Cosmic Rays with the LEP detectors

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This talk covers abstracts 316 and 590:

Results from the L3+C experiment

Cosmic multi-muon bundles detected by DELPHI

The following topics are discussed:

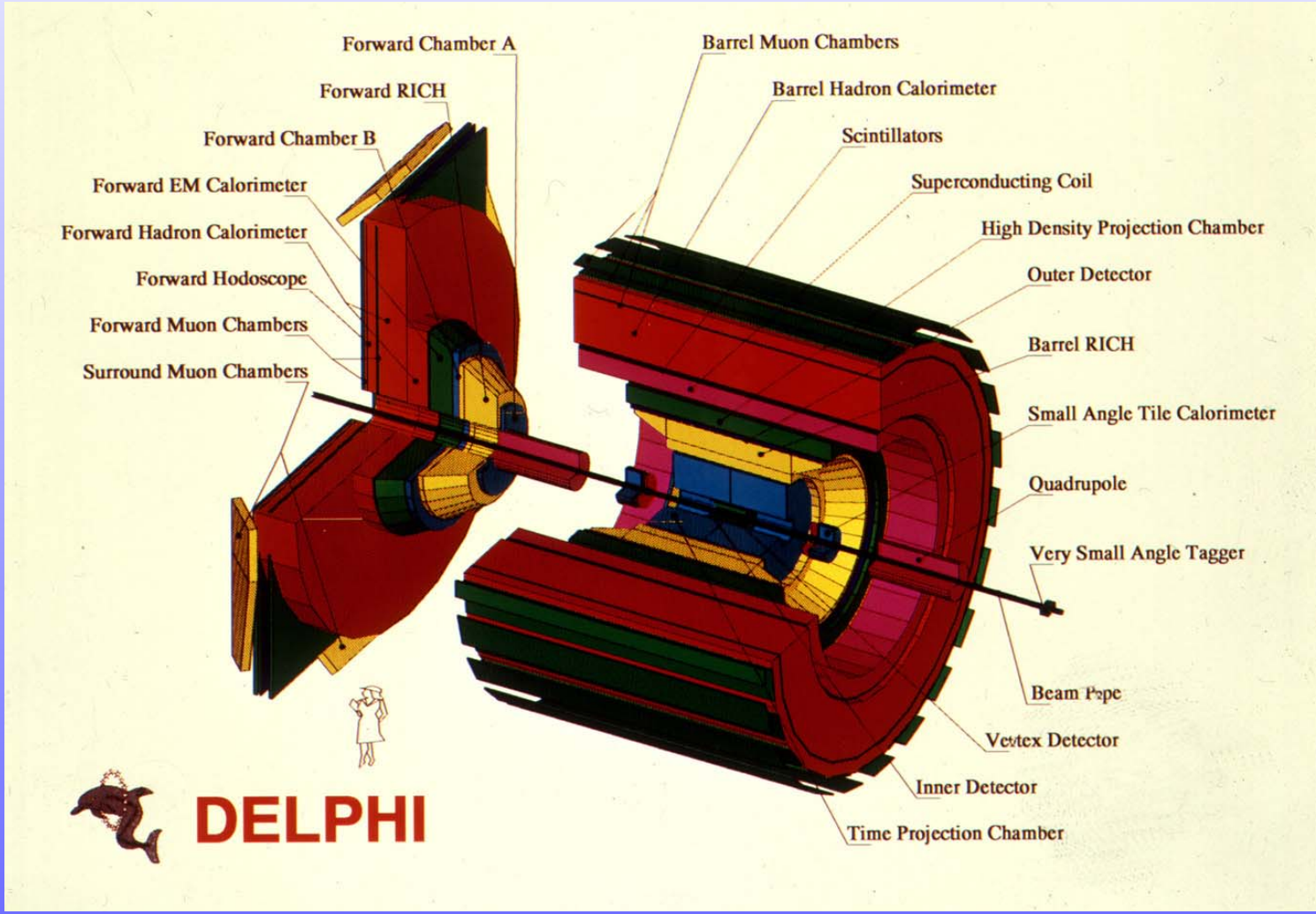
The vertical muon spectrum and charge ratio

The zenith dependence of the muon spectrum and charge ratio

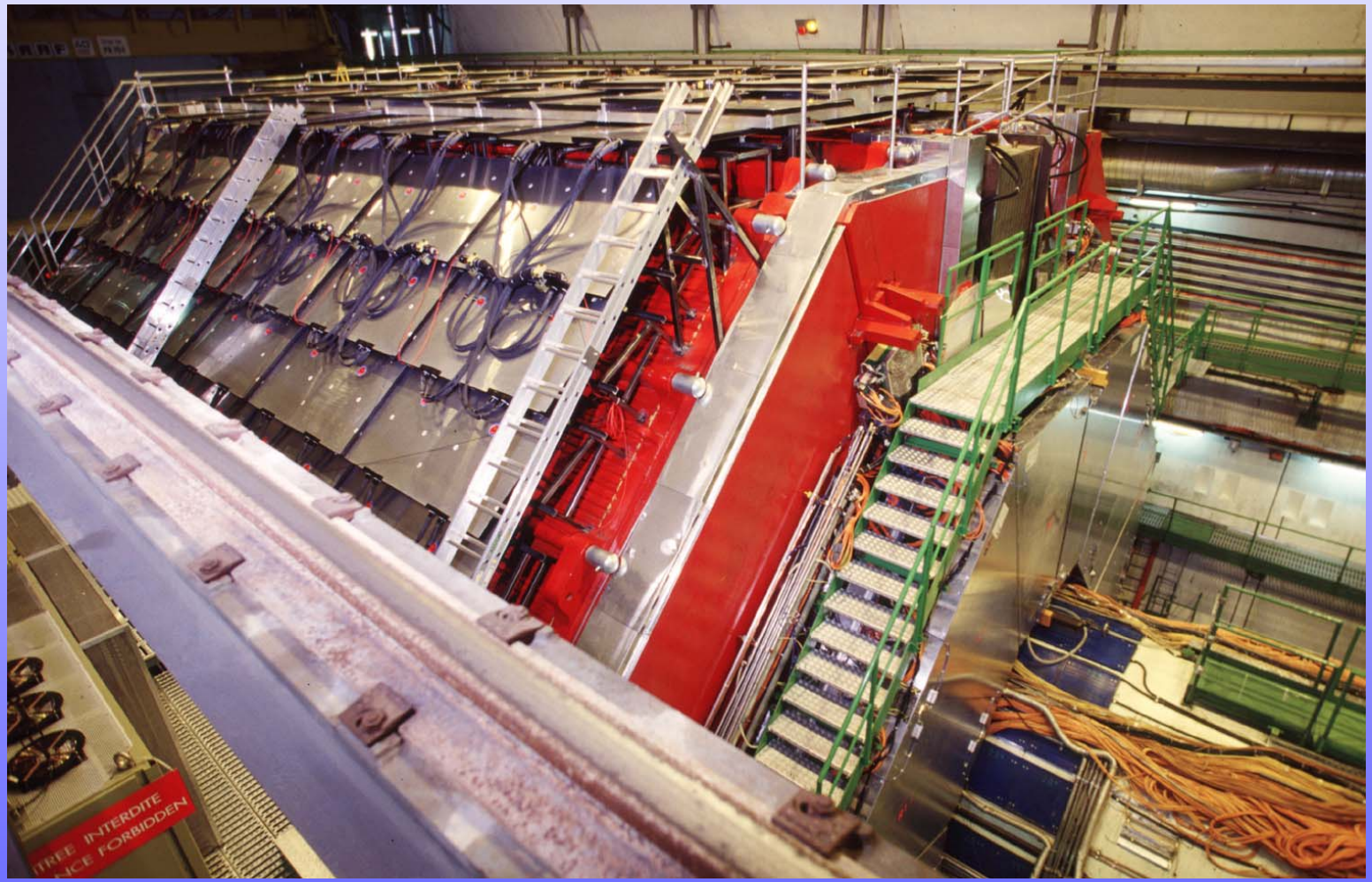
Muon multiplicities and the composition of the primary

