PYTHIA Simulation of Energy-Energy Correlators within jets in $p + p$ at $\sqrt{s} = 200$ GeV

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Advancing the Understanding of Non-Perturbative QCD flows

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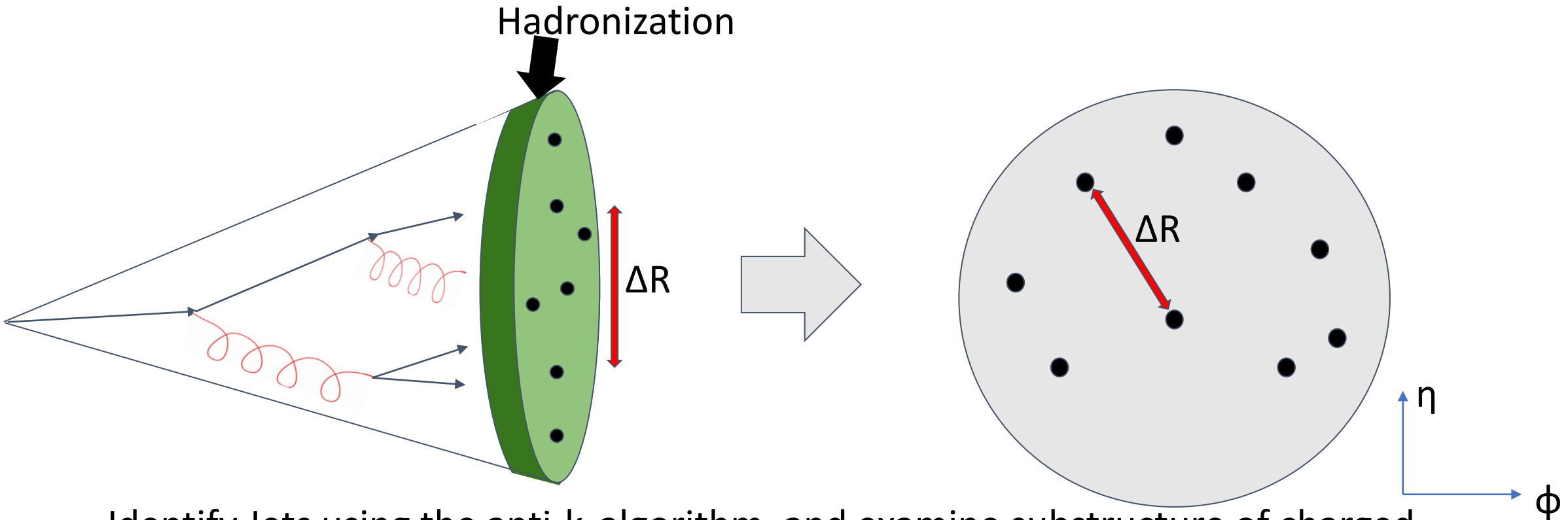
Motivation

- Advancements in jet-finding algorithms allow for increased study into the constituents present within jets
- Want to define an observable that is sensitive to the energy flow of the fragmentation and hadronization processes

Constituents  Correlations

Measure value for every possible combination of charged tracks within a jet

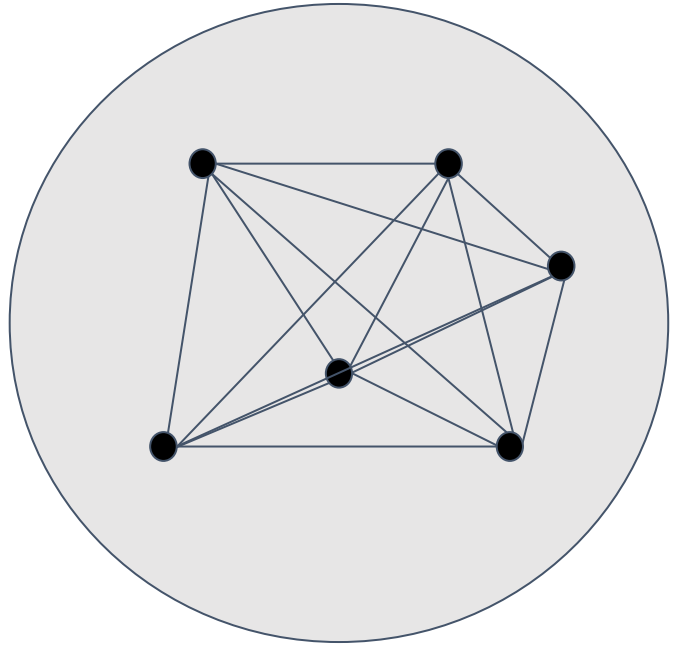
Correlator



- Identify Jets using the anti-k_t algorithm, and examine substructure of charged tracks
- Plot observables as a function of ΔR between constituents
- Correlation functions provide information about fragmentation and hadronization processes

Experimental Measure of Correlator

- Create a multiplicity histogram of the ΔR between all combinations of pairs of charged tracks
  - 2-Point Correlator
- Weight the result by the energy product of the two constituents
  - Infrared and Colinear safe
- Normalize integral of final result out to unity in order to direcly compare observable shape between jet p_T

