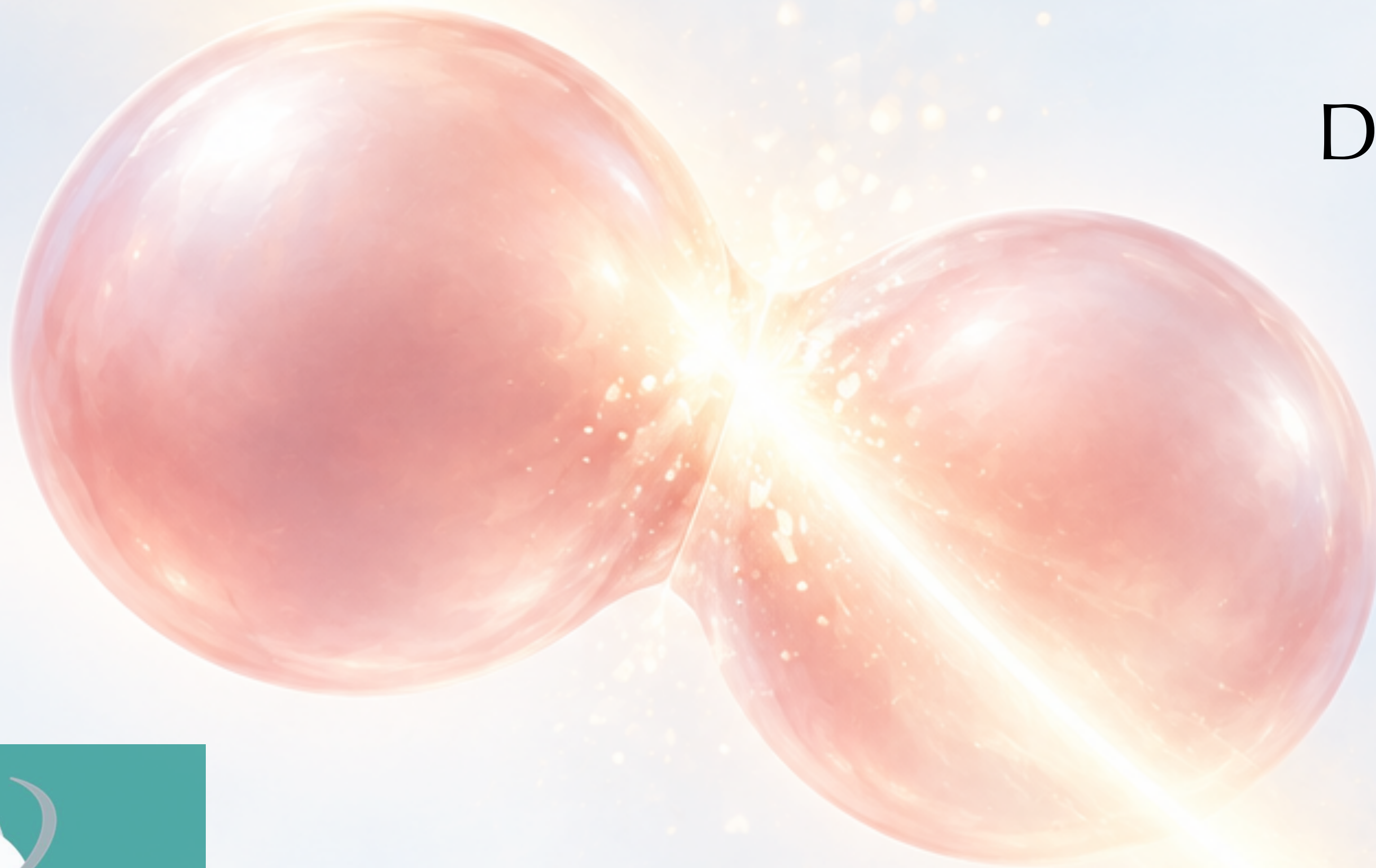




Jet and Heavy Flavour Quenching Overview

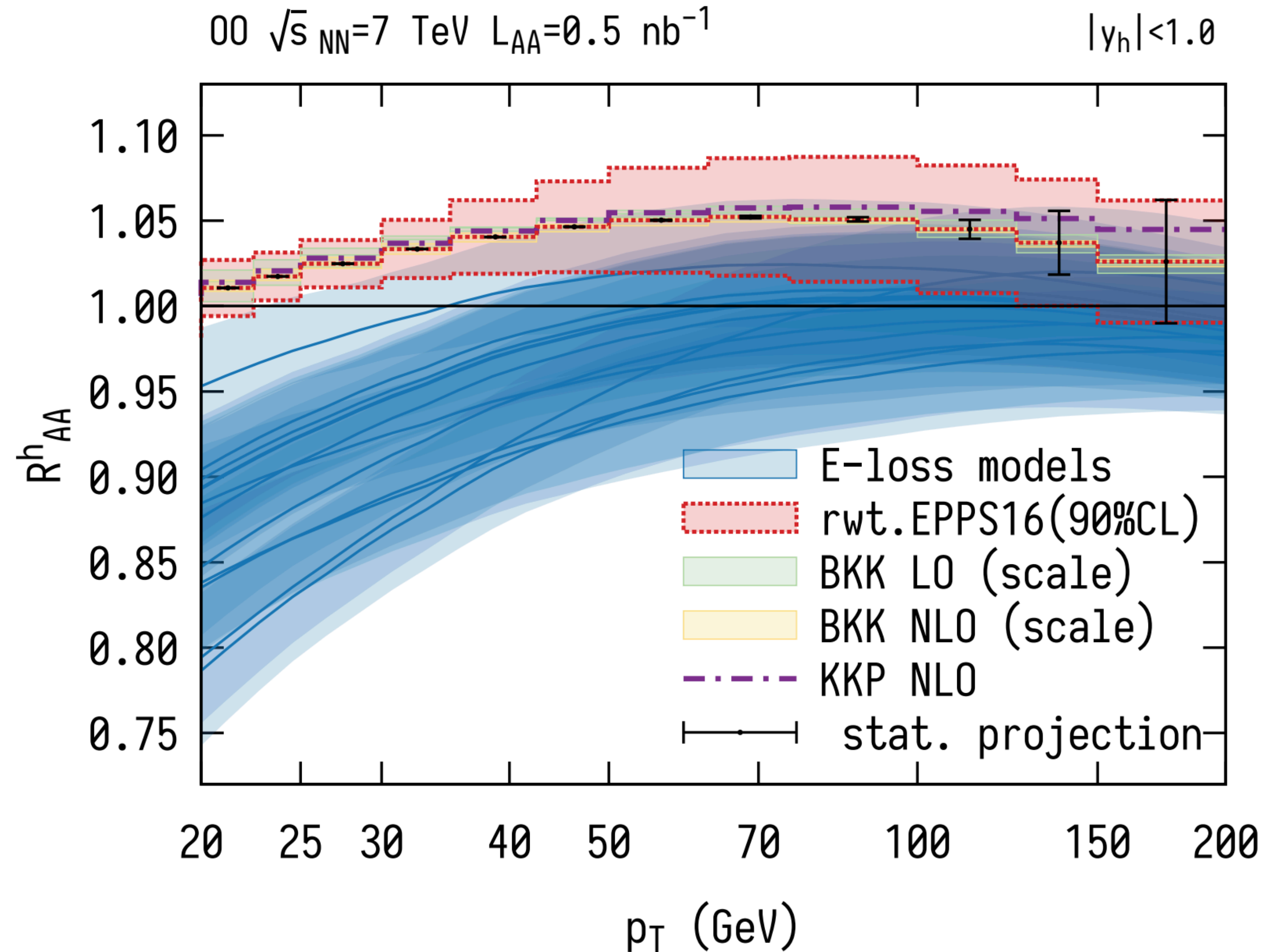
Daniel Pablos

EMMI Light-Ions Workshop
Heidelberg - 22nd Sept. 2026



Energy Loss in Light Ions

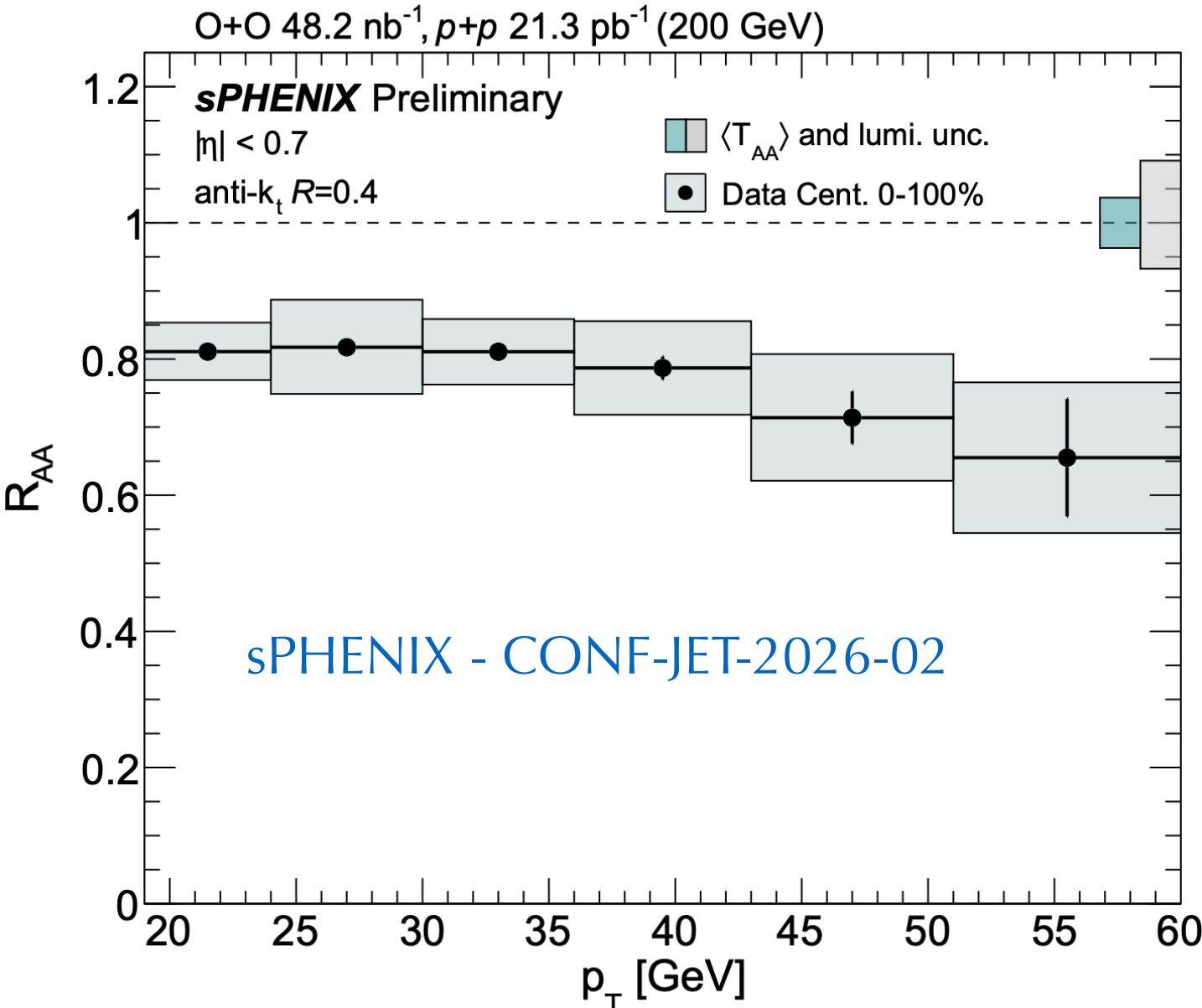
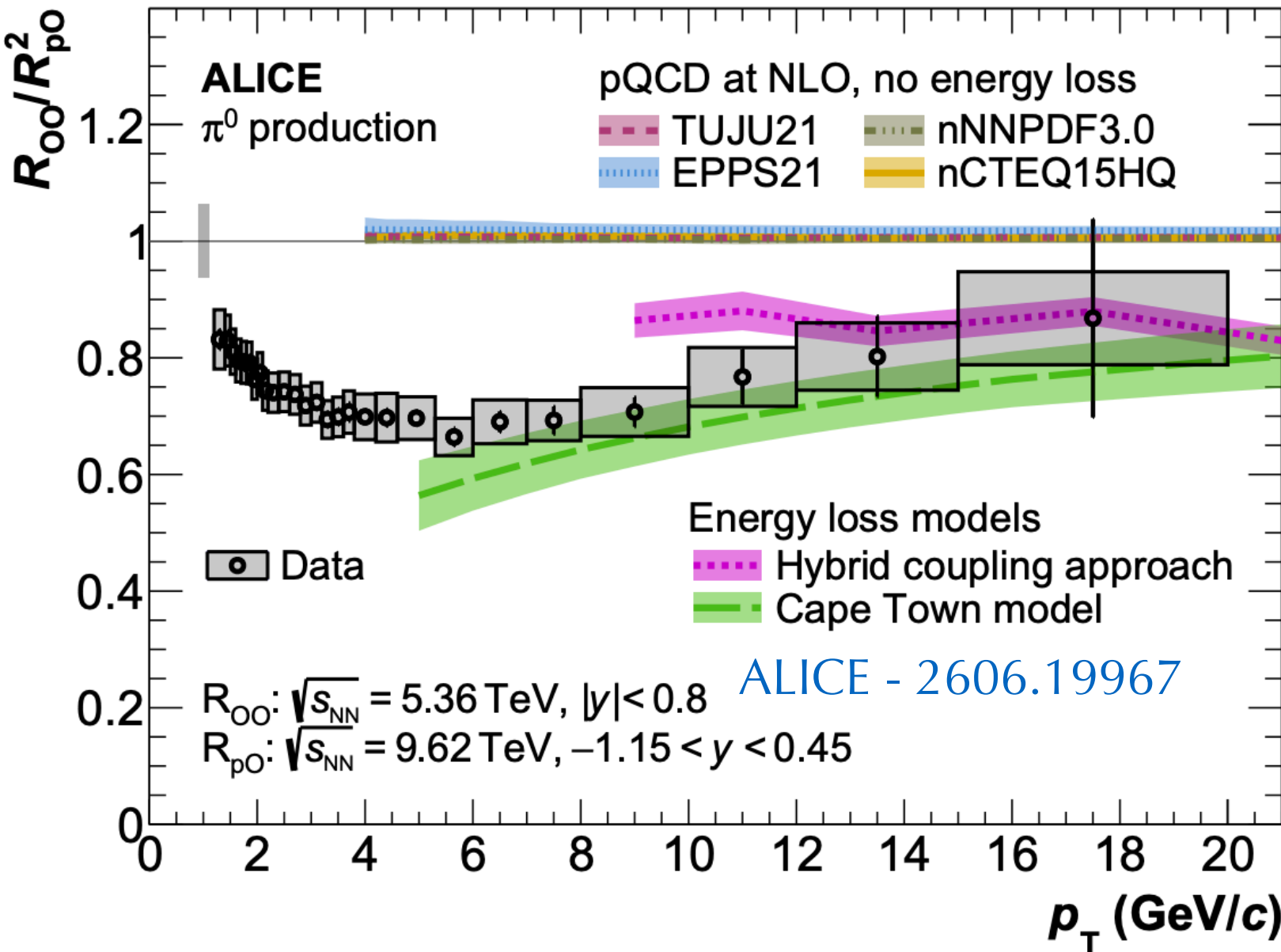
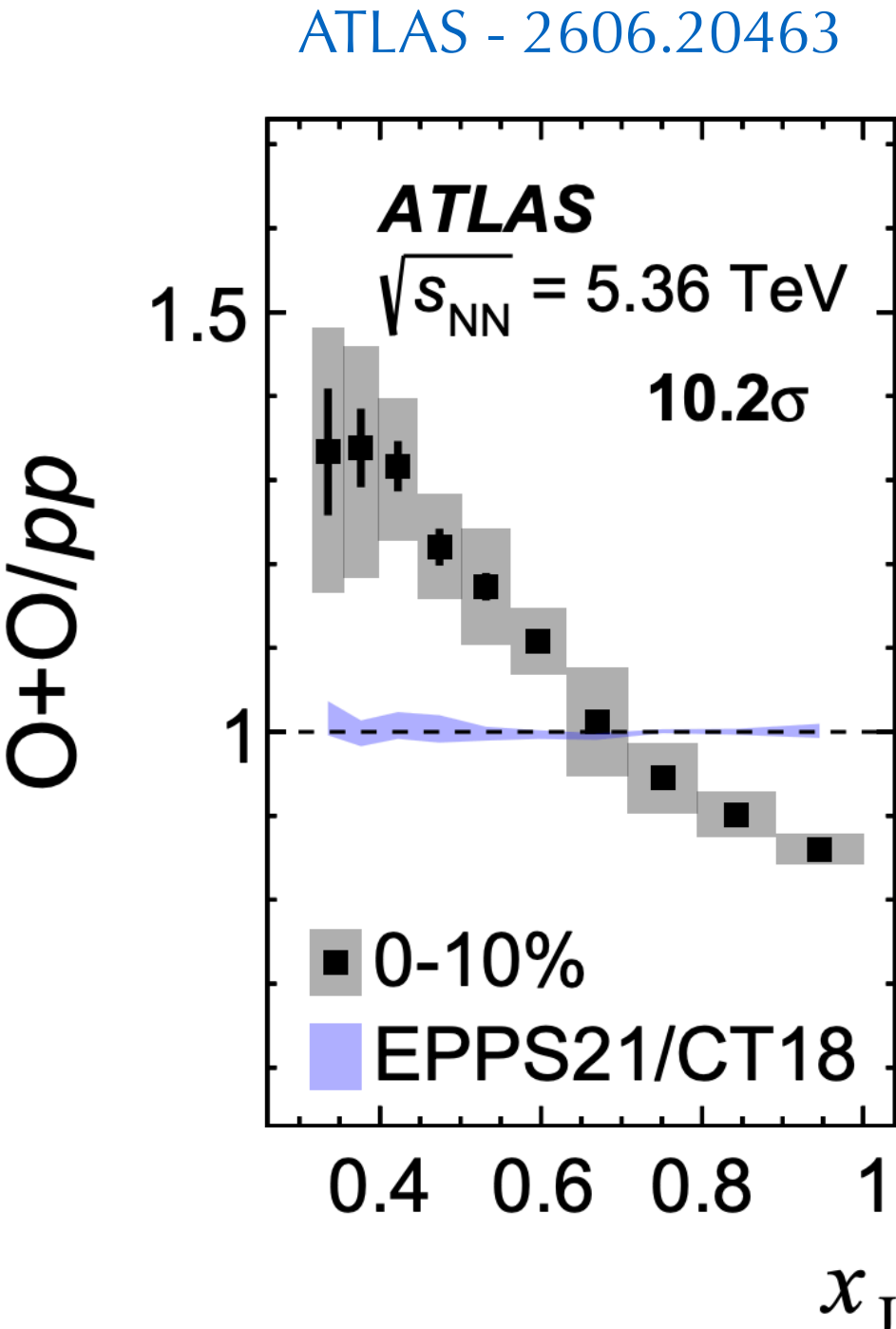
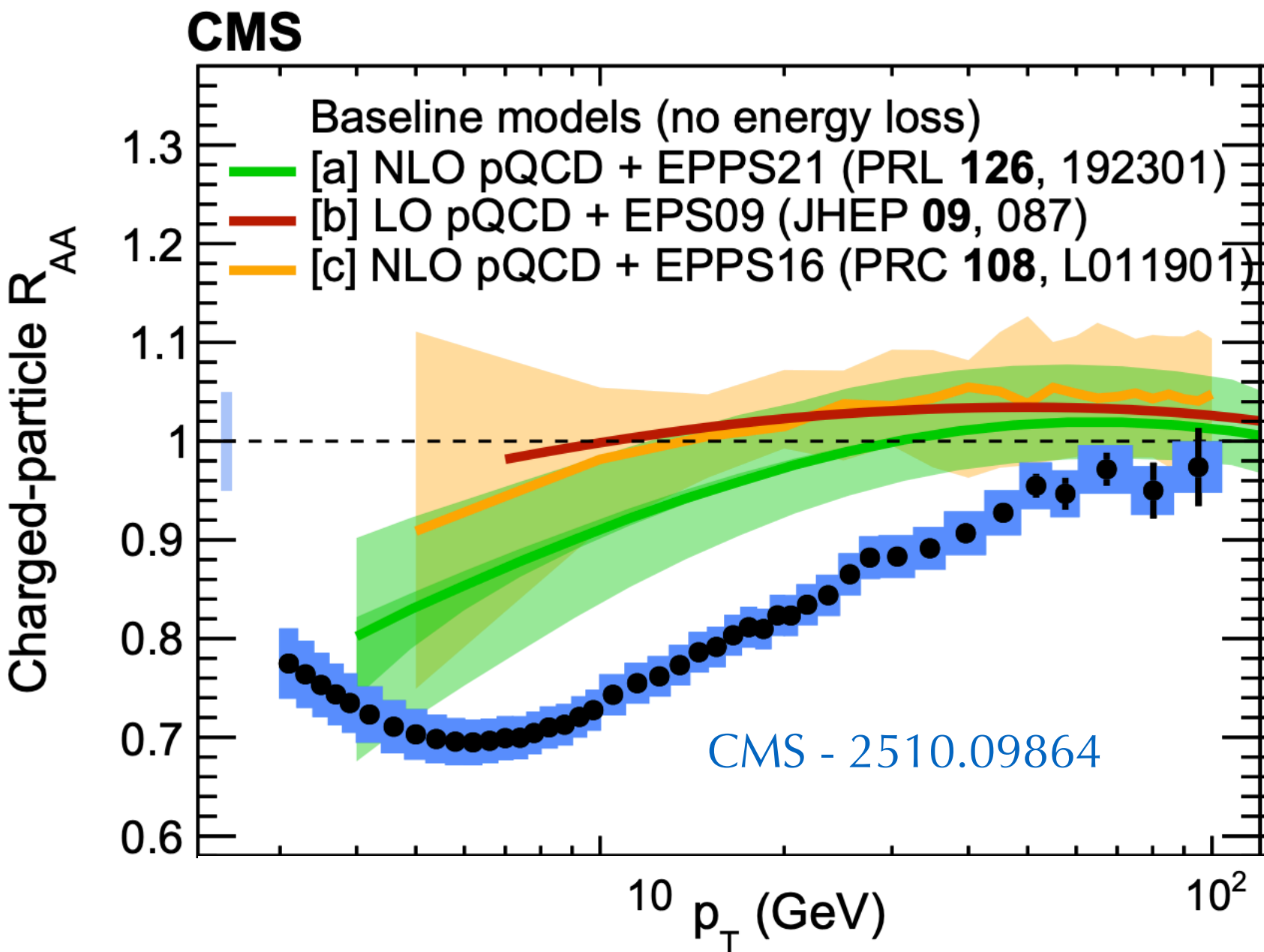
Predicted energy loss effects due to QGP formation in light ions have been experimentally confirmed.



