上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Calibration of Quark versus Gluon Jet Tagging Variables With Charged-Particle Constituent Multiplicity

12/20/2018

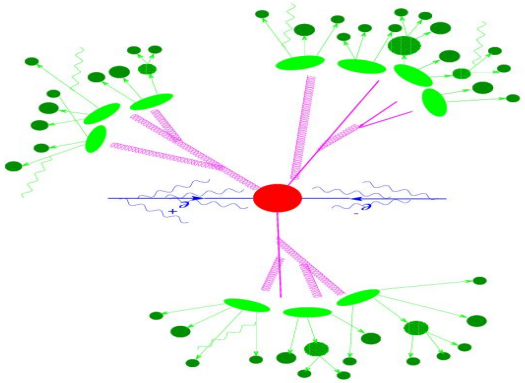
Wanyun Su[1], Ben Nachman[2], Shu Li[1]

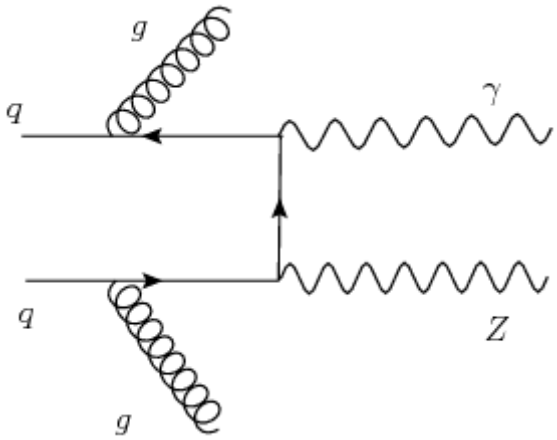
[1]Shanghai Jiao Tong University
[2]Lawrence Berkeley National Laboratory

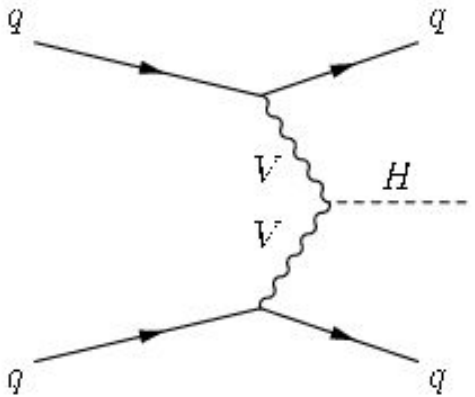
Introduction

- Quarks feel the strong interaction, mediated by gluons
- Not seen in the detector, due to confinement property of QCD,

Instead, they hadronize into mesons (qq) or baryons (qqq)







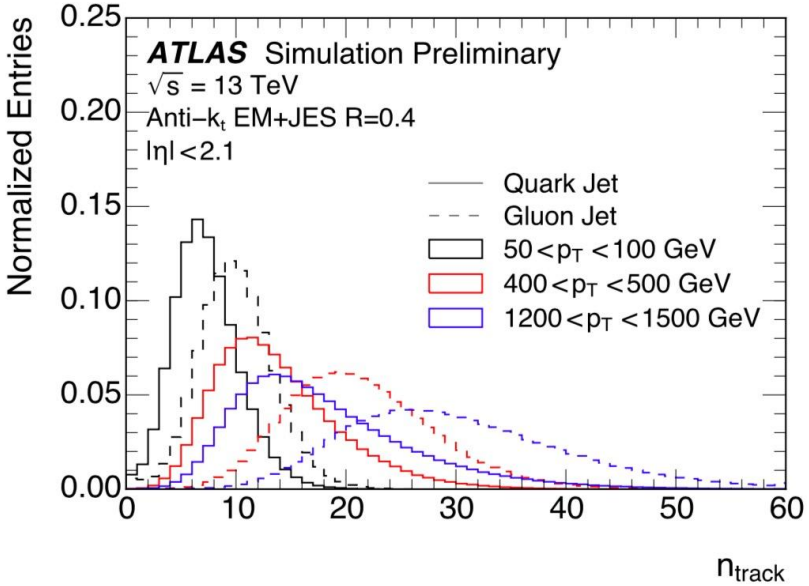
- Gluon and quark jets are difficult to distinguish:

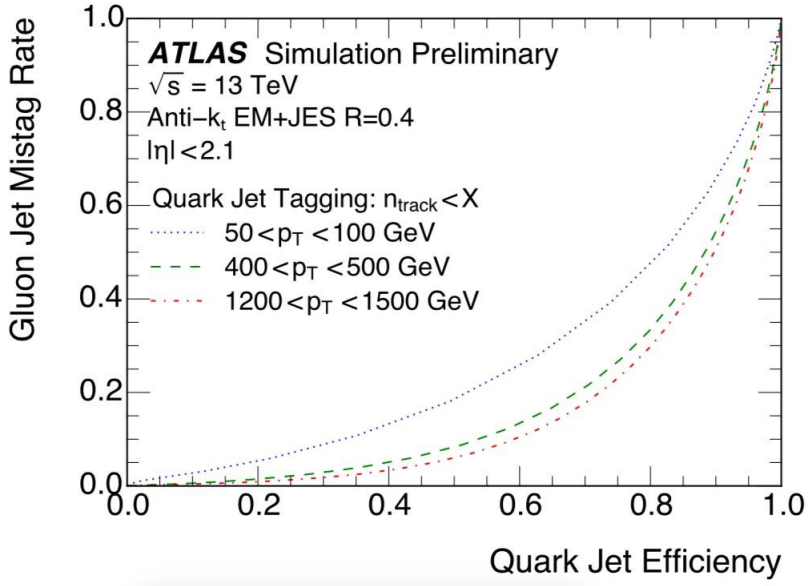
gluon jets tend to be wider and have larger multiplicity.

Track Multiplicity

- Rely on the existing Ntrack to perform in-situ determination of the quark/gluon tagger
- Evaluate the performance of any quark/gluon tagger
- Output the quark and gluon tagging efficiencies as function of the jet pT and eta in order to derive scale factors

ATL-PHYS-PUB-2017-009



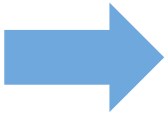


Dijet Topologies

- Dijet plus a gamma (quark dominated)
- Samples:mc16_13TeV.423[099-111].Pythia8EvtGen_A14NNPDF23LO_gammajet_DP*.deriv.DAOD_JETM4.e4453_s3126_r9781_r9778_p3260

- Dijet plus a third jet (gluon dominated)
- Samples:mc16_13TeV.3610[20-32].Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ[0-12]W.deriv.DAOD_JETM1.e*_s3126_r9781_r9778_p3260

Dijet Selection



- Leading jet has $p_T > 25$ GeV
- Subleading jet has $p_T > 20$ GeV
- ϕ separation of two leading jets: $\Delta\phi_{\text{leading,subleading}} > 2.5$
- Ordered $|\eta|$ selection: $|\eta_{\text{subleading}}| > |\eta_{\text{leading}}|$ and same z-hemisphere
- Third jet radiation cut:
  - If $\left|\eta_{3^{\text{rd}}\text{jet}}\right| > 2.5$, then $p_{T,3^{\text{rd}}\text{jet}} < \max\left\{12, 0.25 \cdot p_{T,\text{avg}}\right\}$
  - If $\left|\eta_{3^{\text{rd}}\text{jet}}\right| < 2.5$, then $p_{T,3^{\text{rd}}\text{jet}} < \max\left\{14, 0.25 \cdot p_{T\text{avg}}\right\}$ and $\text{jvf}_{3^{\text{rd}}\text{jet}} > 0.25$

Flavor Label and Match

Labeling

- Jets can be labeled using the attribute 'PartonTruthLabelID'
  - Quarks: PartonTruthLabelID<=8
  - Gluons: PartonTruthLabelID==21 or 9

Matching

- Two methods to identify whether the jets are hard scatter jets
  - DeltaR matching(used in this case)
  - GhostAssociation matching

Quarks

Name	pdgId
d	1
u	2
s	3
c	4
b	5
t	6
b'	7
t'	8

Gauge and Higgs Bosons

Name	pdgId
g	(9)21
γ	22
Z^0	23
W^+	24
h^0/H^0 1	25
H^+	37

Using the package:https://gitlab.cern.ch/atlas- jetetmiss- jesjer/Insitu/ Dijet- Insitu- Calibration- and- Resolution

Control region selection

Gluon jets control region(Dijet jets samples)

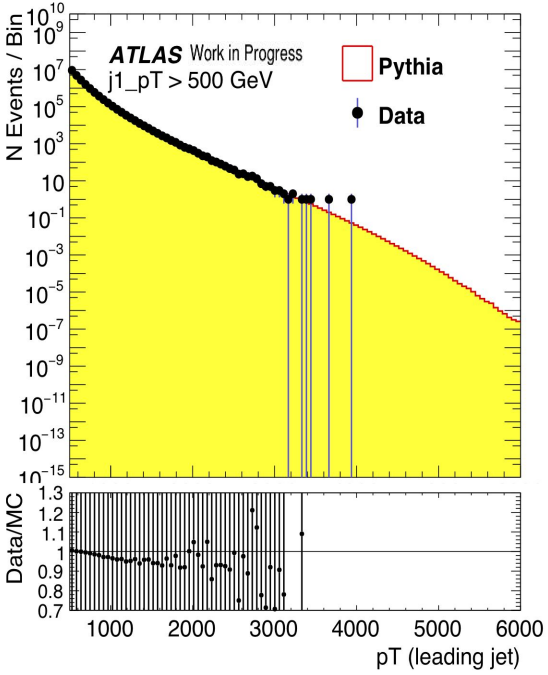
- 1. events firing the lowest unprescaled single jet trigger'HLT j400'
- 2. leading three reco jets with pT>20 GeV, |η|<2.4 (jets between 20<pT<60 GeV, requiring JVT>0.59)
- 3. leading three reco jets are selected to be hard-scatting jets using DeltaR matching : reco jet within ∆R<0.4 of the truth jet,with relevant truth jets pT>10 GeV.
- 4.look at the 3rd jet.

