ATLAS実験におけるボトムジェット同定効率の測定

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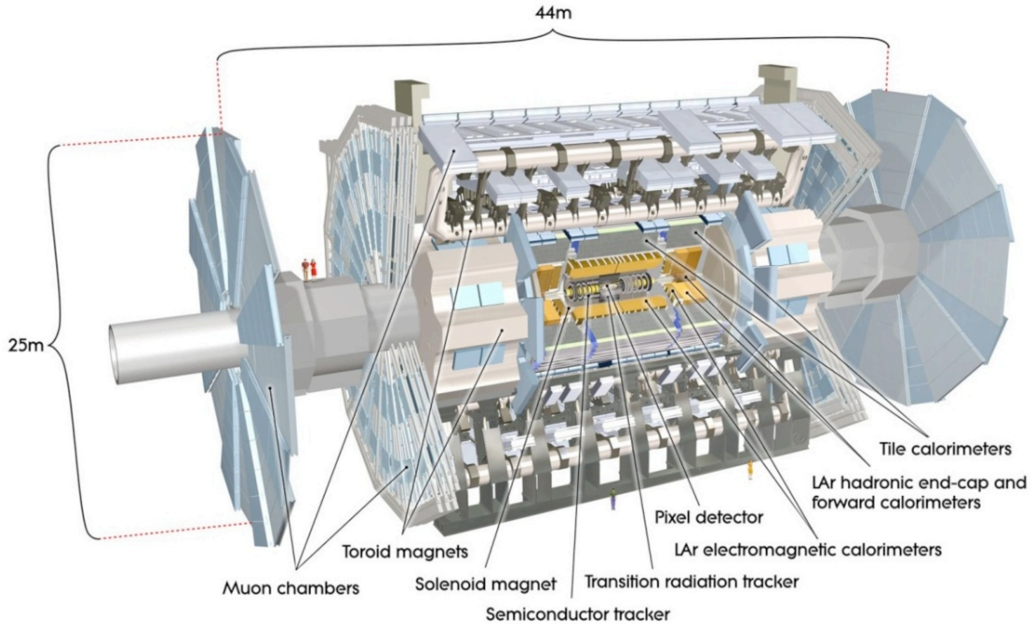
阪大理, Univ. of Freiburg[A]

Outline
1, Introduction
2, Method
3, systematic uncertainty
4, statistic uncertainty
5, summary

LHC、ATLAS experiment



ATLAS detector

- Precise measurement of top quark property
- Search for Higgs boson
- Search for new physics beyond standard model

Under commissioning now ...

b-tagging

b-tagging is important for
- Top quark
- (low mass)Higgs boson,
- SUSY→MissingEt + bjet   and so on...

Performance to be measured

- tagging efficiency
- tagging efficiency for light-jet or c-jet

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Performance to be measured

- tagging efficiency ← This talk !
- tagging efficiency for light-jet or c-jet

Motivation

It is important to measure in several ways.
b-tagging efficiency measurement with real data is needed

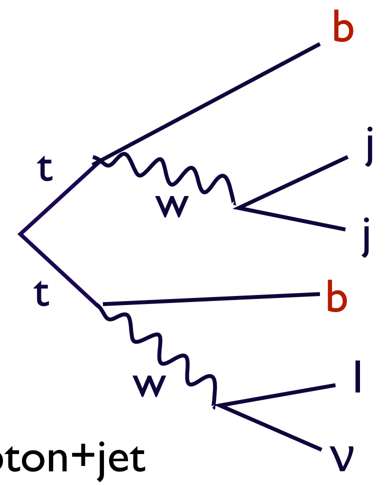
pure b-jet sample is needed.

→**tt sample !**

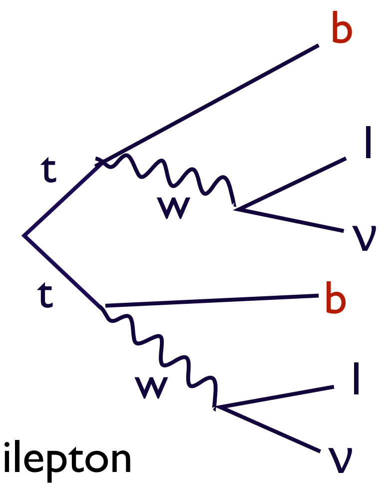
- lepton+jet
- dilepton

→ few background

→ simple and robust !! Can be used with early data!



lepton+jet



dilepton

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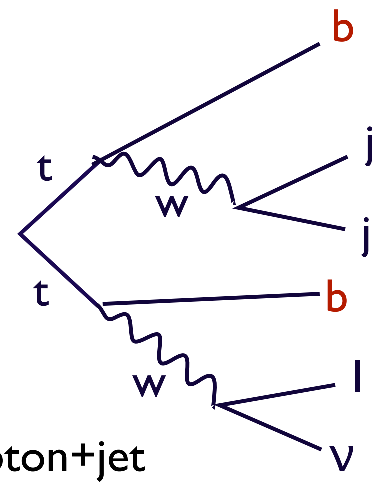
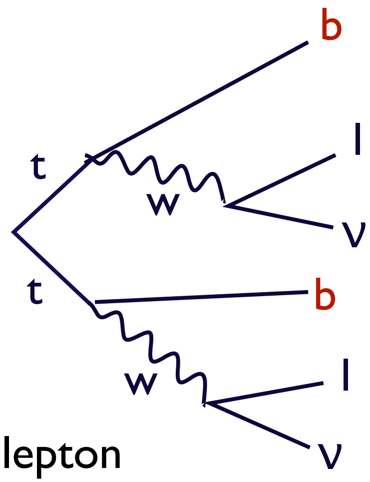


lepton+jet



dilepton

Method

To obtain pure b-jet sample
(1)Choose tt sample : Event selection
(2)Enhance b-jet fraction :"JetMultiplicity=2"

Then, calculate the b-tagging efficiency with equation:

$$\frac{N_{tagged}}{N_{all}} = \frac{\epsilon_b N_b + \epsilon_{other} N_{other}}{N_{all}}$$

N :The number of jet
ε: The tagging efficiency

Higher the b-jet fraction → less dependence on MC.

Method

To obtain pure b-jet sample

(1)Choose tt sample : Event selection

(2)Enhance b-jet fraction :"JetMultiplicity=2"

Then, calculate the b-tagging efficiency with equation:

Monte-Carlo

$$\frac{N_{tagged}}{N_{all}} = \frac{\epsilon_b N_b + \epsilon_{other} N_{other}}{N_{all}}$$

real data

N :The number of jet

ε: The tagging efficiency

Higher the b-jet fraction → less dependence on MC.

