Fundamental Particles

Elementary/fundamental particle: Particle not known to be made up of smaller particles. It has no substructure; other particles are made from it.

Why proton/neutron not elementary: Can't explain why the electrical repulsion of positively charge protons don't split nucleus or the forces involved in radioactive decay producing alpha, beta and gamma radiation.

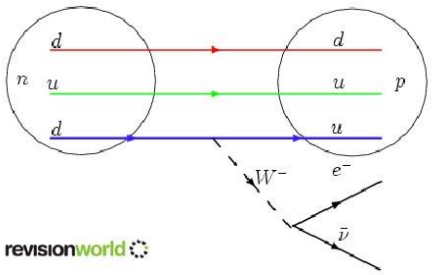
Standard Model: classification of particles based on properties as either gauge bosons, leptons, or hadrons.

Force	**What it does**	**Strength**	**Range**	**Gauge boson**
Strong	Holds nucleus together	1	$1x10^{-15}m \sim$ diameter of nucelus	Gluons
EM	Attractive/repulsive force between charged particles	$\sim\frac{1}{150}$	Infinite	Photon
Weak	Induces beta decay	$1x10^{-6}$	$1x10^{-18}m \sim$ diameter of proton	W and Z bosons (W^+, W^-, Z^0)
Gravity	Attractive force between masses	$\sim 1x10^{-39}$	Infinite	Graviton (theoritical)

Electrons not affected by strong interaction as its range is too short so only acts on hadrons in the nucleus

Leptons: Fundamental. Muons, tau, electron. Not affected by strong interaction. Charged leptons affected by electromagnetic force. Affected by weak interaction. Leptons w/ mass affected by gravity. **Particles** have charge of -1 and lepton number of 1. **Antiparticles** have a charge of 1 and lepton number of -1. **Neutrinos** have no mass or charge and symbol v

Hadrons: Not fundamental. Affected by strong interaction. **Baryons** (neutrons and protons). **Mesons** (pions). Mesons consist of a quark-antiquark doublet whereas baryons consist of a triplet.



Leptons	**Hadrons**
Not affected by strong interaction	Affected by strong interaction
Fundamental (no quark structure)	Composite (have quark structure)

Baryons: particles have a baryon number of 1, anti-particles have a baryon number of -1

Mesons: particles and anti-particles have a baryon number of 0

Equations: Charge, baryon number and lepton number are all conserved in interactions.

Quark	**Charge**	**Baryon**
u	$+\frac{2}{3}e$	$\frac{1}{3}$
d	$-\frac{1}{3}e$	$\frac{1}{3}$

Gauge bosons: exchange particles which mediate the force between the fundamental particles involved in the four fundamental forces

In research: Electrons, unlike protons and neutrons are not affected but the strong nuclear force and so may be used to bombard nuclei.

Beta minus Decay: result of the weak nuclear interaction

$${}^{1}_{0}n + \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e^- + {}^{0}_{0}\overline{\nu_e} \qquad udd + \rightarrow uud + {}^{0}_{-1}e^- + {}^{0}_{0}\overline{\nu_e} \qquad d \rightarrow u + W^- \; followed\; by\; W^- \rightarrow e^- + \overline{\nu_e}$$

Quark Models: p uud, n udd, $\pi^0\ u\bar{u}$, $\pi^+\ u\bar{d}$, $\pi^-\ d\bar{u}$, $\overline{\pi^0}\ u\bar{u}$

Anti-quarks have oppposite charge and baryon number