Cosmic multi-muon bundles detected by DELPHI

P. Travnicek, J. Ridky for DELPHI collaboration

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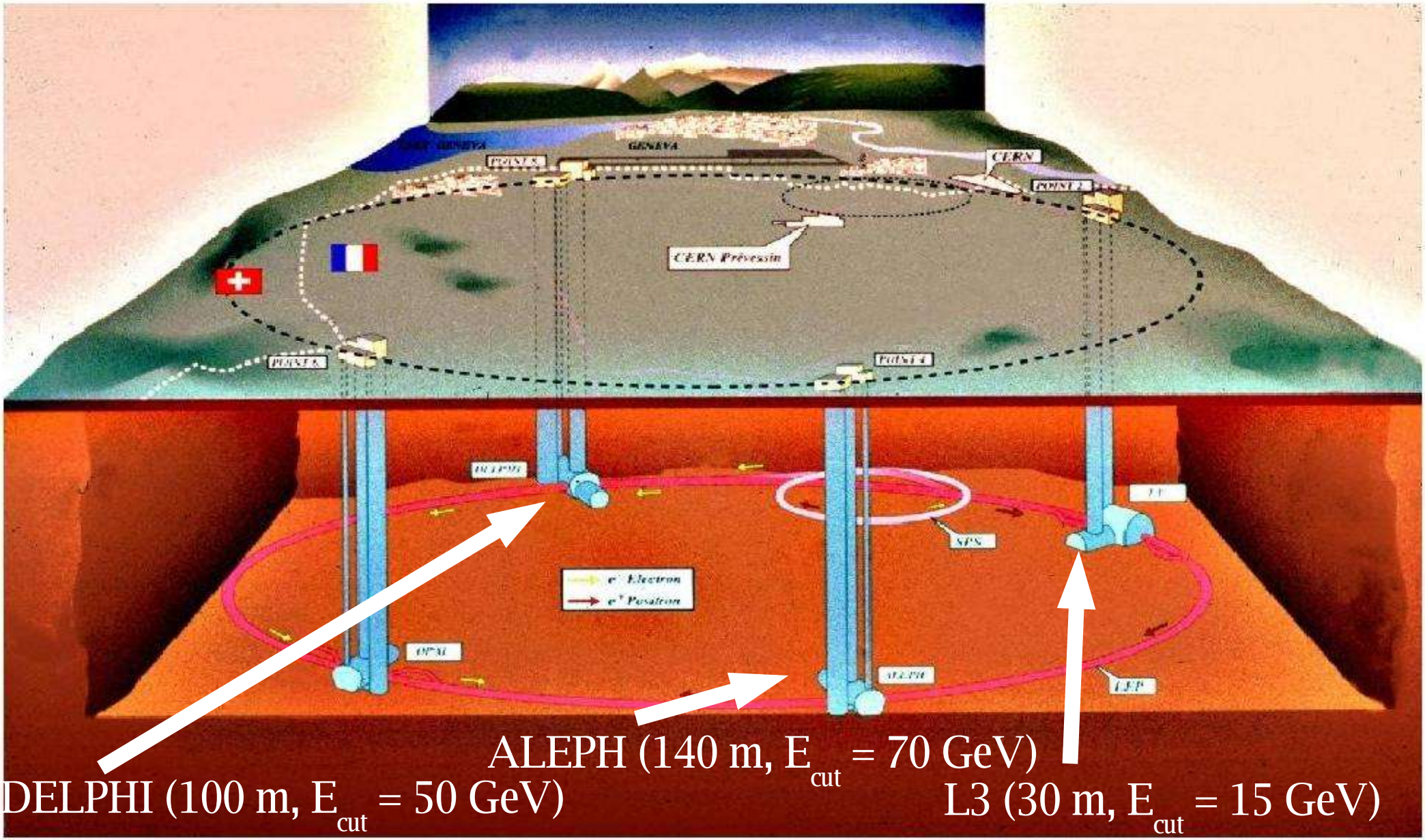
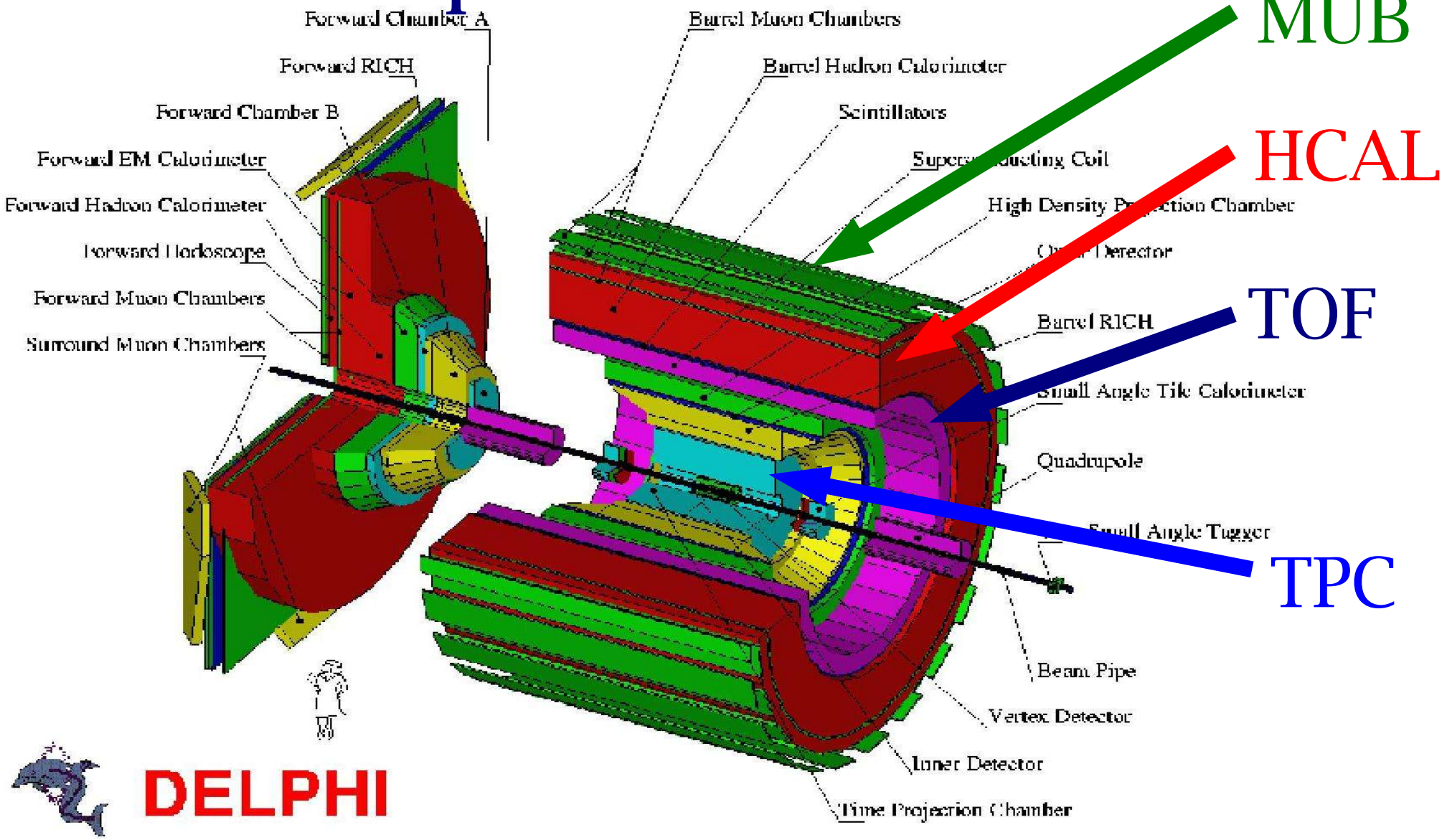
Outline

- Detection of CR by LEP experiments
- DELPHI detector
- DELPHI trigger of CR
- Data sample
- MC simulation
- Results
- Conclusion

Detection of CR by LEP experiments



Delphi detector

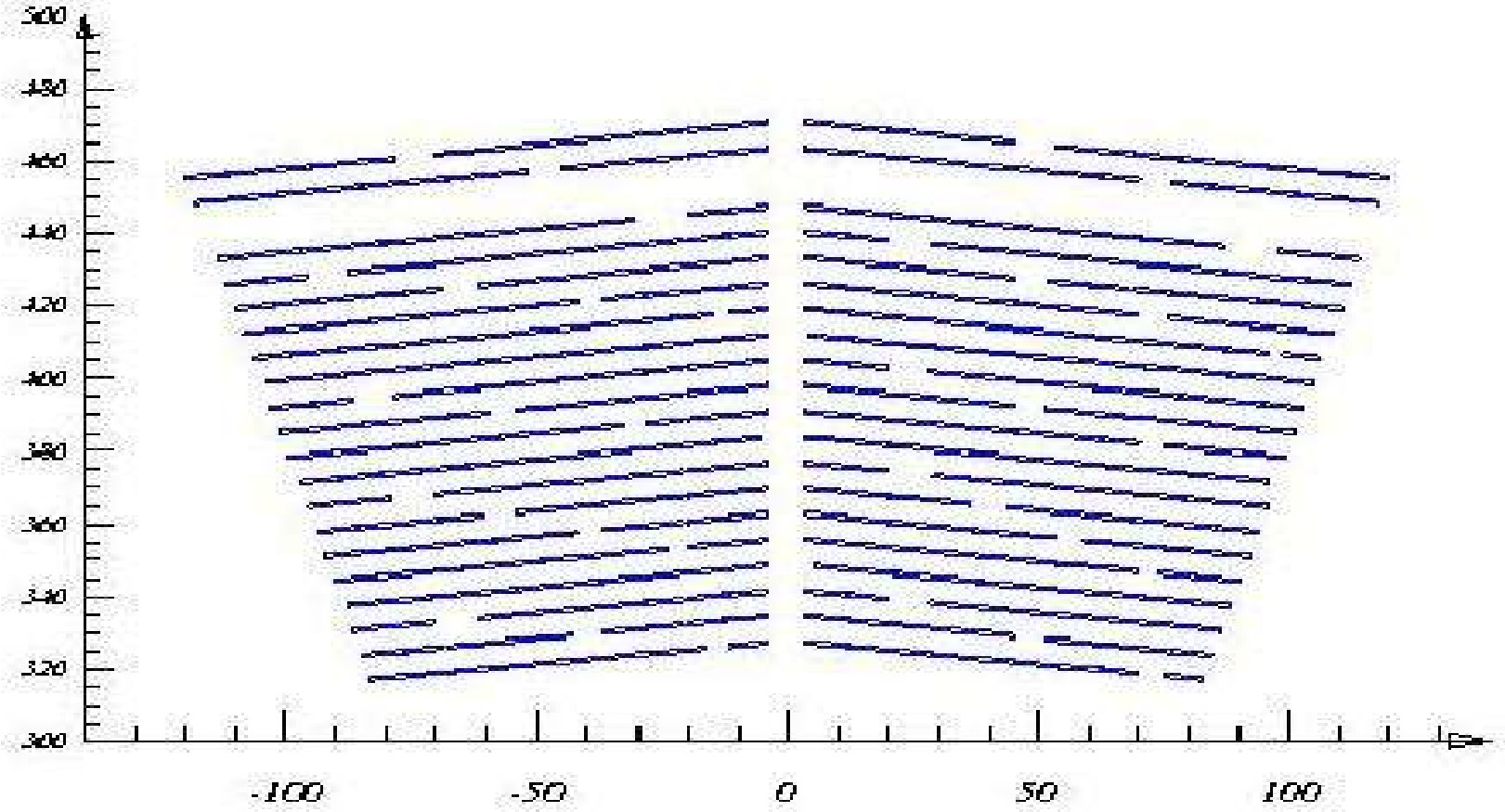


DELPHI

Hadron calorimeter barrel module

Sensitive units - streamer tubes

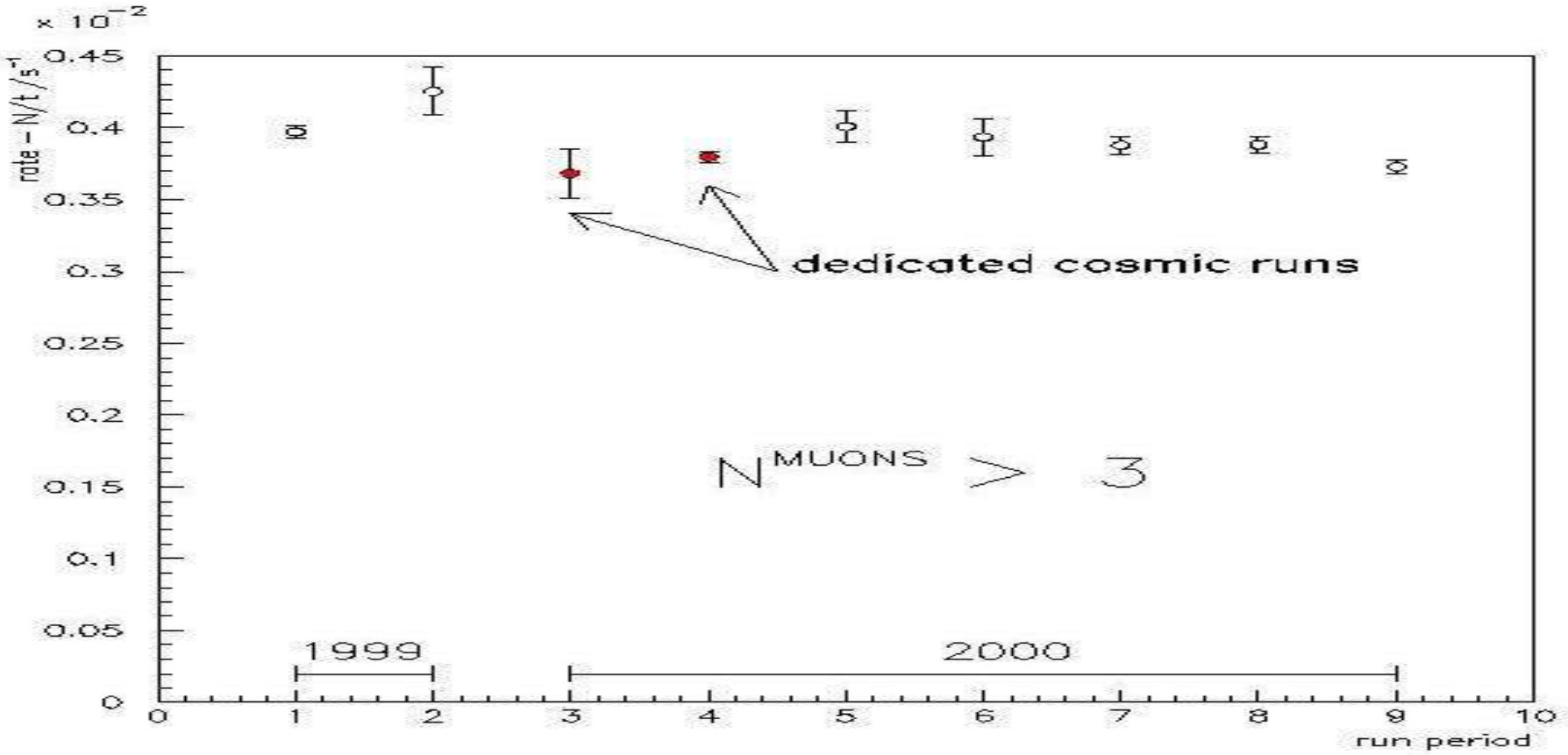
1 tube has x-section 8 ✗ 1 cm in (x,y) plane



Read-out only YES or NO, length of a tube in barrel part 350 cm

DELPHI Cosmic Trigger

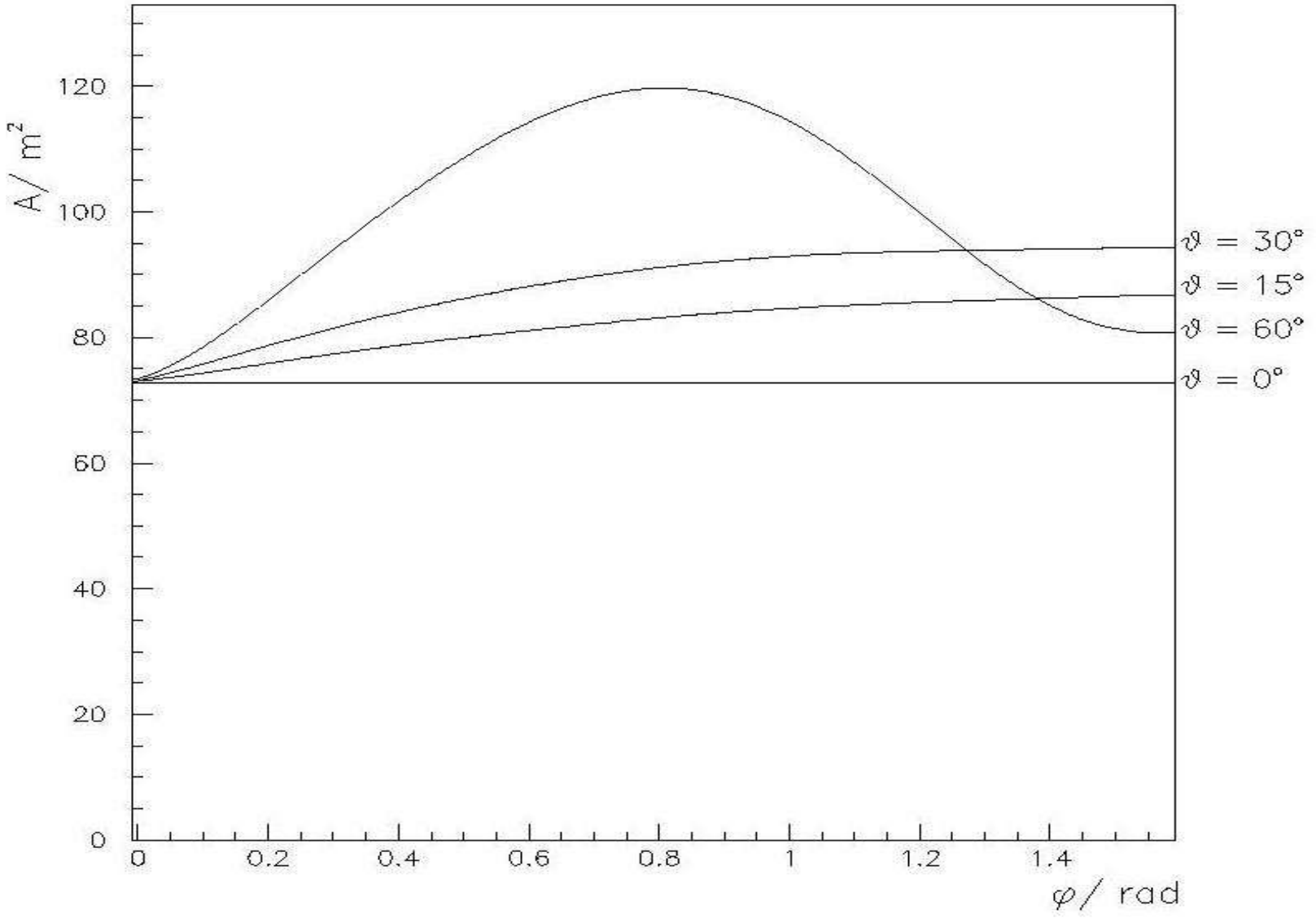
Defined as TOF-MJ3 (coincidence of 3 counters) , parasitic mode: e^+e^- data taking simultaneously with cosmic data, several dedicated cosmic runs



