Resumption Effects from ***W/Z*** *P_T Distributions*

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Representing CDF/DØ Collaborations

Hadron Collider Physics XII

Stony Brook, NY

June 7, 1997

Outline:

- Motivation
- Experimental details
- P_T^{W}
- P_T^{Z}
- g_2
- W asymmetry
- Conclusions

Motivation:

- ***W,Z***:
  - Distinctive event signatures
  - Low backgrounds
  - Large Q^2
  - Well understood EW vertex

- Large P_T: Test pQCD

- Small P_T:
  - Test resummation techniques
  - Extract non-perturbative parameters

- Predict $d^2\sigma/dP_T dy$
  - Needed for M_W measurement

- Knowledge of ***W/Z*** production is foundation for

many searches for new physics

Introduction to theory:

- Large P_T region ($P_T \geq \sim 50$ GeV)

  Use pQCD

  $O(\alpha_s^2)$ calculations exist

  Ellis, Martinelli, Petronzio (83); Arnold & Reno (89)
  Arnold, Ellis, Reno (89); Gonsalves, Pawlowski, Wai (89)

- Small P_T region

  Resum large logs: $\ln(Q^2/P_T^2)$

  Altarelli, Ellis, Greco, Martinelli (84);
  Collins, Soper, Sterman (85)

$$\frac{d\sigma}{dp_T^2 dy} \sim \int db^2 e^{i\vec{b}\bullet\vec{q}_T} W(b_*) e^{-S(b)}$$

- Match two regions and include non-perturbative parameters

  Davies, Webber, Stirling (85)
  AK: Arnold & Kauffman (91) - resum + $O(\alpha_s^2)$
  LY: Ladinsky & Yuan (94) - resum + $O(\alpha_s)$

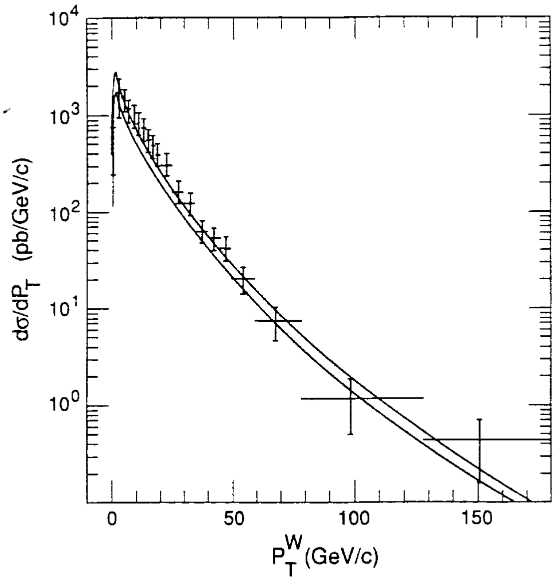
Non-perturbative parameters:

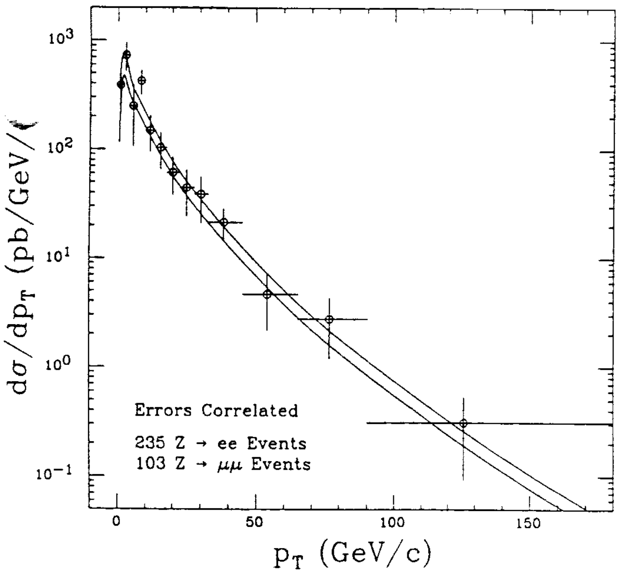
AK: $S(b) = g_1 b^2 + g_2 b^2 \ln(b_{\max} Q/2)$

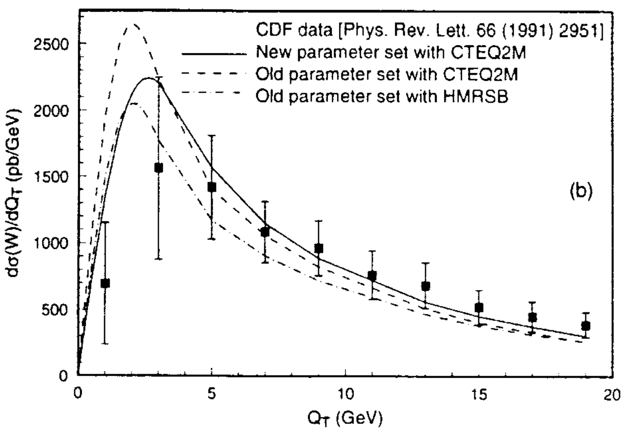
LY: $S(b) = g_1 b^2 + g_2 b^2 \ln(b_{\max} Q/2) + g_1 g_3 b \ln(100 x_a x_b)$

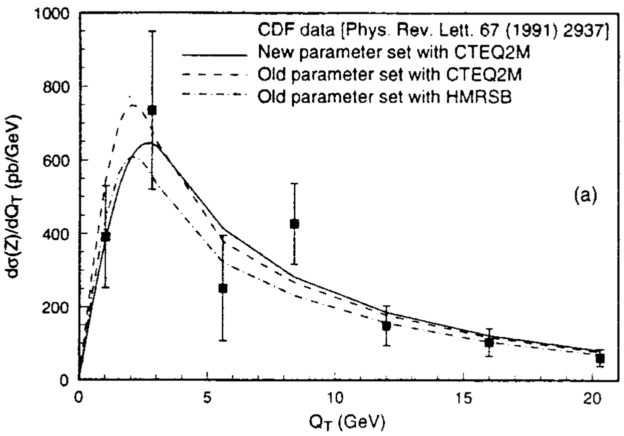
Old CDF measurements:

F. Abe, et al, PRL 66, 2951 (1991); PRL 67, 2937 (1991).









Ladinsky & Yuan, PRD 50, R4239 (1994).

- Above based on 4 pb^{-1} of luminosity
- Current data sets: ~ 100 pb^{-1}

Cross Section Measurement:

For ith bin in P_T:

$$\boxed{\frac{d\sigma}{dp_T^i} = \frac{d_i - b_i}{a_i \times \varepsilon_i \times L \times \Delta p_T^i}}$$

- d_i = # candidate events
- b_i = Background
- a_i = Acceptance
- e_i = Efficiency
- L = Luminosity
- ΔP_T^i = bin width

For current analyses, P_T is *measured*.

Will compare to *smeared theory*.

Focus on shape comparisons.

Event Selection:

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- ***W*** - High P_T, isolated electron; large $\not{E}_T$
- ***Z*** - Two high P_T, isolated electrons; M_{ee}

Electron id:

- *LOOSE* electron:
  - EM object
  - Match long./trans. shower profile
  - Isolated
  - Within good fiducial region of detector
- *TIGHT* electron:
  - LOOSE electron
  - Track pointing to cluster

W sample:

- One tight electron
- $|\eta| < 1.1$, $E^e_T > 25$ GeV
- No other loose electron ($E^e_T > 20$ GeV)
- $\not{E}_T > 25$ GeV

Z sample:

- One tight + one loose electron
- $|\eta| < 1.0$ or $1.5 < |\eta| < 2.5$
- $E^e_T > 25$ GeV
- $76 < M_{ee} < 106$ GeV

Event Samples:

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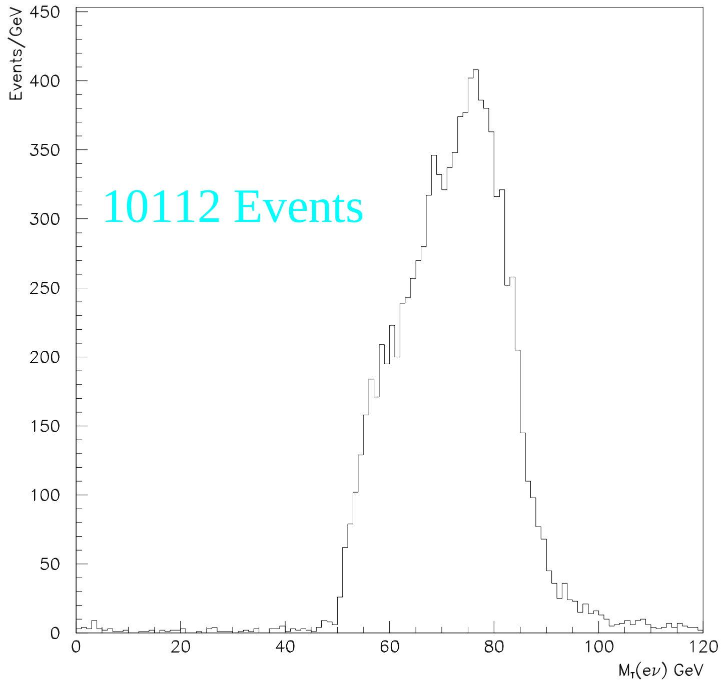
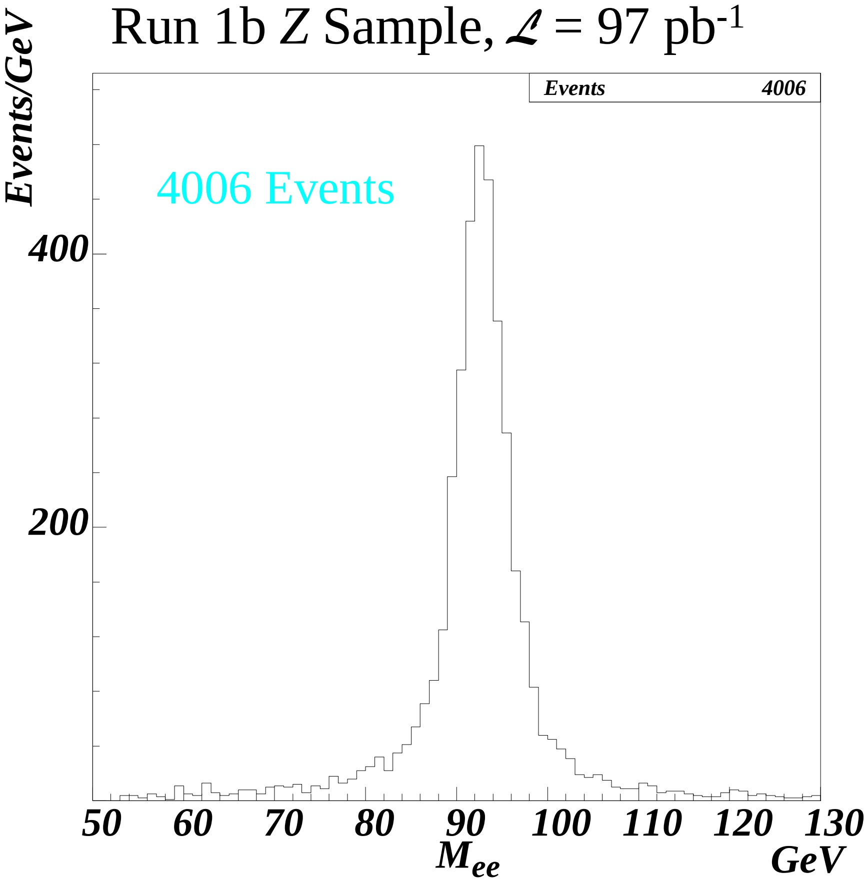
Run 1a ***W*** Sample, $\mathcal{L}$ = 12.4 pb^{-1}



Run 1b *Z* Sample, $\mathcal{L}$ = 97 pb^{-1}



Backgrounds:

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W:

• QCD Multijet + γj	2.95 ± 0.51 %
• $Z \rightarrow e \not{e}$	0.6 ± 0.1 %
• $t\bar{t}$	0.11 ± 0.03%

QCD backgnd method:

Use 2 sets of cuts with known effic/rejection - extract signal/backgnd for each P_T bin (assumes data with $\not{E}_T < 15$ GeV all backgnd).

Z:

• QCD Multijet + γj	4.6 ± 0.7 %
• $Z \rightarrow \tau\, \tau$	-
• $t\bar{t}$	-

QCD backgnd method:

Magnitude: Fit M_{ee} to BW $\oplus$ G + exp/quad
Shape: Use Direct γ / "bad" electrons / dijet

Need background as a function of P_T

W Backgrounds:

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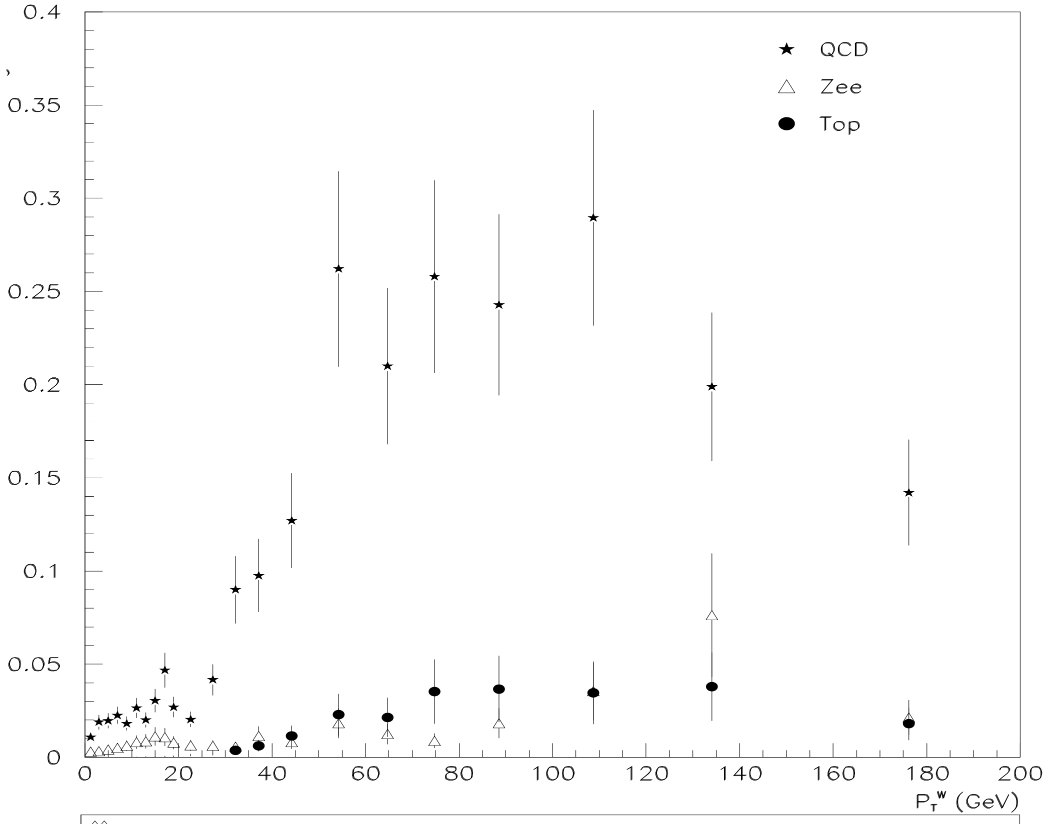
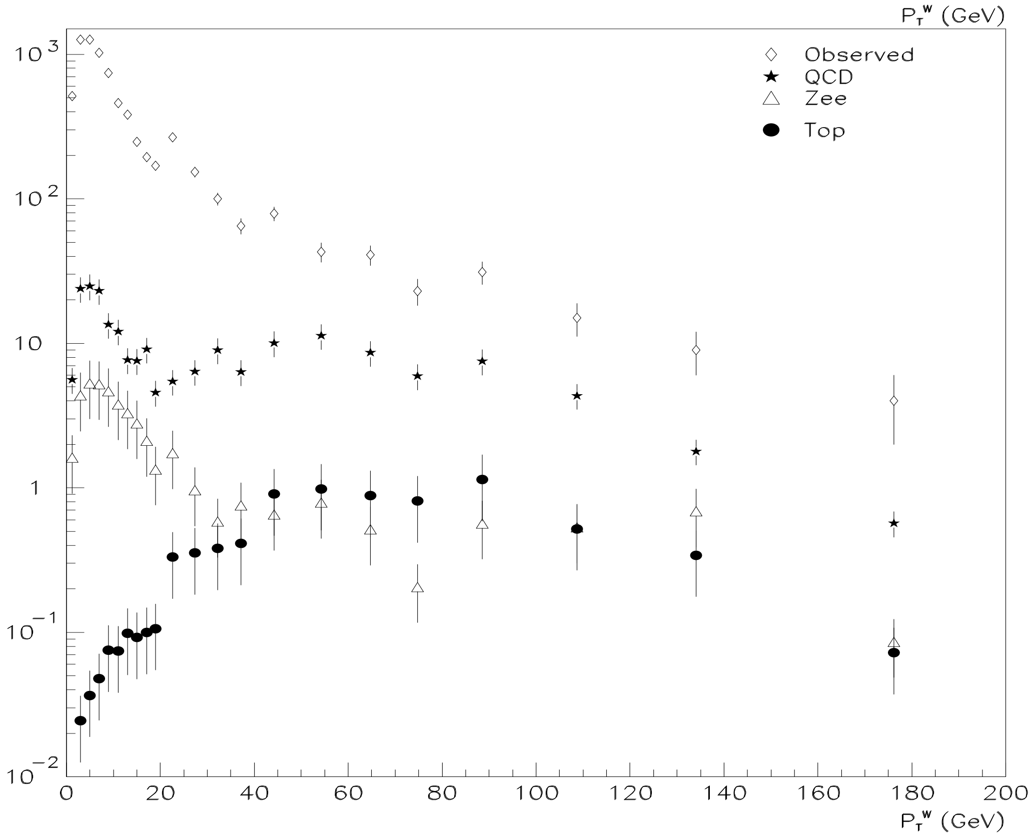
preliminary

