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Dependence of breakup probability estimation on K^+K^- and p$\overline{\text{p}}$ background

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Abstract

Admixture of unidentified K^+K^- and p$\overline{\text{p}}$ pairs provides essential distortion of "Coulomb" background and leads to an error in a number of "atomic pairs" and in a measured value of breakup probability. The value of admixture and resulting distortion are investigated.

Introduction

At present DIRAC setup is not able to identify K^+K^--pairs for any momentum and p$\overline{\text{p}}$ pairs with lab momentum of particles more than 1.8 GeV/c. Protons (antiprotons) with $P_lab < 1.8$ GeV/c are rejected by cut on the difference of times measured by VH and upstream detectors.

As result data are analyzed in assumption that all hadrons are pions. From Lorentz transformation it is known that in this case transverse components of relative momentum in CMS Q_X, Q_Y are measured correctly but longitudinal component Q_L is underestimated by factor $\approx m_\pi/m_K$ (m_π/m_p).

If pair has $Q_T = 0$ and $Q_L \neq 0$ than Coulomb factor is calculated with small error because of error in Q $(Q = Q_L)$ is compensated by error in a particle mass in Eq. 1:

$$A_C(Q) = \frac{\eta}{1 - e^{-\eta}}, \eta = \frac{2\pi\alpha m}{Q} \tag{1}$$

Here $A_C(Q)$ is a Coulomb factor, α is a fine structure constant, m is a particle mass.

But if $Q_T \neq 0$ and $Q_L = 0$ than Coulomb factor is calculated with big error because parameter η in Eq. 1 is underestimated by factor ≈ 3.5 for K^+K^- pairs and ≈ 6.7 for p$\overline{\text{p}}$ pairs. Therefore Coulomb factor is underestimated too. This effect is partly compensated by fit procedure which increases a fraction of Coulomb pairs in order to fit more sharp peak of experimental distribution. But in our analysis a distribution of "free" pairs is fitted in the region $2 < Q_L < 15(22)$ MeV/c, $Q_T < 4$ MeV/c. "Atomic pairs" are found in the region $Q_L < 2$ MeV/c, $Q_T < 4$ MeV/c where Q_T gives more essential contribution by comparison with a region is used for fit and as result an approximation function has lower value for small Q. It leads to overestimation of "atomic" pair number. Number of Coulomb pairs is also overestimated because K^+K^- and p$\overline{\text{p}}$ pairs are included to a number of $\pi^+\pi^-$ pairs. The resulting change of breakup probability estimation is investigated in this report.

1 Sensitivity of “atomic” pair number and breakup probability to the admixture of K^+K^- and $p\bar{p}$ pairs

At the first stage of investigation an approximation function was built in assumption that 1% or 2% pairs are K^+K^- or $p\bar{p}$. Lab momentum spectra of admixtures was taken to be equal to spectrum of $\pi^+\pi^-$ pairs. Table 1 presents a values of estimated “atomic” pair numbers N_a and breakup probabilities for different admixture of non-pion pairs to approximation function. Analysis was done with distribution over F. Column $\delta_{P_{br}}$ contains relative statistical error of a breakup probabilities P_{br} and column ΔP_{br} shows relative change of P_{br} in comparison with analysis fulfilled in assumption that all hadrons are pions.

Table 1: Atomic pair numbers and breakup probabilities with F ($Q_X < 4, Q_Y < 4$ MeV/c) for different assumed admixtures

F	K^+K^- %	$p\bar{p}$ %	N_a	P_{br}	$\delta_{P_{br}}$ %	ΔP_{br} %
1.0	0.00	0.00	1188. ± 97.	0.3975 ± 0.0446	11.23	0.00
1.0	1.00	0.00	1179. ± 97.	0.3938 ± 0.0446	11.32	-0.94
1.0	2.00	0.00	1168. ± 97.	0.3892 ± 0.0444	11.42	-2.09
1.0	0.00	1.00	1170. ± 97.	0.3899 ± 0.0444	11.40	-1.93
2.0	0.00	0.00	3571. ± 240.	0.3526 ± 0.0286	8.10	0.00
2.0	1.00	0.00	3507. ± 241.	0.3457 ± 0.0285	8.25	-1.96
2.0	2.00	0.00	3445. ± 241.	0.3391 ± 0.0285	8.40	-3.81
2.0	0.00	1.00	3447. ± 241.	0.3389 ± 0.0284	8.39	-3.88
2.5	0.00	0.00	4556. ± 322.	0.3758 ± 0.0311	8.28	0.00
2.5	1.00	0.00	4450. ± 323.	0.3667 ± 0.0311	8.48	-2.42
2.5	2.00	0.00	4348. ± 324.	0.3580 ± 0.0311	8.68	-4.75
2.5	0.00	1.00	4351. ± 324.	0.3577 ± 0.0310	8.67	-4.82
3.0	0.00	0.00	5082. ± 413.	0.3822 ± 0.0354	9.27	0.00
3.0	1.00	0.00	4920. ± 414.	0.3699 ± 0.0354	9.57	-3.21
3.0	2.00	0.00	4756. ± 416.	0.3574 ± 0.0354	9.90	-6.50
3.0	0.00	1.00	4771. ± 416.	0.3580 ± 0.0353	9.87	-6.34
4.0	0.00	0.00	5312. ± 614.	0.3757 ± 0.0475	12.65	0.00
4.0	1.00	0.00	5014. ± 617.	0.3549 ± 0.0475	13.40	-5.54
4.0	2.00	0.00	4702. ± 621.	0.3329 ± 0.0476	14.29	-11.40
4.0	0.00	1.00	4740. ± 620.	0.3350 ± 0.0475	14.17	-10.83

