# Recent results on jet and top physics from ATLAS





Hongbo Zhu LHC Physics Discussion 21.03.2010



## Introduction



#### Toroid Magnets Solenoid Magnet SCT Tracker Pixel Detector TRT Tracker



## ATLAS collected ~45 pb-1 data at $\sqrt{s}$ =7 TeV in 2010

Inne De	er Track etector	ing s	Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at Vs=7 TeV between March 30<sup>th</sup> and October 31<sup>st</sup> (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.



#### Part I: Jet

- Jet reconstruction and performance
  - Reconstruction and calibration
  - Energy scale uncertainty and validation in-situ
- Jet physics results
  - Inclusive jet and di-jet cross-section (*in approval*)
  - Multi-jet cross-section
  - Di-jet production with a jet veto
  - Measurement of di-jet azimuthal decorrelations (arXiv:1102.2696)



### Jet reconstruction and calibration

- Calorimeter cells calibrated to electromagnetic scale
- 3D topological clusters (nearest neighbor energy significance to localize showers in the calorimeter, efficient noise suppression)
- Jets are reconstructed using the anti-kt algorithm with size parameter R 0.6 (0.4)



#### REFFERENCE

- Energy and momentum of jets measured in the calorimeter are corrected using kinematics of Monte Carlo truth jets as reference
- EM+JES schema simple default Monte Carlo based calibration
  - (η, p<sub>T</sub>) dependent correction factor
    E<sub>calo</sub><sup>EM</sup>/E<sub>truth</sub>



## Jet energy scale uncertainty

#### ATLAS-CONF-2011-028

#### Evaluated from combination of measurements and Monte Carlo

- response and uncertainty of single hadrons measured in data and propagated to jets using MC, assessed up to |η|=4.5, using di-jet balance measurements, uncertainties from systematic variations of MC
- evaluated from in-situ Monte Carlo, obtained systematic uncertainties in agreement with JES from single hadron response



ATLAS-CONF-2011-014

- In-situ calibration
- o multi-jet balance
- o calorimeter jet-track balance
- direct gamma jet balance
- photon balance using missing transverse momentum projection



## Jet energy resolution

ATL-COM-PHYS-2011-240 (not public)

- default calibration: EM+JES, simple jet (η, pT) approach on top of EM scale
- advanced calibration (% improvement):
  - global sequential calibration
  - global cell energy density based weighting
  - Iocal cluster property based weighting
- Jet energy resolution measured in-situ with di-jets using di-jet balance and bi-sector techniques



## Di-jet production with a jet veto

- Jet activity in rapidity gap between forward-backward jets (wide angle soft gluon radiation, color exchange ...)
- Gap events are identified as the subset of events that do not contain an additional jet with pT> Q0, using Q0=20 GeV

#### probability of no jets with pT> 20 GeV in the gap



HEJ predicts too little activities at large pT
 POWHEG(NLO)
 +PYTHIA gives the best description (but too much activity at large Δy)
 POWHEG+HERWIG predicts too much activity

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ΔV Data (+svs HEJ (parton level) 6 < 240 GeV ----- POWHEG + PYTHIA < D < 210 GeV POWHEG + HERWIG 150 < p\_ < 180 GeV (+1.8) 120 < p\_ < 150 GeV (+1.2) Selection A 90 < p\_ < 120 GeV (+0.6)  $Q_0 = 20 \text{ GeV}$ 70 < p\_ < 90 GeV (+0) ATLAS Preliminary 6

**Gap** Fraction

## **Multi-jet cross section**

- Jet multiplicity up to 6, with pT>60 GeV, leading jet pT>80 GeV
- Uncertainties on the differential cross section 20-40%





## **Part II: Top physics**

- Production cross section (35 pb-1)
  - Single lepton pre-tag
  - Single lepton b-tag
  - Di-lepton (in approval)
  - Combination (in approval)
  - Single top
- Properties (35 pb-1)
  - top mass
  - W helicity
  - $t\bar{t}$  anomalous  $E_T^{miss}$





## **Event selection**

ĒS	n+jets	+jets	jets	all ba	dronio		
ūd	electro	muon	tau+j	all-nadronic			
<mark>ب</mark> ا	еτ	μτ	ξĩ	tau+j	jets		
_µ	еμ	jo <sup>ic</sup>	μτ	muon	+jets		
θ	eð	eμ	eτ	electro	on+jets		
Necan	$e^+$	μ+	$\tau^+$	иd	cs		

#### <u>Electron</u>

- Good isolated electron
- E<sub>T</sub> > 20 GeV
- $|\eta \in [0, 2.47]$  excluding

#### <u>Muon</u>

- Segments in tracker and muon detector
- Isolated track
- p<sub>T</sub> > 20 GeV
- $\eta < 2.5$