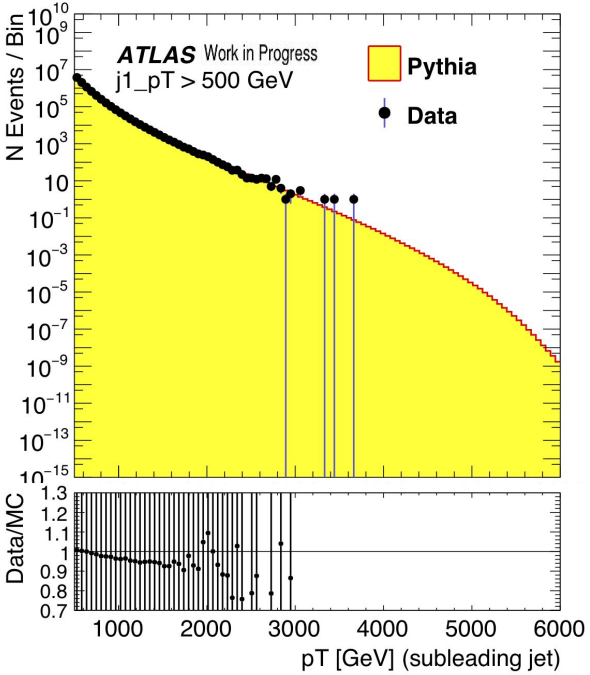
Quark jets control region(gamma+jet samples)

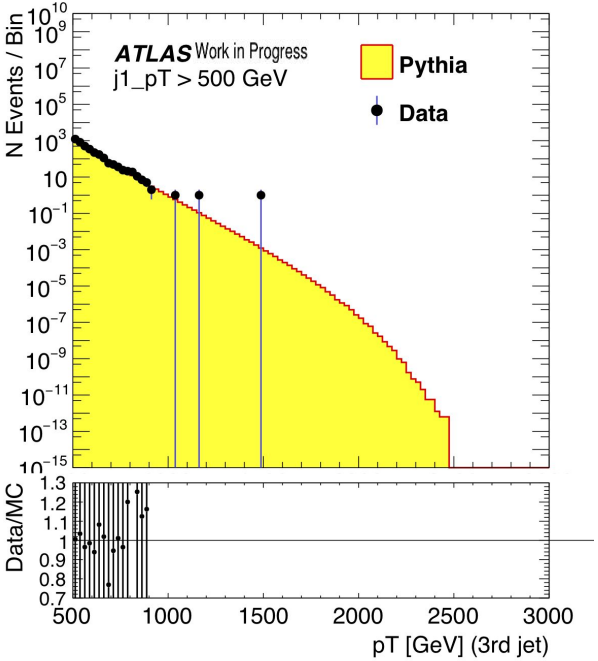
- 1.same requirements as 2,3 above
- 2.look at which of the leading two jets has a smaller ∆R = sqrt(∆η +∆φ) to the photon

Reconstruction jet pT spectrum

- Normalized mc to data ,checked the consistency of leading three jet pT ,drive the ratio of Data/MC

