Top/EWK group meeting 2/23/01

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All-hadronic $t\bar{t}$:

Preliminary study of kinematic selection

As a preliminary approach we follow the Run I strategy. We want to study a possible kinematic selection for all-hadronic top:

1. study the general features of $t\bar{t}$ events generated with **cdf2sim**

2. study the difference between QCD events at 1.8 TeV and at 2.0 TeV to define a sort of expected *enhancement factor*

3. compare $t\bar{t}$ data to Run I multijet data (*enhanced*) to define and characterize a possible kinematic selection

$\boxed{\textbf{Why the all-hadronic } t\bar{t} \textbf{ channel?}}$

Taking advantage of the experience gathered in Run I, we plan to pursue a study of the all-hadronic $t\bar{t}$ channel (i.e. both W's decaying into jets), with the following goals:

1. measure the $t\bar{t}$ cross section: will we see differences w.r.t. the leptonic measurements?
2. measure t mass: will we see the peculiar effect of Run I (i.e. top masses getting larger as the number of leptons decrease)?
3. select a clean sample to study peculiarities: bound states? polarization?

Run I kinematical selection

Reminder:

Run I kinematical selection was based on the following cuts:

- $N_{jet} \geq 5$ ($E_T^{unc} \geq 15$ GeV, $|\eta| \leq 2.0$)
- $\sum E_T^{corr} \geq 300$ GeV
- $\sum E_T^{corr}/\sqrt{\hat{s}} \geq 0.75$
- $\mathcal{A} + 0.0025 \cdot \sum_3 E_T^{corr} \geq 0.54$

At the end of the selection the total $t\bar{t}$ efficiency was $\epsilon = 9.9\%$ with $S/N = 1/30$ ($\sigma_{t\bar{t}} = 5$ pb).

To decouple from jet corrections we use for the time being only **uncorrected energies**.

$\boxed{\textbf{Multijet trigger}}$

As done in Run I, the sample we will use to study the all-hadronic $t\bar{t}$ events is the one coming from a *multijet trigger* which requires at Level 2 (see CDF 4718):

- ≥ 4 clusters with $E_T \geq 15$ GeV
- $\sum E_T^{cluster} \geq 125$ GeV

we expect such a trigger to be quite efficient ($\epsilon \approx 60 - 70\%$, much more on all-hadronic states) and with a reasonable cross section (5 nb).

At Level 3 the request if for ≥ 4 jets (cone 0.4, $E_T \geq 10$ GeV)

$\boxed{t\bar{t}\ \textbf{sample}}$

Release 3.11.0:

$t\bar{t}$ events generated with **HERWIG** and simulated with **cdf2sim.exe** + 3 min.bias events.

As of now we limit ourselves to the application of th multijet trigger only at Level 3: about 70% of the events pass Level 3 requirements, i.e. have ≥ 4 jets (cone 0.4, $E_T \geq 10$ GeV).

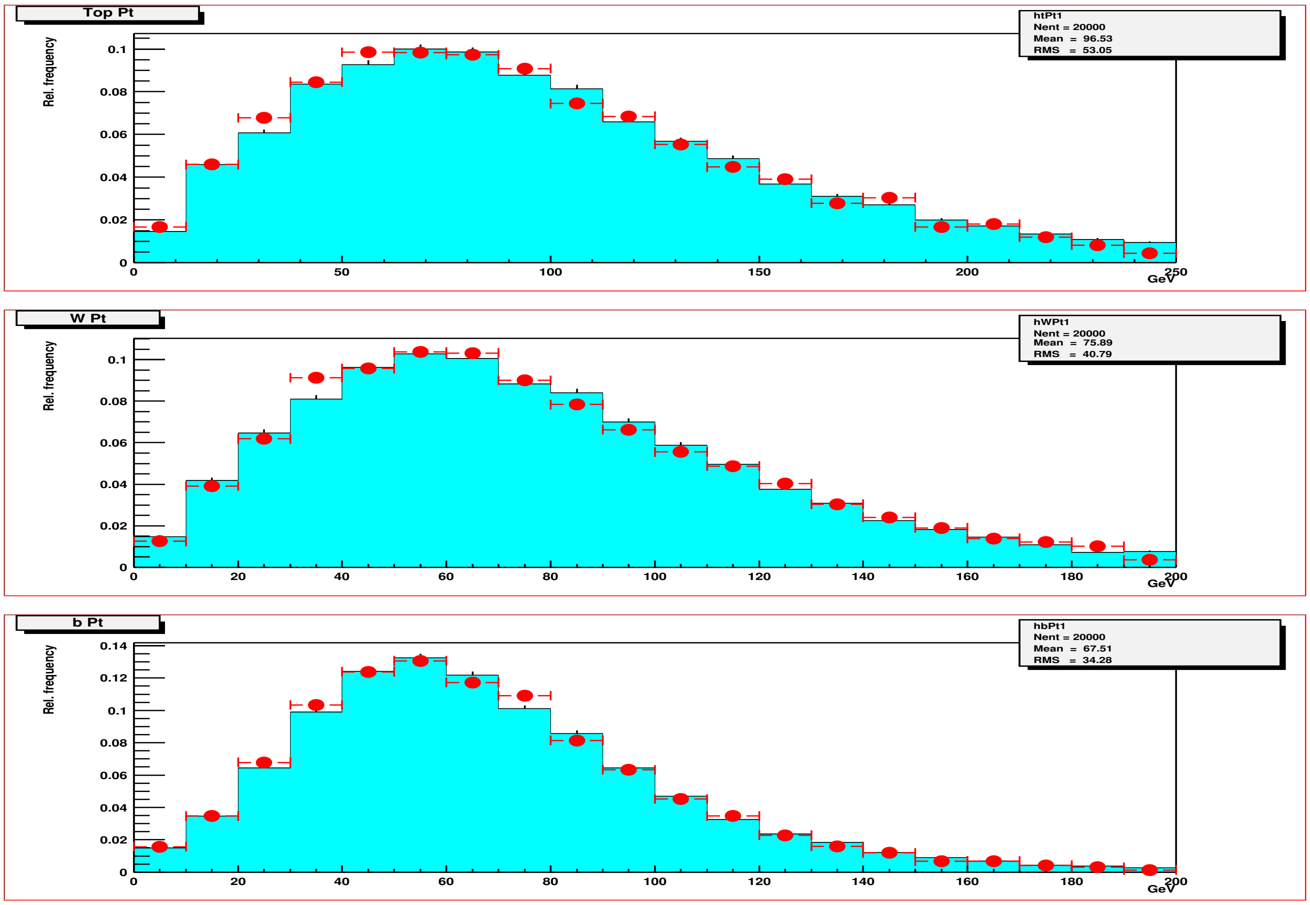
The application of Level 2 requirements should not change much the results we are discussing here (especially once further kinematical cuts are applied).

