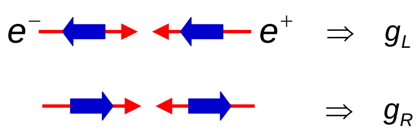
Coupling to LH and RH fermions

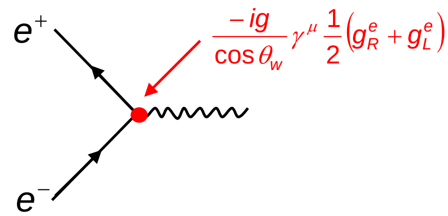
Z boson coupling to LH and RH fermions different:

$$\left|g_L = \frac{1}{2}(g_V + g_A)\right| > \left|g_R = \frac{1}{2}(g_V - g_A)\right|$$

⇒ Coupling to LH leptons stronger

Experimental configuration:





Left-Right Asymmetry at SLC

Measure cross section σ_L (σ_R) for LH (RH) initial state electrons:

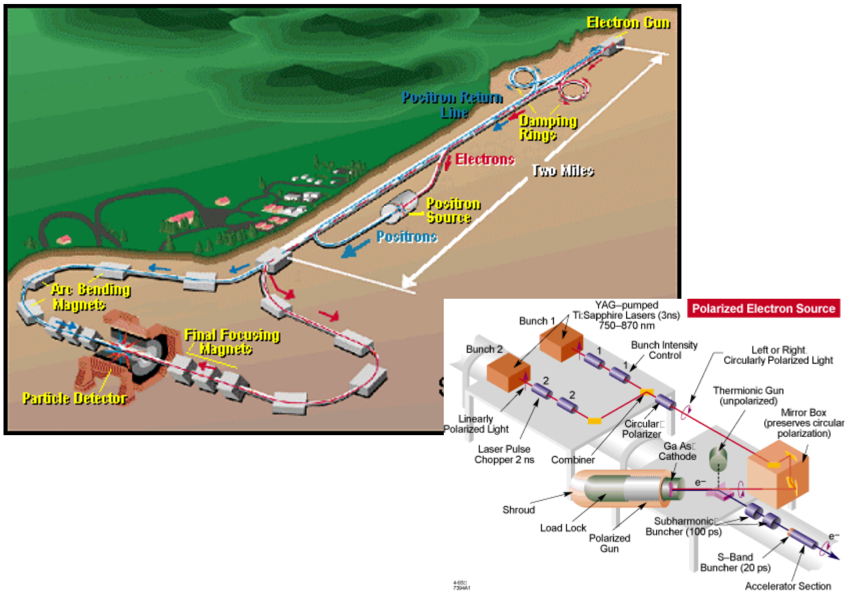
Polarization of electron beam: P~70 – 80%

$$A_{LR} = \frac{1}{P}\frac{\sigma_L^f - \sigma_R^f}{\sigma_L^f + \sigma_R^f} = \frac{1}{P}\frac{2g_V^e g_A^e}{\left(g_V^e\right)^2 + \left(g_A^e\right)^2}$$

$$= \frac{2(1-4\sin^2\theta_w)}{1+(1-4\sin^2\theta_w)^2}$$

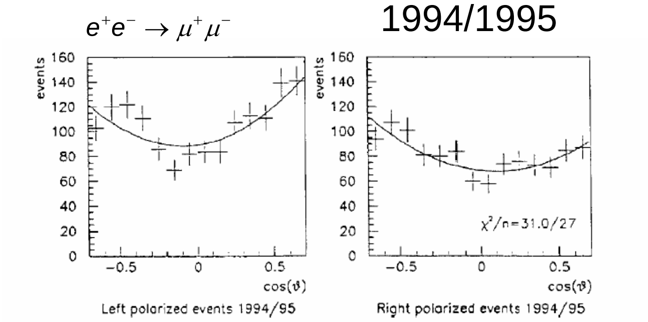
Powerful determination of $\sin^2\theta_w$. Requires longuitudinal polarization of colliding beams: only possible in case of Linear Collider: SLC

SLAC Linear Collider



Leptonic final states:

