Lepton Trigger efficiency evaluation for the first measurement of the top-quark pair production cross-section at ATLAS

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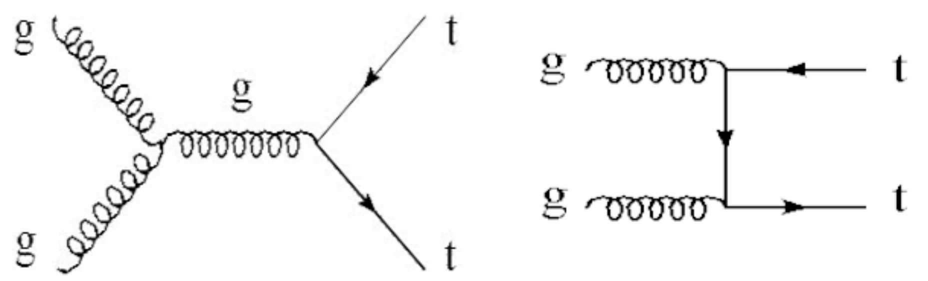
Outline

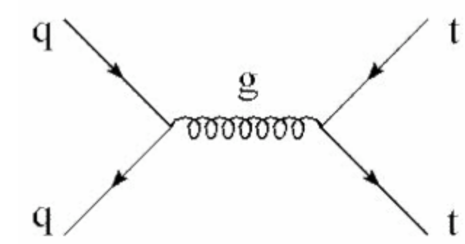
- Intro
- Determination of top-quark pair production cross section
  - signal acceptance
  - trigger efficiency evaluation
  - scale factors
- Conclusions and Outlook

Standard Model Predictions

Production @ LHC

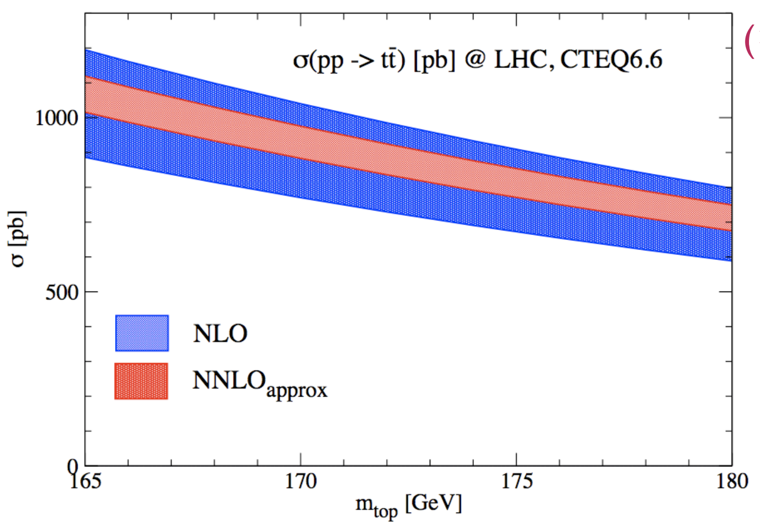


gluon-gluon fusion 90%



quark-antiquark annihilation 10%

Cross-Section



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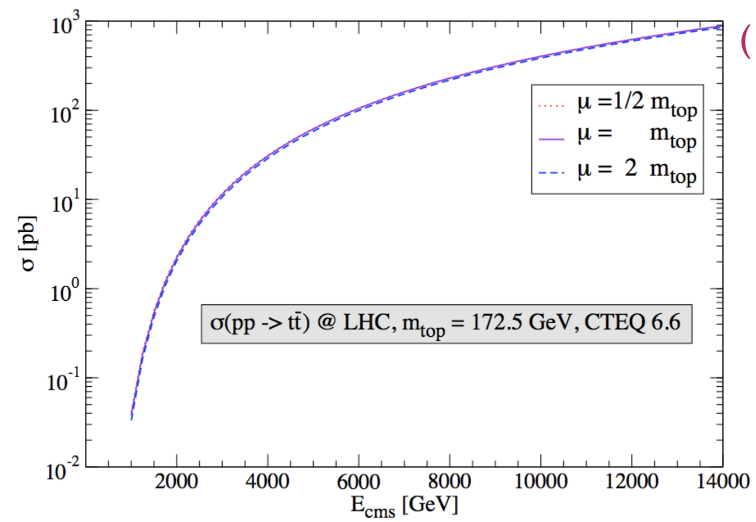


(*)

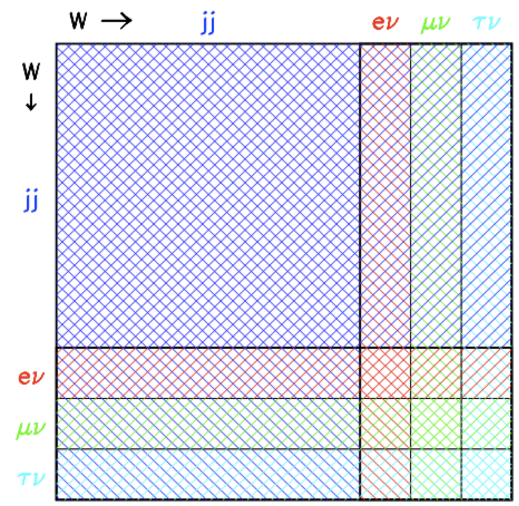
- σ_{tt} ($\sqrt{s}$ = 14 TeV) ≈ 886 pb
- σ_{tt} ($\sqrt{s}$ = 10 TeV) ≈ 403 pb
- σ_{tt} ($\sqrt{s}$ = 7 TeV) ≈161 pb

This translates into ~1600 top pairs in 10 pb^{-1} for $\sqrt{s}$ = 7 TeV.

