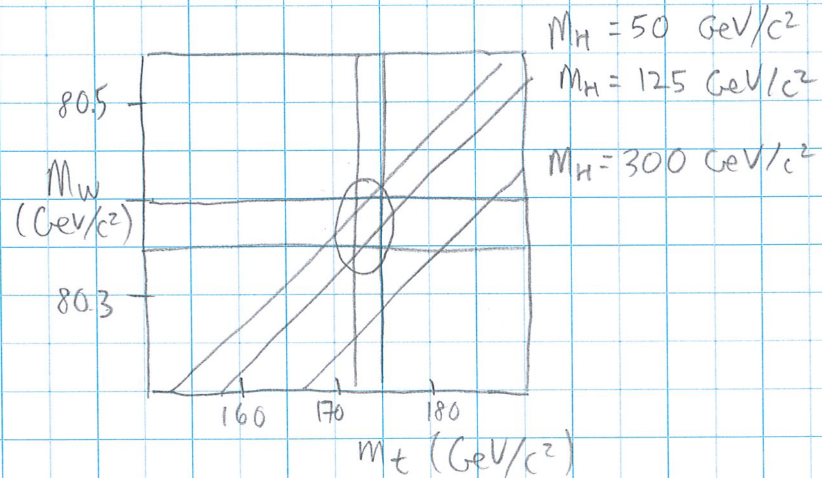
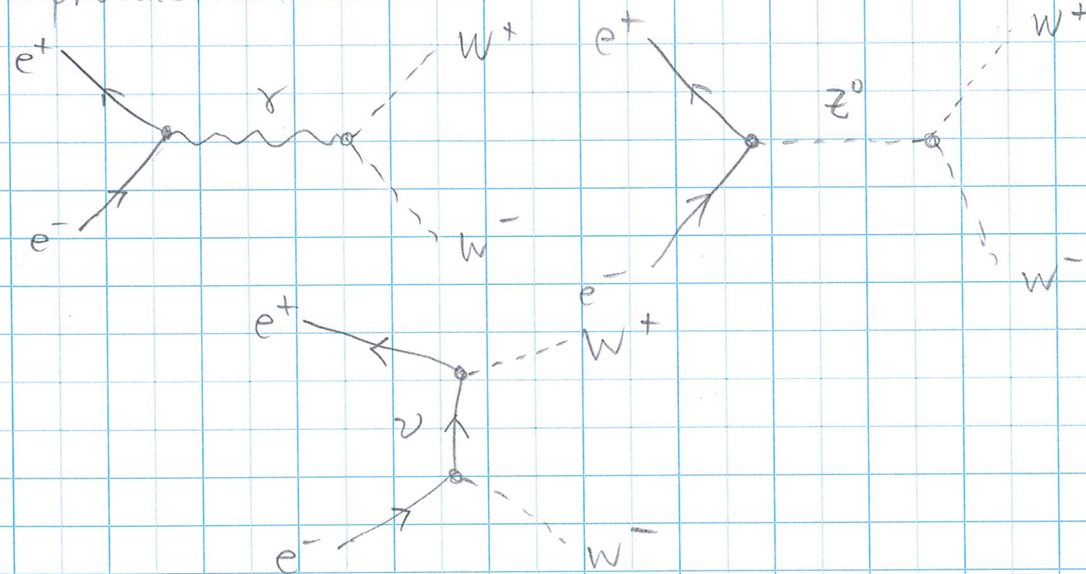
W mass measurements.

Why is it important?



W production at LEP



Data collected from 1996 - 2000 at $\sqrt{s}$ between 161 GeV to 209 GeV by 4 experiments.

$\int \mathcal{L} dt = 700\ pb^{-1}$ per experiment.

$\Rightarrow 10^4$ W pairs per experiment.

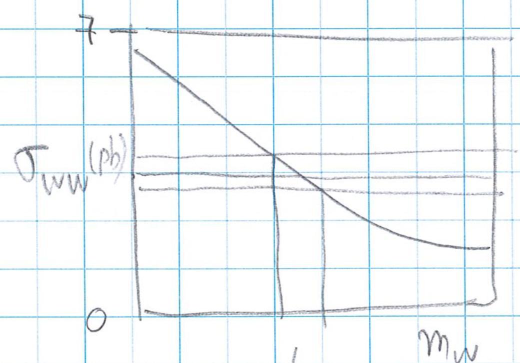
40,000 total.

Three main decay signatures:

		ε	P
$W^+ \to \ell^+ \nu_e$	$W^- \to \ell^- \bar{\nu}_e$	60-80%	80-90%
$W \to \ell \nu$	$W \to q\bar{q}'$	60-90%	85-95%
$W \to q\bar{q}'$	$W \to q\bar{q}'$	60-80%	75-85%

Backgrounds: $\gamma/Z \to \ell^+\ell^-$
$\gamma/Z \to q\bar{q}$

Predicted cross section depends on W mass



$m_W = 80.4 \pm 0.2$ GeV/c^2

Hadronic mass reconstruction

Unambiguous for $\ell\nu q\bar{q}'$ channels but use the "most likely" pairings for $q\bar{q}q\bar{q}$ decays.

$$M_W(q\bar{q}\ell\nu) = 80.411 \pm 0.032 \pm 0.030 \text{ GeV}$$

$$M_W(q\bar{q}q\bar{q}) = 80.420 \pm 0.035 \pm 0.101 \text{ GeV}$$

Measurements at the Tevatron.

proton-antiproton collisions at $\sqrt{s} = 1.96$ TeV

CDF experiment: $p_T(\ell) > 18$ GeV

$W \to \mu\nu$ 625,000 events
$W \to e\nu$ 470,000 events

2.2 fb^{-1} used for the analysis.

Transverse mass measurement:

$$m^2 = E^2 - |\vec{p}|^2$$
$$= (E_\ell + E_\nu)^2 - (\vec{p}_\ell + \vec{p}_\nu)^2$$
$$= 2E_\ell E_\nu - 2\,\vec{p}_\ell \cdot \vec{p}_\nu$$
$$m_T^2 = 2(p_T^\ell p_T^\nu - \vec{p}_T^{\,\ell} \cdot \vec{p}_T^{\,\nu})$$

The neutrino momentum vector is estimated from the missing momentum:

$$\vec{p}_T^{\,\nu} \equiv -\vec{p}_T^{\,\ell} - \vec{u}$$

where $\vec{u}$ is the $\vec{p}_T$ sum of energy in the calorimeter. (degraded by pileup)

Fit m_T distribution to tuned MC templates generated at different m_W.

Check using $Z \to \mu^+\mu^-$ and $Z \to e^+e^-$ events.

M_W obtained from $\mu\nu$ and $e\nu$ samples averaged using best linear unbiased estimator.

$$m_W = 80.387 \pm 0.012 \pm 0.015 \quad GeV/c^2 .$$

ATLAS measurement

$\sqrt{s} = 7$ TeV $\quad 4.6\ fb^{-1}$

Trigger: μ with $p_T > 18$ GeV
e with $p_T > 20$ GeV

Offline: $p_T(\ell) > 30$ GeV
$\not{p}_T > 30$ GeV
recoil, $u_T < 30$ GeV
$M_T > 60$ GeV

$5.9 \times 10^6 \quad W \to e\nu$
$7.8 \times 10^6 \quad W \to \mu\nu$

In addition, $0.6 \times 10^6 \quad Z \to ee$
$1.2 \times 10^6 \quad Z \to \mu\mu$

The W/Z p_T depends on higher order QCD effects that are not easily calculable. Parameters in the MC are tuned to match the Z p_T distribution. ISR should be the same for both W and Z production.

Unlike at the Tevatron, W^+ and W^- have different production cross sections. PDF's affect W polarization and change vs rapidity.

modelling

$$M_W = 80.3695 \pm 0.0068 \pm 0.0106 \pm 0.0136 \quad GeV$$