# Searches for Ttbar Single Lepton Resonances

Farida Fassi[1], Rajaa Cherkaoui El Moursli[2] , Mohamed Amine Hyaya[2],

ILCP GENERAL MEETING

1-IFIC-Valencia, Spain

2-LPNR,Faculté des Sciences,

Université Mohammed V-Agdal, MOROCCO

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# OUTLINE

- Introduction
- Motivation
- Analysis framework details
- Events selection
  - Jets and lepton kinematics
- Event reconstruction
- Summary

# INTRODUCTION

- This work is supported by PCI2012 project between Valencia University and Rabat University, coordinated by **Rajaa Cherkaoui el Moursli** and **Santiago Gonzalez de la Hoz**.

- A PCI2012 "9 months" fellowship has been given to Amine Hyaya.

- **Farida Fassi** is PCI2012 member and the Supervisor of Amine who is based at IFIC in Valencia, Spain.

- Amine is working with Farida in ttbar resonance searches

- → contributing actively to the ATLAS ttbar single lepton resonances analysis working group.

- Analysis Contacts : James Ferrando and Lucia Masetti.

# MOTIVATION

▪Why search for top resonances?

  ▪ New physics might preferentially couple/decay to top
    ▪ it can effect ttbar production in two ways:
    ▪ Production of ttbar via intermediate particles
        → new physics signals in the top sector will distort mttbar
    ▪ Decay of top into new particles

So far we considered the following benchmark scenarios:
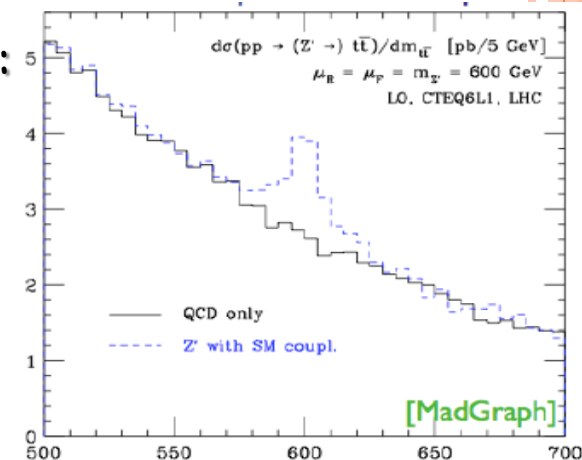• Topcolour-assisted technicolor (TC2), $Z'_{TC2}$ → tt
    - Spin-1
    -Color singlet
    - Narrow width (1.2%) modelled with
      MSSM  Z' (3%) width



• RS Kaluza-Klein Gluon gKK→ tt
    - Spin-1
    - color octet
    - Wide (10-15%)

- Many models predict resonances
  in production, for which a spectacular
   signature would be a peak in $m_{tt}$
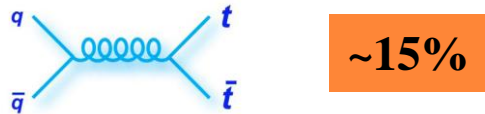-Different spin states and different
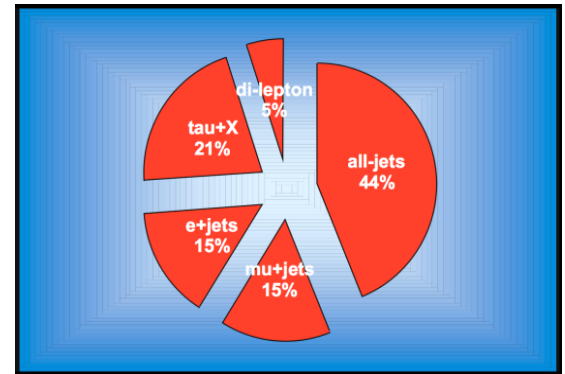widths are possible

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# TOP PRODUCTION AT LHC



- **Pair** production in 7 TeV **proton-proton** collisions:
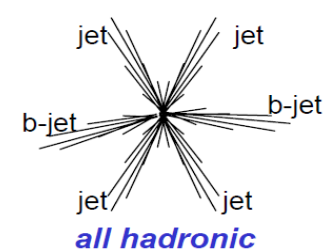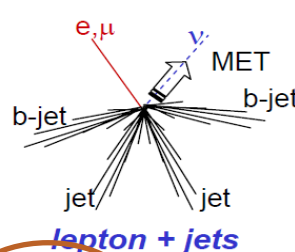- Gluon-Gluon Fusion



**~85%**

- Quark-Antiquark Annihilation



**~15%**
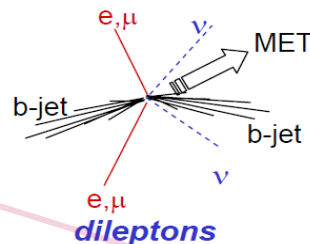
- BR(t->Wb) ~ 1 in Standard Model
- Analysis strategy depends on W decay modes

○ NLO (MCFM):
  - $\sigma t\bar{t}$ ~ 158+23/-24 pb

○ NNLO approx. (PRD 82 (2010) 114030)
  - $\sigma t\bar{t}$ ~ 163+11/-10 pb

○ **With 1 fb$^{-1}$ at LHC, ~ 4 times more $t\bar{t}$ than at Tevatron with 5 fb$^{-1}$**

