Status of the L3+C experiment and its first data set

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Abstract

The high precision muon spectrometer of the L3 detector at LEP is being used to study cosmic ray muons 30 m underground, as discussed at the Durban ICRC two years ago. Initially, we will measure the muon momentum spectrum, the angular distribution and the charge ratio between 20 and 2000 GeV. The phase 1 set-up , with a geometrical acceptance of some 10 $\mathrm{m}^2\mathrm{sr}$, has been commissioned in 1998. This spring data taking has started with an acceptance of 200 $\mathrm{m}^2\mathrm{sr}$ (phase 2).

1 Introduction:

The muon spectrometer of the L3 detector, Figure 1, (Adeva et al., 1990) has a momentum resolution of better than 3 % at 50 GeV, and is located only 30 m below ground, which makes it an excellent device to measure the momentum spectrum of cosmic ray muons in the range of 20 to 2000 GeV. Motivations for performing this measurement and the study of different event types were outlined two years ago (Le Coultre et al., 1997). Recent calculations of the muon flux (Bugaev et al., 1998) and the neutrino flux (Agrawal et al., 1996) at sea level underline the importance of this measurement. This paper will describe the run we took last year, as well as the current status of the L3+C experiment.

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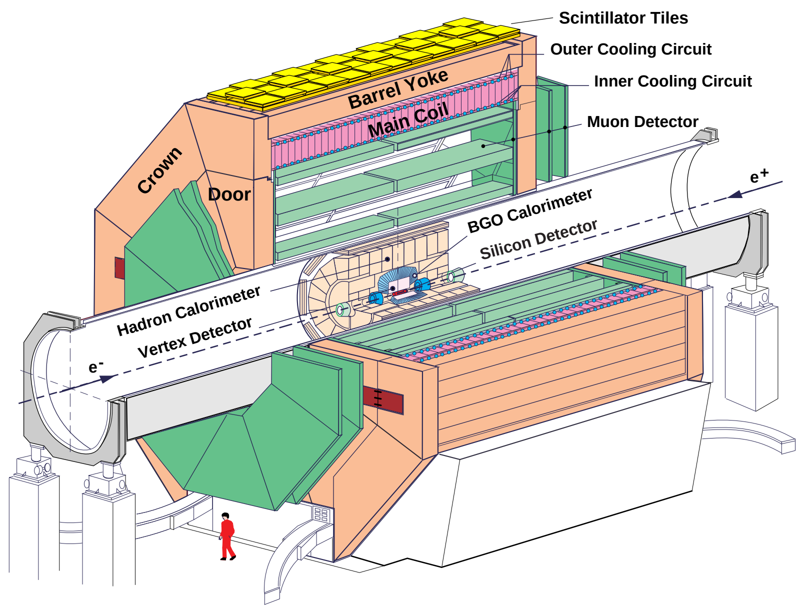

Figure 1: The L3+C set-up

2 The 1998 Run

During October of 1998, we commissioned the L3+C setup, reading out only the top octant of the L3 muon spectrometer, and 72 m^2 of scintillator on top of that octant, separated into 12 modules. The timing resolution and efficiency of the scintillator modules were measured to be 1.5 ns and 98.5% respectively.

Our trigger required that at least two of the three layers of muon drift chambers had at least 8 wires hit. The reconstruction requires in addition a signal from the scintillators. This additional requirement is needed in order to have a precise time information about the muon entering the detector, and is used to reconstruct the muons with good precision.

The 30 million events we took during October 1998 were mainly used to test and debug the complete system. This includes the electronics, online programs, reconstruction and analysis tools. We did not do a complete analysis on this limited data set, but confirmed that the rough features of this data are consistent with expectations.

One of the first things checked was how well one can estimate the absolute uptime. We have two methods to check this: 1.) a livetime counter which automatically stops when the system cannot handle more triggers. 2.) a very precise 1 Hz trigger (created from a GPS module). The ratio of the number of recorded 1 Hz triggers to the total duration of the run gives an efficiency of our DAQ around 88 %. The two independent methods are in good agreement (better than 0.3 %). We can thus expect that the normalization error due to the uncertainty in the absolute livetime of the experiment will be small.

