

Peering into the flavor substructure of the Quark-Gluon Plasma

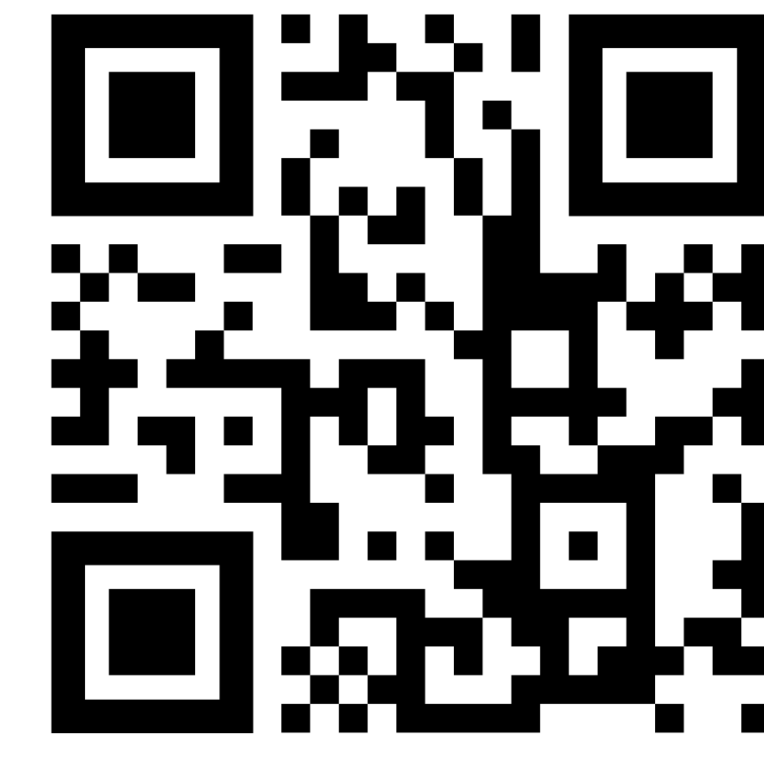
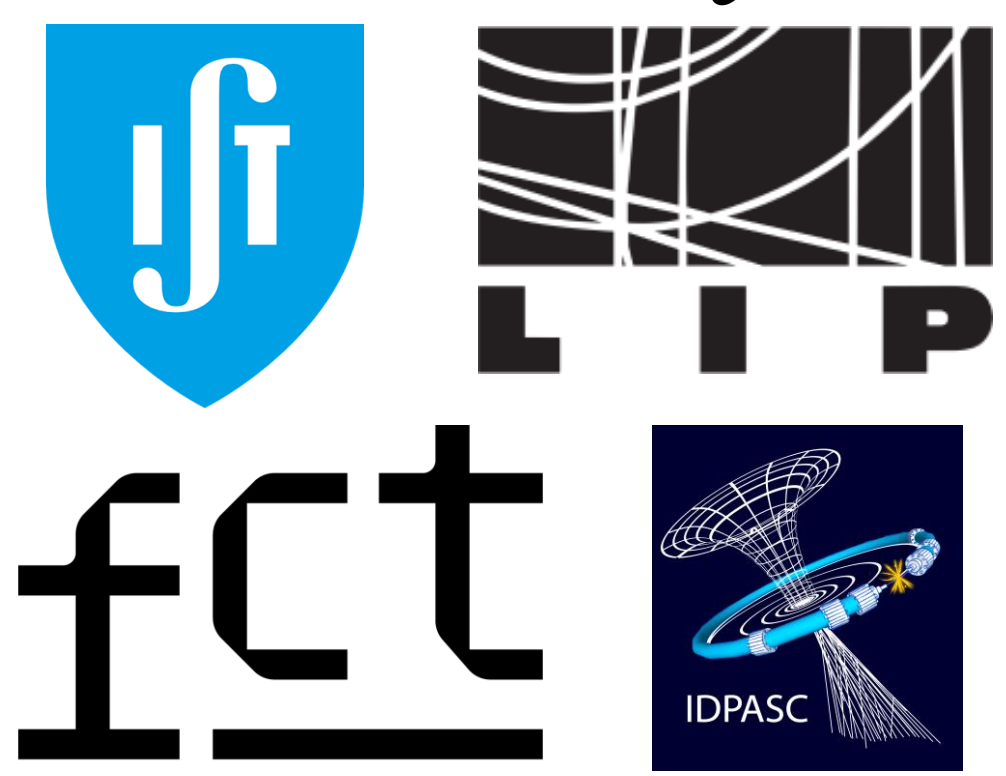
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PhD in Physics



