Study of Chiral Property of Dense Nuclear Matter Through Measurements of Meson Mass Modification in Medium
KEK-PS E325

It is believed that the chiral symmetry, which is spontaneously broken in our world, should be restored in a system with a finite temperature and/or a finite density. Theoretically, it has been suggested that a signature of the chiral symmetry restoration could be seen as a possible mass shift of vector mesons in nuclear matter. The experiment E325 has been carried out at KEK-PS to investigate nuclear media effects on the invariant mass spectra of $\rho$, $\omega$ and $\phi$ mesons through their decays in the $e^+e^-$ or $K^+K^-$ channels. From the earlier data, the experiment has reported the signature of in-medium mass modification of $\rho$ and/or $\omega$ mesons. This was the first observation in the leptonic in-medium decay of vector mesons at a normal nuclear matter density.

Our observation should be compared to the results from the CERES/NA45 experiment which reported the low-mass electron pairs enhancement in Pb-Au collisions at 158 A GeV[2], and from the TAGX experiment which reported the signature of $\rho$ modification in photon induced interaction on a $^3He$ target[3]. Those observations including our results could be explained by a common physics behind, though the experimental verification is not sufficient yet.

The experiment E325 finished its data taking period of $\sim$3200 hours in five years from 1998 to 2002. We have acquired almost 100 times larger statistics compared to the previous publication[1], with which we will be able to provide the dispersion relation of modified $\rho/\omega$ mesons and a spectral function of $\phi$ mesons.

Figure 1: Invariant mass spectra of 2002 $e^+e^-$ data, after the subtraction of the combinatorial background; a) is for the carbon target and b) is for the copper targets.

Figure 1 show the preliminary results for the data taken in 2002; a) is for the carbon target, and b) is for the copper targets. We have reproduced the mass shape with the combinatorial background and the known hadronic sources, $\rho \rightarrow e^+e^-$, $\omega \rightarrow e^+e^-$, $\phi \rightarrow e^+e^-$, $\eta \rightarrow e^+e^-\gamma$, and $\omega \rightarrow e^+e^-\pi^0$. The combinatorial background was evaluated by the event mixing method and subtracted in the figures.

The significant excess can be seen on the low-mass side of the $\omega$, as consistent to the previous data, and some hint below $\phi$. With these improved statistics, we are able to determine the free-decay $\rho/\omega$ ratio from the high mass tail of the spectrum. The obtained values are significantly smaller than the known $\rho/\omega$ ratio, unity, in pp interactions. Because most of $\rho$ will be decaying inside a nucleus due to their short life time, it is natural to consider the excess is mainly dominated by the $\rho$ meson modification.

The key measurements are momentum dependence of observed excess and the spectral-shape modification for $\phi$ mesons. Answers will be obtained when we finish the analysis of all the data we have.

References