# VERITAS detection of VHE gamma-ray emission from the blazar S3 1227+25

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**Abstract.** We report on the first detection in the VHE band (E > 100 GeV) of the intermediate-synchrotron-peaked (ISP) blazar S3 1227+25 (ON 246). Observations were triggered by the Fermi-LAT detection of a hard-spectrum GeV flare from this object on May 15, 2015. The blazar was subsequently detected during the following nights with a very soft spectrum. This is the eighth ISP blazar detected in the VHE range and its study can shed new light on the emission processes at work in blazar flares and how this class fits into the general blazar picture. We summarize the quasi-simultaneous VERITAS, Fermi-LAT, Swift, and optical polarimetry and photometry measurements during the May flaring period.

## The VERITAS Observatory

- Location: Fred Lawrence Whipple Observatory (FLWO) in southern Arizona (31° 40'N, 110° 57'W, 1.3 km a.s.l.)
- Energy range: 85 GeV - 30 TeV. 15-25% energy resolution
- Sensitivity: 1% Crab in ~25h
- Angular resolution: < 0.1° at 1 TeV (68% containtment radius).
- Observation time: ~750 h dark time + ~200 h moonlight per year.

**Figure 1**: Current configuration of VERITAS

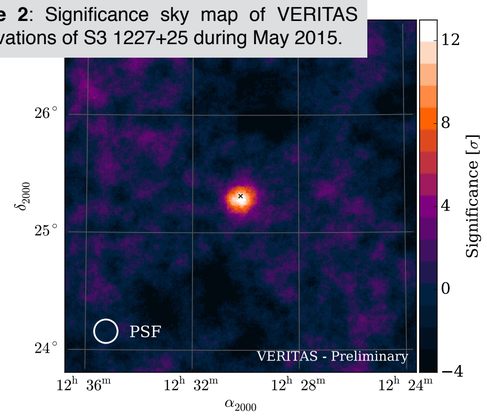
## S3 1227+25 (ON 246, 3FGL J1230.3+2519)

- Classification: **LSP** with $\nu_{peak} \sim 10^{14.11}$ Hz [2], **ISP** in 3LAC [3]
- Parsec-scale jet observed with VLBI.
- Redshift: z = 0.135 (spect.) [4] - No lines detected in recent observations [5].
- GeV flux: ~1% CU for E > 10 GeV (1FHL). VHE candidate. $\Gamma_{1FHL} \sim 3.3$.
- Previous flares: Hard GeV flare in Jan 2015 (ATel #6982). $\Gamma_{LAT} \sim 2.2$. x31 3FGL flux. No detection in VERITAS ToO observation.

