Measurement of the Z P_T distribution and its relevance for the W mass measurement at D0

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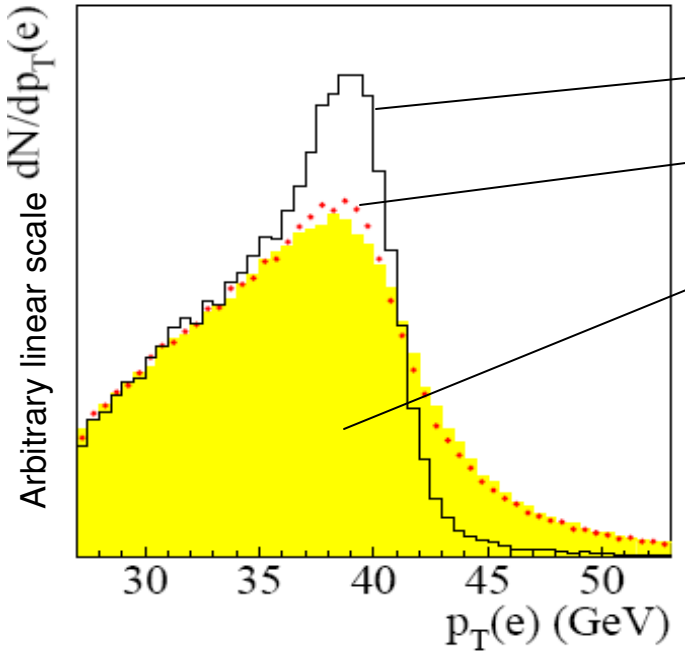
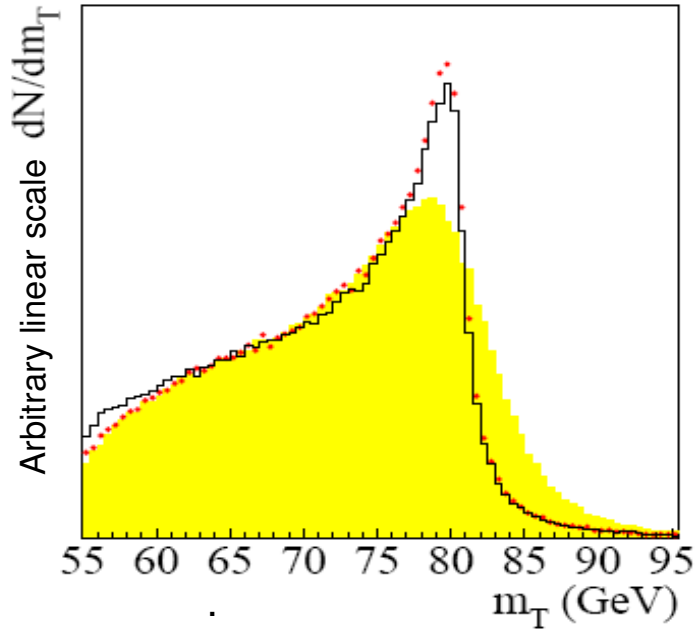
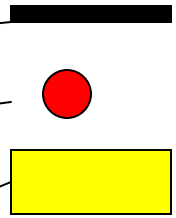
Rencontres de Moriond EW 2008

Overview of a W Mass Measurement







No $P_T(W)$

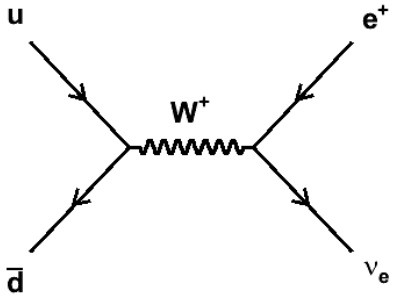
$P_T(W)$ included

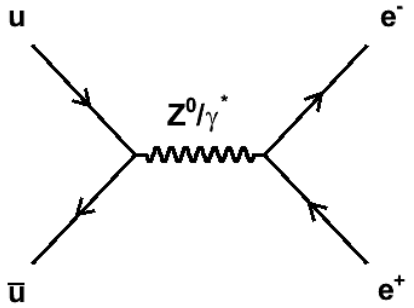
Detector Effects added

- M_W measurement relies on the theoretical description of boson production P_T spectrum.
- Measurement using the $P_T(e)$ distribution most affected by $P_T(W)$.
- Detector calibrated and tuned using Z->ee data.
  - Tuning then scaled down to W mass.
  - Any difference between Z and W events not accounted for will lead to inaccuracy.

