Direct photon flow in ALICE

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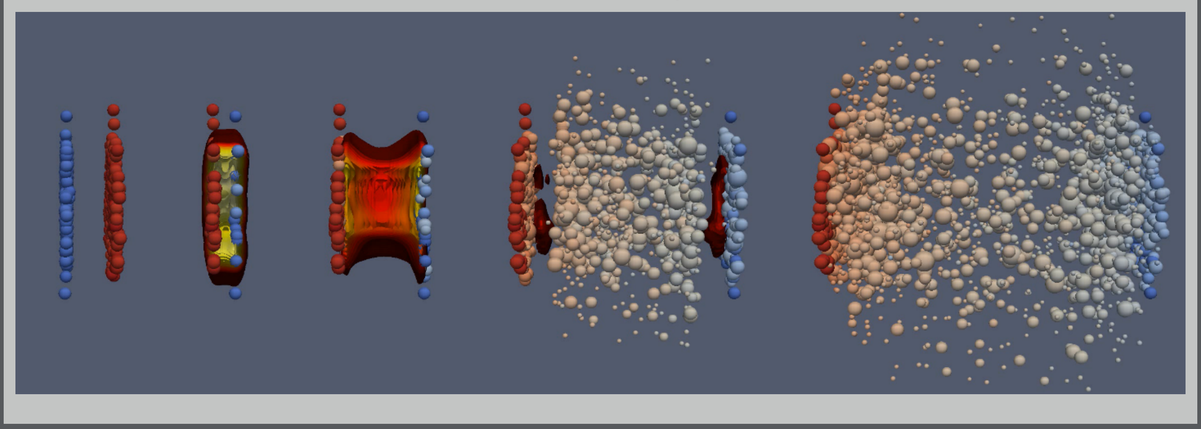
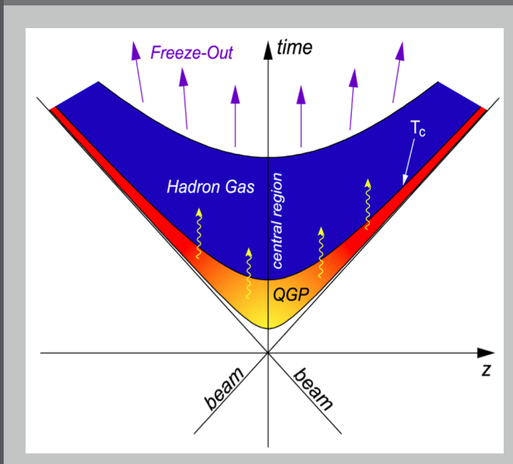
Introduction

Direct photons, which are photons not coming from decaying hadrons, provide information of the evolution of the Quark-Gluon Plasma created in heavy-ion collisions. They are produced at all stages of the collision and can be classified in thermal and prompt (direct) photons. These photons have a mean free path much larger than the system size (unlike hadrons), carrying information about the conditions at the time of their production.



Thermal photons



Thermal (direct) photons are emitted from the hot strongly interacting medium throughout the system evolution and their spectrum depends on the medium properties, such as temperature and flow velocity, of all phases of the collisions. They dominate direct photon yields at low transverse momentum. Next to the spectra, also azimuthal anisotropies v_n of direct photons are measured, which can provide additional constraints to theoretical models.

Definitions:

- **Inclusive photons:** photons from any source
- **Decay photons:** photons from hadronic decays
- **Direct photons:** photons *not* coming from decaying particles

The direct photon puzzle
Theoretical calculations, employing hydrodynamics, struggle to explain both the measured direct photon spectra and v_n <u>at the same time</u> [2].

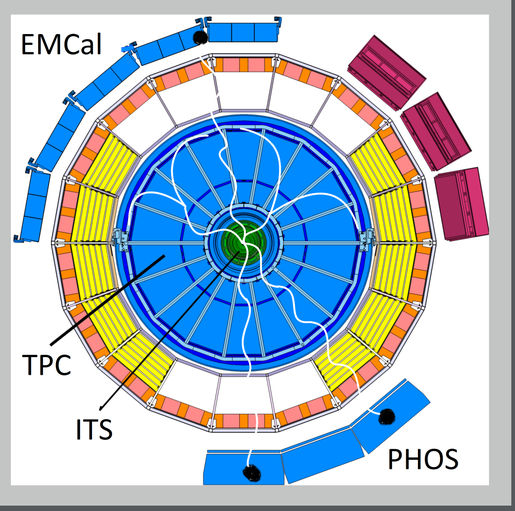
Detection method: Photons in ALICE Run 1

Calorimetric

- Photons hitting the surface of the calorimeter(EMCal or PHOS) produce an electromagnetic shower and deposit their total energy.

Photon Conversion Method

- Photons converting into e^+e^- by interacting with the detector material are reconstructed using the ITS and TPC.