Find our paper here [1]:

Introduction

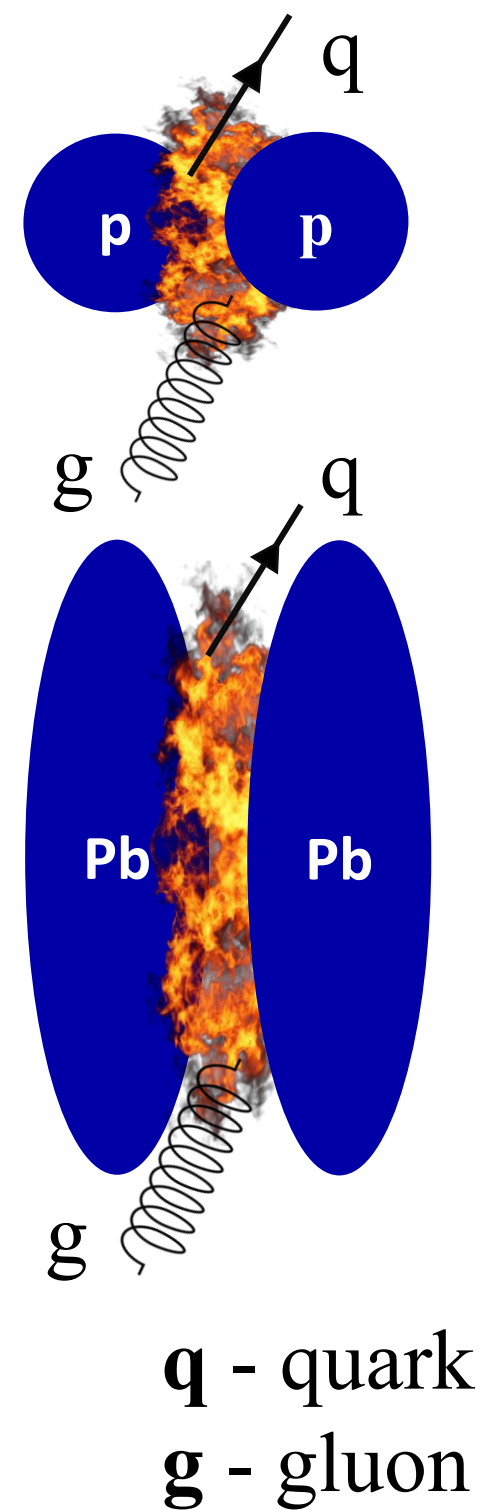
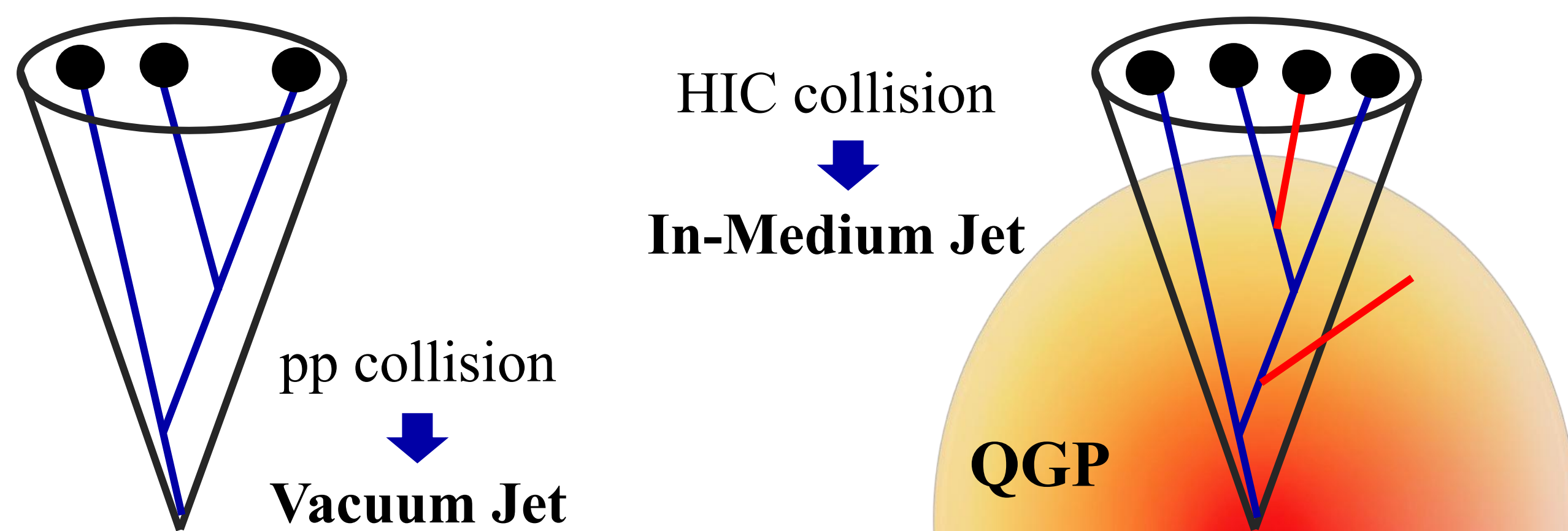
Particle Physics laboratories at Collider Experiments (e.g. RHIC, LHC):

