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Interplay between core and corona from small to large systems

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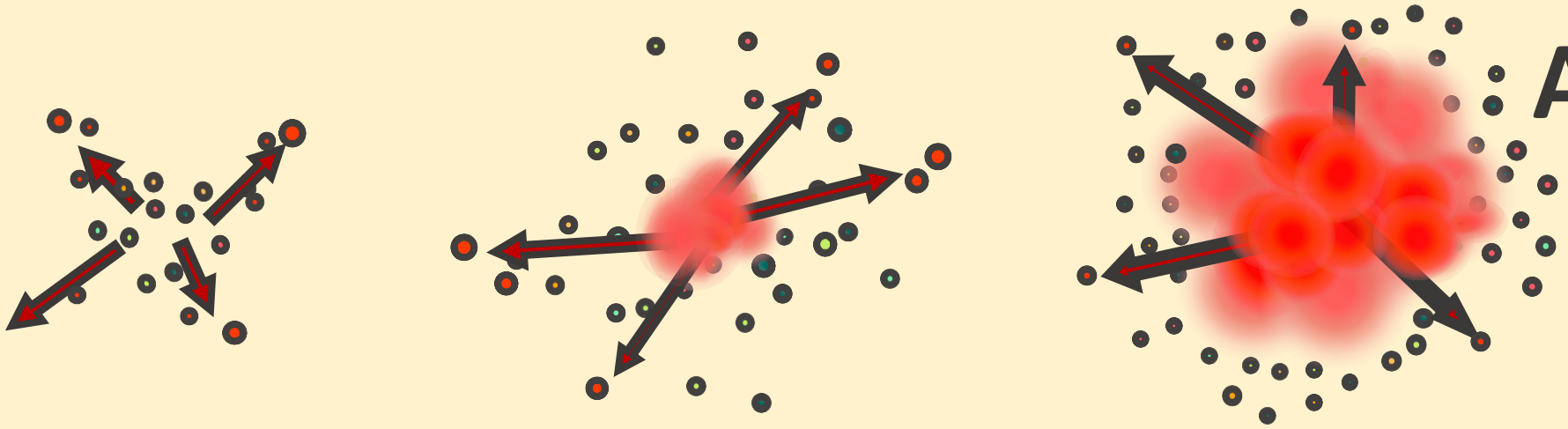
Comprehensive picture from pp to AA



Dynamical Core-Corona Initialization framework (DCCI)

K. Werner, Phys.Rev.Lett. 98 (2007) 152301

Core: fluids (equilibrated matter) **Corona: non-equilibrated partons**

➔ **From low to high p_T, from forward to backward, and from pp to AA**

Y. Kanakubo *et al.*, PTEP 2018 12, 121D01 (2018);
Y. Kanakubo *et al.*, Phys. Rev. C 101 2, 024912 (2020);

Y. Kanakubo *et al.*, Phys. Rev. C 105 (2022) 2, 024905

Model flowchart of DCCI2

Y. Kanakubo *et al.*, Phys. Rev. C 105 (2022) 2, 024905

Initial partons: PYTHIA8/PYTHIA8 Angantyr

T. Sjöstrand *et al.*, Comput. Phys. Commun. 191, 159 (2015)
C. Bierlich *et al.*, JHEP 1610 139 (2016)

Dynamical initialization of QGP fluids based on core-corona

Equilibrated matter (core)

(3+1)-D hydro with source terms

Y. Tachibana *et al.*, Phys. Rev. C 90, 021902 (2014)

iS3D (thermal hadron sampling)

M. McNelis *et al.*, Comput. Phys.Commun.258, 107604 (2021)

Non-equilibrated partons (corona)

PYTHIA8 (string fragmentation)

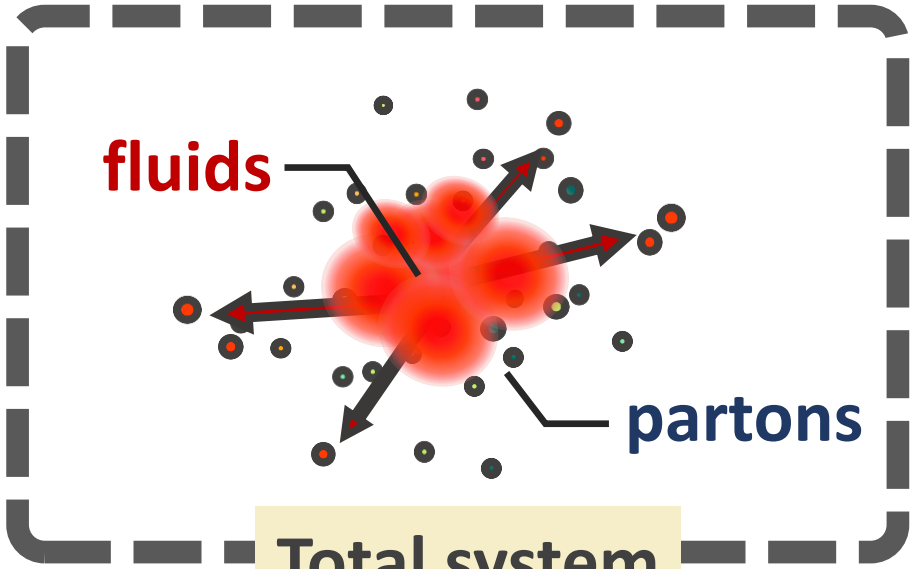
Hadronic afterburner: JAM

Y. Nara *et al.*,Phys. Rev. C61, 024901 (2000)

Dynamical initialization framework

Two-component picture

➔ fluids and partons



Continuum eq. for fluid+parton

$$\partial_\mu \left(T^{\mu\nu}_{\text{fluid}} + T^{\mu\nu}_{\text{parton}} \right) = 0$$

