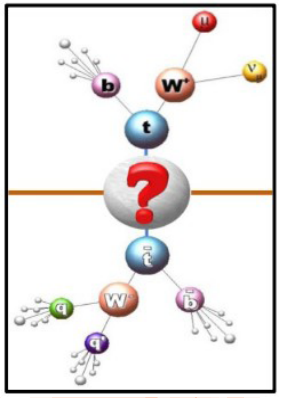

SEARCH FOR TTBAR RESONANCES IN THE LEPTON+JETS CHANNEL WITH 5 FB^{-1} OF DATA AT 7 TEV

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PCI2012 Workshop
27th June 2012

Outline

- Motivation and top quark @LHC
- Boosted tops topology
- Analysis framework
- Events selection
  - Lepton isolation and trigger
- Jets and lepton kinematical variables
- First look at event reconstruction
- Summary

MOTIVATION

- Why search for top resonances?

Top quark is a very special quark → mass of the order of EW scale

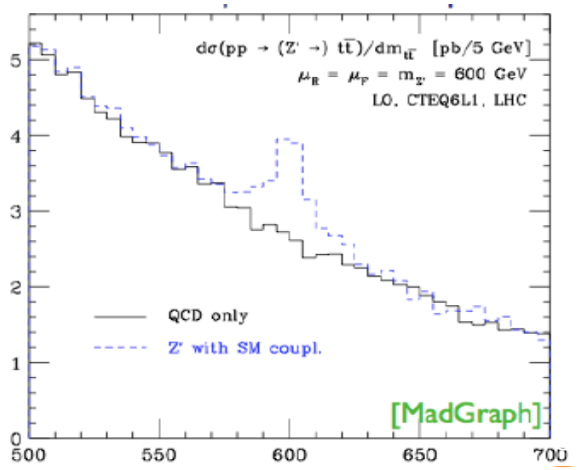
→ New physics (NP) might preferentially couple/decay to top

  - NP can manifest itself in the ttbar production via two ways:
  - Production of ttbar via intermediate particles

    → new physics signals in the top sector will distort mttbar
  - Decay of top into new particles

- 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



Model dependant point of view

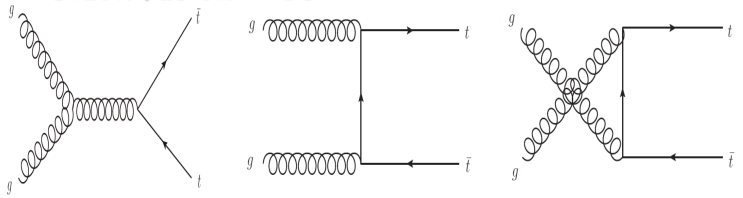
- In this analysis we considered the following benchmark scenarios:
  - Topcolour-assisted technicolor Z´ ([hep-ph/9610382v1])
  - Spin-1
  - Color singlet
  - Narrow width (1.2%)
  - Randall-Sundrum Kaluza-Klein Gluon ([hep-ph/0701166v1])
  - Spin-1
  - color octet
  - Wide (10-15%)

TOP QUARK PHYSICS AT LHC

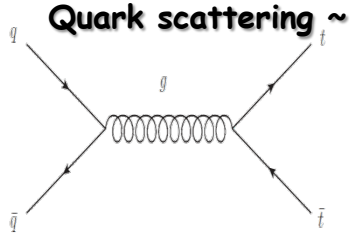
Top production in 7 TeV **proton-proton** collisions via:

Top pair production → Strong interaction

Gluon fusion ~ 85%



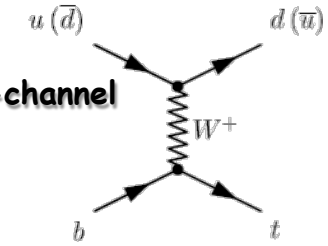
Quark scattering ~ 15%



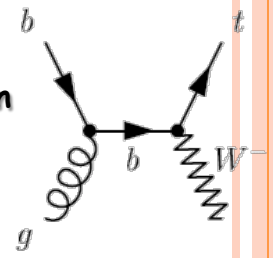
σ_{top} (7 TeV)= 165^{+11}_{-16} pb
(approximate NNLO QCD calculation)

Single top production → Weak interaction

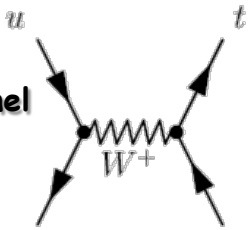
t-channel



Wt production

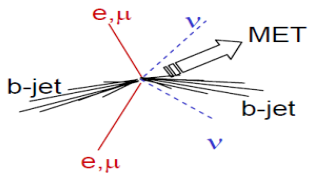


s-channel

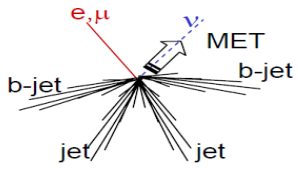


(approximate NNLO QCD calculation)

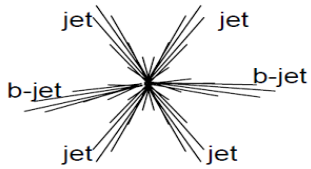
Top quark decay takes place almost exclusively to : BR(t->Wb) ~ 1
Analysis strategy depends on W decay modes



dileptons



lepton + jets



all hadronic

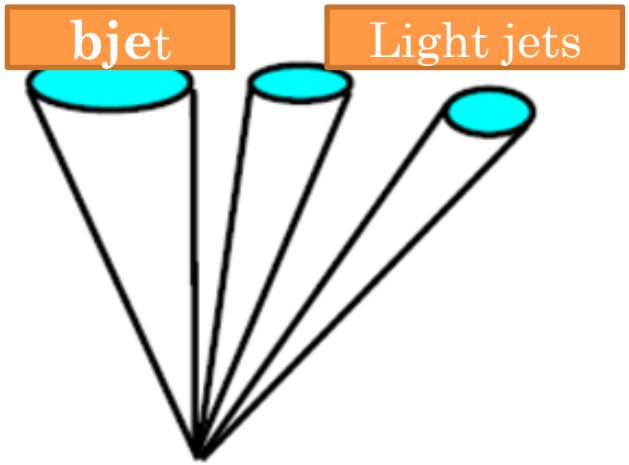
Branching ratio:	**~5%**	**~30%**	**~44%**
Backgrounds:	**(mainly Z+jets)**	**(mainly W+jets)**	**(mainly QCD)**

