The Standard Model

$$\underbrace{U(1)_Y \times SU(2)_L}_{QED \;+\; EW} \times SU(3)_C$$

$EW \rightarrow g_V = T_3 - 2Q\sin^2\theta_W$

$EW \rightarrow g_A = T_3$

free param.

SU(2) doublets $T = 1/2$

$$\begin{array}{c|ccc|c|c|c}
Q & & & & T_3 & & \\
0 & \begin{pmatrix} \nu_e \\ e \end{pmatrix} & \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix} & \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix} & +1/2 & \uparrow & W^+ \\
-1 & & & & -1/2 & \downarrow & Z \\
+\frac{2}{3} & \begin{pmatrix} u \\ d \end{pmatrix} & \begin{pmatrix} c \\ s \end{pmatrix} & \begin{pmatrix} t \\ b \end{pmatrix} & +1/2 & \uparrow & W^- \\
-1/3 & & & & -1/2 & \downarrow &
\end{array}$$

γ

quarks - interact with g (8)

Higgs doublet $\varphi = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v + h(x) \end{pmatrix} \begin{matrix} T_3 \\ +1/2 \\ -1/2 \end{matrix}$

interacts with W, Z $\quad T_3 = -1/2$

not with γ $\quad Q = 0$

not with g $\quad Q_s = 0$

interacts with fermions - ad hoc

$\frac{1}{\sqrt{2}} g_f v(\bar{f}_L f_R + \bar{f}_R f_L)$

$m_f = \sqrt{\frac{1}{2}} g_f v$

9 parameters (no 0)

$$V(\phi) = \mu^2 \varphi^+\varphi + \frac{\lambda^2}{2}(\varphi^+\varphi)^2$$

2 parameters e.g. λ, v

Parameters of SM (2)

$M_H = \lambda v$

$M_W = \frac{1}{2} g v = \frac{e v}{2 \sin\theta_W}$

$M_Z = \frac{1}{2}\left(g^2 + g'^2\right)^{1/2} v = \frac{e v}{2\sin\theta_W \cos\theta_W} = \frac{M_W}{\cos\theta_W}$

$M_\gamma = 0$

$m_f = \frac{1}{\sqrt{2}} v \cdot g_f$

e $\quad v \quad g_f$

$\sin\theta_W$ $\quad \lambda \quad (g)$

α_s $\quad \theta_s$ (QCD vacuum angle)

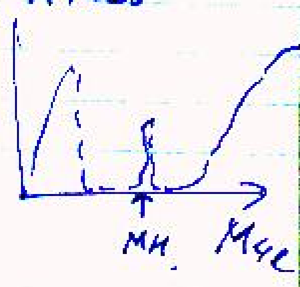
CKM matrix 4 params $\delta, \theta_{12}, \theta_{23}, \theta_{13}$

19 parameters of the SM

Observables:

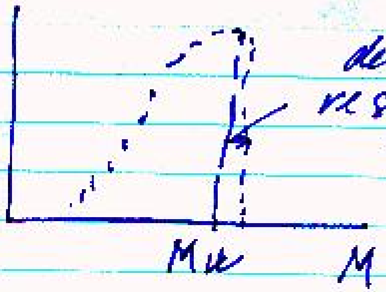
LHC
CMS, Atlas

M_H



③

M_W



detector resolution ⊗ & Γ_W

LEP, Tevatron

$W \to \ell \nu$

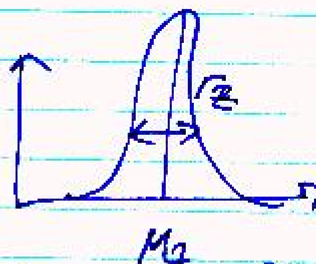
E_T

no p_z

$M_T = \sqrt{(E_\ell + \not{E}_T)^2 - (p_x + \not{E}_x)^2 - (p_y + \not{E}_y)^2}$

Γ_W

M_Z, Γ_Z — LEP



$Z \to q\bar{q} \Rightarrow \sigma_{had}$ — LEP

$R_\ell = \frac{\sigma_{lep}}{\sigma_{had}}$ LEP

$A_{FB}^{\ell,c,b}$ — forward-backward asymmetry (g_V^f, g_A^f) LEP

$A^*_{\ell,c,b}$ left right asym with polarized beams SLC

$\sin^2\theta_W$ LEP, SLC (now TeV, LHC)

$R_c = \frac{\sigma_{Z\to c\bar{c}}}{\sigma_{Z\to had}}$ R_b

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more variables that need input (nuissance params)

$\overline{m}_c$ $\overline{m}_b$ m_t α_{had} (?)

Examples of interconnection:

M_W

tree level

$\frac{e v}{2 \sin\theta_W}$

rad cor

$\propto \ln \frac{M_H}{v}$

$M_W; M_t$ predict range for M_H before higgs discovery

$\propto m_t^2 \Rightarrow$ predict range for m_t before top discovery