QGP fraction based on core–corona picture in high-energy oxygen–oxygen collisions

N. Ito and T. Hirano, arXiv:2604.05307

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Outline

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Introduction

Model

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Summary & Outlook

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- **Introduction**
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High-energy oxygen-oxygen collisions

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Last year, Oxygen-Oxygen run was conducted at the LHC.

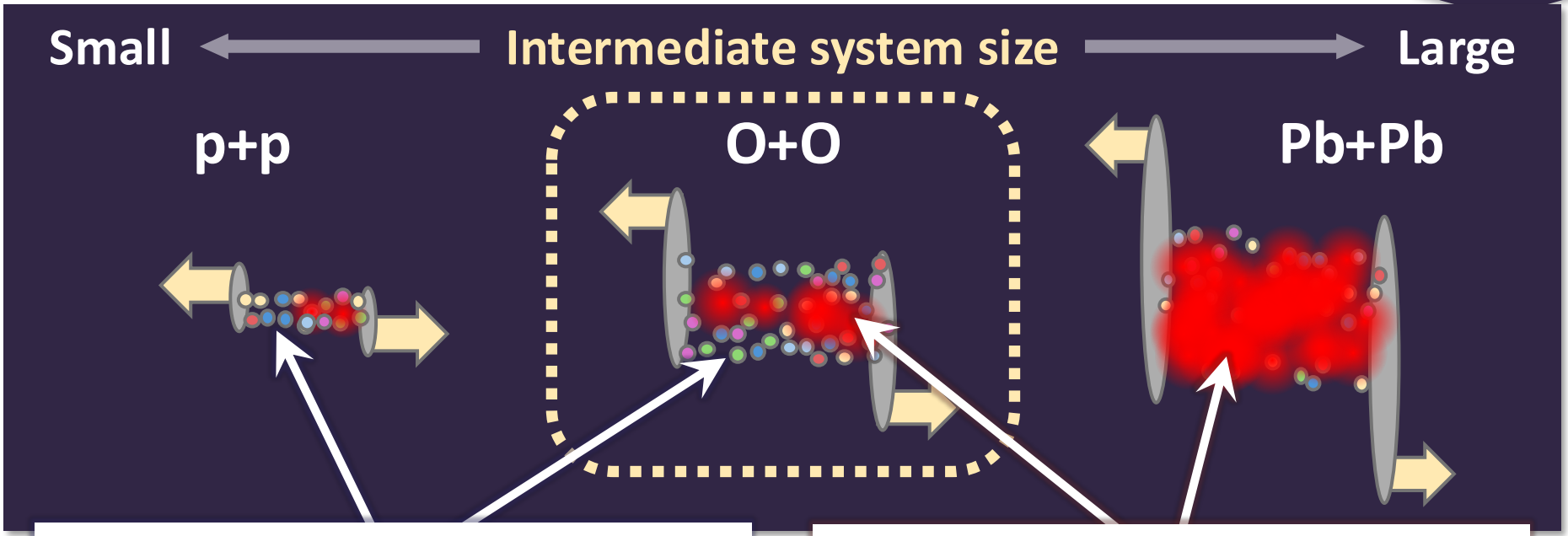
1. Probing the Nuclear Structure

- Alpha cluster structure in Oxygen nuclei?
- Opportunity for nuclear structures from high-energy collisions

2. Bridging the gap between Small and Large systems

- ^{16}O - ^{16}O collision provides the intermediate size system
- Scanning multiplicity between small and large systems

QGP production in an intermediate-sized systems



Intermediate-sized system with core–corona picture

Motivation

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Nuclear structure of intermediate systems by using high-energy nuclear collisions

Core–corona picture for intermediate-sized systems

Quantitative extraction of each contribution within the core–corona framework

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Dynamical Core–Corona Initialization (DCCI2) model