Boosted tops topology

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

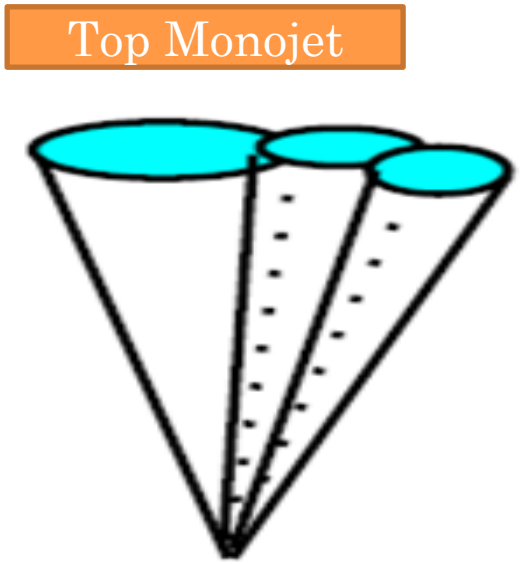
Low Energy tops

- Similar to `standard' to reconstruction top (b-tagging)
- t → bW, W →qq´ gives three distinct "jets":



High Energy tops

- top decay system is highly boosted and reconstructed as only one jet:
- → Need dedicated jet clustering to identify these boosted objects



Search for ttbar resonances: release 17

- Aim is to build a better search strategy by improving rel16 searches
- Combine "resolved" and "boosted" approaches using 5 fb-1 of data

- Specific improvement:
  - Resolved regime: Improve ttbar system reconstruction
  - Boosted regime: consider b-tagging and better jet substructure

- Both regimes improvement:
- Lepton Isolation definition, better W+jet and QCD determination

Time scale:
Short term → All improvements are being implemented
long term → improvements Toward 8 TeV data

This talk will focus on Boosted regime

Analysis framework

Analysis framework setup (1)

- Oficial TopRootCoreRelease (TRCR): tag 00-01-13.
  - →Contains the latest TopCommonObject prescriptions.
- TRCR is the standard l+jets top events candidate selection framework
- Event correction and systematic are provided
- The Boosted selection had to be implemented in TRCR

Event Selection, including:

- Lepton isolation →Mini isolation using track information
- Jet trigger → dedicated Period and Good Run List
- Fat jet and its dedicated observables (jet mass and splitting scale, d12)

- Event corrections:
  - Don´t use the standard objet corrections: scaling/SFs

    → need of lepton scale factor since the search analysis uses a different isolation definition

Analysis framework setup (2)

Systematic:

- Dedicated treatment for anti-kt 1.0 jet
  - needs special treatment of the systematic

- don't apply the standard jet systematic for energy scale and energy resolution
- For akt10 jet we have to use the number from ATLAS-conf-2011-073 to count for systematic
- This affects the Jet energy scale and Jet mass scale also the d12 scale, the jet energy resolution and jet mass resolution

- the machinery to apply those systematic inside TRCR is ongoing

Analysis stretegy

- 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

- The event passes the EF_j240_a10tc jet trigger (see Section 4.4.1).

Fat jet trigger

- At least one anti-k_t0.4 jet must exist, which fulfilled $p_T > 25$ GeV and $\Delta R(\ell, j_4) < 1.5$, where ΔR was the distance to the selected lepton.
  As candidate for the leptonic top jet, j_ℓ, the jet closest to the lepton was chosen.

AntiKt 0.4 →leptonic top

- The existence of at least one anti-k_t1.0 jet, j_{10}, was required, that fulfilled
  $p_T > 350$ GeV,
  $m > 100$ GeV,
  $\Delta\phi(\ell, j_{10}) > 2.3$,
  $\sqrt{d_{12}} > 40$ GeV,
  $\Delta R(j_\ell, j_{10}) > 1.5$.
  The $\Delta R(j_\ell, j_{10})$ cut guarantees that there is no overlap between the two jets.
  The surviving anti-k_t1.0 jet with highest p_T was chosen as the hadronic top candidate.

AntiKt 1.0 →hadronic top→ Boosted

- At least one of the anti-k_t0.4 jets had to be b-tagged. No matching to any other objects was necessary.

