MAGIC and the dawn of multimessenger neutrino-gamma astronomy

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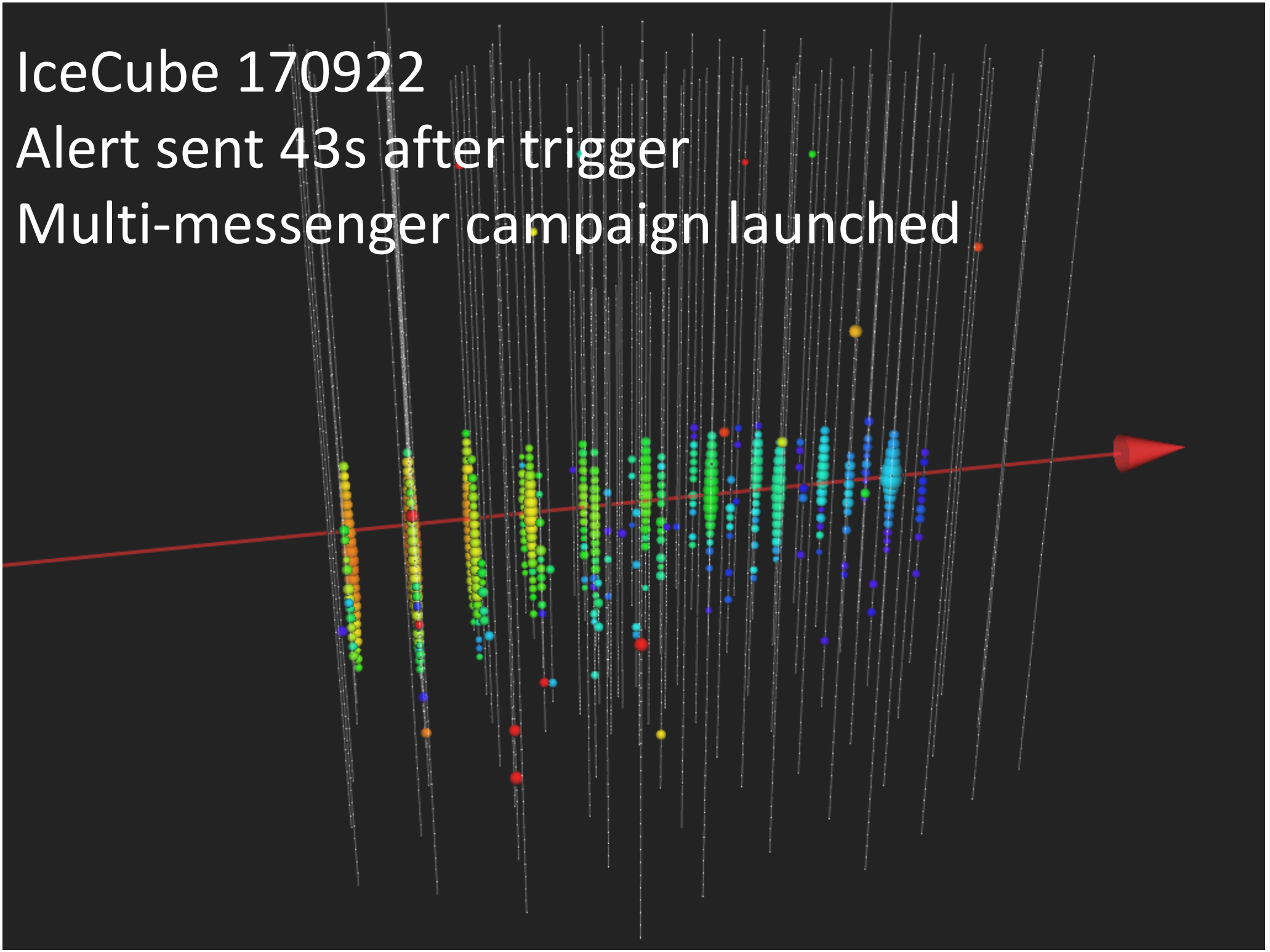
Celebration of MAGIC's XV anniversary
La Palma, June 2018