$t\bar{t}$: Run I simulation vs Run II simulation

As first thing, we want to compare the behaviour of the simulators, i.e. we compare **cdf2sim** to **qfl**, for events generated with $\sqrt{s} = 2.0$ TeV. We compare the two simulations in terms of:

- Parton level quantities (P_T, η of t's, W's and b's)
- Jet quantities (E_T, η)
- Global quantities (N_{jet}, $\sum E_T$, $\sum E_T/\sqrt{\hat{s}}$, $\sum_3 E_T$, aplanarity)

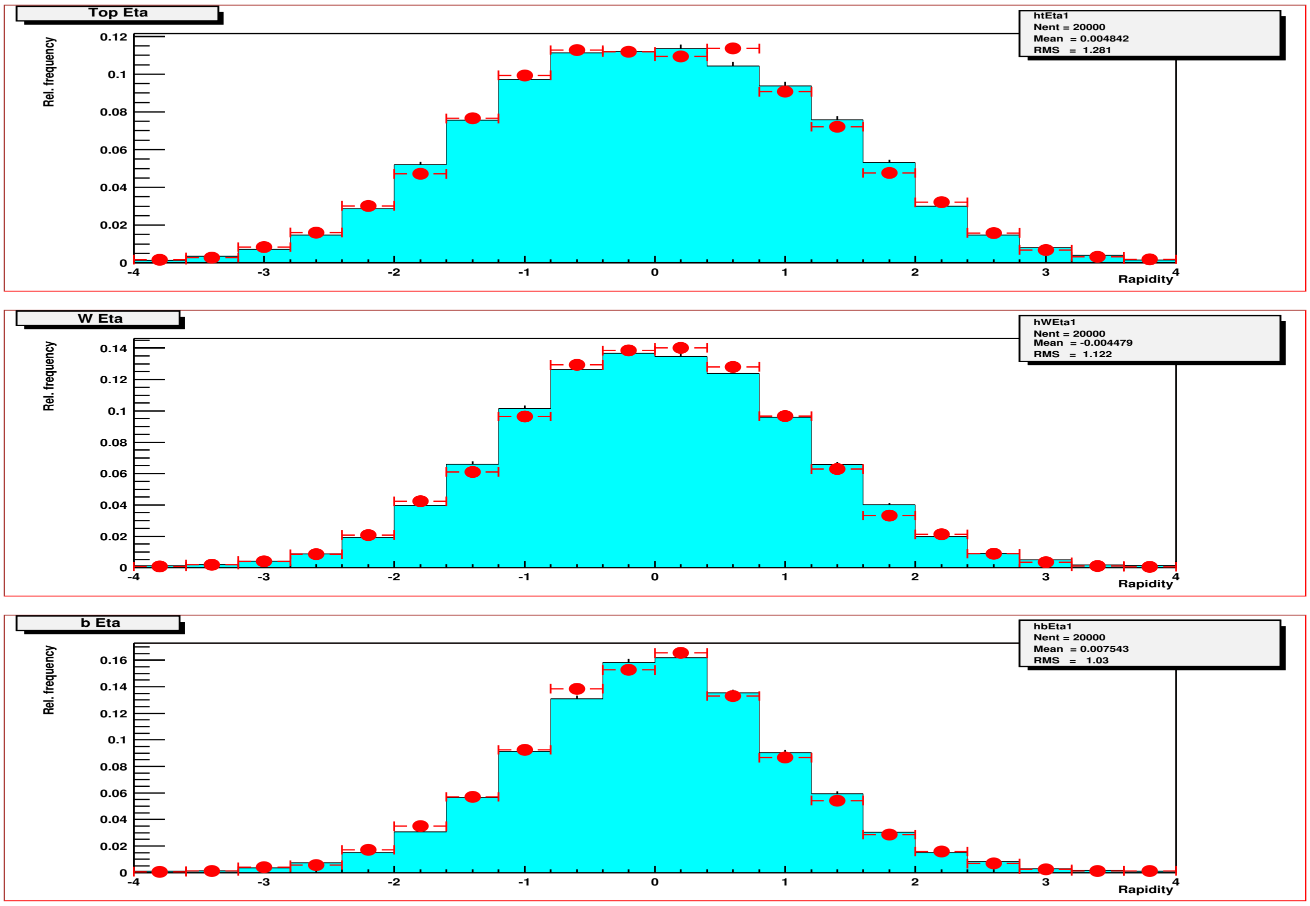
$$\boxed{P_T\text{: } t,\ W,\ b}$$



Histogram: Run I generator

Points: Run II generator

