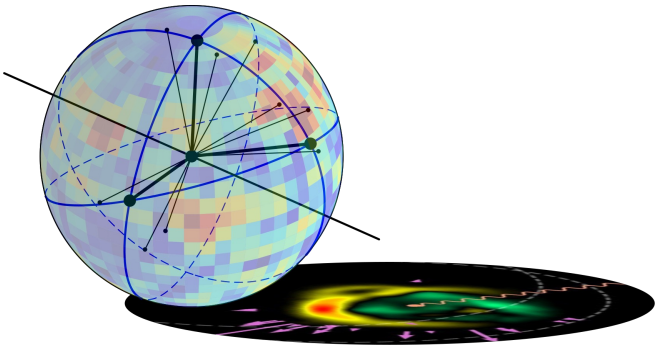


Flavor hierarchy of jet energy correlators inside quark-gluon plasma

Wen-Jing Xing (邢文静)

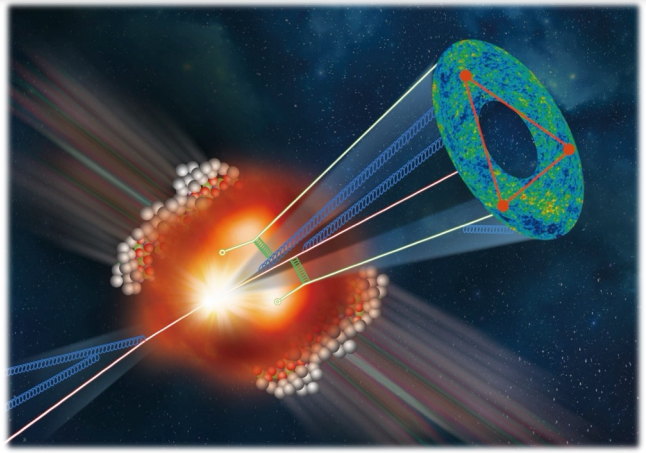
University of South China

New Opportunities in Particle and Nuclear Physics with Energy Correlators

May 6-17, 2025

Outline of my talk

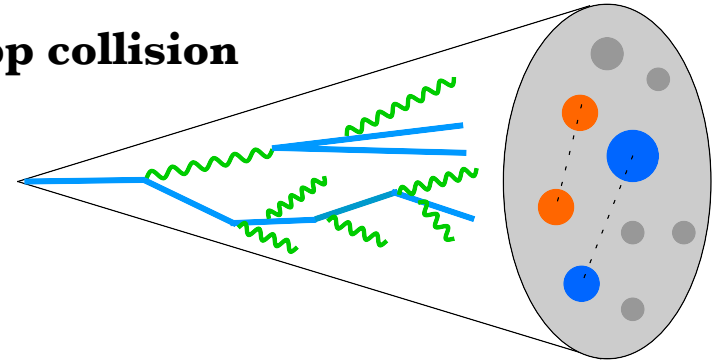
WJX, Cao, Qin and Wang
Phys. Rev. Lett. 134 (2025) 5, 052301



- Introduction to the jet EEC
- The EEC spectra of heavy and light flavor jet in pp and AA
- Interplay of jet-medium interaction on jet EEC
- Summary

Jet energy-energy correlator (EEC)

Jet in pp collision

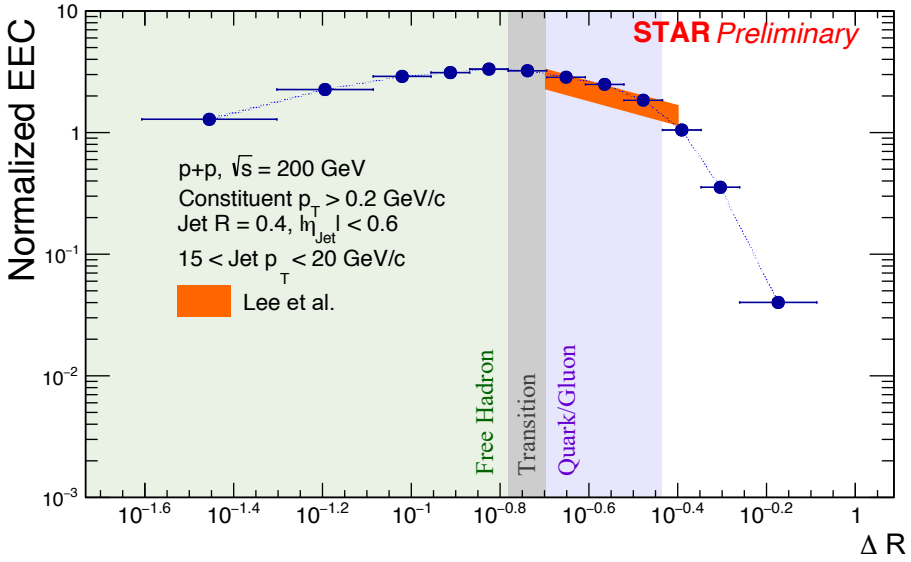


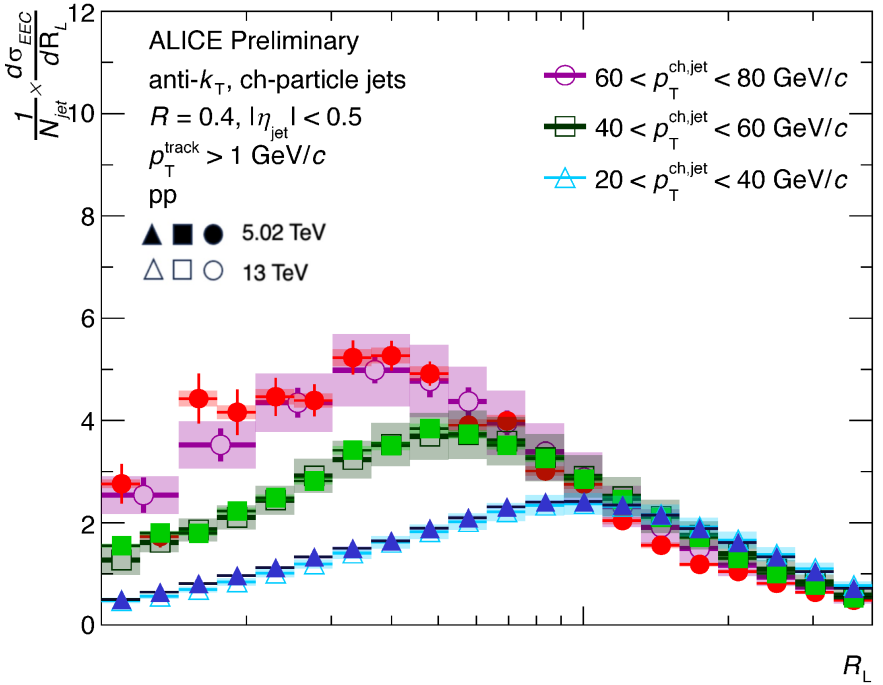
Jet EEC proposed in PRL 130 (2023) 5, 051901

$$\frac{\mathrm{d}\sigma_{\mathrm{EEC}}}{\mathrm{d}R_L} = \int \mathrm{d}\sigma(\Delta R_{ij}) \frac{p_{\mathrm{T},i}\, p_{\mathrm{T},j}}{p^2_{\mathrm{T,jet}}} \delta(\Delta R_{ij} - R_L)$$

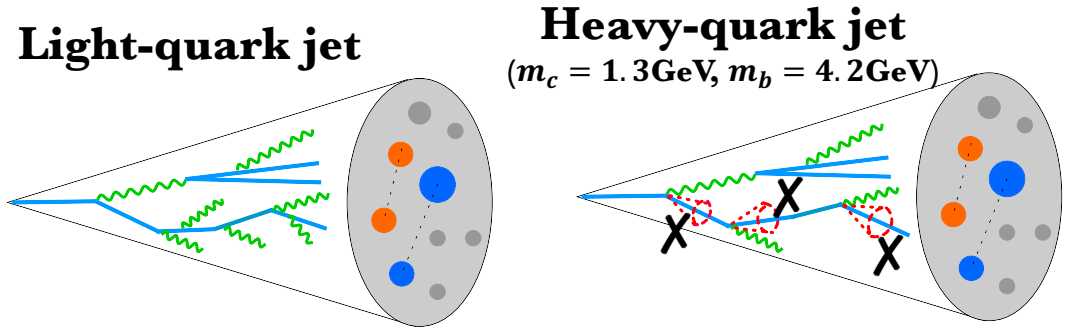
$$\Delta R_{ij} = \sqrt{\Delta\phi^2_{ij} + \Delta\eta^2_{ij}}$$

