

CERN

A horizontal strip at the top of the slide contains a collage of blue-toned particle physics images, including particle tracks, collision events, and mathematical diagrams.

European Organization for Nuclear Research
Organisation Européenne pour la Recherche Nucléaire

Fisica delle particelle oggi

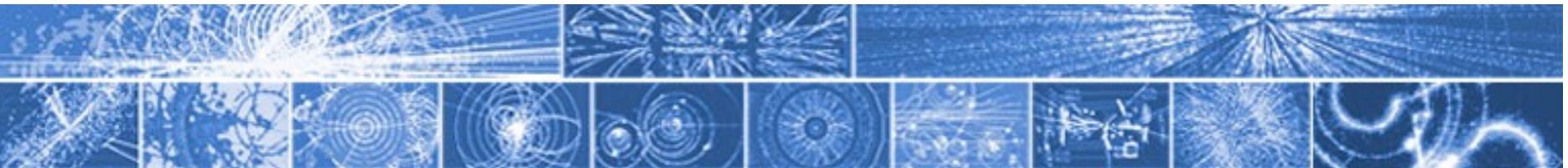
Il Modello Standard

and Beyond

- Bosone di Higgs
- SuperSimmetria
- Astroparticle & Materia Oscura

Marco CIRELLI [CNRS LPTHE Jussieu & Sorbonne]

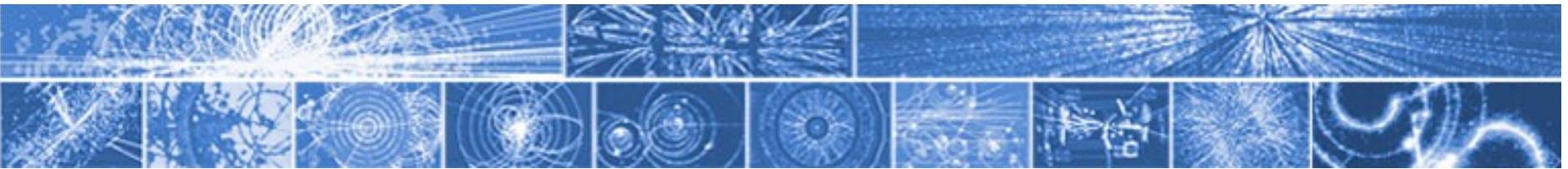
Mini-intro:
- livello variabile
- non storico
- about MC



Cosa si fa al CERN

Ricerca fondamentale in Fisica delle Particelle

- i costituenti elementari della materia
- le forze fondamentali che li governano
- l'origine, il contenuto e la struttura dell'Universo



Come risolvere questi problemi? o... Come si fanno le scoperte?

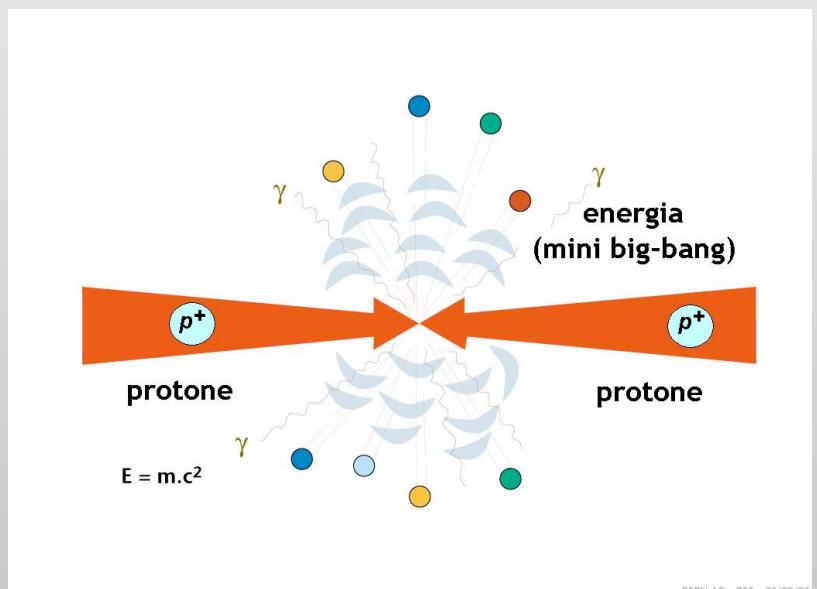
Accelerare le particelle elementari (*protoni, elettroni...*)

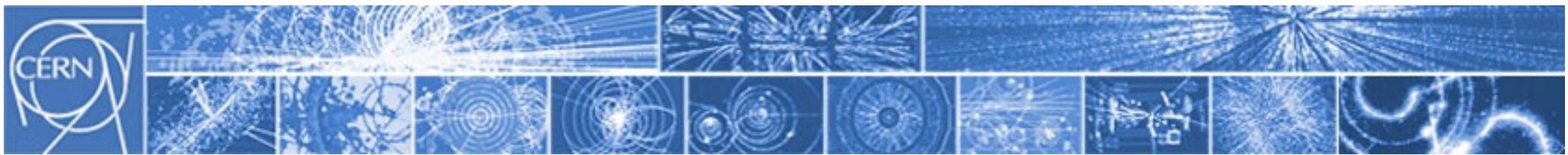
fino a energie elevatissime (14 TeV)

e portarle a collidere. $E=mc^2$

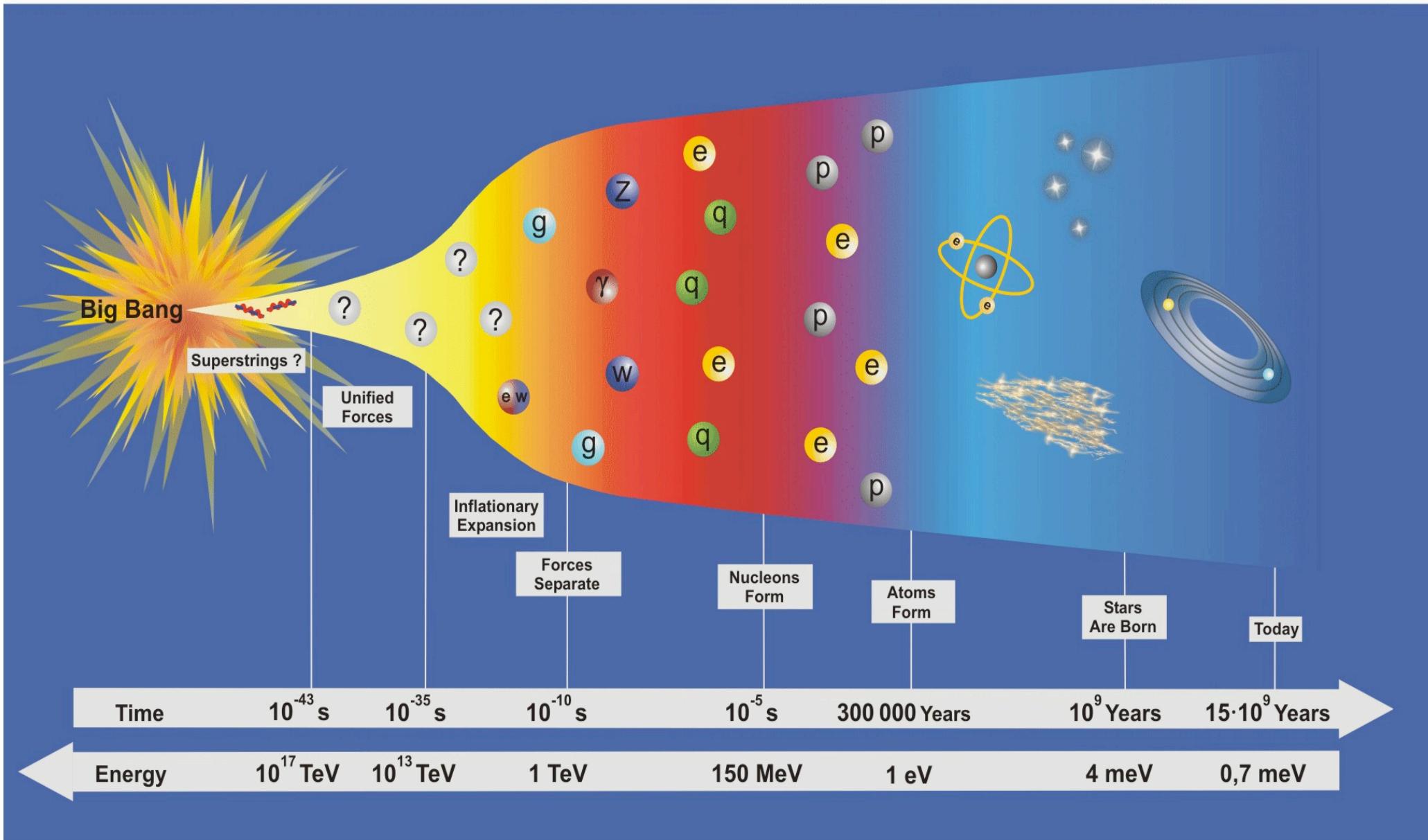
Analizzare accuratamente i prodotti

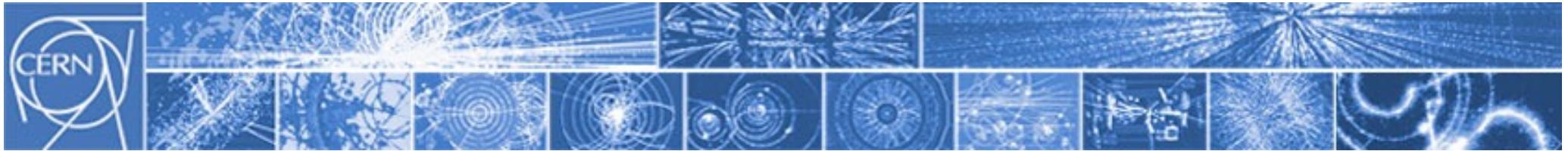
per scoprire nuove particelle,
nuove forze,
'nuova fisica'...





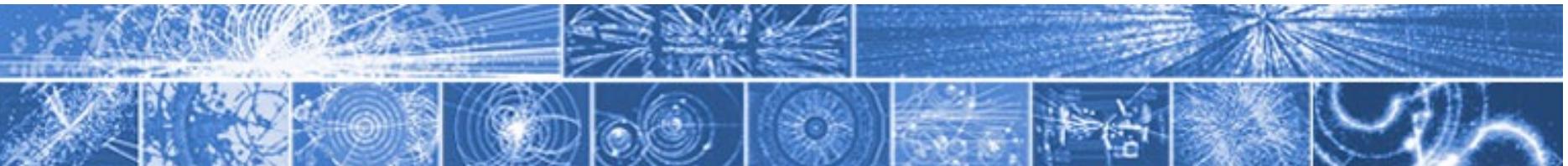
Ripercorrere all'indietro la storia dell'Universo





Modello Standard

(della fisica delle particelle elementari)



Il Modello Standard è la costruzione ('scoperta') fondamentale della fisica delle particelle, nella seconda metà del XX secolo.

