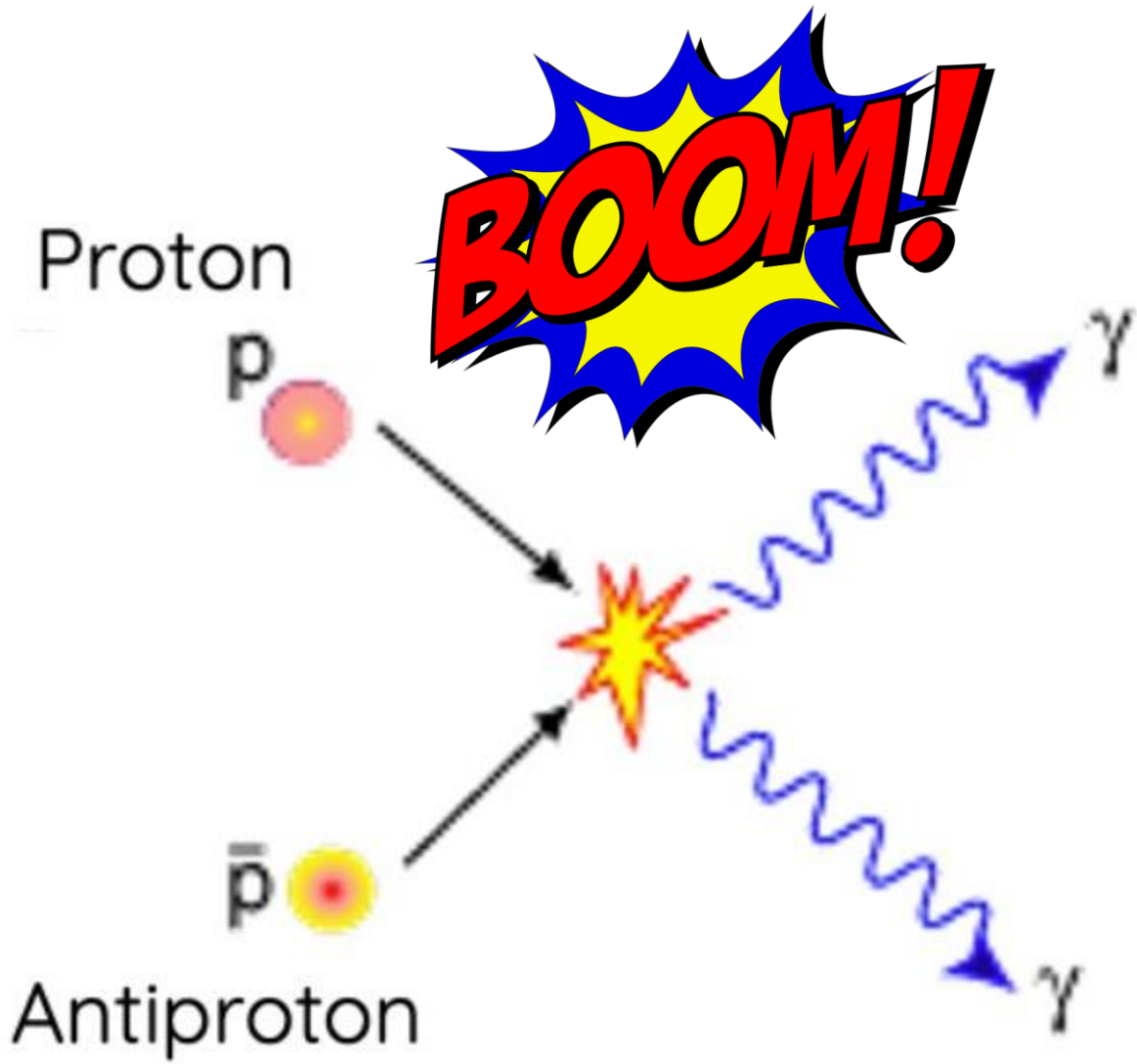


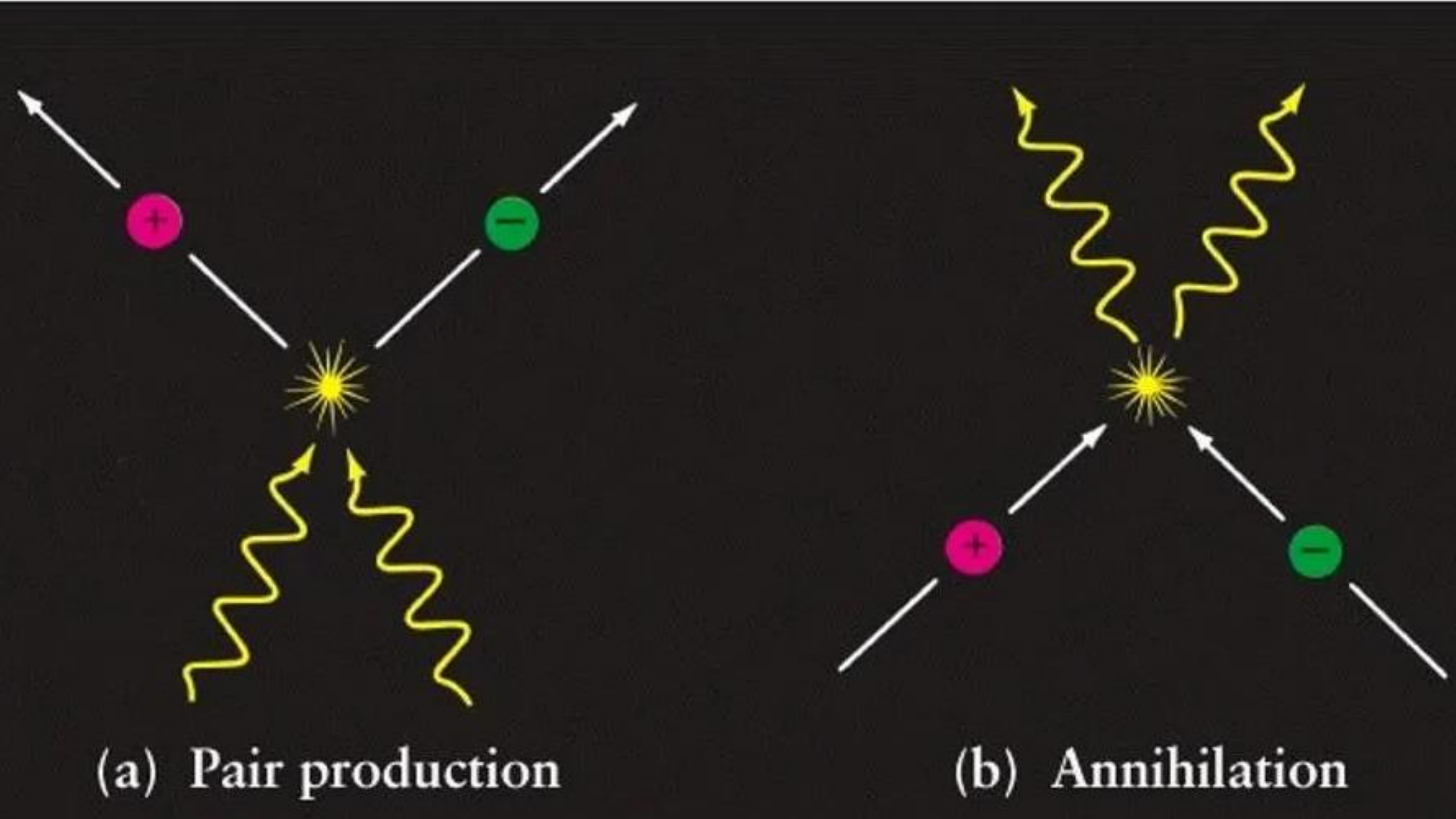
Antiproton

u Up Quark

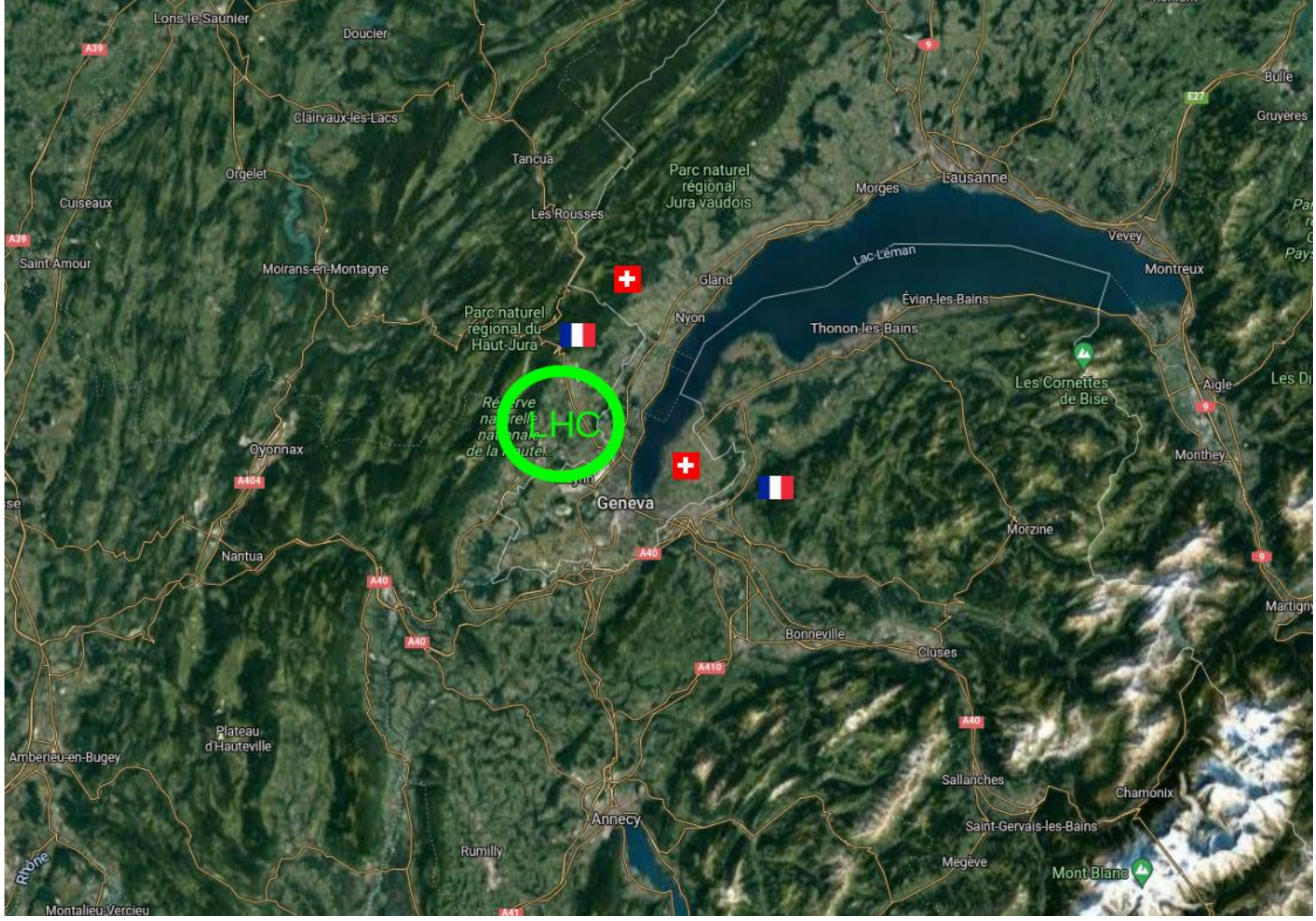
d Down Quark

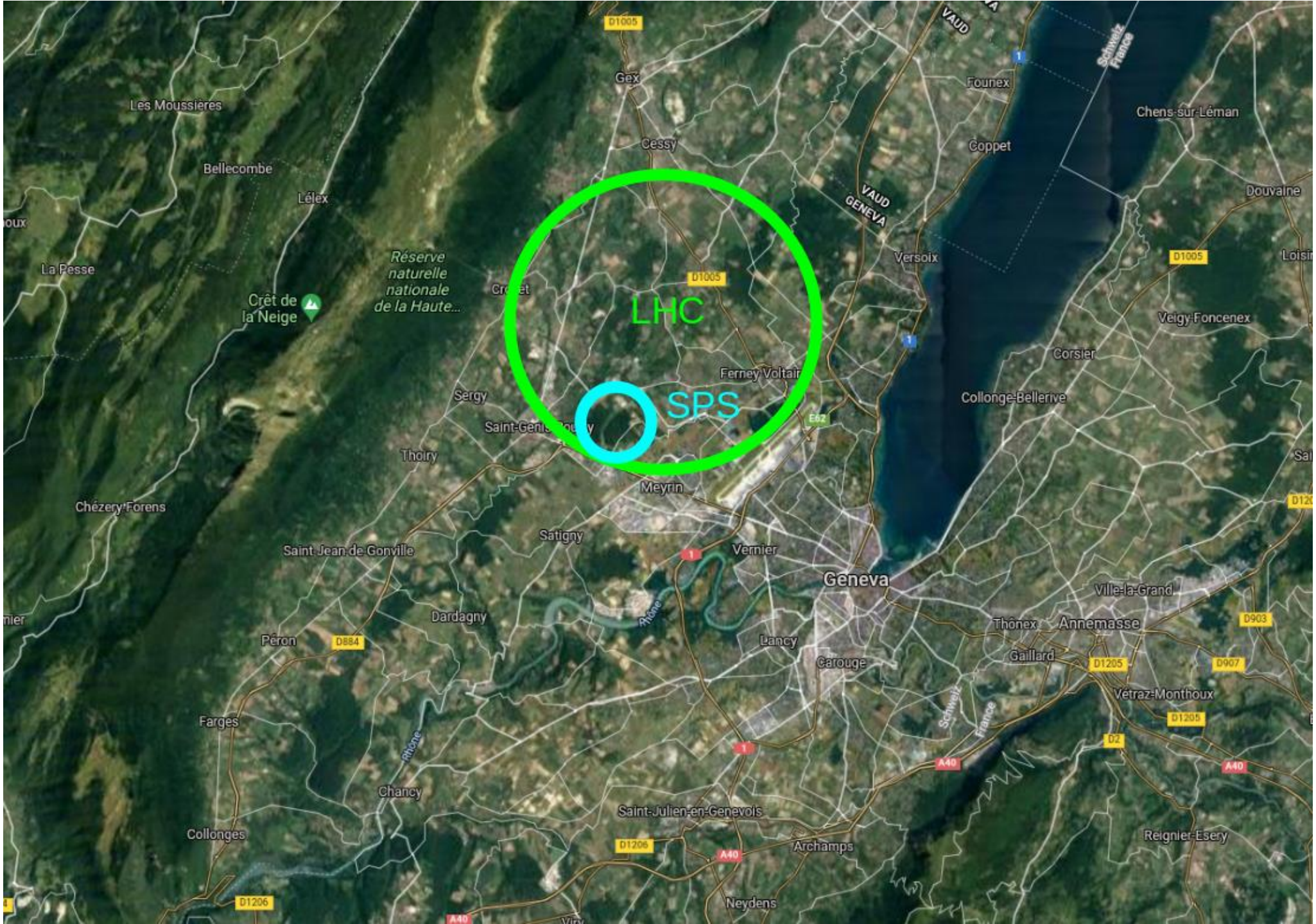
$$E = mc^2$$




(a) Pair production
(b) Annihilation


ANTIMATTER
FACTORY
ELENA

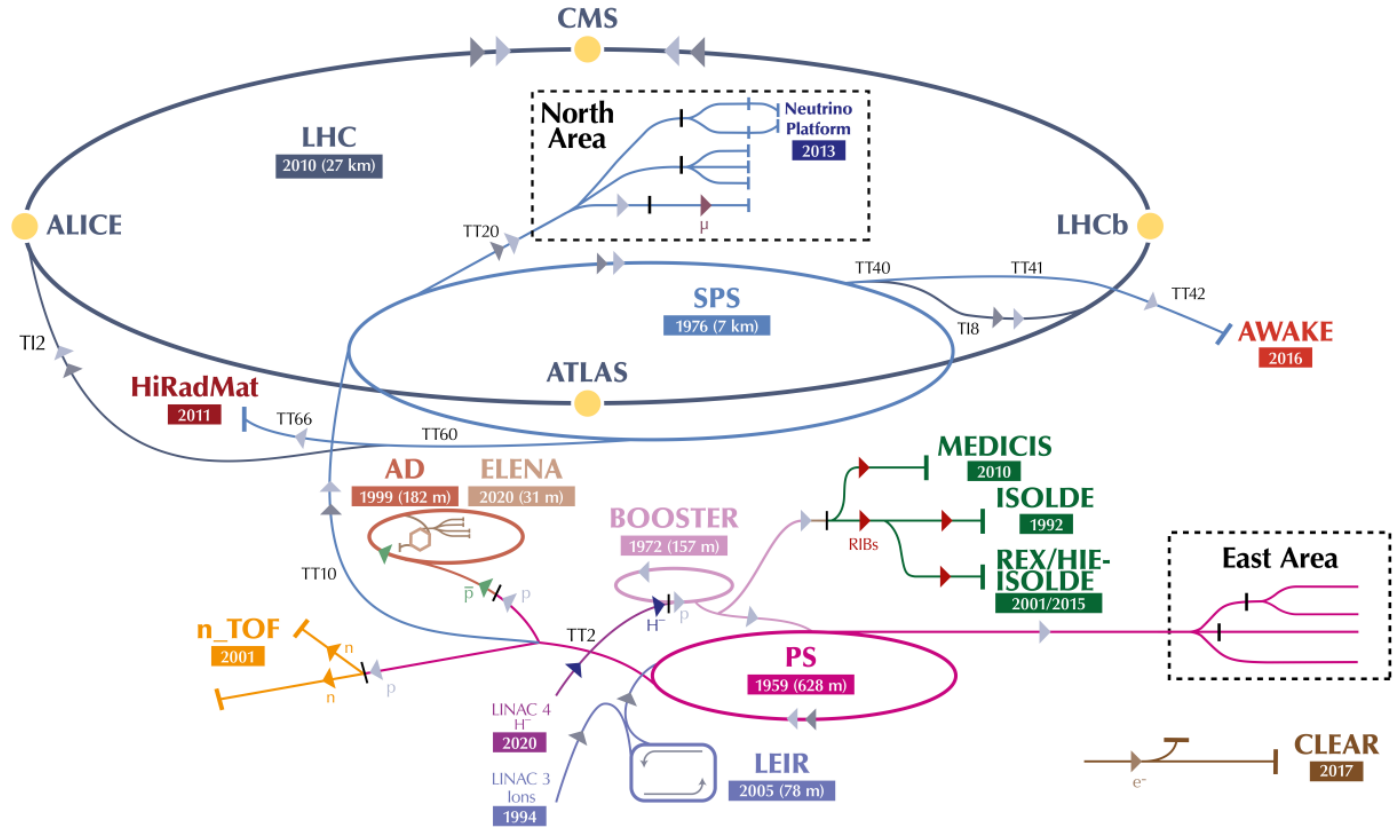

Lons-le-Saunier
Doucier
Clairvaux-les-Lacs
Orgelet
Tancua
Parc naturel régional Jura vaudois
Morges
Lausanne
Bulle
Gruyères
Cuiseaux
Les Rousses
Vevey
Saint-Amour
Moirans-en-Montagne
Lac Léman
Montreux
Gland
Évian-les-Bains
Parc naturel régional du Haut-Jura
Nyon
Thonon-les-Bains
Les Cornettes de Bise
Aigle
Oyonnax
Monthey
Geneva
Morzine
Nantua
Bonneville
Cluses
Plateau d'Hauteville
Ambérieu-en-Bugey
Sallanches
Chamonix
Annecy
