Results on astrophysical neutrinos using 7.5 years of high-energy events with contained vertices

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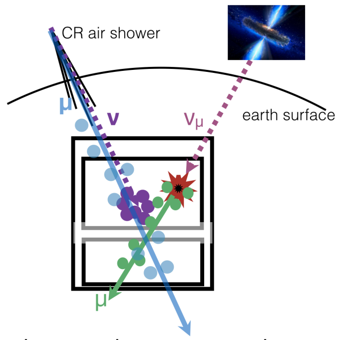
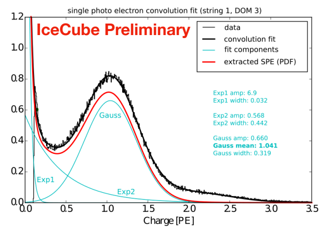
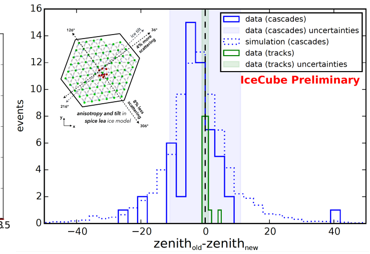
The High Energy Starting Event (HESE) data sample

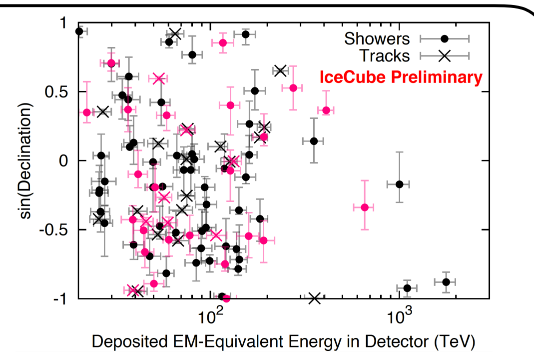


charge and veto cuts to select high-energy starting neutrinos and reject incoming atmospheric muons and neutrinos [1,2,3]





82 previously released events [1,2,3] re-analyzed:
- charge re-calibration (left): DOM-by-DOM single photo electron peak correction by ~4%; consequently some events dropped below the HESE charge threshold of 6000 photoelectrons
- improved reconstructions (right): ice anisotropy and global tilt now taken into account → change in reconstructed event directions, especially for cascade-type events; tracks are mostly unaffected; most events reconstruct within previously assumed uncertainties;



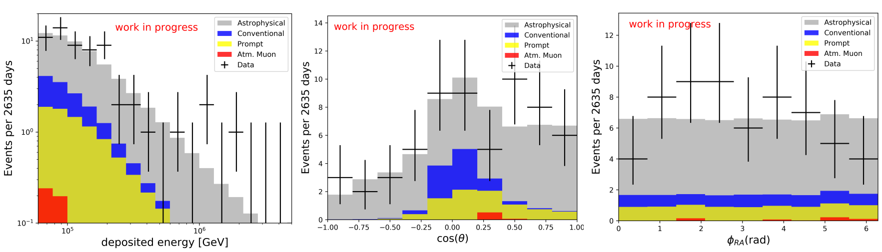
HESE data events in observable phase space
- 103 events out of which 60 have E_{dep} > 60 TeV at 75% astrophysical purity; new events compared to the previous analysis [3] are marked in pink
- energies and directions changed due to data re-calibration and improvements in event reconstruction

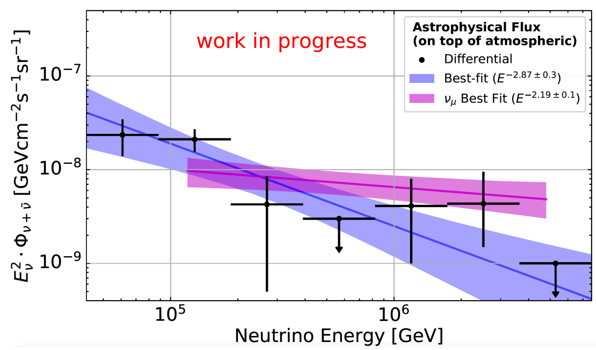
Astrophysical neutrino flux measurement

In order to describe the data, we perform a likelihood fit of all components (atmospheric muons, atmospheric neutrinos from p/K decay ("conventional"), atmospheric neutrinos from charm decay ("prompt") and an astrophysical flux assuming a 1:1:1 flavor ratio). The fit is performed in the energy range of 60TeV < E_{dep} < 10PeV. As in previous iterations of this analysis, we fit an unbroken power-law spectrum with a variable index E^γ.