XIX secolo elettromagnetismo

1932 teoria di Fermi del decadimento beta - interazioni deboli

1960's unificazione em-debole: teoria ElectroWeak
(Glashow, Weinberg, Salam)

1981 scoperta bosoni W e Z (Rubbia)

1970's teoria della QCD - interazioni nucleari forti
(Gross, Politzer, Wilczek)

1936 μ

1956 ν_e

1962 ν_μ

1974 τ

2000 ν_τ

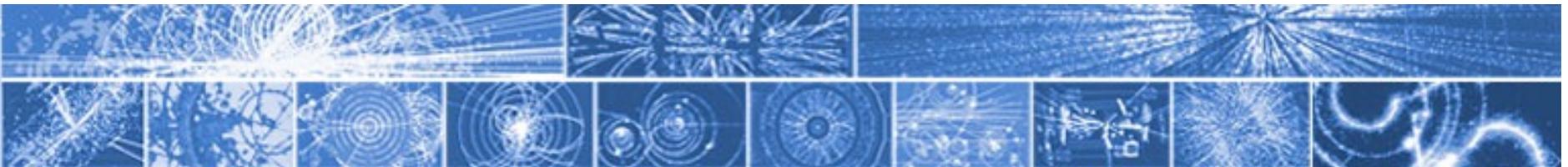
1968 s quark

1974 c quark

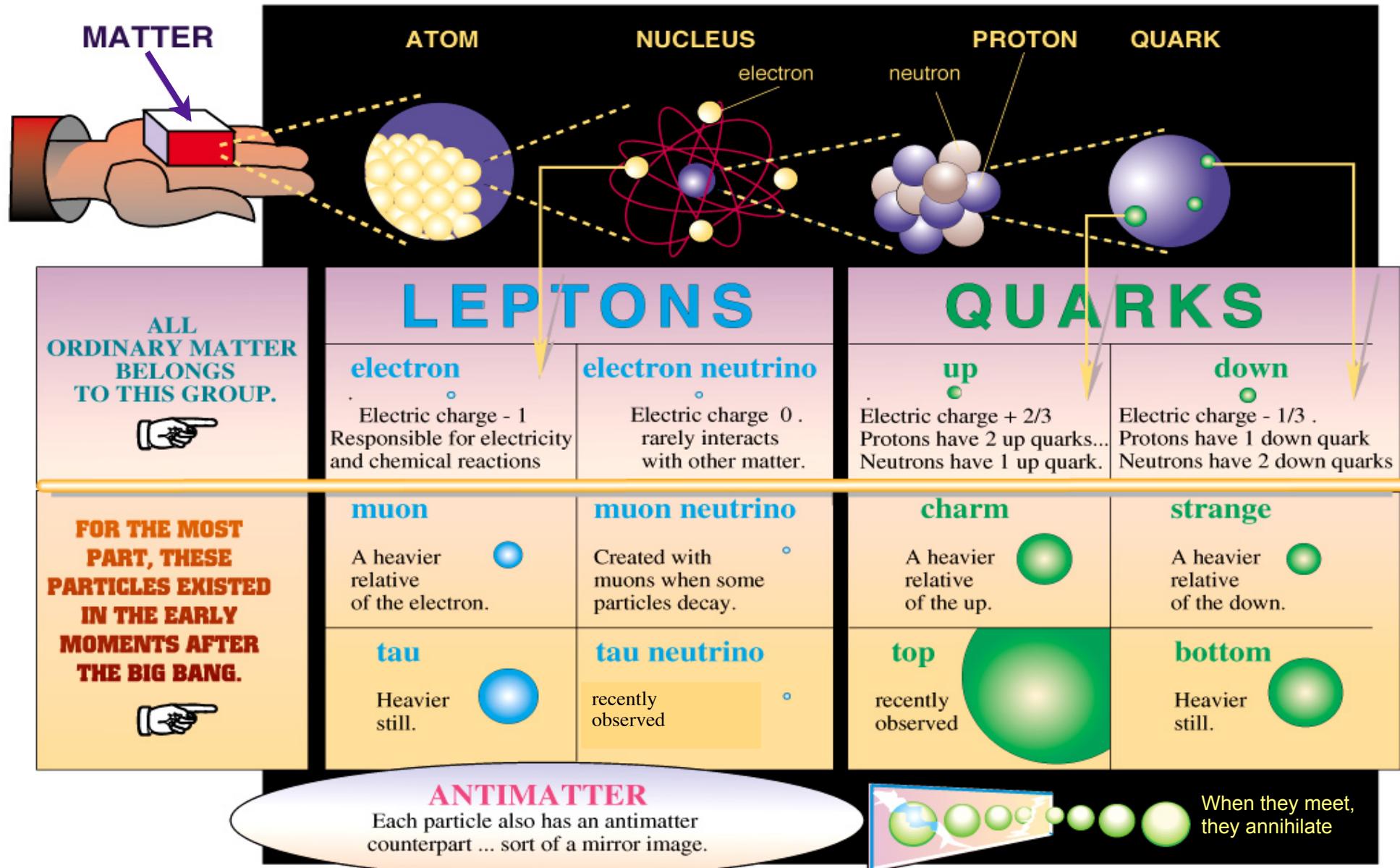
1977 b quark

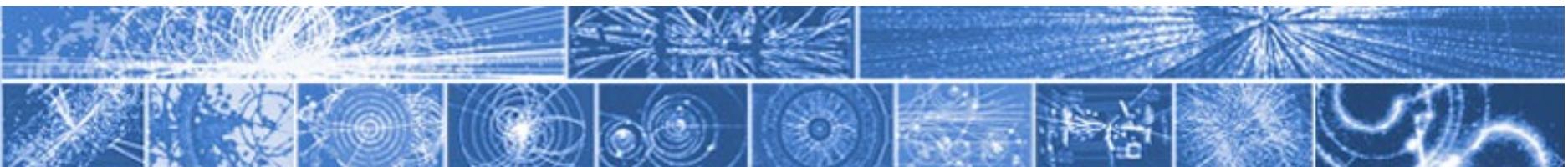
1995 t quark

2012 higgs

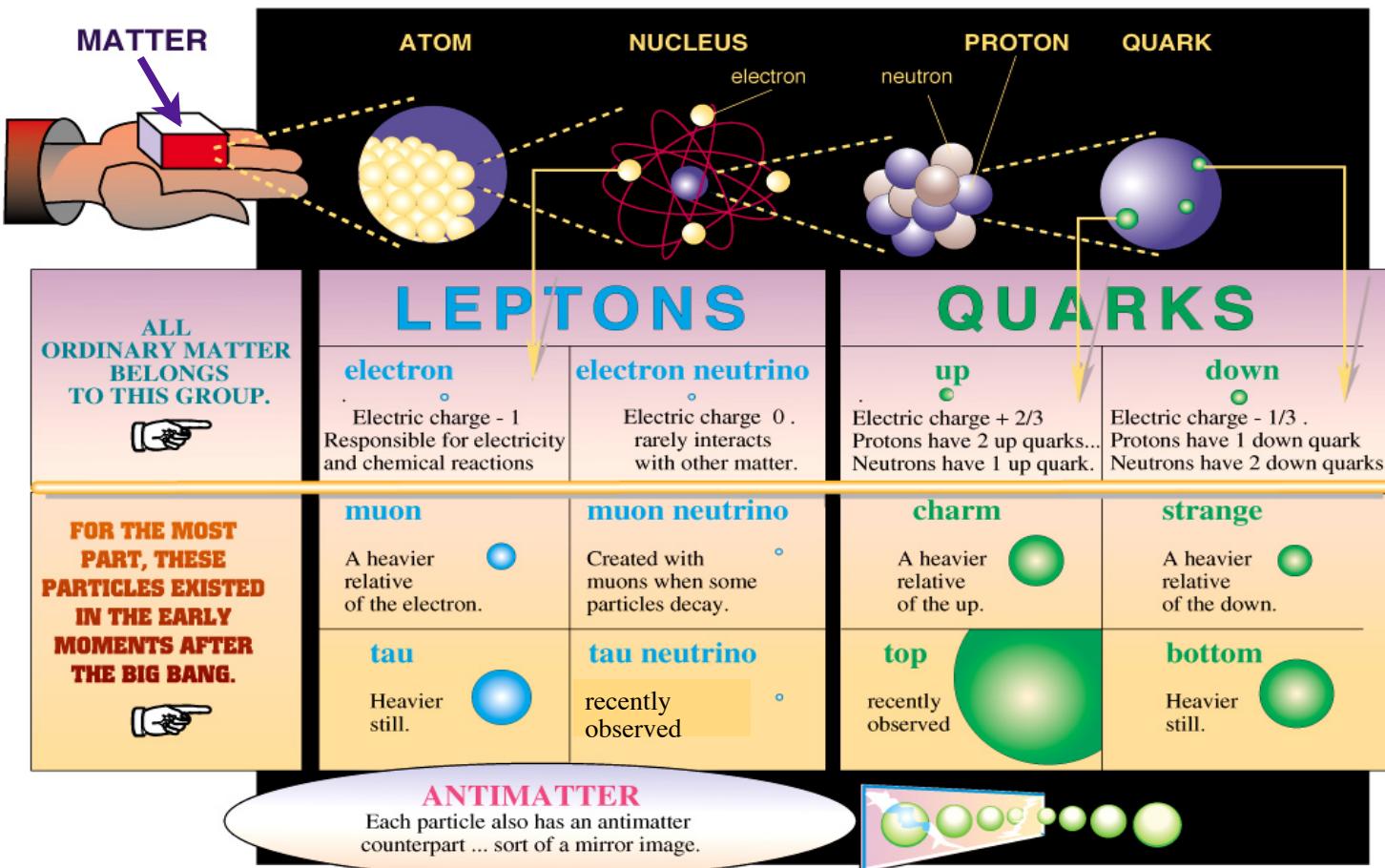


STANDARD MODEL





STANDARD MODEL



from Time magazine

FORCES

Electromagnetic

Photon



Atoms
Light
Chemistry
Electronics

Weak

Bosons (W,Z)



Neutron decay
Beta radioactivity
Neutrino interactions
Burning of the sun

Strong

Gluons (8)



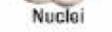
Quarks



Mesons



Baryons



Nuclei



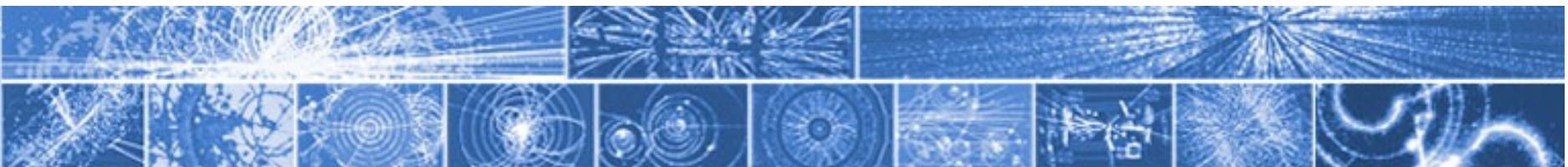
Gravitational

Graviton ?