**Golden channel**



*dileptons*   *lepton + jets*   *all hadronic*

**Branching ratio:**

| ~5% | ~30% | ~44% |
|-----|------|------|

**Backgrounds:**

| (mainly Z+jets) | (mainly W+jets) | (mainly QCD) |
|-----------------|-----------------|--------------|

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# ATLAS Performance for Top Physics



44m

Muon chambers

Toroid magnets

Solenoid magnet

Semiconductor tracker

Transition radiation tracker

Pixel detector

LAr electromagnetic calorimeters

LAr hadronic end-cap and forward calorimeters

Tile calorimeters
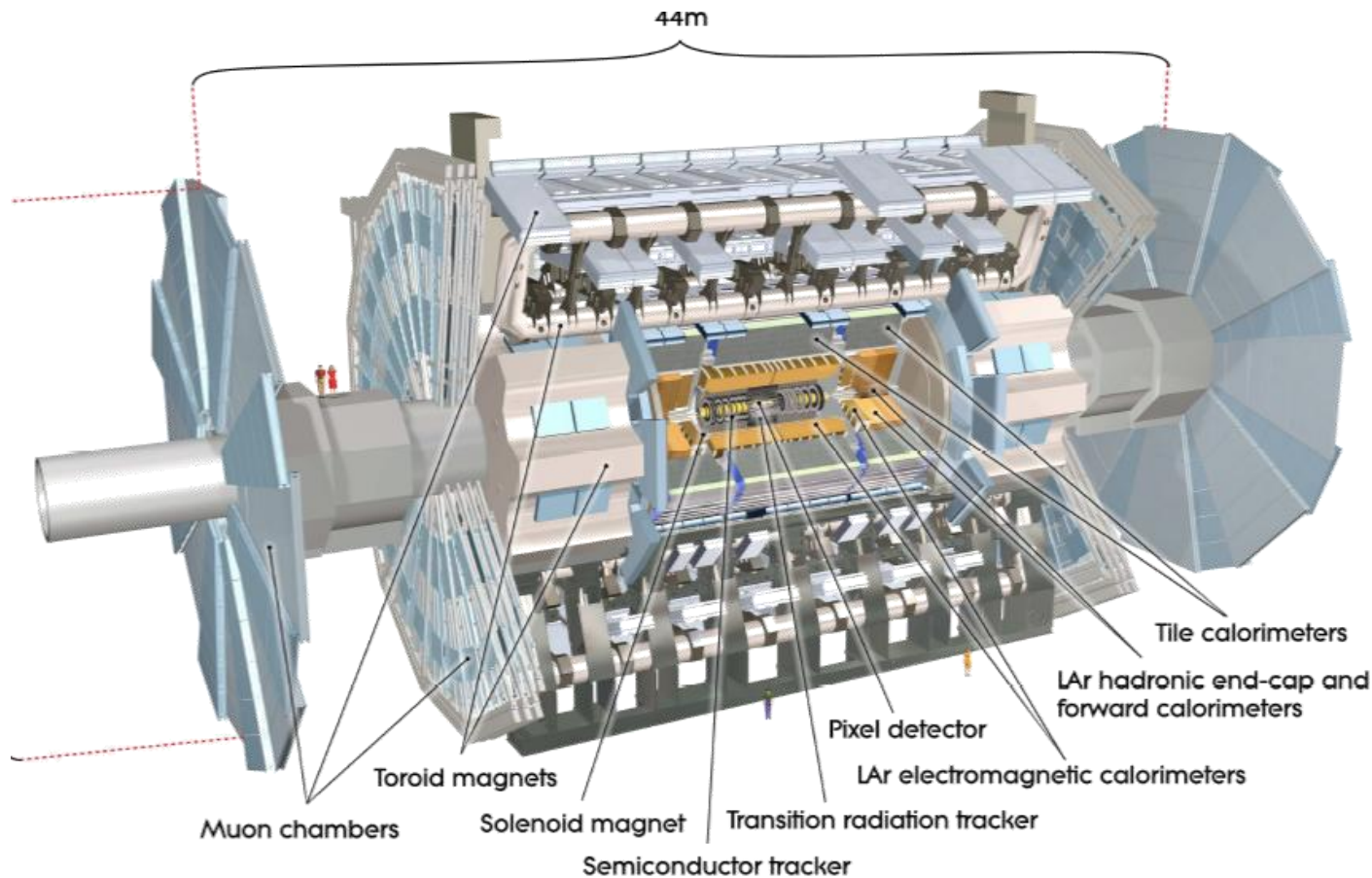
Top quark in ATLAS needs:
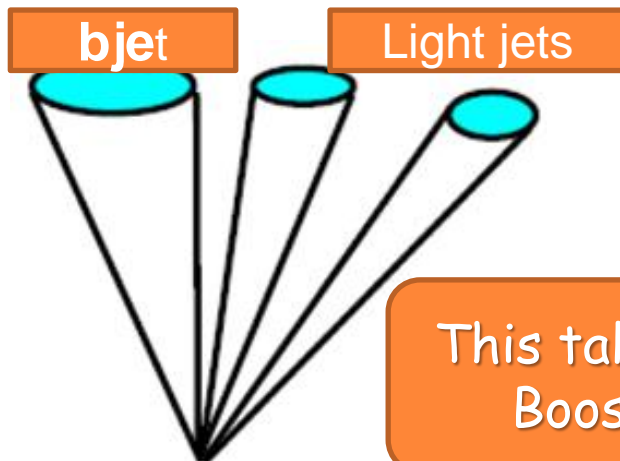 Efficient e,µ,τ reconstruction
 Good Jet reconstruction
 b-jet tagging capability

