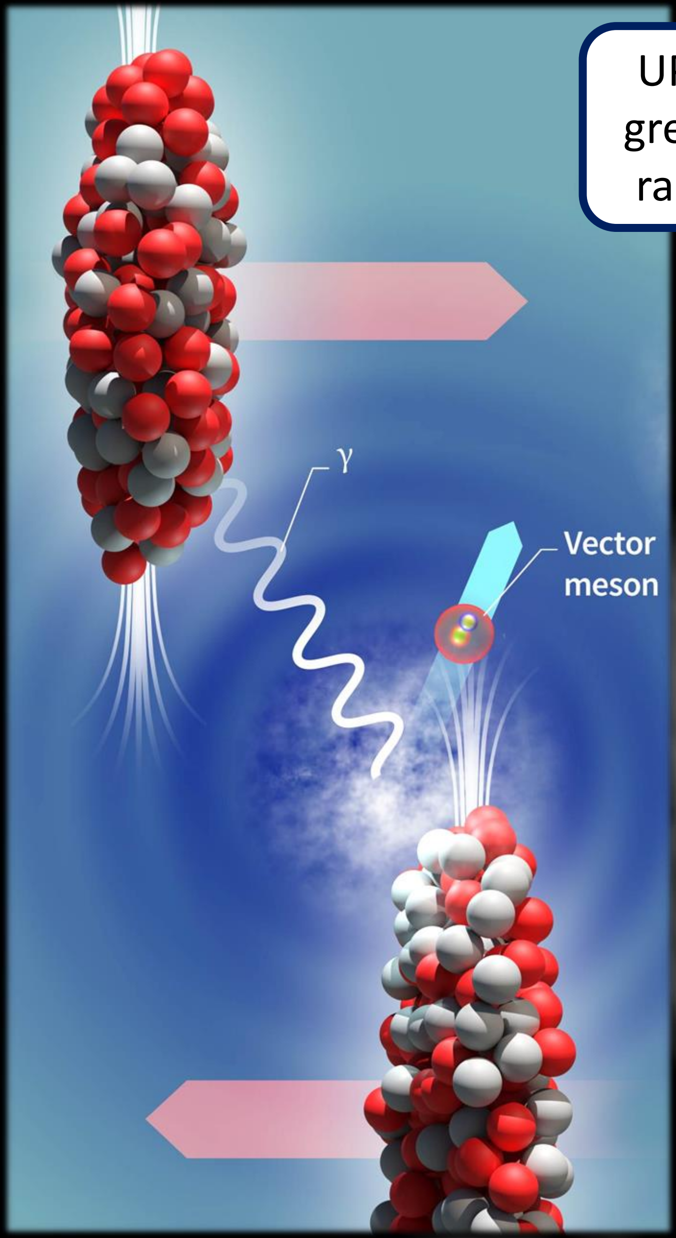
Measurement of azimuthal anisotropy in coherent ρ^0 photoproduction in ultra-peripheral Pb–Pb collisions with ALICE

Andrea Giovanni Riffero[1] on behalf of the ALICE Collaboration

1. University and INFN Torino (IT)

Flash talk – Sesto Incontro INFN, 2024, Trento (IT), February 27th

ULTRA-PERIPHERAL COLLISIONS (UPCs)



UPCs: impact parameter b greater than the sum of the radii of the colliding nuclei

Purely hadronic interactions highly suppressed → study of photon induced reactions

Figure from ALICE webpage

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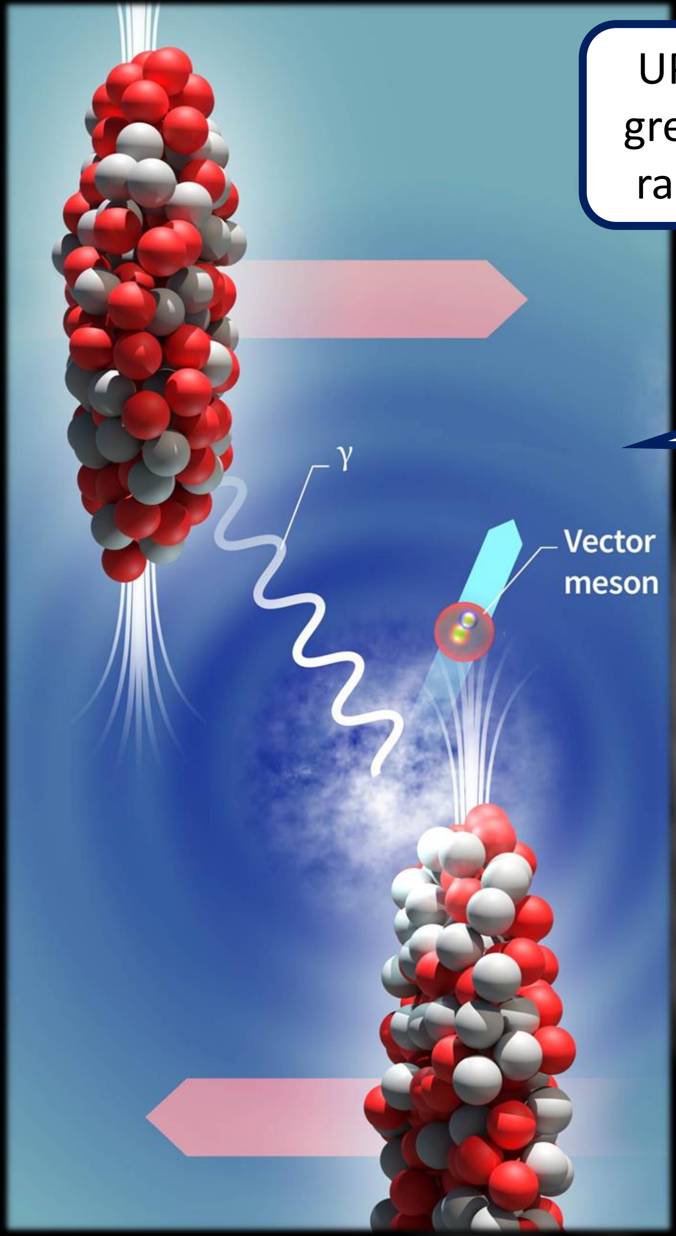

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Interesting process: coherent photoproduction of a vector meson (e.g. ρ^0)

One of the nuclei emits a photon that, after fluctuating into a quark-antiquark pair, interacts strongly with the other nucleus

Clear signal: $\rho^0 \rightarrow \pi^+\pi^-$at midrapidity in an otherwise empty detector