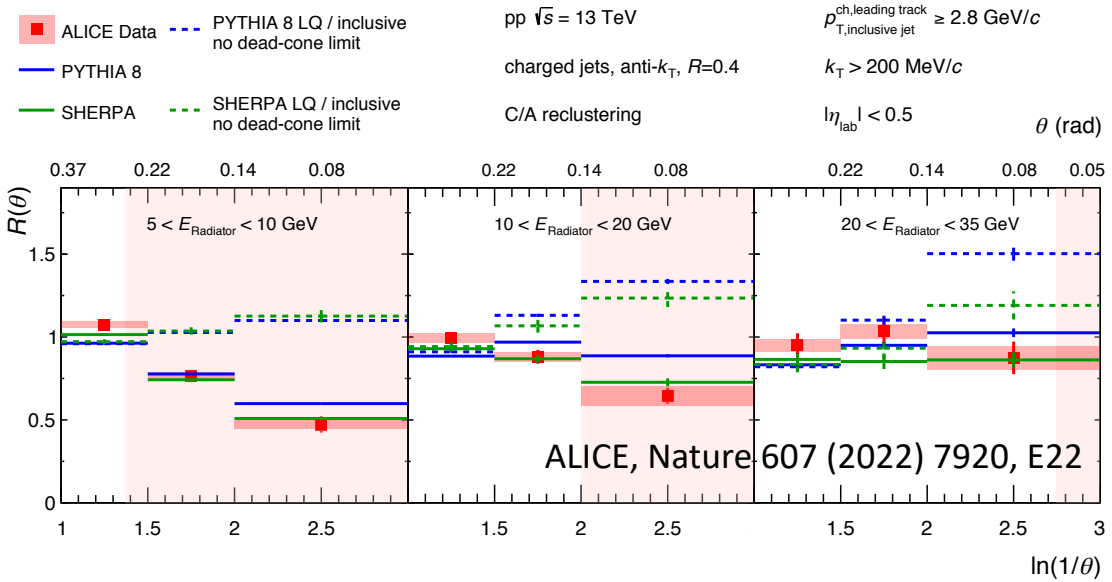
- **Jet EEC presents a clear transition between perturbative region and non-perturbative region.**





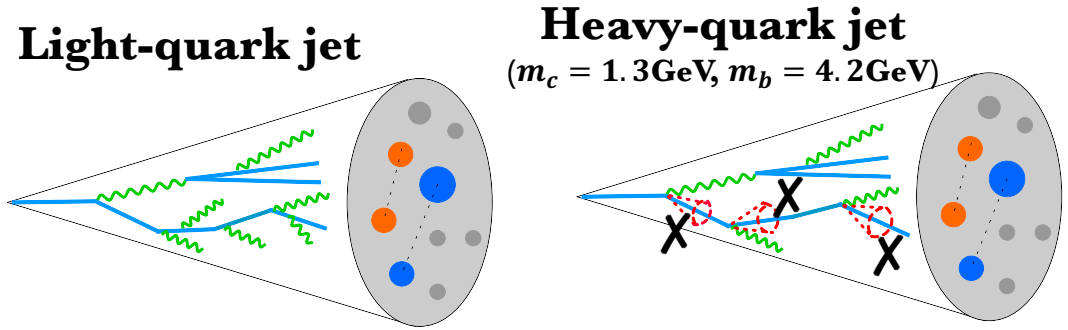
Searches for the flavor dependence of parton splitting



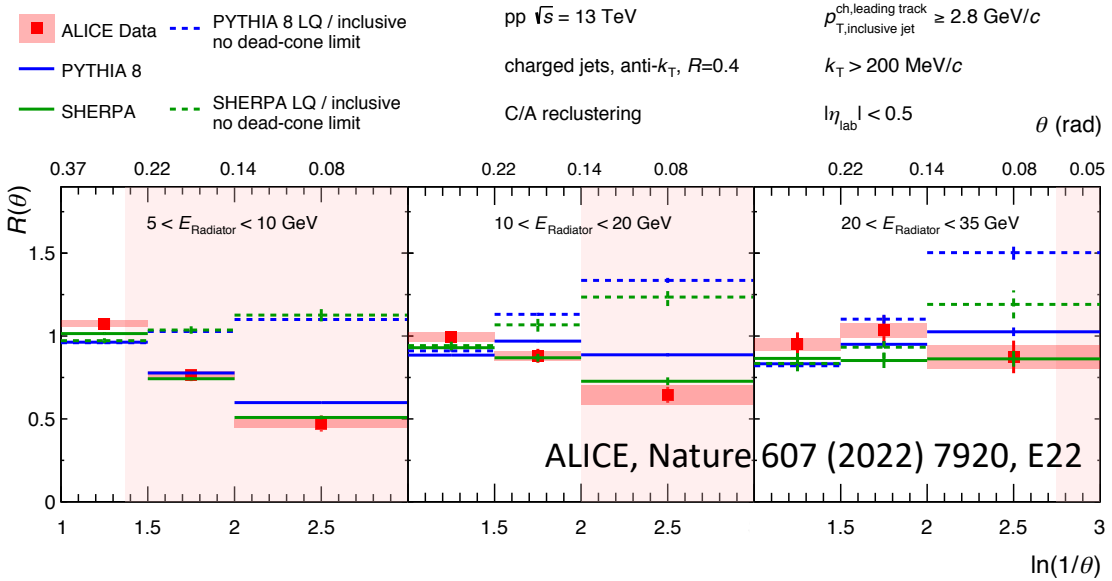


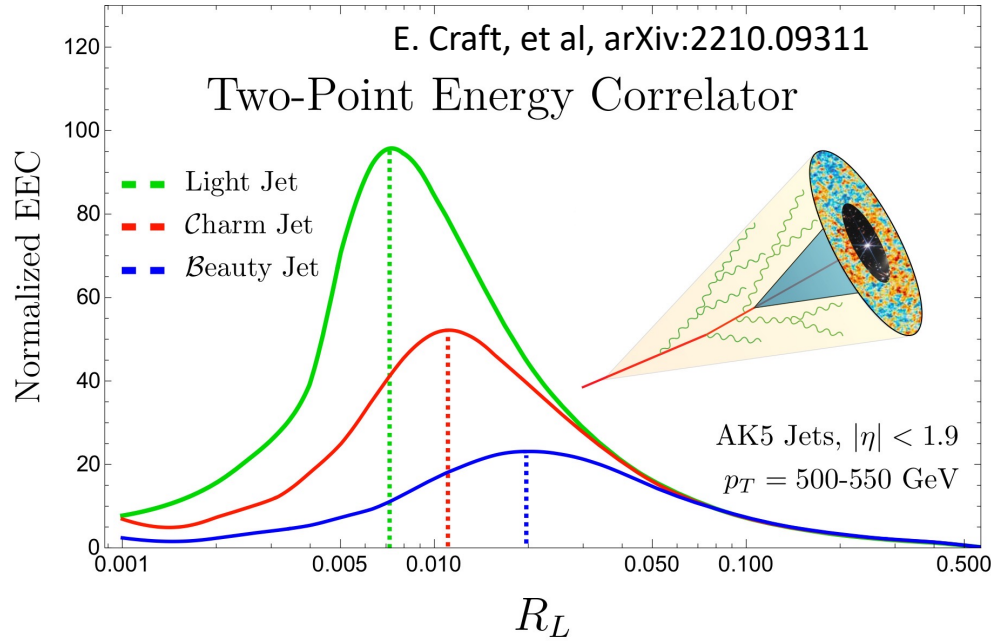
- **Dead-cone effect in QCD: gluon emissions from massive quark are suppressed within a cone of $\theta_0 \sim m_Q/E$.**

Searches for the flavor dependence of parton splitting



- **Dead-cone effect in QCD: gluon emissions from massive quark are suppressed within a cone of $\theta_0 \sim m_Q/E$.**
- **The EEC of heavy flavor jets serve as valuable tools to explore flavor (mass) dependence of parton splitting.**

