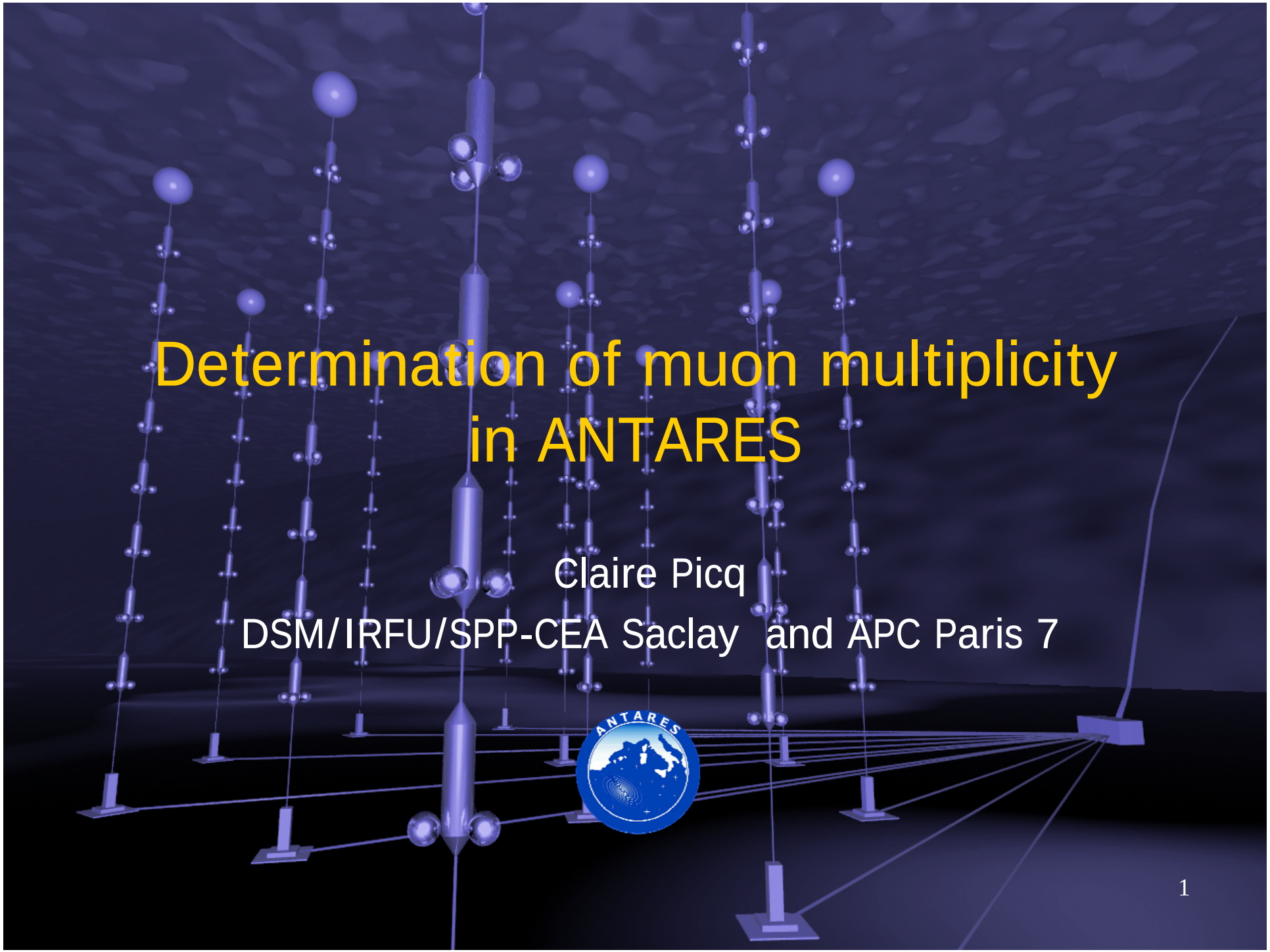
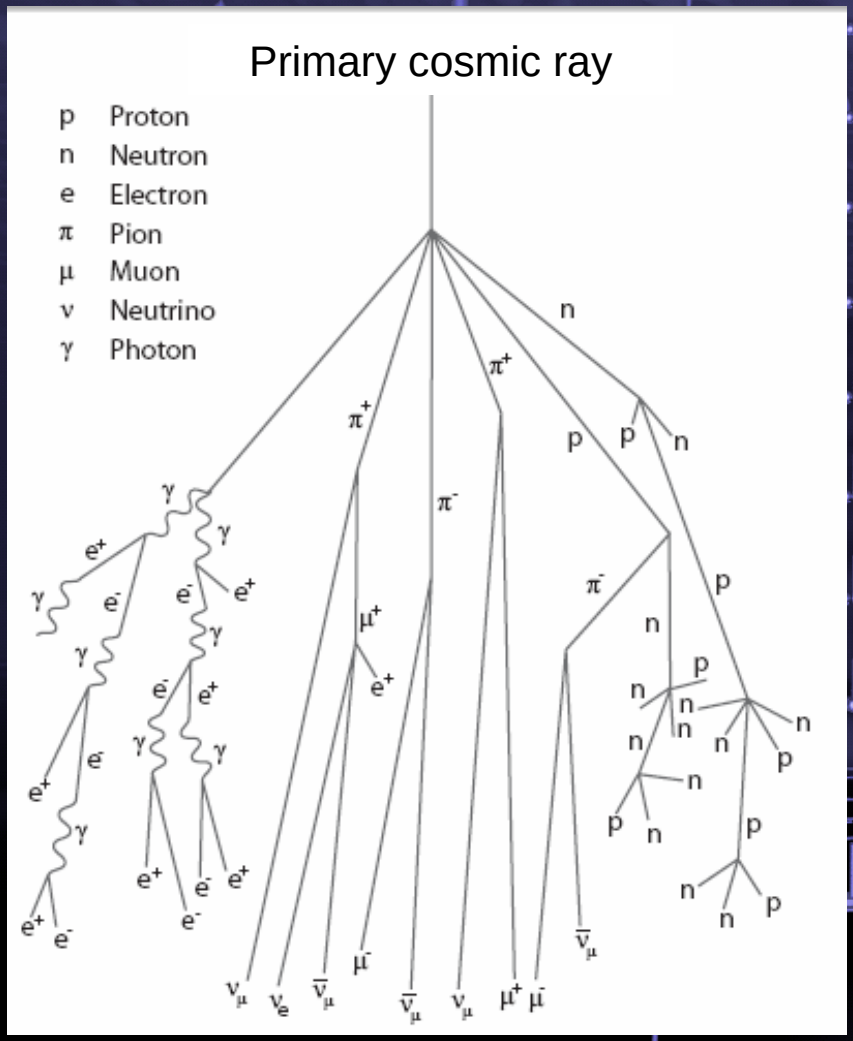


