DIRAC NOTE 2003–05

4e-trigger for DIRAC

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Abstract

Starting from run 5919 (June 2, 2003) the new 4e-trigger was added to the standard mixed trigger for the DIRAC experiment. Its aim is to select events with two simultaneous electron-positron pairs. These statistics can be used whether for detector calibration or the study of different π^0 decay modes. The scheme and characteristics of the new trigger are described in this note.

The main trigger mode used for the data taking in DIRAC is the mixed trigger comprising a physical trigger aimed to detect pionic atoms and auxiliary triggers for calibration purposes. All these calibration triggers (e^+e^-, K and Λ triggers) are prescaled in order to reduce their counting rates to the level where they do not increase essentially the data acquisition system dead time.

The standard trigger for detection of e^+e^--pairs is generated if there is a coincidence of signals from the Vertical and Horizontal Hodoscopes, Cherenkov counter and Preshower detector within each arm, and then the signals of both arms coincide (shown as a component of Fig. 1). The thresholds in the Cherenkov counters are set at the level of almost 100% detection of electrons. The sample of collected e^+e^--pair events contains, in particular, the events with two e^+e^--pairs detected. But the e^+e^-trigger is prescaled with a coefficient of 14, hence the rare process of the double electron-positron pair generation is suppressed by prescaling, too.

In order to detect the double e^+e^--pair events more efficiently, one more dedicated trigger (further referred to as '4e-trigger') has been designed and implemented. The goal was to detect all such events without prescaling and to realize it without interference into the previous electronic configuration. The latter condition has imposed essential restrictions on the choice of a possible trigger scheme. For example, an evident step for this new trigger would be the use of higher discriminator thresholds in the Cherenkov counter channels. But this would request an insertion of additional fan-out modules which increase the signal propagation time and hence influence the detection of "normal" single electron events.

The simplest solution has been found consisting in request of a coincidence of the usual e^+e^--pair signal (non-prescaled) with the decision of the majority logic applied to the Vertical Hodoscope signals (see Fig. 1). The majority logic is realized with the LeCroy module 4532 which receives the signals from the elements of both Vertical Hodoscopes and issues the output signal if the hit multiplicity in VH is ≥ 4.

The counting rate of the 4e-trigger is about 20 events per spill, that is close to 2.5% of the total trigger rate at the nominal beam/target conditions. In order to include the 4e-trigger in the standard mixed trigger, necessary arrangements have been done to make the trigger processors (DNA/RNA and T4) transparent for the 4e-trigger (like it is done for other calibration triggers).

