Status of W Mass RunIIb Analysis

Patrice Lebrun
(For the D0 W Mass Group)

30/05/2011
D0-France Meeting, LPNHE

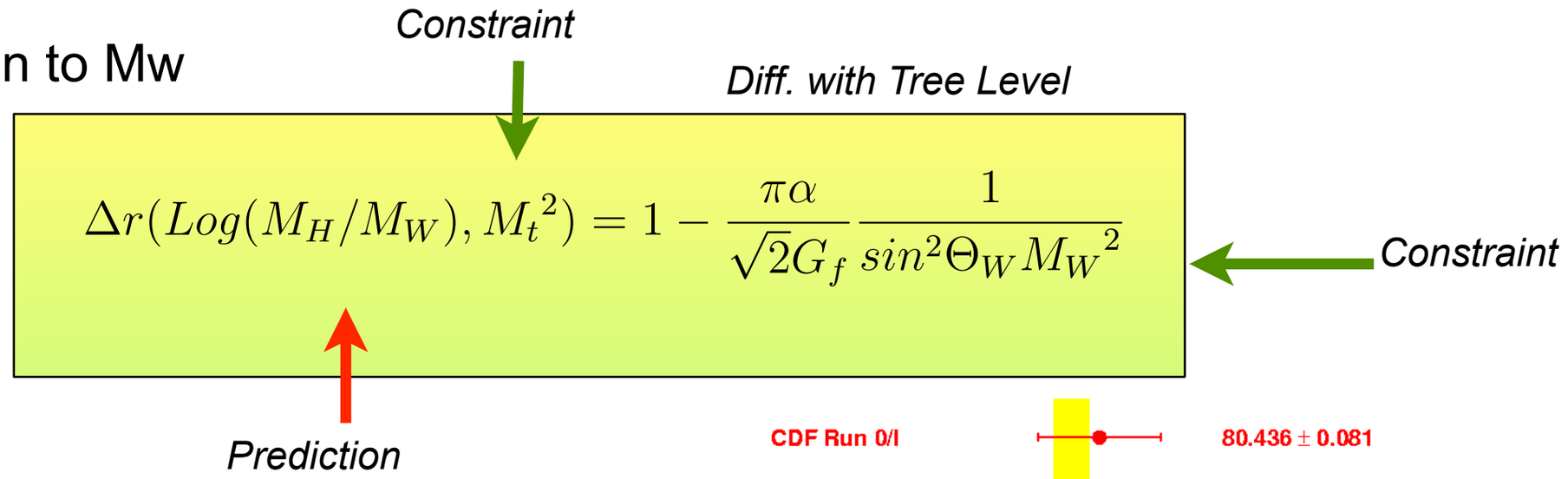
Groups and People Involved

- Near its critical Size or maybe «top heavy»
  - USA
    - Stony Brook University
      - Bob McCarthy - Prof -
      - Daniel Boline - post-doc, started Feb 2010-
      - John Hobbs - Prof , Wmass convener -
      - Rafael Lopes de Sa - grad student, started Oct. 2009 -
    - University of Mississippi
      - Alex Melnitchouck - post-doc, EWK convener -
  - France
    - LPSC Grenoble
      - Hengne Li - post-doc (atlas, d0) started 2010, Wmass convener -
      - Jan Stark - CNRS -
    - LAL
      - Pierre Petroff - CNRS -
    - IPNL Lyon
      - Patrice Lebrun - CNRS -
      - Tibor Kurca - IR info -

- No more active in W mass Group
  - Northwestern University
    - Heidi Schellman - Prof-
    - Sahal Yacoob - gone when his PhD done (runIIb data) -

W Mass measurement and Higgs Mass Prediction

- Radiative Correction to Mw



  - For equal constraint on the Higgs mass uncertainty : $\Delta Mw \approx 0.006\ \Delta M_t$
  - The limiting factor on M_H prediction is ΔMw not ΔM_t

July 2010 World average : ΔM_t = 1.06 GeV
equivalent to : ΔMw = 6.4 MeV

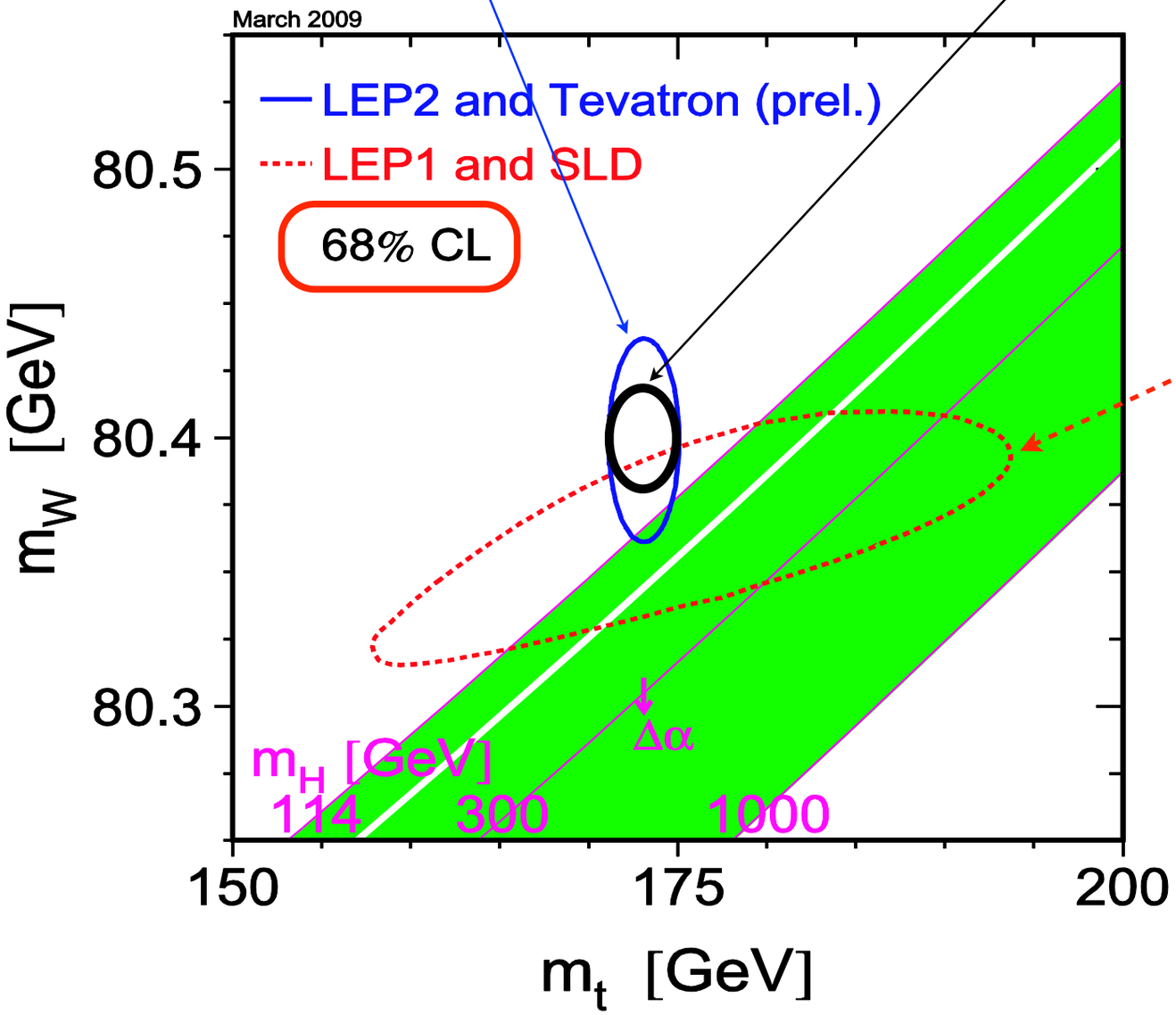
currently we have ΔMw = 23 MeV

- Direct search of Higgs bosons and compatibility with radiative correction is a powerful test of the standard Model. The accuracy on M_W is crucial.
LHC will be not able to improve it for a long time.

SM Consistency

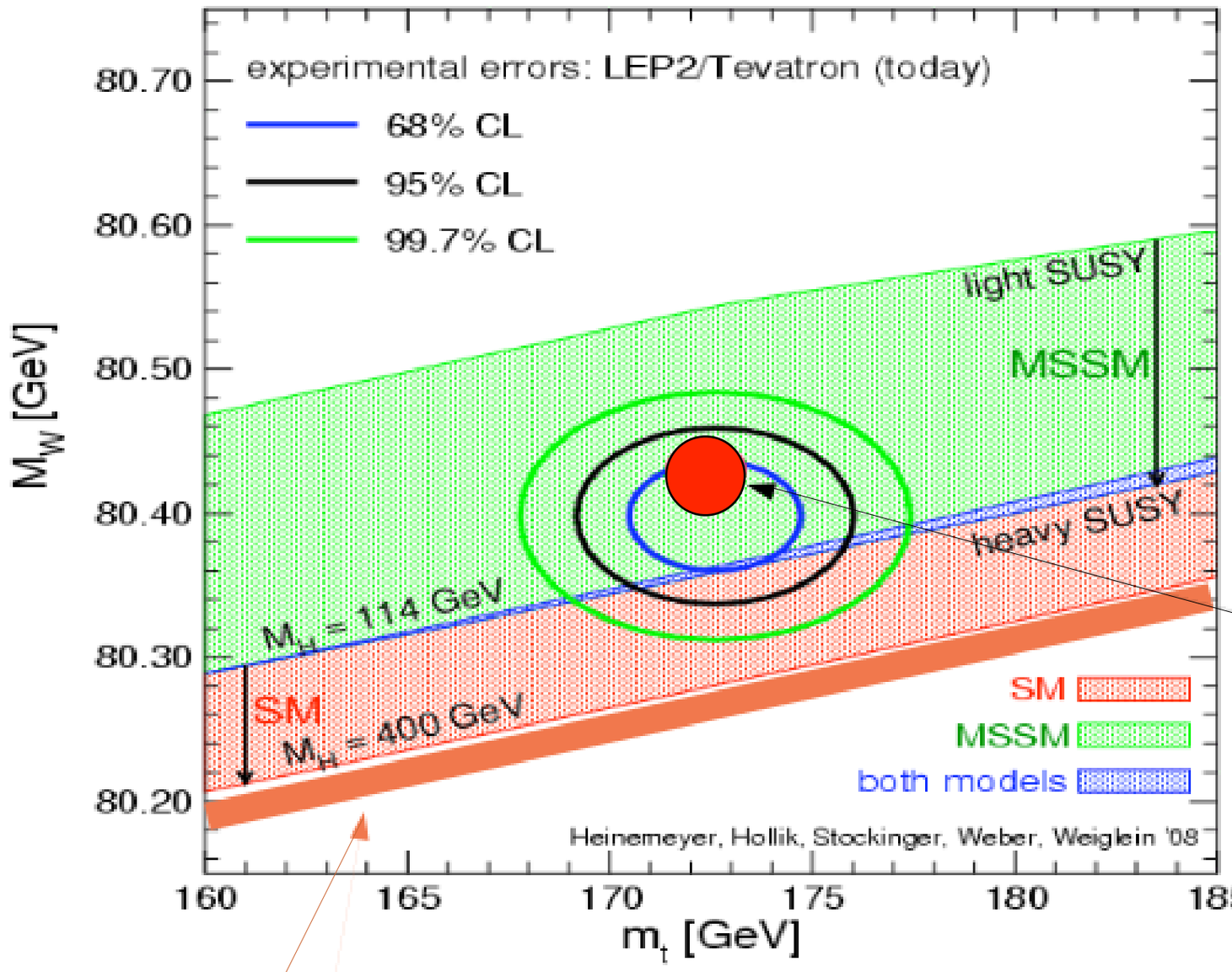
Light Higgs Boson Mass preferred

Extrapolation to 15 MeV
(Same central value on Mw)



