

Modello Standard delle particelle elementari

QUARK	up u	charm c	top t
carica elettrica $2/3$			
carica elettrica $-1/3$			
	down d	strange s	beauty b

MEDIATORI	gluone g
	fotone γ
	bosone W W^\pm
	bosone Z Z



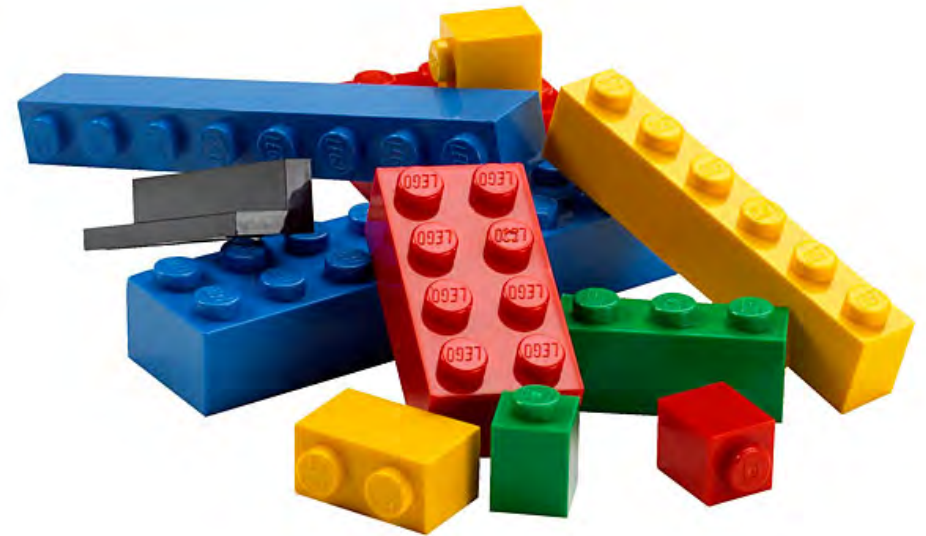
LEPTONI	ν_e	ν_μ	ν_τ
carica elettrica 0			
carica elettrica -1			
	e	μ	τ

Credits: Asimmetrie

Particelle

QUARK	up u	charm c	top t
carica elettrica 2/3			
	down d	strange s	beauty b
carica elettrica -1/3			

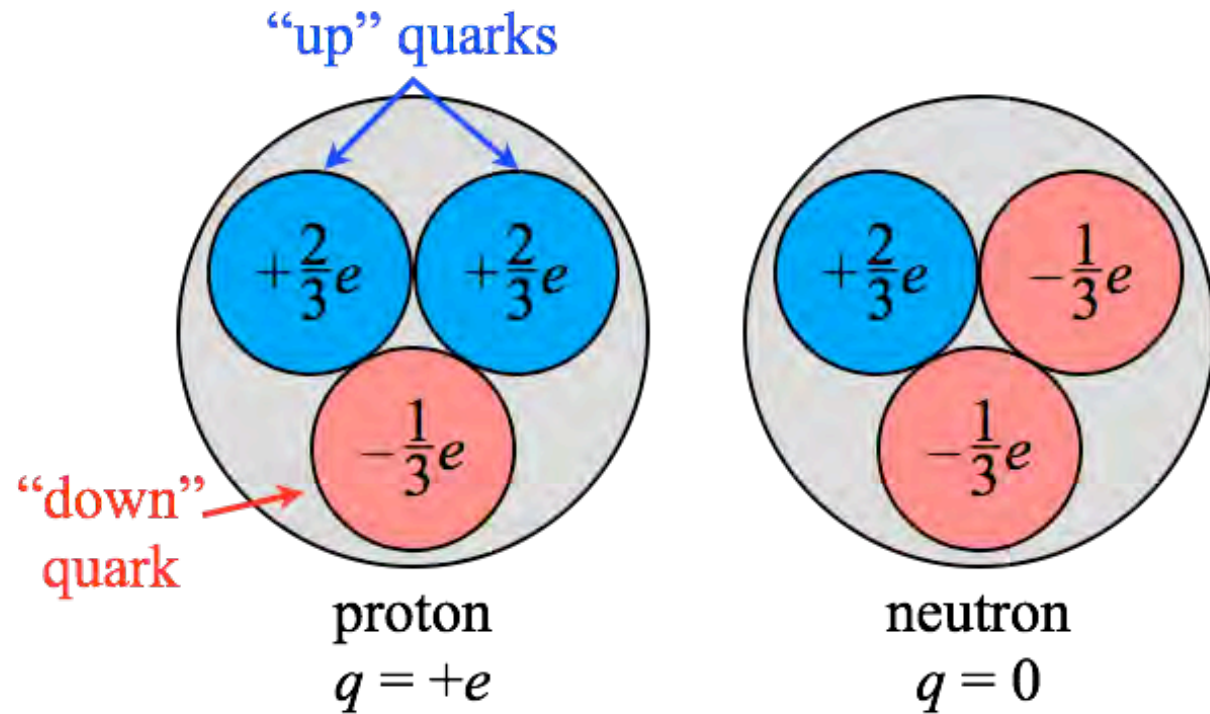
LEPTONI	ν_e	ν_μ	ν_τ
carica elettrica 0			
	e	μ	τ
carica elettrica -1			



Credits: Asimmetrie

Quark up e down

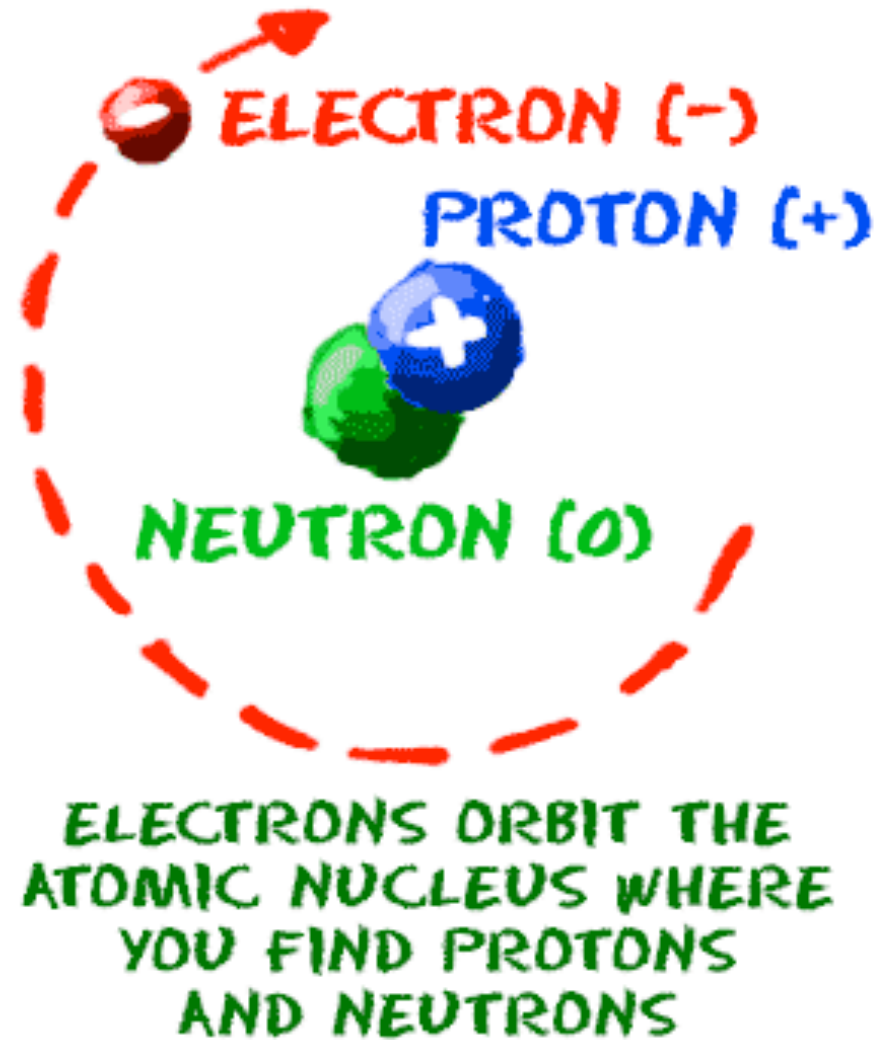
QUARK	up	u
carica elettrica	$\frac{2}{3}$	
	down	d
carica elettrica	$-\frac{1}{3}$	



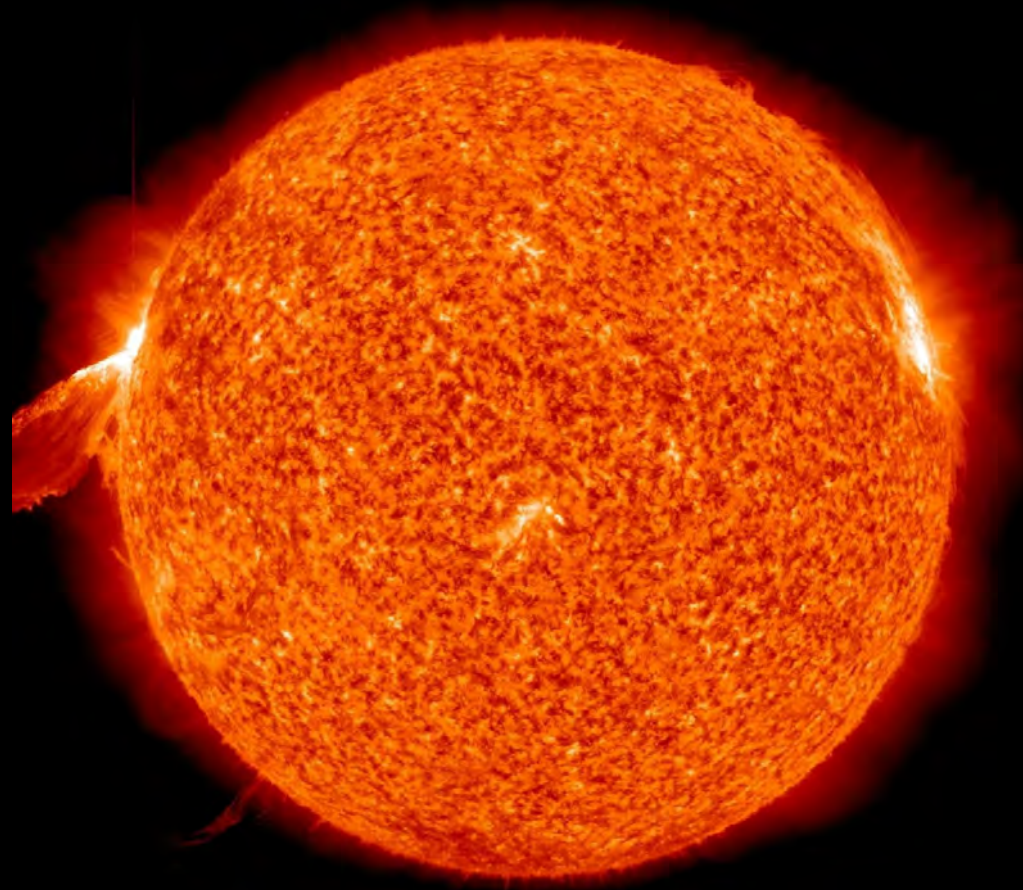
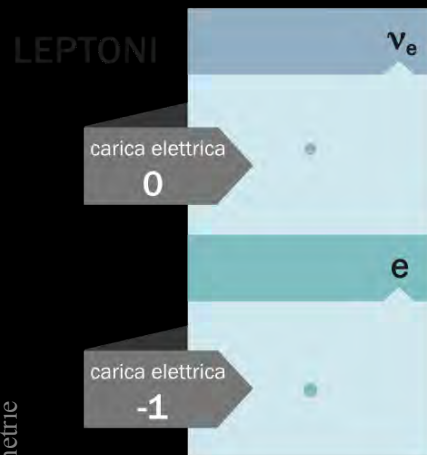
Electrone

