



Observations of Extra-galactic Transient Phenomenon with LHAASO-WCDA

Shicong Hu

on behalf of LHAASO collaboration

Institute of High Energy Physics (IHEP), CAS

I. Monitoring of selected AGN

- 66 TeV AGN + GeV AGN (3FHL)

[Previous | Next | ADS]

LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae

ATel #16850; Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 8 Oct 2024; 01:23 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

16850 LAST optical observations of the blazar BL Lacertae in bright optical state

16851 Detection of flaring very-high-energy gamma-ray emission from BL Lacertae with the MAGIC telescopes

16855 The blazar BL Lacertae is brightening in optical bands

16855 Swift follow-up observations of BL Lacertae

16854 VERITAS Detection of Gamma-ray Flaring Activity from BL Lacertae

16854 LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae

16849 Fermi-LAT detection of enhanced

Subjects: Gamma Ray, TeV, UHE, AGN, Blazar, Variables

Referred to by ATel #: 16854, 16855, 16856, 16861, 16865

Post

Utilizing the LHAASO-WCDA real-time alert system, here we report the detection of a TeV gamma-ray flare from AGN BL Lacertae. LHAASO-WCDA observed a gamma-ray flux enhancement from the active galactic nuclei BL Lacertae, commencing at MJD 60588.43. By MJD 60588.77, the accumulated significance reached 7.0 standard deviations, with a flux of approximately 0.5 Crab Unit above 1 TeV. We strongly encourage multi-wavelength observation. LHAASO is a multi-purpose Extensive Air Shower (EAS) array designed to detect air showers induced by gamma-rays.

[Previous | Next | ADS]

LHAASO detects variability in VHE gamma-ray emission from the blazar 1ES 1727+502

ATel #16881; Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 29 Oct 2024; 13:47 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

Subjects: Gamma Ray, VHE, AGN, Blazar, Transient

[Previous]

LHAASO detection of renewed TeV activity from the radio galaxy IC 310

ATel #16540; Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 20 Mar 2024; 03:33 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

Subjects: Gamma Ray, TeV, VHE, AGN, Transient

[Previous | Next | ADS]

LHAASO detects TeV Gamma-ray Activity from 1ES 1959+650

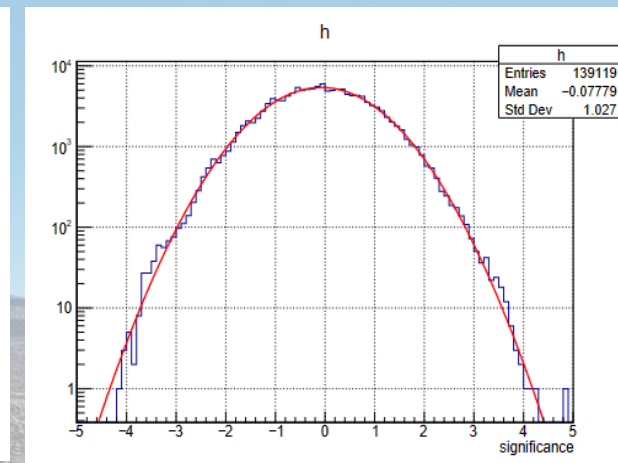
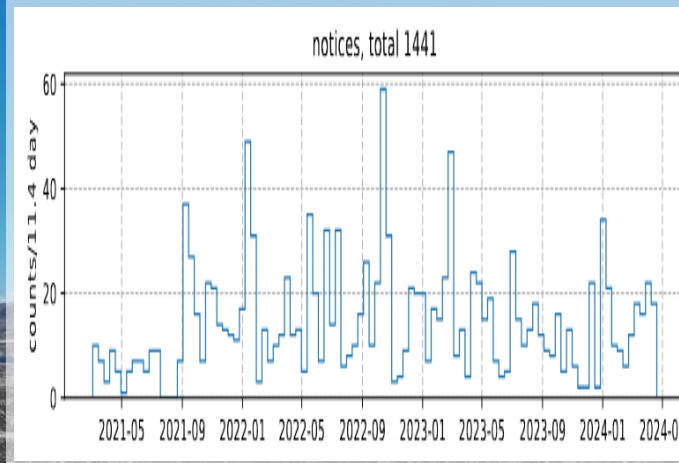
ATel #16437; Guangman Xiang (SHAO), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 9 Feb 2024; 08:30 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

Subjects: Gamma Ray, TeV, VHE, UHE, AGN, Blazar

Referred to by ATel #: 16440, 16456, 16462

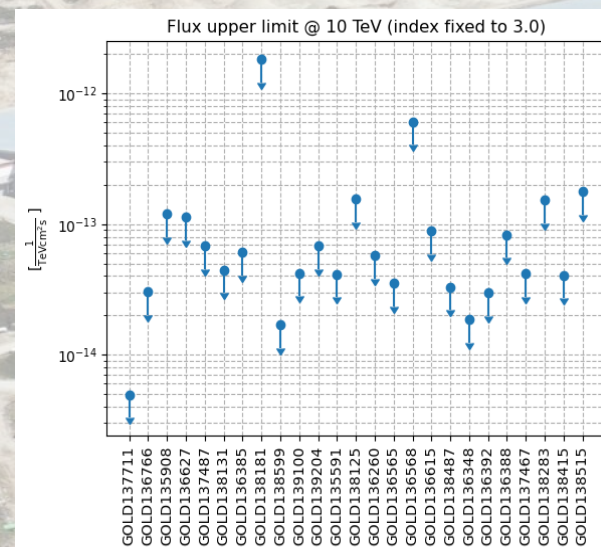
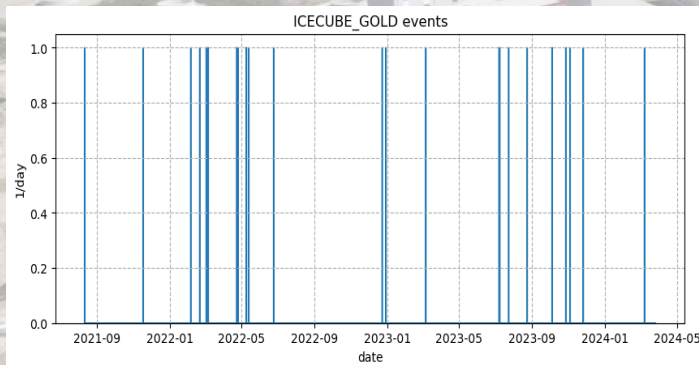
II. GRB follow-up analysis

- 1441 alerts in LHAASO FOV from 202103-202405



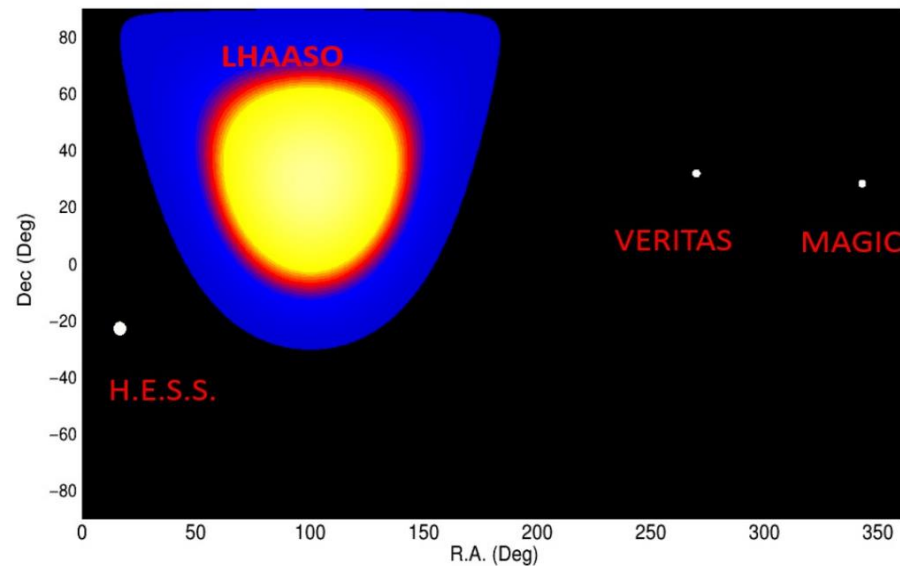
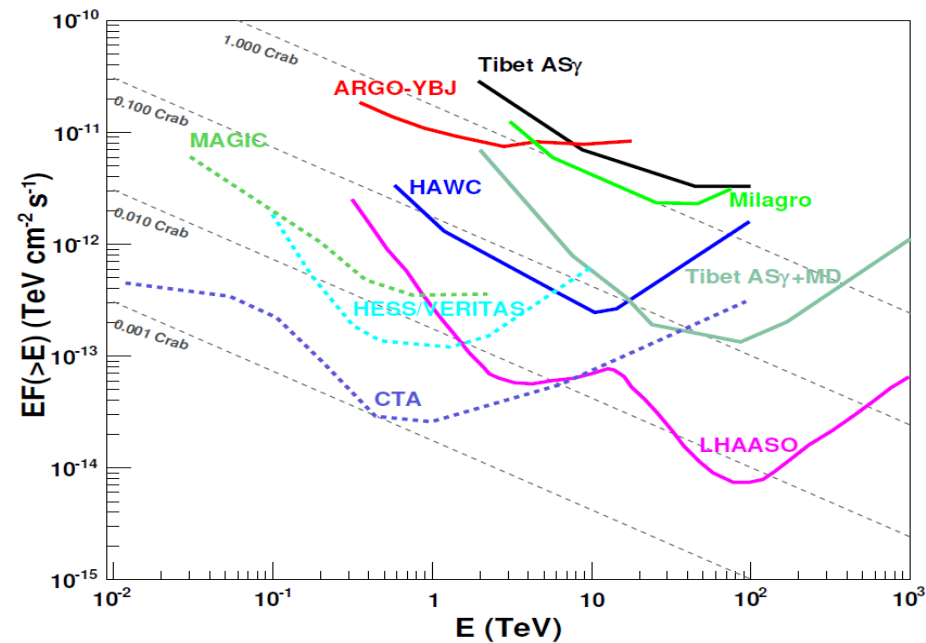
III. Follow-up analysis of the multi-messenger alerts

