DIRAC note 2020-01

Identification and analyses of K^+K^- pairs

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1 KK identification

For this analysis the standard data collected during 2009 and 2010 were used. The reconstruction program ARIANE [1] in the same version and with the same input parameters as for pionium lifetime measurement is used [2]. Only events with one or two tracks per arm are analysed. The positive and negative track with the best fit between downstream and upstream candidates are used in the analysis. The standard method of elimination of accidentals pairs is used. The prompt pairs are selected with the difference of time in Vertical Hodoscope $\Delta(t)_{VH}$ to be $|\Delta(t)_{VH}| < 0.5\,\mathrm{ns}$. This sample contains certain amount of accidentals which should be subtracted. To do this we selected accidentals pairs from the interval of $-7\,\mathrm{ns} < \Delta(t)_{VH} < -5\,\mathrm{ns}$ which should contains double amount of accidentals compared to the prompt ones, since the interval lenght is double compared to the prompt. This subtraction is applied on Time of Flight (ToF), Q and Q_L distributions as described in the following text. Q is defined as absolute value of relative momentum of particles of the pair and Q_L and Q_T are its longitudinal and transverse projections on the full pair momentum.

1.1 Additional Calibration

To improve the results of ToF method fits, a detailed time calibration was done for data with e^+e^- and $\pi^+\pi^-$ triggers. In accordance of ToF method described in the following text, the time of flight between the X-plane of SciFi and Vertical Hodoscope was determined for both tracks in the pair, averaged and subtracted from the expected one. The peak position of the distribution of these differences was studied as a function of slab number of the positive arm of Vertical Hodoscope. The corrections to place the peak position into zero for each slab were introduced for both, e^+e^- and $\pi^+\pi^-$, trigger data. As shown in Figure 1, the delays are different for $\pi^+\pi^-$ and e^+e^- due to different delays in trigger.

1.2 Pair Identification

The pairs of particles with equal masses are classified into three categories: $\pi^+\pi^-$, K^+K^- and $p\bar{p}$. The main part of data consist of $\pi^+\pi^-$ pairs. The classification is based on the ToF measurement. In the momentum range from 3 to 5 GeV/c the additional information from Heavy Gas Cherenkov counters ([3]) is also used. The Cherenkov counters detect pions in this region with increasing efficiency from 45% to 97% [4], whereas kaons and protons (antiprotons) do not produce any signal. Due to finite resolution of ToF system and Cherenkov efficiency the purest K^+K^- sample contains about 10% of $\pi^+\pi^-$ and $p\bar{p}$ events each.

1.2.1 ToF Method

Time of flight is calculated between the X-plane of SFD and Vertical Hodoscope (VH). The distance is evaluated for each track and is about 11m. For positive and negative particles in the pair we evaluate the differences between calculated $t^{\pm}_{calc}$ and measured $t^{\pm}_{exp}$ time of flight $\Delta t^{\pm} = t^{\pm}_{calc} - t^{\pm}_{exp}$. The value of $t^{\pm}_{calc}$ is calculated using momentum $p^{\pm}$, track length $l^{\pm}$ and particle mass m_i, where $i = e, \pi, K, p$, $t^{\pm}_{i,calc} = l^{\pm}\sqrt{1 + m_i^2/|p^{\pm}|^2}$. The relative precision of momentum obtained by the tracking system is about 3×10^{-3} [3]. For the classification of the pair the average value $\Delta t = 1/2(\Delta t^+ + \Delta t^-)$ is used.

Figure 2 shows the distribution of Δt^e for electron pairs. The half width at half height of this distribution is the time resolution of ToF method and it is about 440 ps.

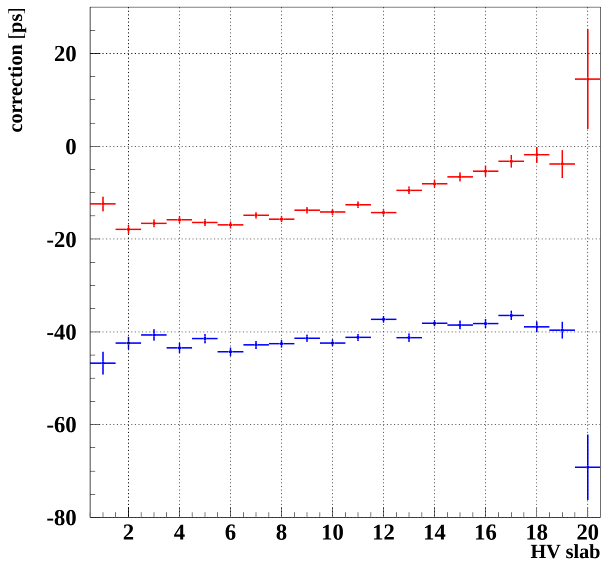

Figure 1: Time corrections for each slab of Vertical Hodoscope in left arm for electrons (red) and pions (blue).

