Update on simulation with Corsika and coincidences

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Status of simulations

Corsika showers were generated in the full solid angle in narrow energy bins.

Showers are available in the range 100 GeV – 9 PeV.
We planned to generate sample for higher energies soon.

To reproduce the rates of our telescopes probably we need to add contribution for lower energy showers (E < 100 GeV) but at the moment we are not able to simulate their high flux (see next slides).

Structure of the simulation

Event generator available:

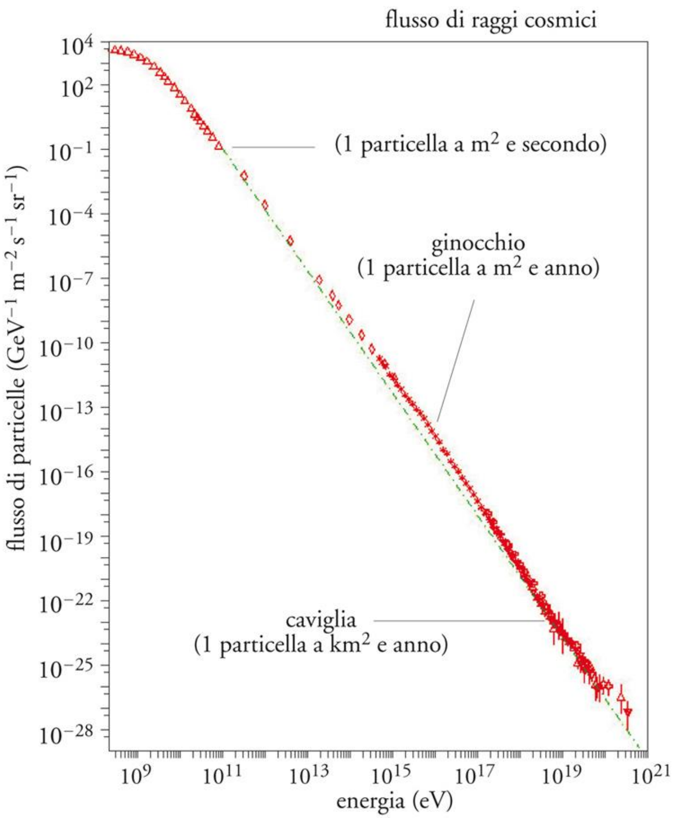
- Corsika
- Isotropic muon generator (i.e. used to compute detector acceptance)

- We generate events accordingly to a known flux
- We keep events with at least one muon close to one detector (5 meter far from the detector)
- We propagate events using geant4 and EEE telescope geometry
- We reconstruct DST as for data

