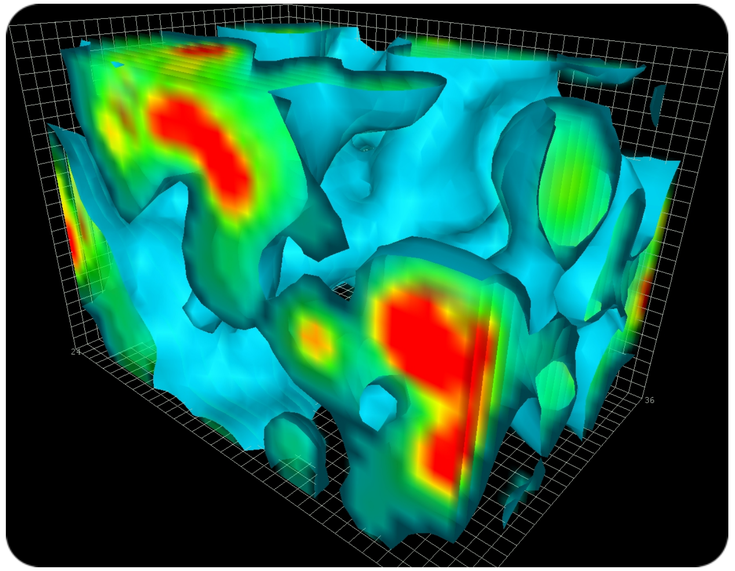
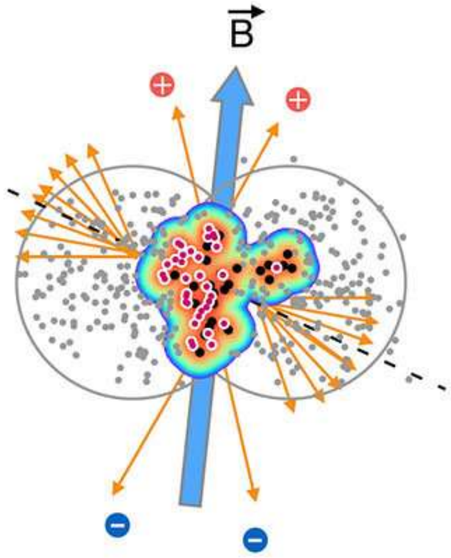
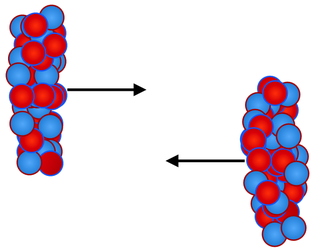
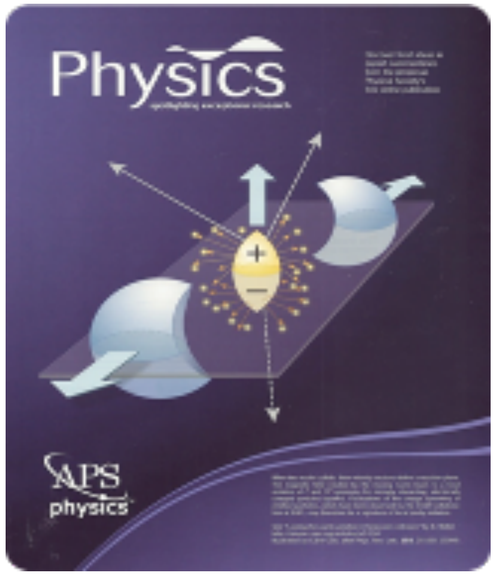
SEARCHES FOR EARLY STAGE E/M FIELDS AND NOVEL QCD PHENOMENA AT THE LHC







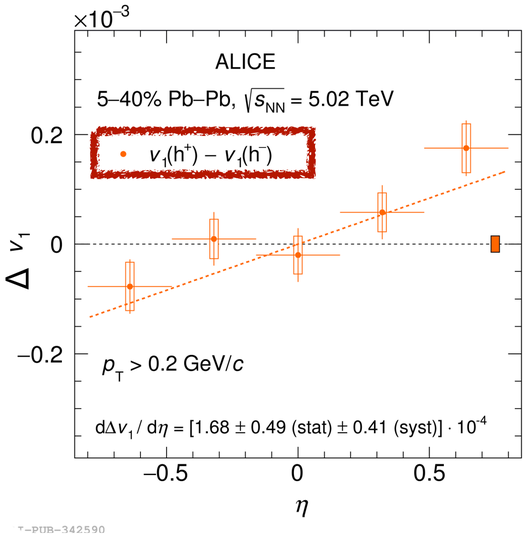


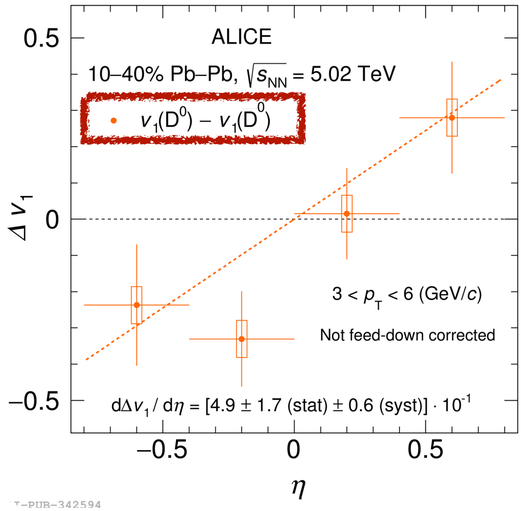
Panos Christakoglou

Nikhef

STATUS OF MAGNETIC FIELD STUDIES (1)

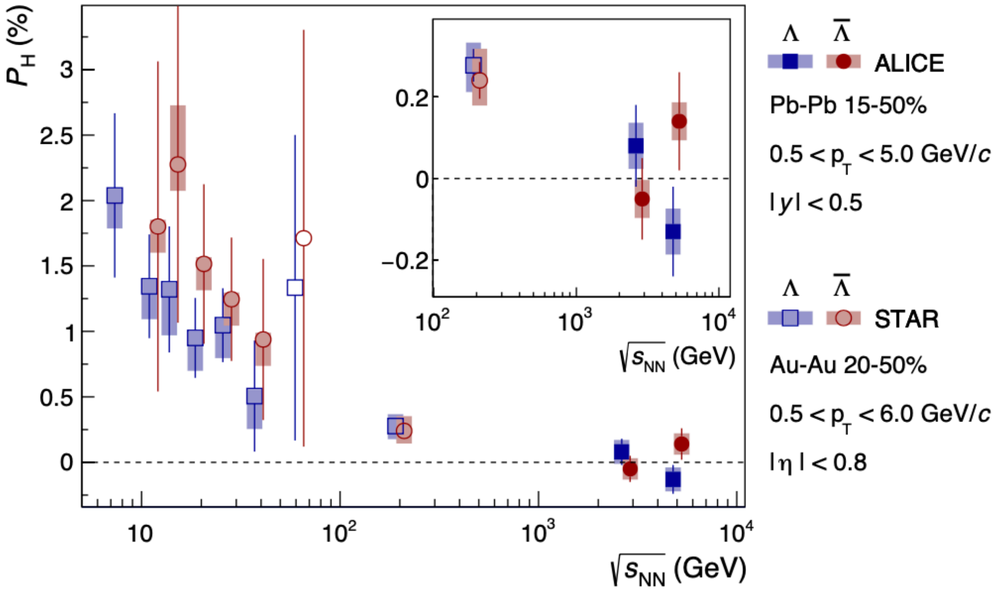
(ALICE Collaboration), Phys. Rev. Lett. 125, 022301 (2020)

