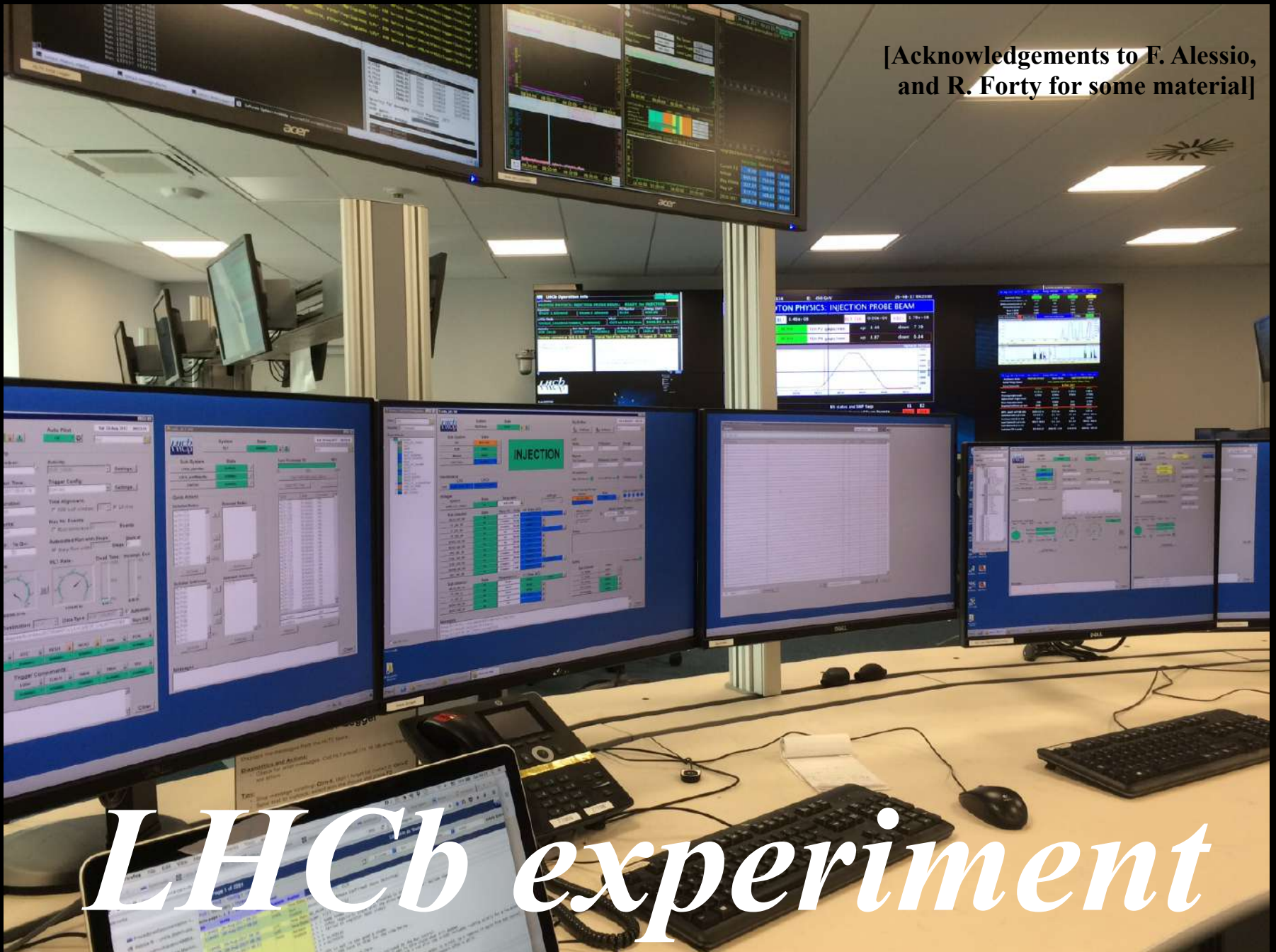


[Acknowledgements to F. Alessio,
and R. Forty for some material]



LHCb experiment



LHCb is an experiment set up to explore what happened after the Big Bang that allowed matter to survive and build the Universe we inhabit today. Fourteen billion years ago, the Universe began with a bang. Crammed within an infinitely small space, energy coalesced to form equal quantities of matter and antimatter. But as the Universe cooled and expanded, its composition changed. Just one second after the Big Bang, antimatter had all but disappeared, leaving matter to form everything that we see around us — from the stars and galaxies, to the Earth and all life that it supports.



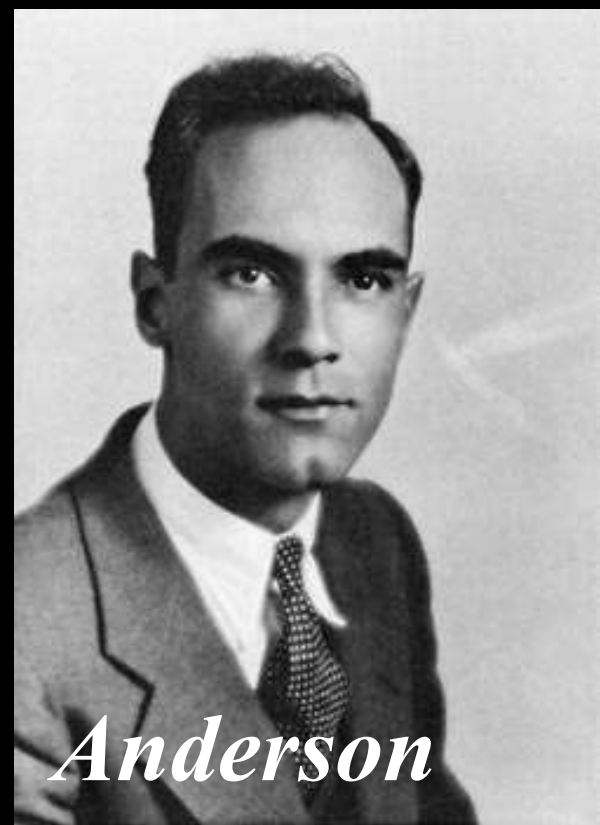
[<https://lhcb-outreach.web.cern.ch/>]

Antimateria!

