HELLO?

LEPTONS

$\begin{pmatrix} \nu_e \\ e \end{pmatrix}$ $\begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix}$ $\begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}$

QUARKS

$2/3$ $\begin{pmatrix} u \\ d \end{pmatrix}$ $\begin{pmatrix} c \\ s \end{pmatrix}$ $\begin{pmatrix} t \\ b \end{pmatrix}$

$-1/3$

BOSONS

γ PHOTON E.M.

$Z^0, W^\pm$ WEAK INTERACTION

g STRONG INTER.

G GRAVITONS

$$\Delta E \Delta t \sim \hbar$$

$$mc^2 \Delta t \sim \hbar$$

$$\Delta t \sim \frac{\hbar}{mc^2}$$

RANGE $r \sim \frac{\hbar}{mc}$

GRAVITATIONAL POTENTIAL

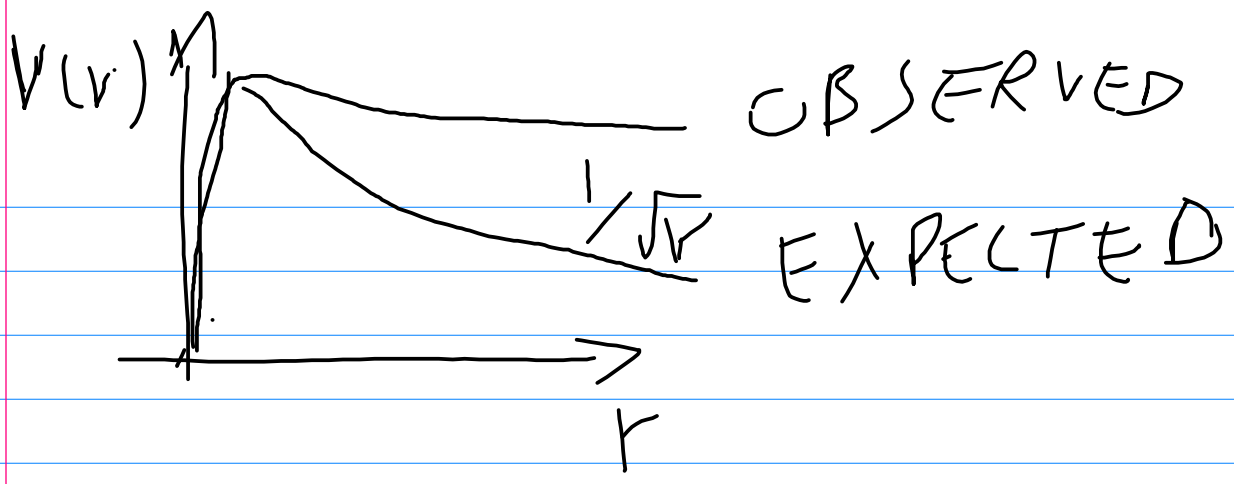
$$V_G = \frac{Gm^2}{r} = \frac{Gm^3c}{\hbar}$$

GRAVITY BECOMES IMPORTANT FOR

$$V_G \sim mc^2$$

$$\frac{Gm^3c}{\hbar} \frac{1}{mc^2} \sim 1$$

$$m_{PLANK} = \sqrt{\frac{\hbar c}{G}} \sim 10^{19}\ GeV$$



DARK MATTER:

COLD — HIGH-MASS, LOW SPEED

HOT — LOW MASS, HIGH SPEED

$E = kT$ $\quad T = 2.7\,k$

$E = mc^2$

$m = \frac{kT}{c^2}$

WEAK FORCE

$n \to p\, e^- \bar{\nu}_e$

$\bar{\nu}_e + U \to d\, e^+$

$\mu^- \to e^-\, \nu_\mu\, \bar{\nu}_e$

$Z^0 \quad m_Z = 91.2\ GeV$

$W^\pm \quad m_W = 80.4\ GeV$

COUPLINGS:

