
# Sergey Petrushanko

SINP MSU & JINR


# Recent Heavy Ion Results from LHC Experiments

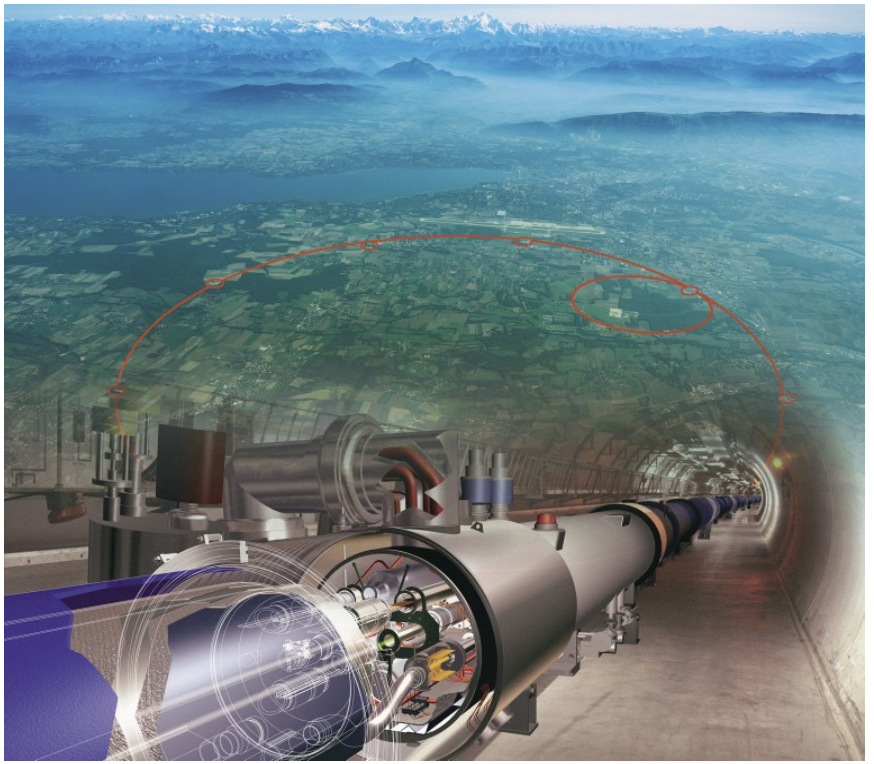

*ICPPA-2024: 7th International Conference on Particle Physics and Astrophysics*

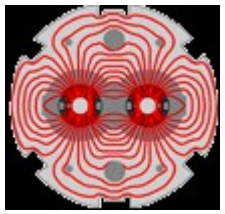
**National Research Nuclear University "MEPhI"**

**Moscow, Russia**

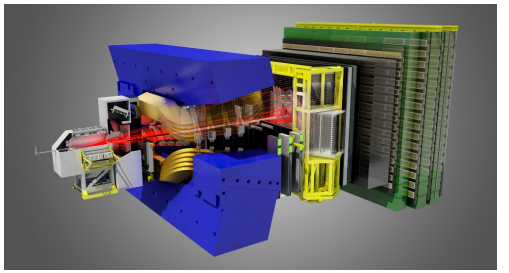
***22 – 25 October 2024***

# Heavy Ion Physics at the LHC

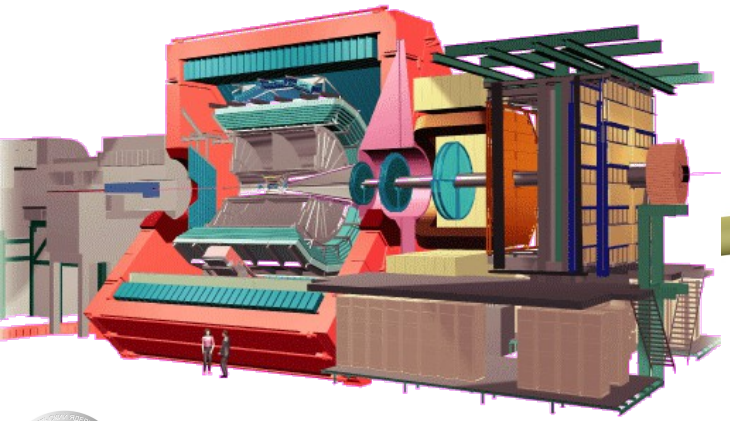




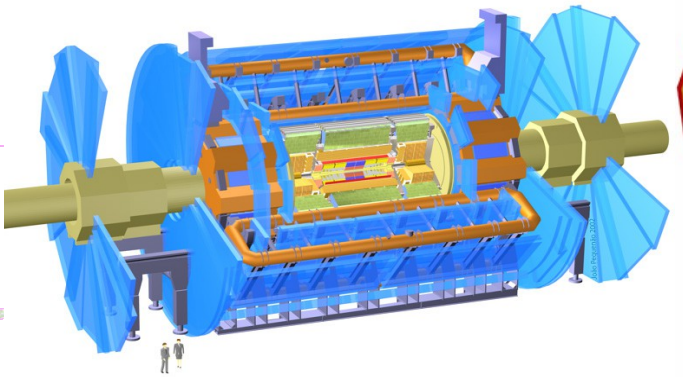
LHCb



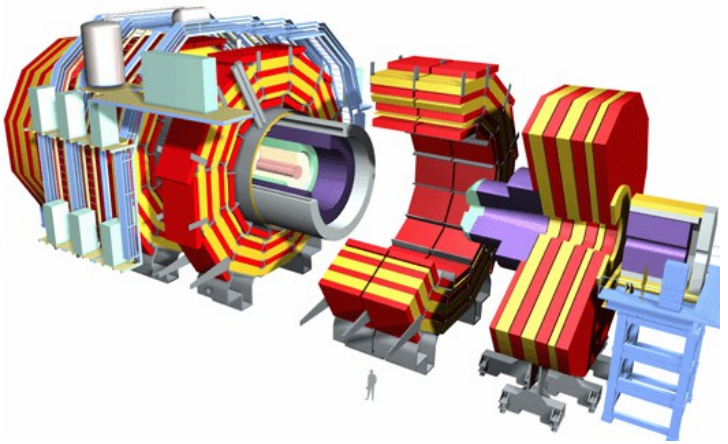
ALICE



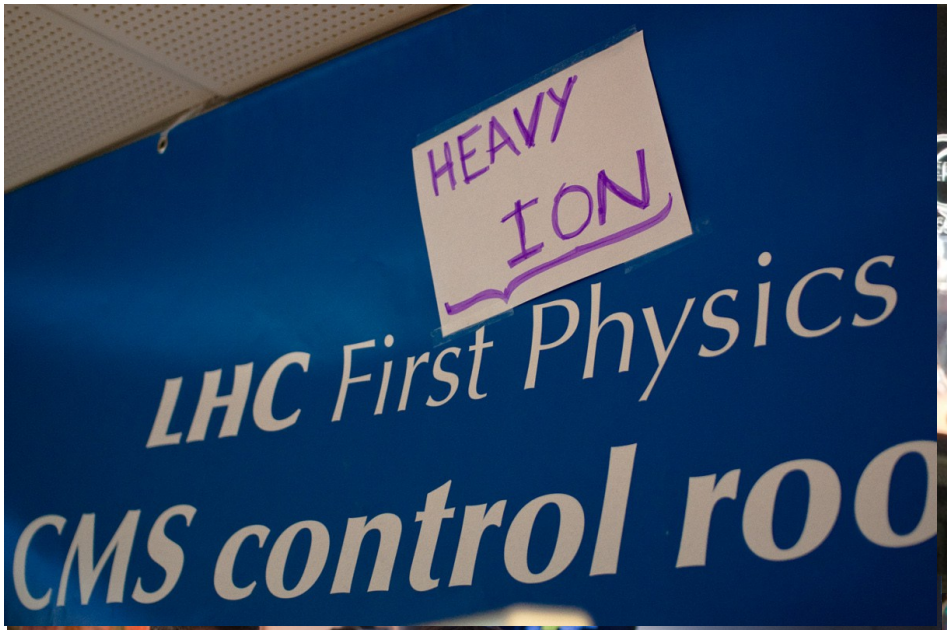
ATLAS

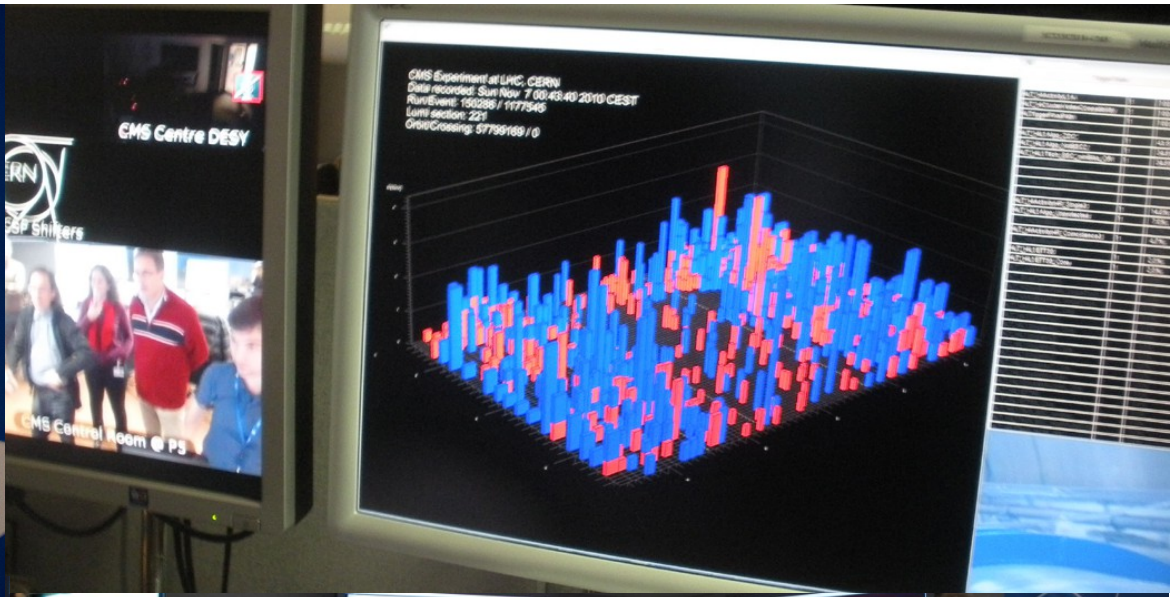


CMS



# November 7, 2010 0:27. CMS Control Room




# Heavy Ion Physics at the LHC
# New Results

## 12th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions

22 – 27 September 2024, Nagasaki, Japan

https://indico.cern.ch/event/1339555/

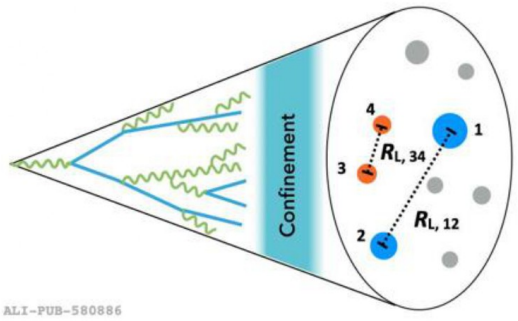
HP2024 NAGASAKI

Xiaozhi Bai **ALICE** Collaboration Overview
Qipeng Hu **ATLAS** Collaboration Overview
Gian Michele Innocenti **CMS** Collaboration Overview
Saverio Mariani **LHCb** Collaboration Overview

# Energy-energy correlators in jets in pp and p-Pb collisions

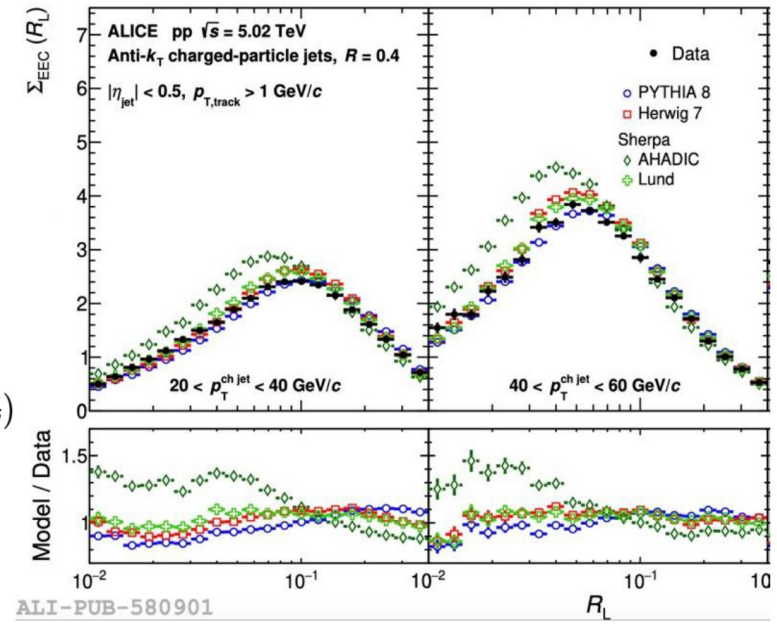
**New publication**

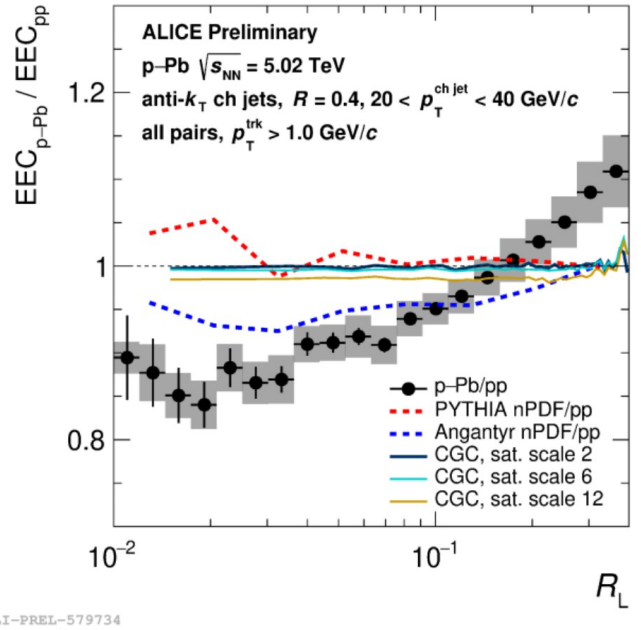
arXiv:2409.12687




$$\frac{d\sigma_{EEC}}{dR_L} = \sum_{i,j} \int d\sigma(R'_L) \frac{p_{T,i} p_{T,j}}{p'_{T,jet}} \delta(R'_L - R_{L,ij})$$

$$R_L = \sqrt{\Delta\phi_{ij}^2 + \Delta\eta_{ij}^2}$$



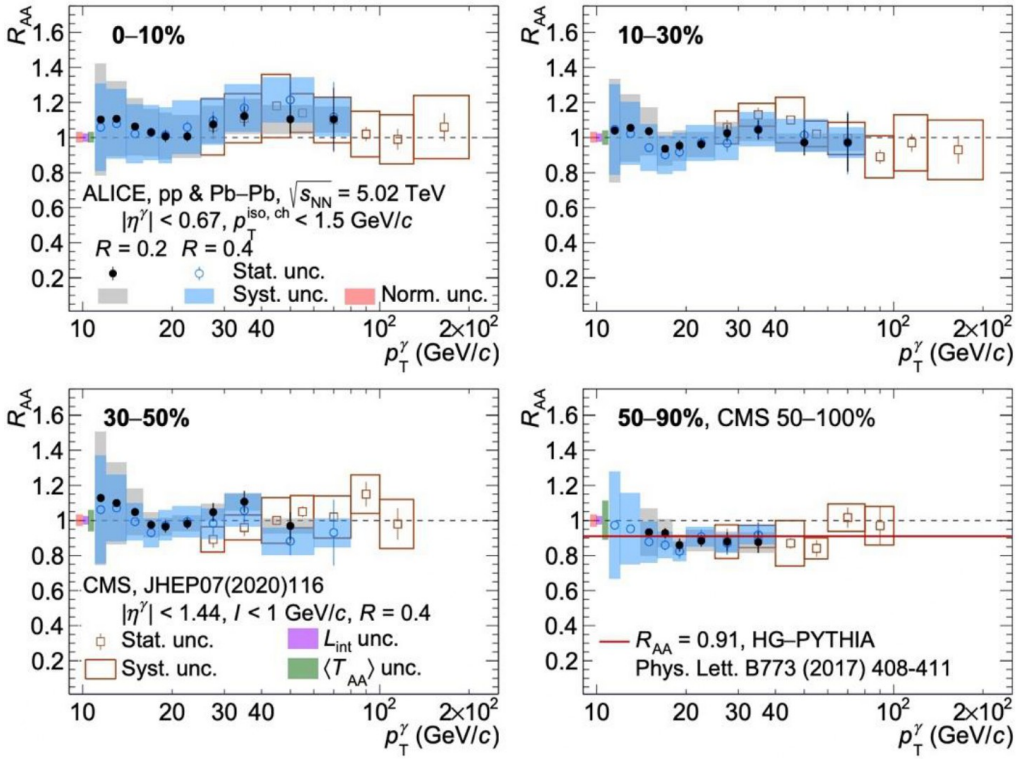




- A novel jet substructure observable describing the energy flow inside jets, can be calculated from first principles in QCD in the perturbative limit
- **Separation of the perturbative and non-perturbative** regimes

**Ananya Rai 24/09 12:10**

- Modification of the energy-energy correlator (EEC) seen in p-Pb collisions, but not explained by purely initial-state effects

# Isolated photon nuclear modification factor $R_{AA}$




**New publication**

arXiv:2409.12641

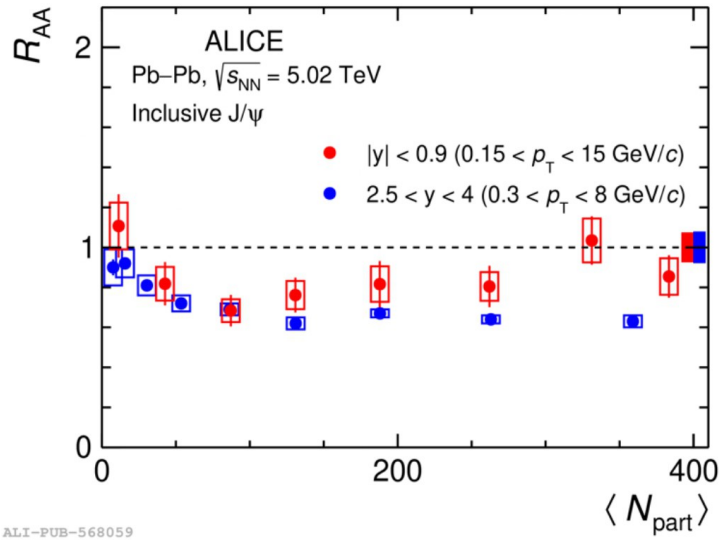
**Gustavo Conesa Balbastre** 25/09 09:00

- $R_{AA}$ **consistent with unity** within the uncertainties for both R= 0.2 and 0.4, **no radiation from QGP at these** $p_T$
- Peripheral collision in agreement with PYTHIA prediction including bias on centrality estimation

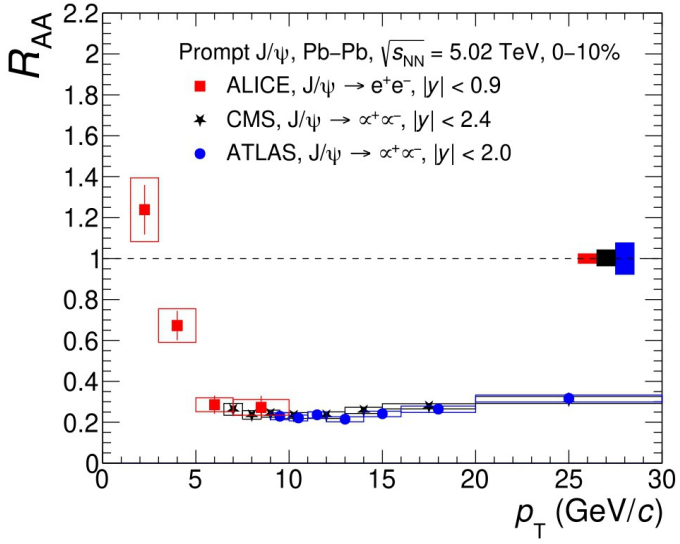
# J/ψ (re-)generation Pb–Pb collisions

ALICE, PLB 849 (2024) 138451, JHEP 02 (2024) 066

**Inclusive J/ψ**




**Prompt J/ψ**

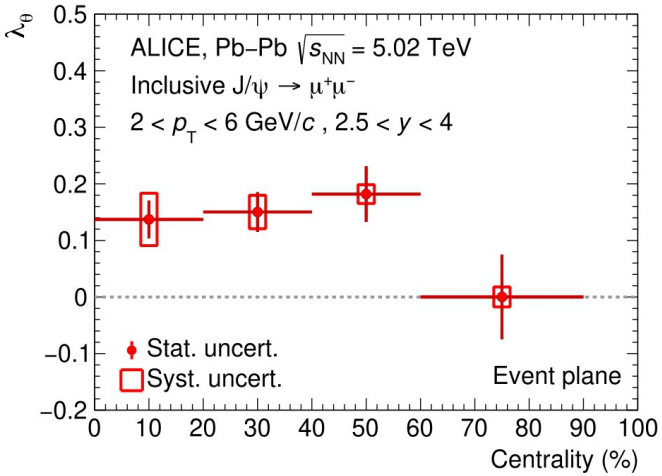


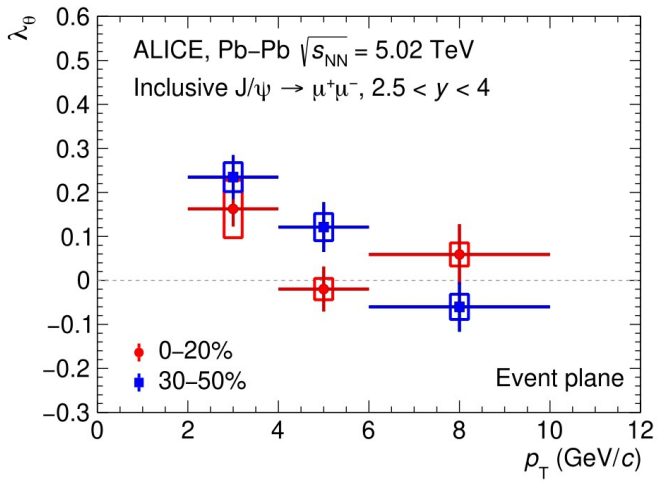

- **Evidence for J/ψ (re-)generation in central collisions, with a larger contribution at low $p_T$, and at midrapidity**
- $R_{AA}$ extended down to $p_T$ = 1.5 GeV/$c$ and compatible within uncertainties with ATLAS and CMS measurements in the common $p_T$ range