Data were also analyzed with Q and Q_L. Results are presented in Tables 2, 3, 4.

It is seen that even small admixtures of K^+K^- and $p\overline{p}$ pairs induce essential change in breakup probability.

2 Estimation of K^+K^- and $p\overline{p}$ pair admixture

Fraction of K^+K^- pairs was estimated with simulation. Samples K^+K^- and $\pi^+\pi^-$ pairs were generated by FRITIOF 6.0 and propagated through DIRAC setup with GEANT-DIRAC code. Finally MC data was processed by ARIANE. Criteria $Q_X < 4$ MeV/c, $Q_Y < 4$ MeV/c and $Q_L < 22$ MeV/c (pion mass was assumed) were applied to events. Ratio (in %) of K^+K^- pair distribution to $\pi^+\pi^-$ pair distribution over total pair momentum $P_{\pi^+\pi^-}$ is shown in Fig. 1a. This ratio growths with momentum. One of the reasons is decay probability of kaons which decreases for high momenta. Figs. 1b,c show ratios of distributions over Q and Q_L. Coulomb factor for creation of this picture was set to 1 in order to simplify shape of distributions over Q and Q_L. Small deep near 0 in Fig. 1b occurred due to more hard spectrum of K^+K^- pairs. As result these pairs with small Q_T had lower efficiency to be detected due to problems with detection of close pairs by ScFi detector.

Fraction of $p\overline{p}$ pairs was estimated from experimental data collected in 2001 with the nickel target. Runs from 3843 to 4301 were used (about 50% of data). Events were processed by ARIANE in assumption that all hadron were protons or antiprotons. Fig. 2a presents time-of-flight of negative particles from upstream detector (2 planes of ScFi and not less than 2 planes of DeDx had signals) to the vertical horoscope. Time expected for antiprotons corresponds to 0. Program applied criterion on absence of hit in vicinity to selected tracks and cuts on momenta of particles $1.4 < P_{h^-} < 1.5$ GeV/c, $2.2 < P_{h^+} < 3.$ GeV/c. It allows to reject partly background of $\pi^+\pi^-$ pairs using difference of time-of-flight of positive and negative particles from the target to the left and right arms of VH. This difference is practically 0 for pions in contradiction to $p\overline{p}$. Fig. 2b contains the similar distribution for pairs which was rejected by this criterion. It is seen that the last picture has much lower peak in the expected region $\Delta t = 0$. The difference of event numbers in regions $[-1, 1]$ ns of Figs. 2a,b allows to obtain a number of proton-antiproton pairs. In Figs. 3, 4 similar distribution of events with different momenta of negative particle are shown. Comparing estimated number of $p\overline{p}$ with a number of $\pi^+\pi^-$ pairs it is possible to find their ratio $R_{p\overline{p}}$ as function of antiproton momentum $P_{\overline{p}}$ (see Table 5).

In Fig. 5a ratio $R_{p\overline{p}}$ is presented for total pair momentum range $3.0 < P_{\pi^+\pi^-} < 8.4$. For calculation of this function at the first stage antiproton lab momentum was replaced by total par momentum with Eq. 2.

$$P_{\pi^+\pi^-} = 2P_{\overline{p}},\ R_{p\overline{p}}(P_{\pi^+\pi^-} > 4.2) = R_{p\overline{p}}(4.2) \tag{2}$$

Hear momentum is in GeV/c. At the second stage this ratio was convoluted with a rejection factor which described suppression of protons and antiprotons by ARIANE at the processing of $\pi^+\pi^-$ pairs. Spectrum of hadron pairs in DIRAC experiment is shown in Fig. 5b.

3 Change of "atomic" pair number and breakup probability due to estimated admixture of K^+K^- and $p\overline{p}$ pairs

Data collected in 2001 with the nickel target were processed in two way. The first one is analysis with approximation function built with accidentals. Influence of finite size corrections [1] was taken into account. For the second one approximation function was corrected by admixture of K^+K^- and $p\overline{p}$ pairs estimated in the previous section. Number of "atomic" pairs N_a and probability of breakup P_{br} are presented in Tables 6, 7, 8, 9. Columns ΔP_{br} contain relative change of P_{br} in comparison with analysis fulfilled in assumption that there is no admixture.

