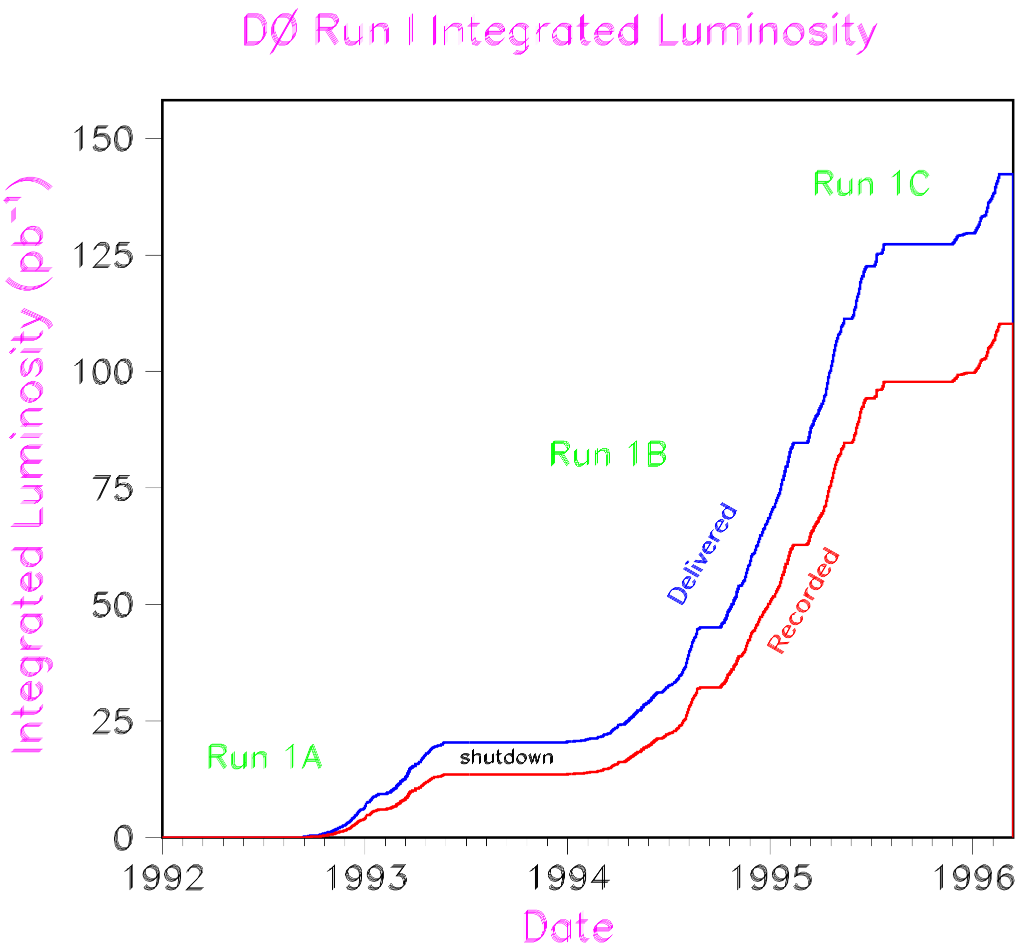
