# Smart Jet Momentum Corrections

As part of our plan to obtain a better peak S/N ratio for the Z signal, we consider the chance of improving our mass resolution.

Other studies have shown that the standard jet corrections are not as far as one can go. But our events are very special: they feature a high $P_T$ muon and a clean dijet topology. **These features have to be dealt with by a dedicate study.**

We have considered various jet observables for an improvement of jet resolutions. The ones we will actually use are:

- the muon momentum (of course)
- the missing $E_T$ of the event, projected along the jet axes
- the charged fraction of the jets (if $|\eta_j| < 1.0$).

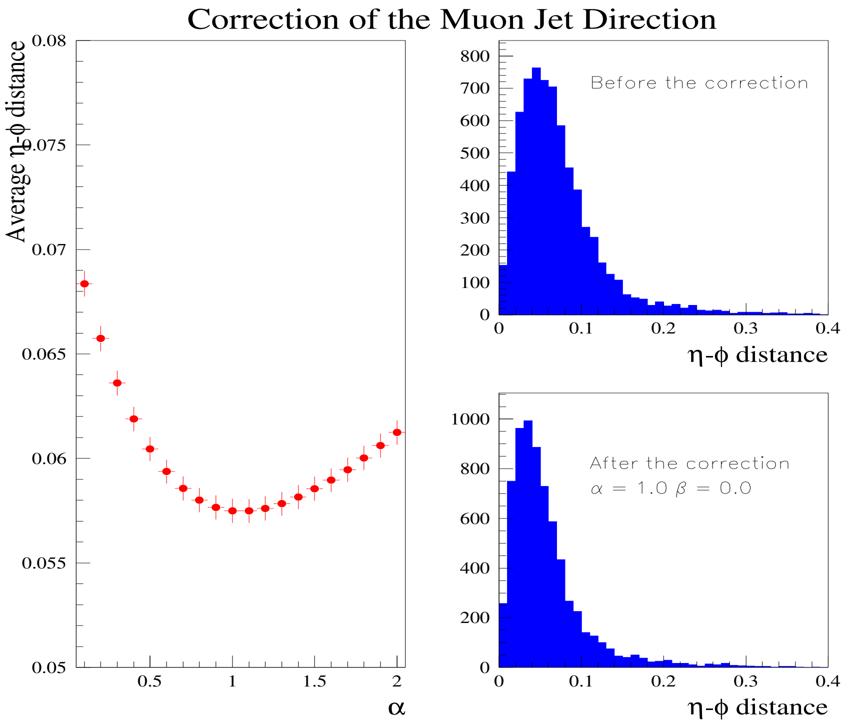
# Jet Corrections - The Muon Direction

The muon momentum vector carries informations on the b direction, as much as the jet does. The amount of energy in the muon tower might carry some information too (it actually doesn't).

We studied the average $\Delta R$ between parton and corrected jet vector: $\bar{J}' = \bar{J} + \alpha \times \bar{P}_\mu + \beta \times \bar{E}^{tow}$,

and found $\alpha$ and $\beta$ such that $< \Delta R >$ was minimized.

Result: $\alpha = 1.0$, $\beta = 0.0$.




Left: Average $\Delta R$ vs $\alpha$.

Right: $\Delta R$ before and after correction.

# Jet Corrections - 2

We generated 2,000,000 Z decays to b quark pairs (PYTHIA 5.7, QFL'), and filtered them exactly as the data.
To keep high enough statistics we did not require any SECVTX tags, yet we discarded events where the b jets were not the two highest $E_T$ ones. The Level 2 muon trigger turn-on curves for run 1a and 1b have been included in the simulation, taking care of dynamic prescaling and all that.
After all the requirements we have 19,015 events to play with.

To correct for the dependence of jet energies on X we:

1. associate b quarks to jets ($\Delta R < 0.7$);
2. fit straight line to $\Delta E \div X$ scatterplot for the jet under study;
3. discard jets who fall outside a 1-rms band centered around the line;
4. refit to a line.

This way we focus on events with no pathological behavior (remember, we want to have the highest peak, NOT necessarily the lowest rms!).

## Jet Momentum Corrections: The Muon

We divide muon jets in two classes:

1. $\mu$-jets with $E_T$ lower than the away jet (86 %);
2. $\mu$-jets with the higher $E_T$.

