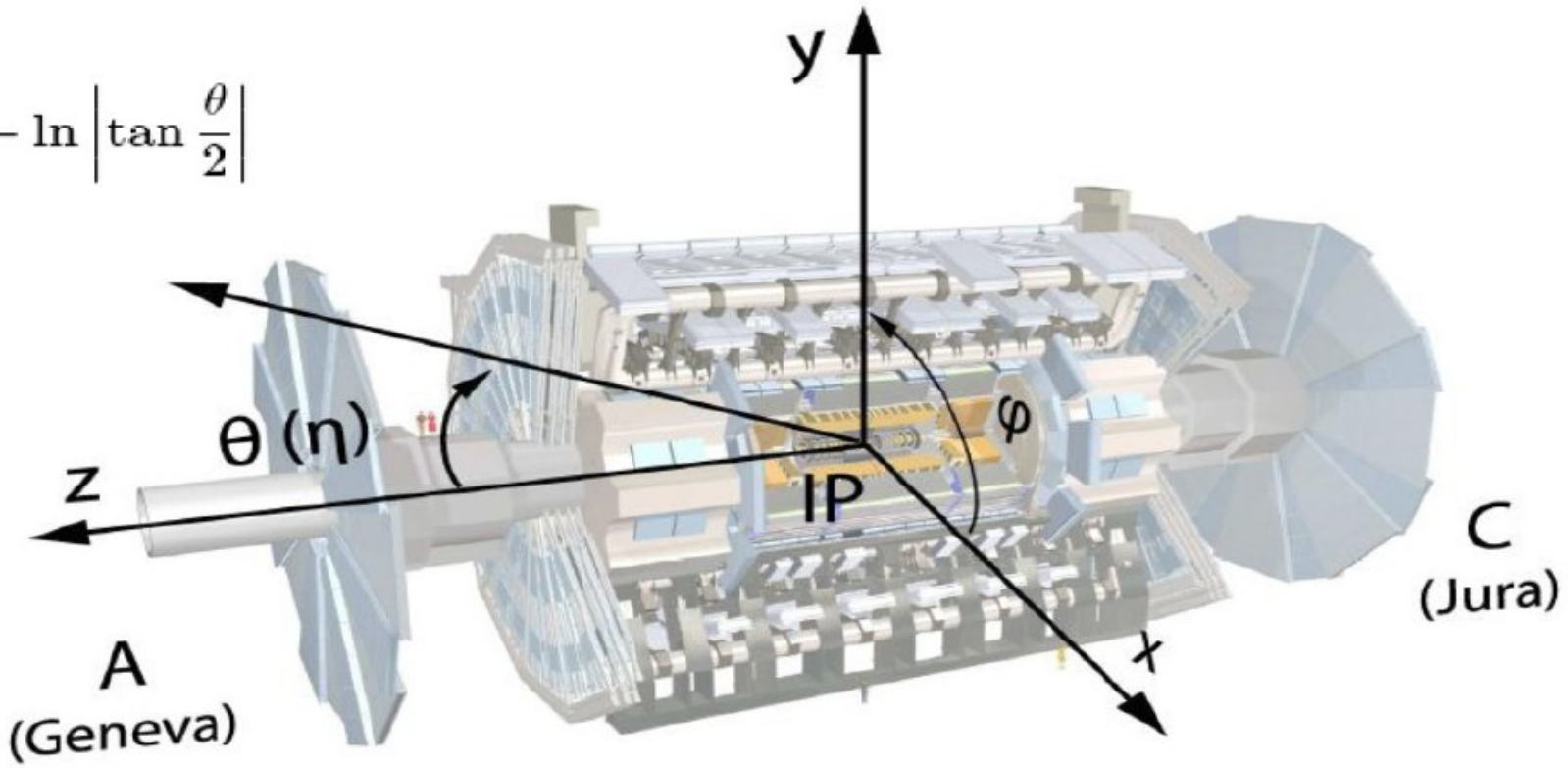
Kinematics

$$\eta = -\ln\left|\tan\frac{\theta}{2}\right|$$

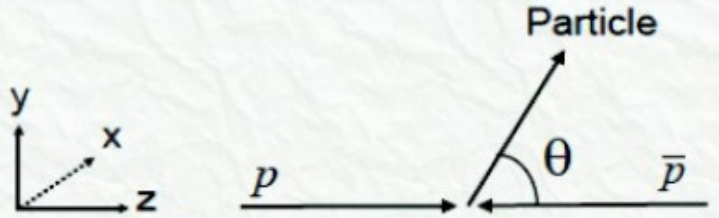


Some kinematic distributions

Rapidity (y) and Pseudo-rapidity (η)

$$y \equiv \frac{1}{2}\ln\frac{E+p_z}{E-p_z} = \frac{1}{2}\ln\frac{1+\beta\cos\theta}{1-\beta\cos\theta}$$

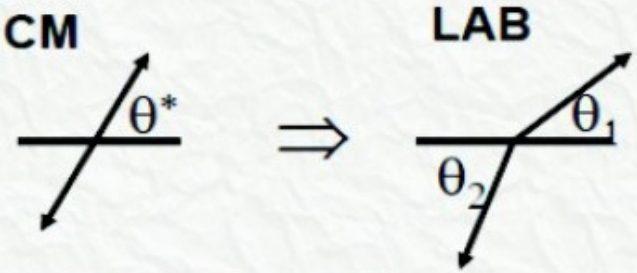
$$\beta\cos\theta = \tanh y \quad \text{where} \quad \beta = p/E$$



In the limit $\beta \to 1$ (or $m << p_T$) then

$$\eta \equiv y\big|_{m=0} = \frac{1}{2}\ln\frac{1+\cos\theta}{1-\cos\theta} = -\ln\tan\frac{\theta}{2}$$

LAB System ≠ parton-parton CM system



Δη and p_T are invariant under longitudinal boosts

Some kinematic definitions

Transverse Energy/Momentum

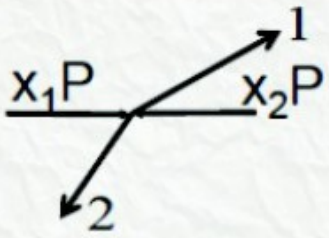
$$E_T^2 \equiv p_x^2 + p_y^2 + m^2 = p_T^2 + m^2 = E^2 - p_z^2$$

$$p_z = E \tanh y$$
$$E = E_T \cosh y$$
$$p_z = E_T \sinh y$$

$$p_T \equiv p \sin\theta \xrightarrow[m \to 0]{} E_T$$

Invariant Mass

$$M_{12}^2 \equiv (p_1^\mu + p_2^\mu)(p_{1\mu} + p_{2\mu})$$
$$= m_1^2 + m_2^2 + 2(E_1 E_2 - \boldsymbol{p}_1 \cdot \boldsymbol{p}_2)$$
$$\xrightarrow[m_1, m_2 \to 0]{} 2E_{T1}E_{T2}(\cosh\Delta\eta - \cos\Delta\phi)$$



