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# MASTER optical observations of the blazar TXS 0506+056 during the IC170922A

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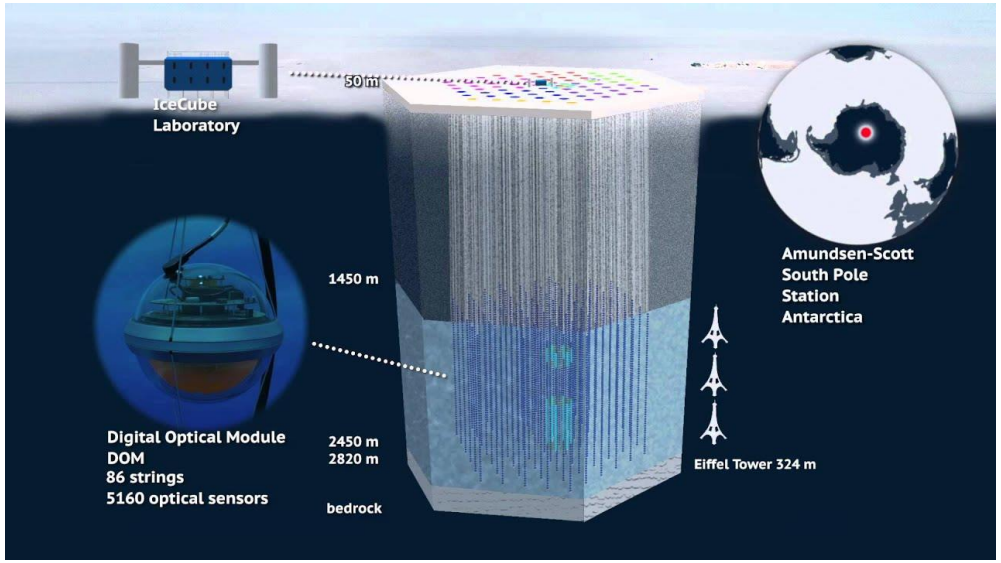
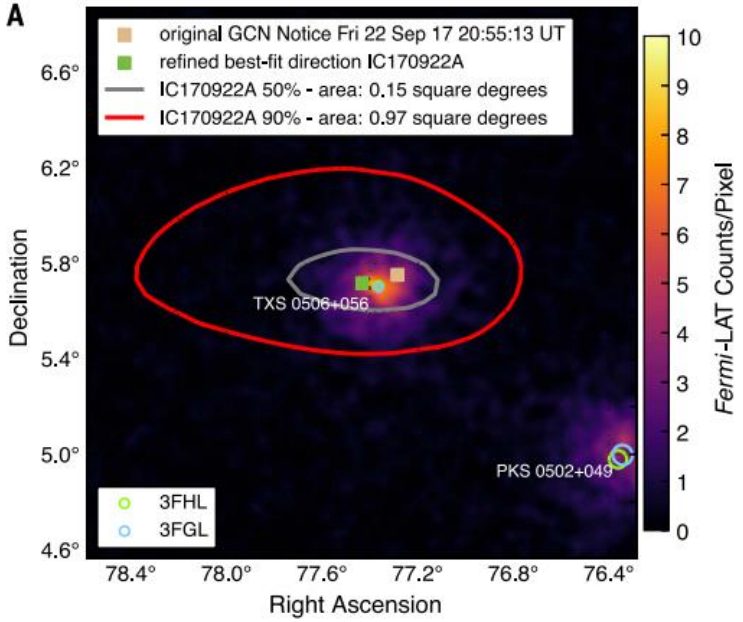
Based on Lipunov et al. 2020 ApJL 896 L19