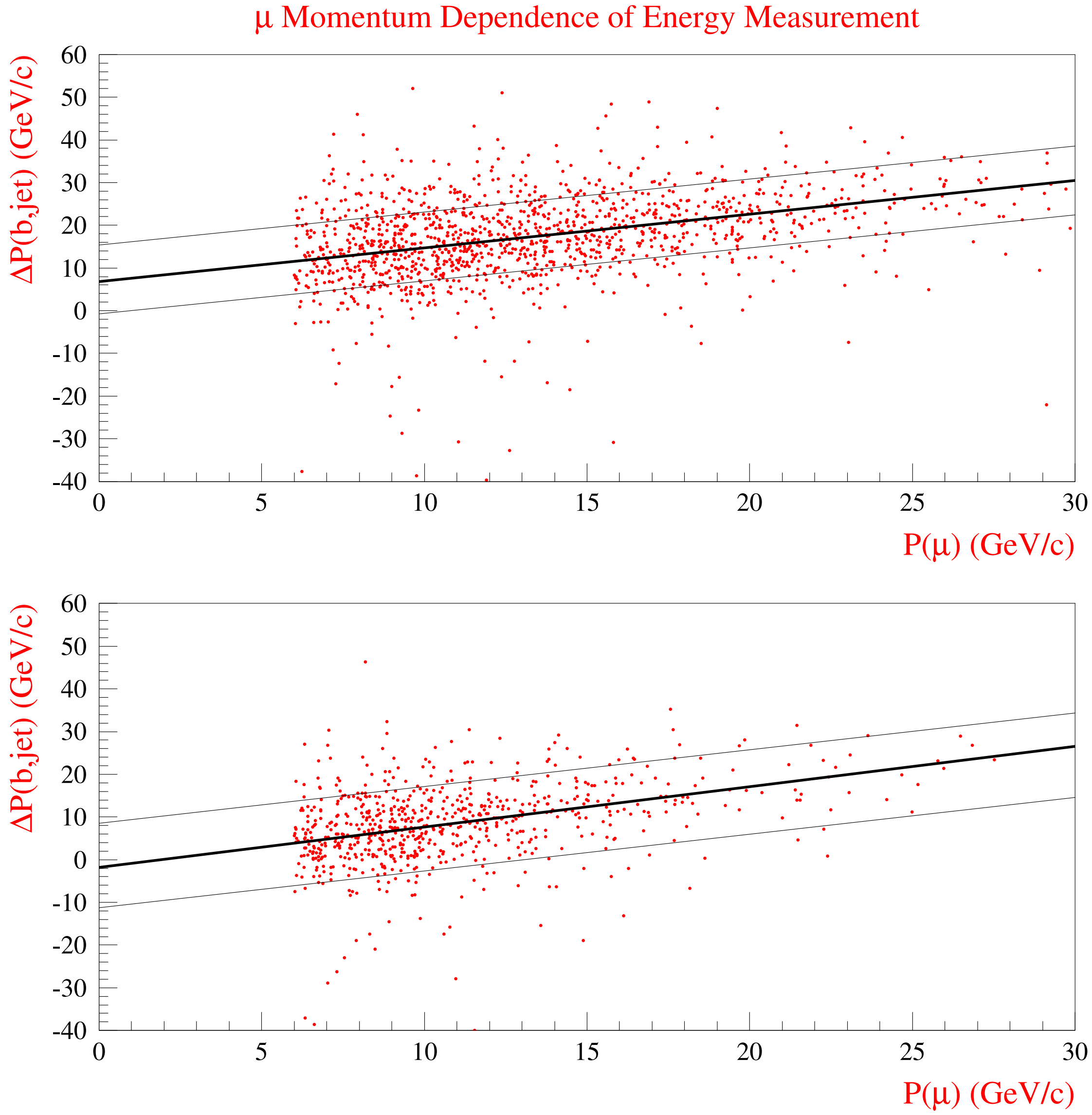
These two classes behave differently w.r.t. the muon momentum.

We find:

| class | slope | offset | r |
|---|---|---|---|
| (1) | 0.79 | 6.77 | 0.68 |
| (2) | 0.95 | -1.84 | 0.58 |

At this stage we only correct for the slopes. This allows a further fruitful division of jets in classes.

