Measurement of the W Boson Mass at CDF

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We present a techniques used for precise measurements of the W boson mass at the CDF experiment at Fermilab. We present the results and the prospects for future improvements at Fermilab and the LHC.

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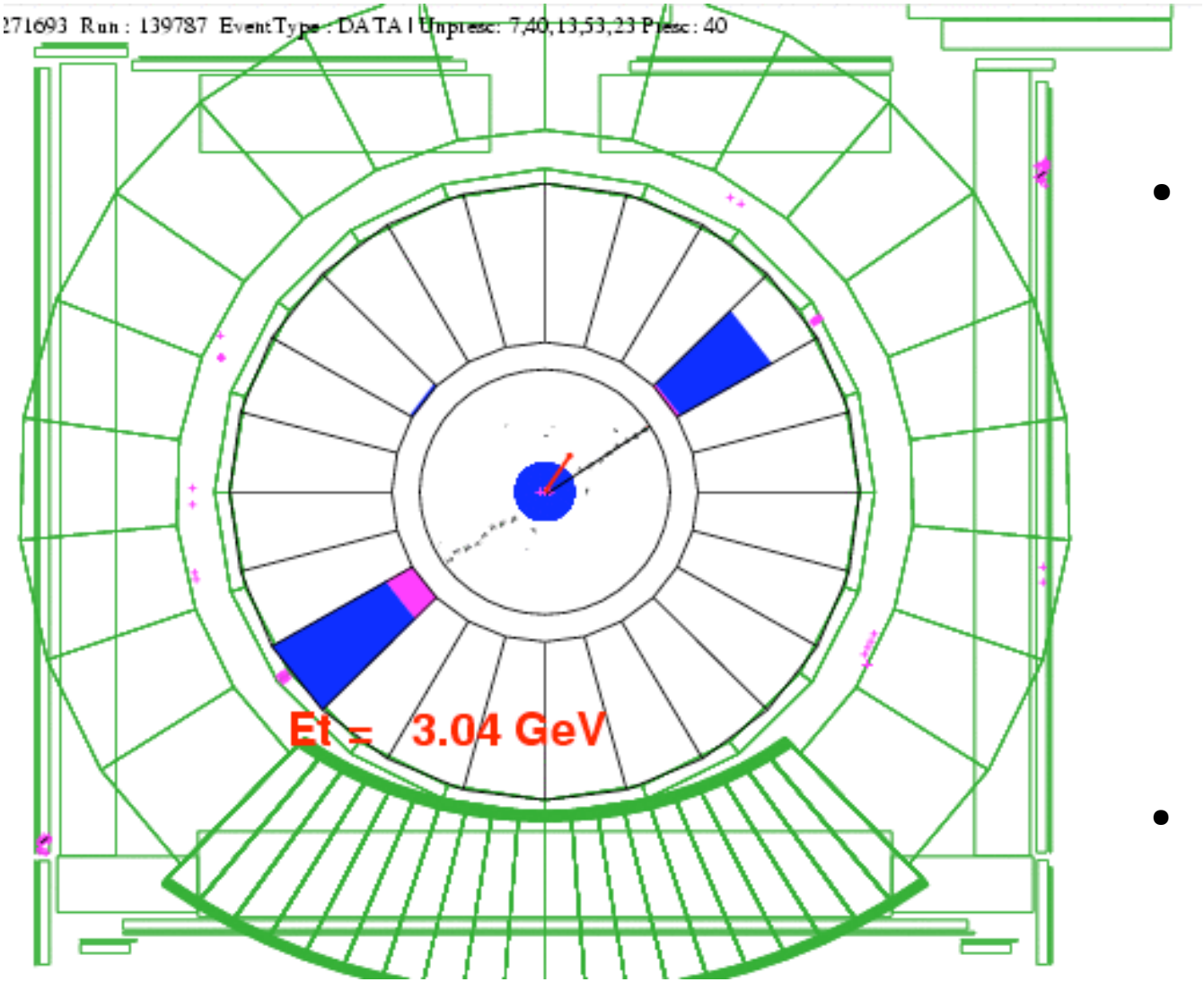
Outline of CDF Analysis