Energy Loss in Light Ions

Predicted energy loss effects due to QGP formation in light ions have been experimentally confirmed.

Initial state effects alone seem to be insufficient to describe data.



From Large to Very Small Systems

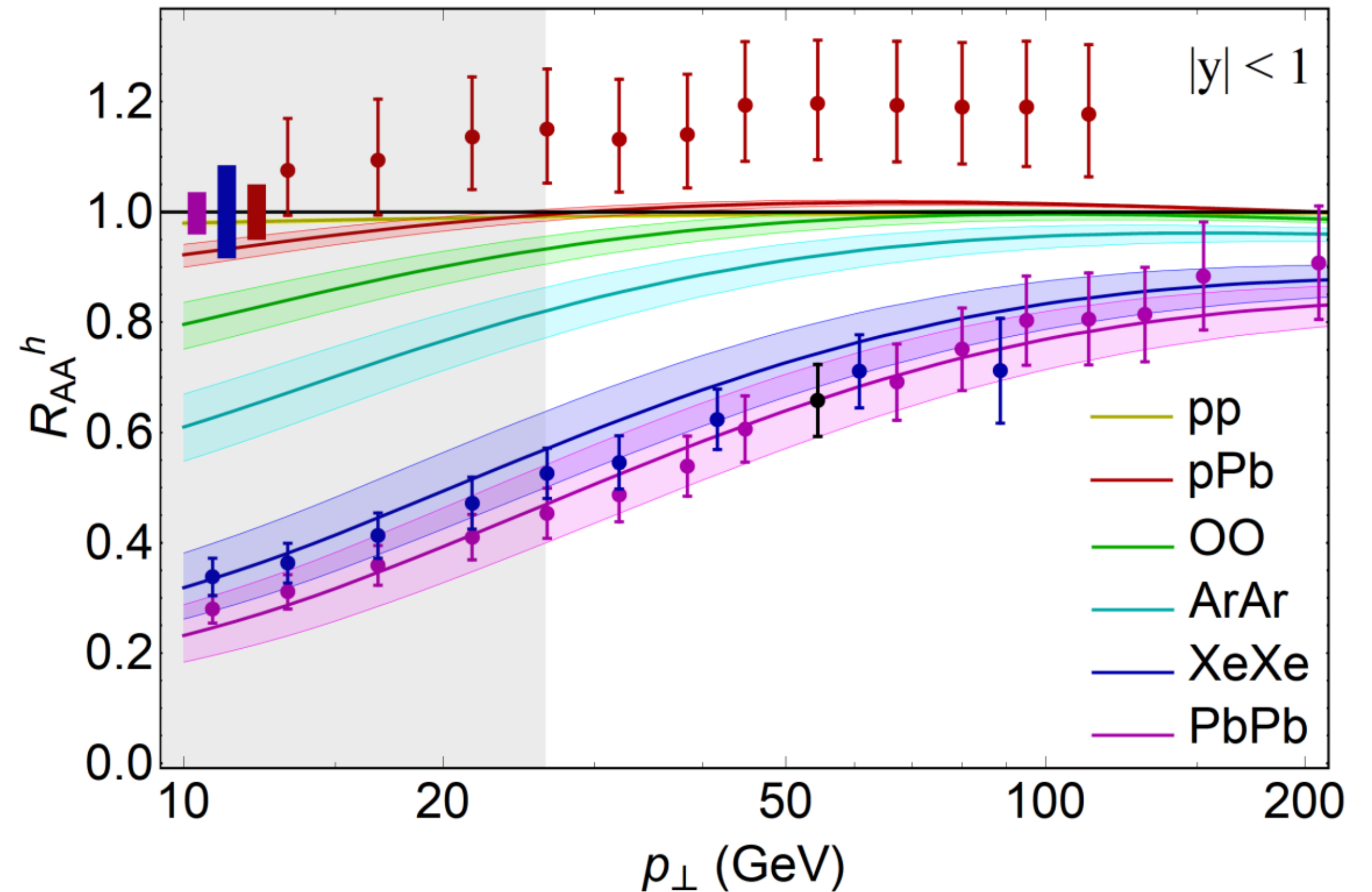
Huss et al. - 2007.13758

Here, the same leading-log BDMPS model applied over all system sizes.

Arnold - 0808.2767

Harmonic oscillator approx. (HO) breaks down for sufficiently small L.

Rare large momentum exchanges are relatively more important at small L.



In general, do we have good theory control of jet quenching towards smaller systems?

Radiation Spectrum Improvements

Semi-analytical way to combine multiple soft scatterings (HO) + rarer hard scatterings (DGLV)

Improved Opacity Expansion (IOE)

[Mehtar-Tani - 1903.00506](#)

Relax soft emissions approximation + large N_c

Sizeable modifications $O(20\%)$ vs IOE

Exact result! [Leitão et al. - 2606.26039](#)

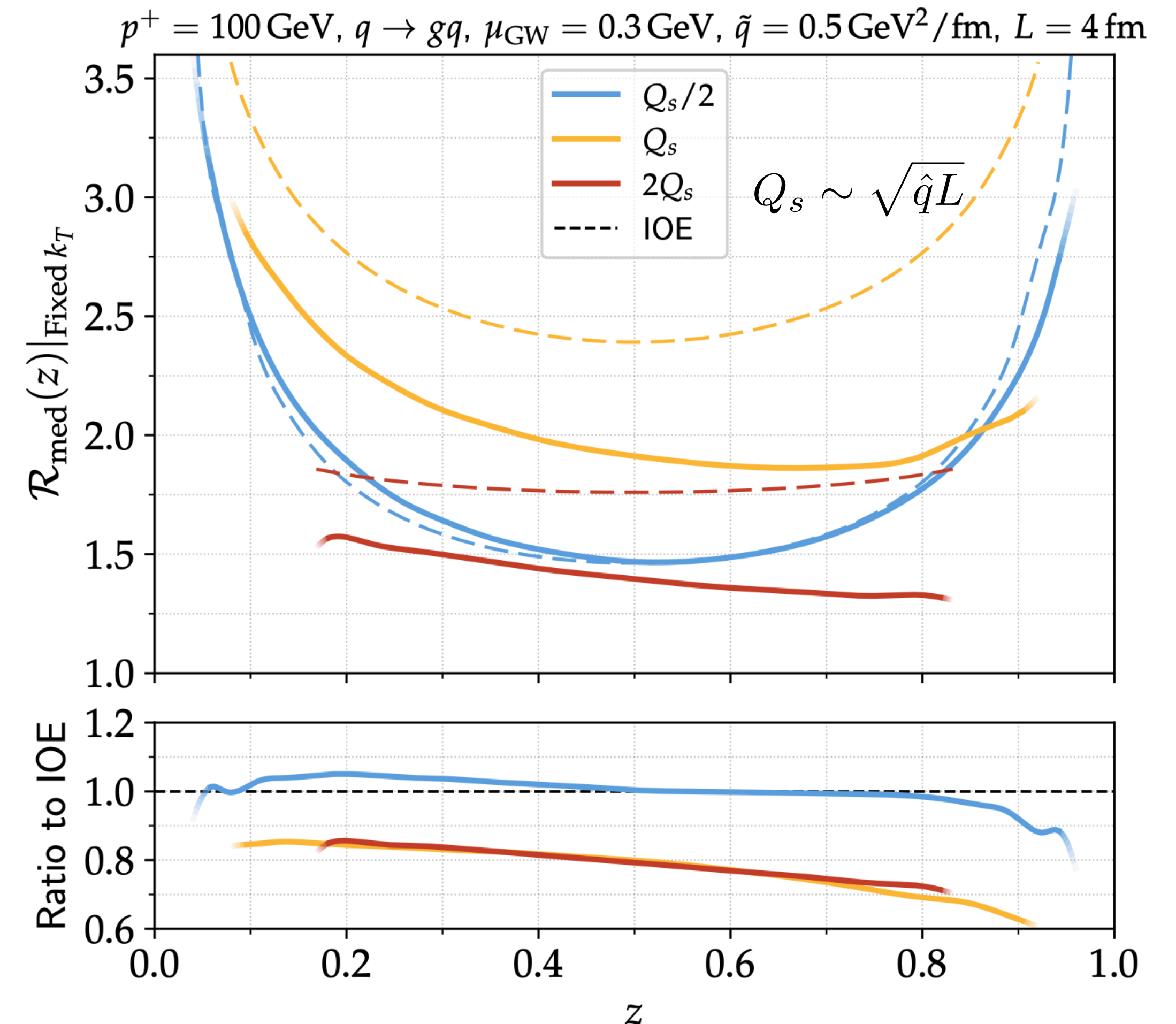
See also:

Quantum simulation (full color tracking)

[Barata et al. - 2604.11616](#)

Semi-analytical full energy fraction in HO

[Andrés & Domínguez - 2603.27846](#)



Short Path Length Corrections to Single Hard Scattering

Short Path Length (SPL) corrections relax approximations made for large systems in DGLV.

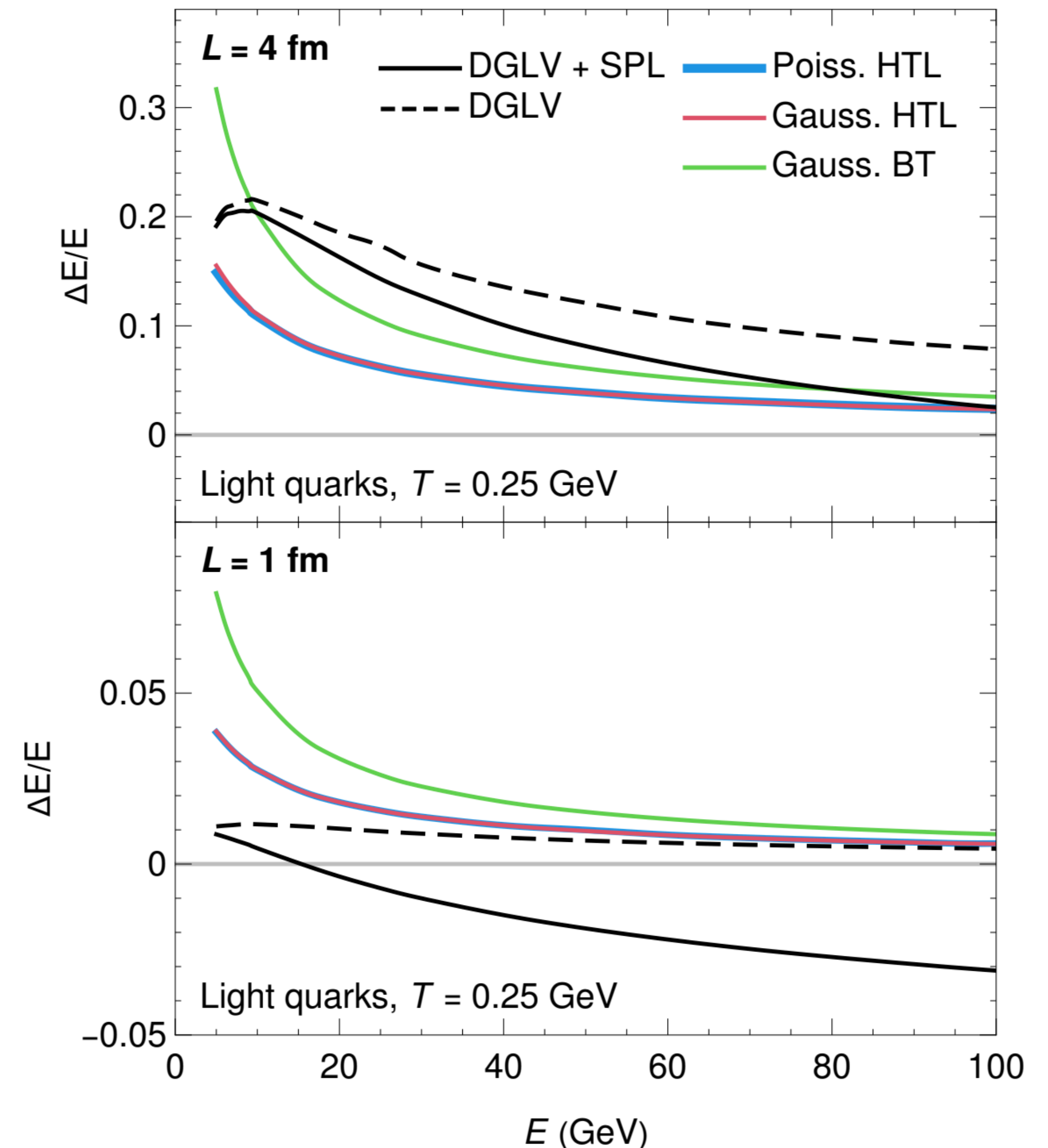
Namely, distance between production and first scatterings need not be large.

Kolbé & Horowitz - 1511.09313

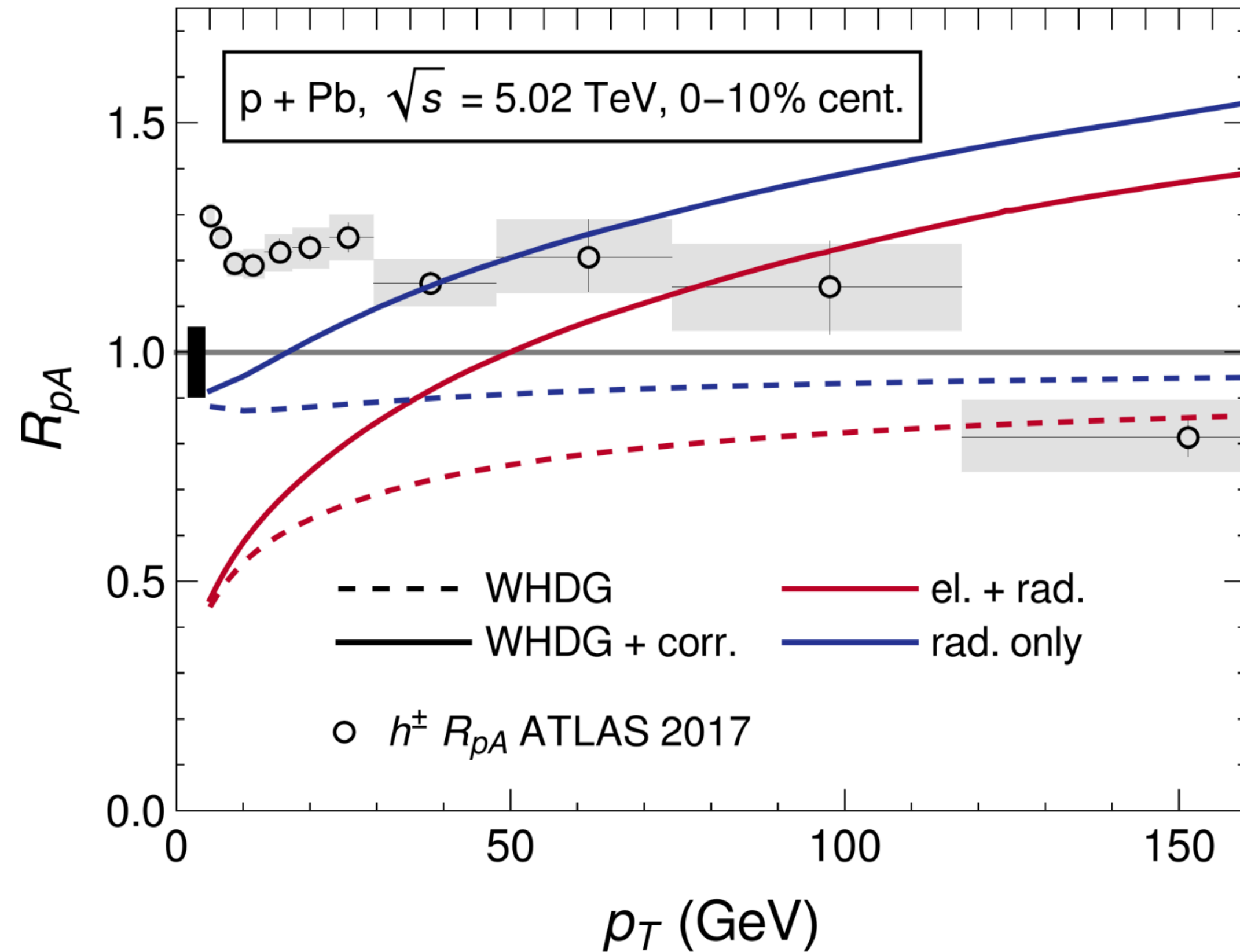
Incorporated for phenomenology in the Cape Town model.