Background Fraction



Number of Events



P_T^W

Z Backgrounds:

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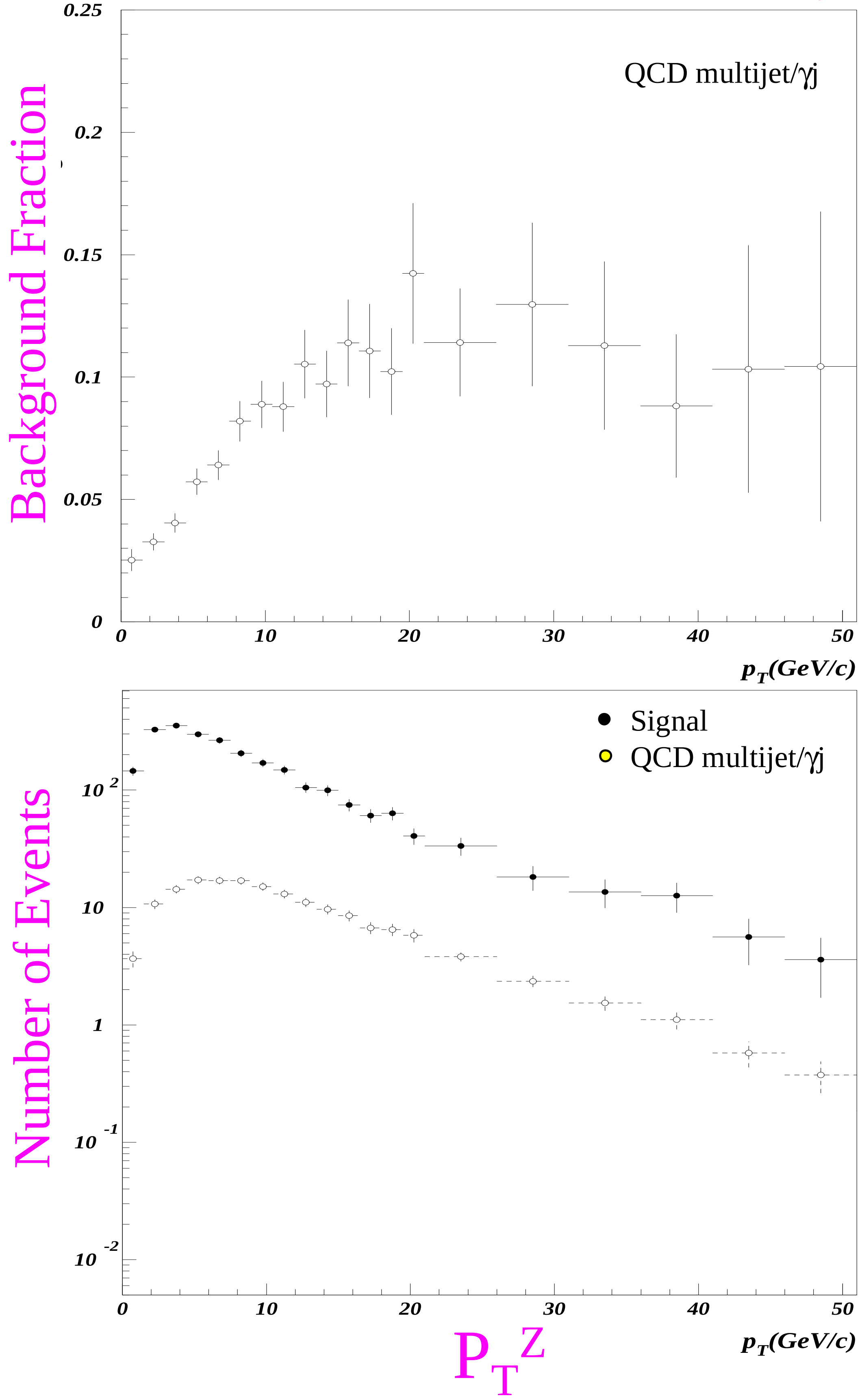

Efficiencies:

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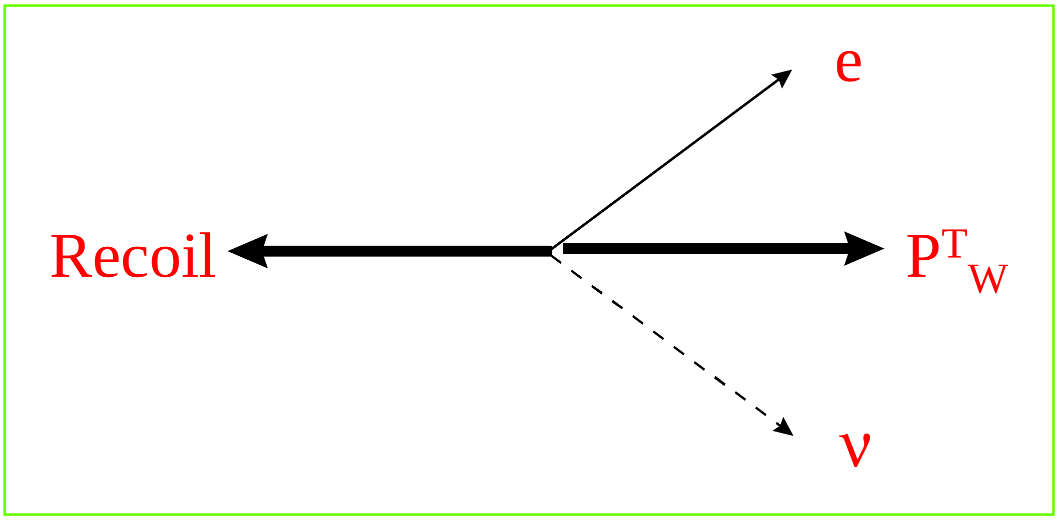
- Electron efficiency: ~ 85 - 90% (depending on cuts)
- Need efficiency vs. P_T



If jet from recoil gets "close" to electron,
electron id affected.

