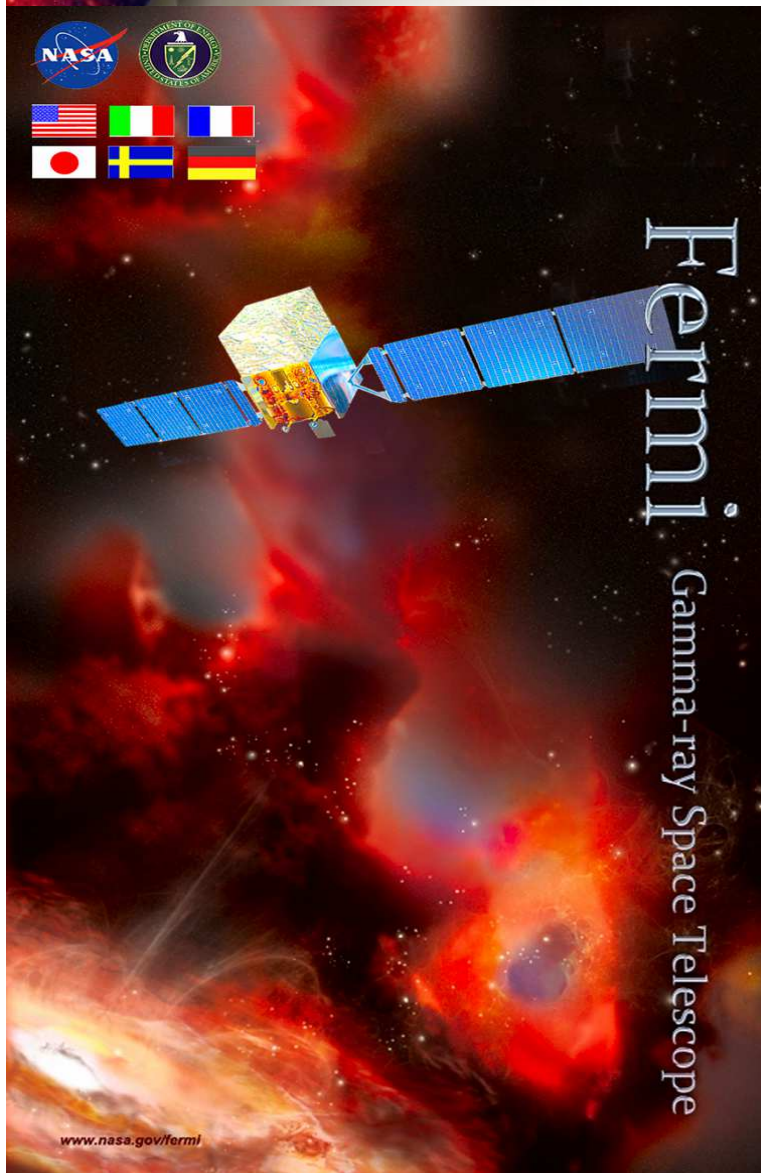


9th International Fermi Symposium



12.5 Years of Fermi LAT Flare Advocate Service

Stefano Ciprini^{1,2},
Roberto Angioni^{1,2}, Simone Garrappa³,
Roopesh Ojha⁴, Sara Buson⁵
on behalf of the Fermi LAT Collaboration

1) INFN Rome Tor Vergata

2) ASI Space Science Data Center, Rome

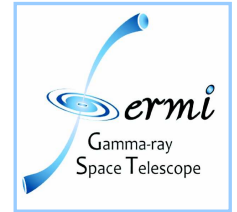
3) DESY Zeuthen

4) NASA/GSFC/UMBC

5) Univ. Wuerzburg

9th International Fermi (Virtual) Symposium





FA-GSW service: prompt/follow-up science

Fermi LAT: unique gamma-ray ALL-SKY + ALL-TIMES mission (spatial sky SURVEY scanning + TIME-DOMAIN monitor). EM photon multi-frequency & particle multi-messenger synergy.

SURVEY → **time-domain science**
uniformity serendipity
variability transients
cross-correl. cross-match.

FA-GSW Blazars

FA-GSW Radio Galaxies

FA-GSW Novae

Sun: flares

FA-GSW Unidentified Sources

Science Neutrinos

FA-GSW

FA-GSWs usually see also:
Moon, Crab flares, long GRBs, Galactic binaries flares, unassociated transients... (anything can be detected over >6 hour all-sky maps, variability scales > hours).

