

Fermi-LAT detection of a flaring blazar inside the error region of IceCube-170922A

Yasuyuki Tanaka (Hiroshima University)

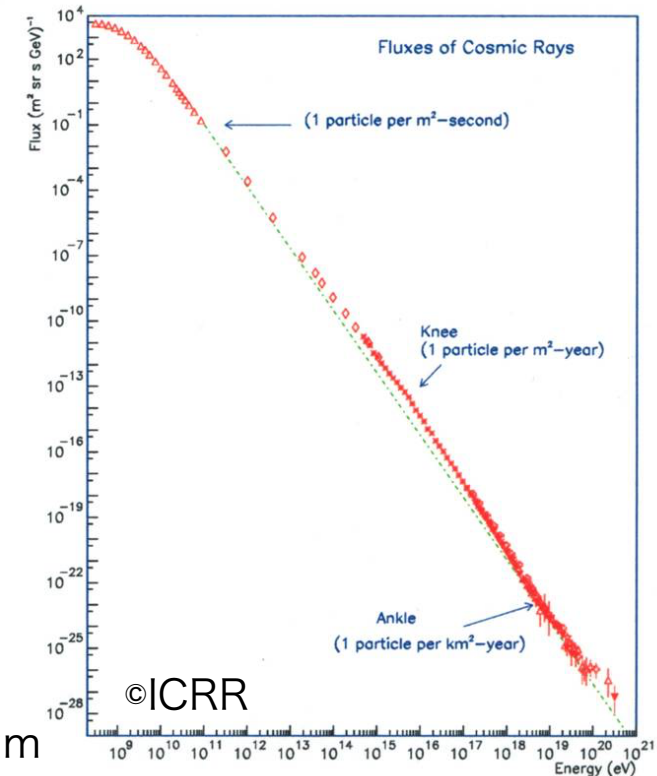
Outline

- **Motivation: why we perform IceCube follow-up**
- Current status of Fermi Gamma-ray Space Telescope
- Fermi-LAT detection of a flaring blazar, TXS 0506+056, inside the error region of IceCube-170922A
- Multi-wavelength light curves and SED of TXS 0506+056
- Summary

Motivation: Understanding the origin of cosmic rays



Radiation measure experiment by Hess



Cosmic-ray spectrum
measured on the Earth

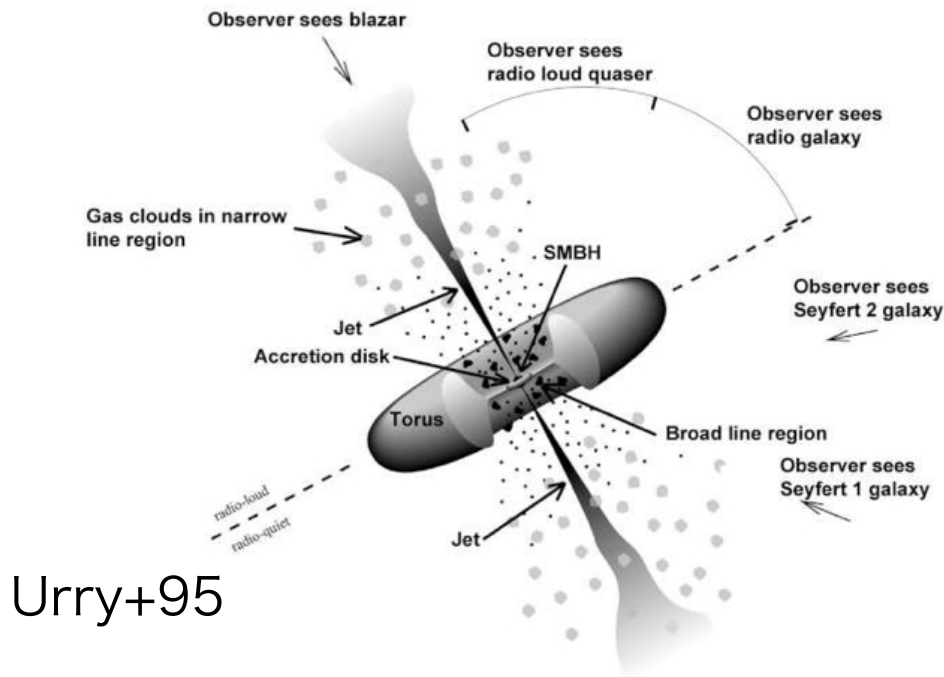
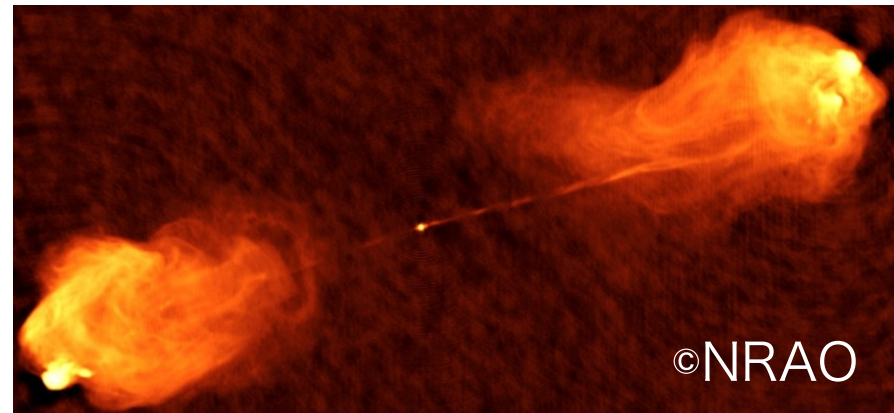
- Highest-energy cosmic rays reach 10^{20} eV and the spectrum is represented by power-law shape
- Long-standing problem since its first discovery in 1912 is where and how cosmic rays are produced

Active Galactic Nucleus Jets

- Jets are ejected from supermassive (10^8 - $10^{10}M_{\text{sun}}$) blackhole and particles are accelerated inside the jets

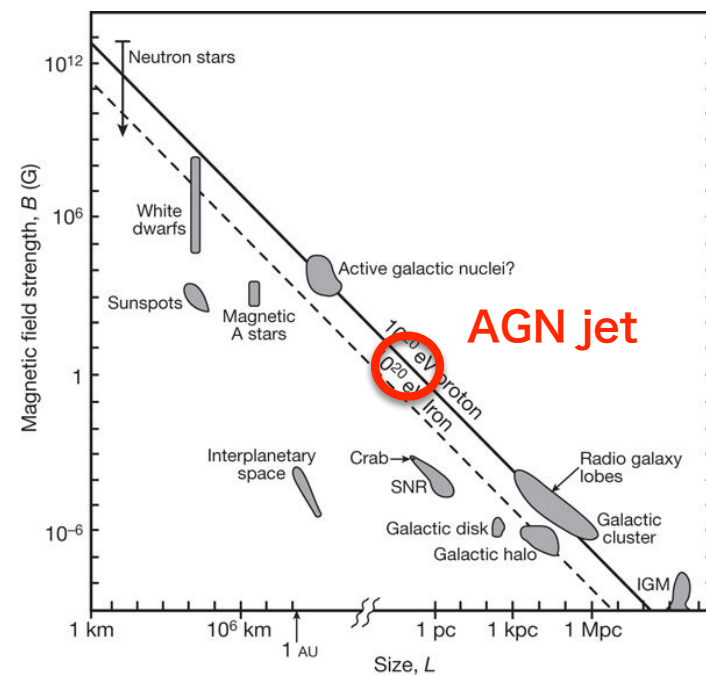
Radio image of Cygnus A

AGN jets are considered to be one of the promising candidates of cosmic-ray source



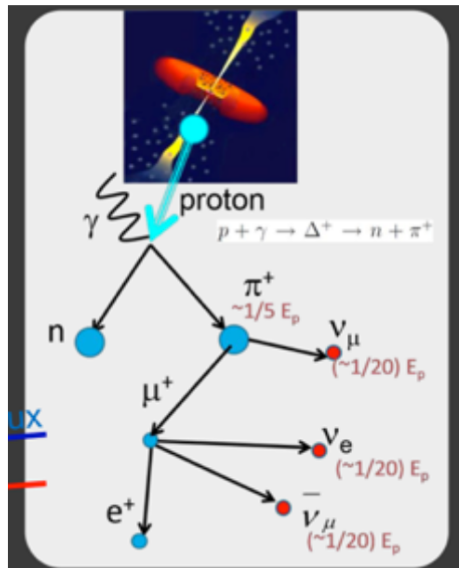
Urry+95

Particles are accelerated by shocks inside the jet



Unveiling the source of cosmic rays through Identifying the IceCube neutrino source

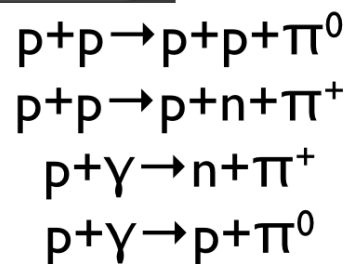
New era of Multi-messenger astronomy



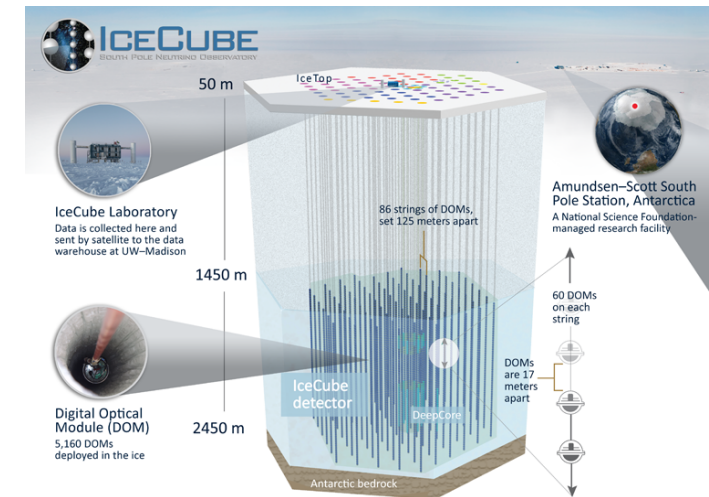
High-energy neutrinos are produced via interaction between cosmic rays and ambient photons ($p\gamma$) or protons (pp)

**Neutrino source
= Cosmic-ray source**

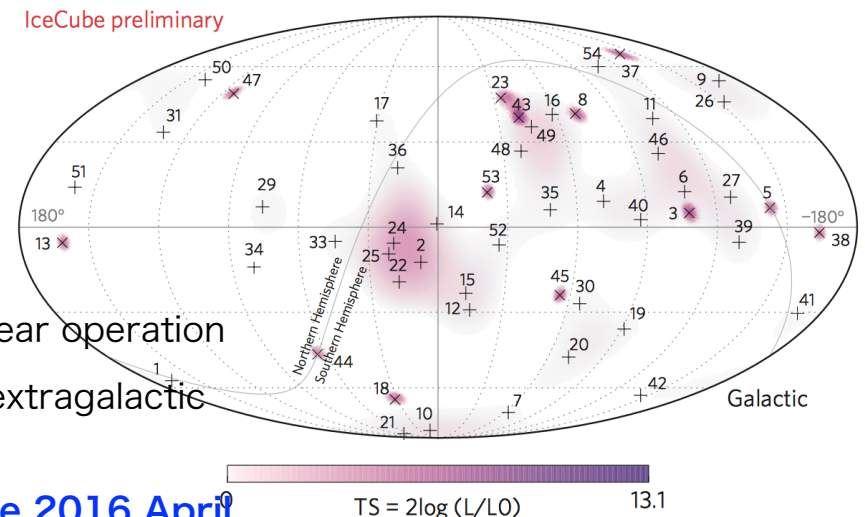
**Neutrino arrival direction
indicates the direction of
cosmic-ray sources**



- 54 events during the first 4-year operation
- Isotropic distribution implies extragalactic origin
- Alert is issued via GCN since 2016 April



taken from IceCube webpage



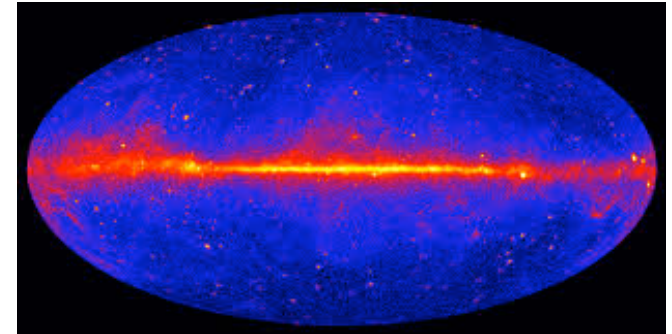
taken from ICRC 2015 proc.