Faraday & Horowitz - 2408.14426

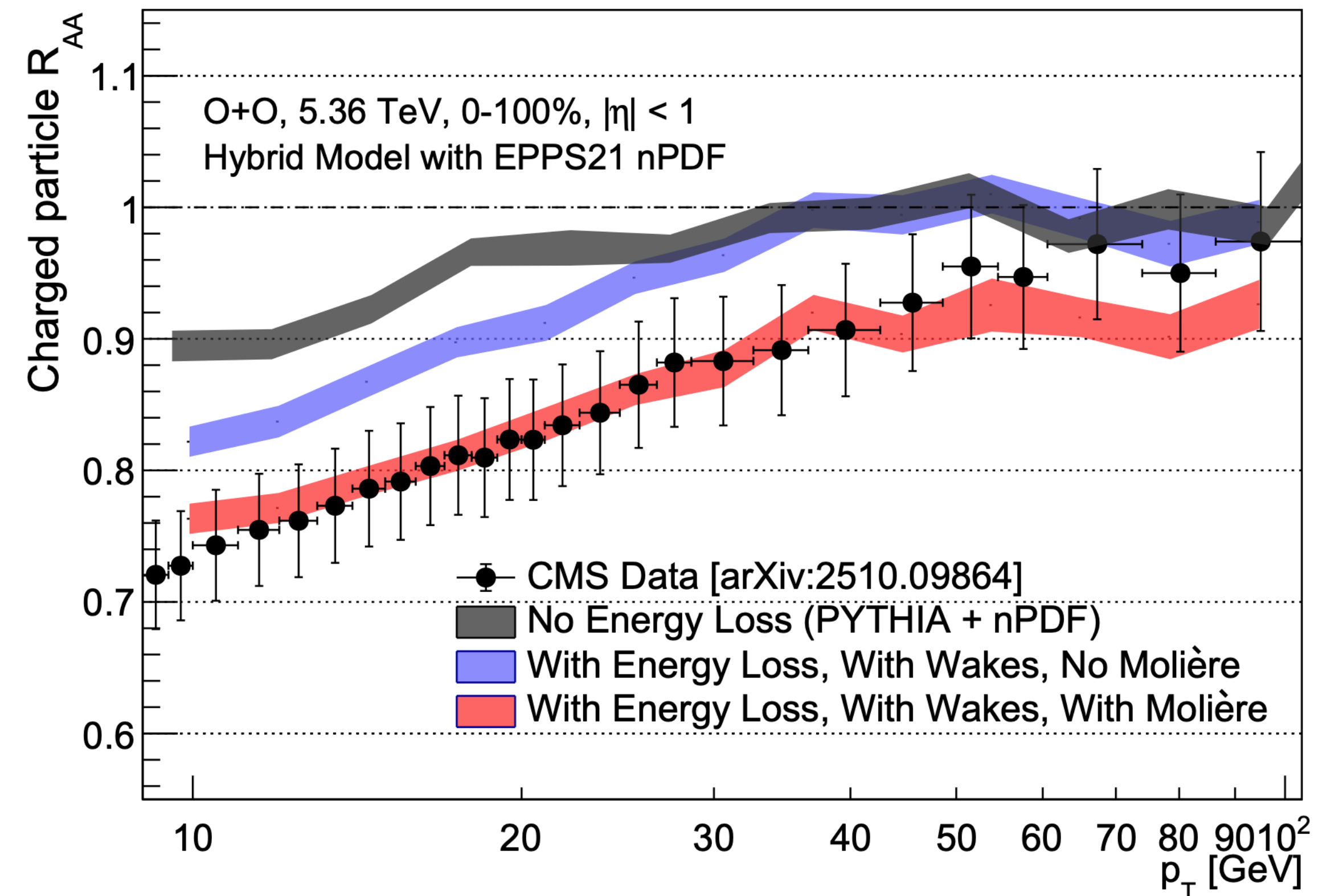
See more about it in C. Faraday's talk today!



Role of Elastic Energy Loss



Faraday et al. - 2305.13182



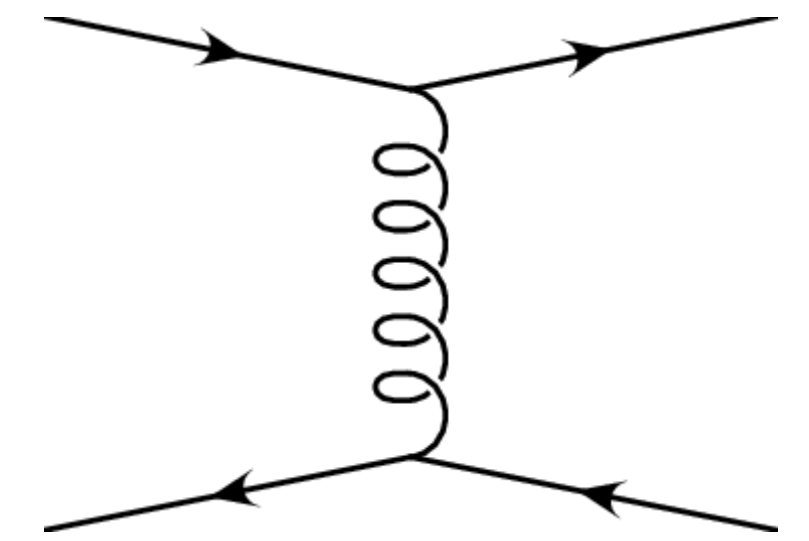
Kudinoor, Lin, DP, Rajagopal - 2603.23596

Path length dependence of energy loss ($\sim L$) becomes relatively more important than radiative ($\sim L^2$) or strongly coupled ($\sim L^3$) in smaller systems.

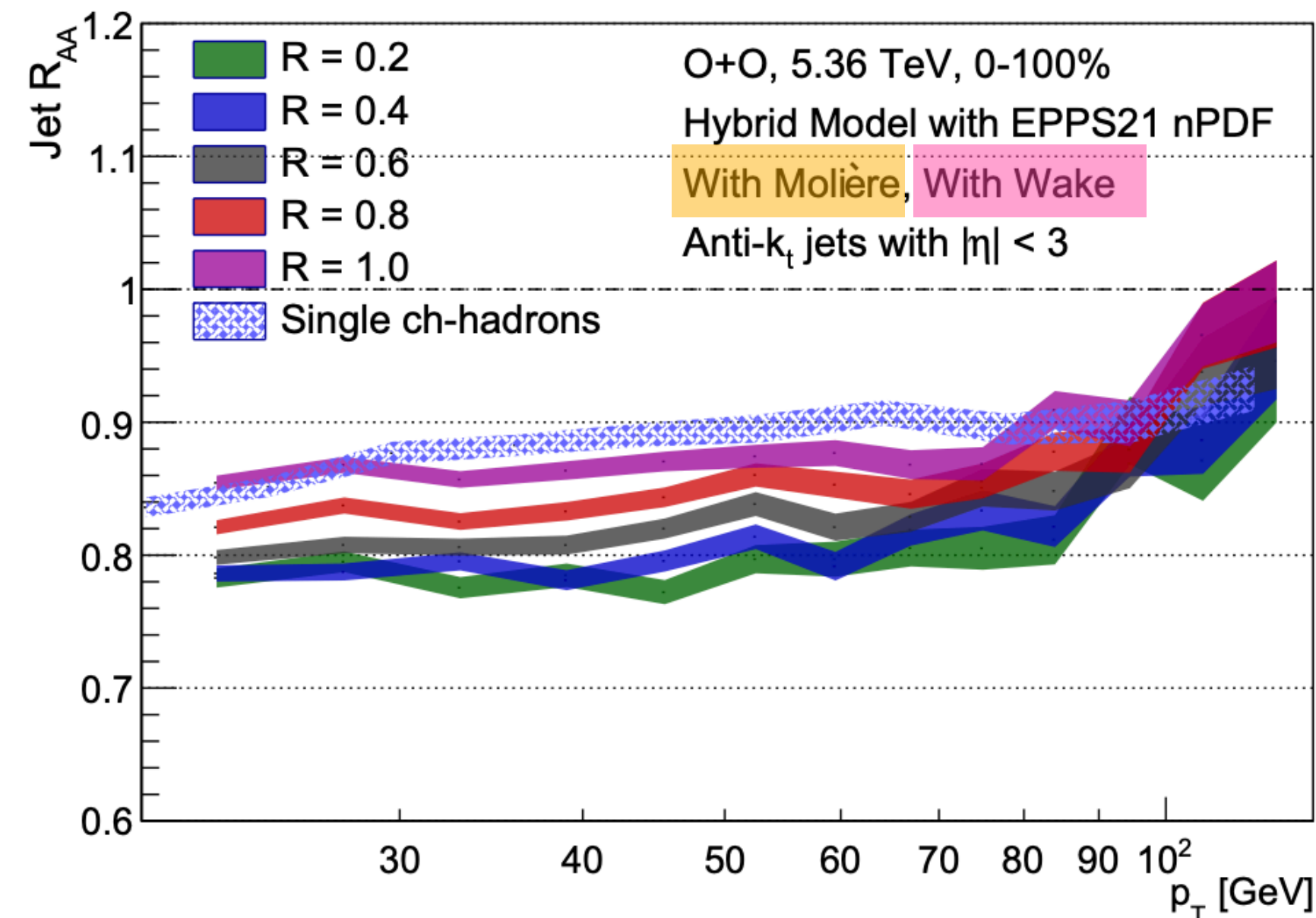
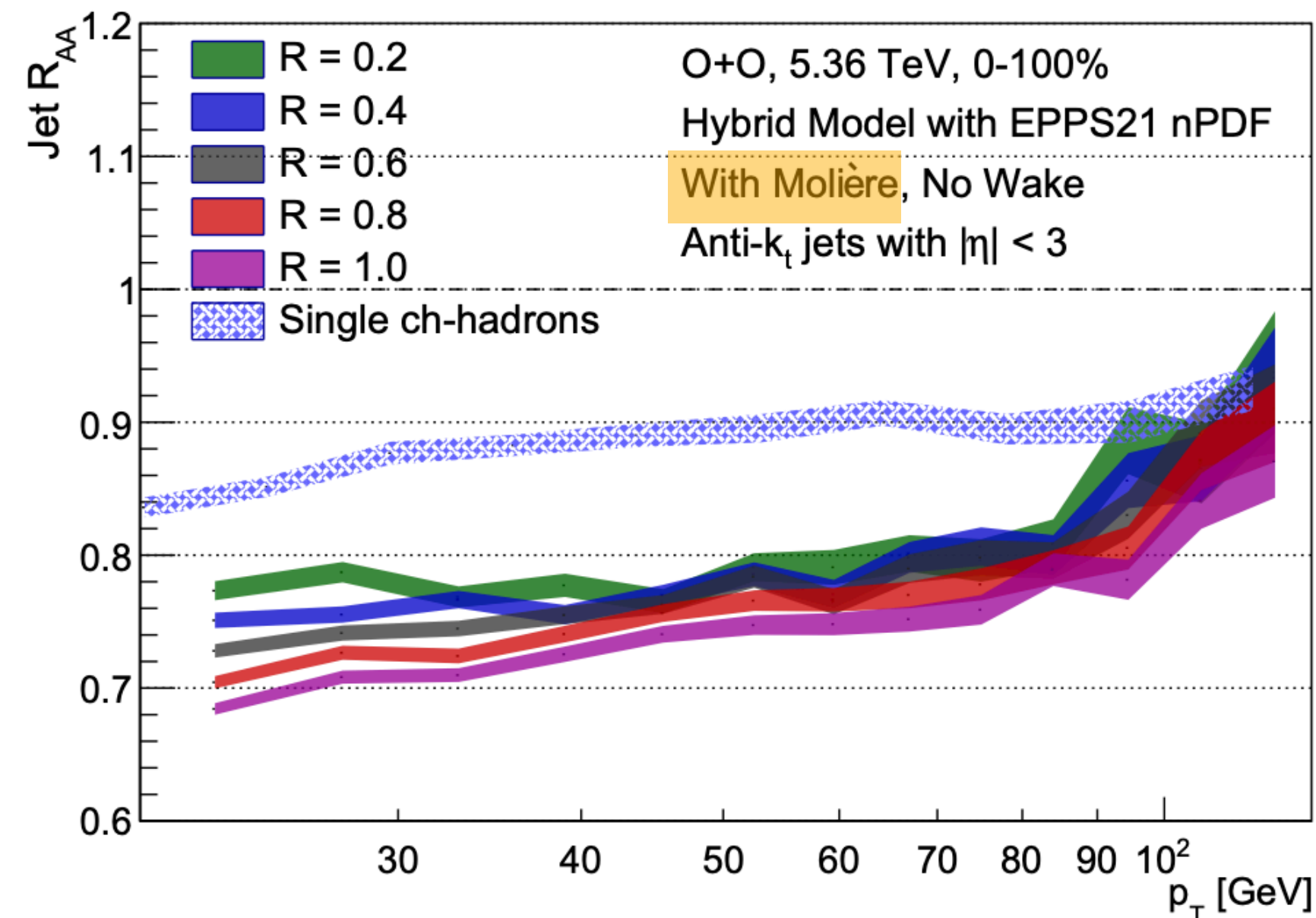
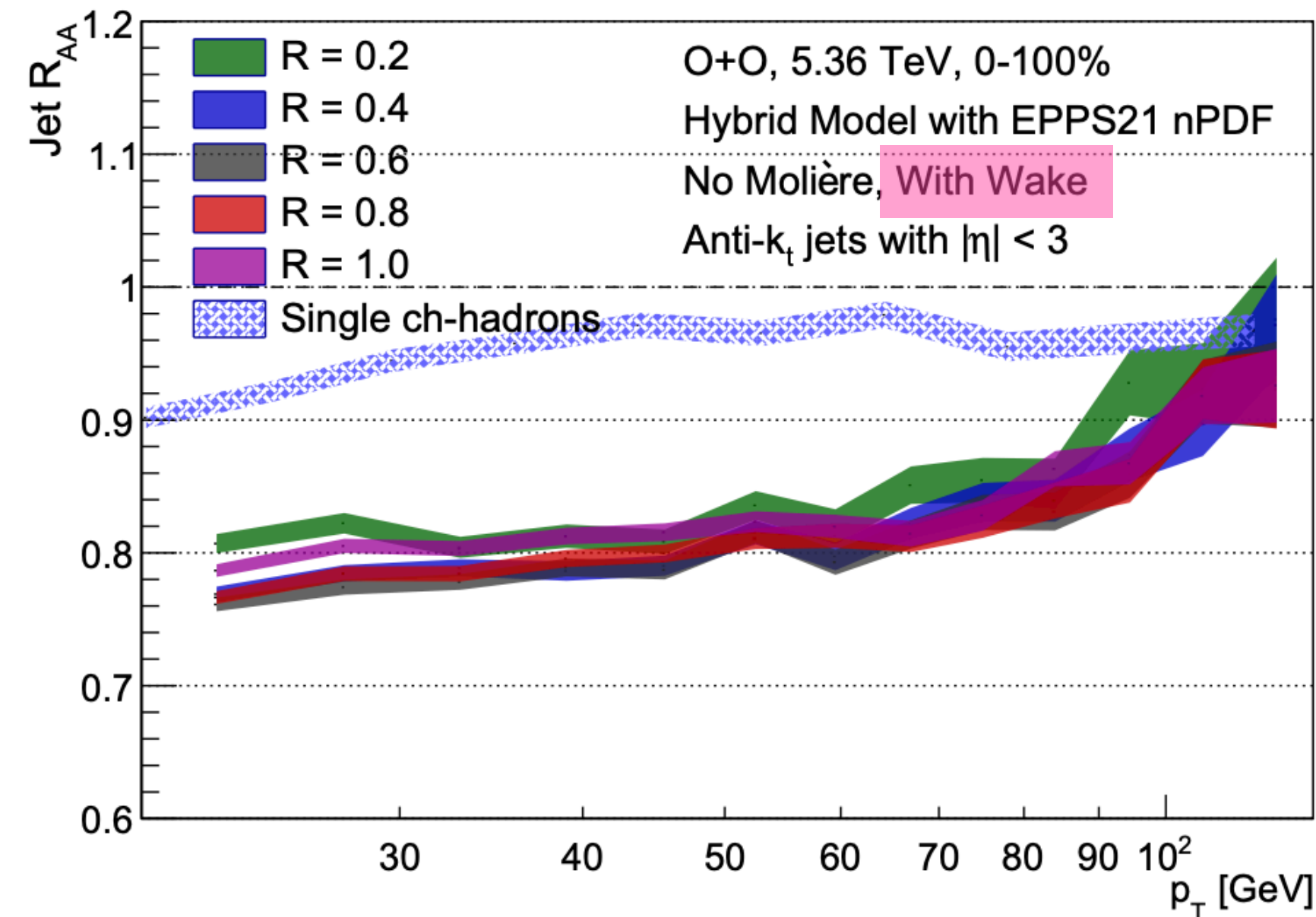
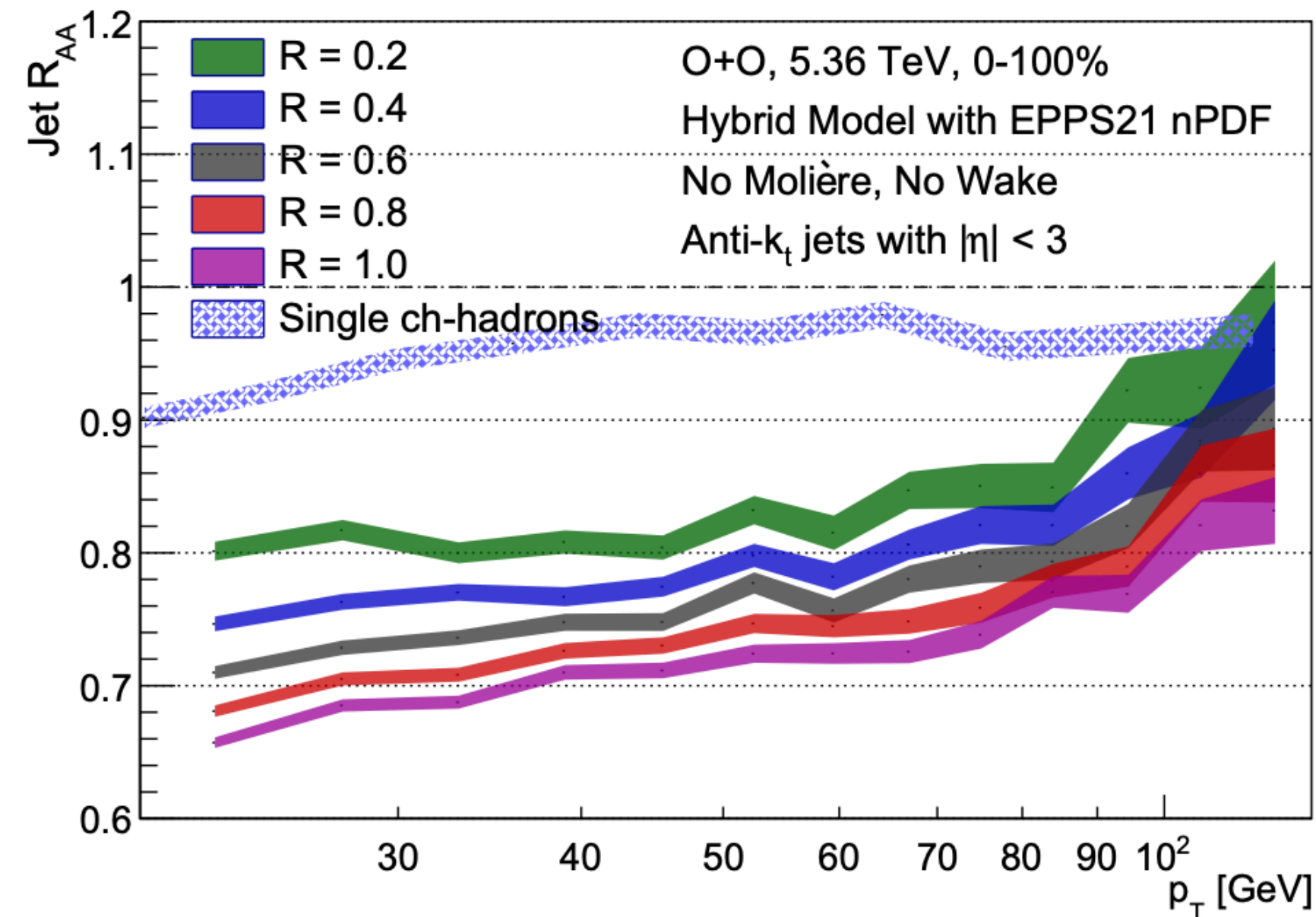
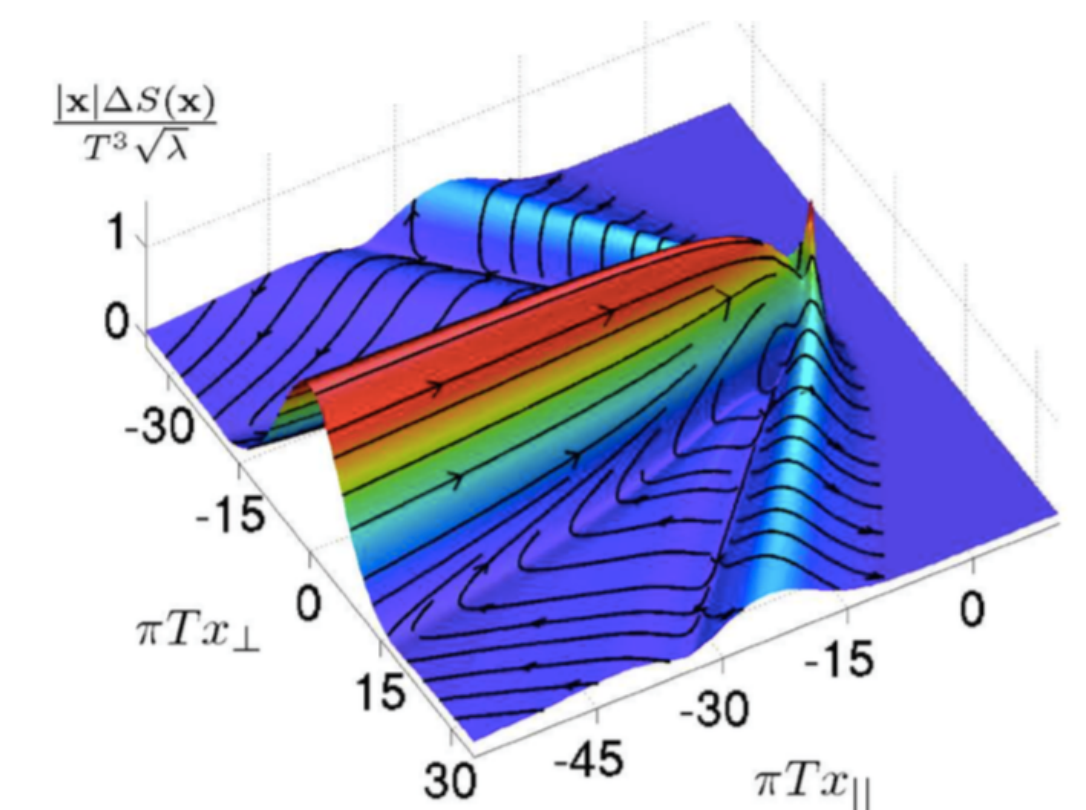
Jet Suppression in OO