- ❑ The **Flare Advocate (FA)**, a.k.a. **Gamma-ray Sky Watcher (GSW)** is a service of the Fermi LAT Science Operations.
→ It is a contribution to avoid leaving the LAT gamma-ray sky unattended, day by day, and to prompt alert flares.
- ❑ Timescales of interest: **one/some days** typically; sometimes also 6-hour intervals.
- ❑ The **FA-GSW service** is **useful** also for neutrino gamma-ray and multi-messenger astro-particle physics.

New shifters from the LAT collaboration are always welcome !
(this is mainly an AGN/blazar topic)



FA-GSW service: prompt/follow-up science



- Supply a **first and prompt human outlook to automatic science processing (ASP) products** (SLAC/Stanford software pipelines for LAT science data processing) and to the Fermi LAT **gamma-ray sky**, day by day, reprocessing with likelihood analysis wavelet seeds by all-sky scans.
- Further tools used: **FAVA** at **GSFC**, SkyExplorer and catalogs at the **SSDC**, **NED** and **Simbad** databases.
- Look for **flares, transients, pop up of new sources, brightness trends, spectral-hard sources, high-redshift source flares**, and anything **of interest** on intervals/skymaps of days (1 week, 1 day, 6 hours).

Flare Advocate (FA) task.

To look for:

- sources **above daily flux threshold** (10^{-6} ph/cm²/s);
- particularly **hard sources** (phot. index <1.8, photons >20GeV);
- new/interesting flares, transients, variability trends;**
- comparison with historical **light curves** in ASP and FSSC.



Gamma-ray Sky Watcher (GSW) task.

To outlook:

- new/interesting transients and sources** (not clearly associated);
- 6h/daily/weekly all sky maps and FAjobs confluence daily report tables;**
- 6h/daily/weekly ASP tables of PGWave sources and DRP monitored sources;**
- guess associations** (FGL/FHL cats, radio/opt/X-ray counterparts, SSDC sky explorer).

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

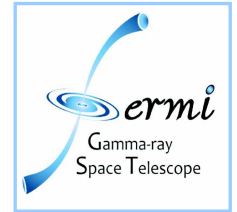
Referred to by ATel #: 10792, 10794, 10799, 10801, 10817, 10830, 10831, 10833, 10838, 10840, 10844, 10845, 10861, 10890, 10942, 11419, 11430, 11489, 12260



