Radio-Inc: Simulating the radio emission from very large particle cascades in the Earth's atmosphere near the horizon

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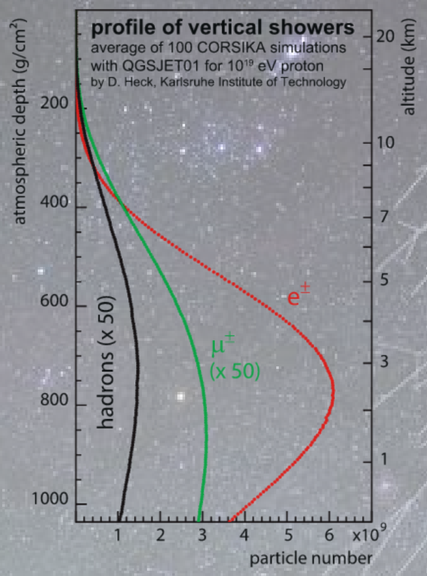
Ultra-high Energy Cosmic Rays, particles with tremendous energies from distant galaxies, are constantly in-pinging on the Earth's atmosphere ...

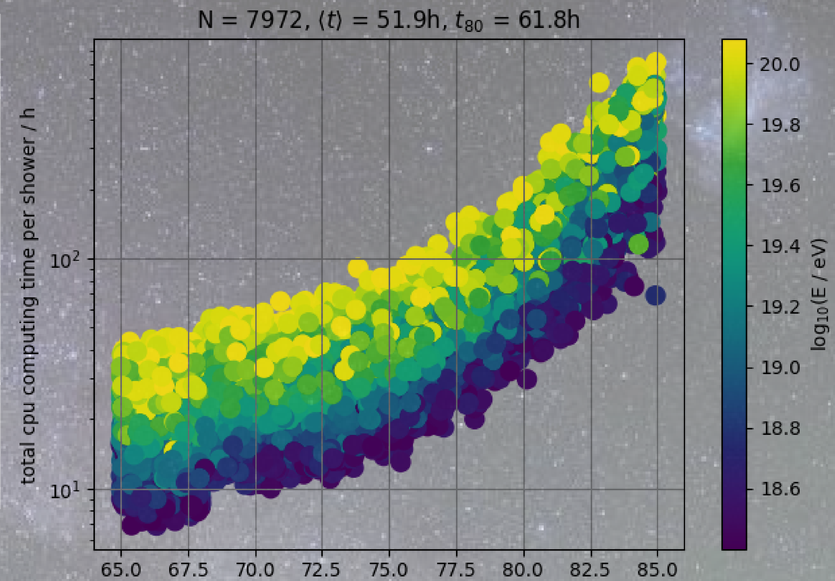


… they initiate huge particle cascades, Extensive Air Showers, with billions of secondary particles in our atmosphere.

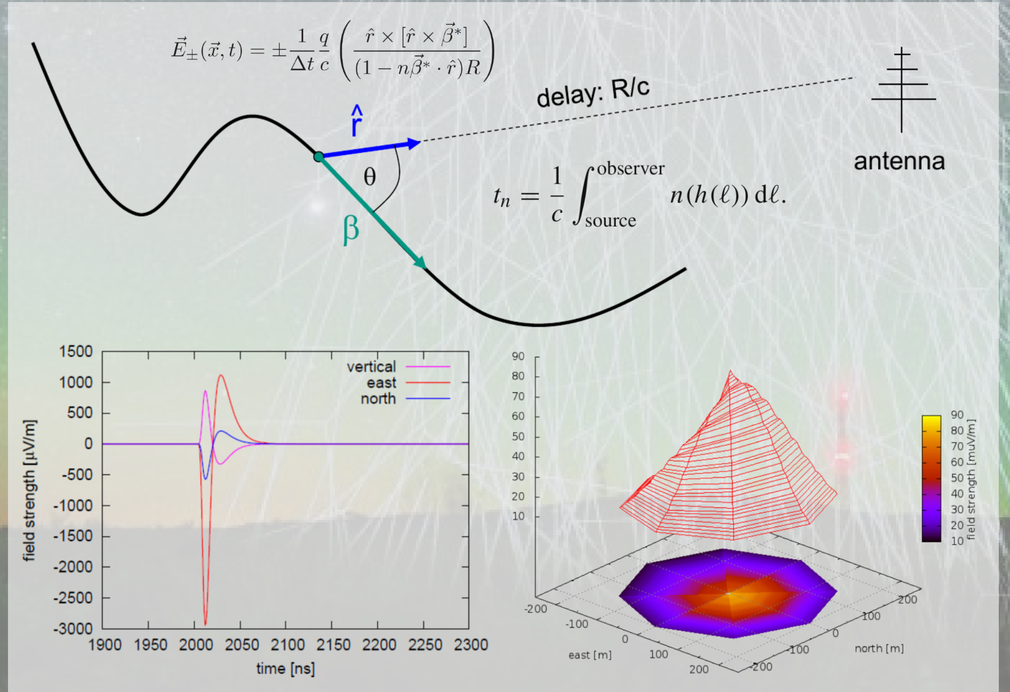
Comprehensive sets of simulations of inclined air showers are imperative to empower the scientific potential of future large scale radio experiments such as the AugerPrime Radio Detector or the Giant Radio Array for Neutrion Detection (GRAND).