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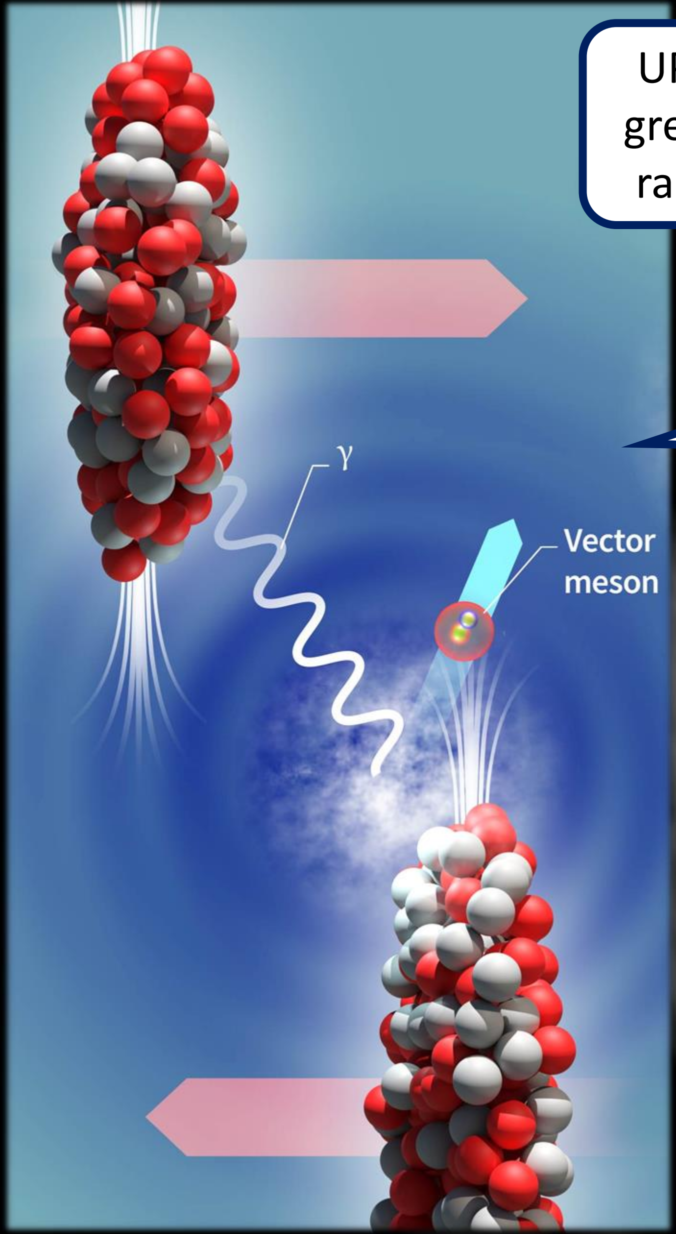

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UPCs with independent electromagnetic dissociation → nuclear break-up with emission of forward neutrons

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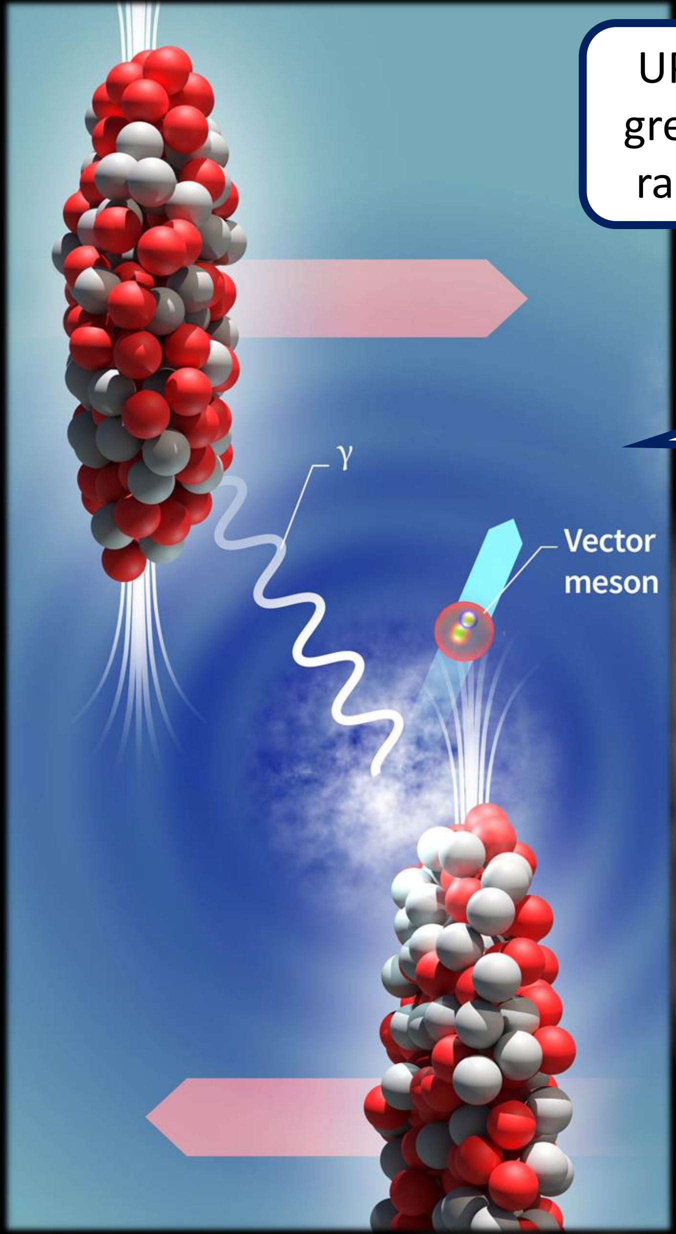

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The EM fields of the nuclei are highly Lorentz contracted → exchanged photons are linearly polarized along b

