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Determination of the probability of accidental coincidence between machine background and collision events and fragmentation of electromagnetic showers

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ABSTRACT

By measuring the rate of clusters observed in an out-of-time window in events with a K_L-crash and 4 prompt photons, we have determined the probability of accidental coindence between machine background and collision events. Data and MC results are compared. Moreover, by fitting the observed rates of events with a K_L-crash and 3-6 prompt photons we have determined the probability of producing shower fragments.

1 Introduction

In the framework of the search for the rare decay $K_S \to 3\pi^0$, it is relevant to have a good understanding of the probability to have accidental overlap between machine background and collision events and of the probability to generate shower fragments. Moreover, since we look for six prompt clusters in the event, we are also interested on the case of "double fake" clusters i.e. on the contribution of two accidental clusters, two fragments or one accidental cluster and one fragment. In this note we have developed a technique to count these probabilities and then compared data and MC.

In the following we call prompt clusters the ones passing the acceptance requirement used in our search [1] i.e. neutral clusters with:

- an energy $E_{cl} > 7$ MeV;
- a production polar angle, θ_{cl}, satisfying $|cos(\theta_{cl})| < 0.915$;
- and a timing, T_{cl}, consistent with a particle coming from the origin, $T_{cl} - R_{cl}/c$, in within a time window, TW, of MIN(3.5$\times\sigma_T$, 2 ns).

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We recall that in this measurement, as well as in our search, we apply the recover-splitting procedure developed in other neutral analysis and described in [2]. Moreover, while comparing the rates between data and MC we have applied to the neutral clusters in the MC the data/MC efficiency correction determined with $e^+e^- \to \pi^+\pi^-\pi^0$ events. In App. A, a short description of this method, and of the corrections used in this analysis, is reported.

2 Determination of the probability of accidental overlap between machine background and collision events

The presence of an high rate of machine background, *dafbkg*, events during data taking makes close to unity the probability to find clusters from this background in accidental overlap with the collision events. For this reason, in the KLOE simulation hits from these events have been added to the simulated hits. The *dafbkg* events have been extracted from data by selecting $e^+e^- \to \gamma\gamma$ events and by subtracting the clusters connected to the main bulk of the collision. A new data stream, *bgg*, was created to contain for each run the background hits. The insertion in the MC was intended to follow the accidental rate run by run which was varying drastically along the running period. This is demonstrated

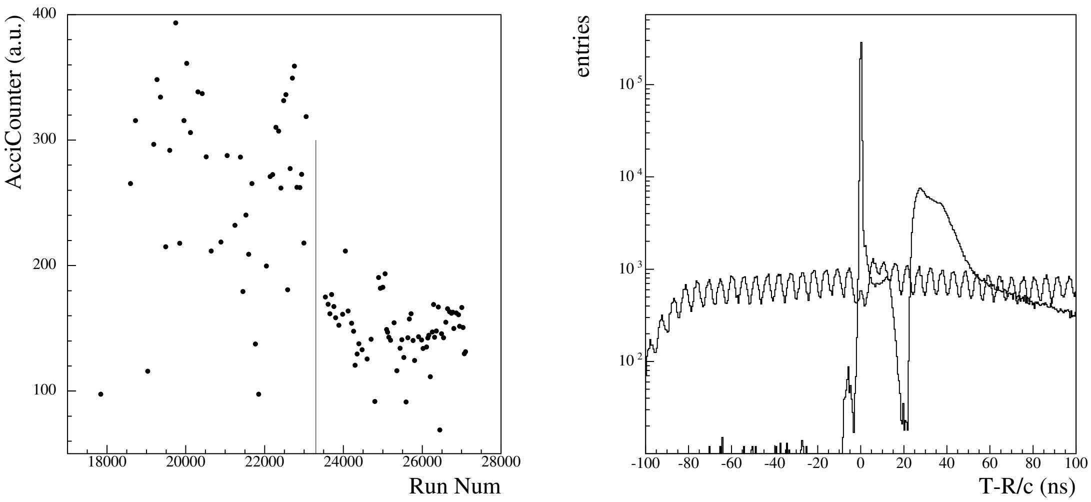

Figure 1: (Left) dependence of the online counter of *dafbkg* vs run number. (Right) distribution of T-R/C for events with a K_L-crash and 4 prompt photons in the MC: solid(dashed) line events without (with) *acci-clusters*.

by Fig. 1.left where the time-dependence of one of the online *dafbkg* counters is shown. A more detailed description of such a procedure can be found in ref. [3].

During the analysis of our (and other) samples there were hints that the rate of *bbg* events inserted was too high. We have therefore developed a new technique to determine the probability of accidental overlap of *dafbkg* with the collision events in different conditions i.e. without any requirement or after applying our acceptance requirements. This technique has been developed and calibrated with the simulation and then applied on data. Finally data and MC results were compared.

The background clusters inserted, *acci-clusters*, in the MC can be identified by looking at the value of the associated GEANT Kine number which has to be zero. We use the sample with a K_L-crash and $K_S \to 2\pi^0$ with 4 prompt photons, to calculate the accidental coincidence probabilities by measuring the rates in out-of-time windows. We have then used the samples with 5 and 6 prompt photons, to estimate how well we reproduce the probability of having one or two *acci-clusters* surviving the acceptance and prompt time-window requirements. In Fig. 1.right the distribution of $T - R/c$ for the *acci-clusters* (dashed line) and the other clusters (solid line) is shown. The *acci-clusters* are bunched with a period of $2 \times T_{RF}$[1], due to the way in which the bunch train were spaced during