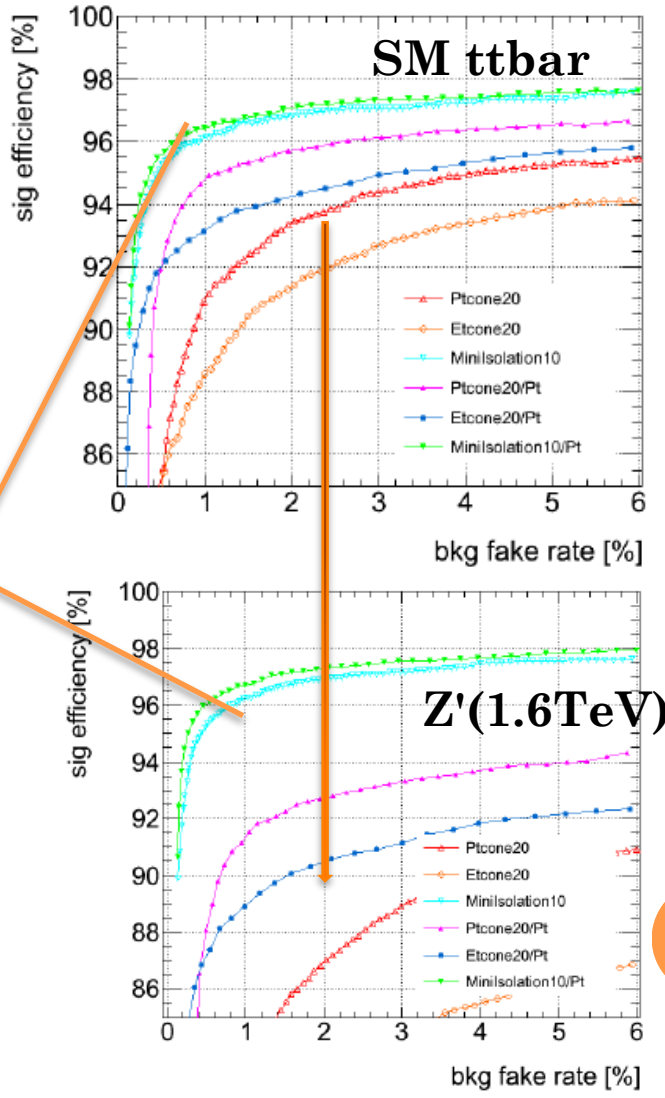
Jet mass→ invariant mass obtained when 4-vectors of all jet constituents are added

LEPTON SELECTION: MINI ISOLATION

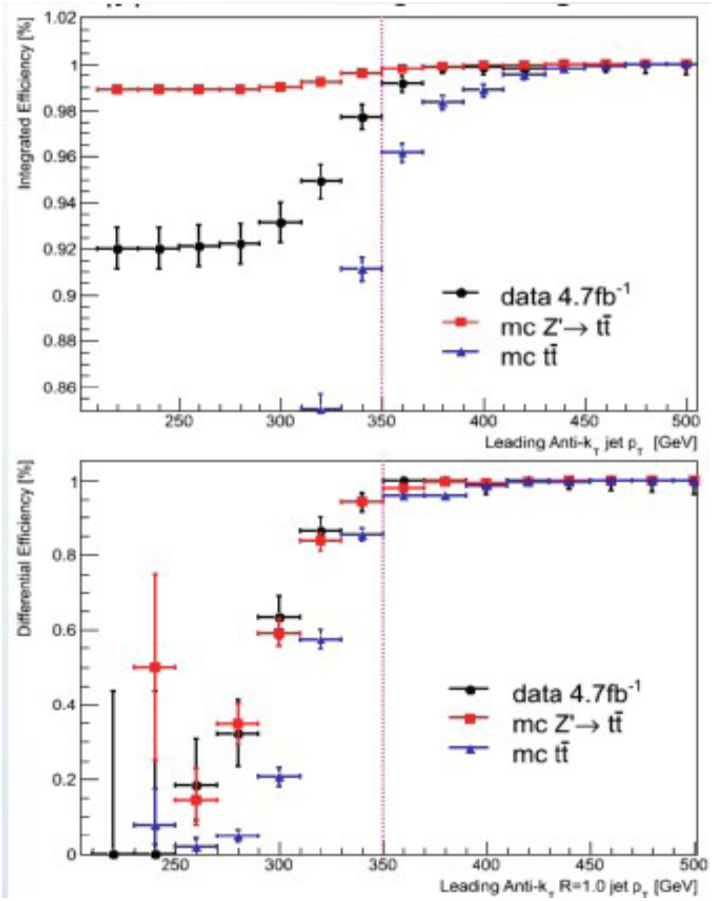
The efficiency of the standard lepton isolation get worst in the top boosted regime

→New isolation: mini-isolation Track-based isolation Sum the p_T of tracks using a cone of radius R=10GeV/ lepton_pt

→ Scale Factor and QCD estimation has to be re-estimated instead of the standard one



Event selection: fat jet trigger



- Fat jet trigger
  - EF_j240_a10tc_EFFS
- Better efficiency than the single lepton triggers

  → Especially at high mass
- Plateau reached at pT>350GeV
- Jet trigger looks for p_T > 350 GeV
  - motivates choice to keep using Antik$_T$10
- ~100% efficient (within the uncertainty)

DATA AND MC COMPARISONS
AND
FIRST LOOK AT RECONSTRUCTION EVENT CANDIDATE

Event yields (data vs. Mc comparisons)

Comparisons made on ~4,7fb-1 dataset

	e_channel	μ_channel
Data	366	629
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

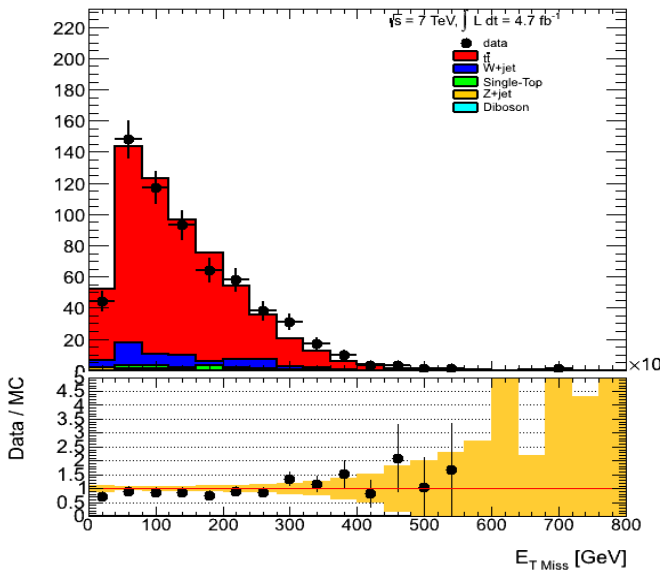
As expected the main background contribution comes from SM ttbar

