Electron Identification - DØ

Offline Selection - Electron Quality Cuts:

- fraction of energy in EM calorimeter $> 90\%$
- longitudinal and transverse shower shape requirements:
  H-matrix $\chi^2 < 100$
- isolation requirement:

$$\frac{E_{tot}(R=0.4) - E_{EM}(R=0.2)}{E_{EM}(R=0.2)} < 0.15$$

- fiducial requirement: $\phi > 10\%$ from module edge
- match between track in central detector and calorimeter

$$\sigma_{trk} < 10$$

  where

$$\sigma_{trk} = \sqrt{\left(\frac{R\Delta\phi}{\sigma(R\Delta\phi)}\right)^2 + \left(\frac{\Delta z}{\sigma(z)}\right)^2}$$

- event requirement: no jets with fraction of energy in CH > 0.4

W and Z Production Cross Sections

Run 1B, preliminary

	Electron	Muon
W candidates	59579	4472
$A_W(\%)$	43.4 ± 1.5	20.1 ± 0.7
$\epsilon_W(\%)$	70.0 ± 1.2	24.7 ± 1.5
Bkg.(%)	8.1 ± 0.9	18.6 ± 2.0
Lum. (pb^{-1})	75.9 ± 6.4	32.0 ± 2.7
Z candidates	5702	173
$A_Z(\%)$	34.2 ± 0.5	5.7 ± 0.5
$\epsilon_Z(\%)$	75.9 ± 1.2	43.2 ± 3.0
Bkg.(%)	4.8 ± 0.5	8.0 ± 2.1
Lum. (pb^{-1})	89.1 ± 7.5	32.0 ± 2.7

ElectroWeak Standard Model

Specified by 3 parameters:

fine structure constant:

- $\alpha = (137.0359895 \pm .0000061)^{-1} \quad (\delta\alpha/\alpha = 0.045\ ppm)$

Fermi constant:

- $G_F = (1.16639 \pm .00002) \times 10^{-5}\mathrm{GeV}^{-2} \quad (\delta G_F/G_F = 17\ ppm)$

Mass of the Z Boson:

- $M_Z = 91.1884 \pm .0022\ \mathrm{GeV/c^2} \quad (\delta M_Z/M_Z = 24\ ppm)$

At lowest order : $M_W = \dfrac{A}{\sin\theta_W}$ and $\sin^2\theta_W = 1 - \dfrac{M_W^2}{M_Z^2}$

$\Rightarrow$ **Data is sufficiently precise**

- must include radiative corrections

$\Rightarrow$ **lump radiative corrections into Δr** **(on-shell scheme, Sirlin)**

$$M_W = \frac{A}{\sin\theta_W(1-\Delta r)^{1/2}} \text{ with } \Delta r \sim \Delta r_o - \rho_t/\tan\theta_W$$

ElectroWeak Standard Model

- $\Delta r_o \approx 0.06$ **- due to running of** $\alpha \rightarrow \alpha(M_Z^2)$
  - vacuum polarization diagrams

- $\rho_t \approx 0.01(M_{top}/180\ \mathrm{GeV})^2$
  due to W, Z **self-energy diagrams**

- **also contributions from bosonic loops which** $\propto (\ln M_{Higgs})$

Therefore $\Delta r(M_{top}^2, \ln M_{Higgs})$

$\Rightarrow$ **Precision Measure of** M_W

$\rightarrow$ **defines size of radiative corrections in SM**
$\rightarrow$ **with** M_{top} **can constrain** M_{Higgs}
$\rightarrow$ **test the SM beyond the tree level**

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Then obtain other parameters M_W and $\sin\theta_W$ at *tree level* from:

$$M_W = A/\sin\theta_W$$

$$\sin^2\theta_W = 1 - \frac{M_W^2}{M_Z^2}$$

where θ_W is the weak mixing angle and

$$A = (\pi\alpha/\sqrt{2}G_F)^{1/2}$$

Radiative Corrections:

$\rightarrow$ **Data is sufficiently precise**

- must include radiative corrections

$\Rightarrow$ **lump radiative corrections into** Δr

$$M_W = \frac{A}{\sin\theta_W (1 - \Delta r)^{1/2}}$$

$\Rightarrow$ **Dominate contributions to** Δr **due to**

- **running of** $\alpha \rightarrow \alpha(M_Z^2)$
  - vacuum polarization diagrams
- W, Z **self-energy diagrams**
- **bosonic loop diagrams**

$\Longrightarrow$ **can write as**

$$\Delta r \sim \Delta r_o - \rho_t / \tan\theta_W \quad \text{with}$$

$$\Delta r_o \approx 1 - \frac{\alpha}{\alpha(M_Z)} \approx 0.06 \quad \text{and}$$

$$\rho_t \approx 0.01 (M_{top}/180 \text{ GeV})^2$$

$+$ **contributions from bosonic loops which** $\propto (\ln M_{Higgs})$

Therefore $\Delta r(M_{top}, M_{Higgs})$

Motivation

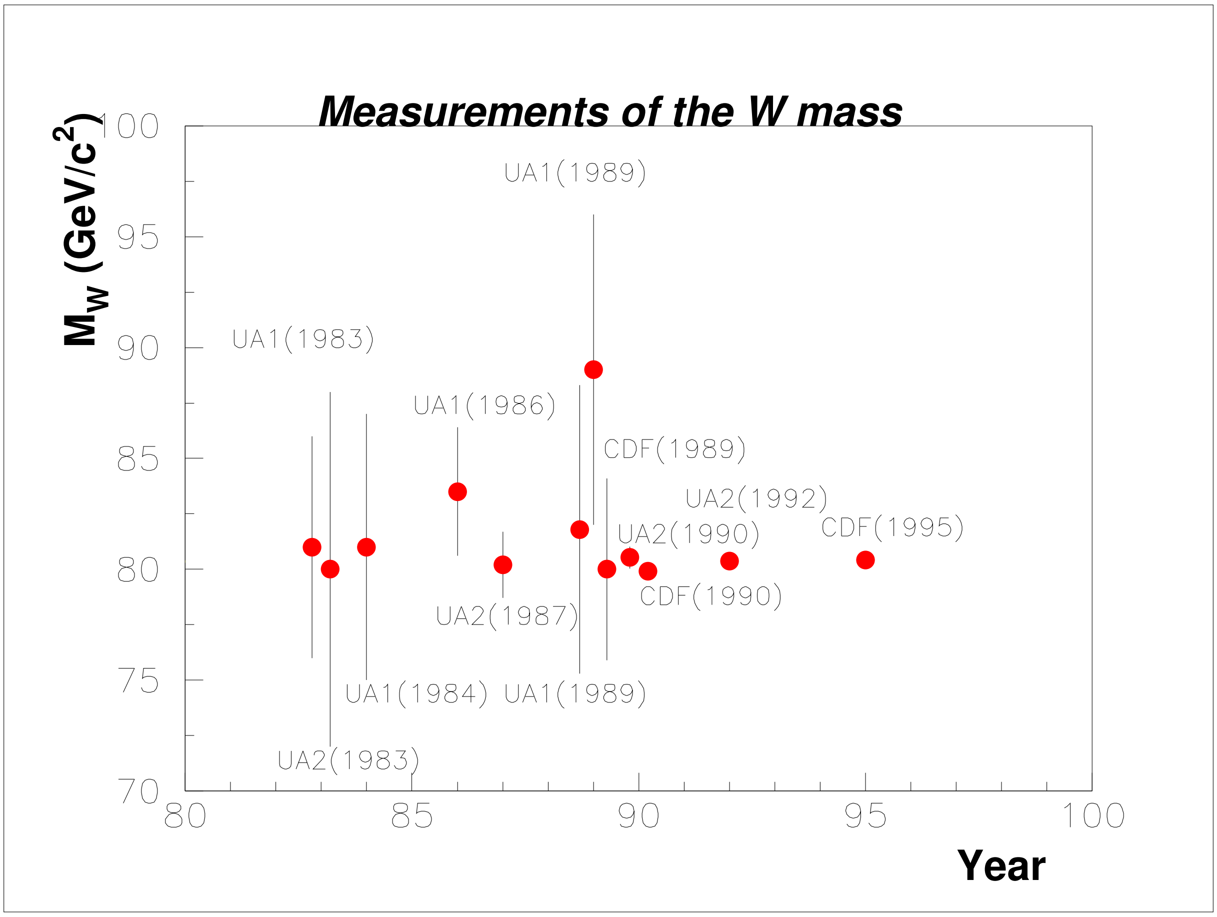
⇒ **Precision Measure of M_W provides**

- ⋆ **test of SM at level of radiative corrections**
  - → **defines size of radiative corrections in SM**
  - → **sensitive to M_{top} and M_{Higgs}**
  - → **with M_{top} can constrain M_{Higgs}**

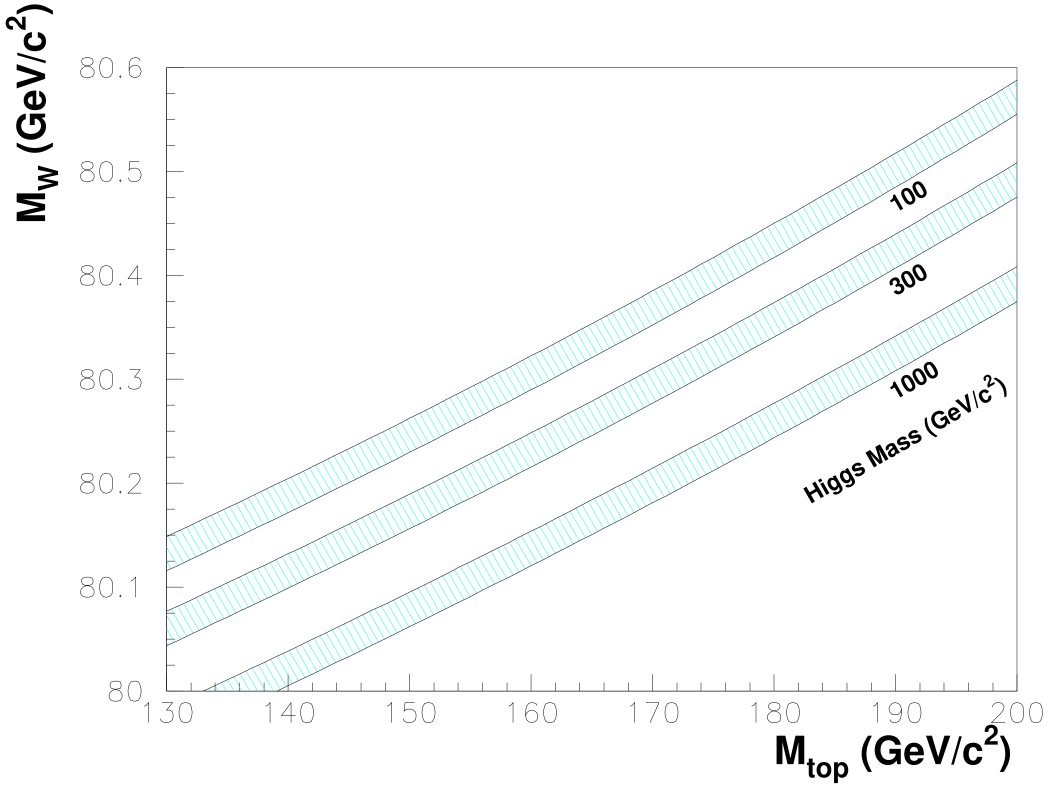
- ⋆ **Improvement in precision can further constrain allowed values of M_{Higgs} in Standard Model or parameter space of other models**

- ⋆ **A precise value of M_W from direct measurement could contradict the value determined indirectly, indicating breakdown of Standard Model**

