

Hadron Level Definition of Boosted Top Topologies.

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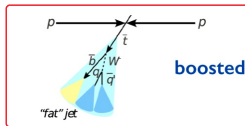
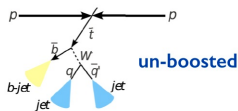
August 29, 2017

Outlook

- Boosted top scenarios.
- Particle Level studies.
- b-Hadron identification in top topologies. (Pre-Selection criteria).
- Jet Mass Cuts for the final definition of the top topologies. (Selection Criteria).
- Results using other MC (NTuples at GEN level).

Remarks of the Analysis

- Regime of boosted topologies because of high p_T^{Top}
- Considered only hadronic top decays for better p_T resolution
- Overwhelming QCD background to deal with



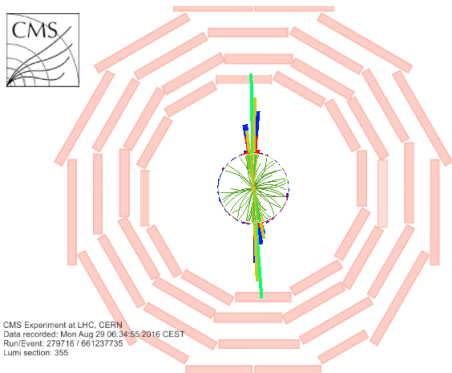
Soft Drop Mass algorithm is used to decluster the fat jet in two sub-jets
removing soft radiation

Decluster and drop softer constituent unless

$$\text{Soft Drop Condition: } \frac{\min(p_{T1}, p_{T2})}{p_{T1} + p_{T2}} > z_{\text{cut}} \left(\frac{\Delta R_{12}}{R_0} \right)^\beta$$

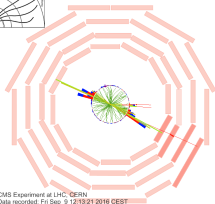
i.e. remove wide-angle
soft radiation from a jet

Boosted Top Scenarios



- Two fat jets with $pt > 400\text{GeV}$. **Top** candidates: leading and sub-leading jets.
- We clustered the fat jets in two sub-jets where ideally we can identify the W decays products and the $b\text{Hadron}$ separately in each of the sub-jets.

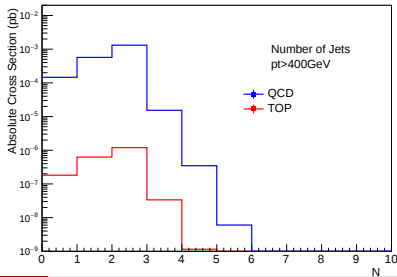
Three Jets Top Scenarios



CMS Experiment at LHC, CERN
Data recorded: Fri Sep 9 12:13:21 2016 CEST
Run/Event: 280385 / 201347787
Lumi section: 160

In three jets topologies our assumption that the two leading jets are the top candidates is not necessary valid.

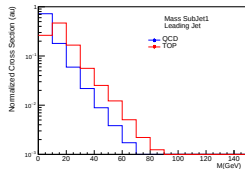
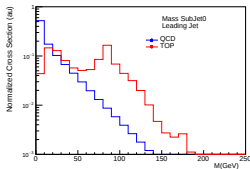
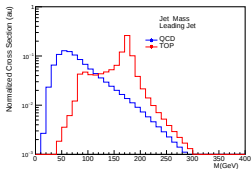
Three jets scenarios play a minor role ($\sim 1\%$) in both Top and QCD scenarios.



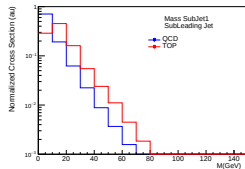
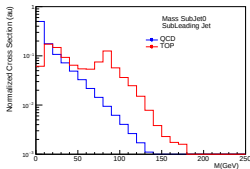
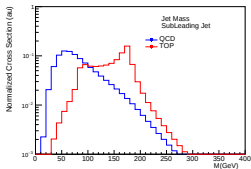
Jet Mass distributions

- Leading and Sub-leading jets are supposed to be the Top-Jet
- The first Sub-Jet in both leading jets could contains the W decays products.