Duty cycle ≈4/22 ≈18 %, running time 8.7 10^6 s

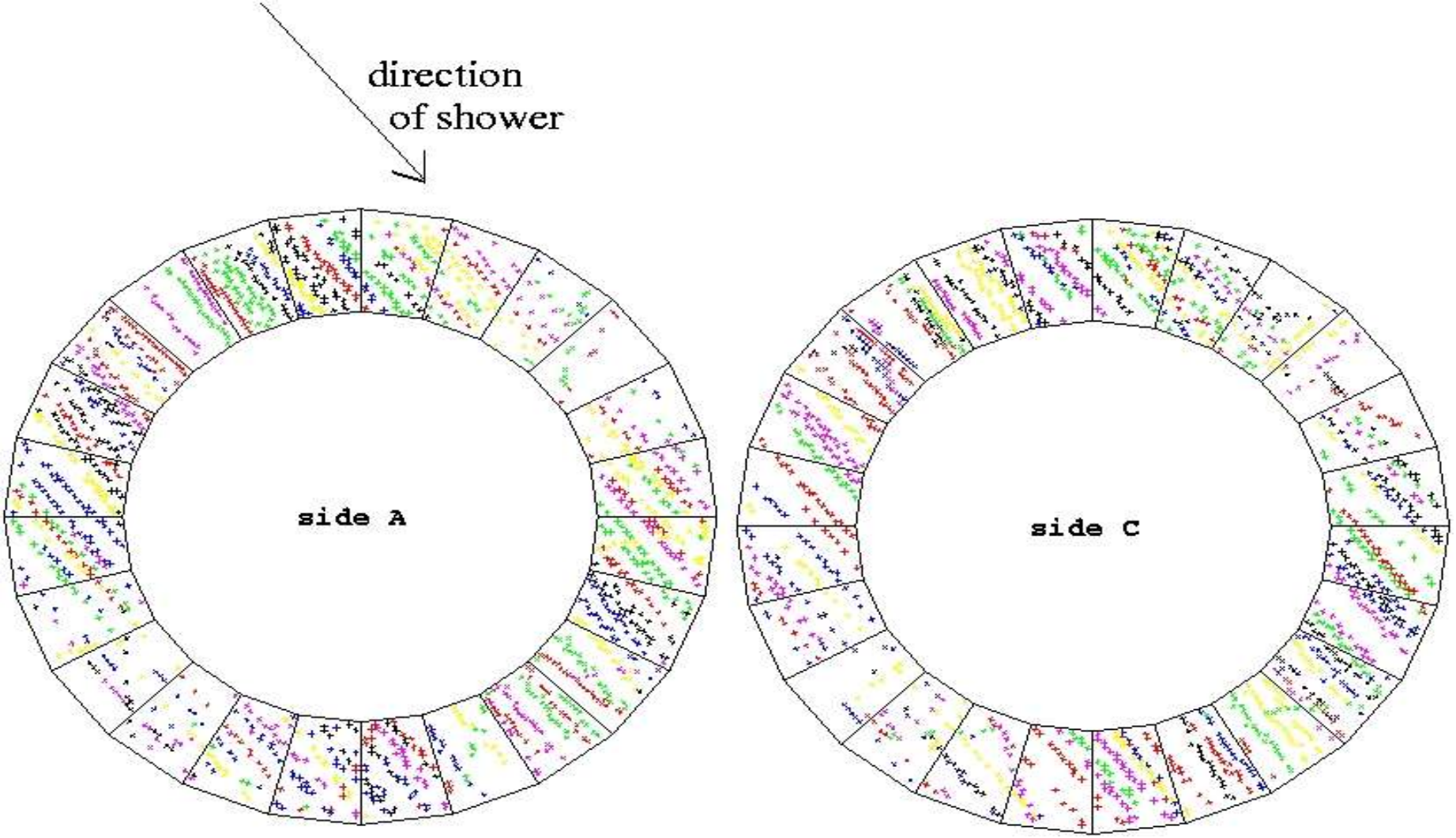
total live time ≈1.6 10^6 s

Detection area

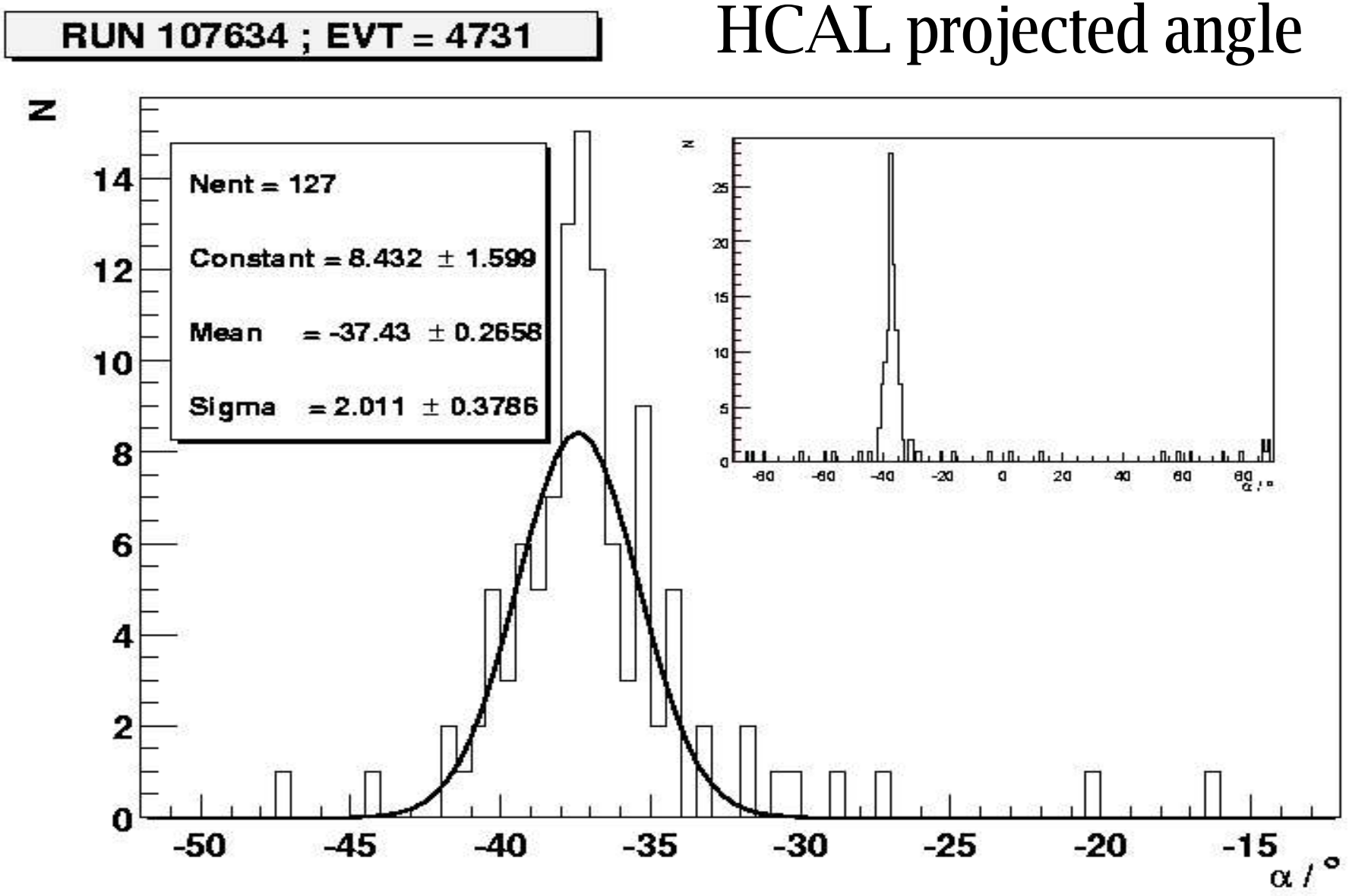


$A > 75\ m^2$

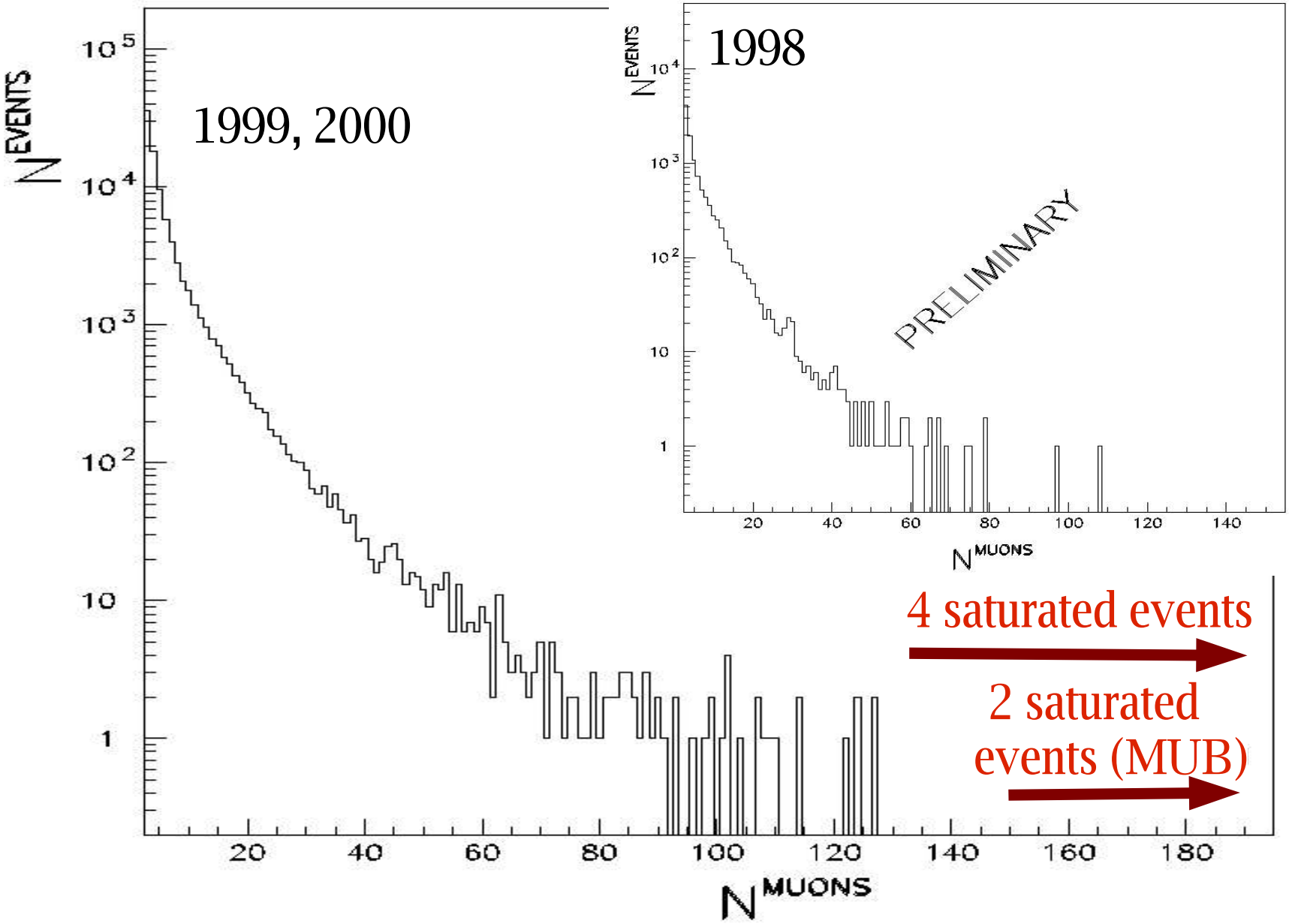
Example of reconstructed event



Example of reconstructed event