EventSelection(signal)

10 TeV data

Categorize events according to the flavor of two leptons.
→ **ee/μμ/eμ** channel

Event Selections

0, Initial

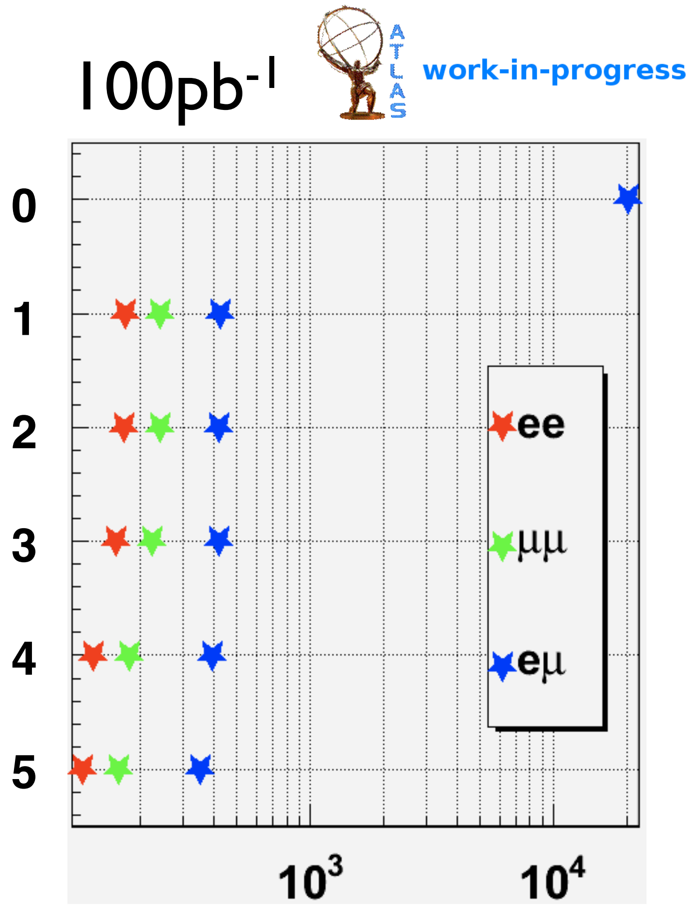
1, Two leptons
(>20 GeV)

2, leptons with opposite sign

3, Z mass veto
(86 GeV < $M_{two\ leptons}$ < 96 GeV for **ee/μμ**)

4, Missing Et
(mET>35 GeV for **ee/μμ**, mET>20 GeV for **eμ**)

5, Jet Multiplicity ≥2



EventSelection (background)

Expected number of events with 100 pb^{-1}

work-in-progress

	ee	$\mu\mu$	emu
W+jets	1.39	0.28	2.62
Z+jets	2.85	10.29	8.83
Diboson(WW, WZ, ZZ)	1.15	1.48	3.77
SingleTop(Wt,t-chan)	3.76	3.28	9.29
total	9.15	15.33	24.51

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tt	**115.8**	**163.6**	**353.0**

few background events!!

S/B > 10

EventSelection (background samples)

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tt	**115.8**	**163.6**	**353.0**

few background events!!

S/B > 10

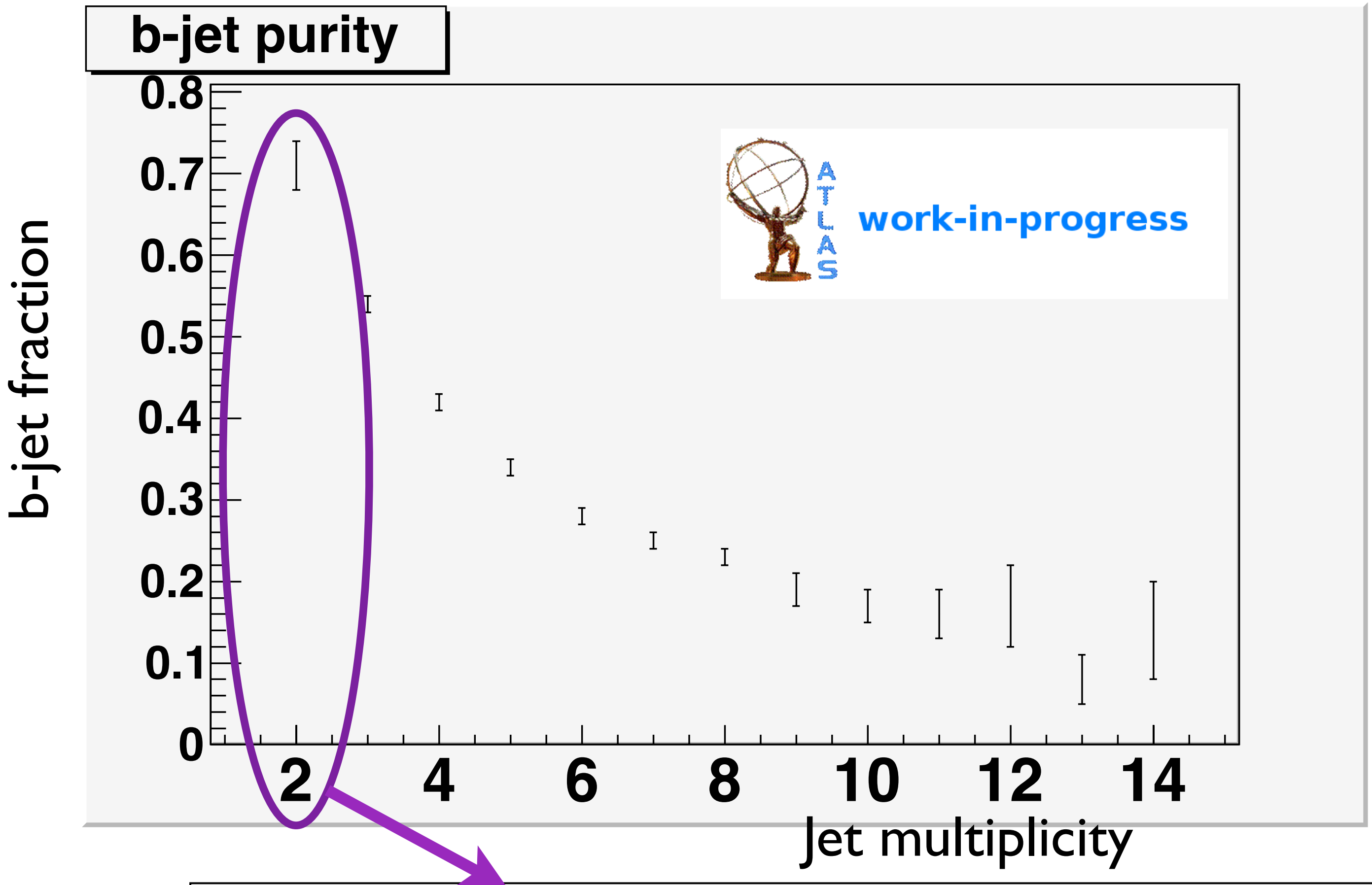
But, still there are light jet in tt events (b-jet fraction is only ~50%)
These light-jets should be removed using kinematic cut!

next slide...

