Measurement of gluon jet fraction in the inclusive jets channel

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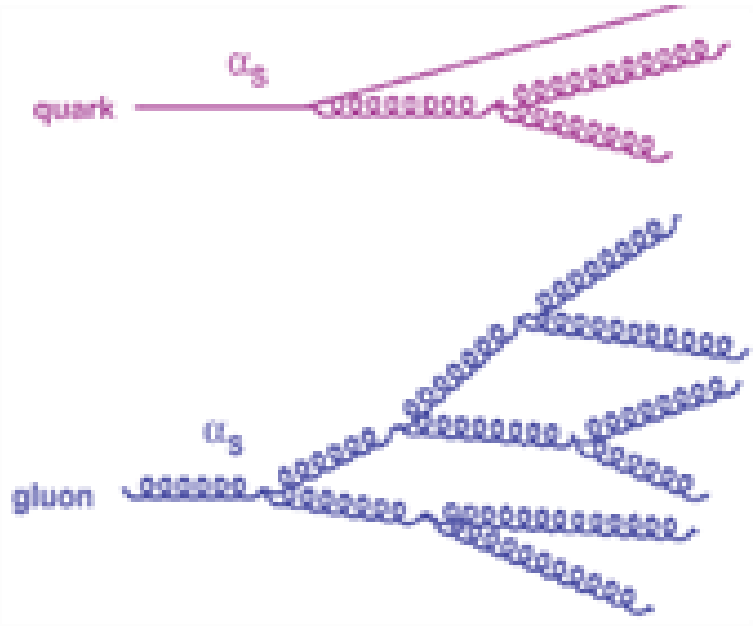
Introduction

- Jets are the result of showering and hadronization of outgoing partons
- If a jet can be associated with a quark/gluon - it is defined as a quark/gluon jet



Quark jet

Gluon jet

- With this analysis we want to measure gluon jet fraction in inclusive multi-jet data

Data and MC Samples

- Data 2016 UltraLegacy SMP-HAD Ntuples:
  - "/eos/cms/store/group/phys_smp/Multijet/13TeV/UltraLegacy/UL16/"
    "B.root", "C.root", "D.root", "E.root", "Fe.root", "Fl.root", "G.root","H.root“
- MC Pythia+MadGraph Ntuples:
  - “/eos/cms/store/group/phys_smp/Multijet/13TeV/UltraLegacy/UL16/MGP8CP5_Binned”
  - “/eos/cms/store/group/phys_smp/Multijet/13TeV/UltraLegacy/UL16/MGP8CP5_Binned_APV”
    "HT_50to100.root", "HT_100to200.root", "HT_200to300.root", "HT_300to500.root",
    "HT_500to700.root", "HT_700to1000.root", "HT_1000to1500.root, , "HT_1500to2000.root“,
    "HT_2000toInf.root"
- Analysis bins:
  - p_t bins: {49, 56, 64, 74, 84, 97, 114, 133, 153, 174, 196, 220, 245, 272, 300, 330, 362, 395, 430, 468, 507, 548, 592, 638, 686, 737, 790, 846, 905, 967, 1032, 1101, 1172, 1248, 1327, 1410, 1497, 1588, 1684, 1784, 1890, 2000, 2116, 2238, 2366, 2500}
  - y bins: {0, 0.5, 1, 1.5, 2}

Event selection

- AK4 CHS jets is used
- At least one jet with $p_T > 49$ GeV and $|y| < 2$
- $E_T^{miss} / \sum E_T < 0.3$
- MET Filters
- Tight Jet ID
- “GoodPV” condition
- Remove jets from hotspots
- Apply prefiring weights
- PU reweighting
- Unfolding of pT-jet distribution

} Not ready yet

MC information

MC file	Number of events	σ, μb
HT_50to100.root	38967841	186.1
HT_100to200.root	96272215	23.63
HT_200to300.root	55579875	1.554
HT_300to500.root	57614989	0.3238
HT_500to700.root	59655356	0.03028
HT_700to1000.root	47387524	0.006392
HT_1000to1500.root	15308062	0.001118
HT_1500to2000.root	10384159	0.0001089
HT_2000toInf.root	5337587	0.00002193

