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Energy-energy correlators of heavy and light flavor jets in heavy-ion collisions

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In collaboration with Shanshan Cao, Guang-You Qin and Xin-Nian Wang

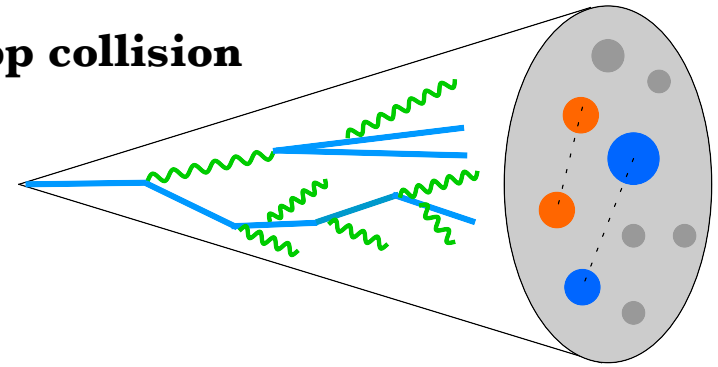
Outline of my talk

Wen-Jing Xing, Shanshan Cao, Guang-You Qin and Xin-Nian Wang
arXiv:2409.12843

- 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

Introduction to jet EEC

Jet in pp collision

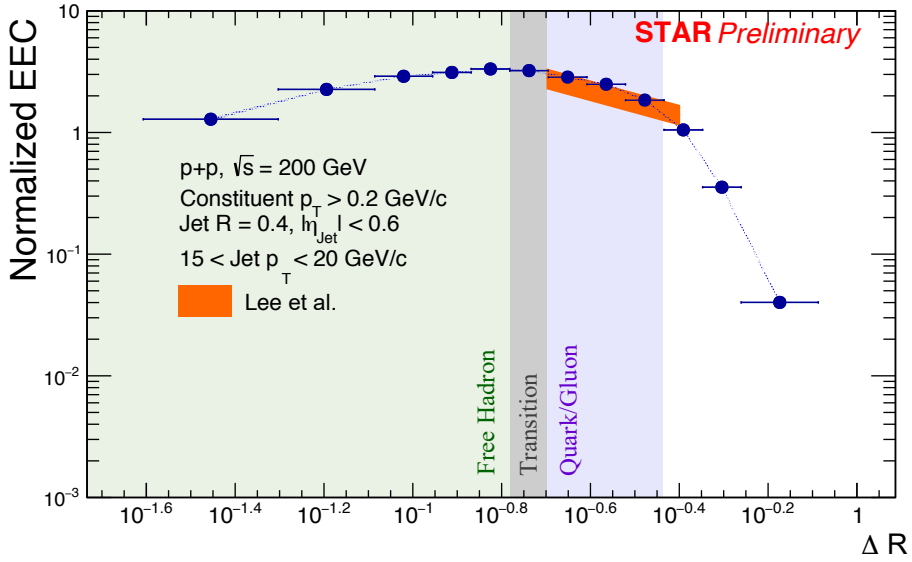


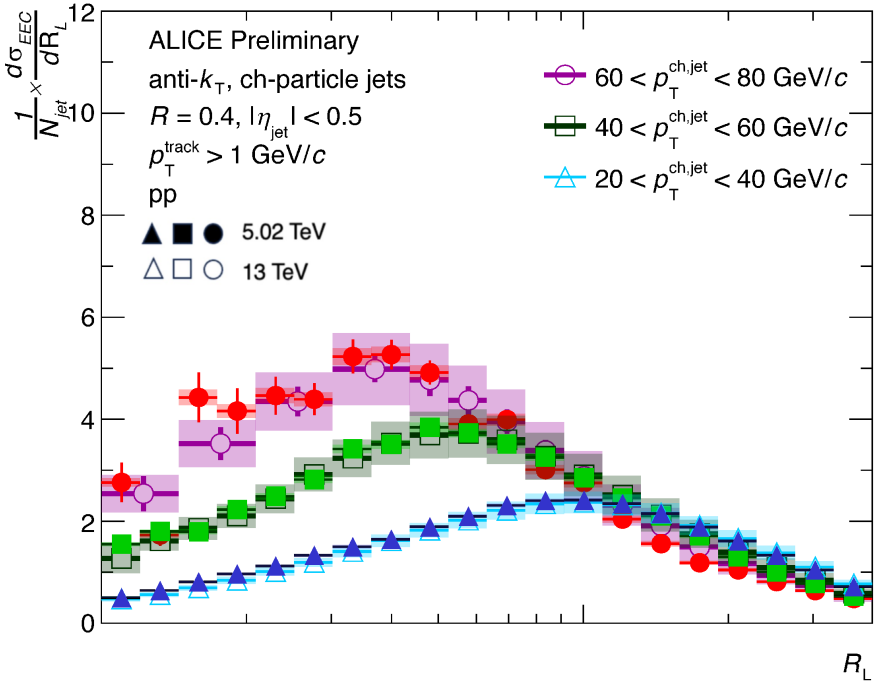
Jet EEC proposed in PRL 130 (2023) 5, 051901

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

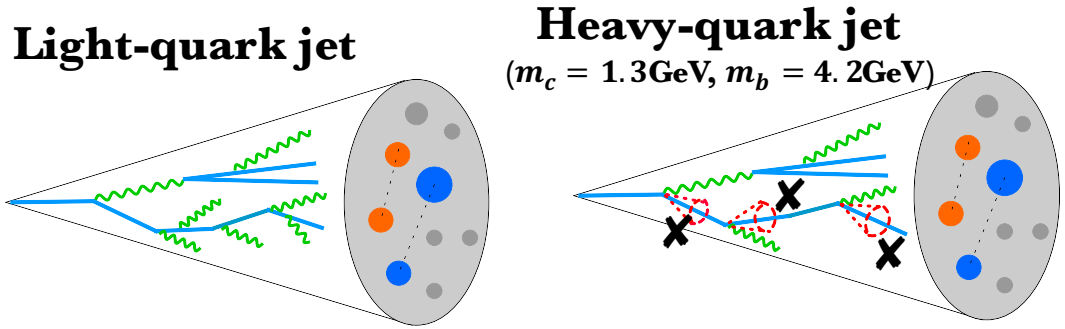
$$\Delta R_{ij} = \sqrt{\Delta\phi^2_{ij} + \Delta\eta^2_{ij}}$$