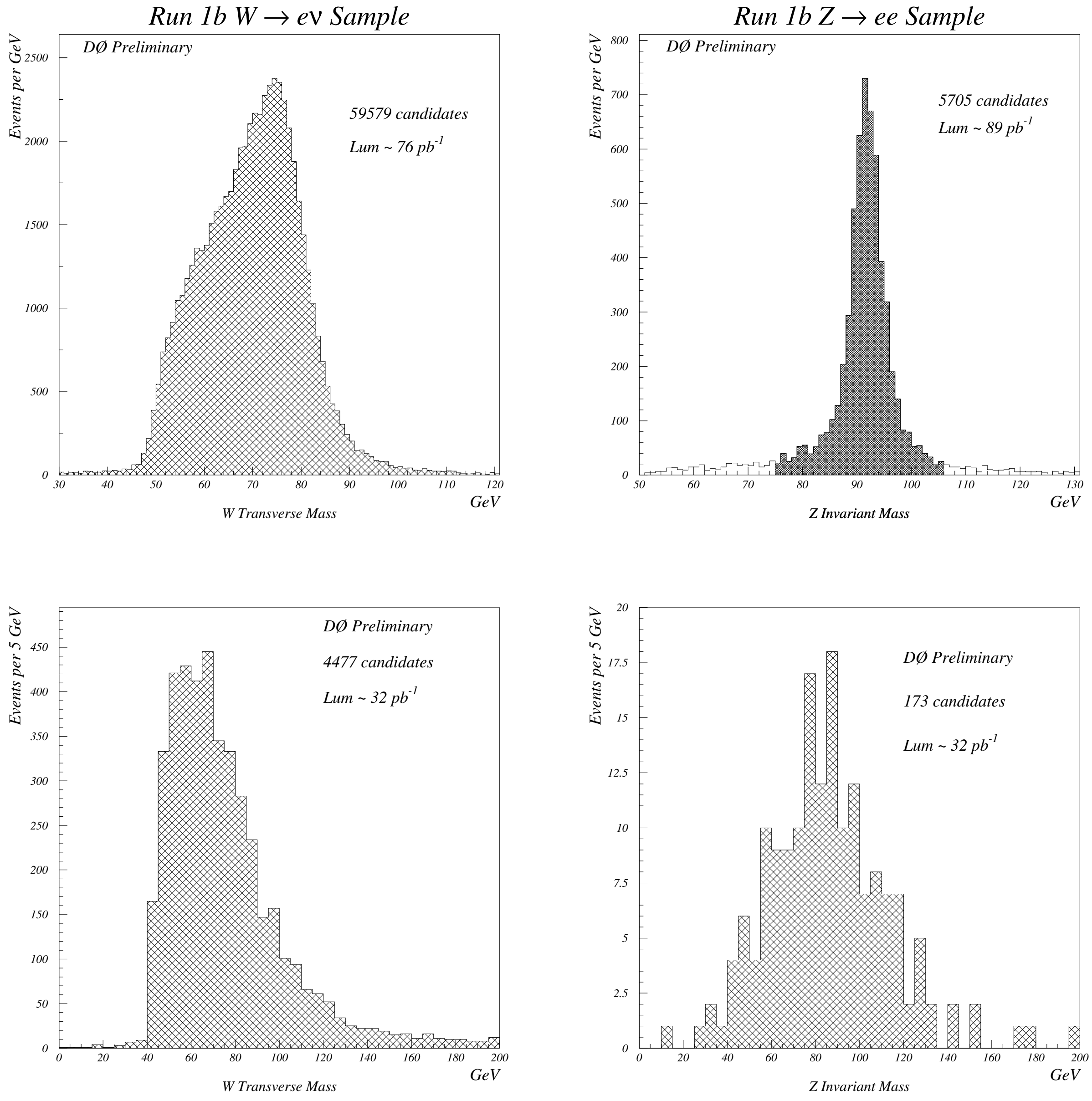