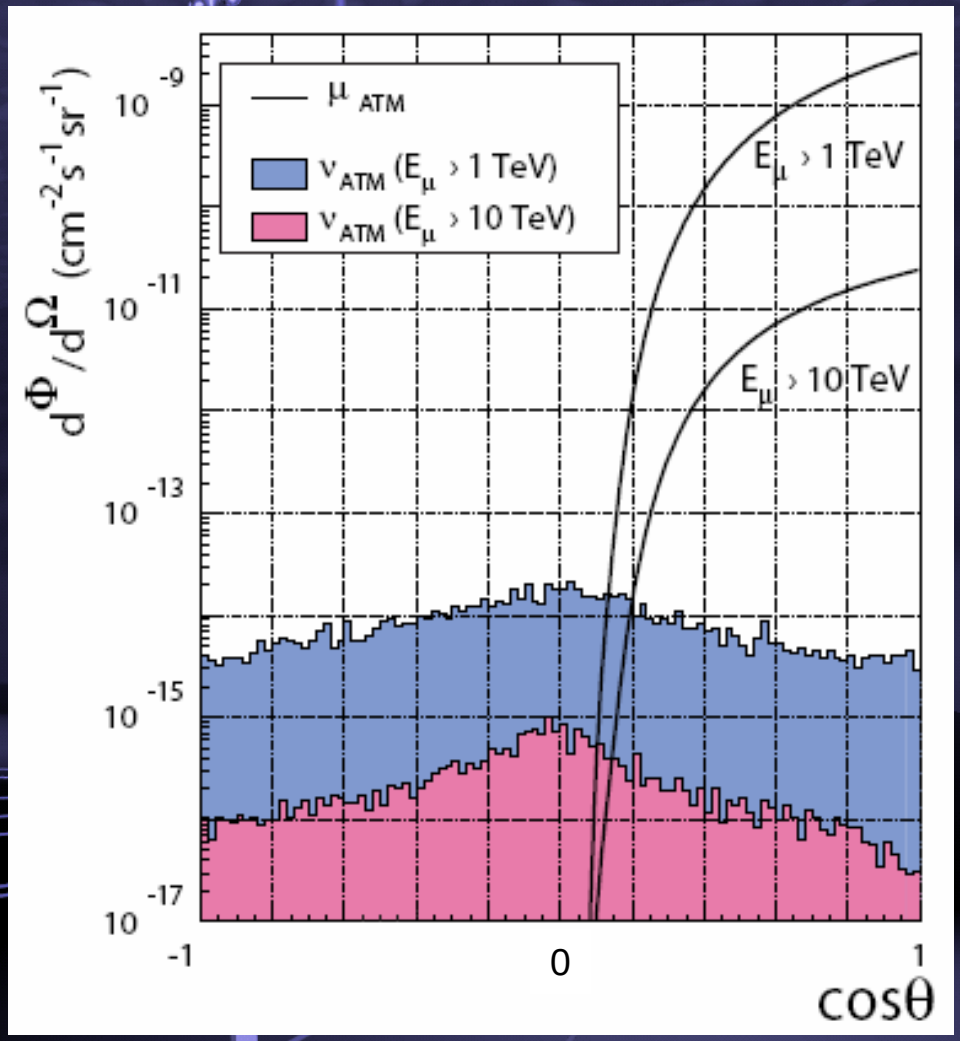
Determination of muon multiplicity in ANTARES

