Single-top t-channel 10 TeV cross section studies at 200 pb^{-1} for ATLAS

Single top physics and fourth generation quarks

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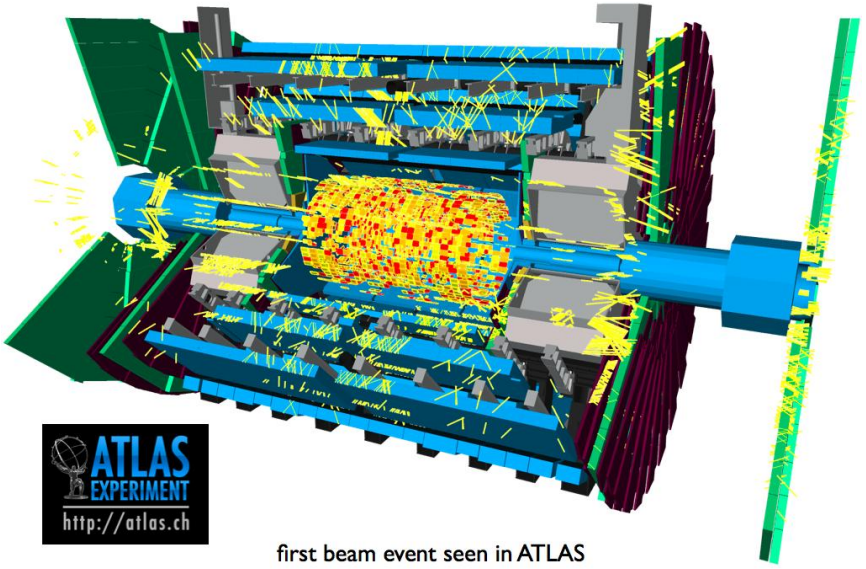
Outline

- Introduction
- MC data samples and settings
- Atlas “topmixing” exercise
- t-channel analysis details and results
- Summary



first beam event seen in ATLAS

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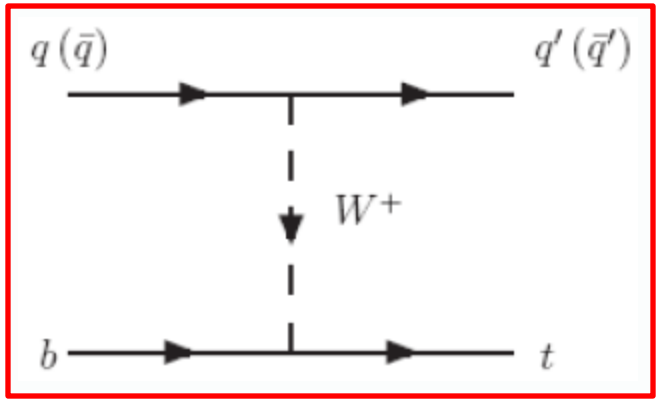
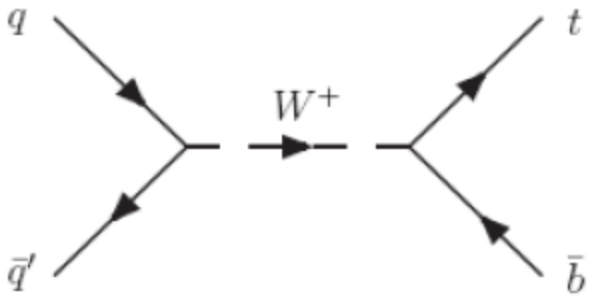
Single Top Production Channels

- Three different channels of single top production:

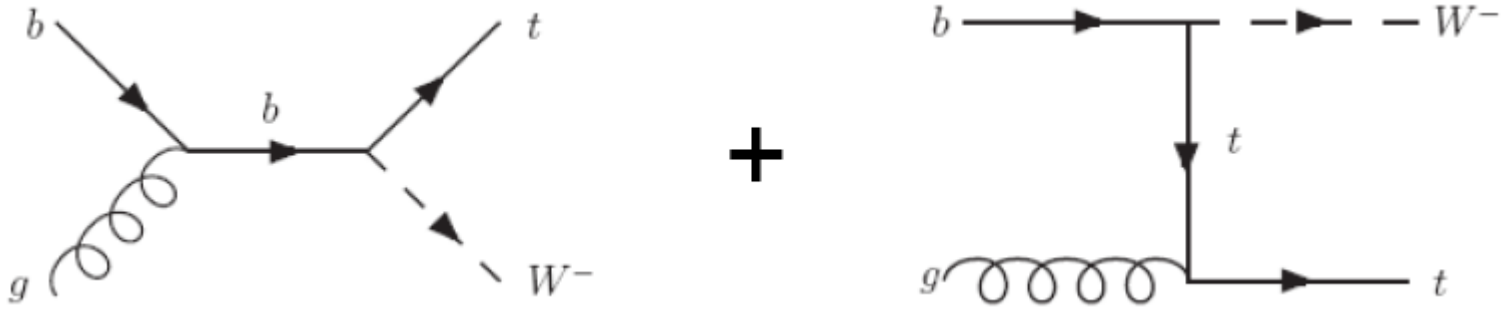
t-channel



s-channel



Wt-channel



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t-channel Cross Section at the LHC

- **t-channel** and **ttbar** cross sections used in the ATLAS top physics study at **14** and **10** TeV c.m. energies of the LHC

Process		σ, pb	References
14 TeV			
	t-channel	246	Z.Sullivan, Phys. Rev., D70, 114012
	ttbar	833	R. Bonciani et al., Nucl. Phys., B529
10 TeV			
	t-channel	125	MC@NLO
	ttbar	402	S. Moch, P. Uwer, Phys. Rev. 2008, D78, 034003

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Monte-Carlo Settings and Samples

