A measurement of the ratio of the W+1 jet to Z+1 jet cross sections with ATLAS

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Outline

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- R_{jets} Measurement With ATLAS
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- Event Selection
- Ratio Measurement Procedure
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Introduction of R_{jets}

I. What is R_{jets}

$$R_{jets} = \frac{\sigma_{W+1-jet}}{\sigma_{Z+1-jet}}$$

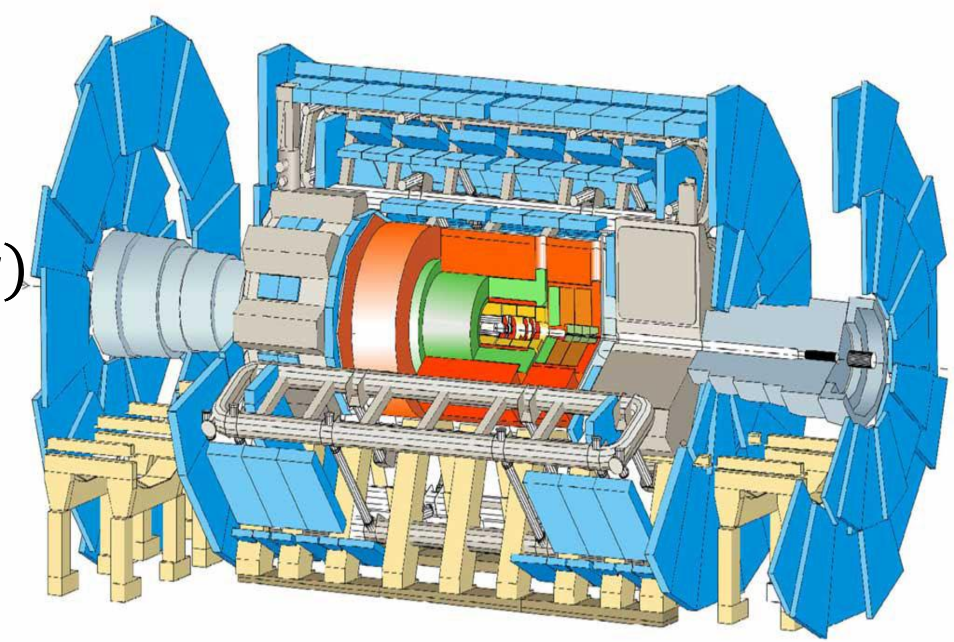
II. Why R_{jets} interesting

- ✓ By measuring R_{jets} many systematic uncertainties present in the V+jets analyses cancel or are significantly reduced, small errors allow precise comparison with theoretical predictions

- ✓ Measurment of R_{jets} in various kinematics and topological regimes, such as jet p_T is also sensitive to new physics