[1] $T_{RF} = 2.715$ ns is the clock period in DAΦNE

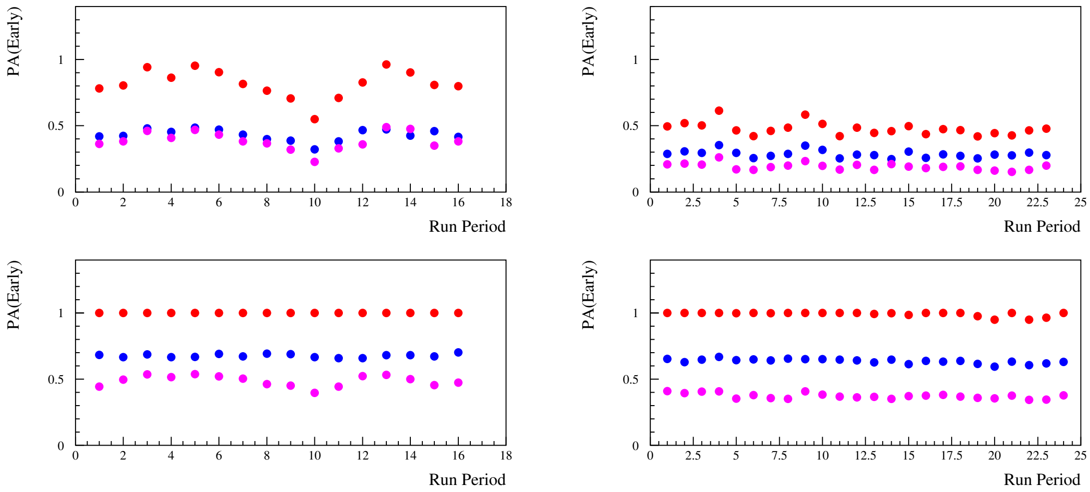

Figure 2: Dependence of the PA variables along running time for the 2001 (left) and 2002 (right) samples: (top) data, (bottom) simulation. In all cases red, blue and purple points represents $PA(\geq 1)$, $PA(1)$, $PA(\geq 2)$ respectively.

2001-2002 running period. The clusters from collisions show instead the expected peak around 0. A second large structure above 20 ns is due to the delaied clusters from the K_L-crash tag.

We start defining an early time window (ETW) as the one with $T - R/c$ in the range (-68,-14) ns which corresponds to integrate a temporal region, TDC_{early}, of 54 ns or, in other words, ten contiguous groups of background sources. We then count the events with at least one, $NA(\geq 1)$, one, $NA(1)$, or more than one, $NA(\geq 2)$, clusters in ETW. The time distribution in ETW is reasonably flat; assuming a constant distribution and a working TDC range, TDC_{wid}, of 190 ns we estimate the probability to get a given number of *acci-clusters* in the event as:

$$PA = (NA/N_{ev}) \times (TDC_{wid}/TDC_{early}), \tag{1}$$

where N_{ev} is the number of tagged $K_S \to 2\pi^0$ events with $N_\gamma = 4$. This formula exceeds the value of 1 whenever there is a too high counting of clusters in the whole TDC range; when this happens we bound the result to one. In the left (right) plot of Fig. 2.top we show this probability vs the running period (each bin corresponds to 10 pb^{-1} of integrated luminosity) for the 2001 (2002) MC sample. In Figs. 2.bottom the same measurement is repeated also for the data samples. It is evident that the data-MC ratio of these probabilities is around 80% (50%) in 2001 (2002). Data show a dependence along

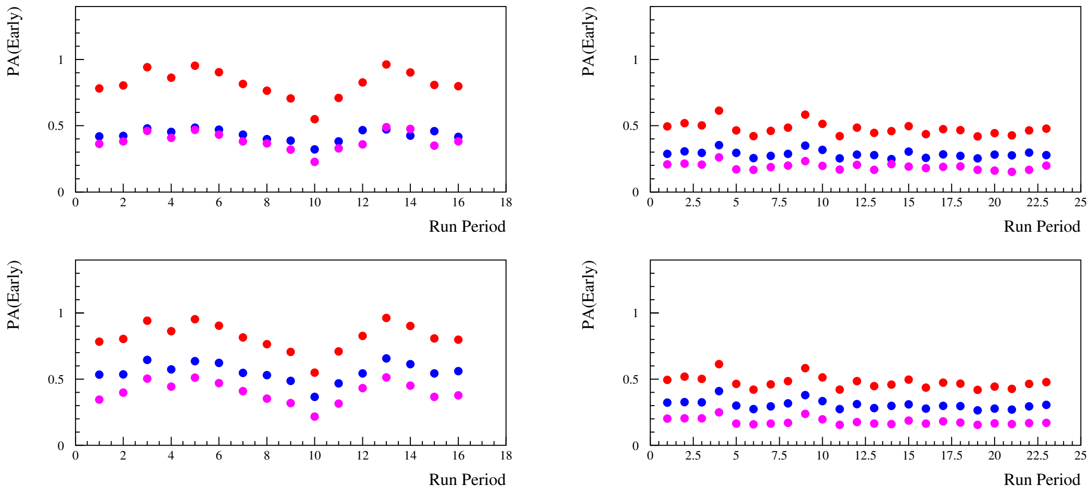

Figure 3: Dependence of the PA variables along running time for the 2001 (left) and 2002 (right) samples after correcting for R_{Acci} (see text): (top) data, (bottom) simulation. In all cases red, blue and purple points represent $PA(\geq 1)$, $PA(1)$, $PA(\geq 2)$ respectively.