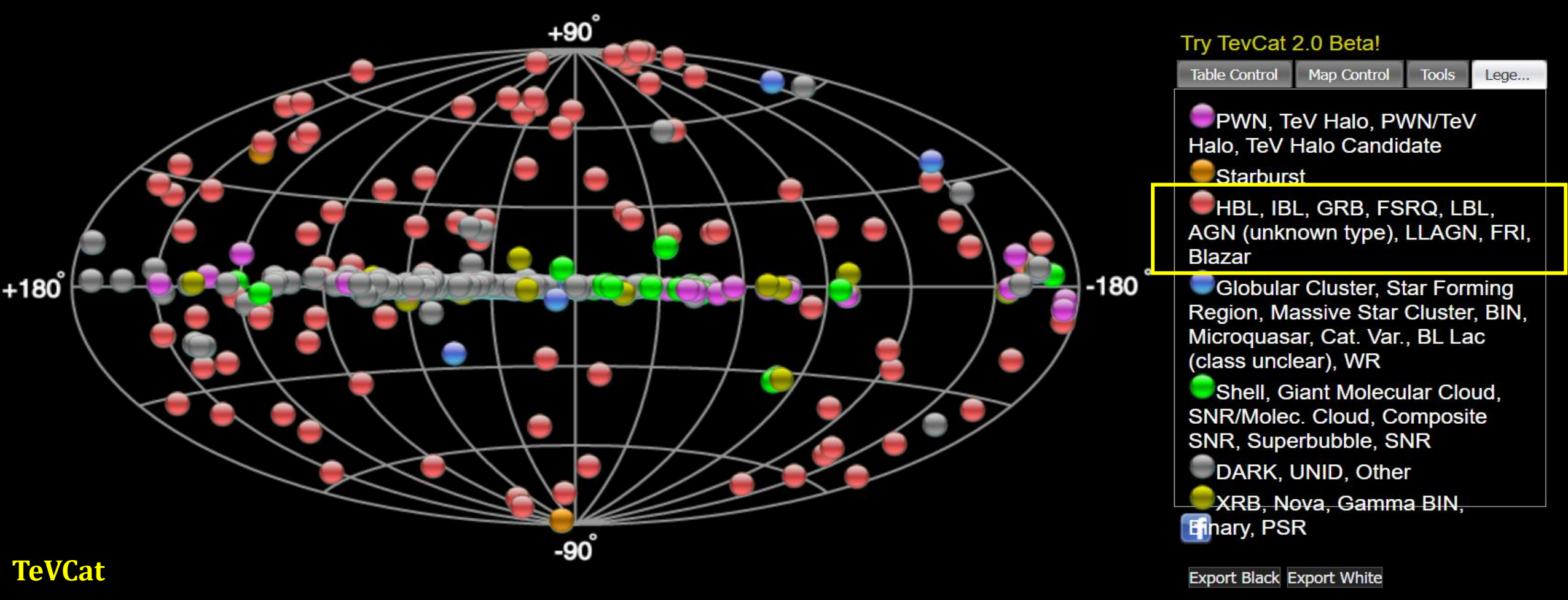
- 25 ICECUBE golden neutrino events
- 1 repeated FRB



LHAASO @ Haizi mountain, 4410m Sichuan Province, China

- **Ground-based detector array**
 - $\sim 100\text{GeV} - \sim 30\text{TeV}$ gamma-ray astronomy
 - Large area : 78000 m^2 , 3120 units
 - Angular resolution: $\sim 0.4^\circ$ @ 1TeV
 - Gamma/Proton discrimination: $Q > 10$
- **High sensitivity**
- Wide field of view: $\sim 2\text{ sr}$
- Duty cycle: $>95\%$
- **Unbiased monitoring**





TeVCat

Blazar: 82

– BL Lac: 2 – FSRQ: 9 – IBL:10
 – Blazar: 4 – HBL: 55 – LBL: 2

BL Lac && RG: 2

– Radio Galaxy: 4

GRB: 5; LLAGN: 1

A real-time monitoring @ selected AGN

➤ Candidates

Continue Flaring	Name	Position (R.A., Dec., 2000)	Sig. max (in sigma)	Position
✓	Markarian521	166. 11. 38. 06	2. 38	4. 0
✓	Markarian581	253. 43. 39. 94	-0. 22	1. 0
✓	W0500	185. 41. 28. 38	1. 31	4. 0
✓	SBL1J001355. 9-185406	3. 66. -18. 96	2. 69	4. 0
✓	1S5003+095	8. 92. 59. 91	0. 97	4. 0
✓	S20109+22	18. 11. 22. 79	3. 51	0. 5
✓	K020136+391	24. 17. 39. 21	0. 80	0. 5
✓	K020152+917	28. 30. 1. 75	1. 33	4. 0
✓	T350210+515	33. 70. 51. 64	0. 55	4. 0
✓	S30218+35	35. 24. 36. 01	0. 38	2. 0
✓	3C06A	35. 72. 43. 06	1. 19	1. 0
✓	MAGICJ0223+003	35. 78. 43. 16	1. 28	0. 5
✓	1S5029+209	38. 23. 20. 22	0. 04	2. 0
✓	1C210	49. 22. 41. 36	1. 65	0. 5
✓	8B09413	50. 05. 18. 76	0. 00	4. 0
✓	NGC1275	69. 78. 41. 51	1. 29	0. 5

TeV: 66
GeV (3FHL): 82

➤ ATel alerts in 2024

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LHAASO detects TeV Gamma-ray Activity from 1ES 1959+650

ATel #16437; *Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 9 Feb 2024; 08:30 UT*

Credential Certification: *Jianeng Zhou (zjn@shao.ac.cn)*

Subjects: Gamma Ray, TeV, VHE, UHE, AGN, Blazar

Referred to by ATel #: 16449, 16456, 16462

9 Feb, 2024

Related
16462 1ES 1959+650: Upper limits from a neutrino search with IceCube
16456 Gamma-ray flaring activity from the blazar 1ES 1959+650 observed by the Fermi-LAT
16449 Strong X-Ray Flare in the TeV-Detected Blazar 1ES 1959+650
16437 LHAASO detects TeV Gamma-ray Activity from 1ES 1959+650

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LHAASO detects rapid variability in TeV Gamma-rays from the galaxy IC 310

ATel #16513; *Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 8 Mar 2024; 03:15 UT*

Distributed as an Instant Email Notice Transients
Credential Certification: *Zhiguo Yao (zhiguo.yao@outlook.com)*

Subjects: TeV, VHE, AGN, Transient

Referred to by ATel #: 16535, 16540

8 Mar, 2024

Related
16540 LHAASO detection of renewed TeV activity from the radio galaxy IC 310
16535 VERITAS Detection of Elevated VHE Emission from IC 310
16513 LHAASO detects rapid variability in TeV Gamma-rays from the galaxy IC 310

[Previous]

LHAASO detection of renewed TeV activity from the radio galaxy IC 310

ATel #16540; *Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 20 Mar 2024; 03:23 UT*

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20 Mar, 2024

Related
LHAASO detection of renewed TeV activity from the radio galaxy IC 310
16535 VERITAS Detection of Elevated VHE Emission from IC 310
16513 LHAASO detects rapid variability in TeV Gamma-rays from the galaxy IC 310

LHAASO detects TeV Gamma-ray Activity from Markarian 501

ATel #16625; *Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 18 May 2024; 09:43 UT*

Credential Certification: *Jianeng Zhou (zjn@shao.ac.cn)*

Subjects: Gamma Ray, TeV, AGN, Blazar

18 May, 2024

[Previous | Next | ADS]

LHAASO detects variability in VHE gamma-ray emission from the blazar 1ES 1727+502

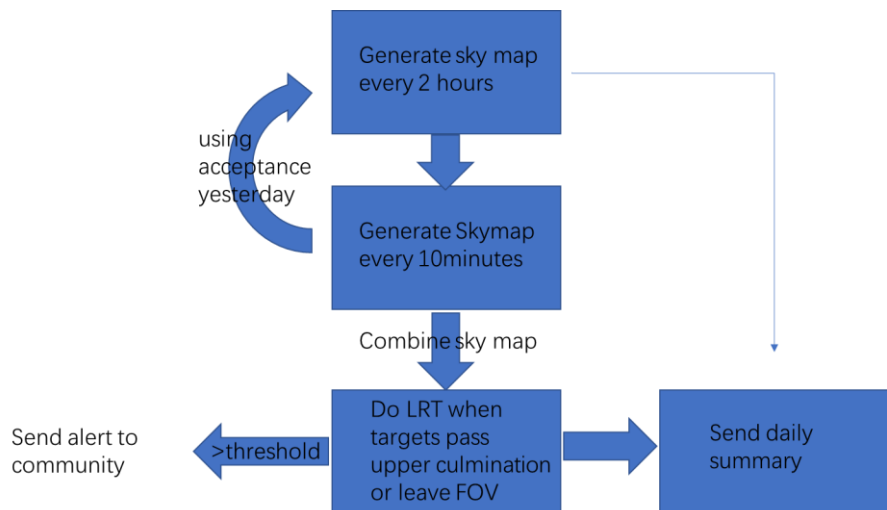
ATel #16881; *Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 29 Oct 2024; 13:47 UT*

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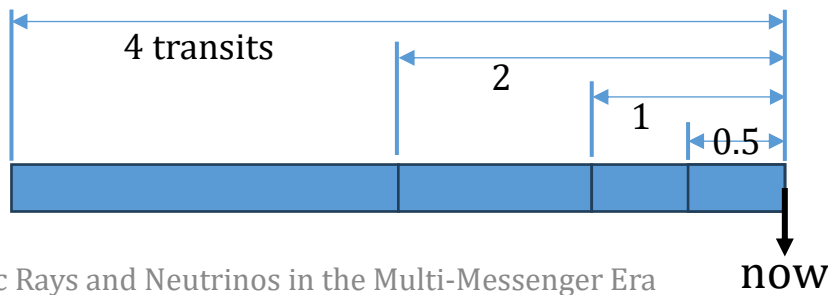
Subjects: Gamma Ray, VHE, AGN, Blazar, Transient

