TeV4LHC Workshop

CERN, April 28–30, 2005

Top/Electroweak WG – Summary

Conveners:

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Webpage: www.hep.anl.gov/tait/tev4lhc/topew.html

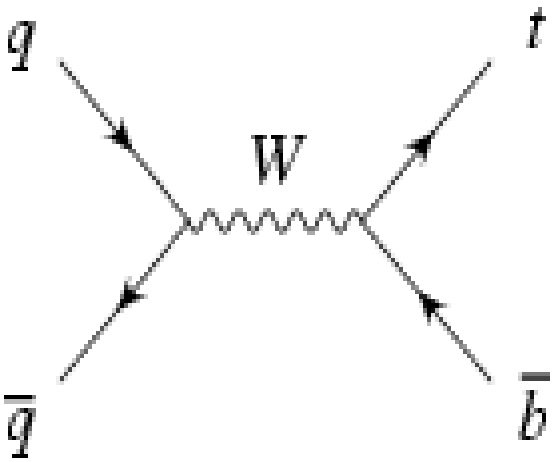
Single Top Production

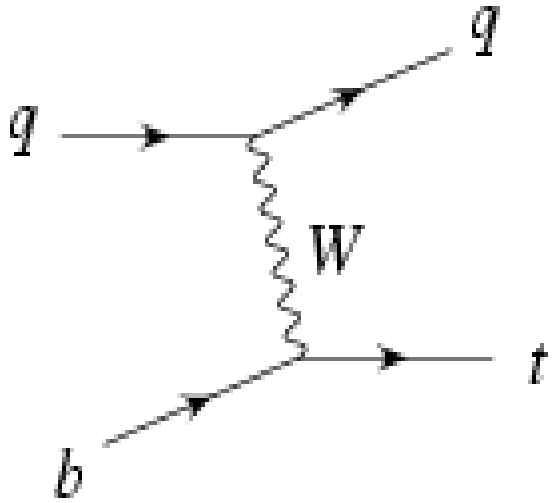
E.Boos, M.Bowen, Q.–H.Cao, K.Ellis, S.Ellis, A.Garcia-Bellido, A.Giammanco, A.Juste, A.Lucotte, R.Schwienhorst, Z.Sullivan, G.Watts, and collaborators

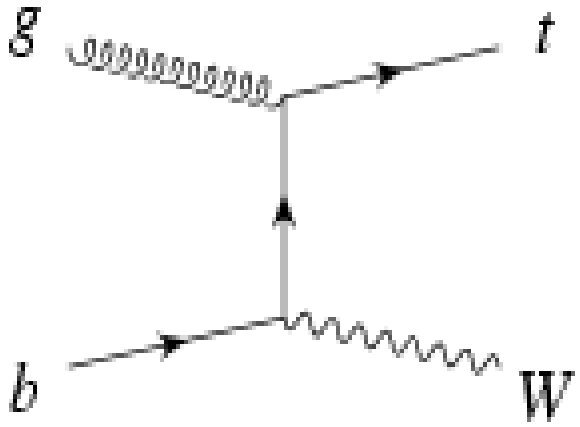
- Direct V_{tb} measurement
- Searches for/bounds on physics beyond the Standard Model
- Important background to Higgs searches
- Measurement of b quark PDF (non-standard Higgs searches)
- Good testing ground for sophisticated analysis techniques, e.g., multi-variant techniques, NN
- Will probe our understanding of important backgrounds, such as W+jets
- Tevatron: Impressive improvement in bounds on single top cross section since the last meeting ...

Top quark electroweak production

s-channel	t-channel	associated tW
TeV: 0.88±0.11 pb	1.98±0.25 pb	<0.1 pb
LHC: 10.6±1.1 pb	246.6±0.25 pb	$62.0^{+16.6}_{-3.6}$ pb







Harris, Laenen, Phaf, Sullivan, Weinzierl: hep-ph/0207055
Cao and Yuan: hep-ph/0408180

Tait: hep-ph/9909352
Belyaev, Boos: hep-ph/0003260

- Observe single top quark production in Run II ← Final Goal!
- Direct access to V_{tb} CKM matrix element
- Look for new physics: FCNC, 4th generation, W', SUSY,...
- Probe W+jets understanding and help SM higgs searches