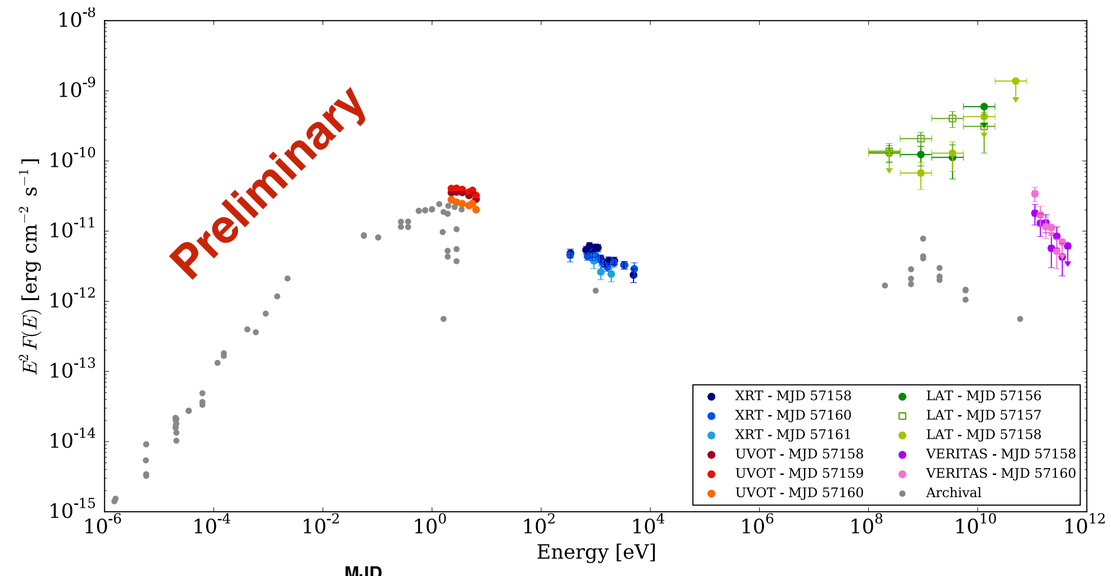
## VERITAS detection

- Hard-spectrum GeV flare observed by the LAT on May 15th ($\Gamma_{LAT} \sim 1.9$). ~x61 3FGL flux above 100 MeV.
- VERITAS observations on May 16 (MJD 57158) detect the source at 6-8% Crab flux (**>8σ**). **ATel#7516**
- Detected on May 16, 18 & 21. No data taken on May 17 due to bad weather. Observed, but not detected, on May 19, 20, and 23 (upper limits).
- Triggered Swift ToO observations (total of ~10.8 ks).
- Very soft spectrum in the ~100-300 GeV range.
- Total significance of **~13σ** in **6 hours** of weather-cleaned data (~420 excess photons).

**Figure 2**: Significance sky map of VERITAS observations of S3 1227+25 during May 2015.




## Spectral properties of the flare




| Fermi-LAT | MJD 57156 | MJD 57157 | MJD 57158 |
|---|---|---|---|
| F(0.1-300 GeV) [x $10^{-7}$ cm$^{-2}$ s$^{-1}$] | 8.1 +/- 1.7 | 11.3 +/- 1.9 | 4.6 +/- 1.3 |
| Γ | 2.0 +/- 0.2 | 1.8 +/- 0.1 | 1.8 +/- 0.2 |
| TS | 118.1 | 296.9 | 118.5 |

| Swift-XRT | MJD 57158 | MJD 57160 | MJD 57161 |
|---|---|---|---|
| F(0.3-5 keV) [x $10^{-11}$ cm$^{-2}$ s$^{-1}$] | 1.21 +/- 0.04 | 1.06 +/- 0.04 | 0.8 +/- 0.05 |
| Γ ($n_H$ = 1.43 | 2.4 +/- 0.1 | 2.4 +/- 0.1 | 2.4 +/- 0.5 |
| Livetime [ks] | 2.7 | 2.7 | 0.5 |

**Figure 7**: Broadband SED for S3 1227+25 built with data taken during the flare compared to archival data from SED Builder **[6]**. The main fit parameters in three energy bands are given below.

| VERITAS | MJD 57158 | MJD 57160 | MJD 57163 |
|---|---|---|---|
| F(>100 GeV) [x $10^{-11}$ cm$^{-2}$ s$^{-1}$] | 4.8 +/- 0.8 | 4.6 +/- 0.7 | 4.0 +/- 1.1 |
| Γ | 3.2 +/- 0.4 | 4.1 +/- 0.6 | 3.7 +/- 1.3 |
| Significance [σ] | 7.1 | 7.2 | 4.1 |
| Livetime [h] | 1.9 | 3 | 1 |

## Optical photometry and polarimetry

S3 1227+25 was observed with the Perkins telescope (1.83 m) at Lowell Observatory, and the Kuiper (1.55 m) and Bok (2.3 m) telescopes of Steward Observatory during May, June and July, starting on MJD 57160. On the first night of observations, a low degree of polarization is observed in both data sets, which is interpreted as being associated with a high level of magnetic turbulence. The turbulence is likely to be associated with the emission region responsible for the VHE detection. Spectroscopic observations from Steward show no variation in the slope of the flux spectrum during the active period.