See substructure discussion
at A. Kudinoor's talk today!

Molière (elastic) scattering

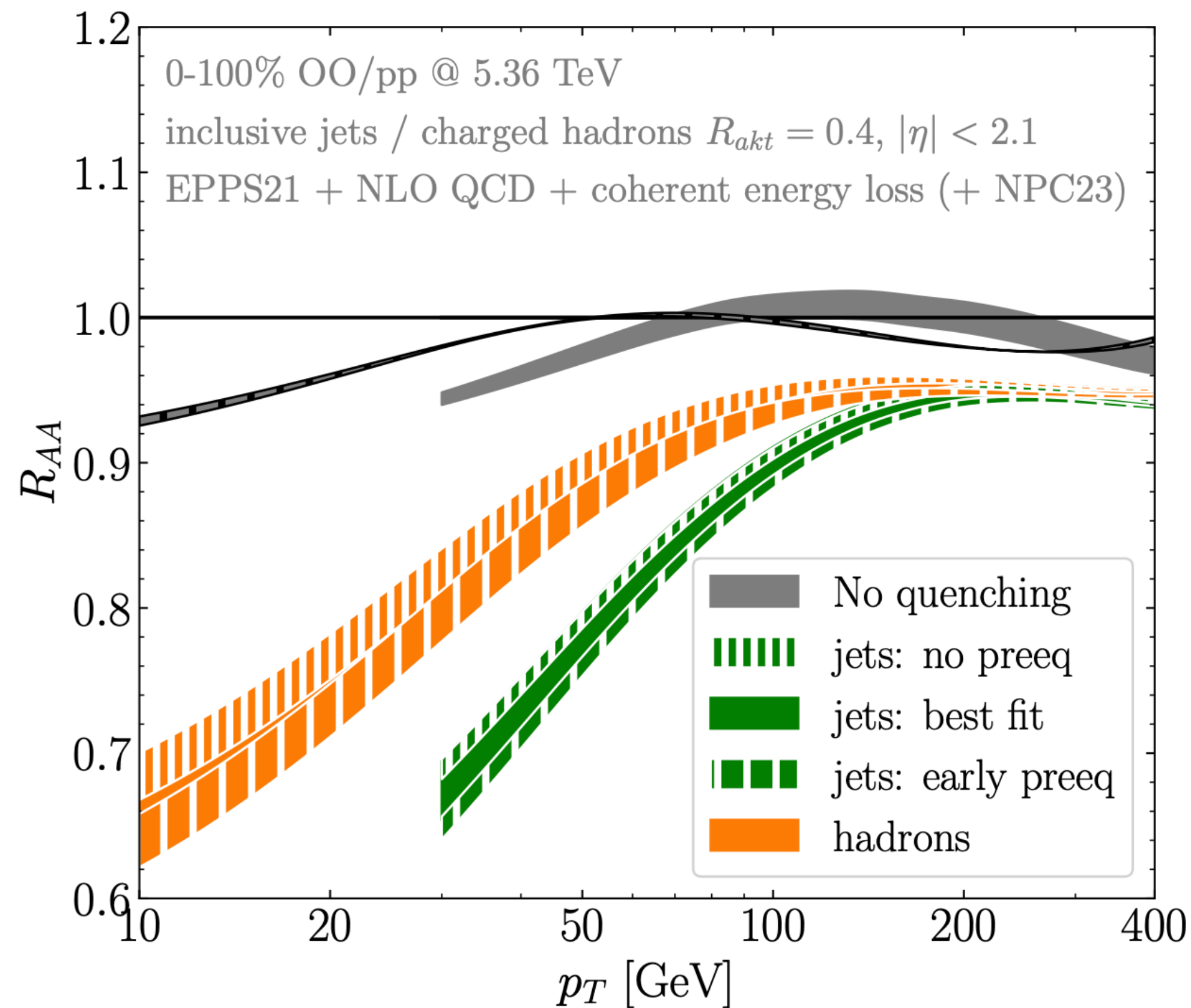


Hydrodynamic wake



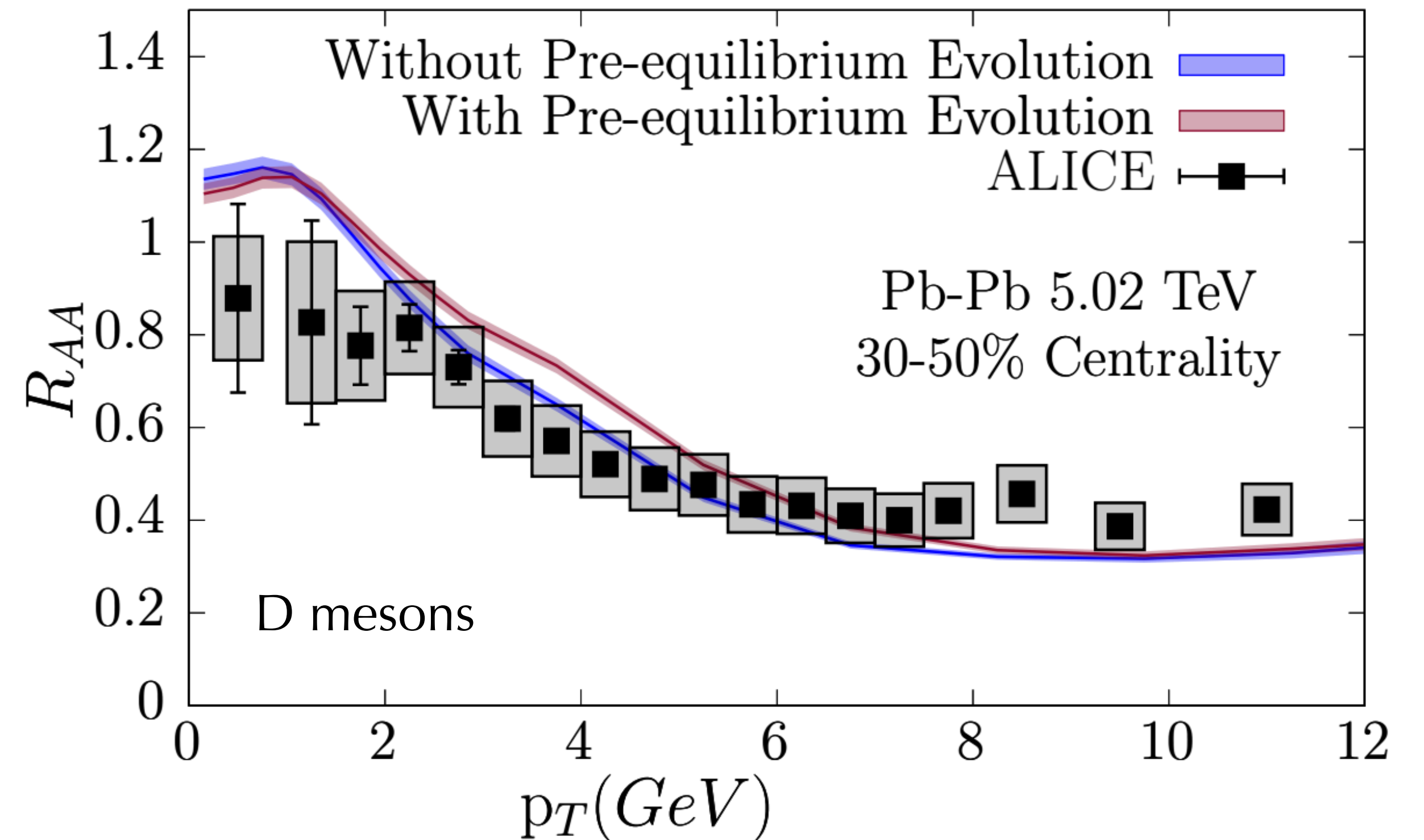
Energy Loss in Pre-Equilibrium Phase

Kinetic theory attractor to estimate energy density before hydro time.



DP & Takacs - 2509.19430

Energy density from IP-Glasma to estimate heavy quark transport coeff.

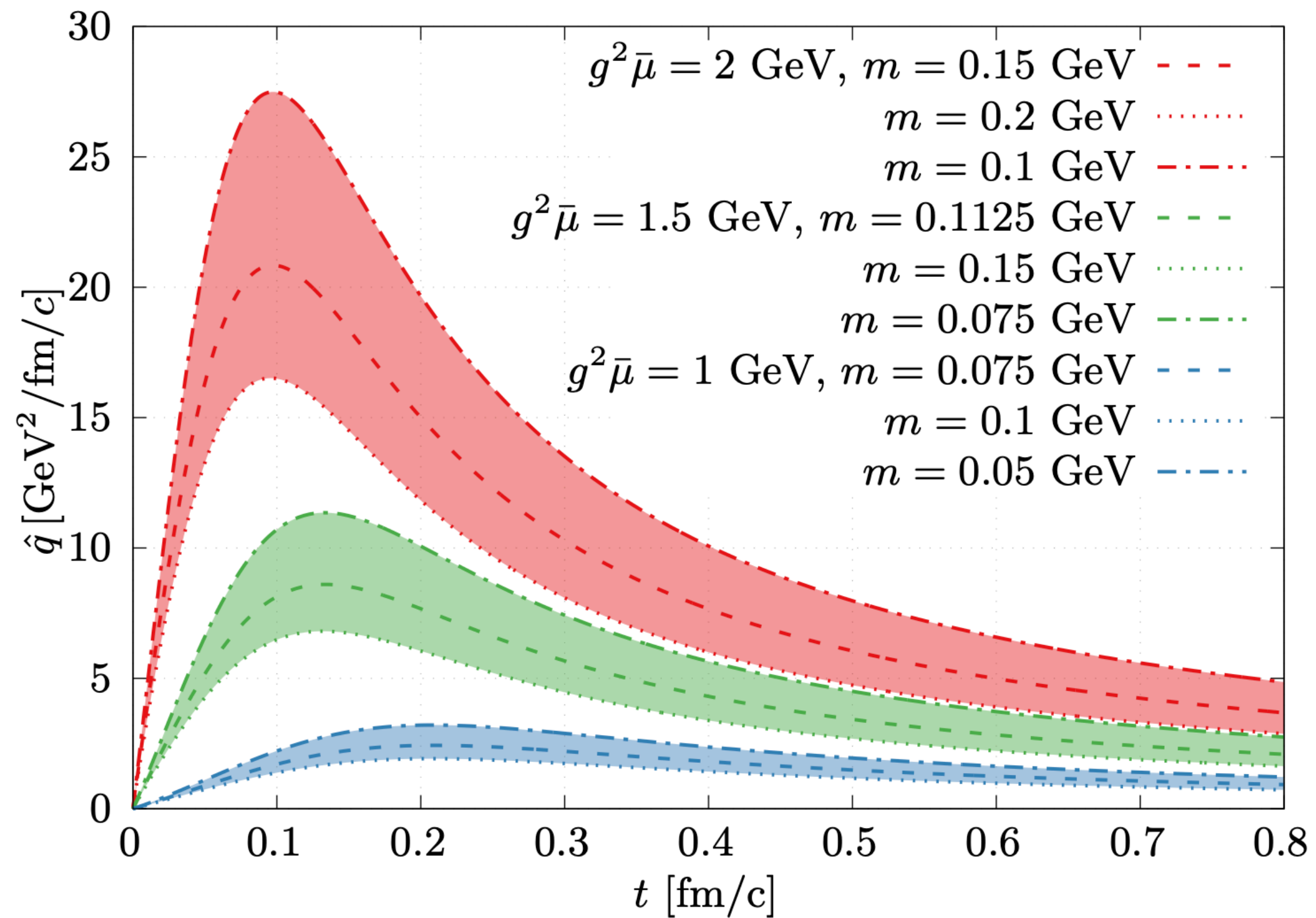


Singh et al. - 2509.18647

Useful approaches to gauge total amount of energy loss.

