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High p_{T} muons from cosmic ray air showers in IceCube

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Cosmic ray air showers with primary energies above $\sim$ 1 TeV can produce muons with high transverse momentum ($p_{\mathrm{T}} > 2$ GeV). These isolated muons can have large transverse separations from the shower core up to several hundred meters. Together with the muon bundle they form a double track signature in km^3-scale neutrino telescopes such as IceCube. These muons originate from the decay of heavy hadrons, pions, and kaons produced very early in the shower development, typically in (multiple) high p_{T} jets. If high p_{T} muons are produced simultaneously in two jets that are oriented back-to-back such interactions can also produce distinctive triple track signatures in IceCube.
The separation from the core is a measure of the transverse momentum of the muon's parent particle and the muon lateral distribution depends on the composition of the incident nuclei. Hence, the composition of high energy cosmic rays can be determined from muon separation measurements. Moreover for $p_{\mathrm{T}} > 2$ GeV particle interactions can be described in the context of perturbative quantum chromodynamics (pQCD) which can be used to calculate the muon lateral separation distribution. Thus these muons may help to test pQCD predictions of high energy interactions involving heavy nuclei.
We discuss the contributions from different components of air showers to the high p_{T} muon flux. Based on dedicated simulations the prospects of composition measurements using high p_{T} muons in km^3-scale neutrino telescopes are studied. We present analysis methods to study laterally separated muons in IceCube with lateral separations larger than 150 m using data taken from May 2012 to May 2013

Collaboration

IceCube

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