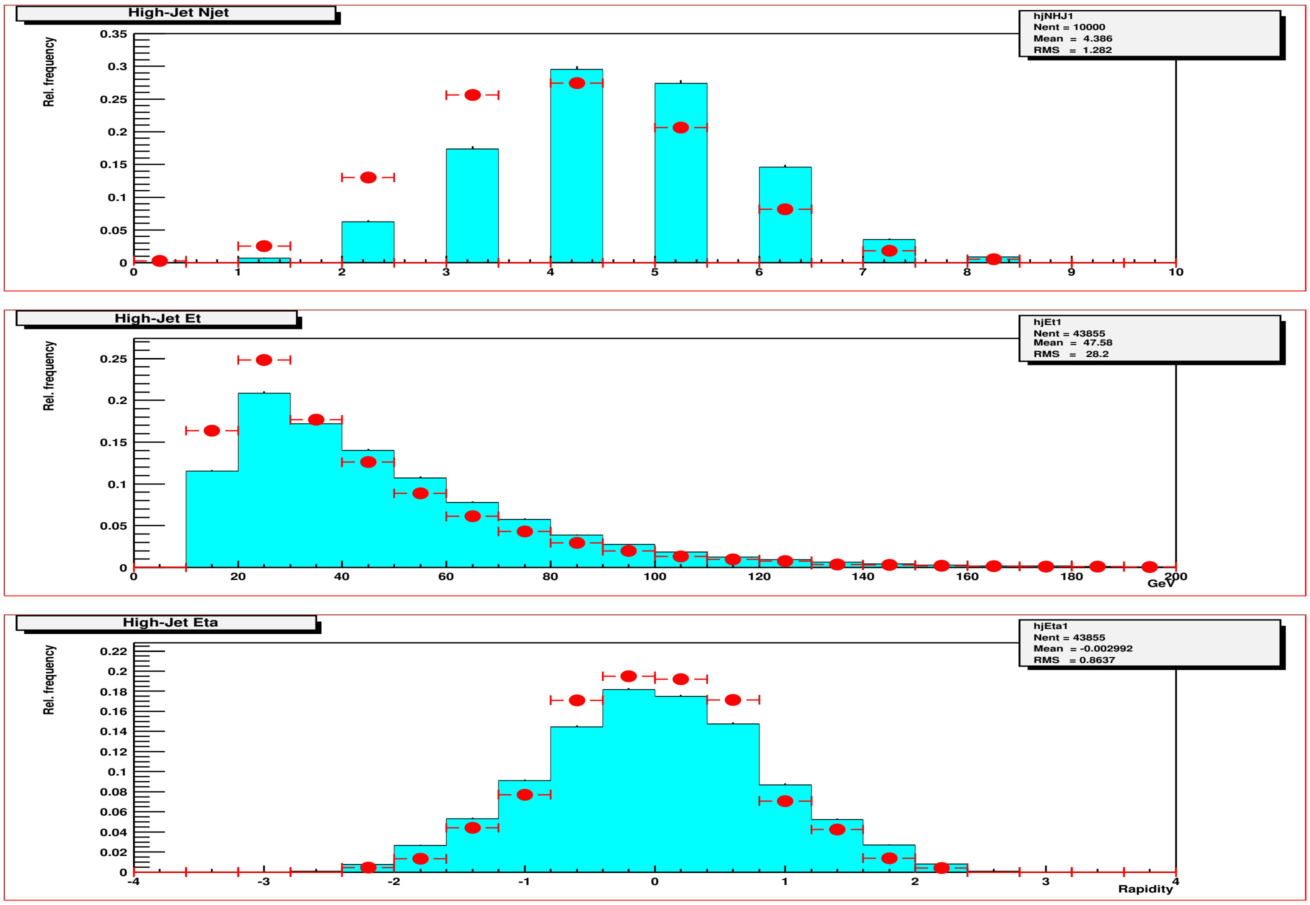
$\boxed{\eta\text{: } t,\, W,\, b}$



Histogram: Run I generator

Points: Run II generator

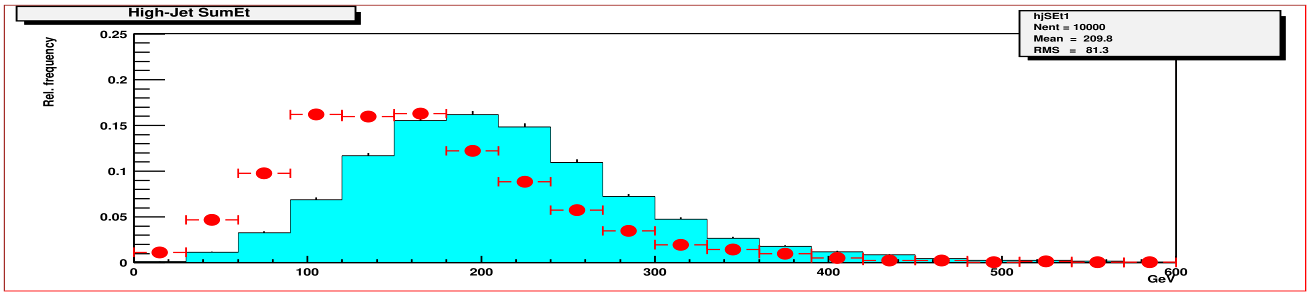
$$\boxed{N_{jet},\ E_T^{jet},\ \eta^{jet}}$$

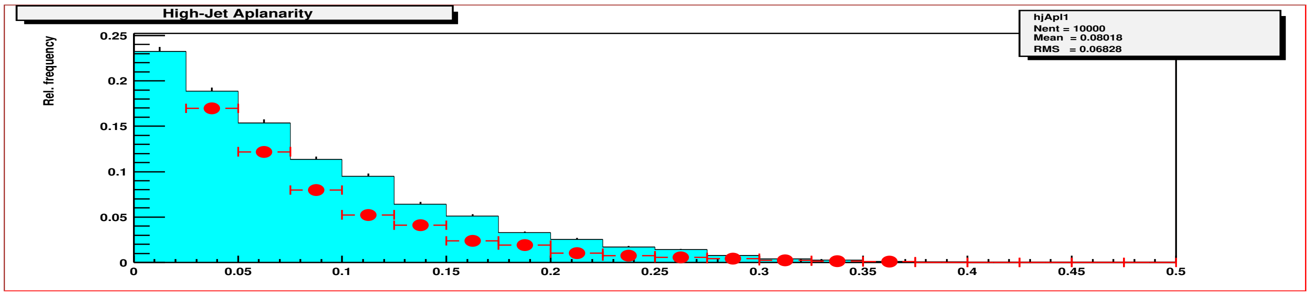


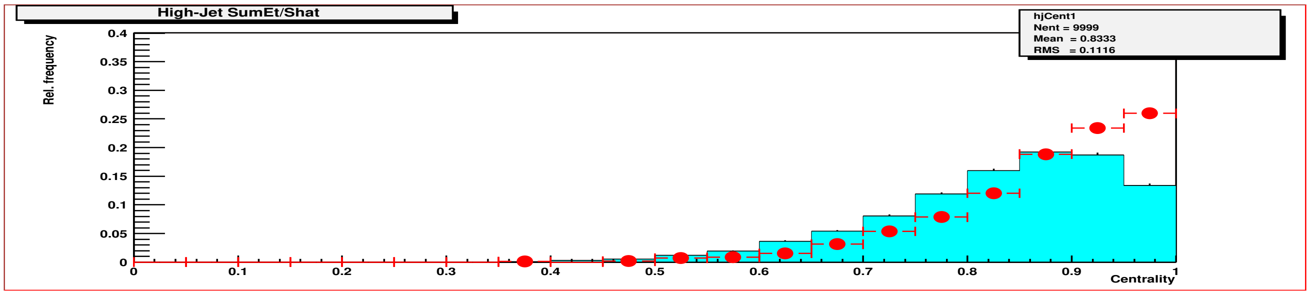
Histogram: **qfl**

Points: **cdf2sim**

$\boxed{\sum E_T^{jet}, \textbf{ aplanarity}, \sum E_T/\sqrt{\hat{s}}}$







Histogram: **qfl**

Points: **cdf2sim**

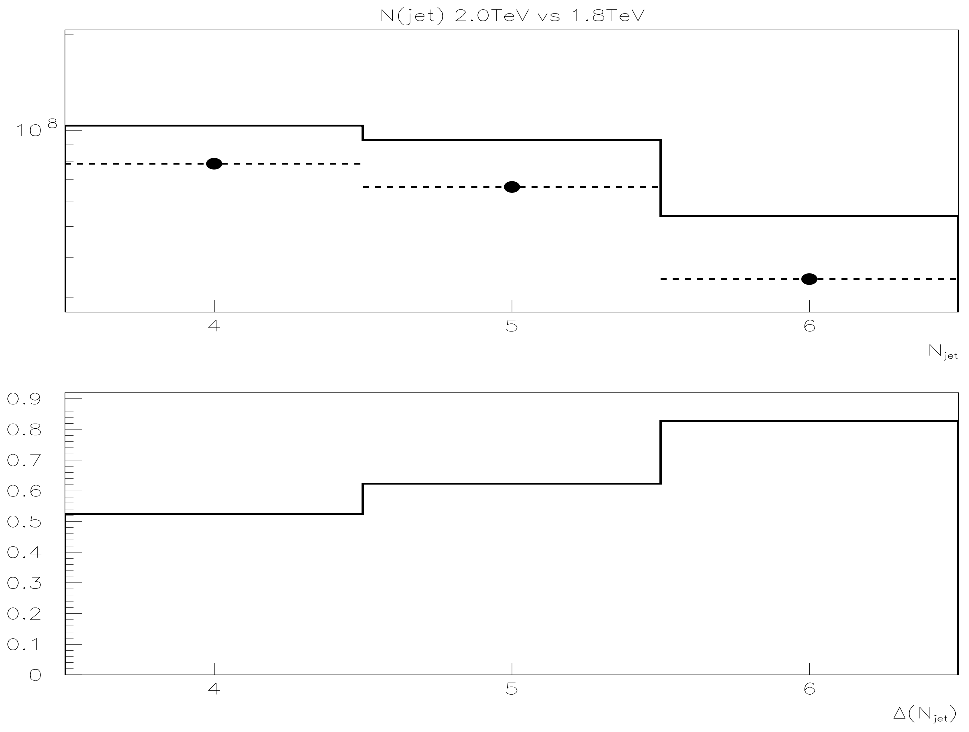
$\boxed{\textbf{qfl } vs \textbf{ cdf2sim}}$