- M_{top} = **172.5** GeV , $\sqrt{s} =$ **10** TeV

- Monte-Carlo generators and **SM** processes:
  - AcerMC + Pythia
    - **t-channel**
    - Wt-channel
    - ttbar
  - Alpgen + Herwig
    - Wbb+jets (0-3 partons)
    - W+jets (0-5 partons)
    - Z+jets (0-5 partons)
  - Herwig
    - ZZ, WZ, WW

- ATLAS detector **Geant4** Simulation

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Atlas Topmixing Exercise – Pseudo Data

- Mix the Monte-Carlo SM processes samples (listed on the previous slide)
- Scale the samples **cross sections** with **unknown factors** (scale factors) during the mixing procedure
- Produce reconstructed **„data“** as the different **event streams** using the different **trigger menus** in the selection:
  - **electron (egamma)** events stream
  - **muon** events stream
- Try to measure these unknown scale factors ➔ cross sections
- **Main assumptions:**
  - our Monte-Carlo model **correctly** describes the **shapes** of SM processes
  - but their total cross sections might be differnet from the expected ones

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Analysis Strategy Overview

- Select **exclusive** events by the presence of an **elctron (egamma)** or a **muon**
  - by applying orthogonal trigger requirements to the event streams

- Use the selected **muon** events to determine the main backgrounds cross section scale factors by **fraction fitting** method
  - Z+jets
  - W+jets together with Wbb+jets
  - ttbar toghether with Wt-channel
    - after single top preselection

- Use the **egamma** events for t-channel analysis into the **electron final state**
  - normalize the backgrounds with the calculated **scale factors**
  - apply pre- and t-channel selection cuts (next slide)
  - determine scale factor for t-channel
    - use the event counting method

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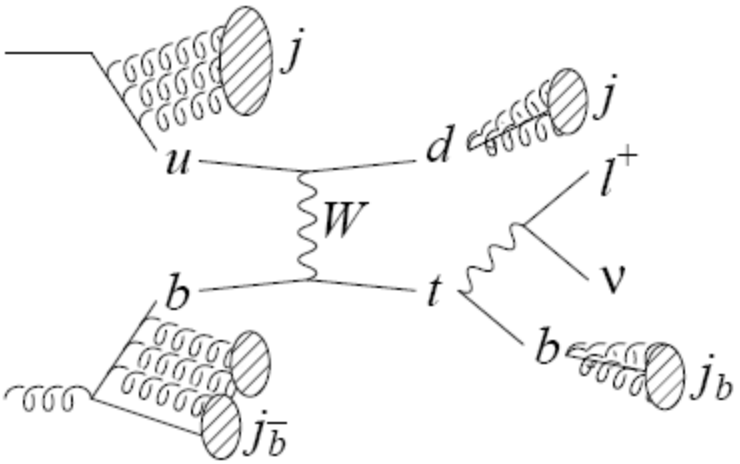
t-channel Selection Cuts

CERN-OPEN-2008-020

- **Pre-selection** cuts
  - E_T^{miss}>20 GeV
  - High p_T lepton, p_T>30 GeV
  - No second lepton with p_T>10 GeV
  - At least two high p_T jets*, p_T>30 GeV
  - less than 5 jets with p_T>15 GeV



- **t-channel** selection cuts
  - Pre-selection, electron final state
  - High p_T b-jet, p_T >50 GeV
  - leading non-b-jet in

    the forward region, |eta|>2.5

** Overlaping jets to electrons are removed, **ΔR<0.2***

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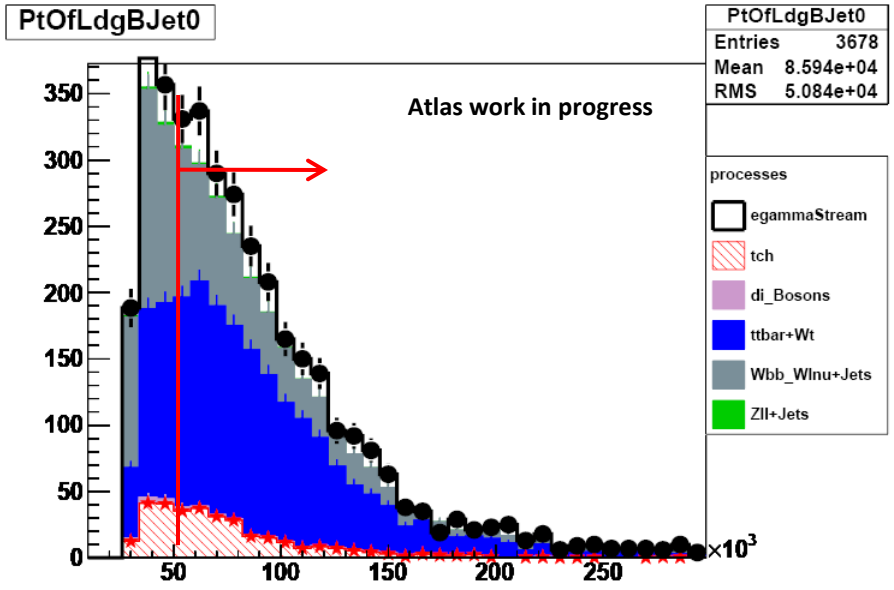
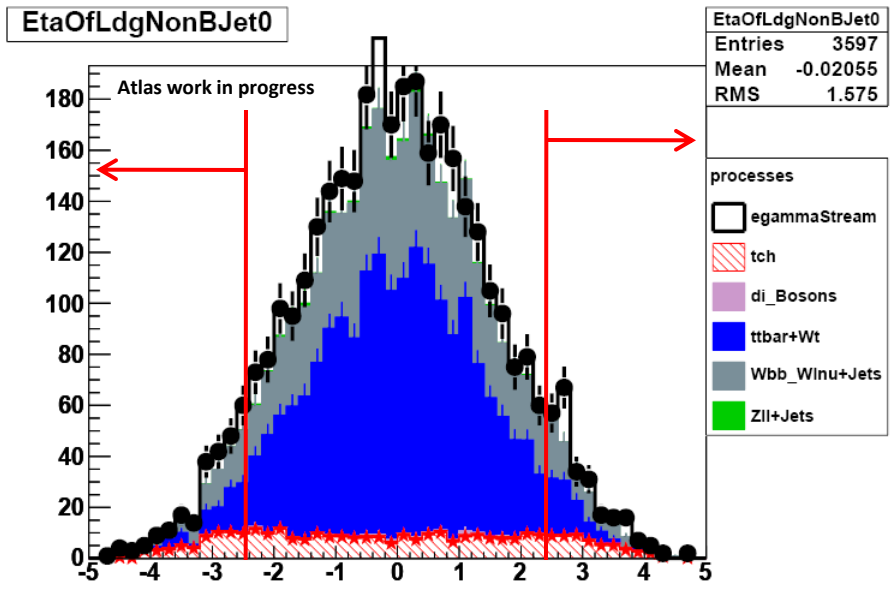
Motivation for the t-channel Selection Cuts

