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 $\gamma \rightarrow \mu\mu$ 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 $E/p \sim 1$
  - 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 ~200k 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 $\gamma \rightarrow \mu\mu$ resonances
  - Consistent within total uncertainties
- Use $J/\Psi$ to study and calibrate non-linear response of tracker
- Systematics-dominated, improved detector modelling required

\[ \Delta p/p = (-1.376 \pm 0.064_{stat}) \times 10^{-3} \]

$\gamma \rightarrow \mu\mu$ mass independent of $p_T(\mu)$

\[ \langle 1/p_T(\mu) \rangle \text{ (GeV}^{-1}) \]

\[ \langle 1/p_T^{\mu}\rangle \text{ (GeV}^{-1}) \]
$Z \rightarrow ll$ Mass Cross-checks

- $Z$ boson mass fits consistent with tracking and E/p-based calibrations
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 $\sim 2$ fb$^{-1}$ (CDF) and $\sim 4$ fb$^{-1}$ (D0)

- Learning as we go: Tevatron $\rightarrow$ LHC may produce $\delta M_W \sim 5$-10 MeV