Energy scale measurements drive the W mass measurement

- Tracker Calibration
  - alignment of the central drift chamber (COT with ~2400 cells) using cosmic rays
  - COT momentum scale and tracker non-linearity constrained using $J/\psi \rightarrow \mu\mu$ and $\Upsilon \rightarrow \mu\mu$ mass fits
    - Confirmed using $Z \rightarrow \mu\mu$ mass fit
- EM Calorimeter Calibration
  - COT momentum scale transferred to EM calorimeter using a fit to the peak of the E/p spectrum, around E/p ~ 1
  - Calorimeter energy scale confirmed using $Z \rightarrow ee$ mass fit
- Tracker and EM Calorimeter resolutions
- Hadronic recoil modelling
  - Characterized using p_T-balance in $Z \rightarrow ll$ events

Internal Alignment of COT

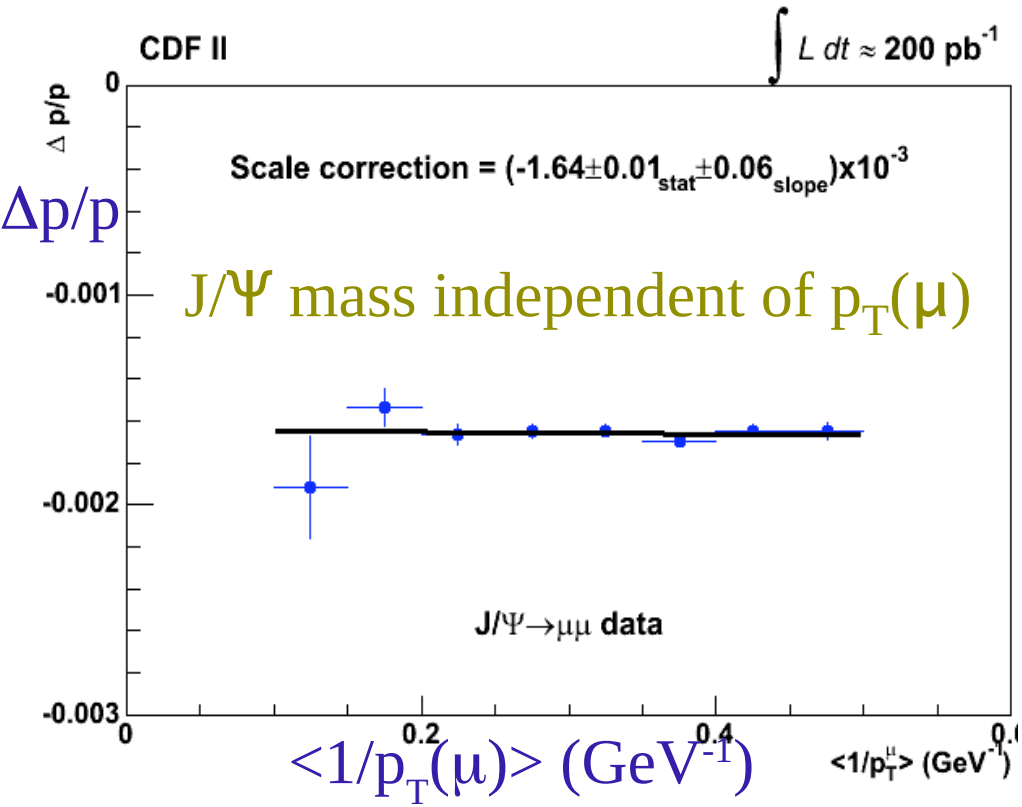
- Use a clean sample of ~200*k* cosmic rays for cell-by-cell internal alignment



- Fit COT hits on both sides simultaneously to a single helix (A.Kotwal, H. Gerberich and C. Hays, NIMA 506, 110 (2003))
  - Time of incidence is a floated parameter
- Same technique being used on ATLAS and CMS

