# Analysis of the W-pair production in the semileptonic channel at 183 GeV

- Direct reconstruction of $M_W$ after a 5C FIT.
- A new method to find $M_W$ ?

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# "Standard" $M_W$ reconstruction with muons

## General cuts

The events should :

- contain at least 7 charged particles.
- have charged energy between 40 and 160 GeV.
- have transverse missing momentum greater than 10 GeV/c.
- do not contain a $\gamma$ with an energy greater than 35 GeV.

| | Data | Signal WW | Background |
|---|---|---|---|
| After General Cuts | 2174 | 496 | 1578 |

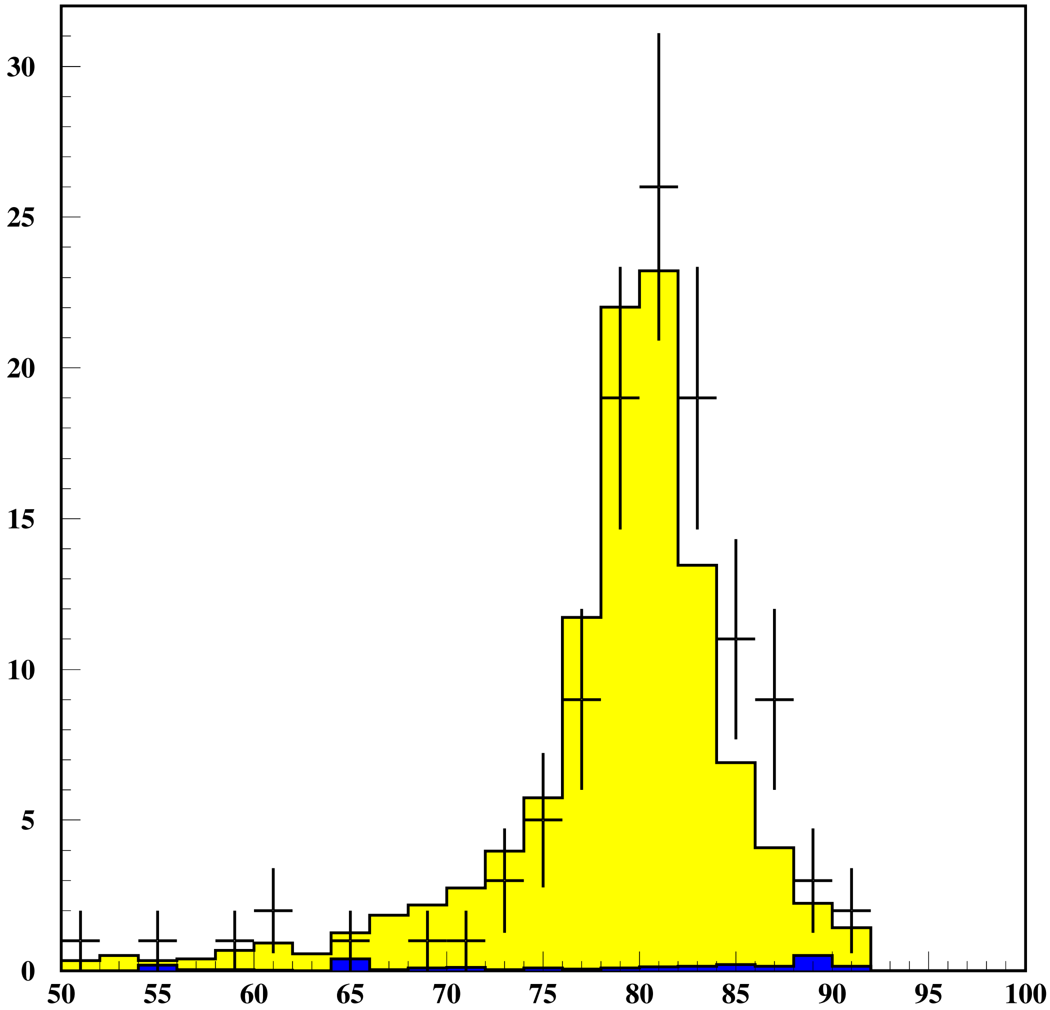
## Muon selection

The candidate muon was chosen with the following properties :

