D0 RunIIb 4.3 fb^{-1} W Mass Analysis

Hengne Li / LPSC Grenoble

For the RunIIb W mass Analysis group:
Daniel Boline, ***John Hobbs****, Tibor Kurca, Patrice Lebrun, ***Hengne Li****, Rafael Lopes de Sa, Bob McCarthy, Alex Melnitchouk, Pierre Pétroff, Heidi Schellman, Jan Stark, Sahal Yacoob

* conveners

Outline

- Motivation
- Analysis Strategy
- Challenges in Run IIb
- The Parameterized Detector Model for RunIIb Analysis
- Status of Full MC Closure Test
- Status of Data Analysis
- Summary

Motivation:

Knowledge of the W mass is currently the limiting factor to tighten the constraint on the Higgs boson mass.

- **Based on the internal consistency of the SM, we can predict the unknown Higgs boson mass**
- **The imperfect knowledge of W boson mass and Top quark mass, brings the biggest uncertainty into this prediction**
- **For equal contribution to the Higgs boson mass prediction uncertainty, it requires :**

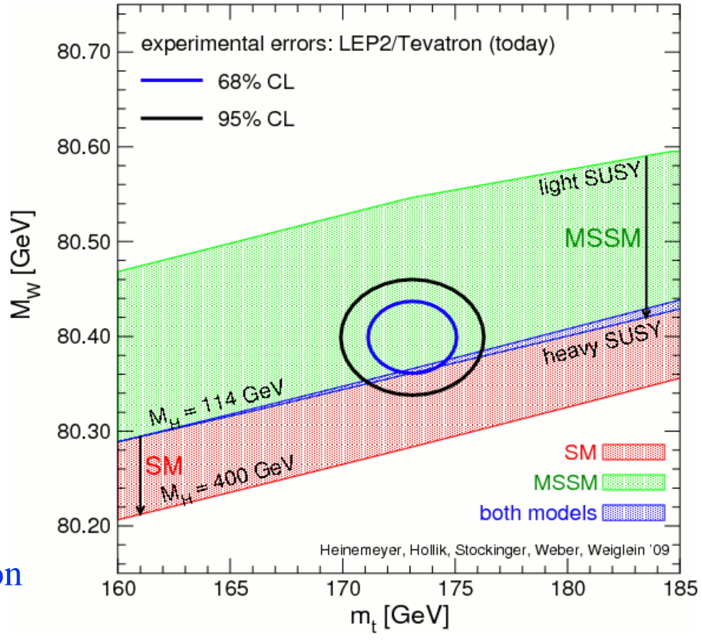
$$\delta M_W \sim 0.006\ \delta M_t$$

I. e. Current World average:

accuracy of Mt : $\delta M_t = 1.1$ GeV needs $\delta M_W = 7$ MeV

accuracy of M_W : $\delta M_W = 23$ MeV

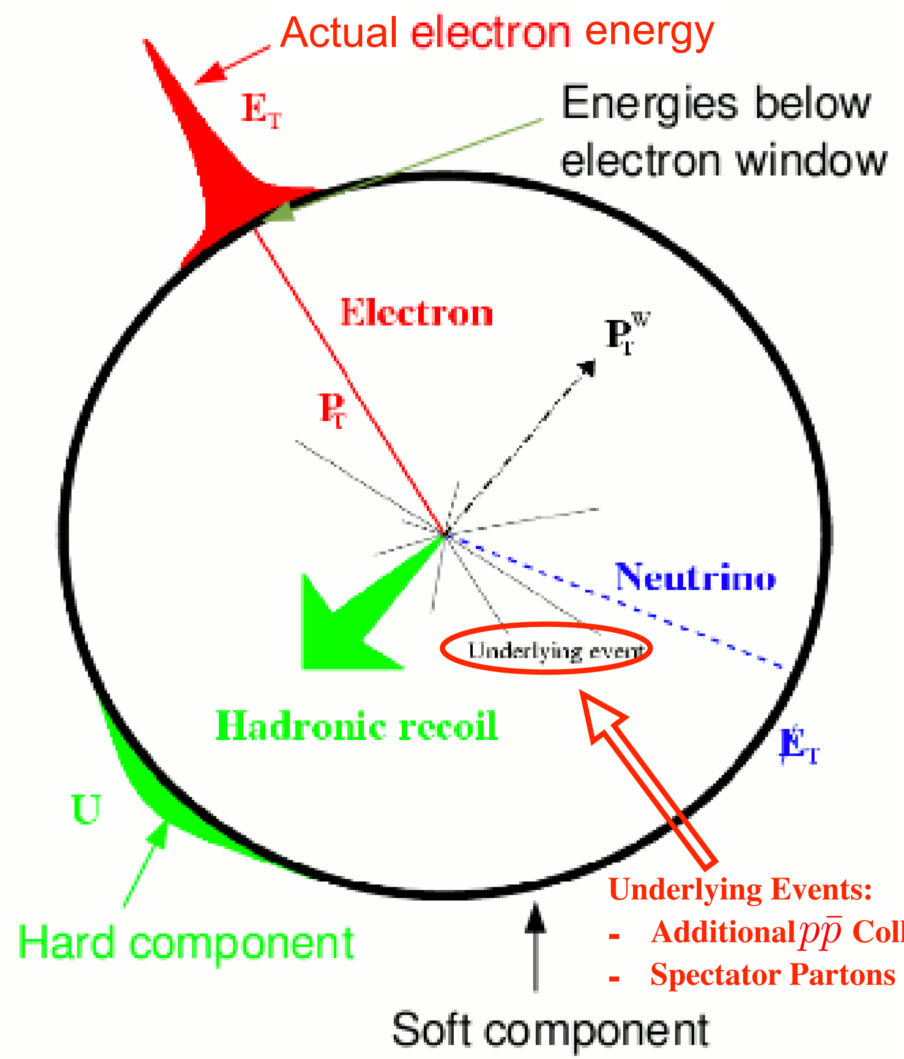
The limiting factor on the M_H prediction is δM_W not δM_t



Current world average central value of W mass (80.399 GeV) prefers a non-SM Higgs:

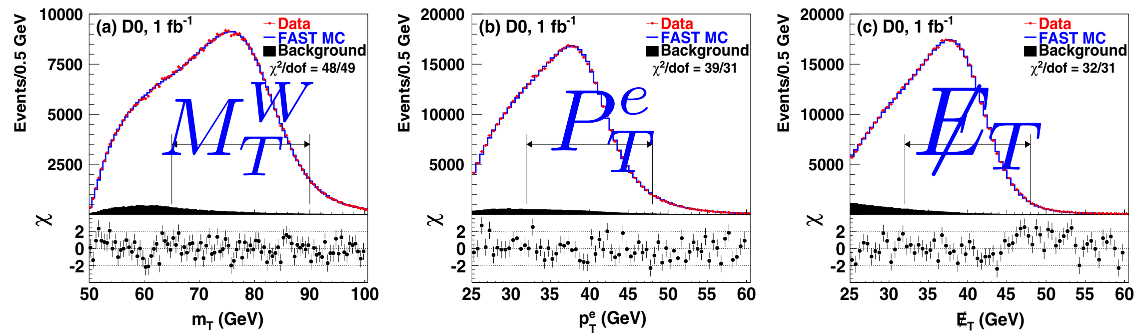
e.g. If the central value of M_W does not change in the future, a **15 MeV** precision will **exclude SM Higgs at 95% CL**. (P. Renton, ICHEP 2008)

A typical W -> eν event



Underlying Events:
- Additional $p\bar{p}$ Collisions (Zero-Bias)
- Spectator Partons (Mini-Bias)

Three observables:



(plots from published RunIIa 1 fb^{-1} analysis, Phys. Rev. Lett. 103, 141801 (2009).)