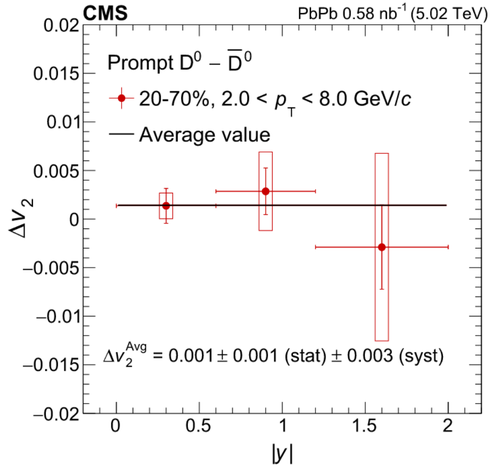




Δv₁ ≠ 0 with a 2.7σ significance

(STAR Collaboration) Nature 548, 62 (2017)
(ALICE Collaboration), Phys. Rev. C101 (2020) 044611





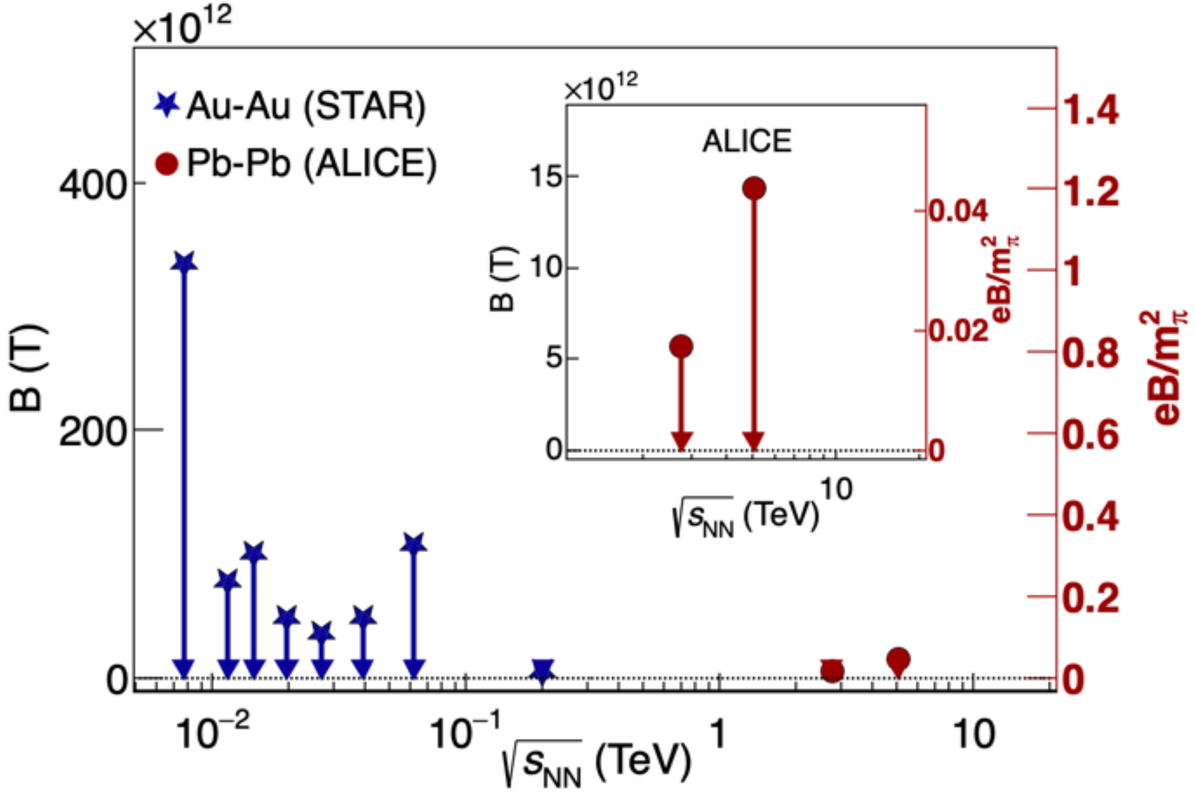
(CMS Collaboration), Phys. Lett. B 816 (2021) 136253

$$P_\Lambda \simeq \frac{1}{2}\frac{\omega}{T} + \mu_\Lambda \frac{B}{T}$$

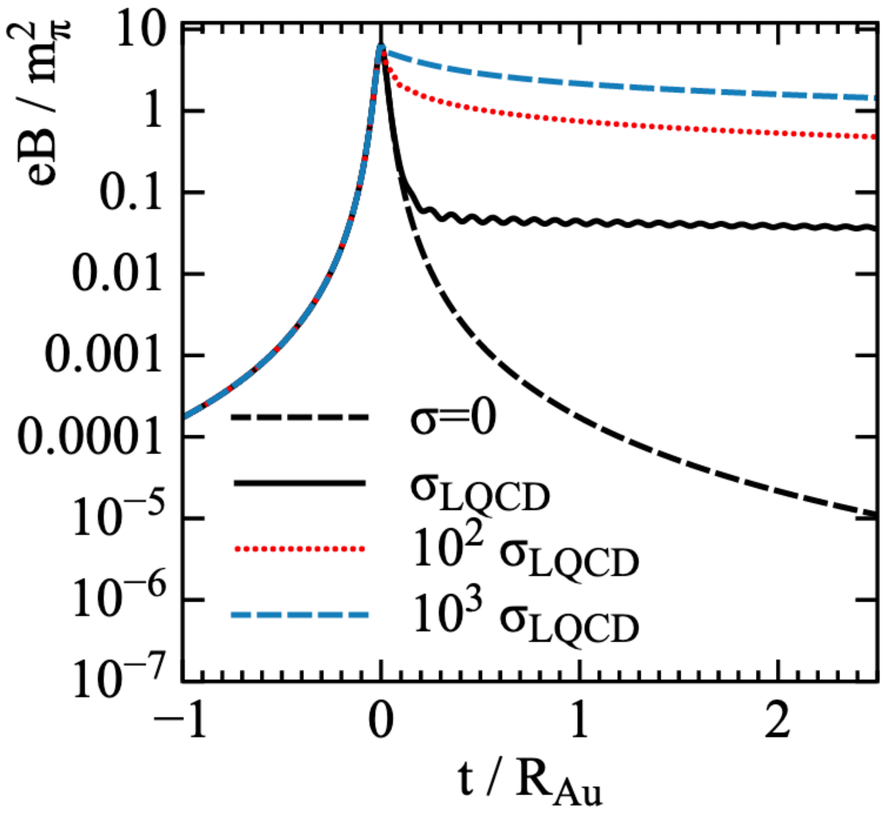
$$P_{\bar{\Lambda}} \simeq \frac{1}{2}\frac{\omega}{T} - \mu_\Lambda \frac{B}{T}$$