$\Rightarrow$ **1992-1993: Run 1A,** $\mathcal{L} \approx 15\ pb^{-1}$

$\Rightarrow$ **1994-1995: Run 1B,** $\mathcal{L} \approx 89\ pb^{-1}$

W and Z Production Cross Sections

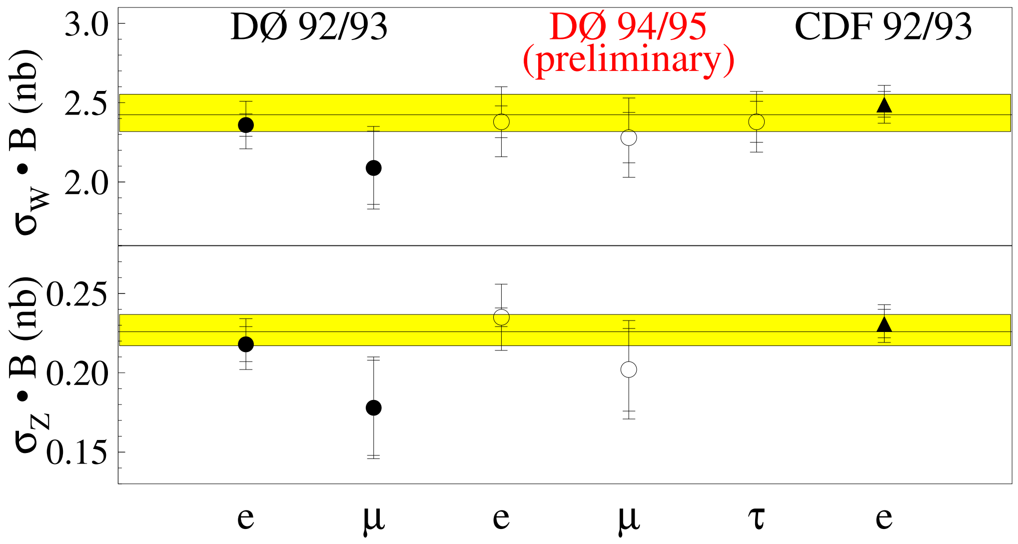
Run 1B, preliminary



Final Event Selection:

- $p_T(e) > 25$ GeV, $p_T(\mu, \mu_2) > 20(15)$ GeV
- $\not{E}_T > 25, 20$ **for** $W \to e, \mu$ **events**
- $75 < M(ee) < 105$ GeV/c^2

W and Z Production Cross Sections



Theoretical Prediction at $\mathcal{O}(\alpha_s^2) \Rightarrow$

- **Hamberg, van Neerven & Matsuura, NP B359, 313; van Neerven & Zijlstra, NP B 382, 11**
- **uses CTEQ2M pdf**
- **error dominated by pdf uncertainties**

$$
\begin{array}{lcllll}
\sigma_W \cdot B(W \to e\nu) & = & \mathbf{2.38} & \pm\, \mathbf{0.01} & \pm\, \mathbf{0.09} & \pm\, \mathbf{0.20\ nb} \\
\sigma_W \cdot B(W \to \mu\nu) & = & \mathbf{2.28} & \pm\, \mathbf{0.04} & \pm\, \mathbf{0.16} & \pm\, \mathbf{0.19\ nb} \\
\sigma_Z \cdot B(Z \to ee) & = & \mathbf{0.235} & \pm\, \mathbf{0.003} & \pm\, \mathbf{0.005} & \pm\, \mathbf{0.020\ nb} \\
\sigma_Z \cdot B(Z \to \mu\mu) & = & \mathbf{0.202} & \pm\, \mathbf{0.016} & \pm\, \mathbf{0.020} & \pm\, \mathbf{0.017\ nb} \\
 & & & (\pm\text{stat}) & (\pm\text{syst}) & (\pm\text{lum})
\end{array}
$$

⋆ **Final Results Soon!**

Cross Section Ratio $\Rightarrow \Gamma_W$

$\rightarrow$ **Take ratio - many errors cancel**

$$R = \frac{\sigma_W \cdot B(W \rightarrow l\nu)}{\sigma_Z \cdot B(Z \rightarrow ll)} = 10.32 \pm 0.43$$

$\rightarrow$ **Use theoretical calculation of σ_W/σ_Z and LEP measurement of $B(Z \rightarrow ll)$ to obtain $B(W \rightarrow l\nu)$**

$$B(W \rightarrow l\nu) = B(Z \rightarrow ll)\frac{\sigma_Z}{\sigma_W}R = (10.43 \pm 0.44)\%$$

