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S. Recksiegel, A. Hoang, S. Paul

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$K \rightarrow 3\pi$ decay results by NA48/2 at CERN SPS

Gianluca Lamanna
Department of Physics and INFN
University of Pisa
I-56127 PISA, ITALY

1 Introduction

CP violation plays an important role in particle physics since its discovery 40 years ago [1]. For more than 20 years this phenomenon appeared as confined in a particular sector of particle physics, through the mixing between states of opposite CP in the neutral kaons. The unambiguous discovery in the late 1990s, after the early indication by NA31 [2], of direct CP violation in $K \rightarrow 2\pi$ decay, by the NA48 [3] and KTEV [4] experiments and the discovery of CP violation, in its various forms, in the neutral B meson system [5] represented important breakthrough in the understanding of the particles dynamics. A complete as possible study of the tiny effects due to the violation of this symmetry in all the systems where it can be carried out, represents an important window on the contribution of new physics beyond the Standard Model: in fact new effects could appear, in particular in the heavy quark loops which are the core of the mechanism allowing the CP violation in the mesons decay. In the kaon sector the most promising places, besides ε'/ε , where this kind of contributions could play some role are the rates of GIM suppressed rare decays and the charge asymmetry between charged kaons. In particular the $K \rightarrow 3\pi$ asymmetry could give a strong qualitative indication of the validity of the CKM description of the direct CP violation or reveal the existence of possible sources outside this paradigm.

In principle Direct CP violation in K^\pm can be detected comparing the different decay amplitudes in the 3π mode:

$$|A(K^+ \rightarrow \pi^+\pi^+\pi^-)| \neq |A(K^- \rightarrow \pi^-\pi^+\pi^-)|$$

Experimentally the easiest way to study the difference between the charge conjugate modes is to compare the shape of the *Dalitz Plot* distribution instead of the decay rates. The small phase space in the three pion decay mode allows to expand the matrix element in terms of the, so called, *Dalitz variables* u and v :

$$u = \frac{(s_3 - s_0)}{m_\pi^2} \quad v = \frac{(s_2 - s_1)}{m_\pi^2}$$

<i>Asymmetry</i>	<i># of events</i>	<i>Experiment</i>
$A_g^0 = (19 \pm 125) \cdot 10^{-4}$	115K	CERN PS(1975) [6]
$A_g^0 = (2 \pm 19) \cdot 10^{-4}$	620K	Protvino IHEP (2005) [7]
$A_g^c = (-70 \pm 53) \cdot 10^{-4}$	3.2M	BNL AGS (1970) [8]
$A_g^c = (22 \pm 15 \pm 37) \cdot 10^{-4}$	54M	HyperCP (2000) prelim [9]

Table 1: Summary of the experimental situation both in “neutral” (A_g^0) and in “charged” (A_g^c) mode, before the NA48/2 results

These variables are defined using the Lorentz invariant $s_i = (p_K - p_i)^2$, where p_K is the kaon four momentum and p_i are the pion four momenta ($i = 1, 2, 3$ the latter being “odd” pion) and $s_0 = (s_1 + s_2 + s_3)/3$. Exploiting the Dalitz variables the matrix element can be written as:

$$|M(u, v)|^2 \sim 1 + gu + hu^2 + kv^2 + \dots \quad (1)$$

where g,h,k are the linear and quadratic slope parameters. Using the fact that $|g| \gg |h|, |k|$, the CP violation parameter