# High-energy neutrino event IC170922A and the flaring blazar TXS 0506+056

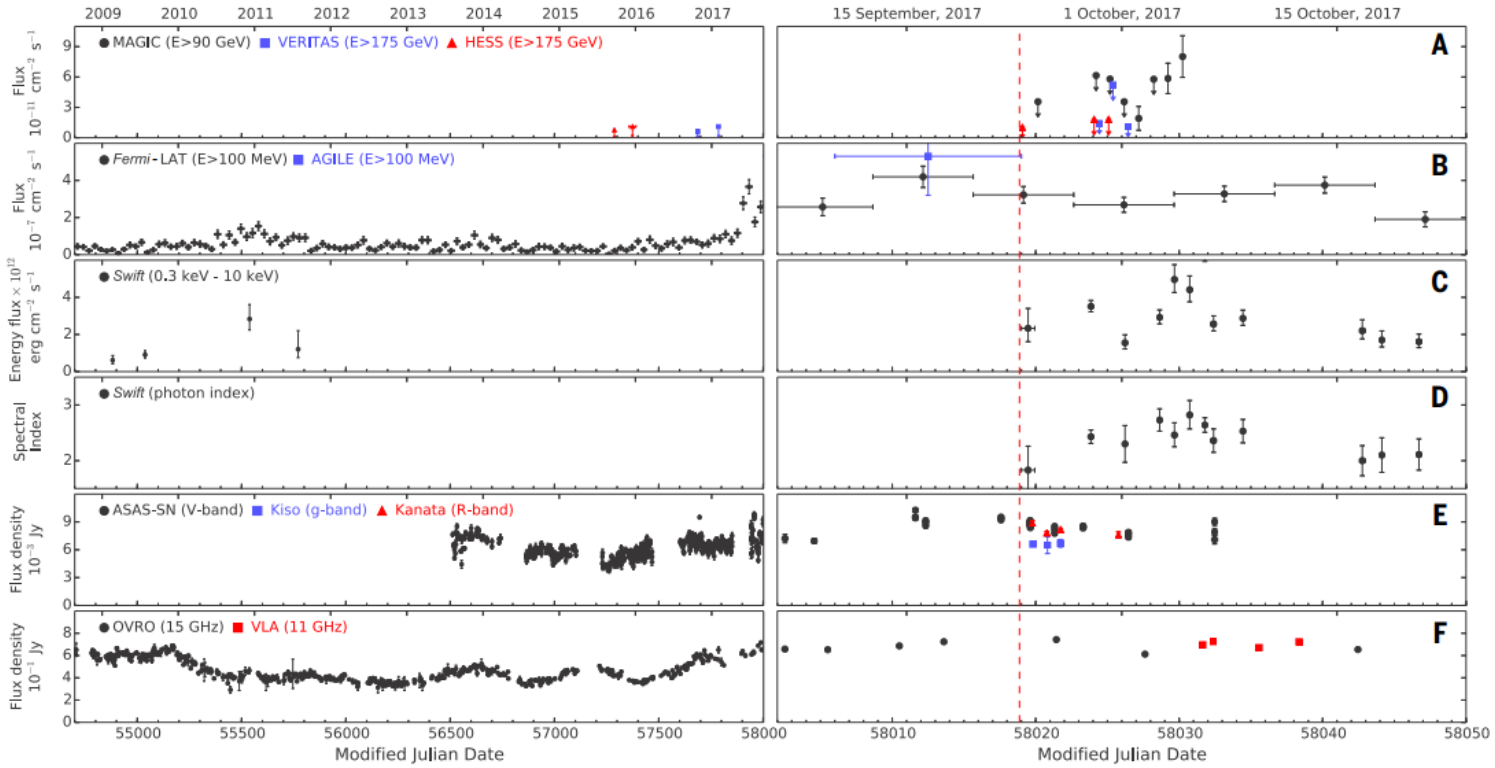
## Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A

The IceCube Collaboration, *Fermi*-LAT, MAGIC, *AGILE*, ASAS-SN, HAWC, H.E.S.S., *INTEGRAL*, Kanata, Kiso, Kapteyn, Liverpool Telescope, Subaru, *Swift/NuSTAR*, VERITAS, and VLA/17B-403 teams*†



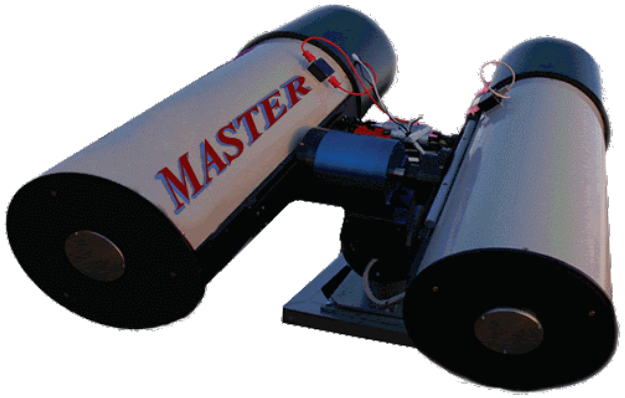



# Light curve resulting from the multimessenger observations




- Variations in high-energy photons after the event
- 3σ chance coincidence probability