29 Oct, 2024

➤ Workflow



12/9/2024



Cosmic Rays and Neutrinos in the Multi-Messenger Era

G.M. Xiang, M. Zha, et.al., RAA
DOI:10.1088/1674-4527/ad8b0d

A real-time monitoring @ selected AGN

➤ ATel alert in 10/08 2024: Rapid Variability of BL Lac

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LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae

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on 8 Oct 2024; 01:23 UT
Credential Certification: *Jianeng Zhou (zjn@shao.ac.cn)*

Subjects: Gamma Ray, TeV, UHE, AGN, Blazar, Variables

Referred to by ATel #: [16854](#), [16855](#), [16856](#), [16861](#), [16865](#), [16890](#)

✕ Post

Utilizing the LHAASO-WCDA real-time alert system, here we report the detection of a TeV gamma-ray flare from AGN BL Lacertae. LHAASO-WCDA observed a gamma-ray flux enhancement from the active galactic nuclei BL Lacertae, commencing at MJD 60588.43. By MJD 60588.77, the accumulated significance reached 7.0 standard deviations, with a flux of approximately 0.5 Crab Unit above 1 TeV. We strongly encourage multi-wavelength observation. LHAASO is a multi-purpose Extensive Air Shower (EAS) array designed to detect air showers induced by gamma-rays.

Related

- [16890](#) BL Lacertae gamma-ray flare: Upper limits from a neutrino search with IceCube
- [16865](#) LAST optical observations of the blazar BL Lacertae in bright optical state
- [16861](#) Detection of flaring very-high-energy gamma-ray emission from BL Lacertae with the MAGIC telescopes
- [16856](#) The blazar BL Lacertae is brightening in Optical bands
- [16855](#) Swift follow-up observations of BL Lacertae
- [16854](#) VERITAS Detection of Gamma-ray Flaring Activity from BL Lacertae
- [16850](#) LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae
- [16849](#) Fermi-LAT detection of enhanced gamma-ray activity from the blazar BL Lacertae

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16890 BL Lacertae gamma-ray flare: Upper limits from a neutrino search with IceCube	Neutrino
16865 LAST optical observations of the blazar BL Lacertae in bright optical state	Optical
16861 Detection of flaring very-high-energy gamma-ray emission from BL Lacertae with the MAGIC telescopes	MAGIC
16856 The blazar BL Lacertae is brightening in Optical bands	Optical
16855 Swift follow-up observations of BL Lacertae	Swift
16854 VERITAS Detection of Gamma-ray Flaring Activity from BL Lacertae	VERITAS
16850 LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae	LHAASO
16849 Fermi-LAT detection of enhanced gamma-ray activity from the blazar BL Lacertae	Fermi-LAT

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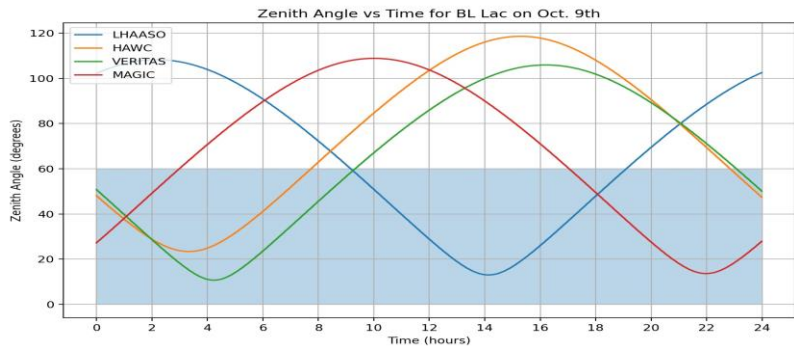
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ATel #	Related	Instrument
16890	BL Lacertae gamma-ray flare: Upper limits from a neutrino search with IceCube	Neutrino
16865	LAST optical observations of the blazar BL Lacertae in bright optical state	Optical
16861	Detection of flaring very-high-energy gamma-ray emission from BL Lacertae with the MAGIC telescopes	MAGIC
16856	The blazar BL Lacertae is brightening in Optical bands	Optical
16855	Swift follow-up observations of BL Lacertae	Swift
16854	VERITAS Detection of Gamma-ray Flaring Activity from BL Lacertae	VERITAS
16850	LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae	LHAASO
16849	Fermi-LAT detection of enhanced gamma-ray activity from the blazar BL Lacertae	Fermi-LAT

More effective alerts to the community

A real-time monitoring @ selected AGN

➤ ATel alert in 10/08 2024: Rapid Variability of BL Lac

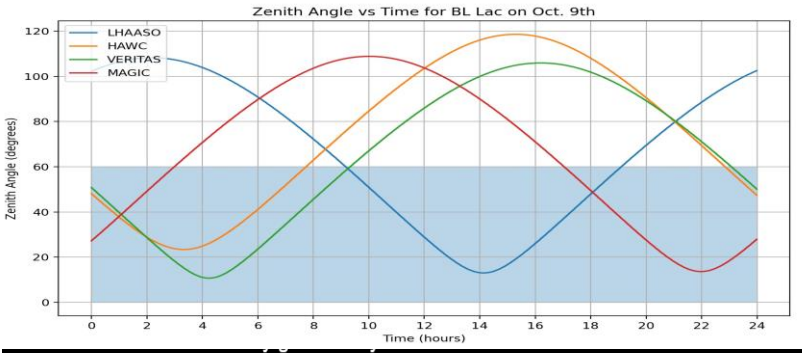
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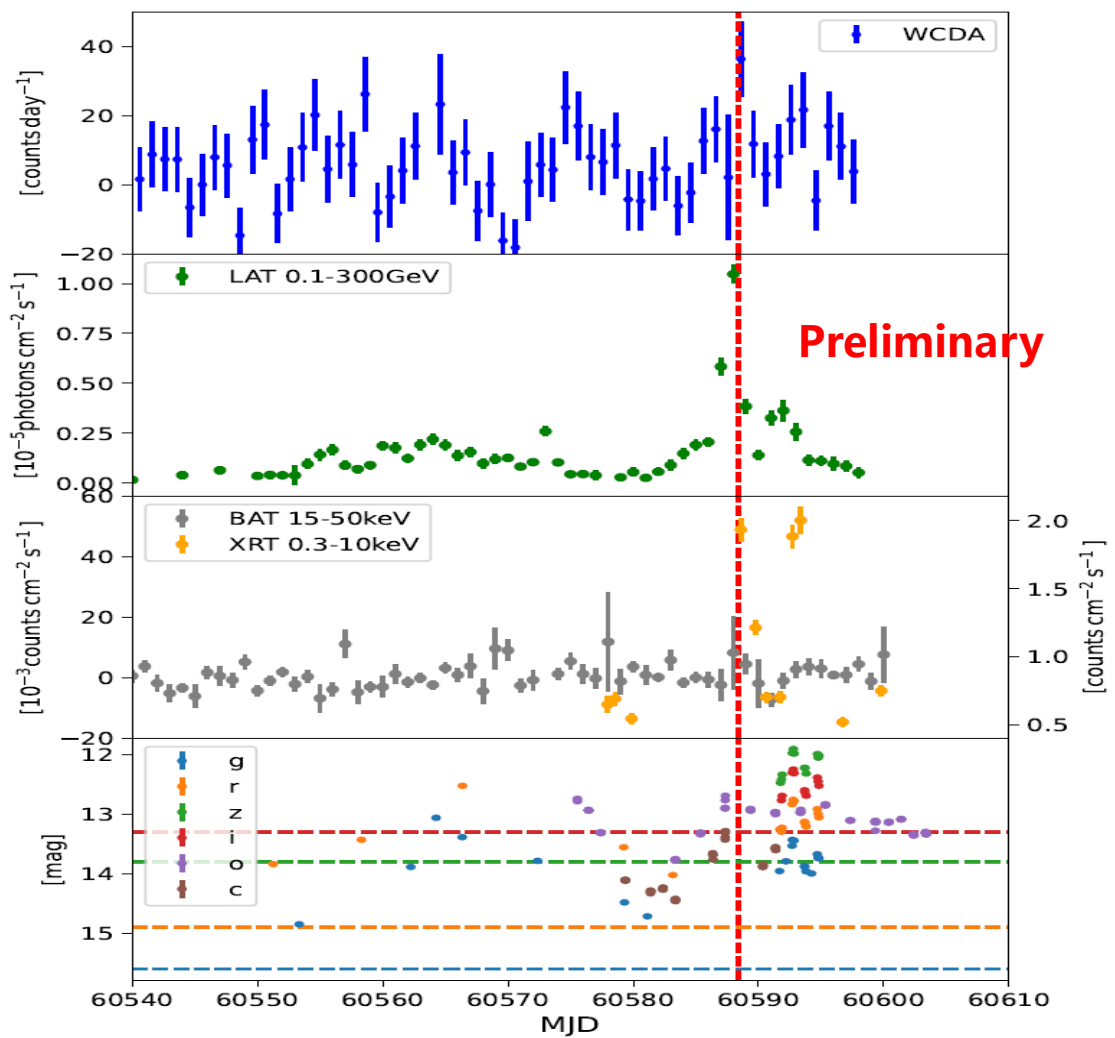
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Related