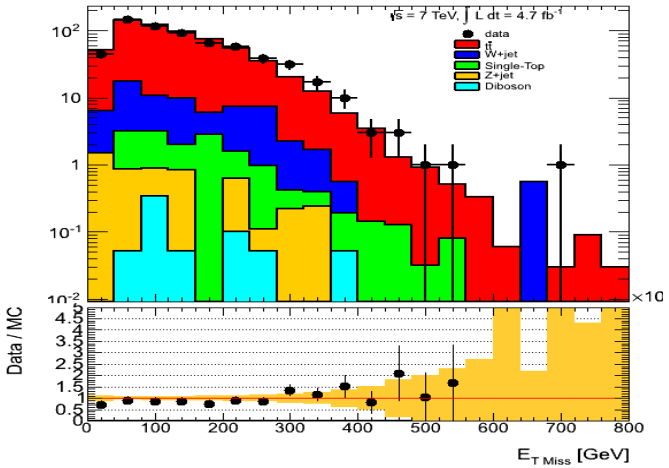
Good agreement with other groups involved in the analysis

Need to update to the last prescriptions in terms of Scale Factors corrections and their systematics

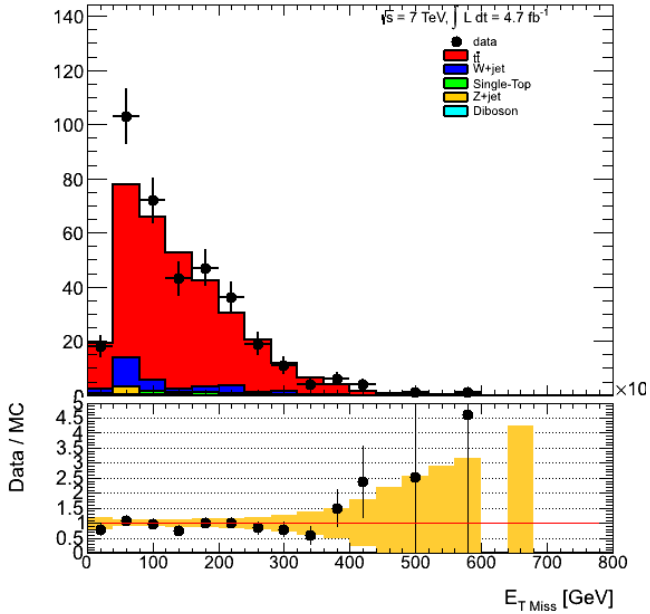
General Control plots (MET)