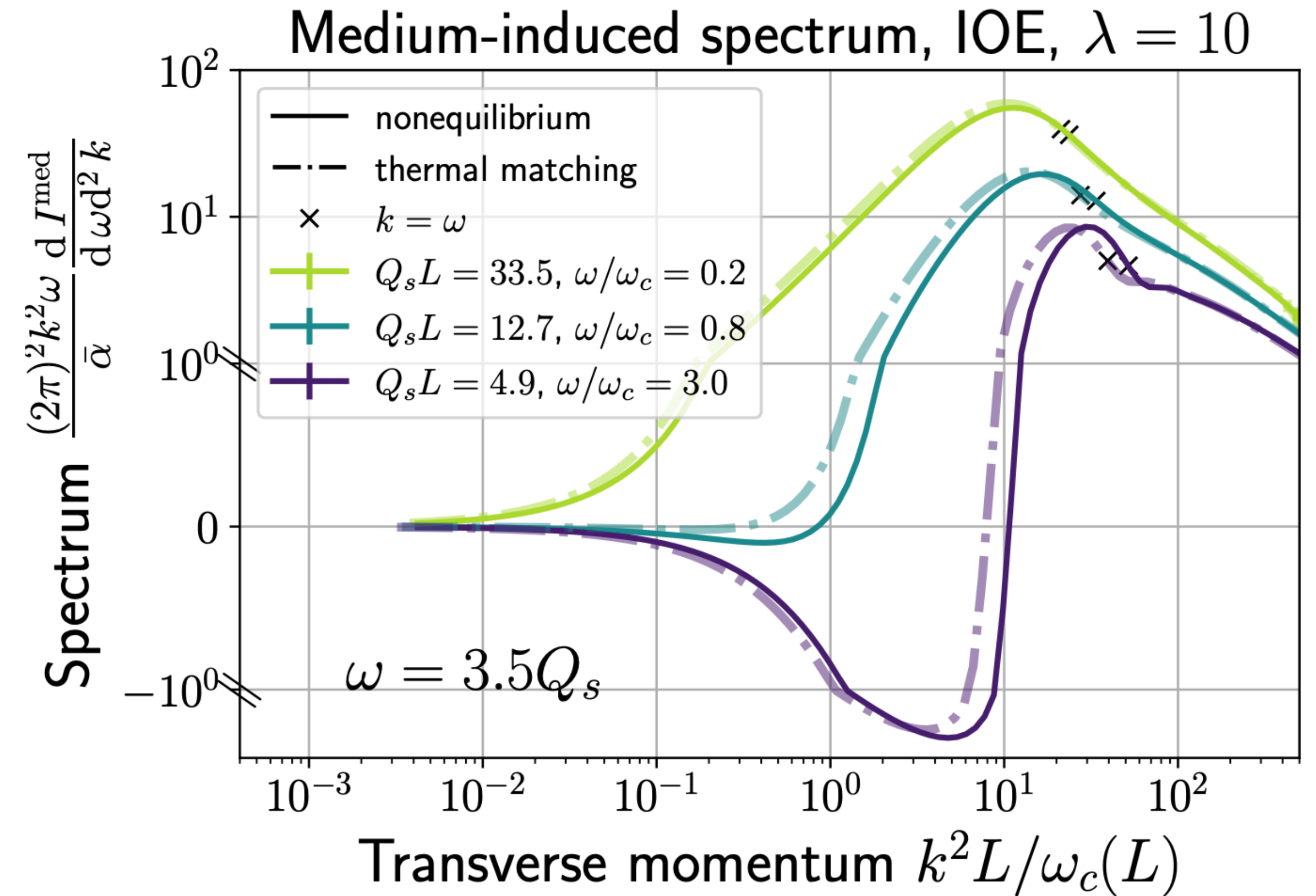
Energy Loss in Pre-Equilibrium Phase

Vlasov-type equation with Glasma evolution



Guerrero et al. - Talk at EMMI Early Stages 2026

Non-equilibrium kinetic theory



Barata et al. - 2511.07519

See also:

Avramescu et al. - 2605.10413

Barata et al. - 2406.07615

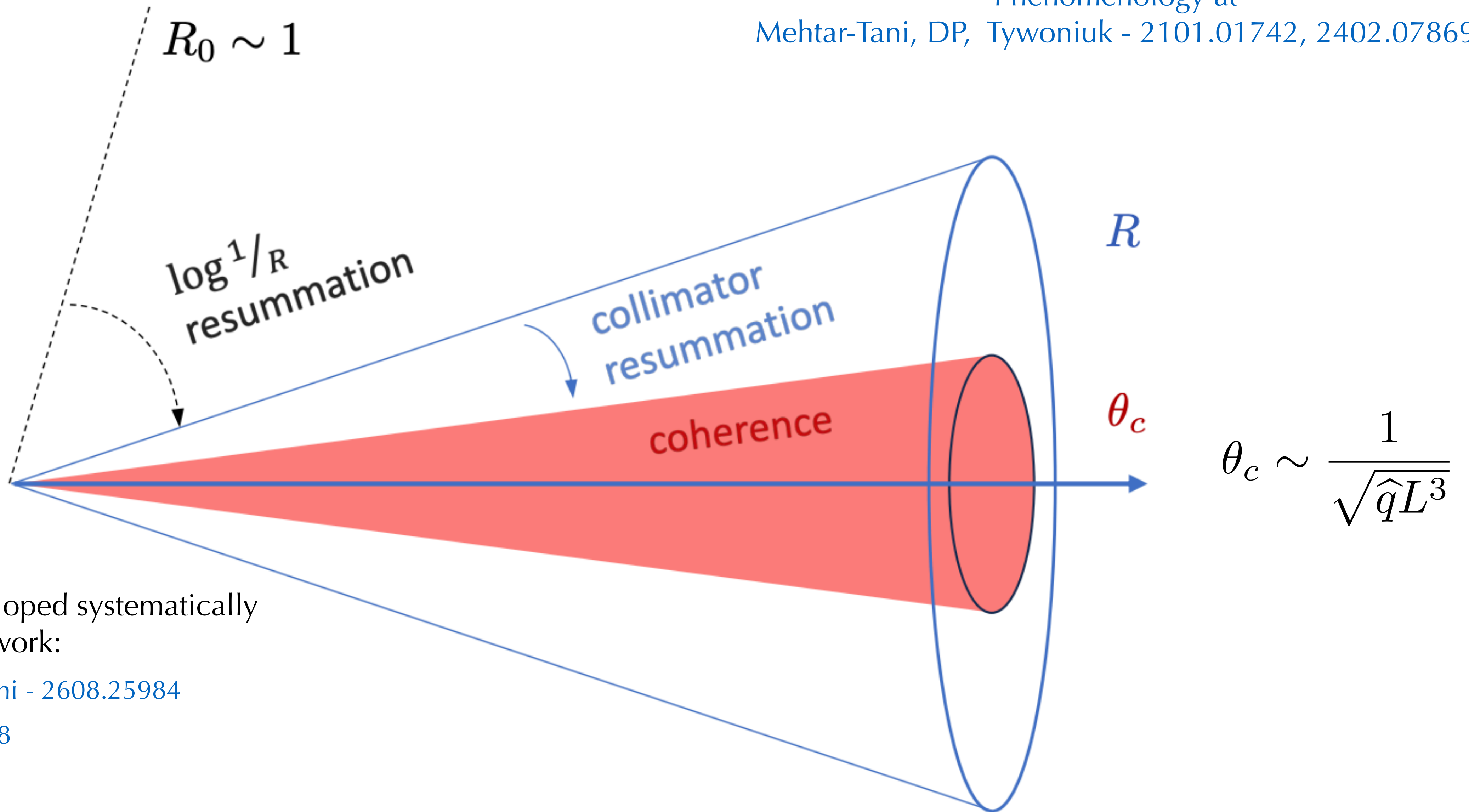
and many more...

Early system anisotropies can be captured.

See I. Soudi's talk today
for fresh calculations!

Jet Suppression with Color Coherence

Phenomenology at
Mehtar-Tani, DP, Tywoniuk - 2101.01742, 2402.07869



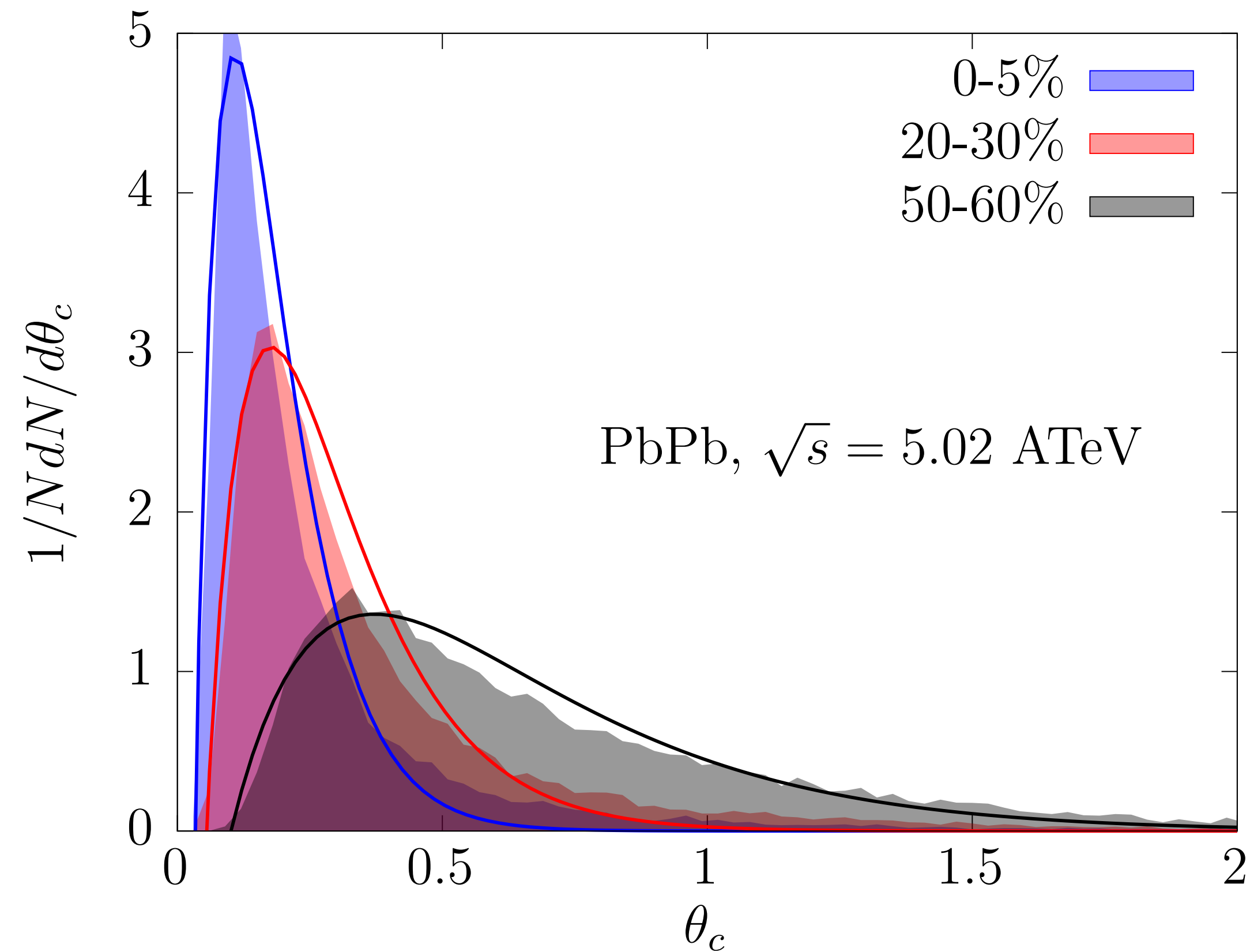
Picture now developed systematically
within EFT framework:

Caucal & Mehtar-Tani - 2608.25984

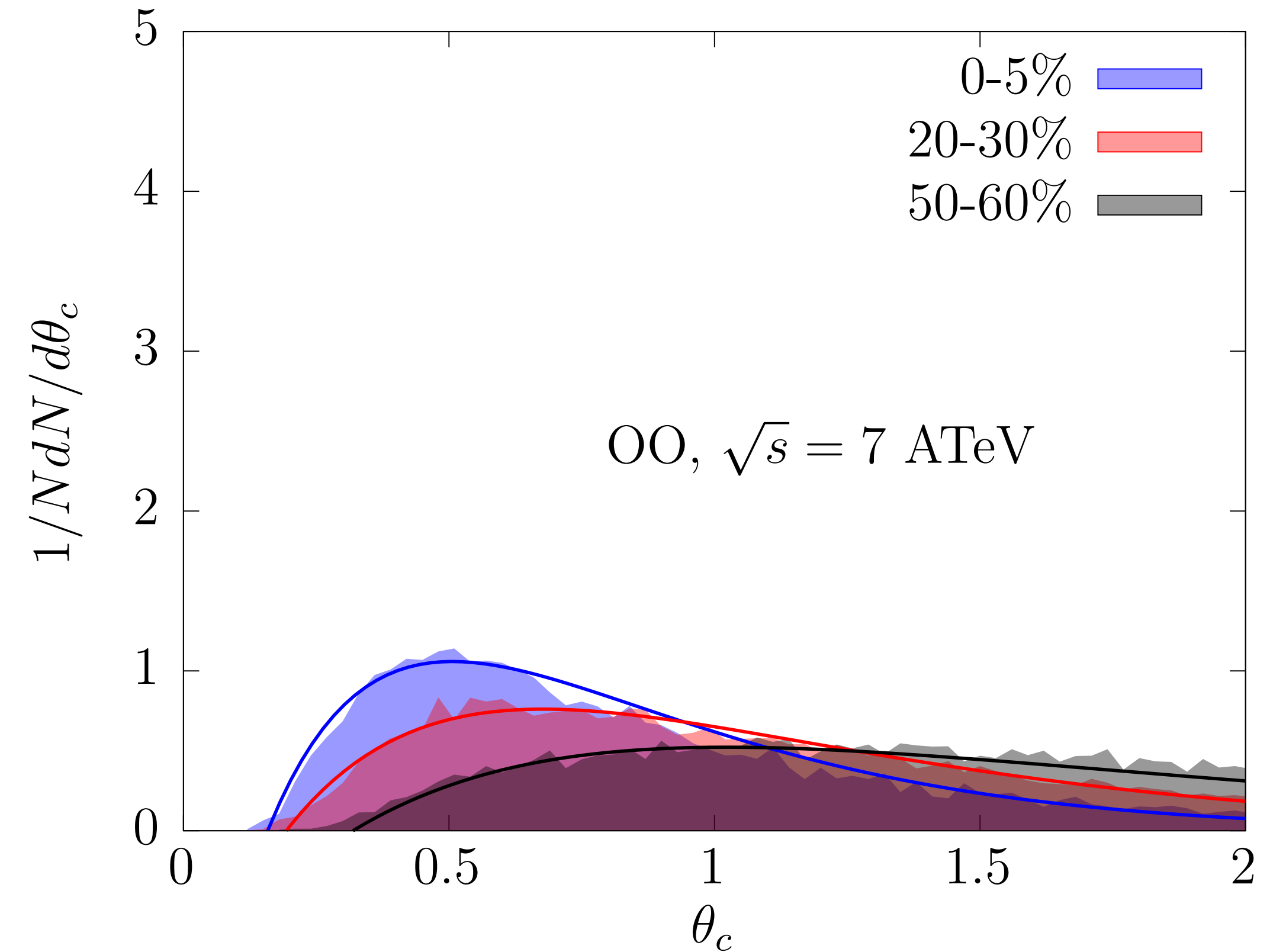
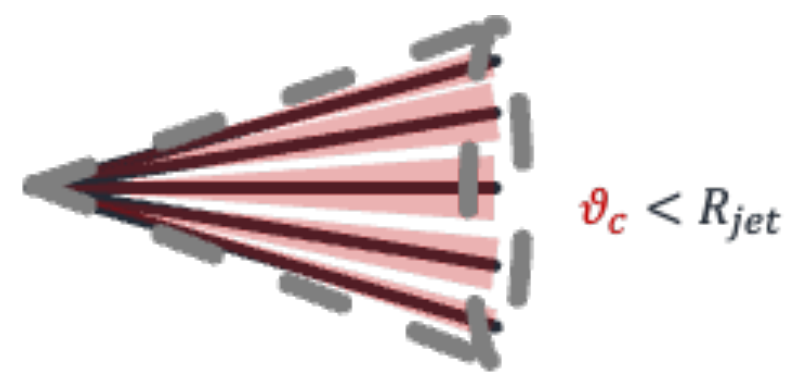
Vaidya - 2603.00238

and some more

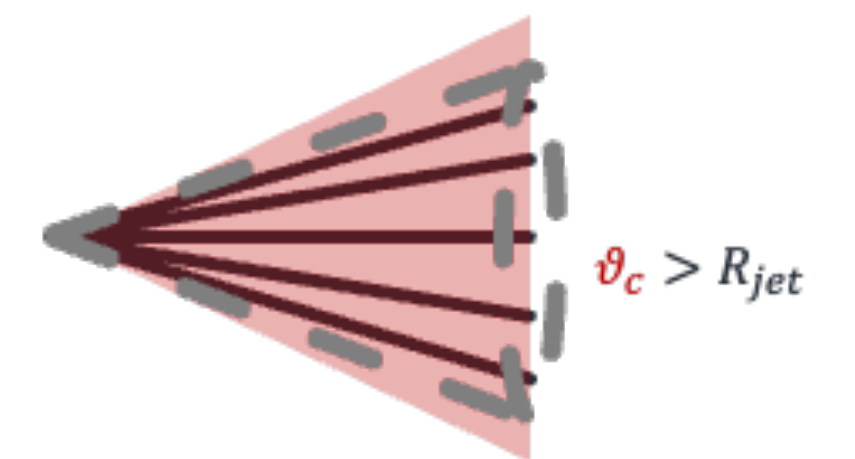
Color Coherence Effects vs System Size



- *PbPb* jets are resolved:



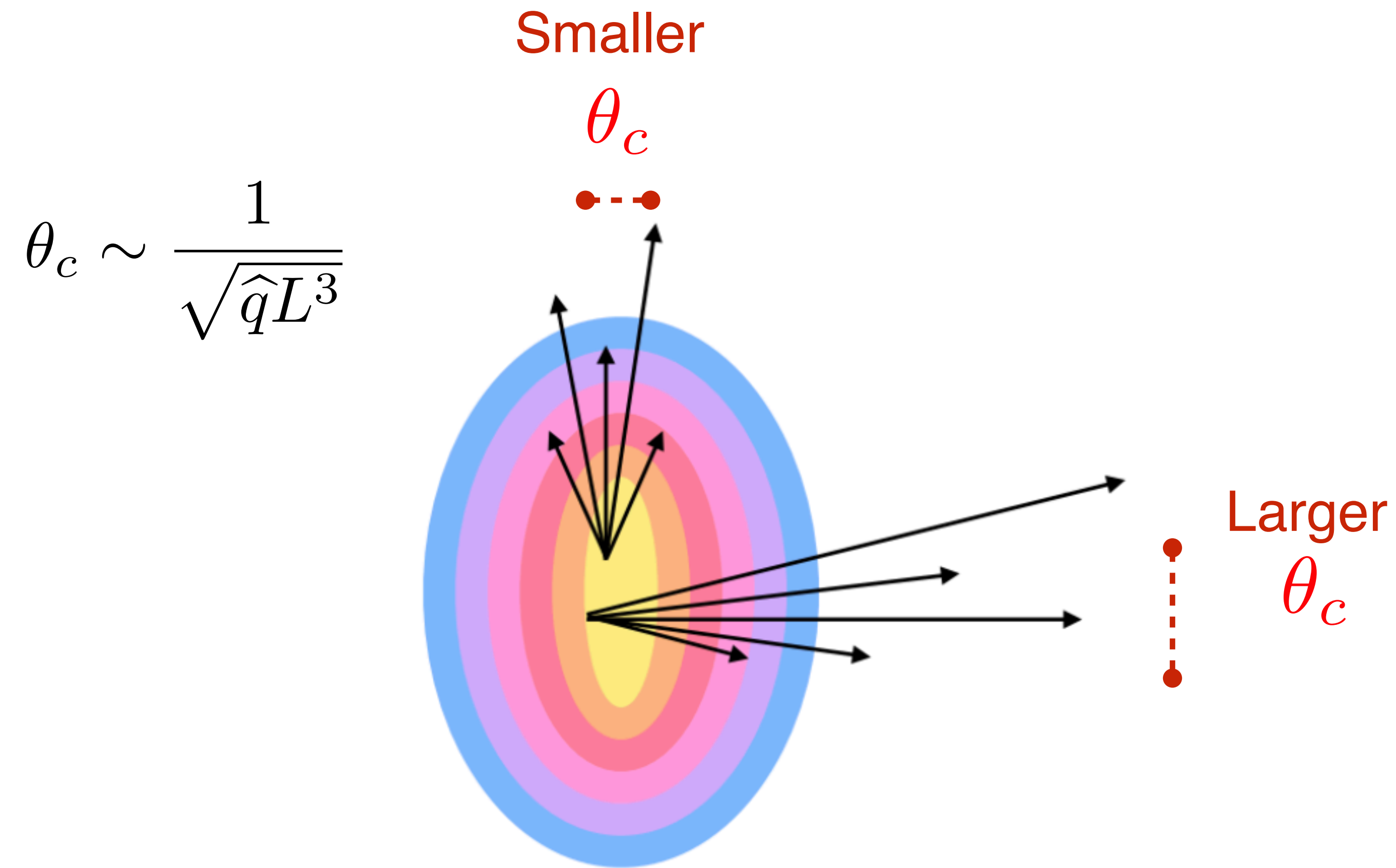
- *OO* jets are unresolved:



Coherence angle actually is dynamical, see [Abreu et al. - 2410.24135](#)

See C. Le Roux's talk today
for color coherence in JEWEL!

