



"LHC & Higgs Discovery"



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**TEACHERS WORKSHOP
QUARKNET**

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<http://charma.uprm.edu/>



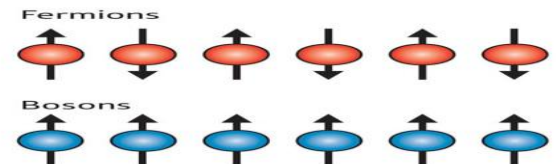
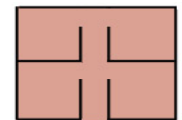
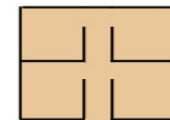
STANDARD MODEL OF ELEMENTARY PARTICLES



✓ Standard Model is the name given to the current theory [Quantum Mechanics + Special Relativity + Symmetry Principles] of elementary particles and how they interact.



✓ These particles are classified as **Fermions** (leptons and quarks) or **Bosons** (Force carriers).

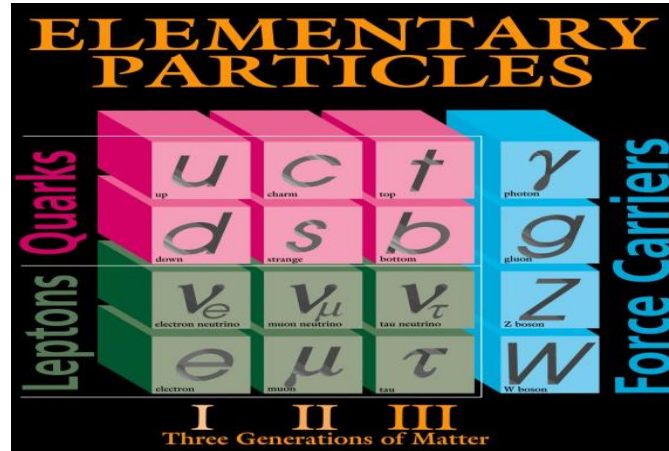




STANDARD MODEL



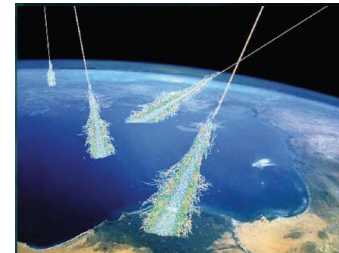
✓ The physical world is composed of: **Quarks & Leptons (Fermions)** interacting: **via the force carriers (Bosons)**



FIRST GENERATION
Ordinary matter
(proton & neutron)

SECOND & THIRD GENERATION
Cosmic Rays & Accelerators

1	H	2															18	He	
2	Li	Be											13	B	C	N	O	F	Ne
3	Na	Mg											14	Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
6	Cs	Ba	Lr	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
7	Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt										
			6	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb		
			7	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No		





Force Carriers (Exchange Particles) [spin= 0,1,2,.. .]

BOSONS			force carriers spin = 0, 1, 2, ...		
Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W^-	80.4	-1	H^0 (SPIN=0)		
W^+	80.4	+1			
Z^0	91.187	0			

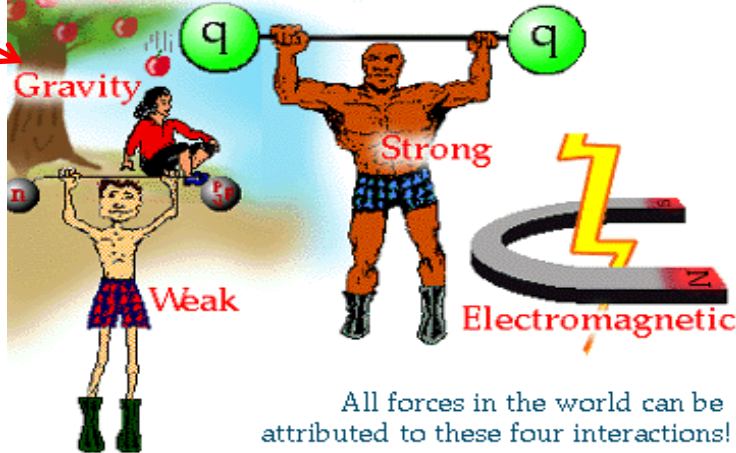
Quarks and Leptons (Building blocks) [spin= 1/2, 3/2, 5/2, ..]