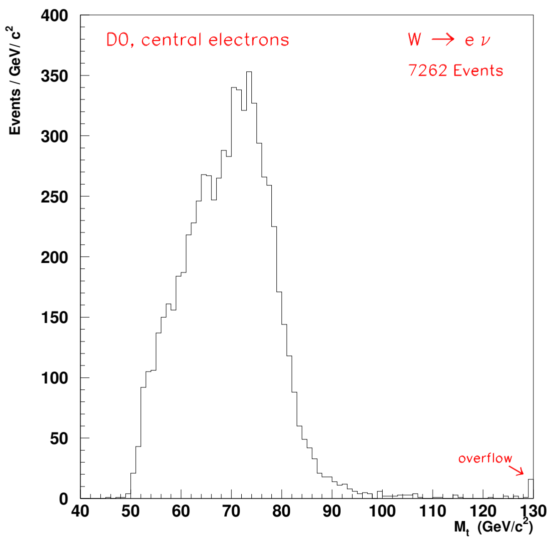
Previous Measurements of M_W

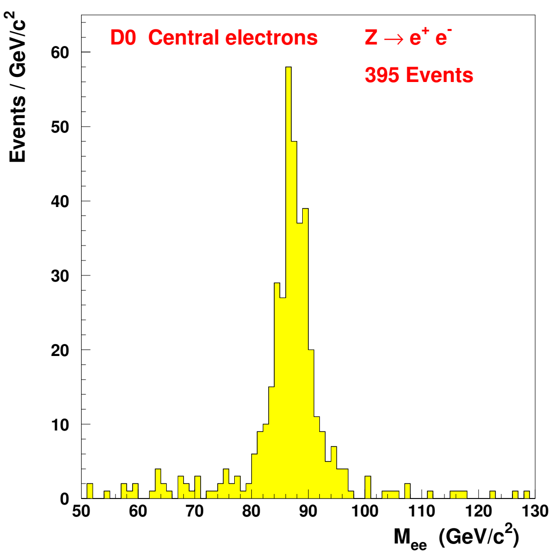


M_W vs. M_{top} - Higgs Mass Dependence

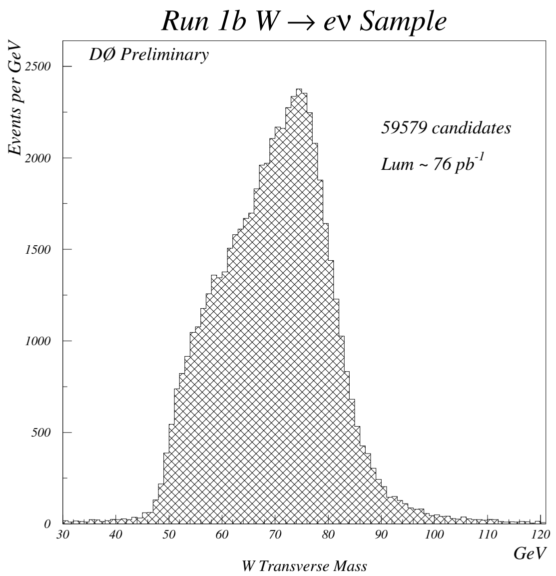


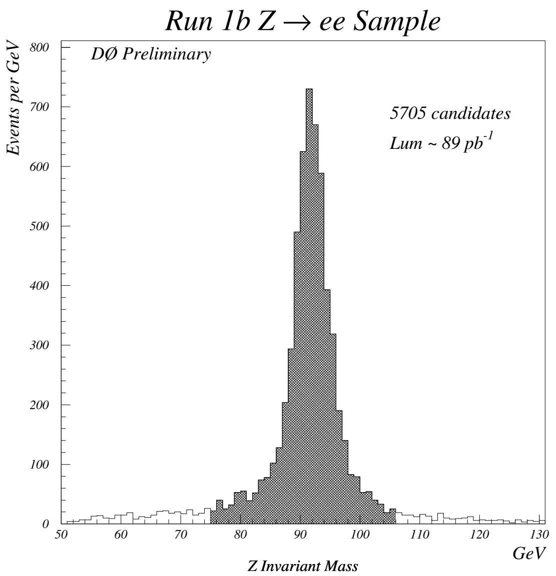
Run 1A - spectra:





Run 1B - spectra:





M_W - Event Sample

		# events: 1A	1B
$W \rightarrow e\nu$		**7234**	**28323**
$\star$ e **in central region:**	$\lvert\eta\rvert < 1.2(1.0)$		
$\star$ **electron:**	$E_T^e > 25$ **GeV**		
$\star$ **neutrino:**	$\not{E}_T > 25$ **GeV**		
$\star$ W **transverse mom.**	$E_T^W < 30(15)$ **GeV**		
$\star$ **transverse mass (1A)**	$50 < M_T^W < 110$ **GeV**		
$Z \rightarrow ee$		**366**	**2179**
$\star$ e**'s in central region:**	$\lvert\eta\rvert < 1.2(1.0)$		
$\star$ **2 isolated electrons:**	$E_T(e) > 25$ **GeV**		
$\star$ **invariant mass (1A)**	$70 < M_Z < 110$ **GeV**		

Underlying Event Correction to $P_T(e)$

Electron energy measured in
$\Rightarrow$ **cone of** 5×5 **towers of size** $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$

- **energy is in cluster that is *not* due to electron from:**
  - spectator interactions
  - recoil energy leaking into cluster
  - positive tails from zero-suppression of asymmetric pedestal distribution
- **energy lost from cluster that *is* due to electron:**
  - electron energy below zero-suppression cut-off

Corrections obtained from

$\star$ **comparing suppressed and non-suppressed minimum bias data**

$\star$ **rotating away from electron in W events**

Corrections in electron direction:

$$\vec{P}_T(e)^{meas} = \vec{P}_T(e) + \vec{U}(e) - \vec{U}_{zs}$$

$\star$ $\vec{U}(e)$ **due to multiple interactions & spectator partons**
$\rightarrow$ **function of luminosity and** $(u_{\parallel})$

