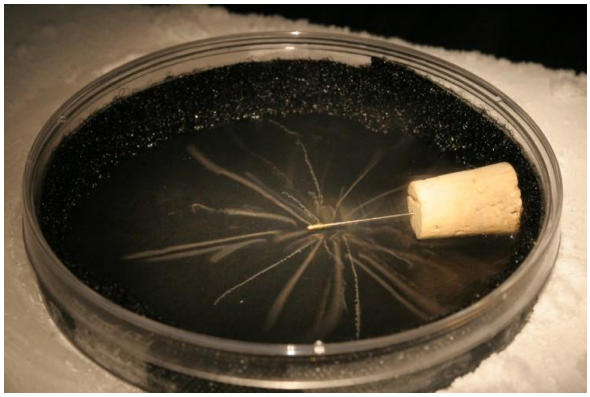
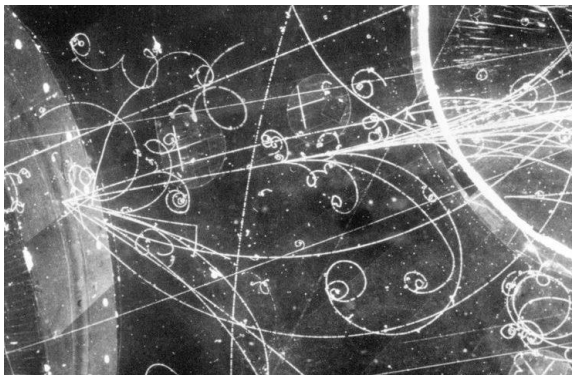
Physics with Synno – Matter – Lesson 3

M.3 Particles of the Standard Model

Video: Particle Accelerator Concept Using Ping Pong Ball
How does an atom-smashing particle accelerator work - Don Lincoln
Quarks and leptons for beginners
Particle Physics #1 _ Fermion vs Boson

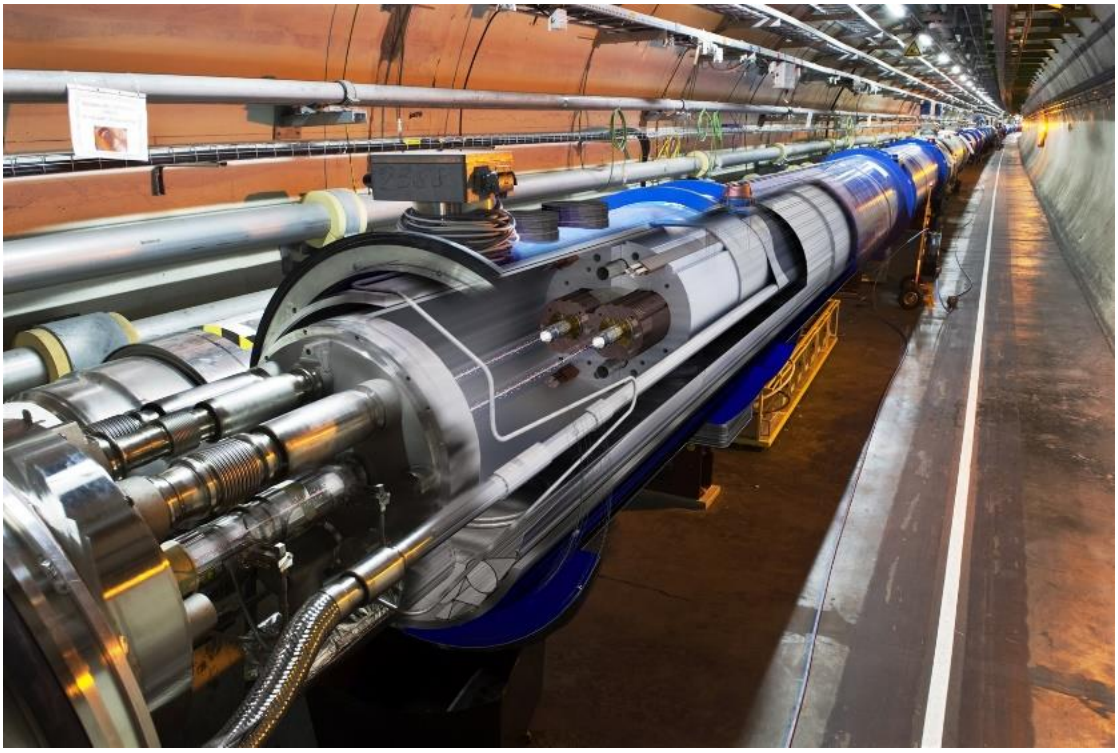
Around the time of the Second World War physicists built particle detectors





Cloud Chamber and Particle tracks

and particle accelerators.



The Large Hadron Collider

As a result of these experiments new particles were discovered. This lead to the formation of The Standard Model of Particle Physics.

The standard model is a mathematical description of all known particles and the forces between them. The standard model consists of two groups of particles: **Fermions**, which make up all matter and **Gauge Bosons** which proved the forces between the other particles.

M.3.1 Gauge Bosons

There are four forces which act between particles.
Nuclear forces are the forces that hold the atoms nucleus together. Electromagnetic and Gravitational forces are not sufficient to explain why positively charge particles are held together. Experiments suggest that there are two other forces involved called the 'strong nuclear force' and the 'weak nuclear force', these forces act over very short distances and are strong enough to overcome electrostatic repulsion.
Three of these, strong nuclear, electromagnetic and weak nuclear, arise through the exchange of bosons. The fourth, gravity, arise from a theoretical particle called a graviton.

Force	What it Does	Relative Strength	Range (m)
Strong Nuclear	Bonds nucleons together, acts between quarks	1	10^{-15} (~ size of a nucleus)
Electromagnetic	Responsible for electric and magnetic fields exerting forces of attraction and repulsion.	$\frac{1}{137}$	Infinite
Weak nuclear	Causes radioactive decay	10^{-6}	10^{-18} (less than the width of a proton)
Gravity	A force of attraction between any two objects with mass	6×10^{-39}	Infinite

M.3.2 Fermions

The standard model states that matter is made up of one or more of the 12 fundamental particles. By fundamental we mean that, in the current scientific knowledge, it is not comprised of smaller particles. The particles are the **fermions**.
The fermions are divided onto two groups. **Quarks** and **Leptons**. There are six Quarks and six Leptons.

M.3.2.1 Quarks

Quarks join together in groups of two or three to form hundreds of known particles including **Baryons**, **Mesons** and **Hadrons**. Two of the better known particles, Protons and Neutrons, are in the Baryon group. Quarks interact using the strong nuclear force and are the only particles that do so.

M.3.2.2 Leptons

Leptons have three types **Electrons**, **Muon** and **Tau**. Associated with these particles are **Neutrinos** (one for each) and the six **antimatter** opposites of these particles. Leptons interact via the weak nuclear force or, for charged leptons, the electromagnetic force.

Problem Set # 3: Text Page 197 Questions 1, 3, 4, 7