

CERN

European Organization for Nuclear Research

Organisation Européenne pour la Recherche Nucléaire

Fisica delle particelle oggi

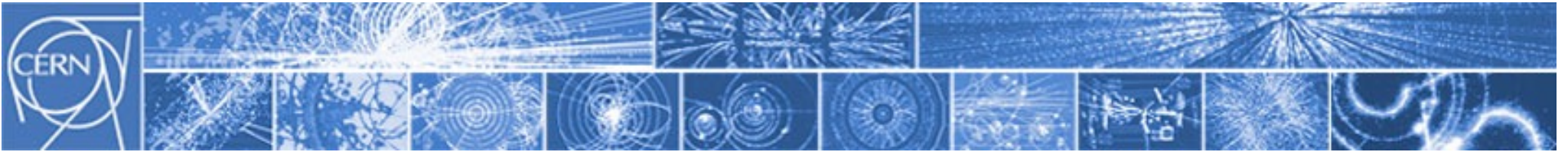
Il Modello Standard

and Beyond

- Bosone di Higgs
- SuperSimmetria
- Astroparticle & Materia Oscura

Marco CIRELLI [CNRS LPTHE Jussieu & Sorbonne]

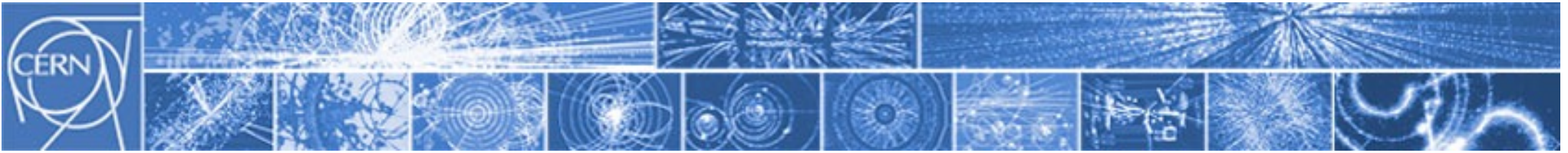
Mini-intro:
- livello variabile
- non storico
- about MC



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?

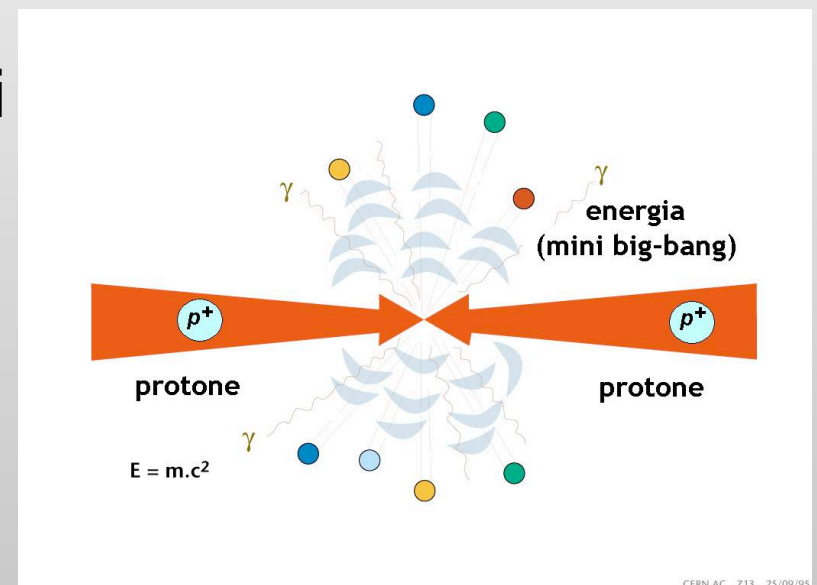
Accelerare le particelle elementari (*protoni, elettroni...*)

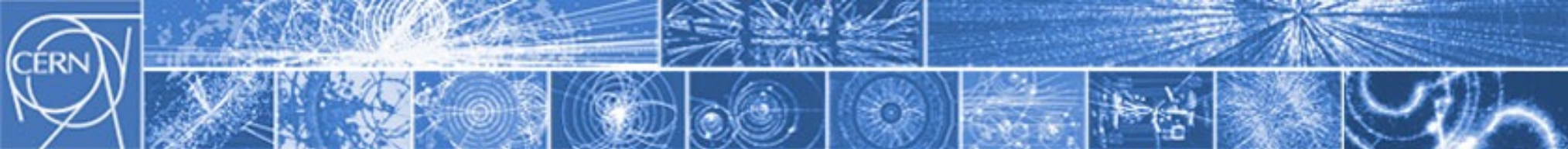
fino a energie elevatissime (*14 TeV*)