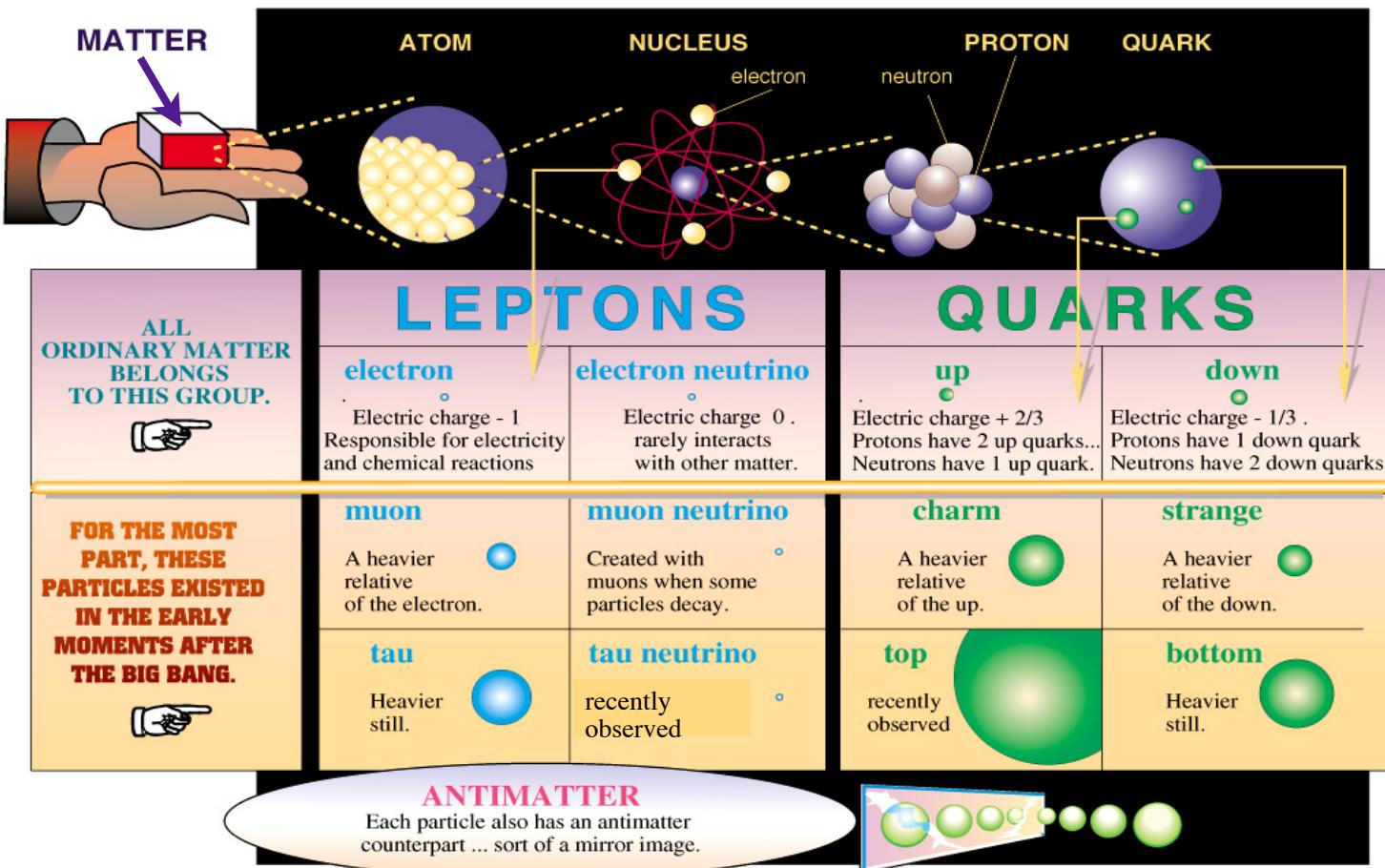


Solar system
Galaxies
Black holes





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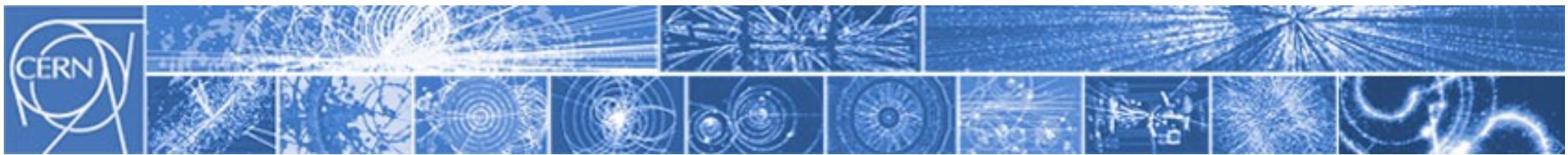


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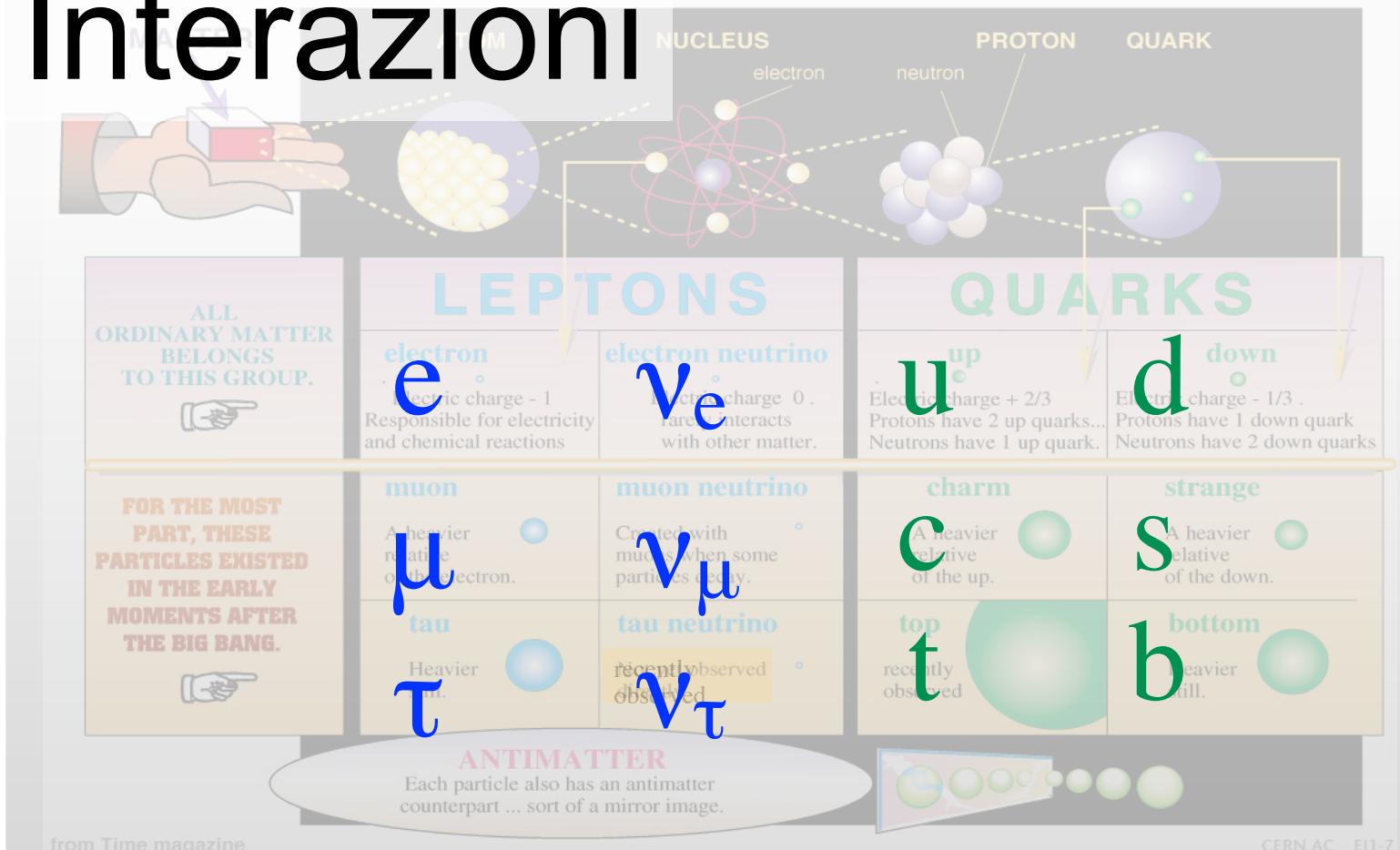
Higgs boson

h

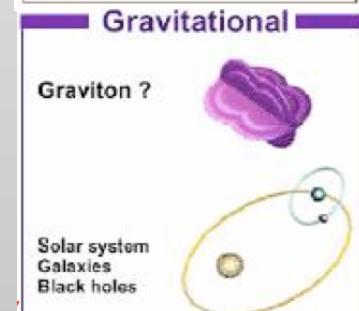
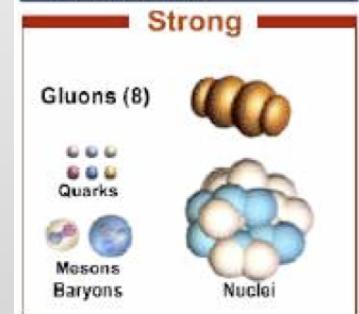
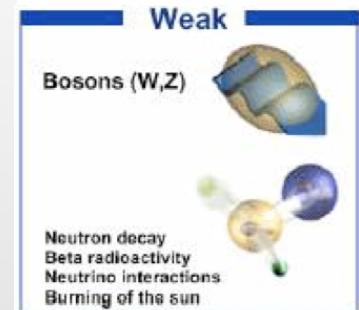
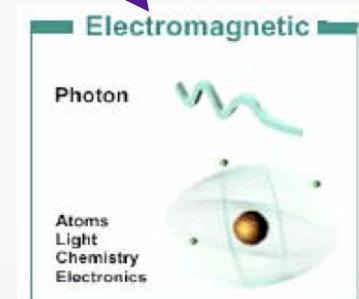


STANDARD MODEL

Interazioni

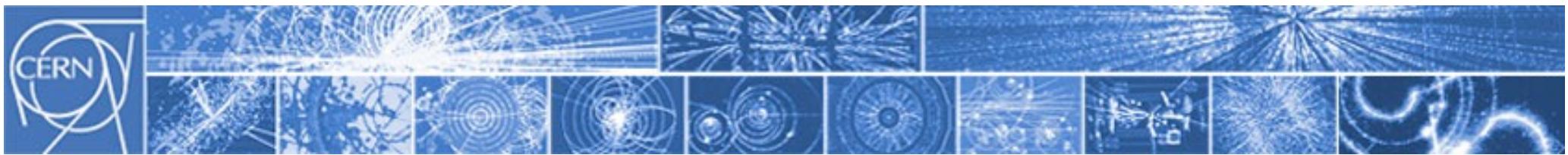


FORCES



Higgs boson

h



STANDARD MODEL

Interazioni

ALL ORDINARY MATTER BELONGS TO THIS GROUP.