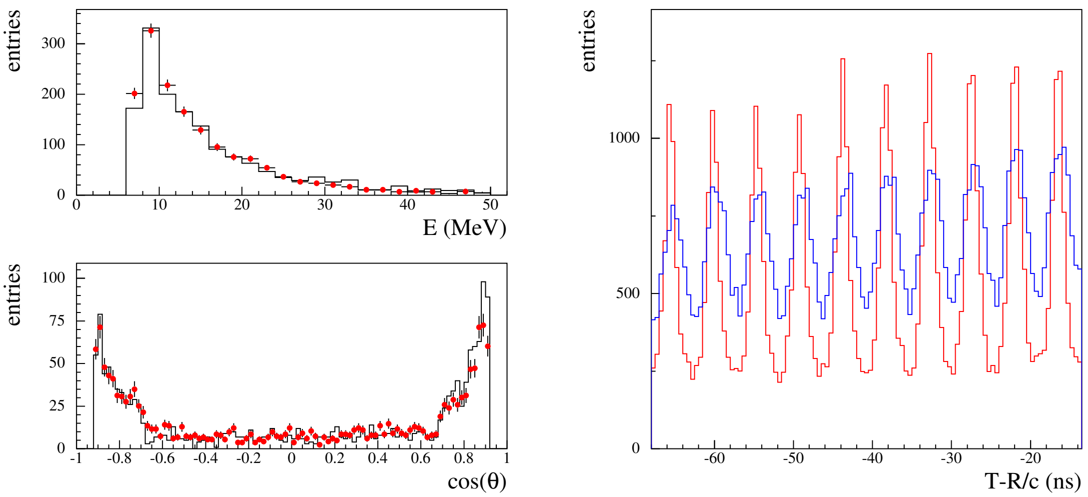

Figure 4: Comparison of properties of the clusters in ETW: (left-top) energy (left-bottom) angular distribution; black points data, solid line MC, (right) time distribution; red (blue) line data (MC).

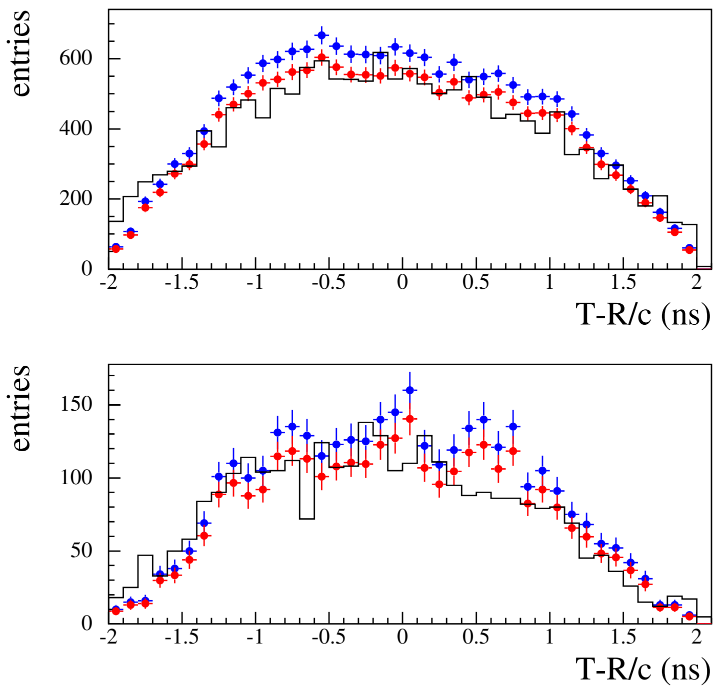

Figure 5: Time distribution in MC for the *acci-clusters* found in the "prompt" time window (black points) compared with expectations extrapolated from the ETW (solid-line): (Top) events with K_L-crash and 5 prompt photons, (Bottom) events with K_L-crash and 6 prompt photons.

the time which follows the one of Fig. 1.left while the simulation shows a flat dependence. Looking at the selection code for *bgg* events, we found the following software bug: *the events without any accidental hits were not stored in the files so corresponding to set the value of PA to 1.* The simplest correction is then to apply the measured data to MC ratio of $PA(\geq 1)$:

$$R_{Acci} = PA(\geq 1)(\mathrm{data})/PA(\geq 1)(\mathrm{MC}), \tag{2}$$

to all distributions. In Table 1, we show the determined correction as a function of run number. The previous plots are shown after applying this correction in Fig. 3.

Indeed, apart from the absolute value of the rate, the comparison of energy and angular distributions for the *acci-clusters* looks in excellent agreement as shown in Fig. 4. A slight data-MC difference is instead visible on the $T - R/c$ distribution (see Fig. 4) which are wider in MC than in data[2]. This width difference can originate some discrepancy while

[2]This is probably due to the fact that the collisions are bunched of T_{RF} in the MC (as expected for a whole filled DAΦNE machine) while in 2001-2002 data-taking collisions were happening each $2T_{rf}$.

RunMin	RunMax	R_{Acci}	δR_{Acci}	RunMin	RunMax	R_{Acci}	δR_{Acci}
17500.00	19059.00	0.782	0.035	23992.00	24173.00	0.614	0.028
19059.00	19385.00	0.804	0.035	24173.00	24317.00	0.466	0.023
19385.00	19782.00	0.941	0.041	24317.00	24445.00	0.421	0.021
19782.00	20191.00	0.862	0.037	24445.00	24649.00	0.461	0.023
20191.00	20492.00	0.953	0.040	24649.00	24874.00	0.485	0.024
20492.00	21061.00	0.903	0.039	24874.00	25005.00	0.583	0.027
21061.00	21390.00	0.815	0.035	25005.00	25120.00	0.514	0.025
21390.00	21592.00	0.764	0.033	25120.00	25261.00	0.422	0.022
21592.00	21801.00	0.706	0.031	25261.00	25387.00	0.485	0.024
21801.00	22099.00	0.549	0.026	25387.00	25502.00	0.449	0.023
22099.00	22245.00	0.710	0.032	25502.00	25637.00	0.460	0.023
22245.00	22459.00	0.825	0.036	25637.00	25764.00	0.504	0.024
22459.00	22626.00	0.962	0.041	25764.00	25940.00	0.436	0.022
22626.00	22812.00	0.901	0.053	25940.00	26024.00	0.473	0.024
22812.00	22981.00	0.807	0.045	26024.00	26133.00	0.465	0.024
22981.00	23123.00	0.798	0.046	26133.00	26206.00	0.431	0.023
				26206.00	26312.00	0.468	0.024
23500.00	23683.00	0.495	0.027	26312.00	26414.00	0.427	0.022
23683.00	23806.00	0.519	0.025	26414.00	26522.00	0.488	0.025
23806.00	23992.00	0.501	0.024	26522.00	26656.00	0.495	0.029

