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Search for Possible LCAL-Inefficiencies with the SATR

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Abstract

A study of LCAL luminosity trigger efficiency is made for the data sample in the 1990 run. This is done using the SATR track trigger, which uses only hit information in the SATR. No inefficient events are found, leading to an lower limit on the LCAL trigger inefficiency of 99.85% at a confidence level of 95%.

1 Introduction

The luminosity in ALEPH is determined from observation of Bhabha events in the luminosity calorimeter (LCAL)[1]. Its error has three contributions, the first being the statistical error of the number of Bhabha events, the second the systematic error related to imperfections of the apparatus and possible inadequacies of the simulation, and the third coming from the limited knowledge of higher order radiative corrections. The statistical error is at present at the 0.2% level. In our current publications we quote the theoretical uncertainty as 0.3%. The systematic experimental uncertainty has been brought down from an originally anticipated value of 2% to 0.5%.

To make sure that such a low systematic error is realistic every possible check is desirable. An independent determination of the luminosity using the small angle tracking device SATR [1] is underway; but parameters entering the standard luminosity determination must also be checked.

At the moment the trigger efficiency of the LCAL is determined from redundant LCAL triggers. For this purpose single side, double side coincidence pad and wire triggers at various thresholds are used [2,3,4] to cross check one another. From these methods the efficiency has been deemed to be negligible, however it is conceivable that some sources of inefficiencies are correlated and might be missed using this method. In this note possible sources of trigger inefficiencies of the LCAL are investigated using a dedicated SATR trigger.

2 Description of the Hardware

The SATR Detector [1,4,5] is a tracking device consisting of four semi-cylindrical modules, two of them mounted on each side of the ALEPH detector. Each module is a stack of nine half planes of drift tubes. The 56 wire signals of each half plane are ORed into 32 electronic channels on detector level. The first stages of signal processing consists of preamplifiers mounted on the detector, and a TDC system. These modules belong to the SATR main readout system and are described elsewhere [5,6].

To trigger on a Bhabha event, it is necessary to recognize candidates for charged tracks in two of the four SATR modules which are opposite in theta while covering the same phi range. This must be done by a simple and fast piece of hardware.

The SATR trigger system makes use of the 500ns TTL level signals generated by each TDC for a START signal detected on its input lines. These START_OUT signals are ORed separately for each of the 36 half planes (Fig.1). The 36 signal ORs corresponding to the 36 half planes are processed in a majority coincidence module. For this purpose the number of hit half planes per SATR module are computed separately, in three crate level controllers. A master controller determines the numbers of hit detector planes of each module and compares it to a preset trigger threshold n of 2...9, in this way providing four trigger signals each corresponding to a module (Fig.2).

A SATR trigger signal is generated if triggers are set by two modules which are opposite to each other with respect to the interaction point and if in addition the number of hits in each of the remaining modules does not exceed $n - 2$. The latter restriction reduced the number of triggers induced by background dramatically.

The ECL-level SATR trigger signal is fed into the ALEPH trigger system, currently as trigger bit 1. A trigger is rejected if more then one ITC trigger bit is set. By this means SATR triggers are suppressed, if wide angle tracks are found. After downscaling by a factor of 4 the rate of accepted SATR triggers for n=8 is roughly 0.1 Hz.

3 Running Conditions

The hardware was implemented in April 1990 with preliminary trigger conditions. During the running-in period the SATR trigger only set a bit in the trigger word, but did not actually start a readout cycle. Various trigger conditions were tried out with the aim to minimize the background trigger rate.

From run 8804 onwards the majority logic described in section 2 was enabled for $n = 8$ and the SATR trigger started the readout of the whole detector. The majority logic made the trigger rate acceptable and a downscale factor of four was introduced after run 8827. After run 8955 the downscale factor was set to two. The data analysis described below includes only runs since then. The ITC veto was implemented from run 8955 onwards resulting in a further reduction of the trigger rate to the level of 0.1 Hz.