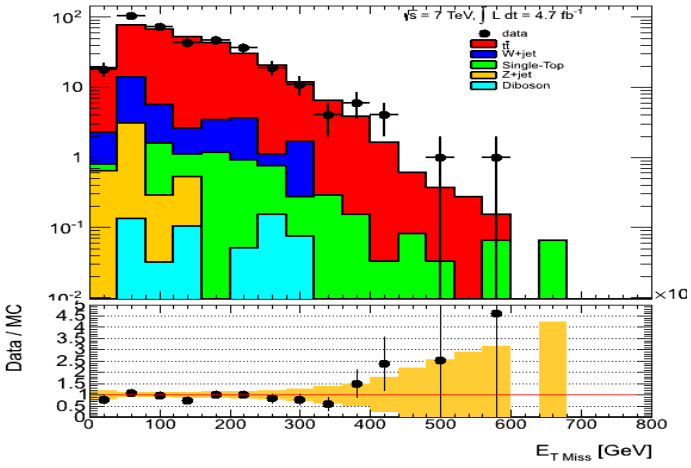
Muon channel





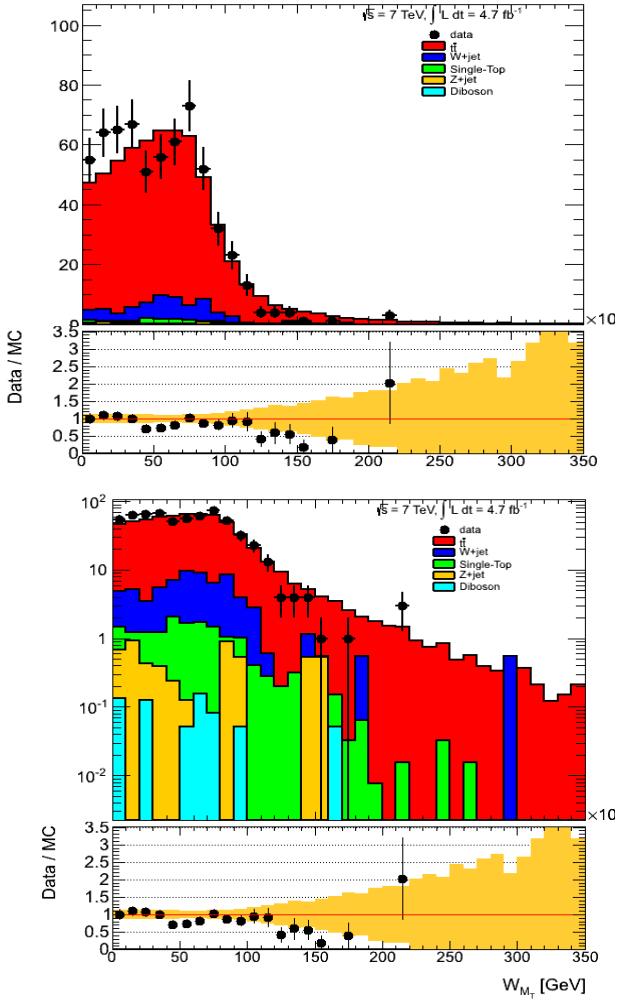
Electron channel



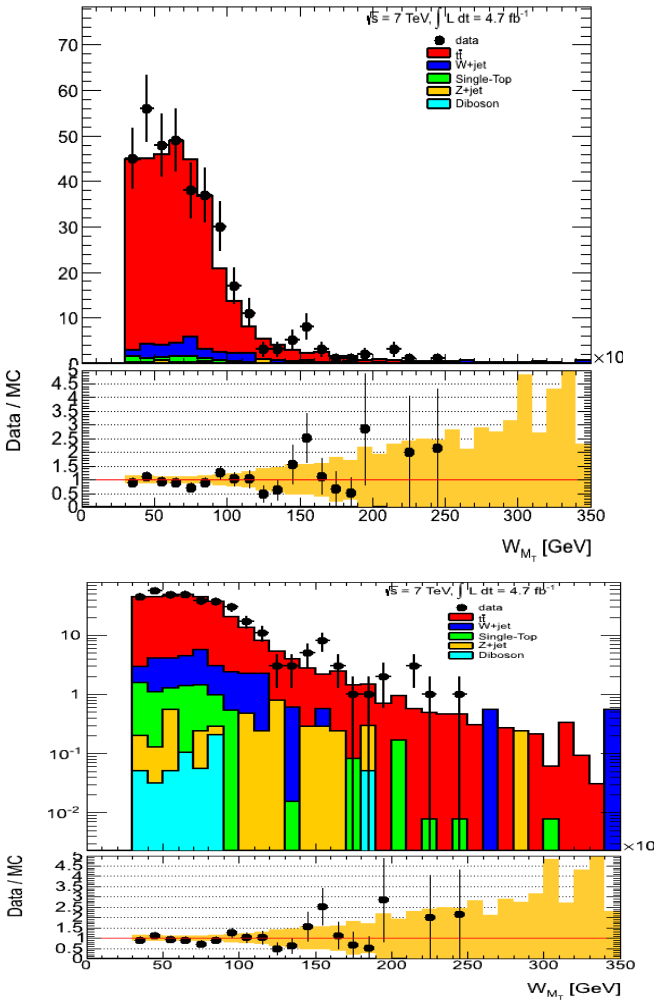


General Control plots (WMT)