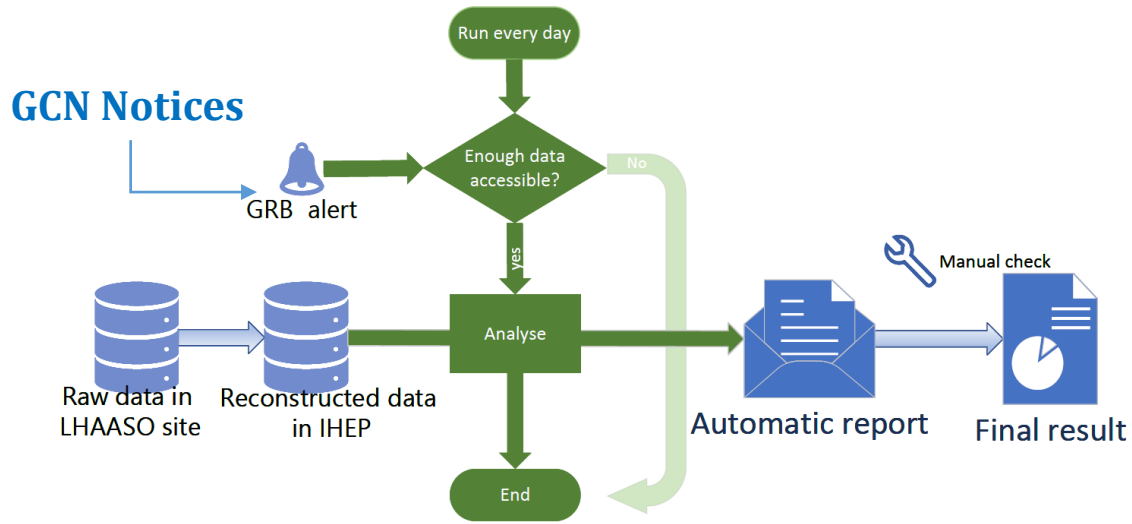
- 16890 BL Lacertae gamma-ray flare: Upper limits from a neutrino search with IceCube **Neutrino**
- 16865 LAST optical observations of the blazar BL Lacertae in bright optical state **Optical**
- 16861 Detection of flaring very-high-energy gamma-ray emission from BL Lacertae with the MAGIC telescopes **MAGIC**
- 16856 The blazar BL Lacertae is brightening in Optical bands **Optical**
- 16855 Swift follow-up observations of BL Lacertae **Swift**
- 16854 VERITAS Detection of Gamma-ray Flaring Activity from BL Lacertae **VERITAS**
- 16850 LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae **LHAASO**
- 16849 Fermi-LAT detection of enhanced gamma-ray activity from the blazar BL Lacertae **Fermi-LAT**



More effective alerts to the community

GRB follow-up analysis @ trigger data

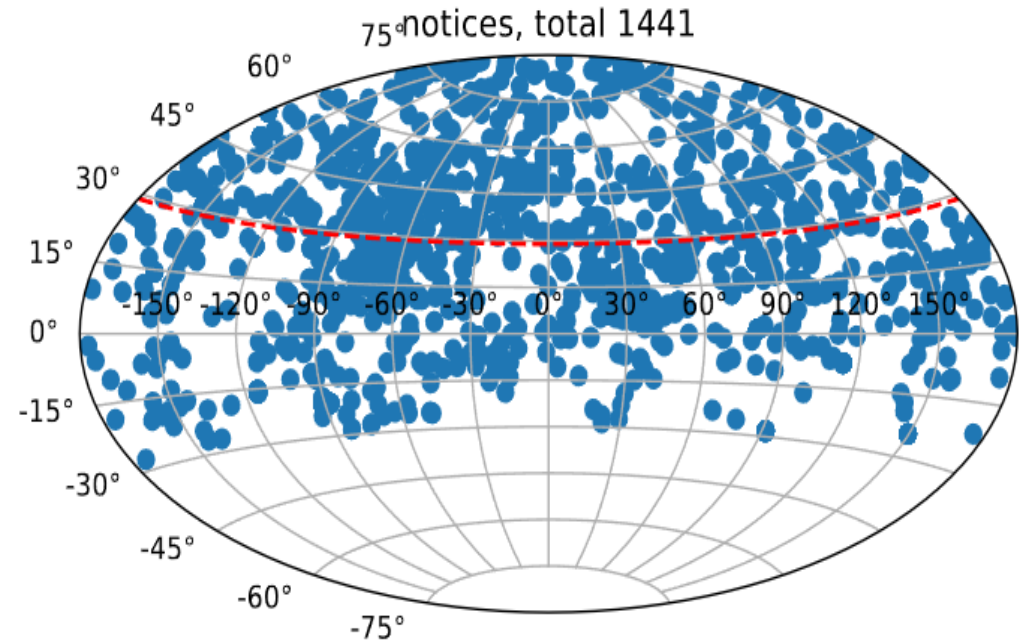
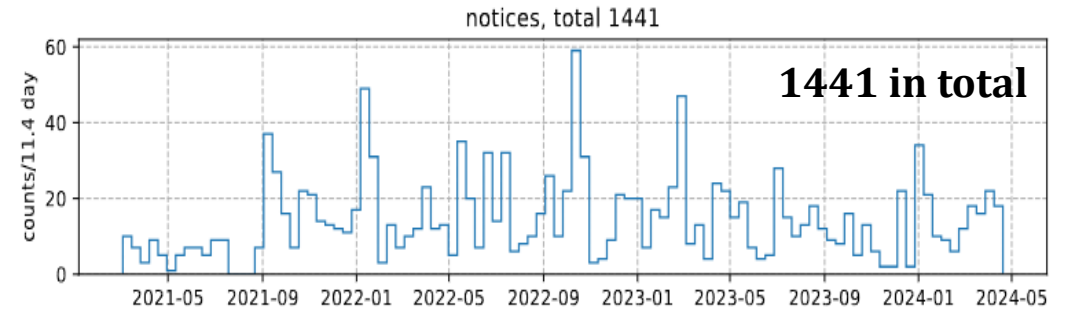
➤ Workflow



Short time scale searching
 T_{range} : -64 sec \rightarrow 64 sec
 T_{width} : $2^{-3}, 2^{-2}, \dots, 2^5$ sec
 half sliding

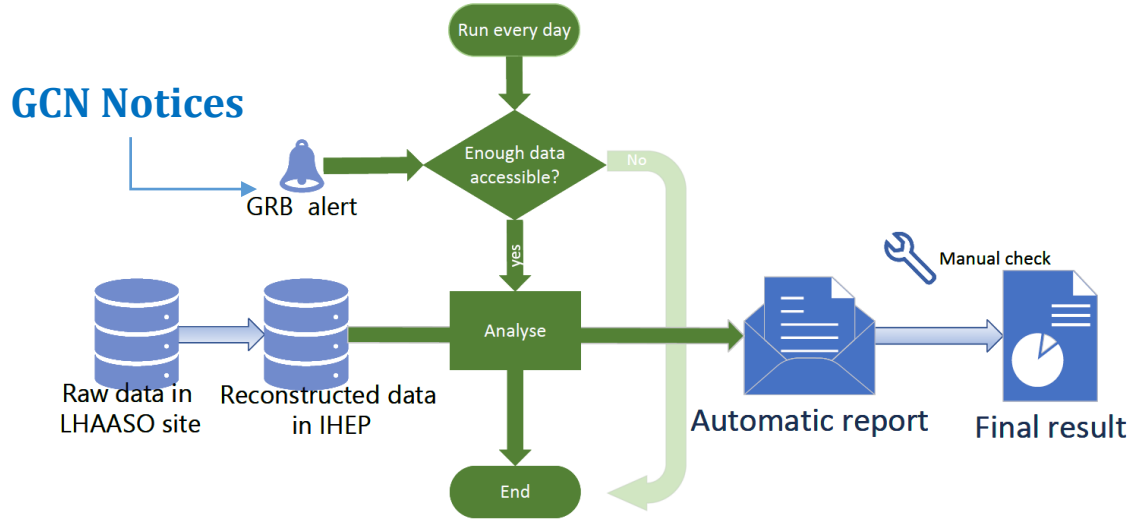
Long time scale searching
 T_{range} : $T_0 \rightarrow$ out of FOV
 T_{width} : $2^6, 2^7, \dots, 2^{15}$ sec
 half sliding

➤ Trigger time and spatial position of the GRBs



GRB follow-up analysis @ trigger data

➤ Workflow

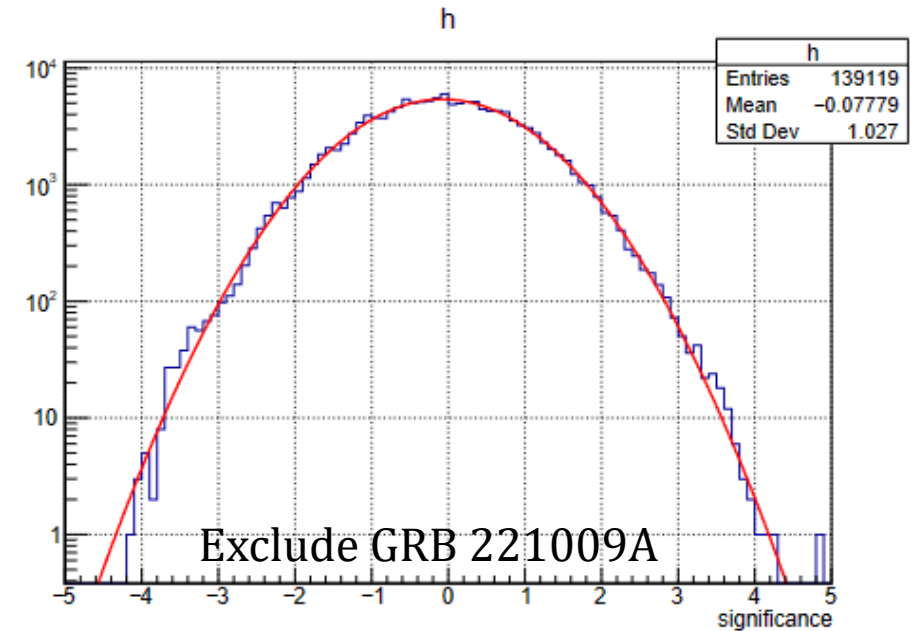
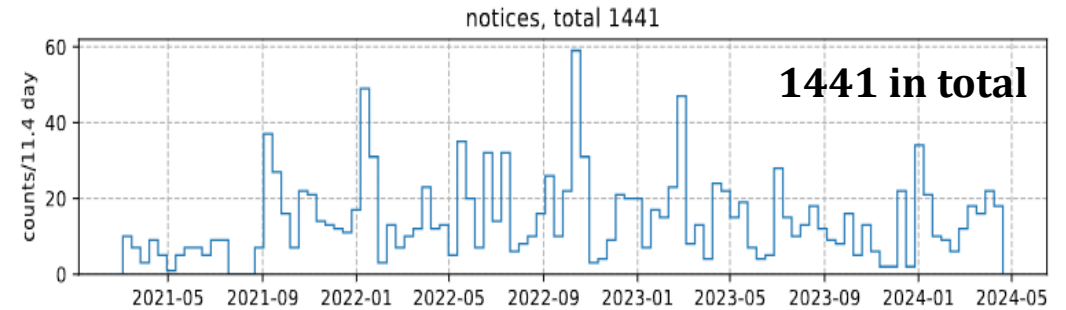