Saint-Gervais-les-Bains
Rumilly
Megève
Mont Blanc
Rhône
Montalieu-Vercieu
A39
A404
A40
A410
A41
E27
9


LHC
SPS
Gex
Les Moussières
Bellecombe
Lélex
La Pesse
Crêt de la Neige
Réserve naturelle nationale de la Haute...
Cessy
Crozet
Ferney-Voltaire
Sergy
Thoiry
Meyrin
Chézery-Forens
Saint-Jean-de-Gonville
Satigny
Vernier
Geneva
Dardagny
Péron
Lancy
Carouge
Farges
Chancy
Collonges
Saint-Julien-en-Genevois
Archamps
Neydens
Reignier-Esery
Thônex
Annemasse
Ville-la-Grand
Gaillard
Vétraz-Monthoux
Versoix
Collonge-Bellerive
Corsier
Coppet
Founex
Chens-sur-Léman
Douvaine
Veigy-Foncenex
Rhône
VAUD
GENEVA
Schweiz
France
D1005
D884
D1206
D903
D1205
D907
D2
A40
E62


Where many CERN users live
Super Car Collider
Fábrica de antimateria
CERN
Genis Pouilly
NOZ
Centrakor Saint Genis Pouilly
CERN Prevessin
CHAMP CORBOZ
PRÉVESSIN
Prévessin-Moëns
Boulangerie Carrillat Sergy
Sergy
Av. du Jura
SAINT-GENIS
SERGY GARE
POUILLY
LE BUGNON
Saint-Genis-Pouilly
Carrefour Market Saint-Genis-Pouilly
Technoparc - Parc Industriel
Netto
Hôtel F1
Grand Frais
Champs Fréchets Kebab, K.COSKUN SA
Centre sportif des Vergers
Rte de Meyrin
Luigia Academy
Meyrin
Conforama
Grimper.ch SA - Meyrin-Satigny
Firmenich
BOURDIGNY
Seazen Buffet
Casino du Lac de
Coop
IKEA Vernier
MONTFLEURY
Satigny
Lidl
France
Schweiz


CMS
Versonnex
Ornex
Ferney-Voltaire
Prévessin-Moëns
Control Center
LHCb
ATLAS
ALICE
Saint-Genis-Pouilly
Max Degtyarev
Geneva

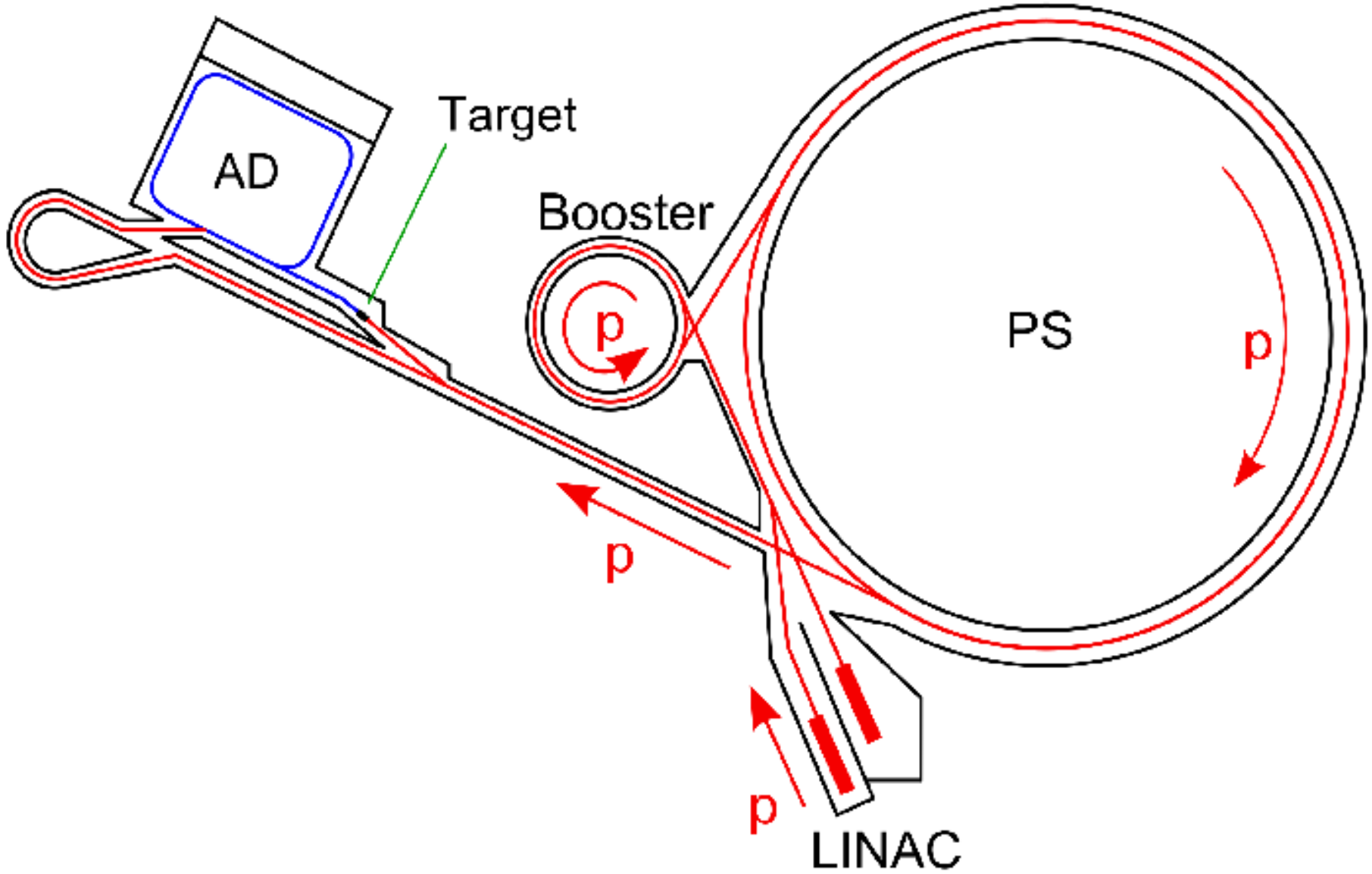
The CERN accelerator complex
Complexe des accélérateurs du CERN