# Boosted tops topology

- Many models of physics BSM predict the existence of new resonances that decay predominantly into top quark pairs
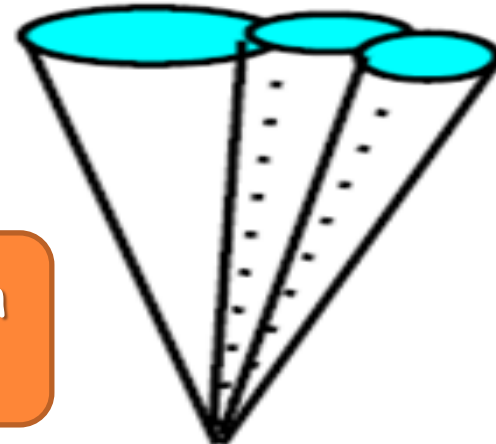
## Low Energy tops

- Similar to `standard' to reconstruction top (b-tagging)

- t → bW, W →qq´ gives three distinct "jets":

bjet    Light jets

## High Energy tops

- top decay system is highly boosted and reconstructed as only one jet:

- → Need dedicated jet clustering to identify these boosted objects

Top Monojet

This talk will focus on Boosted regime

# ANALYSIS FRAMEWORK DETAILS

# Analysis framework setup

- Official TopRootCoreRelease (TRCR): tag 00-01-12.
  - →Contains the latest TopCommonObject prescriptions.
- TRCR is ready to perform the select of the standard l+jets top events candidate, in addition it provides the functionality to apply the required corrections to events candidate.

- To use TRCR in Boosted Top regime, we have implemented and integrated the Boosted selection and reconstruction into TRCR framework:

Event Selection, including:

  Dedicated lepton selection
  - Jet trigger with dedicated Period and Good Run List
  - More details are in the table

- Event corrections:
  - Apply the objet corrections, such as scaling, smearing and SFs also done

Systematic: the machinery to apply the systematic to events candidate
            is implemented too.

# ANALYSIS STRATEGY

- Select boosted ttbar events:
  - Lepton
  - Transverse missing energy
  - Boosted hadronic top
  - b-tagging  (see table for event selection details)

### Lepton Isolation

We are using mini-isolation track energy in a cone that scales with $p_T$ of the lepton

### Trigger

→jet trigger designed for the boosted analysis
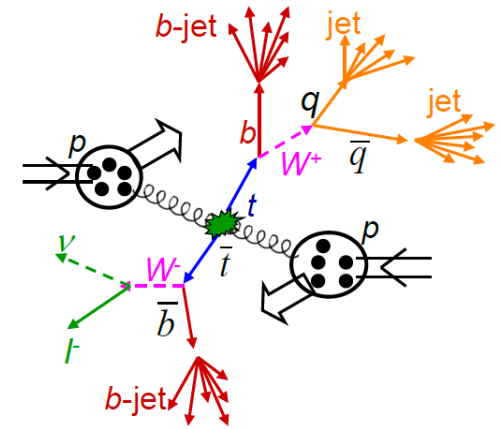
Goal:
look for bumps in the mttbar spectrum
 Considerations for the boosted top reconstruction:
- Lepton and transverse Emiss → small QCD background
- Main background is SMttbar, reasonable fraction of W+jets

# EVENT SELECTION



Considered modes:  **e+jets, μ+jets**

|  | e+jets | mu+jets |
|---|---|---|
| **C0** | total number of events | total number of events |
| **C1** | Pile-up+lumi re-weighting+GRL | Pile-up+lumi re-weighting+GRL |
| **C2** | Pass trigger + LAr error | Pass trigger + LAr error |
| **C3** | 1 good vertex | 1 good vertex |
| **C4** | >=1 lepton, pt > 25 | >=1 lepton, pt > 25 |
| **C5.1** | =1 lepton | =1 lepton |
| **C5.2** | Veto other leptons(e:with pt>25, mu: pt>20) | Veto other leptons(e:with pt>25, mu: pt>20) |
| **C8.1** | Jet cleaning | Jet cleaning |
| **C9** | MET > 30 | MET > 20 |
| **C10** | Mwt > 30 | Mwt+MET > 60 |
| **C11** | >= 1 akt4 jet pt > 25 && DR(lep,akt4 jet) < 1.5 | >= 1 akt4 jet pt > 25 && DR(lep,akt4 jet) < 1.5 |
| **C11.1** | LepJet = akt4 jet with min DR(lep,akt4 jet) | LepJet = akt4 jet with min DR(lep,akt4 jet) |
| **C12** | >=1 akt10 jet (pT > 350 && m > 100 && DPhi(lep,akt10 jet) > 2.3 && SPLIT12 > 40 && DR(LepJet,akt10 jet) > 1.5) | >=1 akt10 jet (pT > 350 && m > 100 && DPhi(lep,akt10 jet) > 2.3 && SPLIT12 > 40 && DR(LepJet,akt10 jet) > 1.5) |
| **C13** | >= 1 akt4 jet with MV1 > 0.601713 (no matching necessary) | >= 1 akt4 jet with MV1 > 0.601713 (no matching necessary) |