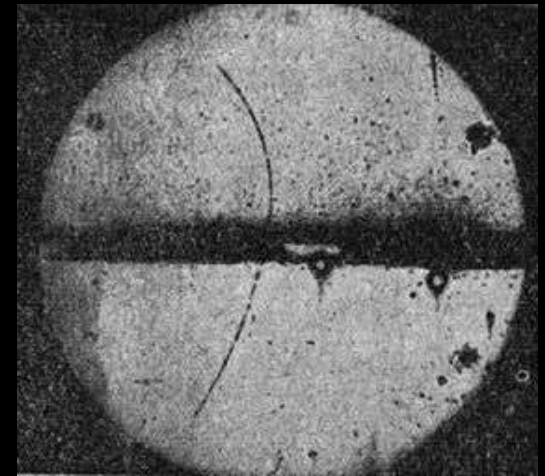


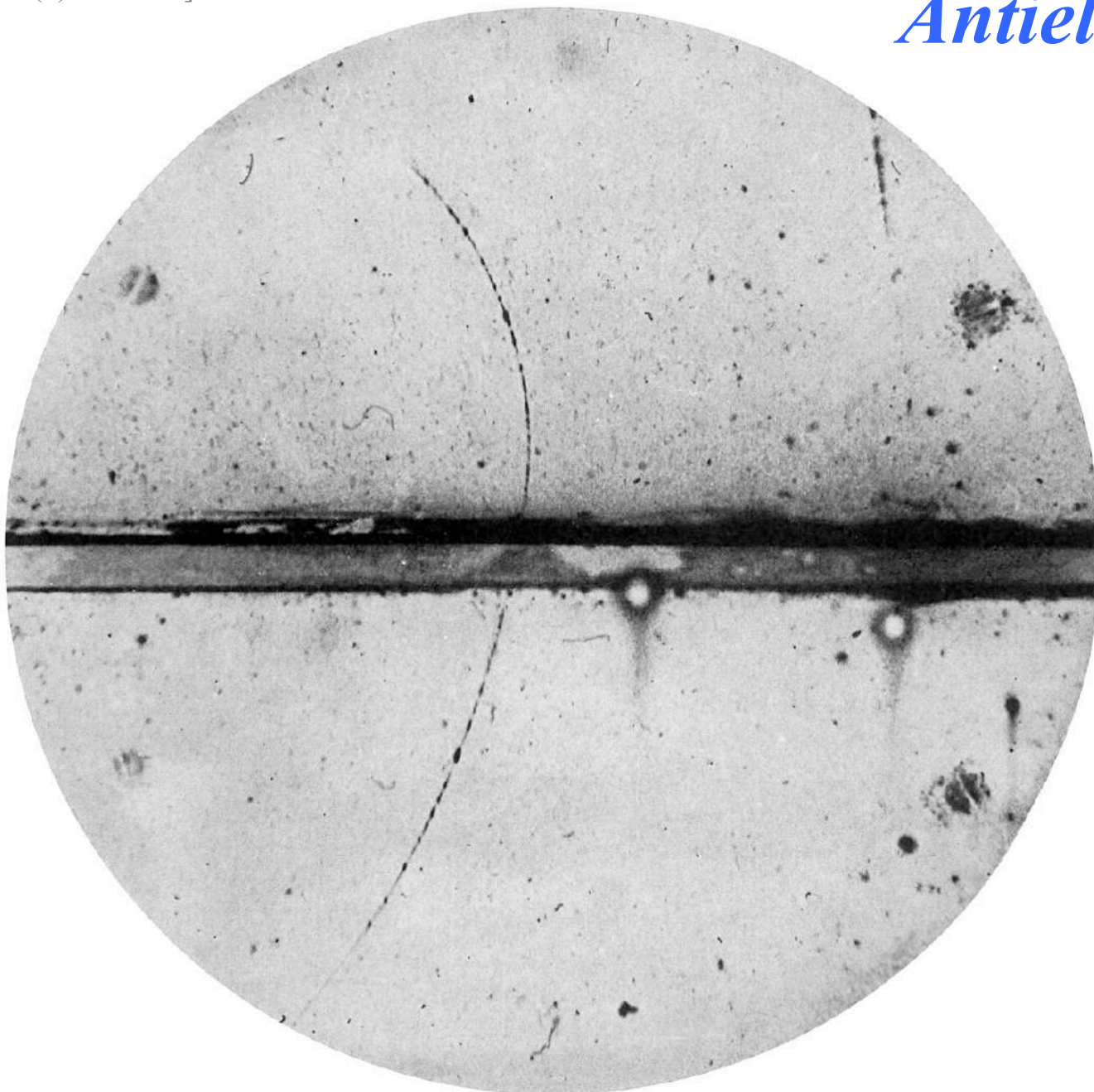
Dirac

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



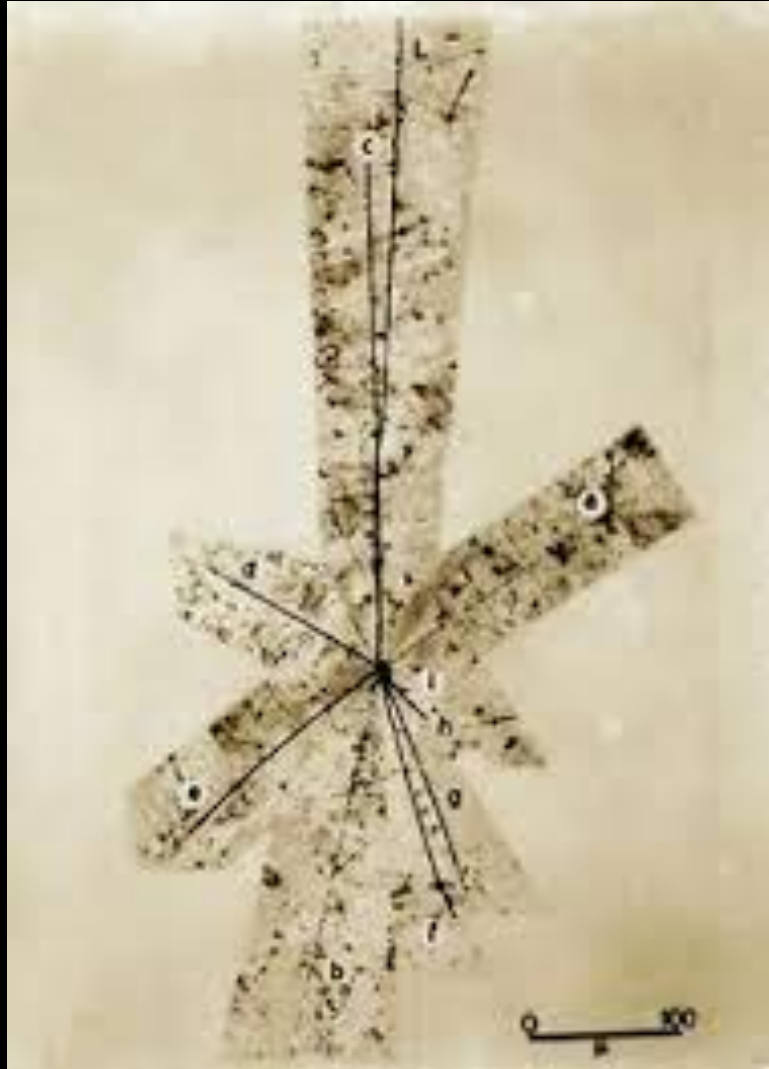
Anderson



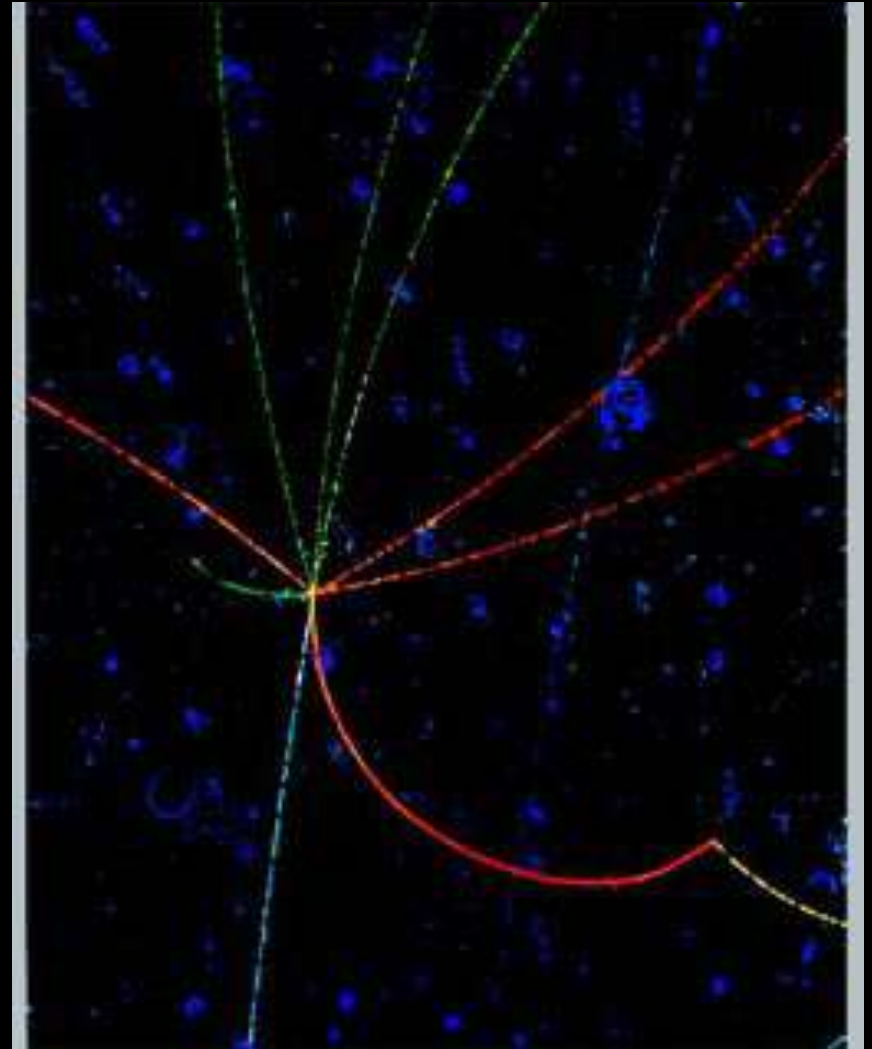


Antiproton

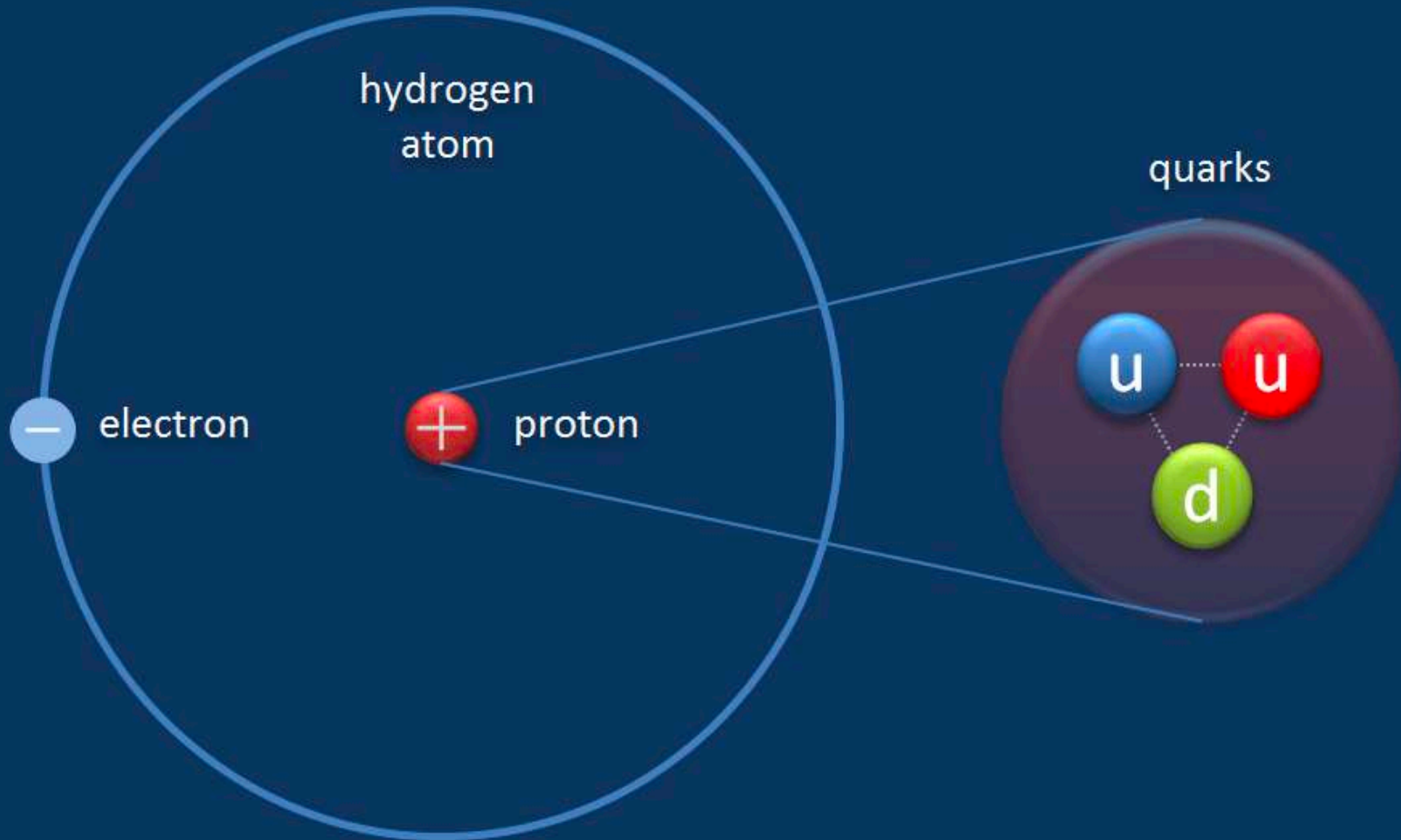