Claire Picq

DSM/IRFU/SPP-CEA Saclay and APC Paris 7

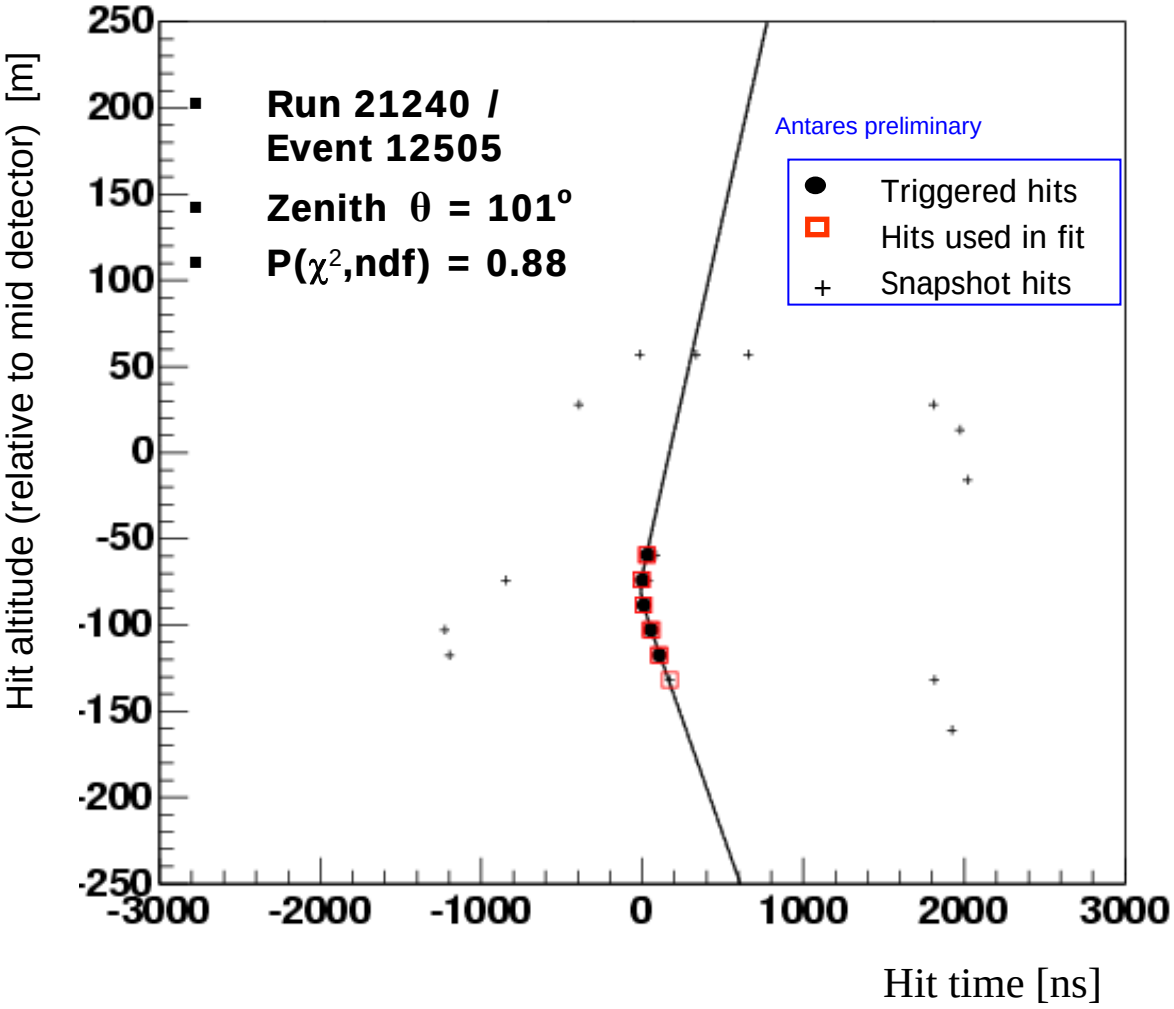
Atmospheric muons



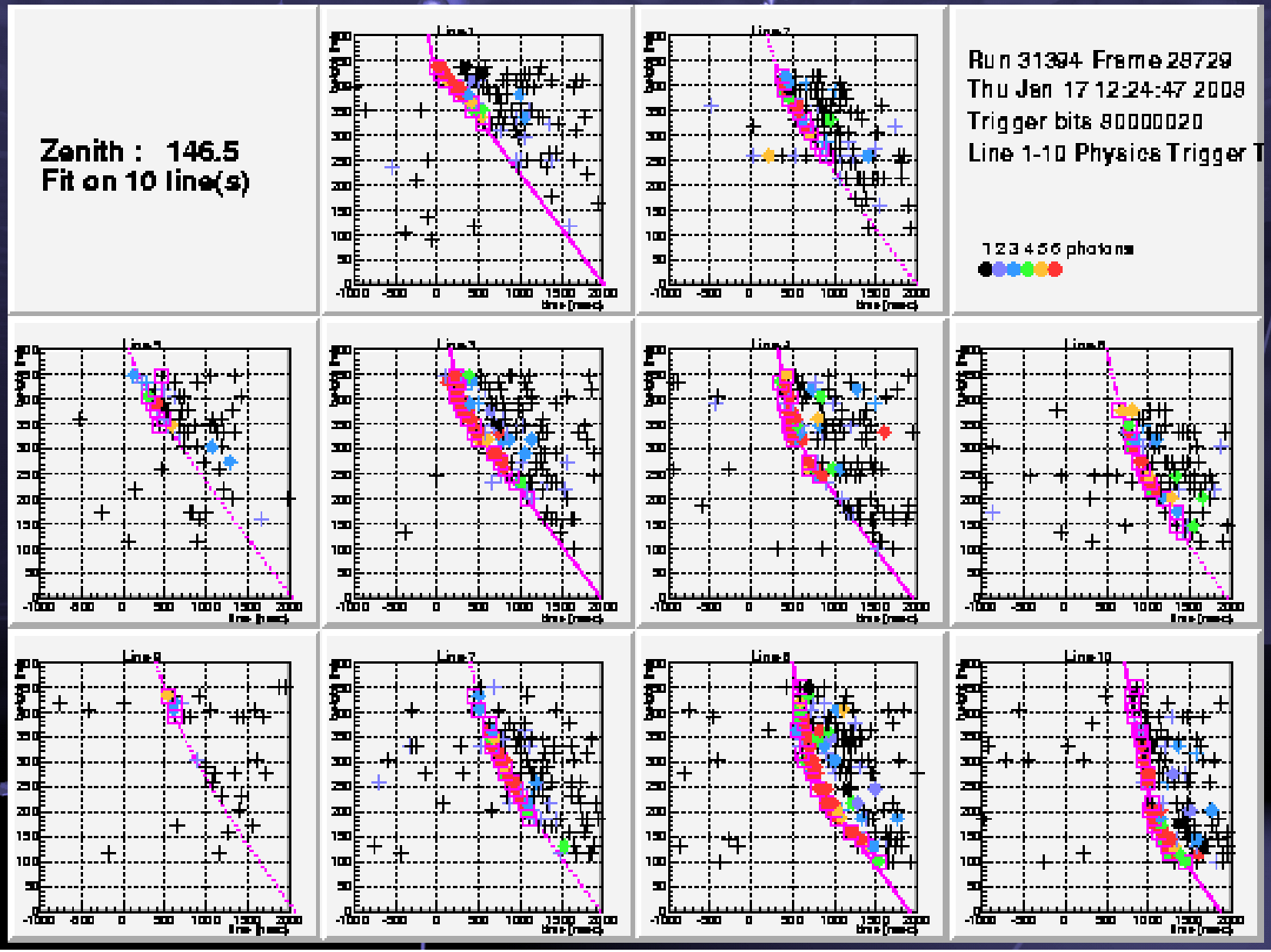


Atmospheric muon

likelihood maximization to estimate the zenith angle



Online display: multi muon event

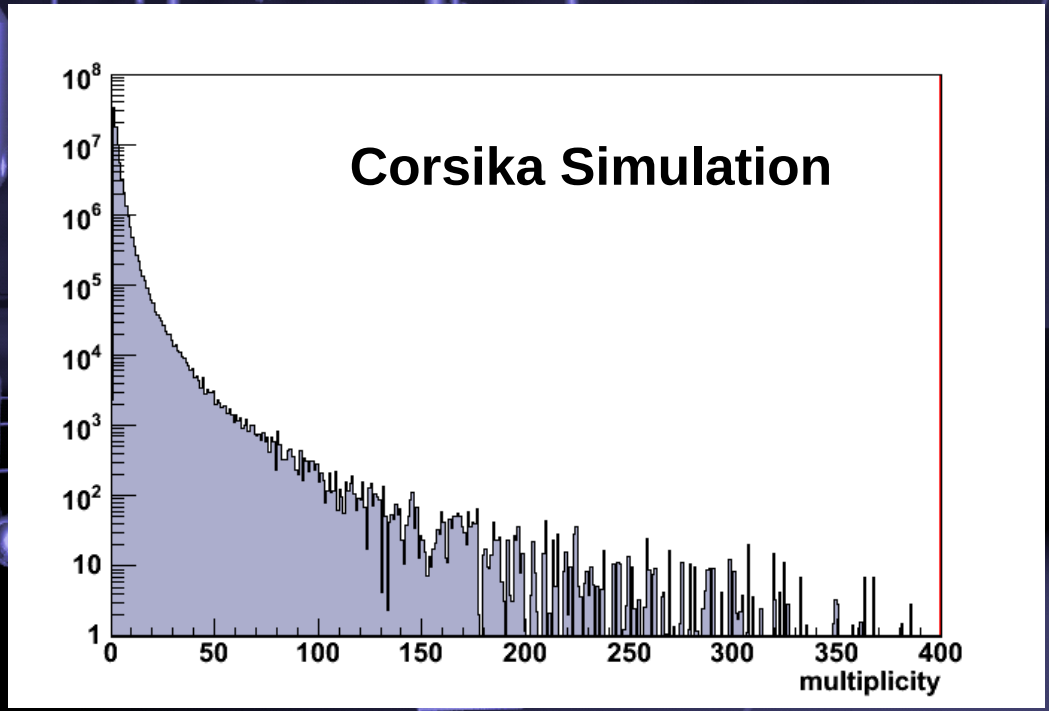


Goals of the study

- Isolate single muons for systematic studies purpose
- Estimator of multiplicity
- Measure the down-going muon flux

Multiplicity definition:

1 muon has given at least 6 hits



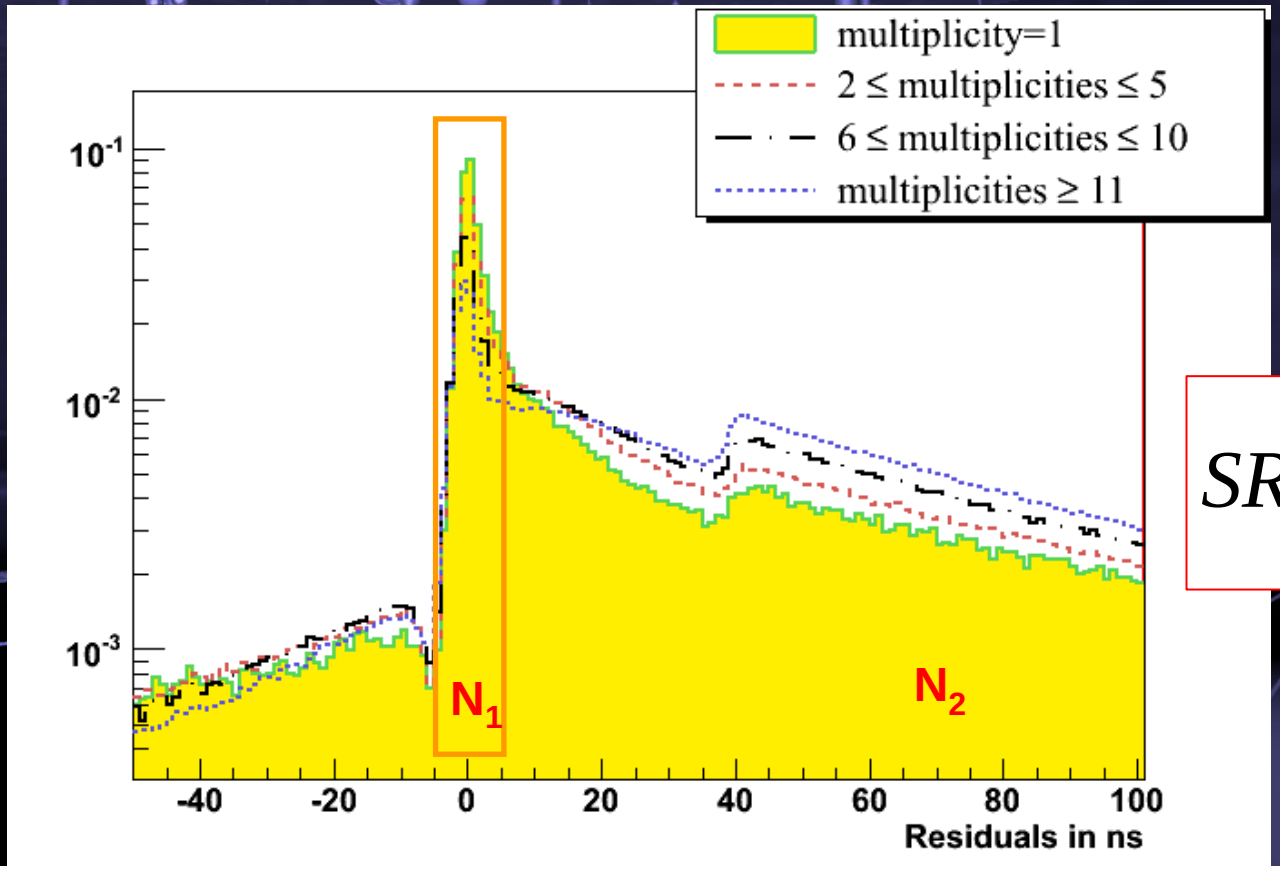
Time residuals

Time residual = reconstructed – real time

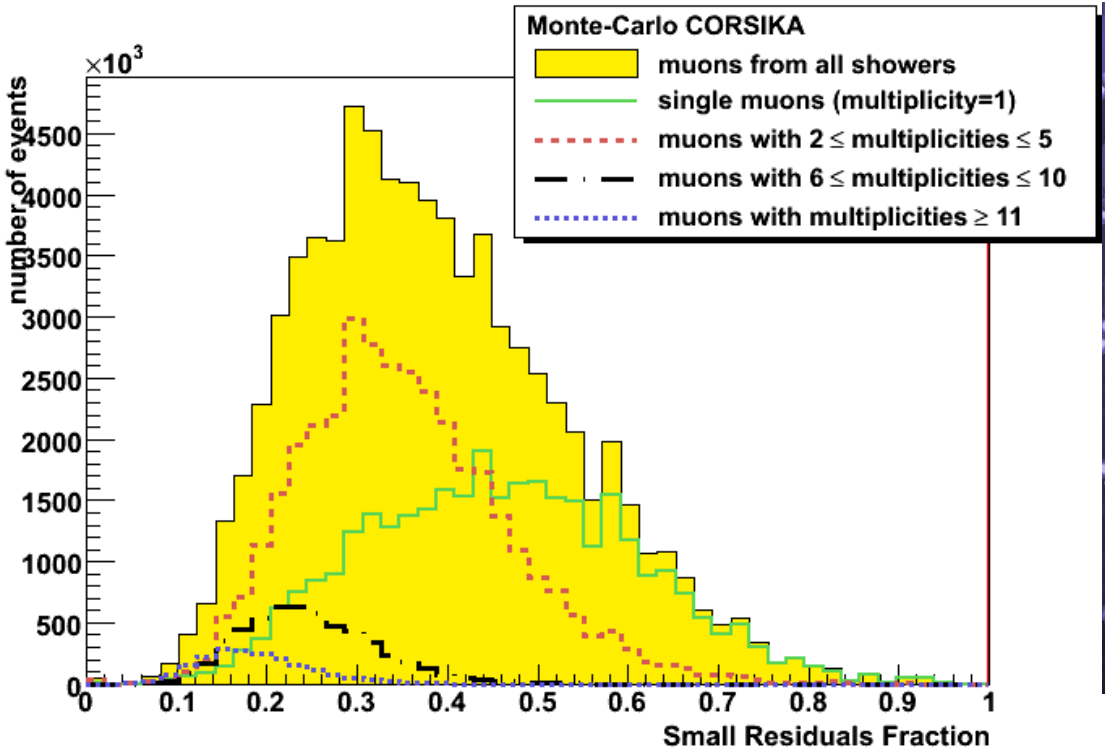
N_1 = number of hits with time residuals in [-5 ns;5 ns]

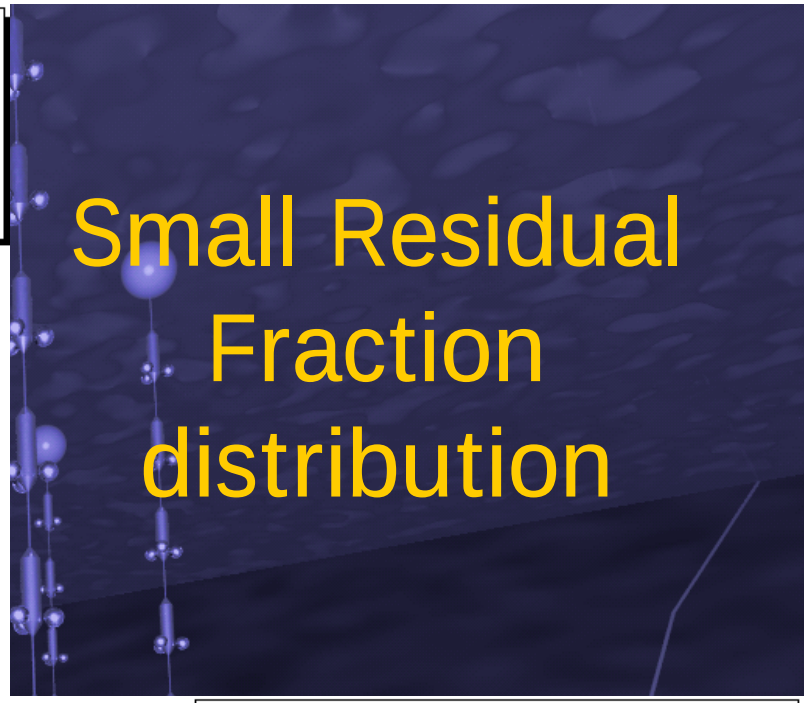
N_2 = number of hits with time residuals in [-50 ns;100 ns]