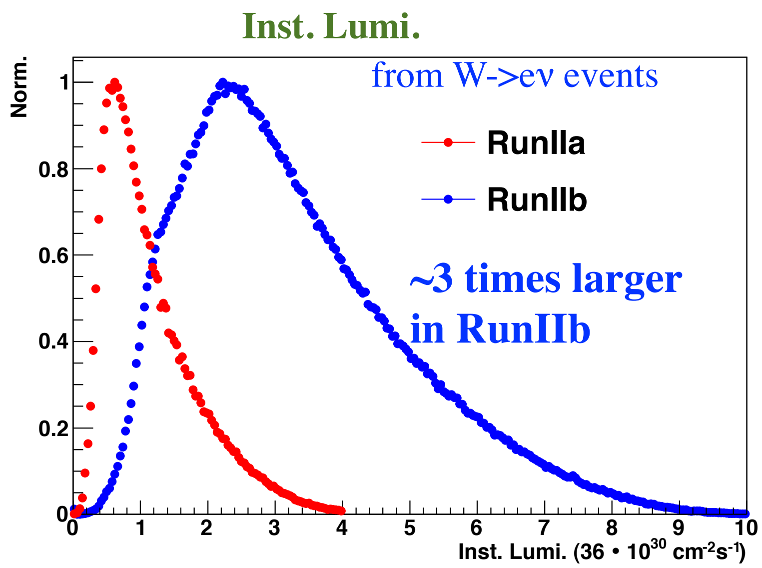
Developed a Fast MC model to generate templates of the 3 observables with different W mass hypotheses. Fit the templates to the Data to extract W mass.

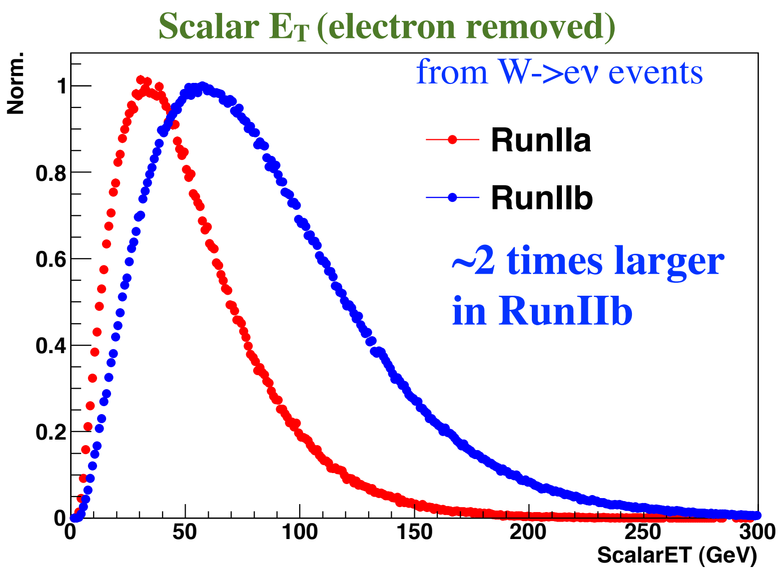
The Fast MC model:
- **Event Generator: Resbos+Photons**
- **Parameterized Detector Model**

The Parameterized Detector Model is essential in this analysis!

Challenges in RunIIb

RunIIb high instantaneous luminosity results in much higher energy flow from additional $p\bar{p}$ collisions (Zero-Bias) complicates the modeling of detector effects:





The Parameterized Detector Model for RunIIa analysis is not sufficient to describe RunIIb Data!

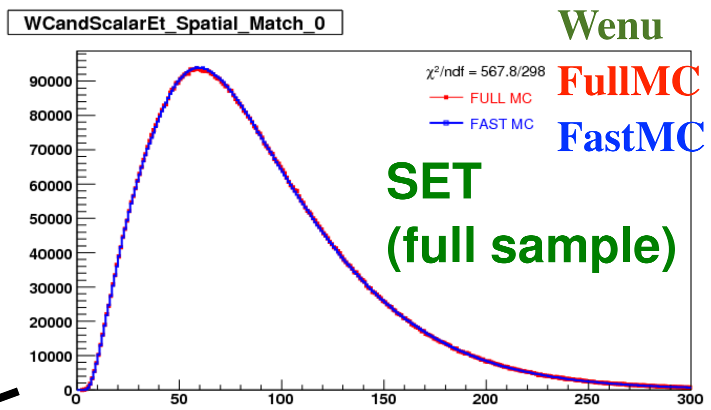
Efficiency Model of Electron Reconstruction:

- Sources: Trigger, Geometry Acceptance, Cluster Structure, and Track Matching
  - Dependence: electron P_T, Eta, distance to Phi Cracks,
- Sources: Zero-Bias Contamination (RunIIb Challenge) and Hadronic Contamination
  - Dependence: electron P_T, Scalar E_T, Inst. Lumi., and $U_{||}$ (recoil projection to the electron direction)

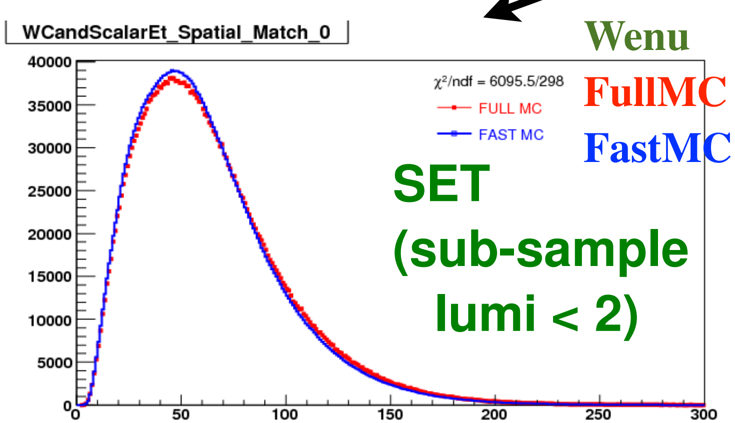
Model Update in RunIIb:

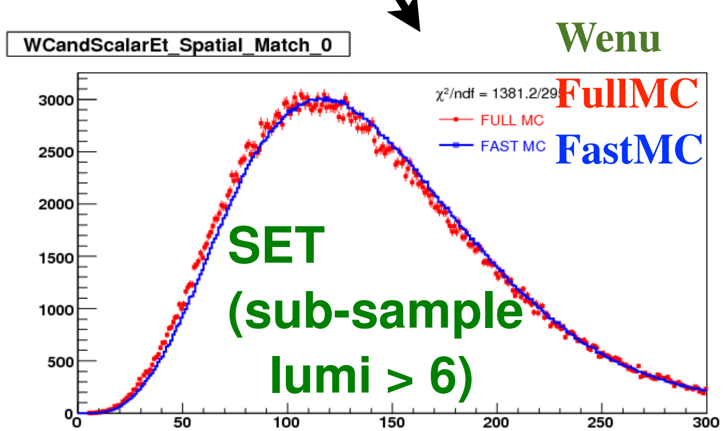
We explicitly included the Inst. Lumi. dependence, and its correlation with SET dependence to describe the inefficiency due to Zero-Bias contamination.

However, we can still observe strong Inst. Lumi. dependence after this update.



Only updating the Efficiency Model is not sufficient.



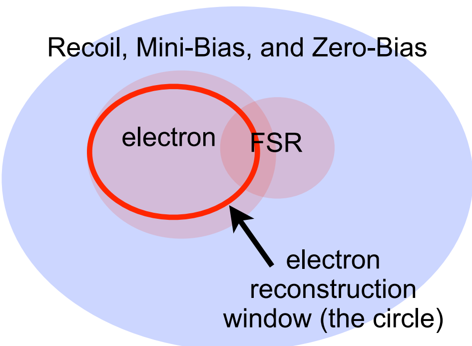


Electron Model:

$$E_{reco} = \underbrace{R_{EM}}_{\text{Response}}(E_{true}) \otimes \underbrace{\sigma_{EM}}_{\text{Resolution}}(E_{true}) + \underbrace{\Delta E_{corr}}_{\text{(RunIIb Challenge)}}$$

Response and Resolution are calibrated using Z invariant mass of Z->ee Data

ΔE_{corr} **Model: Model Update in RunIIb**



1. **Energy Leakage due to FSR**

   Add Inst.Lumi, SET, Eta dependencies

2. **Recoil, Mini-Bias and Zero-Bias Contamination inside electron window**
3. **Effects due to Zero-Suppression and Baseline-Subtraction**

   For modeling 2. and 3., we added Inst. Lumi., SET, electron P_T and $U_{||}$ dependencies in a very complicated way, based on a new Wenu FullMC production with Electron and Recoil separated.