The same comparison was fulfilled for fit procedure which used a shape of "atomic" pair distribution (other conditions are as in the previous case). Tables 10, 11, 12, 13 contain results.

From these data it is seen that an admixture of K^+K^- and $p\overline{p}$ background changes a number of "atomic" pairs and probability of ionization. This effect is maximal for Q_L. Probably the reason is lower sensitivity to this specific distortion of distribution shape which most dangerous for small Q_L. Also effect increases for wider Q_T cut because of growth of background which is misidentified as extra "atomic" pairs.

Conclusions

From above it is possible to make several conclusions:

- Admixture of non-pion pairs should be to take into account during analysis if masses of oppositely charged particles are equal which produces Coulomb peak in the same place as for $\pi^+\pi^-$ pairs.
- Uncertainty in admixture of non-pion pairs induces systematic error. In our case fraction of K^+K^- pairs was obtained with simulation only and was not carefully checked with an experimental data. In this situation it is reasonable to assume that the error equals to the value of effect. Admixture of protons is obtained experimentally but only for one half of $\pi^+\pi^-$ pair statistic. Therefore systematical error is at least 50%. Finally it is possible to suppose that systematic error is ~ 80 % of breakup probability change due to taking into account of K^+K^- and $p\overline{p}$ pair admixture.
- In order to decrease this systematic error it is needed to verify fraction of K^+K^- and $p\overline{p}$ pair admixture with an experimental data available in literature or with dedicated measurements in the of DIRAC experiment itself.

[1] R. Lednicky, E-Mail to DIRAC Collaboration on 1 Nov 2005.

Table 2: Atomic pair numbers and breakup probabilities with Q ($Q_T < 4$ MeV/c) for different assumed admixtures

Q	K^+K^- %	$p\overline{p}$ %	N_a	P_{br}	$\delta_{P_{br}}$ %	ΔP_{br} %
1.0	0.00	0.00	1428. ± 122.	0.3615 ± 0.0407	11.26	0.00
1.0	1.00	0.00	1407. ± 122.	0.3542 ± 0.0405	11.43	-2.01
1.0	2.00	0.00	1382. ± 123.	0.3459 ± 0.0402	11.63	-4.31
1.0	0.00	1.00	1388. ± 123.	0.3477 ± 0.0403	11.58	-3.82
2.0	0.00	0.00	3689. ± 322.	0.3364 ± 0.0348	10.35	0.00
2.0	1.00	0.00	3570. ± 324.	0.3242 ± 0.0347	10.70	-3.62
2.0	2.00	0.00	3449. ± 326.	0.3118 ± 0.0345	11.07	-7.30
2.0	0.00	1.00	3469. ± 325.	0.3136 ± 0.0345	11.01	-6.78
2.5	0.00	0.00	4140. ± 454.	0.3239 ± 0.0405	12.51	0.00
2.5	1.00	0.00	3948. ± 457.	0.3077 ± 0.0404	13.12	-4.99
2.5	2.00	0.00	3753. ± 460.	0.2915 ± 0.0402	13.80	-10.00
2.5	0.00	1.00	3783. ± 459.	0.2936 ± 0.0402	13.70	-9.34
3.0	0.00	0.00	4668. ± 601.	0.3413 ± 0.0491	14.40	0.00
3.0	1.00	0.00	4381. ± 605.	0.3193 ± 0.0490	15.34	-6.42
3.0	2.00	0.00	4089. ± 610.	0.2970 ± 0.0488	16.44	-12.97
3.0	0.00	1.00	4138. ± 609.	0.3004 ± 0.0488	16.24	-11.96
4.0	0.00	0.00	4733. ± 934.	0.3300 ± 0.0701	21.23	0.00
4.0	1.00	0.00	4228. ± 942.	0.2942 ± 0.0699	23.77	-10.84
4.0	2.00	0.00	3703. ± 949.	0.2570 ± 0.0698	27.15	-22.11
4.0	0.00	1.00	3800. ± 948.	0.2635 ± 0.0697	26.45	-20.15

Table 3: Atomic pair numbers and breakup probabilities with Q_L ($Q_T < 4$ MeV/c) for different assumed admixtures.