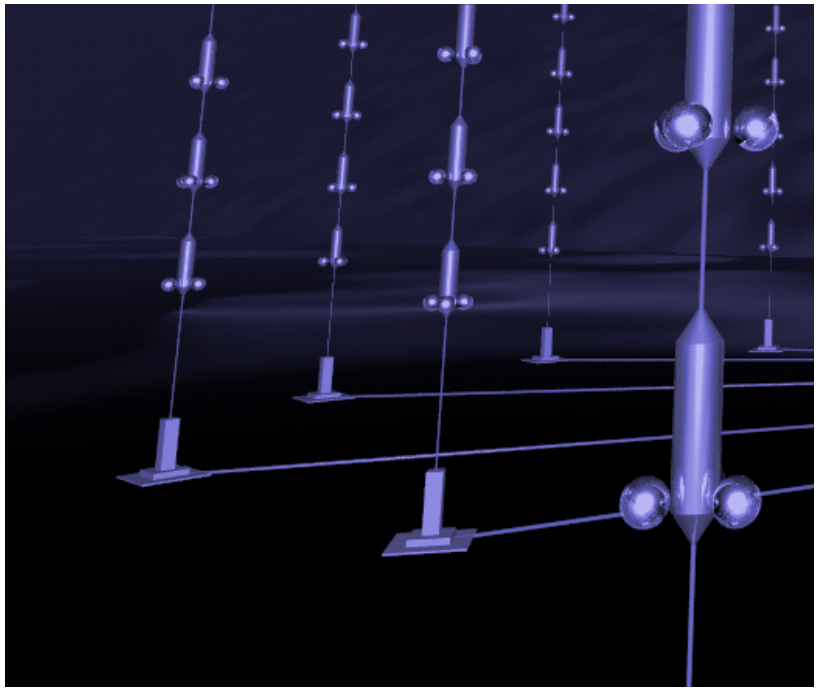
SRF = Small Residual Fraction

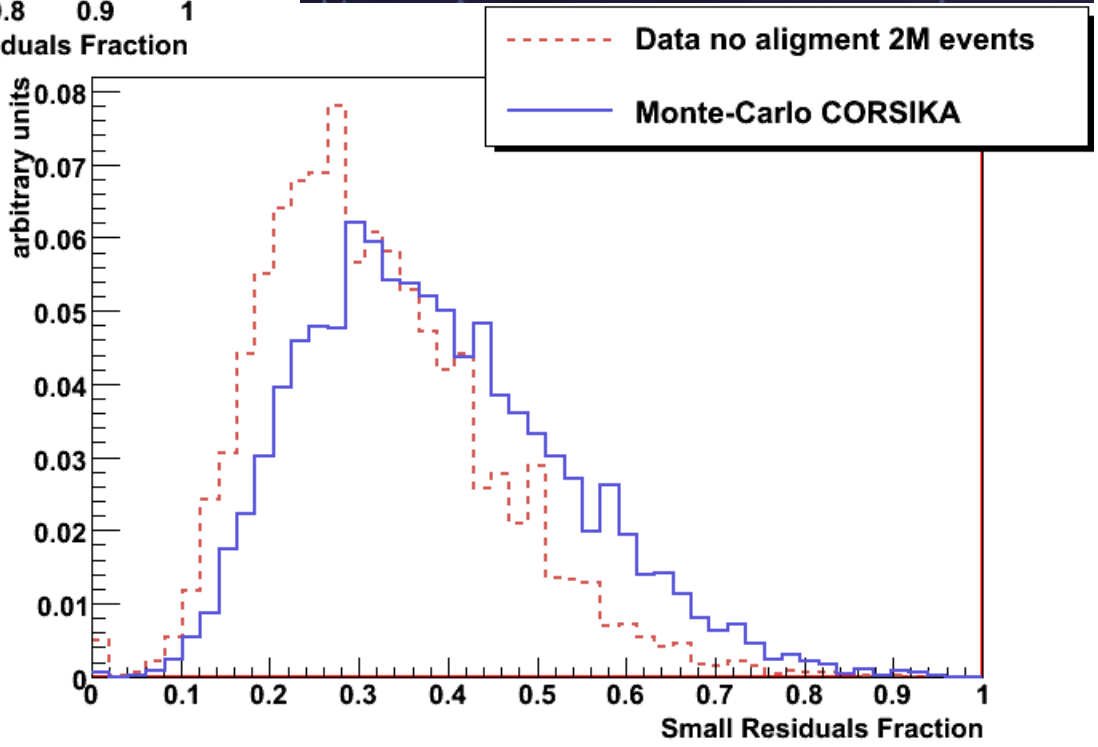


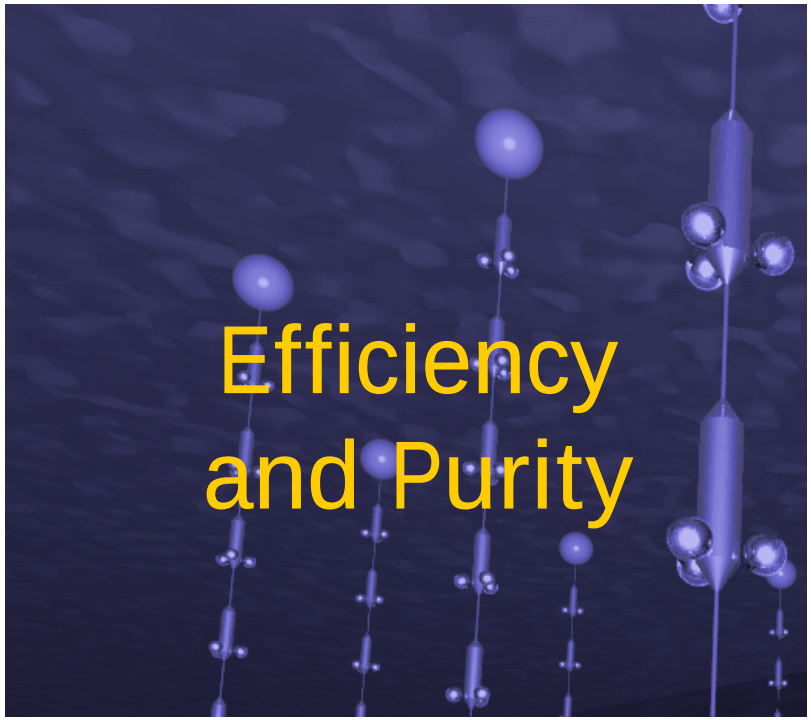
$$SRF = \frac{N_1}{N_2}$$

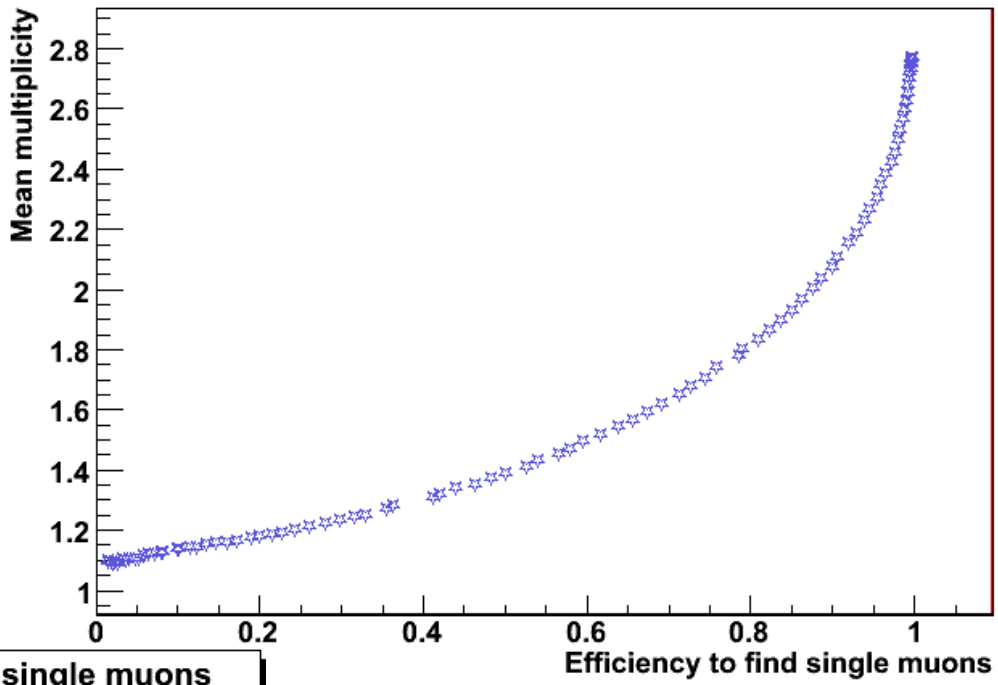

Monte-Carlo CORSIKA
muons from all showers
single muons (multiplicity=1)
muons with 2 ≤ multiplicities ≤ 5
muons with 6 ≤ multiplicities ≤ 10
muons with multiplicities ≥ 11
×10^3
number of events
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Small Residuals Fraction