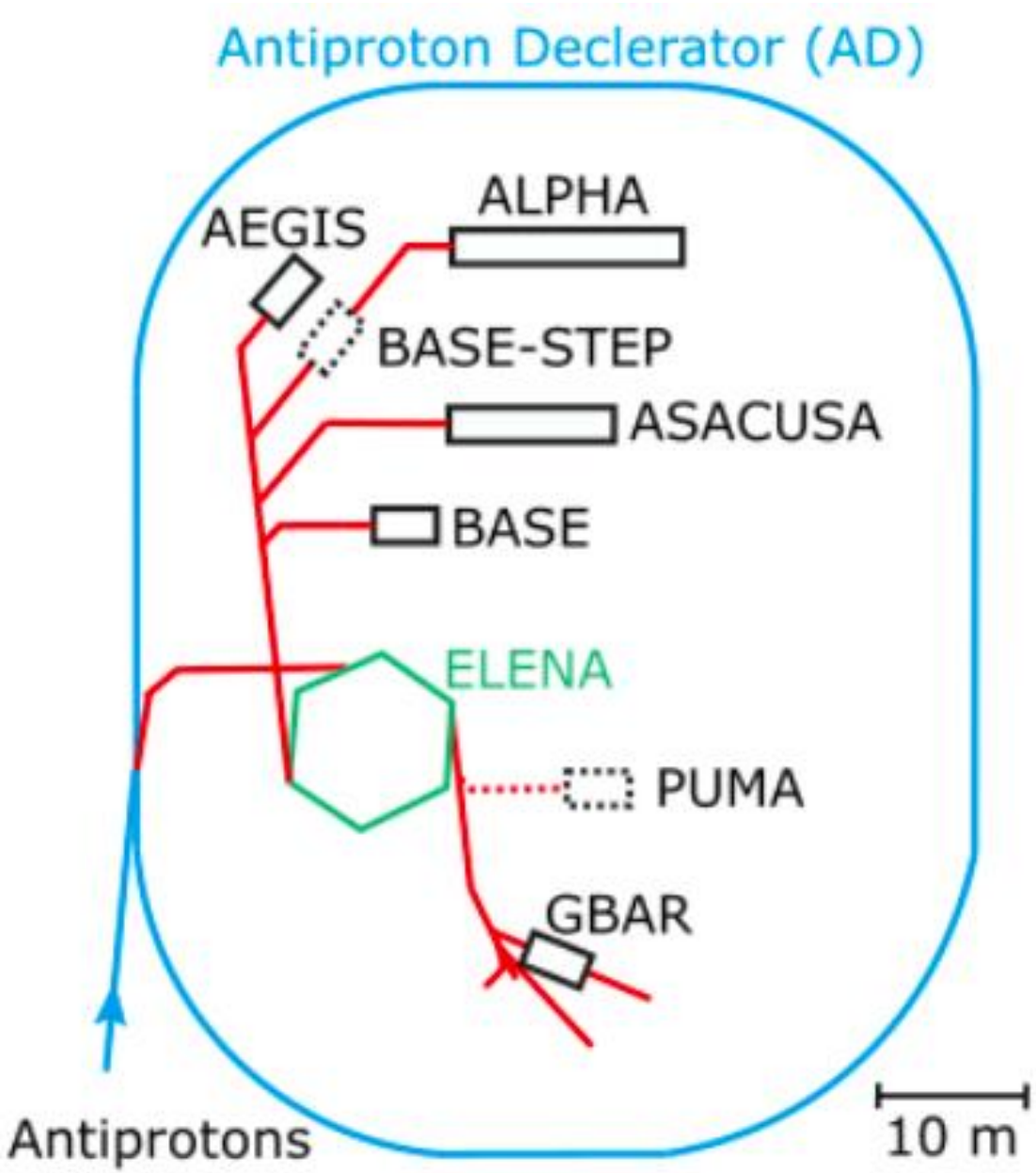


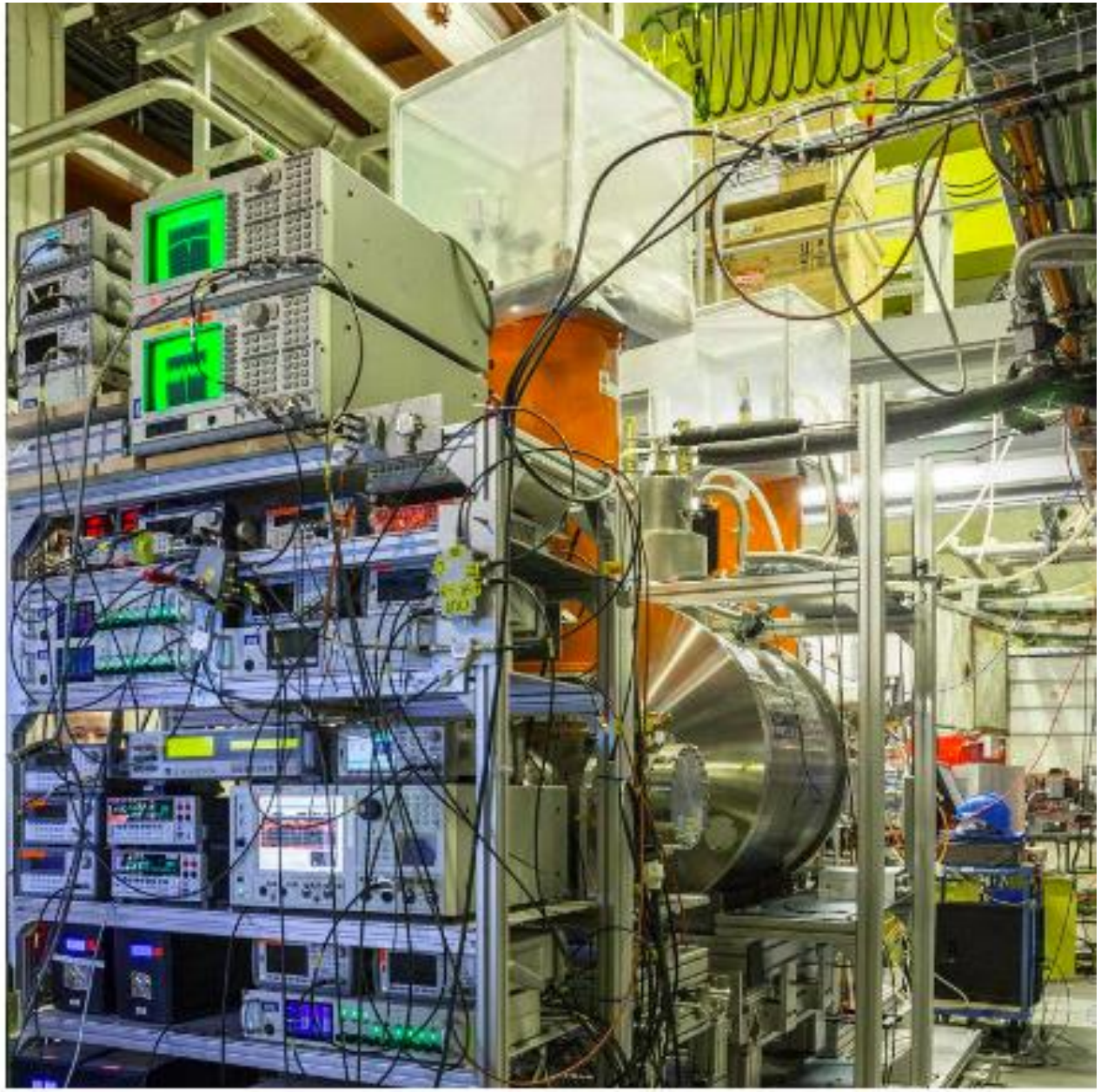
H⁻ (hydrogen anions) · p (protons) · ions · RIBs (Radioactive Ion Beams) · n (neutrons) · p̄ (antiprotons) · e⁻ (electrons) · μ (muons)

LHC - Large Hadron Collider // SPS - Super Proton Synchrotron // PS - Proton Synchrotron // AD - Antiproton Decelerator // CLEAR - CERN Linear Electron Accelerator for Research // AWAKE - Advanced WAKefield Experiment // ISOLDE - Isotope Separator OnLine // REX/HIE-ISOLDE - Radioactive EXperiment/High Intensity and Energy ISOLDE // MEDICIS // LEIR - Low Energy Ion Ring // LINAC - LINear ACcelerator // n_TOF - Neutrons Time Of Flight // HiRadMat - High-Radiation to Materials // Neutrino Platform