Bubble-chamber



Photographic -emulsion

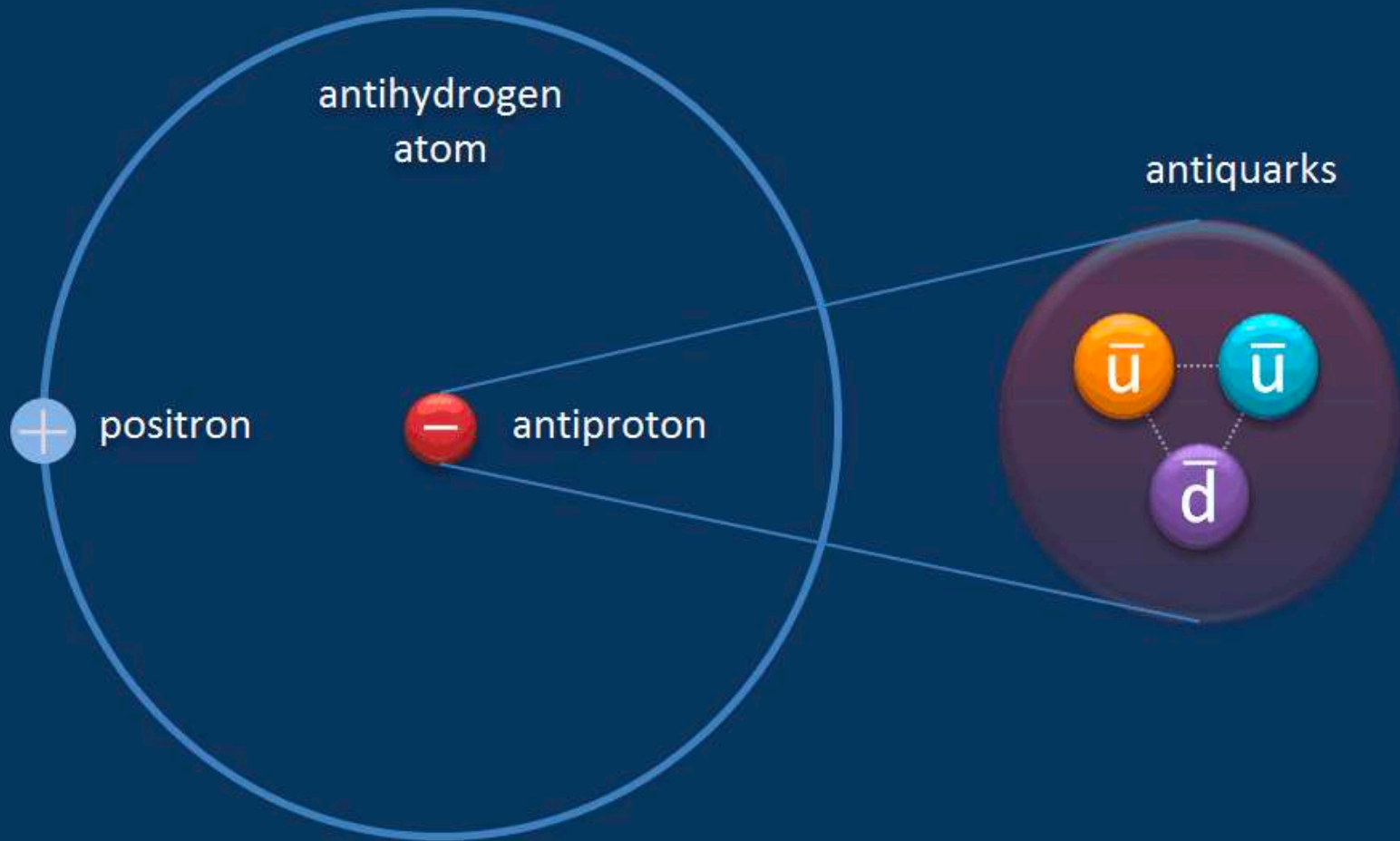


Matter



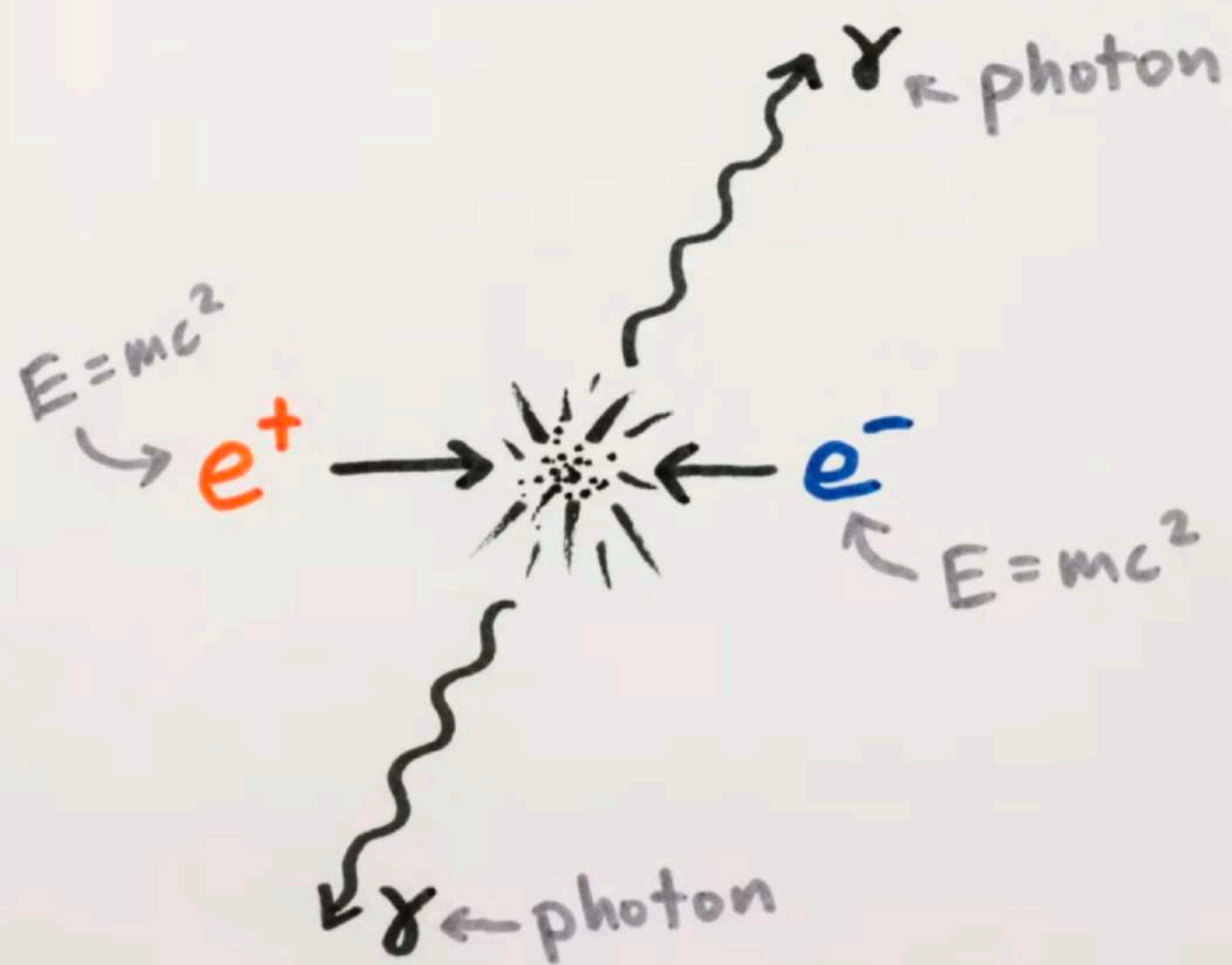
www.nuclear-power.net

Antimatter

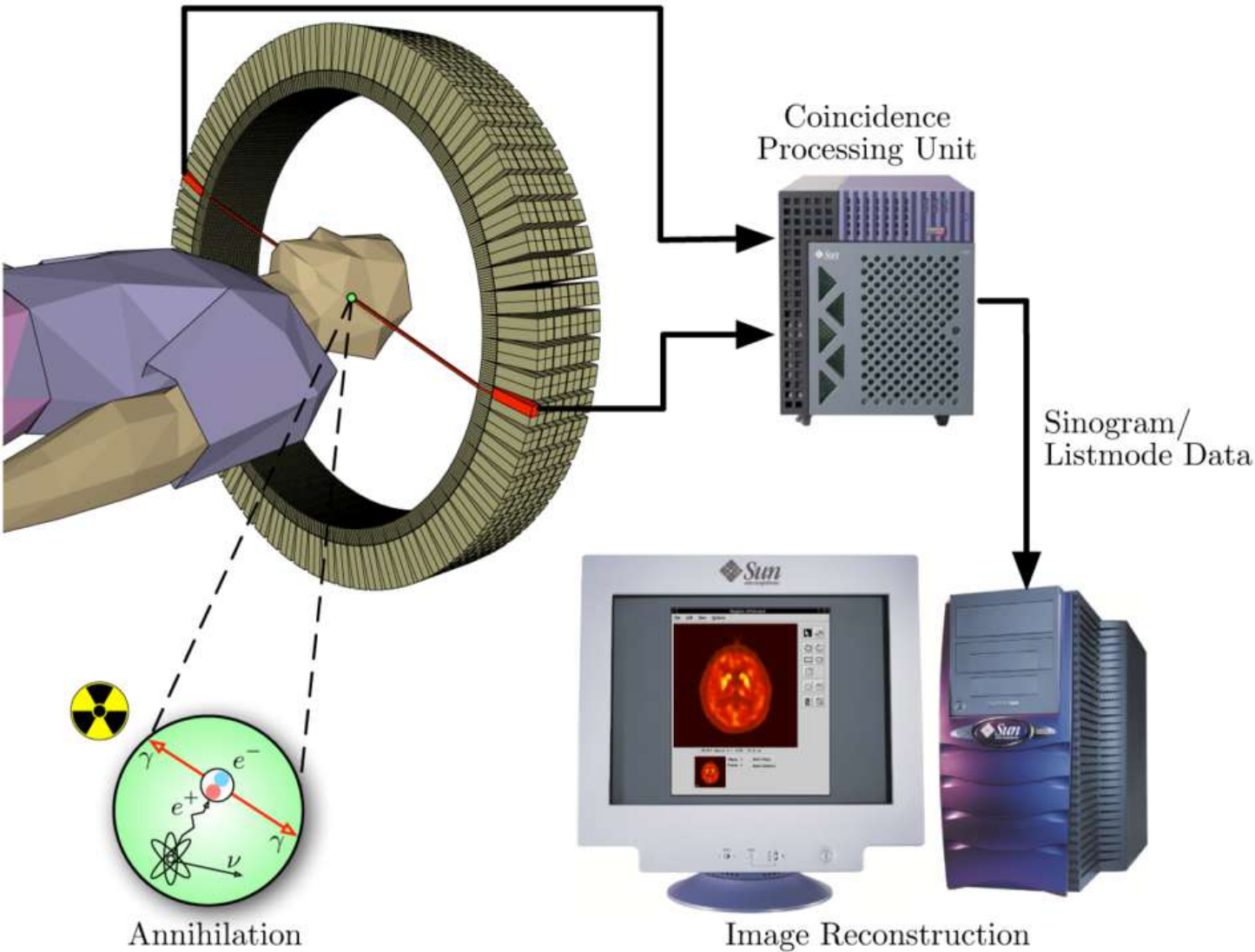


www.nuclear-power.net

Materia e Antimateria

