

Evolution of parton energy loss across collision systems: Insights from the DREENA framework

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Light-Ion Collisions 2026

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(In preparation)

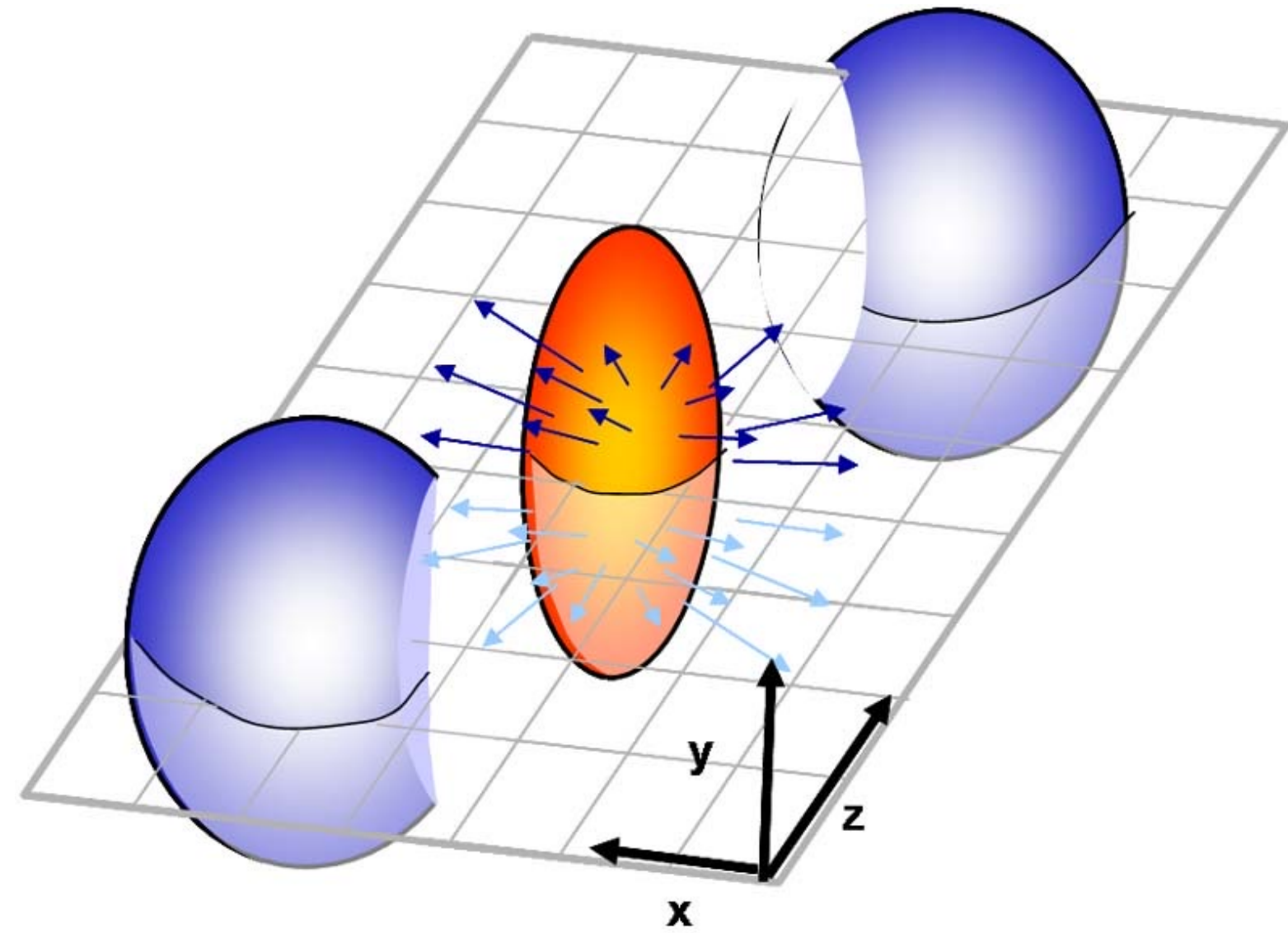
22 September 2026



Contents

- QGP in light ion collisions?
- High- $p_{\perp}$ energy loss: DREENA
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- Summary

QGP in heavy-ion collisions



- Heavy nuclei are collided at ultrarelativistic energies
- LHC, RHIC, FAIR, J-PARC
- **QGP**: Extremely hot and dense matter constituted of deconfined quarks and gluons
- Created at extreme temperature and/or extreme baryon density

- **QGP Signatures**: Collective flow, Strangeness enhancement, Dilepton, photon production
- ☑ **Jet quenching**: High- $p_{\perp}$ partons propagate through the medium. Jet loses energy by interacting with the medium partons.