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- **Current status of Fermi Gamma-ray Space Telescope**
- Fermi-LAT detection of a flaring blazar, TXS 0506+056, inside the error region of IceCube-170922A
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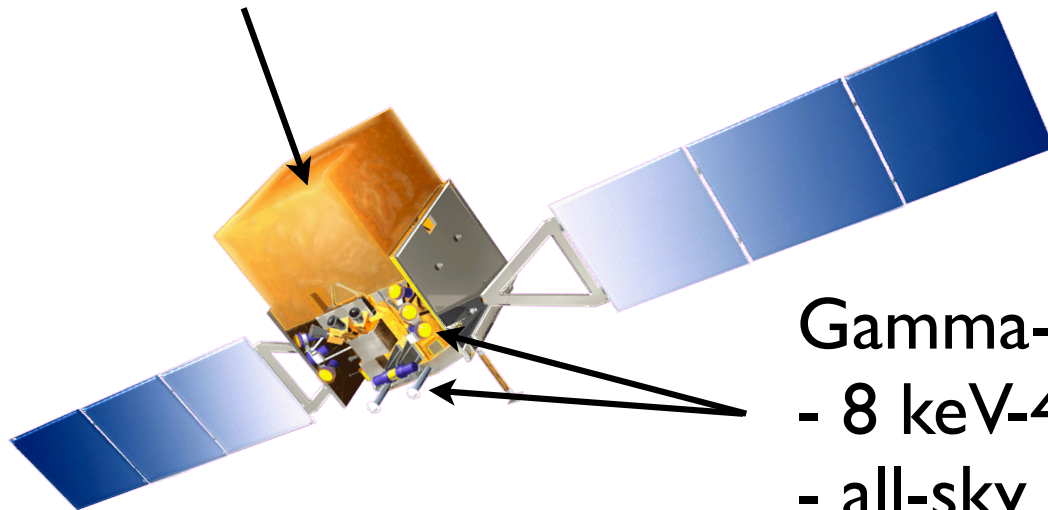
Fermi Gamma-ray Space Telescope

- Launched on 2008 June 11
- Continue to observe without any critical problems
- All sky survey mode



Large Area Telescope (LAT)

- 20 MeV-300 GeV
- Thanks to the wide FoV of 2.4 str, scan all-sky every 3 hours



Gamma-ray Burst Monitor (GBM)

- 8 keV-40 MeV
- all-sky

Large Area Telescope

Pair-conversion telescope

Si-strip Tracker with tungsten foil converter:

Measure the photon direction

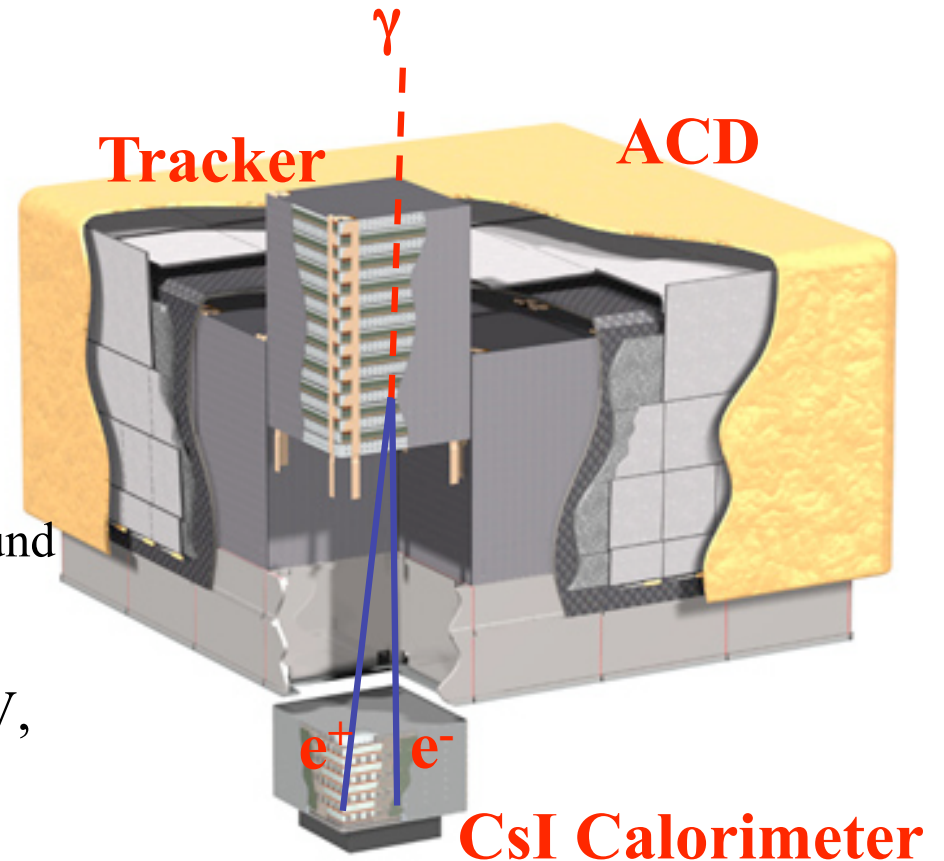
CsI Calorimeter:

Measure the photon energy,
Image the shower

ACD (Plastic scintillator):

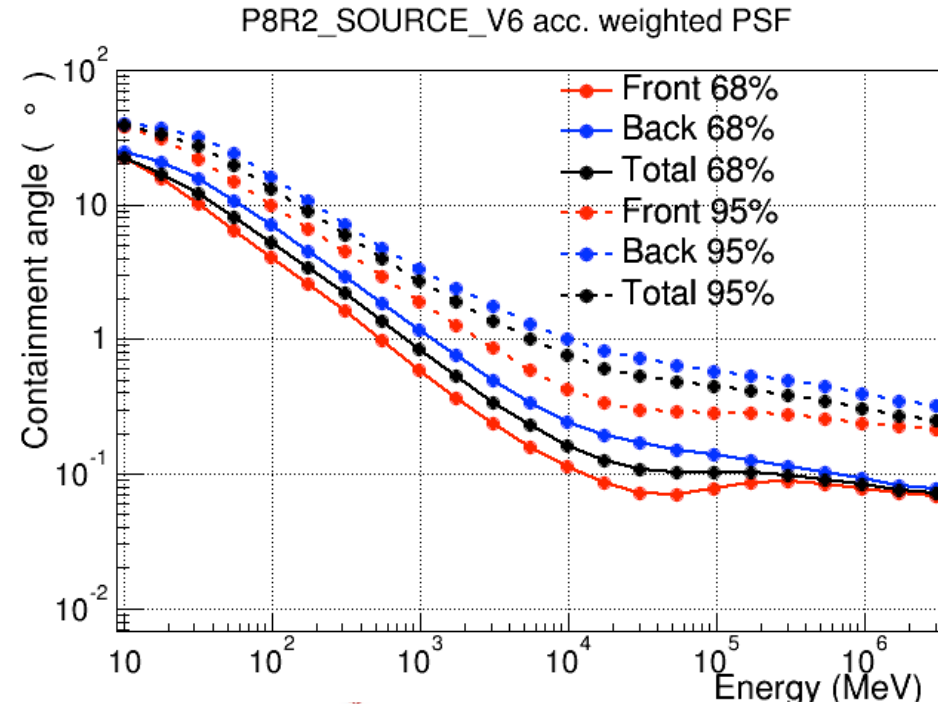
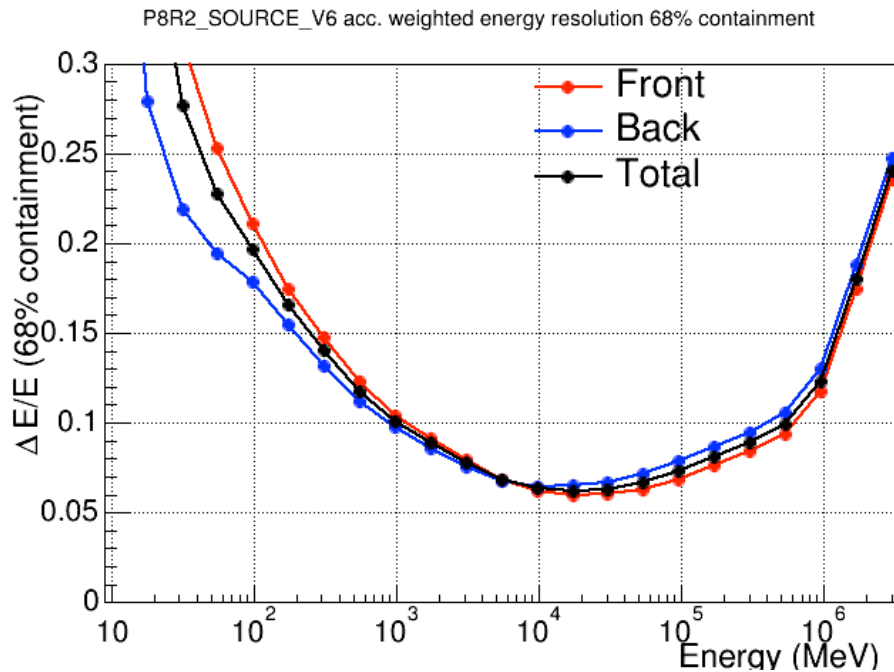
Reject charged-particle background

- Large effective area (9000 cm^2 @ 1 GeV, normal incidence)
- Large field-of-view (2.4 str)
- The entire sky is observed every ~ 3 hours
- Energy range: 20 MeV – 300 GeV
- Angular resolution (68% contaminant radius):
0.6 deg @ 1 GeV

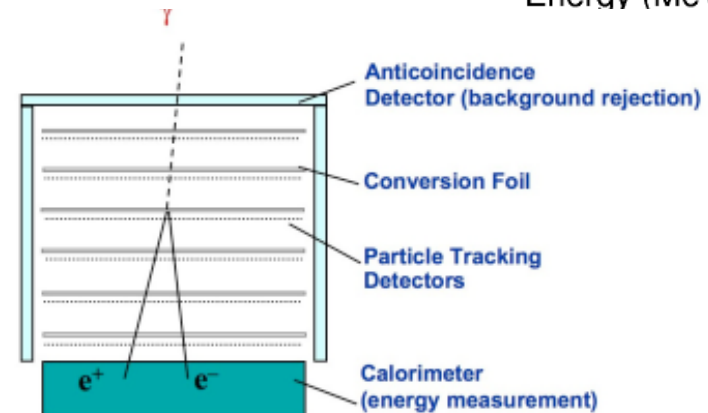


4 x 4 modular array
3000 kg, 650 W

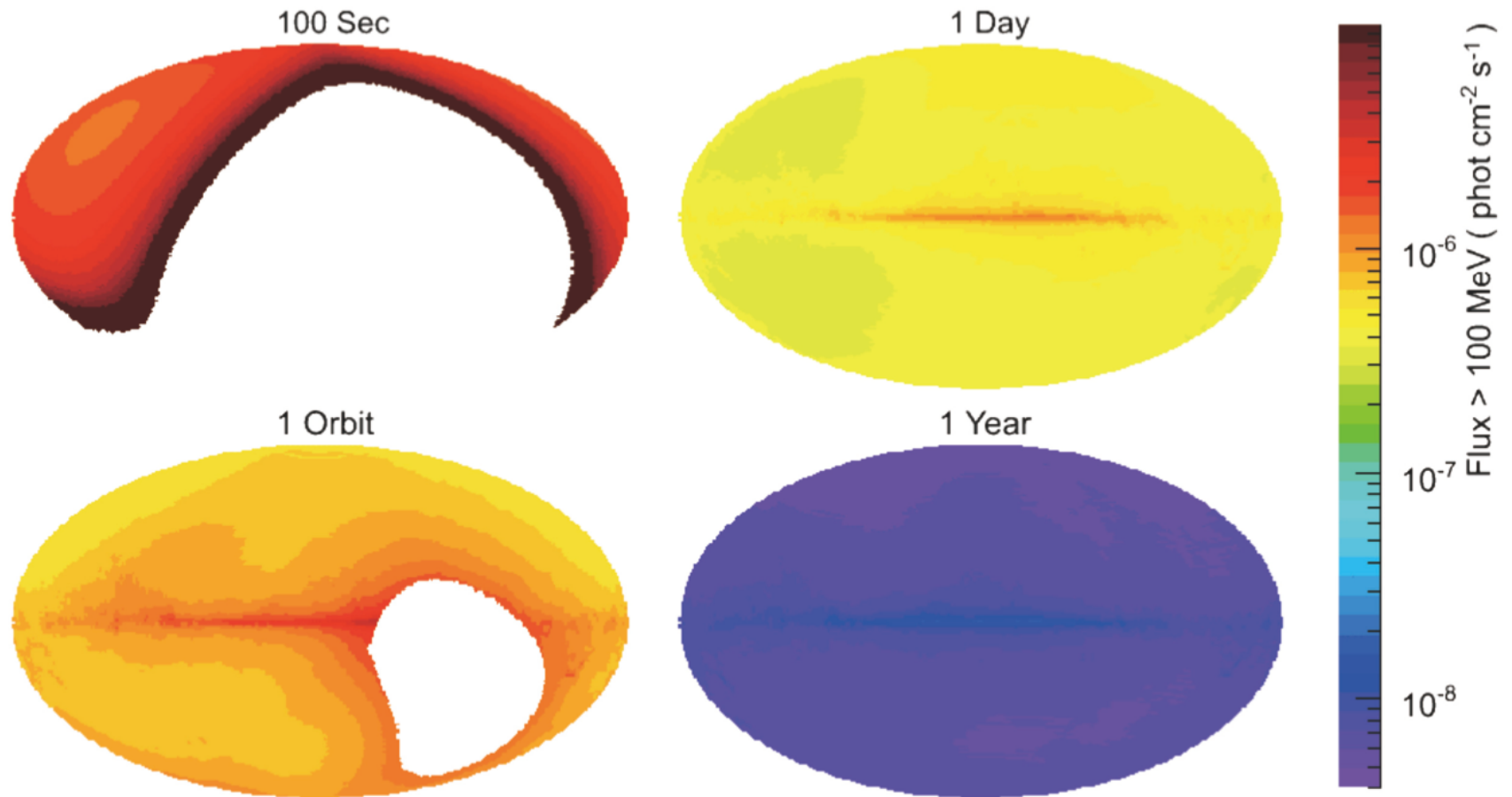
Energy resolution and PSF



- 12 layer (FRONT)
- 4 layers (BACK)



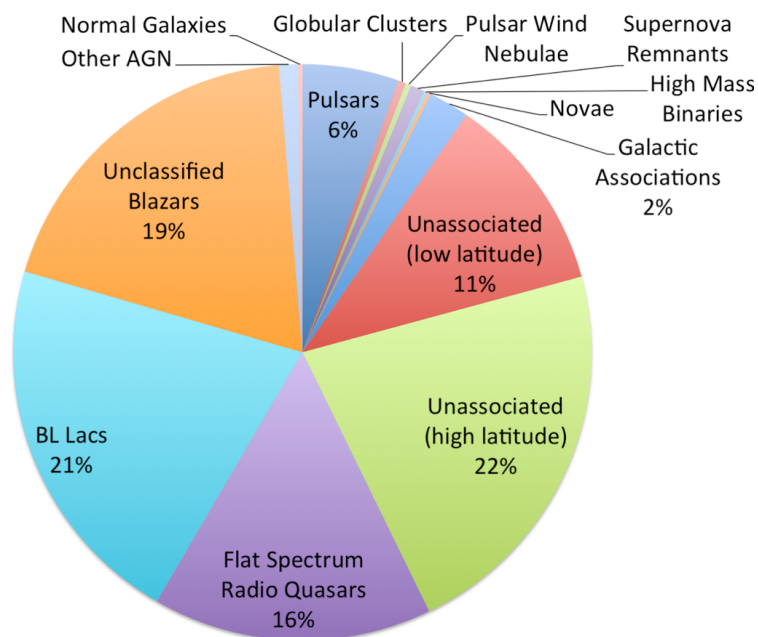
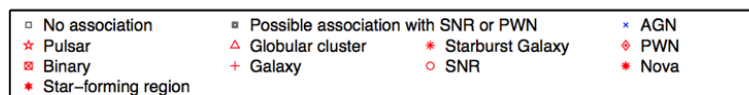
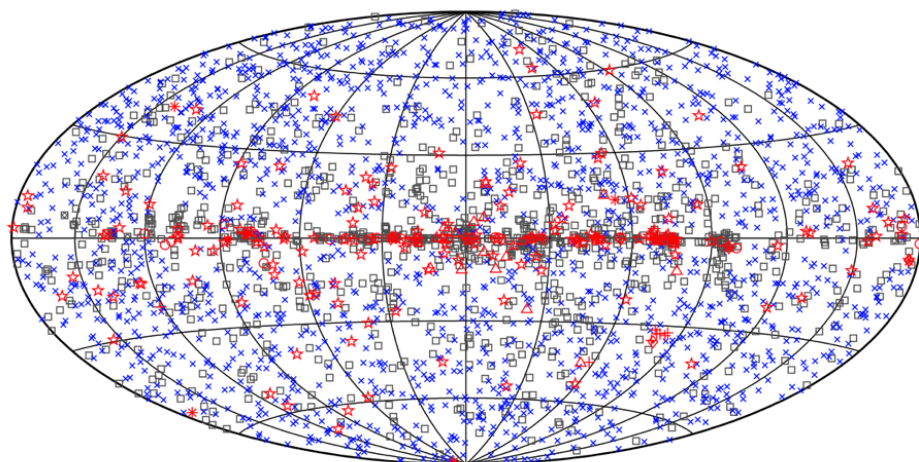
All-sky survey-mode observation



- Thanks to the large FoV of 2.4 str, LAT scans all-sky every 3 hours (i.e., 2 orbits) and perform unbiased survey

3FGL catalog from 4-year data

(http://fermi.gsfc.nasa.gov/ssc/data/access/lat/4yr_catalog/)



- Arxiv: 1501.02003
- 3033 sources with $TS > 25$ (~ 5 sigma) detection
- 992 sources are unID
- GeV spectra and 4-year light curves are available for all the sources from webpage

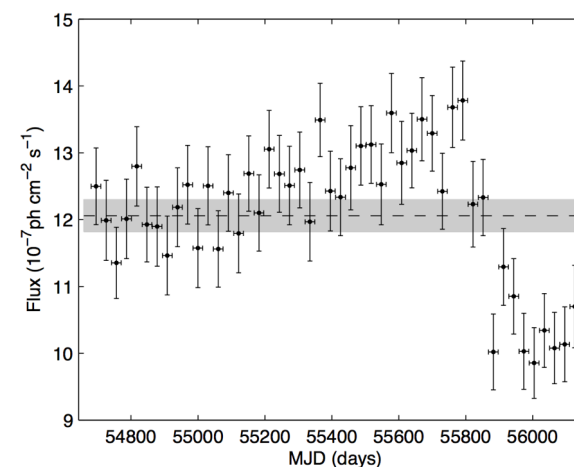
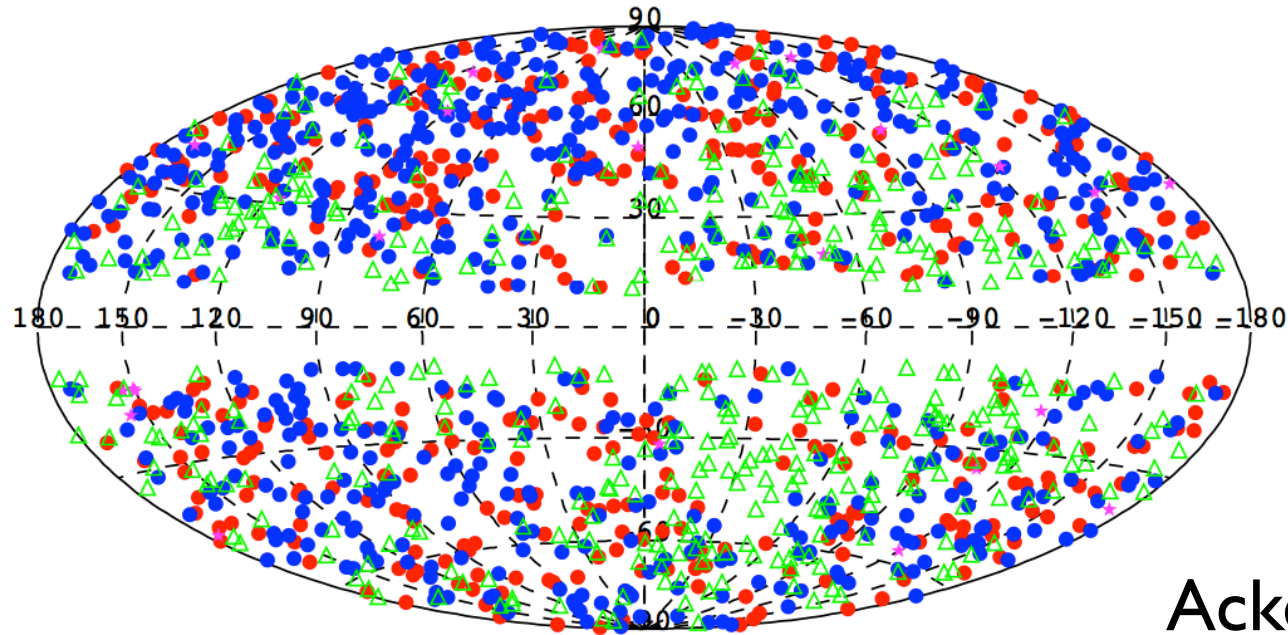


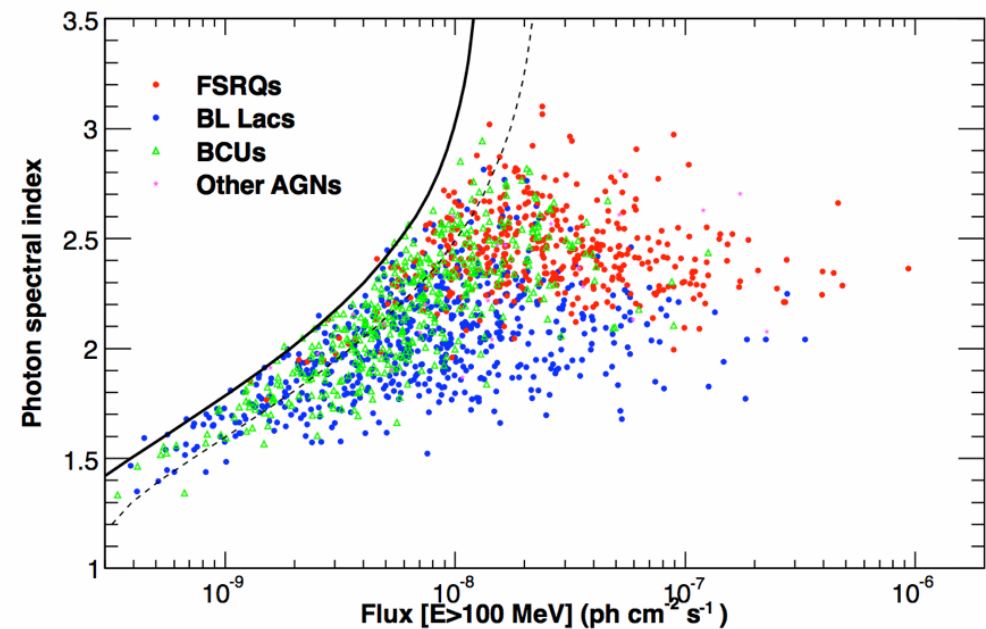
Fig. 12.— Light curve of 3FGL J2021.5+4026 (PSR J2021+4026 in the γ Cygni SNR). The variability of that pulsar is easily detected by the automatic procedure. The vertical scale does not start at 0.