Color Coherence Effects in Jet v_2

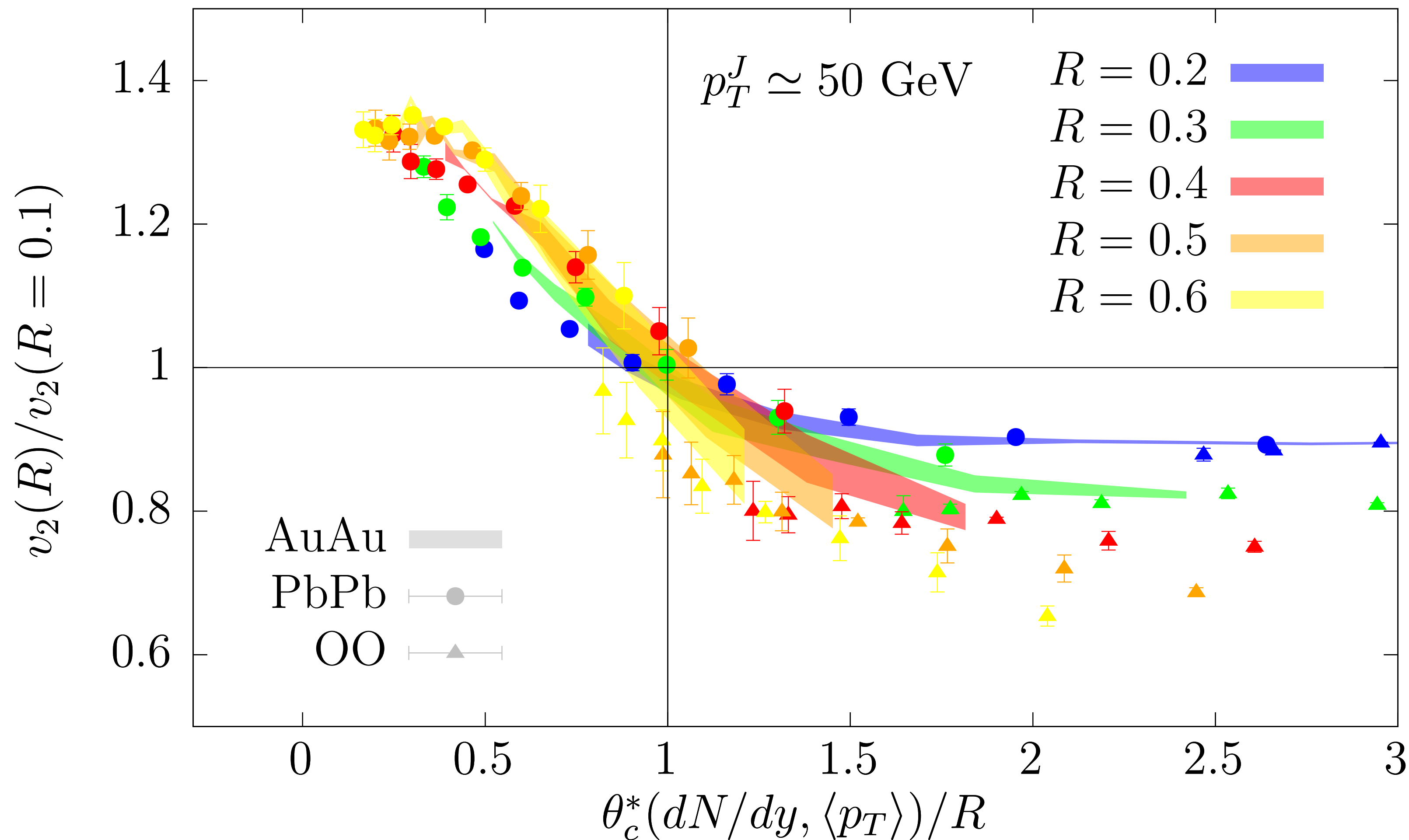


Smaller traversed length

Less quenching per se (only effect in single color charge).

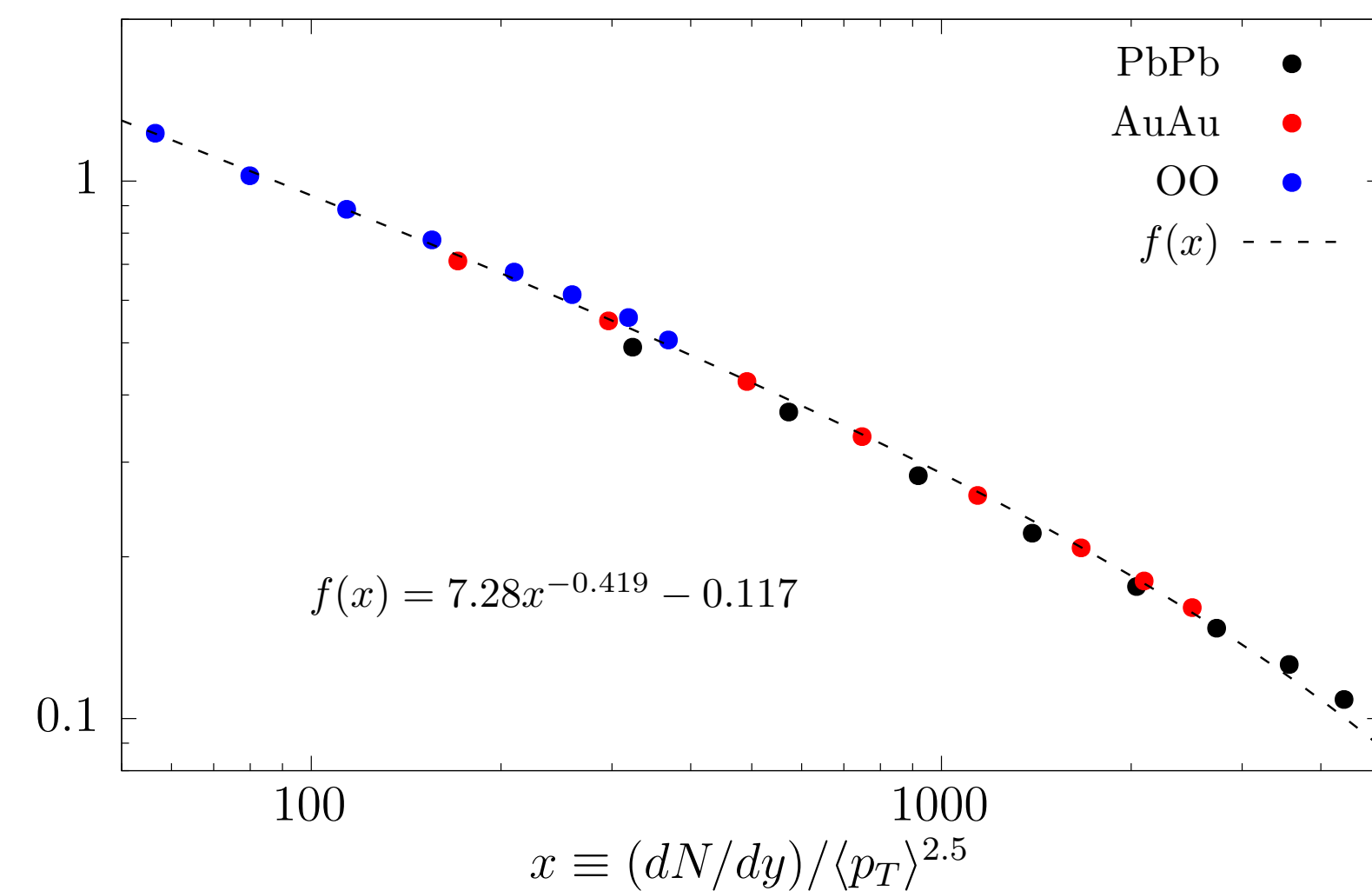
Less quenching due to smaller resolved phase-space.
(Unless $R < \theta_c$, both for L_{in} and L_{out} !).

Color Coherence Effects in Jet v_2



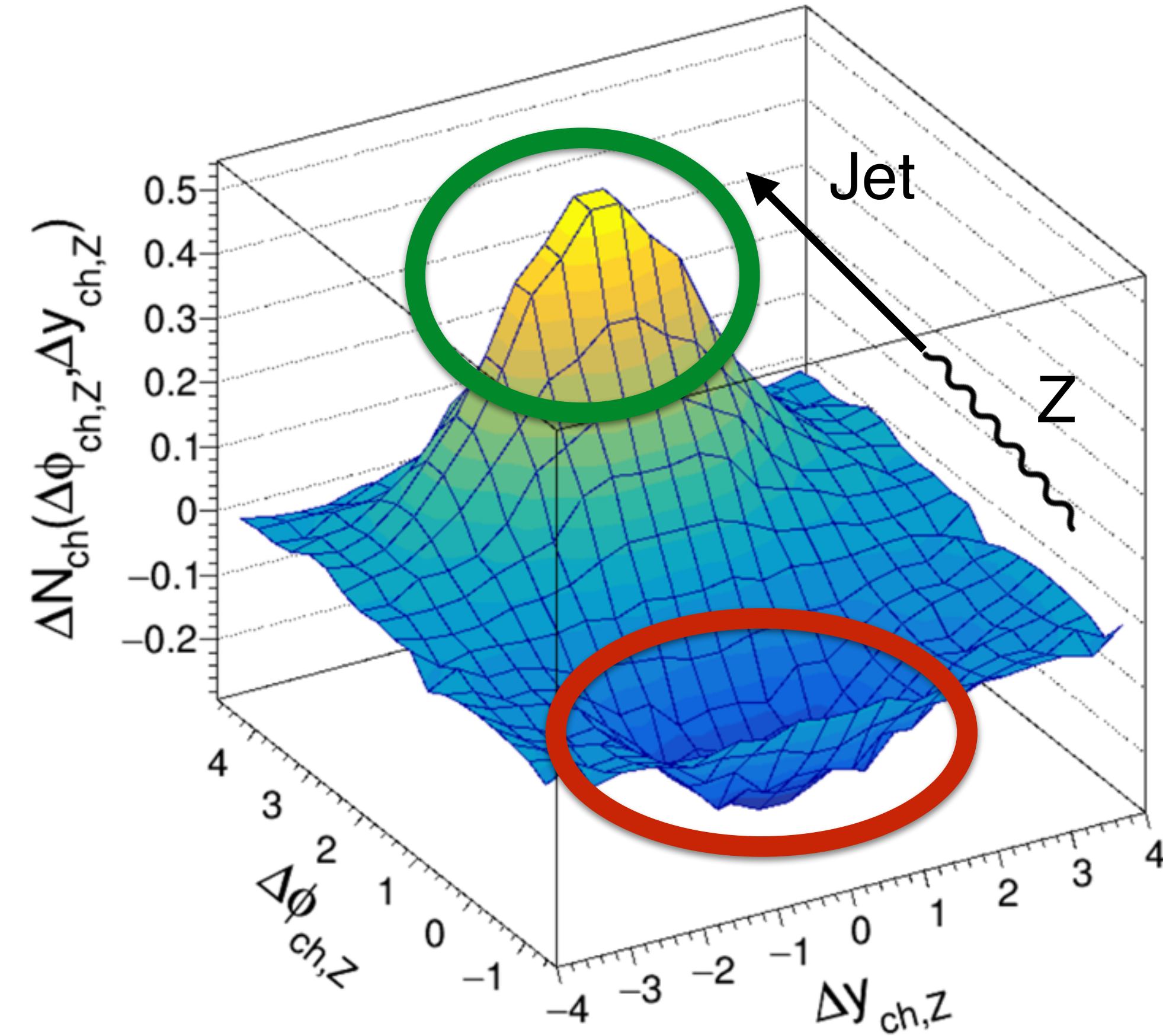
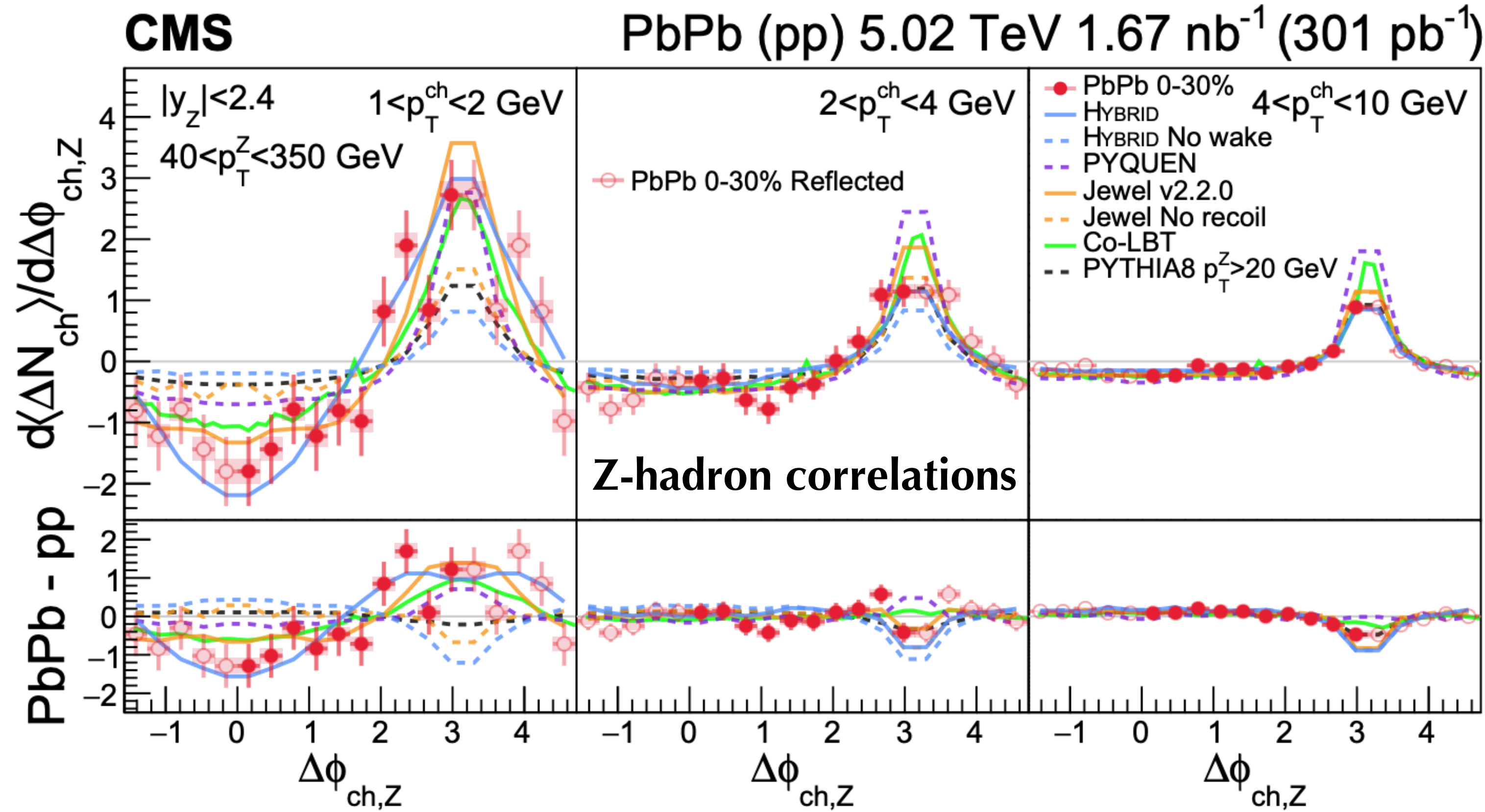
Does jet v_2 follow scaling based on color coherence?

Experimental estimation of $\theta_c^*(dN/dy, \langle p_T \rangle)$



Direct Access to Medium Response

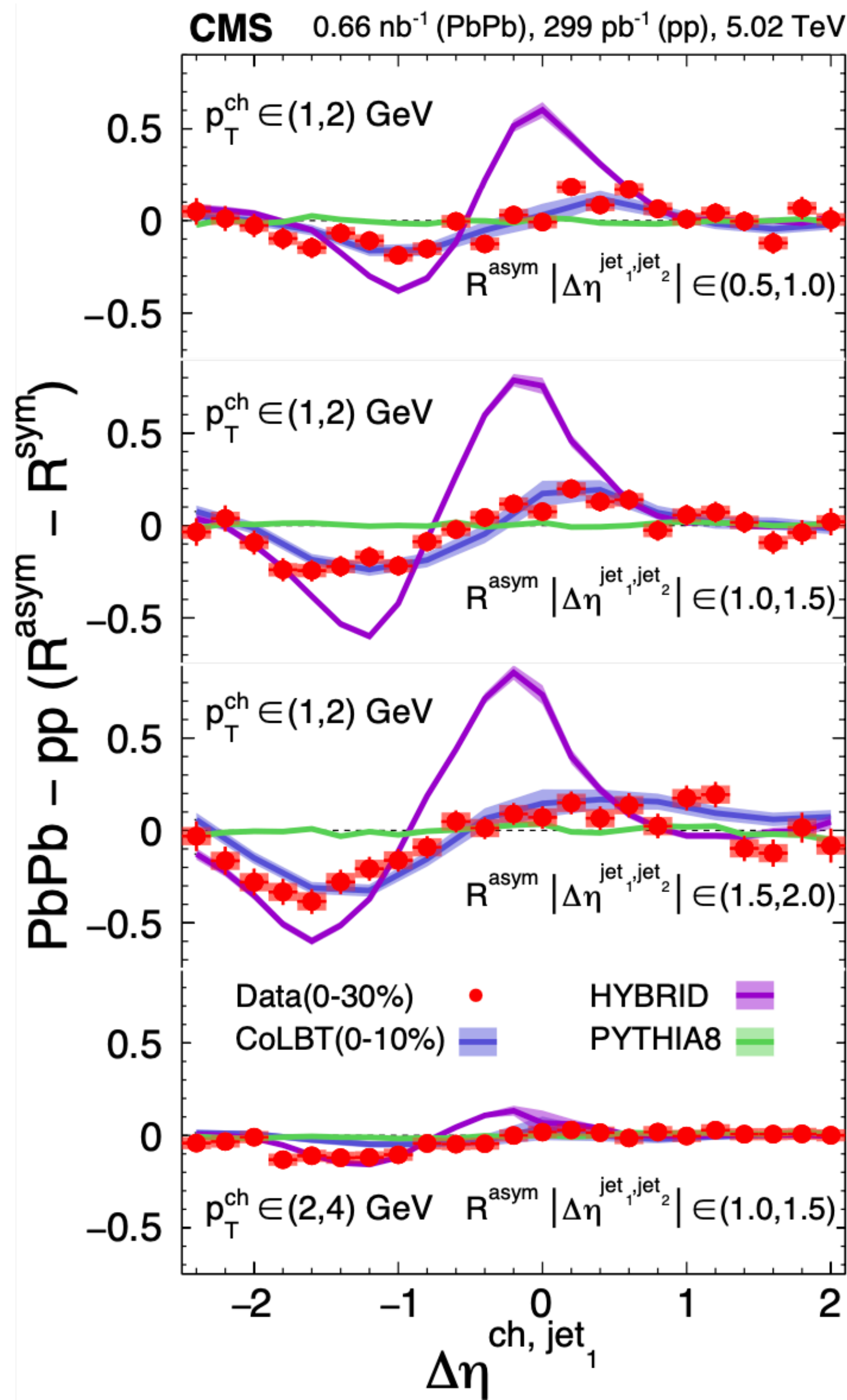
CMS - 2507.09307



First evidence of medium response to jet passage.