From this preliminary comparison we draw the following conclusions:

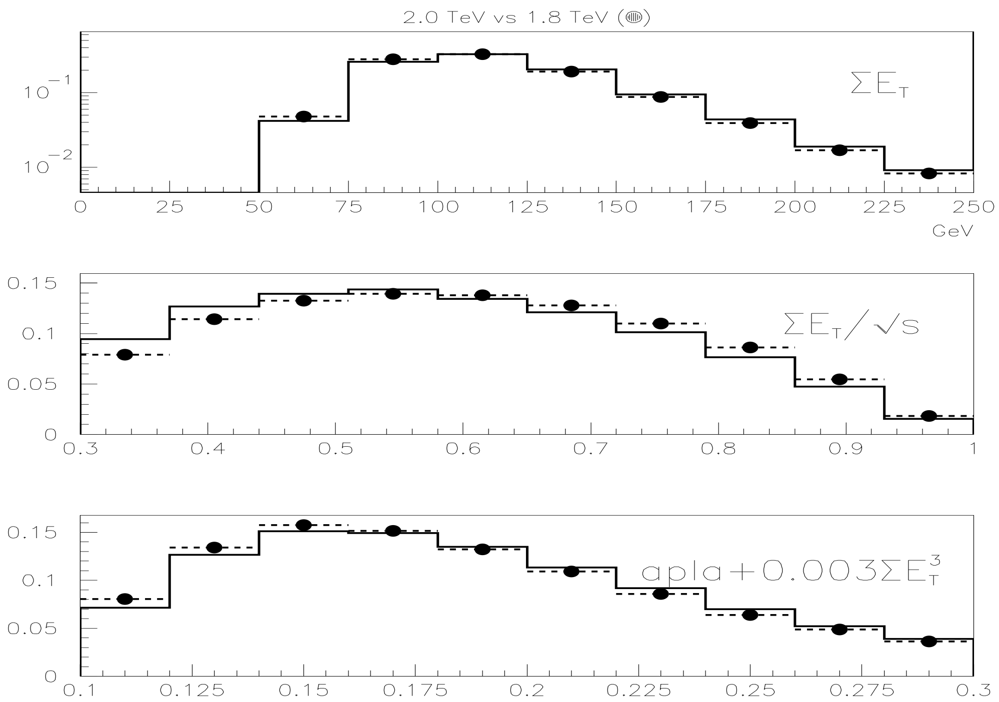
- Parton level quantities for the two generators agree well
- *New* (cdf2sim) jets have a softer E_T spectrum than the *old* (qfl) ones (a few GeV). Is this feature due to the clustering algorithm or to the different calorimeter simulation? Need to investigate this.
- N_{jet}, $\sum E_T$, aplanarity spectra are a little different. See above.

Multijet events in Run II

W.r.t. Run I the cross section and the acceptance will increase. By how much? As a guideline we compare QCD MC events at 1.8 and 2.0 TeV (normalized to equal luminosity):



Multijet events in Run II



We need to *enhance* Run I sample by about 70%, while the spectra remain similar.

$\boxed{\textbf{Comparison } t\bar{t} \textit{ vs } \textbf{multijet} \text{ events}}$

We compare $t\bar{t}$ events (cdf2sim + 3mb) to *enhanced* multijet events, at different level of selection. We normalize both to 2 fb^{-1} and assume $\sigma_{t\bar{t}} = 6.5$ pb, (i.e. $\sigma_{HRW} + \sigma_{PYT}/2$)

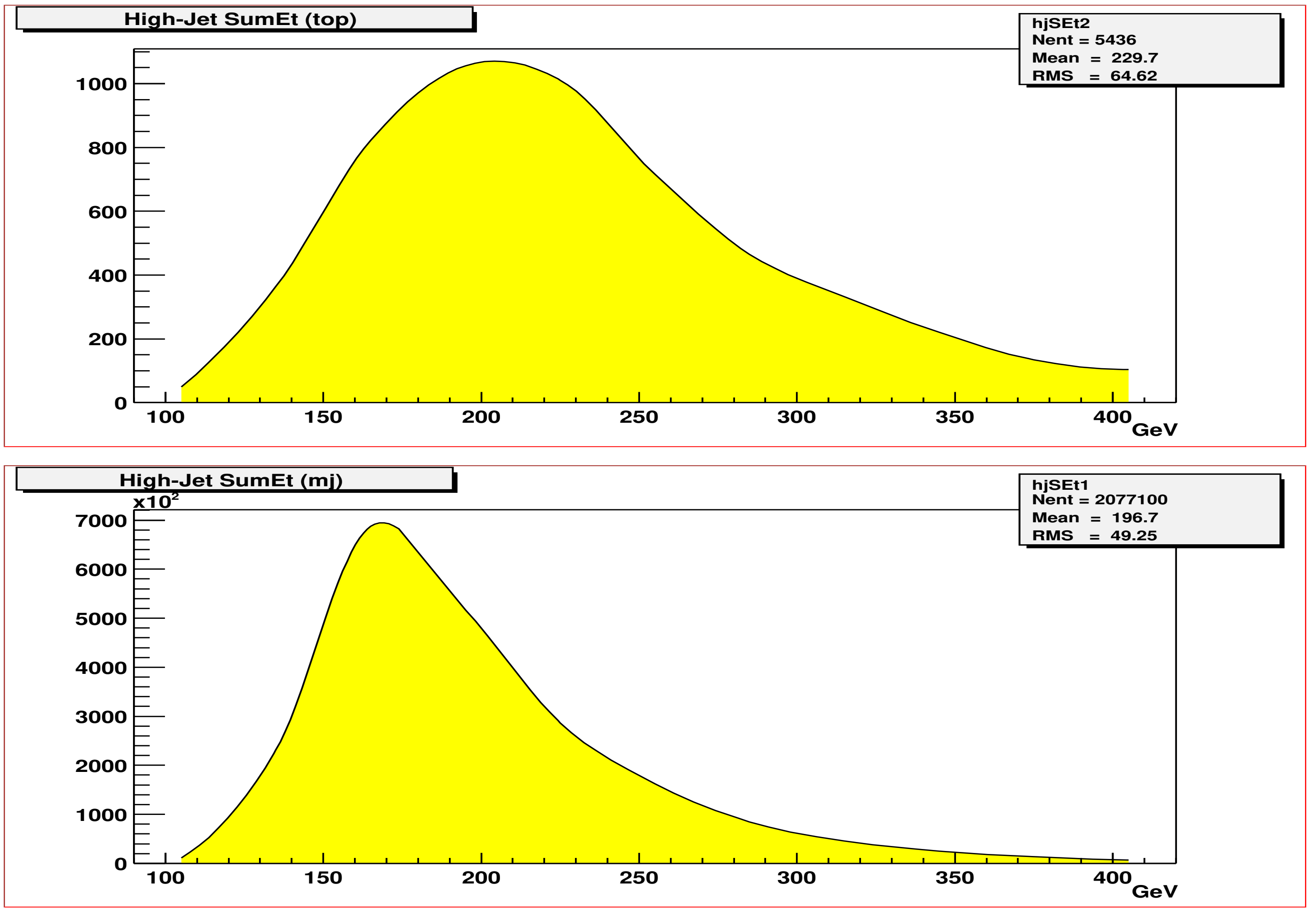
We begin by requiring $N_{jet} \geq 5$ ($E_T \geq 15$ GeV, $|\eta| \leq 2.4$): at this level $S \approx 5500$ evts, $N \approx 2$ million, $S/N \approx 1/380$.