QUARK	up	u
carica elettrica	$\frac{2}{3}$	
down	d	
carica elettrica	$-\frac{1}{3}$	

	e
carica elettrica	-1



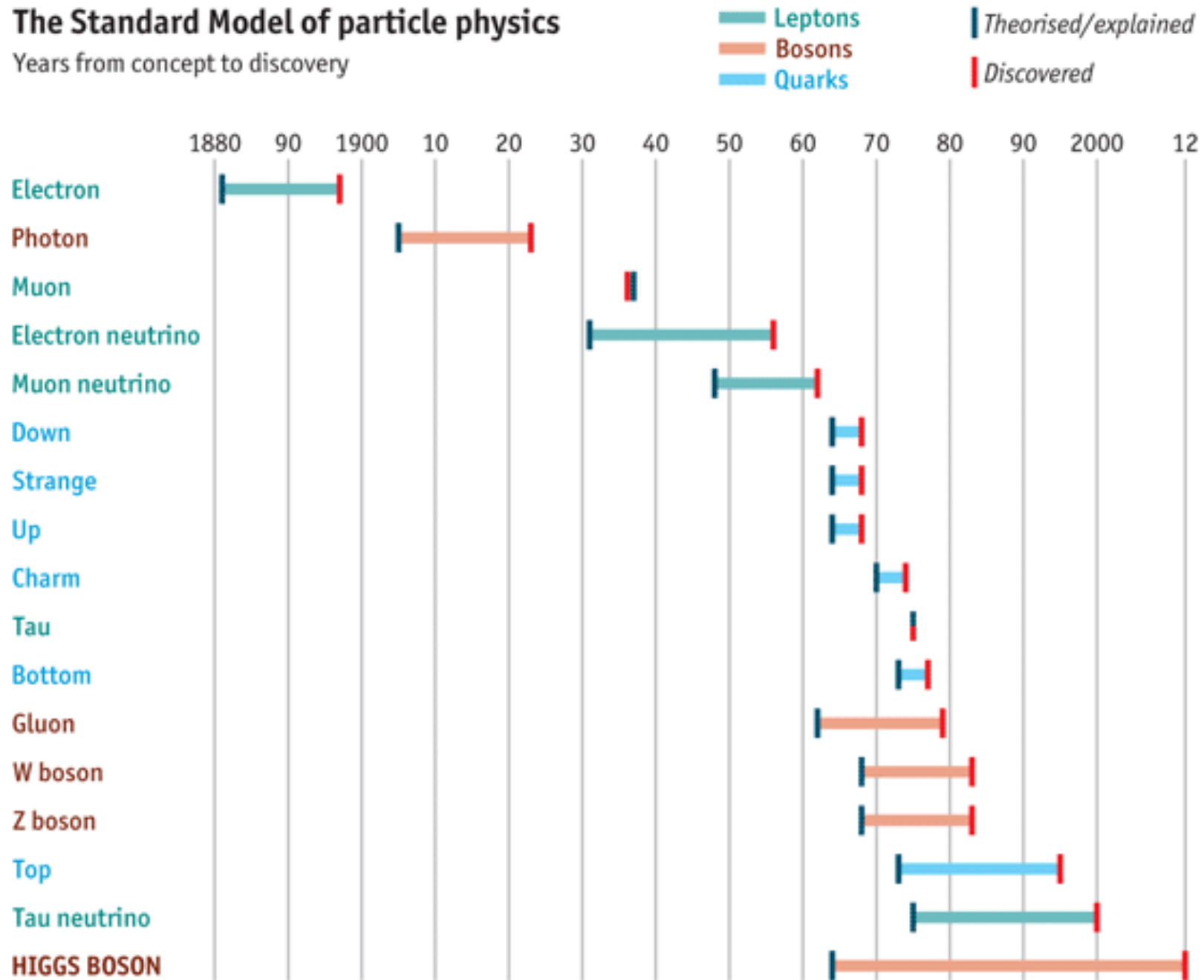
Neutrino elettronico



Credits: Asimmetrie

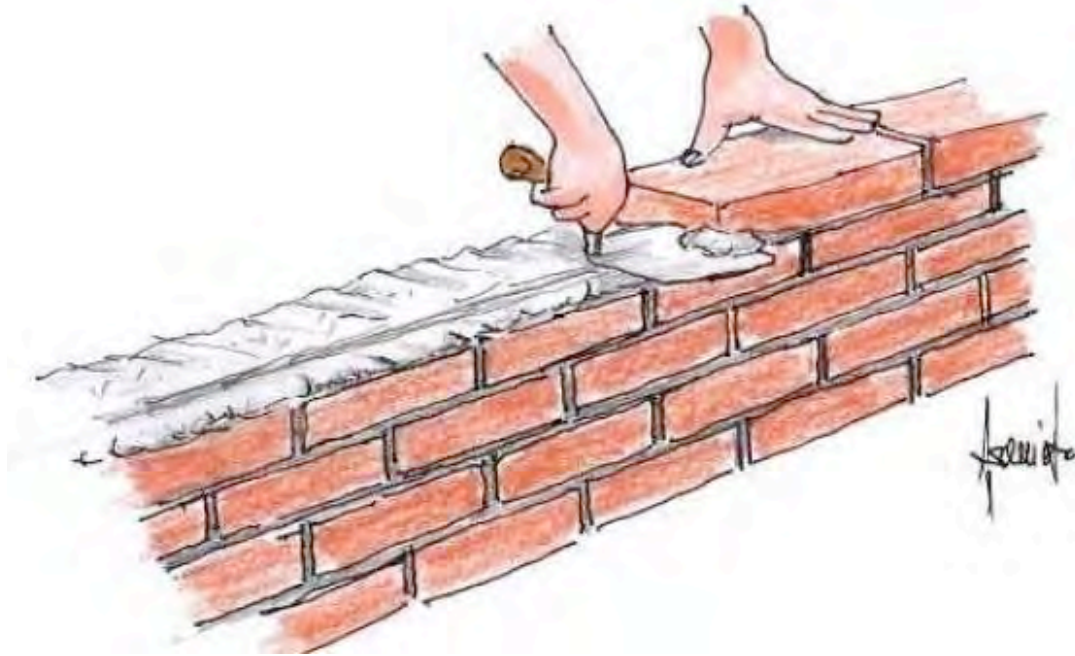
The Standard Model of particle physics

Years from concept to discovery



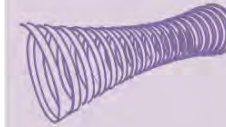
Source: *The Economist*

Forze o interazioni



MEDIATORI

gluone g



fotone γ



bosone W W^\pm



bosone Z Z





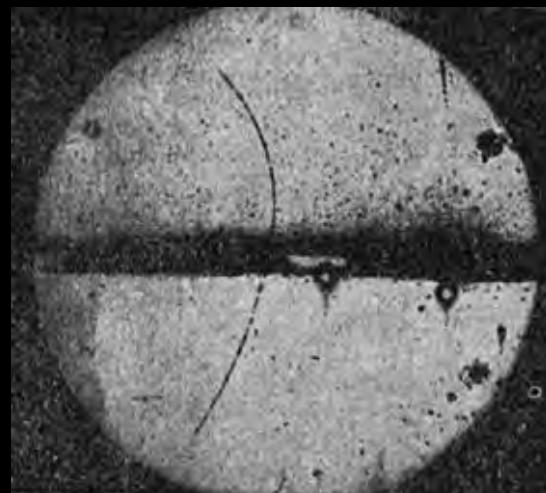
Dirac

Antimateria!