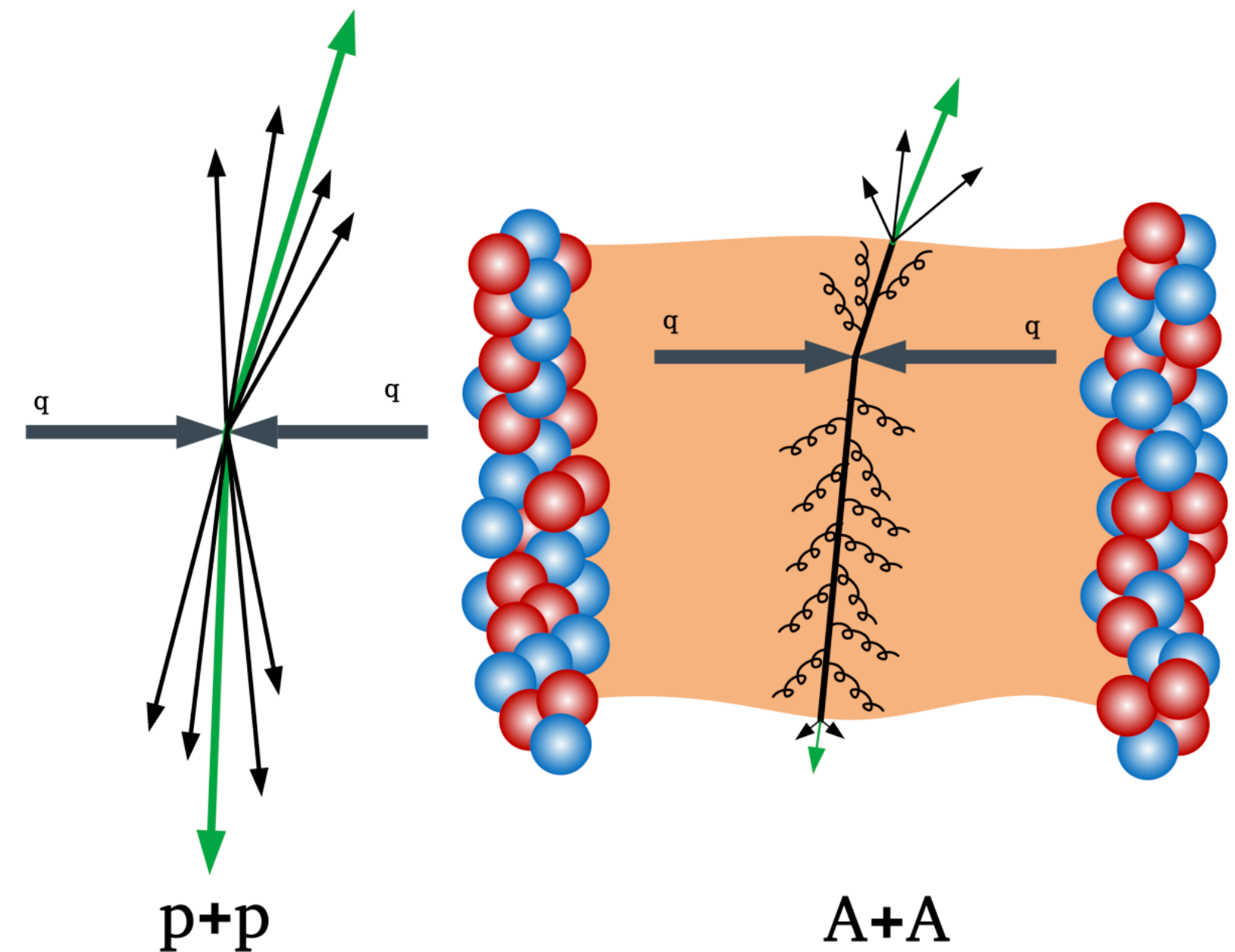
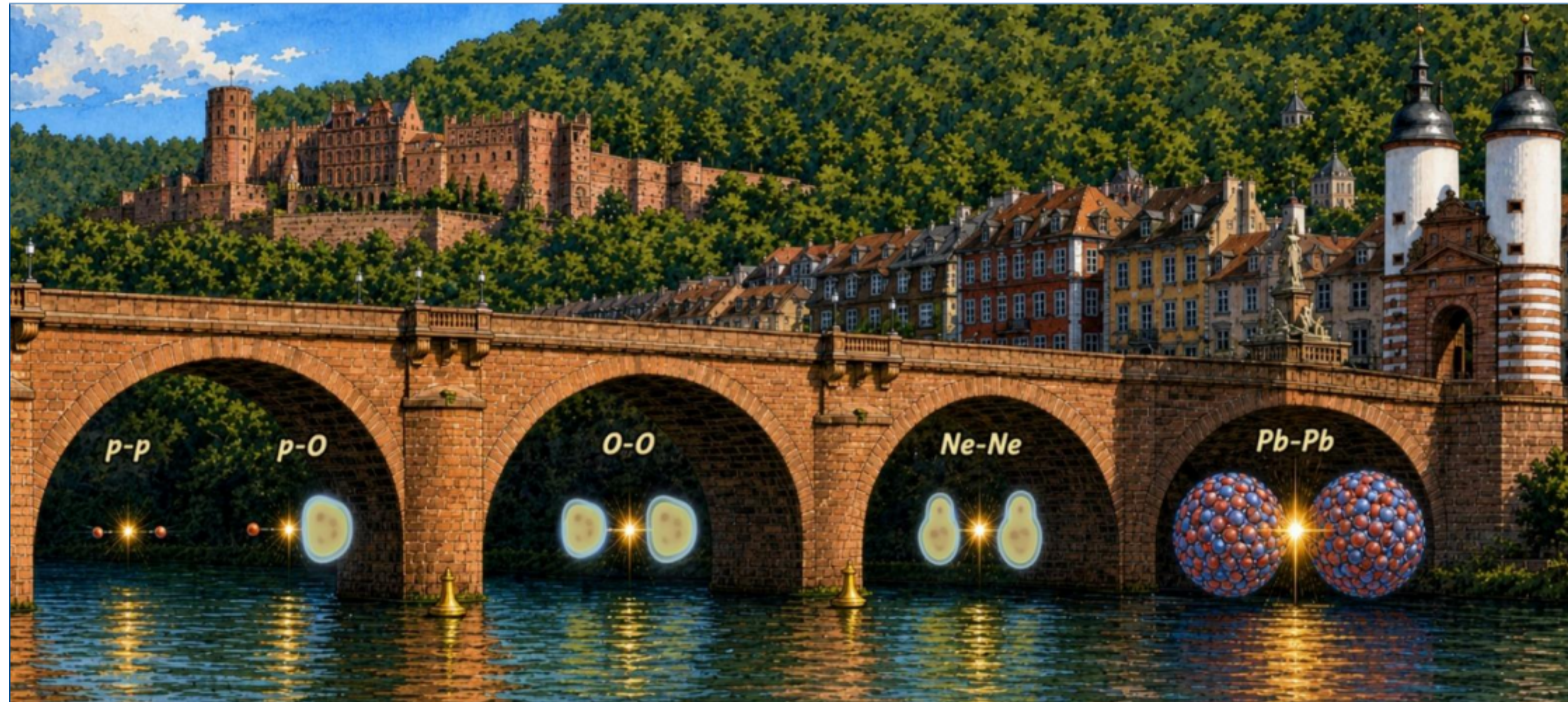