Efficiencies vs. P_T determined with:

- ***Z*** data sample
- HERWIG MC ⊕ Geant
- *W* data sample ⊕ Geant electron

Efficiencies:

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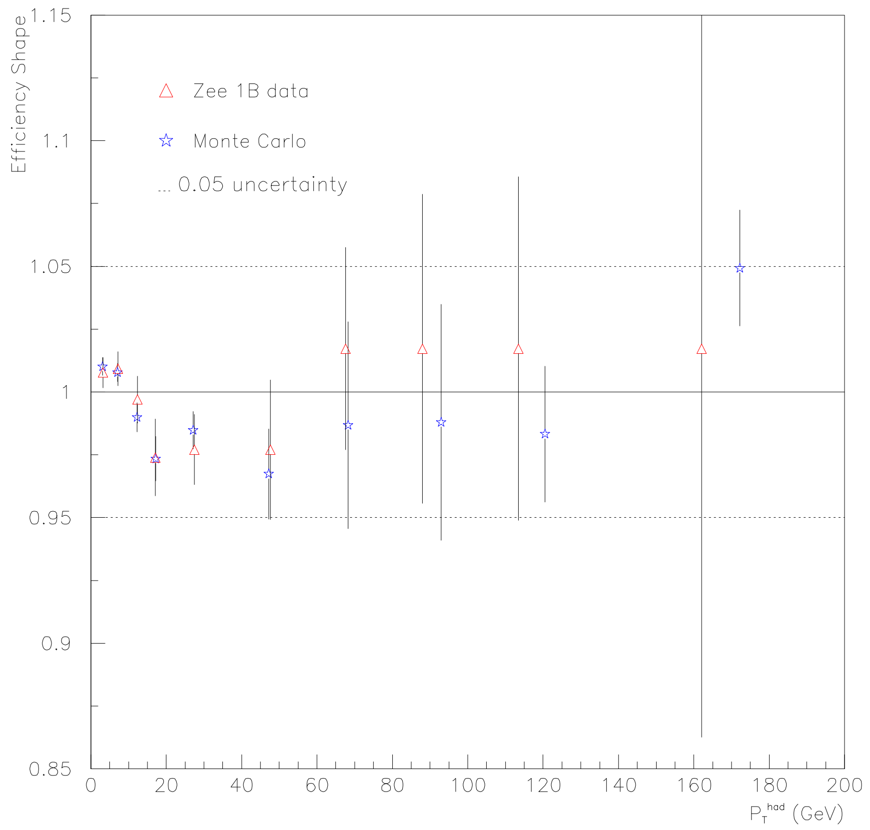
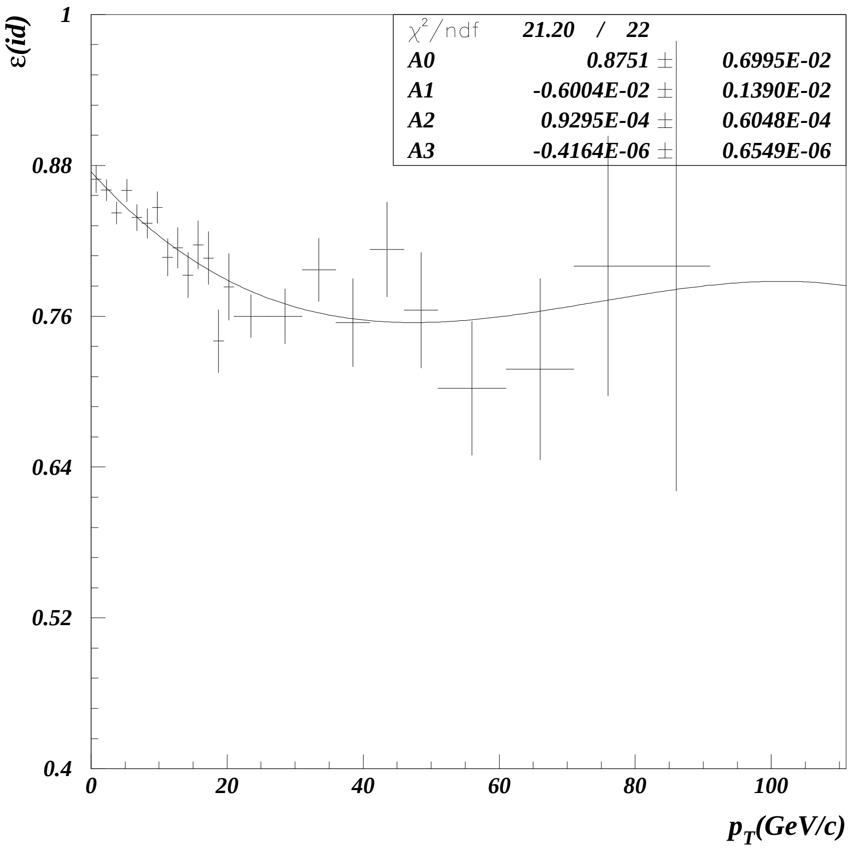
Run 1a ***W***:
Assume flat,
5% sys error



Normalized
to one

Run 1b ***Z***:
Parameterize
shape



Resolutions:

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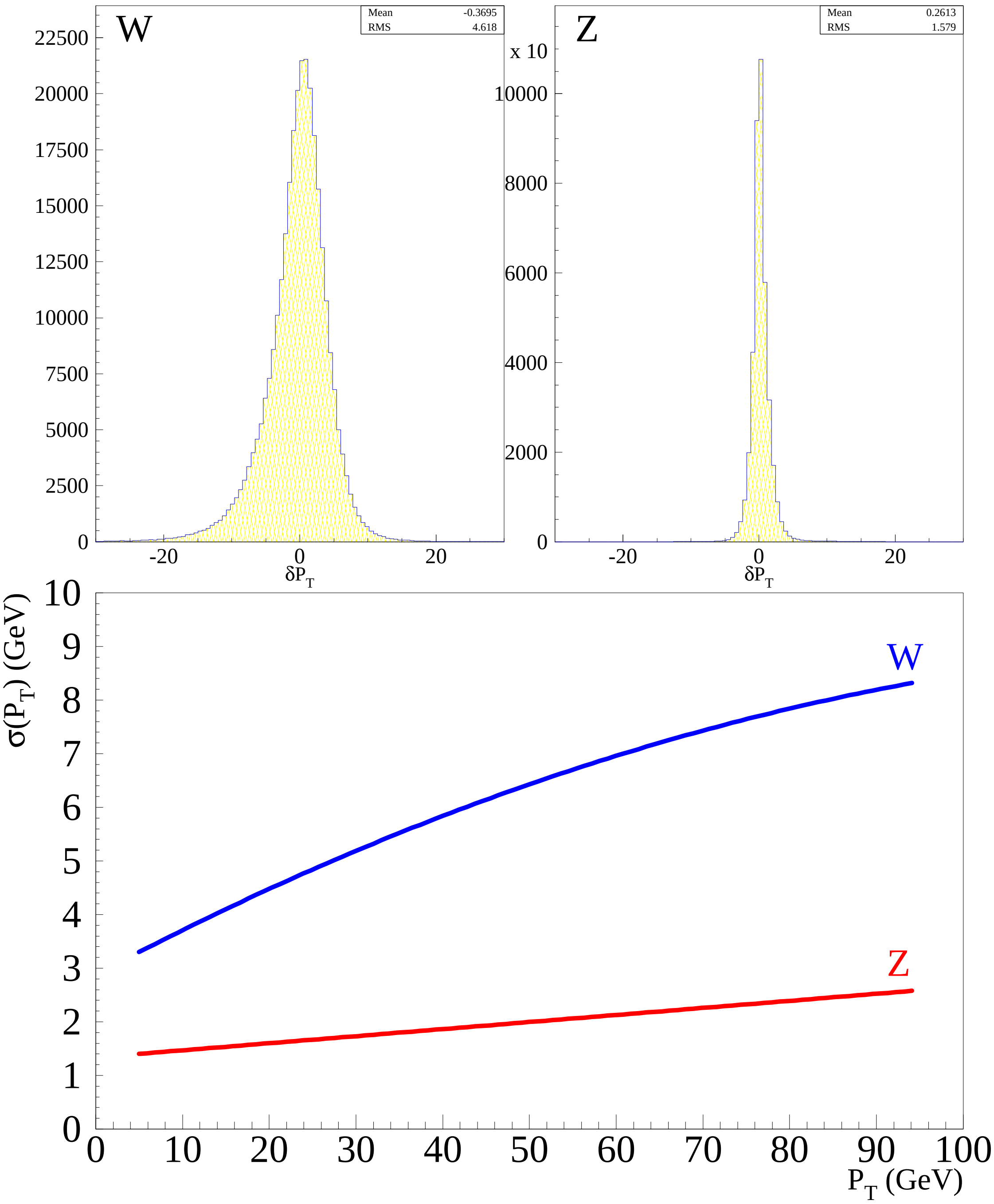
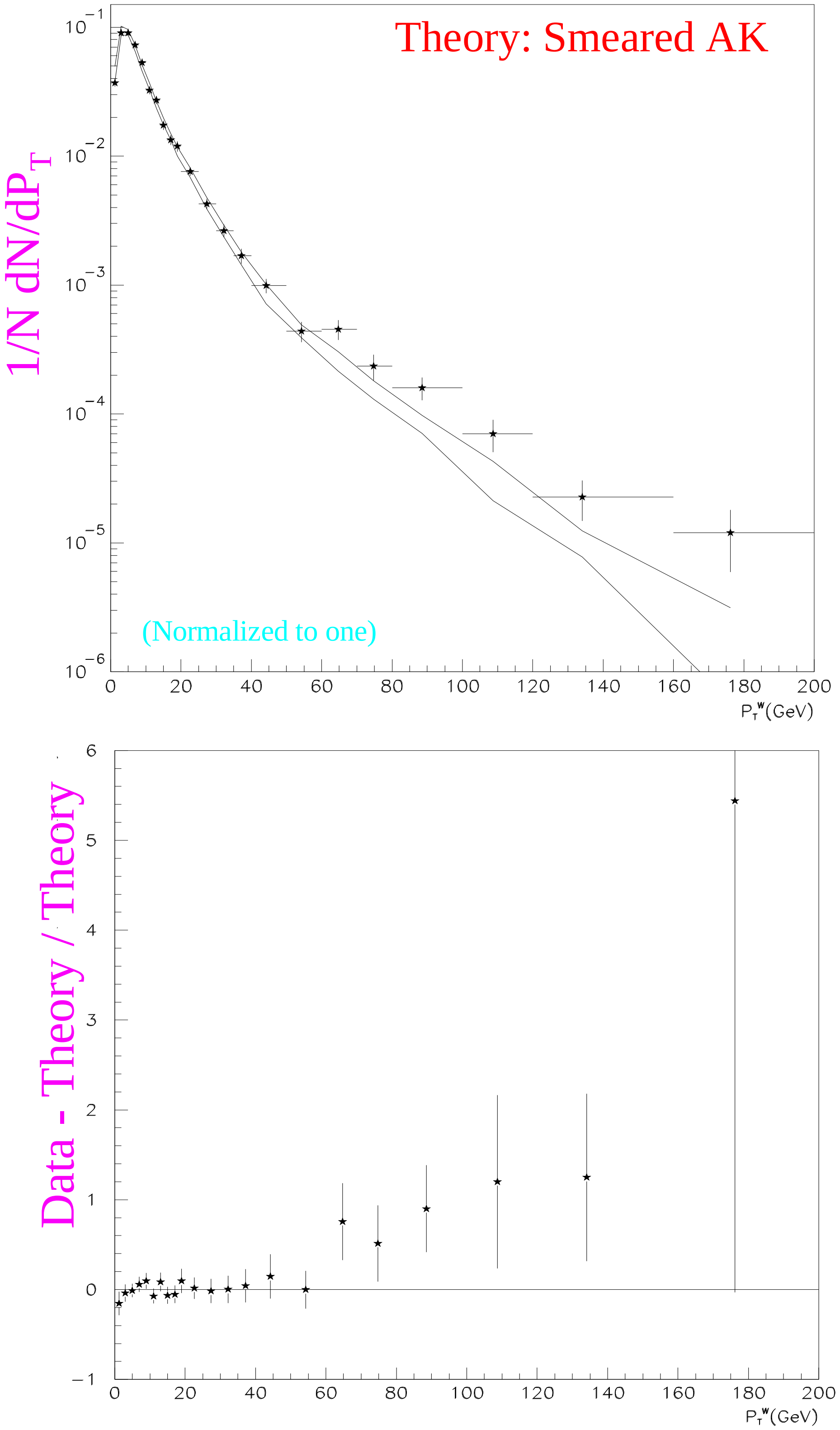
preliminary



Theory *smeared* with experimental resolution.

Results, P_T^W (Run 1a), Preliminary: **DØ**

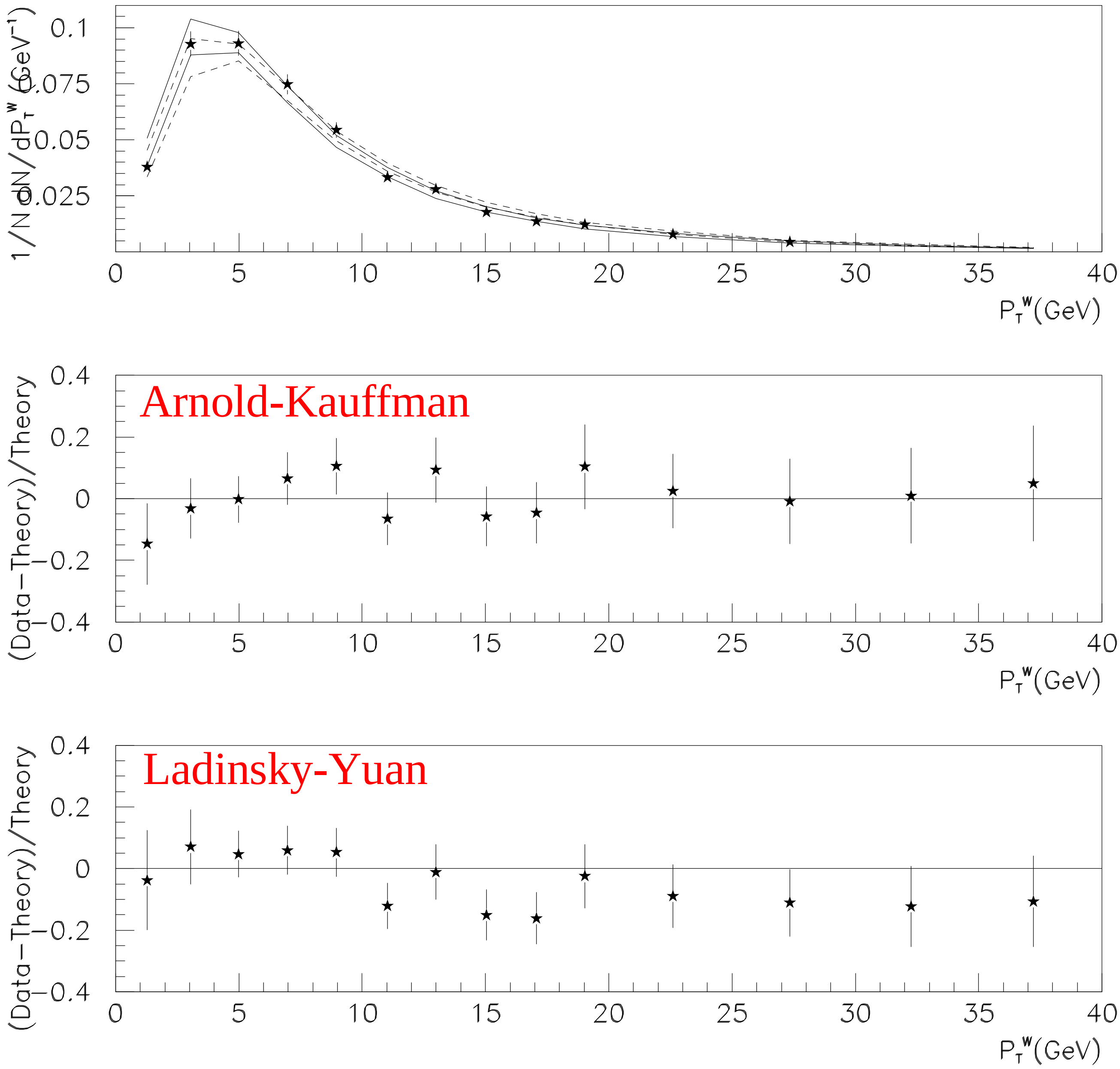
Band reflects uncertainty in hadronic scale / resolution



