Lecture 1 : Overview

In "PHYS 437 High Energy Physics I" course we will mainly cover the following titles :

1. Overview of particle physics, its concepts and theoretical sturucture, latest experimental discoveries. Latest physics news from the leading accelerators and detectors. (Chapter 1-7 of D.Griffiths' well-known textbook "Introduction to Elementary Particles second Ed. J.Wiley 2008) which is adopted as our main textbook). The students are expected to learn these chapters well enough, which constitute the basic groundwork.
2. Historical introduction to the world of elementary particles
3. Elementary particle dynamics
4. Relativistic kinematics
5. Symmetries, groups, and conservation laws
6. Bound states, fine and hyperfine structures of hydrogen atom, positronium, quarkonium.
7. The Feynman Calculus, lifetime and cross section calculations for a toy model of quantum field theory.
8. Dirac equation
9. Feynman rules for qautıum electrodynamics (QED)
10. Analysis of basic QED processes.

On the other hand weak interactions, basics of quantum chromodynamics and neutrino physics are left for the Spring semester and they will be throughly elaborated in PHYS 438.

All the necessary derivations and the details of the mathematical calculations will be presented on the blackboard in the class.

Elementary particle physics deals mainly with two big problems of the physics which are connected to eachother : what are the basic building blocks of the matter and the interactions between them. The right framework to study these questions is the quantum field theory, which is certainly beyond the level of the undergraduate curriculum. So in the beginning we will suffice with using the special relativity and quantum mechanics and in foregoing discussions the relativistic quantum mechanics will be our main tool.

The following concepts are vital for the elementary particle physics so let us mention them at the very beginning :

Indistinguishability : For example all the electrons in the universe are identical. However in macroscopic world we don't observe this striking fact : the televisions, or cell phones of the same model are surely perfectly similar but can never be identical.

Fermions and bosons :

Pauli exclusion principle :

Fundamental forces of nature : Electromagnetic force, weak nuclear force, strong nuclear force, gravitational force

Symmetries : Spacetime symmetries, internal symmetries, continuous symmetries, discrete symmetries, gauge symmetries, local or global symmetries, exact or broken symmetries etc.

Sources of the experimental information and data : Scatterings, decays and bound states

Experimantal facilities : Cosmic rays, particle colliders (accelerators), nuclear reactors, and various detectors for specific purposes. The well known Lorentz force law plays a crucial role in detecting the charged particles.

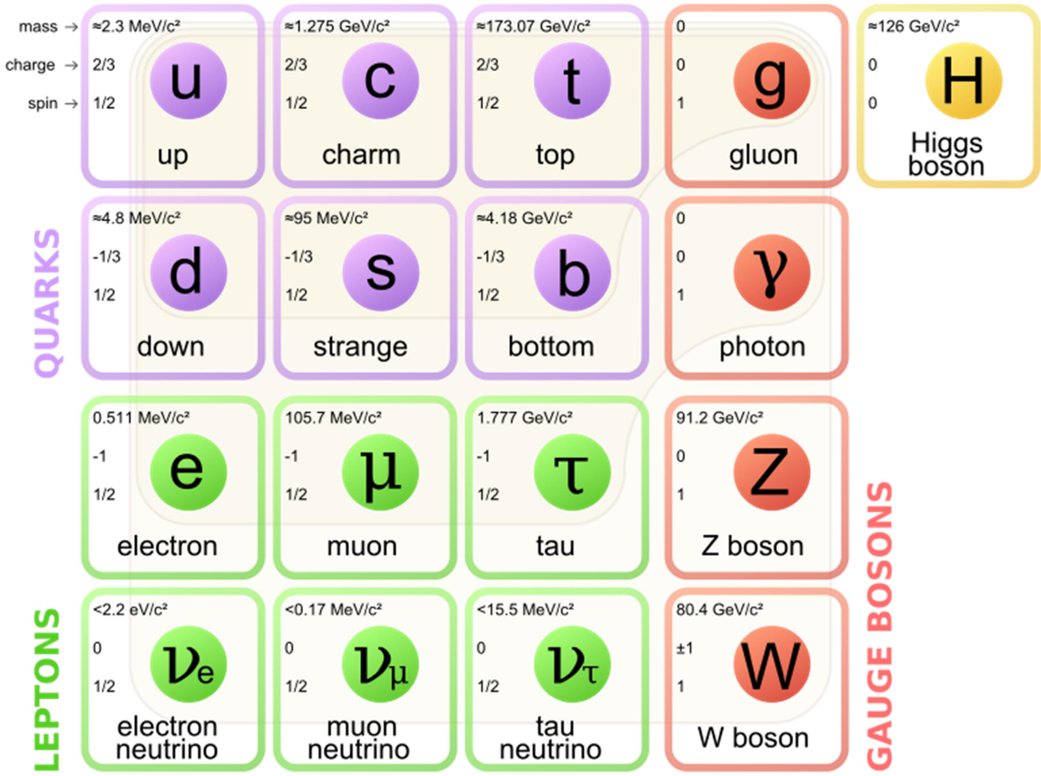
$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

Examples from the past and present : LEP and LHC at CERN, SLAC, Fermilab, HERA at DESY, ATLAS, CMS, LHCb and ALICE detectors at LHC, Neutrino detectors SNO, SuperKamiokande, OPERA, many others ….