**Yuan Zhang** 24/09 10:00

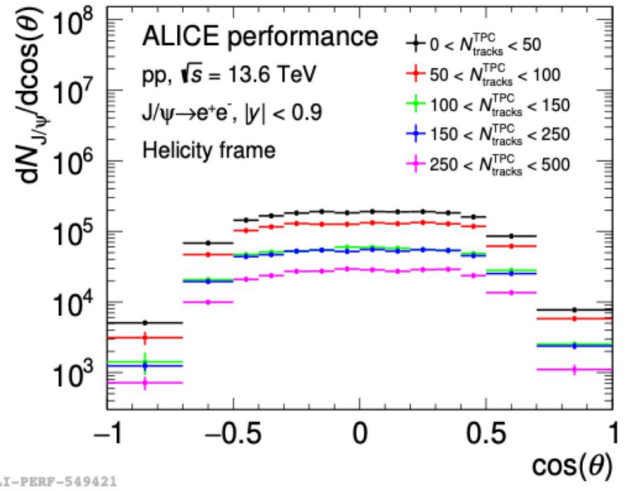
# Charmonium Polarization

ALICE, PRL 131 (2023) 4, 042303




**New performance**

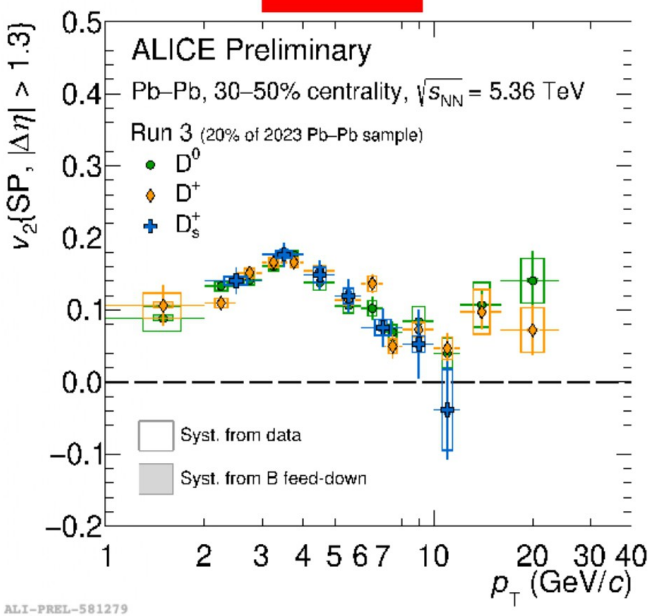



- First measurement of quarkonium polarization **w.r.t the event plane**
- Significant polarization (~**3**.9$\sigma$) observed in semicentral collisions
- Polarization measurements are ongoing at midrapidity with Run 3 data

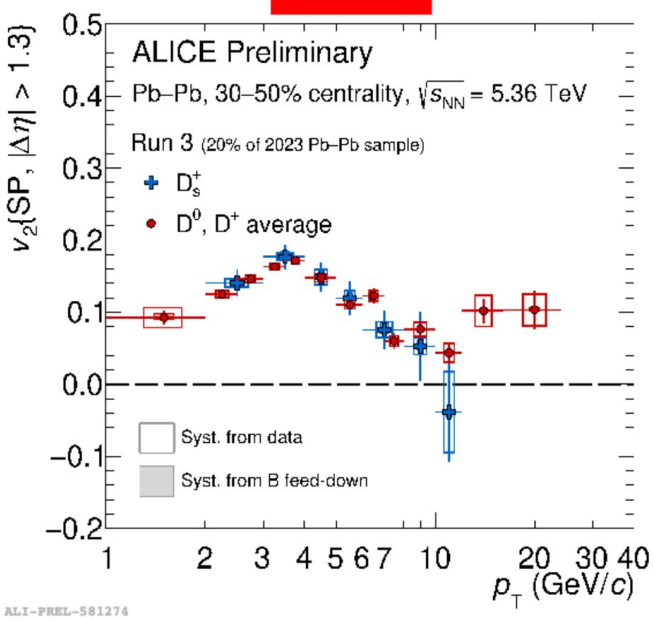
**Zhenjun Xiong** 24/09 11:30

# Strange and non-strange D-mesons elliptic flow

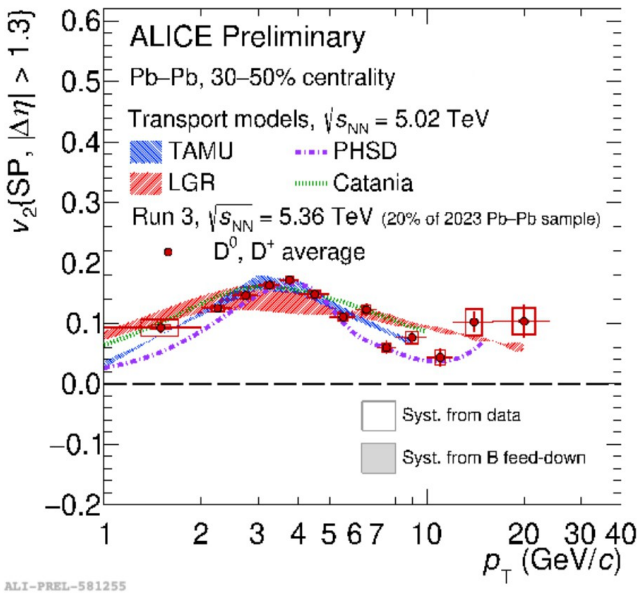
NEW




NEW



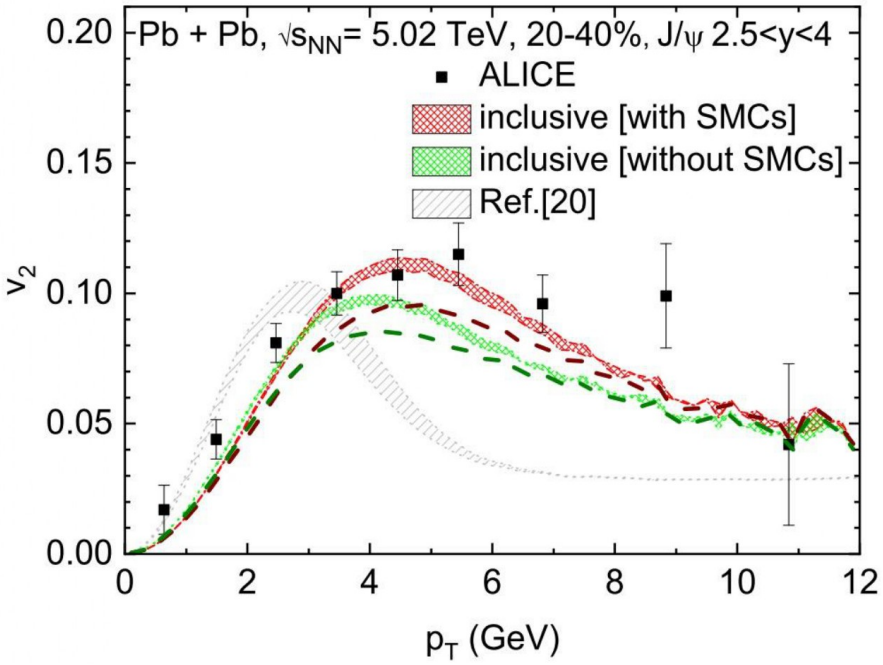

NEW **Run 3 preliminary**




- Prompt D-meson $v_2$ measured using Run 3 Pb–Pb data sample
  - No significant difference between strange and non-strange D mesons
  - Strange D-meson elliptic flow reproduced by the transport models
- About x4 larger statistics more than Run 2 one, x5 more statistics will come soon

**Biao Zhang** 23/09 16:50

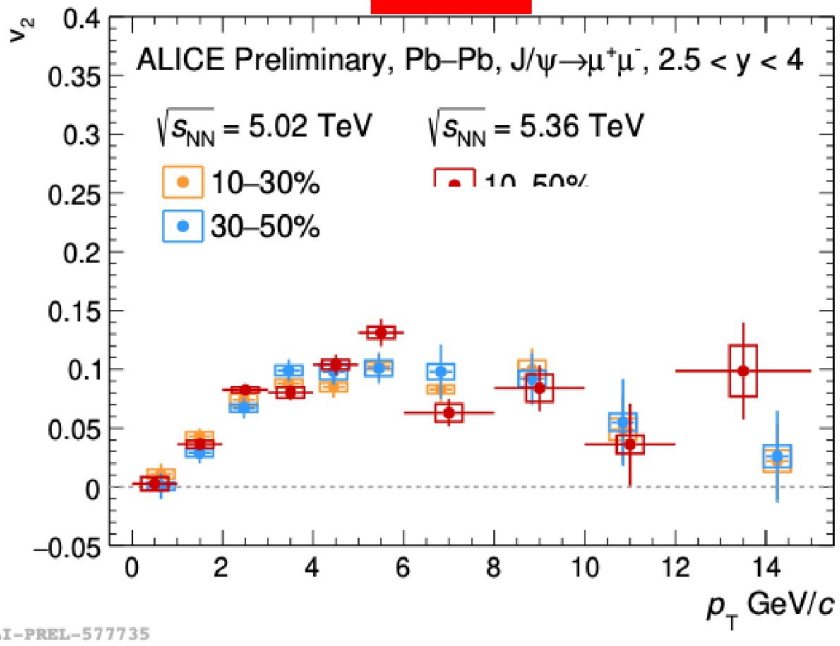
# Charmonium elliptic flow in Run 3




M. He, et al., PRL.128, 162301 (2022)

NEW

Run 3 Preliminary

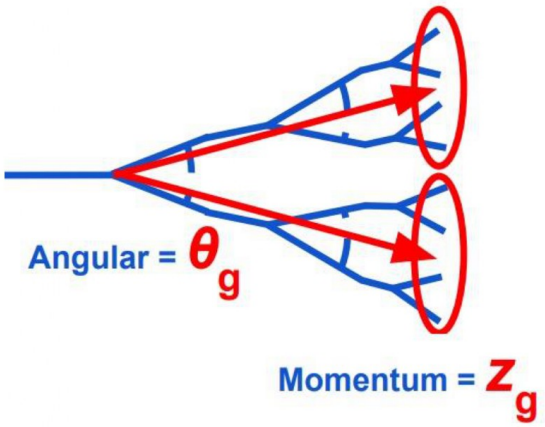


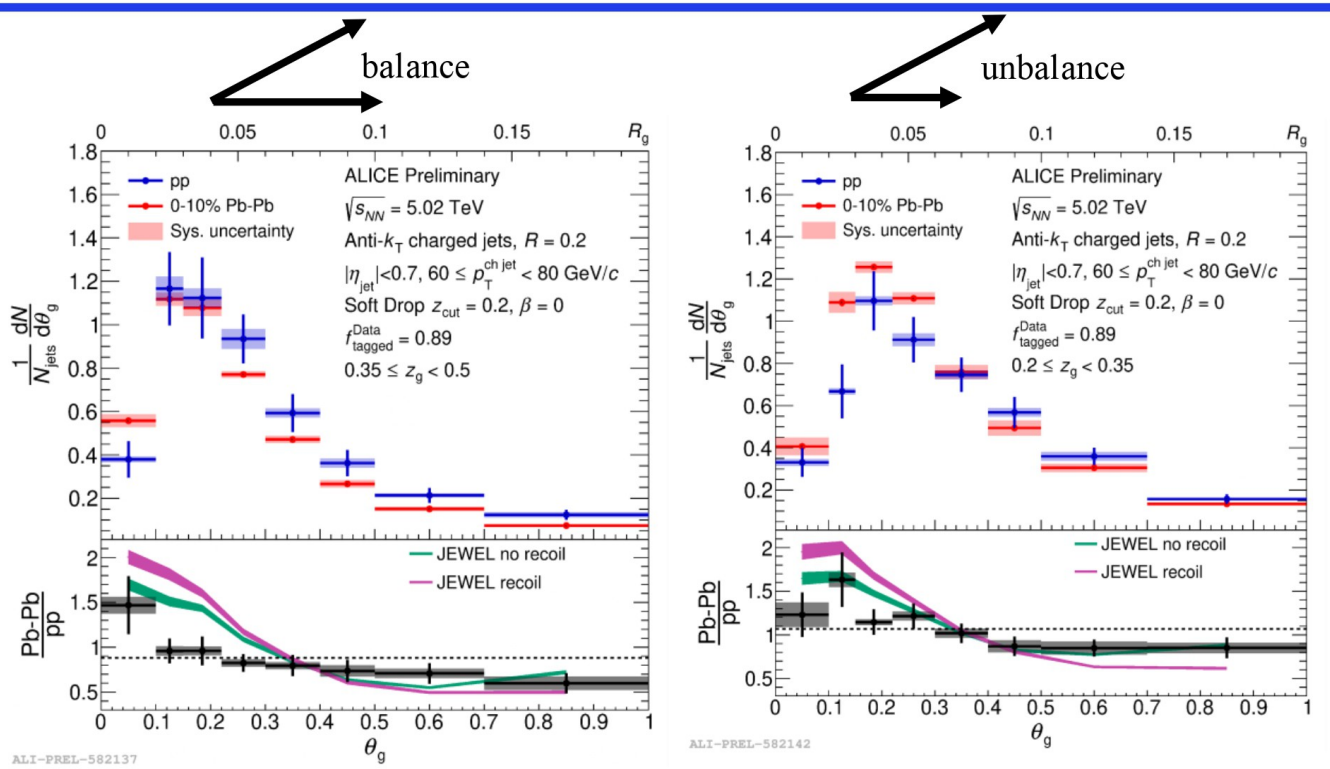

Yiping Wang 24/09 09:00

Poster by Chi Zhang 24/09

- The new result is consistent with Run 2, with statistical precision improved at low $p_T$ at forward rapidity
- A significant J/ψ $v_2$ is observed at forward rapidity, consistent with the charm quark thermalization

# Quenching with correlated jet substructure



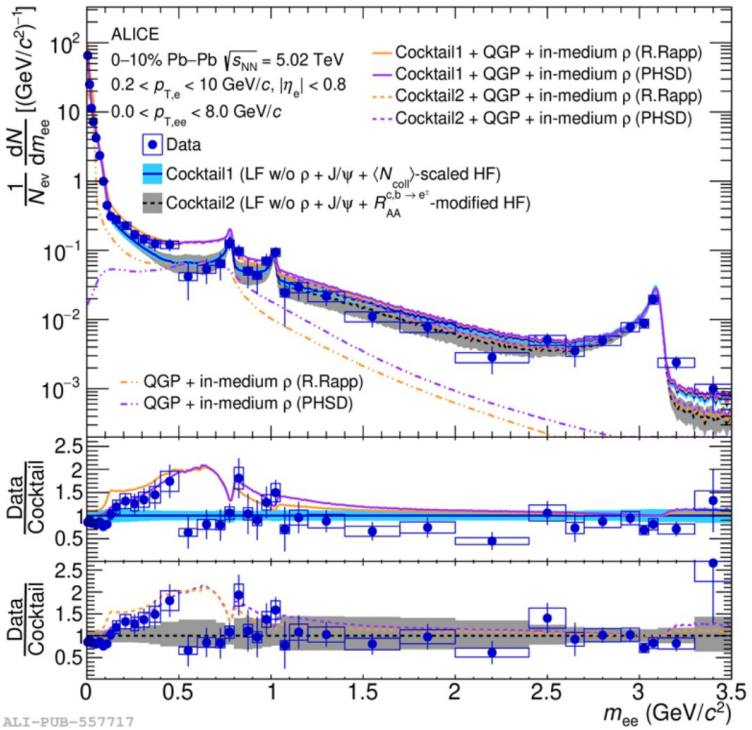

- Multidimensional measurement to disentangle jet survival bias from medium modifications
- Allow disentangling modifications to the substructure of jets from energy loss effects arising from migration of the jet momentum

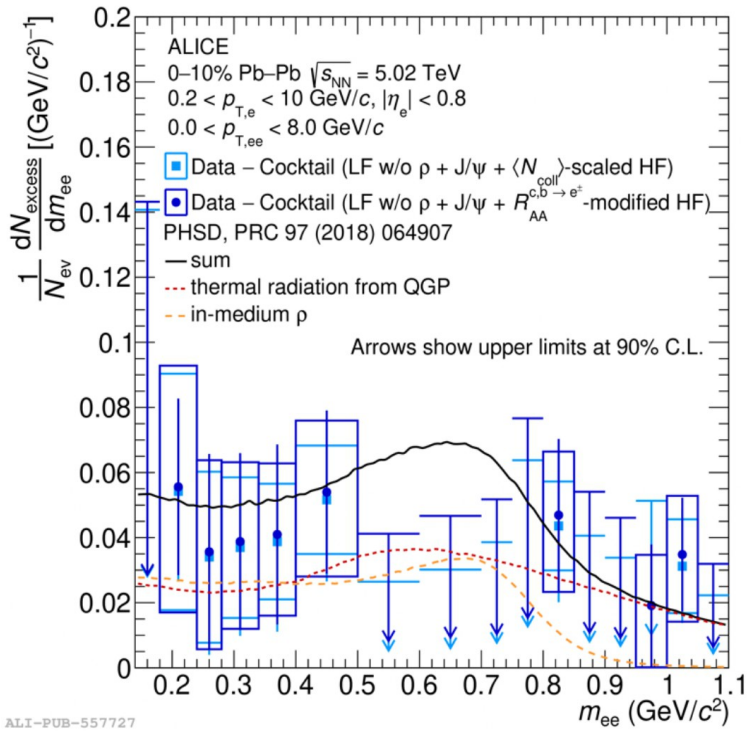
**Bas Hofman** 23/09 14:40

# Dielectron production in Pb–Pb collisions

arXiv:2308.16704

**Jerome Jung** 24/09 12:10



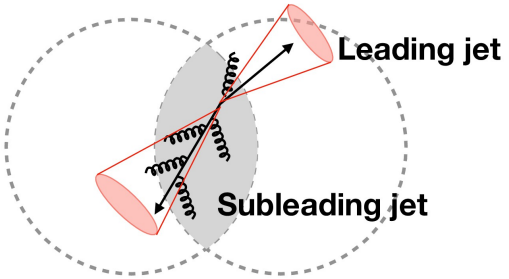




- Dielectron yield is consistent with hadronic cocktail within uncertainty, the excess in the low-mass region is 1.3$\sigma$
- More statistics and better control of HF background are needed to quantify the excess: full statistics from Run 3

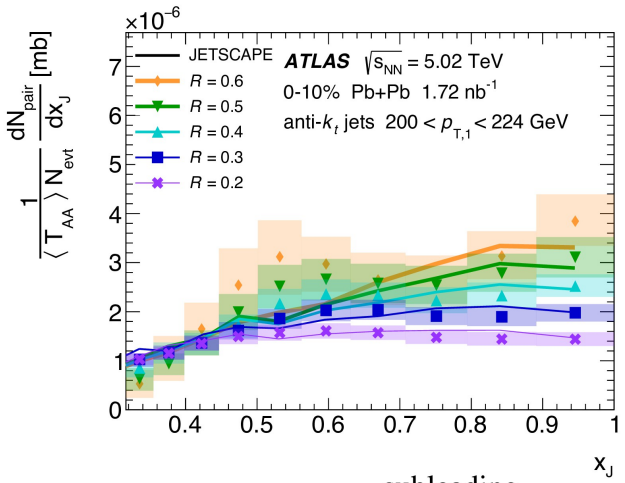
# R-dependence of dijet asymmetry

arXiv:2407.18796

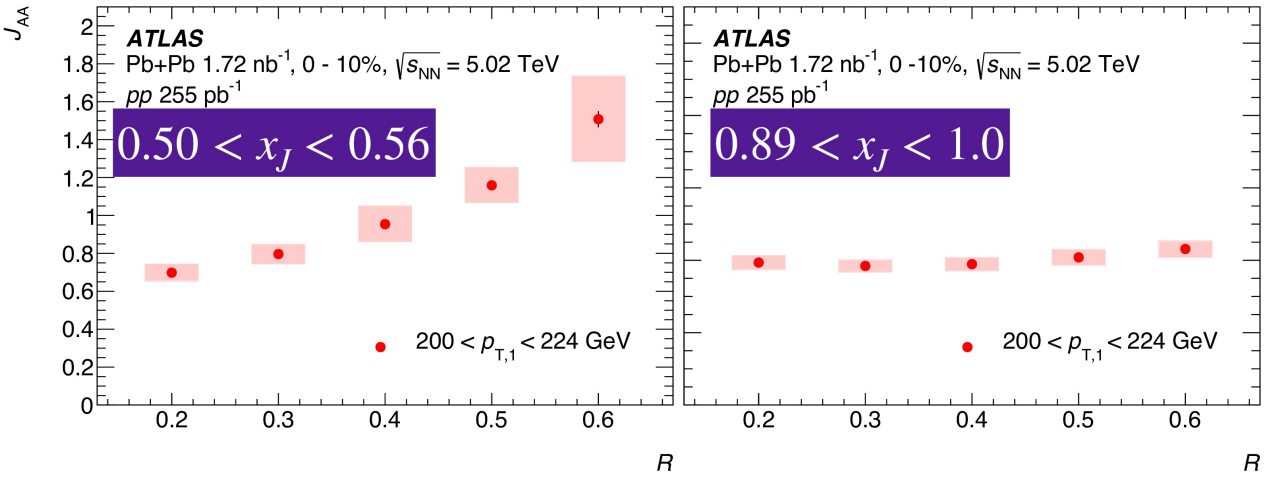
Final for HP2024




$$J_{\mathrm{AA}} = \frac{1}{\langle T_{\mathrm{AA}} \rangle N_{\mathrm{evt}}^{\mathrm{AA}}} \frac{\mathrm{d}N_{\mathrm{pair}}^{\mathrm{AA}}}{\mathrm{d}x_J} \Big/ \frac{\mathrm{d}N_{\mathrm{pair}}^{pp}}{L_{pp}\mathrm{d}x_J}$$




$$x_{\mathrm{J}} = \frac{p_{\mathrm{T}}^{\mathrm{subleading}}}{p_{\mathrm{T}}^{\mathrm{leading}}}$$