With the Z-Pole study at LEP1, SM have predicted the Top Mass very successfully

A Possible Scenario for next few years

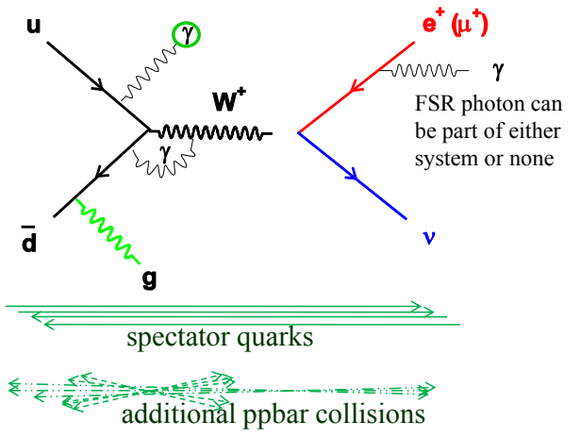


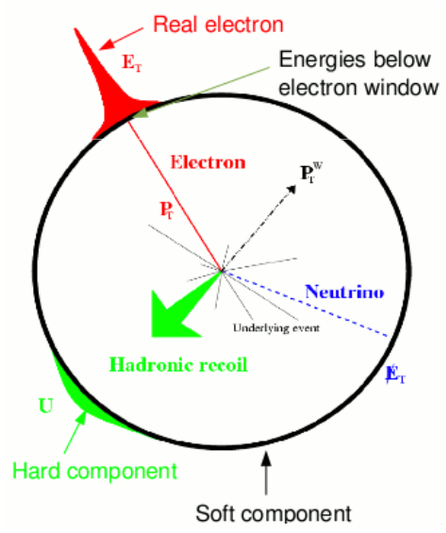
ΔM_W = 15 MeV
ΔM_{top} = 0.5 GeV

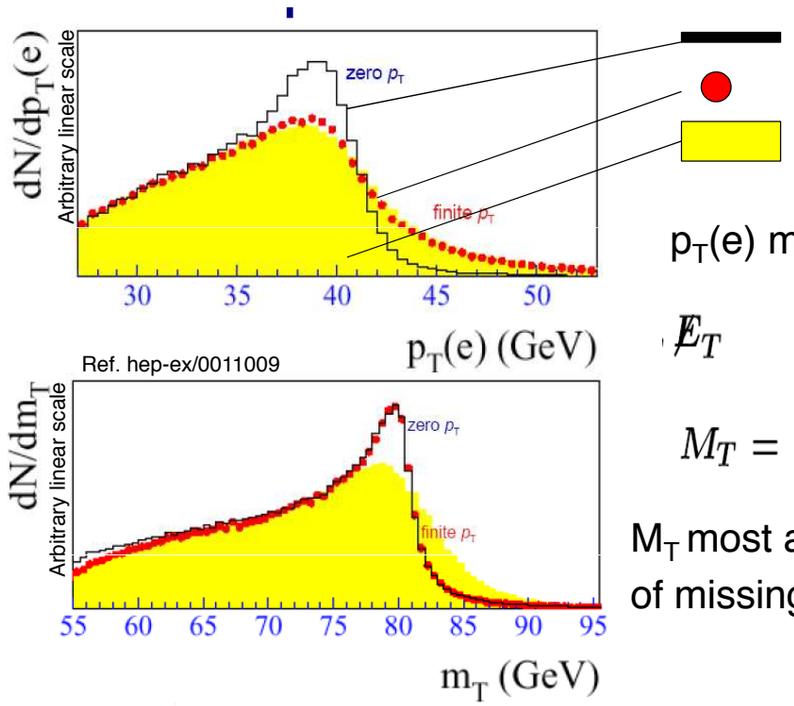
Higgs discovery with a large Higgs mass

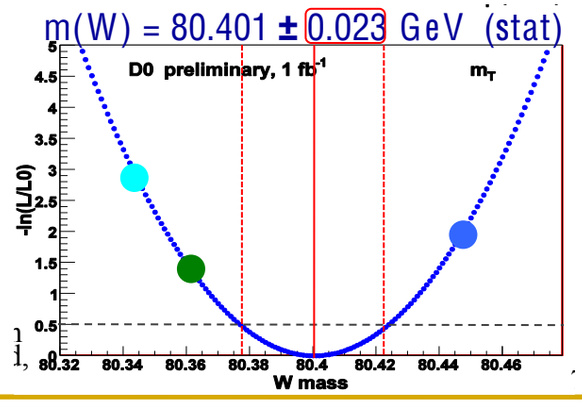
Experimental observables : P_T, Missing E_T, M_T

- MC Simulation to predict the distribution of these observables for a given mass hypothesis (all MC are produced by Lyon at CC).
  - RESBOS + Photos/WGRAD for W/Z production
  - Parameterized detector model (fast MC)
    - Zee used for tuning









No $P_T(W)$
$P_T(W)$ included
Detector Effects added

$p_T(e)$ most affected by $p_T(W)$

$$\not\!\!E_T$$

$$M_T = \sqrt{2E_T^l \not\!\!E_T (1 - \cos\Delta\phi)}$$

M_T most affected by measurement of missing transverse momentum

Current Uncertainties ($1fb^{-1}$) and Projections

With 1 fb^{-1} uncertainties are mainly statistical (including 'systematics' from limited data control samples). Let's extrapolate:

source of uncertainties	1 fb-1	6 fb-1	10 fb-1
Statistics	23	10	8
Systematics			
Electron energy scale	34	14	11
Electron resolution	2	2	2
Electron energy offset	4	3	2
Electron energy loss	4	3	2
Recoil model	6	3	2
Electron efficiencies	5	3	3
Backgrounds	2	2	2
Total Exp. systematics	35	16	13
Theory			
PDF	9	6	4
QED (ISR-FSR)	7	4	3
Boson Pt	2	2	2
Total Theory	12	8	5
Total syst+theory	37	18	14
(if theory unchanged)		20	17
Grand total	44	21	16 (20)

At end of Run II, expect total uncertainty on W mass of 16 MeV from DØ alone.

Expect similar performance from CDF, and combined error of 12 MeV.

This legacy measurement will be in the textbooks for decades to come.

