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# Measurement of the rare decay $K^+ \to \pi^+\mu^+\mu^-$ at the NA62 experiment

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**Abstract.** The NA62 experiment at CERN reports results from the study of the flavour-changing neutral current decay $K^+ \to \pi^+\mu^+\mu^-$, using a data sample recorded in 2017–2018 with a dedicated pre-scaled di-muon trigger. The sample comprises about 28k signal events with negligible background contamination, and the presented results include the most precise determination of the corresponding branching fraction and the form factor parameters.

## 1. Introduction

This contribution to the proceedings summarizes results of an analysis of the $K^+ \to \pi^+\mu^+\mu^-$ decay at the NA62 experiment at CERN [1], based on the dataset collected in 2017–2018.

Dominant contributions to the $K^\pm \to \pi^\pm\ell^+\ell^-$ decays (denoted $K_{\pi\ell\ell}$) are mediated by the process $K^\pm \to \pi^\pm\gamma^* \to \pi^\pm\ell^+\ell^-$ and are described by a complex form factor $W(z)$, where $z$ is the square of the normalized di-muon invariant mass $z = m^2(\mu^+\mu^-)/m_K^2$. The Chiral Perturbation Theory parameterization of $W(z)$ at $\mathcal{O}(p^6)$ with two real parameters $a_+$ and $b_+$, introduced in [2], is used:

$$W(z) = G_F m_K^2(a_+ + b_+ z) + W^{\pi\pi}(z). \quad (1)$$

The abundant decay mode $K^+ \to \pi^+\pi^+\pi^-$ (denoted $K_{3\pi}$) was used in the analysis as the normalization channel.

## 2. Results

The reconstructed distributions of data and simulated events are presented in Figure 1. The $K_{3\pi}$ sample was used to obtain the effective number of kaon decays: $N_K = (3.48 \pm 0.09_{\text{syst}} \pm 0.02_{\text{ext}}) \times 10^{12}$. The $K_{\pi\mu\mu}$ sample contains 27679 data events. The signal sample was used to measure the differential decay width and the form factor; the results are presented in Figure 2. The model-independent $K_{\pi\mu\mu}$ branching fraction was measured to be $\mathcal{B}_{\pi\mu\mu} = (9.15 \pm 0.08) \times 10^{-8}$. The parameters of the form factor were obtained by a $\chi^2$ fit: $a_+ = -0.575 \pm 0.013$, $b_+ = -0.722 \pm 0.043$ with the correlation coefficient $\rho(a_+, b_+) = -0.972$. The total uncertainties are dominated by statistical error.

The NA62 results are compatible with previous measurements (E787 [3], E865 [4], HyperCP [5] and NA48/2 [6, 7]), while the precision is improved by at least a factor of 3.

[1] On behalf of the NA62 collaboration.

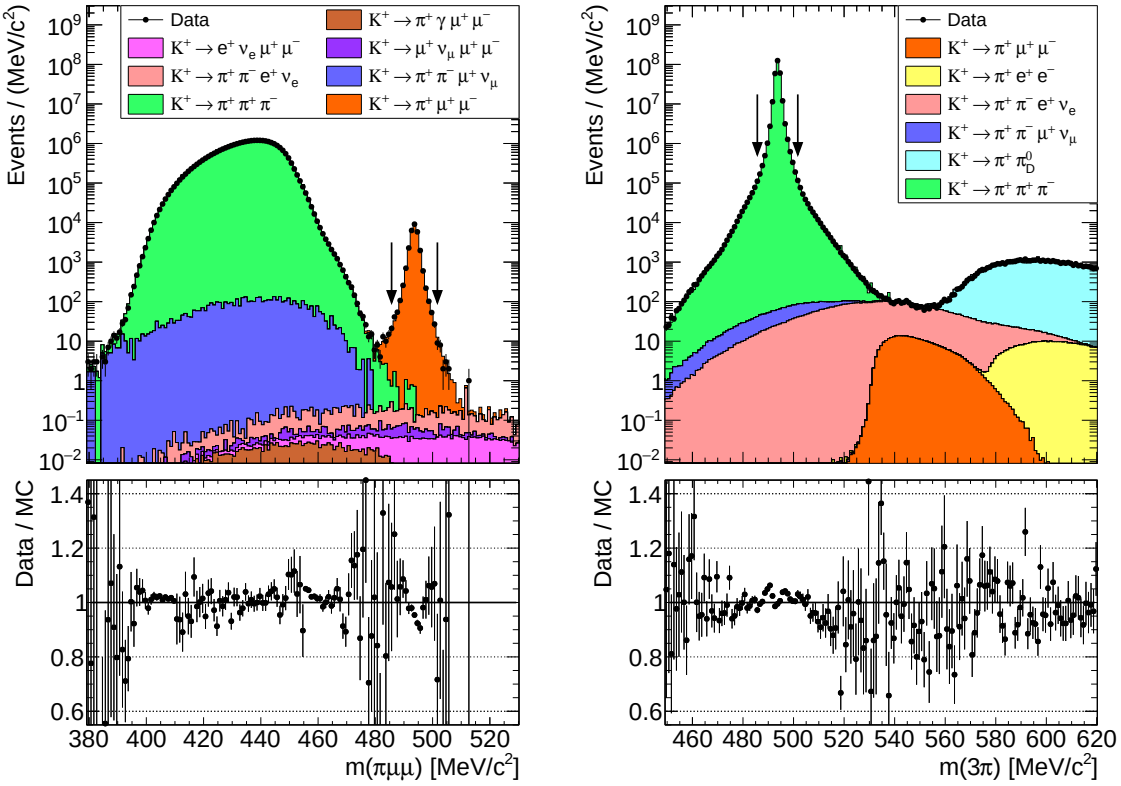


**Figure 1. Top:** reconstructed mass distributions of events satisfying the signal (left) and normalization (right) selections. The arrows indicate the selected mass regions. The contribution from the simulated $K_{\pi\mu\mu}$ decays is scaled according to the PDG branching fraction [8]. **Bottom:** ratios of data and simulated spectra for signal (left) and normalization (right). Figure from [1].