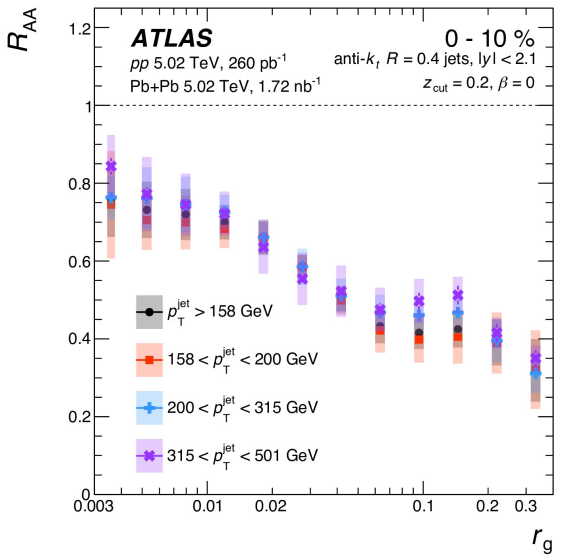


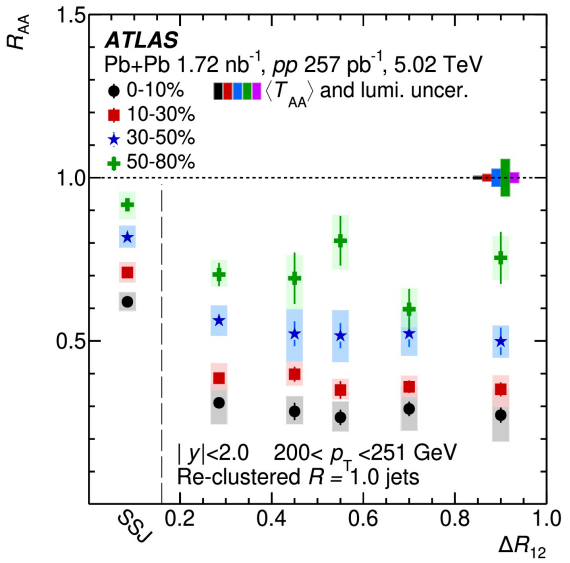

- Strong *R*-dependence for imbalanced dijets
- Smaller-*R* dijets are more suppressed

# Jet substructure — cont.

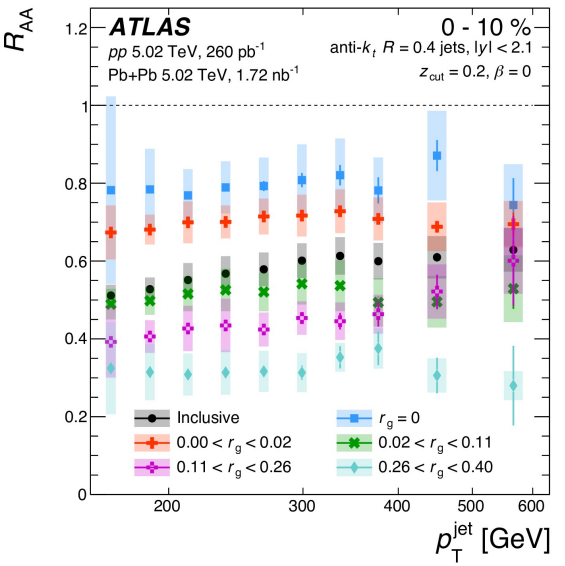
PRL 131 (2023) 172301
PRC 107 (2023) 054909

**substructure opening angle dependence**



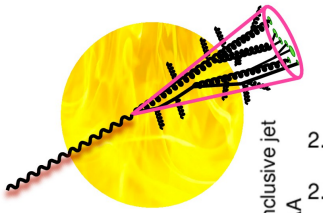

**Jet $p_T$ dependence**



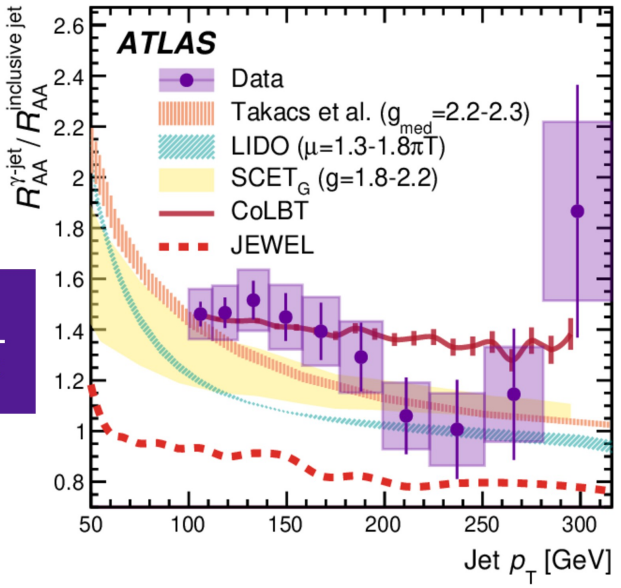

- Decoherence angular scale (**0.1 ~ 0.2**) observed in both large-*R* jets and groomed *R*=0.4 jets: significant larger energy loss above the scale
- Jet energy loss is most directly correlated with the jet substructure not jet $p_T$

# Photon-tagged jet

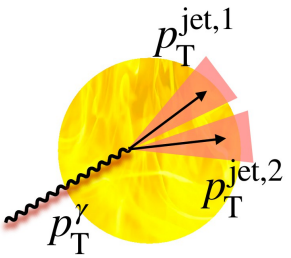
PLB 846 (2023) 138154
ATLAS-CONF-2023-008

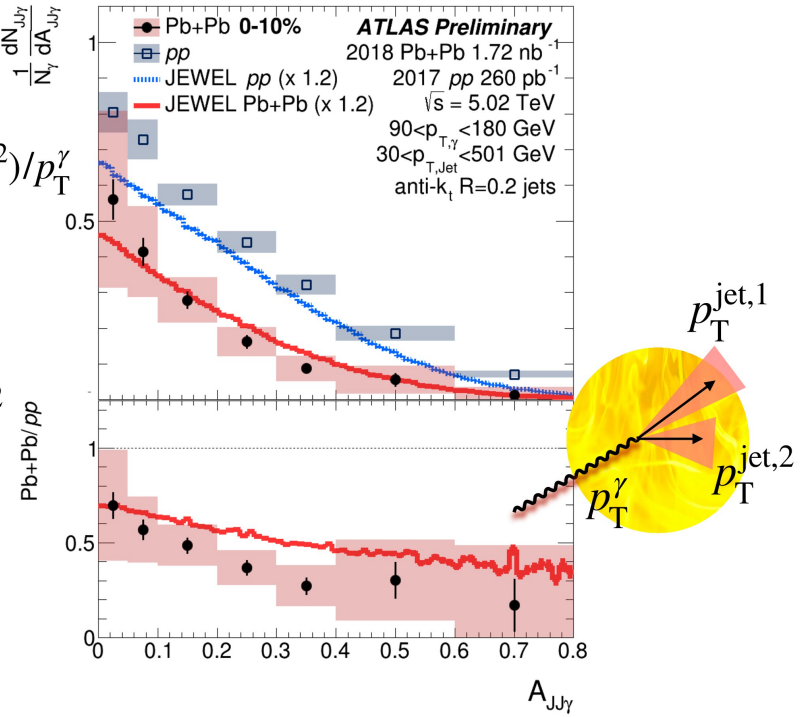


$$\frac{R_{AA}^{\gamma-\text{jet}}}{R_{AA}^{\text{inclusive jet}}}$$




$$A_{JJ\gamma} = (p_T^{\text{jet},1} - p_T^{\text{jet},2})/p_T^{\gamma}$$




- Photon-tagged jets: avoiding jet selection bias and enhancing quark jet fraction; $R_{AA}^{\gamma-\text{jet}}/R_{AA}^{\text{inclusive jet}}$ provides an important constraint for various models
- Photon-tagged multi-jet: complementing the previously shown dijet and jet substructure studies

Qipeng Hu (USTC)

Wednesday 9:00AM
Dominik Derendarz

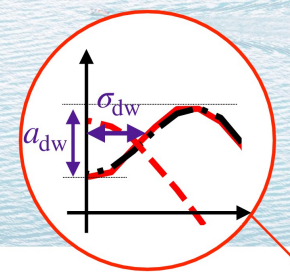
# Jet-induced diffusion wake

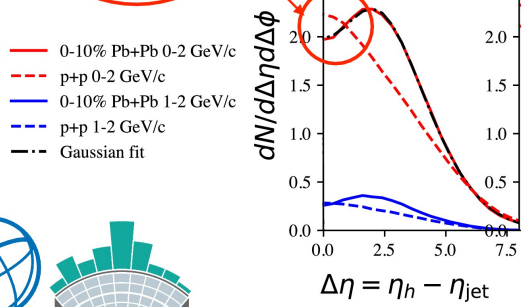
arXiv:2408.08599

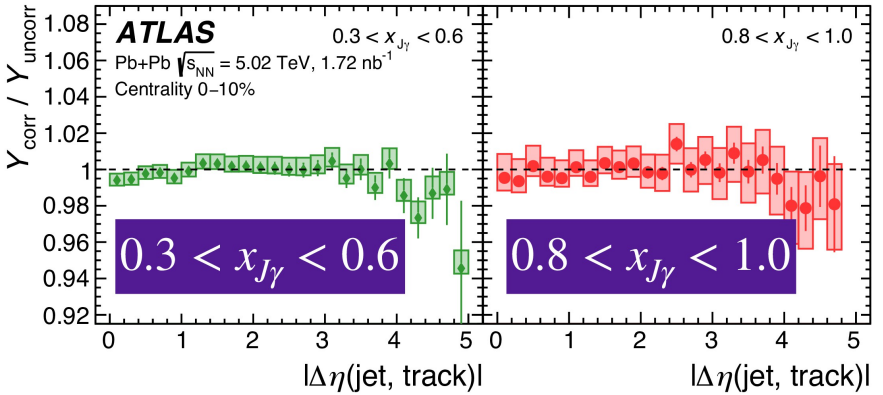
Final for HP2024

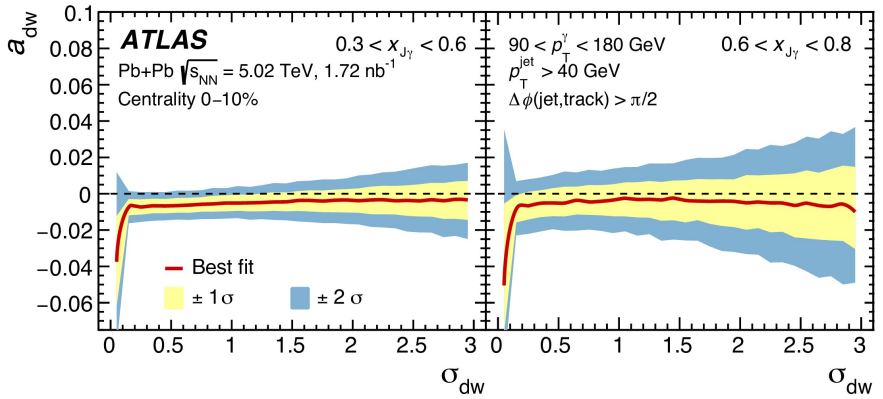
Lost energy → hydrodynamic evolution diffusion wake

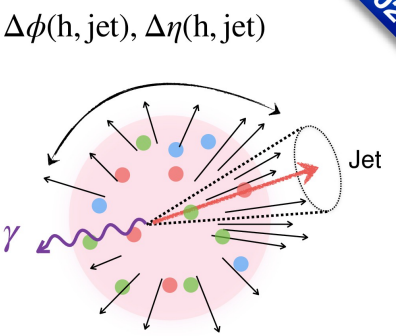
Follow proposal of **CoLBT** PRL 130 (2023) 052301 look at photon-jet: depletion in charged particle production perpendicular to the jet



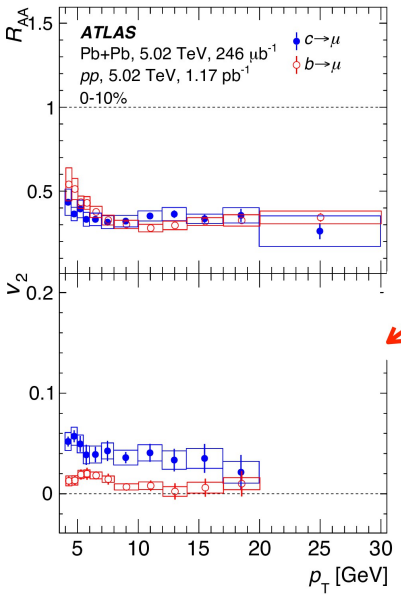

- No significant diffusion wake within the present uncertainties.
- Difference between different $x_{J\gamma}$ are consistent with CoLBT

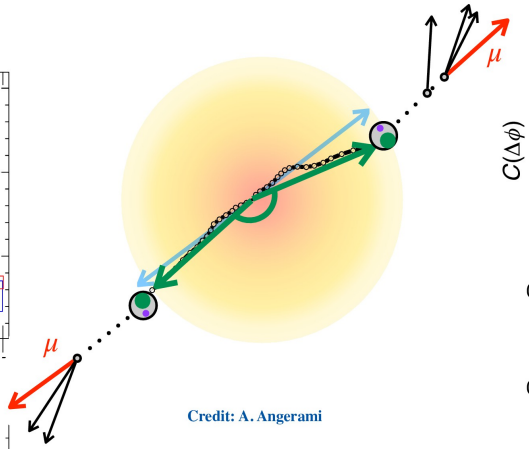
Qipeng Hu (USTC)

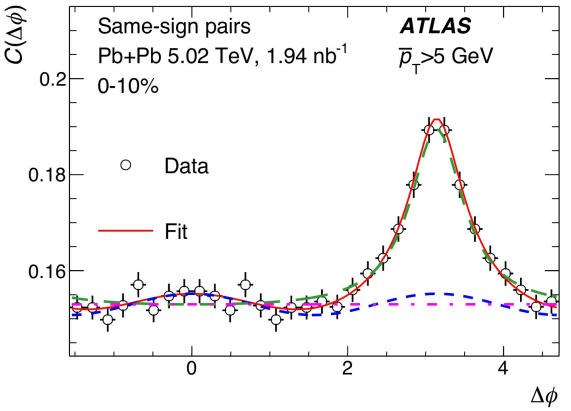
Wednesday 9:20AM
Yeonju Go

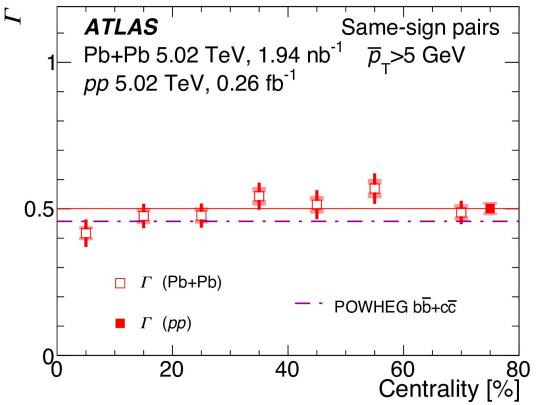
# Heavy flavor probe of QGP

PLB 807 (2020) 135595
PLB 829 (2022) 137077
PRL 132 (2024) 202301



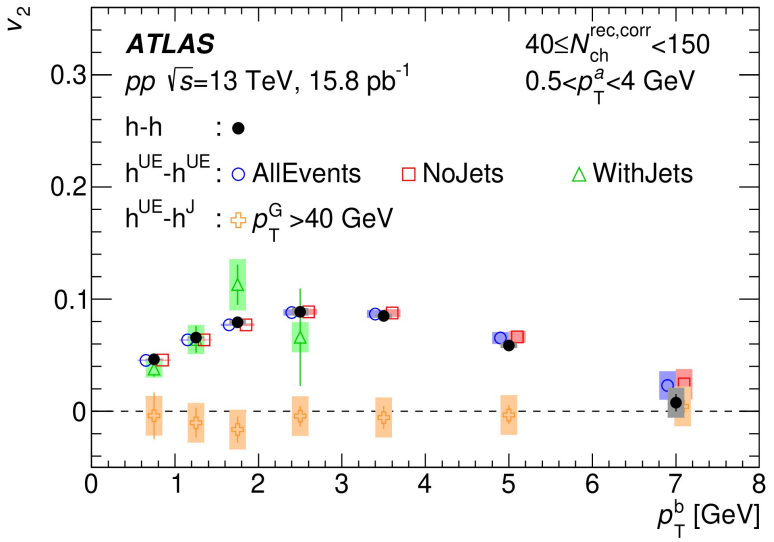




- Single heavy flavor production is strongly modified
- Azimuthal correlation of heavy flavor **pairs** may be distorted by scatterings in the medium, characterized by centrality dependence of away-side width
- No significant broadening compared to pp collisions and NLO generator without QGP

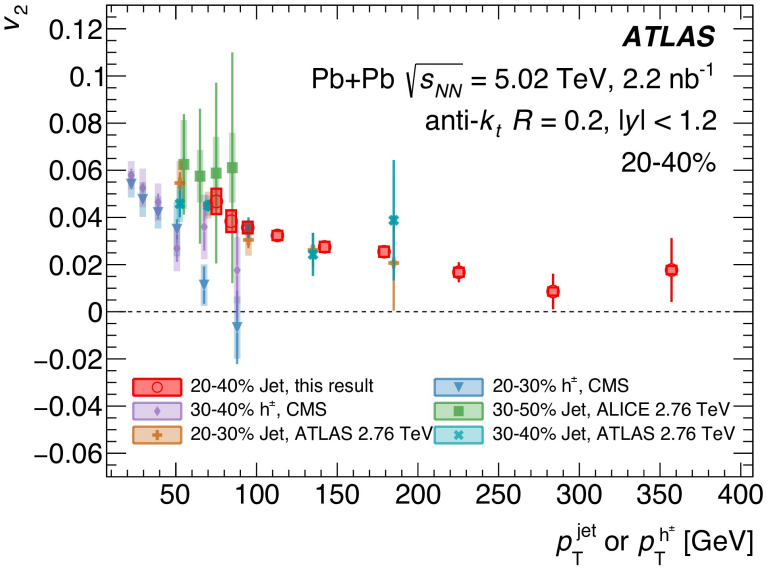
# Jet-UE correlation

PRL 131 (2023) 162301
PRC 105 (2022) 064903

**pp**




**Pb+Pb**




In pp collisions:

- Jets do not affect UE collectivity
- Jet-fragment particles do not exhibit collective behavior

In Pb+Pb collisions: jets have significant elliptic flow from path-length dependence of energy loss

Qipeng Hu (USTC)

Monday 2:20 PM
Blair Seidlitz

12

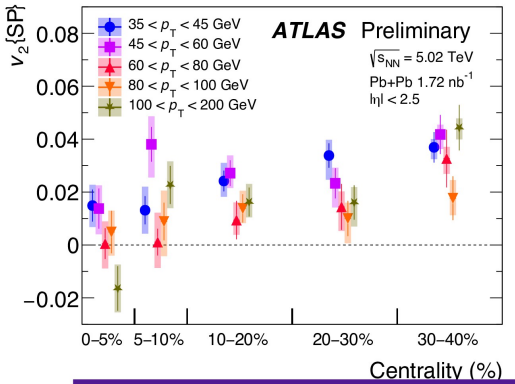
# Jet and Jet-particle $v_n$ in Pb+Pb

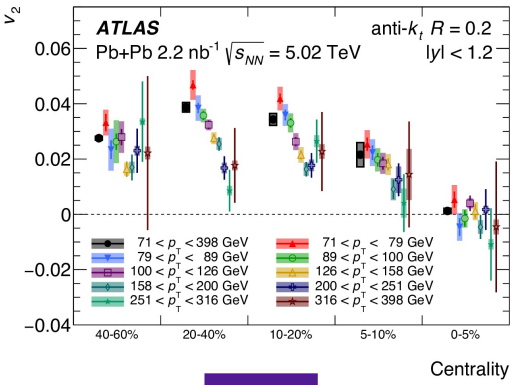
PRC 105 (2022) 064903
ATLAS-CONF-2023-007

**High $p_T$ charged-particle $v_n$**

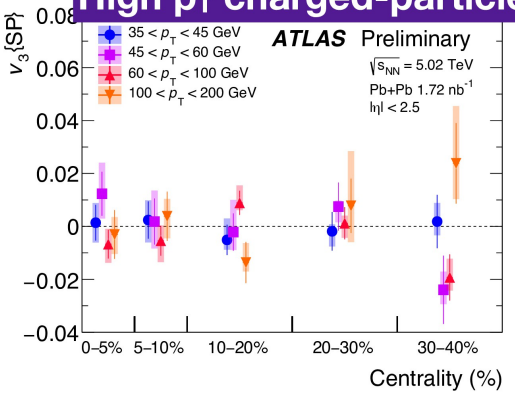
**Jet $v_n$**

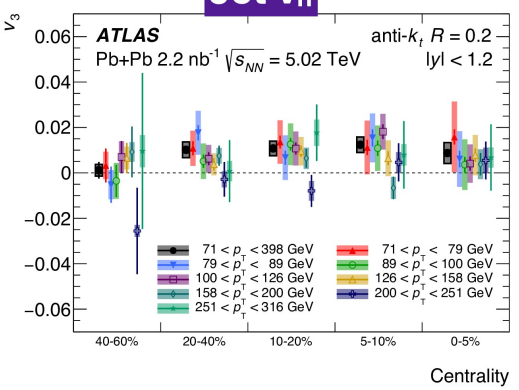
**$v_2$**




**$v_3$**




- Similar $p_T$ and centrality dependence of jet and charged-particle $v_2$
- Jet $v_3 > 0$, while high $p_T$ charged-particle $v_3 \sim 0$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Monday 5:10 PM
Xiaoning Wang