Other topics are also studied by the LEP detectors (L3+C, ALEPH and DELPHI) (long range correlations, point sources, etc), but these are not reported here.

The Detectors



The Detectors



Properties

L3+C

P > ~ 15 GeV

High precision drift chamber in B-field (0.5 T)

Dedicated DAQ

12 10^9 events

DELPHI

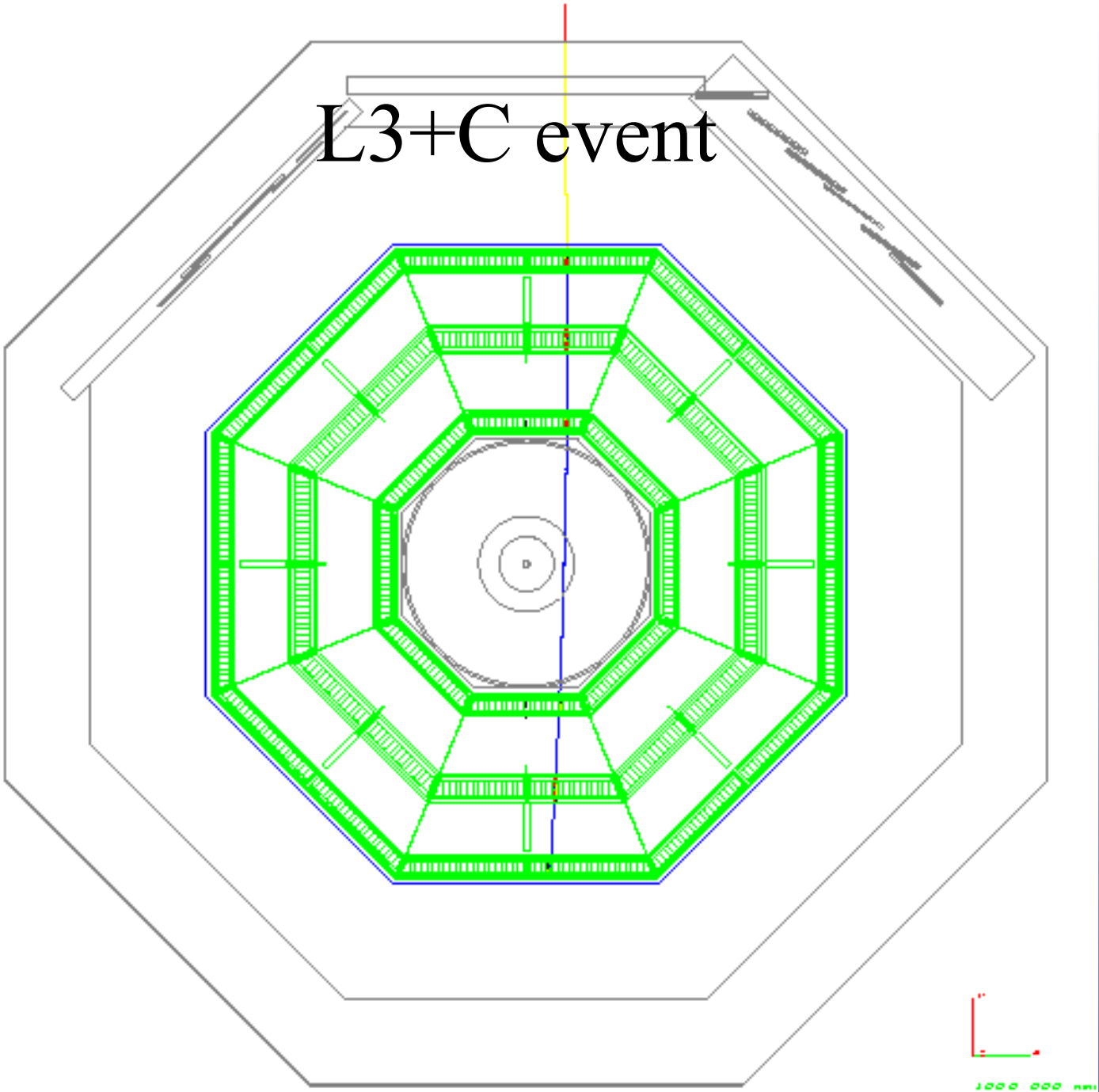
P >~50 GeV

Fine granularity HCAL

Cosmic trigger in standard readout