Q_L	K^+K^- %	$p\overline{p}$ %	N_a	P_{br}	$\delta_{P_{br}}$ %	ΔP_{br} %
0.5	0.00	0.00	3812. ± 286.	0.4247 ± 0.0371	8.74	0.00
0.5	1.00	0.00	3549. ± 289.	0.3913 ± 0.0368	9.39	-7.84
0.5	2.00	0.00	3290. ± 292.	0.3593 ± 0.0364	10.13	-15.38
0.5	0.00	1.00	3284. ± 292.	0.3579 ± 0.0363	10.15	-15.73
1.0	0.00	0.00	5337. ± 448.	0.4136 ± 0.0398	9.63	0.00
1.0	1.00	0.00	4905. ± 453.	0.3771 ± 0.0395	10.48	-8.81
1.0	2.00	0.00	4465. ± 459.	0.3405 ± 0.0392	11.51	-17.67
1.0	0.00	1.00	4499. ± 458.	0.3428 ± 0.0392	11.42	-17.12
1.5	0.00	0.00	5952. ± 577.	0.4321 ± 0.0472	10.94	0.00
1.5	1.00	0.00	5426. ± 584.	0.3914 ± 0.0470	12.00	-9.41
1.5	2.00	0.00	4892. ± 590.	0.3506 ± 0.0467	13.31	-18.85
1.5	0.00	1.00	4964. ± 589.	0.3556 ± 0.0466	13.11	-17.70
2.0	0.00	0.00	6011. ± 685.	0.4298 ± 0.0543	12.64	0.00
2.0	1.00	0.00	5439. ± 692.	0.3870 ± 0.0540	13.97	-9.96
2.0	2.00	0.00	4860. ± 699.	0.3441 ± 0.0538	15.63	-19.95
2.0	0.00	1.00	4957. ± 698.	0.3508 ± 0.0537	15.32	-18.39

Table 4: Atomic pair numbers and breakup probabilities with Q_L ($Q_T < 3$ MeV/c) for different assumed admixtures.

Q_L	K^+K^- %	$\mathrm{p\overline{p}}$ %	N_a	P_{br}	$\delta_{\mathsf{P}_{\mathsf{br}}}$ %	$\Delta\mathsf{P}_{\mathsf{br}}$ %
0.5	0.00	0.00	3822. ± 250.	0.4507 ± 0.0369	8.19	0.00
0.5	1.00	0.00	3644. ± 253.	0.4250 ± 0.0365	8.59	-5.71
0.5	2.00	0.00	3473. ± 256.	0.4007 ± 0.0361	9.02	-11.10
0.5	0.00	1.00	3482. ± 255.	0.4015 ± 0.0361	9.00	-10.92
1.0	0.00	0.00	5337. ± 393.	0.4361 ± 0.0391	8.97	0.00
1.0	1.00	0.00	5046. ± 397.	0.4086 ± 0.0388	9.49	-6.31
1.0	2.00	0.00	4756. ± 402.	0.3816 ± 0.0384	10.07	-12.50
1.0	0.00	1.00	4799. ± 401.	0.3852 ± 0.0384	9.98	-11.67
1.5	0.00	0.00	5771. ± 504.	0.4402 ± 0.0455	10.33	0.00
1.5	1.00	0.00	5427. ± 509.	0.4110 ± 0.0452	10.99	-6.63
1.5	2.00	0.00	5079. ± 515.	0.3819 ± 0.0448	11.74	-13.24
1.5	0.00	1.00	5152. ± 514.	0.3876 ± 0.0449	11.57	-11.95
2.0	0.00	0.00	5724. ± 594.	0.4292 ± 0.0514	11.97	0.00
2.0	1.00	0.00	5360. ± 600.	0.3997 ± 0.0511	12.79	-6.88
2.0	2.00	0.00	4986. ± 606.	0.3696 ± 0.0508	13.75	-13.89
2.0	0.00	1.00	5078. ± 605.	0.3767 ± 0.0508	13.50	-12.25

Table 5: Ratio of $\mathrm{p\overline{p}}$ pair distribution to $\pi^+\pi^-$ pair as function of $P_{\overline{\mathrm{p}}}$

$P_{\overline{\mathrm{p}}}$	$R_{\mathrm{p\overline{p}}}$ %
$1.4 \div 1.5$	0.028 ± 0.009
$1.5 \div 1.6$	0.069 ± 0.010
$1.6 \div 1.7$	0.143 ± 0.011
$1.7 \div 1.8$	0.130 ± 0.013
$1.8 \div 1.9$	0.195 ± 0.016
$1.9 \div 2.0$	0.216 ± 0.020
$2.0 \div 2.1$	0.212 ± 0.028

