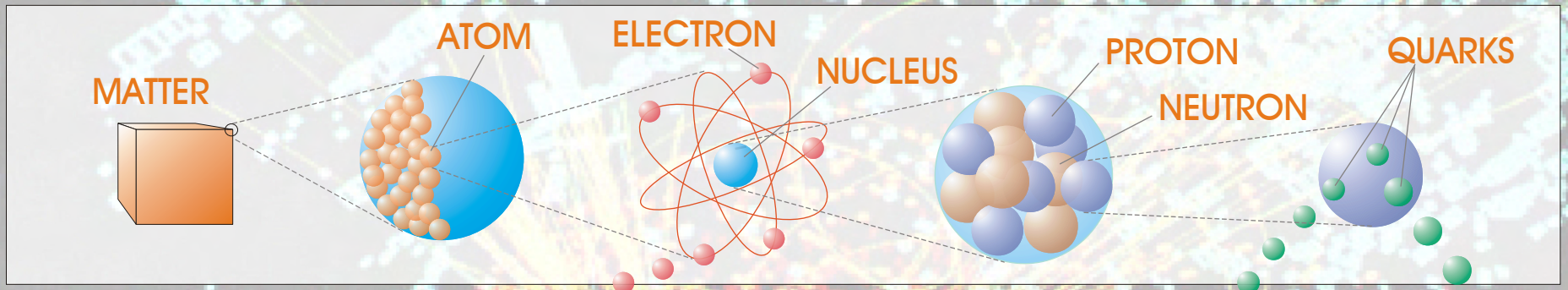
Royal Holloway
University of London

The Structure of Matter



LEPTONS

These particles exist on their own

		Charge = -1	Charge = 0
Constituents of ordinary matter.	1st Family	**ELECTRON** (e^-) Responsible for electricity and chemical reactions. Mass = 0.51 MeV/c^2	**ELECTRON NEUTRINO** (ν_e) Rarely interacts with other matter. Observed 1956.
These particles existed in the early moments after the Big Bang. Now they are found only in cosmic rays and at particle accelerators.	2nd Family	**MUON** (μ^-) A heavier relative of the electron. Discovered 1937. Mass = 0.106 GeV/c^2	**MUON NEUTRINO** (ν_μ) A relative of ν_e Discovered 1962.
	3rd Family	**TAU** (τ^-) A heavier relative of the electron and muon. Discovered 1975. Mass = 1.78 GeV/c^2	**TAU NEUTRINO** (ν_τ) Indirect evidence 1975. Directly observed 2000.

Until recently it was generally thought that the neutrinos have zero mass.
Several recent experiments suggest that the mass of the neutrinos is not zero.

QUARKS

These particles only exist bound together

Charge = +2/3	Charge =-1/3
UP (u) Mass ~ 3 MeV/c^2	**DOWN** (d) Mass ~ 6 MeV/c^2
Protons are made up of two up quarks and one down quark. Neutrons are made up of one up quark and two down quarks.	
CHARM (c) A heavier relative of the up quark. Discovered 1973. Mass ~ 1.2 GeV/c^2	**STRANGE** (s) A heavier relative of the down quark. Evidence 1947. Mass ~ 0.1 GeV/c^2
TOP (t) The heaviest quark. Discovered 1994. Mass ~ 175 GeV/c^2	**BOTTOM** (b) A heavier relative of the down and strange quarks. Discovered 1977. Mass ~ 4.2 GeV/c^2

ALL OF THE ABOVE PARTICLES HAVE AN ANTIPARTICLE COUNTERPART.

A particle and its antiparticle can annihilate to produce the bosons that carry forces, e.g. $e^+e^- \longrightarrow \gamma\gamma$.

A particle - antiparticle pair can be produced from a force-carrying boson, e.g. $Z \longrightarrow b\bar{b}$, $\gamma \longrightarrow e^+e^-$.

Background: Simulation of a Higgs decay to two hadronic jets