Summary and next steps

95% CL Measured Upper Limits in pb	s-channel	t-channel
DØ Run I, 90 pb^{-1}	17	22
CDF Run II, 162 pb^{-1}	13.6	10.1
DØ Run II , 230 pb^{-1} cuts	10.6	11.3
DTs & binned likelihood	8.3	8.1
NNs & binned likelihood	**6.4**	**5.0**
NLO theory	=0.88	=1.98

Current analyses need a few fb^{-1} for observation

Upgrade to improved b-tagging
Explore multivariate methods:
Kinematic fitter, Neural Network, Matrix Element, optimized likelihoods

Optimizing current analyses
Increasing acceptance
Improving object ID
New methods under study

Increased dataset!

talk by M.Bowen

What can be done?

1. Our group's original goal: find a different method of reducing tt than jet veto
2. Found such a method, based on parity-asymmetries
3. Realized W+jets was major background
4. Technique appears to work moderately well for W+jets, but systematics are worrisome

talk by M.Bowen

η_j-η_ℓ Plot for t-channel

CP implies:

$\hat{\eta}_j$ Noted by Yuan '90, used by CDF '02

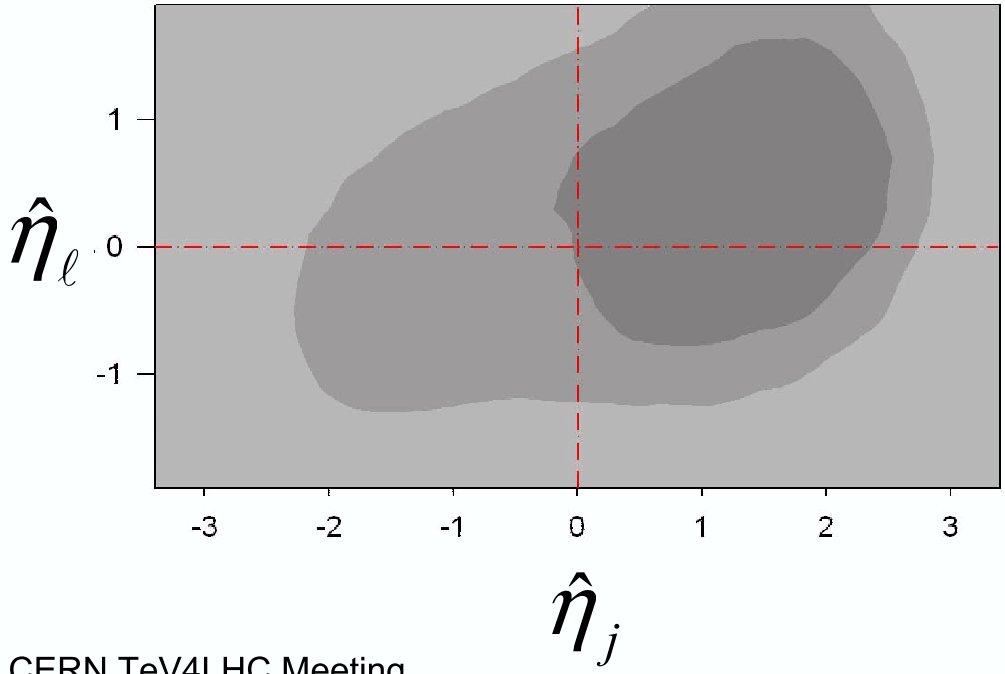
$$\frac{d^2\sigma^+}{d\eta_j d\eta_\ell}(\eta_j,\eta_\ell) = \frac{d^2\sigma^-}{d\eta_j d\eta_\ell}(-\eta_j,-\eta_\ell)$$

Define:

$$\hat{\eta}_j = Q_\ell \times \eta_j$$

$$\hat{\eta}_\ell = Q_\ell \times \eta_\ell$$

$$\frac{d^2\sigma}{d\hat{\eta}_j d\hat{\eta}_\ell}(\hat{\eta}_j,\hat{\eta}_\ell)$$



talk by M.Bowen

Tev4LHC Conclusions

- tt and QCD are “special” backgrounds – symmetric at each collider
- W+jets is THE problem for single top quark searches at both colliders
- Parity asymmetries can help the challenging search at Tevatron for single top quarks
- Charge asymmetries at the LHC make the single top quark signal readily observable in both single-tag and double-tag samples