Hydrodynamic eq. with source term

$$\partial_\mu T^{\mu\nu}_{\text{fluid}} = J^\nu$$

Gaussian profile G and straight trajectory for a parton

$$J^\nu \to -\sum_i \frac{dp_i{}^\nu(t)}{dt} G\left(x - x_i(t)\right)$$

"Sources of fluids"

= "Four-momentum deposition from partons"

Dynamical core-corona picture

Multiple scatterings among partons ➔ partial equilibration

$$\frac{dp_i{}^{\mu}}{d\tau} = -\sum_{j}^{N_{\mathrm{scat}}} \rho_{i,j}\sigma_{i,j}\left|v_{\mathrm{rel},i,j}\right| p_i{}^{\mu}$$

Defined at a co-moving frame with $\eta_{s,i}$

Energy-momentum deposition

➔ # of scatterings with partons (non-equilibrated and equilibrated)

Low p_T and/or dense region ⇨ **Core (fluids)**

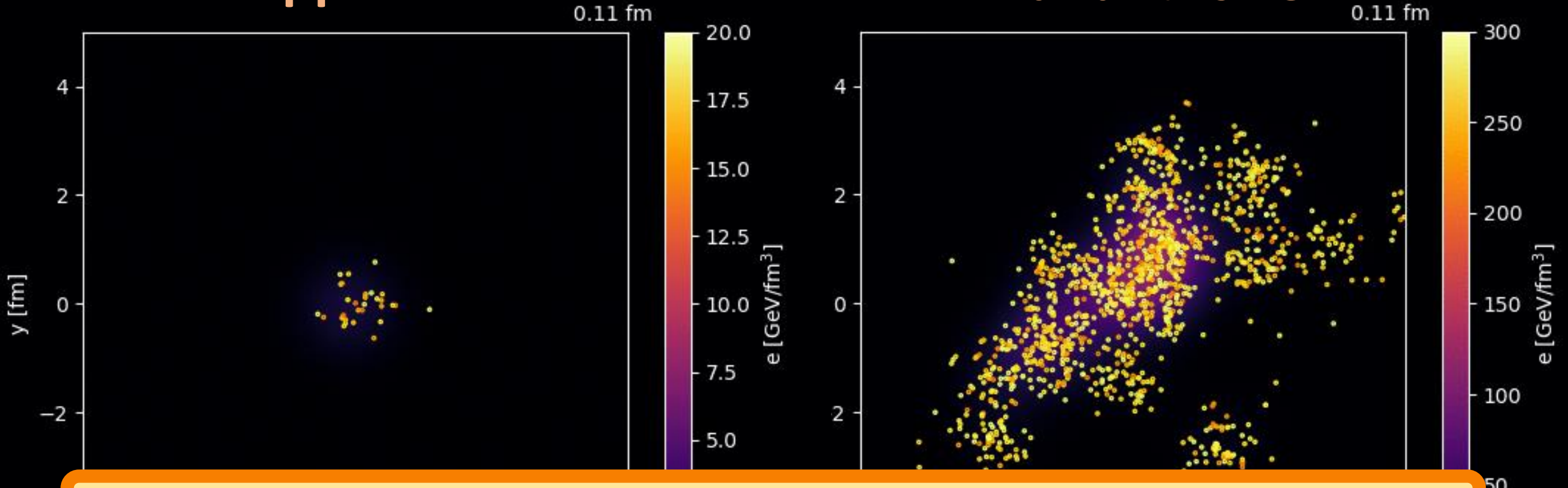
High p_T and/or dilute region ⇨ **Corona (non-equilibrated partons)**

Dynamical core-corona initialization

Transverse plane ($|\eta_s| < 0.5$)