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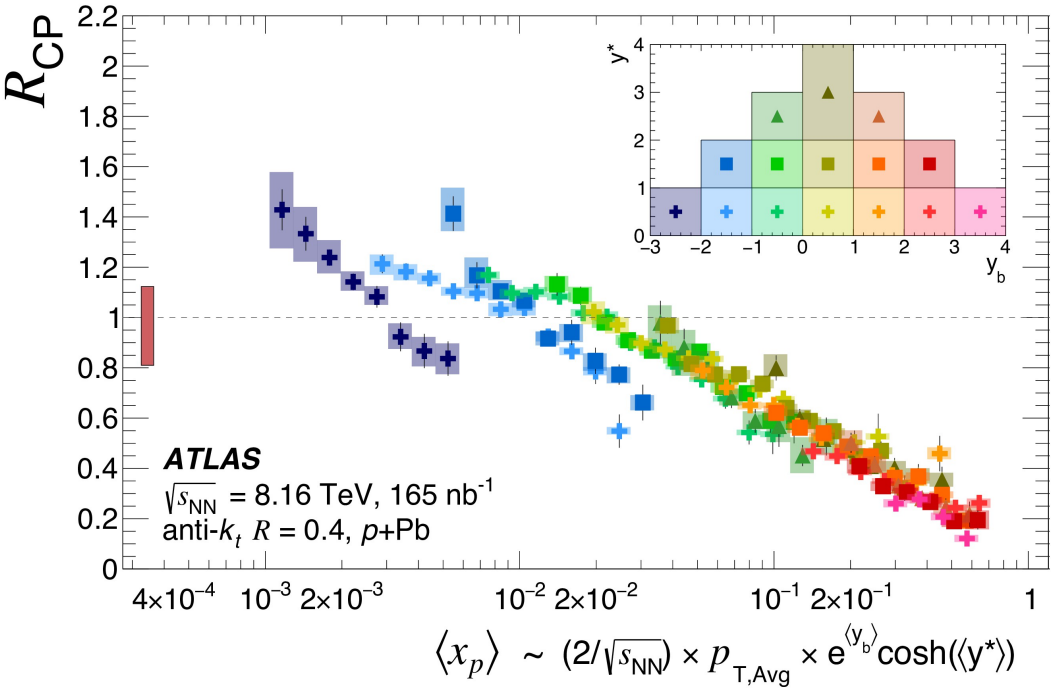
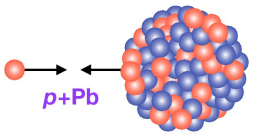
# Dijet in p+Pb

PRL 132 (2024) 102301




Dijet events in 8.16 TeV p+Pb data

$$p_{T,Avg} = \frac{p_{T,1} + p_{T,2}}{2}, \quad y_b = \frac{y_1^{c.m.} + y_2^{c.m.}}{2}, \quad \text{and} \quad y^* = \frac{|y_1^{c.m.} - y_2^{c.m.}|}{2}$$

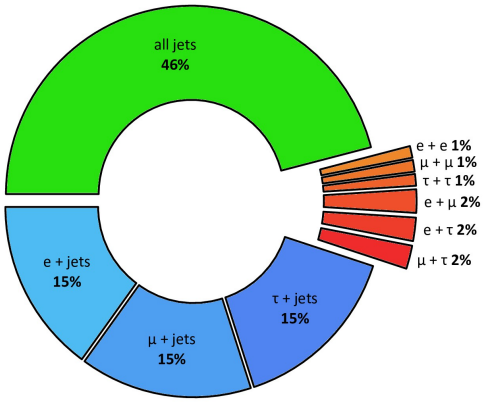
- $R_{CP}(x_p)$ is qualitatively described by the color fluctuations: smaller than average interaction strength at large $x_p$
- Centrality dependences of jet $p_T$- and rapidity-yields in p+Pb collisions were observed in Run1 are directly correlated with $x_p$ biases

Qipeng Hu (USTC)

Poster
Matthew Hoppesch

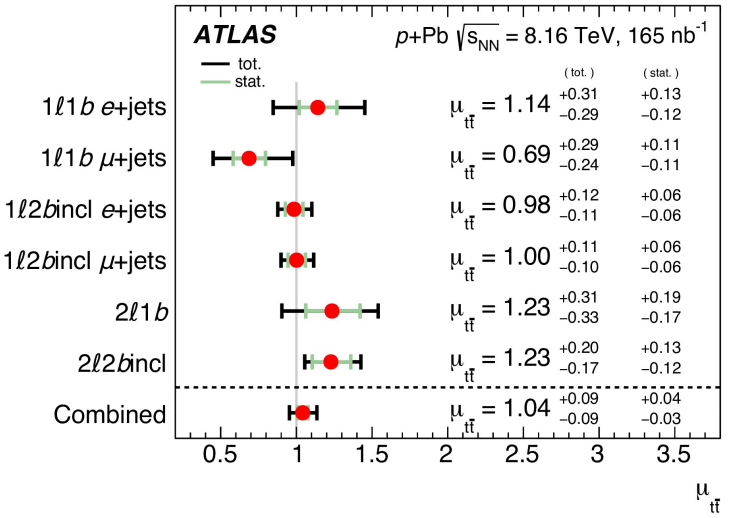
# Top pair in p+Pb

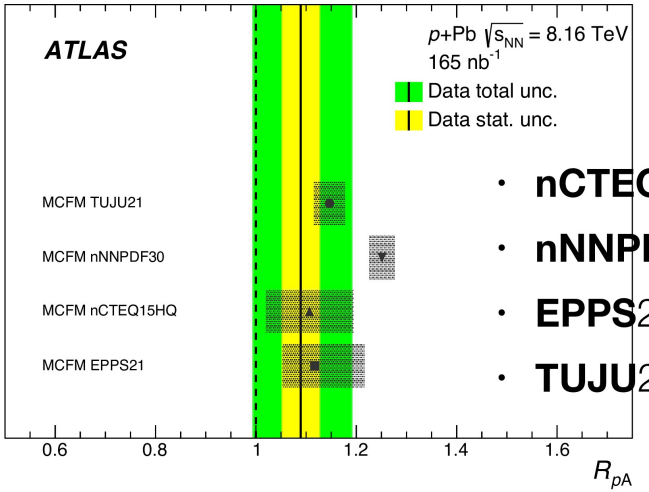
arXiv:2405.05078




$\ell$ + jets : $t\bar{t} \to WbW\bar{b} \to \ell\nu_\ell bq\bar{q}'\bar{b}$

dilepton : $t\bar{t} \to WbW\bar{b} \to \ell\nu_\ell b\ell\bar{\nu}_\ell\bar{b}$




- **nCTEQ**15 HQ
- **nNNPDF** 3.0
- **EPPS**21
- **TUJU**21

- The $t\bar{t}$ cross section is measured to be $\sigma_{t\bar{t}} = 58.1 \pm 2.0^{+4.8}_{-4.4}$ nb
- Extrapolated $R_{\text{p+Pb}}$ is consistent with unity; nNNPDF overestimates of $t\bar{t}$ $R_{\text{p+Pb}}$

HP2024 NAGASAKI

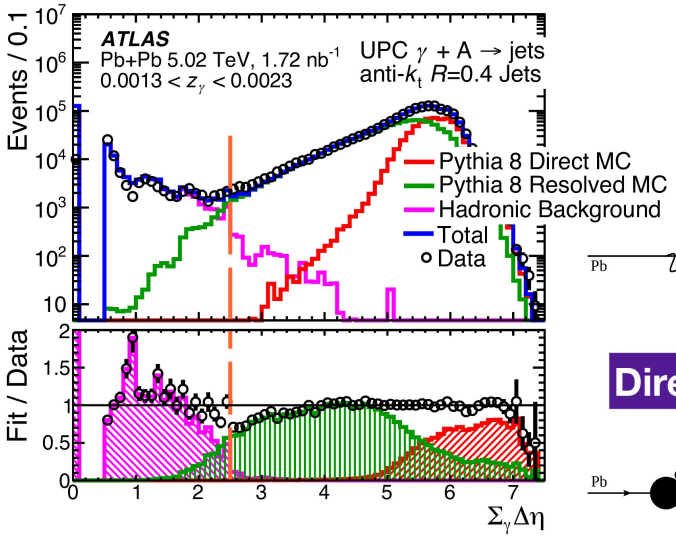
Qipeng Hu (USTC)

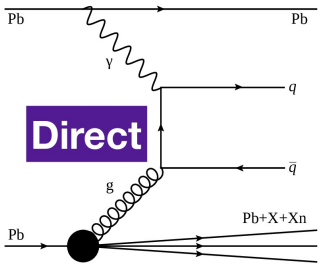
Poster
Patrycja Potepa

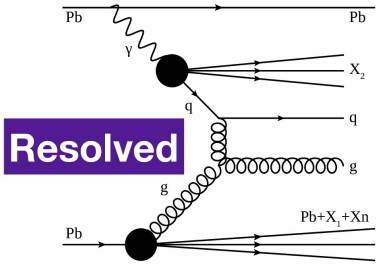
Monday 2:20PM
Patrycja Potepa

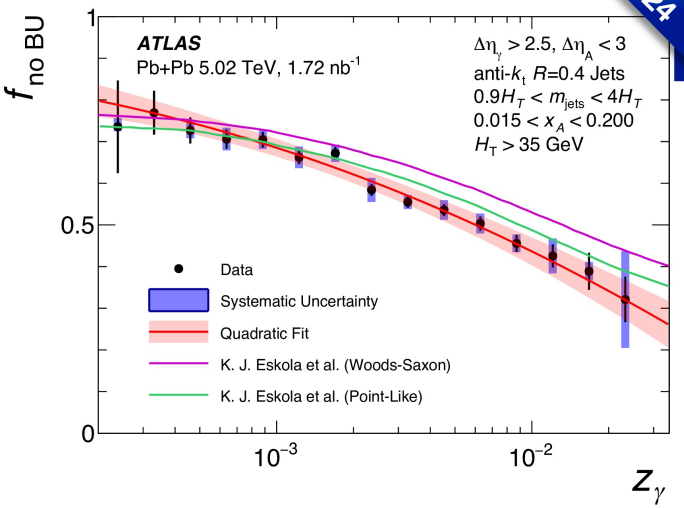
# Jets in photonuclear UPC

arXiv:2409.11060



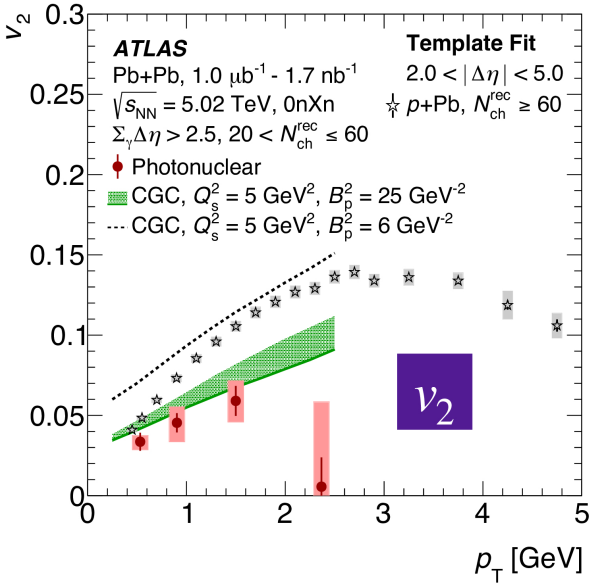



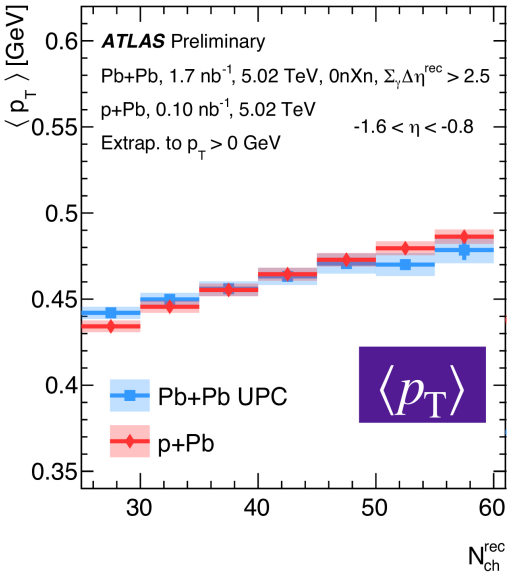

After years of detailed studies, we now confidently understand the basic properties of photonuclear UPCs with jets:

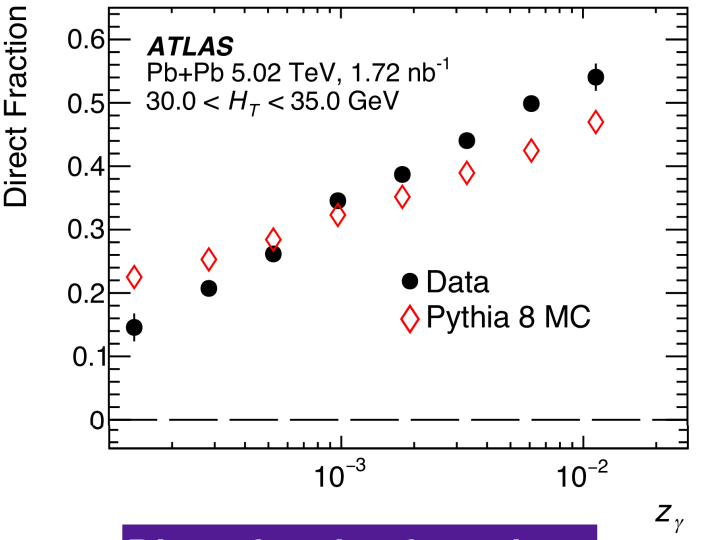
- Achieved well-modeled rapidity gaps that allows us to separate direct from resolved
- Measured break-up corrections to enable direct model comparison
- Extended jet $p_T$ down to 15 GeV while keep control over systematic

# $v_2$ and $\langle p_T \rangle$ in photonuclear interactions

PRC 104 (2021) 014903
ATLAS-CONF-2023-059




$v_2\ (p + \mathrm{Pb}) > v_2\ (\gamma + \mathrm{Pb})$

$\langle p_T \rangle\ (\gamma + \mathrm{Pb}) \approx \langle p_T \rangle\ (p + \mathrm{Pb})$

**Direct fraction from the photonuclear jet analysis**

- Could be understood as different longitudinal decorrelation and similar radial flow in the hydro picture (Zhao et al PRL 129 (2022) 252302)
- However, direct and resolved processes should be studied separately and it becomes possible

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Wednesday 11:10AM
Mateusz Dyndal

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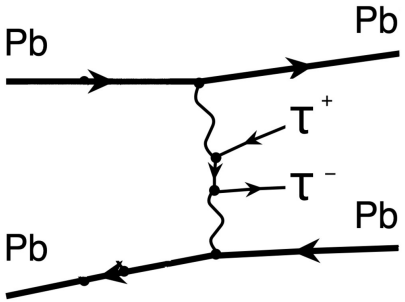
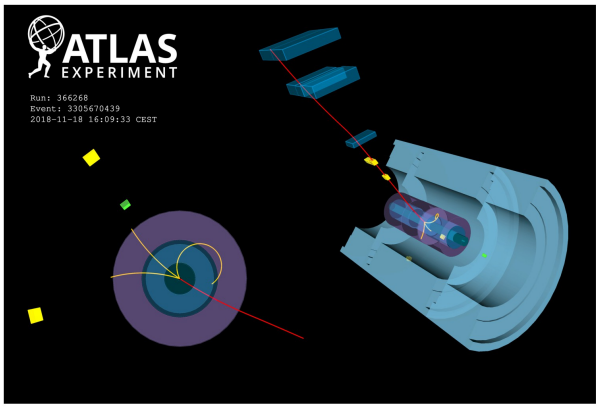
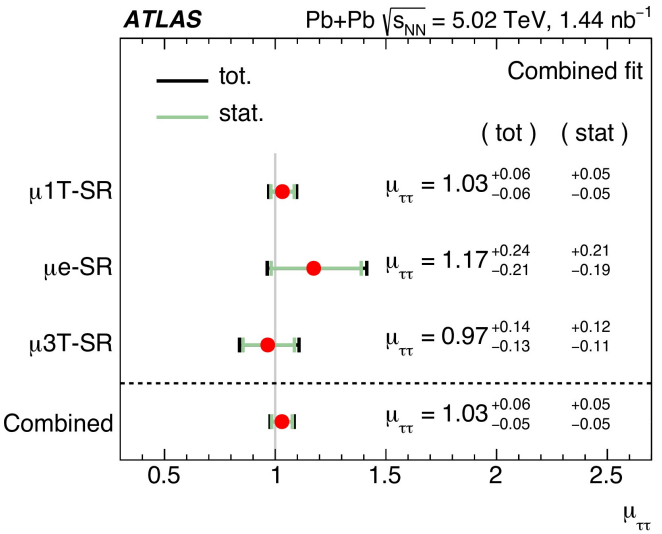
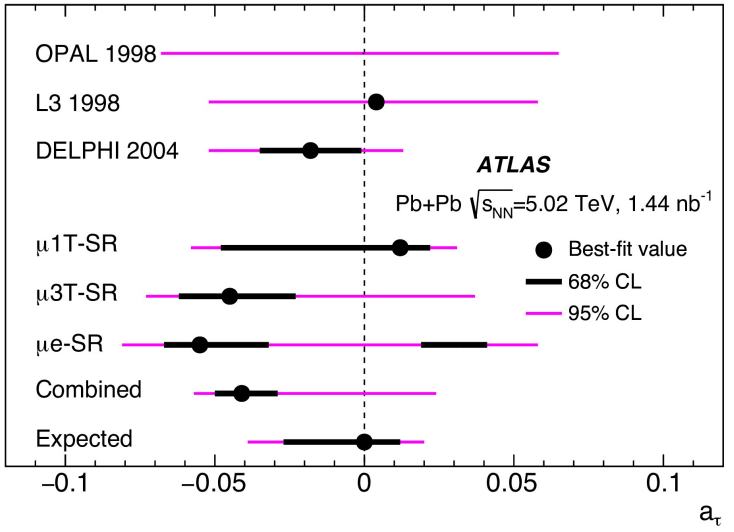
# $\tau$ anomalous magnetic moment via $\gamma\gamma \rightarrow \tau\tau$

PRL 131 (2023) 151802



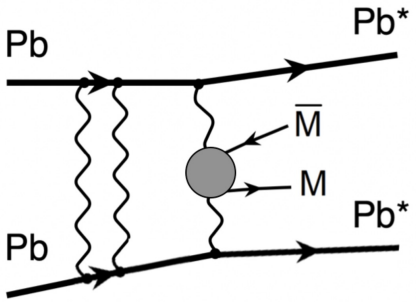



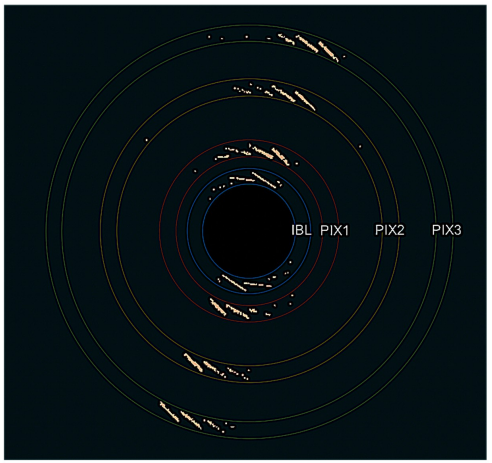

- Study (low-energy) taus for the first time in nuclear collisions
- No nuclear breakup required using ZDC to suppress hadronic background
- Constraints on $a_\tau$ extracted from the interaction strength is competitive with those observed at LEP (DELPHI)

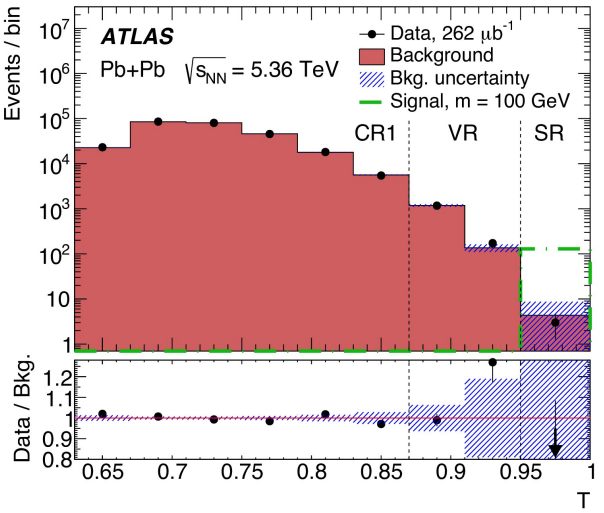
# Magnetic monopoles via $\gamma\gamma \rightarrow M\bar{M}$