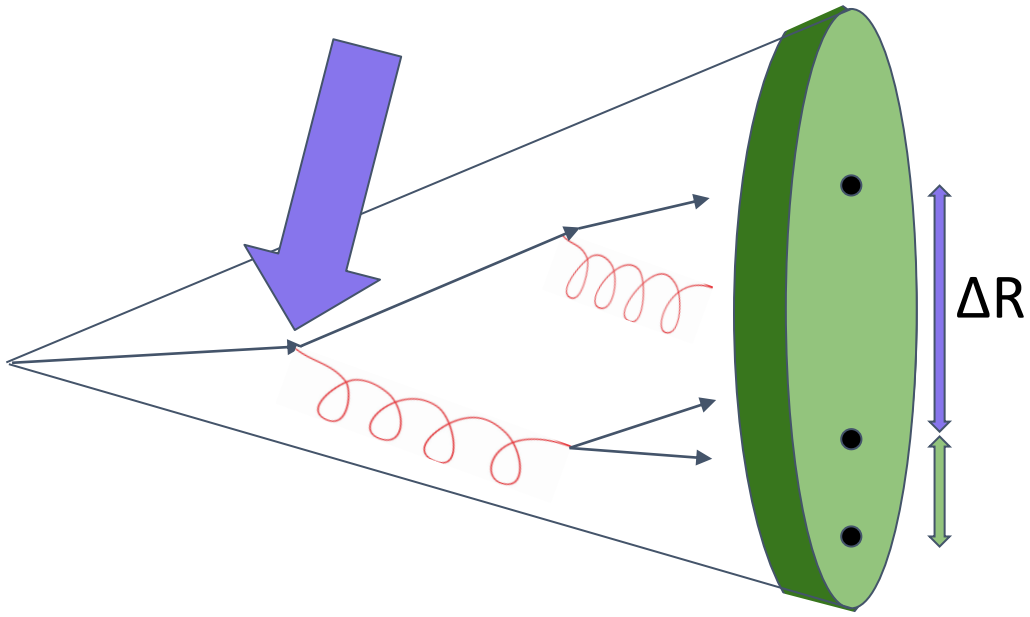


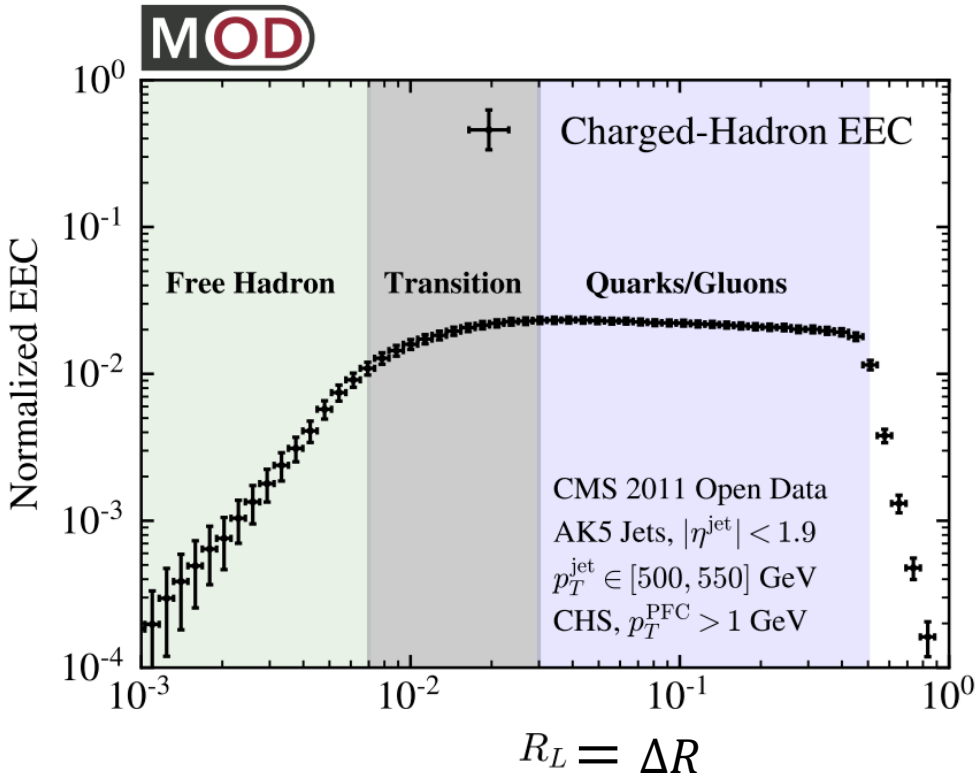
Normalized Energy-Energy Correlator

$$\text{EEC} = \frac{1}{\sum_{Jets}\sum_{i\neq j}\frac{E_i E_j}{Q^2}} \frac{d\left(\sum_{Jets}\sum_{i\neq j}\frac{E_i E_j}{Q^2}\right)}{d\,\ln(\Delta R)}$$

