A Numerical Approach to Angular Distributions in Hadronic Cascades

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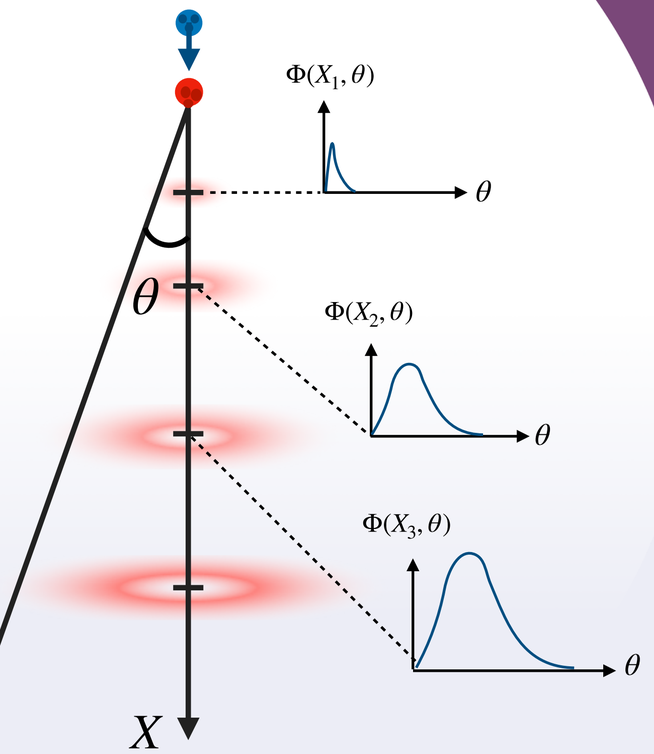
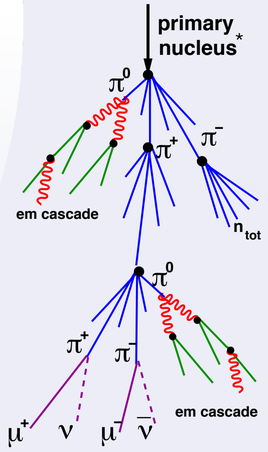




Hadronic cascades are...

> Central in cosmic ray air showers;

> More widely spread at low energies;

> Commonly simulated via Monte Carlo codes → computationally expensive to evolve.

This work is...

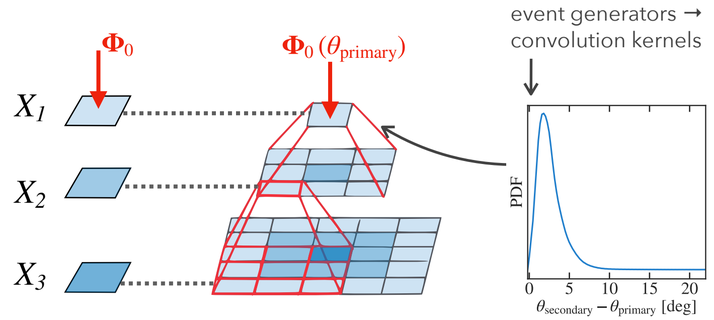
> Modelling the angular spreads of the low-energy cascade secondaries numerically;

> Targeted at 3D fluxes of $\mathcal{O}$(GeV) atmospheric leptons at reduced computational costs.

The Proposed Solution: 1D MCEq → 2D MCEq

> Use MCEq[1,2], a state-of-the-art code that solves matrix cascade equations for particle production, interaction, and decay;

> Extend MCEq from 1D to 2D via sequential convolutions:



> Solve the 2D cascade equations in the frequency domain.

Validation and Benchmarking

> Develop a 100 GeV proton air shower in 2D MCEq;

> Use CORSIKA[3] v7.74 as the benchmark Monte Carlo;

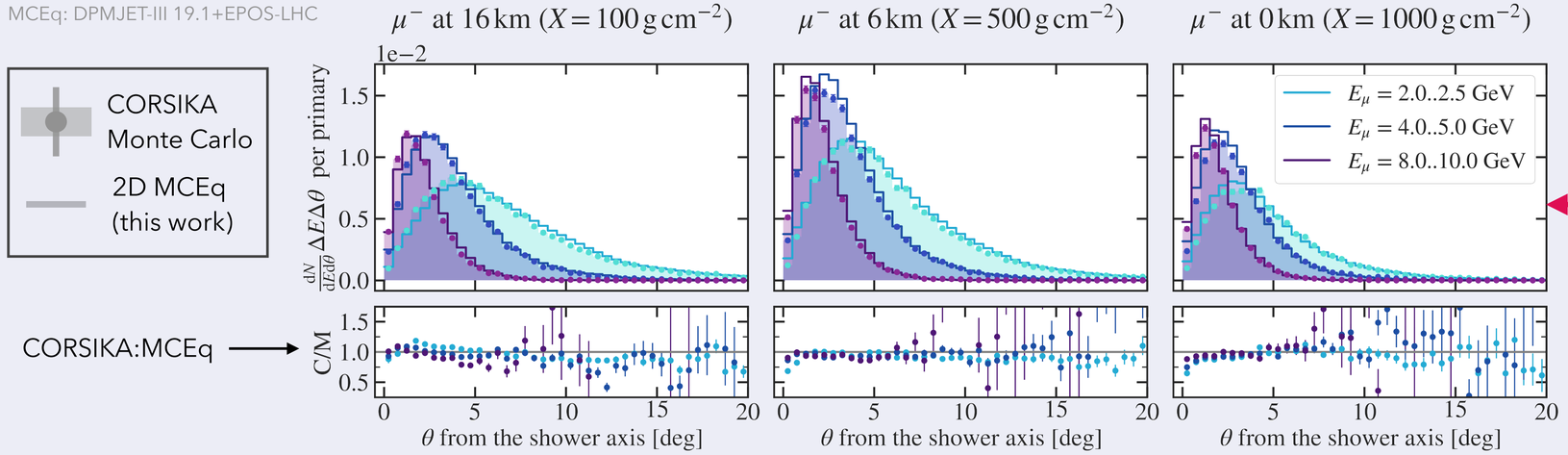
> Compare the muon angular distributions:

→ find a very good agreement;

> Our model can be a fast and accurate alternative to the Monte Carlo codes.

Results

Hadronic interaction models:
CORSIKA: UrQMD+EPOS-LHC
MCEq: DPMJET-III 19.1+EPOS-LHC



[*] Schematic from S. Mollerach and E. Roulet, Prog. Part. Nucl. Phys. 98 (2018).
[1] A. Fedynitch, R. Engel, T.K. Gaisser, F. Riehn and T. Stanev, arXiv:1503.00544 (2015).
[2] A. Fedynitch, F. Riehn, R. Engel, T.K. Gaisser and T. Stanev, Phys. Rev. D100(2019) 103018.
[3] D. Heck, J. Knapp, J.N. Capdevielle, G. Schatz and T. Thouw, Tech. Rep. FZKA-6019 (1998).