4 Data Selection and Cuts

To determine an upper limit for the inefficiency of the LCAL trigger system two samples of events were defined — a reference sample and a sample of possible candidates for trigger inefficiencies. Three kinds of cuts were defined

- Trigger selection
  - i) The SATR-trigger must be active .
  - ii) There must be no large angle physics-trigger, only luminosity type triggers, (i.e. those with mnemonics starting with L), or random triggers may be set.
- Tracks and SATR hits
  - i) The SATR track fit quality flag must be 2 (i.e. a track must be fitted simultaneously to both sides of the detector).
  - ii) The sum of the ITC-bits must not exceed one.
  - iii) The number of SATR wire parallels fired must not exceed a preset value (presently 50).

  The first quality cut requires a common fit for tracks in opposite SATR modules as expected for the majority of Bhabha events. In case too many ITC bits are set, the event is vetoed because one would expect it to be characteristic of some background process. Genuine Bhabha events normally do not have ITC bits set.
- Geometry
  - i) The impact points of the reconstructed tracks into the LCAL are both required to lie within the tight acceptance area defined by the standard luminosity event selection.
  - ii) The impact points of the reconstructed tracks into the LCAL are both required to have the absolute value of their polar angle less than 85.8 mrad.

  The geometry cuts are chosen to guarantee that a Bhabha candidate lies well inside the geometrical acceptance of the LCAL and the SATR.

The events were then divided into two classes, the reference sample and the set of candidates for inefficiencies.

- Event selection
  - i) Event selection for the reference sample: The standard method five luminosity event selection flag must be set.
  - ii) Event selection for the suspected inefficiency sample: No LCAL trigger, i.e. No trigger with mnemonic starting with 'LC', 'LT', or 'LW', may be set, but the SATR trigger must be set.

5 Candidate Events for Inefficiencies

The candidate sample consists of 34 events which were scanned using a dedicated display program for the small angle region[7]. During the scan the energy measured in each side of the LCAL was noted. No candidate was found that met the requirements on energy measured in the LCAL that should have given rise to a luminosity trigger.

All events can be classified into 3 categories.

1. The reconstructed tracks are at low theta angles and consequently only part of the energy is seen in LCAL (10 events).
2. Insufficient LCAL energy on either one (5 events) or both (10 events) side. Most of these events are probably coincident double off momentum electron events. It is also possible that some of these are Bhabhas with strong initial state radiation along the beam line. Single initial radiative events are accounted for by the Monte Carlo.
3. No reconstructed energy was observed in the LCAL (9 events), although no obvious problem was apparent with the LCAL, eg. XLUMOK was true, no problems with the LOLE bank. Events with LCAL energies below a threshold of 0.5GeV have no banks written to the pot. Examination of the raw data indicated that for these events the tower energies were below this threshold. This cut will be removed in future version of Julia, and all events containing LCAL energy will be written. These events can then be explained in a way similar to those in item 2 above.

Among the last category is one obvious background event which is certainly not a Bhabha.

None of the candidate events meets the geometric or energy requirements of a luminosity event. Note that the candidate events have (of course) no LCAL trigger set but that the LCAL energy measurement is used for electron identification. The type of inefficiency that this study can discover is restricted to wrong LCAL energy determination, or a total failure, in the 'fast' trigger readout. Inefficiencies or failures in the 'slower' event readout would go undetected.

Three examples of candidate events are shown, one event of category 1 (Fig. 3), one with insufficient energy on both sides (Fig. 4), and one with insufficient energy on one side (Fig. 5). For every example both sides of the luminosity monitor are displayed. The displays contain the LCAL sensitive area (pad boundaries). In addition on one side the fiducial area representing the tight geometric cut is shown. The outline of one SATR plane is also indicated. The squares represent the measured tower energies. The ellipse is the covariance ellipse of the impact point of the reconstructed shower axis. The cross gives the reconstructed impact point in the SATR. Both are projected onto the LCAL reference plane. In the upper part of the displays the longitudinal shower profiles of the wire energies are given.

6 Efficiency of the Track Trigger

It is valuable to check the efficiency of the SATR-trigger, although it does not enter into the calculation of the luminosity trigger efficiency. This is done using the LCAL triggers as a check on the SATR trigger; it is assumed that the LCAL efficiency is high, so that it enters only to second order in the result. Events are selected using the criteria described above, but without any requirement placed on the SATR trigger being set. The number of events for which one would expect the trigger to be set, from geometrical constraints, is compared with the number that actually have the trigger bit set. This folds both SATR detector and SATR trigger efficiency directly into the calculation. The downscale factors are accounted for by using Level 1 trigger word, where the SATR trigger bit is set independent of the action of the downscale hardware, and then making the additional cut on the ITC trigger bits offline.

