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Detector response simulation for the vertical and horizontal hodoscopes in the DIRAC experiment

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Abstract

This note describes the implementation of the detector response simulation for the vertical and horizontal hodoscope in the DIRAC experiment.

1 Introduction

The following pages explain how the response of the vertical and horizontal hodoscope is simulated in the DIRAC experiment. GEANT[1] adapted to DIRAC is used as a Monte Carlo program. Its output can be read by the offline analysis program ARIANE[2]. The detector response simulation package[3] itself is included in ARIANE and can be enabled or disabled by setting flags.

To simulate the detector response, I take the time resolution of the detectors, the efficiency of the detectors and the uncorrelated background into account.

If the detector response simulation is enabled, the output of GEANT is changed corresponding to the detectors characteristics and is made available for further offline analysis.

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2 Monte Carlo

GEANT software package The simulation of the DIRAC experiment is done within GEANT. The output of GEANT is the exact position, momentum, time of flight and energy loss in every detector.

Detector response simulation package The detector response simulation package is included in ARIANE. It can be controlled by setting a number of flags. The user has also the option to add uncorrelated background.

3 Characteristics of the VH and HH

3.1 Time resolution

The time resolution of the vertical hodoscope is crucial to the DIRAC experiment since the tagging of prompt events is performed by taking the time difference of the two vertical hodoscopes. Their relative time resolution is around 180 ps as can be seen in figure 1, which shows the time difference dt

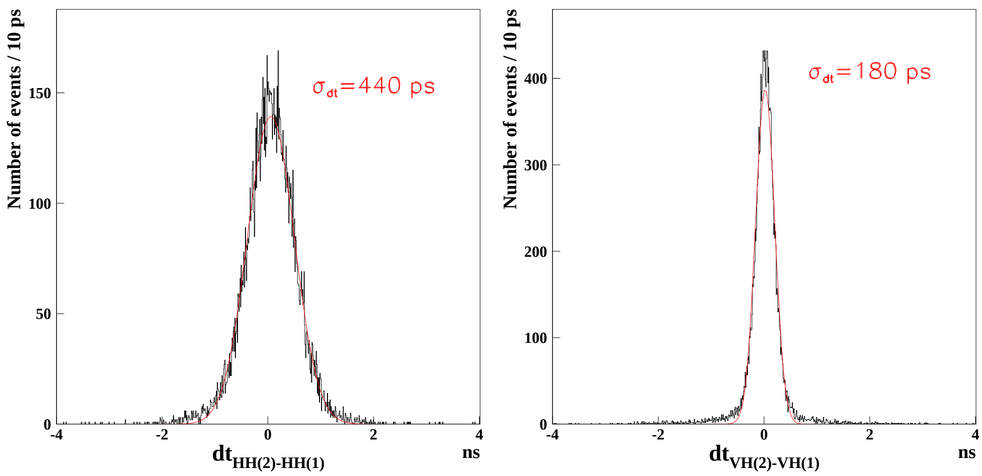

Figure 1: Time difference dt between the two horizontal hodoscopes (left) and vertical hodoscopes (right) for real data e^+e^- pairs. The σ of the Gauss fit is 440 ps for the horizontal and 180 ps for the vertical hodoscopes.

between the two HHs (left plot) and the two VHs (right plot) for e^+e^- pairs obtained with en electron trigger. A cut on the total momentum of $P_{total} <$ 4.5 GeV/c was applied to avoid protons in the sample and the different path lengths of the particles were taken into account.

A relative time resolution of $\sigma_{dt(\mathrm{VH})} = 180$ ps implies an absolute average time resolution per counter of about $\sigma_{t(\mathrm{VH})} = 127.3$ ps, which is in excellent agreement with earlier established values, i.e. $\sigma_{t(\mathrm{VH})} = 127$ ps[4].

The time resolution per counter for pions coming from real data is wider because of different path lengths in the magnetic field due to the input momentum spectra of the pions.

The horizontal hodoscopes on the other hand are mainly used for the coplanarity cut so their time resolution doesn't have to be that precise. They have a relative time resolution of about $\sigma_{dt(\mathrm{HH})} = 440$ ps which implies an absolute average time resolution per counter of about $\sigma_{t(\mathrm{HH})} = 311$ ps. Table 1 summarizes the time resolution for the hodoscopes.