stefano.ciprini@ssdc.asi.it
INFN Tor Vergata & SSDC ASI, Rome

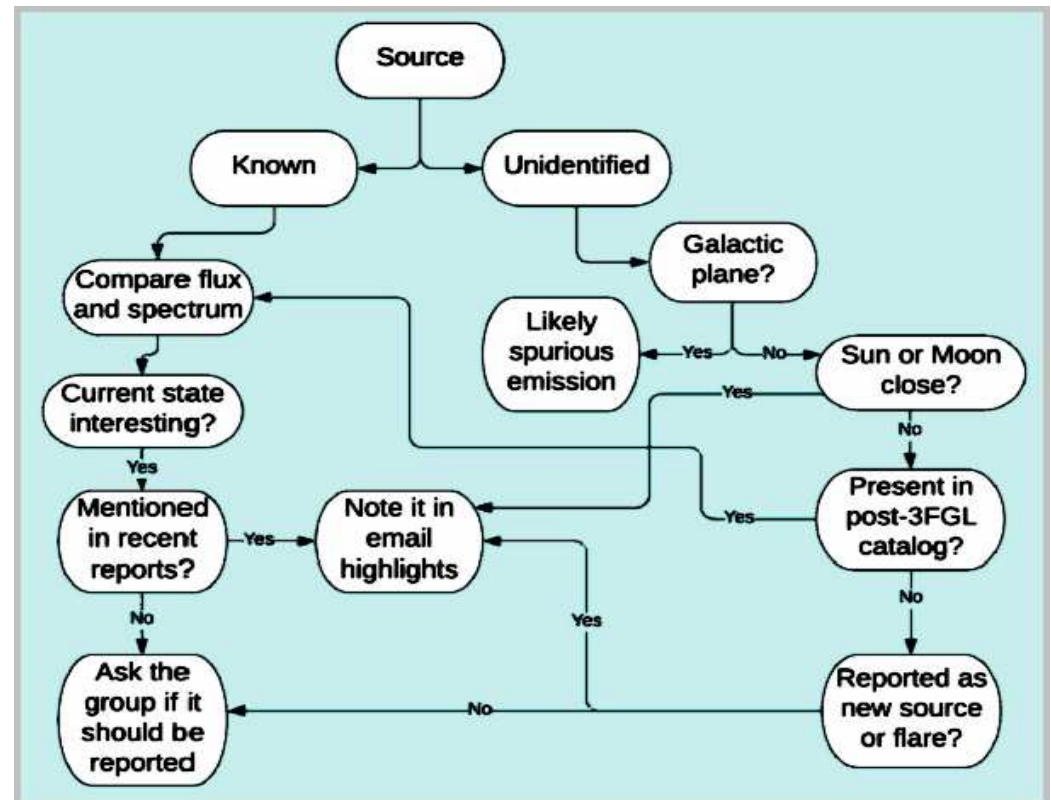


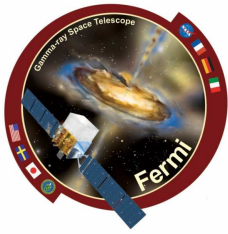
FA-GSW service: a scientific routine



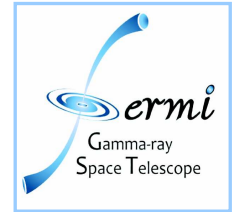
- Point out something potentially **interesting** to **LAT science groups** (AGN, sometimes Galactic).
- Compile systematically **daily reports** internal to the **LAT Collaboration** since the end of July 2008.
- Communicate basic and relevant **information** and **“breaking news”** about the **gamma-ray sky** to the **external** astrophysical community and internal science groups (**Astronomer’s Telegrams, ATels, e-mails, GCNs**), promoting multi-freq. observations following-up LAT data, and maximizing LAT data exploitation:

- provide **timely alerts** about gamma-ray transients;
- trigger **follow-up observations, directly** (e.g. Swift and other radio-optical-X-ray ToOs) or **indirectly** (e-mails to VHE gamma-ray community);
- publish **dedicated studies** on interesting events with **good multi-frequency coverage**;
- participate in **large multi-frequency publications** and **follow-up on neutrino detections**.





FA-GSW: multifrequency and multimessenger



FA-GSWs & MULTIFREQUENCY:

i.e. to emphasize multifrequency nature of LAT-detected sources.

1. **Science** (help to get the best science from the LAT; avoid to miss opportunities; most topics **benefits from multifrequency coverage**; rapid flares need short and quick multifrequency response).
2. **Fermi LAT health** (a service also for the external community; external **cooperative efforts**; initial triggers and contribution to LAT **science**).
3. **FA-GSW's personal recognition** (personal **development** and **recognition** within LAT and external communities; personal visibility; a good way to learn about the gamma-ray sky and multifreq databases and conduct and participate to analysis and papers).

multi-frequency (γ)

ASP-FAjobs comparisons,
LAT coll. internal daily reports,
position/association quicklook,

ATels
emails to science groups,
email to TeV collaborations,
MW ToOs (Swift, optical, etc.),

MW campaigns,
source friendship,
papers on flares/MW-campaigns,
papers on new sources, transients

FA-GSWs & MULTIMESSENGER:

1. emphasize **Fermi LAT potentialities** in this important field;
2. **large visibility** in astroparticle/astrophysics communities, participation to studies and papers .

☐ **Cosmic neutrinos: LAT follow-up of IceCube GCNs** using its position **error regions** and **time intervals longer** (1 year too) than usual prompt/simultaneous flare search .

multi-messenger ($\gamma + \nu + \dots$)

Neutrino IceCube GCN/AMON Notice:

- posit. & err.circ. LAT follow up
(FGLs/FHLs catalogs, ASP+FAreps daily,
ASP+FAVA weekly, MW ATels, more...)

Neutrino IceCube GCN Circular

- refined posit. err.circ. LAT f.up
- quicklook: 1d, 1m, 1y LAT maps/detect.