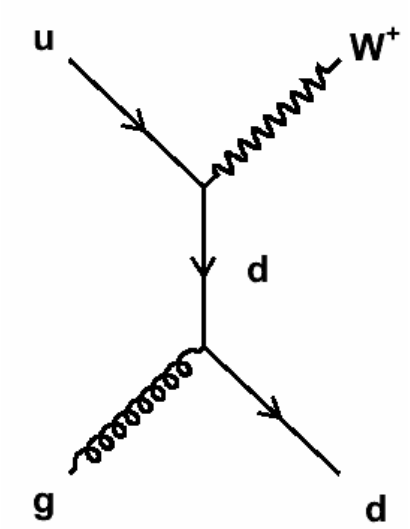
W/Z Production at the Tevatron

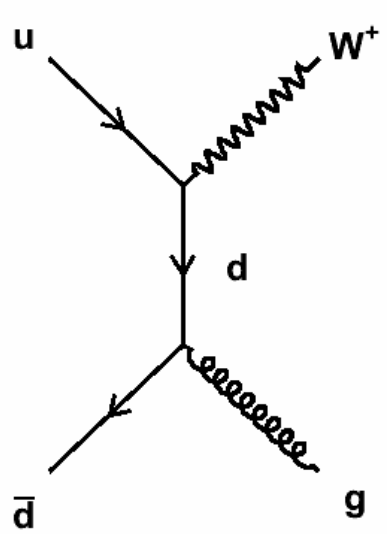
- W/Z boson produced predominately by $q\bar{q}$ at the Tevatron.
- At leading order W/Z $P_T = 0$.





- At NLO W/Z $\langle p_T \rangle \sim 5$ GeV. Need gluon resummation to describe boson p_T:





Soft Gluon Resummation

- The differential cross section for boson production is

$$\frac{d^2\sigma}{dP_T^2} = \sum_{ij} \int dx_1 dx_2 f_i(x_1) f_j(x_2) \frac{d^2\sigma(ij \to V)}{dP_T^2}$$

- We use the RESBOS generator (PRD **56**, 5558 (1997)) to model the boson P_T spectrum. This relies on the Collins, Soper, Sterman formalism (Nucl. Phys. **B250**, 199 (1985)), where the parton level cross section is

$$\frac{d^2\sigma(q\bar{q} \to V)}{dP_T^2} \sim \int_0^\infty d^2b e^{i\vec{P}_T \cdot \vec{b}} \times W(b,Q) + Y(P_T,Q)$$

- W(b,Q) is separated into a perturbative and non-perturbative part. The non-perturbative component is described by the Brock-Landry-Nadolsky-Yuan parameterization (PRD **67**, 073016 (2003)):

$$W_{NP}(b) = \exp\left(-\left(g_1 + g_2 \ln\left(\frac{Q}{2Q_0}\right) + g_1 g_3 \ln(100 x_1 x_2)\right) b^2\right)$$

$$Q \sim 91\text{GeV},\ Q_0 = 1.6\text{GeV},\ x_{i,j} \sim 0.05$$

- The W/Z P_T spectrum is found to be most sensitive to g_2, which determines the most probable P_T.