Table 1: Correction factors R_{Acci} for the 2001 and 2002 running periods. The blank row delimits the two periods.

comparing data and MC when applying the "prompt" time window requirement.

To determine the probability to find a given number of *acci-clusters* in the time window we change all times of the clusters in ETW of a global factor obtained re-phasing, in each event, the time of the first arriving clusters with $2T_{RF}$ as follows:

$$T_{new}(j) = T_{cl}(j) + \mathrm{NINT}(T_{cl}(1) - R_{cl}(1)/c, 2 \times T_{RF}) \times 2T_{RF} \tag{3}$$

where j runs from 1 to the number of clusters in ETW. We then apply the "prompt" time window requirement to the new timing $T_{new}(j)$ and count the number of *acci-clusters* in acceptance, $N_\gamma^{ext}(TW)$. The number of events with expected additional "prompt" clusters, $N_{ev}(N_\gamma^{ext}(TW) \geq 0)$, has then to be scaled of a factor 10 to correct for the width of the TDC_{early} window. In Fig. 5.top (.bottom) the time distribution of events with one (more than one) extrapolated clusters is compared, in the MC, with the same distribution

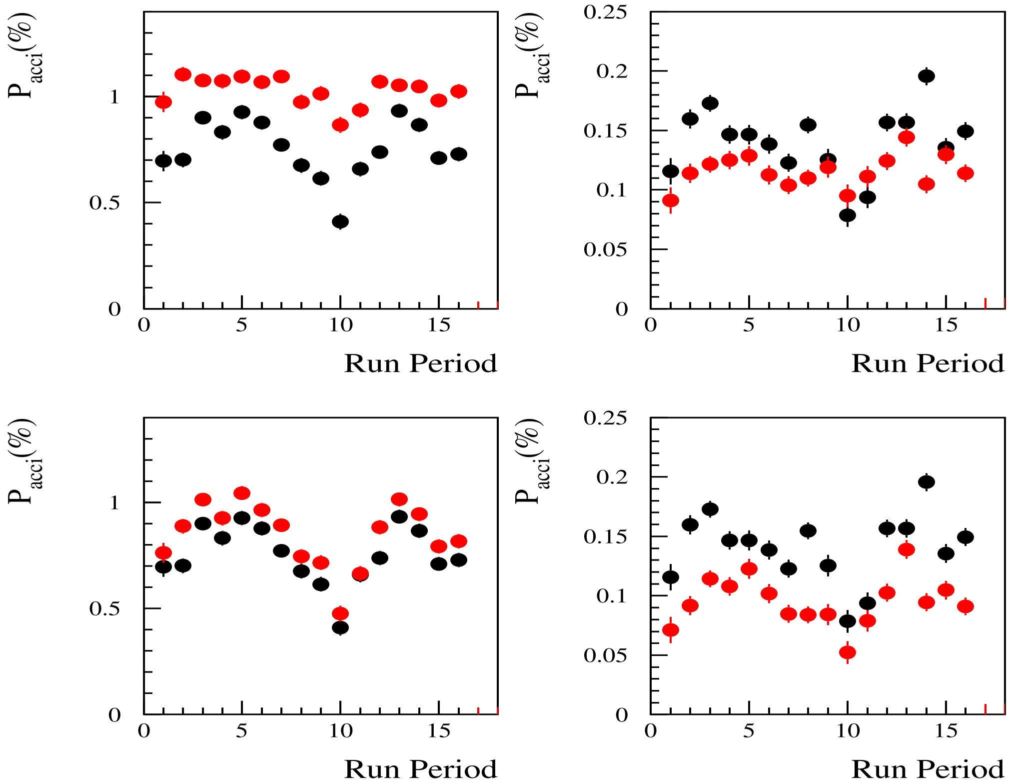

Figure 6: Dependence of the PA_{TW} variables along running time for the 2001 samples: (left) $PA_{TW}(1)$ (right) $PA_{TW}(\geq 2)$. Red (black) points represent MC (data). Top (bottom) plots without (with) application of the R_{Acci} correction (see text).

for events with one (more than one) "prompt" *acci-cluster* in $K_S \to 2\pi^0$ with five (six) prompt photons. The agreement between the number extrapolated from ETW and the one counted in the MC is at a level of 10-15%. The probability to find one or more than one *acci-cluster* in TW is then derived as:

$$PA_{TW}(ext)(1,2) = N_{ev}(N_{\gamma}^{ext} = 1,2)/N_{ev}, \tag{4}$$

In the left (right) top panels of Figs. 6, 7 the dependence of $PA_{TW}(1)(PA_{TW}(2))$ along the running time are reported for the 2001 and 2002 MC samples. Comparison with data is also shown. In the bottom panels of these figures, the same distributions are shown after the application of R_{Acci} correction. Concluding, we can state that we have developed a

