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ASTROPHYSICS

HARVARD & SMITHSONIAN

The VERITAS TeV AGN Catalog

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VERITAS: Very Energetic Radiation Imaging Telescope Array System



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Very-high-energy (~ 100 GeV to ~ 30 TeV) γ -ray studies since 2007 ($\sim 20,600$ h data)

Operations funded through 2026; Collaboration exploring >2026 possibilities

Good-weather: ~ 905 h/yr in dark time ($\sim 50\%$ on AGNs) + ~ 175 h/yr in bright moon (illum. $>30\%$)

Sensitivity:

$\sim 1\%$ Crab in < 25 h

Systematic errors:

$F \sim 20\%$

$\Gamma \sim 0.1$

Angular resolution:

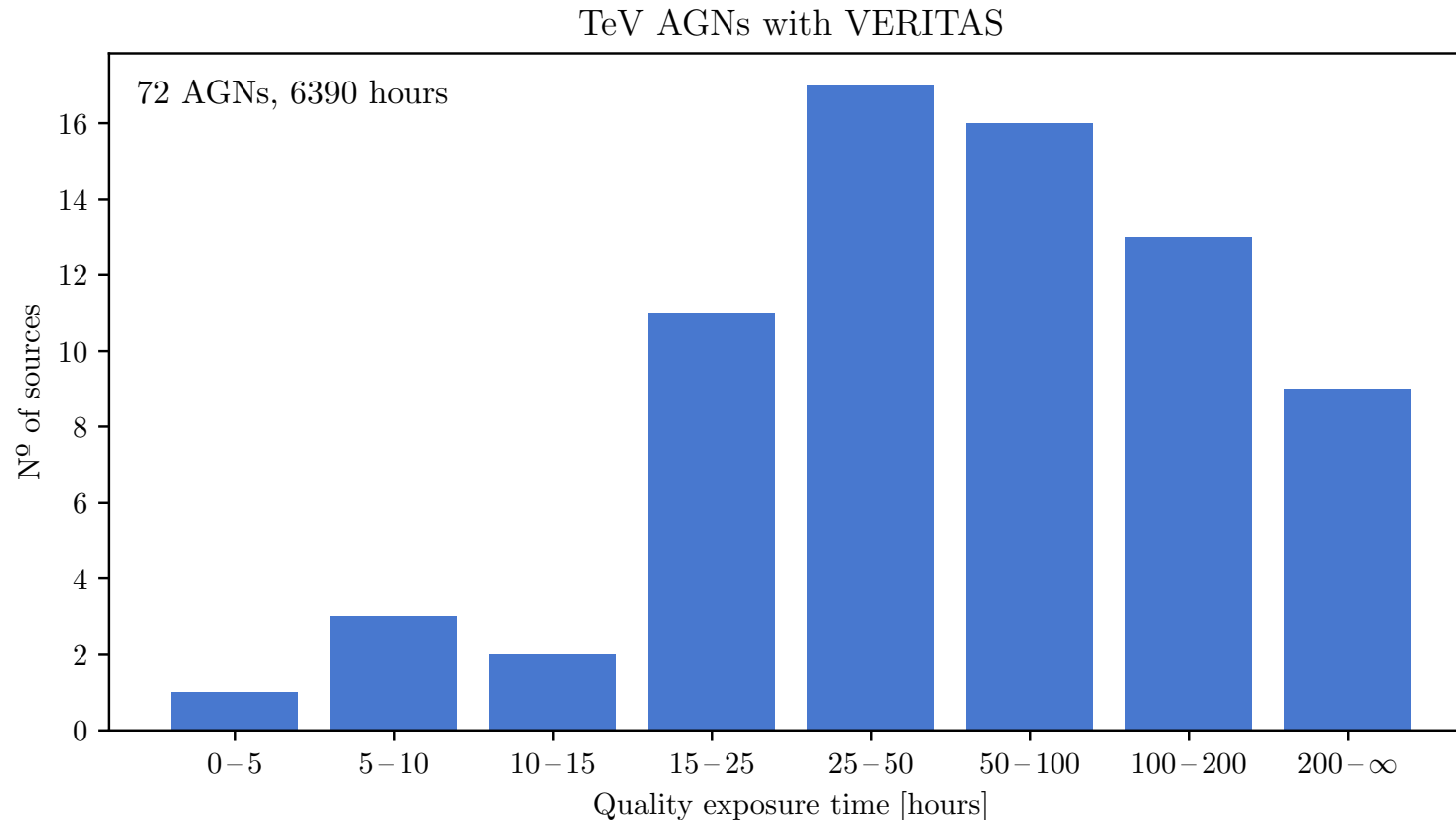
$R(68\%) \sim 0.08^\circ$ at 1 TeV

Energy resolution:

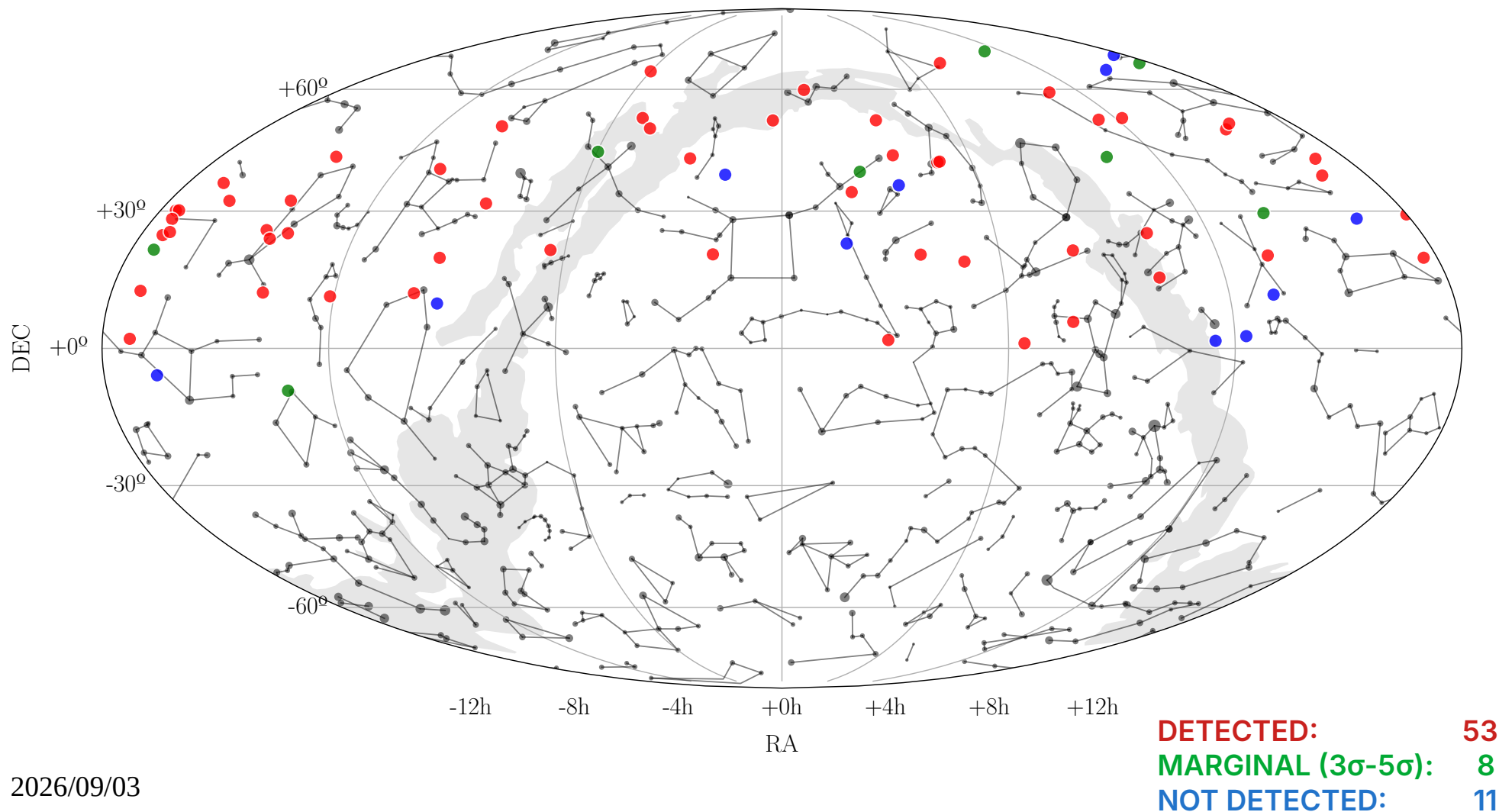
$E \sim 17\%$

The VERITAS TeV AGN Catalog

First systematic study of all known VHE AGNs visible to VERITAS



The VERITAS TeV AGN Catalog



The VERITAS TeV AGN Catalog

Overall Status

- Standardized automatic run lists ✓
- Processed data for all sources ✓
- Evaluated signal for all sources ✓
- Flux, ULs, spectra and variability constraints produced ✓
- First draft (constraints on Known TeV AGNs) to be sent soon. Processing of UL on larger samples on-going.
- Several new detections and discoveries already announced.

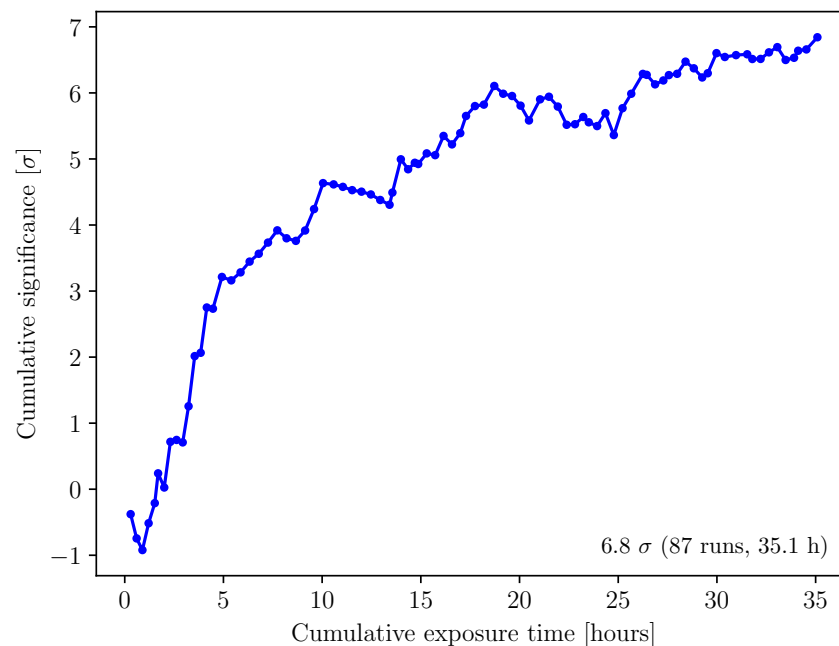
The VERITAS TeV AGN Catalog

Recent VERITAS AGN detections and discoveries (see TeVPA 2025 talk for details):

- **RGB J1725+118** (HBL)
- **RGB J0152+017** (HBL)
- **NVSS J073326+515355** (EHBL)
- **1ES 2037+521** (EHBL)
- **B2 1420+32** (FSRQ, highly variable, $z \sim 0.68$, during 2020 Fermi flare, and recently 2026 flare - Atel #17802)
- **RGB J1243+364** (HBL, $z > 0.48$, *discovery)
- **3C273** (see W. Benbow talk @ ICR2025, *discovery)

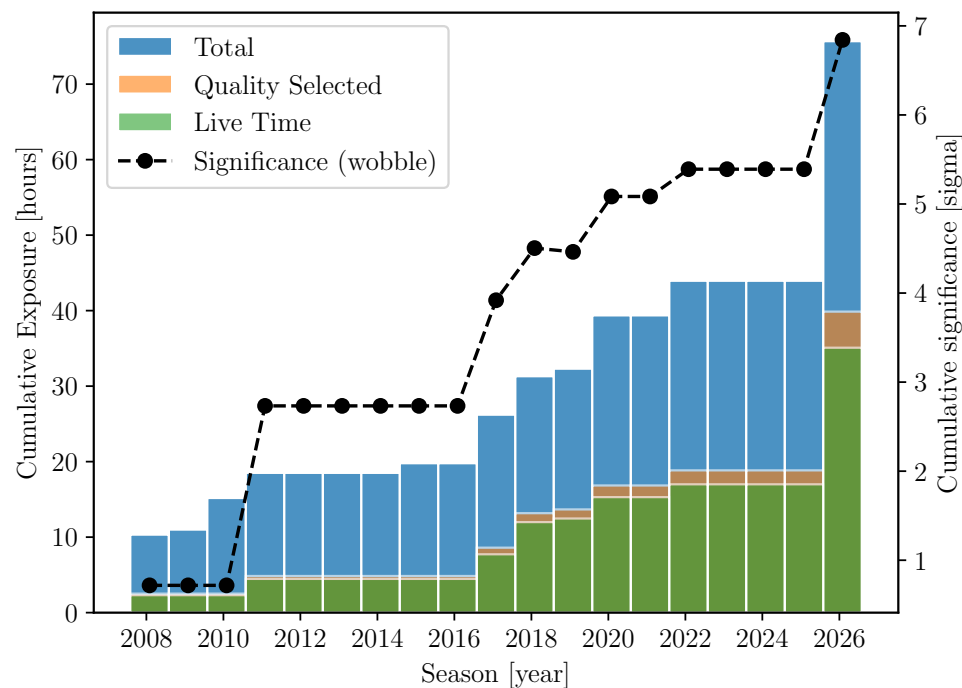
Discovery of TeV Emission from 1ES0120+340

- **NED coordinates:** 01h 23m 09s +34d 20m 48s, $z=0.272$
- **Type:** EHBL
- **Gamma-ray emission:**
 - **4FGL J0123.1+3421**
 - $\Gamma = 1.69 \pm 0.08$
 - **3HSPJ012308.6+342048**
 - $\nu_{\text{peak}} \sim 10^{18}$ Hz
 - TeV FoM ~ 6.31 ,
 - **VERITAS --- VER J0123+343**
 - **6.8σ in 35h**
 - **$\Gamma = 3.26 \pm 0.51$** (observed) $\Gamma = 1.2 \pm 0.5$ (EBL-corrected)
 - Flux(>350 GeV) $\sim (1.1 \pm 0.3_{\text{stat}} \pm 0.2_{\text{syst}}) \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \sim \mathbf{1.1\% \text{ Crab}}$