We now investigate:

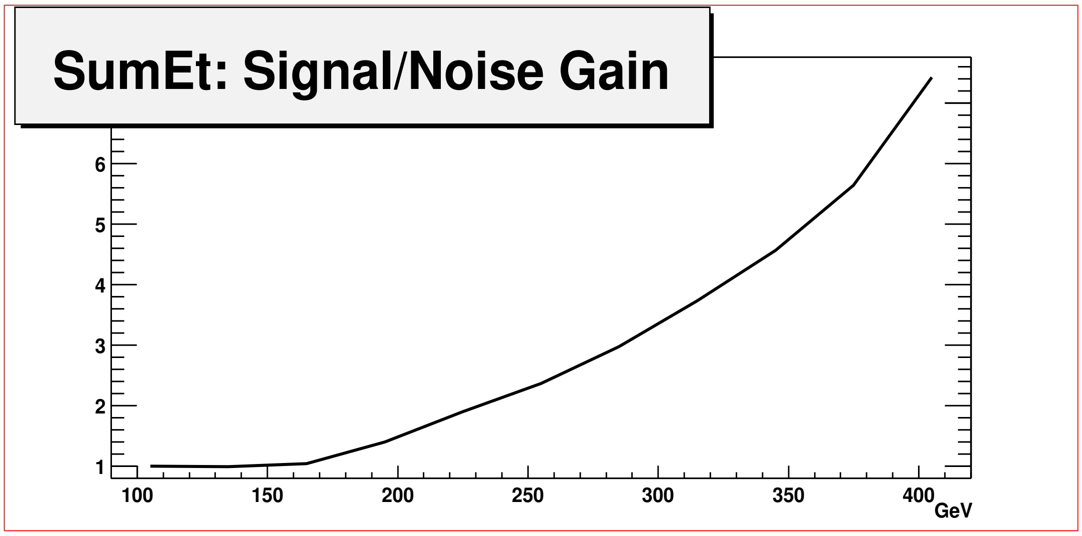
- $\sum E_T$
- $\sum E_T/\sqrt{\hat{s}}$
- $\mathcal{A} + 0.003 \cdot \sum_3 E_T$

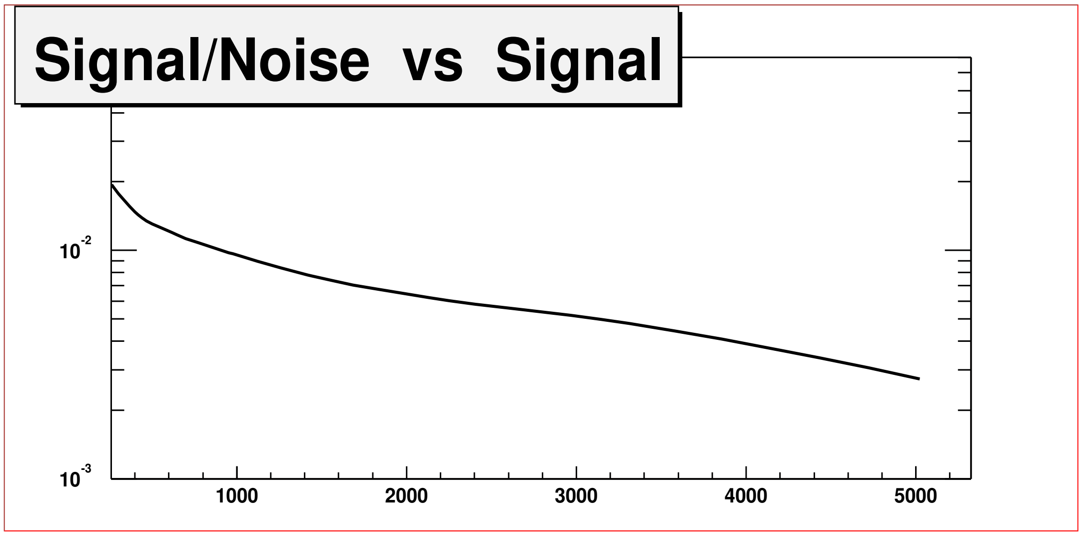
in terms of S/N gain.