Muon channel

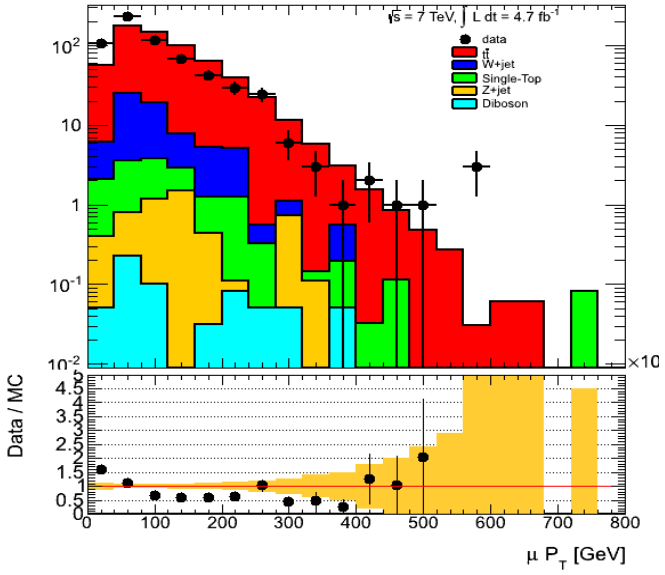


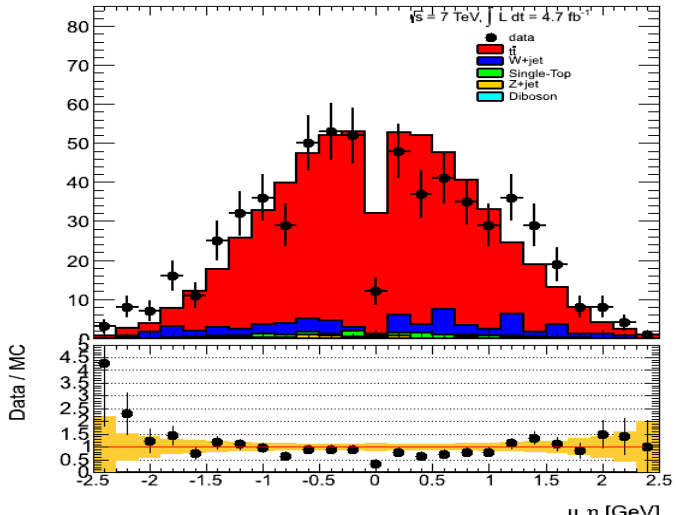
Electron channel



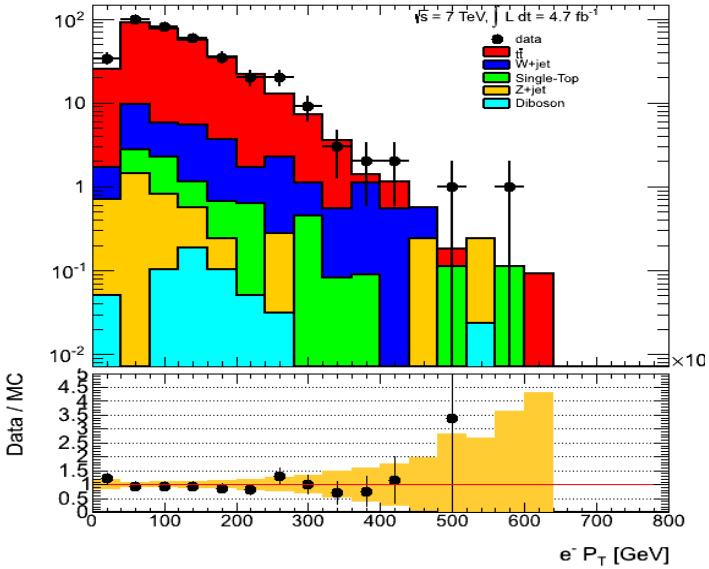
Control plots for the lepton

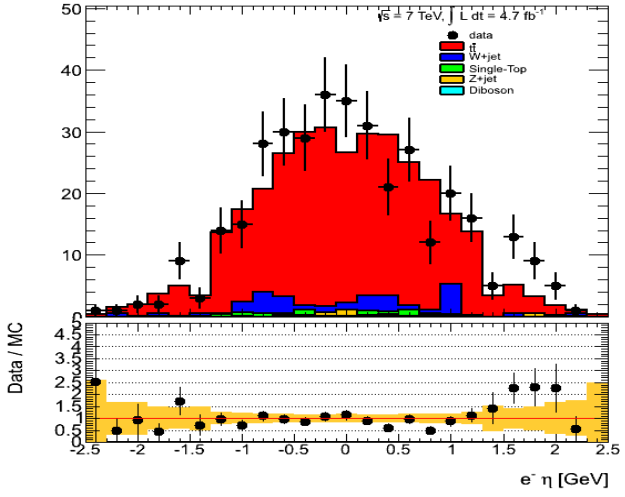
Muon channel





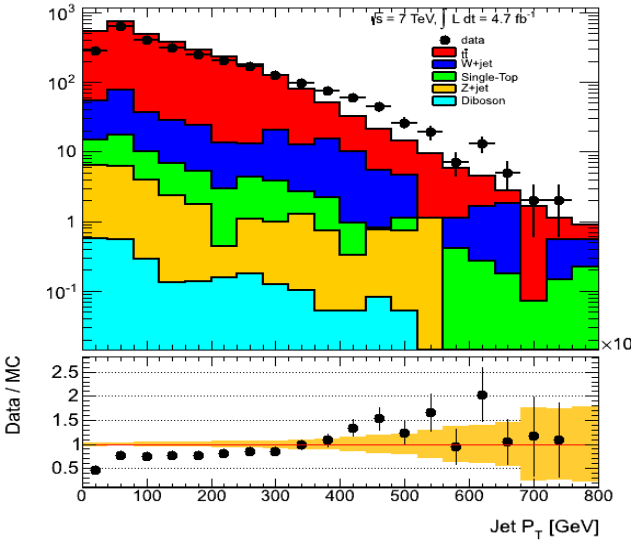
Electron channel

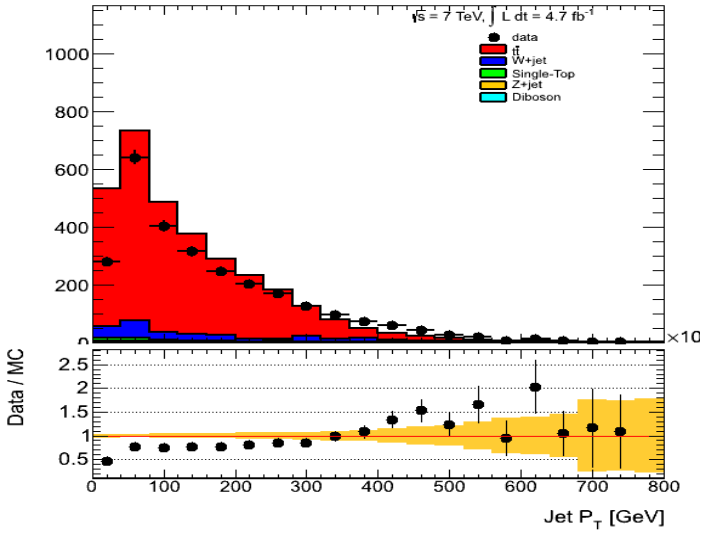




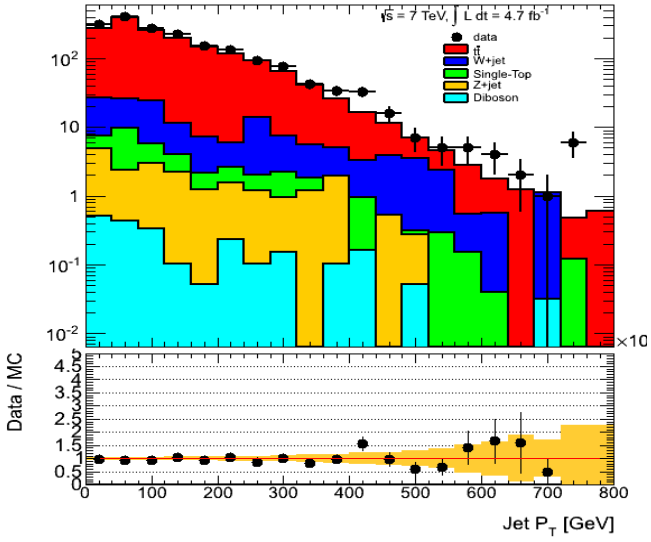
Control plots for the "leptonic jet"

