# Top/Electroweak WG – Electroweak Summary

Conveners:
Cecilia Gerber (D0), Evelyn Thomson (CDF)
Tim Tait (Theory), Doreen Wackeroth (Theory)

*Electroweak Bosons rapidity distributions at hadron colliders*,
Kirill Melnikov (Univ. of Hawaii)

*Multiple Photon corrections to single W/Z production*,
Carlo Carloni Calame (Univ. of Pavia)

*Model of nonperturbative contributions in $q_T$ resummation*,
Pavel Nadolsky (ANL)

*Bottom quark PDF uncertainties in $h + b$ production*,
Chris Jackson (FSU)

## Towards improved predictions for $W/Z$ observables

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

Status (see talks by *C.Carloni Calame, K.Melnikov, P.Nadolsky*):

- 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 nonpertubative part to $q_T$ distribution (*Konychev,Nadolsky*)
  new: W and Z $y$ distributions known at NNLO QCD (*Anastasiou,Melnikov,Petriello*).
  "Fully diffential 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*). (comparison with WINHAC (*Jadach,Placzek*))

# *Electroweak bosons rapidity distributions at hadron colliders*

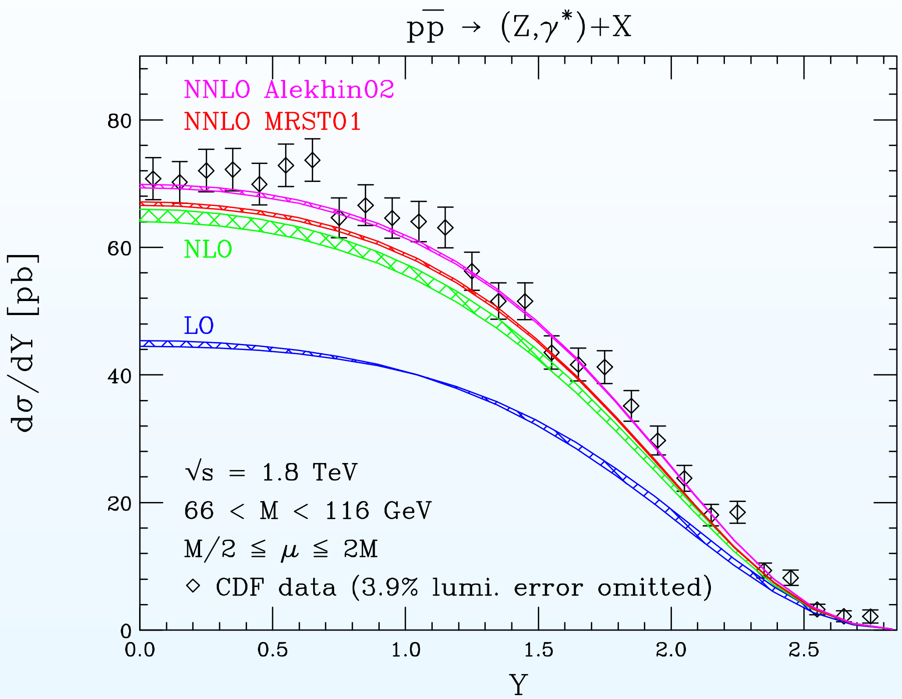
Kirill Melnikov

University of Hawaii at Manoa

with Babis Anastasiou, Lance Dixon, and Frank Petriello