- **pp** – proton-proton collisions;
- **HIC** – Heavy-Ion collisions (e.g. PbPb, AuAu).

Hard scatterings take place and eject **partons** (quarks and gluons) which evolve, ultimately producing groups of collimated hadrons (e.g. pions, kaons, protons) which we call **jets** [2].

However, HICs additionally produce an extremely large number of soft partons, creating a hot and dense medium called the **Quark-Gluon Plasma (QGP)**.

Motivation: QGP cannot be currently described from first principles. Therefore, **in-medium jets**, as they evolve concurrently with the QGP, act as powerful hard probes of the QGP properties, with **vacuum jets** serving as the baseline.



q - quark
g - gluon

EEC p_T Dependence

The **transverse momentum p_T** of a jet obviously plays a role on the shape of the jet's EEC. Relativistic effects mean that

⇒ **higher p_T** leads to more **highly boosted jets**.

However, we have also showed that EECs are highly dependent on jet flavor. We know from proton PDFs that

⇒ **higher p_T** leads to **higher quark content** in the proton, which produce **narrower jets**:

Both factors sum up, meaning that

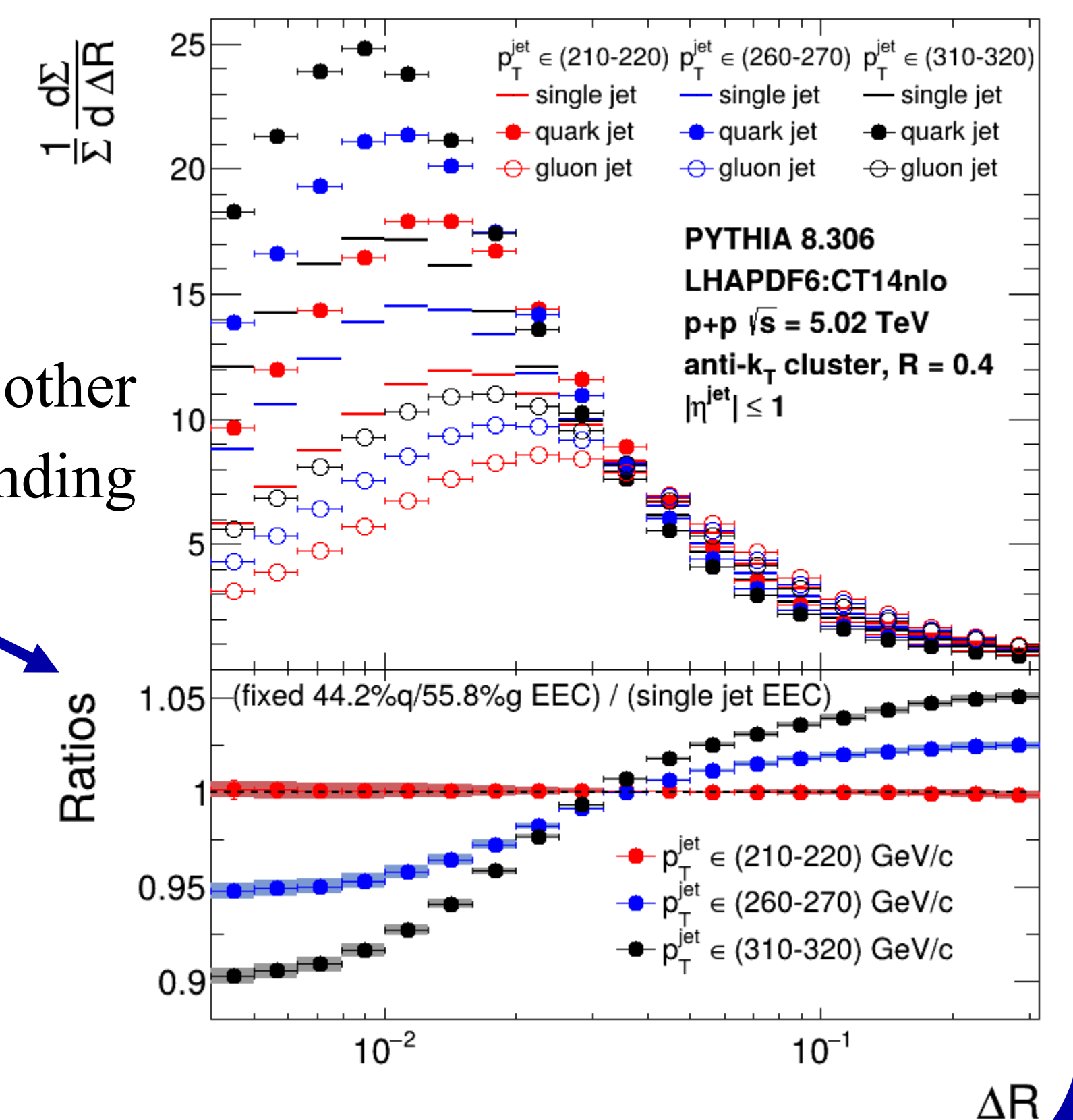
⇒ **higher p_T** leads the EEC to shift to **smaller angles**!

$p_T^{jet} \in (200 - 220) \text{ GeV}$
⇒ **44.2%** quark-initiated jets
⇒ **55.8%** gluon-initiated jets

We fix this q/g fraction for the other p_T^{jet} and divide the corresponding EECs by the real ones.

Conclusion

This exercise shows that the **quark jet fraction increase for higher p_T** has a **significant role on the small angle shift of the EEC-**



EEC Jet Flavor Dependence

Variable in study – **Energy-Energy Correlator (EEC)** [3]:

$$\frac{d\Sigma}{d\theta} = \frac{1}{\sigma} \sum_{i,j} \int d\sigma_{ij} \frac{E_i E_j}{Q^2} \delta(\vec{n}_i \cdot \vec{n}_j - \cos \theta)$$

Select 2 hard scattering diagrams: **γ -jets** and **di-jets**.

