MEASUREMENT OF ELECTROWEAK PARAMETERS FROM W'S & Z'S
1989

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1. COLLIDER RESULTS: UA1, UA2, CDF
2. \( e^+e^- \): SLC & LEP
3. SUMMARY ON WHAT WE KNOW:
   \( \sin^2\theta, M_W, M_Z, \Gamma_Z, N_f \)
4. THE TOP QUARK MASS
1. COLLIDER RESULTS

UA1, UA2, CDF
CERN FNAL

1) Z-MASS:

\[ M_Z = 90.9 \pm 3 \text{ (stat + syst)} \pm 2 \text{ (E scale)} \]  
\[ \Gamma_Z = 3.8 \pm 0.8 \pm 1.0 \]

\[ M_Z = 90.49 \pm 0.56 \pm 1.4 \text{ (E scale)} \]  
\[ \Gamma_Z = 3.8 \pm 0.8 \pm 1.0 \]

2) W-MASS:

\[ M_W = 80.0 \pm 2 \pm 6 \text{ (e)} \]  
\[ 79.9 \pm 4 \pm 6 \text{ (\mu)} \]

\[ M_W = 80.0 \pm 4 \pm 1.2 \text{ (E scale)} \]

\[ \text{HOPE} : 45 \pm 1990 \]

PROSPECTS:

CDF 1991 25 pb\(^{-1}\)

1993 100 pb\(^{-1}\) ! ACCURATE W-
measurement.
2. SLC and LEP

MARK 2

\[
\sigma
\]

\[
\begin{array}{c}
\text{E}_{\text{CM}} \text{ / GeV} \\
87 & 88 & 89 & 90 & 91 & 92 & 93 & 94 & 95 \\
0 & 10 & 20 & 30 & 40 & & & & \\
\end{array}
\]

\[
234 \#
\]

\[
\begin{align*}
\mathcal{m}_Z &= 94.17 \pm 0.18 \text{ GeV} \\
\Gamma_Z &= 1.95 \pm 0.40 \text{ GeV} \\
N_\gamma &= 3.0 \pm 0.9 \\
N_\gamma &< 4.4 \text{ at 95\% C.L.}
\end{align*}
\]

SLAC

MADRID: \( Z \rightarrow \bar{q}q \) \( 3 \pm 2 \)
\( \mu^+ \mu^- \) \( 9 \pm 6 \) \( \text{no change for } m_Z, \Gamma_Z \)
\( e^+ e^- \) \( 13 \pm 4 \)

\[
L = 10 \text{ nb}^{-1} \rightarrow 13 \text{ nb}^{-1}
\]

SLAC MADRID
Initial Zs in LEP, as seen by the four detectors.

1st LEP events

Opal

L3'

Aleph

Delphi
**ALEPH**

\[
\begin{align*}
Z & \rightarrow q\bar{q} & 12 \\
Z & \rightarrow e^+e^- & \text{(large)} \times 2 \\
Z & \rightarrow t^+t^- & 1 \\
\text{Bhabha} & \quad 11
\end{align*}
\]

\[15 \text{ hrs}\]

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**DELPHI**

5 \(Z\)'s
1 Bhabha

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**L3**

\[\geq 1 \# \quad \text{(cf. fig.)}\]

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**OPAL**

\[
\begin{align*}
Z & \rightarrow q\bar{q} & 18 \\
Z & \rightarrow e^+e^- & 2 \\
Z & \rightarrow t^+t^- & 1 \\
\text{Bhabha} & \quad 25
\end{align*}
\]

\[\text{NO } Z \rightarrow \mu^+\mu^- \quad \text{(Stat. Allowed)}\]
For $e^+e^-$ below LEP/SLC, the ratio $R = \frac{\sigma(e^+e^+ \to X)}{\sigma(e^+e^+ \to \mu^+\mu^-)}$.

1) Below TRISTAN ($< 30$ GeV/beam) PETRA/PEP:

$M_3 \in [88, 89.4]$ GeV

2) TRISTAN

$M_2 = 88.9 \pm 1.2$ GeV

$M_3 = 91.17 \pm 0.18$ SLC

$2\sigma$, not yet significant.
3. SUMMARY ON WHAT WE KNOW:

\( M_{W,Z}, \Gamma_{Z}, N_F, \sin^2 \theta \)

**SEPT. 1989:**

- **BEST MEASUREMENTS**

  \( M_Z \)
  \( \Gamma_Z \)

  \( M_W \)

  \( \sin^2 \theta_W \)

- **MARK I**
- **SLC**
- **CDF (UA2)**
- **TEVATRON**
- **DIS AT CERN & FNAL**
  \( \text{(CHARM II)} \) \( \text{(COLLIDER)} \)

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\[
M_Z = 91.17 \pm 0.18 \text{ GeV} \\
\uparrow \text{180 when!}
\]

\[
M_W = 80.0 \pm 2.2 \pm 0.6 \text{ GeV}
\]

\[
\sin^2 \theta = 0.234 \pm 0.004 \pm 0.005 \\
\uparrow 1!
\]

\[
N_Y < 3.9 \quad 95\% \text{ CL}
\]

\( \text{(WATCH: } \Delta H_Z^2 = H_{Z}^{\text{CHARM}} - H_{Z}^{\text{SLC}} \text{)} \)
4. THE MASS OF THE TOP QUARK

i) direct exclusions:

UA1 \[ m_t > 48 \text{ GeV} \]
UA2 \[ m_t > 67 \text{ GeV} \]
CDF \[ m_t > 77 \text{ GeV} \] (or \[ m_t < 33 \text{ GeV} \]) \[ 95\% \text{ CL.} \]
TRISTAN \[ m_t > 33 \text{ GeV} \]
SLC \[ m_t > 40.7 \text{ GeV} \]

ii) Fit from all electroweak data: SM: \( SU_{2L} \times U_1 \)

\[ M_N = \frac{37.284 \text{ GeV}}{\sin^2\Theta_W} \sqrt{1-\Delta r (\alpha_0, \alpha; m_t; m_{W+})} \]

\[ = 1 \cdot \frac{M_N^2}{M_Z^2} \]

\[ m_t \pm \delta m_t \]
LANGACKER: \( m_t = 140 \pm 50 \text{ GeV} \) 10

3. ELLIS et al: \( m_t = 130 \pm 50 \text{ GeV} \) 10

\[ \uparrow \text{ includes SLC result.} \]

iii) OTHER HEAVY PARTICLES:

\( b' \):
- UA1 \( m_{b'} > 41 \text{ GeV} \) 35% CL
- UA2 \( m_{b'} > 53 \text{ GeV} \)
- SLC \( m_{b'} > 45 \text{ GeV} \) \((b' \rightarrow b\gamma)\)

\( L^0 \):
- SLC \( m_{L^0} > 40 \text{ GeV} \) 95% CL