



Multi-Point Energy Correlators in Photon-Tagged Jet Production



Main focus: three-point energy correlators of photon-tagged jets in Pb+Pb collisions

Speaker: Hao Wang

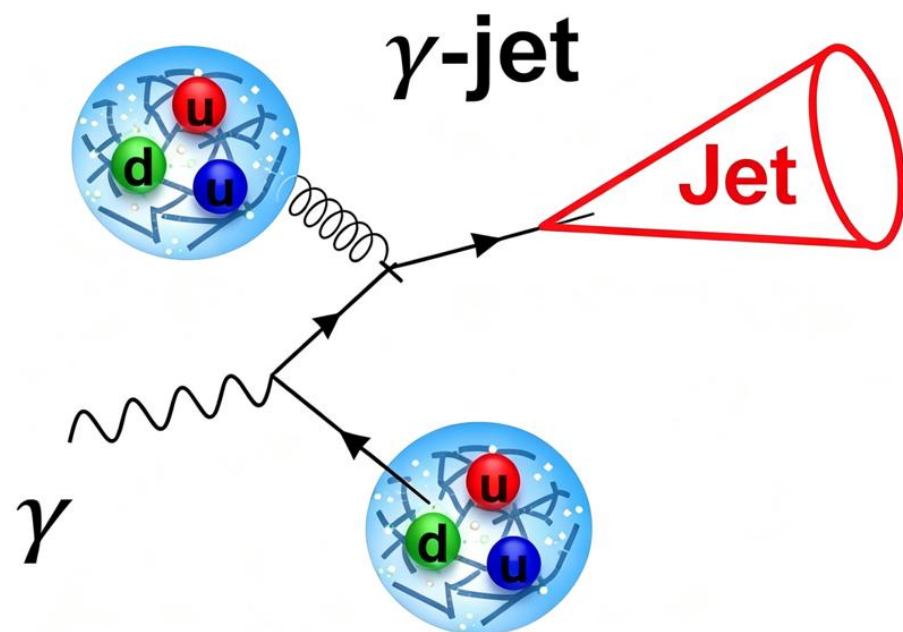
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- **Introduction**
- **Methodology**
- **E3C across angular scales and in shape space**
- **System-Size Dependence**
- **Summary**

Introduction: photon-tagged jets as calibrated probes

- > Prompt photon calibrates the initial hard scale.
- > Tagged jet probes energy loss and medium response.
- > Jet energy flow is redistributed by the medium.



What we calculate

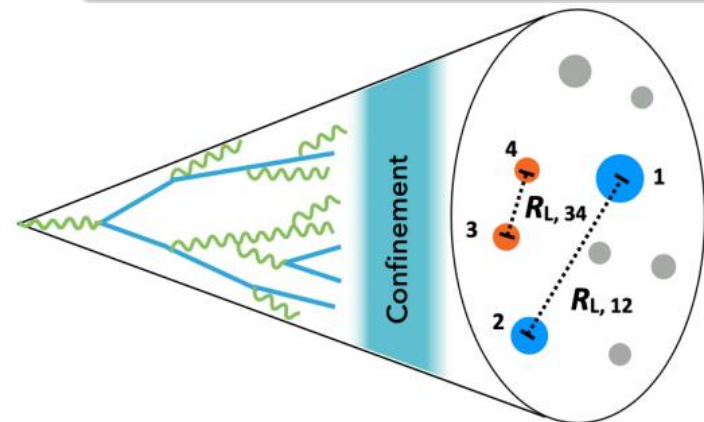
Energy correlations among particles inside reconstructed jets.

What we want

How the medium redistributes jet energy across angular scales.

Gamma-jets provide a calibrated probe for studying medium-induced changes in jet energy flow.

Introduction: from EEC to EEEC



$$\Sigma_{\text{EEC}}(R_L) = \frac{1}{N_{\text{jet}} \cdot \Delta} \int_{R_L - \frac{1}{2}\Delta}^{R_L + \frac{1}{2}\Delta} \sum_{\text{jets}} \sum_{i,j} \frac{p_{T,i} p_{T,j}}{(p_T^{\text{jet}})^2} \times \delta(R'_L - R_{L,ij}) dR'_L.$$

EEC: two-point correlation

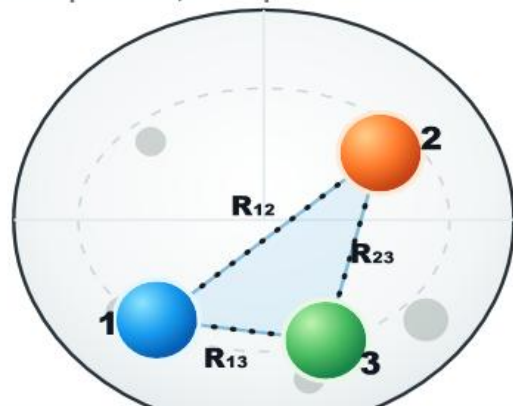
Measures energy flow as a function of one angular distance.

Figure from ALICE Collaboration, arXiv:2409.12687 [hep-ex] (2024).

$$R_{ab} = \sqrt{(\eta_a - \eta_b)^2 + (\phi_a - \phi_b)^2}.$$

E3C

three particles, three pair distances



weight: $E_1 E_2 E_3$ triangle geometry

$$\Sigma_{\text{E3C}}(R_L) = \frac{1}{N_{\text{jet}} \cdot \Delta} \int_{R_L - \frac{1}{2}\Delta}^{R_L + \frac{1}{2}\Delta} \sum_{\text{jets}} \sum_{i,j,k} \frac{p_{T,i} p_{T,j} p_{T,k}}{(p_T^{\text{jet}})^3} \times \delta(R'_L - R_{L,ijk}) dR'_L.$$

$$R_L \geq R_M \geq R_S$$

Komiske et al., Phys. Rev. Lett. 130, 051901 (2023).
Bossi et al., JHEP 12 (2024) 073.

