# Measurements of charged-particle multiplicities in jets and gluon jet fractions for jet samples selected in dijet channel produced in pp-collisions at $\sqrt{S}$ = 13 TeV with the CMS detector (Run-II)


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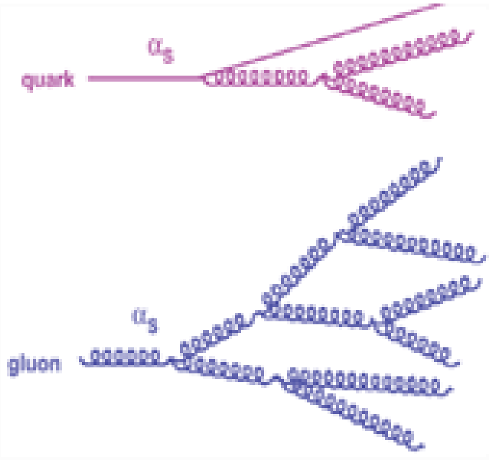
# Introduction

- Hadron jet is a narrow cone of hadrons and other particles produced by the hadronization of a quark/gluon
- The properties of the jets are highly dependent on their flavour

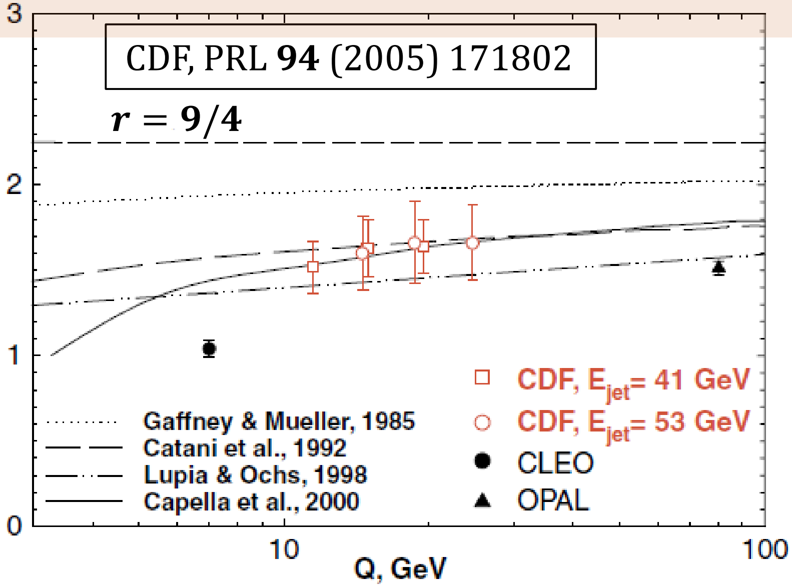



Quark jets $C_F = \frac{4}{3}$

Gluon jets $C_A = 3$

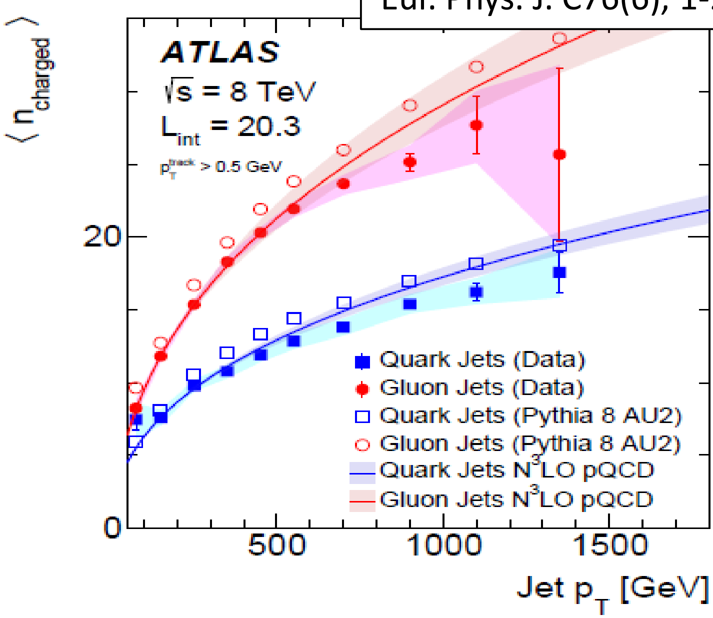
- Difference in the properties of jets makes it possible to separate quark jets from gluon jets

