# W Mass Measurements from the Tevatron

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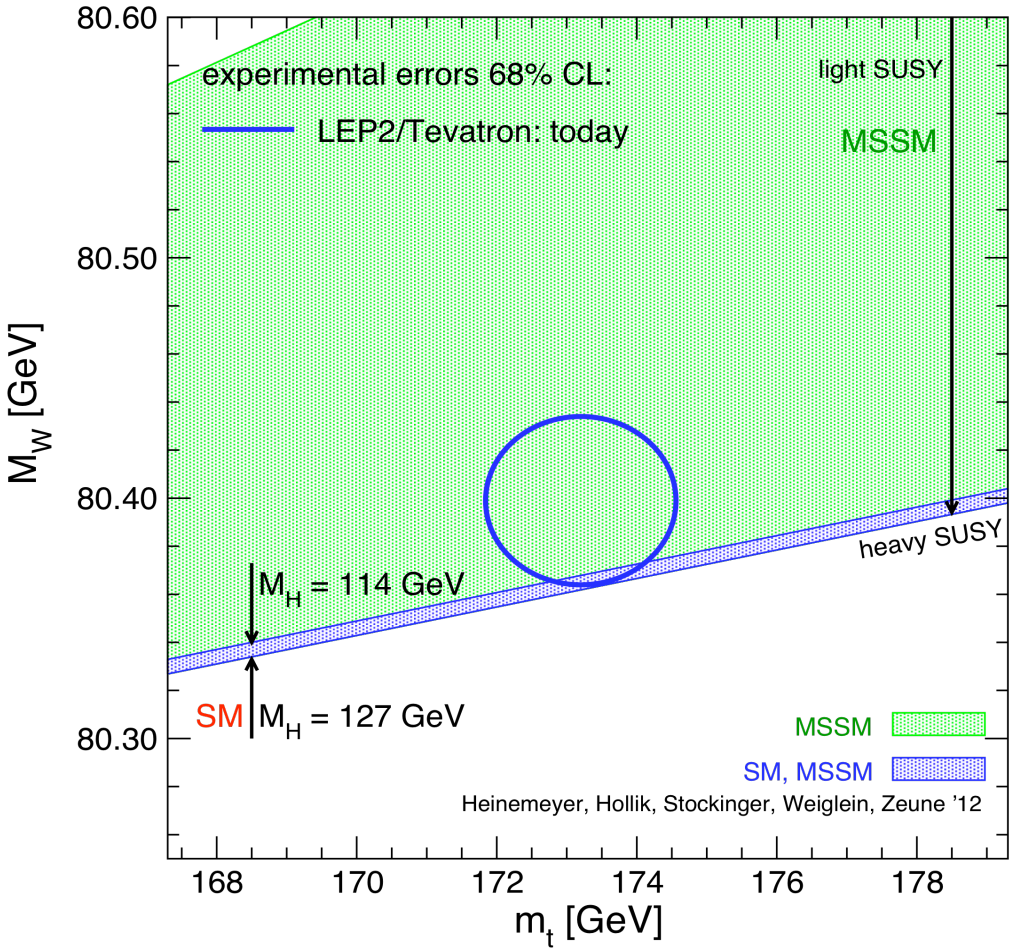
On Behalf of the CDF and DØ Collaborations

# Why Measure the W Mass?




(Using WA $m_W$ excluding the two new Tevatron W mass results)

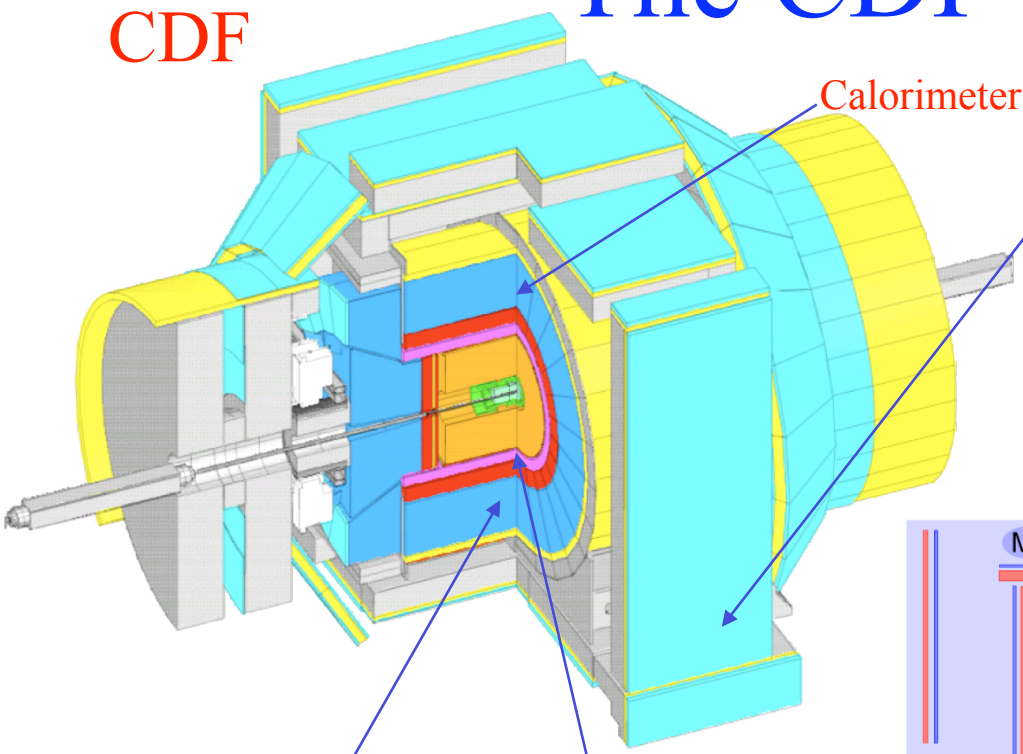
Test of the Standard Model.

As an indirect constraint on the Higgs mass.

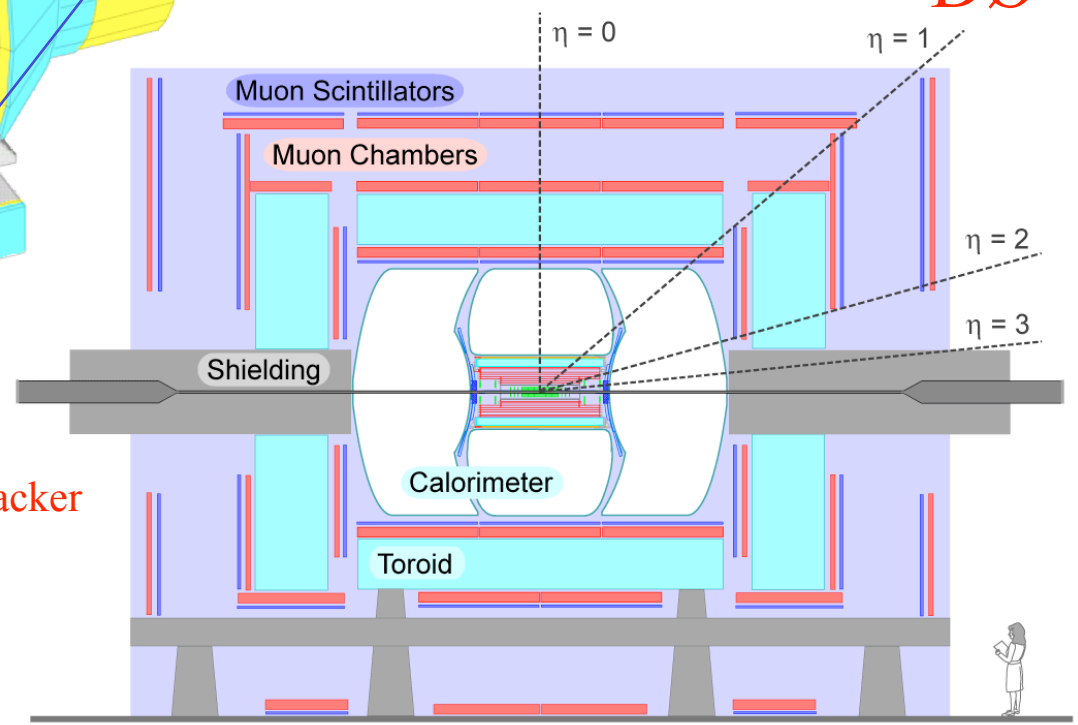
If LHC discovers Higgs, can compare indirect and direct mass measurements for indications of beyond the Standard Model physics