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

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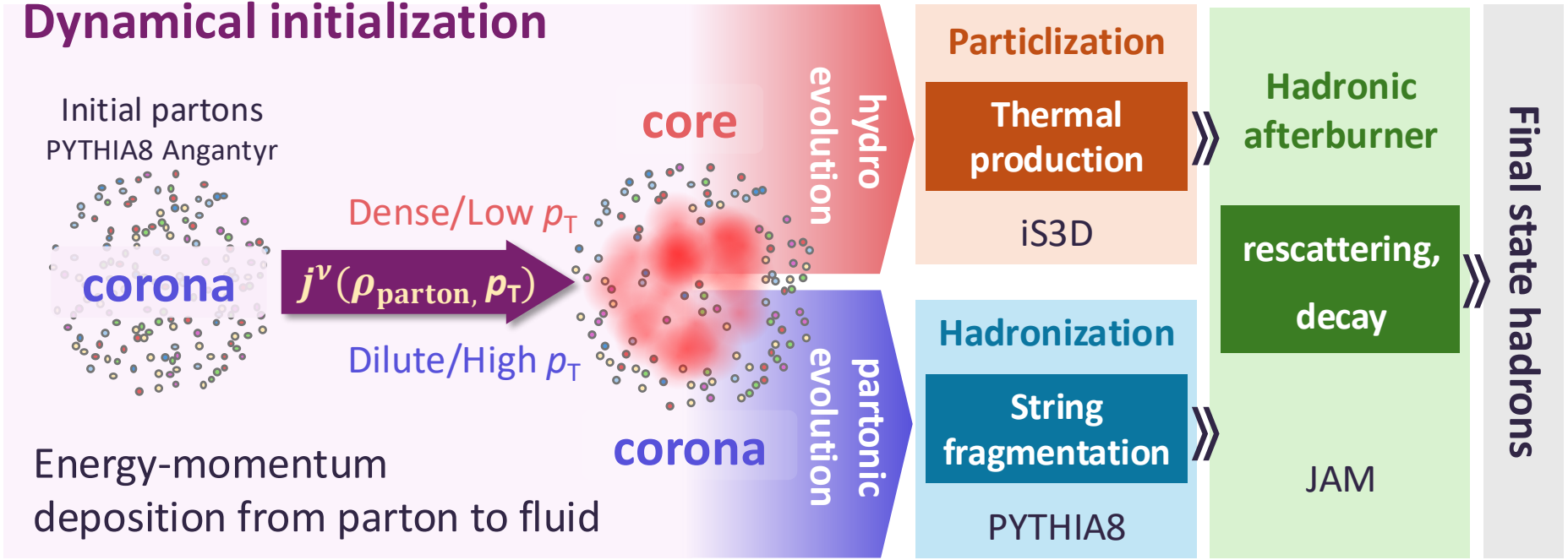

- Dynamical core–corona separation via source term
- Description of the entire evolution of nuclear collisions

Model setups

- $^{16}O + {}^{16}O$
- $\sqrt{s_{NN}} = 5.36$ TeV
- 100,000 events
- **GLISSANDO model**

GLISSANDO model

Woods-Saxon distribution:

$$\rho(r) = \frac{\rho_0}{1 + \exp[(r - R)/a]}$$

Radius:

$$R = 1.1A^{\frac{1}{3}} - 0.656A^{-\frac{1}{3}} \approx 2.51 \text{ fm}$$

Diffusness: $a = 0.54$ fm Hard core: 0.9 fm

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Charged-particle multiplicity distribution

