Charged Kaon Physics with the KLOE experiment.

The KLOE Collaboration

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Abstract

The status of the analyses in progress on charged kaon physics with the KLOE detector is presented, specifically we summarize the study of the charged kaon lifetime and the analyses of two-body and semileptonic decays.

Introduction

The KLOE experiment runs at DAΦNE[1], the Frascati ϕ-factory, an e^+-e^- collider operating at the center of mass of the $\phi(1020)$ meson. K_S K_L pairs and K^+K^- pairs are produced in a well prepared, C-odd, quantum state.
A unique feature is the production of quasi monochromatic K_S , K_L , K^+ and K^- tagged beams.
The KLOE detector consists of a large cylindrical drift chamber[2] surrounded by a lead/scintillating-fiber sampling calorimeter[3]. Two small calorimeters [4], wrapped around the quadrupoles of the low-β insertion, complete the detector hermeticity. A superconducting coil and an iron yoke surrounding the whole detector provide a 0.52 T magnetic field. The momentum resolution

of the drift chamber is $\sigma(p_\perp)/p_\perp \sim 0.4\%$ while the decay vertices are reconstructed with a resolution $\sigma_v \sim 3mm$. The calorimeter ensures 98% coverage of the solid angle, the energy resolution is $\sigma_E/E = 0.057/\sqrt{E\ (\mathrm{GeV})}$ and the time resolution is σ_t=$(54/\sqrt{(E(GeV)} \oplus\ 50)$ ps. The present data set corresponds to an integrated luminosity of $\sim 450\ pb^{-1}$ equivalent to $\sim 7\times10^8$ each K^+ , K^- decays.

With this statistics we are undertaking a comprehensive program for the study of the decays of the charged kaons. The very clean signature of $\mathrm{K}^\pm \to \mu^\pm\nu(\bar\nu)$ and $\mathrm{K}^\pm \to \pi^\pm\pi^0$ decays is exploited to tag charged kaons and provides pure samples of kaons with known charge, as starting point for all the analyses.
Moreover most of the efficiencies (tagging, tracking, vertexing, clustering and track to cluster association) can be evaluated directly from data control samples.

Study of two-body decays of charged Kaons with the KLOE detector. The measurement of the branching ratios of the two-body decays ($\mathrm{K}^\pm \to \mu^\pm\nu(\bar\nu)$ and $\mathrm{K}^\pm \to \pi^\pm\pi^0$) is done using the momentum spectra of the charged secondary evaluated in the kaon rest frame and in the pion mass hypothesis.
The spectra of the three different components ($\mu\nu$ and $\pi\pi^0$ peaks and 3-body distribution) are extracted from data control samples.
The reconstruction efficiencies of the tracking system for these decays are measured directly from data samples by using the redundant calorimetric information. For this purpose several methods have been developed and among them we describe the measurement of the global efficiency, tracking plus vertexing, for the $\pi\pi^0$ decay. The kaon track of the tagging side is extrapolated to the signal hemisphere where the neutral decay vertex is found using the timing of the neutral clusters fired by the photons of the π^0 decay. We step along the path given by the extrapolated kaon in order to find the point giving the best evaluation of the position of the neutral vertex. Thanks to the excellent time resolution of the calorimeter the neutral vertex resolution is about 1 cm. This sample is used as normalization for the evaluation of the global efficiency.

The achievable statistical accuracy on the measurement of the branching ratio of the two-body decays is at the level of a few permil.

Study of the charged Kaon semileptonic decays with the KLOE detector. The semileptonic decays are selected by means of kinematical cuts in the kaon reference frame. The subsequent $\mu - e$ discrimination is achieved by means of time of flight (TOF) measurement. Most of the correlated efficiencies (tracking, vertexing and TOF) can be measured from data using techniques similar to the one described above for the global efficiency, tracking plus vertexing, for the $\pi\pi^0$ decay. The effect of radiative K_{l3} decays is accounted for.

The present data set allows us to reach a $\simeq 0.6\%$ accuracy on the branching ratio measurements.

Study of the charged Kaon lifetime with the KLOE detector. Two independent methods to measure the charged kaon lifetime have been developed. The first one relies on drift chamber information only and evaluates the K^+K^- proper lifetime ($\tau^{\pm}$) stepping along the charged kaon track up to the decay vertex, taking into account the dE/dx loss in the gas mixture of the drift chamber ($10\% isobutane - 90\% helium$).
In the second method the kaon track of the tagging side is extrapolated to the signal hemisphere and the time measurements of the two photons from the π^0 decay are used to evaluate the time of flight.

The statistical uncertainty, based on the available data set, will allow us to improve the present 0.2% accuracy on the kaon lifetime measurement considerably.

Measurement of the branching ratio for the decay $K^{\pm} \to \pi^{\pm}\pi^0\pi^0$ with the KLOE detector. A new measurement of the absolute branching ratio BR($K^{\pm} \to \pi^{\pm}\pi^0\pi^0$) with the KLOE detector has been published [6], using a sample of $\simeq 3.3 \times 10^7$ charged kaon tagged events, and had improved the measurement of the branching ratio of this mode by a factor of $\simeq 1.5$.

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