Status of W Mass RunIIb Analysis

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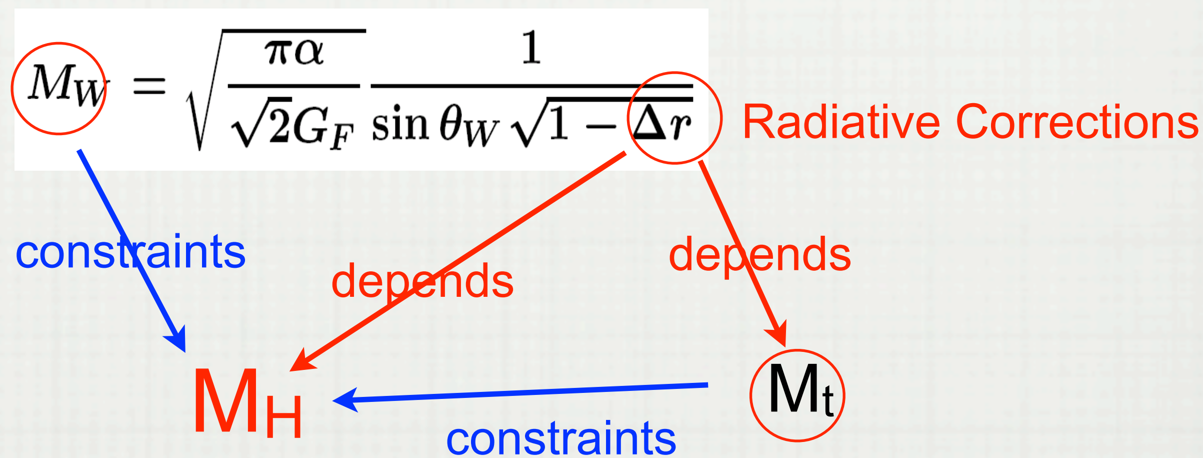
(For the D0 W Mass Group)

Introductory Remarks

- Motivation: Precision measurement of the W mass constrains on the Higgs mass.

$$M_W = \sqrt{\frac{\pi\alpha}{\sqrt{2}G_F}} \frac{1}{\sin\theta_W \sqrt{1-\Delta r}}$$



- For equal constraint on the Higgs mass uncertainty, needs:

$$\Delta M_W \approx 0.006\, \Delta M_t$$

Current Tevatron average:
ΔM_t = 1.3 GeV
equivalent to: ΔM_W = 8 MeV
Currently we have :
ΔM_W = 23 MeV

The limiting factor on the M_H prediction is ΔM_W not ΔM_t

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Results from RunIIa (1 fb^{-1})