pp 7 TeV

PbPb 2.76 TeV



Dynamical core-corona separation

+ energy-momentum conservation **respecting beam energy**

Results from DCCI2

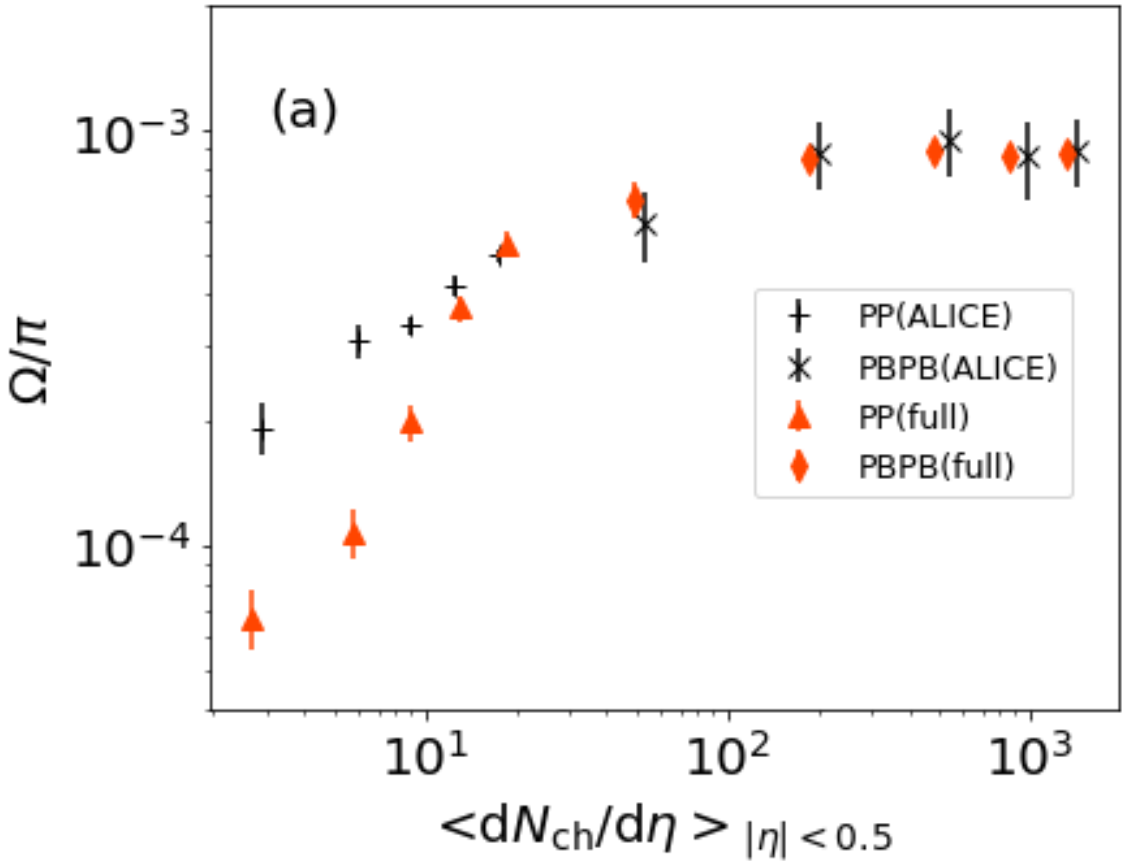
Take-home message!

QGP properties from experiment?

➔ Need both equilibrated and non-equilibrated matter in both pp and AA

Ω/π ratio from pp to PbPb

⇨ Fixing parameters to control fraction of core/corona



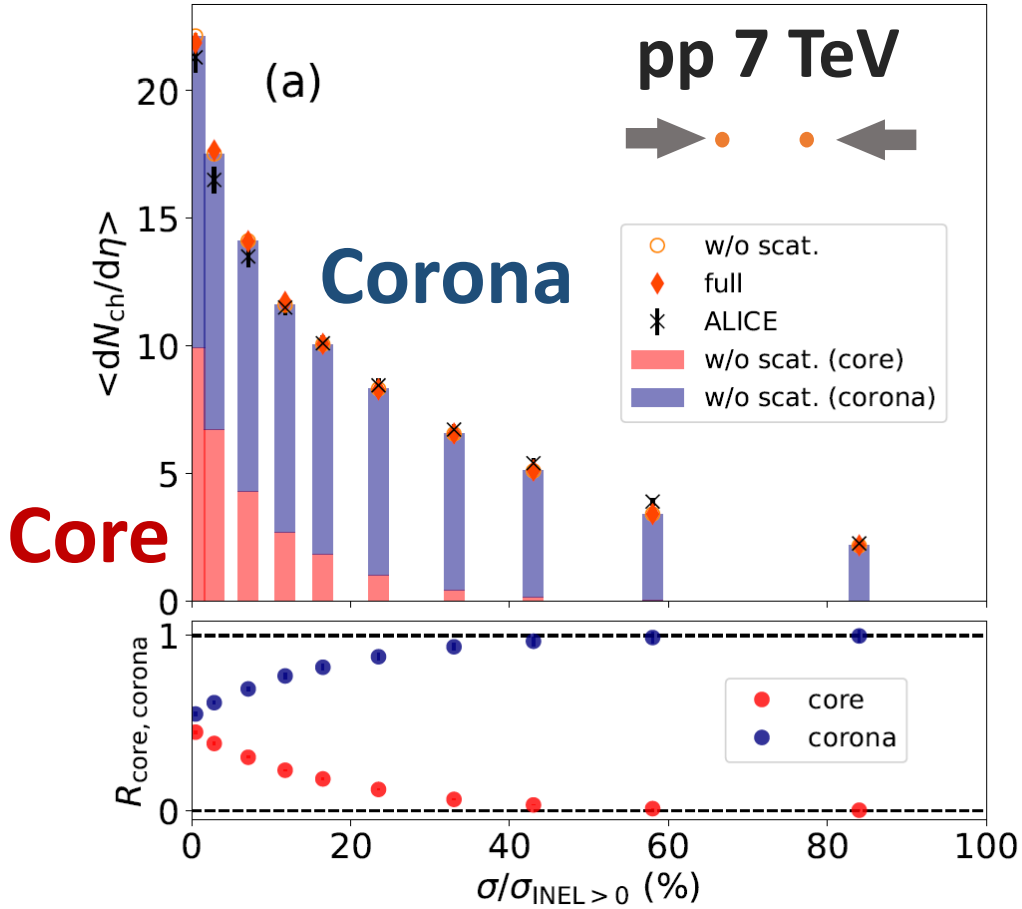
J. Adam *et al.*, (ALICE Collaboration), Nature Phys. 13 535-539 (2017)
B. Abelev *et al.* (ALICE Collaboration), Phys. Lett. B 728, 216-227 (2014); erratum 734, 409-410 (2014)

