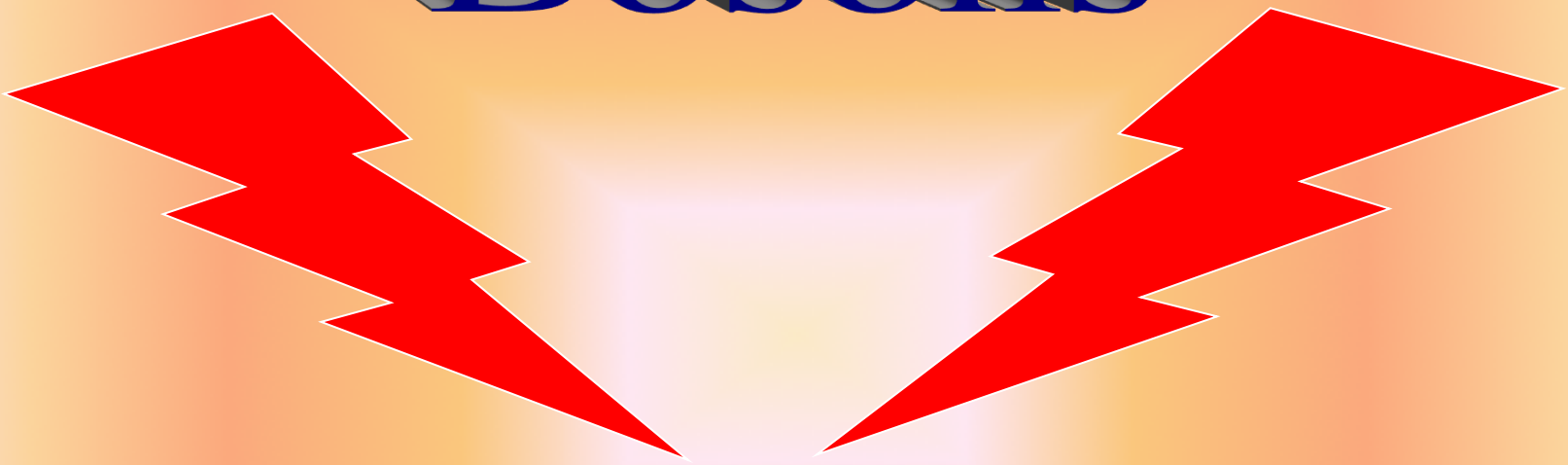
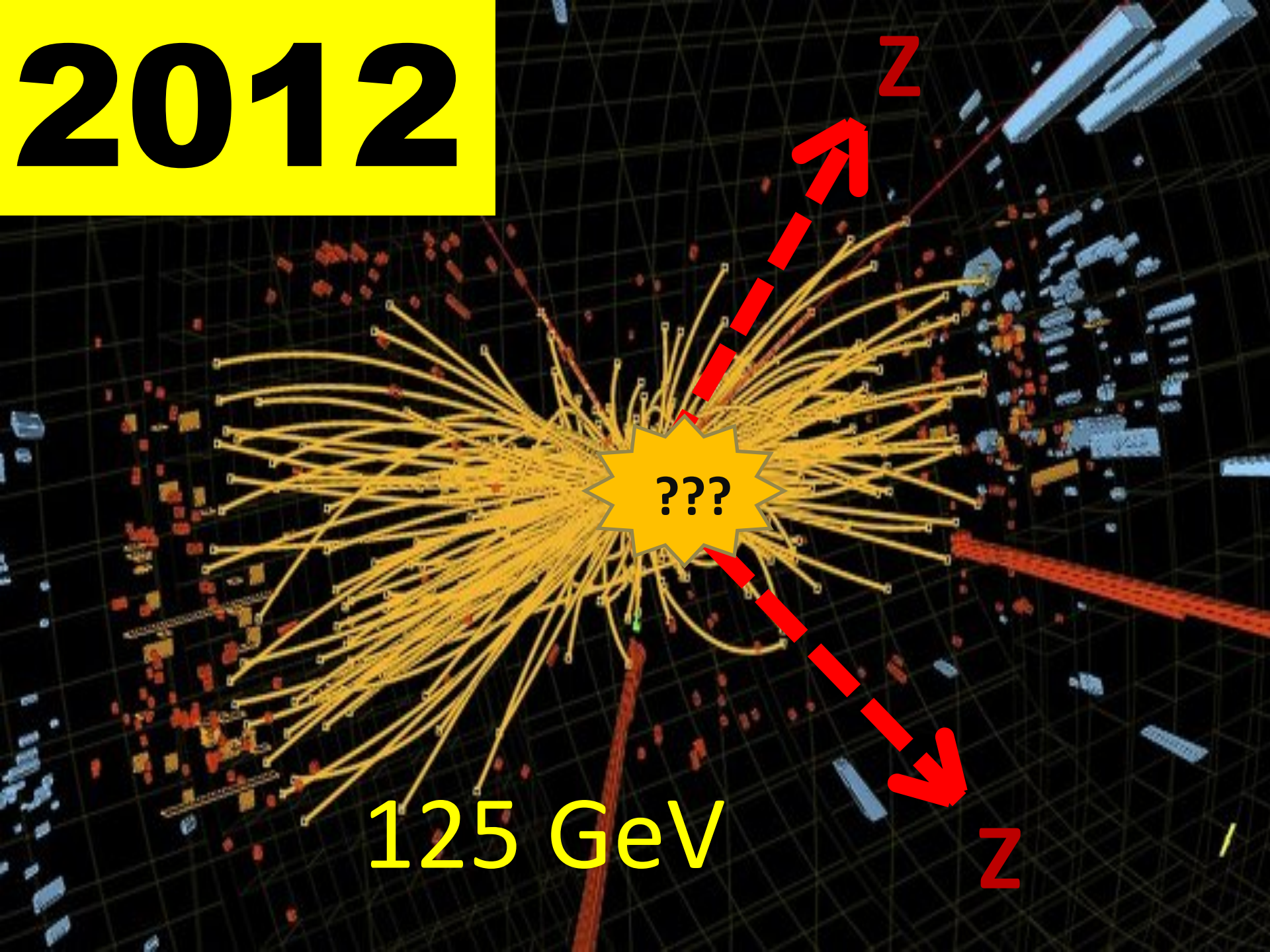
Composite Weak Bosons



Dark Matter

H. Fritzsch


2012
Z
???
125 GeV
Z

???

„Higgs“

boson

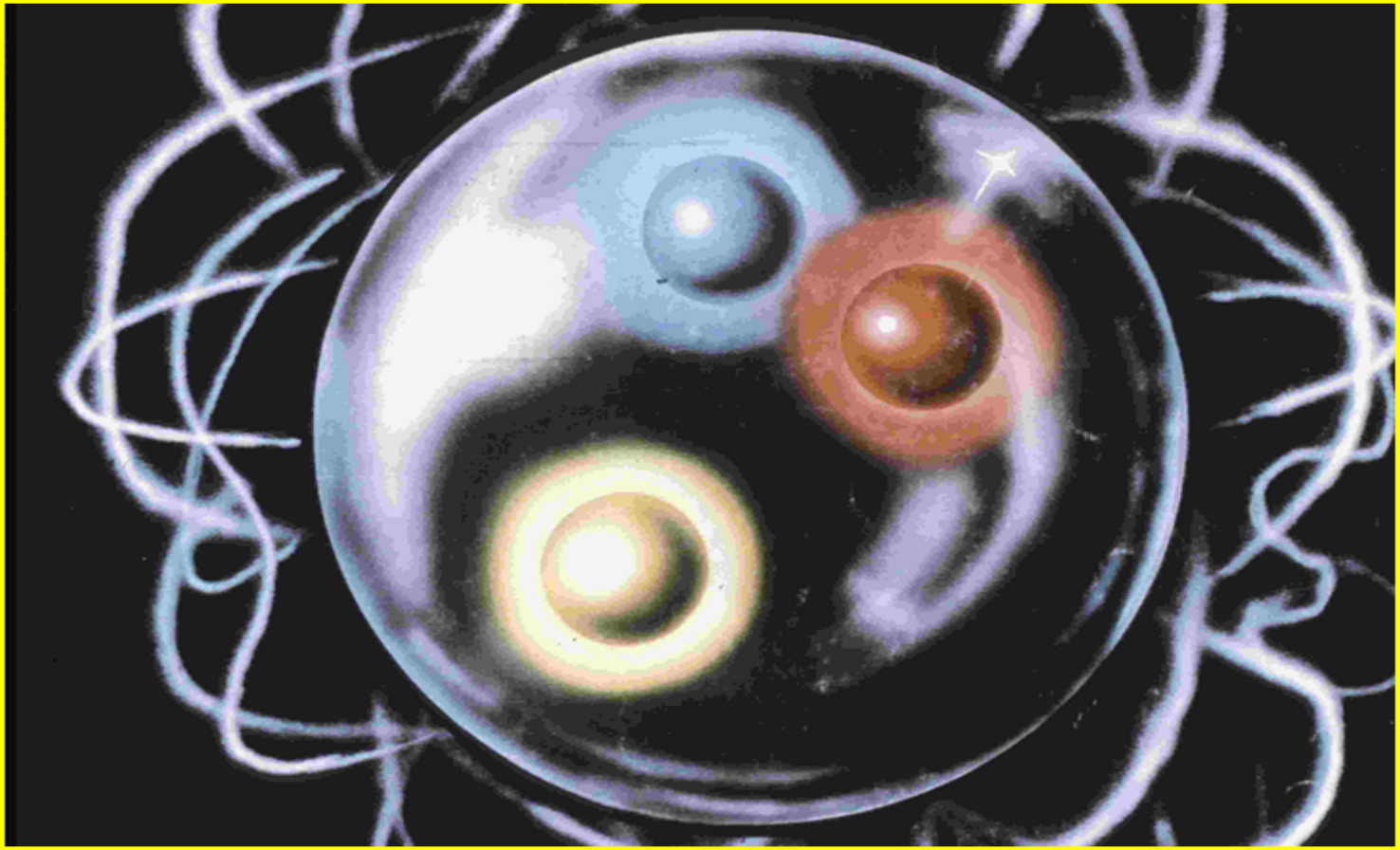
!!!

excited

weak boson

spin 0


weak bosons
composite



$$M_p = (const.) \bullet \Lambda_c$$

weak boson

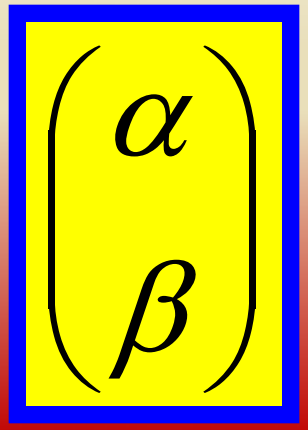
$$M_W = (const.) \bullet \Lambda_?$$

??????????????