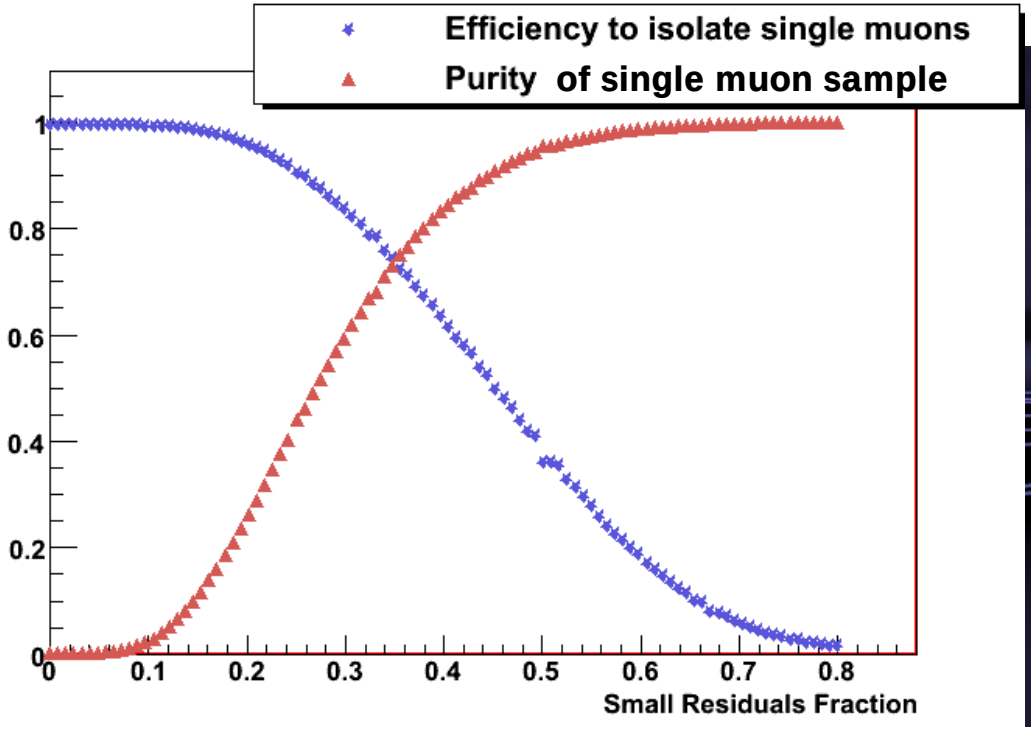

Small Residual Fraction distribution

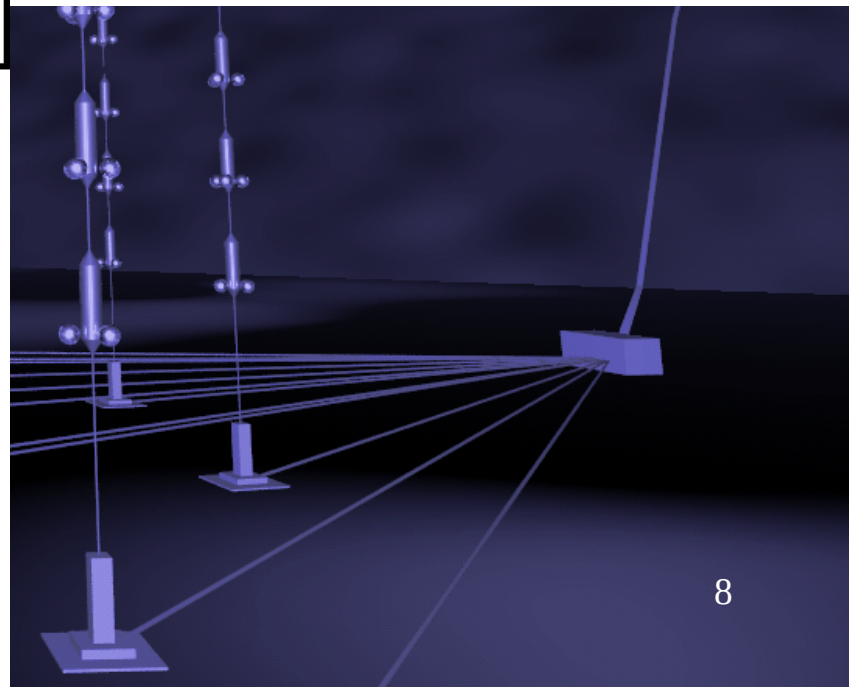


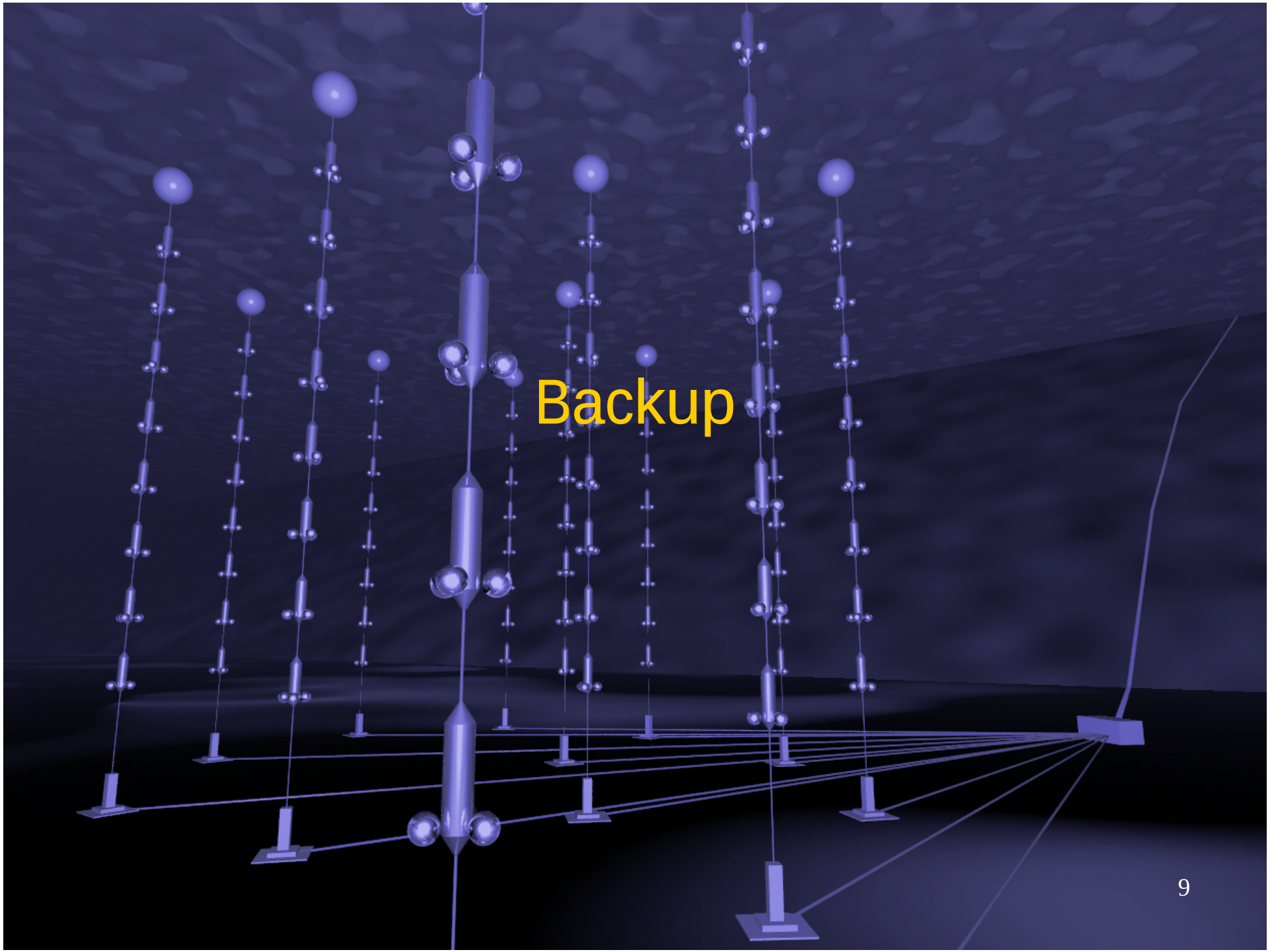

Data no aligment 2M events
Monte-Carlo CORSIKA
arbitrary units
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Small Residuals Fraction


Efficiency
and Purity


Mean multiplicity
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
0.2
0.4
0.6
0.8
1
Efficiency to find single muons


Efficiency to isolate single muons
Purity of single muon sample
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Small Residuals Fraction