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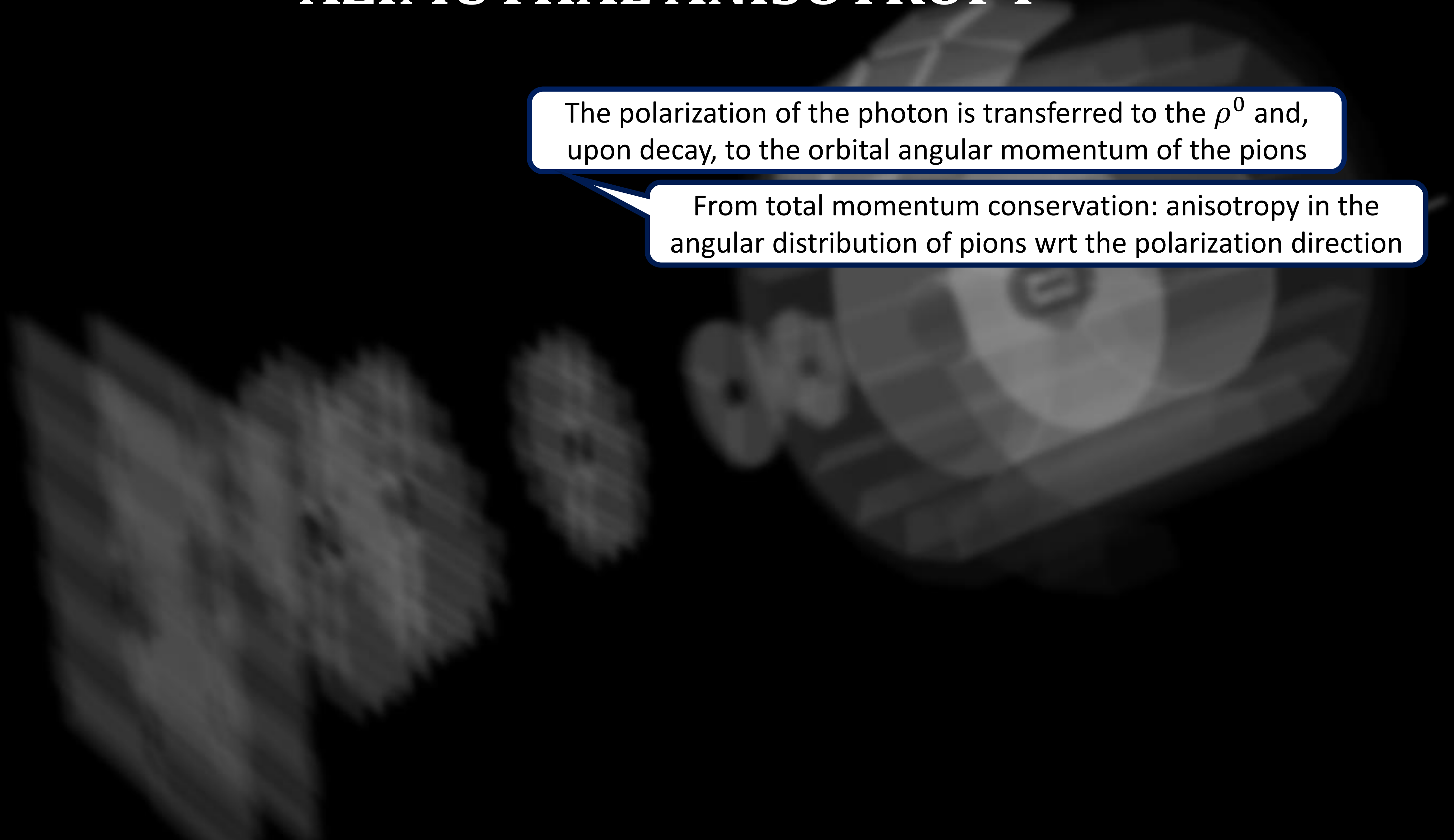
AZIMUTHAL ANISOTROPY



The polarization of the photon is transferred to the ρ^0 and, upon decay, to the orbital angular momentum of the pions

From total momentum conservation: anisotropy in the angular distribution of pions wrt the polarization direction

[2] Phys.Rev.D 103 (2021) 3, 033007

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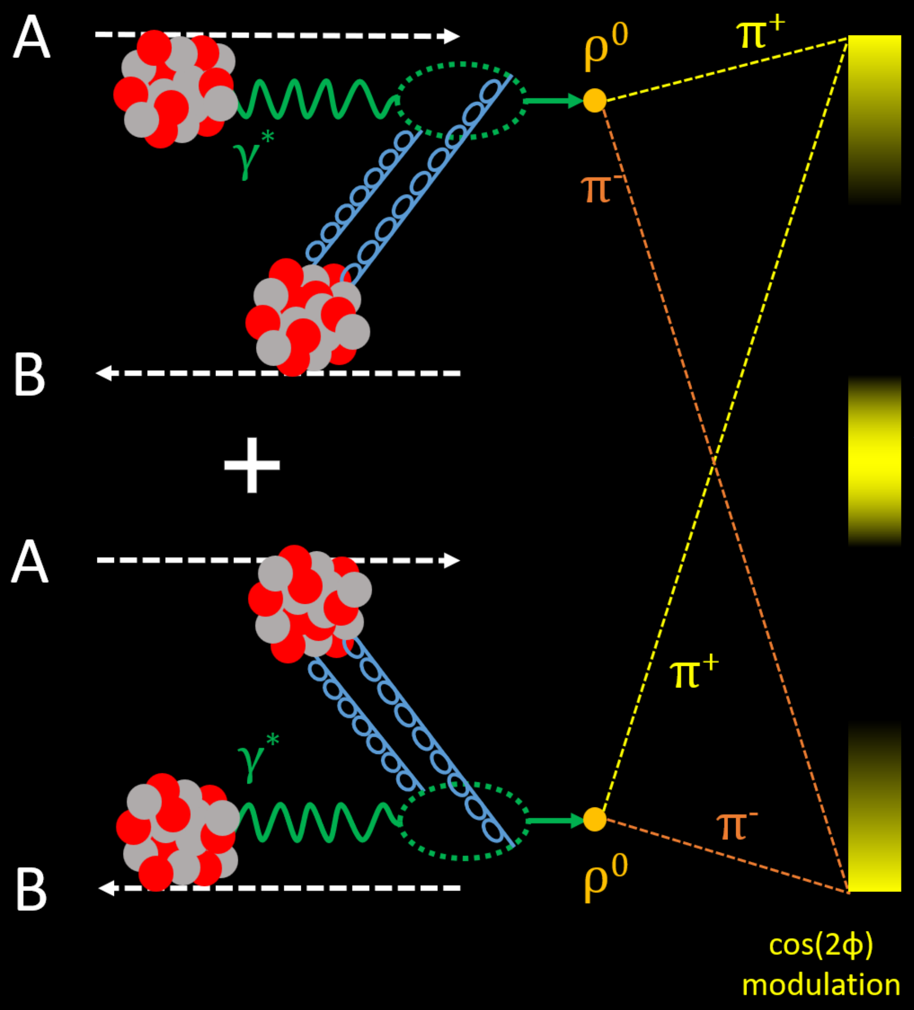

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Each nucleus can act as the source of the photon
or as the target in the interaction
→ two indistinguishable amplitudes contribute to the cross section