Komiske et al. 2022

Motivation

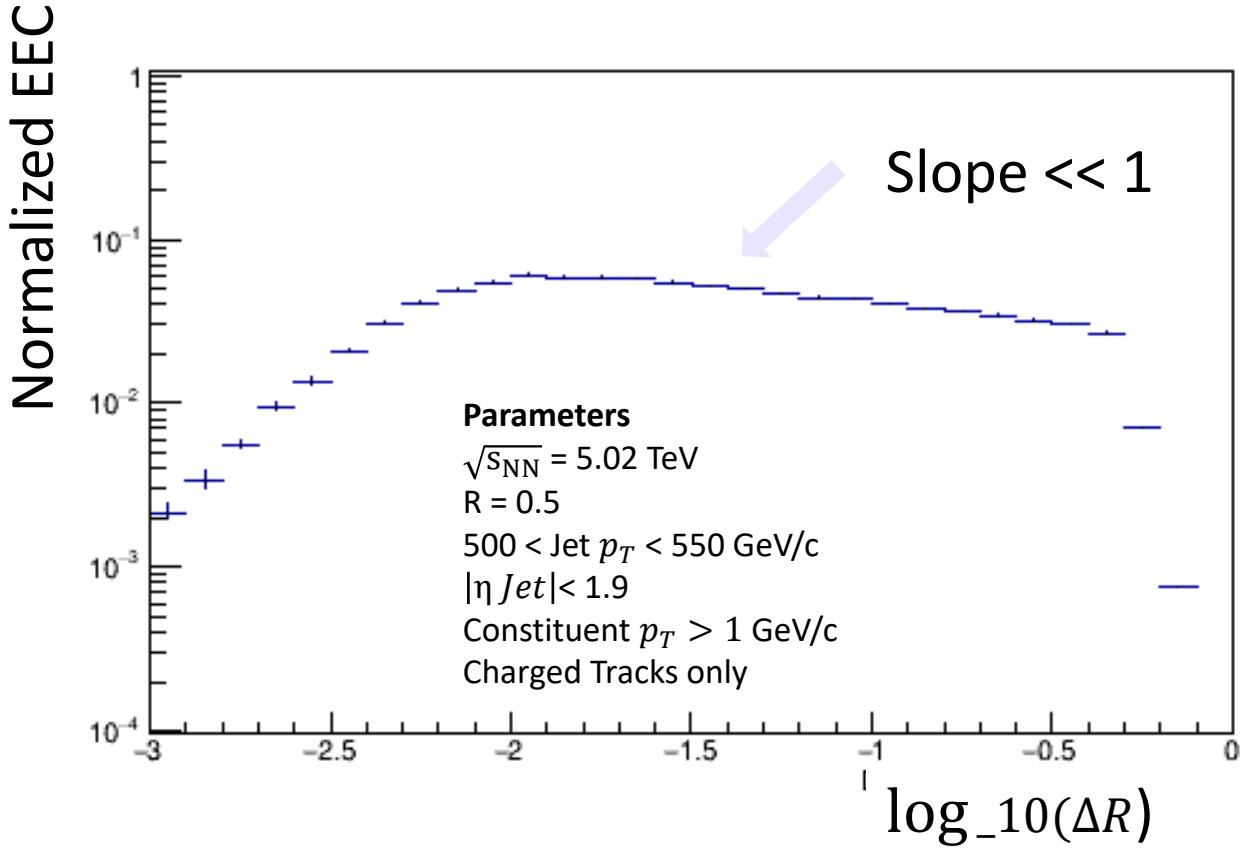


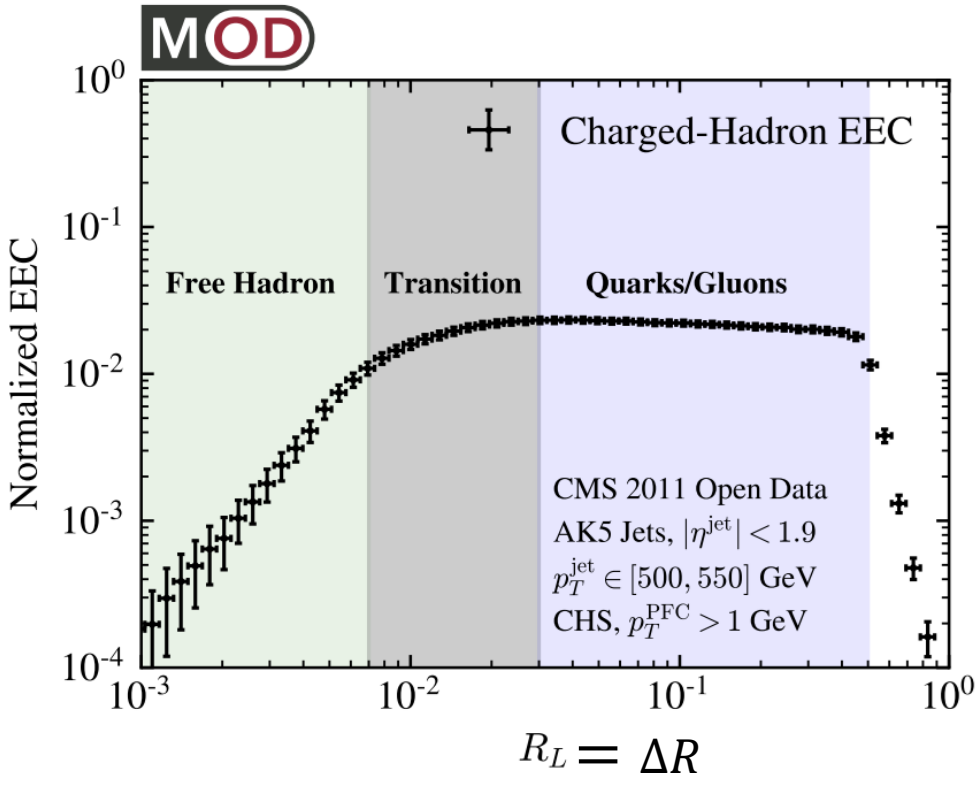


Goal: to probe transition from quarks/gluons to hadrons

Pythia simulations at $\sqrt{s} = 5.02\ TeV$

Komiske et al. 2022

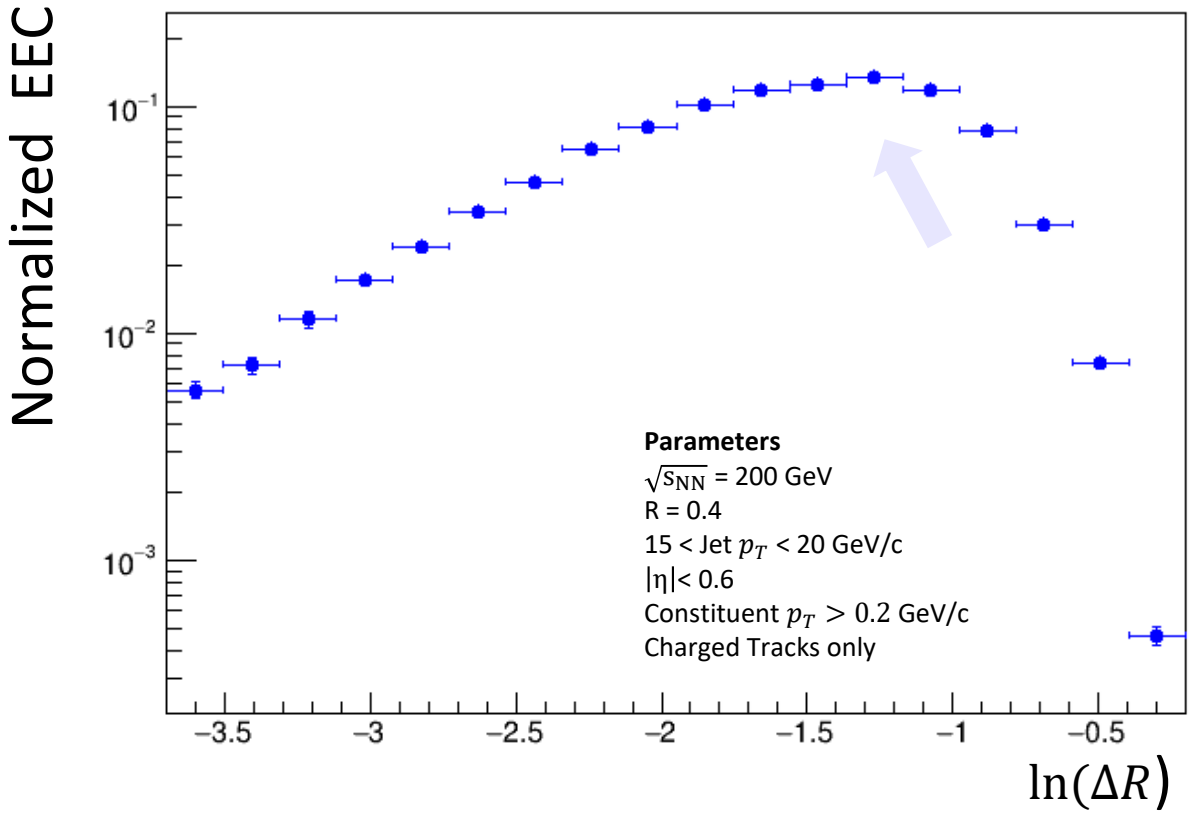