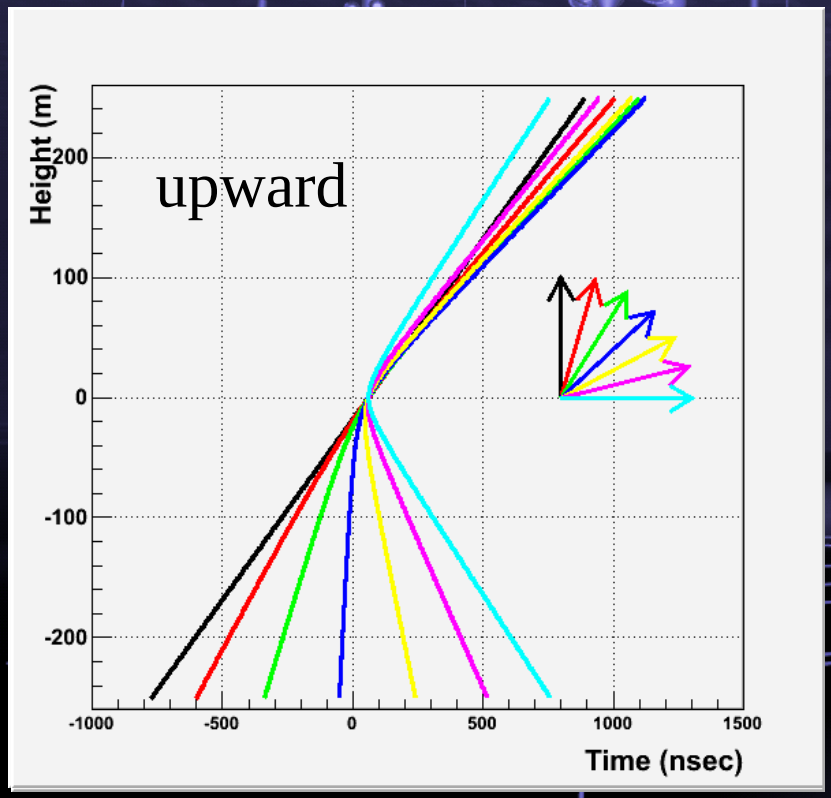

Backup

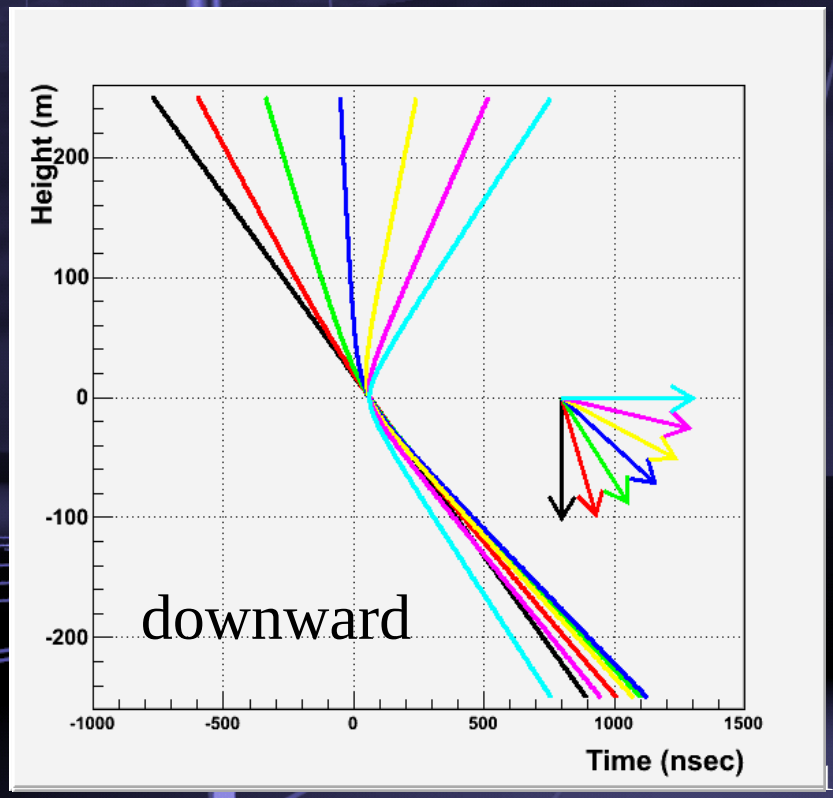
Reconstructed events

Height (z) vs time

⇒ Function of the zenith angle and distance

Many algorithms used by the collaboration 1D, 3D, χ^2,ML





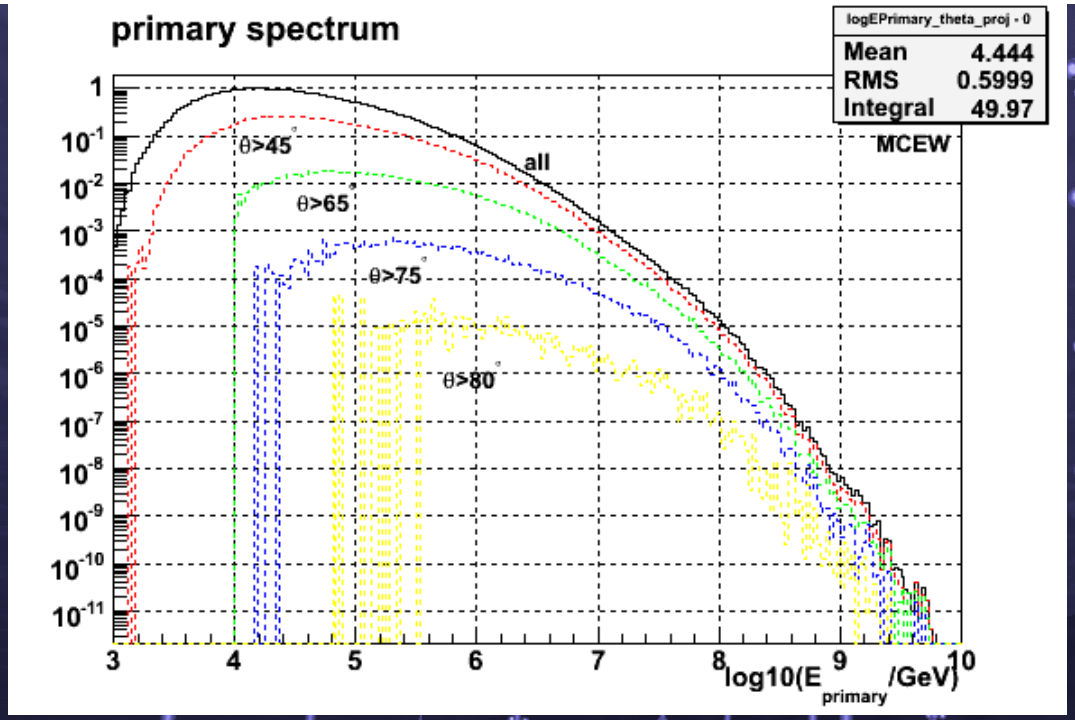
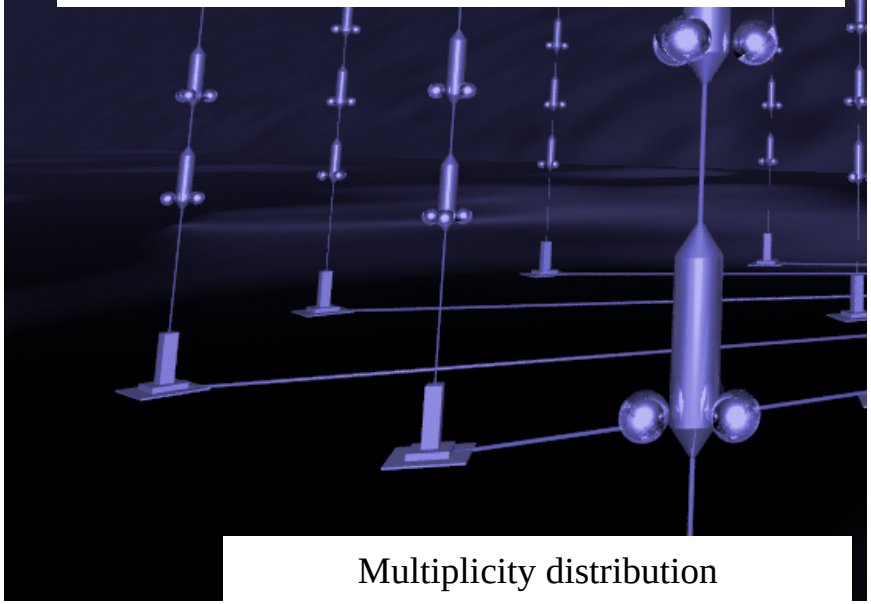
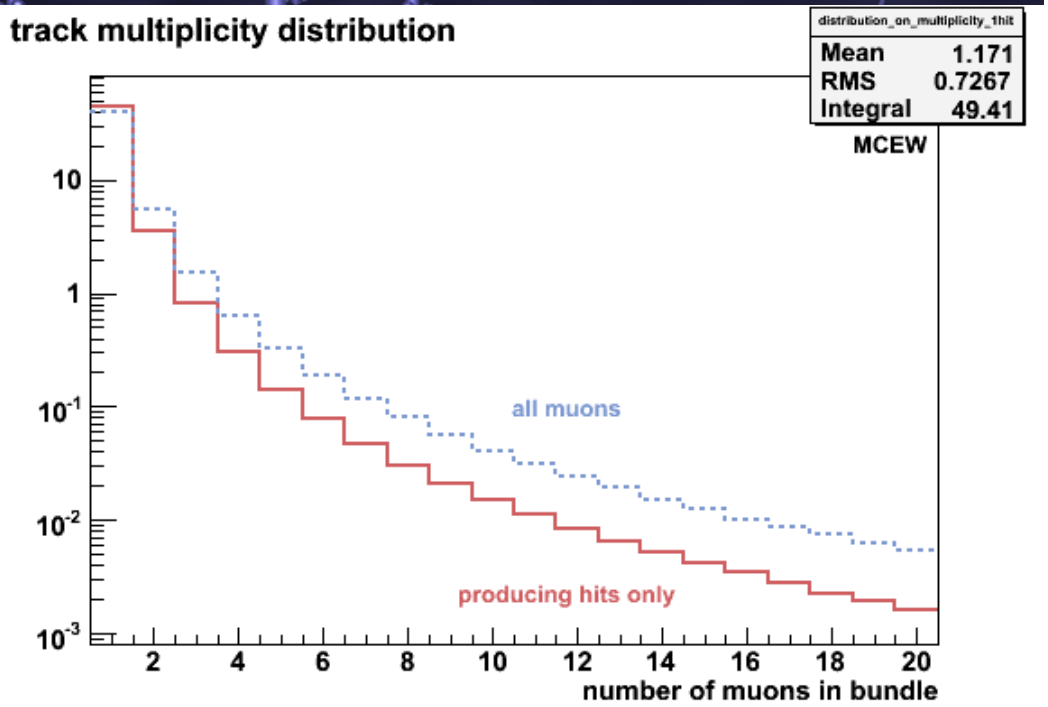