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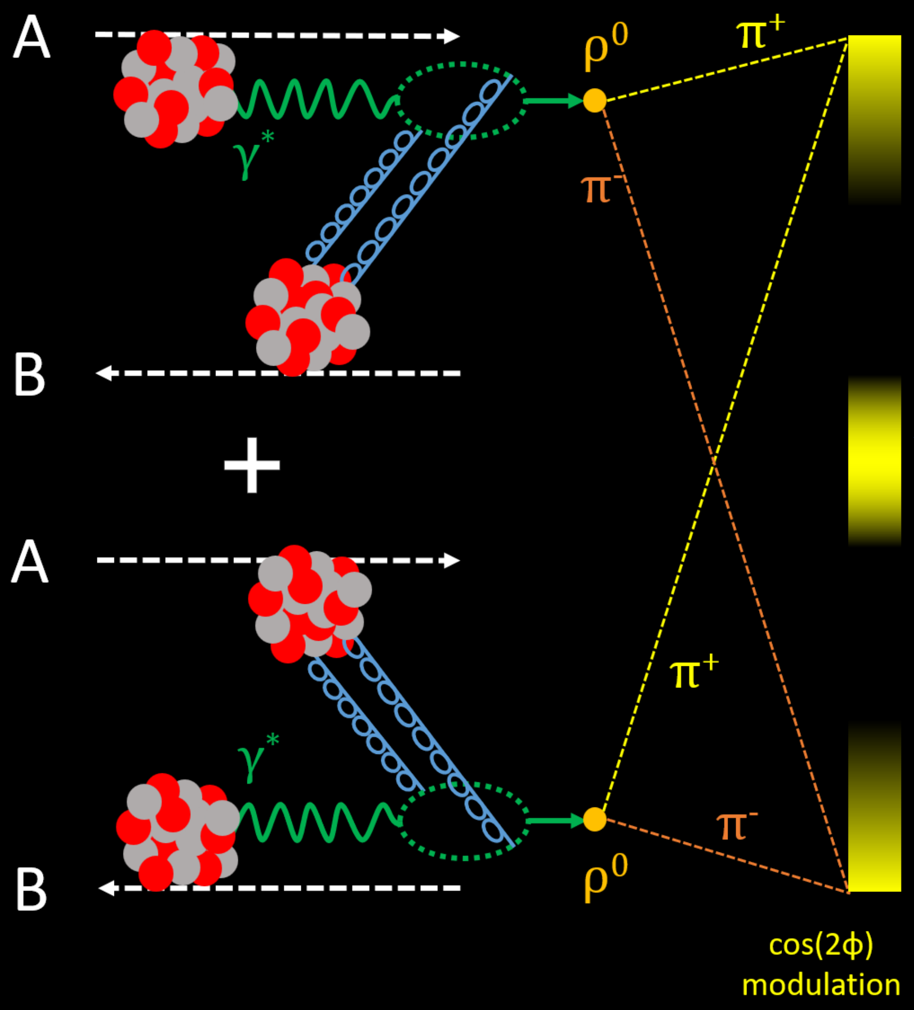

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Interference between the amplitudes!

Correlation between ρ^0 momentum and polarization
→ preserves the anisotropy!

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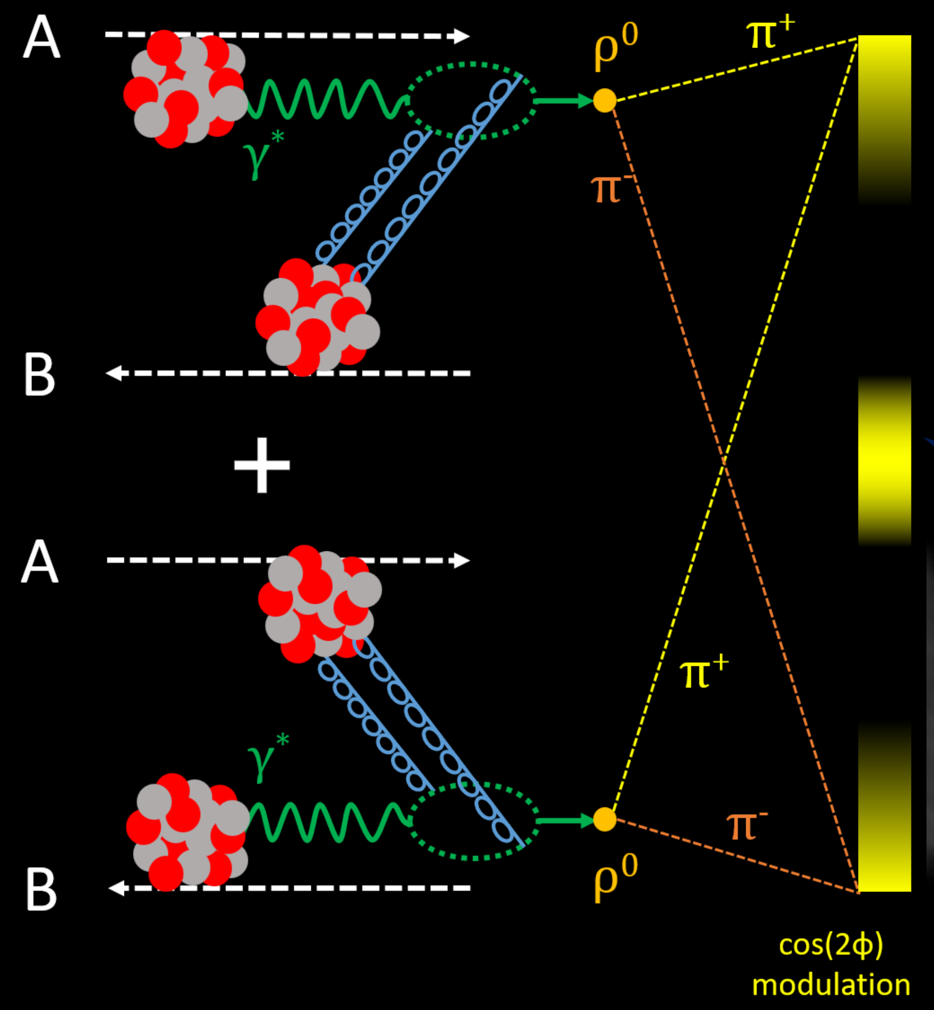

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Double-slit experiment at fm scale [2]
→ b acts as the distance between the openings