Could be an important contribution to getting the standard model into trouble in the near future:

with $\delta m_W = 15$ MeV, $\delta m_t = 1$ GeV and $m_W = 80.400$ GeV :

$$m_H = 71^{+24}_{-19}\ \text{GeV} \quad < 117\ \text{GeV}\ @\ 95\%\ \text{cl}$$

(P. Renton, ICHEP 2008)

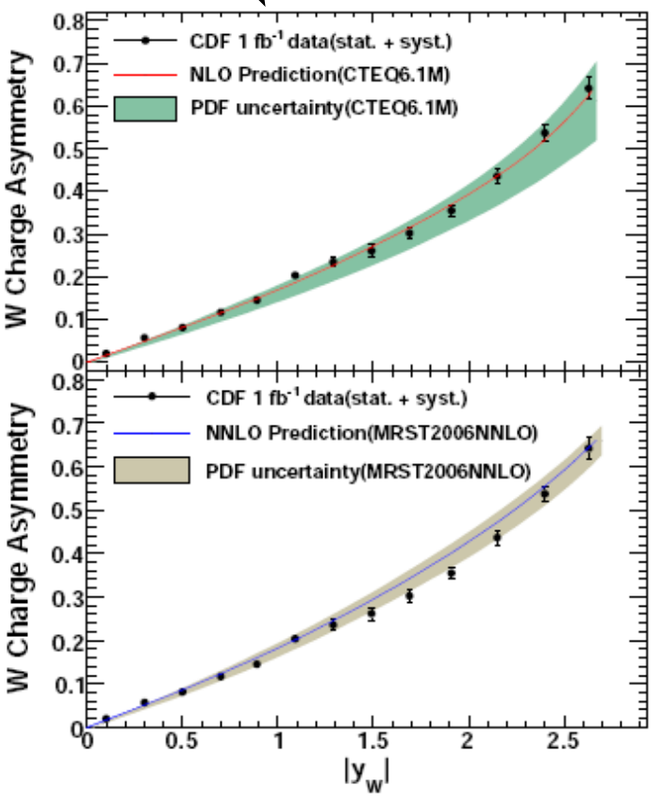
W mass measurement vs PDFs

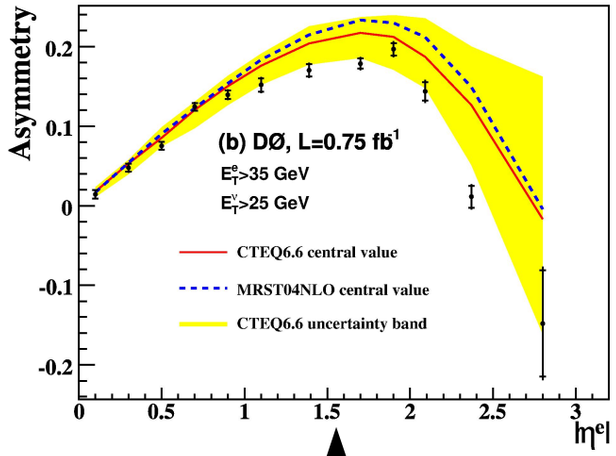
- The momenta of the initial state partons is unknown. We cannot measure the longitudinal momentum of all final states either (neutrino !)
  - Need accurate theoretical description of longitudinal momenta of initial state (i.e. PDFs)
  - Prefer observables that are (almost) invariant under transverse boosts (e.g. transverse mass).

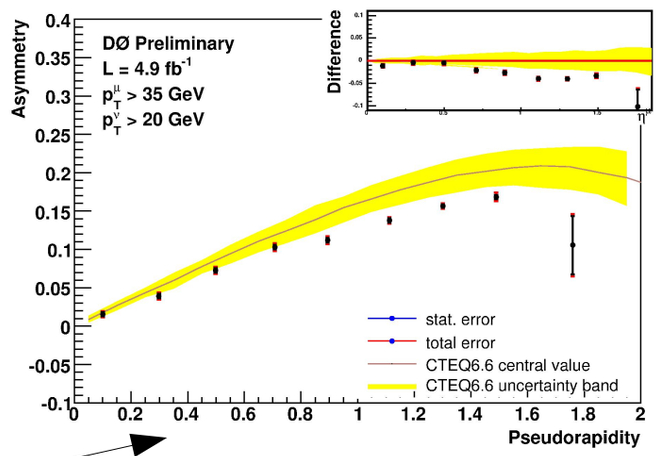
- We have three approaches (that are not mutually exclusive !) to reduce the PDF uncertainty in our m(W) measurement:
  - Reduce the uncertainty on the PDFs themselves (theory + measurements like W charge asymmetry)
    - using the D0 published results of D0 , the PDFs errors on MW could be reduced by 25% or even more with the last results.
  - Reduce sensitivity of m(W) measurement to longitudinal momenta by cutting less harshly on electron |eta| (so far use only central electrons with |eta| < 1.05)
    - Using all calorimeter detector , we expect to reduce by a factor 2 the PDFs errors on M_W
  - Reduce sensitivity of m(W) measurement to longitudinal momenta by using a "JES-corrected" recoil measurement to define m_T ("put electron and recoil on the same energy scale" to improve Lorentz invariance of m_T).
    - Study is going on : a significant improvement is expected too.

Ongoing work: inclusion in PDF sets

CTEQ6.1 and CTEQ6.6 are in excellent agreement with the CDF measurement of the **W boson** charge asymmetry ...

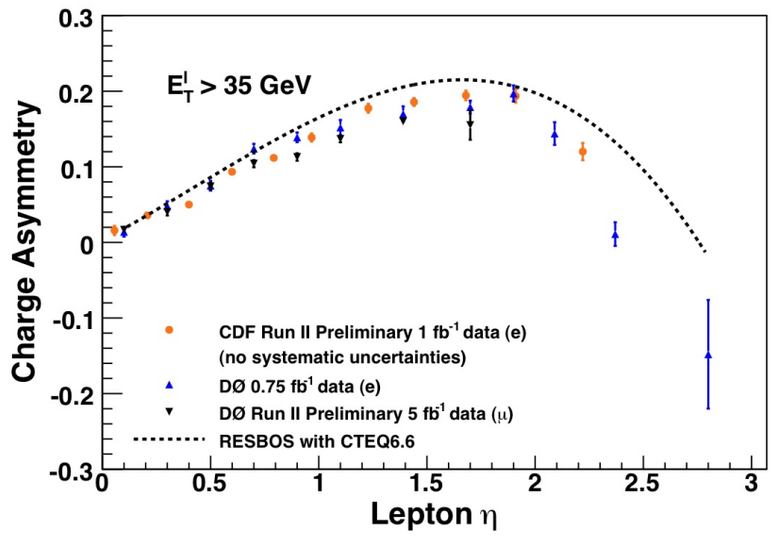






... they do not agree with the D0 **lepton** charge asymmetries (neither with the electrons nor with the muons) ...

