Fisica delle particelle *oggi*

Il Modello Standard and Beyond

- Bosone di Higgs
- SuperSimmetria
- Astroparticle & Materia Oscura

Marco CIRELLI [CNRS Saclay]

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?

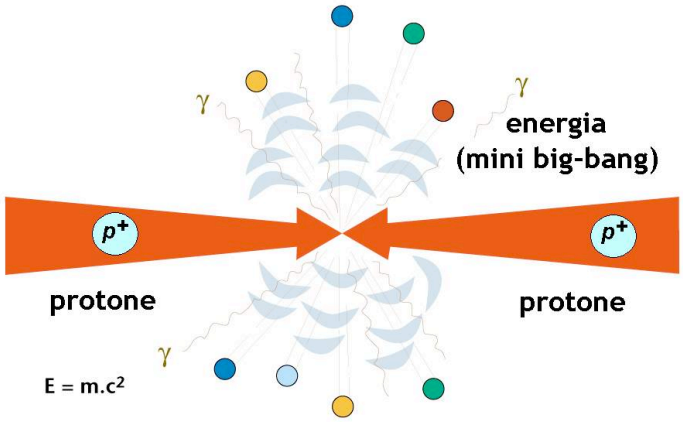
Accelerare le particelle elementari *(protoni, elettroni...)*

fino a energie elevatissime *(14 TeV)*

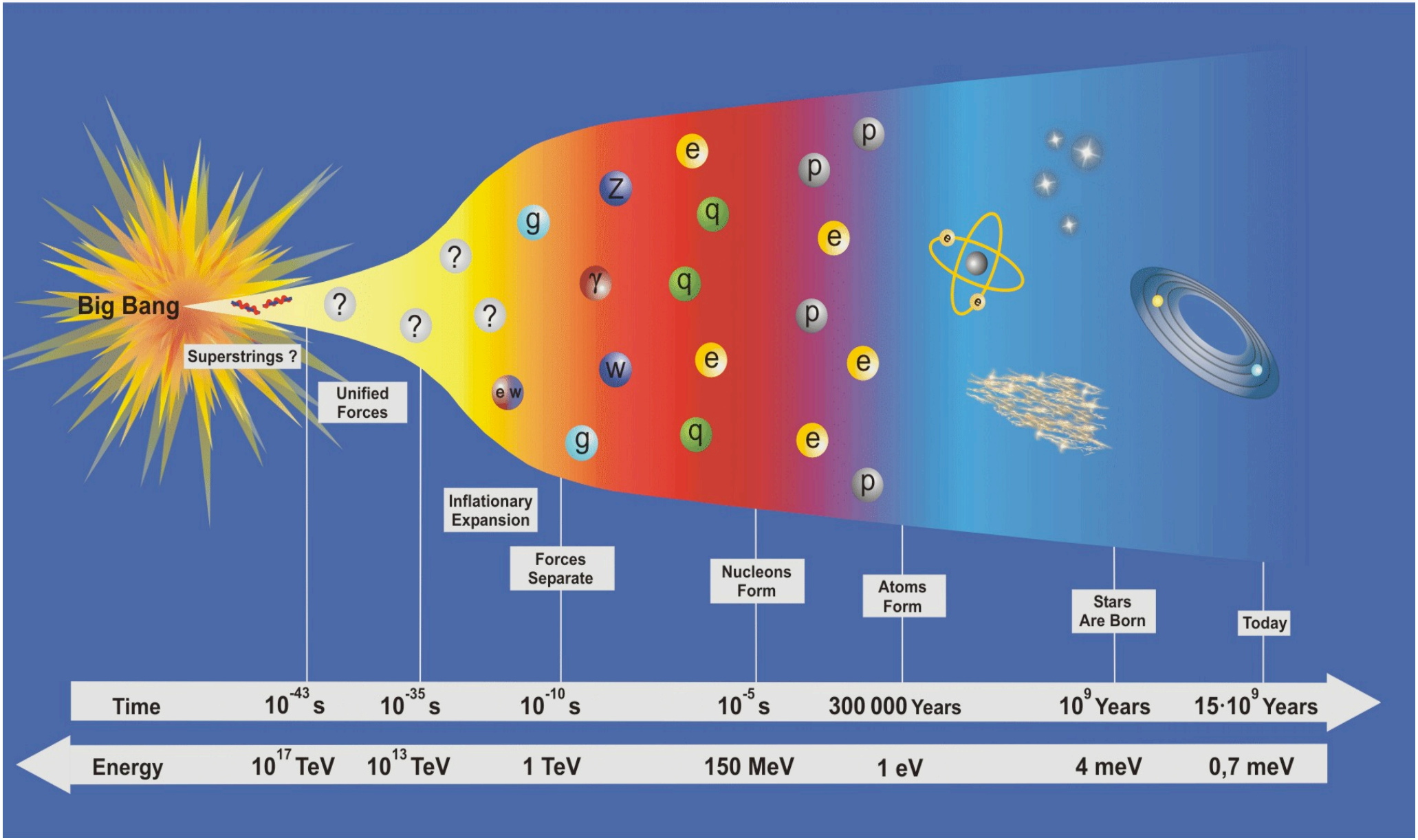
e portarle a collidere. $E=mc^2$

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)

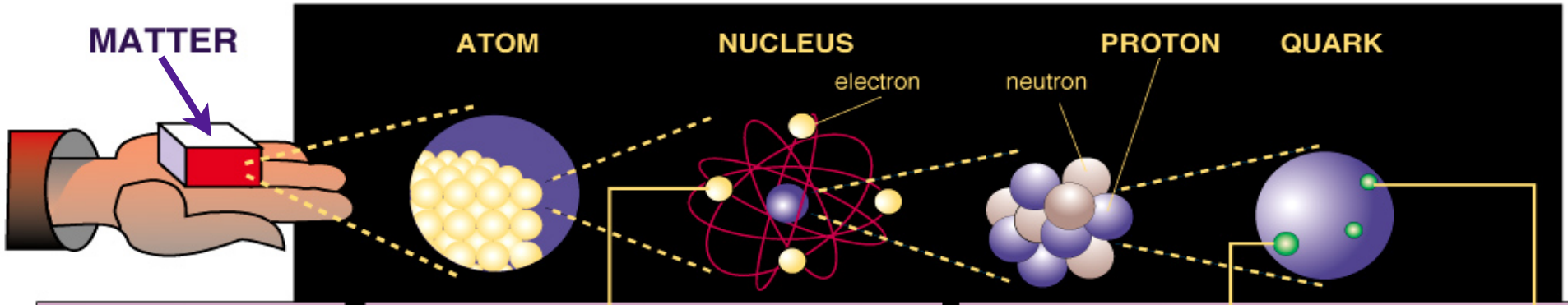
1981 scoperta bosoni W e Z (Rubbia)

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

STANDARD MODEL



ALL ORDINARY MATTER BELONGS TO THIS GROUP.

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

LEPTONS

electron
Electric charge - 1
Responsible for electricity and chemical reactions

electron neutrino
Electric charge 0 .
rarely interacts with other matter.

muon
A heavier relative of the electron.

muon neutrino
Created with muons when some particles decay.

tau
Heavier still.

tau neutrino
recently observed

QUARKS

up
Electric charge + 2/3
Protons have 2 up quarks...
Neutrons have 1 up quark.

down
Electric charge - 1/3 .
Protons have 1 down quark
Neutrons have 2 down quarks

charm
A heavier relative of the up.

strange
A heavier relative of the down.

top
recently observed

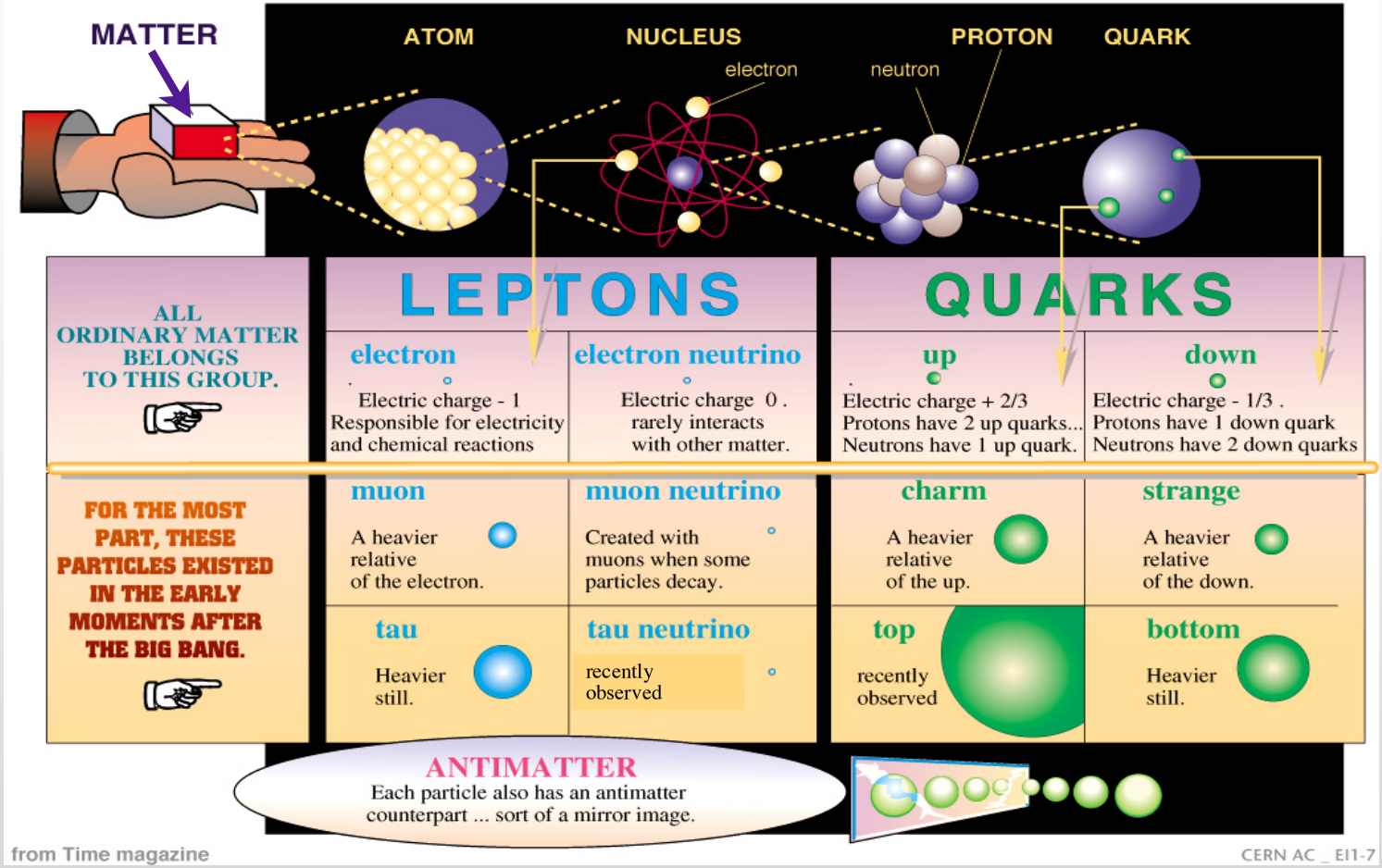
bottom
Heavier still.