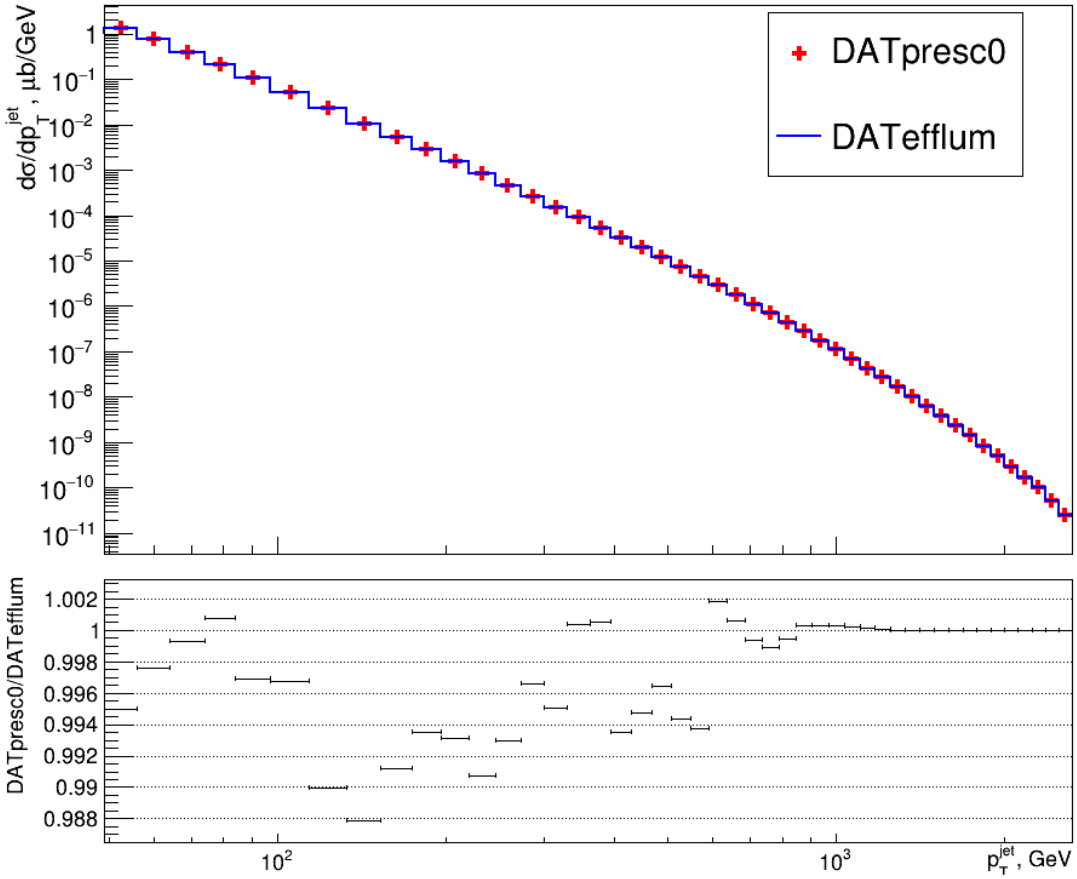
Triggers

Trigger name	Trigger ranges, GeV	L_{eff}, μb^{-1}
HLT_PFJet40	49-84	267102.0
HLT_PFJet60	84-114	726442.6
HLT_PFJet80	114-196	2759571.8
HLT_PFJet140	196-272	24200090.1
HLT_PFJet200	272-330	103855785.3
HLT_PFJet260	330-395	593903056.6
HLT_PFJet320	395-468	1772915556.4
HLT_PFJet400	468-548	5195564785.9
HLT_PFJet450	548-6500	36329675572.0

- All triggers were prescaled, that is why we have to recover initial number of events