b-jet **Pt** and leading non b-jet **eta** distributions after the **pre-selection** cuts





- **Pt>50 GeV** b-jet cut removes large fraction of the W+jet background
- Leading non b-jet eta cut, **abs (eta)>2.5**, significantely reduces the ttbar background

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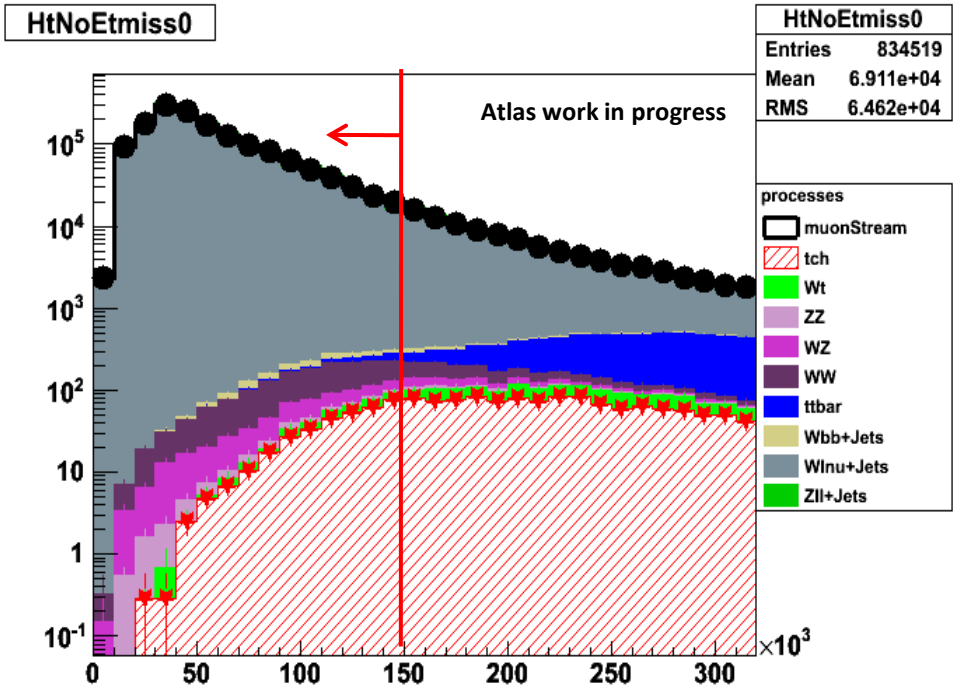
Ideas on Cut Refinement

- **Ht** – scalar sum of all selected analysis objects momenta
  - good electrons and muons
  - jets after overlap removal
  - missing transverse energy is not included
- **Ht** seems to be a good discriminator for **ttbar** background...
- The study is ongoing...



Ht – distribution after the muon trigger selection

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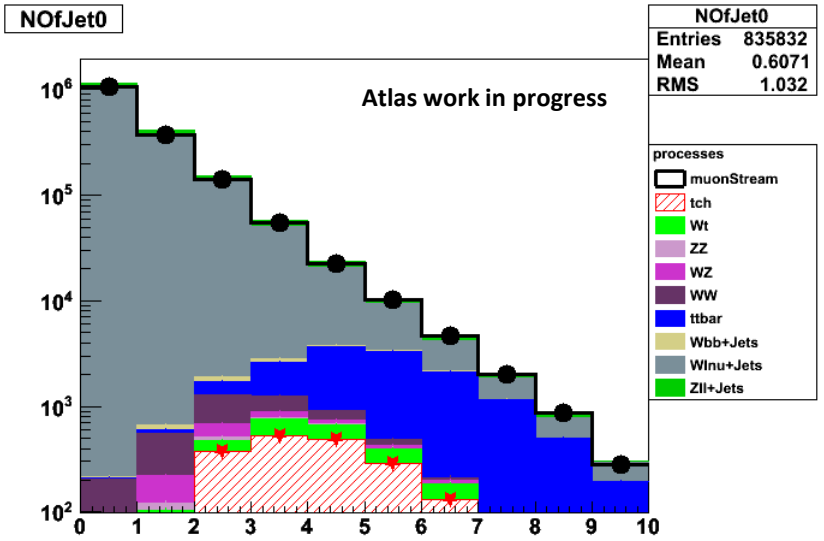
t-channel Selection, Electron Final State

- Jet multiplicity after a muon **trigger** selection



- number of events after t-channel selection:
  - „Data“: 298 ± 17
  - MC bkg: 185.2 ± 14.9
  - t-ch. („data“): **112.8 ± 22.6**
  - t-ch. expected: **76.8 ± 8.8**