Short time scale searching
 T_{range} : -64 sec \rightarrow 64 sec
 T_{width} : $2^{-3}, 2^{-2}, \dots, 2^5$ sec
 half sliding

Long time scale searching
 T_{range} : $T_0 \rightarrow$ out of FOV
 T_{width} : $2^6, 2^7, \dots, 2^{15}$ sec
 half sliding

➤ No significant signal detected from 2021/03-2024/05 except GRB 221009A.

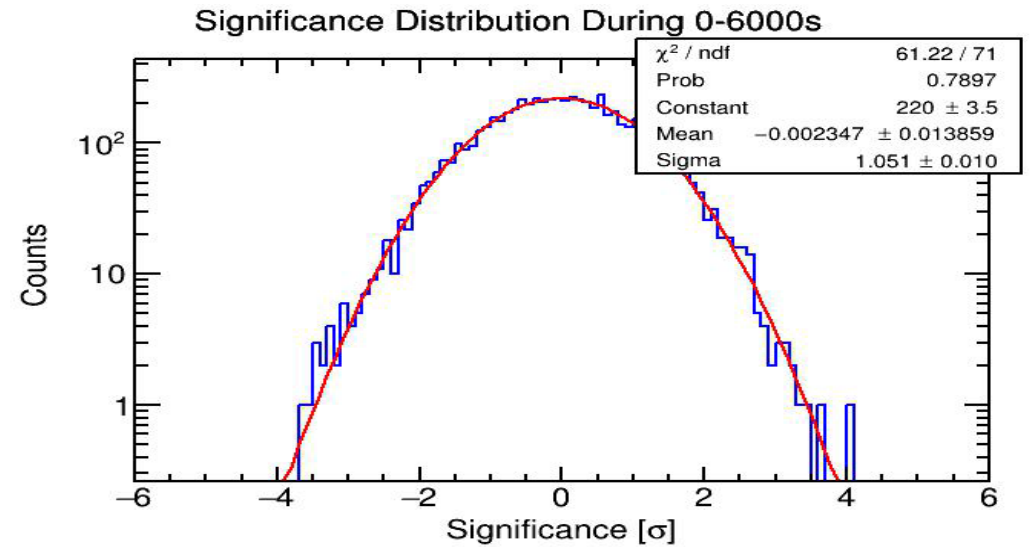
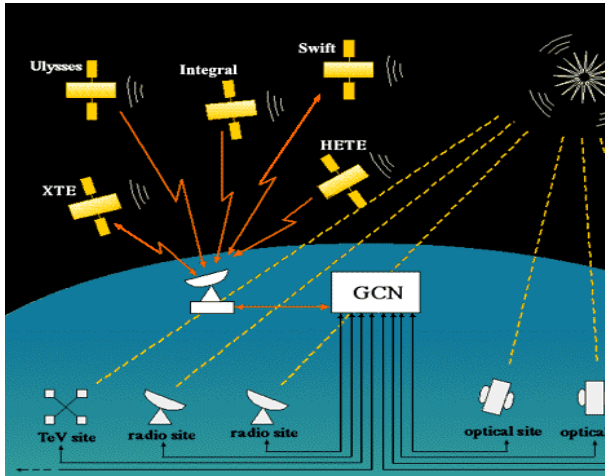
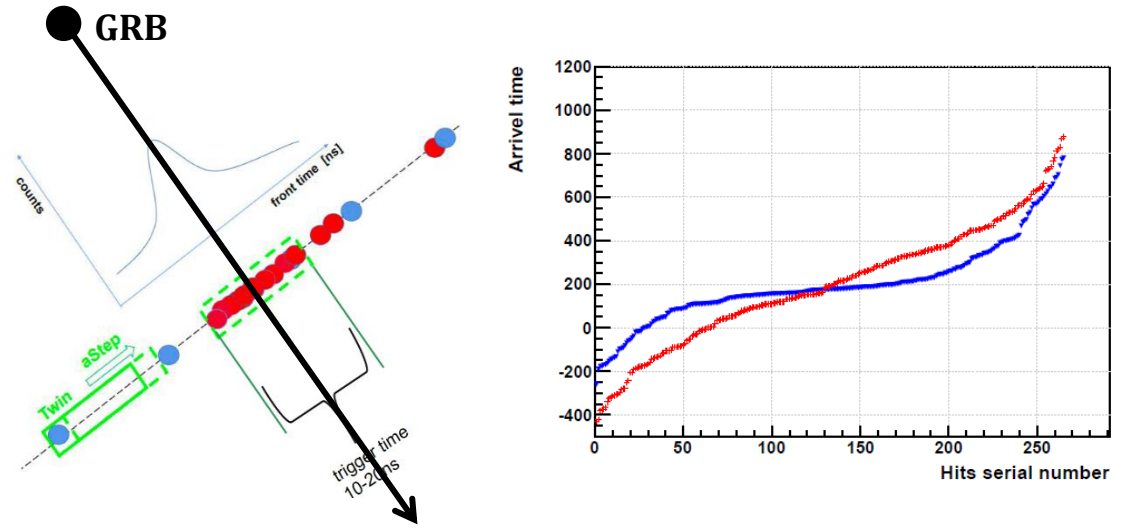
➤ Trigger time and spatial position of the GRBs



GRB follow-up analysis @ triggerless data

➤ Touching low energy band

1. Receive a GCN alert inside LHAASO FOV
 - Alert rate: 2.5/week
2. ToO: Save (T0-0.5 h, T0 + 2 h) hours of data
 - (N_{pe}, T) of 3120 detector units
 - Big data size → 7 TB/alert
3. Analyze using plateau-finding method



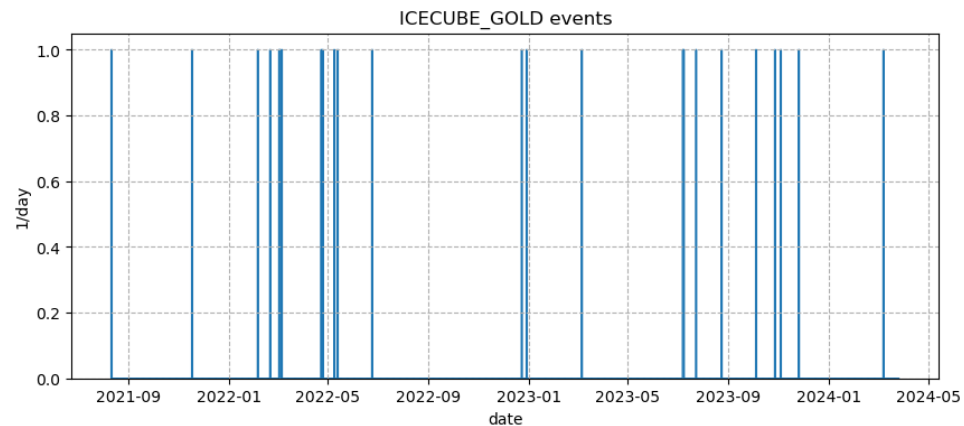
Neutrino events follow-up analysis

- Search for gamma-ray emission associated with ICECUBE GOLD neutrino events

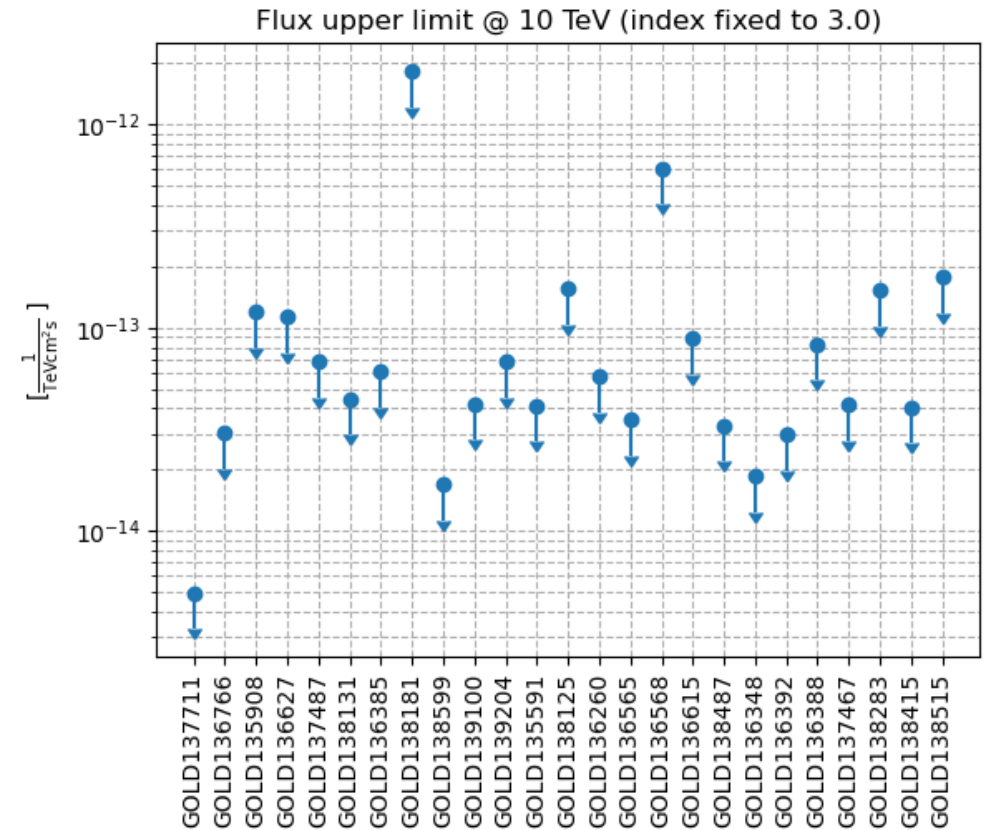
AMON ICECUBE_GOLD and _BRONZE Event Information