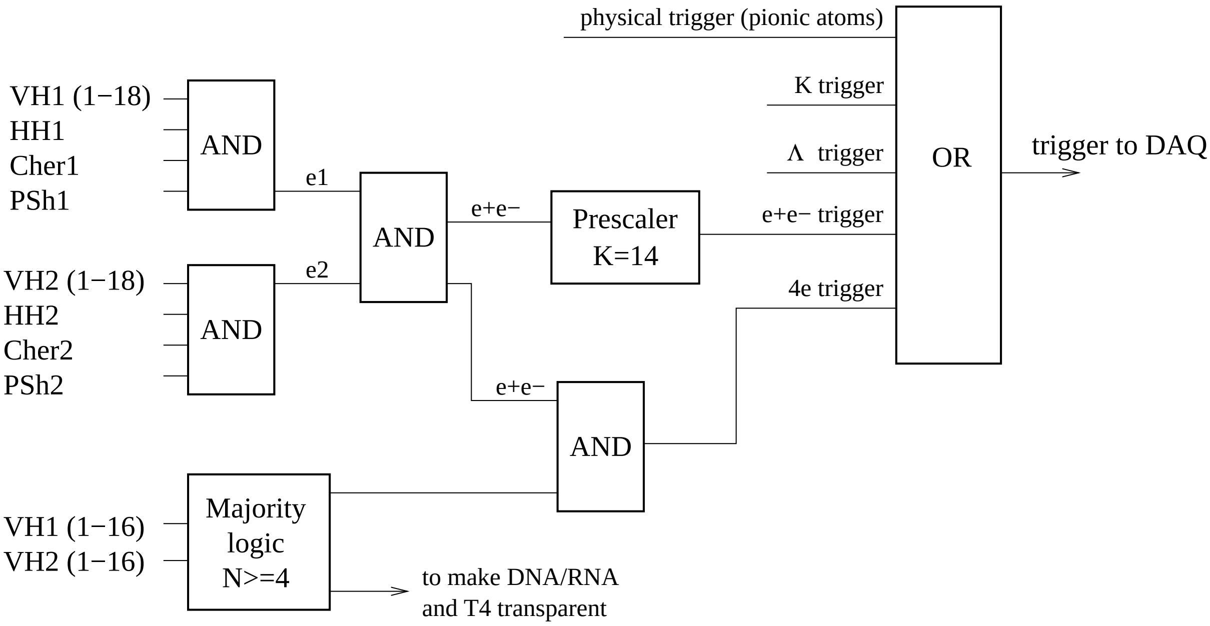

Figure 1: Scheme of 4e-trigger and the common trigger logic.

The simplest schematic solution resulted in some imperfections of the 4e-trigger:
1. Not all but first 16 of total 18 slabs of each Vertical Hodoscope participate in the majority selection. This slightly reduces the setup acceptance for this trigger in the high momentum region.
2. The majority criterion N$\geq$4 is applied to the sum of the number of hits in both VH. That means that detection of events with 1 hit in one of the hodoscopes and with 3 hits in another one is possible (the combination 0+4 is excluded due to coincidence with the usual e^+e^--trigger for which the hits in both arms are mandatory).
3. The thresholds in the Cherenkov counters are set at the level for detection of single electrons. As a result, the 4e-trigger can be produced by a single e^+e^--pair coinciding with, for example, $\pi^+\pi^-$-pair.

Nevertheless, these imperfections are not very essential. Items 2 and 3 reduce only the trigger selectivity but not its efficiency. The selectivity is not important here as the obtained trigger rate is very small even with this selection. The item 1, indeed, results in reduction of the acceptance but this reduction is small, especially taking into account more soft momentum spectrum of electrons from the double-pair events.

To check the efficiency of the new trigger 64 runs (first 12 days of data taking with the new trigger) have been analyzed. Statistics for the processed data is shown in table 1. For events (**DC 2x2**) when two tracks are reconstructed in both arms of the spectrometer additional criteria were applied:
$\boldsymbol{\Delta t}$**(VH) < 1.0ns** — time difference between any of 4 tracks does not exceed 1 ns. This criterion effectively suppresses accidental coincidences. More strict Δt(VH) leads to better selection of two simultaneous e^+e^--pair events (fig. 2).
high Ch thresh — higher software threshold in Cherenkov counter, which was set above the mean number of photo-electrons produced by one ultra relativistic electron (see fig. 2). This criterion eliminates about 3/4 of events when an e^+e^--pair coincides with a non-electron pair.

Table 1: Statistics of selected events. Runs 5919-6031 (12 days)

		4e	T1ee	T1ee AND 4e
0.	total	$0.98 \cdot 10^6$	$7.03 \cdot 10^6$	
1.	DC(2x2)	36512	9022	2553
2.	1. AND Δt(VH) < 1.0ns	3902	398	291
3.	2. AND only 16 VH chns	3766	281	280
4.	2. AND high Ch thresh.	3060	316	236
5.	4. AND only 16 VH chns	2965	226	225

If one looks into T1ee data with two reconstructed tracks in each arm and takes into account only first 16 slabs of Vertical Hodoscopes, one can see the almost 100% efficiency of the 4e-trigger for simultaneous pairs. It is worth to note that the new 4e-trigger enlarges the statistics of double e^+e^--pairs at about 10 times with respect to the prescaled T1ee trigger.

From fig. 3 one can see that the possible (small) relative delays between different channels of the Vertical Hodoscope on the trigger level and difference in duration of logical signals on input of the majority logic do not affect the 4e-trigger.