R_{jets} Measurement With ATLAS

Inclusive ratio



Tevatron <Phy.Rev.Lett.94(2005)091803>

$$R = 10.92 \pm 0.15(stat) \pm 0.14(sys)$$

ATLAS <1010.1007/JHEP12(2010)060>

$$R = 11.7 \pm 0.9(stat) \pm 0.4(sys)$$

We do exclusive ratio R_{jets} with ATLAS

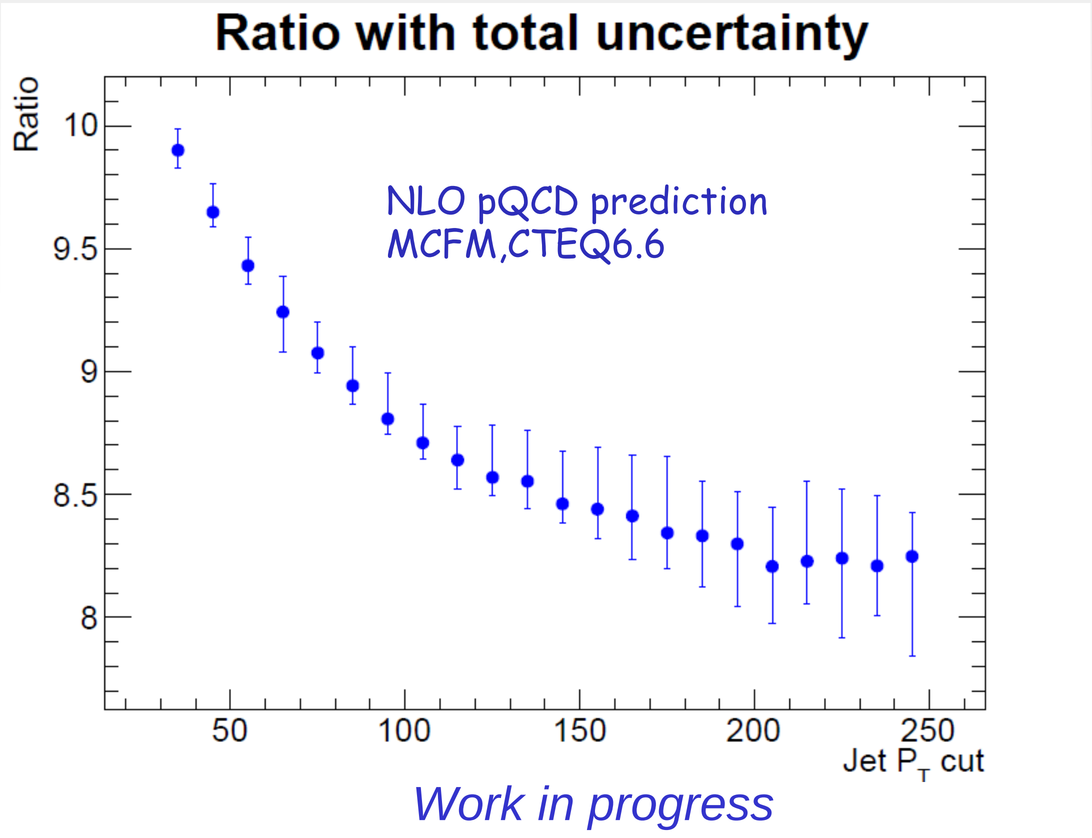
- The ratio of W and Z production cross section with subsequent decay to leptons(e/μ)
- For V+jets events with exaclty one jet
- The ratio R_{jets} presented as function of the cumulative transverse momentum p_T of jet

This is the first time such a measurement performed direclty!

Data Samples and Standard Model Predictions

- With 33.33pb^{-1} of data in the electron and muon channels collected with the ATLAS detector at the LHC in 2010

- Compared to NLO pQCD calculations and the prediction from LO ME+PS generators



Event Selection

	$W \to e\upsilon + j$	$Z \to ee + j$	$W \to \mu\upsilon + j$	$Z \to \mu\mu + j$
Acceptance	$N_e = 1$ $M_T > 40GeV$ $E_T{}^{miss}$>25GeV	$N_e = 2$ 71<m_{ee}<111GeV Opposite Charge	$N_\mu = 1$ $M_T > 40GeV$ $E_T{}^{miss}$>25GeV	$N_\mu = 2$ 71<$m_{\mu\mu}$<111GeV Opposite charge
Jet	|η|<2.8 $p_T > 30GeV$ $N_{jet} \geq 1$			

Ratio Measurement Procedure

The correction formula for correcting the selected events for each gague boson type(V=W, Z) to the number of events at hadron level.

$$\sigma_V(p_T) = \frac{N_V(p_T)}{L} = \frac{N_{data} \cdot (1 - f_{QCD}) \cdot (1 - f_{ewk})}{A \times \epsilon \cdot L}$$

- ✓ f_{QCD}: fraction of QCD background in all data
- ✓ f_{ewk}: fraction of electroweak background remaining after the QCD correction
- ✓ $A \times \epsilon$: lepton and jet acceptance times efficiency
- ✓ L: Integrated luminosity

The R_{jets} can be expressed by the ratio :

$$R_{jets}(p_T) = \frac{\sigma_W(p_T)}{\sigma_Z(p_T)} = \frac{N_W(p_T)}{N_Z(p_T)} = \frac{N_{data,W}}{N_{data,Z}} \cdot \frac{A_Z}{A_W} \cdot \frac{\epsilon_Z}{\epsilon_W} \cdot \frac{1 - f_{QCD}}{1 - f_{QCD}} \cdot \frac{1 - f_{ewk}}{1 - f_{ewk}}$$

All systematic uncertainties are determined as relative errors on R_{jets} itself.