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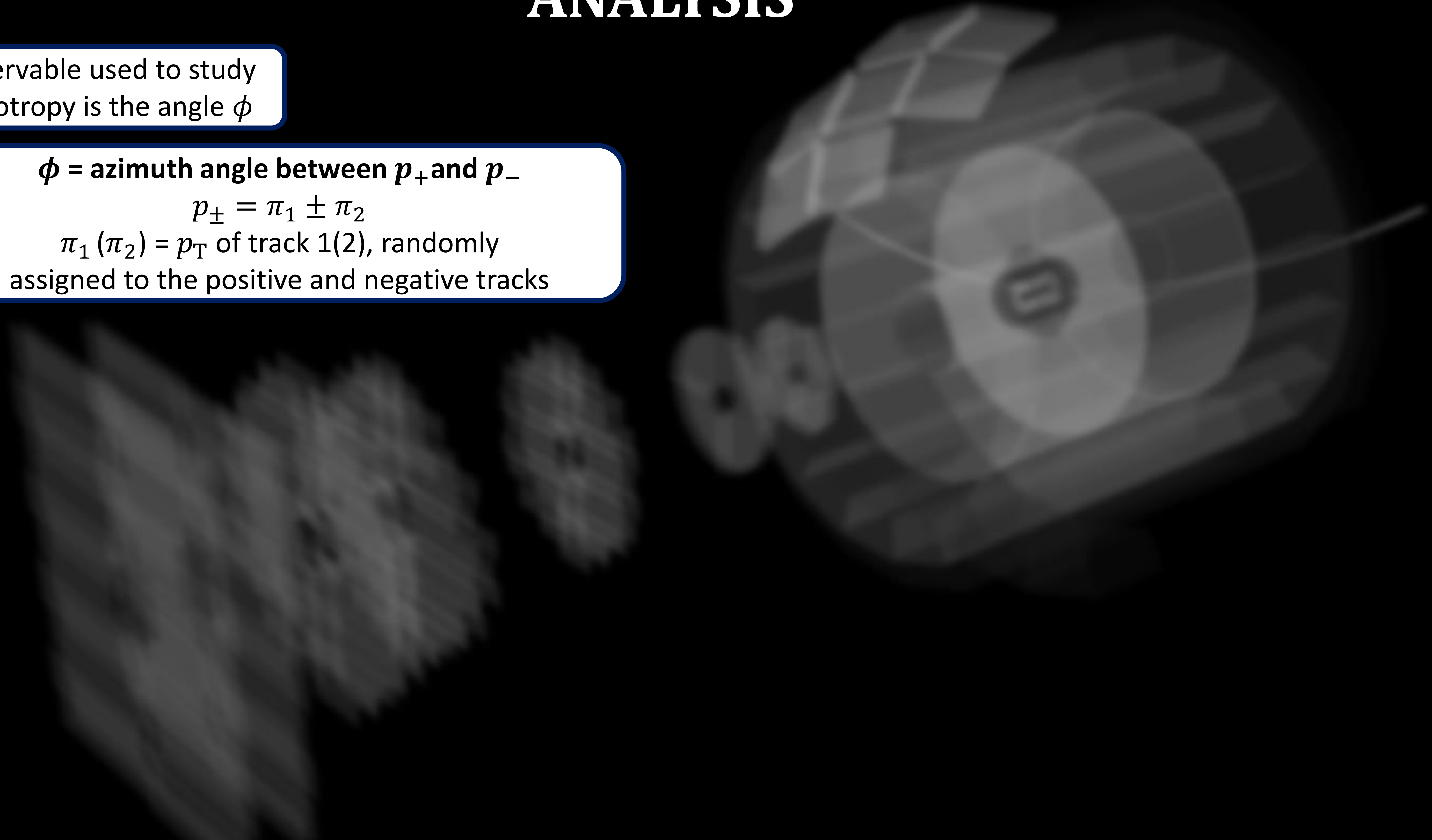
ANALYSIS

The observable used to study the anisotropy is the angle ϕ

ϕ = azimuth angle between p_+ and p_-

$$p_{\pm} = \pi_1 \pm \pi_2$$

π_1 (π_2) = p_T of track 1(2), randomly assigned to the positive and negative tracks



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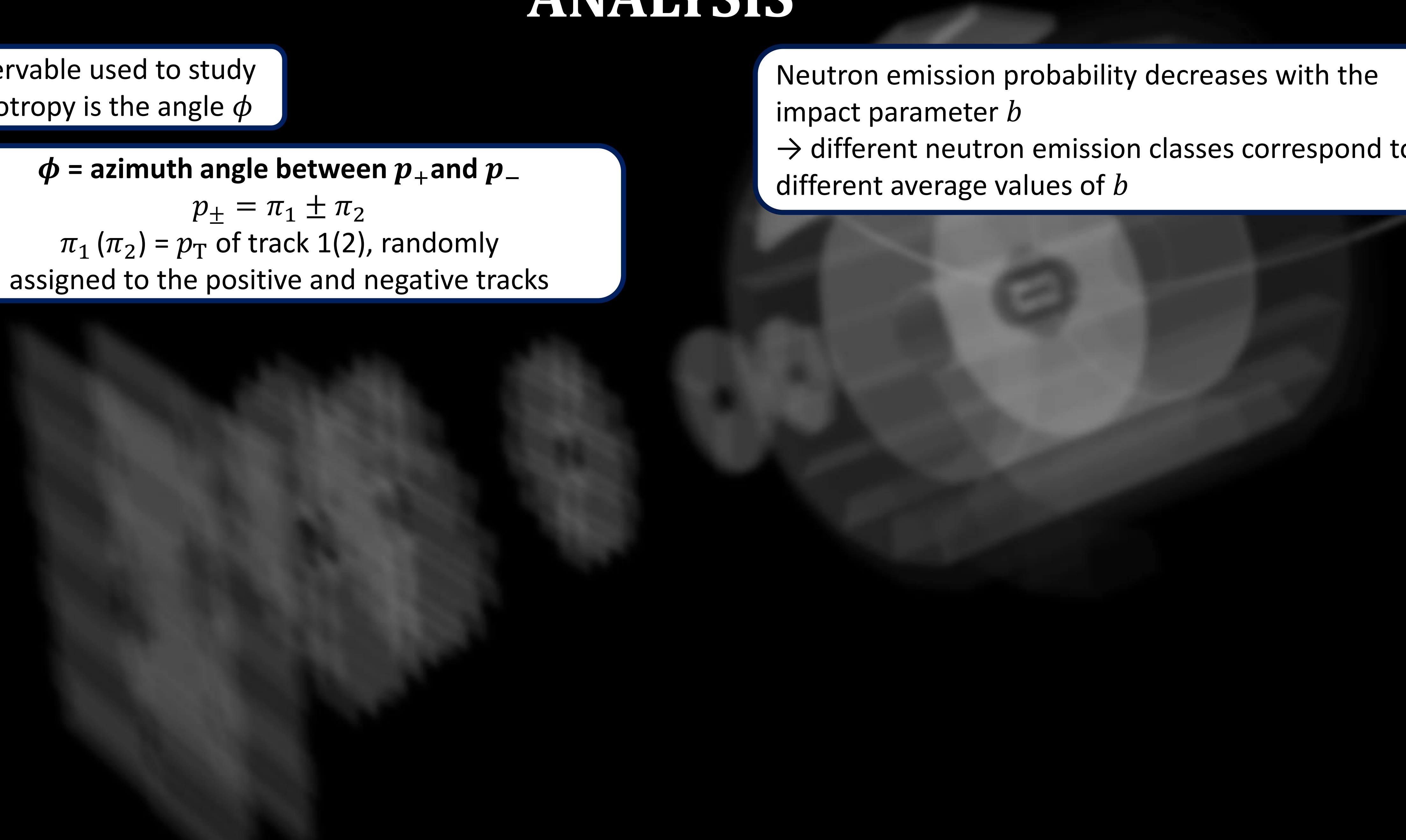
→ different neutron emission classes correspond to different average values of b