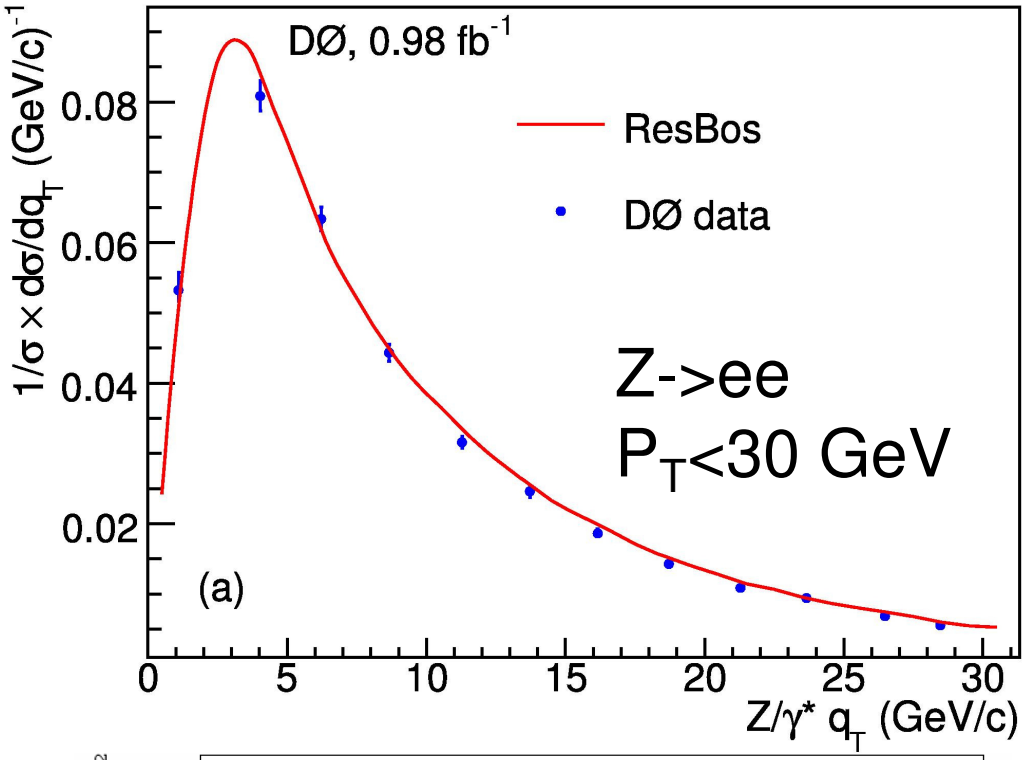
Z P_T Spectrum and Fit for BLNY parameter

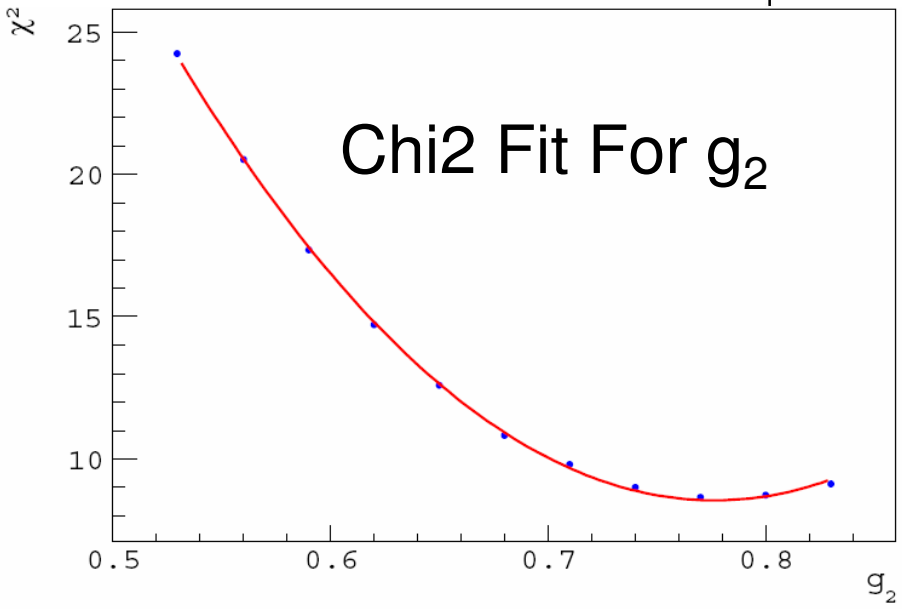
- Z P_T spectrum :
  - Unfolded, can compare directly to theoretical prediction.
  - Default value used for g_i:

$$g_1 = 0.21\ \mathrm{GeV}^2$$
$$g_2 = 0.68\ \mathrm{GeV}^2$$
$$g_3 = -0.60$$

- Now use default g_1, g_3, vary g_2. Fit to data.