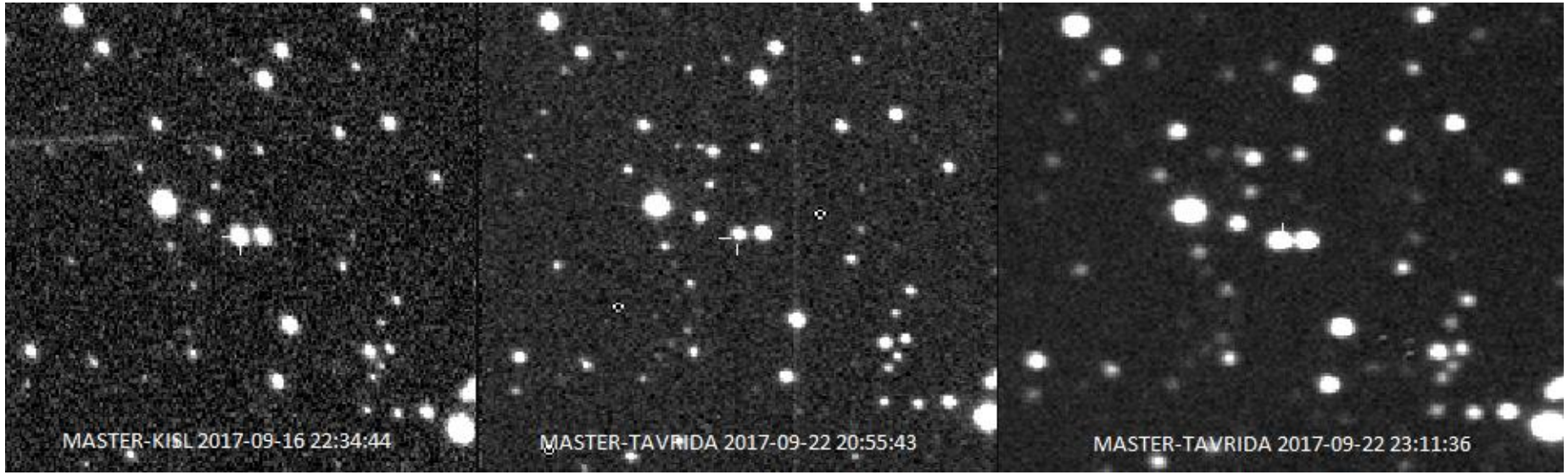
# MASTER Global Robotic Network and its telescopes

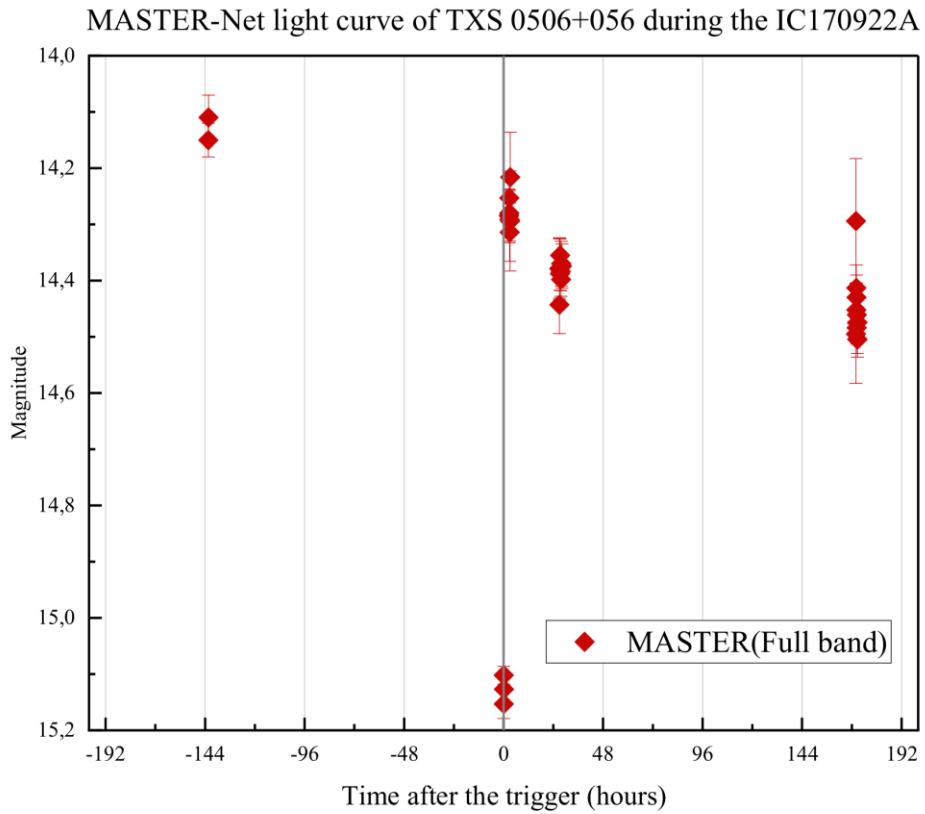

- 8 40-cm catadioptric pair telescopes with a 2° FOV
- Able to automatically respond to an alert 1 minute after the notice