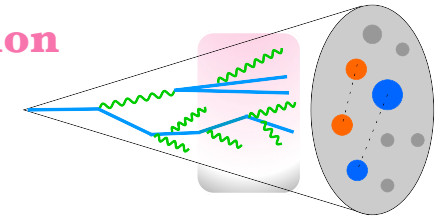


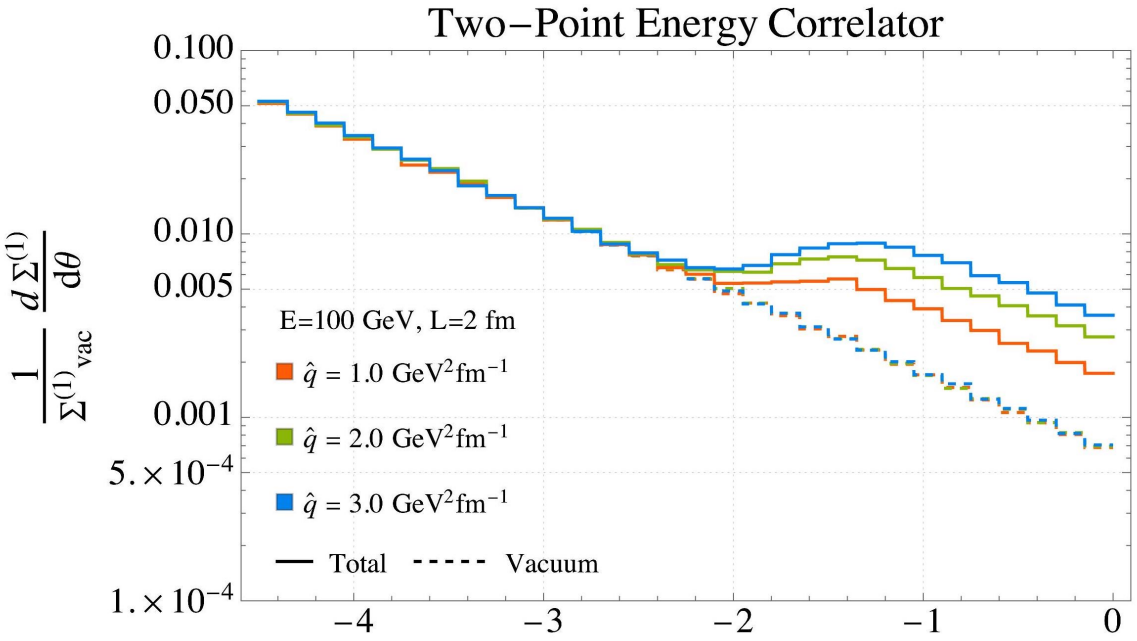


EEC as probe of QGP properties

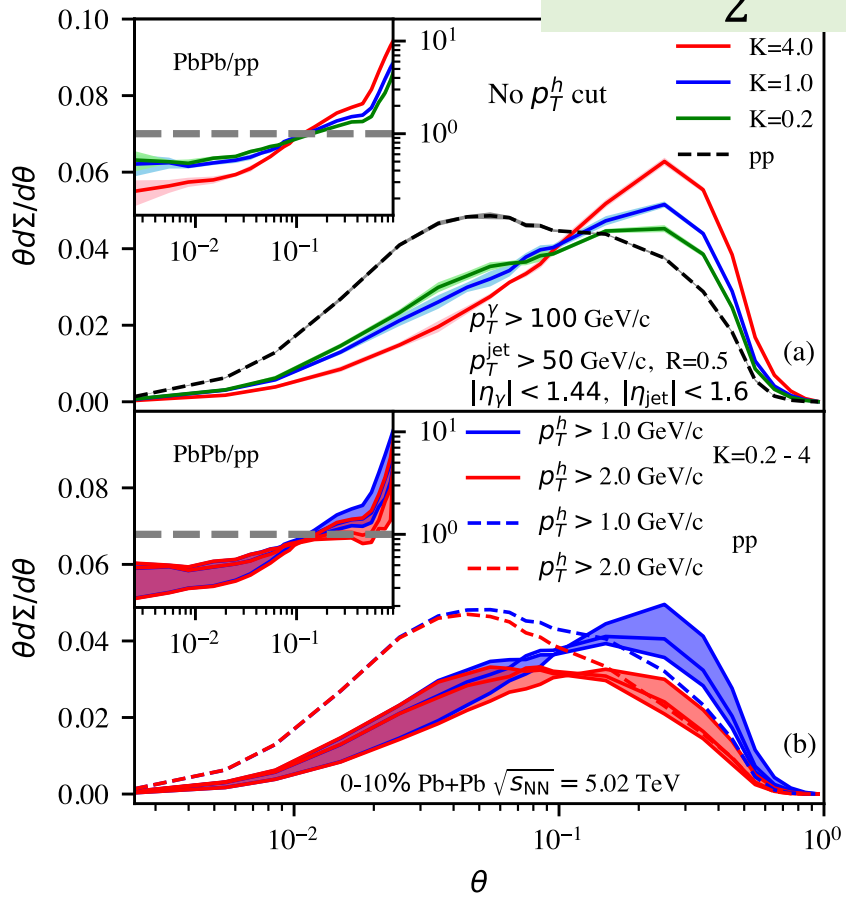
$$\mu_D^2 = \frac{3}{2} K g^2 T^2$$

Jets in heavy-ion collision





C. Andres, et al, PRL, 130 (2023) 26, 262301

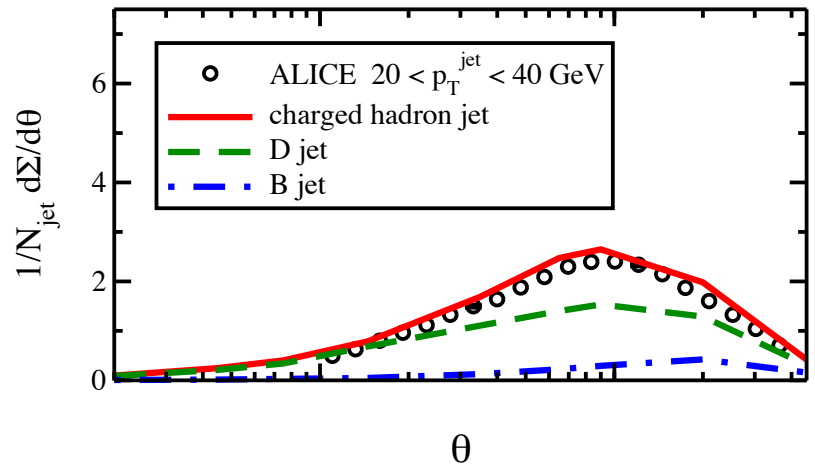


Z. Yang, et al, PRL, 132 (2024) 1, 1

- **Medium-modified jet EECs present remarkable opportunity to probe jet-medium interaction mechanism and QGP properties.**

Light *vs.* heavy flavor jet EEC in pp

Pythia 8



EEC analysis in our work:

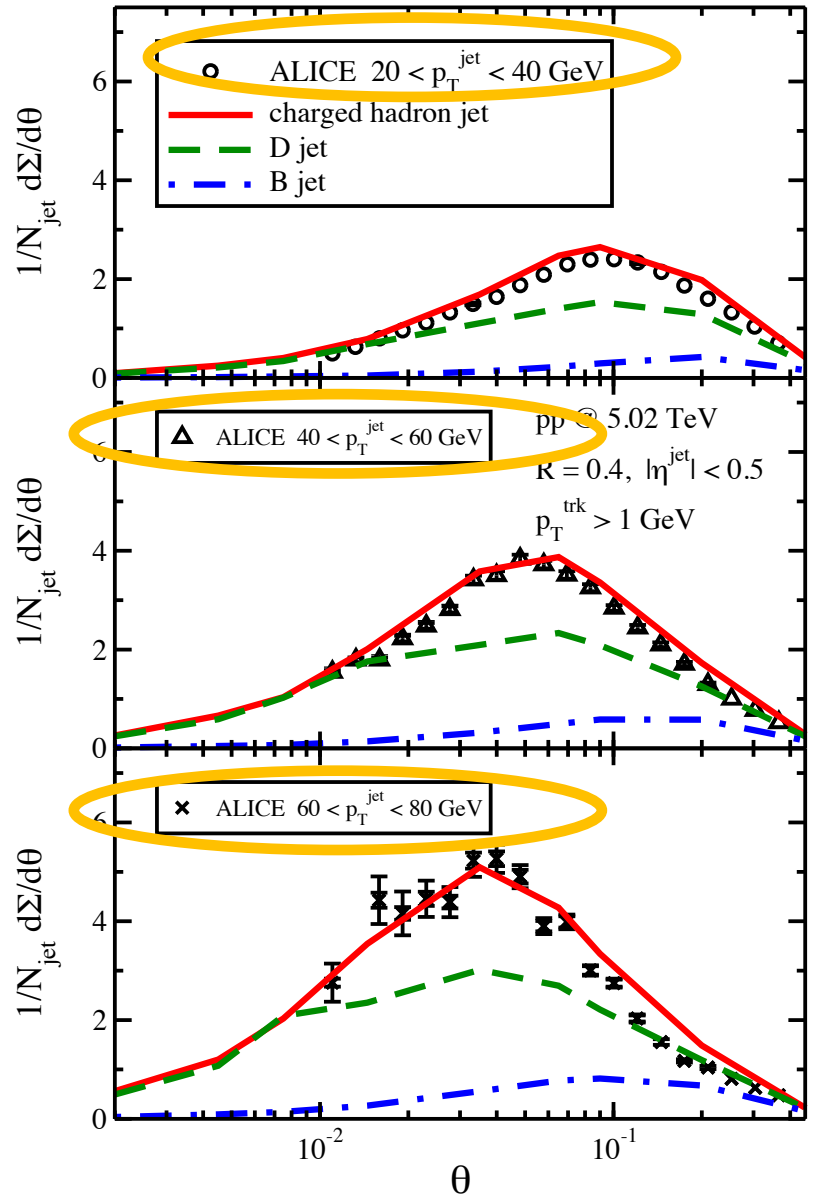
$$\frac{d\Sigma(\theta)}{d\theta} = \frac{1}{\Delta\theta}\sum_{|\theta_{ij}-\theta|<\frac{\Delta\theta}{2}} \frac{p_{\mathrm{T},i}(\vec{n}_i)\, p_{\mathrm{T},j}(\vec{n}_j)}{p^2_{\mathrm{T,jet}}}$$