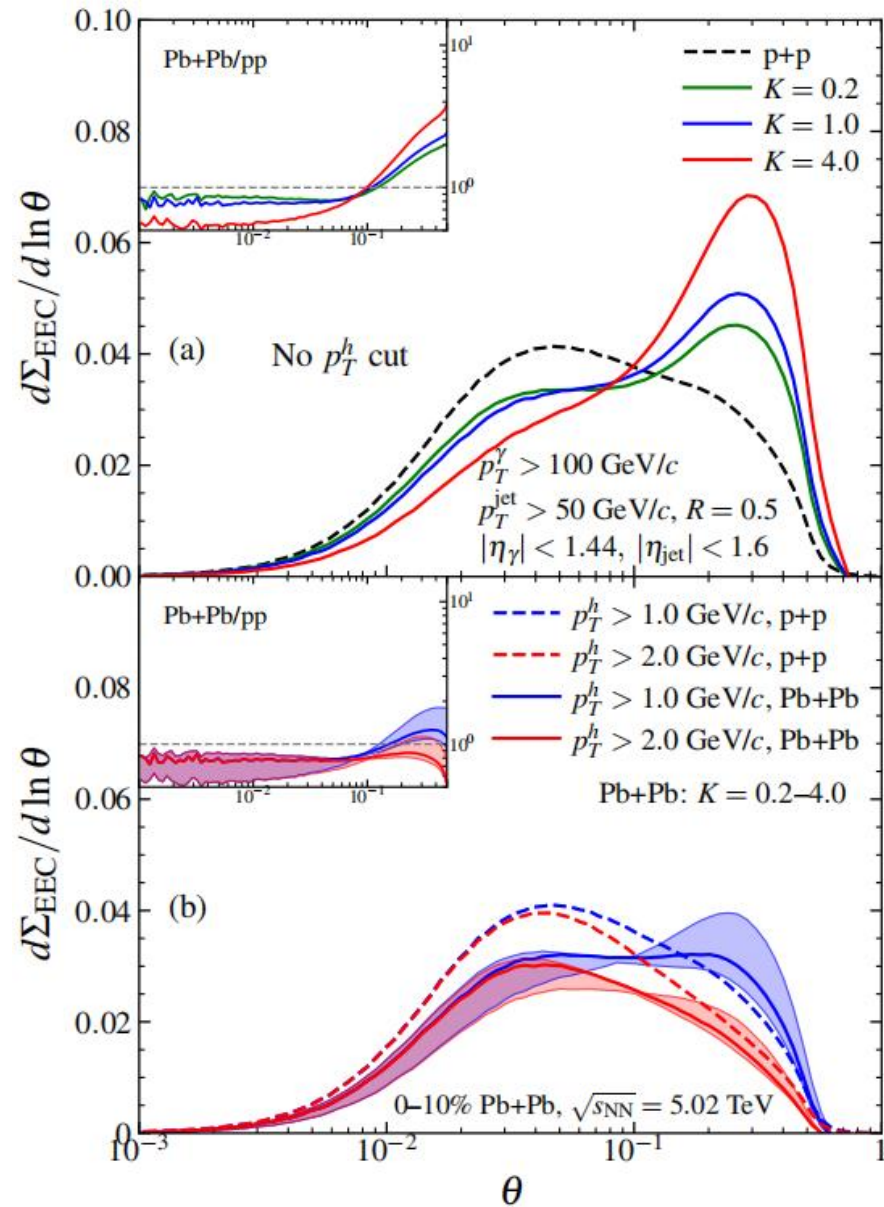
EEEC: three-point correlation

Three ordered distances encode the triangle scale and shape.

Why EEEC?

Different medium components may populate different three-particle geometries.

Introduction: from the established EEC pattern to EEEC



Reference: Yang, He, Moulton, Wang, Phys. Rev. Lett. 132, 011901 (2024).

Previous EEC study

LBT reproduces the EEC:
small-angle suppression and broad-angle enhancement.

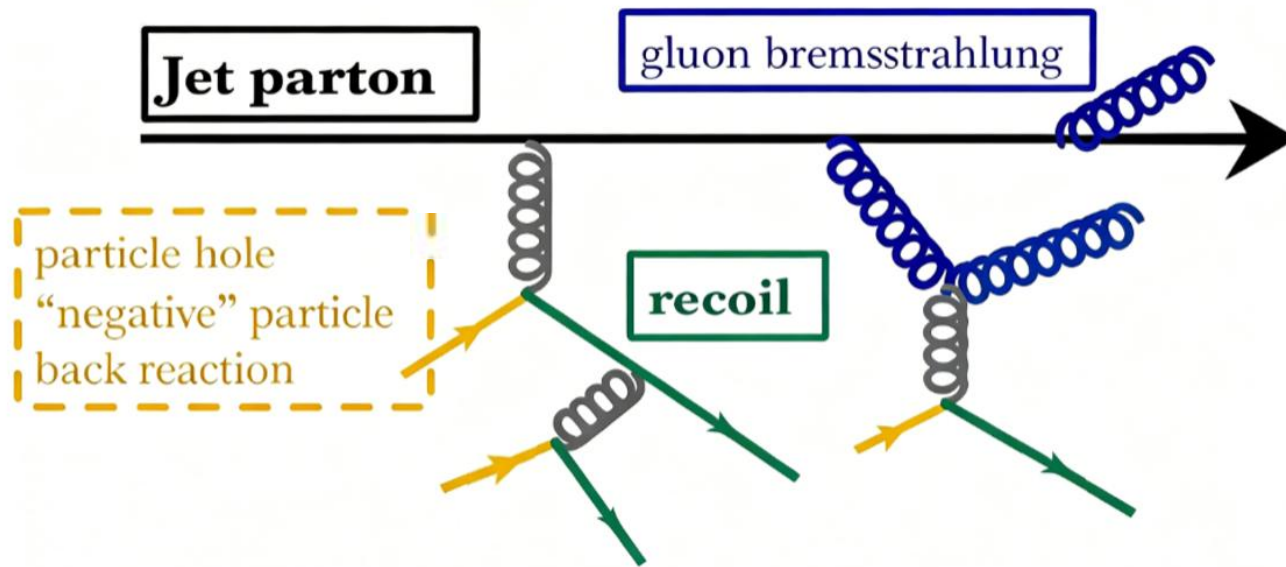
Limitation

EEC no full three-particle geometry.

Next step

Use EEEC

Methodology: Linear Boltzmann Transport (LBT) Model



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

K changes the Debye screening mass and the typical momentum-transfer scale, while the scattering rate is fixed at $K = 1$.



**shower
partons**



**medium-induced
radiated gluons**

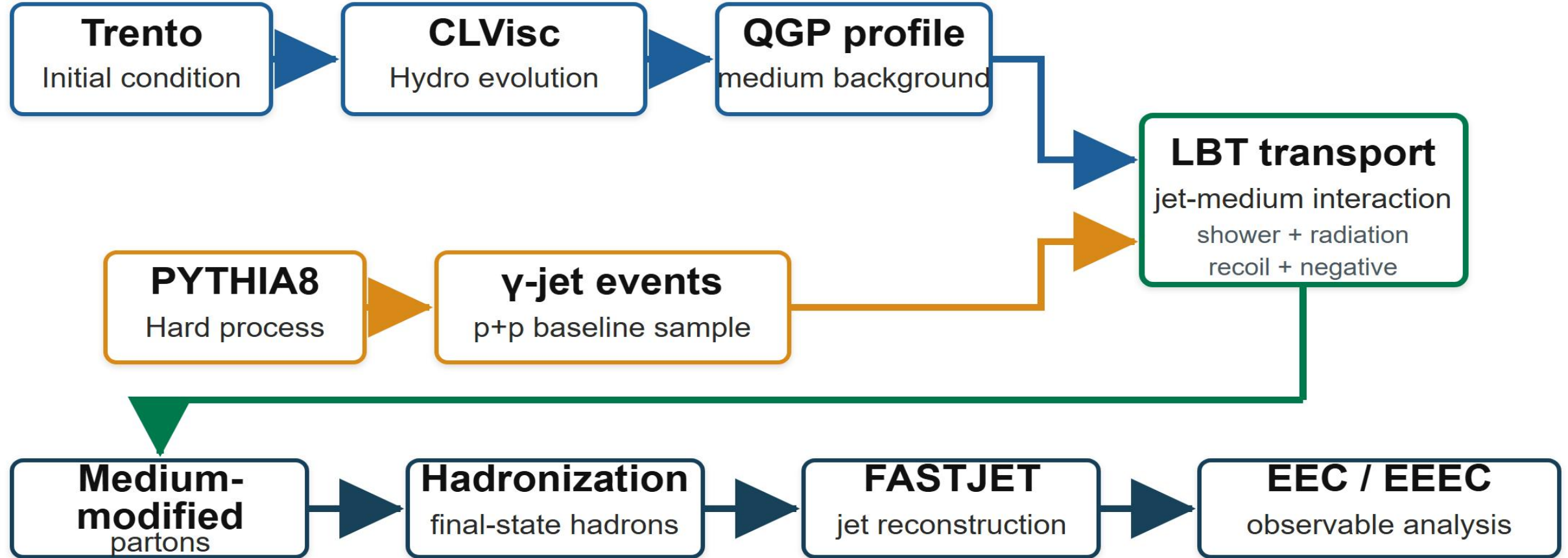


**medium response:
recoil + negative partons**

LBT Code: A Color Tracking LBT Model, <https://github.com/dyczcz/A-Color-Tracking-LBT-Model>