$e^+e^- \to \mu^+\mu^-$ 1994/1995



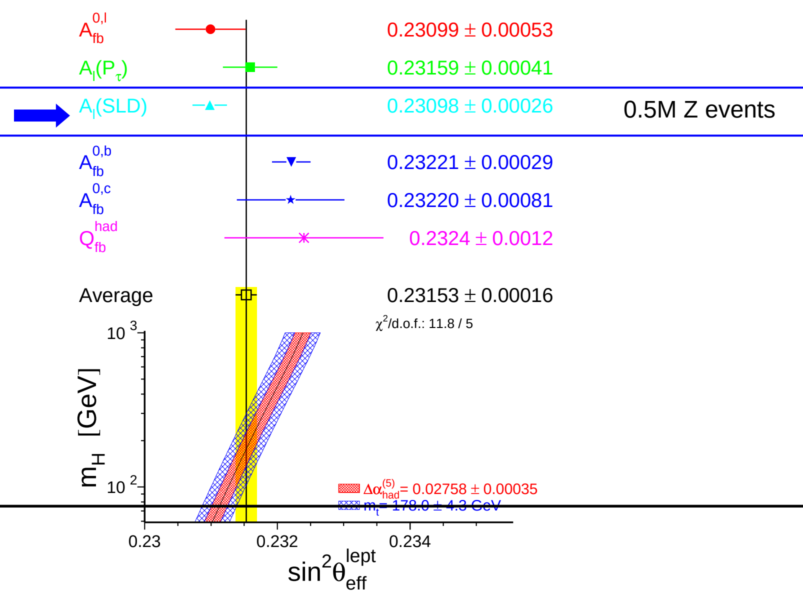
SLD

All data:

$$A_{LR} = 0.1513 \pm 0.0021$$
$$\sin^2\theta_w = 0.23098 \pm 0.00026$$

With 0.5×10^6 Z-decays

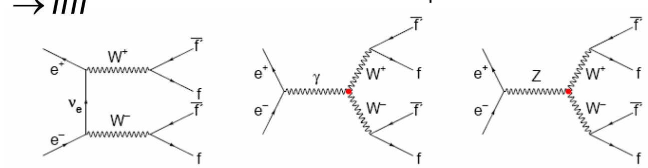
SLD versus 4×4.5 ×10^6 Z-decays at LEP



3. Precision tests of the W sector (LEP2 and Tevatron)

~10K WW events / experiment

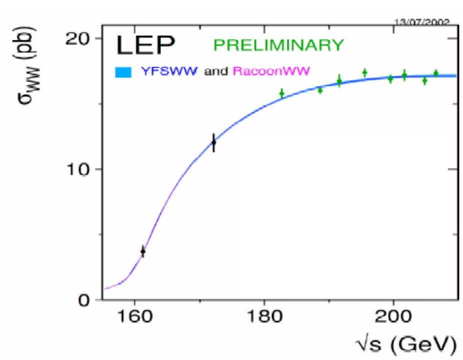
$e^+e^- \to WW \to f\bar{f}f\bar{f}$



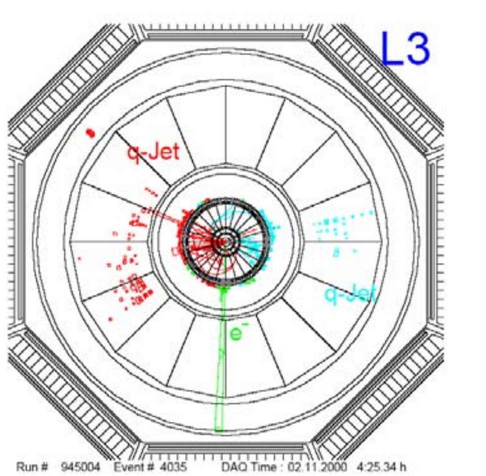
Threshold behavior of the cross section (kinematics, phase space) for ee→WW production:

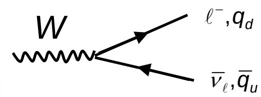
Phase space factor = f(M_W, √s):

→ Allows determination of M_W

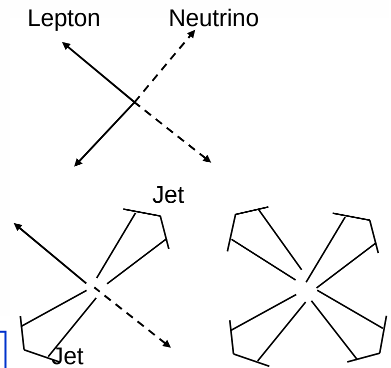


W decays





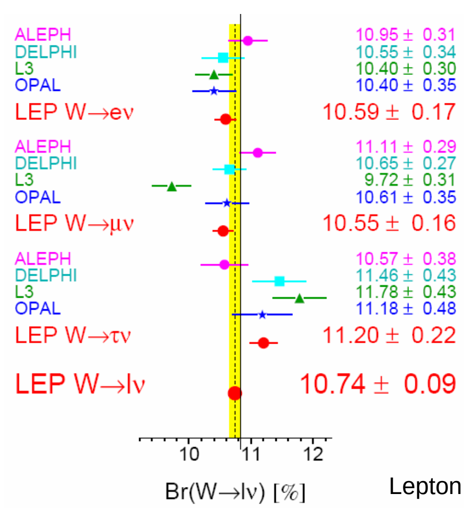
$$WW \rightarrow \begin{cases} qq\ell\nu & 44\% \\ qqqq & 45\% \\ \ell\nu\ell\nu & 11\% \end{cases}$$