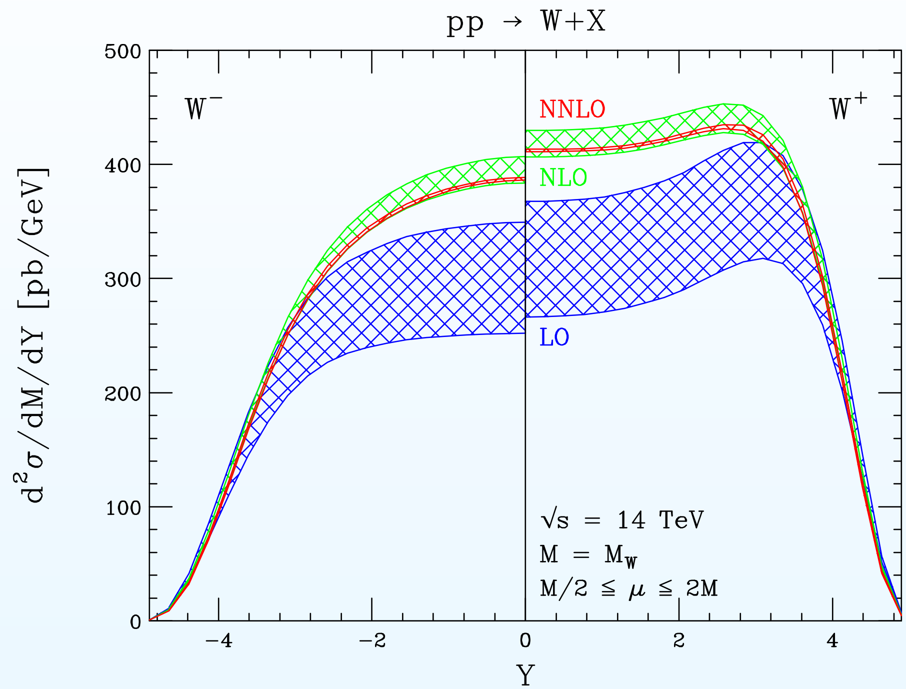
TeV4LHC, BNL, February 2005.

# $Z$ at the Tevatron




- Unnaturally small scale dependence at LO (c.f. large shift from LO to NLO).
- The width of the NNLO band is $1\%$.
- Both Alekhin and MRST are consistent with the data (given the error bars).

# $W^{\pm}$ at the LHC



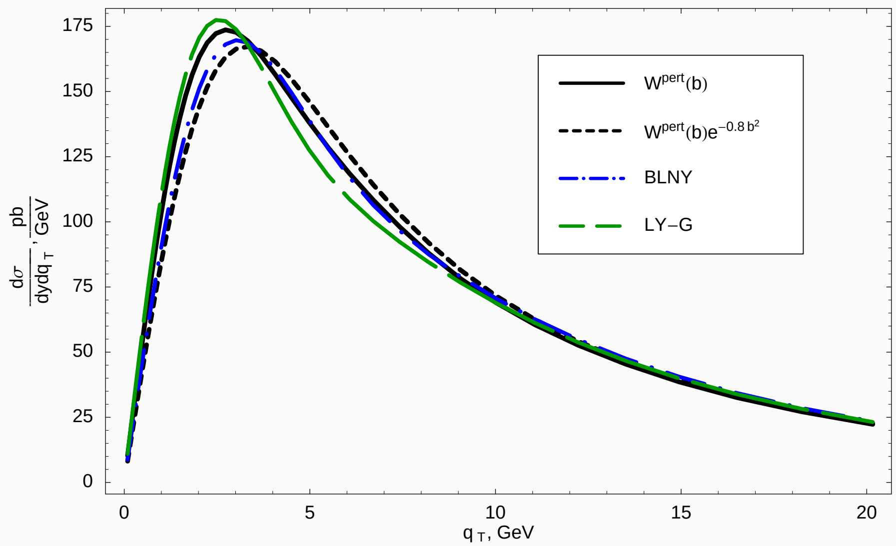

- Very good stability; no QCD uncertainty.
- Different distribution shapes for $W^{\pm}$.
- $W^{\pm}$ charge asymmetry is very stable agains higher order QCD effects and PDF uncertainties.

# Model of nonperturbative contributions in $q_T$ resummation

Anton Konychev (Indiana), Pavel Nadolsky (Argonne)

The largest theory uncertainties in the measured $M_W$ arise from

- ❐ the model of $W$ boson's recoil in the transverse plane
- ❐ parton densities




A $W$ boson acquires $q_T \neq 0$ by recoiling against perturbative or nonperturbative QCD radiation

The peak of $d\sigma/dq_T$ shifts by up to $\sim$ 500 MeV depending on the nonperturbative model (large effect compared to the targeted $\delta M_W \sim$ 30 MeV)

A global analysis of $q_T$ data from production of Drell-Yan pairs and $Z$ bosons reduces this uncertainty to $\sim$ 50 MeV $\Rightarrow$ today's talk