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

When they meet, they annihilate

from Time magazine

STANDARD MODEL

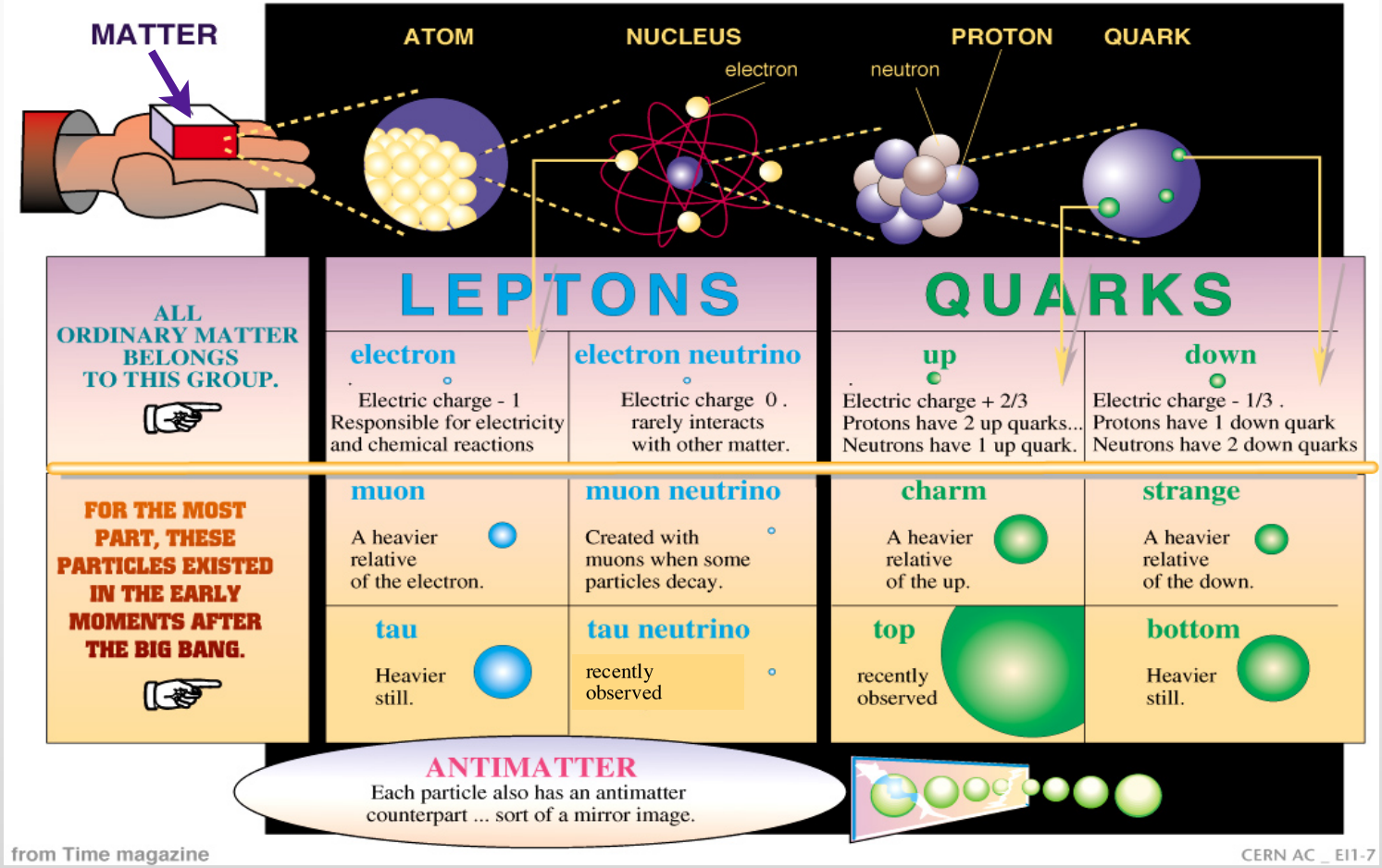


from Time magazine

CERN AC _ EI1-7

FORCES

STANDARD MODEL



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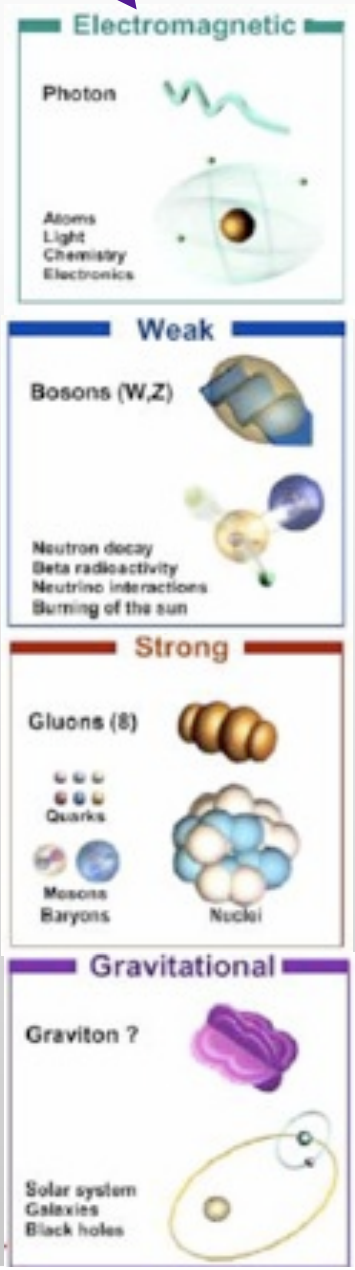
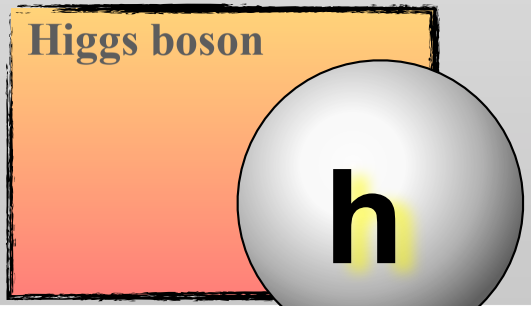
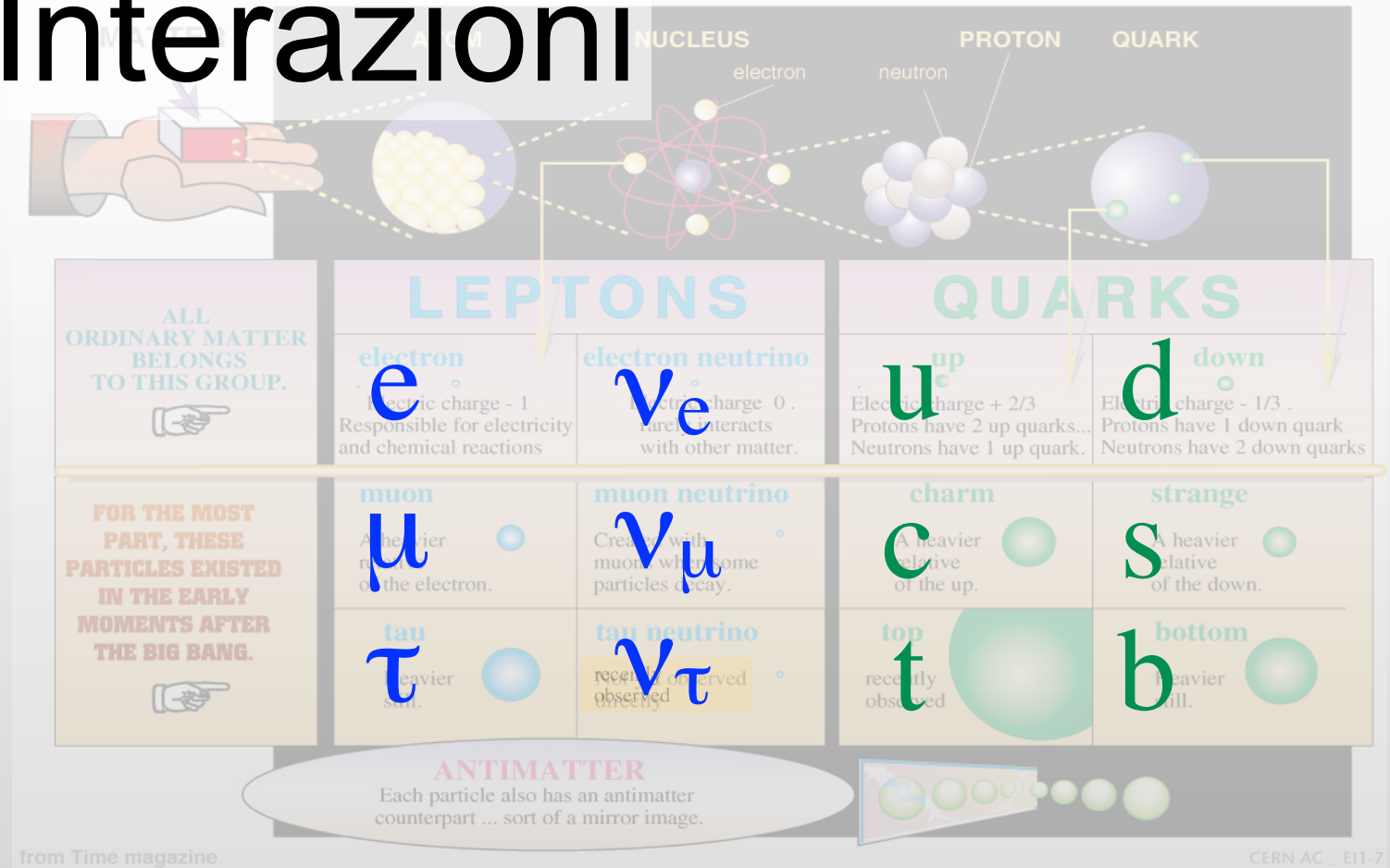
CERN AC _ EI1-7