# The CDF and DØ

CDF

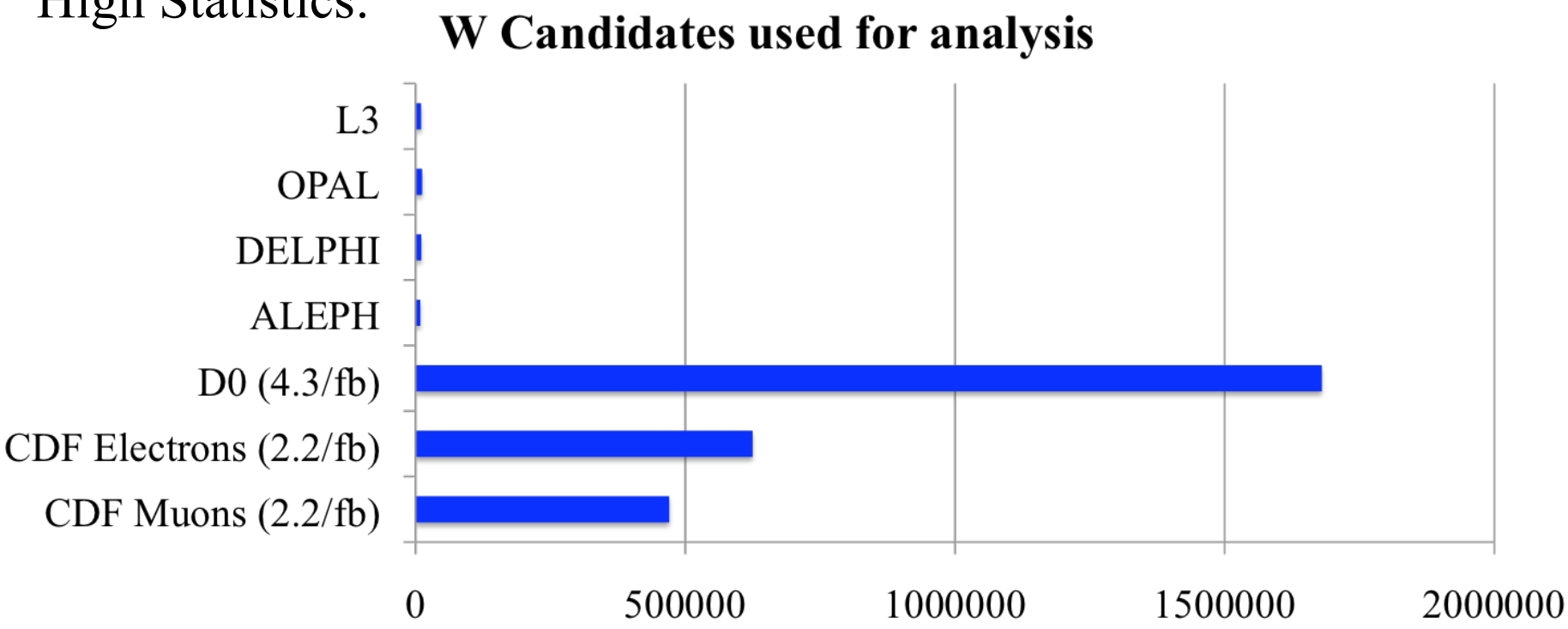



DØ



# Why Measure the W Mass at the Tevatron?

High Statistics:

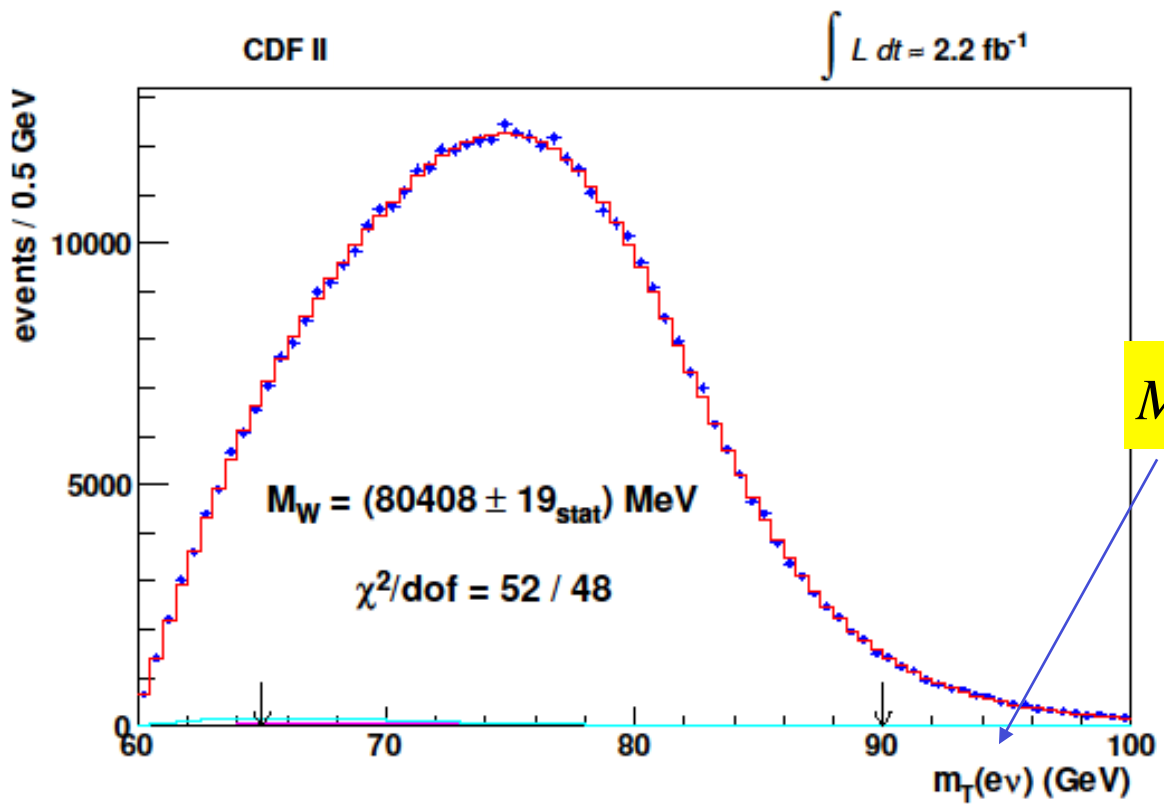



Combining bespoke detector simulation and extensive study can produce competitive systematics despite ‘messy’ hadronic collisions

# How to Measure the W Mass?

Two Channels: $W \rightarrow e\nu_e$ $W \rightarrow \mu\nu_\mu$

Template Fitting Procedure:

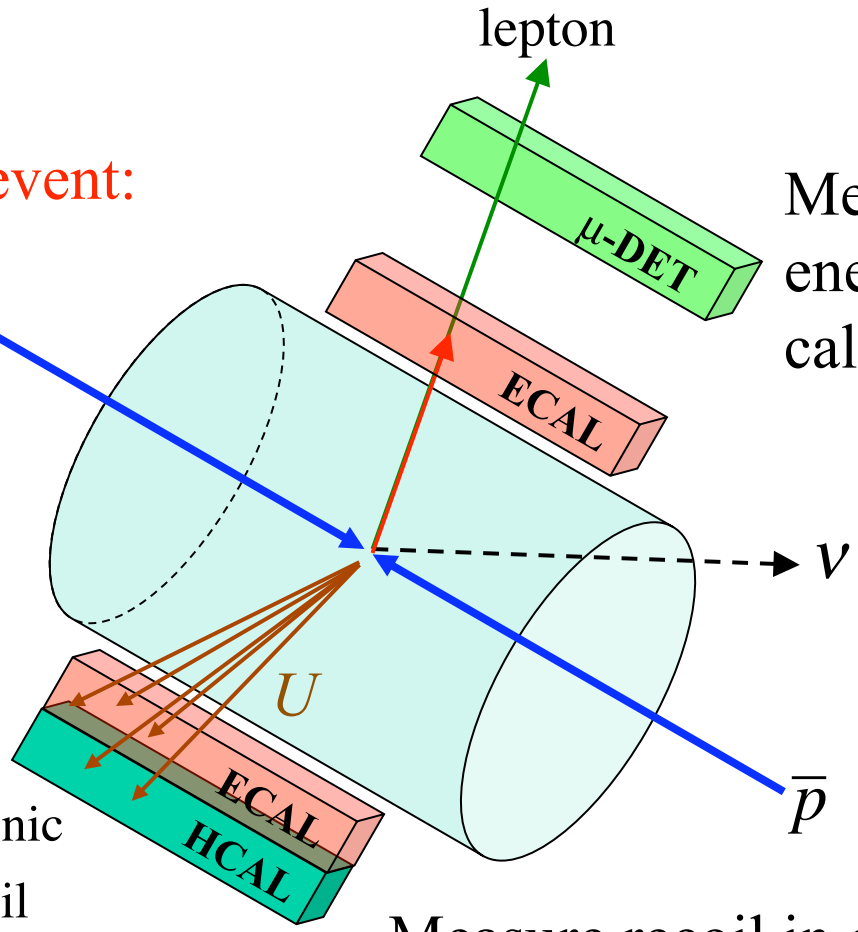



$$M_T = \sqrt{2 p_T^l E_T^{miss} (1 - \cos\Delta\phi)}$$

"Transverse mass of the W boson"