(*) arXiv:0907.2527

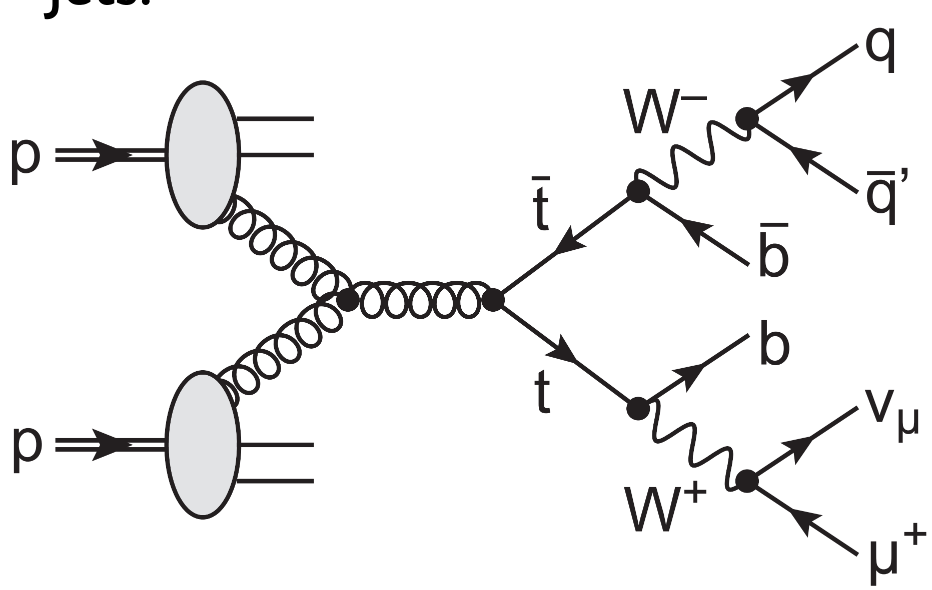
Top-Quark Phenomenology

The top-quark decays rapidly without forming hadrons, and almost exclusively through the single mode $t \rightarrow Wb$



Name	Signature	BR	xsec at 10 TeV
Fully Hadronic	jets	45.7%	191.5 pb
Lepton + Jets	e + jets	17.2%	71.9 pb
	μ + jets	17.2%	71.9 pb
Dilepton	$e\mu$ + jets	3.18%	13.3 pb
	$\mu\mu$ + jets	1.59%	6.67 pb
	ee + jets	1.59%	6.67 pb
Tau + Jets	τ + jets	9.49%	39.8 pb
Lepton + Tau	$\tau + e/\mu$ + jets	3.54%	14.8 pb
Tau + Tau	$\tau + \tau$ + jets	0.49%	2.06 pb
total	all	100%	419 pb

Lepton + Jets:



Signature:

- one lepton
- missing energy from the neutrino
- two jets from a W boson
- two jets from the b quarks

Determination of the Cross Section

Counting method: Accuracy in 100 pb^{-1}: $\Delta\sigma/\sigma$ = (3(stat) ± 16(syst) ± 3(pdf) ± 5(lumi))%

arxiv hep-ex 0901.0512

number of observed events meeting the selection criteria of top-event signature

$$\sigma = \frac{N_{sig}}{L \times \epsilon} = \frac{N_{obs} - N_{bkg}}{L \times \epsilon}$$

number of background events estimated from Monte Carlo simulation and/or data samples