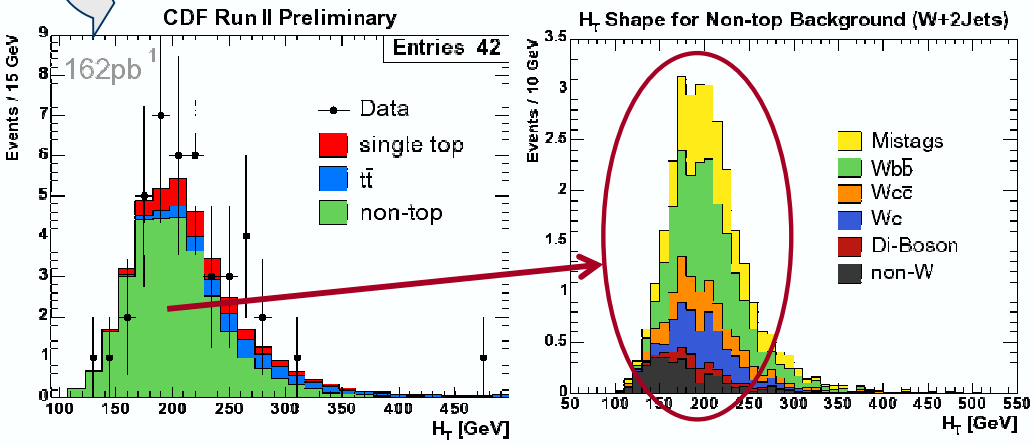
Perspectives

Single-top Measurements

- **Single-top analyses :** talk by A.Lucotte (ATLAS)
  - Performed with LO generator
    → NEED to switch to NLO (for S and B)
  - Performed with Fast Simulation
    → Need to use FullSim

TeVatron Contribution…

- **Knowledge of main backgrounds**
  Use of tt, Wbb and W+jets from the data
  → Validation of NLO (tt, single-top) generators at low √s
  → Validation of Wbb/cc & W+jets generators at low √s
  → Use of techniques NN, likelihood etc…



C.P. Yuan et al, hep-ph/0409040
hep-ph/0408180, Q. Cao, R.Schwienhorst

talk by A.Giammanco (CMS)

What can Tevatron do for LHC?

- Very similar environment: ideal to test analysis strategies and understand similar systematics (e.g. Underlying Event)
- W+jets, in particular Wbb(X), Wcc(X), Wc(X), are significant backgrounds for Top analyses at both accelerators; different MC models give different kinematics => sizeable differences in efficiency estimates. Improvement by tuning generators to Tevatron data?
- PDFs for LHC are currently extrapolated from a global fit heavily relying on HERA ep data.
- But Tevatron pp data contribute with a richer menu (e.g. constraints to gluon PDF), see next slides.
- Impression from the outside(*): Currently relatively few studies at CDF+D0 to constrain PDFs. Is it true?

(*) I.e. by watching public results:
http://www-cdf.fnal.gov/physics/physics.html
http://www-d0.fnal.gov/Run2Physics/WWW/

Projects and Goals – Single Top

- Improve communication between experimentalists and theorists, and Tevatron and LHC experimentalists.
- Make new theory tools, e.g., W+jet at NLO by J.Campbell et al. (MCFM), ZTOP, COMPHEP, available and useful to experimentalists.
- $W + t$ at NLO needed at the LHC.
- How do new ideas for the discrimination between signal and background, e.g., parity/charge asymmetries by M.Bowen et al., look at NLO and when realistic detector models are used ?
  $\rightarrow$ ATLAS and CMS will look into it.
- ATLAS and CMS analysis: full simulation and NLO event generators
- CDF/D0 will try to measure the flavor decomposition in W+jets events and compare to theory.

Precision Physics with W/Z Bosons

S.Berge, U.Baur, C.Carloni Calame, S.Dittmaier, P.Golonka, C.Hays, H.Schellman, M.Kraemer, K.Melnikov, G.Montagna, P.Nadolsky, F.Petriello, A.Vicini, W.Placzek, C.–P. Yuan, and collaborators.