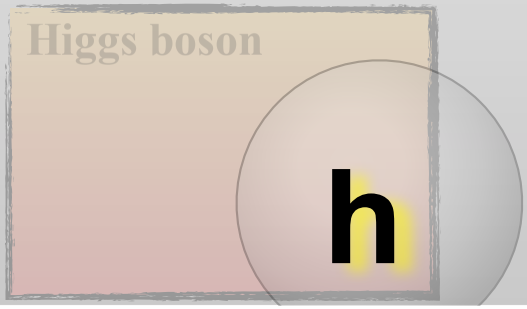
FORCES

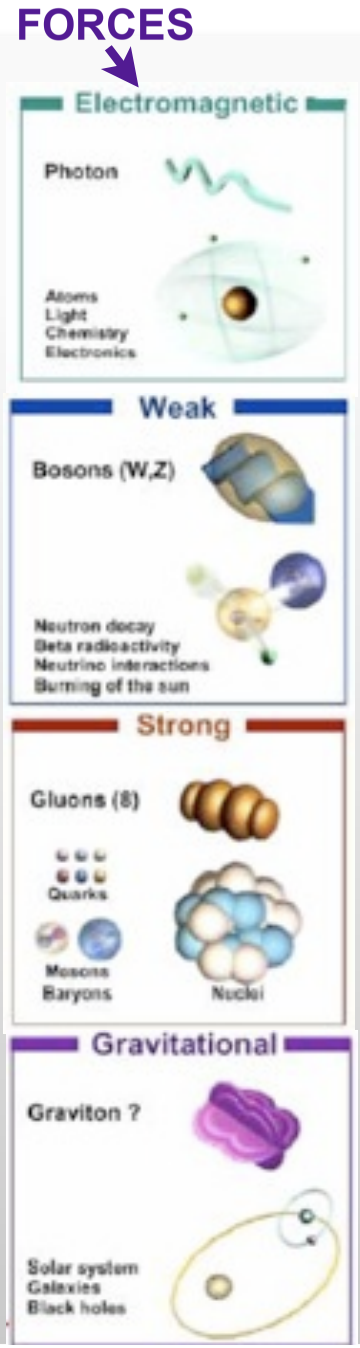




Interazioni







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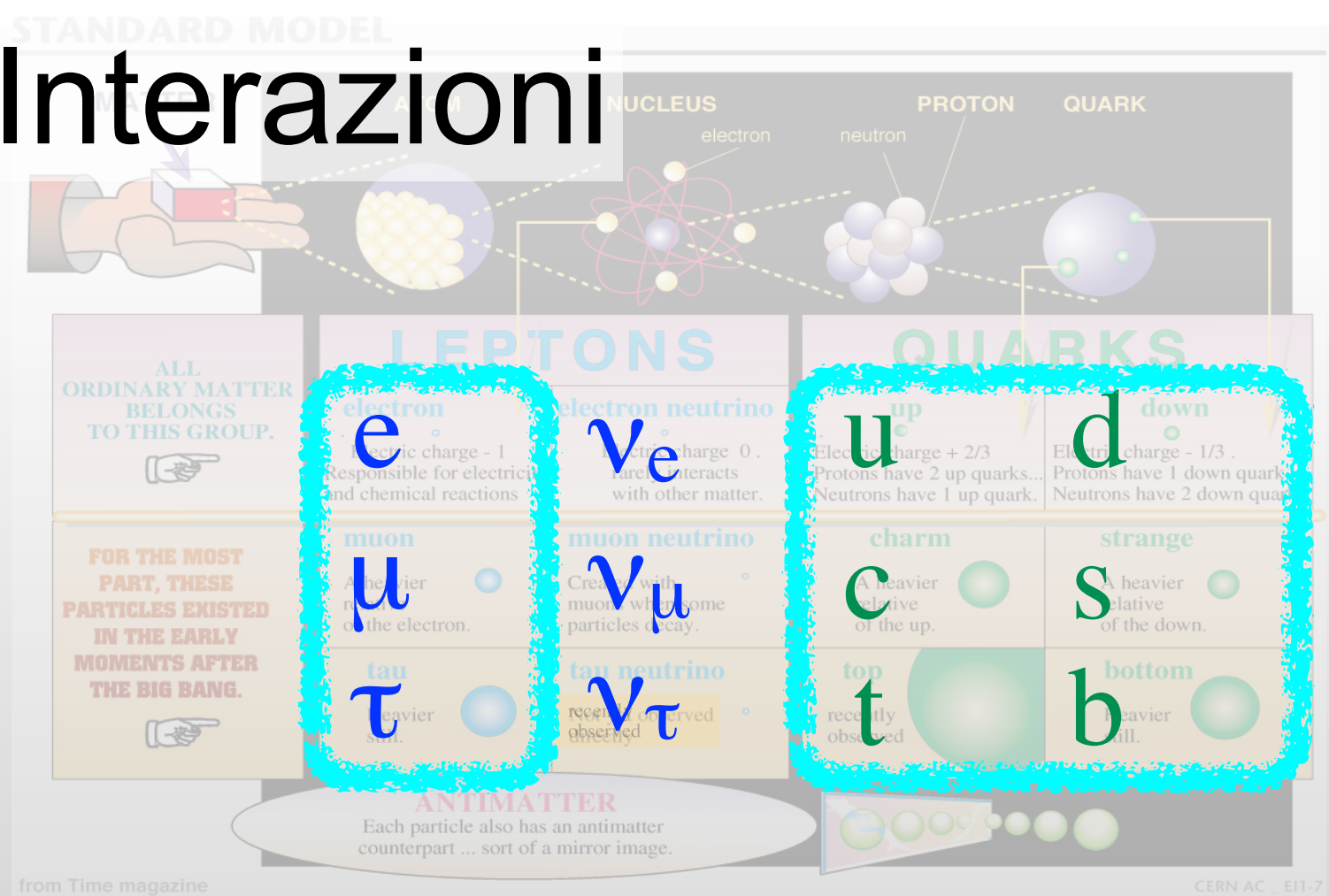

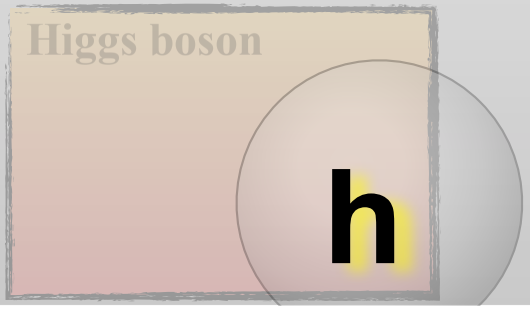

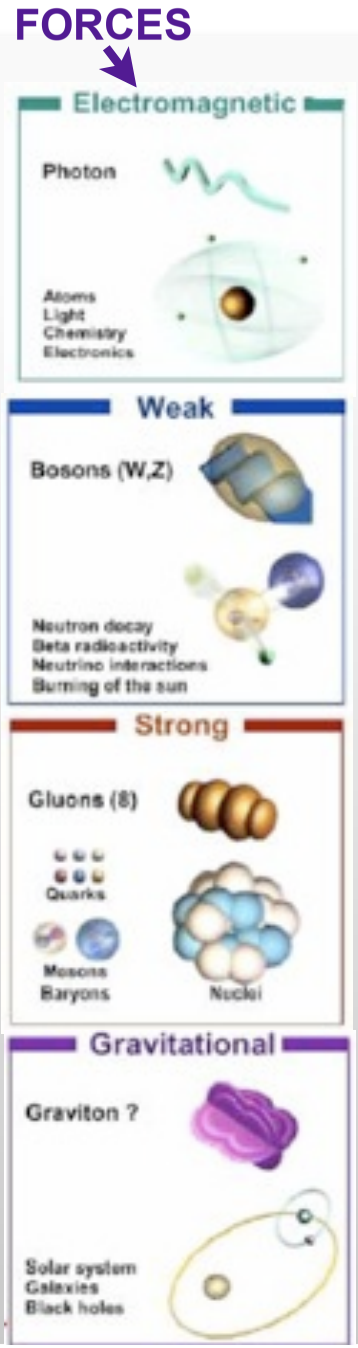

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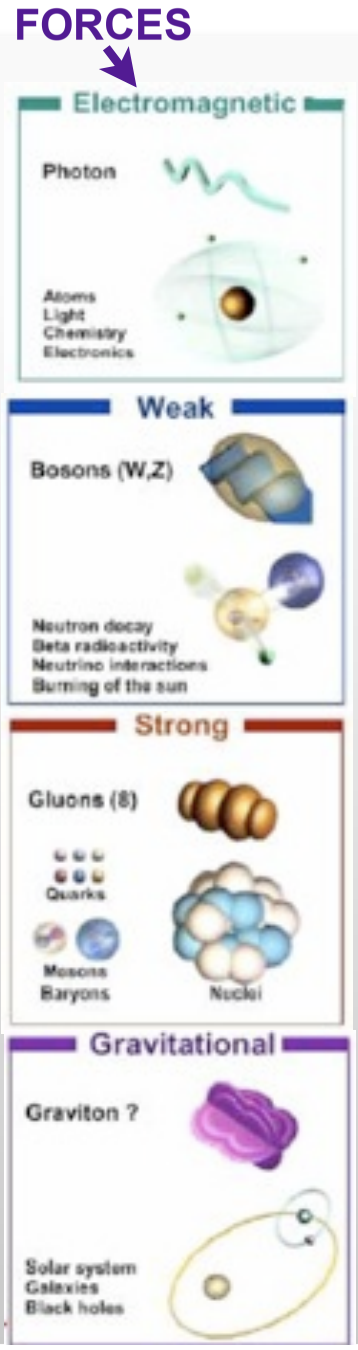
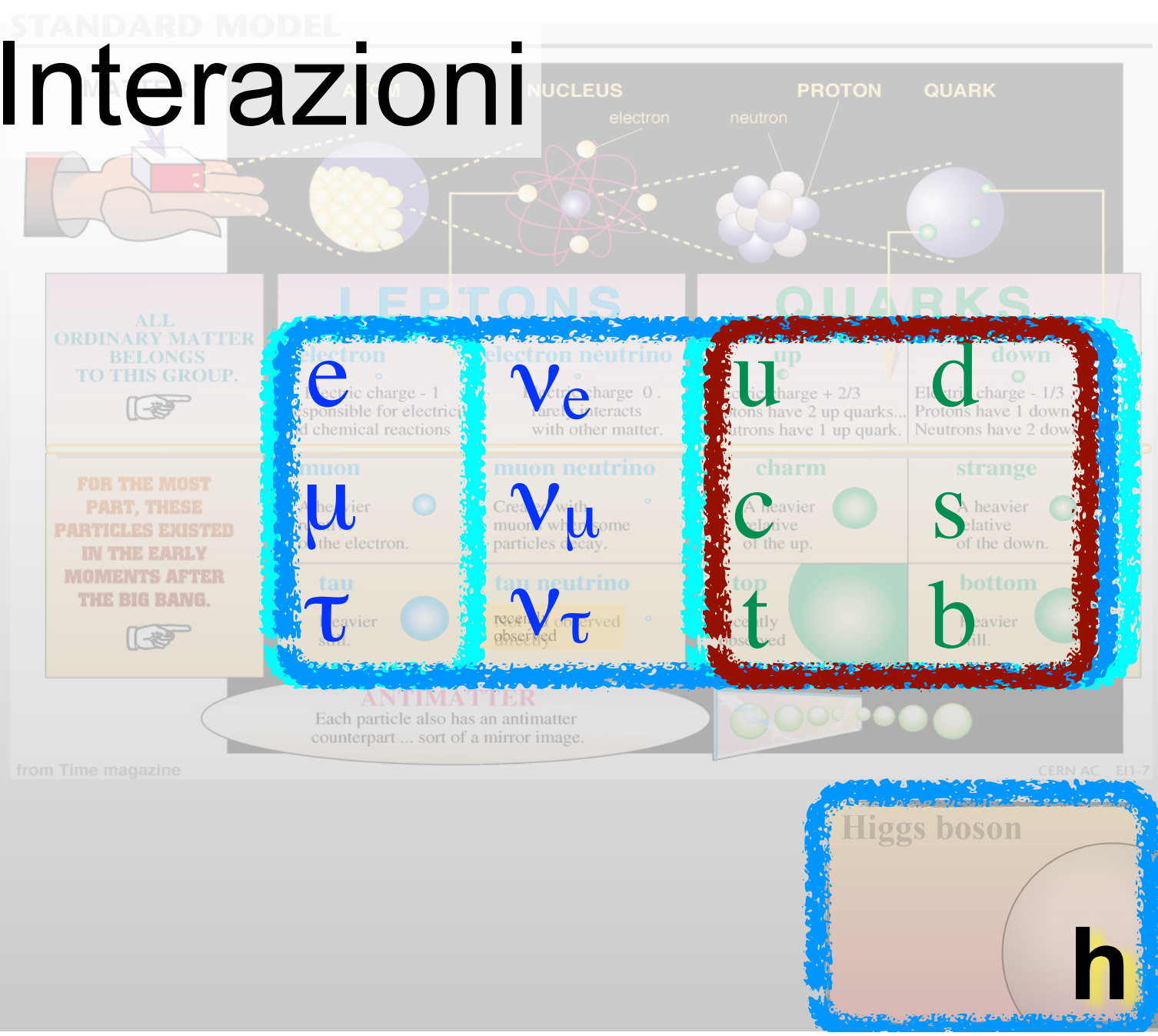
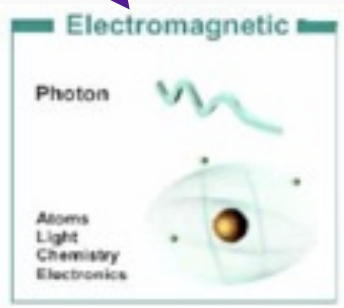
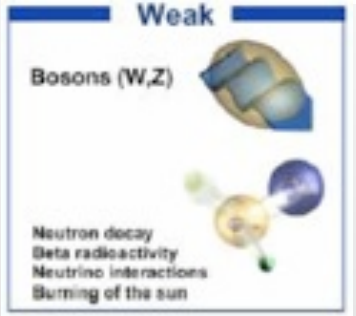


