Monte Carlo studies of energy-energy correlators for D^0-tagged jets in pp collisions

Beatrice Liang-Gilman[1]

[1]Department of Physics, University of California, Berkeley, CA 94720, USA

beatrice_lg@berkeley.edu

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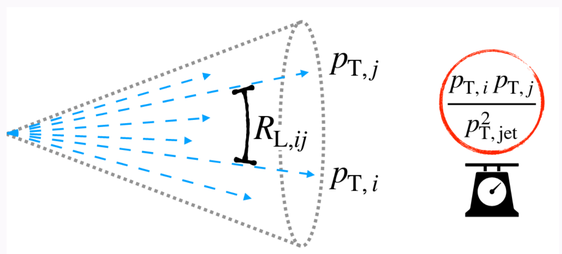
1. Introduction

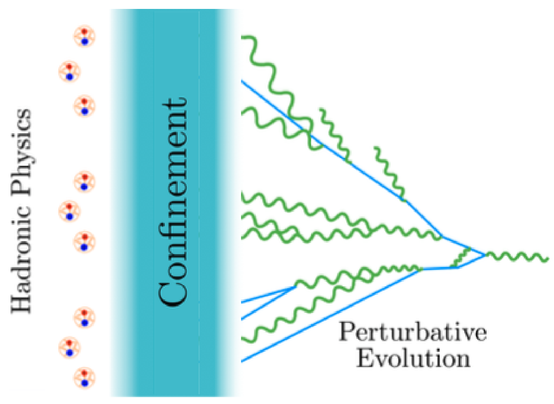
EEC Definition

Energy-energy correlators are the energy weighted per jet cross-section of particle pairs and can be calculated as follows:

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



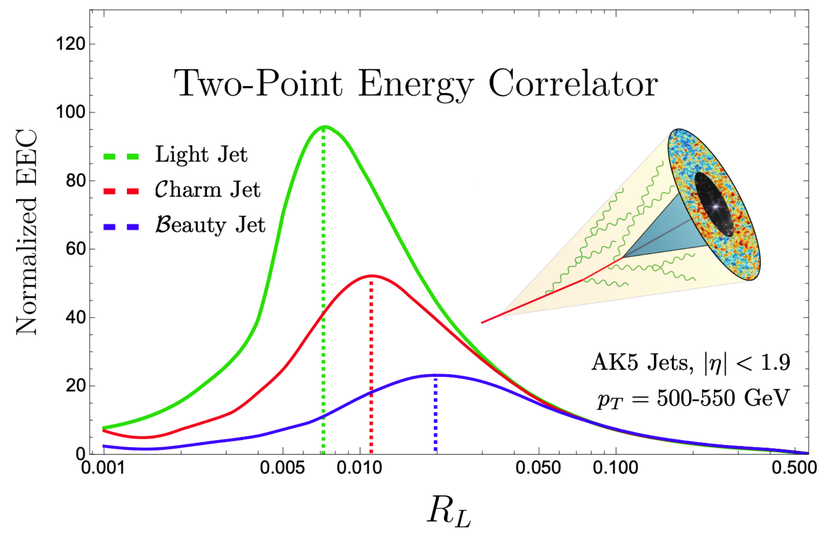
$$R_{\mathrm{L}} = \sqrt{\Delta\phi^2_{\mathrm{ij}} + \Delta\eta^2_{\mathrm{ij}}} \quad (2)$$



❖ Confinement region clearly separates perturbative 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



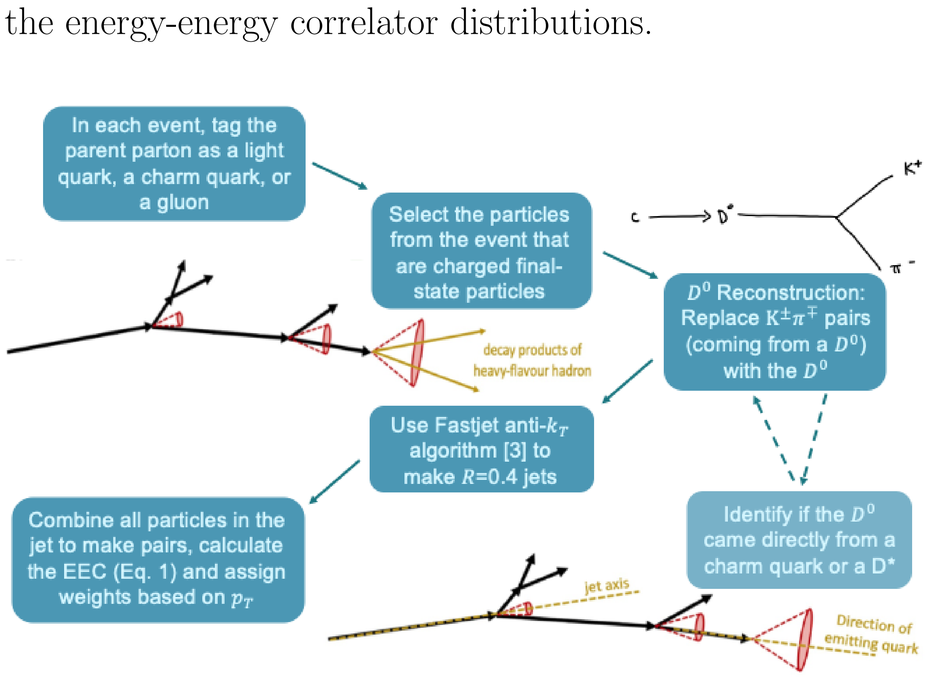
❖ Heavy-flavor quarks are created in the initial scatterings of high-energy collisions