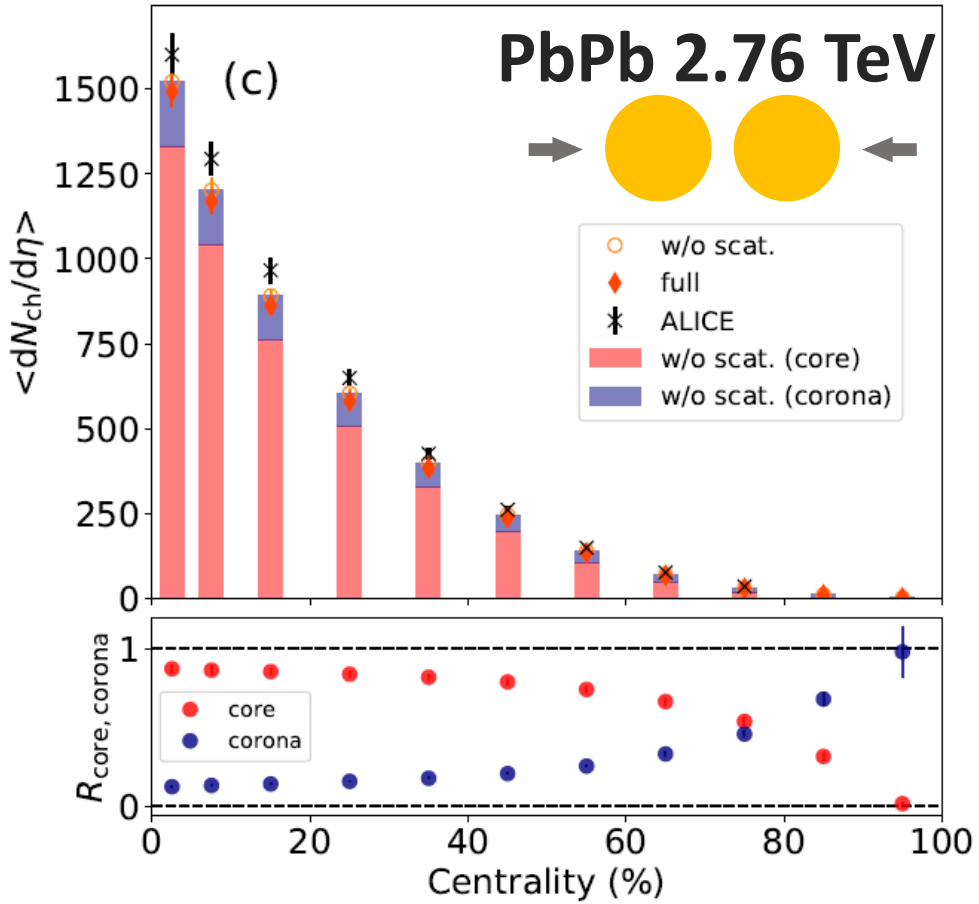
Smooth enhancement of Ω/π
➔smooth increase of
core contribution

Starting point

☑ **Describe composition of matter**

Fraction of core and corona in pp and PbPb





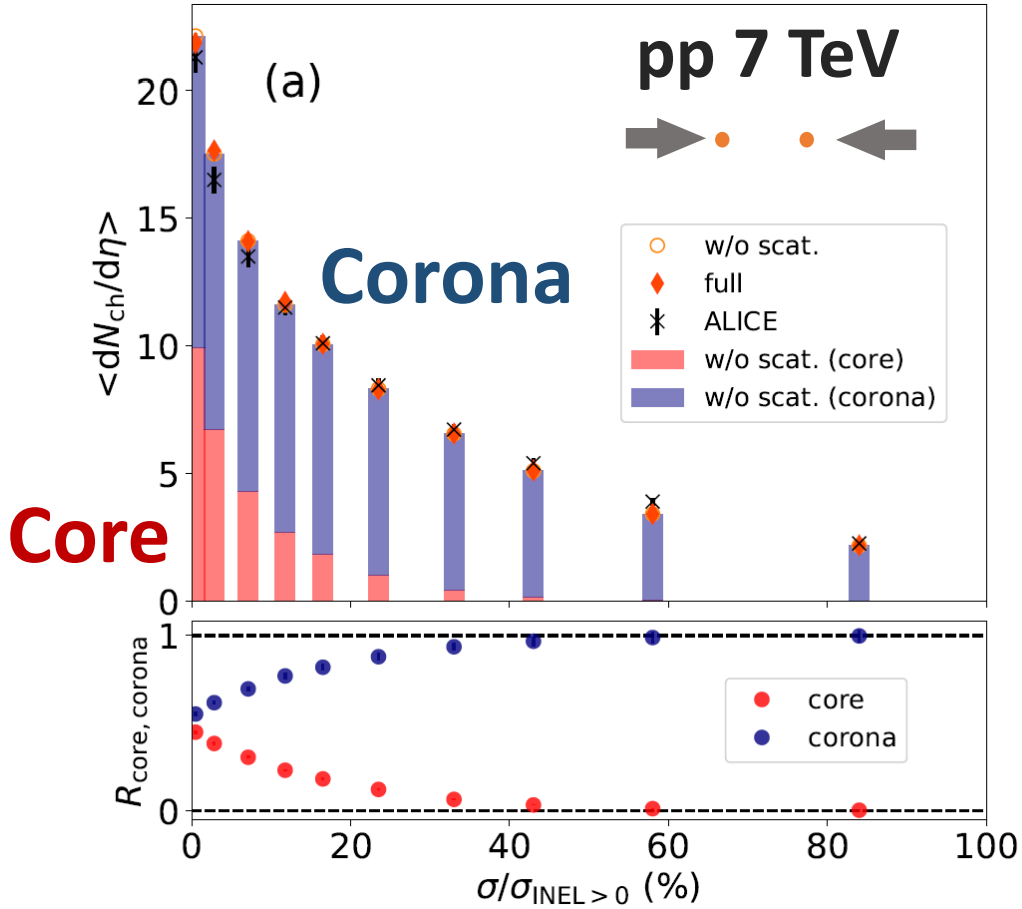
pp: core/corona ~ 50% at the highest multiplicity class (0-0.95%)