FERMIONS						matter constituents spin = 1/2, 3/2, 5/2, ...		
Leptons spin = 1/2			Quarks spin = 1/2					
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge			
ν_e electron neutrino	$<1 \times 10^{-8}$	0	u up	0.003	2/3			
e electron	0.000511	-1	d down	0.006	-1/3			
ν_μ muon neutrino	<0.0002	0	c charm	1.3	2/3			
μ muon	0.106	-1	s strange	0.1	-1/3			
ν_τ tau neutrino	<0.02	0	t top	175	2/3			
τ tau	1.7771	-1	b bottom	4.3	-1/3			

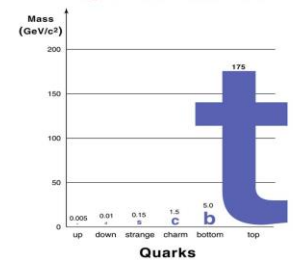
NO IN SM

The Four Fundamental Interactions



All forces in the world can be attributed to these four interactions!

QUARK MASSES

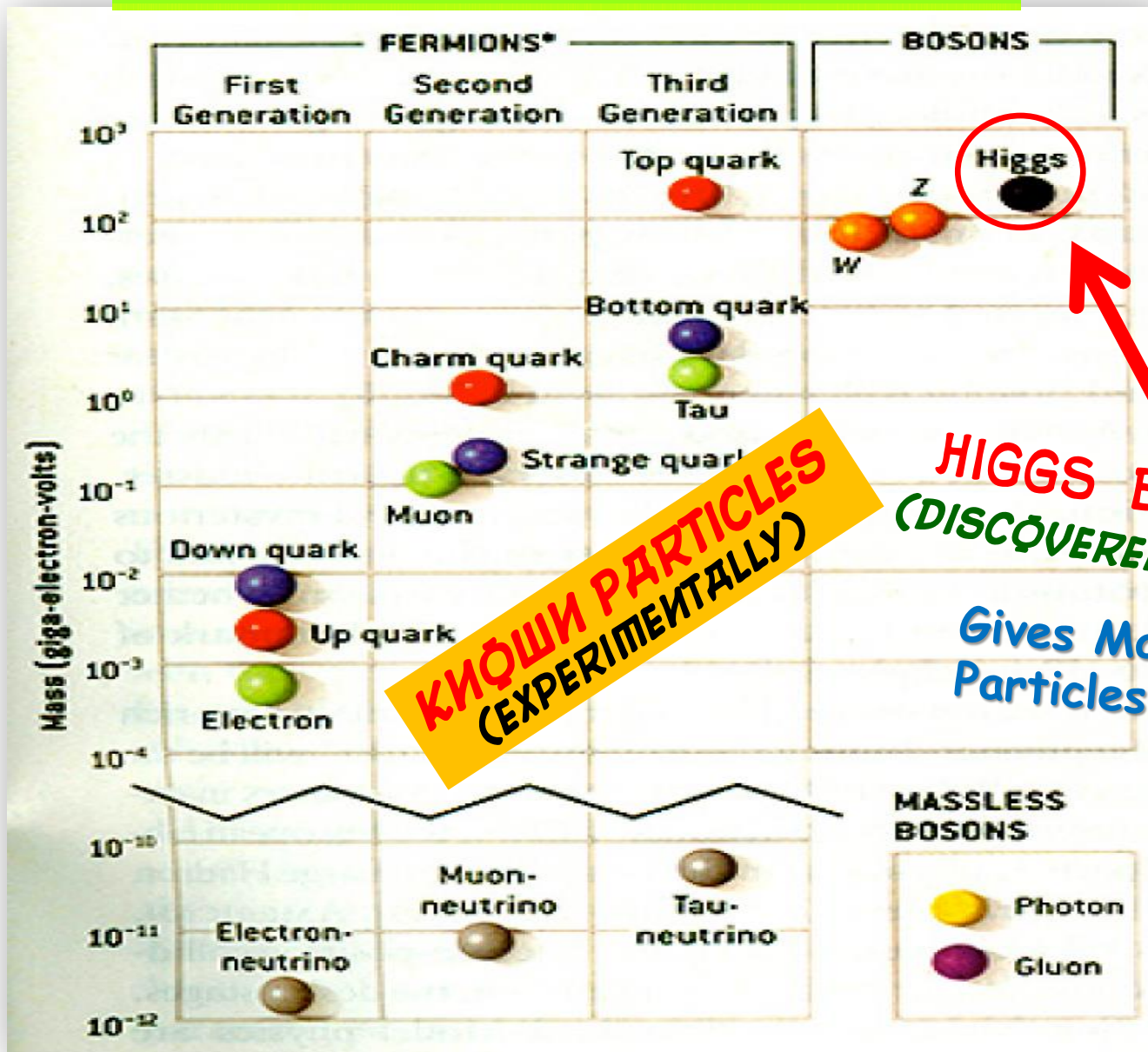


¿a qué hora me vas a presentar?