STATUS OF MAGNETIC FIELD STUDIES (2)

(ALICE Collaboration), arXiv:2211.04384



L. McLerran, V. Skokov, Nucl. Phys. *A* 929 (2014) 184



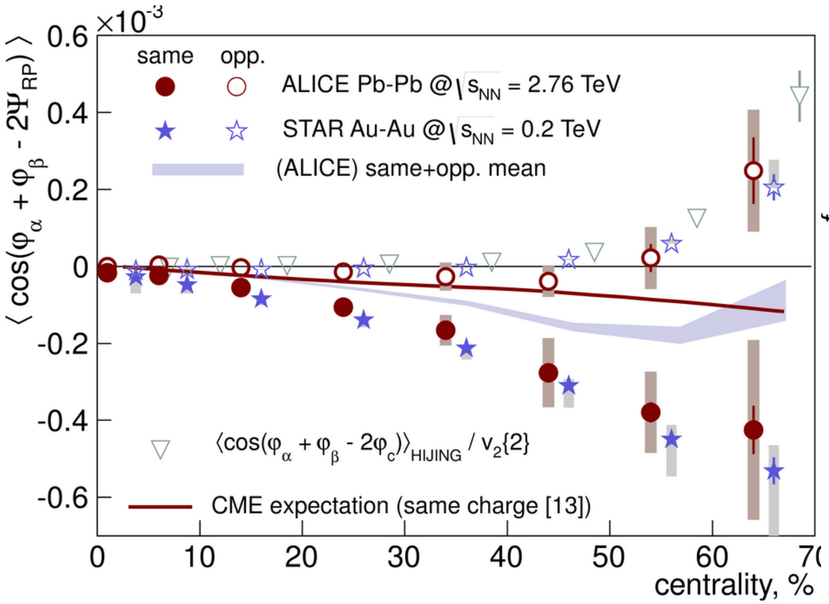
B-field limit

(Lines to guide the eye)

Electrical conductivity poorly constrained experimentally

STATUS OF CME STUDIES (1)

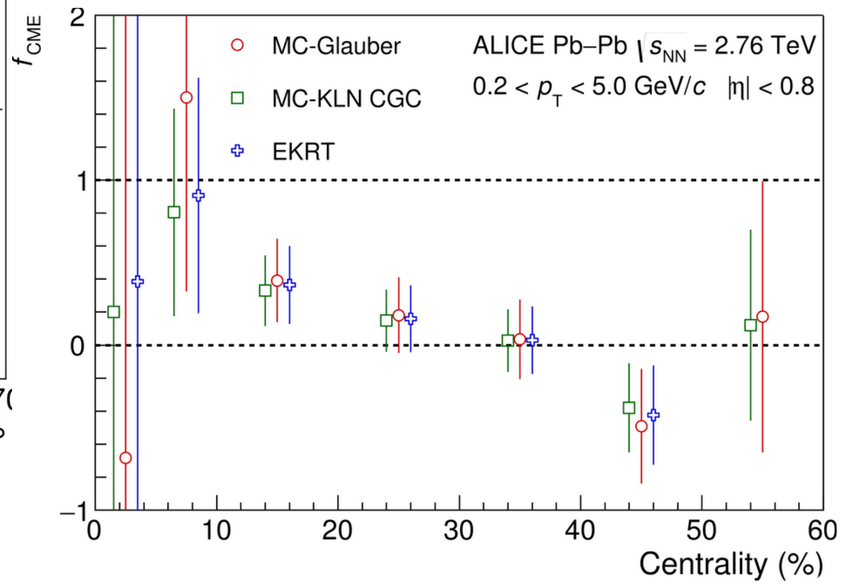
(ALICE Collaboration), Phys. Rev. Lett. **110** (2013) 012301



Surprising agreement between LHC and RHIC measurements

- Bkg dominance

(ALICE Collaboration) Phys. Lett. **B777**, (2018) 151



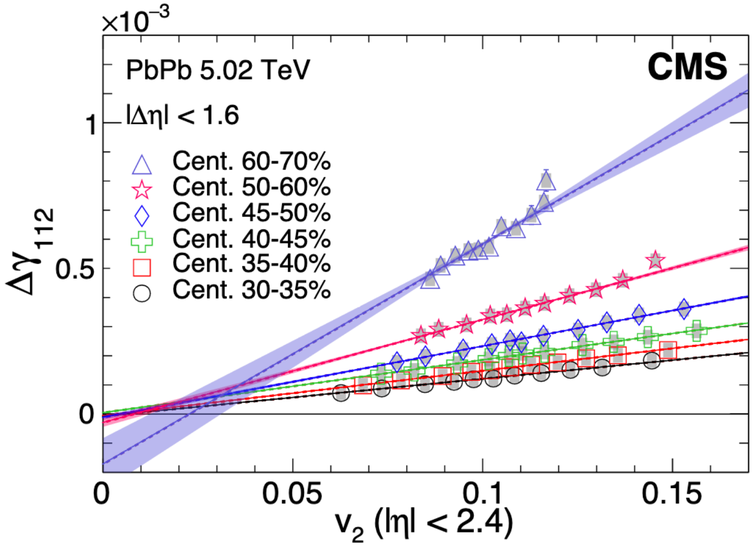
Upper limit on the CME fraction for the 10-50% centrality interval:

- 26-33% at 95% C.L. depending on models of initial state

Upper limit on the CME fraction for Pb-Pb collisions ~7% @ 95% CL

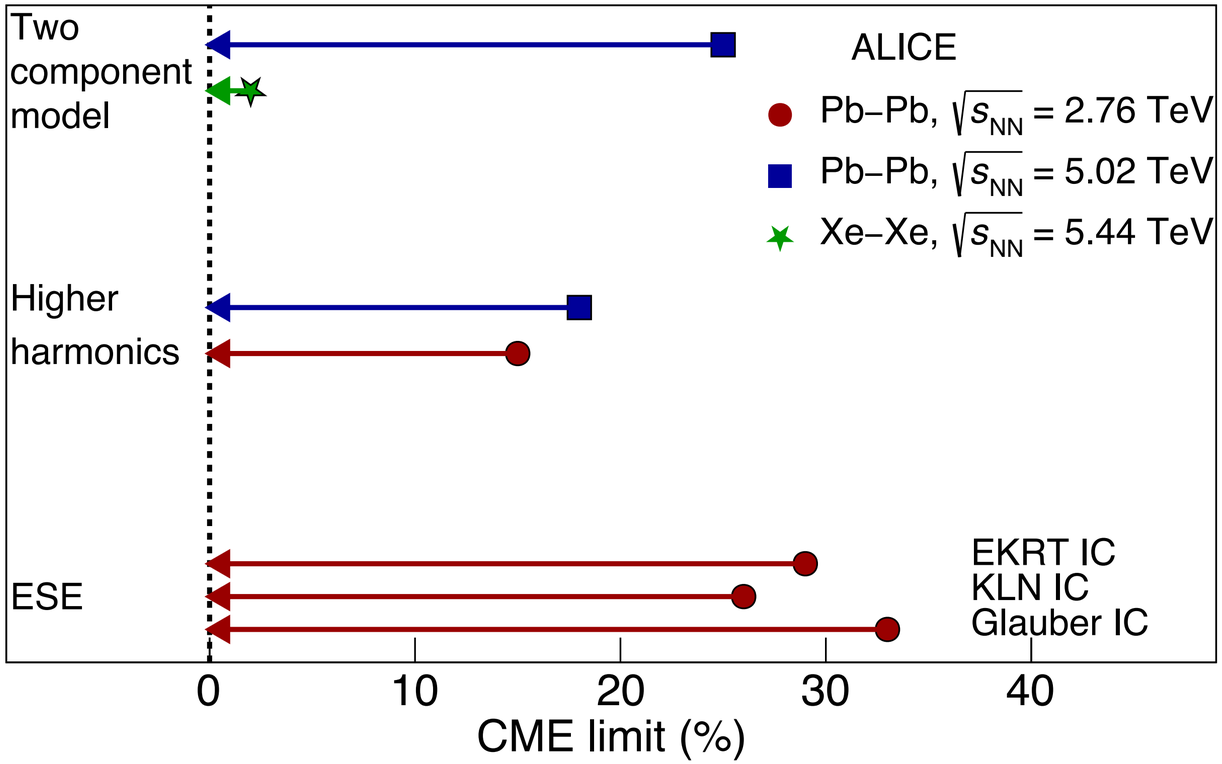
- Based on the assumption of a CME signal independent of v_2 in a narrow multiplicity or centrality range

(CMS Collaboration) Phys.Rev.C 97 (2018) 4, 044912



STATUS OF CME STUDIES (2)

(ALICE Collaboration), arXiv:2211.04384



Summary of upper limits @ LHC (95% CL)		
ALICE	ESE in Pb-Pb collisions	26-33%
	Higher harmonics in Pb-Pb collisions	11-15%
	2-component model	2%(Xe) - 25%(Pb)
CMS	p-Pb collisions	13%**
	ESE in Pb-Pb collisions	7%*

(ALICE Collaboration) Phys. Lett. **B777**, (2018) 151
(CMS Collaboration) Phys.Rev.C 97 (2018) 4, 044912
(ALICE Collaboration) JHEP 2020, (2020) 160

RUN1-RUN2: DATA SAMPLES COLLECTED & RESULTS

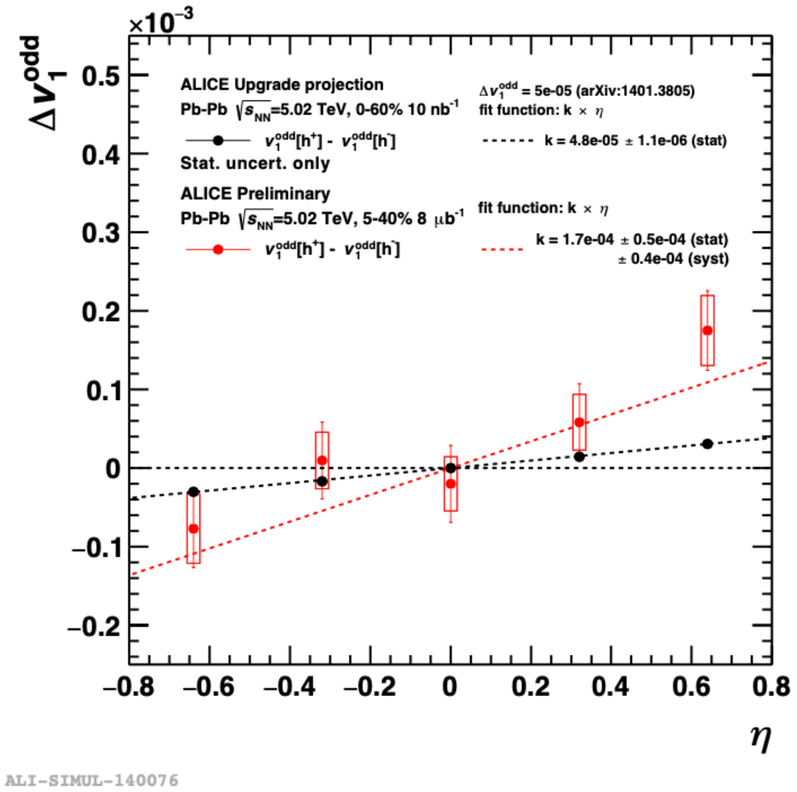
	2010	2011	2013	2015	2016	2017	2018
γ_{11}	ALICE-1		CMS-1	ALICE-4 CMS-1	CMS-2	ALICE-5	
ESE	ALICE-3				CMS-2		Ongoing
Higher harmonics	ALICE-4			ALICE-4	CMS-2		
Ψ_{PP} vs Ψ_{SP}				Ongoing			Ongoing
PID	Preliminary						
CMW	ALICE-2		CMS-3	CMS-3			
CMW/ESE							Ongoing
CMW/Higher harmonics			CMS-3	CMS-3			Ongoing

System	Year	$\sqrt{s_{NN}}$ (TeV)	L_{int}
Pb-Pb	2010, 2011	2.76	~75 μb^{-1}
	2015, 2018	5.02	~0.8 nb^{-1} ~2 nb^{-1}
Xe-Xe	2017	5.44	~0.3 μb^{-1}
p-Pb	2013, 2016	5.02	~18 nb^{-1} ~50 μb^{-1}
	2016	8.16	~25 nb^{-1} ~186 nb^{-1}

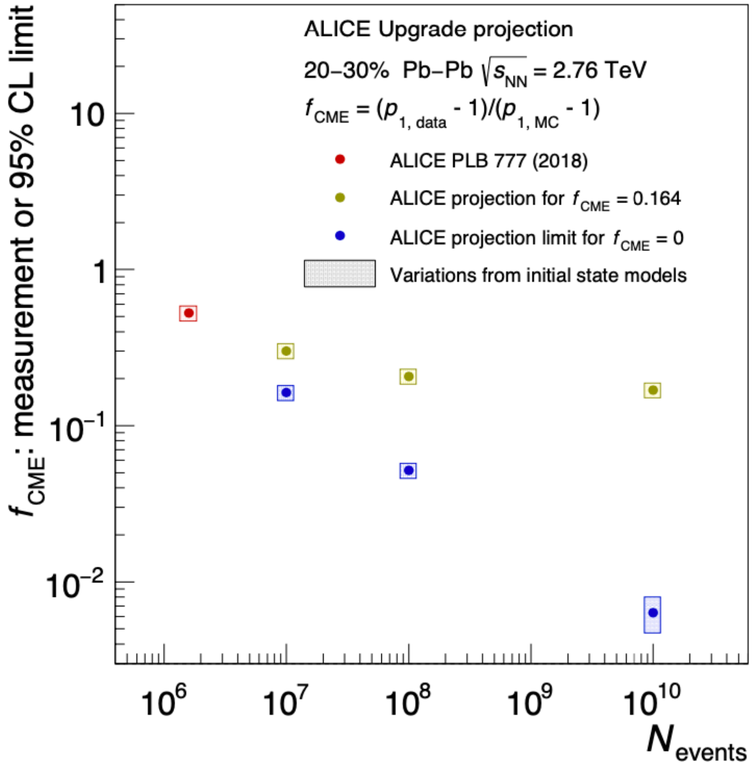
Anticipated results for CME can drive the limit to lower than 10%