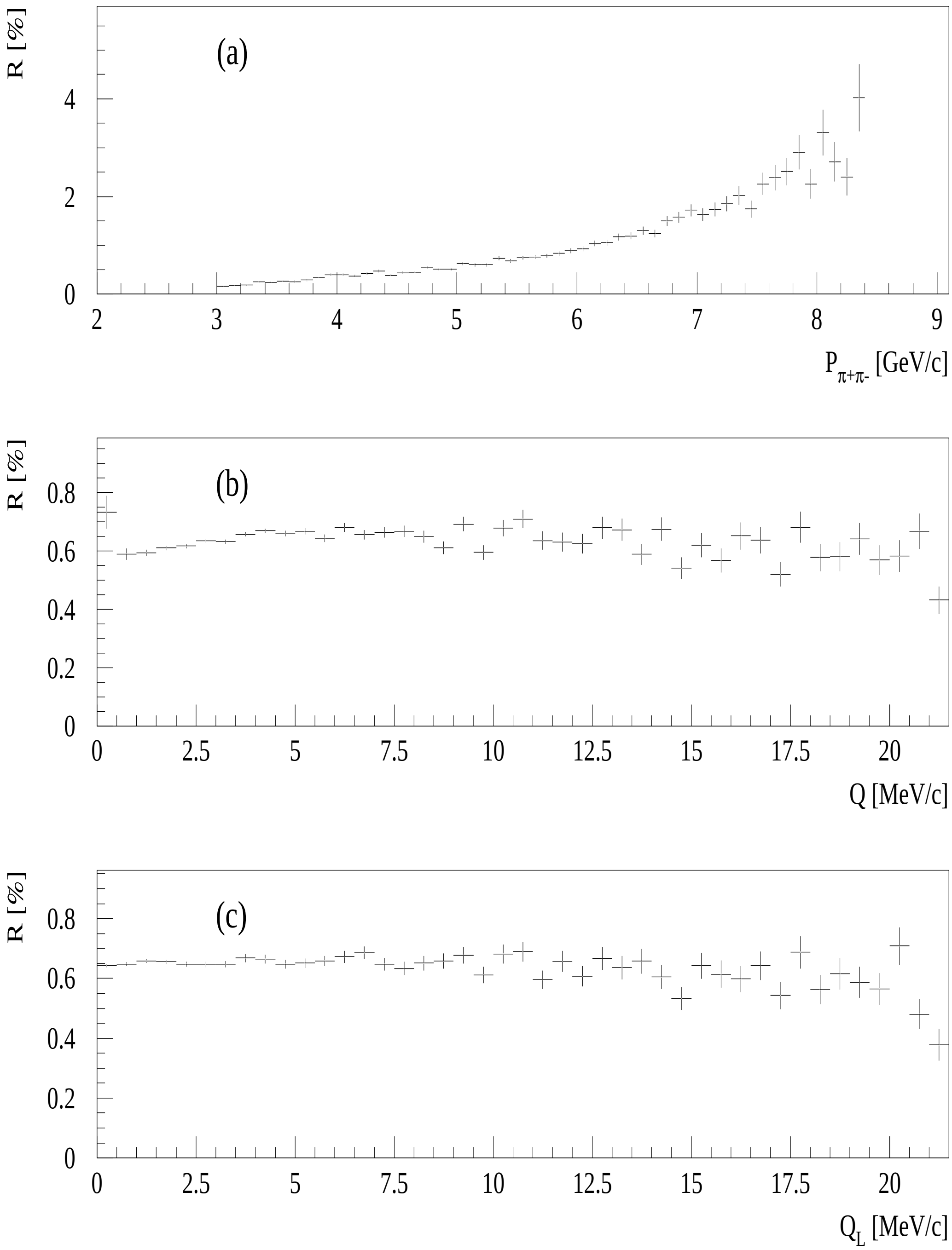

Figure 1: Ratio (in %) of K^+K^- pair distribution to $\pi^+\pi^-$ pair distribution as function of $P_{\pi^+\pi^-}$ (a), Q (b) and Q_L (c)

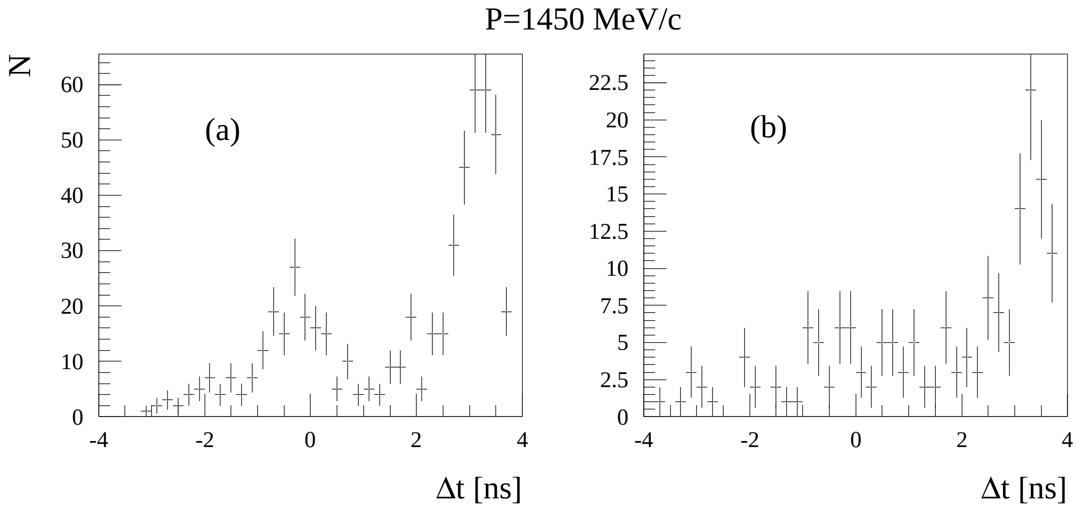

Figure 2: Distribution over time-of-flight of negative particles from upstream detector to the vertical horoscope: (a) pairs expected to be $p\overline{p}$; (b) accidentals. Time-of-flight of antiprotons corresponds to 0. Lab momentum of particles is in range $1.4 < P_{h^-} < 1.5$ GeV/c