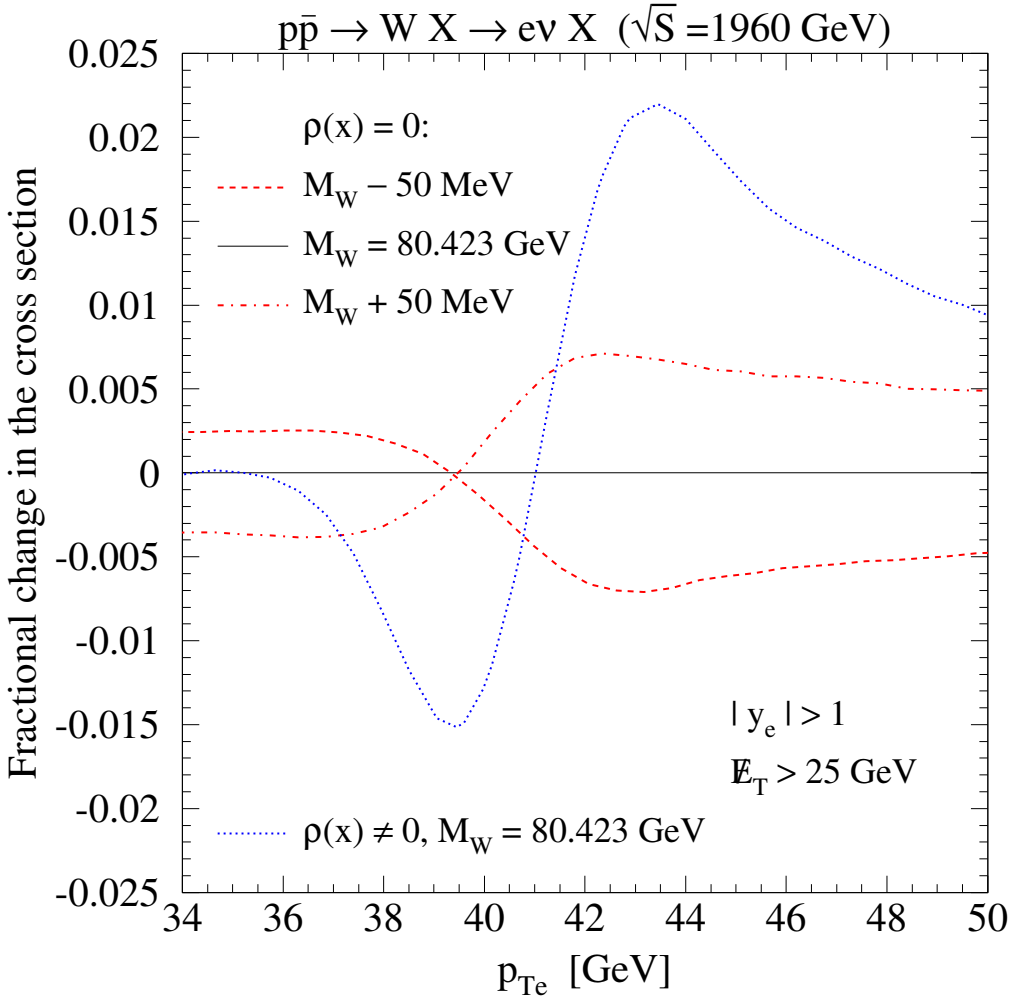
$\sigma_W, \sigma_Z, d\sigma/dM_T(l\nu), A_{FB}, \ldots$
$\Rightarrow$ $M_W, \Gamma_W, \sin^2\theta_{eff}$, detector calibration, luminosity monitor, PDFs, ...

- Advantages/disadvantages of different methods to measure the W mass: revitalization of the ratio method ?
  What can the Tevatron say about it ? $\rightarrow$ D0/CDF will look into this as soon as measurement with "traditional" method is finalized
- Using W,Z cross sections as luminosity monitors at the LHC, PDF uncertainties ?
- W charge asymmetry to constrain quark PDFs. new: CDF uses M_W constraint to measure W rapidity – may be more sensitive than lepton y measurement. Look into Z rapidity distribution to constrain PDFs.

