Determination of the HF-fraction of Additional Jets in Top Pair Decays in the ATLAS Experiment at the LHC

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Motivation - General

- LHC is a top factory $\rightarrow$ top events in abundant numbers waiting to be analyzed
- properties of tops will be measured with greater precisions
- top decays are one of the keys to physics beyond the standard model

Motivation - Analysis Specific

- top pair decays (with or without additional jets) may have the same final state as Higgs decays but the kinematic distributions of the decay products might be different
- a better understanding of these issues may facilitate Higgs searches
- of special interest for us is the **semileptonic** case where one W boson decays into leptons, the other into quarks
Analysis - Step 1: Event Selection

**the semileptonic case has many advantages:**

- good suppression of QCD background via lepton triggers
- the missing transverse energy may be interpreted as a single neutrino which facilitates the top pair reconstruction
- a good branching ratio

**therefore we are searching for events with (all cuts in backup):**

- exactly 1 high energetic and well isolated lepton
  - electrons: $p_T > 20$ GeV, $|\eta| < 2.47$
  - muons: $p_T > 20$ GeV, $|\eta| < 2.5$
- high missing transverse energy
  - muon channel: MET $> 20$ GeV
  - electron channel: MET $> 35$ GeV
- at least 4 high energetic jets ($p_T > 25$ GeV, $|\eta| < 2.5$)
A Top Event Candidate spotted by ATLAS

Ref: ATLAS-CONF-2010-063
Analysis - B-Tagging

- additional information about jets is useful to further suppress background
- top decays into a bottom → jet flavour is additional information → B-Tagging

**SV0 - B-Tagger**

- exploits the long lifetime of the b-hadrons
- reconstructs two track vertices from tracks that fulfill quality requirements
- these vertices are merged into a secondary vertex
- measures the signed decay length significance $L/\sigma(L)$ of the secondary vertex
- jets from b-hadrons exhibit larger decay length significances than lighter jets
Analysis - Reconstruction of the Top Pair

- now we have taken into account the objects in the final state and some of the information they provide

- we want to suppress background further and we need a criterium for separating jets into the classes „additional“ and „jets from top pair“

- algorithm for top pair reconstruction is necessary

- we use the KinFitter developed by T. Göpfert, V. Klose and J. E. Sundermann
Analysis - Fit Hypothesis

- KinFitter uses the kinematic variables of the physical objects in the event to reconstruct the objects from which they stem
  - input variables are $p_T$, $\eta$ and $\phi$ with their covariances of the physical objects in the event
  - constraints on reconstructed tops and W bosons are given
  - top pair candidates are built from combinations of 4 jets, 1 lepton and 1 reconstructed neutrino (calculated from MET)
  - top pair candidate is evaluated:
    - Lorentz vectors of jets and leptons are fitted
    - $t$-quarks and W bosons are reconstructed
    - $\chi^2$ is assigned to top pair candidate
  - this is done for all possible top pair candidates in the event, candidate with smallest $\chi^2$ is retained

constraints:
- W boson mass = 80.4 ± 2 GeV
- top mass = 172.5 ± 13 GeV
distributions of the cut variables of KinFitter

- distributions show different shapes of cut variables for signal and background
- harder cuts enhance the purity of the sample by sacrificing event yield
- flatness of $P(\chi^2)$ for values $> 0.2$ shows that the kinematic fit works as intended
Analysis - KinFitter Output

mass distribution of the hadronic top

- not a top quark mass measurement but a method for selecting jets using top reconstruction
- peak gets smaller due to fitted kinematic variables of the jets
- kinematics of fitted jets are corrected using information about the masses of the t-quark and the W boson
Analysis - Separation of the Jets

After the top reconstruction the jets in the event are divided into two classes, additional jets and jets from the tops.
Results

distribution of the b-tag weights

• observation of lower b-tag weights for additional jets than for jets originating from top quarks (as expected)
• distributions are sensitive to the use of b-tag information in the top pair reconstruction process
Results

number of jets which have been tagged as b-jets

- additional jets are in most cases light jets
- the ratio untagged/tagged is about 1%
Conclusion/Outlook

Conclusion:

• the properties of additional jets are best measured in semileptonic top pair events due to good background suppression and good top pair reconstruction

• The event selection via a cut based analysis and the top pair reconstruction via the KinFitter results in a sample enriched with top pair events

• B-Tagging via the SV0-Tagger delivers additional information about jets and is used for a first estimate of the heavy flavour fraction of additional jets

• the determination of the HF fraction of additional jets in top pair events is possible with the 2010 data (at least with simple methods)

Outlook:

• further data taking will make statistics expensive methods possible (e.g. template fitting)

• one possible application of the results may be used for tuning MC
Thank you for your attention!
### Backup - Full Cutflow

#### Electron channel
1. Trigger: EF_e15_medium
2. more than 4 tracks from primary vertex
3. bad jet veto
4. at least one lepton
5. either one muon or one electron
6. exactly one electron
7. trigger matches electron
8. muon electron track share veto
9. \( \text{MET} > 35 \text{ GeV} && M_T^W > 25 \text{ GeV} \)
10. \( N_{\text{Jets}} > 2 \)
11. \( N_{\text{Jets}} > 4 \)
12. more than 1 jet tagged by SV0 algorithm

#### Muon channel
1. Trigger: EF_mu13_tight
2. more than 4 tracks from primary vertex
3. bad jet veto
4. at least one lepton
5. either one muon or one electron
6. exactly one muon
7. trigger matches muon
8. muon electron track share veto
9. \( \text{MET} > 25 \text{ GeV} && \text{MET} + M_T^W > 65 \text{ GeV} \)
10. \( N_{\text{Jets}} > 2 \)
11. \( N_{\text{Jets}} > 4 \)
12. more than 1 jet tagged by SV0 algorithm