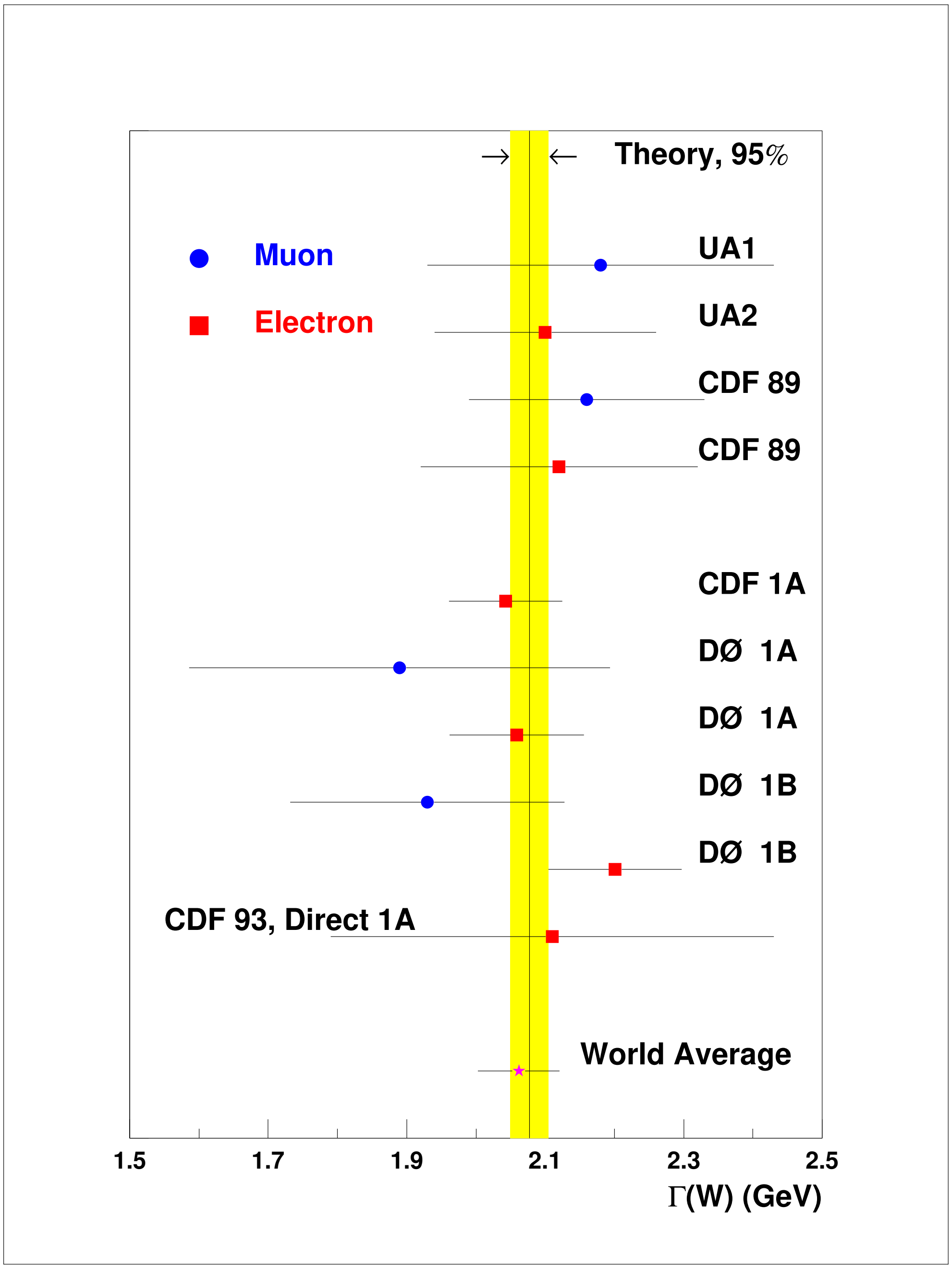
$\rightarrow$ **Use theoretical calculation of $\Gamma(W \rightarrow l\nu)$ to obtain Γ_W (Run 1B, preliminary)**

$$\Gamma_W = \frac{\Gamma(W \rightarrow l\nu)}{B(W \rightarrow l\nu)} = 2.159 \pm 0.092 \text{ GeV}$$

$\Rightarrow$ **Comparison of**
published world average ($\Gamma_W = 2.062$ GeV)
with SM prediction ($\Gamma_W = 2.077 \pm 0.014$ GeV)
gives limit on unknown decay modes of $W \Rightarrow$