P_T^W

Results, P_T^W (Run 1a), Preliminary: **DØ**

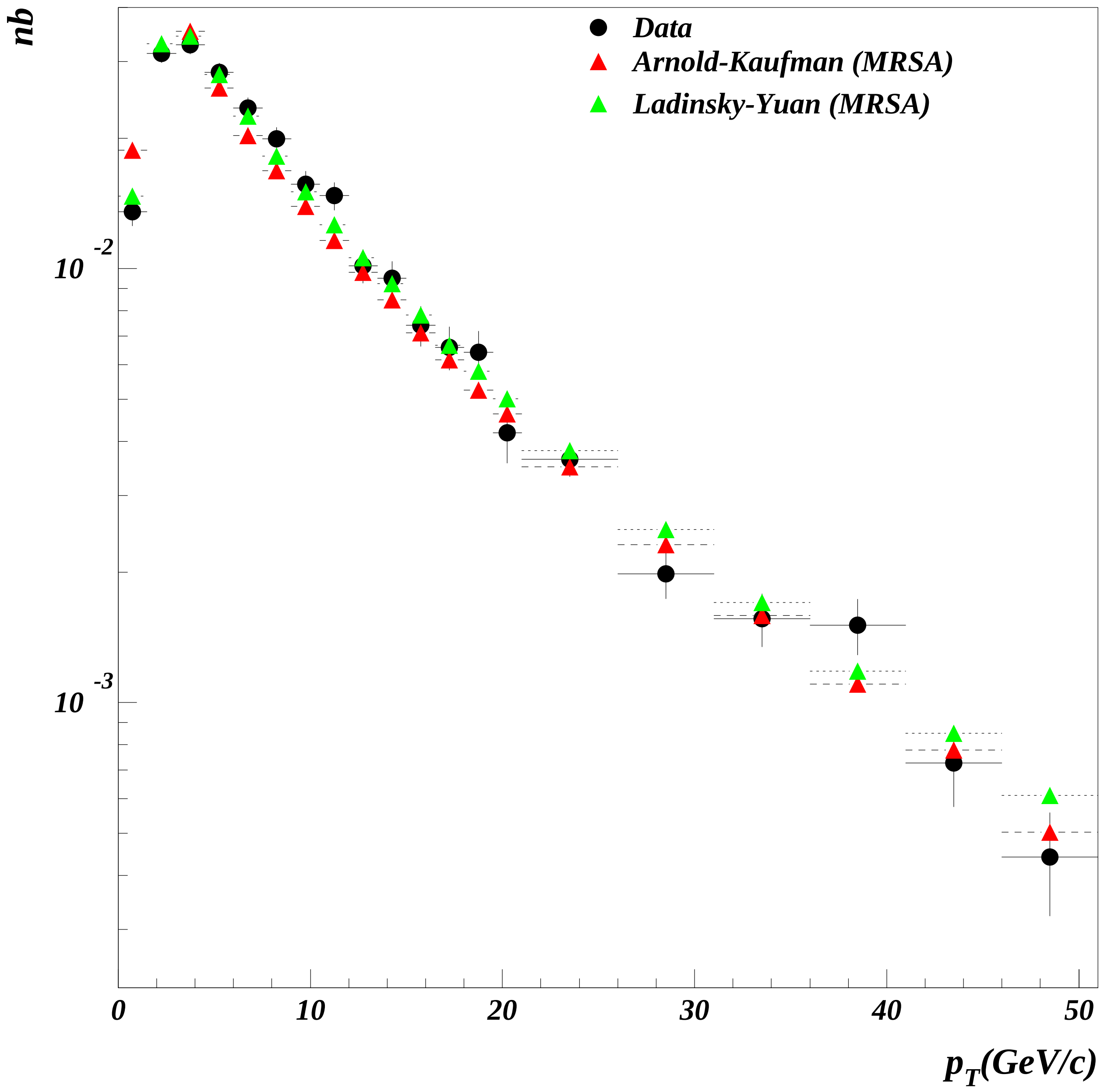
Low P_T region:



P_T^W

Results, P_T^Z (Run 1b), Preliminary: DØ

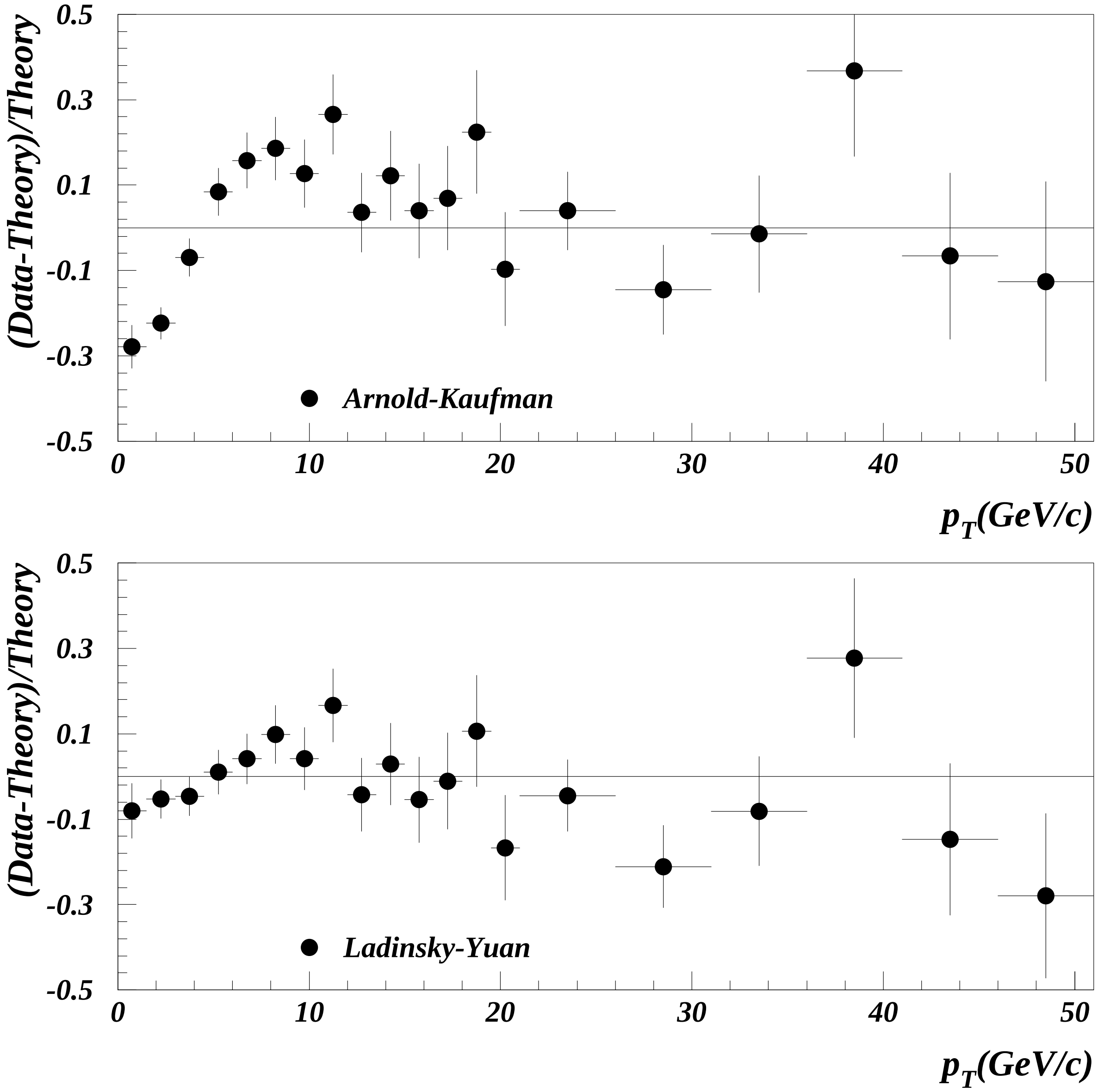
Theory *smeared* with experimental resolution.