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

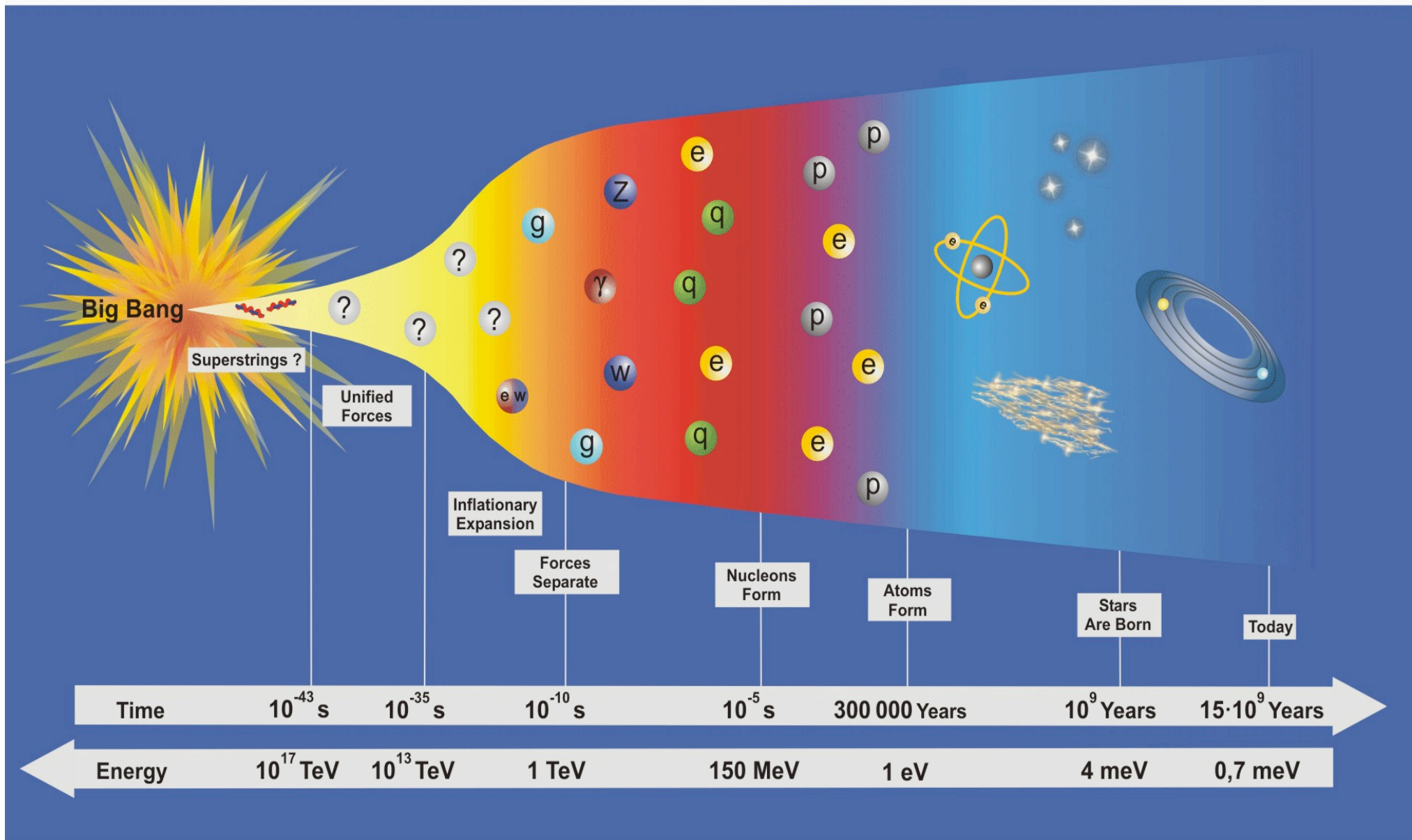
Analizzare accuratamente i prodotti

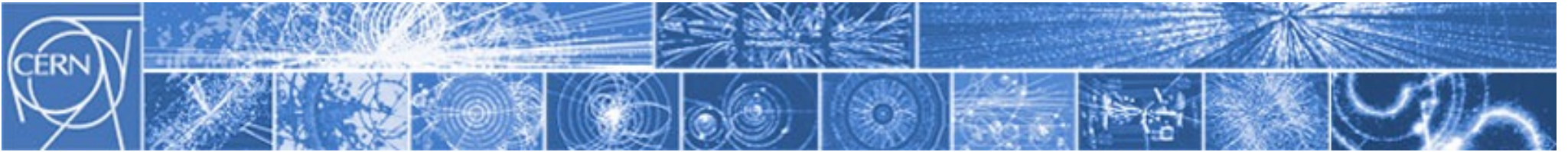
per scoprire nuove particelle,
nuove forze,
'nuova fisica'...





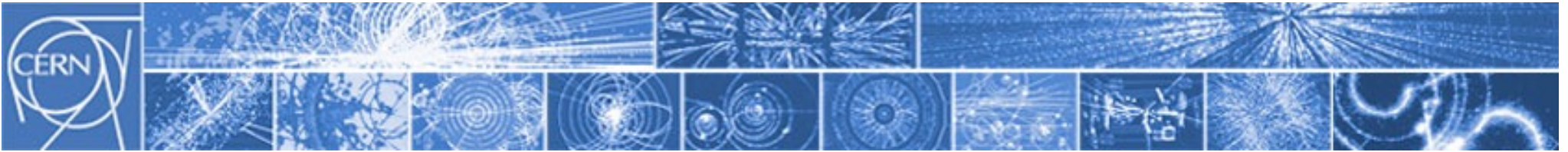
Ripercorrere all'indietro la storia dell'Universo





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

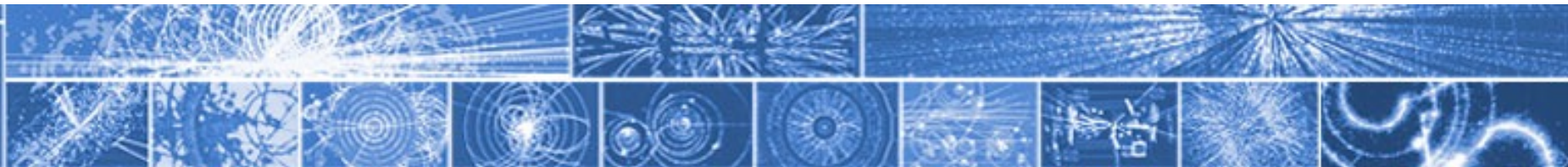
1932 teoria di Fermi del decadimento beta - interazioni deboli

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

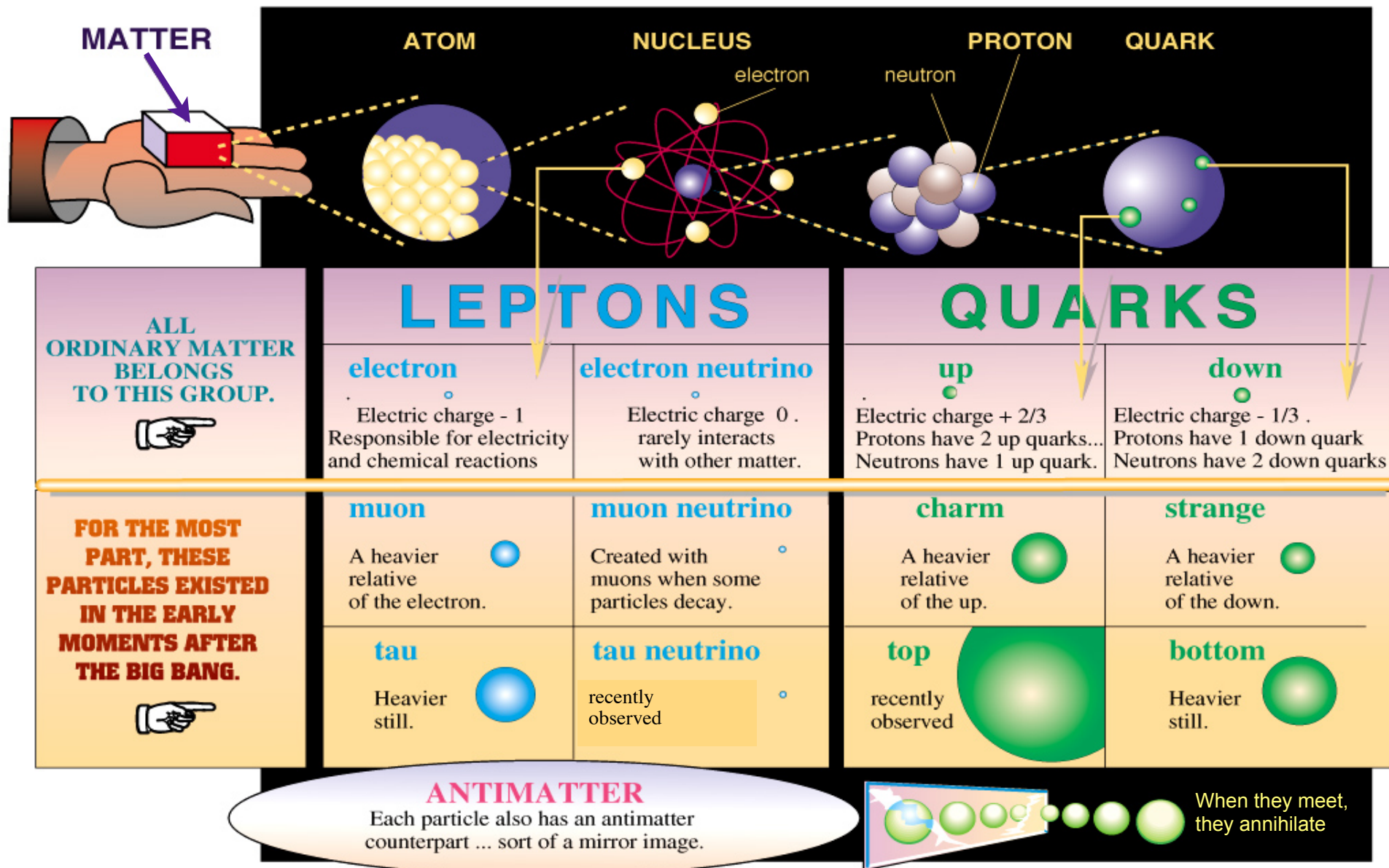
1981 scoperta bosoni W e Z (Rubbia)