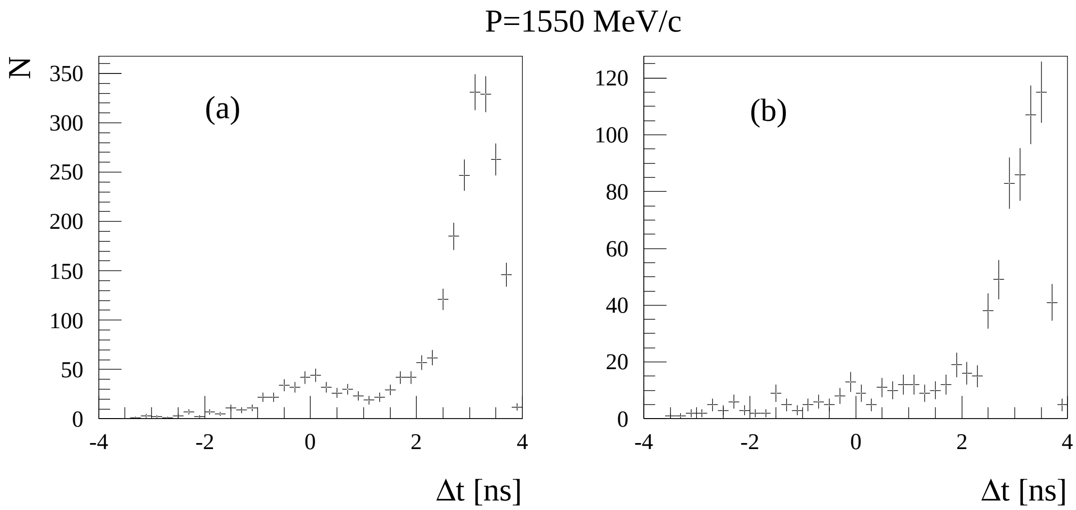

Figure 3: Distribution over time-of-flight of negative particles from upstream detector to the vertical horoscope: (a) pairs expected to be $p\overline{p}$; (b) accidentals. Time-of-flight of antiprotons corresponds to 0. Lab momentum of particles is in range $1.5 < P_{h^-} < 1.6$ GeV/c

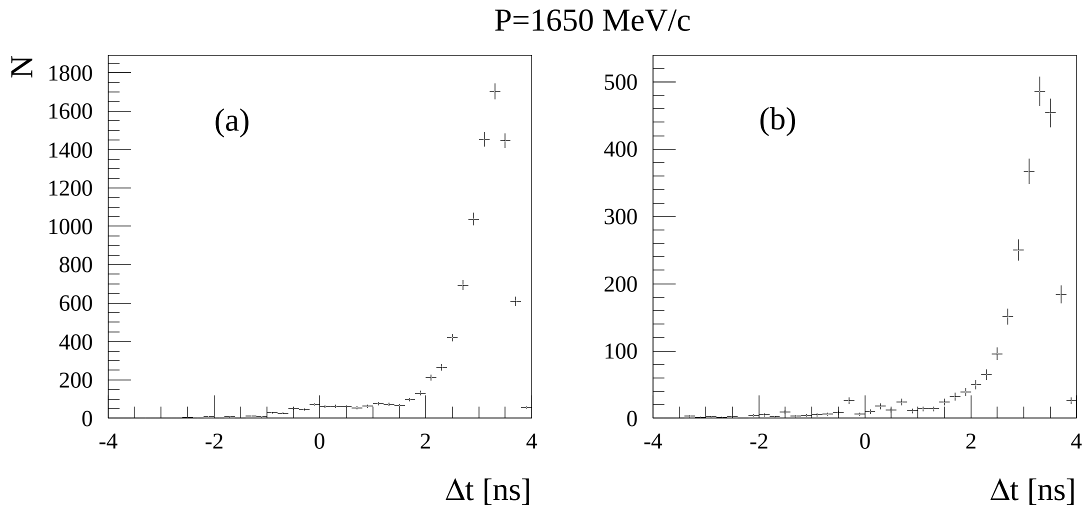

Figure 4: Distribution over time-of-flight of negative particles from upstream detector to the vertical horoscope: (a) pairs expected to be $p\overline{p}$; (b) accidentals. Time-of-flight of antiprotons corresponds to 0. Lab momentum of particles is in range $1.5 < P_{h^-} < 1.6$ GeV/c