Recoil Model:

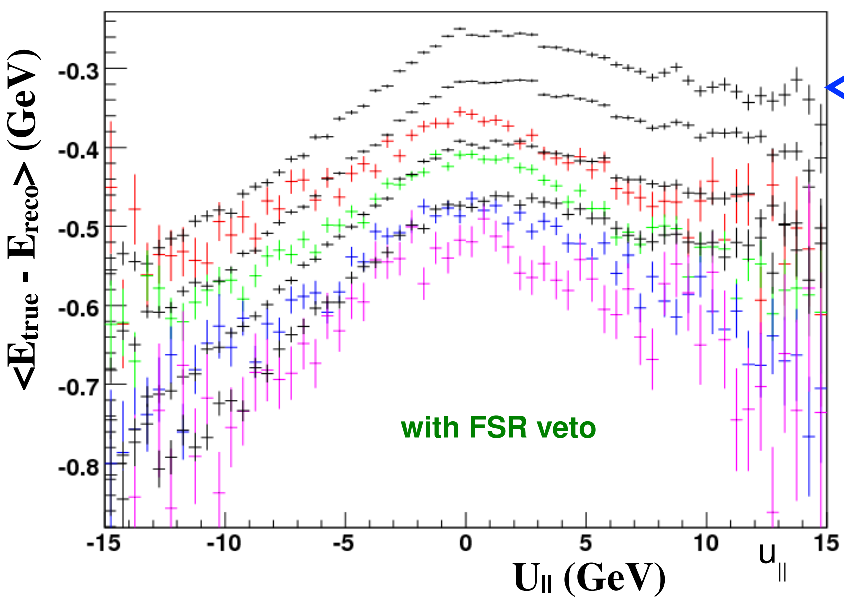
$$\vec{u}_T = \underbrace{\vec{u}_T^{\,\text{Hard}}}_{\text{Hard Recoil balancing W or Z boson}} + \underbrace{\vec{u}_T^{\,\text{Soft}}}_{\text{Soft Recoil: Zero-Bias and Mini-Bias}} + \underbrace{\vec{u}_T^{\,\text{Elec}} + \vec{u}_T^{\,\text{FSR}}}_{\text{Model Update in RunIIb}}$$

In the same framework of ΔE_{corr} Modeling

What has been added to (subtracted from) the electron has to be subtracted from (added to) the Recoil.

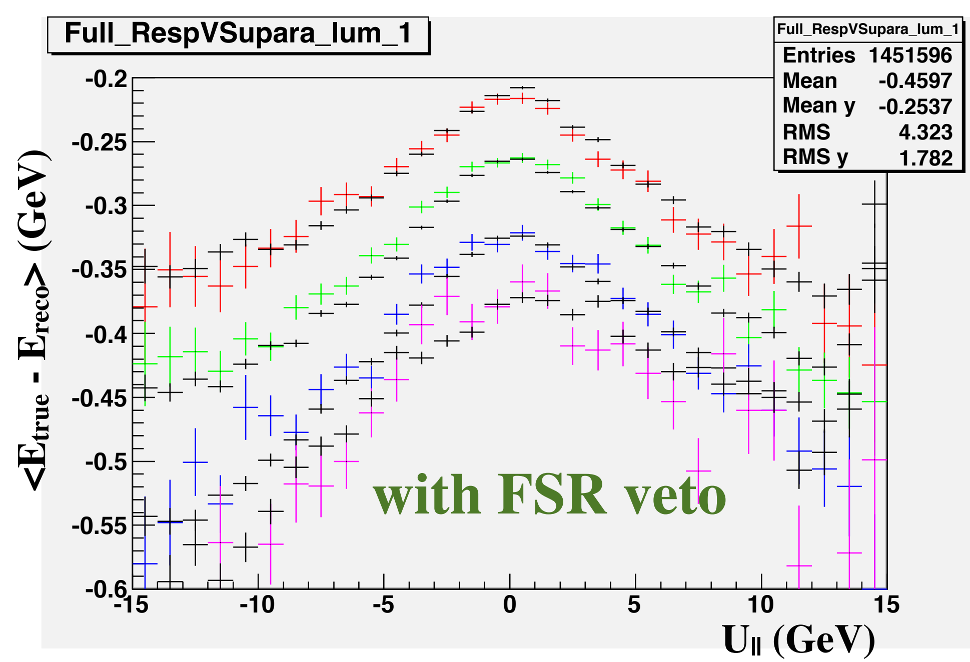
The Model Updates Work? Yes!

Electron mean energy response (truth-reco.) as a function of $u_{\parallel}$ for 4 Inst. Lumi. sub-samples, comparing FullMC and FastMC



Status at Winter Physics Workshop , Feb. 08, 2011

Now



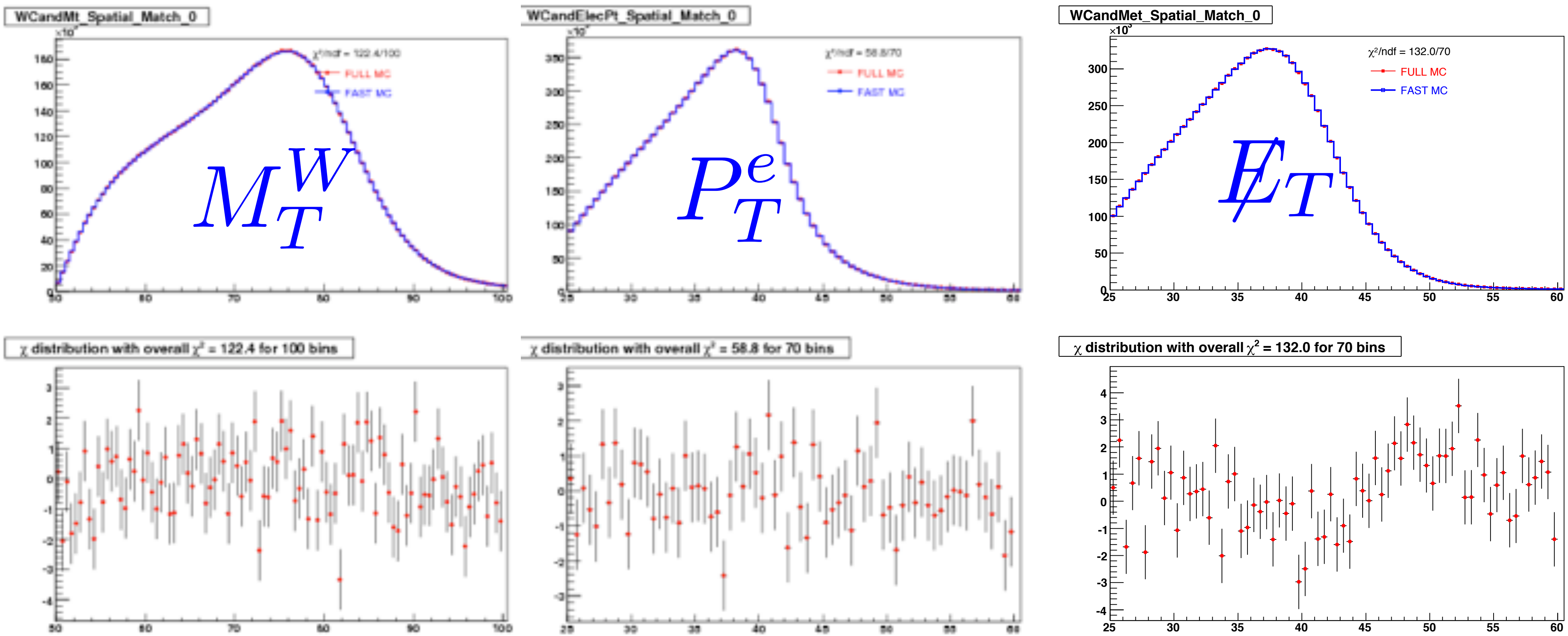
FullMC:	FastMC:
Lumi < 2	Black
2 < Lumi < 4	
4 < Lumi < 6	
Lumi > 6	

You could easily match the Black FastMC profiles with the corresponding FullMC in colors

FullMC Closure Test Status

FullMC W -> e nu

62M events generated, 9.8M events after selection



Looks nice for all the 3 observables:

M_T, $ElecP_T$ and Missing E_T.