# What do we require for $m_T$ fits?

A typical W event:




Measure electron energy in the calorimeter

Measure muon momentum in the tracker

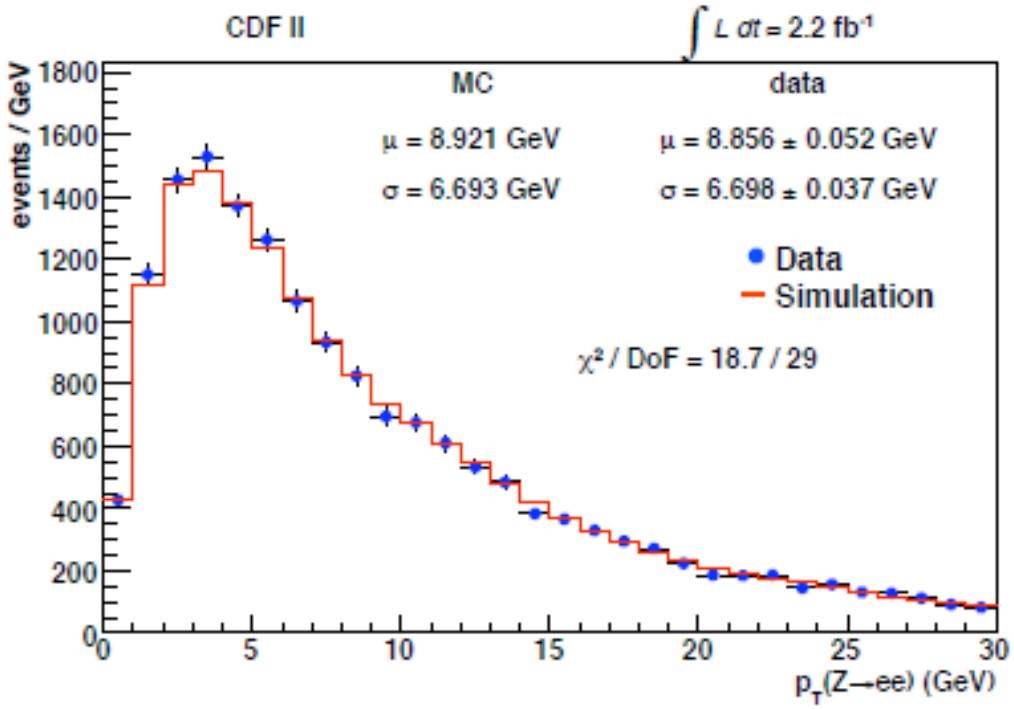
hadronic recoil

Measure recoil in calorimeter to calculate missing energy

# Event Generation

Basic Generator: RESBOS

NLO QCD Corrections: RESBOS + parameters tuned to Z data



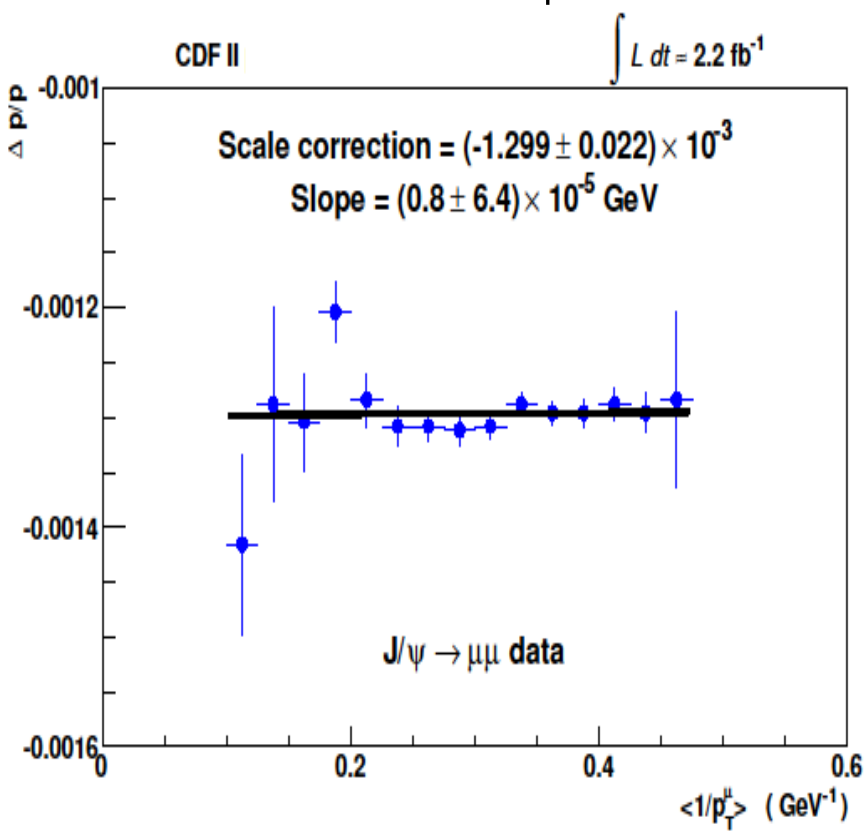

NLO QED Corrections: PHOTOS + comparison to HORACE or WGRAD/ZGRAD

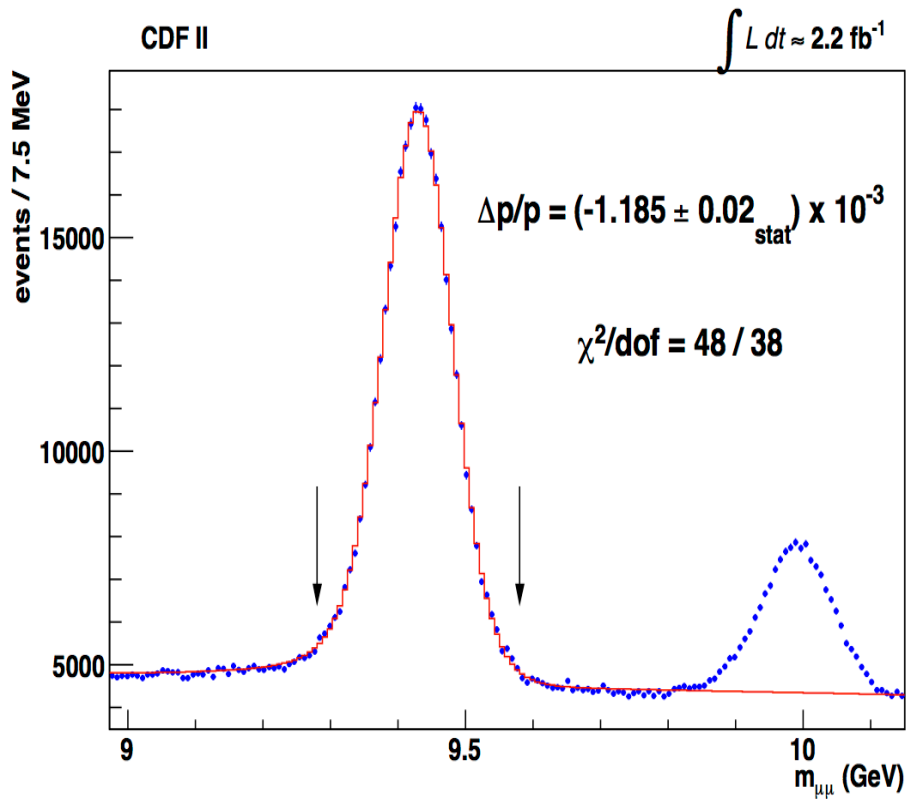
# CDF Momentum Scale Calibration

Precisely align COT using cosmic ray data