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

1936	μ	1968	s quark	2012	higgs
1956	ν_e	1974	c quark		
1962	ν_μ	1977	b quark		
1974	τ	1995	t quark		
2000	ν_τ				



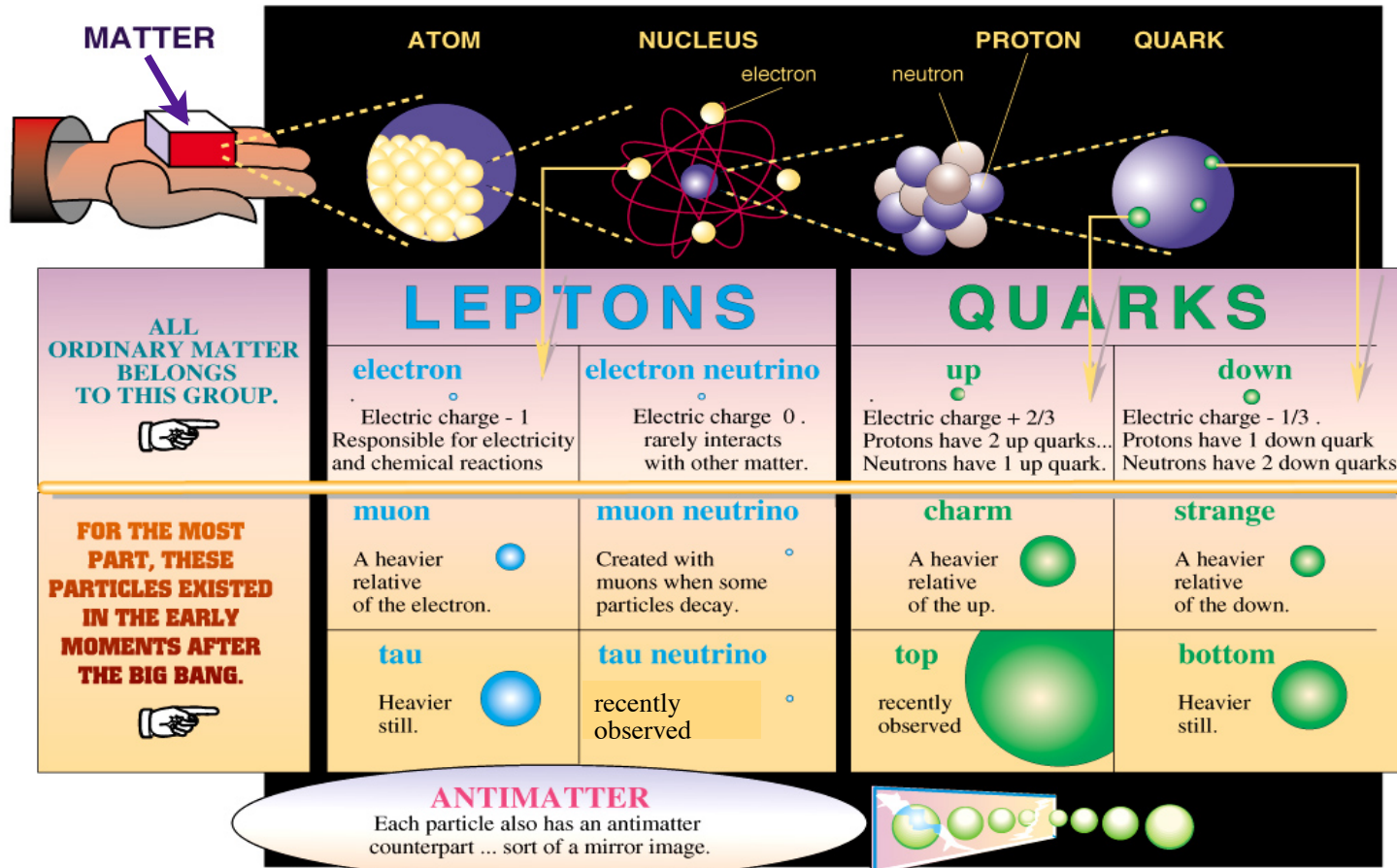
STANDARD MODEL





STANDARD MODEL

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

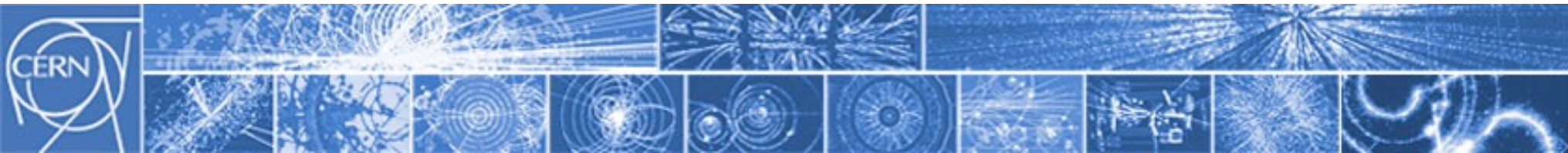
Mesons
Baryons

Nuclei

Gravitational

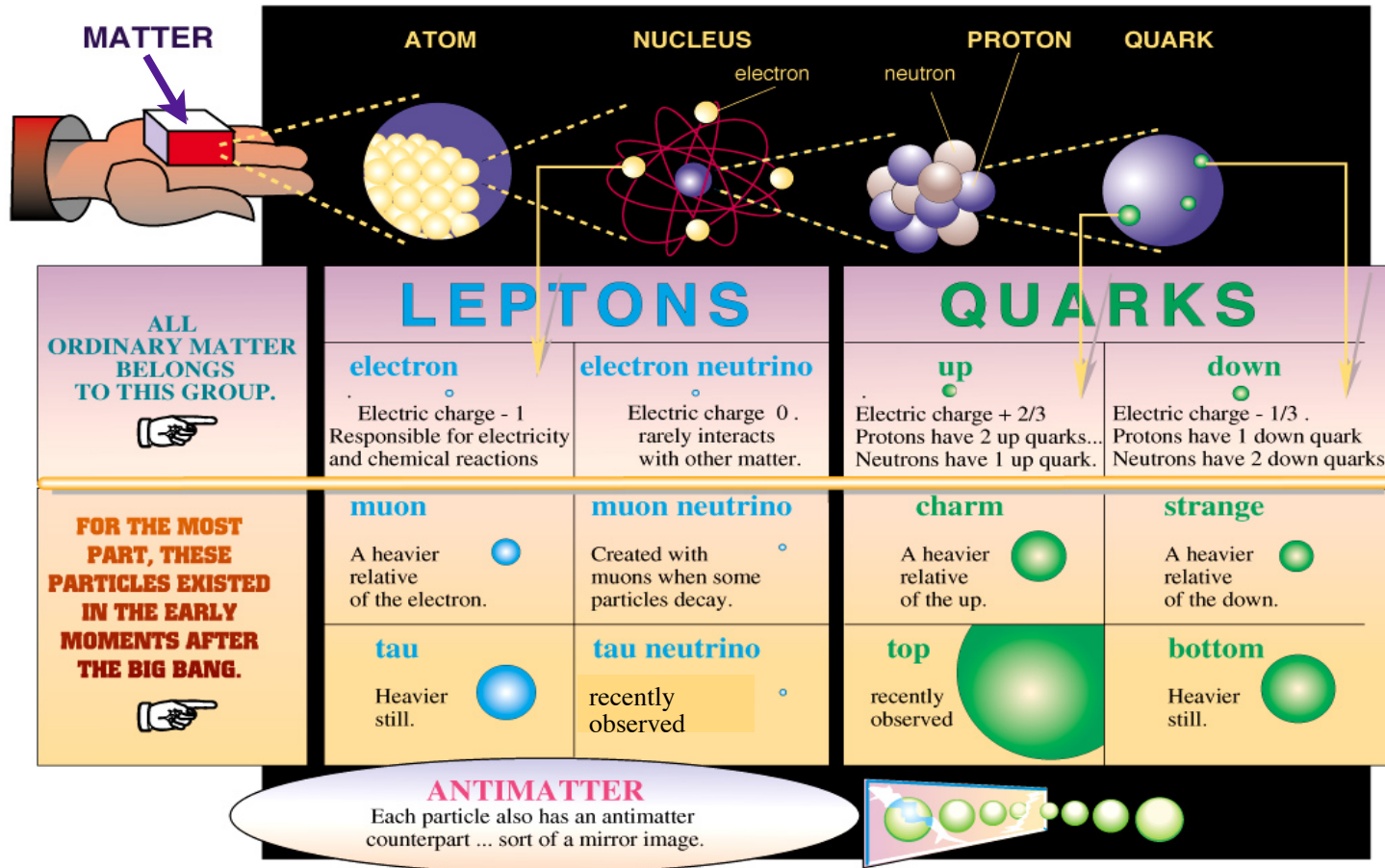
Graviton ?

Solar system
Galaxies
Black holes



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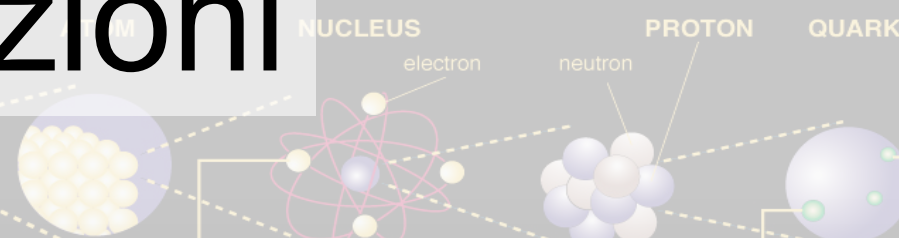
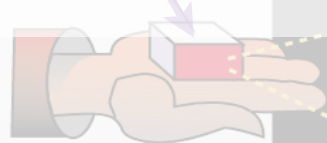
from Time magazine

CERN AC _ E11-7



STANDARD MODEL

Interazioni



<p>ALL ORDINARY MATTER BELONGS TO THIS GROUP.</p>	<p>LEPTONS</p>		<p>QUARKS</p>	
	<p>electron e Electric charge - 1 Responsible for electricity and chemical reactions</p>	<p>electron neutrino ν_e Electric charge 0. Rarely interacts with other matter.</p>	<p>up u Electric charge + 2/3 Protons have 2 up quarks... Neutrons have 1 up quark.</p>	<p>down d Electric charge - 1/3. Protons have 1 down quark Neutrons have 2 down quarks</p>
<p>FOR THE MOST PART, THESE PARTICLES EXISTED IN THE EARLY MOMENTS AFTER THE BIG BANG.</p>	<p>muon μ A heavier relative of the electron.</p>	<p>muon neutrino ν_μ Created with muons when some particles decay.</p>	<p>charm c A heavier relative of the up.</p>	<p>strange s A heavier relative of the down.</p>
	<p>tau τ Heavier still.</p>	<p>tau neutrino ν_τ recently observed</p>	<p>top t recently observed</p>	<p>bottom b heavier still.</p>