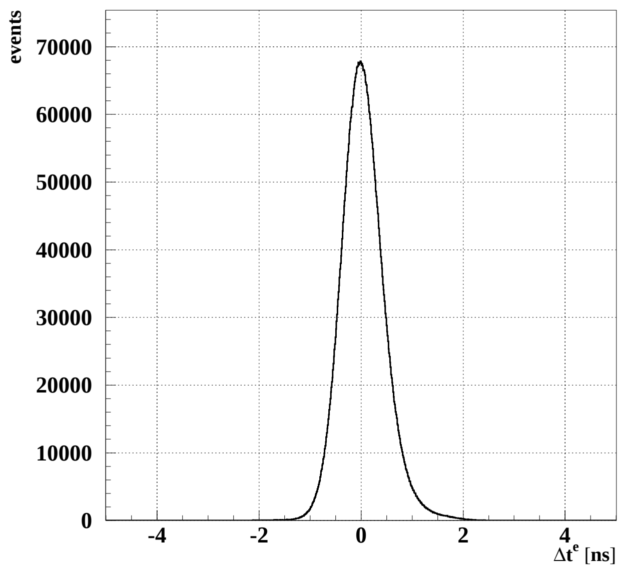

Figure 2: The distribution of Δt^e, difference between expected and measured time of flight for e^+e^- pairs.

As we focus on to analyse the K^+K^- pairs, we choose to work with Δt^K variable i.e. the average difference of calculated and measured time supposing kaon mass of particles. The Δt^K experimental distribution for pairs with momentum around $3.5\,GeV/c$ is shown in Figure 3. It is fitted by model distributions which are described in following text. The peak around zero corresponds to K^+K^- events. The peak on the right side consists of $\pi^+\pi^-$ pairs and the small peak on the left corresponds to $p\overline{p}$ pairs.

To obtain the model Δt^K distributions for the three pairs categories the e^+e^- data were used. The e^+e^- events were collected with a dedicated trigger [3] during standard data taking for calibration purposes. The e^+e^- pairs were identified by nitrogen Cherenkov (ChN) and preshower (PSh) counters. For positive (negative) particle in the e^+e^- pair Δt_e^+ (Δt_e^-) was calculated. As the identification of electrons and positrons is unambiguous, the width of Δt^e corresponds to the resolution of ToF measurement for particles with the same momentum as of the e^+e^- pair. As the difference of ionisation losses of electrons and hadrons in detectors used for triggering and ToF studies is small and compensated by detector electronics, the resolution of ToF method should be the same for hadrons and electrons. Therefore to construct the model distributions of $\pi^+\pi^-$, K^+K^- and $p\overline{p}$ pair from the e^+e^- pair, $t^{\pm}_{calc}$ is calculated using momenta and track lengths of the e^+e^- pair and masses of pion, Kaon and proton, m_π, m_K and m_p. The experimental deviation Δt_e^+ (Δt_e^-) is then added to this variable to obtain the "measured" ToF flight of modelled pair categories.

To ensure to have a similar shape of $\pi^+\pi^-$ pairs distribution in each momentum bins we introduce the new variable $\Delta T_{K-\pi}$. It is define as the avarage value of differences between the expected time of flight for each track in the pair assuming kaon and pion masses:

$$\Delta T_{K-\pi} = 1/2(\Delta T^+_{K-\pi} + \Delta T^-_{K-\pi}),$$

where

$$\Delta T^{\pm}_{K-\pi} = t^{\pm}_{K,calc} - t^{\pm}_{\pi,calc}.$$

The relation between the average momentum of the particles in the pair and $\Delta T_{K-\pi}$ is shown in Figure 4. The 2-D distribution of model events in the space of $\Delta T_{K-\pi}$ and Δt^K variables is shown in Figure 5. We split the full momentum interval into equidistant bins according to $\Delta T_{K-\pi}$. The selection of particular $\Delta T_{K-\pi}$ bin fixes the distance between the peak positions of distributions corresponding to $\pi^+\pi^-$, K^+K^- and $p\overline{p}$ pairs. The bin width of of 25 ps keeps the same shape for $\pi^+\pi^-$ and K^+K^- distributions in each $\Delta T_{K-\pi}$ bin minimising the momentum dependence. The dependence of the shape of $p\overline{p}$ distribution on $\Delta T_{K-\pi}$ bin positions remains but it is smaller than in case of momentum bins.

As the momentum distributions of $\pi^+\pi^-$ and e^+e^- pairs are different, the $\Delta T_{K-\pi}$ spectrum of $\pi^+\pi^-$ and e^+e^- are different, e^+e^- spectra was weighted accordingly to improve the correctness of model distributions. The unweighted $\Delta T_{K-\pi}$ spectra of $\pi^+\pi^-$ and e^+e^-pairs are shown in Figure 6. Recall, that $\Delta T_{K-\pi}$ is momentum dependent and decrease with increasing momentum as shown in Figure 4.

The model distributions of $\pi^+\pi^-$, K^+K^- and $p\overline{p}$ pairs are used to fit the experimental distributions in individual bins of $\Delta T_{K-\pi}$, as shown in Figure 3, to determine the amount of the events of each category. In the fit procedure the used model distributions are taken from the same $\Delta T_{K-\pi}$ bin as the experimental one. The results of the fits are shown in Figure 7.

Since the fluctuations in K^+K^- and $p\overline{p}$ experimental distributions on $\Delta T_{K-\pi}$ are significant we smooth them. For K^+K^- we provide smoothing in three successive intervals using Landau and polynomial functions. Landau function is used in the interval from 0.25 ns to 0.90 ns of $\Delta T_{K-\pi}$, the rest was fitted by polynomial functions. The $p\overline{p}$ distribution was fitted in full range by a exponential function with polynomial argument. The smoothed distribution are shown in Figure 8.