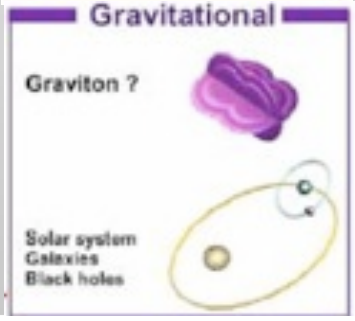
Interazioni



FORCES







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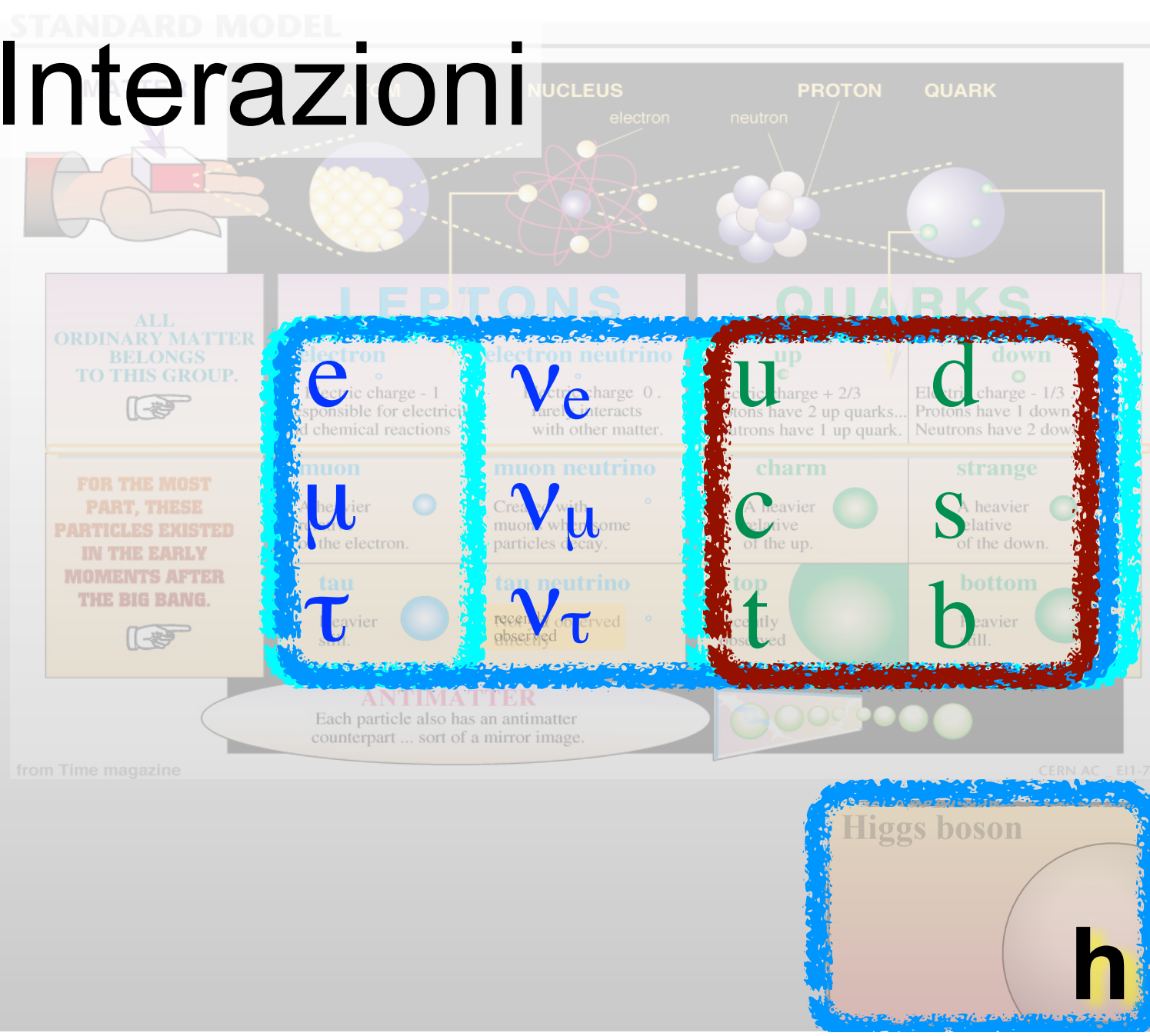
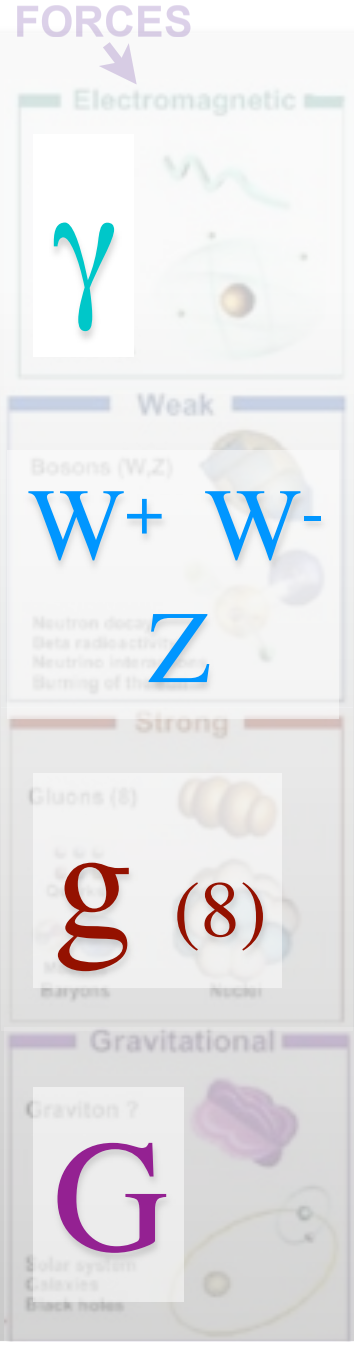
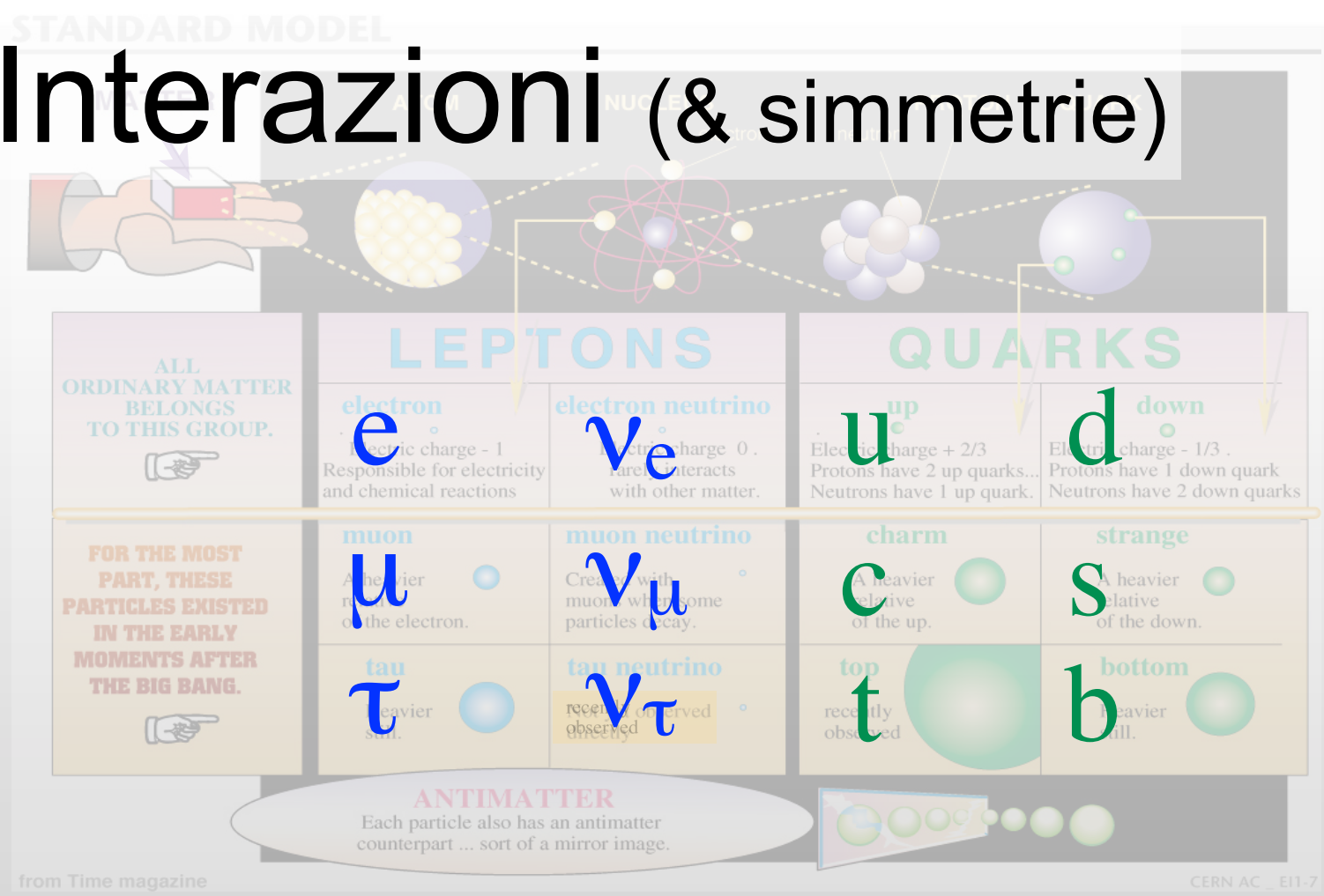
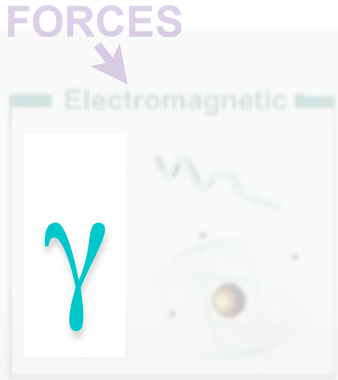


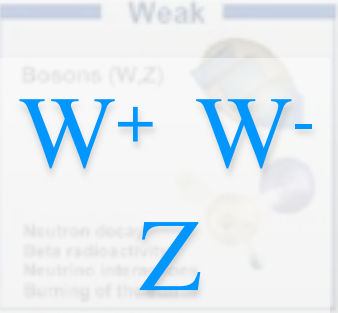


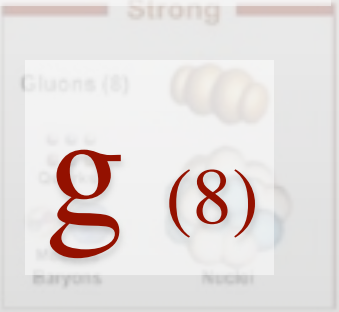
Interazioni

Interazioni (& simmetrie)

