Final report on High-energy neutrinos observed at IceCube

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Introduction

➢**Physics motivation:**

- properties of neutrino, good probe to detect the source of cosmic rays and deep cosmos
- low flux and rare interaction → large
- dominant background: muons and neutrinos generated in interactions of cosmic rays in the atmosphere → deep underground

➢**Other scientific targets of IceCube:**

- study neutrino properties (neutrino oscillations; neutrino mass hierarchy)
- cosmic ray study
- indirect dark matter search
- search for sterile neutrinos

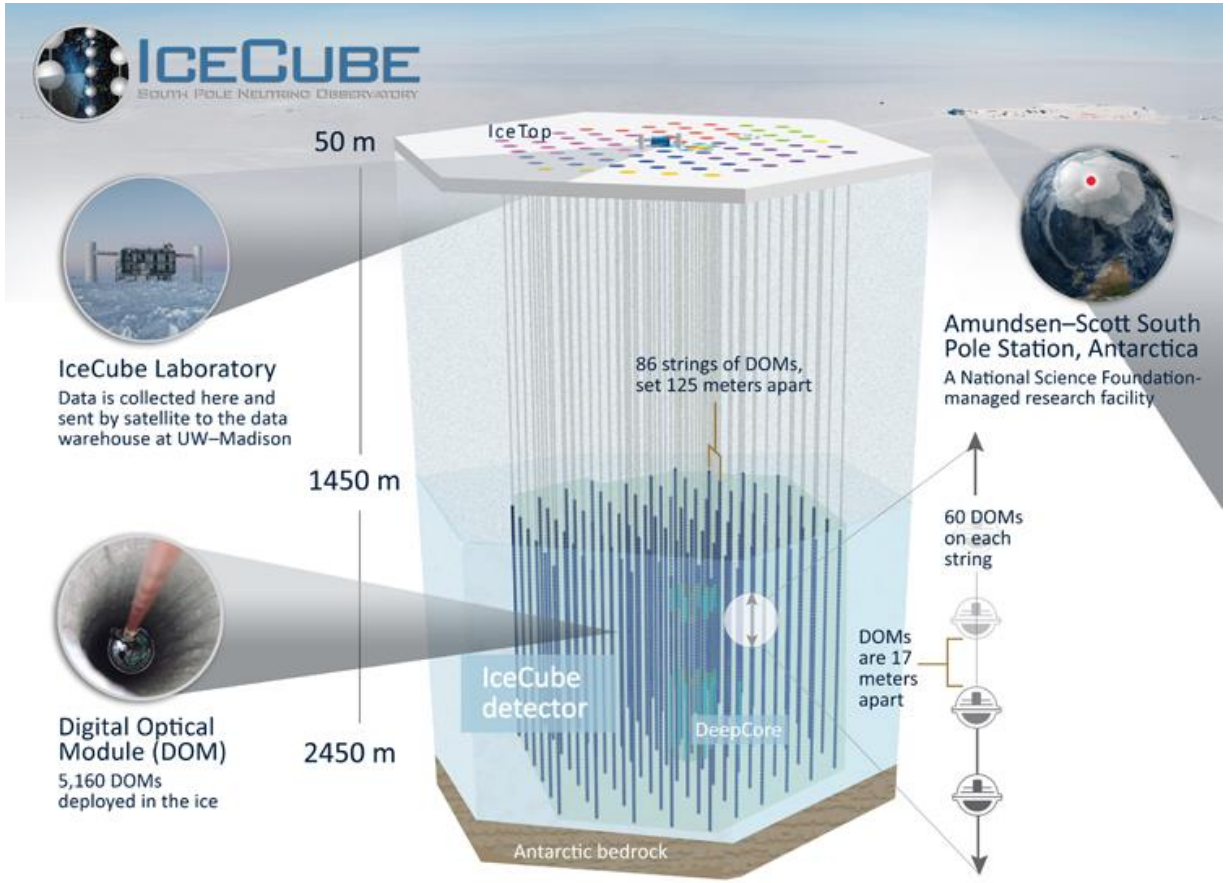
Experimental facility

➢**IceCube detector**

- IceTop, IceCube Array (including DeepCore), predecessor AMANDA
- 5,160 digital optical modules (DOMs), DOMs attached to 86 vertical strings