Analysis method: Direct photon yield and flow

The direct photon spectrum is extracted by subtracting the decay photon spectrum from the inclusive photon spectrum:

$$\gamma_{direct} = \gamma_{incl} - \gamma_{decay} = \left(1 - \frac{1}{R_\gamma}\right) \cdot \gamma_{incl} \quad (1)$$

where

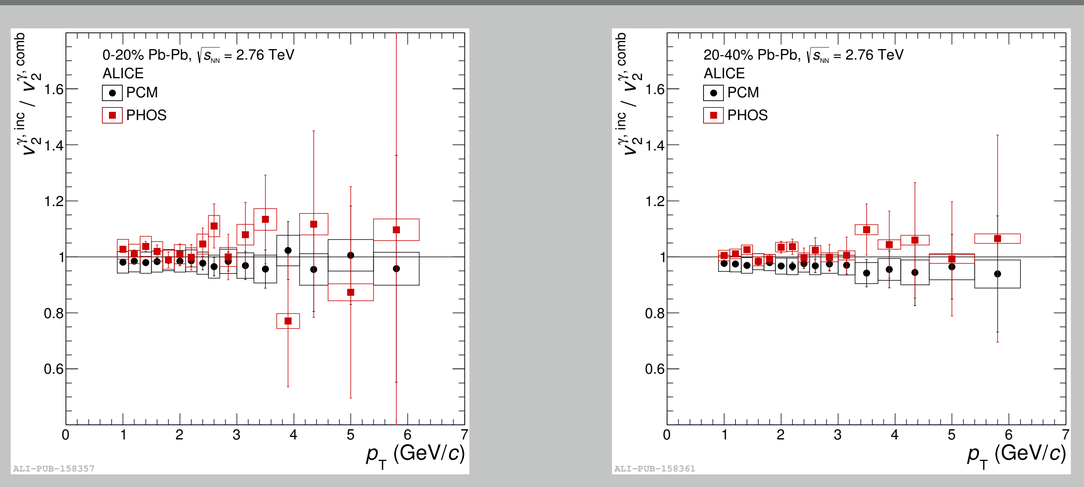
$$R_\gamma \equiv \frac{\gamma_{incl}}{\gamma_{decay}}. \quad (2)$$

The azimuthal anisotropy v_2 of direct photons is measured using:

$$v_2^{\gamma,direct} = \frac{R_\gamma v_2^{\gamma,incl} - v_2^{\gamma,decay}}{R_\gamma - 1}, \quad (3)$$

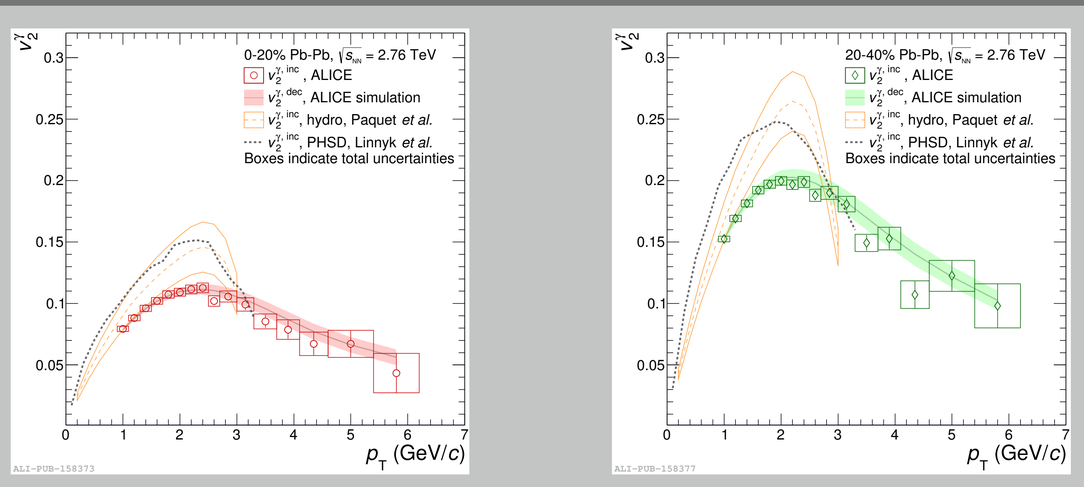
where the inclusive photon flow is measured using the Scalar Product method, using a rapidity gap of $|\Delta\eta| > 0.9$ between the photons and the reference flow particles.