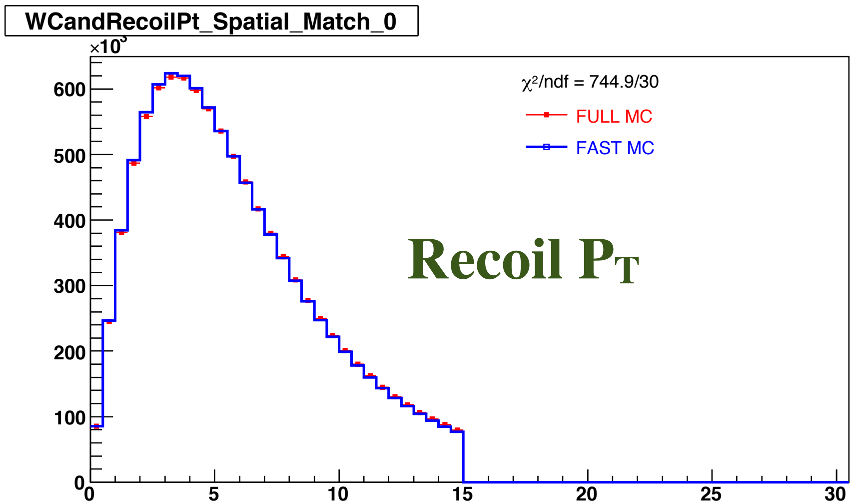
The fits of W Mass and Width close.

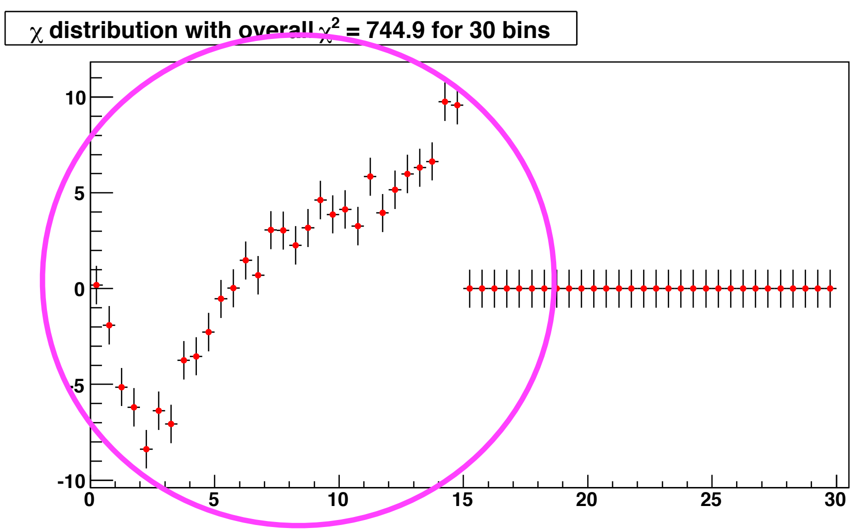
(fitted central values agree with the input value within 1 sigma)

Remaining Recoil Fine Tuning Issue

FullMC W -> e nu

62M events generated, 9.8M events after selection





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

Investigating in two directions:

- Modeling of P_T(ee) in Zee (next slide).
- Choice of parameterization of Recoil Fine Tuning needs to be revisited.
  - Approach is on going for the Recoil Fine Tuning parameterization using the "Recoil Energy Flow", which has proven to be useful in our RunIIa analysis.

Remaining Recoil Fine Tuning Issue

Reminding:

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.

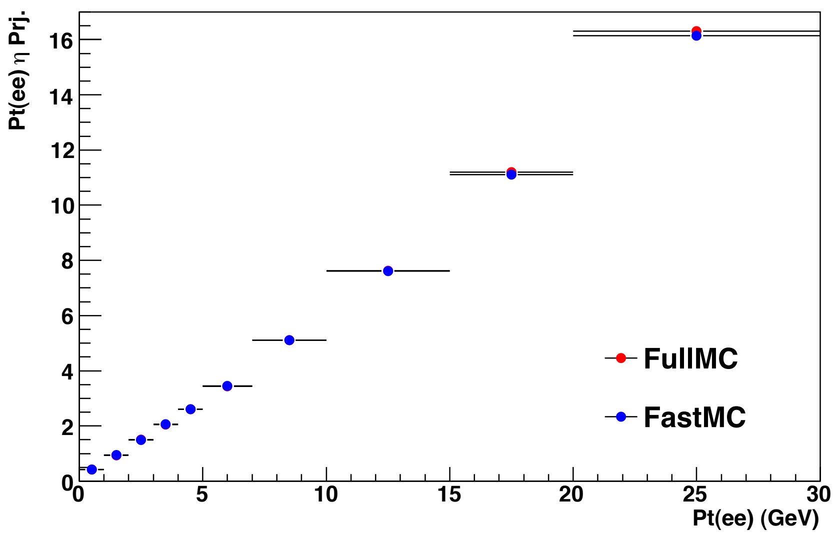
Investigations have shown, it is most likely caused by imperfections in our current description of the Phi Cracks.
Remember, the two electrons from the Z decay are angularly highly correlated.

We observed that Data Zee has the same signature.

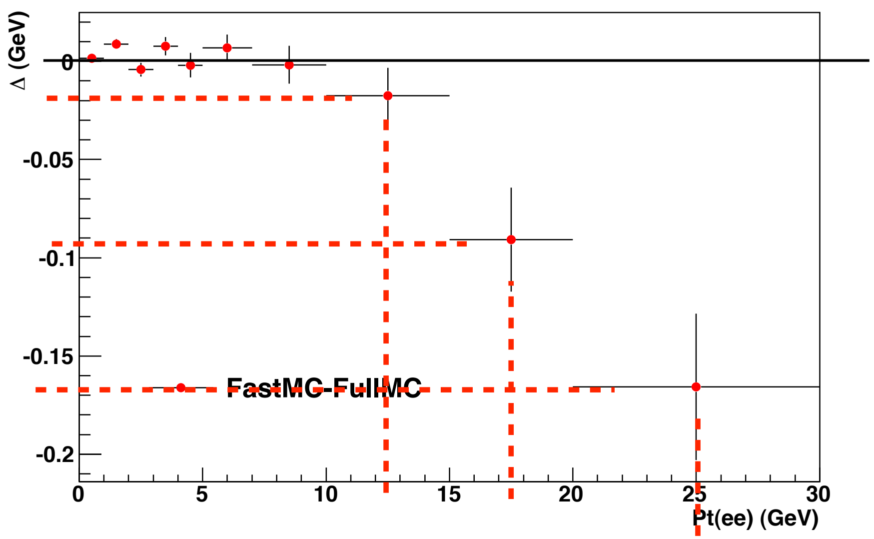
It requires more follow-up.

FullMC Z -> ee

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



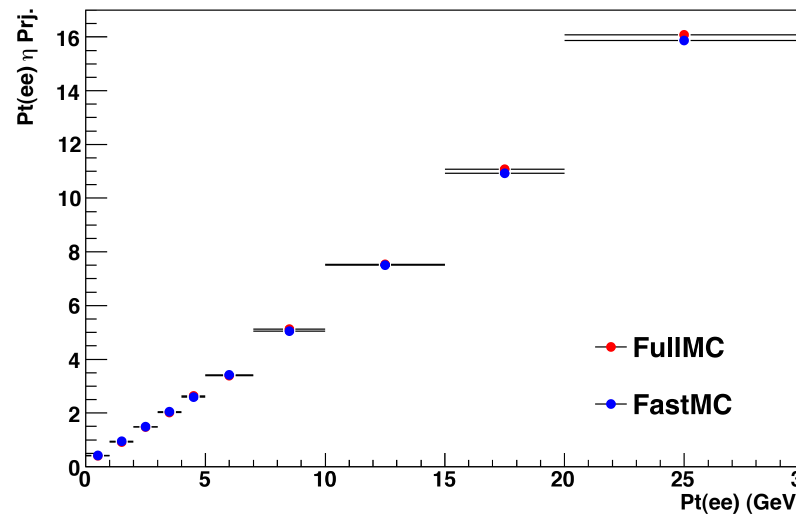
FastMC-FullMC for each bin



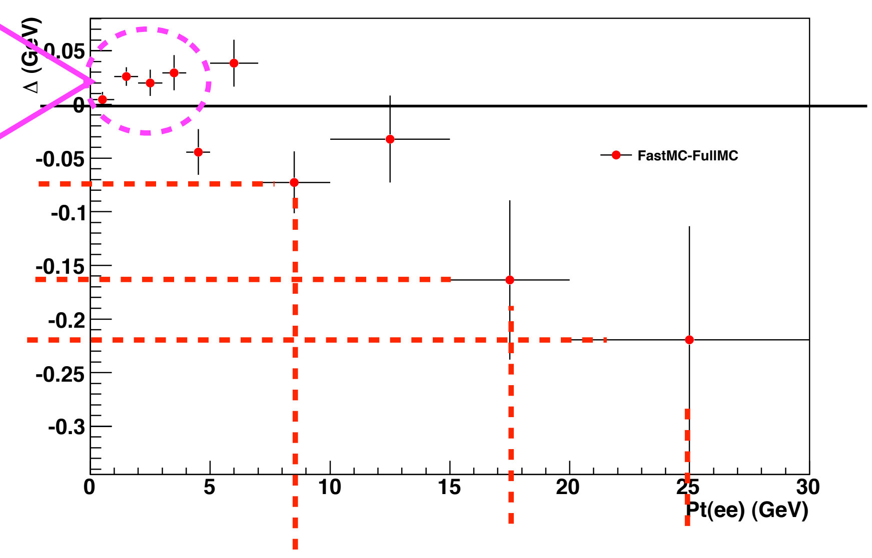
Status of Data Analysis

Data Z -> ee

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



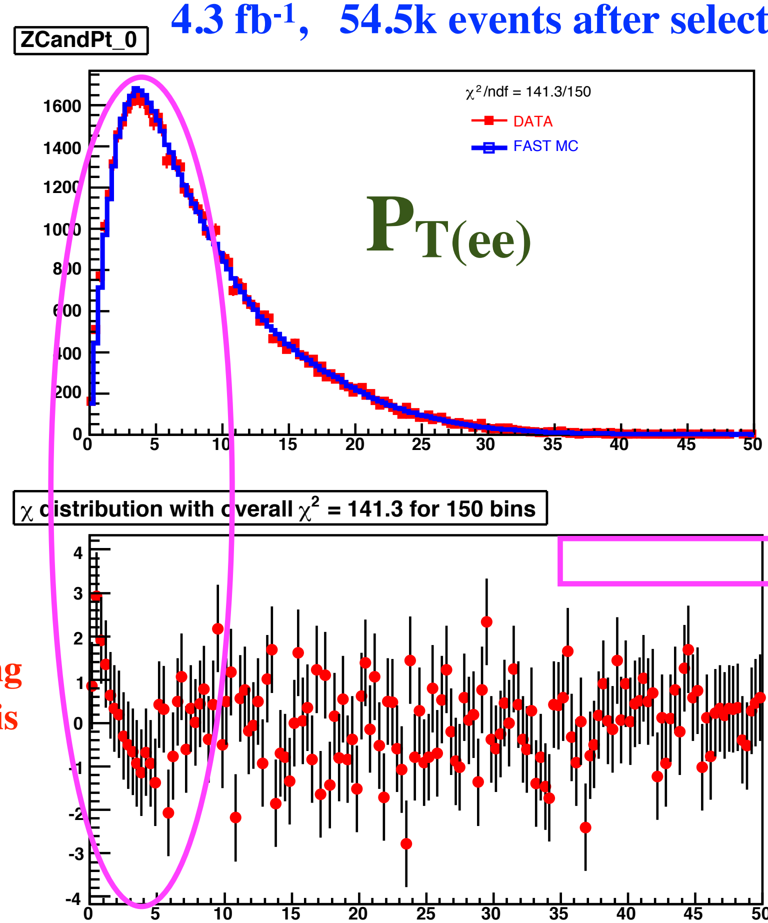
FastMC-Data for each bin



Data Zee has the same issue !
Might be the same source as a long time existing issue.

Data Z -> ee

4.3 fb^{-1}, 54.5k events after selection

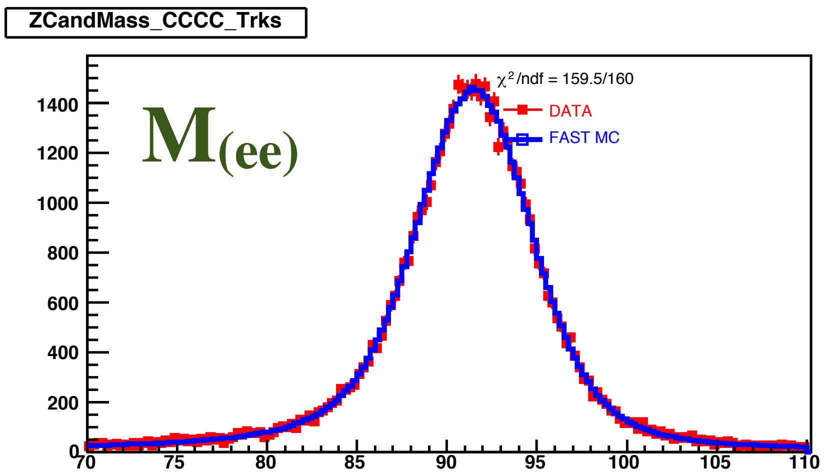


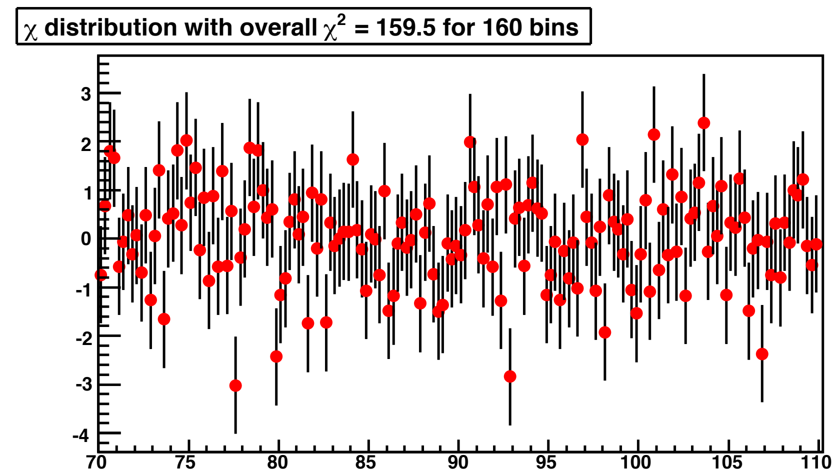
This issue is here since the beginning of RunIIb Analysis without being fixed!