95% CL upper limit of $\Delta\Gamma < 109$ MeV on unexpected decays of the W

Γ_W



Theory, 95%
Muon
Electron
UA1
UA2
CDF 89
CDF 89
CDF 1A
DØ 1A
DØ 1A
DØ 1B
DØ 1B
CDF 93, Direct 1A
World Average
1.5
1.7
1.9
2.1
2.3
2.5
Γ(W) (GeV)

M_W - electron energy scale

→ **Determine EM energy scale using J/ψ, π^0, and Z event samples**

→ **EM energy response:**

$$E^{meas} = \alpha E^{true} + \delta$$

then

$$M_{meas} = \alpha M_{true} + \delta f \qquad \text{with} \qquad f = \frac{2(E_1 + E_2)}{M} \sin^2 \frac{\gamma}{2}$$

Measure Ratio:

$$\left(\frac{M_W}{M_Z}\right)^{meas} = \left(\frac{M_W}{M_Z}\right)^{true} \left[1 + \frac{\delta}{\alpha} \cdot \frac{(f_W \cdot M_Z - f_Z \cdot M_W)}{M_W M_Z}\right]$$

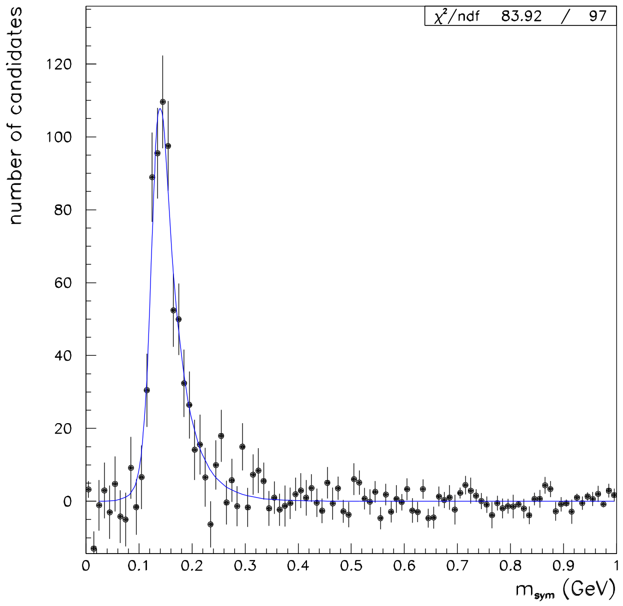
→ **Ratio insensitive to scale (first order)**

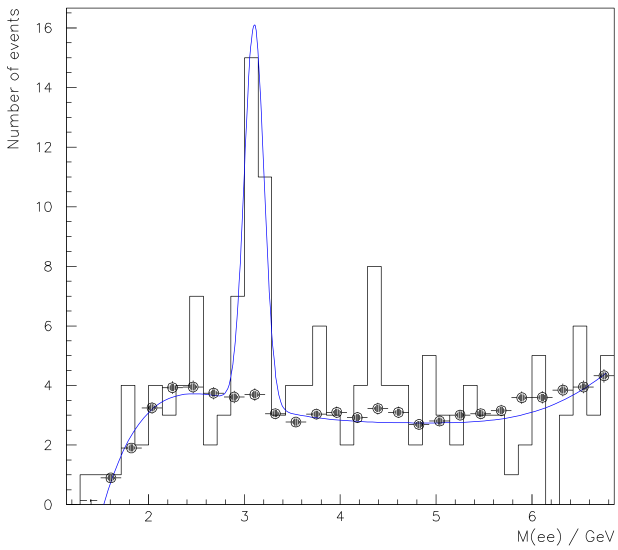
$$\frac{\partial M_W}{\partial \alpha} \approx 0 \quad \text{if} \quad \delta = 0$$

- error from offset suppressed

$$\frac{\partial M_W}{\partial \delta} \approx \frac{f}{\alpha} \cdot \frac{(M_Z - M_W)}{M_Z}$$