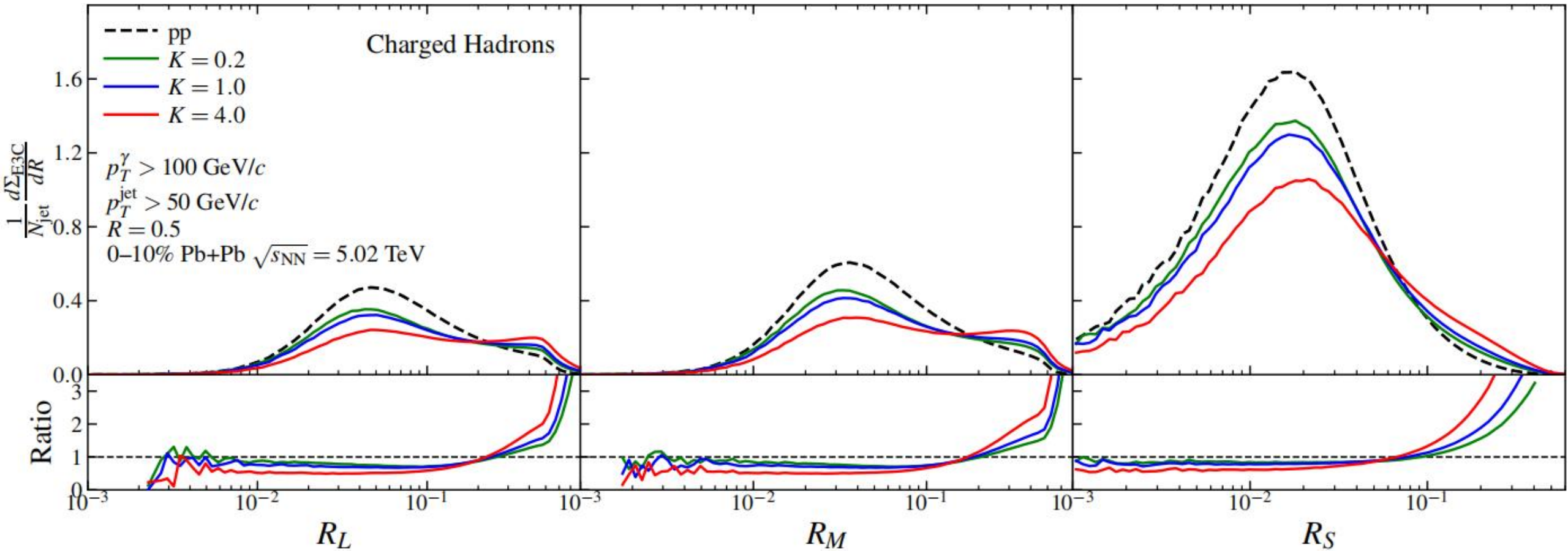
J. Auvinen et al, Phys. Rev. C **82** 024906 (2010); X. F. Guo and X.N. Wang, Phys. Rev. L **85** 3591 (2000); Y. Dang, W.-J. Xing, S. Cao, and G.-Y. Qin, arXiv:2602.10395 [nucl-th] (2026).
B.W. Zhang, E. Wang, and X.N. Wang, Phys. Rev. L **93** 072301 (2004); Y. Y. He et al, Phys. Rev. C **91** 054908 (2015); T. Luo et al, Phys. Rev. C **109** 034919 (2024).

Methodology: LBT Workflow



LBT combines the hydrodynamic QGP background with PYTHIA γ -jet events; evolves shower, radiation, recoil, and negative partons through the medium; followed by hadronization, FASTJET reconstruction, and EEEEC analysis.

EEEC projections at different angular scales



Distributions differ among R_L , R_M , and R_S , the same modification like EEC: small-angle suppression and broad-angle enhancement.

LBT component analysis of EEEEC

Parton Level



shower
partons



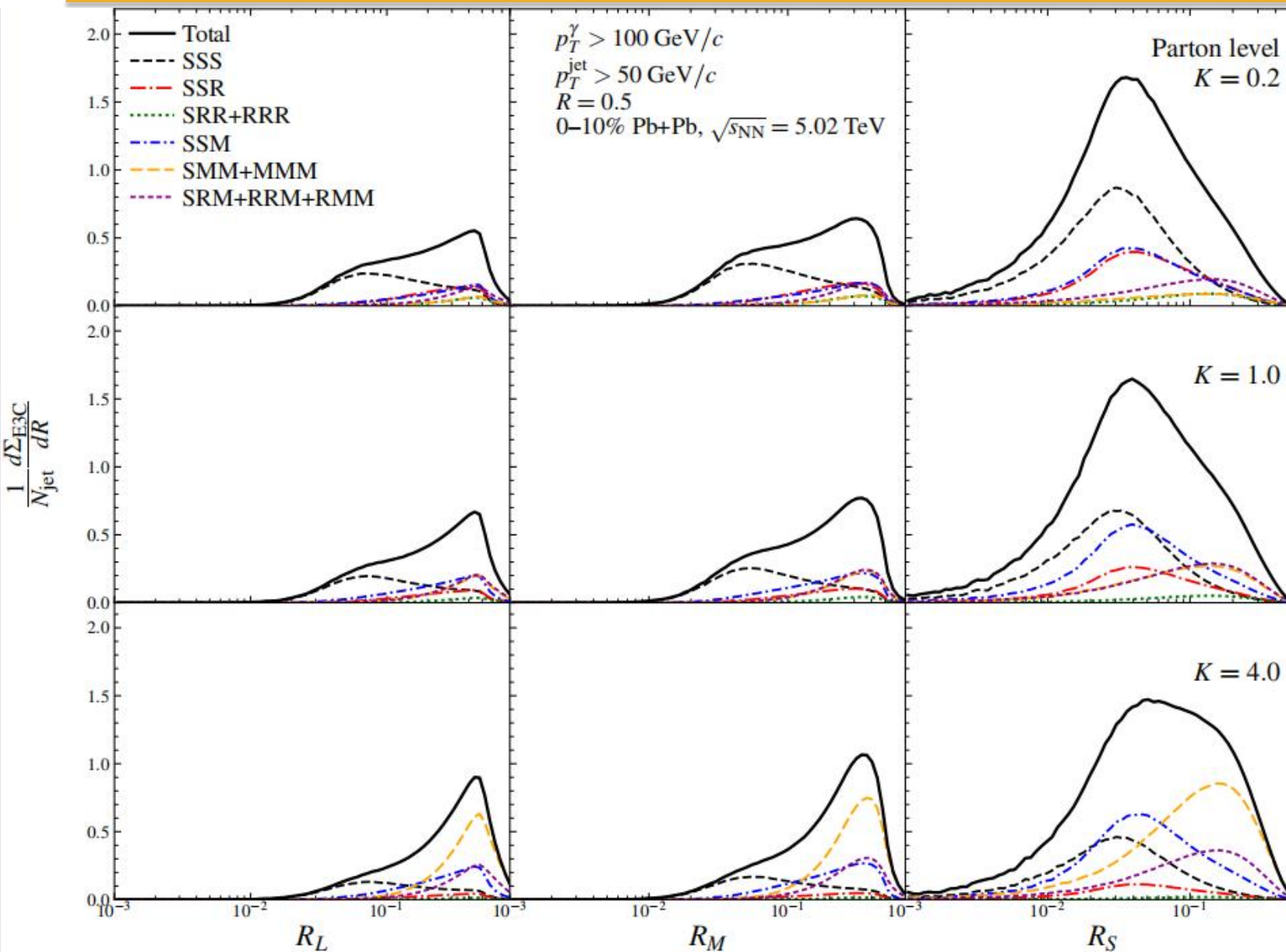
medium-induced
radiated gluons



medium response:
recoil + negative partons

SSS	vacuum-like shower baseline
SSR	one induced radiation gluon correlated with shower partons
SRR + RRR	radiation-dominated triplets
SRM + RRM + RMM	mixed radiation-response triplets
SSM	one response parton correlated with the shower
SMM + MMM	response-dominated triplets

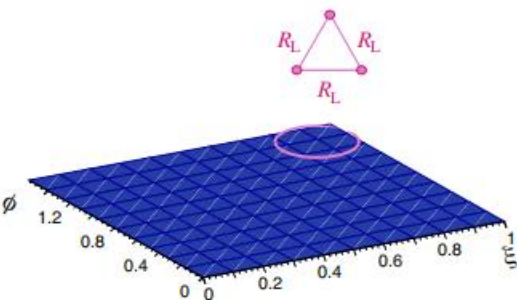
Parton-level component decomposition across angular scales



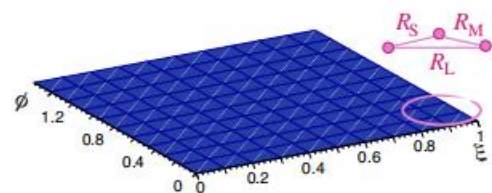
K increase:
M increases, S decreases,
R is relatively stable

Angular scale:
Double-S triplets stay closer to the
shower core
Single-S / non-S triplets populate
broader angles