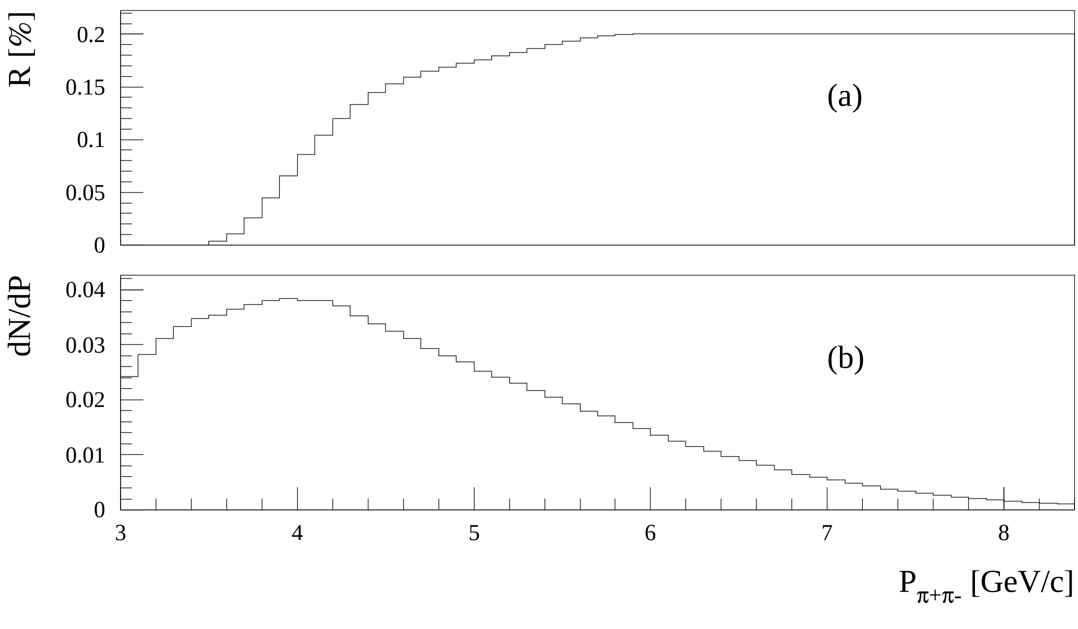

Figure 5: (a) Ratio (in %) of $p\overline{p}$ pair distribution to $\pi^+\pi^-$ pair distribution as function of $P_{\pi^+\pi^-}$. (b) Distribution of $\pi^+\pi^-$ pairs over $P_{\pi^+\pi^-}$

Table 6: Atomic pair numbers and breakup probabilities with F ($Q_X < 4, Q_Y < 4$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$

F	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
1.0	No	1178. ± 97.	0.3906 ± 0.0442	0.0
1.0	Yes	1172. ± 97.	0.3959 ± 0.0450	1.4
2.0	No	3516. ± 241.	0.3434 ± 0.0283	0.0
2.0	Yes	3487. ± 241.	0.3468 ± 0.0288	1.0
2.5	No	4471. ± 323.	0.3651 ± 0.0308	0.0
2.5	Yes	4418. ± 323.	0.3674 ± 0.0314	0.6
3.0	No	4965. ± 414.	0.3704 ± 0.0351	0.0
3.0	Yes	4875. ± 415.	0.3704 ± 0.0358	0.0
4.0	No	5142. ± 616.	0.3609 ± 0.0472	0.0
4.0	Yes	4929. ± 618.	0.3524 ± 0.0480	-2.4

Table 7: Atomic pair numbers and breakup probabilities with Q ($Q_T < 4$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$

Q	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
1.0	No	1411. ± 122.	0.3527 ± 0.0402	0.0
1.0	Yes	1395. ± 122.	0.3533 ± 0.0407	0.2
2.0	No	3603. ± 323.	0.3249 ± 0.0344	0.0
2.0	Yes	3526. ± 324.	0.3221 ± 0.0349	-0.9
2.5	No	4010. ± 456.	0.3105 ± 0.0401	0.0
2.5	Yes	3878. ± 458.	0.3043 ± 0.0407	-2.0
3.0	No	4494. ± 604.	0.3257 ± 0.0487	0.0
3.0	Yes	4290. ± 607.	0.3151 ± 0.0494	-3.3
4.0	No	4488. ± 938.	0.3104 ± 0.0695	0.0
4.0	Yes	4073. ± 944.	0.2855 ± 0.0704	-8.0

Table 8: Atomic pair numbers and breakup probabilities with Q_L ($Q_T < 4$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$

Q_L	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
0.5	No	3756. ± 286.	0.4155 ± 0.0369	0.0
0.5	Yes	3492. ± 290.	0.3908 ± 0.0373	-5.9
1.0	No	5233. ± 449.	0.4025 ± 0.0395	0.0
1.0	Yes	4799. ± 454.	0.3734 ± 0.0400	-7.2
1.5	No	5813. ± 579.	0.4189 ± 0.0469	0.0
1.5	Yes	5301. ± 585.	0.3865 ± 0.0475	-7.7
2.0	No	5848. ± 687.	0.4151 ± 0.0539	0.0
2.0	Yes	5306. ± 694.	0.3809 ± 0.0545	-8.2