M_W - electron energy scale $\Rightarrow$





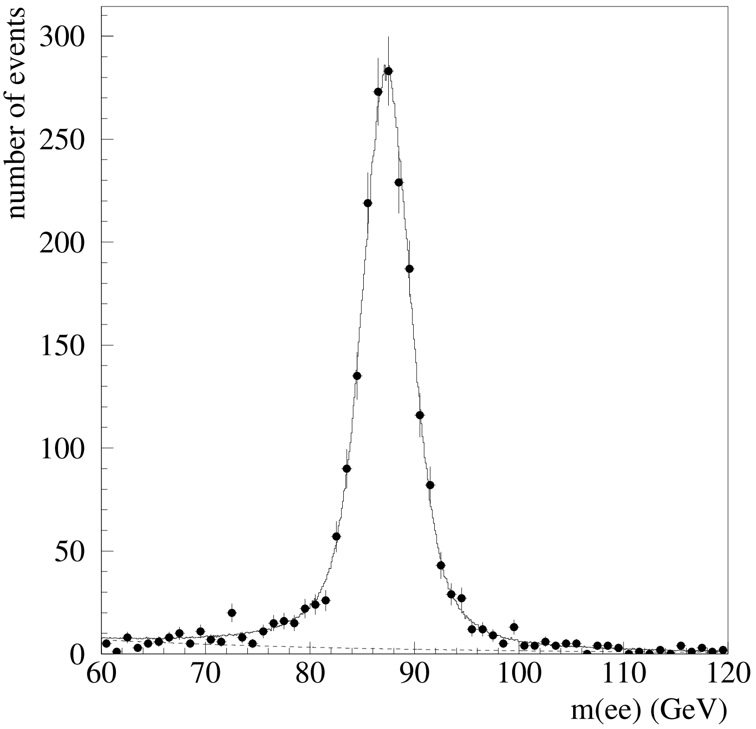


Fig1: $\pi^0 \rightarrow \gamma\gamma \rightarrow e^+e^-e^+e^-$

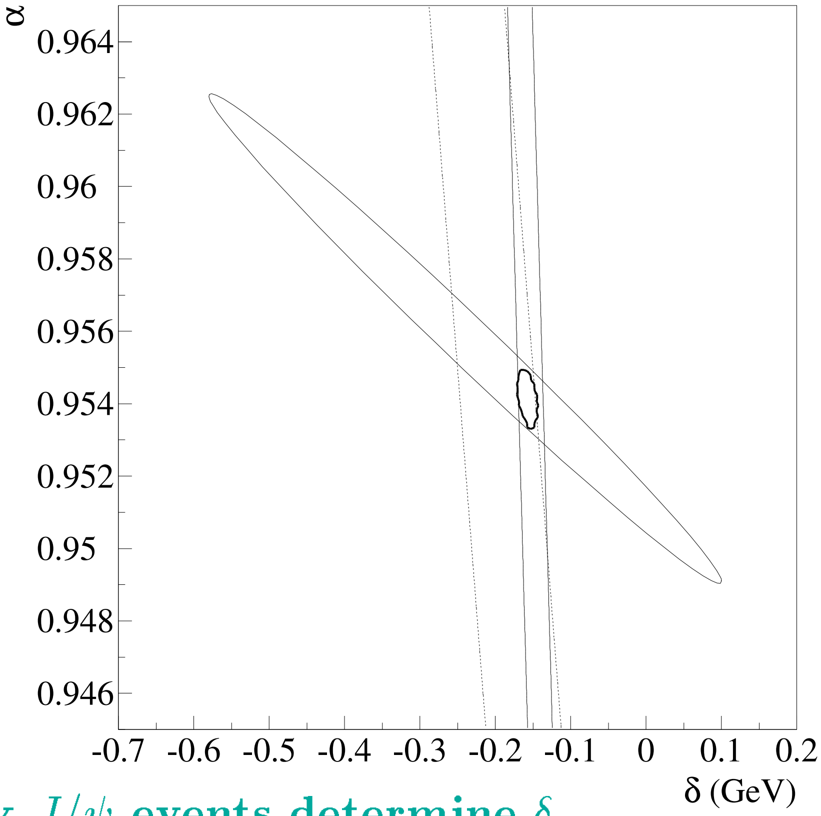
$M(\pi^0) = 135.4 \pm 10$ **MeV**

Fig2: $J/\psi \rightarrow e^+e^-$

$M(J/\psi) = 3.032 \pm .035 \pm .190$ **GeV**

Fig3: $Z^0 \rightarrow e^+e^-$

M_W - electron energy scale



$\star$ **π^0 & J/ψ events determine δ**

$\star$ **Z data determines α**

$$\alpha = 0.95329 \pm 0.00077$$

$$\delta = -0.160 \pm .016(stat)\ {}^{+.060}_{-.210}(syst)\ \text{GeV}$$

Error due to electron energy scale: $\sigma(M_W) = 65$ MeV

$\star$ **error dominated by limited Z statistics**

$J/\psi, \pi^0, Z$ data samples: dotted bands, solid bands, contour

$\Rightarrow$ overlap region is 1σ contour from all data samples

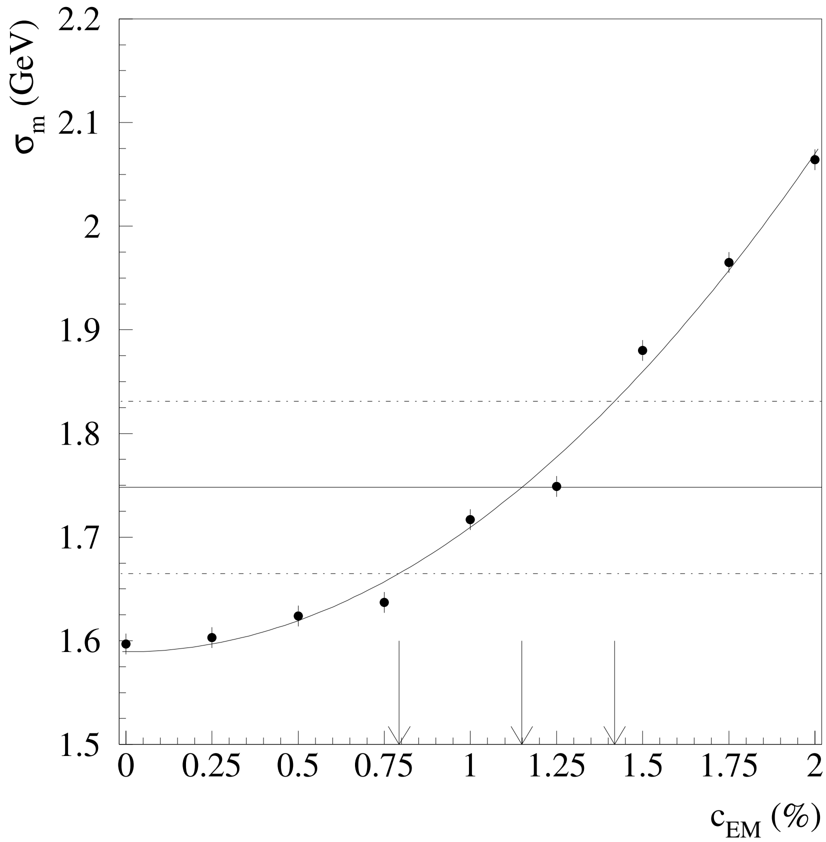
Systematic Error in δ: underlying event ($\pm$ 30 MeV),

γ response ($\pm$ 50 MeV), low energy response ($-$ 200 MeV)