QCD background of W(Muon)

$N_{loose} = N_{nonqcd} + N_{qcd}$

$N_{iso} = \epsilon_{nonqcd} * N_{nonqcd} + \epsilon_{qcd} * N_{qcd}$

ϵ_{nonqcd} is average muon isolation efficiency for all non-QCD processes

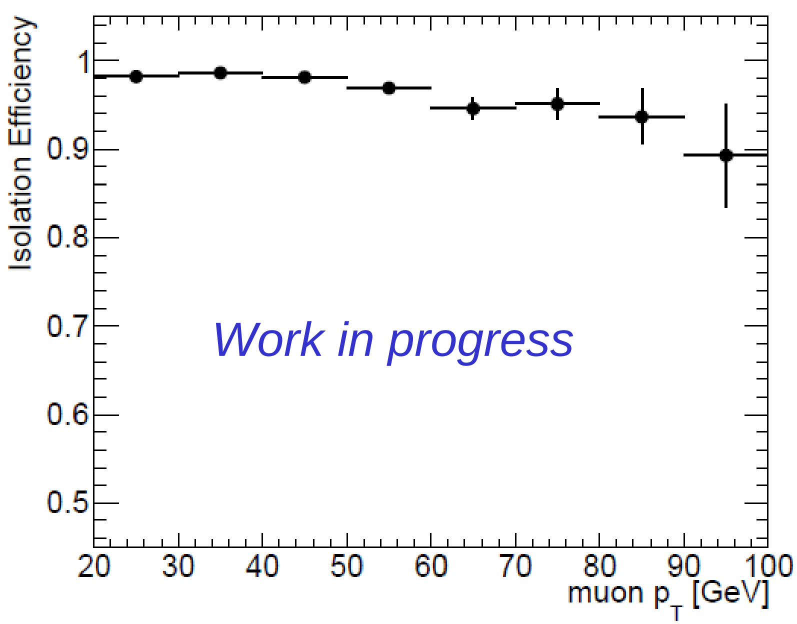
ϵ_{qcd} is muon isolation efficiency for QCD process

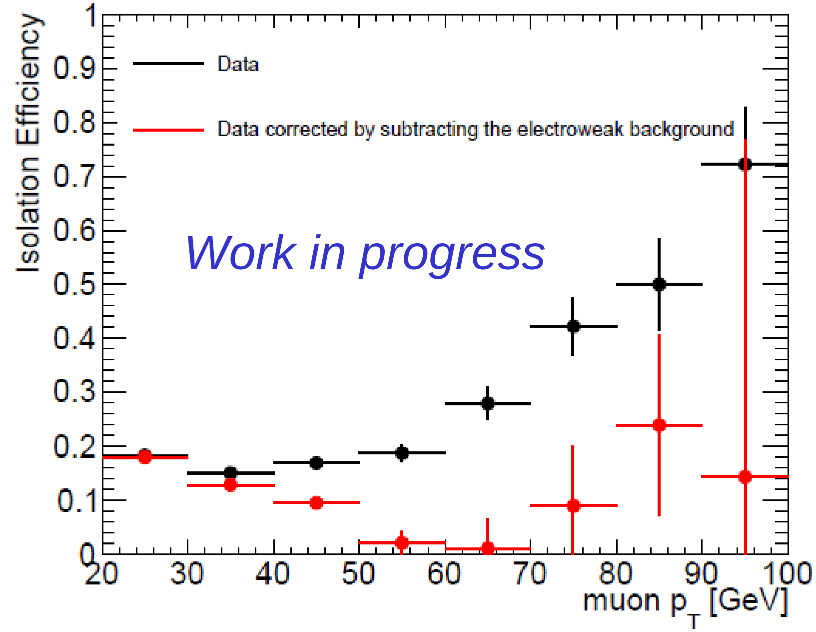
N_{loose} is the number of events from data applied all cuts but isolation

