Real-time identification of short transient neutrino sources within the IceCube optical follow-up program

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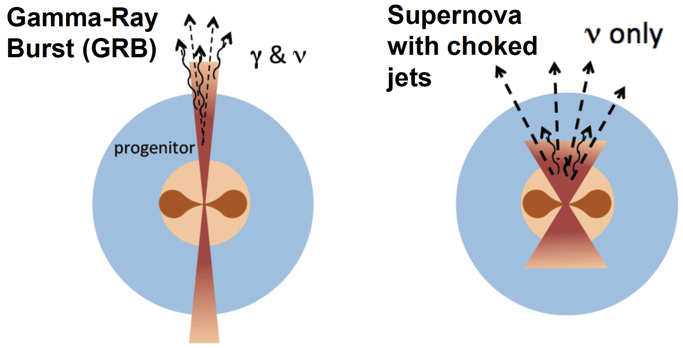
Abstract

The identification of the sources of astrophysical neutrinos is one of the main motivations behind the IceCube real-time follow-up programs. Currently, there are two approaches to distinguish astrophysical neutrinos from atmospheric background. The first is to select single high-energy neutrinos assuming that the signal neutrino spectrum is harder compared to the background. The second is to search for neutrino events clustering in time and space. The latter approach is used by IceCube's optical follow-up program.

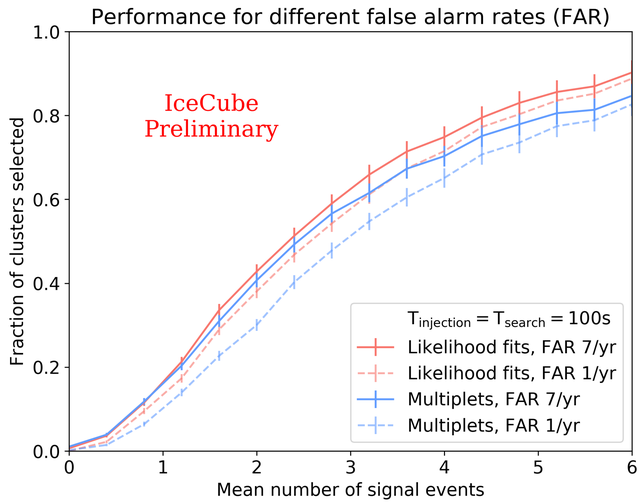
Optical follow-up (OFU) program



Credit:"Multimessenger Astronomy", I. Bartos and M. Kowalski (2017)

- Goal:
  - Identify electromagnetic counterparts to short neutrino signals (≳ 100s)
- Source candidates:
  - GRBs and Supernovae with choked jets
- Data:
  - IceCube neutrino clusters
  - Follow-up with Swift XRT & ZTF
- First results:
  - No counterparts identified and clusters consistent with background expectation → stringent limits set

Two different search algorithms



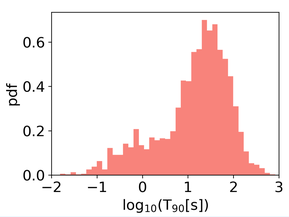
- Multiplets:
  - Neutrinos arriving within 100s and ≤ 3.5° apart
  - Significance threshold for doublets
  - Triplets or higher multiplicities trigger immediately
- Likelihood Fits:
  - Sky around trigger neutrino is scanned under source hypothesis
  - neutrinos arriving before trigger are clustered in all combinations
  - signal and background modelled separately in likelihood

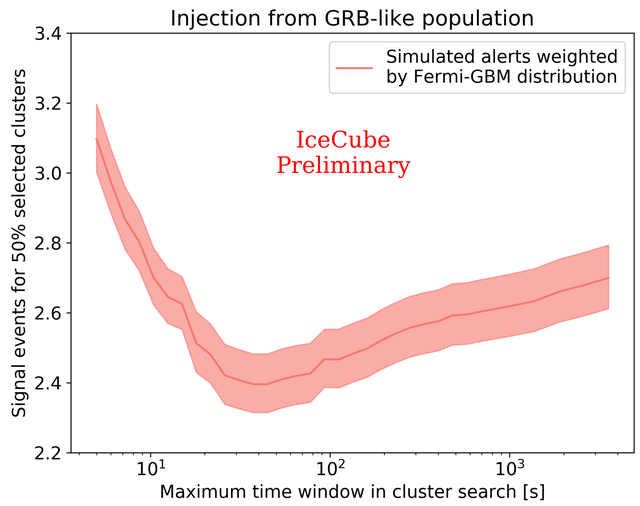
see also M. Mallamaci's poster:
"Rapid response to extraordinary events with the IceCube experiment"

Possible extensions of the program

Using the likelihood fits search algorithm

- Include southern sky:
  - High rate of atmospheric muons handled with likelihood algorithm
  - Alert threshold taking into account detector effective area
- Extended time window:
  - Increased sensitivity to longer neutrino emission
  - Higher background contamination
  - Probe behavior with injection from Fermi-GBM distribution:





References

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