❖ Predicts mass dependence for heavy-quark turnover

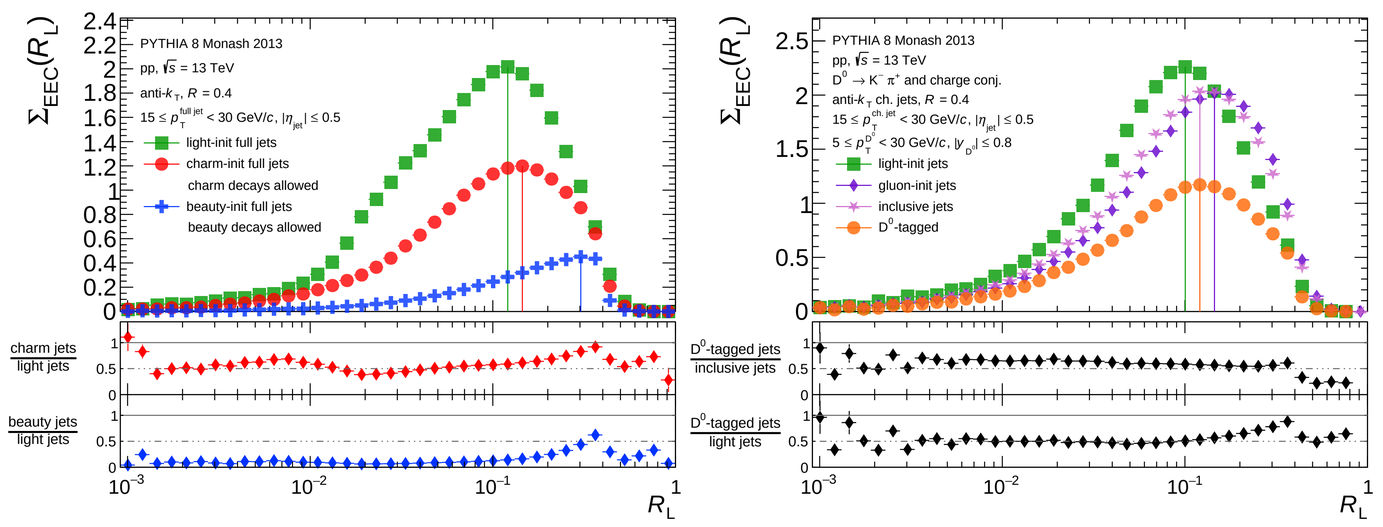
❖ Shift in peak position → mass effect

3. Method

In this study, we used Monte Carlo simulations to look at the energy-energy correlator distributions.



4. EECs from Different Partons



❖ EEC peak position: **Light**-init. (u, d, s quark) < **charm**-init. < **beauty**-init. jets.