# From history




## $p\bar{p}$-collisions (CDF, 2005 )

- dijets (60% g-jets)
  $\gamma$+jet (20% g-jets)
- "biased jets" (cone jet finder R=0.28-0.47)
- Good separation q/g-jets for region
  $E_{jet}$~41-53 GeV

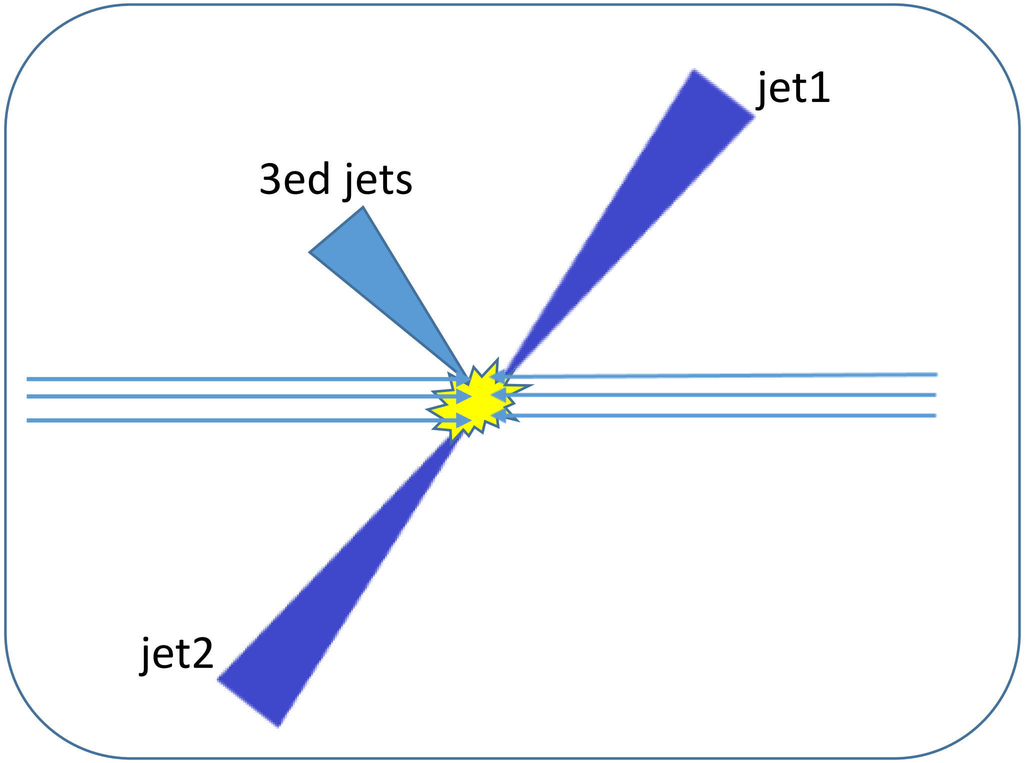



## $pp$-collisions(ATLAS, Run-I, 2016)

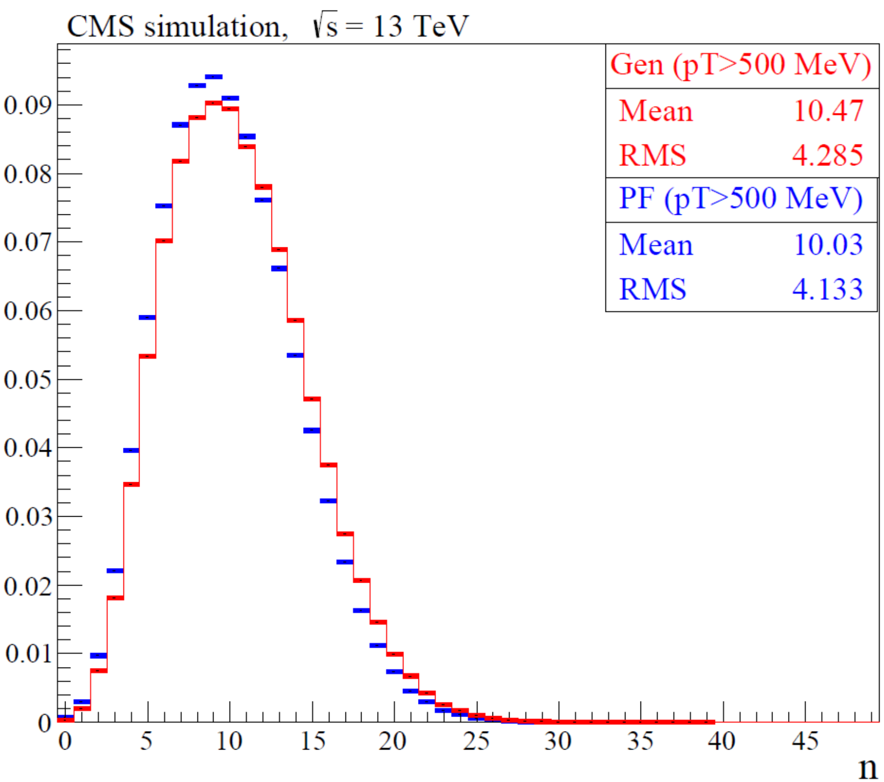
- Measurements in bins ~100 GeV
- For extractions $\langle \boldsymbol{n^g} \rangle$ and $\langle \boldsymbol{n^q} \rangle$ gen values of g-fractions was used
- Track-PV Matching:
  $|z_0 \sin(\theta)| < 1.5mm$ и $|d_0| < 1mm$

# Event Selection

- Jet type: PFchs
- Anti-kt algorithm is used with R=0.4
- At least two jets with $P_T^{jet} > 30$GeV and $|\eta| < 2.3$
- $\Delta\varphi(jet_1, jet_2) > 2.7$
- $\frac{P_T^{jet1}}{P_T^{jet2}} > 1.5$



# Track-PV matching




- If track is used in the PV fit or very close in dZ to the PV (dZ < 5σ и dZ < 0.5 mm ) – PV track
- If the track is not compatible with the PV but it is close to the nearest jet axis starting from the PV – SV track
- If none of the above criteria is satisfied, hence the closest in dZ vertex is associated – PU track

Criterion of matching: **CPM of PF jets should be less, than CPM of Gen jets**

CPM – Charged Particle Multiplicity

# Measurement of mean jet CPM

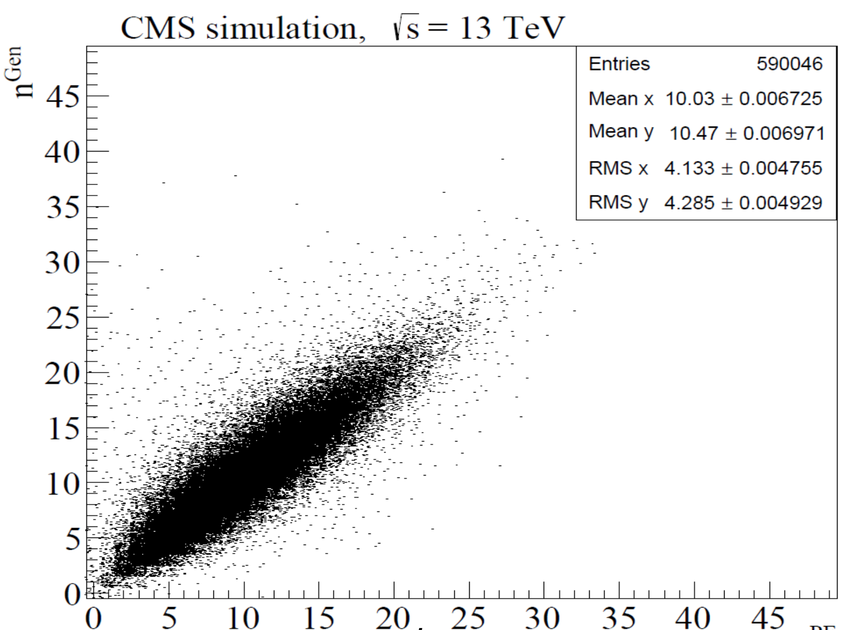
- Mean jet CPM's are measured in three jet samples with different number jets in event:
  - 2, 3 or 4, 5 and more jets in event
- Residual corrections for measured mean jet Pt are applied
- "PU+fake jets" distribution from measured jet CPM distribution are subtracted
- Correction of mean jet CPM for **LET** (low energy tracks and tracks outside tracker acceptance)
- Correction for lost and fake tracks is made by **Unfolging** of jet CPM distributions