# Result of the Muon Corrections




Left: $\Delta E$ vs muon momentum and linear fits
Right: $\Delta E$ distributions before and after the correction.

# The Missing $E_T$ Correction

We use the usual definition of a missing $E_T$ corrected for muons and CMIO's. The correction is normally done only for muons with $P_T > 10 GeV$ $\rightarrow$ *we modify it slightly to correct for CMUP muons having* $6 < P_T < 10 GeV$. We studied various possibilities to use the missing $E_T$ in conjunction with related variables (EMF, CHFR).

The $\not{E}_T$ in our events may have four sources:

1. The neutrino accompanying the muon
2. A "non-MIP" muon
3. A mismeasurement of either of the two jets
4. Bad calorimetric response to the hadronic recoil

We studied various ways of dealing with the combination of these effects, and finally found one that satisfies us!

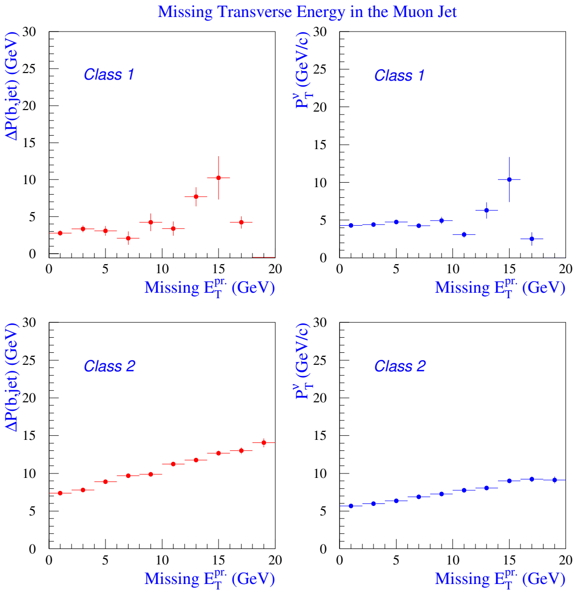
## The Missing $E_T$ Correction - 2

We divide events in classes where the missing $E_T$ has a dominant contribution from only one source: we compare the $\not\!\!E_T$ projections along each jet direction and "choose" the jet to correct as the one with the larger projection.

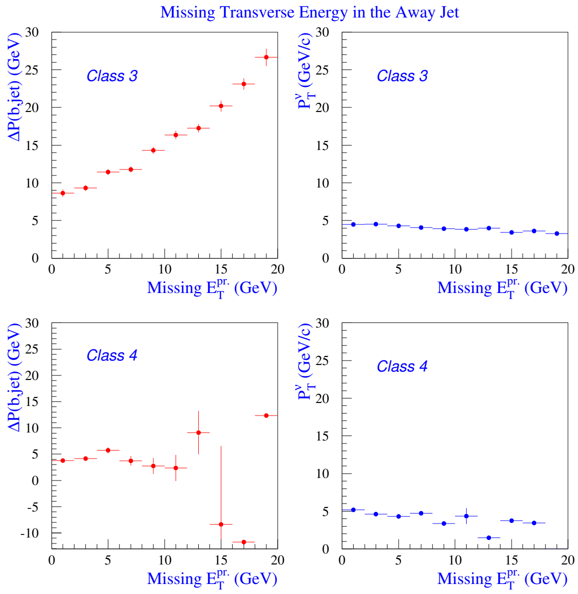
1. $\not\!\!E_T$ has the largest component along the muon jet, but this is the highest $E_T$ $\rightarrow$ do not correct.
2. As above but the muon jet is the lower $E_T$ one $\rightarrow$ correct the muon jet (m=0.37, q=6.63).
3. $\not\!\!E_T$ has a larger component along the away jet, which has lower $E_T$ $\rightarrow$ correct the away jet (m=1.03,q=4.53).
4. As above but the away jet is the higher $E_T$ one $\rightarrow$ do not correct.

Class 2 has the $\not\!\!E_T$ due primarily to the neutrino;
Class 3 has the $\not\!\!E_T$ due primarily to a low calorimeter response to the away jet.