$\boxed{\sum E_T\textbf{: } t\bar{t} \textbf{ vs multijet}}$



$\sum E_T$: S/N gain and S/N vs S

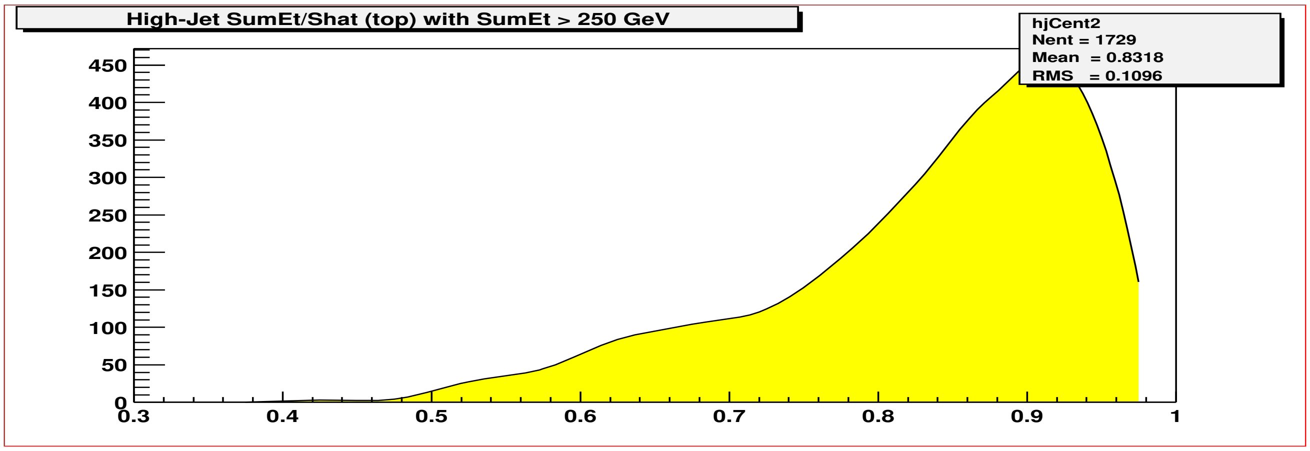


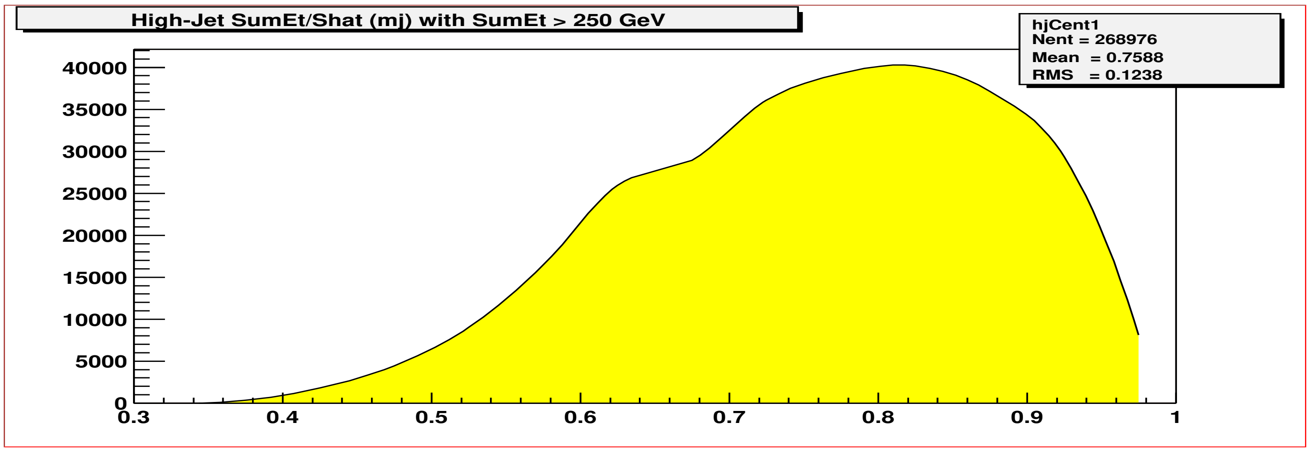


Tentative cut: $\sum E_T \geq 250$ GeV:

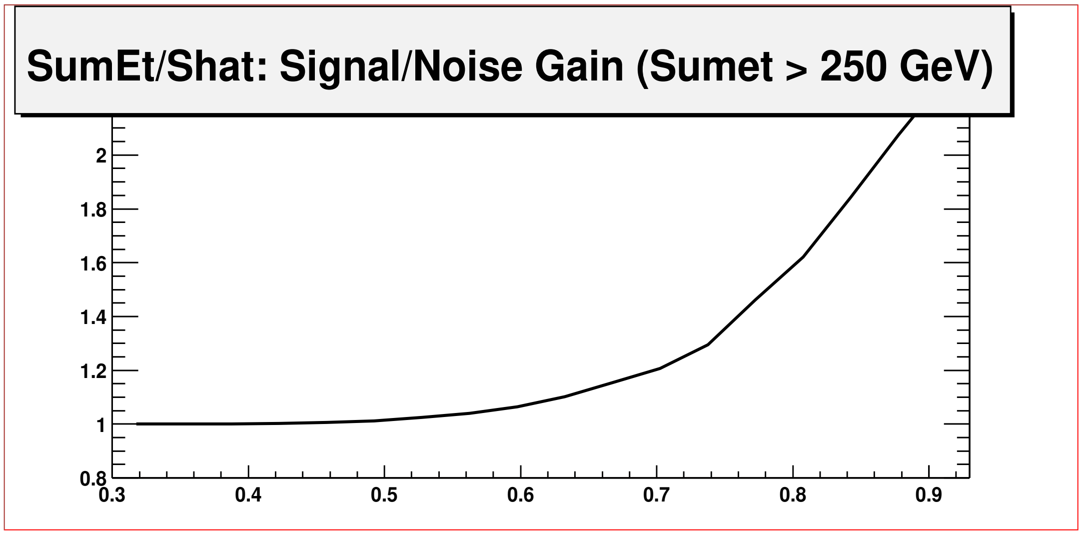
$S/N \approx 1/150$, $S \approx 1900$

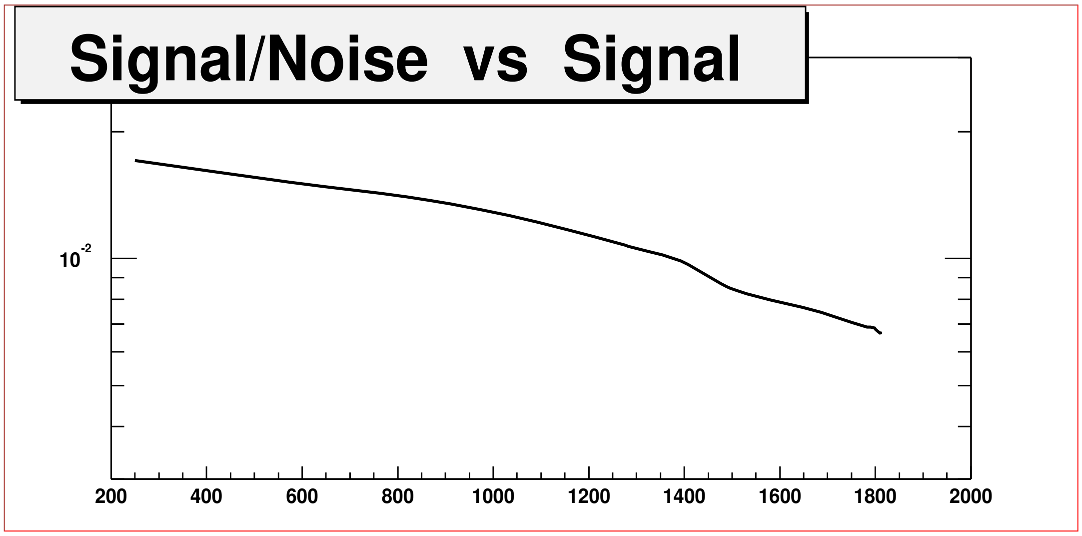
$$\boxed{\sum E_T/\sqrt{\hat{s}}\text{: } t\bar{t} \textbf{ vs multijet}}$$