$$A_g = \frac{g^+ - g^-}{g^+ + g^-} \quad (2)$$

is defined using only the linear slopes given in (1). Being g^+ relative to K^+ decay while g^- to K^- , the parameter defined above is different from 0 only if an asymmetry exists between the matrix element describing kaon decay of opposite charge. Theoretical predictions for the A_g parameter both in the $K \rightarrow \pi^\pm \pi^0 \pi^0$ (A_g^n , the so called “neutral” mode) and in the $K \rightarrow \pi^\pm \pi^+ \pi^-$ (A_g^c , the so called “charged” mode), are very difficult and the available predictions varying from 10^{-6} to few 10^{-5} are unreliable; calculations in the framework of theories beyond the standard model predict a substantial enhancement of this parameter up to the level of few 10^{-4} . Several experiments in the past have searched for asymmetry both in “charged” and “neutral” mode. The sensitivity reached so far is at level of 10^{-3} , as summarized in table 1. The main goals of the NA48/2 experiment are to reach the sensitivity of 10^{-4} both in “neutral” and in “charged” mode, to investigate the possibility of non standard model contributions to the CP violation in charged kaon decays, thus covering the gap existing between the experimental results and the SM theoretical predictions. The large amount of $K \rightarrow 3\pi$ collected by NA48/2 experiment, allows a very precise measurement of the Dalitz plot parameters and, as recently shown [10], the study of the neutral Dalitz plot density allows to extract important informations about the pion scattering length.

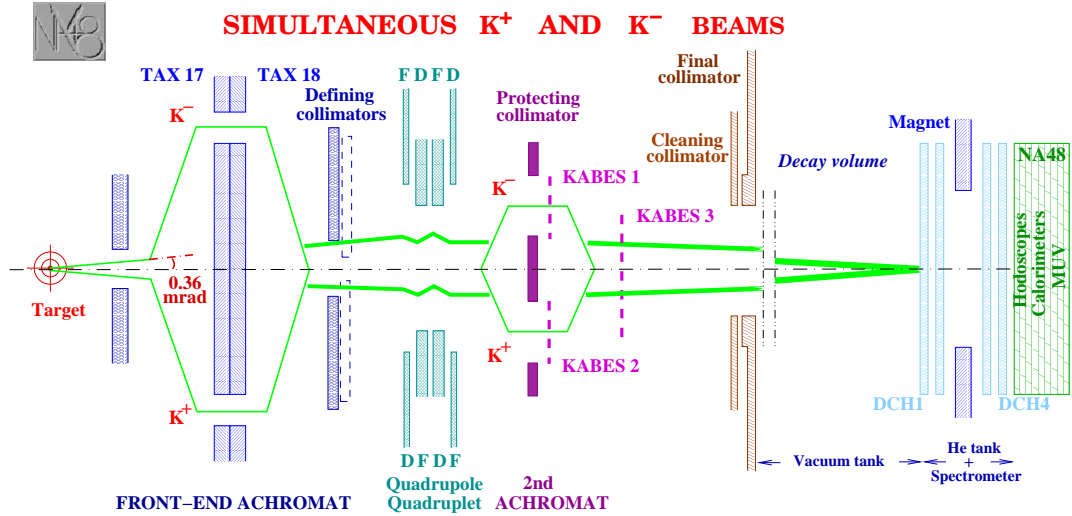


Figure 1: The NA48/2 beam line and detector. Not in scale.

2 Beams and detectors

The simultaneous collection of K^+ and K^- decay with the same apparatus is an essential point of the asymmetry measurement. A novel high intensity beam line was designed in the high energy hall (ECN3) at CERN SPS (fig. 1). The charged particles (kaons, pions, muons and electrons) are produced by 400 GeV high intensity protons beam ($\sim 7 \cdot 10^{11}$ protons per pulse), from the SPS accelerator, with a 40 cm long and 2 mm in diameter beryllium target with an angle of zero degrees. A magnetic device, called *first achromat*, selects the momentum of the beam in the range $(60 \pm 3) \text{ GeV}/c$, splitting the two charges. After being recombined the beams are focused by a quadruplet of quadrupoles, before another splitting in the *second achromat*. The second achromat houses the first detector along the beam line, called KABES [11], a spectrometer measuring the particles' momentum with a resolution of $\sim 1\%$ (this detector is used studying rare decays). The two charged beams, recombined again along the beam axis, contain $\sim 6.4 \cdot 10^7$ particles per 4.8 s spill, with a charge ratio $K^+/K^- \sim 1.8$ (irrelevant for the charge asymmetry measurement) and 12 times more pions with respect to the kaons: however the pions decay products remain into the beam pipe, because of the small momentum and do not cross the detectors. The decay region is housed in an evacuated tube $\sim 114\text{m}$ long and $\sim 2\text{m}$ in diameter. The beams in the decay region are superimposed within 1 mm with a total width of $\sim 5\text{mm}$, so that both K^+ and K^- decays illuminate with the same acceptance the same detector. The central detector is based on the old NA48 detector, described elsewhere [12]. For the asymmetry and Dalitz plot parameters measurement the

