



An investigation of radial collectivity in Oxygen+Oxygen collisions at $\sqrt{s_{NN}} = 5.36$ TeV via the $v_0(p_T)$ observable

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- 1 Motivation: O+O collisions shows anisotropic flow – does it show radial flow?
 - 2 Anisotropic vs. Radial flow
 - 3 The $v_0(p_T)$ observable
 - 4 Our recent work: Au+Au collisions at 200 GeV
 - 5 Global picture: recent ALICE / ATLAS $v_0(p_T)$ measurements
- 4 This work: **O+O collisions at 5.36 TeV**
 - 5 Summary and Outlook

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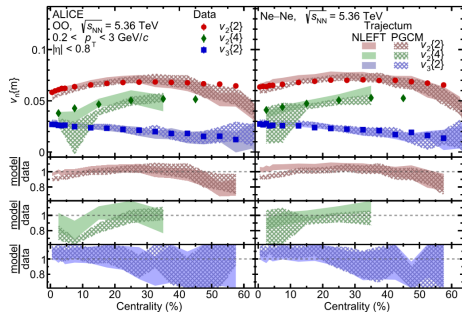
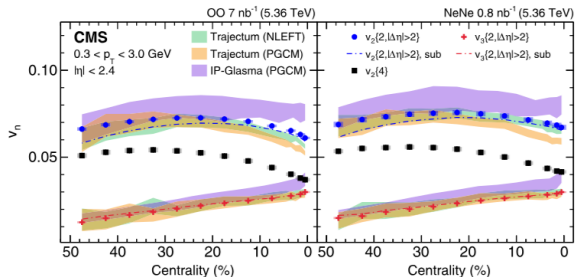
Anisotropic Flow in O+O Collisions

Established this year:

- ALICE and CMS both report geometry-driven anisotropic flow in O+O collisions at $\sqrt{s_{NN}} = 5.36$ TeV – well described by hydrodynamics

CMS, PRL 137, 082302 (2026) ↓

ALICE, PRL 137, 082301 (2026) →

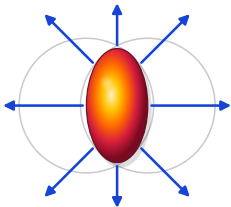


Expt.	$\sqrt{s_{NN}} = 5.36$ TeV
ALICE	First v ₂ , v ₃ in OO/Ne-Ne; centrality-dependent, hydro-consistent
CMS	Long-range collective flow observed in OO/Ne-Ne

Does radial (isotropic) collective flow also develop in O+O collisions?

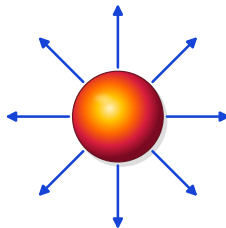
Anisotropic vs. Radial Flow

Anisotropic flow v_n



- Off-centre collision $\Rightarrow$ almond-shaped overlap
- Pressure pushes particles out *preferentially* along the short axis $\Rightarrow$ elliptic pattern, quantified by v_n

Radial flow (isotropic)



- Pressure gradient equal in every direction $\Rightarrow$ **no** preferred azimuthal direction
- Invisible to v_n by construction; traditionally only a single averaged number from blast-wave spectra fits

We need a dedicated, p_T -differential, event-by-event observable for the radial sector.

Defining $v_0(p_T)$: Radial Flow observable

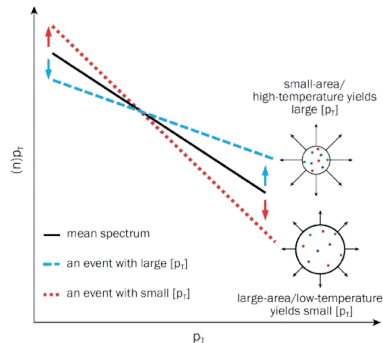
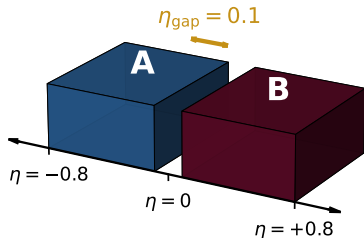
$$v_0(p_T) = \frac{\langle f_A^{p_T} [p_T]_B \rangle - \langle f_A^{p_T} \rangle \langle [p_T]_B \rangle}{\langle f_A^{p_T} \rangle \sigma_{[p_T]}}$$

