2025

Description of the elliptic flow of direct photons in high energy heavy ion collisions, as measured by ALICE at LHC. High level decorations of group members working in the CMS experiment.

In high energy heavy ion collisions a new state of matter, the strongly coupled quark gluon plasma is formed that exhibits similar properties as the Universe had couple of microseconds after the Big Bang, hence such collisions are usually referred as Little Bangs. Subsequent investigations showed that the created medium is a nearly perfect fluid whose time evolution can be described by hydrodynamic models. The distribution of the hadrons that are created in the freeze-out after a rapid expansion carry information about the final state. On the other hand, with penetrating probes, e.g., with direct photons, one can model the time evolution of the quark gluon plasma. In 2025, G. Kasza and collaborators presented a hydrodynamic model that was inspired by an analytical solution of the equation of relativistic hydrodynamics. The invariant transverse momentum spectrum and the elliptic flow of direct photons were calculated, and were found to describe well the recently published ALICE data. The model parameters were determined from fits to LHC ALICE data in Ref. f1]. This result is highlighted because as far as we know no earlier hydrodynamical calculations were able to describe the elliptic flow of direct photons at LHC energies. The hydrodynamical model utilized is based on the Csörgő-Csernai-Hama-Kodama exact solution, Ref. [2], that is based on a triaxial ellipsoid that expands with a directional Hubble flow, utilizing a close analogy of the Little Bangs of heavy ion collisions to the Big Bang of the early Universe.

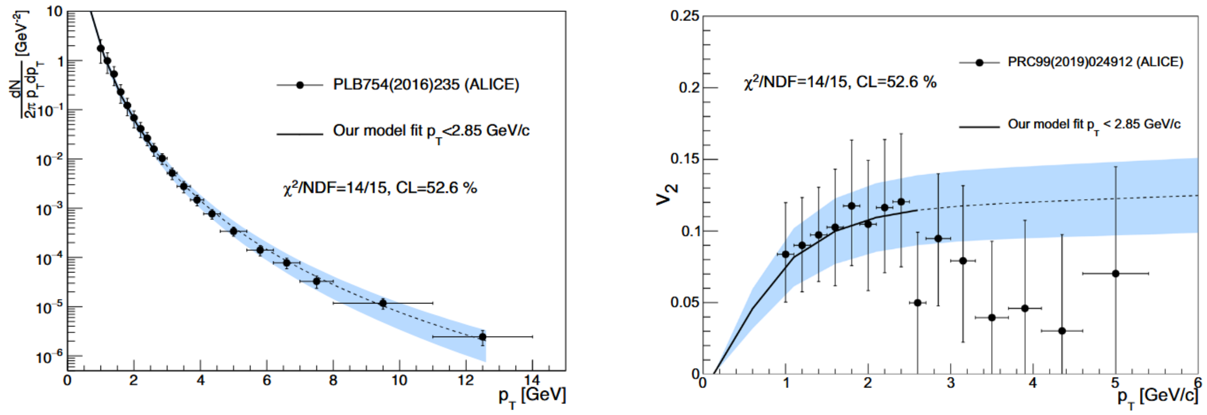

Figure 1. Left panel indicates the hyrdodynamical fit of Ref. [1] to ALICE direct photon spectra in the soft kinematic domain of pT < 2.85 GeV of Pb+Pb collisions at LHC. The right panel indicates the same fit but for the elliptic flow v2 of direct photons in the same collision. No other hydrodynamical model was able to describe these datasets simultaneously.

High level decorations to members of the Femtoscopy Research Group. The 2025 Breakthrough Prize in Fundamental Physics has been awarded to co-authors of publications based on CERN's Large Hadron Collider Run-2 data released between 2015 and July 15, 2024, at the experimental collaborations ATLAS, CMS, ALICE and LHCb. (ATLAS – 5,345 researchers; CMS – 4,550; ALICE – 1,869; LHCb – 1,744). The $3 million prize has bees allocated to ATLAS ($1 million), CMS ($1 million), ALICE ($500,000) and LHCb ($500,000). Two members of the Femtoscopy Research Group, T. Csörgő and F. Nemes were listed among the CMS awardees of this prestigeous and lucrative international prize. The CMS awardees were honored for their detailed measurements of Higgs boson properties confirming the symmetry-breaking mechanism of mass generation, the discovery of new strongly interacting particles, the study of rare processes and matter-antimatter asymmetry, and the exploration of nature at the shortest distances and most extreme conditions at CERN’s Large Hadron Collider.

Figure 2. Two members of the Femtoscopy Research Group, T. Csörgő and F. Nemes were listed among the CMS awardees of the 2025 Breakthrough Prize in Fundamental Physics.

References:
[1] S. Lökös and G. Kasza, *Hydrodynamic description of direct photon spectrum and elliptic flow in Pb + Pb collisions at LHC* , https://doi.org/10.1140/epja/s10050-025-01625-2

[2] T. Csörgő, L. P. Csernai, Y. Hama and T. Kodama, *Simple solutions of relativistic hydrodynamics for systems with ellipsoidal symmetry,* https://doi.org/10.1556/APH.21.2004.1.8

[3] 2005 Breaktrhough Prize in Fundamenal Physics: Laureates
https://breakthroughprize.org/Laureates/1