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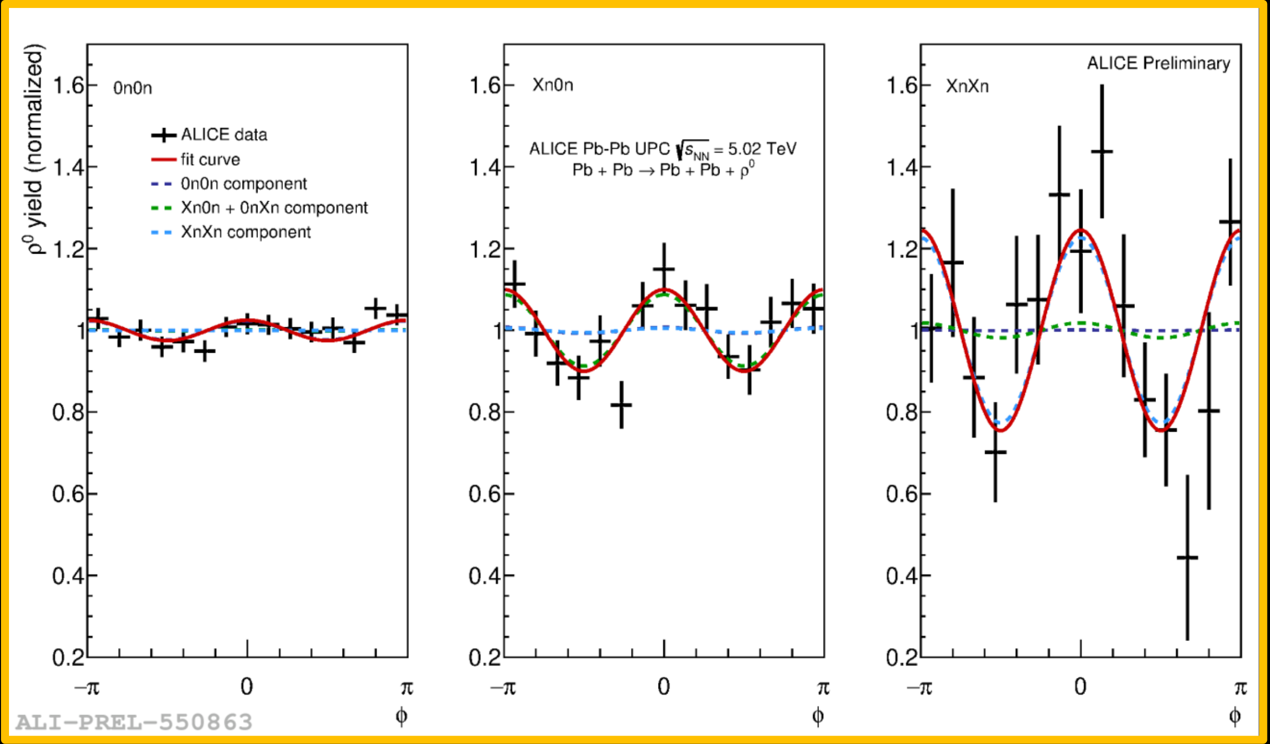

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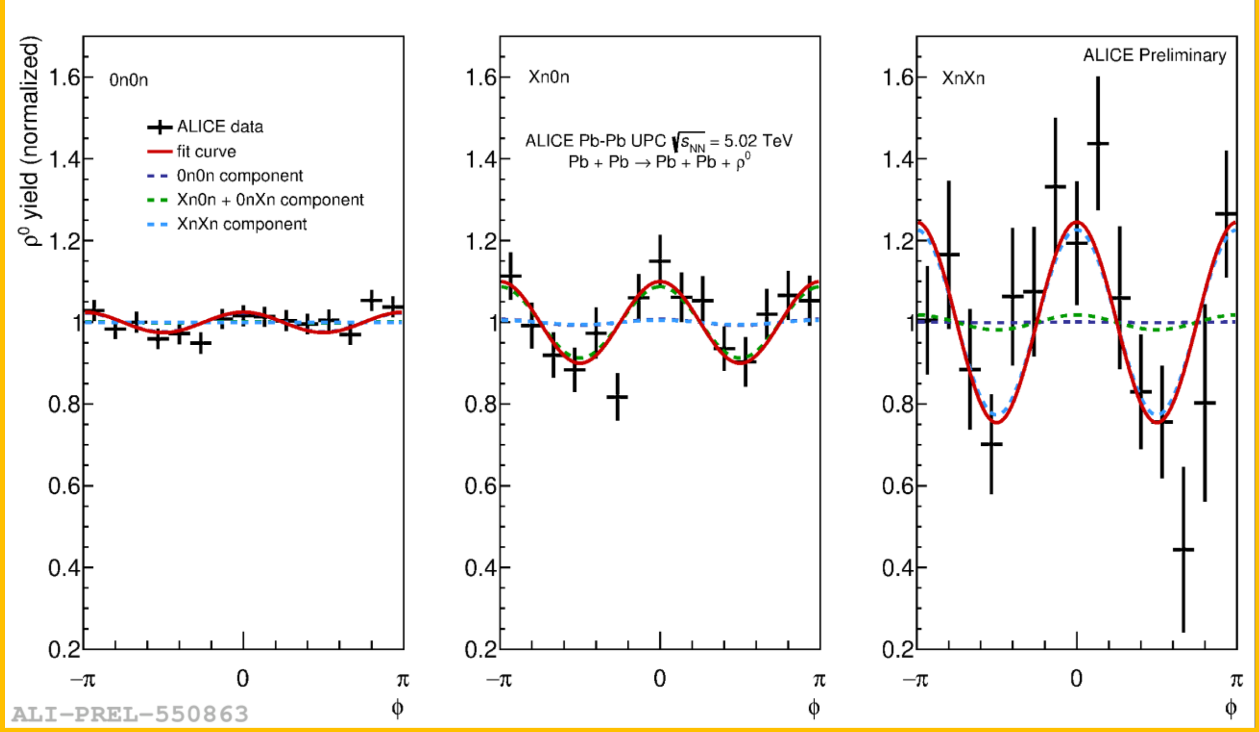
Fit of these distribution to extract the strength of the anisotropy

The fit is done simultaneously in all neutron classes to consider migrations across them [5]