Flavor (mass) dependence:

- **Σ(charged jet) > Σ(D jet) > Σ(B jet)**
- **θ^{peak}(charged jet) < θ^{peak}(D jet) < θ^{peak}(B jet)**

Flavor hierarchy of jet EEC in pp

Pythia 8



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- **θ^{peak}(charged jet) < θ^{peak}(D jet) < θ^{peak}(B jet)**

Jet energy dependence:

- **Higher p_{T} jet peaks at smaller angle.**

LBT model: jet-medium interaction

- **Boltzmann equation:**

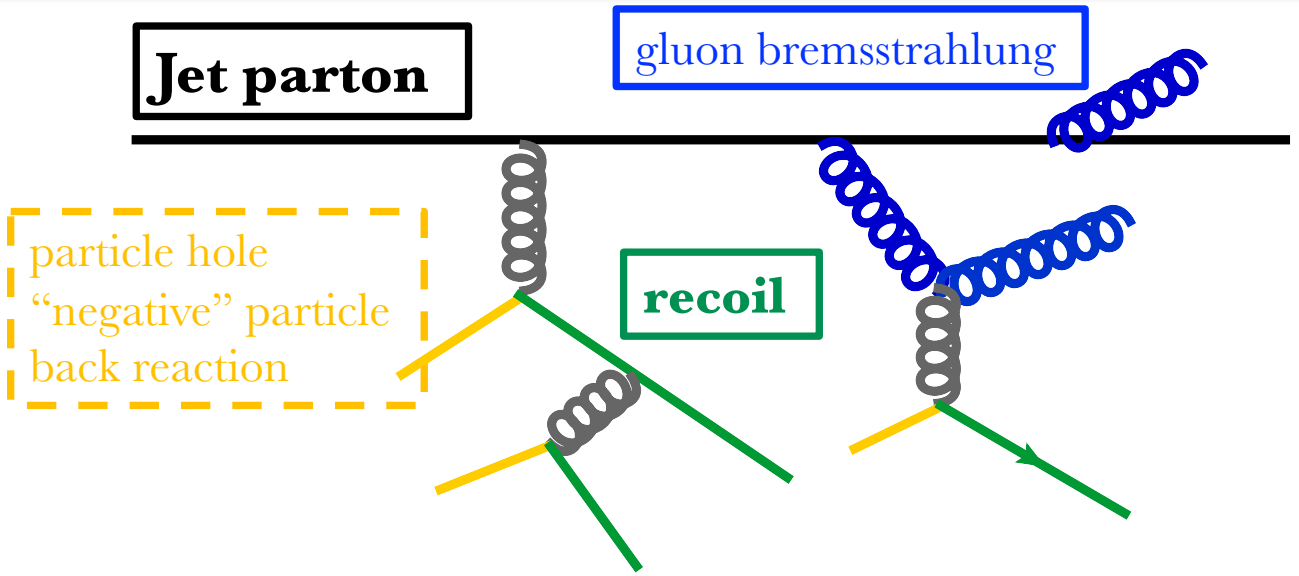
$$p_a \cdot \partial f_a = E_a \left[C^{\rm el}(f_a) + C^{\rm inel}(f_a) \right]$$

- **Elastic collisions:**

$$\Gamma_a^{\rm el}(E_a, T) = \sum_{b,(cd)} \frac{\gamma_b}{2E_a} \int \prod_{i=b,c,d} \frac{d^3p_i}{E_i(2\pi)^3} f_b(E_b, T)$$
$$\times [1 \pm f_c(E_c, T)][1 \pm f_d(E_d, T)] S_2(\hat{s}, \hat{t}, \hat{u})$$
$$\times (2\pi)^4 \delta^{(4)}(p_a + p_b - p_c - p_d) |\mathcal{M}_{ab\to cd}|^2$$

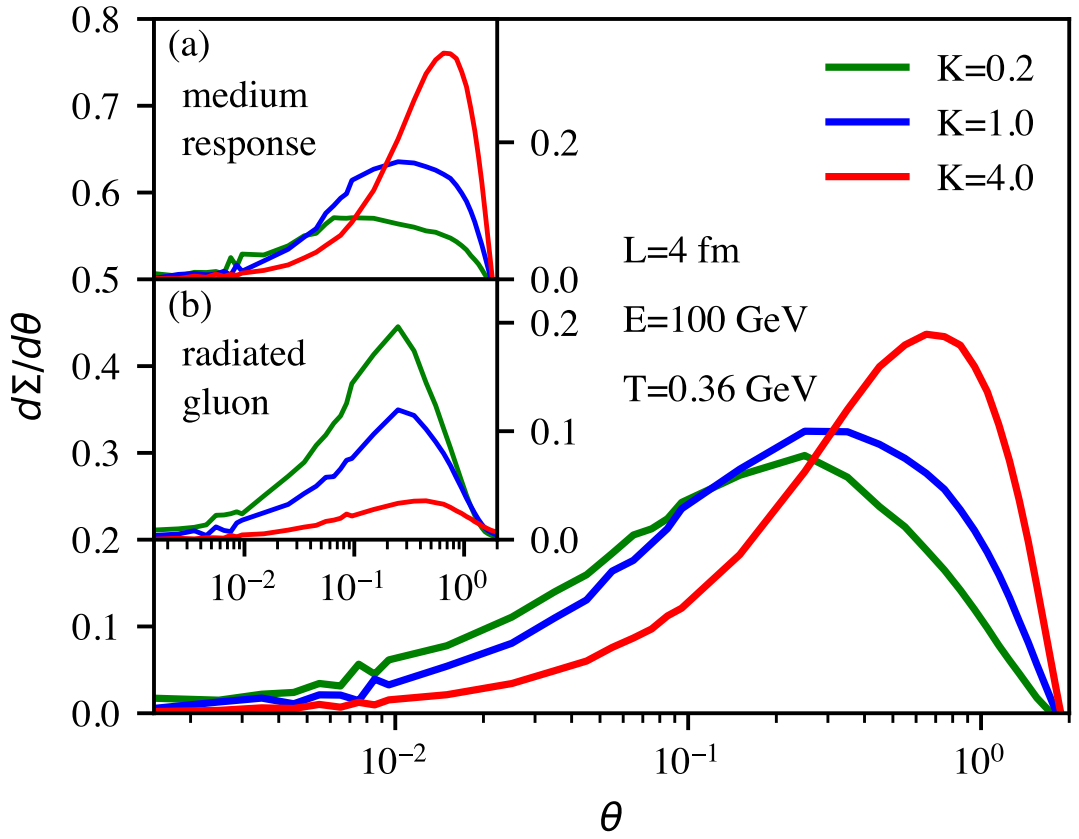
- **Inelastic collisions:**

$$\Gamma_a^{\rm inel}(E_a, T, t) = \int dz dk_\perp^2 \frac{1}{1+\delta^{ag}} \frac{dN_g^a}{dz dk_\perp^2 dt}$$

