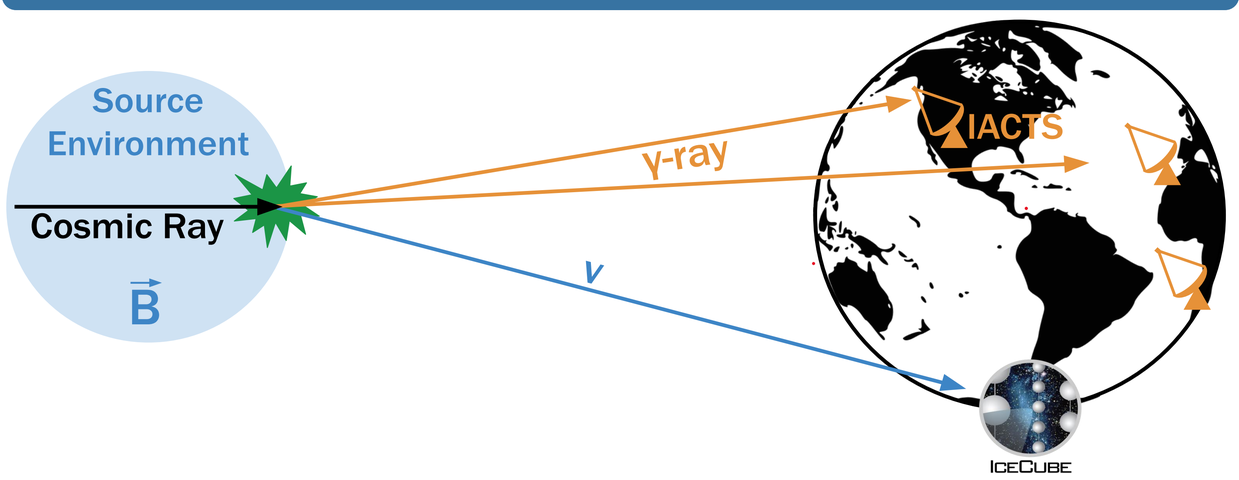
The gamma-ray follow-up platform in IceCube for identifying astrophysical neutrino flares in realtime

Sarah Mancina[1*], Caterina Boscolo Meneguolo[1] for the IceCube Collaboration
[1]Università degli Studi di Padova, *Speaker: sarah.mancina@icecube.wisc.edu

Motivation for IceCube's GFU Alerts



IceCube's **Gamma-ray Follow-Up (GFU) platform** identifies potential **flares of neutrinos** as they develop in realtime

IceCube Neutrino Observatory:
- ~99% uptime
- View of full sky
- Signal obscured by atmospheric backgrounds

Imaging Air Cherenkov Telescopes (IACTs):
- Sensitive to VHE gamma-rays (> 100 GeV)
- Small field of view
- Require clear, dark sky

Offline Analysis of 11.5 Years of Data

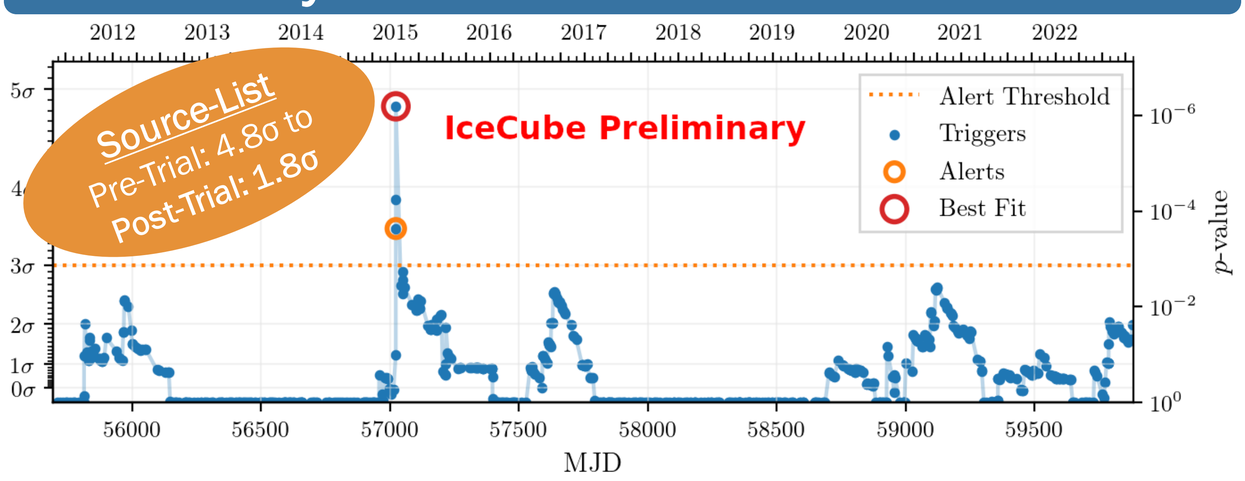


Figure 3. Pre-trial significance of the best fit flare time-window as a function of the triggering event time (t_1) for the most significant source in the monitored source-list, **BL Lac 1ES 0347-121**.

