Discussion on focus for the W mass section

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Warning copied from Dave Water's talk earlier this morning:

This is not a talk.
What might be interesting to see in a write-up ?

W mass working meeting, Tev4LHC,
Fermilab, October 2005

D0 Run I (electron channel)

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TABLE X. W mass uncertainties (in MeV) in the EC measurement and the combined CC+EC measurement from the 1994–1995 data.

Source	EC	CC+EC
W statistics	108	61
Z statistics	181	59
Calorimeter linearity	52	25
Calorimeter uniformity	–	8
Electron resolution	42	19
Electron angle calibration	20	10
Recoil response	17	25
Recoil resolution	42	25
Electron removal	4	12
Selection bias	5	3
Backgrounds	20	9
PDF	17	7
Parton luminosity	2	4
$p_T(W)$	25	15
$\Gamma(W)$	10	10
Radiative corrections	1	12

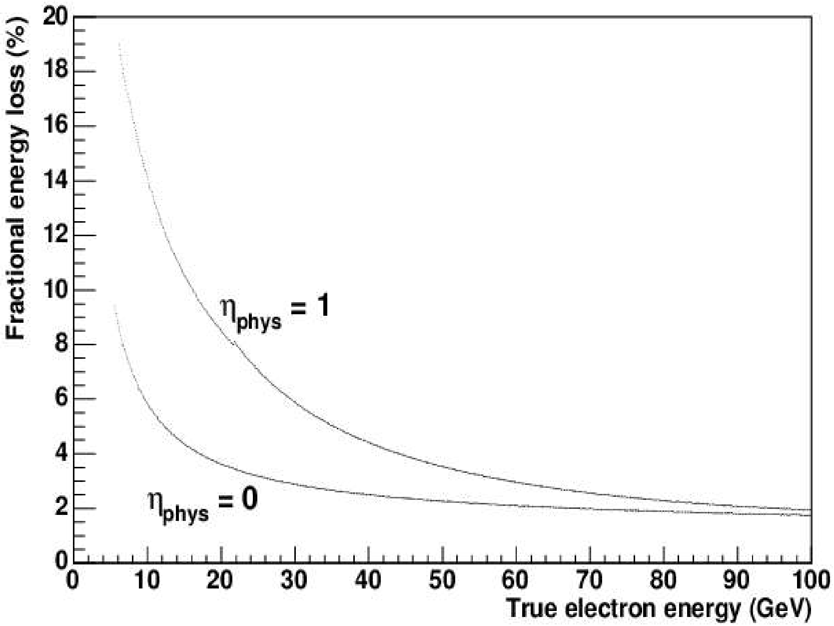
Dominant uncertainties: understanding of the detector

How is this particular topic treated in existing reports ?

Found rather precise information about the required precision on the detector understanding needed to achieve a given (wanted) error on the W mass, but less information on how to get there other than “we will use large statistics of Z events”.

Impact of dead material in front of CAL

Energy loss in dead material in front of CAL. Monte Carlo prediction for a D0-like sampling calorimeter with about 3.5 X_0 of material upstream.



Complex function of electron energy and angle of incidence. Need to understand extrapolation from Z to W energies.
This affects many of the usual methods for the W mass measurement: $m_T(W)$, $m_T(W)/m_T(Z)$, $p_T(e)$

Also an issue at the LHC. Example below is from the ATLAS calorimeter performance TDR.