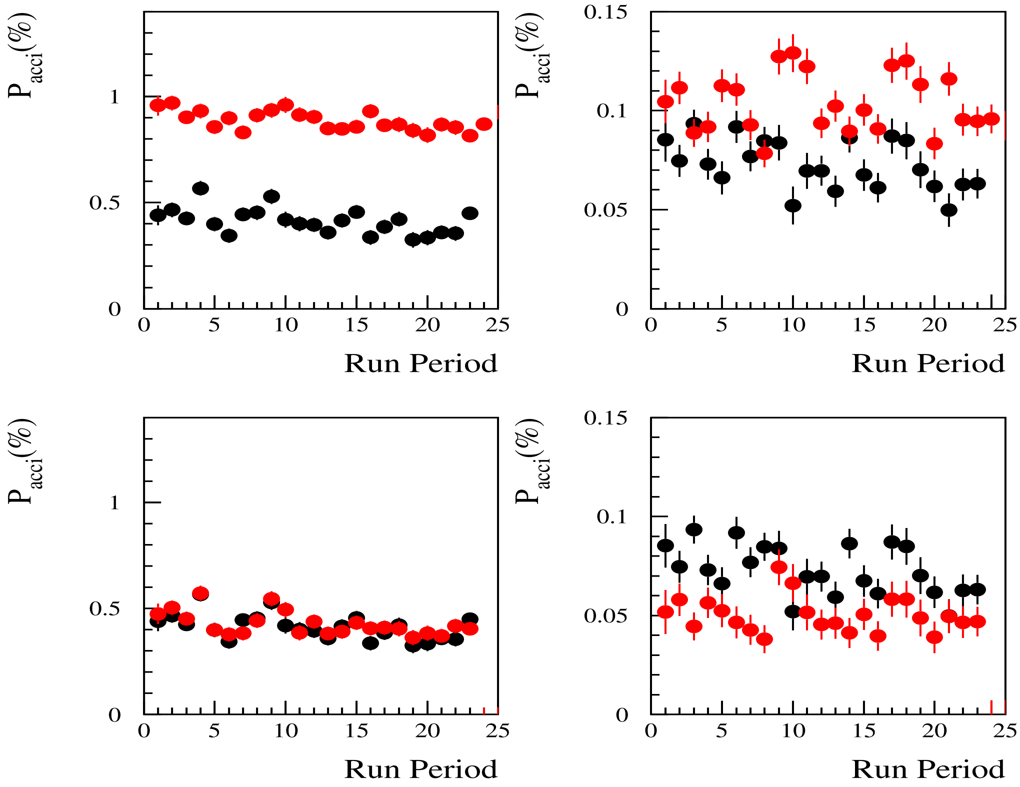

Figure 7: Dependence of the PA_{TW} variables along running time for the 2002 samples: (left) $PA_{TW}(1)$ (right) $PA_{TW}(\geq 2)$. Red (black) points MC (data). Top (bottom) plots without (with) application of the R_{Acci} correction (see text).

method to measure with 10% accuracy the probability of accidental coincidence between collision and *dafbkg* events. Moreover, by correcting for R_{Acci} the simulation, a good agreement is found between data and MC for the $PA_{TW}(1)$, similar conclusions cannot be drawn for the $PA_{TW}(2)$.

3 Determination of the probability of shower fragments

Apart from the *acci-clusters*, the other relevant source of "fake" clusters in the event is the fragmentation of the electromagnetic showers. We often refer to the fragments of the

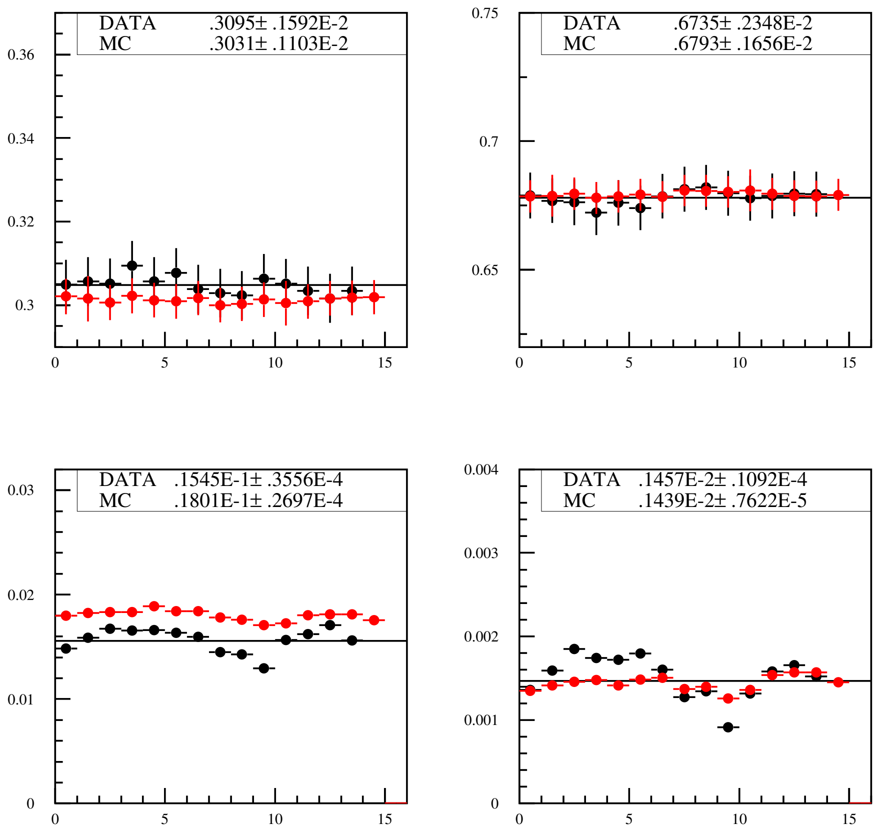

Figure 8: Distribution of $F(K)$ along the 2001 running period in bins of 10 pb^{-1}. For the simulation we use $\phi \to K_S K_L$ with $K_S \to 2\pi^0$ decays. K_L-crash tagged events with a given prompt photon multiplicity: (a) $N_\gamma = 3$, (b) $N_\gamma = 4$, (c) $N_\gamma = 5$, (d) $N_\gamma = 6$. Data (black points), Monte Carlo (red points). In the box the fitted values obtained with a constant are reported. The large errors shown on the $F(3)$, $F(4)$ fractions are due to the prescaling factors of 100 introduced in our selection algorithm.

clusters as *split-clusters*. In the following, we show the method developed to measure the fragmentation (splitting) probability. The technique has been developed and tested on MC and then applied on data. The method is reasonably general but the result found is obviously analysis dependent due to the acceptance requirements applied.