- its momentum must be greater than 15 GeV.
- its radial angle must be greater than 10 degrees.
- the isolation angle between the candidate and the nearest particle must exceed 10 degrees.
- $|ImpactParameter/Error| < 5.$

Finally, we perform a 5C fit, imposing the energy-momentum conservation and the equality of the two W masses.

| | Data | Signal WW | Background |
|---|---|---|---|
| After 5C FIT | 117 | 108 | 2 |




**W(qq) mass (AF)**

The efficiency and the purity of our selection are :

| | efficiency | Purity |
|---|---|---|
| Muon channel | 90% | 98% |

Muon channel : $Mw = 81.32 \pm 0.41\ GeV/c^2$

# "Standard" $M_W$ reconstruction with electrons

## Electron selection

The candidate electron was chosen with the following properties :

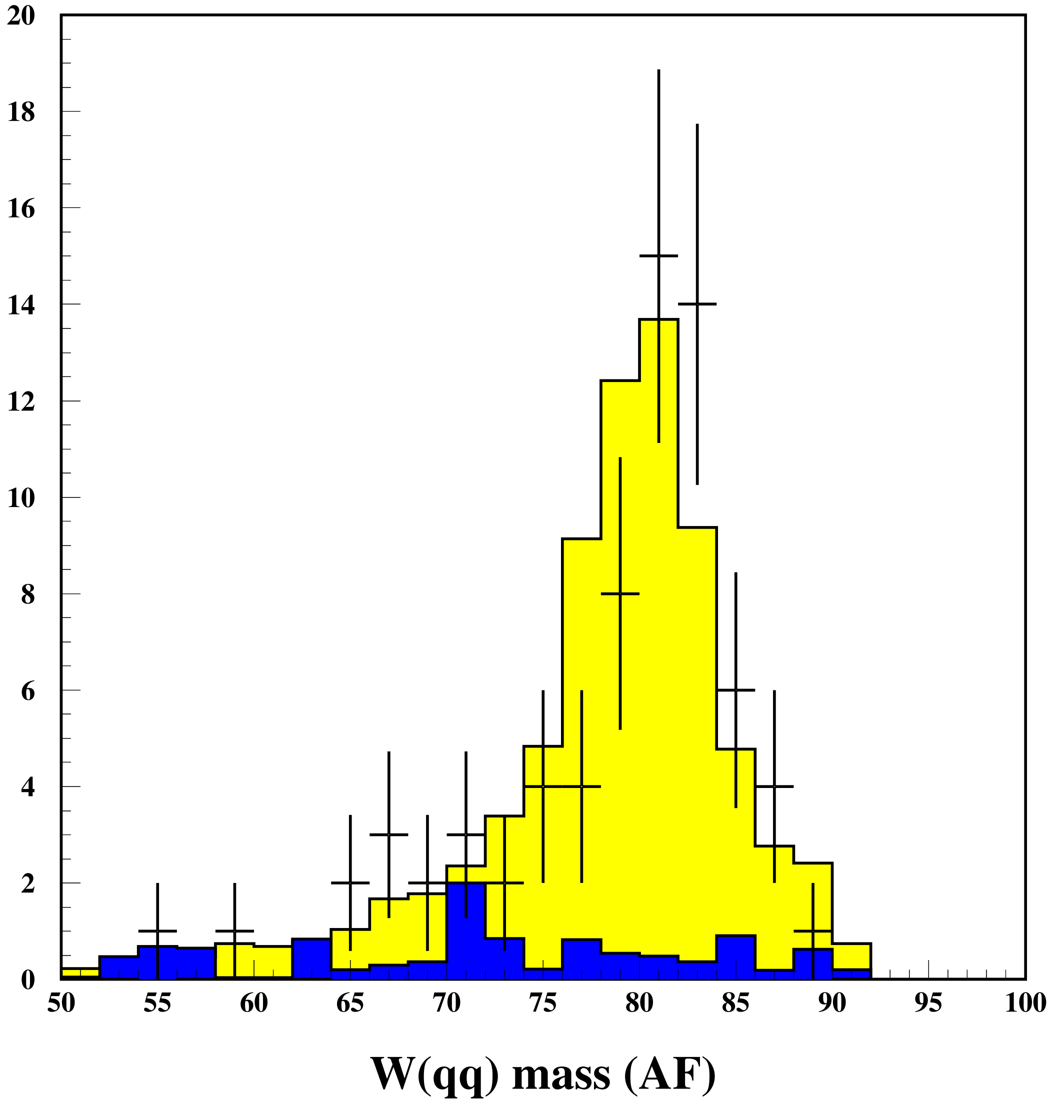
- its momentum must be greater than 15 GeV.
- the isolation angle between the candidate and the nearest charged particle must exceed 10 degrees.
- $|ImpactParameter/Error| < 5$.