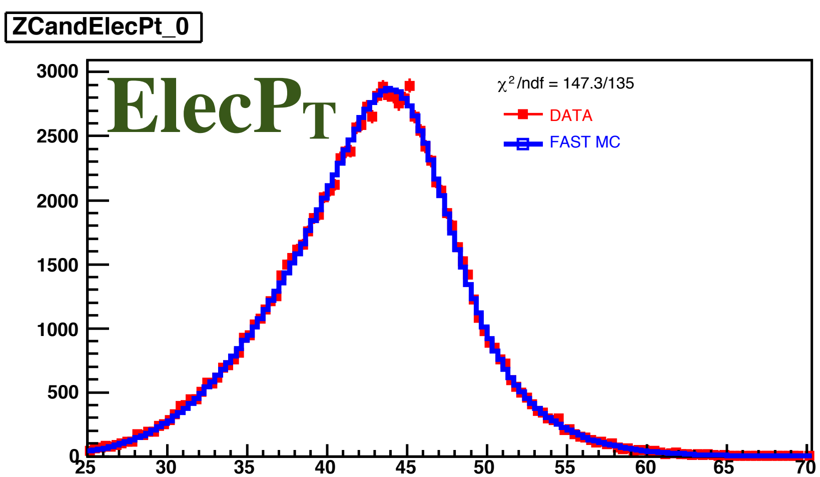
It requires more follow-up.

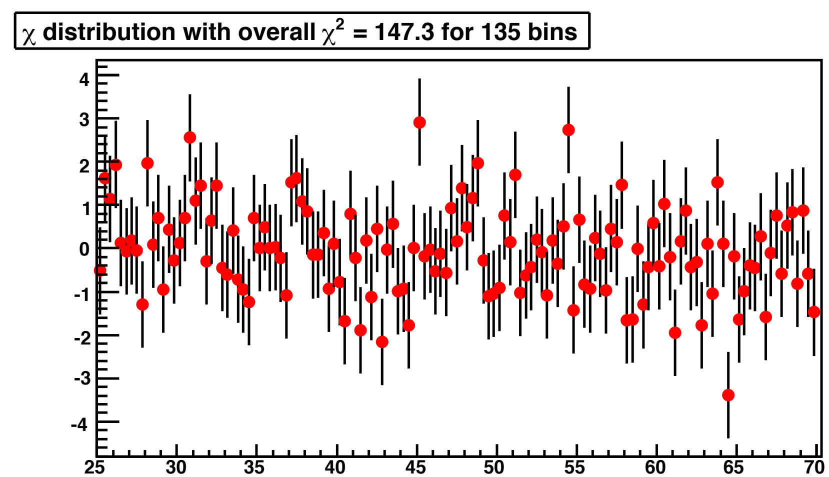
Status of Data Analysis

Data Z -> e e   4.3 fb^{-1}, 54.5k events after selection





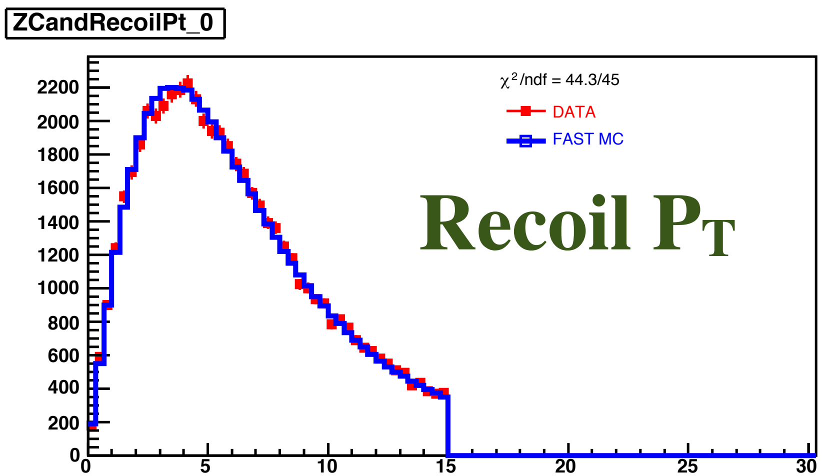


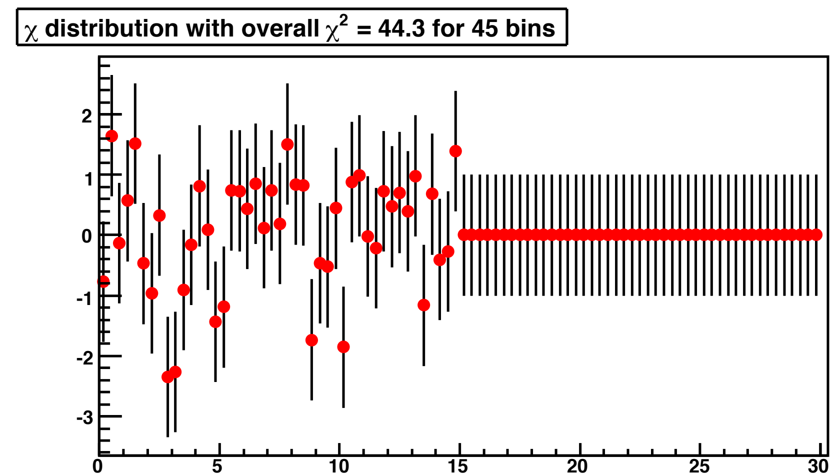


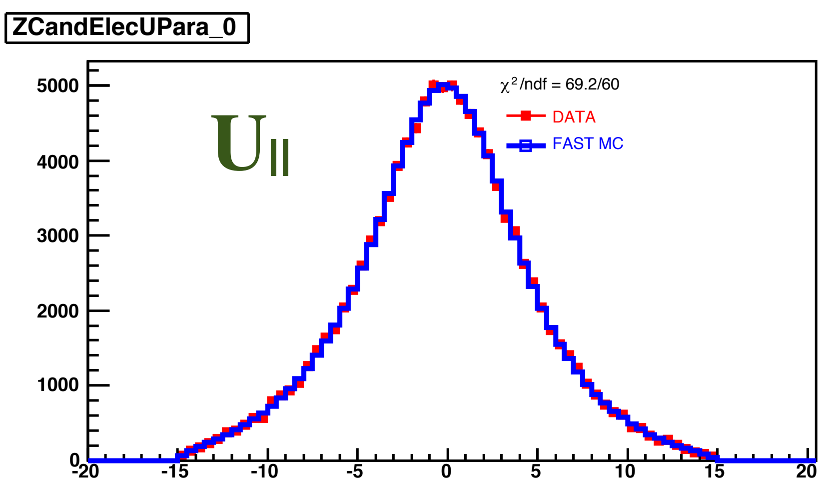
Look Nice!