two main detector are the spectrometer and the LKr calorimeter. The magnetic spectrometer works with a $p_T = 120 \text{ MeV}/c$ kick and the resolution in momentum (GeV/c) is $\sigma_p/p = 1.0\% + 0.044\%$. In order to manage the higher intensity with respect to the previous NA48 runs, the drift chambers read out has been rebuilt. In order to collect the gammas coming from the neutral pions decay a Liquid Krypton (LKr) calorimeter with a resolution in energy (GeV) of

$$\frac{\sigma_E}{E} = \frac{3.2\%}{\sqrt{E}} + \frac{9\%}{E} + 0.42\%$$

is employed. The very good resolution in the reconstructed kaon mass ($1.7 \text{ MeV}/c^2$ for $K^\pm \rightarrow \pi^\pm\pi^+\pi^-$ and $0.9 \text{ MeV}/c^2$ for $K^\pm \rightarrow \pi^\pm\pi^0\pi^0$) allows a precise calibration and monitoring of the characteristics and performances of the apparatus. The data collection is based on a multilevel trigger system. The first level (L1) uses the information coming from a plastic scintillator hodoscope and from a dedicated LKr readout, in which the number of peaks in the calorimeter's energy deposit are computed. The second level (L2) is based on processors for a fast DCH reconstruction. In particular the number of reconstructed vertexes with 2 or 3 tracks, is used to collect $K^\pm \rightarrow \pi^\pm\pi^+\pi^-$ events and the missing one-track mass, assuming the nominal kaon momentum (60 GeV) and direction (z axis), is used to collect $K^\pm \rightarrow \pi^\pm\pi^0\pi^0$, rejecting the main $K^\pm \rightarrow \pi^\pm\pi^0$ background. NA48/2 collected data during two runs in 2003 and 2004, for a total of ~ 100 days of data taking. About $18 \cdot 10^9$ triggers have been registered on tape, for a total of more than 200 TB.

3 Charge asymmetry measurement strategy

The asymmetry method is based on the comparison between the u projection of the Dalitz plot distribution, in order to extract the difference between the matrix element linear components. This difference, defined as $\Delta g = g^+ - g^-$, can be extracted considering the ratio between the density in the u distribution for K^+ and K^- decays. The ratio between the two distribution can be written as:

$$R(u) = \frac{N_{K^+}}{N_{K^-}} \propto \frac{1 + (g + \Delta g)u + hu^2}{1 + gu + hu^2} \quad (3)$$

where $g = (g^+ + g^-)/2$. From Δg the asymmetry parameter A_g can be easily evaluated using the relation $A_g \sim \Delta g/2g$. The simultaneous collection of decays coming from beams with similar momentum spectrum and a similar detection efficiency and acceptance of the decay products, are fundamental points to control the instrumental charge asymmetry. However, the presence of magnetic fields both in the beam sector (achromat) and in the detector (spectrometer magnet) could introduce an intrinsic charge dependent acceptance of the apparatus. To equalize this asymmetry the main

magnetic fields were frequently reversed during the data taking. During the 2003 run the magnet spectrometer polarity was reversed every day while the achromat magnets polarities every week. In the 2004 run the reversal was more frequent: every about 3 hours for the analyzing magnet and 1 day for the beam transport line magnets. It is possible to redefine the ratio in (3) taking into account the magnetic field alternation. For instance, for a given achromat polarities, the ratios:

$$R_J(u) = \frac{N_{K^+}^{B^-}}{N_{K^-}^{B^+}}, \quad R_S(u) = \frac{N_{K^+}^{B^+}}{N_{K^-}^{B^-}} \quad (4)$$

are defined using the same side of the spectrometer, in the sense that the numerator and the denominator in these ratios contain particles deflected in the same direction. The subscripts J and S represent the particles bending direction according to the geographic position of the Jura (J) and Saleve (S) mountains, respectively on the left and right side, with respect to the NA48/2 beam line direction. Considering the possible achromat polarity, four independent ratios can be built exploiting the four different field combinations: instead of the single ratio (3), a *quadruple ratio* can be defined as:

$$R(u) = R_{US}R_{UJ}R_{DS}R_{DJ} \sim \bar{R} \left(\frac{1 + (g + \Delta g)u + hu^2}{1 + gu + hu^2} \right)^4 \quad (5)$$

where U and D stand for the path, up or down, followed by K^+ in the achromat system, and \bar{R} is an inessential normalization constant. This method is independent on the relative size of the four samples collected with different fields configuration and on the K^+ and K^- flux difference. In the value of Δg extracted from the quadruple ratio (5), the benefits due to the polarity reversal are fully exploited and the main systematic biases due to instrumental asymmetries cancel out. In particular in the quadruple ratio there is a three fold cancellation:

- local detector bias (left-right asymmetry), thanks to the fact that each single ratio is defined in the same side of the detector;
- beam local biases, because in each single ratio the path followed by the particle through the achromat is the same;
- global time variation, because the decays from both charges are collected at the same time (this is not true for the same single ratio in which the numerator and the denominator are collected in different period).

The result remains sensitive only to the time variation of the detector with a characteristic time smaller than the inversion period of the magnetic field, if this effect is charge asymmetric and u dependent. Other systematic biases induced by effects

not canceled by the magnetic field alternation of the magnetic fields (for instance the Earth's magnetic field in the decay region and any misalignment of the spectrometer) have been carefully corrected. The intrinsic cancellation of instrumental asymmetries in the quadruple ratio allows to avoid the use of a MonteCarlo simulation. Nevertheless a GEANT3 based MonteCarlo, including the full geometry description and time variations of beam characteristics, DCH inefficiency and spectrometer alignment, is used for systematics studies and as a cross-check of the result.

3.1 Results in $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

The reconstruction in the “neutral” mode is based on LKr to construct the u variable and on the spectrometer to define the event charge and close the kinematics. The possibility to define the u variable using the π^0 's only is a strong point in this kind of analysis, because of the charge independence of them. Anyway an alternative u reconstruction can be done using the DCH and the KABES informations, to obtain a result, useful as cross-check, with different systematic effects. The fiducial region of the detectors is chosen to avoid edge effects. In particular in order to symmetrize the small difference in the spectrometer acceptance between decays coming from K^+ and K^- beams, the spectrometer's inner radial cut is chosen according to the actual beam position, periodically measured as the average of the reconstructed transverse vertex position using three charged pion events. The decay vertex is reconstructed from the γ impact point position on the LKr, for each π^0 , by using the formula:

$$Z_{ij} = \frac{1}{m_{\pi^0}} \sqrt{E_i E_j d_{ij}^2} \quad (6)$$

Among all the possible γ pair, the correct pairing is chosen minimizing the difference between the two π^0 's vertexes. The final vertex is obtained as arithmetic average. The kaon invariant mass is obtained including the charged pion measurement from the DCH, in order to reduce the events background by requiring $|M_{K^\pm} - M_{PDG}| < 6 MeV/c^2$. A total of $59.3 \cdot 10^6$ K^+ and $32 \cdot 10^6$ K^- events has been selected; In plot 2 the reconstructed Dalitz Plot is shown. The photon position on the LKr is corrected to take in to account the calorimeter projectivity. The measurement of the charged momentum, slightly biased by variable DCH misalignment, is corrected exploiting the condition $M_{K^+} = M_{K^-}$ in the $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$. Using the same decay mode the magnetic field inversion is monitored online at level of 10^{-3} studying the reconstructed kaon mass with respect to the nominal (PDG) kaon mass. The effect of the residual magnetic field in the decay region (the so called *Blue Field*), mostly due to the earth magnetic field, is corrected using the maps obtained from a direct measurement before the data taking. Several sources of potential systematic bias have been considered. The effect due to the acceptance has been evaluated studying the stability of the result varying the cuts definition. The MC has been used to