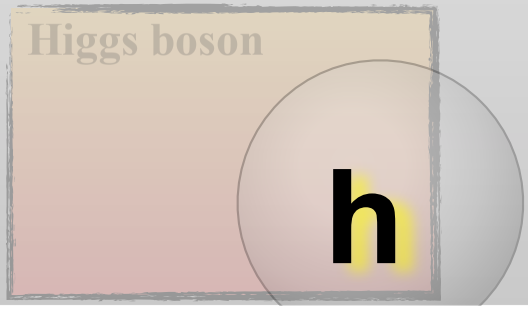








- $SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{em}(1)$



Interazioni (& simmetrie)

e ν_e u d

μ ν_μ c s

τ ν_τ t b

FORCES

Electromagnetic: γ

Weak: W^+ W^- Z

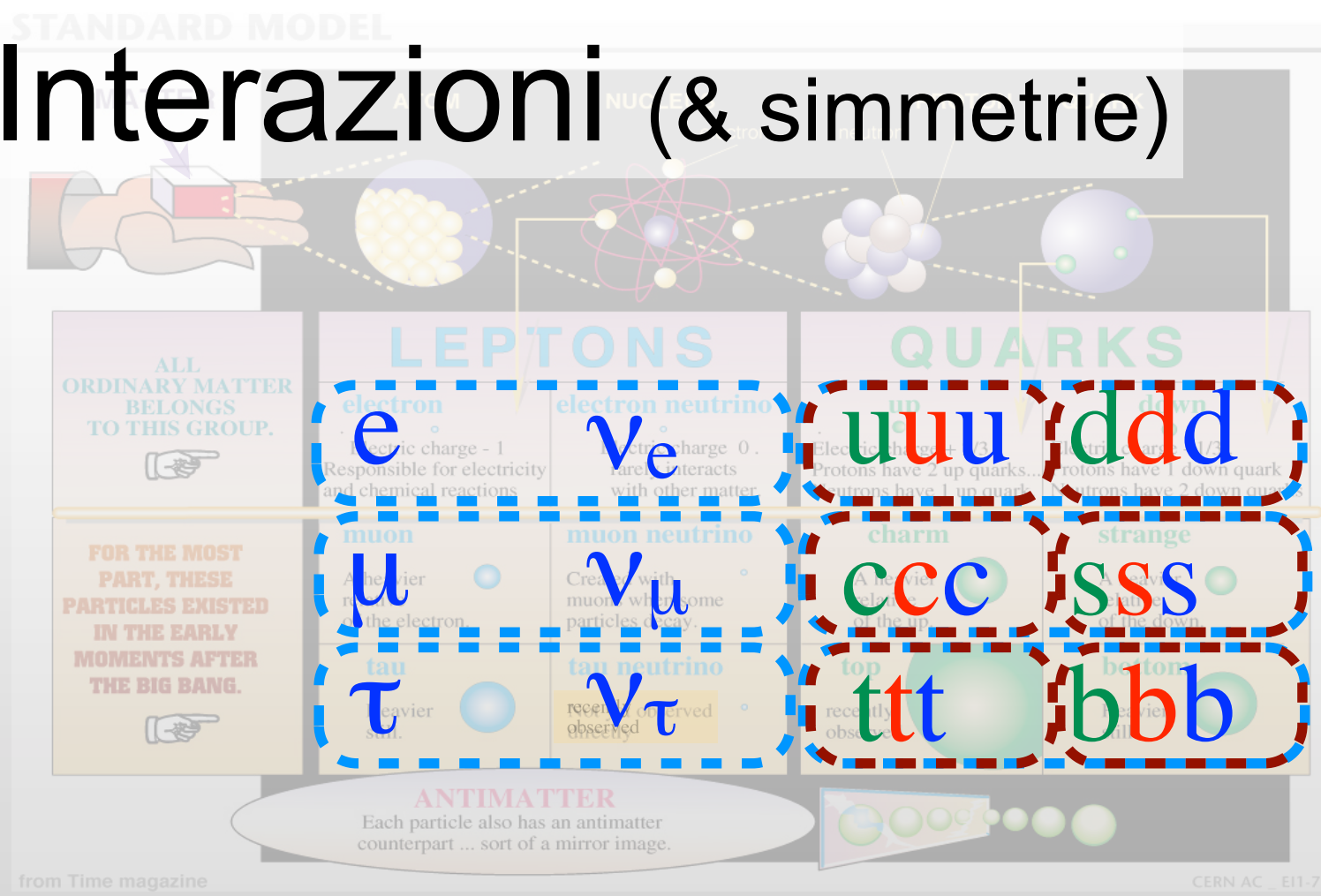
Strong: g (8)

Gravitational: G

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

Higgs boson: h

Interazioni (& simmetrie)

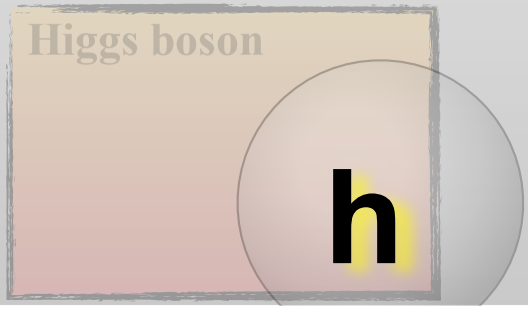


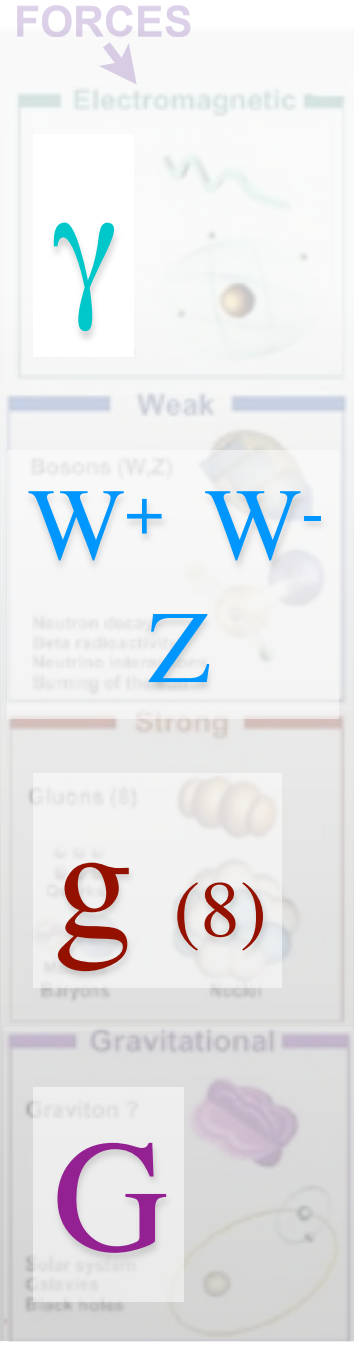
e ν_e uuu ddd

μ ν_μ ccc sss

τ ν_τ ttt bbb

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





Interazioni (& simmetrie)

FORCES

Electromagnetic

γ

Weak

Bosons (W,Z)

W^+ W^-

Z

Strong

Gluons (8)

g (8)

Gravitational

Graviton ?

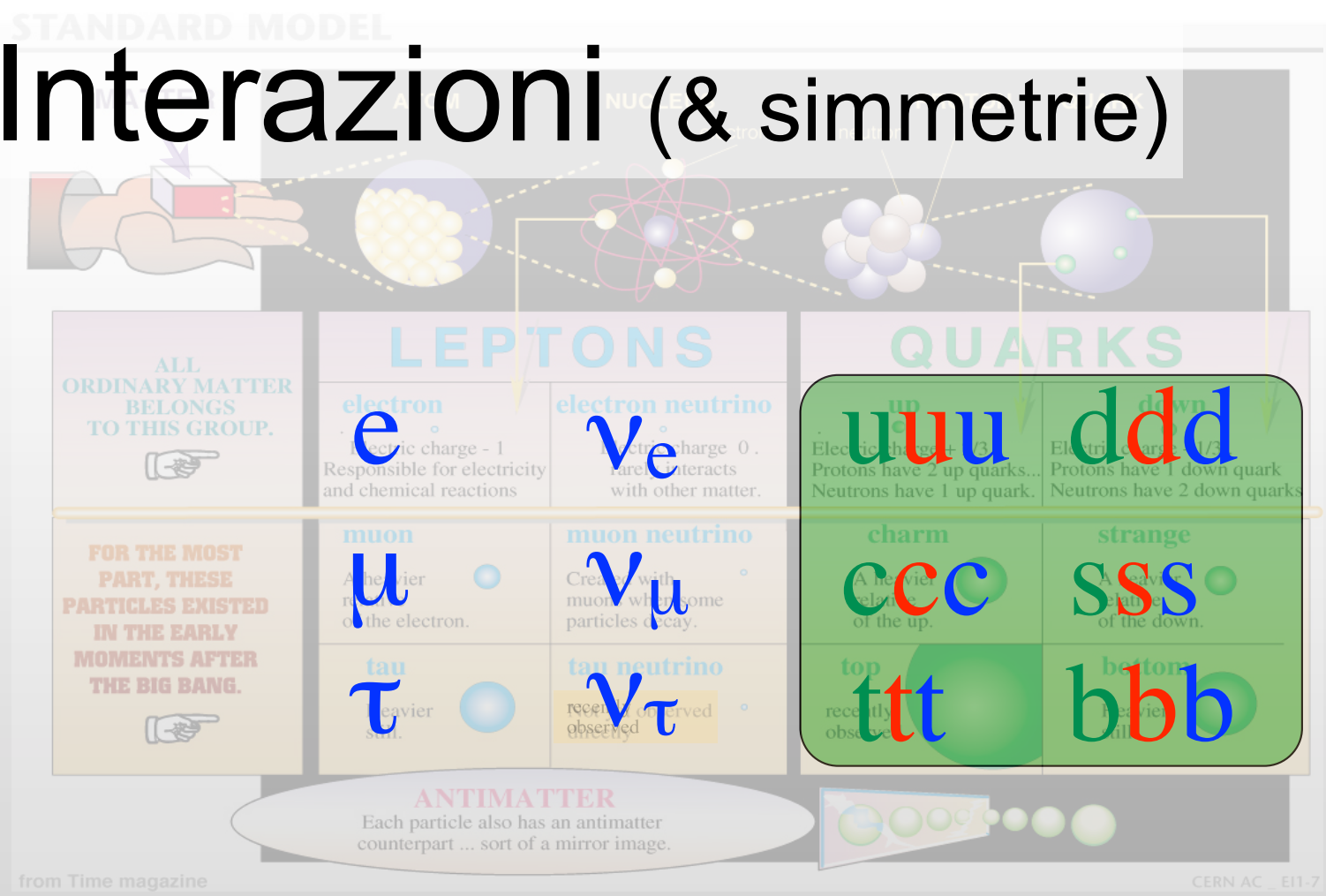
G

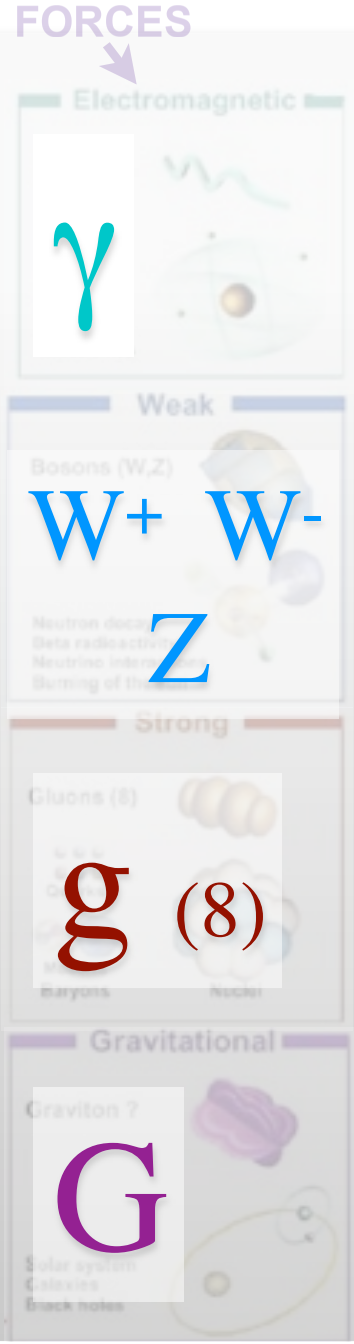
Higgs boson

h

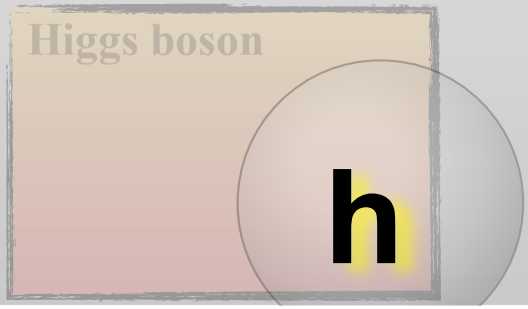
- $SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{em}(1)$
- colore e carica elettrica