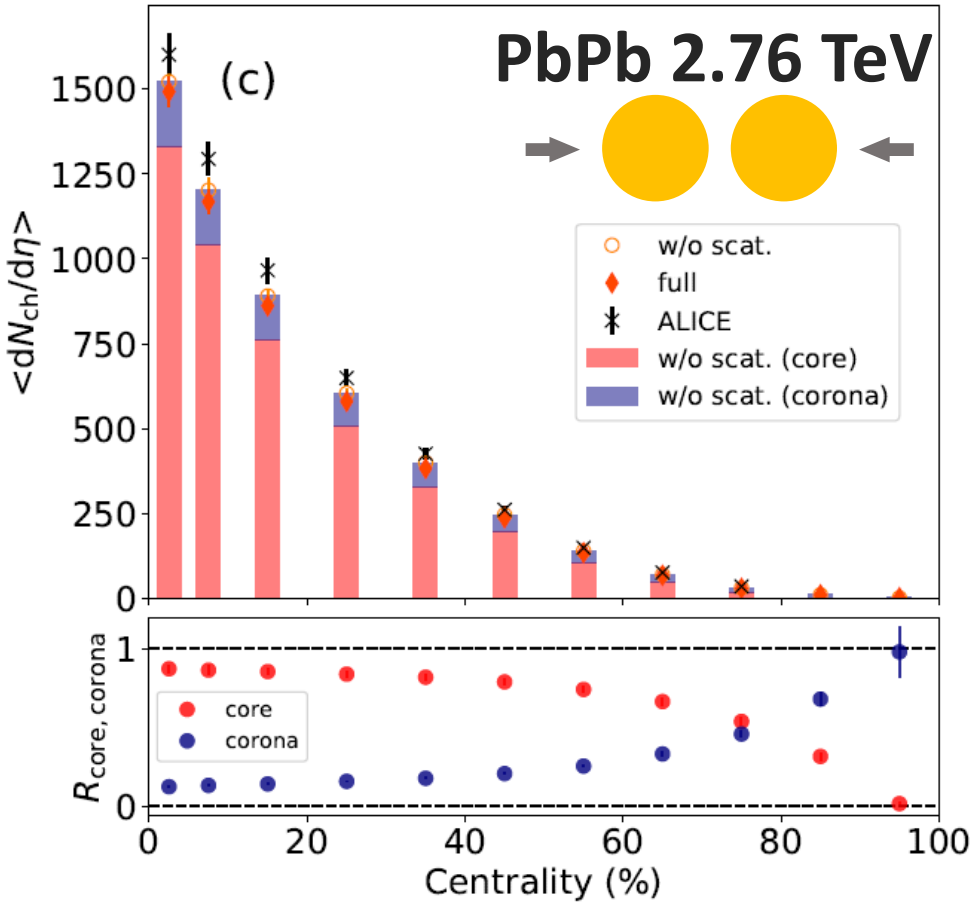
PbPb: corona ~ 20% at intermediate centralities (40-60%)