1.3 Sample selection criteria

As collected data consists mainly of $\pi^+\pi^-$ pairs, to analyse the K^+K^- pairs distributions the subsets (samples) with significant ratio of K^+K^- pairs should be selected. In each $\Delta T_{K-\pi}$ bin we select the contiguous bins in Δt^K demanding the K^+K^- population to be above a threshold level. These selected bins define a cell. We consider three subsets consisting of ($\Delta T_{K-\pi}$,Δt^K) cells with the threshold levels at 30, 50 and 70% of the K^+K^- population.

The cleanest 70% K^+K^- sample consists only of high momentum K^+K^- pairs where Cherenkov counters suppressing $\pi^+\pi^-$ pairs. The population of the categories in the K^+K^- samples for data taken in 2009 and 2010 with Q_T cut by trigger only ($Q_T < 15\,MeV/c$) are shown in Table 1 and in Figure 9.

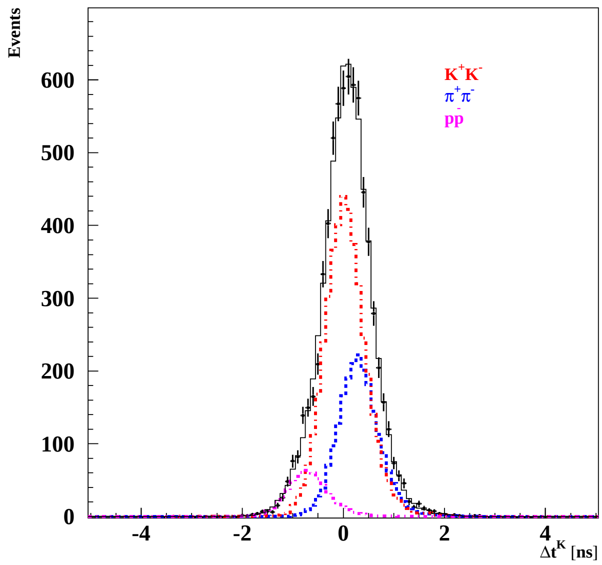

Figure 3: The distribution of Δt^K, difference between calculated and measured time of flight supposing kaon mass of particles in the pair, for pairs with momentum $\sim 3.5\,\mathrm{GeV/c}$.

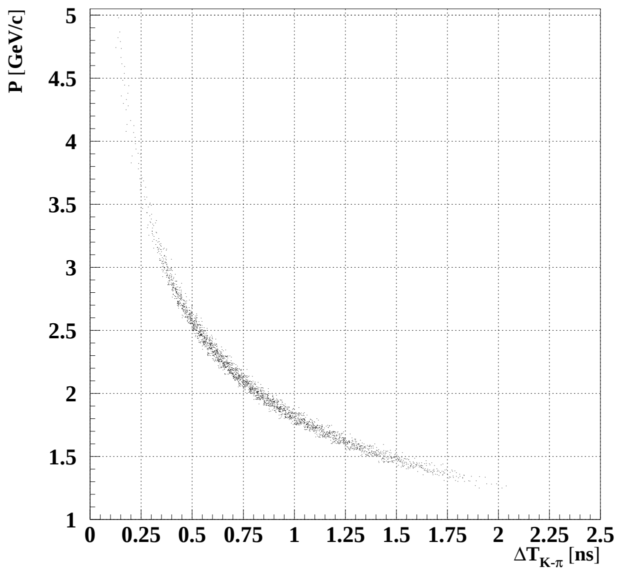

Figure 4: The relation between the average momentum P of the particles in the pair and $\Delta T_{K-\pi}$.

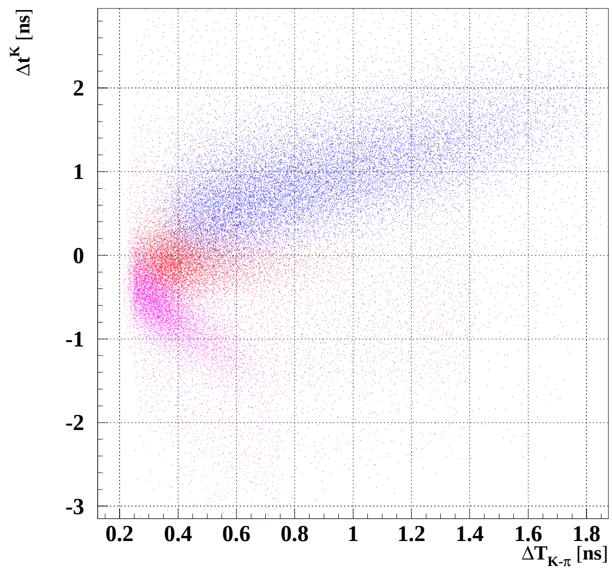

Figure 5: Model distribution for $\pi^+\pi^-$,K^+K^- and $p\bar{p}$ pairs obtained from e^+e^- events.