Interazioni (& simmetrie)

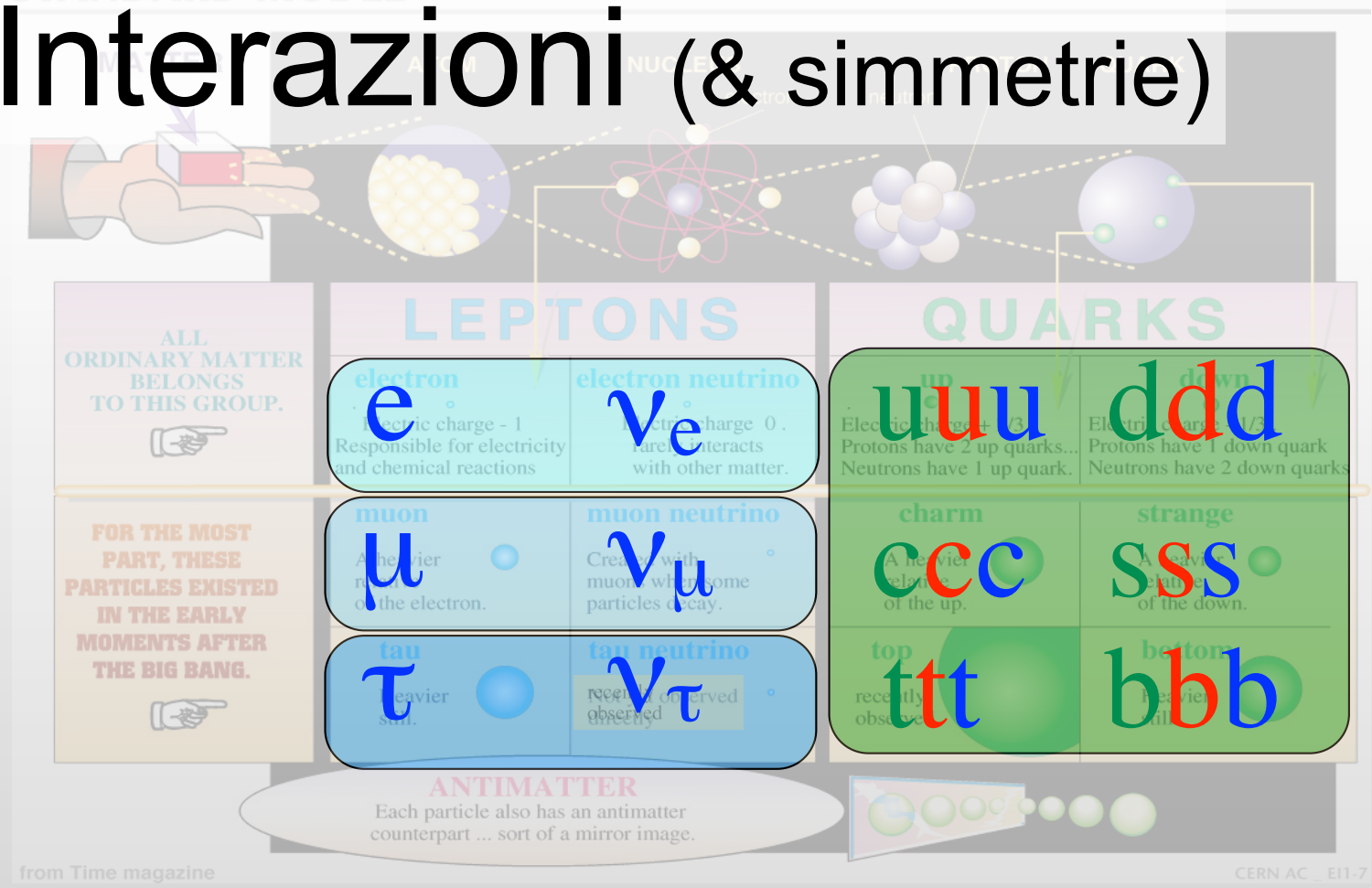


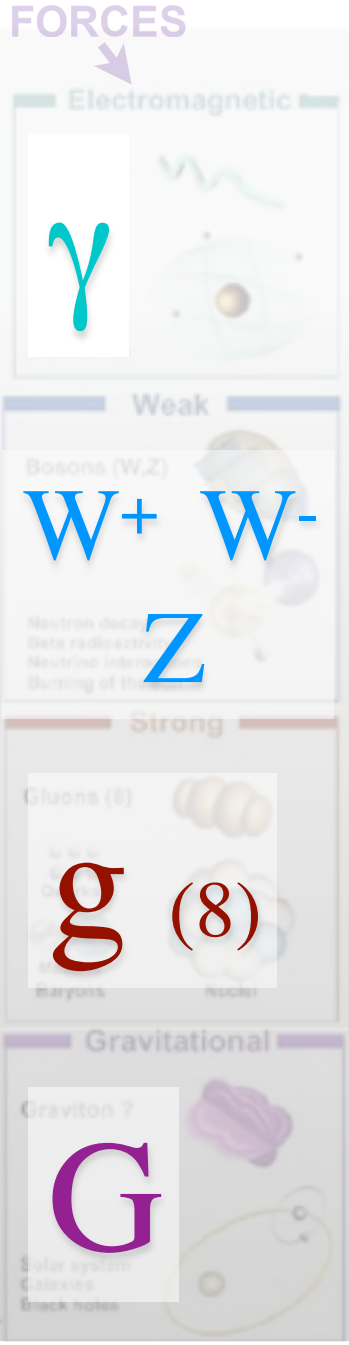


- $SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{em}(1)$
- colore e carica elettrica
- sapore barionico totale

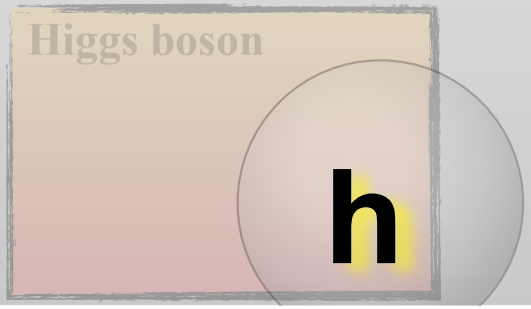


Interazioni (& simmetrie)



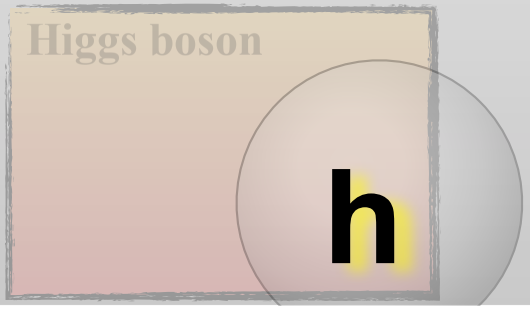


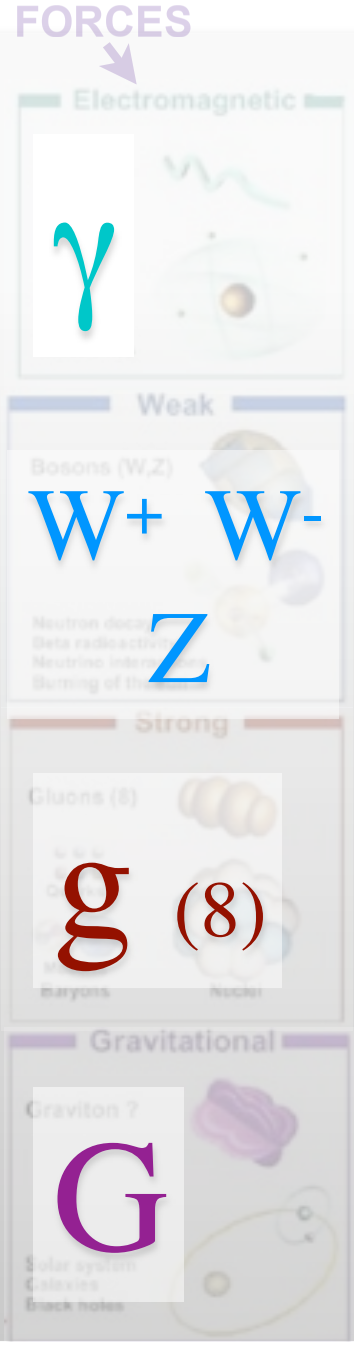
- $SU_c(3) \times SU_w(2) \times U_Y(1) \rightarrow SU_c(3) \times U_{em}(1)$
- colore e carica elettrica
- sapore barionico totale
- sapore leptonico individuale (ma: oscillazioni ν)



Interazioni (& simmetrie)

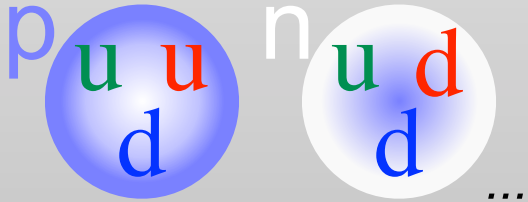
Adroni: stati composti di quarks



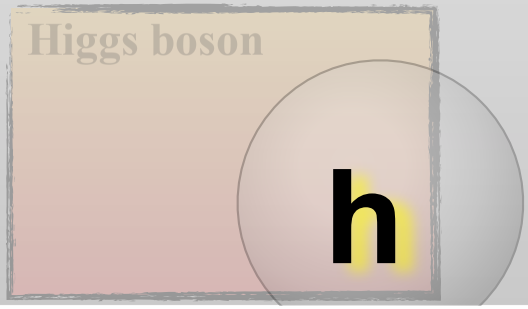


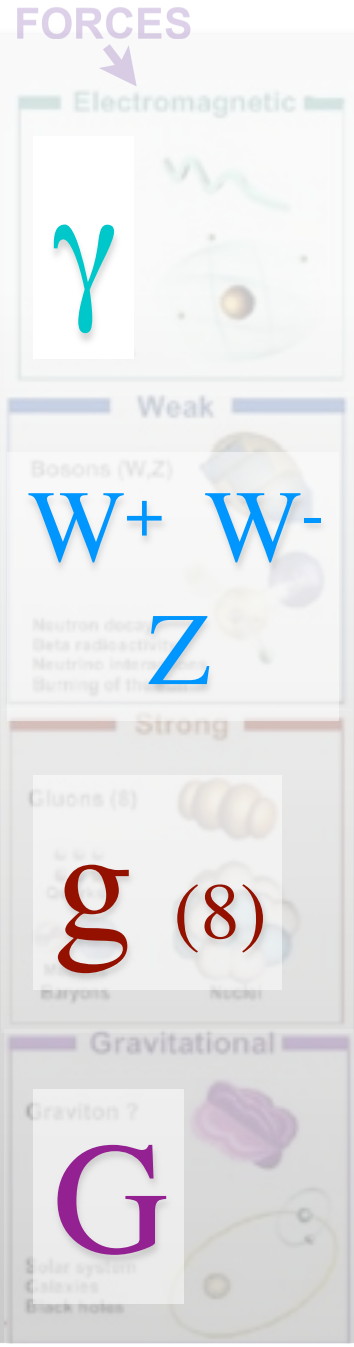
Interazioni (& simmetrie)

Adroni: stati composti di quarks



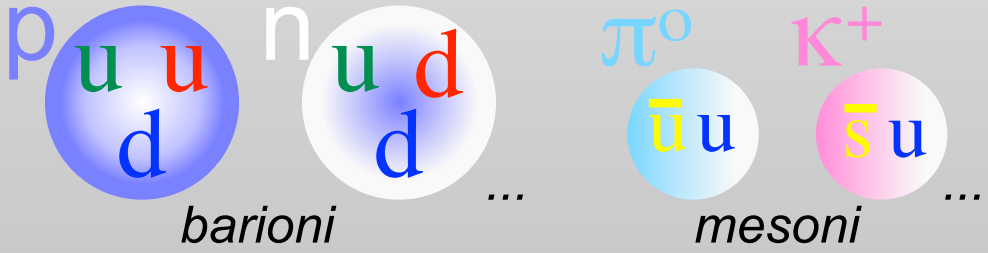
barioni ...