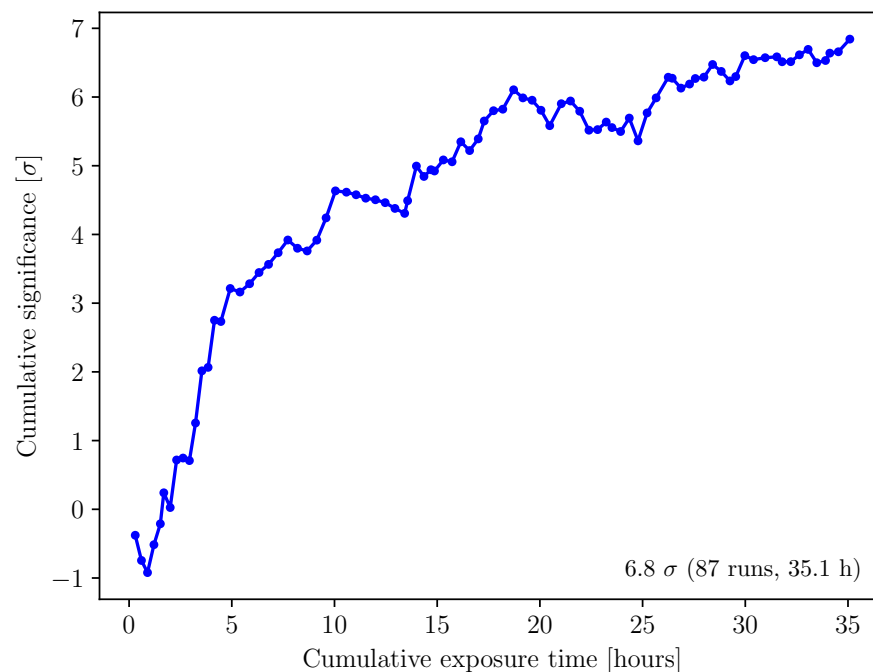


Discovery of TeV Emission from 1ES0120+340

Signal search

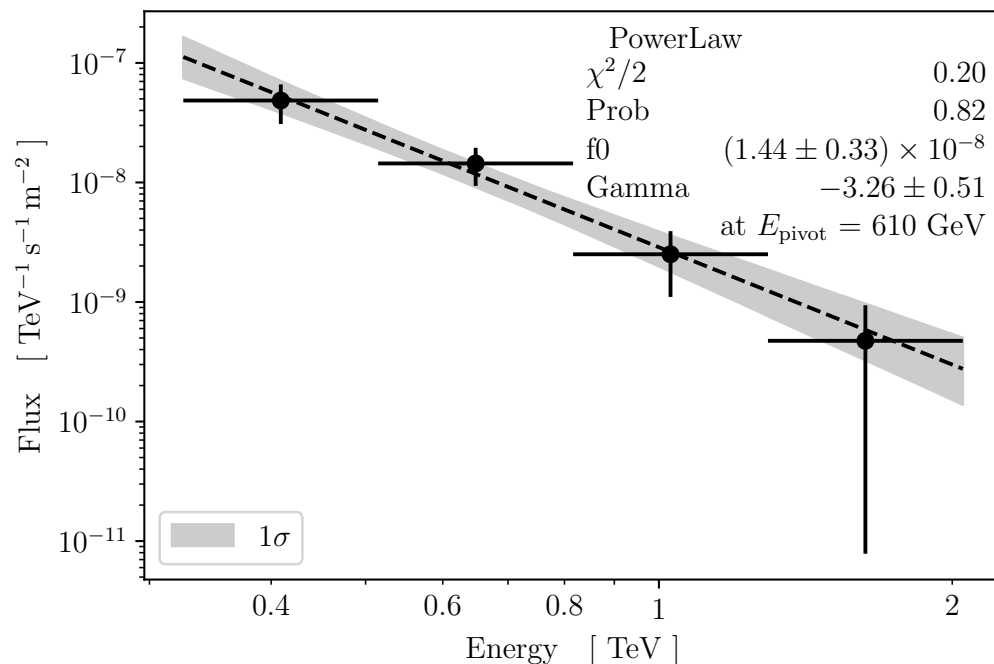


Live time 35.3h
On 181; Off 4567; Alpha 0.023
Excess $\sim 78\gamma$, 6.8σ



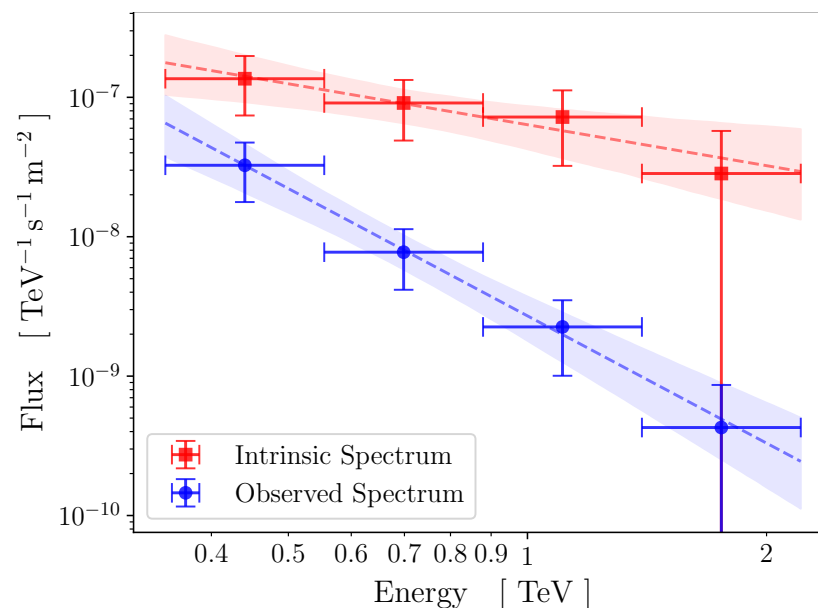
Discovery of TeV Emission from 1ES0120+340