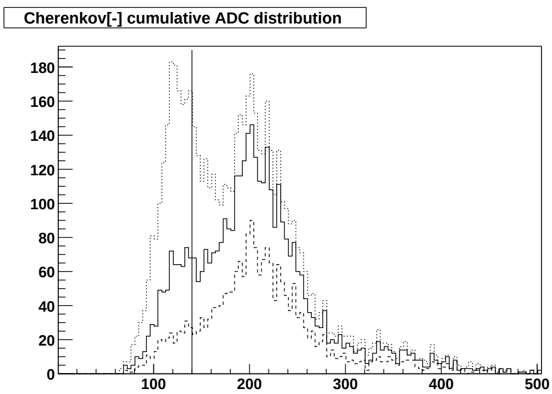

Figure 2: Cherenkov cumulative ADC distributions. Δt(VH) < 1.0ns (solid line), Δt(VH) < 2.0ns (dotted line), Δt(VH) < 0.5ns (dashed line). Vertical line corresponds to the applied higher software threshold.

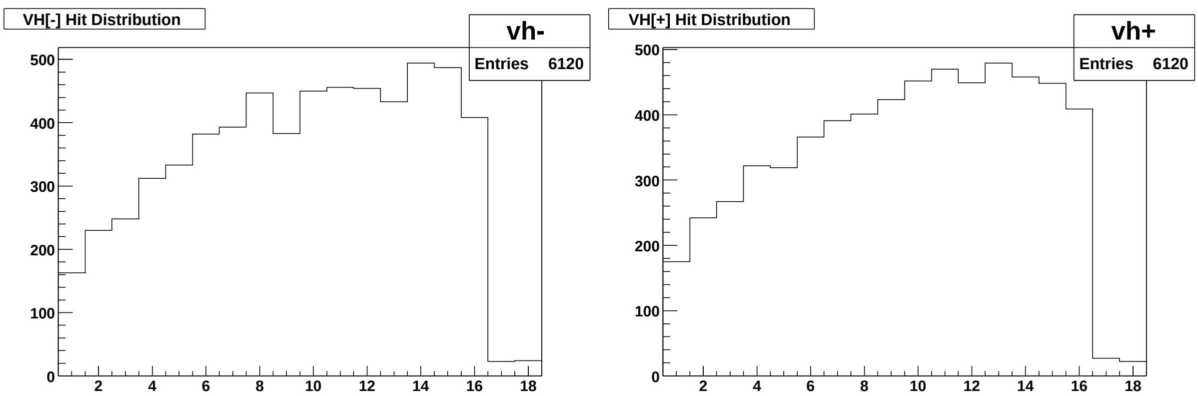

Figure 3: Hit distributions in VH hodoscopes with the 4e-trigger.

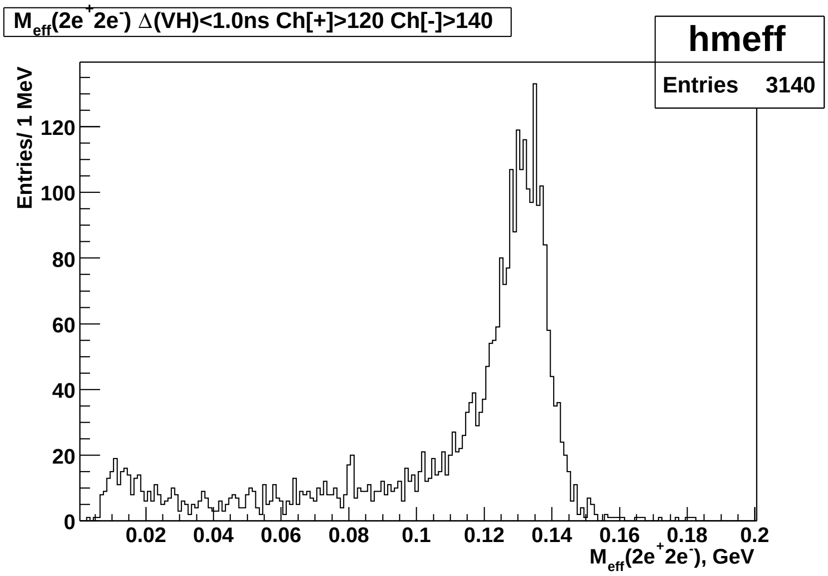

Figure 4: Reconstructed effective mass of 2 simultaneous e^+e^--pairs.

The reconstructed effective mass of selected 4 particles assuming that they are electrons and positrons is presented in figure 4. The clearly seen peak near the π^0 mass (135 MeV) confirms that the main sources of registered double e^+e^--pairs are different π^0 decay modes.

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