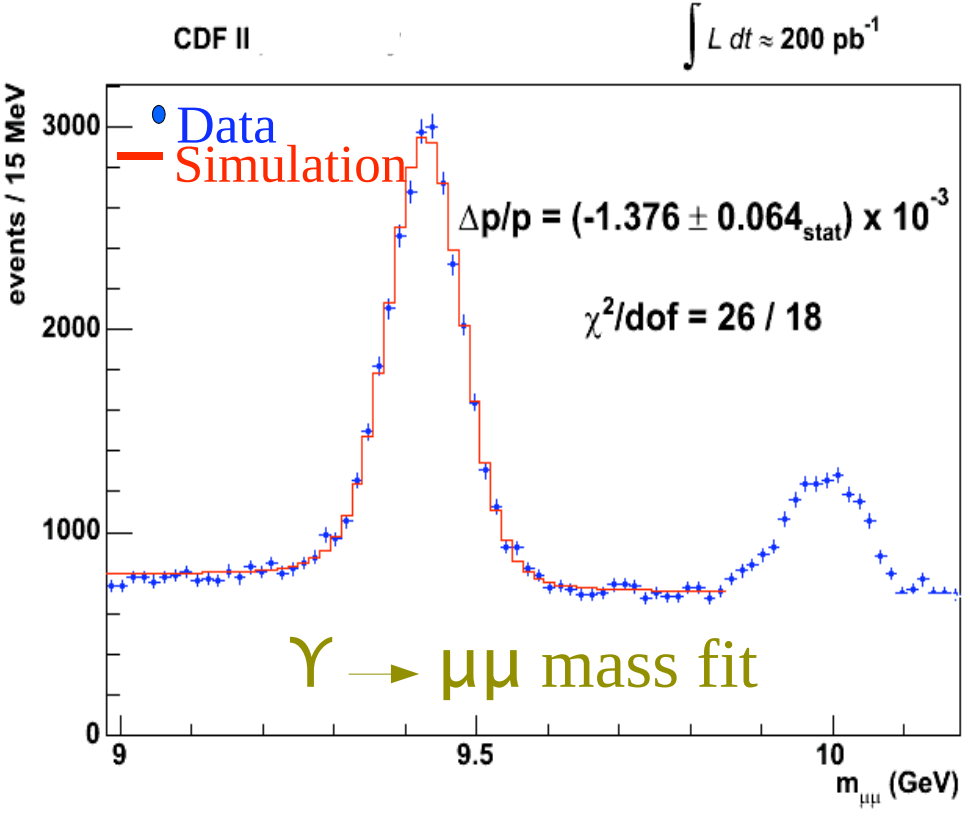
Tracking Momentum Calibration

- Set using $J/\Psi \rightarrow \mu\mu$ and $\Upsilon \rightarrow \mu\mu$ resonances
  - Consistent within total uncertainties
- Use J/Ψ to study and calibrate non-linear response of tracker
- Systematics-dominated, improved detector modelling required