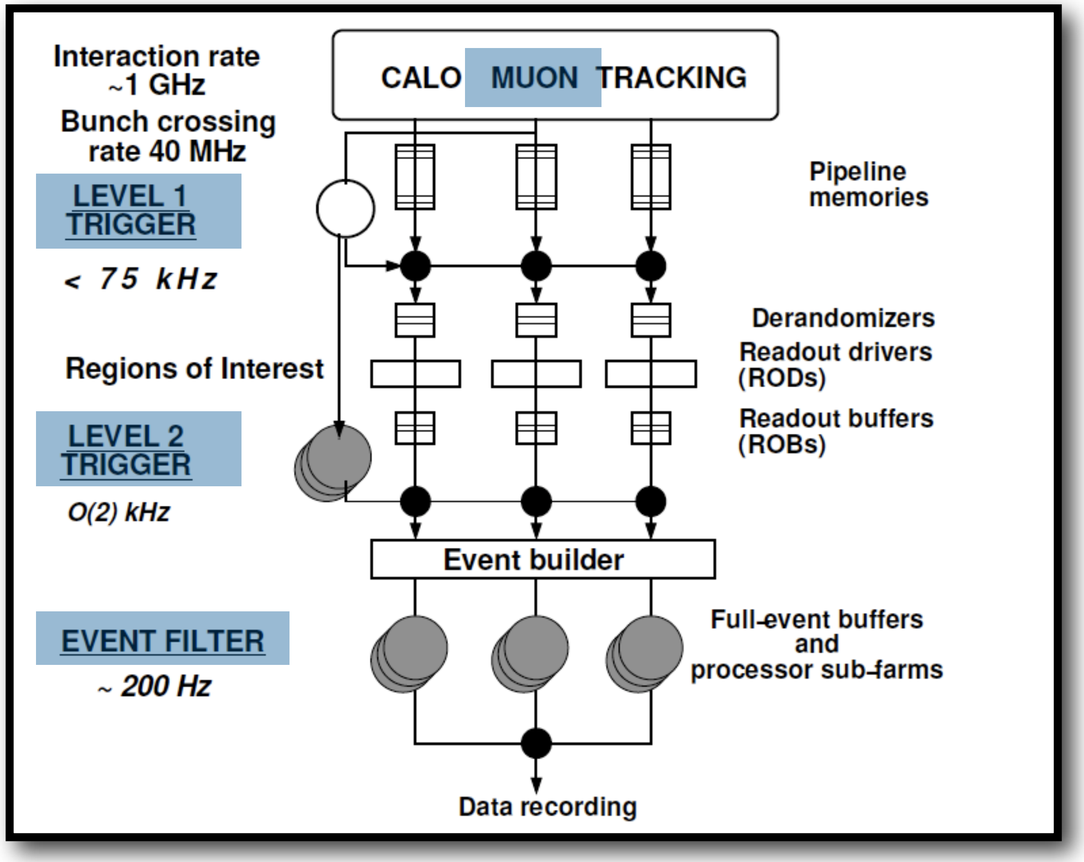
signal acceptance

The signal acceptance depends on:

- the geometry of the ATLAS detector
- object reconstruction (e.g. lepton reconstruction) efficiency
- analysis identification efficiency (e.g. top analysis specific selections)
- the ATLAS trigger efficiency

ATLAS Trigger System

- Only events that fire a trigger will make it to storage
- The primary triggers for $t\bar{t}$ leptonic decays are the leptonic triggers

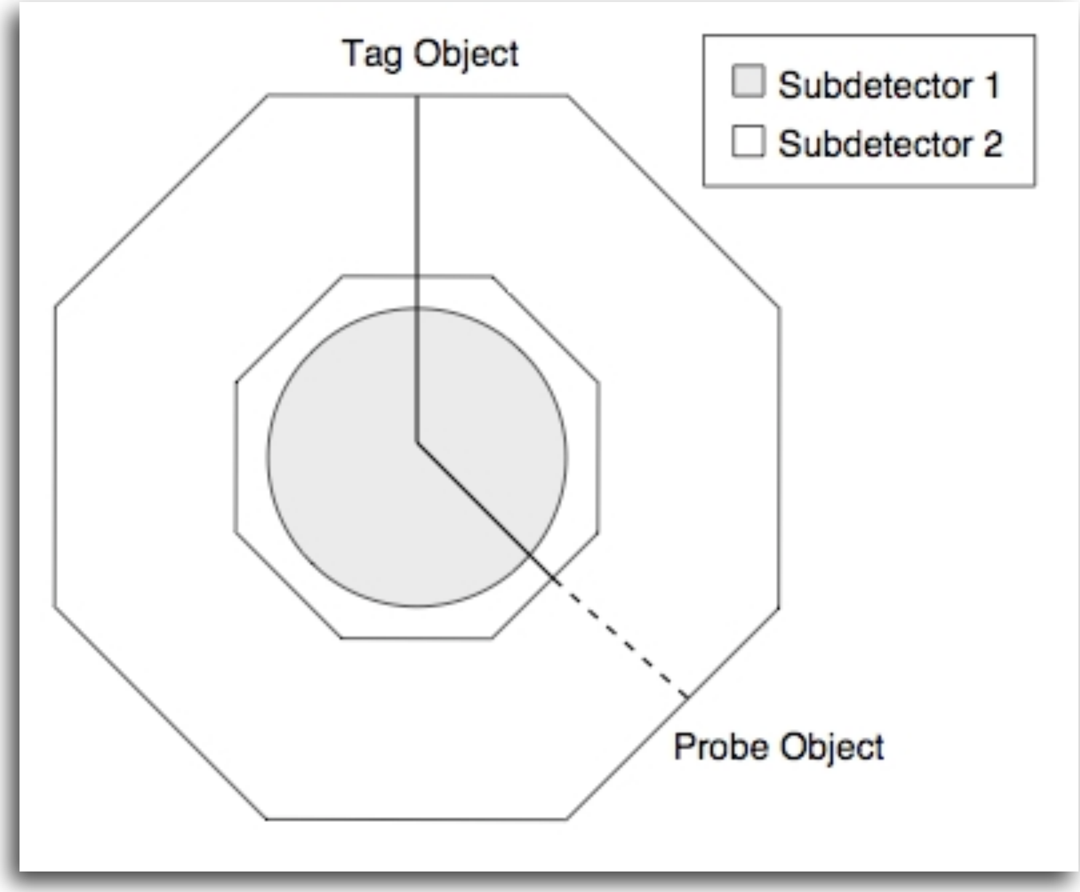


The Muon Trigger is designed to select events with high P_T muons.