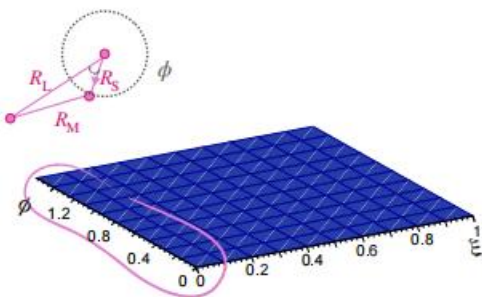
Shape-space definition: separate scale from triangle shape



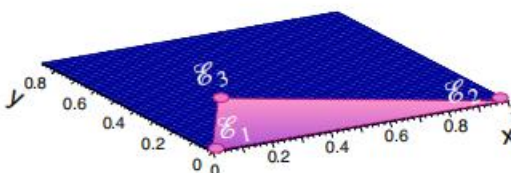
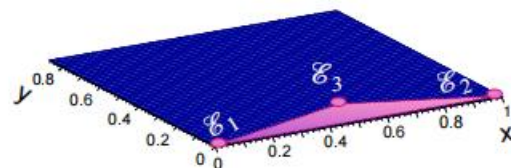
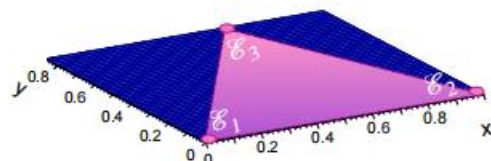
(a) Equilateral



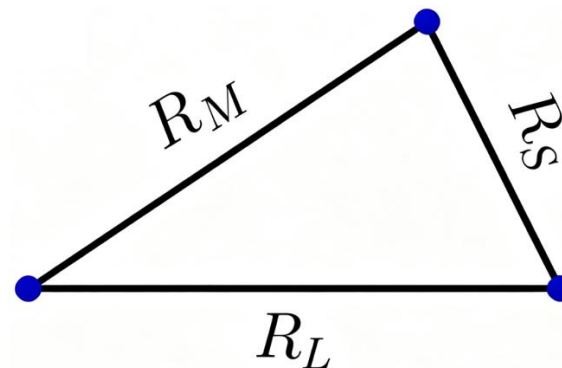
(b) Flattened



(c) Squeezed



Focus on $\xi=1, \varphi=\pi/2, R_L=R_M=R_S$
broad-angle and near-equilateral



ordered distances:
 $R_S < R_M < R_L$

shape variables:

$$\xi = R_S / R_M$$

$$\varphi = \arcsin \sqrt{1 - \frac{(R_L - R_M)^2}{R_S^2}}$$

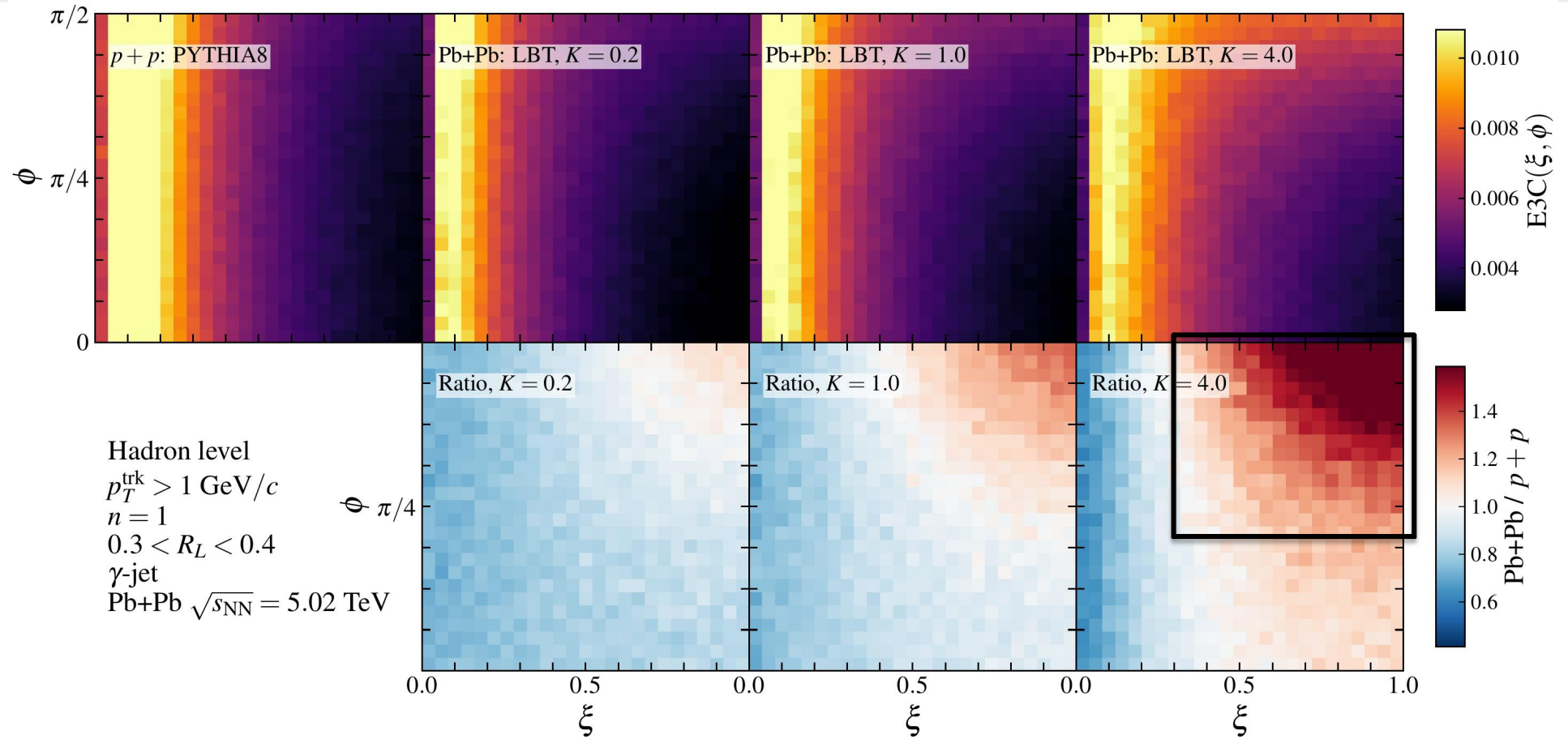
Komiske et al., Phys. Rev. Lett. 130, 051901 (2023).

Shape can be studied in EEEEC.

Fixing R_L , the overall angular scale is fixed,
so we can compare different triangle shapes without
mixing in scale effects

figure source: Bossi et al., JHEP 12 (2024) 073.