PRC, 102 (2020) 034905

PLB, 857 (2024) 138985

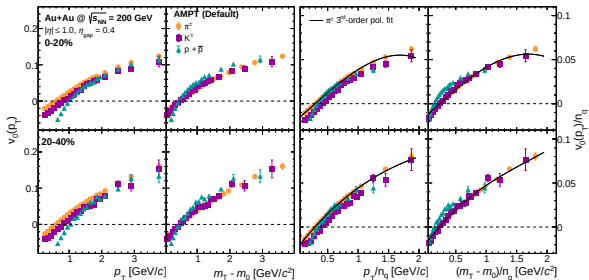
$$v_0 \equiv \frac{\sqrt{\langle (\delta[p_T])^2 \rangle_R}}{\langle [p_T] \rangle_R},$$

where $\delta[p_T] = [p_T] - \langle [p_T] \rangle_R$, and $\langle \cdots \rangle_R$ denotes averaging over events with particles restricted to the reference interval R .

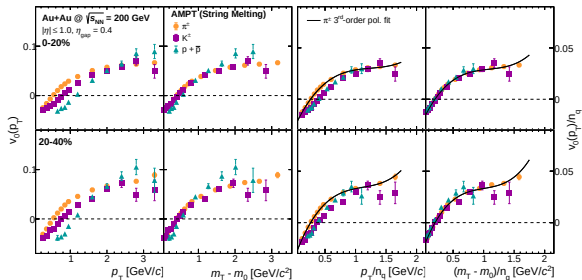


ATLAS, PRL 136, 032301 (2026)

Our recent work: identified-hadron $v_0(p_T)$ and NCQ scaling in Au+Au ([arXiv.2512.15026](https://arxiv.org/abs/2512.15026))



Both share the same ZPC for minijet partons. AMPT-Def: soft strings $\rightarrow$ Lund fragmentation



AMPT-SM: full system melted $\rightarrow$ coalescence

- Mass-ordering observed in both AMPT-SM and Default
- Approximate NCQ scaling *only* in AMPT-SM
- **Finding:** Observation of quark-level radial collectivity in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

Global picture: recent $v_0(p_T)$ measurements in Pb+Pb collisions

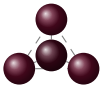
Experiment/Model	System, Energy	Confirmed features of radial collectivity
ATLAS	Pb+Pb, 5.02 TeV	(i) long-range pseudorapidity correlations (ii) factorization of two-particle into single-particle $v_0(p_T)$ (iii) centrality-independent $v_0(p_T)/v_0$, and approximate $\sqrt{N_{\text{ch}}}$ $v_0(p_T)$ scaling ATLAS, PRL 136, 032301 (2026)
ALICE	Pb+Pb, 5.02 TeV	Same three features <i>plus</i> first identified-hadron $v_0(p_T)$: mass ordering, baryon–meson crossing, and NCQ scaling ALICE, PRL 136, 032302 (2026)
AMPT	Au+Au, 200 GeV	All features of radial collectivity confirmed by ALICE/ATLAS also confirmed in our AMPT study R. Agarwala et al., arXiv.2512.15026

These are exactly the hallmarks of collectivity we now test in O+O collisions at $\sqrt{s_{\text{NN}}} = 5.36$ TeV using AMPT String Melting

^{16}O geometry and analysis setup: O+O at 5.36 TeV



Woods-Saxon
smooth, diffuse edge



α -clustered
 4α , tetrahedral

- Doubly-magic ^{16}O : Woods-Saxon is the textbook picture
- Alternative: four tightly bound α clusters in a tetrahedron

Event generation

- AMPT, string-melting, O+O @ $\sqrt{s_{\text{NN}}} = 5.36 \text{ TeV}$
- WS $\rightarrow 40 \text{ M}$; α -cluster $\rightarrow 25 \text{ M}$ statistics
- Charged particles, $|\eta| \leq 0.8$; $p_{\text{T}}^{\text{ref}}$: 0.2–2.0 GeV/c