N_{iso} is the number of events from data applied full selection cuts

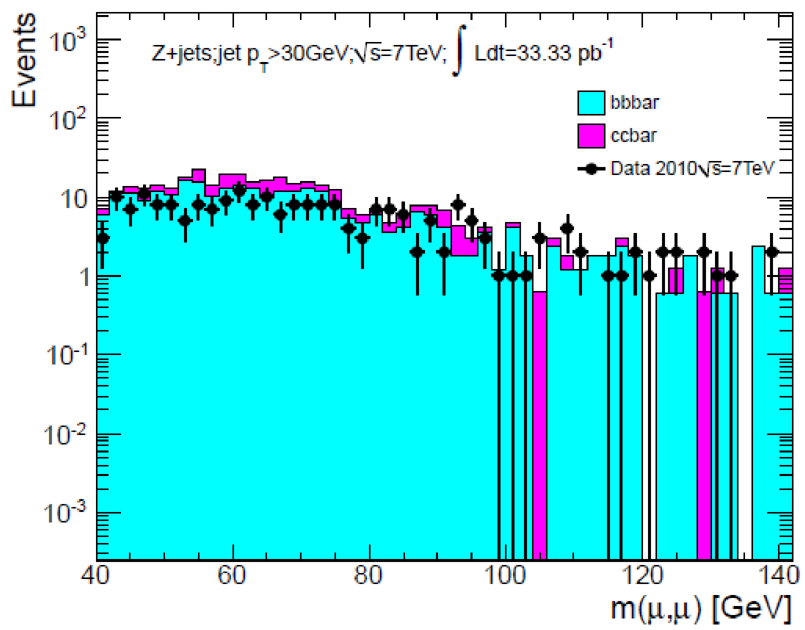
Estimated using $Z \rightarrow \mu\mu$ data

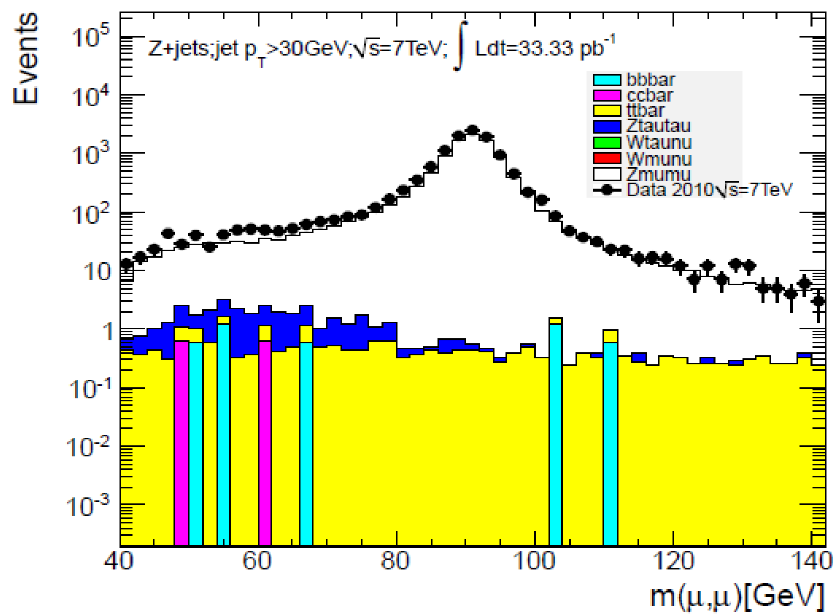
Estimated using QCD data





QCD background of Z(Muon)





Invariant mass distributions for non-isolated muon pairs(left)

Work in progress

Invariant mass distributions for isolated muon pairs(right)

Work in progress

1.The shape of QCD background is obtained from MC

2.The normalization is determined with non-isolated di-muon events in data

Electroweak background(Muon)

The electroweak background is estimated using MC.

The systematic uncertainties are conservatively estimated from these sources:

1. p_T resolution and polar-angular resolution

replace the reconstructed muon by generated muon

2. E_T^miss^ correction

vary the E_T^{miss} correction in muon channel·

3. Model uncertainty

compare different generators

Systematic	$\Delta f_{ewk,W}$ [%]	$\Delta f_{ewk,Z}$ [%]	ΔR_{jets}[%]
p_T and η Resolution	0.01	3.38	0.02
E_T^{miss} correction	1.13	0	0.07
Different generators	4.28	32.5	0.10

Small systematics because of the ratio measurement!

A$\times$ ϵ (Muon)

It is difficult to separate the detector acceptance (A) and detector efficiency(ε) in muon channel, due to large extrapolation distances and inhomogenous efficiency, we study the muon acceptance times efficiency(A×ε) as function of jet p_T threshold using MC.