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

from Time magazine

CERN AC... E11-7

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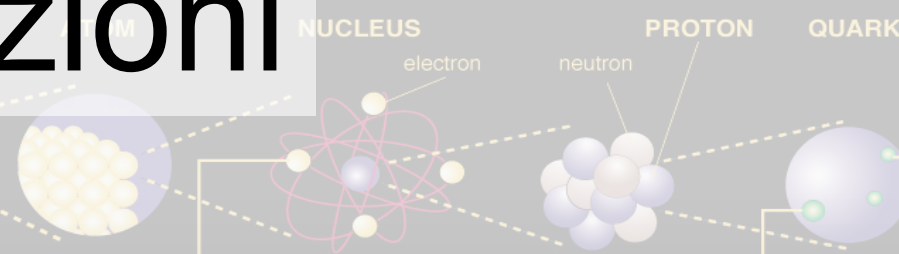
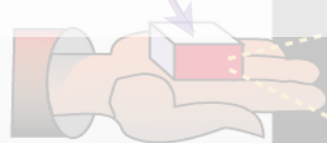
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	<p>μ</p> <p>muon</p> <p>A heavier relative of the electron.</p>	<p>ν_μ</p> <p>muon neutrino</p> <p>Created with muons when some particles decay.</p>	<p>c</p> <p>charm</p> <p>A heavier relative of the up.</p>	<p>s</p> <p>strange</p> <p>A heavier relative of the down.</p>
<p>τ</p> <p>tau</p> <p>Heavier still.</p>	<p>ν_τ</p> <p>tau neutrino</p> <p>recently observed</p>	<p>t</p> <p>top</p> <p>recently observed</p>	<p>b</p> <p>bottom</p> <p>heavier still.</p>	
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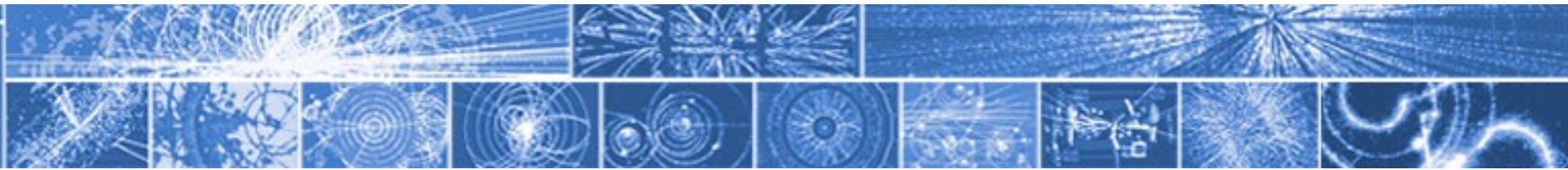
Solar system
Galaxies
Black holes

Higgs boson

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from Time magazine

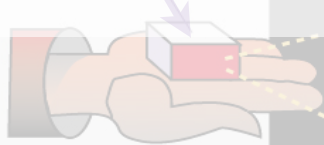
CERN AC E11-7



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<p>τ</p> <p>tau</p> <p>Heavier than the muon.</p>	<p>ν_τ</p> <p>tau neutrino</p> <p>recently observed</p>	<p>t</p> <p>top</p> <p>recently observed</p>	<p>b</p> <p>bottom</p> <p>heavier than the charm.</p>

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from Time magazine

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Higgs boson

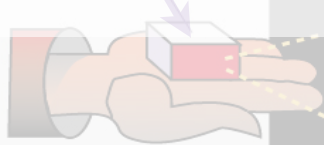
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<p>τ tau Heavier than the muon.</p>	<p>ν_τ tau neutrino recently observed</p>	<p>t top recently observed</p>	<p>b bottom heavier than the charm.</p>	

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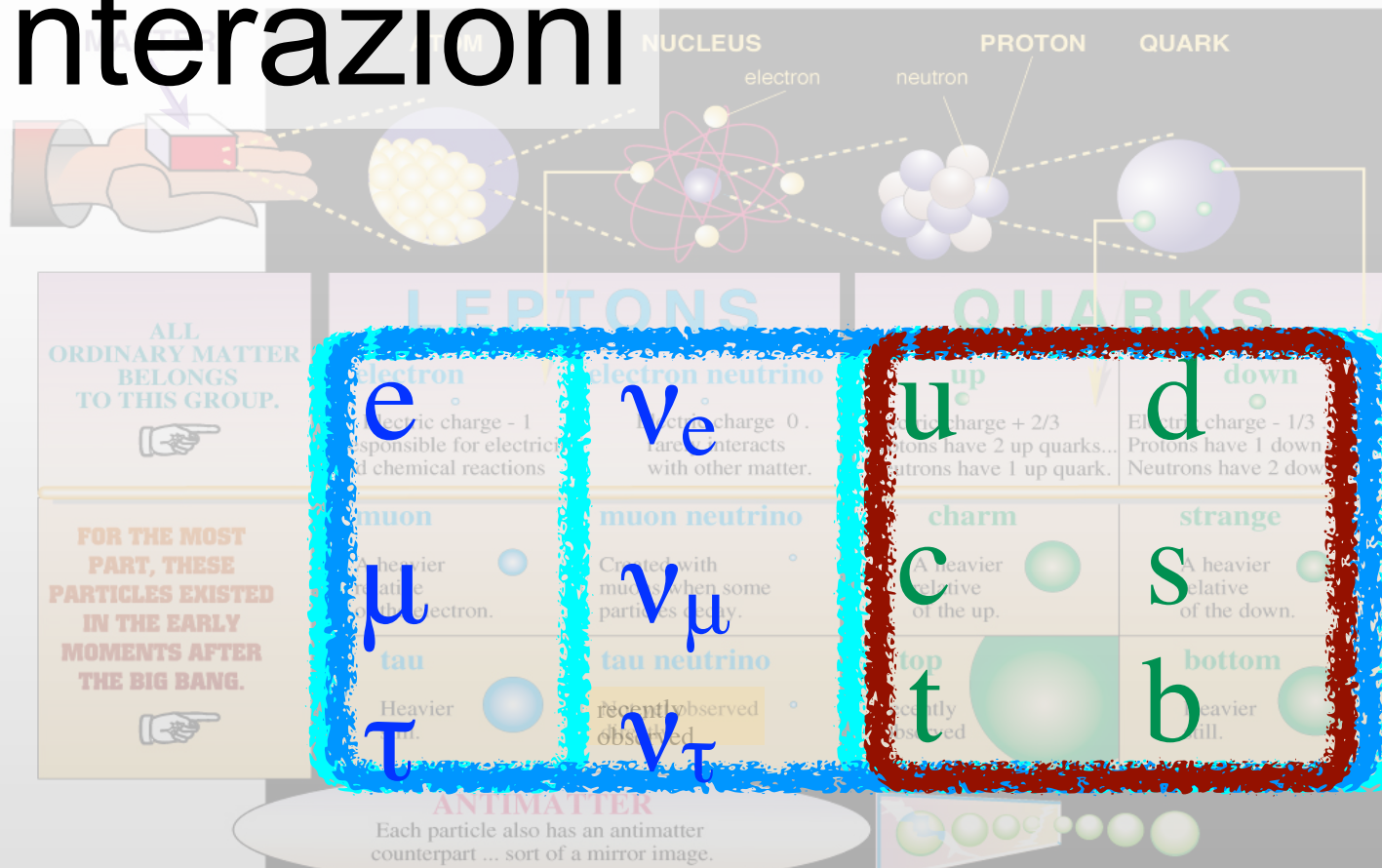
Graviton ?