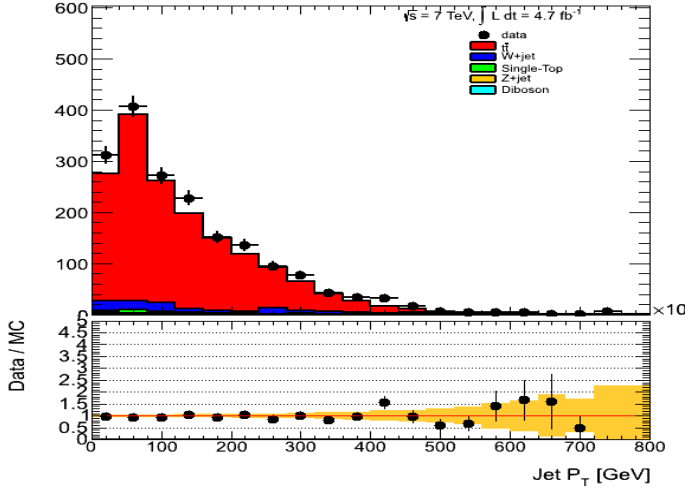
Muon channel





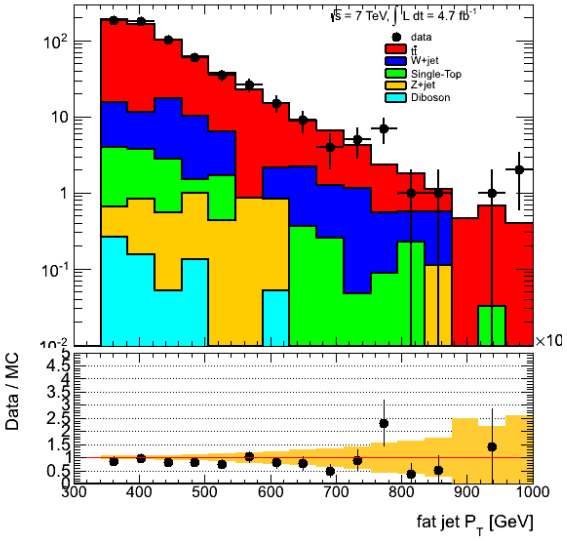
Electron channel

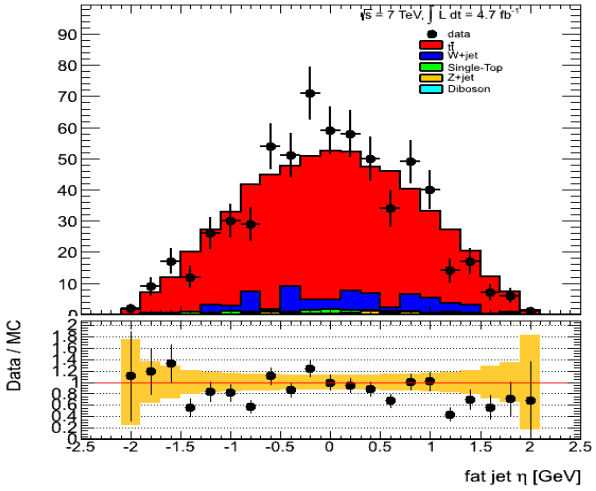




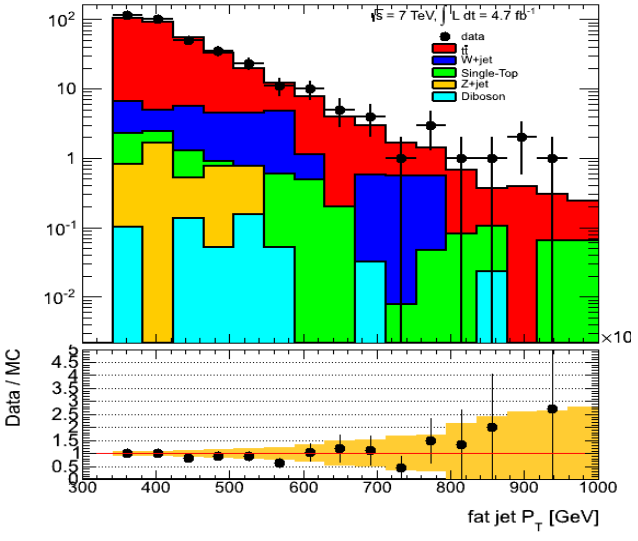
CONTROL PLOTS FOR THE "HADRONIC JET"