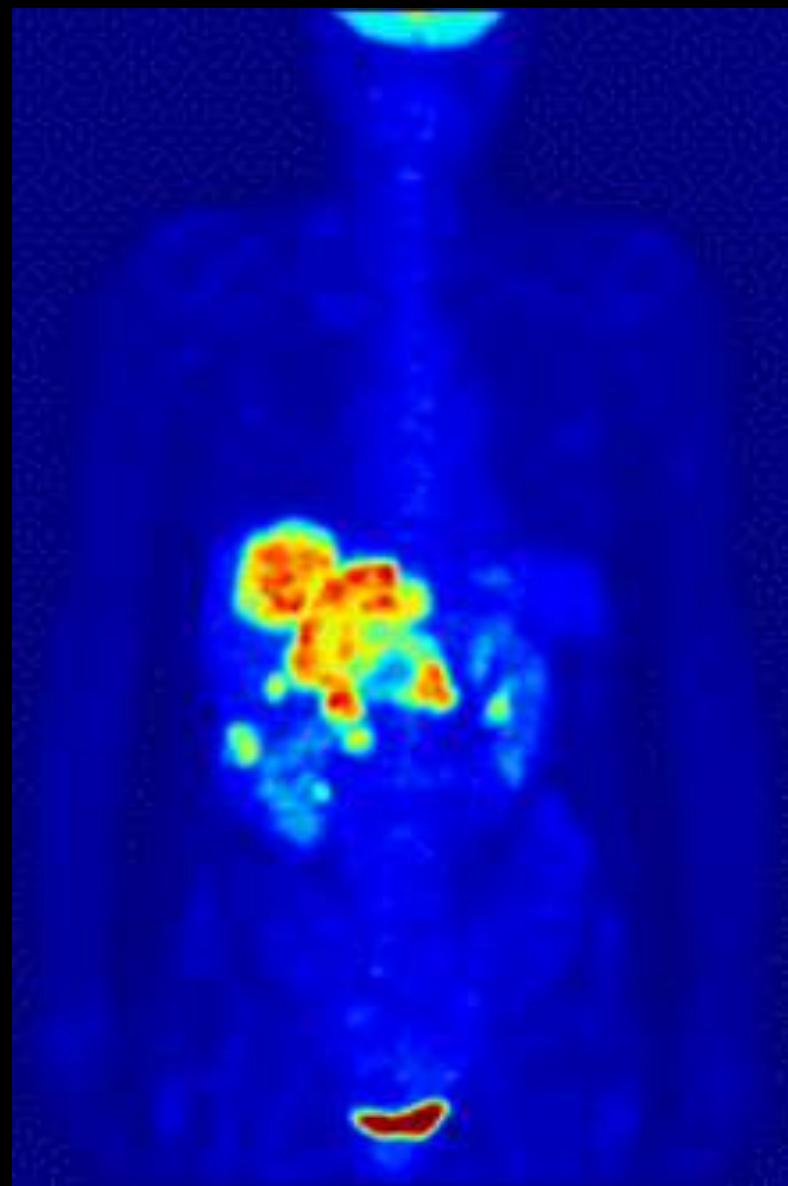
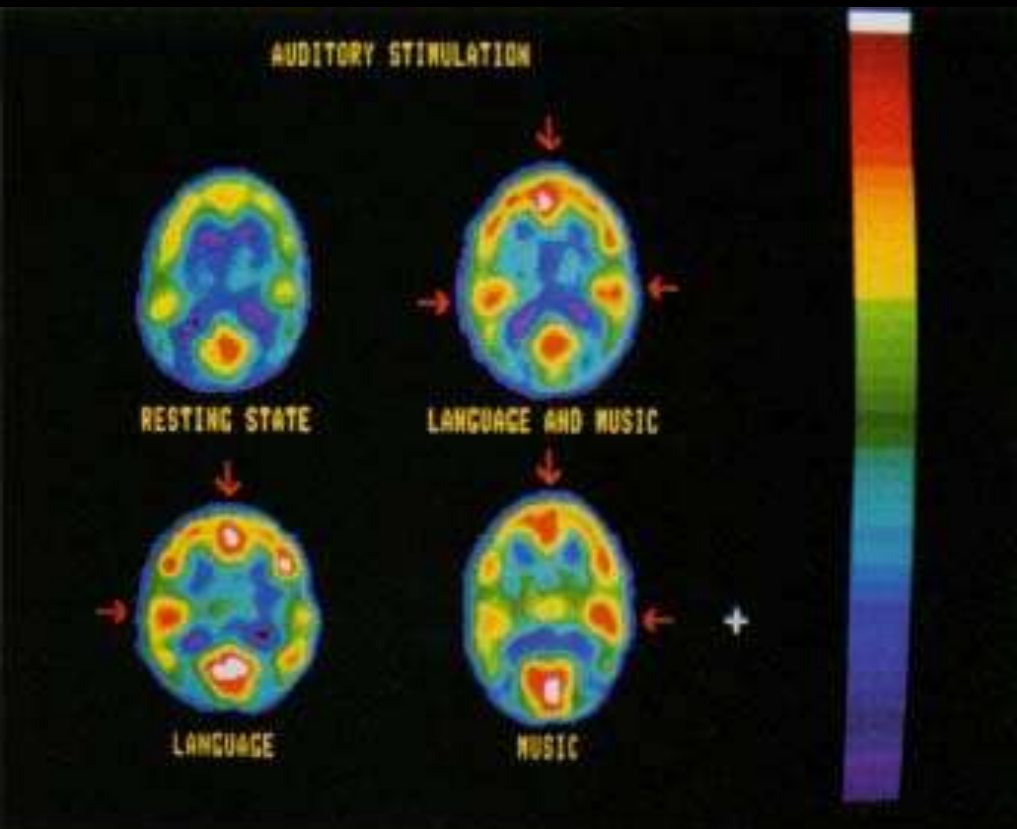


Positron Emission Tomography - PET



[By Jens Maus (<http://jens-maus.de/>) - own work - Public Domain, <https://commons.wikimedia.org/w/index.php?curid=401252>]

Positron Emission Tomography - PET