Enhance the b-jet fraction

light jets are still exist (tt + jets)
→ Enhance b-jet fraction with Jet Multiplicity cut

Fig. b-jet fraction



JetMultiplicity = 2 → b-jet fraction 50% ⇒ 70% !!

I will measure the b-tagging efficiency after obtaining enough amount of data...

In following slides,
Stat. and Syst. uncertainty was estimated
with pseudo experiment.

Pseudo Experiment

$$\frac{N_{tagged}}{N_{all}} = \frac{\epsilon_b N_b + \epsilon_{other} N_{other}}{N_{all}}$$

One Pseudo Experiment

From one dataset (as real data):

Make pseudo data

Make one pseudo data

↓

Calculate:

Ntagged @50% efficiency

From other dataset (as MC):

Calculate the values

Calculate:

Nother, Nb and εother @50% efficiency

Pseudo Experiment

$$\frac{N_{tagged}}{N_{all}} = \frac{\epsilon_b N_b + \epsilon_{other} N_{other}}{N_{all}}$$

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Calculate:

Ntagged @50% efficiency

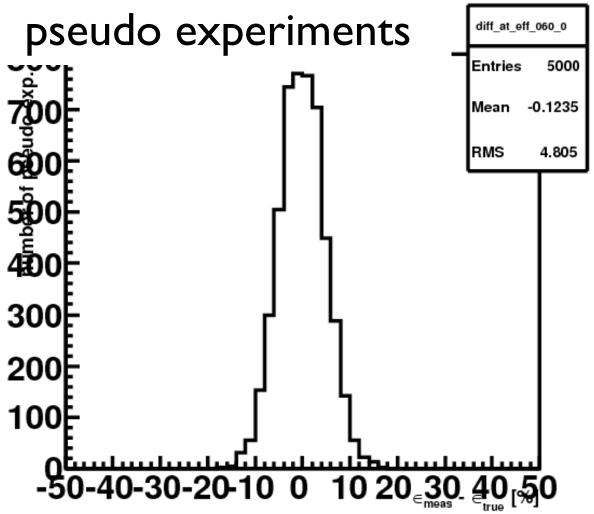
From other dataset (as MC):

Calculate the values

Calculate:

Nother, Nb and εother @50% efficiency

result of 5000 times of pseudo experiments



εmeas-εtrue

mean : -0.12

→no bias !

sigma : 4.8

→stat. uncertainty=4.8%

Systematic uncertainty

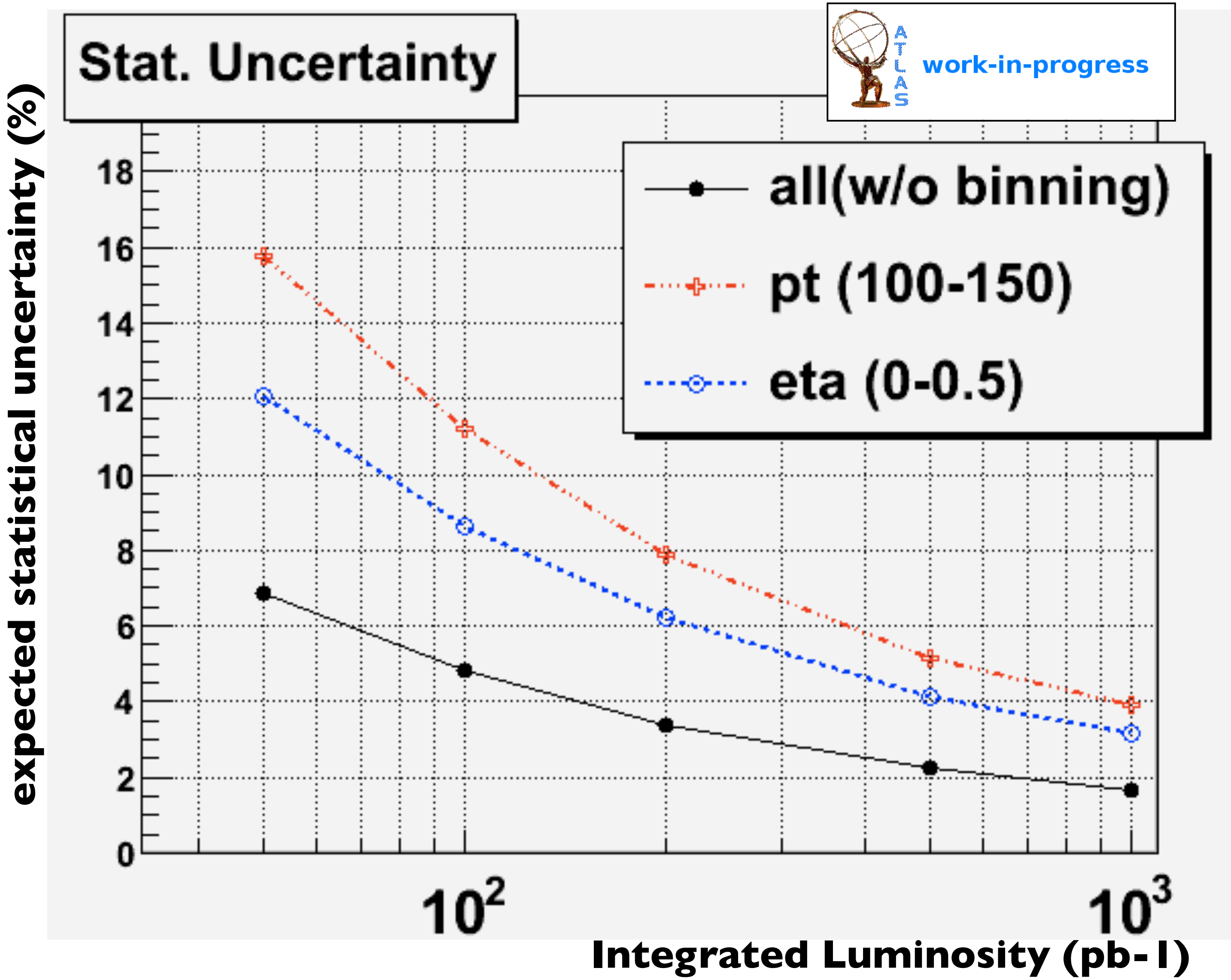
work-in-progress

Table. systematic uncertainty (in %)