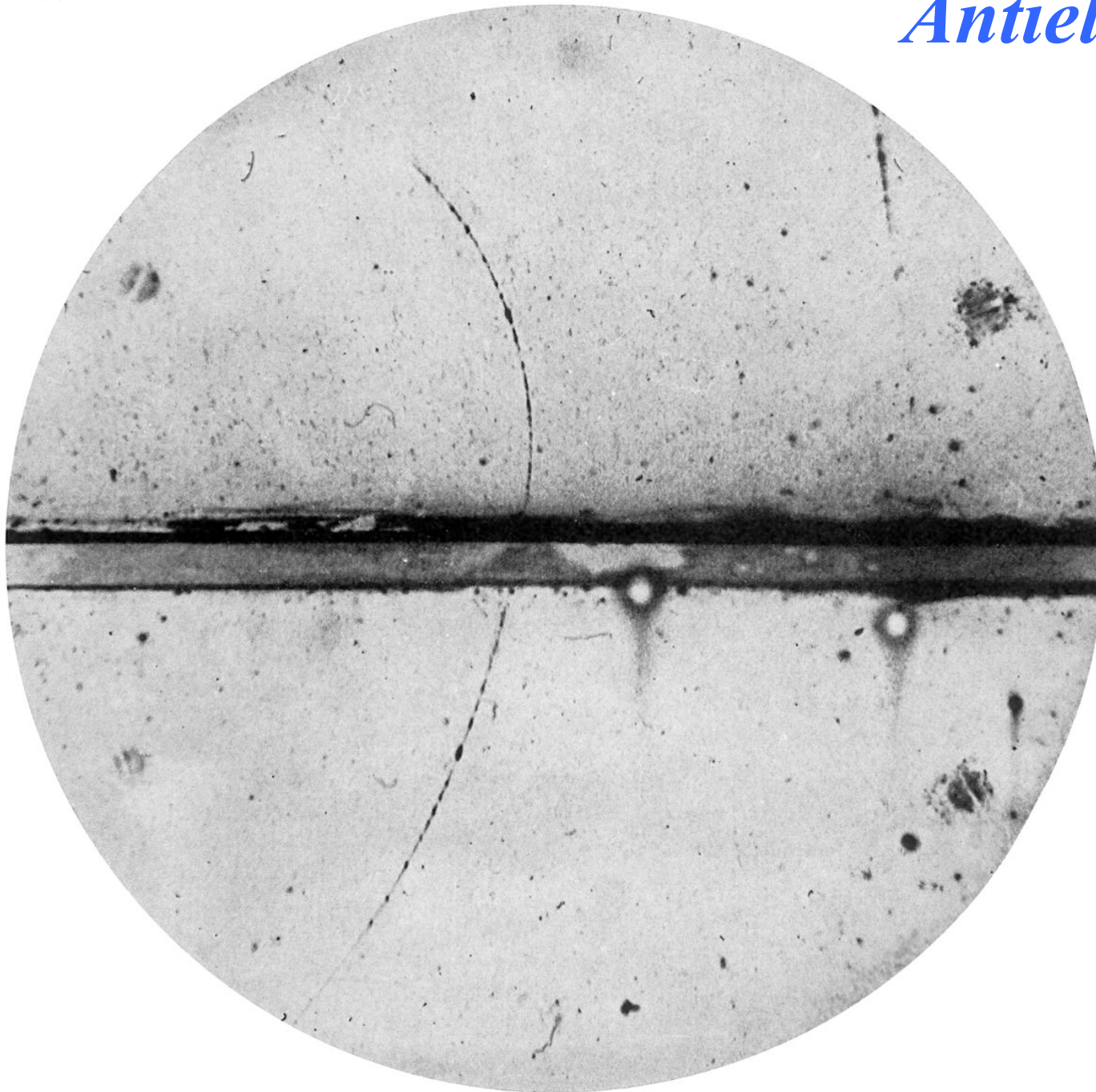


Anderson

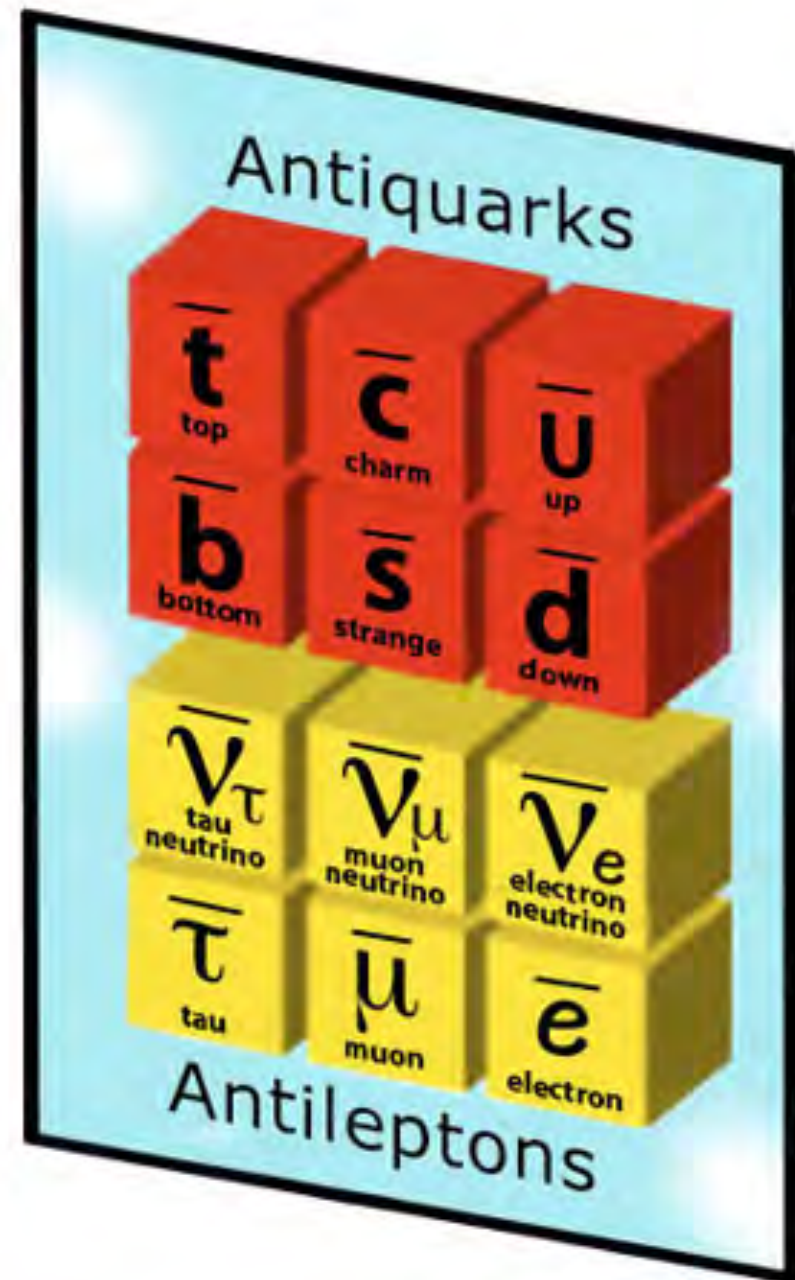
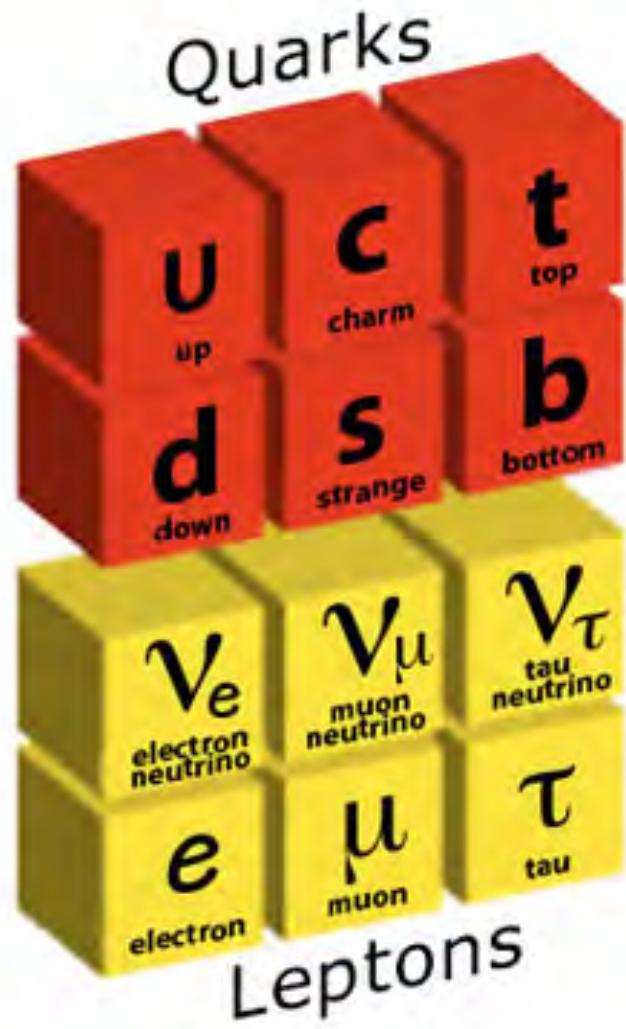
$$(i\gamma^\mu \partial_\mu - m)\psi = 0$$