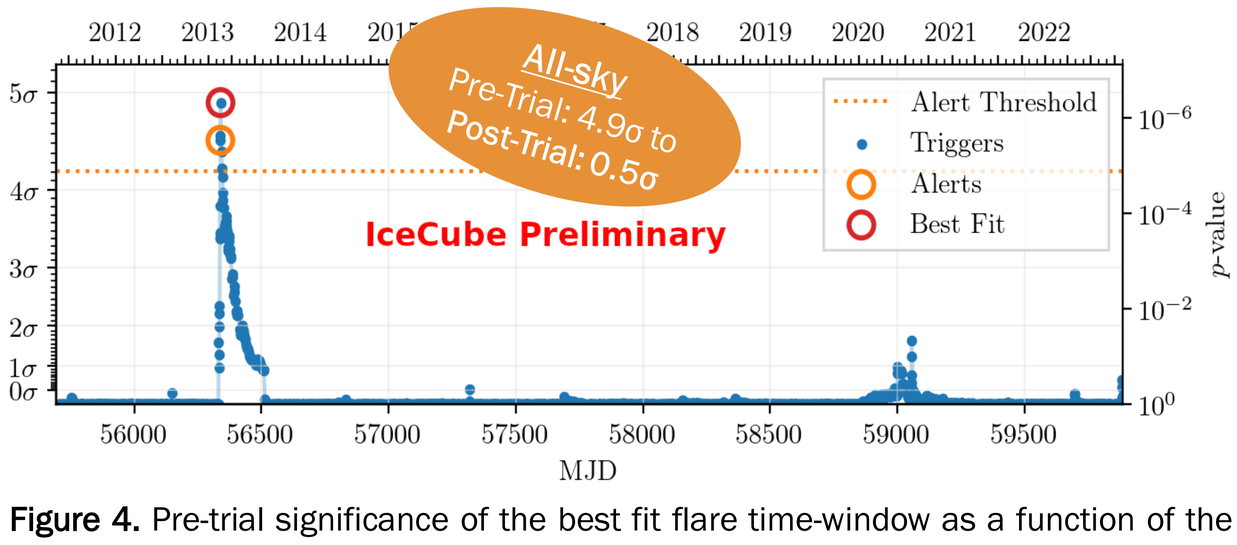


Figure 4. Pre-trial significance of the best fit flare time-window as a function of the triggering event time (t_1) for the most significant location in the all-sky scan.

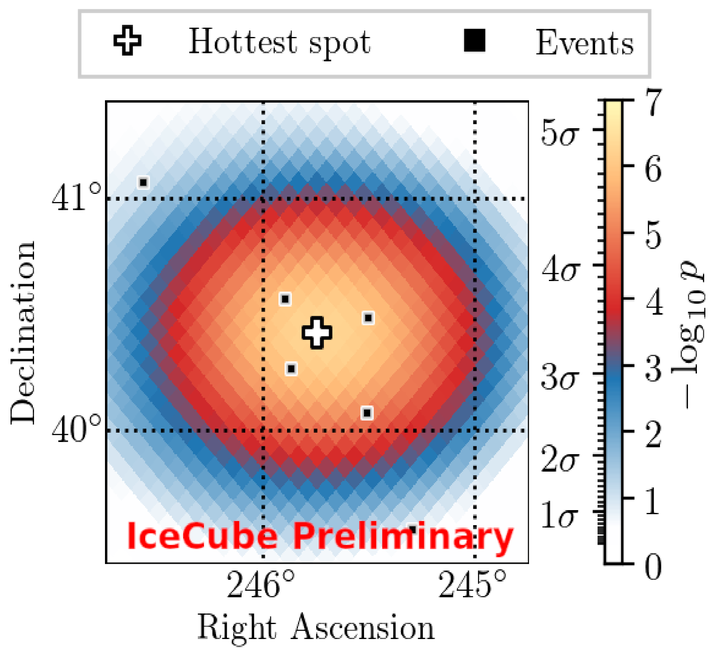


Figure 5. Scan of the pre-trial p-value localized around most significant location in the all-sky scan in equatorial coordinates.