➢**Main difficulties and method to overcome them**

- time: drill holes quickly, circulating heat system
- calibration of ice

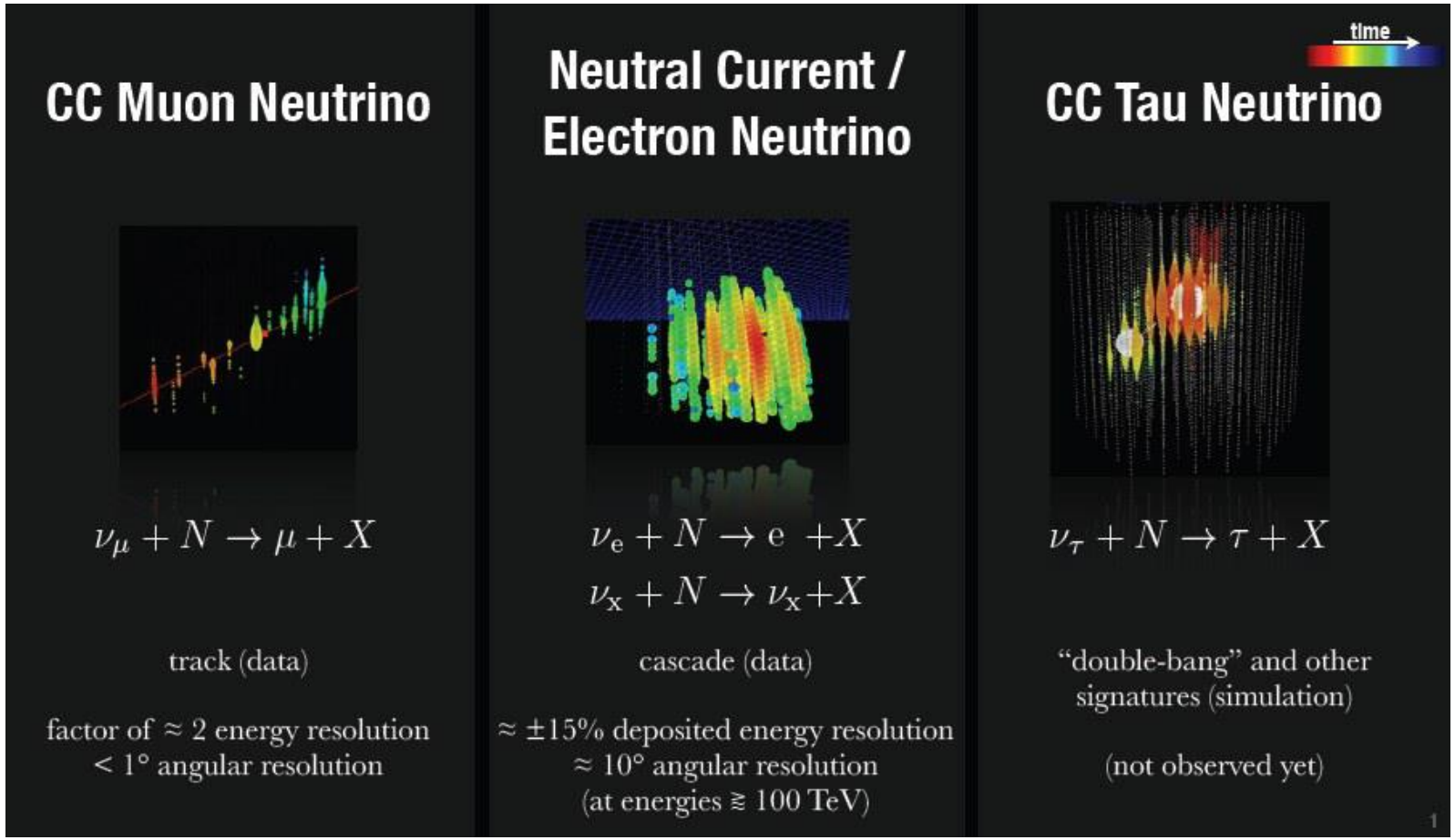


IceCube detector (from IceCube official website)

Analysis method

➢**Detection method**
- Cherenkov radiation

➢ **Signal event signature**



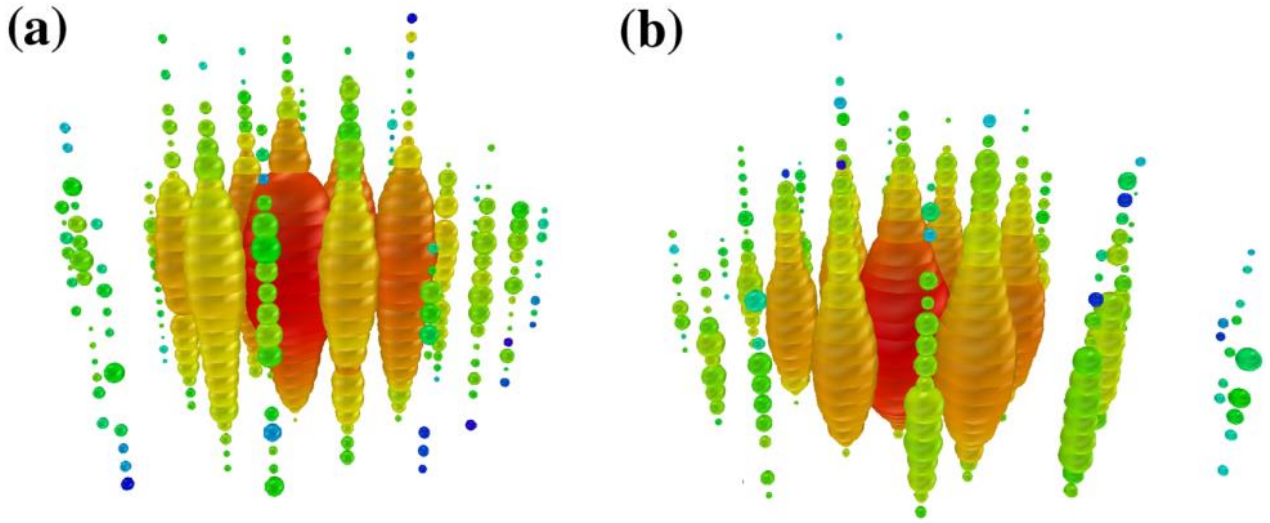
muon track
charged current: μ

cascade (shower)
neutral current: Hadron
charged current: e/τ

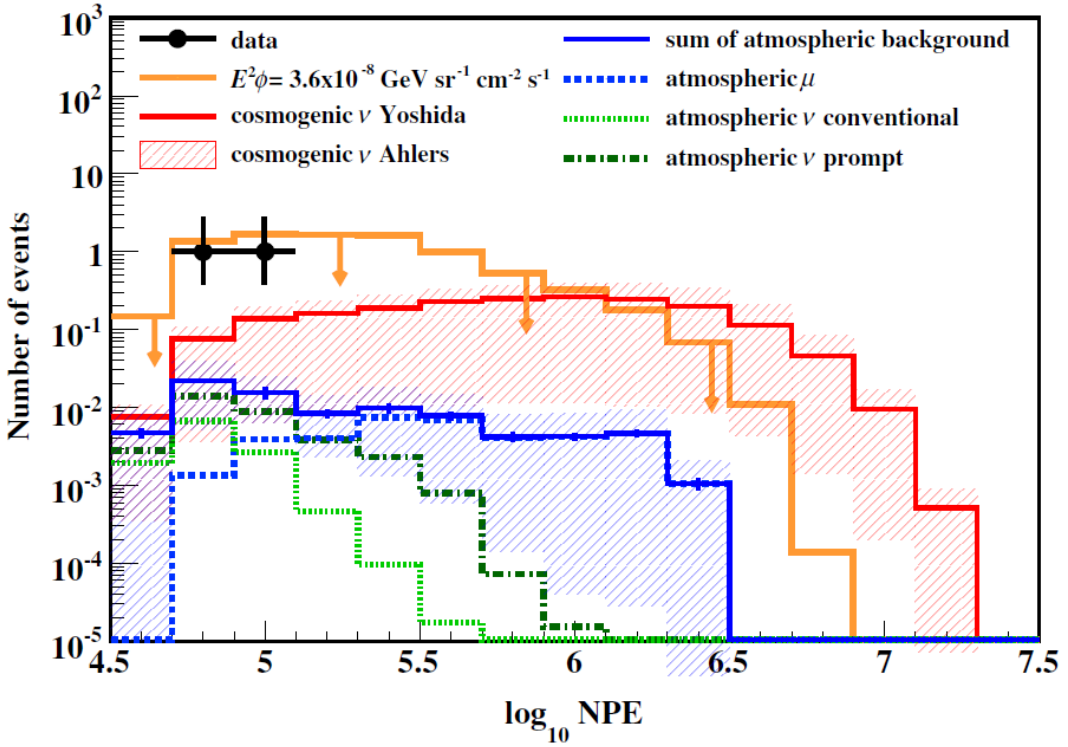
see *arXiv.org:1512.08794*

Analysis method and results