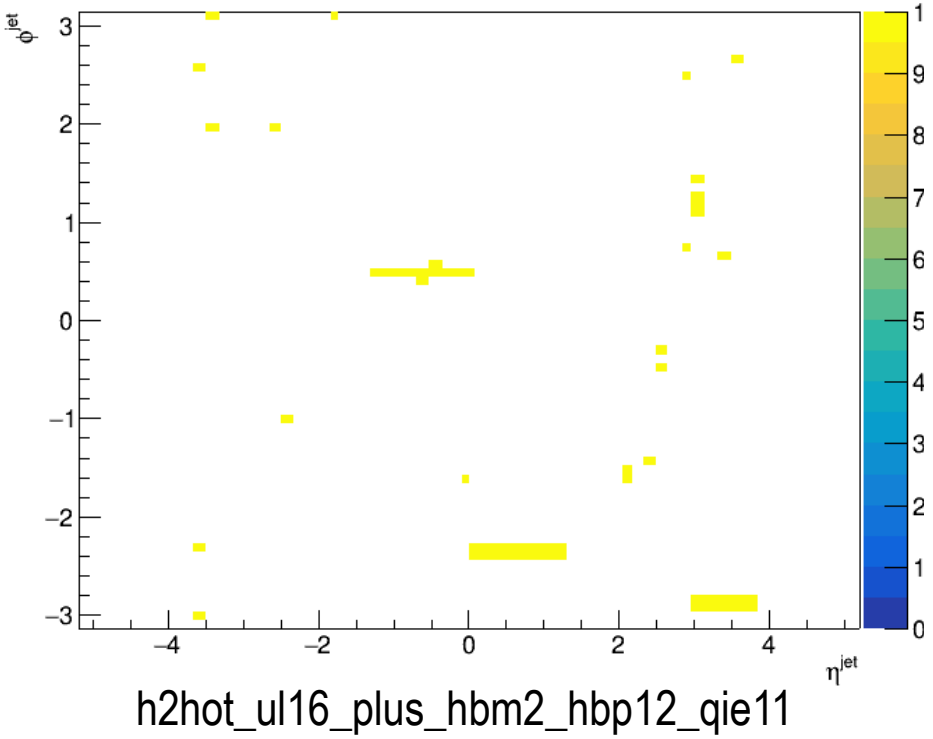
https://twiki.cern.ch/twiki/bin/viewauth/CMS/InclusiveJetsLegacy