90K multi-muon events

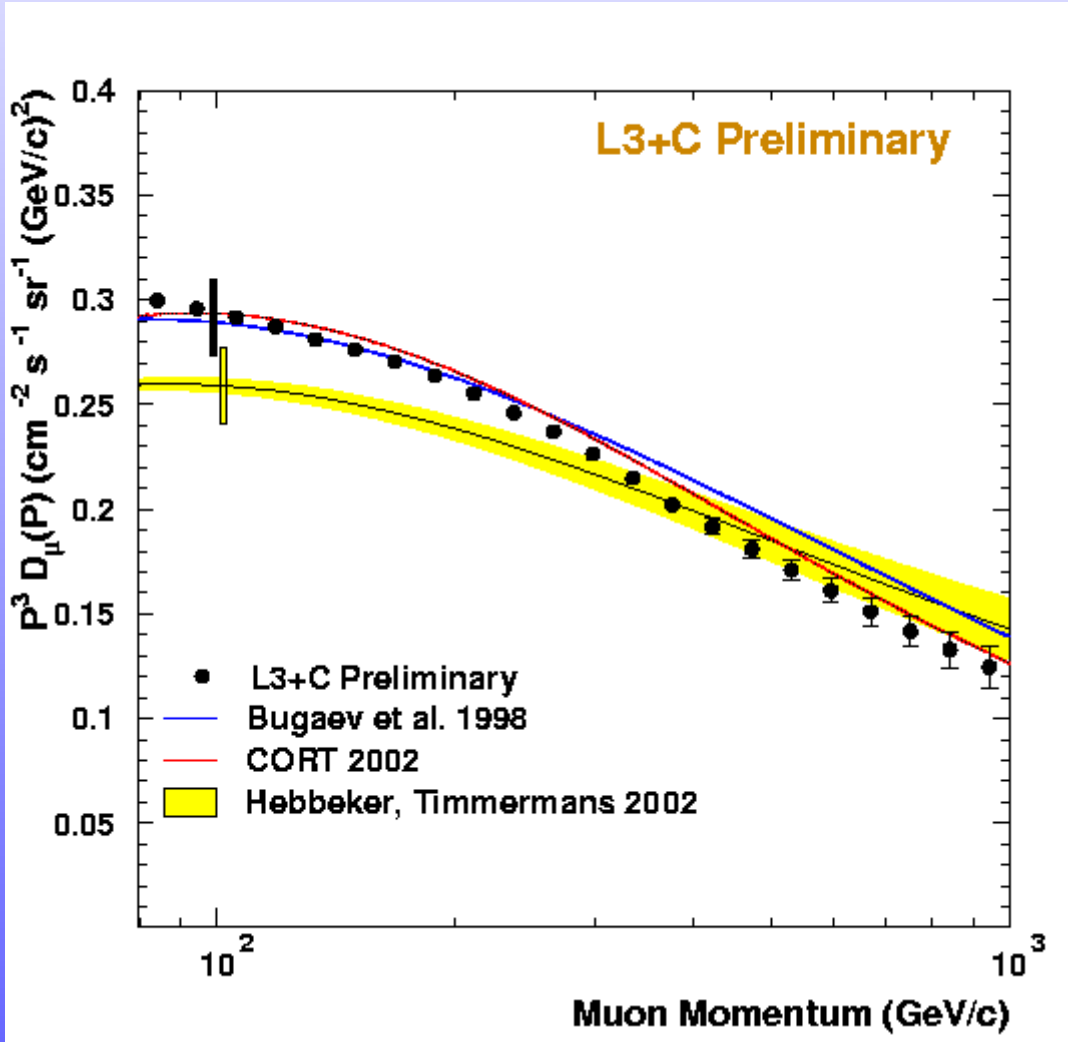
L3+C event



The Muon Spectrum

An absolute measurement of the muon spectrum is one of the main inputs to the neutrino spectrum. L3+C offers an absolute measurement between 80 and 1000 GeV. A range not well covered by other experiments.

The vertical spectrum

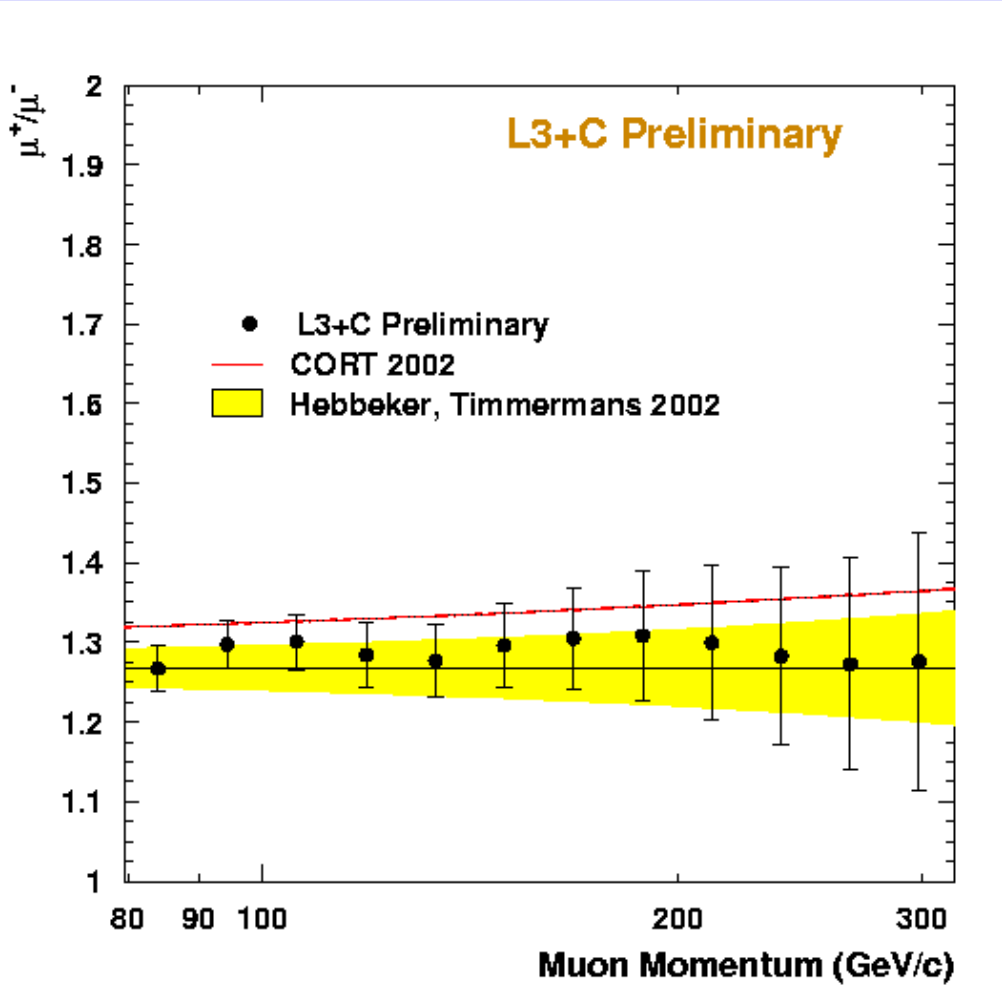


Lower limit: uncertainties in understanding overburden.