Spectrum



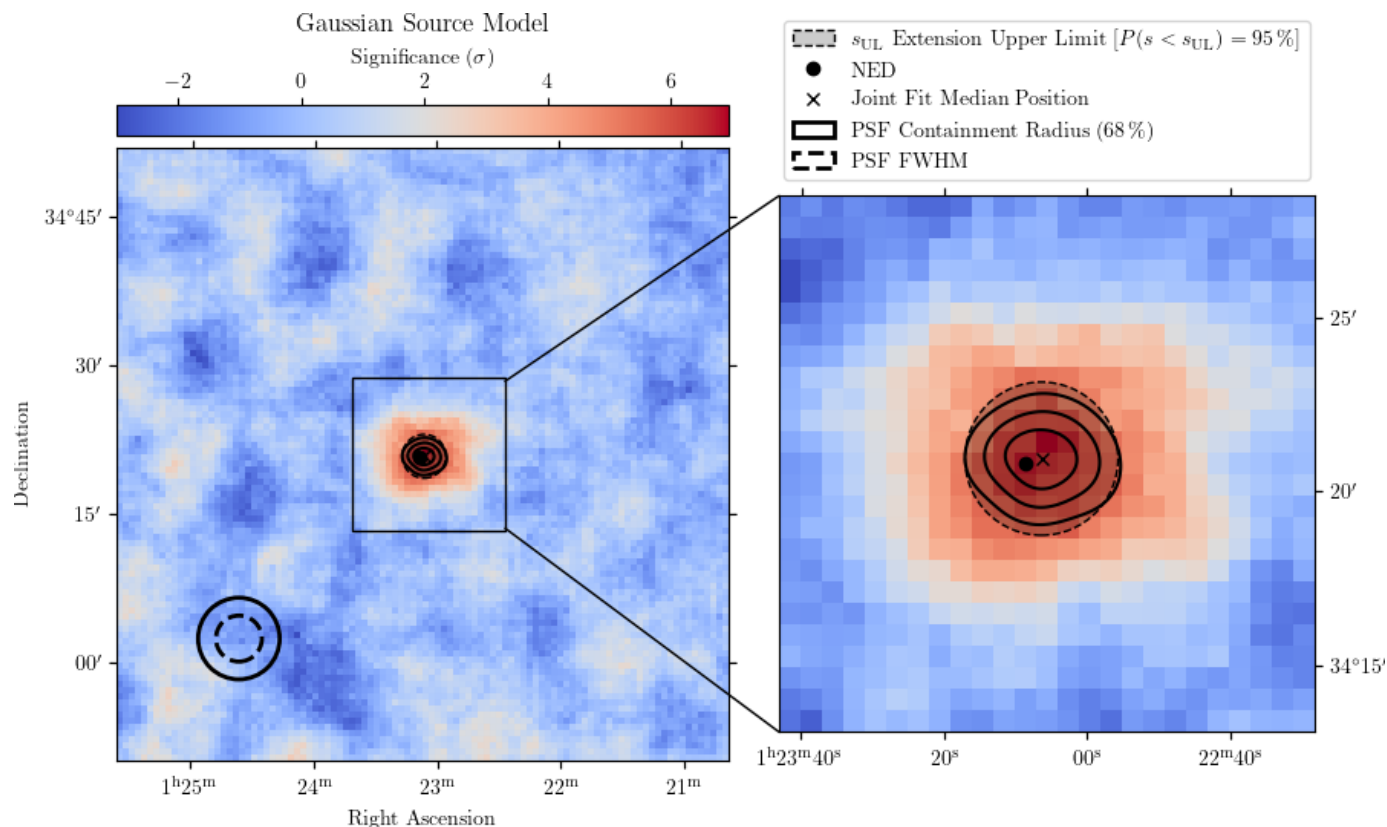
Observed:
 $\Gamma = 3.3 \pm 0.5$

Intrinsic (Dominguez et al. 2011):
 $\Gamma = 1.2 \pm 0.5$



Discovery of TeV Emission from 1ES0120+340

Location and Extension constrains through full Bayesian MCMC modelling



VER J0123+343

RA 01h 23' 06" $\pm$ 50" $_{\text{stat}}$ $\pm$ 12" $_{\text{syst}}$

DEC +34d 20' 57" $\pm$ 30" $_{\text{stat}}$ $\pm$ 12" $_{\text{syst}}$

Extension UL95 2.2 arcmin

2026/09/03

Preliminary

Conclusions



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- We are producing the first standardized **VERITAS TeV AGN Catalog**.
- It will include all **detections & non-detections** by VERITAS, together with constraints on flux, spectrum and variability for each source.
- We have already found at least **5 new VERITAS detections** (some buried in the historical archives, others through a dedicated top-up program).
More are coming, stay tuned!
- Some sources are promising candidates for EBL constraints by the **future CTAO** (e.g. 1ES 2037+521, 1ES0120+340).
- The VERITAS catalog can serve as a **basic reference** for future proposals.
- We are announcing the **discovery of VHE emission from 1ES0120+340**.
- First paper (on known TeV AGNs) is almost ready. Feedback welcome about what and how you would like to see in the catalog.



NVSS J073326+515355

- **Coordinates:** 07h 33m 27s, +51d 53m 55s , $z = 0.065$
Other names: PGC 2402248, 2WHSP J073326.7+515354
- **Type:** Extreme High-energy-peaked BL Lac object (EHBL)
 - Synchrotron peak at $\nu_{\text{peak}} \sim 10^{18}$ Hz
 - 3HSP TeV FoM ~ 2.5
- **Gamma-ray Emission:**
 - **Fermi** 14-years (4FGL J0733.4+5152): $\Gamma = 1.77 \pm 0.08$
 - **MAGIC** [MNRAS 490, 2284–2299 (2019)]:
 - 6.7σ in 23h
 - Flux(>200 GeV) $\sim 1\%$ Crab
 - Power Law, $\Gamma = 2.4 \pm 0.2$

Preliminary

NVSS J073326+515355

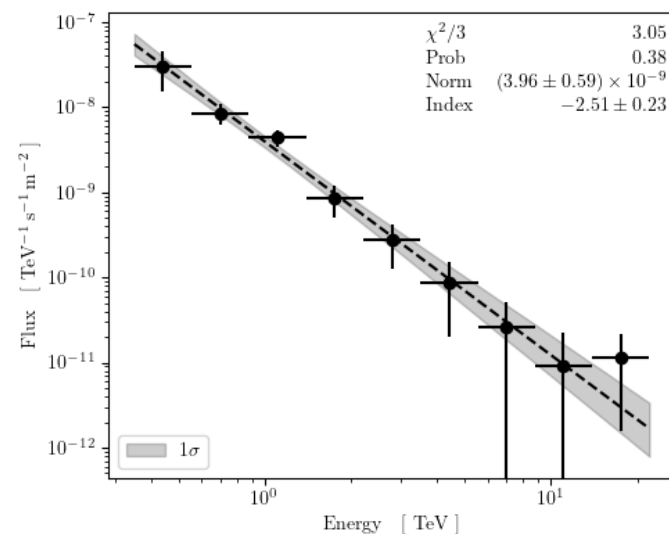
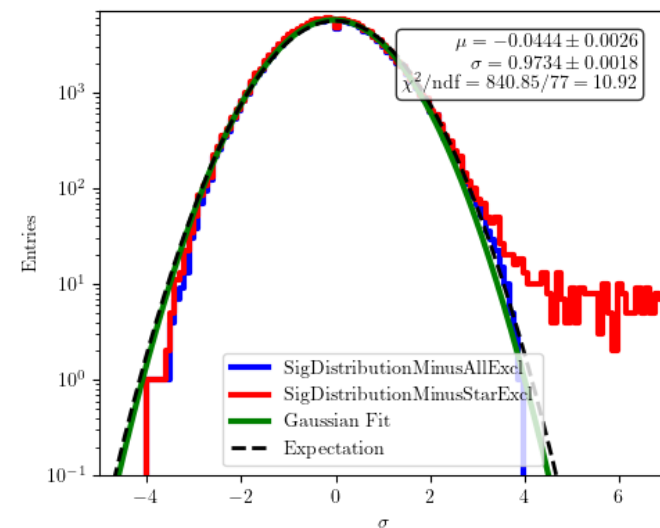
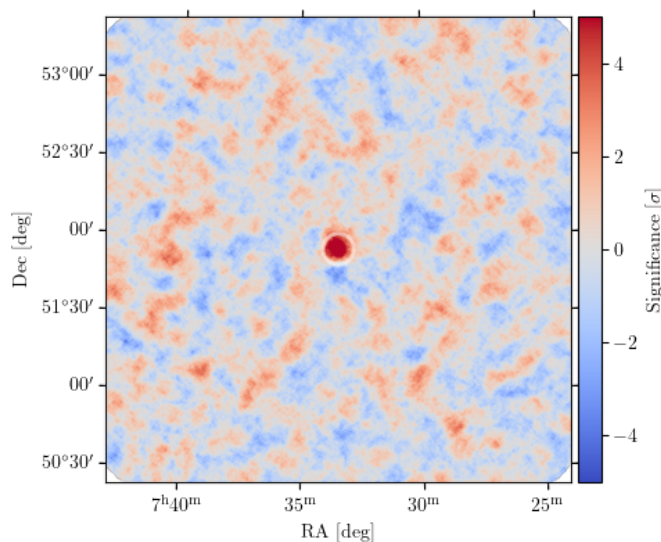
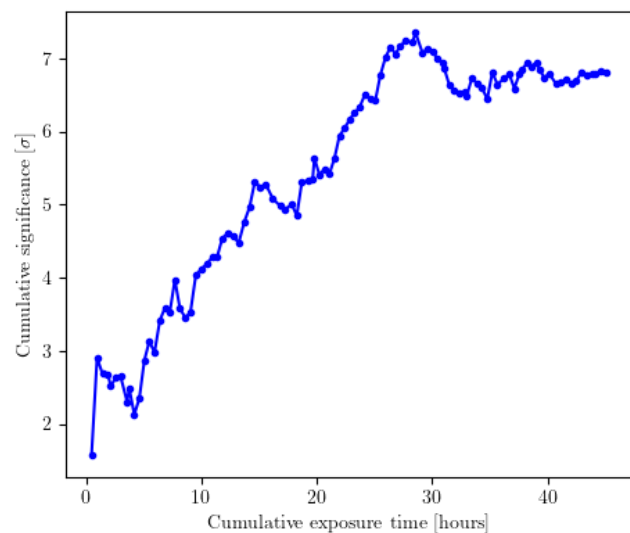
Live time 45.1h