Easiest signature for a mass measurement:

$W_1 \rightarrow l\nu$ $W_2 \rightarrow$ JetJet: use JetJet invariant mass

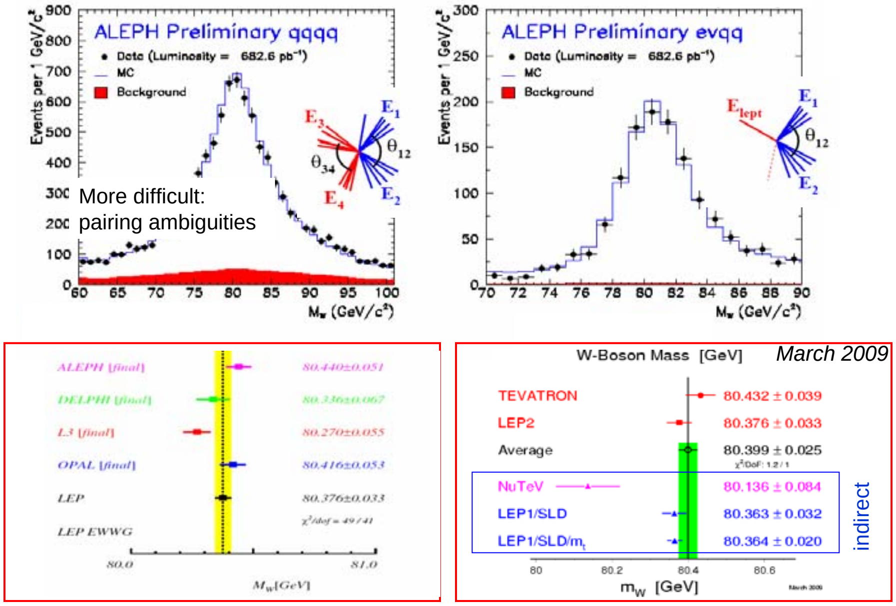
W branching ratios



$Br(W \rightarrow q\bar{q}) = (67.77 \pm 0.28)\%$

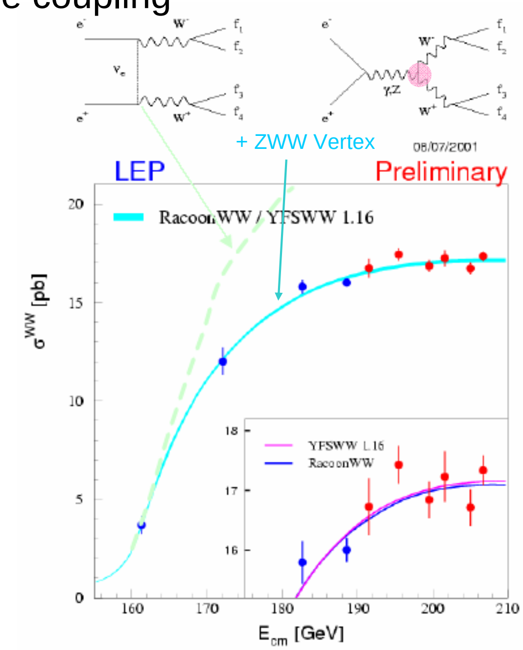
Lepton universality tested to 2%

Invariant W mass recontruction



Effect of triple gauge coupling

Data confirms the existence of the γ/ZWW triple gauge boson vertex



4. Higher order corrections and the Higgs mass

$\sin^2\theta_w = 1 - \frac{M_W^2}{M_Z^2} \qquad \sin\theta_w = \frac{e}{g}$

Lowest order SM predictions:

$$\rho = \frac{m_W^2}{m_Z^2\cos^2\theta_W} = 1 \implies \bar{\rho} = 1 + \Delta\rho$$

$$\sin^2\theta_W = 1 - \frac{m_W^2}{m_Z^2} \implies \sin^2\theta_{\text{eff}} = (1+\Delta\kappa)\sin^2\theta_W$$

$$m_W^2 = \frac{\pi\alpha}{\sqrt{2}\sin^2\theta_W G_F} \implies m_W^2 = \frac{\pi\alpha}{\sqrt{2}\sin^2\theta_W G_F}(1+\Delta r)$$

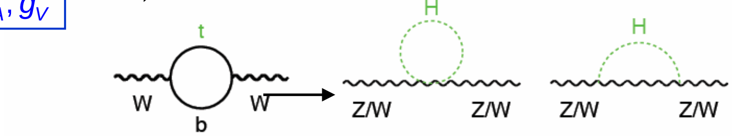
$$\alpha(0) \implies \alpha(m_Z^2) = \frac{\alpha(0)}{1-\Delta\alpha}$$

with: $\Delta\alpha = \Delta\alpha_{\text{lept}} + \Delta\alpha_{\text{top}} + \Delta\alpha^{(5)}_{\text{had}}$

Including radiative corrections

$\sin^2\theta_w$, g_A, g_V ⇒ $\sin^2\theta_{\text{eff}}$, $\bar{g}_A, \bar{g}_V$

$$\Delta\rho, \Delta\kappa, \Delta r = f\,(m_t^2, \log(m_H), \ldots)$$



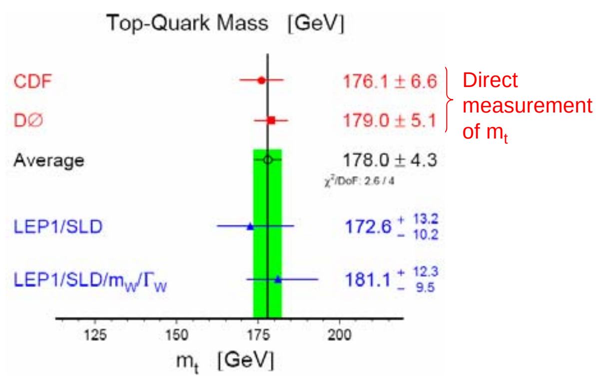
Top mass prediction from radiative corrections

The measurement of the radiative corrections:

$$\sin^2\theta_{\text{eff}} \equiv \frac{1}{4}(1 - \bar{g}_V/\bar{g}_A)$$

$$\sin^2\theta_{\text{eff}} = (1+\Delta\kappa)\sin^2\theta_w$$

Allows the indirect determination of the unknown parameters m_t and M_H.

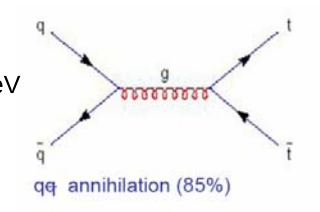


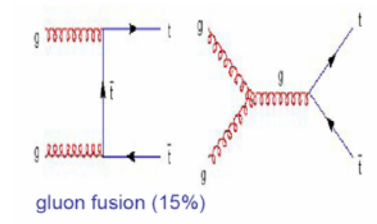
Prediction of m_t by LEP before the discovery of the top at TEVATRON.

Good agreement between the indirect prediction of m_t and the value obtained in direct measurements confirm the radiative corrections of the SM

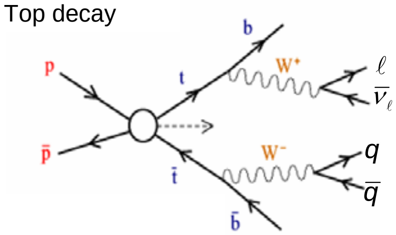
Observation of the top quark at TEVATRON (1995)

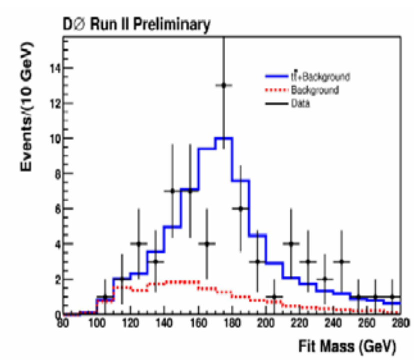
$p\bar{p}$ @ 2 TeV





Top decay

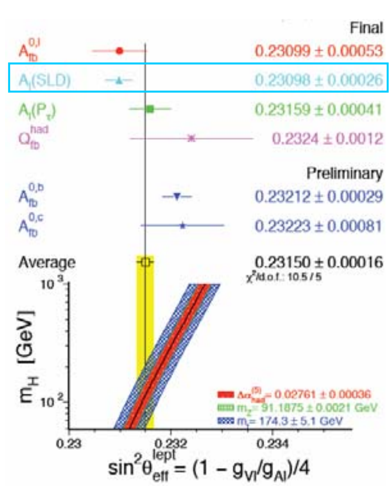


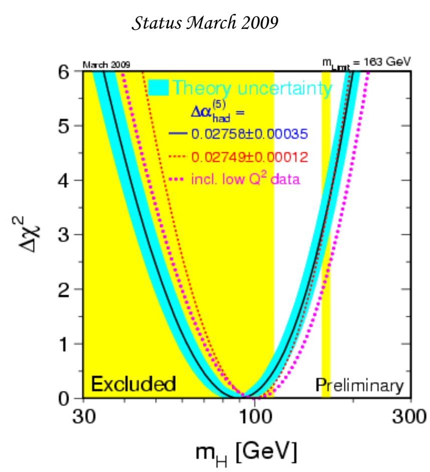


Channel used for mass reconstruction:

$m_t = m_{inv}(b - jet, W \to jet + jet)$

Higgs mass prediction from radiative corrections





Awaiting the discovery of the Higss at LHC

M_H > 114 GeV (from direct searches)

M_H < 300 GeV @ 95 % C.L.