AZIMUTHAL ANISOTROPY OF NEUTRAL MESONS IN HEAVY ION COLLISIONS AT 2 A GeV *

Arkadij Taranenko

Nuclear Physics Institute
250 68 Řež, Czech Republic

for the TAPS collaboration

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Unexpected differences between azimuthal distributions of η and π^0 mesons emitted at midrapidity were observed in collisions of 1.9 AGeV ^{58}Ni+^{58}Ni and 2 AGeV ^{40}Ca+$^{\rm nat}$Ca. The observed elliptic flow signal is negative for η mesons, indicating a preferred emission perpendicular to the reaction plane. In contrast the elliptic flow for π^0 mesons was observed in peripheral Ni+Ni collisions only.

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Recently, the existence of elliptic flow of pions emitted at midrapidity has been clearly established in 1 AGeV Au+Au collisions at SIS (GSI). Similarly to the baryons, negative elliptic flow was observed for high p_t neutral and charged pions [1, 2]. The origin of this anisotropy has been attributed to the final state interactions of pions with the spectator matter located predominantly in the reaction plane [3, 4]. Therefore, an increase of the magnitude of elliptic flow of pions with increasing size of spectator matter was predicted. It is known that heavier η mesons have similar values of mean free path in nuclei as compare to pions. As they are produced in decay of $N^*(1535)$ resonances, the difference between the dynamics of these two baryonic resonances could in principle manifest itself in different magnitude of elliptic flow of these two neutral mesons. Below we present results of the first experimental study of azimuthal distributions of η mesons emitted in collisions of 1.9 AGeV ^{58}Ni+^{58}Ni and 2 AGeV ^{40}Ca+$^{\rm nat}$Ca nuclei, and compare them with azimuthal distributions of π^0 mesons in the same colliding systems.

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The experiments were performed at the Heavy Ion Synchrotron SIS at GSI Darmstadt. Photon pairs from the neutral meson decay were detected in the Two Arm Photon Spectrometer (TAPS) [6]. In this setup, only neutral mesons around mid-rapidity $y_{\rm cm}$ were detected. The reaction centrality was determined by the hit multiplicity of charged participant particles ($\rm M_{react}$) in the reaction detector, positioned close to the target. Projectile-like spectator nucleons, bounced off in the reaction plane, were detected in the plastic Forward Wall (FW). This information was used to reconstruct the reaction plane event-by-event. The resolution in reaction plane determination varies between 43^0 and 55^0 depending on reaction centrality and colliding system. The total charge $Z_{\rm FW}$ of particles detected by the FW allowed us to estimate the average number of projectile-like spectators $\langle A_{\rm sp}\rangle$. The experimental details are given elsewhere [7, 8].

We fitted the resulting azimuthal yields of π^0 and η mesons by the first two members of a Fourier expansion in the azimuthal angle:

$$N(\Delta\varphi) = \frac{N_0}{2\pi}\,(\,1 + v_1 cos(\Delta\varphi) + v_2 cos(2\Delta\varphi)\,)\,, \qquad (1)$$

which is used to parametrize the directed (v_1) and elliptic (v_2) flow [9]. A positive value of the parameter v_2 corresponds to in-plane emission (positive elliptic flow) while a negative value describes preferred emission perpendicular to the reaction plane (negative elliptic flow). The resulting values of $v_2^{\rm true}$ corrected for the uncertainty in the determination of the reaction plane are presented in Fig. 1 for η mesons and for two bins in p_t of π^0 mesons for both Ni+Ni and Ca+Ca collisions. The parameter $v_2^{\rm true}$ is negative for η mesons, indicating a preferred emission perpendicular to the reaction plane (negative elliptic flow). In contrast the elliptic flow signal $v_2^{\rm true}$ for π^0 mesons is observed in peripheral Ni+Ni collisions only. The dependence of the magnitude of the azimuthal anisotropy for η mesons on the number of spectator nucleons seems to be rather flat in analogy with the observation of no dependence of the azimuthal anisotropy of charged pions on the number of spectator nucleons in Bi+Bi collisions at 0.4-1.0 AGeV reported recently in [5]. We estimated expected magnitudes of elliptic flow assuming "shadowing" of neutral mesons by spectators along path of $r = \alpha A_{\rm sp}^{1/3}$, where α=2 fm. Results of corresponding formulas $v_2 = (1-R)/(1+R)$ and $R = \exp(r/\lambda)$, where λ is the mean-free-path for mesons in cold spectator matter are presented in Fig. 1 by dashed lines for two different values of λ: λ=2 fm and λ=6 fm. It is obvious, that the simple scenario of the shadowing by spectators alone can not describe strong difference between the π^0 and η azimuthal asymmetry.

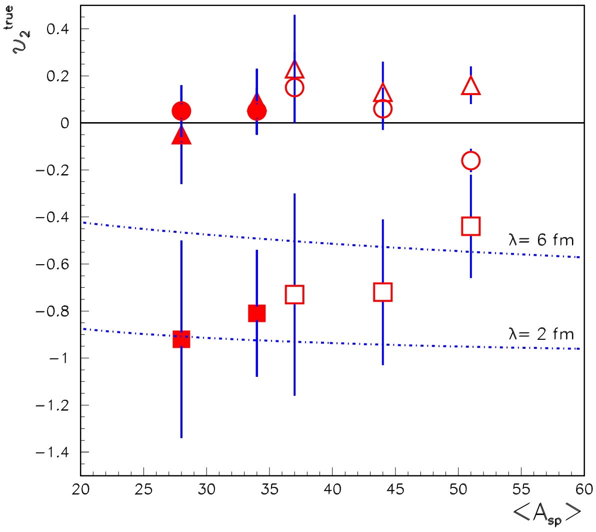

Fig. 1. The parameters $v_2^{\rm true}$: squares-η mesons, triangles-soft π^0 ($0 \leq p_t \leq 200$ MeV/c) and circles-hard π^0 ($600 \leq p_t \leq 800$ MeV/c) as a function of the number of spectators $\langle A_{\rm sp} \rangle$. Full symbols correspond to Ca+Ca and open symbols correspond to Ni+Ni collisions. The dash-dot lines represent results of the geometrical absorption model, see text.

In summary, we have studied simultaneously azimuthal angle distributions of π^0 mesons and of η mesons emitted at midrapidity in two colliding systems: ^{58}Ni+^{58}Ni at 1.9 *A*GeV and ^{40}Ca+$^{\rm nat}$Ca at 2 *A*GeV. We observed strong out-of-plane elliptic flow of η mesons. The elliptic flow of π^0 mesons is very weak in contrast with previous data obtained for heavy colliding systems at 1 *A*GeV. The observed striking difference between elliptic flow of η and π^0 mesons needs further explanations.

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