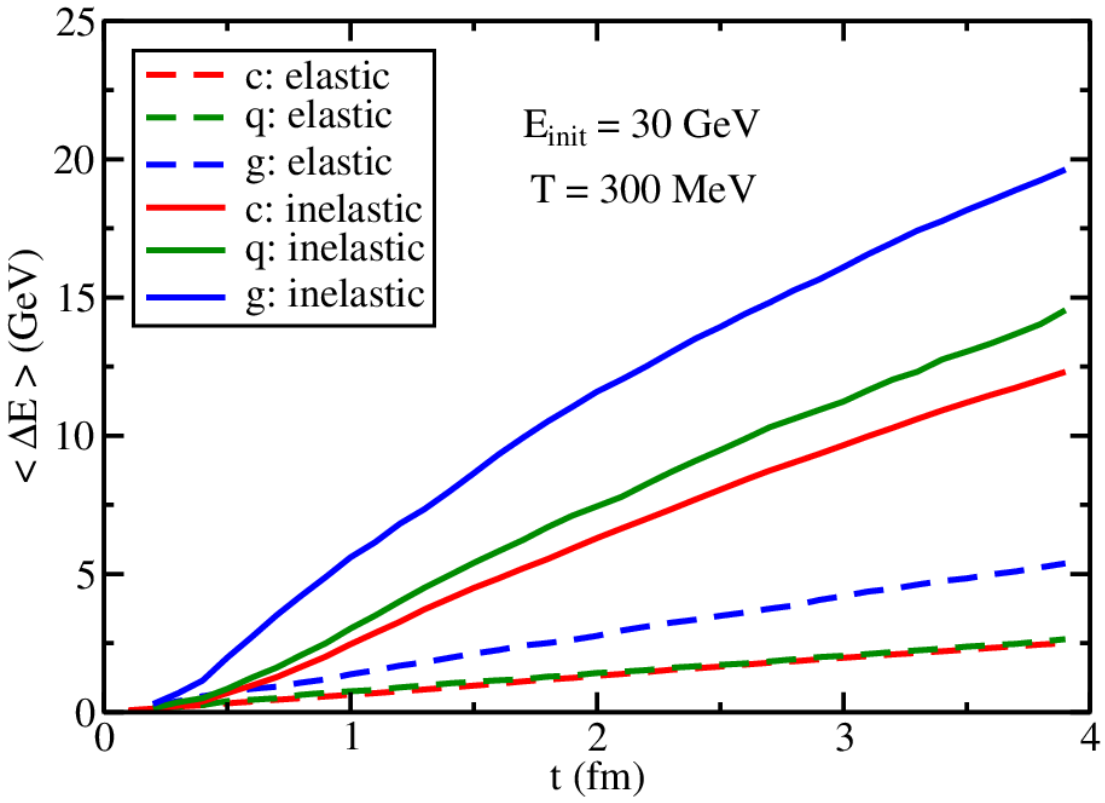


- **Describe jet partons, radiated gluons, recoil partons and "negative" partons within the same transport framework.**

LBT model: jet-medium interaction

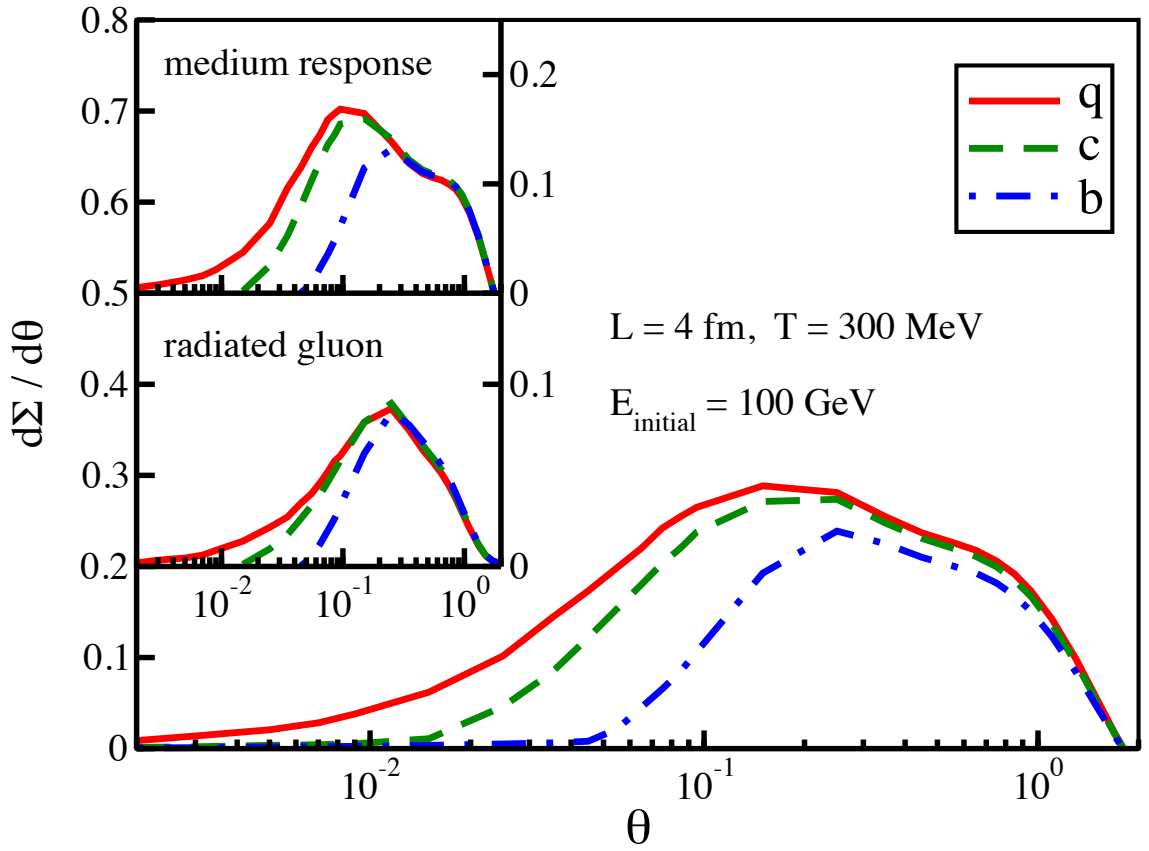


Z. Yang, et al, PRL, 132 (2024) 1, 1



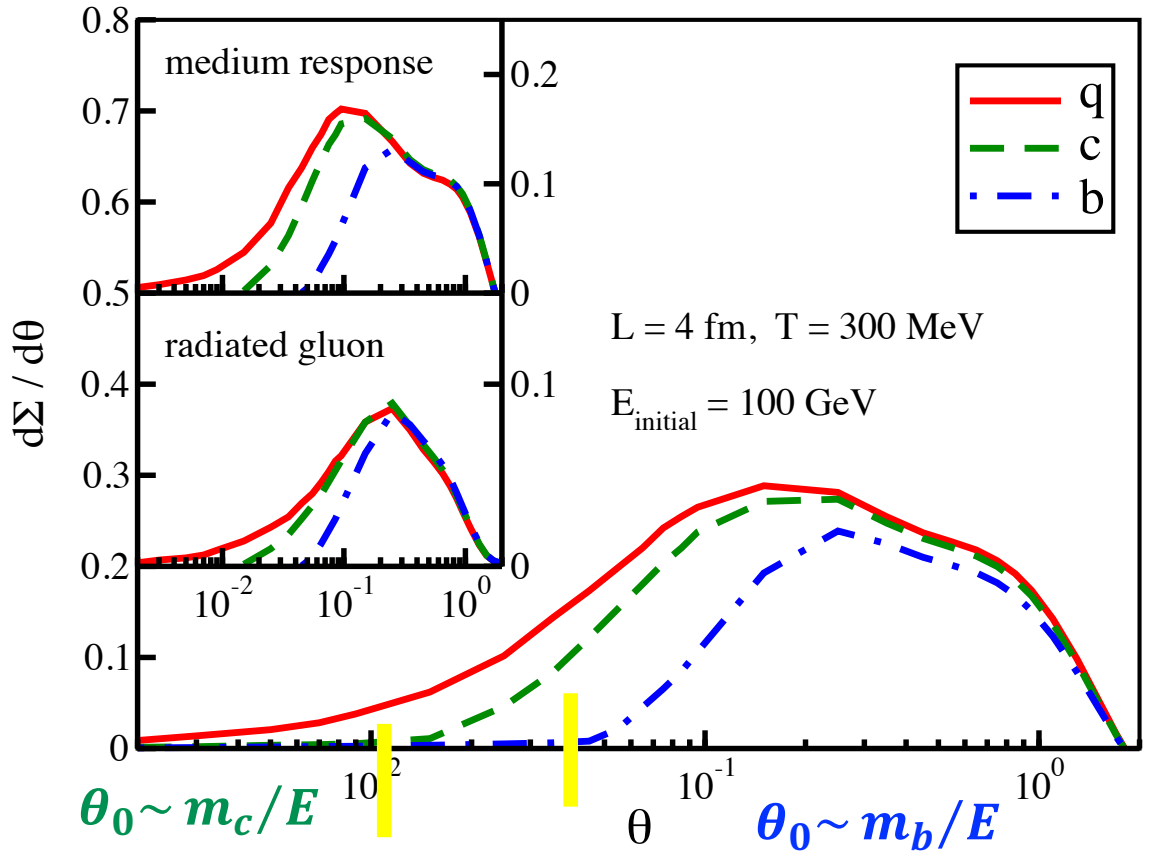
He, Luo, Wang, Zhu, PRC 2015; Cao, Luo, GYQ, Wang, PRC 2016, PLB 2018; etc.