# EVENT YIELDS (DATA VS. MC COMPARISONS)

Comparisons made on ~4,7fb-1 dataset

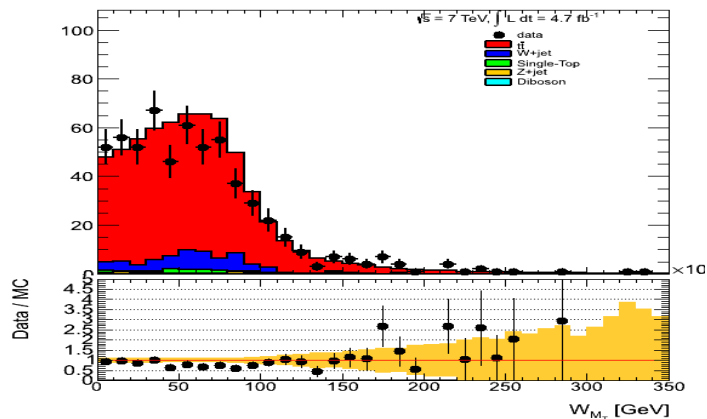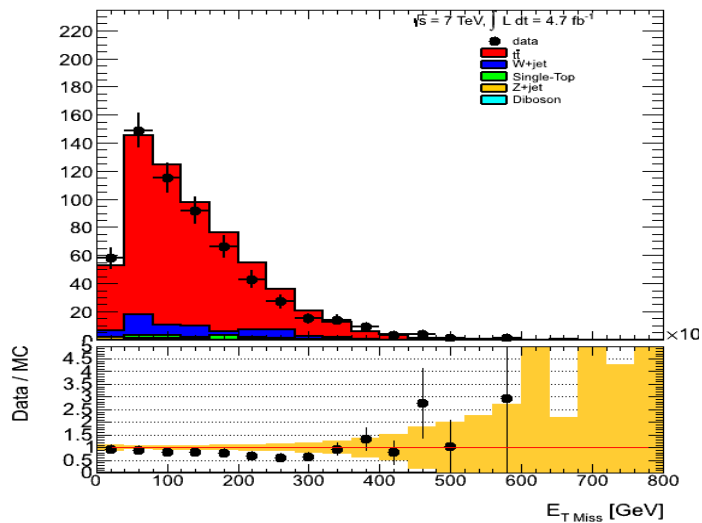|  | e_channel | μ_channel |
|---|---|---|
| Data | 366 | 597 |
| SMttbar | 337.8 | 633.77 |
| W+jets | 34.45 | 71.51 |
| Z+jets | 4.58 | 5.35 |
| Single top | 9.19 | 16,13 |
| diboson | 0.55 | 0.66 |

As expected the main background contribution comes from SM ttbar

Good agreement with other groups involved in the analysis
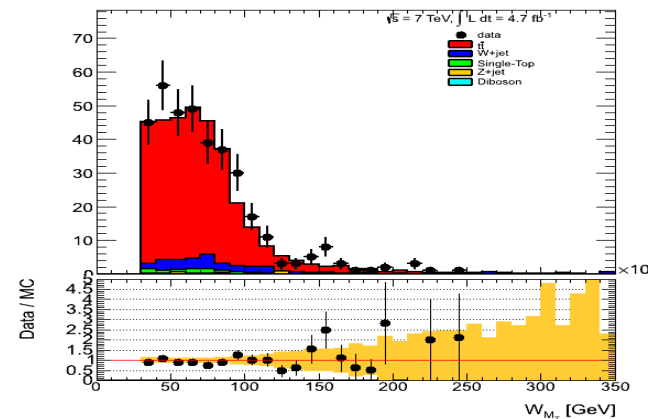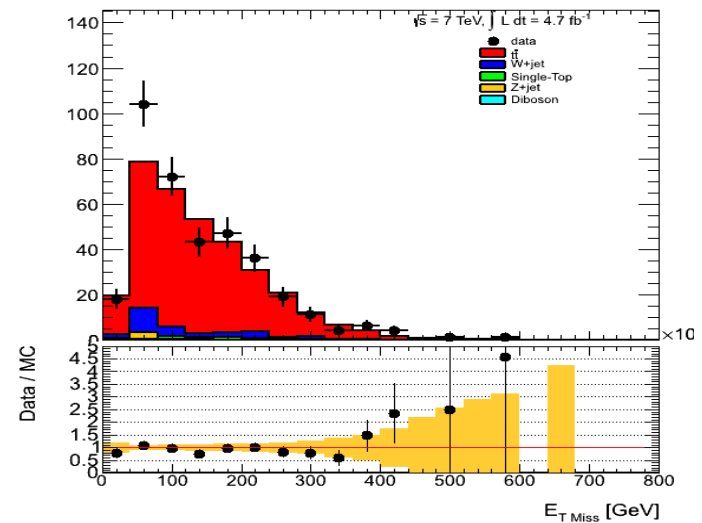**Need to update to the last prescriptions in terms of Scale Factors corrections and their systematics**