FOR THE MOST PART, THESE PARTICLES EXISTED IN THE EARLY MOMENTS AFTER THE BIG BANG.

LEPTONS

e	ν_e
electron	electron neutrino
Electric charge - 1	Electric charge 0
Responsible for electric and chemical reactions	Interacts with other matter.

μ	ν_μ
muon	muon neutrino
A heavier relative of the electron.	Created with muons when some particles decay.

τ	ν_τ
tau	tau neutrino
Heavier than...	recently observed

ANTIMATTER
Each particle also has an antimatter counterpart ... sort of a mirror image.

NUCLEUS
electron

PROTON
neutron

QUARK

CERN AC_EI1-7

from Time magazine

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Gluons (8)



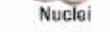
Quarks



Mesons



Baryons



Nuclei

Gravitational

Graviton ?

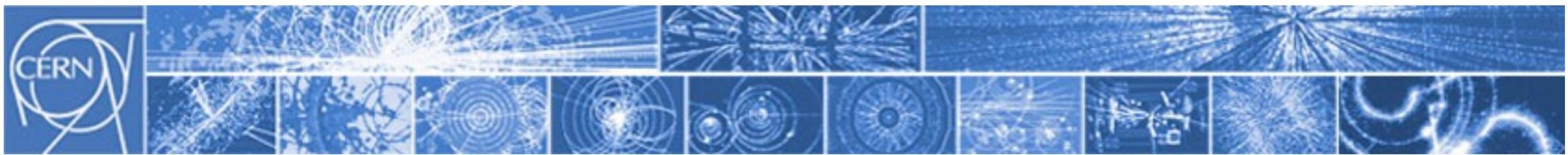


Solar system
Galaxies
Black holes



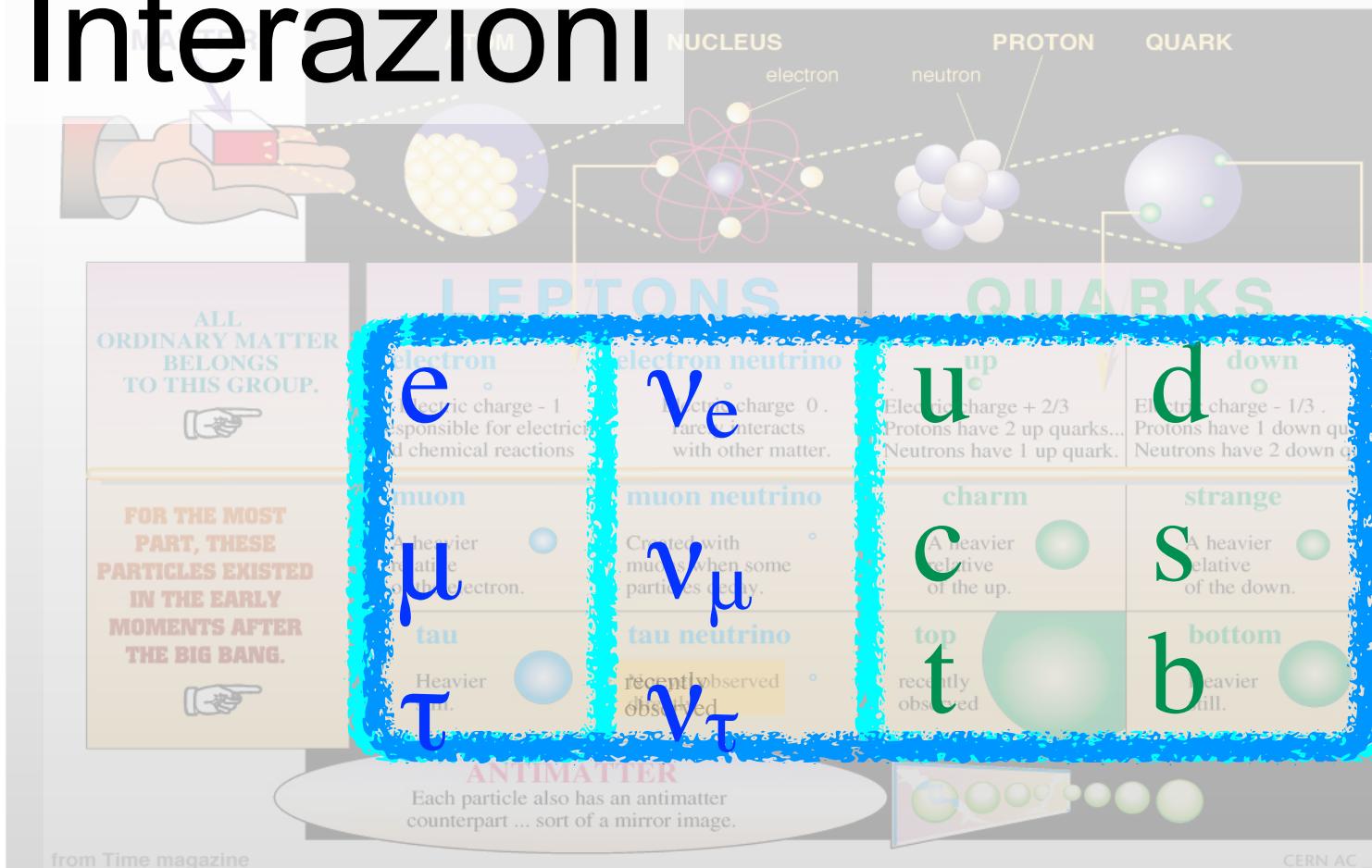
Higgs boson

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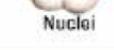
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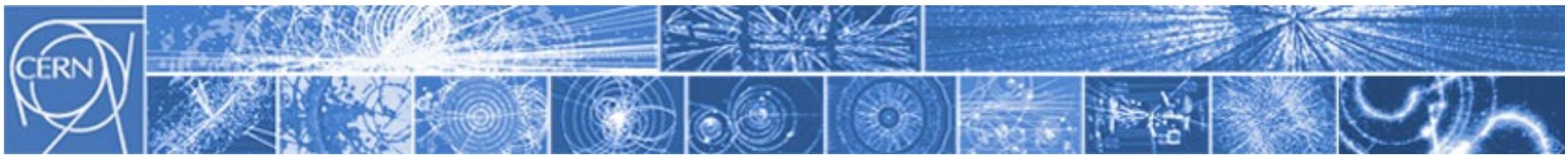


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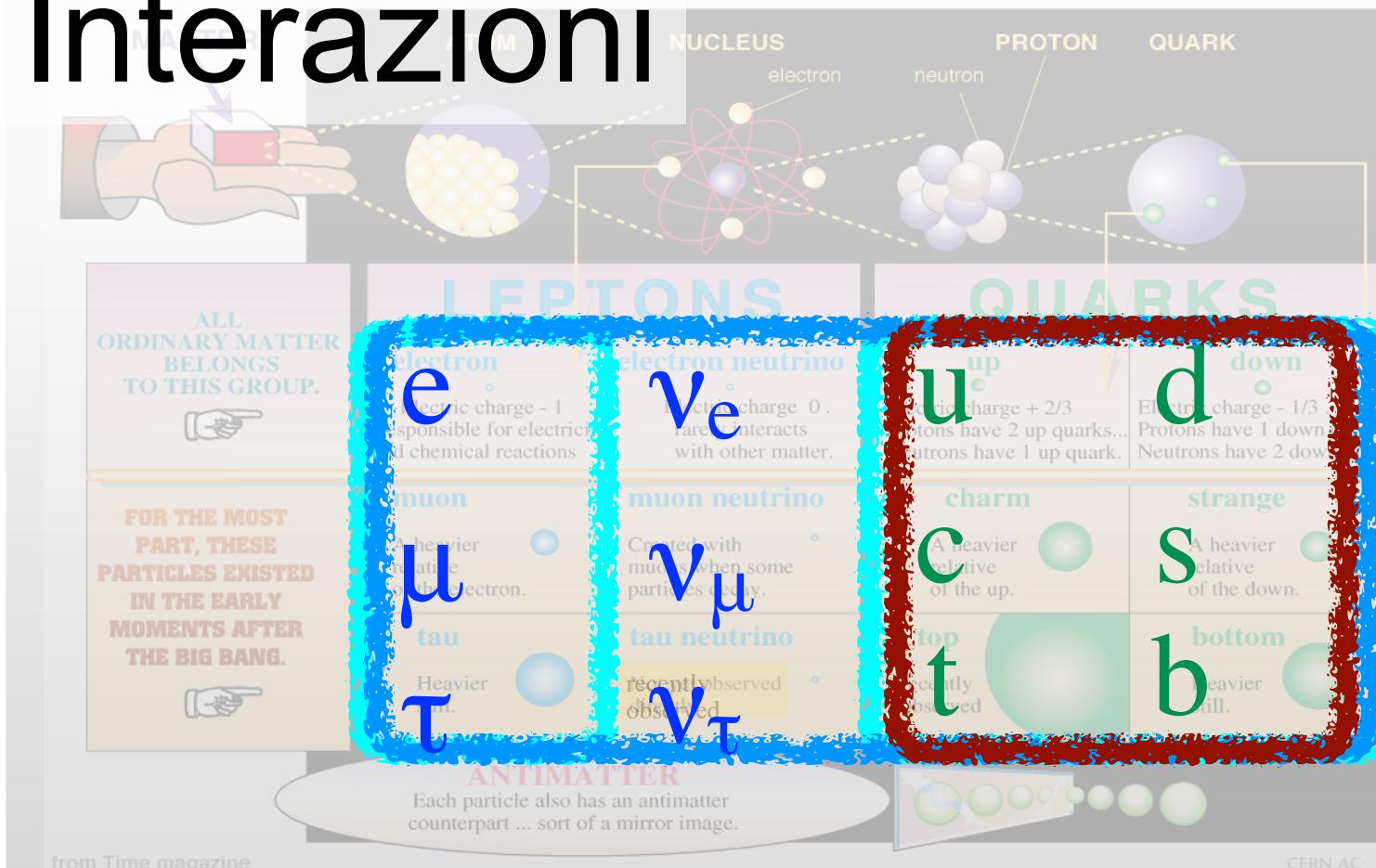
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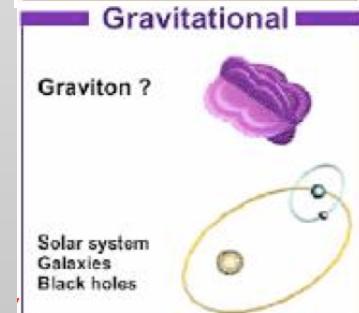
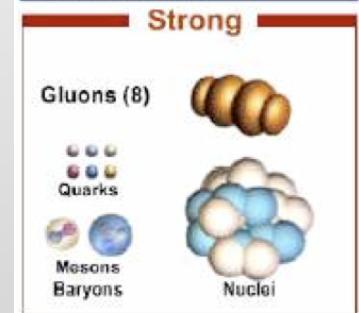
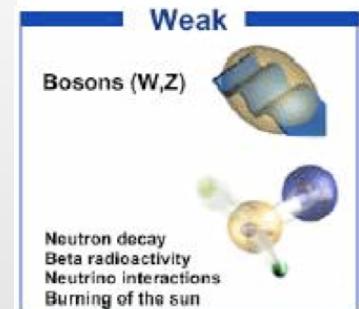
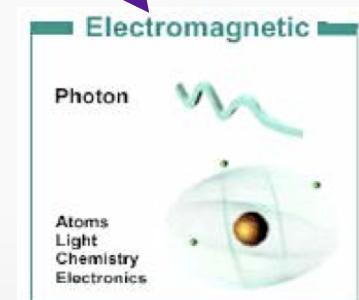