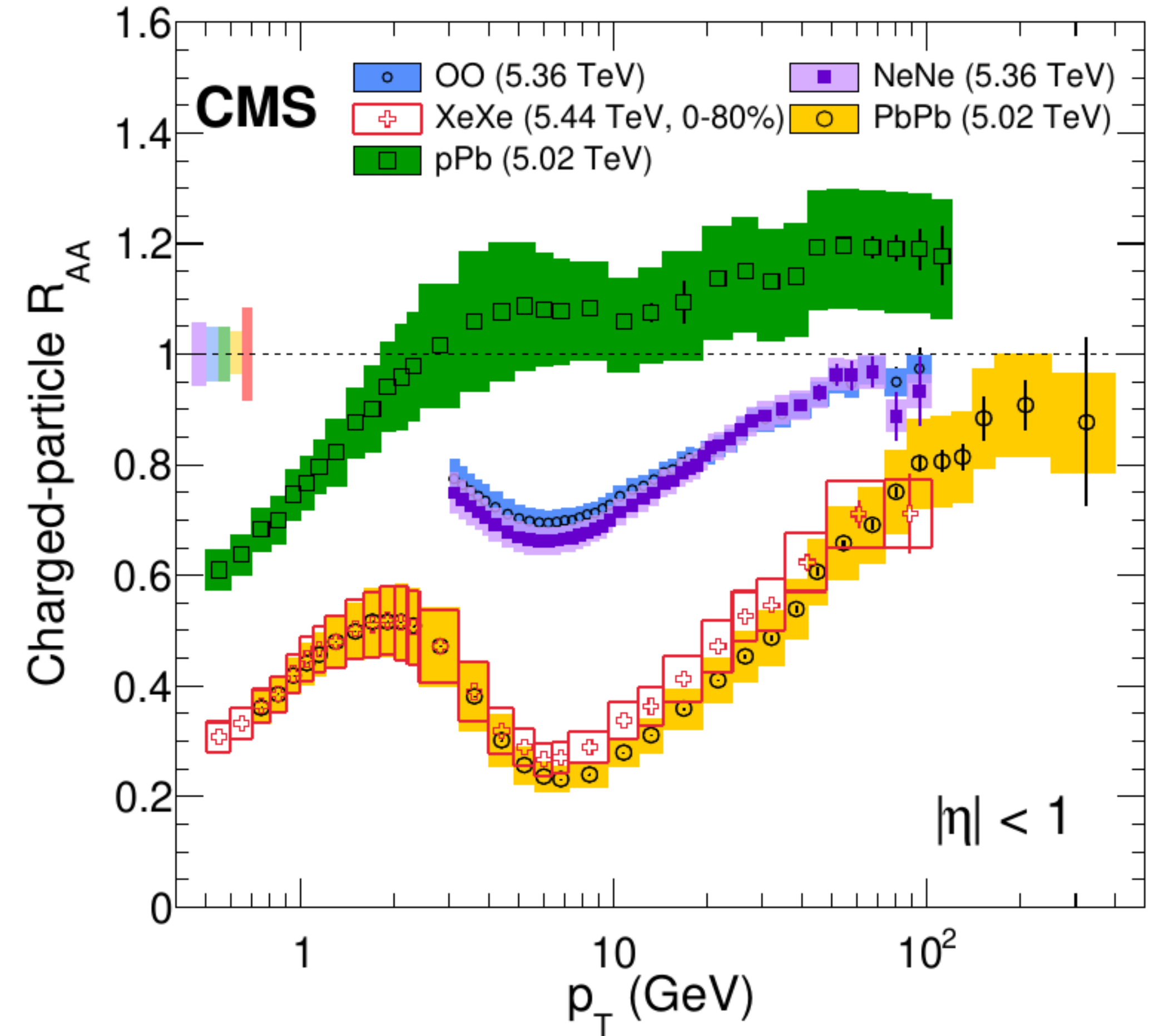
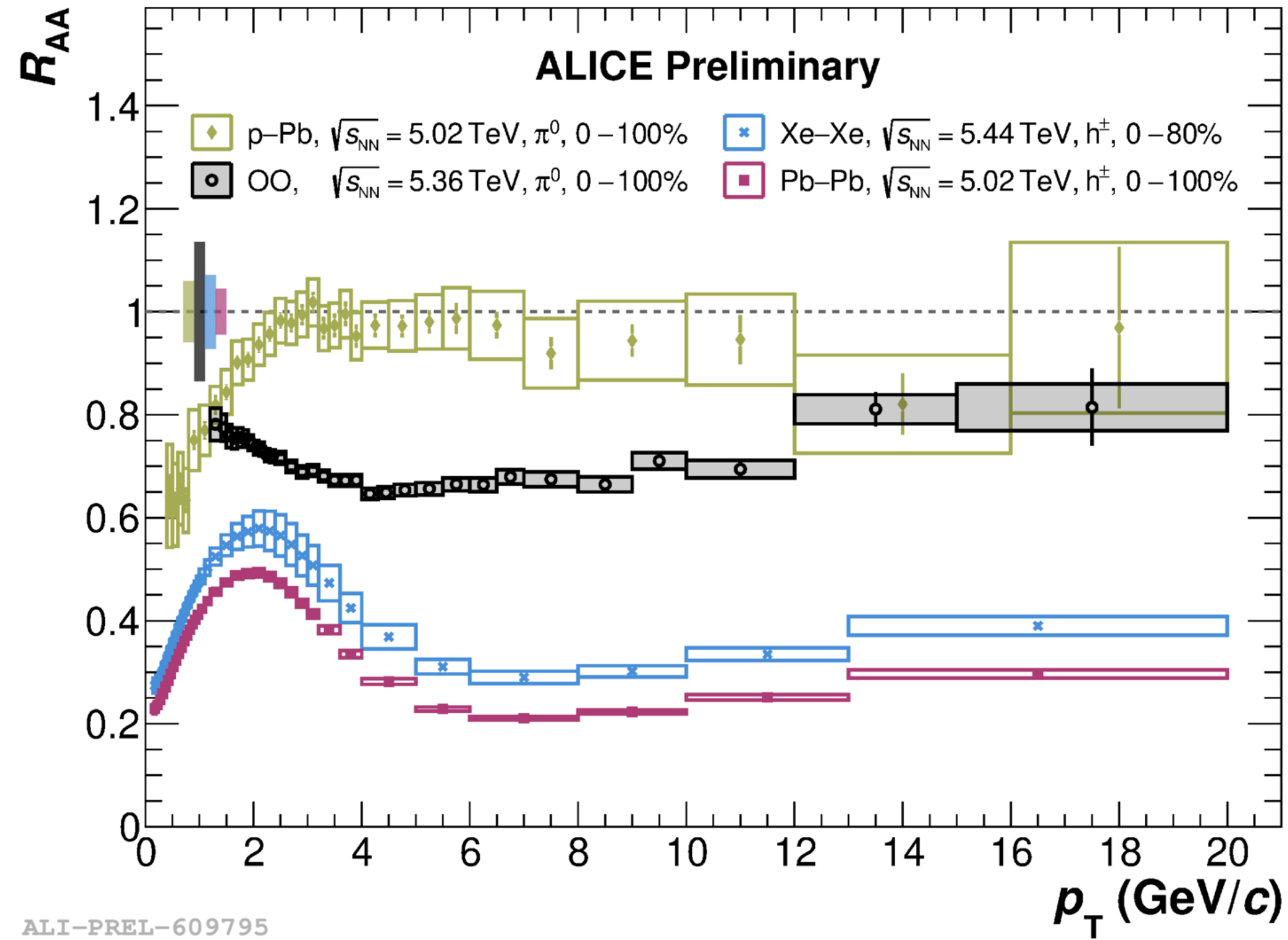
Figure: ATLAS

QGP signatures across collision systems



- **p+p, p+Pb:** Collectivity, enhanced production of strange hadrons; No jet quenching
- Raises questions regarding the minimum size required to observe jet quenching effect
- **O+O, Ne+Ne:** Shows collectivity, signatures of parton energy loss

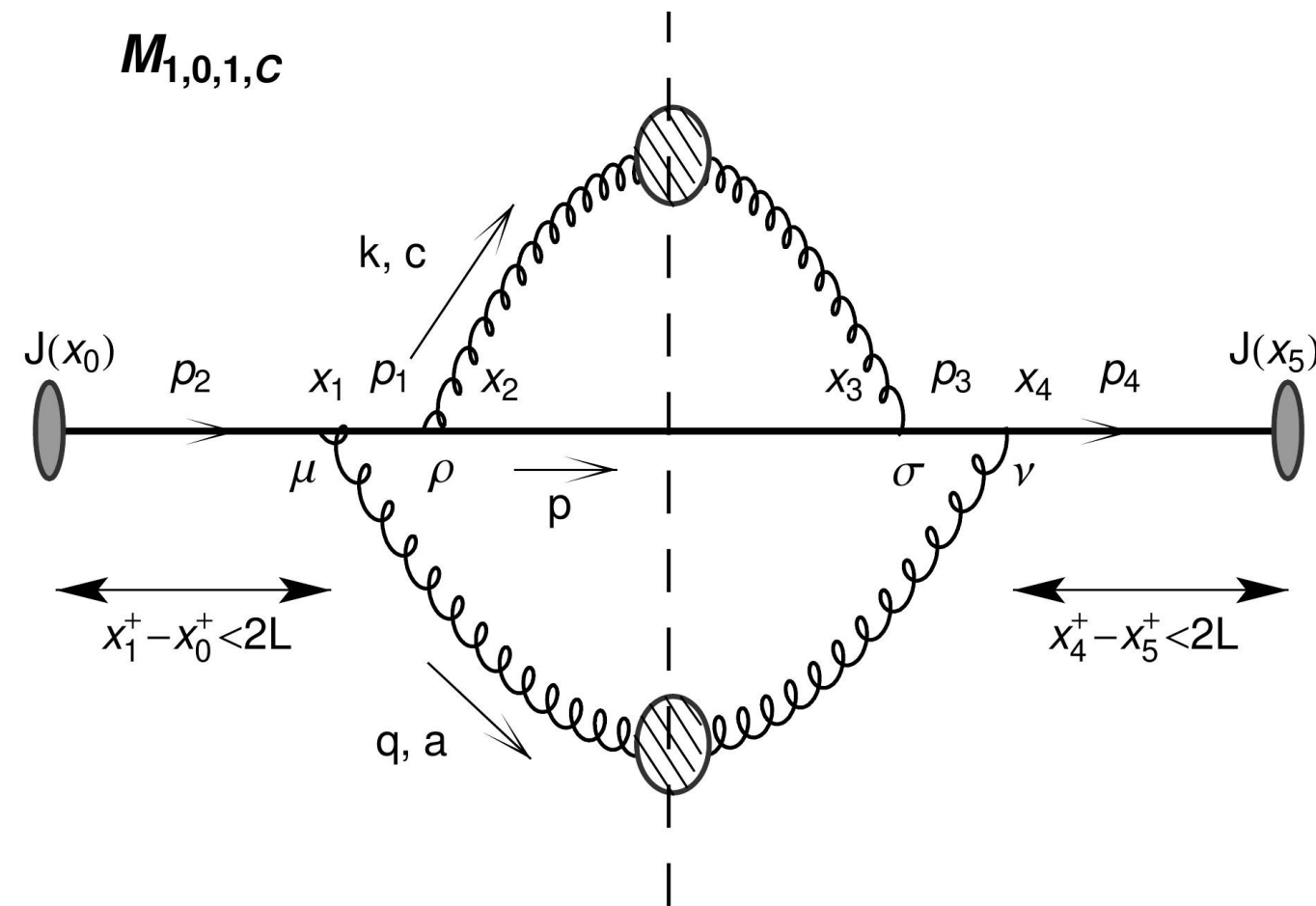
Parton energy loss across collision systems



Phys. Rev. Lett. 136 (2026) 162301

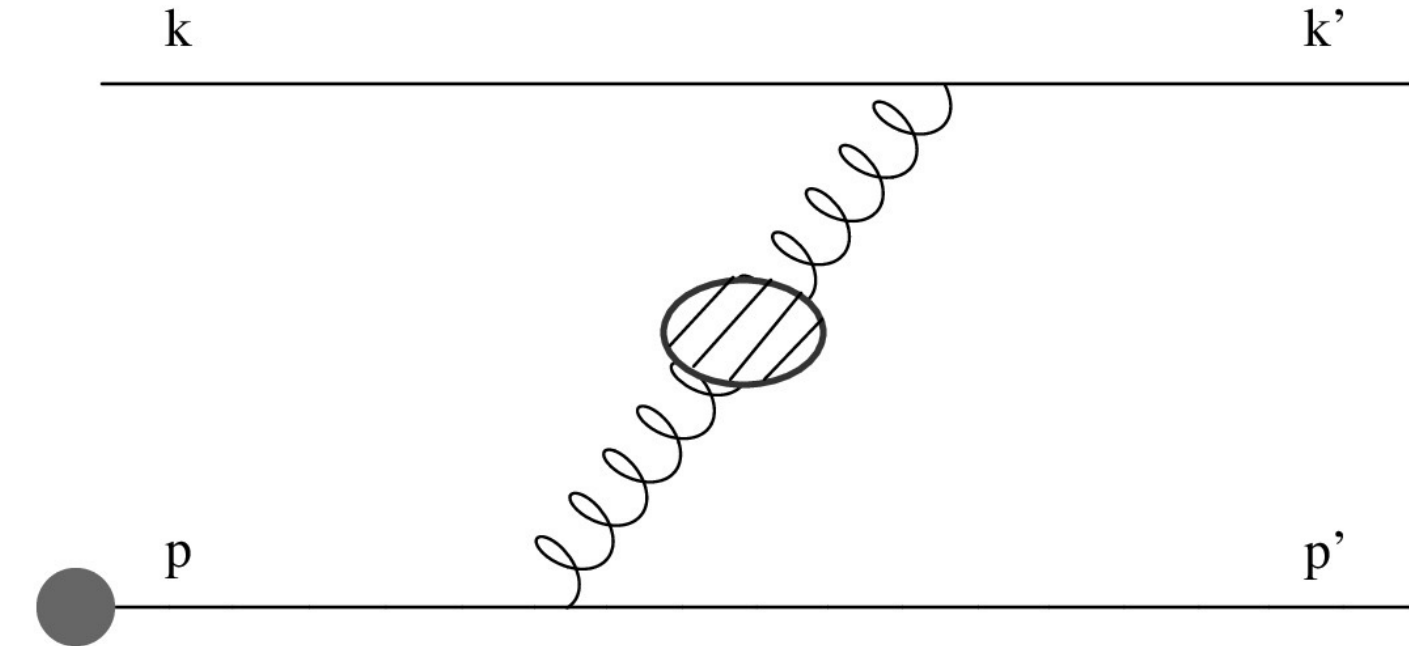
High- $p_{\perp}$ energy loss formalism: DREENA

Radiative energy loss



Collisional interaction with medium + emission of a gluon.