ID	Year	Month	Day	Time	Category	RA	DEC	RA Err	DEC Err	RA Err	DEC Err	RA Err	DEC Err	RA Err	DEC Err	RA Err	DEC Err	RA Err	DEC Err	RA Err	DEC Err	Description
139315_50057906	1	24/04/24	01:49:26.00		GOLD	327.0799	+3.0600	96.89	54.60	1.9235e+02	5.0816e-01	1.2243										IceCube Gold event. The position error is statistical only, there is no systematic added.
139315_50057906	0	24/04/24	01:49:26.00		GOLD	326.5299	+3.1619	76.22	29.69	1.9235e+02	5.0816e-01	1.2243										IceCube Gold event. The position error is statistical only, there is no systematic added.
139303_27647445	1	24/04/19	23:25:41.04		BRONZE	73.1700	+1.6399	130.49	77.54	1.2084e+02	3.1477e-01	3.4261										IceCube Bronze event. The position error is statistical only, there is no systematic added.
139303_27647445	0	24/04/19	23:25:41.04		BRONZE	74.1535	+1.0796	55.67	21.68	1.2084e+02	3.1477e-01	3.4261										IceCube Bronze event. The position error is statistical only, there is no systematic added.
139279_10803235	1	24/04/12	05:33:46.89		BRONZE	102.4399	+6.3499	42.29	26.70	1.2126e+02	3.0910e-01	3.4096										IceCube Bronze event. The position error is statistical only, there is no systematic added.
139279_10803235	0	24/04/12	05:33:46.89		BRONZE	103.7861	+5.8716	69.22	26.96	1.2126e+02	3.0910e-01	3.4096										IceCube Bronze event. The position error is statistical only, there is no systematic added.
139204_39158985	2	24/03/27	11:04:49.92		GOLD	25.3999	+7.7800	257.99	68.99	1.9966e+02	5.3864e-01	1.0306										IceCube Gold event. The position error is statistical only, there is no systematic added.
139205_9784024	1	24/03/27	16:12:30.47		BRONZE	89.2099	+0.9300	84.15	46.34	1.5269e+02	3.7111e-01	2.4194										IceCube Bronze event. The position error is statistical only, there is no systematic added.
139204_39158985	1	24/03/27	13:44:38.00		GOLD	25.3999	+7.7800	257.99	68.99	1.9966e+02	5.3864e-01	1.0306										IceCube Gold event. The position error is statistical only, there is no systematic added.

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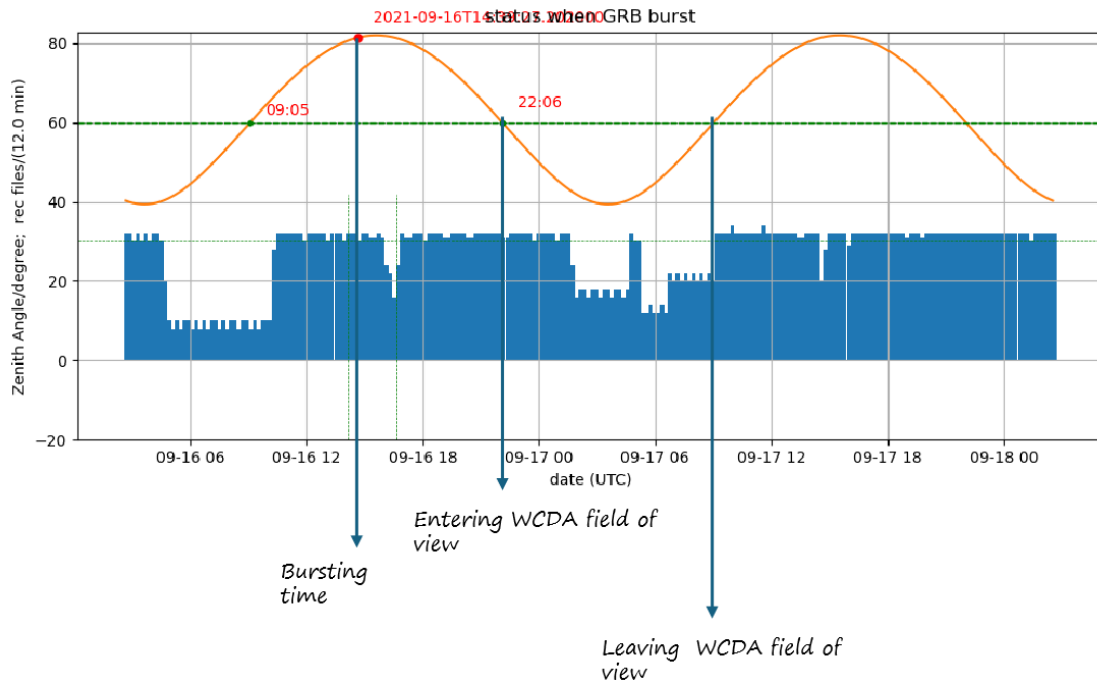


- Search for signals using one-transit data after the arrival time of each neutrino event

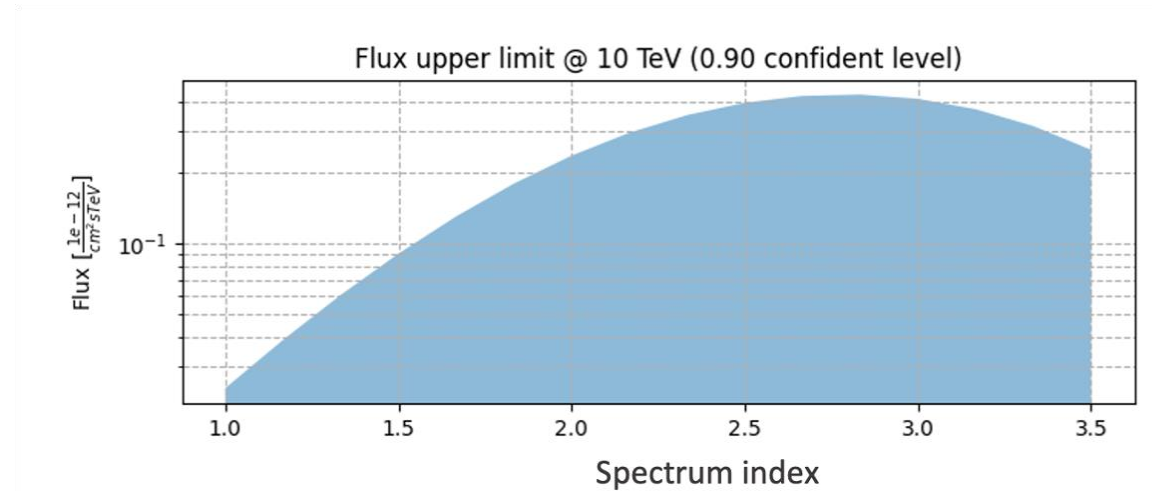
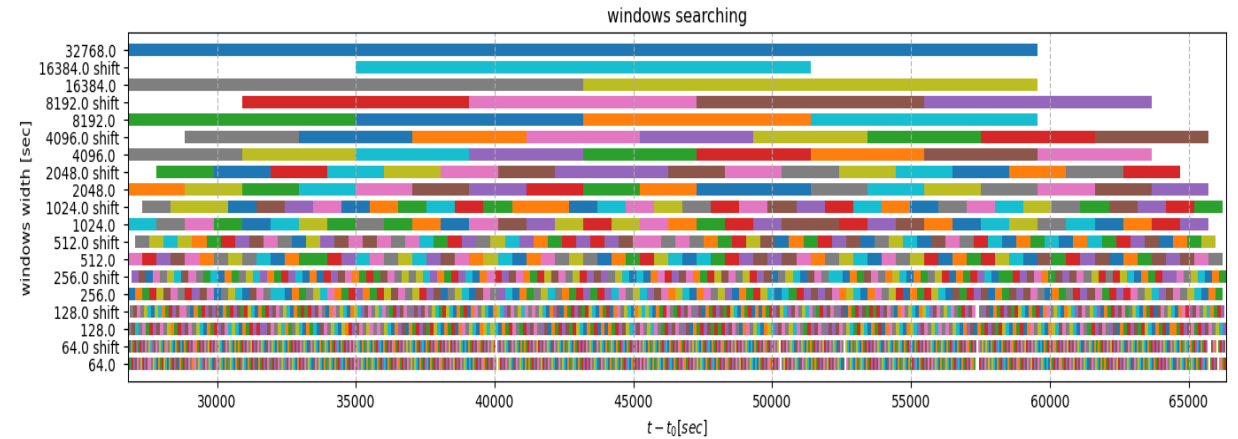


FRB follow-up analysis

- Repeated FRB 20200120E @ M81
 - Searching for TeV gamma-ray signals of its 20210916 burst



- **No significant signal detected**



I. Monitoring of selected AGN

- 66 TeV AGN + GeV AGN (3FHL)
- 6 alerts in 2024

[Previous | Next | ADS]

LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae

ATel #16850; Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 8 Oct 2024; 01:23 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

16850 LAST optical observations of the blazar BL Lacertae in bright optical state

16851 Detection of flaring very-high-energy gamma-ray emission from BL Lacertae with the MAGIC telescopes

16855 The blazar BL Lacertae is brightening in Optical bands

16855 Swift follow-up observations of BL Lacertae

16854 VERITAS Detection of Gamma-ray Flaring Activity from BL Lacertae

16853 LHAASO detects rapid variability of the TeV Gamma-ray Activity of BL Lacertae

16849 Fermi-LAT detection of enhanced

Utilizing the LHAASO-WCDA real-time alert system, here we report the detection of a TeV gamma-ray flare from AGN BL Lacertae. LHAASO-WCDA observed a gamma-ray flux enhancement from the active galactic nuclei BL Lacertae, commencing at MJD 60588.43. By MJD 60588.77, the accumulated significance reached 7.0 standard deviations, with a flux of approximately 0.5 Crab Unit above 1 TeV. We strongly encourage multi-wavelength observation. LHAASO is a multi-purpose Extensive Air Shower (EAS) array designed to detect air showers induced by gamma-rays.

