Study of high p_T jets – an update

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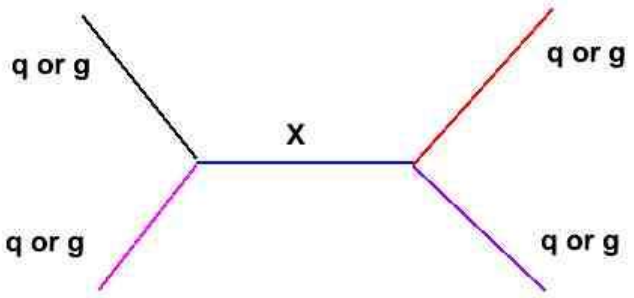
QCD dijets



- **Motivation: Why study dijets?**

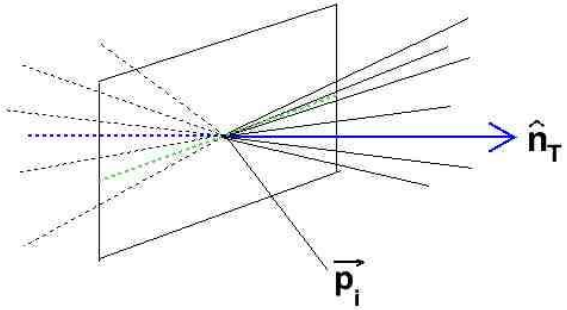
- **Physics**
  - **Test of QCD and parton distributions at *high* Q^2.**
- **Simplicity**
  - **Inclusive dijet production (pp → 2 jets + X) is the dominant hard process in hadron colliders.**
  - **No significant background.**
- **Calorimeter**
  - **Dijet p_T balance will be used to calibrate HCAL in-situ.**
- **Timeliness**
  - **Measurements using only Calorimetry can be done quickly.**

- ***Dijets are studied in the context of CMS (Compact Muon Solenoid), a general purpose detector, in the large hadron collider (LHC).***

An event shape variable : Thrust

- **Event-shape variables, constructed from linear sums of measured particle momenta, are sensitive to the amount of hard gluon radiation and offer a way to measure α_s in hadron collisions. One such variable, *Thrust*, defined as:**

$$T = \max_{\hat{n}} \left(\frac{\sum_i |p_i \cdot \hat{n}|}{\sum_i |p_i|} \right)$$



Where the thrust axis n_T, is defined as the unit 3-vector n, which maximises the expression.

- **For a perfectly '*pencil-like*' two-jet event, the thrust axis lies parallel to the jets, so $|p_i \cdot n_T| = |p_i|$, yielding T=1.**

In the case of a *spherical* event, with an infinite no. of particles distributed *isotropically* in the final state, the thrust becomes a ratio of solid angle integrals:

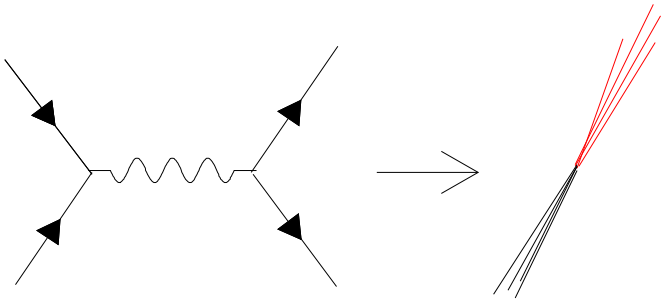
$$T = \frac{\int |\cos\theta| \, d\Omega}{\int d\Omega} = \frac{2\pi}{4\pi} = \frac{1}{2}$$

Major : $T_{maj} = \max_{\hat{n} \perp \hat{n}_T} \left(\frac{\sum_i |p_i \cdot \hat{n}|}{\sum_i |p_i|} \right)$ **Minor :** $T_{\min} = \frac{\sum_i |p_i \cdot \hat{n}_{T_{\min}}|}{\sum_i |p_i|}$

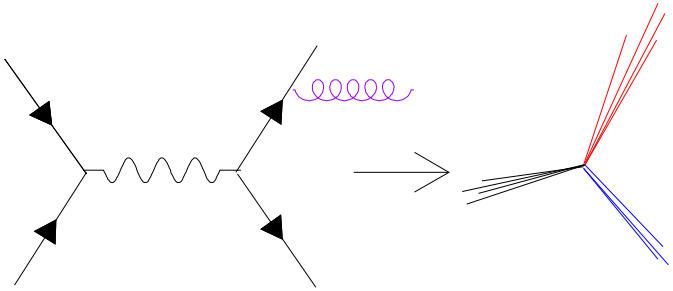
where $\hat{n}_{T_{\min}} = \hat{n}_T \times \hat{n}_{T_{maj}}$

The event shapes for 2-jet, 3-jet, 4-jet topologies

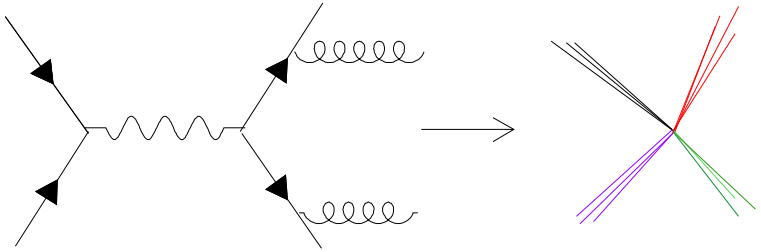
$$T = \max_{\hat{n}} \left(\frac{\sum_i |p_i \cdot \hat{n}|}{\sum_i |p_i|} \right)$$