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Interazioni

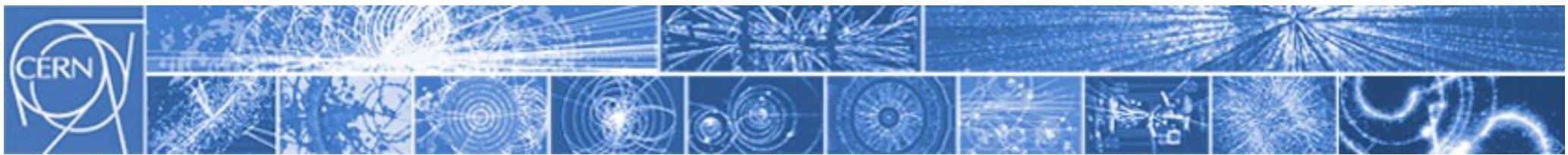


FORCES



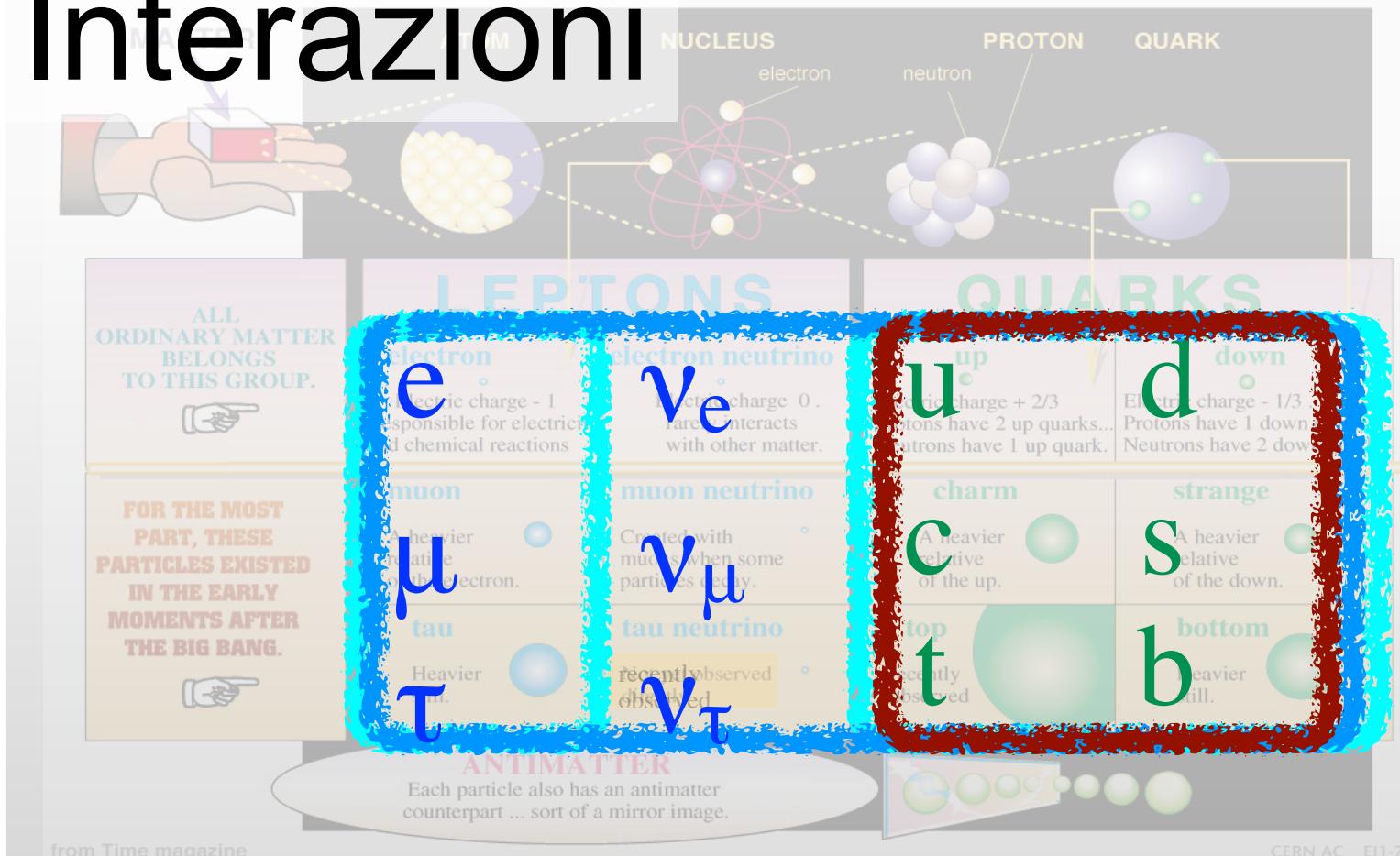
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STANDARD MODEL

Interazioni



FORCES

Electromagnetic



Weak

Bosons (W,Z)

W^+ W^-

Z

Strong

Gluons (8)

g (8)

Gravitational

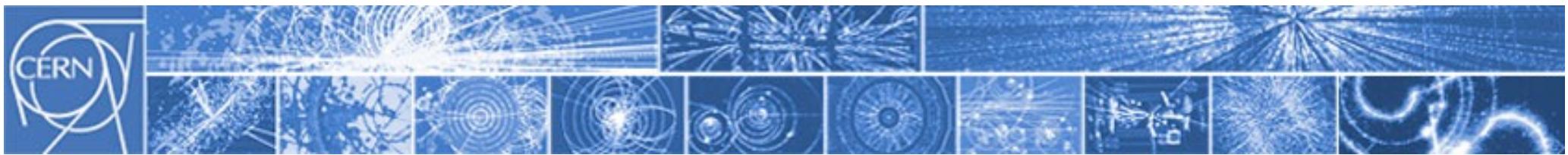
Graviton ?

G

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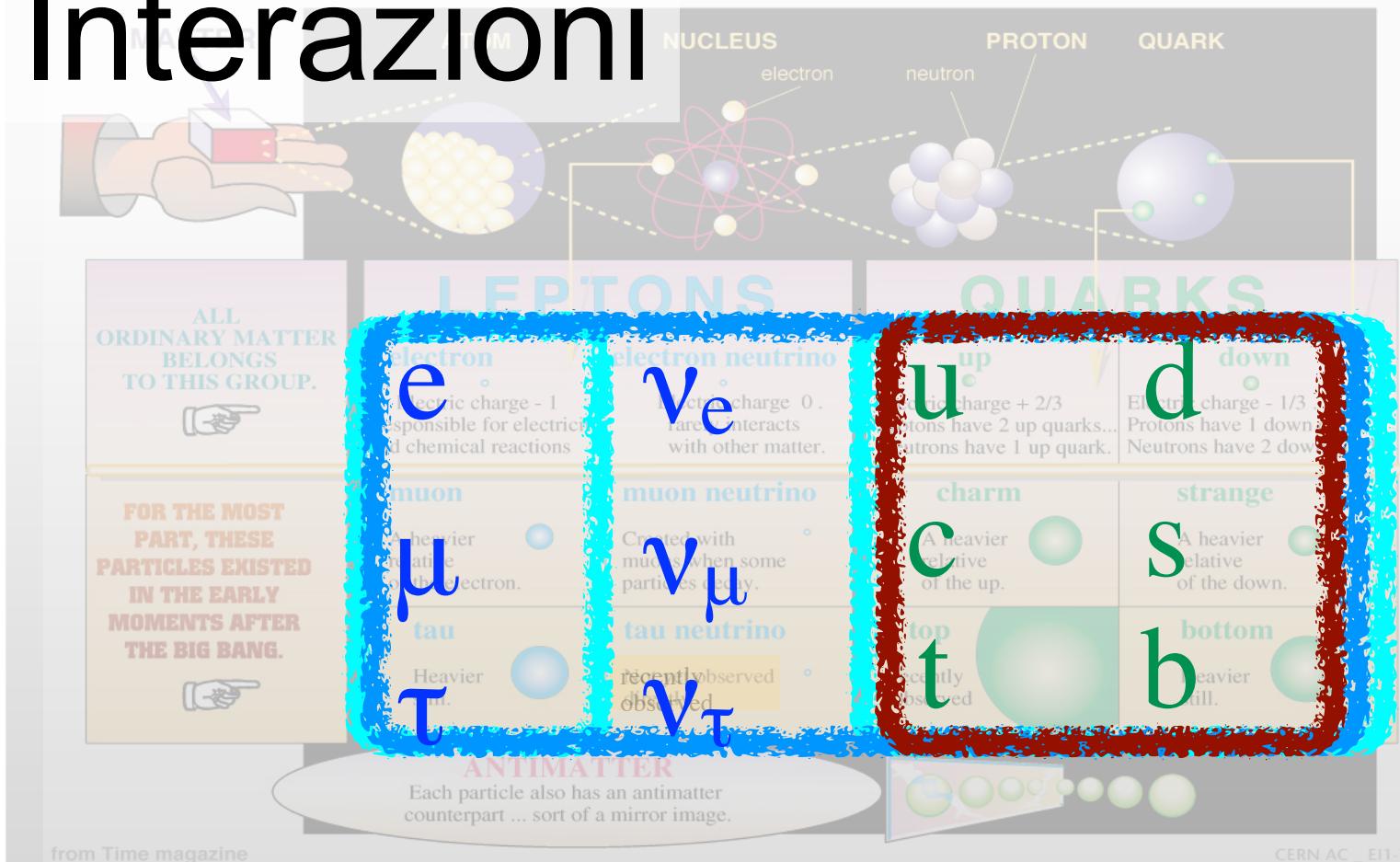
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STANDARD MODEL