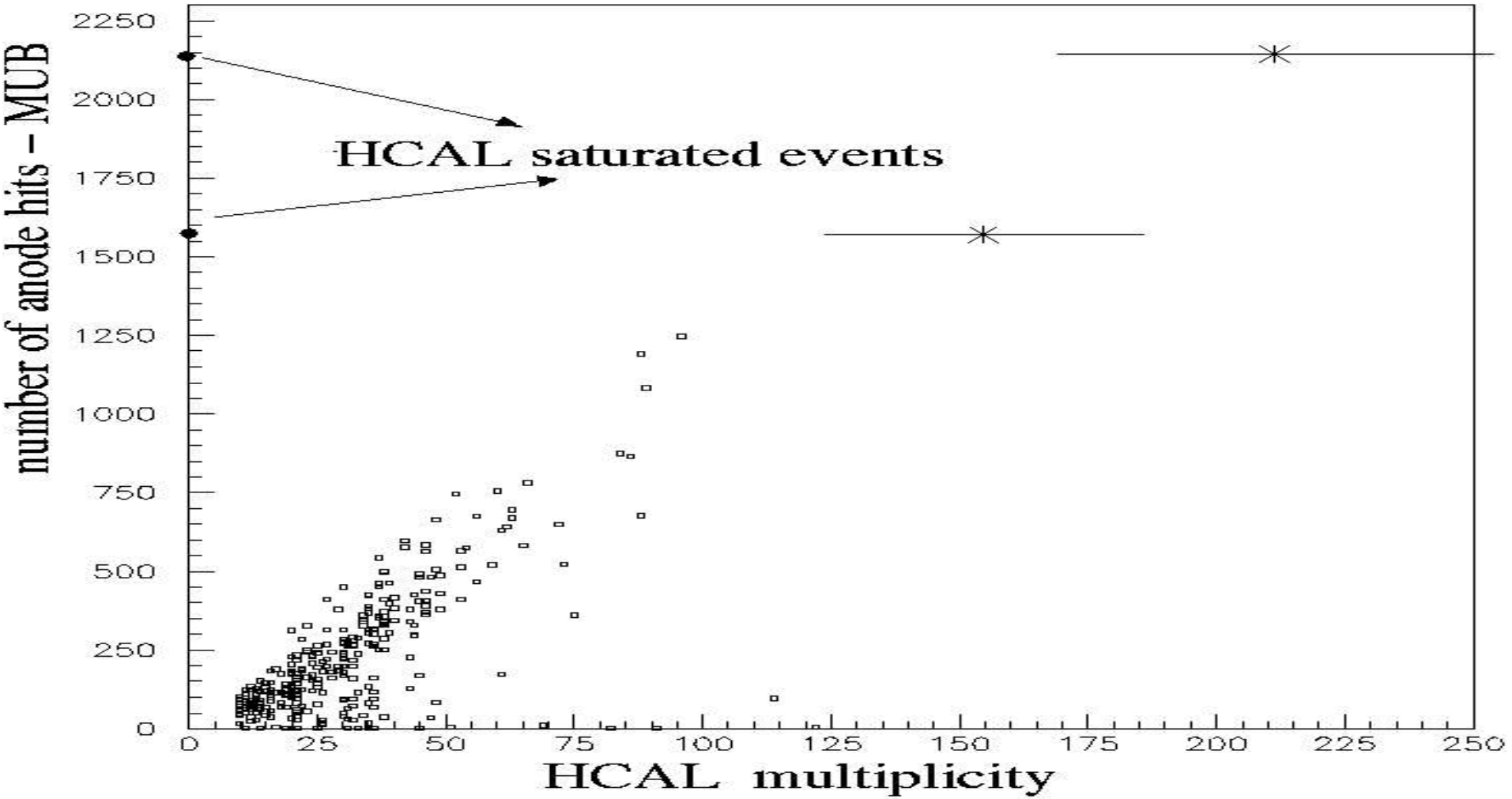
Muon multiplicity distribution



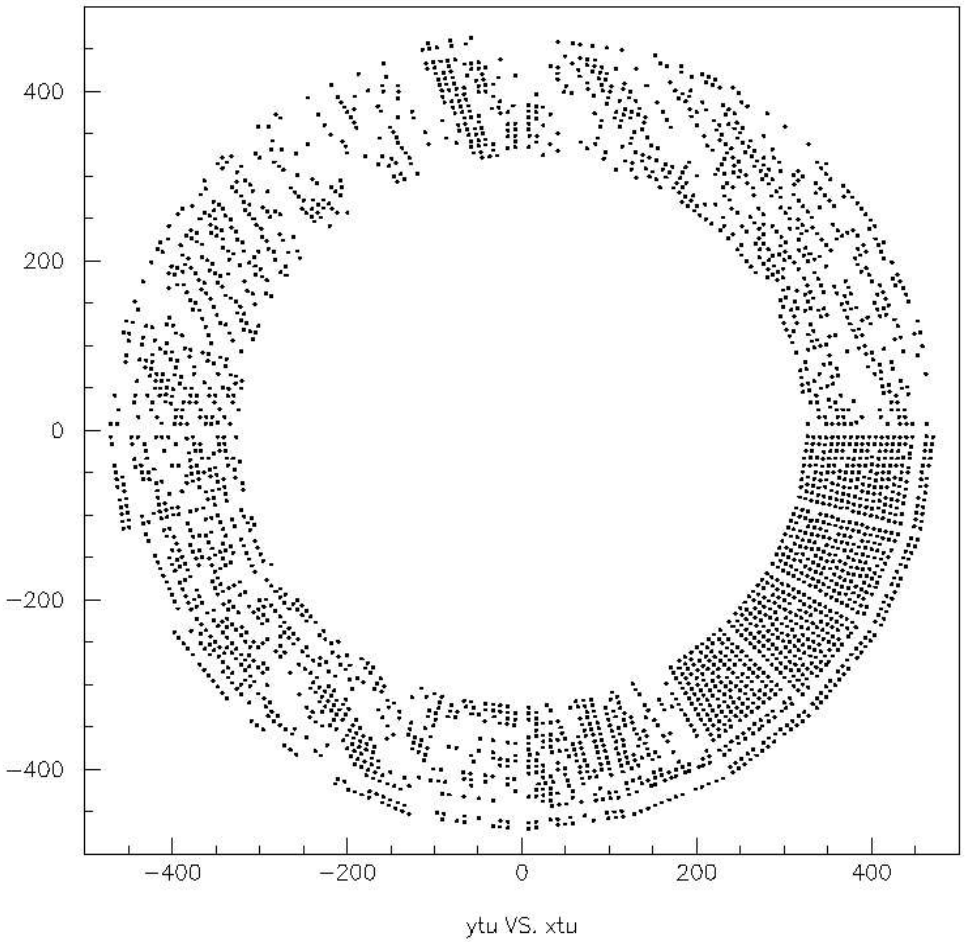
Saturated events

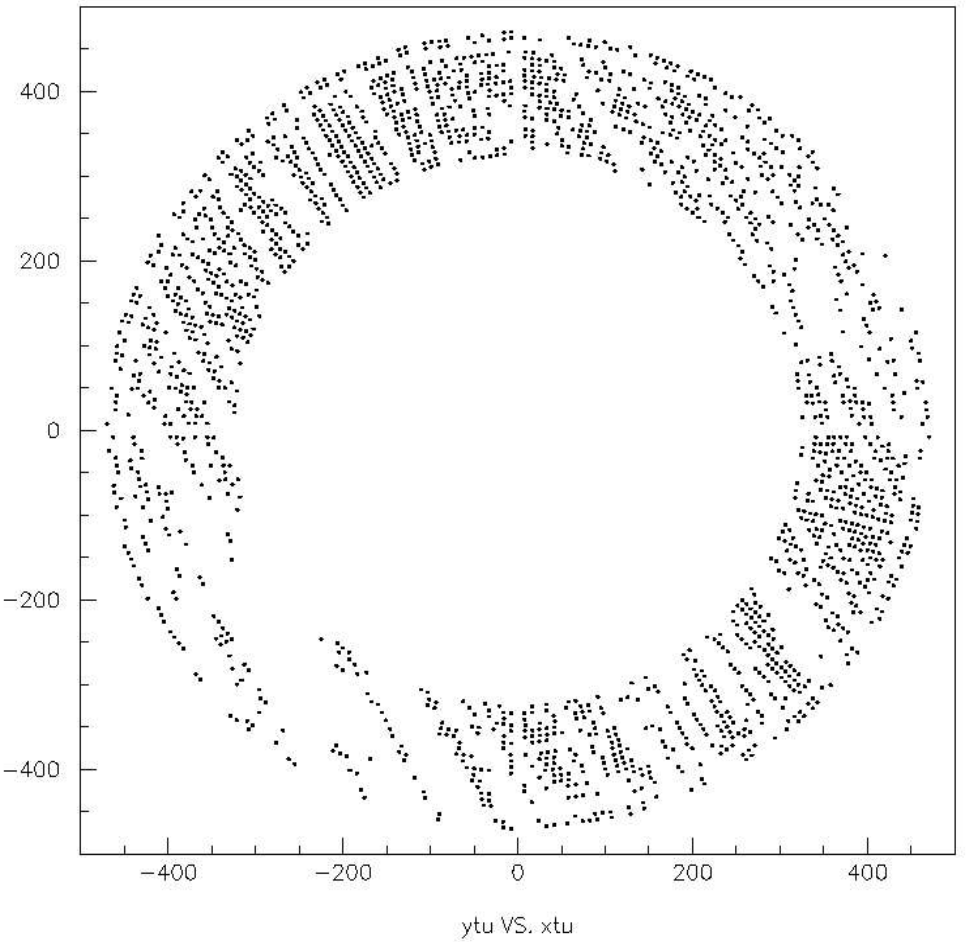
- too many hits to reconstruct all muon tracks
- 6 events to be of cosmic origin – parallel lines of vacancies
- ⇒multiplicity > 127