1 - T = 0

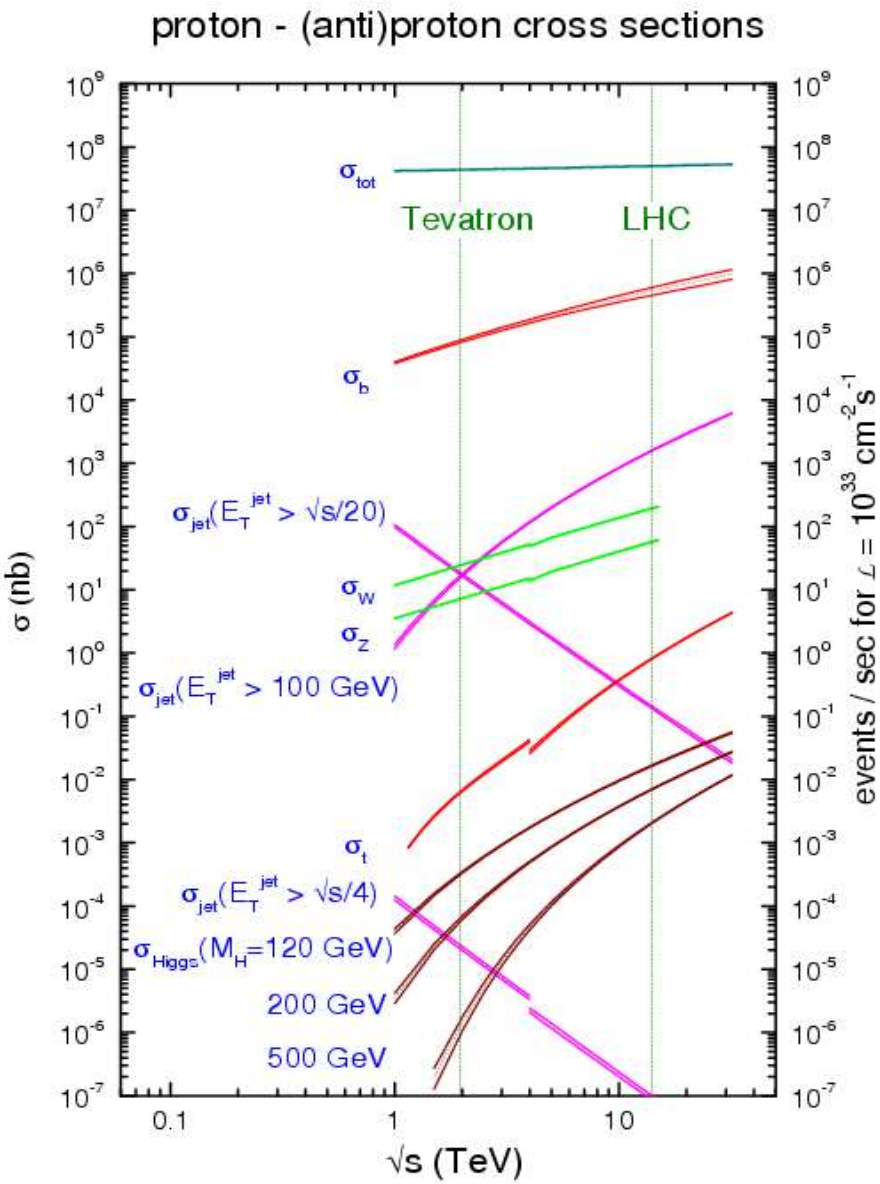


T : [2/3, 1]



T : [1/$\sqrt{3}$, 1]

Trigger criteria in jet energy measurements



- Inclusive jet cross section is smaller than the total cross section by an order of **10^6** approximately.

- Hence one needs to put a trigger to select out the unwanted events to increase the signal to background ratio.

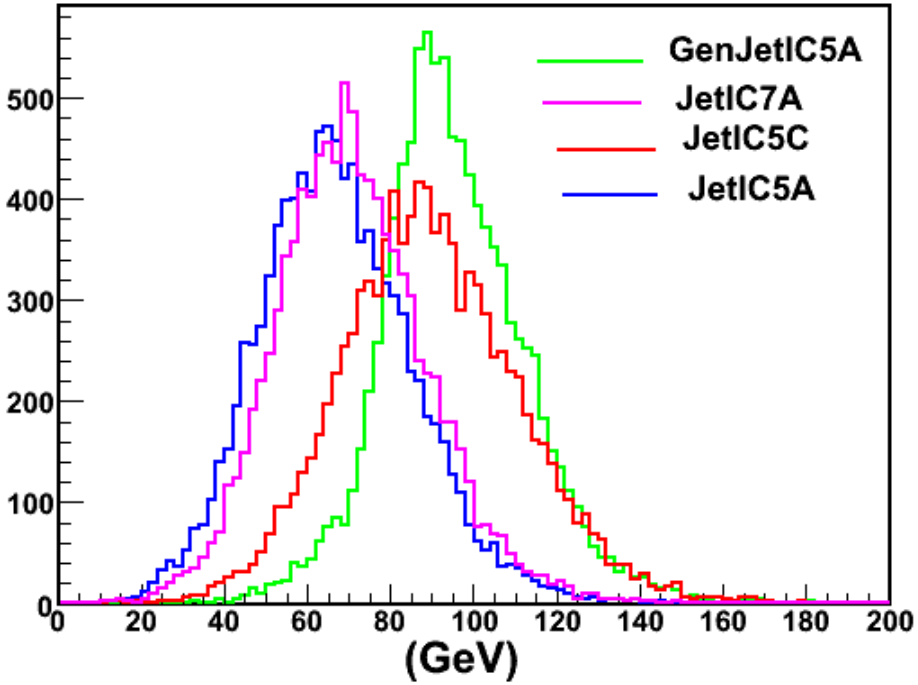
- To decide upon which trigger value to be put one needs a fair understanding of the detector, calorimeters in particular, as jets will be detected through them.