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γ

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W^+ W^-

Z

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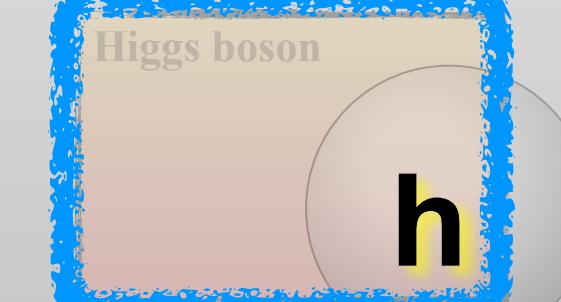
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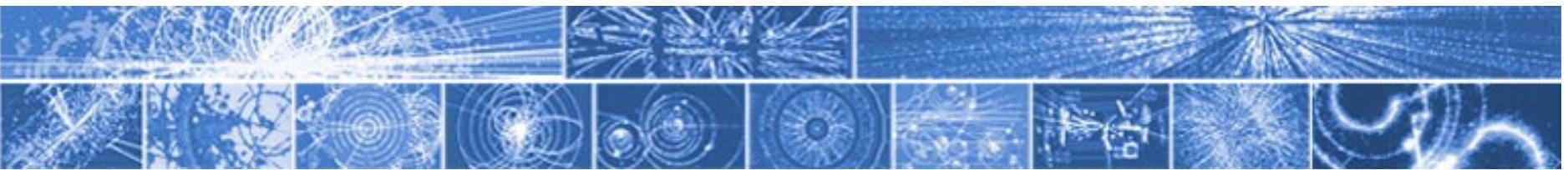
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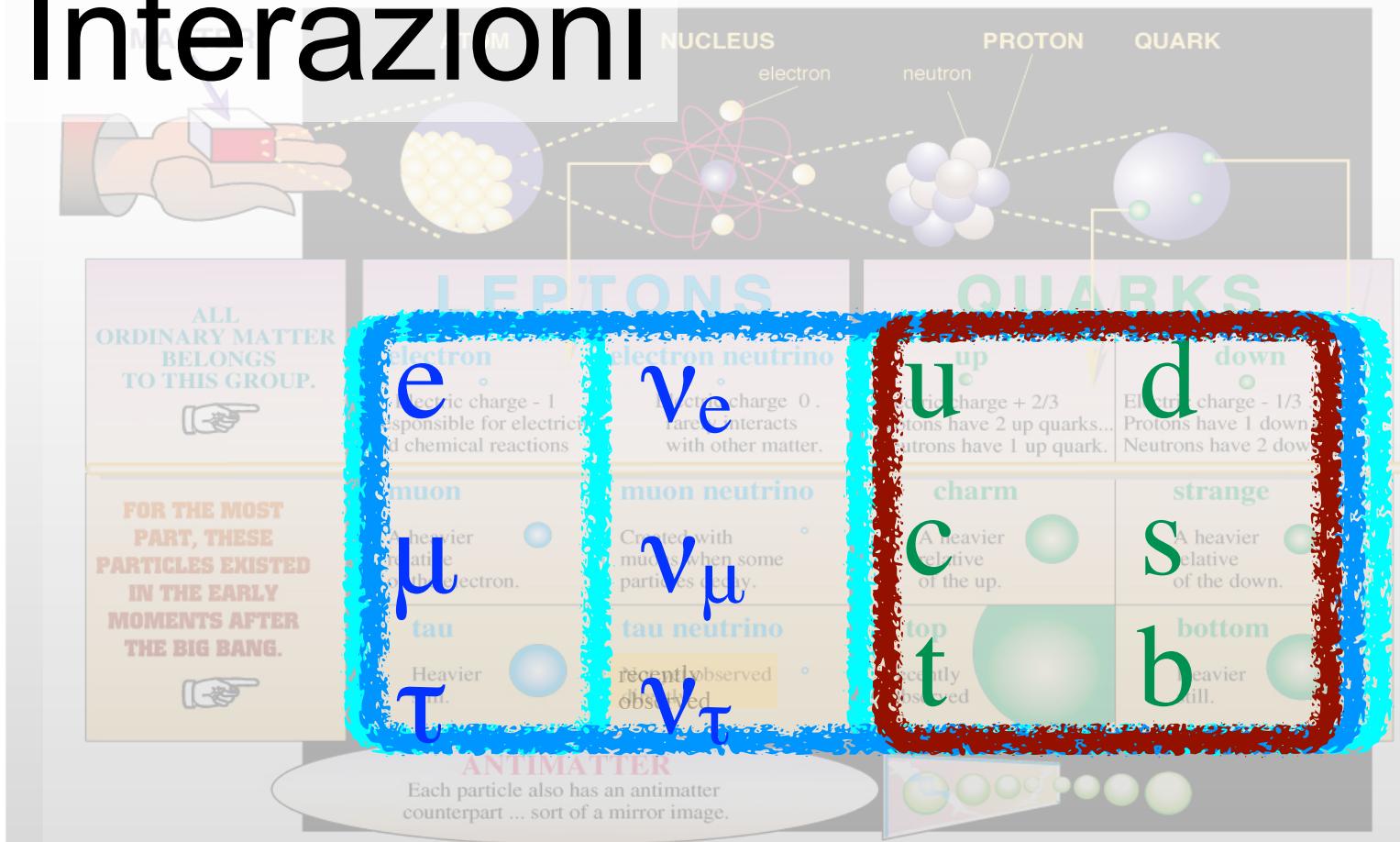
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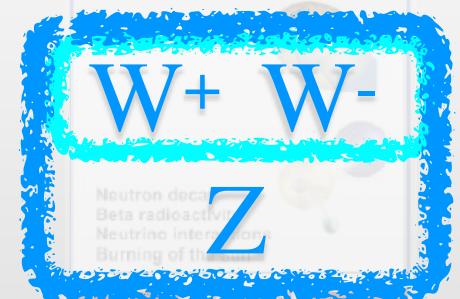
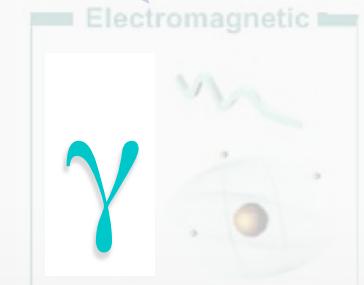
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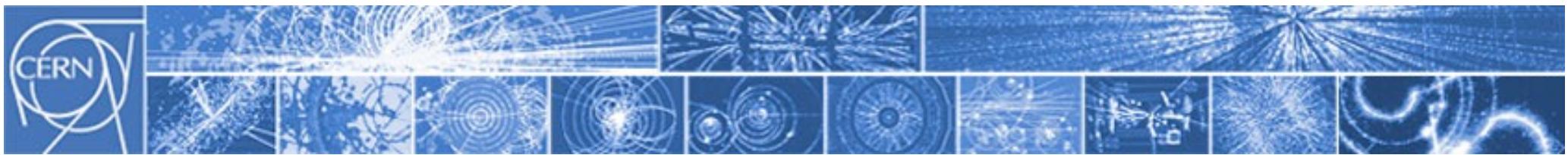
Interazioni



from Time magazine

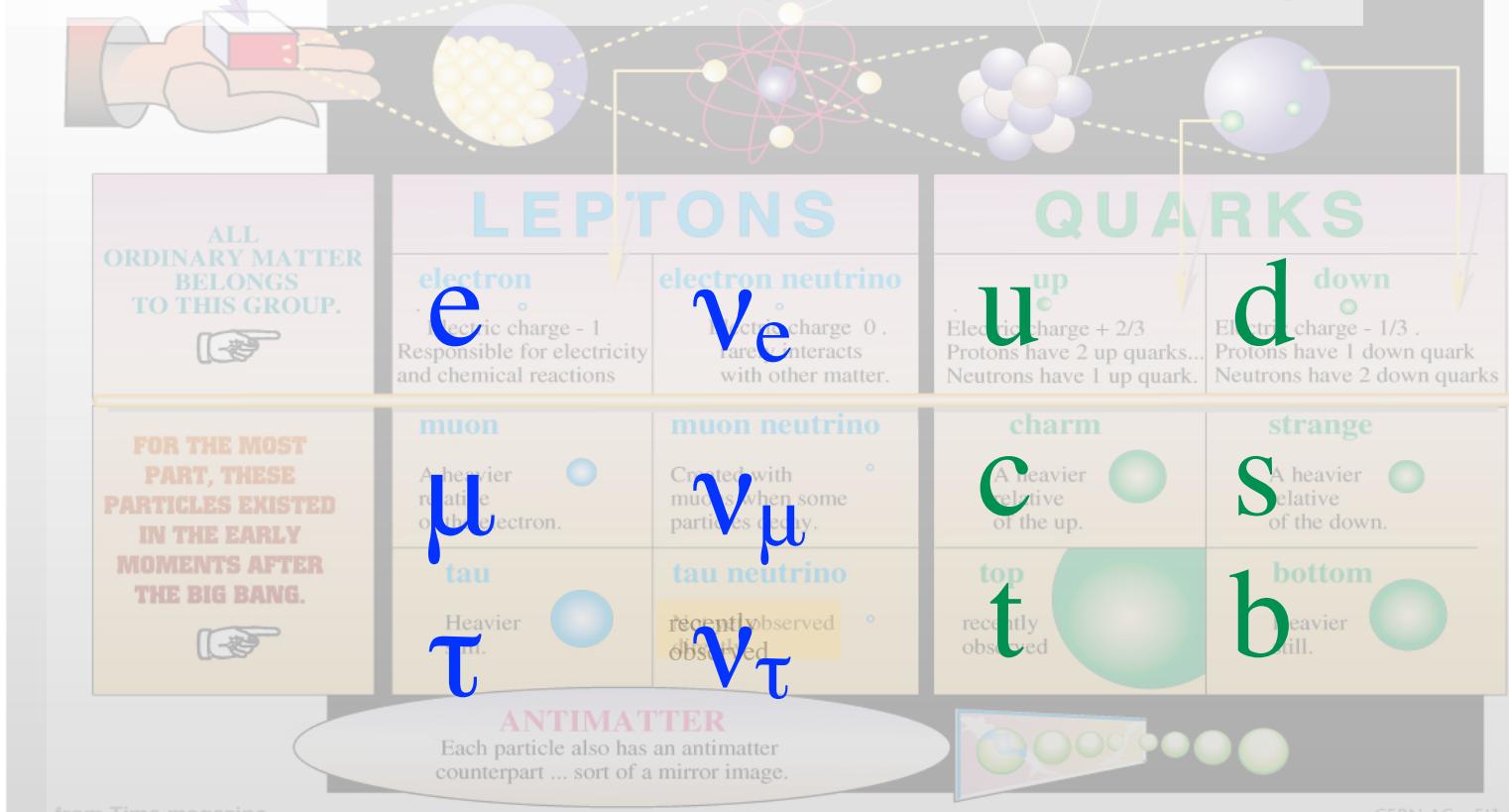
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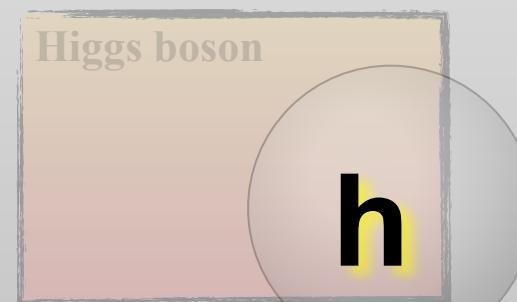


