The Follow-up of Cosmic Explosions with VERITAS

Cosmic Explosions 2019

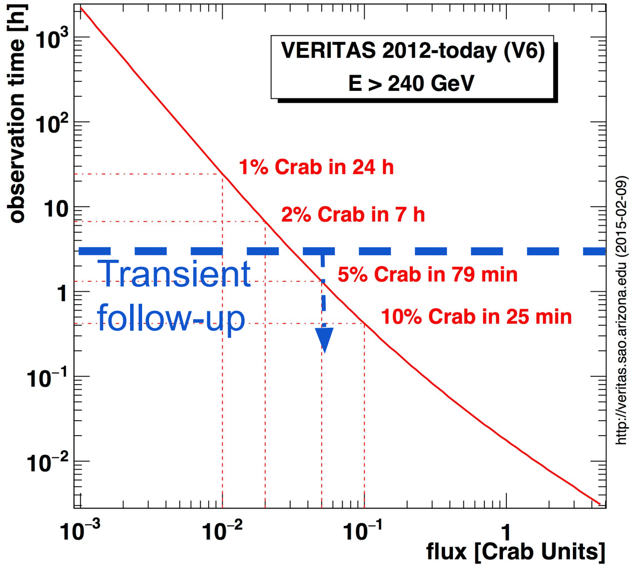
Skyler Scott (UCSC)
For the VERITAS Collaboration

VERITAS

Introduction to VERITAS

- Array of 4 12m Davies-Cotton Imaging Atmospheric Cherenkov Telescopes
- Location: Whipple Observatory, Arizona, USA
- Energy range: 80 GeV-30 TeV
- Angular resolution (E>1 TeV): 0.1°
- FOV: 3.5°

VERITAS Sensitivity Curve



Transient Follow-up Overview

- VERITAS has established follow-up programs for several classes of transients.
- Satellite-detected Gamma-ray Bursts (GRBs):
  - Swift BAT, Fermi GBM/LAT, Integral, MAXI, IPN, Konus-Wind, AGILE
  - Archival dataset includes ~190 unique bursts starting in 2006
    - ~110 BAT-detected, ~117 GBM-detected, ~14 LAT-detected
- LIGO/Virgo Gravitational Wave Events
  - O2: GW170104 (BBH)
    - No gamma-ray emission detected by VERITAS (GCN Circular #21153)
  - O3: Started Apr 1.
    - Roughly ~1-2 GW alerts per week
    - No definitive new EM-counterparts yet
- IceCube Neutrino Events
  - VERITAS follow-up of real-time alerts and archival search results started in 2016
    - 5 events from real-time alerts
    - 30 events from IceCube archival searches

Highlights -- GRB Follow-up

No firm detection yet by VERITAS. Even non-detections are useful, however:

A Strong Limit on the Very-high-energy Emission from GRB 150323A

Abstract

On 2015 March 23, the Very Energetic Radiation Imaging Telescope Array System (VERITAS) responded to a *Swift*-Burst Alert Telescope (BAT) detection of a gamma-ray burst, with observations beginning 270 s after the onset of BAT emission, and only 135 s after the main BAT emission peak. No statistically significant signal is detected above 140 GeV. The VERITAS upper limit on the fluence in a 40-minute integration corresponds to about 1% of the prompt fluence. Our limit is particularly significant because the very-high-energy (VHE) observation started only ~2 minutes after the prompt emission peaked, and *Fermi*-Large Area Telescope observations of numerous other bursts have revealed that the high-energy emission is typically delayed relative to the prompt radiation and lasts significantly longer. Also, the proximity of GRB 150323A ($z = 0.593$) limits the attenuation by the extragalactic background light to ~50% at 100–200 GeV. We conclude that GRB 150323A had an intrinsically very weak high-energy afterglow, or that the GeV spectrum had a turnover below ~100 GeV. If the GRB exploded into the stellar wind of a massive progenitor, the VHE non-detection constrains the wind density parameter to be $A \gtrsim 3 \times 10^{11}$ g cm^{-1}, consistent with a standard Wolf–Rayet progenitor. Alternatively, the VHE emission from the blast wave would be weak in a very tenuous medium such as the interstellar medium, which therefore cannot be ruled out as the environment of GRB 150323A.