RUN3-4 PROJECTIONS

Z. Citron *et al.*, arXiv:1812.06772 [hep-ph]



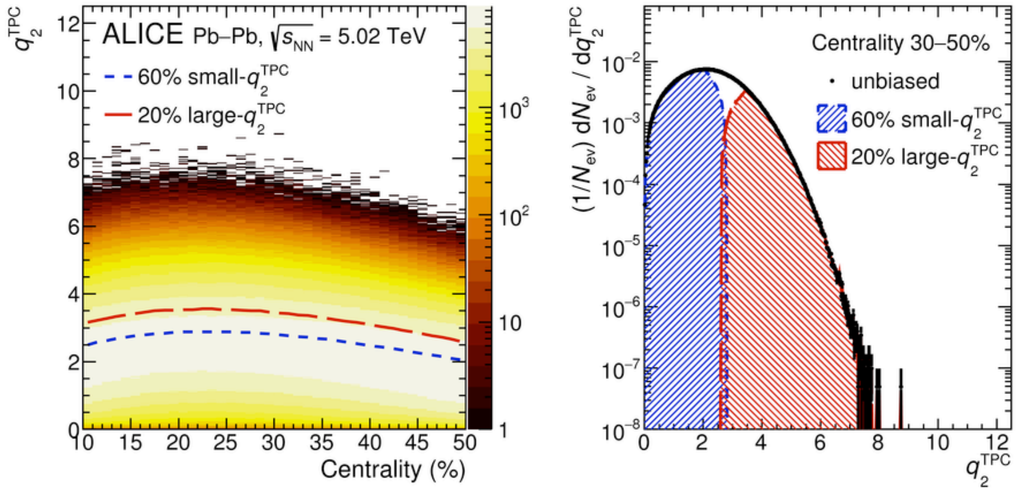
ALI-SIMUL-140076



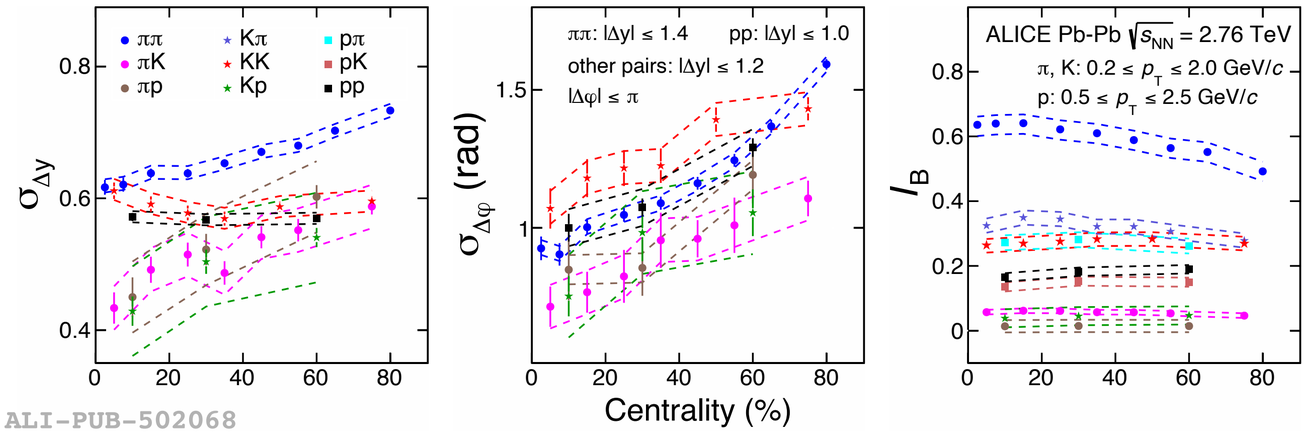
ALI-SIMUL-140080

System	Year	$\sqrt{s_{NN}}$ (TeV)	L_{int}
Pb-Pb	2010, 2011	2.76	~75 μb^{-1}
	2015, 2018	5.02	~0.8 nb^{-1} ~2 nb^{-1}
	2023-2030	**5.5**	**~12 nb^{-1}**
Xe-Xe	2017	5.44	~0.3 μb^{-1}
p-Pb	2013, 2016	5.02	~18 nb^{-1} ~50 μb^{-1}
	2016	8.16	~25 nb^{-1} ~186 nb^{-1}

POSSIBLE FUTURE DIRECTIONS: PID

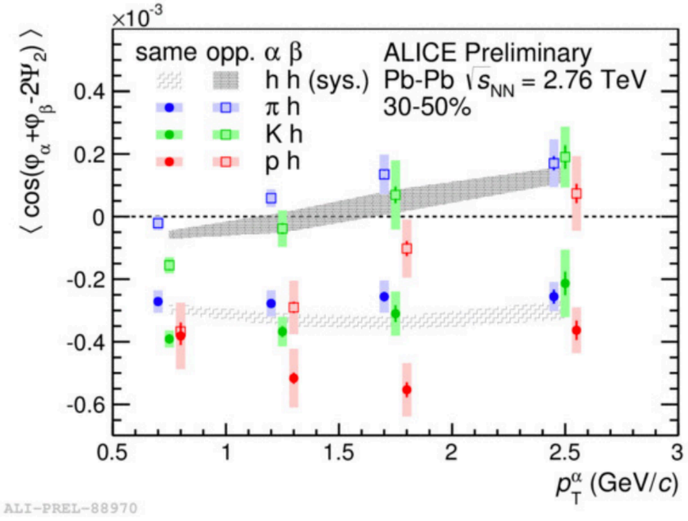


(ALICE Collaboration), Phys. Lett. B 833 (2022) 137338



ALI-PUB-502068

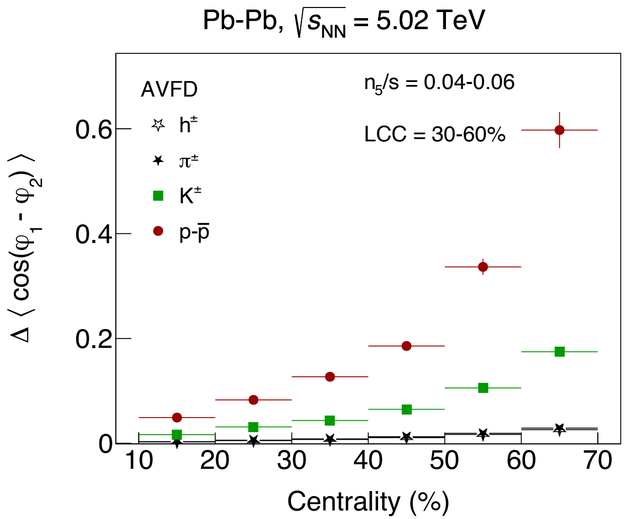
Investigate the background contribution to different particle species in combination with ESE