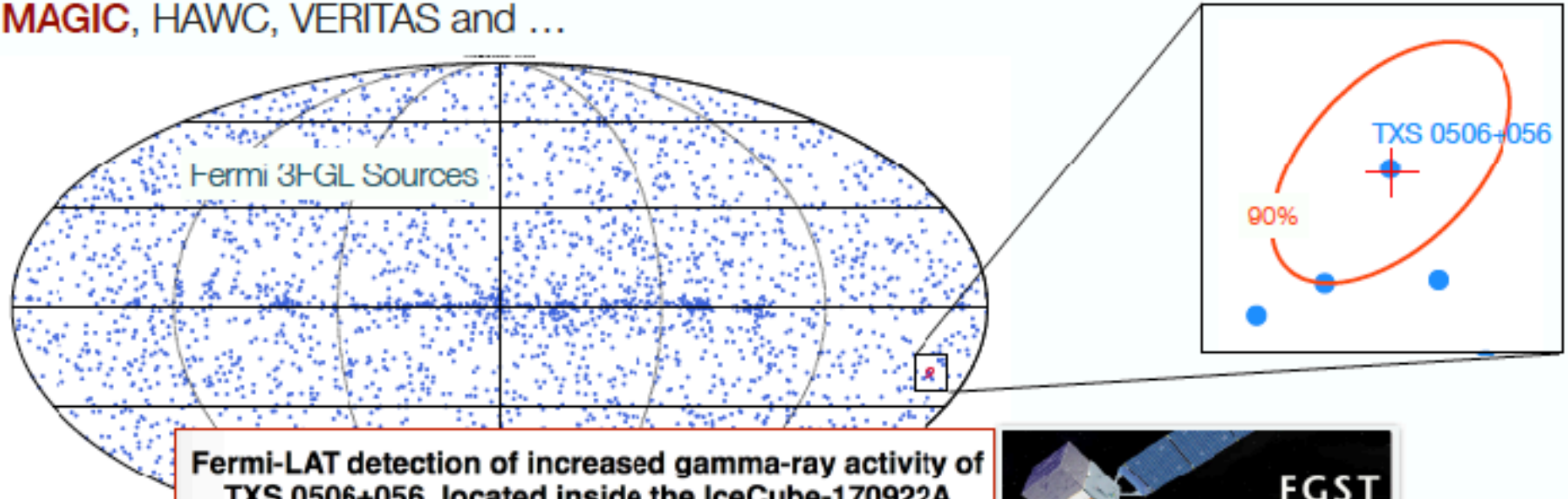
For what MAGIC will be remembered?

- 5 years ago, after several beers (or glasses of wine? I don't remember), I remember that we were discussing with Teshima and wondering. "We did a lot of nice things, but: for what MAGIC will be remembered in 50 years from now?"
- We listed several possibilities
  - Violation of the Lorentz invariance
  - Discovery of axions
  - The extreme energetics of GRBs
  - …
- Multimessenger astronomy/astrophysics was something we did not think of


IceCube 170922
Alert sent 43s after trigger
Multi-messenger campaign launched

- neutrino: time 22.09.17, 20:54:31 UTC
  energy 290 TeV
  direction RA 77.43º Dec 5.72º
- Fermi-LAT: flaring blazar within 0.1º (6x steady flux)
- MAGIC: TeV source in follow-up observations

- Follow up observations by ANTARES, H.E.S.S. , **Fermi-LAT**, **Swift**, AGILE, **MAGIC**, HAWC, VERITAS and …



Fermi-LAT detection of increased gamma-ray activity of TXS 0506+056, located inside the IceCube-170922A error region.