Table 9: Atomic pair numbers and breakup probabilities with Q_L ($Q_T < 3$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$

Q_L	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
0.5	No	3781. ± 251.	0.4424 ± 0.0367	0.0
0.5	Yes	3613. ± 253.	0.4271 ± 0.0370	-3.5
1.0	No	5261. ± 394.	0.4266 ± 0.0388	0.0
1.0	Yes	4993. ± 398.	0.4090 ± 0.0392	-4.1
1.5	No	5669. ± 505.	0.4295 ± 0.0452	0.0
1.5	Yes	5362. ± 510.	0.4104 ± 0.0456	-4.5
2.0	No	5607. ± 596.	0.4175 ± 0.0510	0.0
2.0	Yes	5286. ± 601.	0.3976 ± 0.0516	-4.8

Table 10: Atomic pair numbers and breakup probabilities with F ($Q_X < 4, Q_Y < 4$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$. Shape of "atomic" pair was used in fit

F	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
1.0	No	1084. ± 87.	0.3605 ± 0.0276	0.00
1.0	Yes	1079. ± 87.	0.3598 ± 0.0277	-0.19
2.0	No	3682. ± 269.	0.3605 ± 0.0277	0.00
2.0	Yes	3664. ± 269.	0.3602 ± 0.0278	-0.06
2.5	No	4449. ± 323.	0.3643 ± 0.0280	0.00
2.5	Yes	4428. ± 323.	0.3641 ± 0.0281	-0.03
3.0	No	4882. ± 354.	0.3652 ± 0.0281	0.00
3.0	Yes	4860. ± 354.	0.3652 ± 0.0282	-0.01
4.0	No	5223. ± 378.	0.3676 ± 0.0283	0.00
4.0	Yes	5199. ± 378.	0.3677 ± 0.0284	0.03

Table 11: Atomic pair numbers and breakup probabilities with Q ($Q_T < 4$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$. Shape of "atomic" pair was used in fit

Q	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
1.0	No	1317. ± 116.	0.3315 ± 0.0295	0.00
1.0	Yes	1312. ± 116.	0.3308 ± 0.0296	-0.20
2.0	No	3693. ± 311.	0.3353 ± 0.0299	0.00
2.0	Yes	3678. ± 311.	0.3352 ± 0.0300	-0.02
2.5	No	4314. ± 362.	0.3363 ± 0.0300	0.00
2.5	Yes	4296. ± 362.	0.3363 ± 0.0301	0.02
3.0	No	4643. ± 389.	0.3388 ± 0.0302	0.00
3.0	Yes	4624. ± 389.	0.3389 ± 0.0304	0.04
4.0	No	4902. ± 410.	0.3412 ± 0.0305	0.00
4.0	Yes	4882. ± 410.	0.3415 ± 0.0306	0.08

Table 12: Atomic pair numbers and breakup probabilities with Q_L ($Q_T < 4$ MeV/c) with and without assuming of admixtures of K^+K^- and $p\overline{p}$. Shape of "atomic" pair was used in fit

Q_L	K^+K^- and $p\overline{p}$	N_a	P_{br}	$\Delta_{P_{br}}$ %
0.5	No	3713. ± 288.	0.4106 ± 0.0346	0.00
0.5	Yes	3450. ± 289.	0.3785 ± 0.0343	-7.81
1.0	No	5319. ± 412.	0.4090 ± 0.0345	0.00
1.0	Yes	4943. ± 414.	0.3778 ± 0.0343	-7.63
1.5	No	5694. ± 441.	0.4103 ± 0.0346	0.00
1.5	Yes	5292. ± 443.	0.3798 ± 0.0345	-7.45
2.0	No	5780. ± 447.	0.4102 ± 0.0346	0.00
2.0	Yes	5372. ± 450.	0.3802 ± 0.0345	-7.30

Table 13: Atomic pair numbers and breakup probabilities with Q_L ($Q_T < 3$ MeV/c) with and without assuming of admixtures of K^+K^- and $\mathrm{p\overline{p}}$. Shape of "atomic" pair was used in fit

Q_L	K^+K^- and $\mathrm{p\overline{p}}$	N_a	$\mathrm{P_{br}}$	$\Delta_{\mathrm{P_{br}}}$ %
0.5	No	3801. ± 260.	0.4487 ± 0.0345	0.00
0.5	Yes	3634. ± 262.	0.4251 ± 0.0342	-5.27
1.0	No	5455. ± 372.	0.4462 ± 0.0343	0.00
1.0	Yes	5215. ± 374.	0.4236 ± 0.0341	-5.06
1.5	No	5843. ± 398.	0.4465 ± 0.0344	0.00
1.5	Yes	5586. ± 400.	0.4247 ± 0.0342	-4.88
2.0	No	5932. ± 404.	0.4456 ± 0.0343	0.00
2.0	Yes	5672. ± 406.	0.4245 ± 0.0342	-4.74