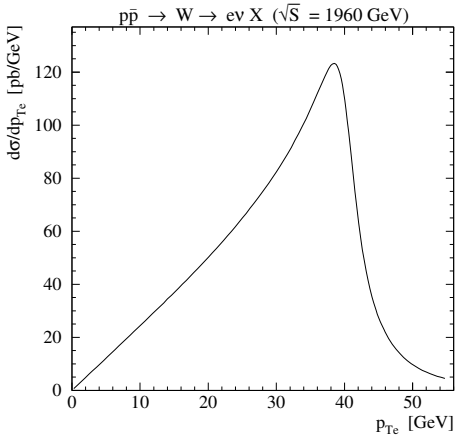
- Improved predictions for W and Z observables:
  - What precision is needed to match the experimental precision ?
  - What calculations are available, in what form (parton level MC, event generators) and what do they include ?
  - What is the remaining theoretical uncertainty ? Do we need improved predictions ?
- q_T broadening of W/Z distributions at small x: if seen at the Tevatron, we have to worry about impact on M_W measurement, especially at the LHC. (see S.Berge's talk)
  $\rightarrow$ DO will try to measure this effect.

Small x: $p\bar{p} \to W^+X \to e^+\nu_e X$ at Tevatron

talk by S.Berge



$|y_e| > 1$



Small x broadening (blue line) compared to a shift of the W boson mass of ± 50 MeV (red line).

Plotted is the ratio

$$\frac{d\sigma_X/dq_T^e}{d\sigma_{M_W}^{\rho(x)=0}/dq_T^e}$$

over the lepton transverse momentum q_T^e!

For $|y_e| < 1$, small-x effect is comparable with a 10-20 MeV mass shift.