The simulation of billions individual particles and the radio emission they produce in numerous detectors is impossible. To improve efficiency and decrease running times, several techniques are employed:

- Particles of same type, similar momentum and spatial vicinity are aggregated and treated as one
- Tabulating numerically determined propagation coefficients
- MPI-parallelisation: division in independent sub-shower



The secondary particles emit electromagnetic radiation. This emission is measured at ground as short, coherent radio pulses.

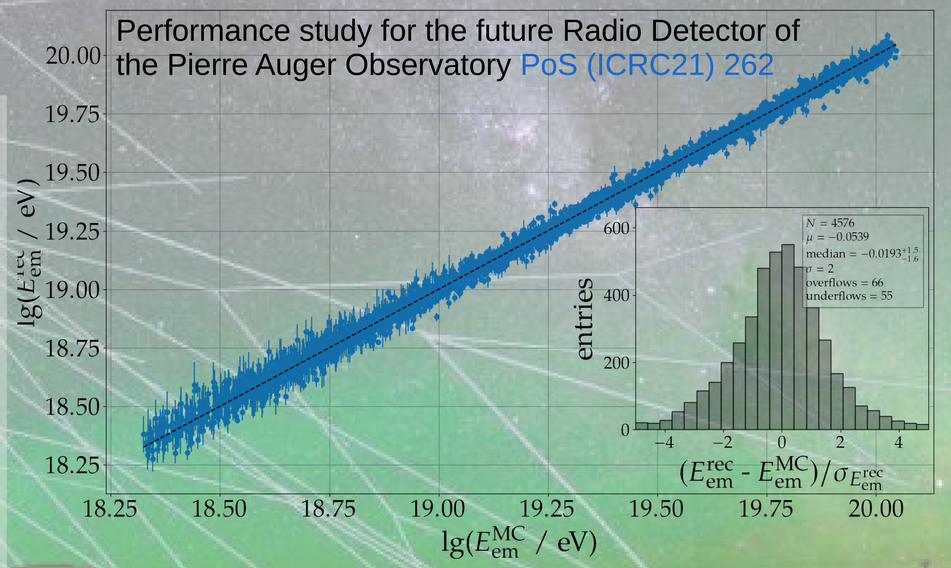


Simulation of Extensive Air Showers with CORSIKA:

- Full Monte-Carlo approach
- Treats every particle individually
- Highly flexible (different atmospheres, hadronic and electromagnetic interaction models,…)

Simulation of the radio emission with CoREAS:

- Simulate emission of each particle (electrons and positrons) ~ 10^{10}
- Simulate propagation between each emitter and each observer ~ 10-400
- Propagation in curved atmosphere for highly inclined air shower can not be computed analytically



Further application:

- Developing a reconstruction model for the radio emission of inclined air shower: PoS (ICRC21) 209
- Evaluate interferometric reconstruction algorithm: JINST 16 P07048
- Investigation of phenomena in inclined air showers: Eur. Phys. J. C 80, 643 (2020)

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Image: A. Chantelauze, S. Staffi, L. Bret