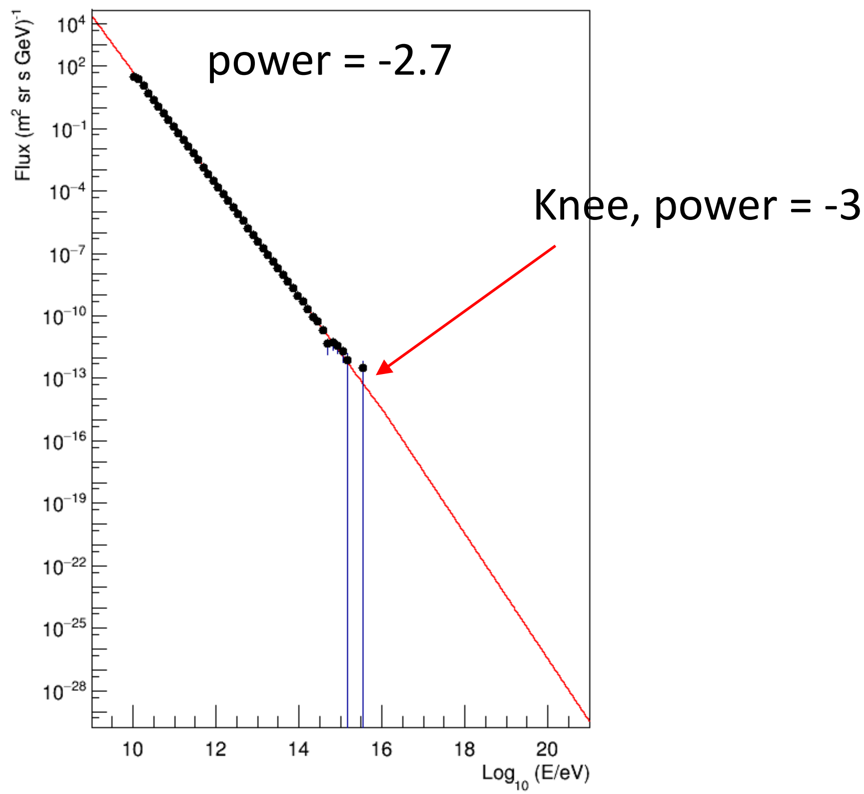
Cosmic ray flux

We are simulating a cosmic ray flux accordingly to the one measured.

Measured



Simulated



Still under tuning

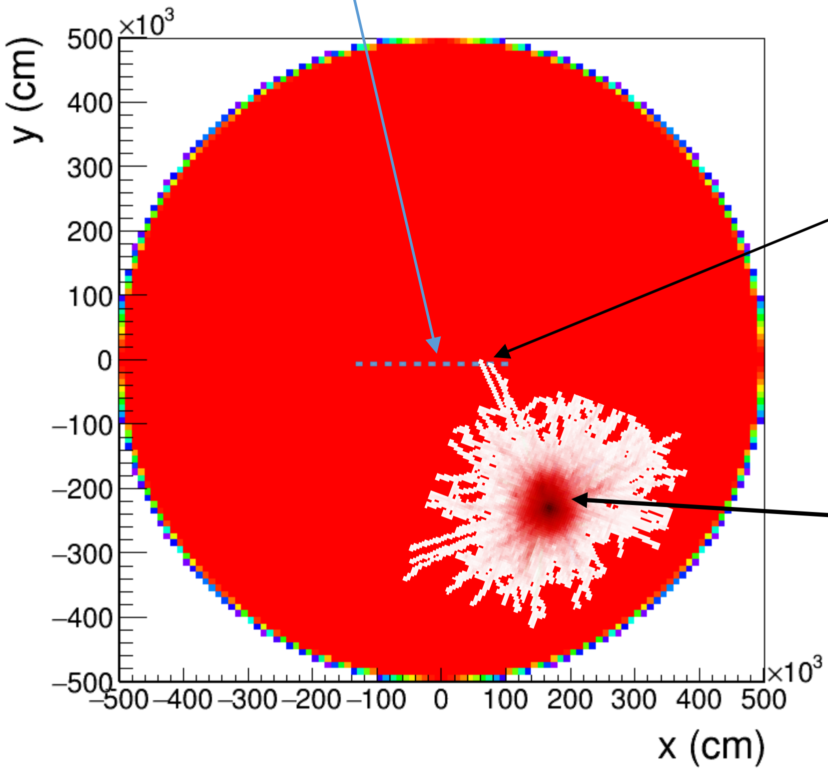
Red → current parameterization

Black → From random sampling

Simulation setup

- Many telescopes can be inserted as input of the simulation
- Cosmic ray flux simulated accordingly to the primary spectrum
- Showers simulated with Corsika
- Output: muon candidates (with a timestamp) for each telescope → Geant4