Partonic Momentum Fractions

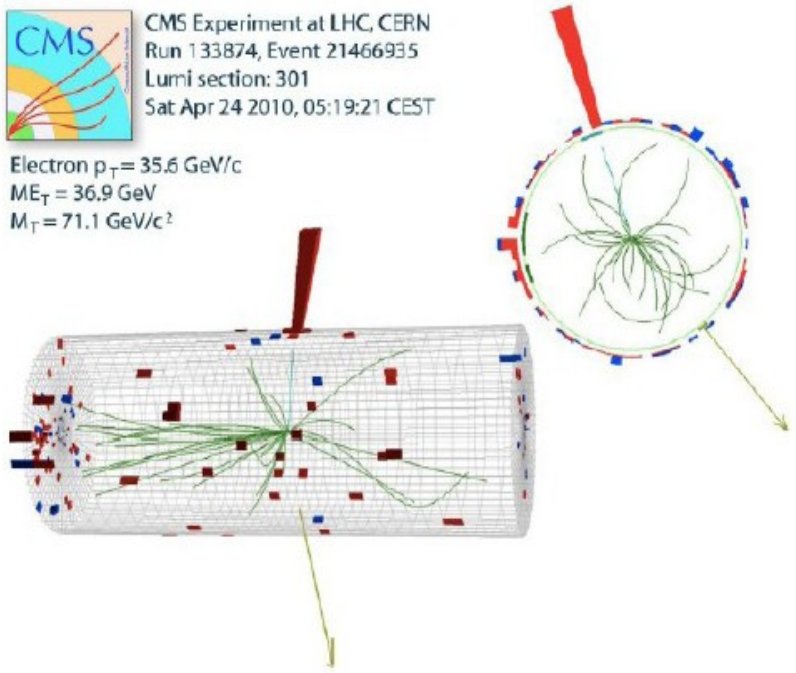
$$x_1 = \left(e^{\eta_1} + e^{\eta_2}\right) E_T / \sqrt{s}$$
$$x_2 = \left(e^{-\eta_1} + e^{-\eta_2}\right) E_T / \sqrt{s}$$

$$x_T \equiv 2E_T / \sqrt{s} = x_{1,2}(\eta_{1,2} = 0)$$

Parton CM $(\text{energy})^2 \rightarrow \hat{s} = x_a x_b s$

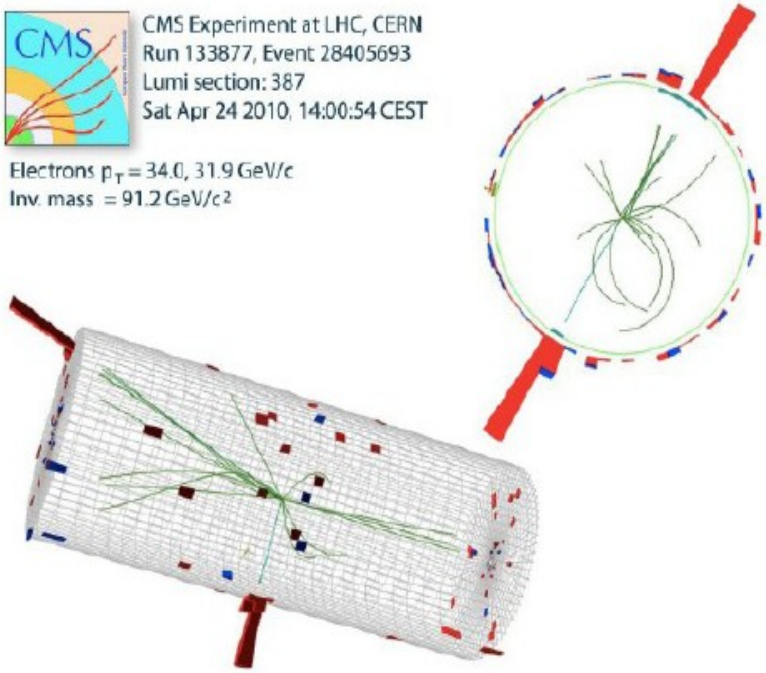
$$0 < x_1, x_2 < 1$$
$$x_T^2 < x_1 x_2 < 1$$