- **L1** defines Regions of Interests (RoI), with a rough estimate of the candidate P_T and position
- **L2** runs on full granularity of the data within the RoI: improves P_T resolution and performs fast track combination between Muon Spectrometer and Inner Detector
- **EF** has access to full event with full granularity. Using offline muon reconstruction algorithms , it confirms or discards L2 candidates.

The Tag&Probe method

Method to evaluate lepton trigger efficiencies from real data, using $Z \rightarrow \ell\ell$.



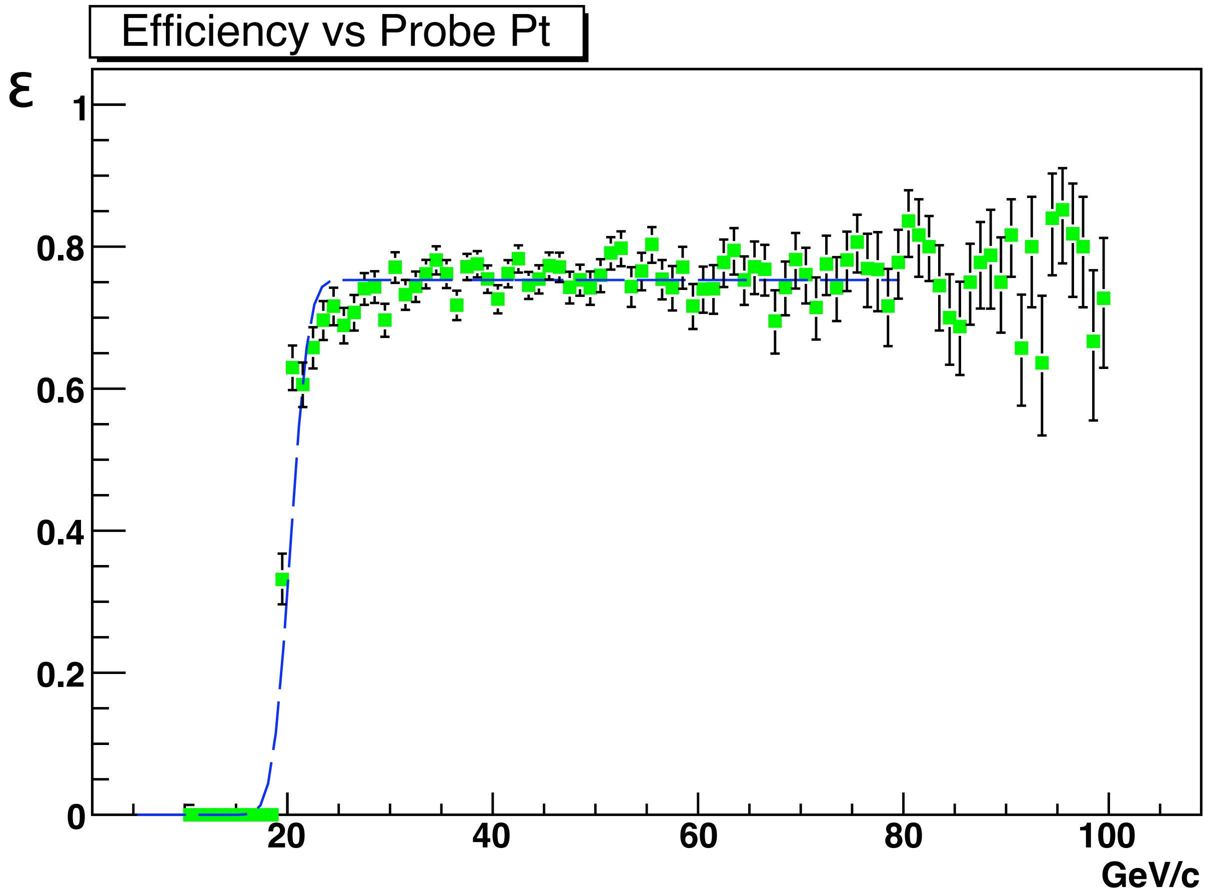
The 2 daughter leptons from the decay of a Z boson produced at the LHC have a large transverse momentum.