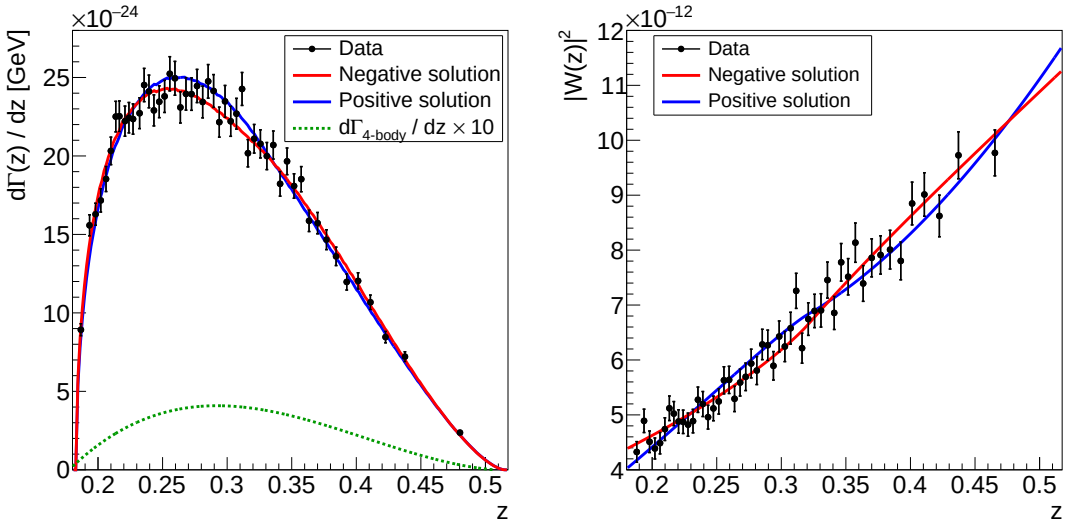


**Figure 2. Left:** reconstructed $K_{\pi\mu\mu}$ differential decay width. The horizontal positions of the data points take into account the non-linearity of the fit function [9]. **Right:** squared modulus of the form factor. The superimposed lines correspond to the two form factor fit solutions. Figure from [1].

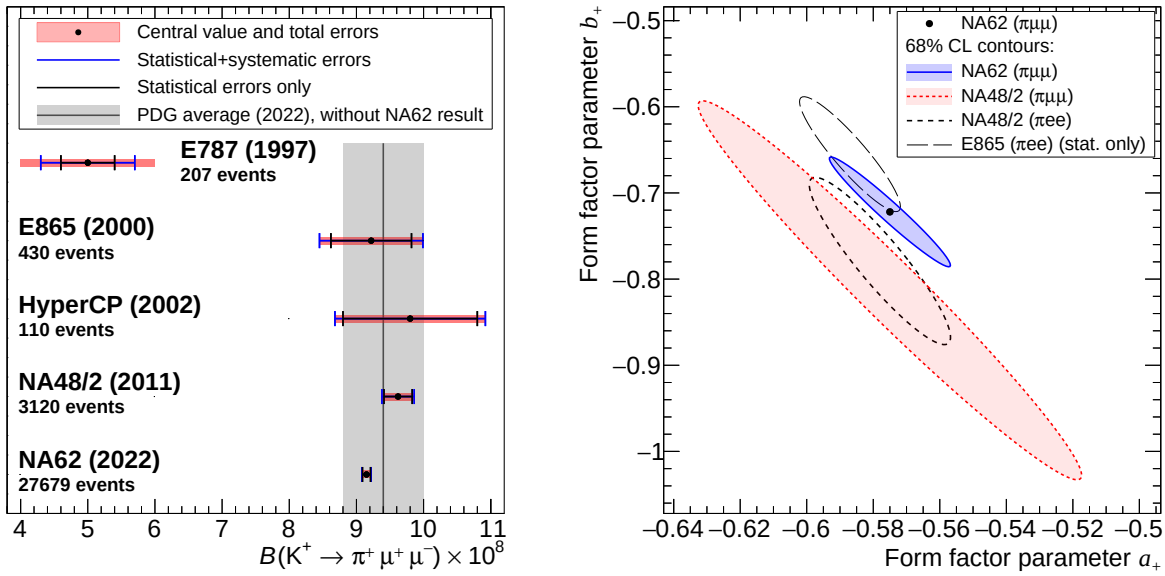


**Figure 3.** Comparison with earlier measurements. **Left:** the $K_{\pi\mu\mu}$ branching fraction, with the PDG [8] average shown as a shaded band. **Right:** combined statistical and systematic 68% CL contours in the $(a_+, b_+)$ plane for the muon and electron modes. The NA48/2 value of $\rho(a_+, b_+)$ for the electron mode is used to construct the E865 contour, as E865 [10] does not quote the correlation. The systematic uncertainties in $a_+$ and $b_+$ are not provided by E865 [10]. Figure from [1].

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