# General Control plots

**Muon channel**

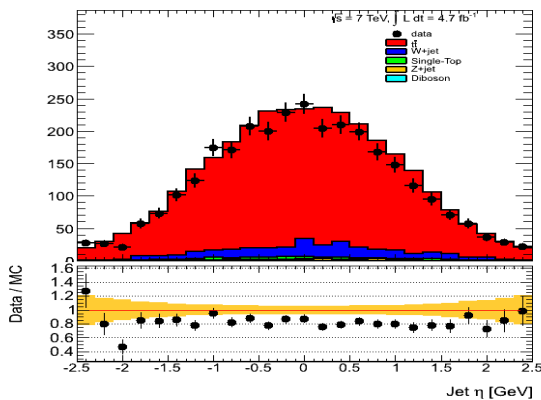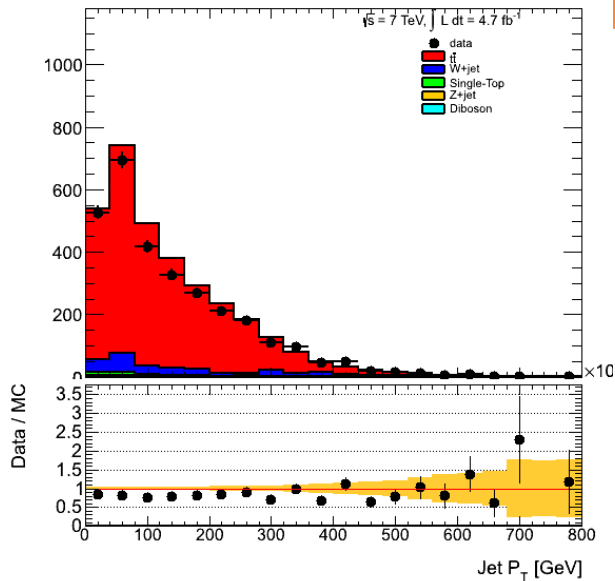**Electron channel**