The main systematics comes from :

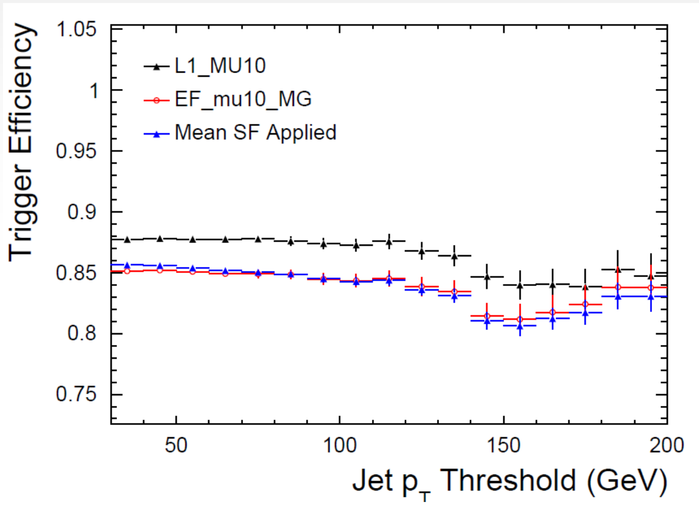
- PDF and Strong Coupling uncertainty
  Total uncertainty within 2.5% seen for jet p_T threshold below 100GeV
- Signal Model uncertainty
  Between Alpgen and Pythia ,less than 3% uncertainty for most of the kinematic range
- Uncertainty due to Pile-Up
  Smaller than 1% for both W(Z) acceptance resulted by Pile-up
- Muon momentum scale uncertainty
  Changing muon momentum up to $\pm$2%,less than 2% variation observed
- Muon momentum resolution uncertainty
  Smearing the muon momentum, less than 2% variation is observed

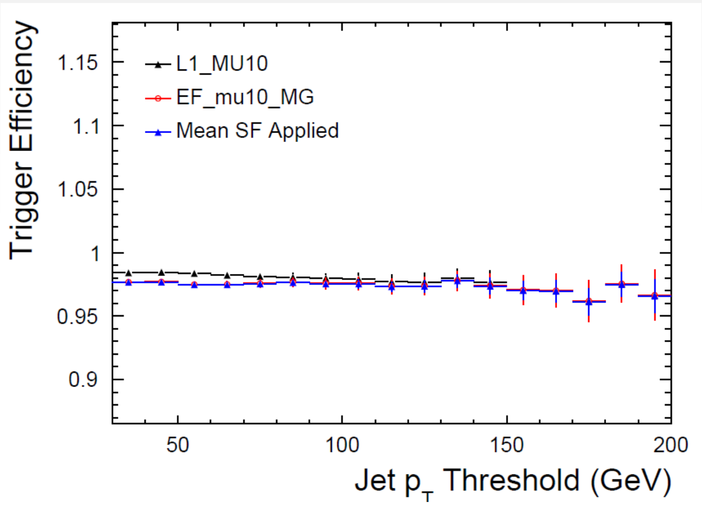
(plots shown in backup)

Trigger Efficiency(Muon)

- For earlier data using uncorrelated jet trigger events to estimate muon trigger efficiency
- For later data, using tag-and-probe method on the $Z \rightarrow \mu\mu$ events

