Jet flavour discrimination and measurement of gluon jet fractions

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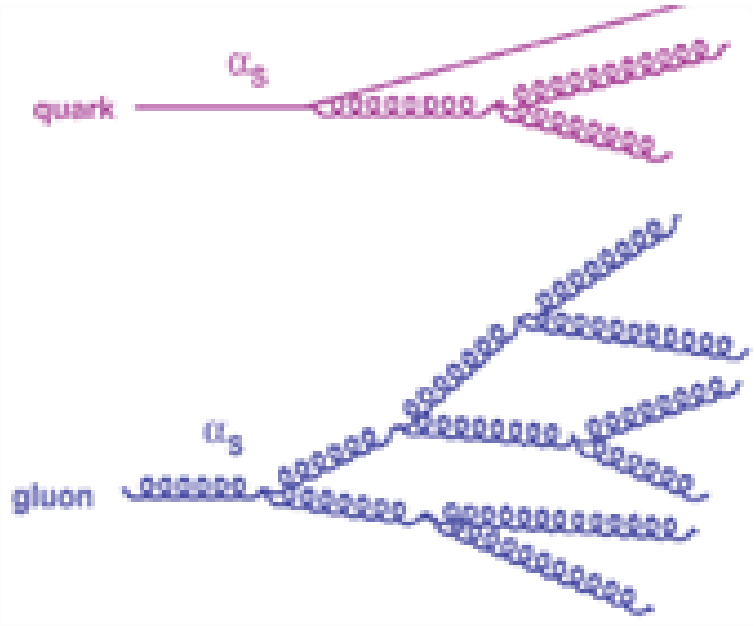
Introduction

- 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



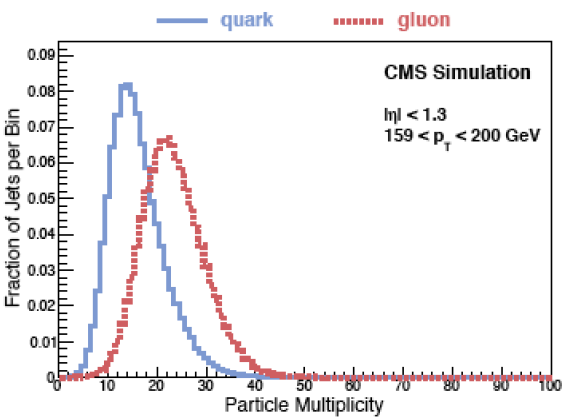
Quark jet

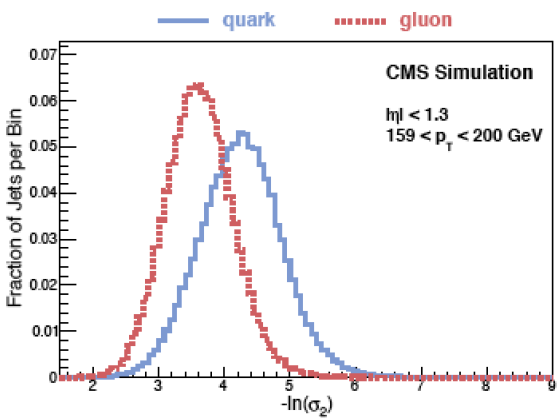
Gluon jet

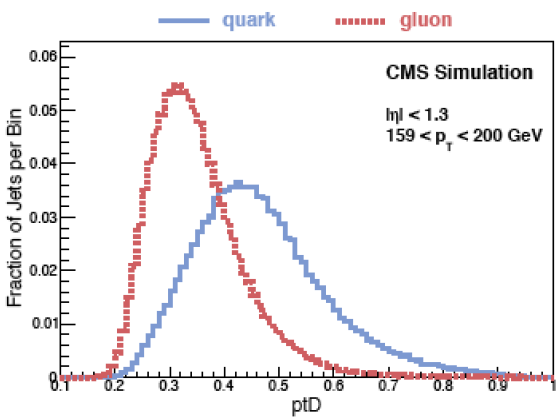
- With this study we want to answer is it possible to find fraction of gluon jets in mixed sample