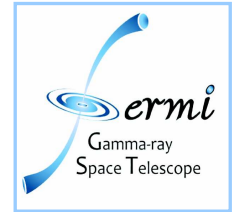
In case of a candidate LAT source:

- LAT **1-year-before light curve**
- Initial work for **paper...**

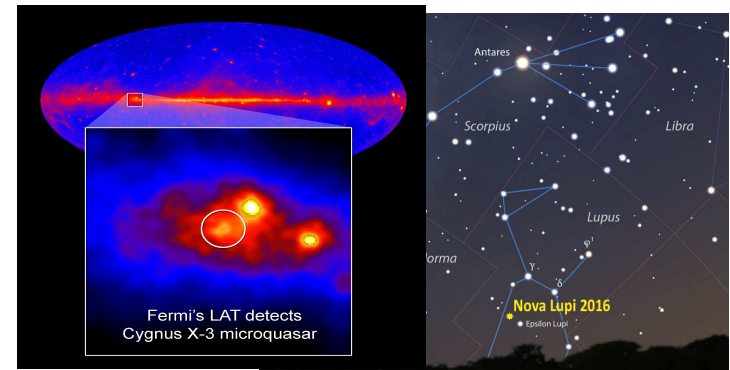
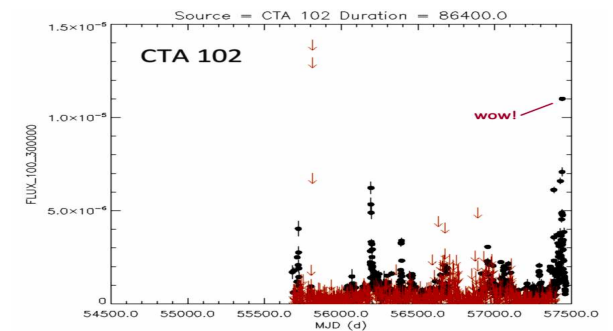
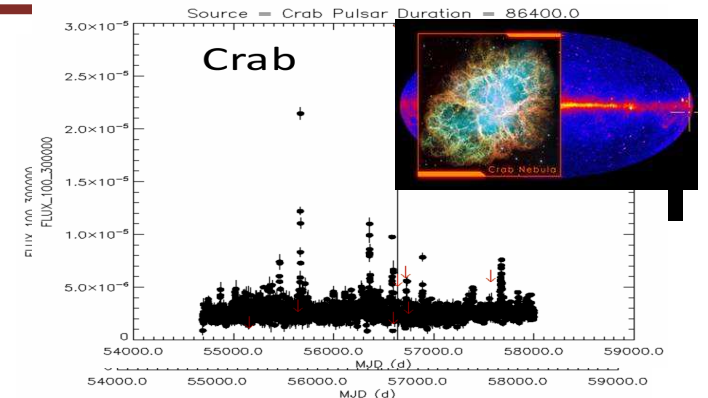
☐ Likely we will have in the next future **CTA/LSST/SKA... flare advocates and sky watchers** (following the Fermi LAT experience) looking at the automated science products and pipelines of these experiments/observatories.



FA-GSW service: interesting facts

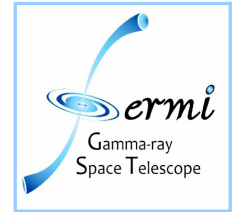


- ❑ Episodes of enhanced gamma-ray activity from the Crab nebula ($> 4.0 \times 10^{-6}$ phot. $\text{cm}^{-2} \text{s}^{-1}$ in daily interval).
- ❑ Outburst and flares of LAT blazars with many Swift ToOs following-up.
- ❑ Important daily/few-day detections on active classical novae.
- ❑ Quite/flaring Sun and Moon detected quite often. Usual LAT microquasars detected often, flares too (ex. Cygnus X-3).
- ❑ Blazars (BL Lacs and FSRQs) detected with hard spectral states sometimes (daily photon index smaller than 1.8, some $> 20 \text{ GeV}$ photons consistent with the source). Last examples: PKS B1035-281, PKS 1717+177, PMN J2052-5533, PKS 0903-57, PKS 0346-27, OQ 334, etc.
- ❑ NLSy1s and radiogalaxies increased activity and flares (rare).
- ❑ Possible new potential sources (associated to radio-opt-X-ray blazars or not) detected and not included in 4FGL catalog.
- ❑ FAVA or ASP weekly-based transients and flares too.