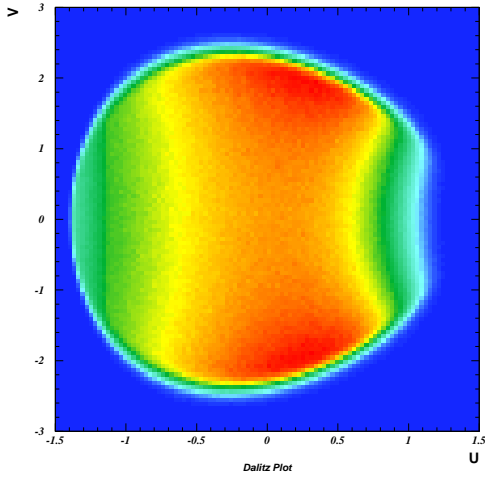


Figure 2: Dalitz plot distribution for $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

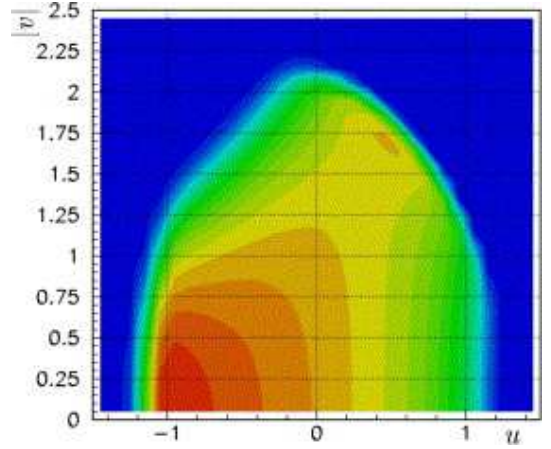


Figure 3: Dalitz plot distribution for $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$

study the contribution of the pion decay in flight to the total systematics error. The contribution to the systematics of the online trigger system has been carefully studied. The efficiencies of the L1 and L2, have been evaluated using data collected with control triggers uncorrelated with the main trigger. In the neutral mode the L1 is essentially obtained with a coincidence between a signal (Q1) coming from the scintillating hodoscope and a signal (NTPEAK) compatible with a deposition of four clusters in the LKr. The L2 (MBX) is based on the algorithm that rejects the $\pi^\pm \pi^0$. The main source of systematics comes from the neutral part of the L1 trigger (NTPEAK) being limited by the number of events in the control sample. In table 2 a summary of systematics is shown. The preliminary result in the slope difference using the whole statistics is:

$$\Delta g = (2.7 \pm 2.0_{stat} \pm 1.2_{syst} \pm 0.3_{ext}) \times 10^{-4}$$

where the external error is due to the $\sim 3\%$ error [13] on the knowledge¹ of the g value. The resulting charge asymmetry parameter is:

$$A_g^n = (2.1 \pm 1.6_{stat} \pm 1.0_{syst} \pm 0.2_{ext}) \times 10^{-4} = (2.1 \pm 1.9) \times 10^{-4}$$

This result is fully compatible with the SM prediction and is almost one order of magnitude better than the previous measurements [6] [7].

¹This contribution becomes negligible using the new g_0 measurement [14]

<i>Systematic effect</i>	<i>Effect on $\Delta g \cdot 10^{-4}$</i>
U calculation & fitting	± 0.2
LKr non linearity	± 0.1
Shower overlapping	± 0.5
Pion decay	± 0.2
Spectrometer Alignment & Momentum scale	$< \pm 0.1$
Accidentals	± 0.2
L1 Trigger: Q1	± 0.1
L1 Trigger: NTPEAK	± 0.8
L2 Trigger	± 0.6
Total systematic uncertainty	± 1.2