In the sample of events used for the efficiency analysis a total of 3679 events were seen which passed the selection criteria, of which 2860 also set the trigger. This gives an efficiency for the method of 0.777 ± 0.013.

7 Results

The number of reference events was found to be 5151 in 88 runs. Taking into account the downscale factor of four, valid for part of the running period, the reference sample contained 2066 events. In both the reference and in the looked for inefficient events the track trigger efficiency has the same effect, so it does not play a role in the final result. No trigger inefficiencies were found, so one may conclude that with a confidence level of 95% that there are not more than 3 inefficiencies in 2066 triggers. The gaussian error on the number of events in reference sample is small enough that there is no effect on the limit.

This leads to an upper value for the inefficiency $(1-\eta)$ of .145%; i.e. we obtain a lower limit of the LCAL trigger efficiency η of

$$\eta \geq 99.85\%,$$

at a confidence level of 95%.

8 References

[1] ALEPH-Collaboration (D. Decamp et al.) Nucl. Instr. Meth. A294 (1990) 121
[2] ALEPH-Collaboration (D. Decamp et al.) Z. Phys. C48 (1990) 365
[3] ALEPH-Collaboration (D. Decamp et al.) Phys. Lett. B235 (1990) 399
[4] H. Meinhard, Ph.D. Thesis, Siegen University, Feb. 1990
[5] G. Gillessen, Diploma Thesis, Siegen University 1989
[6] E. Neugebauer et al. SATR-Electronics User Handbook, Siegen University 1987
[7] H.Trier, Diploma Thesis, Siegen University 1990