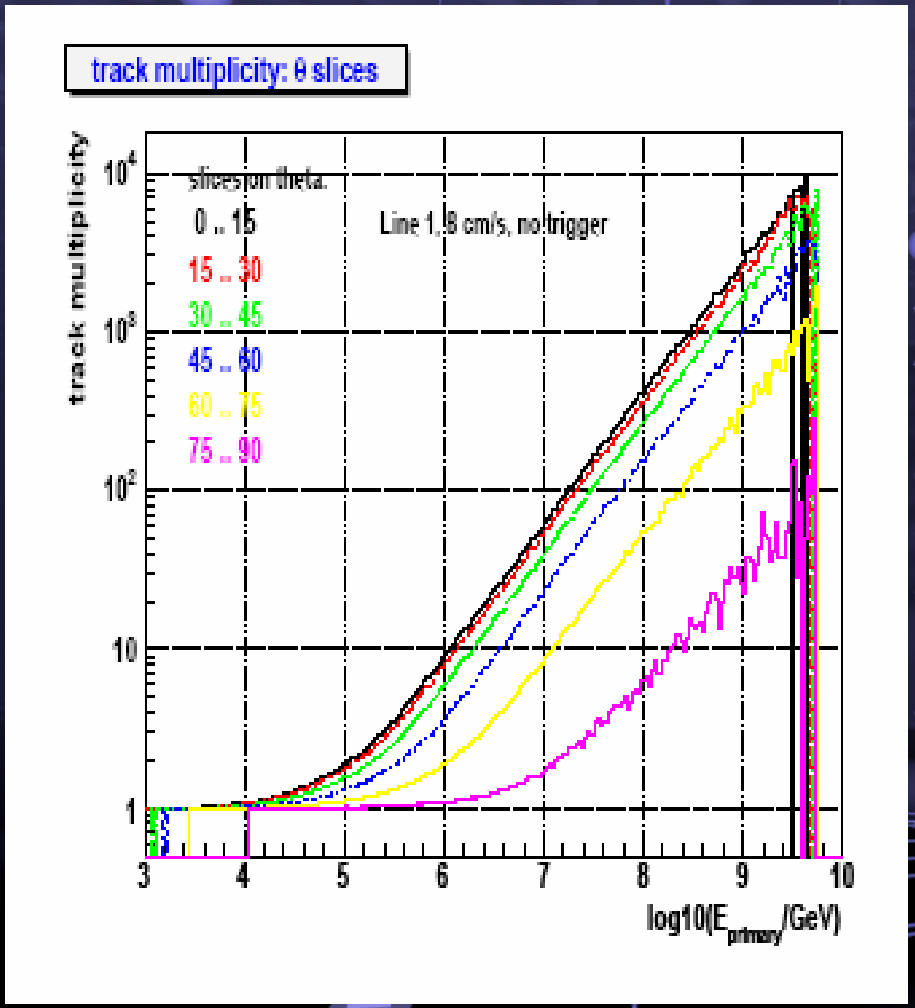
Figure 1: Energy spectra of cosmic ray particles ("primaries") detected with an ANTARES line at one hit level (left plot) and trigger level (right plot). MC simulation. The colored curves correspond to the cuts on incident polar angle, as indicated on the plots.

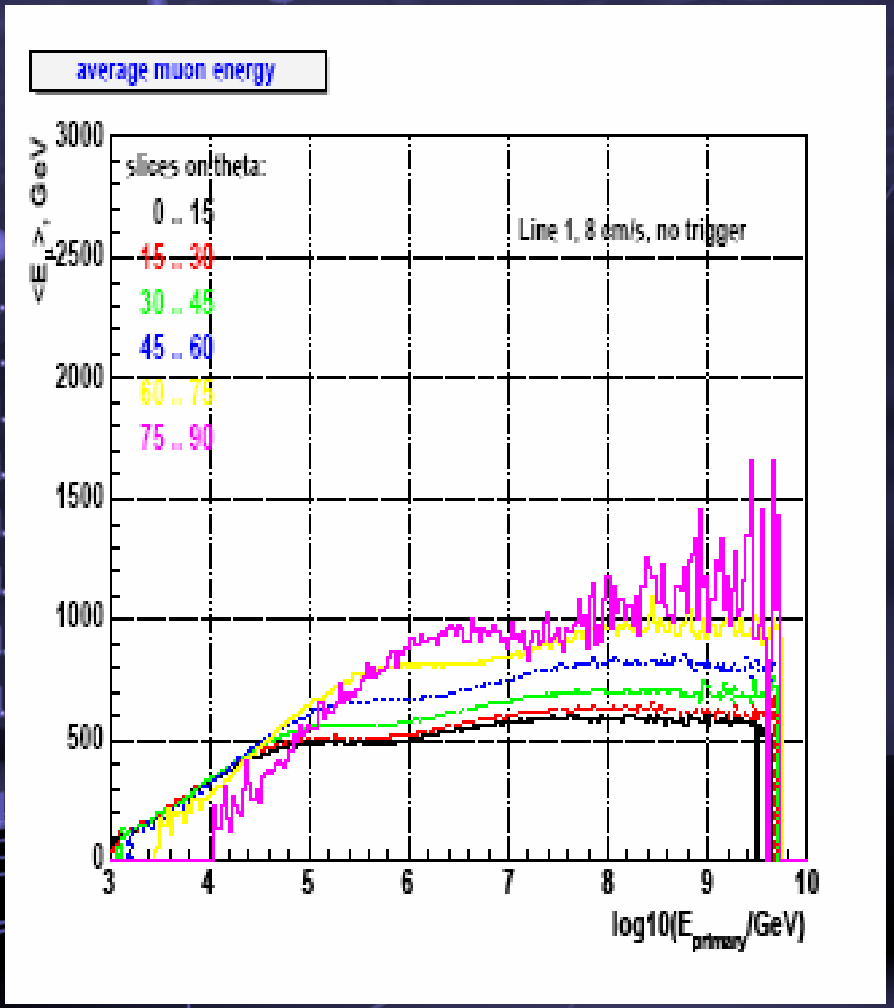


Multiplicity distribution



Monte Carlo 1 lines D. Zaborov





Multi muon event