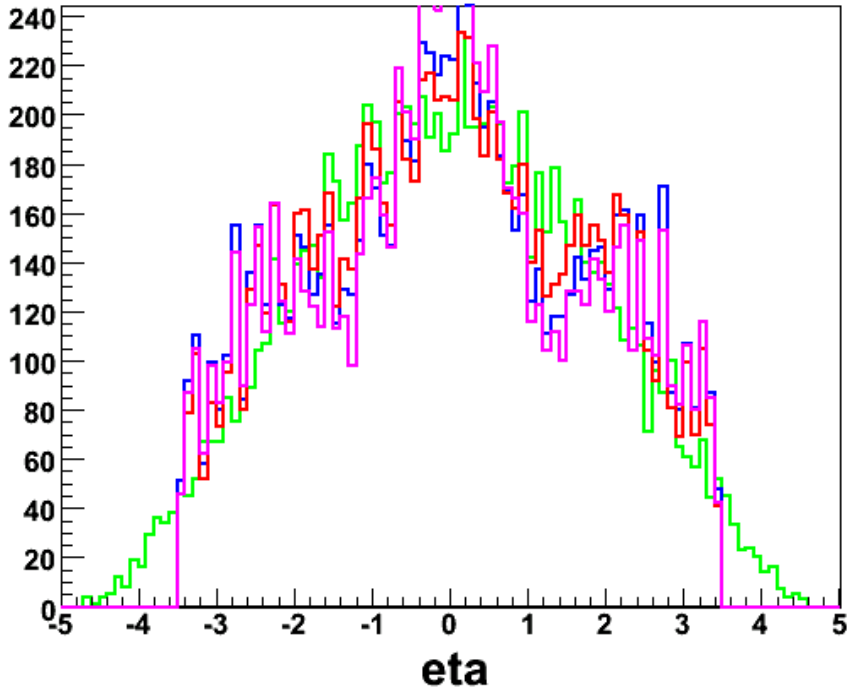
Event Generation and Reconstruction

- Events generated using PYTHIA
- The entire range of momenta (spanning from 0 – 4000 GeV) divided in to 21 p_T bins.
- The structure function chosen - PDF:CTEQ 5L
- Effects of soft physics modelled in the form of *parton showers* and *hadronisation models* with subsequent decays has been taken in account.
- Multiple interactions and fragmentations are allowed.
- Initial and final state soft radiations (ISR and FSR) are considered.
- Transverse energy smearing allowed according to *Gaussian distribution.*
- For reconstruction of jets iterative cone algorithm considered with cone radius R = 0.5 and jet E_T seed cut of 7.0 GeV.
- Jet energy calibration has been applied on a jet-by-jet basis to the *calorimeter jets* depending on the η and p_T.

p_T and η distributions of leading jet at different reconstructed levels

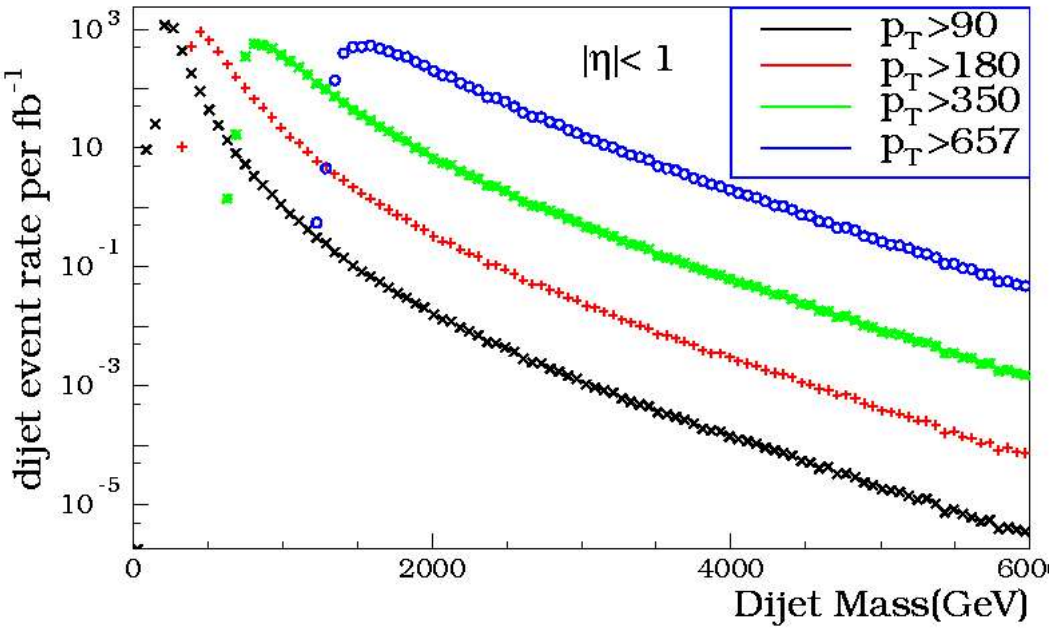
(using FAMOS)





- GenJetIC5A : Iterative cone (R = 0.5) jets from generator particles
- JetIC5A : Iterative cone (R = 0.5) jets
- JetIC5C : Iterative cone (R = 0.5) calibrated (GammaJet) jets
- JetIC7A : Iterative cone (R = 0.7) jets