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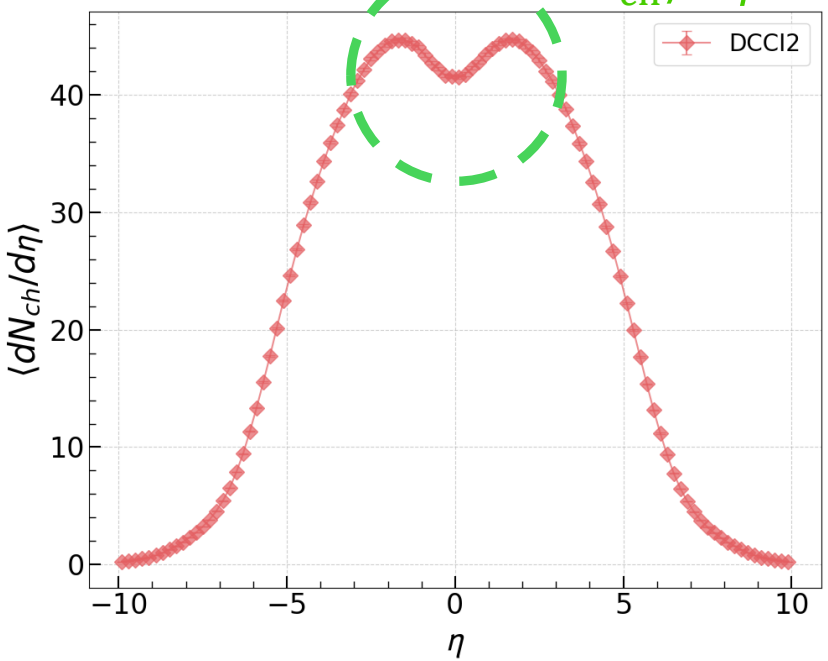
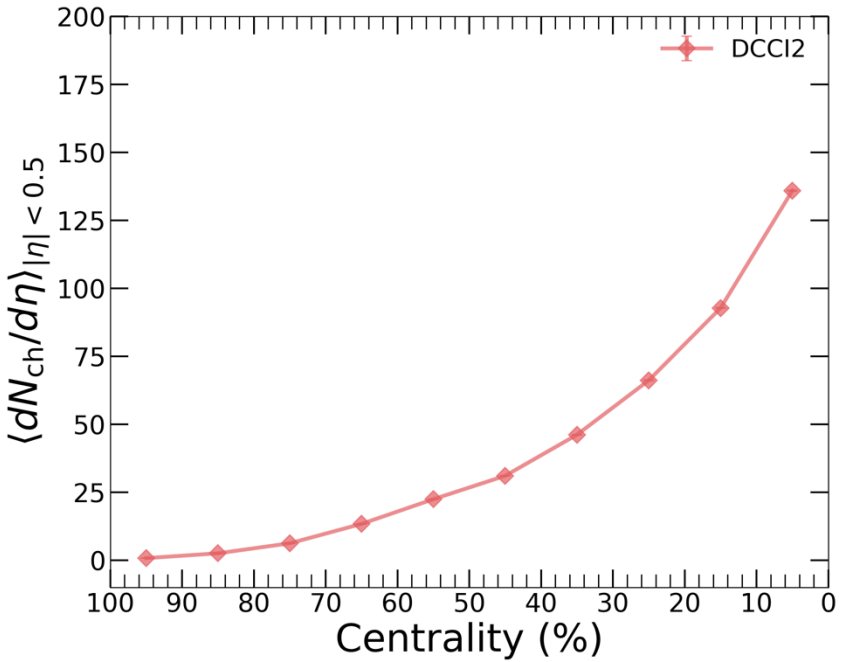
※ min bias