EEC of partons developed from a single quark



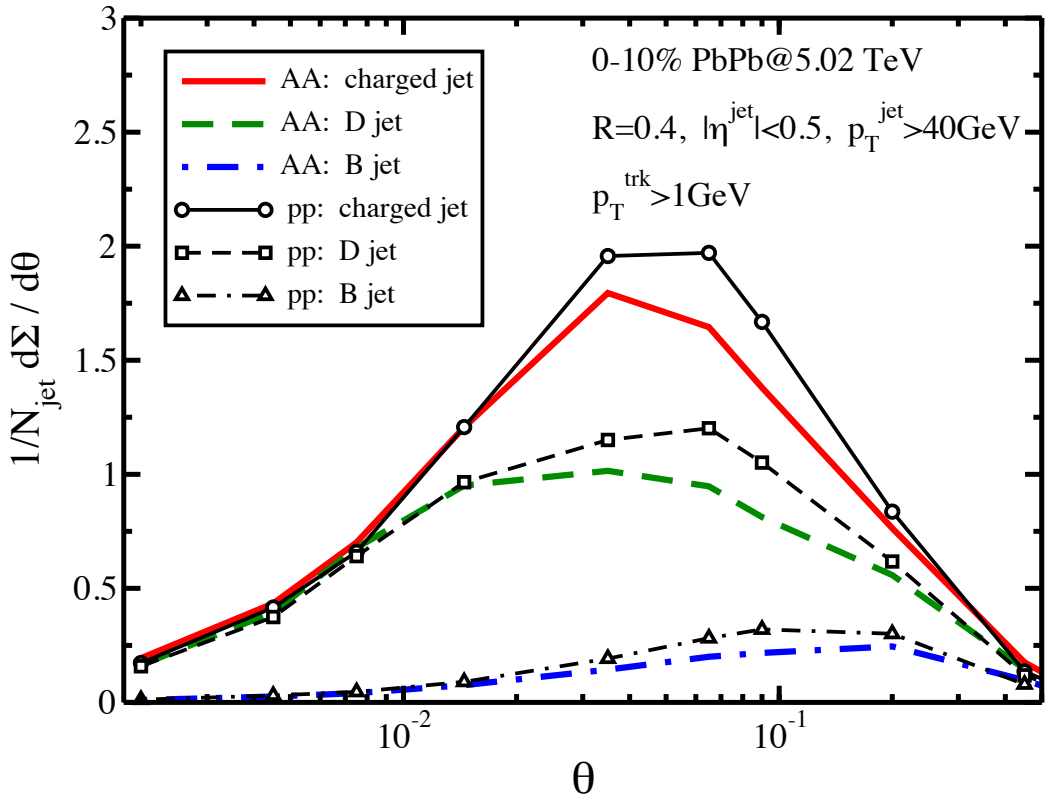
- **Flavor (mass) hierarchy of EEC:**
  - $\Sigma(\text{q jet}) > \Sigma(\text{c jet}) > \Sigma(\text{b jet})$
  - $\theta^{\text{peak}}(\text{q jet}) < \theta^{\text{peak}}(\text{c jet}) < \theta^{\text{peak}}(\text{b jet})$

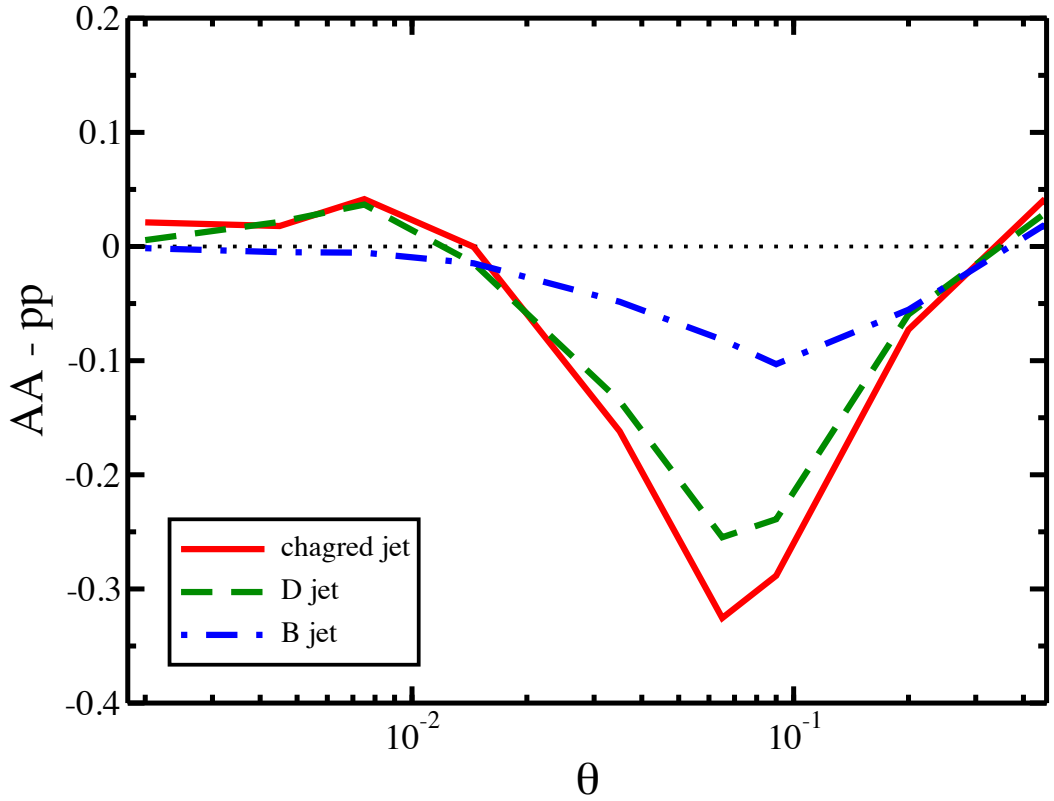
EEC of partons developed from a single quark



- **Flavor (mass) hierarchy of EEC:**
  - **Σ(q jet) > Σ(c jet) > Σ(b jet)**
  - **θ^{peak}(q jet) < θ^{peak}(c jet) < θ^{peak}(b jet)**
- **Contributions from medium response and gluon emission show similar hierarchies**