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

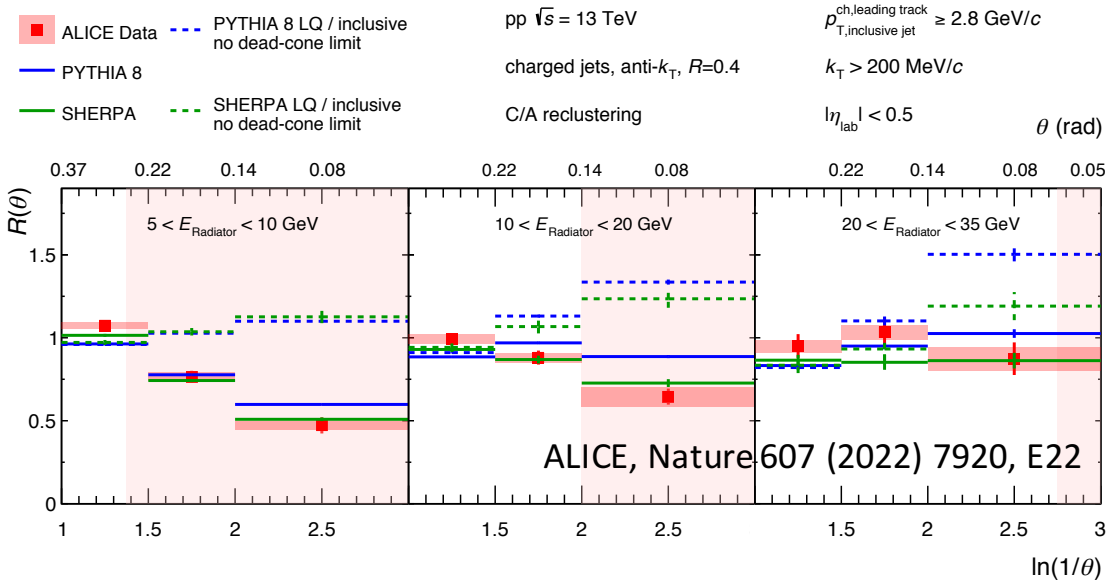


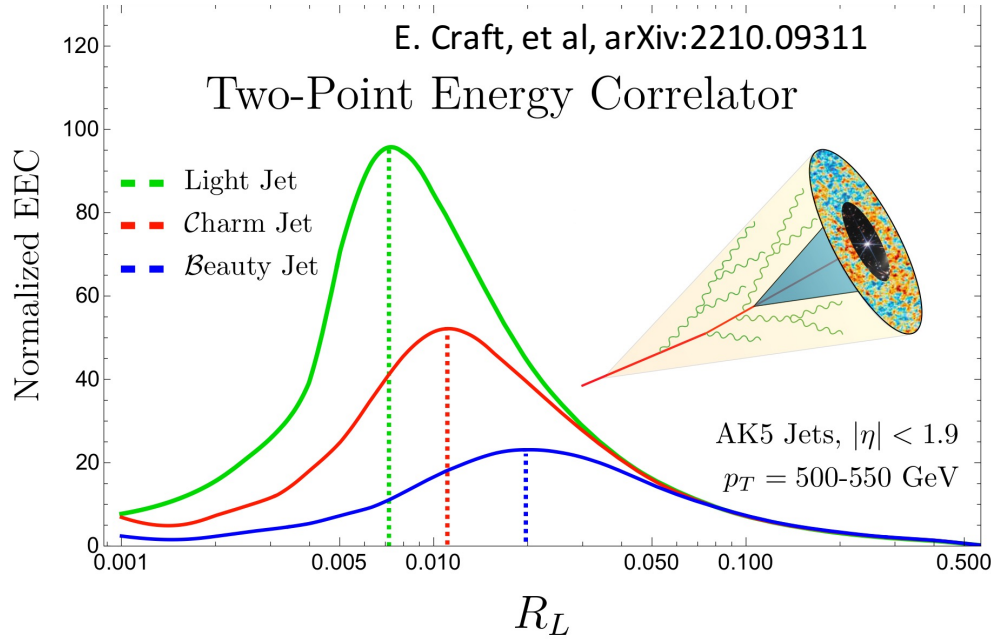


Flavor (mass) dependence of jet EEC



- **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.**

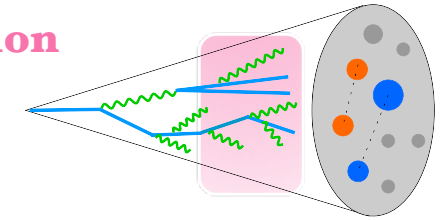


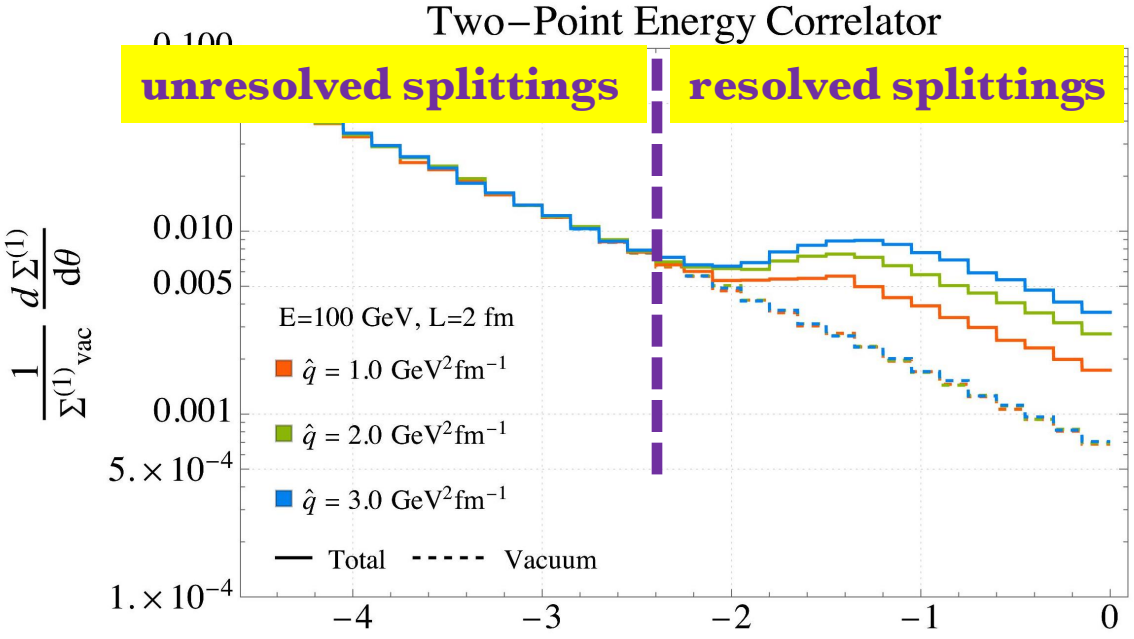


EEC as probe of QGP properties

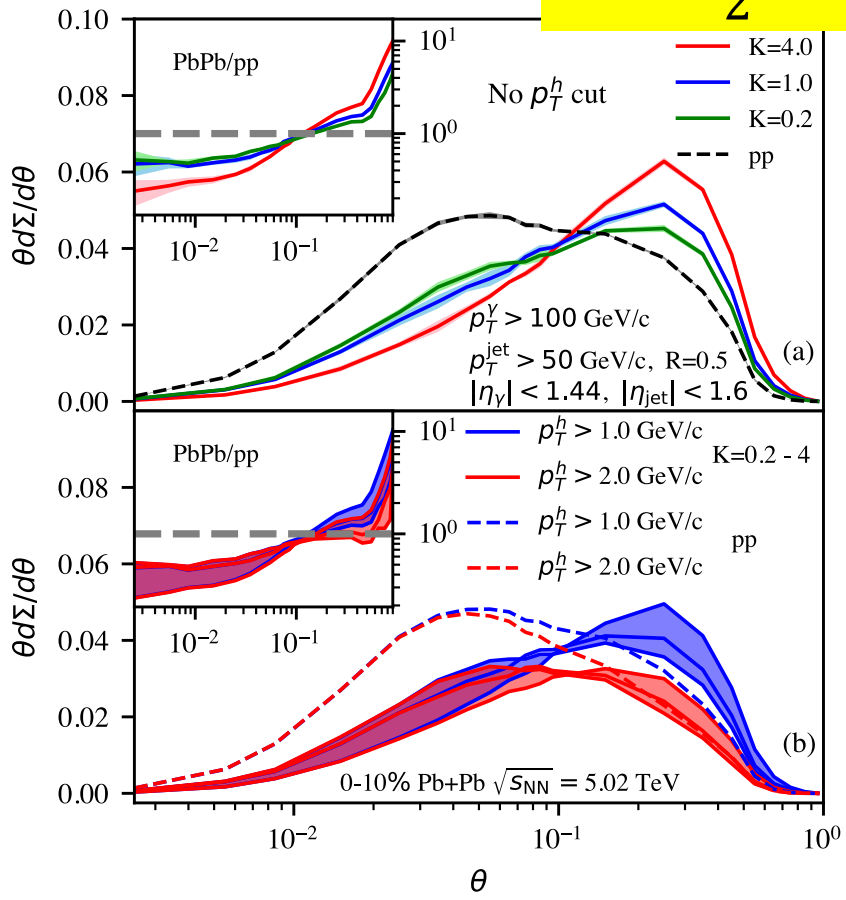
$$\mu_D^2 = \frac{3}{2} K g^2 T^2$$

Jets in heavy-ion collision