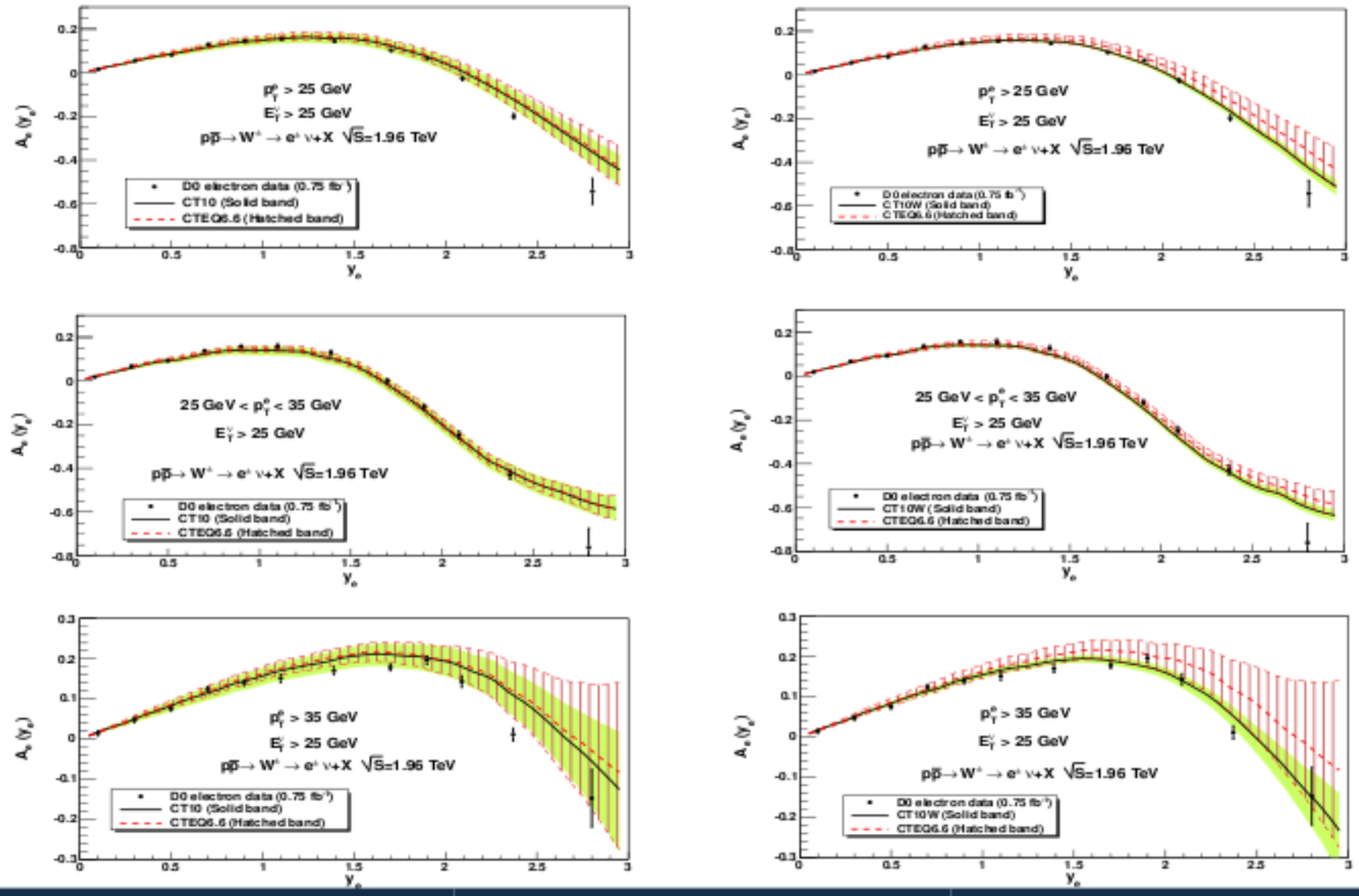
... but when you plot the CDF data in terms of **lepton** charge asymmetry then they do not really disagree with the D0 data !



W charge asymmetry

PDFs CT10W : D0 data are preferred

CT10 and CT10W predictions for $A_e(y_e)$ (D0 Run-2)