$\boxed{\sum E_T/\sqrt{\hat{s}}\text{: S/N gain and S/N vs S}}$

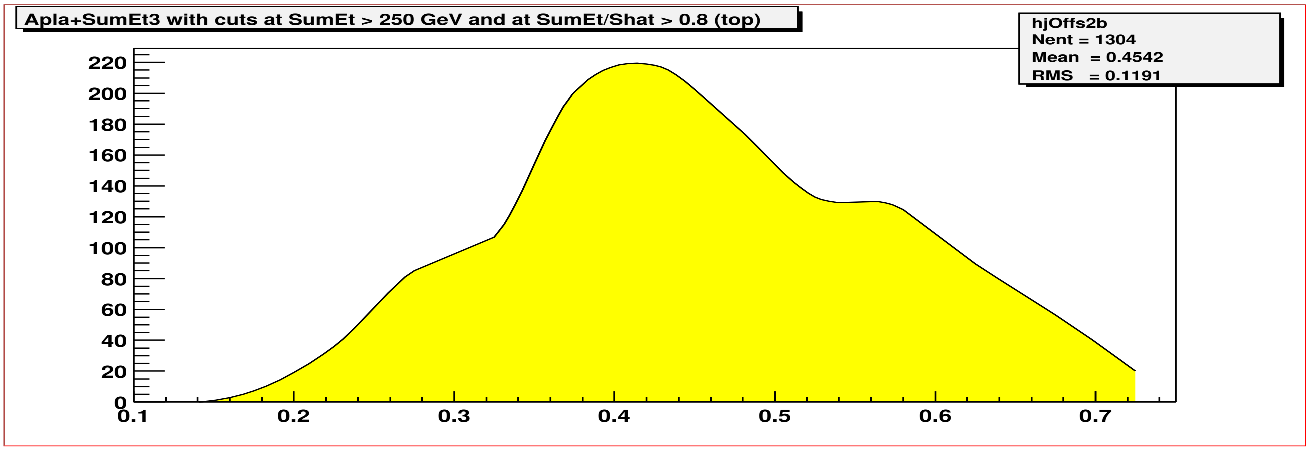


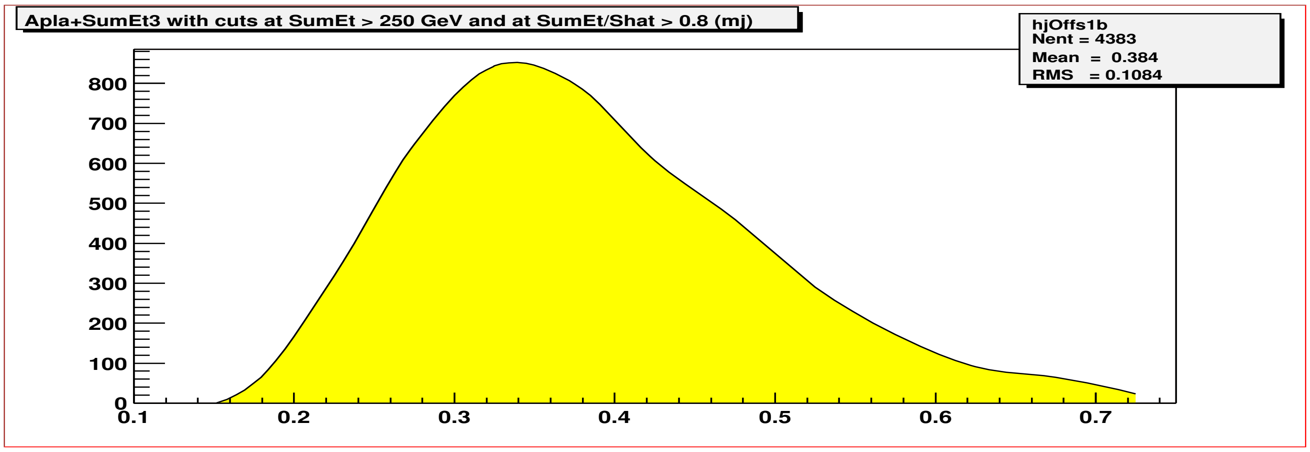


Tentative cut: $\sum E_T/\sqrt{\hat{s}} \geq 0.8$:

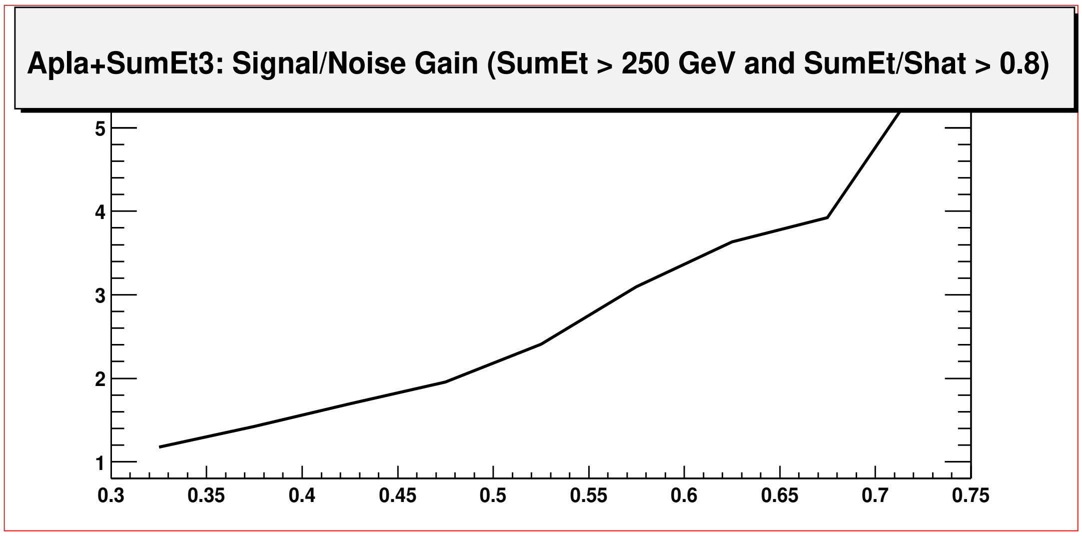
$S/N \approx 1/90$, $S \approx 1300$ after the cut

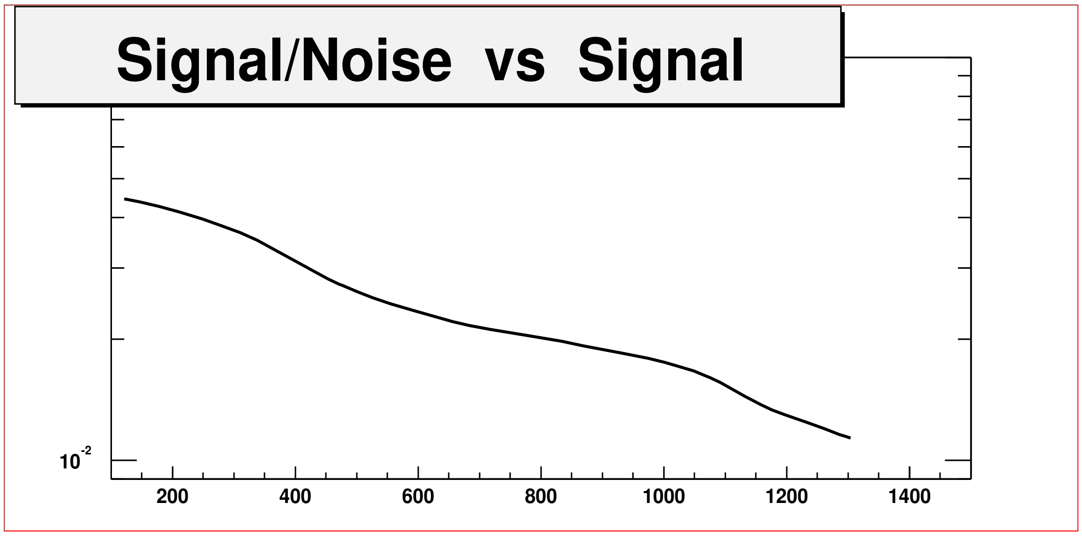
$$\boxed{\mathcal{A} + 0.003 \cdot \sum_3 E_T\text{: } t\bar{t} \textbf{ vs multijet}}$$





$\mathcal{A} + 0.003 \cdot \sum_3 E_T$: S/N gain and S/N vs S





Tentative cut: $\mathcal{A} + 0.003 \cdot \sum E_T \geq 0.5$:

$S/N \approx 1/35$, $S \approx 480$ after the cut.

