Recoil Model contribution to W width analysis

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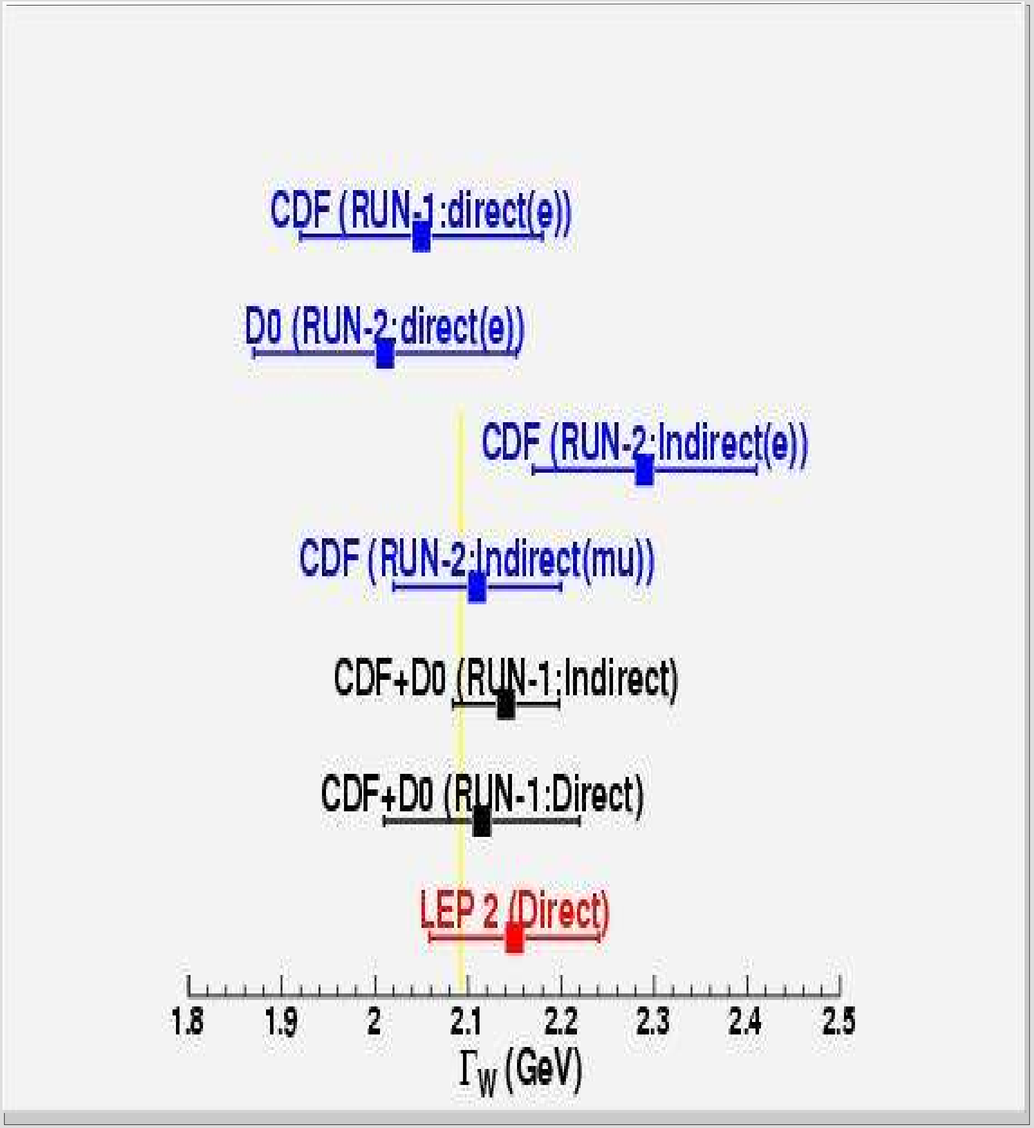
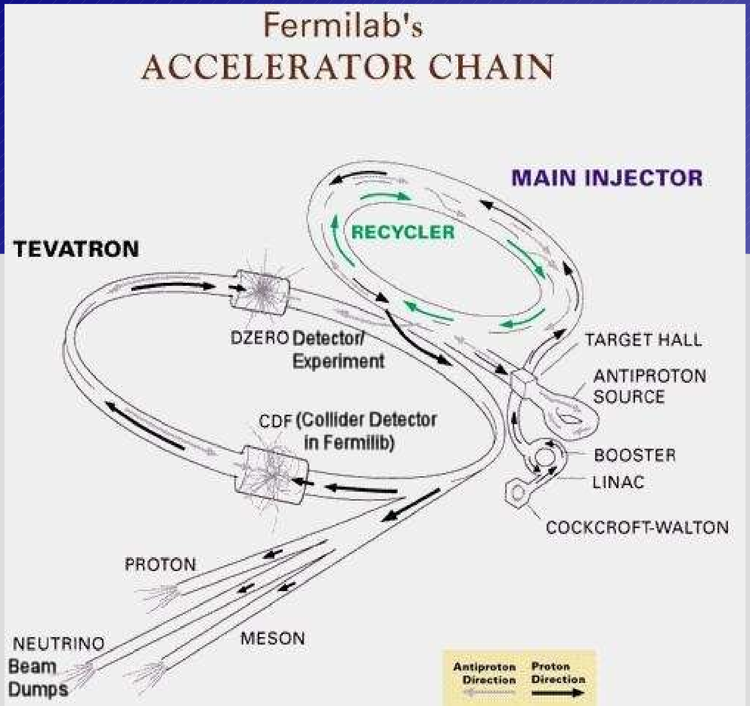
Motivation

- W width is very well predicted by Standard model but it is also one of the least well checked parts of the model;
- SM prediction Γ_w = 2.090±0.008
- An accurate measurement will give insight into presence or not of exotic decay modes of the W.
- An added bonus of such accurate measurement is that we know more about our detector and how it works.