3LAC (LAT AGN Catalog)



Ackermann+15

- 467 FSRQs
- 632 BL Lacs
- 460 Uncertain type
- 32 non-blazar AGN



Confirmation of Blazar sequence

Fossati+98
Kubo+98

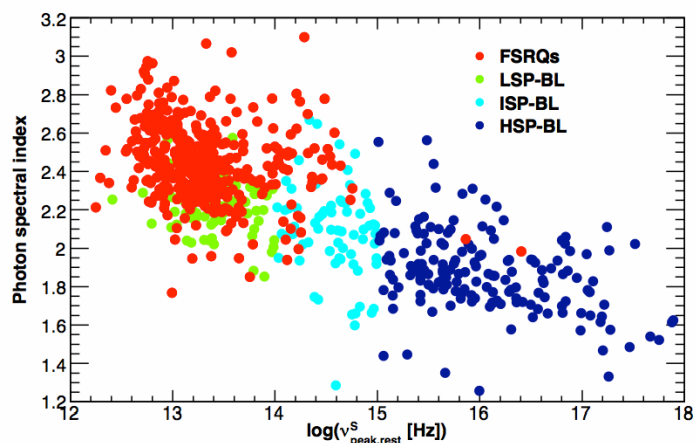
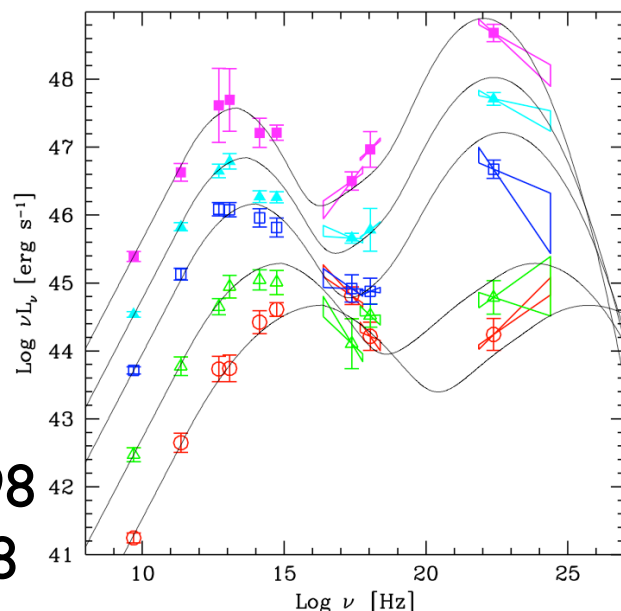


Fig. 10.— Photon index versus frequency of the synchrotron peak $\nu_{peak,rest}^S$. Red: FSRQs, green: LSP-BL Lacs, light blue: ISP-BL Lacs, dark blue: HSP-BL Lacs.

- FSRQ: strong optical emission lines due to bright accretion disk
- BL Lac: weak/no lines ($EW < 5\text{\AA}$)
- Blazar sequence: Bright/faint blazars have lower/higher sync. peak freq.

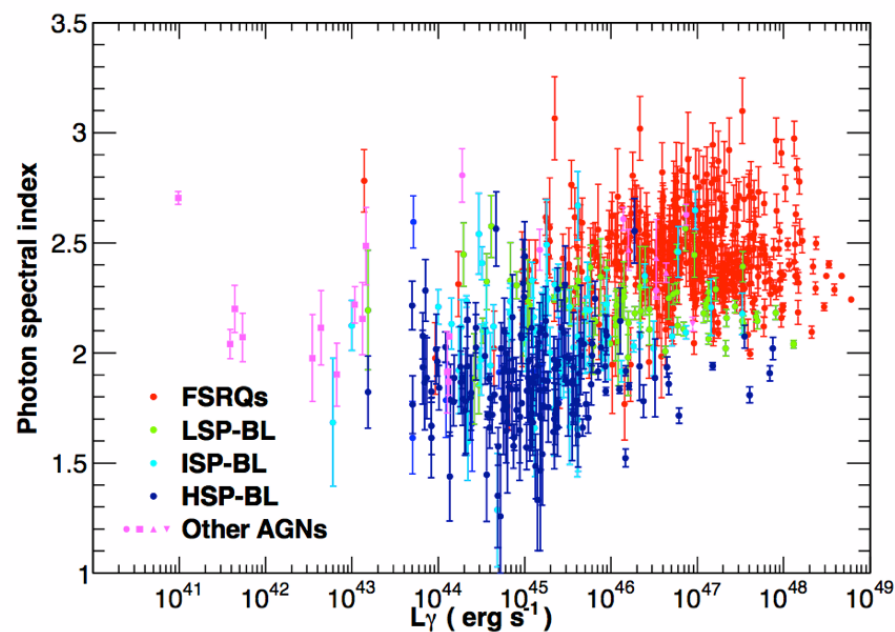


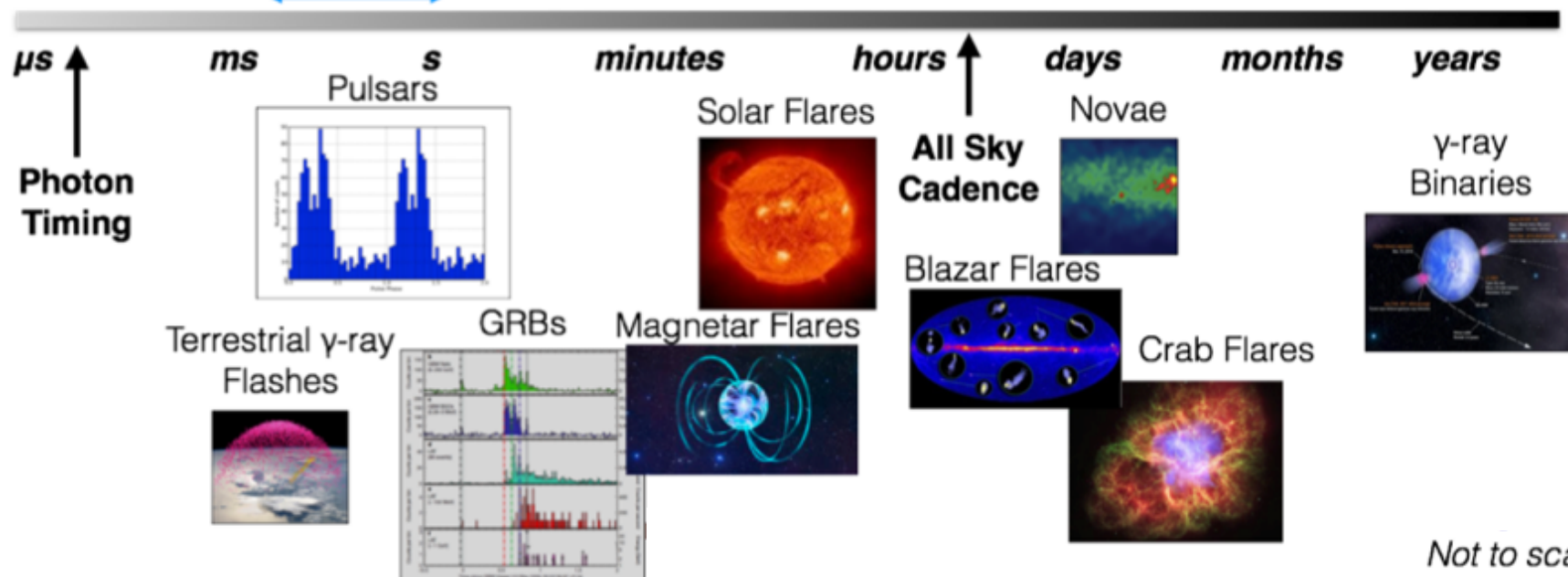
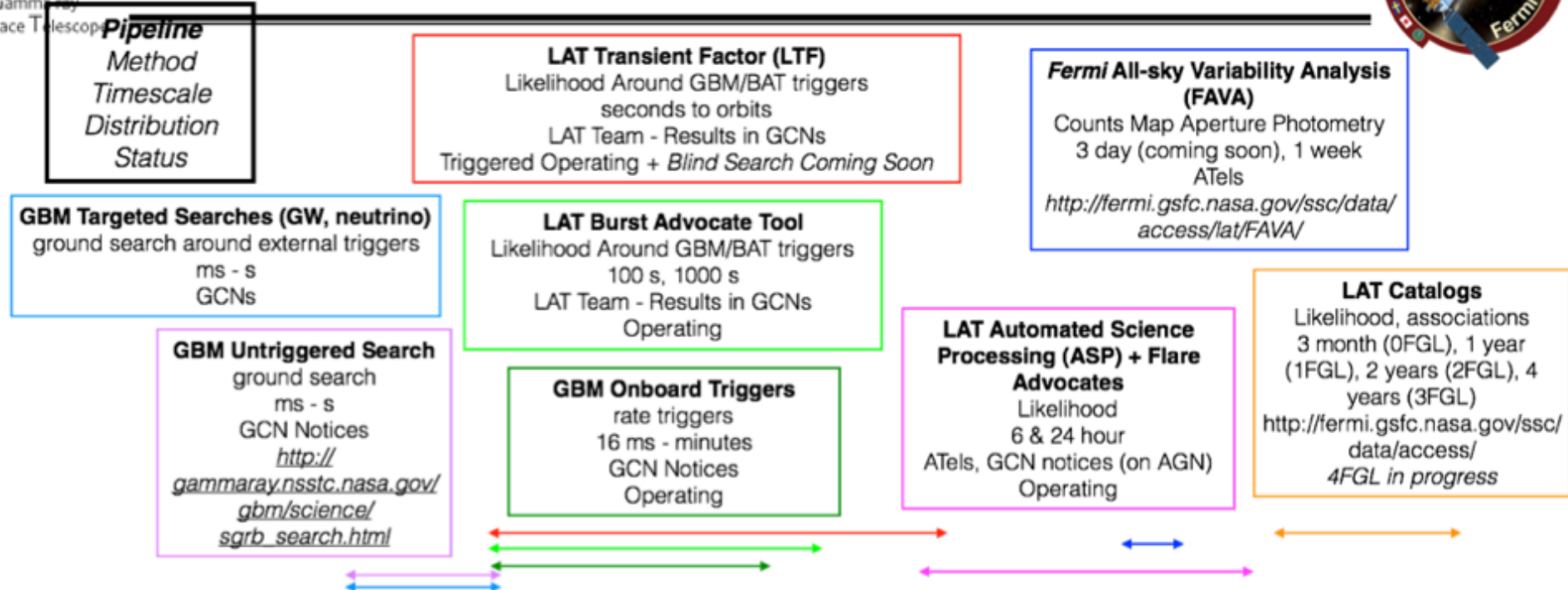
Fig. 14.— Photon index versus gamma-ray luminosity. Red: FSRQs, green: LSP-BL Lacs, light blue: ISP-BL Lacs, dark blue: HSP-BL Lacs, magenta: other AGNs (circles: NLSy1s, squares: radio galaxies, up triangles: SSRQs, down triangles: AGNs of other types).