- selection criteria
1. ≥300 hits and NPE ≥3200
2. log-likelihood fit or robust regression technique



The two observed events from
(a) August 2011 and (b) January 2012. [1]

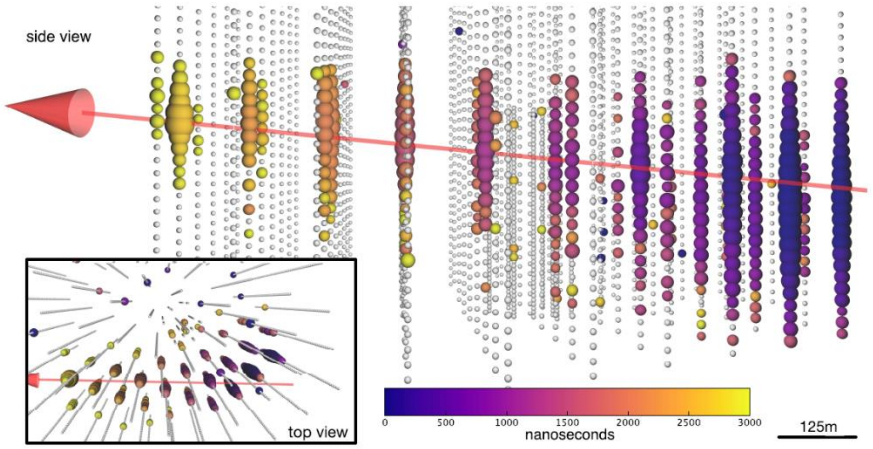


NPE distributions for the experimental data, signal models, and background simulations. [1]