JetEnergyScale (JES)	JES +7%	0.94
	JES -7%	-0.37
b-jet Labelling default: ΔR(jet,b-quark) < 0.3 ⇒ "b-jet"	$\Delta R < 0.2$	0.72
	$\Delta R < 0.4$	-0.69
	$\Delta R < 0.5$	-0.98
Generator	herwig	-1.83
	pythia	0.68
Initial State Radiation(ISR)/ Final State Radiation(FSR)	+ISR/FSR	0.14
	-ISR/FSR	-1.76

<2.9% systematical uncertainty

Stat. uncertainty
Luminosity dependence @ 50% effi. (Scaled to 7TeV)



<4.9% statistical uncertainties for 100pb-1 without binning

summary

- I established the method of b-tagging efficiency measurement with tt dilepton events using real data
- Requirement of "Jet Multiplicity=2" enhanced
  the b-jet fraction 50% ⇒ 70%
- Statistical uncertainties < ~4.9% (100pb-1)
- Systematical uncertainties < ~2.9% (100pb-1)
- It is difficult to use binning method with early data < $1 fb^{-1}$

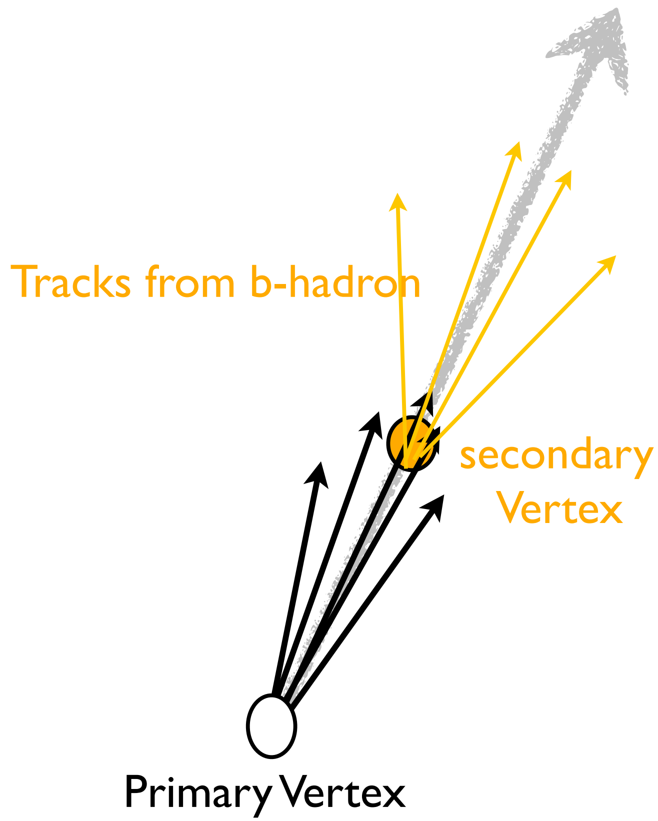
back-up

b-tagging

b-tagging is important for
- Top quark
- (low mass)Higgs boson,
- SUSY→MissingEt + bjet and so on...

Two types of tagger

•Secondary vertex
•Soft lepton (20% of b-jet decay into lepton)



Performance to be measured

• tagging efficiency ← This talk !
• tagging efficiency for light-jet or c-jet

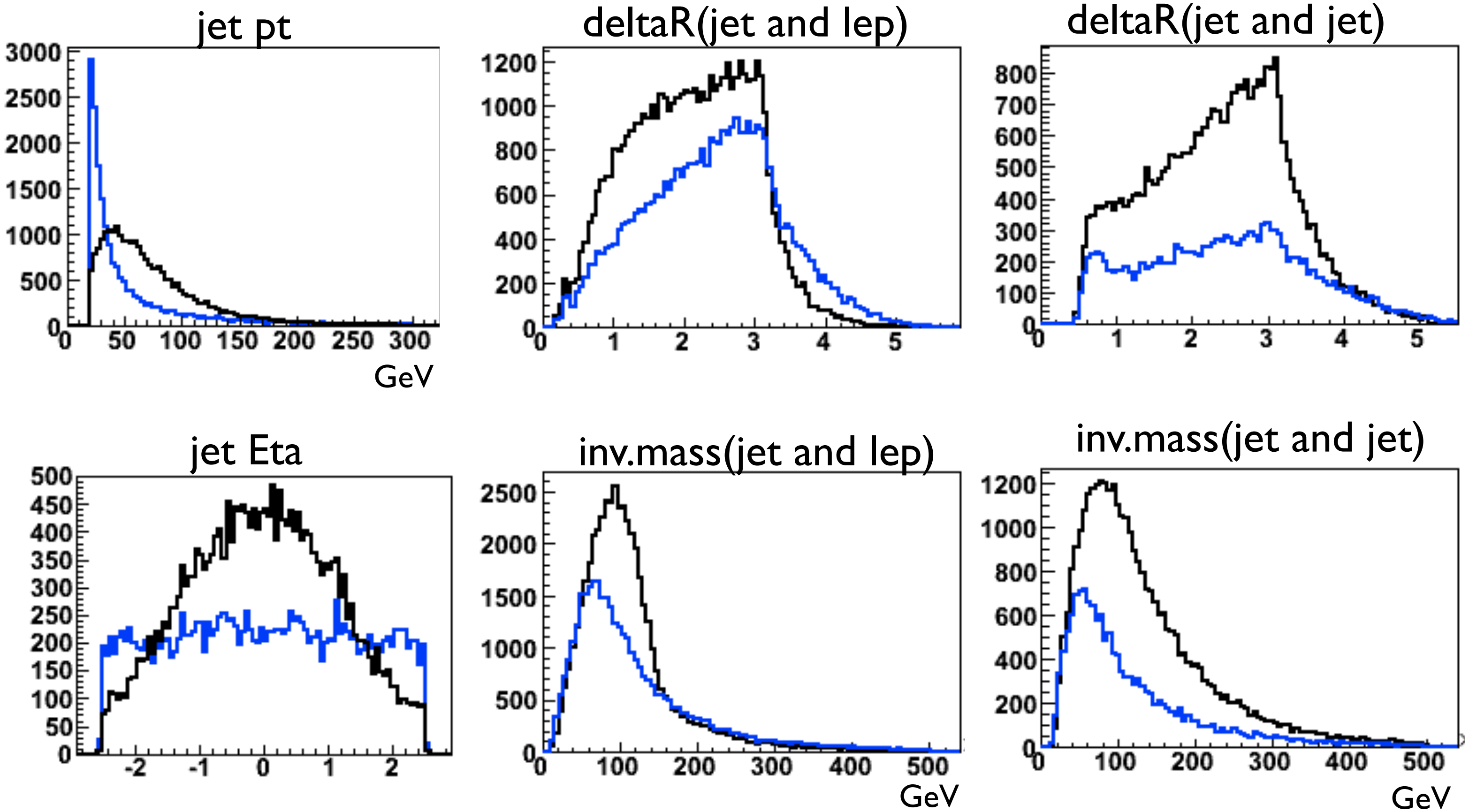
Strategy to enhance the b-jet purity

Kinematics

black:b-jet **blue:l-jet**
not normalized
each event has
2 jet-lep combinations,
>2 jet-jet combinations.

