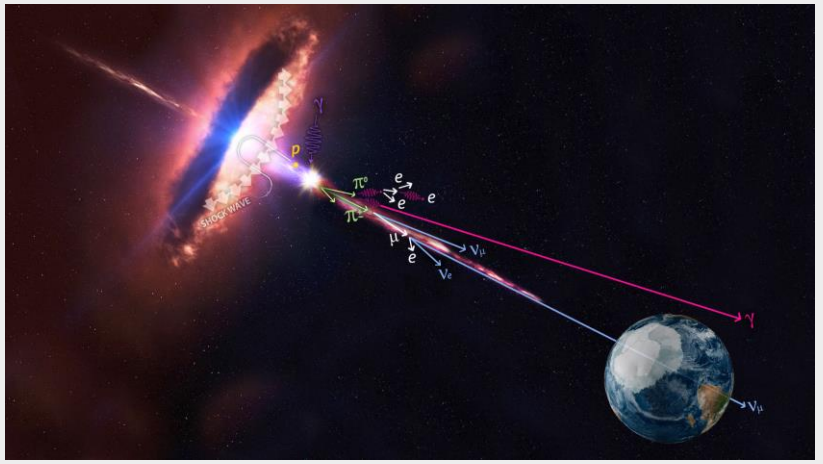
Multi-messenger searches of neutrino sources driven by γ-ray observations

Francesco Lucarelli and Teresa Montaruli

TXS 0506+056: the dawn of multi-messenger neutrinos

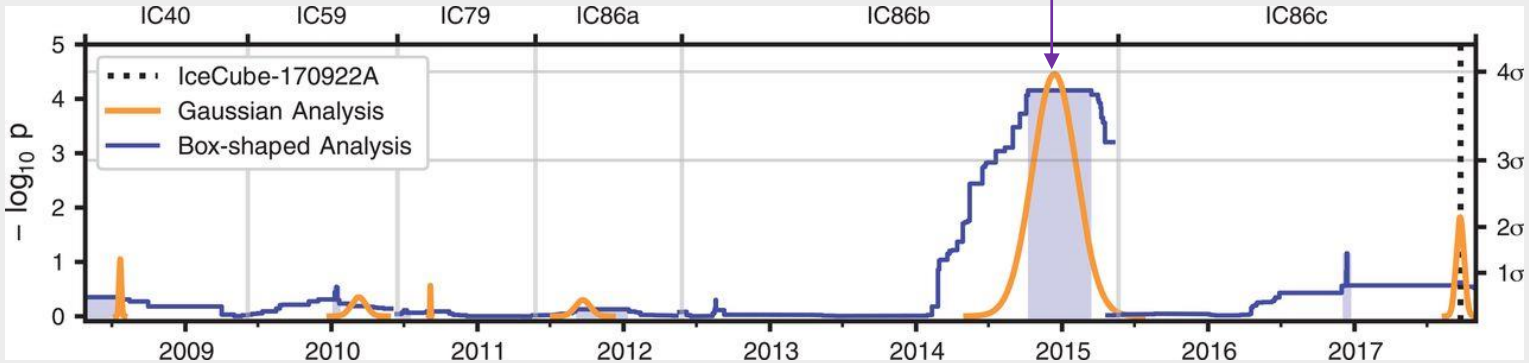
- Neutrinos and γ rays are thought to have a common origin in the decays of π's produced by interactions of cosmic rays in the vicinity of a source
- Despite the discovery of an astrophysical neutrino diffuse flux by IceCube, the sources of astrophysical neutrinos are still unknown
- Hints of such sources might come from a joint neutrino and γ-ray multi-messenger campaign, as happened with TXS 0506+056



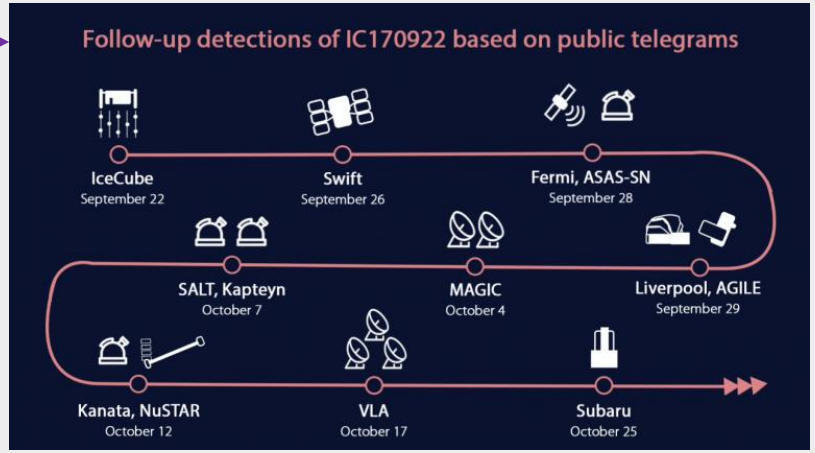
Artistic representation of the common origin of neutrinos and gamma rays

The case of TXS 0506+056

1. In September 2017, a high-energy neutrino alert ($E_\nu > 183$ TeV @ 90% C.L.) was detected by IceCube, coming from a region close to TXS 0506+056
2. Several γ-ray telescopes observed an enriched γ-ray activity from a region compatible with the neutrino alert coordinates
3. The Geneva group analysed the full IceCube data at the coordinates of TXS 0506+056 and discovered a flare in 2014/2015 with a 3.5σ-level significance



Analysis of the IceCube data at the location of TXS 0506+056: a significant flare was observed in 2014/2015



γ-ray telescopes that observed an enriched activity from TXS 0506+056 after the IceCube neutrino alert

Recent results and perspectives with CTA

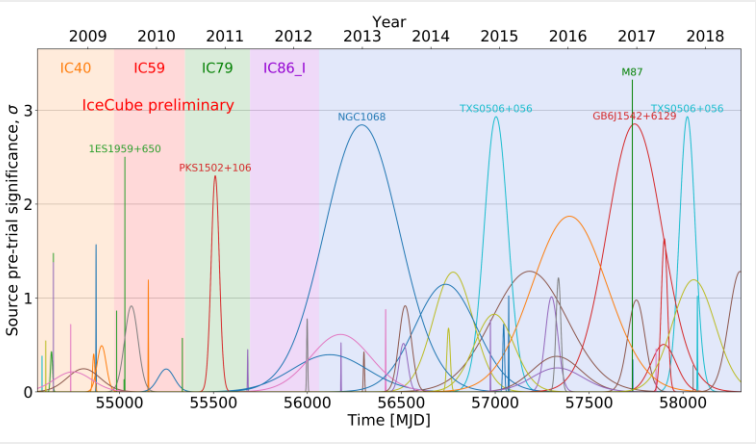
UNIVERSITÉ DE GENÈVE

Recent Results

A catalog of gamma-ray emitters was analysed by the IceCube group in Geneva:

- a cumulative time-integrated excess of neutrinos was observed in the northern sky (3.3σ)
- NGC 1068 is the most significant individual source of the catalog (2.9σ)

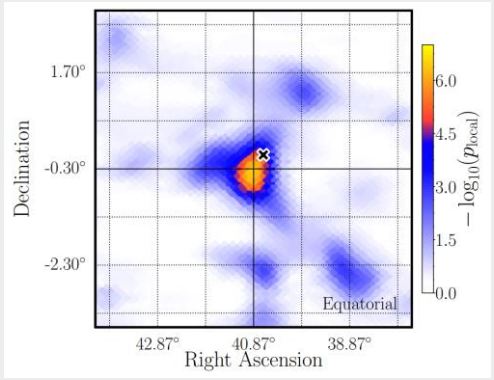
NGC 1068 is also found very close to the most significant spot in a time-integrated all-sky search.



Best-fit flares of the catalog

A multi-flare time-dependent analysis of the same catalog:

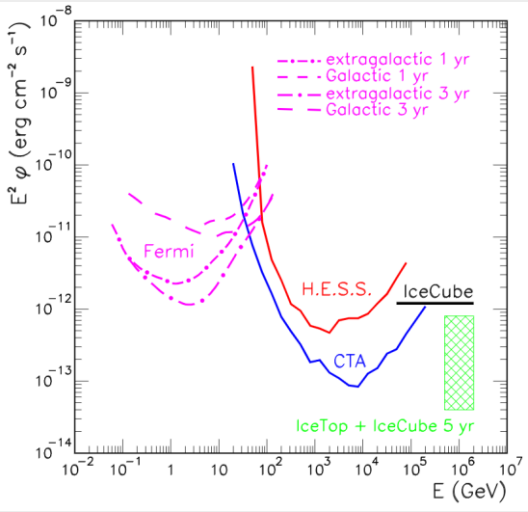
- confirms the neutrino excess at 3.0σ
- reports M87 as the most significant individual source (1.7σ)
- identifies TXS 0506+056 as a multiple flare source



Time-integrated p-value sky map, zoom of the most significant spot. The cross marks the location of NGC 1068

Outlook with CTA

- CTA has 10x better sensitivity and reaches higher energies (300 TeV) than any current telescope
- Thanks to its sensitivity and detectable energy range, CTA will potentially test the galactic origin of the neutrino diffuse flux by identifying the electromagnetic counterpart
- The multi-messenger program of CTA will help investigate the sources of astrophysical neutrinos



CTA sensitivity (blue) and diffuse flux of astrophysical neutrinos (black)


Thank you for
your attention