W

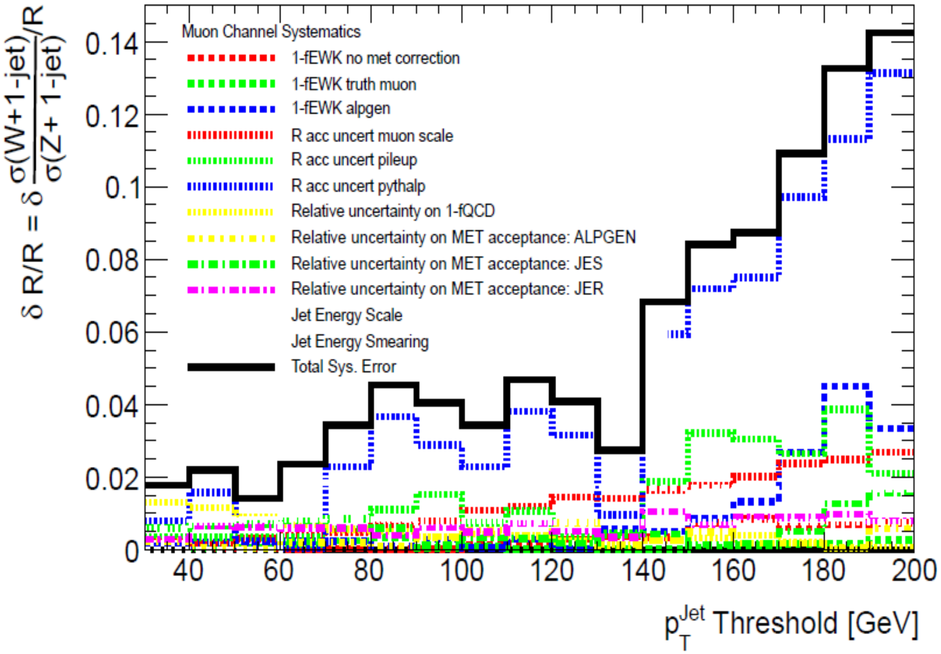


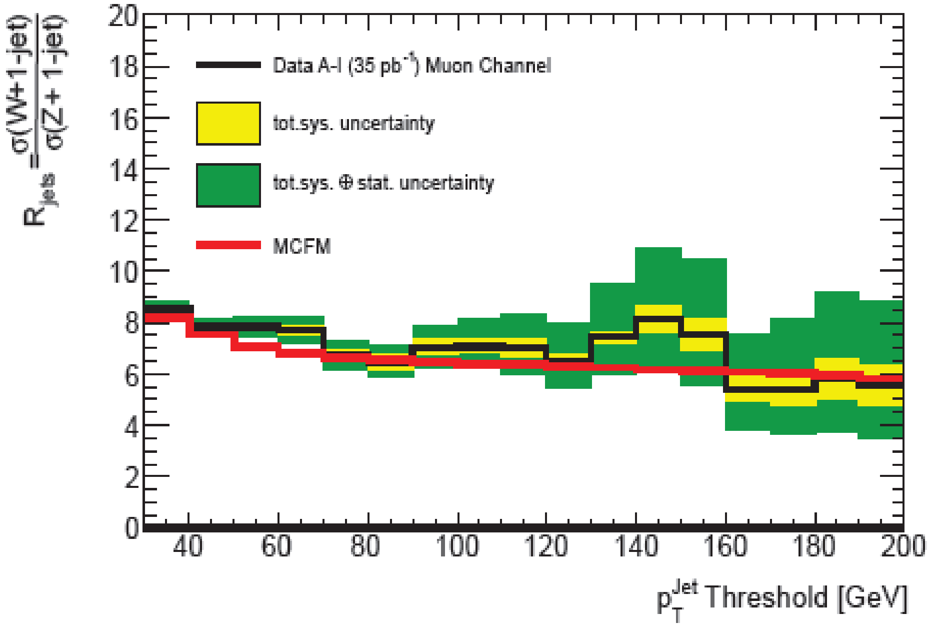


Z

Work in progress

R_{jets} ratio





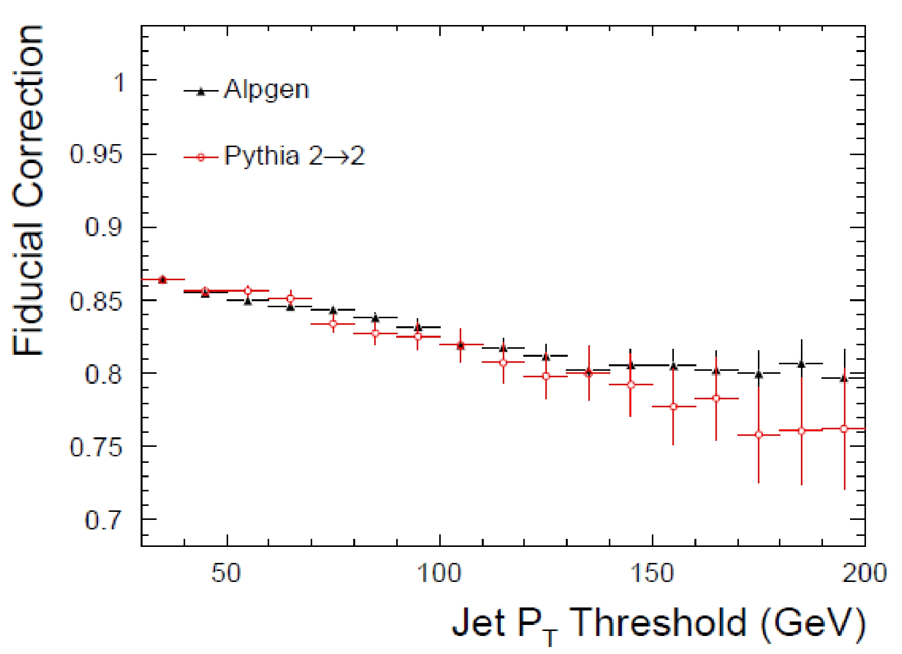
Work in progress

Summary

