Overview of the CDF W-mass measurement

Link to the latest Science article, most material in the talk

(Previous measurement Phys. Rev. D 89, 072003 (2014),
this is a good reference for actual details)

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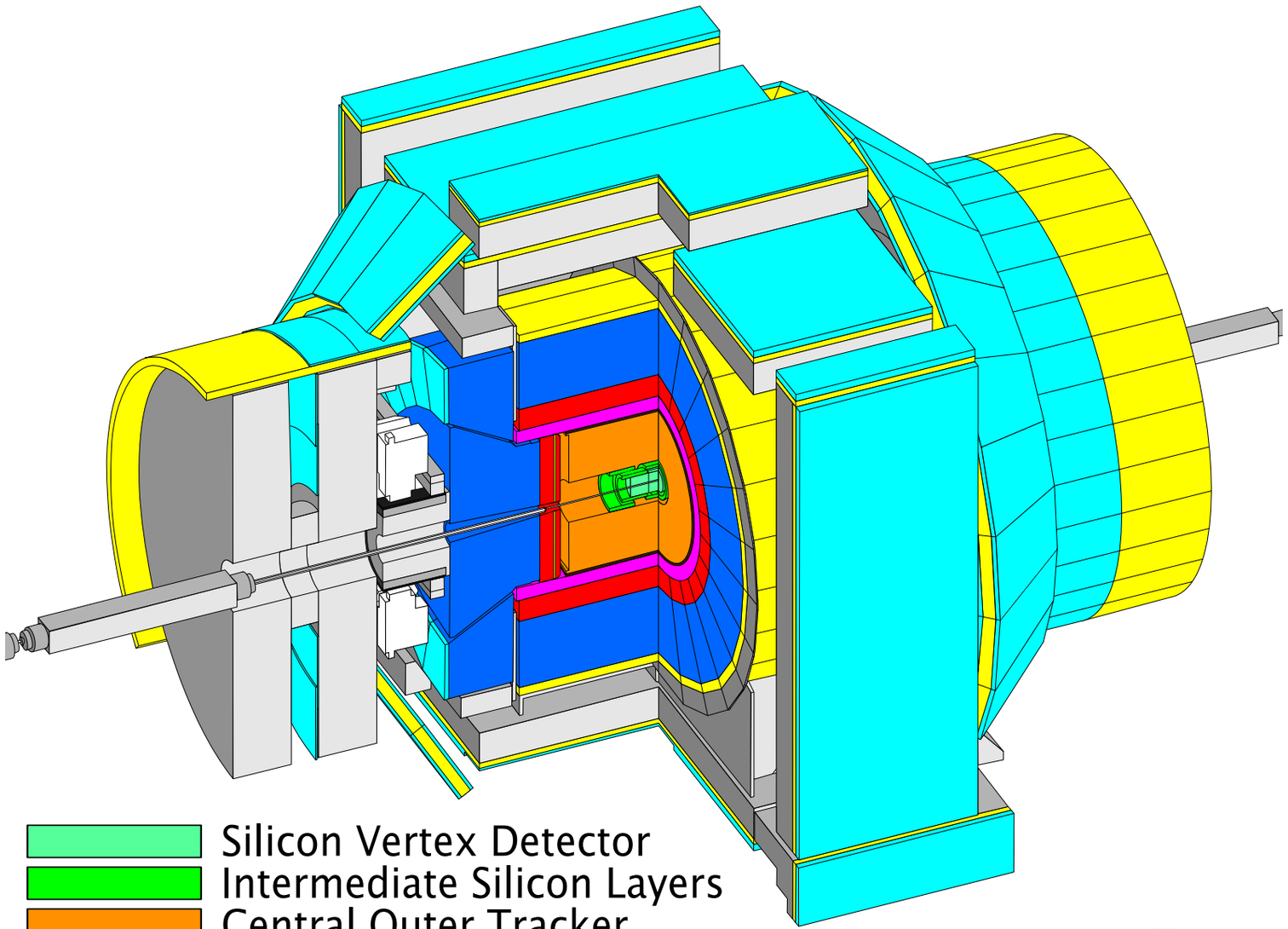
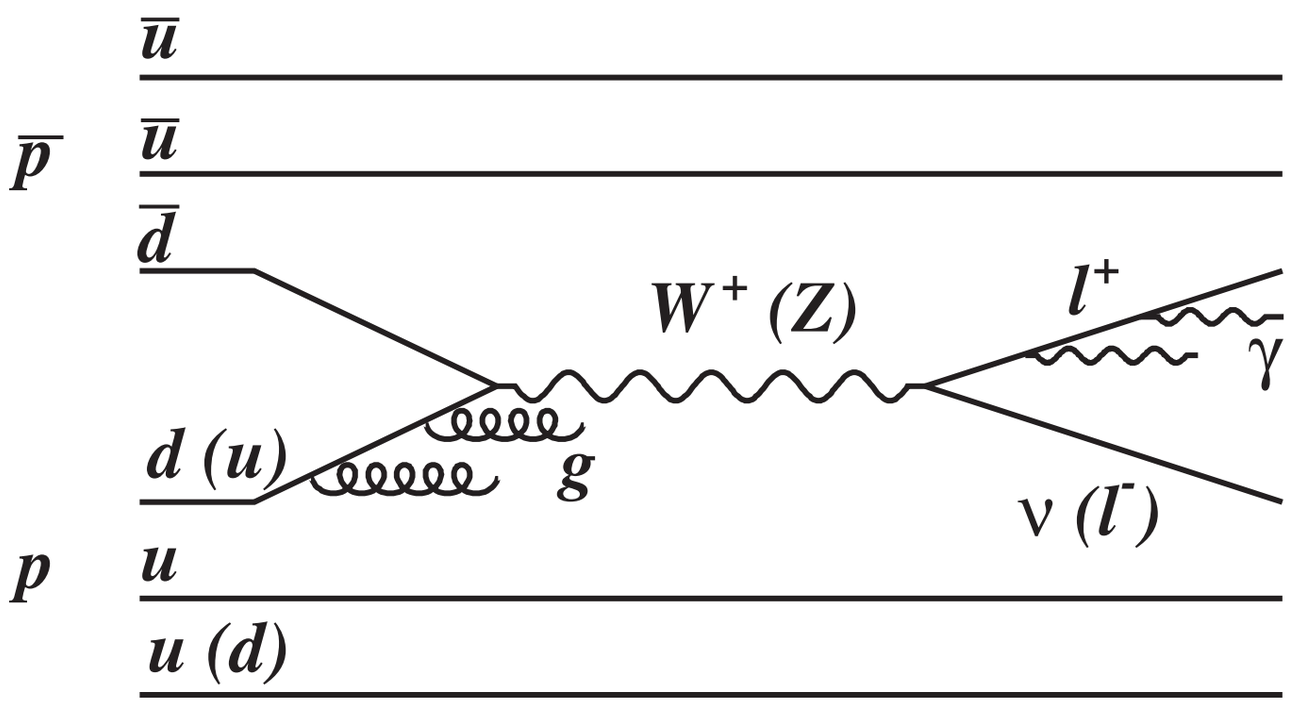
The CDF detector at Fermilab