In each event, we determine in the MC the "true" number of reconstructed photons, n_γ, by counting prompt photons surviving the efficiency correction and ignoring both the *acci-clusters* and the *split-clusters*. To avoid counting these latest objects, we skip the

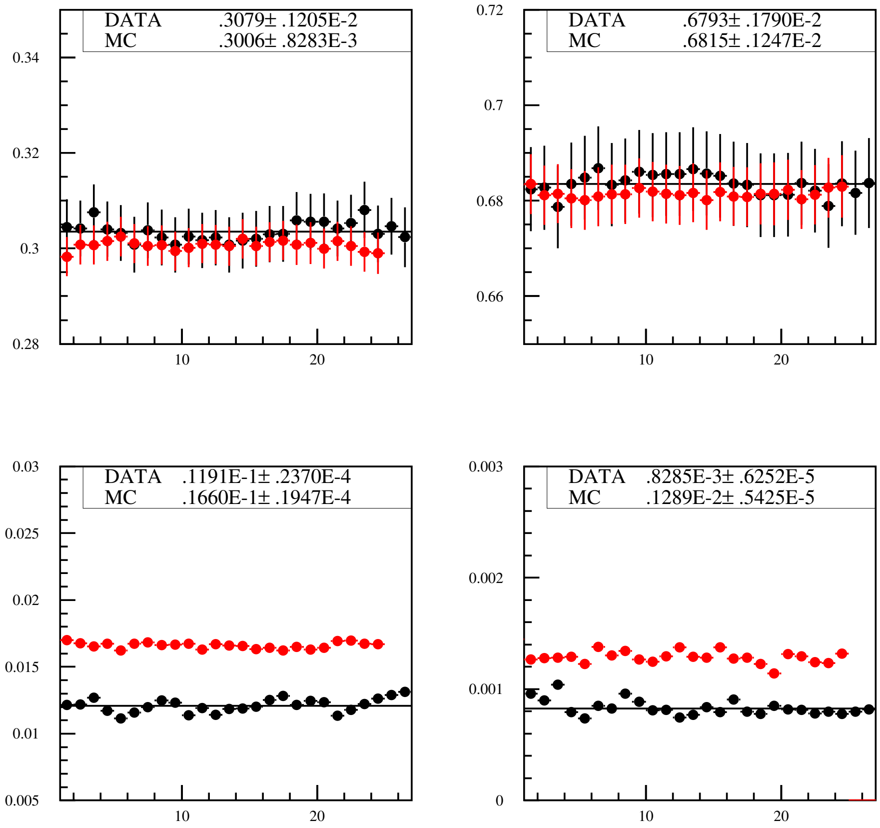

Figure 9: Distribution of $F(K)$ along the 2002 running period in bins of 10 pb^{-1}. For the simulation we use $\phi \to K_S K_L$ with $K_S \to 2\pi^0$ decays. K_L-crash tagged events with a given prompt photon multiplicity: (a) $N_\gamma = 3$, (b) $N_\gamma = 4$, (c) $N_\gamma = 5$, (d) $N_\gamma = 6$. Data (black points), Monte Carlo (red points). In the box the fitted values obtained with a constant are reported. The large errors shown on the $F(3)$, $F(4)$ fractions are due to the prescaling factors of 100 introduced in our selection algorithm.

showers showing a Kine number already appeared in the event. In the overall sample of $K_S \to 2\pi^0$ and a K_L-crash events, we then calculate the fractions with a given n_γ:

$$\begin{aligned} f2 &= N_{ev}(n_\gamma = 2)/N_{ev} \\ f3 &= N_{ev}(n_\gamma = 3)/N_{ev} \\ f4 &= N_{ev}(n_\gamma = 4)/N_{ev}, \end{aligned} \tag{5}$$

starting from this true fractions we then determine the fraction of observed prompt photons, n_γ, by correcting for the probabilities of having one/two *acci-clusters* or *split-clusters*. We call the corrected fractions $f2_{cor}$, $f3_{cor}$, $f4_{cor}$, $f5_{cor}$, $f6_{cor}$. To derive the f_{cor} we recall that the probability of having *acci-clusters* in the event is not a function of n_γ and we have only to use in a proper way the PA_{TW} defined in the previous paragraph. On the contrary, the probability to have *split-clusters* depends on n_γ in a complicated way. Let us define, for the obvious case of $n_\gamma = 1$:

$$\begin{aligned} PS0(1) &= 1 - PS1(1) - PS2(1) \\ PS1(1) &= \text{probability of generating one fragments} \qquad (6) \\ PS2(1) &= \text{probability of generating two fragments,} \end{aligned}$$