α -clustering parameters

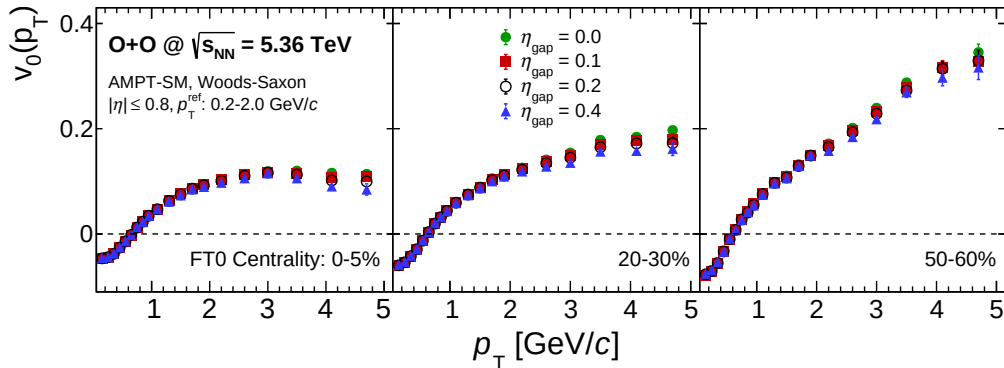
- Tetrahedron edge length = 3.42 fm
- Nucleon smearing width = 1.0 fm

Centrality & correlator

- Forward FT0M, mid-rapidity yield ($N_{\text{ch}}^{|\eta| \leq 0.8}$), impact parameter b , and N_{part}
- Subevent method with an η_{gap}

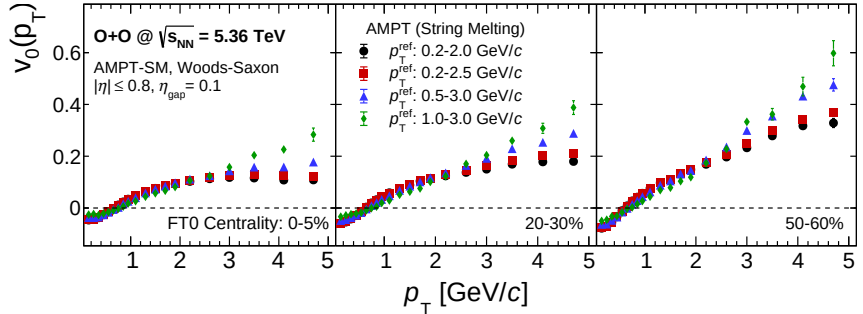
Is $v_0(p_{\text{T}})$ sensitive enough to tell these apart?

Long-range pseudorapidity correlations



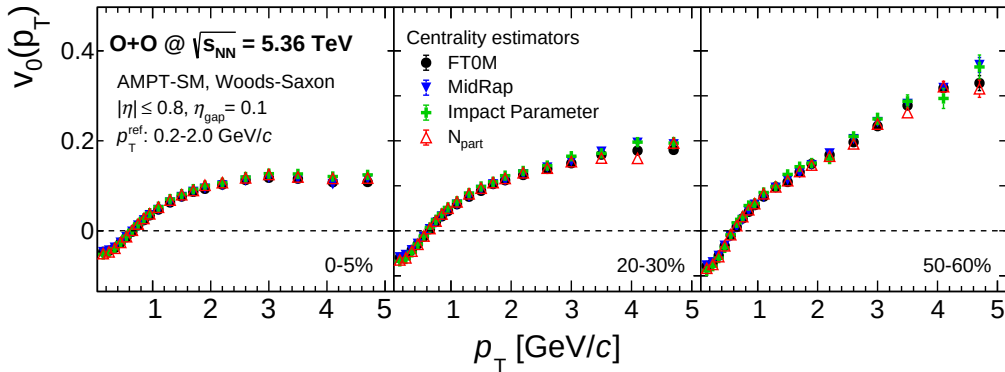
- $v_0(p_T)$ essentially unchanged from $\eta_{\text{gap}} = 0.0$ to $0.4 \Rightarrow$ genuinely long-range, not short-range non-flow
- Small deviations only for $p_T \geq 3$ GeV/c (jets, resonance decays)