STANDARD MODEL

Interazioni (& simmetrie)



$$\rightarrow \text{SU}_c(3) \times \text{SU}_w(2) \times \text{U}_Y(1) \rightarrow \text{SU}_c(3) \times \text{U}_{\text{em}}(1)$$



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Bosons (W, Z)

W^+ W^-



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Gluons (8)

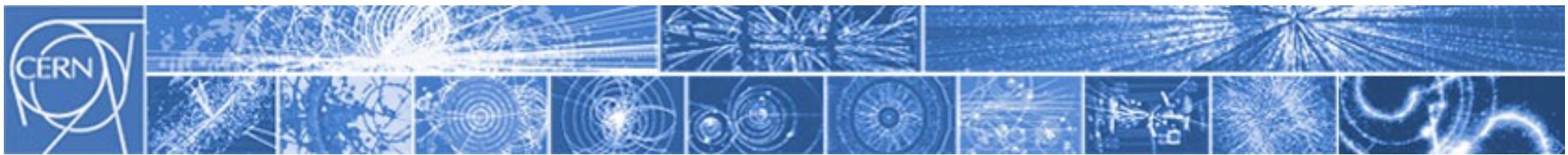
g (8)

Gravitational

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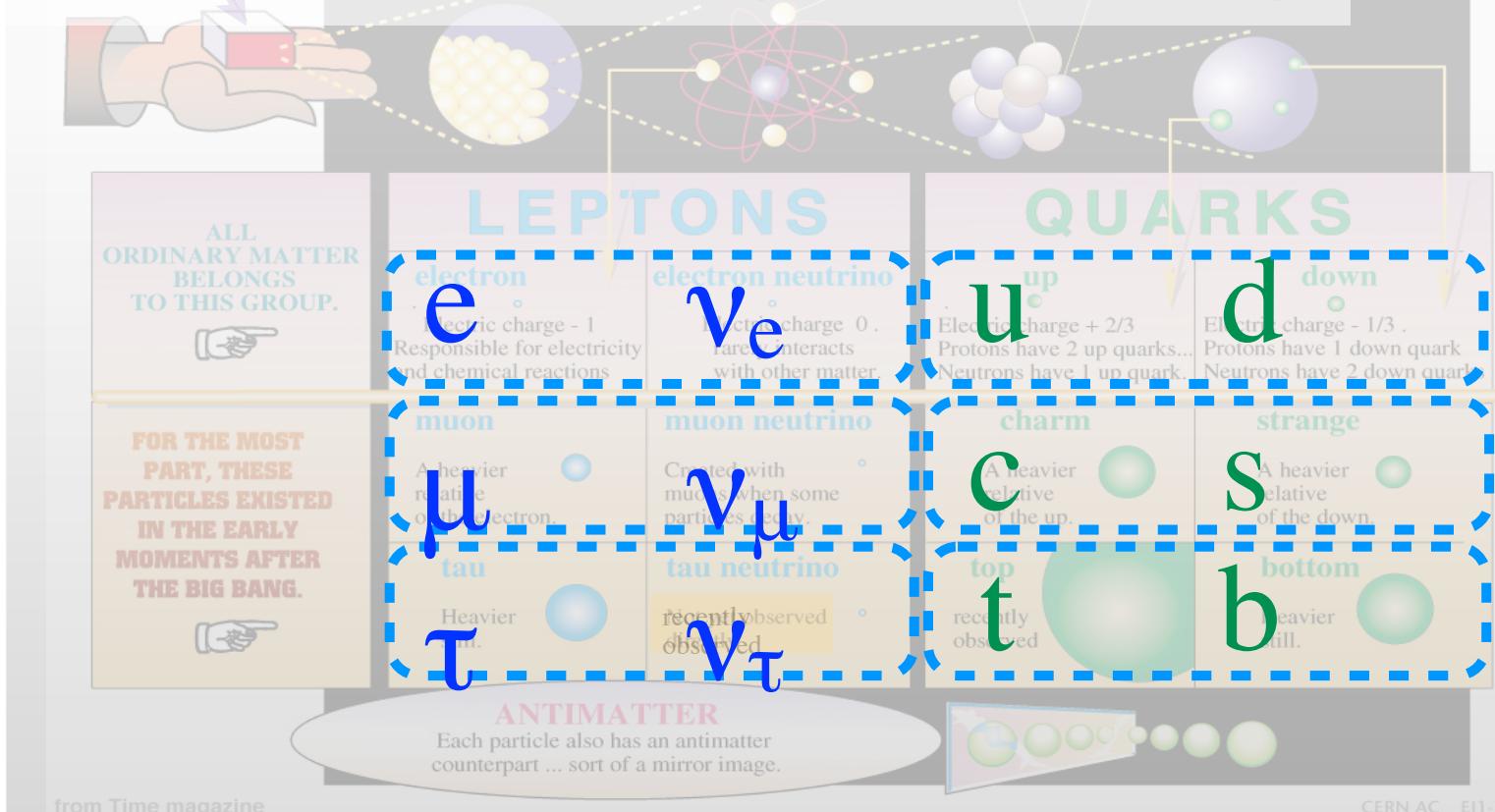
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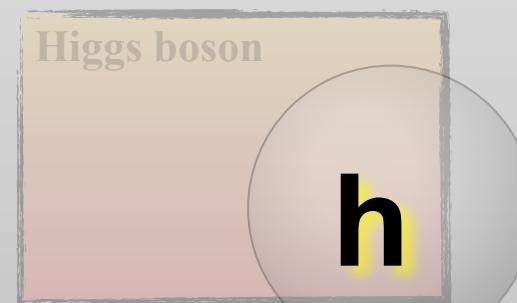


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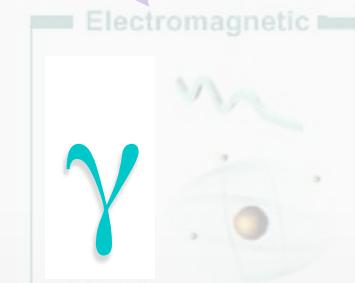
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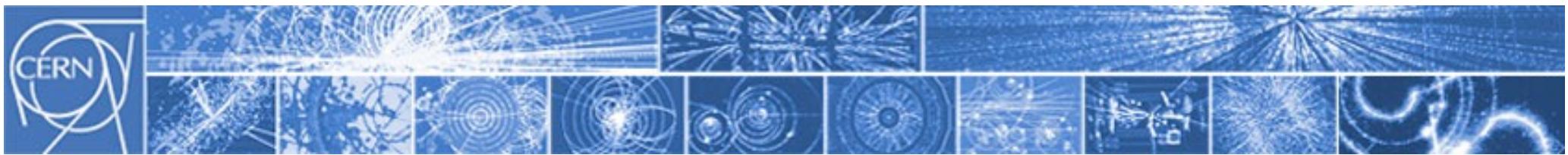