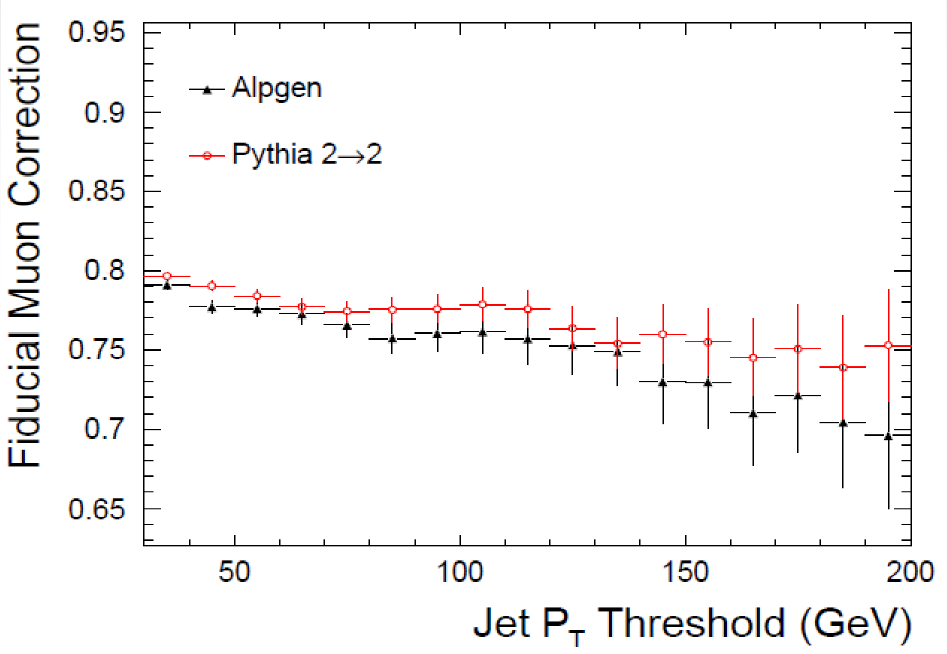
- R_{jets} is the first such measurement made in hadron collider
- Small systematic uncertainty error in the ratio measurement
- Fair agreement between data and theory

A× ϵ (Muon)