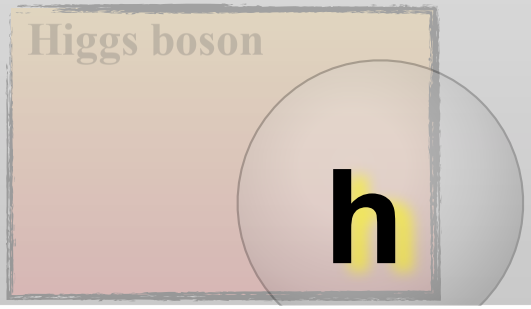


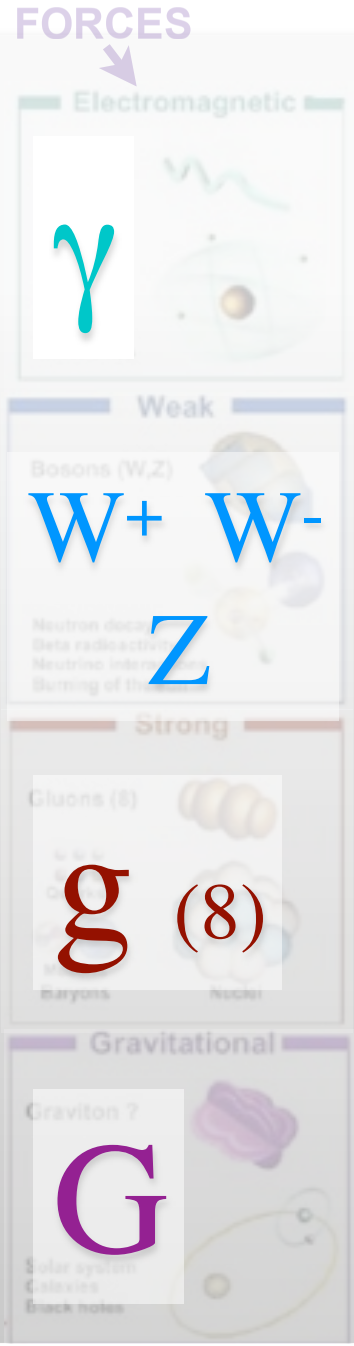


Interazioni (& simmetrie)