Collisional energy loss



Collisional interaction with medium

- Based on finite temperature field theory and generalized HTL approach

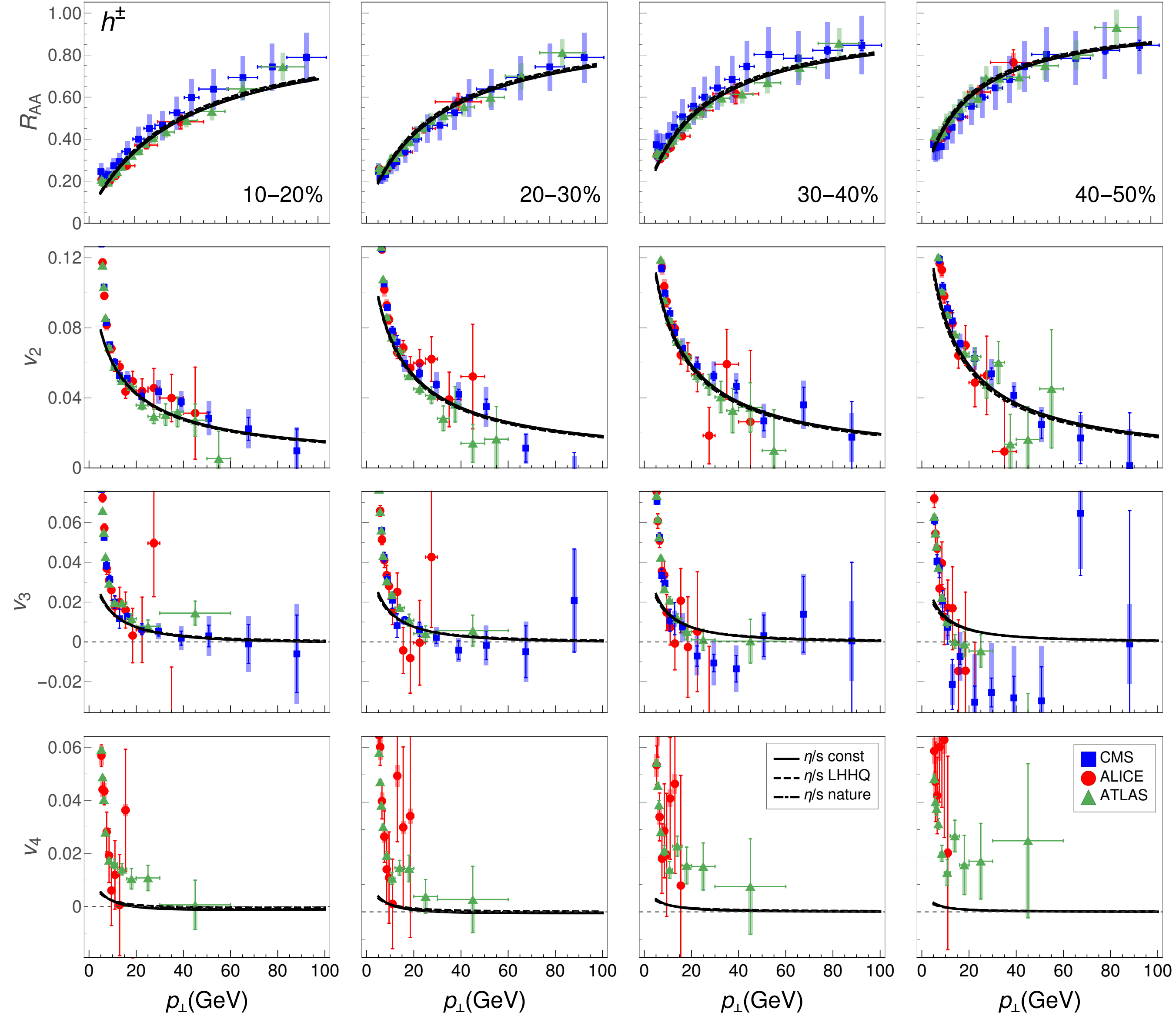
PRC 74, 064907, (2006) ; PRC 80, 064909 (2009), PRL 101, 022302

- Finite size dynamical QCD medium, Generalized to the case of magnetic mass and running coupling, No fitting parameter in the theory

Generalized DREENA-A (Adaptive)

- ◆ Numerical implementation of the radiative and collisional energy loss formalism:
DREENA (**D**ynamical **R**adiative and **E**lastic **E**Nergy loss **A**pproach)
- ◆ Depends on medium temperature. Optimized to incorporate any arbitrary event-by-event fluctuating temperature profile. PRC 106 (2022) 4, 044909
- DREENA-C J. Phys. G **46**, no. 8, 085101 (2019)
- DREENA-B Phys. Lett. B **791**, 236 (2019)
- DREENA-A Front. in Phys. 10 (2022) 957019
- ◆ DREENA-A is available on <http://github.com/DusanZigic/DREENA-A>

Predictions for Pb+Pb 5.02 TeV: Constrains on η/s

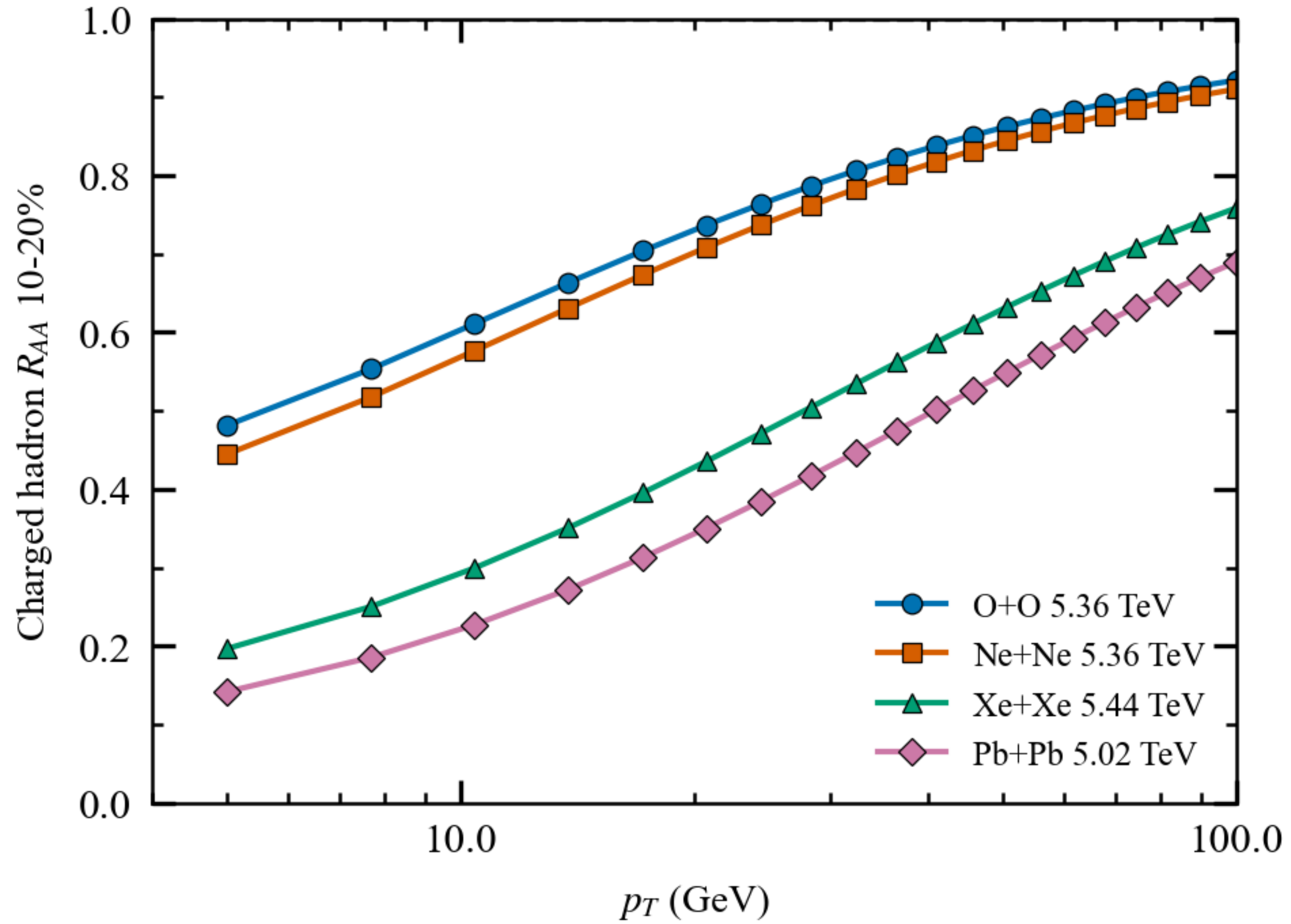


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(2023) 4, 044907

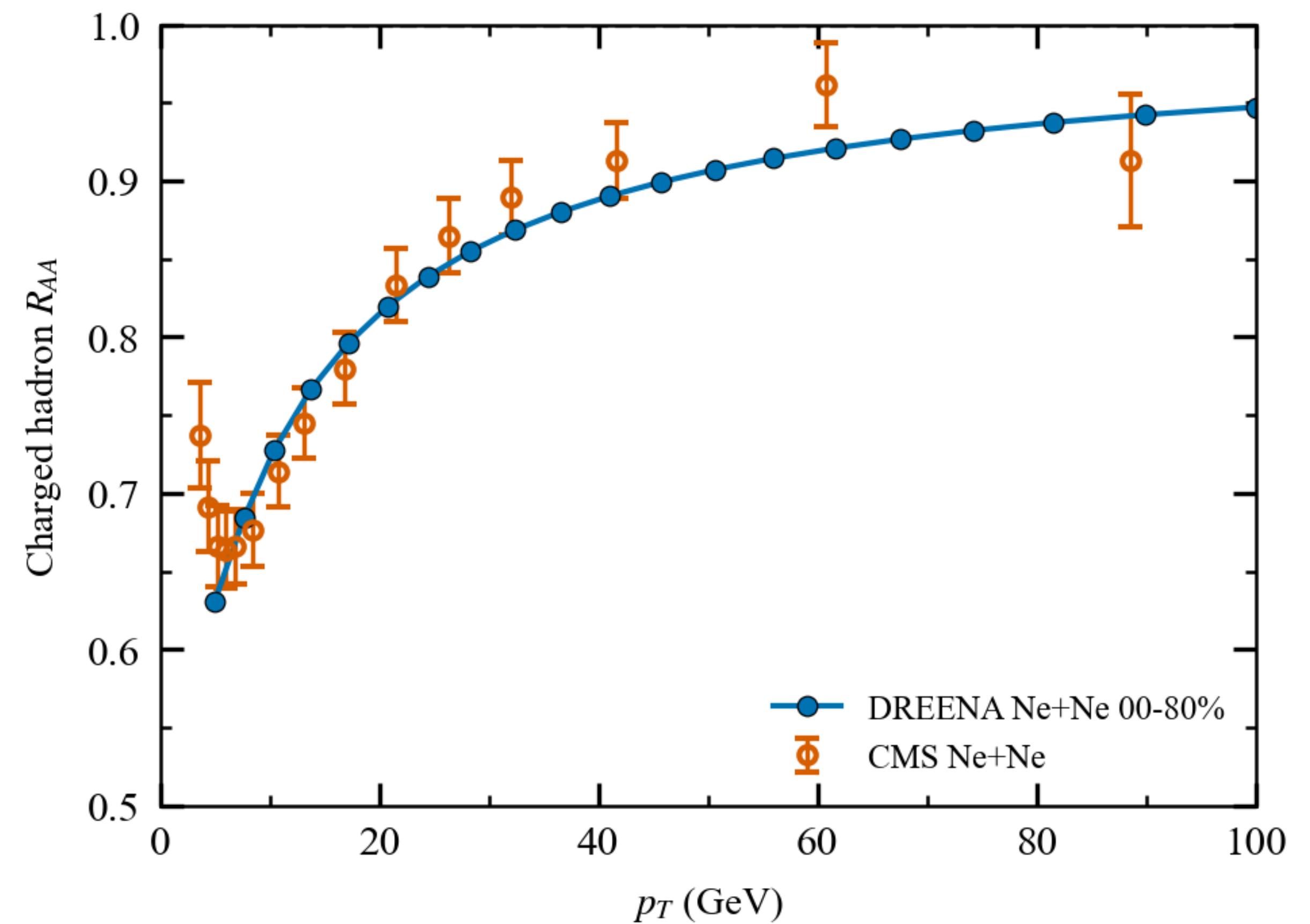
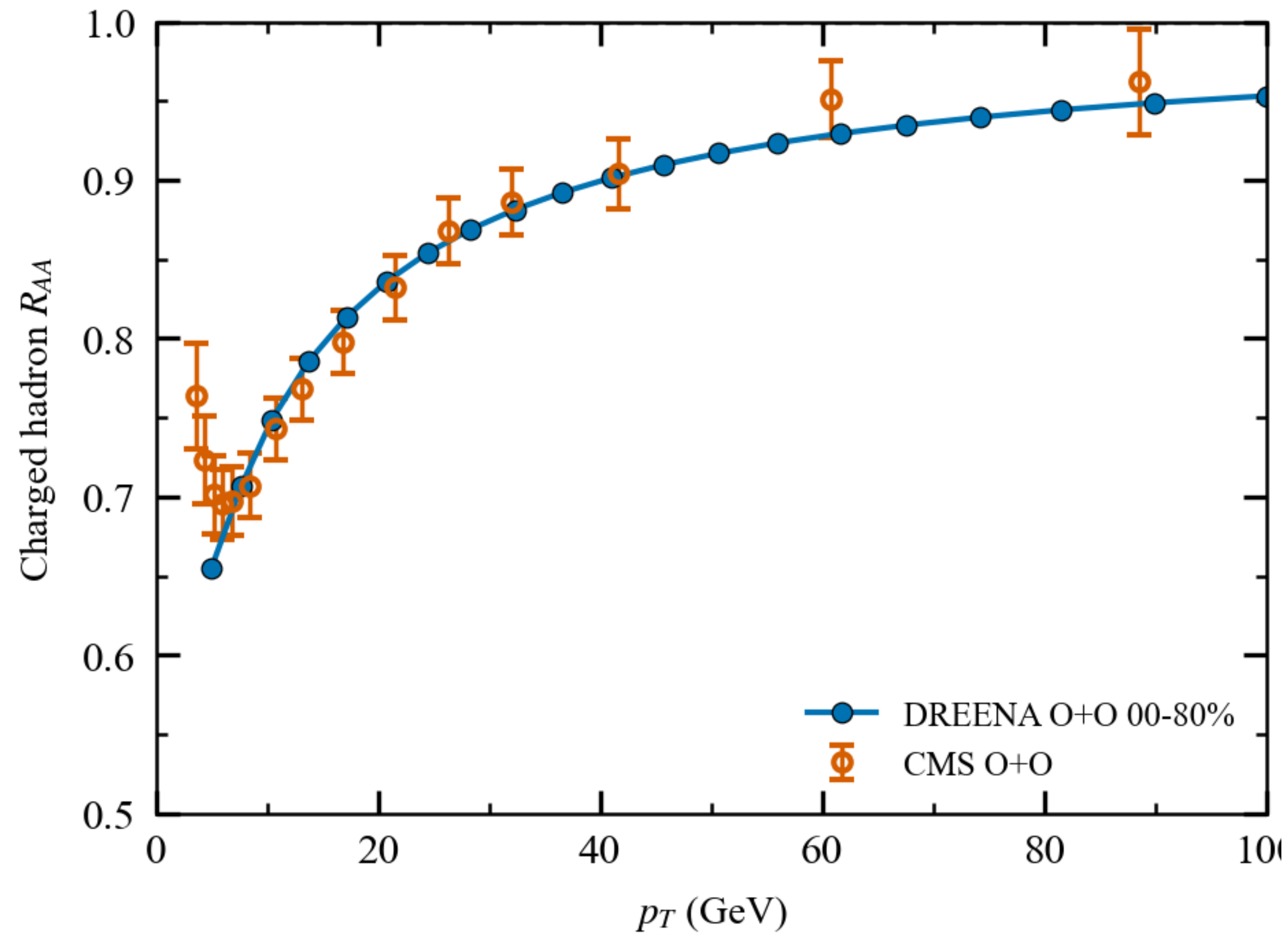
Modeling the bulk evolution: OO, NeNe, XeXe

- T_{RENT}o (Woods-Saxon initial profiles: No clustering) + VISH2+1 + UrQMD
- T_{RENT}o and bulk evolution parameters from Bayesian analysis. *Nature Phys.* 15, no. 11, 1113-1117 (2019)
- Pre-equilibrium free streaming not favored by high- $p_{\perp}$ data. S. Stojku, J. Auvinen, M. Djordjevic, P. Huovinen and M. Djordjevic, *Phys. Rev. C* **105** (2022) 2, L021901
- Tuned T_{RENT}o normalization parameter n , fluctuation parameter k and η/s to get agreement with low- $p_{\perp}$ data. $\eta/s=0.08$ for O+O and Ne+Ne; $\eta/s=0.12$ for Xe+Xe.
- Temperature profiles are used to compute parton energy loss and high- $p_{\perp}$ observables.
- $$R_{AA}(p_f, H_Q) = \frac{E_f d^3 \sigma_q(H_Q)}{dp_f^3} / \frac{E_f d^3 \sigma_u(H_Q)}{dp_f^3}$$