Event rate



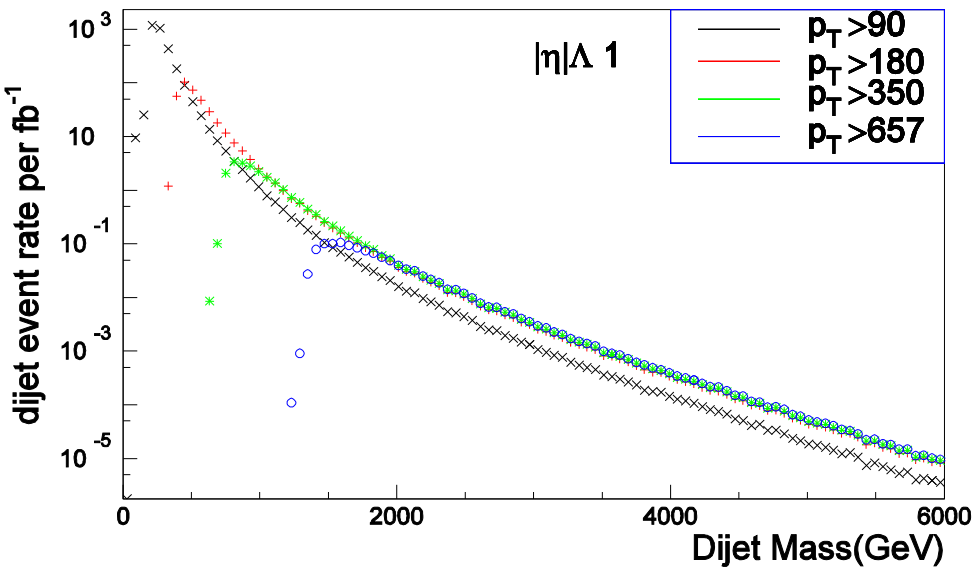
- **The rate expected from the triggers *as a function of dijet mass* plotted at the generator level using PYTHIA.**

- **The distribution is obtained by scaling the dijet mass distribution by appropriate pre-scaling factors and normalising with the cross sections.**

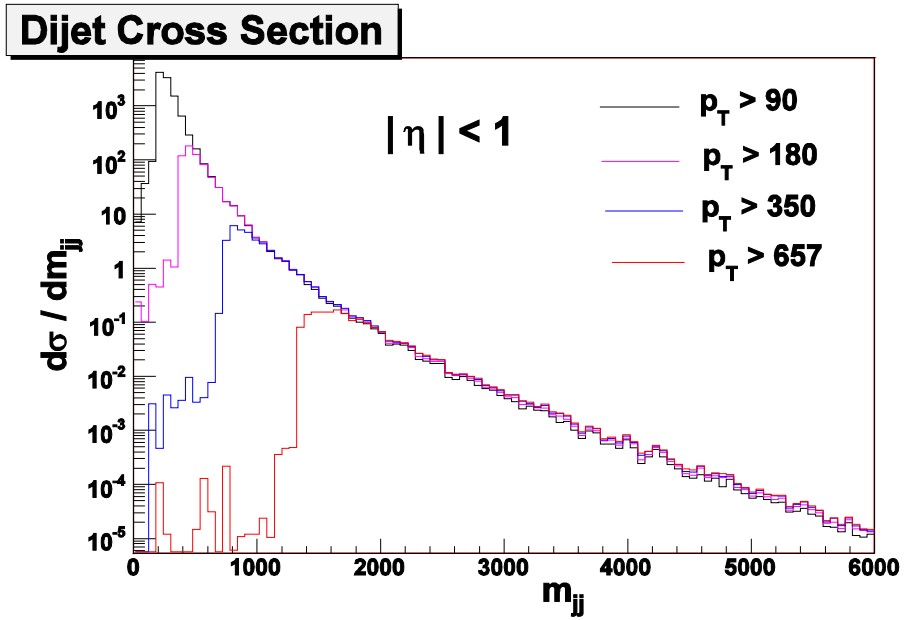
- **The turn-on of each trigger is entirely due to the difference between the HLT p_T threshold.**
- **By construction there are comparable statistics in each trigger.**

Dijet mass distribution

$$M_{jj}=\sqrt{(E_1+E_2)^2-(p_x^1+p_x^2)^2-(p_y^1+p_y^2)^2-(p_z^1+p_z^2)^2}$$



Generated level (PYTHIA)