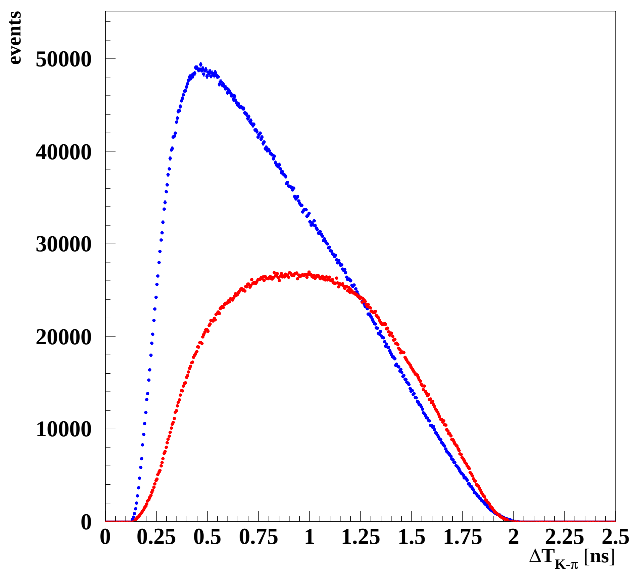

Figure 6: Experimental $\Delta T_{K-\pi}$ distribution of $\pi^+\pi^-$ (blue) and e^+e^- (red) pairs. Note $\Delta T_{K-\pi}$ is decreasing with increasing momentum.

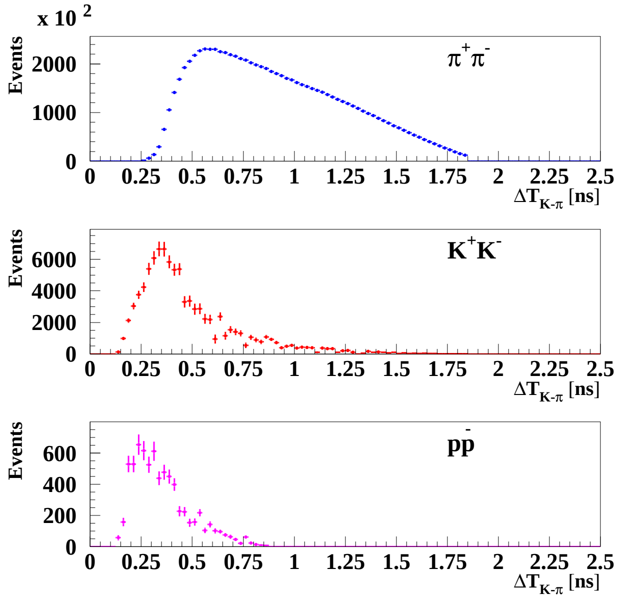

Figure 7: The fitted populations of $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ in $\Delta T_{K-\pi}$ bins obtained from 2010 data.

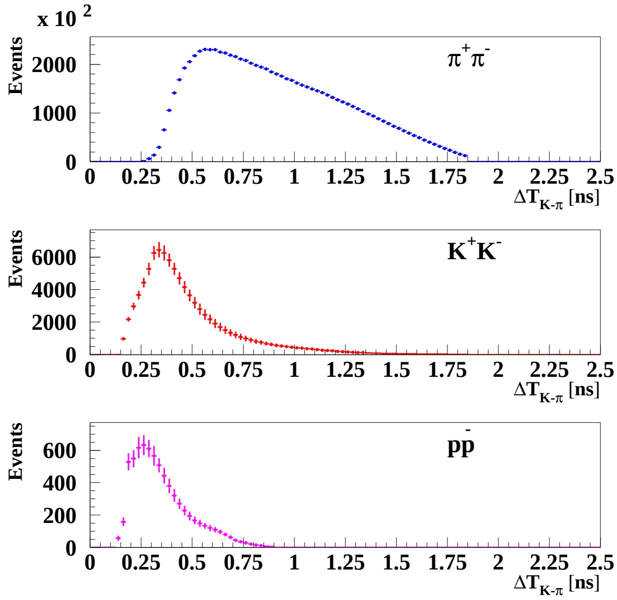

Figure 8: The $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ populations in $\Delta T_{K-\pi}$ bins obtained from 2010 data after smoothing.

As can be seen from the table, the selected K$^+$K$^-$ samples contain non-negligible amount of $\pi^+\pi^-$ and p$\overline{\text{p}}$ pairs.

Table 1: Pair numbers in the RUNs 2009 and 2010 evaluated with different cuts (30%, 50%, 70%) on ToF to select K^+K^- and to suppress background $\pi^+\pi^-$ and $p\bar{p}$ (Q_T cut by trigger only).

2009	Experimental data				Residual R [%]		
Sample	all	30%	50%	70%	30%/all	50%/all	70%/all
$\pi^+\pi^-$	7.77E+06	17290	3540	620	0.22	0.05	0.008
K^+K^-	90840	25660	15040	8210	28.2	16.6	9.0
$p\bar{p}$	7670	2960	1930	880	38.6%	25.2	11.5

2010	Experimental data				Residual R [%]		
Sample	all	30%	50%	70%	30%/all	50%/all	70%/all
$\pi^+\pi^-$	7.96E+06	15230	2970	80	0.19	0.04	0.001
K^+K^-	92960	25550	15910	8330	27.5	17.1	9.0
$p\bar{p}$	7200	2950	1780	770	41.0	24.7	10.7

To correct the Q and Q_L spectra of K$^+$K$^-$ pairs for the admixture of $\pi^+\pi^-$ and p$\overline{\text{p}}$ pairs dedicated samples of these pairs were selected.