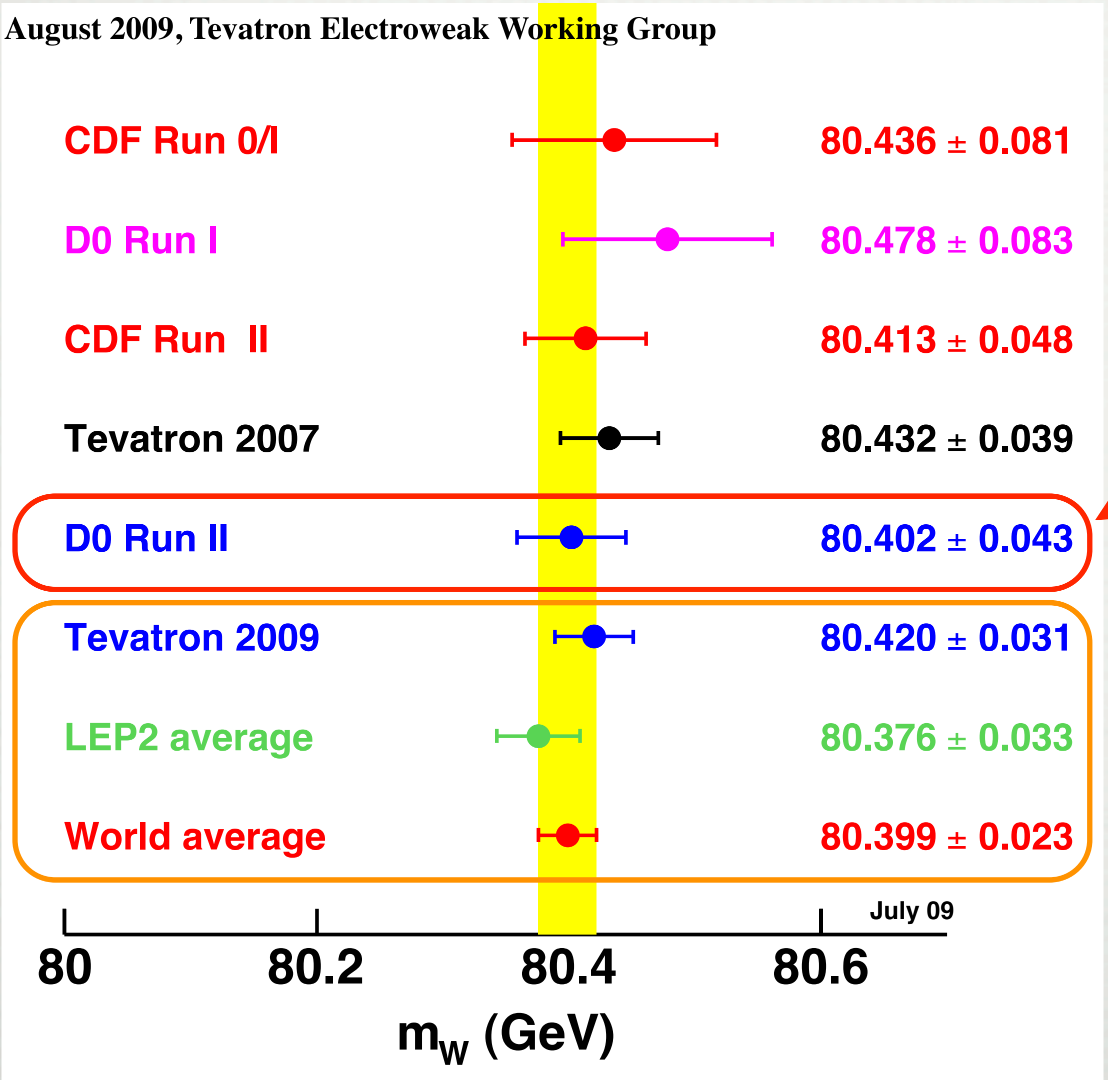
systematic uncertainties

Source	$\sigma(m_W)$ MeV m_T	$\sigma(m_W)$ MeV p_T^e	$\sigma(m_W)$ MeV $\not\!\!E_T$
Experimental			
Electron Energy Scale	34	34	34
Electron Energy Resolution Model	2	2	3
Electron Energy Nonlinearity	4	6	7
W and Z Electron energy loss differences	4	4	4
Recoil Model	6	12	20
Electron Efficiencies	5	6	5
Backgrounds	2	5	4
Experimental Total	35	37	41
W production and decay model			
PDF	9	11	14
QED	7	7	9
Boson p_T	2	5	2
W model Total	12	14	17
Total	37	40	44
statistical	23	27	23
total	44	48	50

$$M_W = 80.401 \pm 0.021(\text{stat}) \pm 0.038(\text{syst})\ \text{GeV}$$

$$= 80.401 \pm 0.043\ \text{GeV}.$$

Current World Average



Single Most Precise Measurement

In good agreement with previous measurements

Potential for RunIIb

Pierre Pétroff

source of uncertainties	1 fb-1	6 fb-1	10 fb-1	
Statistics (MeV)	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 (MeV)	37	18	14	
(if theory unchanged)		20	17	
Grand total (MeV)	44	21	16	(20)

Estimated RunIIb Precision

Estimated D0 RunIIb result with 10 fb^{-1}:
±8(stat) ±14(syst) MeV = ±16 MeV

Now, Combine with CDF, assuming:

- same stat. and exp-syst. error
- stat. and exp.-syst. no correlation;
  theor.-syst. 100% correlation.
- take current center value:
  D0: 80.401 (GeV) / CDF: 80.413 (GeV)

Final Tevatron RunIIb Result:

M_W = 80407 ±6(stat) ±10(syst) MeV
total ± 12 MeV

If take M_W = 80400 ±15 MeV, and M_t error 1 GeV
Higgs mass from EW fit :
71 +24 -19 GeV, < 117 GeV @ 95% CL
With LEP2 exclusion M_H>114 GeV

Strategy of the Measurement

Strategy In a Nut Shell:

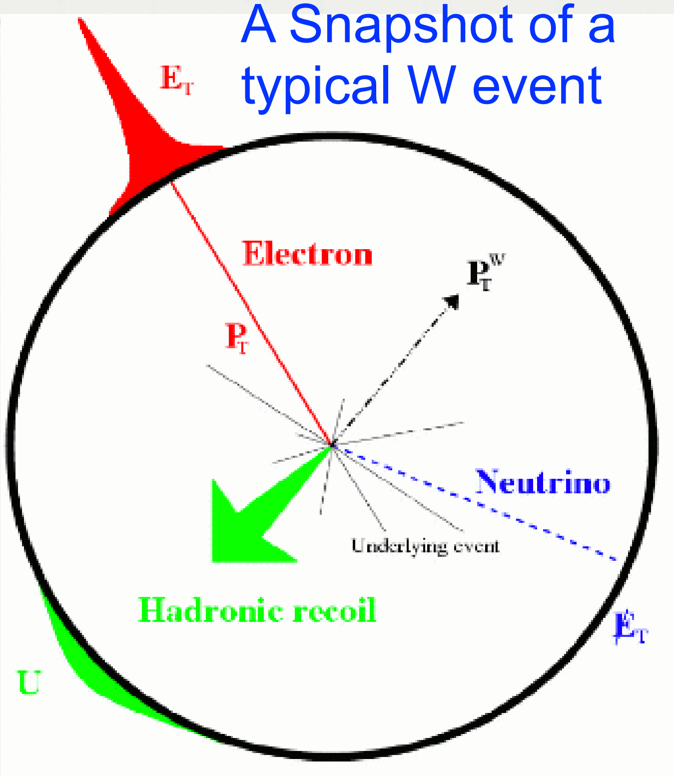
Measure:

Two 2-D vectors in the detector:
- $\mathbf{P_T}$ of the electron
- $\mathbf{U_T}$ Hadronic Recoil

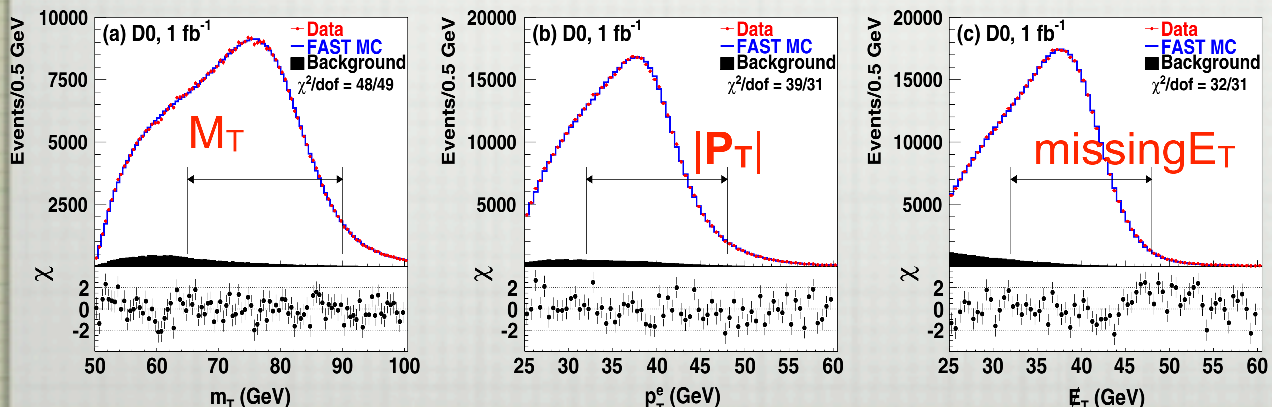
Construct:

Three scalars observables using the two 2D vectors
- M_T : W transverse mass
- $|\mathbf{P_T}|$: of electron
- missingE_T : $|-\mathbf{P_T} - \mathbf{U_T}|$

A Snapshot of a typical W event



Underlying Events:
- Mini Bias (MB)
  - spectator partons in the same ppbar collision
- Zero Bias (ZB)
  - additional ppbar collisions
  - pile-ups from previous collisions



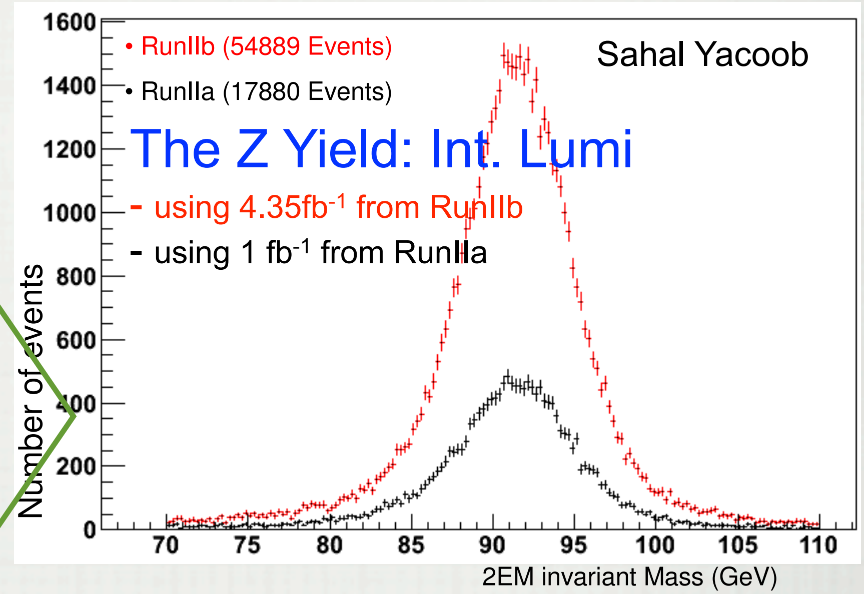
All the three observables have Jacobian Peak:
- **Use template fit to get the W mass**
- **Fast MC to generate templates**

Challenges in RunIIb

The Major change in RunIIb than RunIIa impacts the physics study (so far as I can see) is:

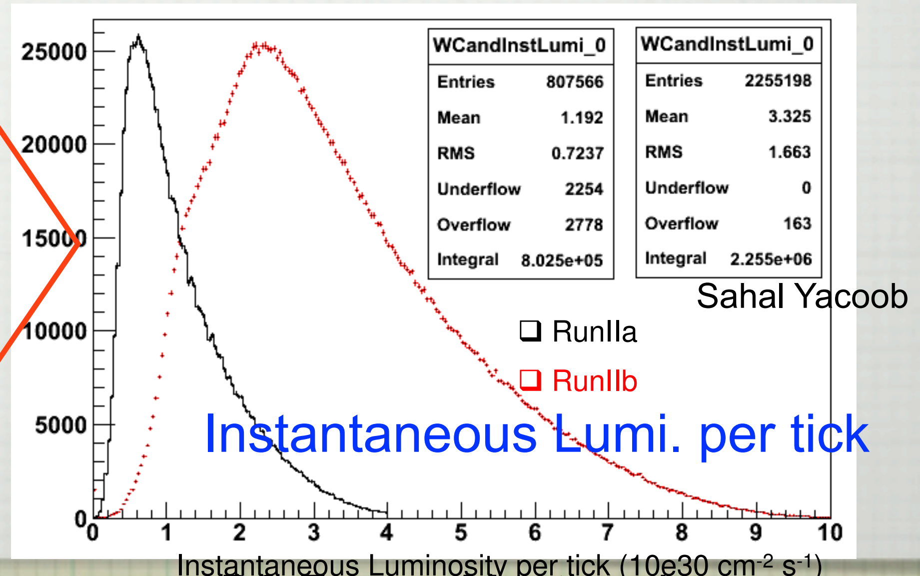
Higher Luminosity of RunIIb in both:

(1) Integrated luminosity: this is good!
- reduce the stat. error (no doubt)
- Increase our Z->ee sample size:
  - decrease the syst. error due to energy scale, efficiencies, etc.,



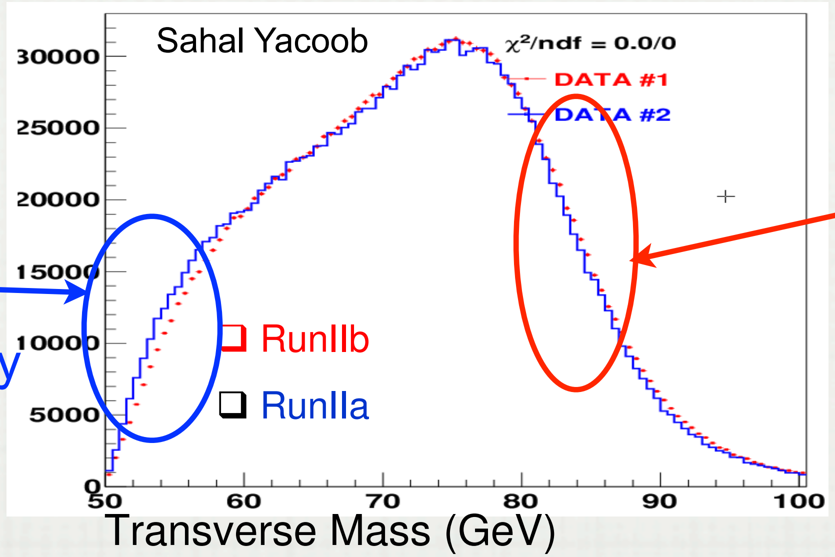
(2) Instantaneous luminosity: this is bad!
- more additional collisions
- more pile-ups from previous collisions

Impacts: Contaminate the signal collision
- lower electron reconstruction efficiency esp. at low P_T
- degrade the resolution of the hadronic recoil