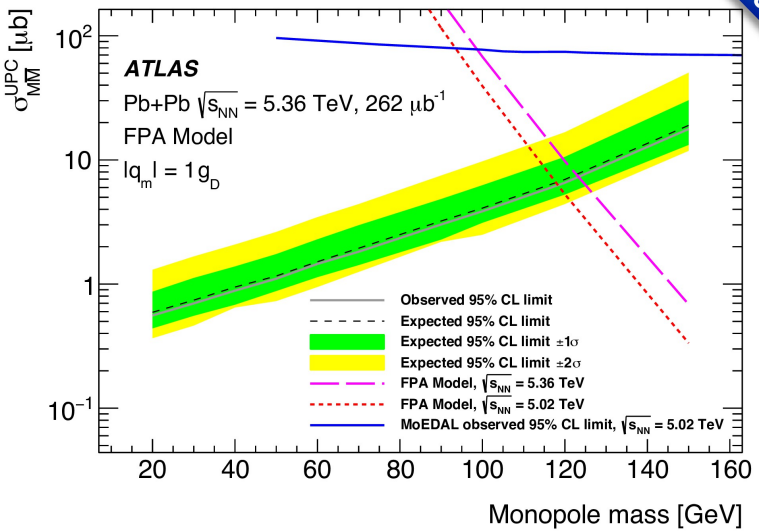
arXiv:2408.11035

Final for HP2024



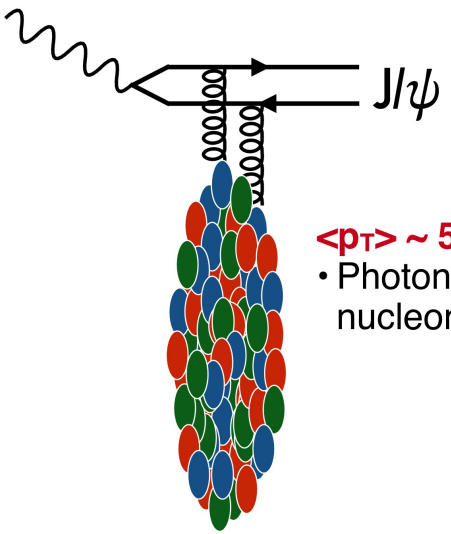

- Magnetic monopoles via the Schwinger mechanism in UPCs. First ATLAS analysis using Run3 heavy ion data
- 3 events in SR, consistent with background estimate (4 ± 4)
- Better limits compared to dedicated MoEDAL experiment (Nature 602 (2022) 63), achieve up to x8 improvement at masses below 120 GeV

Qipeng Hu (USTC)

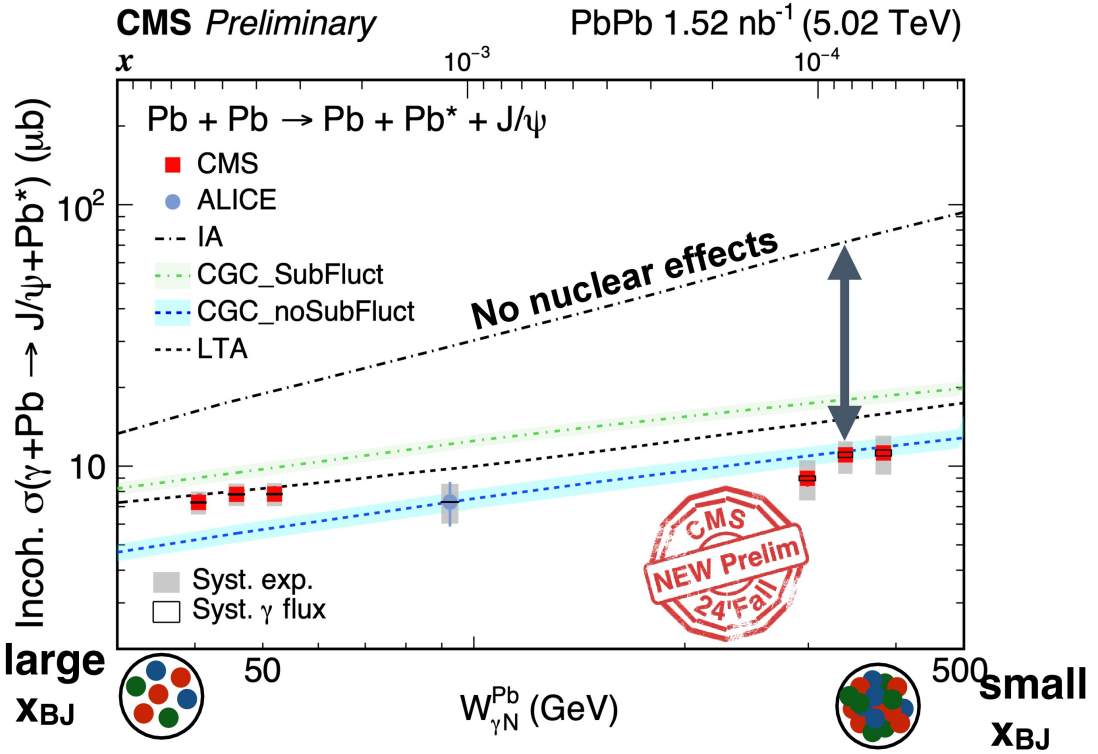
Wednesday 11:10AM
Mateusz Dyndal

# First measurement of incoherent J/$\psi$ in UPCs vs $W_{\gamma N}$

See Zaochen Ye's talk
CMS-PAS-HIN-23-009




**$\langle p_T \rangle \sim 500$ MeV**
- Photon interacts with a single nucleon or sub-nucleon



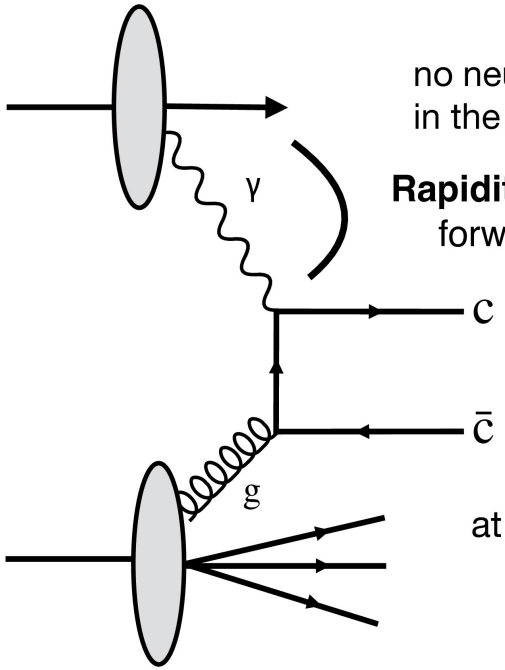

**Strong suppression observed at large $W_{\gamma N}$ (small x) w.r.t. no-nuclear effects predictions**
- **CMS data "challenge" both shadowing and saturation descriptions**

→ **Need to "overconstrain" calculations with new probes that provide additional/complementary constraints**
→ **Overcome the main limitations of current J/$\psi$ measurements: complex theoretical description and limited $Q^2$ coverage**

# $D^0$ photonuclear production in UPCs

→ in Xn0n PbPb events with rapidity gap with **2023 PbPb data**

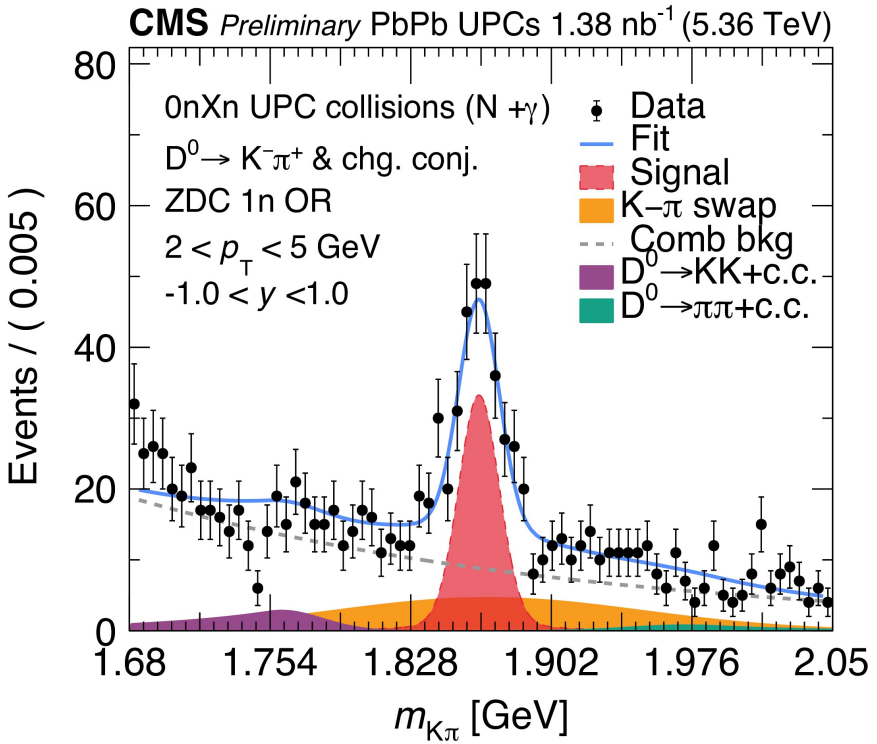
**See Chris McGinn's talk**
CMS-PAS-HIN-24-003




no neutrons (0n)
in the Zero Degree Calorimeter (ZDC)

**Rapidity gap in the hadronic**
forward calorimeter (HF)

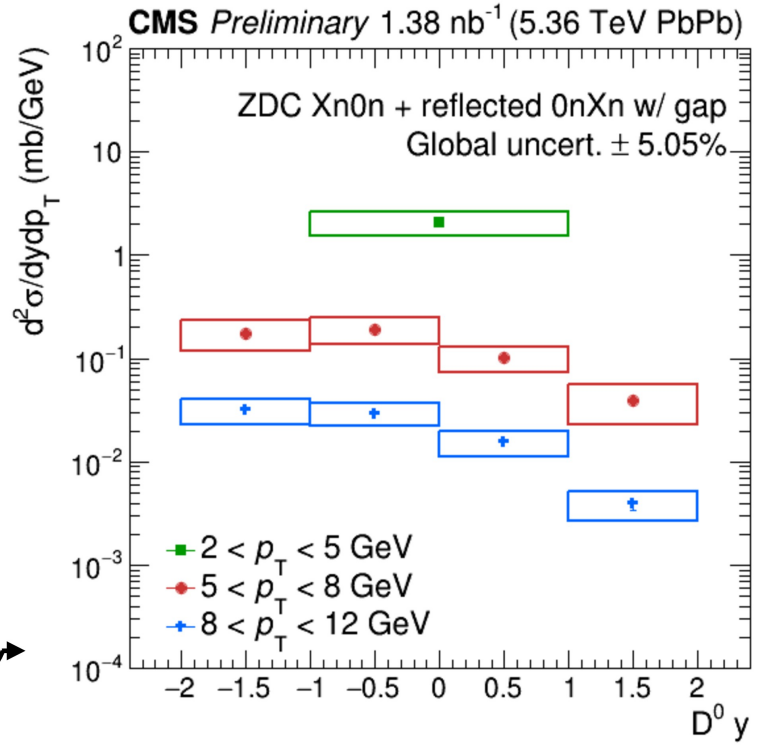
at least one neutron
in the ZDC (Xn)

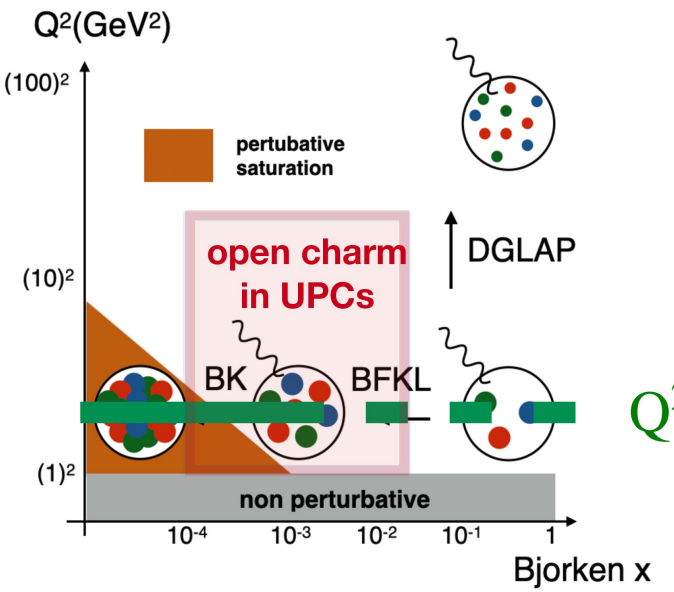



**A new trigger strategy for both soft and hard photonuclear events**
→ O(1000) times more photonuclear events than in Run 2

# First measurement of the $D^0$ photonuclear production in UPCs

**See Chris McGinn's talk**
CMS-PAS-HIN-24-003





$Q^2 \propto m^2_{J/\psi}$

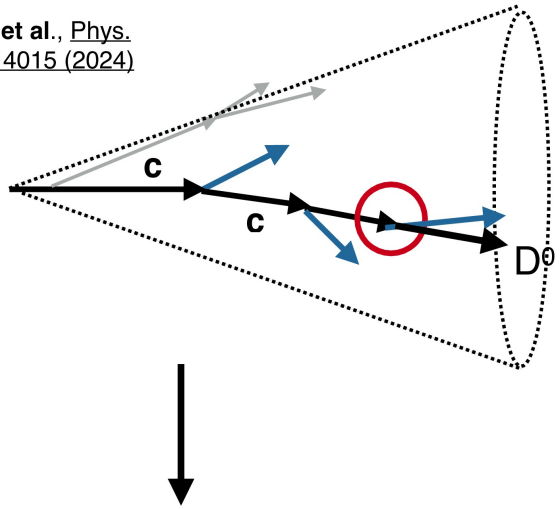
→ **First constraints on nuclear gluon PDFs over a wide region of $Q^2$ ($10 < Q^2 <$ hundreds GeV$^2$)**
at low-x ($\sim 5*10^{-4} < x < 10^{-2}$) **in the absence of sizable final state effects**
→ **opens the way for a large program of open heavy-flavor hadrons, jets and correlations in UPCs collisions at the LHC**

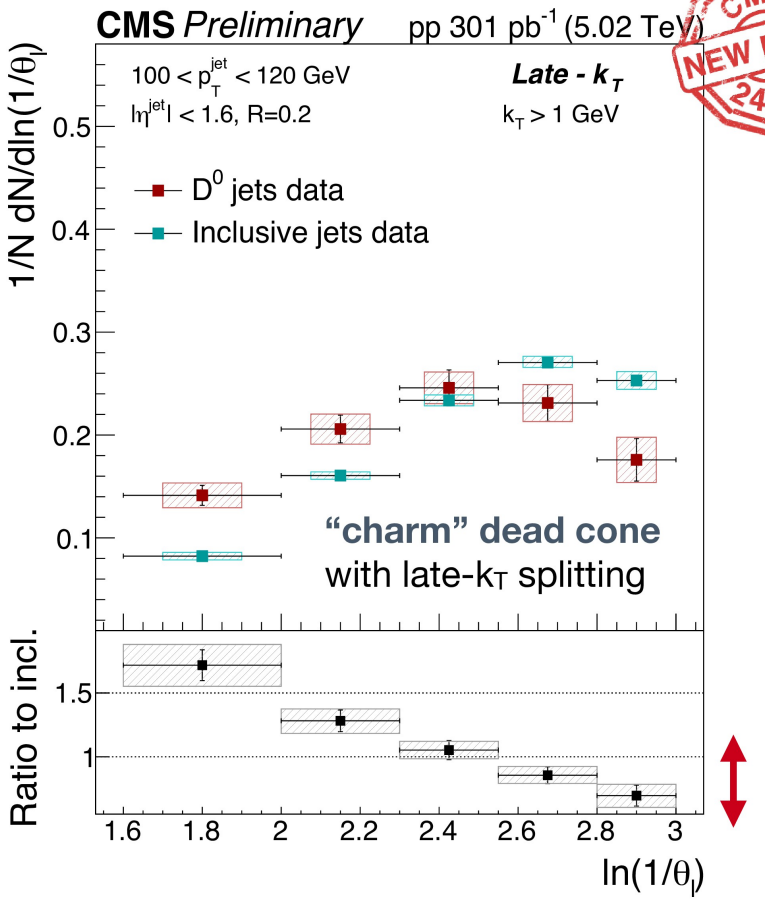
# Charm dead cone with late-$k_T$ algorithm

**See Jelena Mijuskovic's talk**
CMS-PAS-HIN-24-007

- PF jets $p_T > 100$ GeV
- Reclustered with **late-$k_T$ grooming**
  → most collinear splitting with $k_T$>1 GeV

**L. Cunqueiro et al.**, Phys. Rev. D 110, 014015 (2024)

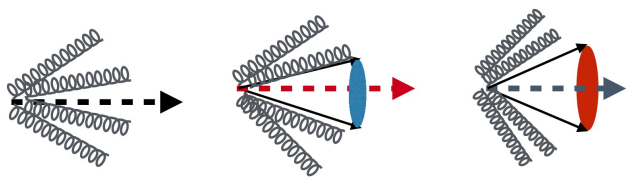



→ stronger constraints on the "perturbative" collinear radiation (where the dead-cone effect is largest)
→ **more direct/unbiased comparison with pQCD calculations**

# First direct manifestation of the beauty dead cone

See Lida Kalipoliti's talk
CMS-PAS-HIN-24-005

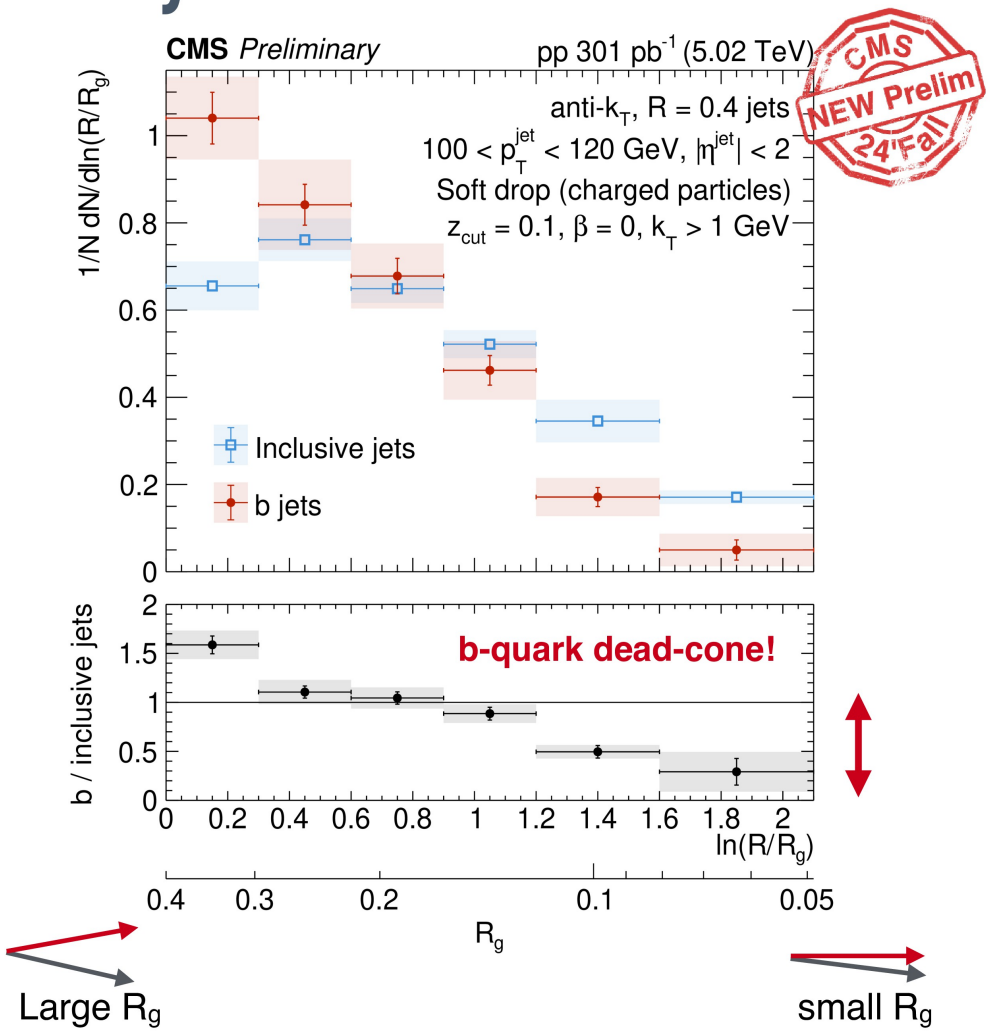



**New experimental technique based on BDT**

- tag hadronic and non-hadronic B-hadron decays
- **substantial increase in B-jet statistics**

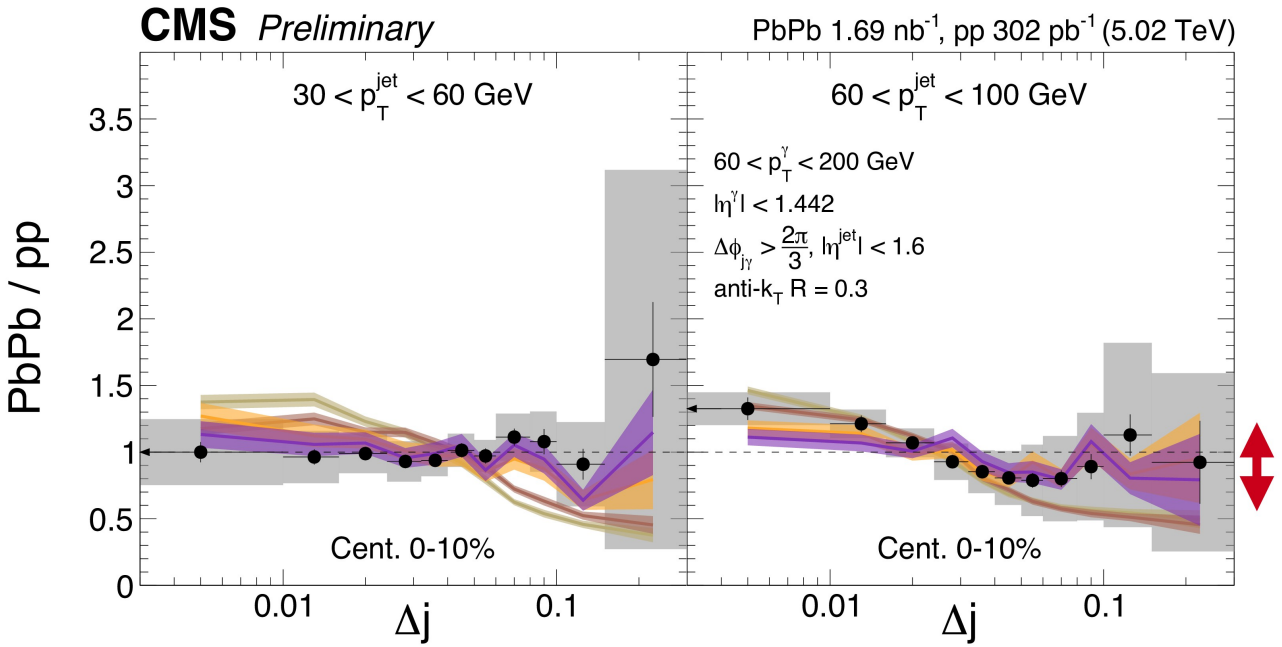
→ **enable reclustering analyses for b-hadron jets**