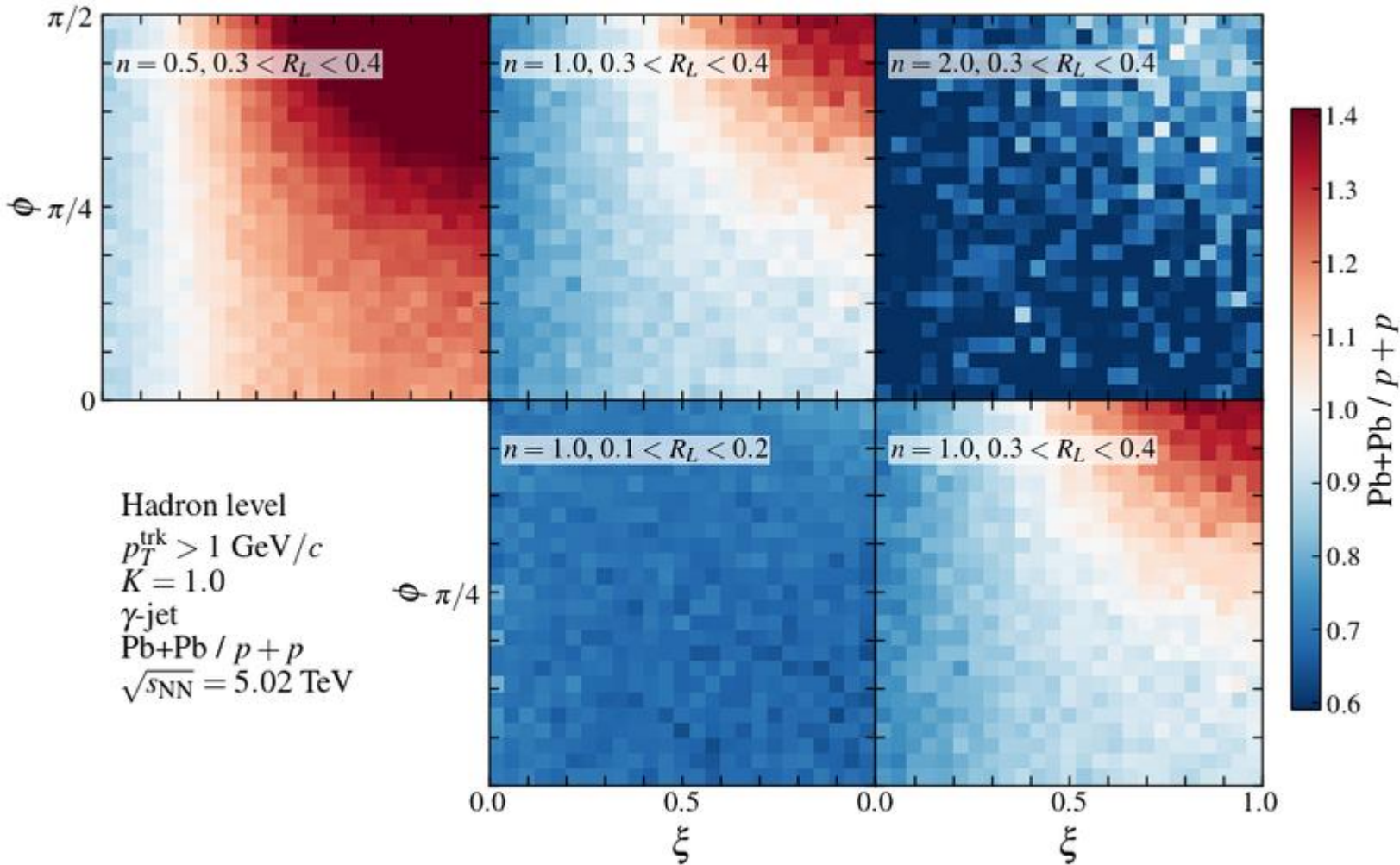
E3C in shape space: absolute yield and AA/pp ratio



Increasing K strengthens the medium modification of EEEC.

Enhancement appears in the broad-angle, near-equilateral region.

Shape-space sensitivity to n and R_L



$n = 0.5$:
soft enhanced
→ stronger broad-angle enhancement

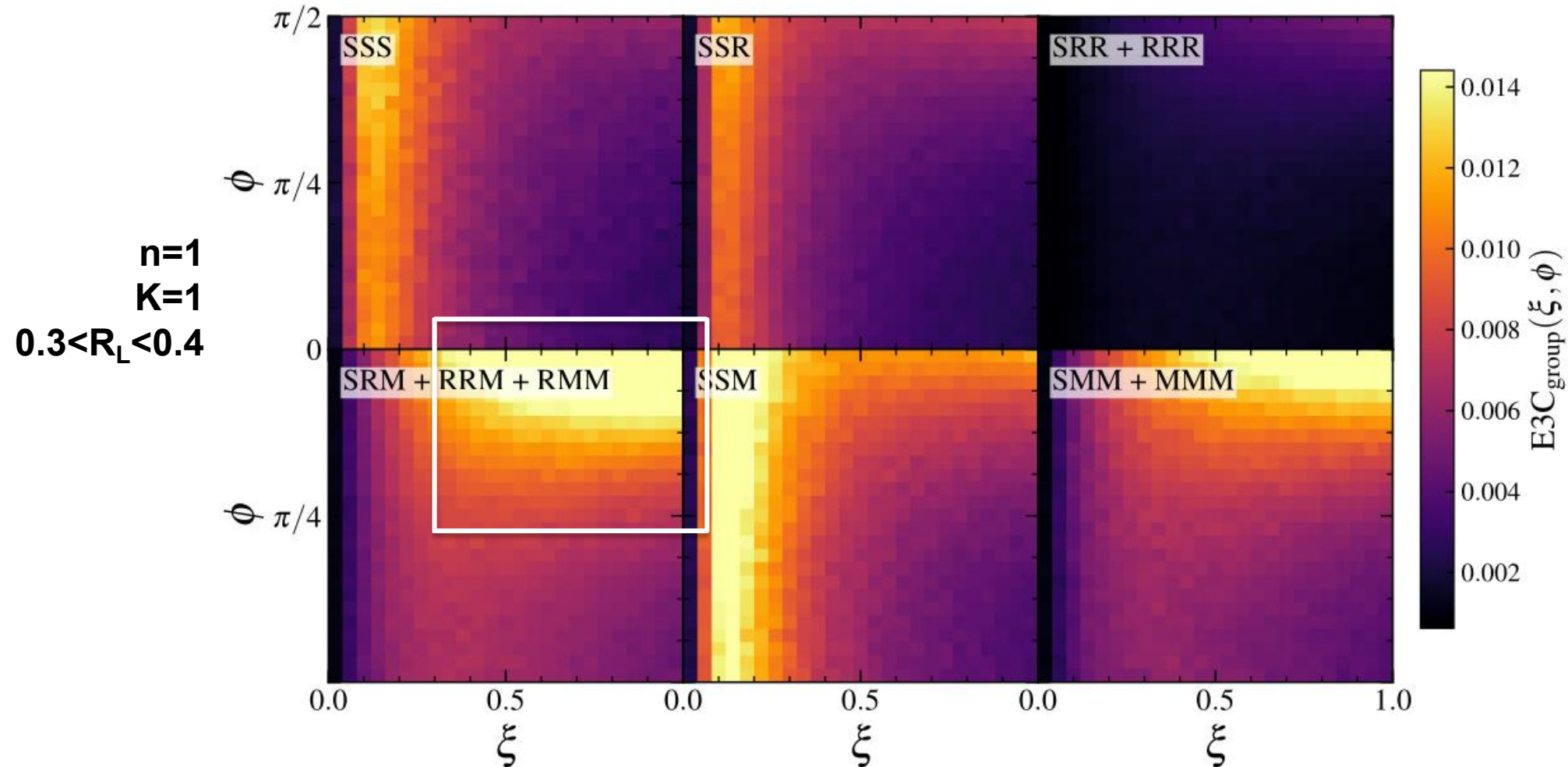
$n = 2$:
soft suppressed
→ broad-angle enhancement reduced