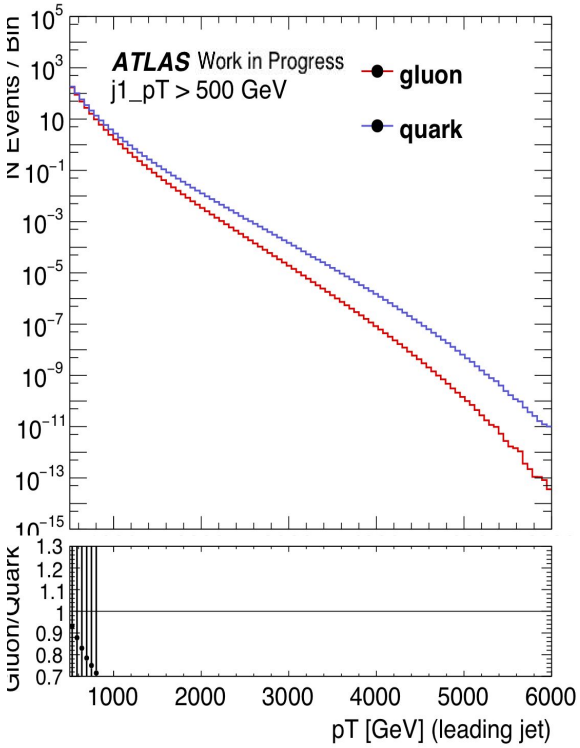


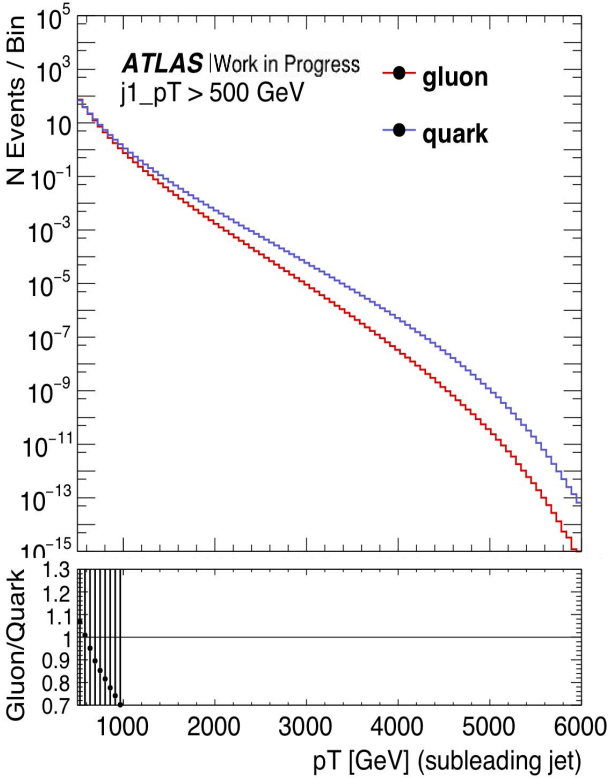


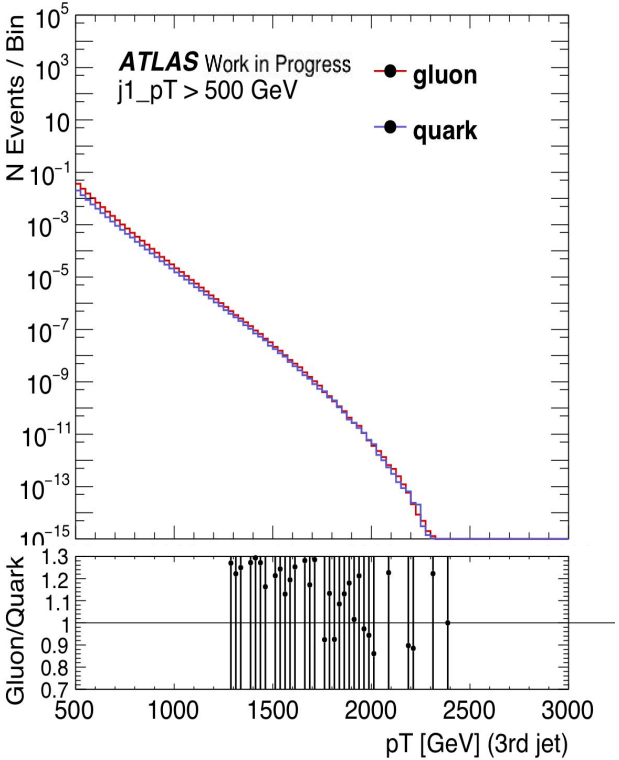


Reconstruction gluon jet fraction

- checking the gluon/quark fraction of leading three jet pT
- 3rd jets in dijet samples are likely to be gluon jet.