Fermi Transient Searches



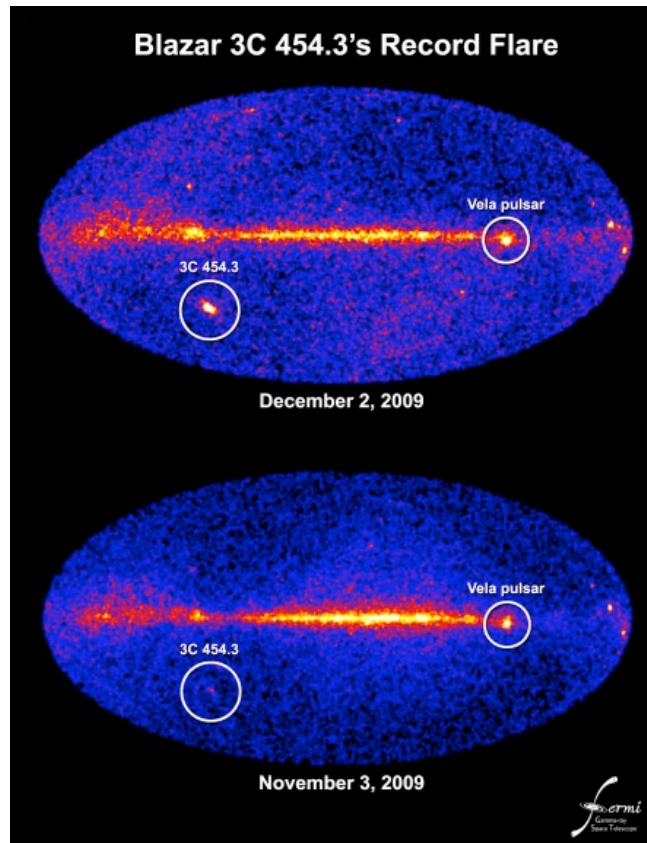
Pipelines
Timescale
Transients



Not to scale

LAT Automated Science Processing (ASP) +Flare advocate

LAT
1-day
data



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GLAST LAT detection of a possible new gamma-ray flaring blazar: PKS 1502+106

ATel #1650; [S. Ciprini \(Univ./INFN Perugia\) on behalf of the GLAST Large Area Telescope Collaboration](#)
on 8 Aug 2008; 00:02 UT
Credential Certification: [Stefano Ciprini \(stefano.ciprini@pg.infn.it\)](#)

Subjects: Gamma Ray, >GeV, AGN, Quasar

Referred to by ATel #: [1661](#), [1905](#)

The Large Area Telescope (LAT), one of two instruments on the Gamma-ray Large Area Space Telescope (GLAST) (launched June 11, 2008), which is still in its post-launch commissioning and checkout phase, has been monitoring high flux from a source positionally consistent with the blazar PKS 1502+106 (R.A.:15h04m24.9797s; Dec.:+10d29m39.198s, also known as OR 103 and S3 1502+10) since August 6, 2008.

Preliminary analysis indicates that the source is in a high state with a gamma-ray flux ($E>100\text{MeV}$) well above pre-defined LAT flaring source reporting threshold of 2×10^{-6} photons $\text{cm}^{-2} \text{s}^{-1}$.

This is a well-known radio source classified as a Flat Spectrum Radio Quasar (FSRQ), observed by several X-ray instruments. This is the first time that it has been reported to have gamma-ray emission.

Please note that PKS 1502+106 has two possible redshifts listed in the literature: $z=0.56$ and 1.83 ; the former seems preferred (A.E. Wright et al. 1979 ApJ 229,73; B.J. Wilkes 1986, MNRAS, 218, 331).

Because GLAST has just started its scientific standard operations, regular gamma-ray monitoring of this source will be pursued. In consideration of the ongoing activity of this source we strongly encourage multiwavelength observations of PKS 1502+106.

The GLAST LAT is a pair conversion telescope designed to cover the energy band from 20 MeV to greater than 300 GeV. It is the product of an international collaboration between NASA and DOE in the U.S. and many scientific institutions across France, Italy, Japan and Sweden.

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Related	
1905	Fermi-LAT detection of renewed activity from the blazar PKS 1502+106
1661	Archival light curve for the flaring GLAST blazar PKS 1502+106
1650	GLAST LAT detection of a possible new gamma-ray flaring blazar: PKS 1502+106

- Flare Advocate run the daily (1-day and 6-hour data) analysis script and check the ASP result
- Once transient objects are found, Astronomers Telegram is issued (typically, flux $> 1.0 \times 10^{-6}$ photons/cm²/s for $E > 100$ MeV)

Flare-Advocate/Gamma-ray Sky-Watcher report: DOY 53 (February 22, 2017)

On duty Flare Advocates:

FA: Sara Cutini <sarac@slac.stanford.edu>

Highlights

Extragalactic Science

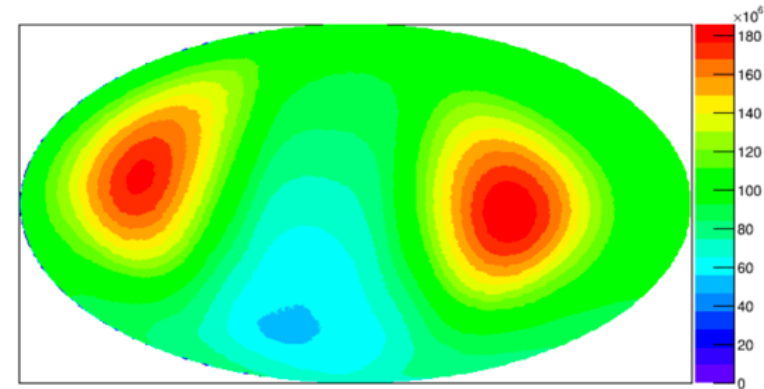
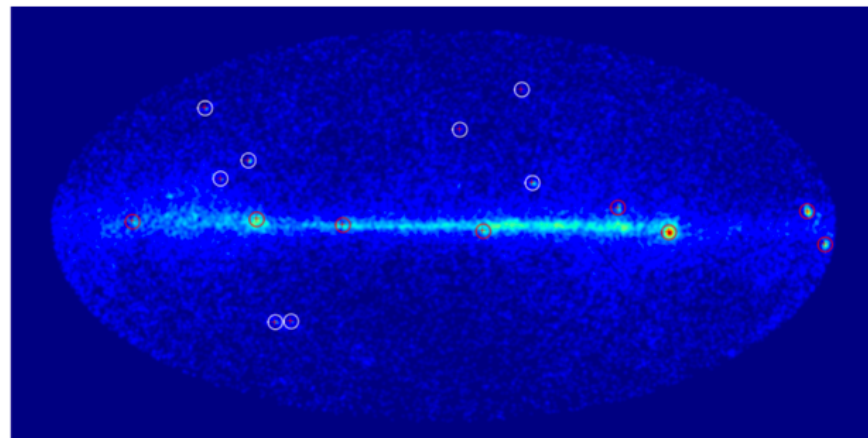
- PKS B1424-418 (TS=174) flux = $(1.3 \pm 0.2) \times 10^{-6}$, detected also in 12658 @TS=41, 12660 @TS=28
- S5 1044+71 (TS=164) flux = $(0.7 \pm 0.1) \times 10^{-6}$, detected also in 12659 @TS=37
- 3C 454.3 (TS=100) flux = $(1.6 \pm 0.3) \times 10^{-6}$, detected also in 12657 @TS=30, 12658 @TS=26
- CTA 102 (TS=54) flux = $(0.8 \pm 0.3) \times 10^{-6}$
- PKS 1510-08 (TS=47) flux = $(0.5 \pm 0.2) \times 10^{-6}$
- 3C 279 (TS=41) flux = $(0.5 \pm 0.2) \times 10^{-6}$
- 1ES 1959+650 (TS=30) flux = $(0.2 \pm 0.1) \times 10^{-6}$

Galactic Science

- LAT PSR J1836+5925 (TS=236) flux = $(0.9 \pm 0.1) \times 10^{-6}$, detected also in 12660 @TS=35
- Gamma Cygni (TS=137) flux = $(3.2 \pm 0.4) \times 10^{-6}$, detected also in 12657 @TS=59
- PSR J1709-4429 (TS=121) flux = $(2.0 \pm 0.4) \times 10^{-6}$
- LS I+61 303 (TS=44) flux = $(0.8 \pm 0.2) \times 10^{-6}$
- PSR J1057-5226 (TS=31) flux = $(0.5 \pm 0.1) \times 10^{-6}$

Likelihood Analysis results:

Daily run (n. 03165)

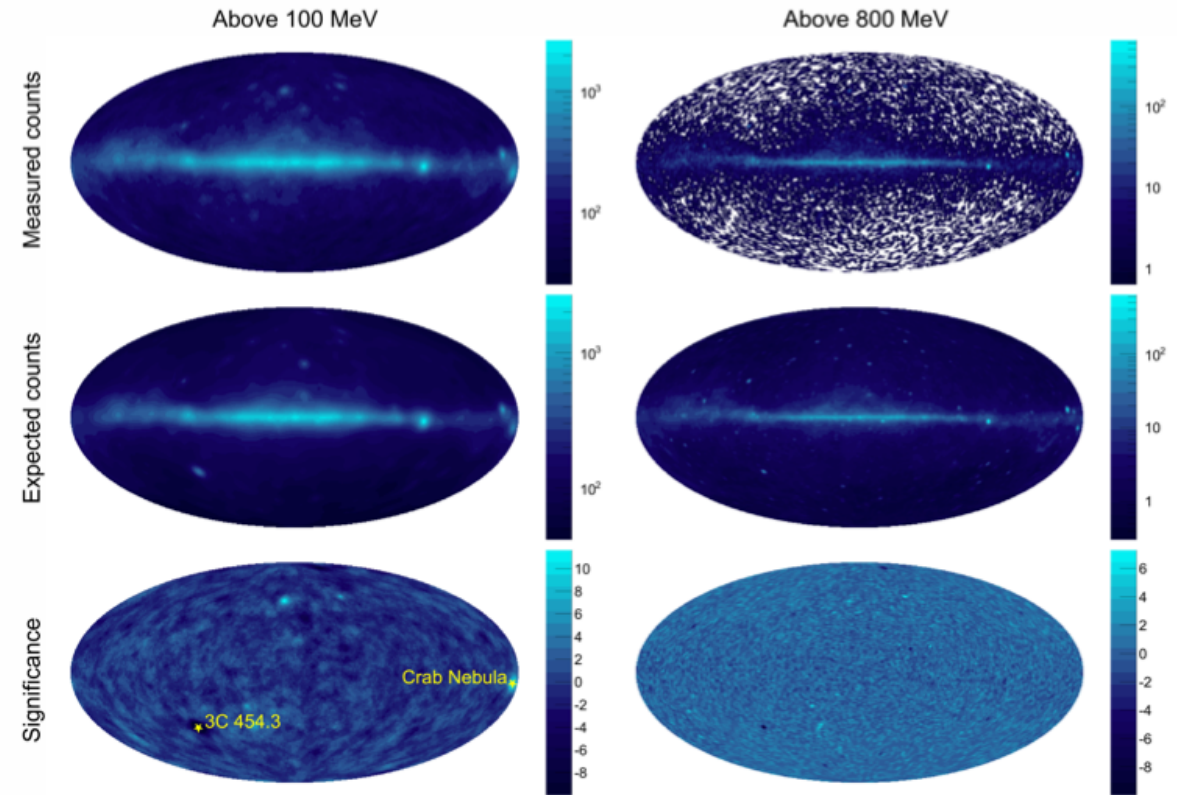


Extragalactic Science	RA(J2000)	DEC(J2000)	L	B	TS	Npred	Flux ^a	index	Delta	Type	3FGL comparison	Associations
ASP J104816p713958	161.8370	71.6814	135.5759	42.2673	164	55	0.68±0.13	1.86±0.12	0° 6.5'	FSRQ	9.9: J1048.4+7144 (6.9±0.3)e-8	S5 1044+71
									0° 59.1'	bl	87: J1047.6+7240 (8±2)e-9	GB6 J1047+7238
3C_279	194.4841*	-5.6478*	305.9164*	57.1863*	41	29	0.54±0.16	2.42±0.27	0° 27.8'	FSRQ	1.2: J1256.1-0547 (4.42±0.06)e-7	3C 279
BM_PKS1424m41	216.8707*	-42.2285*	321.3167*	17.1888*	174	83	1.29±0.20	2.16±0.13	0° 8.9'	FSRQ	4.8: J1427.9-4206 (2.68±0.05)e-7	PKS B1424-418
1510m089	228.1895	-9.0594	351.3050	40.1827	47	26	0.53±0.17	2.11±0.23	0° 3.0'	FSRQ	0.6: J1512.8-0906 (9.4±0.1)e-7	PKS 1510-08
1ES 1959+650	222.5513*	25.9121*	32.1710*	17.1822*	30	16	0.25±0.09	1.22±0.22	0° 12.8'	bl	5.5: J2222.2+2552 (1.52±0.05)e-7	1ES 1959+650