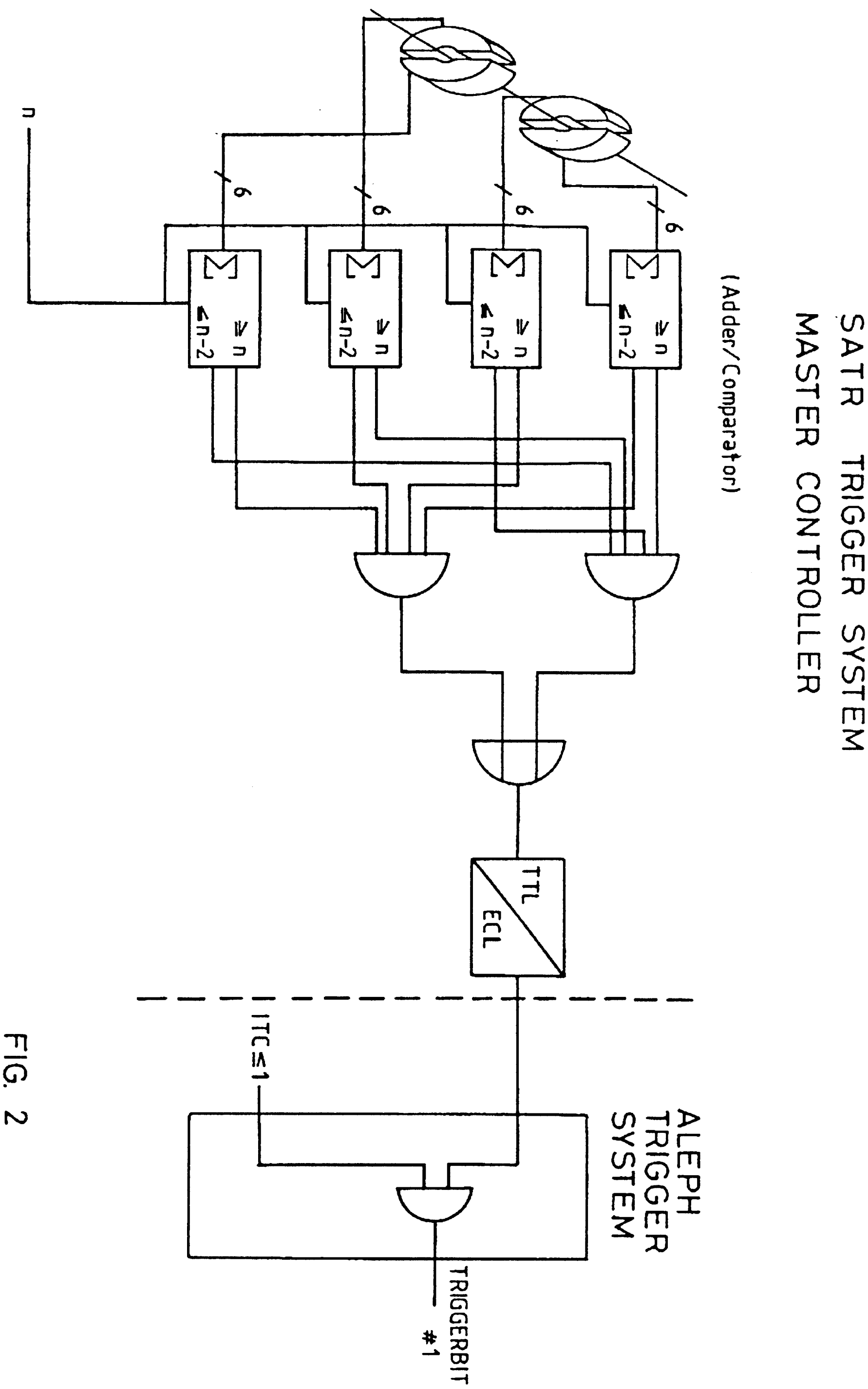

FIG. 2

Figure 1: Readout of one quarter detector consisting of 9 half planes

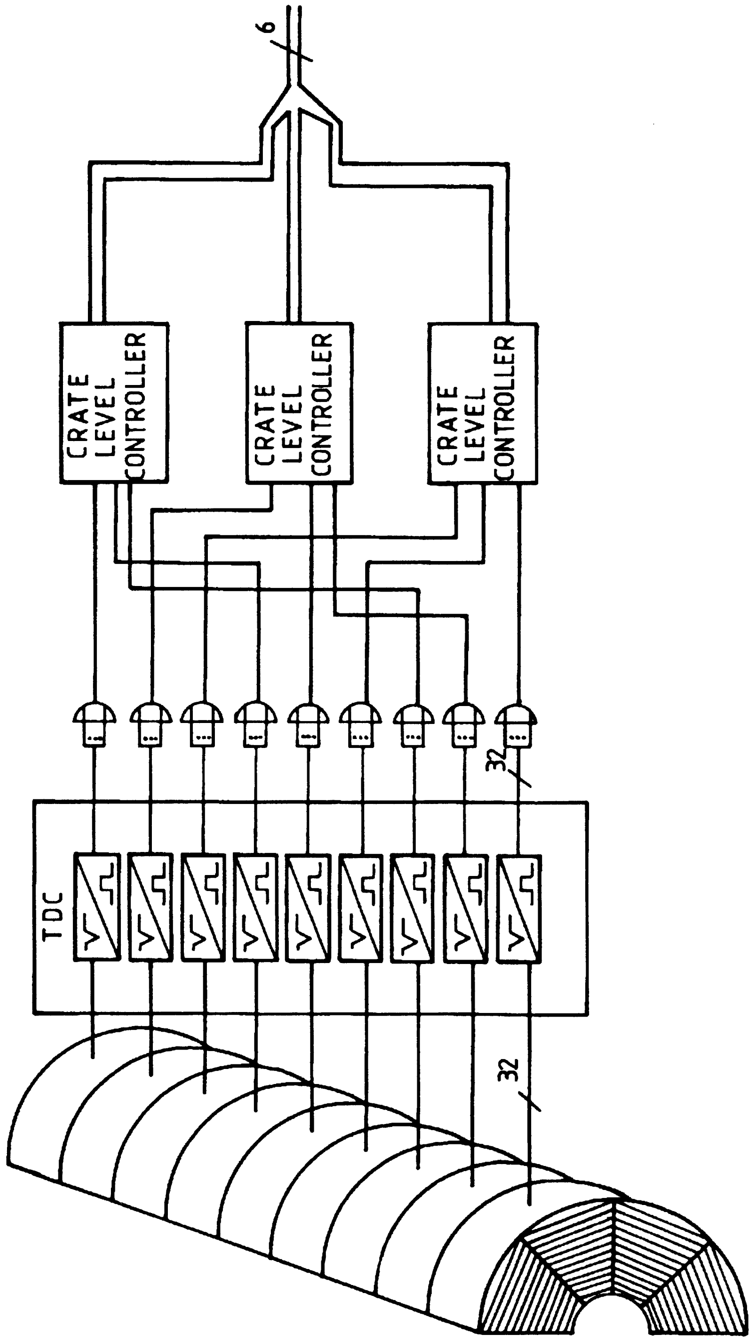

Figure 2: Majority trigger logic