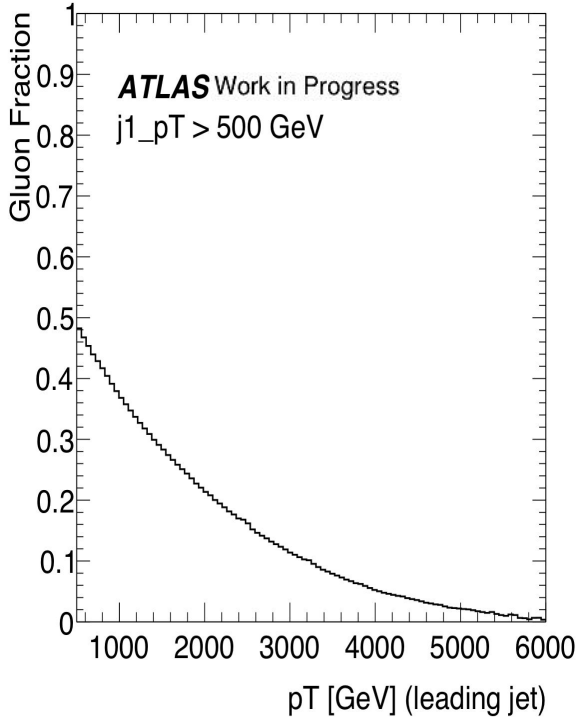


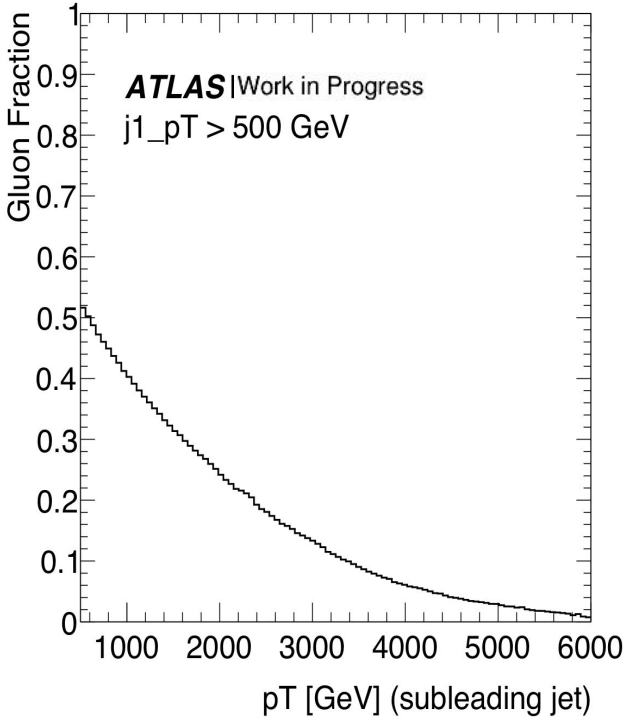


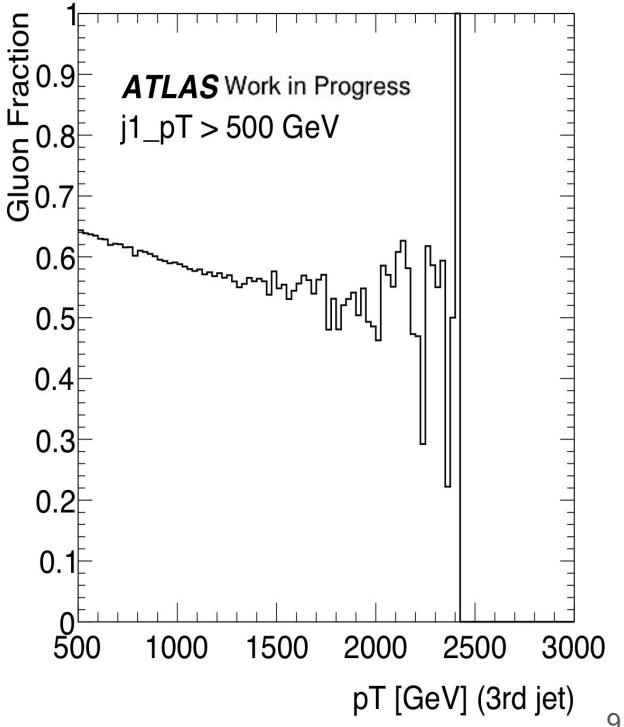


Reconstruction gluon jet fraction

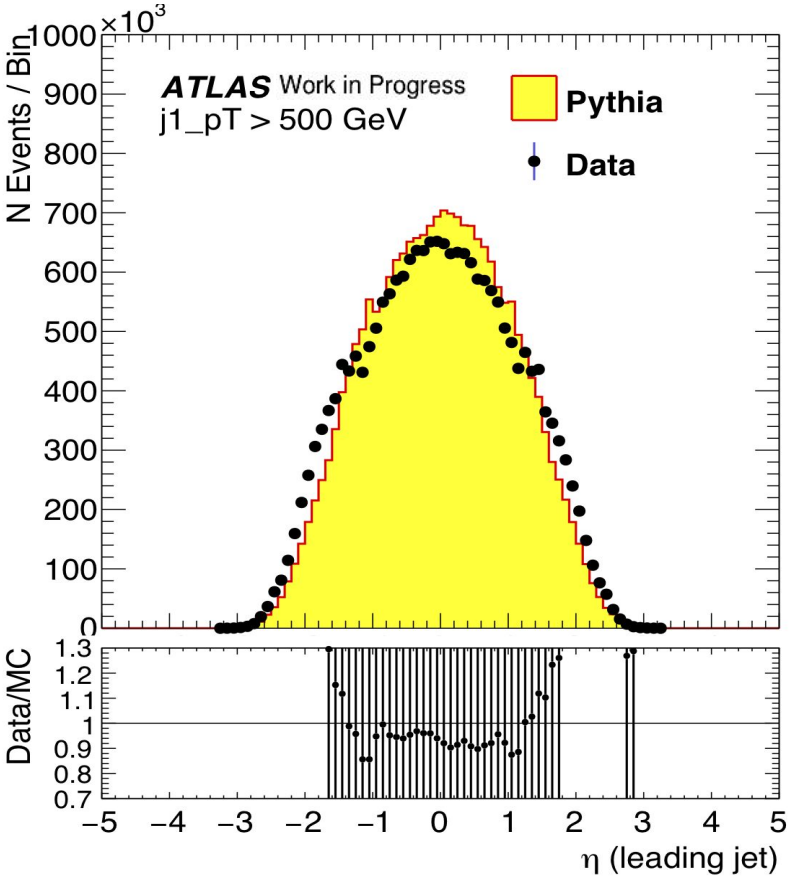
have a more detailed look at gluon fraction..