Above 200 GeV: shape depends on understanding the momentum resolution

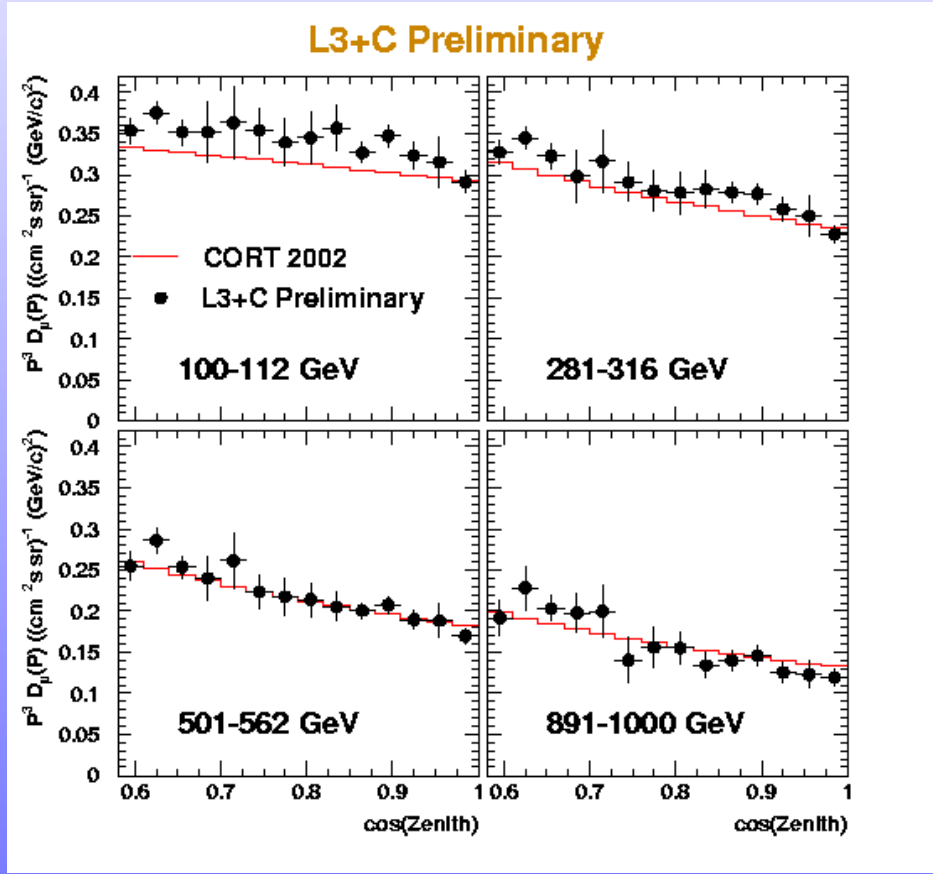
Momentum dependence of detector response and reconstruction effects are being studied.

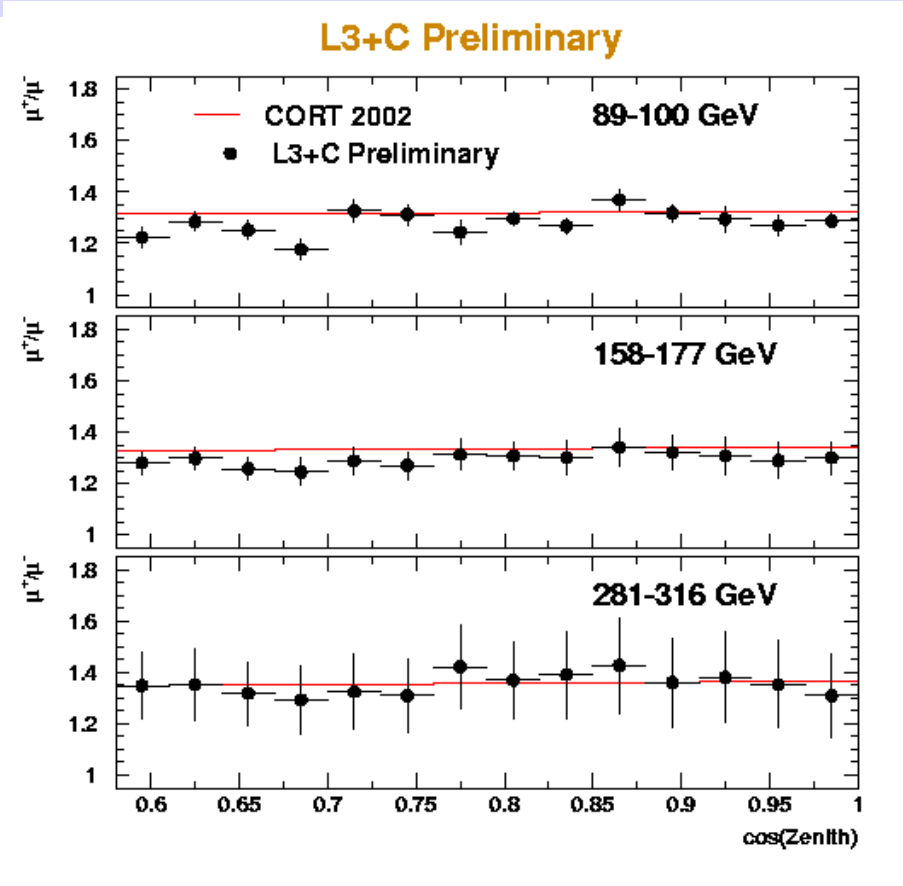
The Charge Ratio



Above 300 GeV uncertainties in understanding the alignment limit this measurement