While I saw various kinematic distributions,
I could not find any reasonable valuable to distinguish b-jets from l-jets.

NOTE: Pt, Eta should not be used to avoid the bias.



I saw
other kinem.
such as,
deltaPhi(jet-lep)
deltaEta(jet-lep)
PtSum(jet-lep)
deltaPhi(jet-jet)
deltaEta(jet-jet)
PtSum(jet-jet)
•
•

EventSelection

Categorize events according to the flavor of two leptons.

→ **ee/μμ/eμ** channel

Event Selections

1, Two leptons (>20 GeV)

2, leptons with opposite sign

3, Z mass veto (86 GeV < $M_{\text{two leptons}}$ < 96 GeV for **ee/μμ**)

4, Missing Et ($\not{E}_T$>35 GeV for **ee/μμ**, $\not{E}_T$>20 GeV for **eμ**)

5, Jet Multiplicity ≥2

←the same cut to: ATL-PHYS-PUB-2009-086

100 pb-1

	initial	2 leptons	opposite sign	Z mass veto	MET	NJet≥2
ee	20286.0	173.7 (0.86%)	171.2 (98.52%)	158.5 (92.62%)	129.0 (81.36%)	115.8 (89.76%)
$\mu\mu$	20286.0	242.8 (1.20%)	241.9 (99.63%)	225.2 (93.11%)	181.7 (80.70%)	163.6 (90.02%)
$e\mu$	20286.0	424.7 (2.09%)	421.0 (99.12%)	421.0 (100%)	394.2 (93.63%)	353.0 (89.56%)

EventSelection (background samples)

Expected number of events with 100 pb^{-1}

	ee	$\mu\mu$	emu
$W \to e\nu$	1.39	0.00	0.00
$W \to \mu\nu$	0.00	0.00	2.62
$W \to \tau\nu$	0.00	0.28	0.00
$Z \to ee$	1.48	0.00	0.00
$Z \to \mu\mu$	0.00	8.70	1.36
$Z \to \tau\tau$	1.37	1.59	7.47
Diboson(WW, WZ, ZZ)	1.15	1.48	3.77
SingleTop(Wt,t-chan)	3.76	3.28	9.29
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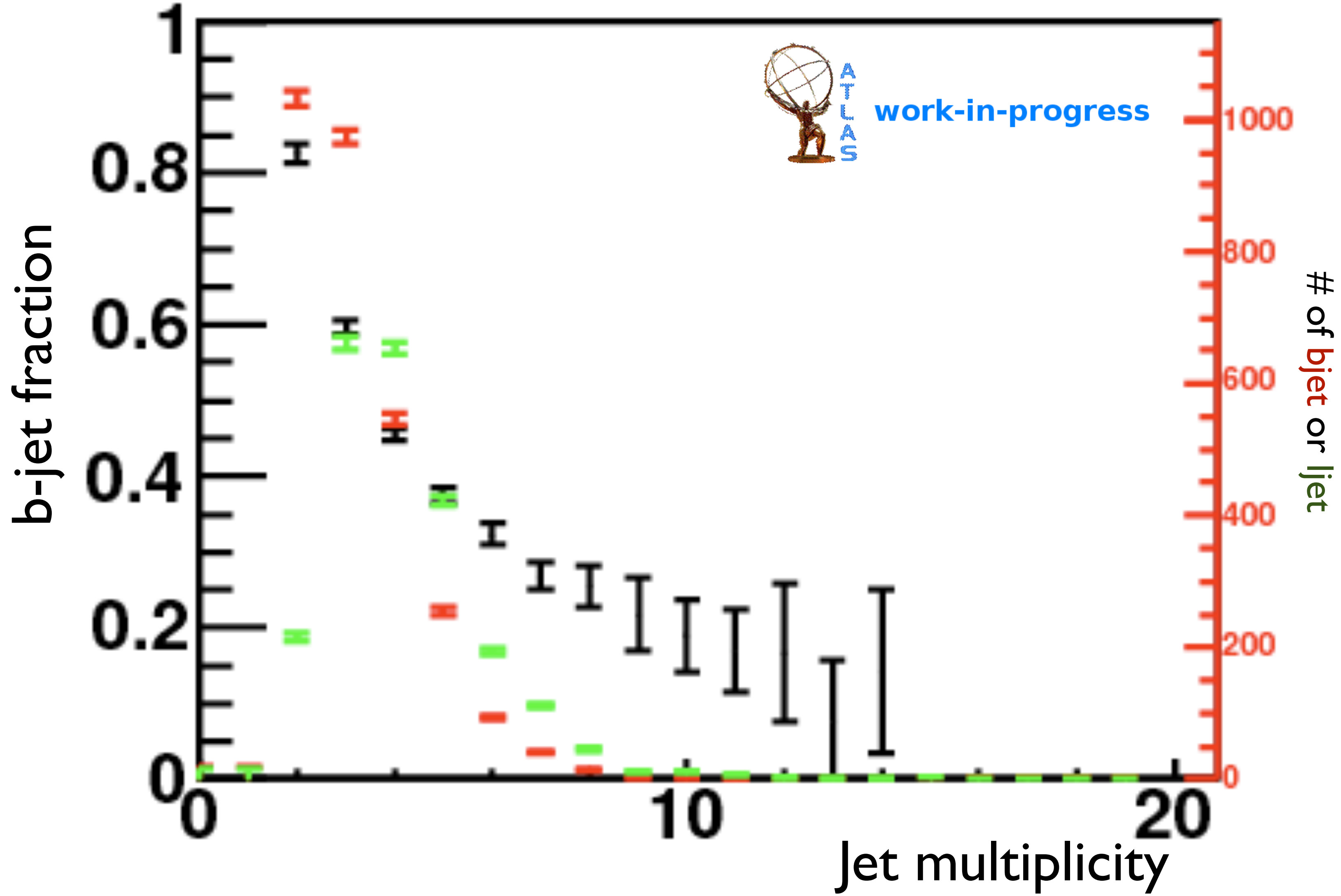
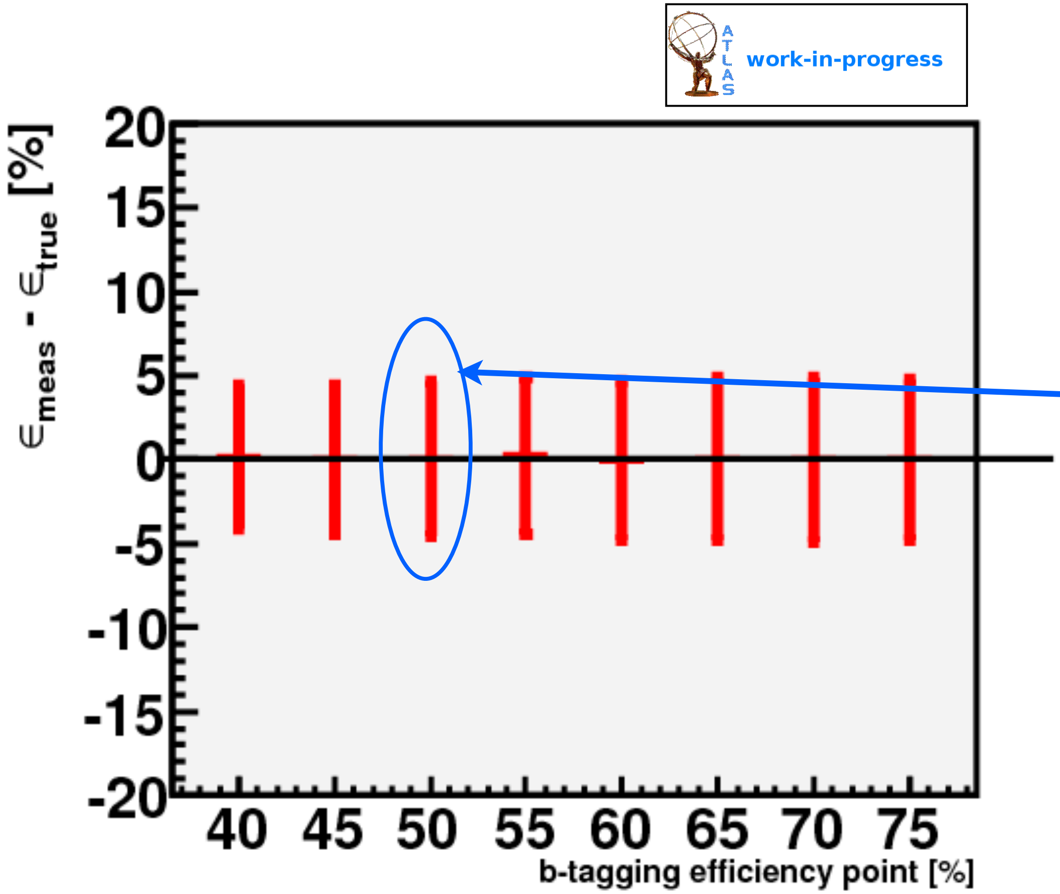
Number of b-,l-jet in tt sample

