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Measurement of the ratio R_K between the Branching Ratio of $K^{\pm} \to e^{\pm}\nu(\gamma)$ and $K^{\pm} \to \mu^{\pm}\nu(\gamma)$ decays at NA48/2

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The measurement of the ratio $R_K = \frac{K^{\pm}\to e^{\pm}\nu(\gamma)}{K^{\pm}\to\mu^{\pm}\nu(\gamma)}$ between the Branching Ratio of $K^{\pm} \to e^{\pm}\nu(\gamma)$ and $K \to \mu^{\pm}\nu(\gamma)$ decays is a sensible test of lepton universality and of $V-A$ structure of the weak interactions.
This ratio is predicted with good theoretical precision [2], but its actual accuracy is affected by the lack of a statistically proportionate sample of $K^{\pm} \to e^{\pm}\nu(\gamma)$ decays[3] [4] [5].
NA48/2 experiment [1], at SPS accelerator of CERN, has collected already more than 4 times the world total $K^{\pm} \to e^{\pm}\nu(\gamma)$ statistics, during 2003 data taking.
Such data set, obtained in an experimental condition that allows an adequate control of the possible systematic effects, allows to fulfil a significant test of theory prediction and to do, for the first time ever, a comparison of R_K between positive and negative Kaon decays.
After the description of the most relevant features of the collected data, a preliminary result based on 2003 data set will be presented:

$$R_K = (2.416 \pm 0.043_{(stat)} \pm 0.024_{(syst)}) \cdot 10^{-5}$$

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1. Experimental Setup

NA48/2 beam line is composed of simultaneous positive and negative beams of average momentum 60 GeV/c and beam bite of $\pm 3.8\%$.
The decay region is 114 m long vacuum region contained in a cylindrical tank of diameter 1.9 m, increasing to 2.4 m in its last 48 m.
A magnetic spectrometer, separated by a Kevlar windows from the vacuum region, is used to measure the momentum and flight direction of charged particles. It is equipped with four drift chambers and a dipole magnet deflecting charged particles in the horizontal direction with a kick of $\sim 120\ MeV/c$. The momentum resolution is $\frac{\sigma(P)}{P} = 1.02\% \oplus 0.044 \cdot P(GeV)\%$. The spectrometer is followed by a scintillator hodoscope providing a fast trigger for charged events and a time reference for reconstruction.
A liquid Krypton calorimeter is employed to reconstruct electron and photon energy. The active part of the calorimeter is 27 radiation lengths long and is segmented transversally in 13248 $2\ cm \times\ 2\ cm$ cells. Its energy resolution is $\frac{\sigma_E}{E} = \frac{0.09}{E_{(GeV)}} \oplus \frac{0.032}{\sqrt{E_{(GeV)}}} \oplus 0.0042$.
Other detectors of NA48/2 setup are a Kaon Beam spectrometer, placed $\sim 65\ m$ in front of the decay volume; a neutral hodoscope embedded in the LKr calorimeter; an hadron calorimeter, a photon veto system around the decay region and a muon veto system.

2. Data Sample

K_{e2} selection used a downscaled trigger requiring a signal from the scintillator hodoscope in coincidence with a signal from the LKr calorimeter compatible with an energy deposition of at least 10 GeV. A second level online processor trigger requires that, in the hypothesis of a $K \rightarrow \pi X$ decay of Kaons with nominal energy, the event missing mass (m_X) is below the π^0 mass.
Offline events are selected requiring a track of at least 15 GeV/c crossing the beam line inside the decay region; no other in-time tracks or photons of energy greater than 3 GeV; a missing mass compatible with the hypothesis of a $K^\pm \rightarrow e^\pm \nu$ decay and $0.95 < E/pc < 1.05$ ratio between the energy released in the calorimeter and the measured track momentum.
$K_{\mu 2}$ selection trigger used a downscaled signal from the scintillator hodoscope. Offline selection requires a track of at least 15 GeV/c crossing the beam line inside the decay region, no other in-time tracks or photons of energy $> 3\ GeV$ and a missing mass compatible with the hypothesis of a $K^\pm \rightarrow \mu^\pm \nu$ decay.

3. Analysis

Fig. 1 shows the missing mass squared distribution of $K_{\mu 2}$ reconstructed events[1].
Fig. 2 shows missing mass squared distribution versus E/pc of K_{e2} candidates events. Background contributions have been identified and subtracted as shown in Fig. 3. The most relevant contaminations are due to $K_{\mu 2}$ events, other sources of background are K_{e3} and $K^\pm \rightarrow \pi^\pm \pi^0$ decays.

[1] Background contamination at 10^{-3} level is due to $K^\pm \rightarrow \pi^\pm \pi^0$ decays.

