On the transverse variables at hadron colliders (from which M_W is extracted)

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On the transverse variable $p_T(e)$

For the leptonic decays at hadron colliders: $W \rightarrow e\nu, \mu\nu$:

In the W-rest frame:

$$p_\ell^{rest} = (p, p_x, p_y, p_z), \quad p_\nu^{rest} = (p, -p_x, -p_y, -p_z), \quad 2p = m_{e\nu}$$

$$m_{e\nu}^2 = (E_e + E_\nu)^2 - (\vec{p}_{eT} + \vec{p}_{\nu T})^2 - (p_{ez} + p_{\nu z})^2$$

$$p_T = p\sin\theta, \quad dp_T = p\cot\theta\, d\cos\theta, \quad dp_T^2 = p(m_{e\nu}^2 - 4p_T^2)^{1/2} d\cos\theta$$

BW, Jacobian, ME

$$\frac{d\sigma}{dm_{e\nu}^2\, dp_T^2} \propto \frac{1}{(m_{e\nu}^2 - M_W^2)^2 + \Gamma_W^2 M_W^2} \frac{1}{m_{e\nu}(m_{e\nu}^2 - 4p_T^2)^{\frac{1}{2}}} (m_{e\nu}^2 - 2p_T^2)$$

Convoluted relation in M_W / $m_{e\nu}$ / p_T !

Narrow Width Approx. $\Gamma_W \rightarrow 0$: $\frac{1}{(m_{e\nu}^2 - M_W^2)^2 + \Gamma_W^2 M_W^2} \rightarrow \frac{\pi}{\Gamma_W M_W} \delta(m_{e\nu}^2 - M_W^2)$

$$\frac{d\sigma}{dp_T^2} \propto \frac{1}{\Gamma_W M_W^2} \frac{(M_W^2 - 2p_T^2)}{(M_W^2 - 4p_T^2)^{\frac{1}{2}}}$$

Jacobian peak at $p_T = M_W/2$ for an on-shell W @ rest.

→ It is an end-point / edge search in p_{eT} .

→ It is sensitive to Γ_W

- In reality: the lab frame with W transverse motion:

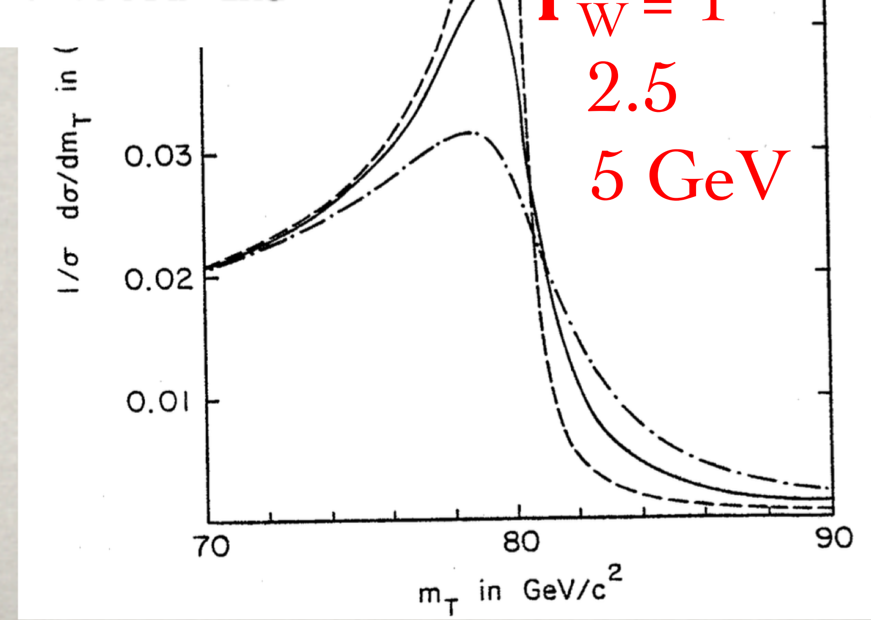
$$\vec{p}_{WT}: \quad \beta = p_{WT}/E_{WT}, \quad E_{WT} = (p_{WT}^2 + M_W^2)^{1/2}.$$

$$p_{eT}^{lab} \approx p_{eT}^{rest} - \beta \frac{p_x}{p_T} p$$ ← Linear dependence on **β** ~ 4% !

- Finite width effect:

Jack Smith, van Neerven, Vermaseren: 1983

One notes that all the qualitative aspects mentioned in the previous paragraph are evident in the Figure. In particular the p_T^W modifications are very small near the peak. Instead of a sharp fall-off at $m_T = M$ the finite width causes a small tail to appear above the peak. Therefore in this region the QCD effects are minuscule so that one can hope to measure Γ in this region. To illustrate this we show three distributions in Figure 2 for different choices of Γ. As Γ is increased the



The edge lowered & shifted.

The current expt error mainly from CDF/D0:

Full width $\Gamma = 2.085 \pm 0.042$ GeV

On the transverse variable $M_T(e\nu)$

For the leptonic decays at hadron colliders, introduce the transverse mass:

$$m^2_{e\nu T} = (E_{eT} + E_{\nu T})^2 - (\vec{p}_{eT} + \vec{p}_{\nu T})^2$$
$$\approx 2\vec{p}_{eT} \cdot \vec{p}_{\nu T} \approx 2E_{eT}\not{E}_T\ (1 - \cos\phi_{e\nu})$$

$$E_T = \sqrt{m^2 + p_T^2} \approx p_T$$

$$\vec{\not{p}}_T = -\sum \vec{p_T}(observed)$$

- Kinematically, $0 < m_{e\nu T}^2 < m_{e\nu}^2$
  🙁 it is NOT Lorentz invariant, only boost invariant; broad range, depending on the W width.
- 😀 Mathematically related to M_W

$$\frac{d\hat{\sigma}}{dm^2_{e\nu}dm^2_{e\nu,T}} \propto \frac{\Gamma_W M_W}{(m^2_{e\nu} - M^2_W)^2 + \Gamma^2_W M^2_W} \frac{1}{m_{e\nu}\sqrt{m^2_{e\nu} - m^2_{e\nu,T}}} (m^2_{e\nu} - m^2_{e\nu T}/2)$$

While the width effect is similar to p_{eT}, less sensitive than p_{eT} in β^2 dependence:

$$m^2_{e\nu,T}(\beta_W) = m^2_{e\nu,T} - \frac{4\beta^2_W p^2_x p^2_z}{{p_T}^2} + O(\beta^4_W)$$