ELEMENTARY PARTICLE MASSES

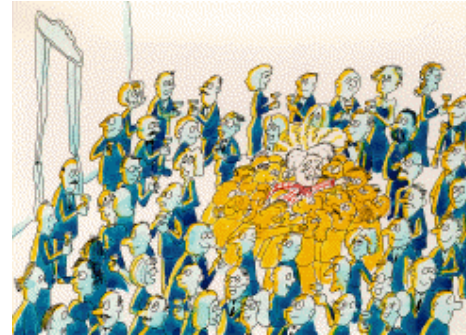


КИОШИ PARTICLES (EXPERIMENTALLY)

HIGGS BOSON (DISCOVERED 2012)

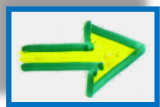
Gives Mass to all Particles !!

Higgs Field



Particle get mass & can't move as fast as it was

- ✓ The Higgs field is composed of Higgs Boson which interact with particles to give the mass.
- * Stronger interaction implies bigger mass (W^\pm , Z^0 , etc).
- * No interaction implies no mass as the photon (γ).



Experiments at LHC @ CERN design to search for H and beyond.





The Higgs Boson Born on the 4th of July

What gives masses to fundamental particles such as quarks and electrons?

On the 4th of July 2012, new results in the search for the Higgs boson and studies of its properties were announced by the ATLAS and CMS Experiments at the Large Hadron Collider, see www.atlas.ch and cms.cern.ch.

In this collision at the ATLAS detector, a Higgs boson and other particles have been produced along with other particles. The Higgs boson was identified from the decay products of two photons and two Z-bosons (positrons), shown by the red and blue lines.

In this collision at the CMS detector, a Higgs boson was identified from the decay products of two photons and two Z-bosons (positrons), shown by the green lines.

The Higgs Field and the Boson

All of space is permeated by a field, the Higgs field.

The Higgs field is responsible for the mass of fundamental particles, like the universe.

This image shows a representation of the field.

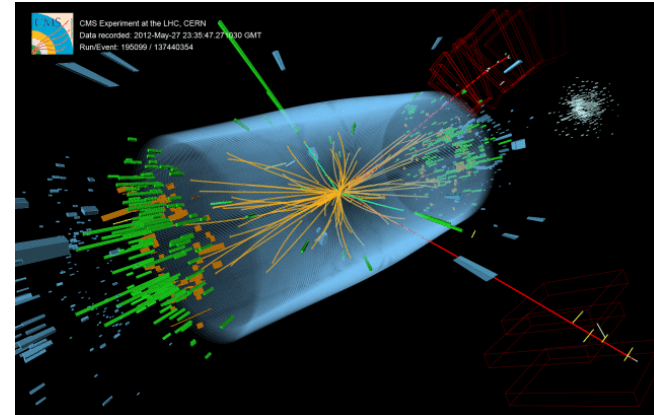
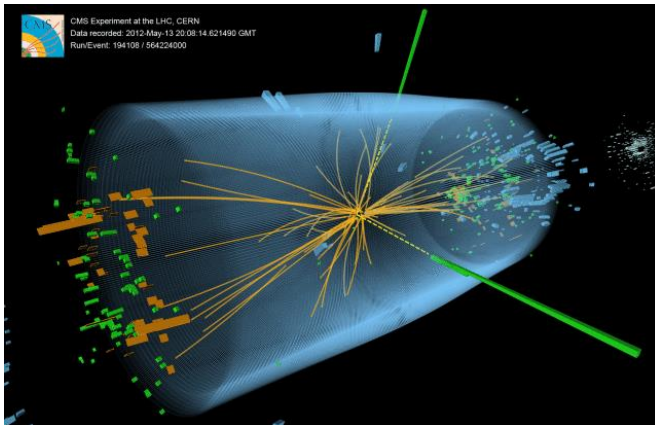
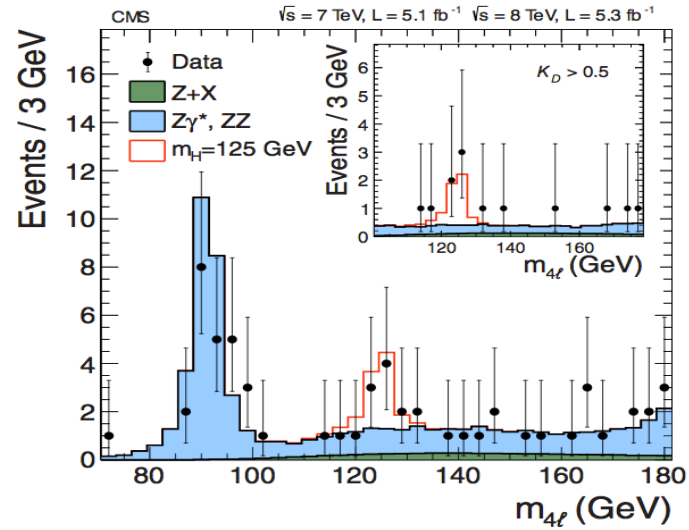
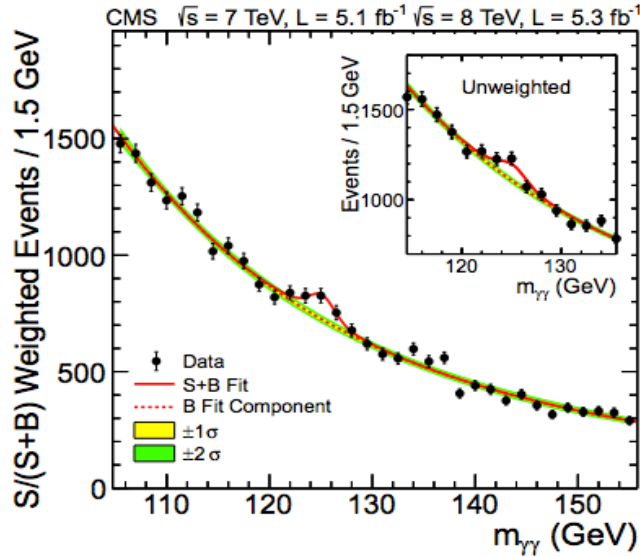
Quantum theory says that all fields have particles associated with them, so...