The sample of p$\overline{\text{p}}$ was selected in a equivalent way to the K$^+$K$^-$ samples with threshold level at 50%, i.e. ($\Delta T_{K-\pi}$,Δt^K) cells with at least 50% population of p$\overline{\text{p}}$ pairs were chosen.

The samples of $\pi^+\pi^-$ are obtained from full statistics without any selection done by Heavy Gas Cherenkov. Furthermore the $\pi^+\pi^-$ sample is supposed to be clean from admixture of K$^+$K$^-$ and p$\overline{\text{p}}$ due to significant dominance ($\sim$ 99%) of $\pi^+\pi^-$ in data. The $\pi^+\pi^-$ events are normalised accordingly to the population of $\pi^+\pi^-$ background in each $\Delta T_{K-\pi}$ bin in each of the three K$^+$K$^-$ sample. So for each K$^+$K$^-$ sample dedicated distribution of $\pi^+\pi^-$ are created.

2 Q and Q_L distributions of K$^+$K$^-$ pairs

For each selected K$^+$K$^-$ sample the Q and Q_L spectra, supposing kaon masses of both particles in each pair, are produced. The cut $Q_T < 6MeV/c$ is applied on all processed data[1]. The original data are limited by the trigger cut $Q_T < 15MeV/c$. To get the cleanest Q and Q_L spectra of K$^+$K$^-$ as possible, the spectra of p$\overline{\text{p}}$ and $\pi^+\pi^-$ processed with kaon masses, are subtracted from ones obtained for K$^+$K$^-$samples supposing the yields of particles according Table 1. The dedicated $\pi^+\pi^-$ sample for each individual K$^+$K$^-$ sample is used. The 50% p$\overline{\text{p}}$ sample is used for all K$^+$K$^-$ samples from the given year.

2.1 Fits of Q_L spectra

The Q_L spectra of the three K$^+$K$^-$ samples for 2009 and 2010 were independently fitted between 0 and 100 MeV/c by simulated Q_L distribution of K$^+$K$^-$ pairs under DIRAC conditions and an admixture of experimental $\pi^+\pi^-$ pairs Q_L distributions or a constant distribution representing accidental pairs. The fit is performed with two free parameters, number of K$^+$K$^-$ and $\pi^+\pi^-$ or accidental pairs, without any constraints. The results are shown in Table 2 in the case of $\pi^+\pi^-$ admixture and in case of flat distribution in Table 3. The χ^2 values in the last column of Tables 2 and 3 show that the fitting curves are describing the experimental distributions well.

The results shows that for 70% samples from 2009 and 2010 the influence of $\pi^+\pi^-$admixture is minimal. For other samples from 2010 the influence of $\pi^+\pi^-$admixture is small, for 2009 it seems to be more important. The studies of possible accidentals show only small possible effect.

The results of the fits with $\pi^+\pi^-$ admixture for both year 2009 and 2010 are shown in Fig 10. The Coulomb enhancement is clearly visible for K$^+$K$^-$ distributions in region of $Q_L < 7MeV/c$.

[1]This cut is applied to ensure good agreement between experimental and MC data as the trigger performance in this region is flat.

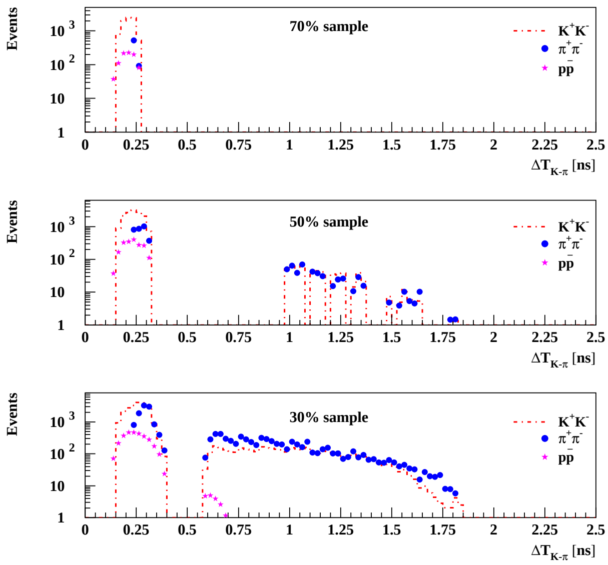

Figure 9: The $\pi^+\pi^-$, $\mathrm{K}^+\mathrm{K}^-$ and $\mathrm{p}\overline{\mathrm{p}}$ populations in $\Delta T_{K-\pi}$ bins in the selected 30, 50, 70% $\mathrm{K}^+\mathrm{K}^-$ samples from 2009.

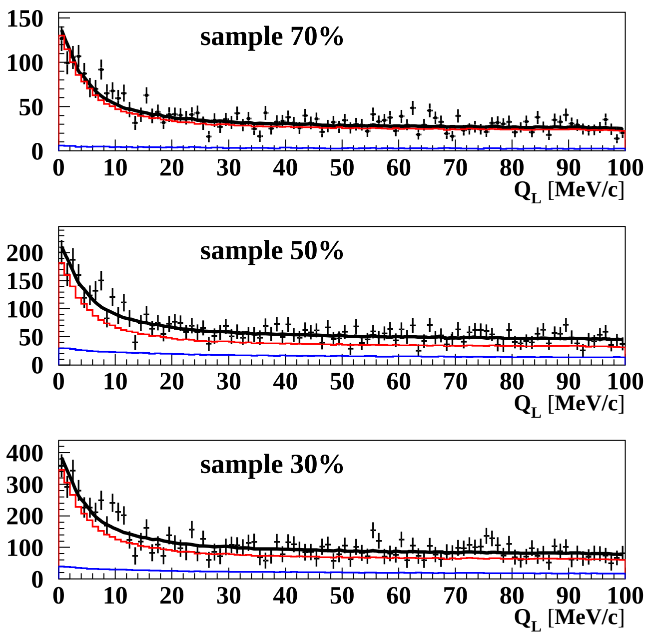

Figure 10: The sum of fitted Q_L distribution of $\mathrm{K}^+\mathrm{K}^-$samples of 2009 and 2010. The red lines are fitted simulated $\mathrm{K}^+\mathrm{K}^-$ distributions, green ones are fitted measured $\pi^+\pi^-$ distribution and black ones are sum of these two.

Table 2: Analysis of the 2009, 2010 years experimental Q_L distributions evaluated for different K$^+$K$^-$ (30%, 50%, 70%) samples. The Q_L spectra fitted in $0 < Q_L < 100$ MeV/c interval by the simulated distributions of K^+K^- and $\pi^+\pi^-$ pairs

year	Sample	total events	K^+K^-	$\pi^+\pi^-$	χ^2/DF
2009	70%	1870	1820 ± 240	-40 ± 230	1.120
	50%	3340	2260 ± 360	990 ± 370	1.171
	30%	6080	3970 ± 660	2040 ± 680	1.029
2010	70%	1920	1460 ± 210	370 ± 210	1.016
	50%	3080	2320 ± 360	700 ± 360	0.931
	30%	4960	4740 ± 630	180 ± 650	0.770
2009+2010	70%	3790	3280 ± 320	330 ± 310	
	50%	6420	4580 ± 510	1690 ± 510	
	30%	11050	8720 ± 910	2220 ± 940	

Table 3: Analysis of the 2009, 2010 years experimental Q_L distributions evaluated for different K$^+$K$^-$ (30%, 50%, 70%) samples. The Q_L spectra fitted in $0 < Q_L < 100$ MeV/c interval by the simulated distributions of K^+K^- and accidental distribution

year	Sample	total events	K$^+$K$^-$	Accidentals	χ^2/DF
2009	70%	1870	1810 $\pm$ 151	150 $\pm$ 141	1,121
	50%	3340	2630 $\pm$ 237	240 $\pm$ 232	1,173
	30%	6080	4730 $\pm$ 424	420 $\pm$ 436	1,032
2010	70%	1920	1670 $\pm$ 144	140 $\pm$ 135	1,032
	50%	3080	2650 $\pm$ 219	230 $\pm$ 212	0,944
	30%	4960	4880 $\pm$ 366	400 $\pm$ 375	0,771
2009+2010	70%	3790	3480 $\pm$ 209	290 $\pm$ 195	
	50%	6420	5290 $\pm$ 322	470 $\pm$ 314	
	30%	1105	9610 $\pm$ 560	830 $\pm$ 575	

2.2 Fits of Q spectra

The Q spectra of K$^+$K$^-$ pairs are processed in similar way to Q_L spectra. They are cleaned of known contribution of $\pi^+\pi^-$ and p$\overline{\text{p}}$ pairs and then they are fitted by linear combination of simulated Q distribution of K$^+$K$^-$ pairs and experimental distributions of $\pi^+\pi^-$ dedicated for each sample. The fits were done between 0 and $100 MeV/c$. Their results are summarised in Table 4 and sum of the distributions are shown in Figure 11. The χ^2 of the fits is very good for both years. From Table 5 we can see good agreement for all samples between numbers of K$^+$K$^-$ pairs evaluated in the analyses on Q_L and Q.

As the Q distributions of K$^+$K$^-$ and $\pi^+\pi^-$ pairs are flat in region from $Q > 30\,MeV/c$ and similar to each other, the fit in the region of $0\,MeV/c < Q < 30\,MeV/c$ was performed. The results are reported in Table 6 and shown in Figure 12. The results are compatible with the fit results in the full range.

In order to visualise the agreement between K$^+$K$^-$ experimental data and MC simulation we produce the ratio of the Q distributions in Figure 13. Here the normalisation of MC simulation is obtained from the fit in the flat region of $50 < Q < 100\,MeV/c$. The agreement is good for $Q > 7\,MeV/c$.

3 K$^+$K$^-$ yield

From the ToF analyses we obtained the total number of K$^+$K$^-$ pairs registered by the experiment during 2009 and 2010 runs and the numbers of these pairs in individual samples. The fits of Q and Q_L distributions give the numbers of K$^+$K$^-$ pairs in K$^+$K$^-$ samples in the region of $Q_T < 6\,MeV/c$. Under assumption that the fraction of the individual categories is independent of Q_T, the number of K$^+$K$^-$ pairs with $Q_T < 6\,MeV/c$ in the full sample can be estimated using Residuals from Table 1.