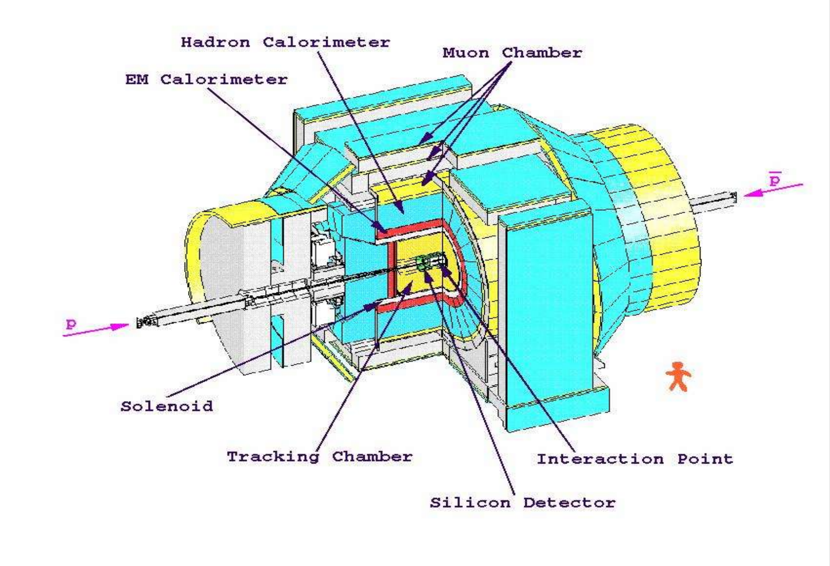
Tevatron



- accelerates 36 bunches of protons and antiprotons and collides them at centre-of-mass energy of 1.96 TeV.
- time in between bunch crossings = 396 ns.
- achieved integrated luminosity of 1 inverse femtobarn on 24th june.
- collision takes place in the 2 detectors, CDF and D0.

CDF detector

- measures particle energy, momenta and ID.
- subdetectors arranged in concentric layers around the beampipe.
- tracking system, calorimeters, muon chambers.



Overview of analysis

- W width determined using transverse mass distribution (high Mt region 110-200 GeV).
- Mt is obtained by transverse energy of lepton and inferred transverse energy of neutrino.
- Calibrate tracker – using Z-->uu and low mass resonances, J/Psi and Upsilon.
- Calibrate energy scale in calorimeter – using Z-->ee and W-->ev.
- Model hadronic recoil using Z-->*ll*
- Backgrounds

Systematic Uncertainties on W width

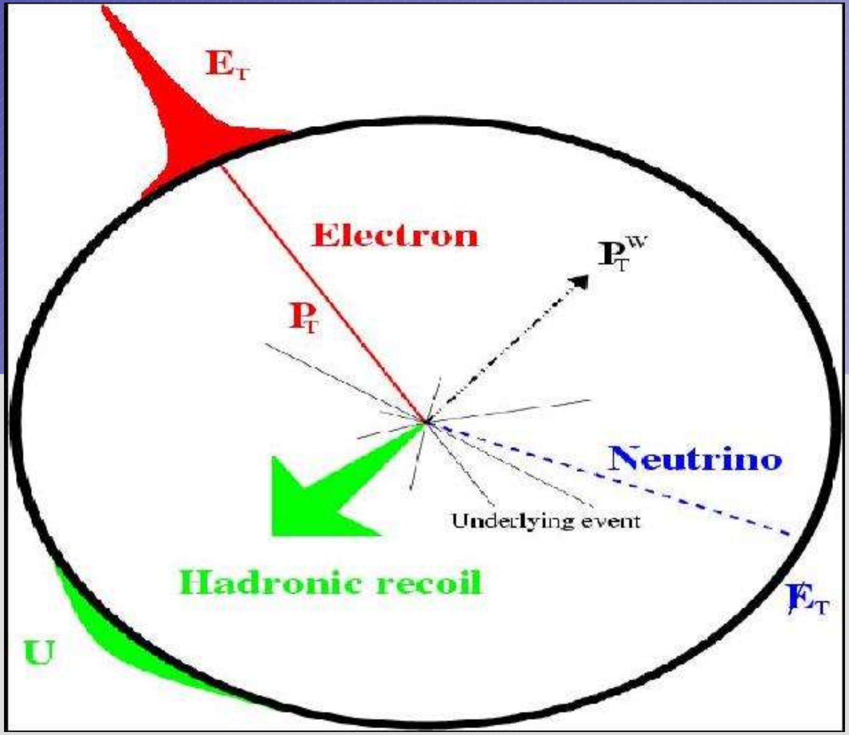
one of the highest systematic uncertainties on width

momentum + energy scale

determine the rapidity distribution of W and hence decay leptons

	run 1		run 2	
	e	mu	e	mu
Recoil + W pt	80	115	40	60
lepton scale/non-linearity	65	15	35	10
backgrounds	30	50	20	30
lepton resolution	10	20	5	5
PDFs	15	15	10	10
QED	10	10	10	10