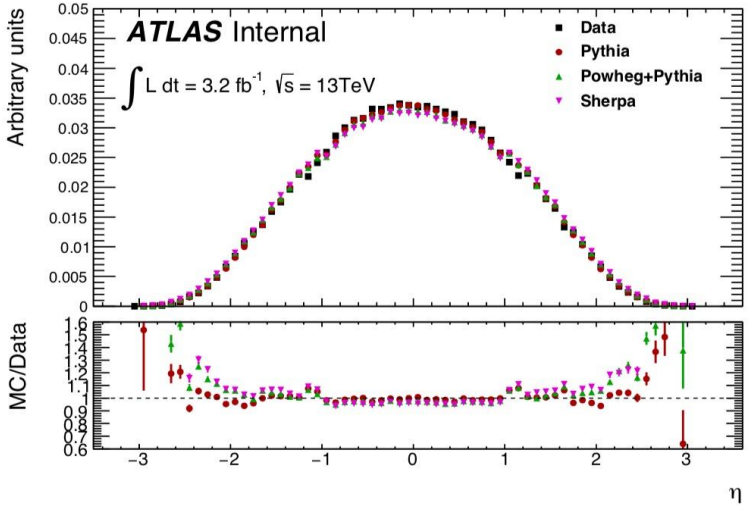




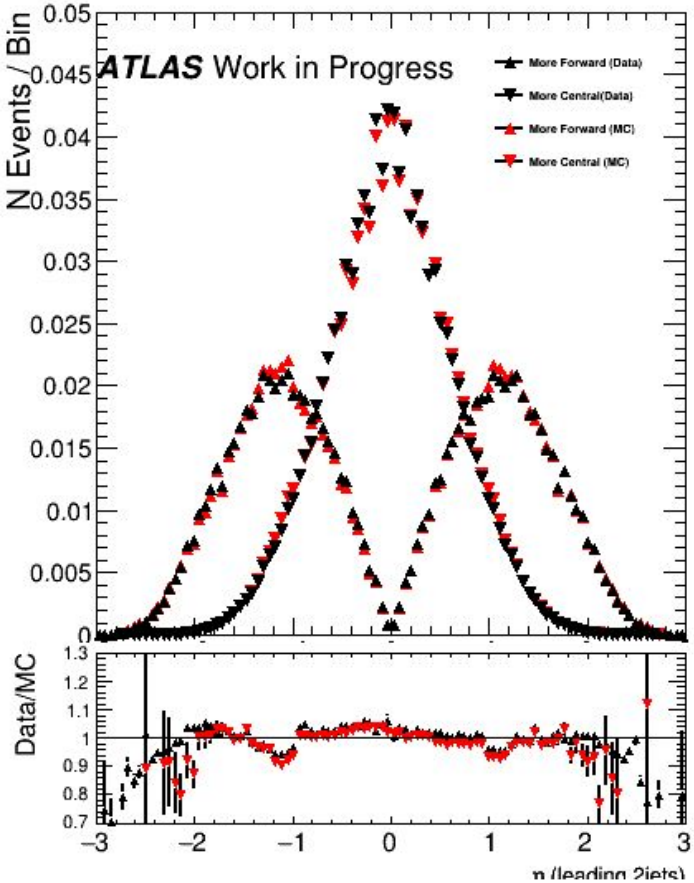
Reconstruction jet η spectrum



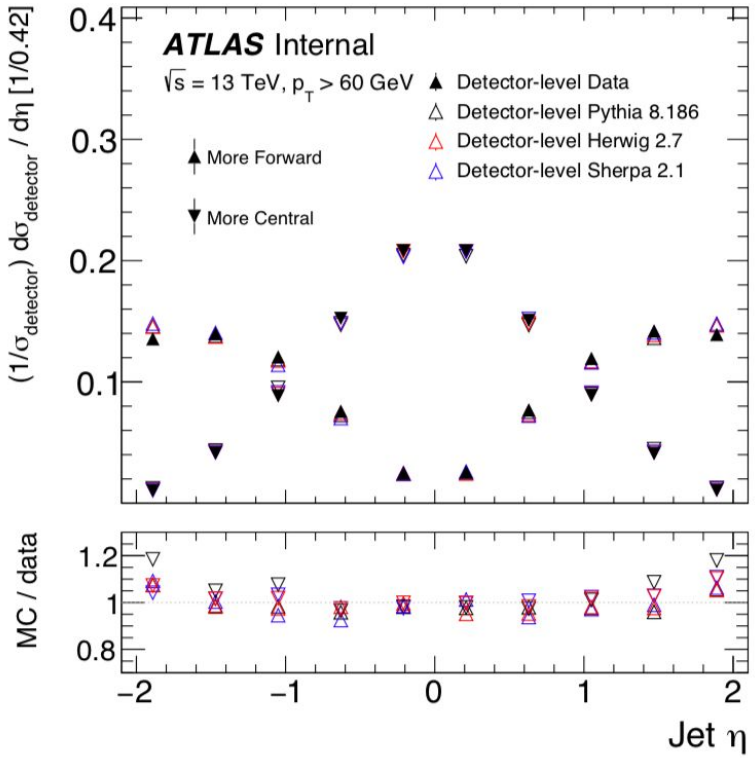
- It's actually consistent with note: https://cds.cern.ch/record/2630397/files/CERN-THESIS-2018-098.pdf



Reconstruction jet η spectrum

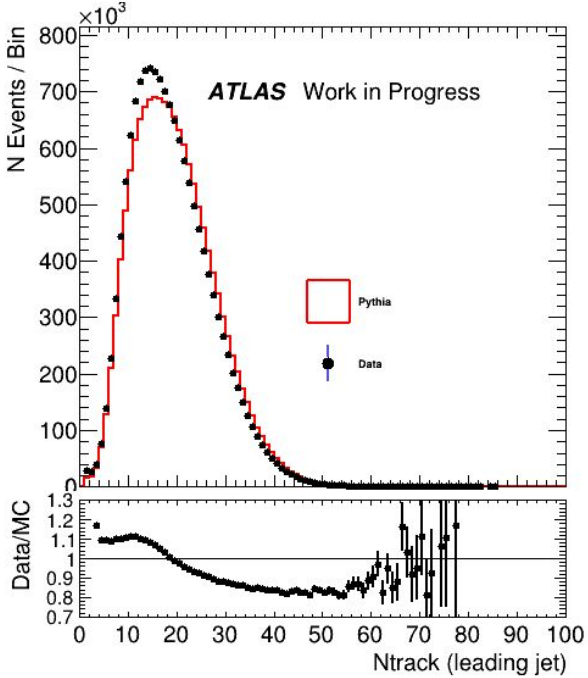


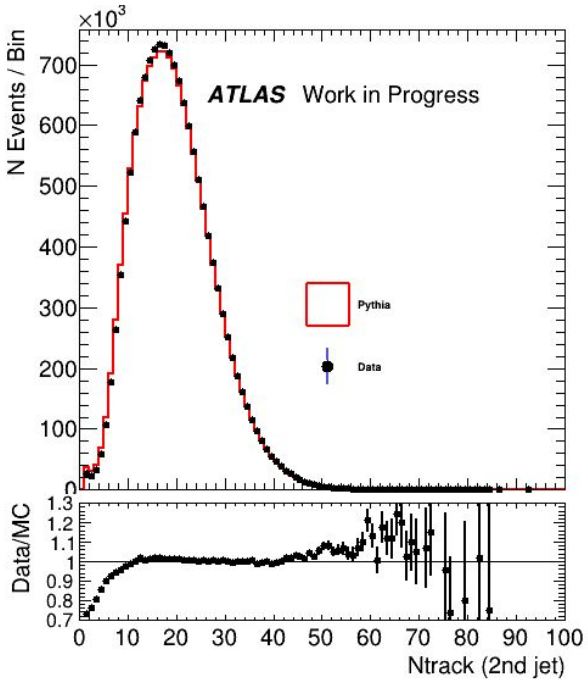
- Support note: https://cds.cern.ch/record/2259091