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

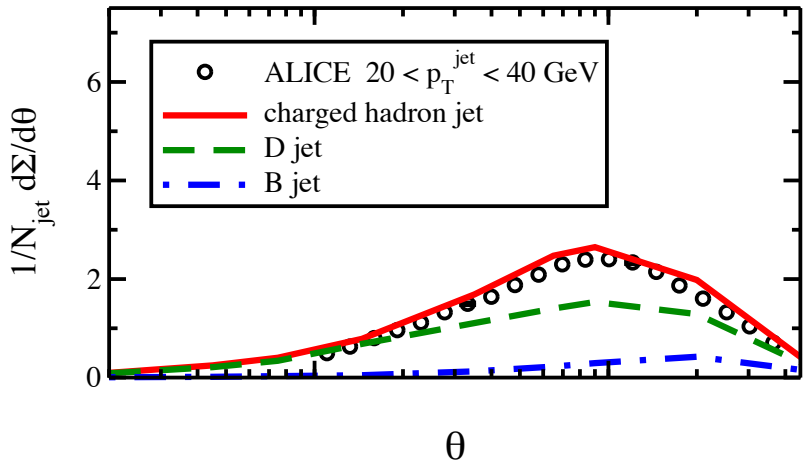


Z. Yang, et al, PRL, 132 (2024) 1, 1

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

Flavor hierarchy of jet EEC in pp

Pythia 8

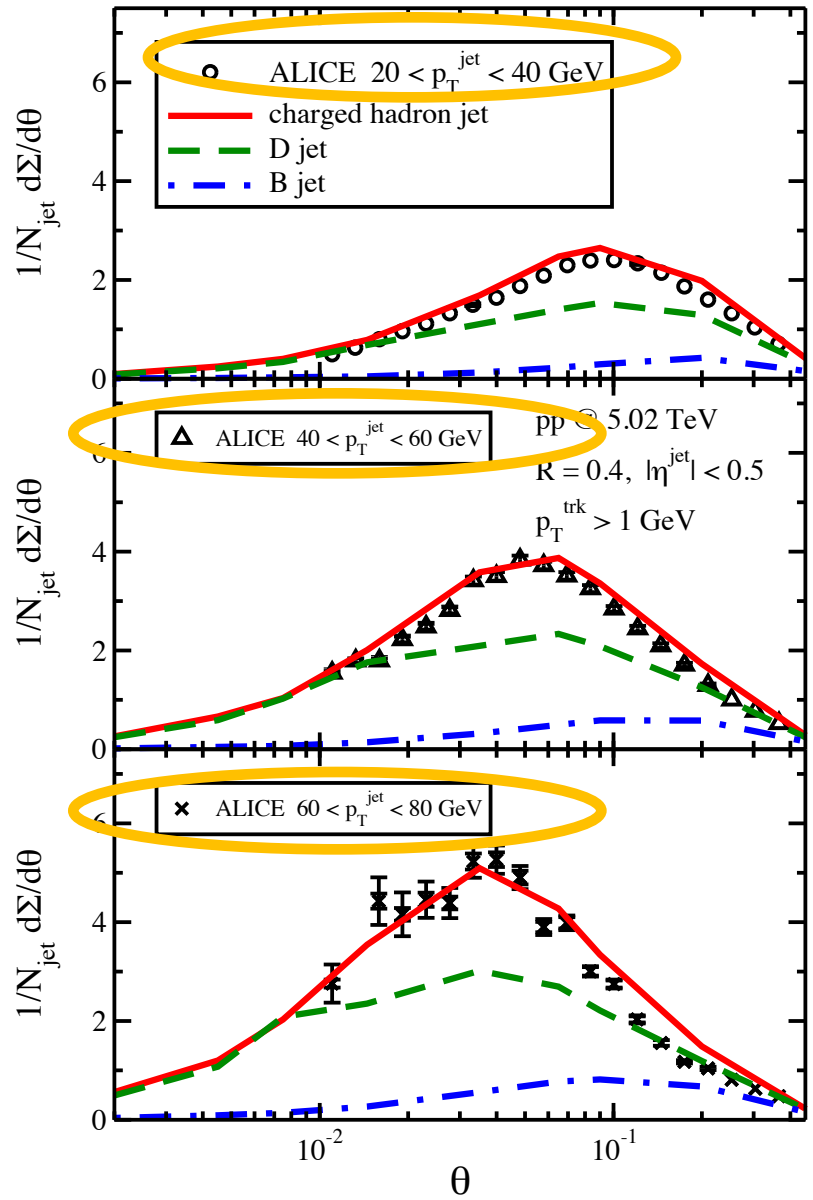


Flavor (mass) dependence:

- $\Sigma(\text{charged jet}) > \Sigma(\text{D jet}) > \Sigma(\text{B jet})$
- $\theta^{\text{peak}}(\text{charged jet}) < \theta^{\text{peak}}(\text{D jet}) < \theta^{\text{peak}}(\text{B jet})$