To check this assumption, the yield of the individual categories in the full sample and in each of K$^+$K$^-$ samples under $Q_T < 8\,MeV/c$ condition was studied. The rejection of $Q_T < 8\,MeV/c$ cut is about 50%

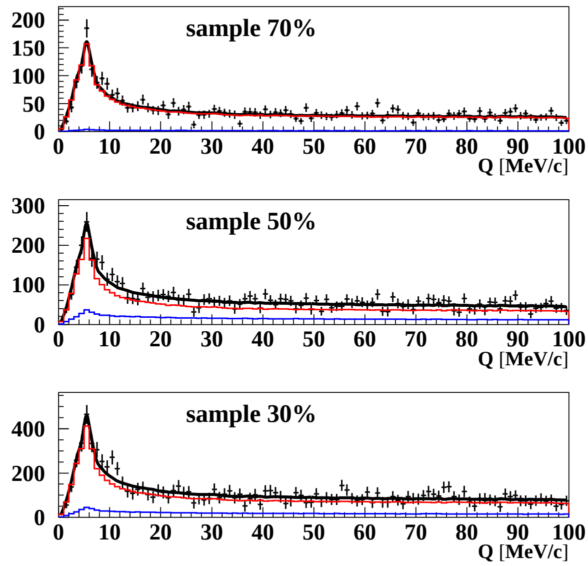

Figure 11: The sum of fitted Q distribution of K^+K^-samples of 2009 and 2010. The red lines are fitted simulated K^+K^- distributions, blue ones are fitted measured $\pi^+\pi^-$ distribution and black ones are sum of these two.

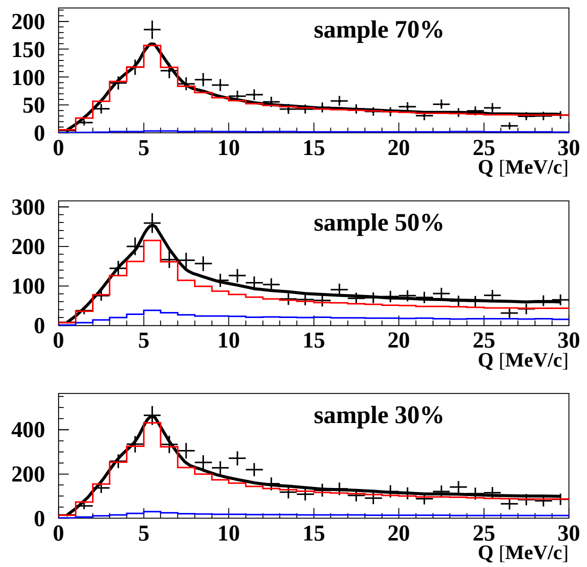

Figure 12: The sum of Q distribution of K^+K^-samples of 2009 and 2010 fitted in region of $0 < Q < 30$ MeV$/c$. The red lines are fitted simulated K^+K^- distributions, blue ones are fitted measured $\pi^+\pi^-$ distribution and black ones are sum of these two.

Table 4: Analysis of the 2009, 2010 years experimental Q distributions evaluated for different K^+K^- (30%, 50%, 70%) samples. The Q spectra fitted in $0 < Q < 100$ MeV/c interval by the simulated distributions of K^+K^- and $\pi^+\pi^-$ pairs.

year	Sample	total events	K^+K^-	$\pi^+\pi^-$	χ^2/DF
2009	70%	1870	1840 ± 240	-70 ± 240	1.180
	50%	3340	2310 ± 380	950 ± 380	1.129
	30%	6070	4150 ± 680	1860 ± 710	0.928
2010	70%	1920	1620 ± 220	220 ± 220	0.962
	50%	3080	2470 ± 370	550 ± 370	0.790
	30%	4960	4910 ± 650	0 ± 670	0.688
2009 + 2010	70%	3790	3460 ± 330	150 ± 320	
	50%	6420	4780 ± 530	1490 ± 530	
	30%	11030	9060 ± 940	1860 ± 980	

Table 5: Similarities of the Q and Q_L distribution analysis

year	Sample	distributions	K^+K^-	$\pi^+\pi^-$
2009+2010	70%	Q	3460 ± 330	150 ± 320
		Q_L	3280 ± 320	330 ± 310
	50%	Q	4780 ± 530	1490 ± 530
		Q_L	4580 ± 510	1690 ± 510
	30%	Q	9060 ± 940	1860 ± 980
		Q_L	8720 ± 910	2220 ± 940

from the full statistic. More strict rejection does not allow to study the yields of the categories due to low statistics. The results of this study are reported in Table 1. The Residuals obtained for $Q_T < 8\,MeV/c$ and $Q_T < 15\,MeV/c$ (Table 1) are in agreement taking into account the precision of this study.

The estimated numbers of produced K^+K^- pairs for the full sample using the results of Q and Q_T fits are shown in Table 7. These results can be used to estimate the production rate of K^+K^- atomic pairs under DIRAC conditions.

4 Conclusion

The K^+K^- pairs were identified, the Coulomb enhancement in Q and Q_L distributions is evident and well reproduced by MC simulation. The results are compatible in Q and Q_L analysis (Table 5) and are consistent for 2009 and 2010. The K^+K^- yield is presented for full statistics and for data with $Q_T < 8\,MeV/c$ and $Q_T < 6\,MeV/c$.