Silicon Vertex Detector
Intermediate Silicon Layers
Central Outer Tracker
Time Of Flight
1.4 T Superconducting Solenoid
EM Calorimeter
Hadron Calorimeter
Muon Counters/Chambers
Cherenkov Light Counters: not shown

W production in proton-antiproton

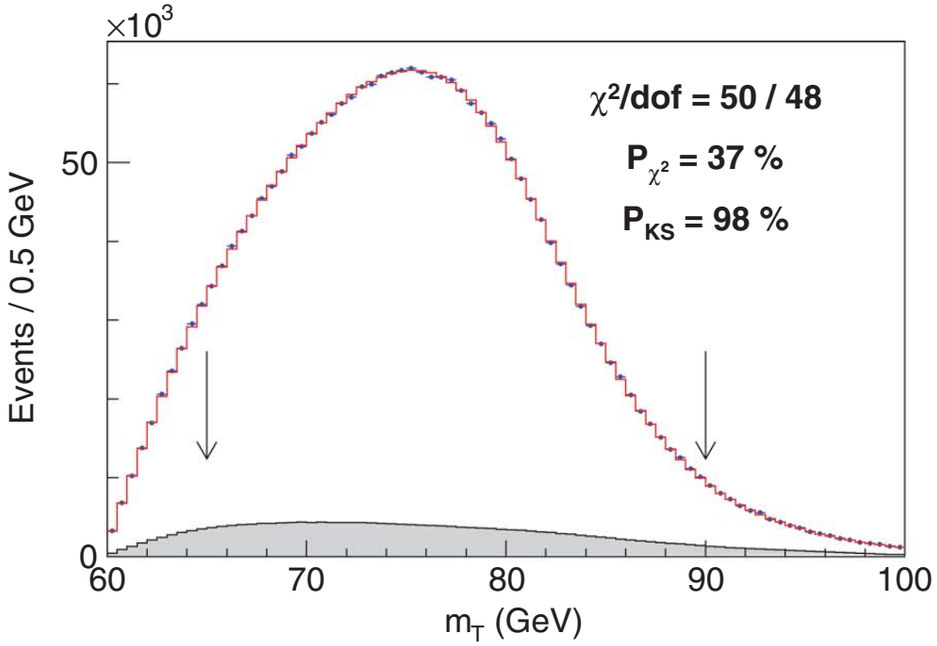


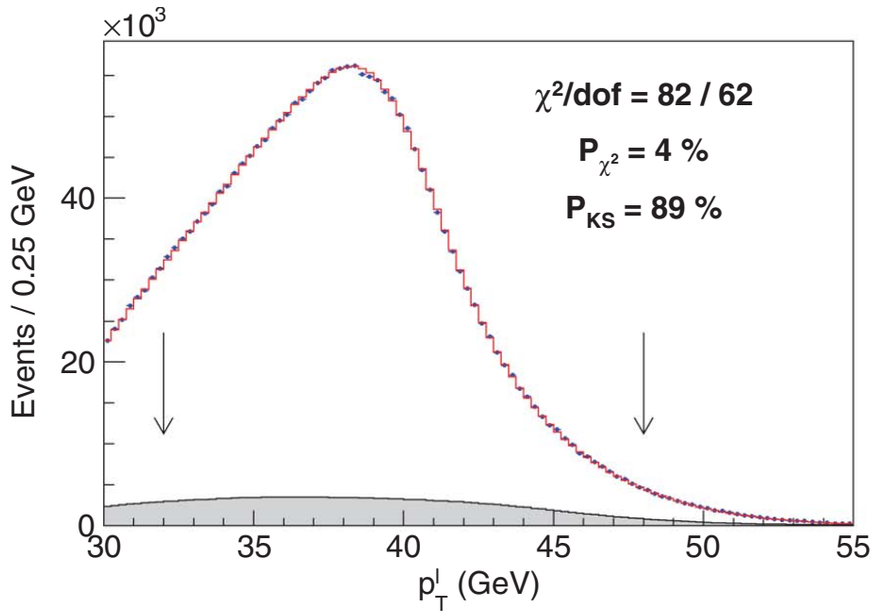
From
Phys. Rev. D 89, 072003 (2014)