- Numbers of the „data“, total MC background, **measured** and **expected** t-channel events
- Shows mismatch of the **t-channel** cross section

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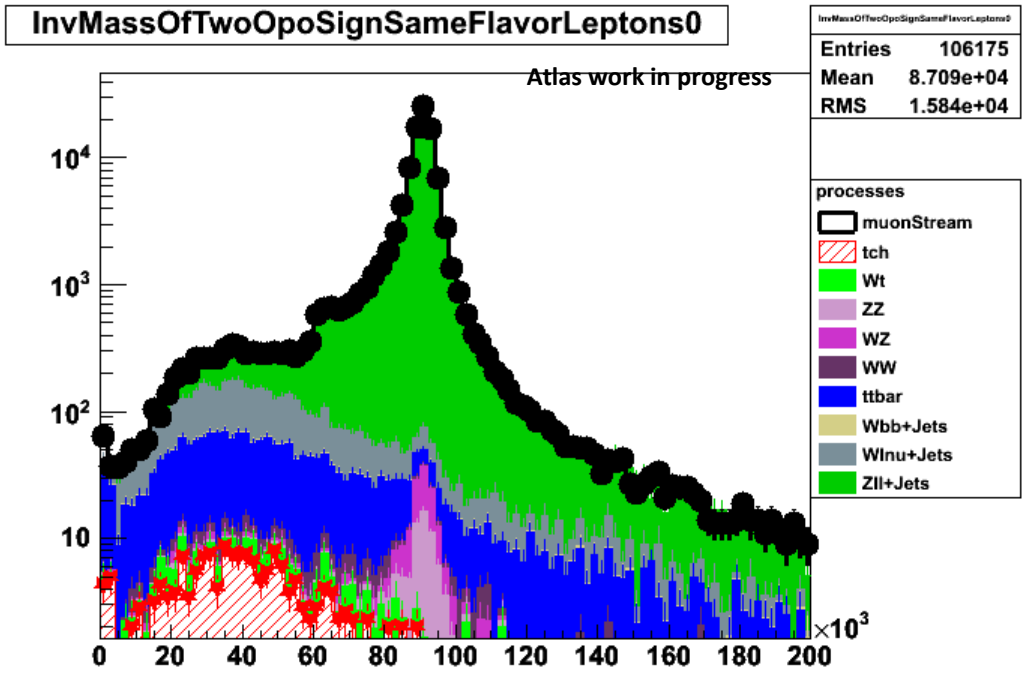
Background Scale Factors Estimation



- Muon trigger selection is applied
- Use **Z-mass window** cut to determine Zll+jets scale factor
- The window: **84 – 98** GeV
- **SF = ($N_{data} - N_{bkg}$)/ $N_{Zll+jets}$**

N of events in the data = 83190.2
N of events in the **Z** bkg = 88219.6
N of events in the rest bkg = 383.6

Z+jets scale factor = 0.939 ± 0.005 (stat.)

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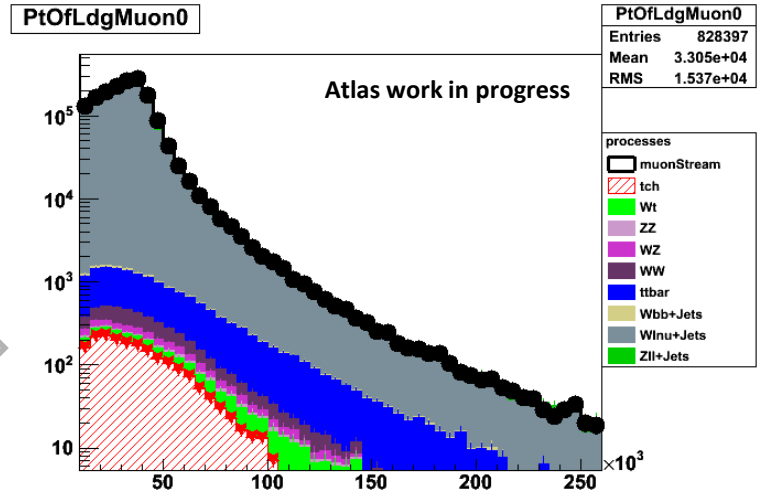
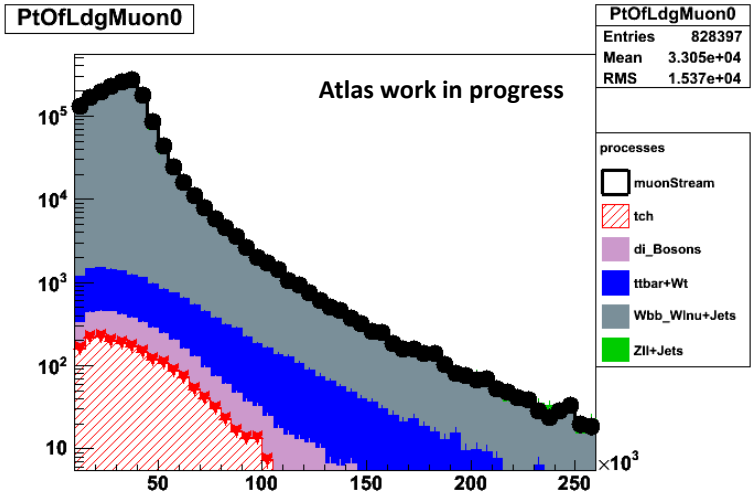
Background Sampling for Fraction Fitting

- Other background normalization is also needed
- Use the **fraction fitting** method
- Fit **1-** and **2-dimensional** distributions after **trigger** selection
- It is difficult to to get reliable results because of the large number of processes involved in a fitting procedure