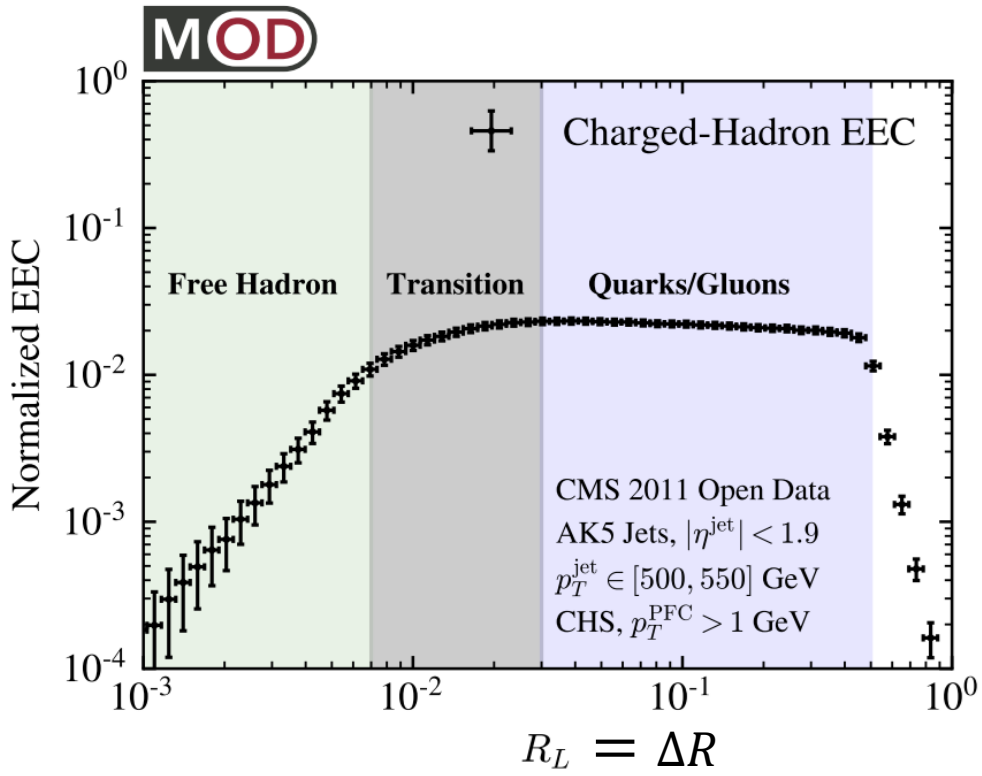


- PYTHIA simulations at CMS energies allow us to see that we reproduce the same effects as Komiske et al. and thus PYTHIA simulations at STAR energies are relevant to analyze EEC

Move to STAR energy

Komiske et al. 2022





