IceTop Cosmic Ray Anisotropy

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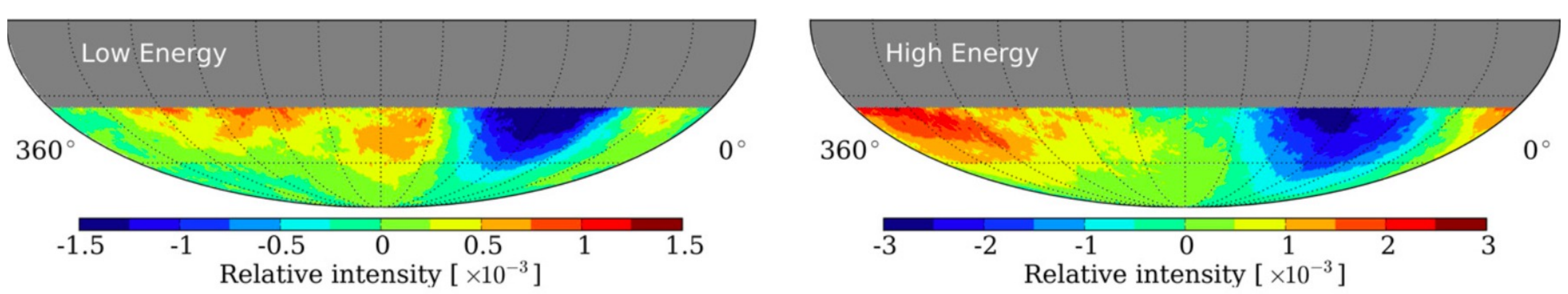
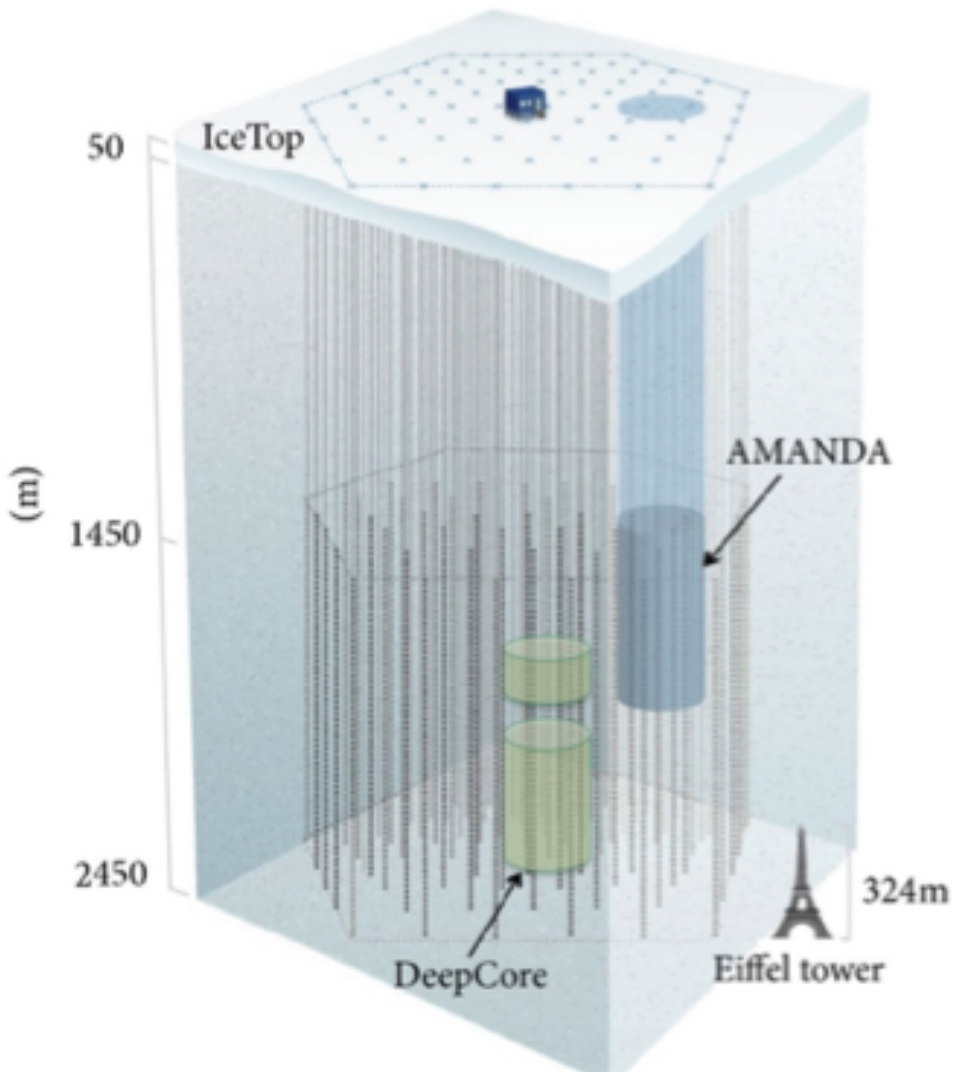
Introduction and Motivation