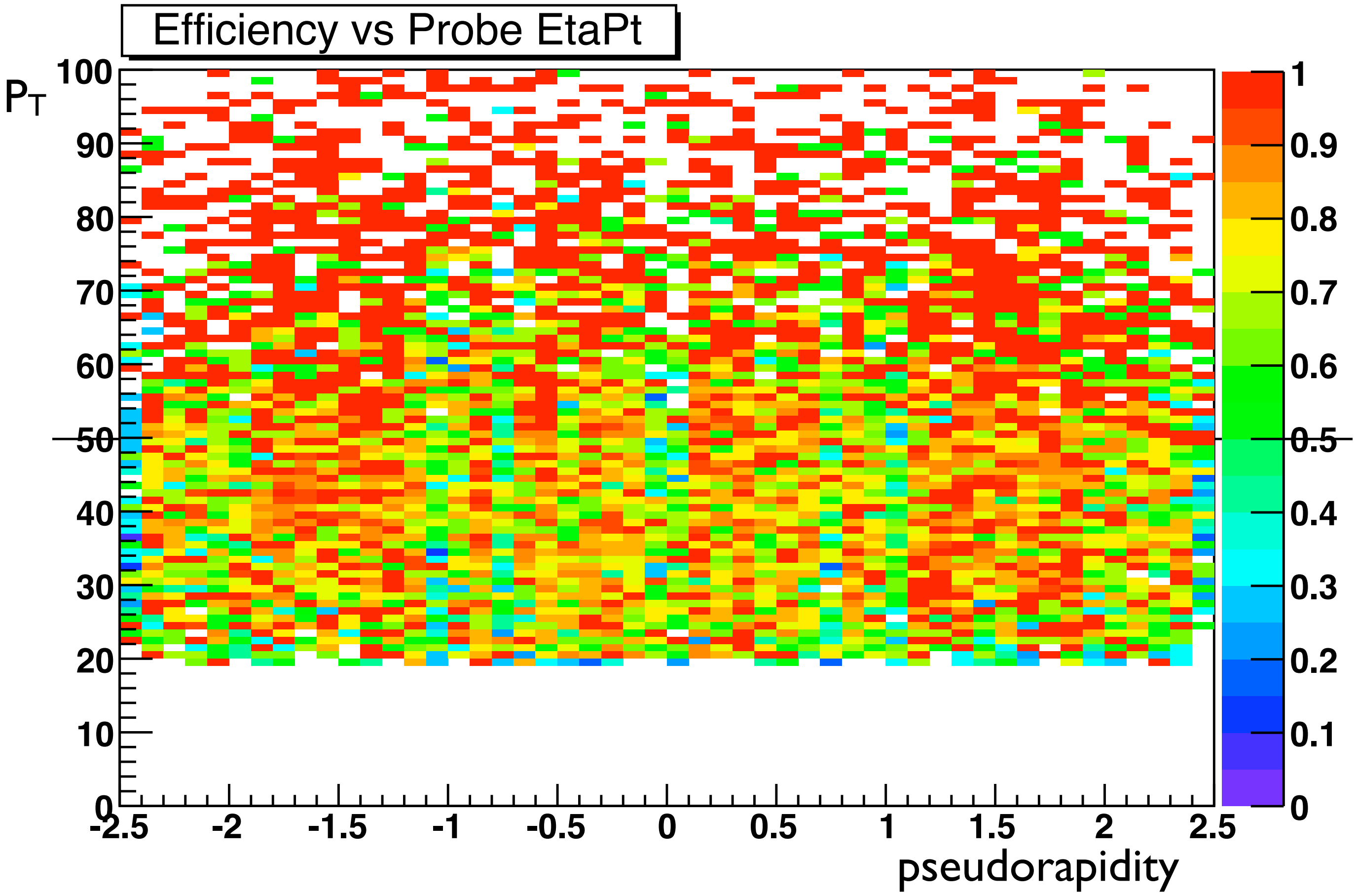
When only one of the two daughter leptons fires a trigger with a defined P_T threshold, we say the trigger has been inefficient in detecting the other one.

$$\varepsilon_{tot} = \frac{N_{(Tag\&Probe)}}{N_{(Tag)}}$$

MC Muon Trigger efficiency

In general, the muon trigger efficiency depends on a number of kinematic and isolation variables.