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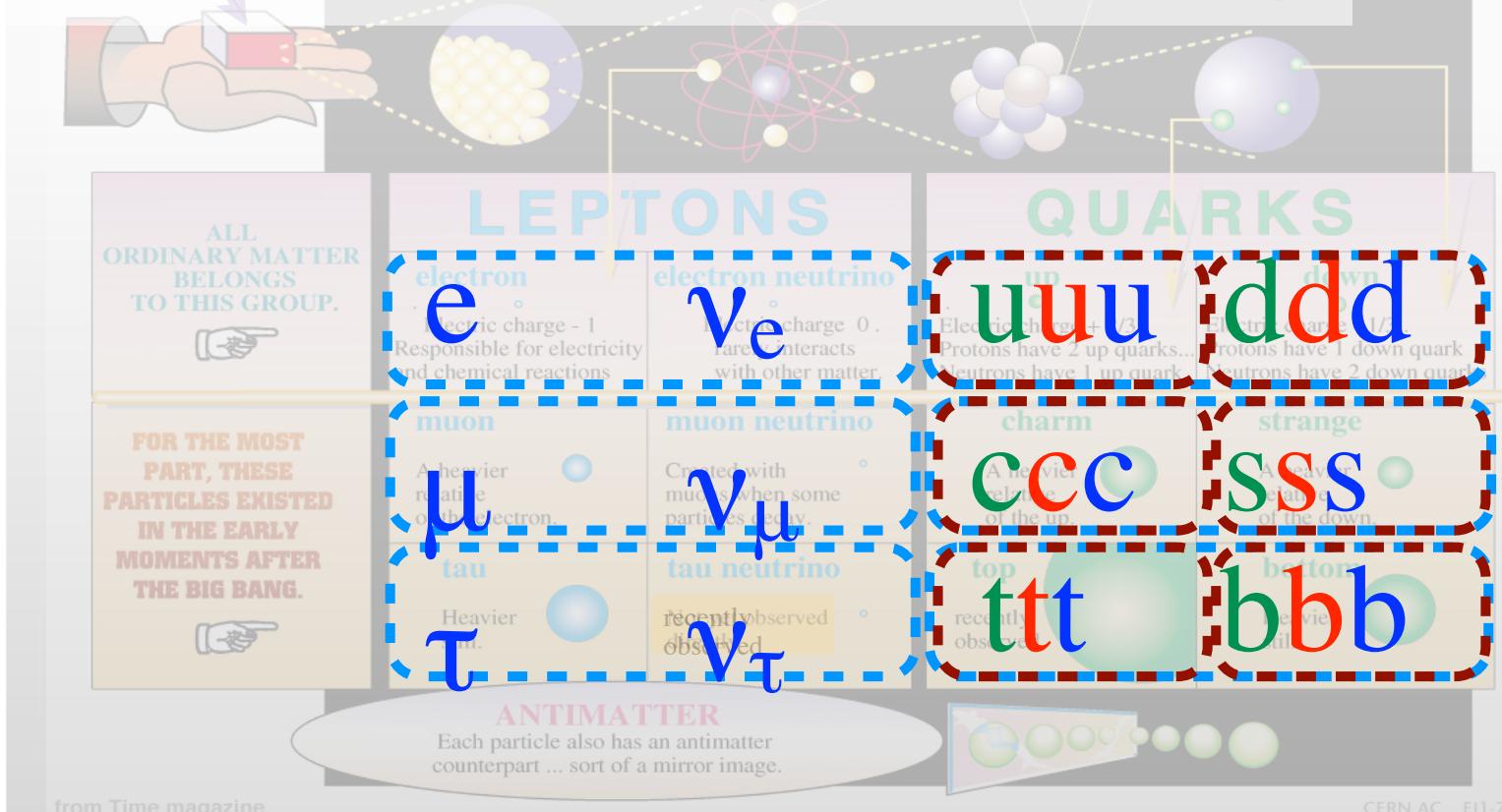
FORCES



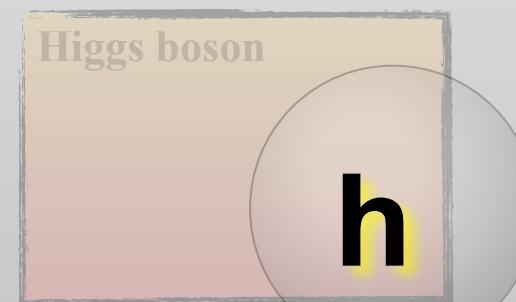


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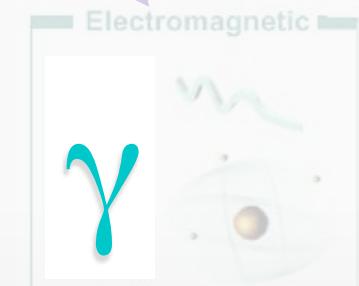
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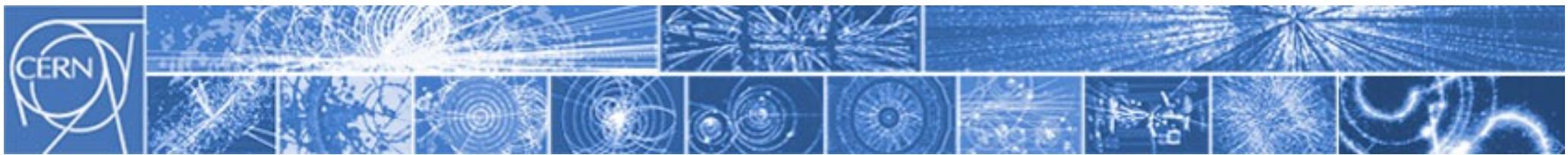


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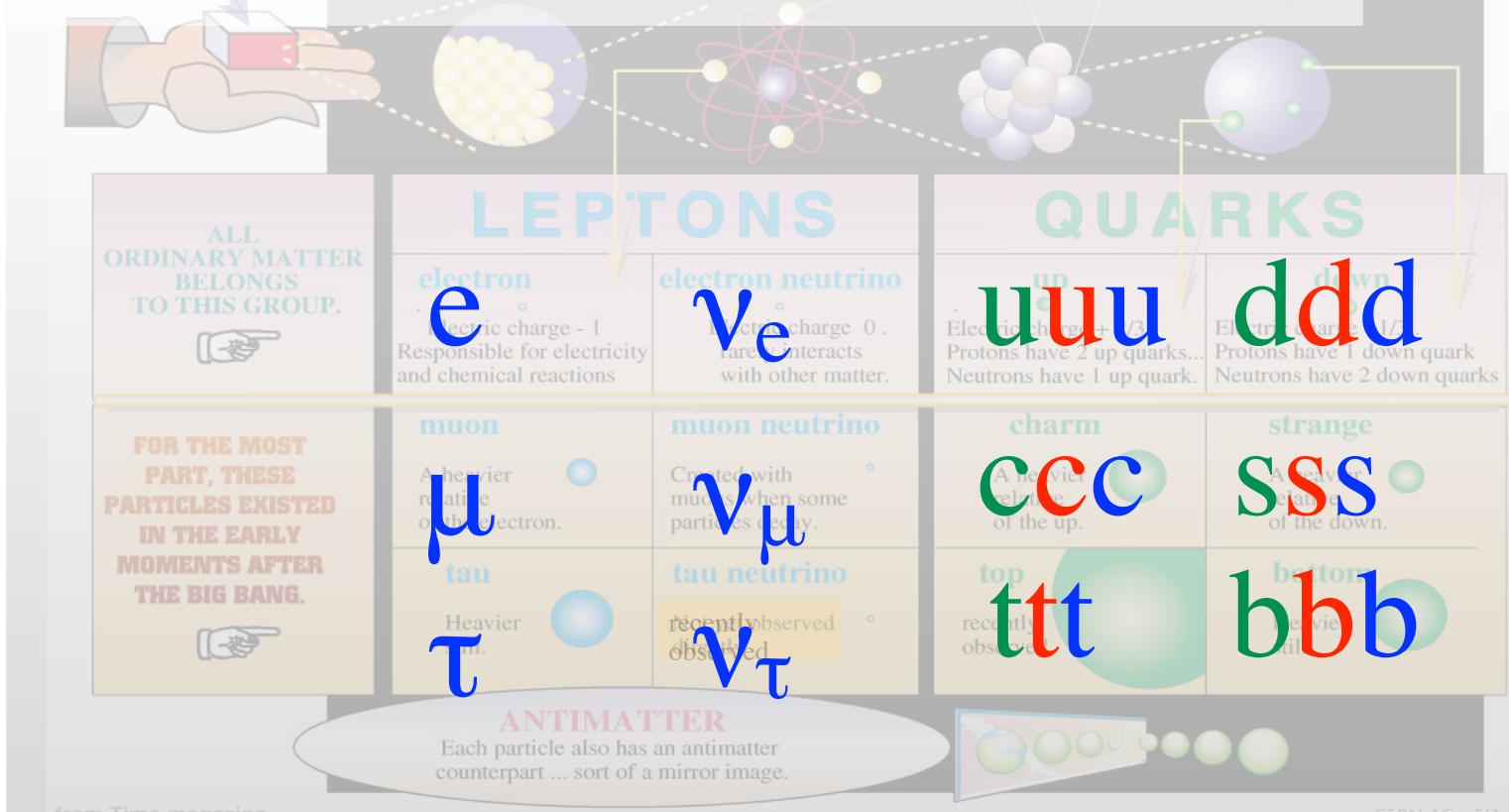
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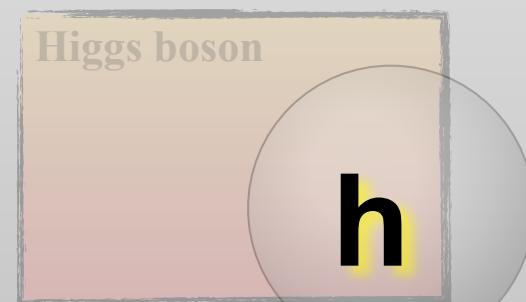


STANDARD MODEL

Interazioni (& simmetrie)



- $SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{\text{em}}(1)$
- colore e carica elettrica



FORCES

Electromagnetic



Weak

Bosons (W, Z)

W^+ W^-



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Gluons (8)

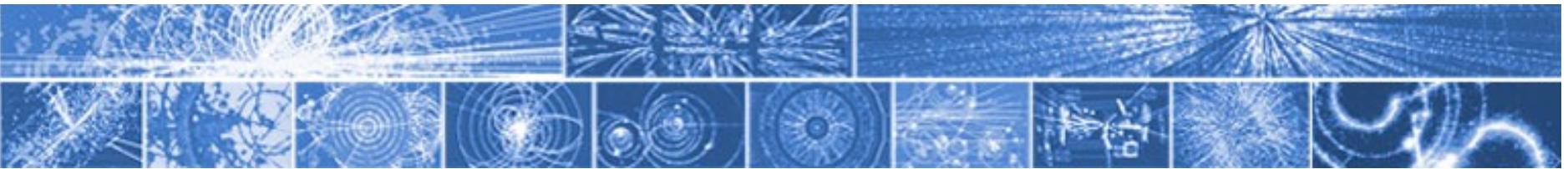
g (8)

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Interazioni (& simmetrie)

Family 1

Particle	Mass	Electric Charge	Strong Charge	Weak Charge
<i>Electron</i>	.0054	-1	0	-1/2
<i>Electron-Neutrino</i>	<10 ⁻⁸	0	0	1/2
<i>Up Quark</i>	.0047	2/3	red, green, blue	1/2
<i>Down Quark</i>	.0074	-1/3	red, green, blue	-1/2

Family 2

Particle	Mass	Electric Charge	Strong Charge	Weak Charge
<i>Muon</i>	.11	-1	0	-1/2
<i>Muon-Neutrino</i>	<.0003	0	0	1/2
<i>Charm Quark</i>	1.6	2/3	red, green, blue	1/2
<i>Strange Quark</i>	.16	-1/3	red, green, blue	-1/2

Family 3

Particle	Mass	Electric Charge	Strong Charge	Weak Charge
<i>Tau</i>	1.9	-1	0	-1/2
<i>Tau-Neutrino</i>	<.033	0	0	1/2
<i>Top Quark</i>	189	2/3	red, green, blue	1/2
<i>Bottom Quark</i>	5.2	-1/3	red, green, blue	-1/2