Prescaling method comparison

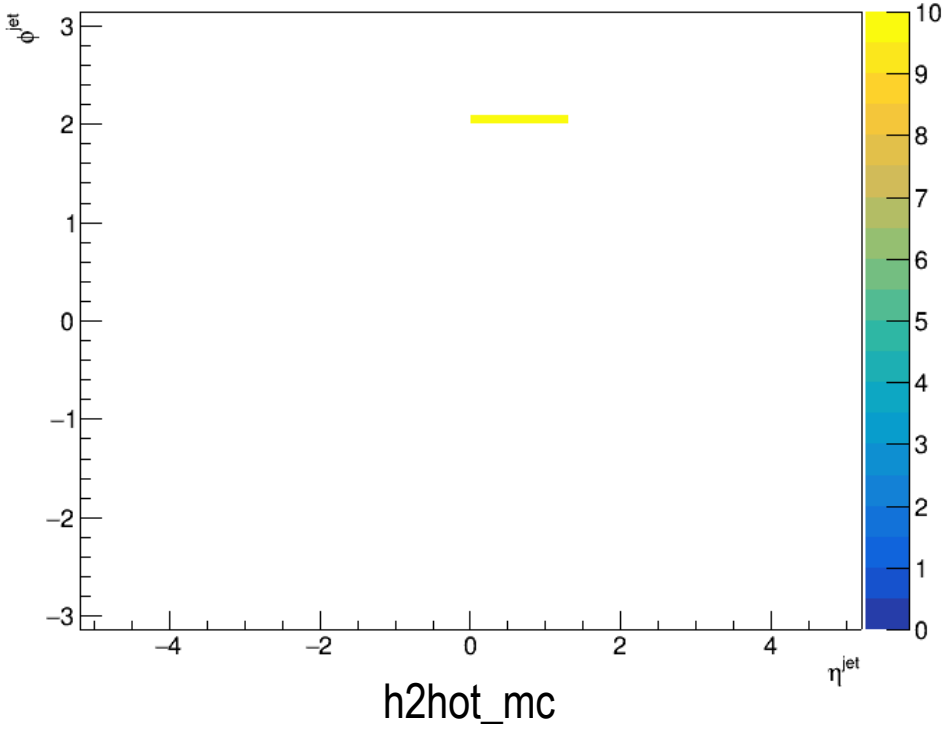


- The difference between two methods within 1%

Hot zones



h2hot_ul16_plus_hbm2_hbp12_qie11

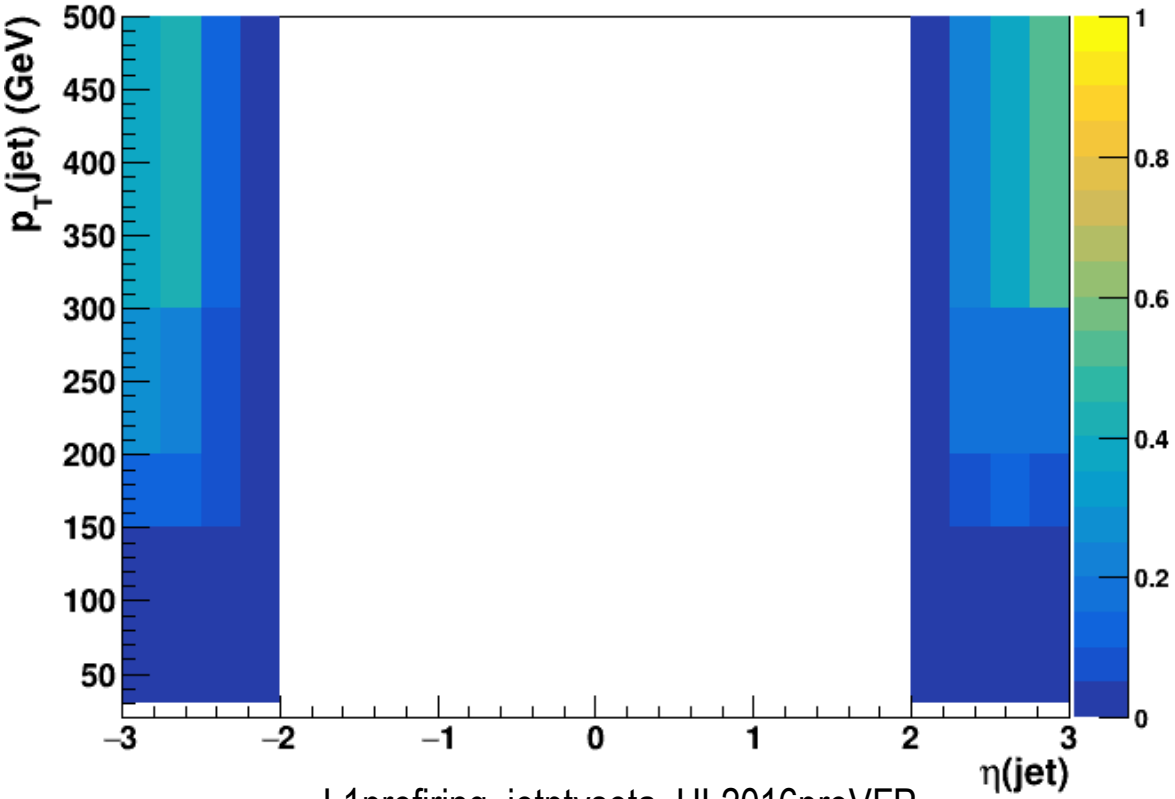


h2hot_mc

- We merge these maps and apply combine version for data and MC

https://github.com/cms-jet/JECDatabase/tree/master/jet_veto_maps/Summer19UL16_V0/hotjets-UL16.root