LEADING JET

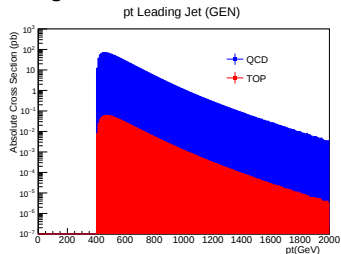


SUB-LEADING JET



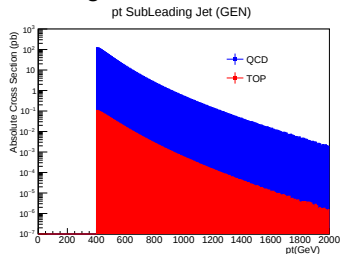
Cross Section with Pre-Preselection Criteria

Leading JET



Pre-Preselection Criteria: There are at least two jets with $p_t > 400\text{GeV}$ and in the tracker region of the detector $\eta < 2.4$

Sub-leading JET

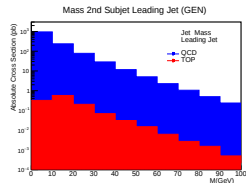
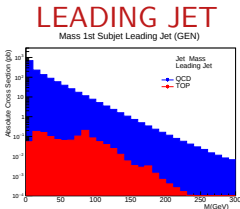
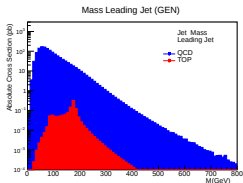


$$\sigma_{QCD}/\sigma_{TOP} = 1082$$

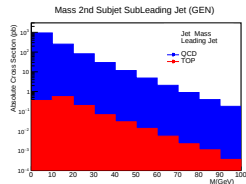
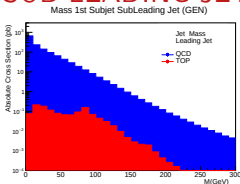
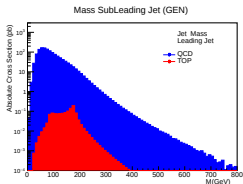
Efficiency: $\sim 60\%$

Jet Mass distributions. Absolute Cross Section

After Pre-Preselection Criteria.



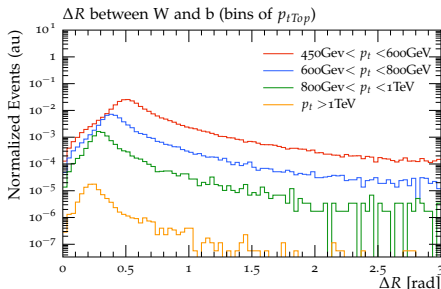
SUB-LEADING JET



Particle Level Studies

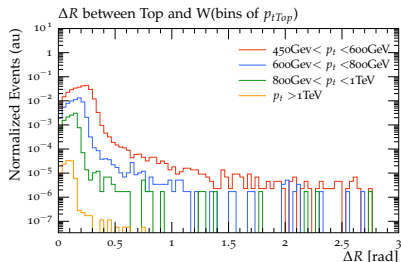
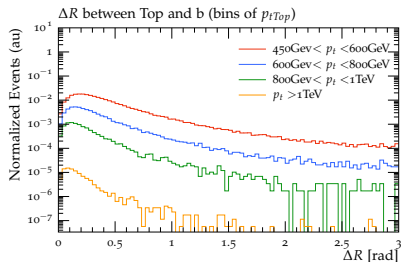
To understand better the scenarios which we are dealing with, we will look at particle level distributions.