Best-fit astrophysical flux with per-flavor normalization: $E^2\Phi_\nu = 1.86^{+0.75}_{-0.65}\cdot 10^{-8}\cdot\left(\frac{E}{100\,\text{TeV}}\right)^{-0.87^{+0.31}_{-0.22}}\ \text{GeV cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$

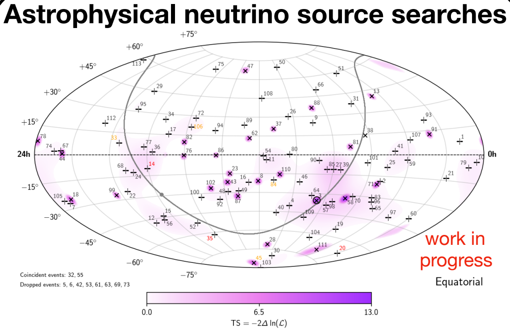
Bottom: deposited energies and directions of 60 data events with predictions from the unbroken power law fit: 44^{+6}_{-5} astrophysical ν, $6.5^{+1.5}_{-1.5}$ conventional atmospheric ν, 8^{+10}_{-8} prompt ν and $0.65^{+0.2}_{-0.2}$ atmospheric muons



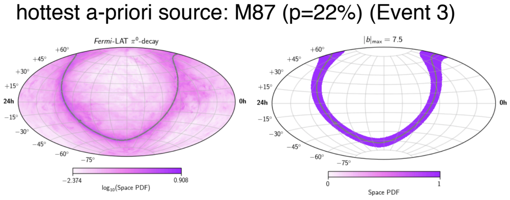


Top: Astrophysical neutrino flux as a function of energy. The black points with error bars are extracted from a combined likelihood fit of all background components and several pieces of E^{-2} components in neutrino energy. Error bars indicate the ΔL=±1 contours of the flux in each energy bin. The single power law fit result is shown in blue, the pink band shows the 8yr high energy up-going muon best fit [4]. Both results are compatible at neutrino energies > 200 TeV.

Astrophysical neutrino source searches



103 events with per-event statistical & systematic uncertainties: tracks (x) ~1°, cascades (+) ~10°
no significant clustering in all-sky search (p=81%)
hottest a-priori source: M87 (p=22%) (Event 3)

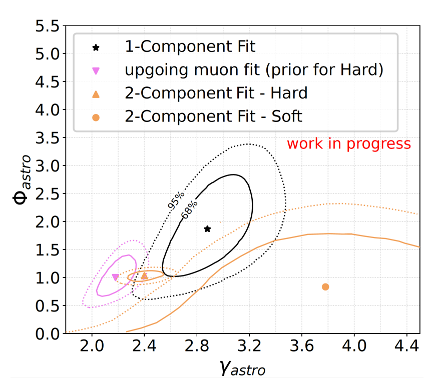


left: no excess correlated with Fermi-LAT pi0 decay model (p=60%)
right: no excess in galactic center box-template search (p=40%)

Data consistency and future steps

The seemingly large differences in the best-fit slopes between different datasets could suggest a second astrophysical component. This possibility has been previously investigated using 4 years and 6 years of HESE data [3][5].
Here, we performed a fit to the HESE 7.5 year dataset introducing a second astrophysical component, described by a power-law without cutoffs.

Right: Contours for unbroken (black) and broken power law (orange) fits, where we used the independent 8yr high energy up-going muon best-fit astrophysical flux (pink) as a prior for the high-energy ("hard") component of the HESE broken power-law fit. Due to the large uncertainties on the low-energy ("soft") component it is compatible with zero within 1σ in which case the fit reduces to a single astrophysical component. In both cases, a fit without a high-energy cutoff is preferred.



Due to its limited statistics and energy range, the HESE data sample cannot distinguish between different astrophysical flux models. Future analyses [8] will combine electron, muon [4] and tau neutrino [6,7] detection channels, at energies down to 1 TeV where atmospheric neutrinos are dominant. Therefore, an improved treatment of atmospheric uncertainties [9,10,11] will be employed. Future detector upgrades [12] will further result in a better understanding of the detector and ice systematics.

References

[1] IceCube, Science, 342 (6161) 2013
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[3] IceCube, PoS (ICRC 2017) 974
[4] IceCube, PoS (ICRC 2017) 1005
[5] Vincent et al, PRD 94, 023009 (2016)
[6] IceCube, PoS (ICRC 2017) 973
[7] IceCube, PoS (ICRC 2017) 1009
[8] IceCube, PoS (ICRC 2017) 976
[9] Fedynitch et al., PRD 86, 114024 (2012)
[10] Barr et al., PRD 74, 094009 (2006)
[11] Argüelles et al, arXiv:1805.11003 (2018)
[12] IceCube-Gen2, arXiv:1412.5106
[13] IceCube-Gen2, arXiv:1510.05228

more info here: