DEAR Technical Note IR-36

Report on the run period DECEMBER 2000: Kaon Monitor

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1 Introduction

During the first DEAR runs on DAΦNE (December 1999) kaons were identified using a **time-of-flight** analysis which allowed to separate the slow charged kaons from the fast minimum ionizing background particles (*mips*) [1]. The amplitude analysis of signals was not implemented at that time, and hence the cross check allowing an unambiguos kaon identification (slower times *and* high amplitude pulses generated from scintillators due to the highly ionizing charged kaons) could not be performed.

In the second DEAR run period (September 2000), non only time analysis but also **amplitude analysis** of the pulses from the scintillators was simultaneously performed, and kaons were successfully identified in the TDC versus ADC spectra [2]. Having obtained a clean kaon identification, the determination of the integrated luminosity delivered by DAΦNE could be done [2]. These values, however, were obtained only in off-line analysis.

For the third DEAR runs period (December 2000), both hardware and software improvements were introduced in order to:

- acquire ADC and TDC spectra of all PMs of the monitor, so recording the full set of information;

- improve signal over background ratio by means of four new scintillator counters properly arranged to intercept the background *mips* and exclude them through anticoincidence;

- produce **on-line measurement of the DAΦNE luminosity** in the DEAR interaction point (IP2) and show this data continuously in a dedicated LNF web page.

This Note presents the experimental results of this last runs period in terms of data taking and analysis.

Section 2 recalls the experimental features of the kaon monitor and describes the above implementations, while in the 3rd Section the experimental results are presented. In Section 4 luminosity measurements in IP2 are reported. Section 5 contains conclusions and perspectives for the improvement of the kaon monitor performance.

2 The kaon monitor setup

The kaon monitor is made by two fast NE104 scintillators, 2 mm thick each. The scintillators are both 8 cm high and 15 cm long and are placed back-to-back on the two sides of the DEAR pipe, parallel to it and perpendicular to the horizontal plane, both at a distance from IP2 of 10 cm. This configuration takes advantage of the back-to-back topology of produced kaons to cut an important amount (factor of about 200) of background. Each scintillator is seen by two fast XP2020 phototubes [1].

In order to further reduce background particles, which mainly travel at grazing angles outside the pipe, four new scintillator counters were installed, in a $two + two$ configuration at the two sides of the beam pipe, before and after the interaction point, with the respective kaon monitor scintillators in between [2]. These additional counters can be hit by the background particles travelling sideway along the pipe, but not by kaons, which come only from IP2. Hence, the anticoincidence of the four new counters with the coincidence of the back-to-back thin scintillators of the kaon monitor provide much cleaner TDC and ADC spectra of the kaon signals. The four anticoincidence scintillators (NE102) have each a thickness of 1 cm, a heigth of 10 cm and a length of 8 cm, and are seen each by a Hamamatsu R1894 phototube, 1 cm diameter.

The analog signals from the anode of each phototube of the kaon monitor are split using a passive splitter: one output is sent to a CAMAC ADC (Lecroy 2249A) for amplitude analysis, the other one is sent to a Dual Constant Fraction and Mean Timer Module (CAEN Mod N253), in order to feed the fast logic electronics and obtain a timing as independent as possible both on pulse height and on the crossing point on the scintillator. This module releases also the constant fraction output of each PM pulse, which is sent to a CAMAC TDC (CAEN C414).

The logic of the trigger requires a coincidence between the two back-to-back scintillators of the monitor (charged kaons from ϕ decay at rest), each of them veto-cleaned by the OR of the two anticoincidence counters on the same side of the pipe.

The TDC and ADC distributions of each PM of the monitor, as well as the TDC distribution of the (veto-cleaned) coincidences between the two scintillators, are recorded. The machine RF signal, divided by 4 and reformed using an ORTEC (935 quad CFD) discriminator, provides the clock for the time measurements and is used as STOP for the TDC module. In order to reduce the rate (90 MHz) of this signal, the STOP is fed to the TDC only if gated by the (cleaned) coincidence between the kaon monitor scintillators.