Jet Algorithm: ANTIKT08 (Fat jet $\Delta R = 0.8$)



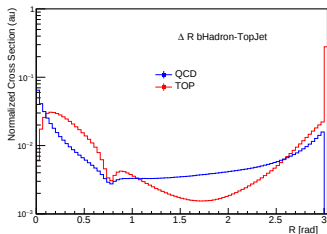
Not always the top decays products (W and b) can be clustered in the same fat jet ($\Delta R < 0.8$), specially at our lower p_t ranges.

Particle Level Studies

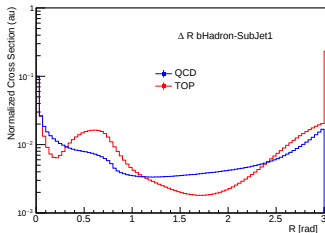
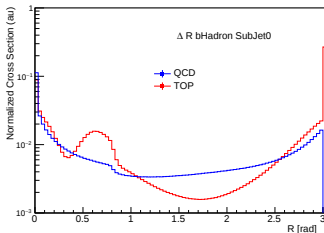


- The probability of the b-Hadron to be outside the fat jet is not negligible, specially at the lowest p_t range ($\Delta R_{bHadronTop} < 0.4$).
- The W is almost always inside the fat jet.

Top Jet Definition (first step)

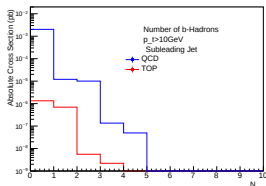
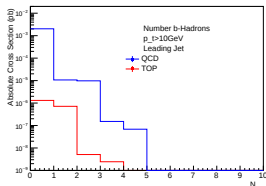


- ΔR b-Hadron and the fat jet
- ΔR b-Hadron and the first sub-jet
- ΔR b-Hadron and the second sub-jet



Top Jet Definition (first step)

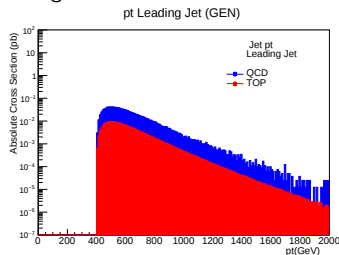
The fat jet should contain a b-Hadron ($\Delta R < 0.4$) inside.



- With this requirement we don't expect to discriminate totally the background.
- The probability in the top topologies to find two b-Hadrons inside the same fat jet is negligible
- If we reject those jets with more than one b-Hadron, we are already rejecting at least half of the background!!!
(feasibility to apply double b-tagging techniques at DET level???)

Cross Section (Preselection Criteria)

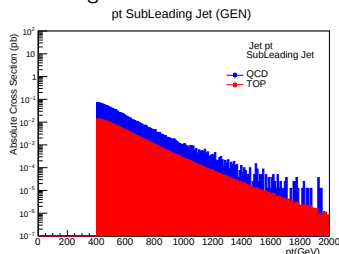
Leading JET



Pre-selection Criteria: There are at least two jets with:

- $p_t > 400\text{GeV}$, $\eta < 2.4$
- at least one b-Hadron inside ($\Delta R_{bj} < 0.4$) and $SD_{Mass} > 50\text{GeV}$.

Sub-leading JET



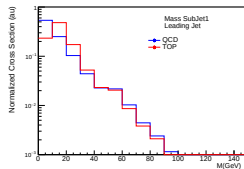
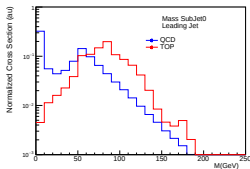
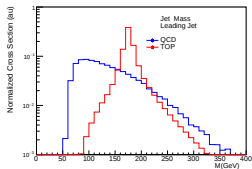
$$\sigma_{QCD}/\sigma_{TOP} = 4.6$$

Efficiency: $\sim 12.5\%$

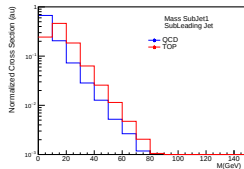
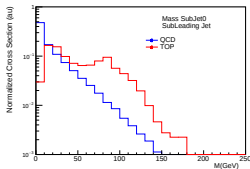
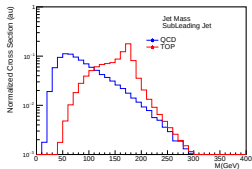
Jet Mass distributions

After Pre-selection Criteria.