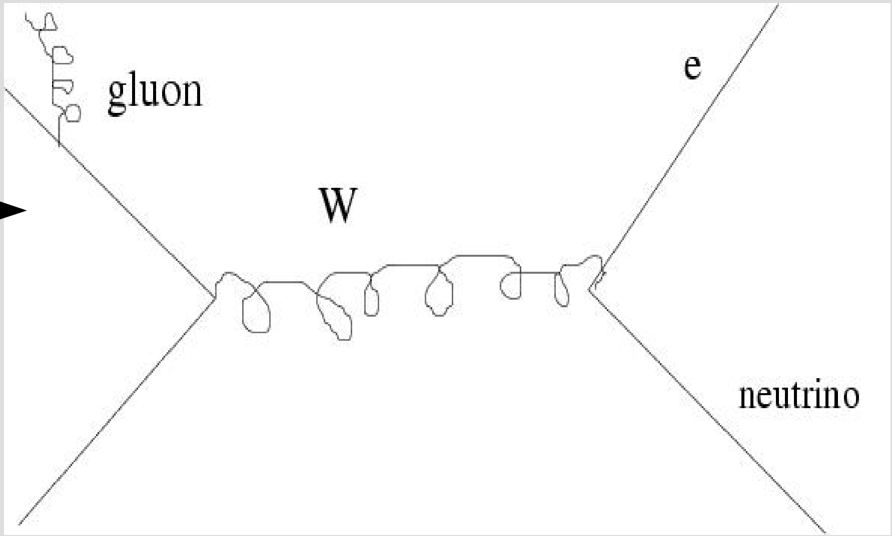
Recoil Model



essentially everything in event except charged lepton(s).

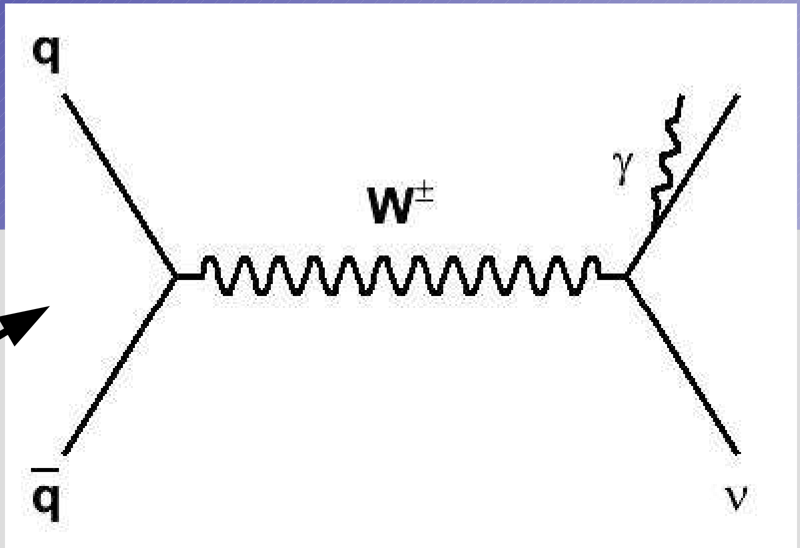
Recoil model receives contributions from 2 main sources:

- Hard QCD subprocess – boson pt recoiling against gluon. 'hard recoil' is pt dependant.



- **underlying event, 'soft component', i.e multiple interactions, spectator parton interactions, remnants of pp collision.**

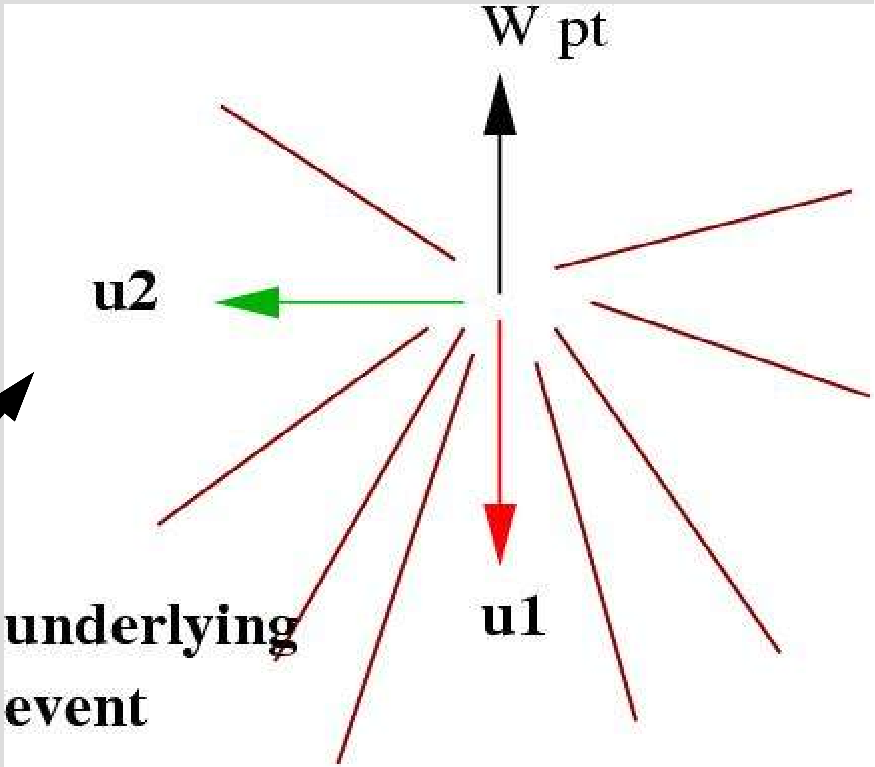
- **bremsstrahlung - a photon radiated by a lepton that doesn't end up in same tower contributes to recoil.**