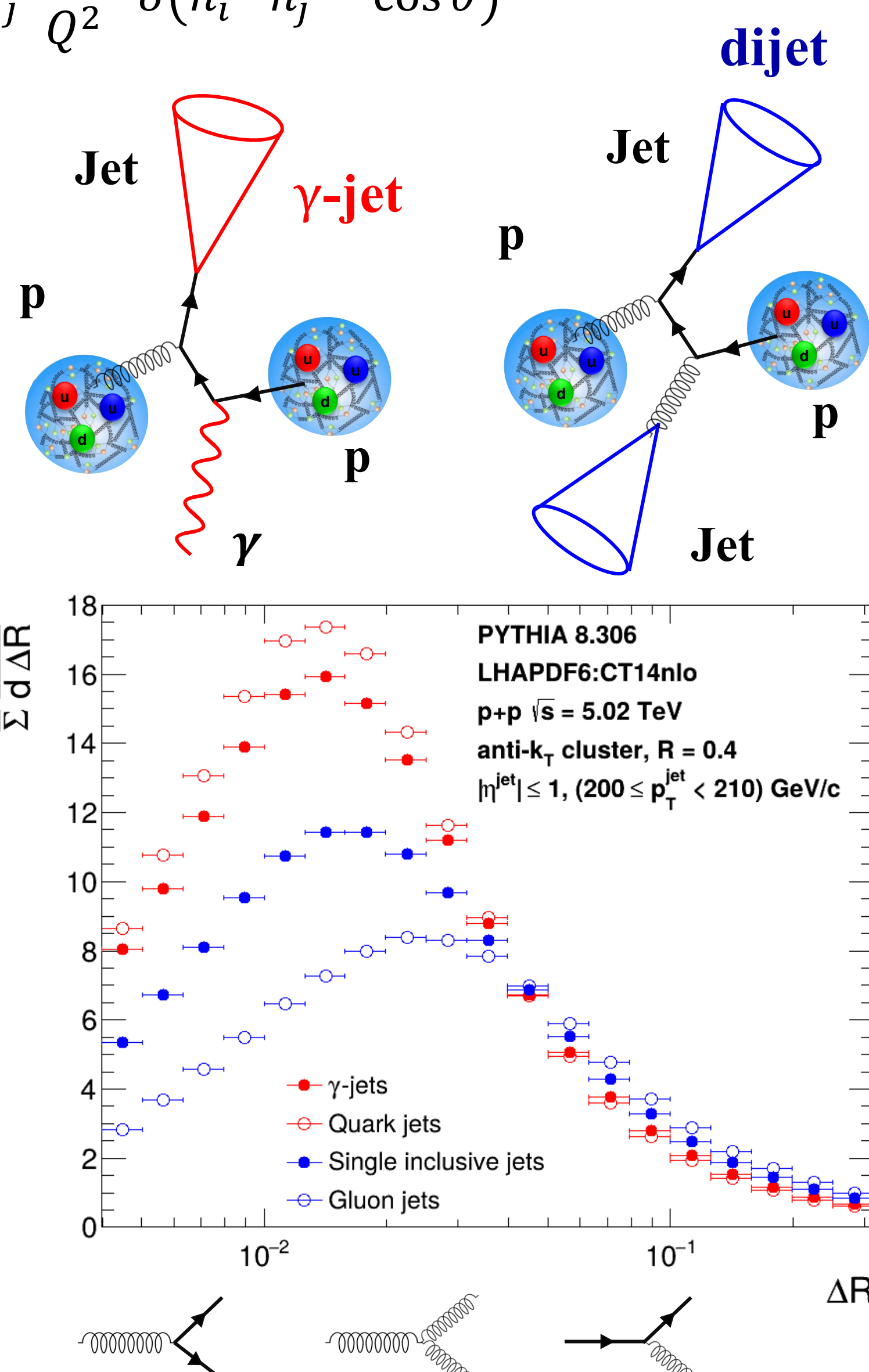
Major differences between their EECs, but why???

Even greater differences between EECs of **quark-initiated jets** and **gluon-initiated jets**!