3 Experimental results

The first period of the runs was dedicated to the optimization of the system performance of the new harwdare part of the setup, i.e. the four anticoincidence detectors, and to tune the new software handling all the TDC and ADC spectra and providing the luminosity on-line on web to users. The effect of applying the anticoincidence resulted in a reduction factor on average equal to 6 in the rate of background coincidences between the two kaon monitor scintillators.

Then, a systematic series of measurements could be performed in parallel with the DEAR data taking, in order to provide the experimental luminosity in the DEAR interaction point (IP2). In all these measurements the kaon monitor showed a stable and reliable operation mode, identifying kaons with both TDC and ADC analysis and providing to users on-line luminosity measurements. Since the RF stop signal was RF/4, while DAΦNE worked in the RF/2 mode (with 45 bunches, one filled-one empty), all TDC spectra showed a doubled structure.

Typical recorded spectra of a single measurement (of duration about 40 min, corresponding to a mean integrated luminosity of 4.5 nb^{-1}) are shown in Fig.1. The bidimensional plots of TDC versus ADC of both the inner and outer kaon monitor scintillators clearly allow to discriminate the background *mips* signals from the kaon signals. The TDC spectra are the software mean time of the PMs of the same scintillator referred to the (RF/4): hence the slow kaon signals follow the fast *mips* ones. The ADC spectra are the mean value of the two corresponding PMs: the slow kaon signals provide also higher amplitude pulses.

In Fig.2, the spectra of Figure 1 are projected on the TDC axis: software mean time of the PMs of the same scintillator referred to the (RF/4) signal. The smaller kaon peaks are clearly visible. The 1.4 ns distance between the *mips* and kaons peaks is in good agreement with the Monte Carlo calculations of kaons time-of-flight, while *mips* are almost synchronous with the bunches.

In Fig. 3, mean values of the amplitude spectra of the PMs of each scintillator of the kaon monitor are shown. The upper plots show such amplitude spectra for all signals (*mips* and kaons) from the inner and outer scintillators, respectively. The lower plots show the corresponding amplitude spectra resulting after the selection of time windows in the TDC spectra corresponding to kaons. As it is clearly seen, the tails in the amplitude spectra are completely suppressed by the time cuts. This definitely confirms the identification of the kaons from ϕ decay.

4 Measurement of DAΦNE luminosity

To measure the luminosity, the number of detected kaon pairs is needed [2]. This number is the integral of the ADC spectra of any one of the two kaon monitor scintillators obtained after selection of proper TDC windows, and, eventually, applying a lower cut to eliminate a residual tail contamination. A software has been written to calculate on-line the number of kaons collected in a given time interval, and then, with the procedure described in [2], to give the DAΦNE luminosity in IP2.

One has:

$$\mathcal{L} = C_{KM} R(K^+K^-) \tag{1}$$

where C_{KM} is the kaon monitor constant: $C_{KM} = 7.15 \cdot 10^{30}\ cm^{-2}$, and $R(K^+K^-)$ (s^{-1}) is the kaon rate.

It turns from (1) that, for instance, for a luminosity $\mathcal{L} = 10^{30}\ cm^{-2}\ s^{-1}$ the rate of the detected kaons is about 0.14 Hz.