In this case... a Higgs Boson.

Learn more at ParticleAdventure.org and of CPEPphysics.org

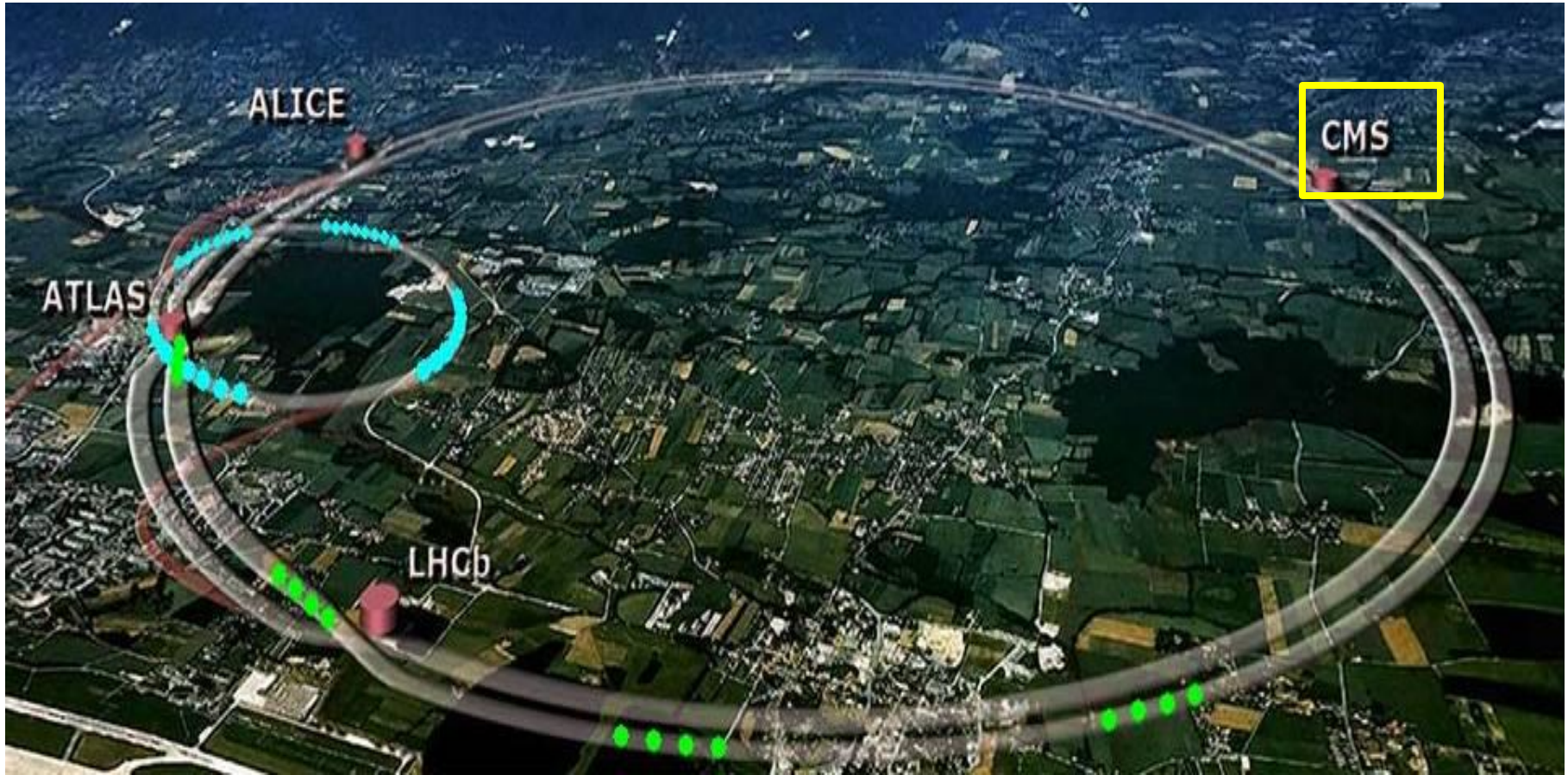


FOUND A RESONANCE AT ~ 125 GeV.
 CONSISTENCY WITH THE SM HIGGS BOSON
 IS UNDER STUDY.