Small R_L :
suppression-dominated

Large R_L :
near-equilateral region enhancement

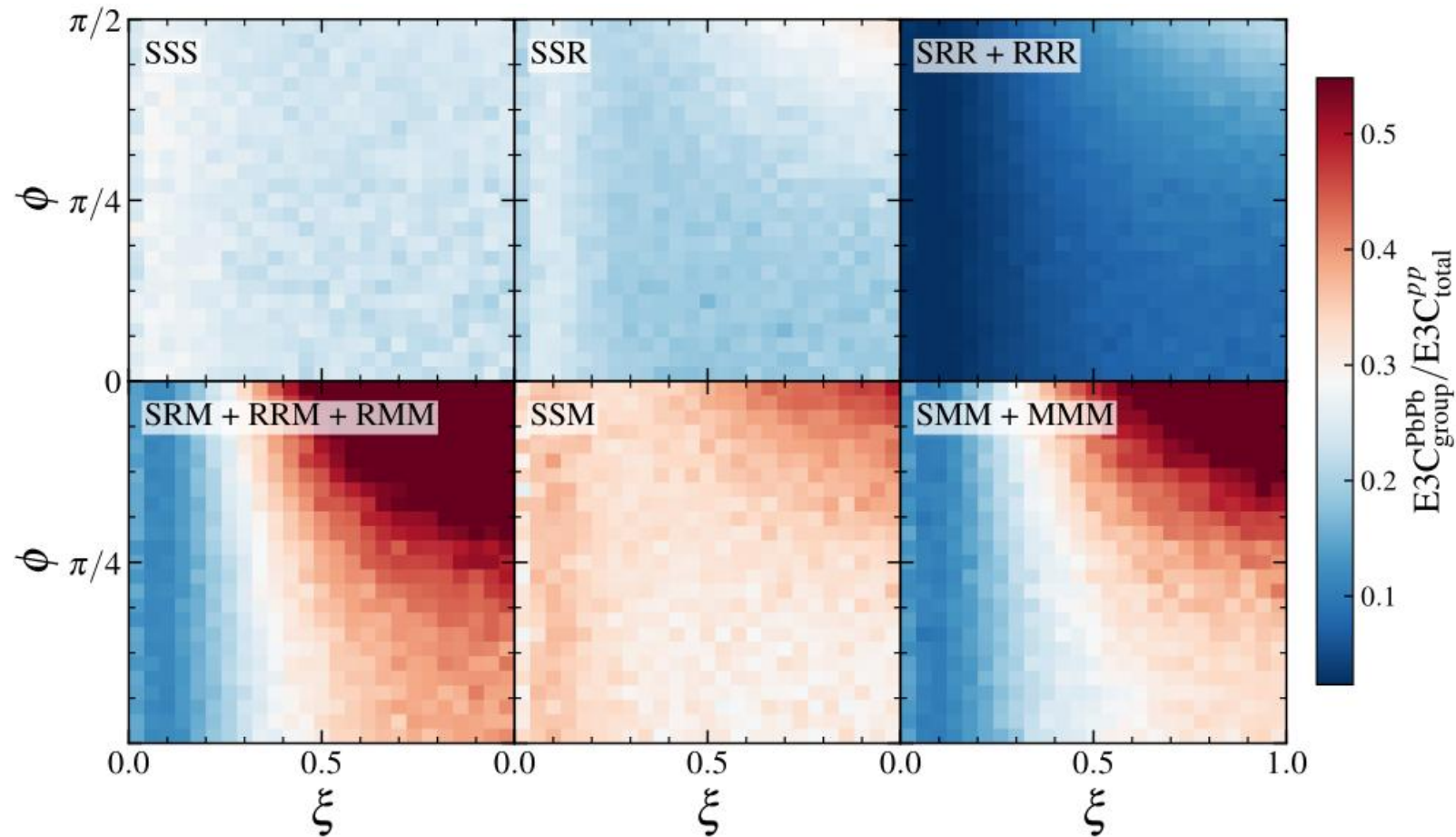
medium modification:
large R and soft-sensitive

Shape-space component decomposition



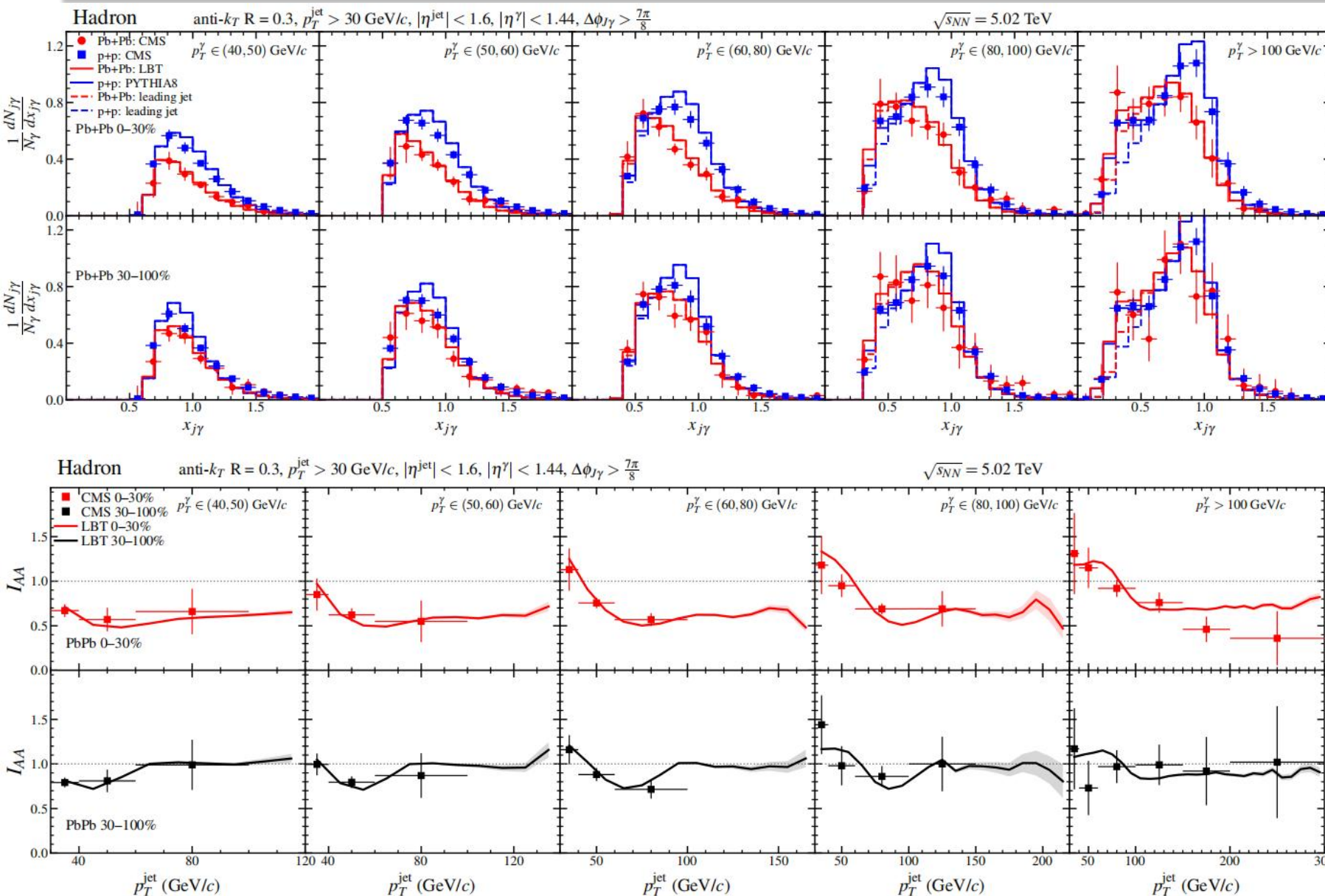
EEEC is most sensitive to mixed radiation-response triplets in the LBT component decomposition.

Shape-space component decomposition



Radiation and Medium response both populate broad-angle near-equilateral configurations.