January 2022

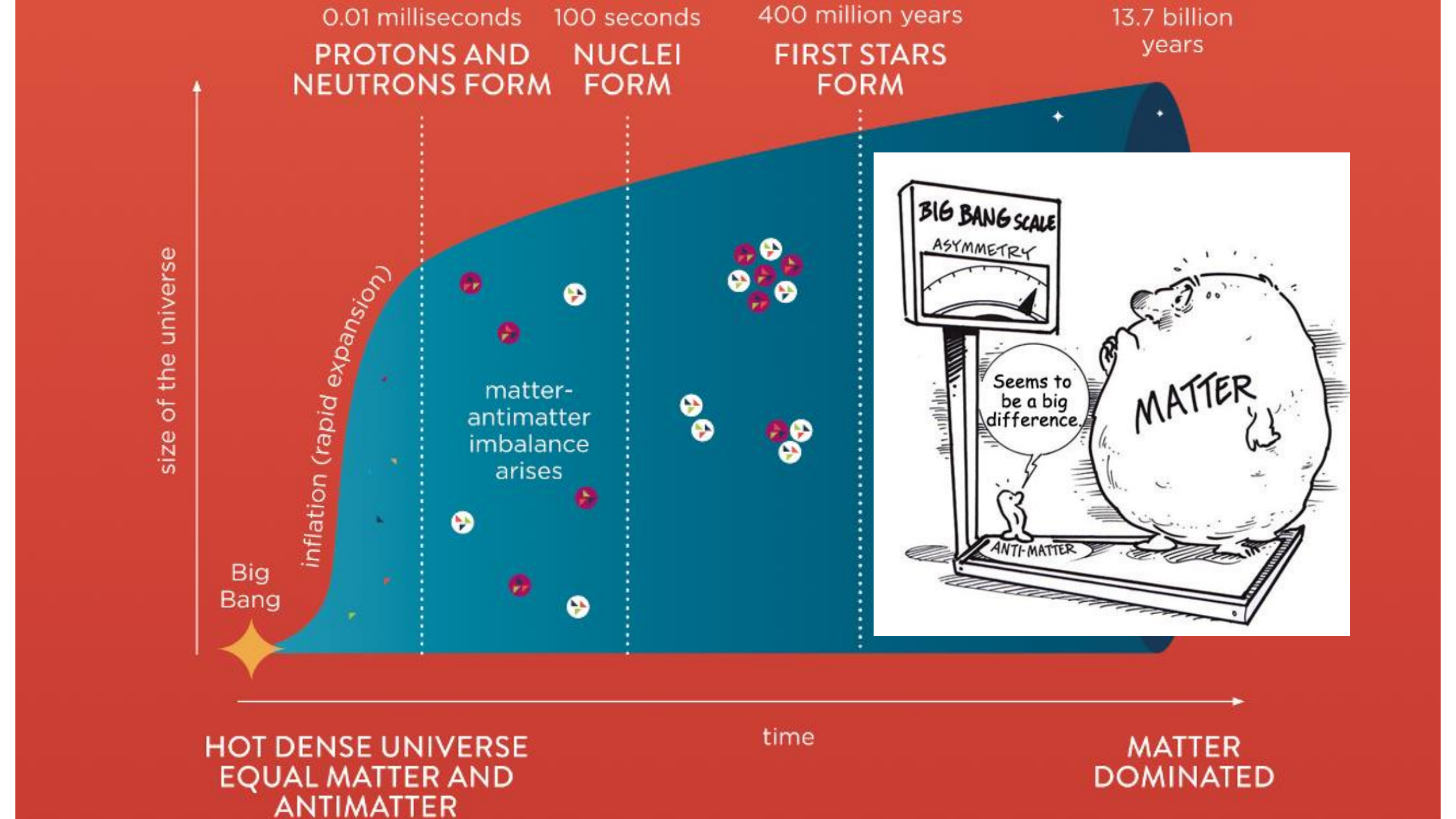

AD
Target
Booster
p
PS
p
p
p
LINAC

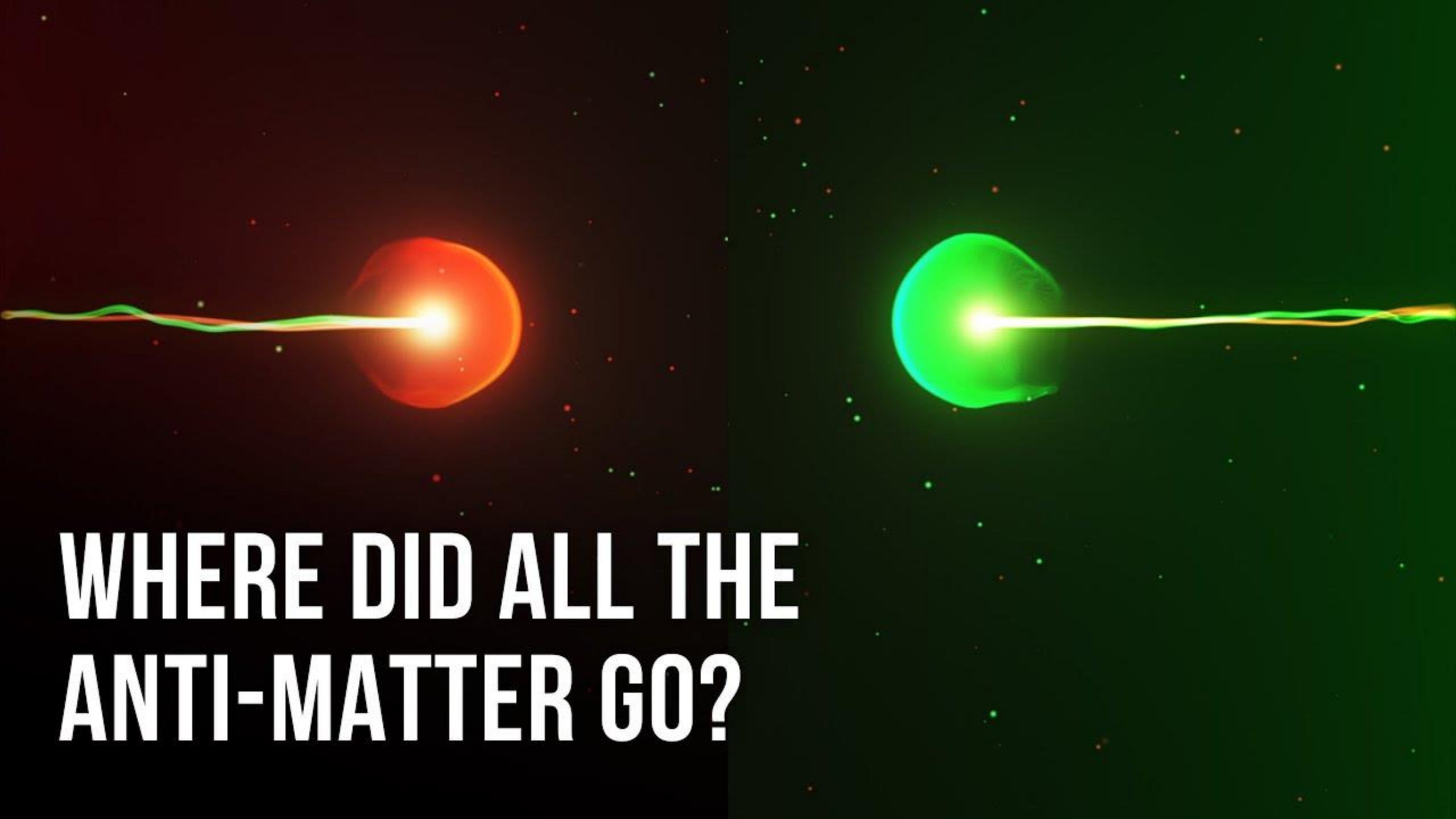

Antiproton Declerator (AD)
AEGIS
ALPHA
BASE-STEP
ASACUSA
BASE
ELENA
PUMA
GBAR
Antiprotons
10 m