Solar system
Galaxies
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Interazioni

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γ

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g (8)

Baryons, Nuclei

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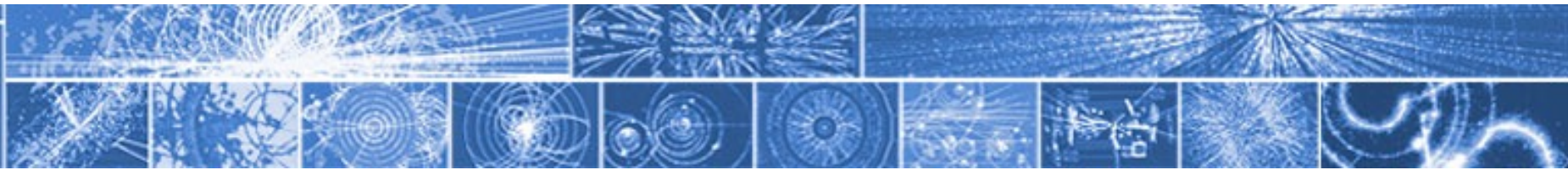
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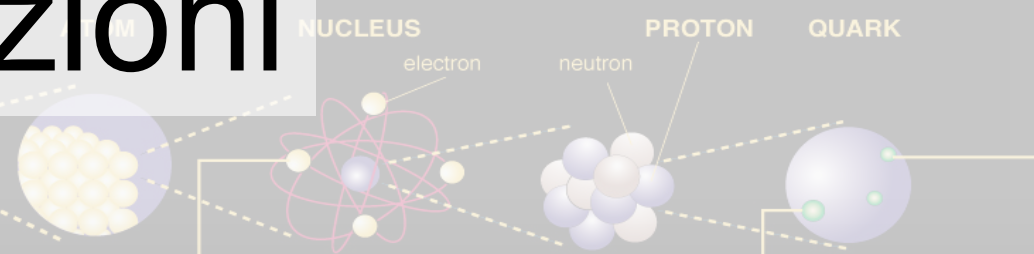
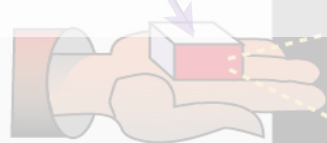
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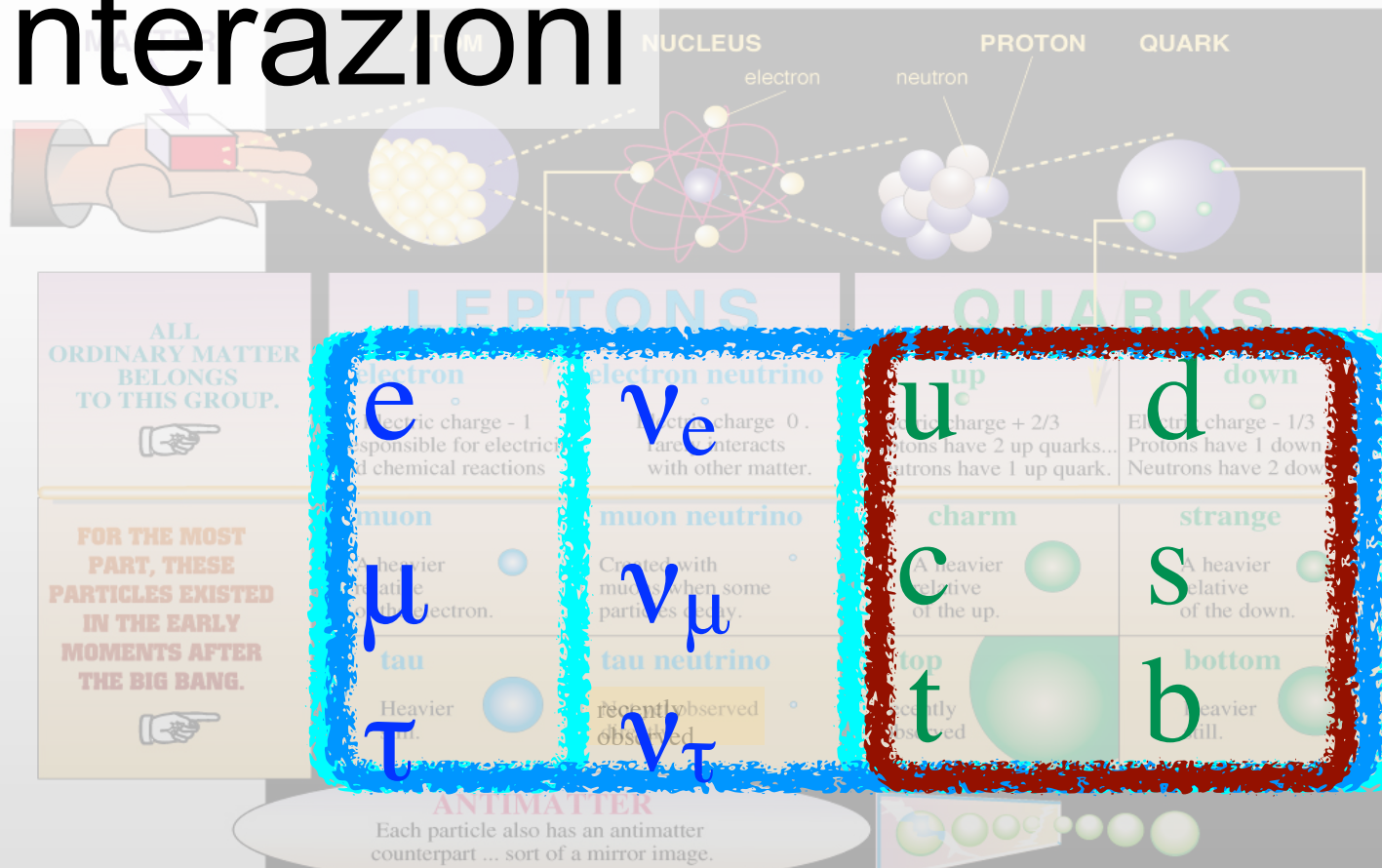
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Interazioni (& simmetrie)



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$$\triangleright SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{em}(1)$$