- Signal Model uncertainty



W

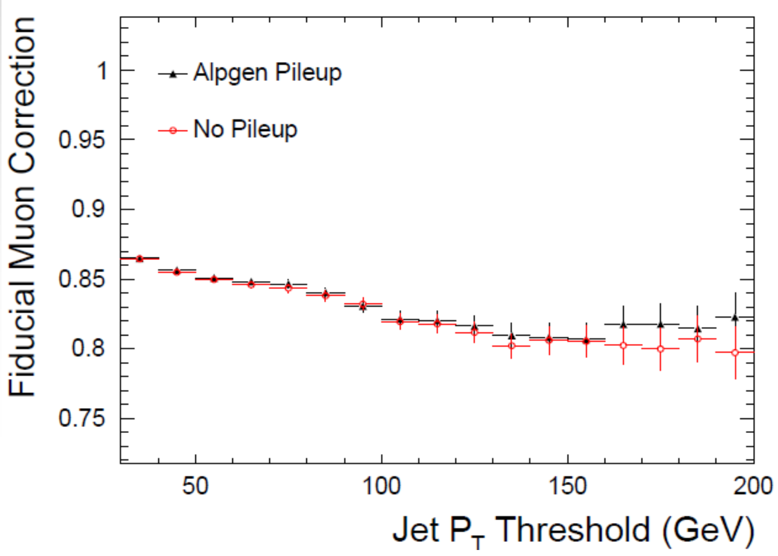


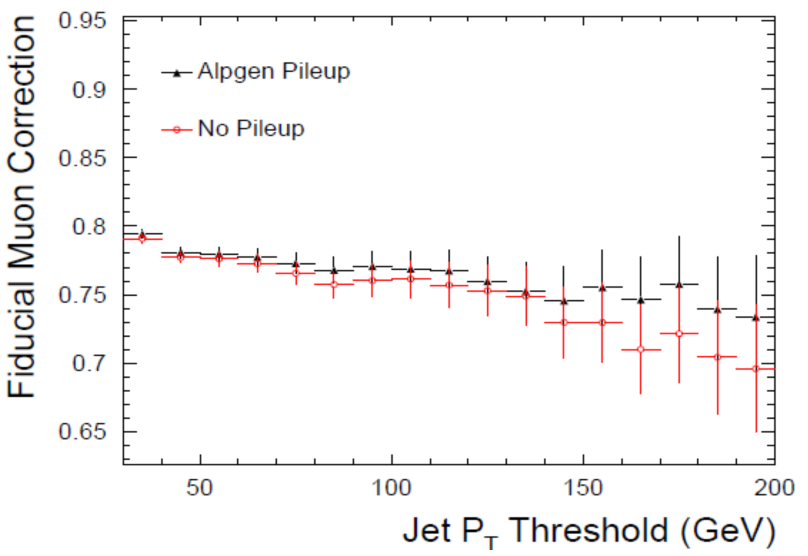
Z

A× ϵ (Muon)

- Uncertainty due to Pile-Up

W



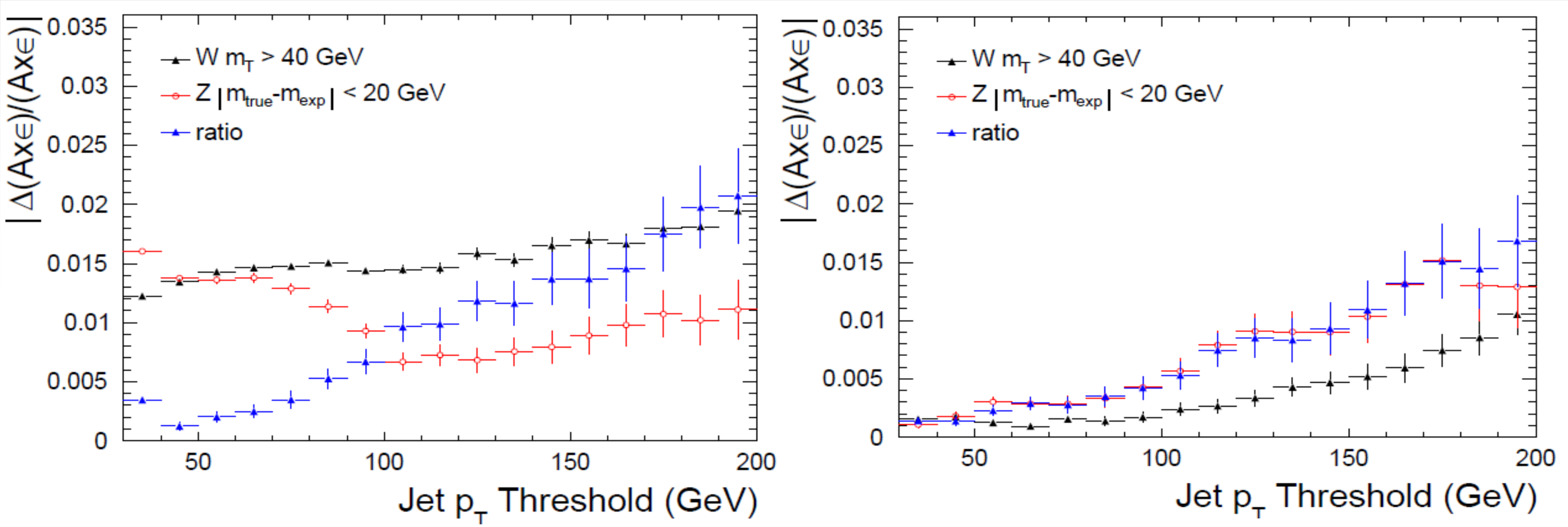


Z

A× ϵ (Muon)

- Muon momentum scale uncertainty and resolution uncertainty

scale



smear

The Trigger efficiency are caculated from Monte Carlo after all other selections.Corrected using efficiency scale factor derived from data.The scale factor corrections applied as function of Muon η and p_T