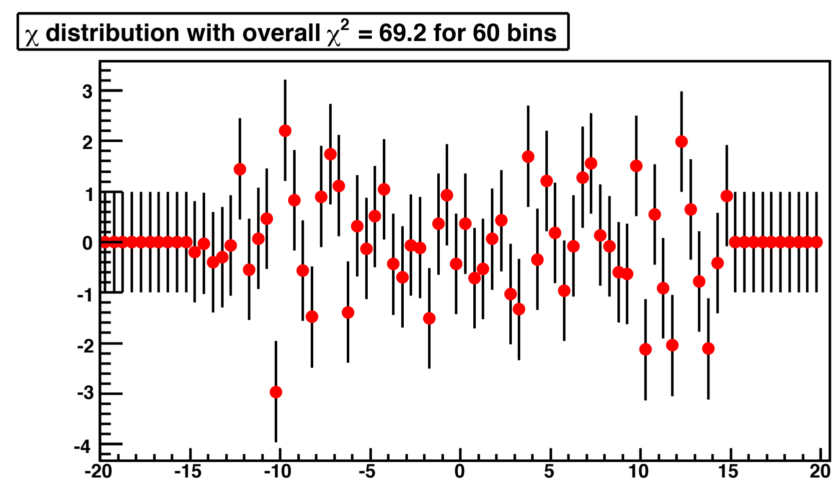
Status of Data Analysis

Data Z -> e e   4.3 fb^{-1}, 54.5k events after selection







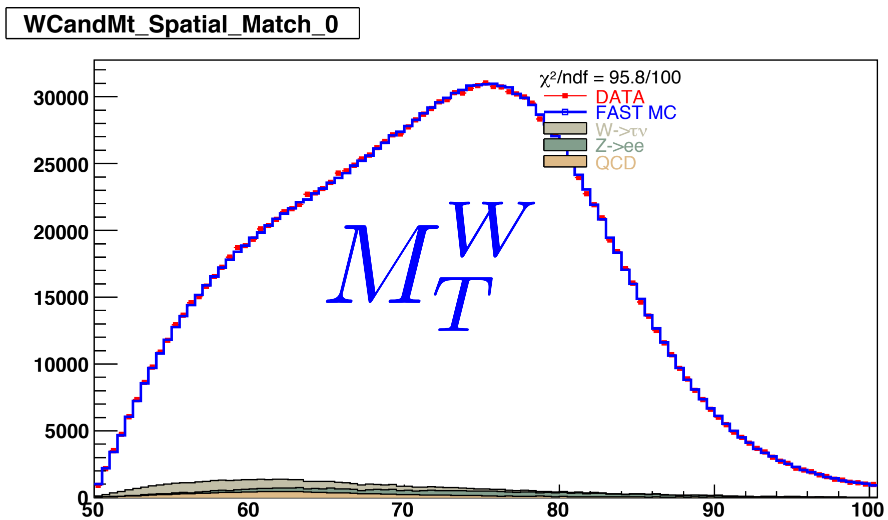


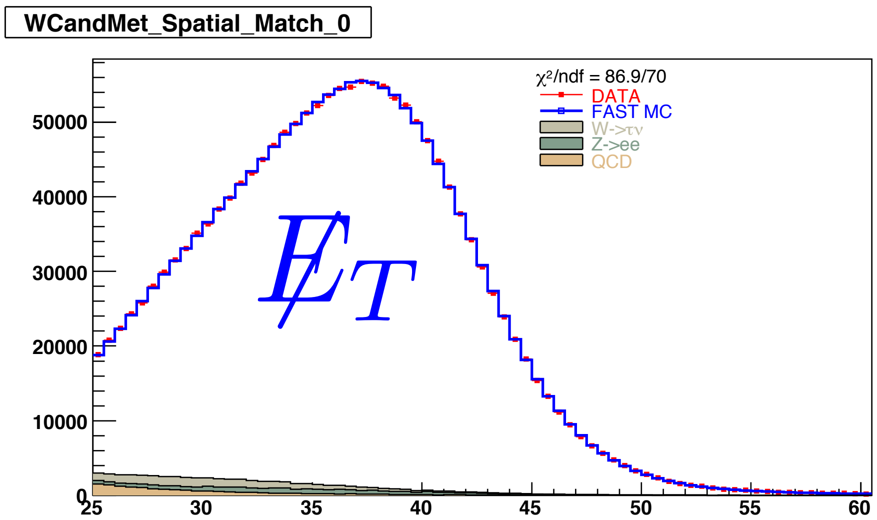
Look Nice, given the statistics of Zee Data