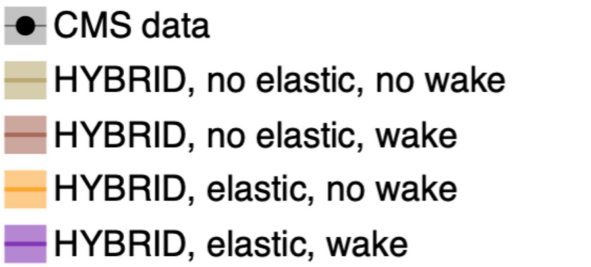
**First observation of a reduction of the collinear radiation** for B-hadron tagged jets → **b-quark dead-cone!**



# Photon-tagged jet axis decorrelation

See Molly Park's talk, CMS-PAS-HIN-21-019



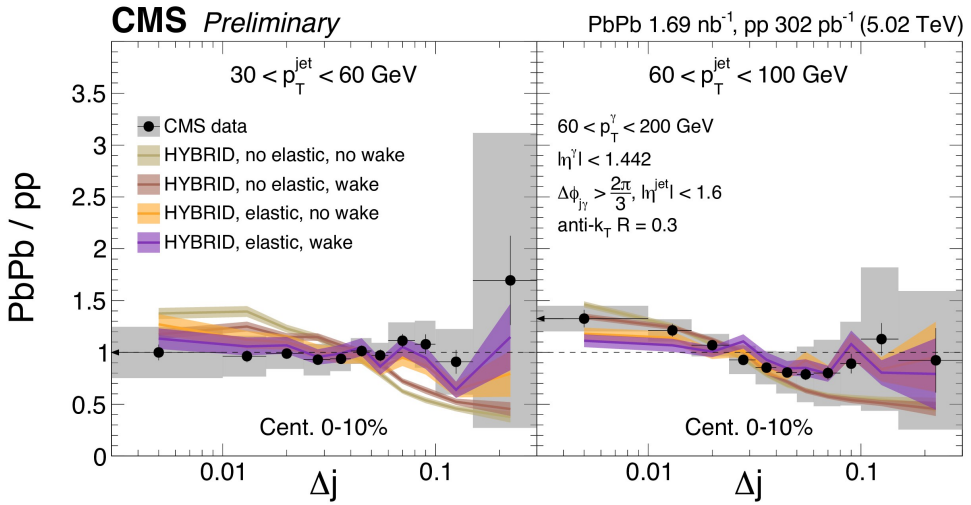

**For low-$p_T$ jet**
→ similar Δj in PbPb and pp

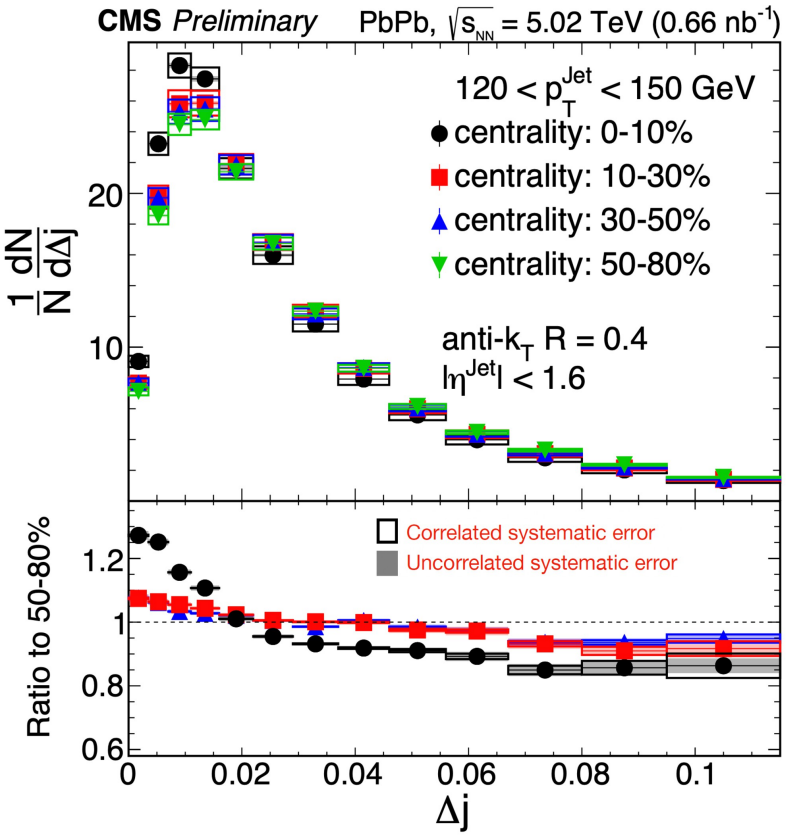
**For high-$p_T$ jet**
→ **suppression of large-Δj jets in PbPb**

**Unambiguous evidence for a higher survival rate of narrow jets in PbPb collisions:**
→ in the presence of an energy-calibrated probe (no bias due to jet-$p_T$ bin migration)
→ limited dependence on the medium response

# Jet axis decorrelations for inclusive jets

**See Raghunath Pradhan's talk**
CMS-PAS-HIN-24-010



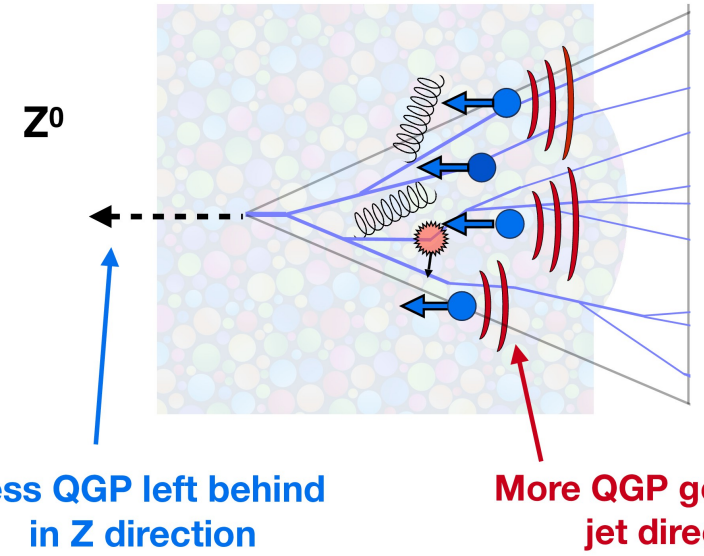



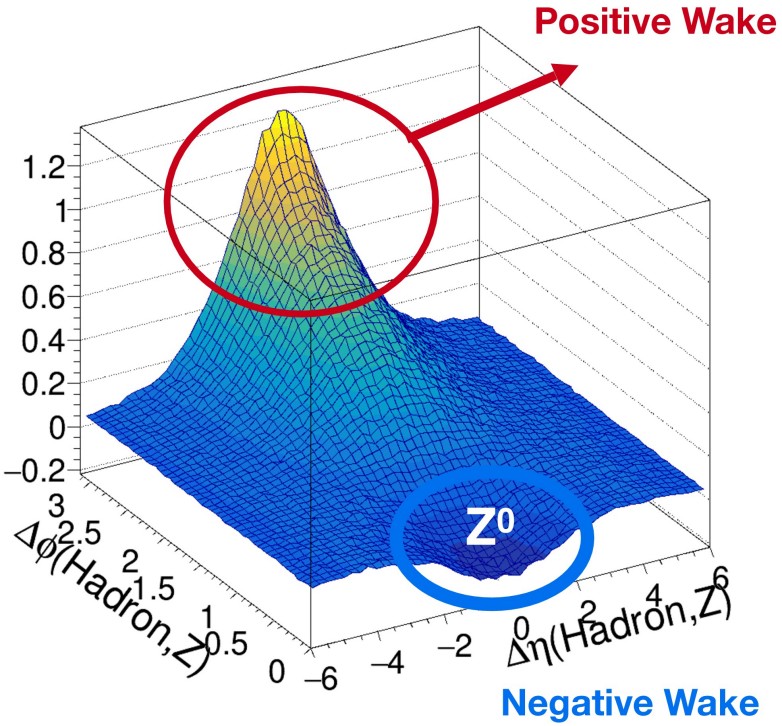

**Complementary (highly-differential) constraints from jet axis decorrelations with inclusive-jet measurements:**
→ folding medium-induced jet medium modifications with bin-migration effects

# Z⁰–hadron correlations in PbPb

See Yen-Jie Lee's talk
CMS-PAS-HIN-23-006


→ "isolate" the effects of medium-response

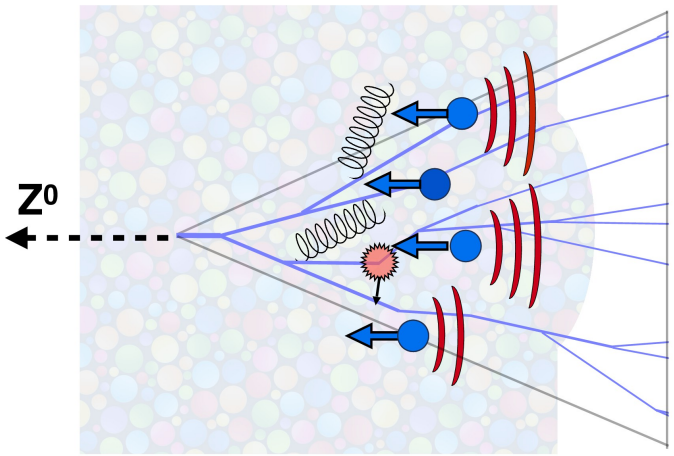


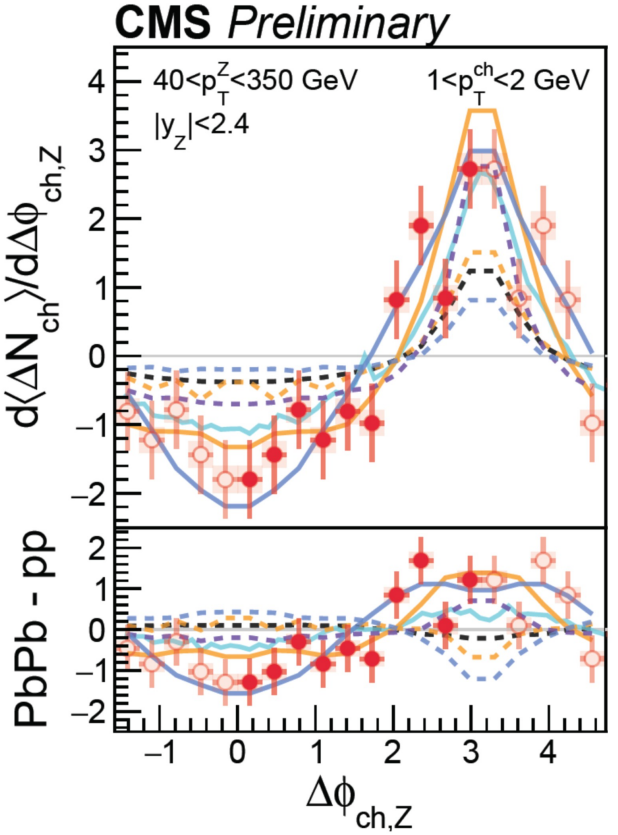

**Z⁰ provides an unquenched reference with high experimental accuracy**
→ medium response effects without jet fragments

**Z⁰ and Wake Hadron correlation in Hybrid model**
D. Pablos, K. Rajagopal, YJ Lee

# Medium response with $Z^0$–tagged hadrons in PbPb and pp




**Clear depletion in PbPb on the Z side** ($\Delta\phi$=0)




PbPb 0-30%
pp
PbPb 0-30% Reflected
pp Reflected

**Hadron-yield enhancement along the jet direction**

PbPb 0-30%
Hybrid
Hybrid No wake
PYQUEN
Jewel v2.2.0
Jewel No recoil
CoLBT
PYTHIA8 $p_T^Z$>20 GeV

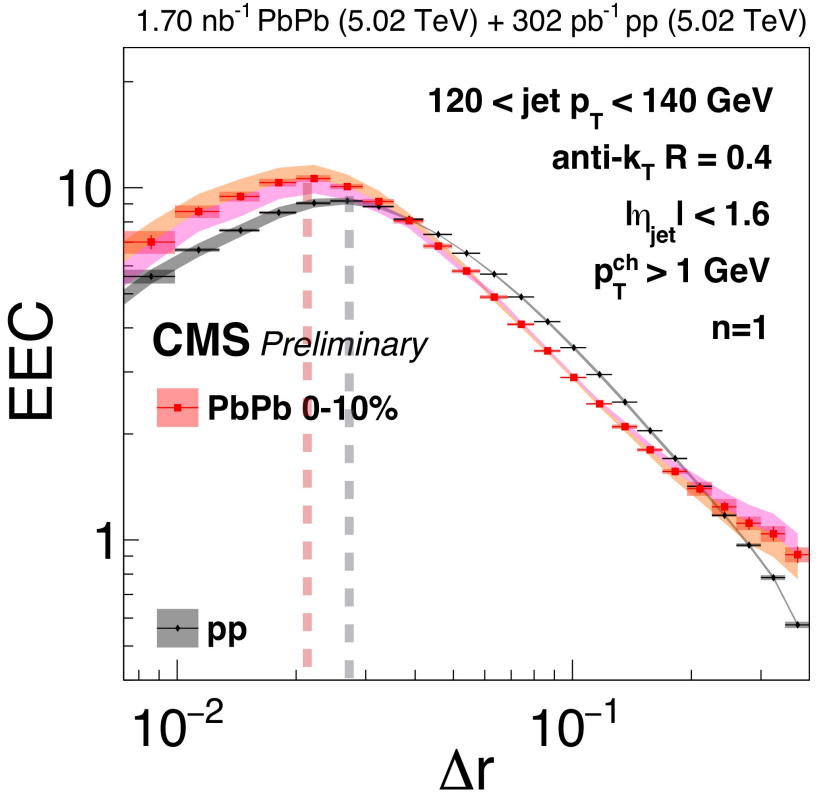
**See Yen-Jie Lee's talk**
CMS-PAS-HIN-23-006

→ **Good agreement when including medium response (e.g. recoil, wake, ..)**
→ **direct evidence of medium-response with the Z+Jet event** (confirmed by analogous study as a function of $\Delta y_{ch,Z}$)

## Energy-energy correlators

# First EEC measurement in PbPb collisions at 5.02 TeV


**→EEC measurements are feasible with high accuracy in PbPb collisions!**
**→PbPb results present qualitatively the same structure as in pp collisions**

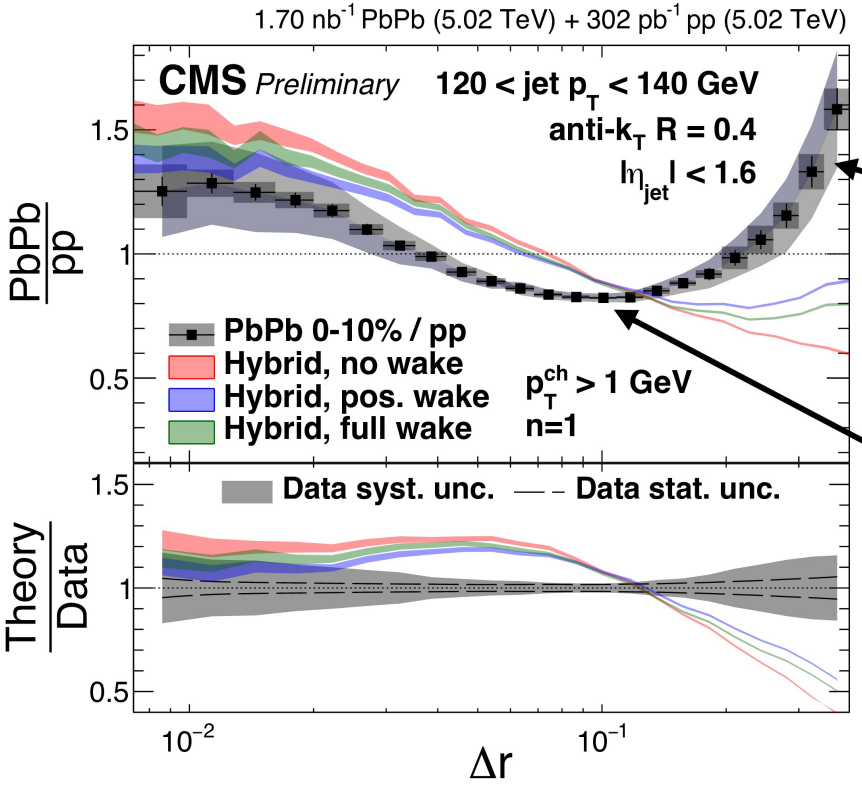



**See Jussi Viinikainen's talk,**
CMS-PAS-HIN-23-004

## Energy-energy correlators

# EEC PbPb/pp ratio at 5.02 TeV


**See Jussi Viinikainen's talk,**
CMS-PAS-HIN-23-004




**Shift in the position of the "transition" peak**

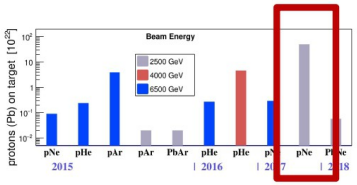
Large angular scale Δr
→ **sensitivity to medium response**

Intermediate angular scale Δr
→ **modification of the parton shower**
(e.g. coherence scale)

First PbPb measurement shows the potential of this new observable:
→ **Map the angular properties of jet-medium interaction with a "self-analyzing" observable**
with well-defined boundaries between perturbative and non-perturbative physics

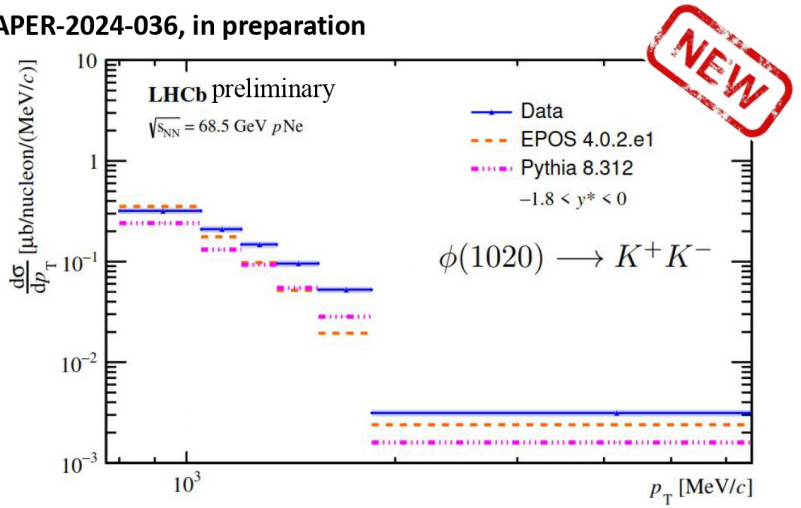
**Carlota Andres et al.**, Phys. Rev. Lett. 130, no.26, 262301 (2023)

# Strange and charm physics in fixed-target collisions

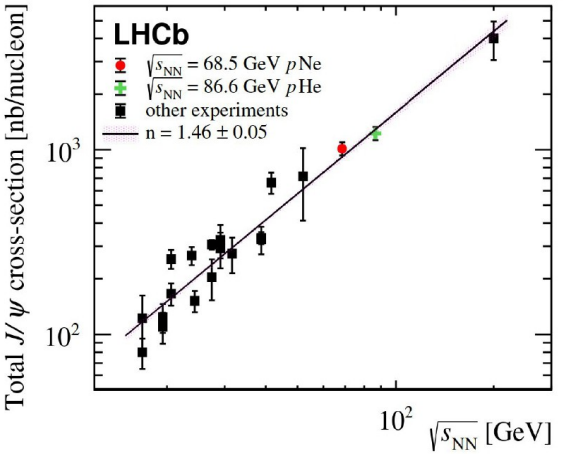


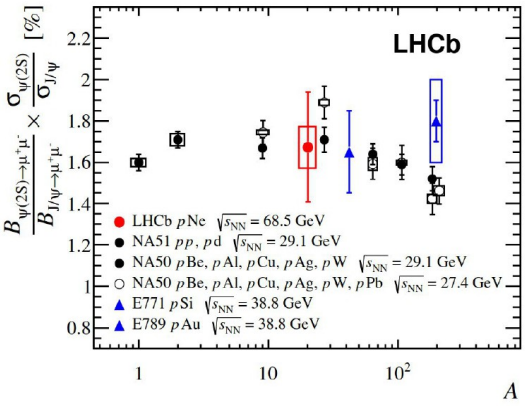

- *p*Ne data with $\sqrt{s_{NN}}$ = 68.5 GeV, intermediate to SpS and RHIC top energy ⟶ access to poorly explored high-$x$ at moderate $Q^2$ ⇒ **unique inputs** to models!
- **Discrimination of Quark Gluon Plasma from Cold Nuclear Matter effects** require precise measurements in different collision systems and c.m. energies