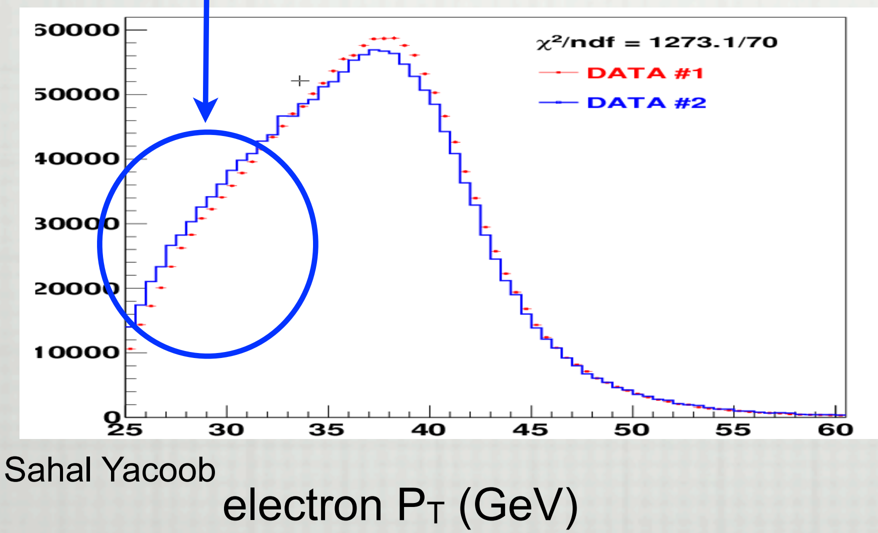


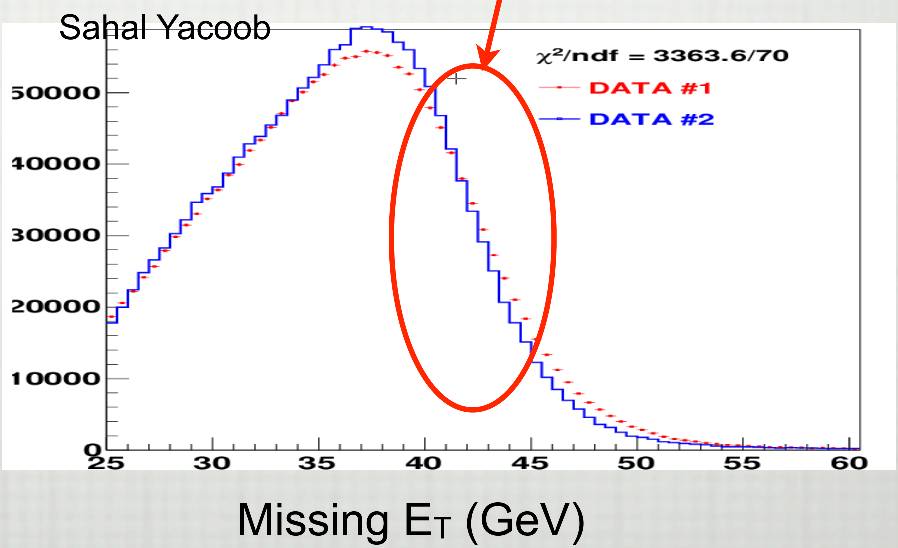
Compare Observables in Run II a and b

Less events for small electron P_T , due to
--- low electron reconstruction efficiency



Less sharp Jacobian Edge, due to
--- degraded resolution of the hadronic recoil

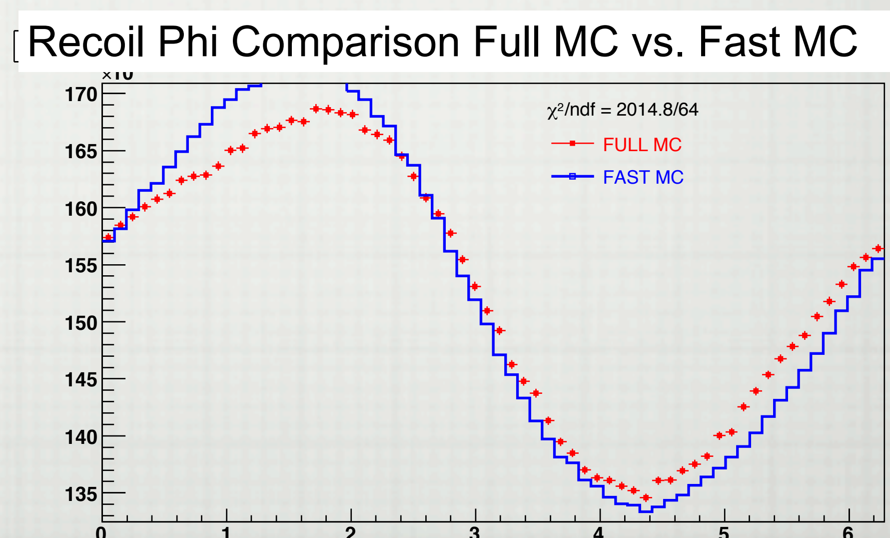




Recoil Modeling of the TB Asymmetry

- Top-Bottom asymmetry: To remove the electronic noise (σ), the Zero-Suppression cut is applied, which is 2.5 σ .But σ of the bottom part of calorimeter is higher than the top part. Thus, the Zero-Suppression is smaller on top part of the Calorimeter and larger on bottom part.
- Impacts the Hadronic Recoil. The hadronic jets deposition in a given Calorimeter cell is mostly very soft. Many energy depositions are just cut away by Zero-Suppression. And more are cut away on the bottom part of the Calorimeter than on the top part.
- More events on top than on bottom.
- Full MC and Fast MC do not mach!
- The Object of this study is to find a good correction (Δ) on the recoil, and implement it in our Fast MC.

  Recoil = Hard + MB +ZB+Δ



- It is one of the not so many remaining issues we still don't understand, it indeed affects many of our control plots.

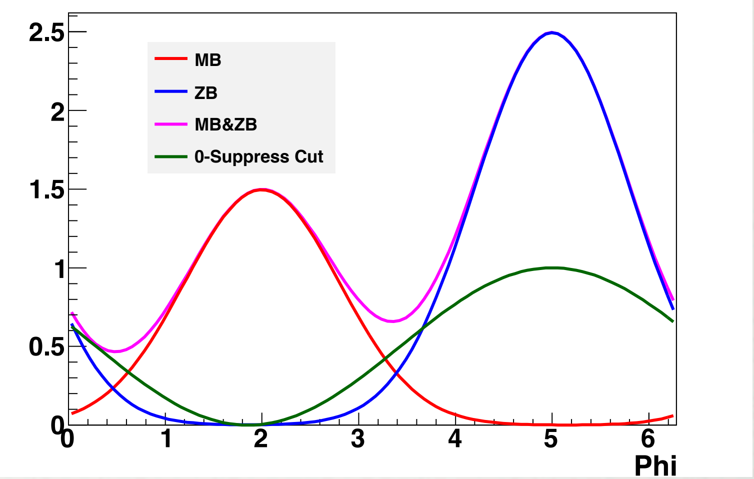
Recoil Modeling of the TB Asymmetry

- The work starts with only the MB and ZB

Figure on right, illustrates the MB and ZB energy flows over the Phi angle, and the Zero-Suppression

There are regions where individual MB or ZB cannot pass the 0-Suppression, while the sum of them can pass!

for illustration only



Now:

- In Full MC, the overlay of the MB and ZB, defined as MB&ZB.