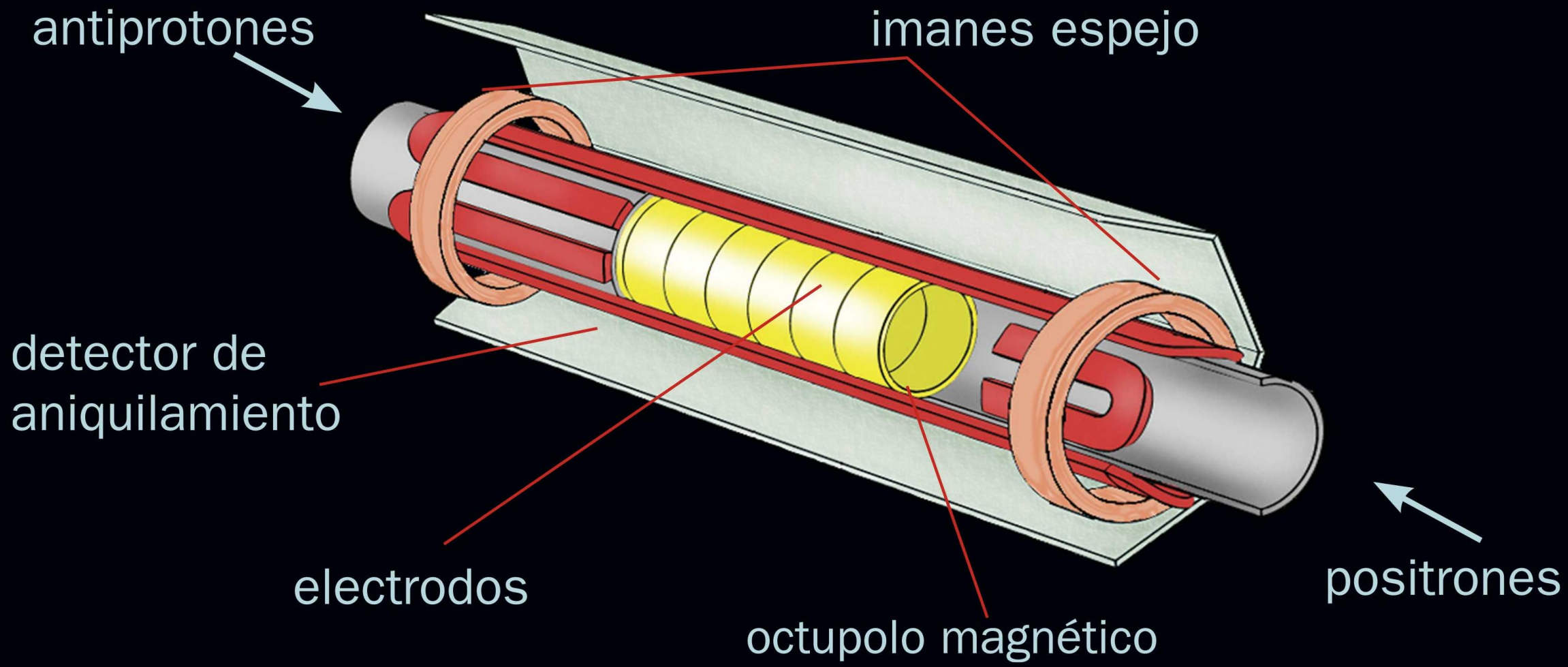


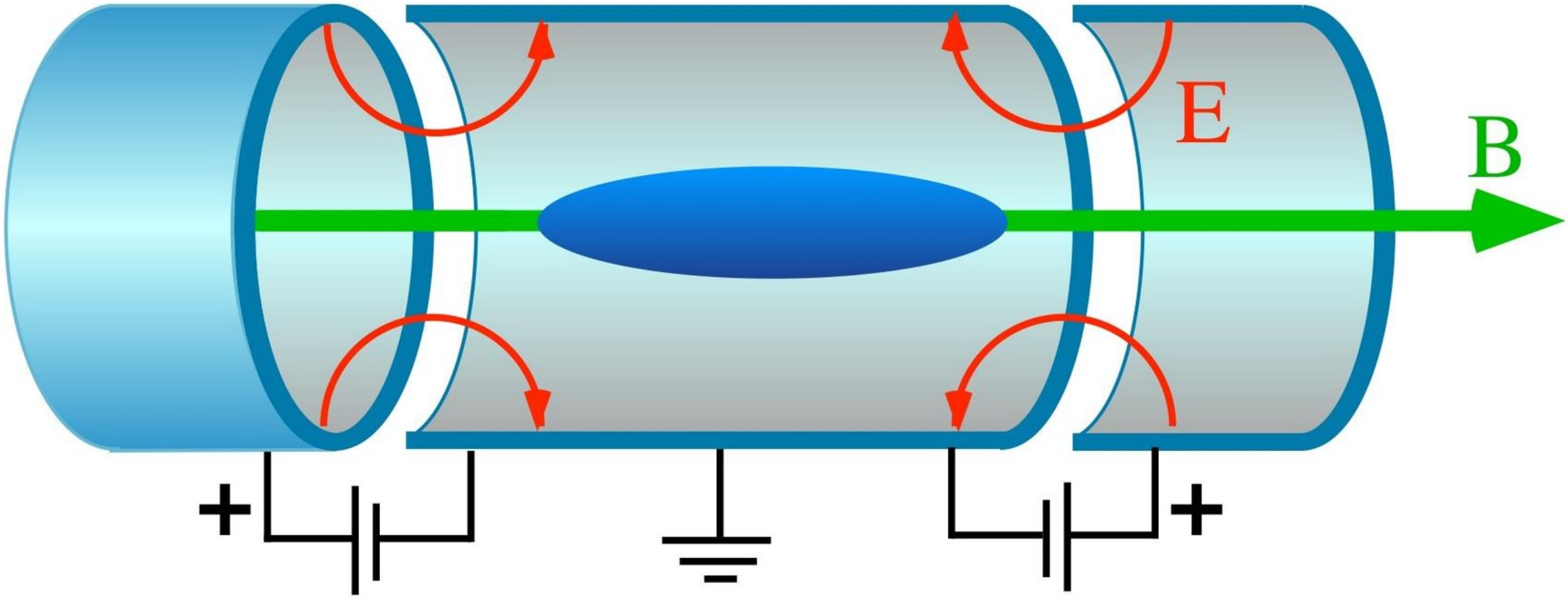

ANTIMATTER
FACTORY
ELENA


¿por qué?

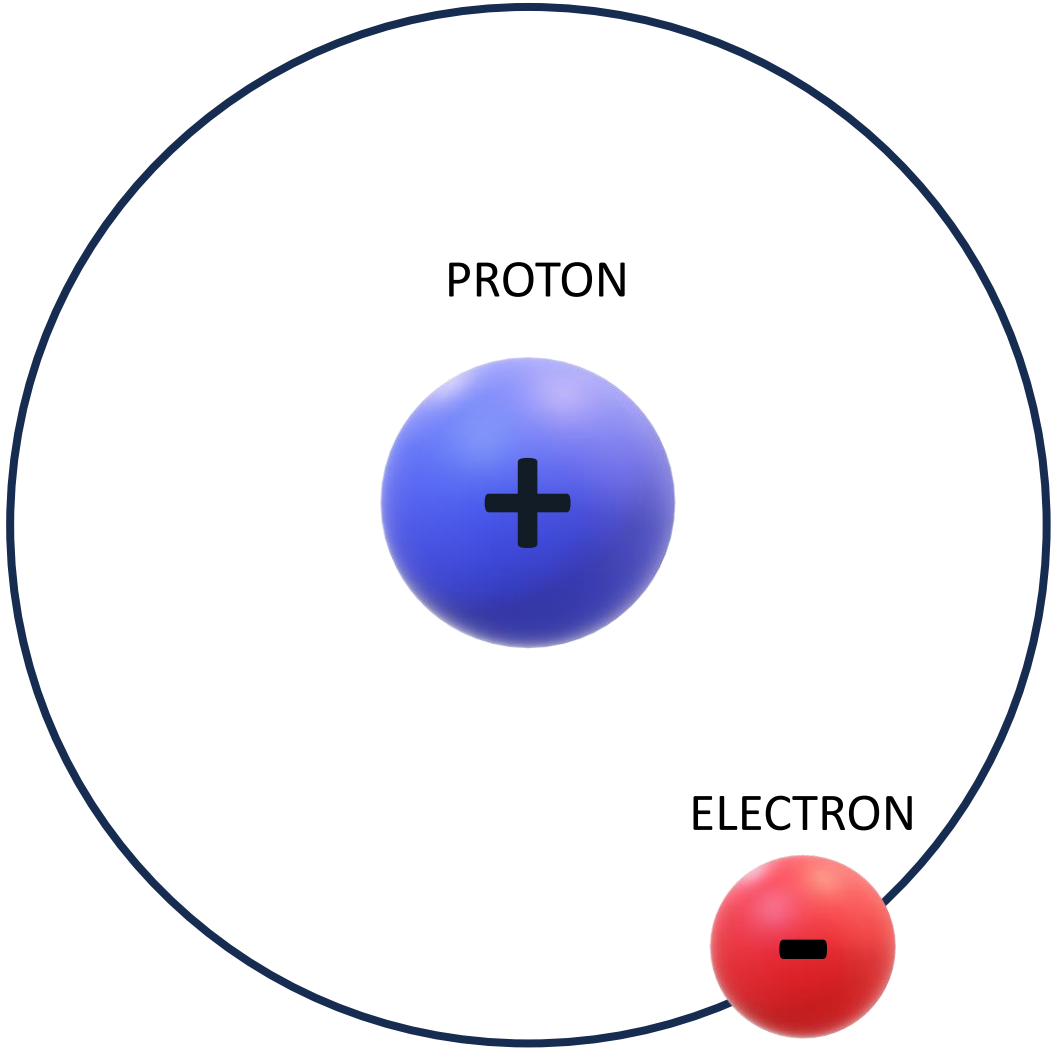

0.01 milliseconds
PROTONS AND NEUTRONS FORM
100 seconds
NUCLEI FORM
400 million years
FIRST STARS FORM
13.7 billion years
size of the universe
inflation (rapid expansion)
Big Bang
matter-antimatter imbalance arises
BIG BANG SCALE
ASYMMETRY
Seems to be a big difference.
MATTER
ANTI-MATTER
time
HOT DENSE UNIVERSE EQUAL MATTER AND ANTIMATTER
MATTER DOMINATED


WHERE DID ALL THE
ANTI-MATTER GO?


antiprotones
imanes espejo
detector de aniquilamiento
electrodos
octupolo magnético
positrones

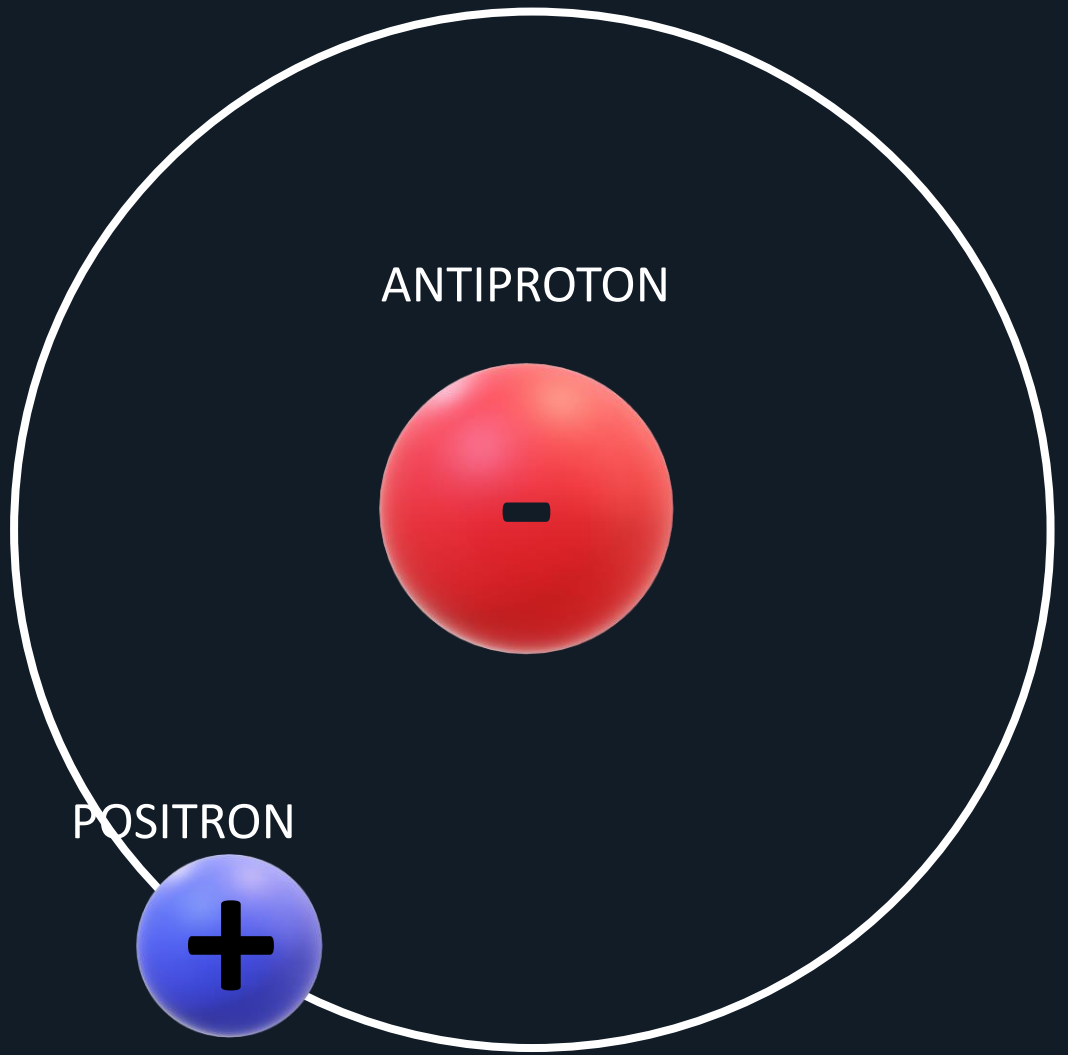

E
B
+
+

MATTER



HYDROGEN

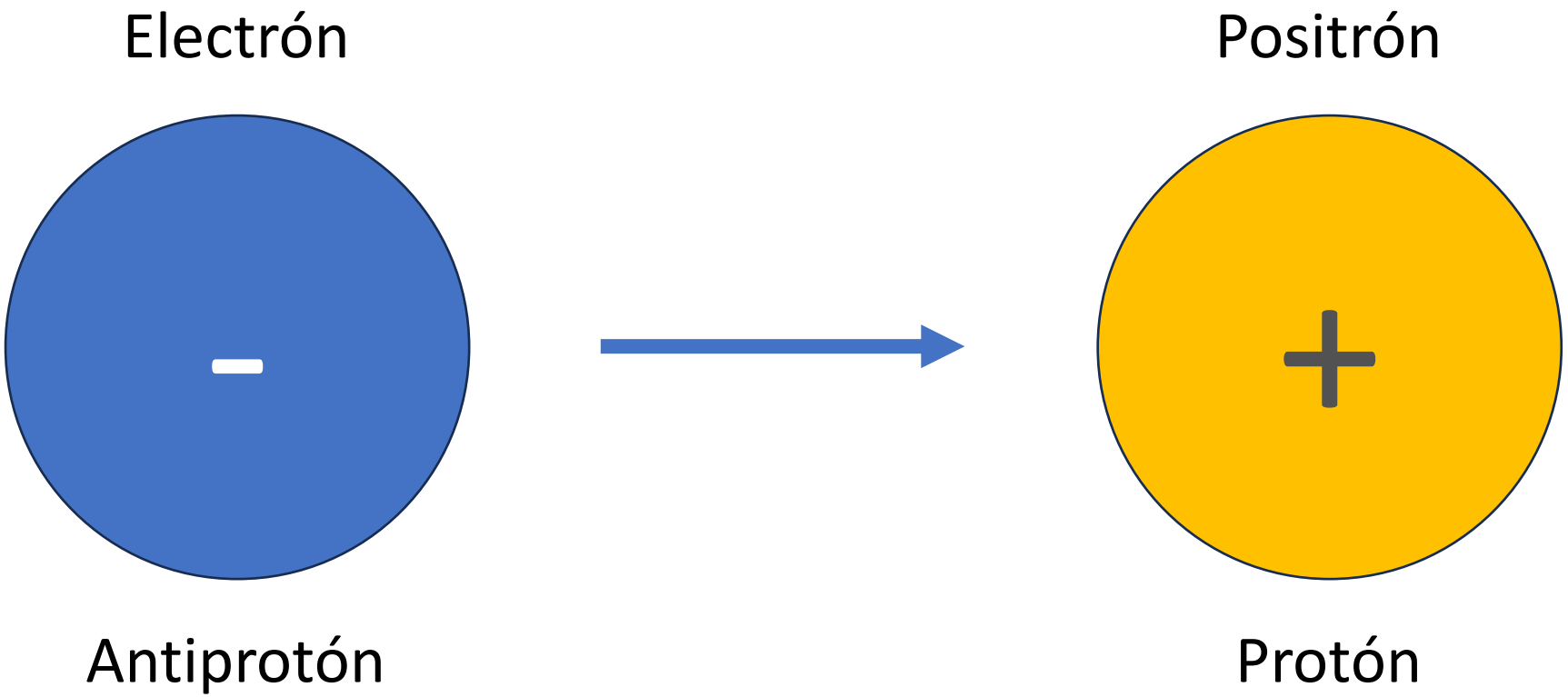
ANTIMATTER



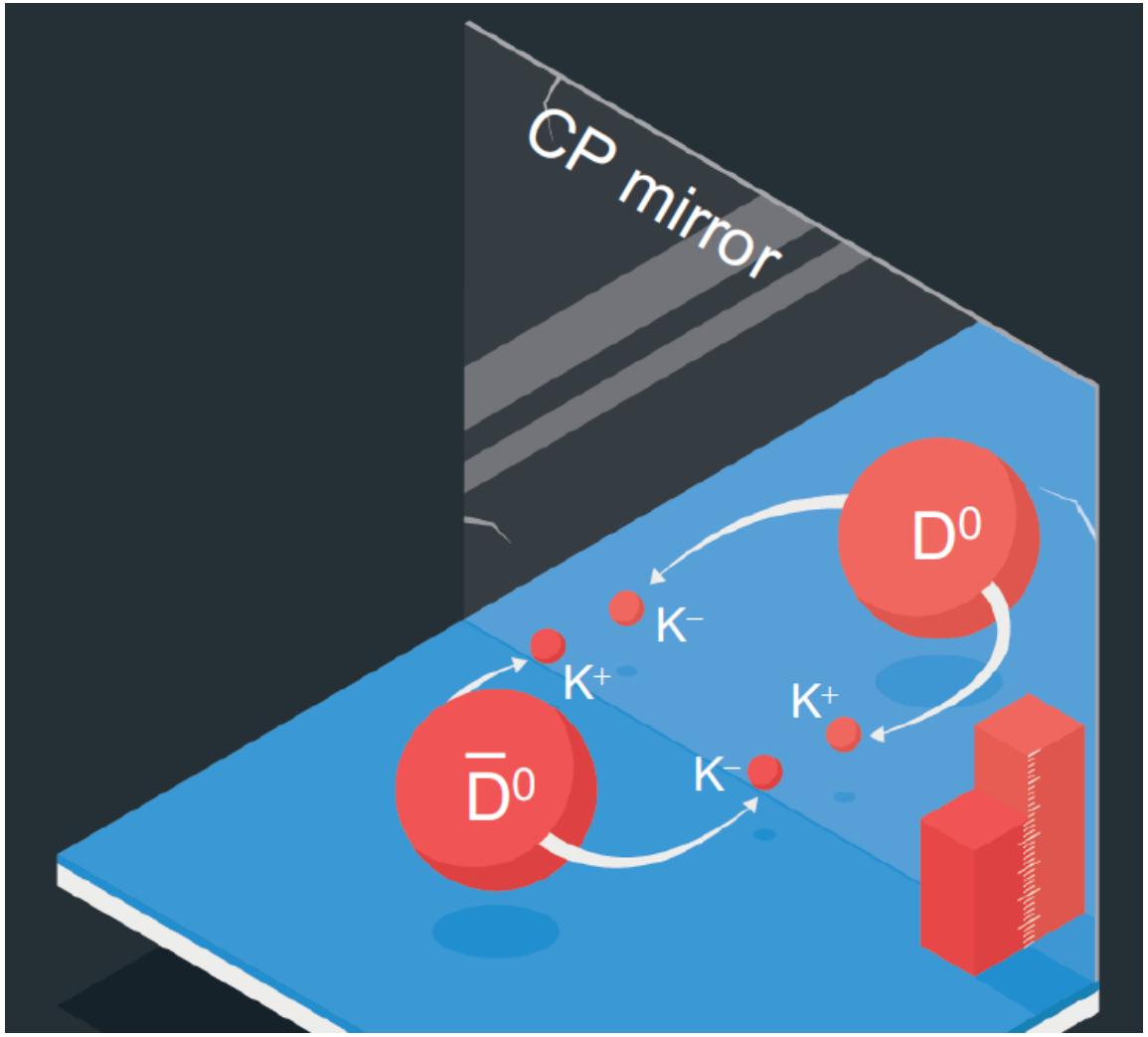
ANTIHYDROGEN


ANTIMATTER
FACTORY
ELENA