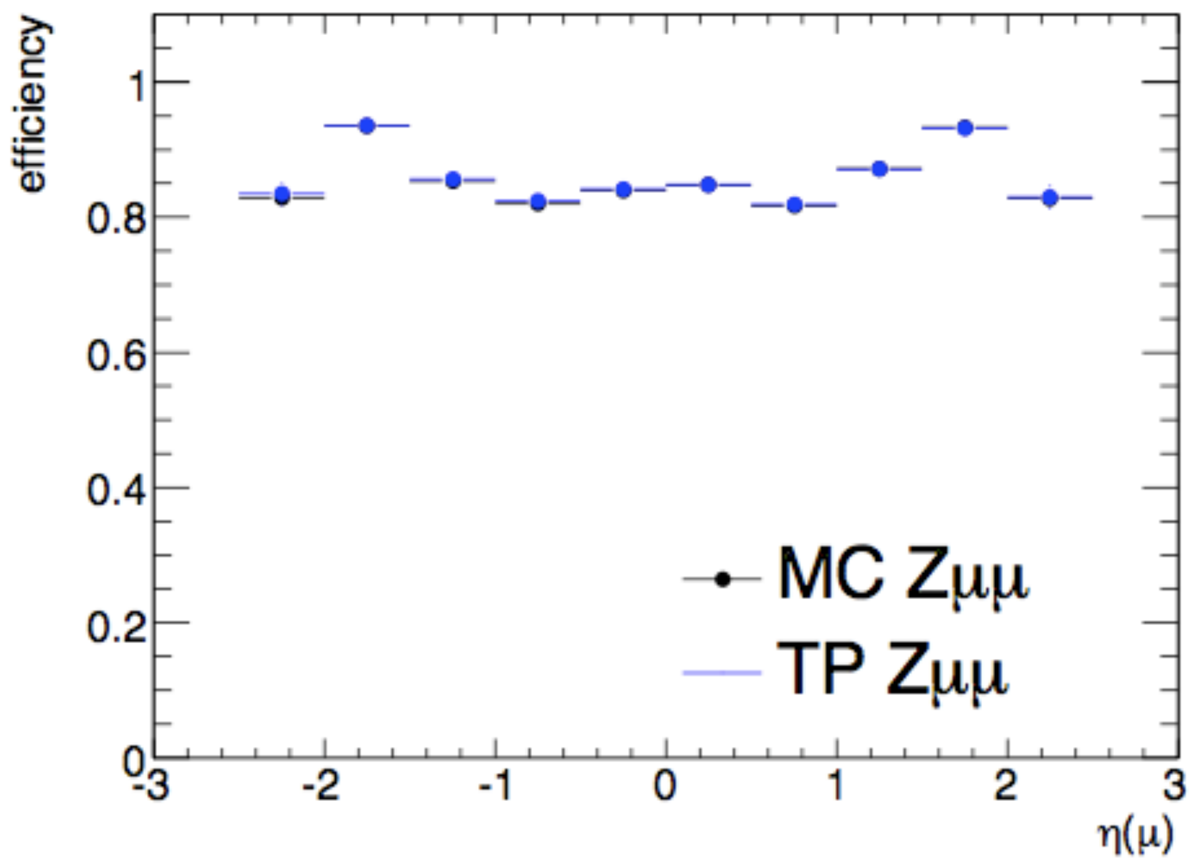


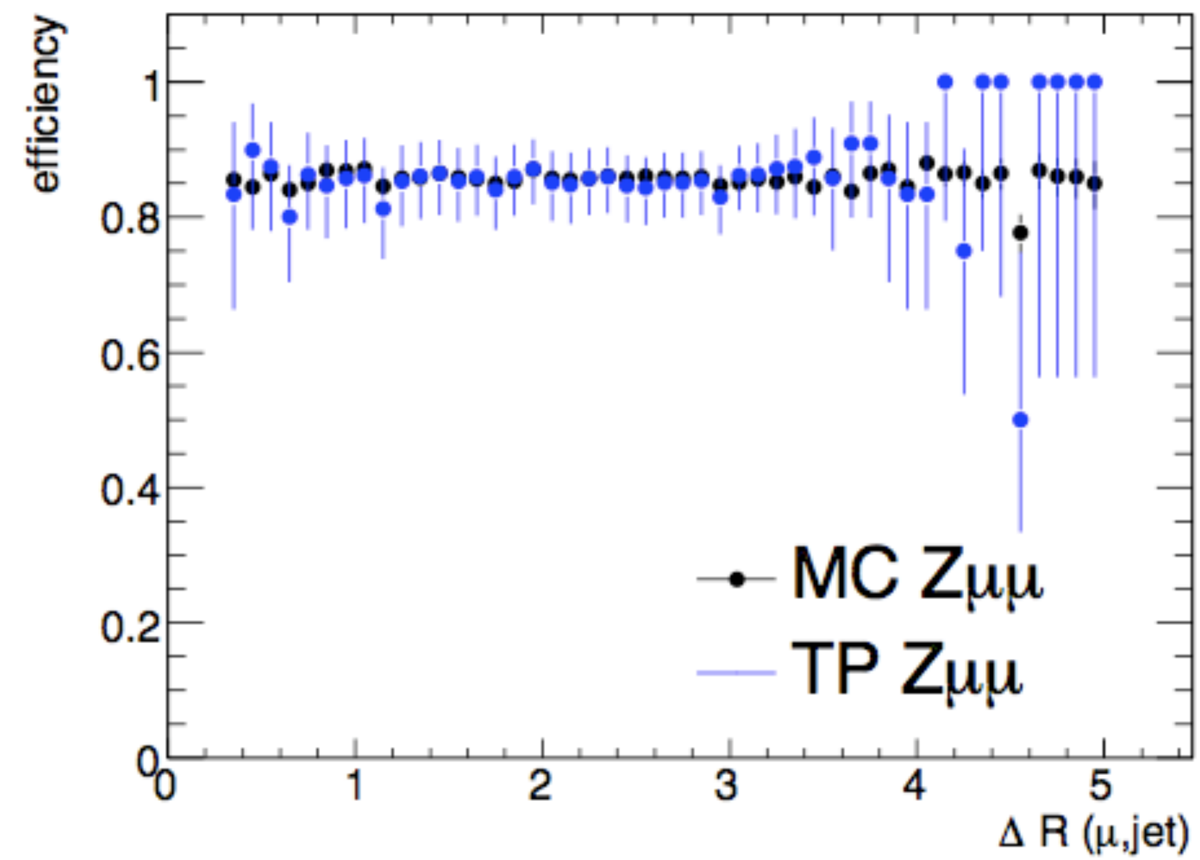


ATLAS work in progress

MC Muon Trigger efficiency

Comparison between the muon trigger efficiency measured with the Tag&Probe method and that from MC truth: the integrated trigger efficiency is found to be 85.77% from MC truth and 85.74% from Tag&Probe.