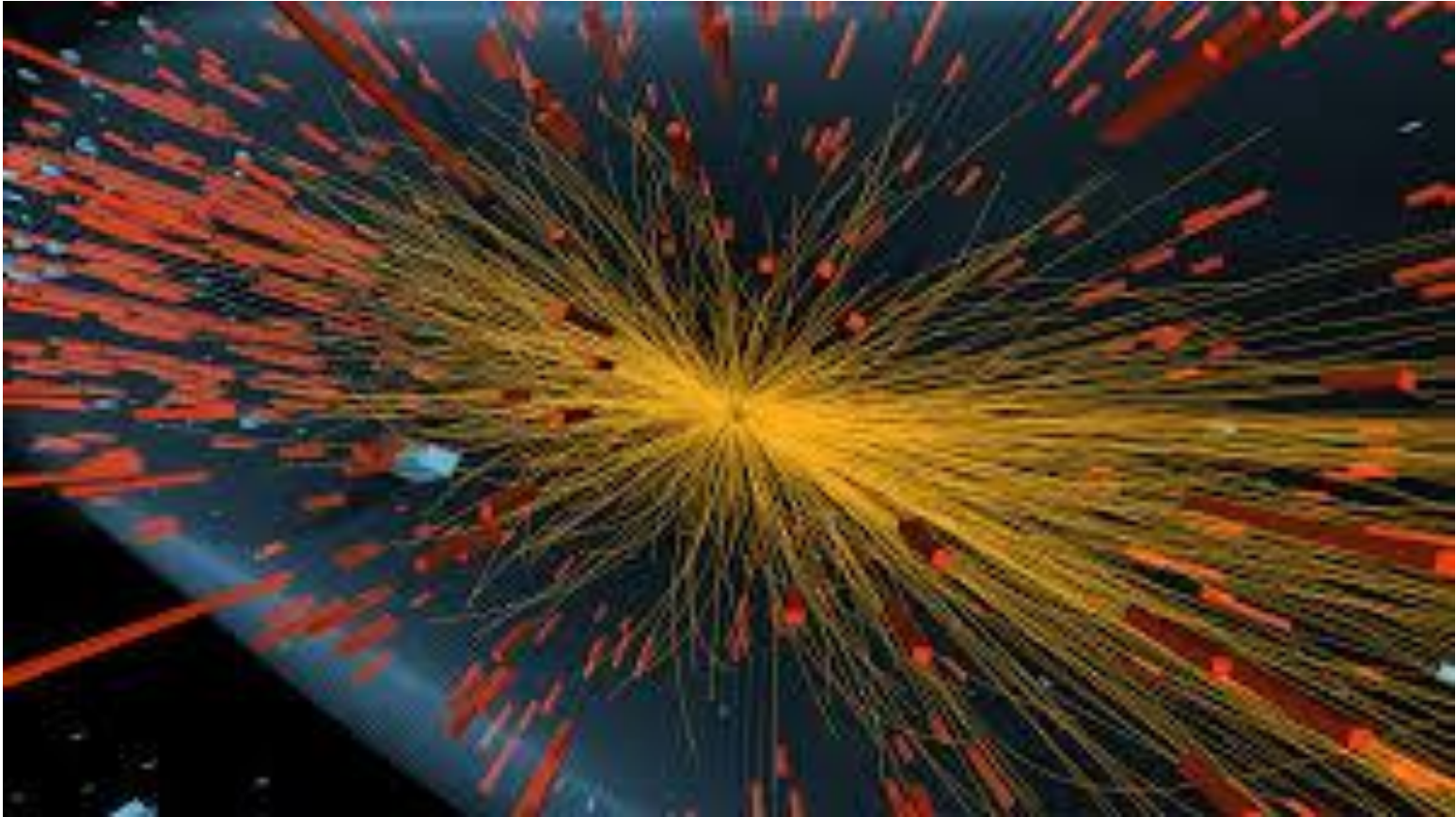


LHC will accelerated (2015) p up to 6.5 TeV
producing collisions of pp at energies of 13 TeV.
(p travel at $\sim 99.99999999\%$ speed of light)