On 184; Off 4662; Alpha 0.022

Excess $\sim 83\gamma$, 7.3σ

$F(>290 \text{ GeV}) = 1.3 \times 10^{-12} \text{ s}^{-1} \text{ cm}^{-2} \approx 1.0 \pm 0.2 \% \text{ Crab}$

$\Gamma = -2.51 \pm 0.23$



2026/09/03

1ES 2037+521

- **Coordinates:** 20h 39m 23.5s, +52d 19m 50.20s, $z=0.053$
- **Type:** HBL
 - Synchrotron peak at $\nu_{\text{peak}} \sim 10^{16.9}$ Hz
 - 3HSP TeV FoM ~ 1
- **Gamma-ray Emission:**
 - **Fermi** 14-years (4FGL J2039.5+5218):
 - $\Gamma = 1.84 \pm 0.07$
 - **MAGIC** 2016 (ATel #9582, 2020ApJS..247...16A):
 - 7.5σ in 28h
 - $\Gamma = 2.3 \pm 0.2$ (observed) $\Gamma = 2.0 \pm 0.5$ (EBL-corrected)
 - $\text{Flux}(>300 \text{ GeV}) \sim (1.8 \pm 0.4) \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \sim 1.5\% \text{ Crab}$

Preliminary

1ES 2037+521

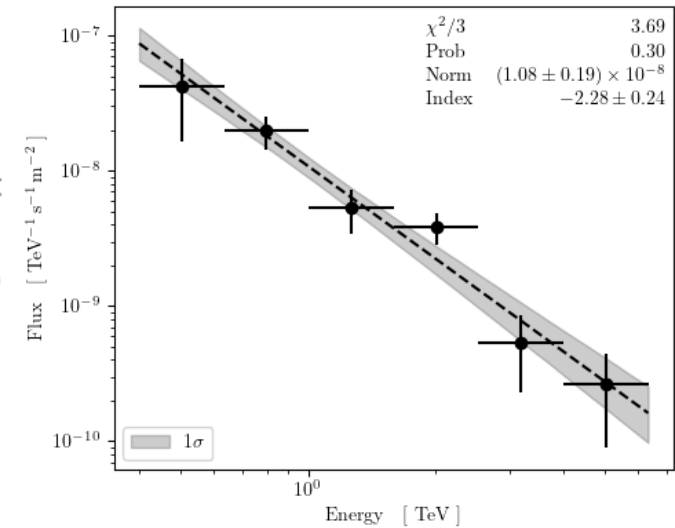
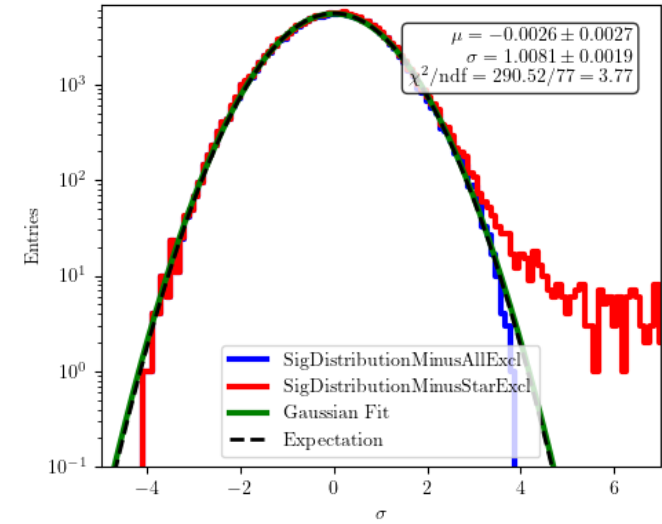
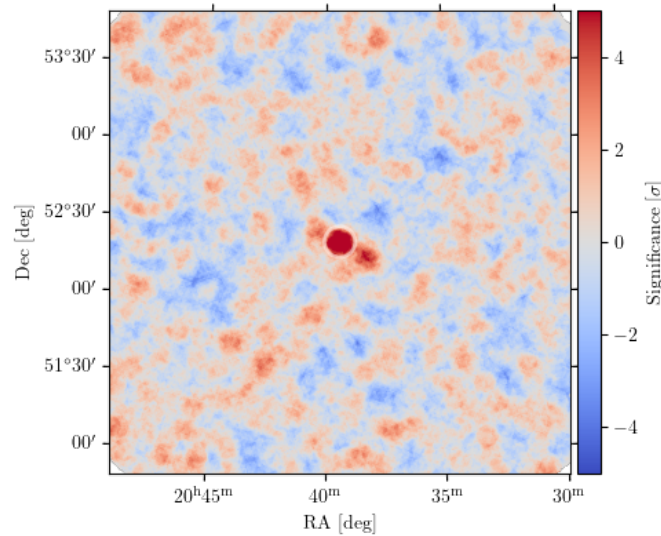
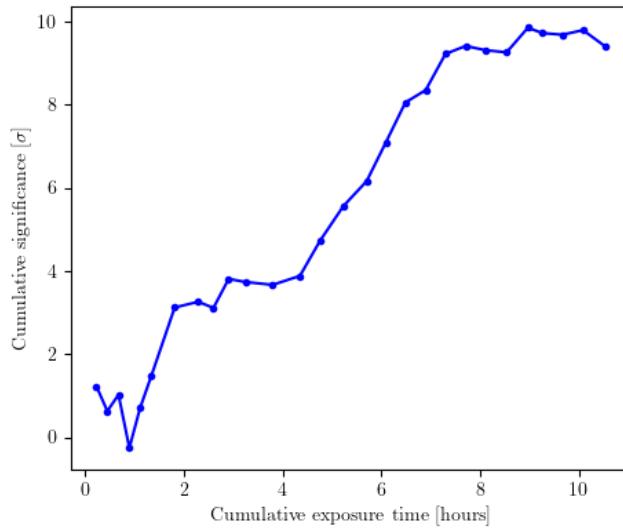
Live time 8.1h

On 117; Off 1702; Alpha 0.023

Excess $\sim 77\gamma$, 9.7σ

$F(>320 \text{ GeV}) = 4.2 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \approx 3.8 \pm 0.5 \% \text{ Crab}$