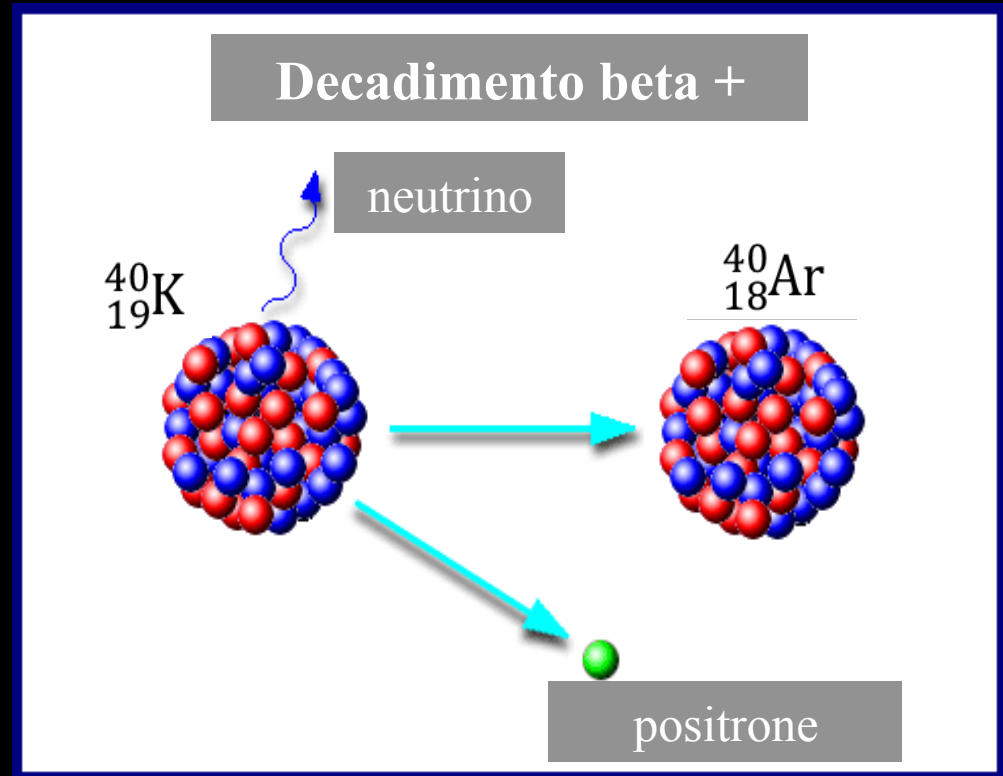
Antielettrone



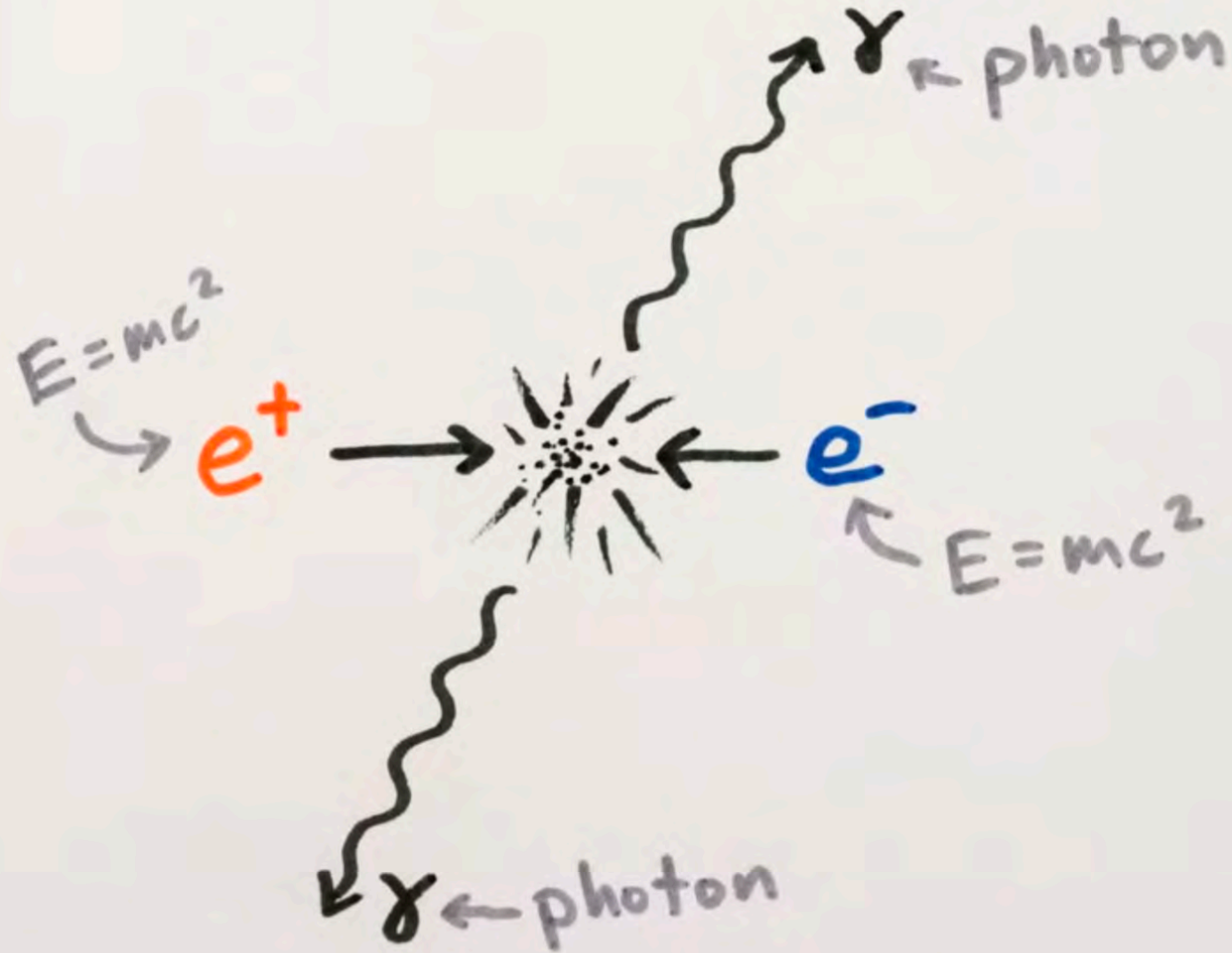
Antimateria



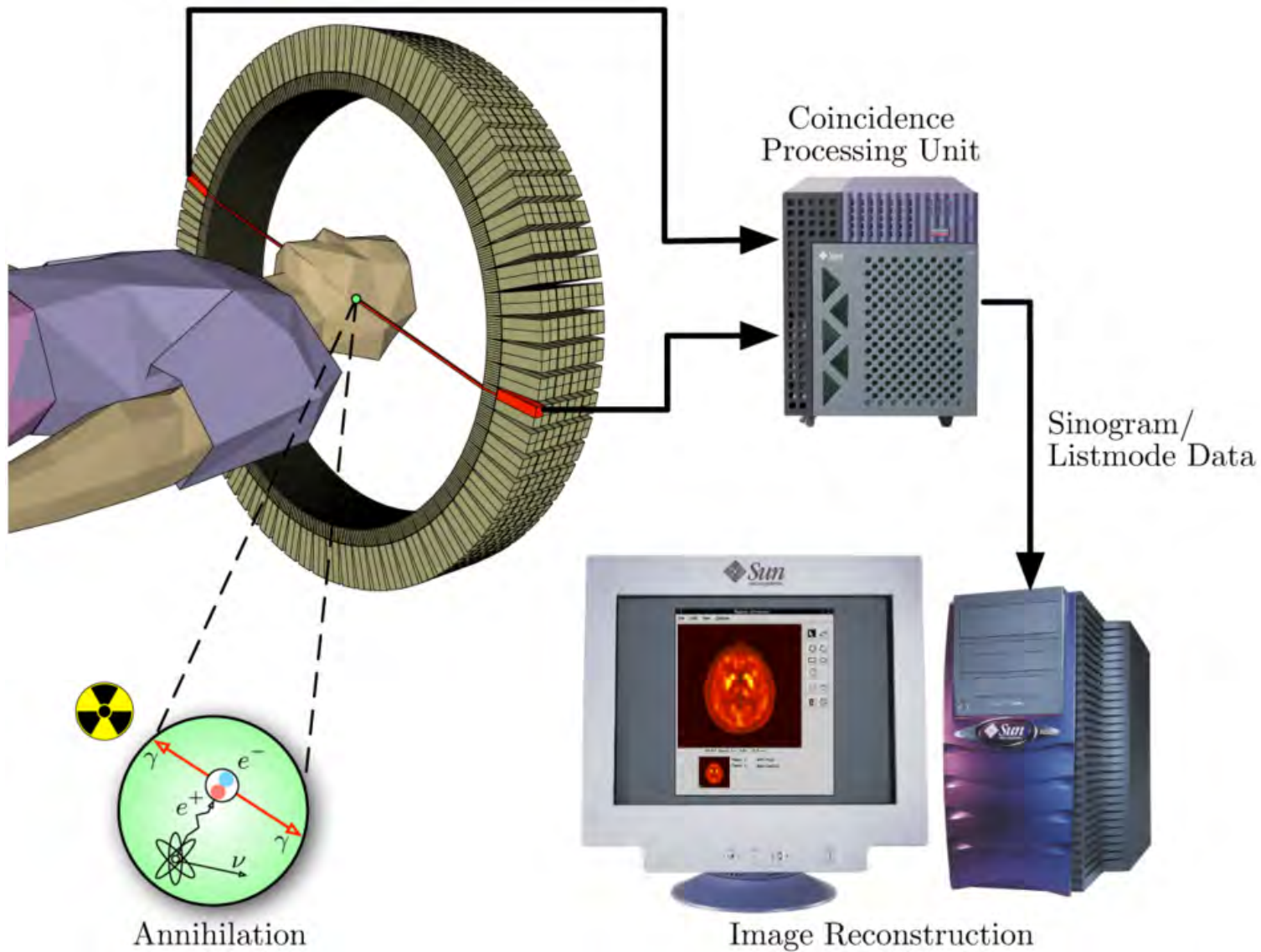
Antimateria



Materia e Antimateria

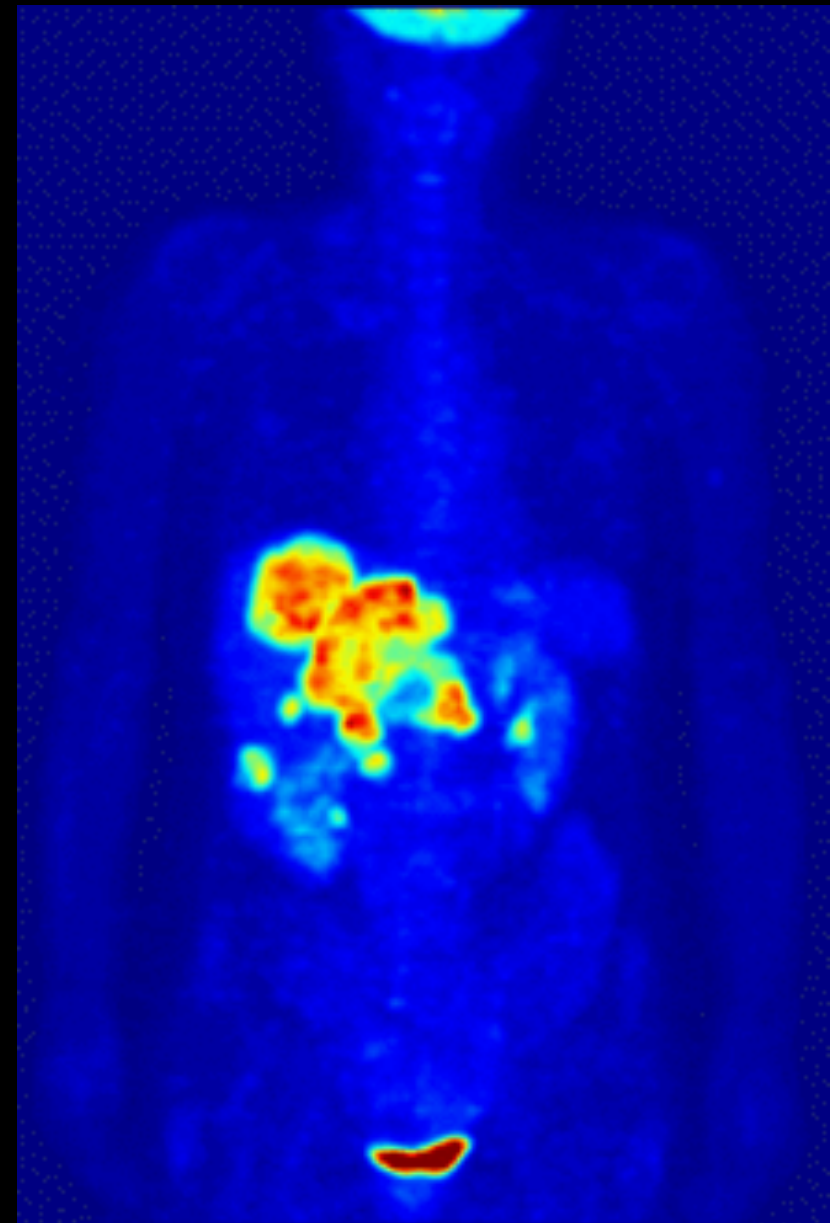
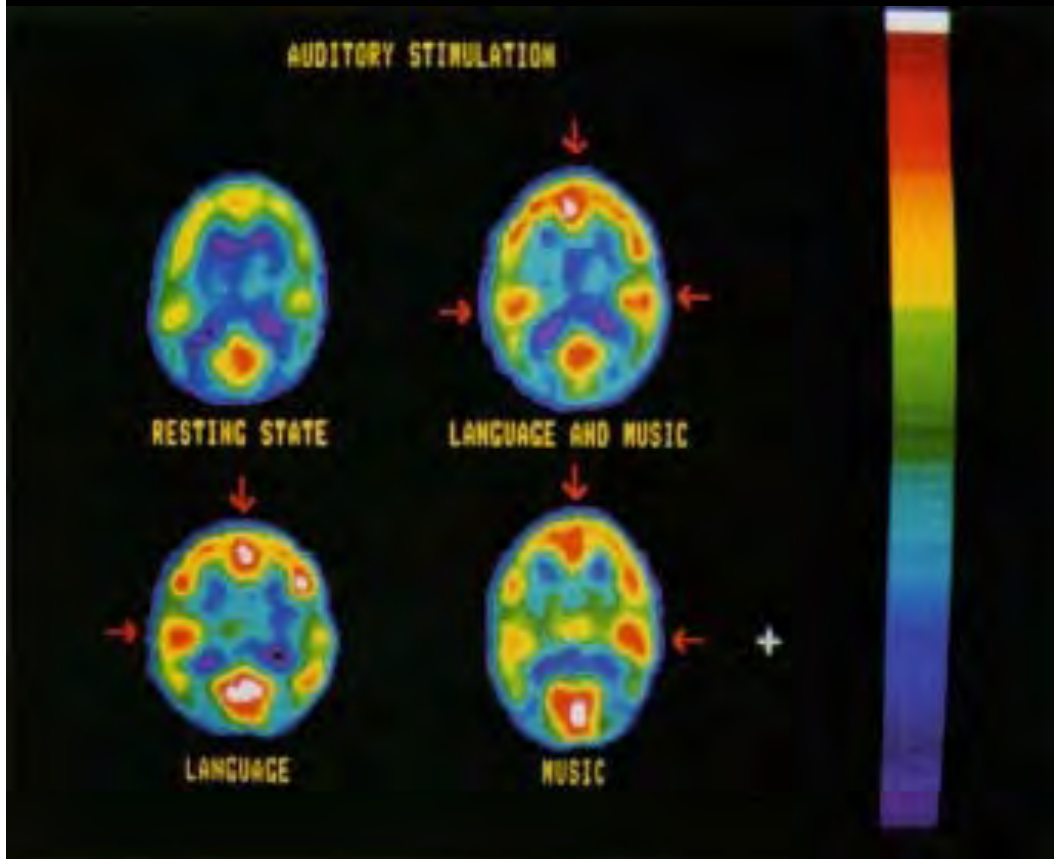


Positron Emission Tomography - PET



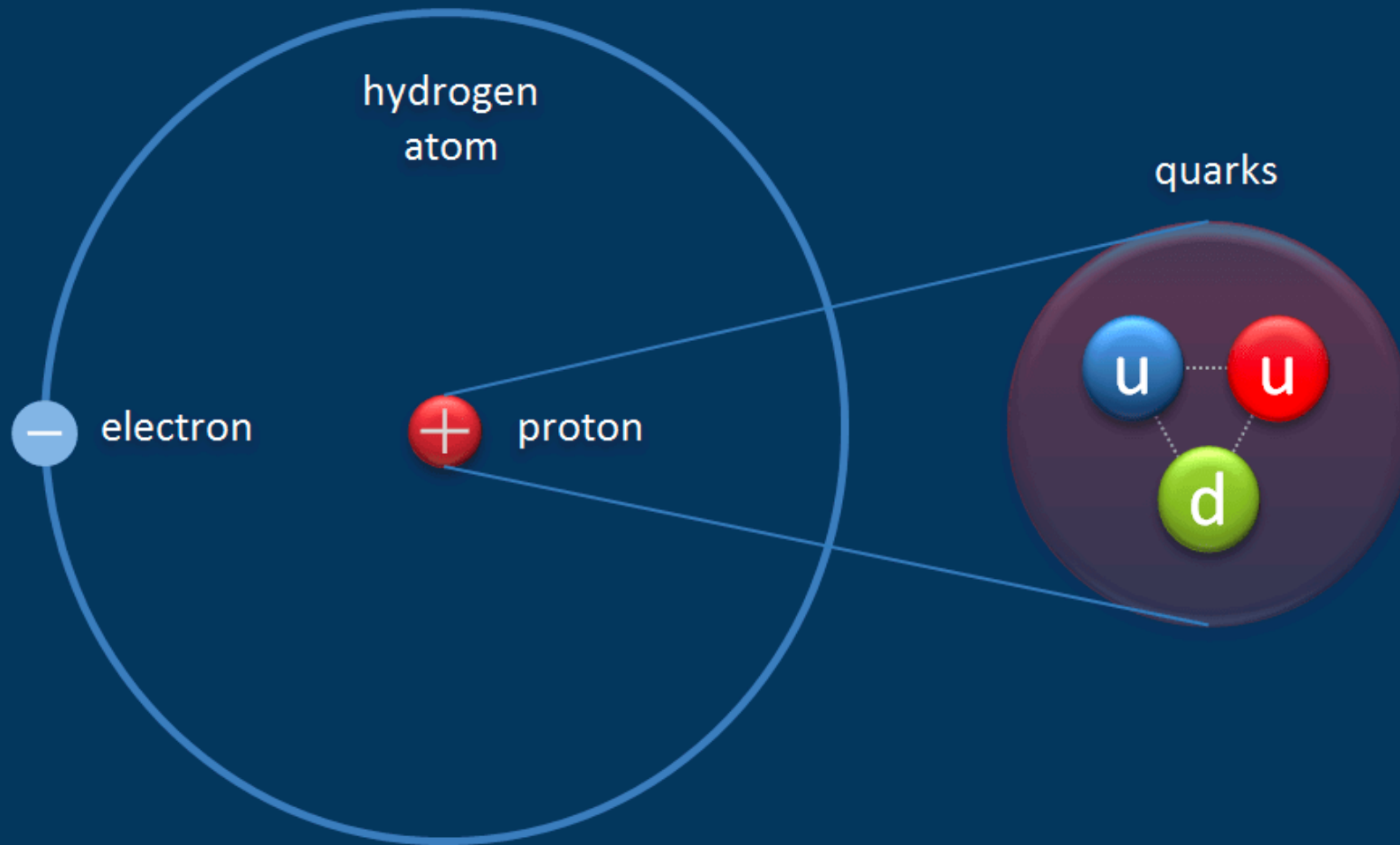
[By Jens Maus (<http://jens-maus.de/>) - own work - Public Domain, <https://commons.wikimedia.org/w/index.php?curid=4012521>]