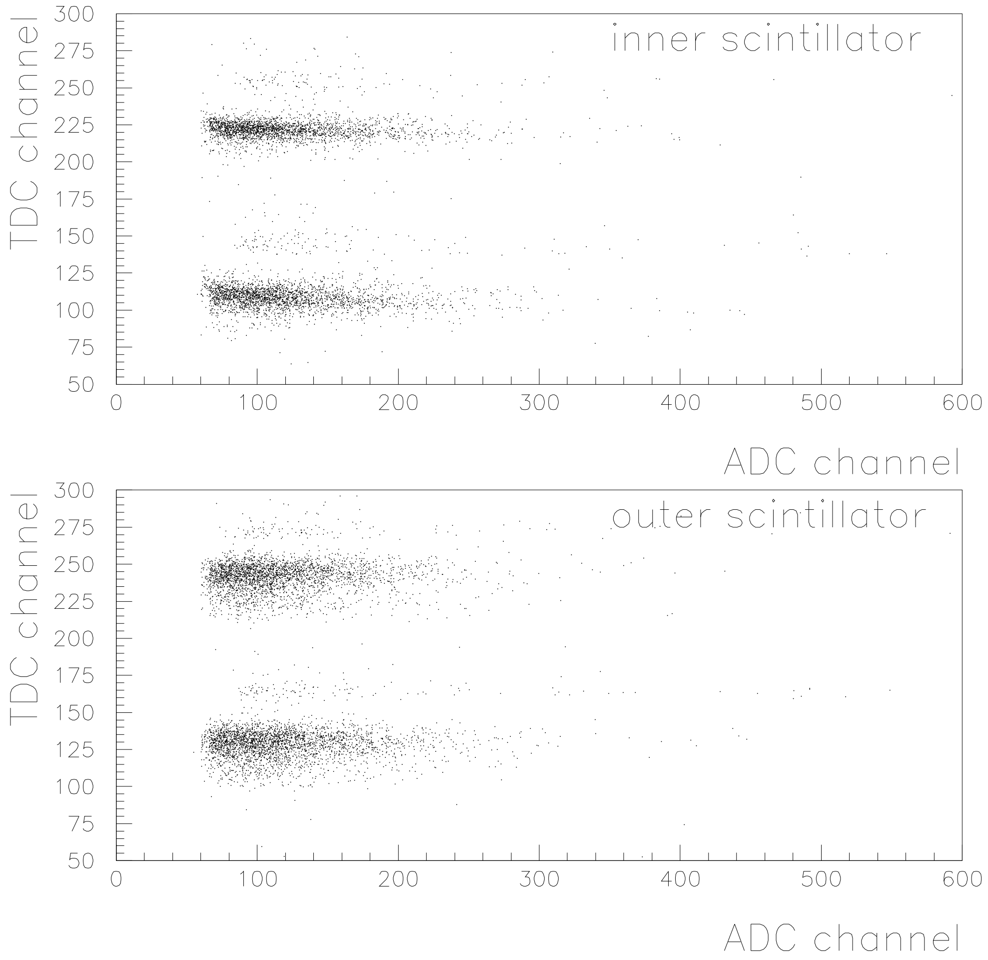

Figure 1: The bidimensional TDC versus ADC spectra collected by the kaon monitor in a single measurement (about 40 minutes).