FORCES

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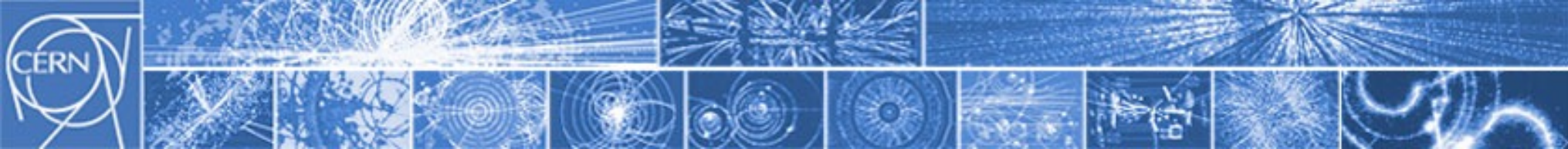
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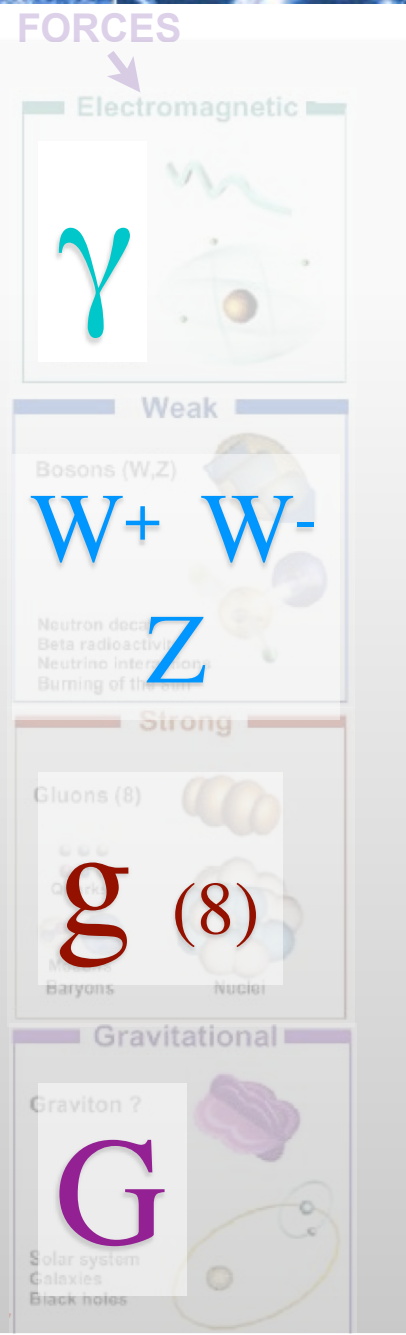
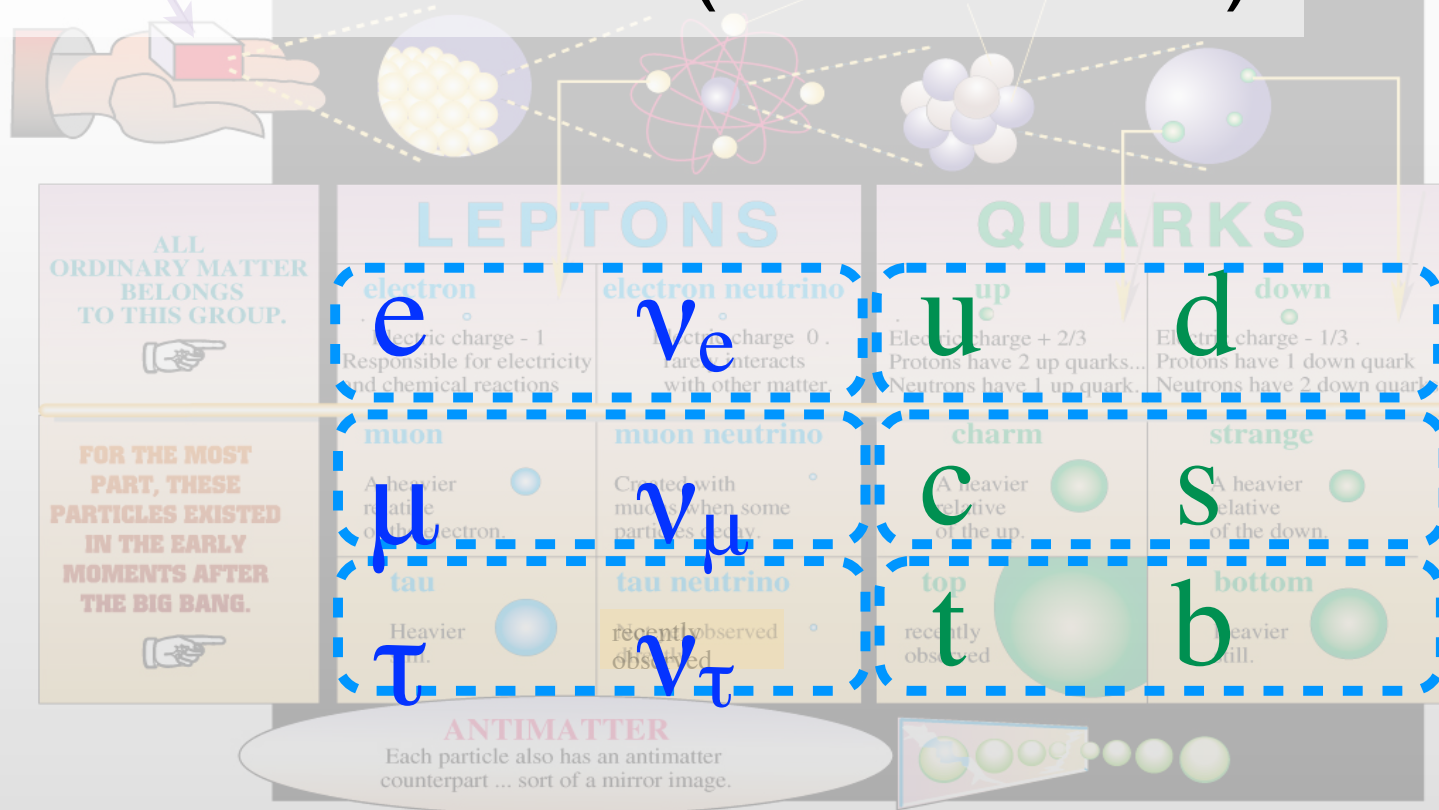
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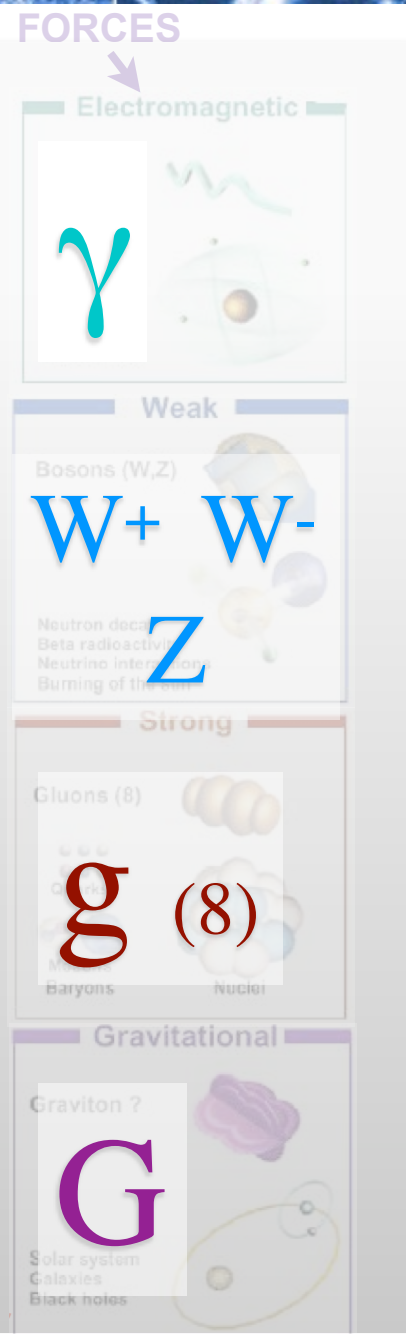
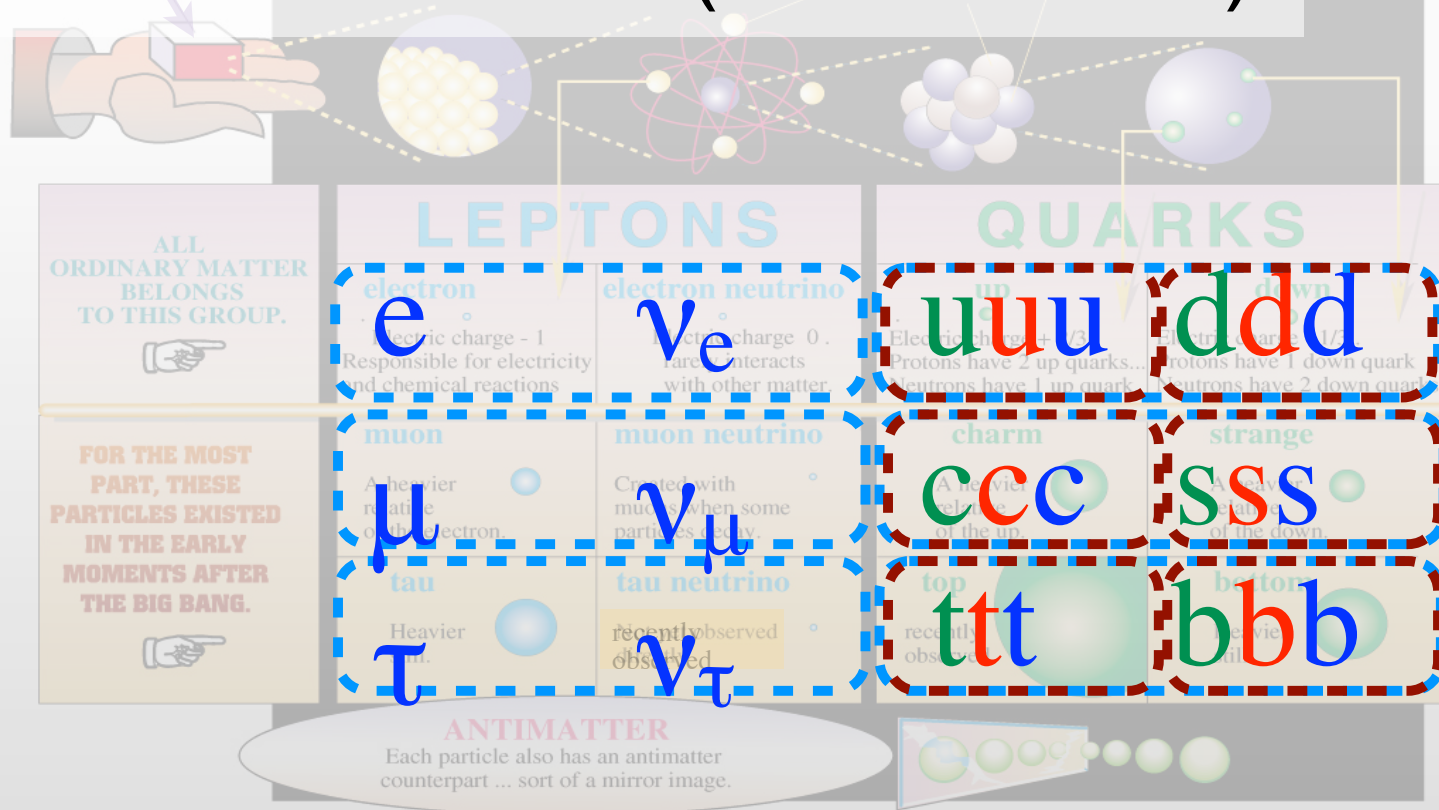