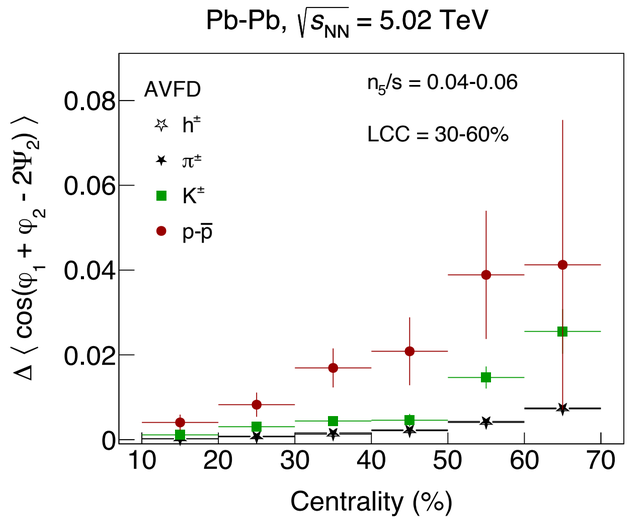


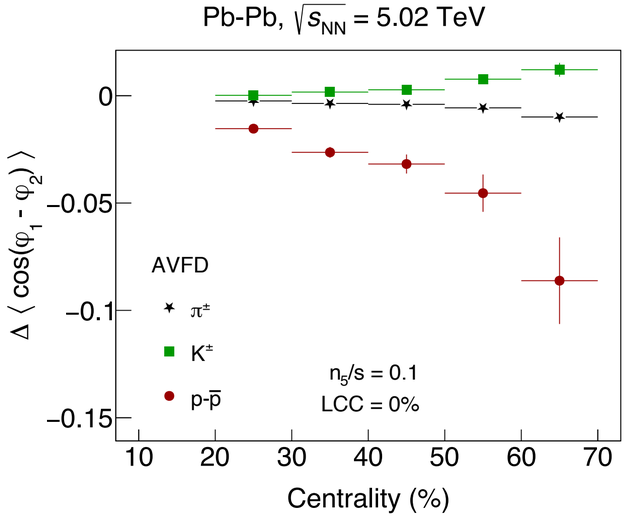
ALI-PREL-88970

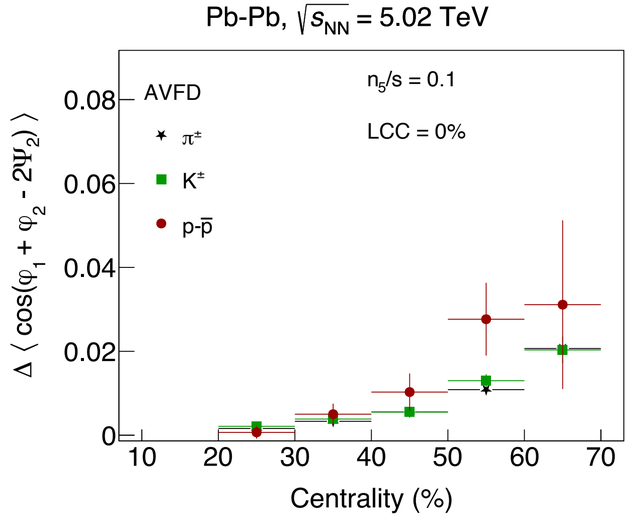
POSSIBLE FUTURE DIRECTIONS: PID

Short article in preparation…









Systematic study of effects from LCC and chirality imbalance on different combination of species

- Include also non-identical correlations e.g. π-p

POSSIBLE FUTURE DIRECTIONS: ESE + B

$$\mu_5 = N_L - N_R$$

$$J = \frac{e^2}{2\pi^2}\mu_5 B$$

Gauge the value of B from the energy deposited in the proton ZDC

- Fluctuations within a given centrality

Probing the signal

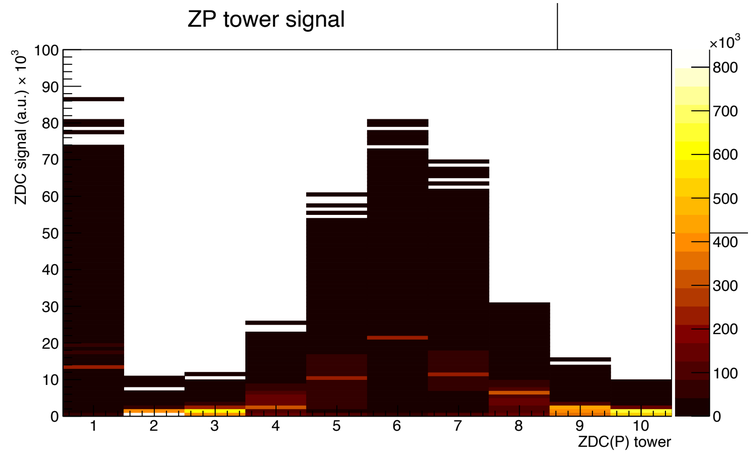
- Look for quadratic dependence between Δγ and E_{ZDC}

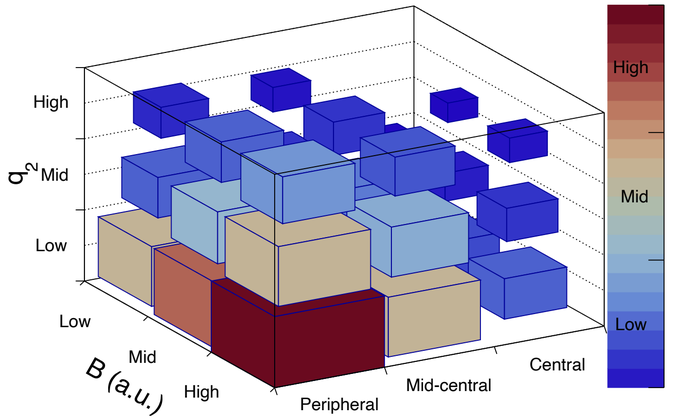
Ongoing quantitative study

- Need for simulation of spectator protons
- Statistics

Caveat:

- ZDC detector @ ALICE affected by beam optics



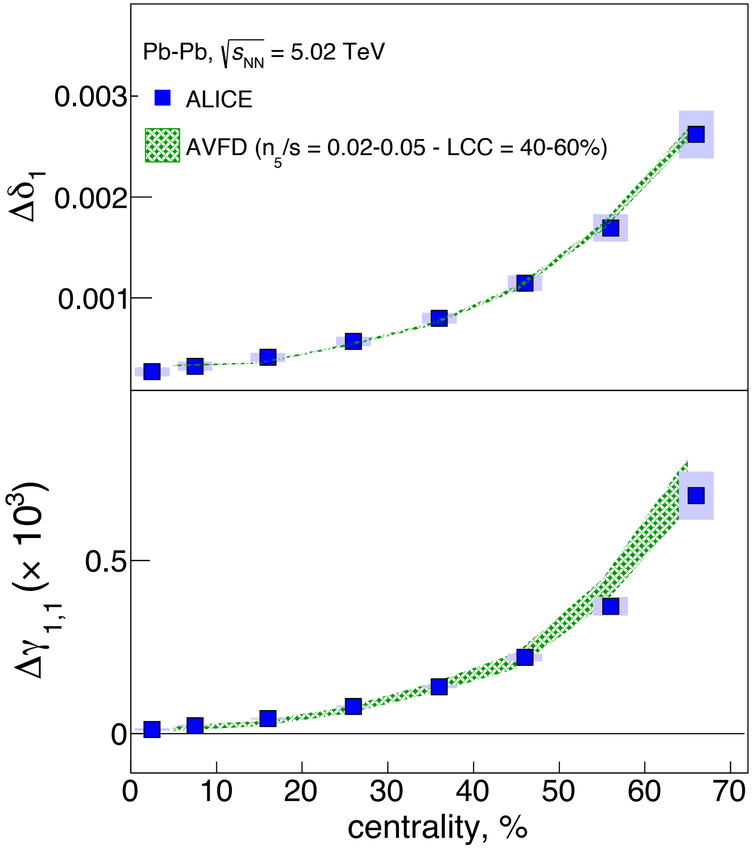


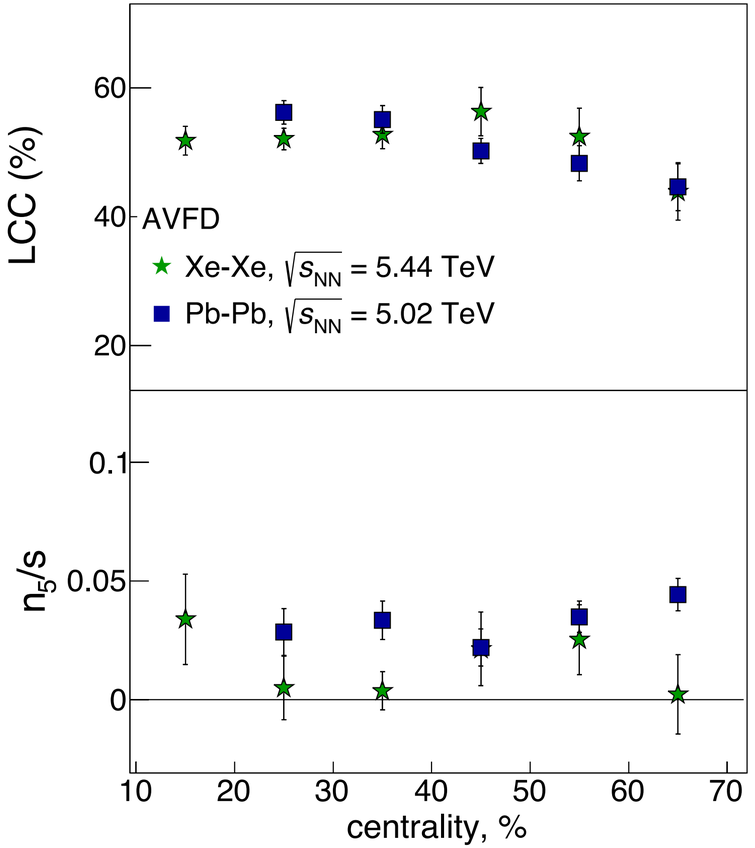
POSSIBLE FUTURE DIRECTIONS: ISOBAR@LHC

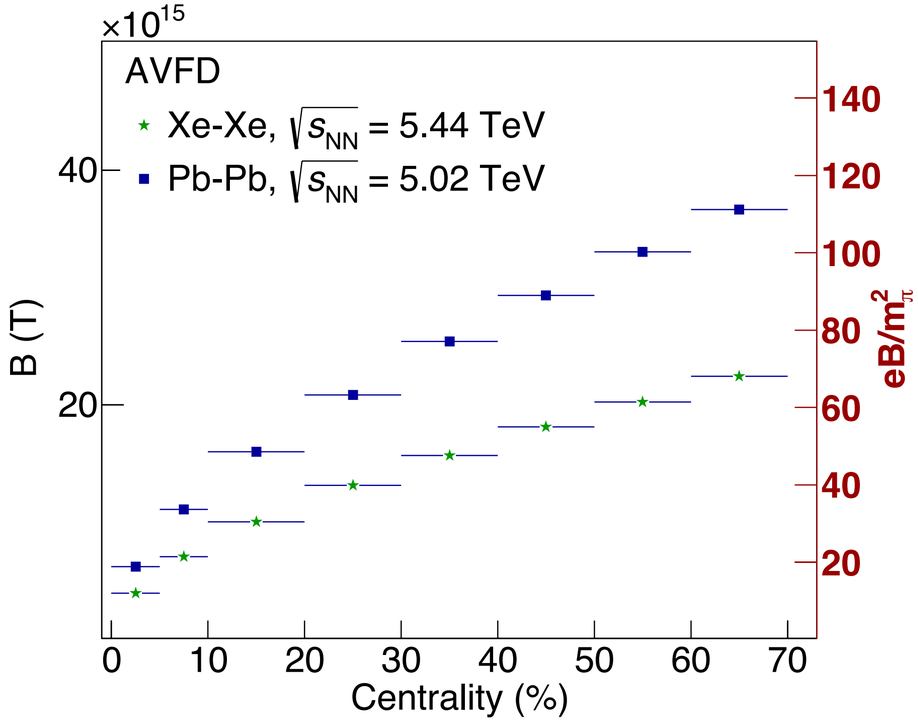
Model tuned to describe at the same time both Δδ and Δγ