Pavel Nadolsky (SMU) | W boson workshop, Fermilab 2010 | October 4, 2010 | 11

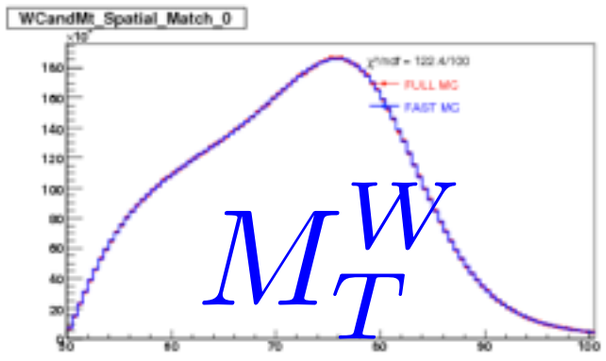
Current Analysis Issues

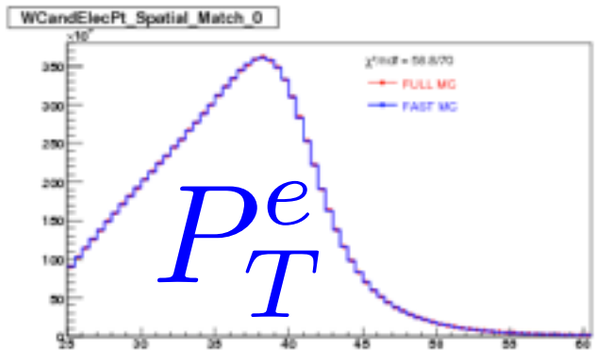
More details tomorrow : Hengne’s talk

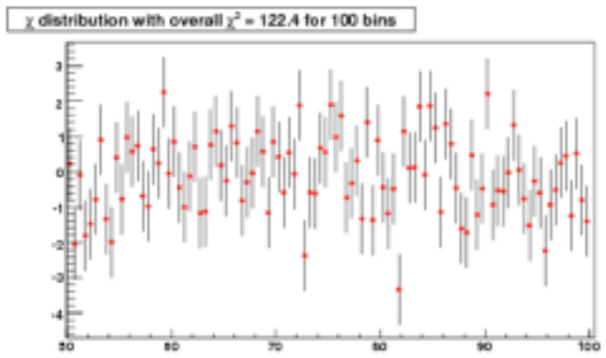
W Mass Status

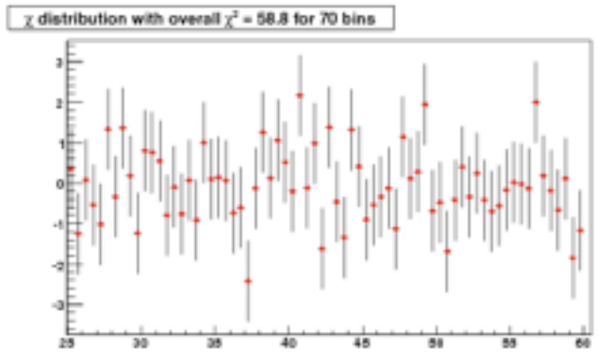
FullMC W -> e nu

62M events generated, 9.8M events after selection







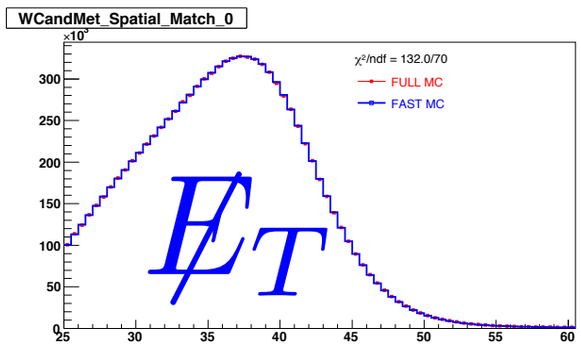


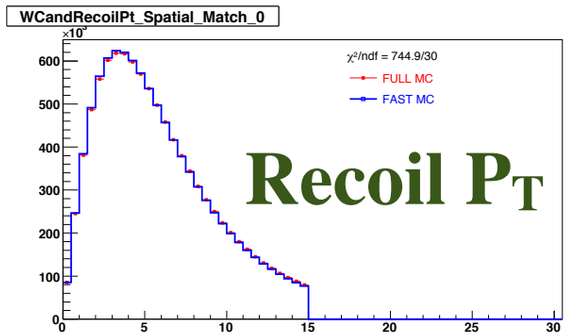
Looks good for all the 3 observables:

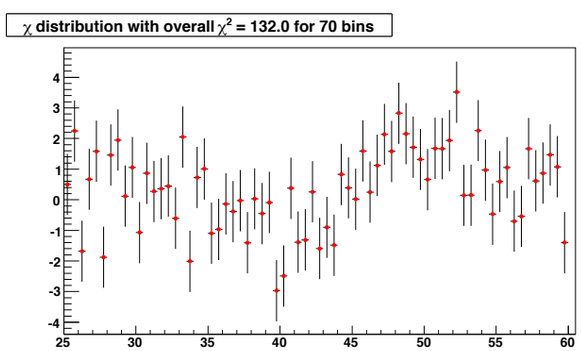
MT, ElecPT and Missing ET.

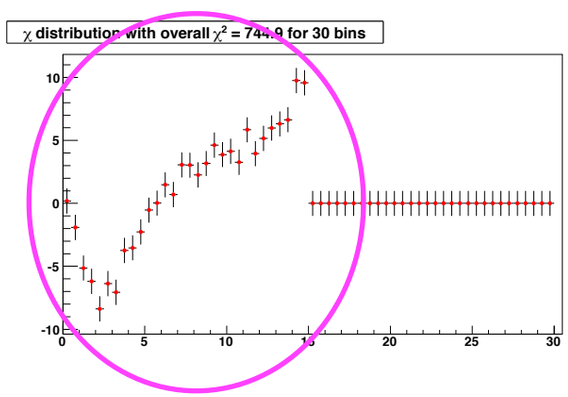
And the fits of W Mass and Width close.

However, there is a small issue related to the Recoil Fine Tuning. This affects the MissingET a little.









Two issues:

- Modeling of PT(ee) in Zee (next slide).
- Choice of parameterization of recoil fine tuning need to be revisited.
  - Another approach is on going for the Recoil Fine Tuning using the "Recoil Energy Flow" which has proven to be useful in our RunIIa analysis.

W Mass Status

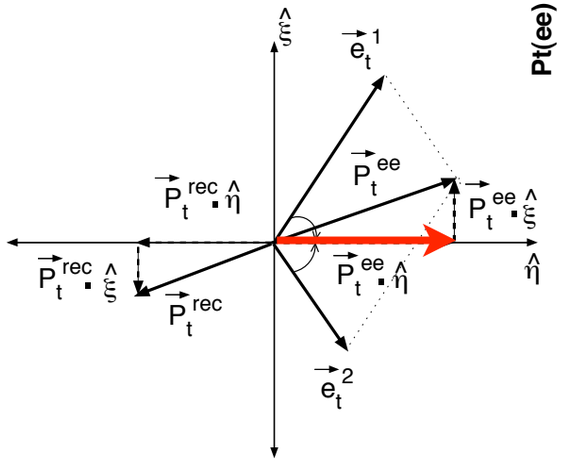
Eta-Imbalance is the reference for Recoil Fine Tuning.

$$\eta_{imb} = (\vec{p}_T^{\,Z} - \vec{u}_T) \cdot \hat{\eta}$$

η-axis: the bisector in R-φ plain of two electrons from Z decay

The Issue:

The Pt(ee) projection to Eta-Direction has a mis-match when Pt(ee) is large (small fraction of events). See plots on the right.



Consequences:

It will impact our Recoil fine tuning. If the Pt(ee) is wrong, this mistake will be transferred to the Recoil.