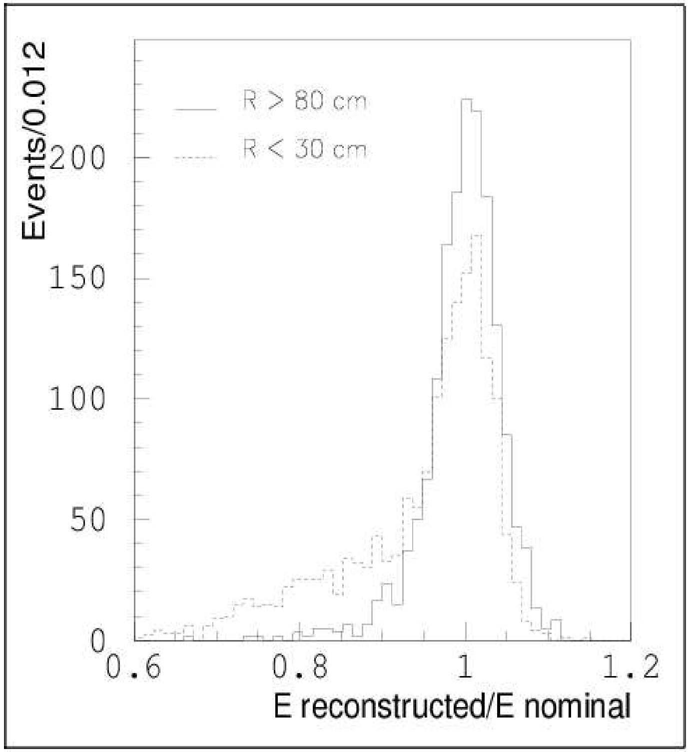


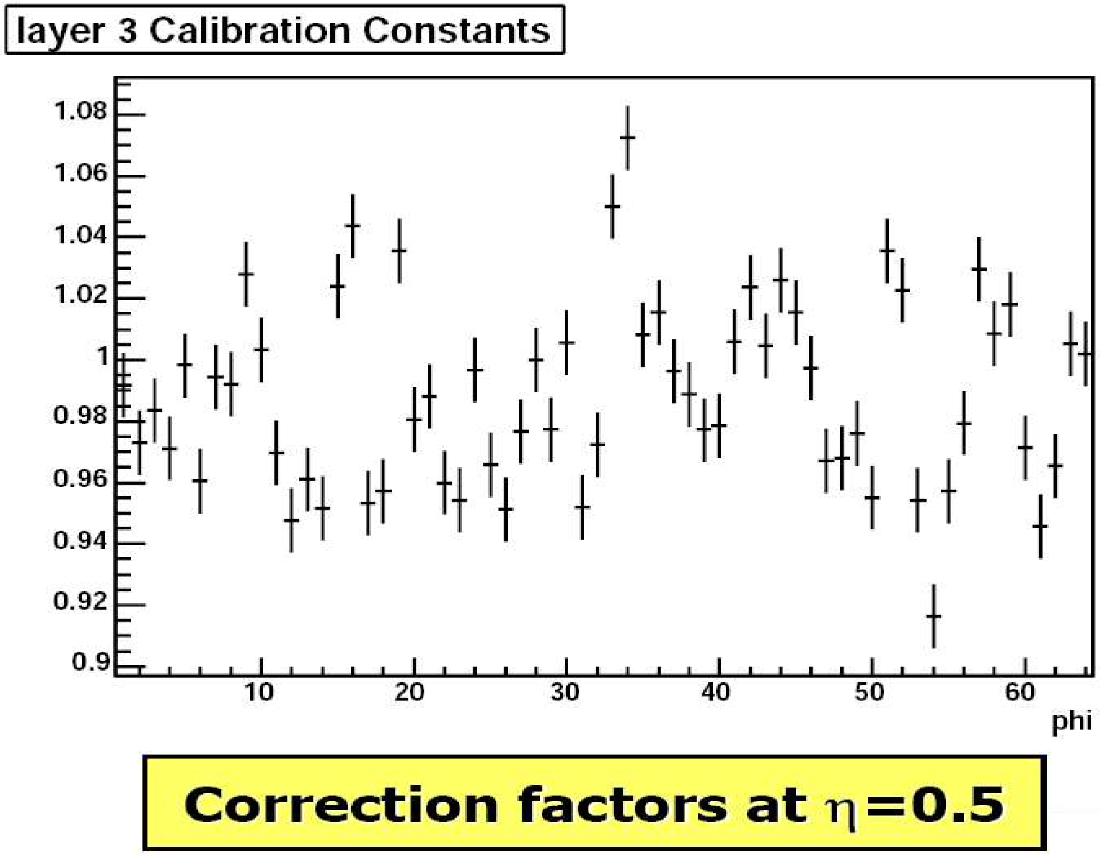
Figure 2-27 Energy spectra reconstructed in the EM calorimeter in a $\Delta\eta \times \Delta\phi$ = 3 x 7 cell cluster (normalised to the generated particle energy) for electrons of E_T = 10 GeV at η = 1.2. The full (resp. dashed) histogram is for electrons with an interaction radius larger than 80 cm (resp. smaller than 30 cm).

