Energy Energy Correlator Measurements for D^0-tagged jets in pp collisions at 13 TeV

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1. Introduction

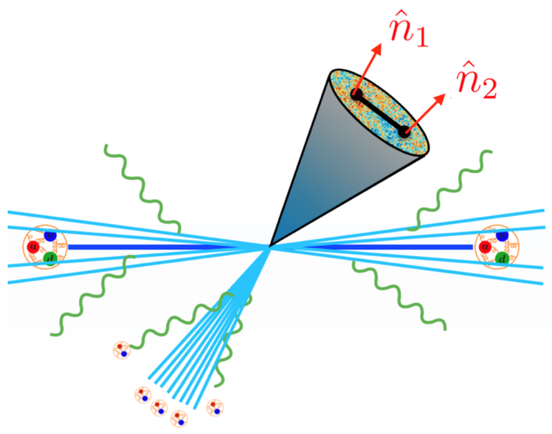
EEC Definition

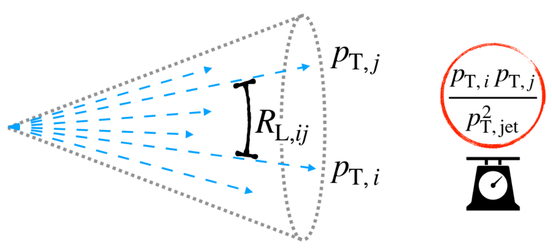
Energy-energy correlators [1] are the energy weighted cross-section of particles pairs and can be calculated as follows:

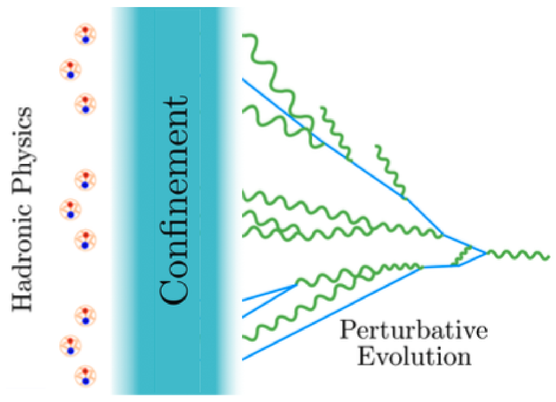
$$\sigma_{\mathrm{EEC}}(R_{\mathrm{L,ij}}) = \sum_{\mathrm{i,j}} \int dR'_{\mathrm{L}} \frac{p^{\mathrm{n}}_{\mathrm{T,i}} p^{\mathrm{n}}_{\mathrm{T,j}}}{p^{2\mathrm{n}}_{\mathrm{T,jet}}} \delta(R'_{\mathrm{L}} - R_{\mathrm{L,ij}}) \quad (1)$$

where the indices i and j correspond to the track pair i and j within the jet, R_{L} is the pair distance, or distance between these tracks, and n (fixed at $n = 1$) is the weight power.

$$R_{\mathrm{L}} = \sqrt{\Delta\phi^2_{\mathrm{ij}} + \Delta\eta^2_{\mathrm{ij}}} \quad (2)$$

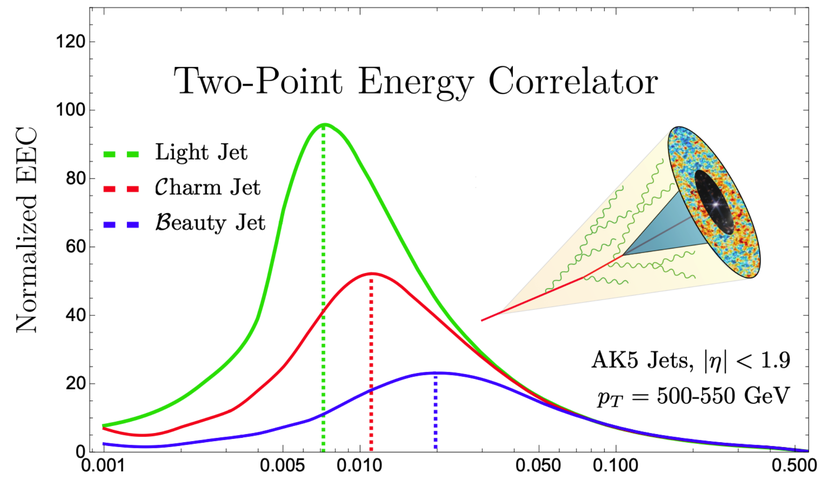






- Study the angular structure of energy flow within jets
- Clear separation of perturbative, transition, and non-perturbative regions
- Allows us to probe partonic-level jet formation and how partons are confined into hadrons