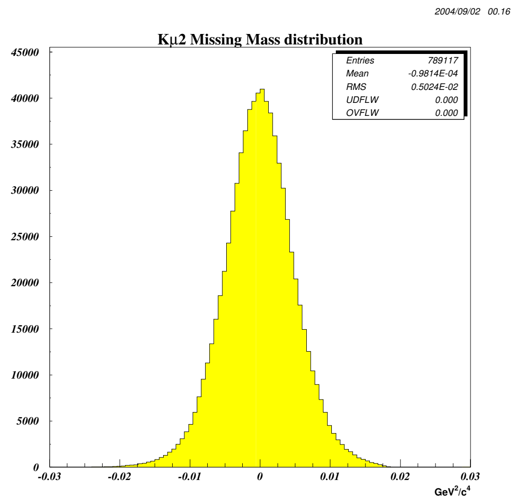

Figure 1: *Distribution of the missing mass for $K_{\mu 2}$ reconstructed events. The signal is almost completely contained in the signal region $-0.02\ GeV^2/c^4 < MM^2(\mu) < 0.02\ GeV^2/c^4$*

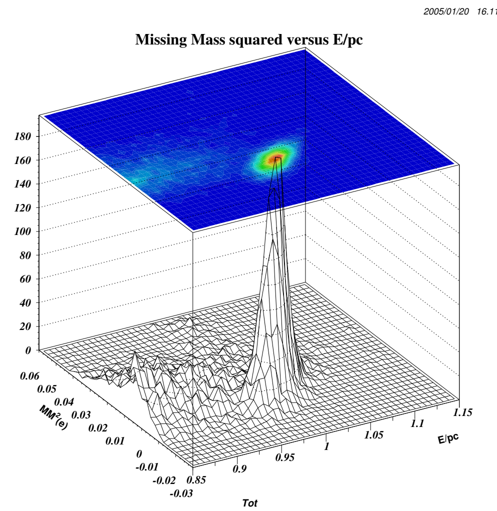

Figure 2: *$MM^2(e)$ versus E/p distribution for K_{e2} event candidates. The bounds on lepton E/pc and $MM^2(e)$ have been removed , allowing to explore background events distribution outside the signal region.*

The measurement of R_K ratio allows the cancellation of acceptance and trigger effects common to K_{e2} and $K_{\mu 2}$ events. Residual corrections in the trigger selection, acceptance, accidental activity are shown in Table 4. Radiative corrections are taken into account according to [6] and [2].

4. Preliminary Result and Conclusions

The number of collected K_{e2} events is:

$$4670 \pm 77\ _{(stat)}\ {}^{+29}_{-8}\ _{(syst)}$$

585 of these events have been collected with a downscaling factor of 40, all the others with with a downscaling factor of 20.
The number of collected $K_{\mu 2}$ events is 619179. These events have been collected with a downscaling factor of 10000.
The value of R_K ratio measurement with 2003 statistics is:

$$R_K = (2.416 \pm 0.043_{(stat)} \pm 0.024_{(syst)}) \cdot 10^{-5}$$

to be compared with the theoretical prediction: $(2.472 \pm 0.001) \cdot 10^{-5}$ and the present world average (PDG 2004) $(2.45 \pm 0.11) \cdot 10^{-5}$.
The uncertainty of R_K ratio measurement is dominated by the statistical error.
NA48/2 data taking in 2004 included a special run with a simplified trigger logic. K_{e2} special run data sample is similar in size to 2003 data sample, but its simplified trigger logic allows a better cancellation of systematic corrections between K_{e2} and $K_{\mu 2}$ events.

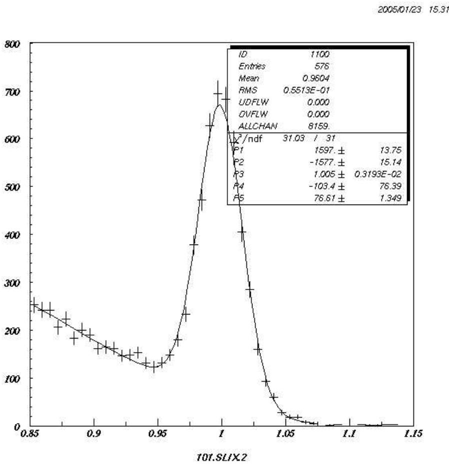

Figure 3: *Fit of the E/pc distribution for signal and background events. The variable $P(3)$ indicates the point where the background distribution changes of slope (close to 1, as expected). $P(2)$ and $P(4)$ are the slopes of background events distribution. The background contamination in the signal region is 14% of the signal.*

Summary of R_K corrections		
	$\frac{\Delta R_K}{R_K}$ Correction	$\frac{\Delta R_K}{R_K}$ error
Cut Acceptance	+1.144	0.007 $_{(syst)}$
Accidental losses	0.9976	$(\pm 2.3_{(syst)}) \cdot 10^{-3}$
Trigger Efficiency	+1.169	$\pm 0.008_{(stat)}$
Radiative Corrections	+1.063	$\pm 0.005_{(syst)}$
Total	**+1.424**	$\pm 0.008_{(stat)}$ $\pm 0.008_{(syst)}$
Downscaling factor	$2.25 \cdot 10^{-3}$	
Raw K_{e2} and $K_{\mu 2}$ ratio	$(7.54 \pm 0.09_{(stat)}\ {}^{+0.03}_{-0.01(syst)}) \cdot 10^{-3}$	
R_K **Result**	$(2.416 \pm 0.043_{(stat)}\ \pm 0.024_{(syst)}) \cdot 10^{-5}$	

Figure 4: *Summary of corrections and uncertainties to R_K measurement. The largest statistical error comes from the uncertainty on the trigger efficiency. This is due to the limited amount of statistics, especially, in the control sample of the L1 trigger logic. The greatest contributions to the systematic error come from the uncertainty on the cut acceptance and on acceptance correction due to $K_{l2\gamma}$ decays. The uncertainty due to K_{e2} background subtraction is not reported here, but taken into consideration in the final result.*

References

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