Further motivation for multimessenger approach and alerts!

GFU Neutrino Cluster Alert Algorithm

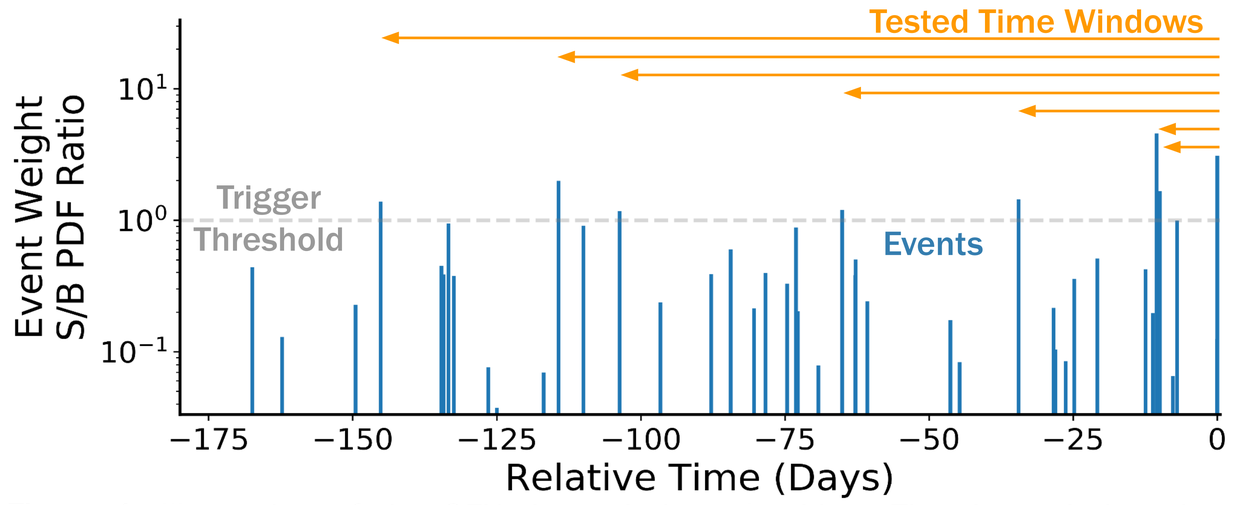


Figure 1. Illustration of the GFU time window algorithm. The time window that returns the largest test statistic (TS) is used to calculate pre-trial p-value.

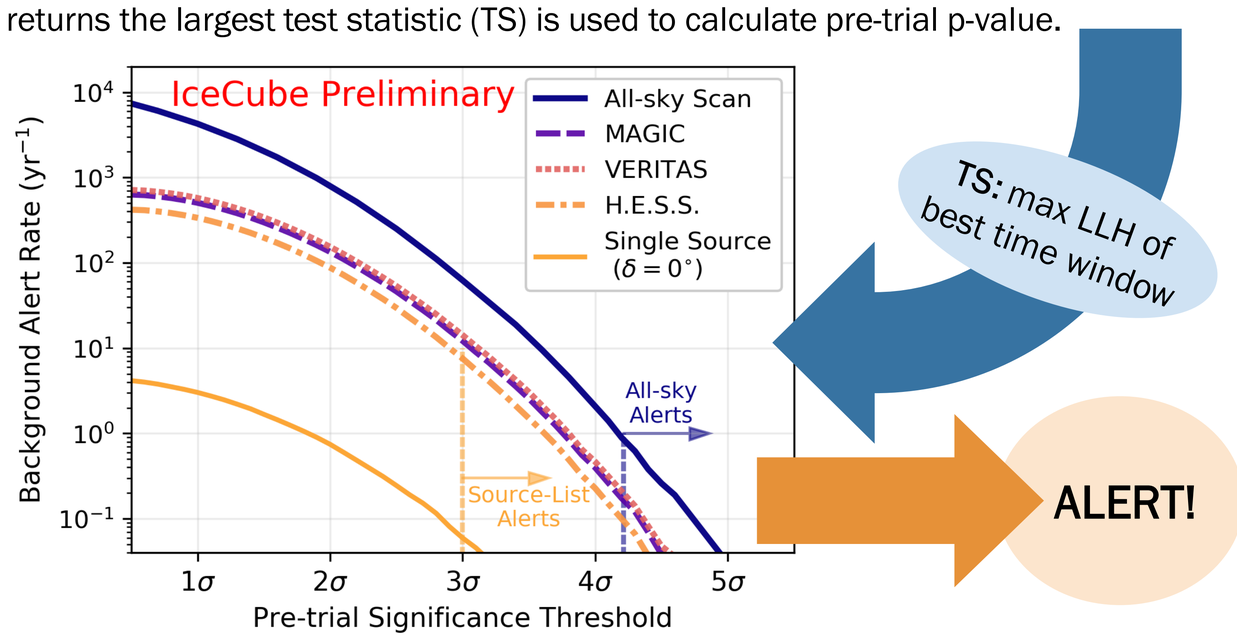


Figure 2. False alarm rate (FAR) from background for different choices of pre-trial p-value alert threshold. The dashed curves represent the FAR accounting for all sources in the different IACT source lists.