#### **ETmiss**

- Vector sum of calo energy deposits
- Corrected for identified objects





## $\sigma_{tt}$ Single lepton (without b-tagging)

#### ATLAS-CONF-2011-023

0.9

#### Project likelihood based on three discriminating variables



## $\sigma_{tt}$ Single lepton (with b-tagging)

baseline analysis from DESY & Goettingen

- Project likelihood with 4 input variables: lepton η, aplanarity, HT,3p, btag weight, in 6 channels (3-jets, 4-jets, ≥5-jets, e & μ)
- Profile likelihood fit to extract the cross section (and syst. uncertainties)



$\sigma_{t\bar{t}} = 186 \pm 10$ (sta	$t.)_{-20}^{+21}$	ol (sy	st.) ± 6(lumi.)
Statistical Error (%)	+5.3	-5.2	
Object selection (%)	•		
Jet energy scale	+3.8	-2.8	
Jet reconstruction efficiency	+4.2	-4.2	
Jet energy resolution	+0.8	-0.2	
Electron scale factor	+1.2	-0.8	
Muon scale factor	+0.5	-0.6	
Electron smearing	+0.3	-0.2	
Muon smearing	+0.6	-0.4	
Background modeling (%)	•		
Wjets HF content	+7.2	-6.3	
Wjets shape	+1.5	-1.5	
QCD shape	+1.0	-1.0	
$t\bar{t}$ signal modeling (%)	•		
ISR/FSR	+4.0	-4.0	
NLO generator	+0.5	-0.7	
Hadronisation	+0.0	-0.6	
PDF	+1.7	-1.7	
Others (%)			
b-tagging calibration	+7.5	-6.3	
Simulation of pile-up	+1.5	-0.6	
Templates statistics	+1.6	-1.5	
Total Systematic (%)	+11.5	-10.5	1   Page 12 ( DESY )

ATLAS-CONF-2011-035

## **Di-lepton, combined and extract mass from cross-section**

- Conference notes are still in the pipeline of approval ...
- Main contribution from us to the note "extracting mass from crosssection measurements"



## Single top: t- and Wt-channel

- t-channel: cut-based (cross-checked with likelihood method)
  - 1 lepton, 1 b-jet, 1 light-jet, Etmiss
  - Bkg: QCD multi-jet, W+jets
  - Final cut mtop (130, 210 GeV), |light-jet| > 2.5



- wt-channel: cut-based
  - I+jets: 2-4j jets, exactly 1 b-jet,
  - dilepton: data driven Z+jets, fakes, tt (from Njets >1) Hongbo Zhu| LHC Physics Discussion | 21.03.2011 | Page 14
  - combined channels, expect

ATLAS-CONF-2011-027

Z(→ ee/µµ)+jets

ts

Z(→ ττ)+jets Diboson

Top pair

Dilepton Combi

Data

Number of Events

 $\sigma_{wt} < 94 \text{ pb}$ 

50

40

30

20

10

ATLAS Preliminary

Ldt = 35 pb<sup>-1</sup>



#### **Top quark mass**



 Cross checks: kinematic fit templates, 2D templates with JES scaling

$$n_{top} = 169.3 \pm 4.0(stat.) \pm 4.9(syst.) GeV$$





- tt + anomalous Etmiss: ATLAS-CONF-2011-036
- W helicity in top decays: ATLAS-CONF-2011-037



### Conclusion

- Recent results on jet and top from ATLAS have been presented. With the 2010 data, we have improved the jet calibration and looked into several jet physics. With 35 pb-1, we have already measured top production cross-section, mass, single-top and several properties.
- 2011: further improved understanding of the detector (reduced systematic uncertainties) and the year of top precision measurement (together with significantly more data)



Lepton pseudorapidity  $\eta = -\ln(\tan(\theta/2))$ , cluster  $\eta$  for electrons Aplanarity A: 1.5 times smallest eigenvector of momentum tensor  $M_{ij} = \frac{\sum_{k=1}^{N'_{objects}} p_{ik} p_{jk}}{\sum_{k=1}^{N'_{objects}} p_{ik}^2}$  $\rightarrow$  transformed to exp[-8×A]

 $H_{T,3p}$ : transverse momentum of all but the leading two jets, divided by sum of absolute values of all longitudinal momenta in the event (neutrino pz from solving event kinematics and taking solution with smallest  $p_z$ )

$$H_{\mathrm{T,3p}} = \frac{\sum_{i=3}^{N_{\mathrm{jets}}} |p_{\mathrm{T},i}^2|}{\sum_{j=1}^{N_{\mathrm{objects}}} |p_{z,j}|}$$

 $\rightarrow$  transformed to exp[-4×H<sub>T,3p</sub>]

Continuous b-tagging weight  $w_{JP}$  from JetProb tagger  $\rightarrow$  transformed to  $-\log_{10}(w_{JP})$ Our choice: mean of two highest b-tagging weights (expect two b-jets in tt signal)