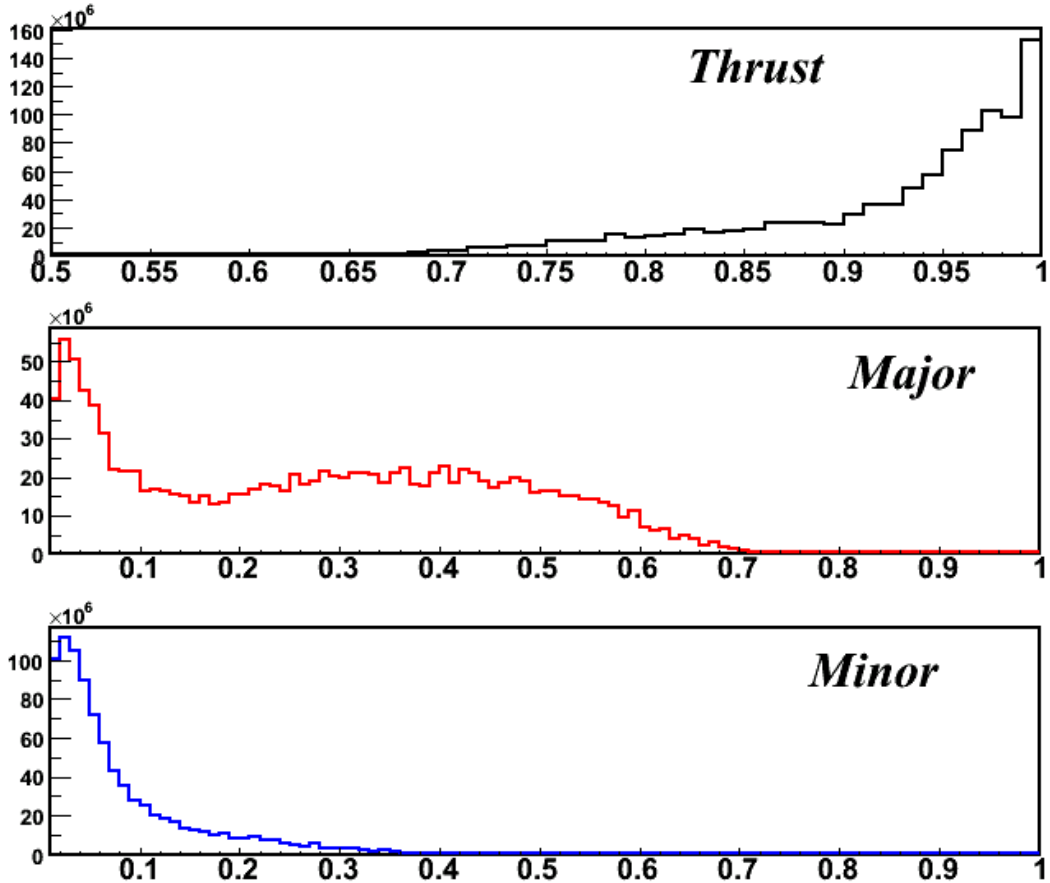
Reconstructed level (FAMOS)

- The triggers are combined to produce a differential cross section across the full mass spectrum resulting from QCD dijet production.
- Multiple triggers, with roughly equal total rate, allow to measure dijet mass for a wide range of dijet mass.

Event shape variables

$$T = \max_{\hat{n}} \left(\frac{\sum_i |p_i \cdot \hat{n}|}{\sum_i |p_i|} \right)$$

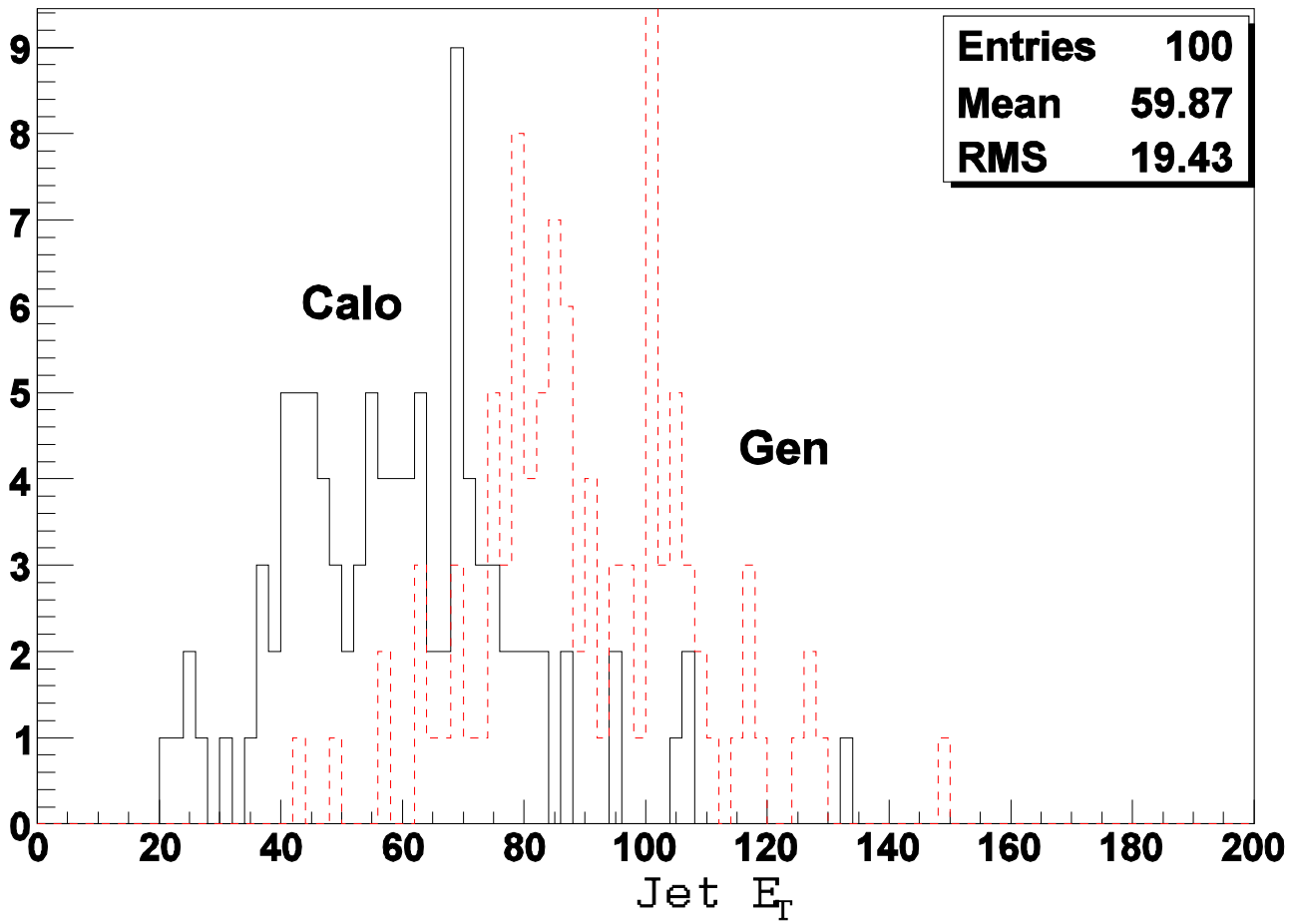
- **Clear spread towards small thrust values.**
- **Hints the production of more than two jets.**
- **Quantitatively measures the amount of gluon production.**
- **Will give a handle to measure the strong coupling constant as a function of Q^2.**