ATLAS work in progress

Scale Factors

The signal acceptance for the first measurement of the top-quark production cross-section will be estimated from MC $t\bar{t}$ samples:

$$\sigma_{t\bar{t}} = \frac{N_{sig}}{L \times \alpha'}$$

α' needs to be corrected for imperfect detector modeling and object reconstruction in the MC.

A set of scale factors (SF) are defined to express the difference in the efficiency between data and MC at the trigger, reconstruction and identification stage:

$$SF_{trigger,reco,Id} = \frac{\varepsilon_{trigger,reco,Id}(Z,\ data)}{\varepsilon_{trigger,reco,Id}(Z,\ MC)}$$

Scale Factors

Assuming that:

$$SF_{trigger,reco,Id} = \frac{\epsilon_{trigger,reco,Id}(Z, data)}{\epsilon_{trigger,reco,Id}(Z, MC)} = \frac{\epsilon_{trigger,reco,Id}(t\bar{t}, data)}{\epsilon_{trigger,reco,Id}(t\bar{t}, MC)}$$

and that the SFs do not depend on any kinematic or isolation variable (i.e. that the data/MC ratio is flat within errors), the Lepton+Jets $t\bar{t}$ cross-section becomes:

$$\sigma_{t\bar{t}} = \frac{N_{sig}}{\mathscr{L} \times \alpha \times SF_{trigger} \times SF_{reco} \times SF_{Id}}$$

So far, we have only been able to evaluate:

$\epsilon_{trigger,reco,Id}(Z, MC) = \epsilon_{trigger,reco,Id}(T\&P(Z), MC)$ in L = 10 pb^{-1}

Summary and Outlook

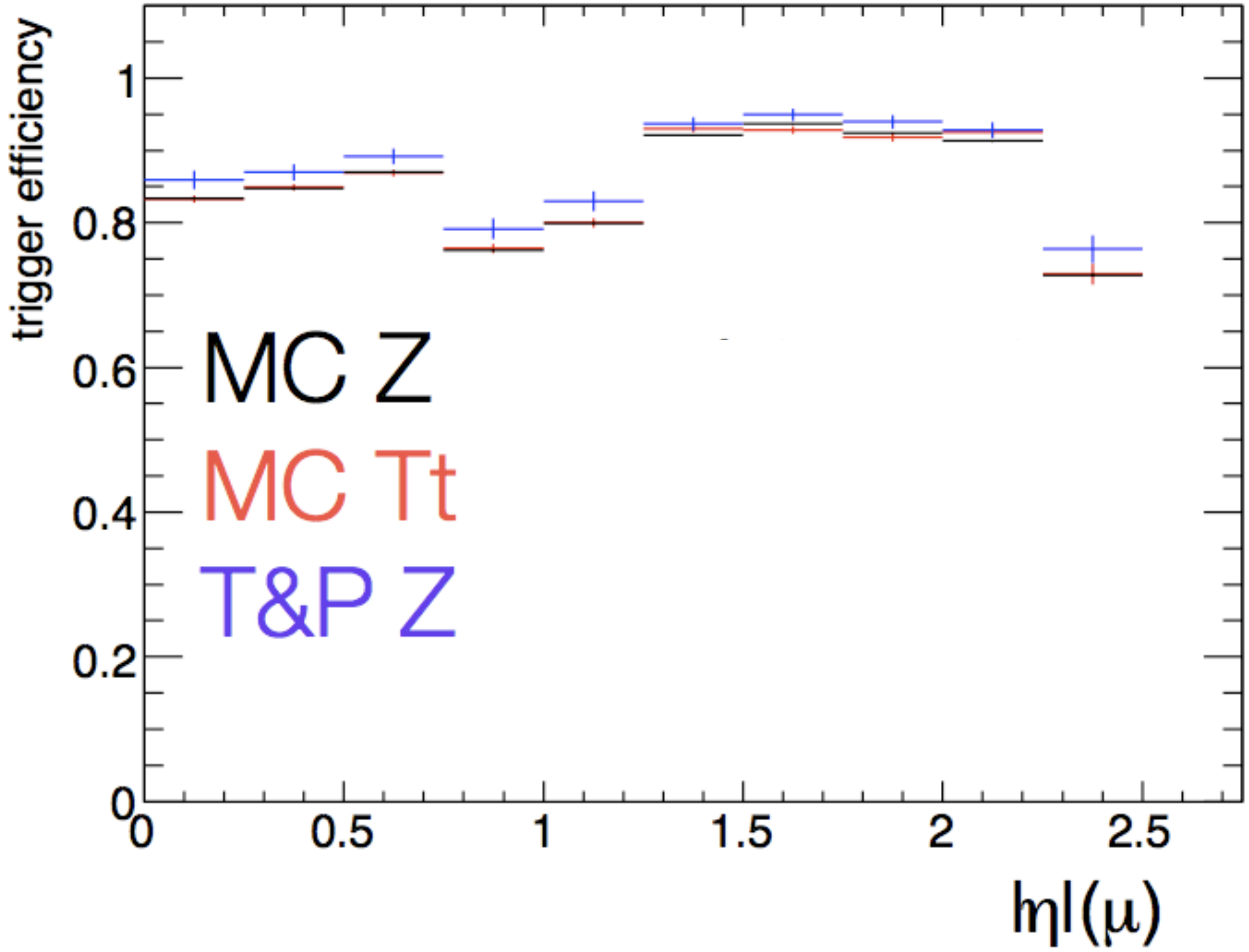
The top-quark pair production cross section will be one of the first measurements at ATLAS, requiring $O(10\text{-}100\ \mathrm{pb}^{-1})$ for first results.

The signal acceptance in the leptonic channels comprises lepton reconstruction, event identification and the leptonic trigger efficiency.

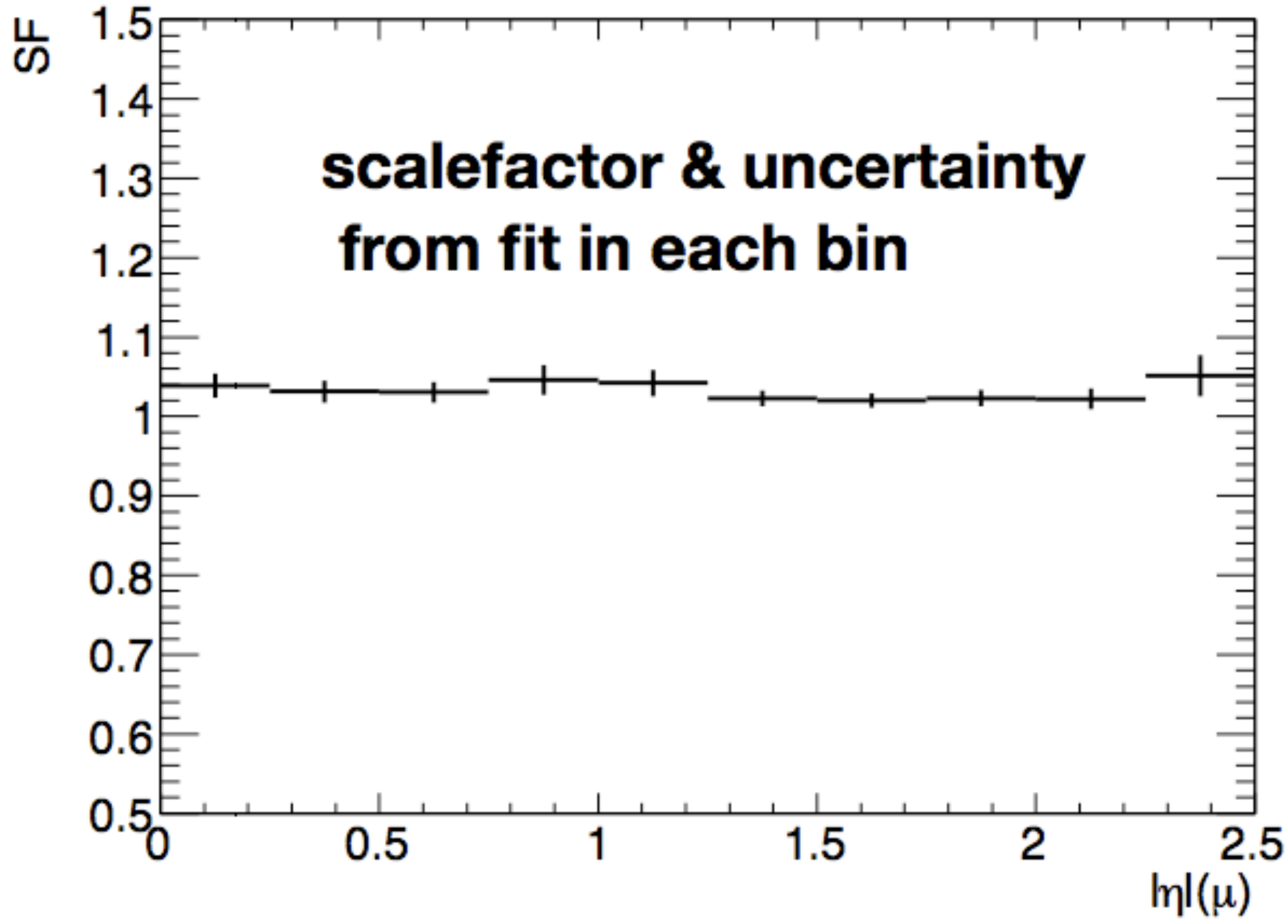
For the first cross-section measurement, the signal acceptance will be estimated from $t\bar{t}$ MC and corrected with SFs. Only the MC-based part of the SFs has been evaluated.

We are waiting for the first 10 pb^{-1} of data to evaluate $\epsilon_{trigger,reco,Id}(Z, data)$.

back up



back up



SF
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0
0.5
1
1.5
2
2.5
|η|(μ)
scalefactor & uncertainty
from fit in each bin