Zenith dependence



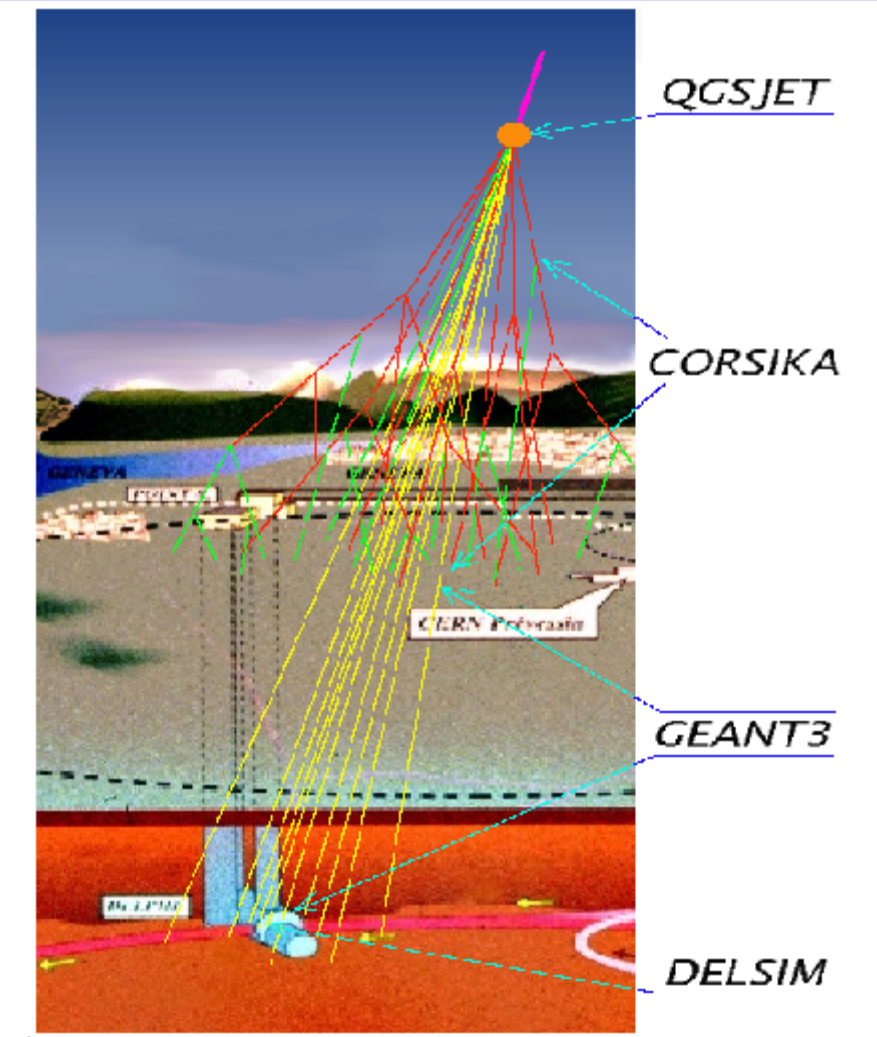


Muon Multiplicity Study

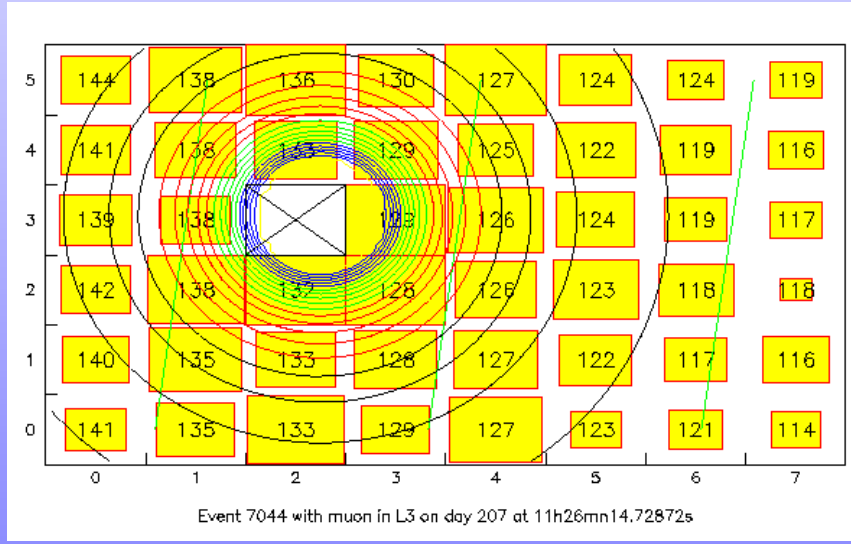
The muon density depends on the primary composition and energy. These are hard to disentangle. L3+C combines the muon measurement with an air shower array for part of 2000.

DELPHI has a better detector for counting the muons, as these are followed through HCAL.

