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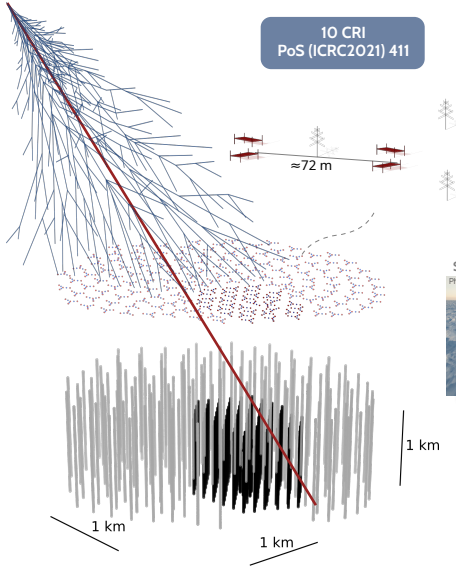
Simulation study for the future IceCube-Gen2 surface array

Agnieszka Leszczyńska, Mark Weyrauch, Alan Coleman for the IceCube-Gen2 Collaboration



Surface array delivers infromation about cosmic-ray energy while the measurement of the ***muonic core*** in the ice improves the mass identification.

1

The next generation of the IceCube Neutrino Observatory, IceCube-Gen2, with its surface array, will be a unique detector to study cosmic rays in the ***energy region where extragalactic sources are expected to begin to dominate***. Increased aperture, in particular for coincident events, will be beneficial not only for air shower studies but will also for vetoing atmospheric background for astrophysical neutrino events.

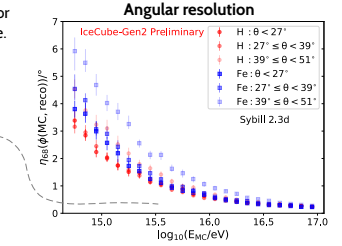
See F. Schröder (407)

See H. Dujmovic (314)

Hybrid station with 8 scintillators and 3 antennas above each in-ice string.

2

- A library of air showers was prepared and processed through the detector arrays using CORSIKA/CoREAS and Geant4 within the IceCube software.
- Reconstruction algorithms were optimised for the scintillator array. The signal and timing information is included in a likelihood minimization in which the shower geometry, energy estimator, LDF and shower front parameters are obtained. Scintillators provide sub-degree resolution above 10 PeV. Initial studies on the energy estimator for the scintillator array were performed.
- Radio reconstruction is in preparation and will further improve energy estimation and will deliver Xmax estimation.



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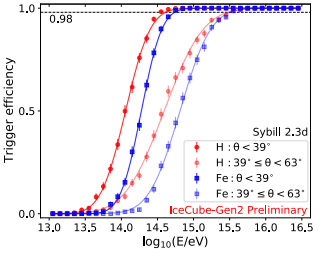
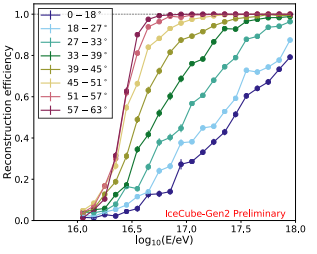
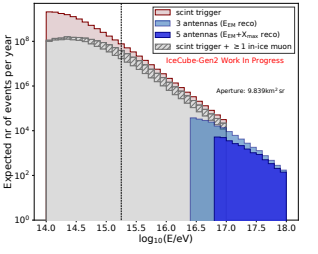


Trigger efficiency for at least 5 hits. The threshold reaches sub-PeV for zenith angles up to 39° and increases with the increasing zenith angle.



See A.Coleman (317)

Condition requires 3 antennas with signal above the threshold and angular reconstruction within 5°. Radio detection is more efficient for inclined showers.



Sufficient number of events for scintillator, radio, and ***coincident in-ice detection*** for probing *Galactic-to-extragalactic* transition.

Simulations will be continued beyond 1 EeV.

4 Summary & Prospects

- IceCube-Gen2, with its surface array, will be a unique detector to study cosmic rays in the PeV-EeV cosmic-ray energies.
- A hybrid air-shower array in combination with the in-ice detection of the muonic core has a potential to boost the CR energy and mass determination as well as to improve our understanding of hadronic interactions.

References and further readings:
[1] IceCube-Gen2 Collaboration, A. Karle and M. Kowalski, PoS(ICRC2021)
[2] IceCube-Gen2 Collaboration, F. Schröder, PoS(ICRC2021) 407
[3] IceCube Collaboration, A. Coleman, PoS(ICRC2021) 317
[4] IceCube Collaboration, A. Leszczyńska and M. Plum, PoS(ICRC2019) 332 (2020)

Karlsruher Institut für Technologie
UNIVERSITY OF DELAWARE BARTOL RESEARCH INSTITUTE


agnieszka.leszczynska@kit.edu


mark.weyrauch@student.kit.edu


alanc@udel.edu