$(\eta_5/s)_{Xe\text{-}Xe}$ consistent with 0

$(\eta_5/s)_{Pb\text{-}Pb} = 0.034 \pm 0.003$





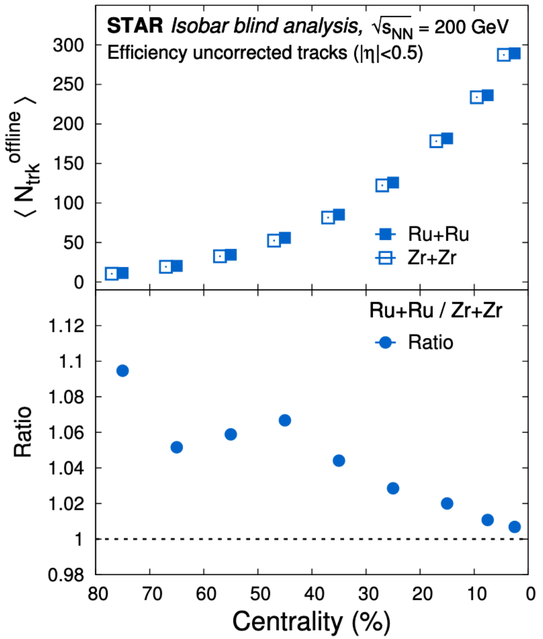


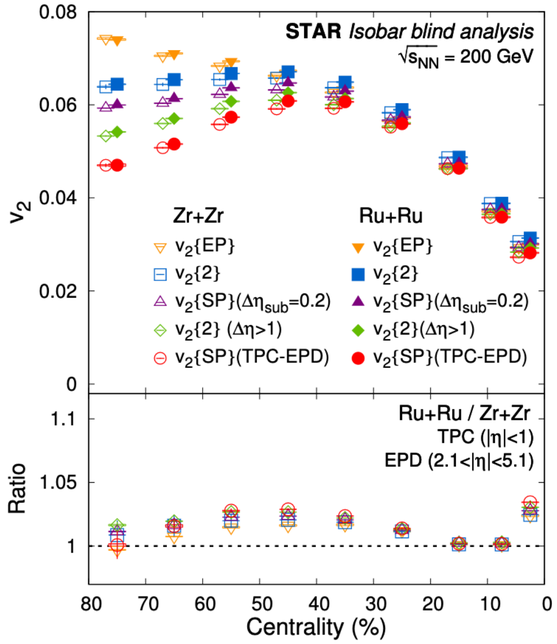
P.C. S. Qiu, J. Staa, Eur. Phys. J. C 81 (2021) 717

Preference for large systems

POSSIBLE FUTURE DIRECTIONS: ISOBAR@LHC

Background components





Jasper Westbroek - Nikhef and UvA

Investigating the usage of two isobaric pairs

- Xe_{54}^{136} vs Ce_{58}^{136}
  - Why was this system not selected @ RHIC?
- Os_{76}^{194} vs Hg_{80}^{194}

Currently studying the effects of deformations (in contact with Jia et al. @ Stony Brook)

- Expansion to CME studies

Article in preparation…

Details are important!

- Nuclear structure should be well understood and studied
  - Neutron skin/charge radius
  - Overall size differences → energy density → multiplicity

INSTEAD OF A SUMMARY

The LHC provides a wonderful opportunity to study such effects with high accuracy

- Large data sets recorded by constantly upgraded detectors
- Largest (initial) magnetic field → lifetime unknown?
- Long lived medium
- Versatile, “flexible” machine
- Baryon free environment

Synergies are needed → increase in critical mass

- Physics program that will allow to study chiral anomalies

Lots of opportunities and room for new ideas

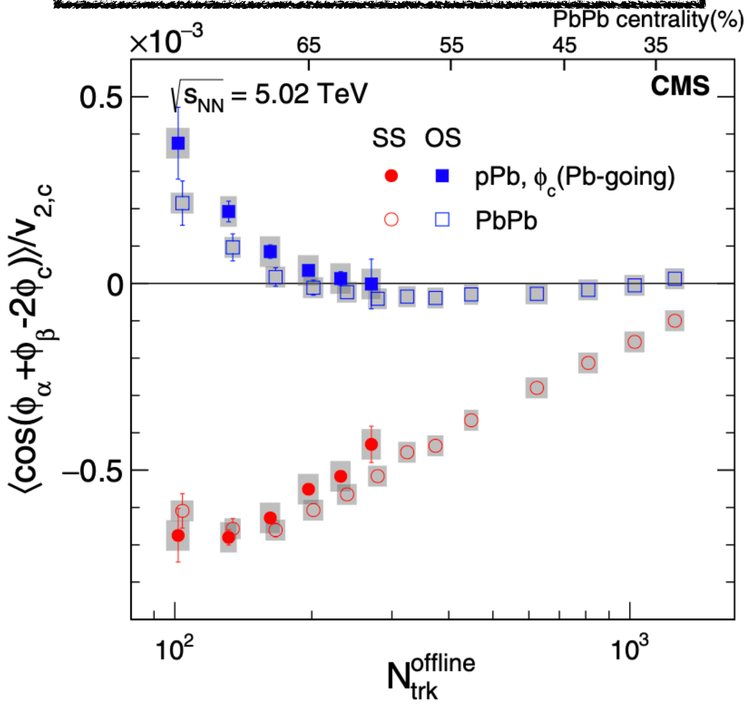
- If you are interested, more than happy to share things with you!

Thank you for
your attention!

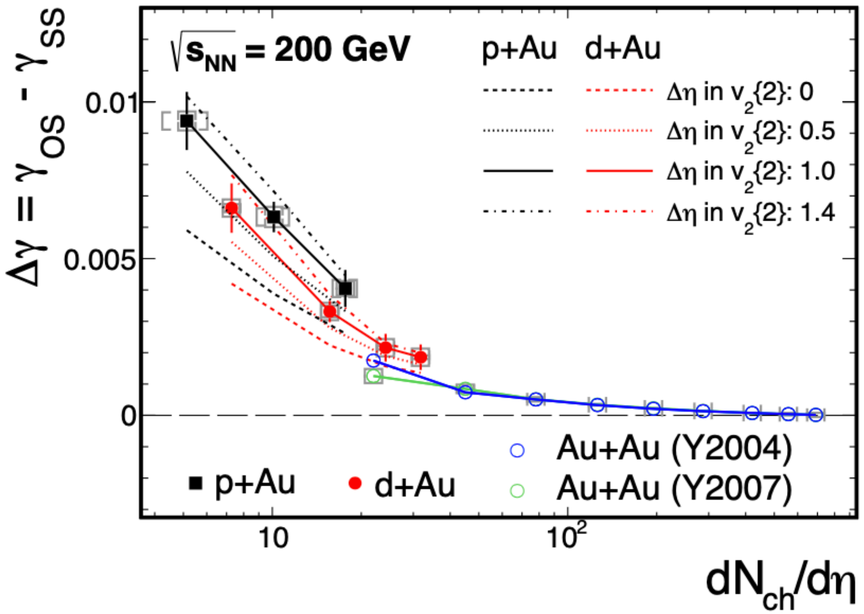
BACKUP

AT THE SAME TIME…SMALL SYSTEMS

(CMS Collaboration) PRL **118**, (2017) 122301



(STAR Collaboration) PRL **118**, (2017) 122301



Significant charge dependent correlations in small systems

- Note: the results should not be used to rule out the CME
- They can be used (at best) as an indication that background effects can be dominant → (measurements hampered by dominant parity independent effects)

AT THE SAME TIME…SMALL SYSTEMS

(STAR Collaboration), Phys. Rev. Lett. **103**, 251601 (2009)

Lines: Expectations from HIJING on 3-particle correlations

Solid: Au-Au

Dashed: Cu-Cu