	σ [ps]
VH Timing	
Relative (arm 2 - arm 1)	180
Absolute per counter	127
HH Timing	
Relative (arm 2 - arm 1)	440
Absolute per counter	311

Table 1: Time resolutions of the hodoscopes in [ps] obtained from real data e^+e^- pairs.

3.2 Detector efficiency

The efficiency of the hodoscopes is assumed to be one.

3.3 Uncorrelated background

The correct level of uncorrelated background for the VH and HH is found by looking at single tracks in minimum bias trigger data. Single track events are events with just one track in one arm and no track in the other arm. Minimum bias trigger in the positive arm requires at least one hit in DeDx and one hit in VH in the positive arm.

Most events have just one single hit in the VHs and HHs. For events with multiplicities higher than one, the relative timing of the hit from the DC track and the other hits is important. Figure 2 shows the relative timing of all other hits compared to the chosen hit by the DC tracking for the HH 2 and the VH 2. From the plot one can conclude that about 45% (25%) of

	all				uncorrelated background			
multiplicity	HH 1	HH 2	VH 1	VH 2	HH 1	HH 2	VH 1	VH 2
1	91%	88%	92%	90%	4%	6%	4%	7%
2	7%	10%	6%	9%	1%	1%	2%	1%
> 2	2%	2%	2%	1%	-	-	-	-

Table 2: Multiplicities for the hodoscopes (left) and the resulting uncorrelated background multiplicities (right). The numbers were obtained using real data minimum bias trigger.

such events are within 1 ns for the HH (VH) and are therefore correlated. The uncorrelated background is uniformly distributed between -25 ns and +25 ns relative to the track hit.

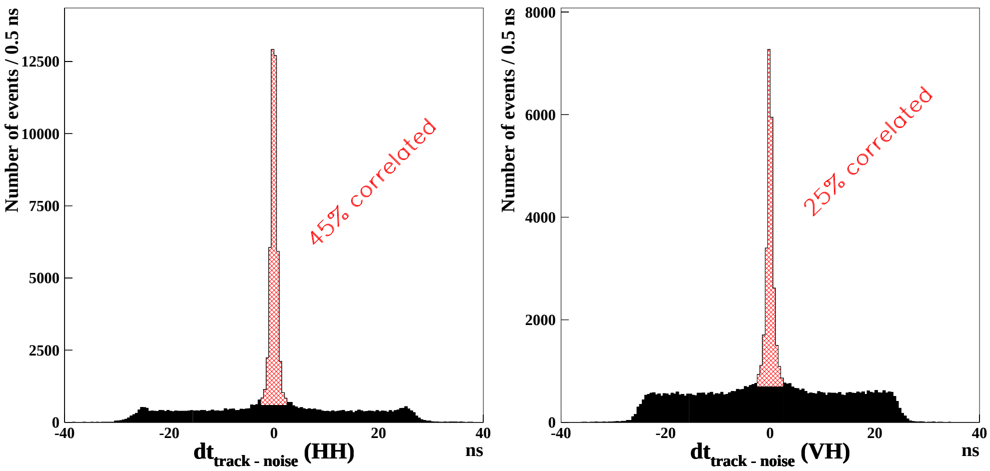

Figure 2: Relative timing in HH 2 and VH 2 for single tracks using minimum bias trigger data.

Table 2 shows the multiplicities for the hodoscopes and the resulting uncorrelated background multiplicities. The values for the uncorrelated background were used for the background simulation.

Figure 3 shows how the uncorrelated background is distributed spatially. Clearly visible is the asymmetric distribution due to the beam for the vertical hodoscopes, while the background of the horizontal hodoscopes is more symmetric.