Light *vs.* heavy flavor jet EEC in central PbPb

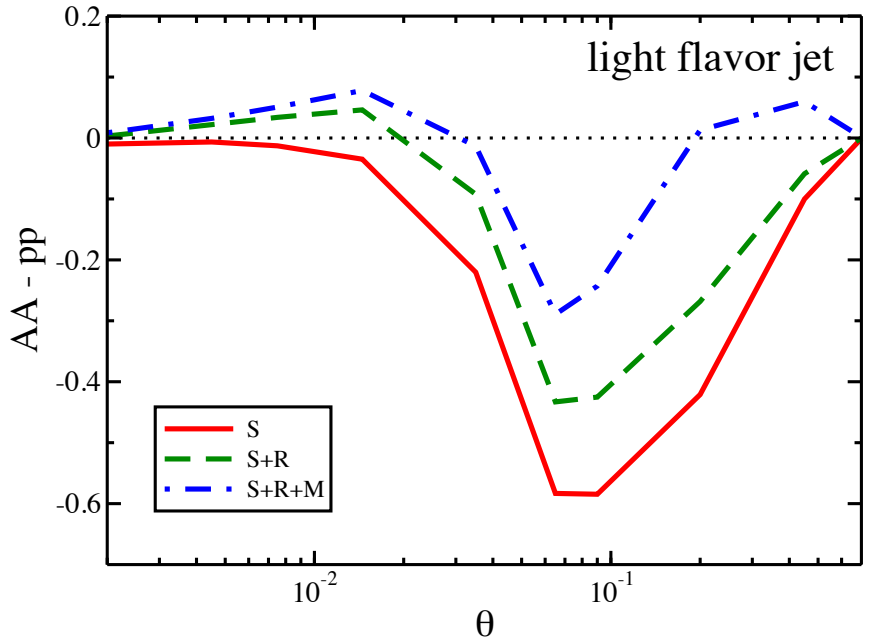




Nuclear modification (AA-pp) of jet EEC:

- **General features: suppression at intermediate θ, enhancement at small θ (except for *B*-jet) and large θ.**
- **Flavor hierarchy: weaker nuclear modification (both suppression and enhancement) for heavy-meson-jets.**

Effect of jet-medium interaction on jet EEC



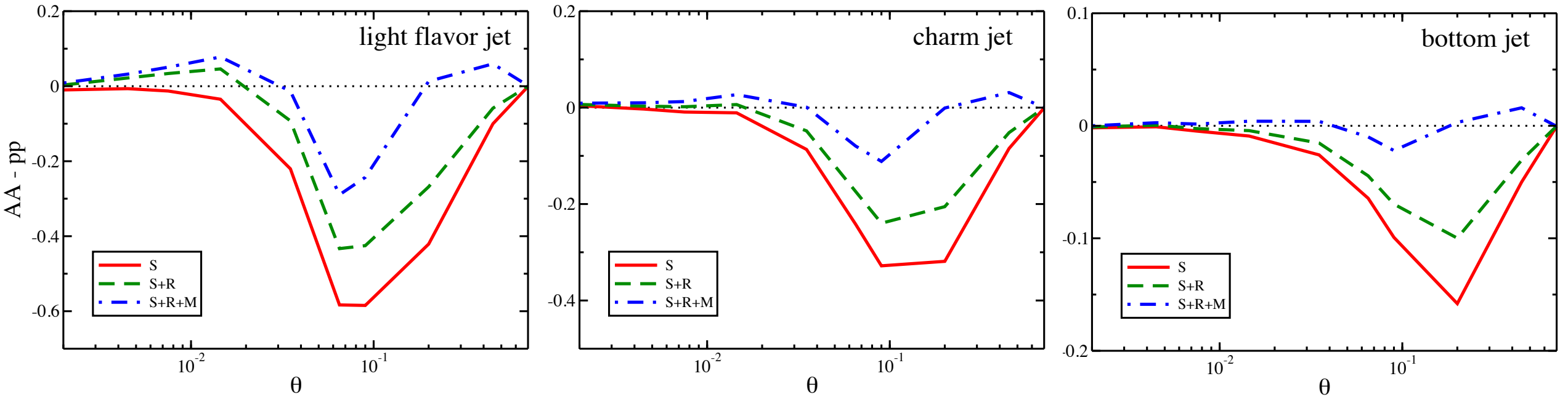
S: shower partons inherited from Pythia

S+R: add medium-induced radiated gluons

S+R+M: further add medium response

- **Jet energy loss causes suppression over the entire θ region.**
- **Medium-induced gluon emission enhances EEC at small θ.**
- **Medium response enhances EEC at large θ.**

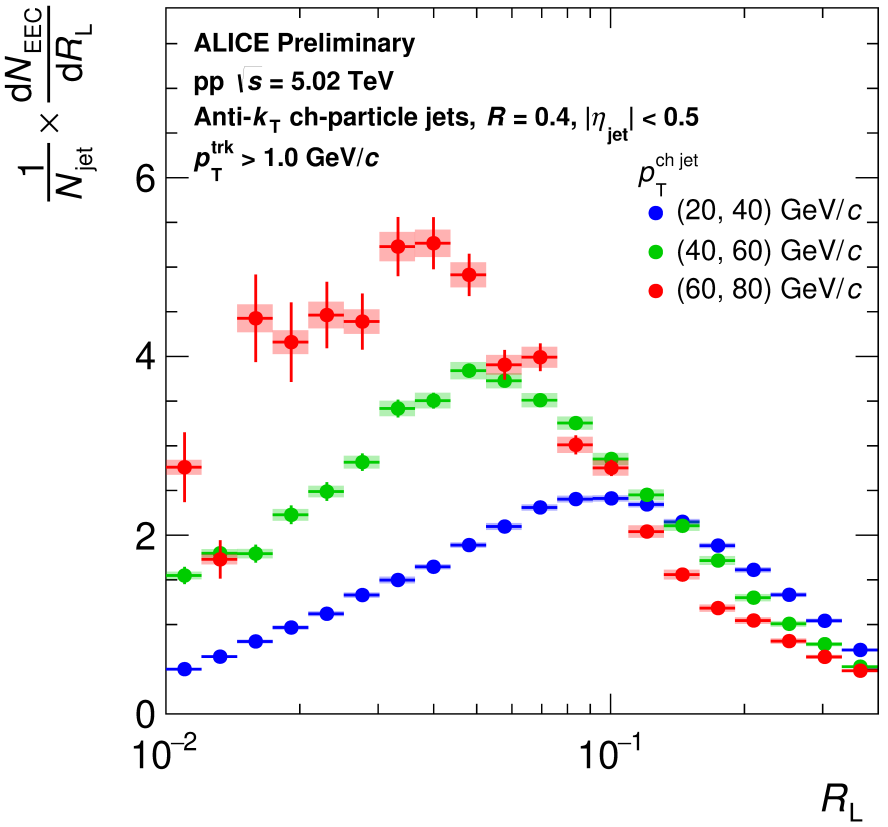
Effect of jet-medium interaction on jet EEC



From light flavor jets to heavy flavor jets:

- **the contribution from energy loss, radiated gluons and medium response to jet EEC becomes smaller due to mass dependence of jet-medium interactions.**

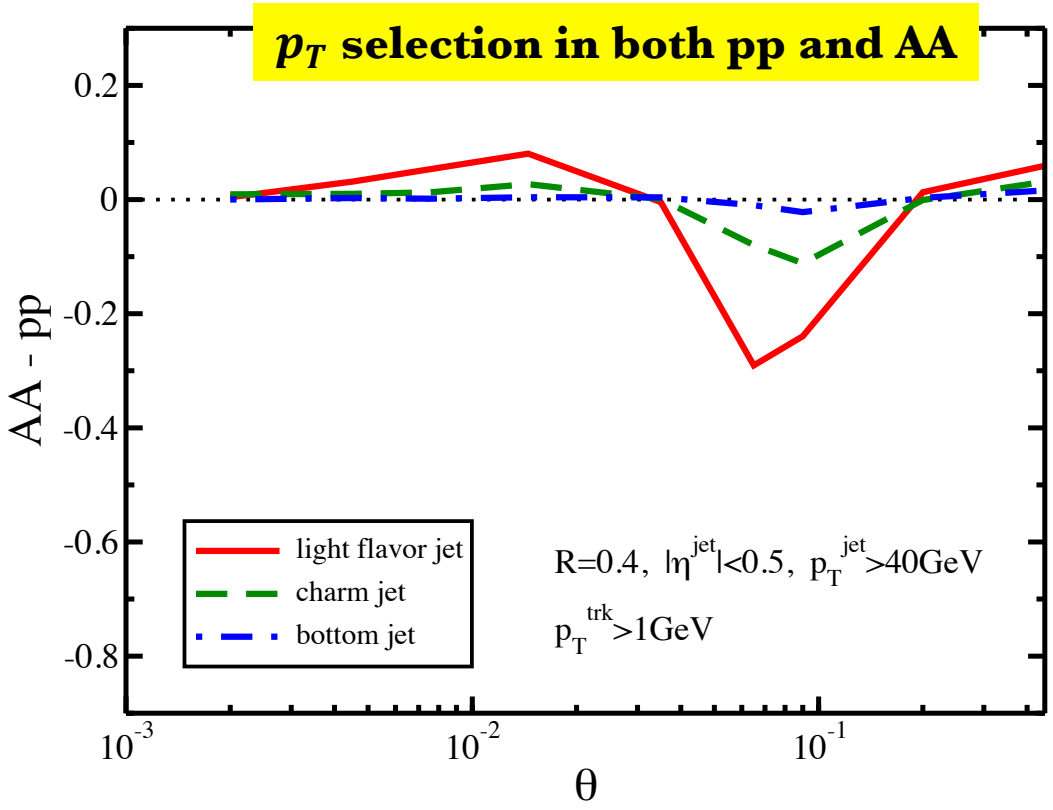
Inclusive jets: selection bias due to energy loss