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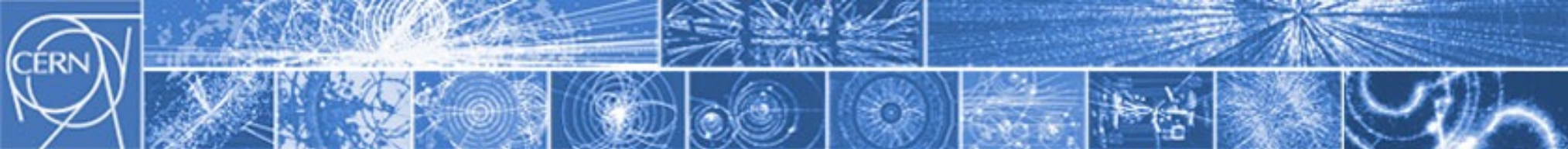
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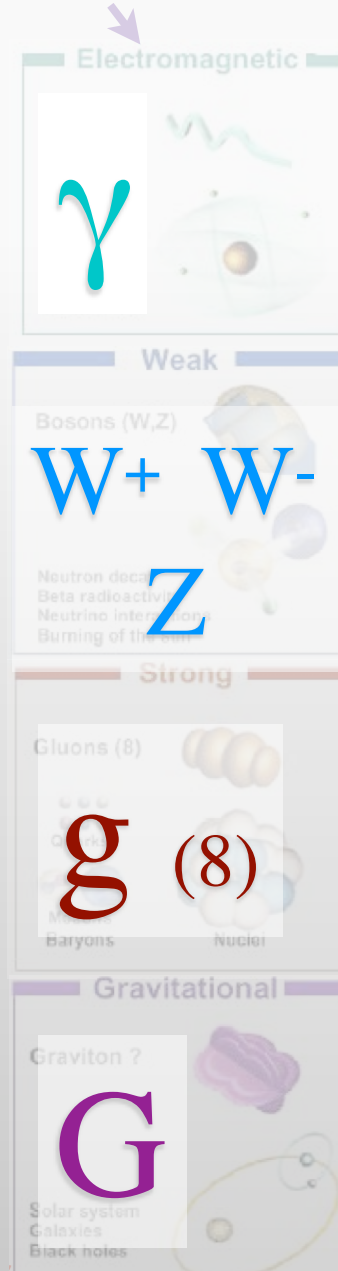
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- ▶ $SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{em}(1)$
- ▶ colore e carica elettrica

Higgs boson

h