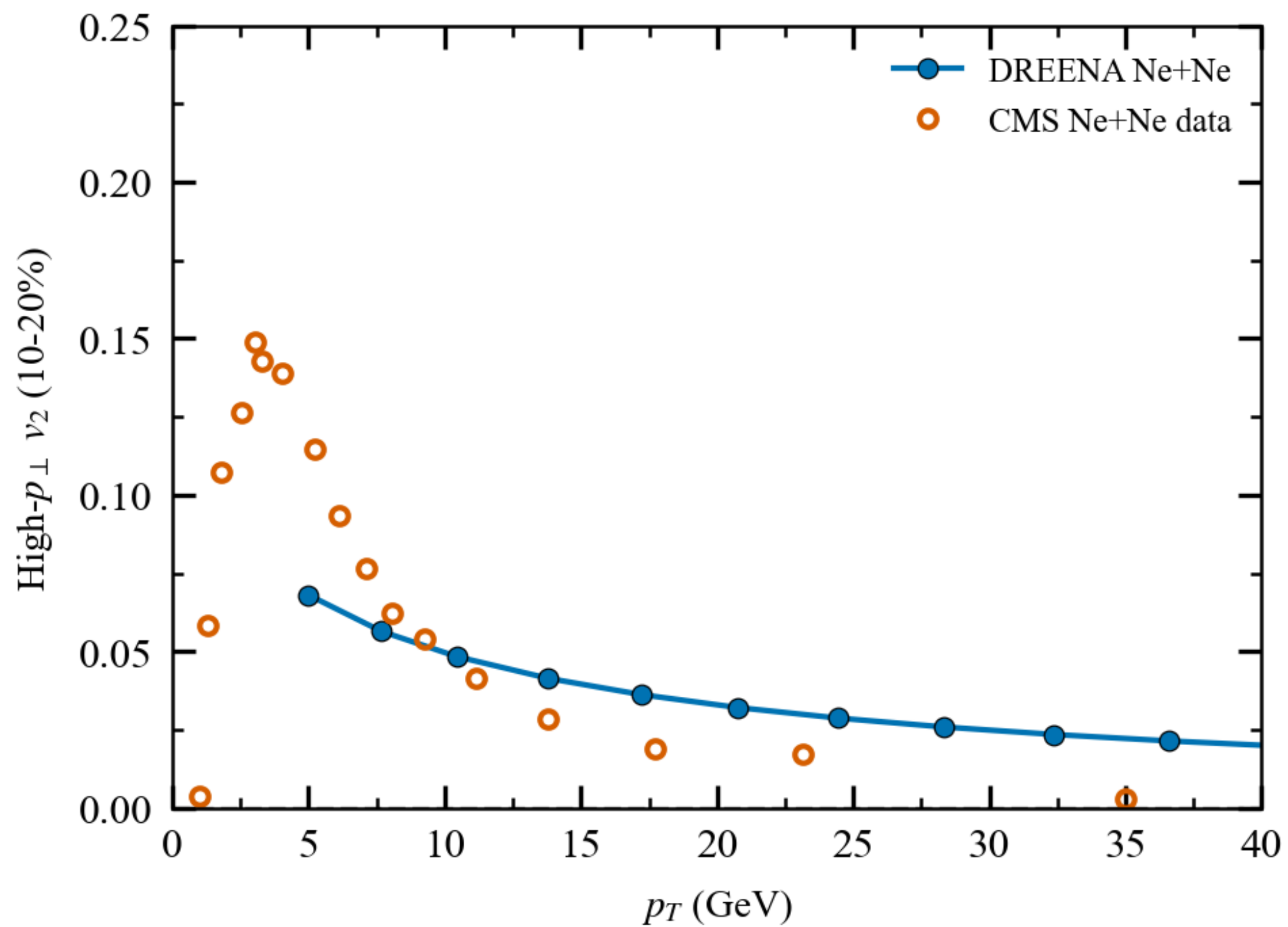
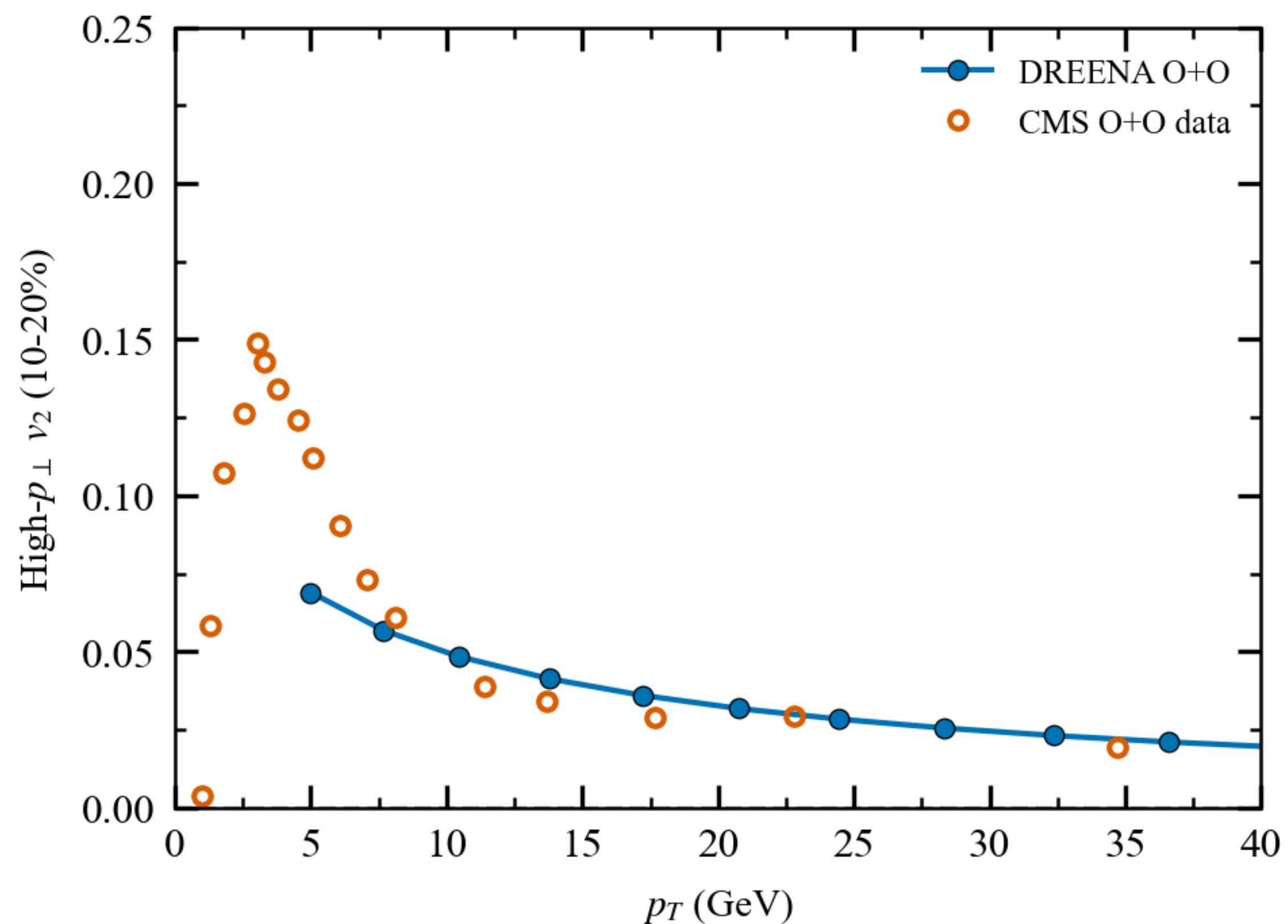
System size dependence of R_{AA}



DREENA predictions for R_{AA} (O+O, Ne+Ne 5.36 TeV)



DREENA predictions for high- $p_{\perp}$ v_2



Summary

- Study of parton energy loss in light ion system
- DREENA: Radiative + Collisional energy loss within HTL approach
- Nuclear modification factor shows system size dependence.
- Hint of deformation/presence of clustering in Ne nuclei.
- Future study with clustered initial profiles for O+O and Ne+Ne: Ne results may improve.

Thank you