LHCb-PAPER-2024-036, in preparation



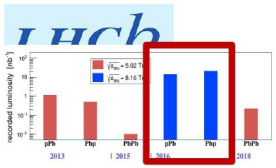

Eur. Phys. J. C83 (2023) 625

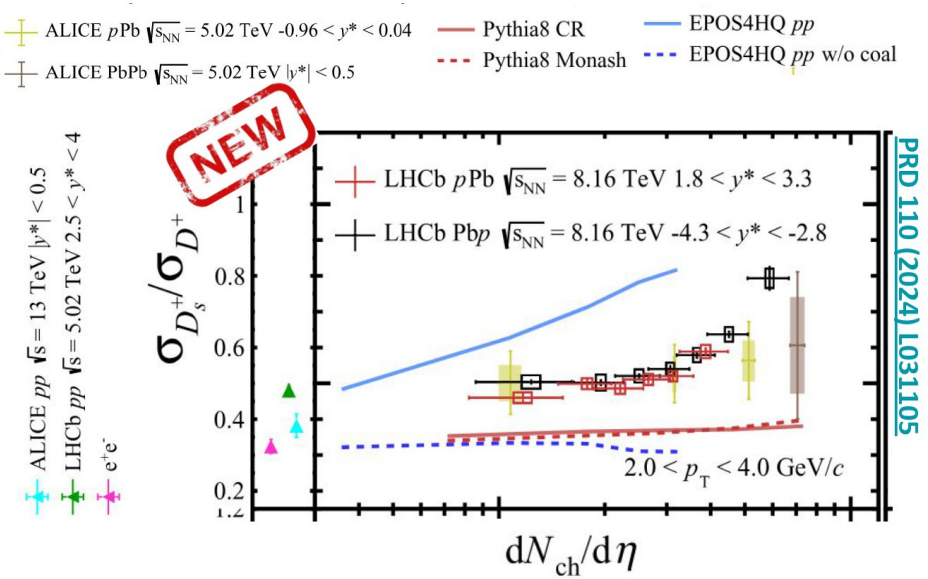



- Models found to **underestimate φ production** at this energy ⟶ good constraining power for strangeness in phenomenological models
- Better precision wrt previous experiments for J/ψ, but **statistically dominated** for heavier probes
- Motivates **fixed-target system upgrade** (SMOG2)

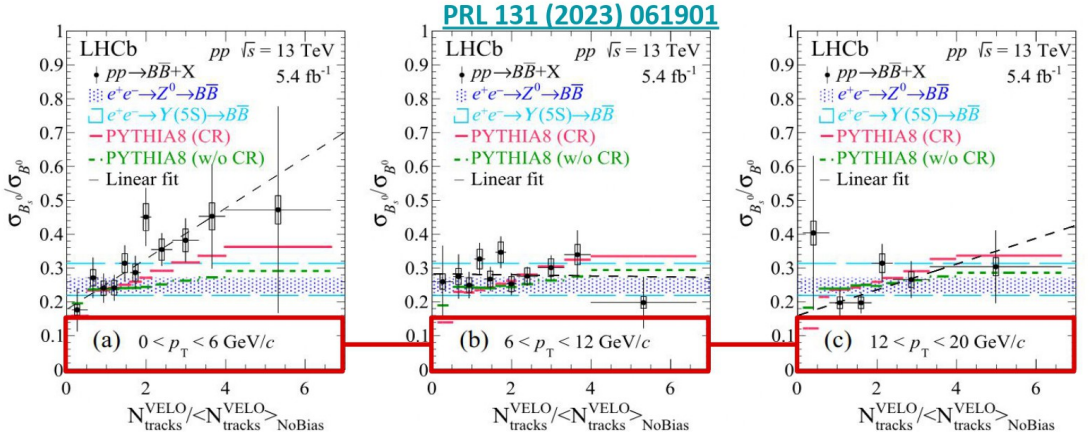
# Strangeness enhancement in charm and beauty





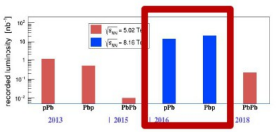

PRD 110 (2024) L031105

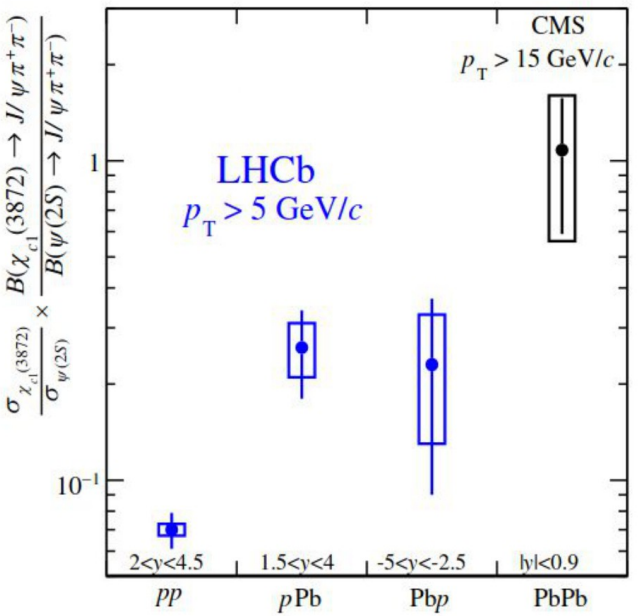
PRL 131 (2023) 061901



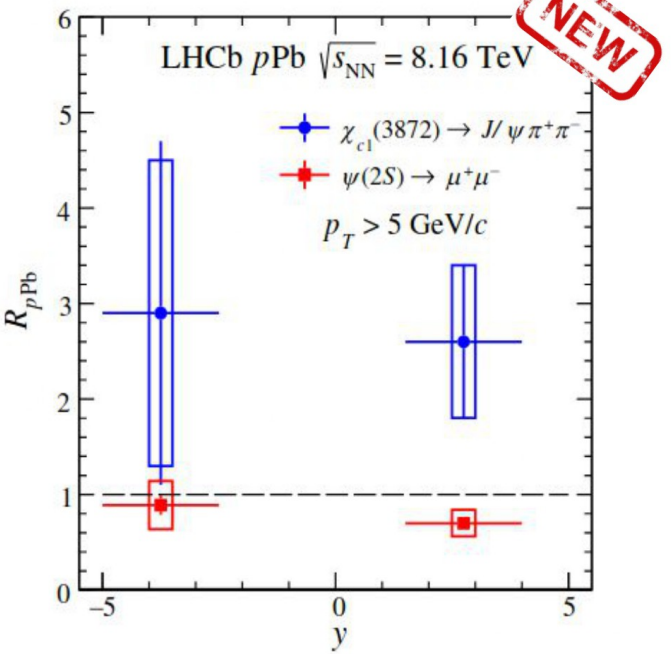

- By studying charm and beauty particle yields as a function of multiplicity, **observed clear indications of strangeness enhancement** in both the charm (left) and beauty (right) sectors, especially at low transverse momenta
- **Final state effects such as coalescence are important at low $p_T$ and high multiplicity,** while the pure fragmentation limits from *ee* collisions are recovered elsewhere

# Exotic hadrons in *pp* and *p*Pb collisions



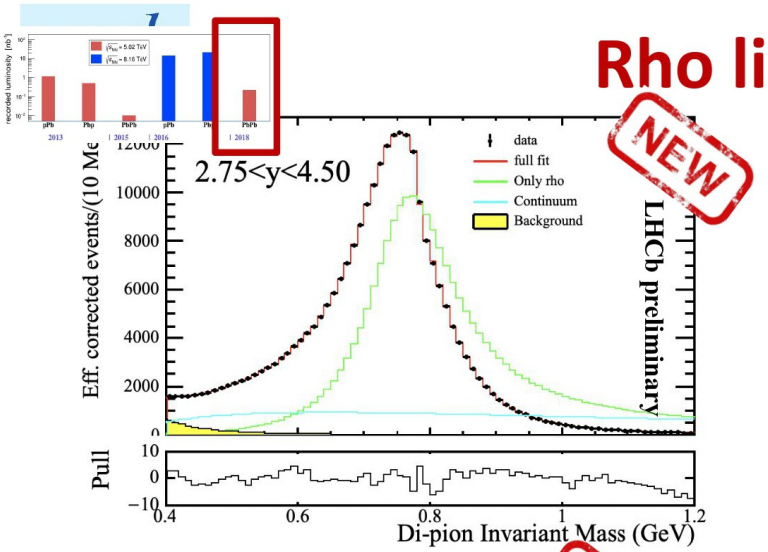



PRL 132 (2024) 242301

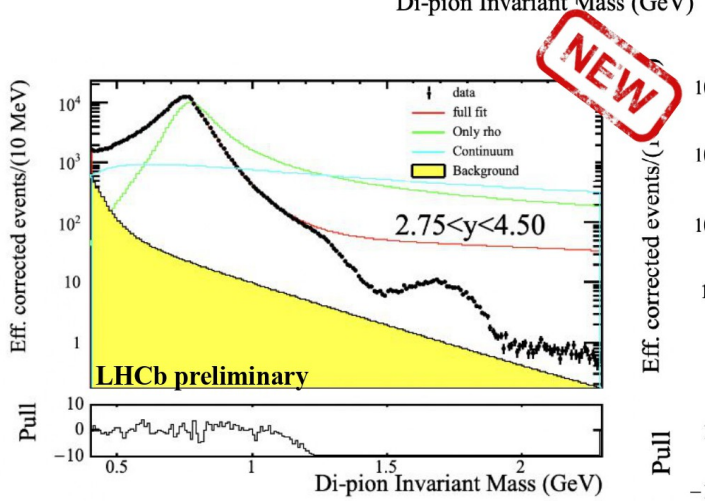


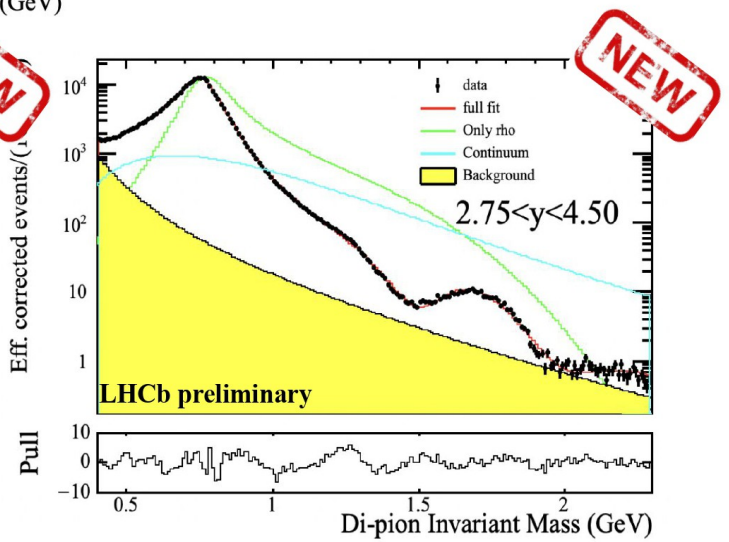

- Exotic multi-quark states also provide a unique view on hadronization mechanisms: does X(3872) have **a compact, a molecular or a hadrocharmonium structure**?
- X enhancement wrt ψ(2s), despite ~cancellation of initial state effects, hints at a different interaction with the medium → is this X enhancement or ψ(2s) suppression?
- **Nuclear modification factor shows X enhancement** → coalescence dominating over breakup?

# Rho lineshape in UPC PbPb collisions




- Very **clean sample of UPC di-pions** selected by requiring no additional activity in the detector and with PID selections
- Fit model by H1 preferred wrt the STAR one in **modelling the distribution and the ρ - ω interference**



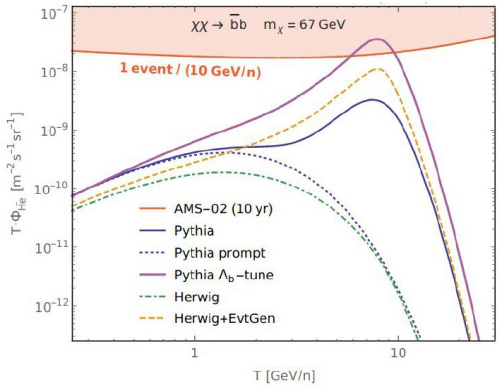




- …but extrapolating shows the model is clearly not correct
- **Unambiguous additional resonance**, confirming previous observation by ALICE and STAR
- Fit results **consistent with PDG ρ' particle**
- Cross-sections and $p_T$ spectrum being measured

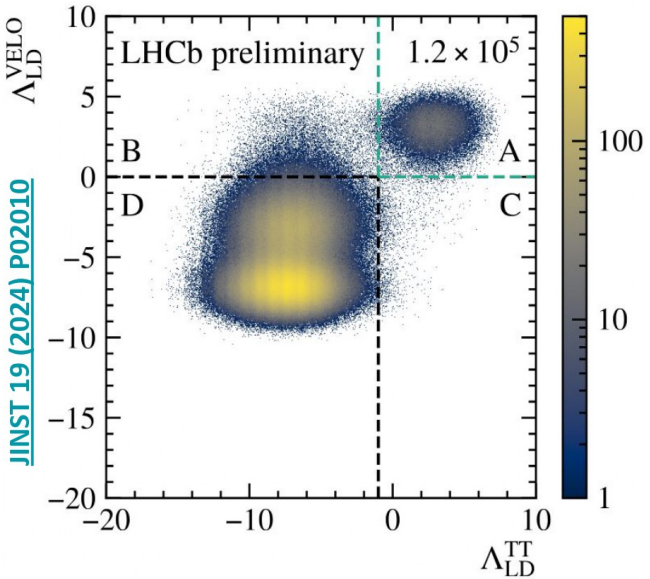
LHCb-PAPER-2024-042, in preparation

# Nuclei production and identification at LHCb

PRL 126 (2021) 101101

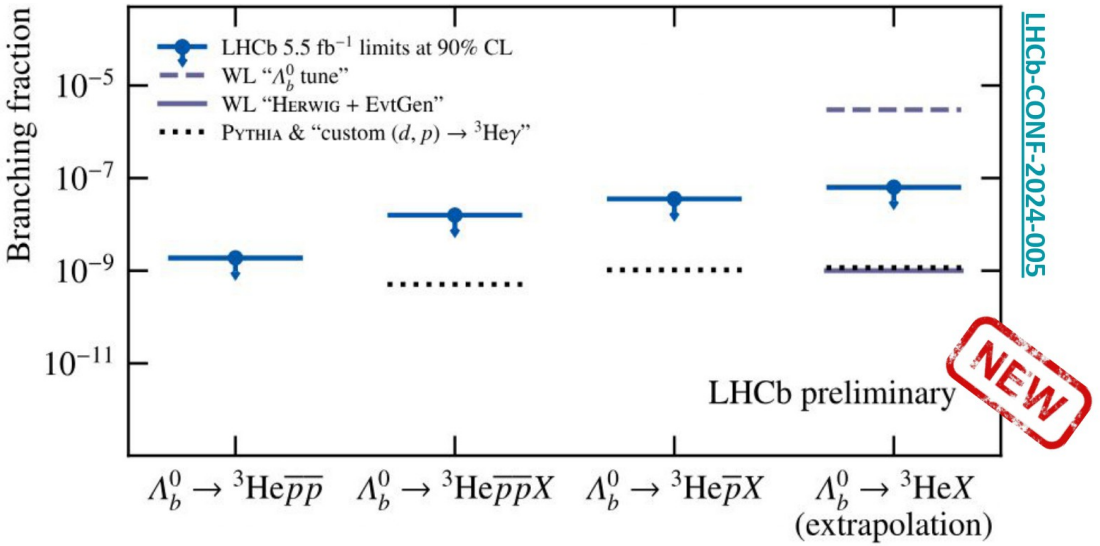



JINST 19 (2024) P02010




- Discussion ongoing about a **possible explanation of measured AMS He flux** due to $\Lambda_b$ -> HeX decays (if BR ~ O($10^{-6}$)) PRC 108 (2023) 024903
- Innovative **He identification technique** via discriminators built from energy loss in LHCb detectors → **very clean** He samples (A)

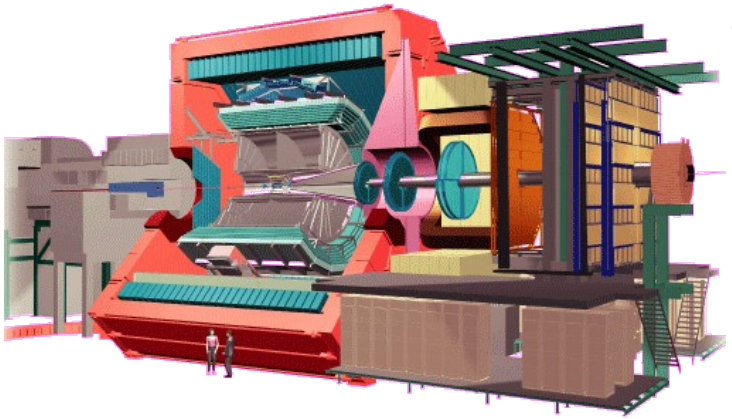
LHCb-CONF-2024-005



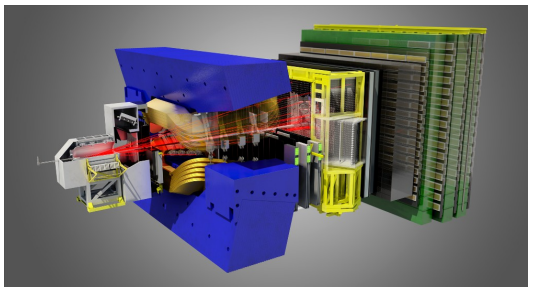

- $\Lambda_b^0 \to {}^3He\overline{p}p$ decay fully reconstructed and extrapolated limits to inclusive channels **significantly restricts He abundance in cosmic rays**

# SUMMARY

ALICE

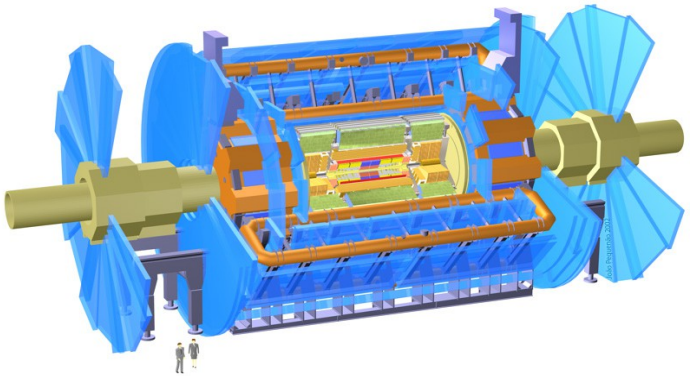


LHCb

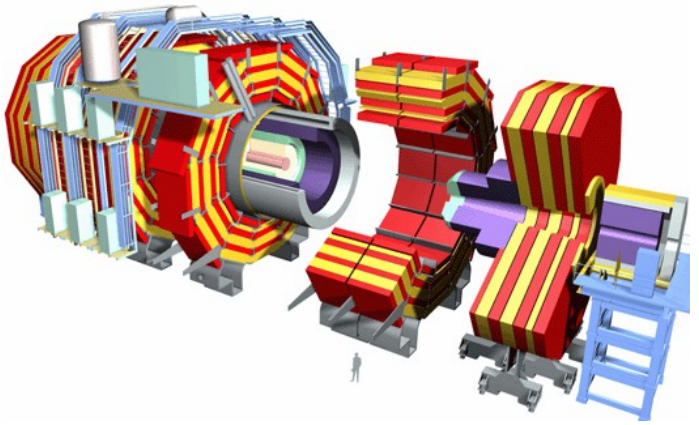


- So many interesting heavy-ion physics results with LHC experiments in p+Pb, Pb+Pb and Xe+Xe collisions...
- Heavy-ion program at the LHC with Run 3 and 4 will provide us more exciting opportunities!
- Stay tuned!