At reconstructed level - FAMOS

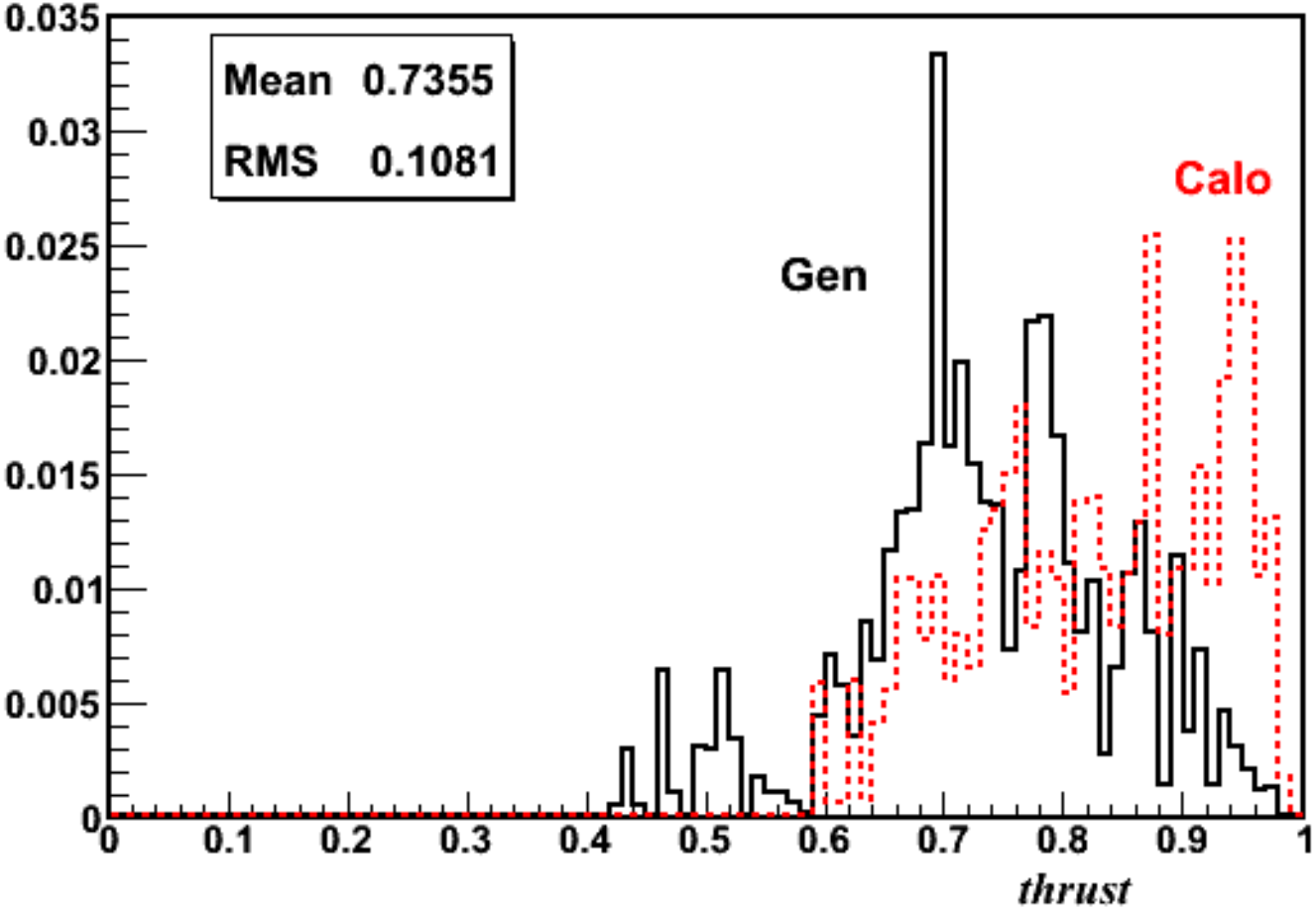
Jet-E_T distributions

Using CMSSW_1_1_1 (perliminary plots)