And we perform the 5C FIT.

| | Data | Signal WW | Background |
|---|---|---|---|
| After 5C FIT | 74 | 76 | 10 |

The efficiency and the purity of our selection are :

| | efficiency | Purity |
|---|---|---|
| Electron channel | 63% | 88% |




Electron channel : $Mw = 81.71 \pm 0.46\ GeV/c^2$

## "Standard" $M_W$ reconstruction with taus

The value of $ycut = 0.001$ (with Durham algoritm) define the number of jets of the event.

### Tau selection

We demand at least one jet with :

- radial angle between 20 and 160 degrees.
- the leading particle must be a charged particle.
- the jet should contain less than 5 particles.
- the total number of charged tracks is at most 3.
- the jet momentum is greater than 15 $GeV$.
- its angle with the nearest jet should exceed 30 degrees.
- the jet mass is lower than 2 $GeV/c^2$

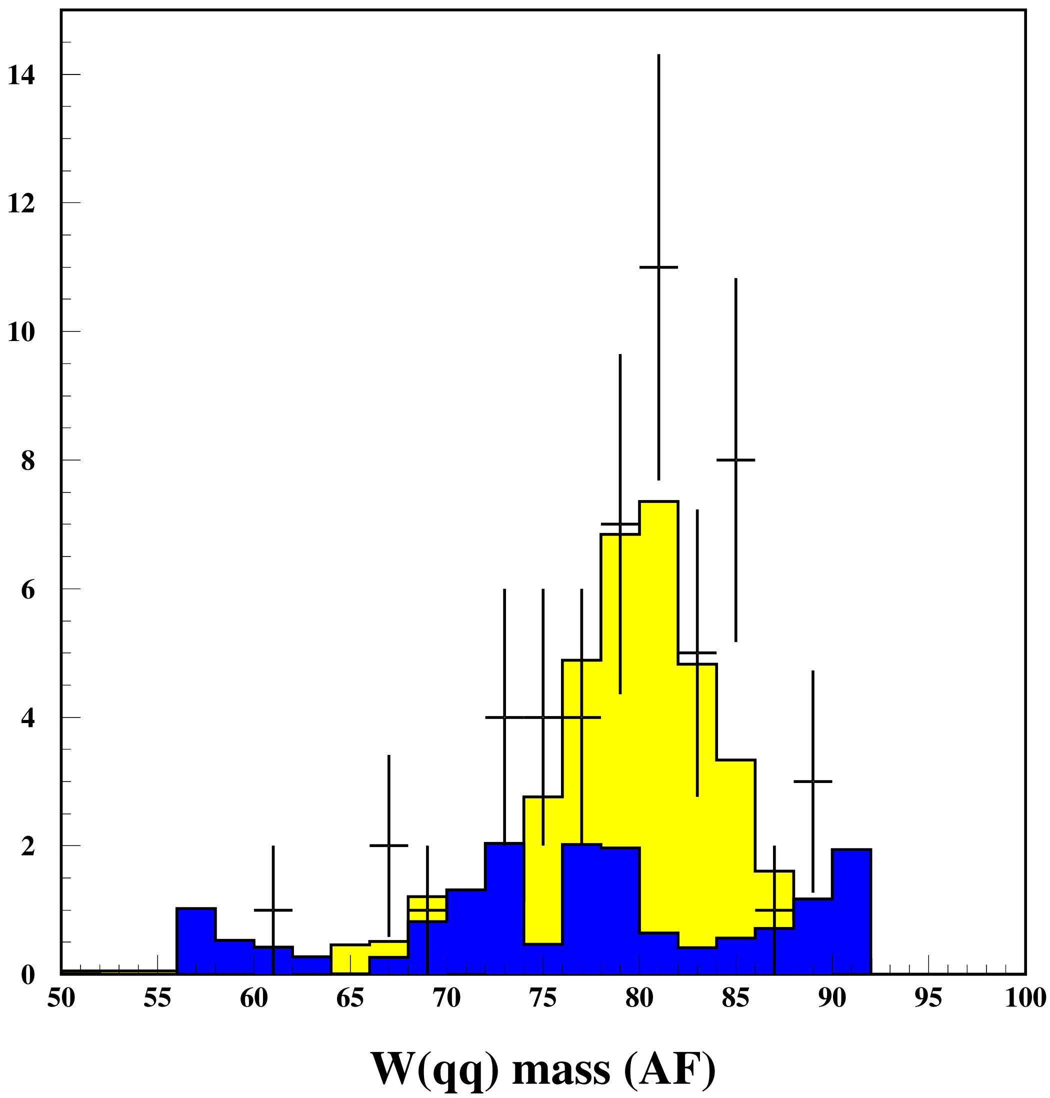
We perform cuts in the plane $Pt_{miss}$ versus $\sqrt{s'}$ to reduce the $q\bar{q}\gamma$ background.