Positron Emission Tomography - PET



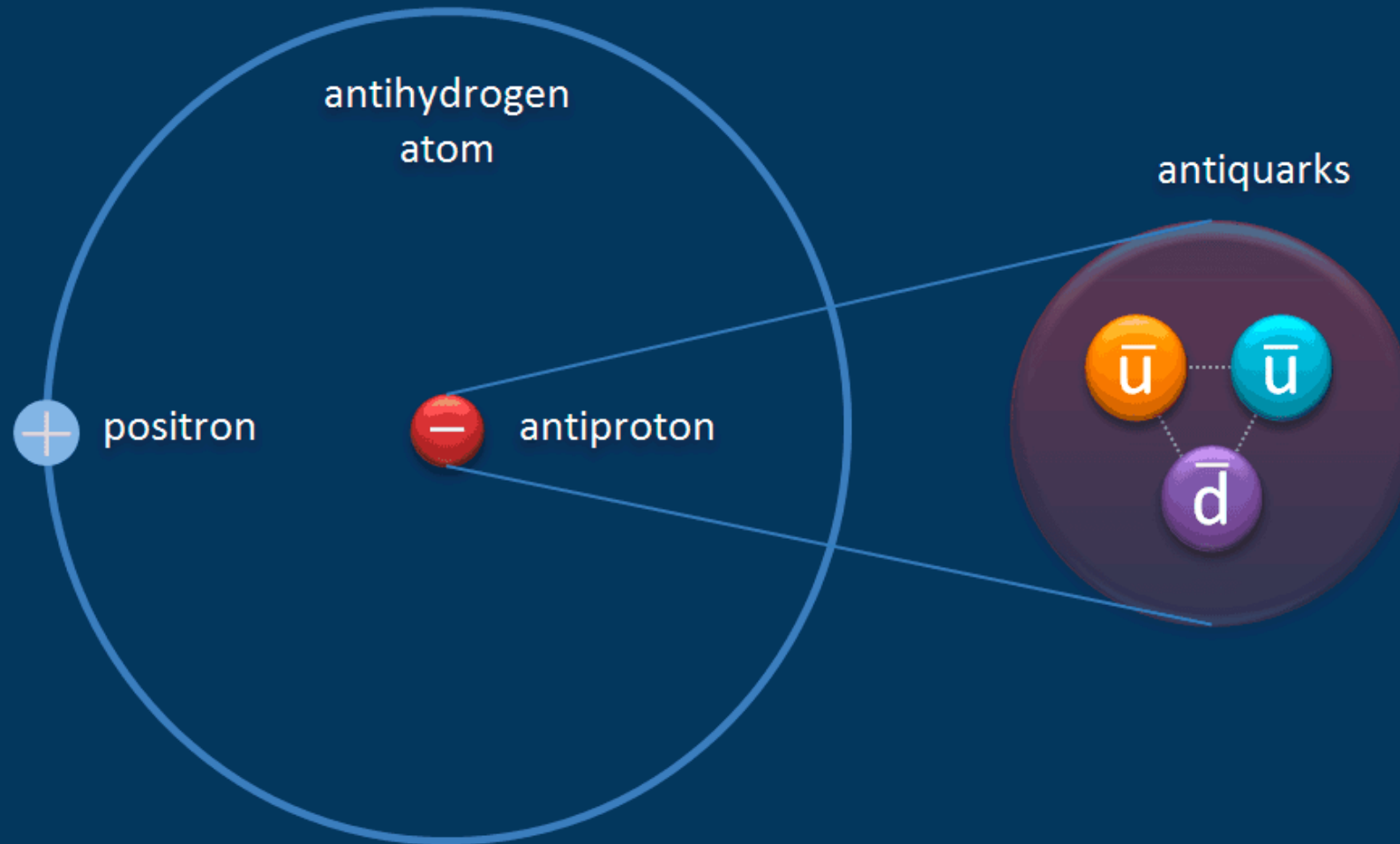
[Di Jens Maus (<http://jens-maus.de/>) - <https://commons.wikimedia.org/w/index.php?curid=801896>]

Matter



www.nuclear-power.net

Antimatter



www.nuclear-power.net

Big bang

[tempo]

$t = 0$



Materia e Antimateria

-1

-1

0

+1

+1



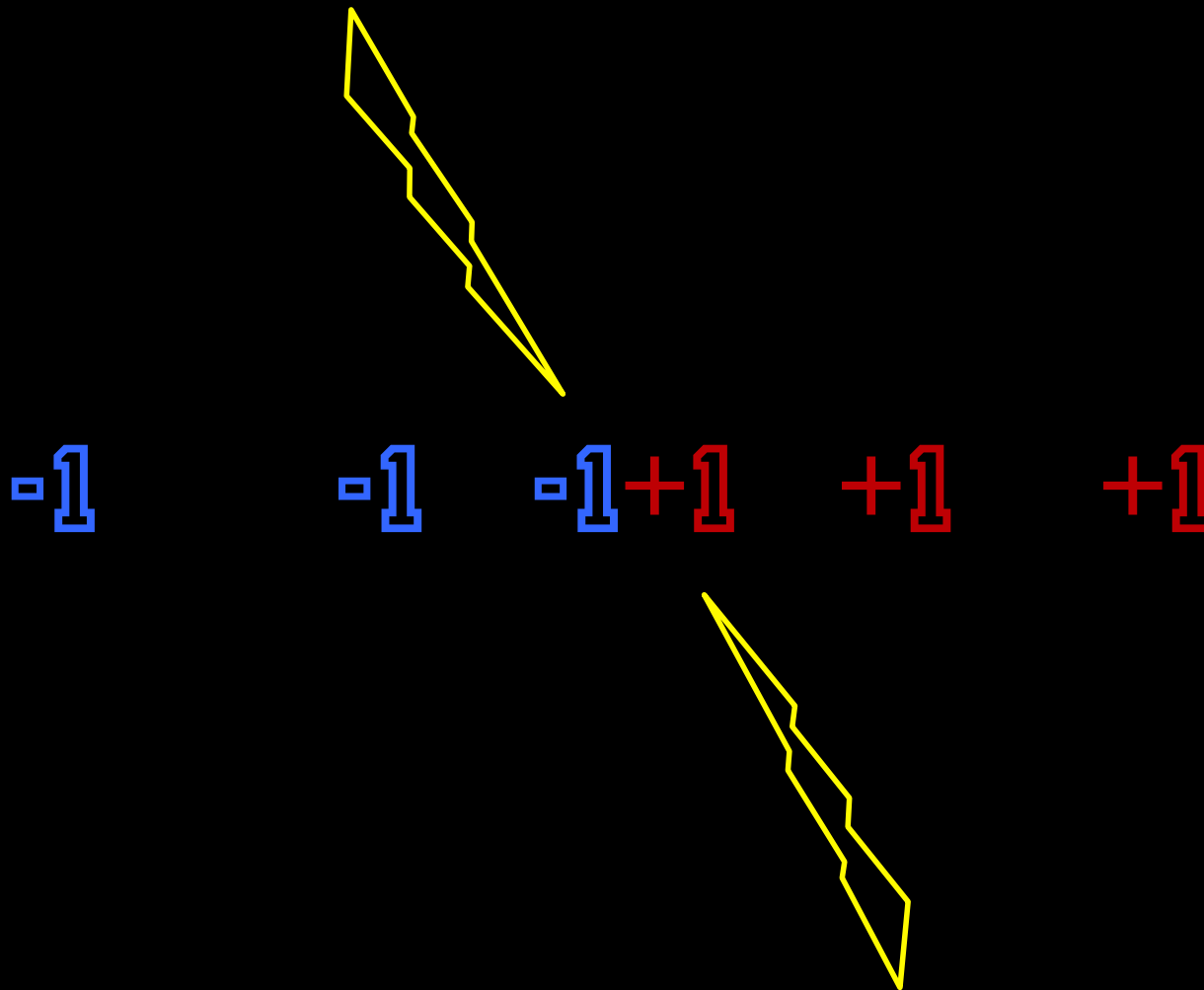
HUBBLE
SPACETELESCOPE.ORG

Hubble



- Barbara Sciascia (INFN/LNF) -

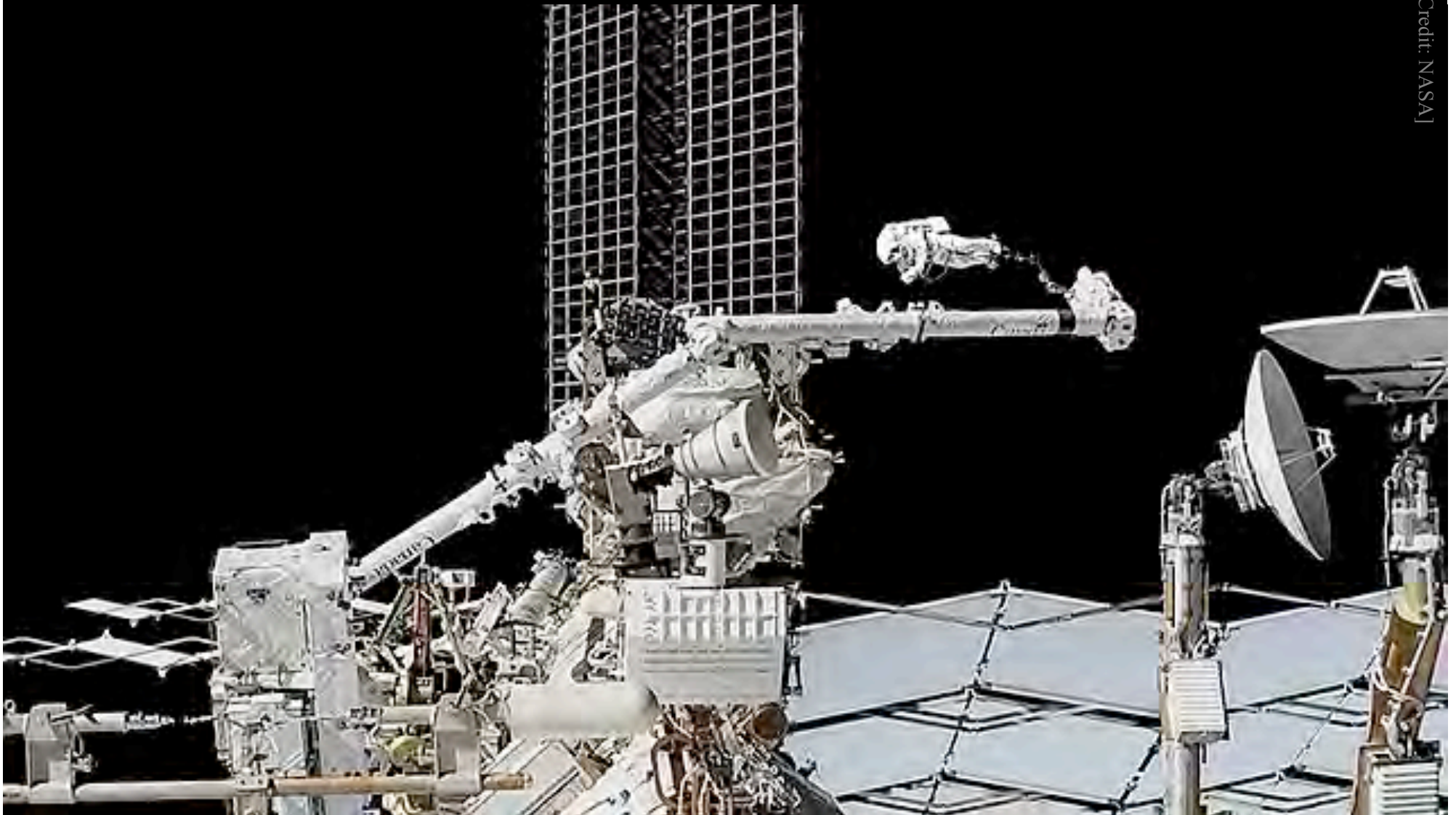
Materia e Antimateria



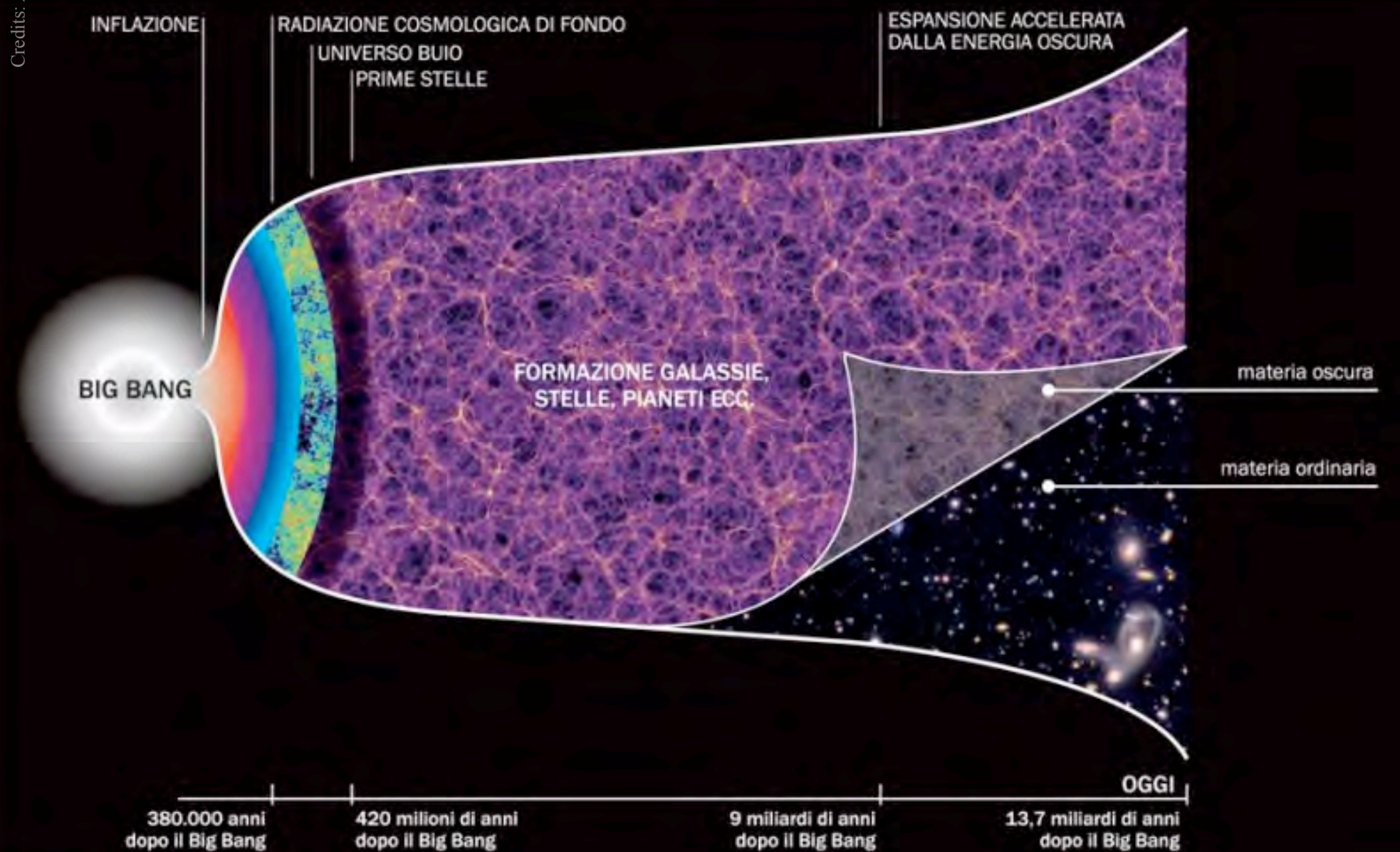
Antimateria primordiale







Modello Standard Cosmologico



Materia e Antimateria

10 000 000 001

10 000 000 000

Materia

Antimateria

Credits: Hitoshi Murayama

Materia e Antimateria

1

Noi

Credits: Hitoshi Murayama

Andrei Sakharov

[Christian Hirou/Gamma-Rapho, via Getty Images]



Le condizioni di Sakharov

[proposte nel 1967]



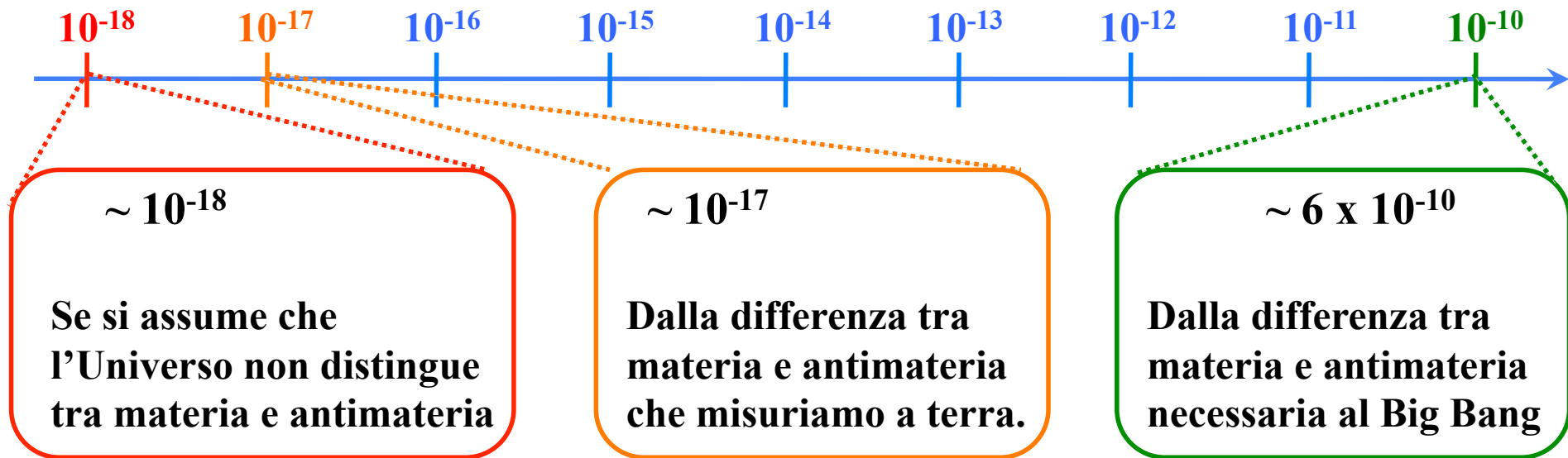
Necessary for evolution of matter-dominated universe, from symmetric state

(1) baryon number violation

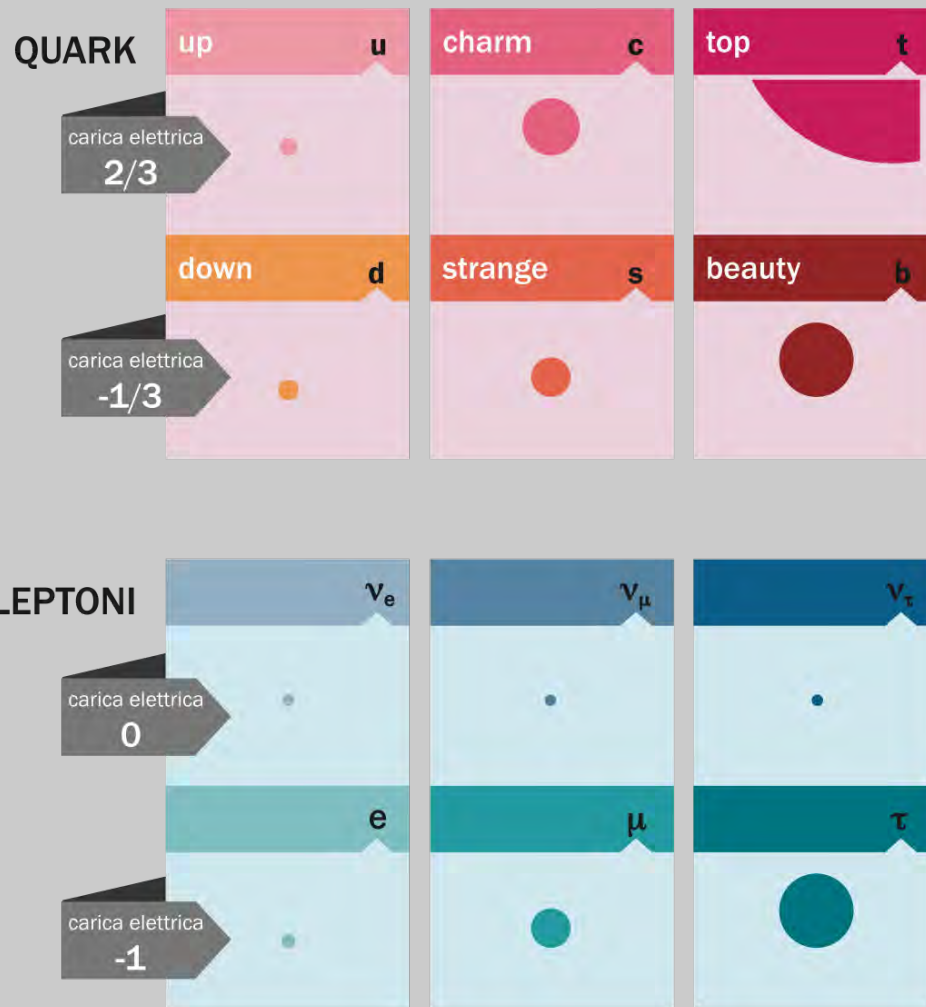
(2) C and CP violation

(3) thermal inequilibrium

“Deve esserci una differenza tra materia e antimateria”

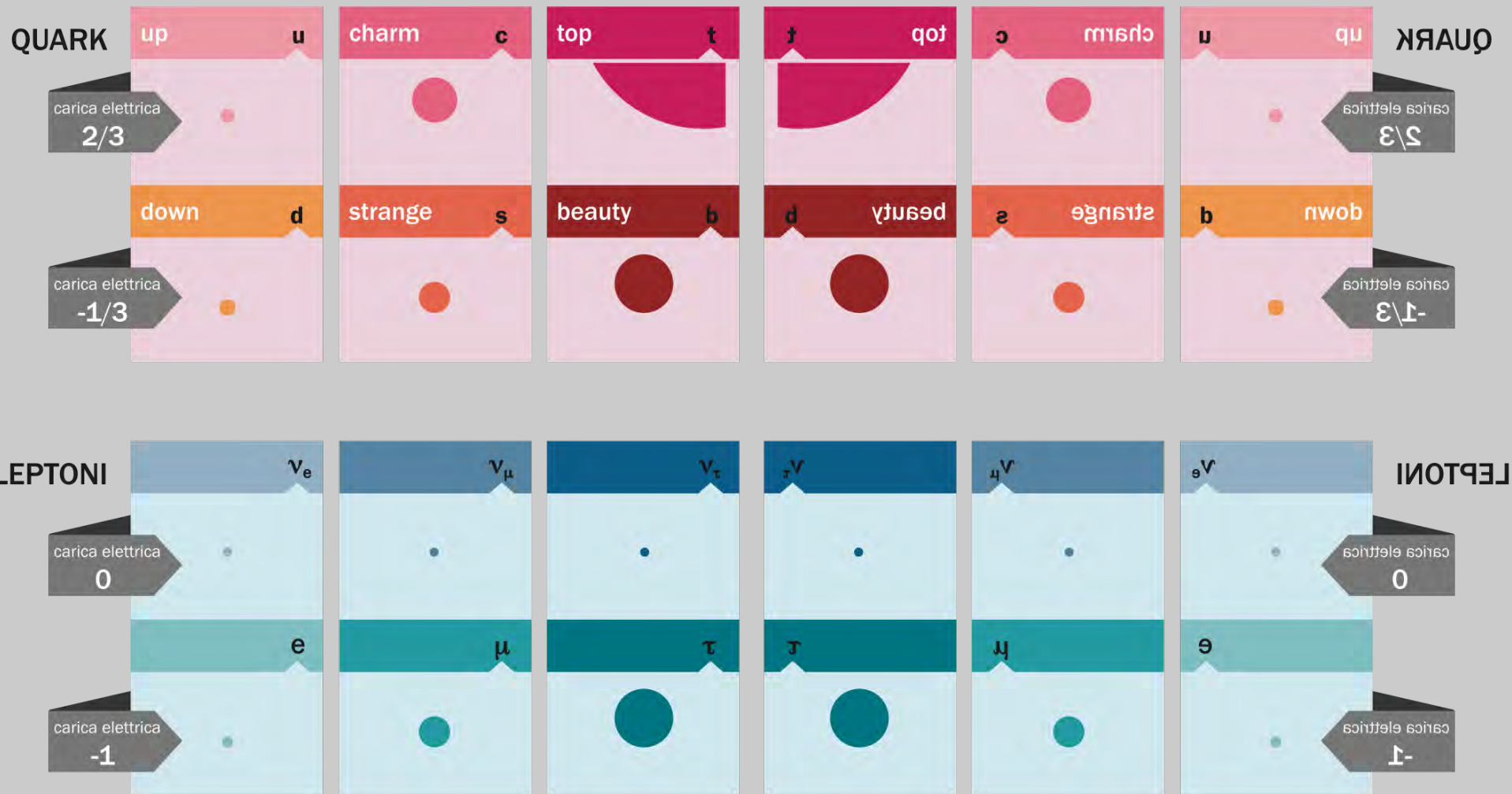


Differenza tra materia e antimateria



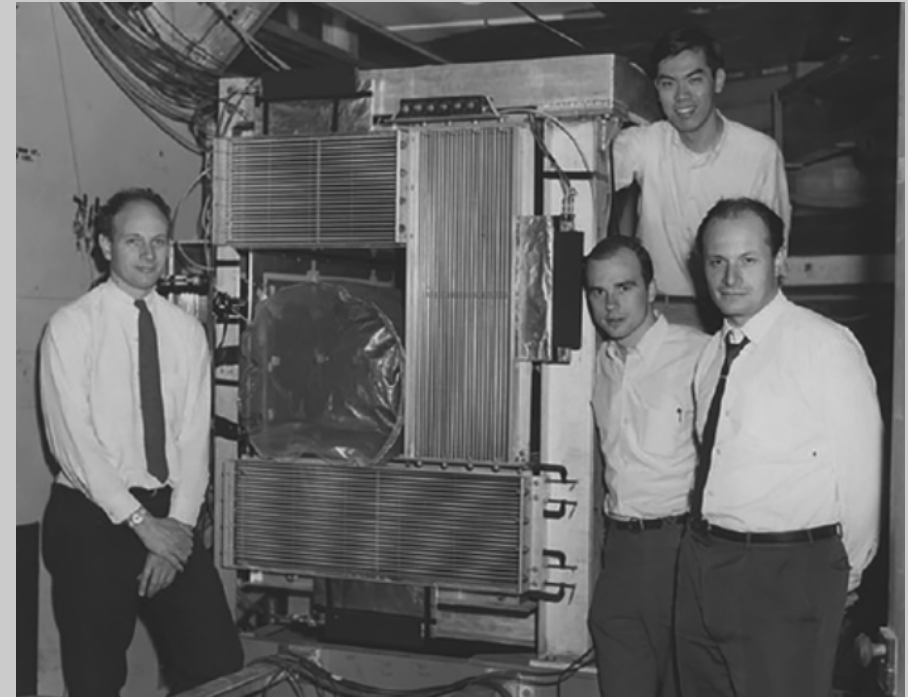
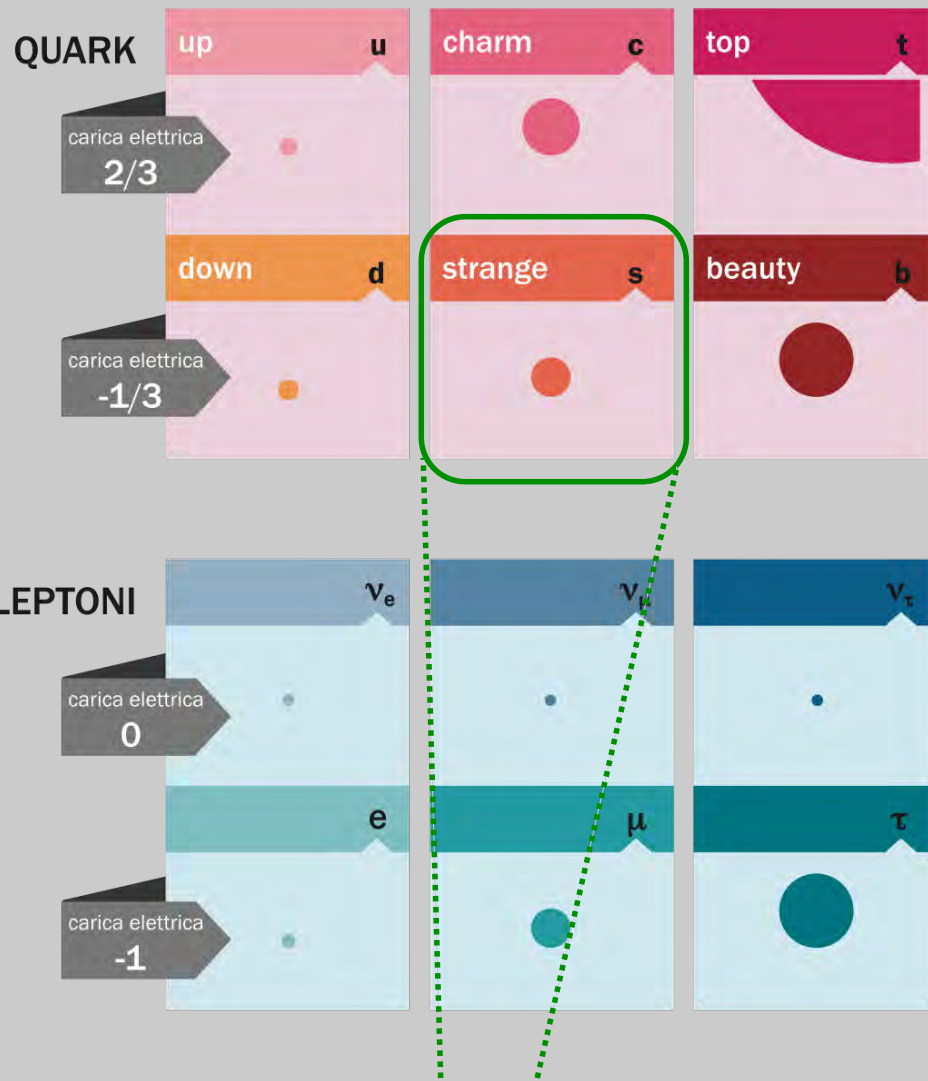
Credits: Asimmetrie

Differenza tra materia e antimateria



Credits: Asimmetrie

Differenza tra materia e antimateria



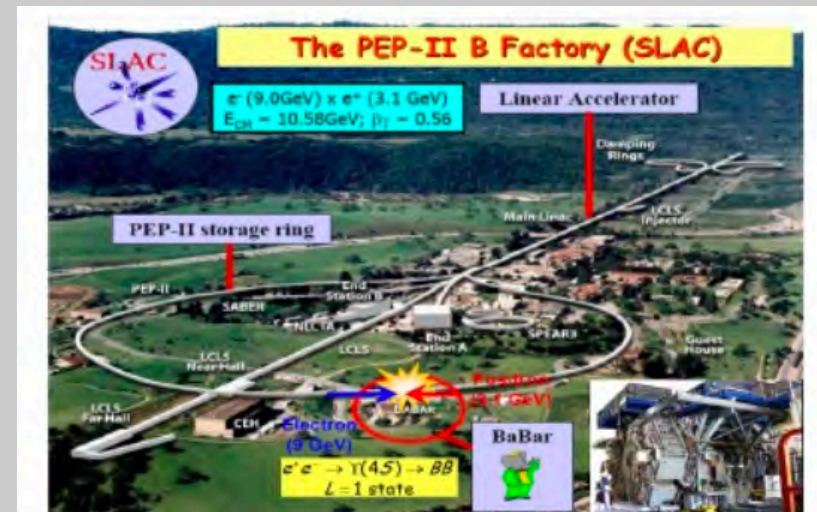
[J. Cronin et al., Phys. Rev. Lett. 13, 138]

1964

Differenza tra materia e antimateria

QUARK	up u	charm c	top t
carica elettrica 2/3			
carica elettrica -1/3	down d	strange s	beauty b

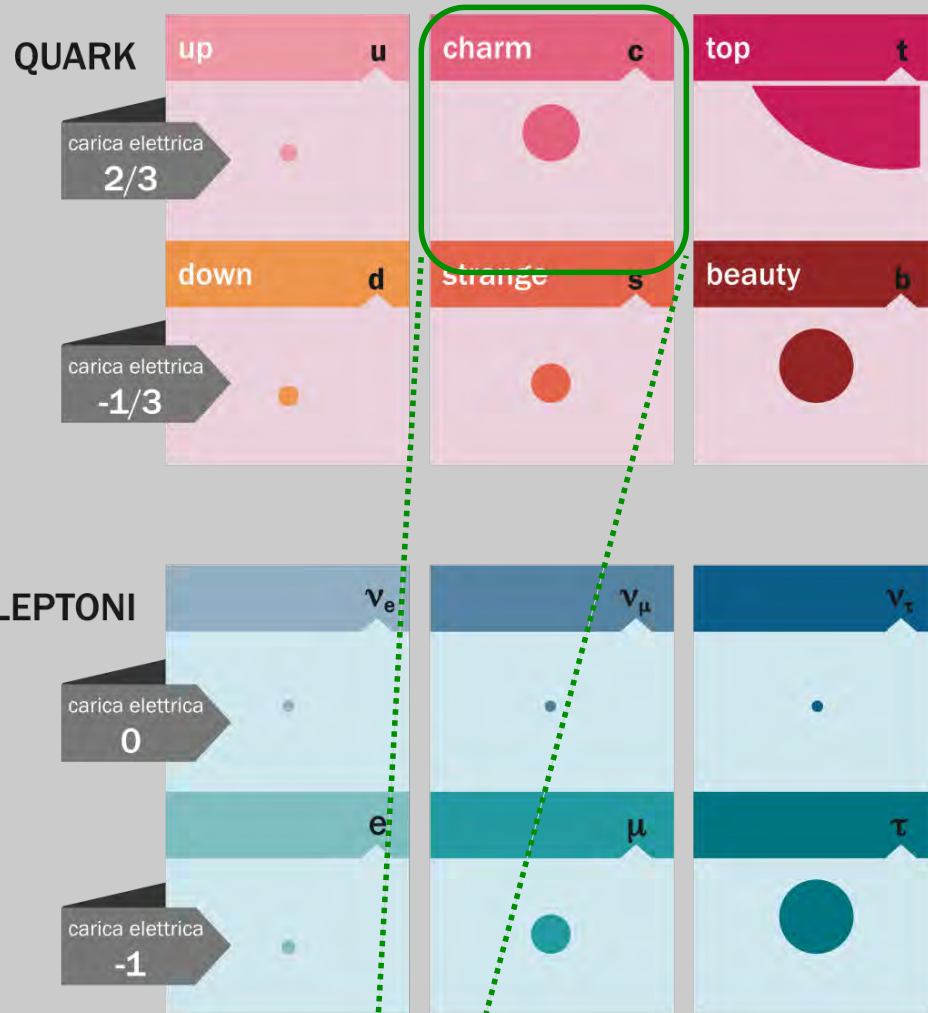
LEPTONI	ν_e	ν_μ	ν_τ
carica elettrica 0			
carica elettrica -1	e	μ	τ