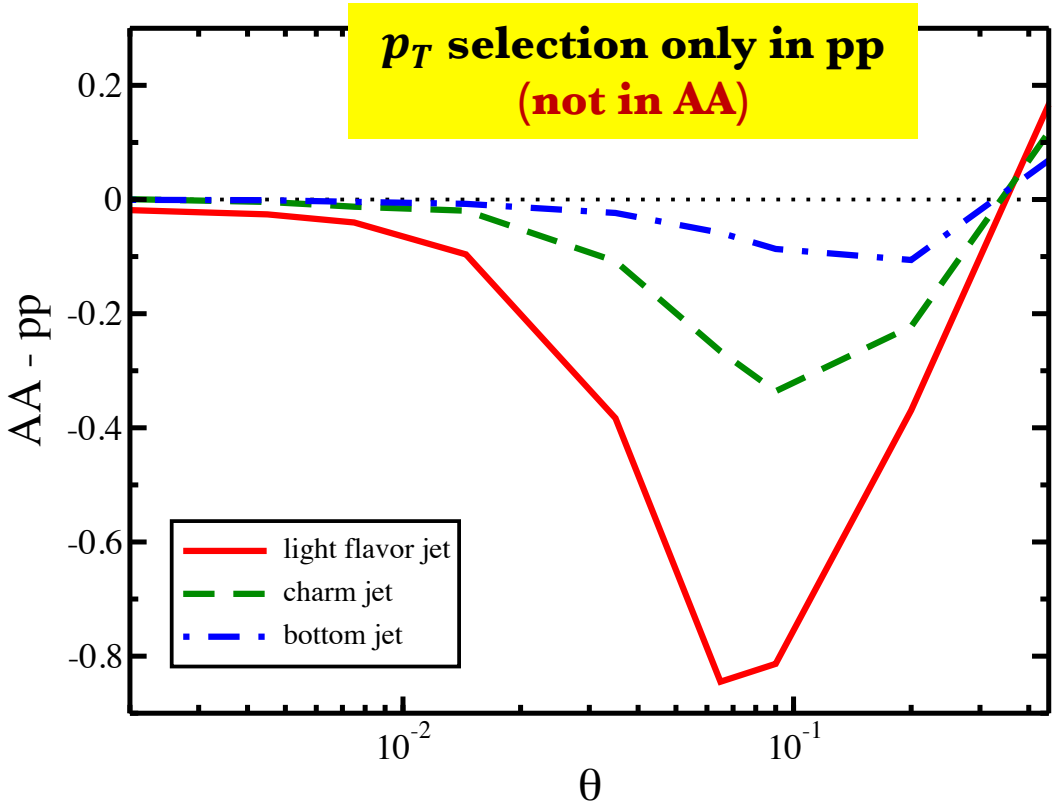


- **In pp collisions, the feature of jet EEC spectra depends on jet p_T.**
- **Comparing to pp jets with a given p_T, AA jets originate from higher pp jets.**

  → Enhancement of jet EEC at small θ in AA collisons.

Effect of selection bias on jet EEC





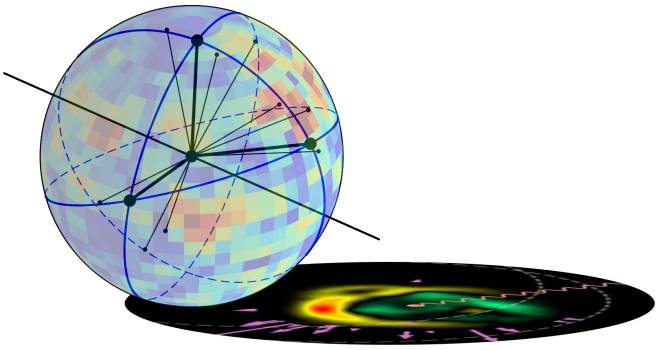
Removal of selection bias:

- **Implement p_T selection for pp jets, and evolve jet partons through the QGP and analyze their final-state EEC without additional jet reconstruction and p_T selection.**
- **Significantly smaller EEC at small to intermedium θ.**

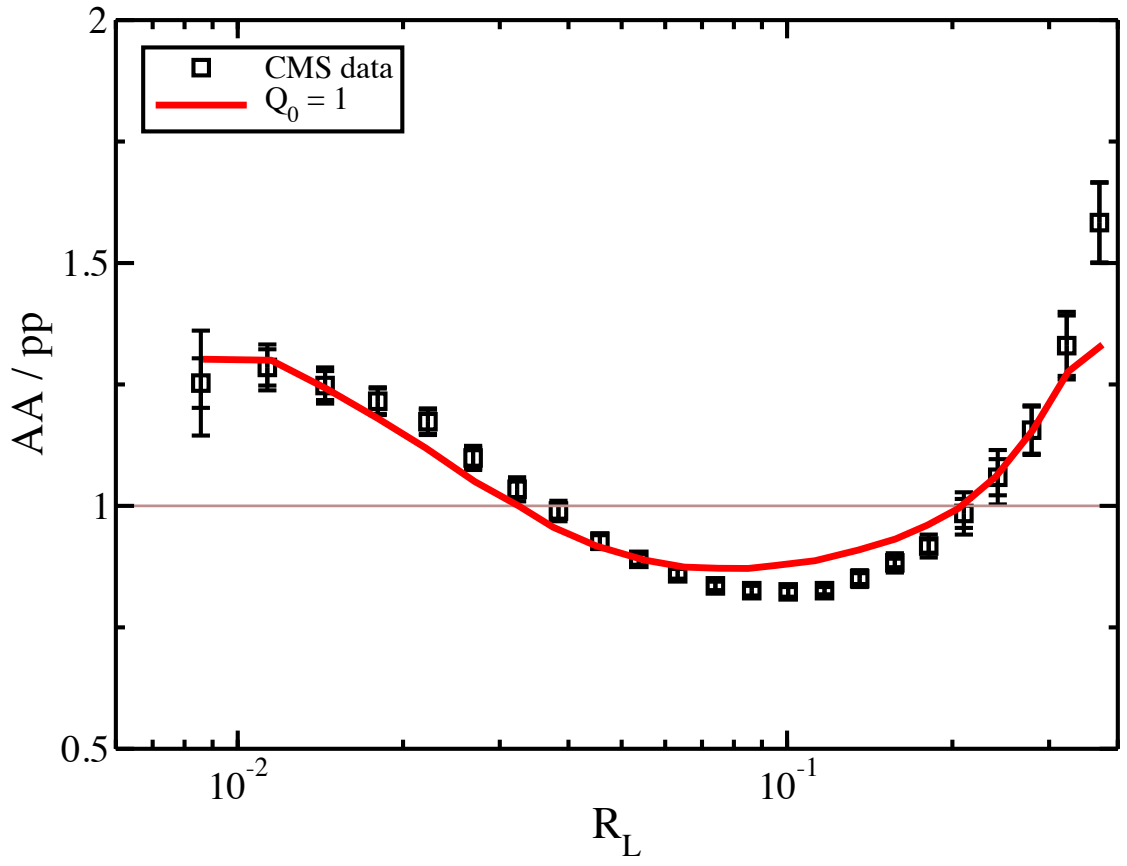
Summary

Xing, Cao, Qin and Wang, *Phys. Rev. Lett.* 134 (2025) 5, 052301

- **We have performed a complete realistic simulation on the medium modification of heavy and light flavor jets in heavy-ion collisions.**
- **A clear flavor hierarchy is observed for jet EEC in both vacuum and QGP due to mass effect.**
- **The medium modification of jet EEC exhibits rich structure: suppression at intermediate angles, and enhancement at small and large angles, which can be explained by the interplay of mass effect, energy loss, medium-induced radiation and medium response.**



Thank You !


CMS data
$Q_0 = 1$
AA / pp
R_L
2
1.5
1
0.5
10^{-2}
10^{-1}