$\Gamma = -2.28 \pm 0.23$

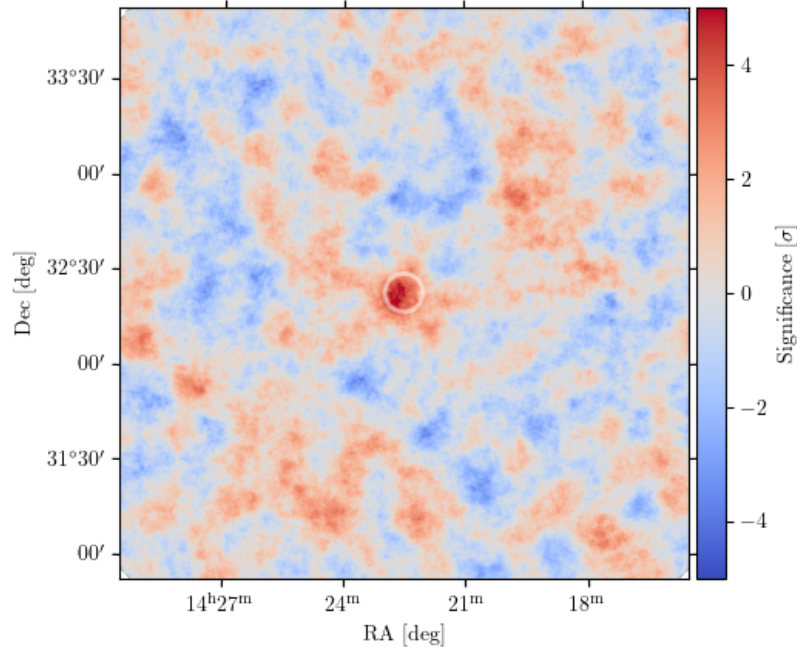


2026/09/03

B2 1420+32

- **Coordinates:** 14h 22m 30.38s +32d 23m 10.44s, $z=0.68$
- **Type:**
 - FSRQ, highly variable
- **Gamma-ray Emission:**
 - **Fermi** 14-years (4FGL J1422.5+3223):
 - LP Norm $2.2 \times 10^{-11} \text{ MeV}^{-1} \text{ s}^{-1} \text{ cm}^{-2}$ $\Gamma = 2.16$ $\beta = 0.05$ (PL $\Gamma = 2.23 \pm 0.01$)
 - **MAGIC** 2020 (Atel #13412, 2021A&A...647A.163M):
 - $14.\sigma$ in 1.3 h
 - $\Gamma = 4.22$ (observed); $\Gamma = 3.5$ (EBL-corrected)
 - Flux(>100 GeV) $\sim (7.8 \pm 1.3) \times 10^{11} \text{ cm}^{-2} \text{ s}^{-1} \sim 11\%$ Crab during the 2-day flare

B2 1420+32 (during the Fermi 2020 Flare)

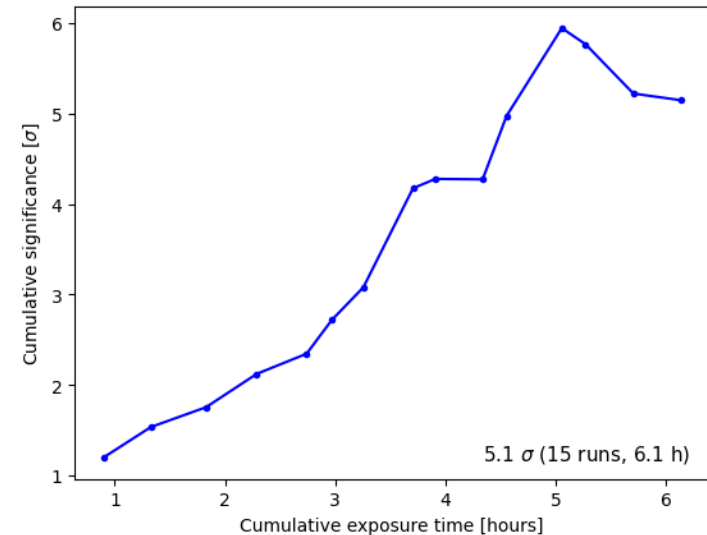
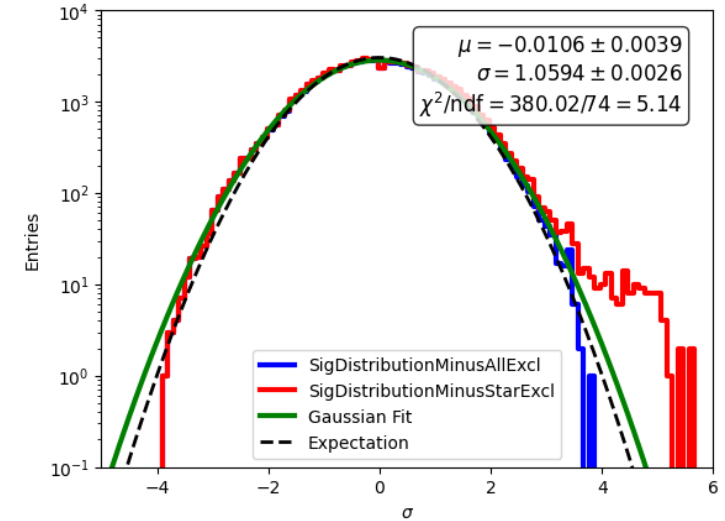