A Collision





IF LHC were at Puerto Rico

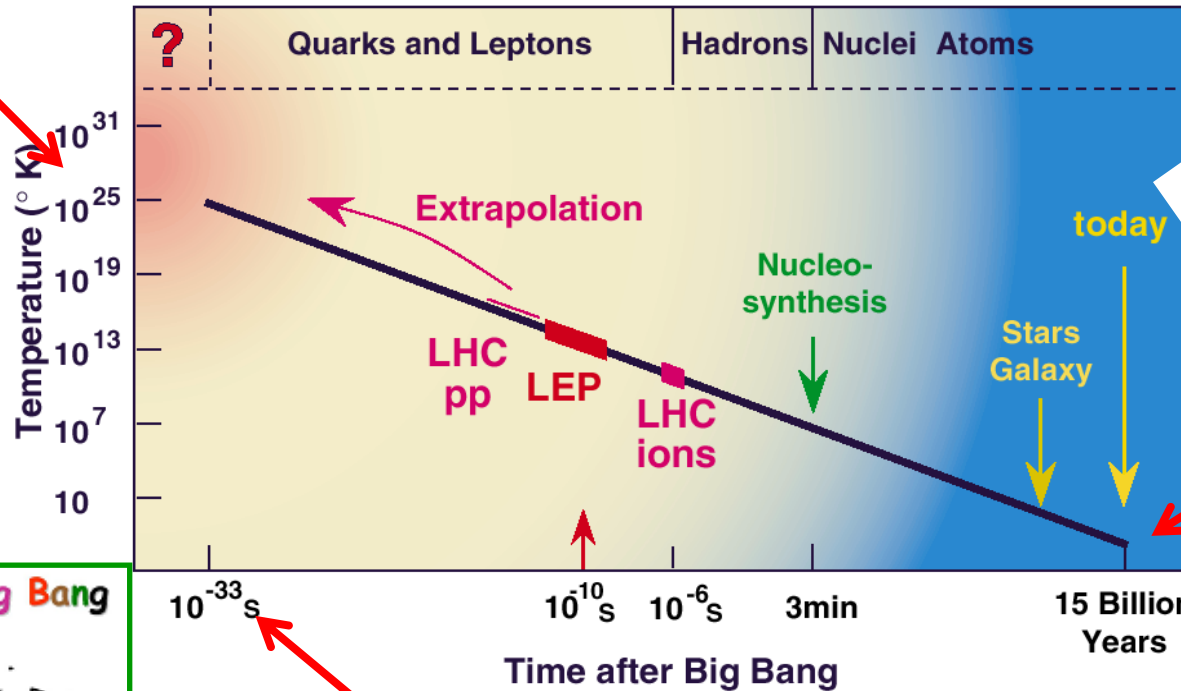




"A time machine" (Particle Accelerator)