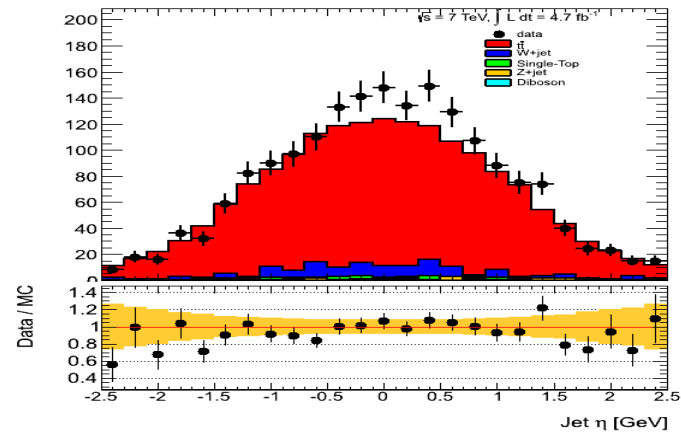# CONTROL PLOTS FOR THE LEPTON
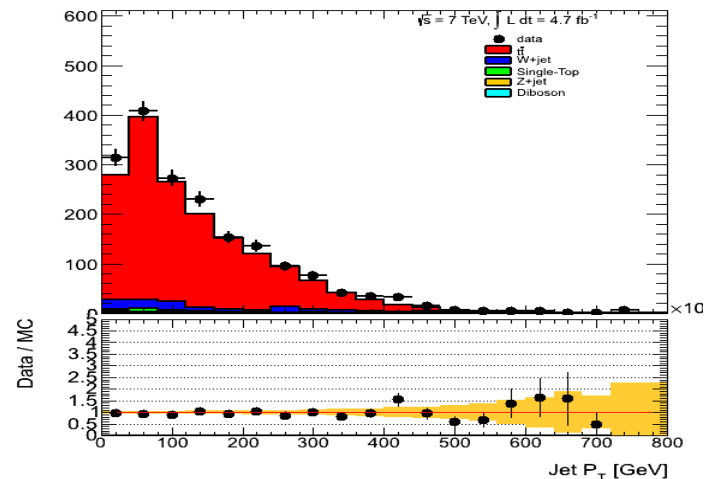
**Muon channel**
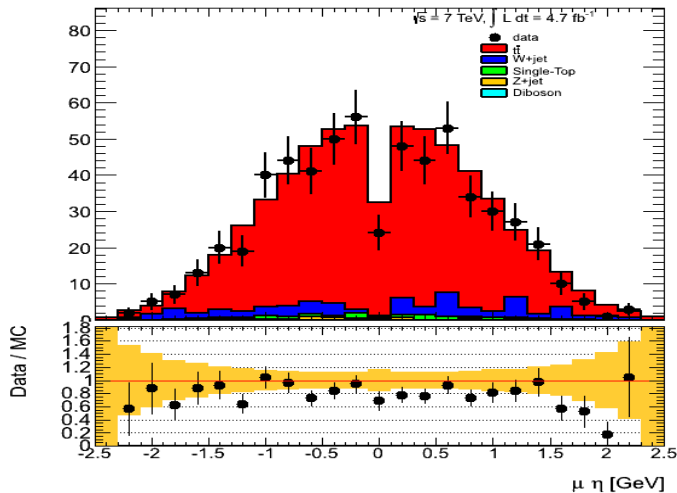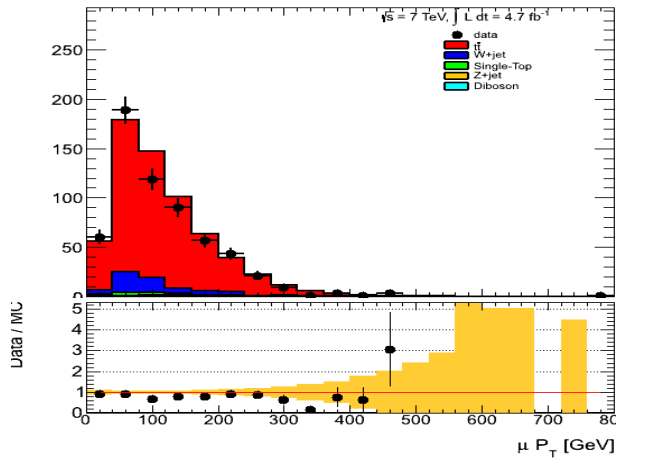
**Electron channel**
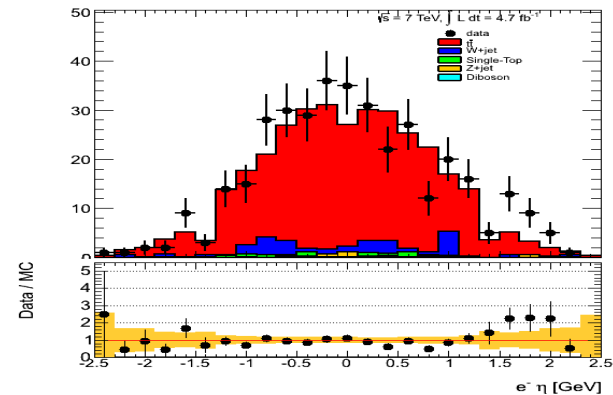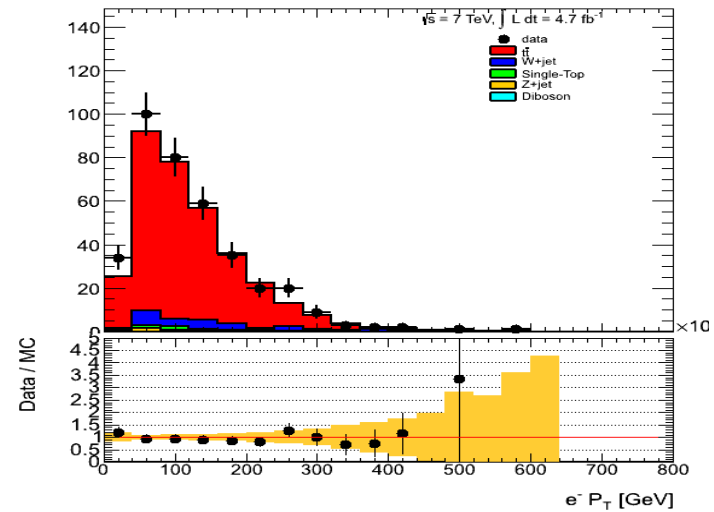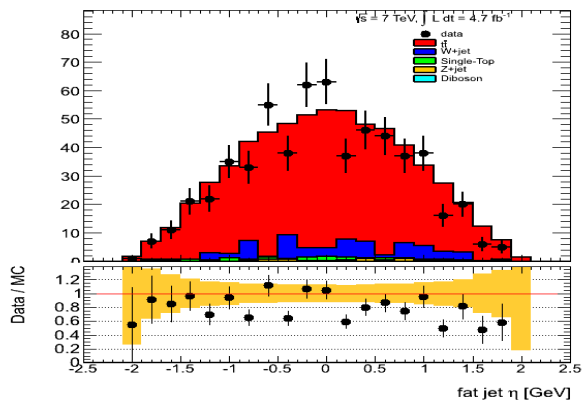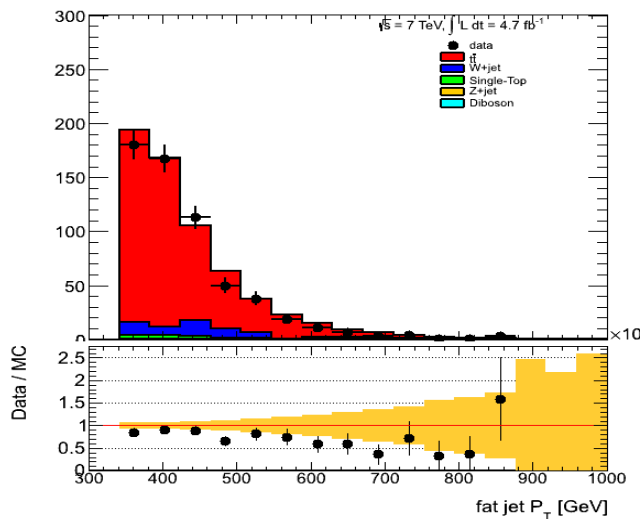
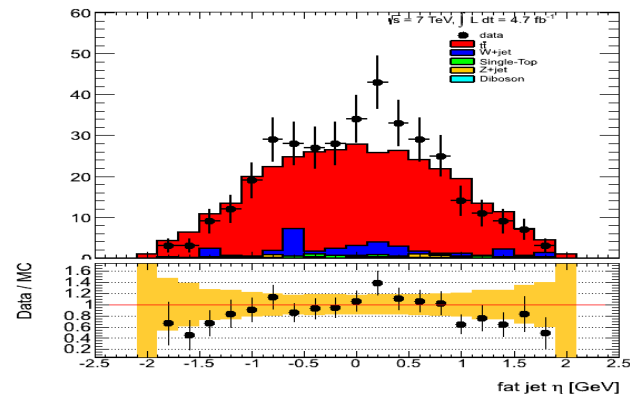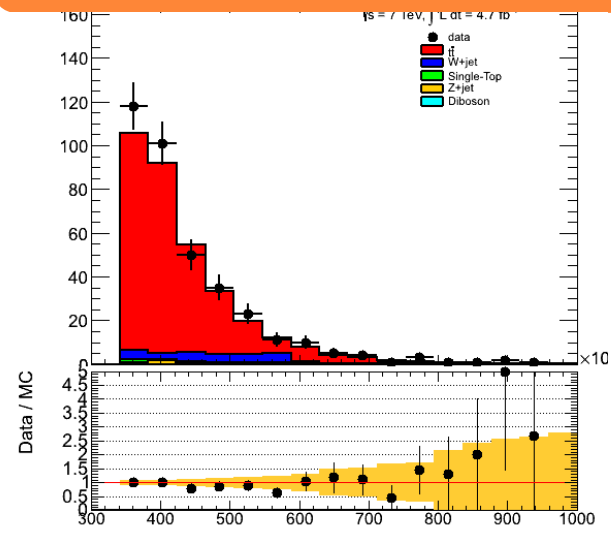# Control plots for the "leptonic jet"

