2012

- From measurement of width of Z boson, we know there are 3 neutrinos with mass below 45GeV (Half ① the mass of Z boson) $Z \to \nu\bar{\nu}$, so another neutrino species would increase ~~it~~ its subsequent decay width.

3) $\nu_e \bar{\nu}_e \to Z^0 Z^0$

$(E_{\nu e} + E_{\bar{\nu} e})^2 - (P_{\nu e} + P_{\bar{\nu} e})^2$

$= \cancel{E_{\nu e}^2} + \cancel{E_{\bar{\nu} e}^2} + 2E_{\nu e}^2 - \cancel{E_{\nu e}^2} - \cancel{E_{\bar{\nu} e}^2} - 2E_{\nu e}^2 \cos\theta$

$W^2 = 4E_{\nu e}^2$

~~90 GeV~~ $W = 2E_{\nu e} = 90$

$E_{\nu e} = \frac{90}{2} = 45\ \mathrm{GeV}$

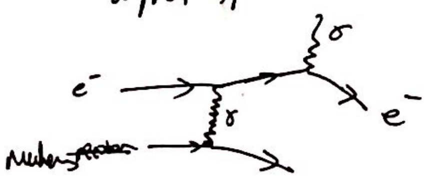
5) $\vec{r} \xrightarrow{P} -\vec{r}$

$\vec{p} \xrightarrow{P} -\vec{p}$

$\vec{L} \xrightarrow{P} \vec{L}$

Parity flips the helicity of the particle, makes it into the opposite value. The weak interaction violates parity as it suppresses any decay which produces right handed neutrinos as these do not exist in nature, as momentum must also be conserved, decay products must be emitted in opposite directions and ~~spin~~ ~~helicity~~ where one might expect helicity to be aligned and anti-aligned with the same ratio, this is in fact not the case and the reaction favours ~~to~~ the helicity producing the left handed neutrino or right handed antineutrino, thus violating parity.

6) Bremsstrahlung: Electron interacts with the electric field of a nuclei and accelerates (is deflected) from the nuclei and emits a photon in the process thus losing energy.



Muons tend to have a much higher mass, travelling much faster with greater decay as they are very penetrating ~~so doesn't~~ and interacts weakly so ~~does~~ ~~not~~ Bremsstrahlung (EM interaction) is suppressed for it.

This is explained as muons are typically found in the outermost detectors of a collider detector.

c) As they nuclei (heavy nuclei) are neutron heavy due to coulomb repulsion of protons (the ~~a~~ asymmetry term of the SEMF) so prefer β^- decays to become more stable, (closer to $Z=N$ stability line).

$$n \to p + \beta^- + \bar{\nu}_e$$

The rest of the energy may be locked in such as binding energy of daughter nuclei or kinetic energy of particles.

d) $P = 1400\,MW$ $\quad \bar{E} = Pt$

$$E = 1400 \times 10^6 = m c \Delta T = M \times 4.2\times10^3 \times 80$$

$$\frac{M}{s} = \frac{1400 \times 10^6}{80 \times 4.2\times10^3} = 4166\ kg\,s^{-1}$$

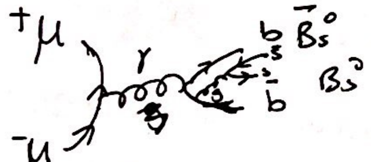
e) Inertial confinement: fire pulsed laser at tritium deuterium pellets to induce fusion

$${}^2_1H + {}^3_1H \to {}^4_2He + n$$

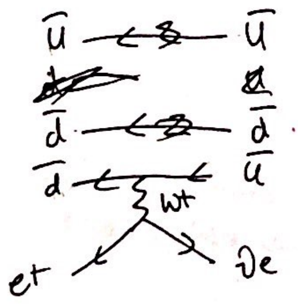
10 i) $p \to e^+ + \pi^0$, forbidden, violates baryon & lepton number

ii) $\mu^+ + \mu^- \to B_s^0 + \bar{B}_s^0$, allowed

$\quad\quad\quad\quad\quad\quad \bar{b}s \quad b\bar{s}$



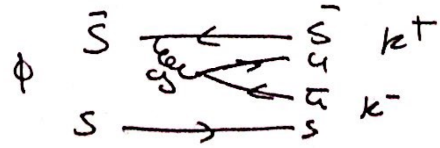
iii) $\bar{n} \to \bar{p} + e^+ + \nu_e$ allowed



iv) $\mu^- + p \to \nu_e + n$, Forbidden, violates individual lepton numbers.

v) $\phi \to K^+ K^-$ Allowed.

$s\bar{s} \quad u\bar{s} \quad \bar{u}s$



$A \to B \to \cdots$

$\tau_A \gg \tau_B \cdots$

- $t \ll \tau_A$

$N_A \simeq N_B$

$N_A = N_0 e^{-t/\tau_A}$

$N_B = N_A e^{-t/\tau_B} = N_0 e^{-t/\tau_A} e^{-t/\tau_B} = N_0 e^{t\left(\frac{1}{\tau_A} - \frac{1}{\tau_B}\right)}$

At equilibrium, $N_B \simeq N_A$

$\Rightarrow \frac{N_B}{N_A} \simeq e^{-t\left(\frac{1}{\tau_A} - \frac{1}{\tau_B}\right)}$

$\cancel{\frac{N_0}{2} = e^{-T_{1/2}/\tau}}$

$\cancel{\ln 2 = T_{1/2}/\tau}$

$\cancel{\tau = \frac{T_{1/2}}{\ln(2)}}$

$N_B = \cancel{10^{-9} e^{-}}$

$A = \frac{N}{\tau}$

$A_A \tau_A \simeq A_B \tau_B$

$A_A = \frac{A_B \tau_B}{\tau_A} \cdots$