- Try to combine the different processes, which have the **similar shapes**
  - ZZ + WZ + WW
  - ttbar + Wt
  - W+jets + Wbb+jets
- Reduces the number of fit free parameters
  ➔ **reliable** results from fits

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1- & 2-Dimensional χ^2 - Fraction Fits

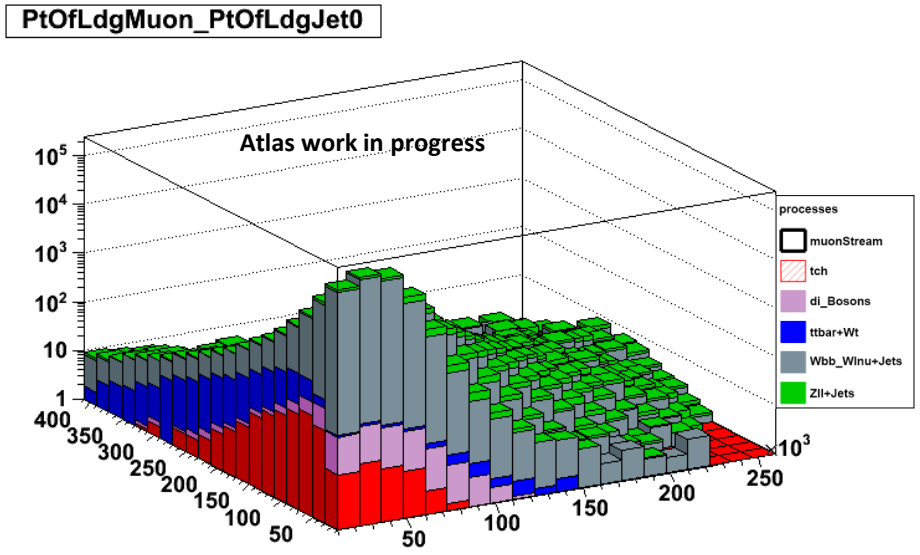
- Apply **trigger** selection to the „Data“ & MC

- Use several basic distributions for **1-** and **2-**dimensional χ^2 - fits:

PtOfLdgMuon
PtOfLdgJet
PtOfLdgNonBJet
EtaOfLdgNonBJet

PtOfLdgMuon_Etmiss
PtOfLdgMuon_PtOfLdgJet
EtaOfLdgMuon_EtaOfLdgJet
NOfJet_Etmiss
NOfJet_PtOfLdgJet
NOfJet_EtaOfLdgJet
NOfJet_PtOfLdgNonBJet
NOfJet_EtaOfLdgNonBJet
NOfJet_PtOfLdgMuon
NOfJet_EtaOfLdgMuon
PtOfLdgJet_Etmiss
PtOfLdgJet_EtaOfLdgMuon
PtOfLdgNonBJet_PtOfLdgElec
EtaOfLdgNonBJet_EtaOfLdgMuon

InvMassOfTwoOpoSignSameFlavorLeptons



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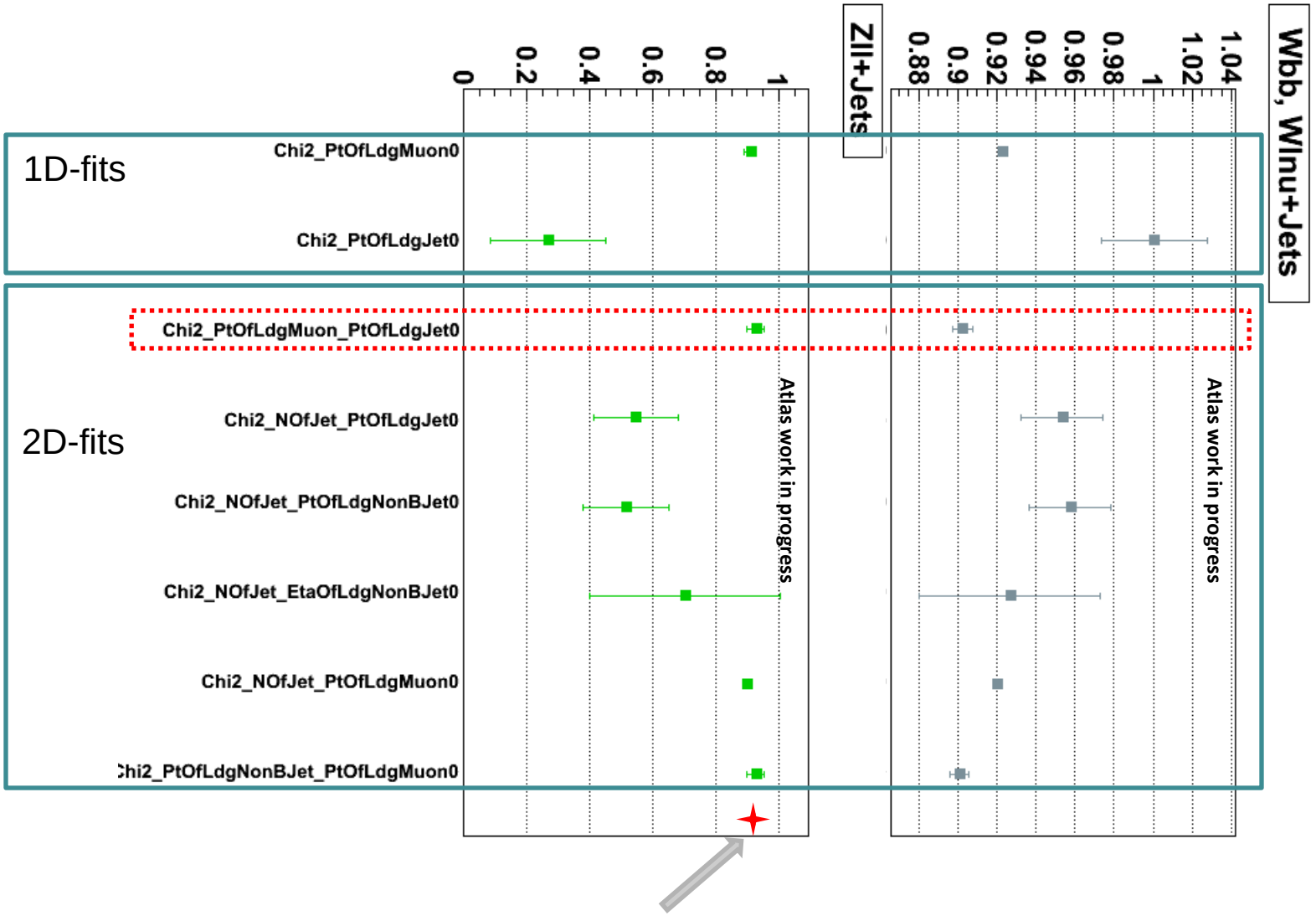
Z+jets and Wbb, W+jets Scale Factors