# Unfolding

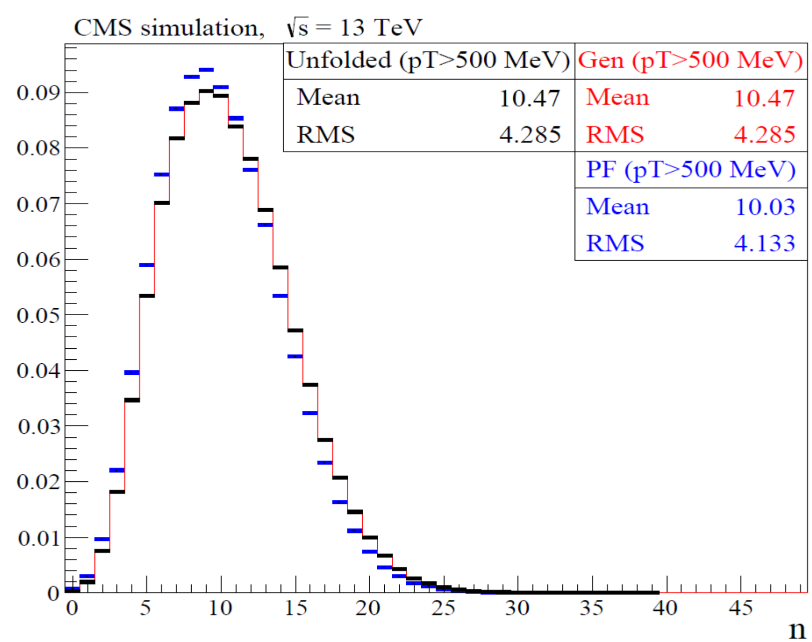
## How it works

1. We compare objects (tracks, jets) on generator level with the same objects after reconstruction
2. We correlate them and make response matrix
3. Apply response matrix for data

- ➢ Unfolding corrects CPM in data for lost and fake tracks
- ➢ Iterative Bayesian unfolding with 4 iterations (RooUnfold package) is used
- ➢ Uncertainty of Unfolding are obtained by random variations of unfolded histogram (toy MC)




Response matrix, $P_T^{jet} \in [120,150]$ GeV



# Quark-Gluon Likelihood

- Discriminating variables $(x_i)$ :
  - The particle multiplicity (larger for gluon jets)
  - The minor axis of the jets profile ellipse (larger for gluon jets)
  - The fragmentation function : $\frac{\sqrt{\sum_i p_{T,i}^2}}{\sum_i p_{T,i}}$ (smaller for gluon jets)

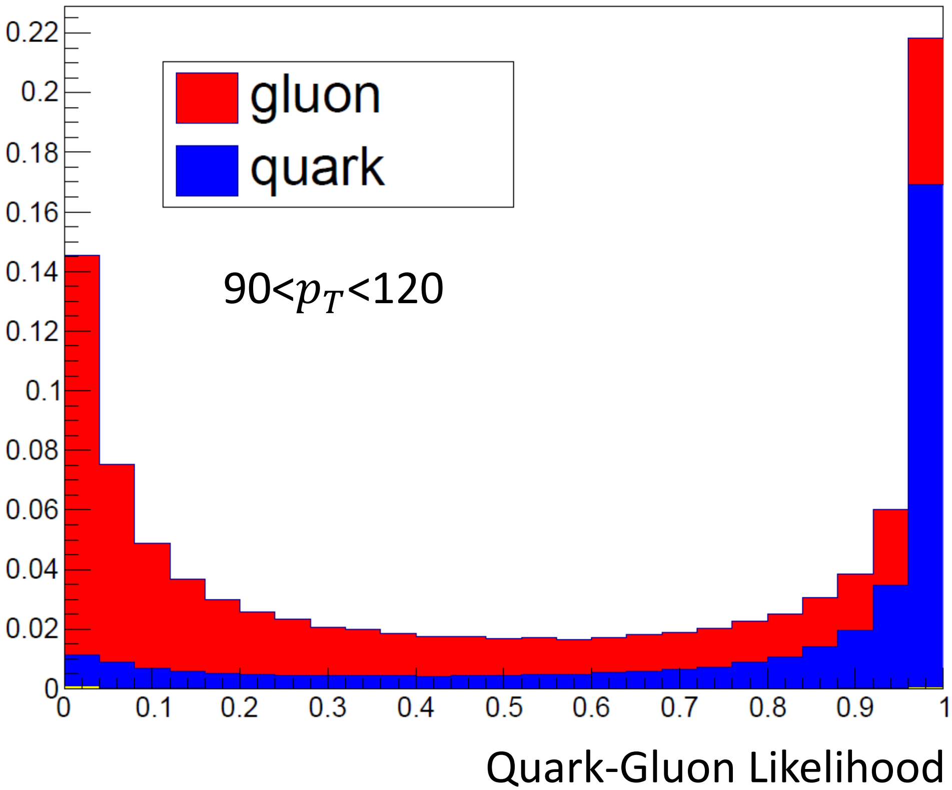
- $\mathrm{QGL}(\vec{x}) = \frac{Q(\vec{x})}{Q(\vec{x})+G(\vec{x})}$ - QGL value