All-sky Alerts: Test pixels near each event that passes filter

Source-List Alerts: Test directions of blazars (z < 1)

Next Steps for GFU Alerts

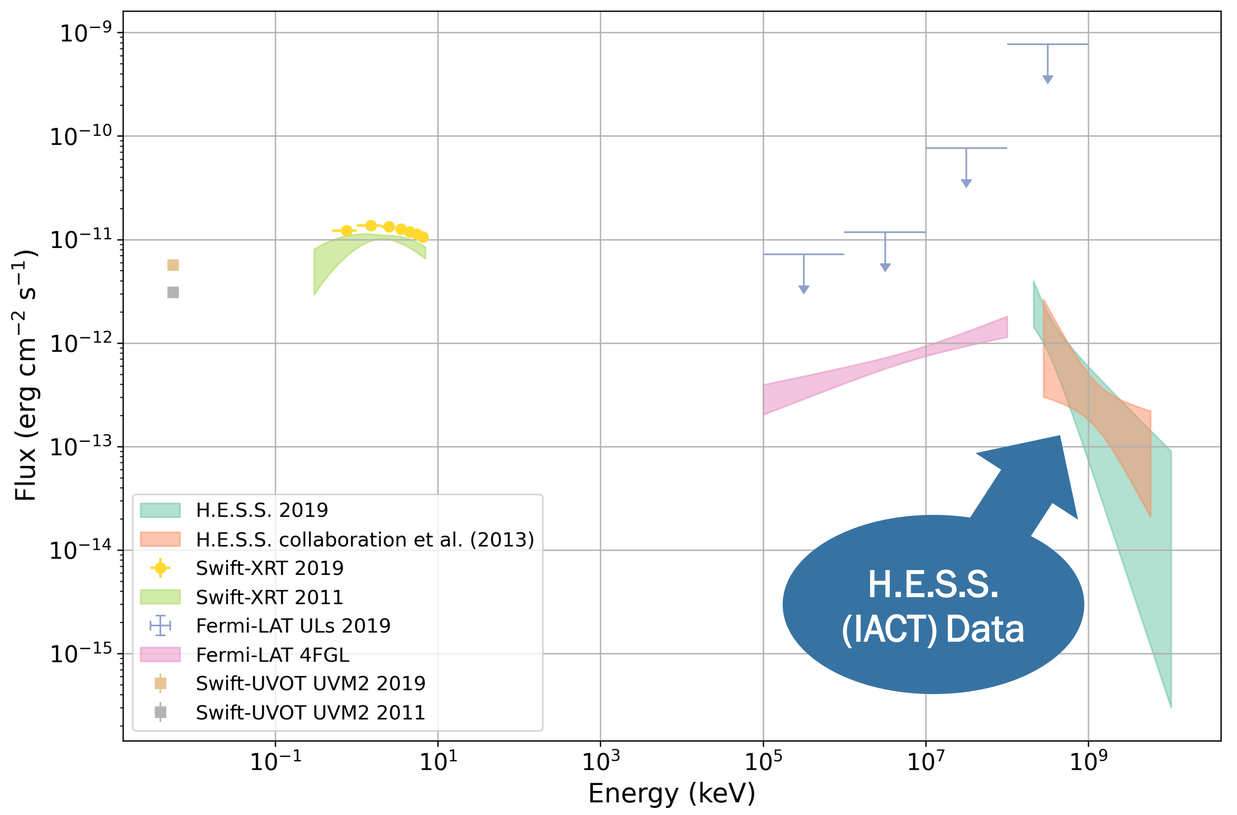


Figure 6. Multiwavelength spectral energy distribution of 1ES 1312-423 from archival data and data collected in response to a 2019 GFU alert, from Ref. [1].

IACTs have performed follow-up, but no statistically significant results [1]

Future:
- Public alerts: look for neutrino correlation with other wavelengths of light
- Collaboration with other neutrino telescopes

References
[1] FACT, H.E.S.S, IceCube, MAGIC and VERITAS Collaborations, F. Schüssler *et al.* PoS(ICRC2023)1501.