ATLAS



CMS

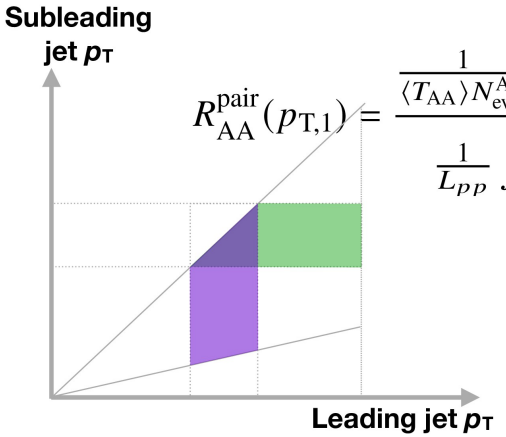


# BACK UP

# R-dependence of dijet quenching

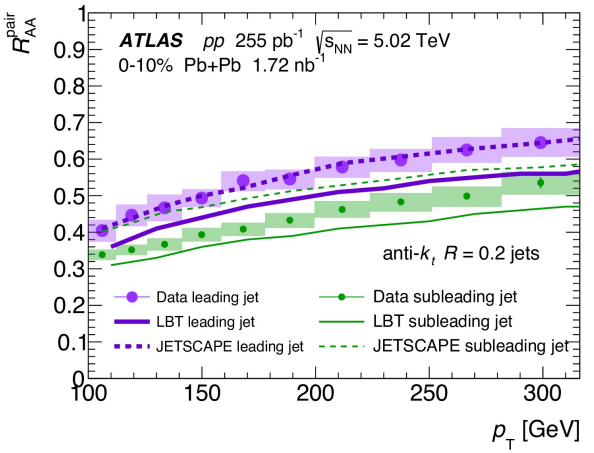
arXiv:2407.18796

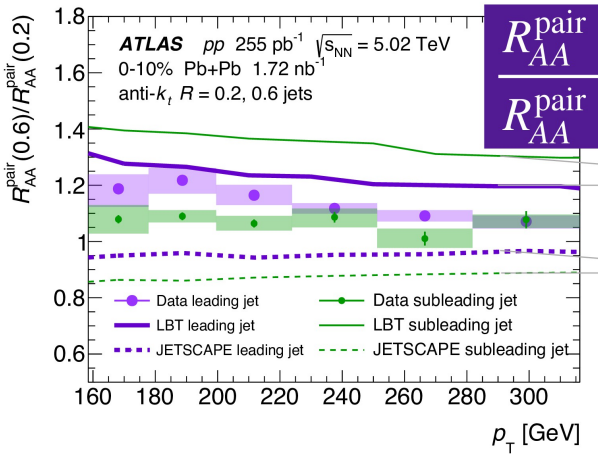
Final for HP2024




$$R_{AA}^{\text{pair}}(p_{T,1}) = \frac{\frac{1}{\langle T_{AA}\rangle N_{evt}^{AA}} \int_{0.32\times p_{T,1}}^{p_{T,1}} \frac{d^2 N_{pair}^{AA}}{dp_{T,1}dp_{T,2}} dp_{T,2}}{\frac{1}{L_{pp}} \int_{0.32\times p_{T,1}}^{p_{T,1}} \frac{d^2 N_{pair}^{pp}}{dp_{T,1}dp_{T,2}} dp_{T,2}}$$

- Leading and subleading jet $R_{AA}^{\text{pair}}$ are probing different population of dijet events, useful differential information to improve modeling
- Smaller-*R* dijets are more suppressed




$$\frac{R_{AA}^{\text{pair}}\ (R=0.6)}{R_{AA}^{\text{pair}}\ (R=0.2)}$$

LBT

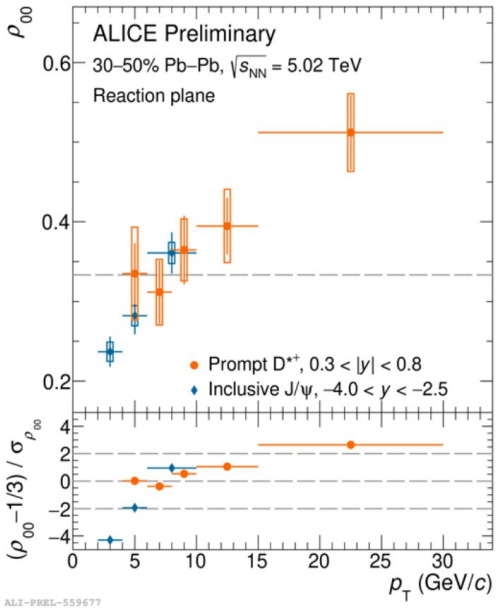
JETSCAPE

Qipeng Hu (USTC)

Monday 2:00 PM
Anne Sickles

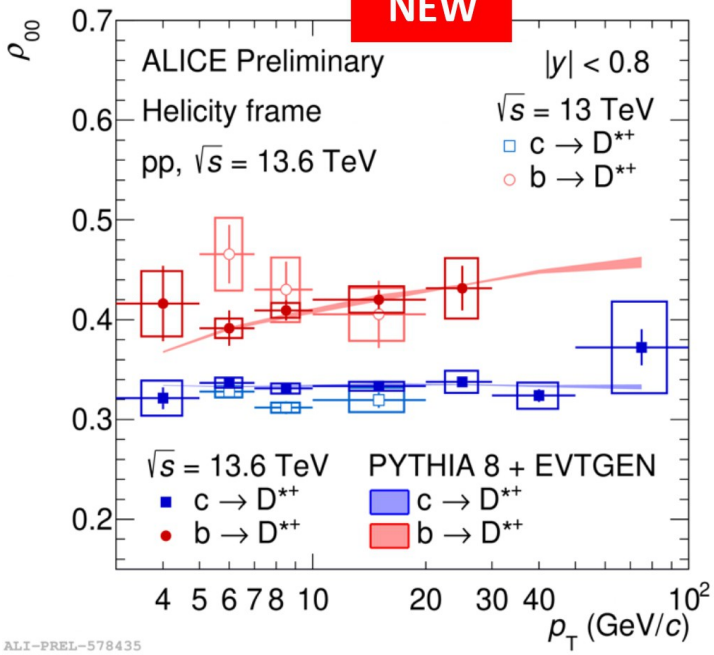


# $D^{*+}$ spin alignment in pp and Pb-Pb collision




NEW

Run 3 Preliminary

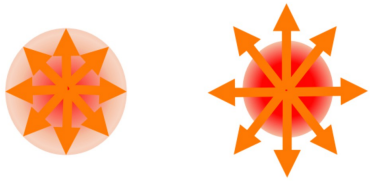



- In Pb-Pb collisions:
  - Spin density matrix $\rho_{00} > ⅓$ for $D^{*+}$ at high $p_T$ ⇒ quark fragmentation scenario
- In pp collisions:
  - $\rho_{00} = ⅓$ for prompt $\mathbf{D}^{*+}$, $\rho 00$ larger than ⅓ for non-prompt $\mathbf{D}^{*+}$, due to the helicity conservation in weak decays
  - New measurement in pp collisions provides an important baseline for Pb-Pb collisions

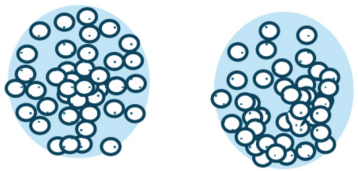
Mingze Li 24/09 11:50

# Disentangling sources of initial fluctuations

arXiv:2407.06413



"Geometric Component"



"Intrinsic Component"

Understand roles of fluctuations in initial conditions:

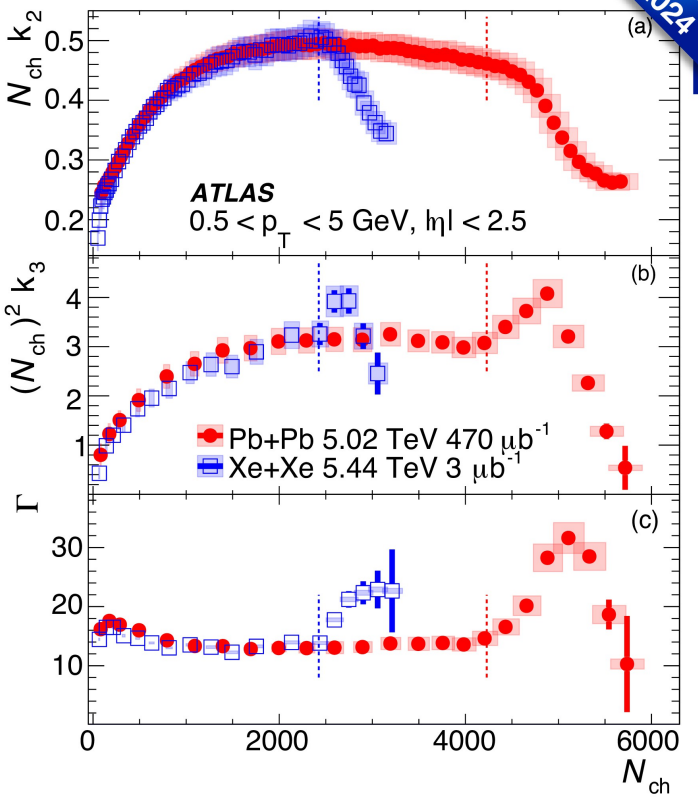
- Geometric fluctuations
- Intrinsic fluctuations

Moments of event-wise average $p_T$ distribution in **ultra-central** Pb+Pb and Xe+Xe via n-particle momentum correlators:

$$c_n = \frac{\sum_{i_1 \neq \ldots \neq i_n} w_{i_1} .. w_{i_n} (p_{T,i_1} - \langle [p_T] \rangle) \ldots (p_{T,i_n} - \langle [p_T] \rangle)}{\sum_{i_1 \neq \ldots \neq i_n} w_{i_1} \ldots w_{i_n}}$$

$$k_2 = \frac{\langle c_2 \rangle}{\langle [p_T] \rangle^2}, \quad k_3 = \frac{\langle c_3 \rangle}{\langle [p_T] \rangle^3}, \quad \gamma = \frac{\langle c_3 \rangle}{\langle c_2 \rangle^{3/2}}, \quad \Gamma = \frac{\langle c_3 \rangle \langle [p_T] \rangle}{\langle c_2 \rangle^2}.$$

Final for HP2024



# UE vs. nuclear break-ups in p+Pb

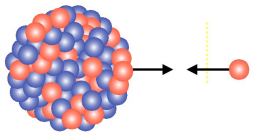
ATLAS-CONF-2024-013

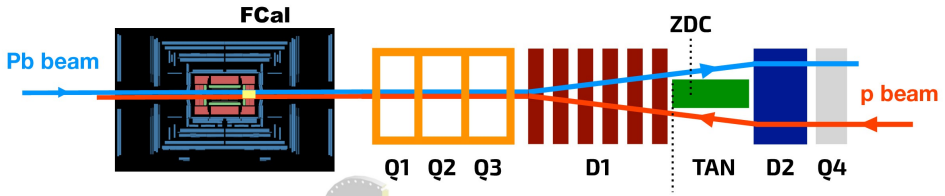
New for HP2024

$$x_p = \frac{p_{\mathrm{T},1} e^{y_1^{\mathrm{c.m.}}} + p_{\mathrm{T},2} e^{y_2^{\mathrm{c.m.}}}}{\sqrt{s_{\mathrm{NN}}}} \simeq \frac{2 p_{\mathrm{T,Avg}}}{\sqrt{s_{\mathrm{NN}}}} e^{y_b} \cosh(y^*)$$

**Zero-Degree Calorimeter (ZDC)**

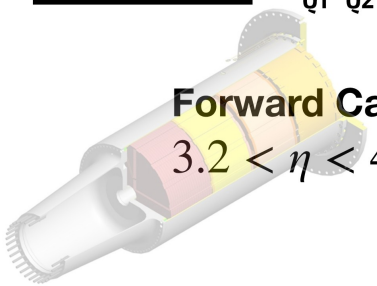
$\eta > 8.3$, break-up neutrons from nucleus

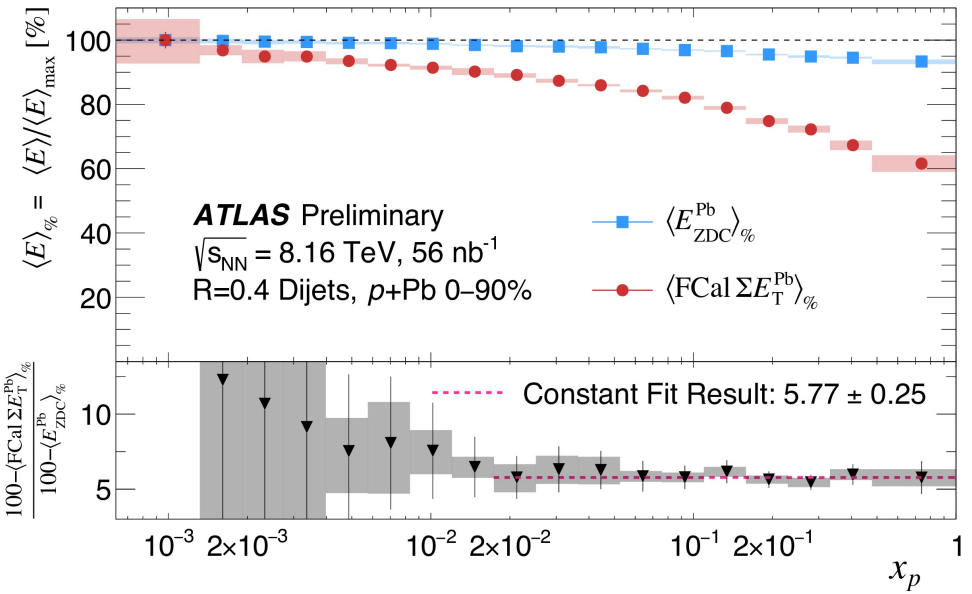





**Forward Calorimeter (FCal)**

$3.2 < \eta < 4.9$, underlying events activity



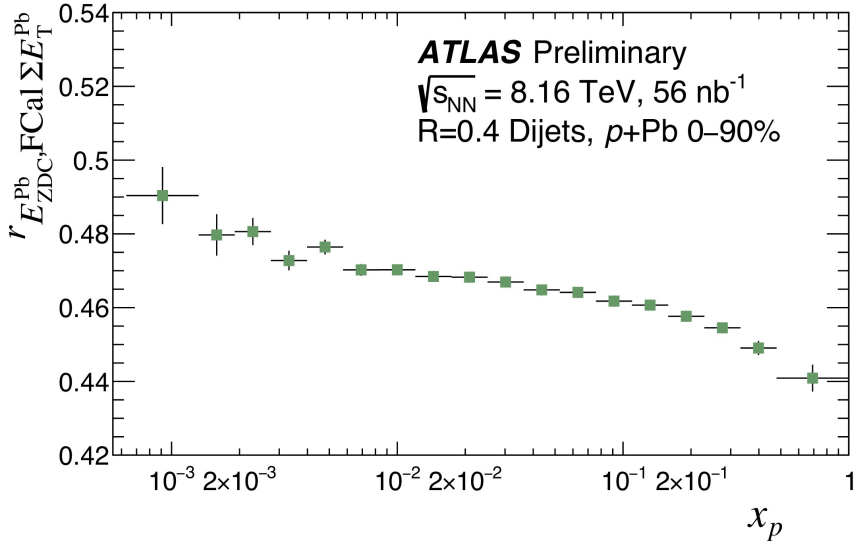


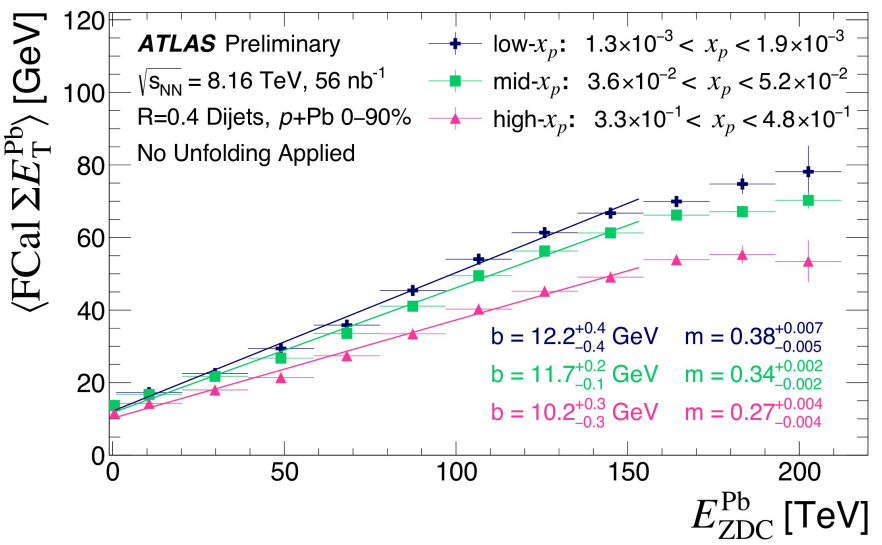

- Decreasing UE energy and break-up neutrons with increasing $x_p$
- UE is more sensitive to the change in $x_p$

# UE vs. nuclear break-ups in p+Pb — Cont.

ATLAS-CONF-2024-013

New for HP2024




- Correlation between UE energy and break-up neutrons becomes weaker with increasing $x_p$
- Scaling of UE energy and break-up neutrons at low ZDC energy, fluctuation of break-ups when UE energy saturated
- Offer a new approach to exploring hard-scattering biases in UE based centrality classifications and biases in modeling nuclear break-ups

HP2024 NAGASAKI

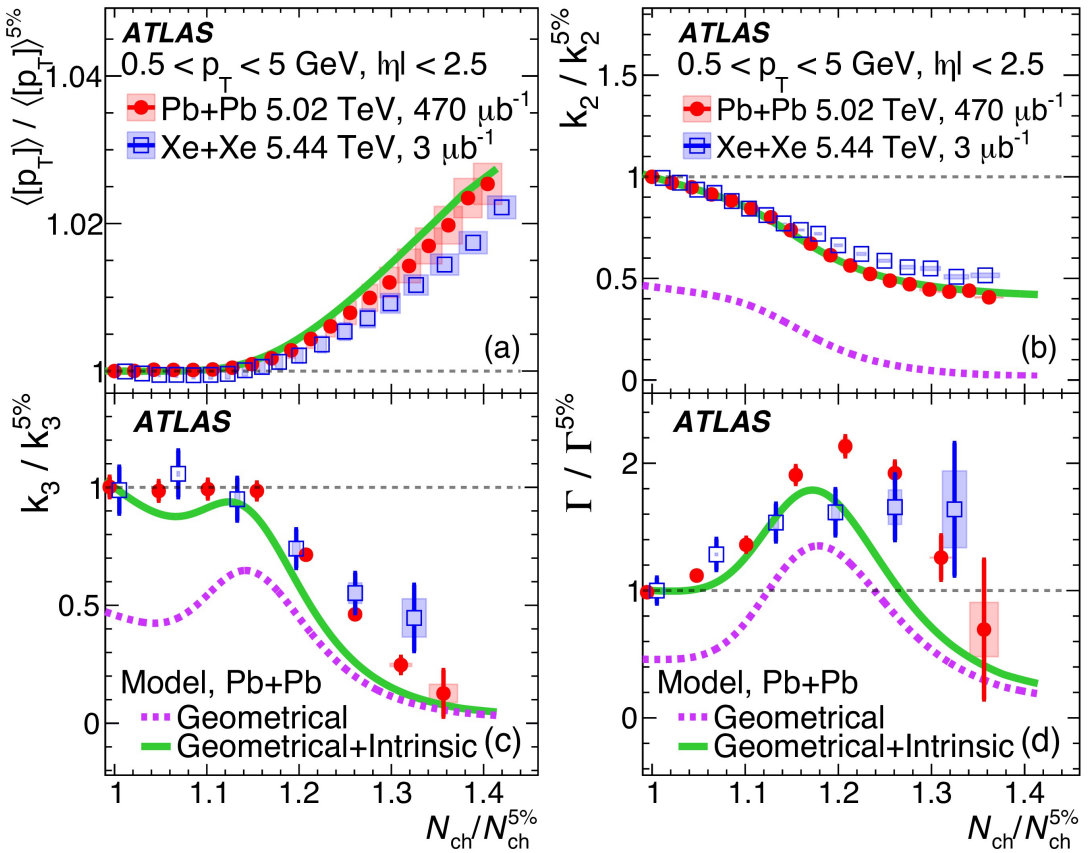
Qipeng Hu (USTC)

Poster
Matthew Hoppesch

# Disentangling sources of initial fluctuations — cont.

arXiv:2407.06413

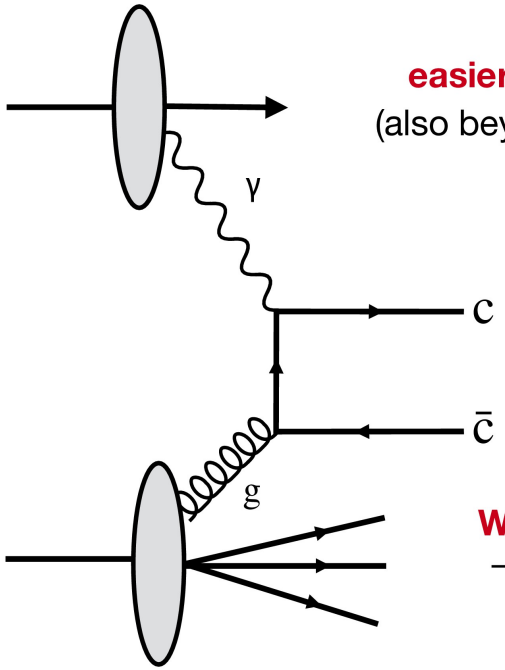
Final for HP2024




- A phenomenological 2D Gaussian fluctuations predicts the trends well (R. Samanta et al. Phys. Rev. C 109 (2024) L051902)

# Open charm production in UPCs: a new probe for small-x matter

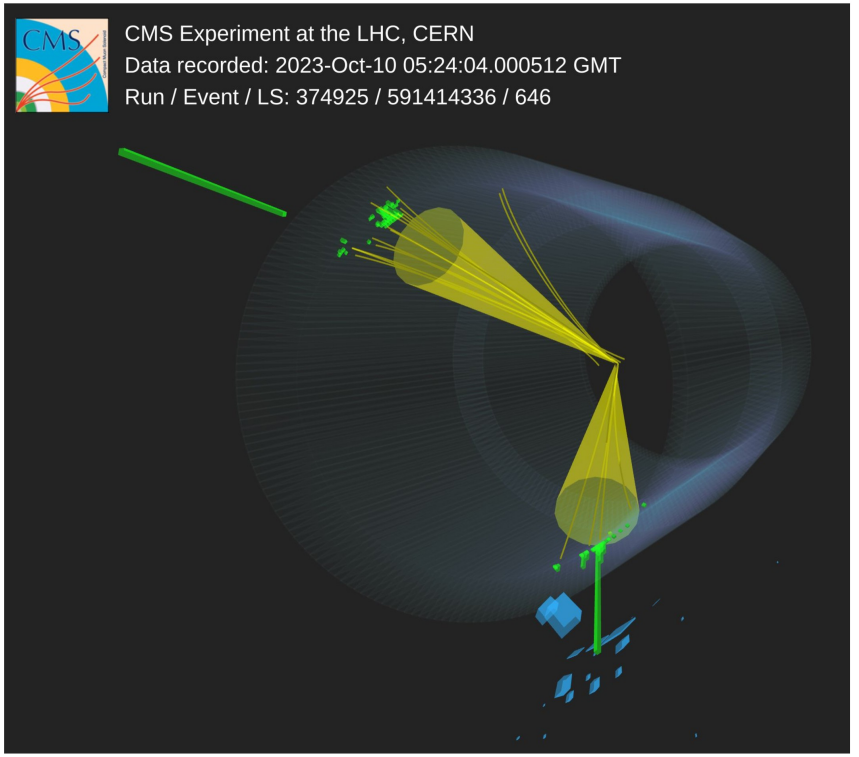
**See Chris McGinn's talk**
CMS-PAS-HIN-24-003




**easier pQCD description at any $p_T$**
(also beyond LO) due to **simple 1-gluon exchange channel**

**Accurate final state reconstruction**
(e.g. $D^0 \rightarrow K^-\pi^+$ or HF jets)

**Wide x, $Q^2$ coverage**
→ differential measurements in y and $p_T$ of the heavy hadron:




**→ ideal probe to test the transition towards low-x nuclear matter in absence of sizable final state effects**

**ATLAS**, ATLAS-CONF-2017-011
**S. Klein, R. Vogt et al**: Phys. Rev. C, v66, 2002