W

==>>>

$\begin{pmatrix} \alpha \\ \beta \end{pmatrix}$ fermions



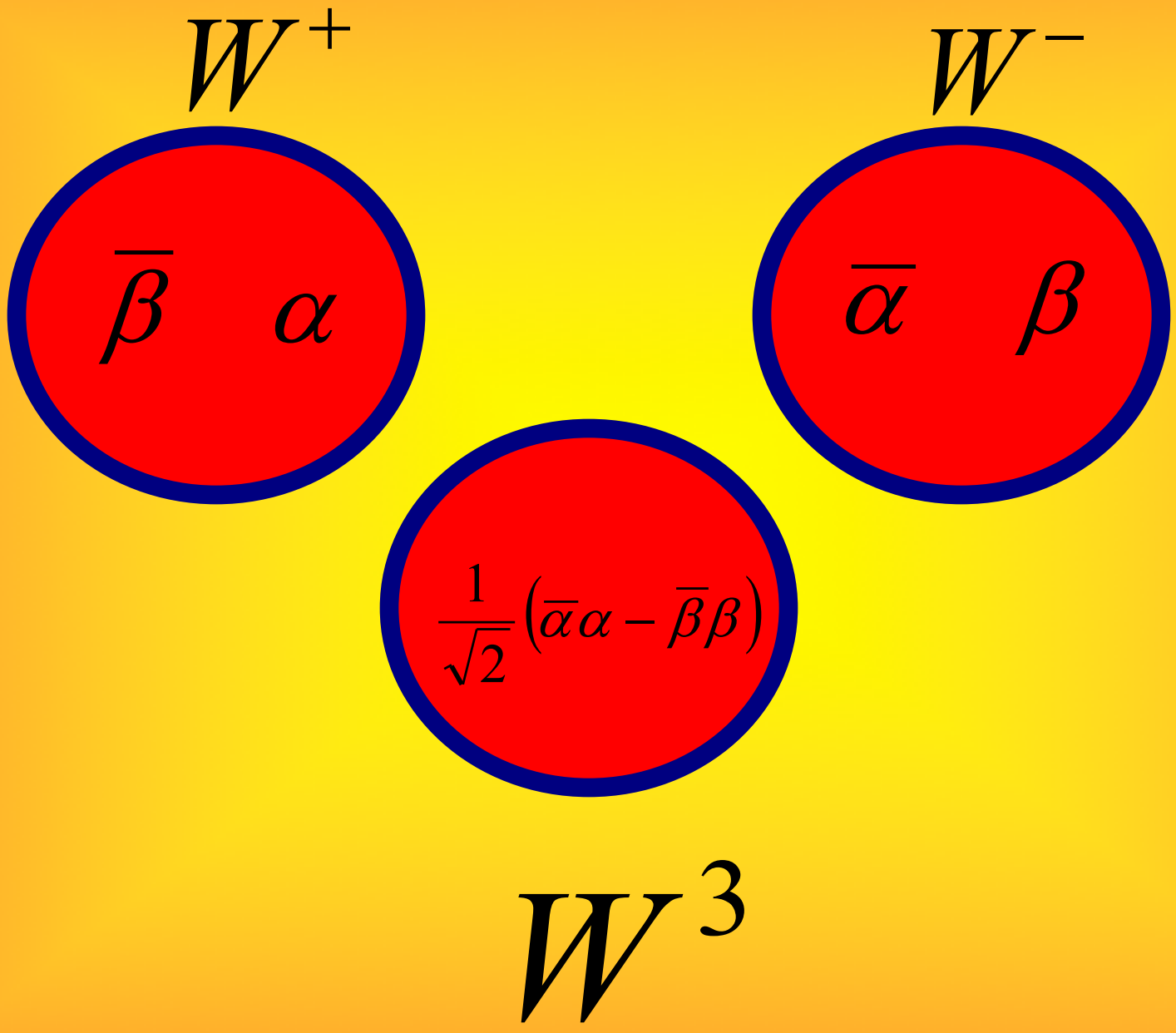
Gell – Mann : haplons

haplos ⇔ simple

electric charges

$$\alpha \Rightarrow +2/3$$

$$\beta \Rightarrow -1/3$$


W^+
W^-
$\bar{\beta}\quad\alpha$
$\bar{\alpha}\quad\beta$
$\frac{1}{\sqrt{2}}\left(\bar{\alpha}\alpha-\bar{\beta}\beta\right)$
W^3

haplons confined

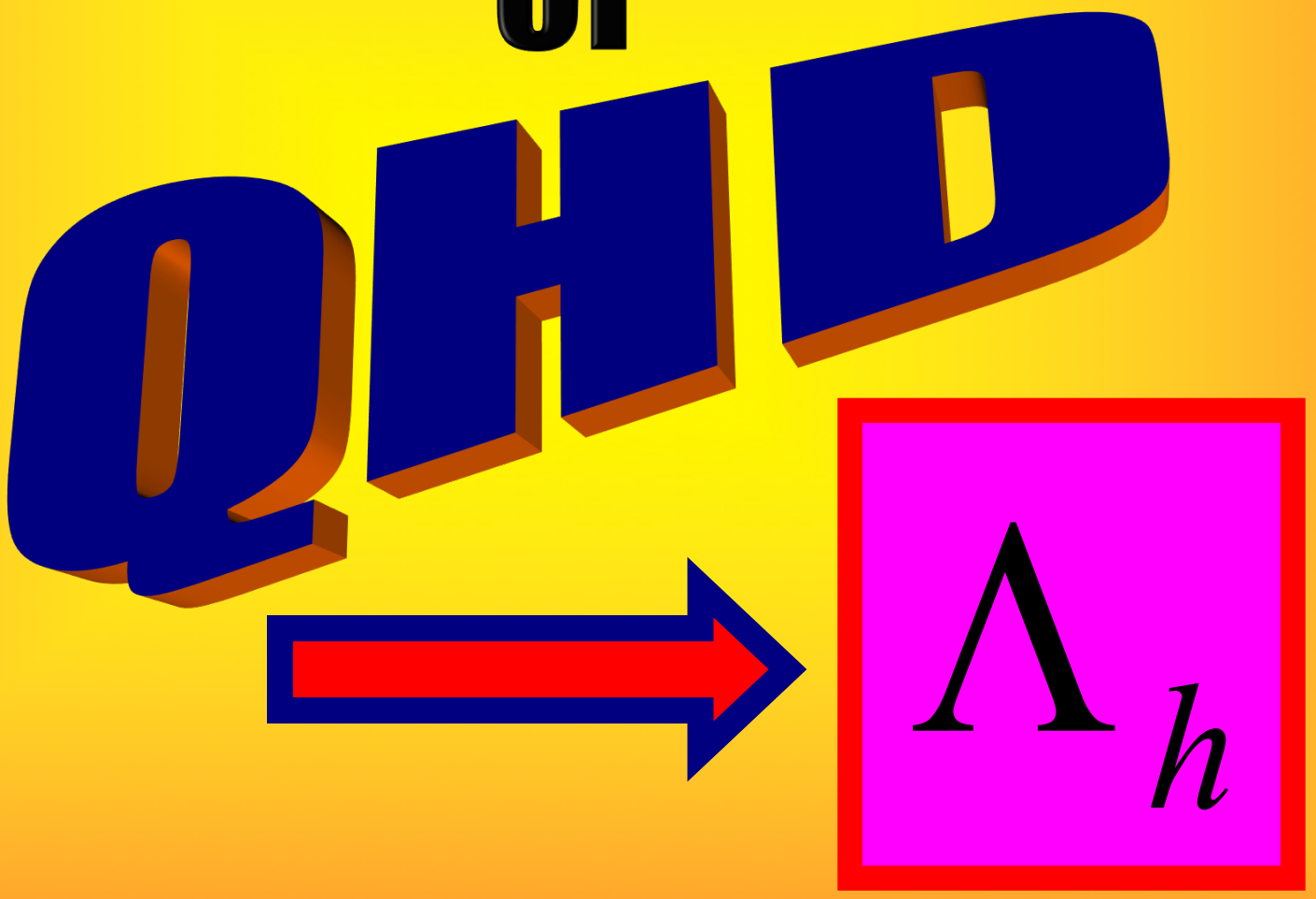
(=> QCD)

