Background reduction in the Forward RICH Detector of DELPHI

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Abstract

The Forward Ring Imaging Cherenkov detector is part of the particle identification system of the DELPHI detector at LEP. It does particle identification in the momentum range up to 40 GeV/c. The detector covers the forward region of DELPHI between $15^\circ < \Theta < 35^\circ$ and $145^\circ < \Theta < 165^\circ$.

A quarter of the detector was operated in DELPHI during the 1992 LEP running. The complete detector has been installed during the 1992/1993 winter shut down. Short description of the detector will be given. First results from the background reduction algorithms will be presented for the partially installed detector.

1 Introduction

The Forward Ring Imaging Cherenkov (Forward RICH) detector [1] is part of the particle identification system of the DELPHI experiment [2] at the LEP collider at CERN. It is used to do hadron identification over most of the momentum range up to 40 GeV/c by Cherenkov angle reconstruction.

In the first part of this paper a description of the detector and the performance during the 92 running will be given.

In a second part, using a dimuon sample, different algorithms to improve the signal-background ratio will be presented .

2 Description of the Detector

As has been explained in detail elsewhere [1], the Forward RICH detector, placed in a magnetic field of 1.2 Tesla, covers the forward-backward regions ($15^\circ \geq \theta \geq 35^\circ$ and $145^\circ \geq \theta \geq 165^\circ$). In azimuth the detector is segmented into sectors of 30° . Two radiator systems are used to cover the momentum range, a liquid C_6F_{14} layer for hadrons up to a momentum of about 6 GeV/c and a gaseous C_4F_{10} radiator volume for hadrons at high momentum . The imaging of the Cherenkov light from the liquid radiator is done by proximity focusing. Light from the gas radiator is focused by spherical mirrors onto a photo-sensitive Time Projection Chamber (TPC). The particle identification power of the detector is directly linked to the accuracy of the photon reconstruction. This requires a high precision for the alignment of the TPC, the liquid radiator volumes and the position of the mirrors. The analog electronics must be able to detect very small signals, from single photo-electrons, while not being disturbed too much by the large signals from ionizing tracks.

3 Background from electronic noise and signal

A large number of electrons arrive in the chambers of the Forward RICH producing different sources of noise :

- Feedback photoelectrons. They are created due to the presence of the photosensitive gas converting to electrons the U.V. light emitted during the gas amplification process. These feedback photoelectrons create ambiguities in the position reconstruction.
- Induced cross-talk between strips of the same cathode block due to big pulses. This effect confuse the coordinate defined along wires for other real electrons coming just after.
- Oscillations produced by after pulses. The effect is having more secondary hits in the same channel masking the good ones.
- Charged particles crossing the detector . The ionization electrons produce an excess of ghost wire-strips associations on top of the signal.

4 Background reduction algorithms

Two different groups of algorithms have been proposed [3] in order to reduce the background level in the Forward RICH. The first based in the detection of the high hit density spots correlated with the presence of tracks. In the second group we look for the presence of a reconstructed track to discard hits in the neighbourhood. Some of these algorithms are applied on hits (wires or strips) and others on space-points (wire-strip association having fired in a time window of $\pm 50ns$).

- Neighbours. If there are more than 2 space-points in the volume defined by a sphere of 1 cm of radius around every space-point all the spatial-points inside this volume are rejected.
- Electronic noise. A linear density cut is provided to remove the cross-talk. If more than 4 contiguous wires (strips) are fired in a time range of $\pm 10ns$ all of them are rejected.
- Cylinder around a charged particle identified by the tracking detectors. A cylindrical volume is defined having the longitudinal axis in the track trajectory direction and a radius of 0.5 cm . All the space points inside are rejected.
- $R\phi$ clustering for the signal originated from liquid radiator. This algorithm mixes density and track methods. Planes perpendicular to the identified track are divided in cells along the radial distance from the track and the azimuthal angle. An estimation of the cell hits density is done taking into account the expected azimuthal isotropy of the Cherenkov photons and the noise level. This algorithm can be tuned to optimize the noise rejection power. If the density in the cell is bigger than the estimated one, all hits into the cell are rejected.

5 Results

Table 1 shows the background rejection power defined by :

$$R = 1 - \frac{N_b^f}{N_b^i} \quad (1)$$

where N_b^f and N_b^i are the number of photoelectrons from background after and before the cut respectively. The amount of signal lost are shown in the same table.

Some of the algorithms presented are strongly correlated. In particular the $R\phi$ for the liquid radiator englobe most (96%) of the others.

The cuts can be ORed in order to improve the signal-noise ratio. In Table 2 results are shown for this combined method. The associated errors come from the statistical fit.

Figure 1 (a) and (b) shows the Cherenkov angle distributions for liquid and gas radiators respectively. The dashed area represents background photoelectrons rejected for the different cuts. It can be seen that even optimized, the $R\phi$ clustering is cutting significant part of the signal, this we think is due to the geometry of the method that matches exactly with the expected Cherenkov rings.

Conclusions

A method for noise reduction , based on an OR of the less correlated algorithms and cuts is proposed. The rejection power is $62.6 \pm 4\%$ for the liquid radiator and $69.4 \pm 5\%$ from the gas. The signal loss is $8.8 \pm 5\%$ and $12.6 \pm 4\%$ for liquid and gas respectively. Another method, the $R\phi$ clustering, for the photons coming from the liquid radiator has been investigated. Preliminar results show that it has a high background rejection power.

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		Neighbours	Electronic noise	Cylinder	$R\phi$
Liquid radiator					
	Signal lost (%)	$2.3 \pm 4.$	$5.2 \pm 4.$	$0.1 \pm 4.$	$38.9 \pm 4.$
	Rejection power(%)	$8.7 \pm 2.$	$36.4 \pm 2.$	$0.2 \pm 2.$	$79.1 \pm 2.$
Gas radiator					
	Signal lost (%)	$2. \pm 5.$	$2.3 \pm 5.$	$2.4 \pm 5.$	
	Rejection power(%)	$14.5 \pm 2.$	$47.6 \pm 2.$	$7.9 \pm 2.$	

Table 1: Background rejection power and signal lost in percent for the different noise rejection algorithms in the liquid and gas radiator.

	Gas radiator	Liquid radiator
Signal lost (%)	$12.6 \pm 4\%$	$8.8 \pm 5\%$
Rejection power(%)	$69.4 \pm 4\%$	$62.6 \pm 5\%$

Table 2: Background rejection power and signal lost for the ORed noise rejection algorithm in the liquid and the gas radiators

Figure 1: Cherenkov polar angle distribution in the liquid (a) and in the gas (b) radiators

References

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