Factorization of $v_0(p_T)$ w.r.t p_T^{ref} ranges



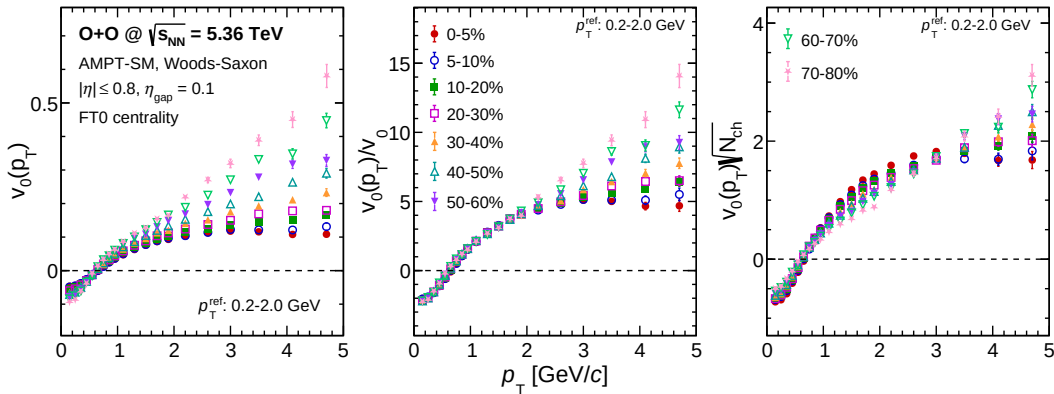
- $v_0(p_T)$ independent of the chosen p_T^{ref} range for $p_T \leq 2$ GeV/c – approximate factorization holds
- Breaks down above 2 GeV/c, growing toward peripheral events – onset of non-flow contributions

Centrality estimator dependence of $v_0(p_T)$



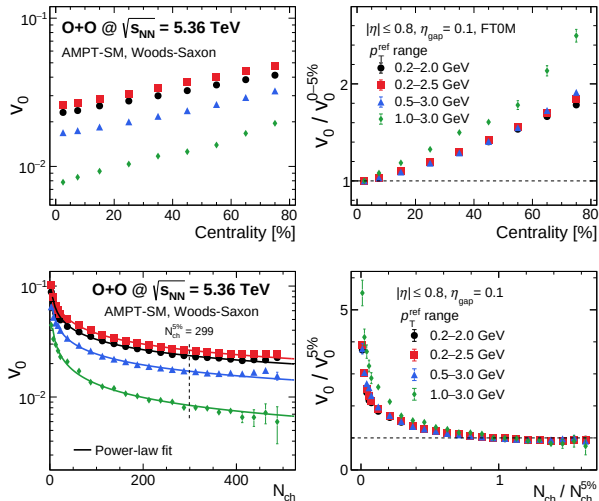
- All four estimators agree within uncertainties across the full p_T range across centralities.
- A small spread opens up only towards mid-central and peripheral collisions at $p_T \gtrsim 3$ GeV/c

Centrality-independent $v_0(p_T)/v_0$ and $\sqrt{N_{ch}} v_0(p_T)$ scaling



- Characteristic shape at all centralities; most central events show the *smallest* $v_0(p_T)$ (larger multiplicity dilutes EbyE fluctuations)
- $v_0(p_T)/v_0$ and $v_0(p_T)\sqrt{N_{ch}}$ both collapse onto a single curve below ~ 2 GeV/c – same as our Au+Au result and ATLAS/ALICE in Pb+Pb

Integrated radial flow v_0 vs. centrality in O+O



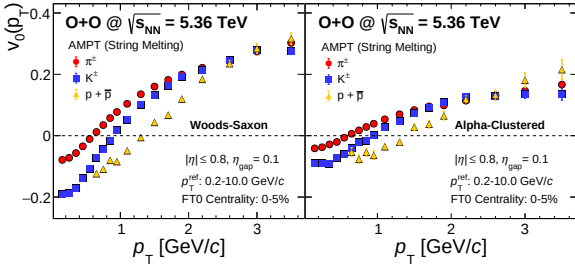
- v_0 increases from *central* to *peripheral*; strong dependence on p_T^{ref}
- Normalizing by the 0–5% value removes the reference- p_T dependence
- p_T^{ref} : 1–3 GeV (harder) does not scale like the softer ranges