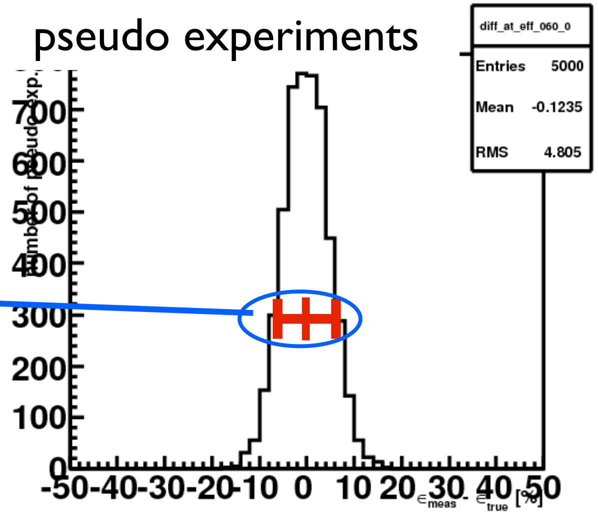


Pseudo Experiment
check the bias

$$\frac{N_{tagged}}{N_{all}} = \frac{\epsilon_b N_b + \epsilon_{other} N_{other}}{N_{all}}$$



result of 5000 times of pseudo experiments



εmeas-εtrue

No bias for every efficiency point!!

Systematic uncertainty

$$\frac{N_{tagged}}{N_{all}} = \frac{\epsilon_b N_b + \epsilon_{other} N_{other}}{N_{all}}$$