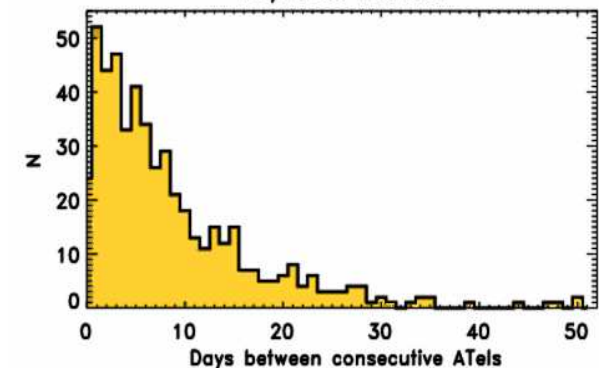
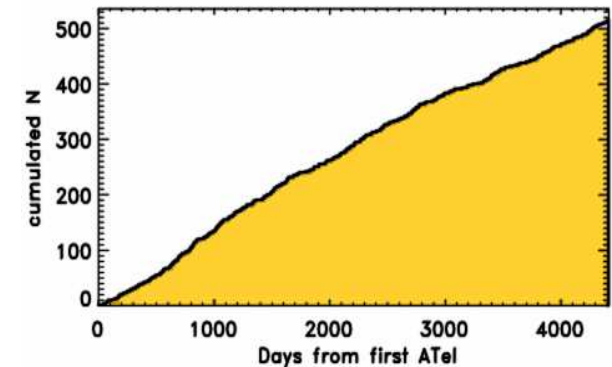
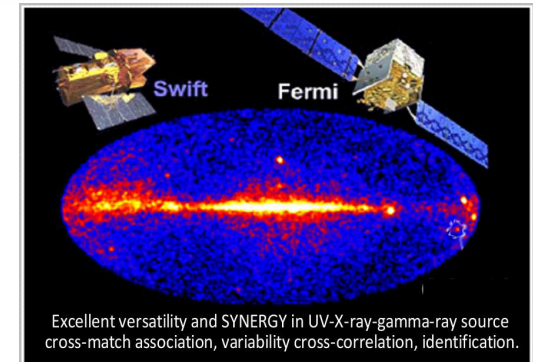


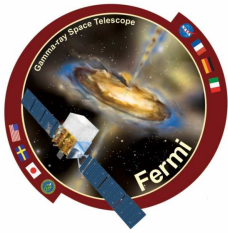


FA-GSW ATel summary



- ❑ From July 24, 2008 to April 12, 2021 (12.7 year period) **554 ATels are published** (3 erratums) by the Fermi LAT Collaboration. Part of these reports **Swift ToO quicklook** results.
- ❑ From September 5, 2008 to March 6, 2021, **327 GCN circulars are issued** by the Fermi LAT Coll.
- ❑ News are continuing to be posted (**Fermi multi-wavelength (MW) mailing list**, **Astronomer's Telegrams (ATels)**, Gamma-ray Coordination Network notes (**GCNs/Fermi Notices**), other notes, **emails** and **communications** to VHE and multifrequency communities).
- ❑ **During the year 2020:**
 - **54 ATels** by the LAT-Collaboration published;
 - two blazars **LAT+multifrequency observing campaign papers** following-up FA-GSW shifts and activities published,
 - **two new hard/VHE/TeV blazars** of interest for Cherenkov telescopes and CTA were announced: OQ 334 (aka B2 1420+32, $z=0.682$) and B2 1811+31 ($z=0.117$).





FA-GSW: example of recent multifrequency campaign on PKS 0346-27



A&A 627, A140 (2019)
<https://doi.org/10.1051/0004-6361/201935461>
 © R. Angioni et al. 2019