- Much more work is needed to investigate
  - agreement between the different experiments;
  - correlations between $S_{NP}(b, Q)$ and normalizations of low-$Q$ DY data;
  - correlations between $S_{NP}(b, Q)$ and PDF's;
  - simultaneous fit of $S_{NP}(b, Q)$ and PDF's $\Rightarrow$ tools developed within CTEQ
  - effect of the NNLO corrections
  - rapidity dependence
- CTEQ $W$ & $Z$ working group systematically explores these topics

Carlo Michel Carloni Calame *INFN, Sezione di Pavia, and DFNT, Pavia University*

# Multiple photon corrections (and √*little* more) to single $W$ and $Z$ production

TeV4LHC Workshop
BNL, February 3-5 2005

# $W$ & $Z$ mass shifts estimate

$\longrightarrow$ the $\chi^2$ fit shows (with “our” simplified detector!)

| Particle | Smearing | Lepton ID | $\Delta M_Z^{\alpha}$(MeV) | $\Delta M_Z^{\mathrm{h.o.}}$(MeV) | $\Delta M_W^{\alpha}$(MeV) | $\Delta M_W^{\mathrm{h.o.}}$(MeV) |
|---|---|---|---|---|---|---|
| $e$ | ✗ | ✗ | 595 | $-135$ | | |
| $\mu$ | ✗ | ✗ | 270 | $-31$ | | |
| $e$ | ✗ | ✓ | 75 | $-5$ | | |
| $\mu$ | ✗ | ✓ | 215 | $-28$ | | |
| $e$ | ✓ | ✗ | 780 | $-159$ | 400 | $-40$ |
| $\mu$ | ✓ | ✗ | 565 | $-49$ | 220 | $-10$ |
| $e$ | ✓ | ✓ | 105 | $-6$ | 20 | $-2$ |
| $\mu$ | ✓ | ✓ | 420 | $-44$ | 110 | $-10$ |

- ⋆ detailed simulation performed for the TeVatron. For the LHC, the results are similar
- ⋆ higher orders reduce the $\mathcal{O}(\alpha)$ effect
- ⋆ $|\text{higher orders}| \sim 10\% \times \mathcal{O}(\alpha)$
- ⋆ the shifts significantly depend on the detector details... ;-)

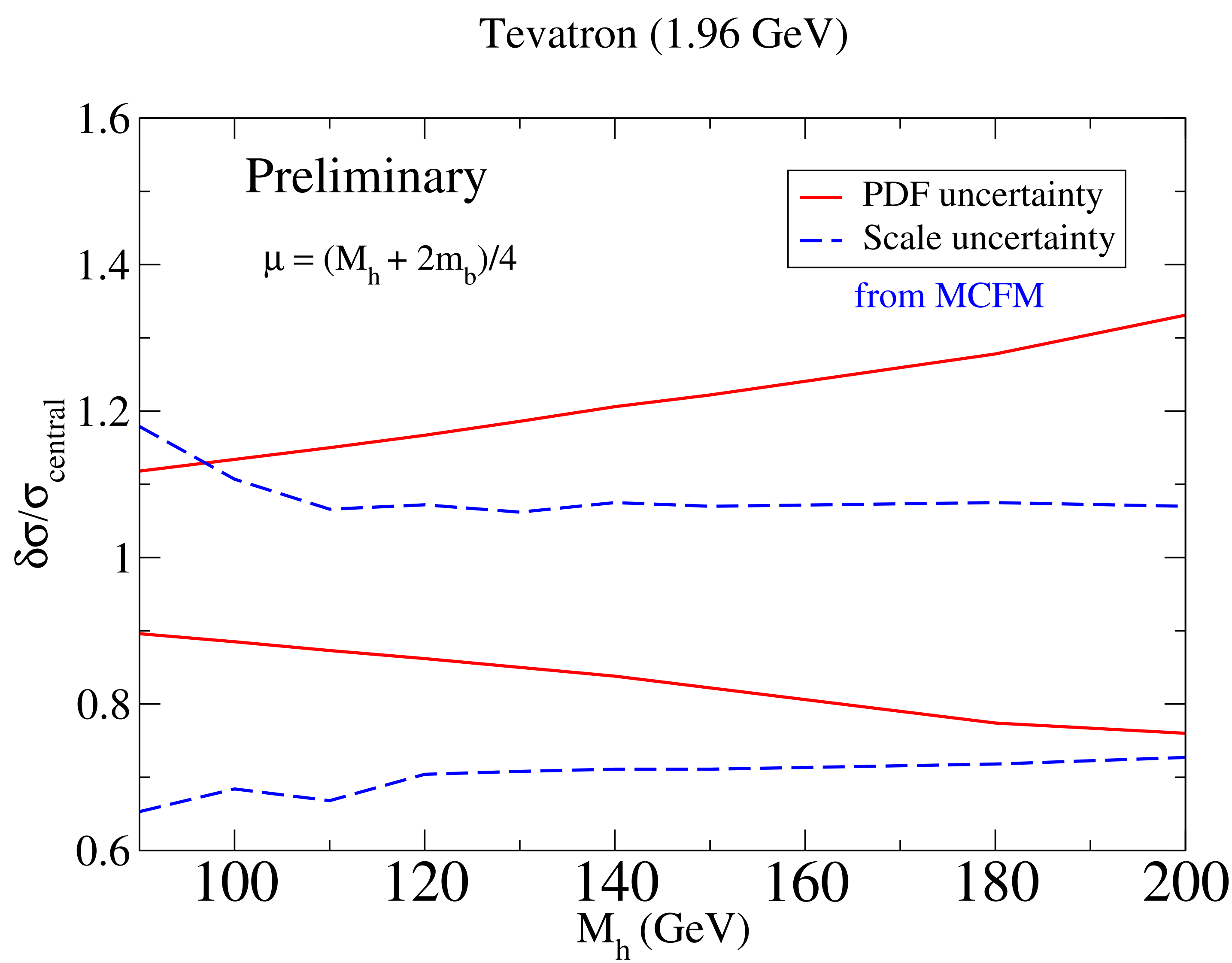
# Bottom Quark PDF Uncertainties and $h + b$ Production

Chris Jackson (Florida State University)

