

Hybrid cosmic ray measurements using the IceAct telescopes in coincidence with the IceCube and IceTop detectors

Executive Summary

IceAct is a proposed surface array of compact (50 cm diameter) and cost-effective Imaging Air Cherenkov Telescopes installed at the site of the IceCube Neutrino Observatory at the geographic South Pole. Since January 2019, two IceAct telescope demonstrators, featuring 61 silicon photo-multiplier pixels have been taking data in the center of the IceTop surface array during the austral winter. We present:

Science goals of IceAct:

- Hybrid cosmic ray composition studies
- Calibration of IceCube/IceTop geometry and energy reconstruction
- Low energy cosmic ray veto capabilities for neutrino analysis

Setup and performance:

- Two years of operation with the two-telescope setup (Data-acquisition unified 2020)
- Successful data-taking during high moonlight and auroras, overall duty cycle of $> 20\%$ realistic

Coincident events synchronization and analysis:

- Event-to-event synchronization using only the drift corrected internal telescope timestamps successful
- Spatial distribution of air-showers shown for a single and stereo telescope triggers
- Correlation of shower direction between IceCube reconstruction and IceAct image center of gravity

Simulation and Cosmic Ray composition:

- First full detector simulation combining optical and electronic telescope and a full IceCube simulation
- Decent data/MC agreement, but not fully tuned and minor parts not yet implemented
- Very promising capabilities to improve the composition measurement with hybrid events using a random forest reconstruction

Outlook:

- An simulation based improved geometry and energy reconstruction for pure telescope and hybrid events. Improving the reconstruction of the primary particle in the energy range from 10 TeV to a few PeV.
- Multiple telescopes are under construction to be added to the current setup at the South Pole, increasing the total field-of-view to 36° .