i.e. 11 telescopes setting

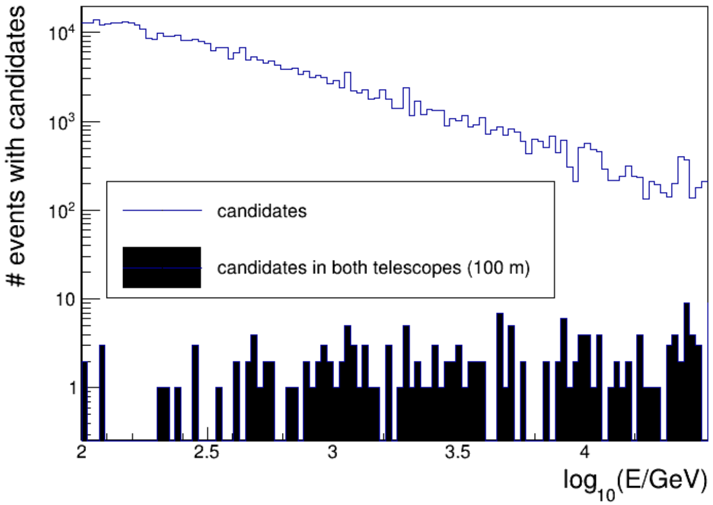


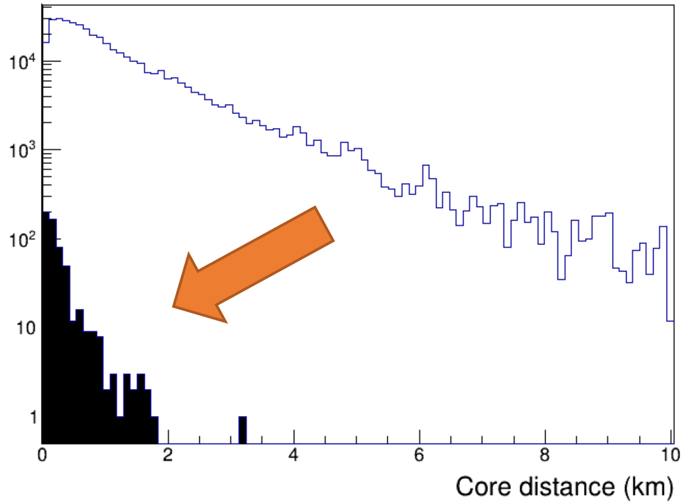
Muon cadidates

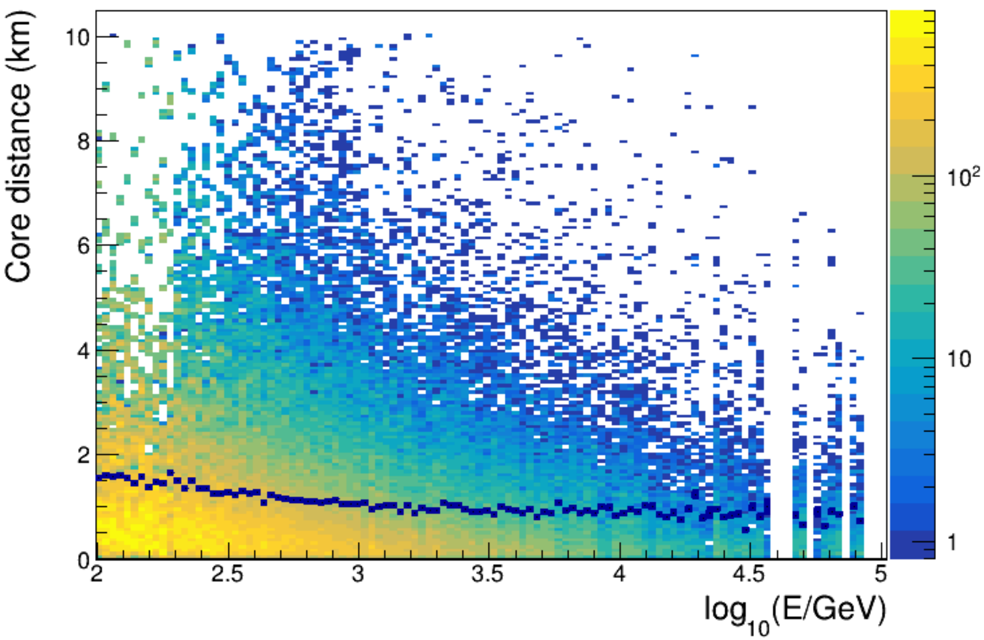
Shower generated randomly:

- Energy (previous slide)
- Direction (θ from Corsika,ϕ random)
- Position core (x,y) randomly generated in a large area (10 km radius)

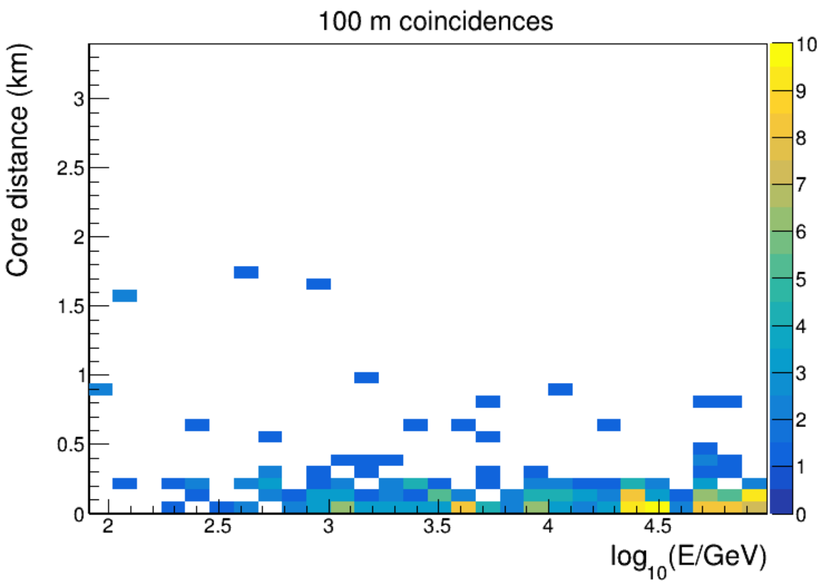
Events with candidates

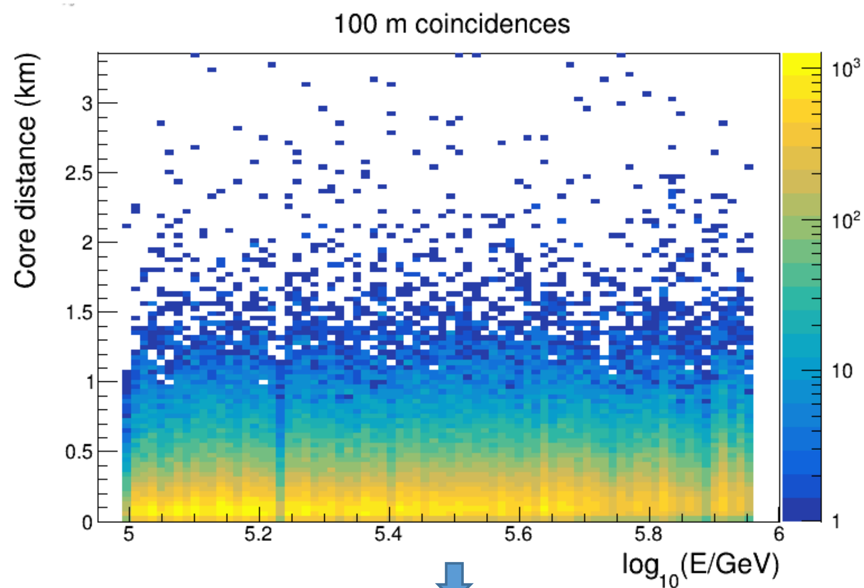


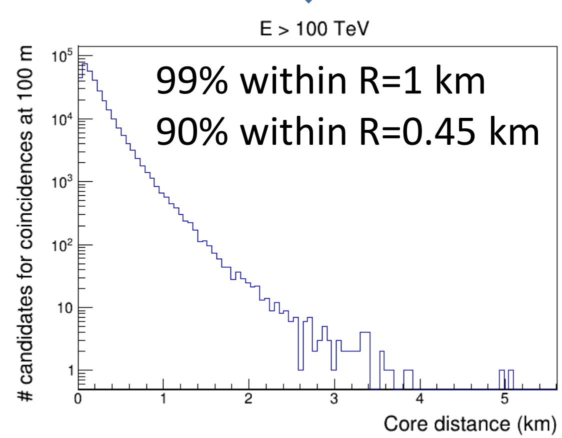




Core distance for coincidences



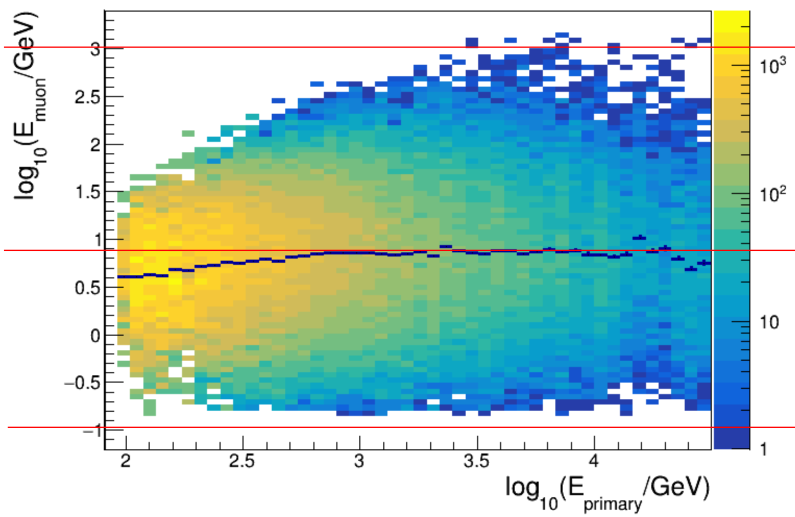


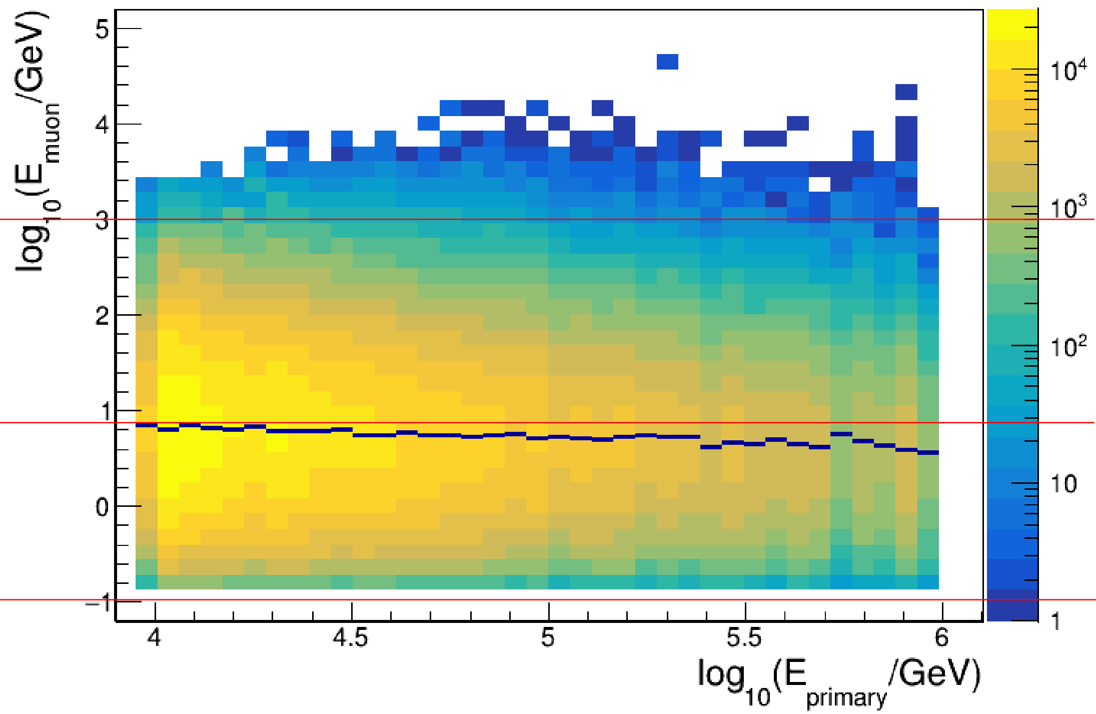


CPU time during generation proportional to R^2

→ We can gain a factor 400 in performance for coincidence studies

Muon vs primary energies





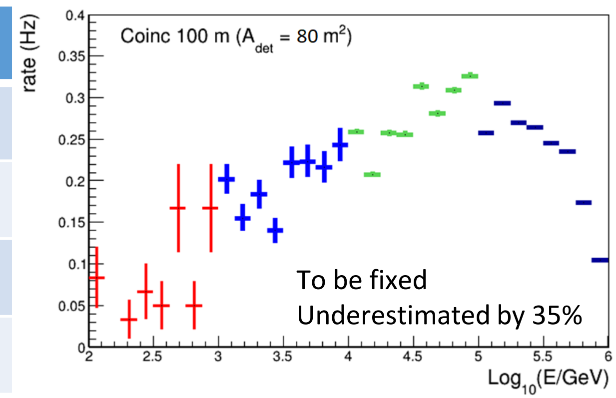
Computing time

Not the official one (2 tel)

1 μs to simulate a shower, mainly trigonometric operations!