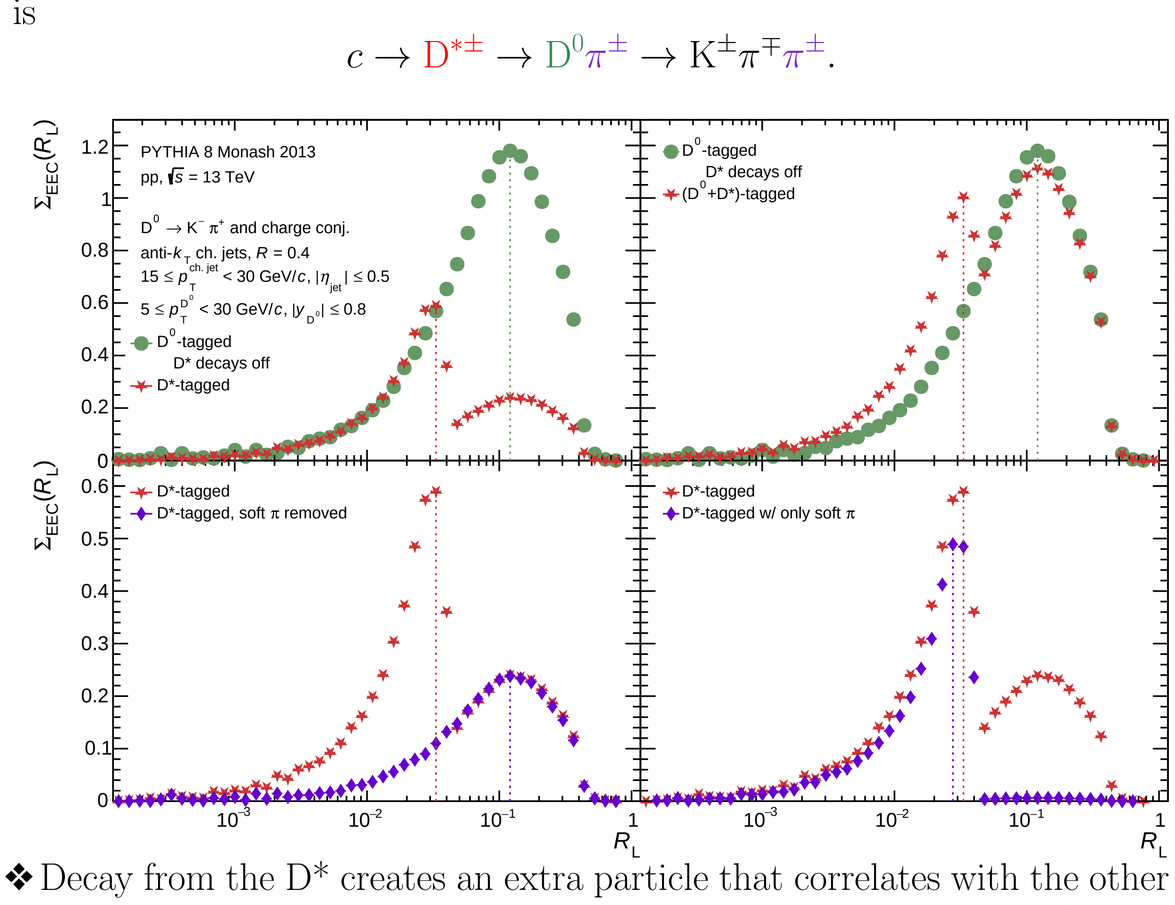
❖ Significant amplitude differences → mass effects (i.e. dead-cone effect)

❖ Quark-initiated jets EEC peak position < **gluon**-initiated jets EEC peak position. Gluon jets EEC is broader than quark jets EEC → Larger color factor

5. D* Meson Contribution to D^0 jet EECs

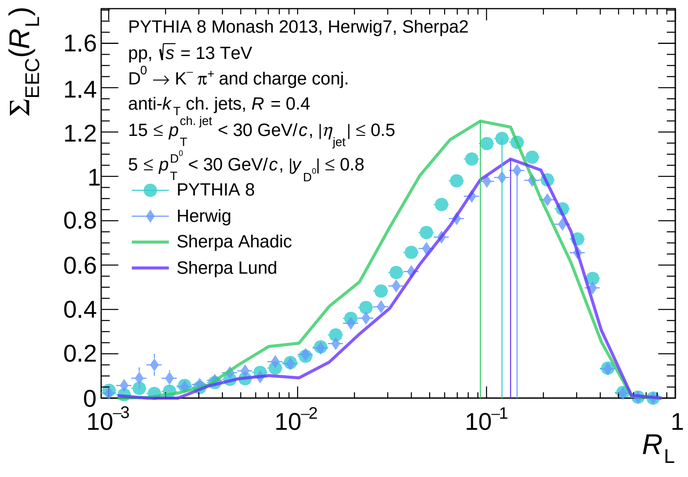
The charm quark can fragment into a D^0 meson in multiple ways.

1. Directly into a D^0, where
$$c \to D^0 \to K^{\pm}\pi^{\mp}.$$
2. Creating a D^*, which then decays into a D^0 and a soft pion. This process is
$$c \to D^{*\pm} \to D^0\pi^{\pm} \to K^{\pm}\pi^{\mp}\pi^{\pm}.$$



❖ Decay from the D* creates an extra particle that correlates with the other particles at lower values of R_{L} → adds to background of prompt D^0 EECs

6. Probing Charm Hadronization with MC Models



- Lund string model: **PYTHIA 8** and **Sherpa Lund**
- Cluster hadronization model: **Herwig 7** and **Sherpa Ahadic**
- Sherpa also has different parton shower models than PYTHIA and Herwig

❖ Qualitatively, all models match in shape at lower and higher R_L

❖ Models differ quantitatively in the peak position and peak amplitude → dominated by hadronization mechanisms

Summary and Outlook

❖ Mass hierarchy visible in peak positions of heavy flavor EECs

❖ D* decay observed in low R_L (i.e. non-perturbative/hadronic) region

❖ Comparisons of different Monte Carlo models show that EECs are sensitive to hadronization mechanisms

❖ pp measurement of D^0-tagged EECs has been made in ALICE!

❖ Future work includes analyzing ALICE Run3 and Pb-Pb data