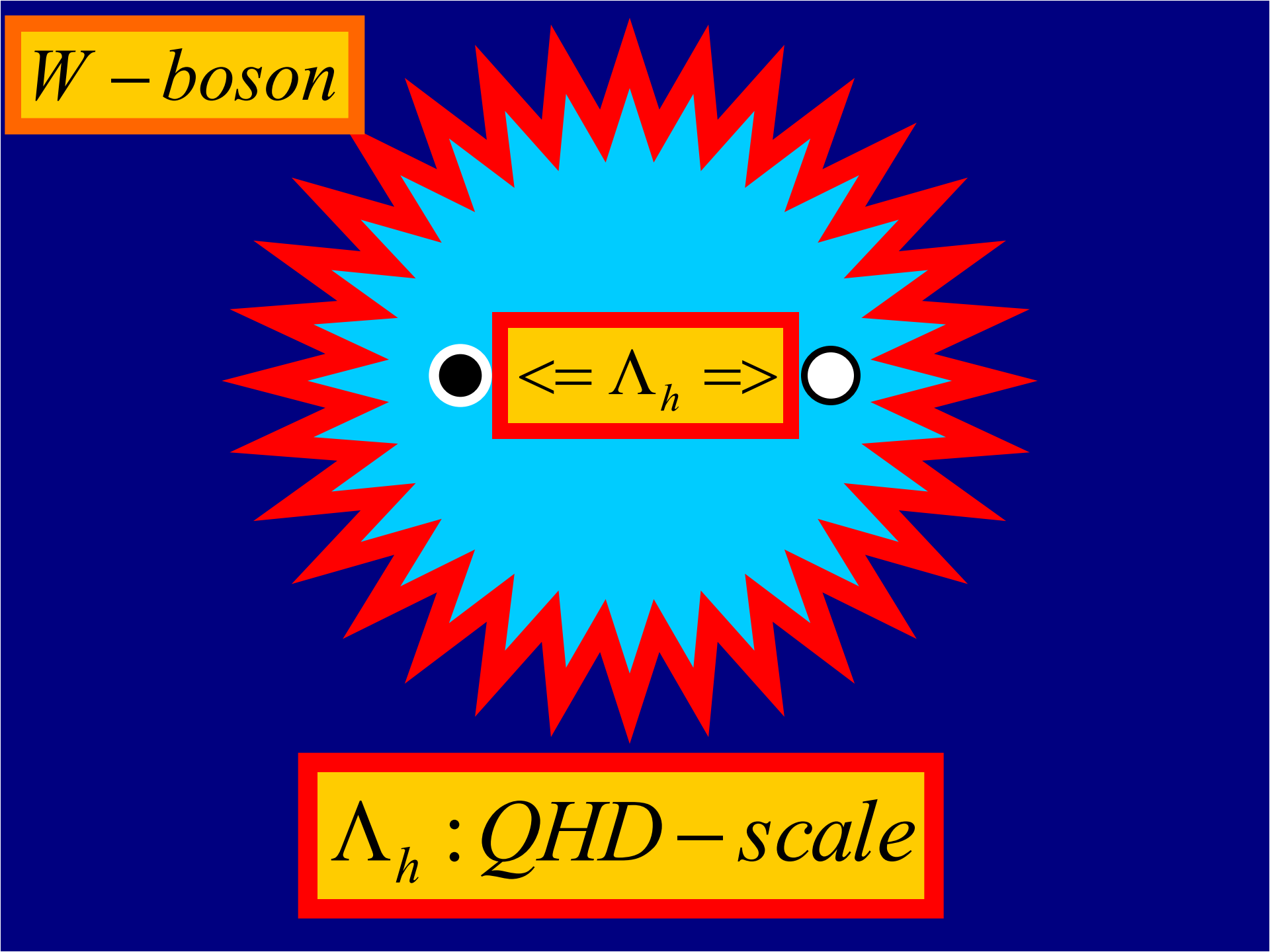
QHD

gauge group QHD

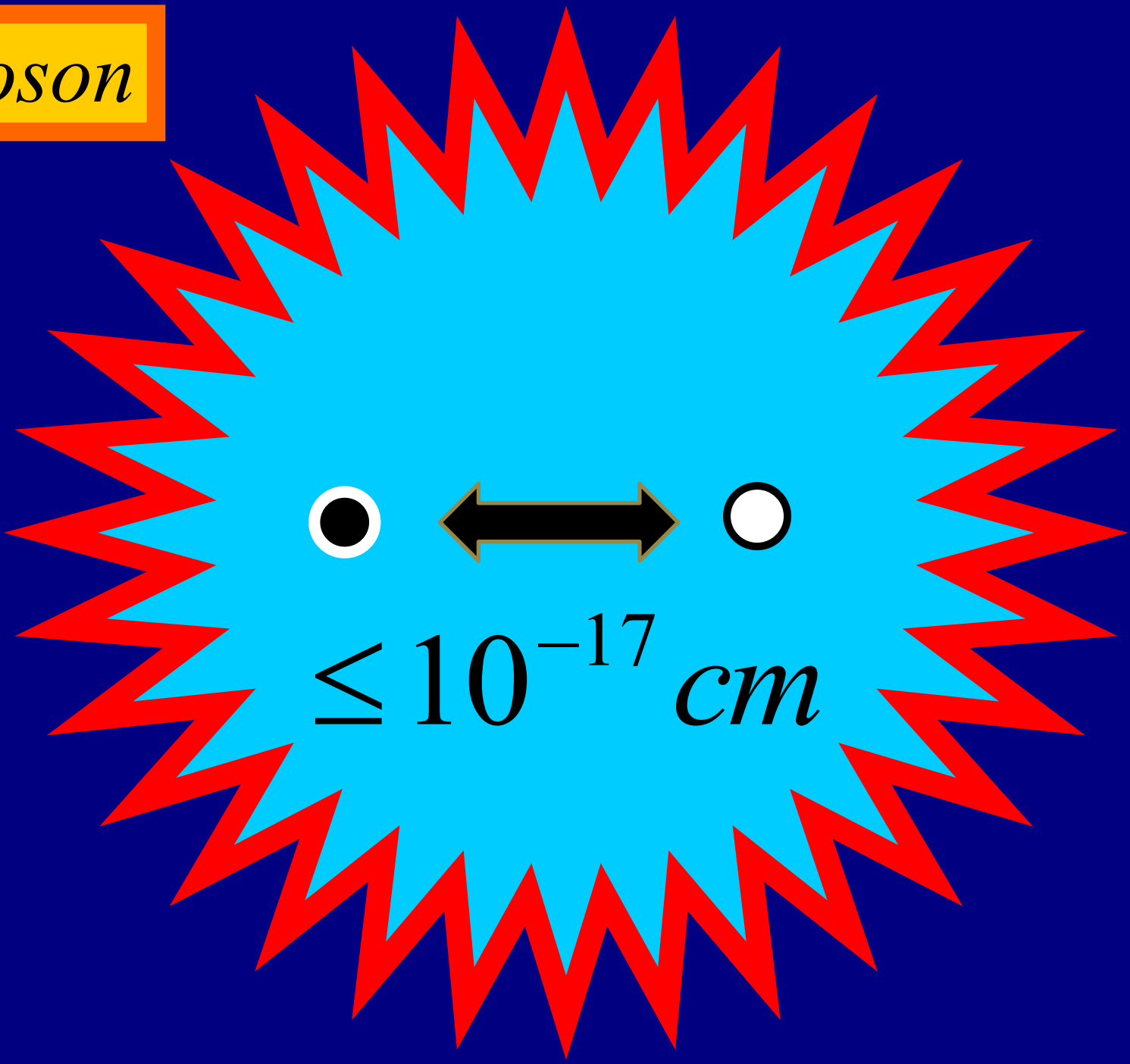
? SU(3) ?

mass scale of QHD

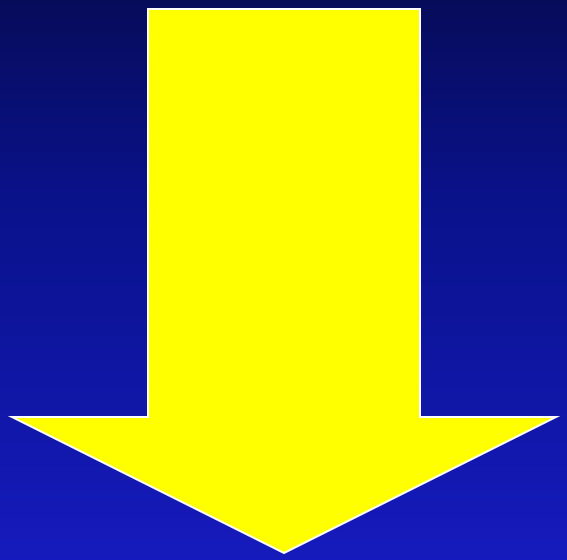



$W-boson$
$<= \Lambda_h =>$
$\Lambda_h : QHD-scale$

$W-boson$



weak boson mass



$$M_W \Rightarrow const. \bullet \Lambda_h$$

$$QHD \Rightarrow SU(3)$$

$$\Lambda_h \approx 0.30 \quad TeV$$

EXCITED WEAK BOSONS

$I(J)$

$I : SU(2)$

$J :$ *angular momentum*

p-wave bosons

three SU(2) singlets

$$S = \frac{1}{\sqrt{2}}\left(\bar{\alpha}\alpha + \bar{\beta}\beta\right)$$

S(0) = 0 (0)

S(1) = 0 (1)

S(2) = 0 (2)

p-wave bosons

three SU(2) triplets

$$T^{+} = \bar{\beta}\alpha \qquad T^{-} = \bar{\alpha}\beta \qquad T^{0} = \frac{1}{\sqrt{2}}\left(\bar{\alpha}\alpha - \bar{\beta}\beta\right)$$

T(0) = 1 (0)

T(1) = 1 (1)

T(2) = 1 (2)

p-wave mesons (QCD)

isospin singlets

$$scalar: \quad \sigma(\sim 500)$$

$$vector: \quad h_1(1170)$$

$$tensor: \quad f_2(1270)$$

p-wave mesons (QCD)