Flavor hierarchy of jet EEC in pp

Pythia 8



$\langle\theta\rangle$	Charged jet	*D* jet	*B* jet
$20 < p_T^{jet} < 40$ GeV	0.207	0.214	0.263
$40 < p_T^{jet} < 60$ GeV	0.167	0.18	0.233
$60 < p_T^{jet} < 80$ GeV	0.144	0.162	0.214

Flavor (mass) dependence:

- Σ(charged jet) > Σ(D jet) > Σ(B jet)
- 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:**

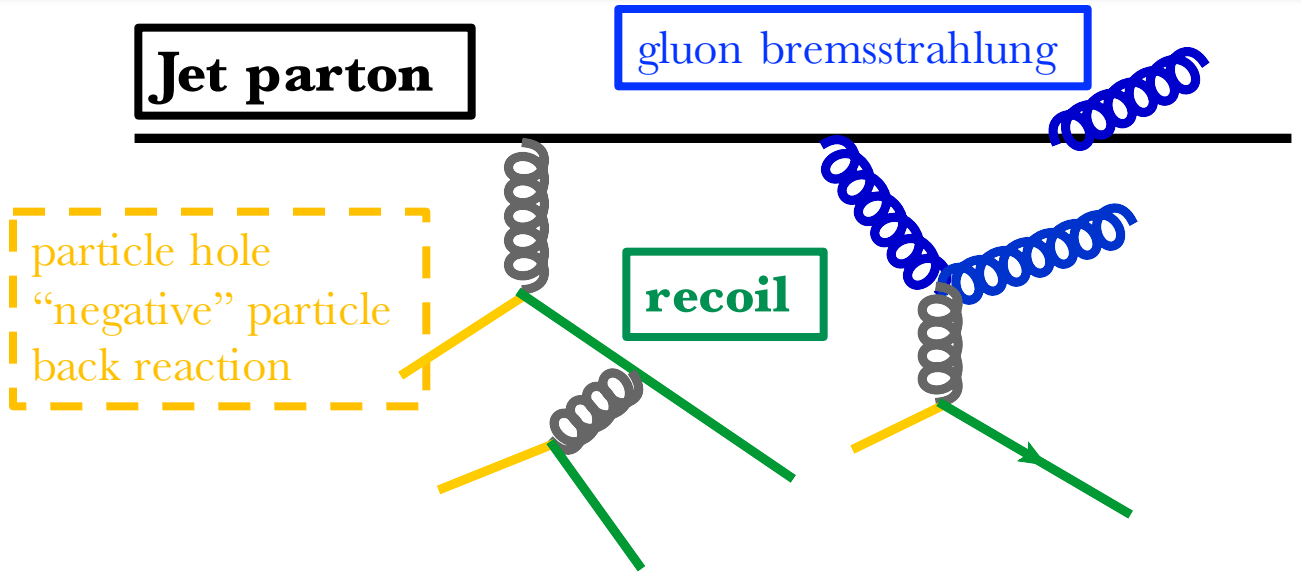
$$p_a \cdot \partial f_a = E_a \left[C^{\rm el}(f_a) + C^{\rm inel}(f_a) \right]$$