See also [Kurkela et al. - 2607.26851](#)

Diffusion Wake in Dijet Events



More differential measurements exhibit pronounced model differences.

HYBRID: Wake under no transverse flow.

CoLBT: Full non-linear wake response.

Computational speedups needed for comprehensive studies:

Machine learning medium response [Wu et al. - 2605.17511](#)

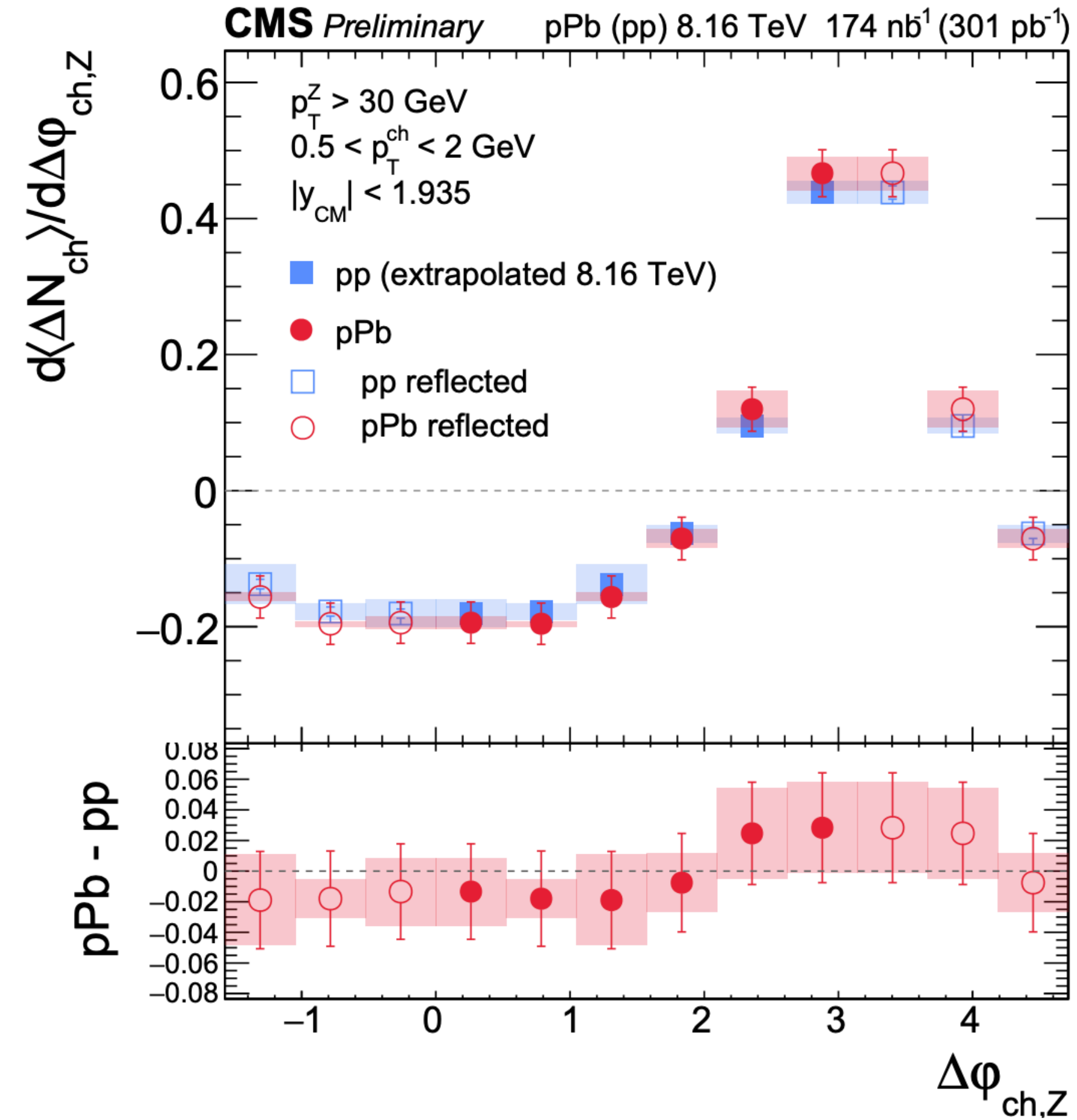
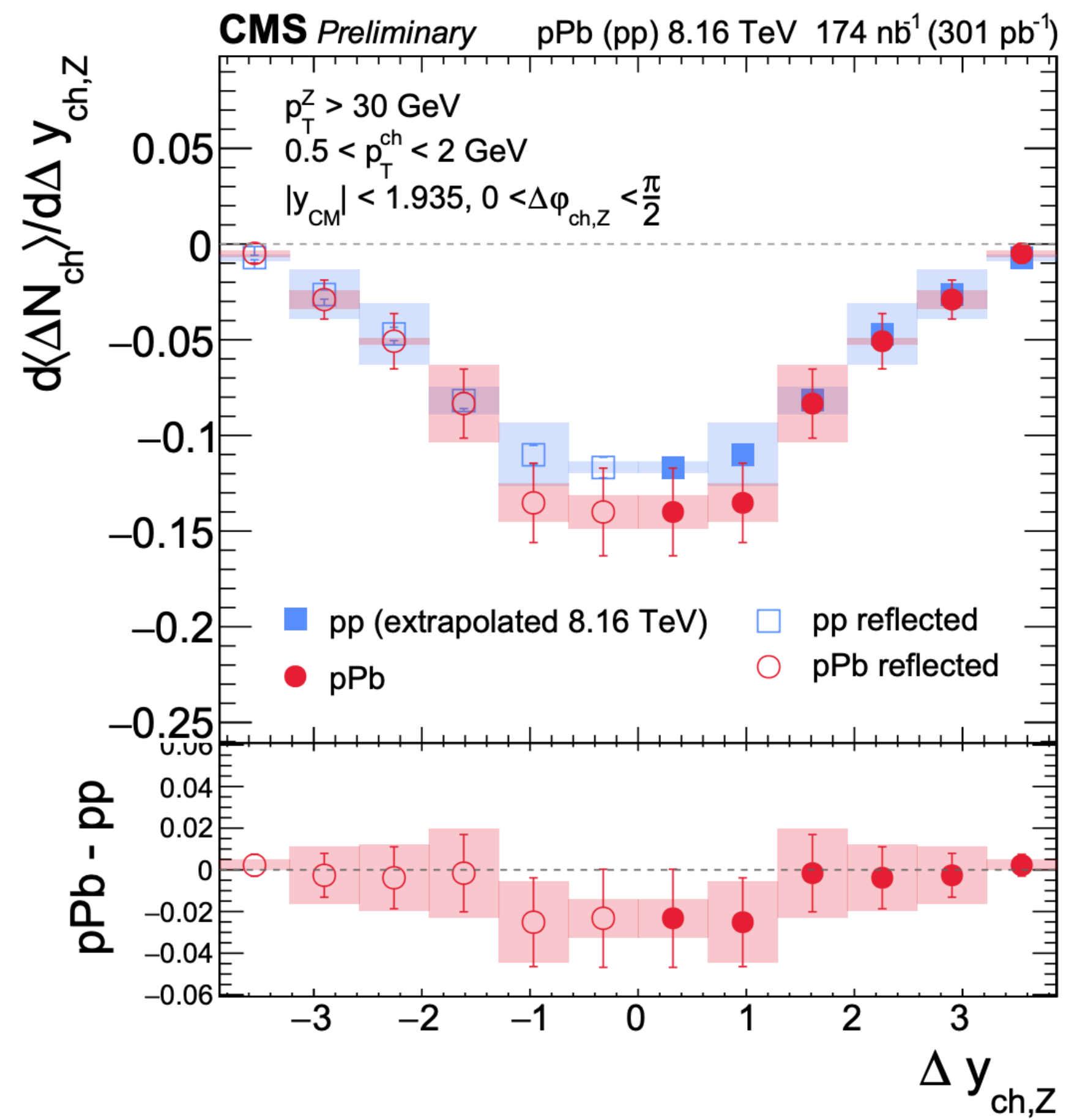
Semi-analytic linearized hydro [Casalderrey-Solana et al. - 2609.10679](#)

Parton showers for EKT [Soudi & Takacs - 2607.26143](#)

What about smaller systems?

Z-Hadron Correlations in pPb

CMS - PAS HIN-26-007



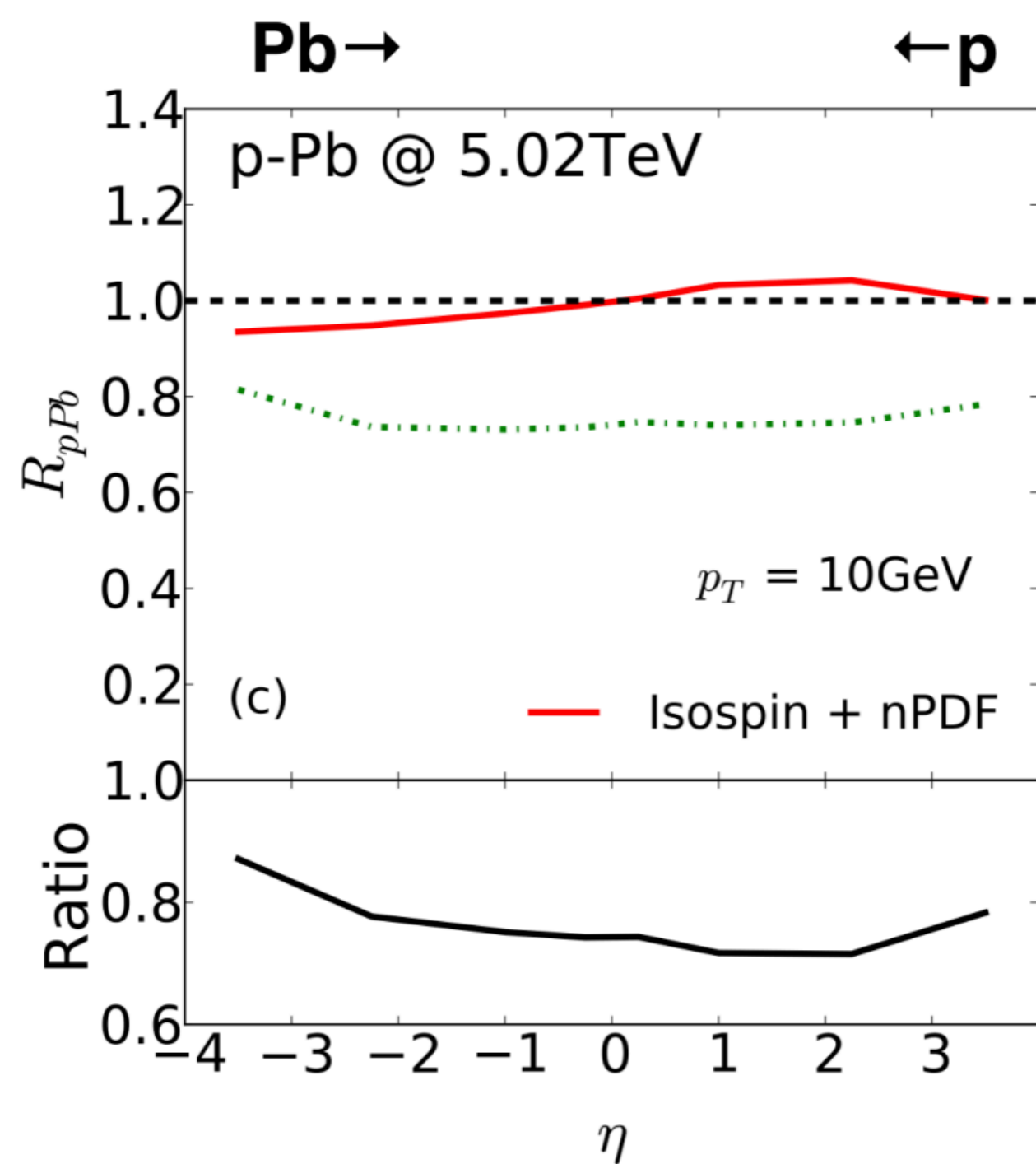
No evidence of energy loss nor medium response — consistent with previous measurements.

Applying Energy Loss Models in pA

pA events are well described by hydrodynamic explosion.

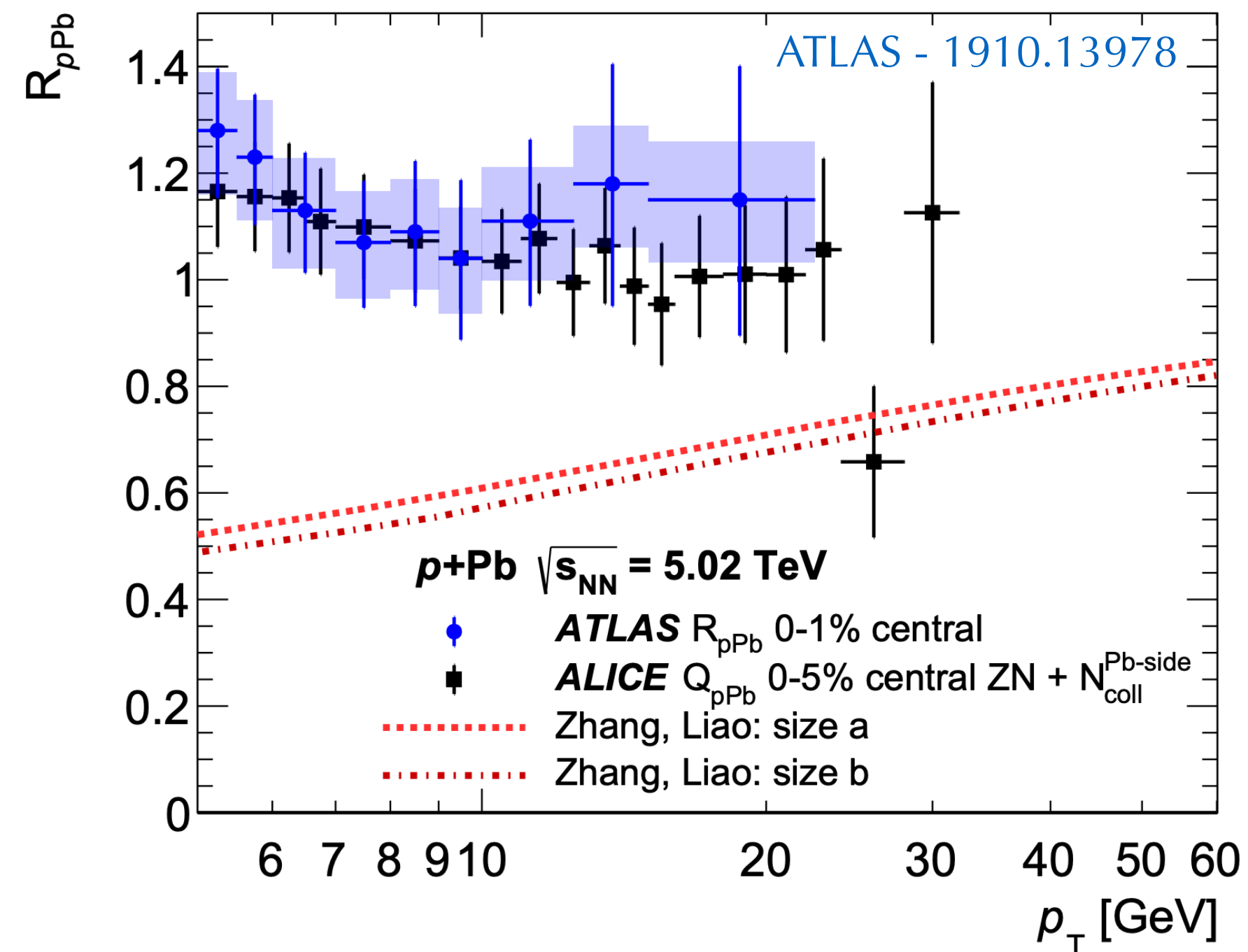
Can we apply jet quenching as if there was a QGP droplet?