**Muon channel**



**Electron channel**

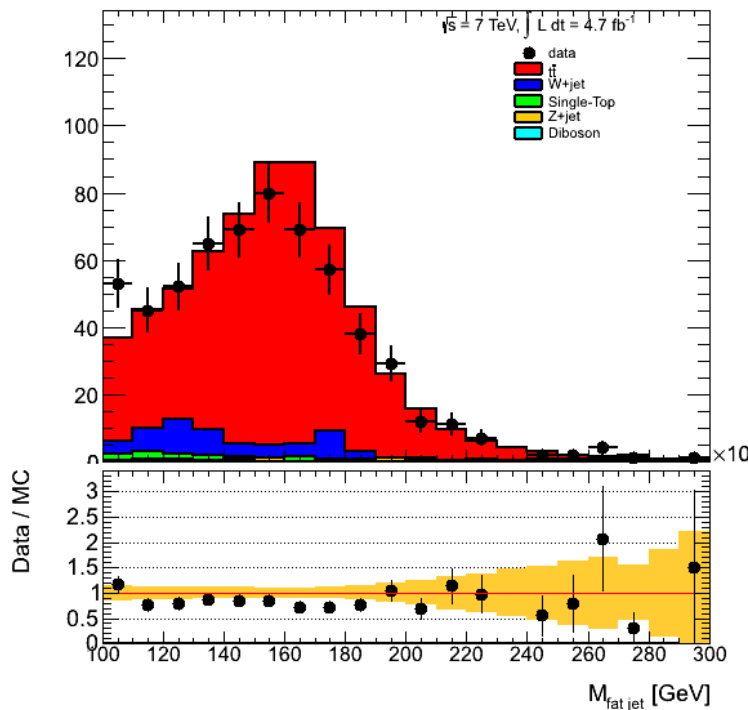# CONTROL PLOTS FOR THE "HADRONIC JET"
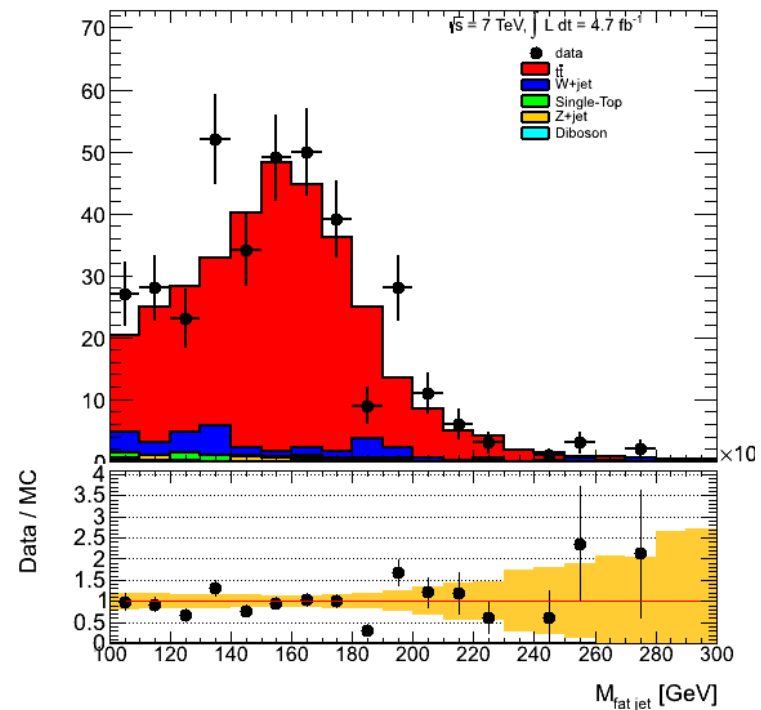
**Muon channel**