Simulation Setup

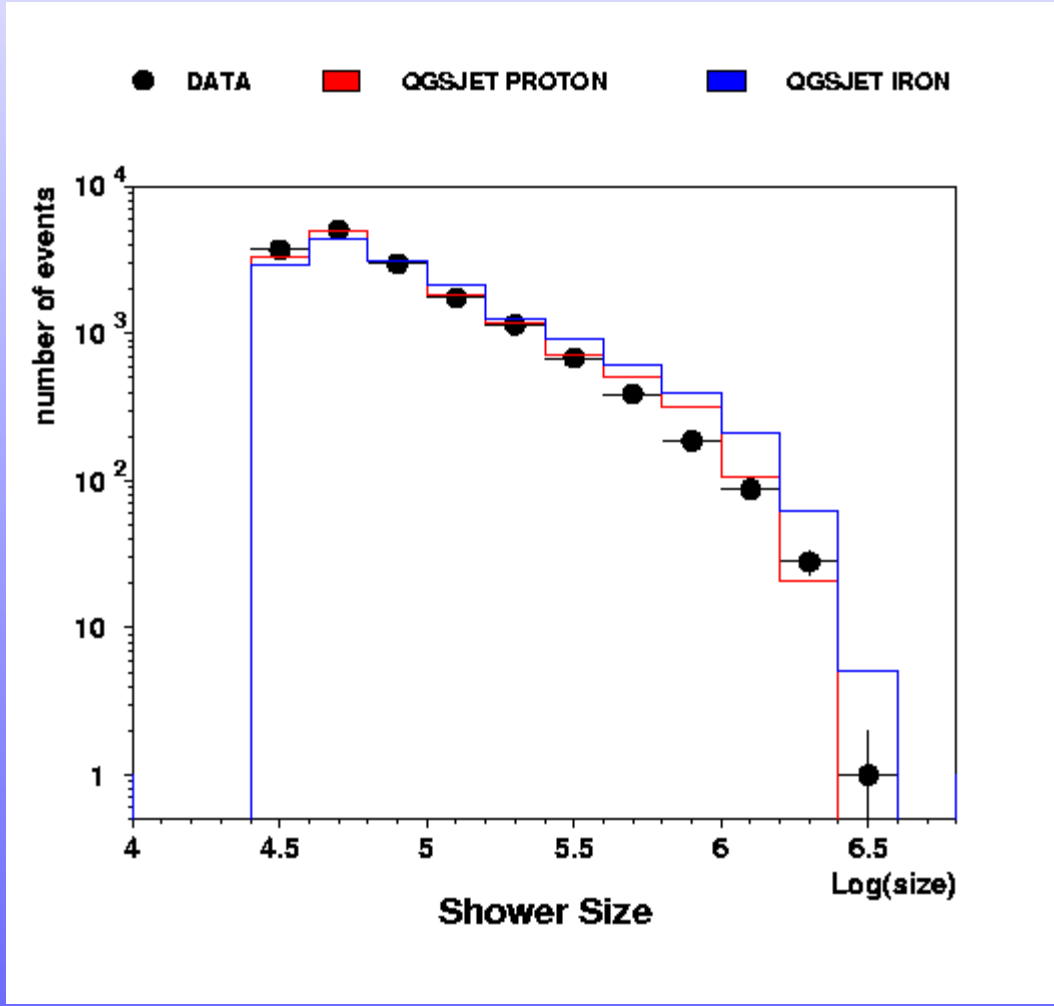


L3+C air shower setup



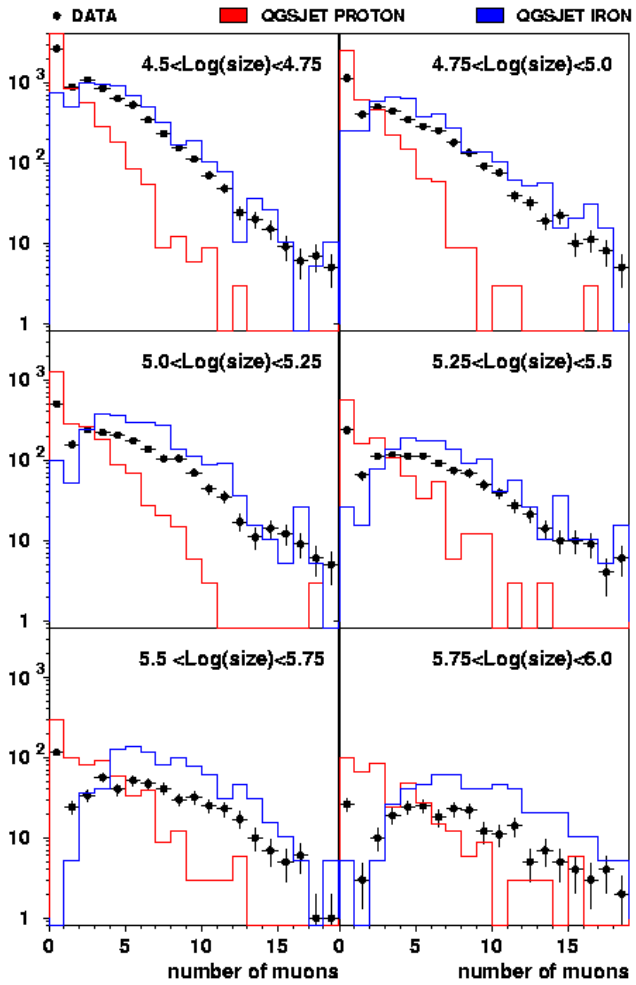
Reconstructed EAS-event

Shower Size



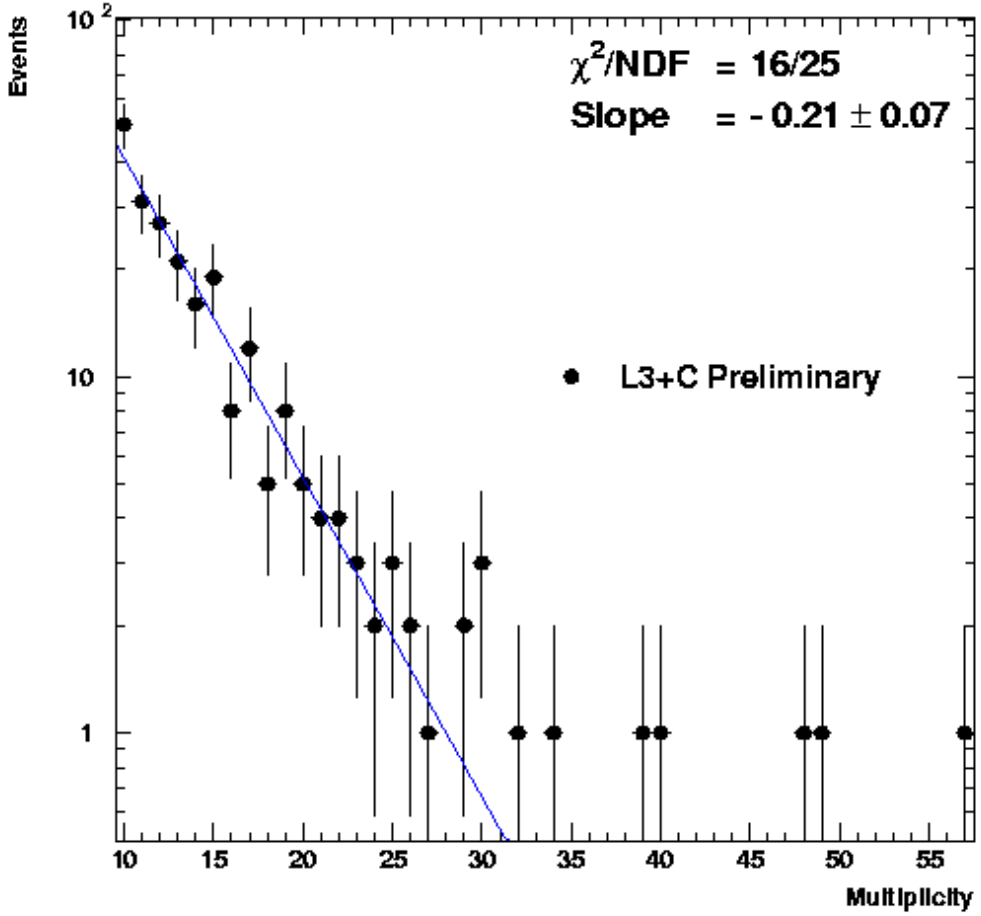
The shower size distribution is well described by protons.

Multiplicity vs Shower Size

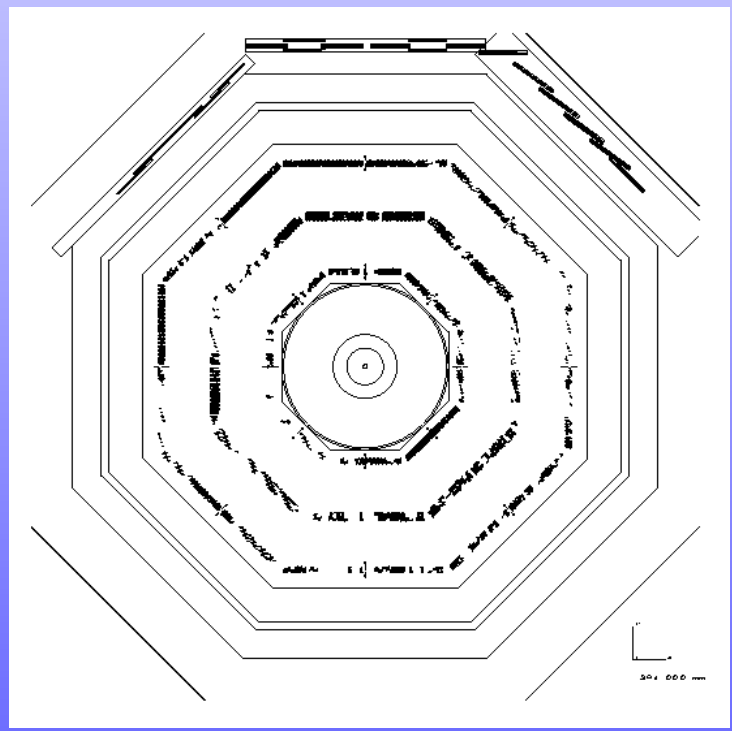


However, simulations of the muon multiplicity show that the data is not easily interpreted. The simulations underestimate the number of muons in the detector, even for relatively low multiplicities.