Abeysekara et al. (VERITAS) 2018, ApJ, 857, 1

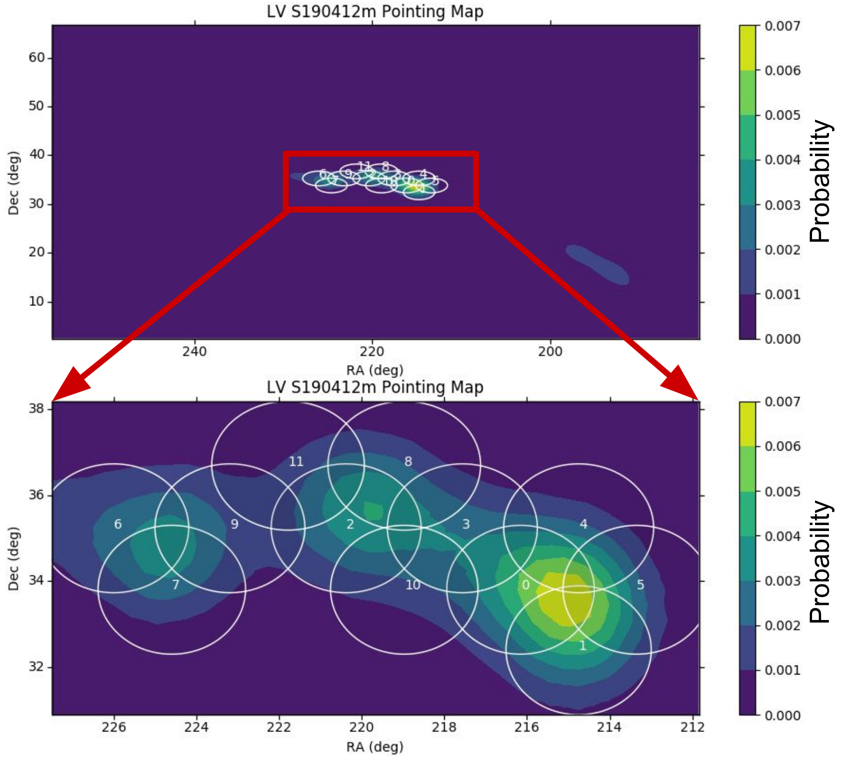
Highlights -- Ligo/Virgo Follow-up

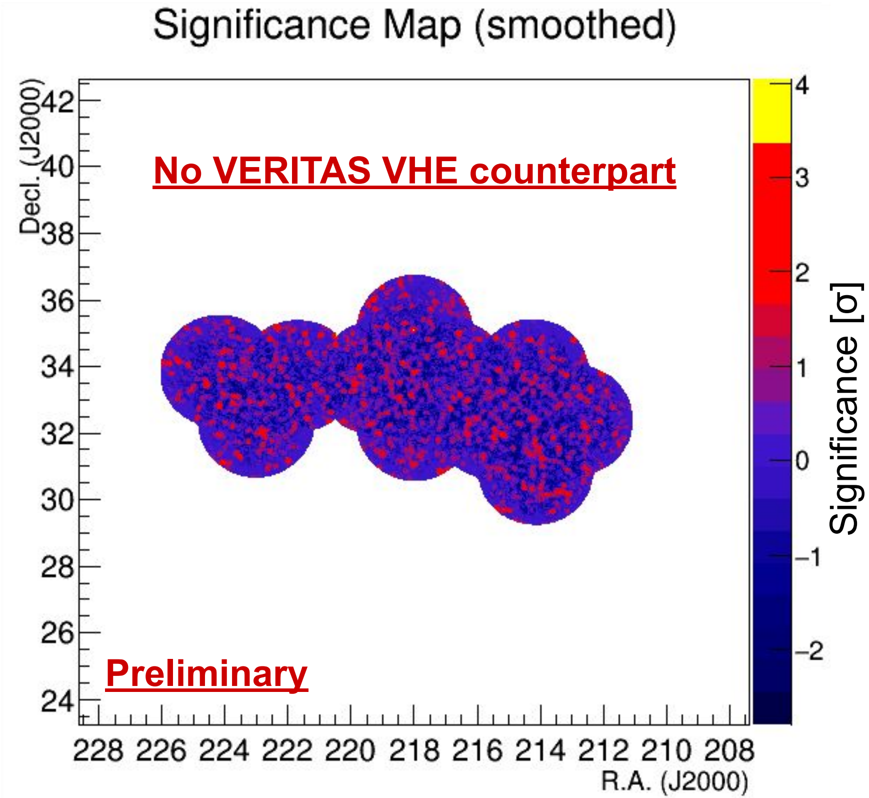
- O3 GW Follow-up
    - No VERITAS observations from 2019-05-12 to 2019-05-22 because of full moon

Superevent	Merger Type	Data?	Comments
S190408an	BBH	No	No visibility
S190412m	BBH	180 min	~50% Probability coverage
S190421ar	Terrestrial/BBH (96%/4%)	No	Limited visibility. Astrophysical origin unlikely.
S190425z	BNS	60 min	Only 2% probability coverage.
S190426c	NSBH : MassGap : BNS : BBH = 12 : 5 : 3 : 0	147 min	~20% probability coverage.
S190503bf	BBH	No	No visibility.
S190510g	BNS	No	No observing due to weather