- In Fast MC, treat the MB and ZB separately, and add them up in the end, defined as MB+ZB.

Thus a correction is needed to recover the missing part:

i.e. (MB+ZB) + correction = MB&ZB

Recoil Modeling of the TB Asymmetry

- MC/Data Samples used in this study:

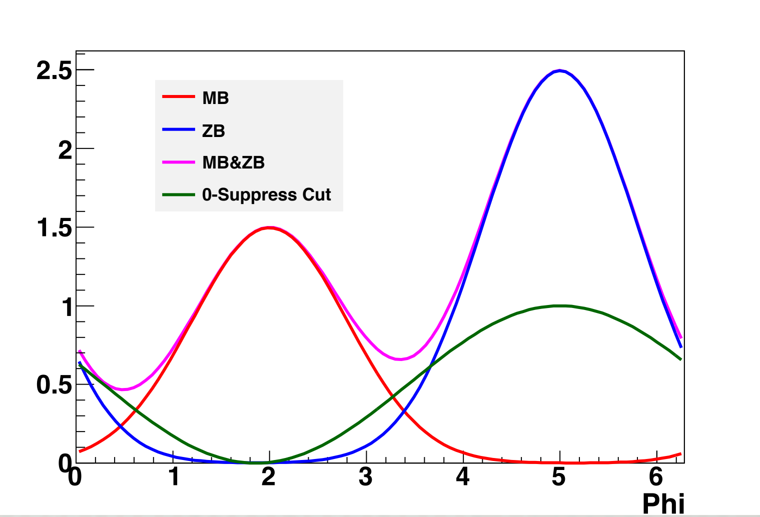
MB only : Pythia generated MB with Full Simulation
-> Reconstruction (0-sup)

ZB only : Real Data w/o Zero-Suppression
-> convert to Faked-Simulation
-> Reconstruction(0-sup)

MB&ZB : overlay ZB Faked-Simulation with MB Full Simulation
-> Reconstruction(0-sup)

MB+ZB : Sum of MB only and ZB only, which have already been 0-suppressed.

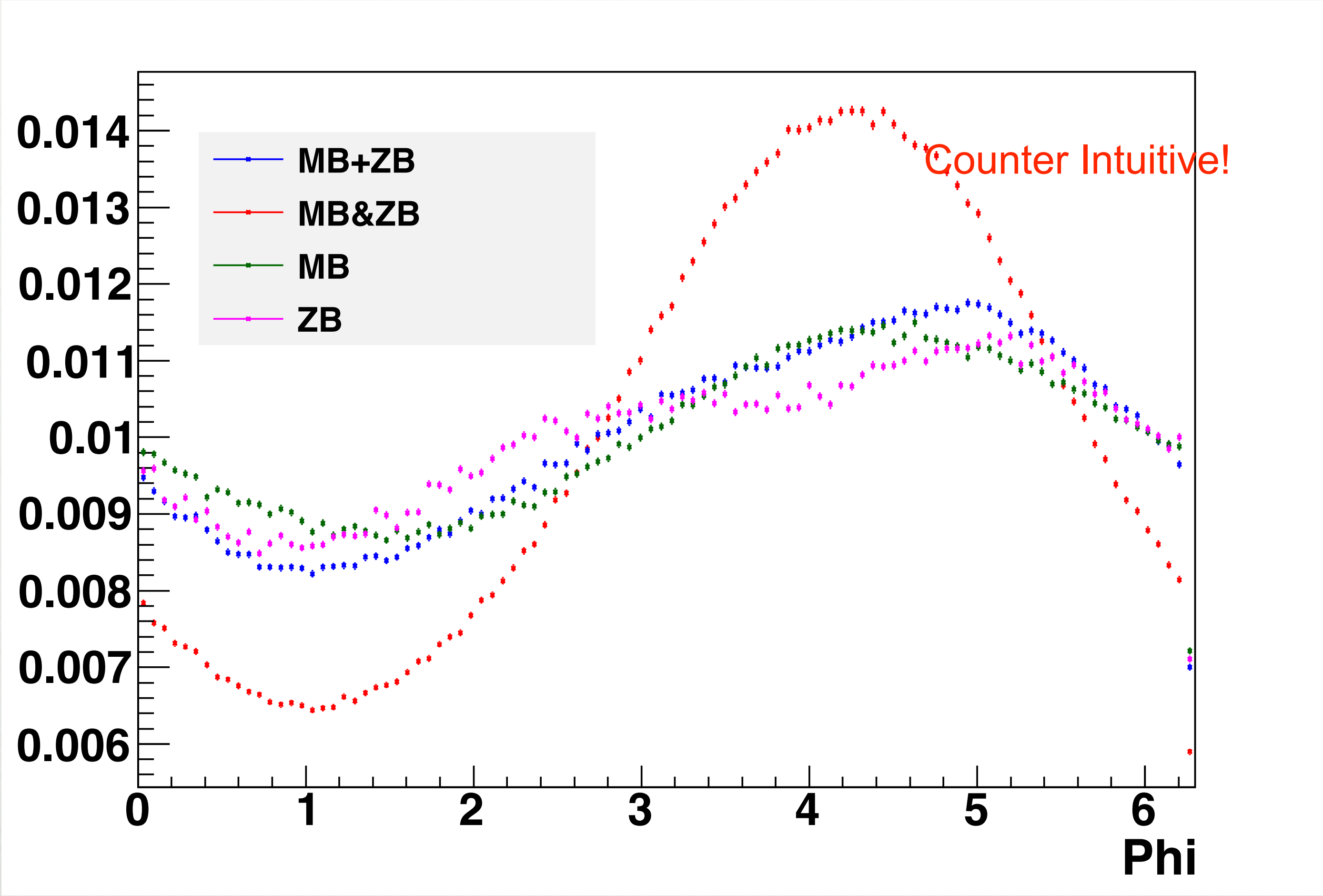
- If compare MB+ZB and MB&ZB, I expect MB&ZB is more evenly distributed than MB+ZB
- Because MB&ZB should be less affected by the 0-suppression