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

Materia e Antimateria

-1

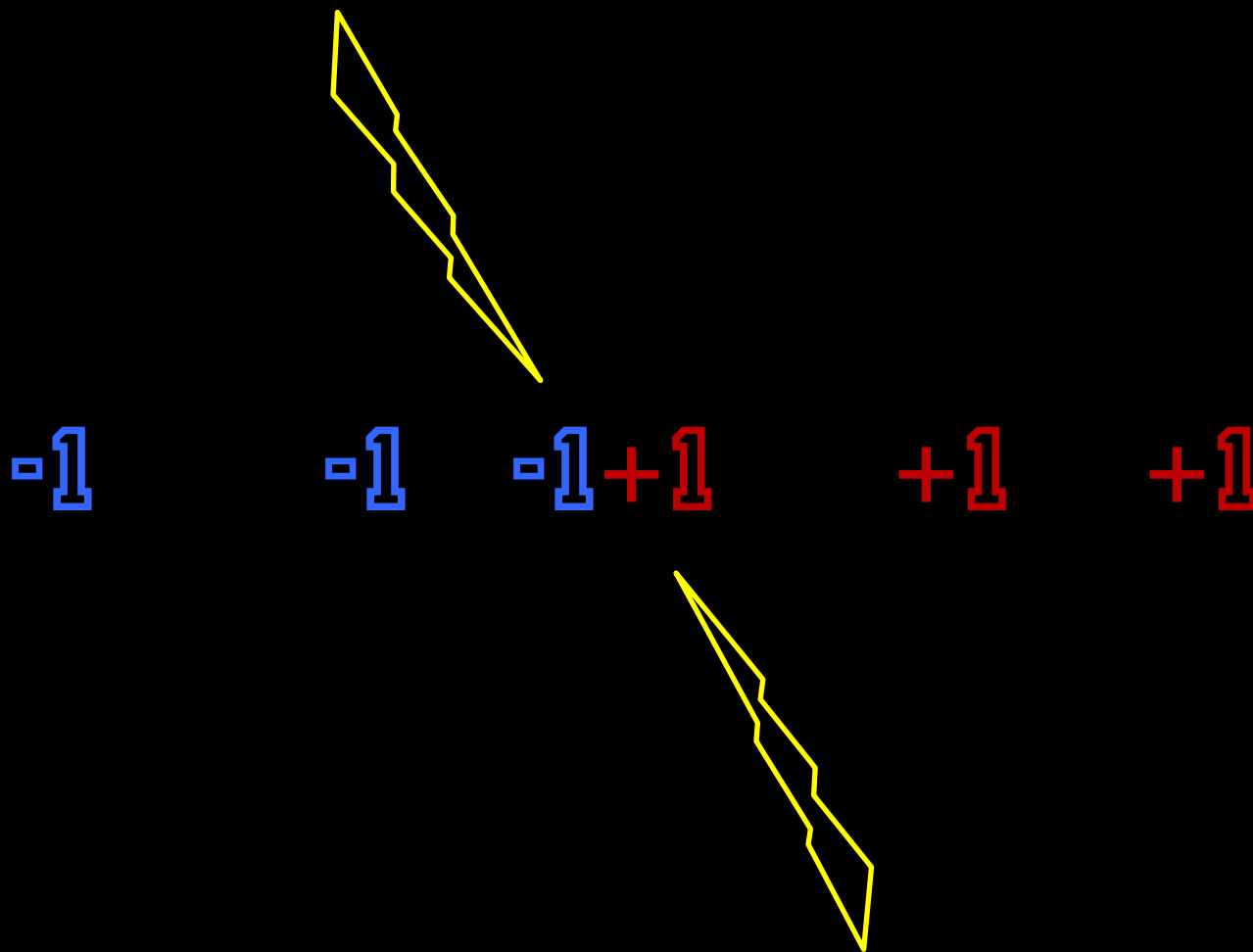
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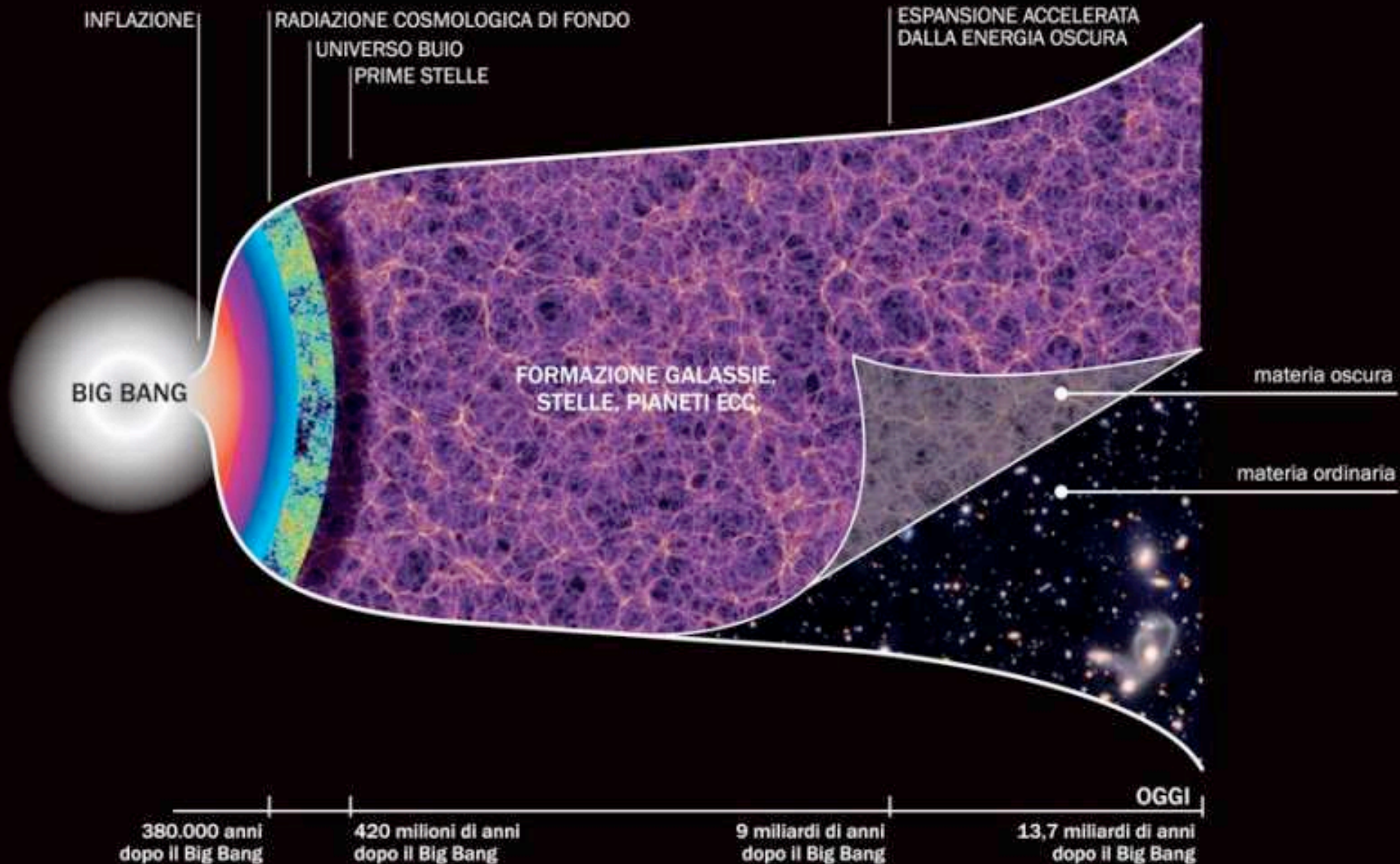
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+1