EM $\quad \dfrac{e^2}{q^2}$

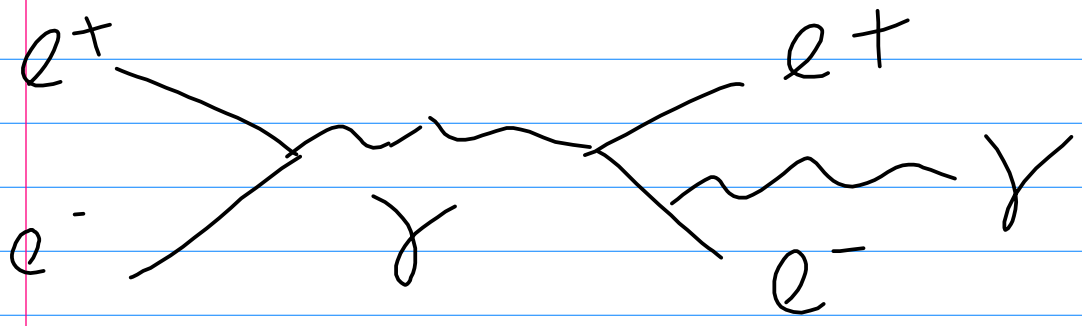
WEAK $\quad \dfrac{g_W^2}{q^2 + M_W^2}$

FOR $q^2 \ll M_W^2$ EM IS STRONGER

FOR $q^2 \gg M_W^2$ SIMILAR STRENGTH