# MASTER-Net follow-up optical observations

- Two telescopes (MASTER-Amur and MASTER-Tavrida) reacted to the event but only one (MASTER-Tavrida) was able to make proper frames
- Start of the observations 73s after the trigger, 3 frames in the first 15 minutes, 23 frames in the first 3 hours.
- Zenith distance 84° at the start

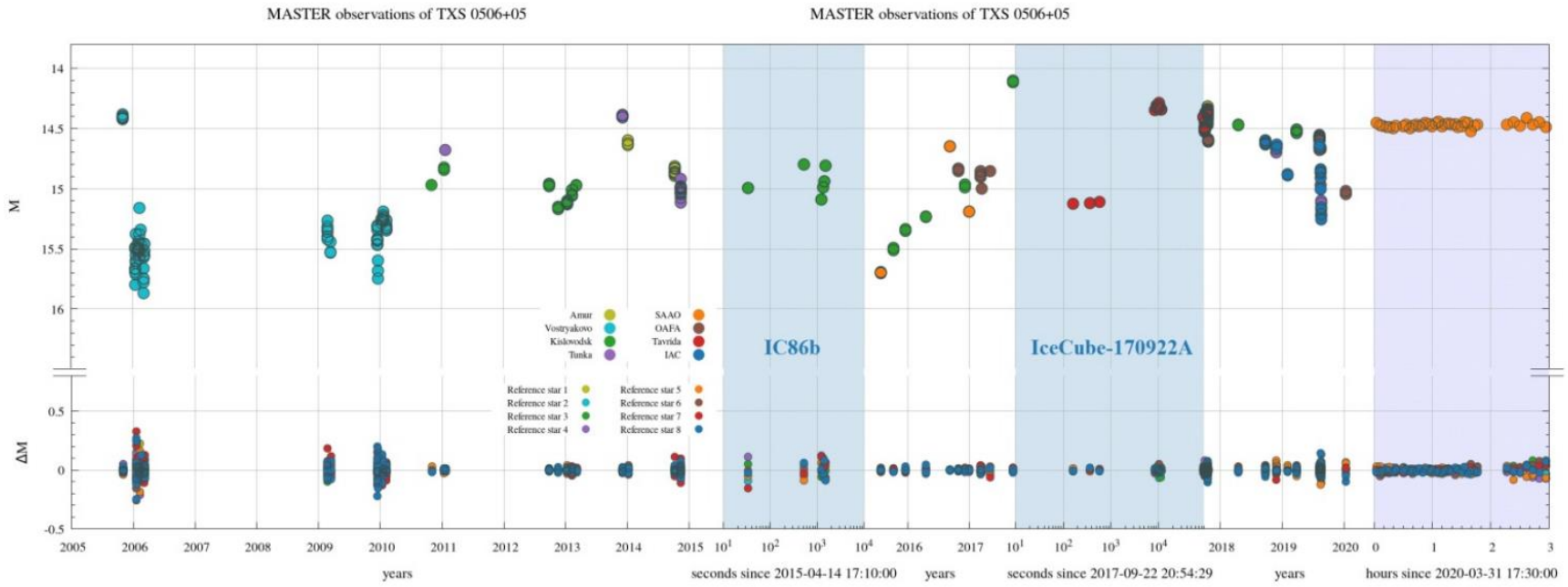


# Light curve during the event




- A significant optical decay immediately after the event, followed by a rebrightening to the past level two hours later (amplitude 0,81±0,02 mag)