$\langle \vec{U}(e) \rangle = 479 \pm 2(stat) \pm 6(syst)$ **MeV**

$\star$ $\vec{U}_{zs}$ **due to the zero-suppression**

$\vec{U}_{zs} = 212$ **MeV**

Error due to e underlying event modelling: $\sigma(M_W) = 16$ MeV

M_W - Summary of Errors

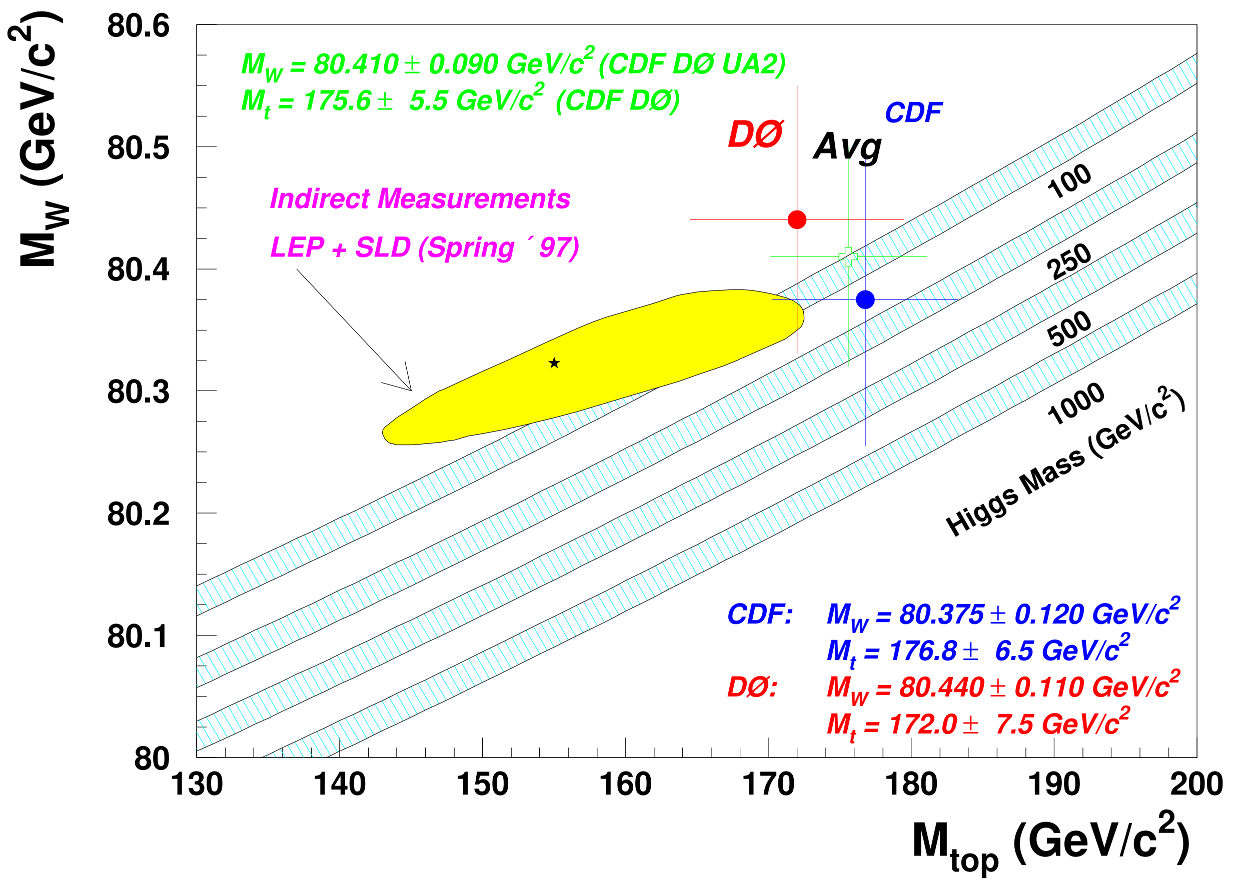
Source	$\sigma_{M(W)}$ in MeV/c^2 Run 1B	Run 1A
Statistical (W events)	69	140
Energy Scale (Z events)	65	160
Non-Uniform energy response (η)	10	10
Electron Angle Calibration	28	50
Electron Energy Resolution	23	70
Electron Energy Linearity	20	*
Electron Underlying Event	16	35
Efficiencies	-	30
Hadronic Energy Scale	23	50
Hadronic Energy Resolution	*	65
# of Min. Bias Events	33	60
P_T^W, pdf, parton luminosity	24	65
W Width	9	20
Radiative Decays	20	20
Backgrounds	11	35
Fit Error	-	5
Systematic Total	70	165
Total	118	270