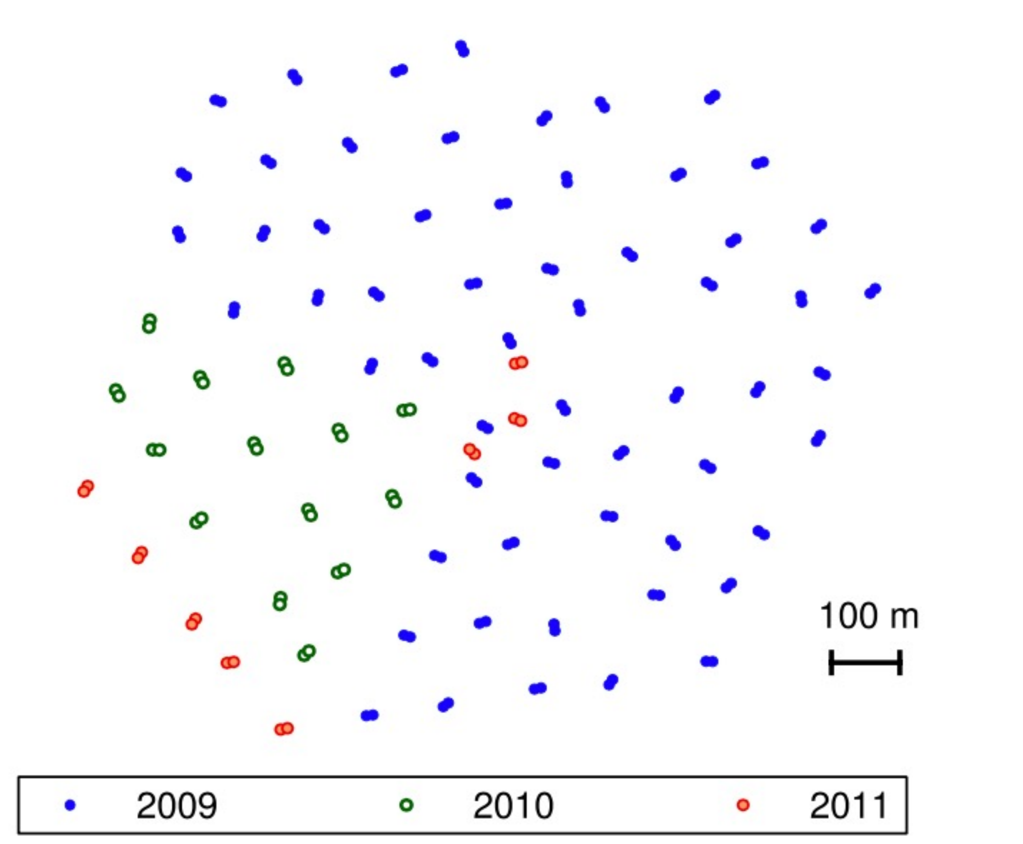
IceTop is a group of cosmic ray detectors located on top of the IceCube neutrino detector at the south pole. This detector array was originally built to act as a veto for IceCube to distinguish astronomical neutrino events from cosmic rays. In doing so, the detector can also be used to study these cosmic rays. IceTop is sensitive to events with energies between 100 TeV and 1 EeV. This allows us to investigate higher-energy cosmic rays than those detected by IceCube itself. By analyzing these events, large-scale cosmic ray anisotropy can be studied on the order of 10^{-3}. We are specifically interested in the distribution of arrival directions of high-energy cosmic rays, in the PeV scale[1]. The work described in this poster is concerned with updating previous anisotropy analyses to study a longer time period and to use new data reconstruction methods.