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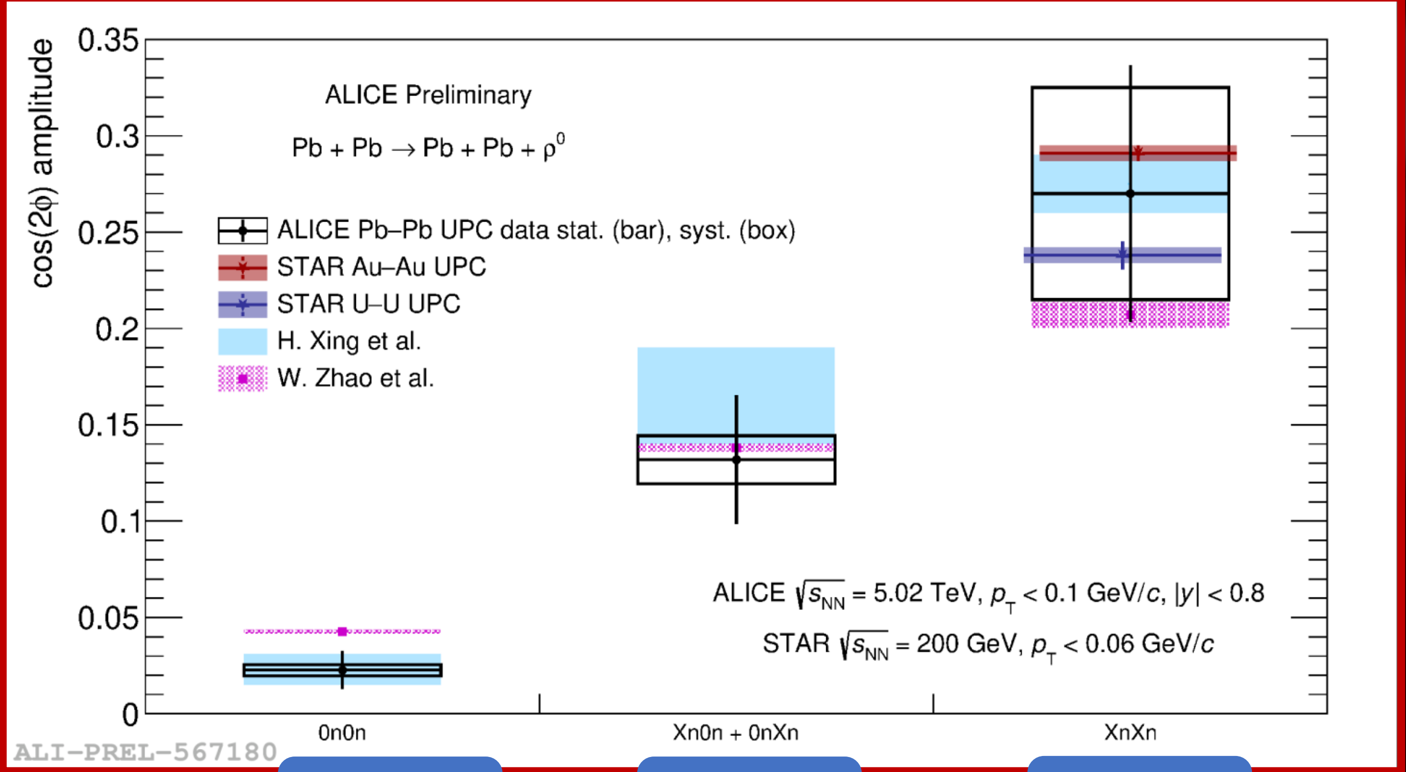
ASYMMETRY RESULTS



b~49 fm | b~23 fm | b~18 fm

First measurement of the azimuthal anisotropy of the ρ^0 yield as a function of the impact parameter

Median values of b in different neutron classes

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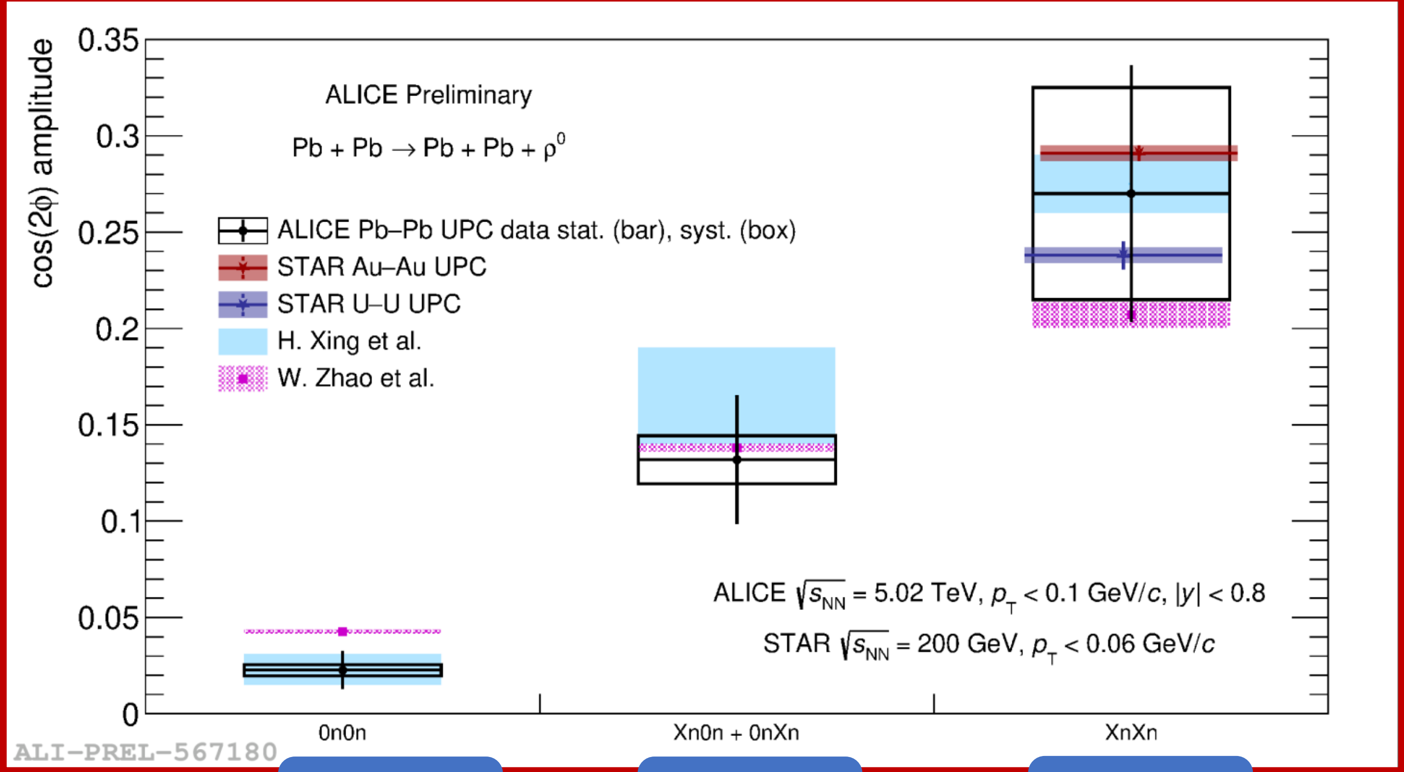