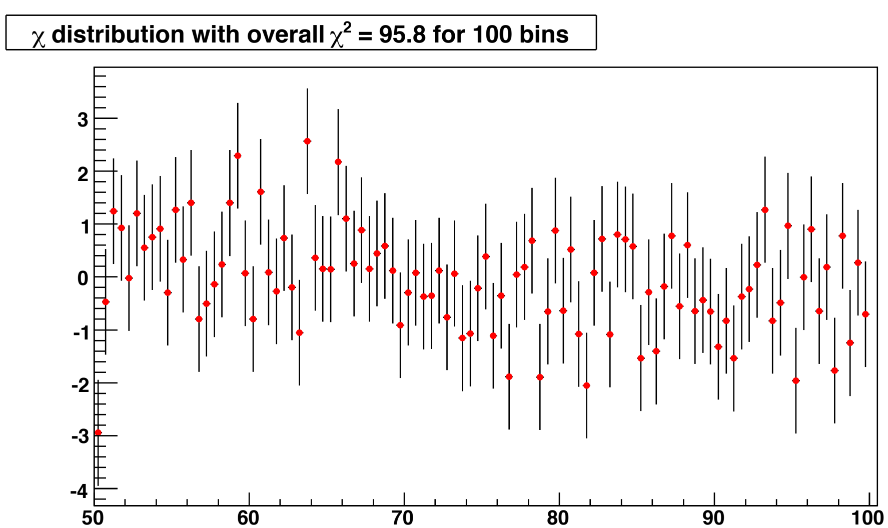
Status of Data Analysis

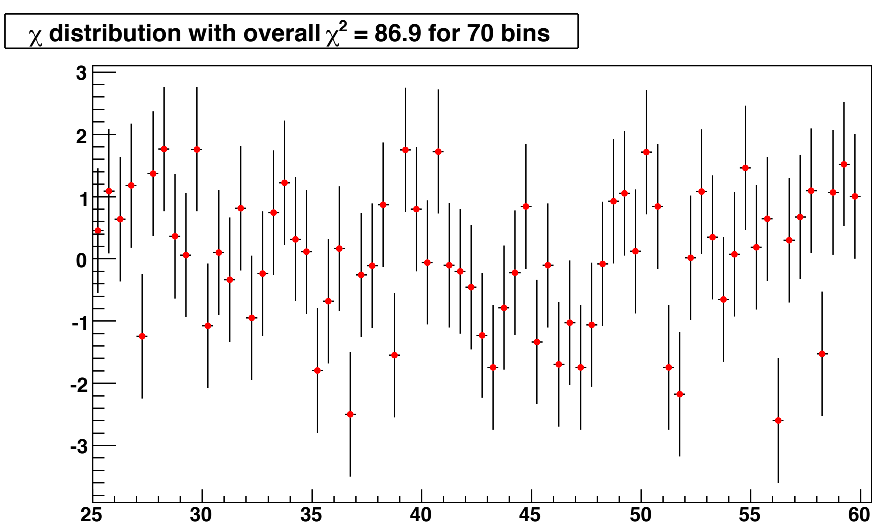
Data W -> e nu

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





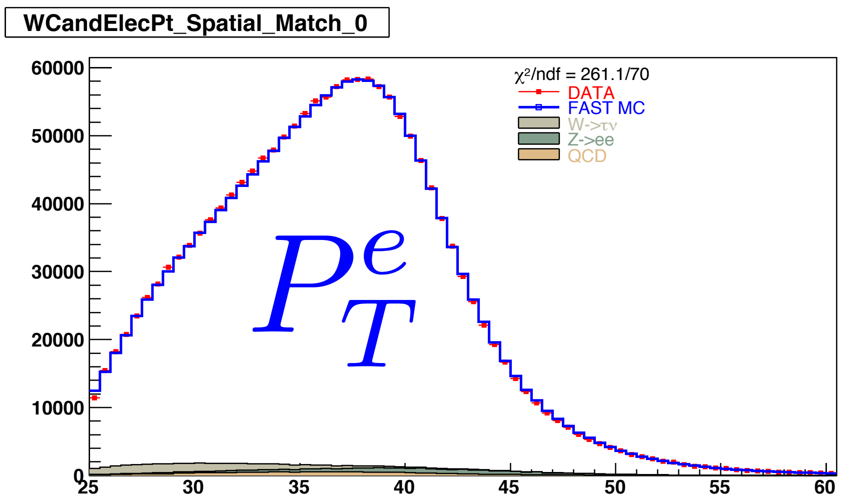


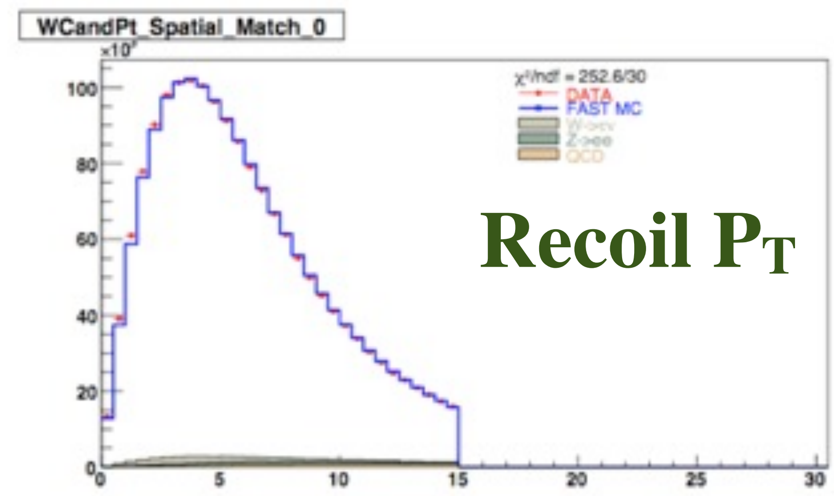


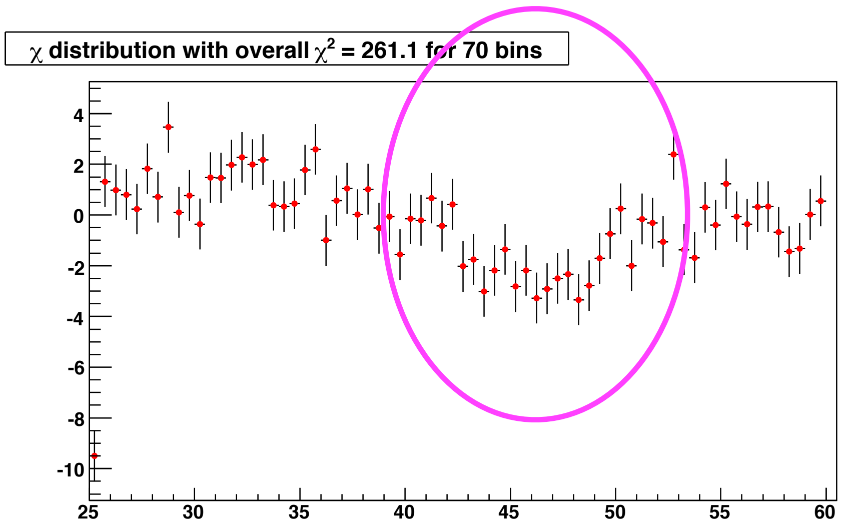
Look Nice!

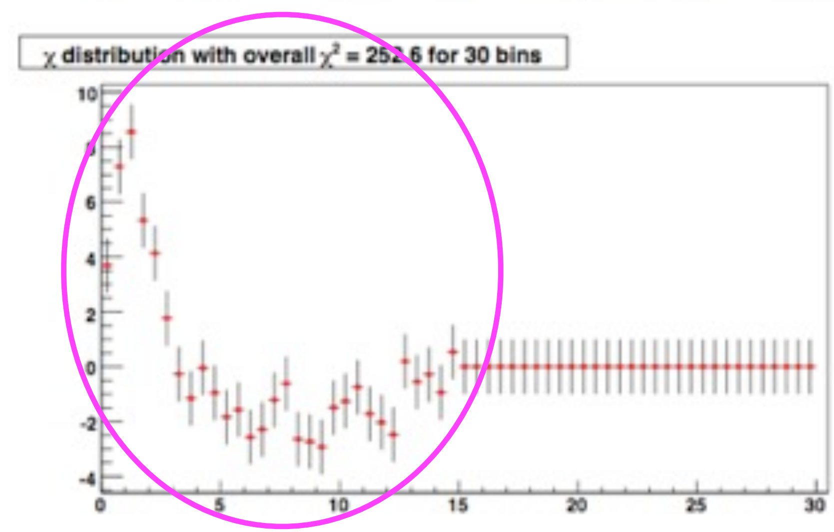
Data W -> e nu

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







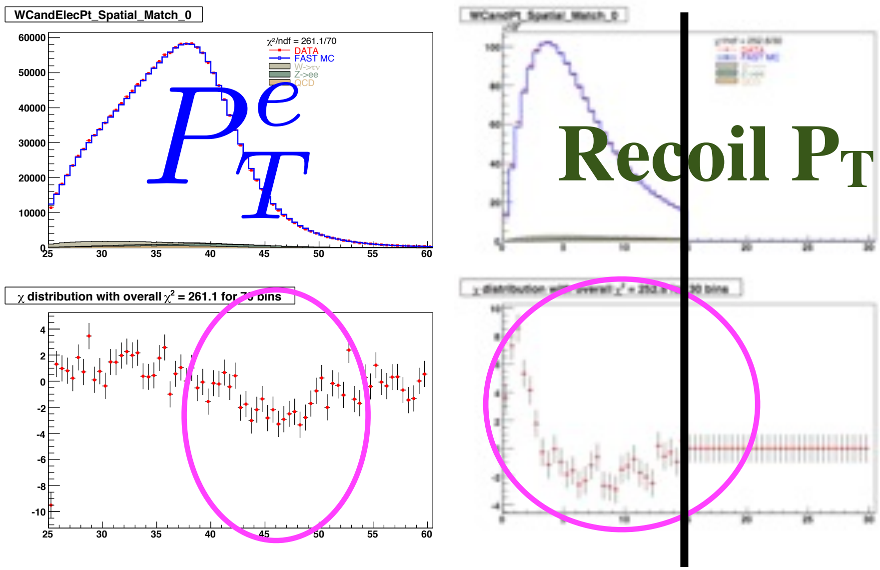


ElecP$_T$ doesn't look nice, because of the Recoil P$_T$

Issue in Data Analysis

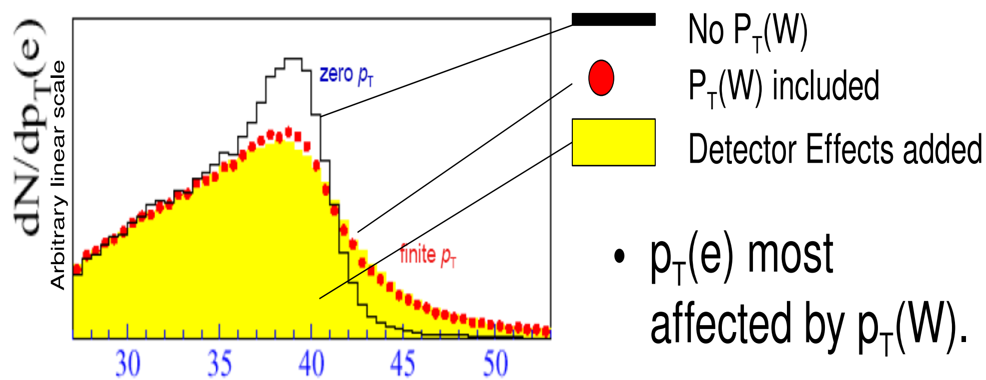
Data W -> e nu

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



Recoil P_T Cut at 15GeV

We know the degradation of the ElecP$_T$ Jacobian peak is due to the boost of the W boson.



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

To investigate this issue:

- 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
- Cannot exclude the possibility that it is directly coming from the same source as the P$_T$(ee) issue discussed before.

Summary

- **FullMC Closure Test Closed!**
- **RunIIb High Inst. Lumi. is a formidable challenge, but we are almost there!**
- **The electron side is almost done, remaining issues related to the Recoil Fine Tuning.**
- **Consistency check is ongoing.**
- **Expected RunIIb (4.3 fb^{-1}) accuracy:**
  - **~25 MeV (Stat. ~13 MeV + Syst. ~22 MeV)**
  - **Plus RunIIa 1 fb^{-1}, Total RunII (5.3fb^{-1}): ~22MeV**