- Quark and Gluon region is less pronounced at lower energies
- Less “time” is being spent there during jet evolution
- Two different scales on y axis highlight different properties of EEC

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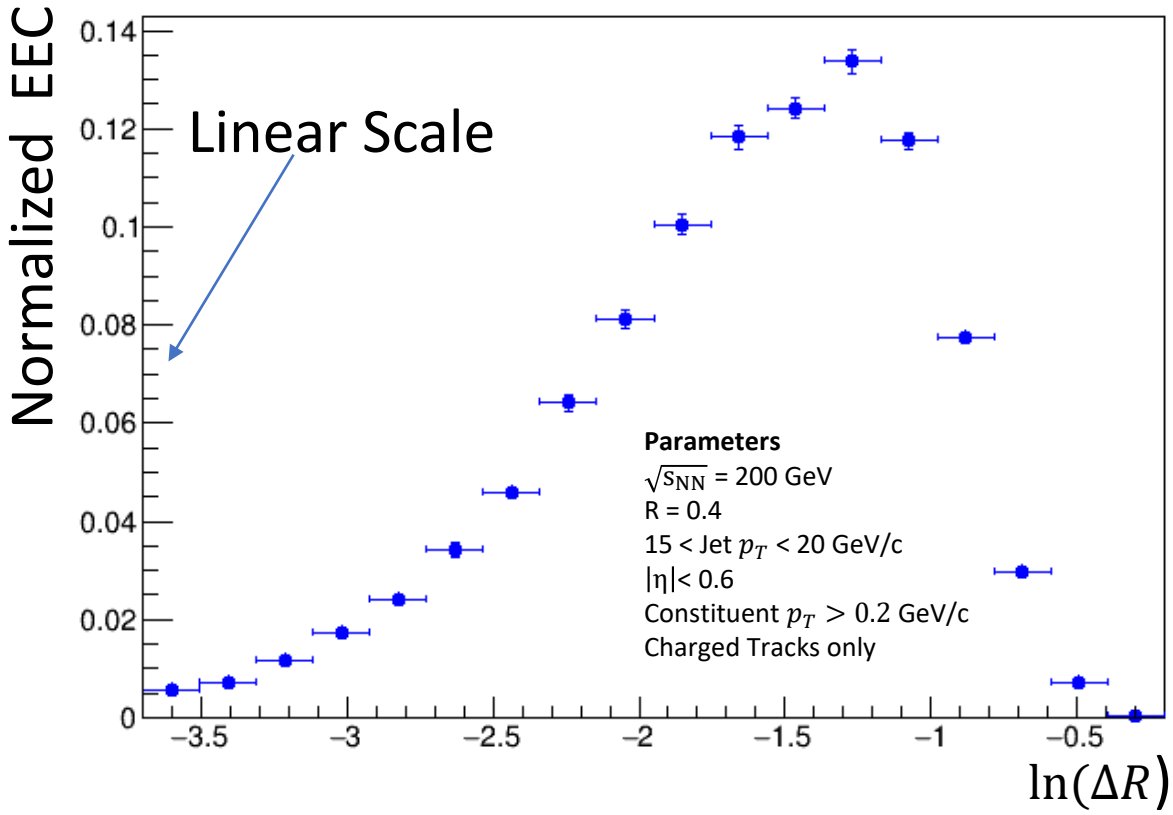