here very verry
verrrrry HOT



here very very
verrrry COLD

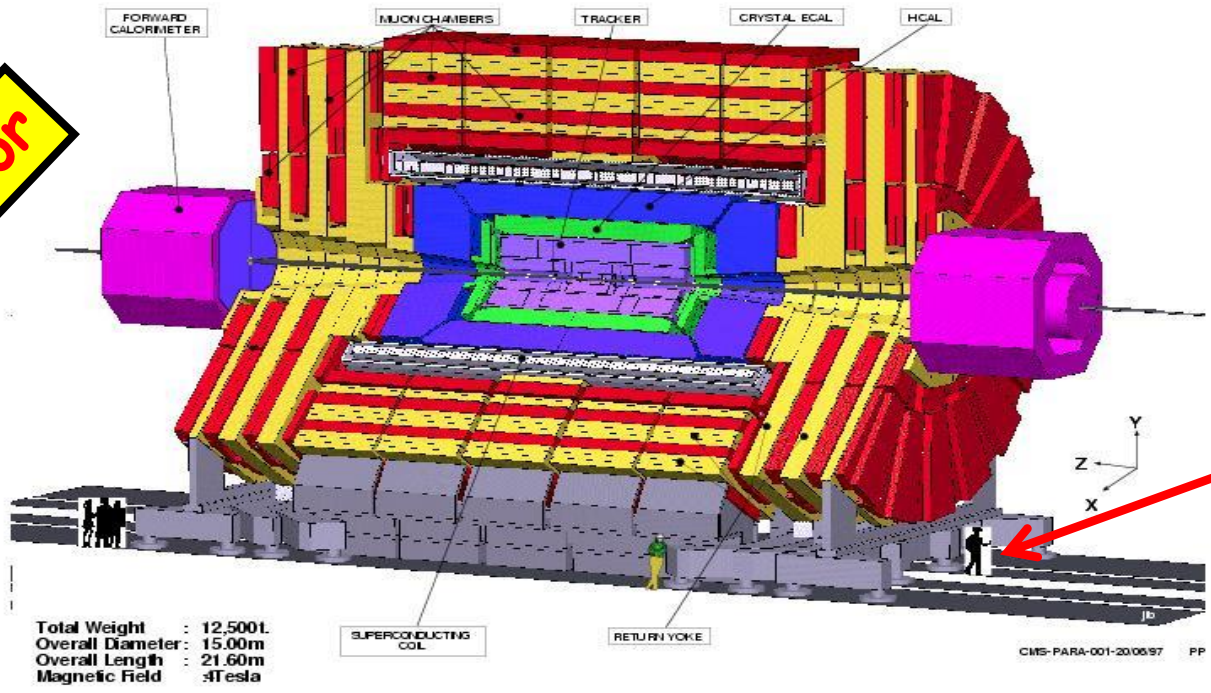


here very very
verrrry YOUNG

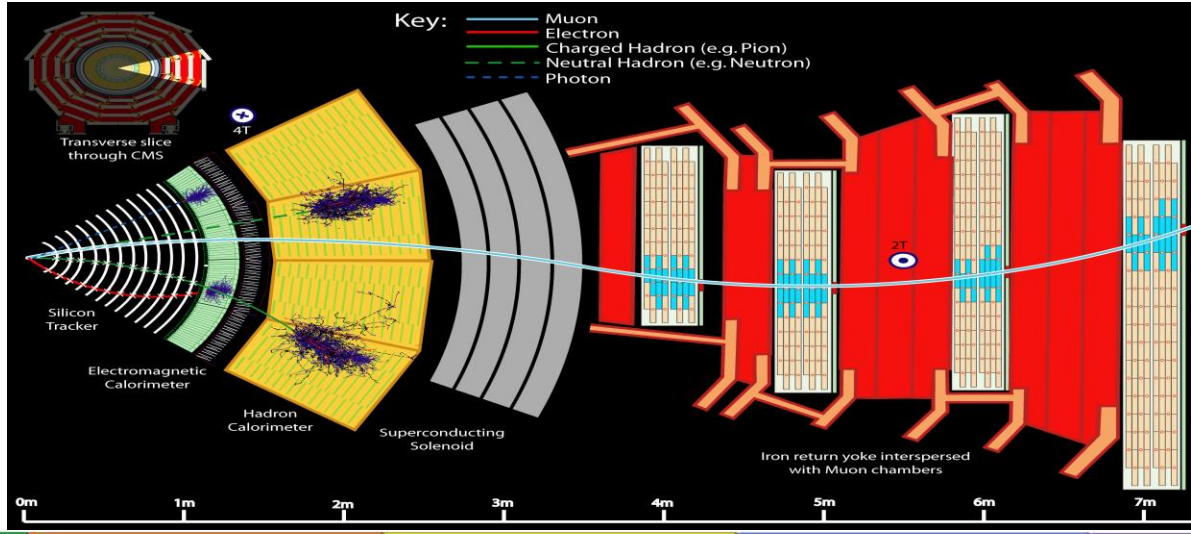




CMS Detector



A CMS Collaborator

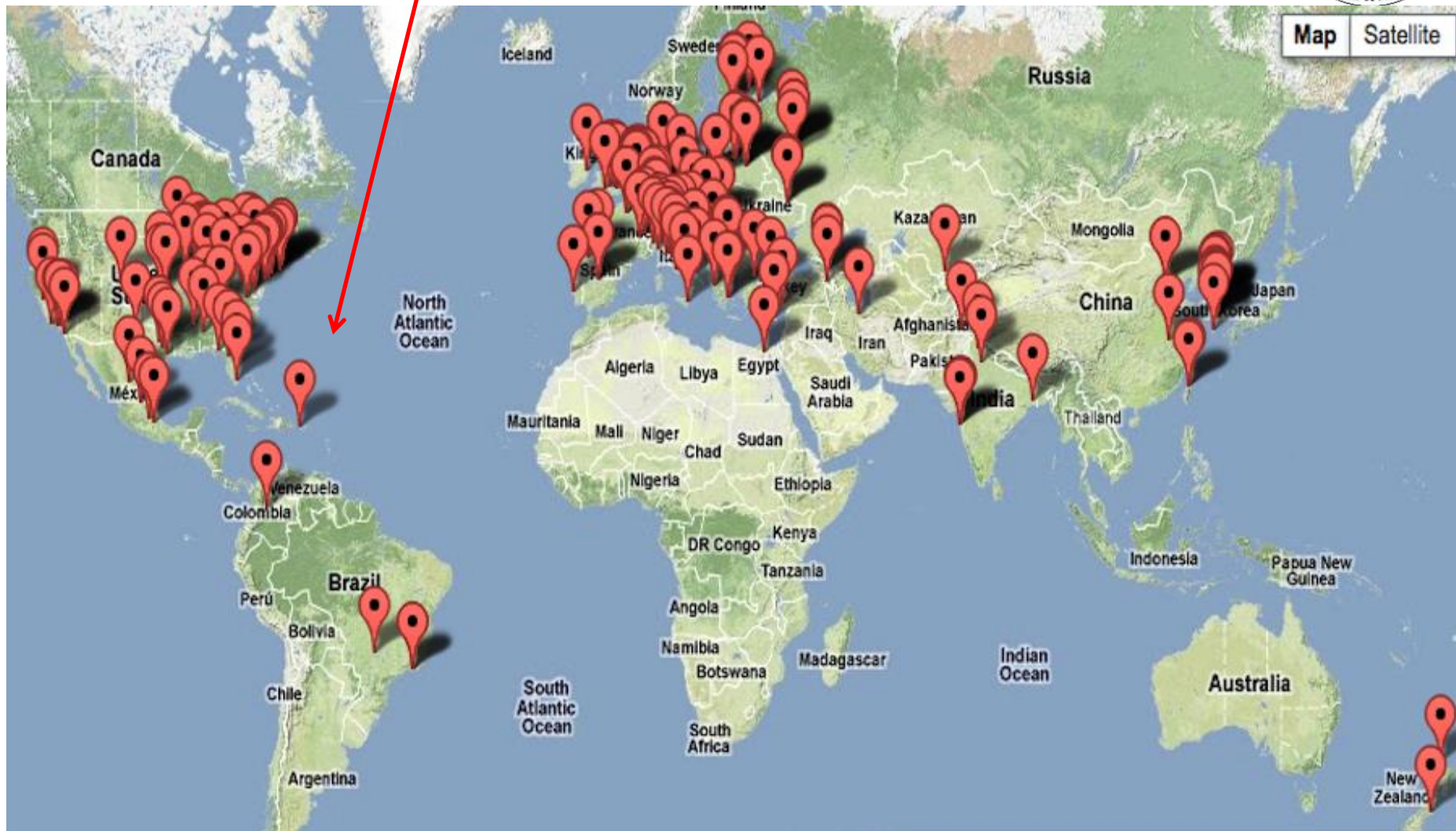




CMS COLLABORATION (~3000)