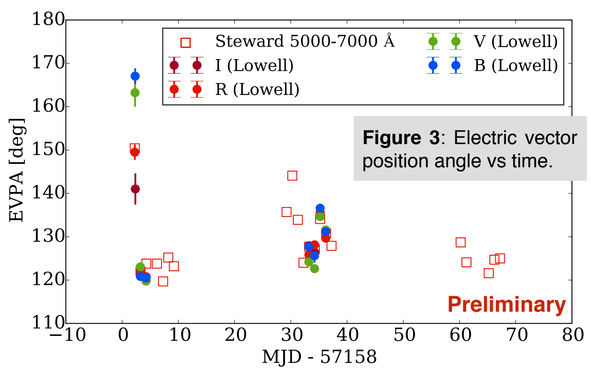



**Figure 3**: Electric vector position angle vs time.

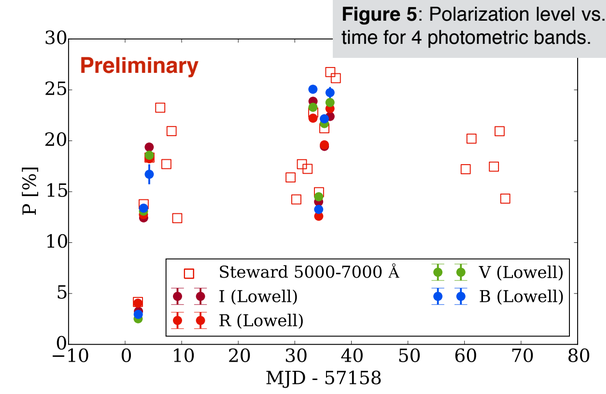



**Figure 5**: Polarization level vs. time for 4 photometric bands.

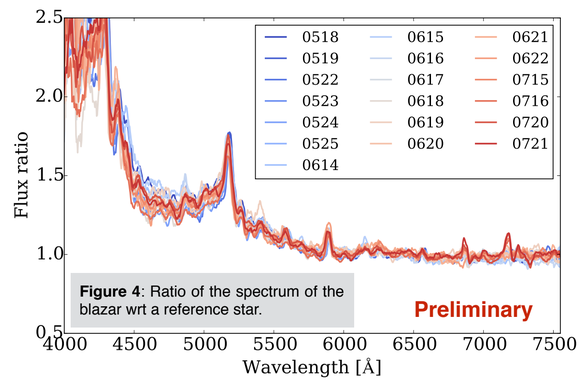



**Figure 4**: Ratio of the spectrum of the blazar wrt a reference star.

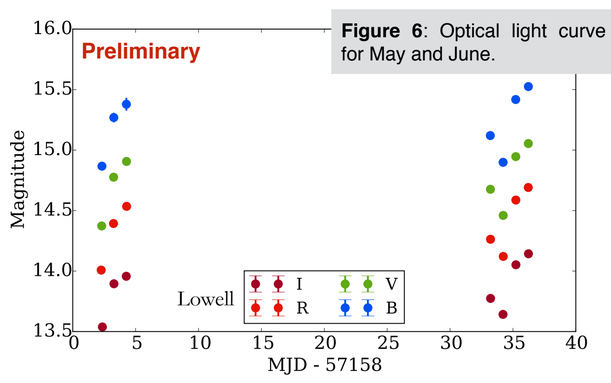
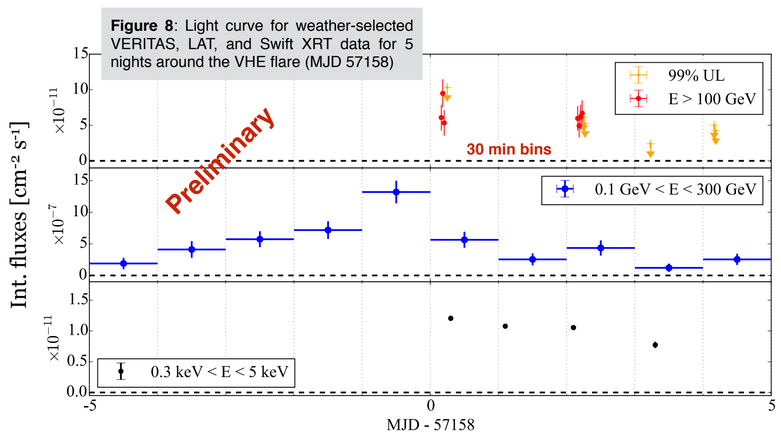



**Figure 6**: Optical light curve for May and June.

## Light curve

The light curve shows slow variability in both X-ray and GeV gamma-rays. The detection of VHE emission on MJD 57160 appears to be associated with only a weaker relative increase in GeV emission. The integral flux on that night was ~ 7% Crab above 100 GeV lowering to ~3% Crab above 200 GeV, consistent with the soft spectrum of the source. A preliminary analysis shows no variability of the blazar at the hour level, although the impact of weather during this period was significant and needs to be assessed.

**Figure 8**: Light curve for weather-selected VERITAS, LAT, and Swift XRT data for 5 nights around the VHE flare (MJD 57158)




**References**

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