Constants of nature : speed of light (c), universal gravitational constant G, charge of the electron (e), Planck's constant h …

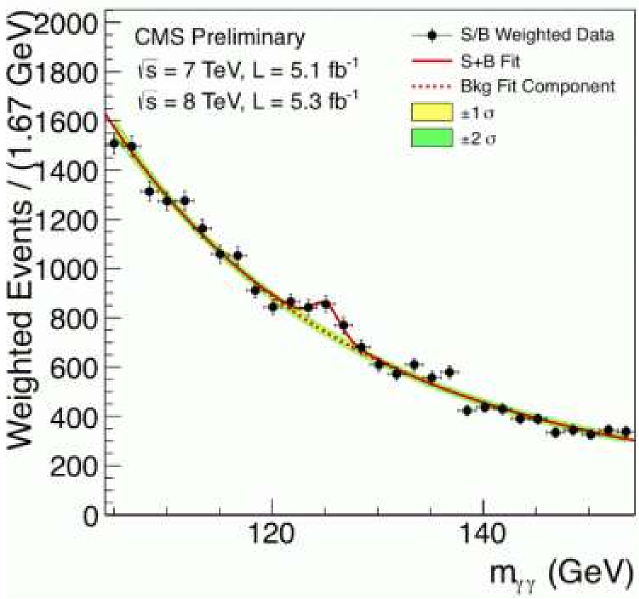
Unit systems : SI, Gaussian, Heaviside-Lorentz, natural unit system $c = \hbar = 1$

Standard Model (SM) of the elementary particle physics prefectly describes the subnuclear world and is summarised by the tables given below (taken from the US Lawrence Berkeley Lab web page) :

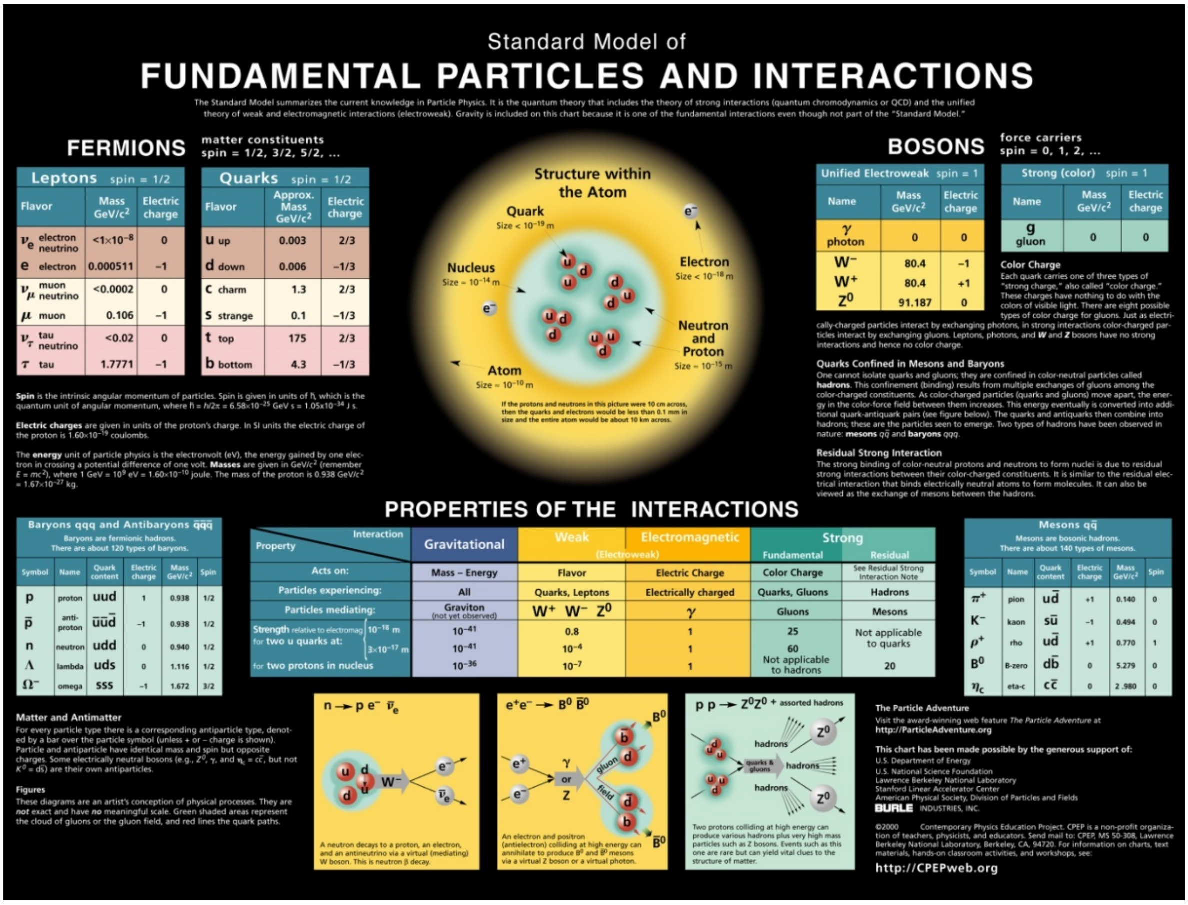


The discovery of the Higgs boson on July 4, 2012 at LHC CMS and ATLAS detectors constitutes surely an historical landmark for the whole humanity.

CMS Preliminary Data 2012



CERN – Geneva July 04, 2012



http://CPEPweb.org (Contemporary Physics Education Project)

This web page has very rich educational charts and other valuable materials. Visit the web page and examine the updated charts and discuss them.