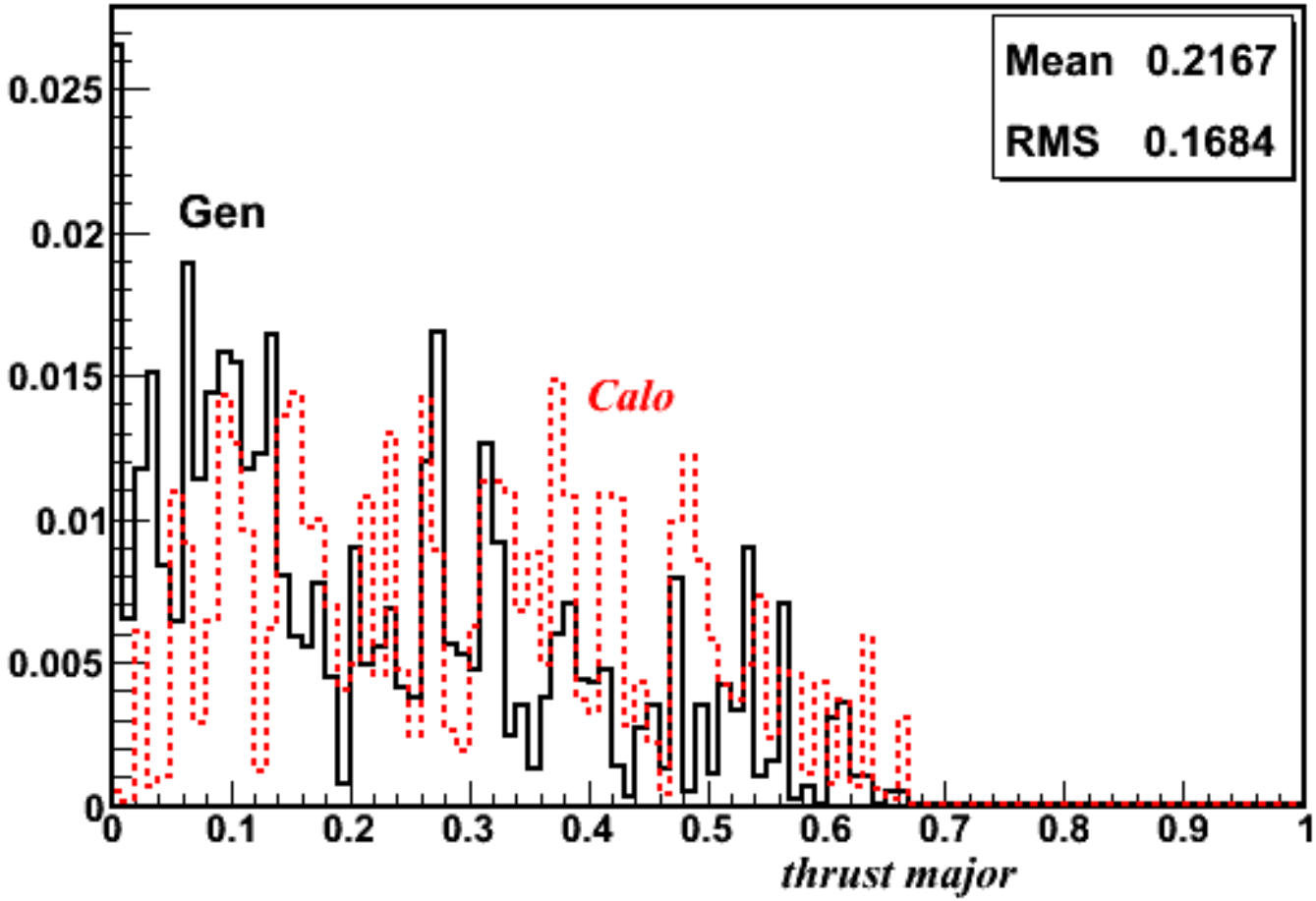
Thrust distributions

Using CMSSW_1_1_1 (perliminary plots)



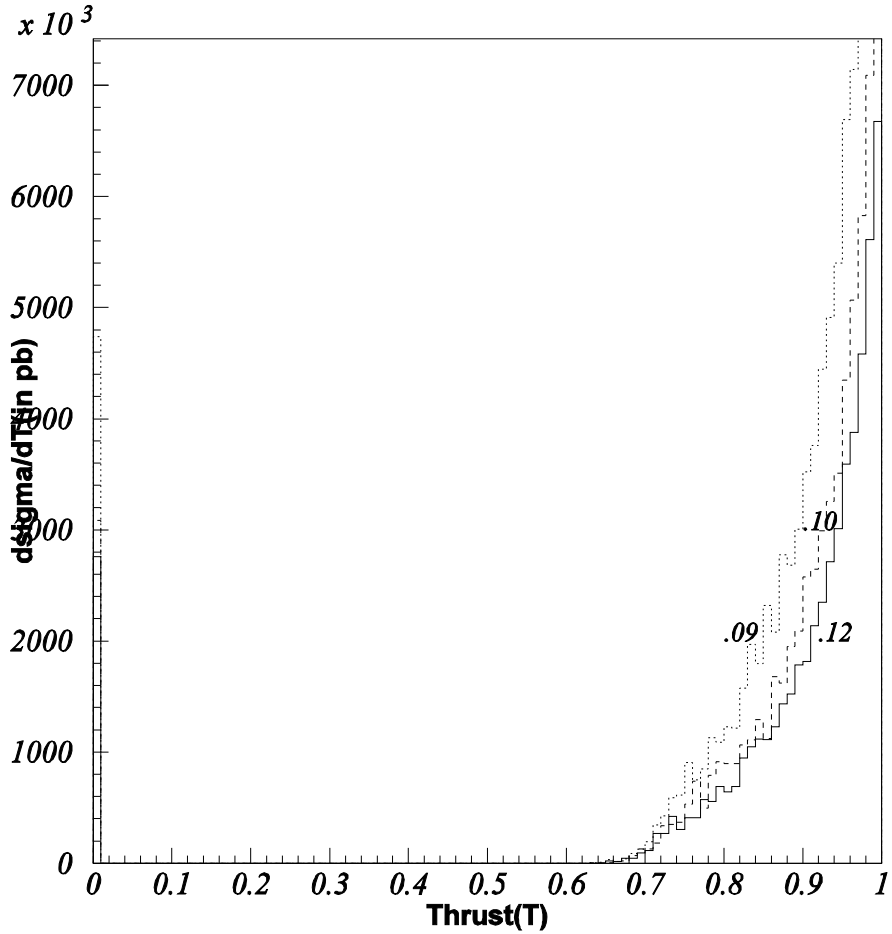
Thrust – Major distributions

Using CMSSW_1_1_1 (perliminary plots)