Set overall momentum scale by fits to J/ψ , ϒ and Z data

Have sufficient J/ψs to break into $<1/p_T>$ bins for a material scale fit



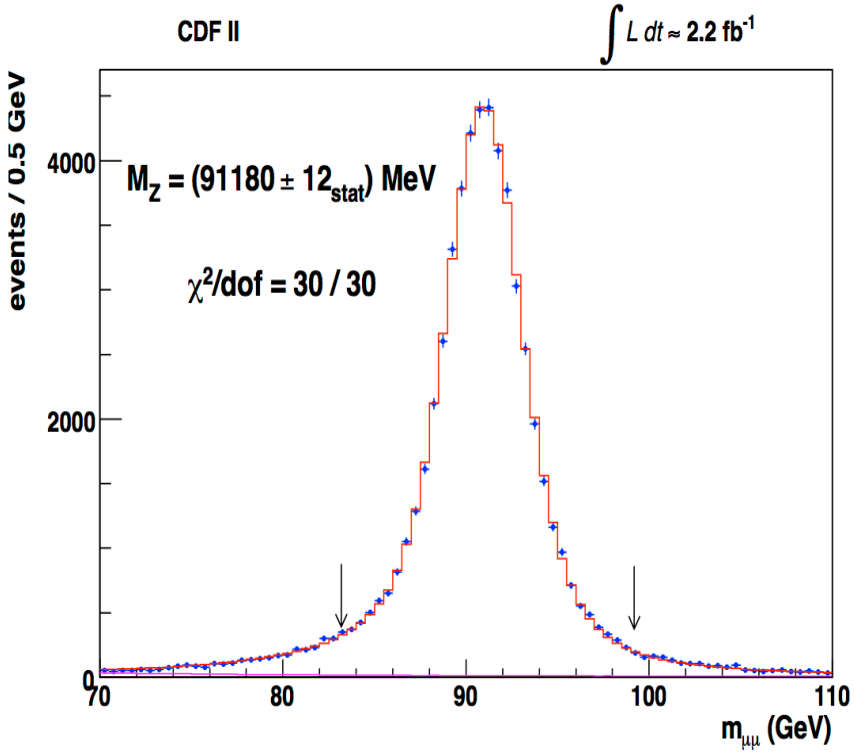
# Testing the Momentum Calibration

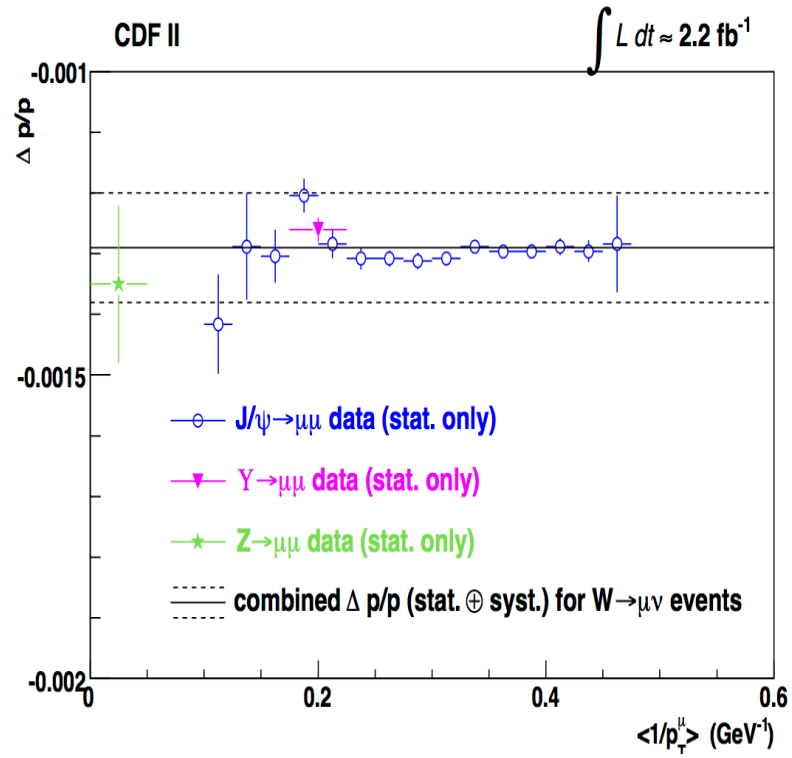
Measure $Z \rightarrow \mu\mu$ mass using just J/ψ and ϒ contributions:

$M_Z$ = 91180 +/-16

(WA is 91187 +/-0.002, this is consistent!)

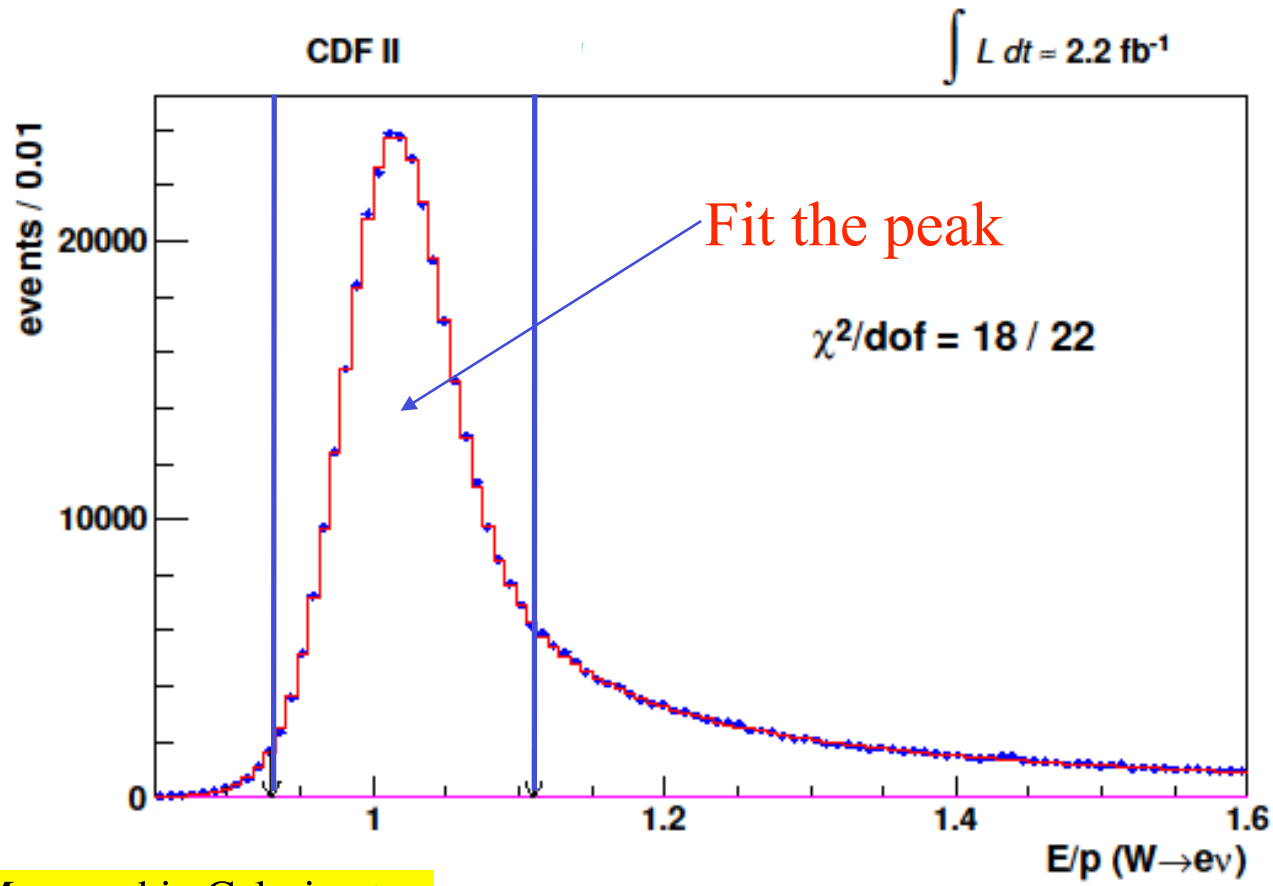
Then incorporate $Z \rightarrow \mu\mu$ mass fit as a final contribution



# CDF Energy Scale Calibration I

Use both:

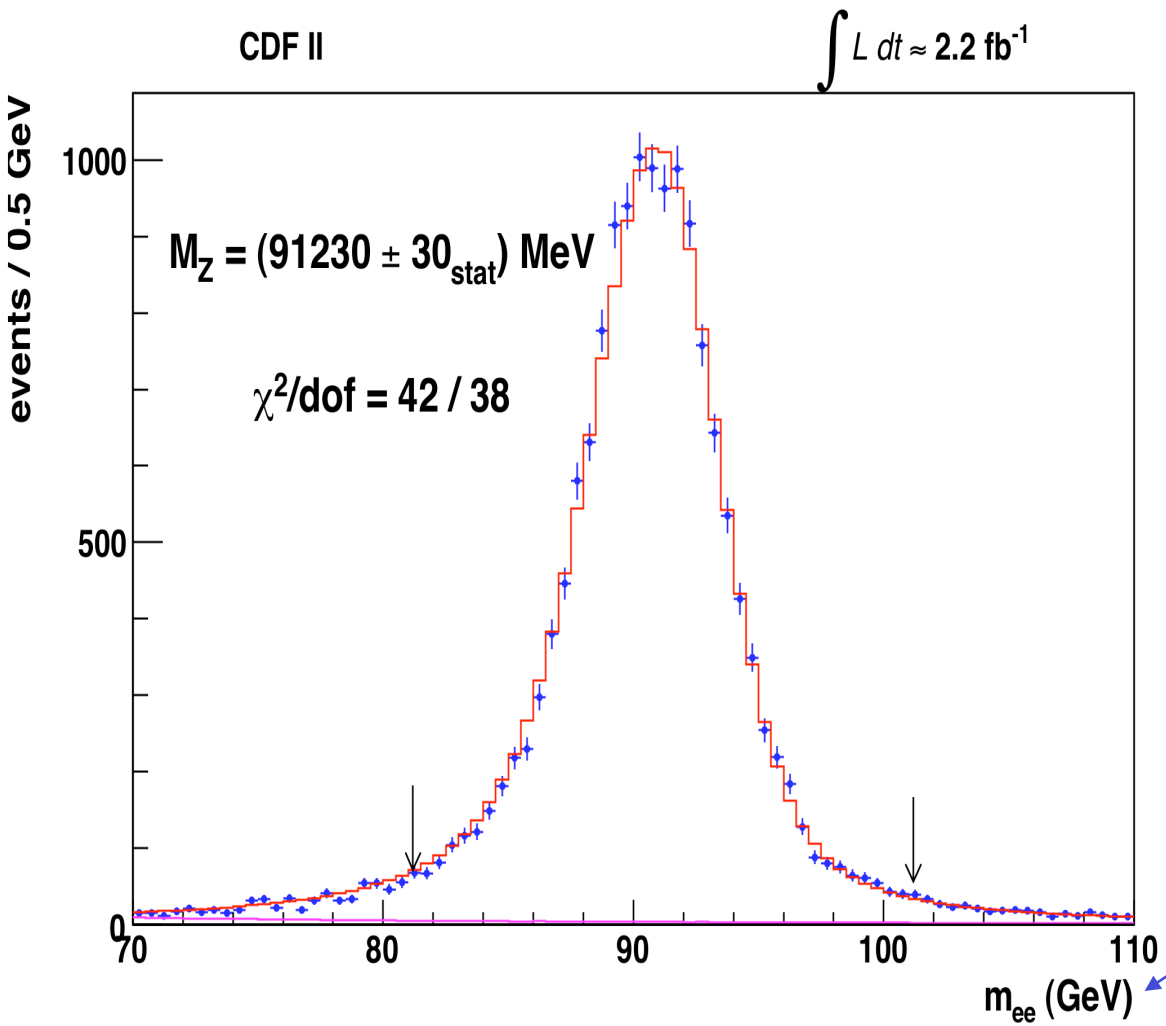



$$E/p = \frac{\text{Electron Energy Measured in Calorimeter}}{\text{Electron Momentum Measured in Tracker}}$$

Momentum measurement uses precise momentum scale calibrations described previously

# CDF Energy Scale Calibration II

And:




Use E/p calibration make a $M_Z$ measurement.

Result:

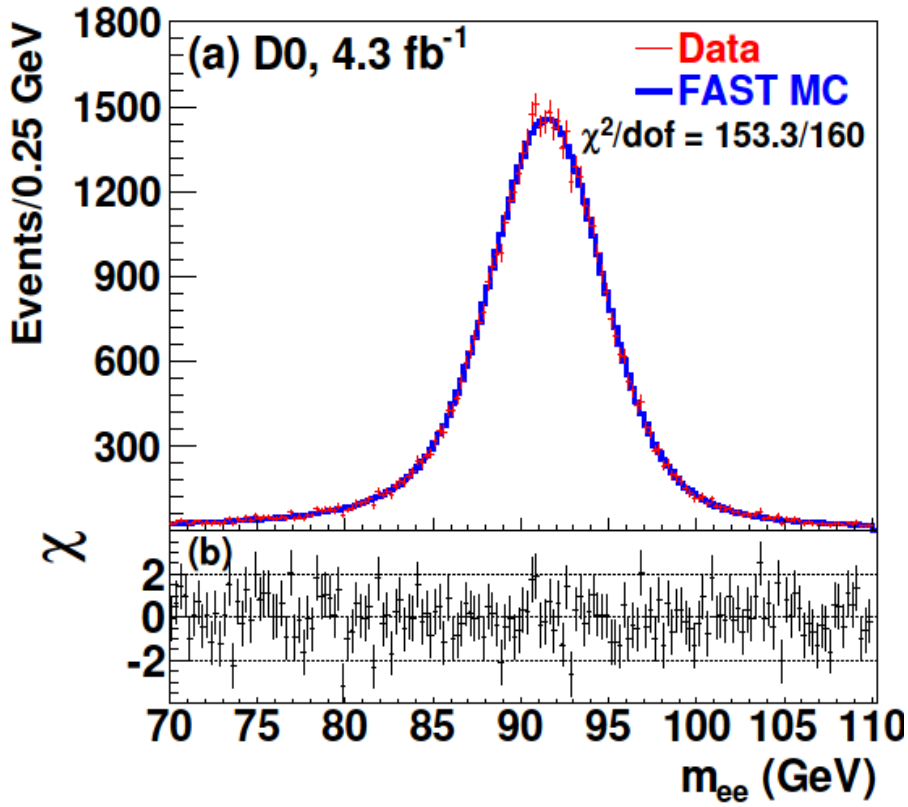
$m_Z$ = 91230 +/- 33 MeV

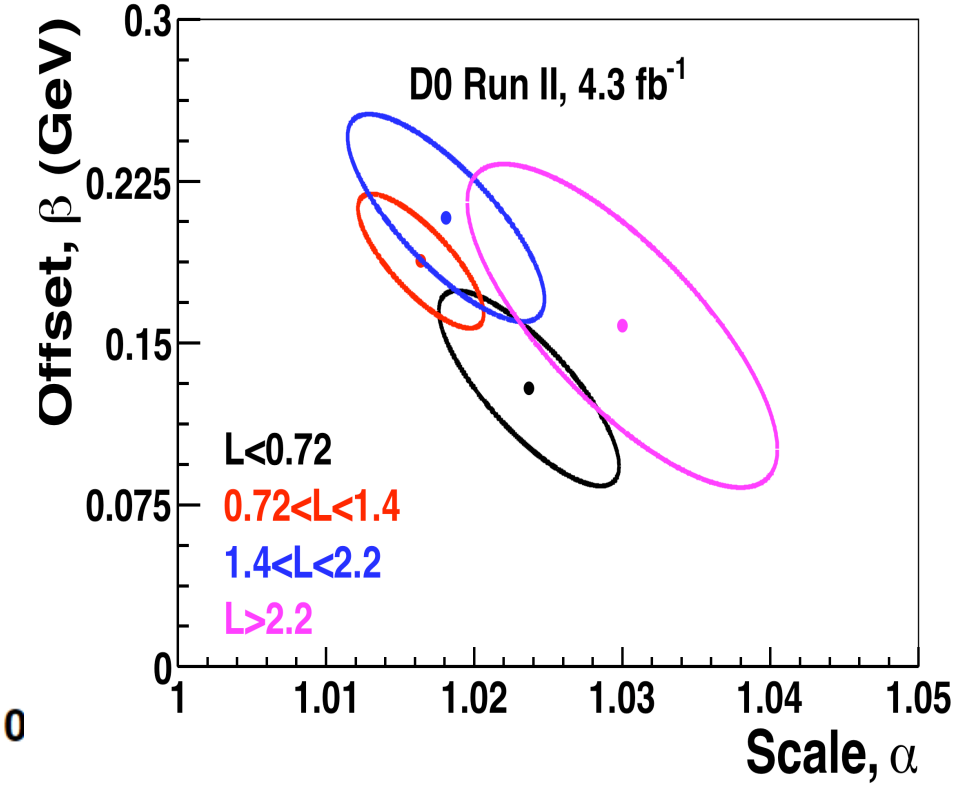
(WA is 91187 +/- 0.002, this agrees with WA)