recoil energy vector;

$$\vec{u}=(u_{px},u_{py})=\Sigma_i E_i \sin\theta_i (\cos\phi_i, \sin\phi_i)$$

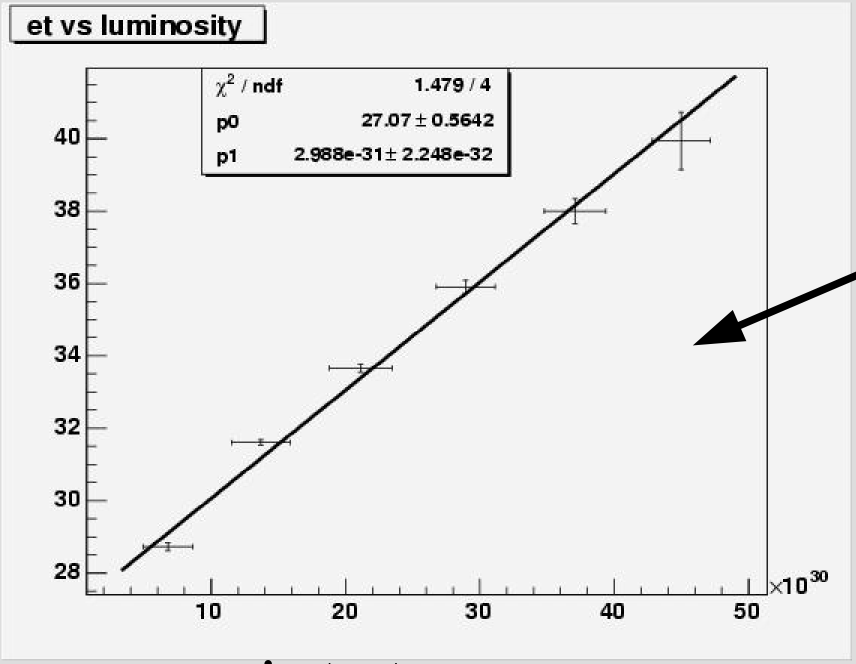
- **Divide recoil energy vector u into 2 components, u1 parallel to direction of boson pt and u2 which is perpendicular to it.**



Parameterizing the recoil model

- u1 = f(pt) + G (UE)   resolution of u1 is dependent on boson pt
- u2 = H(UE)   resolution of u2 dependent on luminosity and hence ∑Et.

ΣE_T



instantaneous luminosity

increase in instantaneous luminosity → more interactions per beam crossing, hence greater ΣE_T

Z --> *ll* events – pt of hard recoil measured w.r.t pt of Z which is obtained from the reconstructed pt of 2 electrons, but this is not true pt.

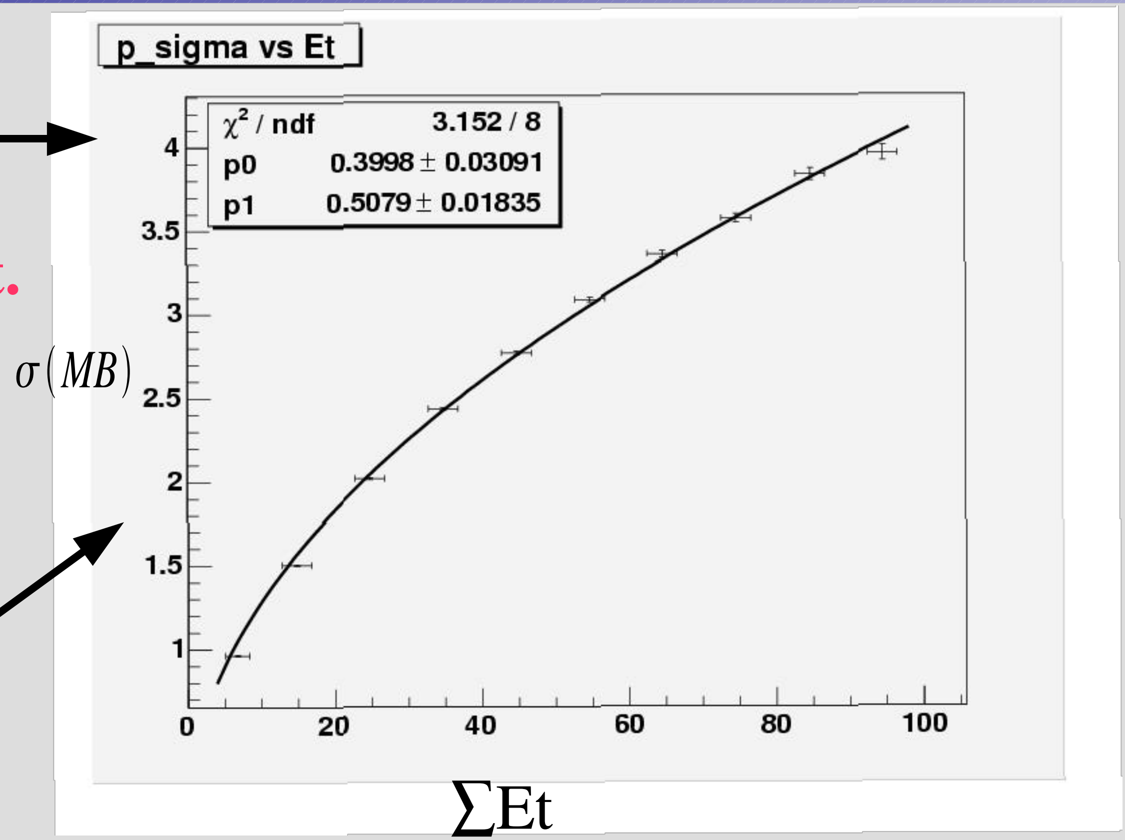
W --> eν events – pt of recoil is measured w.r.t pt of the lepton.