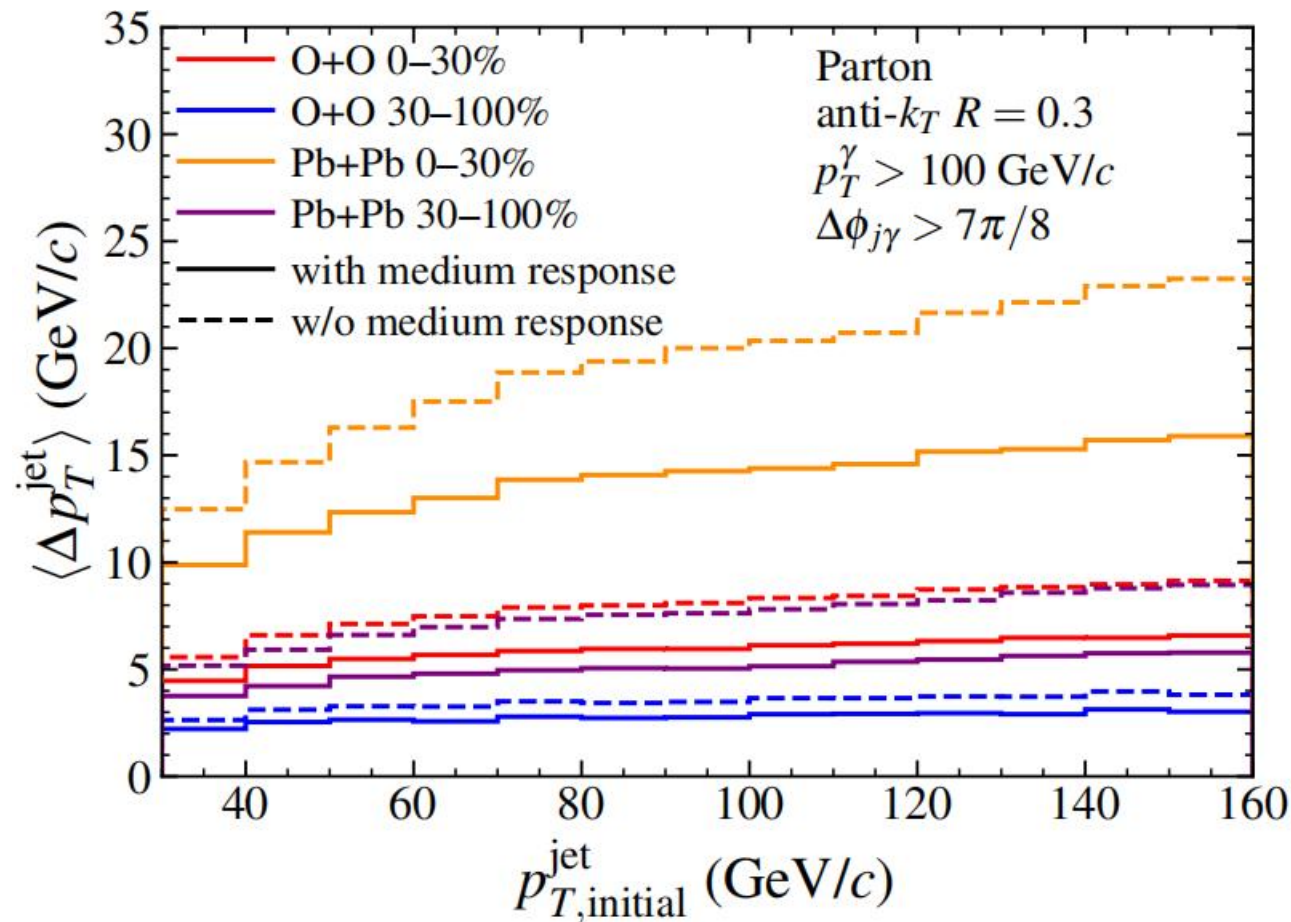
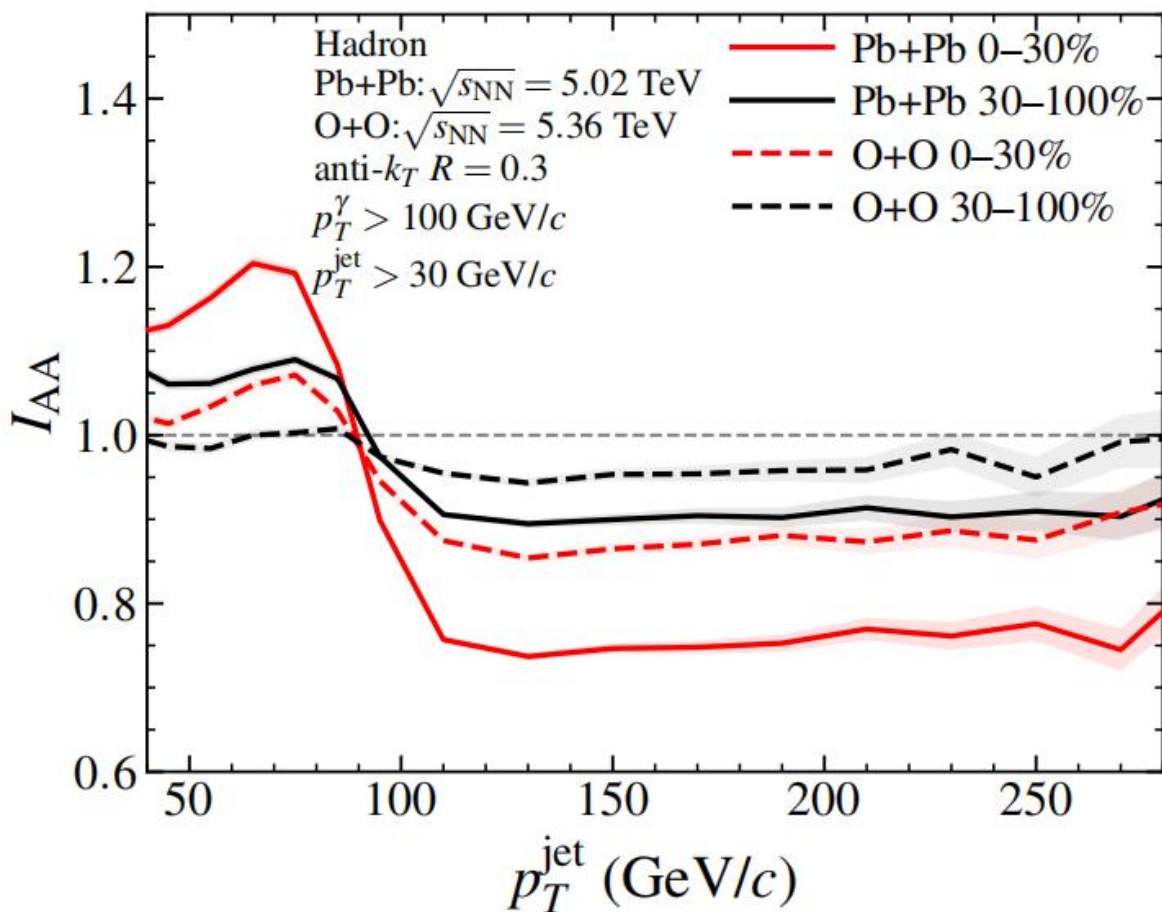
System-Size Dependence



**LBT describes CMS
 γ -jet observables
such as
 $X_{J\gamma}$ and I_{AA}
in Pb+Pb collisions.**

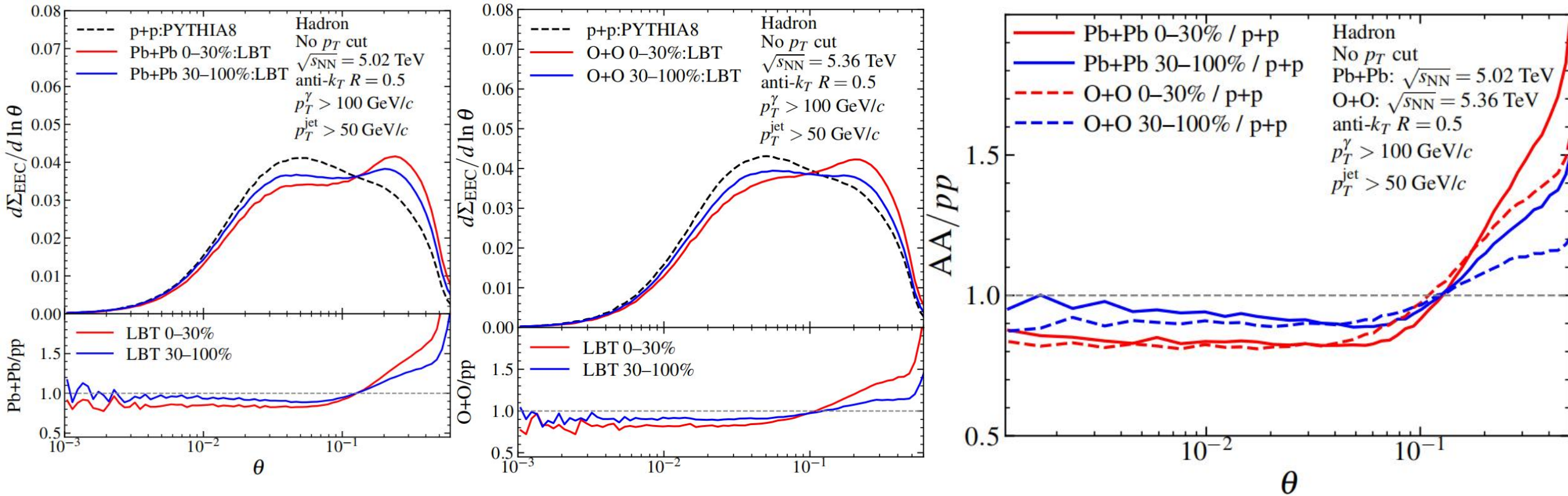
CMS data from CMS Collaboration,
Phys. Lett. B 785 (2018) 14–39;
LBT calculations by the authors.