LEADING JET

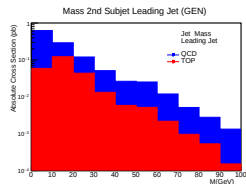
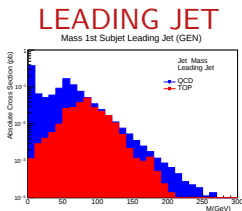
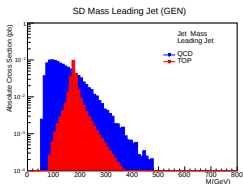


SUB-LEADING JET

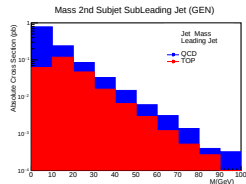
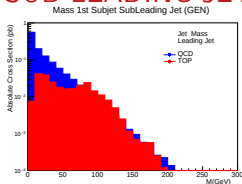
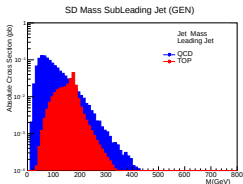


Jet Mass distributions. Absolute Cross Section

After Pre-selection Criteria.

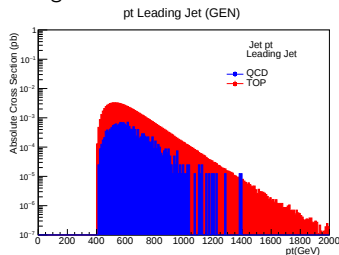


SUB-LEADING JET

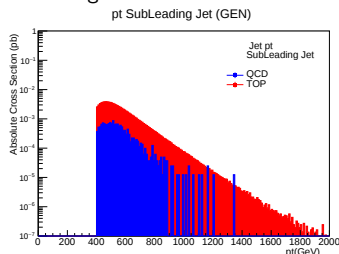


Cross Section (Selection Criteria)

Leading JET



Sub-leading JET



Pre-Preselection Criteria: There are at least two jets with::

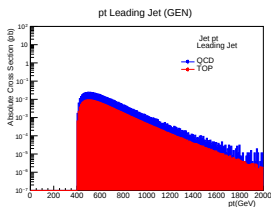
- $p_t > 400\text{GeV}$, $\eta < 2.4$
- at least one b-Hadron inside ($\Delta R_{bj} < 0.4$) and $SD_{Mass} > 50\text{GeV}$.
- $150\text{GeV} < Mass < 200\text{GeV}$, $Mass_{1stSubJet} > 30\text{GeV}$.