# The Missing $E_T$ Correction - 4




These plots show the correlations of the projected missing transverse energy with muon jet momentum mismeasurement (left) and neutrino $P_T$ (right). Class 1 muon jets are shown on the top plots, class 2 muon jets are on the bottom plots. One clearly sees that class 2 muon jets are to be corrected since the projected missing $E_T$ has some sensitivity to the neutrino, while in class 1 there is no evident correlation between $\not{E}_T$ and $P_T^\nu$.




These plots show the correlations of the projected missing transverse energy with away jet momentum mismeasurement (left) and neutrino $P_T$ (right). Class 3 away jets are shown on the top plots, class 4 away jets are on the bottom plots. One can see how the momentum measure of class 3 away jets is probed by the measurement of the projected missing $E_T$, while for class 4 away jets there is no effect to correct for. In both cases, there is no dependence on the neutrino $P_T$, as expected.

# The Charged Fraction Correction

The last useful variable is the charged fraction. We take jets inside CTC acceptance (a cut $|\eta_j| < 1.0$ is appropriate) and extract the dependence of their $\Delta E$ on the *corrected charged fraction*:

$$CHFR_{corr} = CHFR_{JETS} \times \frac{E_T^u}{E_T^{corr}}.$$

This is done separately for muon and away jets in each of the four classes. We find reasonable ($\geq 0.5$) correlation coefficients in the scatterplots:

Muon jets:

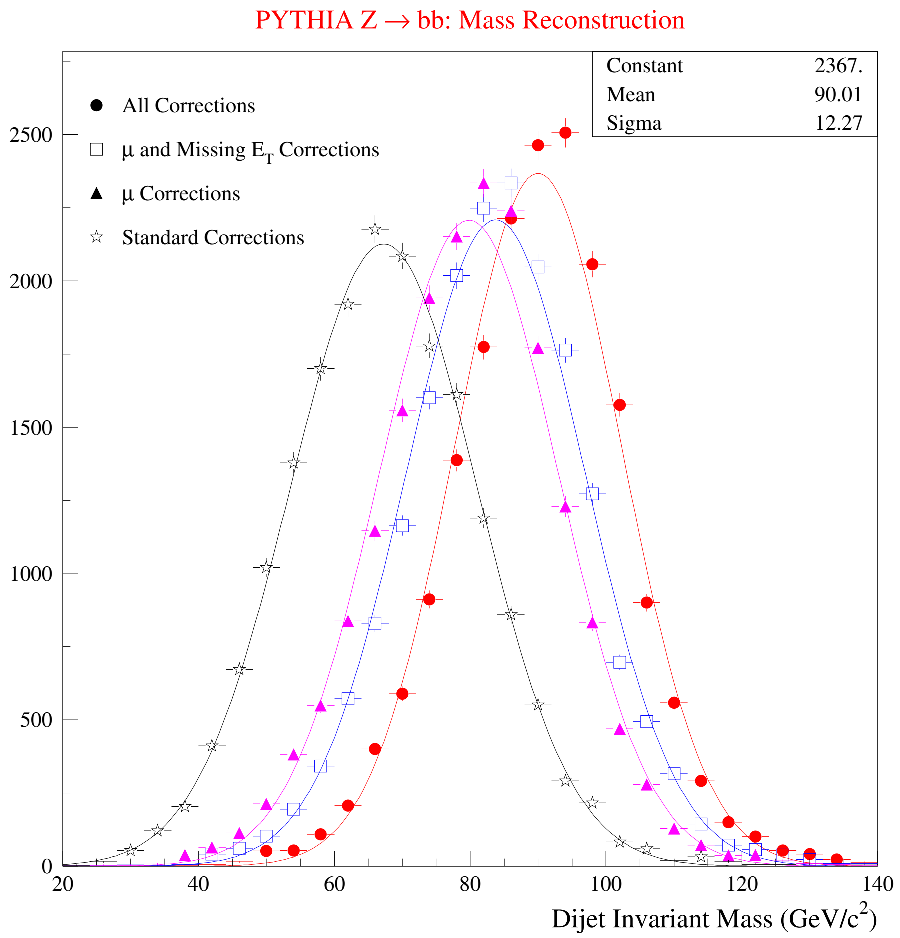
| Event class | slope | offset | r |
|---|---|---|---|
| (1) | 15.50 | -7.87 | 0.53 |
| (2) | 8.37 | 0.93 | 0.47 |
| (3) | 13.77 | -7.75 | 0.89 |
| (4) | 12.70 | -3.63 | 0.69 |