  events with additional information from MUB ⇒multiplicity >150



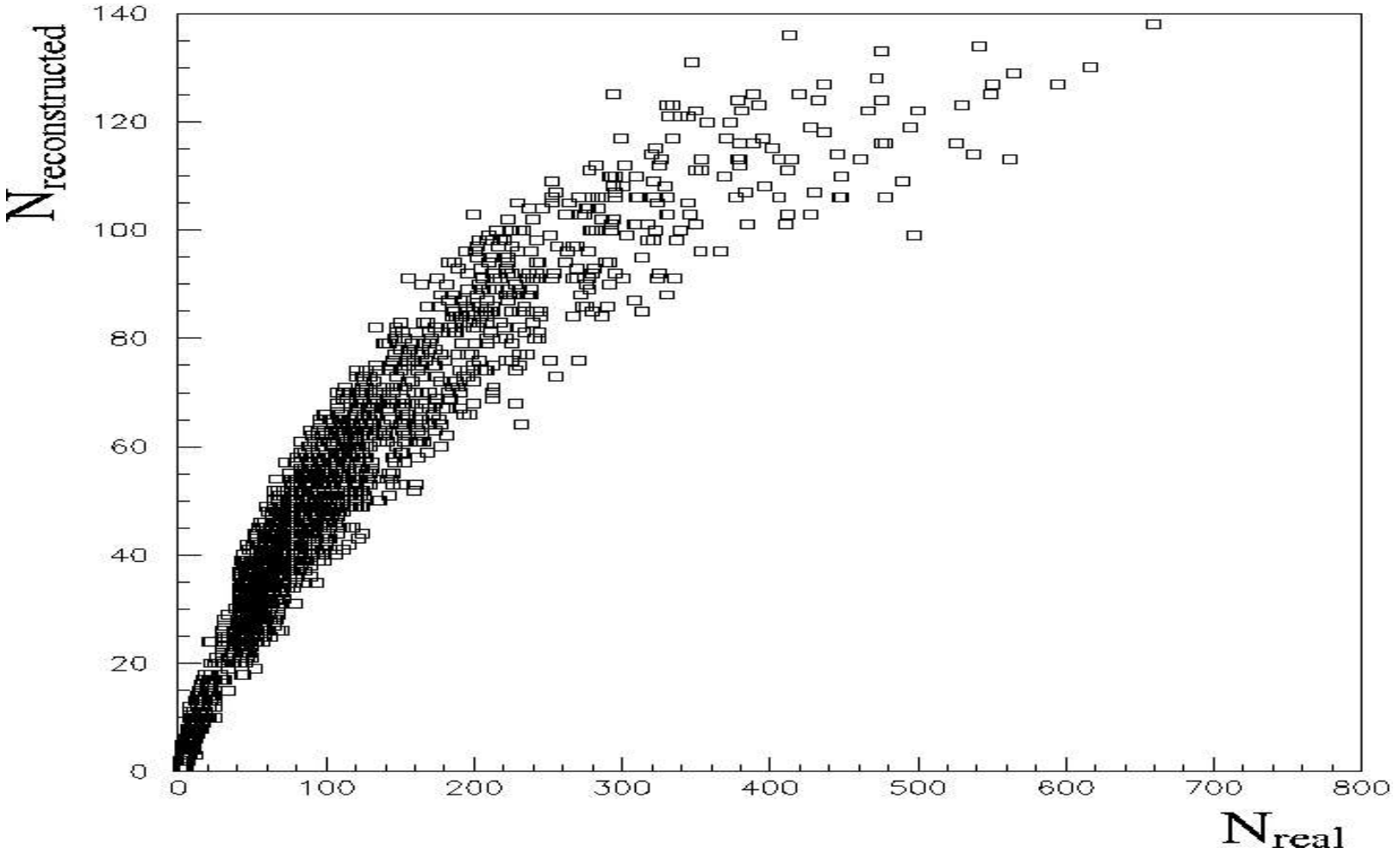
Saturated events



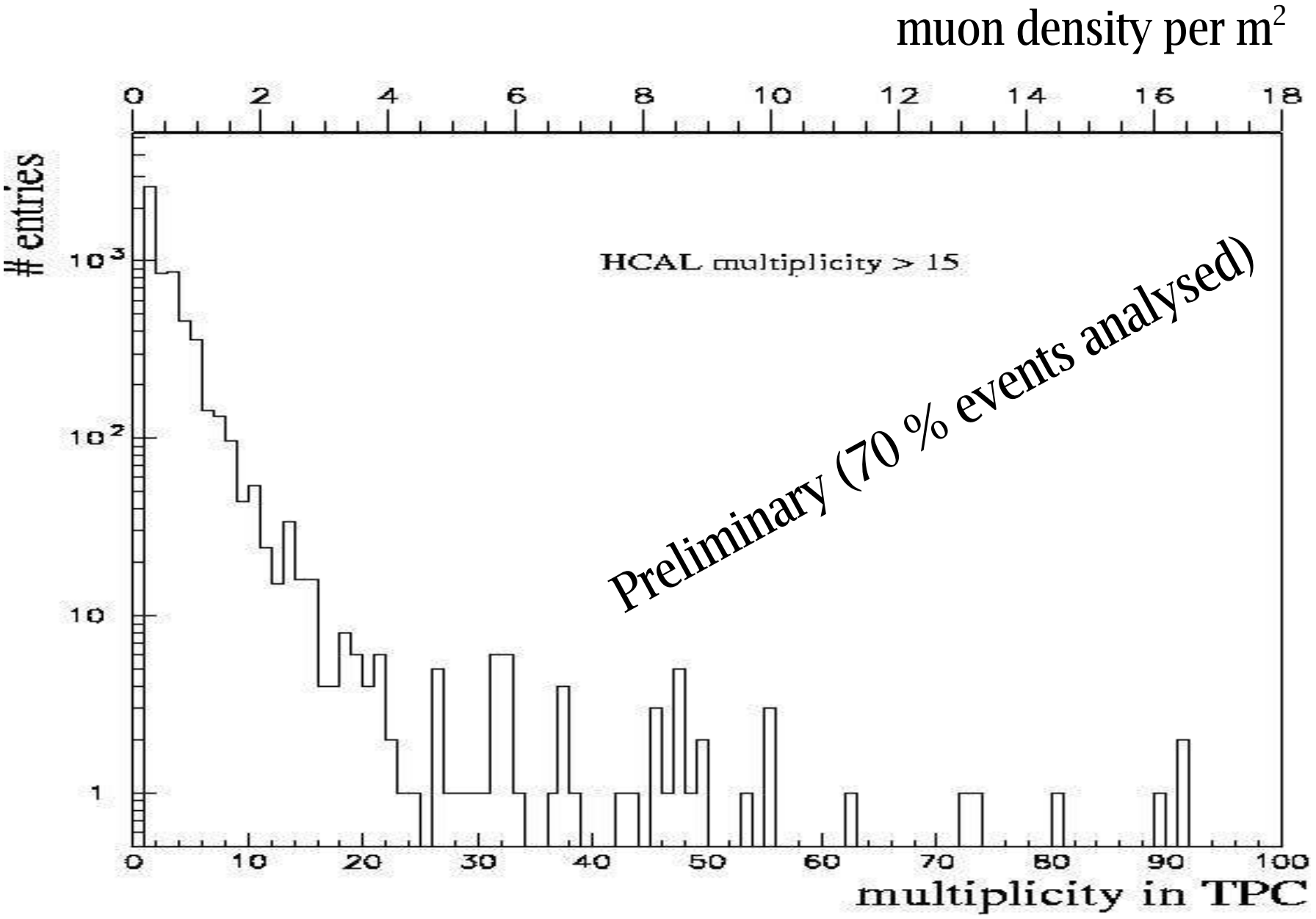


Overlapping tracks

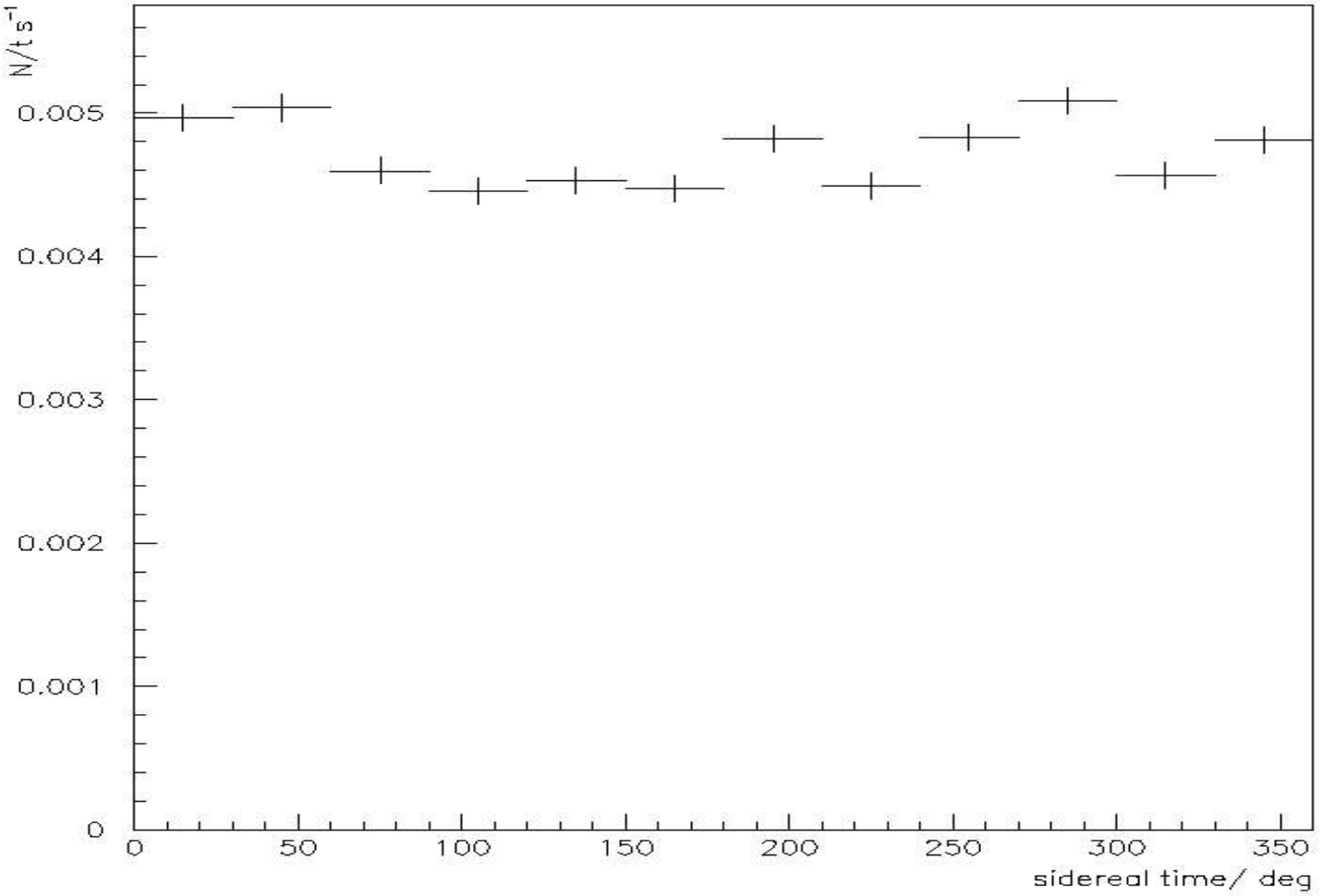
Reconstruction only in 1 projection -> overlapping tracks