Suppression



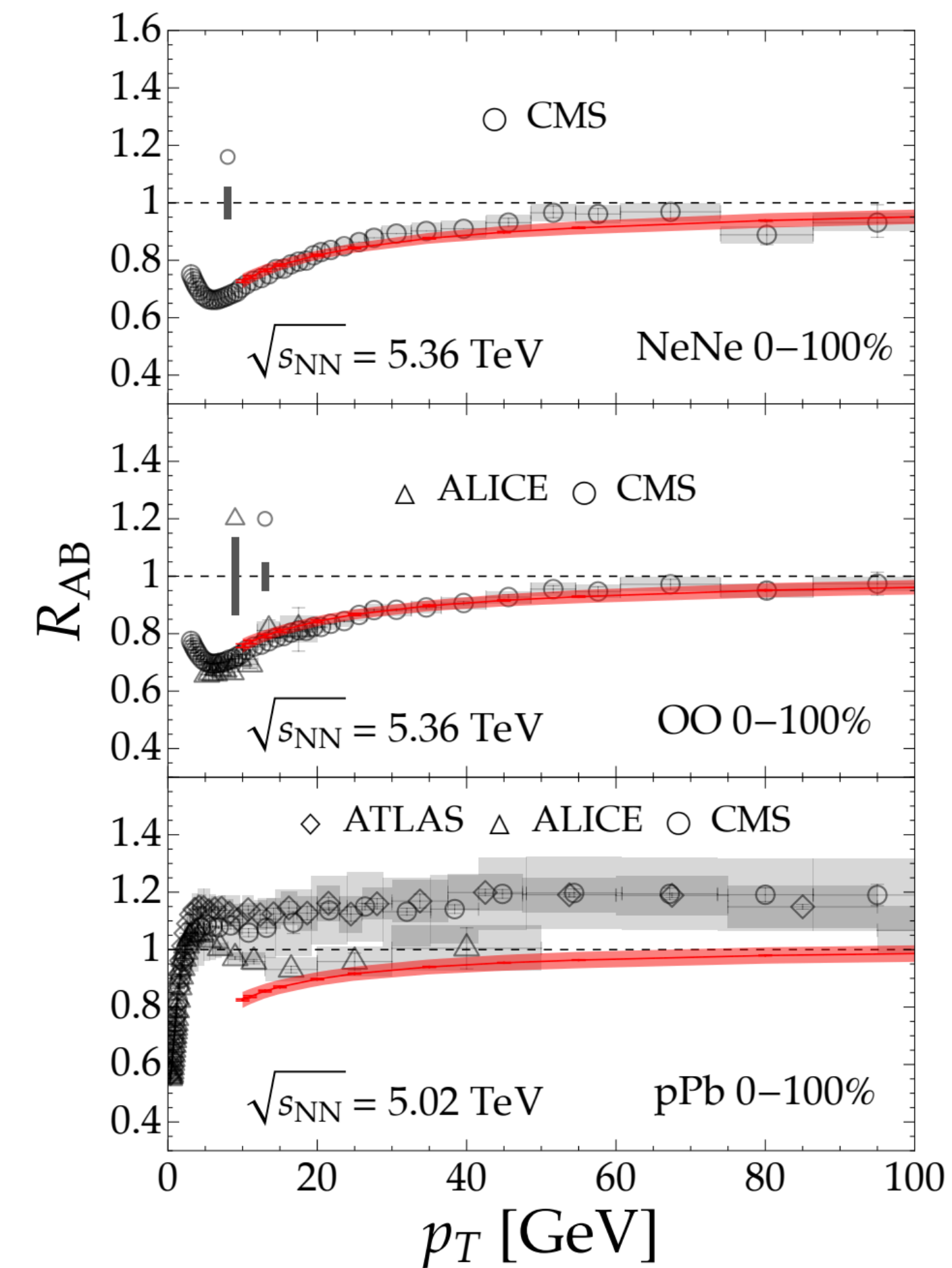
MARTINI

Park et al.- 1612.06754



Path-length model

Zhang & Liao - 1311.5463



Cape Town model

Bert et al. - 2603.21861

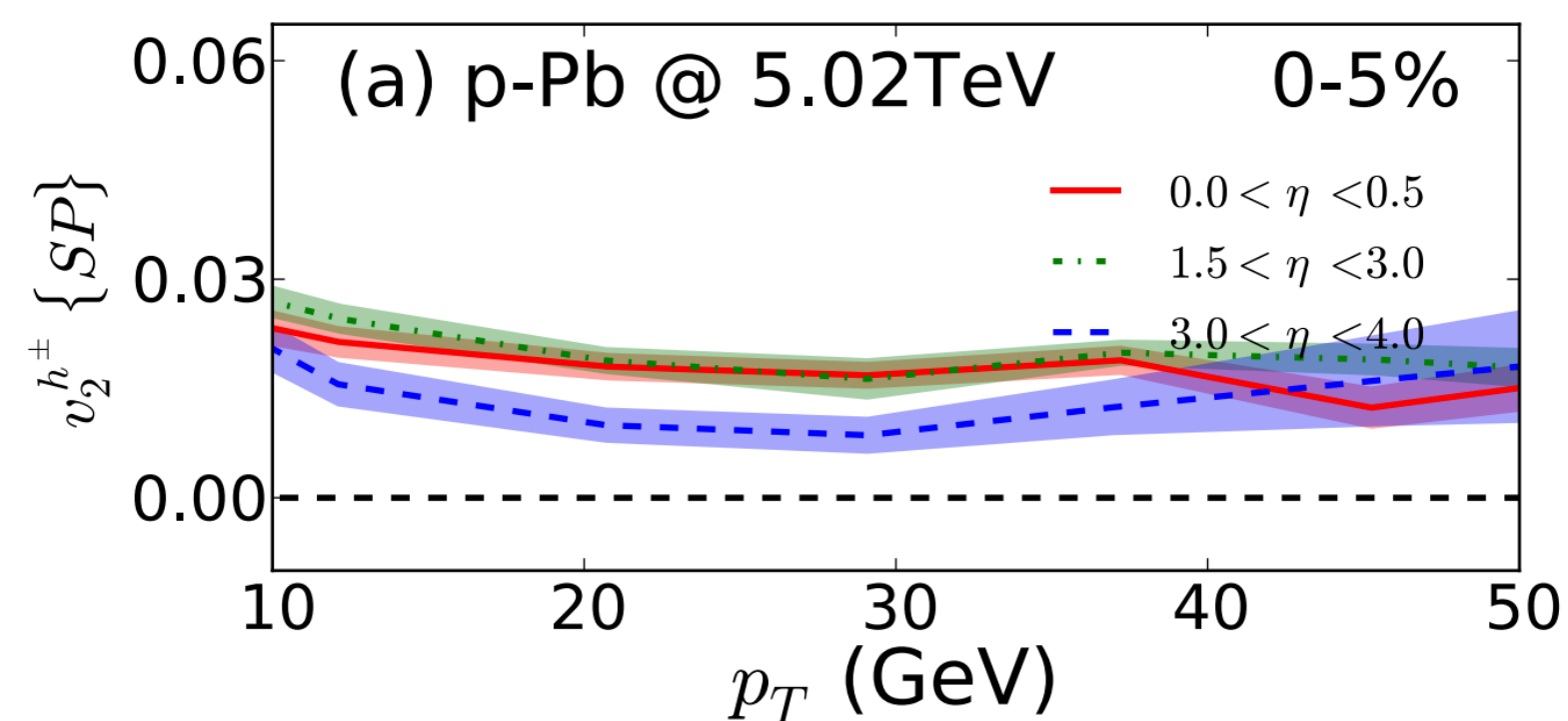
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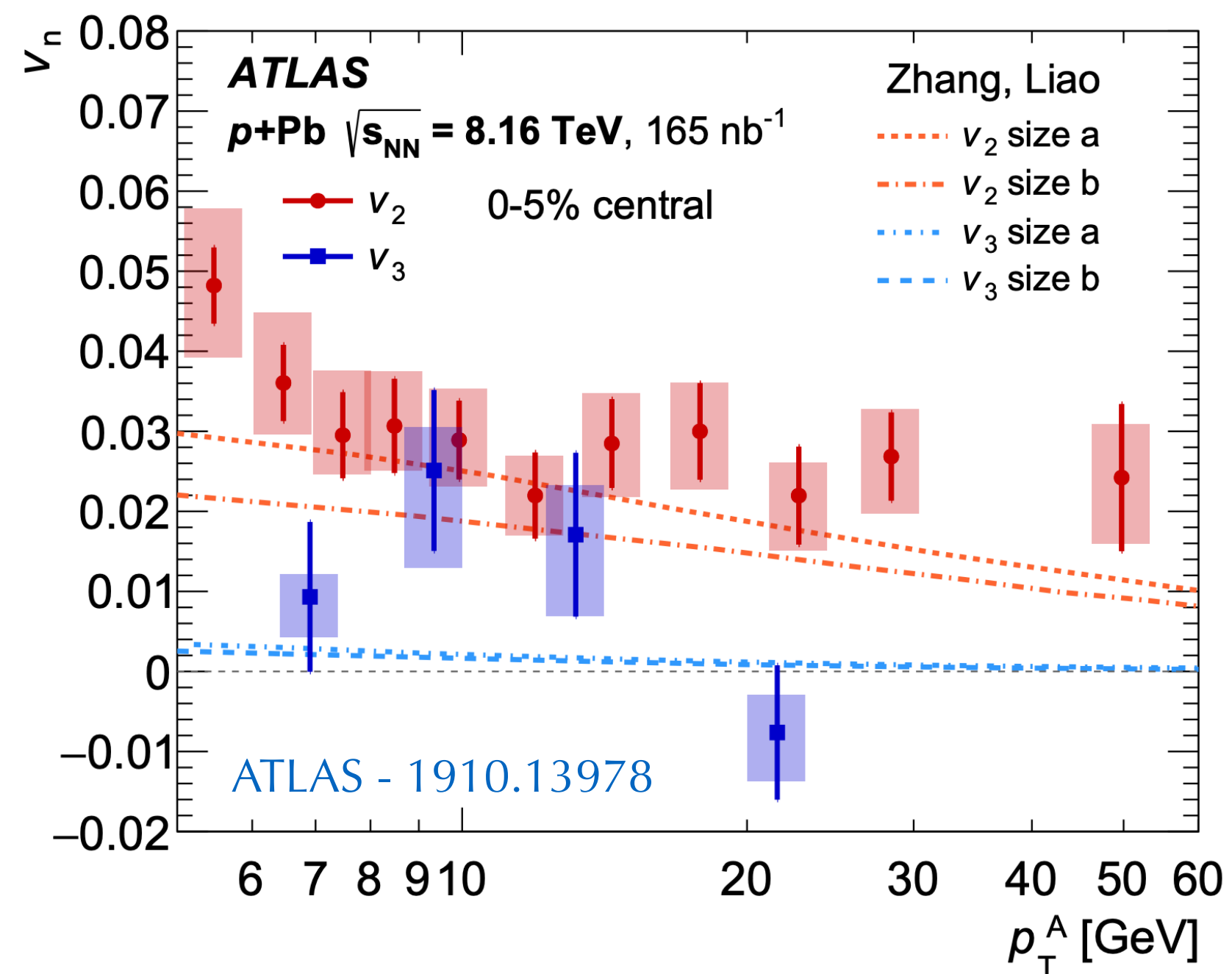
Energy loss typically insufficient to produce high- p_T v_2 .

Azimuthal Anisotropies



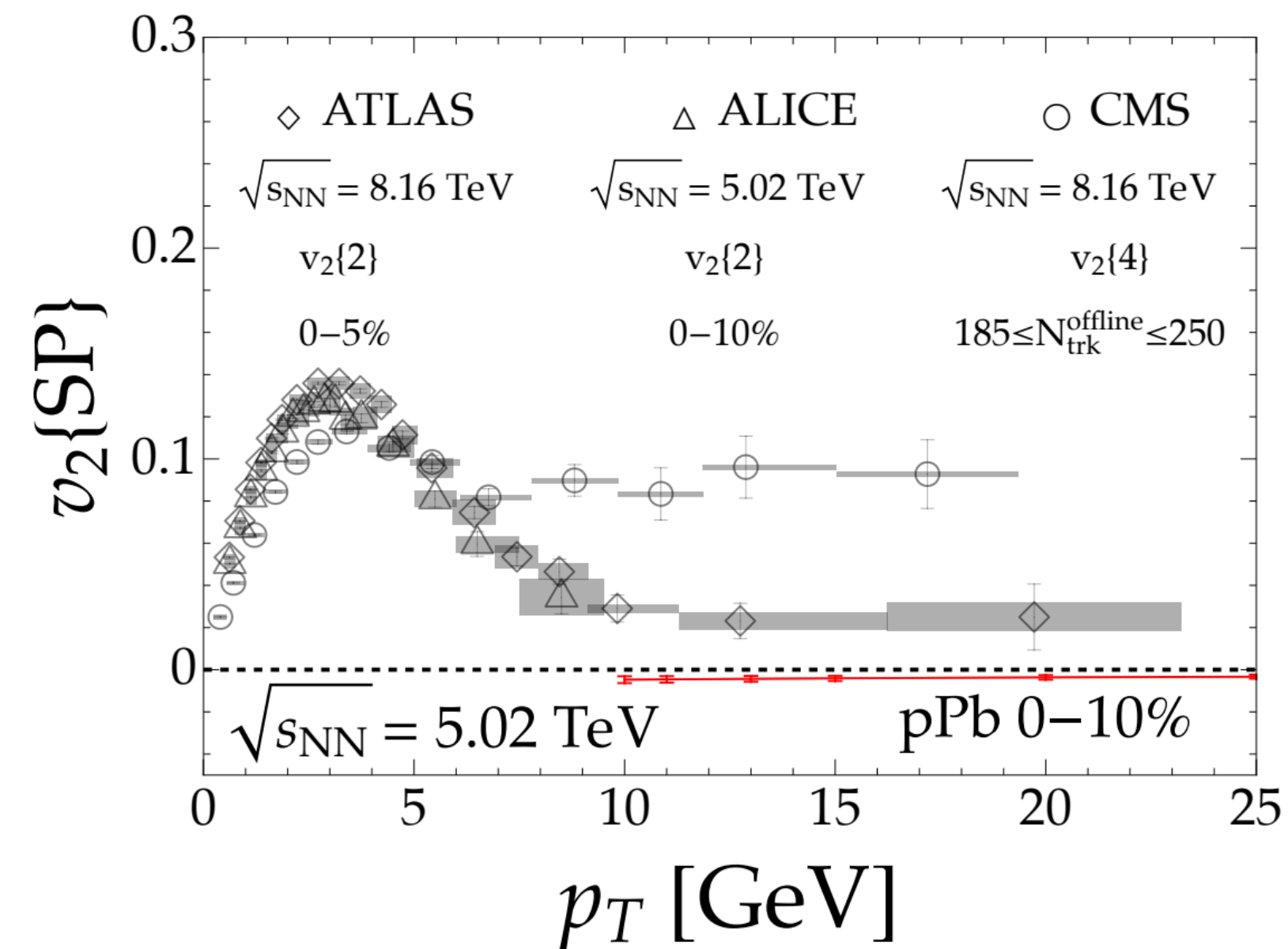
MARTINI

Park et al. - 1612.06754



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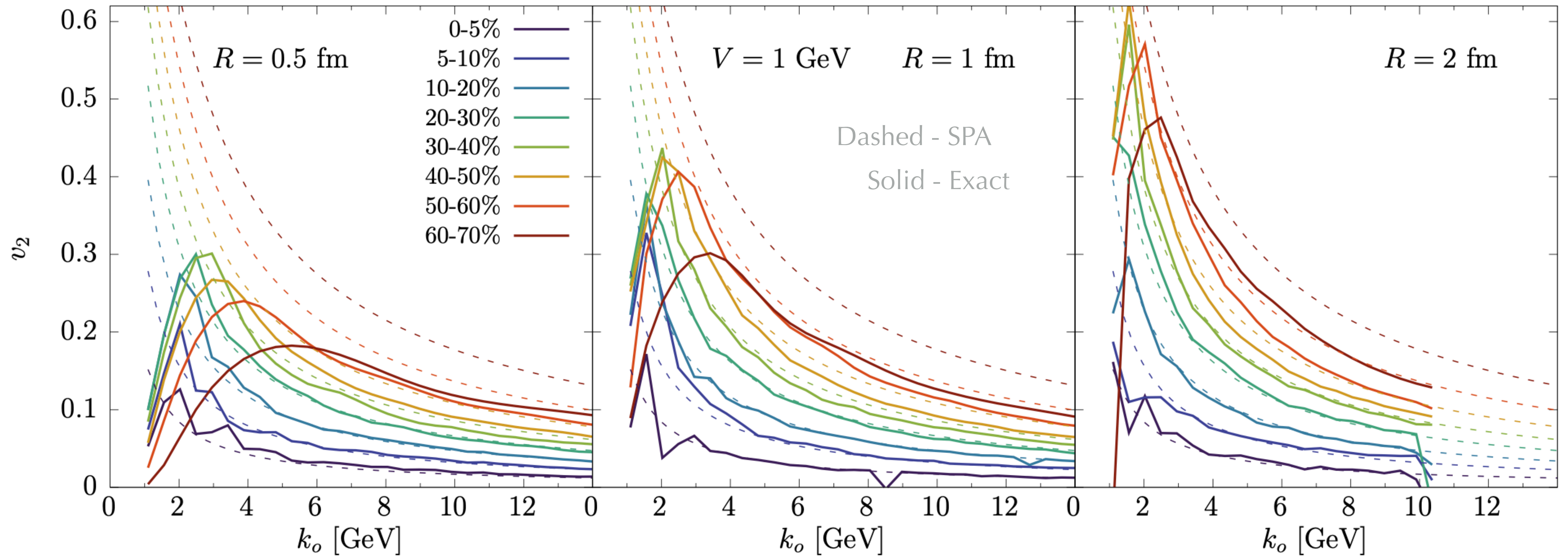


Cape Town model

Bert et al. - 2603.21861

Azimuthal Anisotropies without Energy Loss

Consider non-local propagation effects: quantum phase shift + medium geometry.

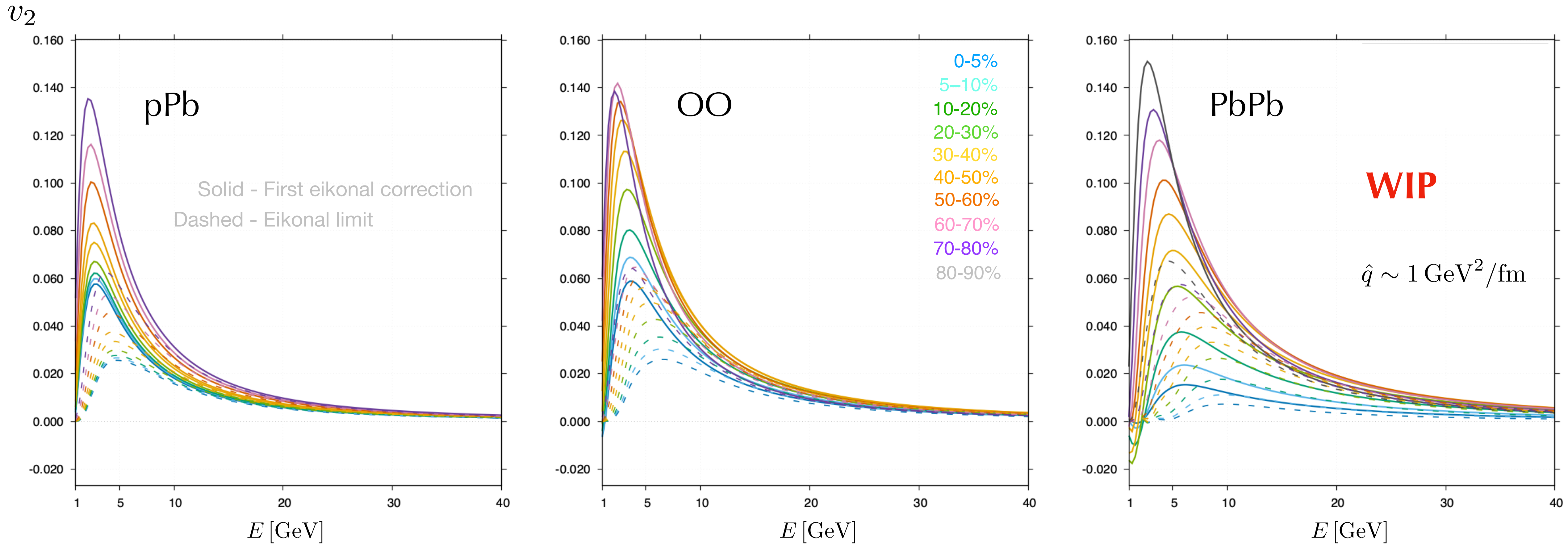


Toy model in QM with constant electrostatic potential.

No energy loss, just modified dispersion relation.

Azimuthal Anisotropies without Energy Loss

Consider non-local propagation effects: Wilson line + medium geometry.



See also:

[Soudi & Majumder - 2308.14702](#)

[Barrera Cabodevila et al. - 2607.07796](#)

Stochastic screened potential in QFT.

[Carrió, Mayo López, DP - WIP](#)

No energy loss, just broadening.

Summary

Energy loss modeling in smaller systems calls for ingredients (sometimes) overlooked in larger systems:

- Elastic energy loss (easy, but need to include recoils for substructure)
- Energy loss in pre-equilibrium phase (hard, but a lot of progress)
- Color coherence, or, can the medium resolve the jet? (ideally within EFT)

QGP response to jet passage *can now be measured*. What can we learn?

When do large system tools become inappropriate? Revisit calculations!

Summary

Energy loss modeling in smaller systems calls for ingredients (sometimes) overlooked in larger systems:

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Danke schön!