Live time 6.1 h

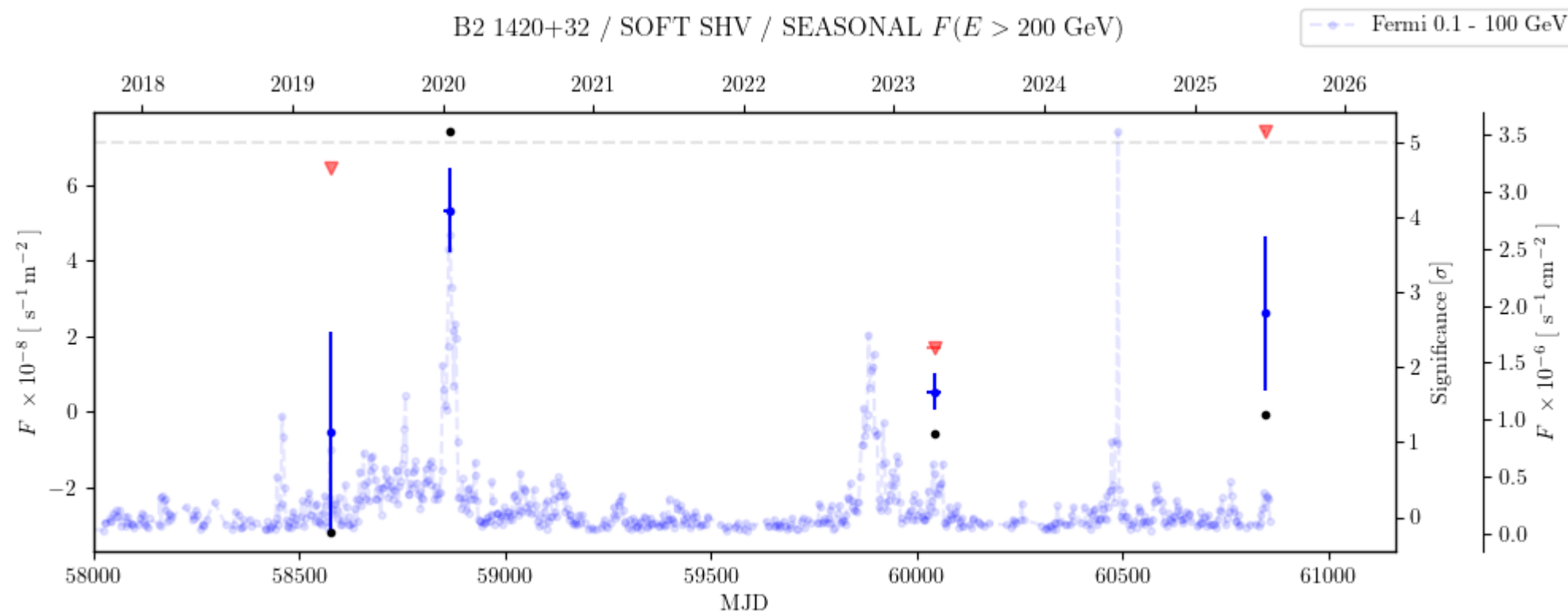
On 402; Off 3337; Alpha 0.091

Excess $\sim 99\gamma$, 5.1σ

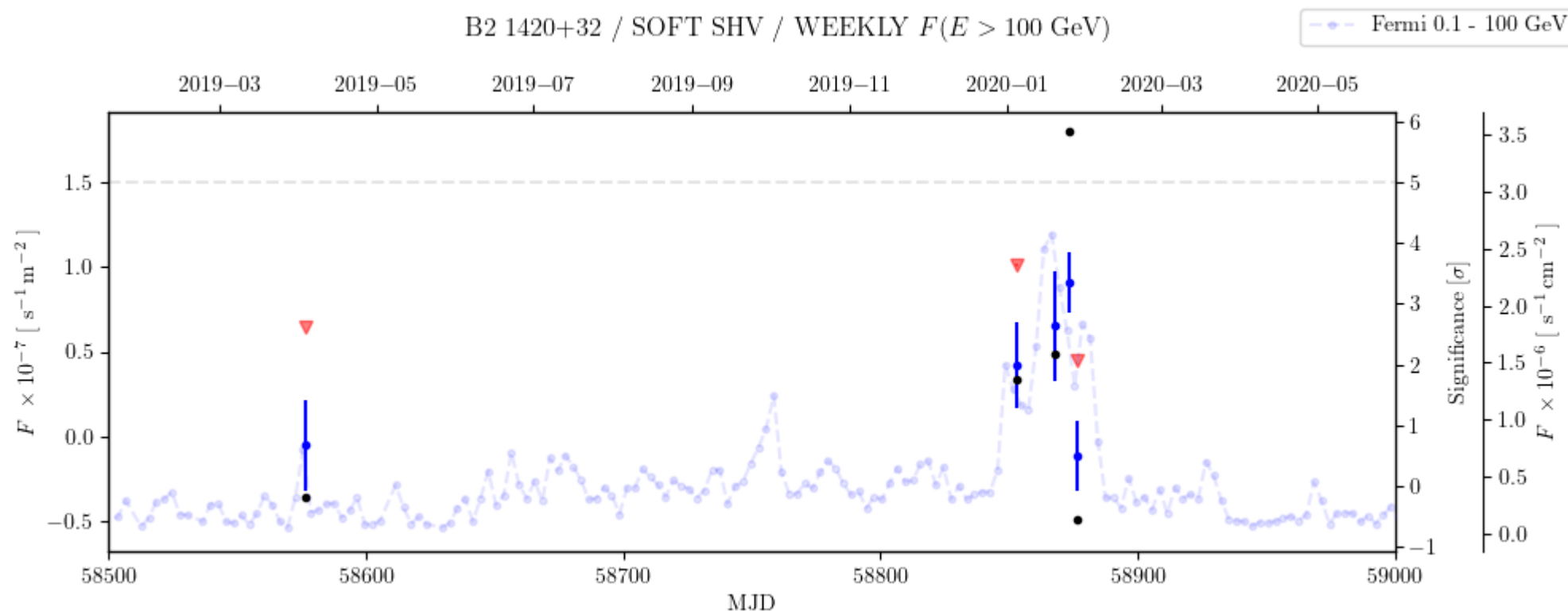
Flux(>200 GeV) $\sim 5.3 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \sim 2.6 \pm 0.5 \% \text{ Crab}$



B2 1420+32 (during the Fermi 2020 Flare)



B2 1420+32 (during the Fermi 2020 Flare)



RGB J1725+118

- **Coordinates:** 17h 25m 04.3s +11d 52m 15.5s, $z=0.18$
- **Type:** HBL
 - Synchrotron peak at $\nu_{\text{peak}} \sim 10^{15.7}$ Hz
 - 3HSP TeV FoM ~ 5
- **Gamma-ray Emission:**
 - **Fermi** 14-years (4FGL J1725.0+1152):
 - LP Norm $7.5 \times 10^{-13} \text{ MeV}^{-1} \text{ s}^{-1} \text{ cm}^{-2}$ $\Gamma = 1.77$ $\beta = 0.06$ (PL $\Gamma = 1.87 \pm 0.02$)
 - **MAGIC** 2013 (ATel #5080, 2016MNRAS.459.3271A):
 - 5.9σ in 12.5h
 - $\Gamma = 3.3 \pm 0.9_{\text{stat}}$ (observed); $\Gamma = 2.3 \pm 0.4$ (EBL-corrected)
 - Flux(> 150 GeV) $\sim (6.3 \pm 1.6) \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \sim 2.0\%$ Crab

Preliminary

RGB J1725+118

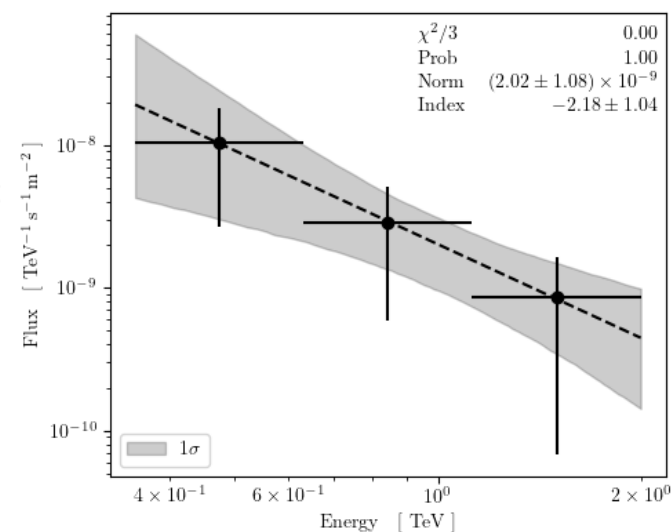
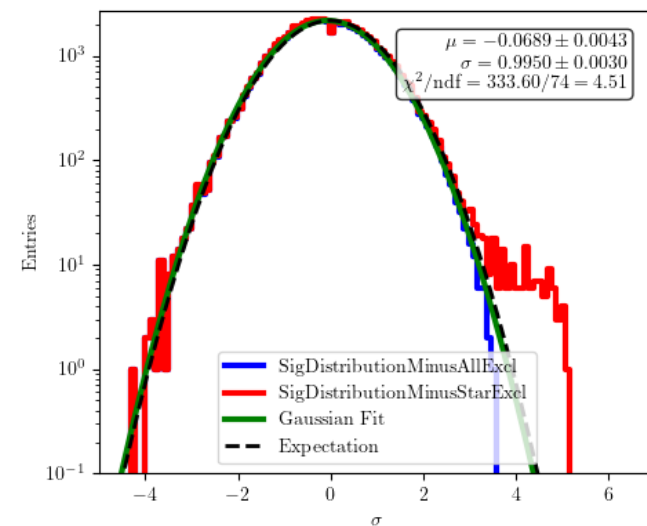
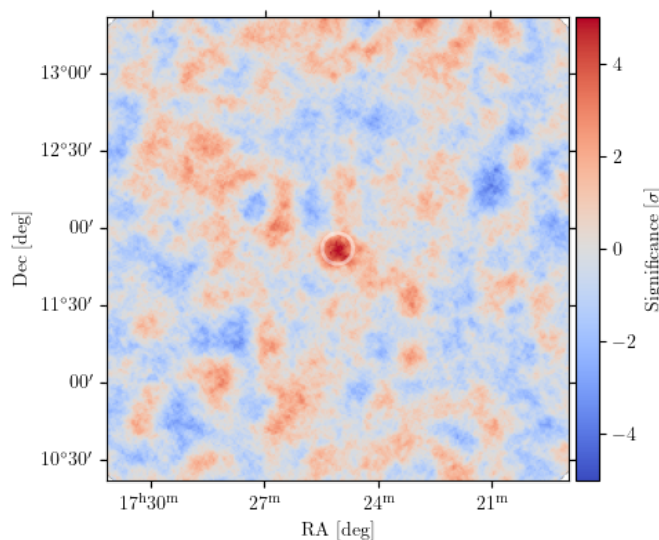
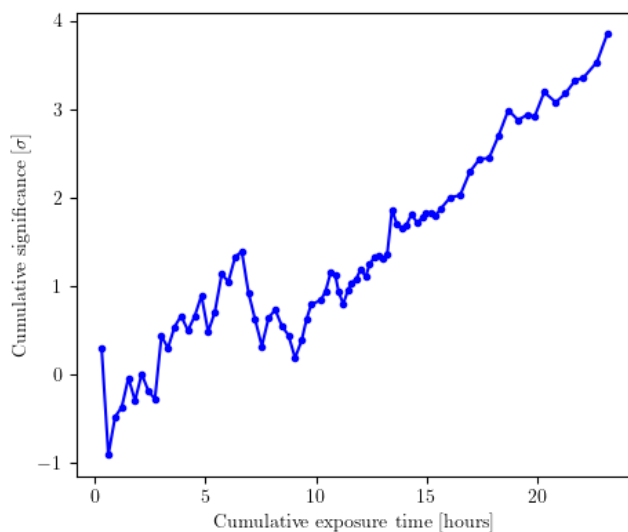
Live time 23.1h