Then combine both methods to obtain a final energy scale

Calorimeter Z mass

# DØ Energy Scale Calibration

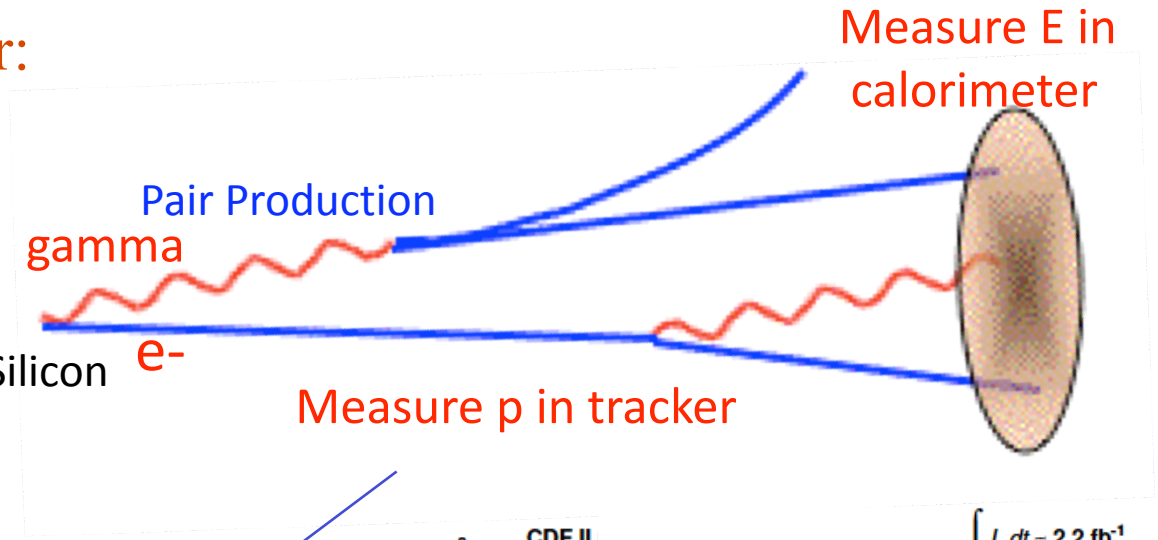



$$E_{\text{Measured}} = \alpha(E_{\text{True}} - < E_{\text{True}} >) + \beta + < E_{\text{True}} >$$

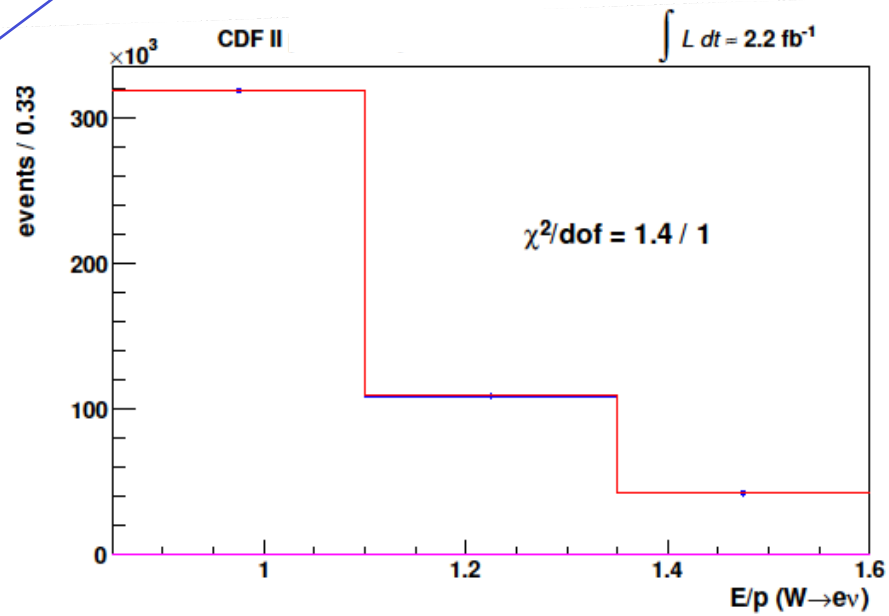
# Material Scale Determination

In Tracker:




Bremsstrahlung in Silicon tracker

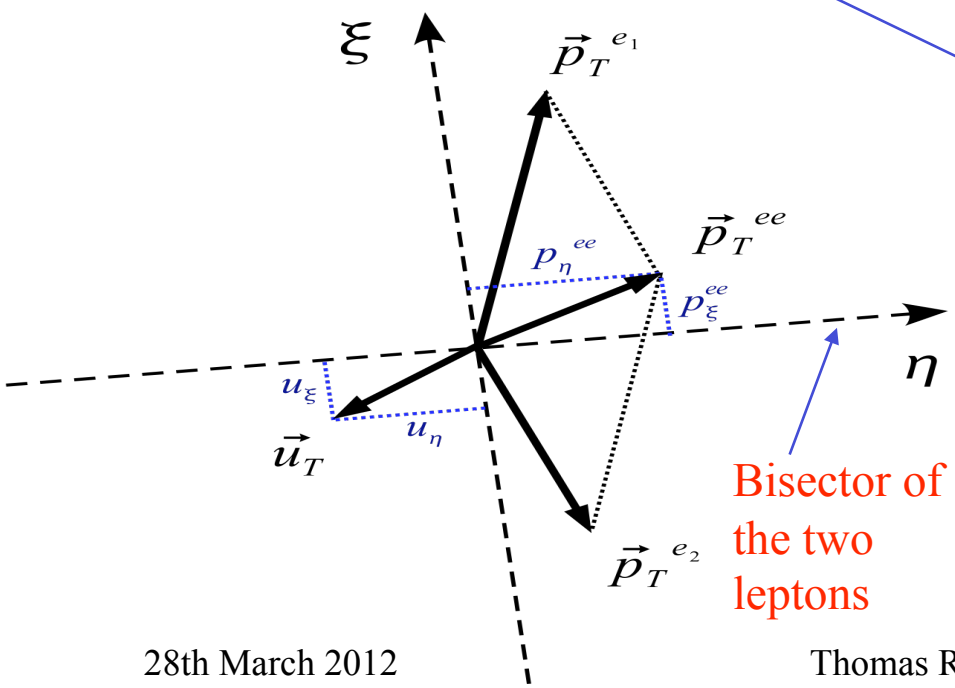
Use radiative tail of E/p fit to determine material scale

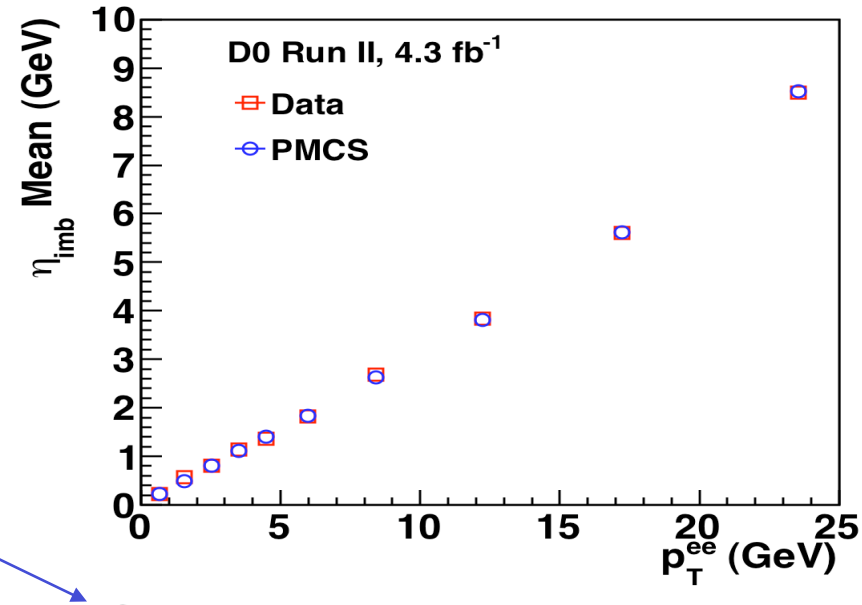


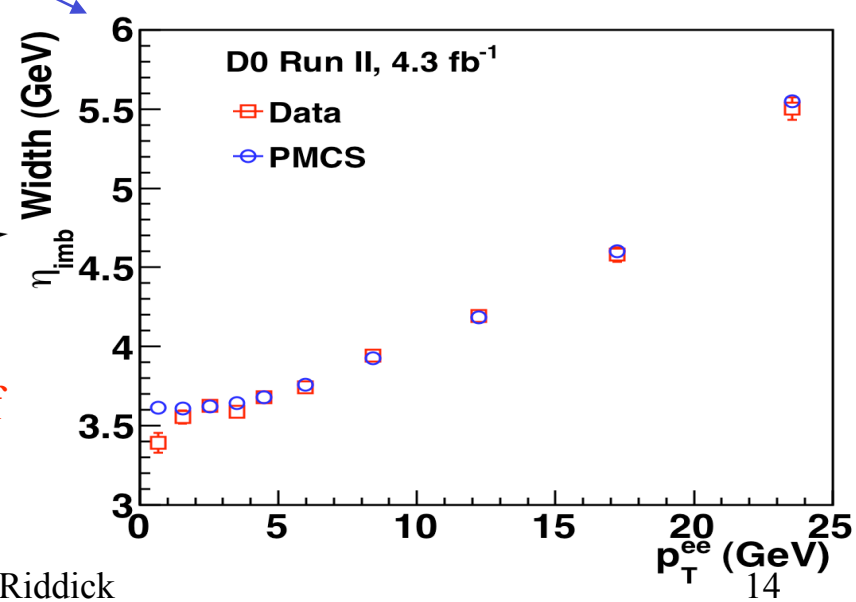
# Recoil Simulation

Define recoil as all the energy in the transverse plane not associated with the lepton