Small x: $pp \to Z/W + X$ at LHC

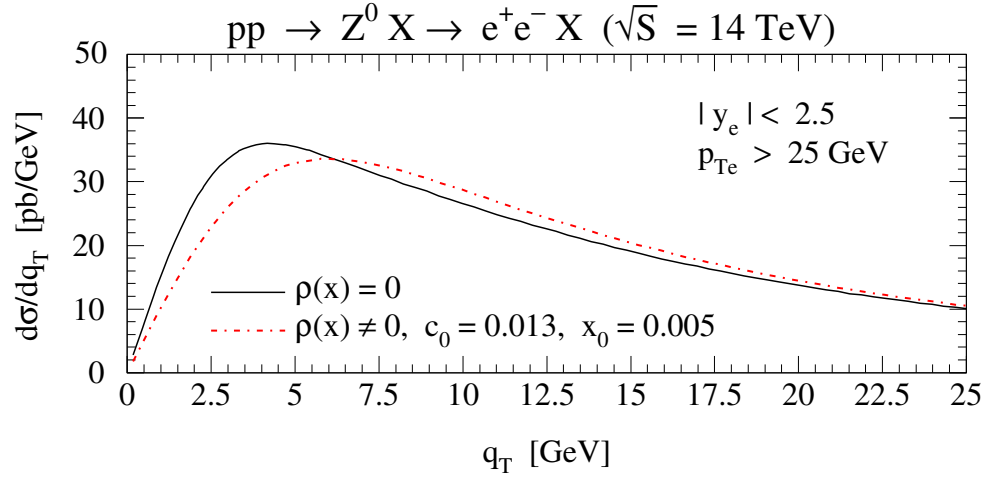
talk by S.Berge

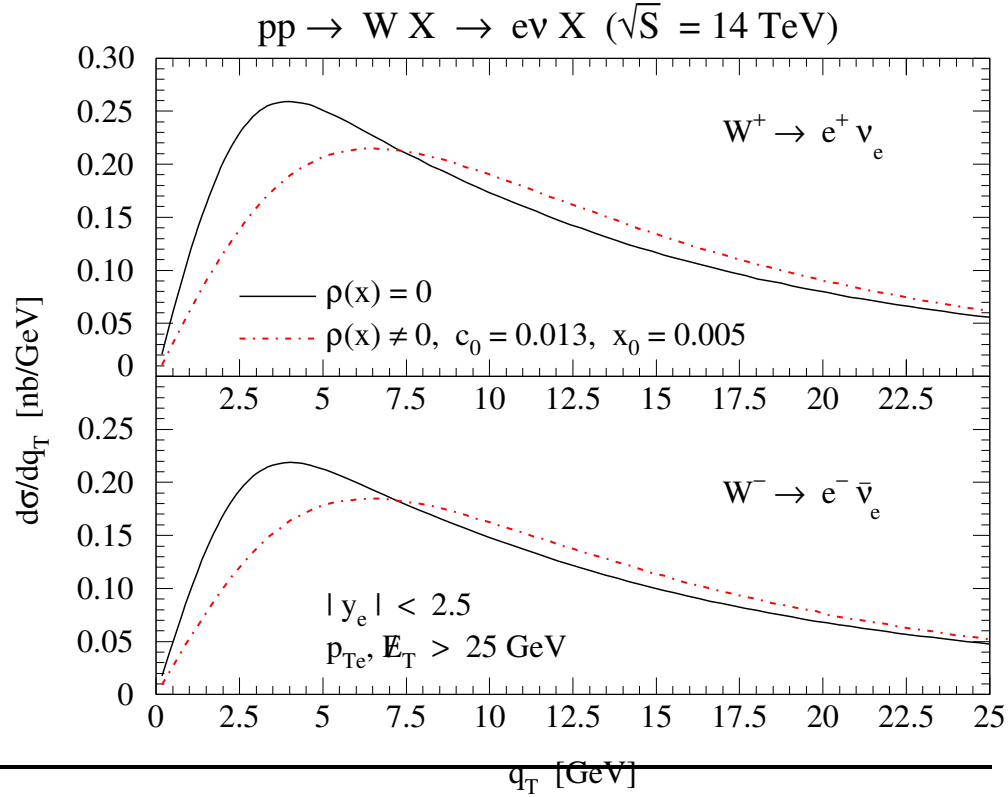
$|y_e| < 2.5$:

- x stays above 10^{-4} (SIDIS data)
- coverage of the inner ATLAS detector

Small x broadening enhanced even in the central region due to $x|_{y\approx 0} \approx 0.006$

Dependence of $d\sigma/dq_T^W$ on transverse W-boson momentum q_T^W





Toward improved predictions for W/Z observables

- QCD: $\mathcal{O}(\alpha_s^2)$ and W and Z q_T resumed implemented in MC program RESBOS (*Balazs,Nadolsky,Yuan*).

  new: improved fit for nonperturbative part to q_T distribution (*Konychev,Nadolsky*)

  new: final state QED contribution included (*Cao,Yuan*)

  new: W and Z y distributions known at NNLO QCD (*Anastasiou,Melnikov,Petriel*

  "Fully differential calculations for W,Z production may be getting within reach"

- EWK: Complete $\mathcal{O}(\alpha)$ corrections (*Dittmaier, Krämer; Baur,D.W.*) implemented in MC programs WGRAD, ZGRAD (*Baur,D.W.*).

  new: Multiple photon radiation in W and Z production implemented in MC program HORACE (*Carloni Calame,Montagna,Nicrosini,Treccani*) and WINHAC (*Jadach,Placzek*).

  new: QED corrections included in extraction of PDFs (*J.Stirling et al.* – effect on W/Z observables ?

Projects and Goals

- Unified Monte Carlo program(s) (QCD+EWK, multi-photon radiation, $\mathcal{O}(\alpha_s^2)$, $\mathcal{O}(\alpha\alpha_s)$, EWK Sudakov logs, . . .)
  $\rightarrow$ ongoing work by authors of WINHAC,RESBOS,HORACE,WGRAD/ZGRAD
  $\rightarrow$ will be also discussed at LesHouches (S.Dittmaier)

- Tuned comparison of available Monte Carlo programs (RESBOS, W/ZGRAD, HORACE, WINHAC, PYTHIA+PHOTOS, MC@NLO . . .) that provide precise predictions for W/Z observables (a la LEPI/II CERN yellow books):
  - Provide a recommendation of how to implement (dominant) electroweak corrections.
  - Provide an estimate of remaining theoretical uncertainties due to missing higher order corrections.

Summary Table for Proceedings

Observable	exp. precision			impact of h.o. corr.		
$\mathcal{L}[fb^{-1}]$	0.5	1	2	QED FSR	EWK	expon. FSR
$\sigma_{W,Z}$						
$M_W(\mu(e))$[MeV]	51	32	27	$-168 \pm 20(-65 \pm 20)$	10	10(2)
$d\sigma/dM_T$						
Will be ready by the final meeting in Oct. 2005!						
$d\sigma/dM$						
$d\sigma/dp_T$						
$d\sigma/dy$						
$d\sigma/dp_T/dy$						
A_{FB}						
W charge asymmetry						

exp. prec.: see talks by C.Hays and P.Murat at the 1.meeting at Fermilab.