Results, P_T^Z (Run 1b), Preliminary: **DØ**

AK: χ^2/DOF = 105.9 / 20 = 5.3

LY: χ^2/DOF = 24.4 / 20 = 1.2



Sensitivity of P_T^Z to g_2

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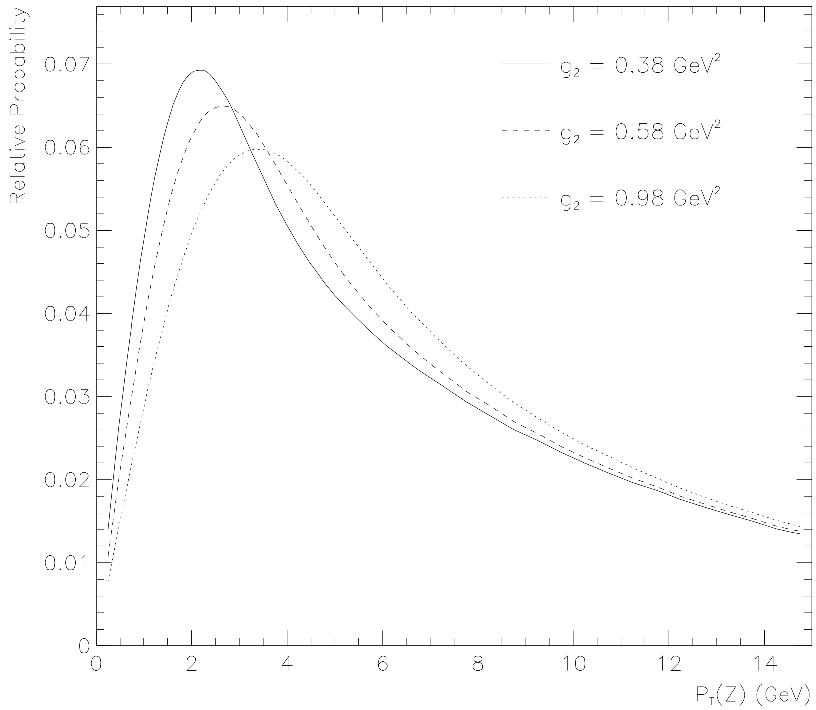
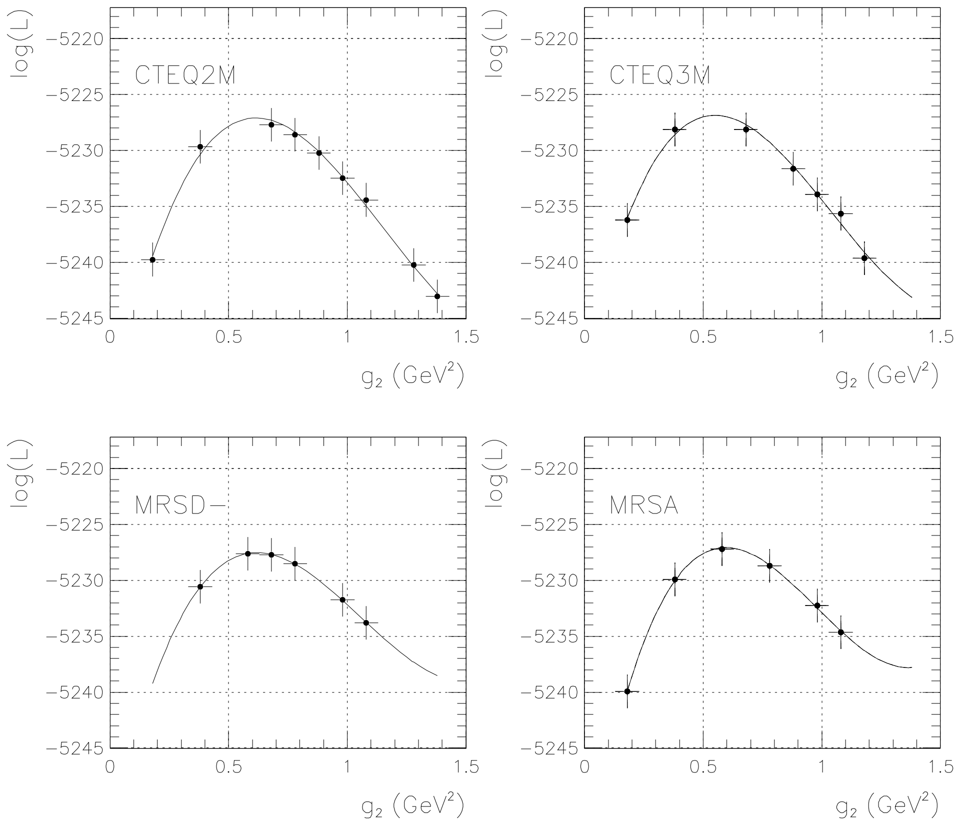


Fix g_1, g_3, Λ^{QCD}; vary g_2, fit P_T^Z < 15 GeV

Preliminary



(LY fit: $g_1 = 0.11^{+0.04}_{-0.03}$ GeV², $g_3 = -1.5^{+0.1}_{-0.1}$ GeV^{-1})

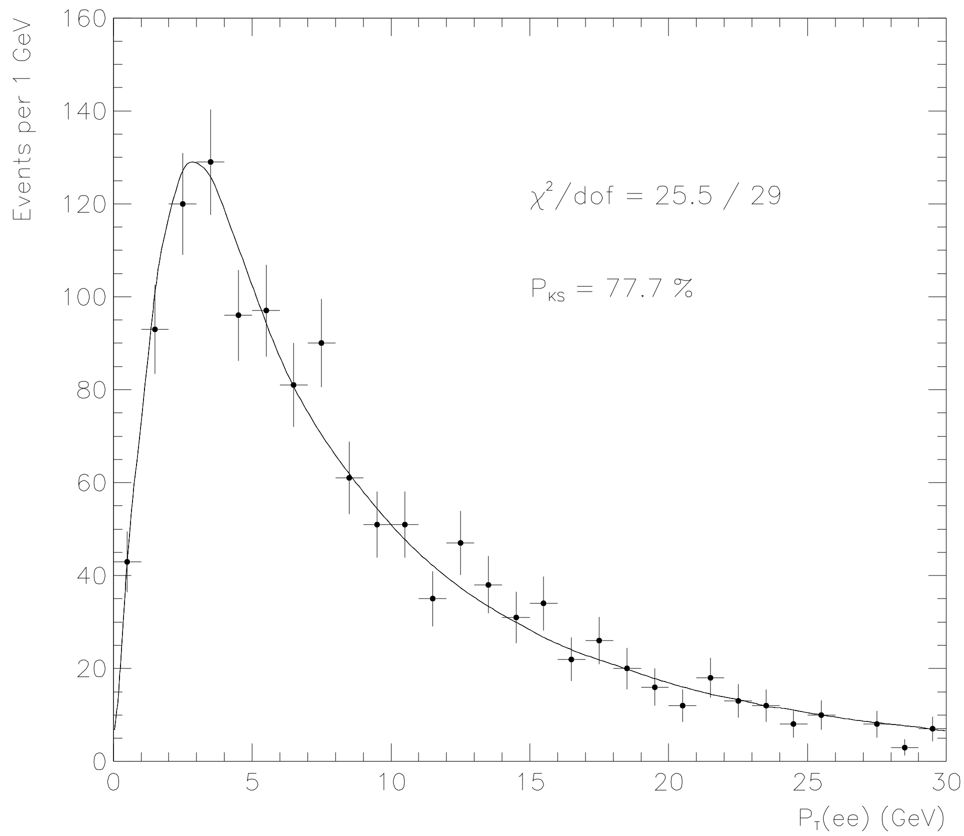
Sensitivity of P_T^Z to g_2

DØ

preliminary

Source of Error	Error (GeV^2)
Statistical	0.095
Systematic	0.052
Background normalization	< 0.017
Background shape	< 0.007
Energy scale	< 0.02
Energy resolution	0.02
u|| efficiency	< 0.02
ϕ acceptance	< 0.01
Radiative decays	< 0.03
Fitting procedure	< 0.009
PDF	0.043
TOTAL ERROR	**0.12**

This analysis: $g_2 = 0.59 \pm 0.12$ GeV^2 (*preliminary*)
Previous LY fit† to old DY+Z: $g_2 = 0.58^{+0.1}_{-0.2}$ GeV^2

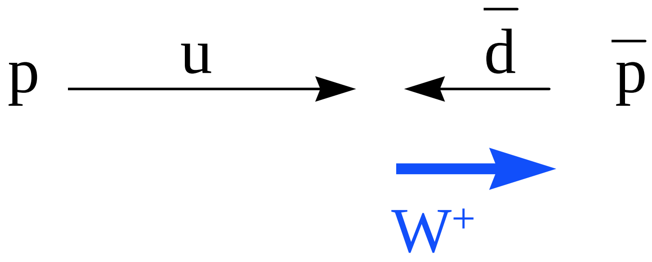


† Ladinsky & Yuan, PRD50, 4239 1994.

