



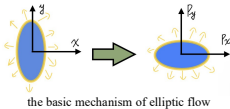
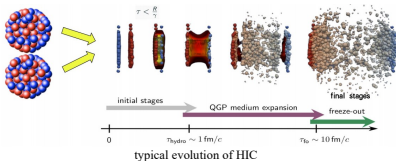
Collective flow measurements in OO and NeNe collisions with CMS

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For the CMS collaboration
QCD@LHC 2026



復旦大學
FUDAN UNIVERSITY

1 Flow in heavy ion collisions



The azimuthal (ϕ) distributions of particles:

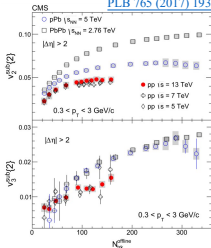
$$\frac{2\pi}{N} \frac{dN}{d\phi} = 1 + 2 \sum_{n=1}^{\infty} v_n \cos(n(\phi - \Psi_n))$$

Flow coefficient: $v_n = \langle \cos[n(\phi_i - \Psi_n)] \rangle$

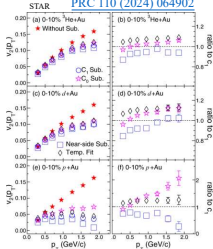
v_2 : elliptic flow v_3 : triangular flow

1 QGP in small systems

PLB 765 (2017) 193



PRC 110 (2024) 064902

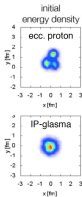
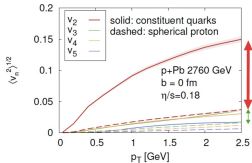


Flow-like signals have been observed in pp, pA and light ion-heavy ion systems.

Is QGP produced in small systems?

1 QGP in small systems

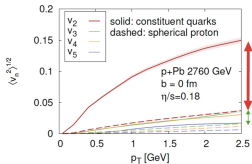
credit: bjoern schenke



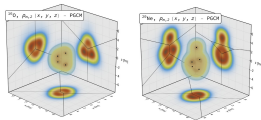
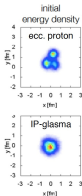
Challenge from the proton structure

1 QGP in small systems

credit: bjoern schenke



Challenge from the proton structure



ab initio models of ^{16}O and ^{20}Ne

Advantages:

- The nucleon-level geometry** dominates over the subnucleon structure
- The comparable size** leads to similar hydrodynamic evolution

2 Dataset

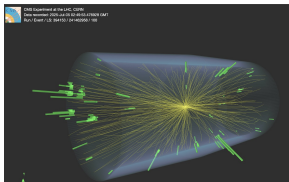
Collision systems:

$^{16}\text{O}-^{16}\text{O}$ (7nb^{-1}) & $^{20}\text{Ne}-^{20}\text{Ne}$ (0.8nb^{-1})

Collected in July 2025 at CMS, $\sqrt{s_{NN}} = 5.36\text{TeV}$

Standard CMS HIN event and track selection

- Minimum bias events, only one reconstructed vertex
- $0.3 < p_T < 3.0 \text{ GeV}/c$, $|\eta| < 2.4$

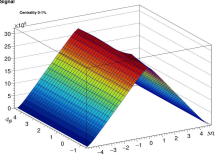


event display of OO collisions

2 Flow measurement method

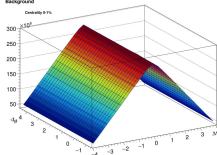
- Two-particle correlation:
$$\frac{1}{N_{trig}} \frac{d^2 N^{pair}}{d\Delta\eta d\Delta\phi} = B(0,0) \times \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}$$

OO ($\sqrt{s_{NN}} = 5.36$ TeV) $|\eta| < 2.4$ $0.3 < p_T < 3.0$
Signal



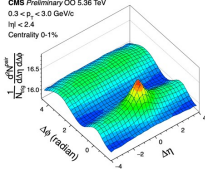
Signal

OO ($\sqrt{s_{NN}} = 5.36$ TeV) $|\eta| < 2.4$ $0.3 < p_T < 3.0$
Background



Background

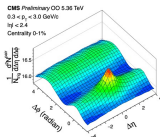
CMS Preliminary OO 5.36 TeV
 $0.3 < p_T < 3.0$ GeV/c
 $|\eta| < 2.4$
Centrality 0-1%



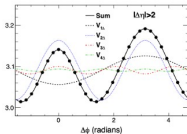
2D function: S/B

2 Flow measurement method

- 1D projection:
$$\frac{1}{N_{trig}} \frac{dN^{pair}}{d\Delta\phi} = \frac{N_{assoc}}{2\pi} \left[1 + \sum_n 2V_{n\Delta} \cos(n\Delta\phi) \right]$$



$|\Delta\eta| > 2$



$$v_n\{2\} = \sqrt{V_{n\Delta}}$$

- In line with previous CMS analyses, the peripheral subtraction method is employed to suppress non-flow

$$V_{n\Delta}^{sub} = V_{n\Delta} - V_{n\Delta}(\text{peripheral}) \times \frac{N_{assoc}(\text{peripheral})}{N_{assoc}} \times \frac{Y_{jet}}{Y_{jet}(\text{peripheral})}$$

In this analysis, events from 70-80% centrality are selected as peripheral events