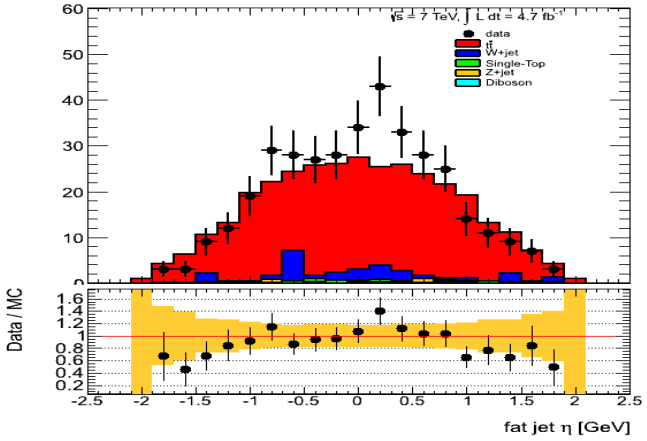
Muon channel





Electron channel





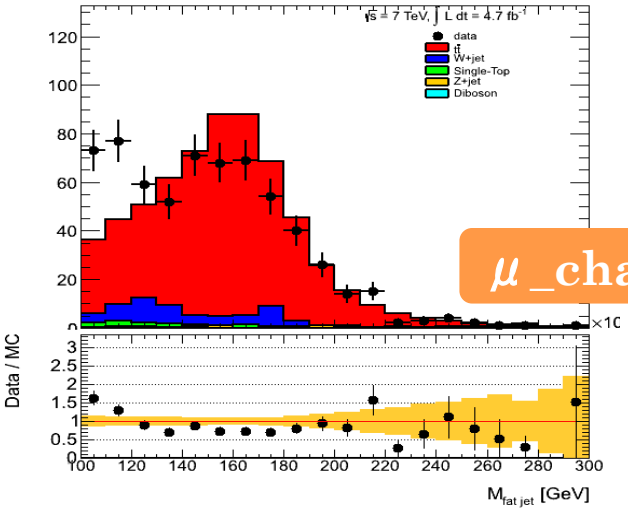
Almost similar shape as Arisona group

SUBSTRUCTURE: FAT JET MASS

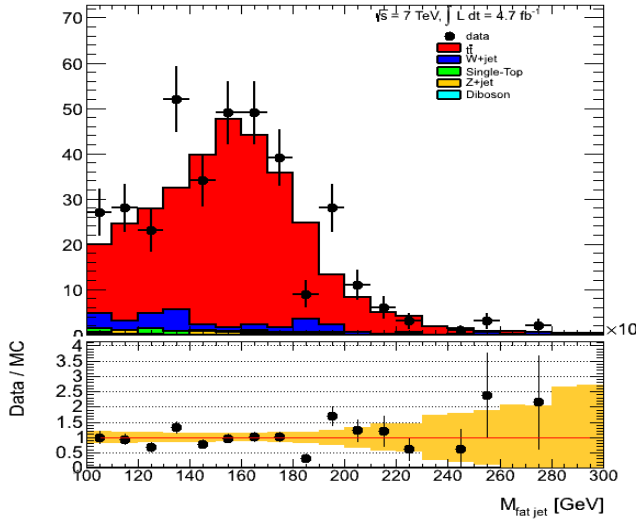
(arXiv:1203.4606)

- Jet substructure technique is used to identify the hadron decay of boosted heavy particles using k_T splitting scale (d12) and jet mass.

we really reconstructing boosted tops?
→ Jet substructure study rely upon the assumption that the internal substructure if jets generated by QCD radiation is well understood.



μ _channel

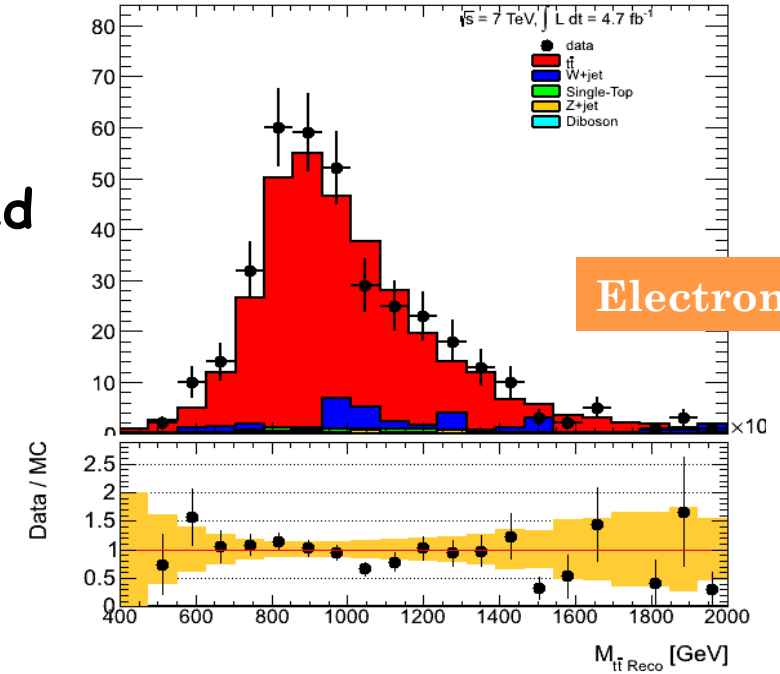


e_channel

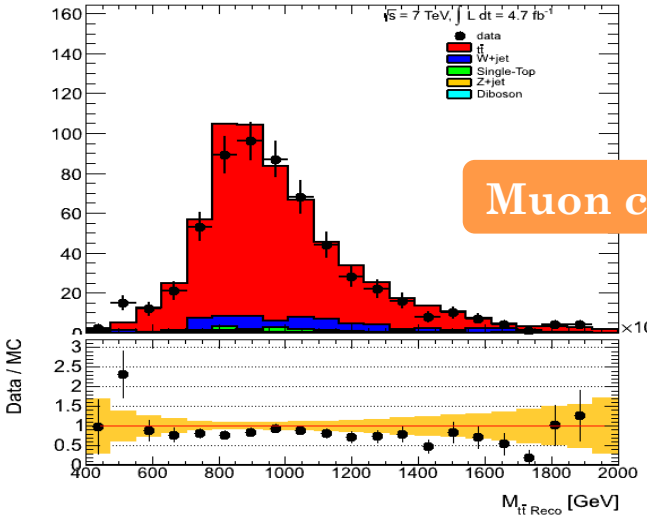
d12: re-cluster Akt 10 jet with exclusive k_T algorithm, split it into 2 jets and look at distance parameter between those jet

RECONSTRUCTION MASS SPECTRUM (preliminary)

- First look at event reconstructed
- Reconstruction strategy:
- akt4 jet closest to lepton with W boson as leptonic top
- akt10 jet far from lepton and leptonic jet as hadronic top
- Corrected MET as neutrino if quadratic equation has negative discriminant



Electron channel



Muon channel

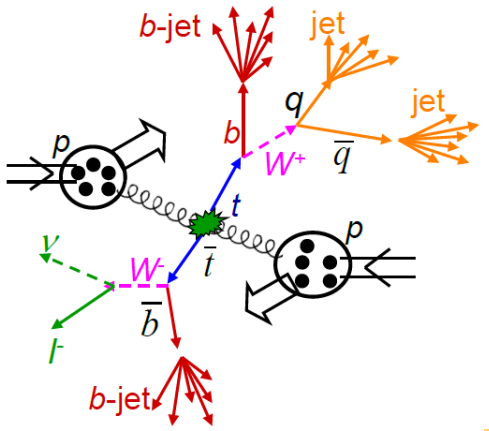
Summary

- 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 analysis aspects are on-going
- Systematic study is planed soon

BACKUP

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)