System-Size Dependence



O+O shows a weaker but still visible γ -jet modification compared with Pb+Pb.

System-Size Dependence

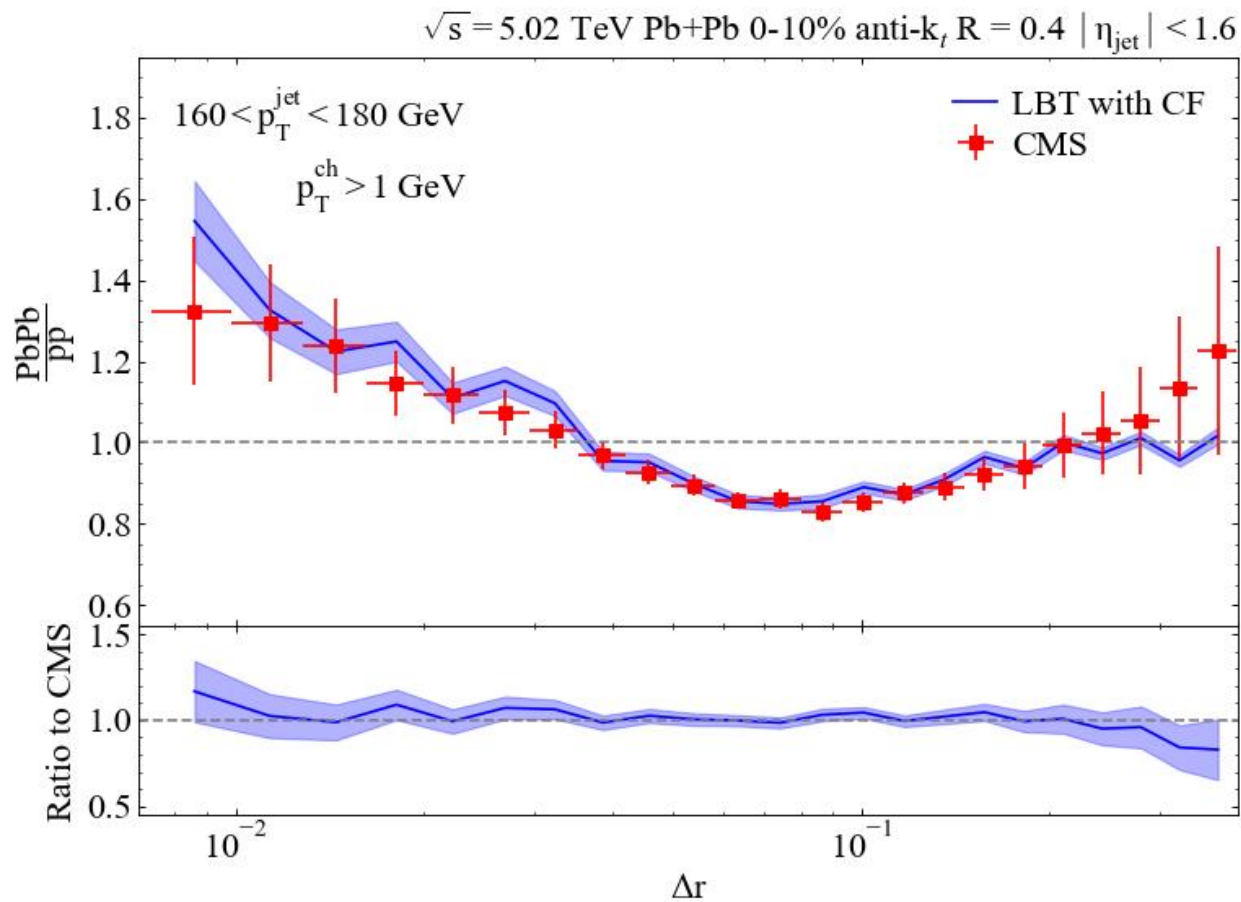


**Both Pb+Pb and O+O show the same EEC pattern: small-angle suppression and broad-angle enhancement.
The modification is weaker in O+O.**

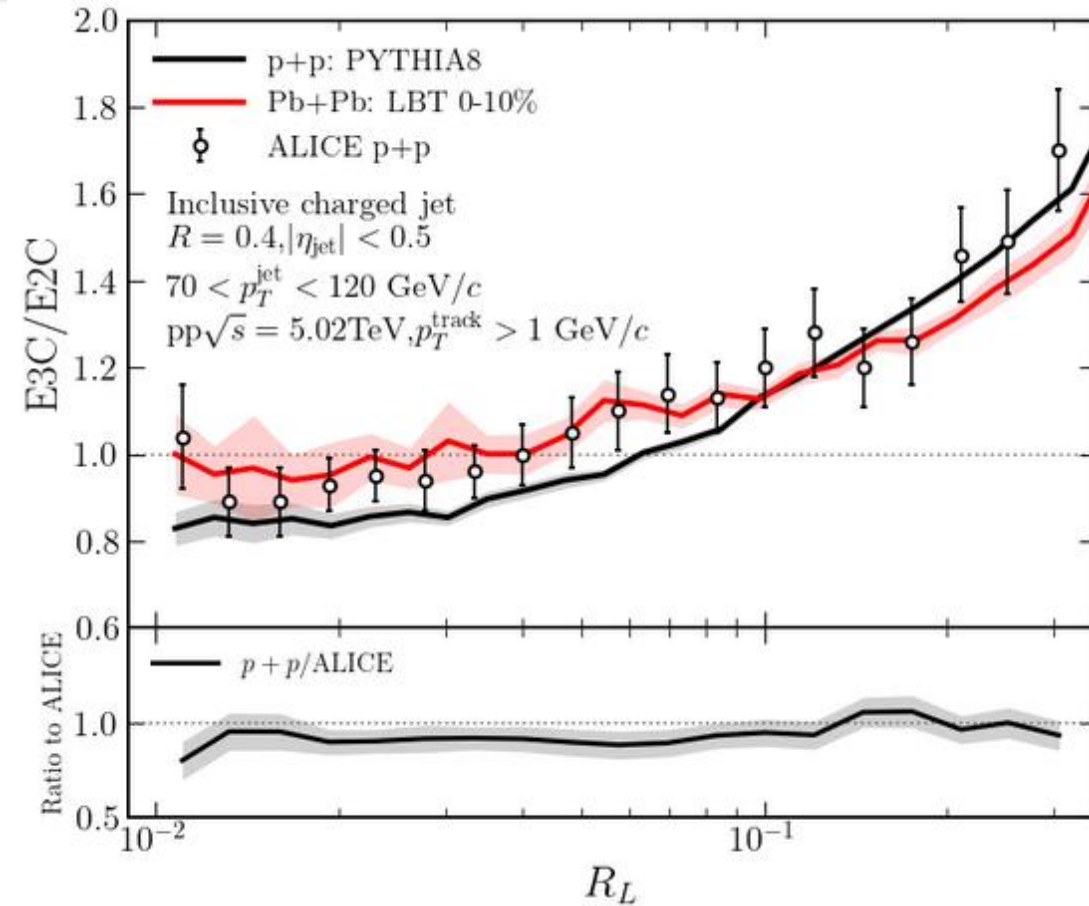
- ✓ EEEEC extends EEC from one angular distance to full three-particle geometry.
- ✓ In Pb+Pb, EEEEC shows small-angle suppression and broad-angle, near-equilateral enhancement.
- ✓ Component decomposition shows a shift from shower-correlated triplets toward radiation and medium-response-related triplets, especially in broad-angle, near-equilateral configurations.
- ✓ O+O predictions extend the study to a smaller collision system with weaker jet-medium modification.

Thanks for your attention

Backup: LBT comparisons with measured energy correlators



CMS data: CMS Collaboration, Phys. Lett. B 866, 139483 (2025);
 LBT calculation/figure courtesy of Cheng Xu.



ALICE pp preliminary data at 5.02 TeV: ALI-PREL-604282.
 PYTHIA8 and LBT curves are from this work.