Obtained using the Z-mass window method

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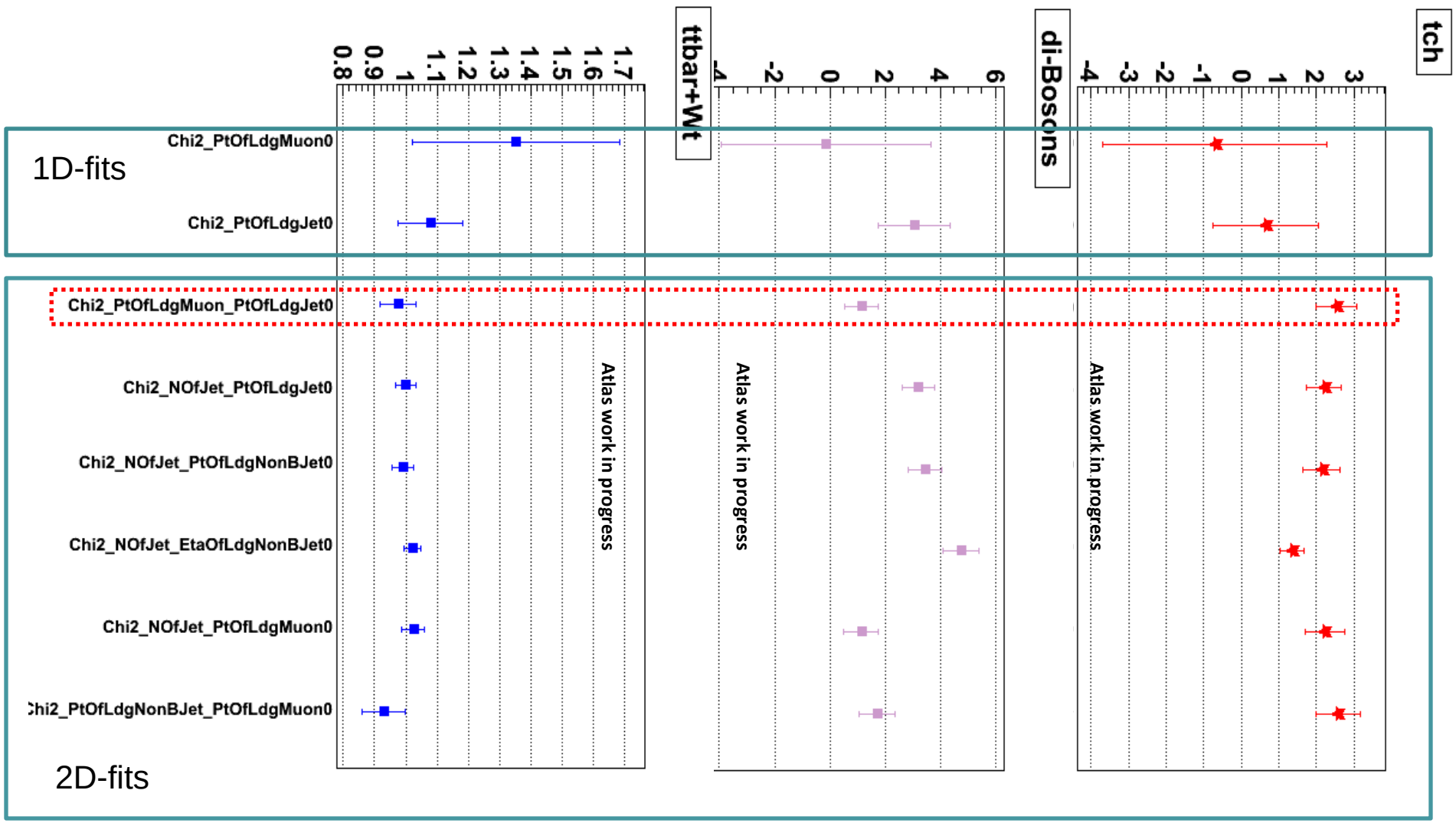
ttbar+Wt , di-Bosons and t-ch. Scale Factors