Energy	Duration	#showers	#cand	#hits	DST rate	Time gen.	Time G4
> 10^2 GeV	40 s	5×10^{11}	394k	18k	33 Hz	164 h	80 min
> 10^3 GeV	400 s	1×10^{11}	620k	30k	5.2 Hz	31 h	5 h
> 10^4 GeV	3h 20 m	6×10^{10}	2.8M	135k	0.70 Hz	24 h	24 h
> 10^5 GeV	31 h 40 m	1×10^{10}	3.6M	186k	0.05 Hz	19 h	32 h

Energy	Coinc 100 m (A_{sel} = 78.5 m^2)	EEE at 100 m
$10^2 – 10^3$ GeV	1 Hz	Not available
$10^3 – 10^4$ GeV	2.4 Hz	Not available
$10^4 – 10^5$ GeV	3.35 Hz	17 +/- 7 day^{-1}
$10^5 – 10^6$ GeV	2.8 Hz	18 +/- 3 day^{-1}



Real rate reduced:

- Active area 1 m^2 (1/78.5)
- Telescope eff. = 94%
- Angular acceptance (?)

→ $(1/80 \times 0.94)^2 \sim 10^{-4}$

E < 10^6 GeV is responsible only of 1/3 of the coincidences

Note that in past simulation we reached 10^7 GeV

Consideration on CPU time

With the current setup (E > 100 GeV, R=10 km) we need 4h to generate 1 s of cosmic ray flux

Moving to E > 1 TeV, R=0.5 km we gain a factor **400x50=20000** which means we need about 2.5 s to simulate 1 s of cosmic ray flux! (+ time to propagate with geant4)

For coincidence studies we expect to miss only 15% of the signal! For single telescope events we miss 50% of the signal.

Fast propagation

1 day → 5 10^{10} showers

Energy	Duration	#showers	#cand	#hits	DST rate	Time gen.	Time G4
> 10^3 GeV	1 day	5×10^{10}	61M	2.4M	2.58 Hz	60 h	60 h (2tel)