After the 5C constrained fit, the number of events is :

| | Data | Signal WW | Background |
|---|---|---|---|
| After FIT | 54 | 39 | 20 |

The efficiency and the purity of this selection is :

| | efficiency | Purity |
|---|---|---|
| Tau channel | 33% | 66% |




$$Mw = 80.72 \pm 0.63\ GeV/c^2$$

## Results

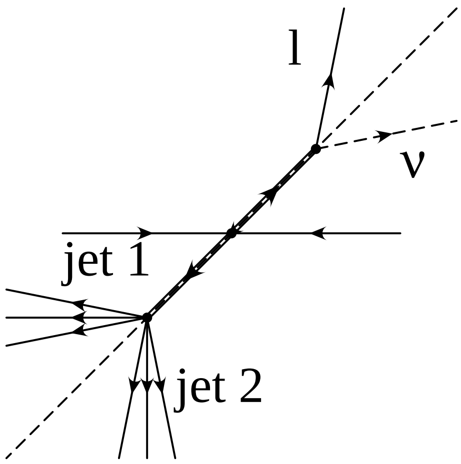
The analysis of the semileptonic decay channel using direct reconstruction provides the values :

| | w mass |
|---|---|
| Muon channel | $Mw = 81.32 \pm 0.41\ GeV/c^2$ |
| Electron channel | $Mw = 81.71 \pm 0.46\ GeV/c^2$ |
| Tau channel | $Mw = 80.72 \pm 0.63\ GeV/c^2$ |

The combined result is :

$$\boxed{Mw = 81.35 \pm 0.28\ GeV/c^2}$$

## Can we use the transverse momentum distribution to find Mw ?




The reaction $e^+e^- \rightarrow W^+W^-$ allows us to define a main direction since the two bosons are back to back. We define the transverse momentum of the lepton and of the jets with respect to this direction.

$$\frac{d\sigma}{dP_t} = \frac{d\sigma}{d\cos\theta}\frac{d\cos\theta}{dP_t}$$

In the W center of mass frame :

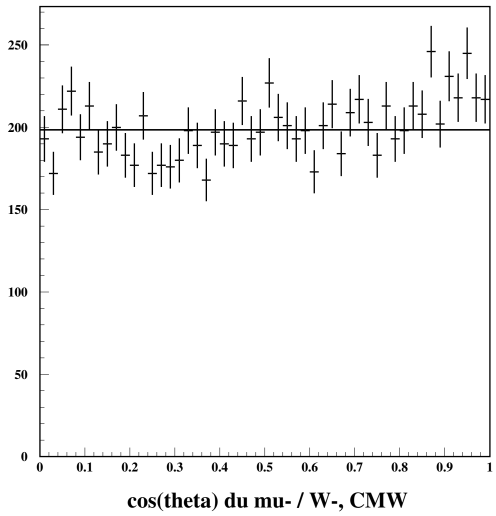
$$P_t = \frac{M_w}{2}\sin\theta$$

$$\frac{d\cos\theta}{dP_t} = \frac{4P_t}{M_W}\frac{1}{\sqrt{M_W^2 - 4P_t^2}}$$

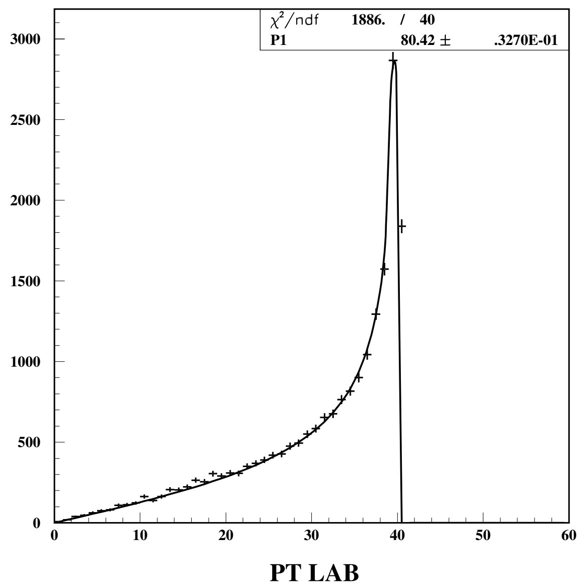
Because of this factor, the transverse momentum distribution should peak at $P_t = M_W/2$ and drop rapidly.

## Simulation with Pythia

The first point is to check that the angular distribution $d\sigma/d\cos\theta$ of the lepton and of the jets related to the W direction is flat :

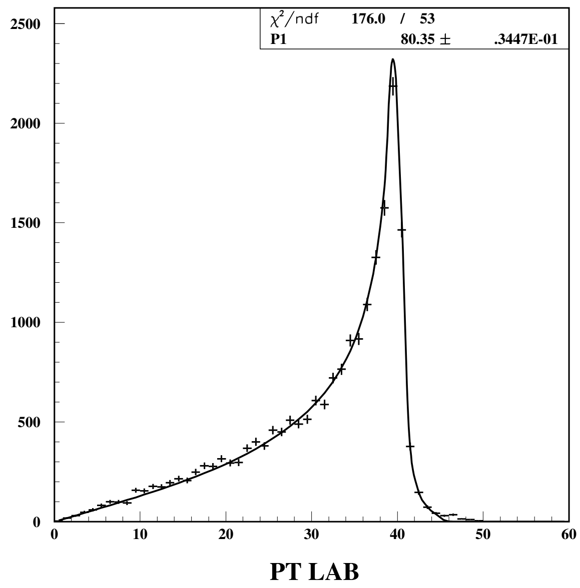



First, we generate zero-width W events and apply the zero-width formula.



Afterwards, we generate off-shell W events and we include the width of the W with a Breit-Wigner distribution .

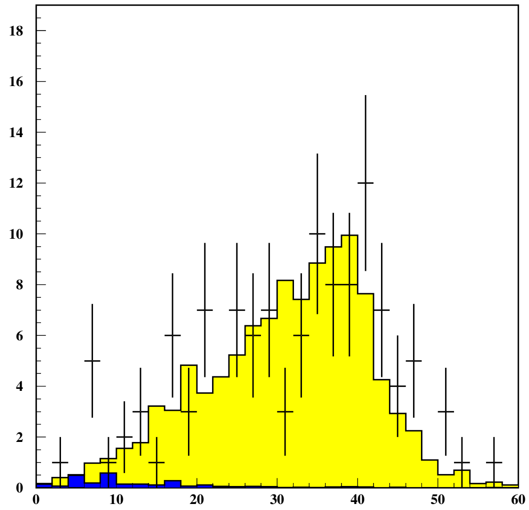
$$\frac{d\sigma}{dP_t}(P_t, M_W) = \int_{E_b}^{0} \frac{d\sigma}{dP_t}(P_t, \sqrt{s}) \times BW(s, M_W)\, ds$$