p_T^{ref} (GeV)	b
0.2-2.0	-0.307 ± 0.001
0.2-2.5	-0.320 ± 0.001
0.5-3.0	-0.325 ± 0.002
1.0-3.0	-0.405 ± 0.007

$$v_0 = A \cdot N_{ch}^b$$

A $\rightarrow$ Normalization constant; $b \rightarrow$ fit parameter

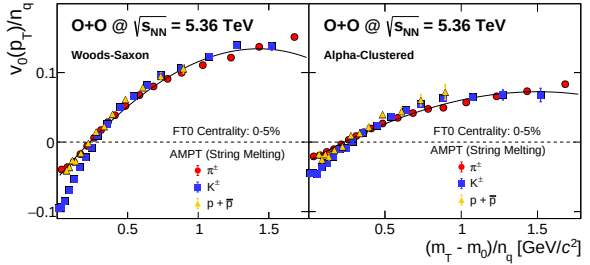
First O+O result: identified hadron $v_0(p_T)$ and NCQ scaling



- Mass-ordering (low p_T) & baryon-meson crossing ($\sim 2.5-3 \text{ GeV/c}$)
- α -clustered $v_0(p_T)$ magnitude $<$ WS at high- p_T

$$S_f = \sum_{i=1}^2 \sum_{j=1}^N |y_j - f(x_j)|_i$$

N is the number of bins in which $v_0(p_T)$ is calculated; y_j correspond to $v_0(p_T)$ values of $K^\pm$ and $p + \bar{p}$.



- An approximate NCQ scaling in *both* geometries
- Visibly better NCQ scaling for α -clustered geometry

Geometry profile	S_f
Woods-Saxon	0.371
α -Clustered	0.283

Summary and outlook

O+O at $\sqrt{s_{NN}} = 5.36$ TeV, AMPT String Melting

- All three features of radial collectivity confirmed: long-range η_{gap} independence, p_T^{ref} factorization, and centrality-independent $v_0(p_T)/v_0$ & $\sqrt{N_{\text{ch}}} v_0(p_T)$ scaling
- **First** identified-hadron $v_0(p_T)$ and NCQ scaling in O+O: mass-ordering, baryon-meson crossing, approximate scaling with $(m_T - m_0)/n_q$
- **First** look at nuclear-structure sensitivity: α -clustering *suppresses* high- p_T $v_0(p_T)$ relative to Woods-Saxon

Context

- Builds on our AMPT String Melting vs. Default NCQ-scaling evidence in Au+Au at $\sqrt{s_{NN}} = 200$ GeV [arXiv:2512.15026](https://arxiv.org/abs/2512.15026)
- Complements ALICE/ATLAS $v_0(p_T)$ Pb+Pb results and the new ALICE/CMS v_n measurements in O+O

Outlook

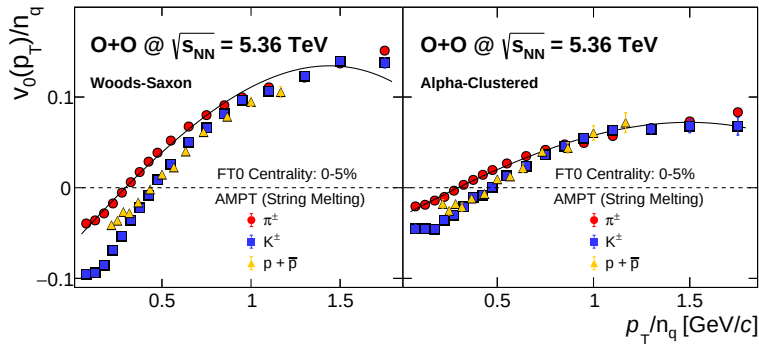
- Confront model results with O+O data from RHIC and LHC
- Extend to pp , $p+O$, Ne+Ne with PYTHIA8 and AMPT models for the full system-size trend

Thank you for listening!

“Ich hab’ mein Herz in Heidelberg verloren”

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Supported by the DST-INSPIRE Fellowship, Government of India.

Backup: p_T/n_q vs. $(m_T - m_0)/n_q$ scaling variable



Geometry profile	S_f
Woods-Saxon	0.843
α -Clustered	0.415

- p_T/n_q scaling does *not* hold well in either geometry
- Switching to $(m_T - m_0)/n_q$ markedly improves the collapse, quantified via S_f parameter