Modified Characteristics of Hadronic Interactions (MOCHI)

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What is this contribution about?

Simulations of extensive air showers (EAS) produced by ultra-high energy cosmic rays (UHECR) using the standard CORSIKA package with Sibyll 2.3d – with the added twist of **ad-hoc modifications of parameters** of the hadronic collisions: **cross-section, multiplicity and elasticity.**

Why is it relevant/interesting?

There is t**ension between data** from UHECR experiments – such as the Pierre Auger Observatory and Telescope Array – **and simulations**. The data show more muons reaching ground than the simulations predict. **Could this tension be relieved if the basic properties of the interactions were reasonably modified?** This question was asked previously (R. Ulrich et al., Phys. Rev. D, 83 (2011) 054026) – but answered only in 1-D simulations. Now with **full 3-D simulations**, we have access to much more relevant observables for ground-based detection – we can now also change multiple parameters at once!

What has been done?

The code allowing the change of interaction parameters has been ported to CORSIKA. A library of proton-induced showers was produced at different zenith angles and with different values of modification strength for all three parameters – **cross-section, multiplicity and elasticity –** within bounds of the current accelerator data. The depth of the shower maximum X_{max} and the number of muons 1000 meters from the shower core $S_\mu*(1000)$ were retrieved.

What is the result?

The effect of the modifications on $S_\mu*(1000)$ **depends a lot on the zenith angle** of the primary cosmic ray. Different parameters push the results in different directions in the $X_{max} - S_\mu*(1000)$ plane – **not quite far enough** compared to published data, but in **promising** ways. Modifications of different parameters in parallel make sense, because the result is **not a simple addition of individual effects.**