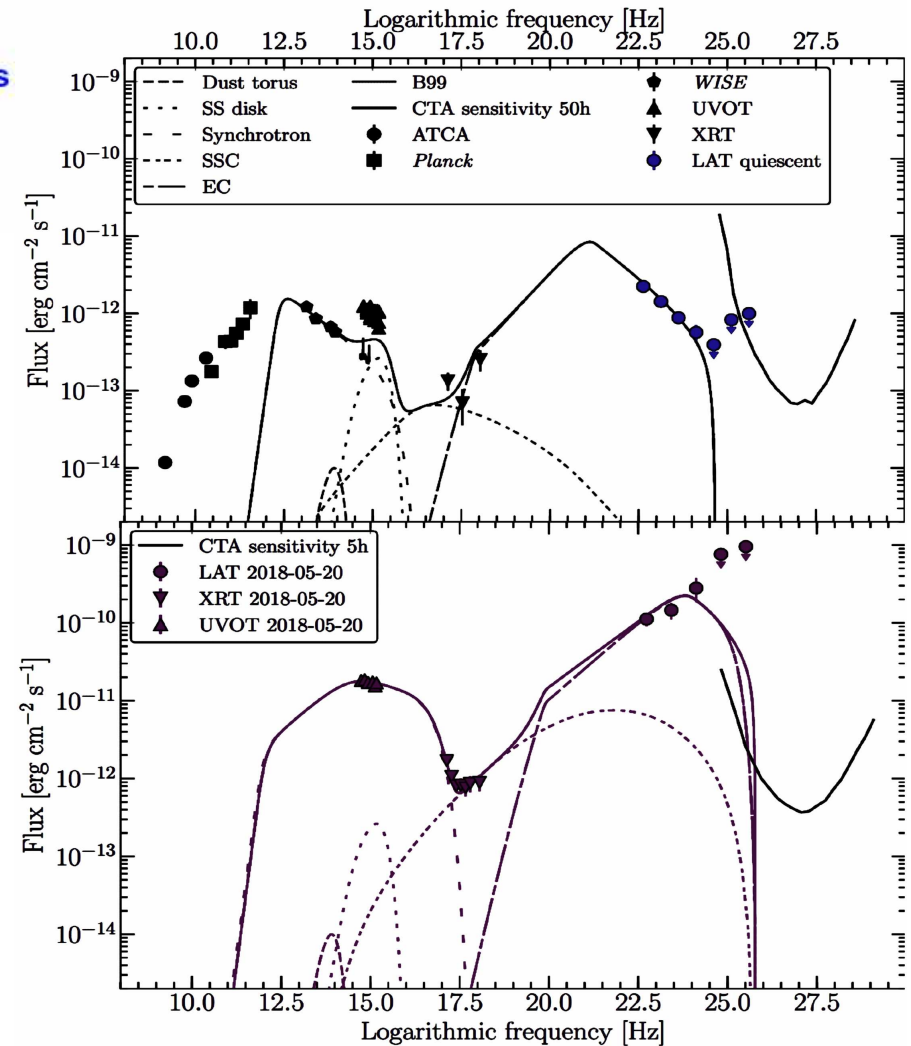
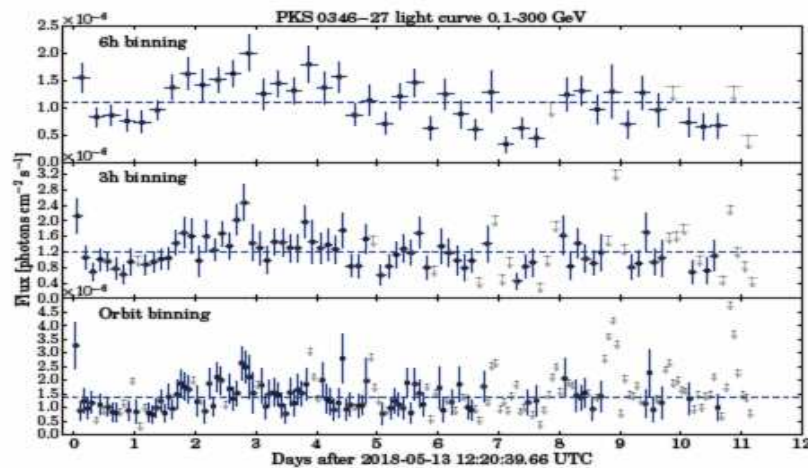
Astronomy
&
Astrophysics

The large gamma-ray flare of the flat-spectrum radio quasar PKS 0346-27*

R. Angioni^{1,2}, R. Nesci³, J. D. Finke⁴, S. Buson², and S. Ciprini^{5,6}

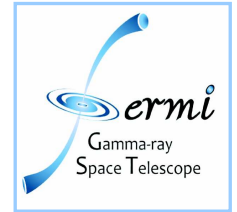
[LAT Cat2 paper: Angioni et al. 2019, A&A 627, 140]

- ❑ FSRQ at $z=0.991$
- ❑ Awakened in 2017-18 with very long lasting flaring state (last ATel Feb.2020)
- ❑ Two orders of magnitude flux increase and SED shift from typical LSP quasar to ISP
- ❑ Promising TeV candidate at relatively high- z

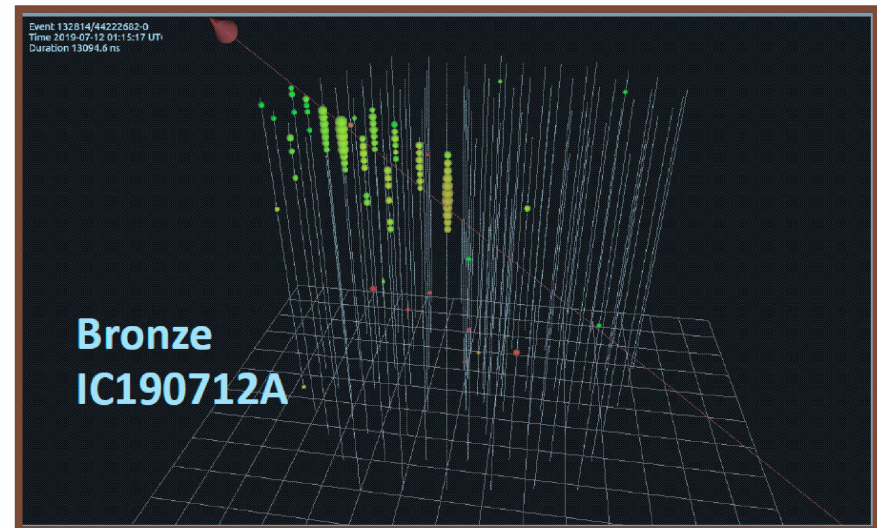
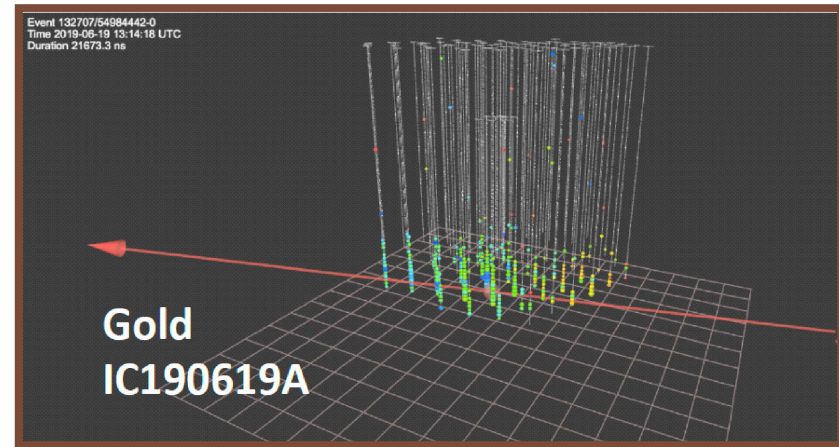




LAT The IceCube Realtime alerts system v2.0



- ❑ LAT Follow-ups of realtime alerts.
- ❑ IceCube sending alerts since April 2016 (within 60 seconds from event detection).
- ❑ New stream as of June 2019.
- ❑ LAT follow-ups crucial to trigger multi-frequency observing campaigns on peculiar sources.



Updated alerts	Gold	Bronze
Signalness	> 50%	>30%
Expected signal/yr	6.6	2.8
Expected bkgd/yr	6.1	14.7



LAT follow up of neutrino alerts



Recent example: analysis of blazar PKS 1502+16 (OR 103).

THE ASTROPHYSICAL JOURNAL, 710:810–827, 2010 February 10
© 2010. The American Astronomical Society. All rights reserved. Printed in the U.S.A.

doi:10.1088/0004-637X/710/1/810

□ First AMON/GCN Notice:

- First reconstruction of the event, with small error and very preliminary

□ First follow-up:

- Check for coincident catalog sources
- Check for transients at short timescales (1-day/1-month)

□ Second GCN Circular (IceCube refined localization) and second follow-up:

- Check for transient at short timescales and in full-mission data.

→ Full, in depth analysis (lightcurves, mwl counterparts...)

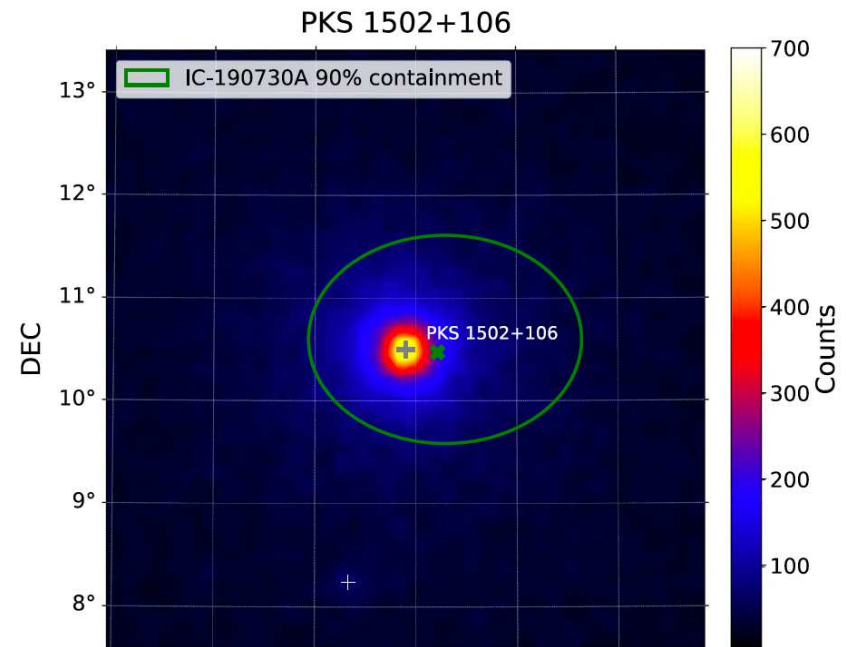
- If we have a detection, we promptly alert the community:

→ Publish ATel, trigger MWL follow-ups...

PKS 1502+106: A NEW AND DISTANT GAMMA-RAY BLAZAR IN OUTBURST DISCOVERED
BY THE *FERMI* LARGE AREA TELESCOPE

LAT gamma-ray discovery Cat1 paper

Abdo et al. 2010, ApJ, 710, 810

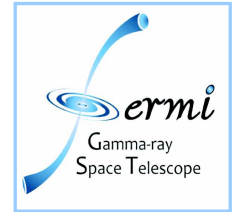


Recent LAT Cat2 paper,
Franckowiak et al. 2020, ApJ 893, 2, 162.





Conclusions



- ❑ The dynamic/variable gamma-ray sky (blazars too) **is continuing to be interesting** hence the **FA-GSW service** is **continuing smoothly**. ASP at SLAC, FAVA and other tools at GSFC for automatic science software processing producing several products.
- ❑ **FA-GSW shifters outlook** these automatic software products and results and **quickly reprocess some data** and **conduct significance/flux checks**, day by day (seven days per week). Particular attention to counterpart preliminary guess association of flares/transients/pop-ups in the LAT sky.
- ❑ Roughly **constant rate** of LAT (LAT data + MW data) **ATels. 554 ATel** up to now (54 in 2020), published on behalf of LAT Coll. **following mainly** (but not entirely) the FA-GSW service.
- ❑ **Prompt reactions** is often crucial in FA-GSW service.
- ❑ Particular **Fermi-Swift synergy** demonstrated here over many years. Other ToOs joint observations performed (radio observatories, Cherenkov telescopes, NuSTAR, INTEGRAL, etc.).
- ❑ Follow-up multi-frequency blazar (and **neutrino multimessenger**) studies are ongoing.
- ❑ FA-GSW routine and shifters also contributes to Fermi's health and scientific productivity.



Backup slides



FA/GSW duty

- ❑ The FA-GSW activities are supported by ISOC.
- ❑ The FA-GSW activities are based on the ISOC Fermi LAT Portal (Science section):
 - ASP Data Viewer,
 - Source Catalog,
 - FA scripts area on /u20/skyWatchers/ in the SLAC Glast Farm)

ASP Data Viewer "processes" task



The daily wiki report

Start a new wiki page

You should start by adding a new *Blog Post* from a protected conference page, like this same page. To add a new *Blog Post* click on the **Blog Post** button at the top left of any protected page. From the drop-down menu select "Blog Post".

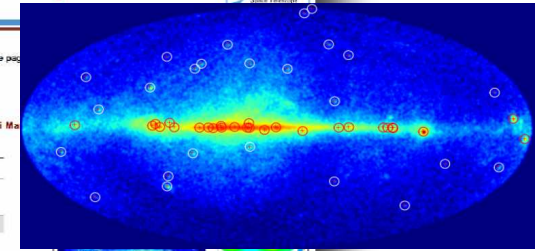
Fill the wiki

- Paste the content of daily.txt file
- Add the page title
- check the DRP output
- add the label #facalryreport

if complete the automatic highlights with your remarks
 if complete the automatic highlights with the list of daily sources seen by DRP process (and not by Pgwave therefore not included in these automatic wiki tables and report)

What about the 10 images archived in the lgz file?
 You attach them to the newly created page by choosing the same Add button, but selecting the Attach button. You can directly drag and drop all the attachments in one move if you have installed Google Gears you can directly drag and drop all the attachments in one move

Email the FA group



ASP Resources

The ASP runs Pgwave and Drp for each daily and 6h interval of the day should be quickly outlooked



ASP DRP process

ASP DRP & DataViewer configuration choices:

- "configuration" link lead to this page
- choose time range (longer → slower)
- disable RSP product
- enable only daily-weekly-six hour data frequency and only flux_100_300000