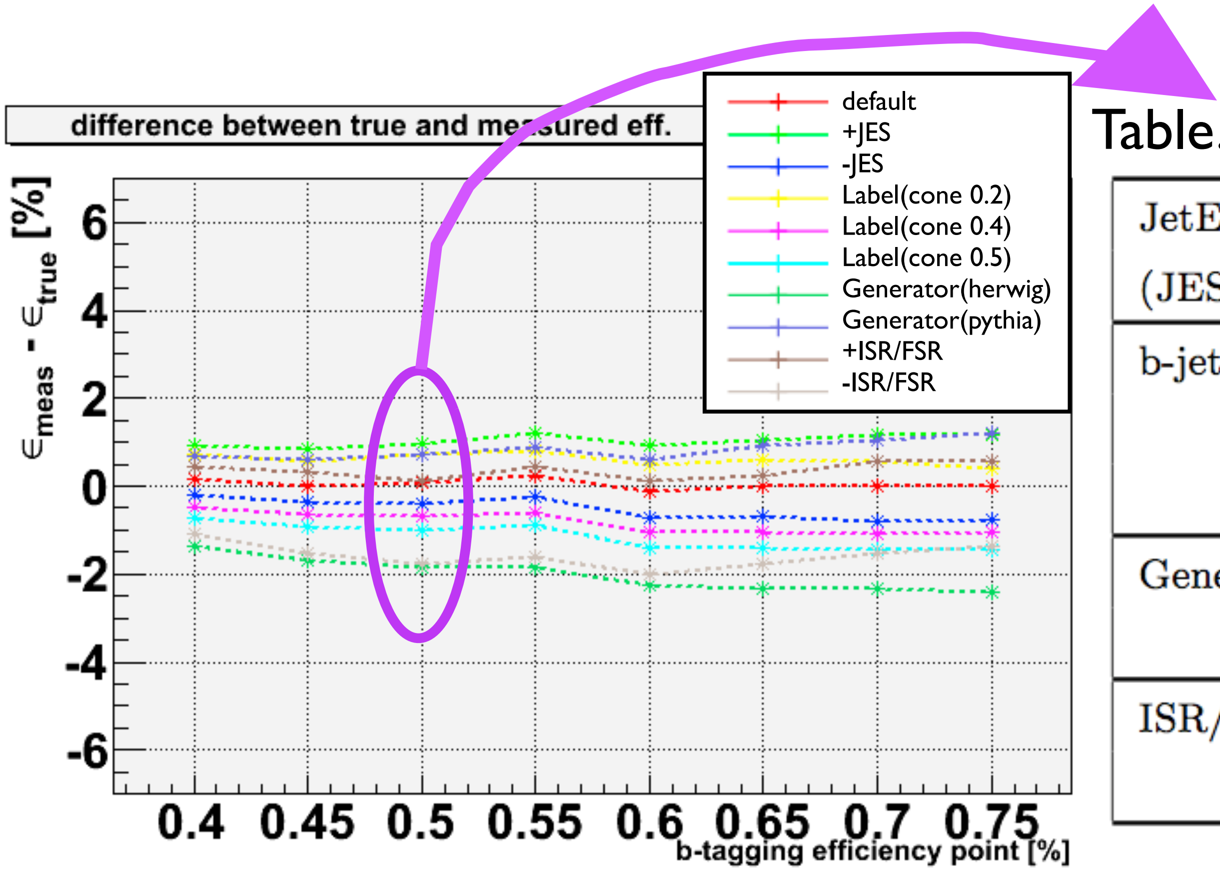


Table. systematic uncertainty (in %)

JetEnergyScale (JES)	+JES	0.94
	-JES	-0.37
b-jet Labelling	cone size = 0.2	0.72
	cone size = 0.4	-0.69
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Generator	herwig	-1.83
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ISR/FSR	+ISR/FSR	0.14
	-ISR/FSR	-1.76

<2.88% systematical uncertainty for 100pb-1 for 50% effi.

Systematic uncertainty (explanation) skip this slide....

- Jet Energy Scale

source	f_+	f_-
Jet energy scale |eta|<3.2	1.07	0.93
Jet energy scale |eta|>3.2	1.15	0.85
Jet energy resolution |eta|<3.2	σ(E)=0.45*sqrt(E) (3) (E in GeV)	
Jet energy resolution |eta|>3.2	σ(E)=0.63*sqrt(E) (3) (E in GeV)	

This recipe was introduced in the talk by Wolfgang Mader (TU Dresden)
@http://indico.cern.ch/conferenceDisplay.py?confId=69521

- Labeling

  DeltaR(jet,b-quark) < 0.2, 0.3, 0.4, 0.5
  (default is 0.3)

- Generator

  mc08.105205.AcerMCttbar.merge.AOD.e429_s462_r635_t53 (Pythia)
  mc08.105206.AcerMCttbarHerwig.merge.AOD.e429_s462_r635_t53 (Herwig)

- ISR/FSR

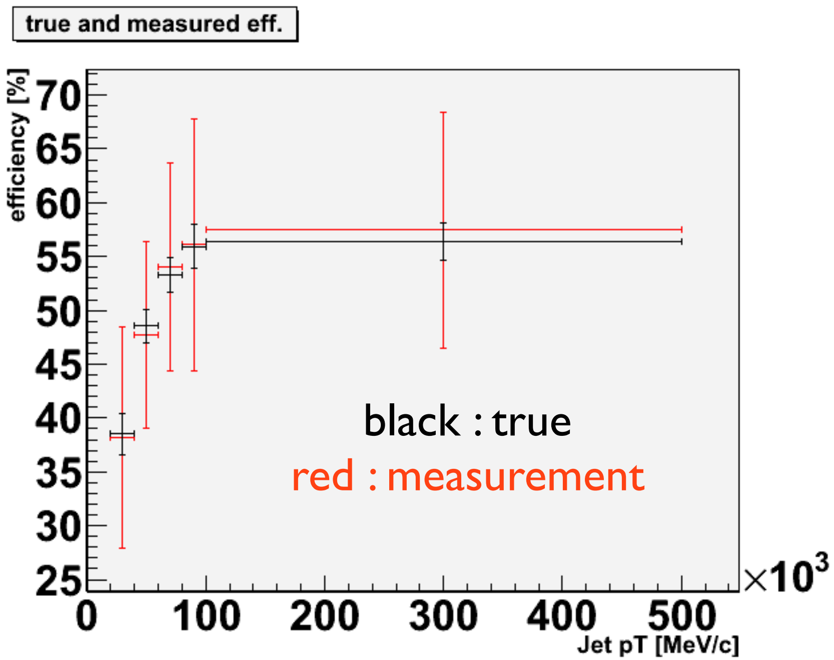
  mc08.106250.AcerMCttbar.merge.AOD.e429_a84_t53
  mc08.106251.AcerMCttbar.merge.AOD.e429_a84_t53

Binning method for Pt, Eta

ex) luminosity 40 pb-1 with 10 TeV data
roughly corresponding to 100pb-1 with 7TeV data

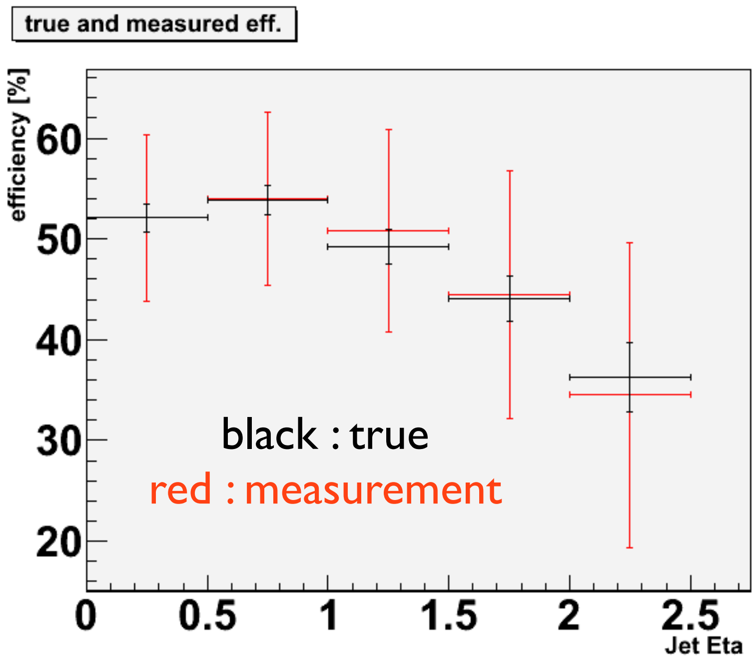
- Same method was used for pseudo experiment.
- Weight value for 50% effi. was used.