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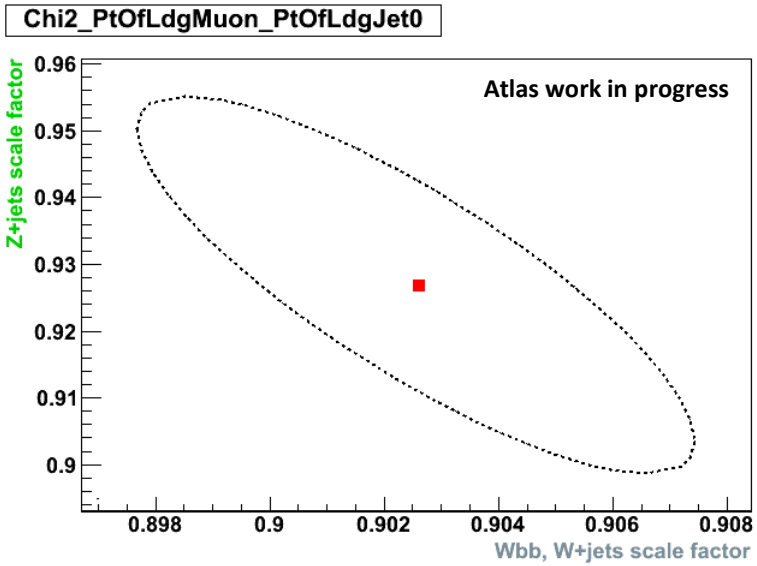
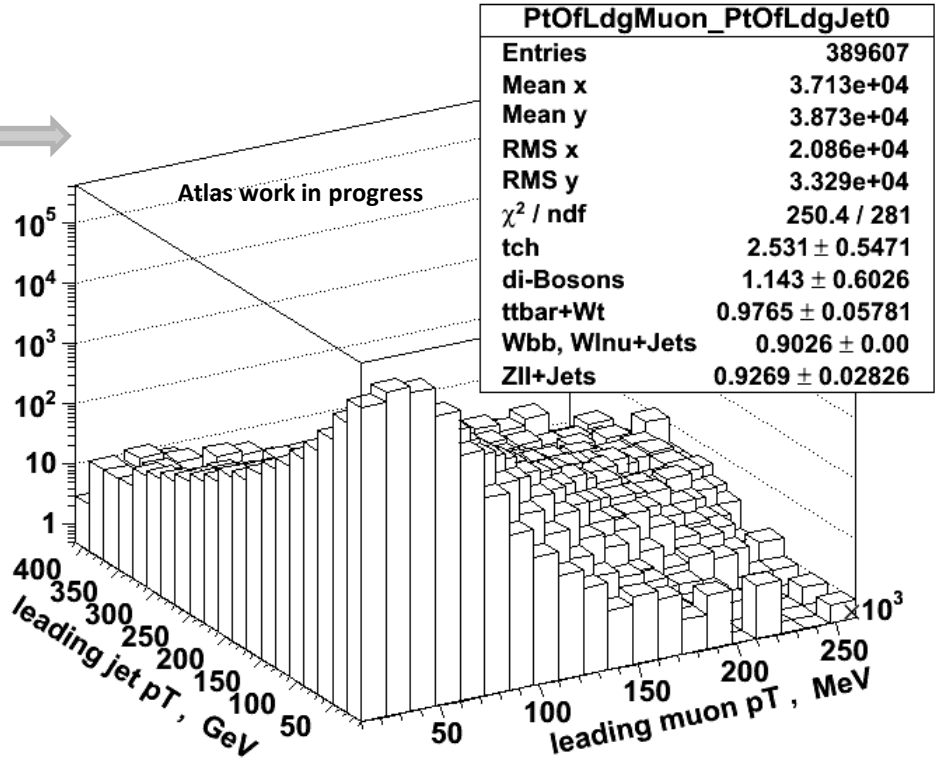
Leading Muon vs. Leading Jet Pt Distribution Fit Result for Scale Factors

- Fit **converged** and results are within expectations

- **Z+jets scale factor** is the same (within the errors) of the one obtained using Z-mass window cut





- 1-sigma **error contour** for the W+jets scale factor vs. the Z-jets scale factor shows clear anti-correlation

Wbb, W+jets scale factor = 0.903 ± 0.006 (stat.)

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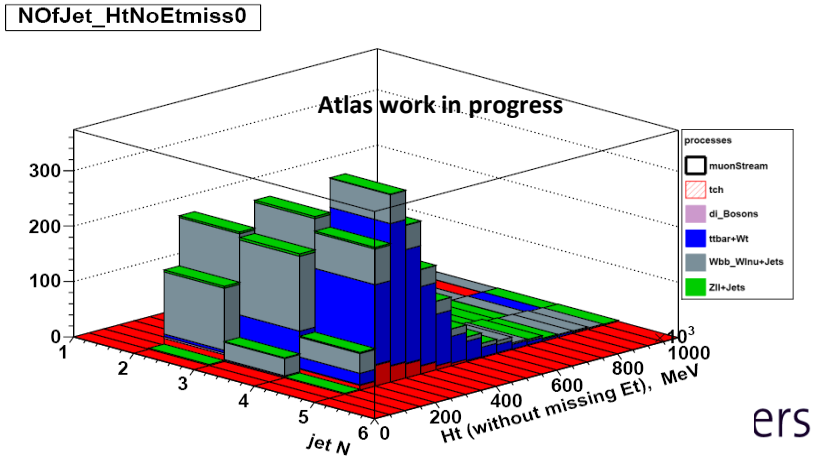
Determination of the ttbar Scale Factor