Table 2: Systematics in $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

3.2 Results in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$

The offline reconstruction of the $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ is totally based on the Spectrometer. The decay vertex is obtained extrapolating the track segment from the first two chambers from the spectrometer to the decay volume, taking into account the presence of the Blue Field in the decay region. The track momentum is rescaled, to compensate the variation of the DCH alignment, as described above. In the three charged pion mode the chambers' acceptance and the spectrometer performance are most critical with respect to the neutral case where the spectrometer is used only to tag the event. In particular the beam pipe crossing the chambers determines the main difference in the acceptance between the two beams for which the beam optic can not control the transverse position better than $\sim 1mm$. The cut centered on the actual beam position (at level of the first and last chamber) must be applied to all the pions, resulting in a reduction of $\sim 12\%$ of the whole statistics. In plot 3 the reconstructed Dalitz Plot is shown. The only relevant physical background come from the pion decay in flight. More than $2 \cdot 10^9$ K^+ and $1.1 \cdot 10^9$ K^- decays are collected in this channel. The main systematics in the charged mode comes from the pion decay in flight as reported in table 3 where the contributions to the systematic error are summarized. A simpler fitting function can be used in the charged mode case with respect to (5) to extract the Δg value, exploiting the relative smallness of the measured g :

$$R(u) \propto \bar{R}(1 + \Delta g u)^4$$

The preliminary result, based on the 2003+2004 data taking, is:

$$\Delta g = (0.6 \pm 0.7_{stat} \pm 0.7_{syst}) \times 10^{-4}$$

<i>Systematic effect</i>	<i>Effect on $\Delta g \cdot 10^{-4}$</i>
Spectrometer alignment	± 0.1
Momentum scale	± 0.1
Acceptance and Geometry	± 0.2
Pion decay	± 0.4
Accidentals	± 0.2
Resolution effects	± 0.3
L1 Trigger: Q1	± 0.3
L2 Trigger	± 0.3
Total systematic uncertainty	± 0.7

Table 3: Systematics in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$

leading to a charge asymmetry parameter of

$$A_g^c = (-1.3 \pm 1.5_{stat} \pm 1.7_{syst}) \times 10^{-4} = (-1.3 \pm 2.3) \times 10^{-4}$$

Also in this case the goal to increase by a factor 10 the sensitivity with respect to the previous measurement has been reached. The reason for a similar precision of asymmetry results in “neutral” and “charged” mode, in spite of the different statistics, lies in the fact that the Dalitz Plot density is most favourable in the “neutral” mode.

4 Dalitz plot parameters measurement in $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

In fig. 4 the $\pi^0 \pi^0$ invariant mass square (M_{00}^2) distribution (proportional to the u distribution) is shown. The change of slopes, seen for the first time by NA48/2 at $M_{00}^2 = (2m_{\pi^+})^2$, can not be explained by the simple matrix element parametrization given in (1). This structure has been interpreted by Cabibbo [10] as due to the rescattering process $\pi^+ \pi^- \rightarrow \pi^0 \pi^0$ coming from the $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ decay. In fact the $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ amplitude can be written as the sum of two terms (just considering the first rescattering order): the direct $\pi^0 \pi^0$ emission \mathcal{M}_0 , parametrized by the standard polynomial expansion, and the terms due to the rescattering process \mathcal{M}_1 . This last term, proportional to the difference ($a_0 - a_2$) between the pionic scattering length for $I=0$ and $I=2$, is real below the threshold of $2m_{\pi^+}$ and imaginary above. The total amplitude can be written as:

$$\mathcal{M}^2 = \begin{cases} (\mathcal{M}_0)^2 + (\mathcal{M}_1)^2 + 2 \cdot \mathcal{M}_0 \mathcal{M}_1 & s_{\pi\pi} < 4m_{\pi^+}^2 \\ (\mathcal{M}_0)^2 + |\mathcal{M}_1|^2 & s_{\pi\pi} > 4m_{\pi^+}^2 \end{cases} \quad (7)$$