Away jets:

| Event class | slope | offset | r |
|---|---|---|---|
| (1) | 17.03 | -3.39 | 0.63 |
| (2) | 13.61 | -9.04 | 0.74 |
| (3) | 13.62 | -5.47 | 0.54 |
| (4) | 11.74 | -4.15 | 0.51 |

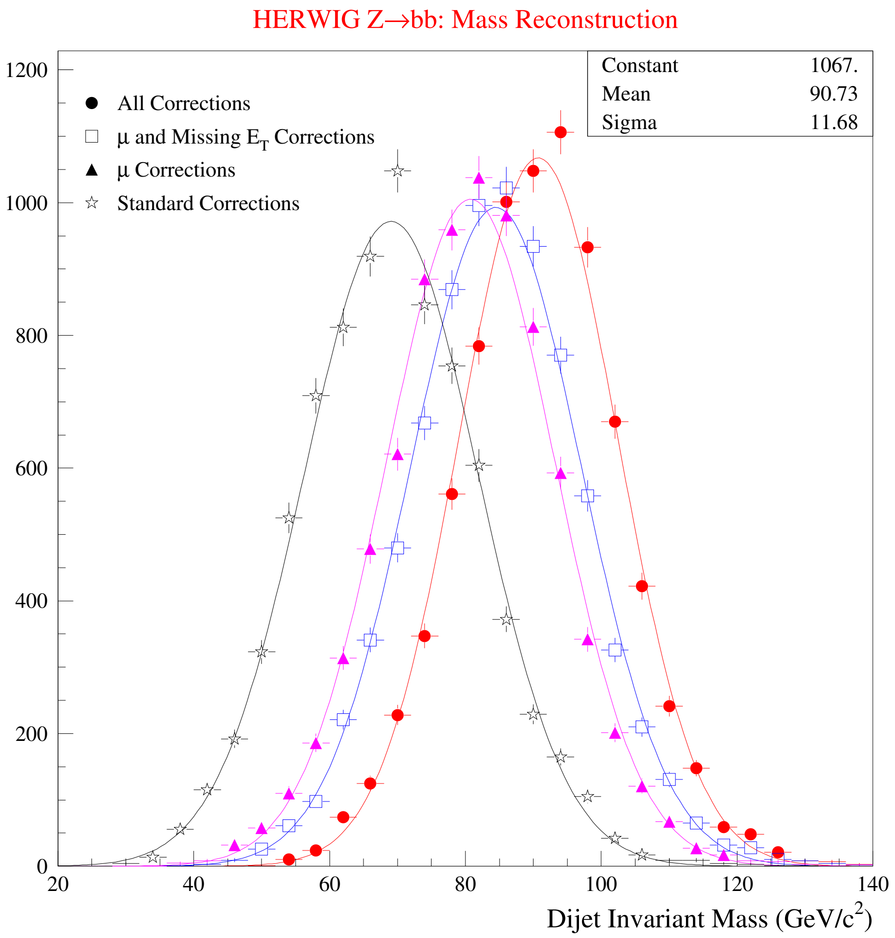
# How Do They Work on the Z Mass ?

We apply the corrections and register an improvement of about 15% in the mass resolution. This result may look not so great, but it must be considered that what matters is the improvement of $\frac{\sigma_M}{M}$. This indeed improves by a fat 55%.



# How Do They Work with a Different Generator ?

The fragmentation model in Pythia may give a bias. We checked that by using 1,000,000 $Z \to b\bar{b}$ events with HERWIG 5.6, applying the corrections with the parameters obtained with PYTHIA. The results on the mass peak are impressively similar.



# How Do They Work on the Higgs ?

Doubts may be cast on the appropriateness of the jet corrections at different energy scales: all of our Z events have jets in the $E \sim 50GeV$ ballpark. We checked against that by generating 1,000,000 $H \to b\bar{b}$ events with HERWIG 5.6, choosing $M_H = 120GeV$.

**The corrections work fine!**