2. EECs in Heavy-Flavor Jets



- Heavy-flavor quarks are created in the initial scattering process of high-energy collisions
- The heavy-quark mass $\gg$ the natural scale of QCD ($\Lambda_{\mathrm{QCD}} \sim 200\mathrm{MeV}/c^2$), so their production is governed by perturbative quantum chromodynamics (pQCD).
- Turnover for heavy quarks occurs at $R_{\mathrm{L}} \to m_{\mathrm{Q}}/p_{\mathrm{T}}$ vs for massless jets at $R_{\mathrm{L}} \to \Lambda_{\mathrm{QCD}}/p_{\mathrm{T}}$
- Turnover region can improve heavy quark description in parton shower
- Ratios of massive and massless EEC isolate mass effects
- Small angle suppression $\to$ the "dead-cone effect" [1]

3. Method

In this study, we used PYTHIA 8 simulations [2] to look at the energy-energy correlator distributions.

In each event, tagged the parent parton as a light quark (u, d, s), a charm quark, or a gluon.

↓

Selected the particles from the event that are charged final-state particles

↓

Replaced $K^{\pm}\pi^{\mp}$ pairs with D^0 track to reconstruct D^0

↓

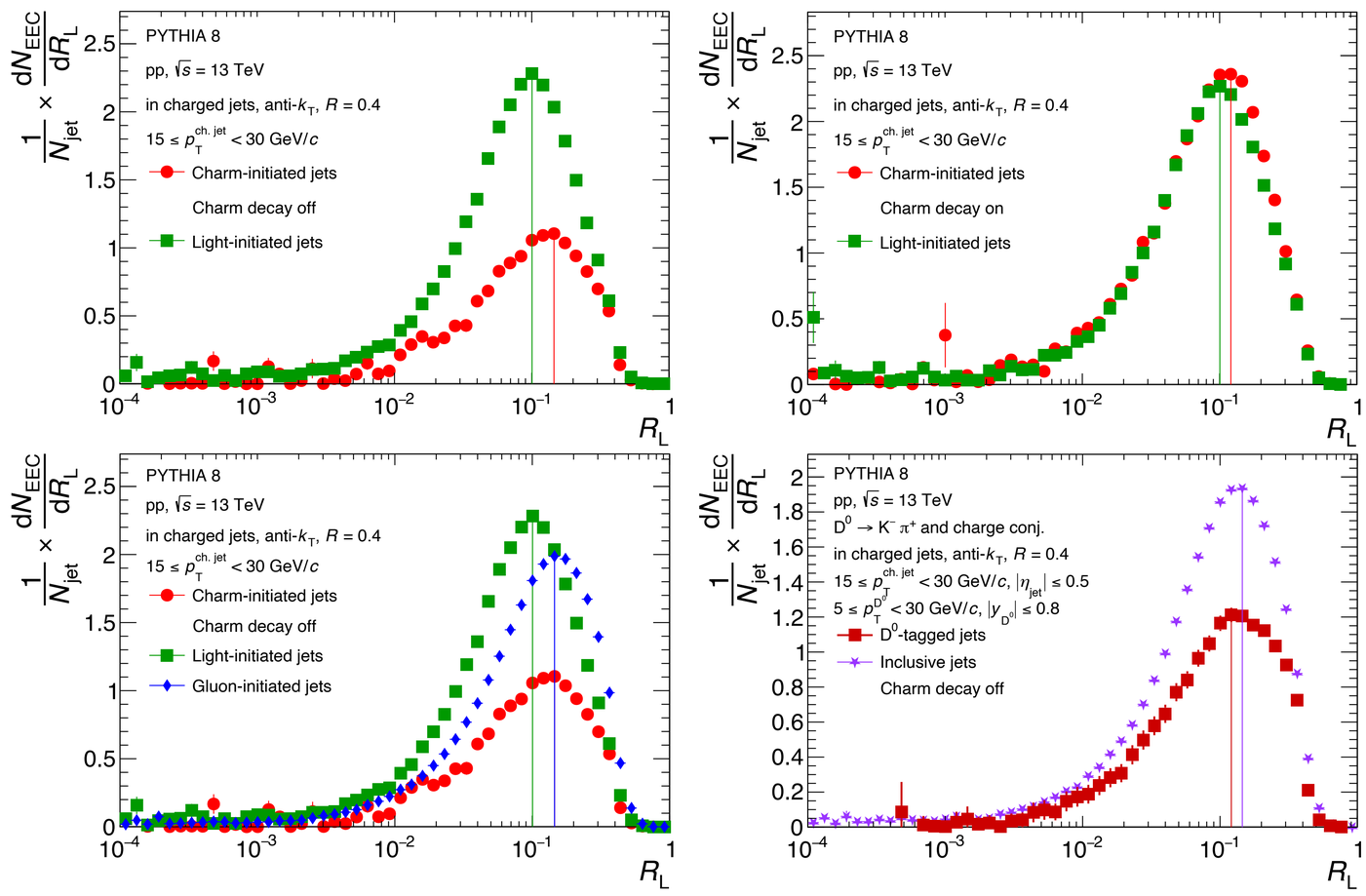
Used Fastjet anti-k_{T} algorithm [3] to make R=0.4 jet