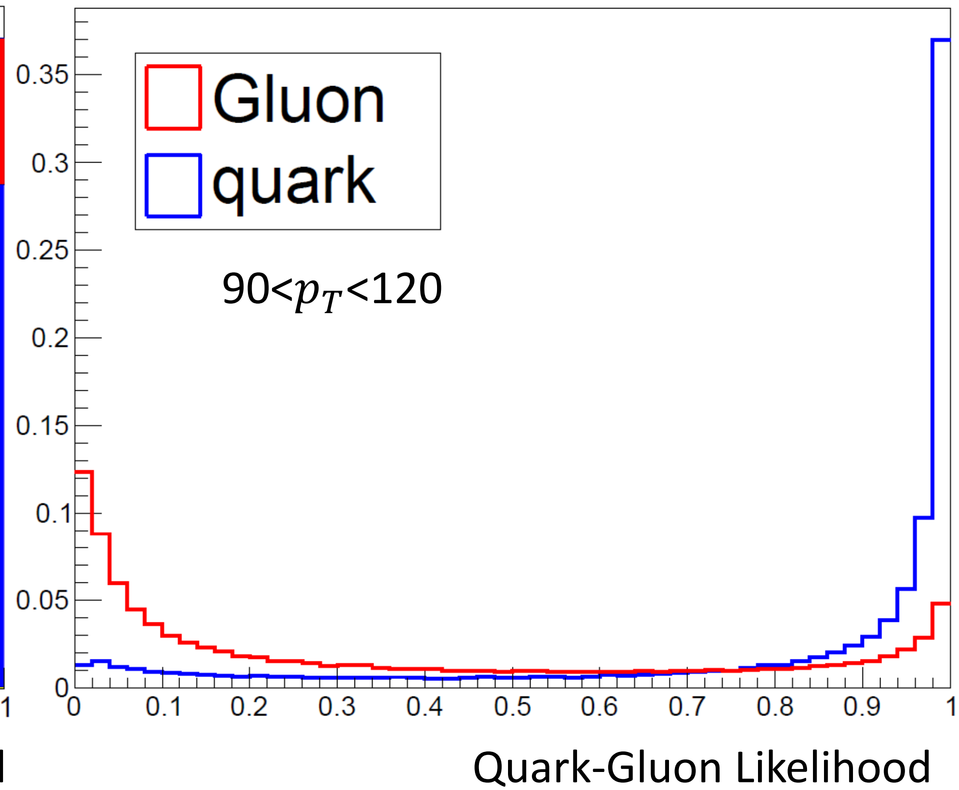
$$Q(\vec{x}) = \prod_{i=1}^{3} f_Q{}^{(i)}(x_i)\,, \qquad G(\vec{x}) = \prod_{i=1}^{3} f_G{}^{(i)}(x_i)$$

- $f_{Q/G}{}^{(i)}(x_i)$ - q/g jet normalized $x_i$ distribution

# Extraction of gluon-jet fraction

- Creation of quark-jet $H^q(D)$ and gluon-jet $H^g(D)$ QGL MC templates normalized to unity
- Fitting the data QGL distribution $H_k^{DAT}(D)$ to these templates with gluon-jet fraction as free parameter
  - $H_k^{DAT}(D) = (1 - \alpha_k^g)H^q(D) + \alpha_k^g H^g(D)$ - equation for fitting



# Results

- **Measurement of mean jet CPM**

  Results are ready

  Not approved yet

- **Measurement of** g-**jet fractions**

  Results are ready

  Not approved yet

- **"Universal" (averaged) q/g-jet mean CPM's**

  Results will be ready in May 2020

# Conclusion

- The 2016 data (35,9 $fb^{-1}$) was analyzed
- A technique for measuring the mean jet CPM was developed and implemented as a program code
- CPM of jets from dijet channel and gluon-jet fraction was measured as a function of pt for three samples with different number of jets in event (not approved)
- Next step is measurement of CPM in quark and gluon jets