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First results from the L3+C experiment at CERN(*)

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Summary. — The L3+C experiment combines the high-precision spectrometer of the L3 detector at LEP, CERN, with a small air shower array. The momenta of cosmic ray induced muons can be measured from 20 to 2000 GeV/c. During the 1999 data taking period 5 billion muon events were recorded in the spectrometer. From April until mid Summer 2000 an additional 3 billion muon events have been recorded as well as 25 million air shower events. Here the first results on the muon momentum spectrum and charge ratio will be presented.

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1. – The L3+C experiment

The L3 detector [1] at CERN's LEP accelerator is located near Geneva (6.02° E, 46.25° N) at an altitude of 450 m, and is installed underground below a 30 m layer of molasse. The L3 detector has been employed very successfully since 1989 in the study of e^+e^- interactions for which the center-of-mass energy has ranged from 90 to 208 GeV.

The muon spectrometer is located inside a half tesla solenoidal magnetic volume exceeding 1000 m^3; its modular structure consists of two octagonally shaped rings each with eight "octants", see fig. 1. Each octant has 3 layers of precise multi-wire drift chambers. The outer, middle and inner layers have 16, 24 and 16 sensitive wires, respectively. These measure coordinates in the bending plane of the magnet. In addition 4 layers of drift chambers measure the coordinate along the magnetic field.

Two hundreds and two square meters of scintillators were installed outside the magnetic yoke on the face of the three upper octants. They provide the arrival time of the muons, which is needed to determine the drift times inside the chambers. An independent readout and data acquisition system has been installed, which enables data taking at all times.

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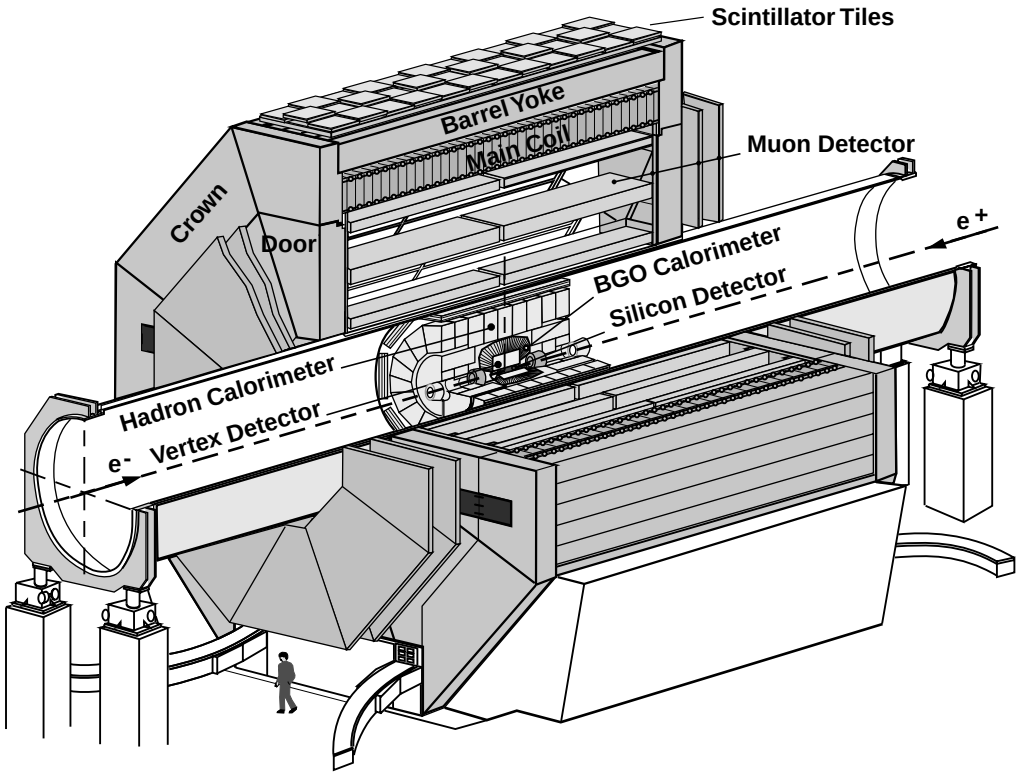

Fig. 1. – Schematic view of the L3 detector. Outside the yoke the additional L3+C scintillators can be seen.

In Spring 2000 a small air shower array was installed on the flat roof of the large hall at the surface above L3. It consists of 50 scintillator modules each with a surface of 0.5 m^2, which are distributed over an area of 30×54 m^2. The independent air shower trigger has an energy threshold of about 10 TeV and is fully efficient above a shower energy of 100 TeV. Trigger signals are exchanged between the two independent DAQ systems, which enables an offline merger of the two data streams.

The L3 muon spectrometer together with the scintillators on the magnet and the air shower array constitutes the L3+C experiment [2].

2. – Performance and data taking

The molasse layer provides a shield against the electro-magnetic and hadronic components of the air shower. It also imposes a muon momentum threshold of 15 GeV/c and limits the angular resolution to 0.2° at 100 GeV/c.