Adroni: stati composti di quarks

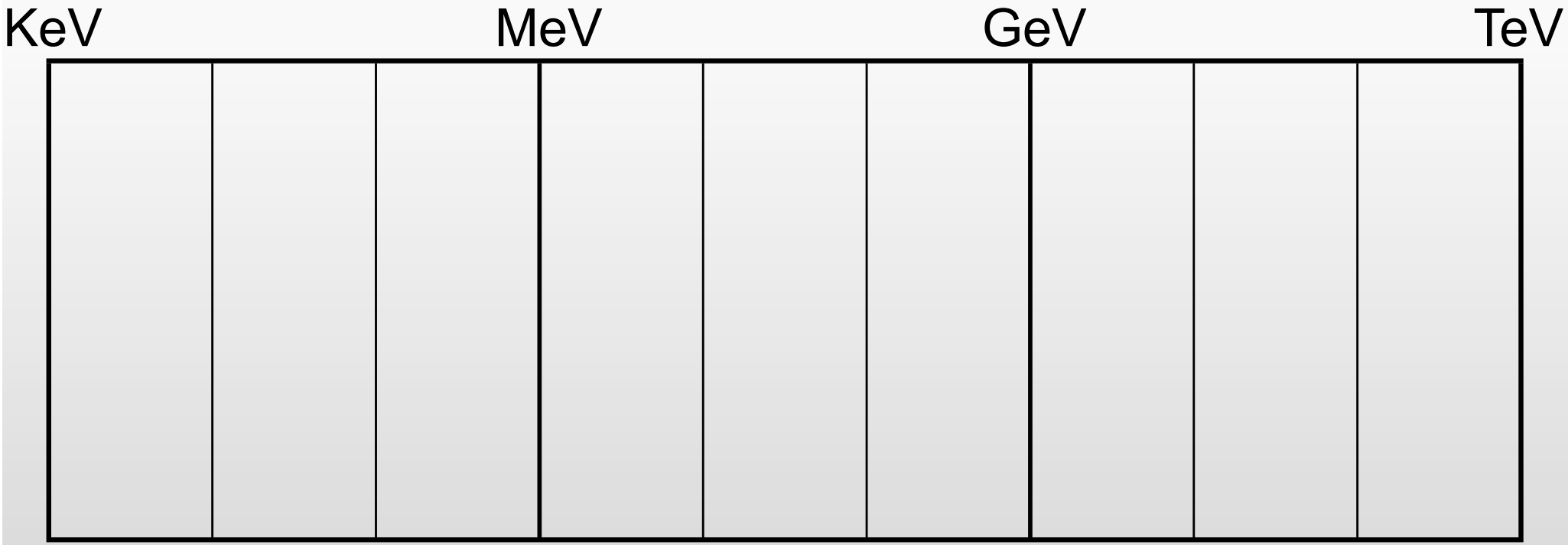




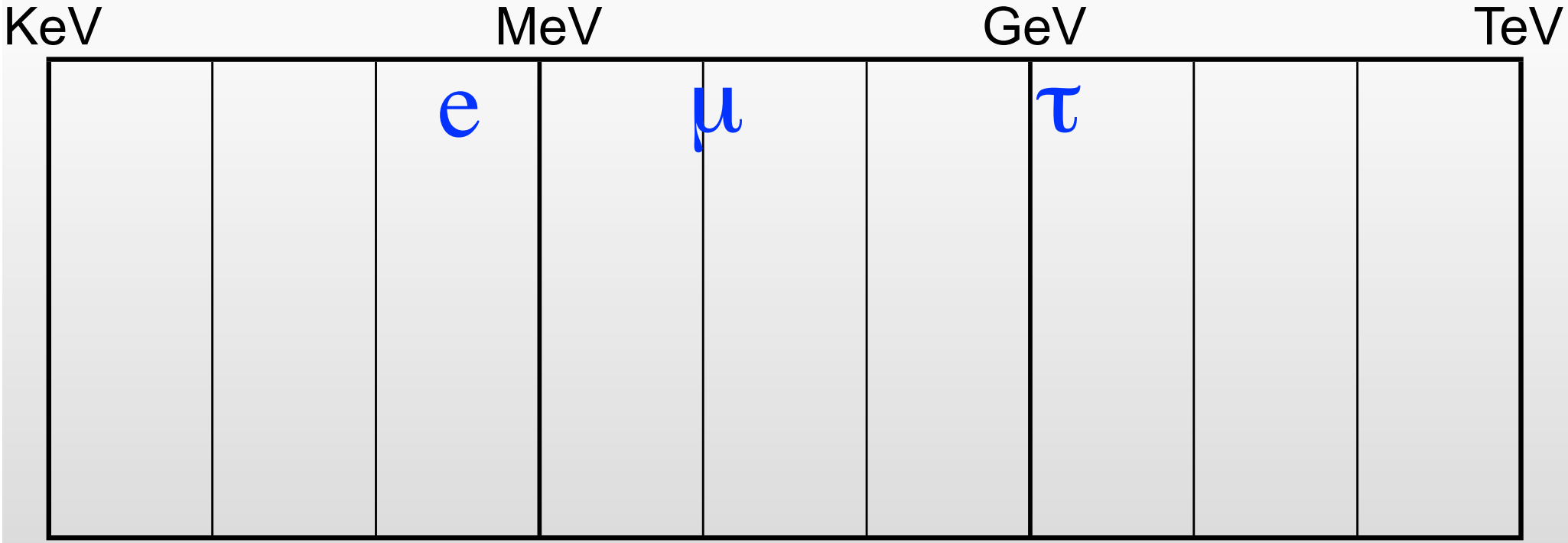


Masse

Masse



Masse

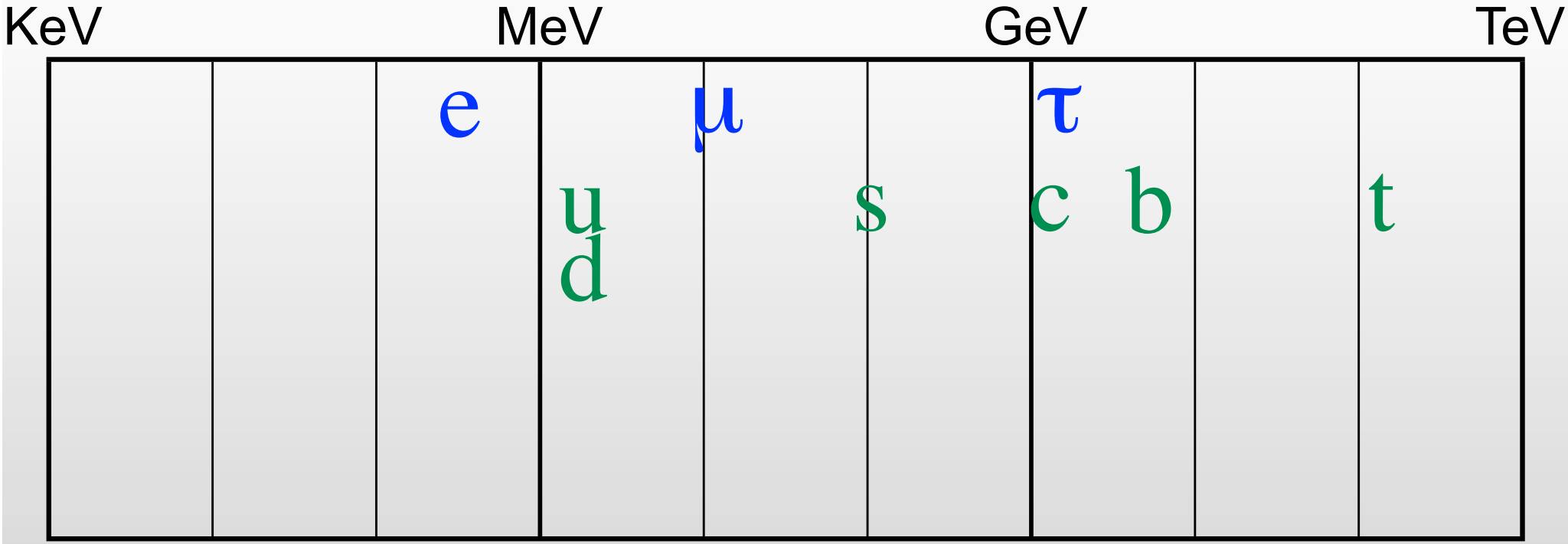


e 511 KeV

μ 105.7 MeV

τ 1.777 GeV

Masse

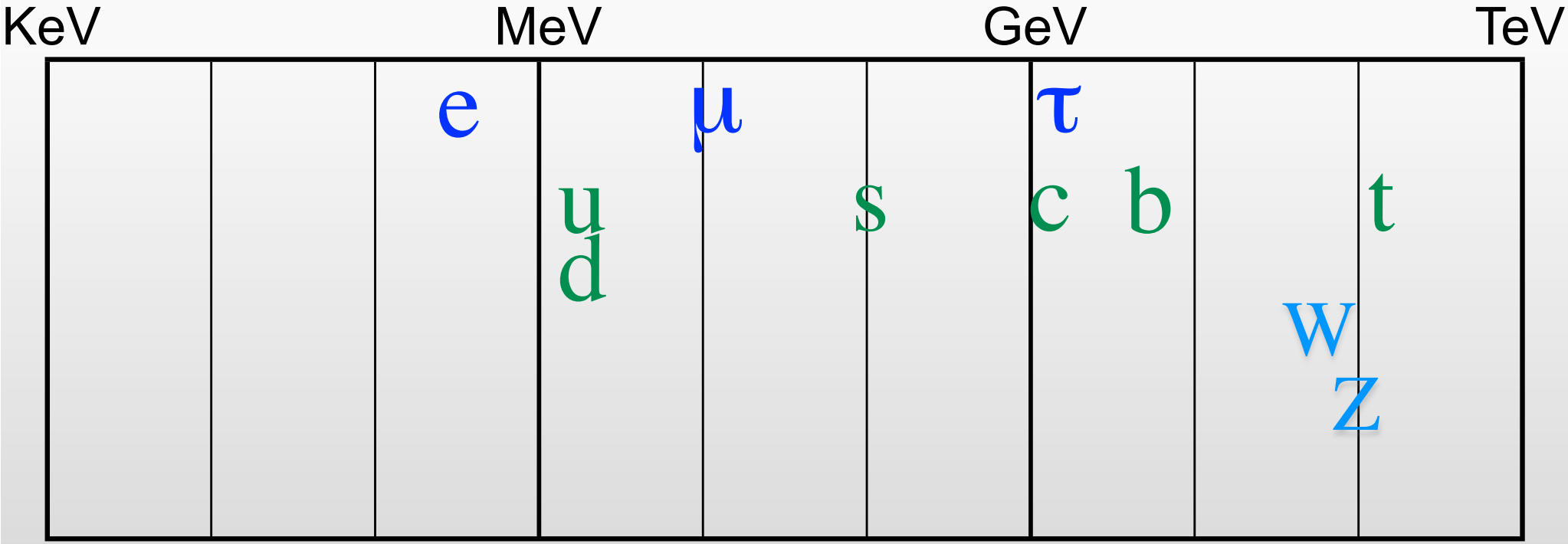


e 511 KeV
μ 105.7 MeV
τ 1.777 GeV

u ~2.3 MeV
d ~5 MeV
s ~95 MeV

c 1.27 GeV
b 4.2 GeV
t 173.2 GeV

Masse



e 511 KeV
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u ~2.3 MeV
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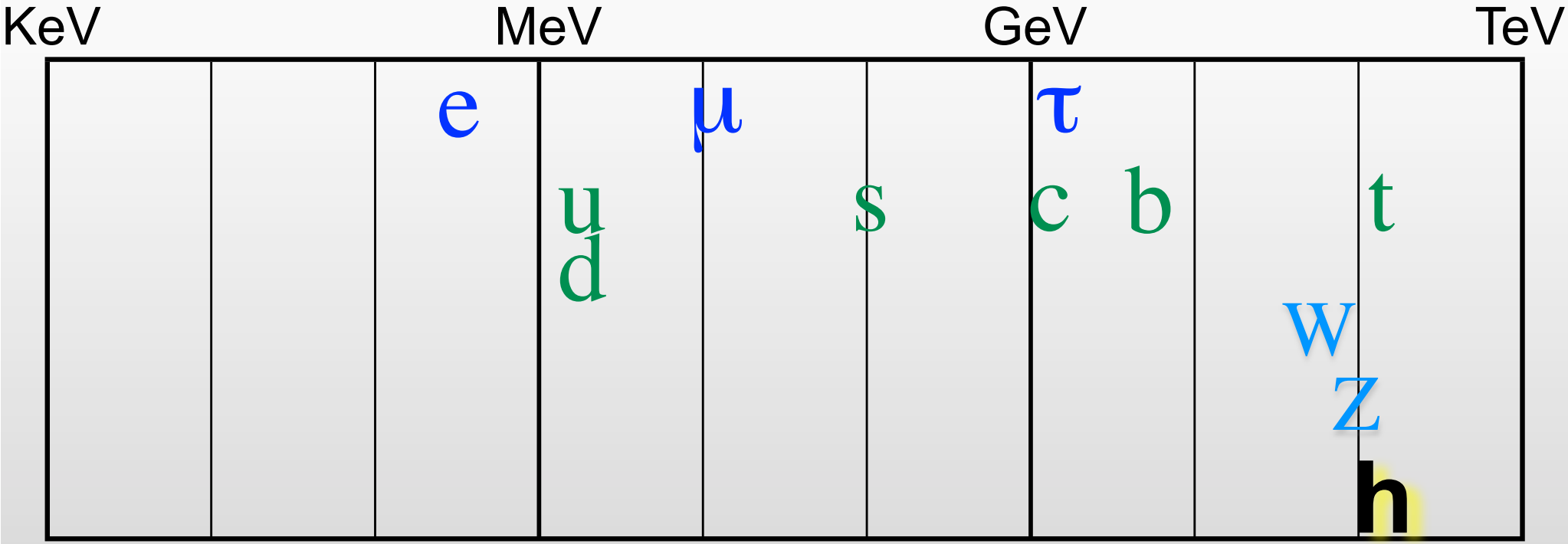
t 173.2 GeV

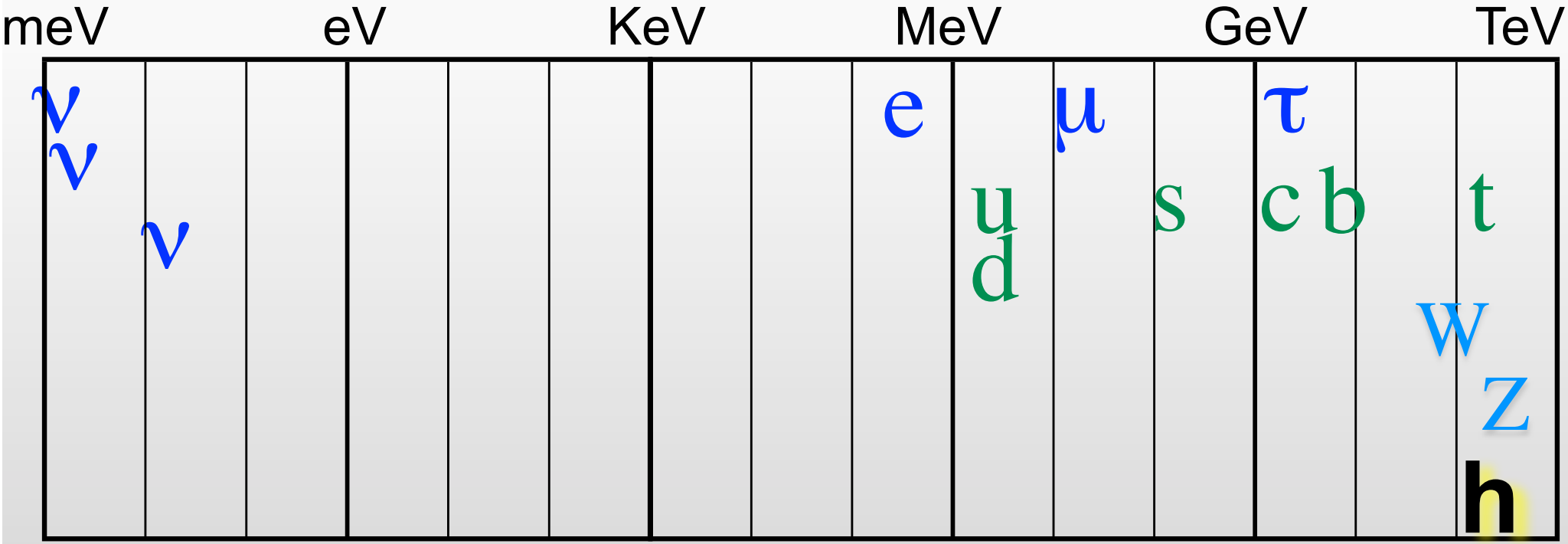
$W^{\pm}$ 80.385 GeV
Z 91.1876 GeV

Masse



e 511 KeV	u ~2.3 MeV	c 1.27 GeV	$W^{\pm}$ 80.385 GeV
μ 105.7 MeV	d ~5 MeV	b 4.2 GeV	Z 91.1876 GeV
τ 1.777 GeV	s ~95 MeV	t 173.2 GeV	**h** 125.7 GeV

Masse



e 511 KeV	u ~2.3 MeV	c 1.27 GeV	$W^{\pm}$ 80.385 GeV
μ 105.7 MeV	d ~5 MeV	b 4.2 GeV	Z 91.1876 GeV
τ 1.777 GeV	s ~95 MeV	t 173.2 GeV	**h** 125.7 GeV

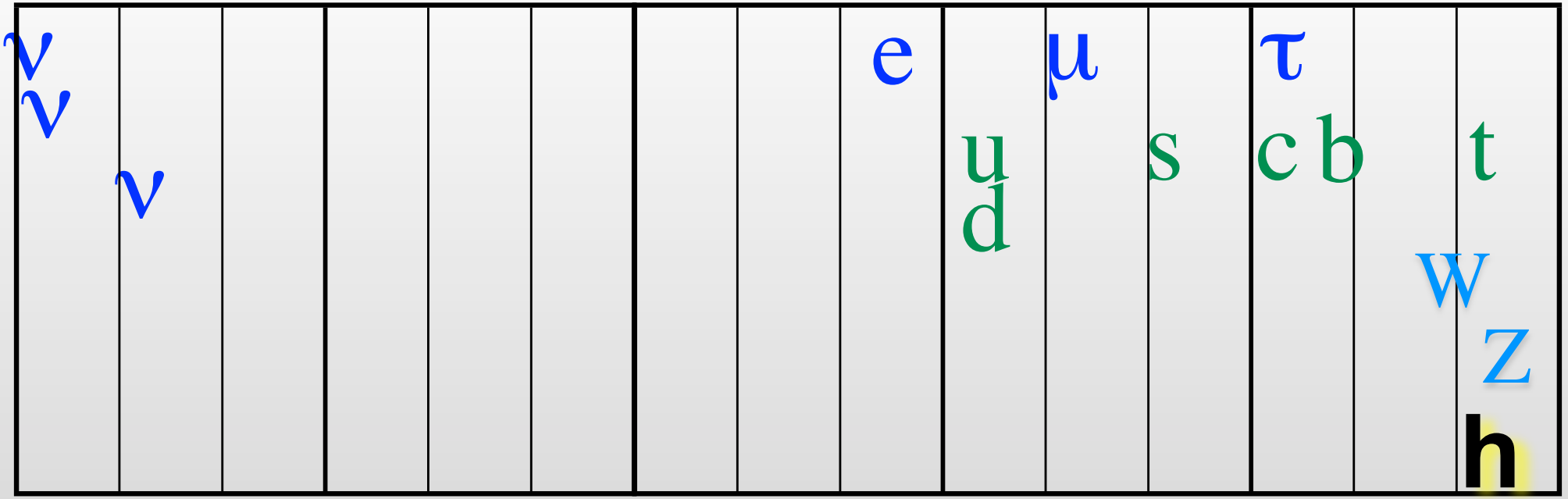
$9\ 10^{-3}$ eV ≲ ν_i ≲ 0.2 eV

Masse

massa zero: γ g G

p ^{238}U

meV eV KeV MeV GeV TeV



e 511 KeV	u ~2.3 MeV	c 1.27 GeV	$W^{\pm}$ 80.385 GeV
μ 105.7 MeV	d ~5 MeV	b 4.2 GeV	Z 91.1876 GeV
τ 1.777 GeV	s ~95 MeV	t 173.2 GeV	**h** 125.7 GeV

$9\ 10^{-3}$ eV $\lesssim \nu_i \lesssim$ 0.2 eV