2 Flow measurement method

- Four-particle correlation (Q-cumulant): [PRC.96.034906](#)

$$\vec{Q}_n \equiv \sum_i e^{in\bar{\phi}_i} = |Q_n| e^{in\bar{\psi}_n}$$

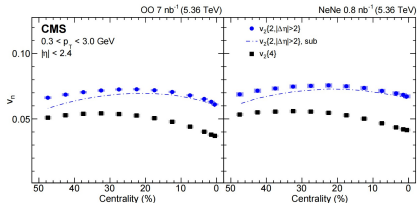
$$\langle 2 \rangle = \frac{\vec{Q}_n^2 - M}{M(M-1)},$$

$$\langle 4 \rangle = \frac{\vec{Q}_n^4 - 2\text{Re}[\vec{Q}_{2n}\vec{Q}_n^{*2}] - 4(M-2)\vec{Q}_n^2 + 2M(M-3) + \vec{Q}_{2n}^2}{M(M-1)(M-2)(M-3)}$$

$$c_n\{4\} = \langle\langle 4 \rangle\rangle - 2\langle\langle 2 \rangle\rangle^2$$

$$v_n\{4\} = \sqrt[4]{-c_n\{4\}}$$

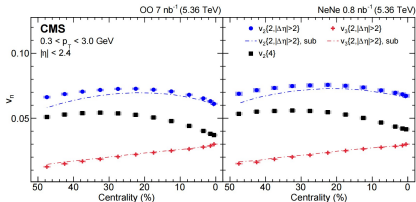
3 Results: v_n values



- Significant flow is observed
- v_2 increase and then decrease, from peripheral to central events -- the same as PbPb
- Non-flow contribution is small -- 4 to 15%
- $v_2\{4\} < v_2\{2\}$ -- impact of event-by-event fluctuations



Results: v_n values



- v_3 increase from peripheral to central events
- different from Pb-Pb, but the same as where multiplicities are comparable in PbPb collisions
- Non-flow contribution is small

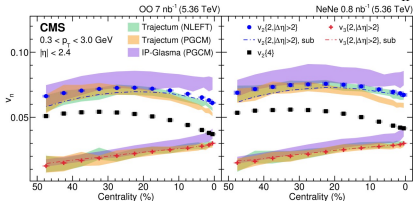


Results: v_n values

Published article: [PRL 137 \(2026\) 082302](#)

Trajectory from [PRL 135 \(2025\) 012302](#)

IP-Glasma from [PRL 135 \(2025\) 022302](#)



NLEFT:

nuclear lattice effective field theory

PGCM:

projected generator coordinate method

For v_2 values:

- All three models agree with the trend
- Trajectory with NLEFT is the best in central collisions

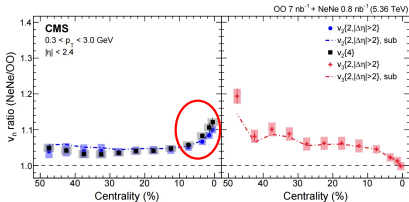
For v_3 values:

- All three models agree well with trend
- IP-Glasma overestimates in central collisions

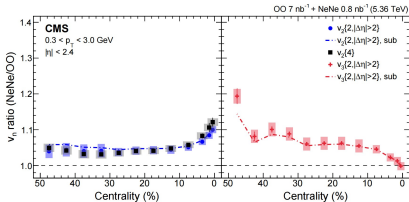


Results: Ne/O ratios of v_n

Published article: [PRL 137 \(2026\) 082302](#)



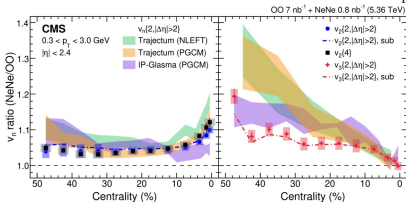
- v_2 ratio significantly increase in the most central collisions
 - non-flow is negligible
 - $v_2\{4\}$ and $v_2\{2\}$ ratio are consistent
- In central collisions, it seems that $v_2\{4\}$ ratio are larger than $v_2\{2\}$ ratio



- v_3 ratios exhibit a decreasing trend from peripheral to central collisions
- non-flow is negligible

3 Results: Ne/O ratios of v_n

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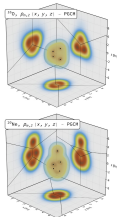


For v_2 ratios:

- Trajectory PGCM agrees with data, Trajectory NLEFT overestimates
- IP-Glasma predicts no rising trend towards central collisions

For v_3 ratios:

- All three models predict the decreasing trend
- None of the three models agrees with data quantitatively



ab initio models of ^{16}O and ^{20}Ne

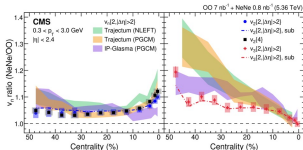
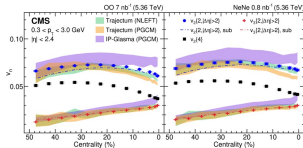
- New measurement of $v_2\{2\}$, $v_2\{4\}$ and $v_3\{2\}$ in OO and NeNe collisions at 5.36 TeV

Significant flow is observed

- Measurement of the ratios of NeNe to OO v_n values

Significant rising trend towards central collisions in v_2 ratio

Further flow measurements in OO collisions are ongoing, with more results to come

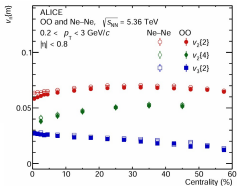
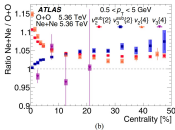
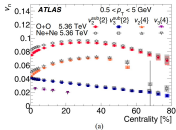
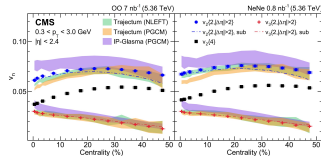


Thanks for your attention !

Jiateng Peng, FDU
For the CMS collaboration

Backup: results from ALICE and ATLAS

CMS: [PRL 137 \(2026\) 082302](#)
 ALICE: [PRL 137 \(2026\) 082301](#)
 ATLAS: [PRC 113 \(2026\) 045205](#)



Backup: results from ALICE and ATLAS

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