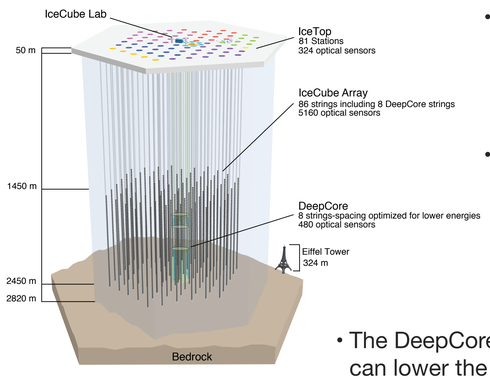
Low Energy Astrophysical Transients with IceCube-DeepCore

Michael Larson for the IceCube Collaboration

Abstract

IceCube has presented evidence for a time-dependent flux of TeV neutrinos from the blazar TXS 0506+056. Additional events may be observable by IceCube at lower energies, although the existing analysis rapidly loses sensitivity below about 1 TeV. The densely instrumented DeepCore sub-array improves the threshold for observation from 1 TeV down to approximately 10 GeV, giving a unique window to probing low energy transient astrophysical fluxes that are largely unexplored. We present a result from a recent all sky, self triggered ~100 second flares in the 10-200 GeV energy range. This analysis, using a data selection originally optimized for neutrino oscillations, improves sensitivity on a prior study by a factor or 5. A new event selection has been developed - including planned analyses with Choked GRBs and Novae - with the ultimate goal of providing community alerts for low energy neutrino astrophysical transients.

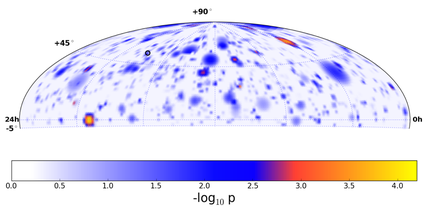
IceCube-DeepCore

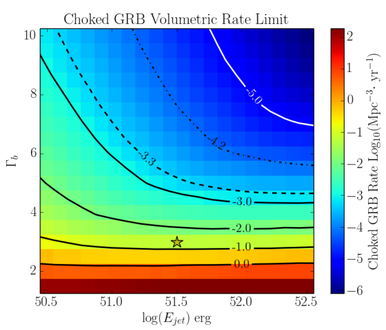


- IceCube is a cubic kilometer Cherenkov detector located at the geographic South Pole
- Searches for astrophysical transients have traditionally used the full array, with an energy threshold around 1 TeV
- The DeepCore low-energy infill array can lower the threshold down to approximately 5 GeV
- DeepCore can contribute to searches for soft spectra transients
- IceCube is developing new analyses aimed at searching for low energy astrophysical transients

Previous Measurements

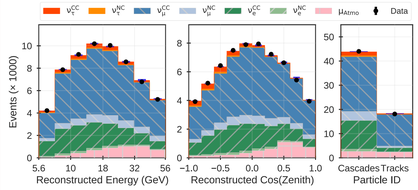
- A previous analysis[1] used one year of data from the completed detector to search for choked GRBs
- The event selection focused on northern sky muon neutrino events



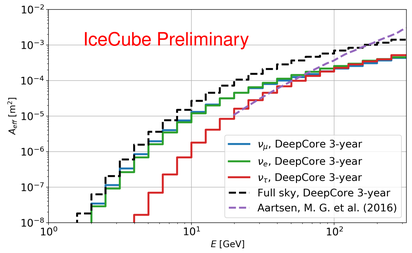


- No significant sources were discovered from neutrino events with energies between 30 and 300 GeV
- Limits were placed on generic soft-spectra astrophysical transients on timescales from 1 second to 10 days

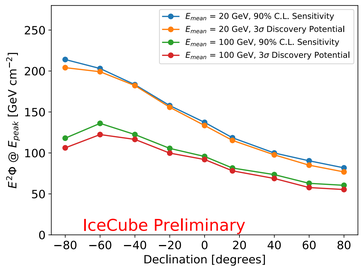
A Three-year DeepCore Search



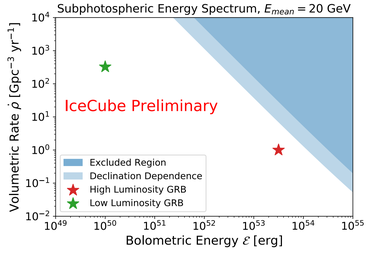
- A DeepCore event selection[2] of starting events for atmospheric neutrino oscillations from 5-56 GeV was repurposed for transient astrophysical search
- Neutrino effective areas are significantly improved relative to previously published DeepCore GRB analysis
- All-sky, all-flavor untriggered search for low energy transients performed using existing sample