Underlying event contribution to recoil can be analysed by looking at minimum bias events.

- Detector response to MB events, resolution on MB increases with increasing ∑Et.
- obeys simple power law:

$$\sigma(MB) = 0.3998(\Sigma E_T)^{0.5079}$$

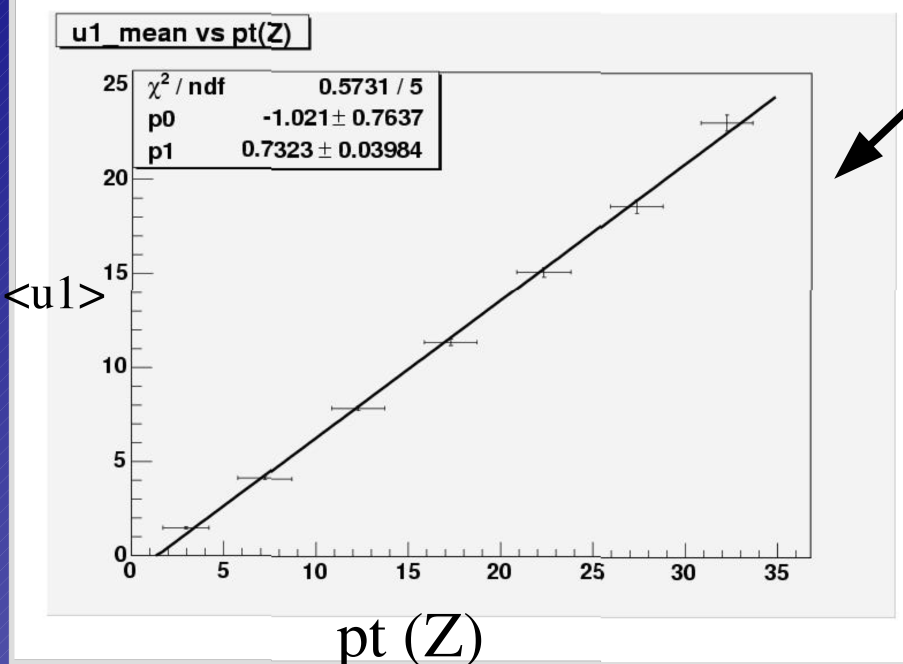
average σ from gaussian fits to vector sum of Ex and Ey in the hadronic and EM calorimeters.



minimum bias events

QCD contribution to recoil studied using Z --> *ll* events. Z data gives u1, u2, ∑Et and smeared Z pt. In W events only the pt of lepton and energy of recoil is measured.

Parameterize recoil model by fitting to these variables.

