MAGIC observation strategy of IceCube neutrino alerts

Ilaria Viale\textsuperscript{1}, Wrijupan Bhattacharyya\textsuperscript{2} for the MAGIC Collaboration

\textsuperscript{1}University and INFN Padova, Italy
\textsuperscript{2}DESY, Zeuthen, Germany
Alerts received by MAGIC

Alerts from IceCube:
- Single high energy tracks, E>60 TeV
  - BRONZE and GOLD alerts
- Neutrino clusters, E>100 GeV
  (see Caterina Boscolo Meneguolo’s talk for more details)

Sources selection:
- Extragalactic
- Redshift <1
- Flux variability
- detectability prospects for MAGIC

Total of 179 interesting sources for MAGIC
MAGIC follow-up observations

**MAGIC observations** (neutrino clusters and BRONZE tracks):
• Significance of neutrino alert
• Observing conditions
• Multiwavelength information

**If interesting alert:**
• Observe as soon as possible
• Continue observations if:
  ➢ Excess >3.5σ in IC error region
  ➢ Enhanced flux in multiwavelength observations

**Automatic repointing** (GOLD tracks):
• IC error region <0.5 deg
• Fast movement to alert position (~7 deg/s)
A successful follow-up: TXS 0506+056

IC-170922A: Track-like event with $E \sim 290$ TeV
MAGIC observations: detection in VHE $\gamma$-rays ($E > 90$ GeV) with 6.2$\sigma$ significance

Significance of blazar-neutrino coincidence: 3$\sigma$
First multimessenger SED!

The IceCube Collaboration et al. (2018)
Modeling

One zone lepto-hadronic model:
- Dominant contribution of leptonic emission
- Constraints from X-rays and VHE γ-rays on hadronic one
- Neutrinos from hadronic processes

\( E_{p,\text{max}} = 10^{16} \)

- e- sync. jet
- e- sync. sheath
- SSC
- EC
- \( \gamma \)-n cascade
- \( \mu \)-sync.
- BH cascade
- total EM
- \( \bar{\nu}_e \)
- \( \nu_e \)
Thank you for your attention!
Backup
Real-time neutrino alerts from IceCube

Three types of alerts sent to MAGIC:

1. **Neutrino flares from pre-selected sources:**
   - Cluster of neutrino events with $E>100$ GeV
   - Duration from few seconds to 180 days
   - Location of a known $\gamma$-ray emitter
     - Sources selection based on flux variability, redshift and detectability prospects for MAGIC

2. **Single high energy astrophysical neutrino tracks:**
   - Single high energy ($>60$ TeV) track-like event
   - BRONZE and GOLD events
   - Expected events: 10/yr GOLD, 30/yr BRONZE
Real-time neutrino alerts from IceCube

3. All-sky neutrino flares:
   • Neutrino clusters from the whole sky
   • Clusters hint at a transient point source, compared to the isotropic background
   • Angular resolution <0.3°
     ➢ Constrains the search area for counterparts in MAGIC
MAGIC automatic repointing

• Alert from IceCube interpreted by the **automatic alert system**
• Check alert **visibility**: maximum allowed zenith angle 50 deg.
• If visible:
  ➢ Automatic repointing: telescopes stops the current observation and move in fast mode (~7 deg/s) to the target position
  ➢ 2.5h observation maximum with automatic procedure
• **BRONZE alerts**: no automatic repoint
• **GOLD alerts**: automatic repointing only for alerts with error circle <0.5 deg.
• **Neutrino clusters**: automatically generated emails --> no automatic procedure