$\eta = 1.2 \Rightarrow 3.5\ X_0$

Energy calibration *in situ*

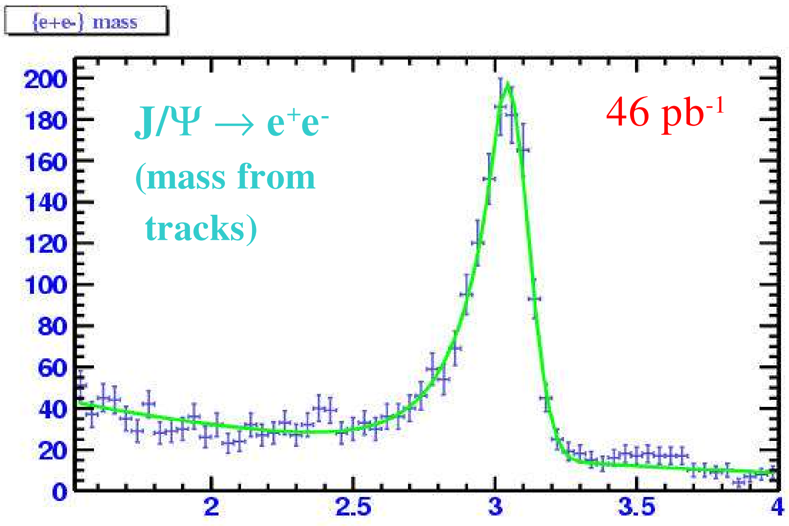
Example from detailed intercalibration of D0 EM calorimeter with a few weeks worth of data.

Uses special calibration trigger. Running in parallel to Physics data taking at the end of every store.



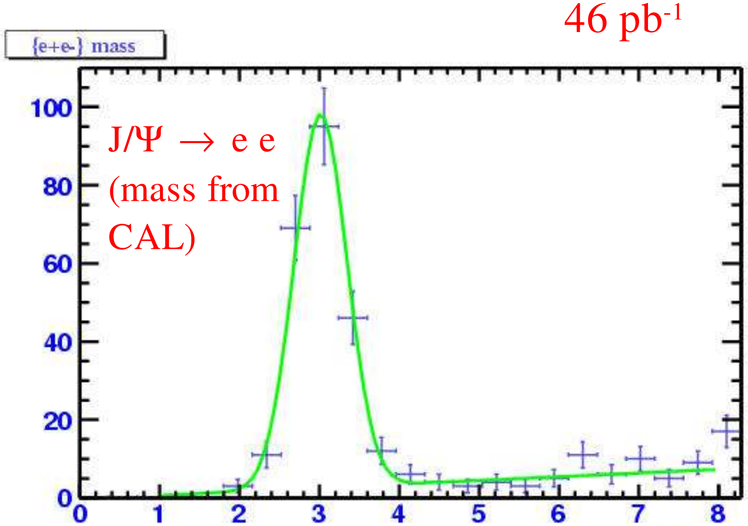
Energy calibration *in situ*

Di-EM resonances other than the Z help to constrain the energy response (both scale and resolution) over a large range in energy.

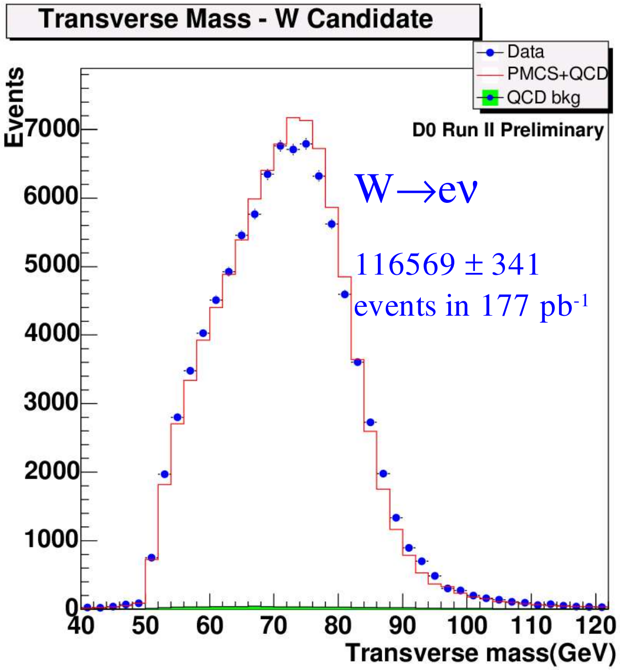


Plots on the right are an example from D0.
Collect events using a trigger that mainly relies on tracks. Then thry to reconstruct isolated clusters in the calorimeter.