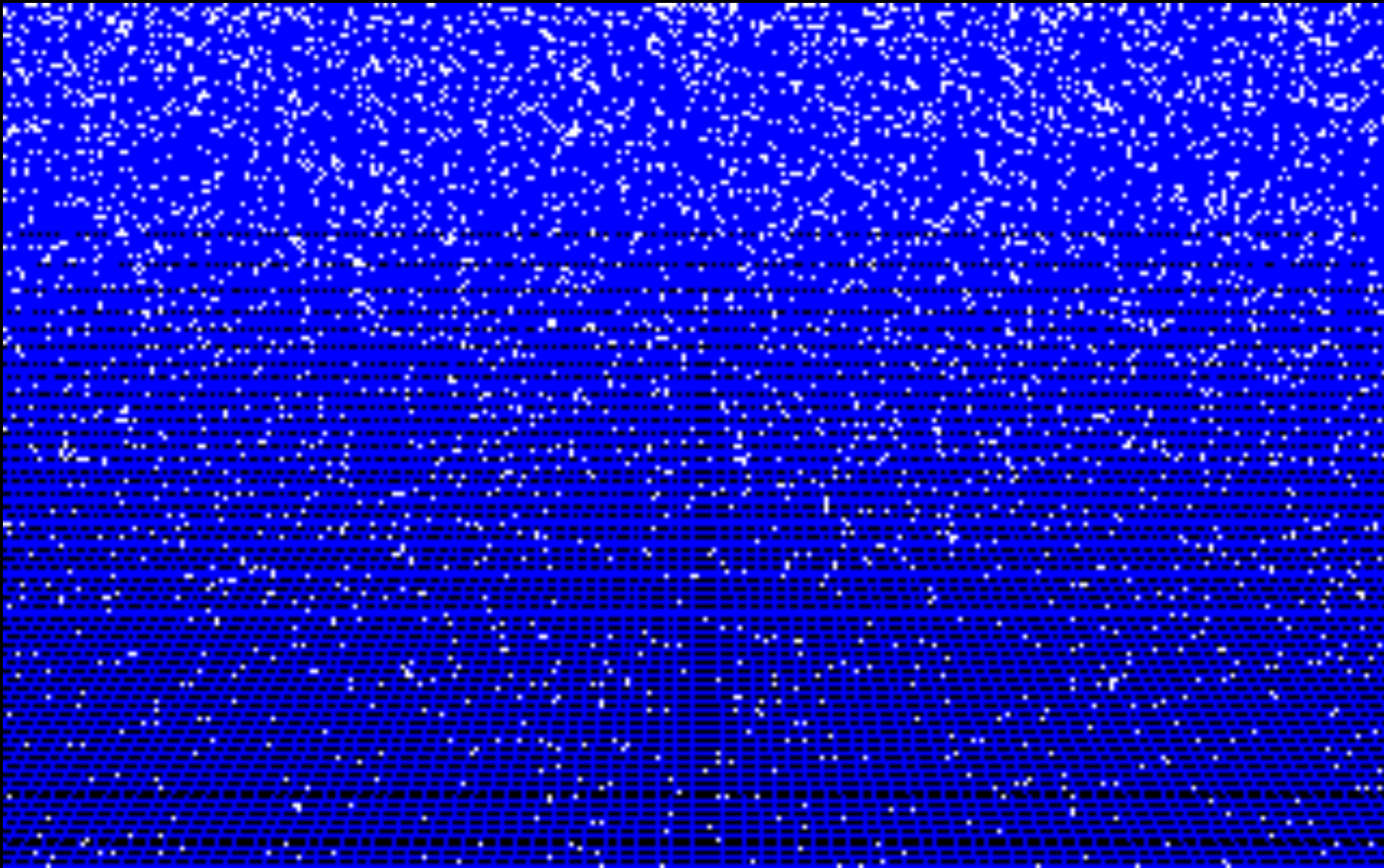
Materia e Antimateria



Big bang



Intermezzo: espansione



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”



$\sim 10^{-18}$

Se si assume che
l'Universo non distingue
tra materia e antimateria

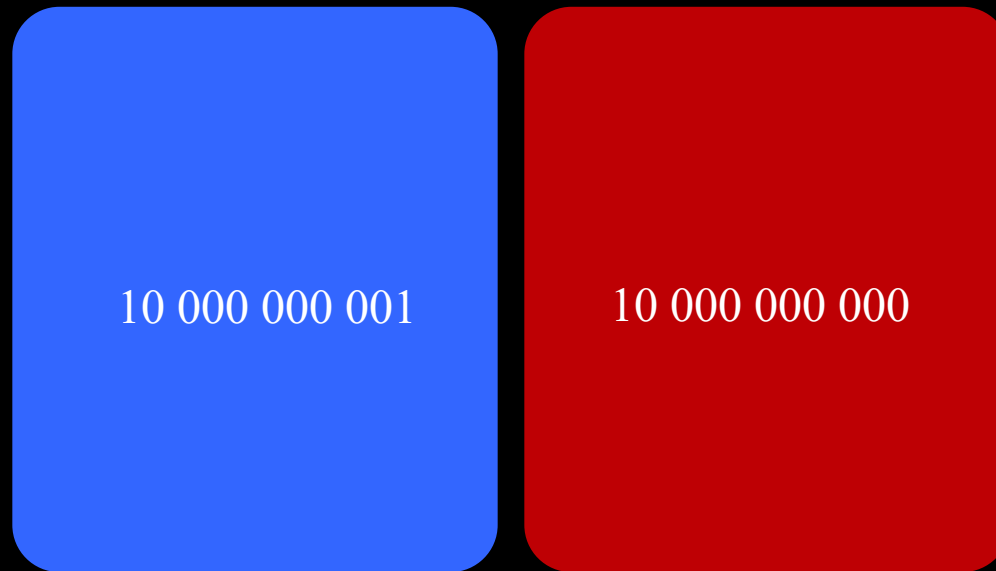
$\sim 10^{-17}$

Dalla differenza tra
materia e antimateria
che misuriamo a terra.

