CMS proposal for Top Quark studies : detailed
Les Houches 2005

People participating :

CERN (theory division) :	Fabio Maltoni
IHEP Protvino :	Sergey Slabospitsky
INFN Sezione di Pisa :	Andrea Giammanco, Boris Mangano
SINP MSU Moscou :	Edward Boos
Vrije Universiteit Brussel :	Jorgen D'Hondt, Jan Heyninck, Steven Lowette

Present at Workshop (TBC) :

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INFN Sezione di Pisa :	Andrea Giammanco, Boris Mangano
SINP MSU Moscou :	Edward Boos
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- **General interests :**

  These are topics we are working on within the CMS Collaboration and are of general interest within the Standard Model community.

  1. Theoretical framework
  2. Jet reconstruction
  3. B-tagging efficiencies
  4. Event kinematics
  5. Top quark physics in $t\bar{t}$ events
  6. Top quark physics in single-top events
  7. Searches beyond the Standard Model in $t\bar{t}$ or single-top events

- **Detailed topics to be studied :**

  These are selected topics on which we will effectively work and discuss during the Les Houches workshop. Their title is meant as a first indication for the proceedings. We hope to work and discuss with other experts during the workshop in order to extend our knowledge on these specific topics. They have to be interpreted as worktopics on which we would like to reach a result at the end of the workshop. Hence the list of contributors is meant to be extended.

  1. Top mass estimator in single-lepton $t\bar{t}$ final state
  2. Influence of the jet definition on cross-sections and invariant mass estimations
  3. Treatment of pile-up and underlying event in $t\bar{t}$ events
  4. Definition and procedure for systematic uncertainties
  5. Single-top Monte Carlo generators
  6. Estimate b-tagging efficiency using $t\bar{t}$ events

1 General interests

In general the CMS Top Physics group is interested to study $t\bar{t}$ and single-top events at the LHC. The full reconstruction of the event is the first item to investigate. For this Workshop we would like to interact with people from the Tevatron Collaborations on topics like jet reconstruction, b-tagging and calibration, and with people working on the phenomenology of $t\bar{t}$ and single-top events. This with the general aim to develope optimal physics measurements such as the top quark mass and possibly search for signals beyond the Standard Model. In general we would like to learn what the Tevatron Collaborations would like to do if they would have 10^3 more data.

1.1 Theoretical framework

- The role of top quark physics and perspectives
- Theoretical status of for example its mass definition

1.2 Jet reconstruction

- Compare jet clustering algorithms
- How to quantify the quality of the jet reconstruction ?
- Input objects of the algorithms (cuts on these input objects)
- Testing new jet clustering algorithms or combining the existing algorithms
- Jet calibration methods and identification of control jet-samples
- In single-lepton $t\bar{t}$ events identify of the 4 best reconstructed jets (best agreement with the primary partons) among all reconstructed jets (normally this happens as a function of the p_t of the jet, but isn't there something more optimal)

1.3 Efficiency for tagging b-jet

- One of the most important uncertainties on Higgs searches (discovery or limits) arises from the determination of the b-tagging efficiency. The single-lepton and di-lepton $t\bar{t}$ event sample from the first year(s) of data taking at LHC is large enough to be able to select a b-quark enriched jet sample with only a very small contamination of jets arrizing from light quarks. We envisage to study the possibility to develope such a pure selection of b-quark jets via the kinematics of the $t\bar{t}$ event. We are also interested to develope methods to determine the correct b-tagging efficiency to be applied on Higgs studies from that $t\bar{t}$ jet sample.

1.4 Event kinematics

- Selection of the correct lepton in the final state (electron and muon)
- Optimal reconstruction of the missing energy
- Kinematic fit issues

- How to parameterize the uncertainties on the objects
- How to deal with the beam remnant, the pile-up, recoil, ISR/FSR, ...

1.5 Top quark physics in $t\bar{t}$ events

- Inference techniques for the top quark mass (correct definition ?)
- The top quark width ?
- How to determine systematic uncertainties on m_t ?
- Higher order corrections and influence of PDF definition
- Background determination and connected systematics
- Fragmentation model tuning influence
- How to reduce the above systematic uncertainties ?
- Cross-section and differential cross-sections

1.6 Top quark physics in single-top events

- Event selection for t-channel, s-channel and tW-channel
- Monte Carlo simulations
- NLO corrections on cross section and differential cross section
- Extraction of the V_{tb} element in the CKM matrix
- Methods to determine the top polarization and spin determination
- Methods to determine the top quark charge
- Methods to determine the top quark mass
- Indentify the major systematic uncertainties related to the above measurements

1.7 Searches beyond the Standard Model in $t\bar{t}$ or single-top events

- Potential for discovery of SUSY Higgses in $d\sigma_{t\bar{t}}/dM_{t\bar{t}}$
- Potential to discover anomalous Wtb couplings
- Potential of a search for FCNC in single-top events
- Possible light SUSY signals in single-top events (hep-ph/0410089)

Prior to the Workshop date (May 2005) we will prepare a software framework to study the above issues. We will also have the Monte Carlo simulation needed for that.

2 Detailed topics to be studied in Les Houches

2.1 Top mass estimator in single-lepton $t\bar{t}$ final state

Contributors : Jorgen D'Hondt, Jan Heyninck, Steven Lowette
Items : A complete top mass estimator is constructed based on event-by-event likelihood methods and kinematic fitting tools.

2.2 Influence of the jet definition on cross-sections and invariant mass estimations

Contributors : Jorgen D'Hondt, Jan Heyninck
Items : Different jet algorithms are implemented to reconstruct the $t\bar{t}$ event, for example iterative cone, midpoint cone and k_T based algorithms. Each algorithm can be optimized on several points, for example the input object, the recombination scheme, the calibration, etc. The influence on the selection efficiency and the bias and resolution of an estimate of the top invariant mass will be checked.

2.3 Treatment of pile-up and underlying event in $t\bar{t}$ events

Contributors : Jorgen D'Hondt, Jan Heyninck, Andrea Giammanco
Items : How to deal with the pile-up and the underlying event when reconstructing $t\bar{t}$ and single-top events? We have generated $t\bar{t}$ Monte Carlo samples with and without low-luminosity pile-up, for which we can try to reduce the influence on the reconstructed event by optimizing for example the fake jet reduction.

2.4 Definition and procedure for systematic uncertainties

Contributors : Jorgen D'Hondt, Fabio Maltoni
Items : In order to prepare the top quark analyses for the first real data at the LHC, a detailed procedure has to be defined to estimate or determine the systematic uncertainties. This is true for the PDF uncertainty, the initial and final state radiation, the detector effects, the underlying event, etc. These definition should be unified for all analyses in order to make combinations and comparisons easier.

2.5 Single-top Monte Carlo generators

Contributors : Edward Boos, Sergey Slabospitsky, Andrea Giammanco, Boris Mangano
Items : Several single-top Monte Carlo generators exists and must be compared on the level of event selection efficiencies and differential distributions. Procedures should be defined to explain and take into account these differences.

2.6 Estimate b-tagging efficiency using $t\bar{t}$ events

Contributors : Jorgen D'Hondt, Steven Lowette
Items : From the selected $t\bar{t}$ events a b-enriched jet sample can be extracted. This jet sample can be used to extract from the first LHC data the b-tag efficiency. A method will be designed and implemented to select the b-enriched jet sample and to extract the b-tag efficiency from it.