**Electron channel**

# CONTROL PLOTS FOR THE "HADRONIC JET"
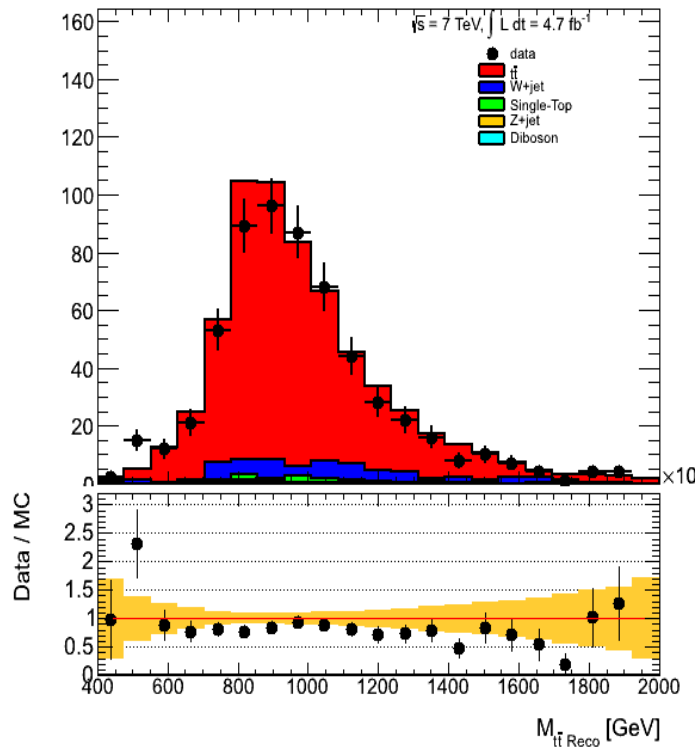
**Muon channel**

**Electron channel**



Jet mass is the  invariant mass obtained when 4-vectors
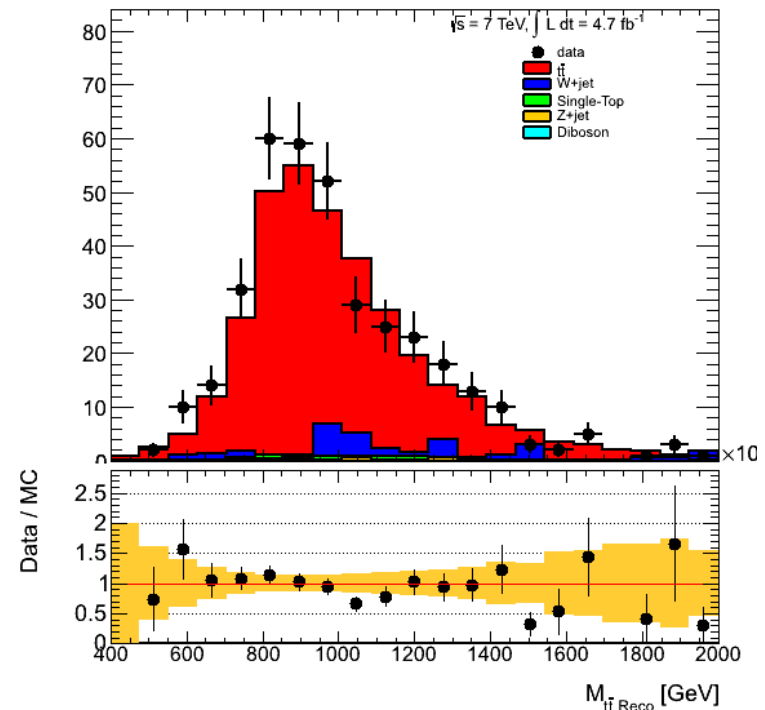   of all jet constituents are added

# RECONSTRUCTED MASS SPECTRUM (PRELIMINARY)

**Muon channel**

**Electron channel**



ttbar mass reconstruction ingredients
→ Leptonic side, AKT4 jets
 → Use mass spectrum of AKT10 jet + (closest jet to lepton) +
→   lepton + neutrino

# Summary

- Searches for new physics in the top sector is on-going

- Target: results will arrive for next conferences

- We are contributing actively to this effort

- The development of the Boosted ttbar resonances analysis is done

- Integration of this analysis into the official top analysis

- framework which is "TopRootCoreRelease" is done

- Optimisation and improvemnet of the differents analysis aspects are on-going

# backup

# TopRootCoreRelease

**TopD3PDAnalysis**

**TopD3PDSelection**

**TopD3PDCorrection**

**TopMiniNtuple**

*RootCore*

ApplyJetCalibration

ApplyJetResoluti...

CalibrationDataInte

FakesMacros

FakesTriggerUtils

FudgeMCTool

GoodRunsLists

JetEffiProvider

JetResolution

ApplyJetCalibration

TopMetTool

TopGoodRunsList

TopRootCoreRelease

TopElectronSFUtils

TopDileptonSFUtils

egammaEvent