Subjects: Gamma Ray, TeV, UHE, AGN, Blazar, Variables

Referred to by ATel #: 16854, 16855, 16856, 16861, 16865

Post

[Previous | Next | ADS]

LHAASO detects variability in VHE gamma-ray emission from the blazar 1ES 1727+502

ATel #16881; Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 29 Oct 2024; 13:47 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

Subjects: Gamma Ray, VHE, AGN, Blazar, Transient

[Previous]

LHAASO detection of renewed TeV activity from the radio galaxy IC 310

ATel #16540; Guangman Xiang (SHAO, IHEP), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 20 Mar 2024; 03:33 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

Subjects: Gamma Ray, TeV, VHE, AGN, Transient

[Previous | Next | ADS]

LHAASO detects TeV Gamma-ray Activity from 1ES 1959+650

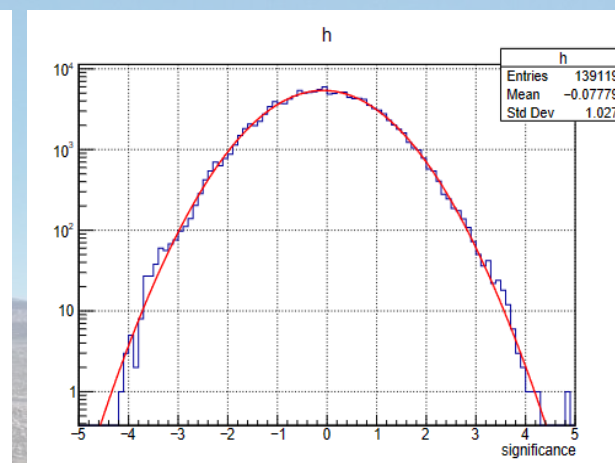
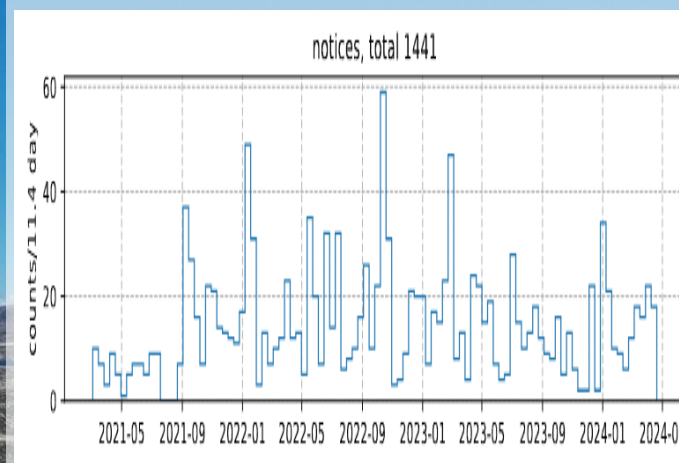
ATel #16437; Guangman Xiang (SHAO), Min Zha (IHEP), Zhiguo Yao (IHEP), Jianeng Zhou (SHAO) and Yi Xing (SHAO) report on behalf of the LHAASO Collaboration on 9 Feb 2024; 08:30 UT
 Credential Certification: Jianeng Zhou (zjn@shao.ac.cn)

Subjects: Gamma Ray, TeV, VHE, UHE, AGN, Blazar

Referred to by ATel #: 16440, 16456, 16462

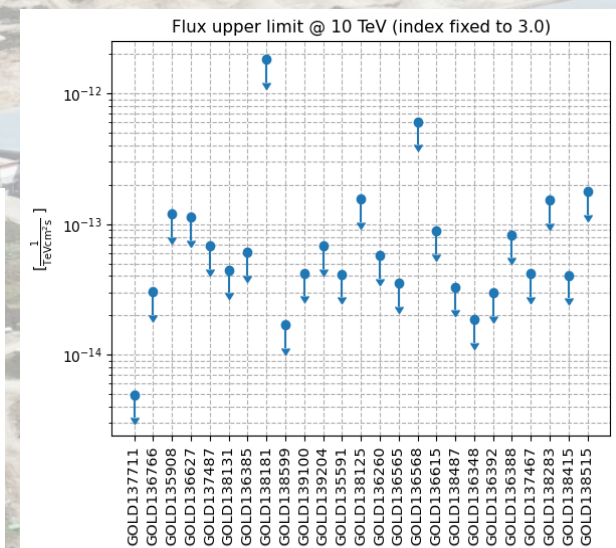
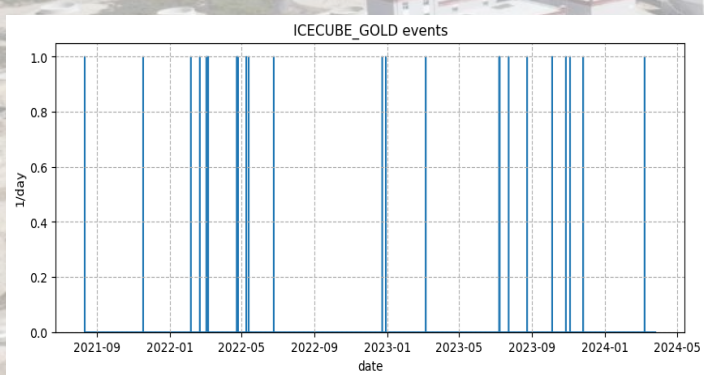
II. GRB follow-up analysis

- 1441 alerts in total in LHAASO FOV from 202103-202405
- No significant excess detected except GRB 221009A



III. Follow-up analysis of the multi-messenger alerts

- 25 ICECUBE golden neutrino events
- Energy flux upper limits: ~1.e-9 erg/cm^2/s @ 0.3-10 TeV
- 1 repeated FRB



IV. Outlook

- Monitoring system
 - Release daily excess light curve in real time
- Blind search in multiple time scale
 - Arxiv data
 - Real-time analysis
- Follow-up of the multi-messenger alerts
 - GW EM-counterpart
 - UHE cosmic ray
 - Supernova (SN) at nearby galaxy

GRB 221009A

```
////////////////////////////////////  
TITLE:   GCN CIRCULAR  
NUMBER:  32677  
SUBJECT: LHAASO observed GRB 221009A with more than 5000 VHE photons up to around 18 TeV  
DATE:    22/10/11 09:21:54 GMT  
FROM:    Judith Racusin at GSFC <judith.racusin@nasa.gov>
```

Yong Huang, Shicong Hu, Songzhan Chen, Min Zha, Cheng Liu, Zhiguo Yao and Zhen Cao report on behalf of the LHAASO experiment

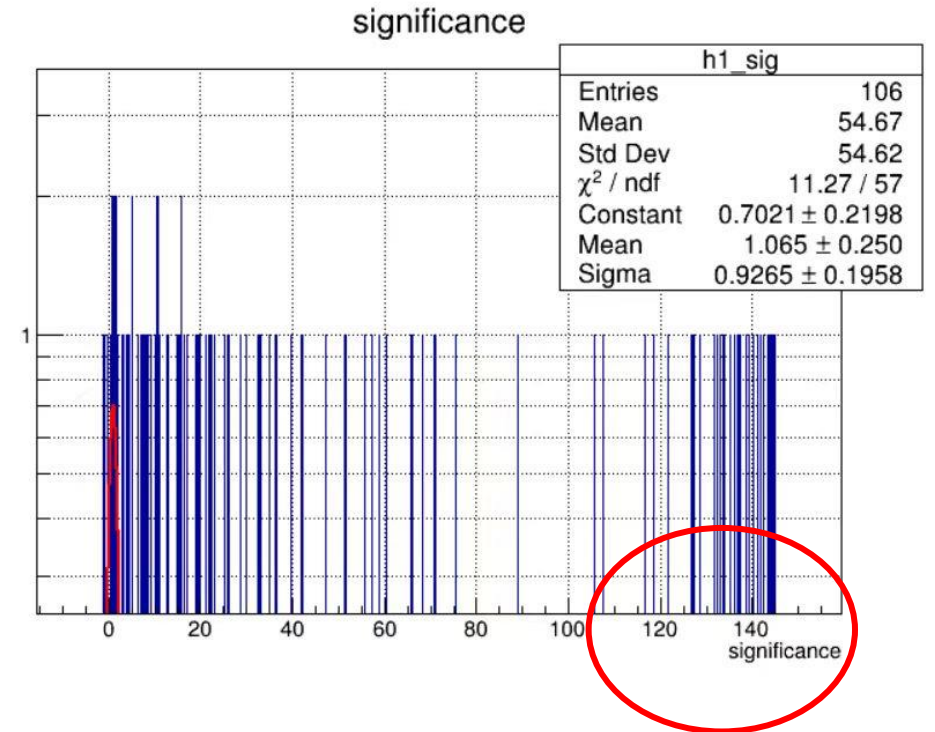
We report the observation of GRB 221009A, which was detected by Swift (Kennea et al. GCN #32635), Fermi-GBM (Veres et al. GCN #32636, Lesage et al. GCN #32642), Fermi-LAT (Bissaldi et al. GCN #32637), IPN (Svinkin et al. GCN #32641) and so on.