J. Adam *et al.*, (ALICE Collaboration), Nature Phys. 13 535-539 (2017)

K. Aamodt *et al.*, (ALICE Collaboration), Phys. Rev. Lett. 106 032301 (2011)

Fraction of core and corona in pp and PbPb



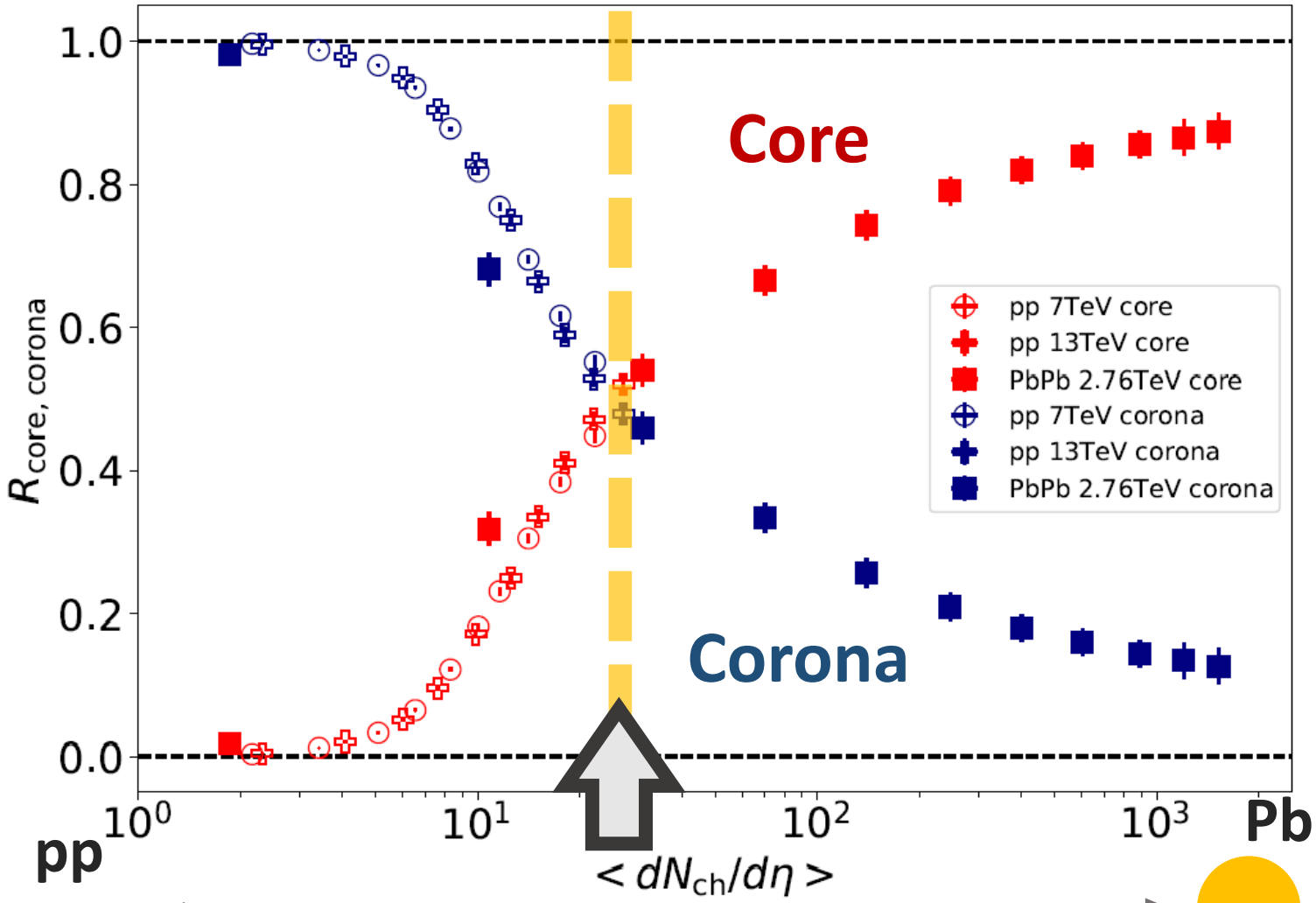


J. Adam *et al.*, (ALICE Collaboration), Nature Phys. 13 535-539 (2017)

K. Aamodt *et al.*, (ALICE Collaboration), Phys. Rev. Lett. 106 032301 (2011)

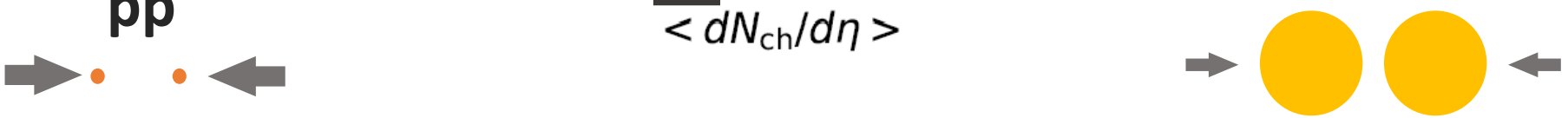
➔ **Need both equilibrated and non-equilibrated matter in both pp and AA**