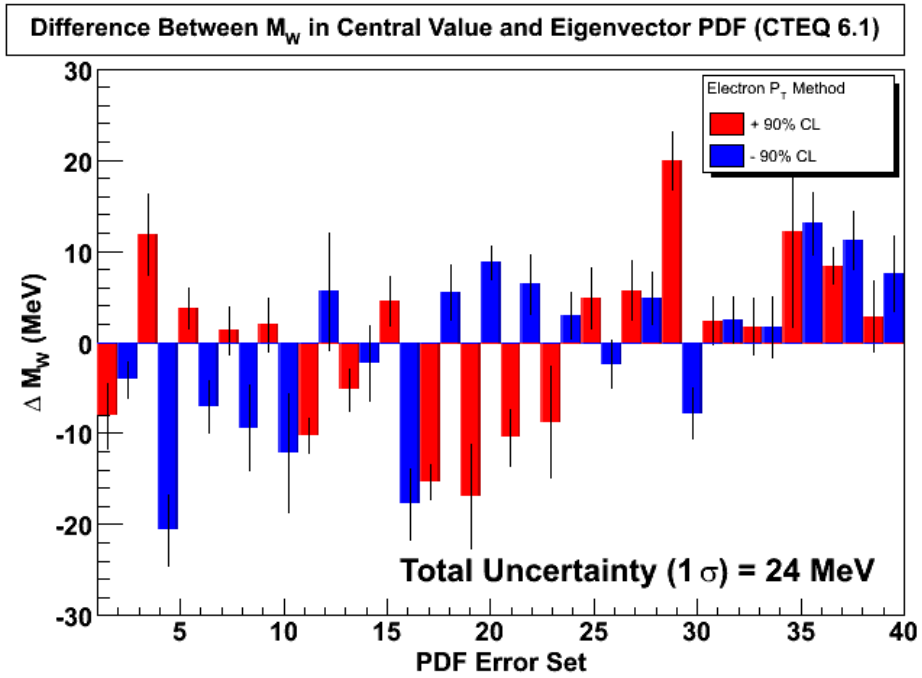
Result g_2 = 0.77 ± 0.06 GeV².

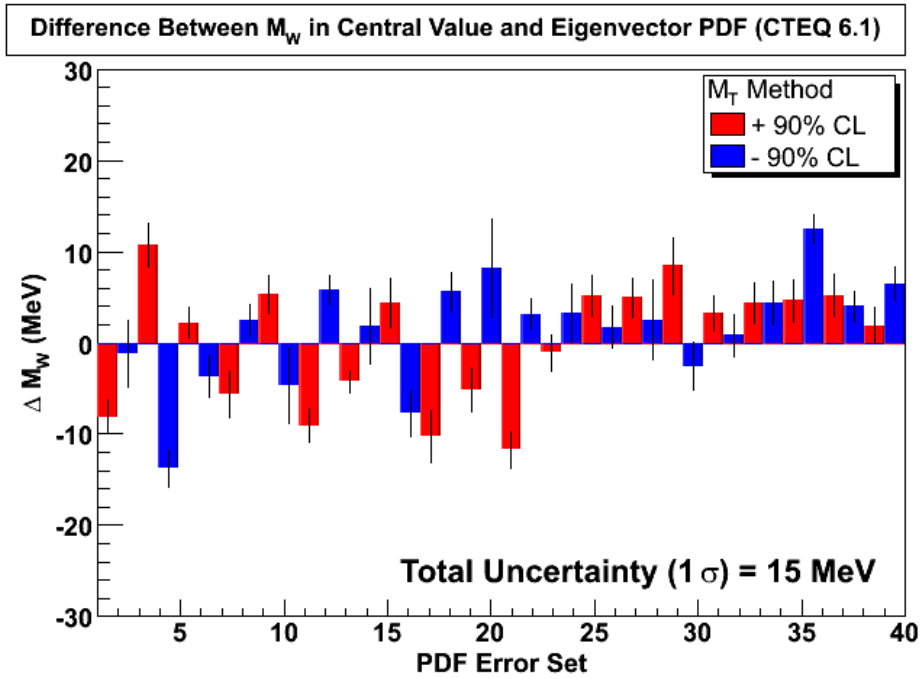




PDF Uncertainty

Parton distributions used as input to RESBOS are derived from global QCD fits to many experiments. We use CTEQ 6.1 parton distribution functions (JHEP 0310 046 (2003)), which gives us a way to estimate the uncertainty.





$$\sigma_{PDF}^{\pm} = \frac{1}{1.6}\left(\sum_{i=1}^{n}\left[\Delta M_W\left(S_i^{\pm}\right)\right]^2\right)^{\frac{1}{2}}$$

Conversion to1σ

Implications of W Mass Measurement

- Use D0 data to constrain boson production model
  - Reduces sensitivity to external inputs.
  - W/Z p_T distributions are calculated independently.
  - Includes boson rapidity-p_T correlation.
- Preliminary estimate of contribution to uncertainty (1/fb sample):

	Stat. (MeV)	g_2 (MeV)	PDF (MeV)
ΔM_W (M_T)	22	5	15
ΔM_W ($P_T(e)$)	25	16	24

- Uncertainty due to W P_T spectrum is small compared to the statistical uncertainty. Add…
- Most significant production model uncertainty still due to PDFs.