- **Elastic collisions:**

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

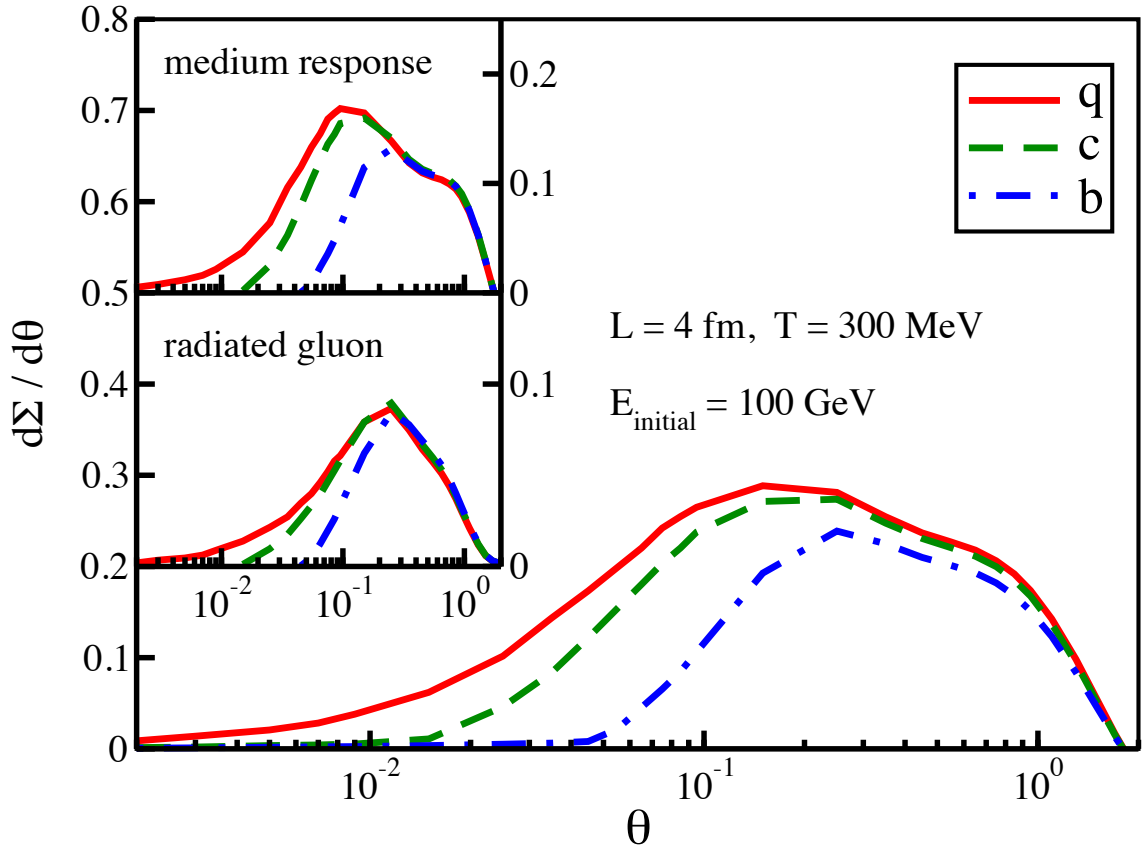
- **Inelastic collisions:**

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



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

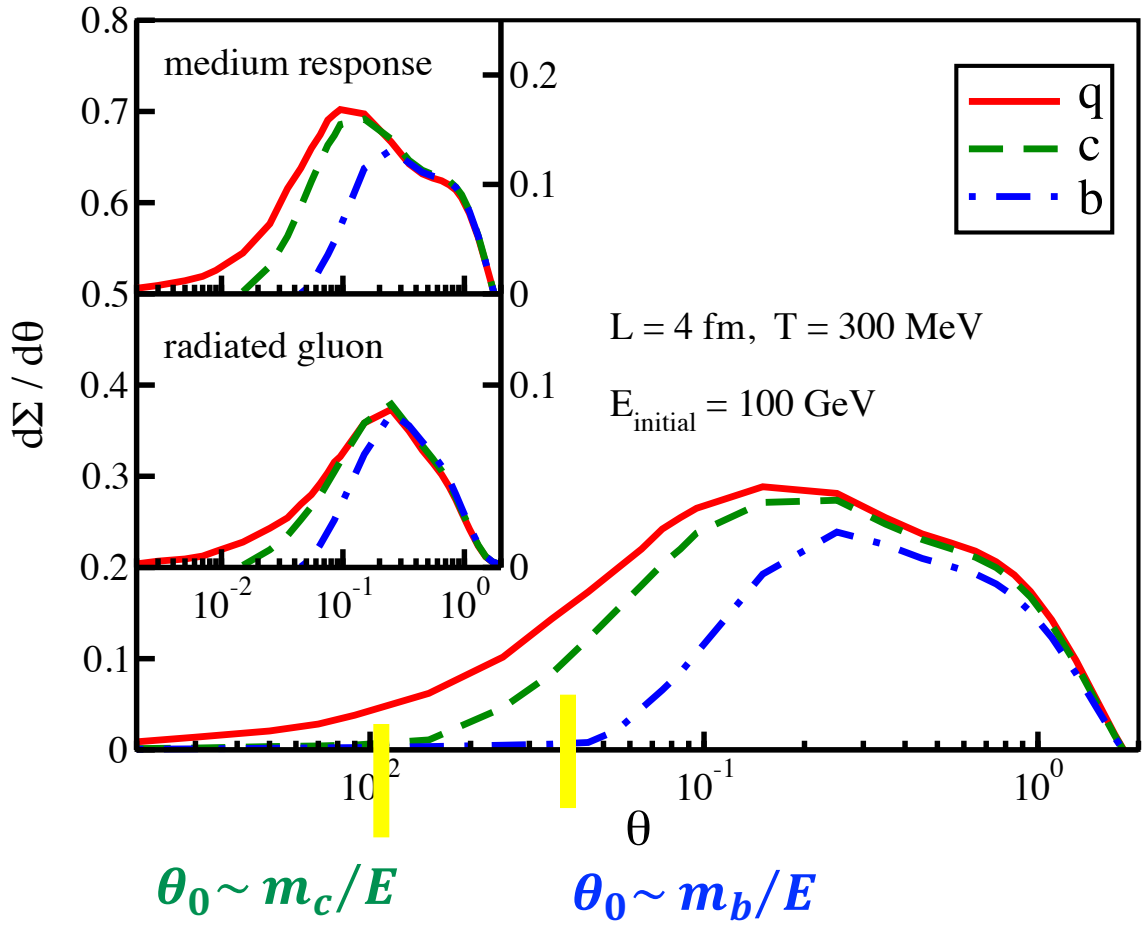
Medium response and medium-induced radiation to jet EEC



Flavor (mass) hierarchy in quark-jet EEC:

- **Σ(light jet) > Σ(charm jet) > Σ(bottom jet), this hierarchy maintains in the contribution from medium response and medium-induced radiation.**

Medium response and medium-induced radiation to jet EEC



Flavor (mass) hierarchy in quark-jet EEC:

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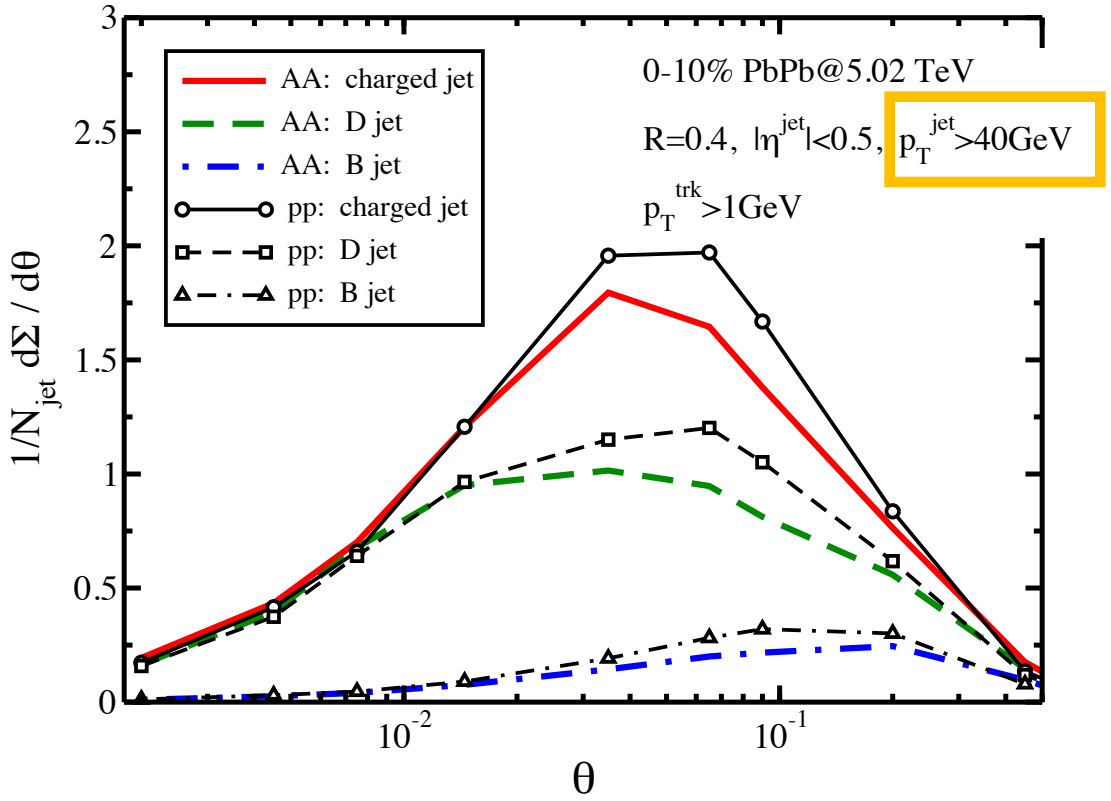
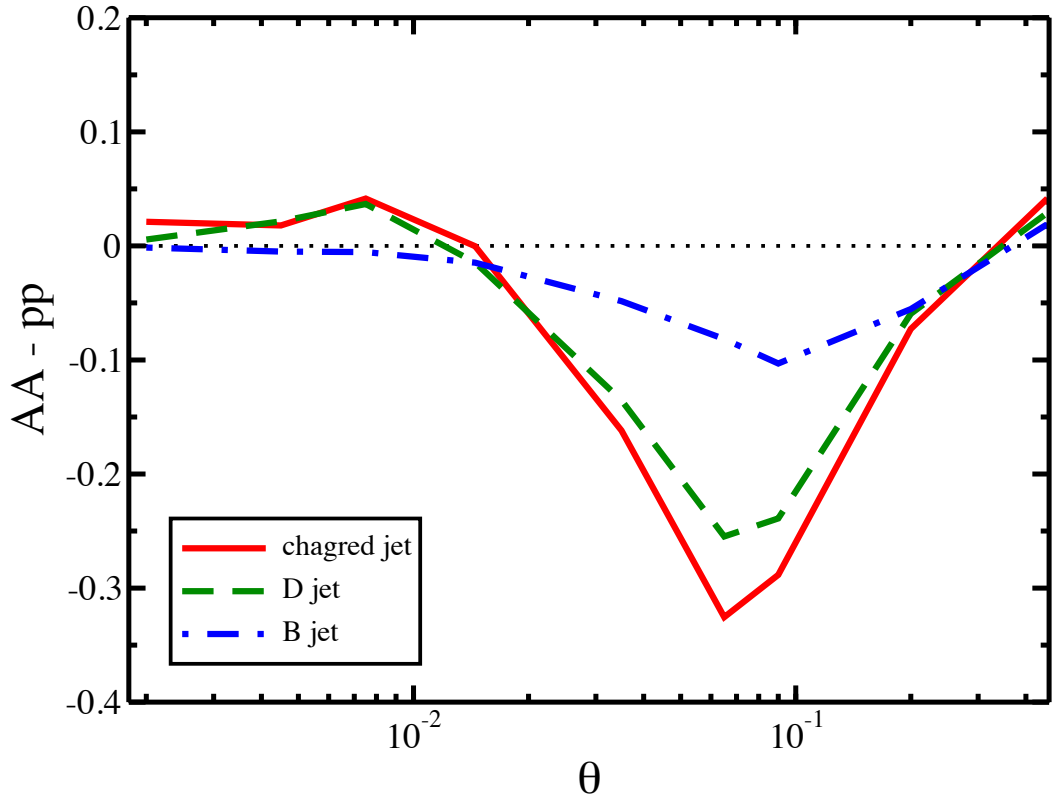
Flavor hierarchy of jet EEC in central PbPb

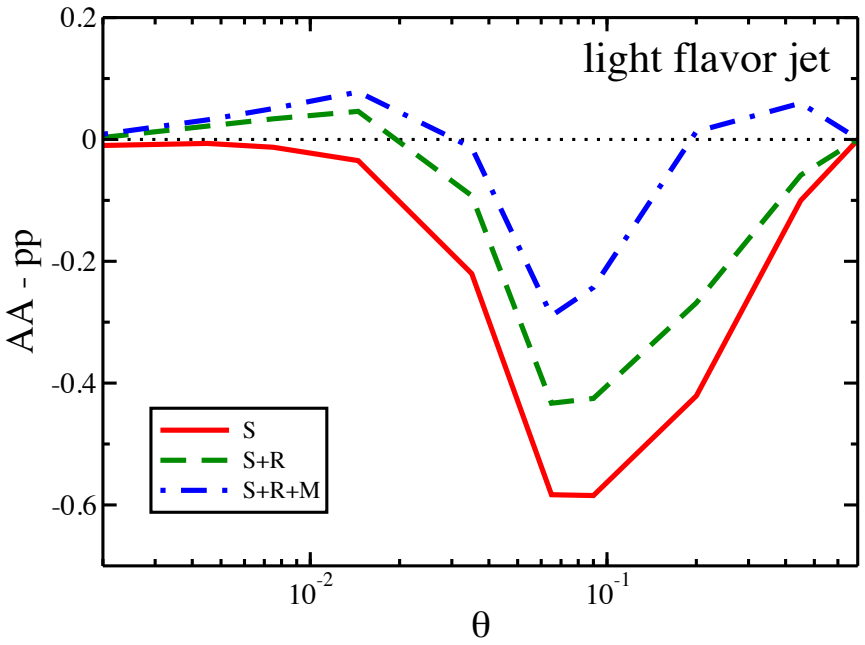




Flavor (mass) hierarchy in the nuclear modification of jet EEC:

- **For charged jets , the EEC spectra gets a strong suppression at intermediate angle, and gets enhanced at small and large angles.**
- **For heavy-meson-tagged jets, both suppression and enhancement become weaker.**

Effect of jet-medium interaction on jet EEC



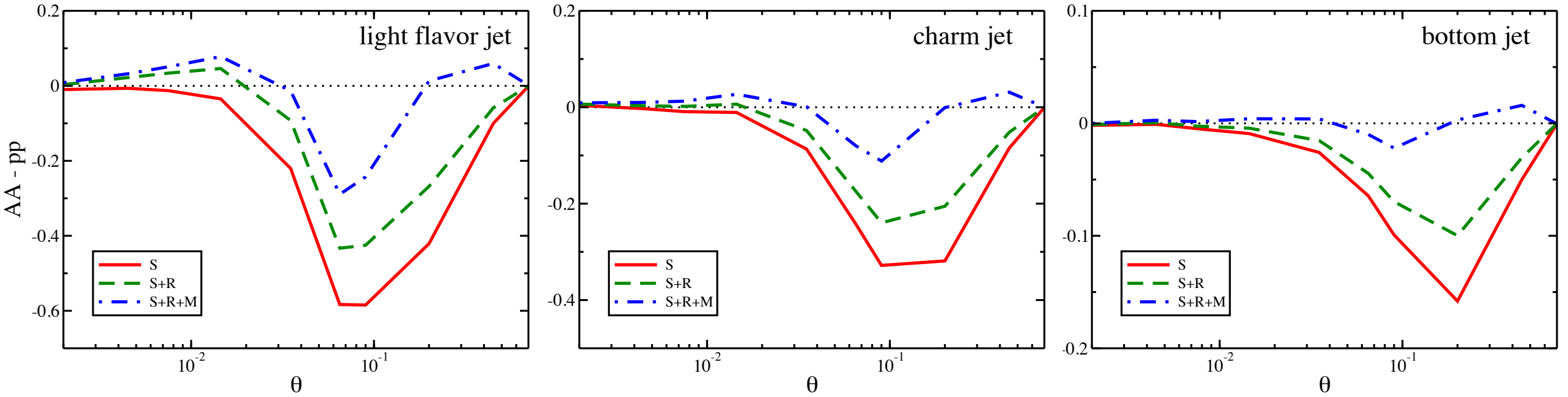
S: shower partons from Pythia

R: medium-induced radiated gluons

M: medium response

- **Jet energy loss is responsible for the suppression of jet EEC at intermediate angles.**
- **Medium response provides the most significant contribution to the enhancement of jet EEC at large angles.**

Effect of jet-medium interaction on jet EEC



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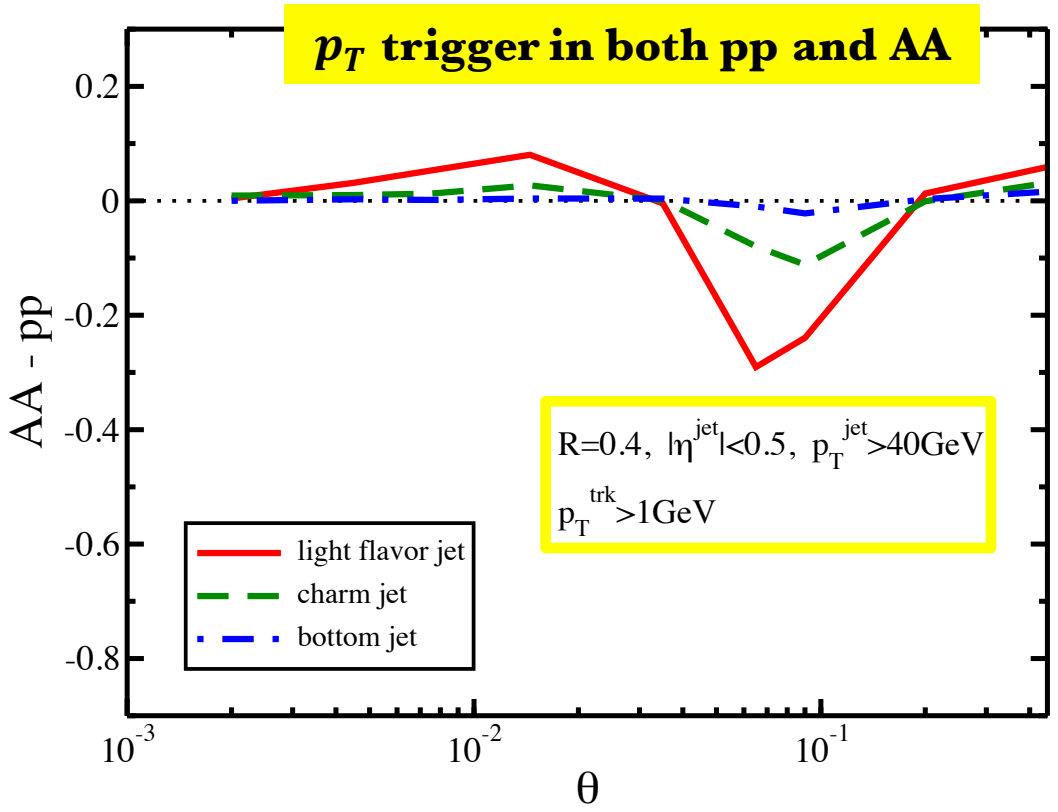
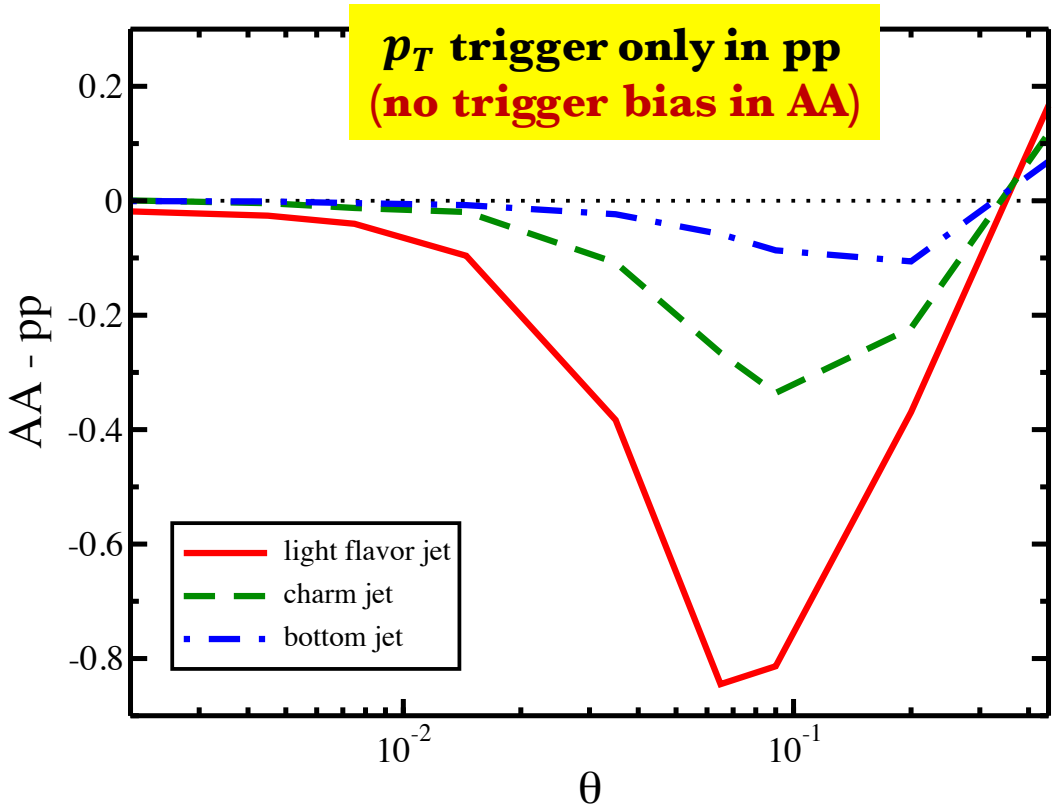
- **Jet energy loss is responsible for the suppression of jet EEC at intermediate angles.**
- **Medium response provides the most significant contribution to the enhancement of jet EEC at large angles.**