Prefiring



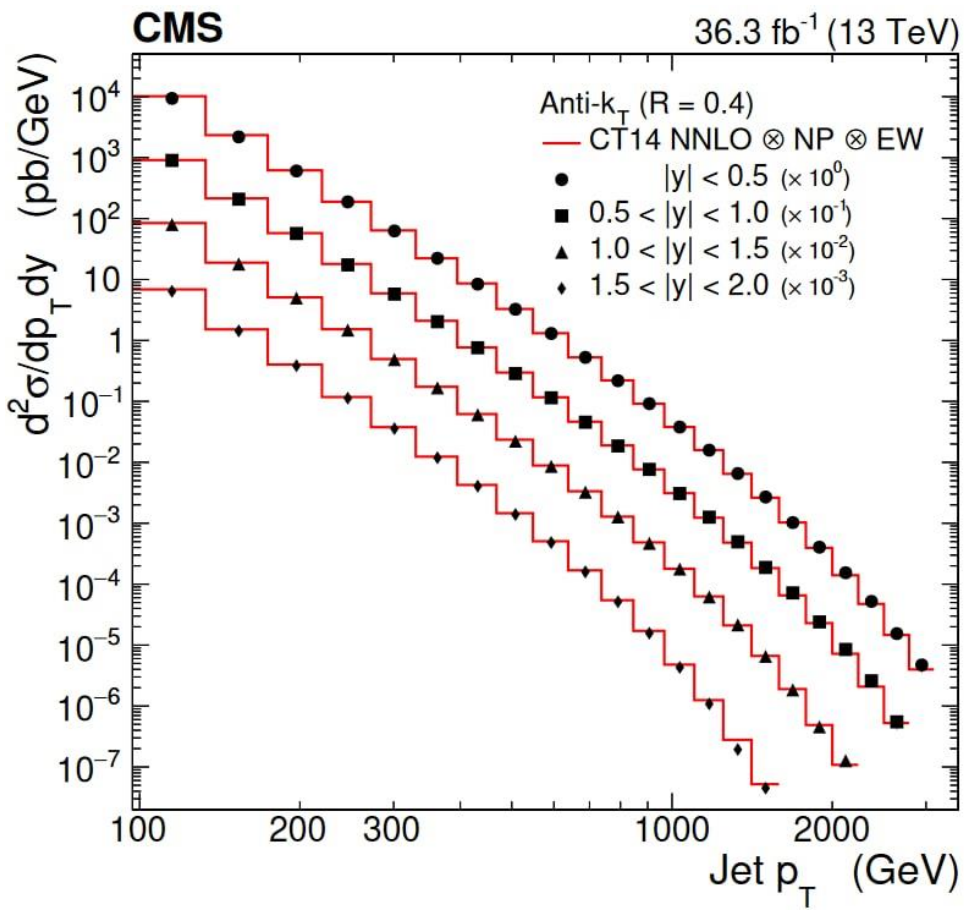
L1prefiring_jetptvseta_UL2016preVFP

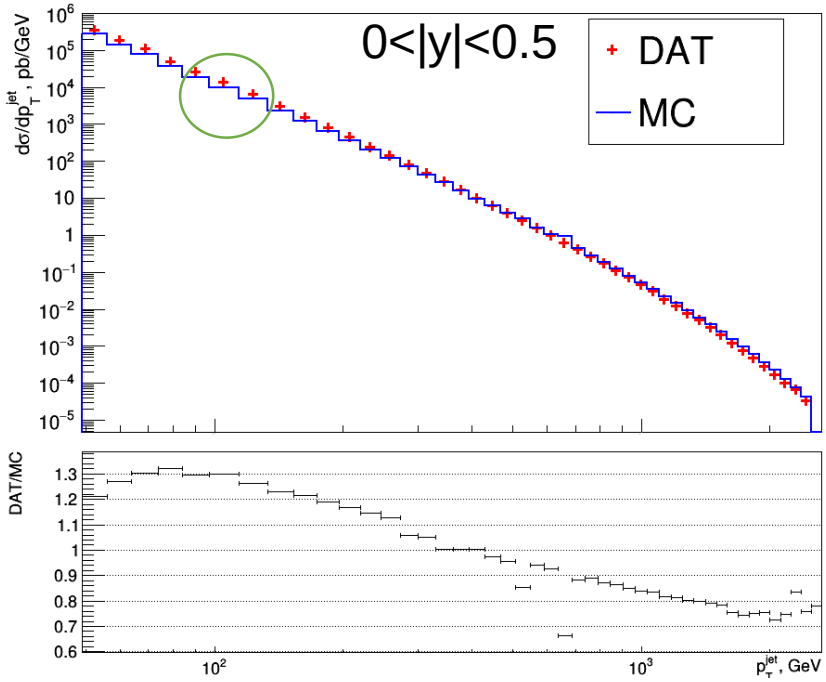
- Prefiring weights applied **after JEC**
- If multiple jets are in prefiring regions we **multiply weights**
- Prefiring weights are applied on **all jets** from event

- Each prefired event is multiplied by: $weight = \frac{1}{\prod_i (1 - P_i(\eta, p_T))}$

https://twiki.cern.ch/twiki/bin/viewauth/CMS/L1PrefiringWeightRecipe

Differential inclusive jet cross sections





- The agreement between data and MC is within 20% up to 1 TeV, and data are lower than MC in the region pTjet > 1 TeV no more than 30%.

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Gluon jet fraction extraction

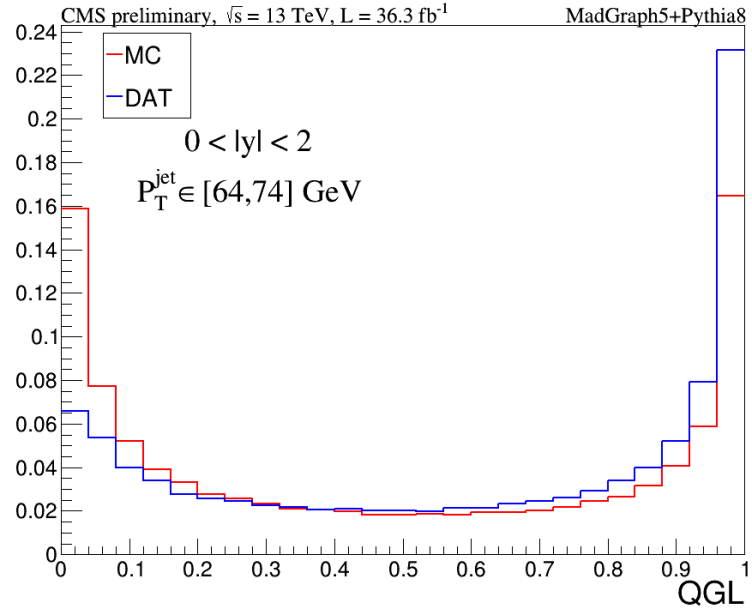
- Gluon jets are distinguished from quark jets with the use of a Quark-Gluon Likelihood (QGL)

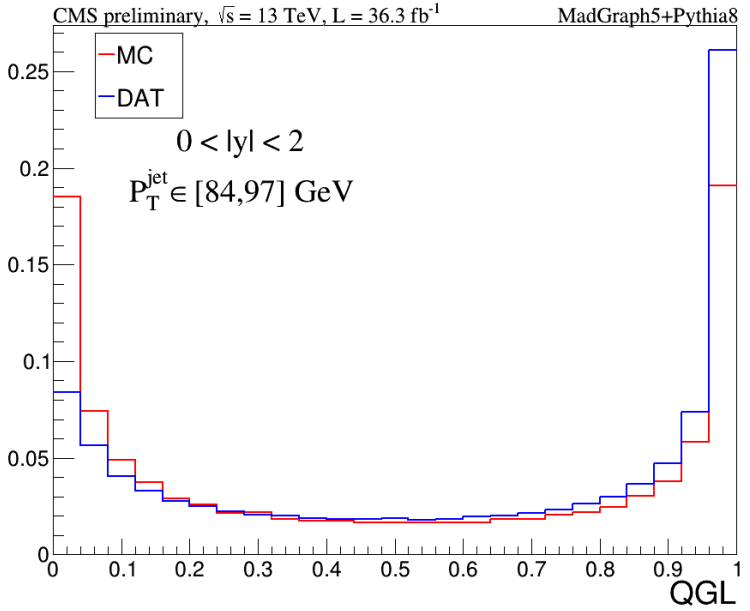
- We first make QGL distributions for data and MC: $H^{data/MC}(D)$