Recoil Modeling of the TB Asymmetry

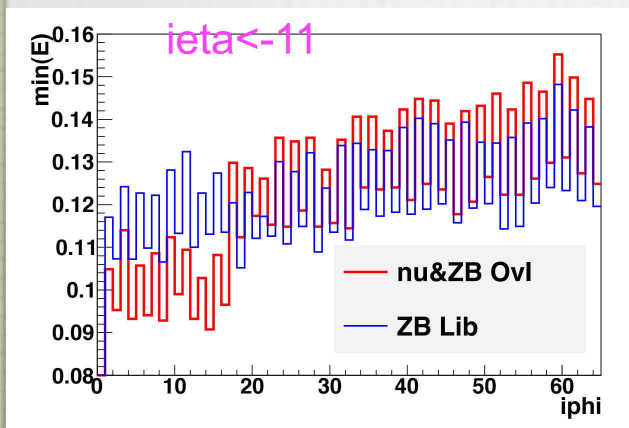
MB&ZB has much larger wave amplitude than MB+ZB !

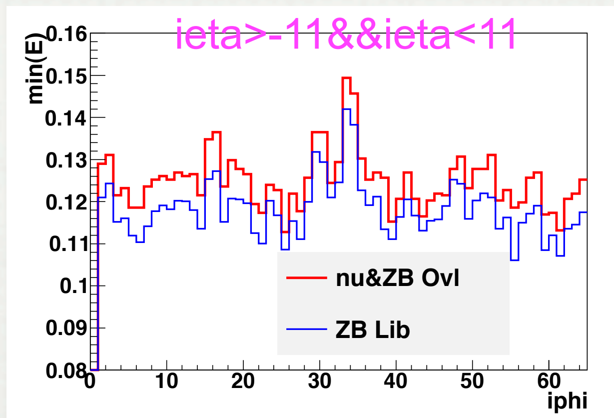
Opposite to our prediction!

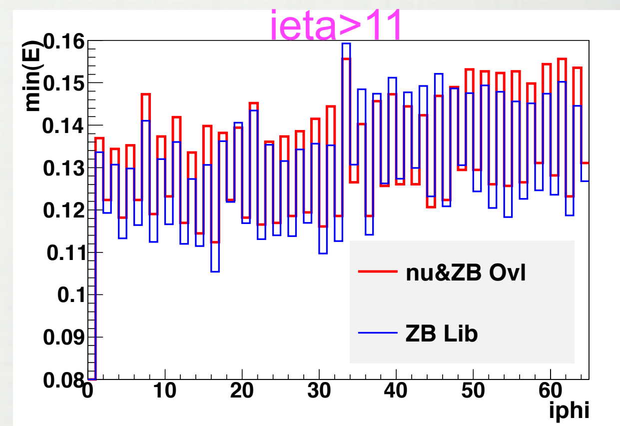


Recoil Modeling of the TB Asymmetry

Take a cell level study: got the Zero-Suppression cuts







The Zero-Suppression cuts are not the same! It is apparently a bug!

Then Jan dig into the codes, identified and corrected this bug.

The bug is due to the different σ values used in ZB overlay (wrong) and in building the ZB library (correct).

This bug affects ALL Our Full MC Samples! We have to re-do all our production.

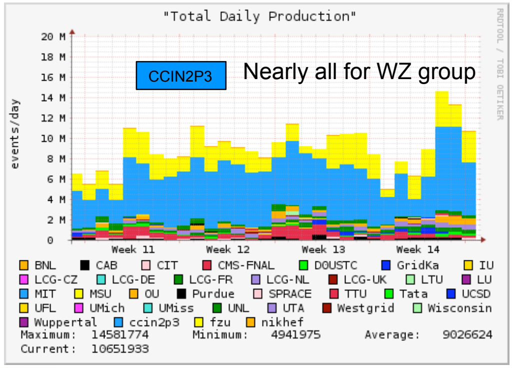
New Full MC Production

Thanks to Patrice LEBRUN, Tibor KURCA and the CC-Lyon for the tremendous work to get our large samples done in record time.