↓

Found every combination of pairs within jet, calculated EEC (Eq. 1), and assigned weights based on p_{T}

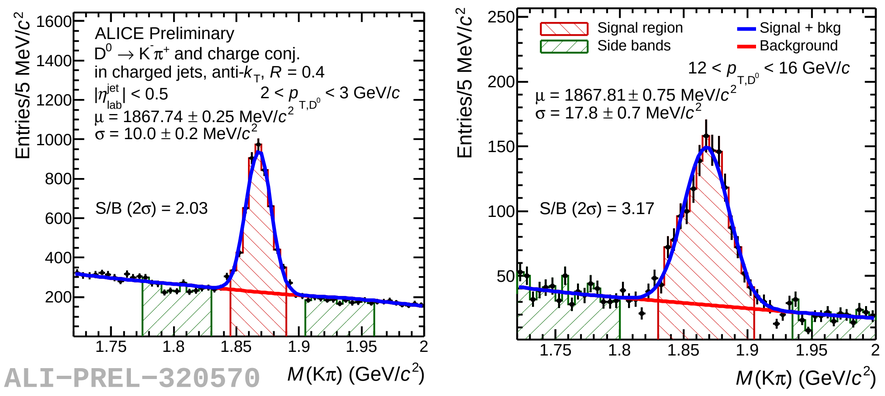
4. Results

- Probing mass (dead cone) effect and color charge dependence of jets
- Light-initiated (u, d, s quark) jets EEC peak position < charm-initiated jets EEC peak position. Suppression of small angle radiation $\to$ Dead-cone effect
  - In case of charm decay on, presence of decay products dilute the heavy-flavor effects $\to$ important to fully reconstruct the HF-hadron in data.
- Quark-initiated jets EEC peak position < gluon-initiated jets EEC peak position. Gluon-initiated jets EEC shape broader than quark-initiated jets EEC $\to$ Larger color factor



5. Summary and Outlook

- PYTHIA results show that turnover region for charm-initiated jets is shifted towards higher R_{L} compared to light-initiated jets
- Gluon-initiated jets had wider EEC distribution due to larger color factor
- Work on-going in ALICE 13 TeV pp collisions to compare inclusive and D^0-tagged jet EECs to probe mass effects. Stay tuned!



References

[1] Evan Craft et al. *Beautiful and Charming Energy Correlators*. 2022. arXiv: 2210.09311 [hep-ph].
[2] *Pythia 8.3*. https://pythia.org. Accessed: 2023-08-24.
[3] Matteo Cacciari, Gavin P. Salam, and Gregory Soyez. "FastJet user manual". In: *Eur. Phys. J. C* 72 (2012). Comments: 69 pages. FastJet 3 is available from http://fastjet.fr/, p. 1896. DOI: 10.1140/epjc/s10052-012-1896-2. arXiv: 1111.6097. URL: https://cds.cern.ch/record/1402449.