# MASTER optical history

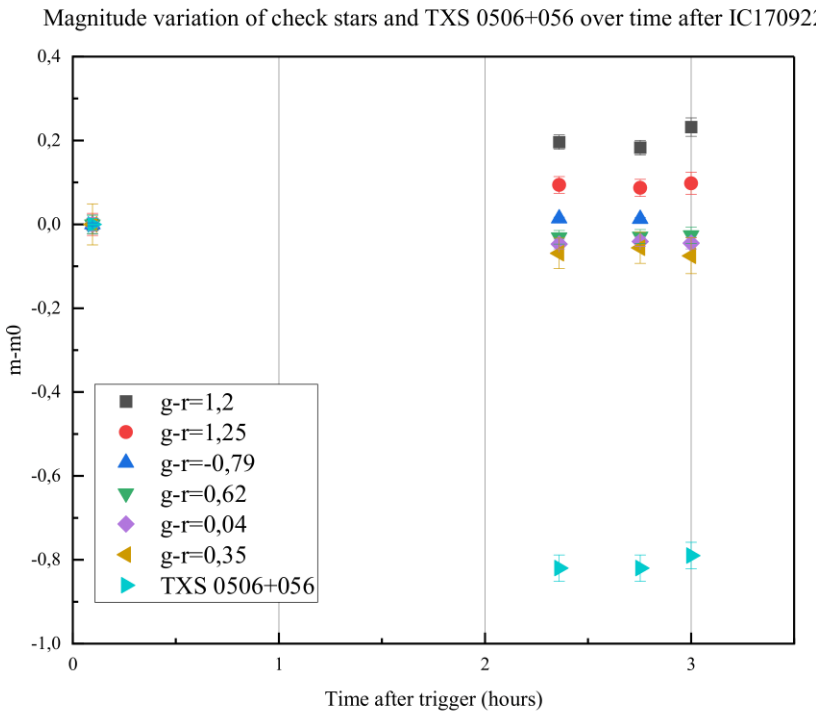



- TXS 0506+056 didn't decay to the absolute minimum ever observed during IC170922A

## Causes of optical decay

- First, decay is connected to the blazar itself and therefore to the neutrino production
- Second, decay is due to the absorption in the atmosphere(zenith distance 84° right after the event) and so not connected to the neutrino production
- The only cause verifiable with our data is the second

# Magnitude variations of check stars




Colors from PanSTARRS DR1

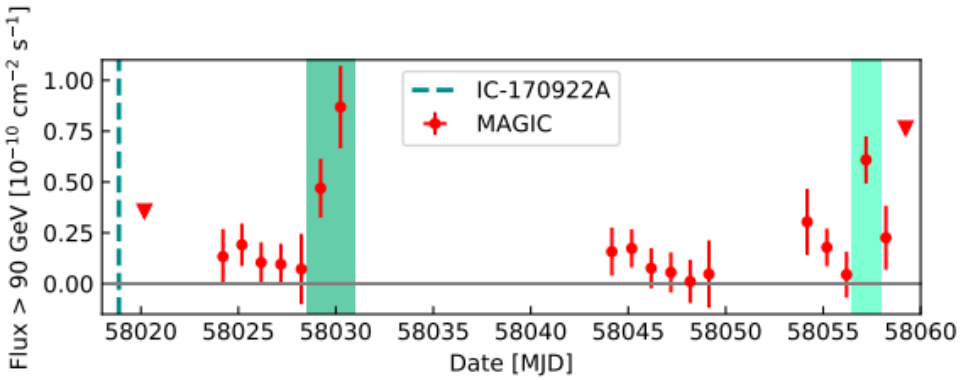
- Optical decay can't be explained by atmospheric absorption (g-r=0,38 for TXS 0506+056) if blazar's spectrum doesn't change extremely with no increase in overall luminosity

# Decay connected to the blazar

- Could be explained if the optical emission is mostly produced in proton synchrotron emission

$$p + \gamma_t \rightarrow \begin{cases} p + \pi^0 \rightarrow p + 2\gamma_{\text{Fermi}} \\ n + \pi^+ \rightarrow n + \mu^+ + \nu_\mu \end{cases}$$

  Contradicts very high-energy gamma-ray data that hints towards lepto-hadronic emission models (see Ansoldi et al 2018 ApJL 863 L10, Gang Cao et al 2020 PASJ 72 2)
- Limitation on the neutrino production zone size: several light days for Lorentz factor of 5 (see Xiaofeng Li et al 2020 ApJ 896 63)
- Similar effect is seen in very high-energy gamma-ray data (see Ansoldi et al 2018 ApJL 863 L10)



# Results

- TXS 0506+056 underwent a significant optical decay during IC170922A and rebrightened 2 hours later (amplitude 0,81±0,02 mag)
- Can’t be explained by atmospheric absorption if spectrum doesn’t change extremely
- Similar effect on a different timescale is seen in very high-energy gamma-ray data
- Neutrino production zone doesn’t span for more than several light days