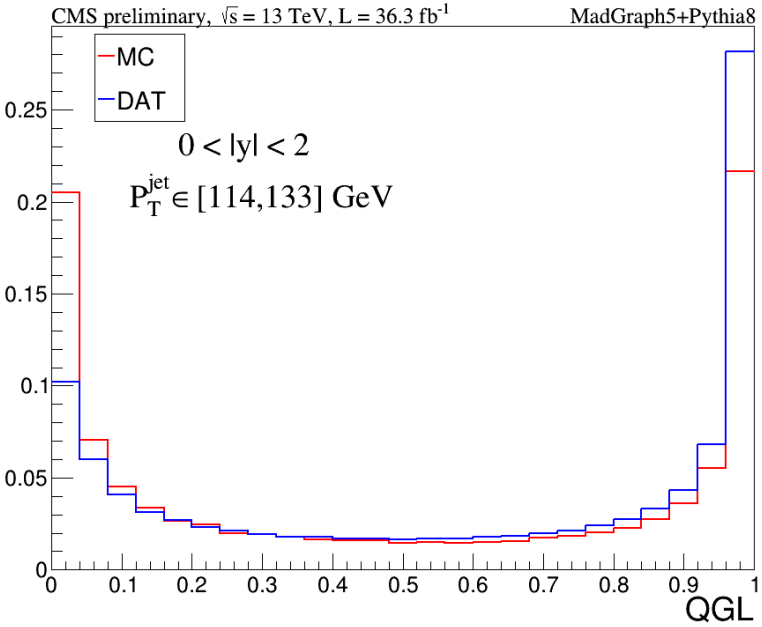
- Then we create quark jet ($H_q^{MC}(D)$) and gluon jet ($H_g^{MC}(D)$) QGL templates normalized to unity from MC and fit QGL distributions by these templates
  - We use 1-parameter fit with weighted least squares method
  - After fitting of MC QGL distribution we are expecting full match with generator gluon fraction

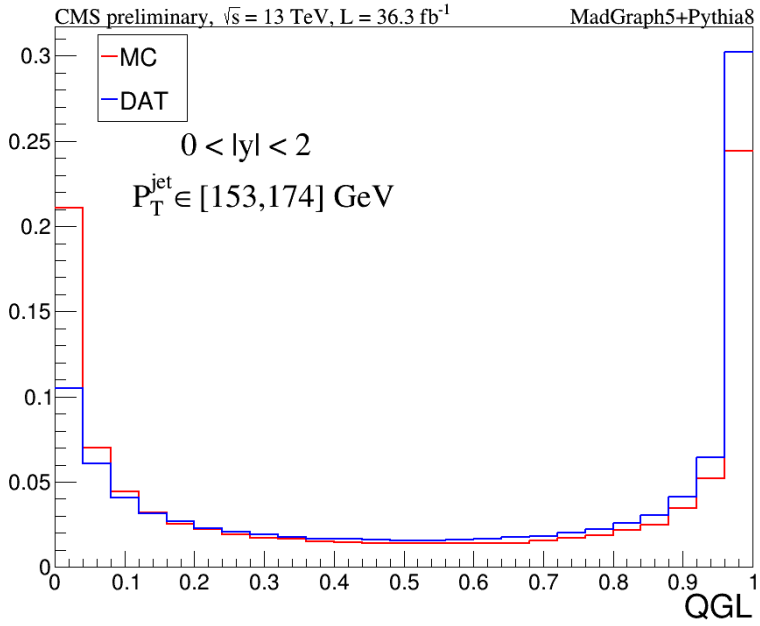
$$H^{data/MC}(D) = \alpha_g H_g^{MC}(D) + (1 - \alpha_g) H_q^{MC}(D)$$