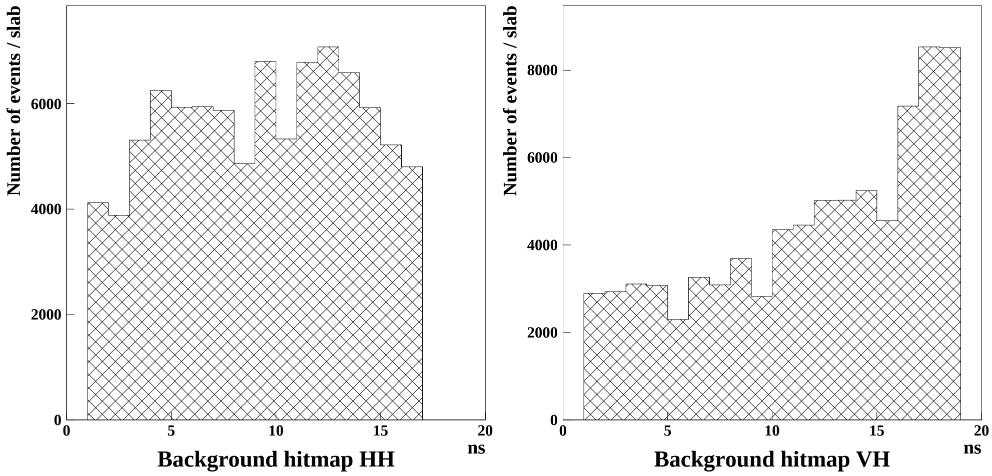

Figure 3: Background hitmap for HH 2 and VH 2.

3.4 Results and Conclusions

Depending on the users settings, the digitalization package now changes each event coming from GEANT. The resulting absolute time distributions for the VH and HH for simulated Monte Carlo data are shown in figure 4. The black distribution is the original GEANT output, while the result of the detector simulation is shown as the red distribution. The σ increases after the detector

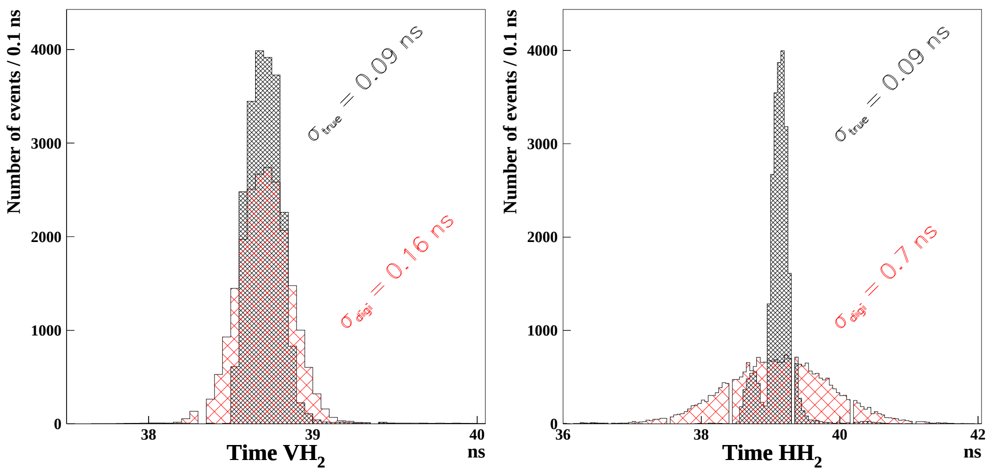

Figure 4: GEANT output of simulated Monte Carlo data before and after the detector response correction for the VH and HH.

simulation for both detectors, from about 0.1 ns to 0.16 ns (VH) and from 0.1 ns to 0.7 ns (HH) respectively. These values are in agreement with the σ's obtained from T1$\pi^+\pi^-$Copl real data prompt events of $\sigma_{VH} = 0.18$ ns and $\sigma_{HH} = 0.65$ ns.

If background simulation is enabled by the user it is added and spatially distributed according to the above established detector characteristics.

References

[1] GEANT version 3.21 adapted to DIRAC in version 2.61.

[2] ARIANE version 304-12.

[3] "Simulated data processing - little guide", DIRAC Web page, A. Benelli (2001).

[4] "The high resolution and rate capability Time of Flight detector of DIRAC experiment", P. 15. Departamento de Fisica de Particulas, Universidade de Santiago de Compostela, (2000).