A double momentum measurement (one in the top half and one in the bottom half of the detector) enables the determination of the resolution, which at 100 GeV/c was found to be 7.4%. In addition, the momentum measurement, resolution and detector efficiency have been checked using the yearly LEP calibration runs, where a few hundreds ${}^{+}e^{-} \to Z^0/\gamma \to \mu^{+}\mu^{-}$ events were recorded. For these events the muon momentum is known to be 45.6 GeV/c.

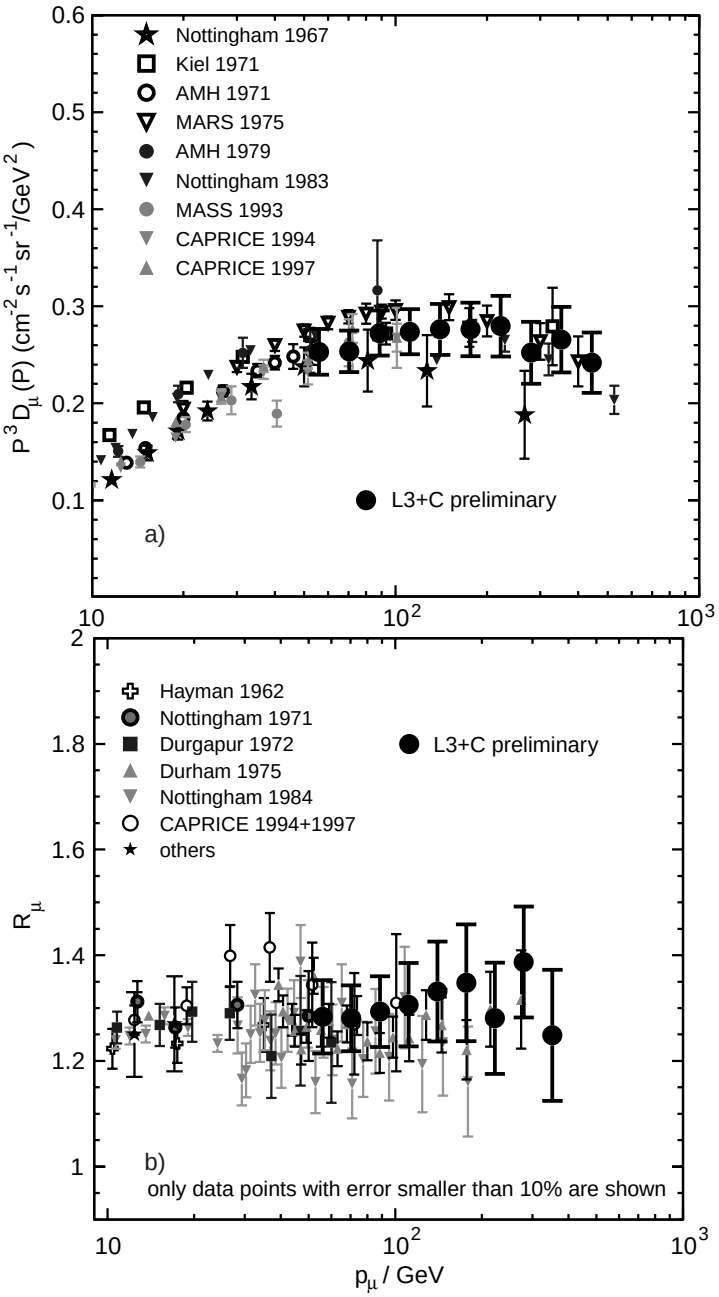

Fig. 2. – The very first results from the L3+C experiment. a) The flux of atmospheric muons weighted with p^3 as a function of momentum p. b) The muon charge ratio as a function of momentum.

The energy resolution of the air shower array is expected to be 30% for events with the core inside the array. The zenith angle can be determined using the arrival times of particles in the individual scintillator modules. An accuracy of 1°–2° is expected.

The dedicated data taking with the muon spectrometer started in 1999. From May to November a total of five billion events were recorded. The total number of events is expected to be more than 10 billion by the end of 2000. The air shower array has been fully operational since April 2000, and by early July a total of 25 million air shower events have been recorded. About 30% of these showers are accompanied by muon(s) in the spectrometer.

Data taking of the L3+C experiment will stop with end of the LEP program, which is scheduled for November 2000.

3. – Very first results

Data from September to November of 1999 were used to determine a first muon momentum spectrum from 50 to 500 GeV/c. The total lifetime used was slightly more than 30 days. Strict quality cuts have been applied, among others, to achieve a good momentum measurement in both upper and lower octant. The zenith angle has been restricted to a range from 0° to 10° to measure the vertical flux. The measured flux weighted by p^3 can be seen in fig. 2a together with the results of other experiments [3]. The systematic error of 9% dominates the total error plotted in fig. 2a. In the future we hope to reduce the total error to 2.5%.

The charge ratio was calculated from the same event sample. In fig. 2b the preliminary result can be seen along with the results of other published measurements [3]. With the small sample used for the analysis up to now the statistical error is dominant at high momenta.

4. – Conclusions

A new type of cosmic ray detector, L3+C, combines air shower data with precise muon measurements. First preliminary results on the muon spectrum and charge ratio in the range from 50 to 500 GeV/c have been presented. A substantial reduction in the statistical and systematic errors is expected in the future.

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We acknowledge with appreciation the effort of the engineers, technicians and support staff who have participated in the construction and maintenance of this experiment.

REFERENCES

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