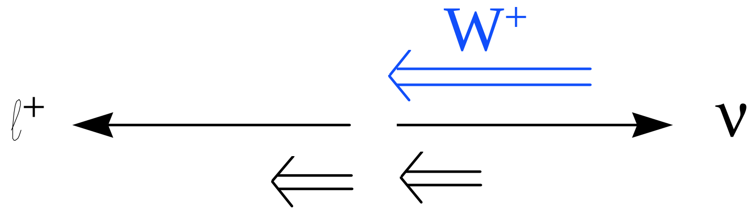
CDF

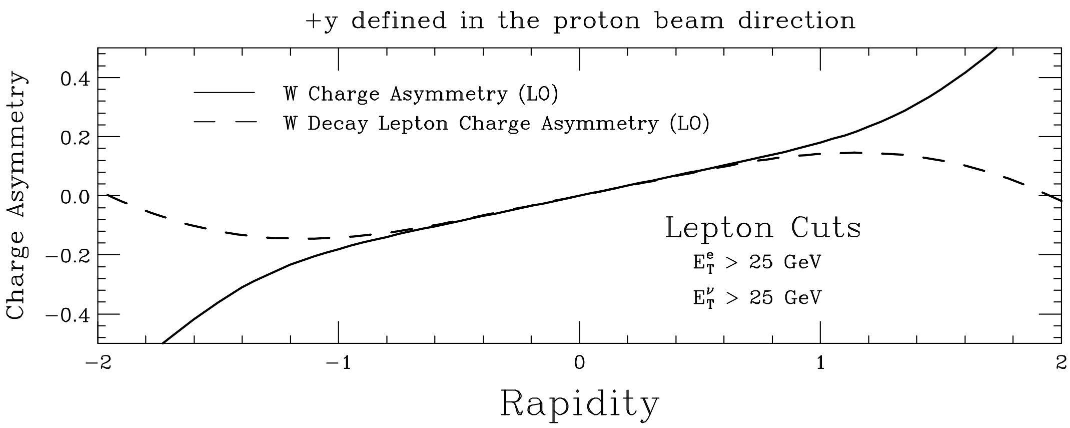
W charge asymmetry

- *W* production is asymmetric: $x_u > x_d$



- *V-A* decay introduces opposite asymmetry:



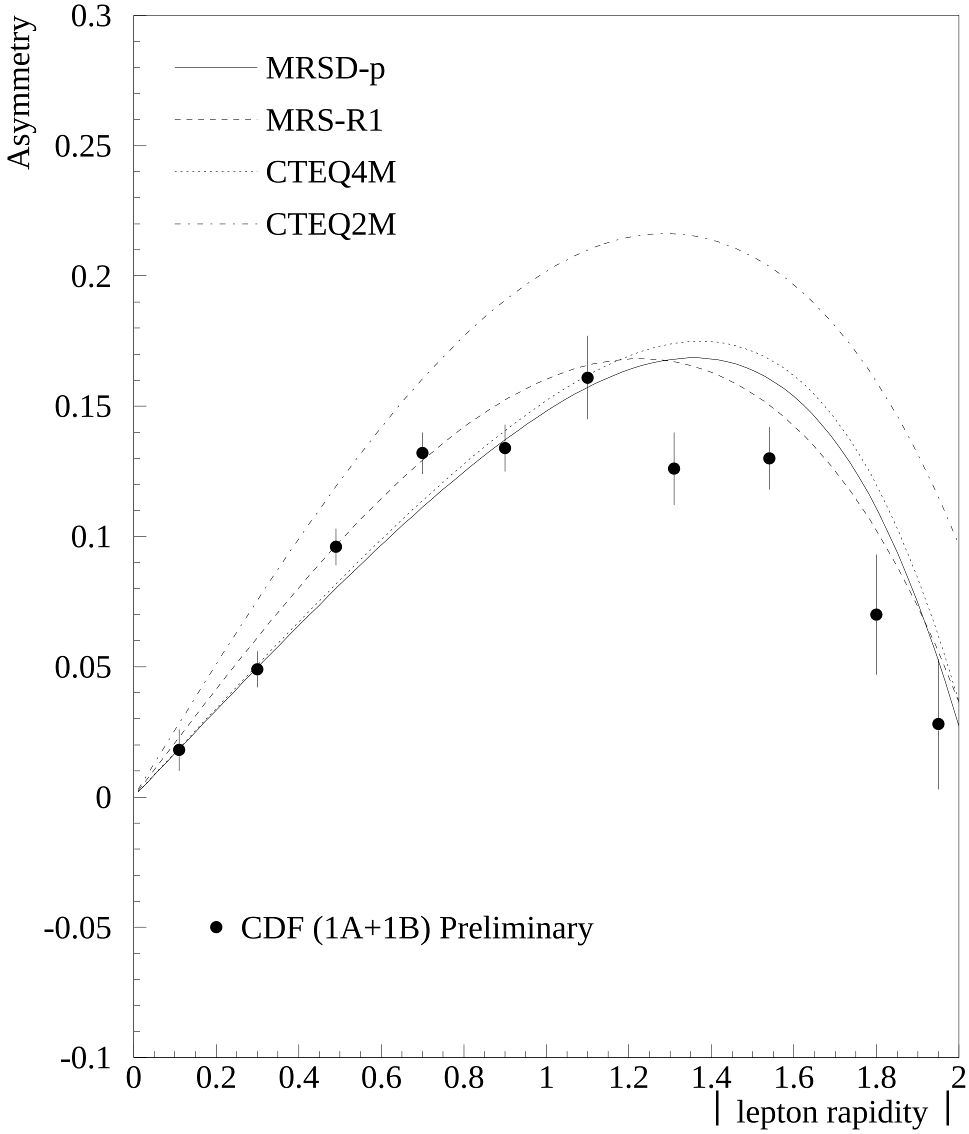


- CP conservation: $A(y) = -A(-y)$

  $\rightarrow$ Fold distribution

W Lepton Charge Asymmetry **CDF**

- CDF: Complete '92-93, '94-95 sample
- $W \rightarrow e\,\nu,\ \mu\,\nu$ (central, plug, FMU)
- Theory: DYRAD MC, Giele et al, NP **B405,** 663.



- Issues:
  - Will PDF new fits accommodate shape?
  - Resummation? (Balazs & Yuan, hep-ph/9704258)

Conclusions

- New (*preliminary*) measurements of P_T^W and P_T^Z presented.
- LY formalism describes P_T^Z well.
- New data will push phenomenology of low P_T region.
- Will be very important for measurements of ***W*** mass in Run II, when P_T^{lepton} fits become more important.

- *Shape* of CDF W Asymmetry not reproduced with current PDF's
- Will new fits match data?
- Possible resummation issues (via cuts on P_T)

- Near future: still more data to analyze from Run I, CDF and DØ

BACKUP SLIDES

DØ

Fits with different PDF's

Fix g_1, g_3, Λ^{QCD}; vary g_2 *Preliminary*

pdf choice	g_2 (GeV^2)	δg_2 (stat) (GeV^2)
MRSA	0.587	0.095
MRSD-‘	0.613	0.104
CTEQ3M	0.544	0.096
CTEQ2M	0.608	0.098