(7)

to determine the probability to have none, one or more than one *split-clusters* from n_γ clusters a recursive formula is obtained as follows:

$$\begin{aligned} PS0(n_\gamma) &= PS0(1)^{n_\gamma} \\ PS1(n_\gamma) &= n_\gamma \times (PS1(1) \times PS0(1)^{n_\gamma - 1}) \qquad (8) \\ PS2(n_\gamma) &= n_\gamma \times PS2(1) \times PS0(1)^{n_\gamma - 1} + \frac{n_\gamma!}{2!(n_\gamma - 2)!} PS1(1)^2 \times PS0(1)^{n_\gamma - 2} \end{aligned}$$

(9)

given the small values of $PS3(1)$ we did not propagate this term in the formulae. Once we have determined these composed probabilities, we estimate the corrected fractions starting from the MC ones as:

$$\begin{aligned} f2_{cor} &= f2 \times PA_{TW}(0) \times PS0(2) \\ f3_{cor} &= f3 \times PA_{TW}(0) \times PS0(3) + f2 \times (PA_{TW}(1) + PS1(2)) \\ f4_{cor} &= f4 \times PA_{TW}(0) \times PS0(4) + f3 \times (PA_{TW}(1) + PS1(3)) \\ &\quad + f2 \times (PA_{TW}(2) + PS2(2)) \qquad (10) \\ f5_{cor} &= f4 \times (PA_{TW}(1) + PS1(4)) + f3 \times (PA_{TW}(2) + PS2(3)) \\ f6_{cor} &= f4 \times (PA_{TW}(2) + PS2(4) \end{aligned}$$

(11)

To determine the value $PS1(1), PS2(1)$ we assumed the PA_{TW} previously measured and we fit the reduced observed fractions by minimizing the χ^2_{frac} variable. We start defining the measured (expected) reduced observed fraction $F(k)$ ($F_{exp}(k)$), with k ranging from 3 to 6, as:

$$\begin{aligned} F(k) &= N_{ev}(N_\gamma = k) / \sum N_{ev}(N_\gamma = j) \\ F_{exp}(k) &= f''k''_{cor} / (f3_{cor} + f4_{cor} + f5_{cor} + f6_{cor}) \end{aligned}$$

(12)

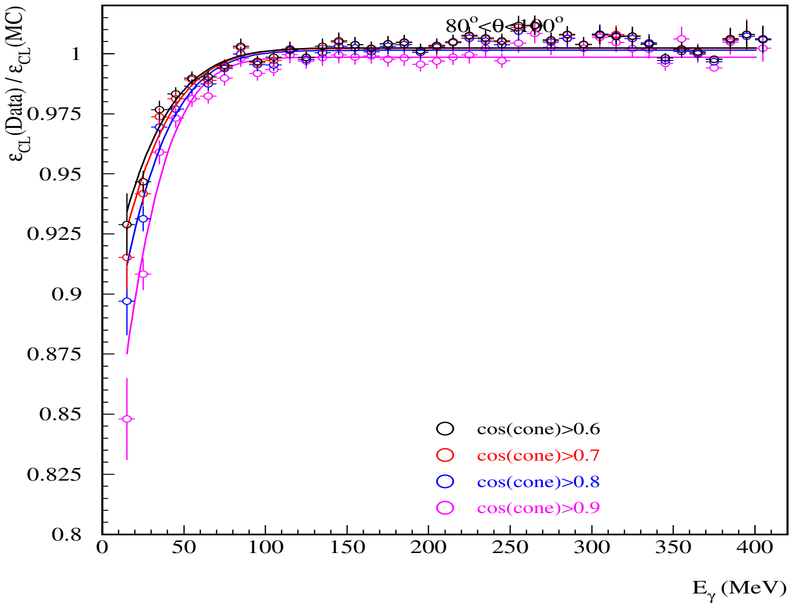

Figure 10: Data/MC ratio for the ε_γ obtained with a sample of $e^+e^- \rightarrow \pi^+\pi^-\pi^0$ events for tagged photons with θ between 80°-100°. The different colors represent results obtained for different values of the association cone.

and we avoided considering the bin $N_\gamma = 2$ since in data we should then take into account also some background contamination. The χ^2_{frac} is defined as follows:

$$\chi^2_{frac} = \sum(F(k) - F_{exp}(k))^2/\Delta F(k)^2 \ . \tag{13}$$

In Figs. 8, 9 we report the $F(k)$ values measured in 2001 and 2002 samples for data and MC. The dependence along the time of these rates follows the average values of PA_{TW}. The average values of these quantities and their errors, summarized in Tab. 2, have been used for the fit. For the error of the $F(3)$, $F(4)$ in the data we add in quadrature a small error (0.3% in 2001, 0.2% in 2002) to take into account a residual background contamination . The determined values of $PS1(1), PS2(1)$ for the different samples,

sample	F(3) (%)	F(4) (%)	F(5) (10^{-3})	F(6) (10^{-3})
mc 2001 (value)	(30.31 $\pm$ 0.11)	(67.93 $\pm$ 0.17)	(18.01 $\pm$ 0.27)	(1.44 $\pm$ 0.07)
mc 2001 (fit)	30.35	67.71	18.00	1.40
data 2001 (value)	(30.95 $\pm$ 0.16)	(67.35 $\pm$ 0.23)	(15.45 $\pm$ 0.35)	(1.46 $\pm$ 0.10)
data 2001 (fit)	30.44	67.86	15.50	1.50
mc 2002 (value)	(30.06 $\pm$ 0.12)	(68.15 $\pm$ 0.12)	(16.60 $\pm$ 0.20)	(1.29 $\pm$ 0.05)
mc 2002 (fit)	30.40	67.80	16.60	1.30
data 2002 (value)	(30.79 $\pm$ 0.12)	(67.93 $\pm$ 0.18)	(11.91 $\pm$ 0.24)	(0.82 $\pm$ 0.06)
data 2002 (fit)	30.59	68.13	11.90	0.80

Table 2: Measured values of $F(K)$ for different photon multiplicity and data and Monte Carlo samples. Results of the fitted $F(K)$ values are also shown.