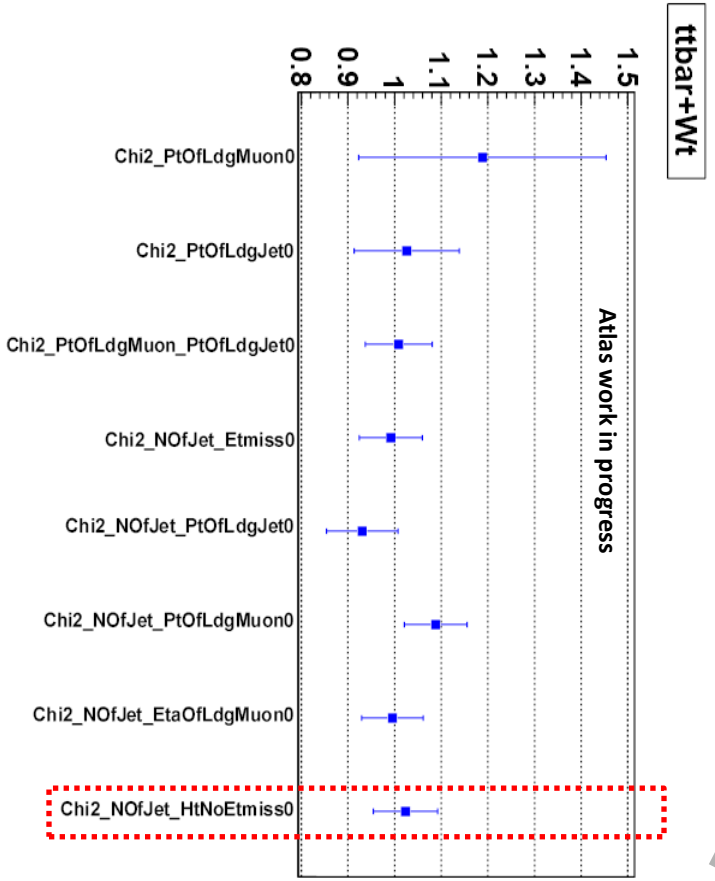
- Use 1- and 2-dimensional fraction fits to determine the ttbar cross section scale factor

- Use events after the **pre-selection**
  - **ttbar** background relative fraction in data increases
    → better fit results for the ttbar scale factor can be obtained

- After the pre-selection cuts the **event statistics** is significantely reduced
  - use 2-dimensional distributions with the relativlely smaller number of bins
    - NOfJet_PtOfLdgMuon
    - NOfJet_PtOfLdgJet
    - **NOfJet_HtNoEtmiss**
    - ...



Determination of the ttbar Scale Factor



- Fits give **consistent results** for the ttbar scale factor
- Use **NOfJet_HtNoEtmiss** distribution fit result as a best estimate for the **scale factor**

ttbar scale factor: **1.02 ± 0.07(stat.)**

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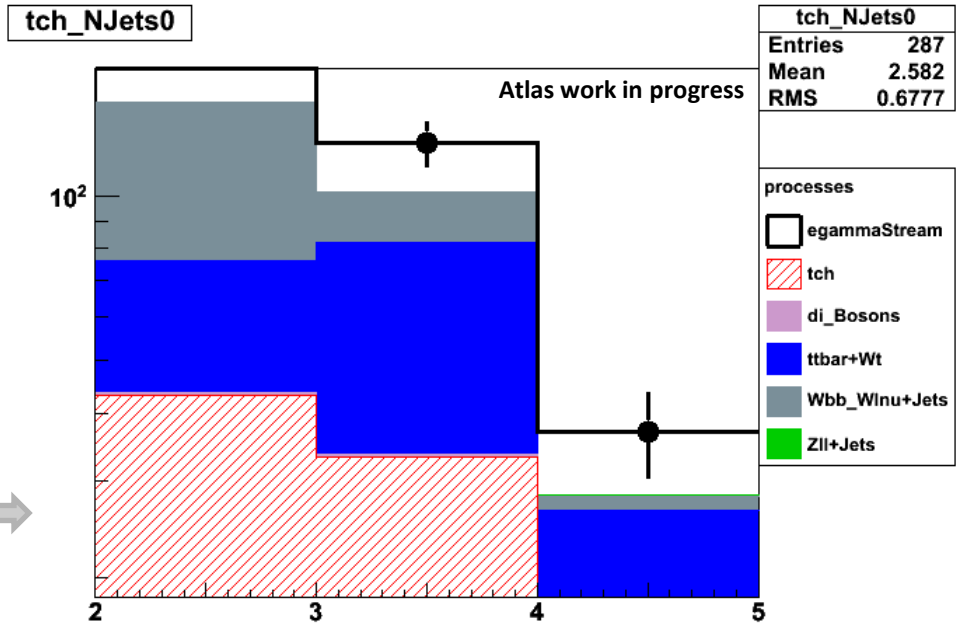
t-channel Scale Factor Measurement, 200 pb^{-1}

- **Re-scale** Z+jets, Wbb_W+jets and ttbar+Wt cross sections by the estimated scale factors
- Apply **electron trigger** and t-channel selection to **egamma events**
- The plot on the right shows **jet multiplicity** after the final t-channel selection
- W+jets (with Wbb+jets) and ttbar (with Wt-channel) still remain as the main backgrounds



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t-channel Scale Factor Measurement, 200 pb^{-1}

- Numbers of „data“, t-channel signal and other background events remaining after the electron **trigger** and **t-channel selection cuts**

	data	t-ch.	ttbar+Wt	Wbb,W+jets	Z+jets	di-Bosons
Trigger selection	1.94242e+06	2413.24	15496.9	1.66852e+06	222049	2828.3
t-channel selection	341.2	83.94	99.5	93.2	1.1	1.2
			Total MC Bkg.: 195.0			

- Determine t-channel scale factor as

$$(N_{data} - N_{bkg}^{MC}) / N_{t\text{-}ch.}^{MC}$$

t-channel scale factor: **1.74 ± 0.34 (stat.)**

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Summary

- Single top t-channel cross-section determination analysis into the electron final state has been done

- The analysis have been performed using the 10 TeV MC and pseudo data at the 200 pb^{-1} integrated luminosity of the LHC run

- Unknown scale factors for cross sections of the main background and t-channel signal have been determined using Z-mass window and multi-dimensional fraction fitting methods

Cross Section Scale factors:	
Zll+Jets	**0.939 ± 0.005 (stat.)**
Wbb, Wlnu+Jets	**0.903 ± 0.006(stat.)**
ttbar+Wt	**1.02 ± 0.07 (stat.)**
t-channel	**1.74 ± 0.34 (stat.)**

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