Δp/p

J/Ψ mass independent of $p_T(\mu)$

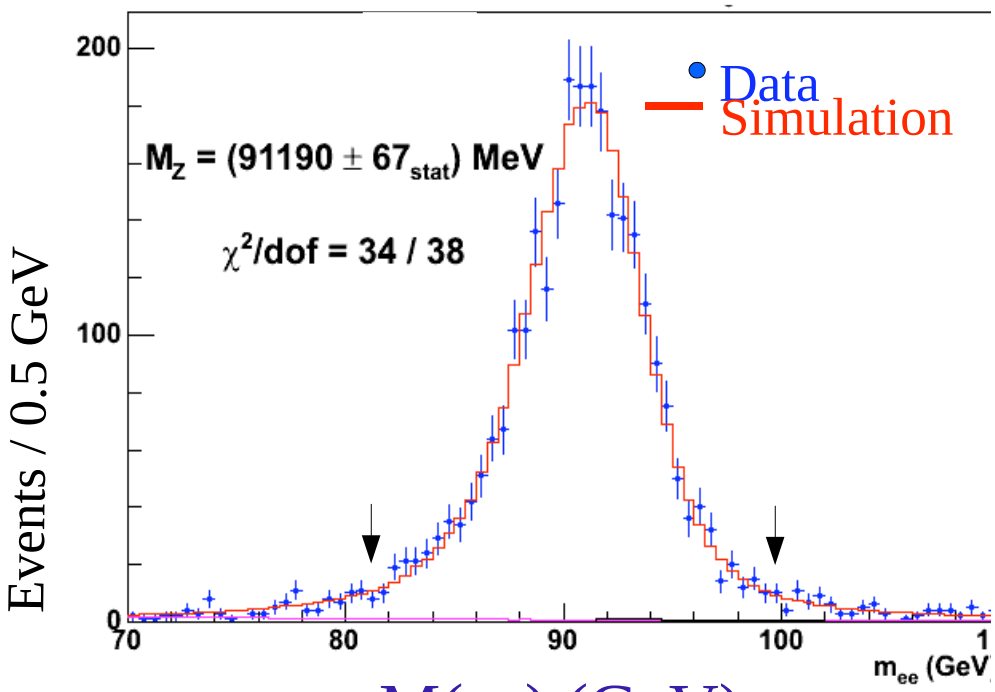


$\Upsilon \rightarrow \mu\mu$ mass fit

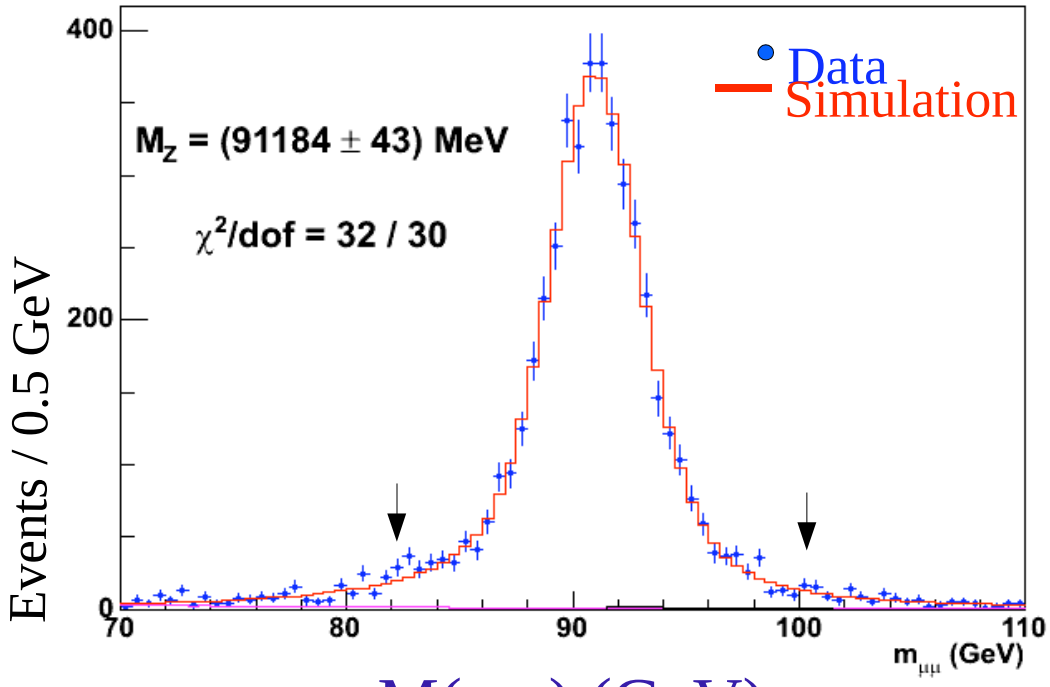
$Z \rightarrow ll$ Mass Cross-checks

- Z boson mass fits consistent with tracking and E/p-based calibrations

CDF II $L \sim 200/pb$



M(ee) (GeV)



M(μμ) (GeV)

Summary

- The *W* boson mass is a very interesting parameter to measure with increasing precision
- CDF Run 2 W mass result with 200 pb^{-1} data:
  - $M_W = 80413 \pm 48$ MeV
- D0 Run 2 W mass result with 1 fb^{-1} data:
  - $M_W = 80401 \pm 43$ MeV
- Most systematics limited by statistics of control samples
  - CDF and D0 are both working on $\delta M_W < 25$ MeV measurements from ~ 2 fb^{-1} (CDF) and ~ 4 fb^{-1} (D0)
- Learning as we go: Tevatron → LHC may produce δM_W ~ 5-10 MeV