A Numerical Approach to Angular Distributions in Hadronic Cascades

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Executive summary

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What is this contribution about?

This study is about a **novel numerical technique** to evolve hadronic cascades in two dimensions (longitudinal + angular).

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Why is it relevant / interesting?

- Three-dimensional modelling of hadronic cascades in air showers is important for **angular distributions of $\mathcal{O}$(GeV) neutrinos** — the leading signal for atmospheric neutrino oscillation measurements;

- Hadronic cascades are typically evolved via Monte Carlo codes, which are computationally expensive;

- It is therefore very appealing to build a **fast and flexible numerical solver** for angular distributions of low-energy cascade secondaries.

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What have we done?

- We extended the state-of-the-art numerical code MCEq to 2D by treating the angular cascade development as a sequence of convolutions;

- We then calculated angular distributions of muons in a proton-induced air shower and benchmarked them against the standard Monte Carlo codes.

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What is the result?

A good agreement between the angular distributions from our “2D MCEq” solver and the Monte Carlo codes was reached, which shows that **our tool can be a fast and accurate alternative to the Monte Carlo approaches**.