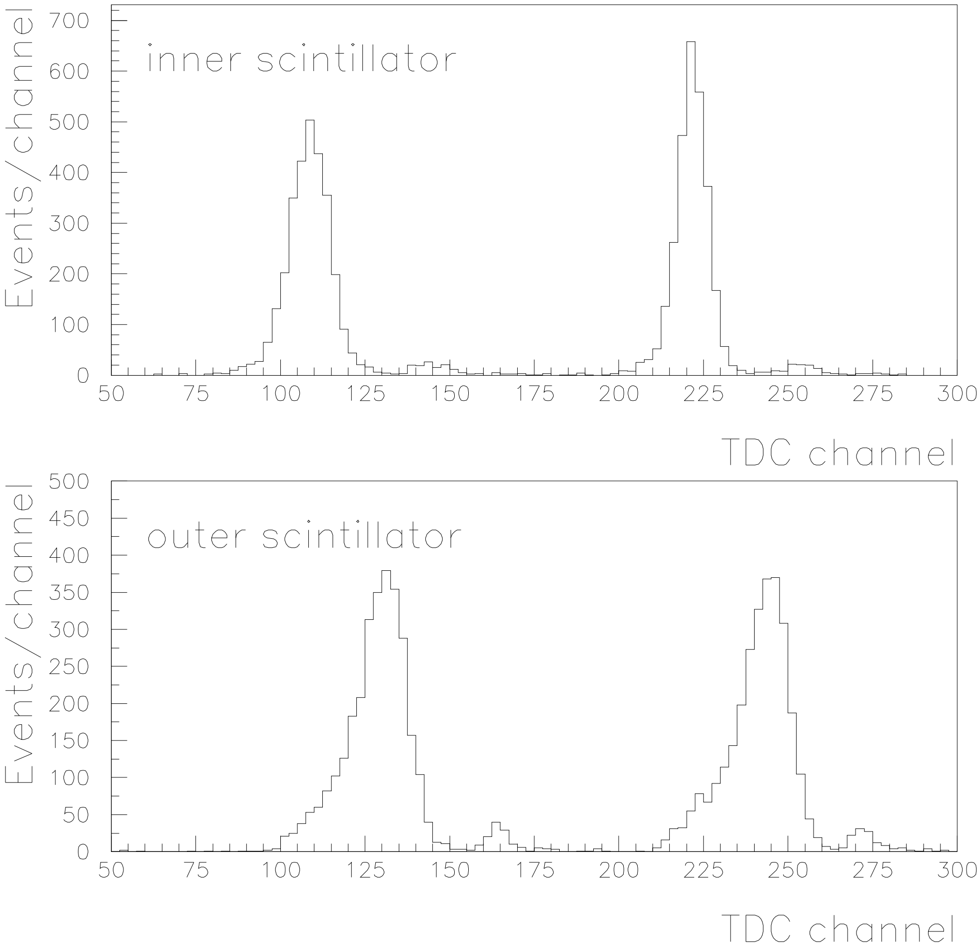

Figure 2: The TDC spectra of the inner and outer kaon monitor scintillators collected in a single measurement (about 40 minutes).