- LAT daily report is uploaded on the confluence page (collaboration member only)
- 24-hour, 6-hour x4

Fermi All sky Variability Analysis (FAVA)

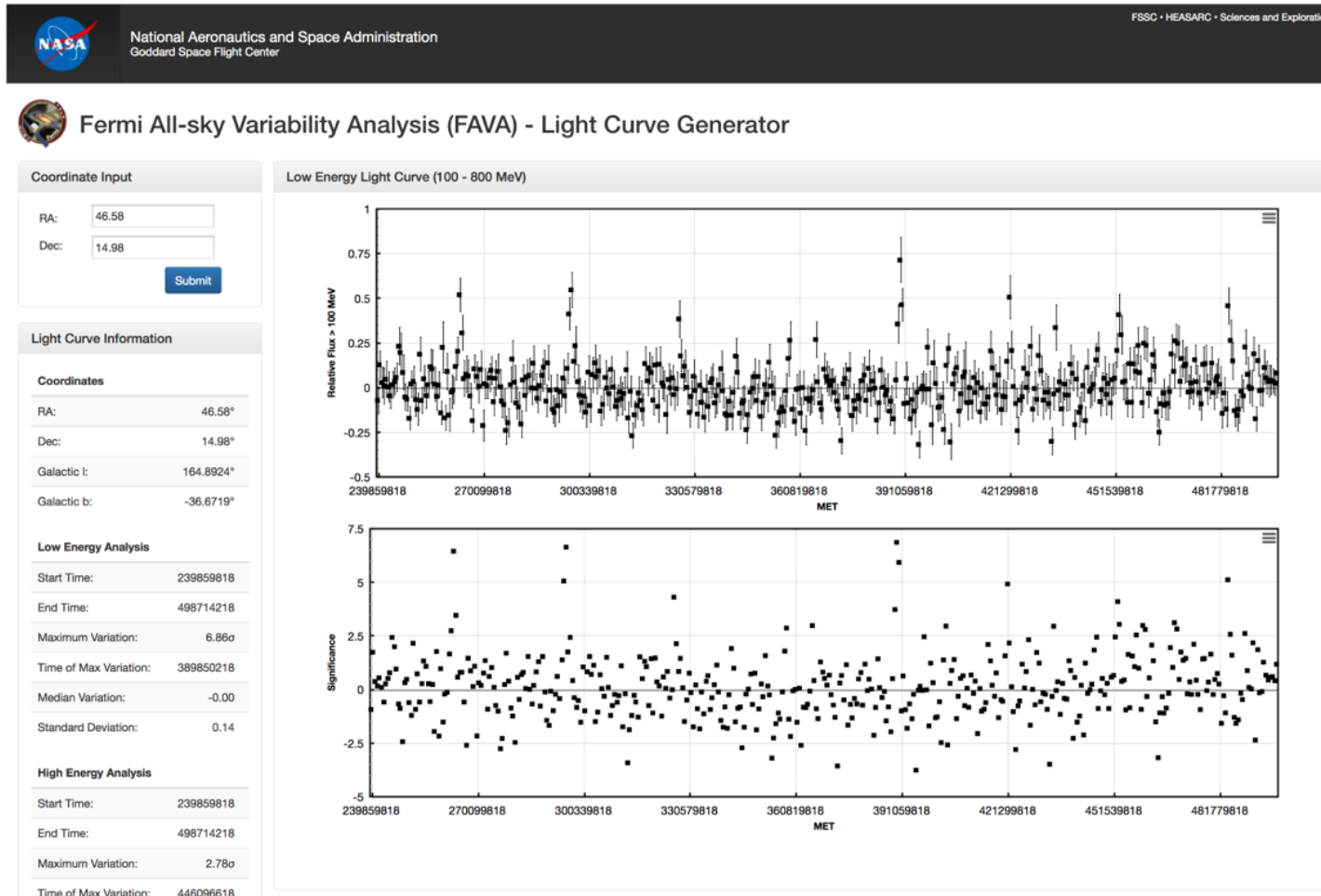
- For Weekly-binned data
- Comparison of observed counts with average (expected) counts
- $E > 100$ MeV, $E > 800$ MeV
- Crab nebula flare is first detected by this analysis
- By using 47 month Fermi/LAT data, 215 sources in the first flare catalog (FAVA catalog paper)



$$N^{exp}(\phi, \theta) = \sum_{E:j=1..12} \sum_{\alpha:i=1..4} N_{i,j}^{tot}(\phi, \theta) \times \frac{\epsilon_{i,j}^{week}(\phi, \theta)}{\epsilon_{i,j}^{tot}(\phi, \theta)},$$

Exposure ratio

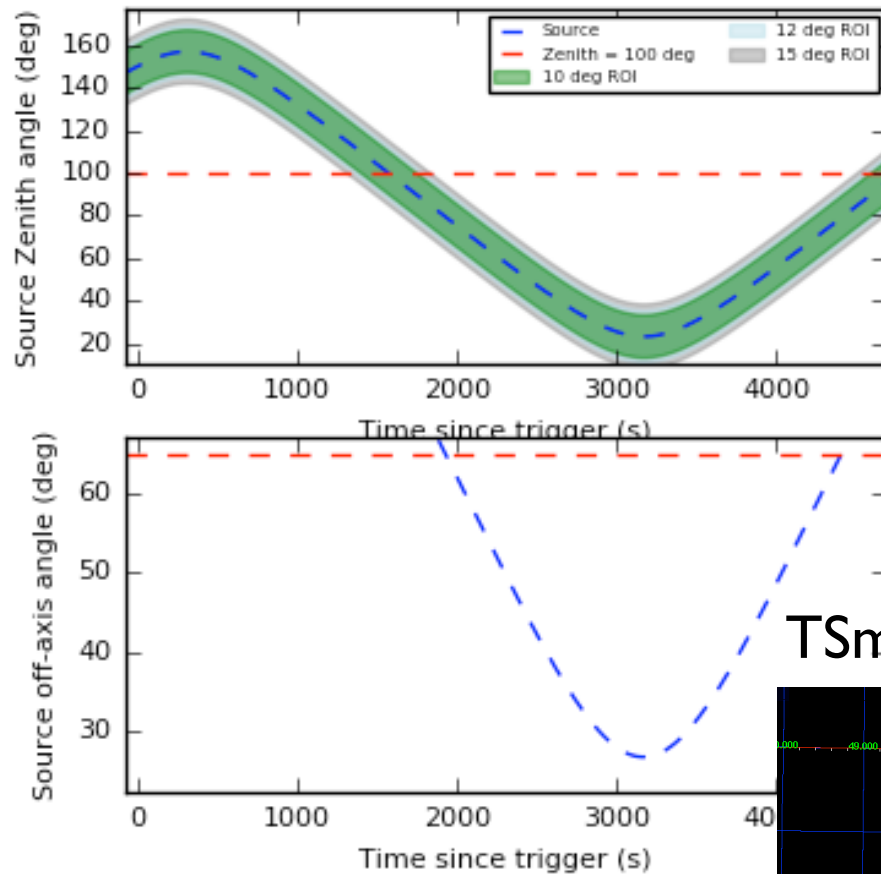
FAVA webpage



- <https://fermi.gsfc.nasa.gov/ssc/data/access/lat/FAVA/LightCurve.php>
- Automatic production of light curve at any locations (RA, Dec)

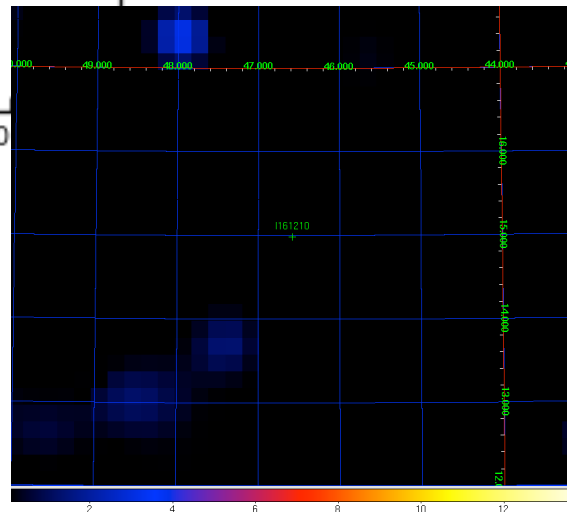
IceCube-161210

Navigation plots

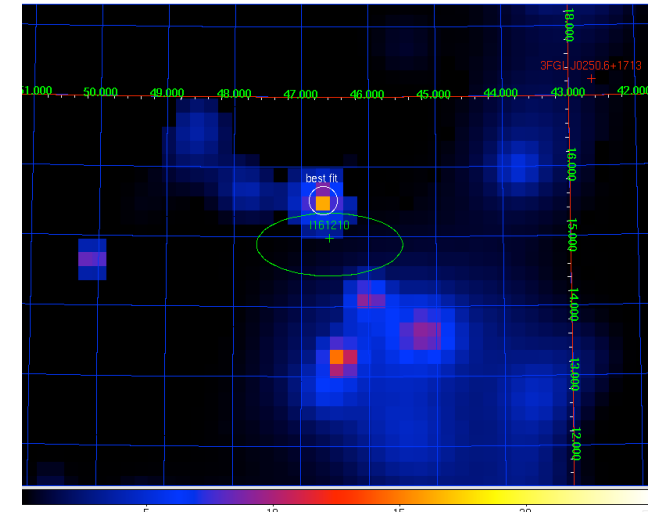


- At the IceCube trigger time, the event position is outside LAT FoV
- No LAT emission by LTF
- TS maps by manual analysis found weak sources at the edge of the IceCube error circle??
- Probably statistical fluctuation