Modelling using parameterisation tuned on min bias and Z data



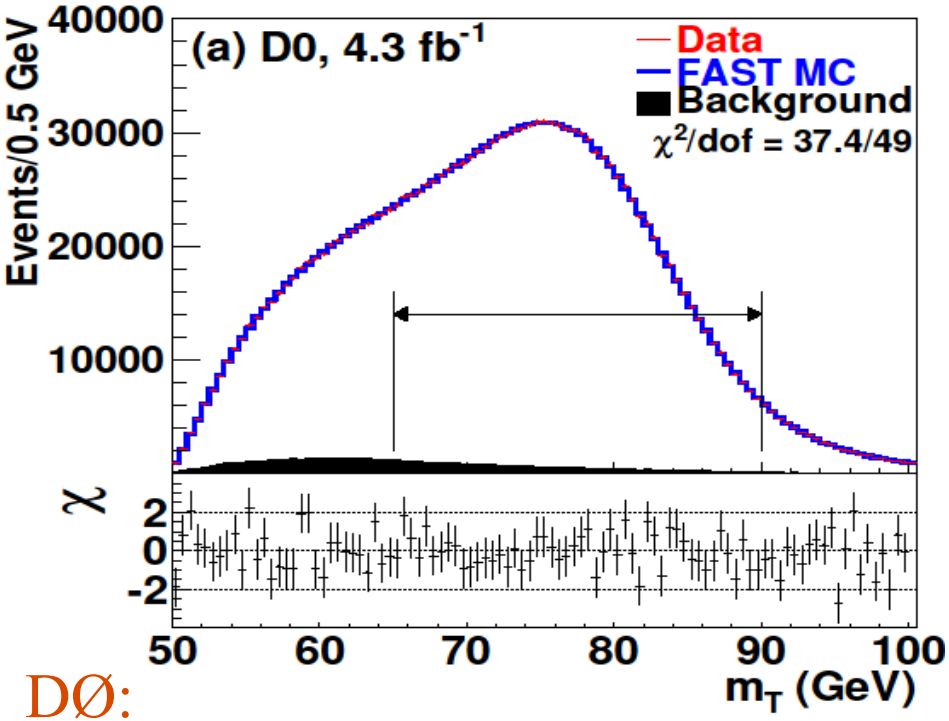



# Uncertainties

| Uncertainty Source | Total CDF Uncertainty (MeV) | DØ Uncertainty (MeV) |
|---|---|---|
| Energy (and Momentum) Scale Calibration and Resolution | 7 | 17 |
| Recoil Model | 6 | 5 |
| Efficiencies | - | 2 |
| Backgrounds | 3 | 2 |
| **Experimental Sub Total** | **10** | **18** |
| PDFs | 10 | 11 |
| QED | 4 | 7 |
| Boson Pt | 5 | 2 |
| **Production Sub Total** | **12** | **13** |
| **Total Systematic** | **15** | **22** |
| **W sample statistics** | **12** | **13** |
| **Total** | **19** | **26** |

# Results

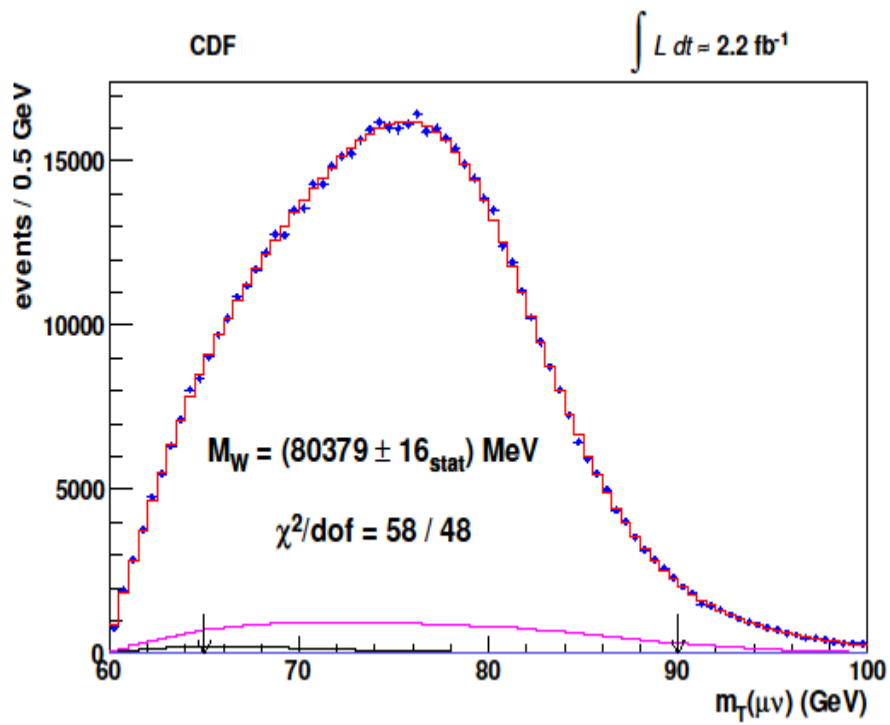



Add in $p_T^l$ (and $p_T^\nu$ too at CDF) for additional statistical precision

CDF:

$$M_W = 80387 \pm 19 \text{ MeV}$$

arXiv:1203.0275




DØ:

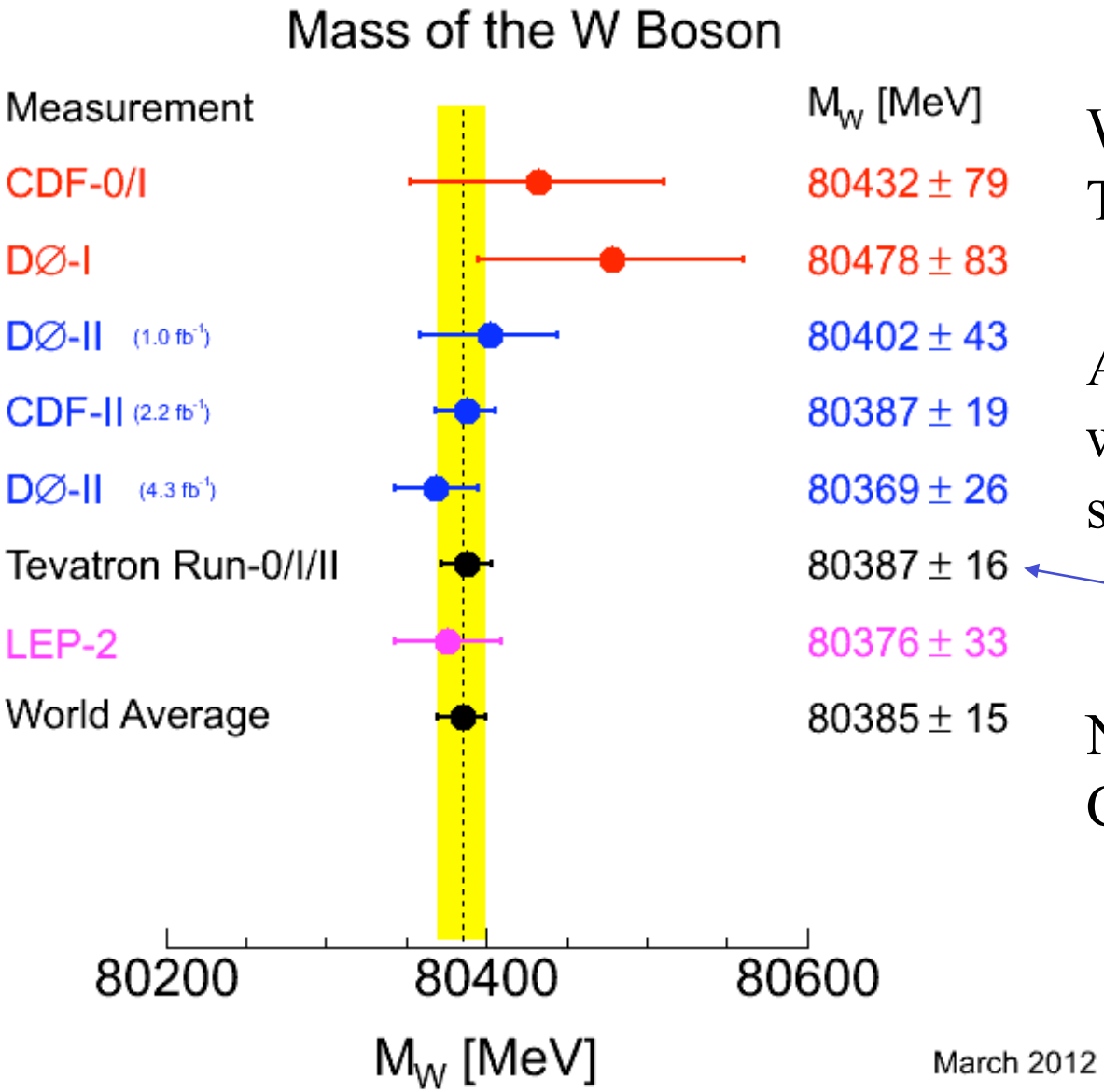
$$M_W = 80367 \pm 26 \text{ MeV}$$

arXiv:1203.0293

Combining with previous measurement (on 1/fb) by DØ:

$$M_W = 80375 \pm 23 \text{ MeV}$$

# New World Average




With the two new Tevatron results!