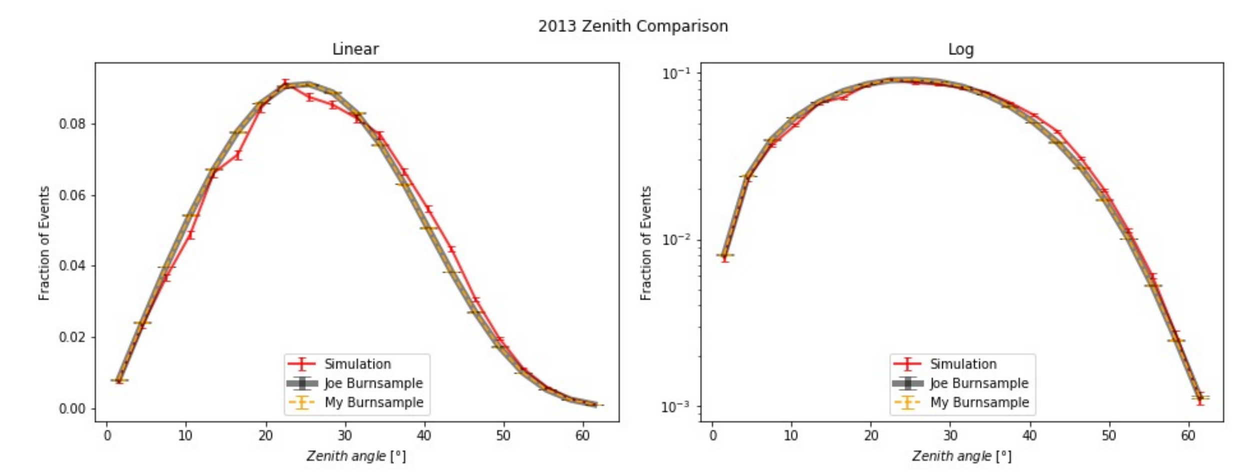
Relative intensity skymaps from the previous anisotropy study[1]. The events were broken down into low-energy (median 400 TeV) and high-energy (median 2PeV). These maps represent the data with a smoothing angle of 20°.



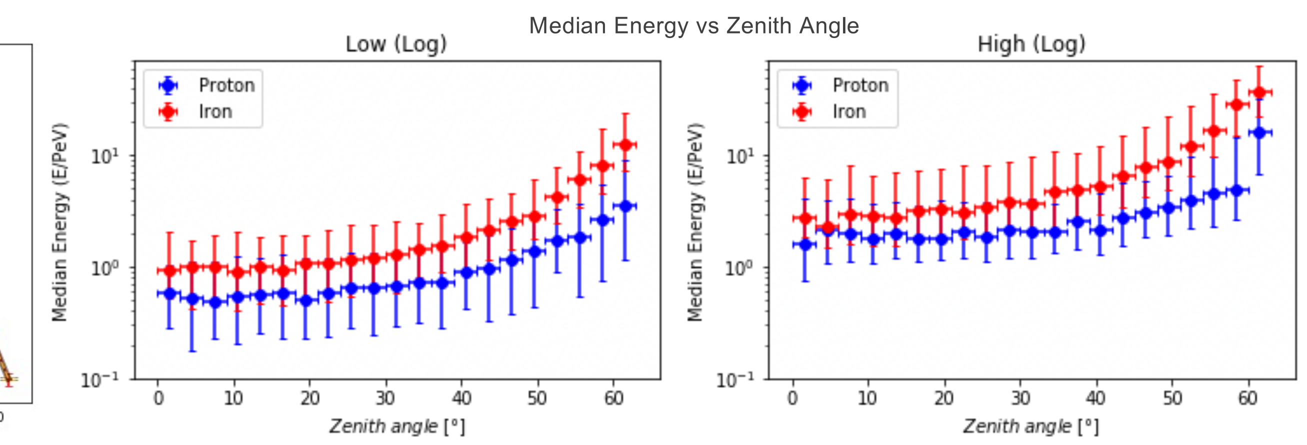
Configuration of IceCube and IceTop detectors in Antarctica. The data used in this work was taken by the IceTop detectors.