isospin triplets

$scalar:$ $a_0(980)$

$vector:$ $b_1(1235)$

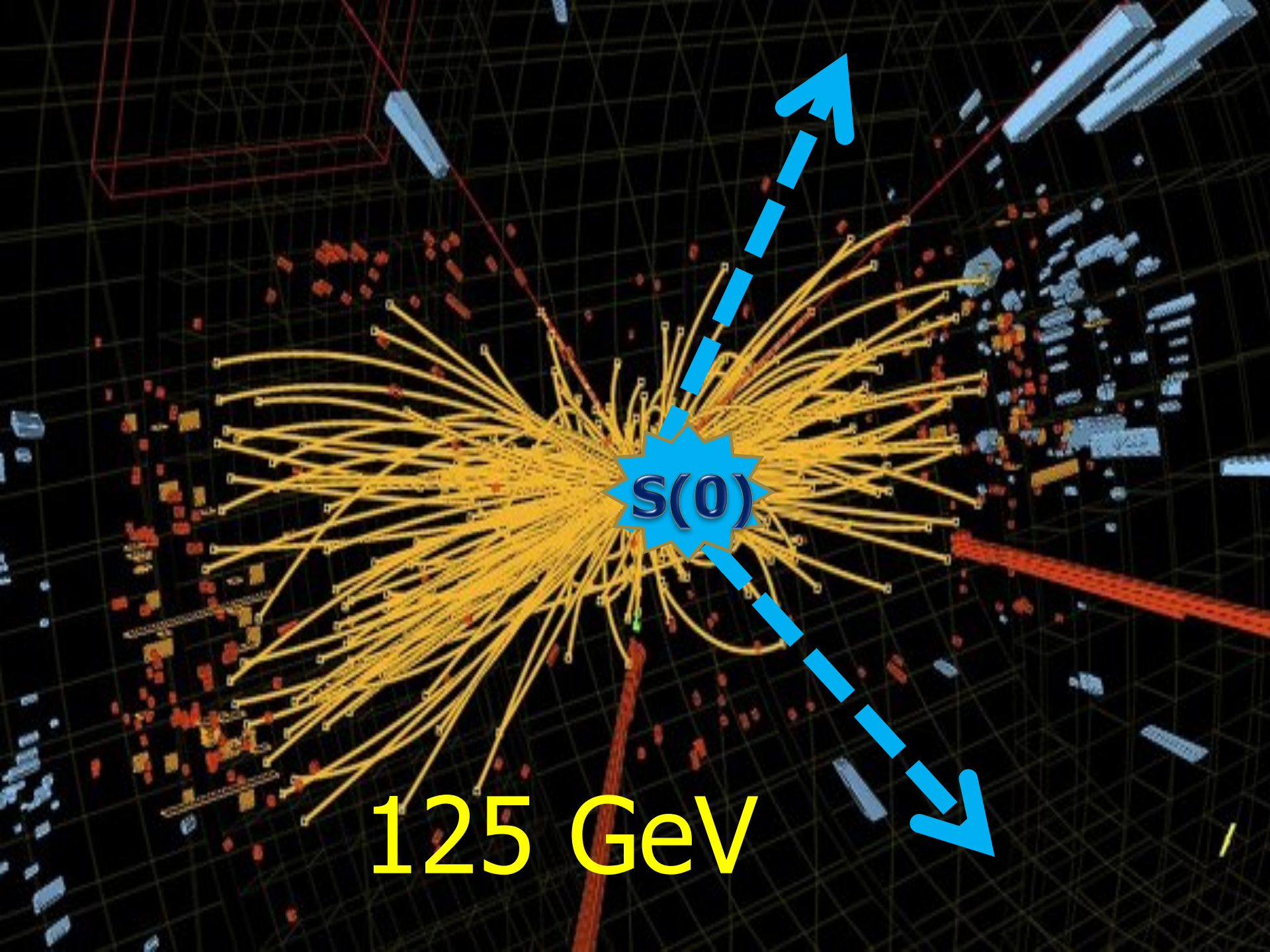
$tensor:$ $a_2(1320$

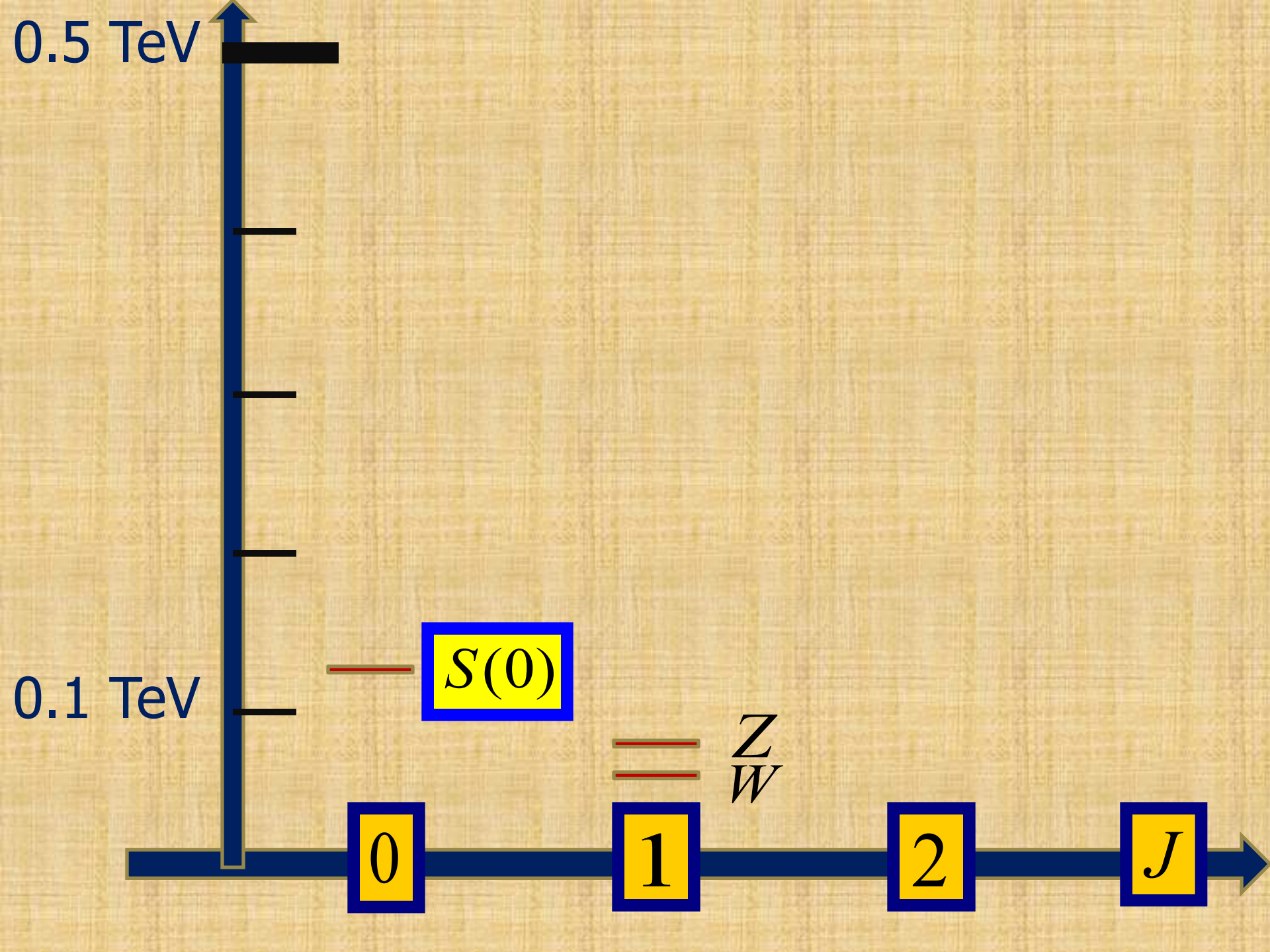
analogy

$$\sigma \quad \Rightarrow \quad S(0)$$

$$h_1 \quad \Rightarrow \quad S(1)$$

$$f_2 \quad \Rightarrow \quad S(2)$$


S(0)
125 GeV


0.5 TeV
0.1 TeV
S(0)
Z
W
0
1
2
J

$$\sigma : \sim 500 \quad MeV$$

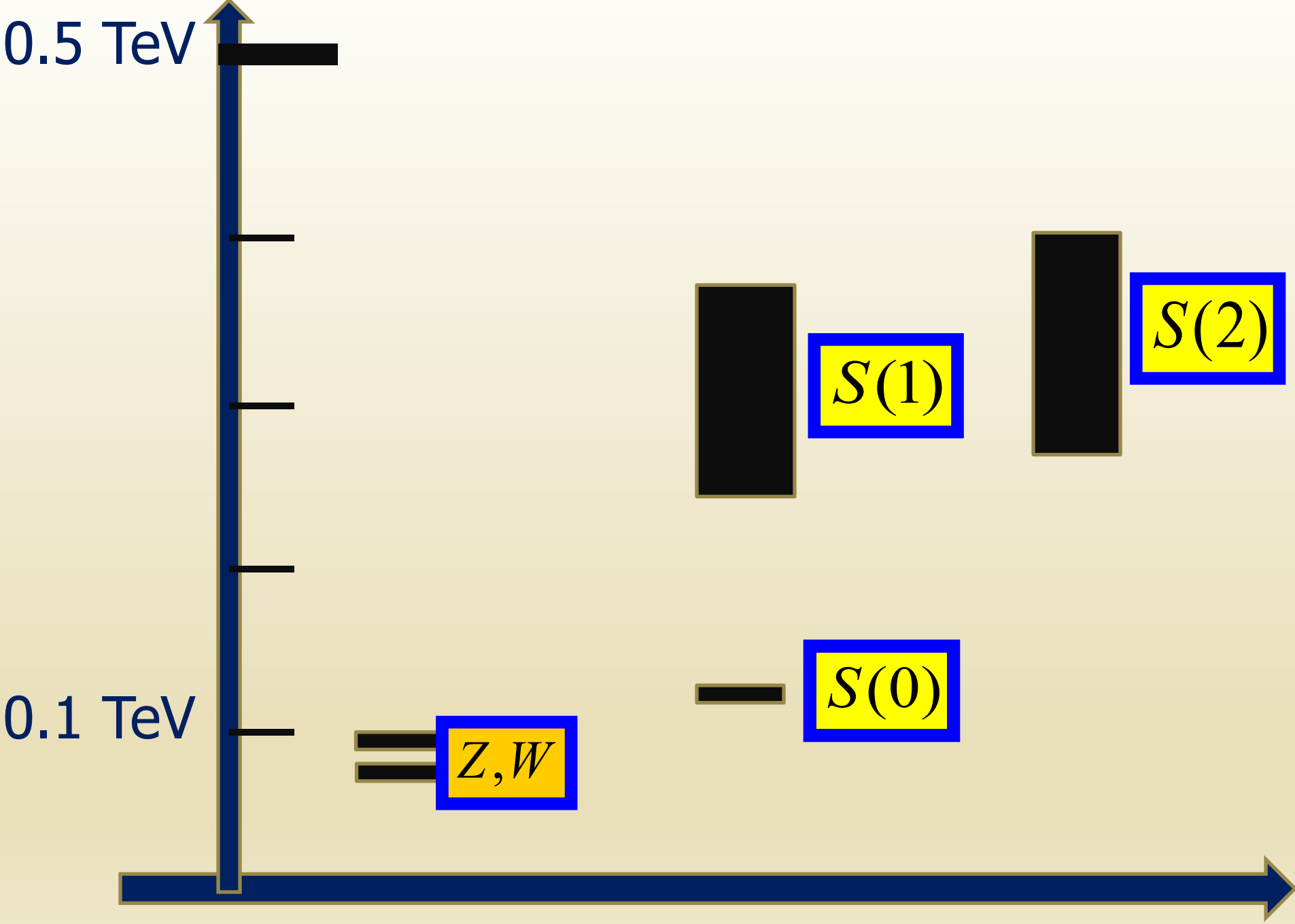
$$h_1 : 1170 \quad MeV$$

$$f_2 : 1270 \quad MeV$$

$$S(0) : 125 \quad GeV$$

$$S(1) \Rightarrow (320 \pm 60) \quad GeV$$

$$S(2) \Rightarrow (340 \pm 60) \quad GeV$$

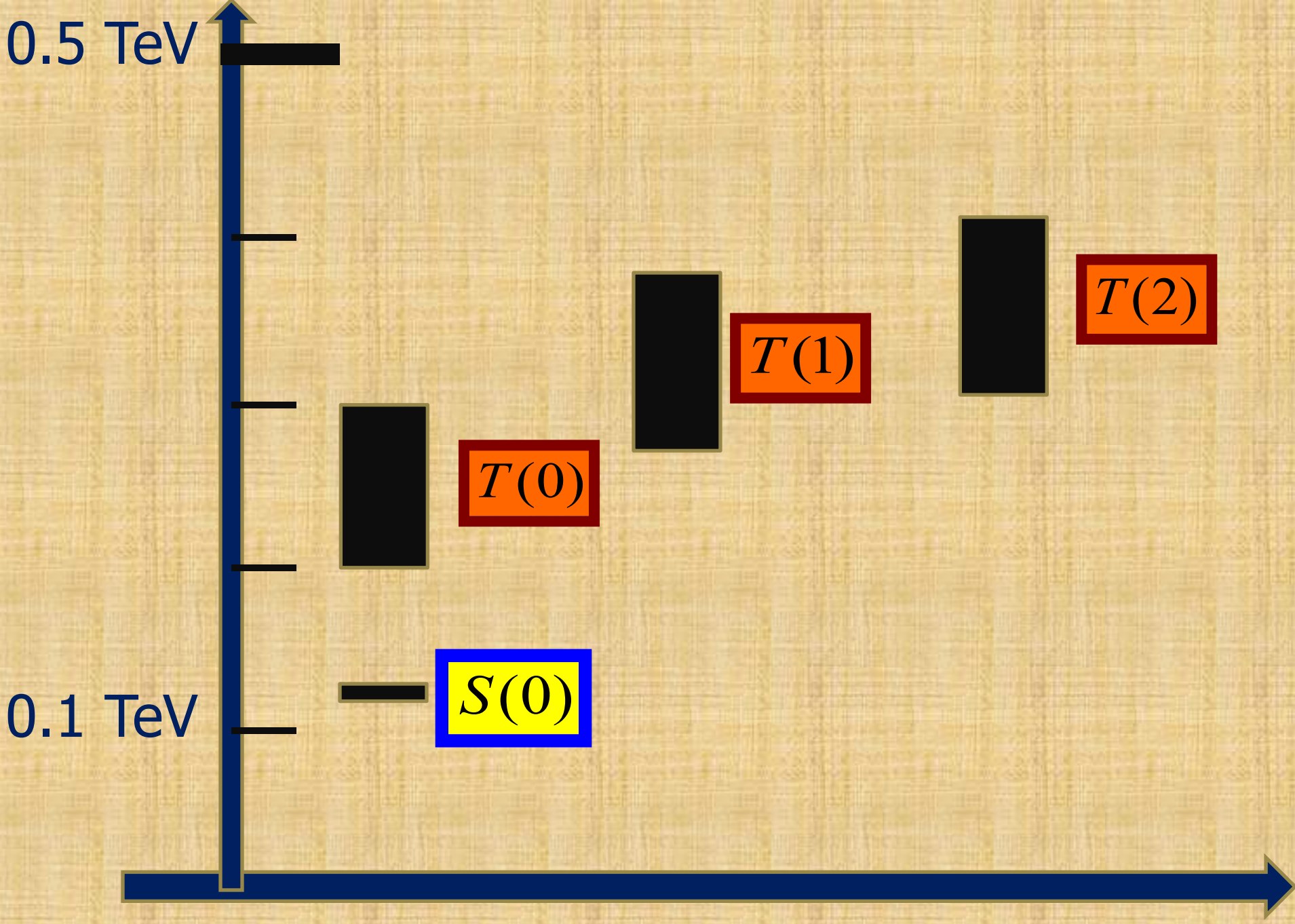

0.5 TeV
0.1 TeV
$S(2)$
$S(1)$
$S(0)$
Z, W

$scalar:$	$a_0(980)$
$vector:$	$b_1(1235)$
$tensor:$	$a_2(1320)$

$$T(0) \Rightarrow (250 \pm 50)\, GeV$$

$$T(1) \Rightarrow (330 \pm 50)\, GeV$$

$$T(2) \Rightarrow (360 \pm 60)\, GeV$$


0.5 TeV
0.1 TeV
$T(0)$
$T(1)$
$T(2)$
$S(0)$

SM „Higgs" particle

$$H \Rightarrow$$

$$\gamma + \gamma : 0.23\%$$

$$Z + Z : 2.6\%$$

$$W + W : 22\%$$

$$b + \bar{b} : 58\%$$

$$\tau + \bar{\tau} : 6.3\%$$

S(0) - decays

$$S(0) \Rightarrow "W^+"+W^-$$

$$S(0) \Rightarrow W^+ +"W^-"$$

$$S(0) \Rightarrow "Z"+Z$$

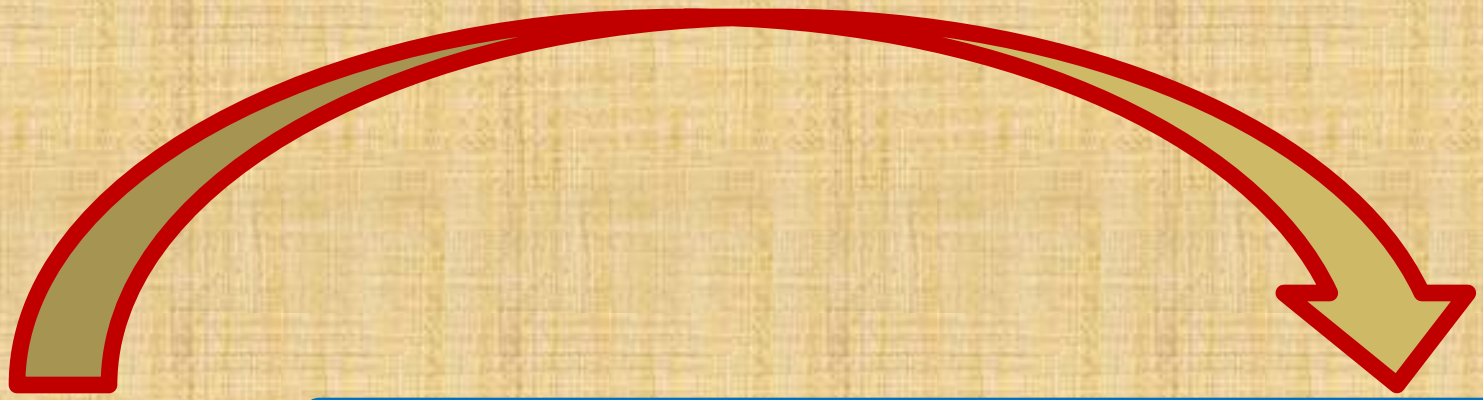
$$"Z" \Rightarrow \quad virtual \quad Z$$

$$S(0) \Rightarrow W^{+} + W^{-}$$

$$S(0) \Rightarrow W^{-} + W^{+}$$

$$S(0) \Rightarrow W^{3} + W^{3}$$

$$W^{3} = \cos\theta_{w} Z + \sin\theta_{w} \gamma$$



$$S(0) \Rightarrow W + W \qquad 22\%$$

$$S(0) \Rightarrow Z + Z \qquad 2.7\%$$

$$S(0) \Rightarrow Z + \gamma \qquad 0.14\%$$

$$S(0) \Rightarrow \gamma + \gamma \qquad 0.25\%$$

$$S(0) \Rightarrow \textit{fermions} \qquad 75\%$$

S(1)
(M= 320 GeV)

BRANCHING RATIOS

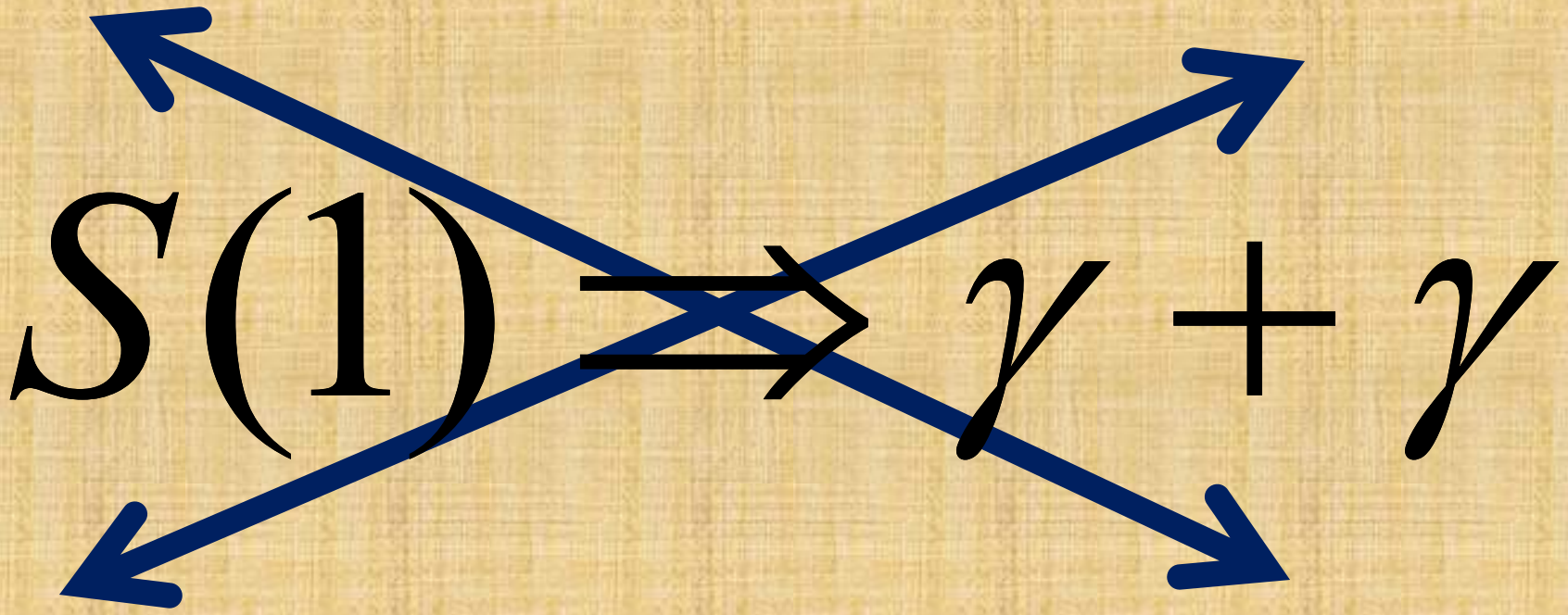
$WW : 0.18 \quad ZZ : 0.06$

$Z\gamma : 0.04 \quad WWZ : 0.12$

$WW\gamma : 0.04 \quad ZZZ : 0.03$

$ZZ\gamma : 0.02 \quad Z\gamma\gamma : 0.01$

$\bar{l}l - \bar{q}q : 0.50$



Landau-Yang-Theorem

T(0)
M: 250 GeV

T(0,+) - T(0,0) - T(0,-)

Branching ratios

T(0,0) - decay

$WW : 0.19 \quad ZZ : 0.04 \quad Z\gamma : 0.04$

$\gamma\gamma : 0.01 \quad WWZ : 0.10 \quad WW\gamma : 0.04$

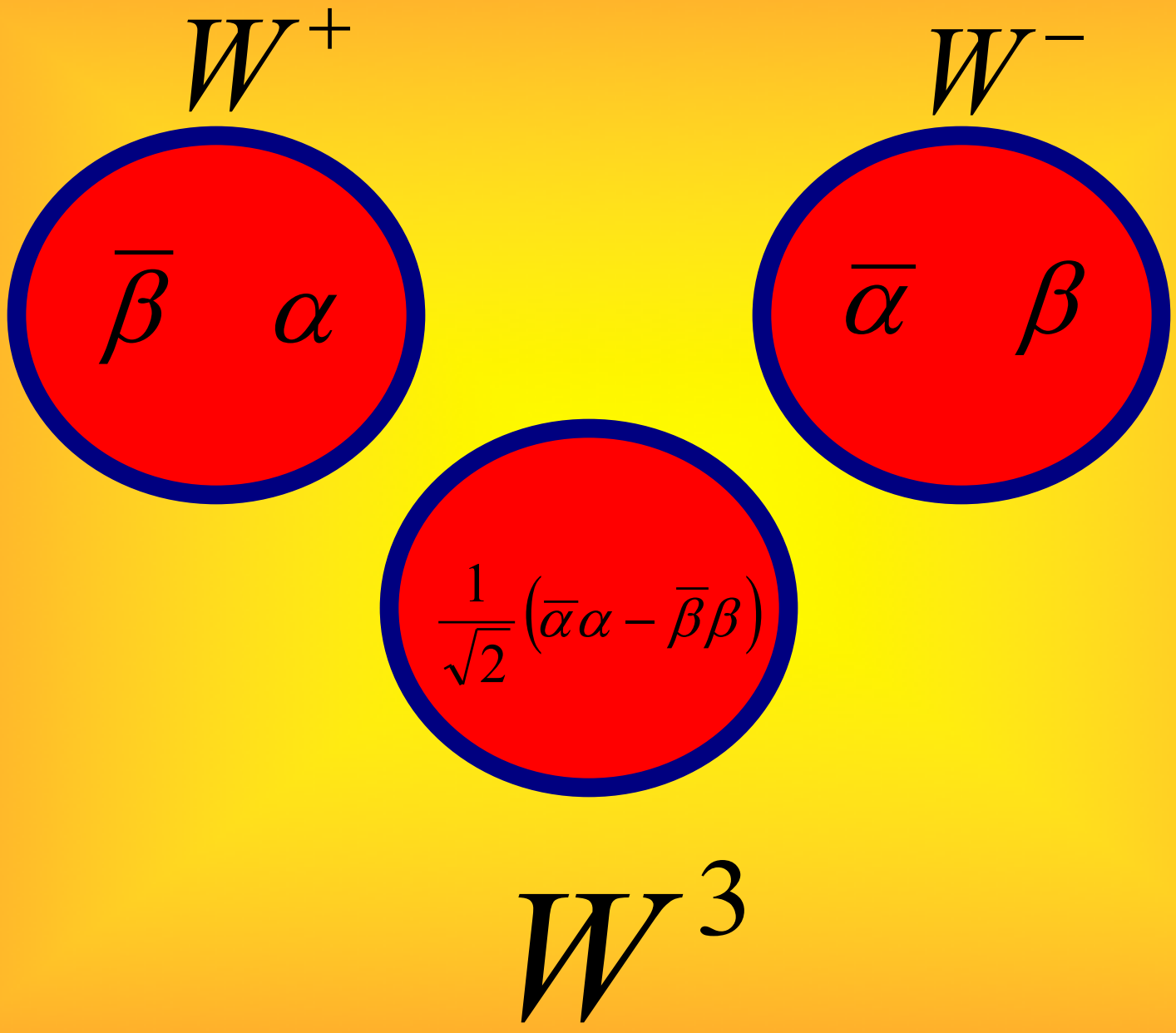
$ZZZ : 0.03 \quad ZZ\gamma : 0.04 \quad Z\gamma\gamma : 0.01$

$\bar{l}l - \bar{q}q : 0.50$

14 TEV:

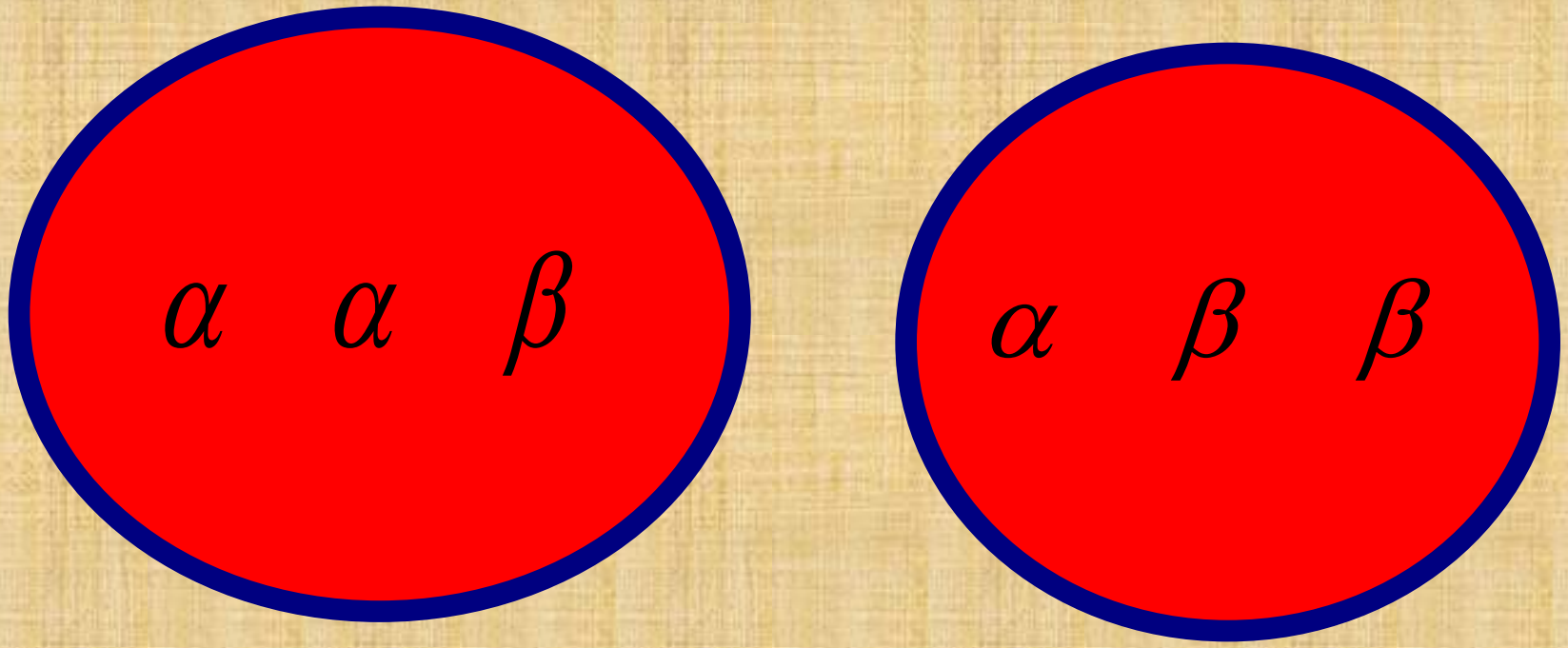
$$\frac{p + p \Rightarrow T(0,0)}{p + p \Rightarrow S(0)} \approx 0.07$$

$$\frac{p + p \Rightarrow (T(0,0) \rightarrow \gamma + \gamma)}{p + p \Rightarrow (S(0) \rightarrow \gamma + \gamma)} \approx 0.2$$


W^+
W^-
$\bar{\beta}\quad\alpha$
$\bar{\alpha}\quad\beta$
$\frac{1}{\sqrt{2}}\left(\bar{\alpha}\alpha-\bar{\beta}\beta\right)$
W^3

fermions

D^+ D^0



$$M(D^+) \approx M(D^0) + (\sim 1 GeV)$$

$$D^+ \Rightarrow D^0 + e^+ + \nu_e \qquad etc.$$

D^0 → H=3

stable

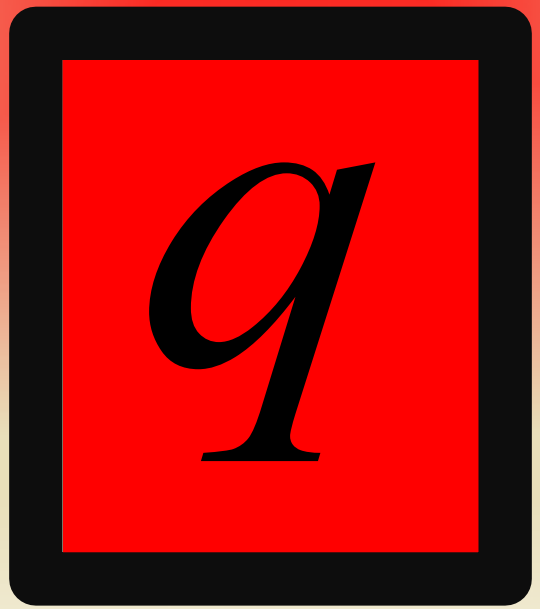
→ Dark matter

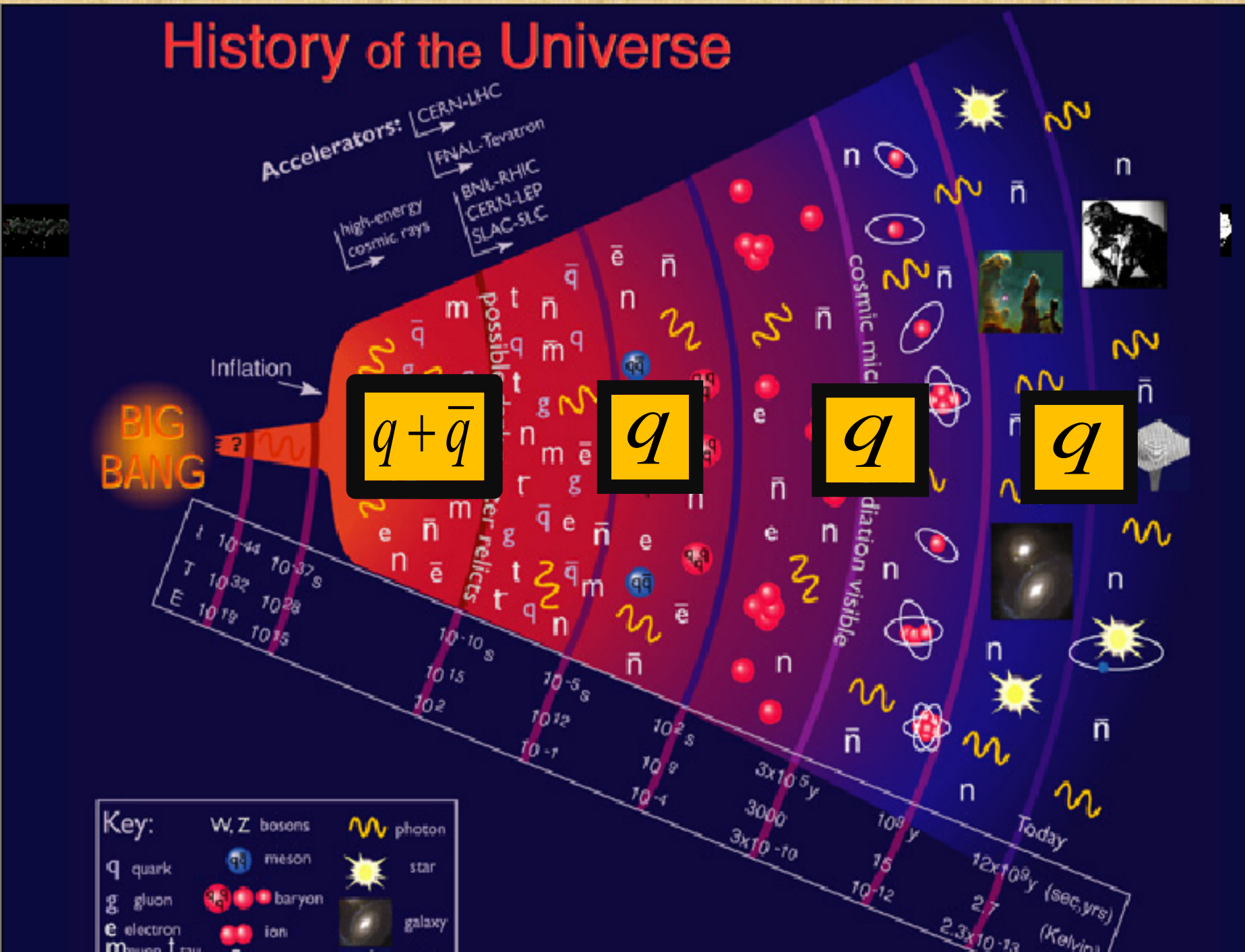
Cosmology

$$q > \bar{q} \Rightarrow$$

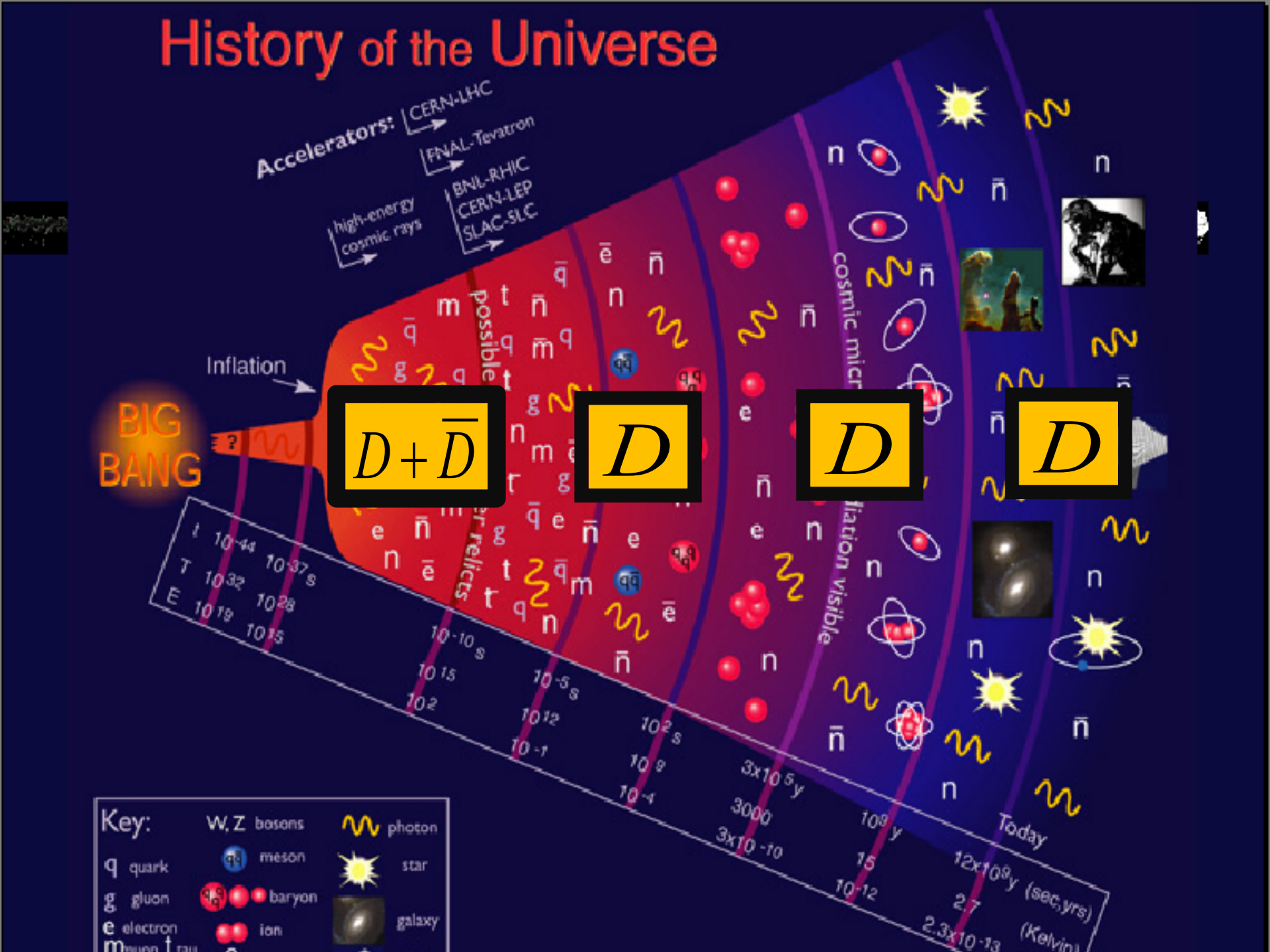
$$\Rightarrow D > \bar{D}$$

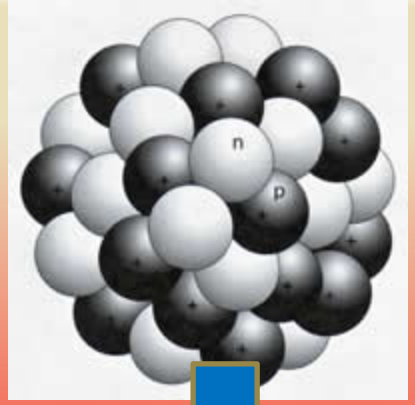
$$q + \bar{q} \Rightarrow \gamma + \gamma$$




History of the Universe
Accelerators:
CERN-LHC
FNAL-Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible
cosmic mic
diation visible
$q+\bar{q}$
q
q
q
Today
Key:
q quark
g gluon
e electron
W, Z bosons
meson
baryon
ion
photon
star
galaxy

$$D + \bar{D} \Rightarrow \gamma + \gamma$$


History of the Universe
Accelerators:
CERN-LHC
FNAL-Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible relics
cosmic microwave visible
$D+\bar{D}$
D
D
D
Today
Key:
q quark
g gluon
e electron
W, Z bosons
meson
baryon
ion
photon
star
galaxy



Z

D

EXPERIMENT:

M(D) > 400 GeV

average local density of dark matter in our galaxy:

$$\rho_{DM}^{local} = (0.39 \pm 0.03) GeV \cdot cm^{-3}$$

D-mass ~ 0.5 TeV

===>

780 D - fermionS / m^3

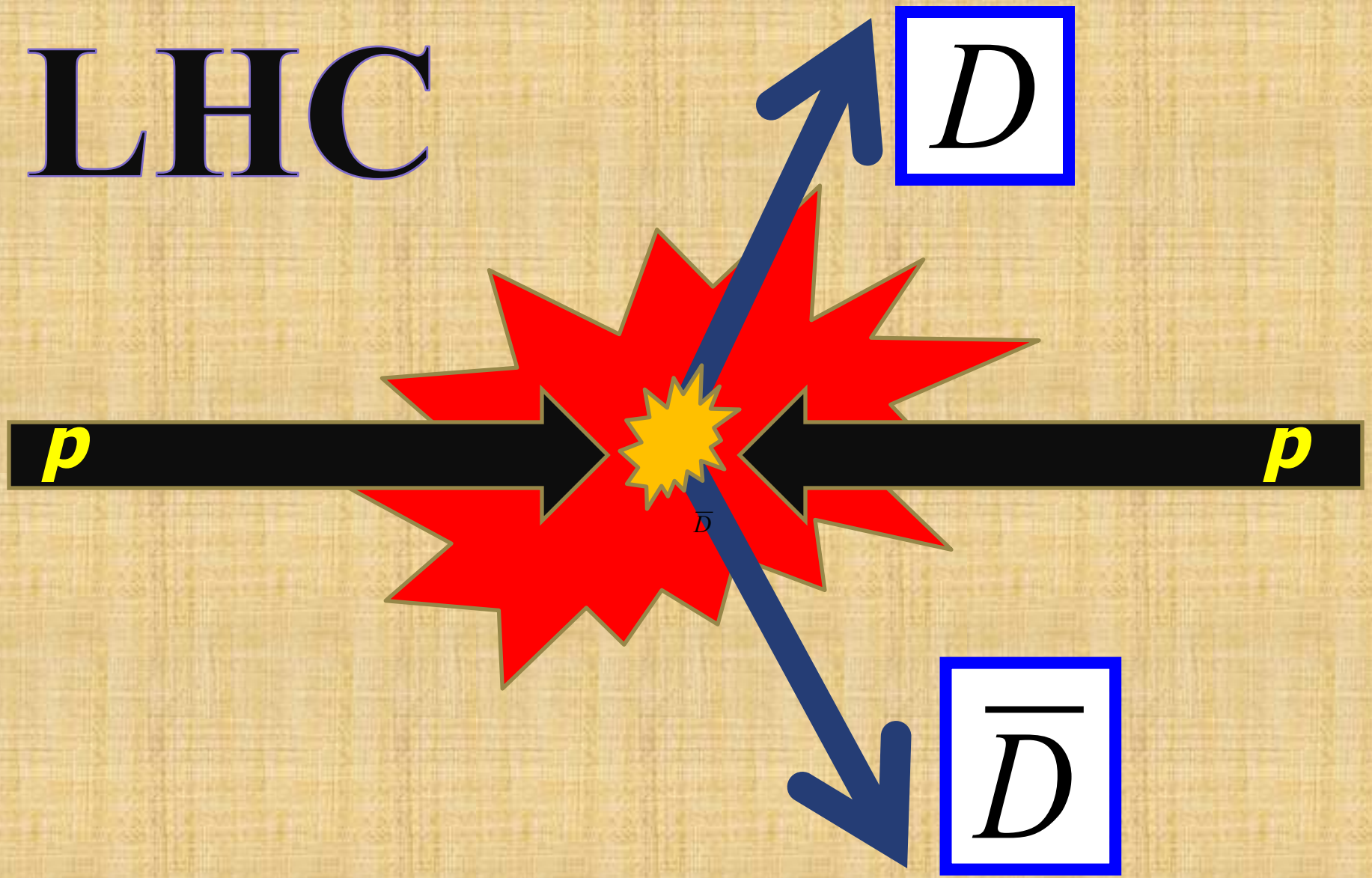
velocity: 7 m/sec

D

7 M/SEC

Gran Sasso ?

LHC



! missing energy !

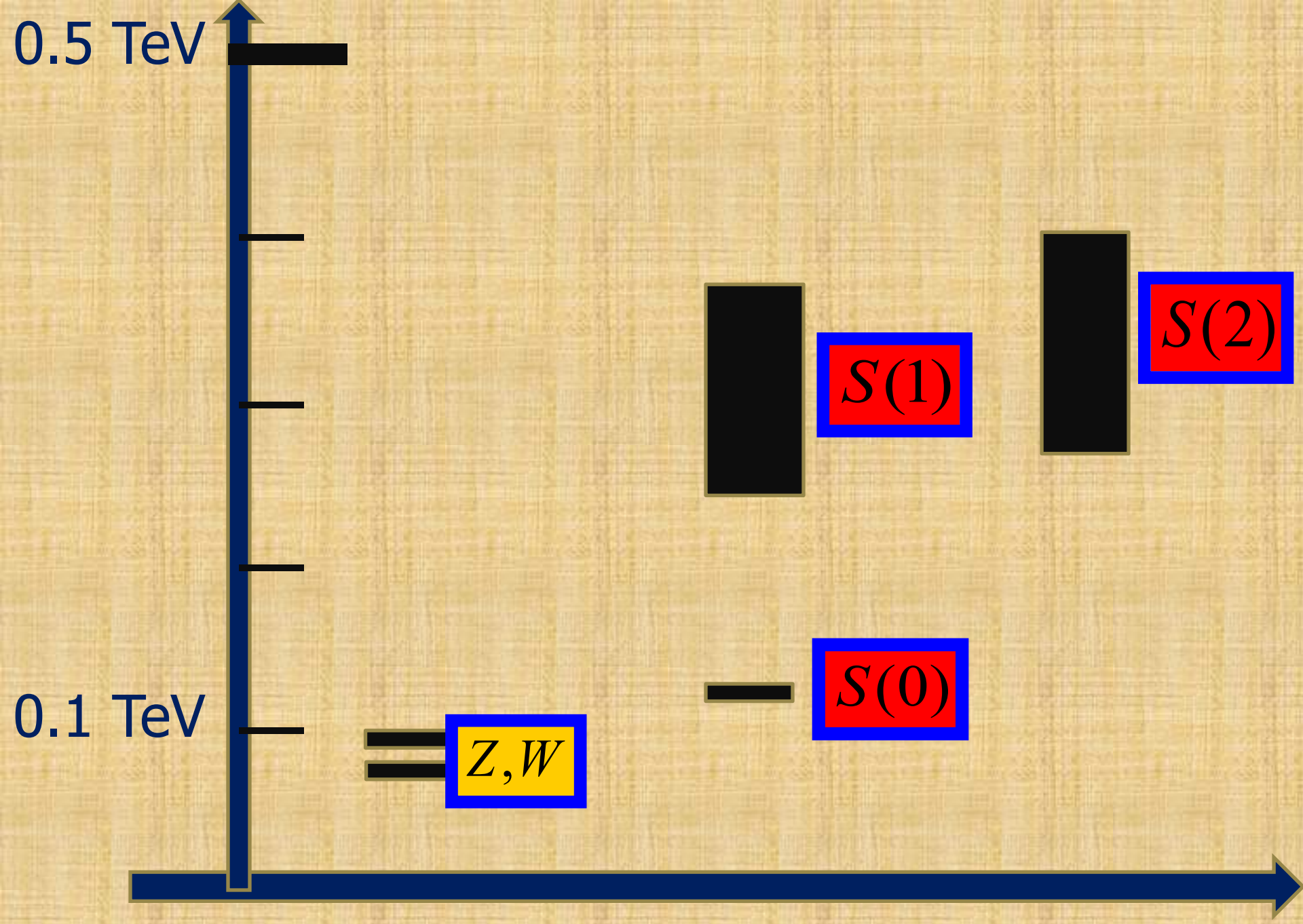
conclusions

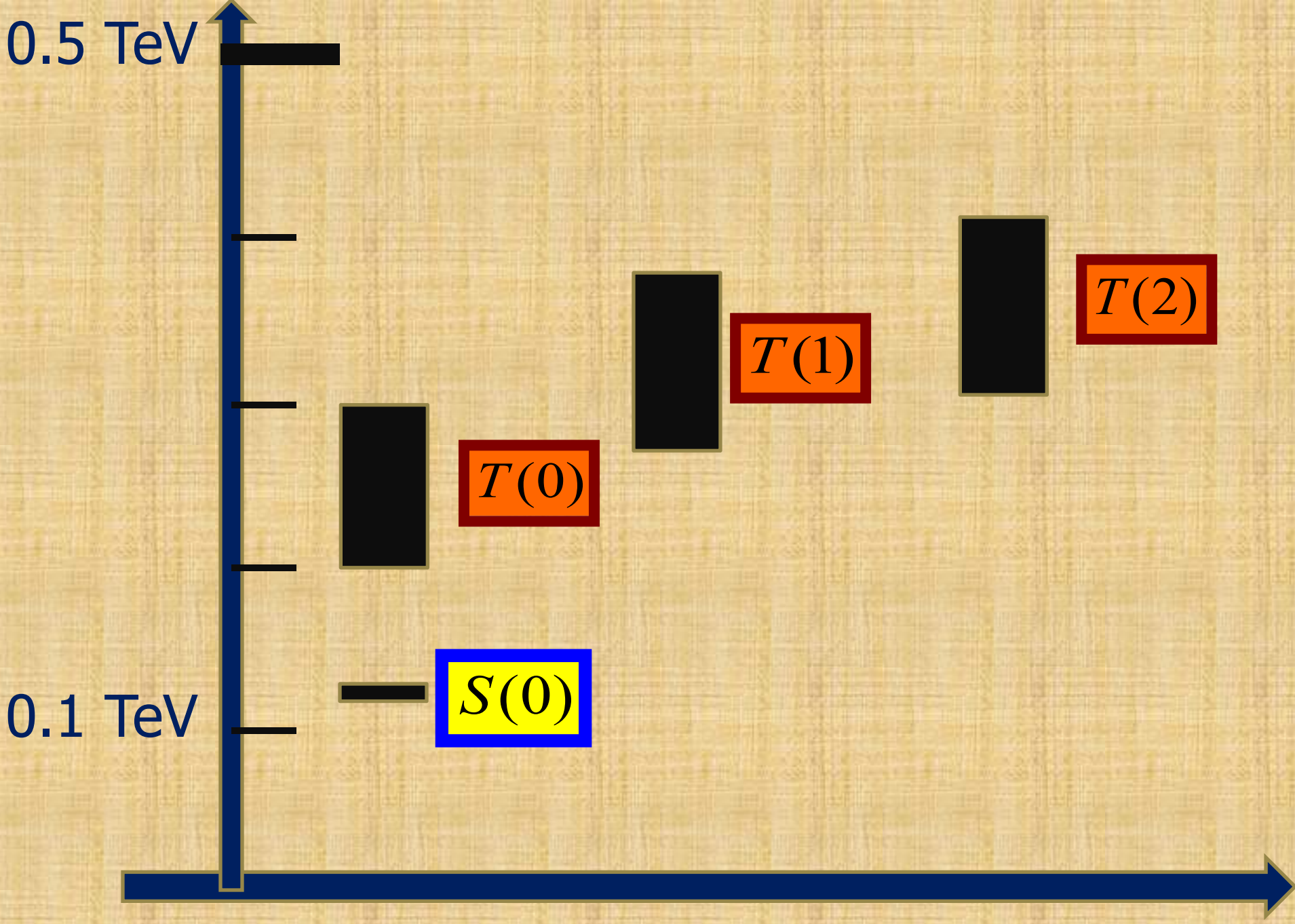
weak bosons

$\Rightarrow$composite

S(0)
excited
weak boson
Spin 0


12 p-wave bosons
below 1 TeV
above
1 TeV
L H C


0.5 TeV
0.1 TeV
$S(1)$
$S(2)$
$S(0)$
Z, W

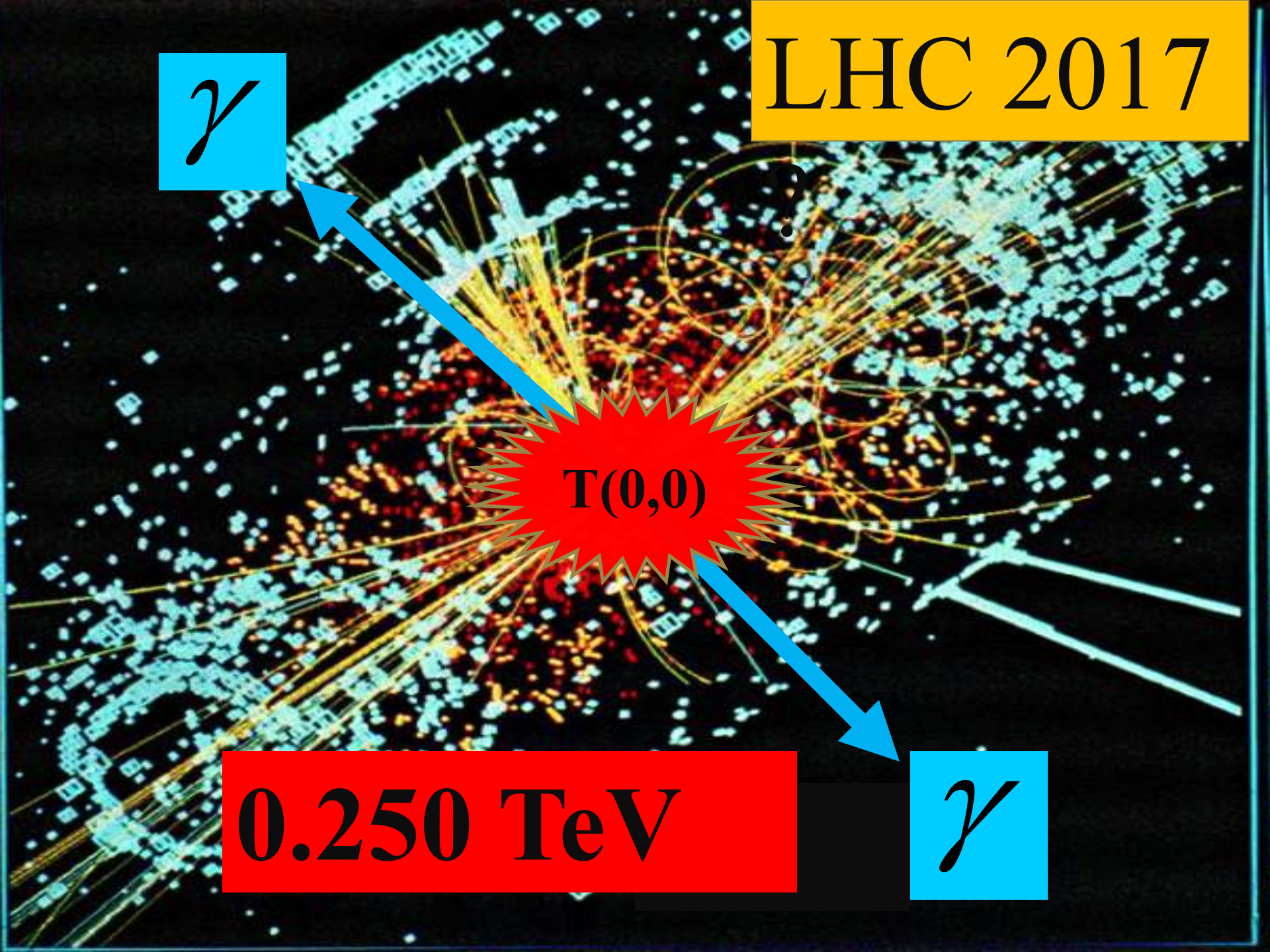

0.5 TeV
0.1 TeV
$T(0)$
$T(1)$
$T(2)$
$S(0)$

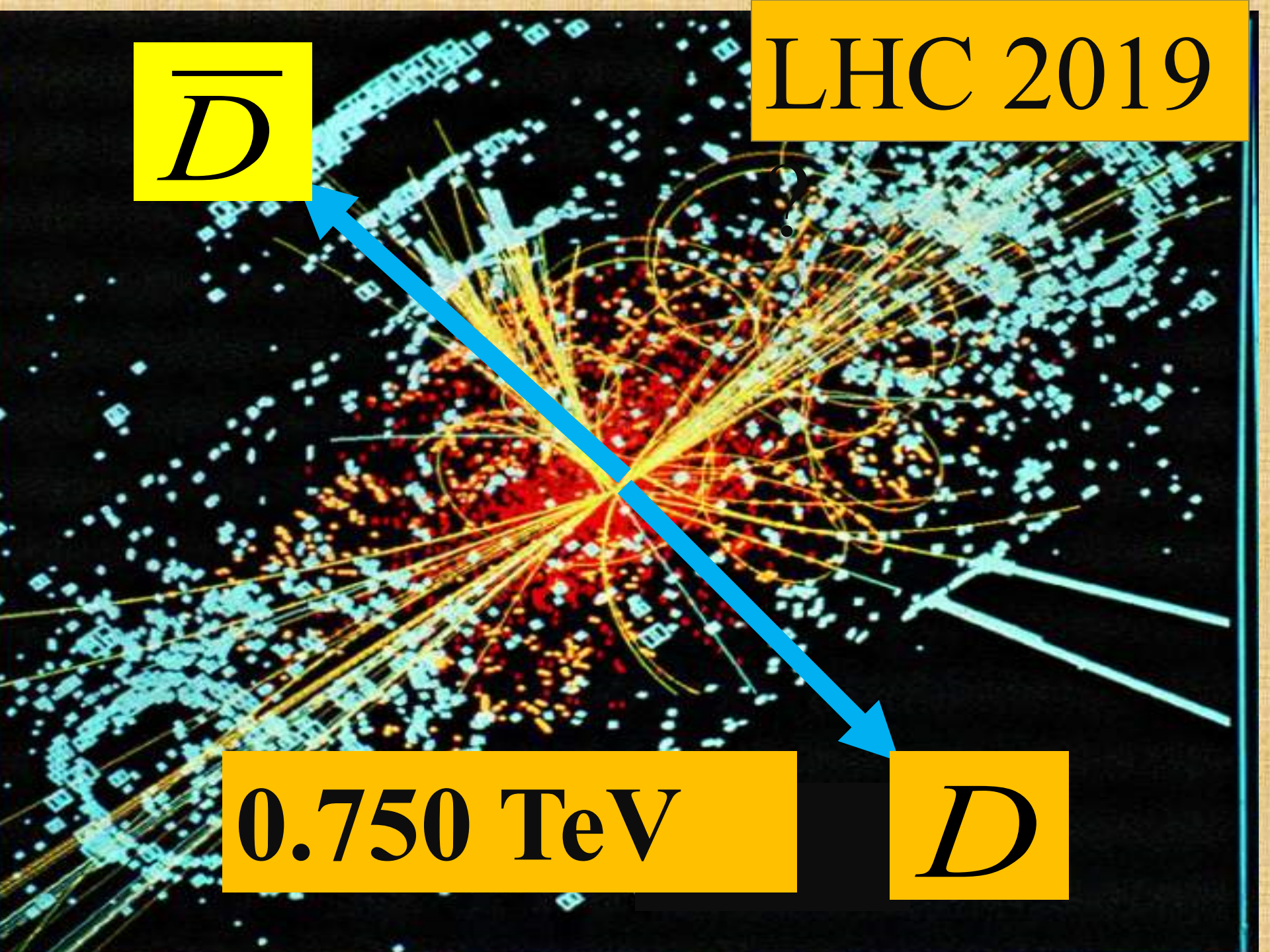
Dark Matter

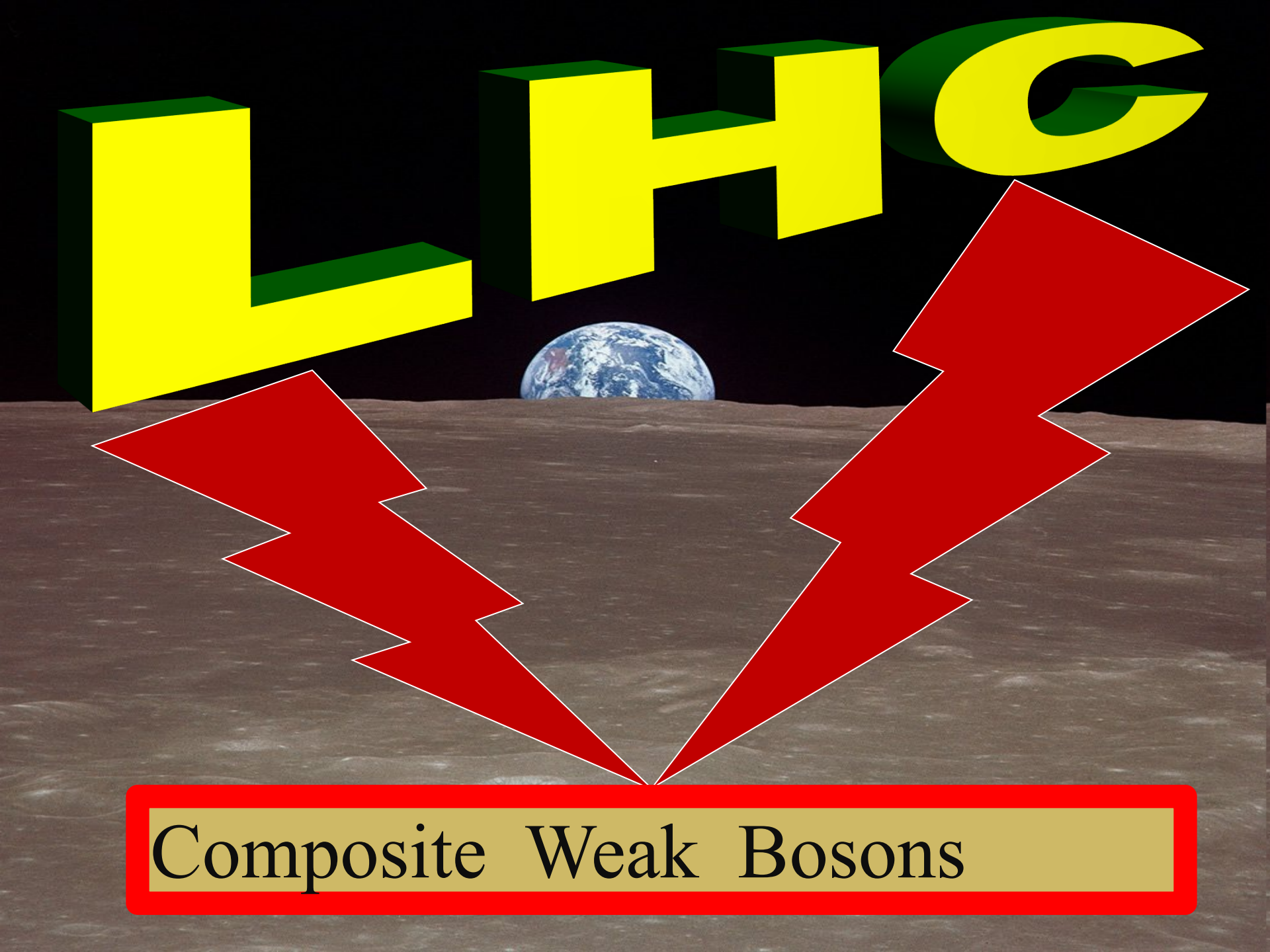
D-fermions

future

LHC


LHC 2017
γ
?
T(0,0)
0.250 TeV
γ


$\overline{D}$
LHC 2019
?
0.750 TeV
D


LHC
Composite Weak Bosons