Divided into 5 Bins for Pt:
20~40, 40~60, 60~80, 80~100, 100~150 GeV



Uncertainty : ~10 %

Divided into 5 Bins for Eta:
0~0.5, 0.5~1.0, 1.0~1.5, 1.5~2.0, 2.0~2.5



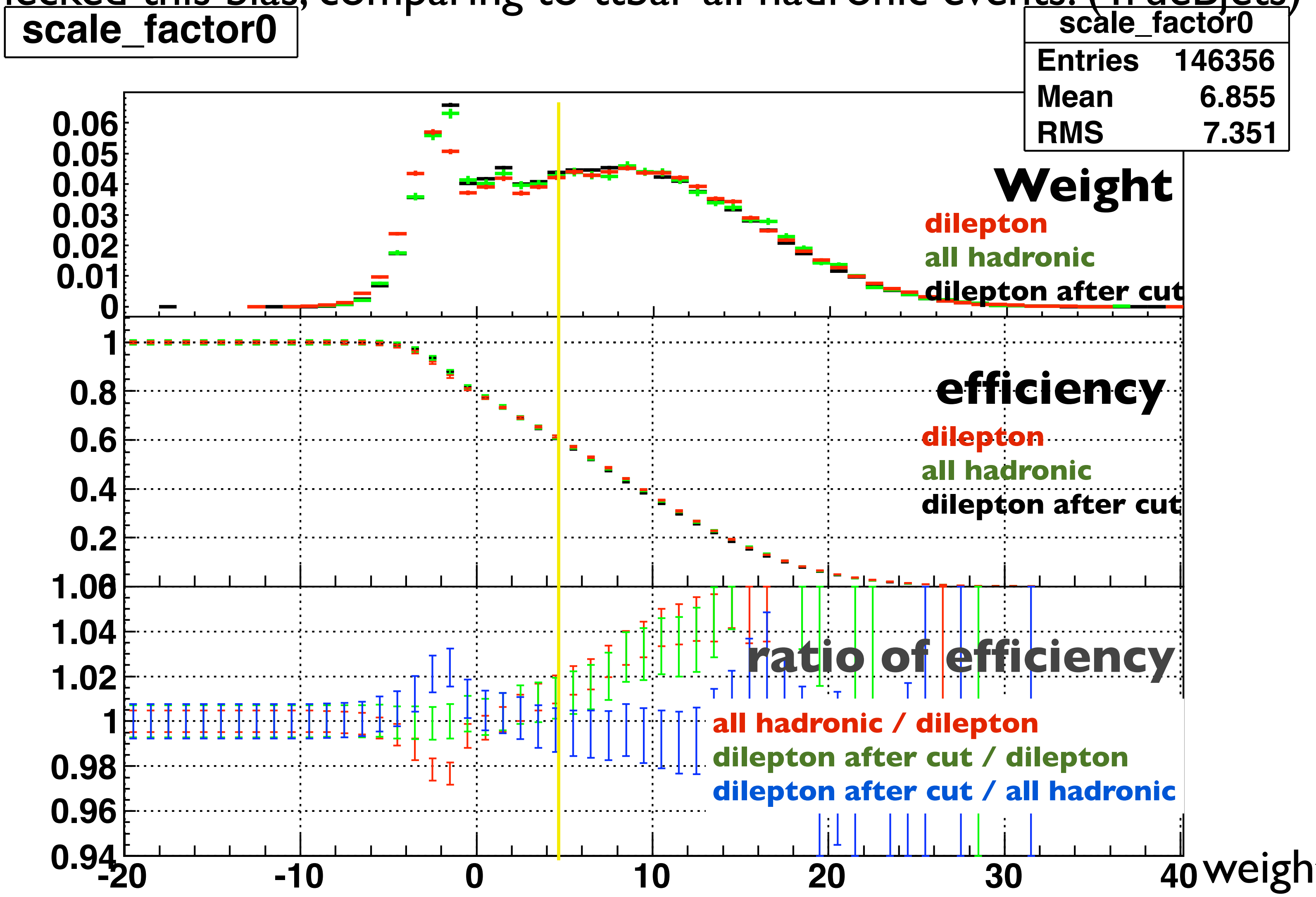
Uncertainty : ~10 % in small eta region

Scale factor

ex) luminosity 40 pb-1 with 10 TeV data
Including all background samples

Using only dilepton event could lead bias for weight distribution and then b-tagging efficiency.

I checked this bias, comparing to ttbar all hadronic events. (TrueBjets)



If you look red datapoint on bottom plot, we can see there are no bias between all hadronic and not all hadronic event.

Some informations

Used release : 14.2.25
Used code: TopPhysDPDMaker

Used Dataset :
Signal sample:
ttbar : mc08.105200.T1_McAtNlo_Jimmy.merge.AOD.e357_s462_d150_r642_t53

10 TeV

Background samples:
W+jets : mc08.10768XX.AlpgenJimmyWenuNpXX_pt20.recon.AOD.e368_s462_r635 (rel 14.2.25.8)
Z+jet : mc08.10765XX.AlpgenJimmyZeeNpXX_pt20.merge.AOD.e376_s462_r635_t53 (rel 14.2.25.8)
("XX" is from 0 to 5)
Diboson:
mc08.105985.WW_Herwig.merge.AOD.e379_s462_r635_t53_tid094701
mc08.105986.ZZ_Herwig.merge.AOD.e379_s462_r635_t53_tid065594
mc08.105987.WZ_Herwig.merge.AOD.e368_s462_r635_t53_tid065595
Single top:
mc08.105500.AcerMC_Wt.merge.AOD.e352_s462_r635_t53_tid064630
mc08.105502.AcerMC_tchan.merge.AOD.e352_s462_r635_t53_tid068303_3

Systematics samples:
Generator:
mc08.105206.AcerMCttbarHerwig.merge.AOD.e429_s462_r635_t53 (Herwig)
mc08.105205.AcerMCttbar.merge.AOD.e429_s462_r635_t53 (Pythis)
ISR/FSR
mc08.106250.AcerMCttbar.merge.AOD.e429_a84_t53_tid072754
mc08.106251.AcerMCttbar.merge.AOD.e429_a84_t53_tid072755

Physical object reconstruction

Electron
Pt>20GeV
isEM :Medium
0<|eta|<1.37 , 1.52<|eta|<2.47
Isolation (cone=0.2) : <6GeV

Jets
Pt>20GeV
|eta|<2.5
Cone4H1TowerJets
OR: electron within delR<0.2

Muon
Pt>20GeV, |eta|<2.5
Isolation (cone=0.2) :<6GeV
isCombinedMuon=true
author Staco muons
OR: jet within delR<0.3

MET
MET_RefFinal