Electron channel W and Z events



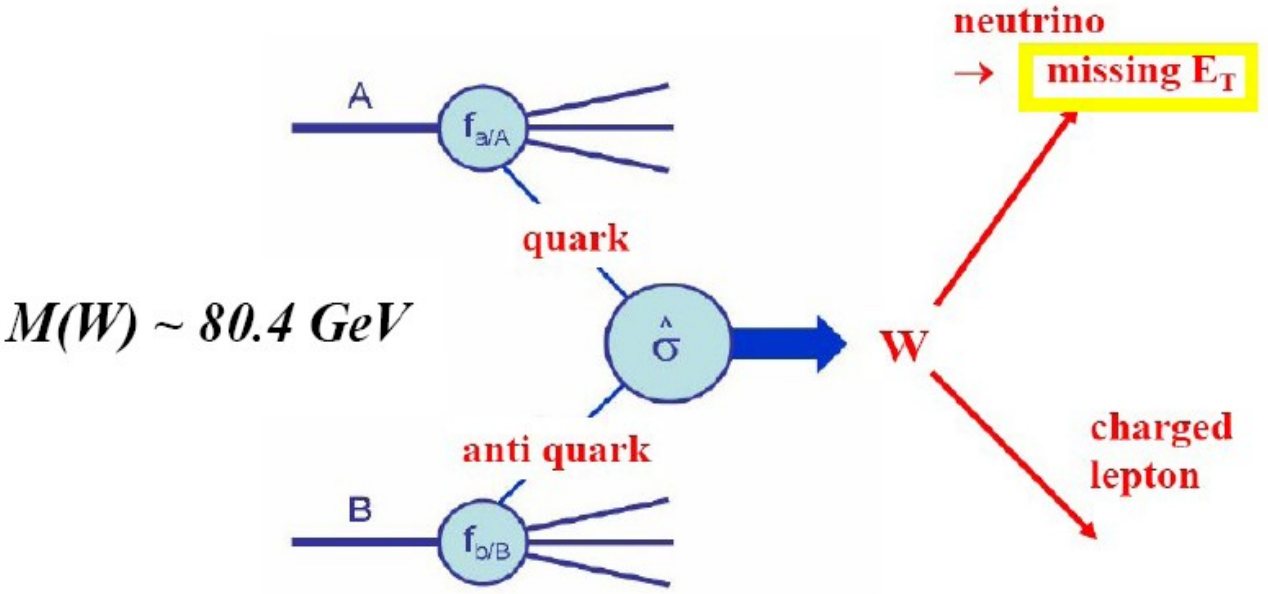
$W \rightarrow e\nu$

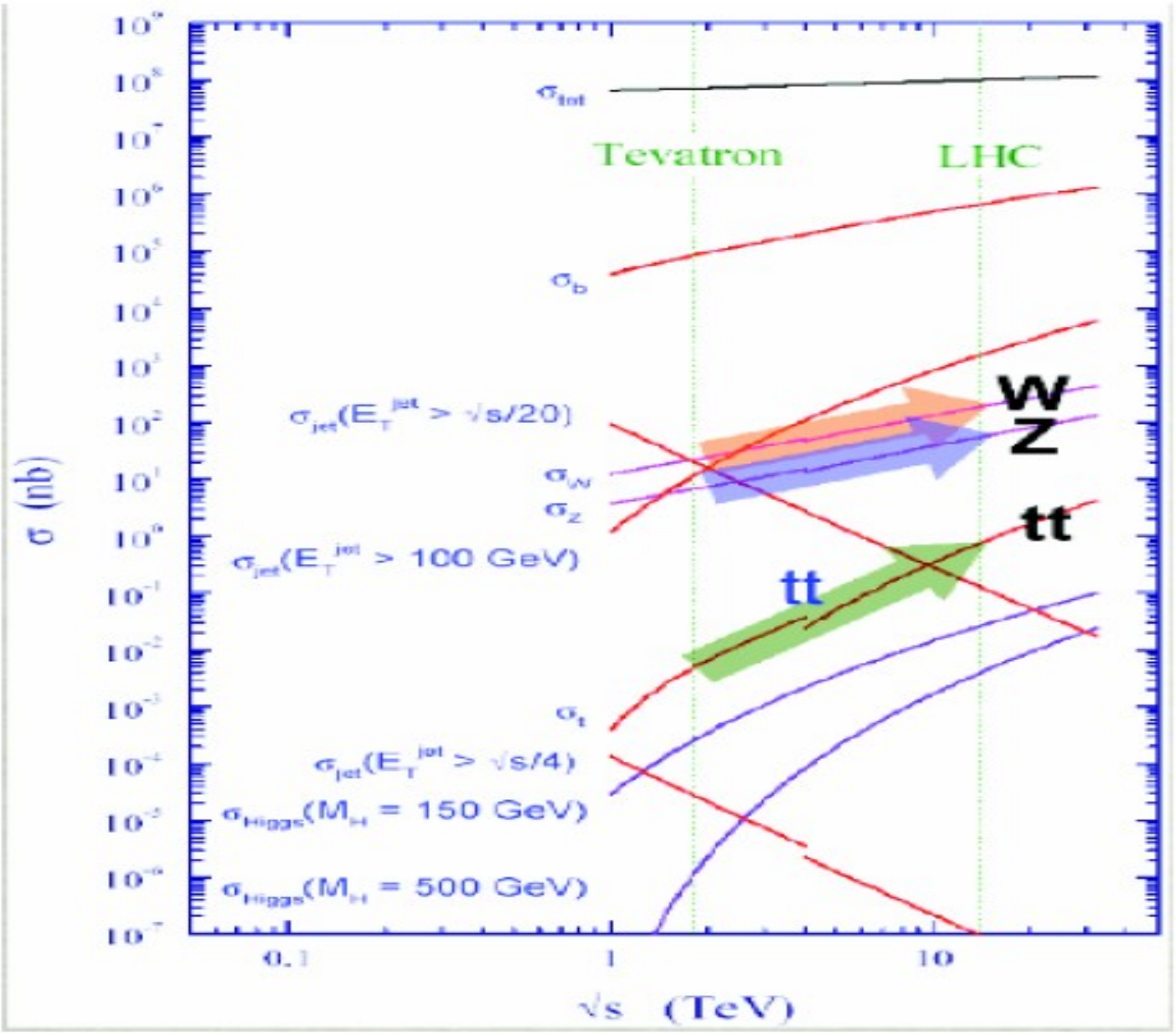
$Z \rightarrow ee$



Measurement: W → l ν

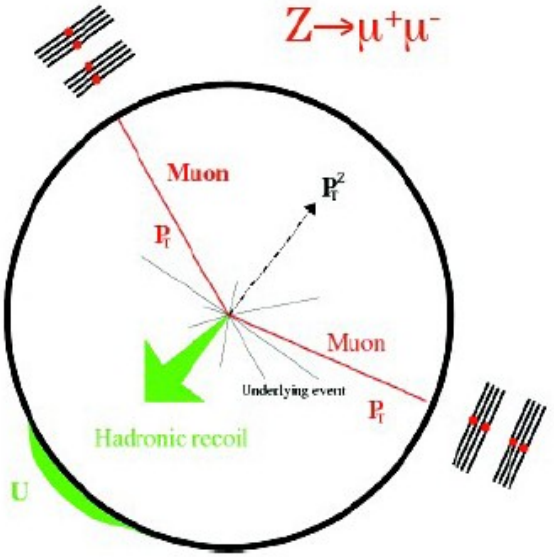
- Signature:
  - Single charged lepton and missing transverse energy (MET)
  - Leptons are high p_T and isolated
  - MET from neutrino
  - Peaking at transverse invariant mass