One of the main strengths of the L3+C experiment is its ability to not only detect single and multiple muons, but also fully reconstruct them. This poses several challenges to the reconstruction program, in terms of matching the different track segments and the scintillator hits. An example of a fully reconstructed four muon event is shown in figure 2. This capability will be extremely useful in the analysis of the primary cosmic ray composition (Watson, 1997) at primary energies above 10^{14} eV.

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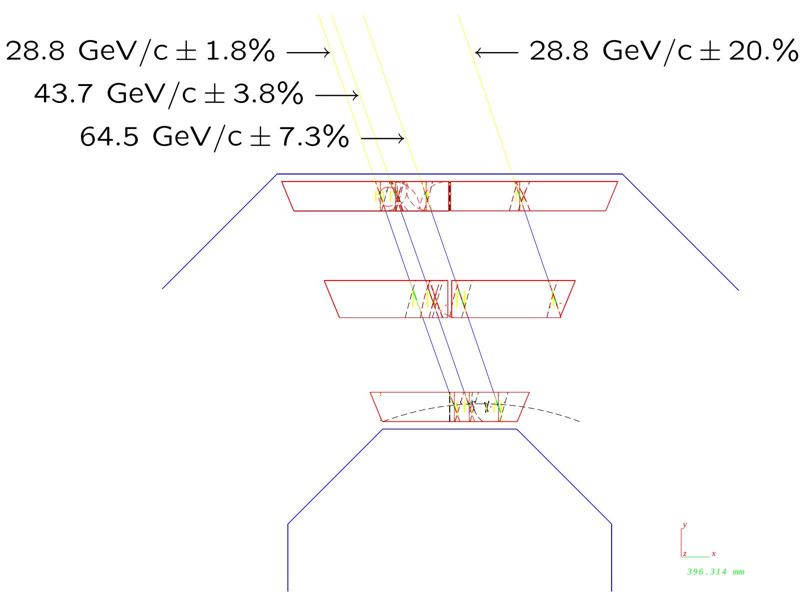

Figure 2: A four muon event.- In the three chamber layers, track segments reconstructed for all ambiguities are shown. Fully reconstructed tracks are drawn for the surviving ones only.

3 The full L3+C setup

This year, we started taking data with the full L3+C setup, consisting of a readout of the full L3 muon chamber barrel, and scintillator modules (204 m^2) on top of the top three octants, as shown in figure 1. Table 1 contains a list of some of the relevant parameters.

Acceptance	$200\mathrm{m}^2\mathrm{sr}$
Threshold	$\mathrm{E}_\mu > 15\,\mathrm{GeV}$ (> 7 GeV for a subset of data)
Momentum Resolution	$\Delta\mathrm{p}/\mathrm{p} = 3.5\%\ (45.\,\mathrm{GeV})$
(for one octant)	$\Delta\mathrm{p}/\mathrm{p} = 65\%\ (1\,\mathrm{TeV})$
Angular Resolution	$\Delta\Theta < 3.5\,\mathrm{mrad}$ above $100\,\mathrm{GeV/c}$
(limited by mult. scatt. only)	
systematic errors	$\leq$ 1%

Table 1: Parameters of the L3+C detector.

Using a GEANT simulation of the full setup, and the measured rate from the 1998 data, we estimated the total throughput requirements for 1999. The observed rate, corrected for the livetime of 94 %, is 540 Hz, close to our calculations (560 Hz). We produce about 30 million events per day, or about 5 billion events for the complete running period of 1999.

Data taking started in the first week of May 1999. During this week, the LEP machine delivered e^+ and e^- beams to the detectors at a center of mass energy of 91.2 GeV such that Z-bosons are created. Some of the resulting events contain two muons with an energy of around 45.6 GeV. We expect to have taken about 1000 such events, which will provide us with an excellent way of confirming our expected momentum resolution.

4 Summary

The amount of data we expect to get (5 billion events) will provide enough statistics to measure the muon spectrum to the 1 percent level. From the 1998 data, we conclude that the absolute normalization is under control as well. Next to the measurement of the spectrum, our ability to determine the momenta in events with several muons will help to improve our knowledge of the cosmic ray composition in the knee region of the primary spectrum. The excellent angular resolution allows us to perform searches for point sources or to record burst like signals. These searches will be helped by our ability to take data almost continuously during the LEP running period.

References

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