sample	$PA_{TW}(1)$	$PA_{TW}(2)$	χ^2_{frac}	$PS1(1)10^{-3}$	$PS2(1)10^{-4}$	$\rho_{PS1-PS2}$
MC01	1.03 %	0.16 %	0.12	(3.80 $\pm$ 0.30)	(1.50 $\pm$ 0.30)	0.04
D01	0.75 %	0.14 %	2.16	(3.57 $\pm$ 0.20)	(1.50 $\pm$ 0.35)	0.05
MC02	0.89 %	0.10 %	1.21	(3.65 $\pm$ 0.20)	(1.72 $\pm$ 0.23)	-0.10
D02	0.38 %	0.07 %	0.48	(3.28 $\pm$ 0.10)	(0.88 $\pm$ 0.18)	-0.08

Table 3: Results of the fit to the measured $F(k)$ for the different data and MC samples. The "true" $f(k)$ values and the PA_{TW} measured with the early out-of-time method (reported in columns 2-3) are assumed for the fit. In the last four columns we report the χ^2_{frac}, $PS(1)$, $PS(2)$ and the correlation between $PS(1)$ and $PS(2)$ resulting from the fit.

together with the χ^2_{frac} value of the fit are shown in Tab. 3. To understand how the PA_{TW} values modify the results on $PS1(1)$, $PS2(1)$, we have varied them of $\pm 10\%$ and repeated the fit. The final errors on the splitting probabilities are shown in Tab. 3. The comparison between the measured $F(K)$ rate and the fitted value is reported in Tab. 2.

4 Conclusions

In this note we have measured, both for data and MC, the probability of having *acci-clusters* or *split-clusters* in a prompt time window. We observe up to a factor two discrepancy in the probability of counting accidental clusters between data and MC. The origin of such a discrepancy has been identified in a software bug in the selection procedure of *bgg* files. Moreover, we find that the probability of generating a single fragment is comparable between data and MC along the whole running period while the probability of generating two fragments lowers from 1.5×10^{-5} to 0.8×10^{-5} in the data from 2001 to 2002 running periods.

5 Acknowledgments

We thank T. Spadaro to provide us with the correction functions for the cluster efficiency.

A Evaluation of the cluster efficiency

For this calculation, a sample of $e^+e^- \rightarrow \pi^+\pi^-\pi^0$ events have been used with the aim of identify a cluster, from the π^0 decay, as a tagging photon. This allows us to look for a candidate photon and determine the reconstruction efficiency by counting the matching clusters. The selection cuts are briefly summarized below:

- A charged vertex from the interaction point with two opposite charges and with associated calorimeter "pion" clusters. The pion clusters are also required to satisfy the trigger to avoid any bias on the cluster energy of the tagging photon.
- A tight cut on the missing invariant mass around M_{π^0}. The missing mass is built using both pion track momenta and the ϕ energy and momentum estimated with Bhabha events.
- For each other cluster in the event, the momentum of the tagging photon is estimated, in the π^0 rest frame, by relying on the missing momentum, $\mathbf{P}_{MISS}$, measured by the chamber and on the cluster position, $\mathbf{R}_{cl}$. The boost parameters and the photon energy are calculated as:

$$\gamma = \sqrt{M_{\pi^0}^2 + |\mathbf{P}_{MISS}|^2} \tag{14}$$

$$\cos\alpha = \frac{\mathbf{R}_{cl}}{|\mathbf{R}_{cl}|} \cdot \frac{\mathbf{P}_{MISS}}{|\mathbf{P}_{MISS}|} \tag{15}$$

$$E_{DC} = 0.5\gamma \times M_{\pi^0} \frac{1 + \beta(-\beta + \cos\alpha)}{1 - \beta\cos\alpha} \tag{16}$$

  Since E_{dc} estimates the energy of the cluster with $\sim$ 1 MeV precision, parametrized function of energy and time resolution are used to construct a χ^2_γ-like variable for the selected cluster to check its consistency of coming from a π^0. Cutting on this χ^2_γ we get the tagging photons.

- The momentum of the candidate photon is then estimated as:

$$\mathbf{P}_\gamma = \mathbf{P}_{MISS} - E_{dc} \cdot \frac{\mathbf{R}_{cl}}{|\mathbf{R}_{cl}|} \tag{17}$$

A candidate cluster is then considered *matched*, if it is prompt and lies inside a cone centered around the estimated direction. Different widths of the opening angle of the cone, $\cos(\theta_{\gamma-clu})$, have been used. The reconstruction cluster efficiency has been calculated in 10-MeV bins of energy and $10°$ bins of polar angle of the candidate photon. For each energy-angular bin the photon efficiency is defined as:

$$\varepsilon_\gamma(E_\gamma, \theta_\gamma) = \mathrm{N_{ev}\ with\ match\ cluster/N_{ev}} \tag{18}$$

where N_{ev} is the number of events in the selected bin. This procedure has been applied both on data and MC samples. In Fig. 1 the data, MC ratio of such an efficiency, $\varepsilon^\gamma_{corr}$, is shown for θ_γ in the range $(80° - 90°)$ as a function of E_γ. The different colors represent the resulting curve when changing the width of the association cone from the default one, $|cos(\theta_{\gamma-clu})| > 0.8$ to 0.6, 0.7 and 0.9. A data, MC discrepancy from few $\%$ up to 10$\%$ exists in the energy range 10-80 MeV. This drop is probably due to the missing simulation of the signal shape and of the connected readout electronics (especially the discriminators).

The data-MC ratio of this efficiency has been applied on the MC simulation. The clusters connected to photons in the MC have been deleted of a proper amount according to this ratio. This has been done before running the recover splitting procedure.

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