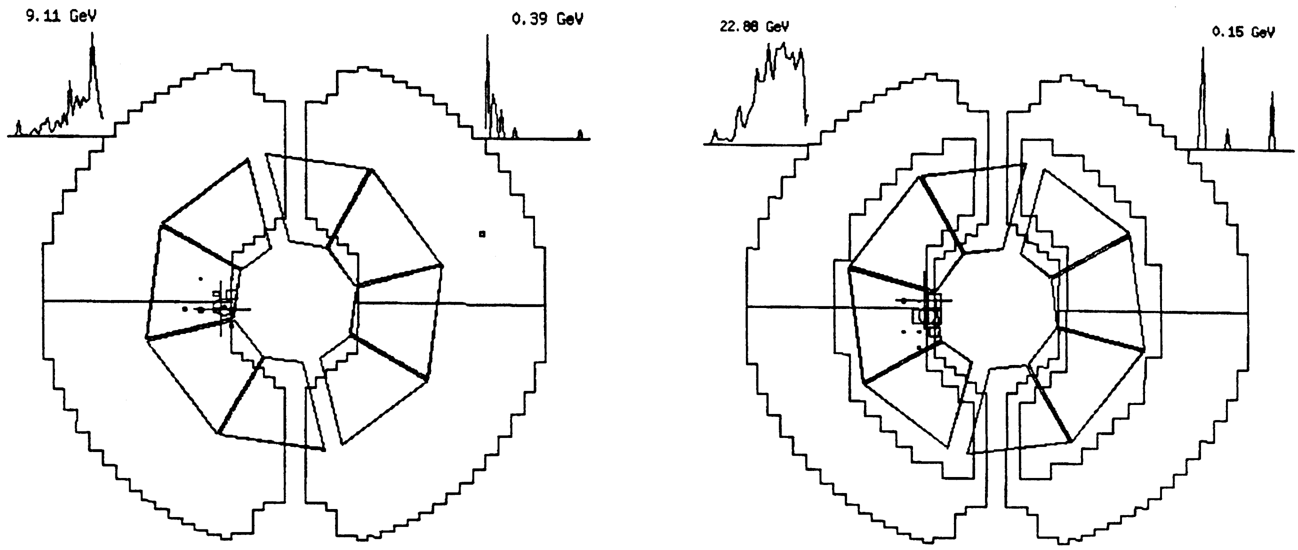

Figure 3: Low theta event with only part of the energy seen in LCAL (RUN 8898, EVENT 5298, tower energies 22.1 GeV / 8.2 GeV)