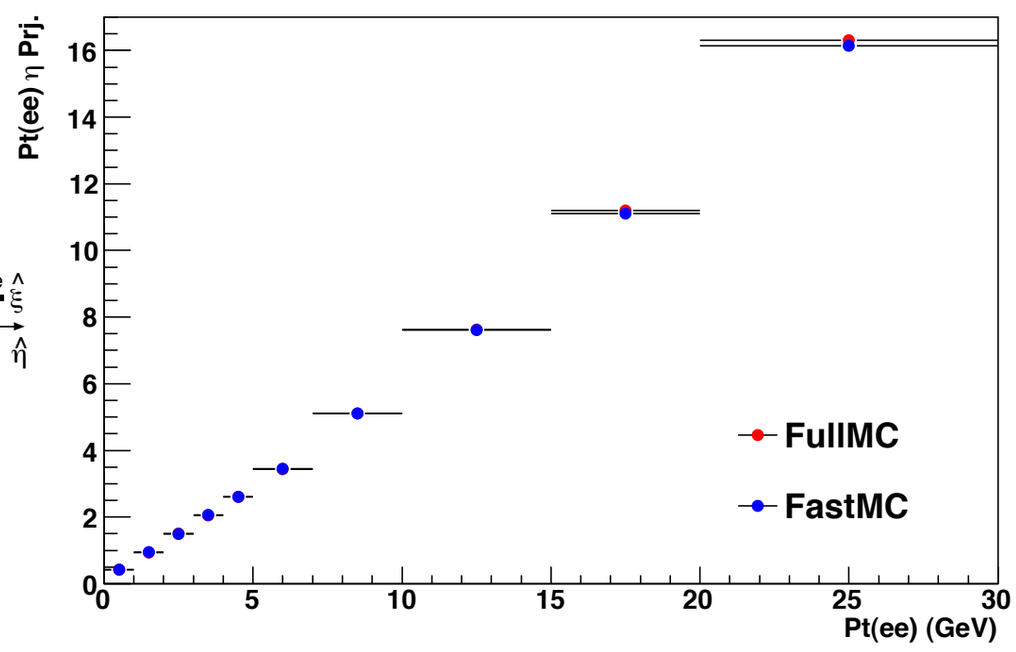
Investigations have shown, it is most likely caused by imperfections in our current description of the Phi Cracks. Remember, the two electrons from the Z decay are angularly highly correlated.

We observed that Data Zee has the same signature.
It requires more follow-up.

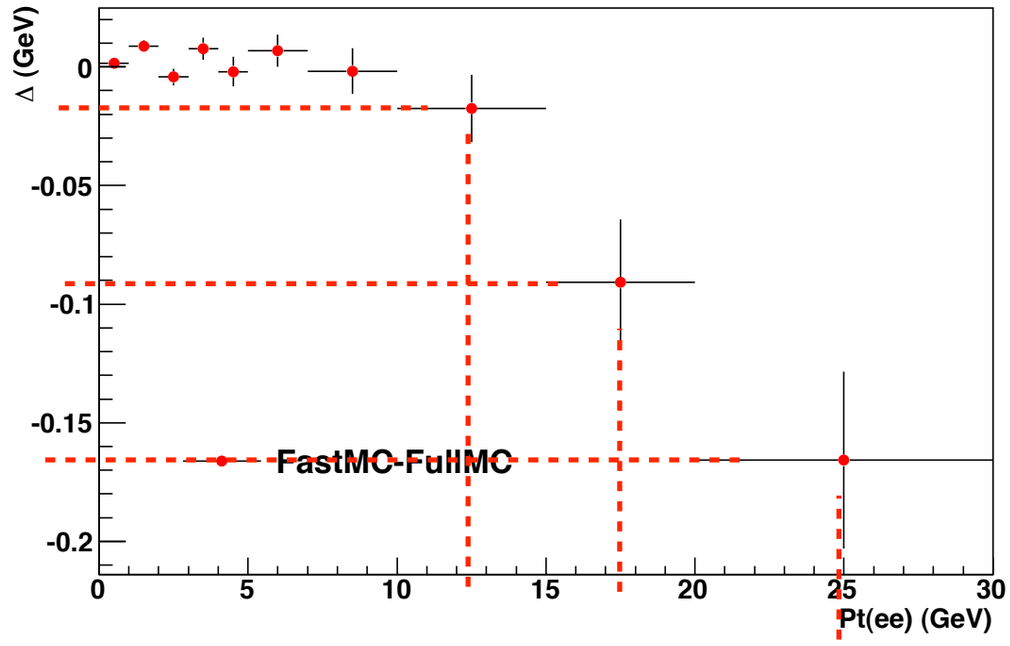
pour fitter le recoil

FullMC Z -> ee

Mean of Pt(ee) projection to Eta-Direction vs. Pt(ee)