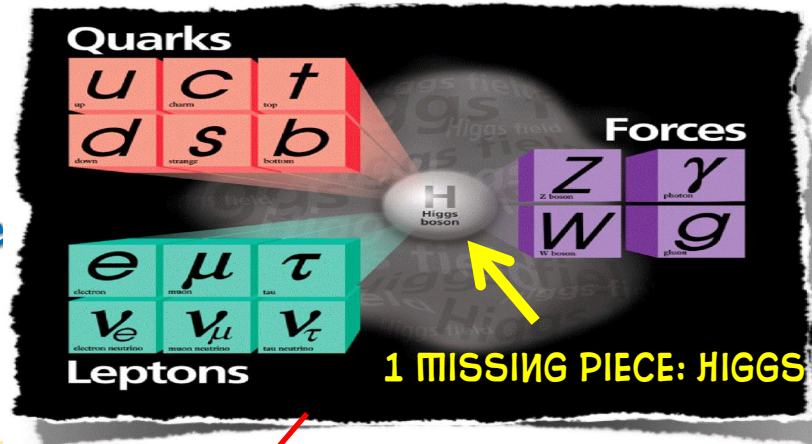


UPR-MAYAGÜEZ





Good News: Standard Model almost completed



SM only explain ~5% of all matter in the Universe

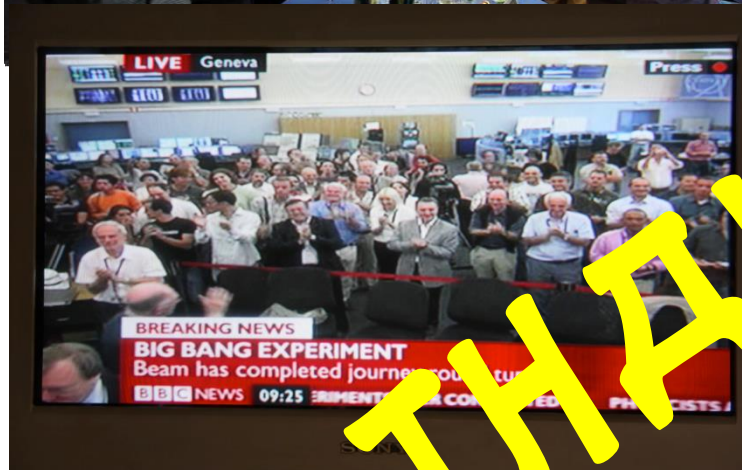
Good We Physicists have work to do.

~~Bad News: ~95% unknown matter~~





THE EXCITEMENT IN PICTURES



THANK YOU