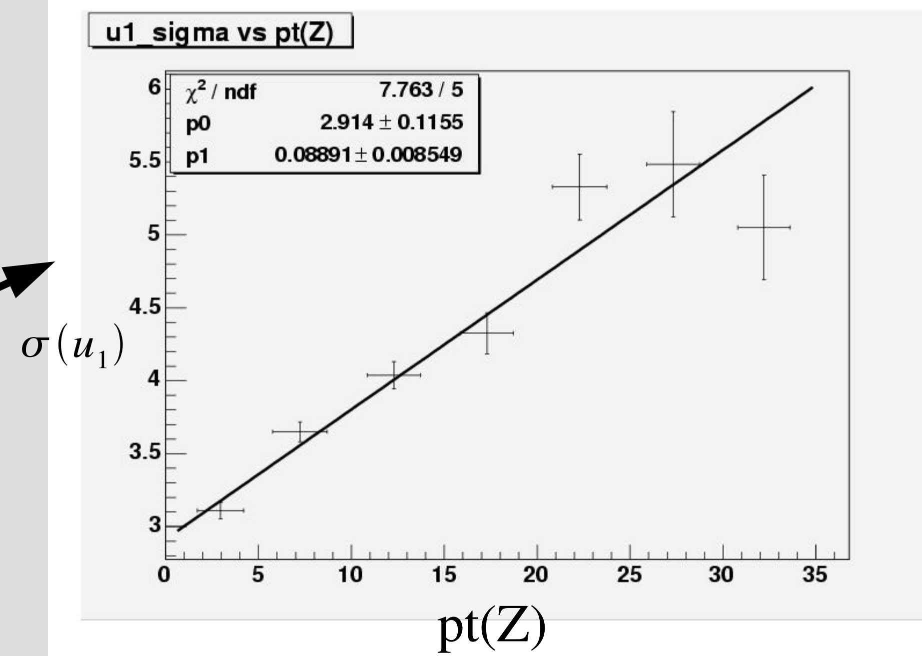


u1 mean increases with pt(Z), gluon recoil must balance pt of Z so as Z pt increases, u1 will increase.

Z --> ee sample

resolution on u1 increases with increasing Z pt, hadronic recoil energy deposited in calorimeter increases, resolution in calorimeter;

$$\sigma(E_T)/E_T = \sqrt{(C/E_T + \kappa)}$$

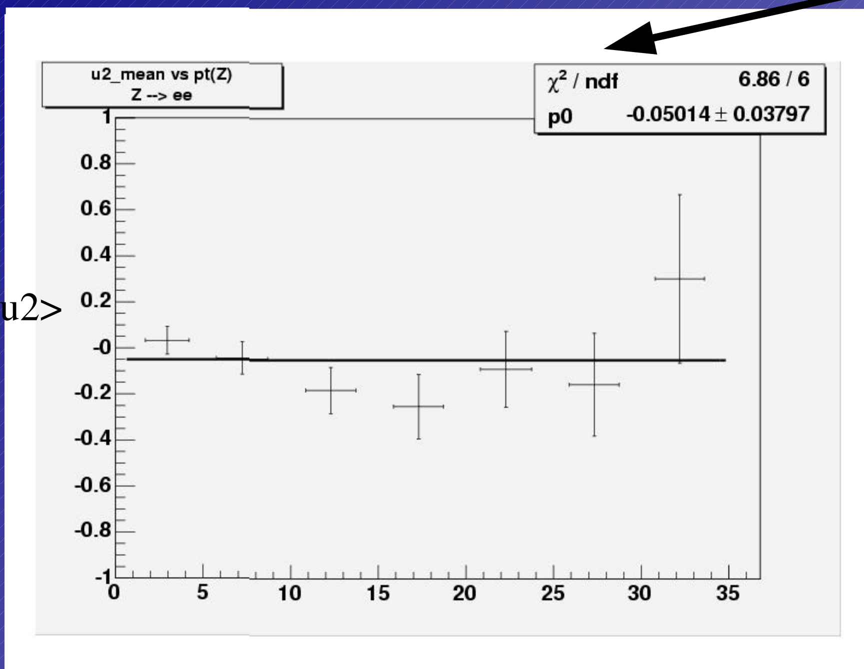


so sigma increases with increasing Et.

Perpendicular component u2

mean of u2 plotted in bins of pt(Z)

<u2>



pt(Z)

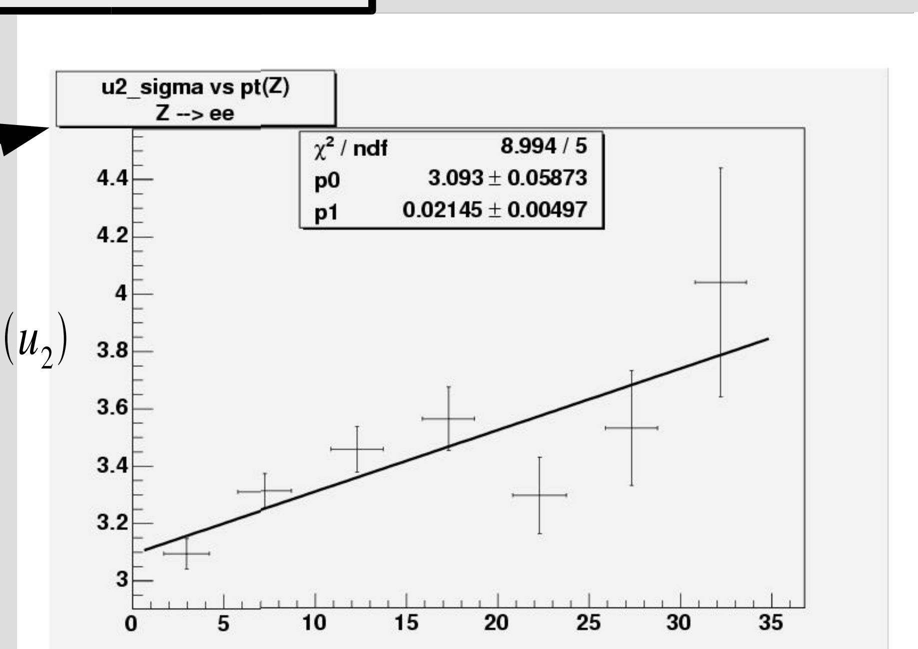
- mean is approx zero as expected since u2 component consists of mainly underlying events and therefore has little dependence on pt of Z.