$$\sigma_{QCD}/\sigma_{TOP} = 0.18$$
$$(\sigma_{TOP}/\sigma_{QCD} = 5.5)$$

Efficiency: $\sim 4.3\%$

Double B-Tagging

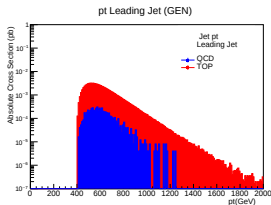
Results after pre-selection criteria



$$\sigma_{QCD}/\sigma_{TOP} = 2.7, \text{ Eff} \sim 12.2\%$$

$$\sigma_{QCD}/\sigma_{TOP} = 4.6, \text{ Eff} \sim 12.5\%$$

Results after selection criteria

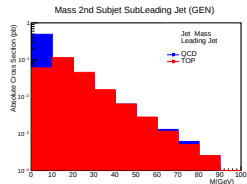
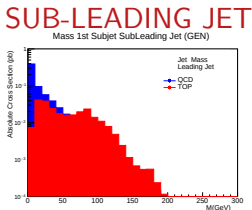
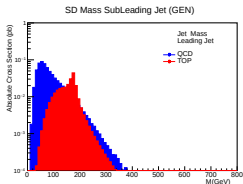
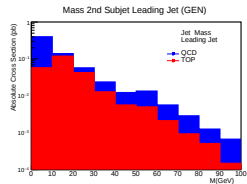
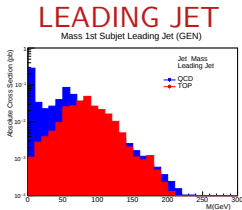
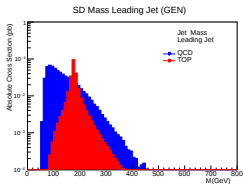


$$\sigma_{QCD}/\sigma_{TOP} = 0.07, \text{ Eff} \sim 4.2\%$$
$$(\sigma_{TOP}/\sigma_{QCD} = 13.73)$$

$$\sigma_{QCD}/\sigma_{TOP} = 0.18, \text{ Eff} \sim 4.3\%$$
$$(\sigma_{TOP}/\sigma_{QCD} = 5.5)$$

Absolute Cross Section. Double B-Tagging

After Pre-Selection Criteria.



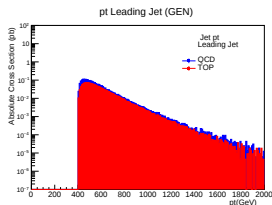
Results from GEN level studies using NTuples:

QCD: Madgraph-P8

TOP:

GEN Level Results

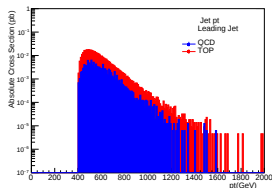
Results after pre-selection criteria



$$\sigma_{QCD}/\sigma_{TOP} = 1.4$$

$$\sigma_{QCD}/\sigma_{TOP} = 4.6$$

Results after selection criteria



$$\sigma_{QCD}/\sigma_{TOP} = 0.29$$

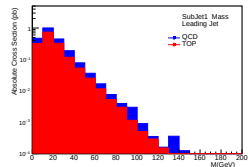
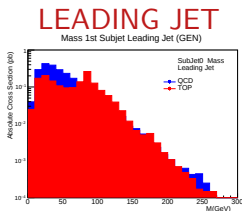
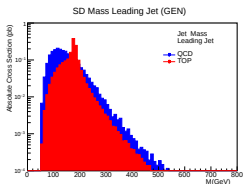
$$(\sigma_{TOP}/\sigma_{QCD} = 3.43)$$

$$\sigma_{QCD}/\sigma_{TOP} = 0.18$$

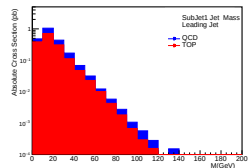
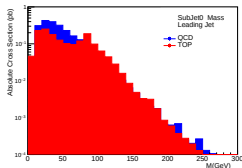
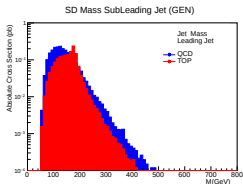
$$(\sigma_{TOP}/\sigma_{QCD} = 5.5)$$

Absolute Cross Section. GEN Level

After Pre-Selection Criteria.



SUB-LEADING JET



Summary

- Top Jet definition: there are at least two jets with $p_t > 400\text{GeV}$, $\eta < 2.4$, with a b-Hadron inside, within the top mass window ($150\text{GeV} < M_{jet} < 200\text{GeV}$), and with the first subjet mass condition: $M_{firstSubj} > 30\text{GeV}$.
- We discriminated the background in factor of ~ 5 with respect of the signal.
- But need to understand the the model dependence that we are getting from other Monte Carlos.