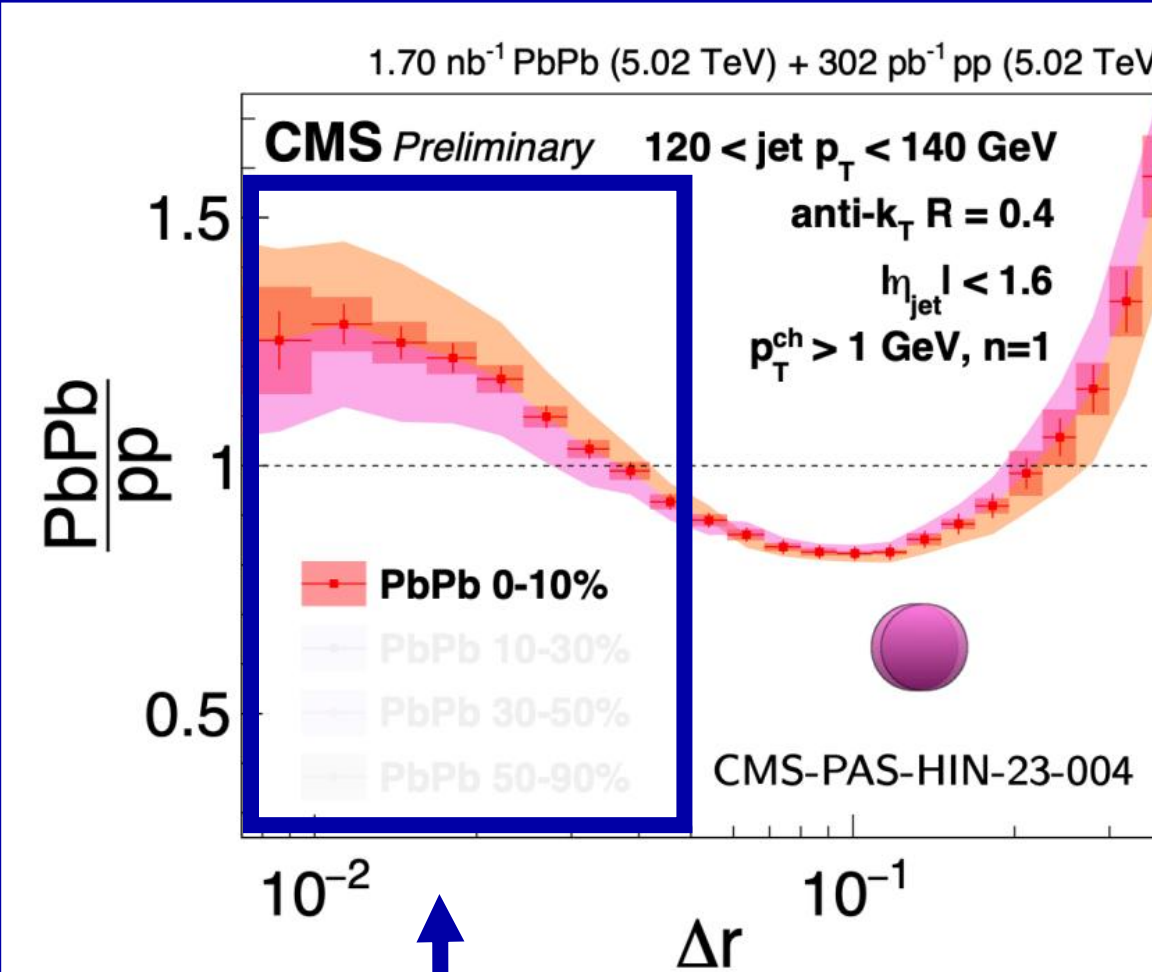
⇒ **dependence on q/g fraction**

Conclusion

Differences between **γ -jet EEC** and **single inclusive jet EEC** are due to their different **flavor composition**, more **quark** and **gluon** dominated, respectively.