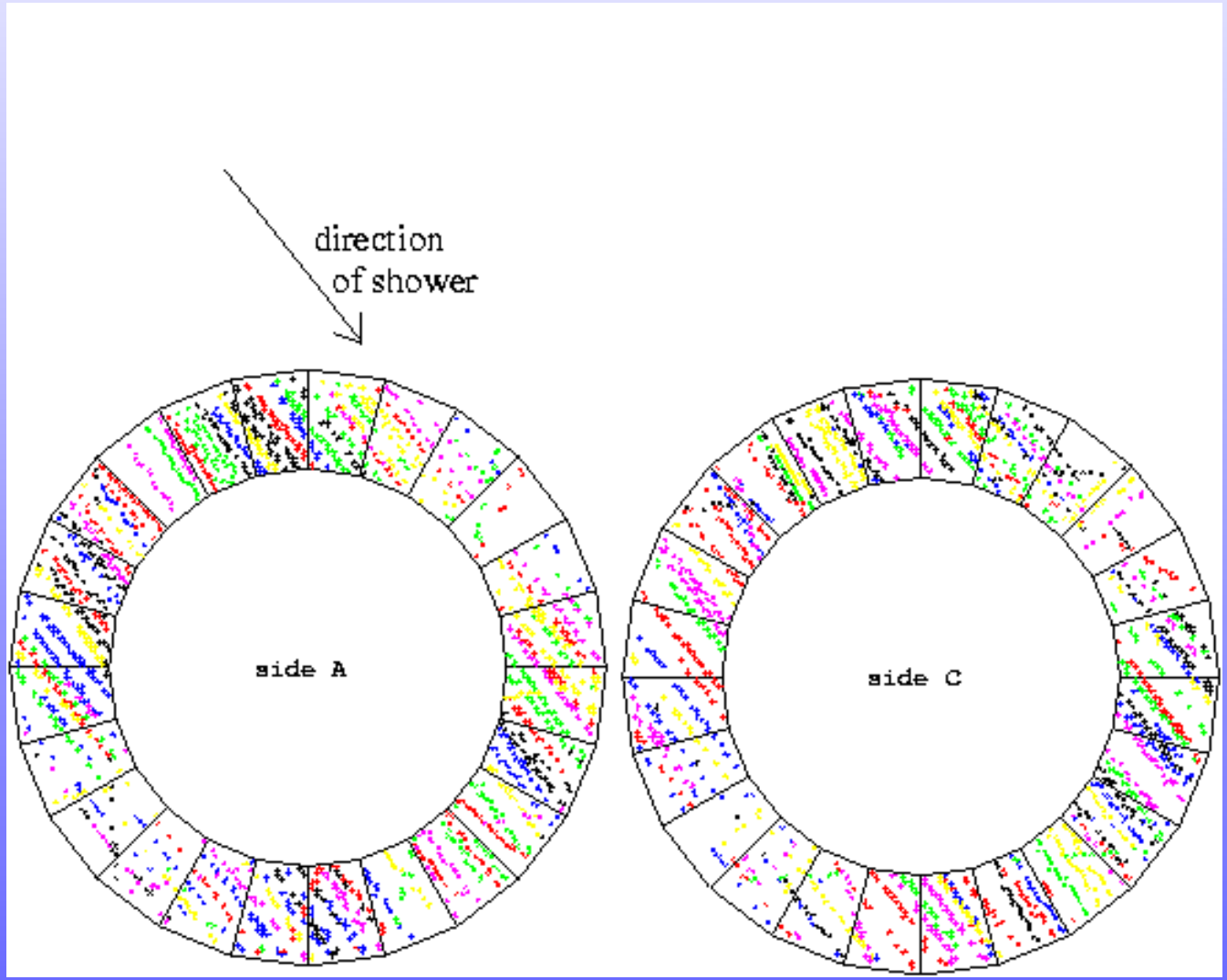
Higher multiplicities



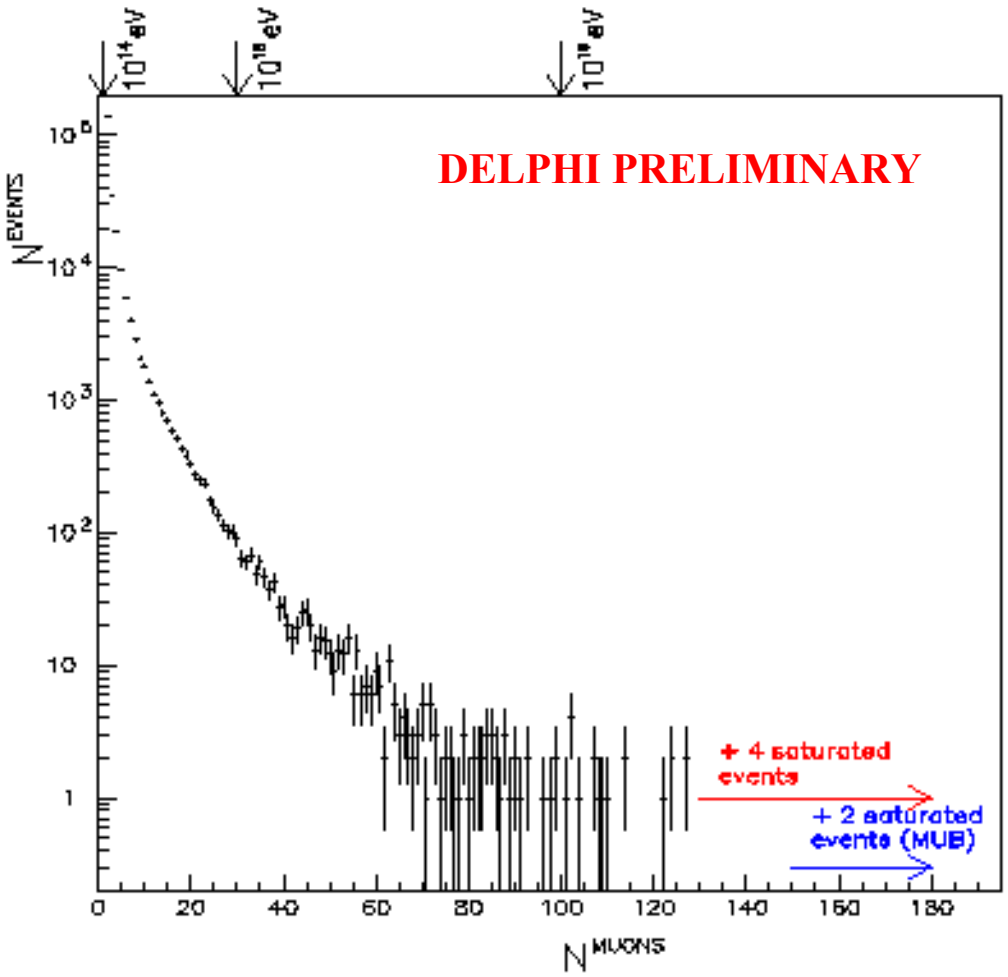
L3+C has problems in counting, and relies on manual scanning.