$\sim 6 \times 10^{-10}$

Dalla differenza tra
materia e antimateria
necessaria al Big Bang

Materia e Antimateria



Materia

Antimateria

Materia e Antimateria

1

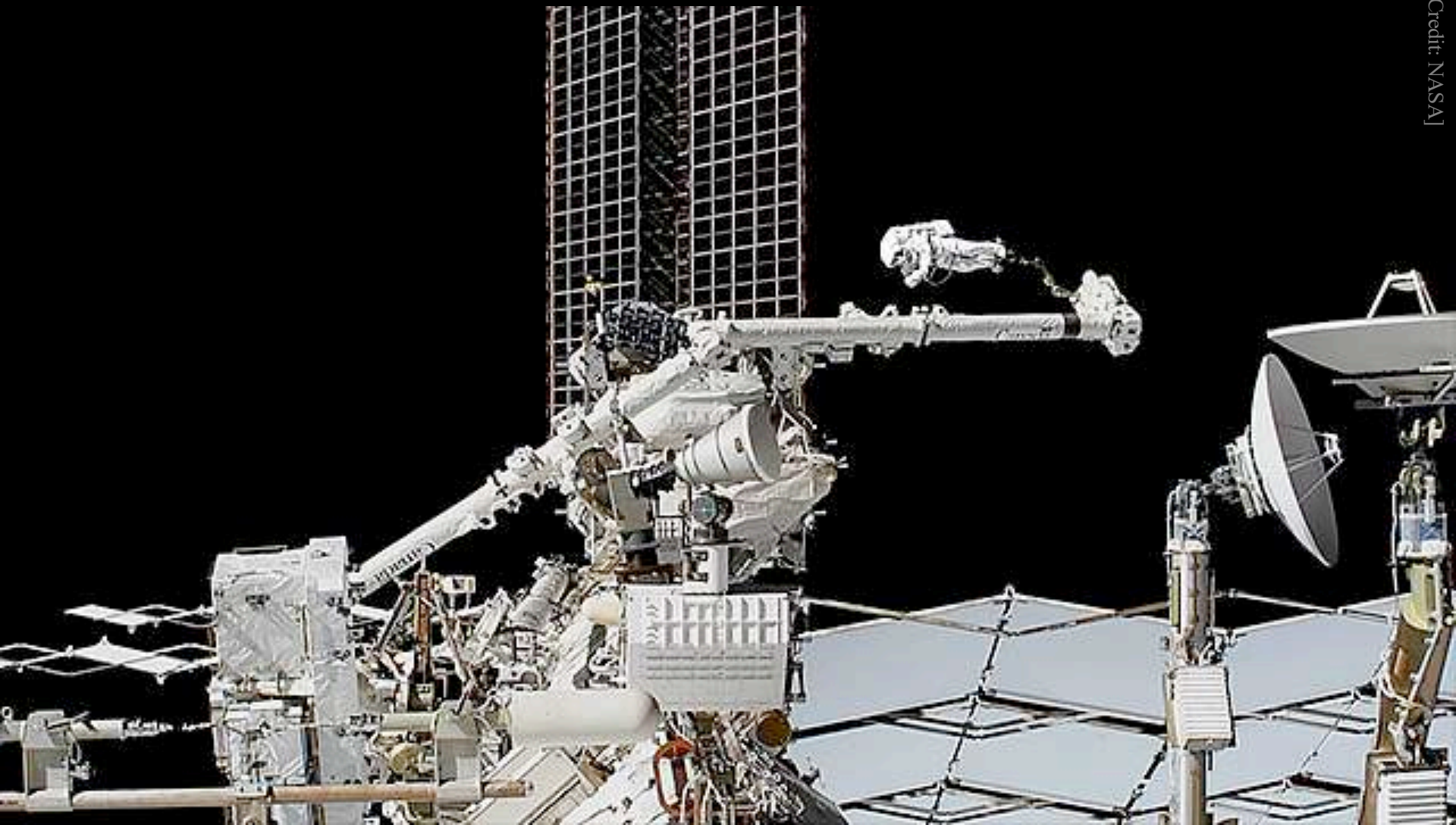
Noi

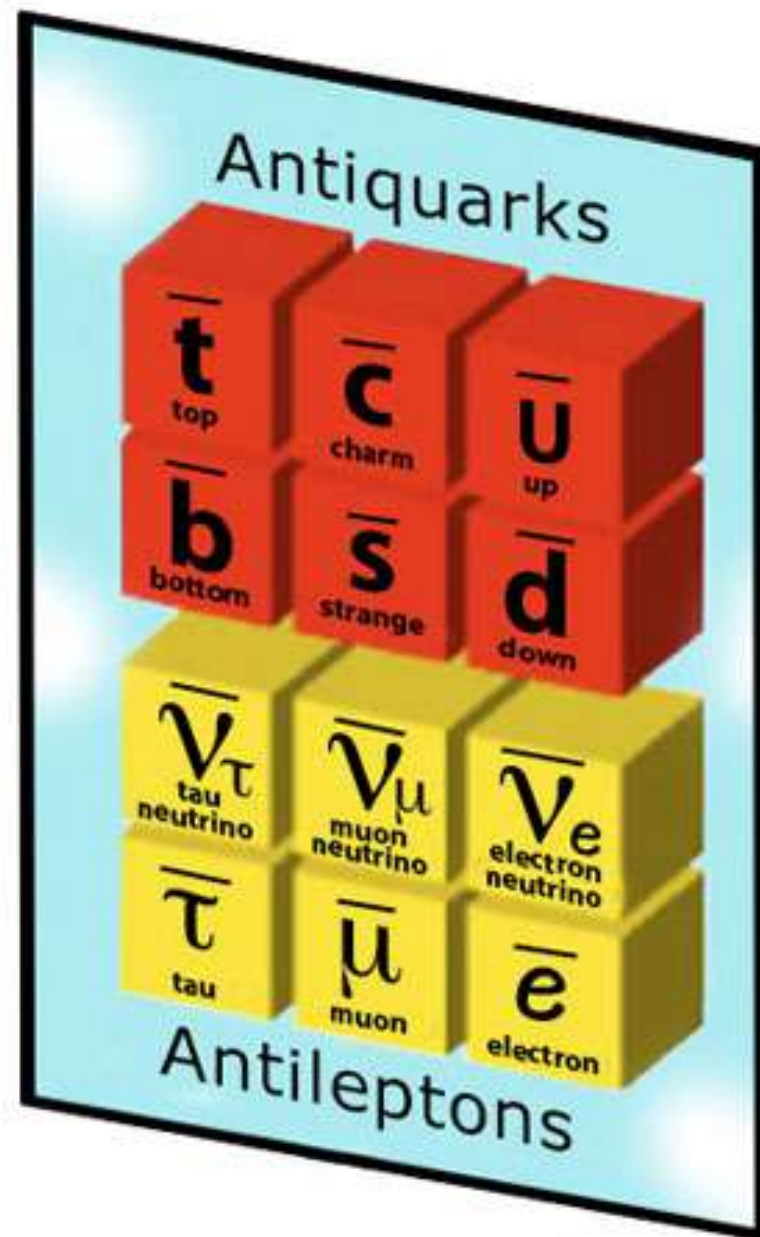
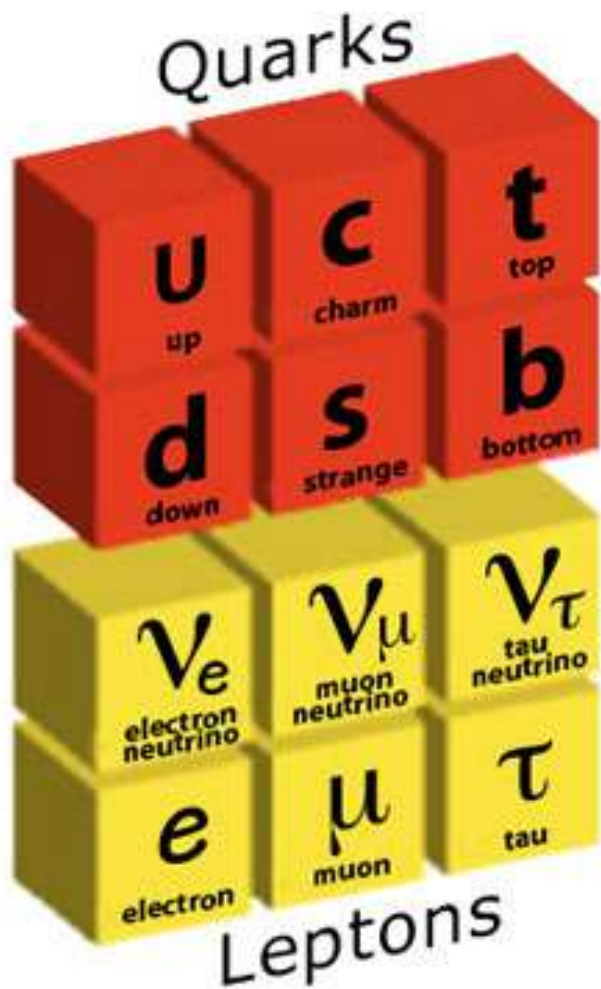


- Barbara Sciascia (INFN/LNF)

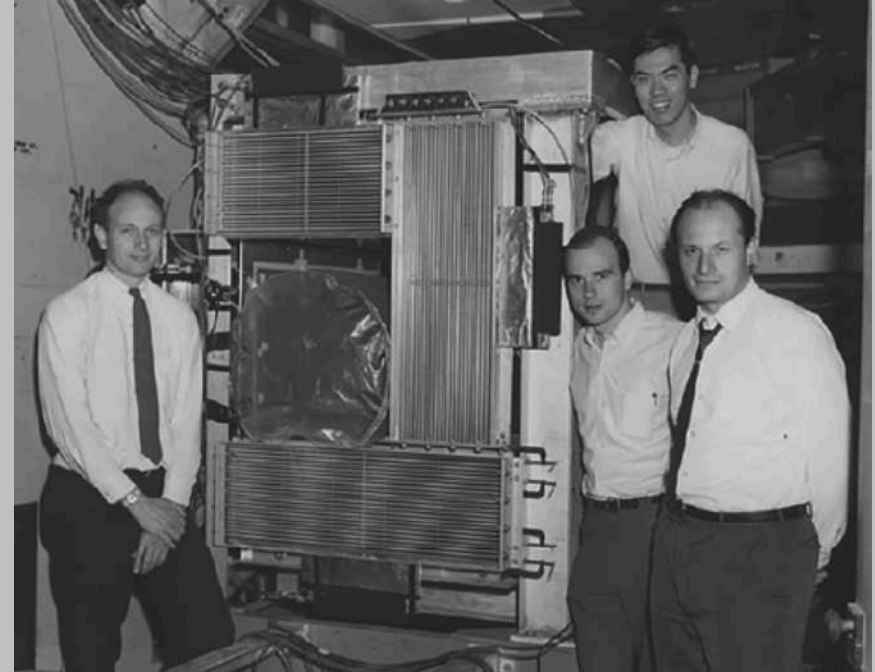
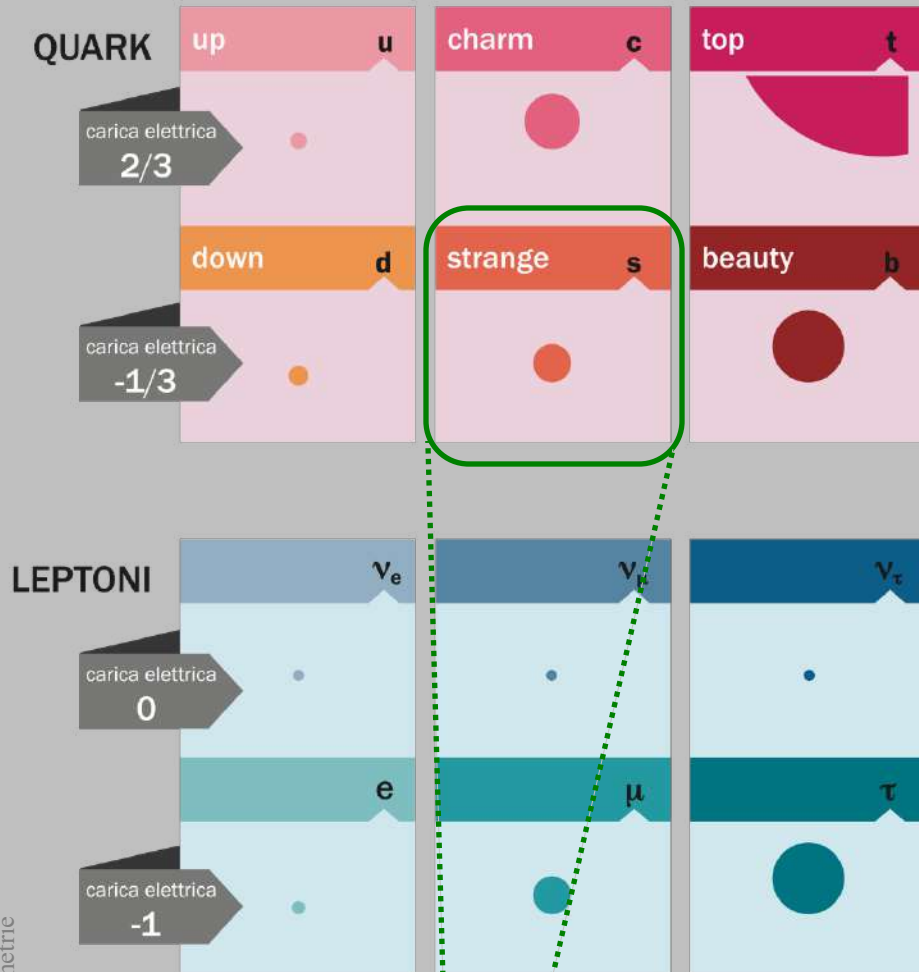


[Credit: ESA]





Differenza tra materia e antimateria



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

1964

Differenza tra materia e antimateria

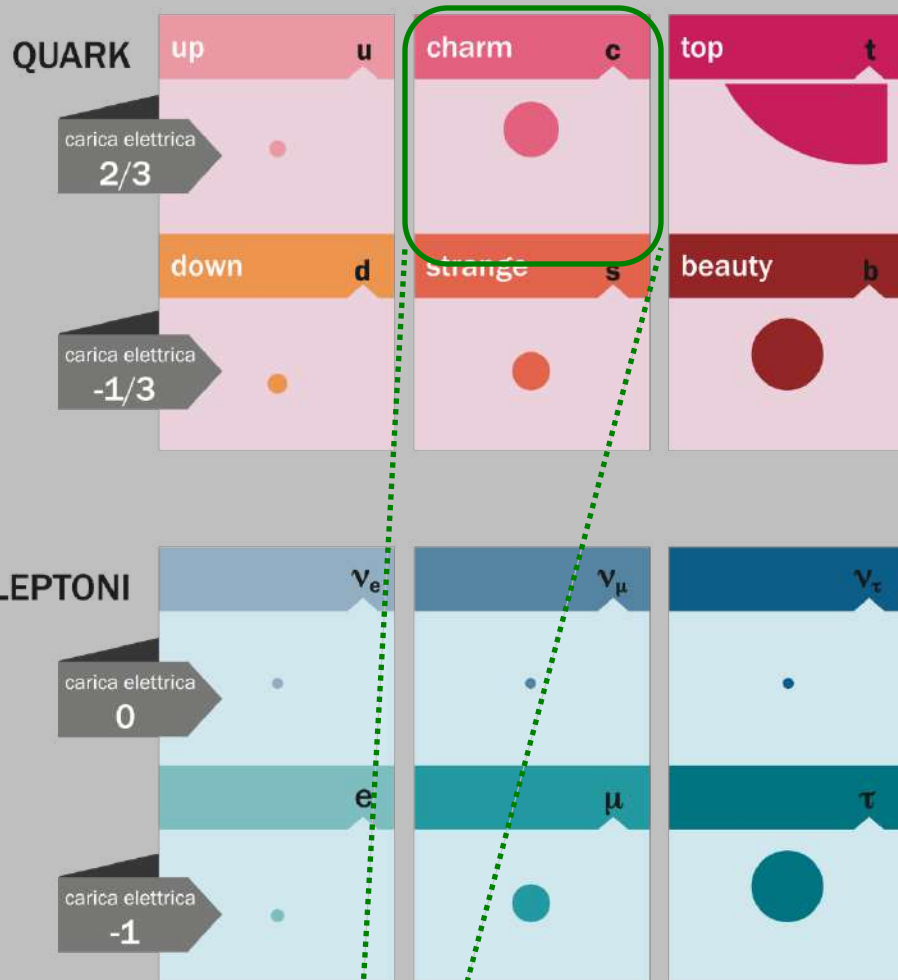
QUARK	up u	charm c	top t
carica elettrica 2/3			
carica elettrica -1/3			

LEPTONI	ν_e	ν_μ	ν_τ
carica elettrica 0			
carica elettrica -1			



2001

Differenza tra materia e antimateria



[Credits: Maximilien Brice et al./CERN]

2019