GRB 221009A is detected by LHAASO-WCDA at energy above 500 GeV, centered at RA = 288.3, Dec = 19.7 within 2000 seconds after T₀, with the significance above 100 s.d., and is observed as well by LHAASO-KM2A with the significance about 10 s.d., where the energy of the highest photon reaches 18 TeV.

This represents the first detection of photons above 10 TeV from GRBs.

The LHAASO is a multi-purpose experiment for gamma-ray astronomy (in the energy band between 10¹¹ and 10¹⁵ eV) and cosmic ray measurements.

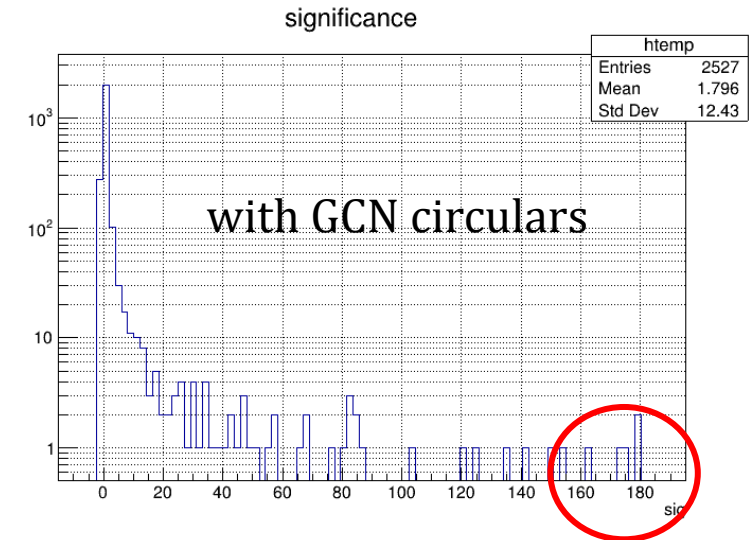
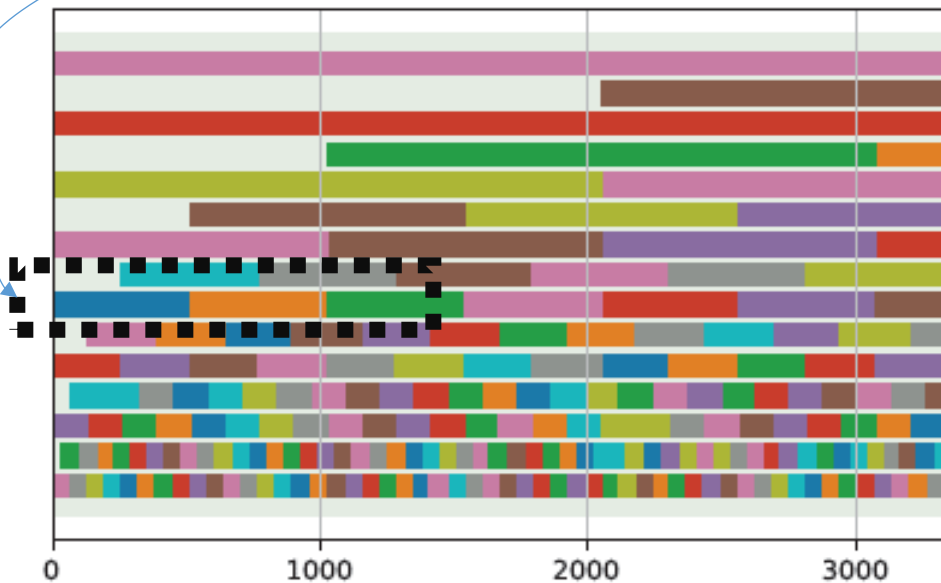
In October 2022, after a delay of approximately **36 hours**, GRB 221009A was detected with a significance exceeding **~143**. On October 11, the observation results were published via **GCN Circulars** by the LHAASO collaboration.



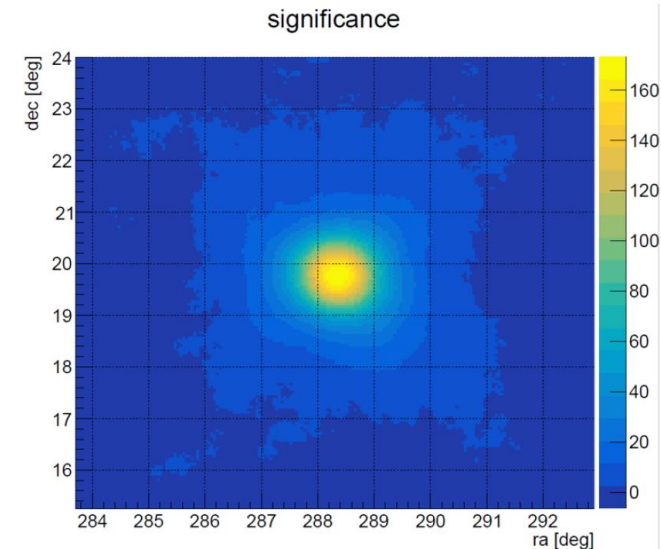
Y. Huang et al., GRB Coordinates Network 32677, 1 (2022), <https://ui.adsabs.harvard.edu/abs/2022GCN.32677....1H>.

GRB 221009A

- Pre-trial significance: 179
- Post-trial significance: 179
- $239 < \text{Trial number} < 2527$
- Most significant time window: 0 sec \rightarrow 1024 sec

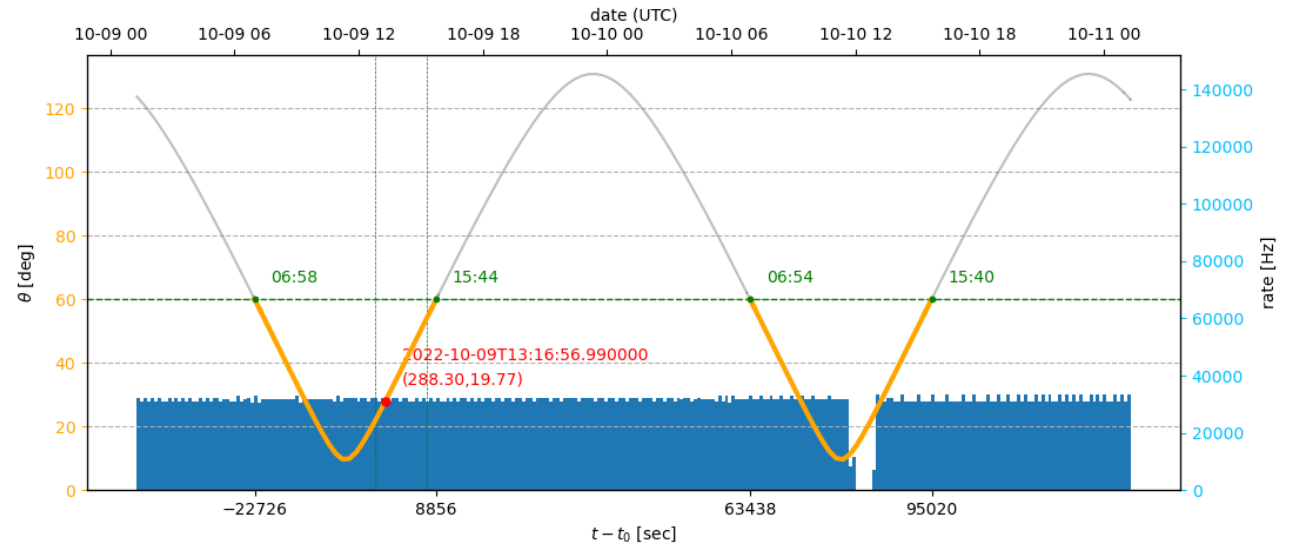
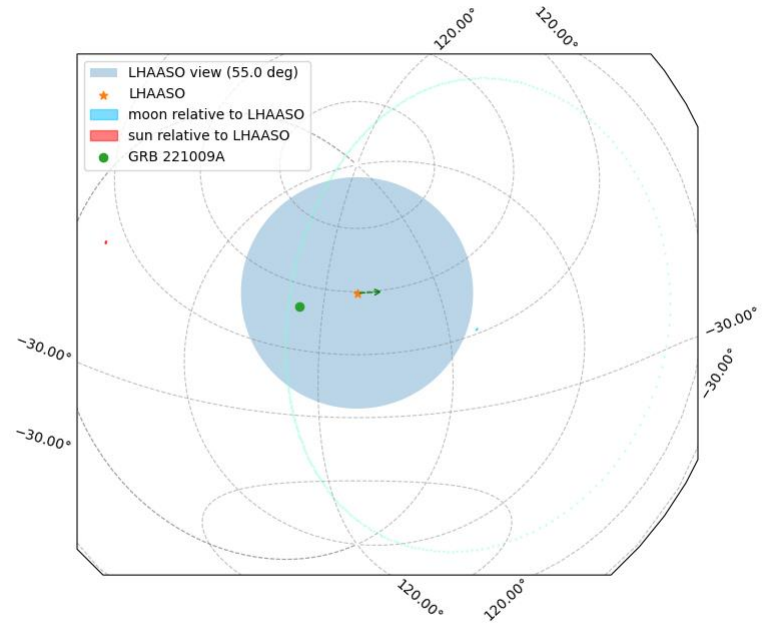


The currently upgraded monitoring system can detect bursts with a significance exceeding 179 times



GRB 221009A

2022-10-09T13:16:59.990 (UTC), ICRS



The detector is operating stably, and the observation field is in good condition