DELPHI event



Multiplicity



$N_\mu >$ 3: 89991 events

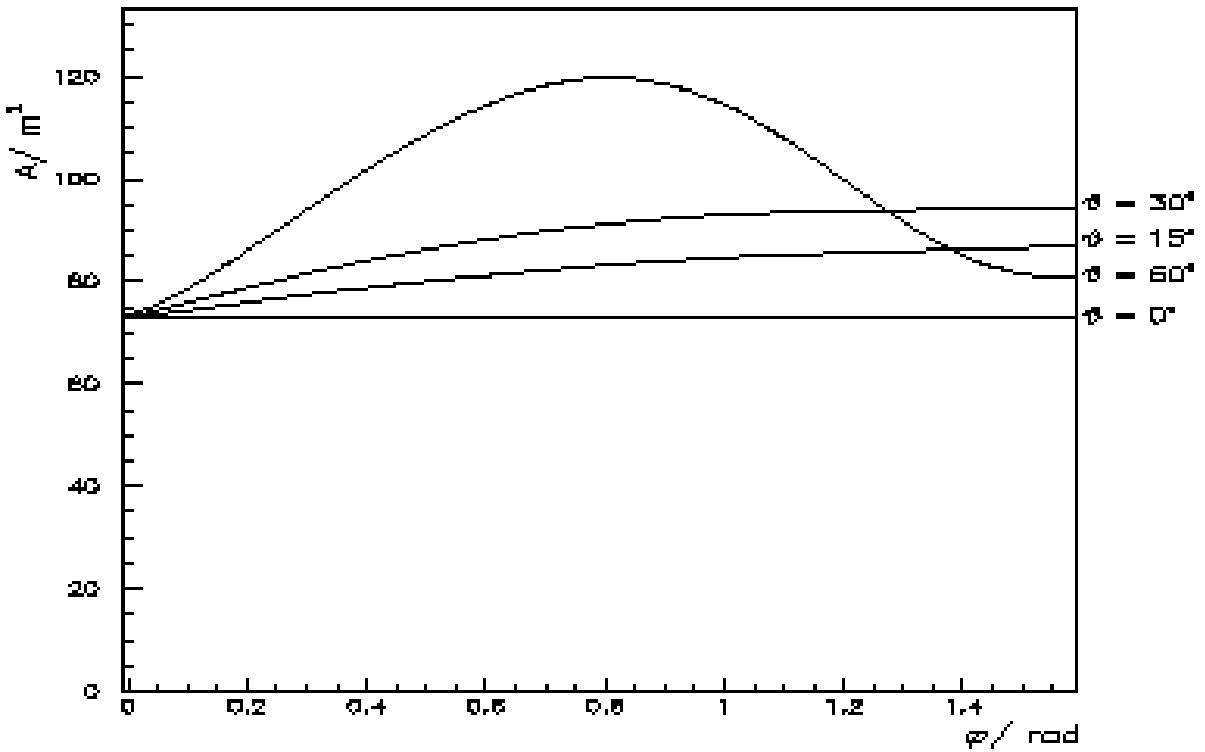
$N_\mu \geq 30$: 1065 events

$N_\mu \geq 70$: 78 events

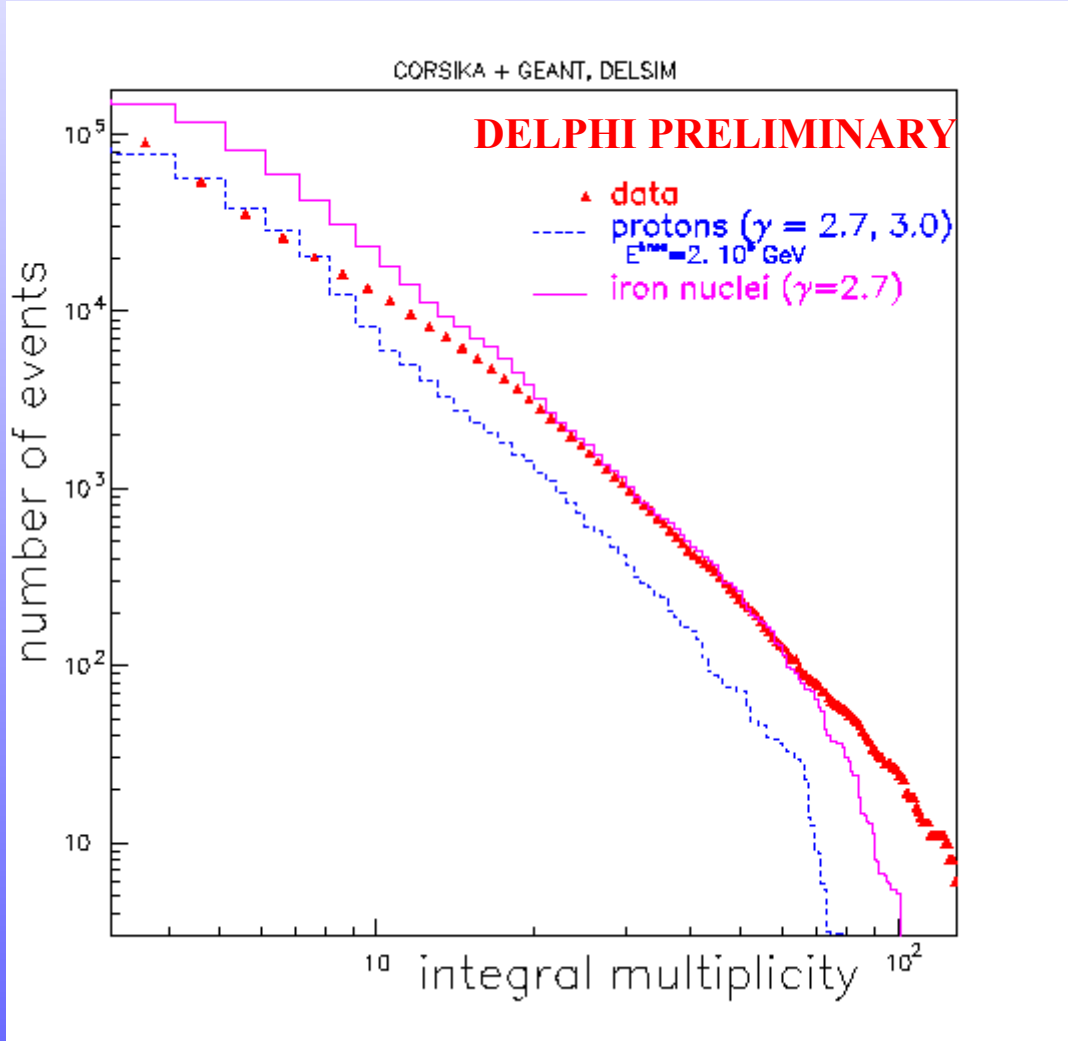
$N_\mu \geq 100$: 24 events

Detection Area

$$A > 73\ m^2$$



Comparison to simulation



The MC results are normalized to the live time of the experiment

Conclusions

1. New results on the muon spectrum and charge ratio have been presented.
2. These results are well described by current calculations.
3. The measured muon multiplicity distributions are not well described by current models. DELPHI shows that there are problems at high multiplicities, L3+C has problems already at modest multiplicities.
4. Both DELPHI and L3+C are still working on the analysis of the cosmic ray induced muons.