IceTop air shower array geometry finished in 2011. IceTop consists of 81 stations with 2 detectors each (represented by the circles). The detectors are Cherenkov tanks filled with clear ice. They record the muonic and electromagnetic components of incident air showers.



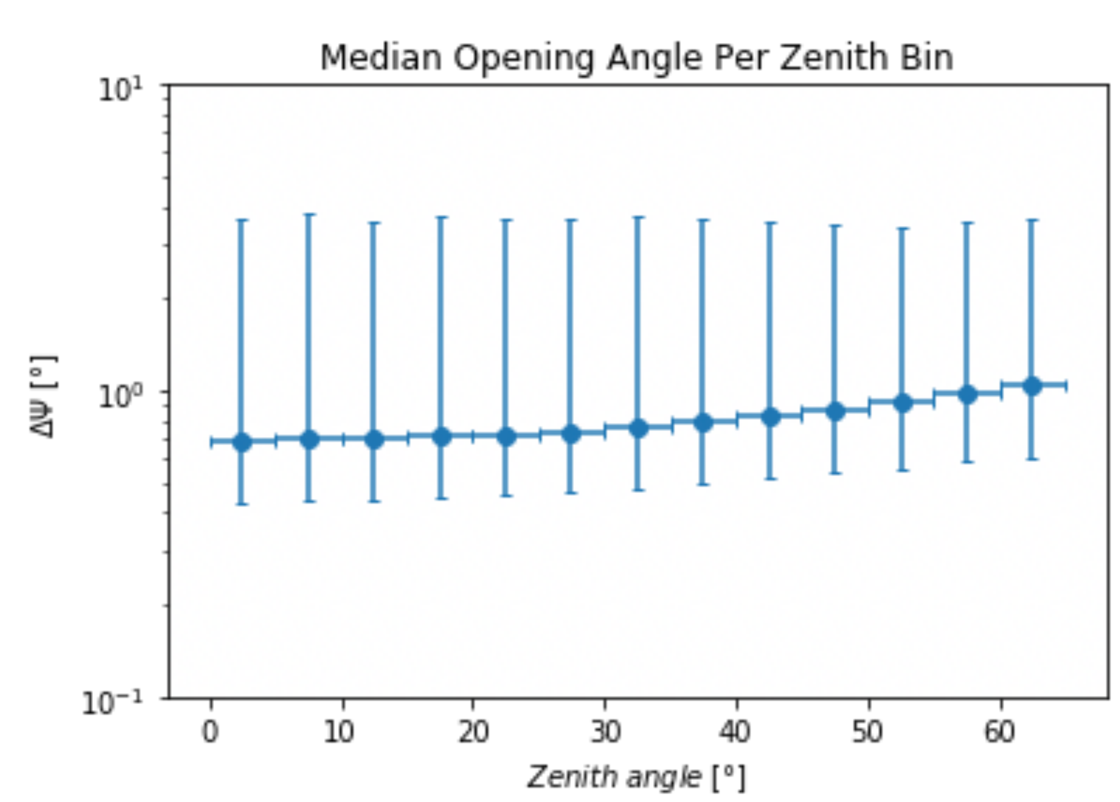
IceTop zenith distribution of reprocessed data (My Burnsample), previous data (Joe Burnsample) and data from IceTop simulations (Simulation)[2].