$dN_{\mathrm{ch}}/d\eta \approx 40$



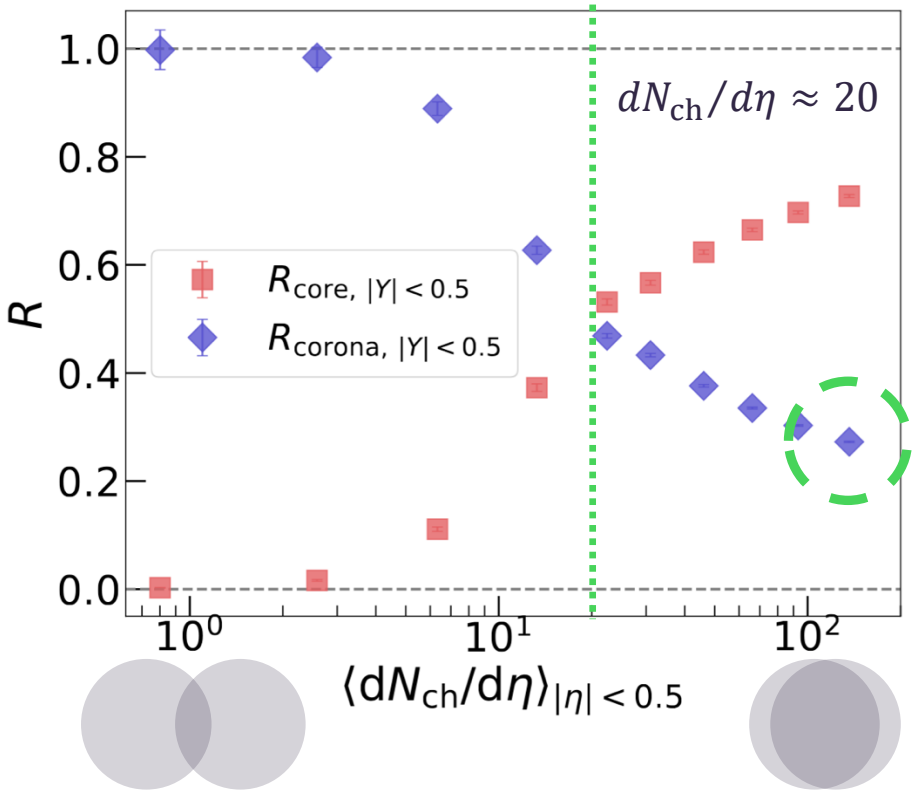


- **DCCI2 results are consistent with the CMS preliminary data.**

CMS PAS HIN-25-010

- **Reliable baseline of DCCI2**

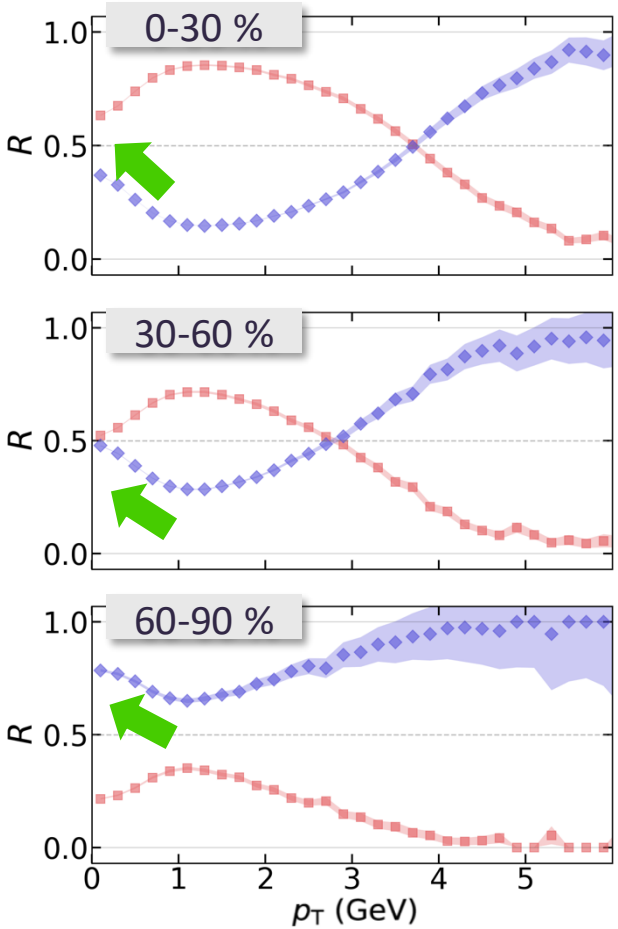
Multiplicity dependence of core–corona fraction