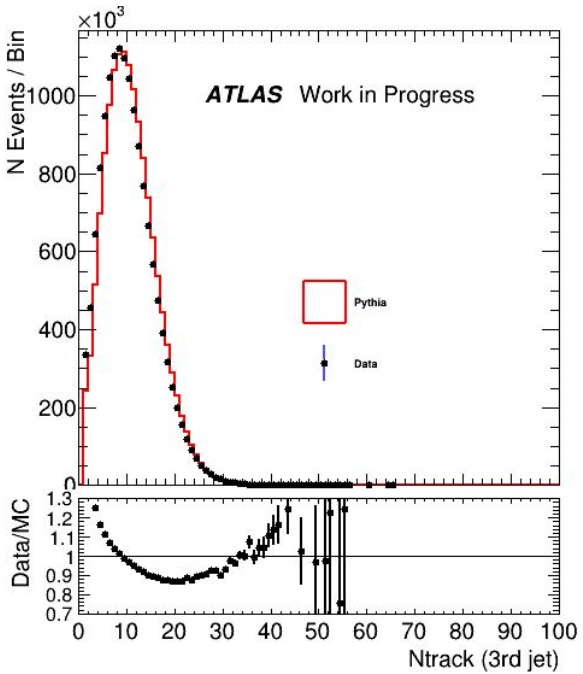


Reconstruction Ntrack for MC and Data

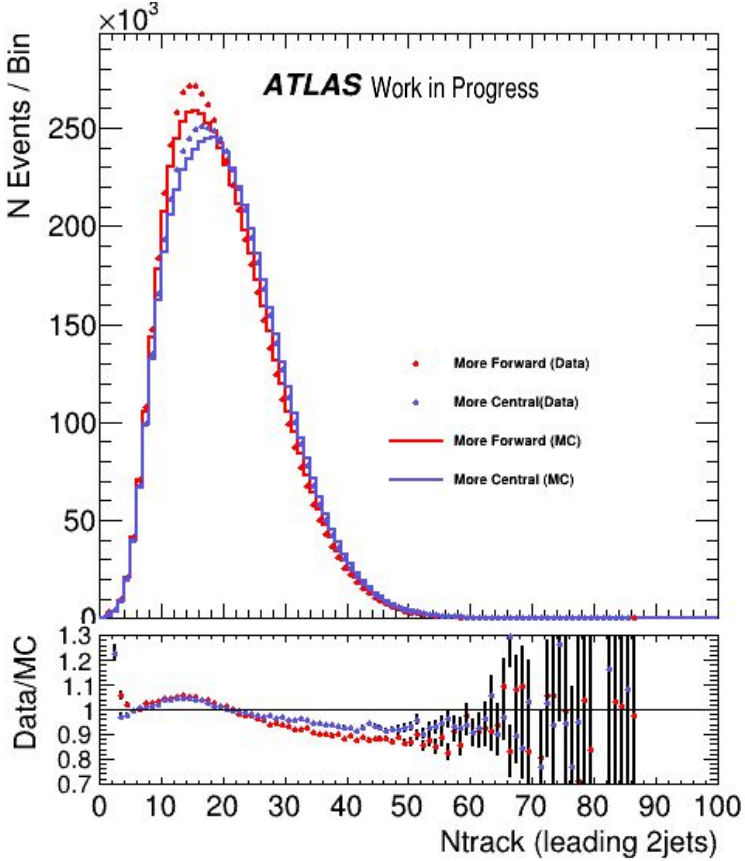
Cut: both leading and subleading jet pT > 500 GeV and |η| < 2.1

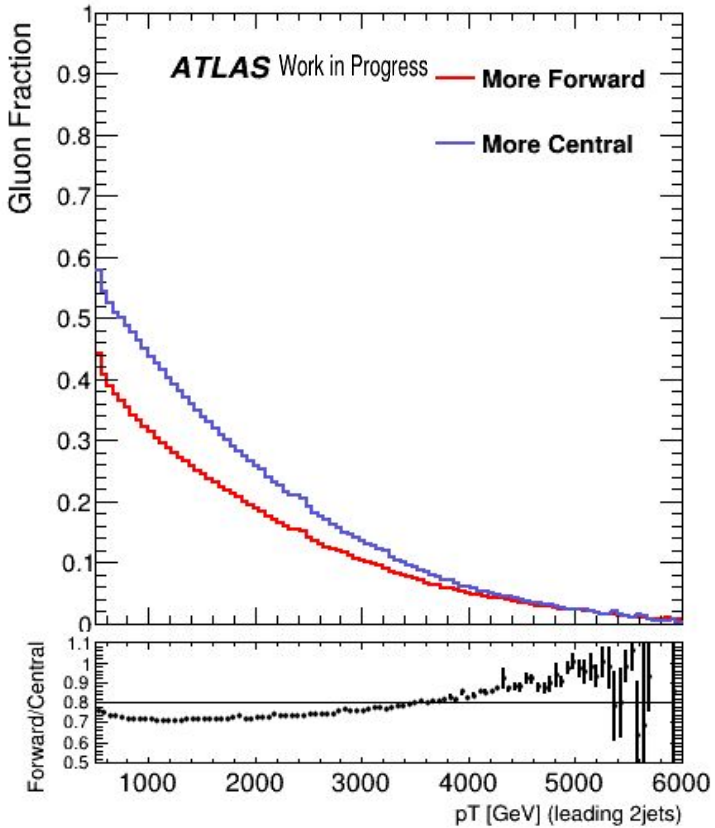






Ntrack and pT spectrum for more forward/central jet





In conclusion:

- Jet fragmentation can be distinguished by the jet pT and η, the inhomogeneous detector response and particle-level topology effects might cause the difference.

- Check the fraction of the more forward and the more central jets that are gluon-initiated.

- More central jets have higher gluon fraction,as their Ntracks indicate more constituent multiplicity