Highlights -- Ligo/Virgo Follow-up

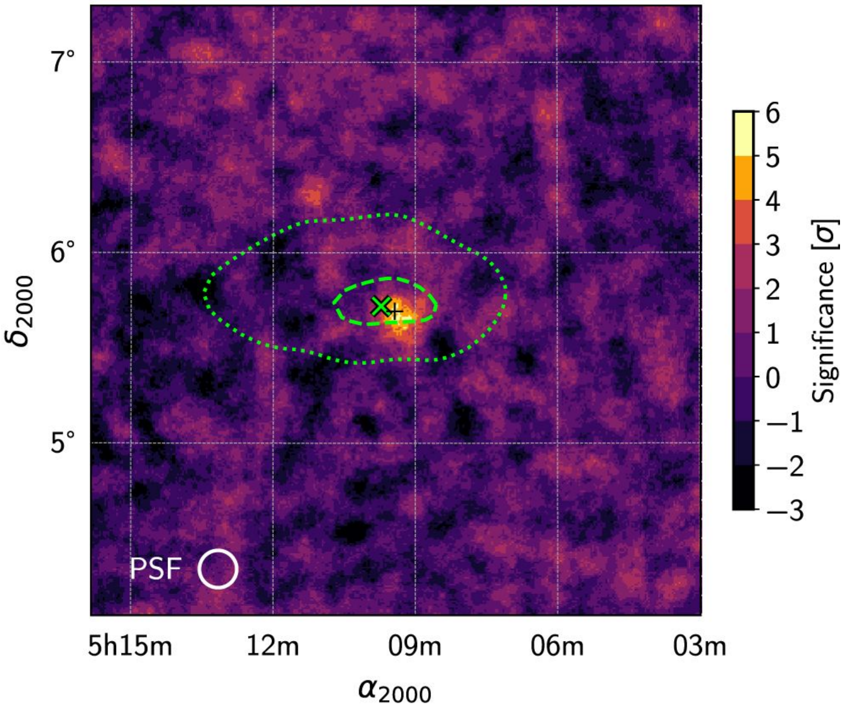
- LV S190412m (BBH)

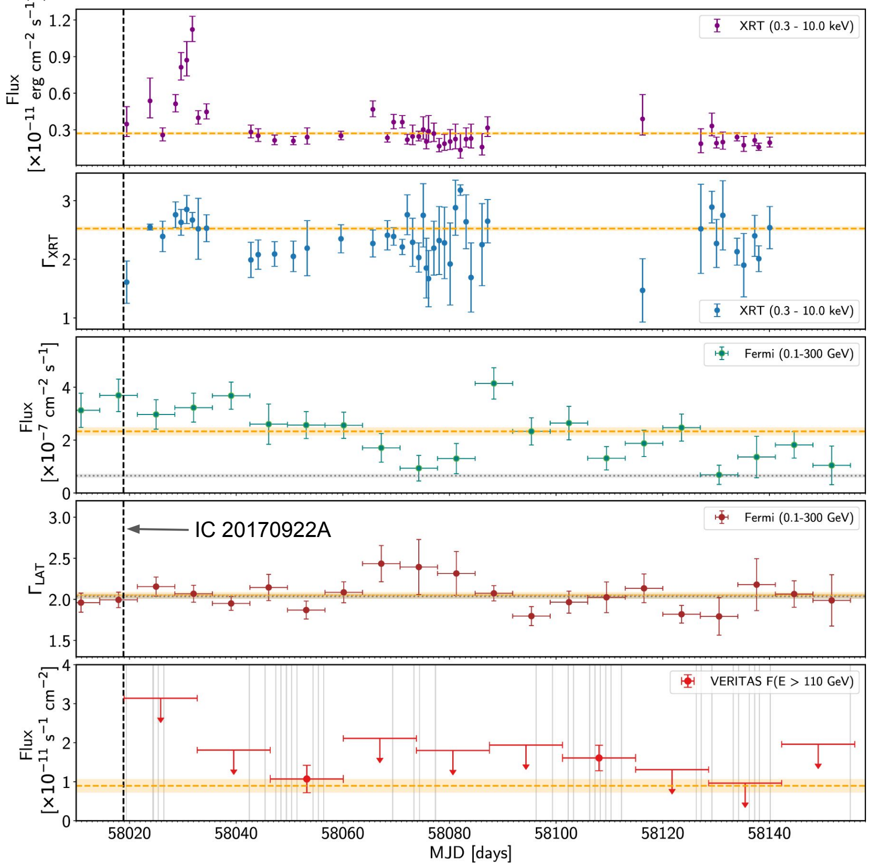




Highlights -- Neutrino Follow-up

TXS 0506+056 & IC 170922A





Abeysekara et al. (VERITAS) 2018, ApJL, 861, 2

My To-do List

- Re-analyze the full archival VERITAS GRB dataset
    - Use newer, more sensitive analysis techniques for older bursts
    - Careful analysis of bursts with sub-optimal observing conditions
        - Low elevation data
        - Moonlight data
- Optimize GRB observing protocol in light of the detections of GRB 180720B (H.E.S.S.) and GRB 190114C (MAGIC).
    - For Swift-detected bursts, select a maximum follow-up delay based on the Swift fluence.
        - Brighter bursts ---> Longer maximum delay.
        - Currently: Fixed 3 hour post-burst observation window.
            - Extended up to 24 hours for remarkable bursts.
- Fold galaxy catalog into GW follow-up target generation.
    - Important for nearby ($\lesssim$200 Mpc), well-localized GW events.
        - Galaxy density is still sparse on the scale of the VERITAS FOV