TSmap for T0-24h~T0

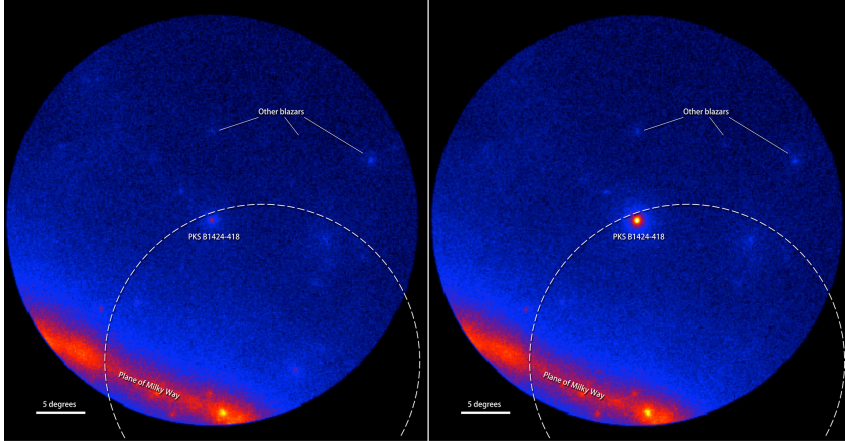


T0~T0+24h



Produced by Burst
Advocate tool

Possible association of PeV neutrino with high fluence GeV blazar PKS 1424-418



Cascade event of
error radius of ~ 10 deg
 $\sim 5\%$ chance probability

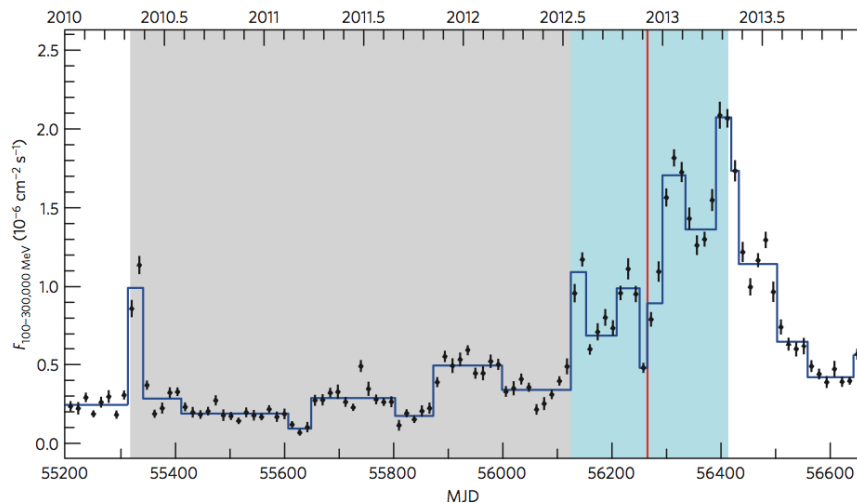
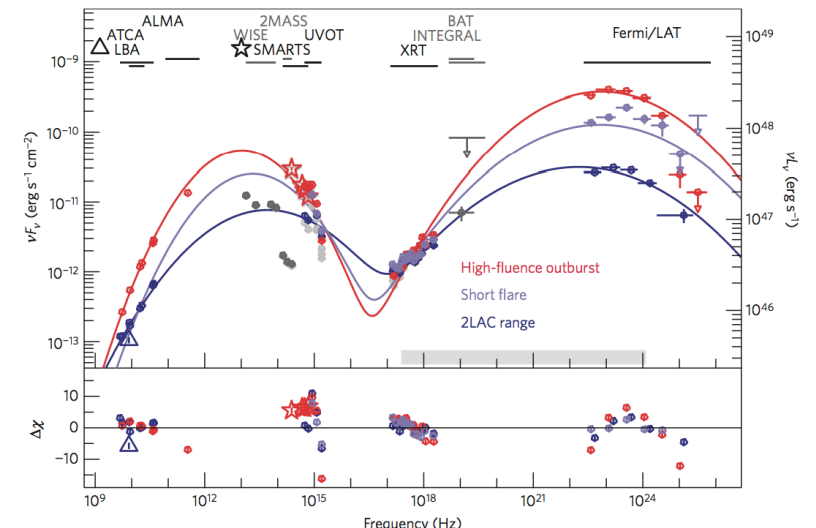


Table 1 | Maximum-possible number of petaelectronvolt-neutrino events in 36 months (988 days live-time) of IceCube data for the 17 2LAC γ -ray blazars in the field of the 2 PeV IceCube event based on 2LAC catalogue γ -ray spectra and contemporaneous X-ray data.

2FGL name	Common name	F_γ (erg cm $^{-2}$ s $^{-1}$)	$N_{\nu, \text{PeV}}^{\text{max}}$
2FGL J1230.2-5258	PMN J1229-5303	$(2.4^{+1.5}_{-1.5}) \times 10^{-11}$	0.14
2FGL J1234.0-5733	PMN J1234-5736	$(1.1^{+0.4}_{-0.4}) \times 10^{-11}$	0.06
2FGL J1303.5-4622	PMN J1303-4621	$(1.9^{+0.6}_{-0.6}) \times 10^{-11}$	0.11
2FGL J1303.8-5537	PMN J1303-5540	$(1.04^{+0.11}_{-0.11}) \times 10^{-10}$	0.38
2FGL J1304.3-4353	1RXS 130421.2-435308	$(2.11^{+0.25}_{-0.25}) \times 10^{-11}$	0.12
2FGL J1307.5-4300	1RXS 130737.8-425940	$(8.4^{+1.7}_{-1.7}) \times 10^{-12}$	0.05
2FGL J1307.6-6704	PKS B 1304-668	$(1.54^{+0.15}_{-0.15}) \times 10^{-10}$	0.89
2FGL J1314.5-5330	PMN J1315-5334	$(8.1^{+0.9}_{-0.9}) \times 10^{-11}$	0.47
2FGL J1326.7-5254	PMN J1326-5256	$(1.04^{+0.21}_{-0.18}) \times 10^{-10}$	0.59
2FGL J1329.2-5608	PMN J1329-5608	$(1.38^{+0.36}_{-0.29}) \times 10^{-10}$	0.93
2FGL J1330.1-7002	PKS B 1326-697	$(1.53^{+0.11}_{-0.11}) \times 10^{-10}$	0.89
2FGL J1352.6-4413	PKS B 1349-439	$(5.4^{+1.0}_{-1.0}) \times 10^{-11}$	0.32
2FGL J1400.6-5601	PMN J1400-5605	$(6.9^{+0.8}_{-0.8}) \times 10^{-11}$	0.40
2FGL J1407.5-4257	CGRaBS J1407-4302	$(1.6^{+0.5}_{-0.5}) \times 10^{-11}$	0.09
2FGL J1428.0-4206*	PKS B1424-418*	$(2.04^{+0.17}_{-0.16}) \times 10^{-10*}$	1.57*
2FGL J1508.5-4957	PMN J1508-4953	$(7.6^{+3.0}_{-2.3}) \times 10^{-11}$	0.55
2FGL J1514.6-4751	PMN J1514-4748	$(5.6^{+0.6}_{-0.6}) \times 10^{-11}$	0.32
Sum (2LAC)			7.9



Kadler+16

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IceCube-170922A

- JST 2017/9/23 5:55AM: GCN notice is issued
- 10:09AM: Offline analysis result is issued (GCN 21916)

EHE alert

```
////////////////////////////////////  
TITLE:          GCN/AMON NOTICE  
NOTICE_DATE:    Fri 22 Sep 17 20:55:13 UT  
NOTICE_TYPE:    AMON ICECUBE EHE  
RUN_NUM:       130033  
EVENT_NUM:     50579430  
SRC_RA:        77.2853d {+05h 09m 08s} (J2000),  
              77.5221d {+05h 10m 05s} (current),  
              76.6176d {+05h 06m 28s} (1950)  
SRC_DEC:       +5.7517d {+05d 45' 06"} (J2000),  
              +5.7732d {+05d 46' 24"} (current),  
              +5.6888d {+05d 41' 20"} (1950)  
SRC_ERROR:     14.99 [arcmin radius, stat+sys, 50% containment]  
DISCOVERY_DATE: 18018 TJD; 265 DOY; 17/09/22 (yy/mm/dd)  
DISCOVERY_TIME: 75270 SOD {20:54:30.43} UT  
REVISION:      0  
N_EVENTS:      1 [number of neutrinos]  
STREAM:        2  
DELTA_T:       0.0000 [sec]  
SIGMA_T:       0.0000e+00 [dn]  
ENERGY :       1.1998e+02 [TeV]  
SIGNALNESS:    5.6507e-01 [dn]  
CHARGE:        5784.9552 [pe]  
SUN_POSTN:     180.03d {+12h 00m 08s} -0.01d {-00d 00' 53"}  
SUN_DIST:      102.45 [deg] Sun_angle= 6.8 [hr] (West of Sun)  
MOON_POSTN:    211.24d {+14h 04m 58s} -7.56d {-07d 33' 33"}  
MOON_DIST:     134.02 [deg]  
GAL_COORDS:    195.31,-19.67 [deg] galactic lon,lat of the event  
ECL_COORDS:    76.75,-17.10 [deg] ecliptic lon,lat of the event  
COMMENTS:      AMON_ICECUBE_EHE.
```

TITLE: GCN CIRCULAR
NUMBER: 21916
SUBJECT: IceCube-170922A - IceCube observation of a high-energy
DATE: 17/09/23 01:09:26 GMT
FROM: Erik Blaufuss at U. Maryland/IceCube <blaufuss@icecube

Claudio Kopper (University of Alberta) and Erik Blaufuss (Univer

On 22 Sep, 2017 IceCube detected a track-like, very-high-energy (EHE) track event selection. The IceCube detector was in a normal muon that traverses the detector volume, and have a high light l

After the initial automated alert (<https://gcn.gsfc.nasa.gov/not> sophisticated reconstruction algorithms have been applied offlin

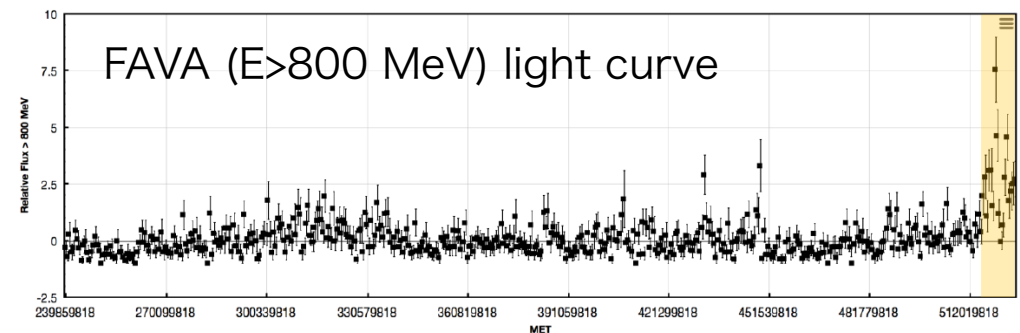
Date: 22 Sep, 2017
Time: 20:54:30.43 UTC
RA: 77.43 deg (-0.80 deg/+1.30 deg 90% PSF containment) J2000
Dec: 5.72 deg (-0.40 deg/+0.70 deg 90% PSF containment) J2000

We encourage follow-up by ground and space-based instruments to

The IceCube Neutrino Observatory is a cubic-kilometer neutrino d
at roc@icecube.wisc.edu

Fermi-LAT detection of a flaring blazar TXS 0506+056 inside the error region of IceCube-170922A

Fermi-LAT count map



Flaring blazar, TXS 0506+056 was
detected inside the IceCube-170922A
error region
(Tanaka et al. ATel #10791)

[[Previous](#) | [Next](#) | [ADS](#)]

Fermi-LAT detection of increased gamma-ray activity of TXS 0506+056, located inside the IceCube-170922A error region.

ATel #10791; *Yasuyuki T. Tanaka (Hiroshima University), Sara Buson (NASA/GSFC), Daniel Kocevski (NASA/MSFC) on behalf of the Fermi-LAT collaboration*
on 28 Sep 2017; 10:10 UT

Credential Certification: David J. Thompson (David.J.Thompson@nasa.gov)

Subjects: Gamma Ray, Neutrinos, AGN

Referred to by ATel #: [10792](#), [10794](#), [10799](#), [10801](#), [10817](#), [10830](#), [10831](#), [10833](#)



Tweet



Recommend 3

We searched for Fermi-LAT sources inside the extremely high-energy (EHE) IceCube-170922A neutrino event error region (<https://gcn.gsfc.nasa.gov/gcn3/21916.gcn3>, see also ATels 10773, 10787) with all-sky survey data from the Large Area Telescope (LAT), on board the Fermi Gamma-ray Space Telescope. We found that one Fermi-LAT source, TXS 0506+056 (3FGL J0509.4+0541 and also included in the 3FHL catalog, Ajello et al., [arXiv:1702.00664](https://arxiv.org/abs/1702.00664), as 3FHL J0509.4+0542), is located inside the IceCube error region. The FAVA (Fermi All-sky Variability Analysis) light curve at energies above 800 MeV shows a flaring state recently (<https://fermi.gsfc.nasa.gov/ssc/data/access/lat/FAVA/SourceReport.php?week=477&flare=27>). Indeed, the LAT 0.1--300 GeV flux during 2018 September 15 to 27 was $(3.6 \pm 0.5) \times 10^{-7}$ photons cm⁻² s⁻¹ (errors are statistical only), increased by a factor of ~6 compared to the 3FGL flux, with