Default value given in Pythia of α_S is used

Thrust distributions with different α_s

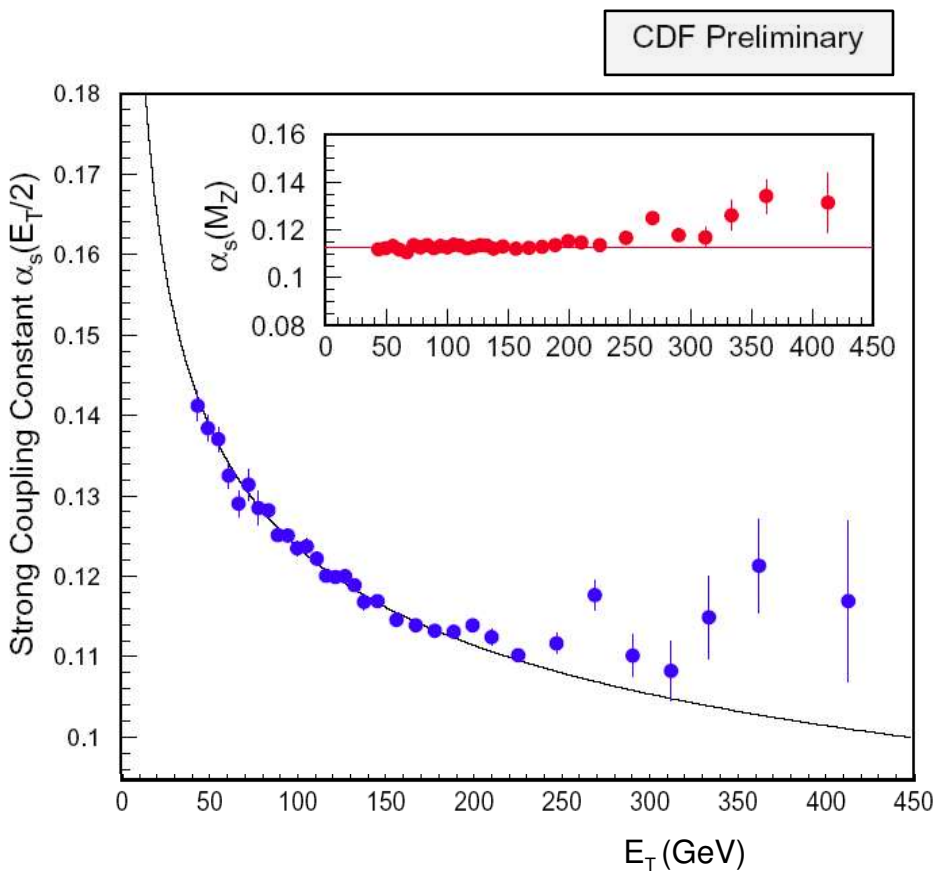
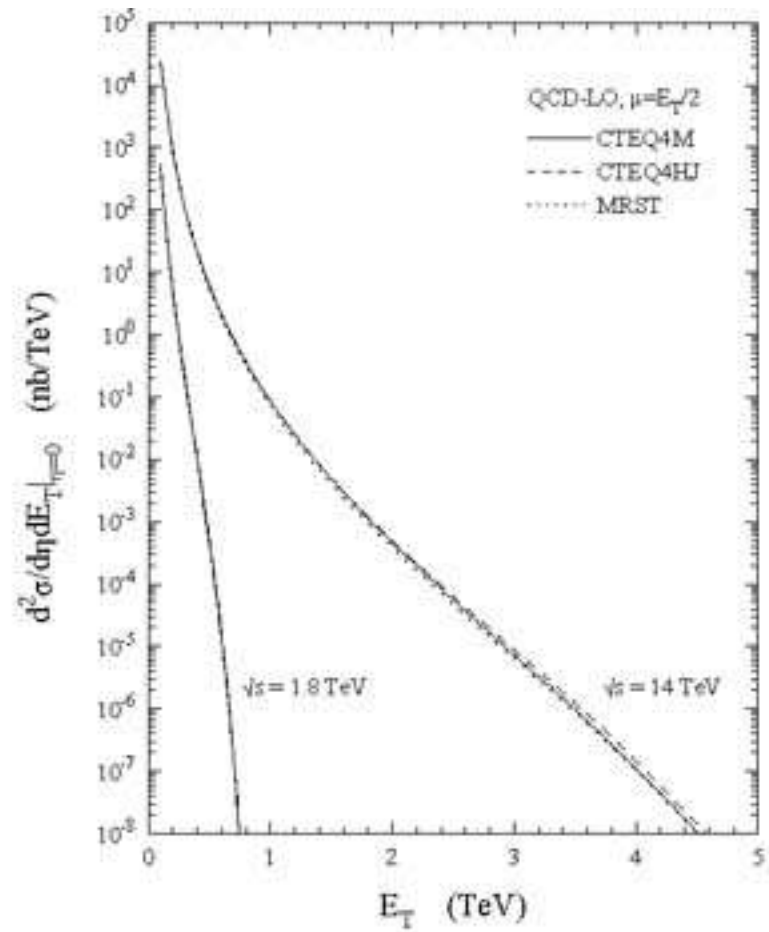


Stand-alone pythia is used.

Plotted for three different values of α_s – 0.09, 0.10, 0.12

Outlook

Study of the event shapes will give a handle to measure the strong coupling constant for the QCD processes involved.

$$\alpha_s(\mu) = \frac{\alpha_s(\mu_0)}{1 + \beta_0 \alpha_s(\mu_0) \ln(\mu^2/\mu_0^2)}$$

In LHC we can go upto 6 TeV in E_T as compared to the Tevatron where one can go upto a max of 450 GeV in transverse energy.