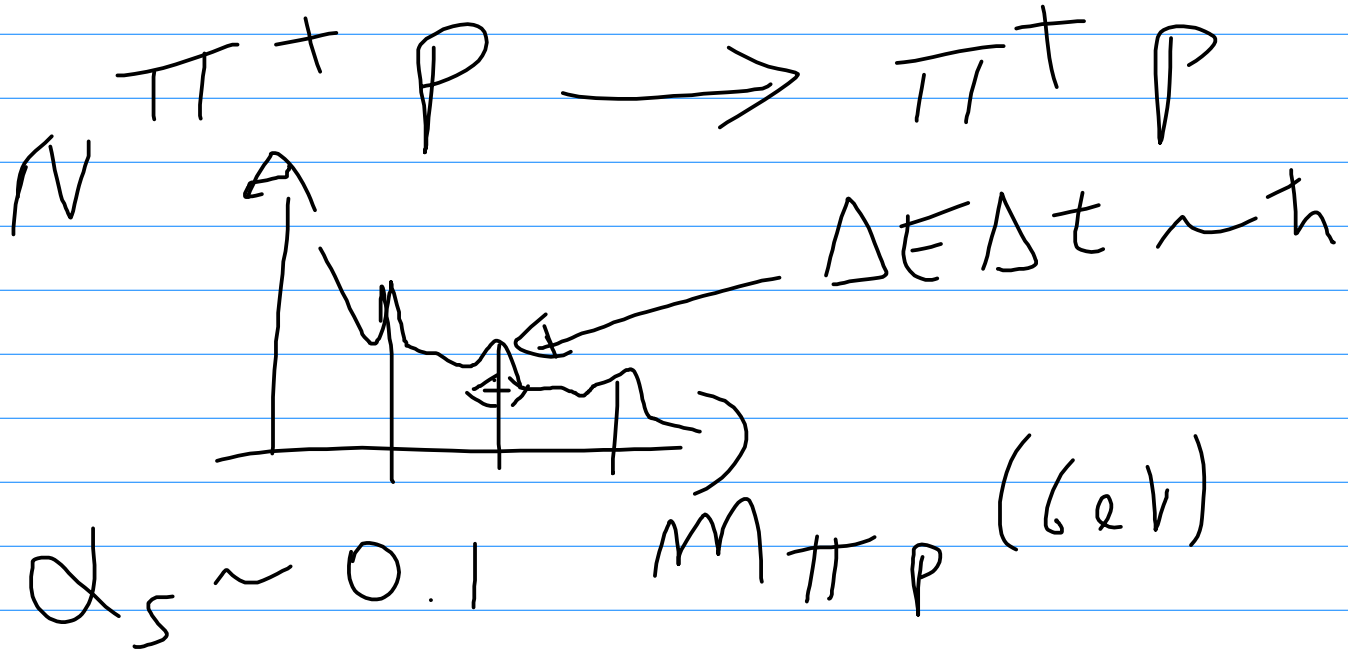
STRENGTH of E.M. INTERACTION

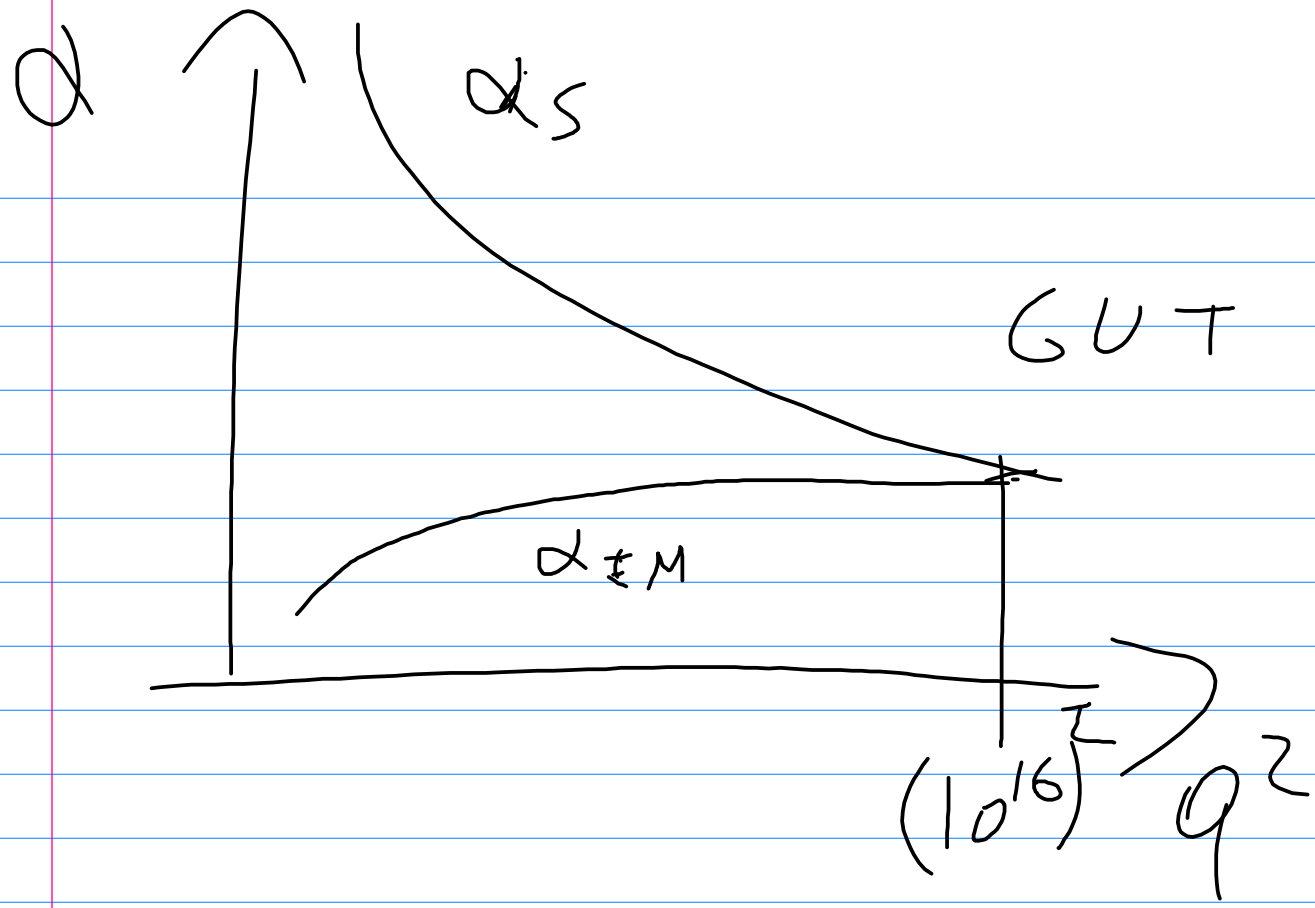
$$\alpha = \frac{e^2}{\hbar c} \sim \frac{1}{137}$$