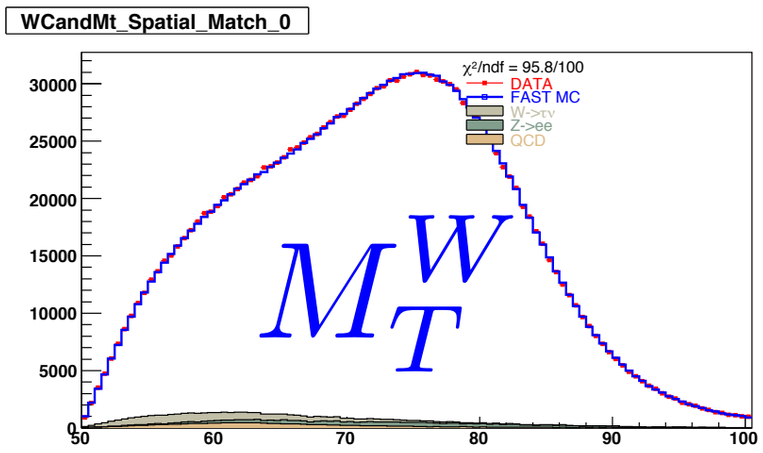
FastMC-FullMC for each bin

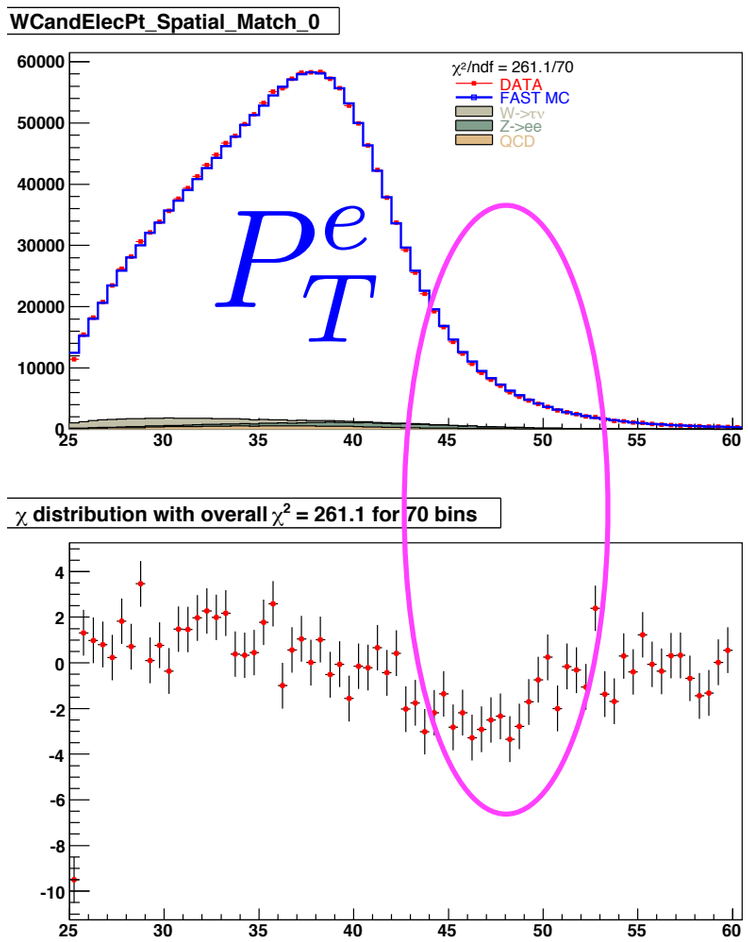


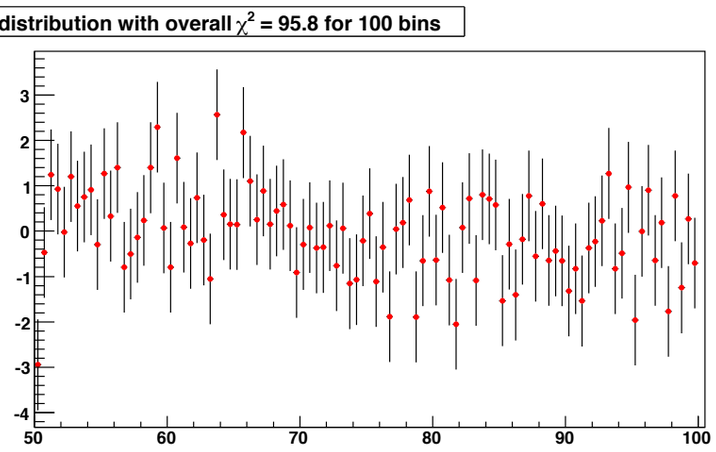
W Mass Status

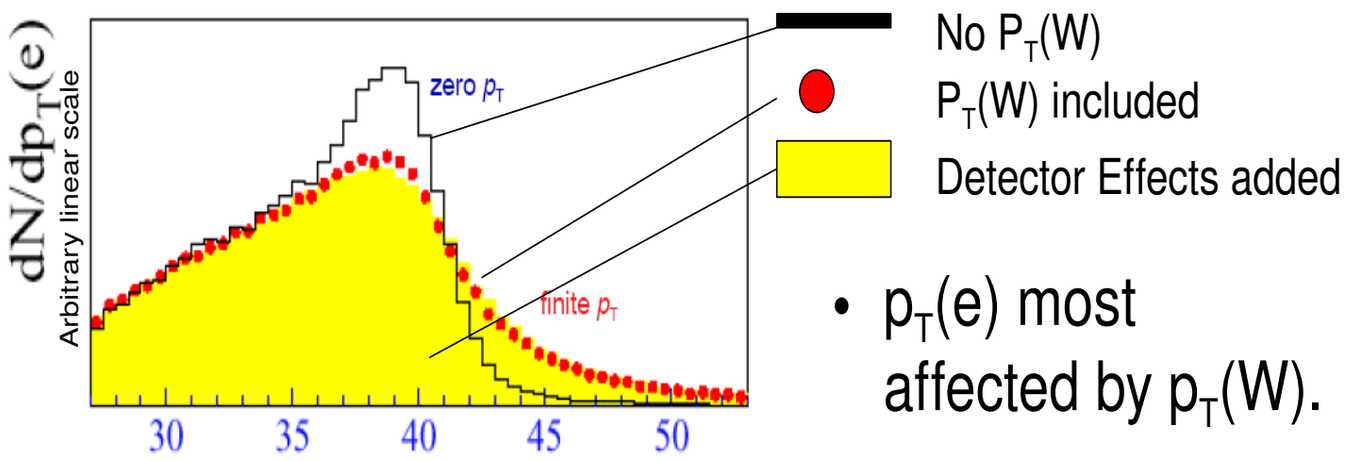
Data W -> e nu

RunIIb 4.3 fb^{-1} 1.7M events after selection









- p_T(e) most affected by p_T(W).

M_T looks good, but ElecP_T doesn't.

- We know the degradation of the ElecP_T Jacobian peak is due to the boost of the W boson. (see plot on the bottom)
- At the generator level, we tried to re-weight Resbos using Phi* measured from D0 Data (Vesterinen et., al.,), we found the impact is negligible.
- But, we do have a certain mis-modeling of the Recoil. This is reflected in the ElecP_T distribution because of the cut at RecoilP_T<15GeV

Conclusion

- Results at 1 fb^{-1} : we are the «best» in the world :

DØ RunII 1fb^{-1}
80.401 ± 0.021(stat.) ± 0.038(syst.) GeV
80.401 ± 0.043 GeV

- Analysis on 6 fb^{-1} : is new compared to previous one due to the highest instantaneous luminosities
  - Now the current work is on some details (see Hengne's talk)

- At the end the analysis with the last 4 fb^{-1} will be not too much different.

Our goal : reach 15 MeV resolution on M_W to be able to affirm SM is over.