A warning on resolution: keep in mind that the dead matrial upstream of the CAL does not only increase the constant term in the energy resolution, it also degrades the sampling term (e.g. from 16 % to 21 % in the example Monte Carlo shown on slide 3). This also need to be studied in situ with the final detector setup. Testbeam alone will not do the trick.



Energy calibration *in situ*: E_T/p_T



Have large data samples of well-identified electrons from W→eν.
Top plot is from the preliminary cross section measurement we contributed to ICHEP 2004.

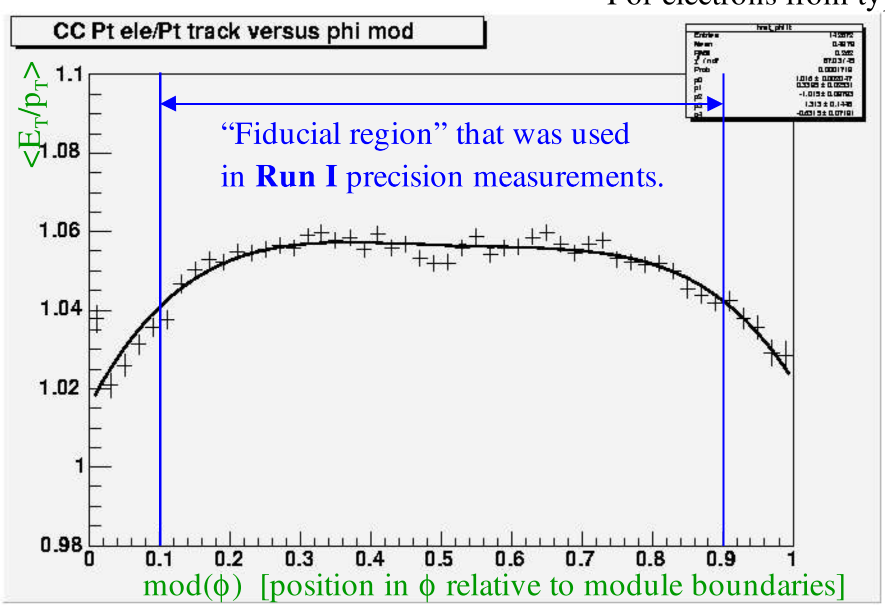
We use E_T/p_T for these (and other) electrons to study the calorimeter response.

E_T = transverse energy inferred from energy measured by calorimeter and direction from tracking

p_T = transverse momentum measured by tracking

Special benefit of this kind of study: have very precise spatial information on the electron.

At this energy, the p_T resolution is significantly worse than the E_T resolution.
For electrons from typical $J/\Psi \to e\,e$ decays, we are in the opposite situation.



Example E_T/p_T study: measurement of calorimeter response as a function of the point of impact inside a CC module.

The horizontal axis in left plot represents the point of impact in ϕ into the CC module (there are 32 of them).
mod(ϕ) = 0 and mod(ϕ) = 1 represent the edges of the modules.

Other studies: e.g. constrain linearity of the energy response over relatively wide range in E_T.
One of the complications: effects of material on p_T measurement (Brems etc.), depends on η etc.

Event simulation

And of course, once all this detector work is done, we will have to worry about the details of the Physics in the event simulation ...

- W events are generated e.g. with RESBOS (QCD-models the pT(W) spectrum) coupled with WGAD for QED processes
- QED : major contribution from FSR photons (radiated off the final state leptons)
  - shift the W mass by :
  - mu :   Pt   -130   Mt   -150   Etmiss   -95   MeV
  - electron :   -90   -110   -55   MeV
  - Experimental concern: detection and measure of the photon..
  - on MT   PtW model (g1/g2/g3) ~   10-20 MeV (g2   mean PtW)

    PDF   ~   15-20 MeV

    QED FSR   ~   15-20 MeV