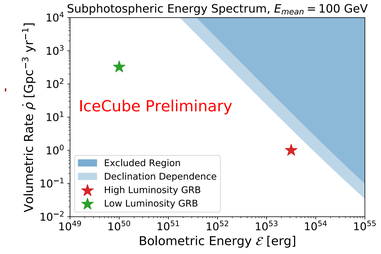


- A KDE in time was used to identify periods of high activity in sample followed by evaluation using standard point source methods[3]
- Analysis sensitive to O(100) second timescales



- No significant emission found in three-year sample
- Limits were placed using a model of subphotospheric γ-ray emission of GRBs[4] tested using three years of DeepCore data
- Paper currently in progress



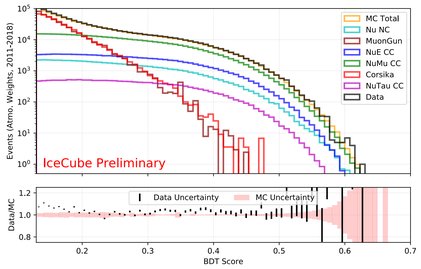


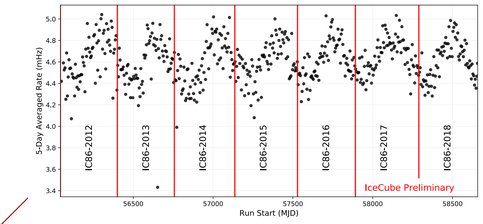
References

[1] M.G. Aartsen et al., ApJ, 816, 75 (2016)
[2] M.G. Aartsen et al., Phys. Rev. D 99, 032007
[3] J. Braun et al., Astropart.Phys. 29:, 299-305 ,2008
[4] K. Murase, K. Kashiyama, and P.,Mészáros, Phys.Rev.Lett. 111 (2013) 131102
[5] G. de Wasseige et al., PoS-ICRC2019-865
[6] M.G. Aartsen et al., JINST 11, P11009, 2016

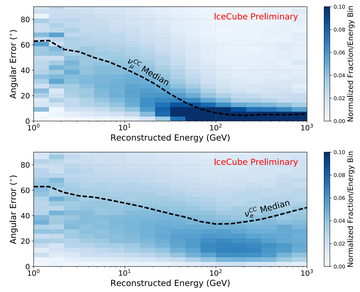
A Dedicated Low Energy Transient Selection

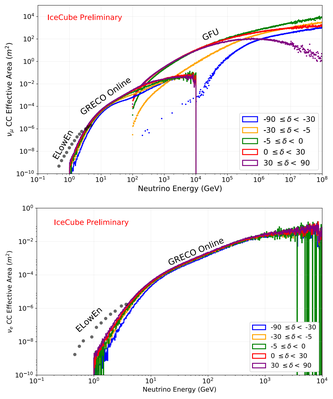
- Improvements in effective area possible for short transients
- Re-optimization of the sample increases the effective area by ~2x
- Good agreement between data and simulation across 7+ years of detector data





- Atmospheric neutrinos dominate the backgrounds in the northern sky while atmospheric muons dominate for the southern sky
- Data is stable with a rate of around 4.6 mHz
- Reconstruction assumes hadronic cascade + muon track
- Reasonably good resolution for muons above 50 GeV
- Limited resolution in the detector for cascades, but can grant additional significance if in-time with transient signals





- **Sensitivity improvements expected up to 200 GeV in the northern sky and up to ~10s of TeV in the southern sky**
- **Searches planned for largely unexplored gap between IceCube's existing extremely low energy[5] and high energy gamma-ray followup[6] searches**
- For planned analyses, see Poster #266: Search for Astrophysical Neutrino Transients with IceCube DeepCore