M_W - Electron Energy Resolution

Data: range shown by horizontal bands

MC: solid dots with parameterization



EM Energy resolution:

$$\frac{\Delta E}{E} = \sqrt{C^2 + (\frac{S}{\sqrt{E_T}})^2 + (\frac{N}{E})^2}$$

- **from test beam have:** $S = 0.13$ **and** $N = 0.4$
- **width of** M_Z **constrains EM energy resolution:**

$$\longrightarrow C = (1.15\ ^{+0.27}_{-0.36})\%$$

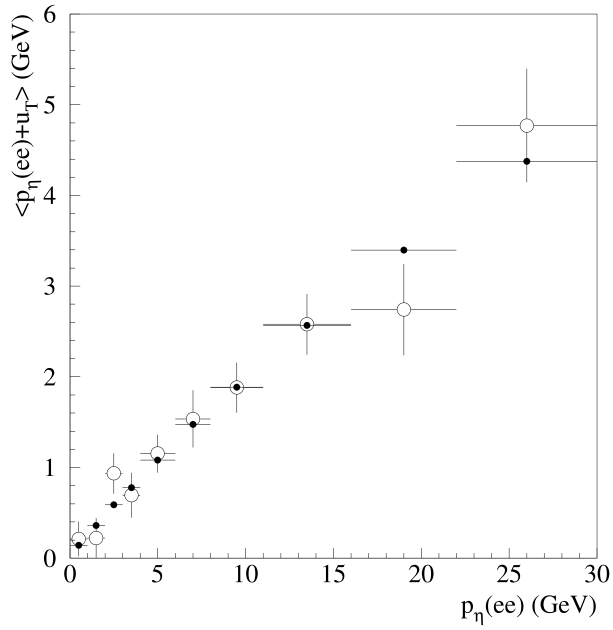
Error due to EM energy resolution: $\sigma(M_W) = 23\ \text{MeV}$

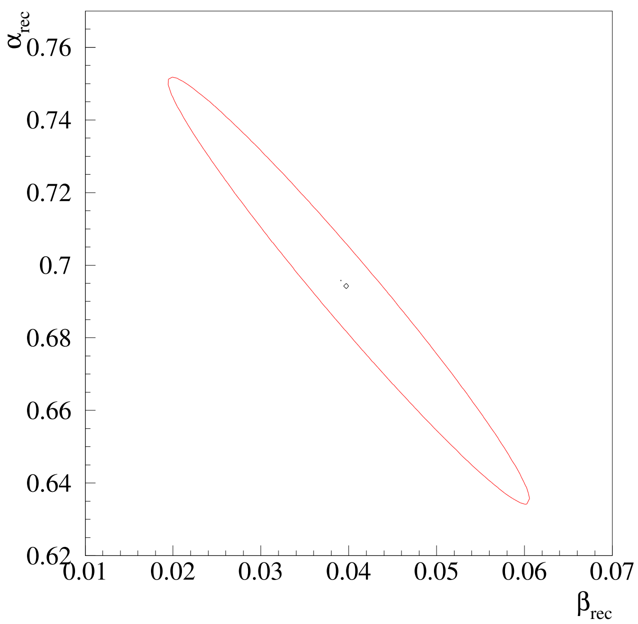
M_W - Hadronic (Recoil) Energy Scale

$\Longrightarrow$ **determine hadronic relative to electron energy scale**

$\Longrightarrow$ Z **events - measure** $P_T(Z)$ **from** ee **or the recoil:**

$$P_T\text{−balance} \equiv [\vec{P}_T(ee) + \vec{P}_T(R)] \cdot \hat{\eta} \quad \text{vs} \quad \vec{P}_T(ee) \cdot \hat{\eta}$$





have $P_T(rec) = \mathcal{R}_{rec} P_T(ee)$

with $\mathcal{R}_{rec} = \alpha_{rec} + \beta_{rec} \log\, p_T(W)$

Determine from fits of data to MC simulation:

$$\Rightarrow \alpha_{rec} = 0.69 \pm 0.06 \ \textbf{and} \ \beta_{rec} = 0.04 \pm 0.02$$

Error due to hadronic energy scale: $\sigma(M_W) = 23$ MeV

Data and MC Comparison

⋆ $u_{\|} = \vec{P}_T^R \cdot \hat{e} = P_T^R \cos\phi$
$\rightarrow$ **hadronic energy in electron direction**

⋆ **A bias in $u_{\|}$ directly affects the M_T spectrum**

⋆ $u_{\|}$ **is sensitive to the recoil resolution**