Table 6: Analysis of the 2009, 2010 years experimental Q distributions evaluated for different K^+K^- (30%, 50%, 70%) samples. The Q spectra fitted in $0 < Q < 30$ MeV/c interval by the simulated distributions of K^+K^- and $\pi^+\pi^-$ pairs.

year	cut on ToF	total events	K^+K^-	$\pi^+\pi^-$	χ^2/DF
2009	70%	1870	1880 ± 290	-140 ± 330	1.324
	50%	3340	2300 ± 450	930 ± 540	1.124
	30%	6070	4830 ± 830	780 ± 1030	1.124
2010	70%	1920	1560 ± 260	280 ± 290	1.067
	50%	3080	2420 ± 440	620 ± 530	0.504
	30%	4960	4640 ± 780	410 ± 960	0.831
2009 + 2010	70%	3790	3440 ± 380	140 ± 440	
	50%	6420	4720 ± 630	1550 ± 760	
	30%	11030	9470 ± 1140	1190 ± 1410	

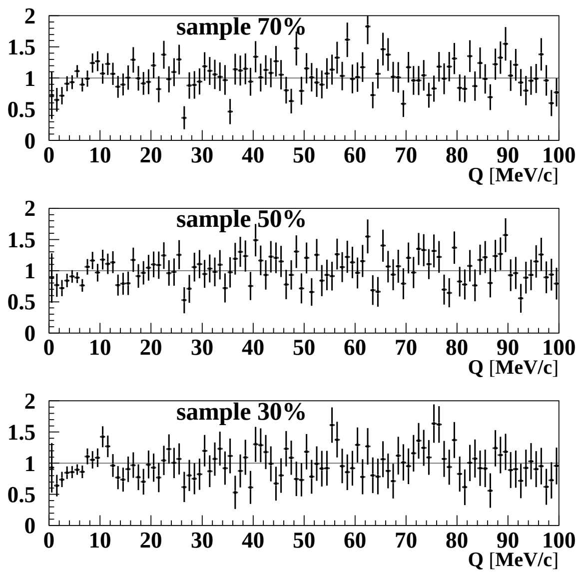

Figure 13: The ratio between data and MC simulation of K^+K^- Q distributions. The normalisation factor of MC is obtained from the fit in the flat region of $50 < Q < 100$ MeV/c. Data are from 2009 and 2010.

Table 7: Numbers of K$^+$K$^-$ pairs in full sample for $Q_T < 6\,MeV/c$ estimated from fit results of Q_L (upper table) and Q (bottom table).

year	Sample	fitted K$^+$K$^-$	Residual R [%]	total K$^+$K$^-$
2009	70%	1820 ± 240	9.0 ± 0.7	20120 ± 3060
	50%	2260 ± 360	16.6 ± 1.4	13650 ± 2480
	30%	3970 ± 660	28.2 ± 2.8	14070 ± 2710
2010	70%	1460 ± 210	9.0 ± 0.7	16320 ± 2560
	50%	2320 ± 360	17.4 ± 1.4	13310 ± 2260
	30%	4740 ± 630	28.2 ± 2.7	16830 ± 2750
2009+2010	70%	3280 ± 320		36440 ± 3990
	50%	4580 ± 510		26960 ± 3360
	30%	8710 ± 910		30900 ± 3860

year	Sample	fitted K$^+$K$^-$	Residual R [%]	total K$^+$K$^-$
2009	70%	1840 ± 240	9.0 ± 0.7	20400 ± 3110
	50%	2310 ± 380	16.6 ± 1.4	13950 ± 2540
	30%	4150 ± 680	28.2 ± 2.8	14680 ± 2820
2010	70%	1620 ± 220	9.0 ± 0.7	18050 ± 2830
	50%	2470 ± 370	17.4 ± 1.4	14160 ± 2410
	30%	4910 ± 650	28.2 ± 2.7	17440 ± 2850
2009+2010	70%	3460 ± 330		38450 ± 4200
	50%	4780 ± 530		28110 ± 3500
	30%	9060 ± 940		32120 ± 4010

Table 8: Pair numbers in the RUNs 2009 and 2010 evaluated for different K$^+$K$^-$ (30%, 50%, 70%) samples to select K^+K^- and to suppress background $\pi^+\pi^-$ and $p\bar{p}$ (with $Q_T < 8$ MeV/c).

2009	Experimental data				Residual R [%]		
Sample	all	30%	50%	70%	30%/all	50%/all	70%/all
$\pi^+\pi^-$	4.59E+06	9970	2030	380	0.22%	0.04%	0.008%
K^+K^-	50500	14470	8350	4510	28.7%	16.5%	8.9%
$p\bar{p}$	3730	1520	990	450	40.8%	26.5%	12.1%
2010	Experimental data				Residual R [%]		
Sample	all	30%	50%	70%	30%/all	50%/all	70%/all
$\pi^+\pi^-$	4.69E+06	8590	1660	90	0.18%	0.04%	0.002%
K^+K^-	50200	14140	8750	4510	28.2%	17.4%	9.0%
$p\bar{p}$	3180	1470	880	390	46.2%	27.7%	12.3%

References

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