All results are re-weighted to the same W width value

10 MeV from PDFs

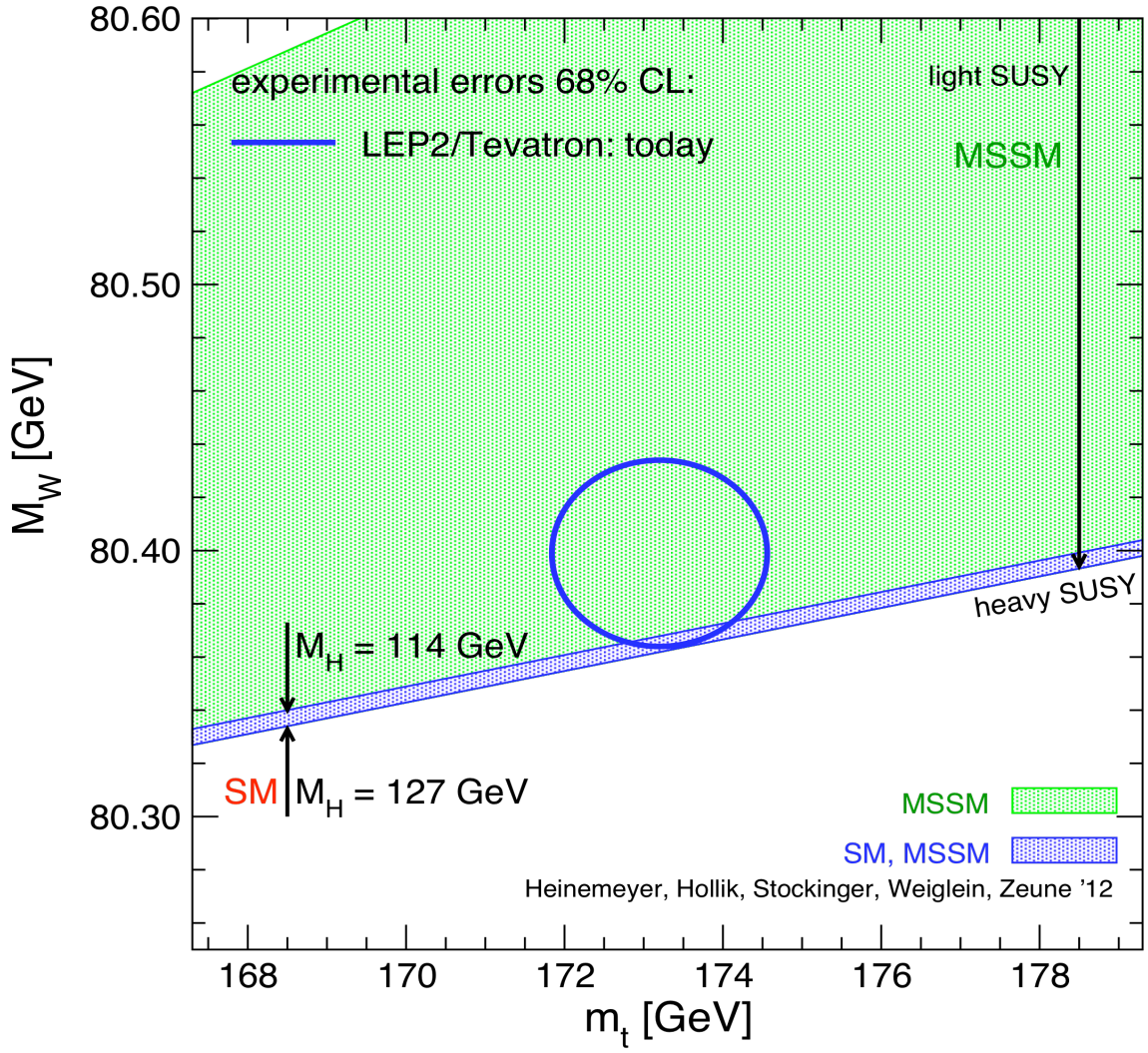
New Indirect Higgs Constraint (95% CL):

$$m_H < 152 \text{ GeV}$$

# Conclusions?

Our conclusions is…

Before:

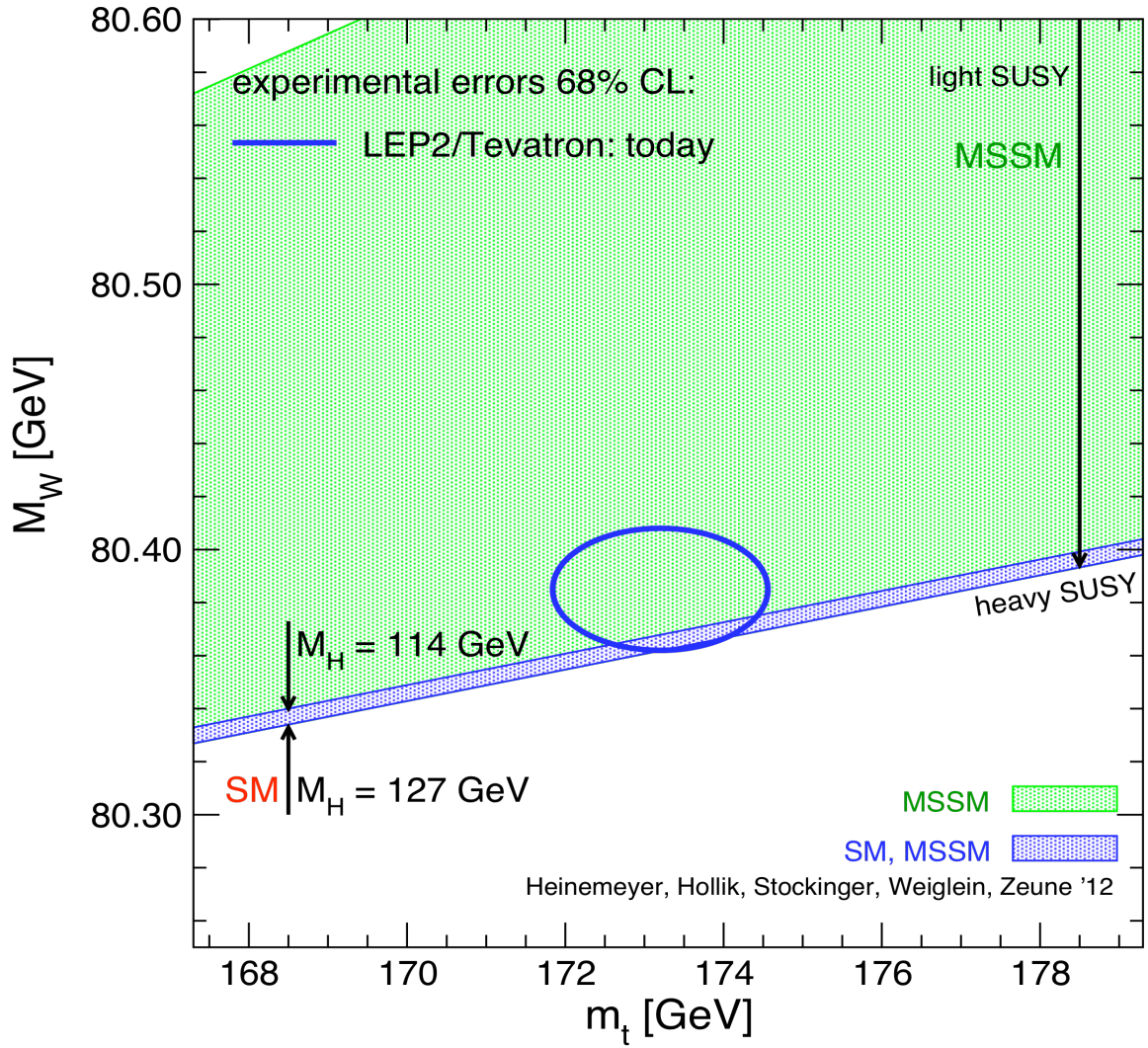



(Using WA $m_W$ excluding the two new Tevatron W mass results)

# Conclusions

The blue circle is smaller but its center has moved down!

After:




(Using WA $m_W$ including the two new Tevatron W mass results)