ATel #10791; *Yasuyuki T. Tanaka (Hiroshima University), Sara Buson (NASA/GSFC), Daniel Kocevski (NASA/MSFC) on behalf of the Fermi-LAT collaboration*
on 28 Sep 2
Credential Certification: David J. Th

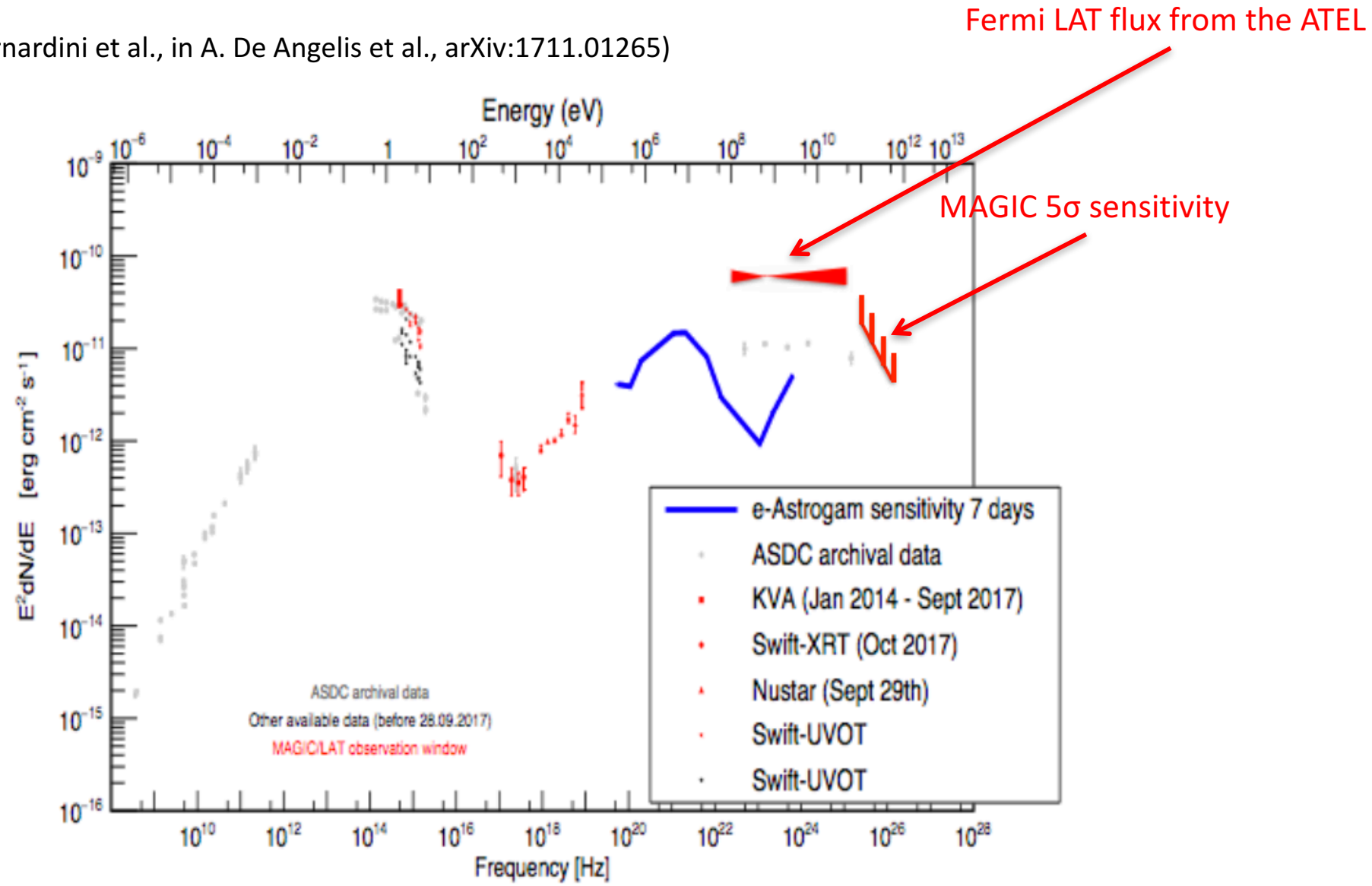
First-time detection of VHE gamma rays by MAGIC from a direction consistent with the recent EHE neutrino event IceCube-170922A