2001

Credits: Asimmetrie

Differenza tra materia e antimateria



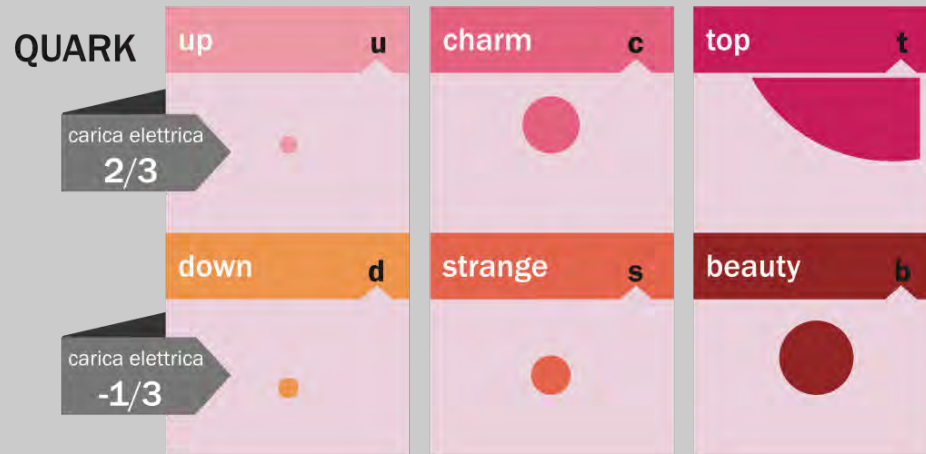
[Credits: Maximilien Brice et al./CERN]

Credits: Asimmetrie

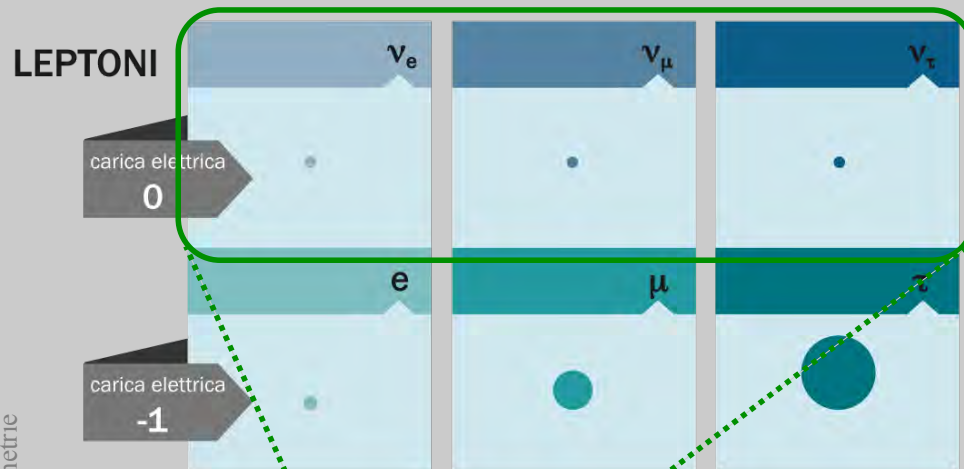
2019

Differenza tra materia e antimateria

[Enrico Sacchetti/Science Source]



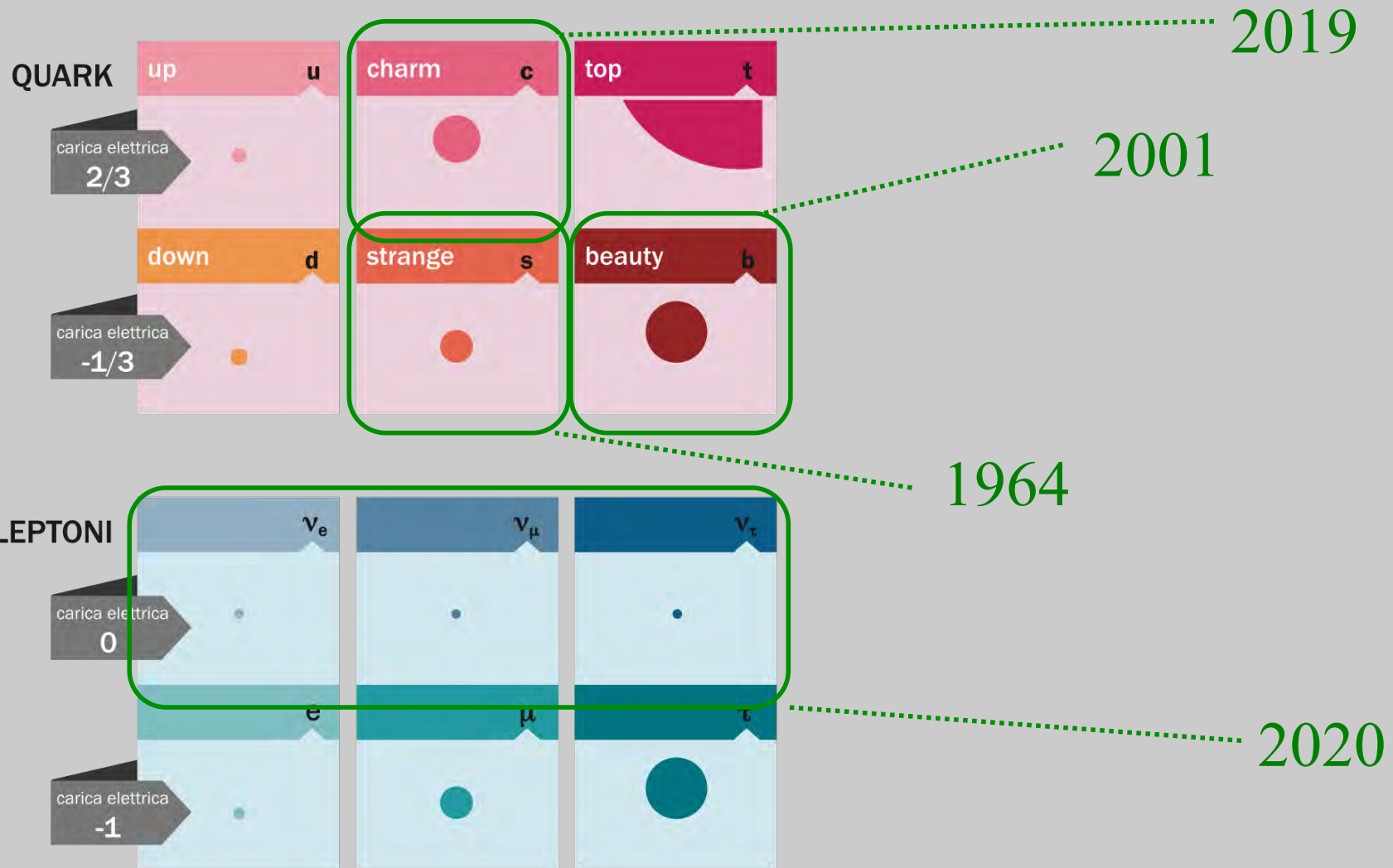
スーパーカミオカンデ
Super-Kamiokande

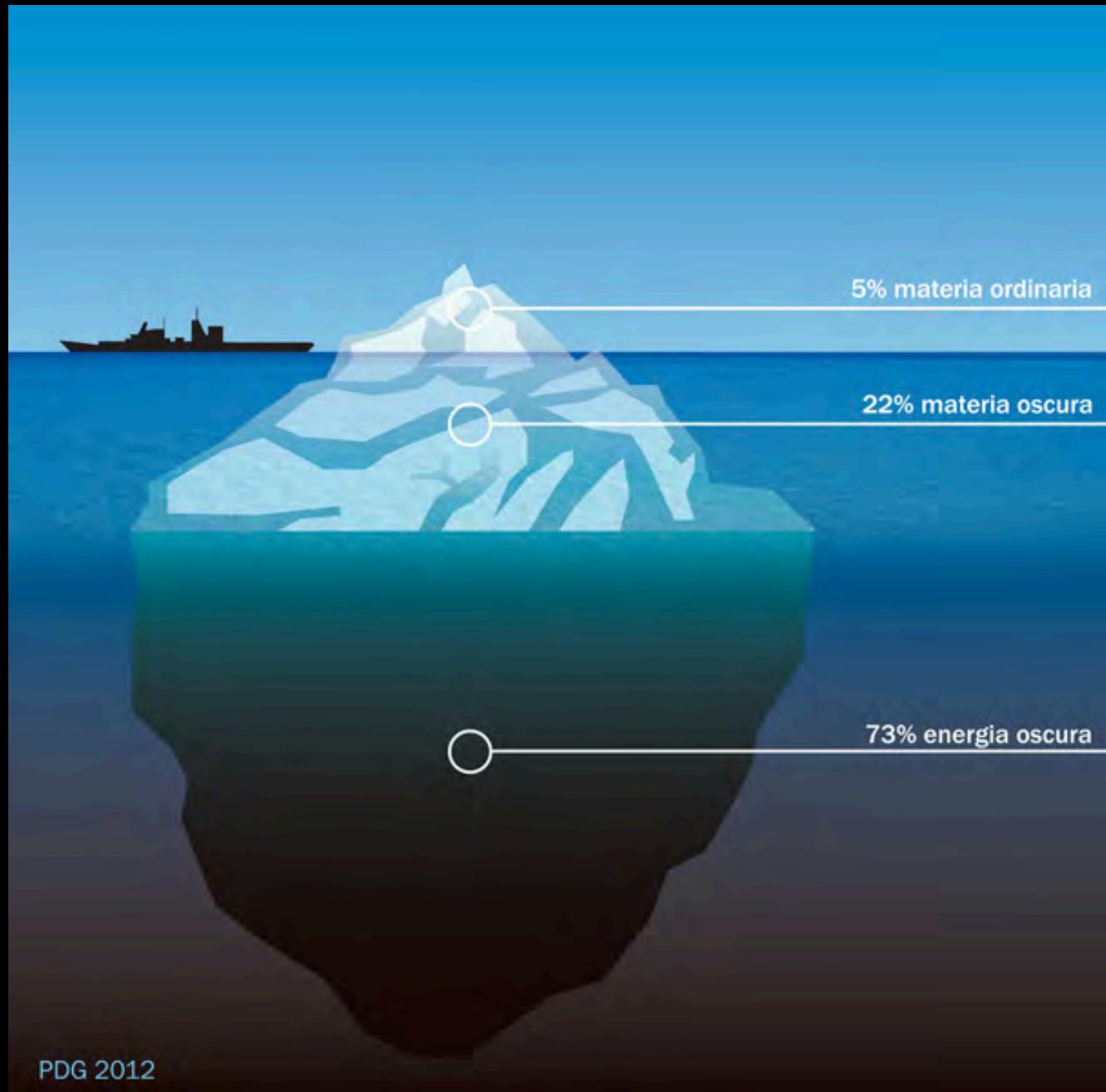


2020

Credits: Asimmetrie

Differenza tra materia e antimateria





PDG 2012

[PDG 2018:
Materia ordinaria 4.84%
Materia oscura 25.8%
Energia oscura 69.2%]

Approfondimenti:

- Libro “Antimateria” di Frank Close, Einaudi
- Dall’ASI: https://www.youtube.com/watch?v=rDlP_2pHVOA
- Dall’INFN: <https://www.youtube.com/watch?v=rusI4r2OoRo>

Ringraziamenti: alle professoresse Amalia Contessini e Fabiana Di Pasquale e agli alunni delle classi III [AS 2018/2019 e 2019/2020] della scuola media D. Bramante, IC S. Pio V, Roma, per i tanti spunti e suggerimenti per raccontare meglio la scienza difficile.

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