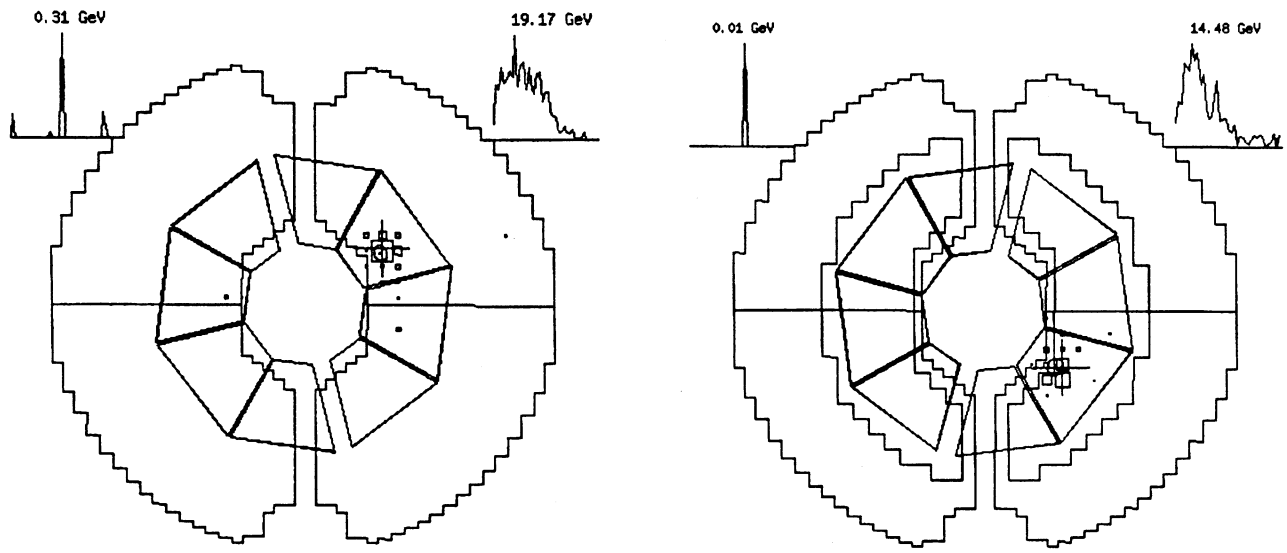

Figure 4: Event with insufficient LCAL energy on both sides (RUN 8948, EVENT 2892, tower energies 13.6 GeV / 19.1 GeV)

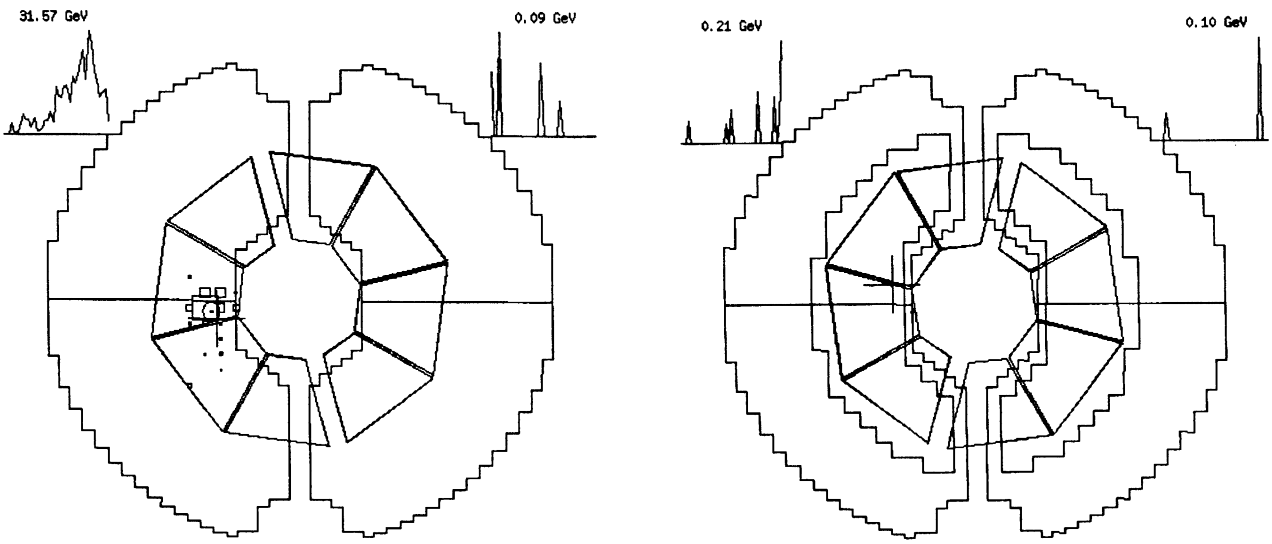

Figure 5: Event with insufficient LCAL energy on one side (RUN 9062, EVENT 7208, tower energies .1 GeV / 28.3 GeV)