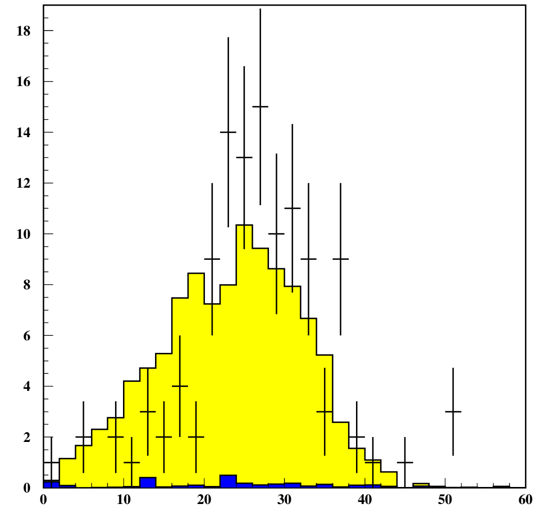

## Fitting the DATA

The analysis has been made only for the muon channel.

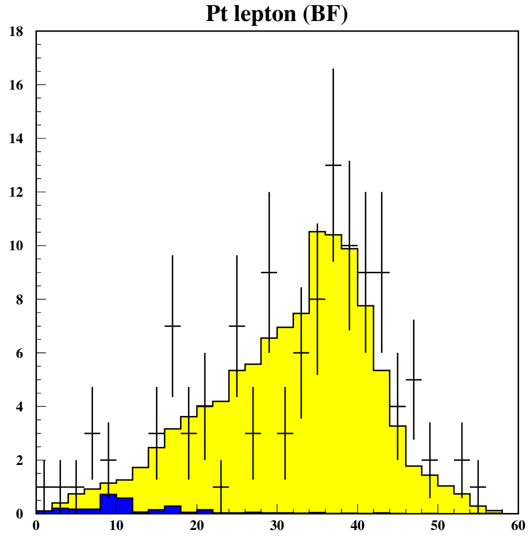
- After a 4C FIT, the resolution is too bad to fit the transverse momentum distribution, we must do it after a 5C fit.
- We must introduce a resolution function since some events slip from the peak to lower transverse momentum. We convolute with an error function : $exp[(P_t - P_t')/a]$, tested at high statistics MC events.