IF YOU HAVE EXTRA VERTICES ON AVERAGE PROBABILITY WILL BE SMALLER BY A FACTOR ~ 100

- STRONG FORCE





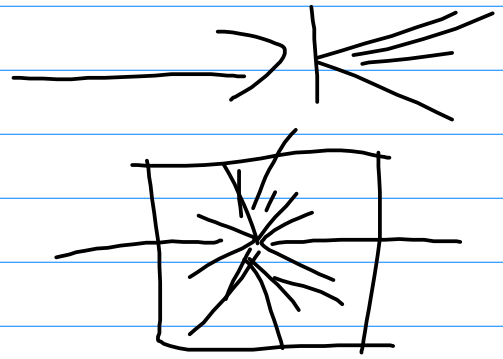
TOO HIGH FOR DIRECT TEST, BUT GUT PREDICT

$$p \rightarrow e^+ \pi^0$$

$$\tau_p > 10^{30} \text{ yrs}$$

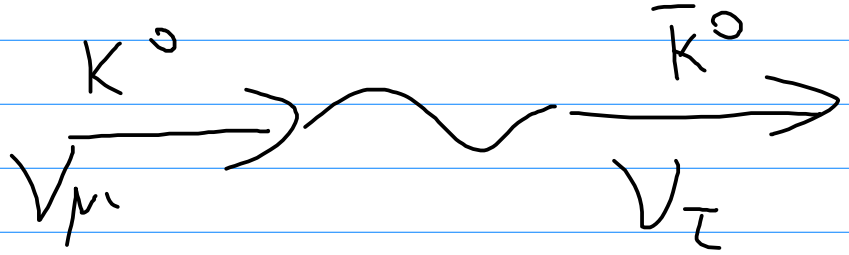
EXPERIMENTAL CONCEPTS

- SCATTERING



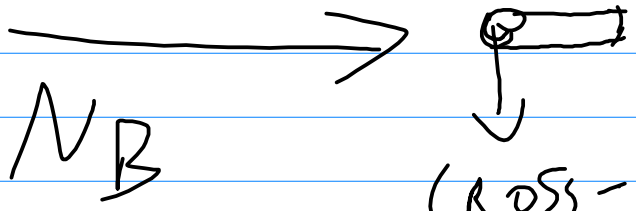
- DECAYS

- OSCILLATIONS



- PROPERTIES (MASS, CHARGE, COUPLINGS)

CROSS-SECTION



AREA A

LENGTH ℓ

DENSITY ρ

$$N_T = \frac{\ell A \rho N_A}{m}$$

N_A: AVOGADRO NUMBER

m: MOLECULAR MASS TARGET

- PROBABILITY TO HAVE AN INTERACTION

$$P = \frac{\ell \cancel{A} \rho N_A}{m} \frac{\sigma}{\cancel{A}}$$

~~# TARGETS~~

TOTAL # INTERACTIONS

$$N_I = \ell \rho N_A N_B \sigma / m$$

DENSITIES OF BEAM AND TARGET ρ_B ρ_T

SPEED OF BEAM u

TARGET PARTICLES IN VOLUME

V IS $\rho_T V$

$$\frac{dM}{dt} = u V \rho_B \rho_T \sigma$$

IN A COLLIDER

n BUNCHES EACH WITH N_B

$u \sim c$

IN 1 s f BUNCHES WILL CROSS

$$\frac{dN_I}{dt} = f N_A N_B n \sigma / A = \mathcal{L} \sigma$$

LUMINOSITY $\mathcal{L} = n N_B^2 f / A$

$1\ b = 10^{-28}\ m^2$

FIRST SCATTERING EXP.

$$\sigma_{pp} > \sigma_{pm} \gg \sigma_{\gamma p} \gg \sigma_{\gamma\gamma}$$

PARENTESIS: DEFINE UNITS

$$E = h\nu = \hbar\omega$$

$$p = h/\lambda = \hbar k$$

NATURAL UNITS $c = \hbar = 1$

$$[c\hbar] = [L][T^{-1}][E][T] = [E][T]$$

$$c\hbar = 1.97 \cdot 10^{-16}\ \text{GeV m} = 1$$

$$\frac{1}{(\text{GeV})^2} = 3.89 \cdot 10^{-32}\ m^2 = 0.389\ \text{mb}$$

$$\frac{1}{\text{GeV}} = 6.6 \cdot 10^{-25}\ \text{s}$$