Related

- 10833 VERITAS follow-up observations of IceCube neutrino event 170922A
- 10831 Optical photometry of TX0506+056
- 10830 SALT-HRS observation of the blazar TXS 0506+056 associated with IceCube-170922A
- 10817 First-time detection of VHE gamma rays by MAGIC from a direction consistent with the recent EHE neutrino event IceCube-170922A
- 10802 HAWC gamma ray data prior to IceCube-170922A
- 10801 AGILE confirmation of gamma-ray activity from the IceCube-170922A error region
- 10799 Optical Spectrum of TXS 0506+056 (possible counterpart to IceCube-170922A)
- 10794 ASAS-SN optical light-curve of blazar TXS 0506+056, located inside the IceCube-170922A error region, shows increased optical activity
- 10792 Further Swift-XRT observations of IceCube 170922A
- 10791 Fermi-LAT detection of increased gamma-ray

MAGIC sub-TeV gamma-ray detection from TXS 0506+056

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First-time detection of VHE gamma rays by MAGIC from a direction consistent with the recent EHE neutrino event IceCube-170922A

ATel #10817; *Razmik Mirzoyan for the MAGIC Collaboration*
on 4 Oct 2017; 17:17 UT

Credential Certification: Razmik Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de)

Subjects: Optical, Gamma Ray, >GeV, TeV, VHE, UHE, Neutrinos, AGN, Blazar

Referred to by ATel #: [10830](#), [10833](#), [10838](#), [10840](#), [10844](#), [10845](#), [10942](#)

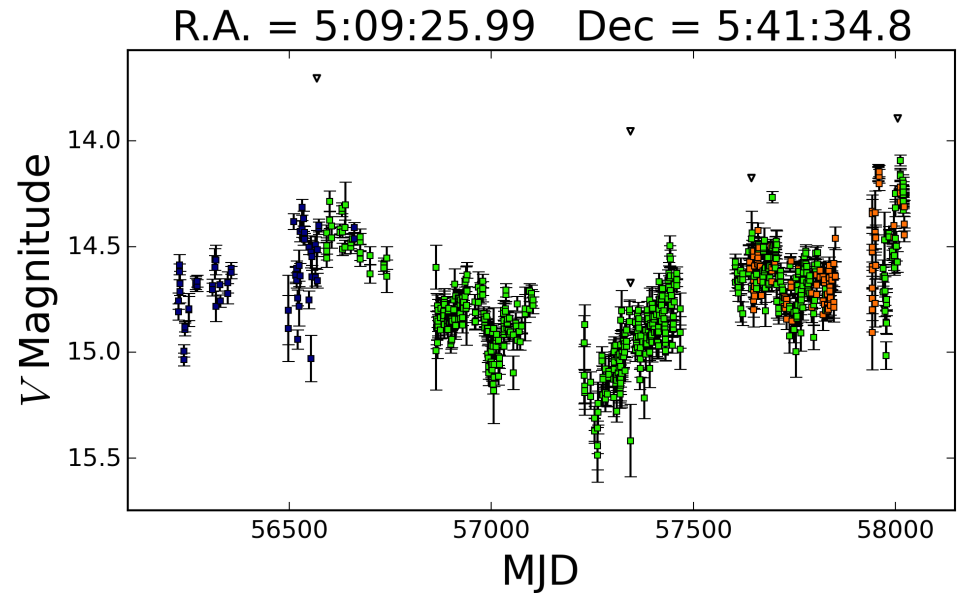
 [Tweet](#)  [Recommend 448](#)

After the IceCube neutrino event EHE 170922A detected on 22/09/2017 (GCN circular #[21916](#)), Fermi-LAT measured enhanced gamma-ray emission from the blazar TXS 0506+056 (05 09 25.96370, +05 41 35.3279 (J2000), [Lani et al., Astron. J., 139, 1695-1712 (2010)]), located 6 arcmin from the EHE 170922A estimated direction (ATel #[10791](#)). MAGIC observed this source under good weather conditions and a 5 sigma detection above 100 GeV was achieved after 12 h of observations from September 28th till October 3rd. This is the first time that VHE gamma rays are measured from a direction consistent with a detected neutrino event. Several follow up observations from other observatories have been reported in ATels: #[10773](#), #[10787](#), #[10791](#), #[10792](#), #[10794](#), #[10799](#), #[10801](#), GCN: #[21941](#), #[21930](#), #[21924](#), #[21923](#), #[21917](#), #[21916](#). The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) E. Bernardini (elisa.bernardini@desy.de), K.Satalecka (konstancja.satalecka@desy.de). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Observatory Roque de los Muchachos on the Canary island La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

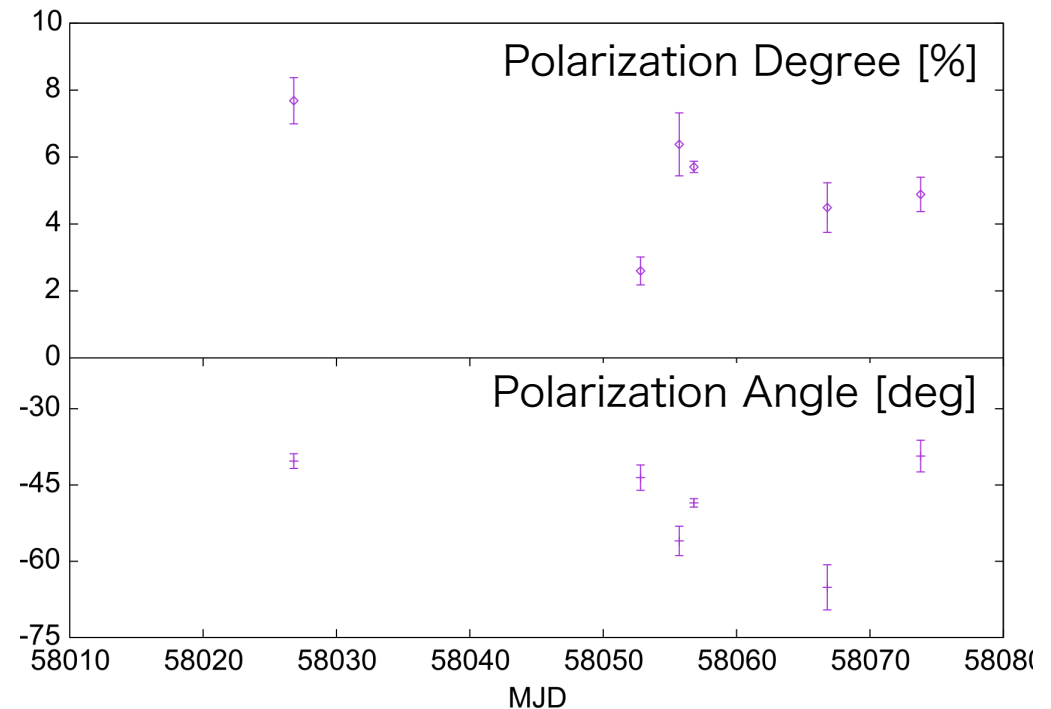
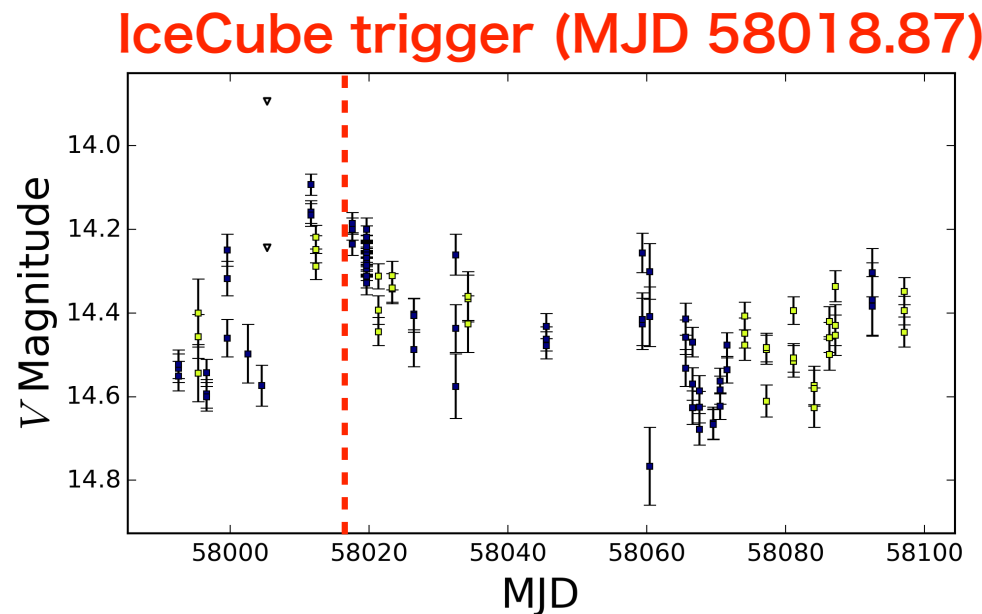
Related

- 10942 [IceCube-171106A: Swift observations](#)
- 10890 [Subaru/FOCAS Optical Spectroscopy for a possible IceCube-170922A counterpart TXS 0506+056](#)
- 10861 [VLA Radio Observations of the blazar TXS 0506+056 associated with the IceCube-170922A neutrino event](#)
- 10845 [Joint Swift XRT and NuSTAR Observations of TXS 0506+056](#)
- 10844 [Kanata optical imaging and polarimetric follow-ups for possible IceCube counterpart TXS 0506+056](#)
- 10840 [VLT/X-Shooter spectrum of the blazar TXS 0506+056 \(located inside the IceCube-170922A error box\)](#)
- 10838 [MAXI/GSC observations of IceCube-170922A and TXS 0506+056](#)
- 10833 [VERITAS follow-up observations of IceCube neutrino event 170922A](#)
- 10831 [Optical photometry of TXS 0506+056](#)
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- 10817 [First-time detection of VHE gamma rays by MAGIC from a direction consistent with the recent EHE neutrino event IceCube-170922A](#)
- 10802 [HAWC gamma ray data prior to IceCube-170922A](#)
- 10801 [AGILE confirmation of gamma-ray activity from the](#)

ASAS-SN optical V-band light curve and polarization measurement by Kanata/HONIR



- IceCube trigger time corresponds to the brightest phase in the optical band, indicating the possible association with IceCube neutrino and this flaring blazar
- Significant polarization (~6% PD) was detected (interstellar polarization is <1%)



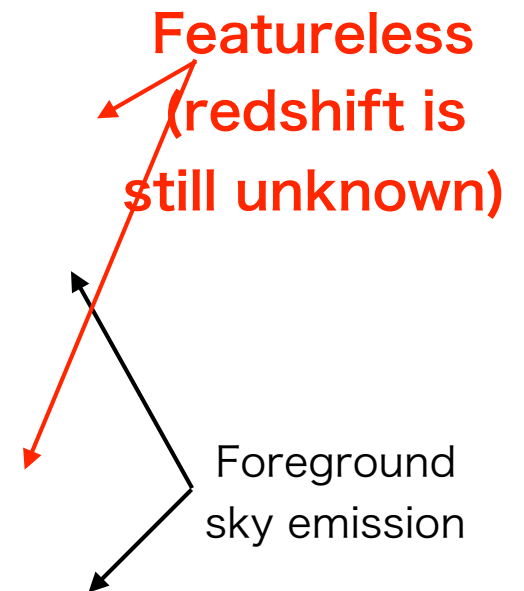


Subaru/FOCAS spectroscopy (Morokuma+, ATel #10890)

Subaru/FOCAS follow-up to measure the redshift

TXS 0506

Nearby star



Summary

- Fermi-LAT detected a flaring blazar, TXS 0506+056, inside the error region of IceCube-170922A
- MAGIC also detected sub-TeV emission from TXS 0506+056, supporting the possible association between the IceCube neutrino and the blazar
- The neutrino flux is comparable to GeV-TeV gamma-ray flux, further supporting the association
- Multi-wavelength follow-ups were triggered after the Fermi-LAT detection
- We have also performed optical ToO observation toward this blazar with Kanata/HONIR, Kiso/KWFC, Subaru/HSC, FOCAS etc
- Redshift is still unclear
- CTA-LST follow-up for IceCube alert is definitely important to discover the second blazar association