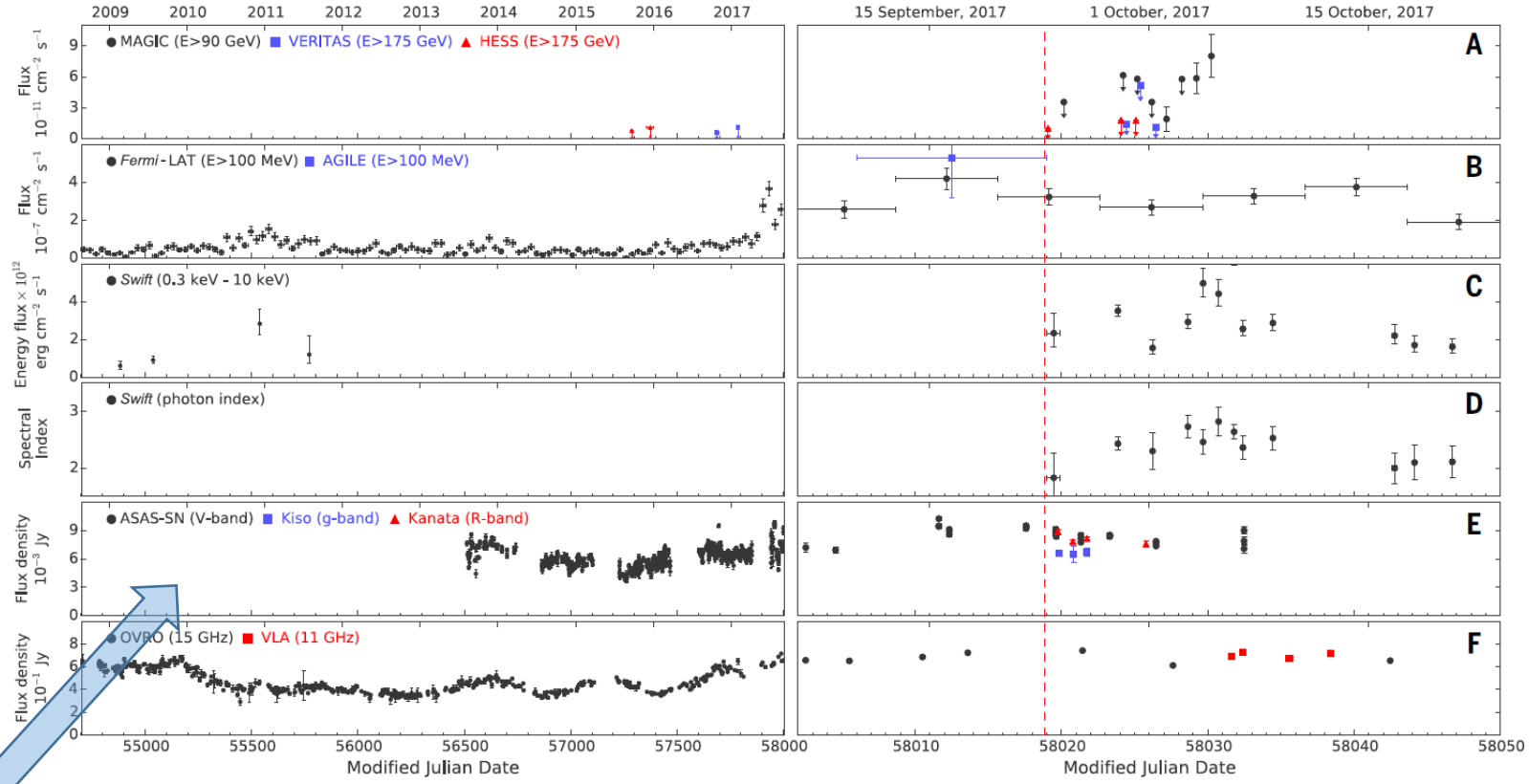
Reconstructed deposited energy: 1.04 ± 0.16(PeV) and 1.14 ± 0.17(PeV), respectively.
p value=$2.9 \times 10^{-3}(2.8\sigma)$

[1] 10.1103/PhysRevLett.111.021103

Analysis method and results



Event display for neutrino event IceCube-170922A. [2]



Time-dependent multi-wavelength observations of TXS 0506+056 before and after IceCube-170922A. [2]

(A) VHE g ray observations
(B) high energy g ray observations
(C and D) x ray observations
(E) optical light curves
(F) radio observations

[2] 10.1126/science.aat1378

Summary and prospects

- Two PeV neutrinos: a first hint of an astrophysical neutrino flux, but a firm astrophysical interpretation requires more data.
- The origins of the diffuse flux of high-energy cosmic neutrinos remain unidentified.
- IceCube-170922A observed in 2017: in spatial coincidence with a flaring g-ray blazar, suggesting that blazars may be a source of high-energy neutrinos.
- Multimessenger observations.
- IceCube upgrade

- **Thanks!**