- R_{core} ↑ as multiplicity ↑
  - Density-dependent fluidization via j^ν
- Transition occurs at $dN_{ch}/d\eta \approx 20$
  - CMS report: $dN_{ch}/d\eta \approx 40$ (min. bias)
    CMS PAS HIN-25-010
  - Competitive regime btwn core & corona
- Significant corona contribution
  - $R_{corona} \approx 30$ % in most central (0-10 %)

core–corona picture is essential for understanding OO collision

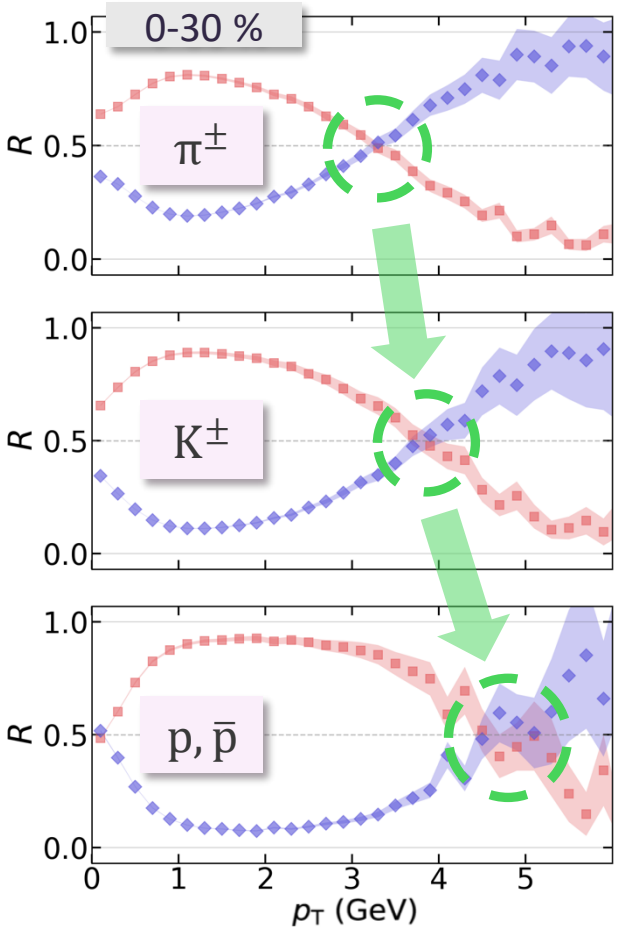
p_T dependence of core–corona fractions: centrality



- R_{core} ↓ as p_T ↑
  - Hard partons are less likely to be fluidized
- **Corona dominant in peripheral OO**
  - Peripheral (low $dN_{\mathrm{ch}}/d\eta$) → Corona dominant
- ***Soft-from-Corona***
  Y. Kanakubo *et al.*, Phys. Rev. C **106**, 054908 (2022)
  - Non-trivial enhancement of R_{corona} in very low p_T

Non-negligible corona contribution even in the soft region

p_T dependence of core–corona fractions: identified particle



- ***Mass ordering***

  T. Hirano, Y. Nara, Phys. Rev. C **69**, 034908 (2004)

  - Transition point shift to high p_T

$\pi^{\pm}$	<	$K^{\pm}$	<	$p, \bar{p}$
3.3 GeV		3.8 GeV		4.5 GeV

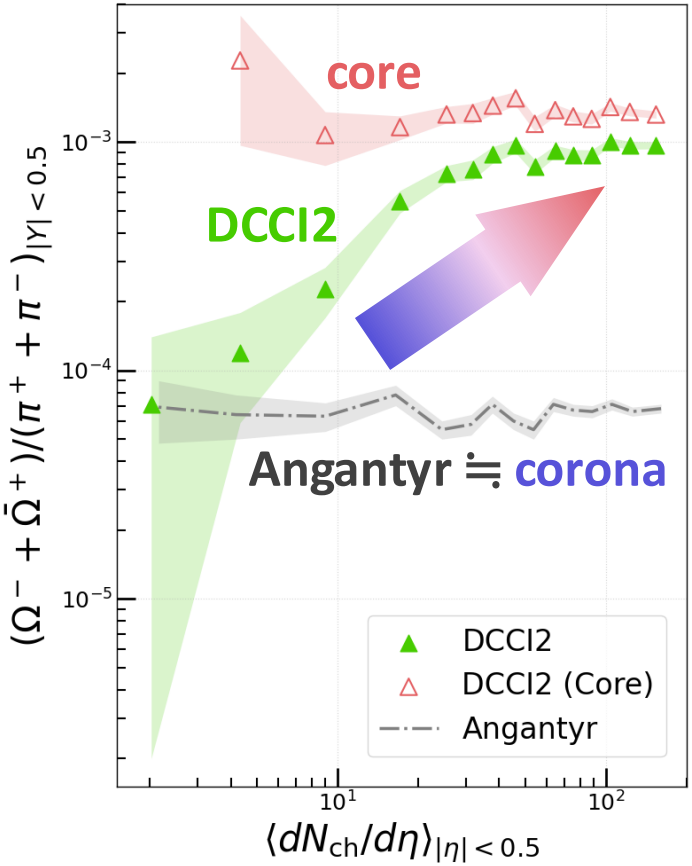
- **Radial flow**

  - Heavier particles receive larger p_T from fluid

  - Higher core fraction at higher p_T

Clear evidence of core effects in Oxygen–Oxygen collision

Strangeness enhancement



- **Significant enhancement over baseline**
  - Key signature of QGP production

Low $dN_{ch}/d\eta$
corona dominant
String fragmentation

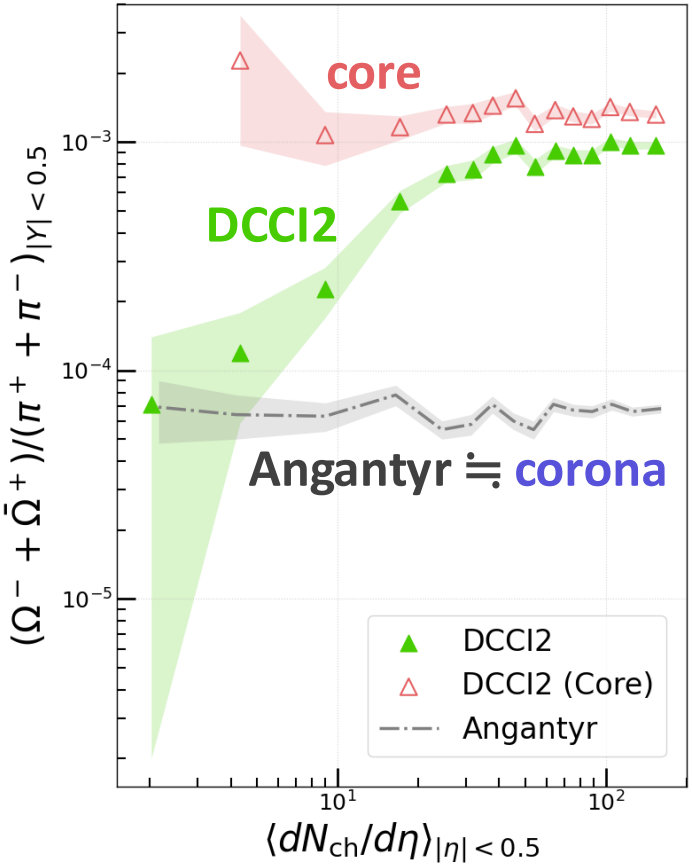
High $dN_{ch}/d\eta$
core dominant
Thermal production

※ more strange production

- **Smooth & monotonic behavior**
  - Gradual transition from corona to core

Dynamical transition is essential for describing intermediate system

Strangeness enhancement



- **Comparable with corona**
  - Low $dN_{\rm ch}/d\eta$ (low centrality) region
  - $R_{\rm core} \approx 0$ %, $R_{\rm corona} \approx 100$ %
  - Corona dominance
- **Never reaching the "core-only" limit**
  - High $dN_{\rm ch}/d\eta$ (high centrality) region
  - $R_{\rm core} \approx 70$ %, $R_{\rm corona} \approx 30$ %
  - Core-dominance but corona persistence

Both Core and Corona are non-negligible in O-O collisions.

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QGP formation in intermediate system

Dynamical Core–Corona Initialization Model

$^{16}\mathrm{O} + {}^{16}\mathrm{O}$, (GLISSANDO), $\sqrt{s_{NN}} = 5.36\ \mathrm{TeV}$

- O+O collisions as a competitive regime of core & corona
- Both core & corona effects are essential
- DCCI2 is unique tool for intermediate systems

Outlook: DCCI with nuclear deformation

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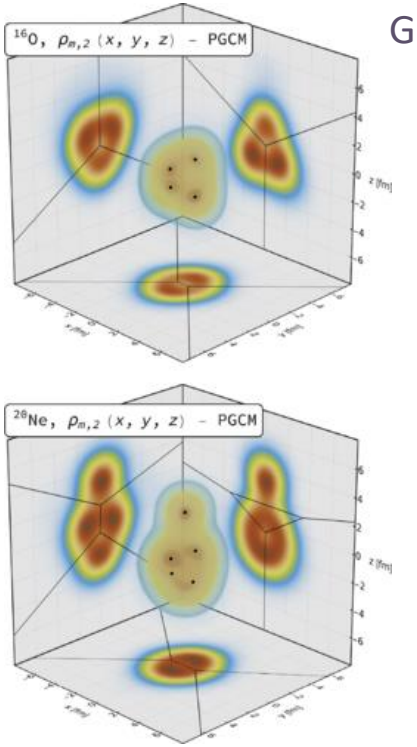
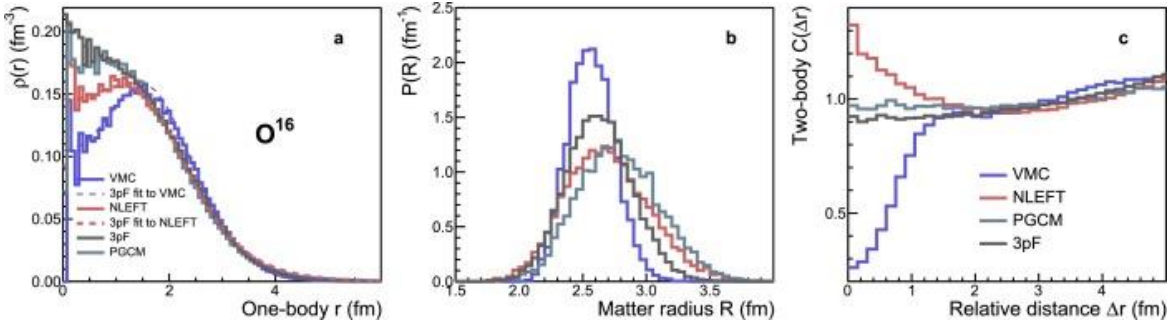
Calculations with nuclear deformation are currently underway.



G. Giuliano *et al.*, Phys. Rev. Lett. **135** 012302 (2025)

C. Zhang *et al.*, Phys. Lett. B **862** 139322 (2025)



Towards uncovering *initial nuclear structures*

Stay tune!!