EECs and the QGP



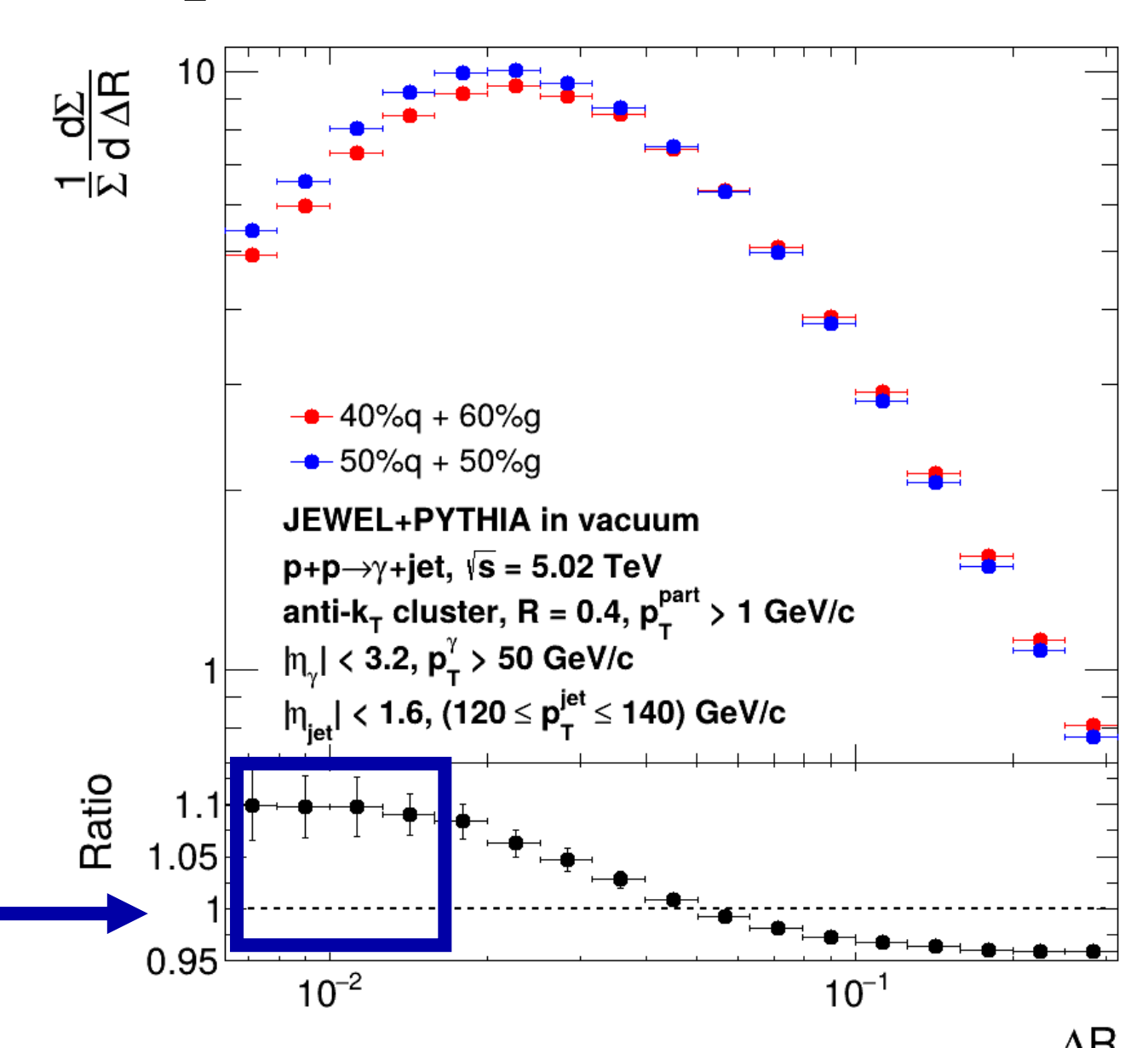
CMS Collaboration recently measured **the ratio of the EEC for PbPb collisions**, where QGP is expected to form, **with respect to pp**.

Small angle enhancement of the in-medium EEC is usually explained by the fact that jets lose energy to the QGP – **p_T selection bias**.

⇒ Jets from PbPb with same reconstructed p_T come from higher p_T processes than pp jets.

It follows that **PbPb jets are enriched in quark-initiated jets due to this bias**, which current studies do not account for!

10% increase in q-fraction
⇒ 10% enhancement of EEC



In-medium EECs have to be corrected for both the p_T and flavor selection biases to unlock their potential as probes of the QGP!

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References

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[2] G. F. Sterman and S. Weinberg (1977), Phys. Rev. Lett. 39, 1436.
[3] C. L. Basham, L. S. Brown, S. D. Ellis, and S. T. Love (1978), Phys. Rev. D 17, 2298