Onset $\langle dN_{\mathrm{ch}}/d\eta \rangle$ of core dominance



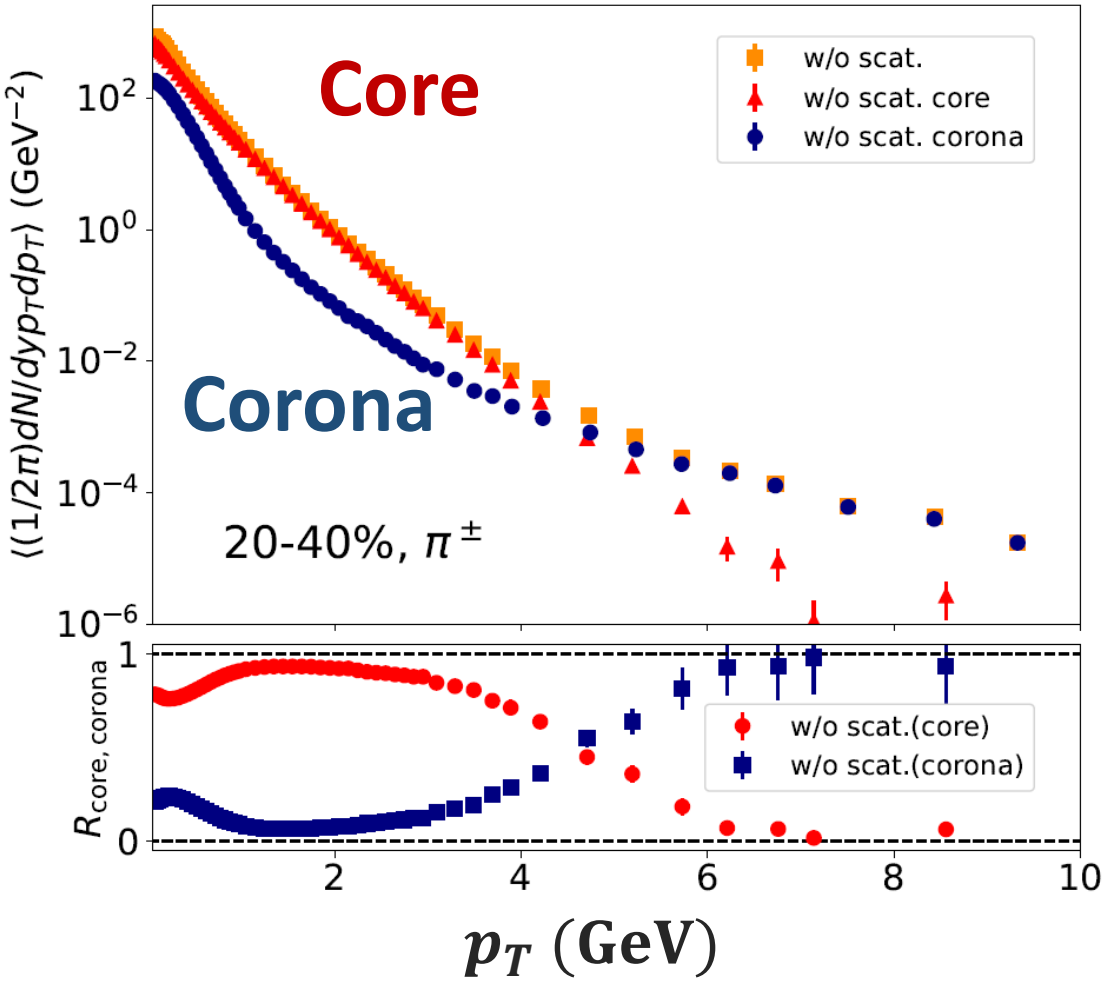
Clear scaling with multiplicity

Onset of core dominance at $\langle dN_{\mathrm{ch}}/d\eta \rangle \sim 20$



Fraction of core and corona vs. p_T

Charged π, PbPb 2.76 TeV, 20-40%



Low p_T: core dominance

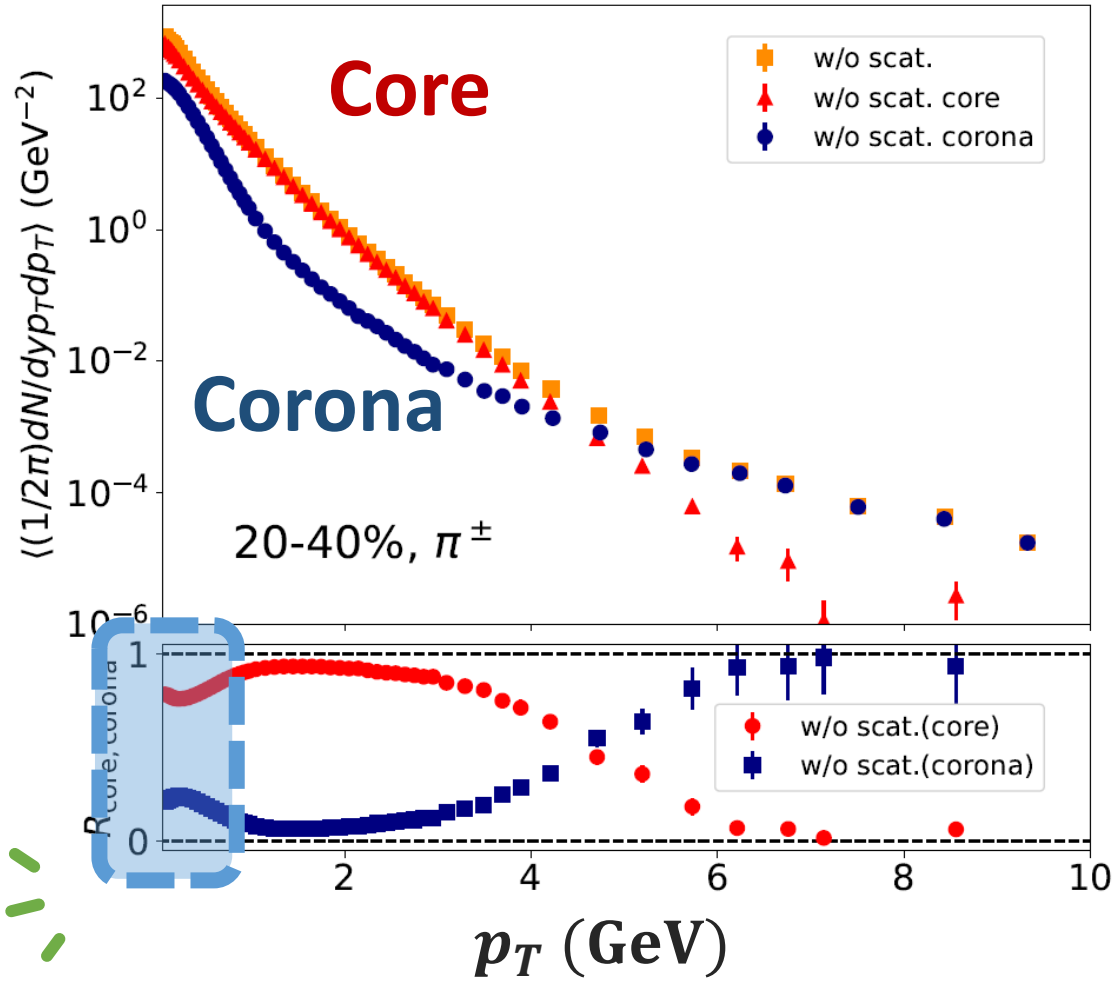
high p_T: corona dominance

Core-corona picture

➔ From low to high p_T within one framework

Fraction of core and corona vs. p_T

Charged π, PbPb 2.76 TeV, 20-40%



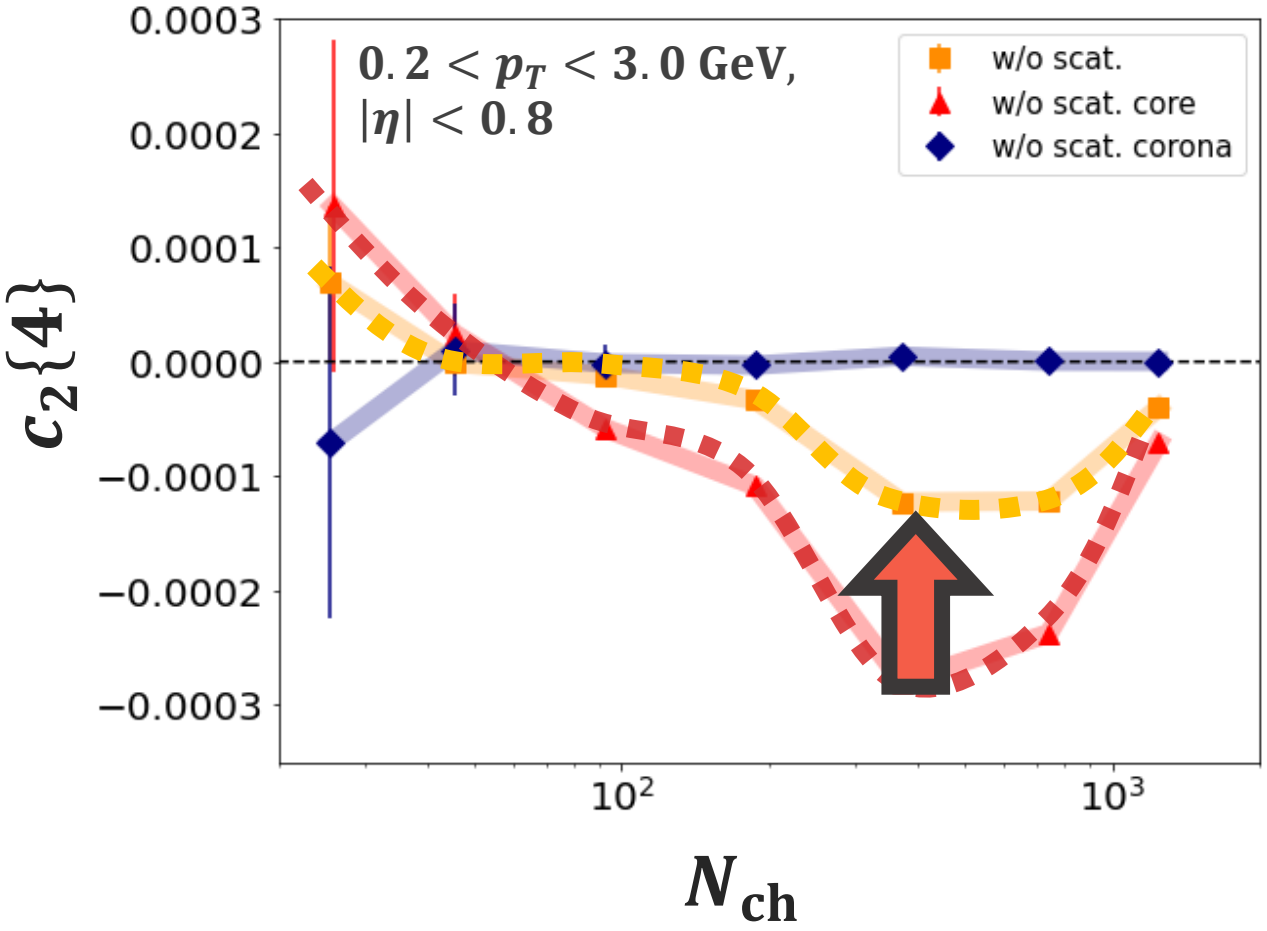
Very low p_T (< 1 GeV)

Slight enhancement of corona components

Non-equilibrium corrections to core (equilibrium)

Corona corrections to flow

$c_2\{4\}$ from PbPb 2.76 TeV



$c_2\{4\}_{\mathrm{core}} \neq c_2\{4\}_{\mathrm{tot}}$

➔ Diluted by corona

Conventional Hydro model

Comparison

Experiment

➔ Need both equilibrated and non-equilibrated matter

Summary

Dynamical core-corona initialization (DCCI2)

- Respect beam energy in initialization of QGP
- Both equilibrated and non-equilibrated matter

➔ From low to high p_T, from forward to backward, and from pp to AA

Yield ratios of strange hadrons from pp to PbPb

Onset of core dominance at $\langle dN_{\mathrm{ch}}/d\eta \rangle \sim 20$

Non-equilibrium corrections to core (equilibrium)

Proper extraction of QGP properties from experiment?

➔ **Need both equilibrated and non-equilibrated matter in both pp and AA**

Thank you!