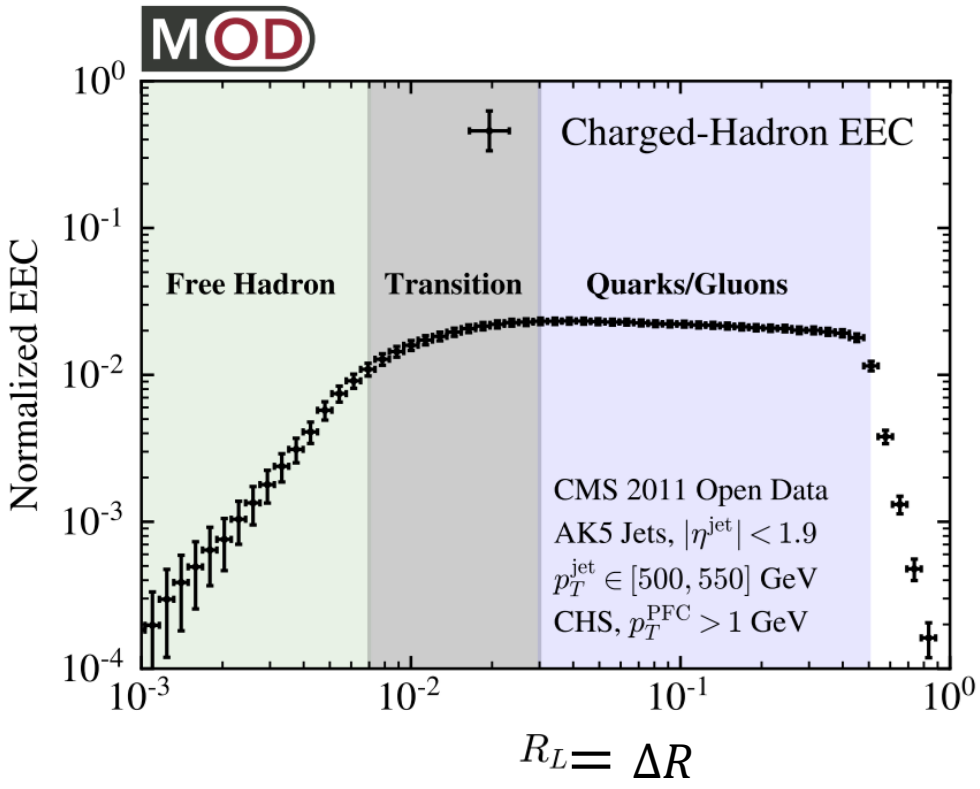

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