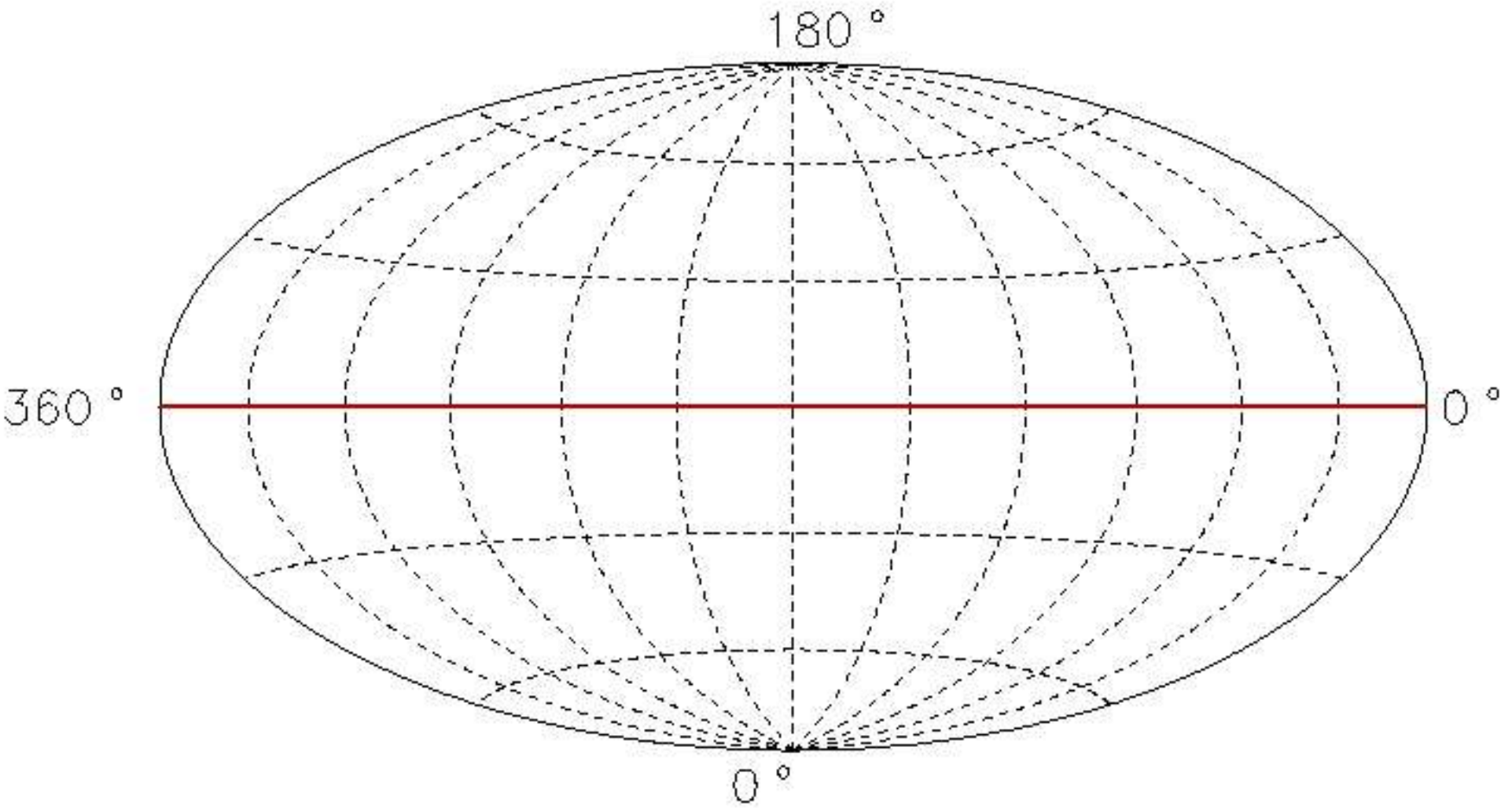
TPC preliminary reconstruction



Point sources – sidereal time, HCAL multiplicity > 3



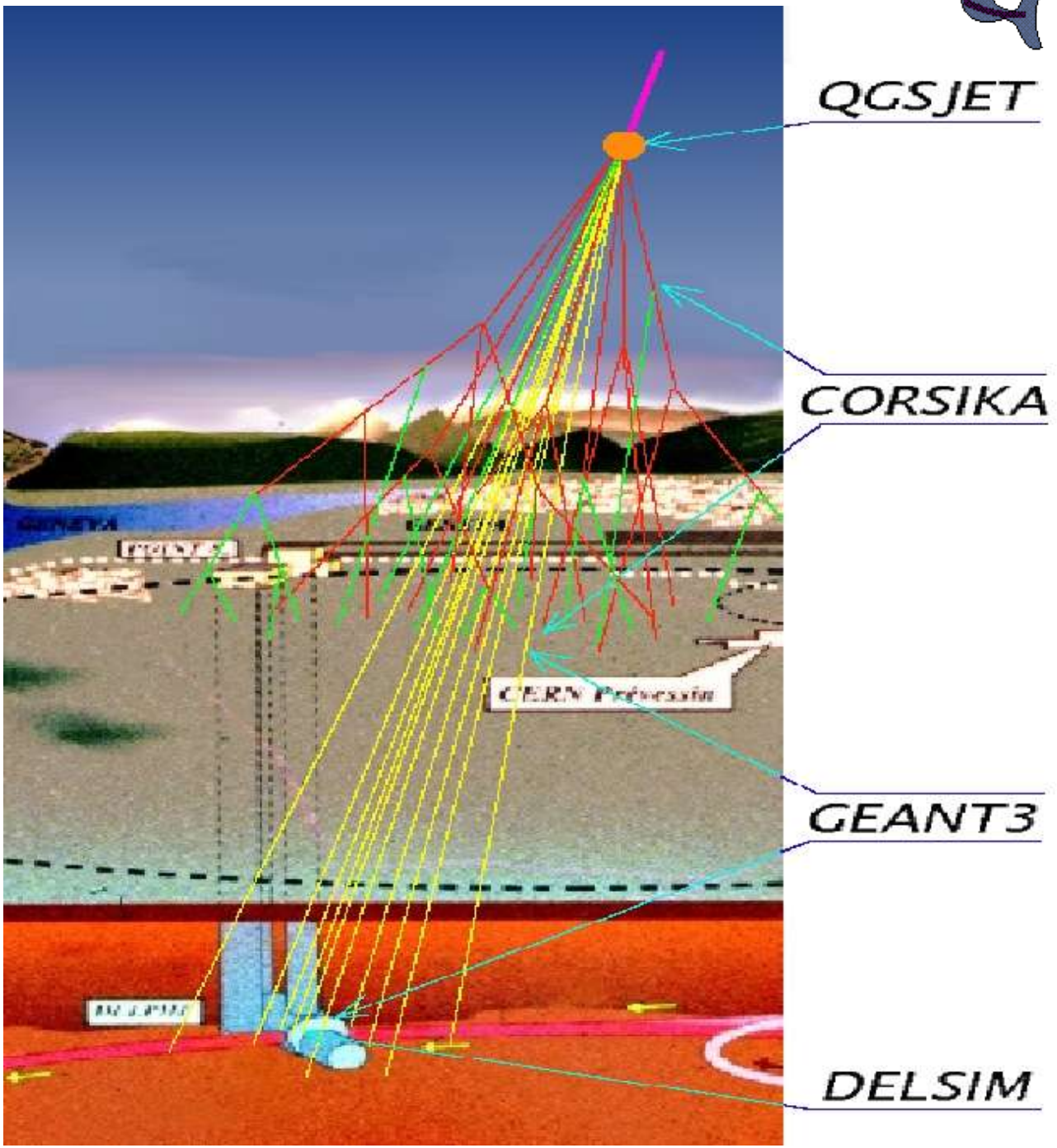
Point sources – TPC sky plot, HCAL multiplicity > 15



MC simulation of cosmic events in HCAL

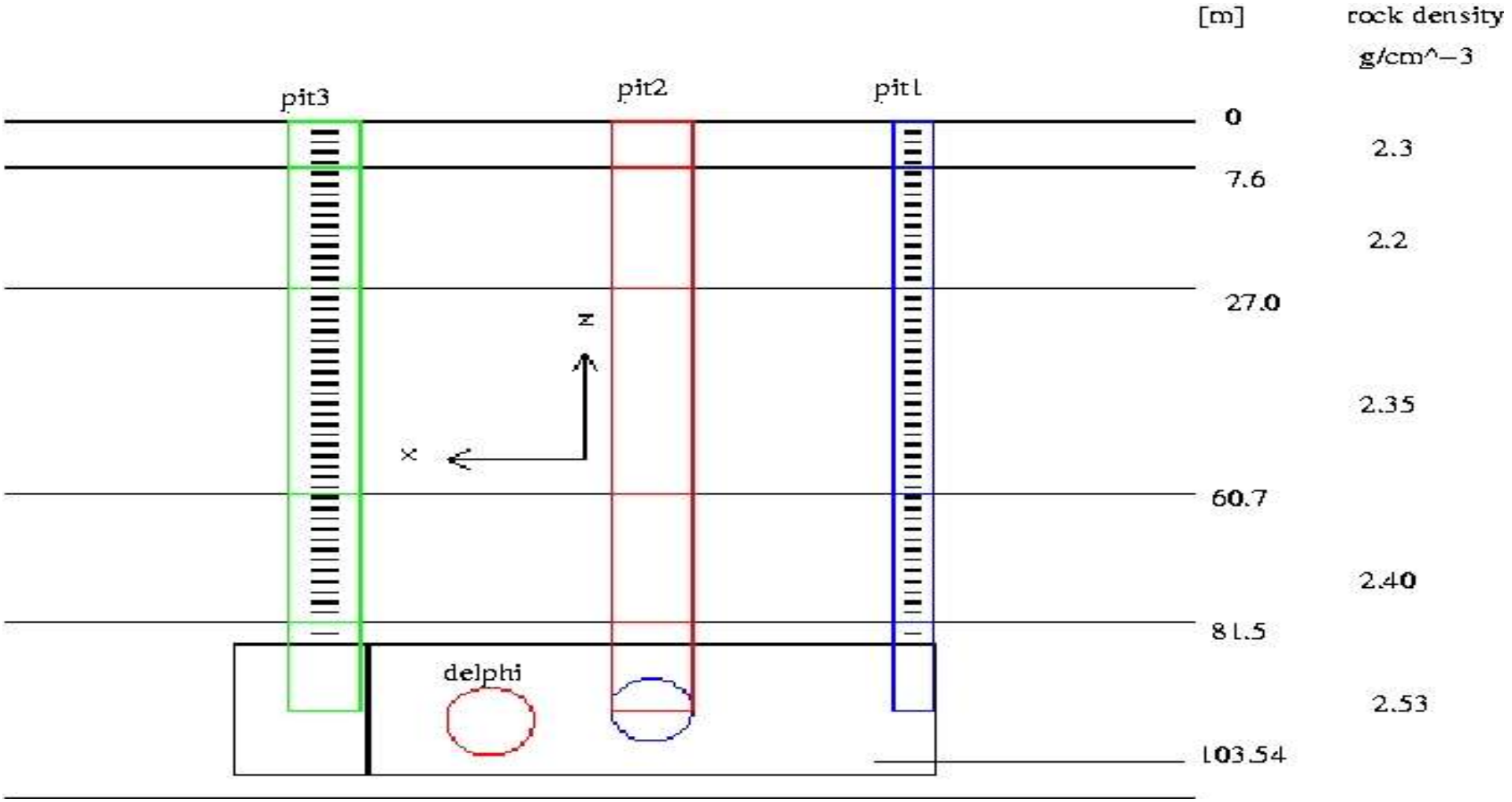
- QGSJET, CORSIKA, GEANT3, DELSIM
- Cosmic particles: p, Fe
- Primary particle energy 10^{12} – 10^{18} eV
- Events generated according to E^{-1} and weighted to $E^{-2.7\ (3.0)}$
- Shower impact points smeared over circle with radius R = 200 m

Simulation chain

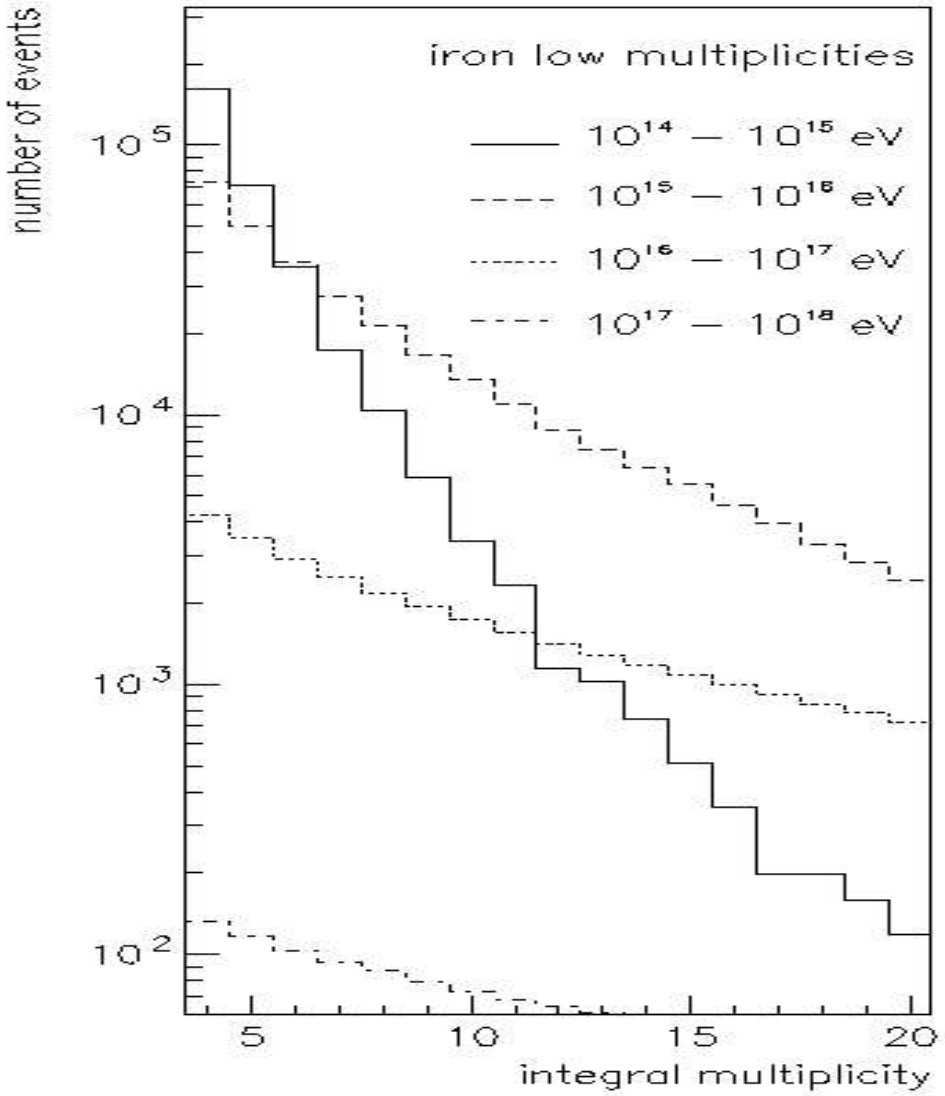


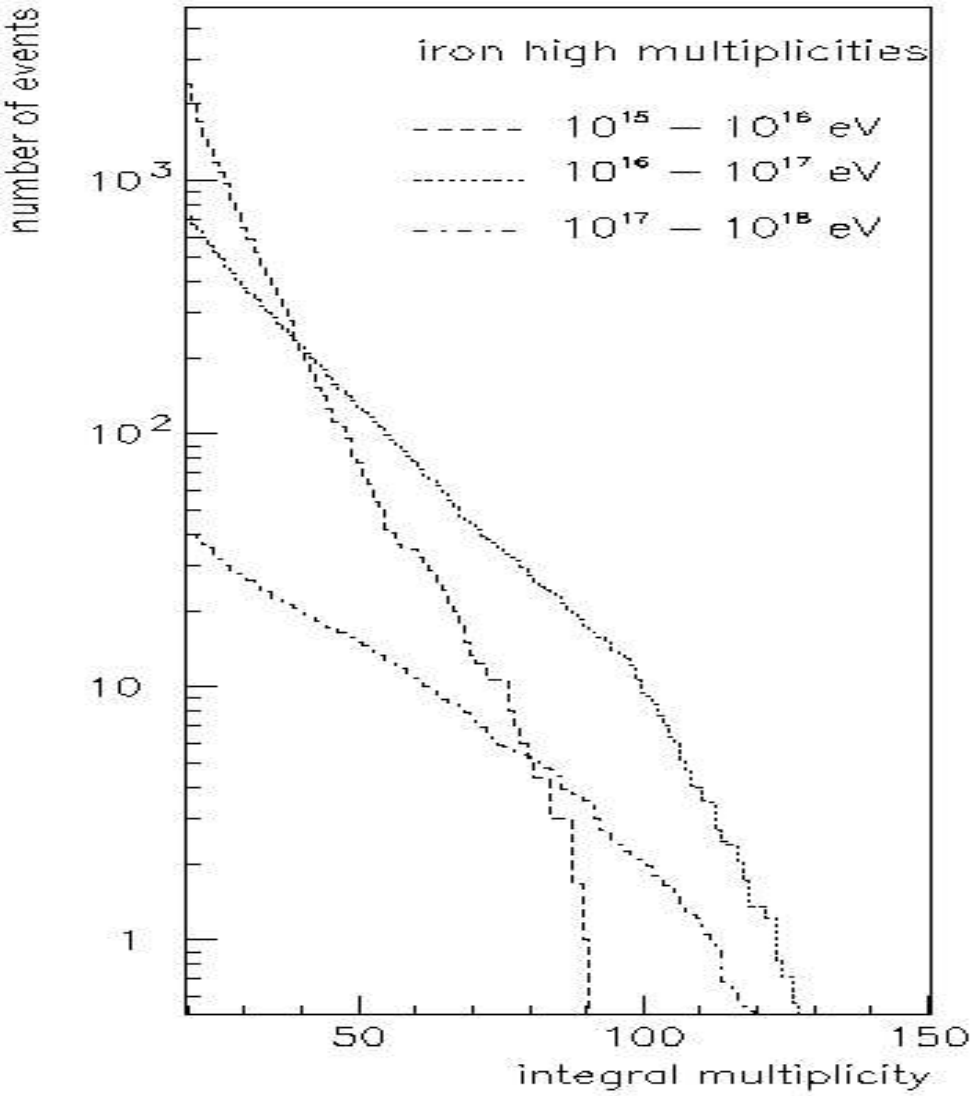
Rock/Cavern geometry

5 layers of rock with different mass densities,
3 pits included

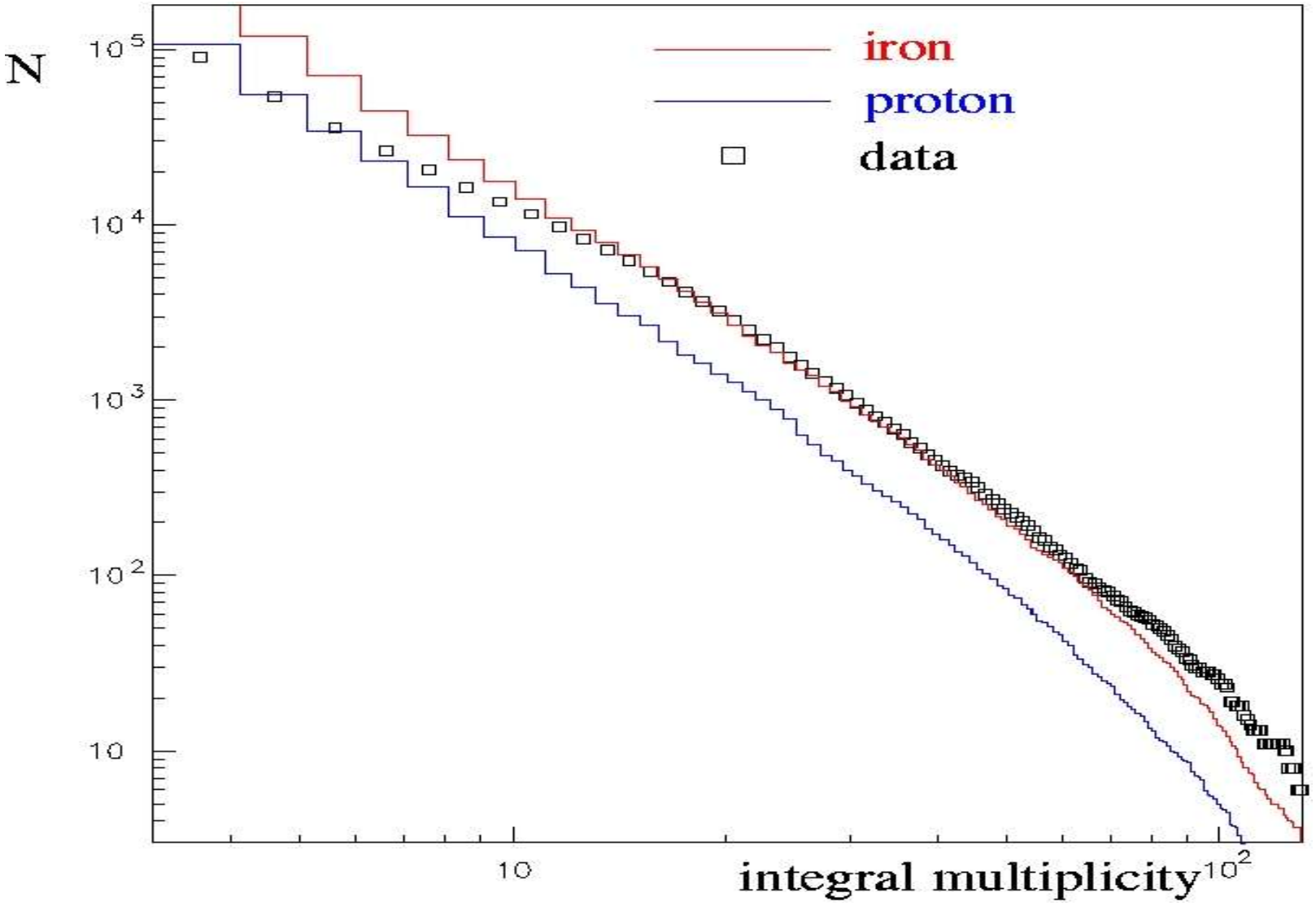


Contribution of different energy intervals



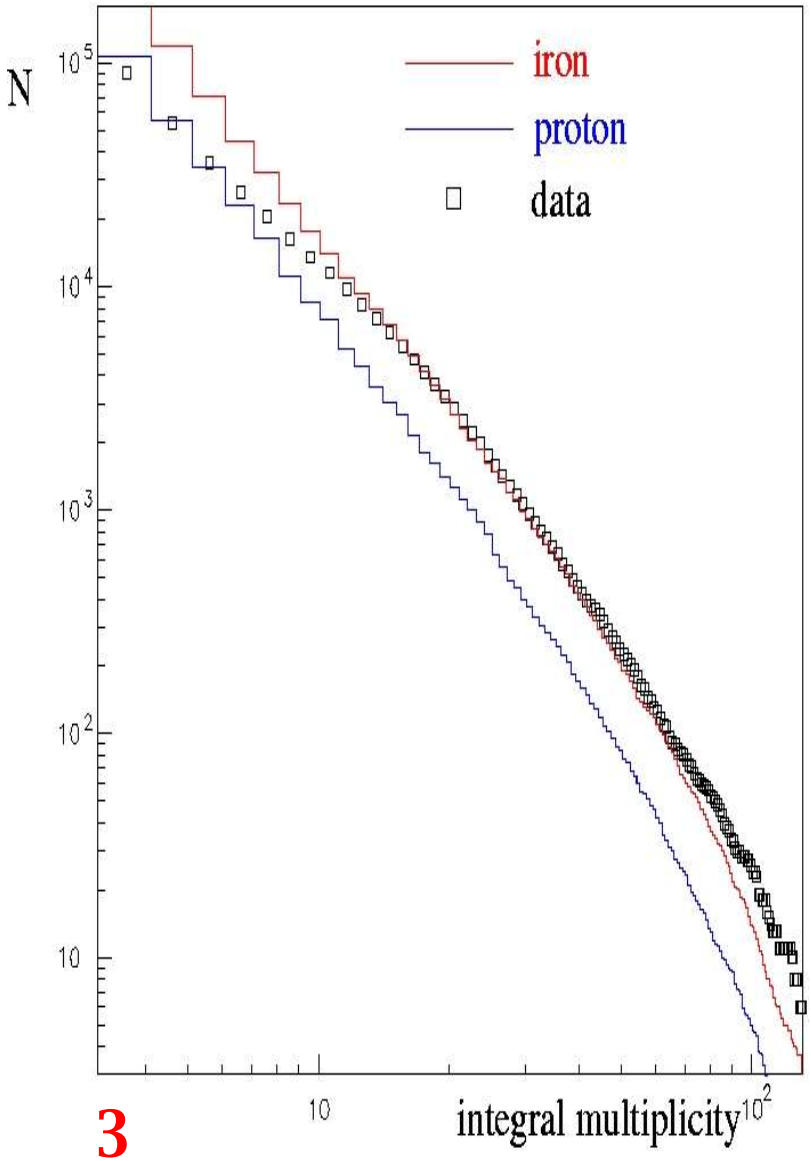


Results – MC and DATA

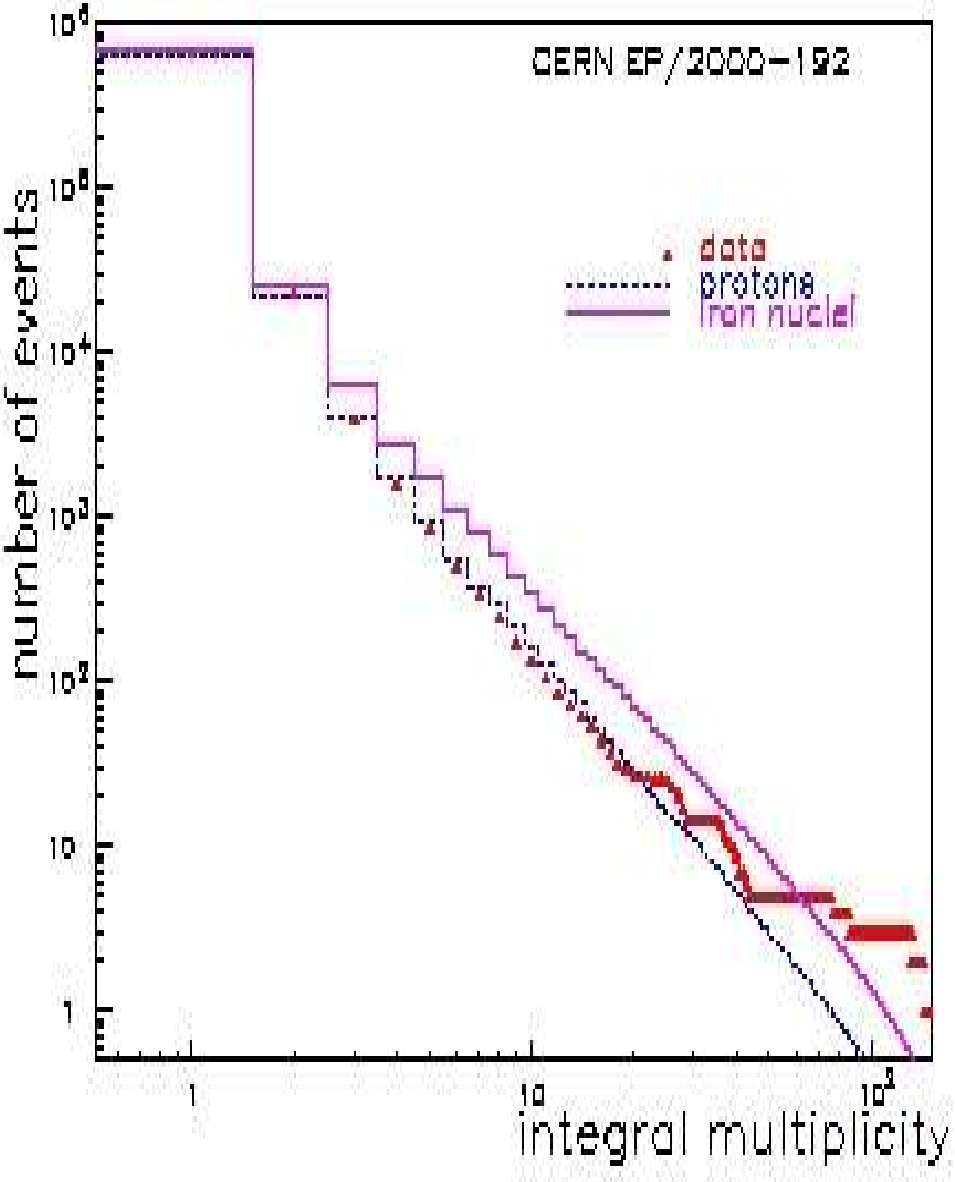


Results

Delphi



Aleph



Conclusions

- Multi-muon bundles reconstructed from DELPHI HCAL and TPC (preliminary)
- Measurement of multiplicity distributions
- Comparison of MC and DATA
  - Proton MC prediction is in agreement with the data for small multiplicities (first 3 bins)
  - Trend from light to heavier component in cosmic ray composition
  - Possible excess of high multiplicity events with respect to MC prediction