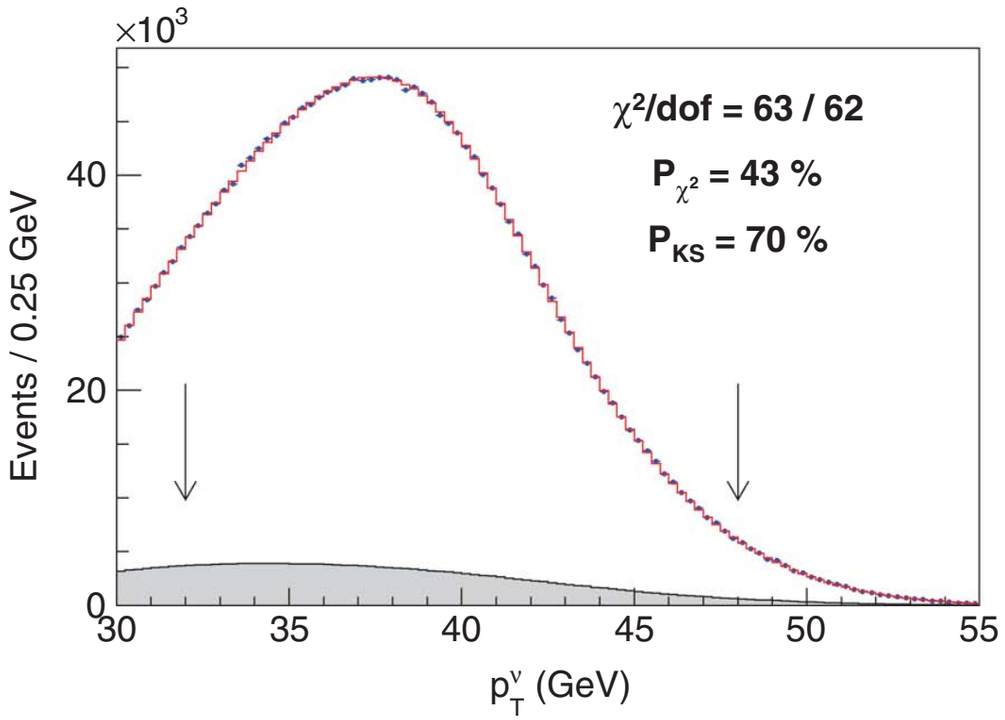
Overview of the W-mass measurement

- The new CDF W- mass measurement uses 8.8/fb of 1.96 TeV proton-antiproton data from the Tevatron collected between 2002-2011.
- Observables are $\overrightarrow{u} = \sum_i E_i \sin(\theta_i)\hat{n}_i$, $\overrightarrow{p_T^\nu} = \overrightarrow{p_T^l} - \overrightarrow{u}$ and $m_T^2 = 2(p_T^l p_T^\nu - \overrightarrow{p_T^l} \cdot \overrightarrow{p_T^\nu})$.
- Selection: $30 < p_T < 55$ GeV, $u < 15$ GeV and $60 < m_T < 100$ GeV.
- The sample contains: 1.8M W(e), 70k Z(ee), 2.4M W(mu) and 240k Z(ee). About four times the previous measurement.
- Lepton momentum scale calibrations from $J/\Psi, \Upsilon$(1S) and Z.
- Calorimeter energy scales from E/p using Z and W.
- The key to the precision is that everything is with respect to data, except the scape of propagator. I.e. it is a pure shape analysis (binned likelihood).

Some example distributions in the muon channel







Final uncertainties

The previous measurement
Phys. Rev. D 89, 072003 (2014)

TABLE XIV. Uncertainties in units of MeV on the final combined result on M_W.

Source	Uncertainty
Lepton energy scale and resolution	7
Recoil energy scale and resolution	6
Lepton tower removal	2
Backgrounds	3
PDFs	10
$p_T(W)$ model	5
Photon radiation	4
Statistical	12
Total	19

New measurement 2022

Table 2. Uncertainties on the combined M_W result.

Source	Uncertainty (MeV)
Lepton energy scale	3.0
Lepton energy resolution	1.2
Recoil energy scale	1.2
Recoil energy resolution	1.8
Lepton efficiency	0.4
Lepton removal	1.2
Backgrounds	3.3
p_T^Z model	1.8
p_T^W/p_T^Z model	1.3
Parton distributions	3.9
QED radiation	2.7
W boson statistics	6.4
Total	9.4

A potential missing uncertainty under investigation is flavor dependent transverse PDFs, see e.g. DIS 2019

Fit results

Table 1. Individual fit results and uncertainties for the M_W measurements. The fit ranges are 65 to 90 GeV for the m_T fit and 32 to 48 GeV for the p_T^ℓ and p_T^ν fits. The χ^2 of the fit is computed from the expected statistical uncertainties on the data points. The bottom row shows the combination of the six fit results by means of the best linear unbiased estimator (*66*).

Distribution	*W* boson mass (MeV)	χ^2/dof
$m_T(e,\nu)$	$80{,}429.1 \pm 10.3_{stat} \pm 8.5_{syst}$	39/48
$p_T^\ell(e)$	$80{,}411.4 \pm 10.7_{stat} \pm 11.8_{syst}$	83/62
$p_T^\nu(e)$	$80{,}426.3 \pm 14.5_{stat} \pm 11.7_{syst}$	69/62
$m_T(\mu,\nu)$	$80{,}446.1 \pm 9.2_{stat} \pm 7.3_{syst}$	50/48
$p_T^\ell(\mu)$	$80{,}428.2 \pm 9.6_{stat} \pm 10.3_{syst}$	82/62
$p_T^\nu(\mu)$	$80{,}428.9 \pm 13.1_{stat} \pm 10.9_{syst}$	63/62
Combination	$80{,}433.5 \pm 6.4_{stat} \pm 6.9_{syst}$	7.4/5

The W and top mass plane