What about enhancement at small angle ?





Jet trigger bias can explain the enhancement of inclusive jet EEC

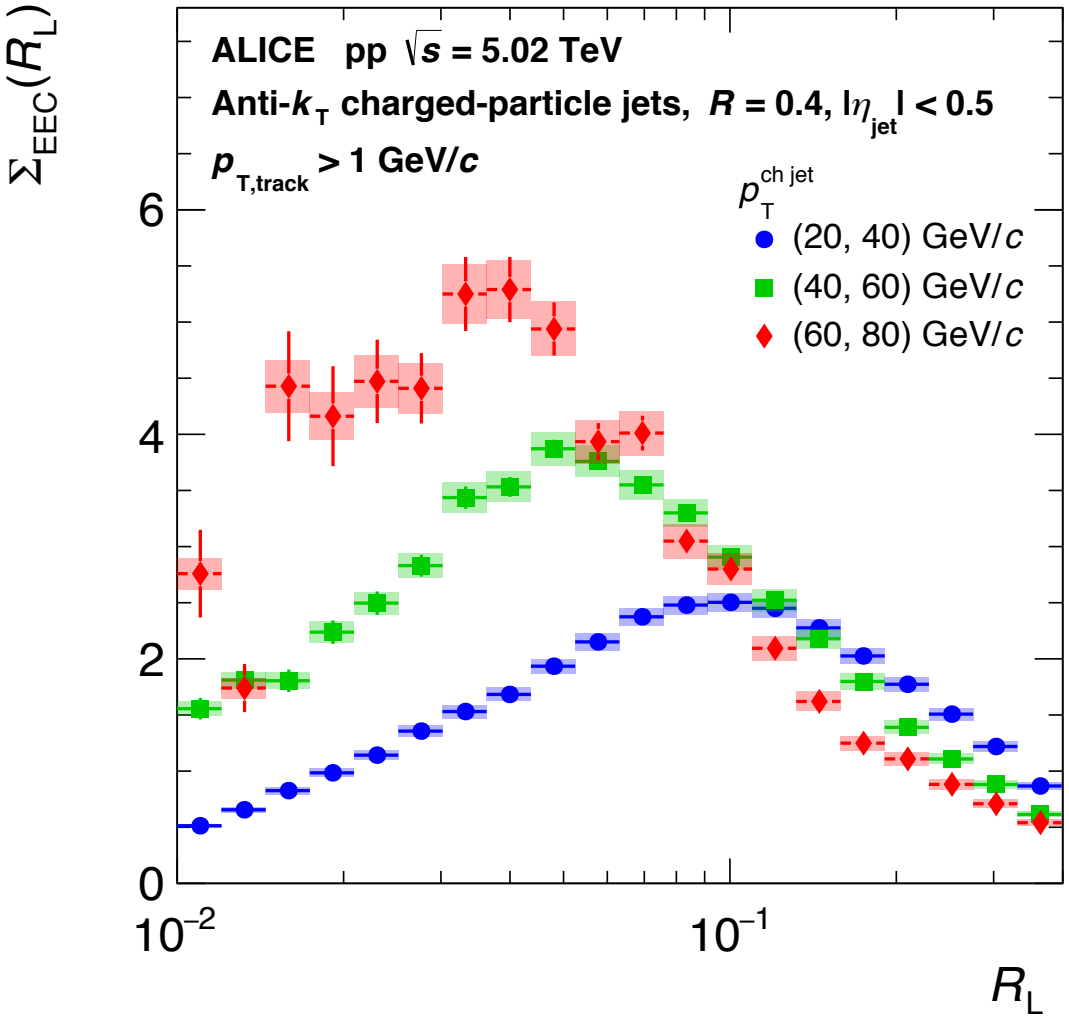
☆ **High energy jets tend to radiate more gluons, which facilitates the enhancement of EEC at small angle.**

Summary

Xing, Cao, Qin and Wang, arXiv:2409.12843

- 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 inclusive 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 !



ALICE, arXiv:2409.12687