Z --> e+ e-

resolution of u2 increases with pt(Z);

- possible reason is Z recoiling against more than one gluon, so u2 w.r.t 'resultant' pt(Z) is not pt independent.
- also if hadronic recoil is spread out, i.e not well collimated.

$\sigma(u_2)$



pt(Z)

These distributions were also fitted with quadratics, for both muon channel and electron channel.

quadratic fits give slightly better χ^2/ndf but need to look at probabilities .

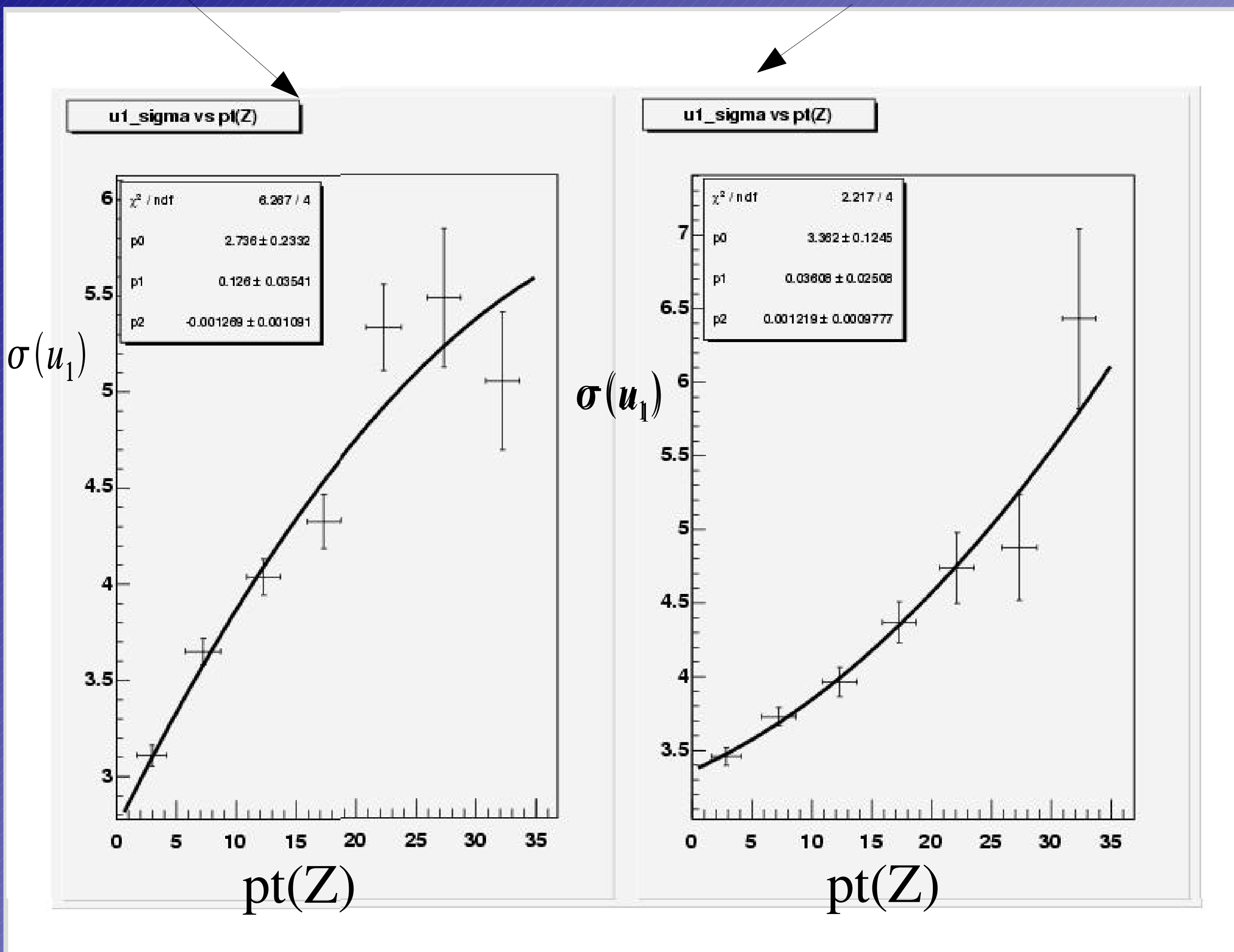
χ^2/ndf	electrons	muons
quadratic fit to $\sigma(u_1)$	6.267/4	2.217/4
linear fit to $\sigma(u_1)$	7.763/5	3.637/5
quadratic fit to $\sigma(u_2)$	6.201/4	1.566/4
linear fit to $\sigma(u_2)$	8.994/5	3.455/5
quadratic fit to $< u_1 >$	0.1411/4	0.2182/4
linear fit to $< u_1 >$	0.5731/5	0.4774/5

The resolution on u1 for electron and muon channel;

parameters are very different, need to look at the effects producing the difference.