On 1309; Off 24752; Alpha 0.046

Excess $\sim 176\gamma$, 5.0σ

$F(>170 \text{ GeV}) = 2.8 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \approx 1.1 \pm 0.3 \% \text{ Crab}$

$\Gamma = -2.18 \pm 1.03$



2026/09/03

RGB J0152+017

- **Coordinates:** 01h 52m 39.6 +01d 47m 17.4s, $z=0.08$
- **Type:** HBL
 - Synchrotron peak at $\nu_{\text{peak}} \sim 10^{15.9}$ Hz
 - 3HSP TeV FoM ~ 2.5
- **Gamma-ray Emission:**
 - **Fermi** 14-years (4FGL J0152.6+0147):
 - $\Gamma = 2.00 \pm 0.05$
 - **HESS** 2008 (2008A&A...481L.103A):
 - 6.6σ in 14.7h
 - $\Gamma = 2.95 \pm 0.36_{\text{stat}}$ (observed)
 - $\text{Flux}(> 300 \text{ GeV}) \sim (2.7 \pm 0.51_{\text{stat}}) \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \sim \% 2.2 \% \text{ Crab}$

Preliminary

RGB J0152+017

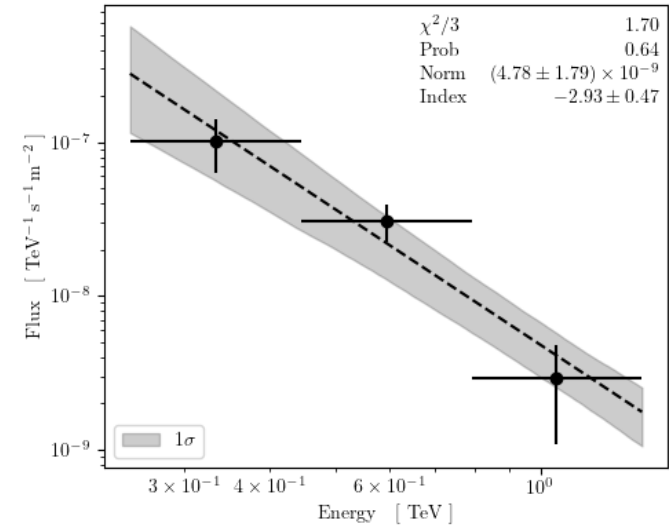
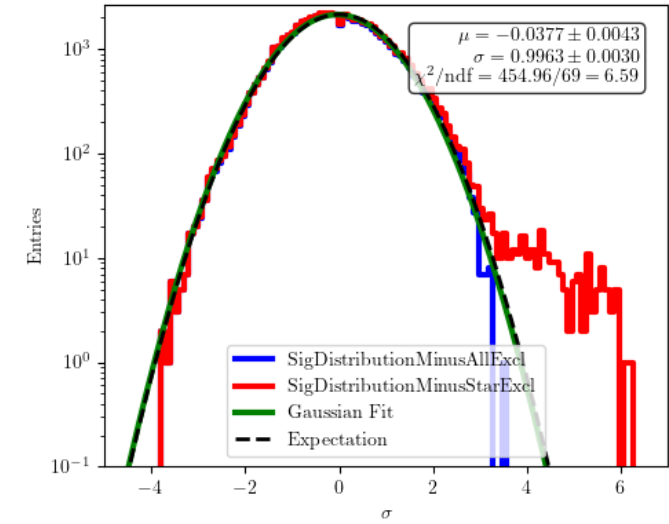
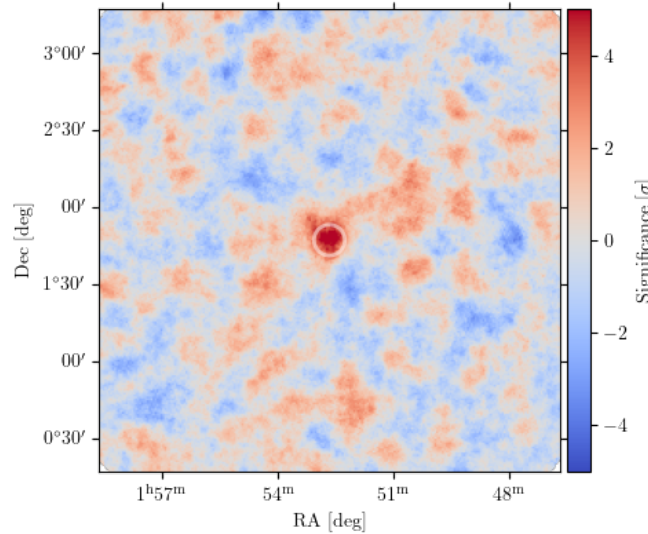
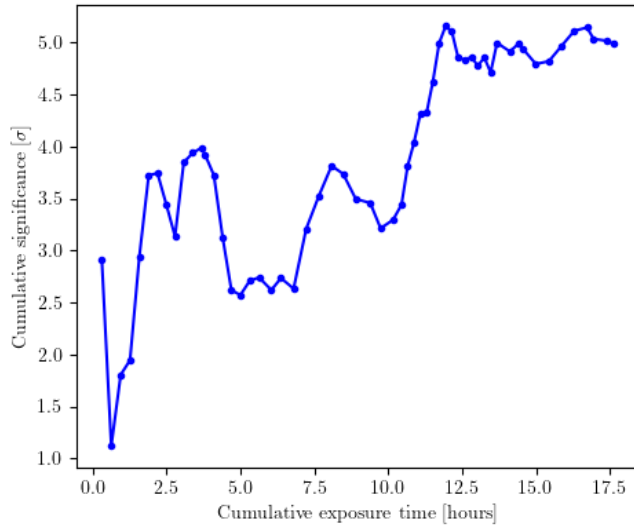
Live time 17.6h

On 1020; Off 20245; Alpha 0.042

Excess $\sim 172\gamma$, 5.6σ

$F(>180 \text{ GeV}) = 3.7 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \approx 1.6 \pm 0.3 \% \text{ Crab}$

$\Gamma = -2.93 \pm 0.43$



2026/09/03

Discovery of TeV Emission >100 GeV from RGB J1243+364

RGB J1243+364:

HBL ($v_{\text{sync}} = 16.1$ Hz) at $z > 0.48$
3HSP Catalog figure of merit = 6.31

Fermi-LAT (4FGL J1243.2+3627):

78.6σ
Spectral Index 1.65 ± 0.03
Variability Index 24 (not variable)
2FHL catalog: highest γ -ray at 116 GeV

VERITAS:

72 hours of quality-selected obs. (2009 –2025)
Significance of 5.0σ , 333 γ -rays
Flux (>200 GeV): $(9.8 \pm 2.0) \times 10^{-9} \text{ m}^{-2} \text{ s}^{-1}$
0.4% Crab

Soft spectrum, $\Gamma \approx 4$

Preliminary

Observed Significance for RGB J1243+364

