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Measurements of Cosmic Ray Mass Composition with the IceCube Neutrino Observatory

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The IceCube Neutrino Observatory is a multi-component detector at the South Pole capable of measuring high-energy cosmic rays from PeV to EeV. This energy region is typically thought to cover the transition from galactic to extragalactic sources of cosmic rays. The observatory consists of the IceTop surface array, which is sensitive to the electromagnetic and low-energy muonic part of an air shower, and the deep in-ice IceCube array, which measures the high-energy ($\geq$ 500 GeV) muonic component. One of the recent cosmic ray detector enhancements at the South Pole consists of the IceAct prototype array, which is measuring the Cherenkov light produced by low-energy extensive air showers directly in the atmosphere, extending the energy range to below 100 TeV.

The primary energy and the mass composition can be measured simultaneously by applying modern machine-learning techniques and statistical methods to reconstruct cosmic ray air showers. In this contribution, we will discuss recent improvements to the reconstruction techniques, the mass composition sensitivity, and an outlook on future improved measurements with the full surface scintillator/radio array and improved air Cherenkov telescopes.

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