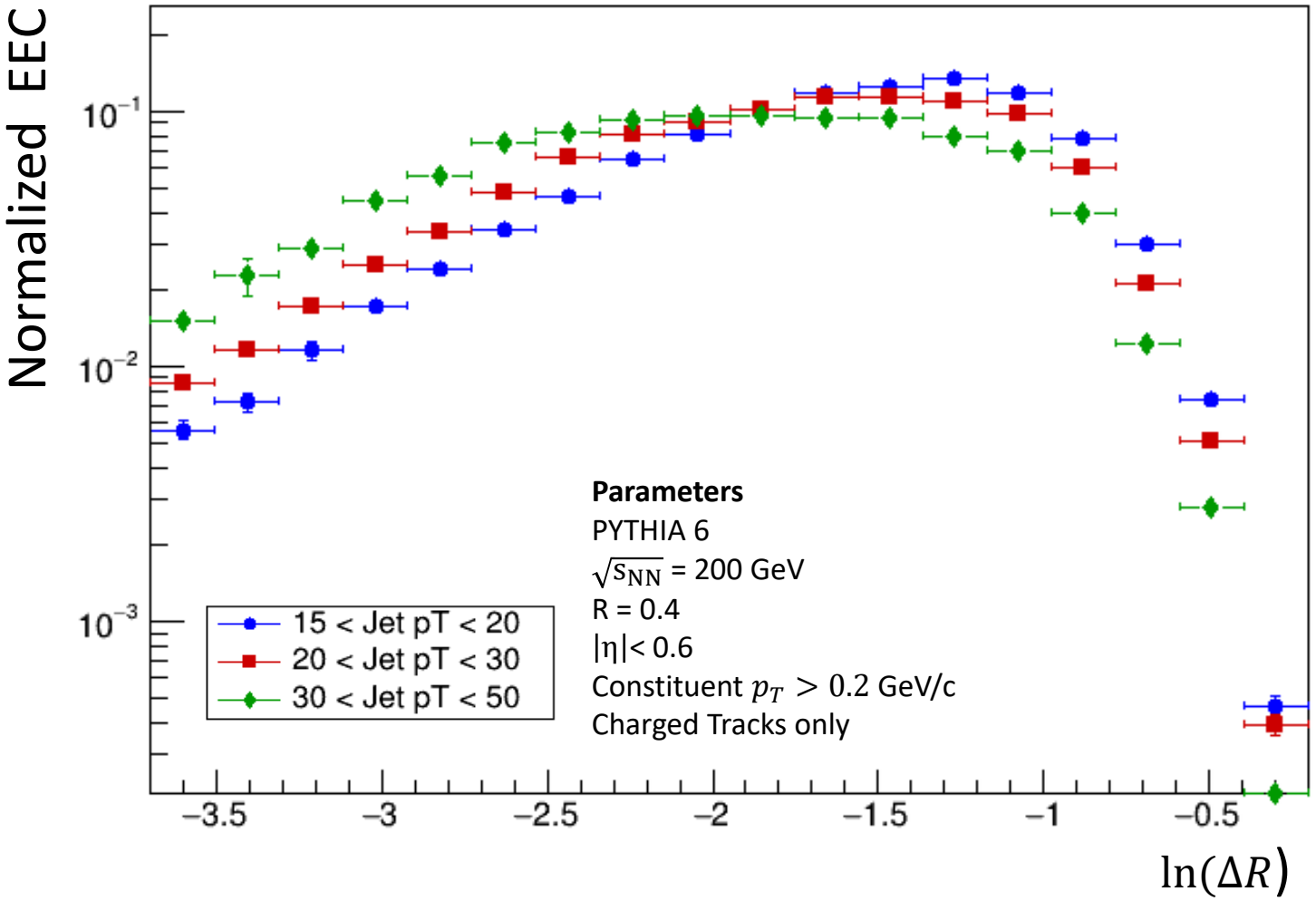
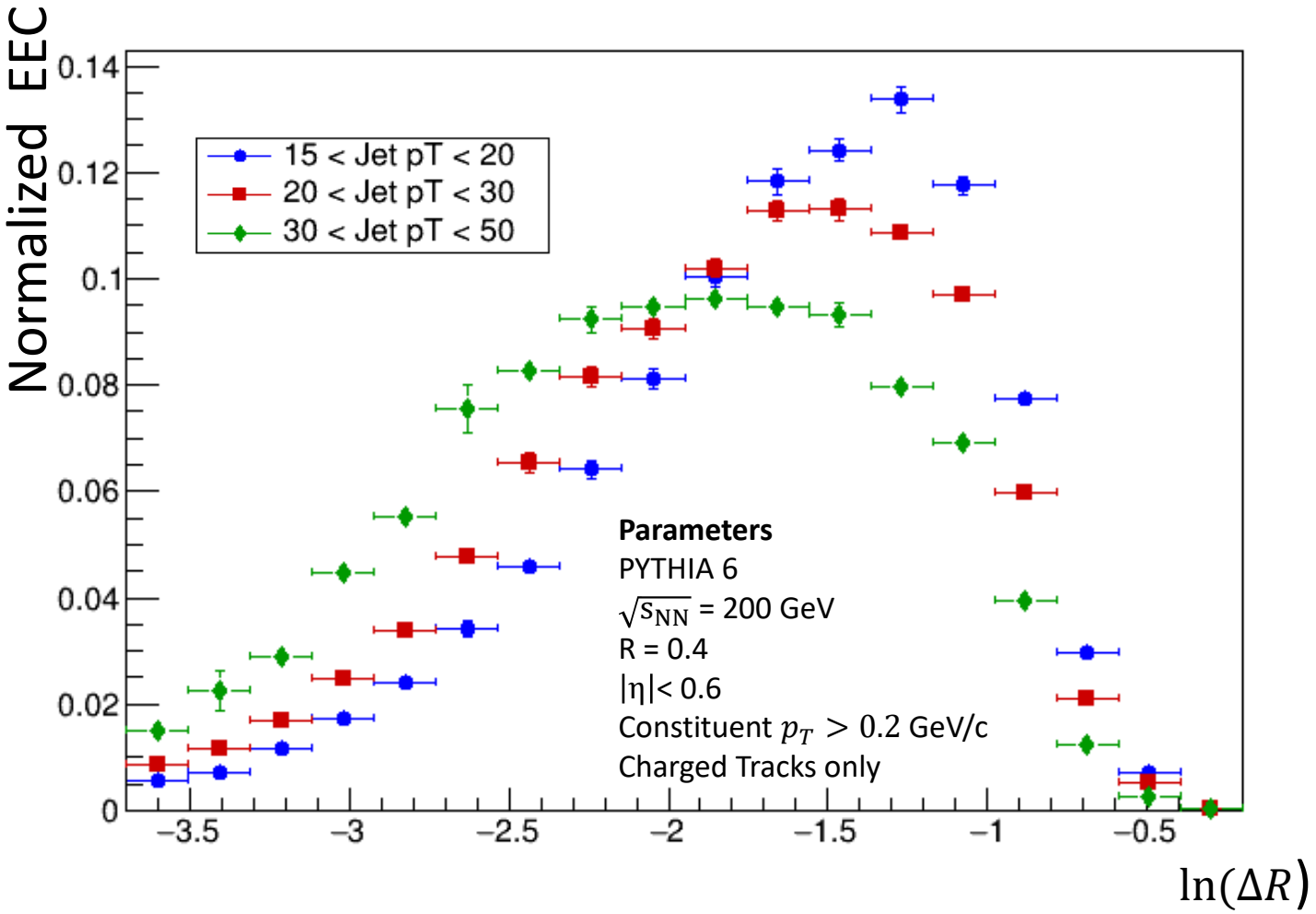
Jet Pt Behavior