Results: Inclusive photon flow with PCM and PHOS



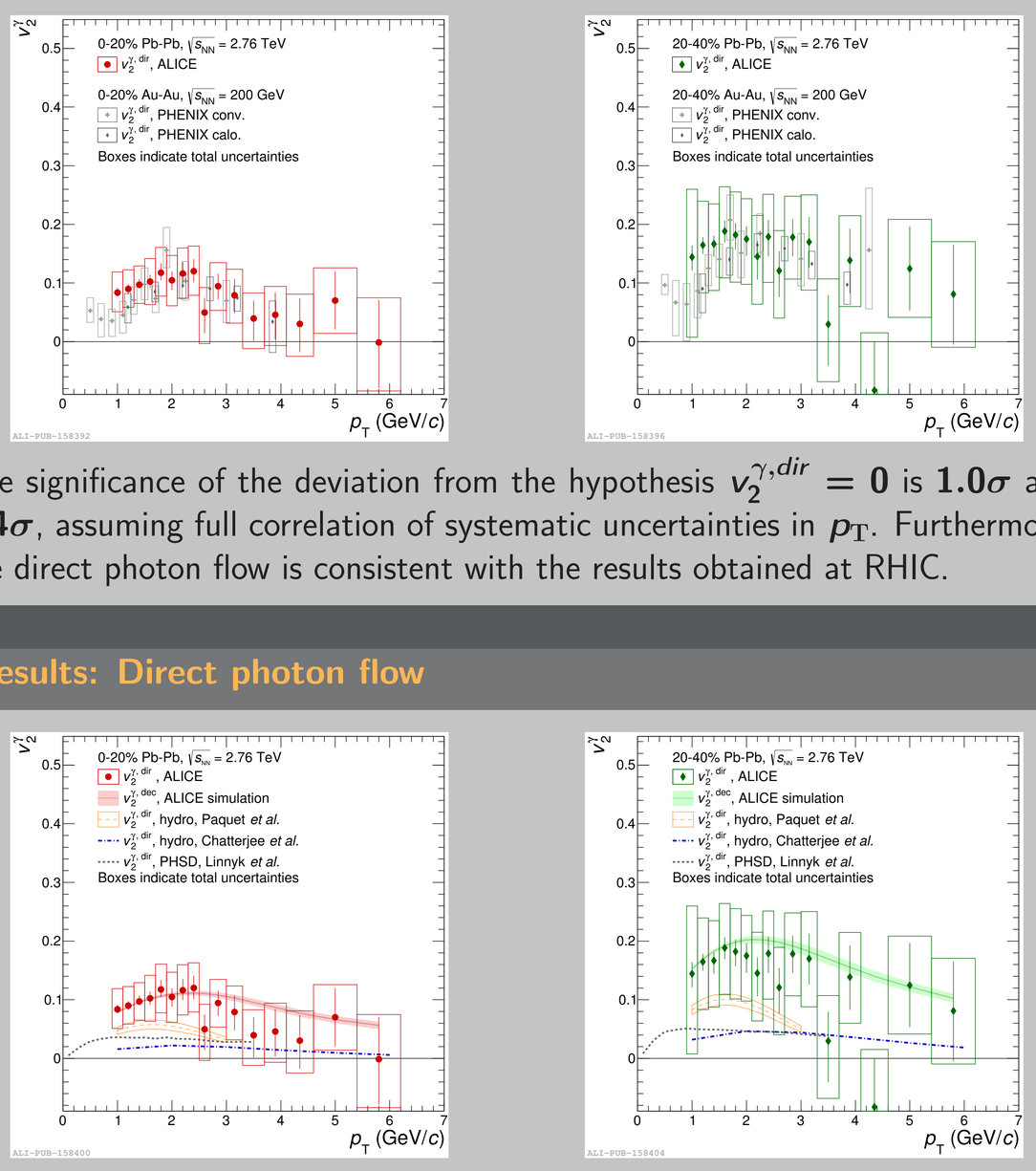
The individual measurements are consistent for both centrality classes.

Results: Inclusive and decay photon flow



The theoretical predictions, based on hydrodynamics, are overestimating the elliptic flow of inclusive photons for both centrality classes.

Results: Direct photon flow



The significance of the deviation from the hypothesis $v_2^{\gamma,dir} = 0$ is 1.0σ and 1.4σ, assuming full correlation of systematic uncertainties in p_T. Furthermore, the direct photon flow is consistent with the results obtained at RHIC.

Results: Direct photon flow

The direct photon flow is generally under-predicted by theoretical calculations. In addition, it is consistent with the flow of decay photons.

Conclusion and Outlook

The flow of inclusive photon has been measured in Pb-Pb collisions at $\sqrt{s_{NN}}$ =2.76TeV for two centrality classes and is obtained by combining the PCM and PHOS measurements. The measured inclusive photon flow is over-predicted by about 40% by the theoretical models and the direct photon elliptic flow is not inconsistent with the expectation from theory.

References:
[1] ALICE Collaboration, J. Adam et al., "Direct photon flow in PbPb collisions at $\sqrt{s_{NN}}$ =2.76TeV" (2018) arXiv:1805.04403 [nucl-ex].
[2] PHENIX Collaboration, A. Adare et al., "Azimuthally anisotropic emission of low-momentum direct photons in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV" (2016) arXiv:1509.07758 [nucl-ex].