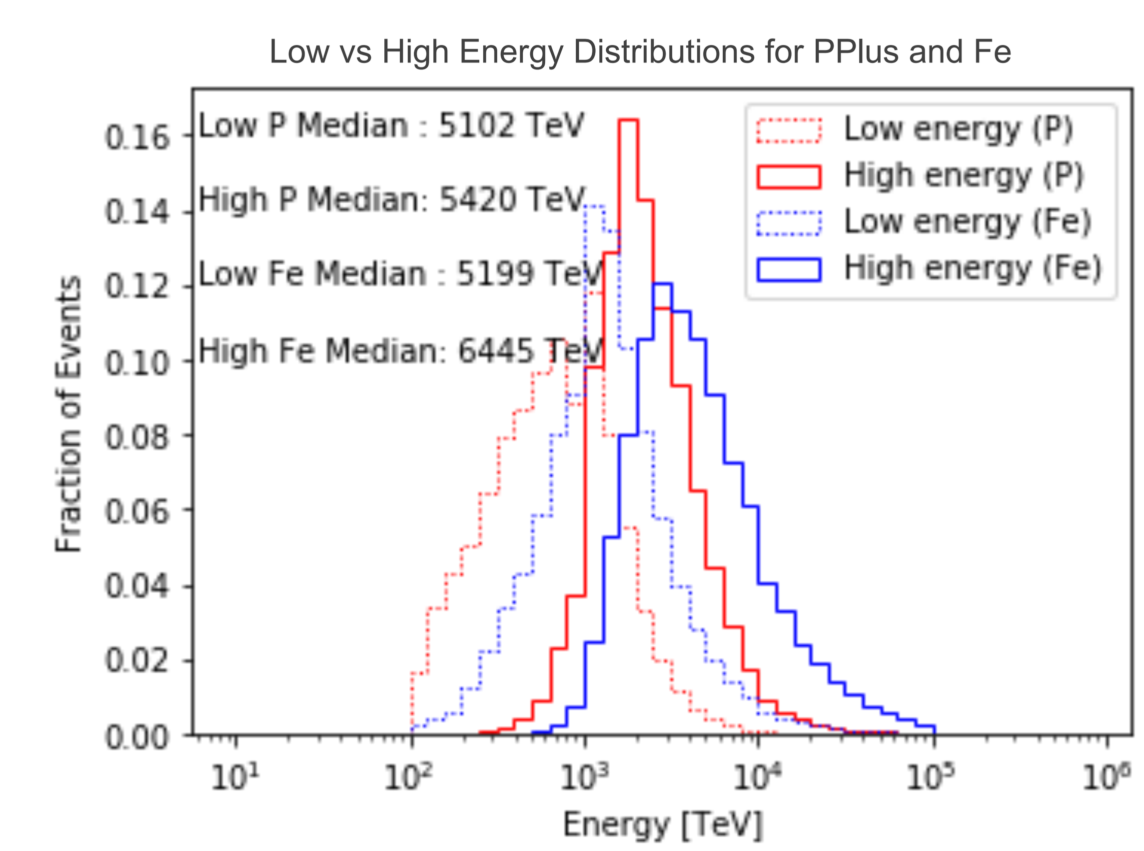
Median energy and zenith angle of incoming cosmic rays based on IceTop simulations[2]. The data is split between low energy and high energy events. We would like to use data in which the median energy is relatively constant over the zenith angle.

Data Processing

The reconstruction process for data from the IceTop detectors was recently updated by the IceCube collaboration. In order to continue and update past cosmic ray anisotropy analysis, the data files needed to be reprocessed and compared to previous results and simulations. If there is reasonable agreement, we can continue to use similar data cuts and analysis processes. If there are major discrepancies, further exploration is needed. The figure on the left above depicts the zenith angle distribution of incident cosmic rays during the year 2013 for different data sets. Based on this agreement, we conclude that the new reconstruction method is valid and that the data was processed correctly.



The median opening angle of incoming cosmic rays per zenith angle bin[2]. As with the median energy plot above (right), we want to use data in which the opening angle is relatively constant over the zenith angle.



Median energy of proton and iron showers from IceTop Monte Carlo simulations[2]. The data here is again split into low and high energy particles.

Future Work: Cosmic Ray Anisotropy Analysis

Based on the above plots, we will be using two data cuts. The first cut is to ignore all events with a zenith angle above 55°. This ensures that the median energy and opening angle stay relatively constant across our data. The second cut excludes any events in which less than 3 stations were active. Low energy events are those in which at least 3 but less than 8 stations were active while high energy events are those in which 8 or more stations were active. Using the reprocessed data from 2011-2021 with these cuts applied, we will begin analyzing the large-scale anisotropy.

References and Sources

[1]M. G. Aartsen *et al* 2013 *ApJ* **765** 55
[2]Previous work by Joseph Summers under Dr. Rasha Abbasi

IceCube Neutrino Observatory

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