Z --> ee

Z --> uu

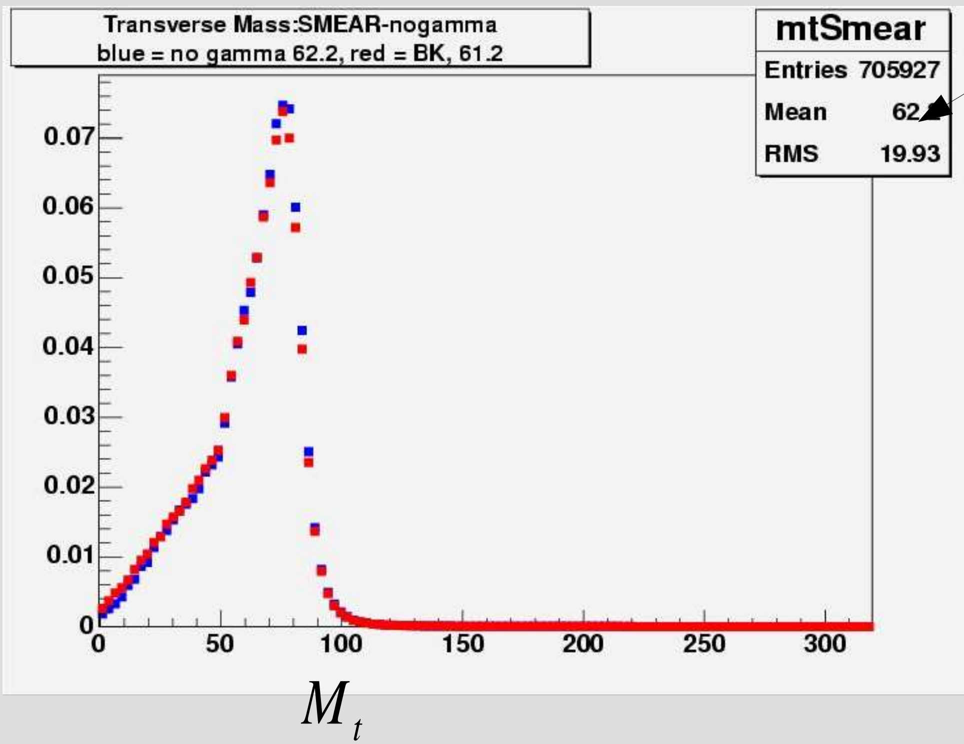


eventually would like to combine the 2 channels to parameterize the recoil model.

Bremsstrahlung contribution:

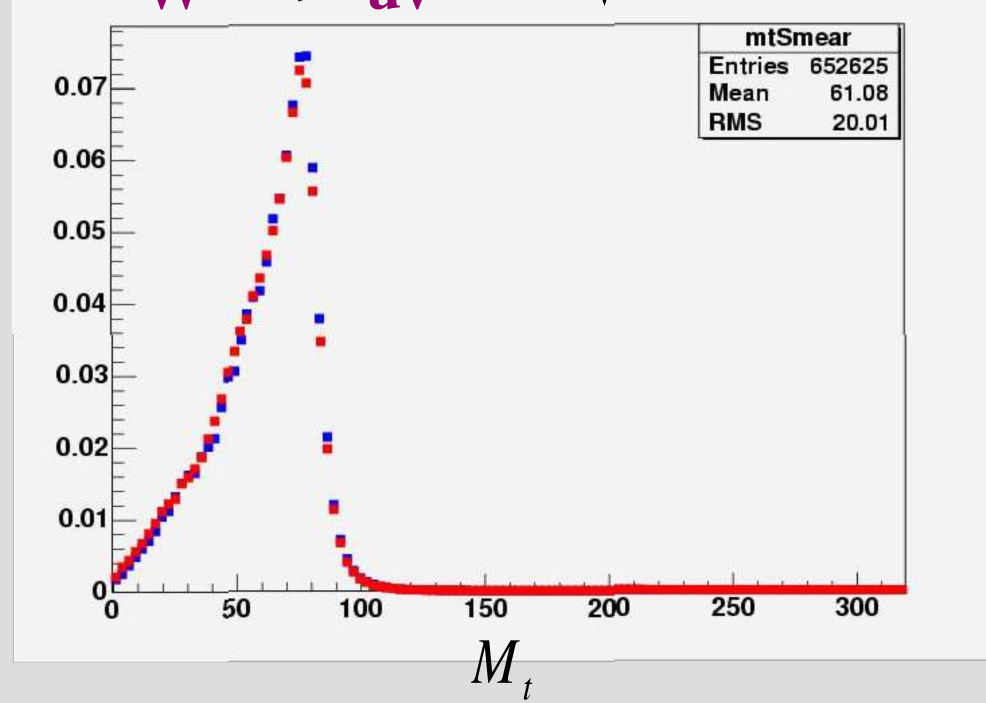
- a lepton radiating a photon which does not end up in the same tower will contribute to the recoil energy.

W → ev



transverse mass distribution for electrons and muons with no final state radiated photon (blue) and with one final state photon (red).

W → uv



next step: fit templates with different W widths to these to quantify the shift in transverse mass.

Future plans

- Ultimately we want to use parameterization obtained for the recoil model from the Z events and apply it to Ws.
- Parameterize recoil model in simulation using Z events, fit to the data and minimize χ^2 for the fit.
- Assume closeness of mass of W and Z means that pt distribution will be similar but have to account for other effects.

For Z events, both electrons are required to be in central region, in W events, the electron is in central region but neutrino can be anywhere, so could be in plug.

Need to account for all these effects in the simulation when deriving recoil model for the Ws.