P20.09.08 D0sim+D0reco on P20.09.03 Wenu D0gstar files with unsupp. ZB overlay (wmass_runIIb_forMC_Unsupp_ZBOverlay_all)

- Procssed at CCIN2P3
- ~ 53 M of events produced
- The last ~ 9.6 M will be produced by next Friday
- That means about 63 M of Wenu with p20.09.08 will be available
  - I'll give the exact number of events when the all production will be done
    - Due to one tape issue some D0gstar files are missing (357 Kevents). Maybe not definitely lost.
- Details:

p20.09.03	->	p20.09.08
108177 - 108181	->	116732 - 116736
108562 - 108580	->	116792 - 116800 , 116810, 116812, 116815, 116818, 116820, 116823, 116826, 116828, 116830, 116832
108581 - 108611	->	117012 - 117042
108161 - 108176	->	117043 - 117058
108182 - 108191	->	117572 - 117581
107962 - 107971	->	117582 - 117591
89881 - 89887	->	117592 - 117598
89627 - 89631	->	117599 - 117603
89612 - 89616	->	117604 - 117608
89472 - 89476	->	117609 - 117613
89212 - 89216	->	117614 - 117618
88612 - 88616	->	117619 - 117623
105012 - 105029	->	117624 - 117641
105030 - 105130	->	117772 - 117872
105131 - 105201	->	118012 - 118082



Patrice lebrun 2

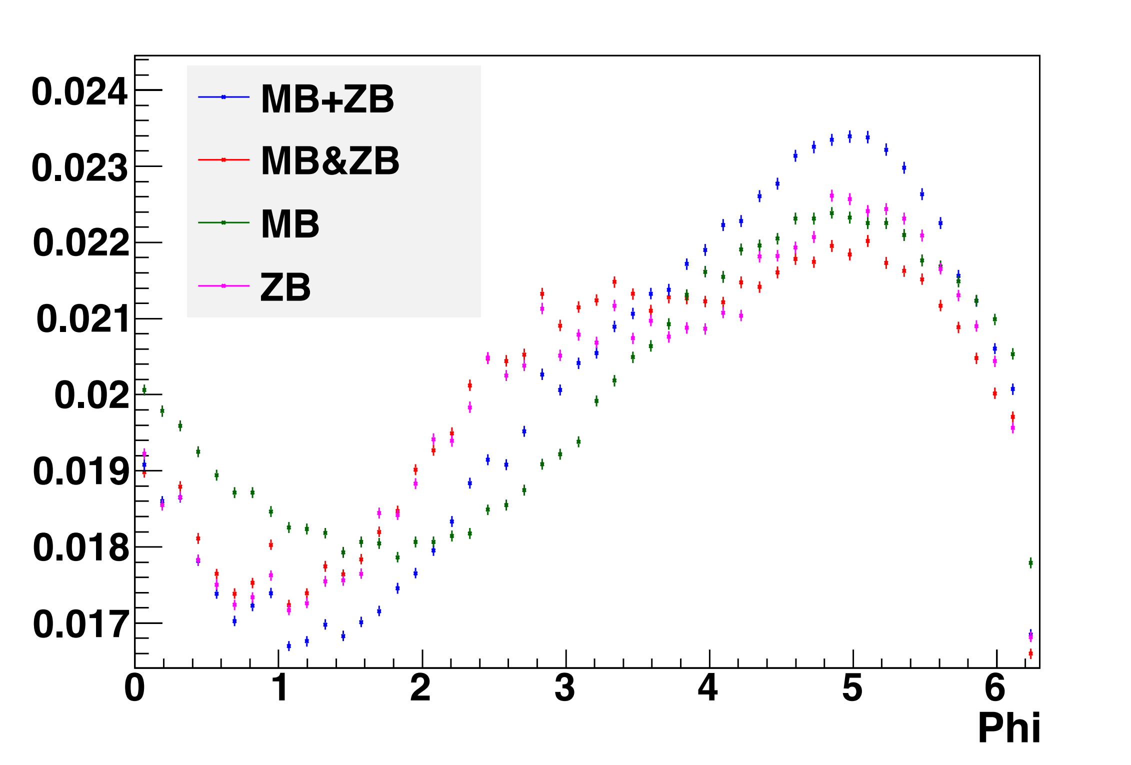
After bug-fix

After the bug-fix, with the new Full MC, many parameters in our Fast MC are affected. Fitting to update these new parameters is going on.

On the TB asymmetry correction: MB&ZB is more even distributed than MB+ZB

The work is still going on...

One of the interesting signature is the MB&ZB is more similar to ZB only, which is not yet fully understood.



Summary and Outlook

- RunIIa result is published, the most precise single experimental result

- Expect a precision of 21MeV of M_W with RunIIb 6fb^{-1}

- Major difference of RunIIb compared to RunIIa is Higher luminosity:
    - Higher integrated luminosity increases the precision
    - Higher instantaneous luminosity introduces more ZB, degrades the recoil resolution, and reduces electron reconstruction efficiency

- TB asymmetry correction for the Hadronic Recoil Model is an urgent topic to be finalized.

- During the work of TB asymmetry correction, a bug in ZB overlay is identified, which affects all our Full MC

- New Full MC is done: Thanks to Patrice LEBRUN, Tibor KURCA and CC-Lyon for the tremendous work

- Updating the parameters in Fast MC is going on based on the bug-fix new production.