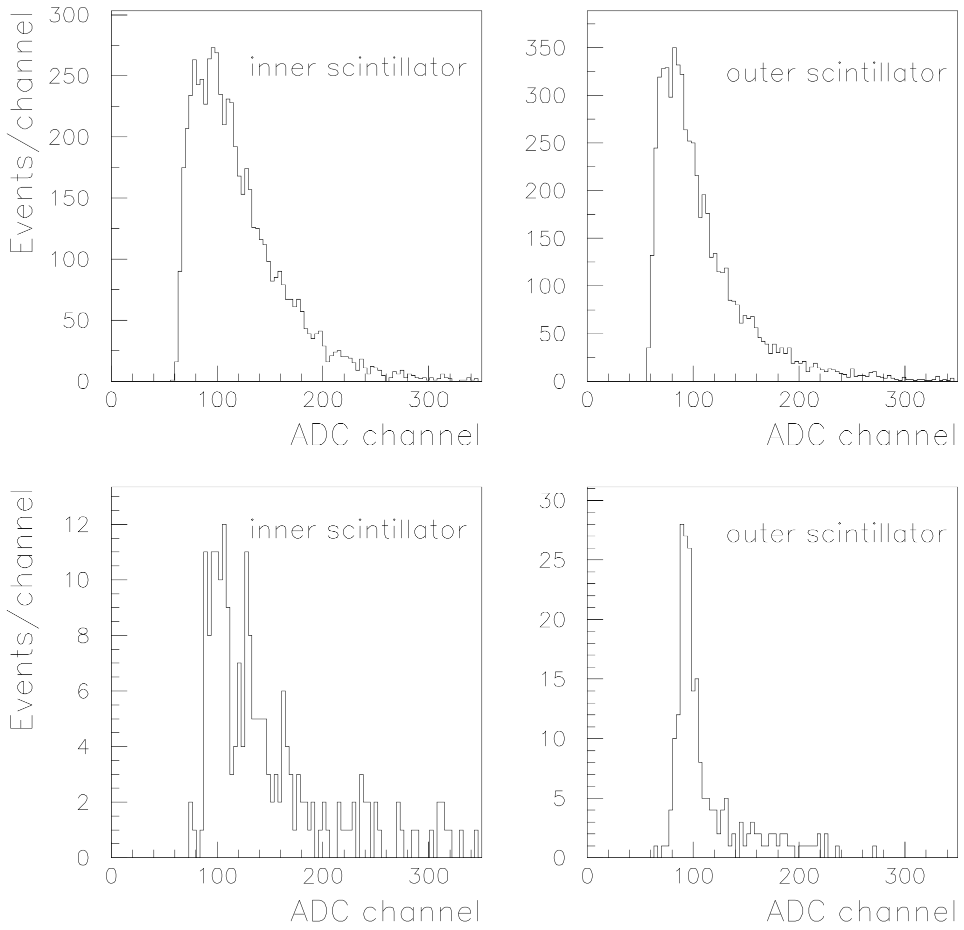

Figure 3: The ADC spectra of the inner and outer kaon monitor scintillators recorded in a single, 40 min long, measurement. The upper plots are the total (*mip*s+kaons) amplitude spectra; the lower plots show the resulting ADC distributions when the cuts in the TDC spectra corresponding to the slow kaons are applied.

Table 1: DAΦNE luminosity in IP2. Kaon monitor measurements in a period of stable data taking.

Date and time	Initial current e^- (mA)	Initial current e^+ (mA)	Measurement duration (s)	Collected kaons	$\mathcal{L}_{peak}$ (10^{30}cm^{-2}s^{-1})	$\mathcal{L}_{int.}$ (nb^{-1})
17.12.00 2 : 37 : 15	271	389	2069	601	3.79 ± 0.42	4.30 ± 0.17
4 : 05 : 01	337	376	2105	612	3.65 ± 0.41	4.40 ± 0.18
4 : 51 : 03	343	377	2471	783	5.05 ± 0.63	5.60 ± 0.20
5 : 48 : 35	334	380	2105	625	4.43 ± 0.59	4.50 ± 0.18
6 : 40 : 11	342	371	2044	645	5.98 ± 0.68	4.60 ± 0.19

For practical reasons, since the luminosity decreases with time, instead of measuring the luminosity every given time interval, a fixed numer of counts of kaons is preselected, taking into account the time needed to collect it. The preselected number (50 counts in this case) is a reasonable compromise between statistical precision and frequency in giving a luminosity value (few minutes at $\mathcal{L} = 1 \cdot 10^{30}\ cm^{-2}\ s^{-1}$).

In Table 1, kaon monitor measurements in a period of stable data taking are reported.

5 Conclusions and perspectives

The experimental work performed on the DEAR kaon monitor during the runs of December 2000 was reported. The full TDC and ADC information was collected. The new anticoincidence set up was installed and put into operation, resulting in an average cut of background of a factor 6. A clear identification of charged kaon pairs from $\phi - meson$ decay at rest could be observed. A software was written that routinely, every few minutes, fed the web page with the on-line DAΦNE luminosity value in the DEAR IP.

The kaon monitor is now able to perform all the tasks for which it has been built.

A few improvements, however, are foreseen to still better tune its performance. The first is a systematic study of the effects of the anticoincidence counters, since the background peak is still overwelming, even if the kaons are very well separated. The second is the insertion of a better performing C.F. discriminator (as the ORTEC 935 quad CFD) before the CAEN Mod N253 module, since, as the analysis has shown, some "swing" effect is present at low ADC values, which causes the widening of the TDC spectra of the mips signals. Correcting this effect should result in a narrowing of the mips TDC peak and an even better separation of kaons.

We want to thank Sergio Bertolucci for his constant advices in tuning the kaon monitor and L. Passamonti and M. Giardoni for building the anticoincidence detectors.

References

[1] A. Bragadireanu *et al.*, "The DEAR Kaon Monitor: results of the first measurements", DEAR Note-IR-16, January 24, 2000.

[2] A. Bragadireanu *et al.*, "Report on the run period August-September 2000: Kaon Monitor", DEAR Note-IR-30, October 3, 2000.