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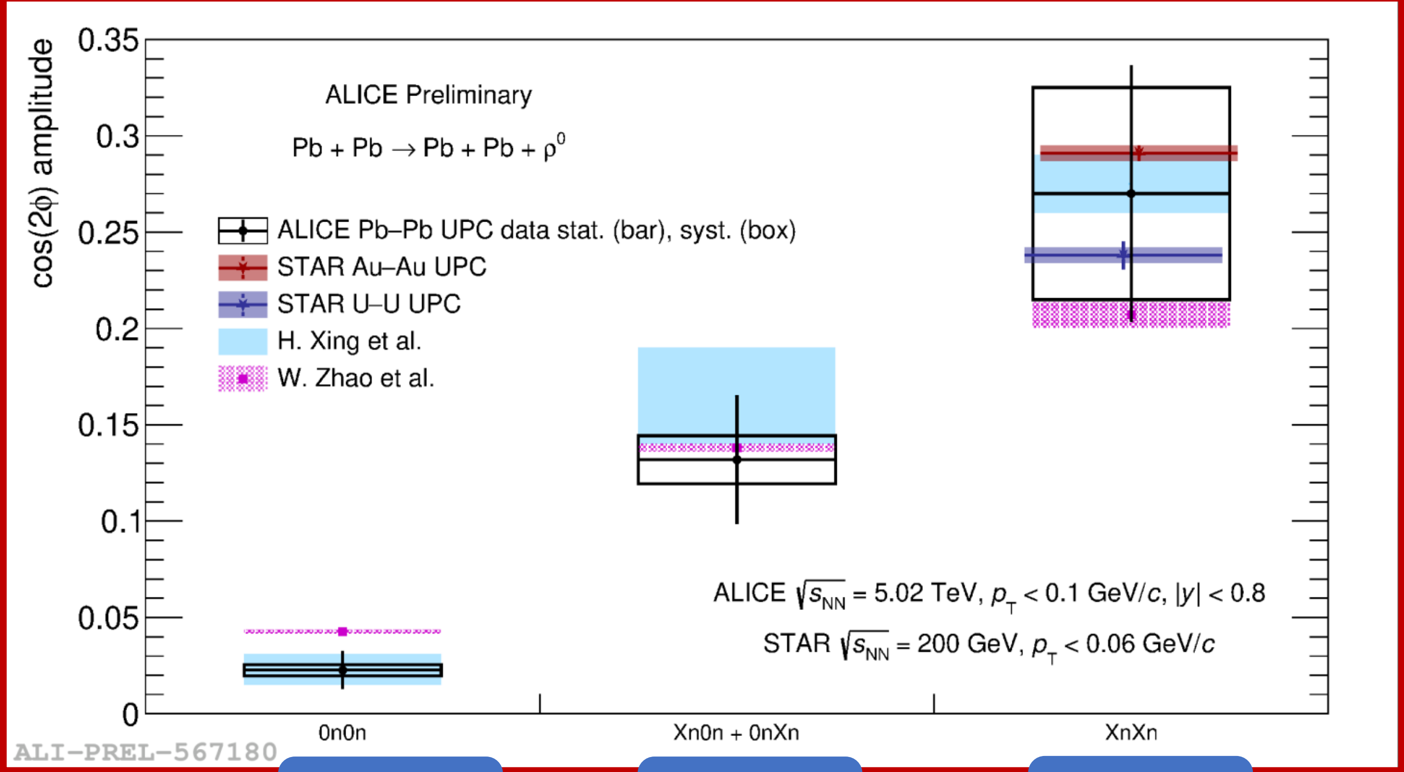

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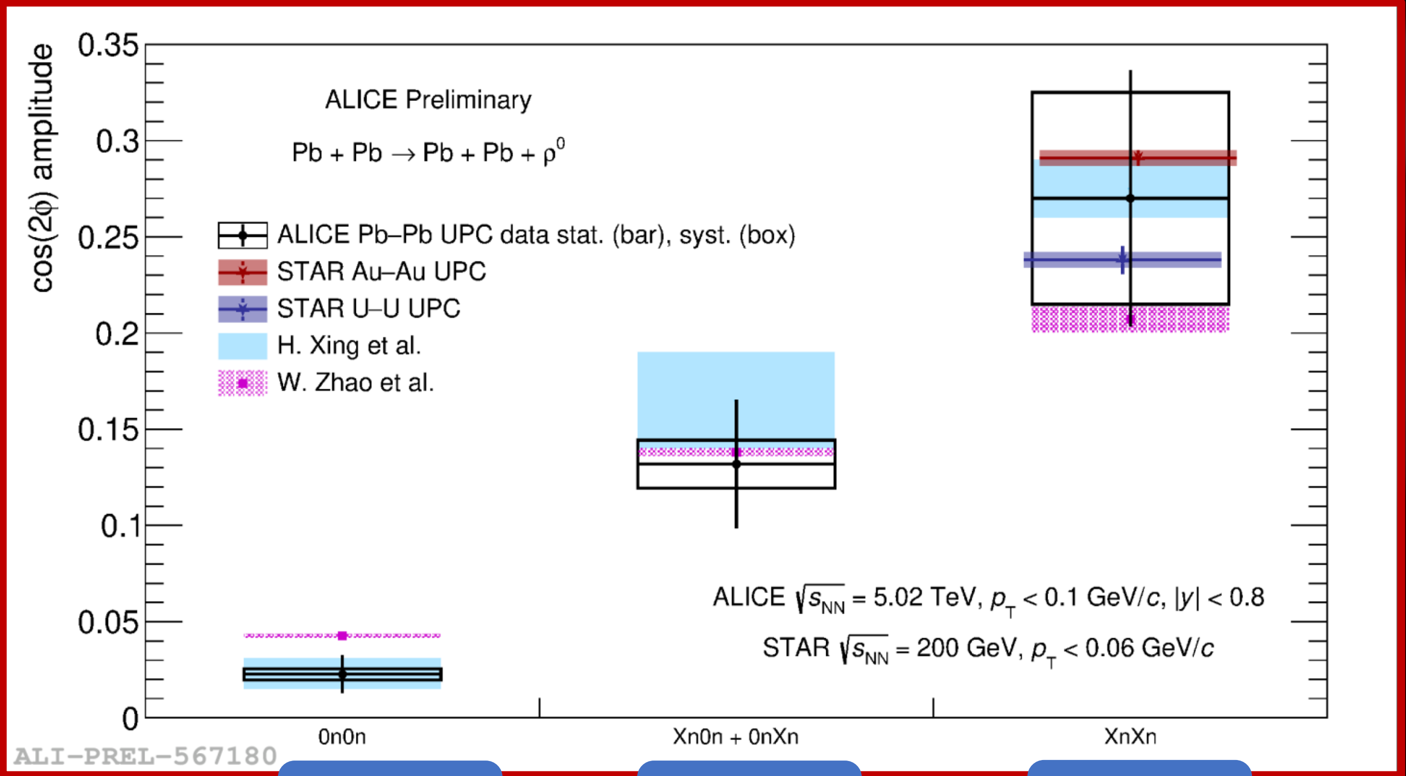

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It is not possible to constrain models yet → goal with Run 3 data!

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REFERENCES

[1] ALICE webpage

[2] W. Zha et al. *Exploring the double-slit interference with linearly polarized photons,* Phys.Rev.D 103 (2021) 3, 033007

[3] H. Xing et al. *The cos 2φ azimuthal asymmetry in ρ0 meson production in ultraperipheral heavy ion collisions,* JHEP 10 (2020) 064

[4] W. Zhao et al. *Effects of nuclear structure and quantum interference on diffractive vector meson production in ultra-peripheral nuclear collisions*, arXiv:2310.15300 [nucl-th] (2023)

[5] STAR Collaboration, *Tomography of ultrarelativistic nuclei with polarized photon-gluon collisions,* Sci.Adv. 9 (2023) eabq3903

[6] ALICE Collaboration*, Coherent photoproduction of ρ0 vector mesons in ultra-peripheral Pb-Pb collisions at √sNN = 5.02 TeV,* JHEP 06 (2020) 035

THANK YOU FOR YOUR ATTENTION!