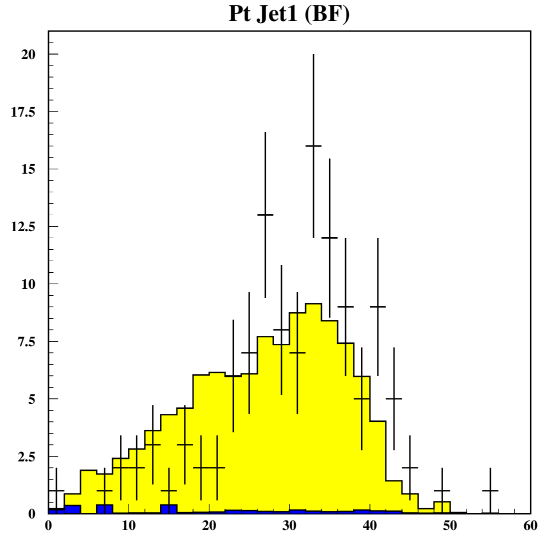
**Pt lepton (BF)**



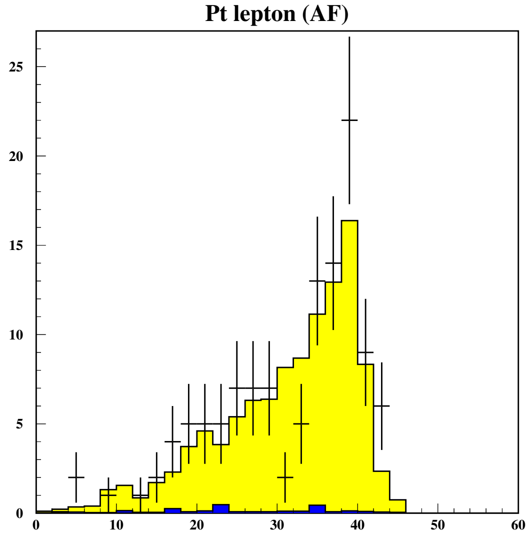
**Pt Jet1 (BF)**



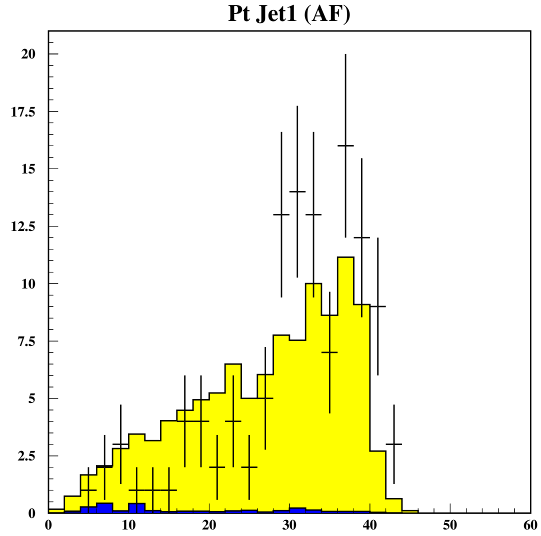
**Pt lepton (AF)**



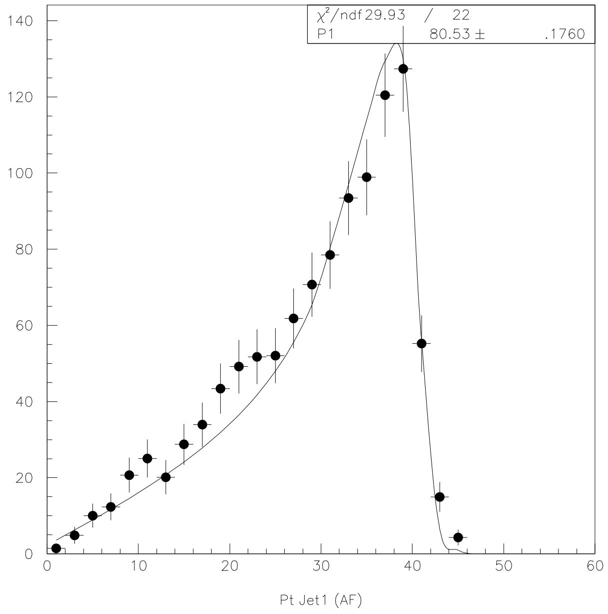
**Pt Jet1 (AF)**



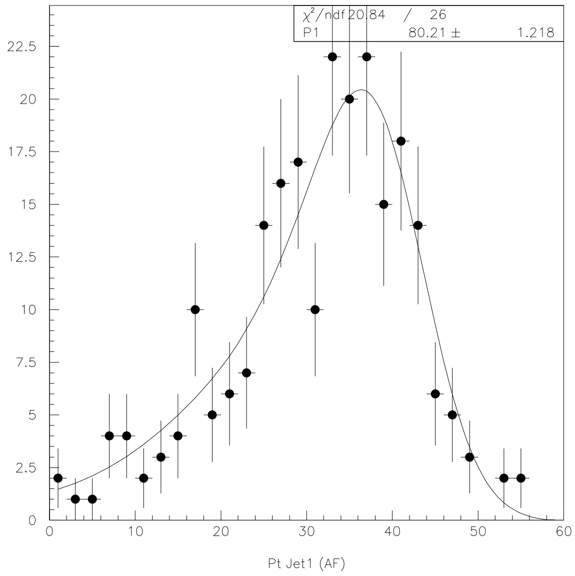
**Pt lepton (AF)**

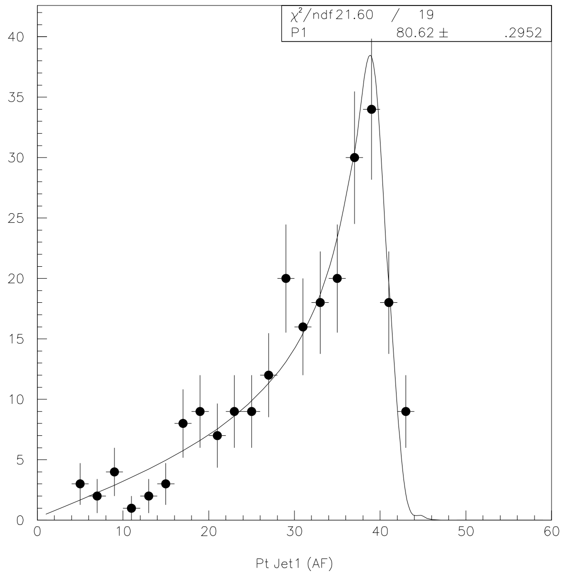


**Pt Jet1 (AF)**



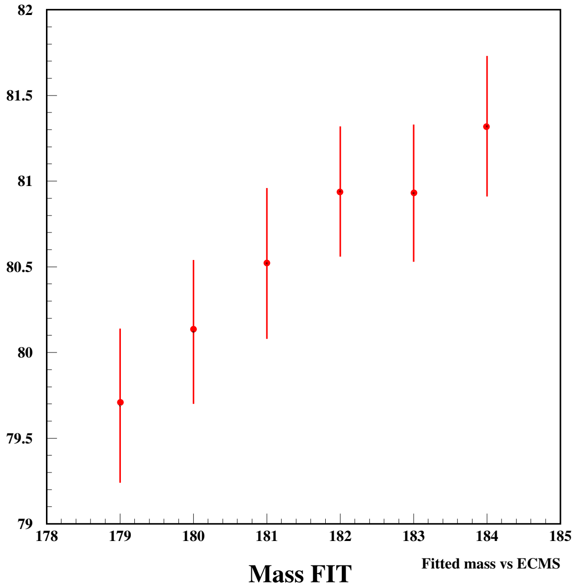

Then we sum the muon and jet $P_t$'s.



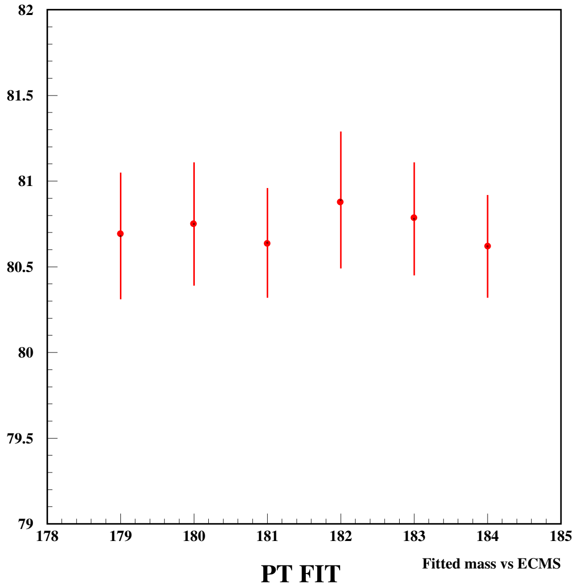




The results of the fit on the transverse momentum distribution after a 5C FIT is :

$$\boxed{Mw = 80.62 \pm 0.30\ GeV/c^2}$$




**Mass FIT**




**PT FIT**

We study the stability of this fit with respect to the CMS energy : we perform 5C FIT at different energies and compare the fitted mass obtained with the two methods.

# conclusion

this new method :

- Uses the statistics of both W's, but a study to determine their correlation should be made.
- It looks more independent from the $E_{CM}$ energy.
- The resolution function should be studied more carefully.
- Leptons and jets should be treated separately.
- It is certainly correlated to the "standard" mass reconstruction method. How much ? Can we use it to diminish our global statistical error.