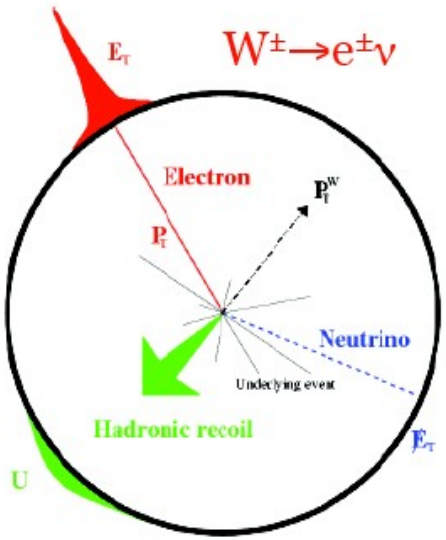



Tevatron
LHC
W
Z
tt
tt
σ (nb)
√s (TeV)
0.1
1
10

Detecting W and Z

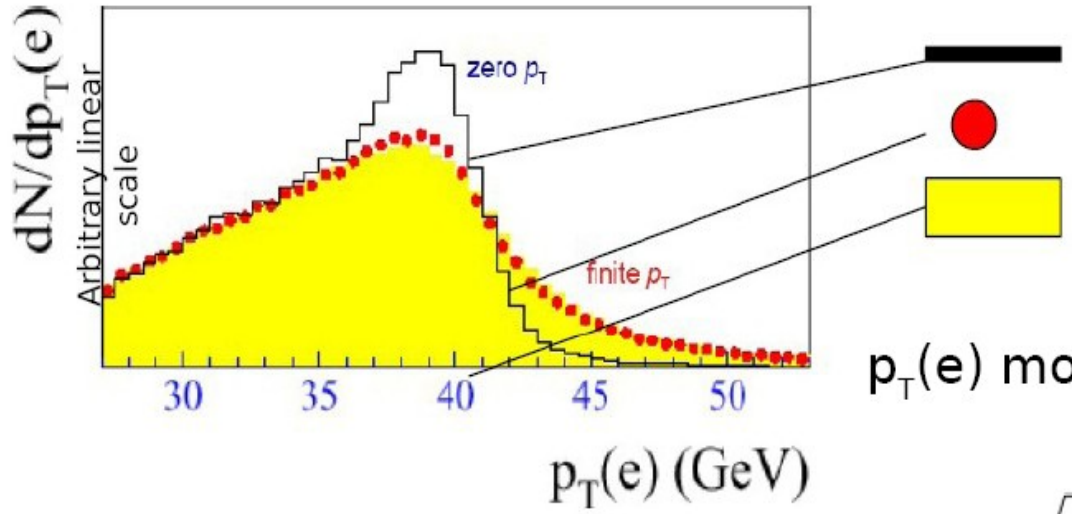
- $Z \rightarrow l^+l^-$
  - **Signature:** pair of charged leptons with opposite sign charge
    - Leptons are high p_T and isolated
  - Peak in l^+l^- invariant mass





- $W \rightarrow l^{\pm}\nu^{\pm}$
  - **Signature:** single charged lepton and missing transverse energy (MET)
    - Leptons are high p_T and isolated
    - MET from neutrino
      - $p_T\nu$ is inferred
  - Peak in transverse invariant mass

Experimental observables

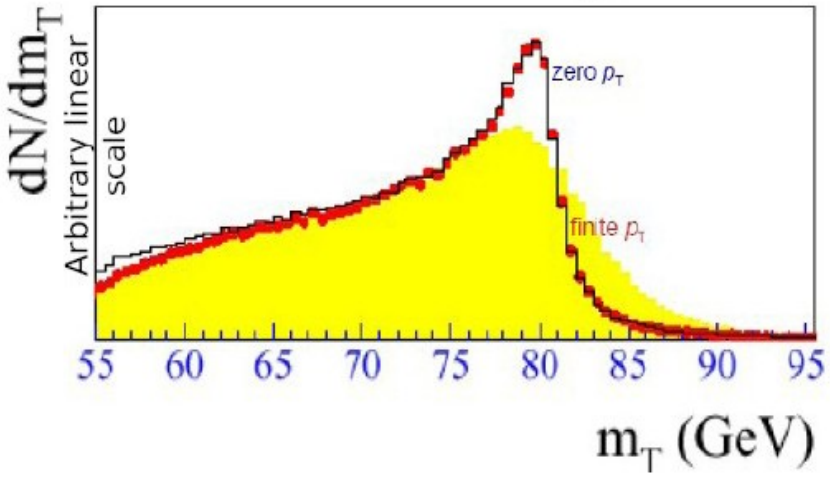


No $P_T(W)$

$P_T(W)$ included

Detector Effects added

$p_T(e)$ most affected by $p_T(W)$



$$m_T = \sqrt{2p_T^l p_T^\nu (1 - \cos\Delta\phi)}$$

m_T most affected by measurement of MET