* this error combined with another one

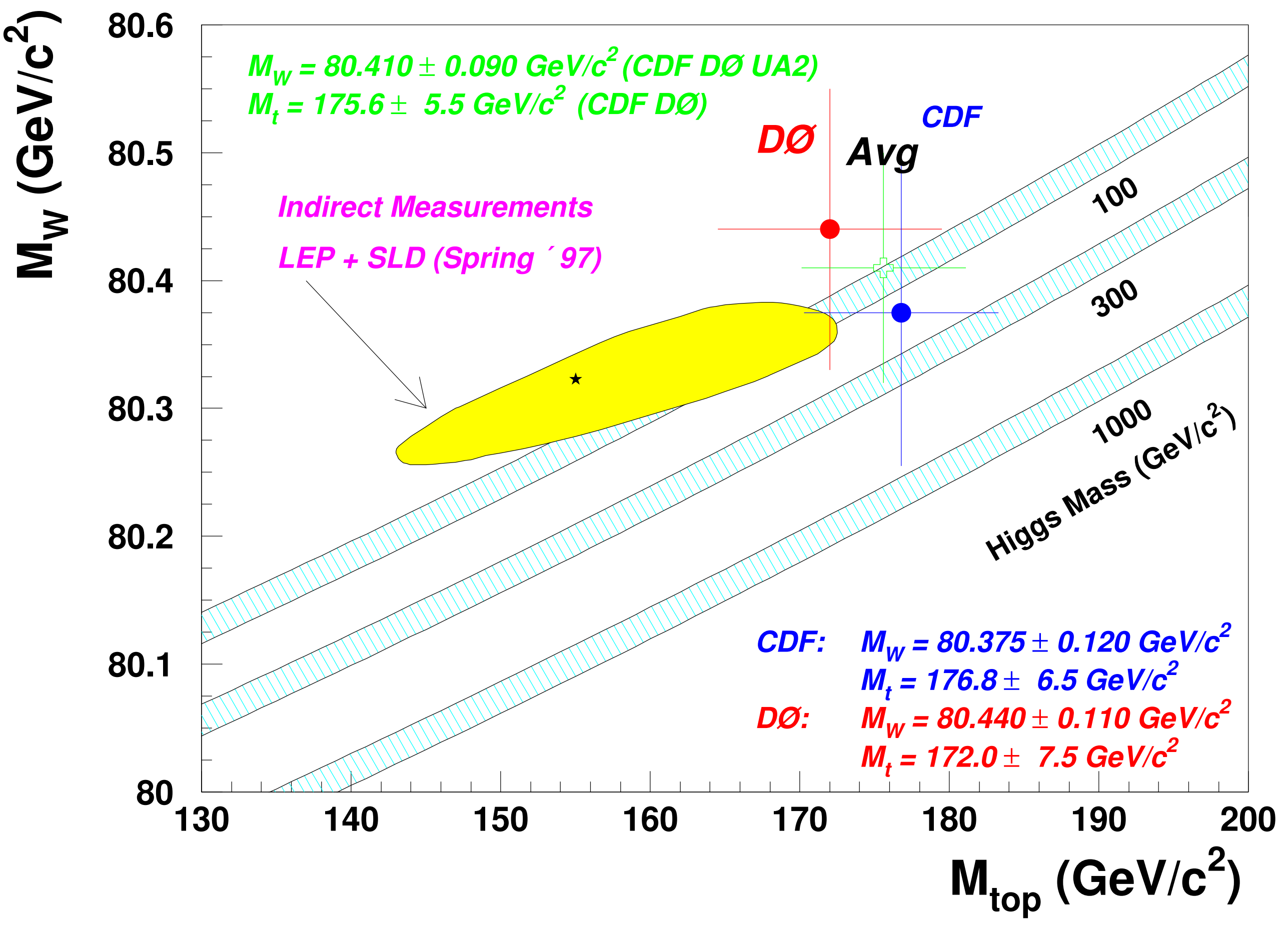
$$M_W(\mathrm{Run1A}) = 80.350\pm0.140(stat.)\pm0.160(scale)\pm0.165(syst.)\ \mathrm{GeV/c^2}$$

$$M_W(\mathrm{Run1B}) = 80.450\pm0.070(stat.)\pm0.065(scale)\pm0.070(syst.)\ \mathrm{GeV/c^2}$$

Higgs Mass Constraints



Higgs Mass Constraints



W charge asymmetry - Preliminary

At Tevatron:
W **bosons produced primarily by** $q\bar{q}$ **annihilation**

$$u + \bar{d} \to W^+ \to \mu^+ + \nu_\mu$$

$$\bar{u} + d \to W^- \to \mu^- + \bar{\nu_\mu}$$

On average, the $u(\bar{u})$ **quarks carry** $>$ **momentum fraction than** $d(\bar{d})$ **quarks**

$\Rightarrow$ **leads to production asymmetry in rapidity** (y)

$$A(y_w) \equiv \frac{d\sigma_W^+(y)/dy_W - d\sigma_W^-(y)/dy_W}{d\sigma_W^+(y)/dy_W - d\sigma_W^-(y)/dy_W}$$

$\Rightarrow$ **Measure muon charge asymmetry in** η

$$A(|\ \eta\ |) = \frac{N^+(|\ \eta\ |) - N^-(|\ \eta\ |)}{N^+(|\ \eta\ |) + N^-(|\ \eta\ |)},$$

W charge asymmetry - Preliminary