TeV4LHC, February 2005

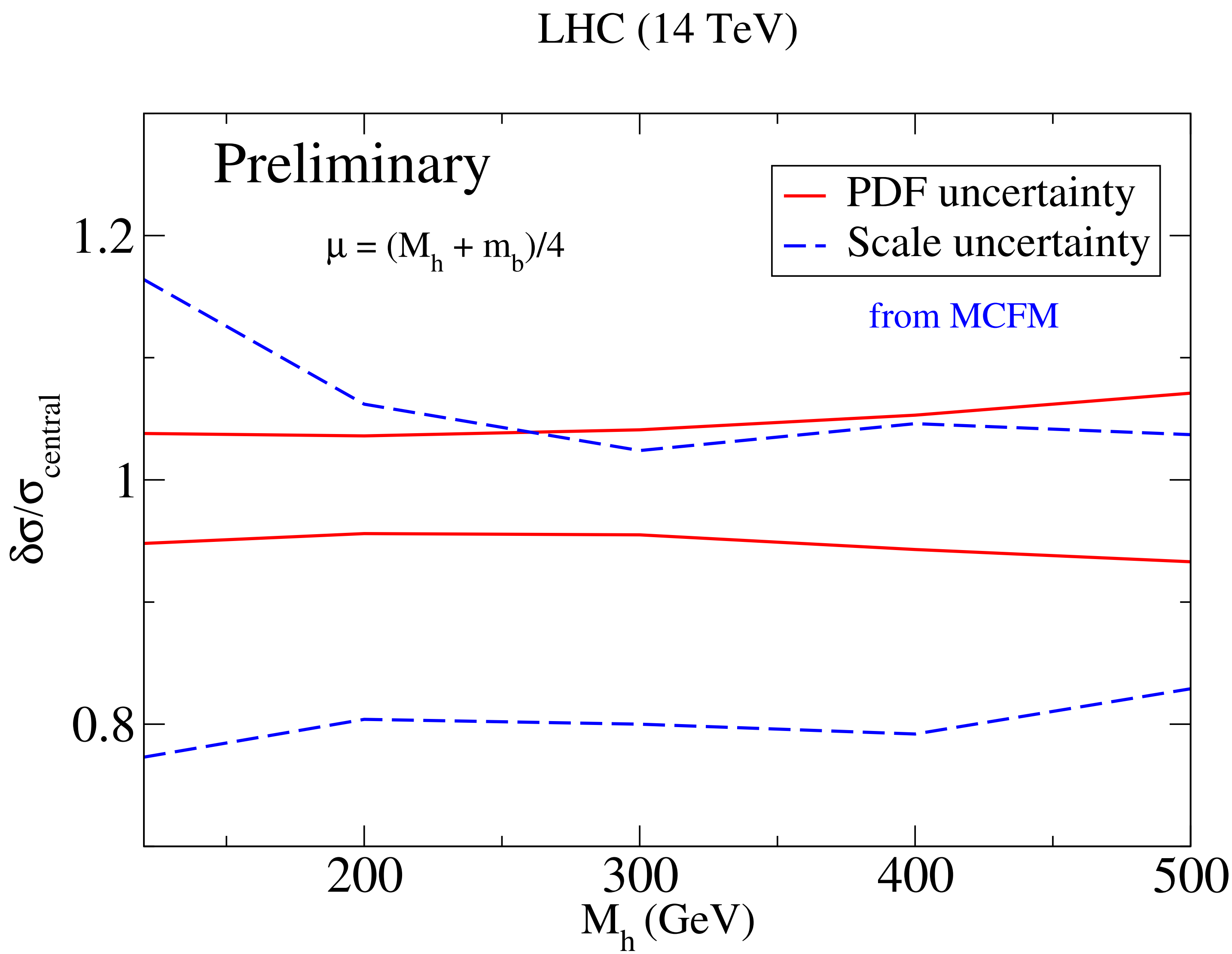
with S. Dawson (BNL), L. Reina (FSU), and D. Wackeroth (SUNY-Buffalo)

# PDF Uncertainties for $gb \to bh$ at the Tevatron (cont.)




- For larger $M_h$, PDF uncertainties $\geq$ uncertainties from scale dependence

# PDF Uncertainties for $gb \to bh$ at the LHC (cont.)



## Discussion (electroweak)

*Participants:* U.Baur, C.Carloni Calame, K.Melnikov, G.Montagna, P.Murat, P.Nadolsky, L.H.Orr, F.Petriello, A.Vicini

### Towards improved predictions for $W/Z$ observables . . .

- Towards unified generator(s) (QCD+EWK, multi-photon radiation, $\mathcal{O}(\alpha_s^2)$, $\mathcal{O}(\alpha\alpha_s)$, EWK Sudakov logs, . . .).
- Tuned comparison of Monte Carlo programs (RESBOS, W/ZGRAD, HORACE, WINHAC, MC@NLO, PYTHIA+PHOTOS . . . ) 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.

## Discussion (electroweak) *cont.*

*Participants:* U.Baur, C.Carloni Calame, K.Melnikov, G.Montagna, P.Murat, P.Nadolsky, L.H.Orr, F.Petriello, A.Vicini

| Observable | exp. precision | | | | impact of h.o. | | |
|---|---|---|---|---|---|---|---|
| $\mathcal{L}[fb^{-1}]$ | 0.2 | 0.5 | 1 | 2 | FSR | EWK | expon. FSR |
| $\sigma_{W,Z}$ | | | | | | | |
| $M_W(\mu(e))$[MeV] | | 51 | 32 | 27 | $-168 \pm 20(-65 \pm 20)$ | 10 | 10(2) |
| $d\sigma/dM_T$ | | | | | | | |
| $d\sigma/dM$ | | | | | | | |
| $d\sigma/dp_T$ | | | | | | | |
| $d\sigma/dy$ | | | | | | | |
| $d\sigma/dp_T/dy$ | | | | | | | |
| $A_{FB}$ | | | | | | | |
| $W$ charge asymmetry | | | | | | | |
| $\ldots$ | | | | | | | |

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