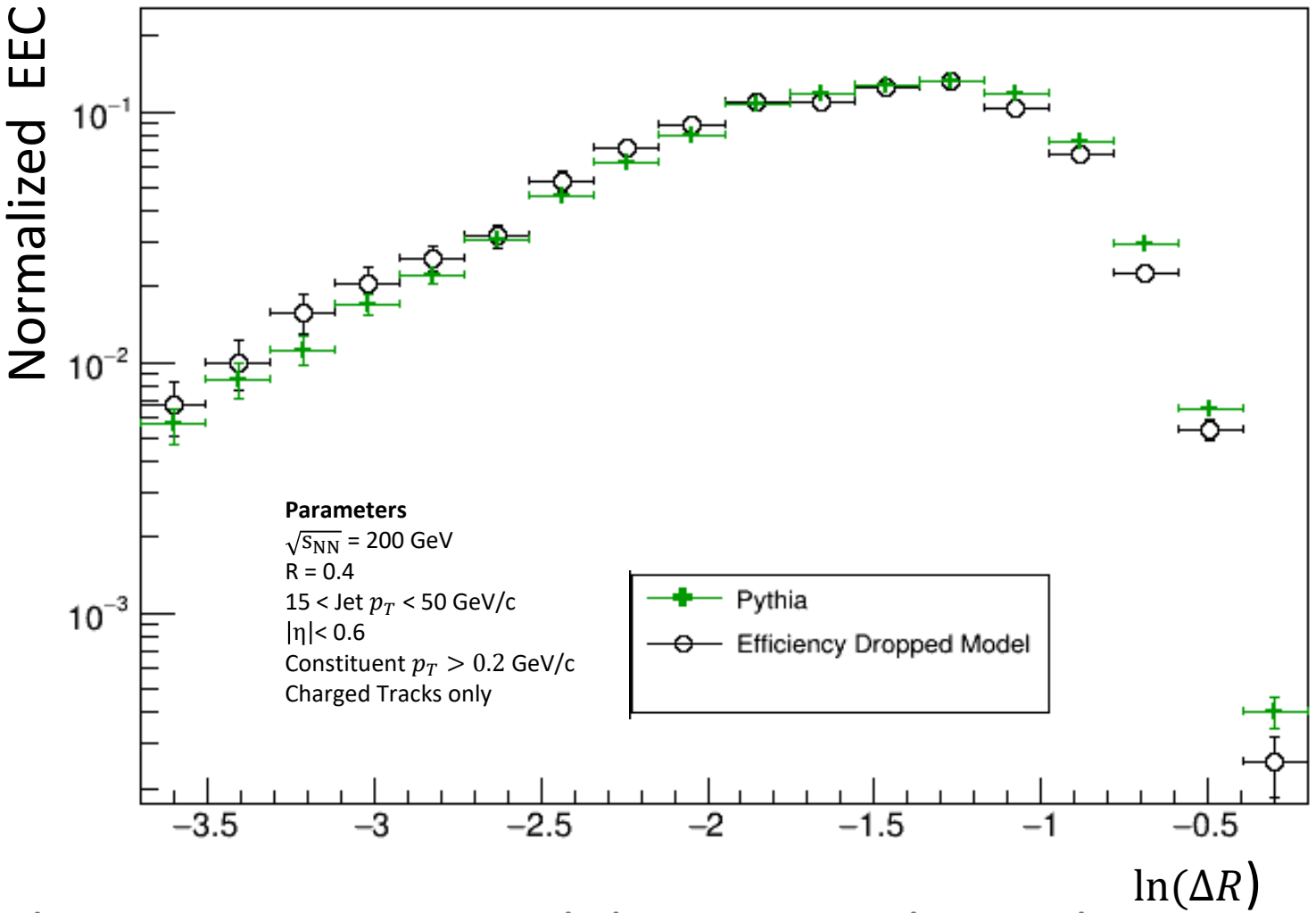
- Transition region moves to smaller opening angle with higher Jet momentum
- Additionally, the “Quark and Gluon region” grows wider

Jet Pt Behavior



- The “Quark and Gluon region” grows wider with higher jet momentum
- Additionally, transition region moves to smaller opening angle

Tracking Efficiency Modeling



- As a test to detector effects, drop 20% of constituents randomly within jets, then re-run jet finder
- Shape of EEC has minimal change with p_T - **Independent** tracking efficiency

Conclusions

- EEC is an exciting observable with growing interest
- Examines jet substructure and probes behavior of jet during both fragmentation and hadronization
- Interesting behavior in response to p_T cuts
- Robust to p_T-independent tracking efficiency effects
- Currently measuring EEC in STAR Run 12 data
- Will present at DNP in October