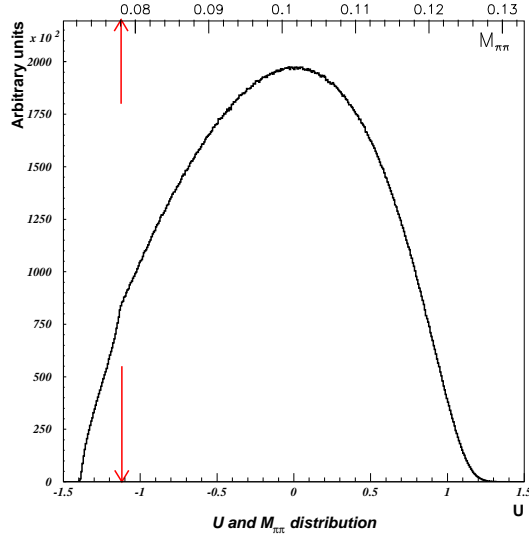


Figure 4: U distribution for $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$. The $\pi^0 \pi^0$ invariant mass square (M_{00}^2) is related to the u variable by $u = (M_{00}^2 - s_0)/m_\pi^2$. In the arrow position (corresponding to $(2m_{\pi^+})^2$) it is possible to see the “cusp” structure.

The $\mathcal{M}_0 \mathcal{M}_1$ term gives a destructive interference below threshold. Other rescattering diagrams can be included in a systematic way as shown by Cabibbo and Isidori [15]. Fitting data with only the \mathcal{M}_1 term yields a fair agreement only above the $2m_{\pi^+}$ threshold, because of the anomaly introduced by the pions strong rescattering in the M_{00}^2 distribution, while the standard expansion is not enough to explain the complex dynamics contributing to the whole decay amplitude. Using the Cabibbo one-loop model, the fit quality increase giving a χ^2 of 420.1 for 148 degree of freedom, as shown in fig. 6. Including the two-loop Cabibbo-Isidori approach the χ^2 becomes more reasonable (158.8 for 146 degree of freedom). Near the threshold the relative pions velocity decreases and the possibility to have electromagnetic $\pi^+ \pi^-$ bound states increases. However the description of the so called pionic atoms (pionium) needs particular care, because of the Coulomb interaction correction and the critical experimental resolution (the fit obtained including the pionium is shown in the third plot in fig. 6). For that reason we prefer to exclude 7 bins around the threshold position to perform the final fit (last plot in fig.6) in which we have a χ^2 of 145.5 for 139 degree of freedom. The results [16], based on $23 \cdot 10^6$ events collected in 2003, are obtained setting k, the quadratic v slope, to 0:

$$g^0 = 0.645 \pm 0.004_{stat} \pm 0.009_{syst}$$

$$h' = -0.047 \pm 0.012_{stat} \pm 0.011_{syst}$$

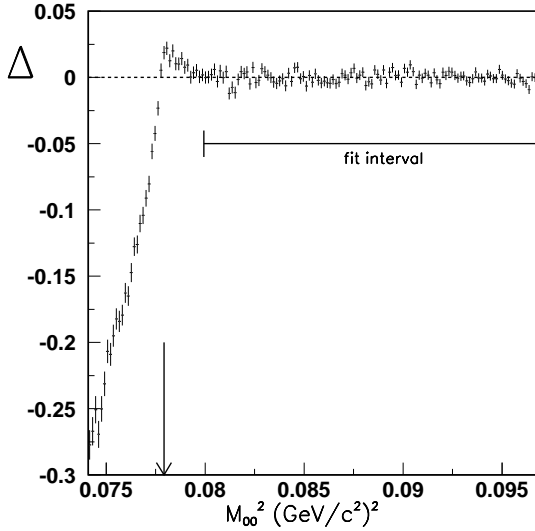


Figure 5: $\Delta = (data - fit)/data$ is shown as a function of $M_{\pi^0\pi^0}$. The cusp threshold is indicated by an arrow. The fit χ^2 is reasonable only if the fit is restricted to the indicated fit interval.

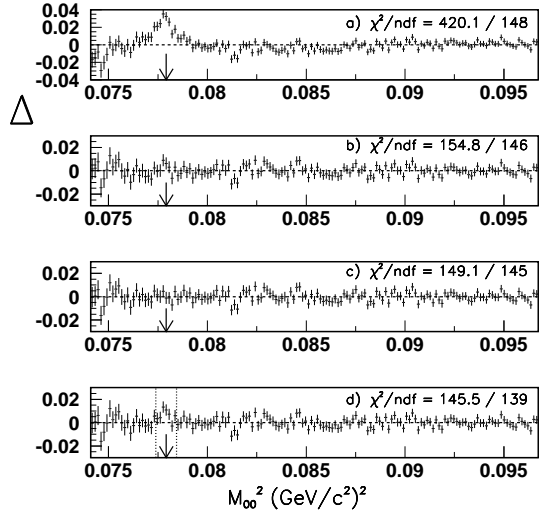


Figure 6: The application of the rescattering hypothesis improves the quality of the fit (see text)