Quark-Gluon Likelihood (QGL)

- To recognize jet flavour classification algorithms are used
- In this study we use Quark-Gluon Likelihood (QGL) discriminator proposed in CMS, which formed with three discriminating variables:
  - The **particle multiplicity** (larger for gluon jets)
  - The **minor axis** of the jets profile ellipse (larger for gluon jets)
  - The **fragmentation function** (smaller for gluon jets)
- QGL is determined in bins of p_T and η







CMS PAS JME-16-003

Quark-Gluon Likelihood (QGL)

- Discriminator is a likelihood built from the product of the probability density functions of the three variables described on previous slide:

$$\mathrm{QGL}(x_i) = \frac{Q(x_i)}{Q(x_i)+G(x_i)}$$ - discriminator value

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

  - Where ${f_{Q/G}}^{(i)}(x_i)$ – the probability density functions of three variables, x_i – jet properties

- Meaning of QGL value is probability to be a quark jet

Gluon jet fraction extraction

- For two component sample we can write an equation:

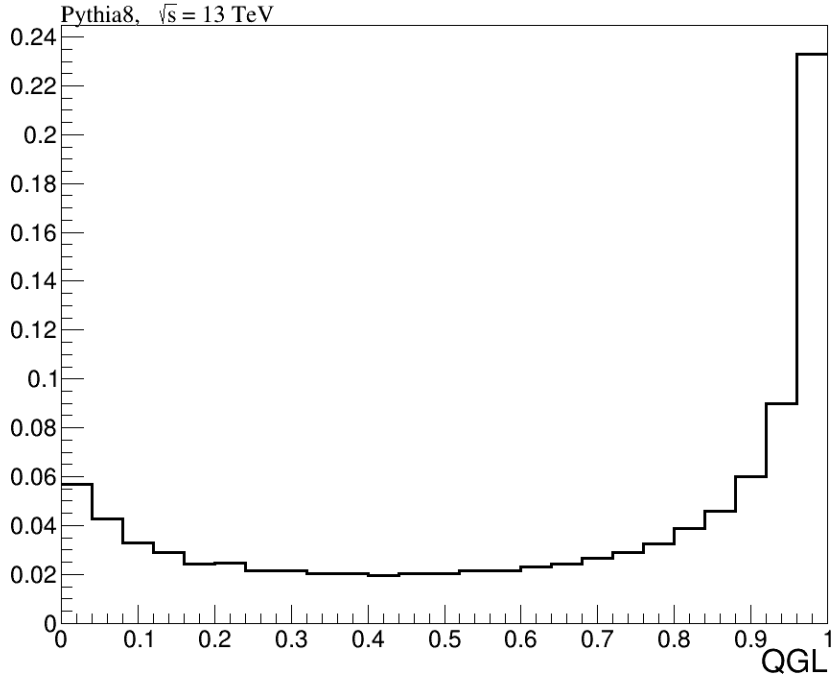
$$H = \alpha_g H_g + (1 - \alpha_g) H_q$$

  - Where H - distribution of some jets property, $H_{g/q}$ - distributions for pure quark and gluon jets, α_g - gluon jet fraction

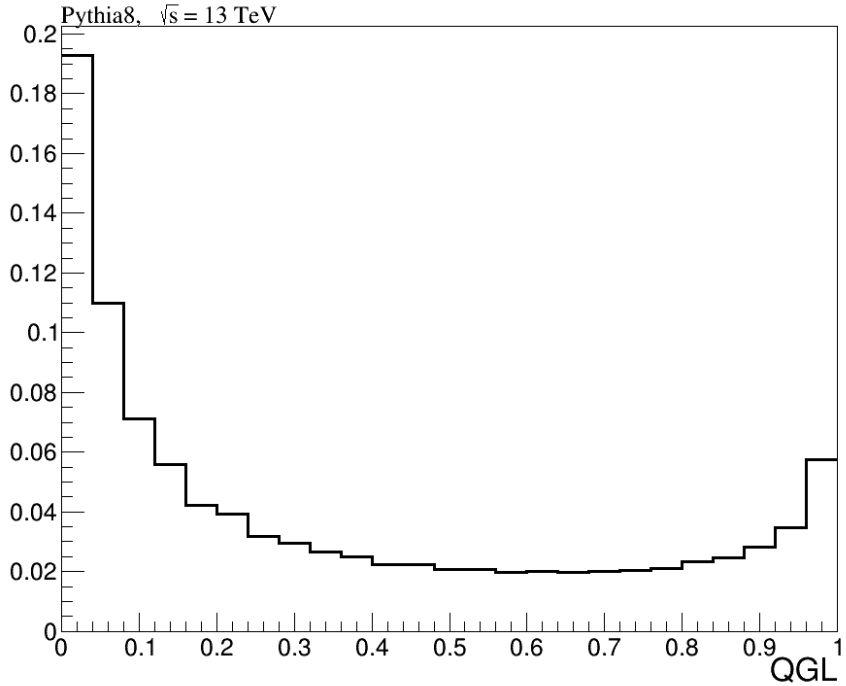
- We propose to use QGL distributions to find gluon fraction

- Quark jet (H_q) and gluon jet (H_g) QGL templates normalized to unity are created from MC and are used to fit mixed QGL distributions (H)
  - We use 1-parameter fit with weighted least squares method

Quark and gluon QGL templates



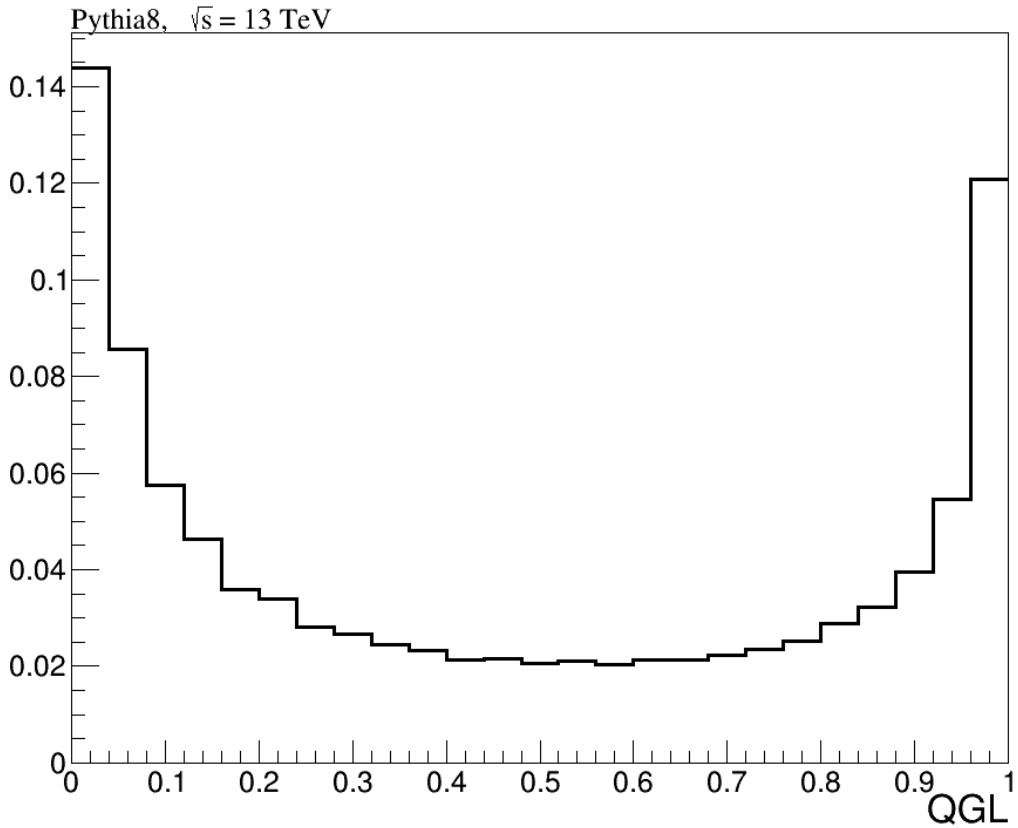
Quark template (H_q)



Gluon template (H_g)

- Quark template have a maximum at 1, it means quark jets has a higher probability to identify by discriminator as a quark jet and the same is true for gluon jets

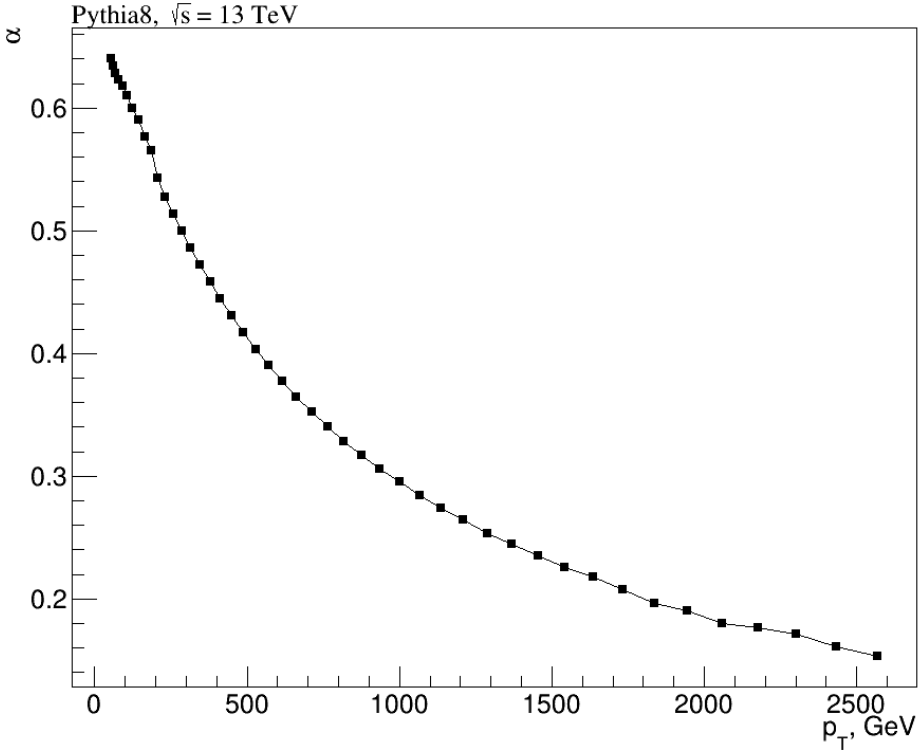
QGL distributions for MC



- Peaks at 0 and 1 means that mixed sample have both gluon and quark jets
- Such distributions may also be used to choose working point to make a cut

g-fraction in inclusive jets channel

- AK4 jets is used
- At least one jet with $p_T > 49$ GeV and $|y| < 2$



p_T, GeV	α_g^{MC}	α_g^{fit}
[64, 74]	0.6284	0.6281
[133, 153]	0.5902	0.5921
[272, 300]	0.5001	0.5001
[507, 548]	0.4168	0.4168

- g-fraction measured with our method (α_g^{fit}) in good agreement with MC value (α_g^{MC})

- This method is model depended:
  - To build QGL discriminator we MC jets, which properties may differ from data jets
  - For fitting procedure quark/gluon MC templates are used

Conclusion

- An algorithm which distinguish quark jets from gluon was described
- We propose a method to measure gluon jet fraction in mixed sample with QGL distributions
- Correct workability of the method was demonstrated in MC sample
- Possible problems in application of this method for data was listed