$\boxed{\textbf{Alternative selection}}$

This kinematical selection described so far required $N_{jet} \geq 5$: $S/N \approx 1/35$, $S \approx 480$ after all cuts, with $\epsilon = 7\%$ for all-hadronic states.

What if we begin with $N_{jet} \geq 6$? In order not to loose much we release a little the cut on $\sum E_T$. For instance:

- $\sum E_T \geq 200$ GeV
- $\sum E_T/\sqrt{\hat{s}} \geq 0.8$
- $\mathcal{A} + 0.003 \cdot \sum_3 E_T \geq 0.5$

$S/N \approx 1/30$ and $S \approx 520$, with $\epsilon = 8\%$ for all-hadronic states.

Mass fitting using MINUIT

We want to reconstruct the kinematics of

$$p\bar{p} \to t\bar{t} \to W^+ b W^- \bar{b} \to j_1 j_2 b j_3 j_4 \bar{b}$$

using the four-momenta of the 6 leading jets (using Run I jet corrections for now).

Measurements provide 3 constraints:

- $M_{j_1 j_2} = M_W$
- $M_{j_3 j_4} = M_W$
- $M_{j_1 j_2 b_1} = M_{j_3 j_4 b_2}$

We mimimize a 3C χ^2:

$$\chi^2 = \frac{(M_{jj} - M_W)^2}{\sigma^2_{M_W}} + \frac{(M_{jj} - M_W)^2}{\sigma^2_{M_W}} + \frac{(M_{jjb} - M_{jjb})^2}{\sigma^2_{M_t}}$$

($\sigma_{M_W} = 2.1$, $\sigma_{M_t} = 2.5$ GeV/c^2).

We require ≥ 1 (0) btag and this means (using the 6 leading jets) 30 (90) permutations and pick the lowest-χ^2 one.

Mass fitting

We compare:

- the triplet mass for signal events, i.e. $t\bar{t}$ events passing the kinematical selection and having **at least one btag**
- the triplet mass for background events, i.e. multijet events passing the kinematical selection and having **no btag**

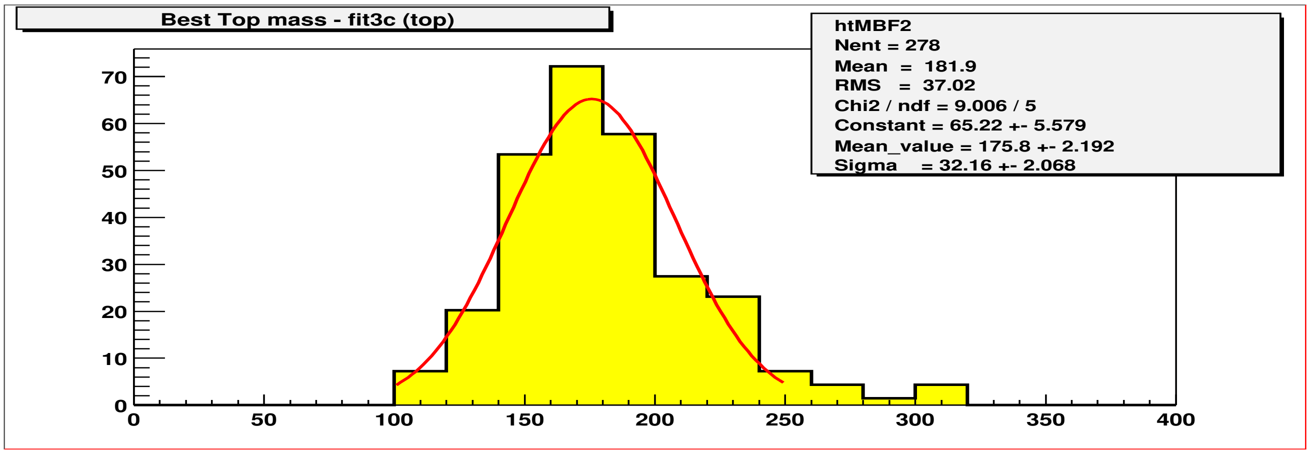
All spectra are normalized to the amount of signal and background expected for 2 fb^{-1} after the kinematical selection and the *kludge btag.*

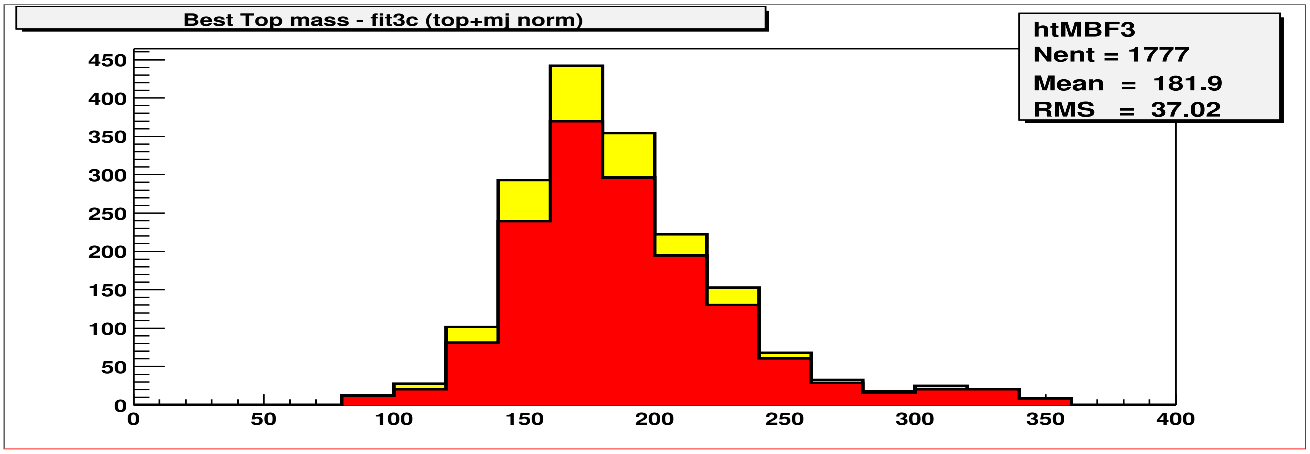
Kludge btag:

- $\mathcal{P}(j) = 30\%$ for each b-jet in acceptance ($|\eta| \leq 2$)
- $\mathcal{P}(j) = 2\%$ for each jet in acceptance ($|\eta| \leq 2$)
- efficiency for $t\bar{t}$ passing kin-selection: 50% (**?**)
- acceptance for multijet passing kin-selection: 10% (**?**)
- S/N gain = 5 (**?**)

Mass fits

Very preliminary!





280 evts $t\bar{t}$; 1500 evts multijet

Conclusions

We have conducted a **preliminary** study for a possible kinematic selection of all-hadronic $t\bar{t}$ pairs in multijet events.

Such a study, based on **cdf2sim** $t\bar{t}$ samples and on extrapolation of the Run I multijet data, allows to define a simple set of kinematic requirements (derived from Run I analysis) and its behavior in terms of S and S/N.

The arrival of real data will permit soon to check the results obtained here, characterize better (hopefully improve) the performance of this selection, or to look for better strategies.

The next step is to implement real b-tagging.