	NA48/2 results	PDG06
g	$(-21.131 \pm 0.009_{stat} \pm 0.012_{syst})\%$	$(-21.54 \pm 0.35)\%$
h	$(1.829 \pm 0.015_{stat} \pm 0.036_{syst})\%$	$(1.2 \pm 0.8)\%$
k	$(-0.467 \pm 0.005_{stat} \pm 0.011_{syst})\%$	$(-1.01 \pm 0.34)\%$

Table 4: Results for Dalitz Plot parameter in charged mode.

where $h' + (1/4)g^2 = h$. The data are compatible with a non zero value for the k parameter, never measured before. The value of the fit

$$k = 0.0097 \pm 0.0003_{stat} \pm 0.0008_{syst}$$

is still preliminary. The $(a_0 - a_2)$ value is not affected by the $k \neq 0$ term, but the g and h values change respectively by $\sim 2\%$ and $\sim 25\%$.

5 Dalitz plot parameters measurement in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$

Thanks to the huge statistics collected in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ decay and to the well tuned MC, very precise measurement of the Dalitz plot parameters can be performed. The

pion rescattering effects can influence the matrix element also in the “charged” mode but, being on the border of the Dalitz Plot, is not so evident like in the “neutral” mode. The goal of the first and preliminary study presented here is to measure the parameters in the standard polynomial expansion verifying the validity of (1). The parameters (g,h,k) are obtained minimizing the

$$\chi^2(g, h, k, N) = \sum_{u,v} \frac{(F_{data} - NF_{MC})^2}{\delta F_{data}^2 + N^2 F_{MC}^2}$$

where F represents the population (in data or in MC) in the (u,v) bin. The MC population is obtained adding the 4 components corresponding to the four possible terms in (1). The relative weights, obtained from the fit, are the polynomial expansion parameters. The coulomb correction is applied to take into account the pion electromagnetic interaction. The main contributions to the systematic uncertainty, at this analysis stage, come from the momentum scale in the charged pions measurement, the kaon momentum spectrum in the MC and trigger inefficiencies. The preliminary result is based on $0.47 \cdot 10^9$ events collected in the 2003 run. In table 4 the results are presented and the agreement with the PDG06 values is shown. The previous measurements, by experiments made in 70s, are one order of magnitude less precise with respect to the NA48/2 measurement, based on 1/4 of the whole statistics.

6 Conclusions

The main goal of the NA48/2 experiment was to measure, with a precision at level of 10^{-4} the charge asymmetry parameter A_g , both in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ and in $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ decays. The preliminary results obtained in the “neutral” (A_g^n) and “charged” (A_g^c) mode:

$$A_g^n = (2.1 \pm 1.6_{stat} \pm 1.0_{syst} \pm 0.2_{ext}) \times 10^{-4} = (2.1 \pm 1.9) \times 10^{-4}$$

$$A_g^c = (-1.3 \pm 1.5_{stat} \pm 1.7_{syst}) \times 10^{-4} = (-1.3 \pm 2.3) \times 10^{-4}$$

are compatible with the SM predictions and with our previous results based on partial samples [17] [18].

In $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ the standard polynomial matrix element expansion is not enough to describe the observed $\pi^0 \pi^0$ invariant mass spectrum. Taking into account the rescattering processes, whose contributions are proportional to the $(a_0 - a_2)$ term the corresponding slope are found to be (setting k=0)

$$g^0 = 0.645 \pm 0.004_{stat} \pm 0.009_{syst} \quad h' = -0.047 \pm 0.012_{stat} \pm 0.011_{syst}$$

However a $\sim 1\%$ for the k quadratic slope is obtained with a complete fit (preliminary result).

In the charged mode the standard polynomial fit has been employed. The Dalitz plot parameters have been remeasured with higher precision with respect to the previous old measurement.

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