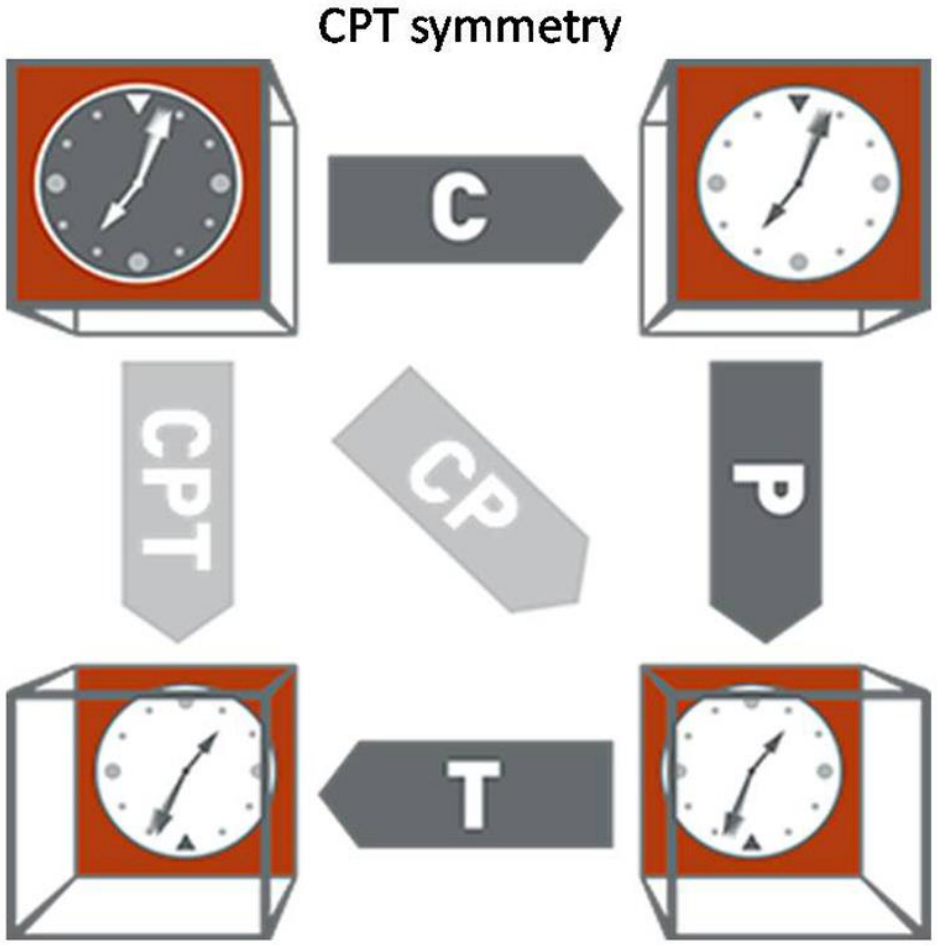
Carga



Carga - Paridad



¿Existe una violación de CPT?

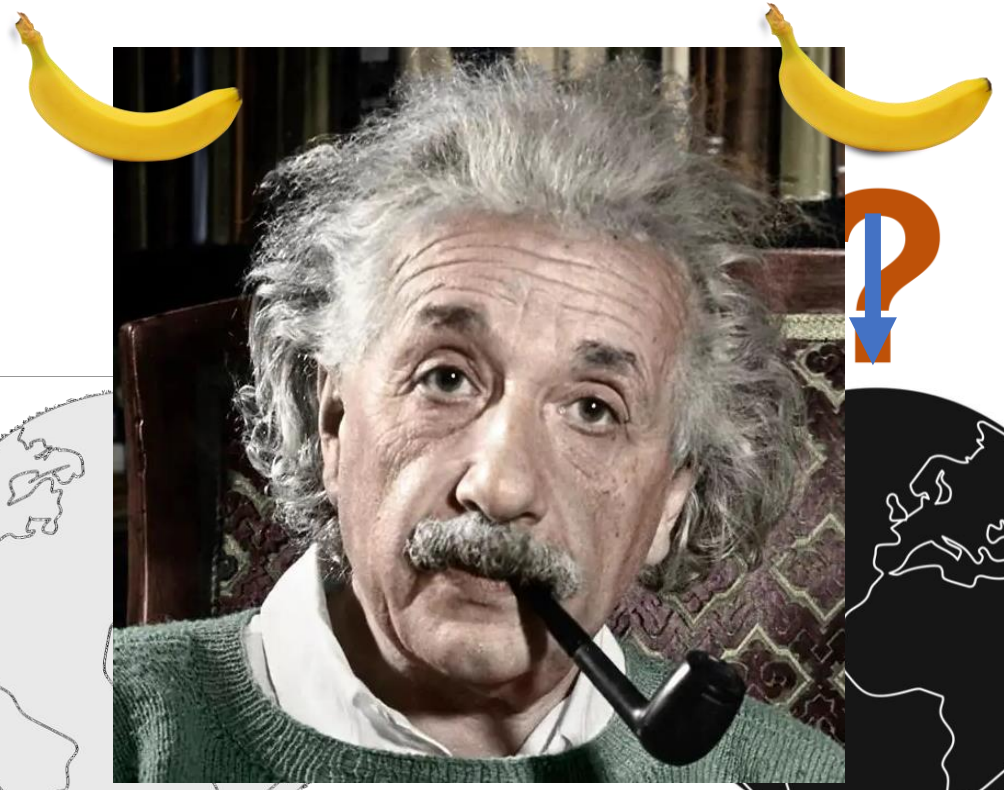


¿Se cumple WEP?

Materia

Tierra

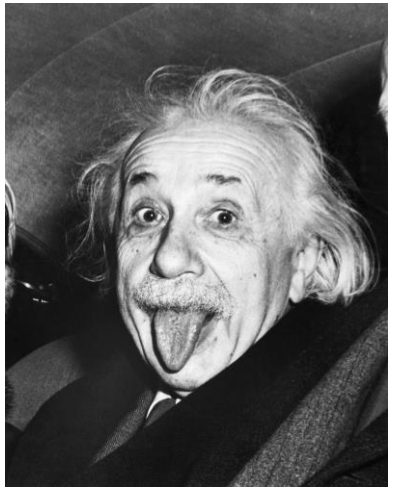
Antimateria



Antitierra

Antimateria

Tierra

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ELENA


NO LO DIGO YO
LO DICE LA CIENCIA