ATel #10817, *Razmik Mirzoyan for the MAGIC Collaboration*
on 4 Oct 2017; 17:17 UT
Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

(F. Halzen, CIPANP 2018)

The SED

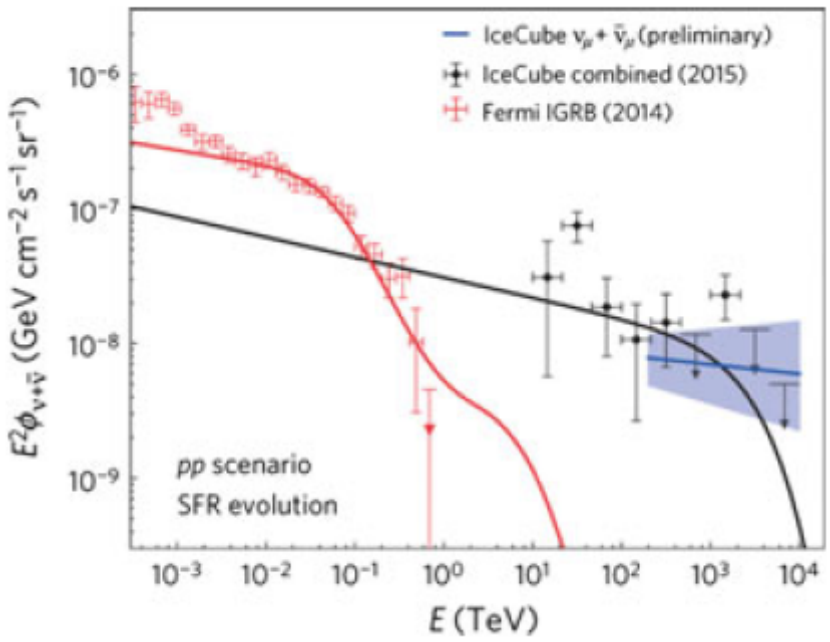
(From E. Bernardini et al., in A. De Angelis et al., arXiv:1711.01265)



The highest gamma-ray energies are the key to understand physics behind this emission

- Photons and neutrinos are hadroproduced at ~ the same energy, but photons are likely to be reprocessed and degrade
  - Dramatic evidence when you think to the diffuse neutrino and gamma-ray backgrounds measured by IceCube and Fermi
- From a ~300 TeV neutrino to MAGIC energy range photons
  - A lot of information on the target of the beam dump
    - Wait a minute: an ingredient is missing! DISTANCE

(F. Halzen, Nature 2017)



Energy density of TeV gamma rays consistent with EHE neutrinos

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THE REDSHIFT OF THE BL LAC OBJECT TXS 0506+056.

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ABSTRACT

The bright BL Lac object TXS 0506+056 is a most likely counterpart of the IceCube neutrino event EHE 170922A. The lack of this redshift prevents a comprehensive understanding of the modeling of the source. We present high signal-to-noise optical spectroscopy, in the range 4100-9000 Å, obtained at the 10.4m Gran Telescopio Canarias. The spectrum is characterized by a power law continuum and is marked by faint interstellar features. In the regions unaffected by these features, we found three very weak (EW $\sim$ 0.1 Å) emission lines that we identify with [O II] 3727 Å, [O III] 5007 Å, and [NII] 6583 Å, yielding the redshift z = 0.3365±0.0010.

z ~ 0.34

A genuine multimessenger/multiwavelength analysis

One result, many consequences and a message

- For the first time an AGN neutrino source was detected, opening a new sector of multimessenger astronomy. The comparison of neutrino energies and VHE gamma rays is the key
  - Previously seen: the Sun, The Earth, SN1987A
- We likely saw a multi-PeVatron in action
  - In $p\gamma$, Ep ~ 350 PeV/ε_γ [eV]

- We just observed the tip of the iceberg
- If neutrino detectors will improve from ~ 1 astrophysical neutrino/month to ~ 10 astrophysical neutrinos/month, which new gamma-ray paradises will we explore?
- The other key is low threshold with rather high sensitivity (MAGIC, LST)