QGL distributions for data and MC









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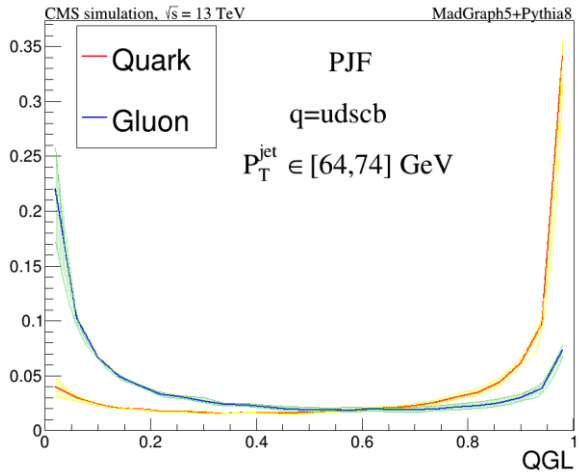
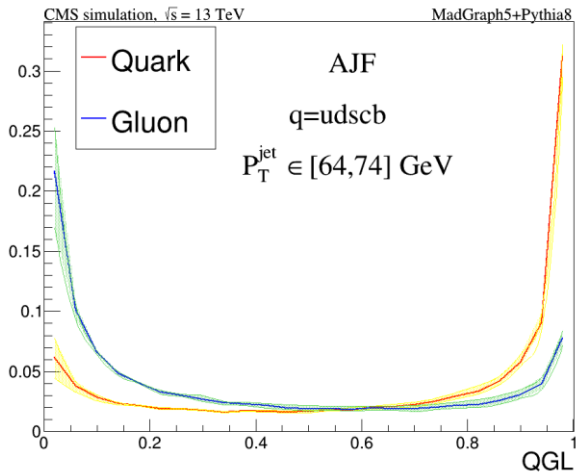
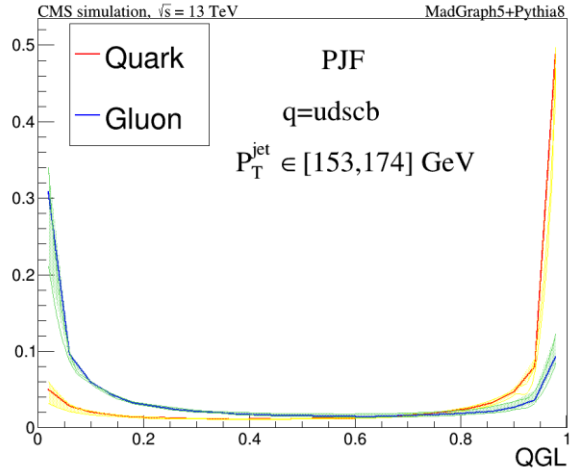
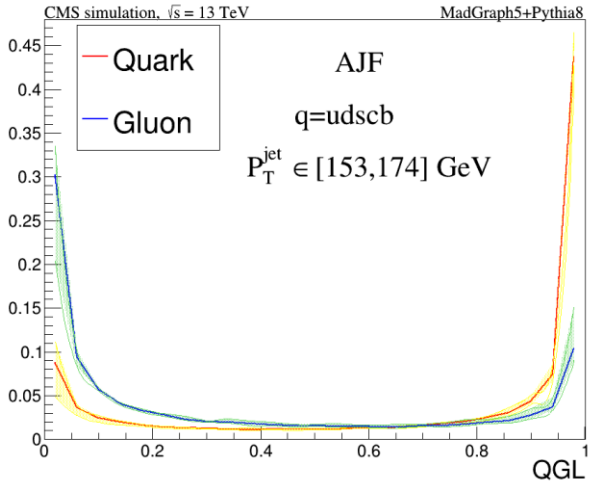
Quark and gluon QGL templates









- We demonstrate here that q/g-templates depend on jets kinematics:
  - Lines – q/g-templates for 0<|y|<2;
  - Shaded areas are minimum and maximum among jet samples in y bins

Conclusion

- The aim of this work is to measure g-fractions in pT-jet bins
- To be able to compare MC and data several corrections were applied after which corrections differential cross section should be same in MC and data
- Two methods of prescaling were done and shown that there give similar results
- Hot zones of detector and prefiring effect was taken into account and latest JEC was applied
- Measurement of differential inclusive jet cross section was done on CMS data (Run-II, 2016, $36.3 fb^{-1}$): the results are in good agreement with the published CMS results.
- The difference between differential inclusive jet cross section in MC and data was shown, but it should be corrected by PU reweighting and unfolding – it will be done soon
- A technique for measuring fractions and calculating uncertainties has been developed. The results are being prepared for approval in the CMS collaboration