

An optical and NIR survey of Fermi sources

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GH workshop, 6 July 2011

MultiWavelength survey of Fermi AGNs

- Simultaneous observations as only tools to understand the various blazar / AGN engines
- Opportunity given Fermi permanent survey mode and telescope time availability
- This survey first conceived around the mm-band

Teams

- Infrared: Luis Carrasco, Alicia Porras, Divakara Mayya, Elsa Recillas, José Ramón Valdés, Gustavo Escobedo & equipo OAGH
- Optical: Daniel Rosa, Divakara Mayya, César Álvarez Ochoa, Oscar Martínez, Vahram Chavushyan, Ibrahim Torres, Eduardo de la Fuente, Gustavo Escobedo...
- mm: ...?
- HAWC: INAOE, BUAP, UNAM, UNaCh, UMD, LANL...

Instrumentos

Fermi γ -ray telescope (operacional desde 2008)

- rango de 100 MeV a 100 GeV
- relevamiento continuo del cielo (cada 3 horas con 25% cobertura)
- datos de dominio público desde 2009

Telescopio de 2m del OAGH - Cananea (operacional)

- fotometría y espectroscopía en el visible (BVRI) = (2.8 - 1.4 eV)
- fotometría en el infrarrojo cercano (JHKs) = (1.0 - 0.6 eV)
- campo de visión de 4 arcmin

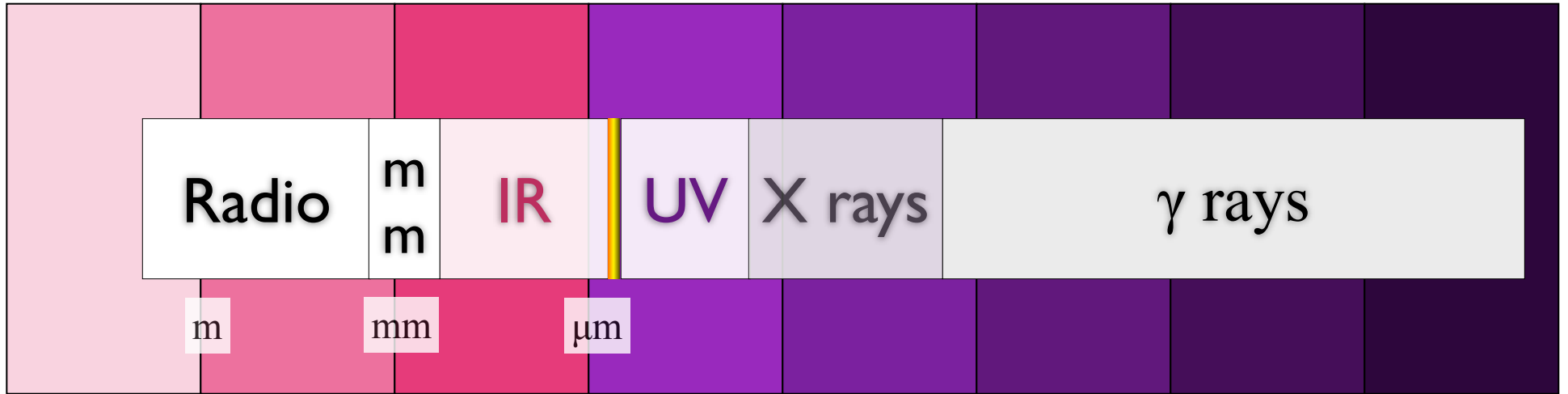
GTM - Sierra Negra (operacional desde junio 2011)

- flujos en bandas de 3.0 a 0.8 mm (0.4 - 1.6 meV)

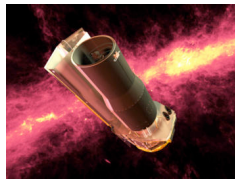
Observatorio de rayos gamma HAWC (en instalación)

- rango de 100 GeV a 100 TeV
- relevamiento continuo de 2/3 del cielo cada 24 horas (<6h / fuente)
- limitado en z

neV μeV meV eV keV MeV GeV TeV PeV

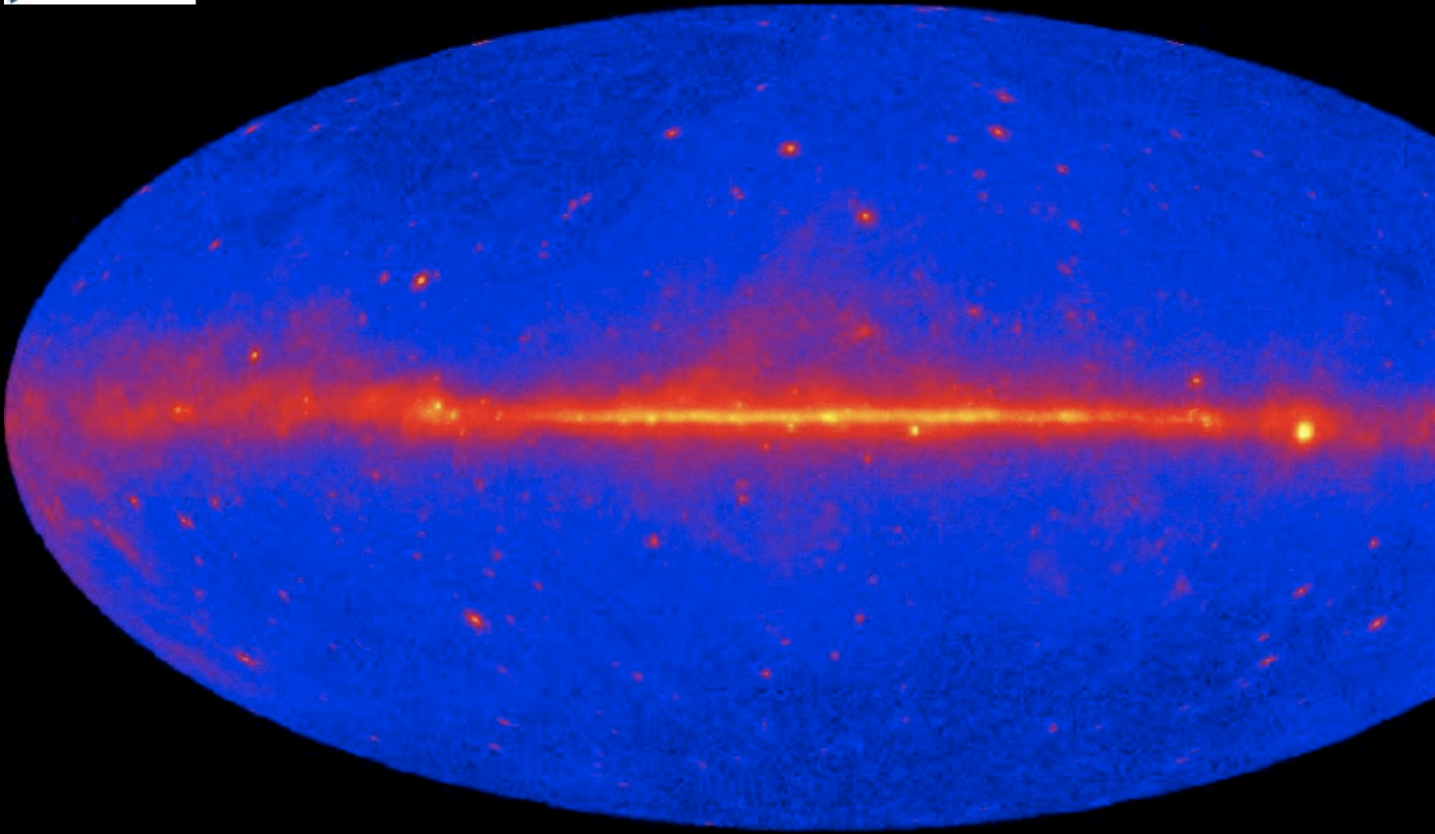


MHz GHz THz



Non thermal (e) \rightarrow **Thermal** \leftarrow Non thermal (CRs)

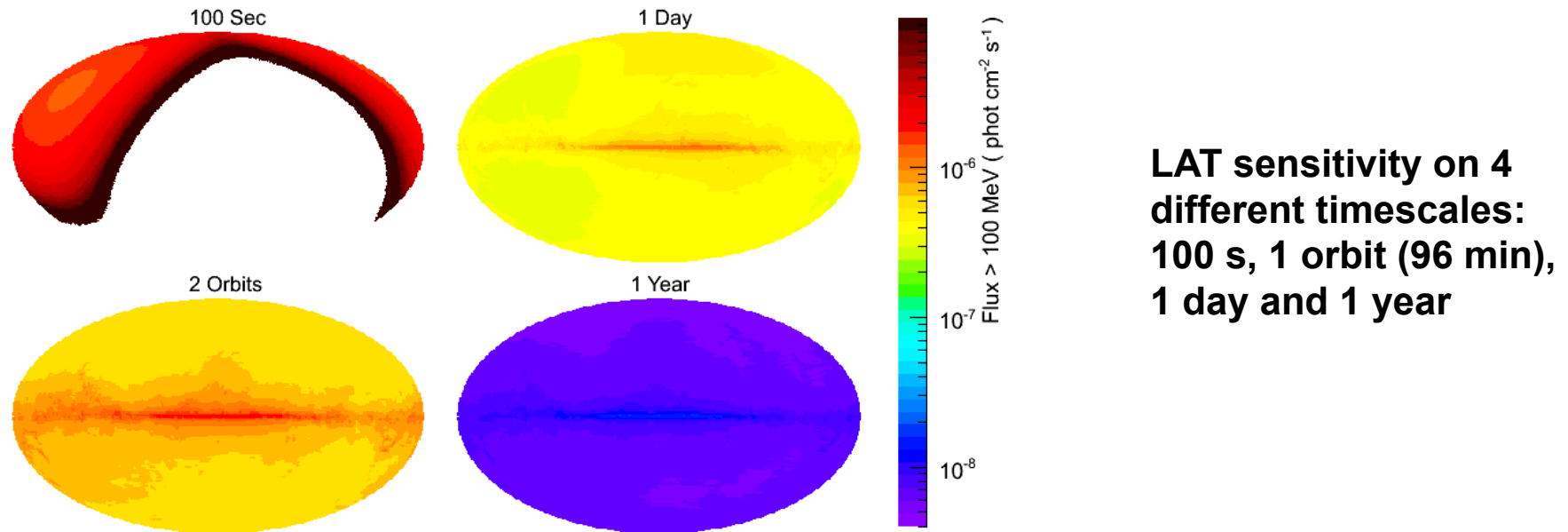
> 1000 LAT sources



- Front > 200 MeV, Back > 400 MeV, log color scale
- Galactic coordinates, Aitoff projection

1FGL	
Extragalactic = 658	
Bl Lac	292
FSRQ	278
Non blazar AGN	25
Uncertain AGN	59
Starburst galaxy	2
Normal galaxy	2
Galactic = 85	
Pulsar	52
SNR	4
snr, pwn, psr	18
Globular cluster	8
XRB	2
μ -quasar	1
No association = 708	

Fermi operations and observing modes

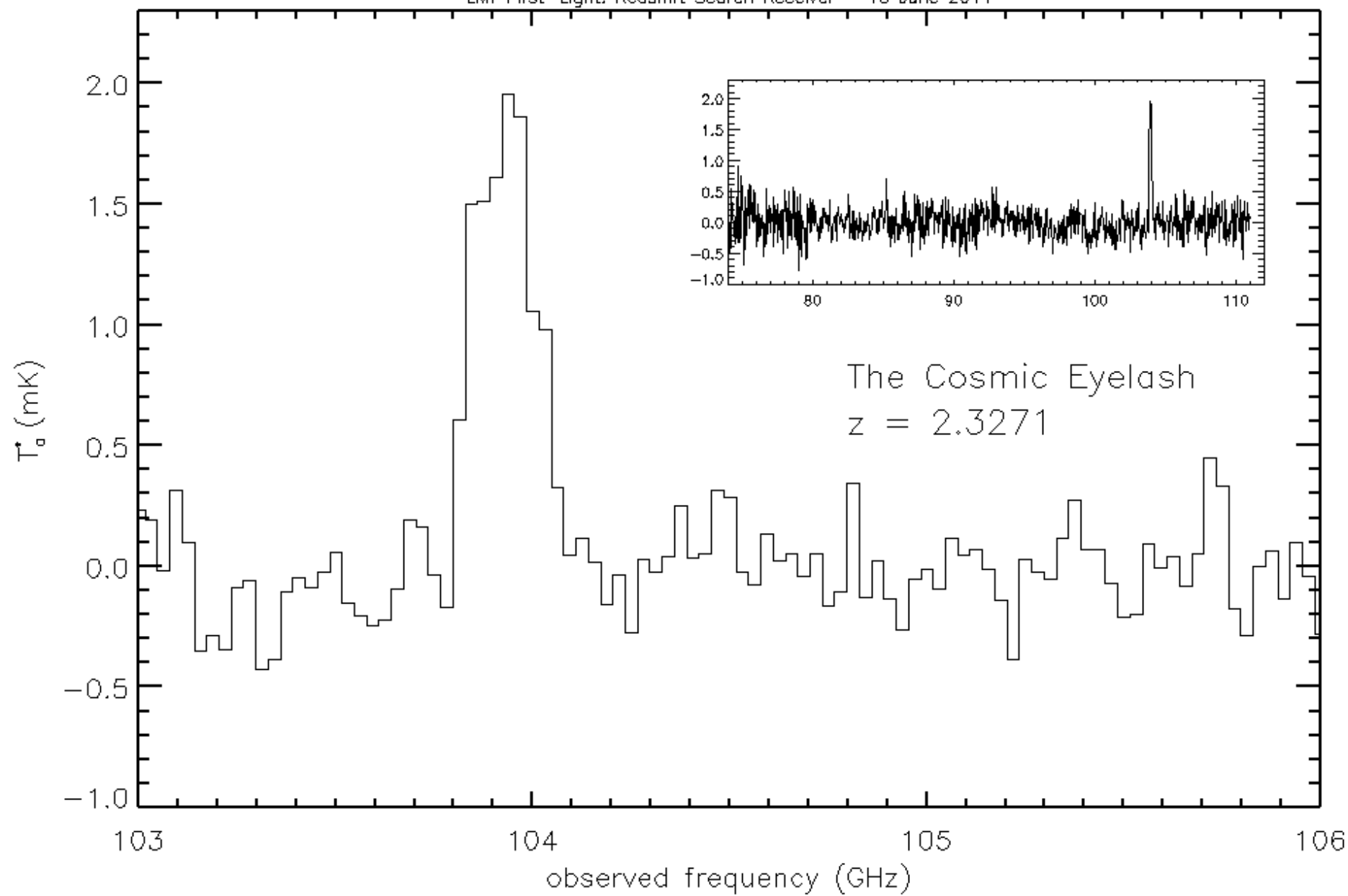


LAT sensitivity on 4 different timescales: 100 s, 1 orbit (96 min), 1 day and 1 year

- Almost all observations in survey mode - the LAT observes the entire sky every two orbits (~ 3 hours), each point on the sky receives ~ 30 mins exposure during this time.
 - 35 deg rocking angle to Sept 2, 50 deg thereafter.
- 30 ARRAs
 - 5 hour pointed mode observations in response to bright GBM detected GRB
- LAT Calibrations (13 hours), Engineering (5 days)
 - Very high ontime!

J. Mc Enery talk, 1st Fermi Symp.





Fermi - OAGH monitoring

- γ -blazar monitoring since August 2007.
- Optical (LFOSC) and infrared (CANICA) photometry
- Programme / sample originally conceived for LMT:
 - GLAST sources of interest
 - 3EG / WMAP matches
 - then 0FGL / WMAP
 - then 1FGL / WMAP
 - + ATELS and fermisky blog reports



Sample

- Pre-launch:
 - GLAST high priority list: 3EGs and TeV sources
 - WMAP 2yr \cap EGRET (3EG and VHE photons - Thompson et al. 2005)
 - First revisions:
 - WMAP 5yr \cap 0FGL
 - ATELS + fermisky.blogspot.com
 - Second revision:
 - WMAP 5yr \cap 1FGL
- Loose association: any positional match $< 2.5\sigma$ accepted

WMAP Catalog

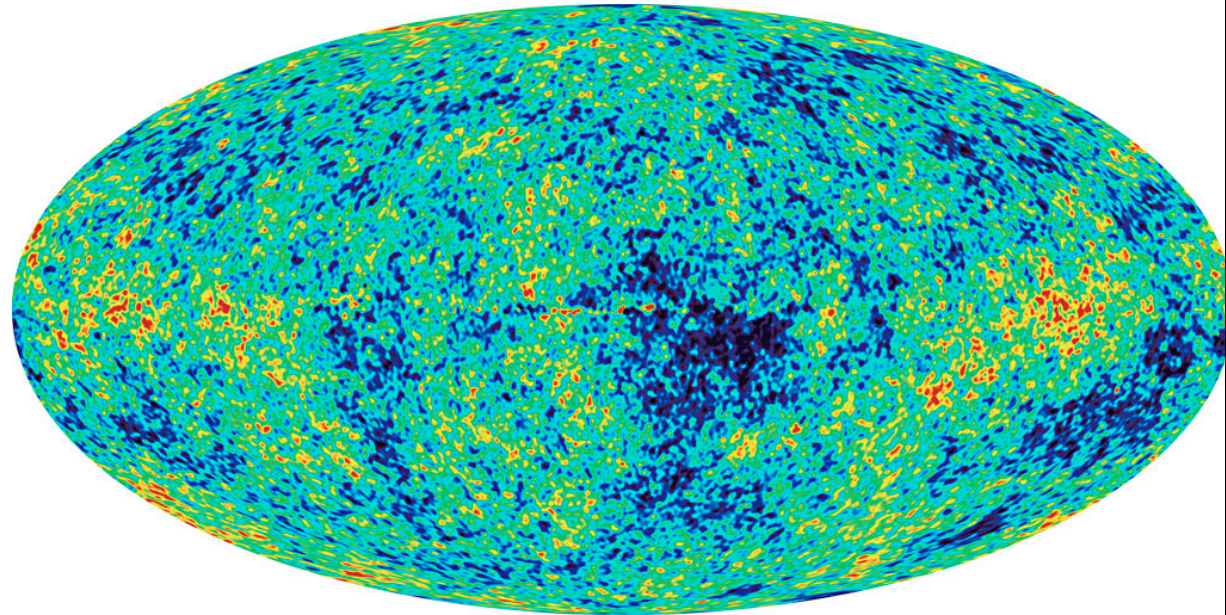
First WMAP foreground source catalog had 208 entries (labelled WMAP nnn - Bennett et al. 2003).

Sources outside a mask covering 11.5% of the sky - Galactic emission.

5 years catalog comprises 390 sources detected above 5σ and catalogued according to celestial coordinates (Wright et al. 2009).

Mrk 421, 1ES 128+304, PKS 1622-297 and NRAO 530 not in WMAP catalog.

Nominal 4 arcmin positional uncertainty.



Band	K	Ka	Q	V	W
Frequency (GHz)	23	33	41	61	94
Noise 1σ (Jy)	0.27	0.41	0.36	0.27	0.14

WMAP variables

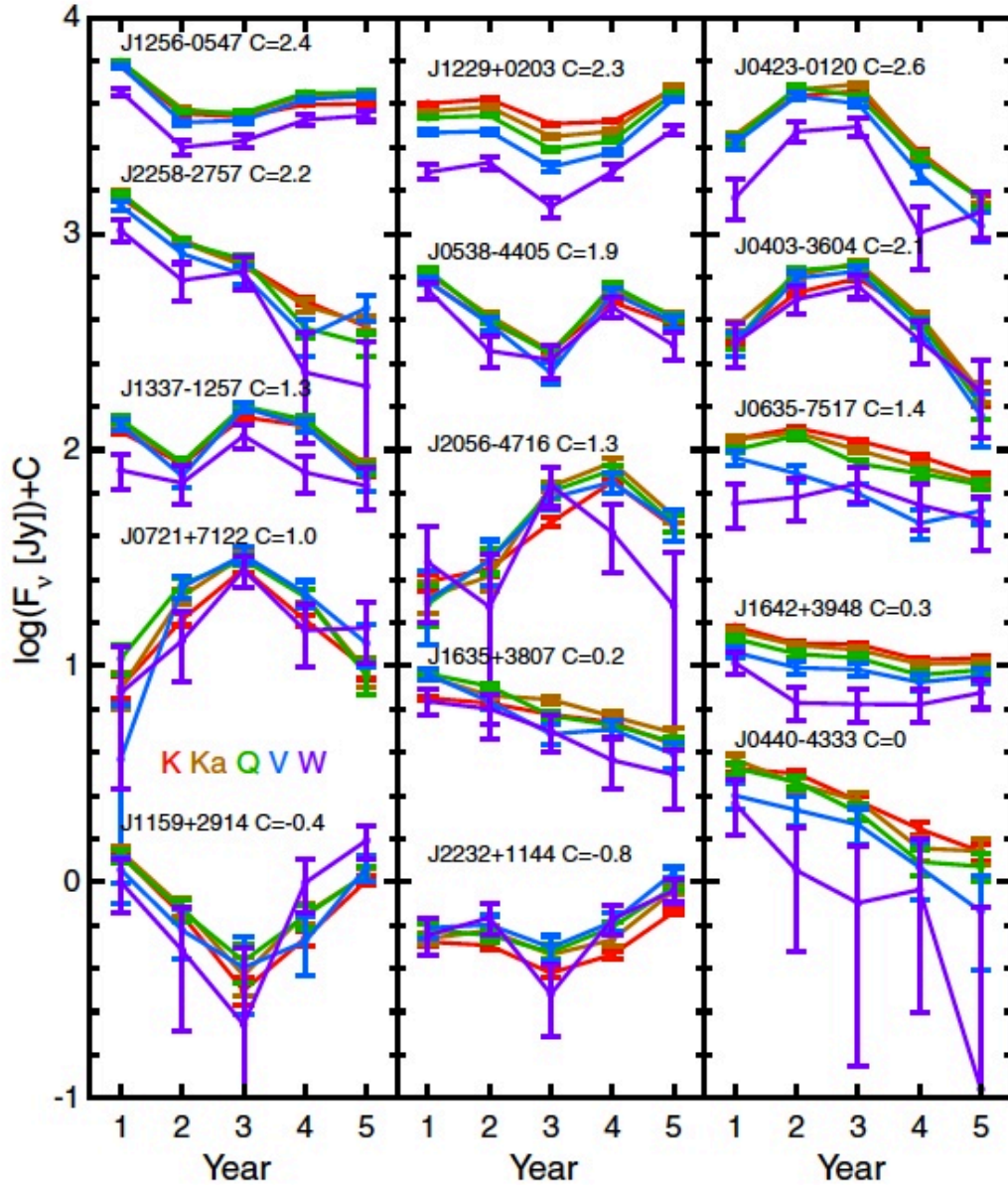
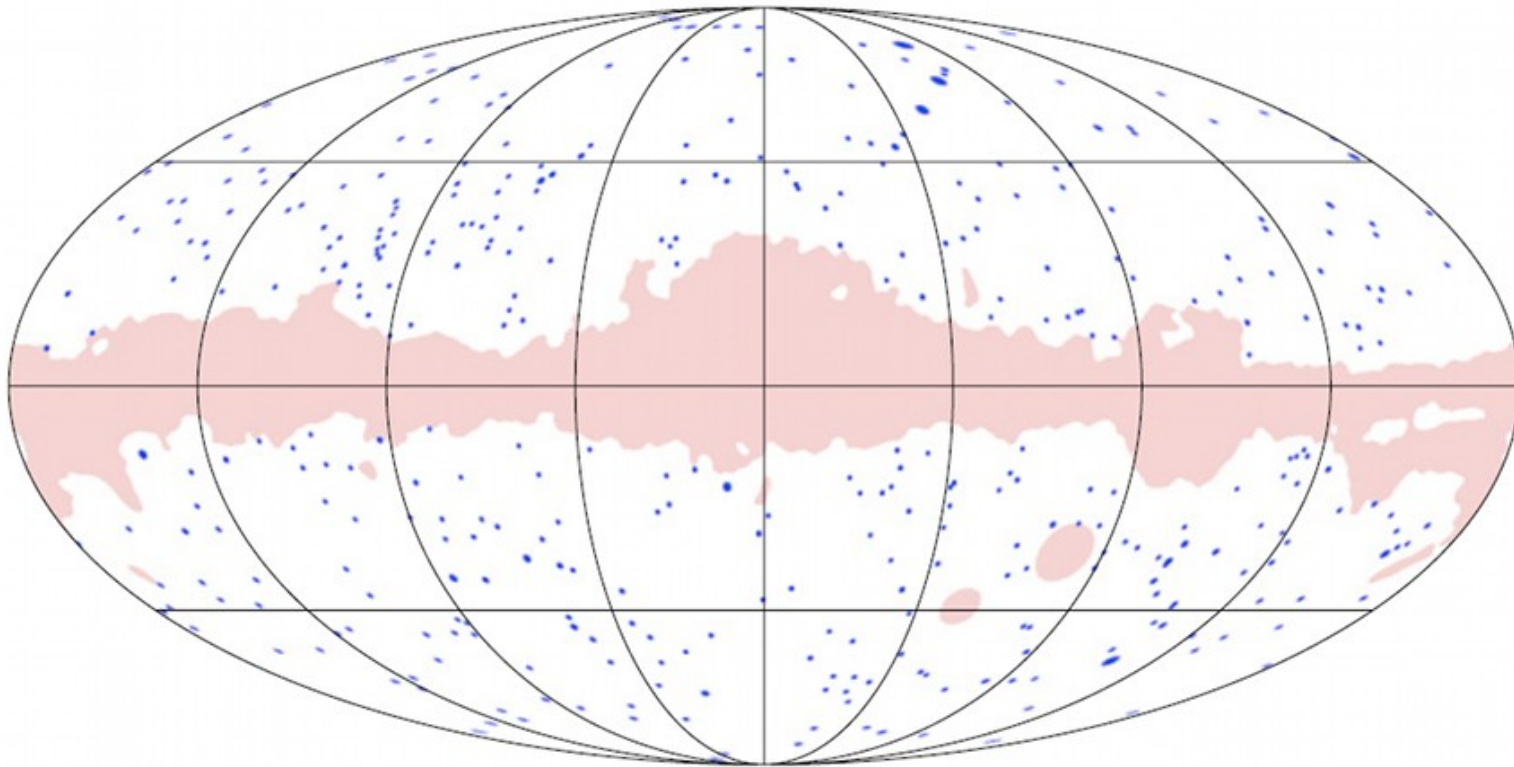


Table 3
Significant Polarization Percentages

WMAP ID	K	Ka	Q
J0322-3711	8.5 ± 0.4	9.3 ± 1.2	8.1 ± 2.2
J0519-4546	5.7 ± 0.9	8.6 ± 2.0	...
J1229+0203	4.9 ± 0.3	4.4 ± 0.6	4.8 ± 0.8
J1230+1223	3.8 ± 0.4	4.8 ± 0.7	4.4 ± 1.0
J1256-0547	3.6 ± 0.4	3.1 ± 0.7	3.8 ± 0.8

J1159+2914 = 4C 29.45
 J1229+0203 = 3C 273
 J1230+1223 = M87
 J1256-0547 = 3C 279
 J1635+3807 = 4C +38.41
 J2232+1144 = CTA 102
 J1642+3948 = 3C 345



(509 / 962) 1FGL sources (inside / outside) WMAP mask

Inside mask:

- 40/52 pulsars; 4/4 SNR; 405/708 unassociated
- BZB: J0035+5950, J0303+4716, J1931+0937, J2012+4628
- 14 PKS sources, including PKS 0528+134
- Two Cambridge radio sources: 4C -06.46, 4C +9.57
- Cen A and μ Bl Lac!!

1FGL - WMAP

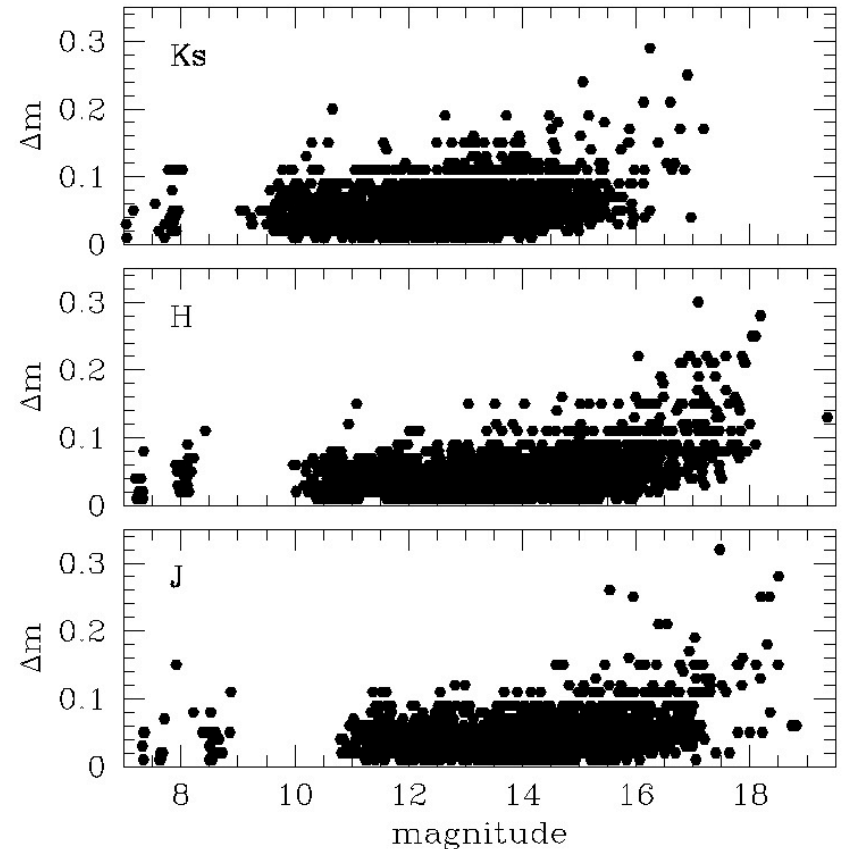
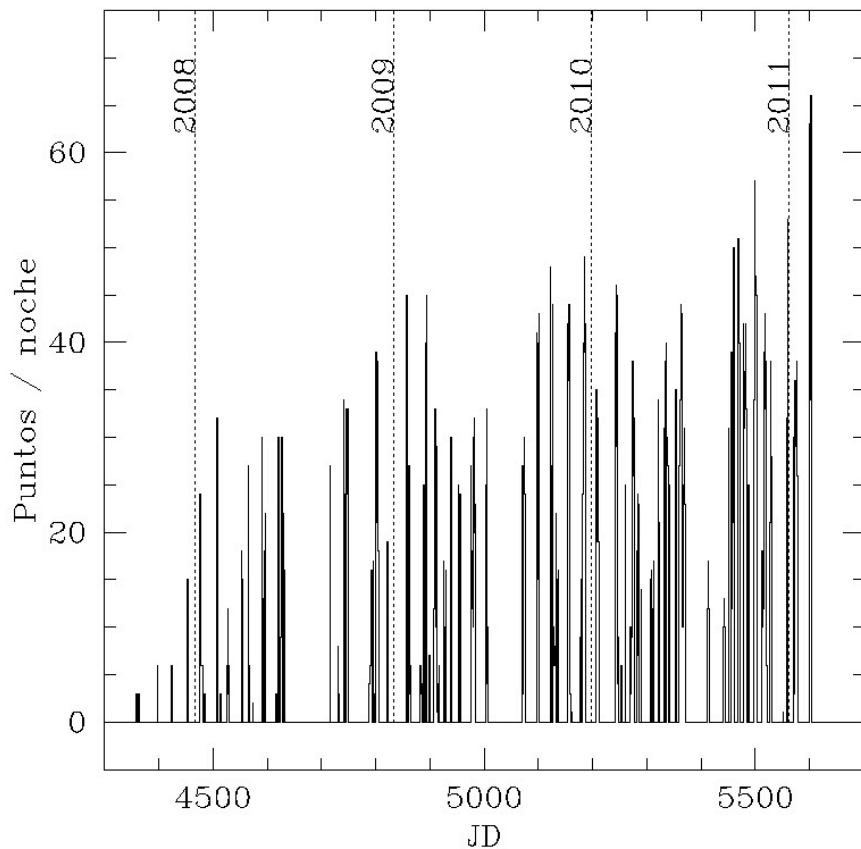
- 1FGL = first Fermi-LAT catalog - 1471 sources of photons $E > 100$ MeV
- WMAP = Wilkinson Microwave Anisotropy Probe Catalog: 390 sources in 23-94 GHz outside the Galactic plane (mask).
- 962 (/1471) 1FGL sources outside the mask
→ 167 positional matches with WMAP (B1 Lac “by hand”) of which 33 are too south ($\delta \leq 37^\circ$)
- Error boxes do not warrant IDs

Sample (2)

- Pre-launch:
 - GLAST / *Fermi* high priority list: 3EGs and TeV sources
 - WMAP 2yr \cap EGRET (3EG and VHE photons - Thompson et al. 2005)
 - First revisions:
 - WMAP 5yr \cap 0FGL
 - ATELS + fermisky.blogspot.com
 - Second revision:
 - WMAP 5yr \cap 1FGL
- Loose association: any positional match $< 2.5\sigma$ accepted

Muestra OAGH Canica

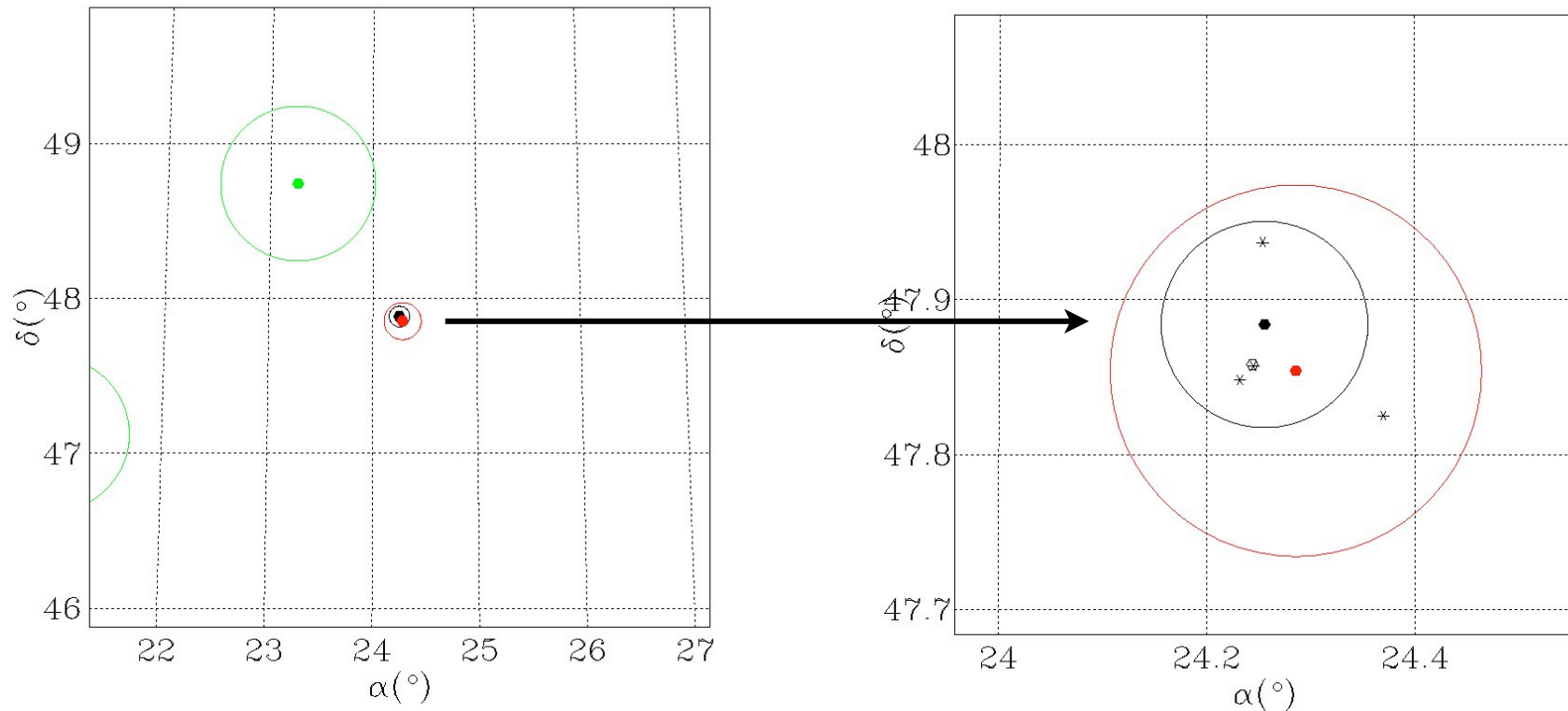
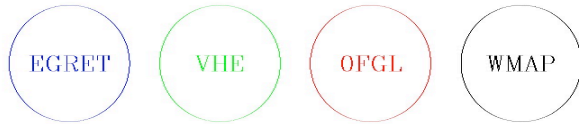
- 6190 mediciones fotométricas desde JD 2454358
- 207 objetos medidos: blazares + algunos Galácticos



Object	Npoints	
Mrk 421	243	Good short term data; γ -ray data with low S/N
3C454.3	218	Very good correlation
BL Lac	176	apparent correlation
3C 66A	142	No clear correlation; missed brief γ -ray flare in mid 2008
Mrk 501	112	Noisy Fermi data
PKS 0716+714	112	High variability in both bands, with no clear correlation
QSO B0133+476	112	No Fermi light curve
W Comae	111	Good short term data; γ -ray data with low S/N
3C 273	110	Missed fall γ -ray flare. Normalization pending.
OJ 287	109	Noisy γ -ray data; no clear correlation
1ES 1959+650	102	Noisy γ -ray data; no clear correlation
PKS 0235+164	102	Correlated flare second half 2008
PKS 0528+134	99	Partial correlation; IR data prior to Fermi
OJ 248	97	Noisy γ -ray data; no clear correlation

Table 2: Better sampled objects.

QSO B0133+476



Not a 3EG source

Our first evidence was the single VHE photon

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Infrared flaring of the potential gamma-ray source QSO B0133+47

ATel #1874; [A. Carramiñana, L. Carrasco, E. Recillas, V. Chavushyan \(INAOE\)](#)
on 12 Dec 2008; 17:44 UT

Distributed as an Instant Email Notice (Transients)

Password Certification: Alberto Carramiñana (alberto@inaoep.mx)

Subjects: Infra-Red, Gamma Ray, AGN, Quasars

Referred to by ATel #: [1877](#)

We call attention on our recent observations of QSO B0133+47 with the Cananea NIR camera (CANICA) on the 2.1m telescope at the Observatorio Astrofísico Guillermo Haro. We found this quasar to show fluxes 2.5 magnitudes brighter than 2MASS values, of epoch 1999, but undergoing a rapid decline:

H = 12.356 ± 0.01 at JD 2454788.761732

H = 12.440 ± 0.03 at JD 2454790.816569

H = 12.769 ± 0.02 at JD 2454794.642166

QSO B0133+47 is positionally coincident with the bright mm source WMAP 80 (Bennett et al. 2003) and the VHE photon 1379 (Thompson, Bertsch, O'Neal Jr. 2005) and we consider it of high interest for space borne gamma-ray observatories. We encourage multiwavelength monitoring of this object.

Related

- 1877 [Fermi LAT detection of a gamma-ray source positionally consistent with QSO B0133+47](#)
- 1874 [Infrared flaring of the potential gamma-ray source QSO B0133+47](#)

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Fermi LAT detection of a gamma-ray source positionally consistent with QSO B0133+47

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- 1874 [Infrared flaring of the potential gamma-ray source QSO B0133+47](#)

ATel #1877; [H. Takahashi \(Hiroshima University\)](#), [G. Tosti \(INFN/University Perugia\)](#) on behalf of the [Fermi Large Area Telescope Collaboration](#)

on 16 Dec 2008; 23:57 UT

Password Certification: [Hiromitsu Takahashi \(hirotaka@hep01.hepl.hiroshima-u.ac.jp\)](mailto:hirotaka@hep01.hepl.hiroshima-u.ac.jp)

Subjects: Gamma Ray, >GeV, AGN, Quasars

The Large Area Telescope (LAT), one of two instruments on the Fermi Gamma-ray Space Telescope (formerly GLAST, launched June 11, 2008), has detected one gamma-ray source positionally consistent with QSO B0133+47 reported in ATEL #1874.

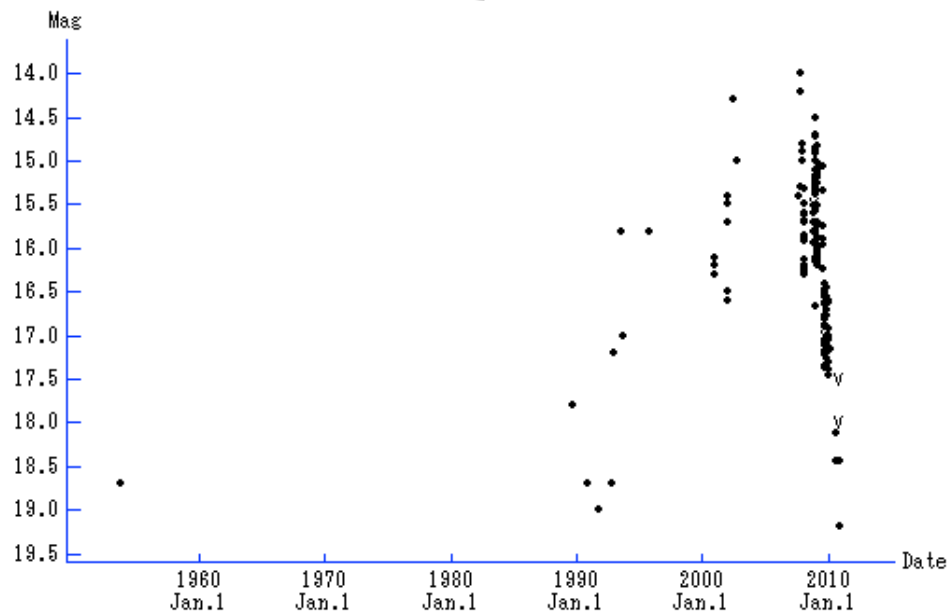
Preliminary analysis indicates that the source has been regularly detected by the LAT since the beginning of the all-sky scanning mode (August 2008). The LAT has not seen any strong variability of this source, and the average integral flux is about 1×10^{-7} ph cm⁻² s⁻¹ above 100 MeV with 30% systematic uncertainty. Because Fermi operates in the all-sky scanning mode, observing ~20% of the sky at any instant and all points in the sky every 3 hours, regular gamma-ray monitoring of this source will continue.

The Fermi 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.

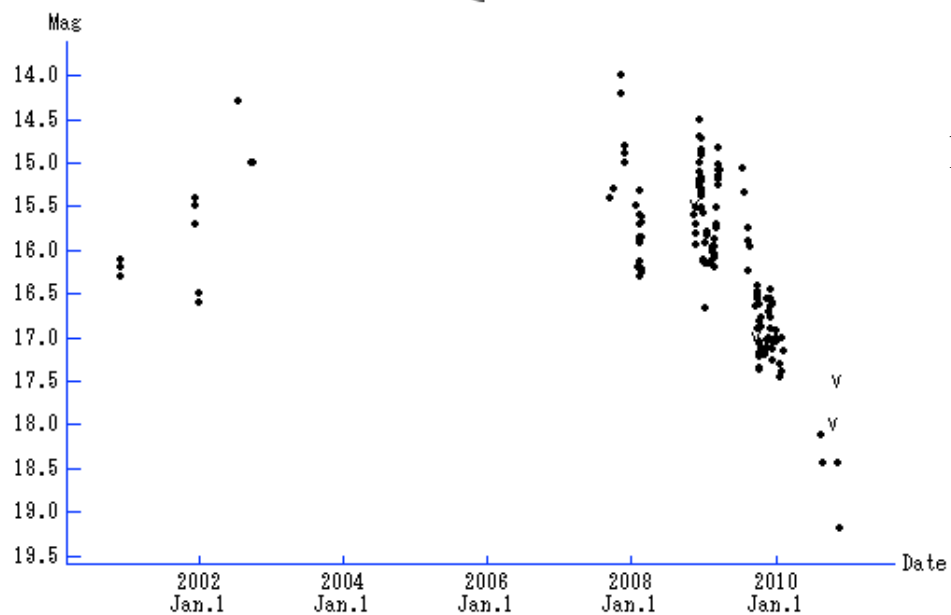
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Included in
0FGL and 1FGL

MisV1436 = QSO B0133+47



MisV1436 = QSO B0133+47



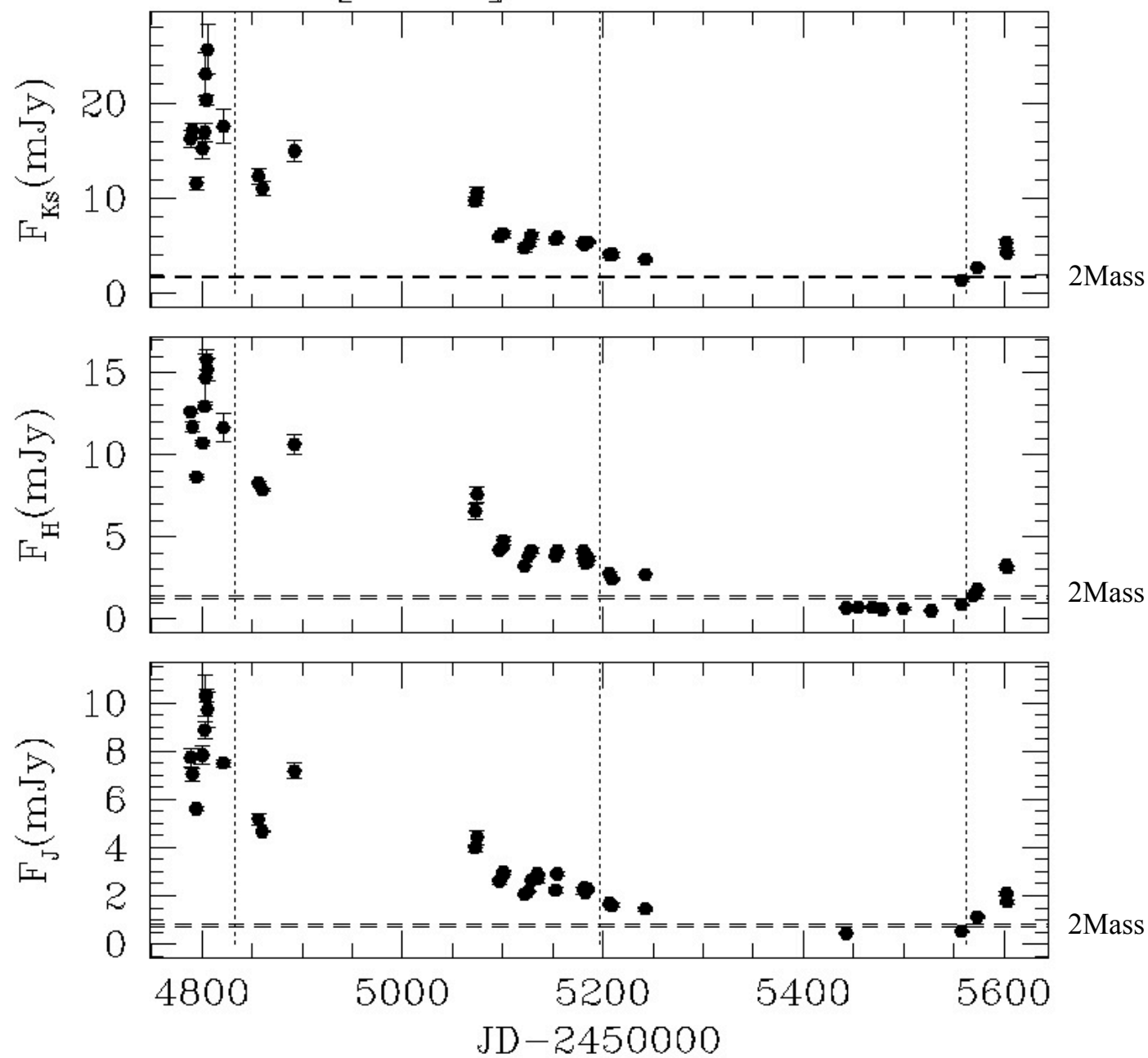
MisV1436 = QSO B0133+47

MISAO Project!

<http://www.aerith.net/misao/variable/MisV1436.html>

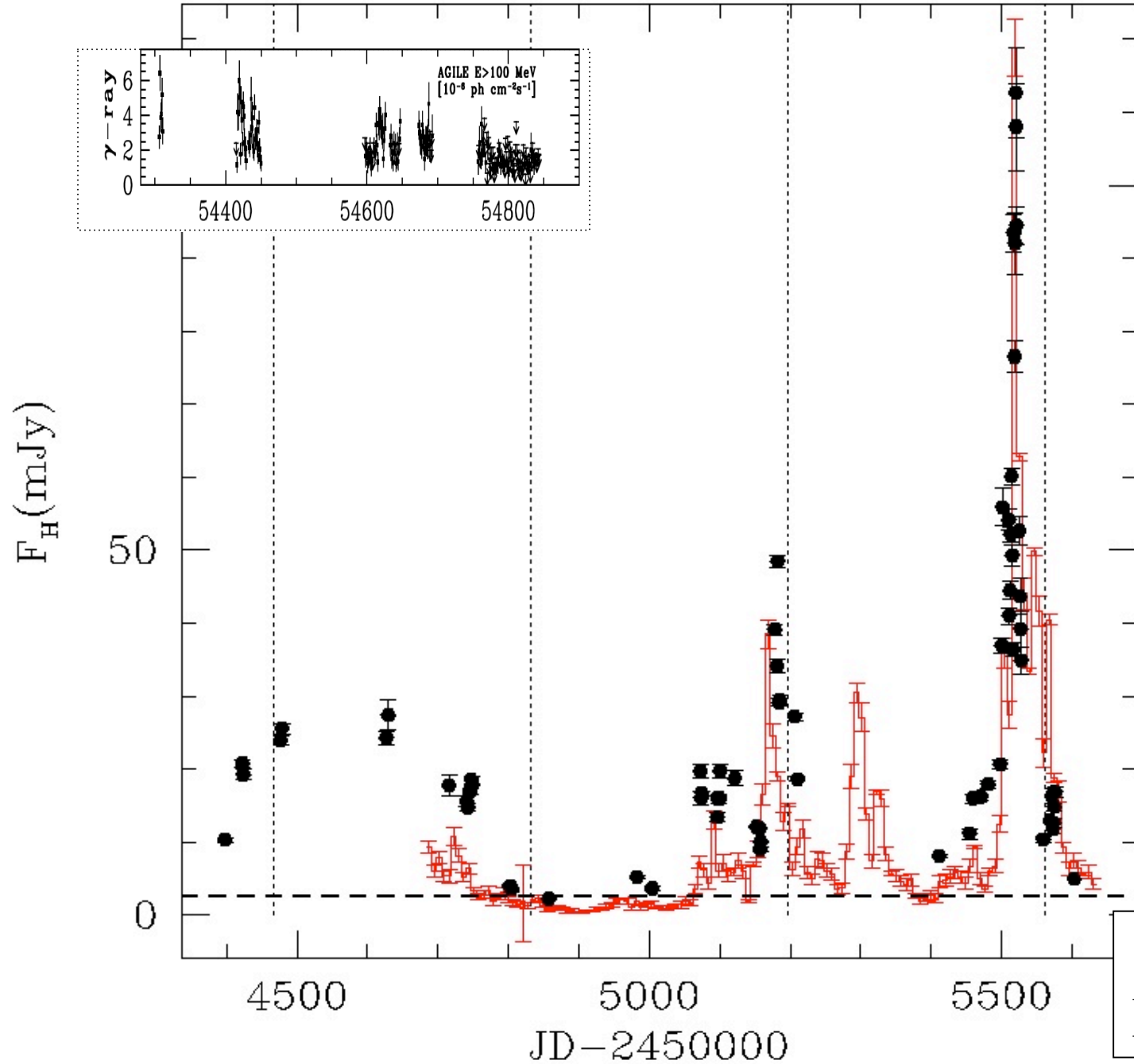
QSO B0133+47 also as DA 55

[HB89]0133+476

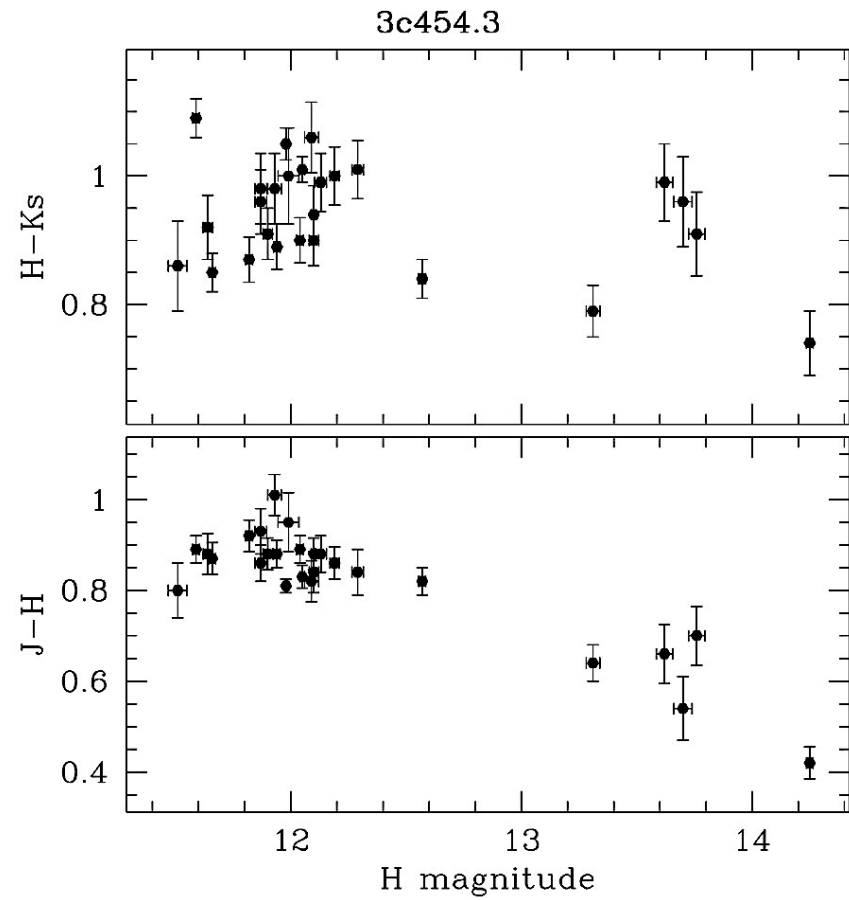
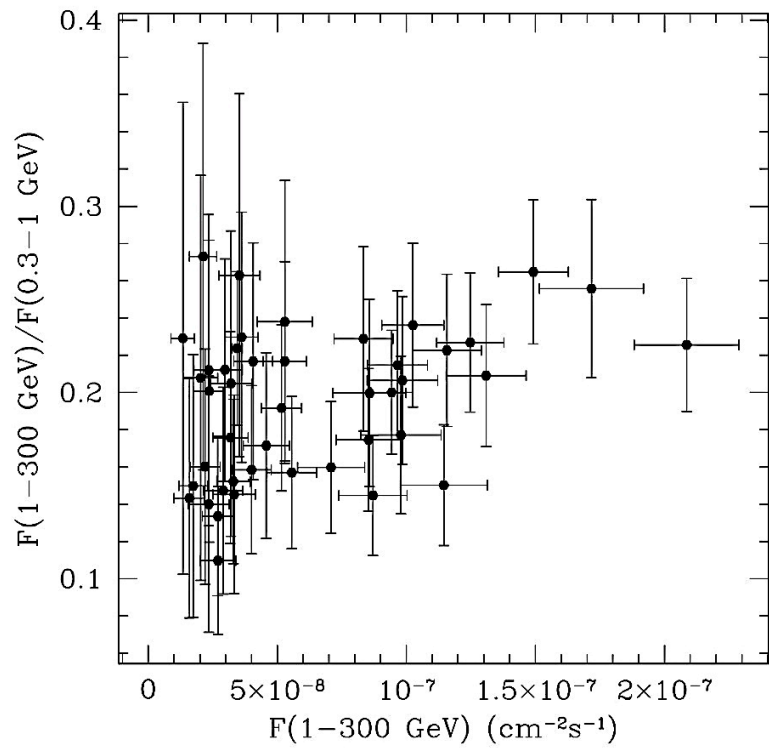


No Fermi
light curve

3C454.3

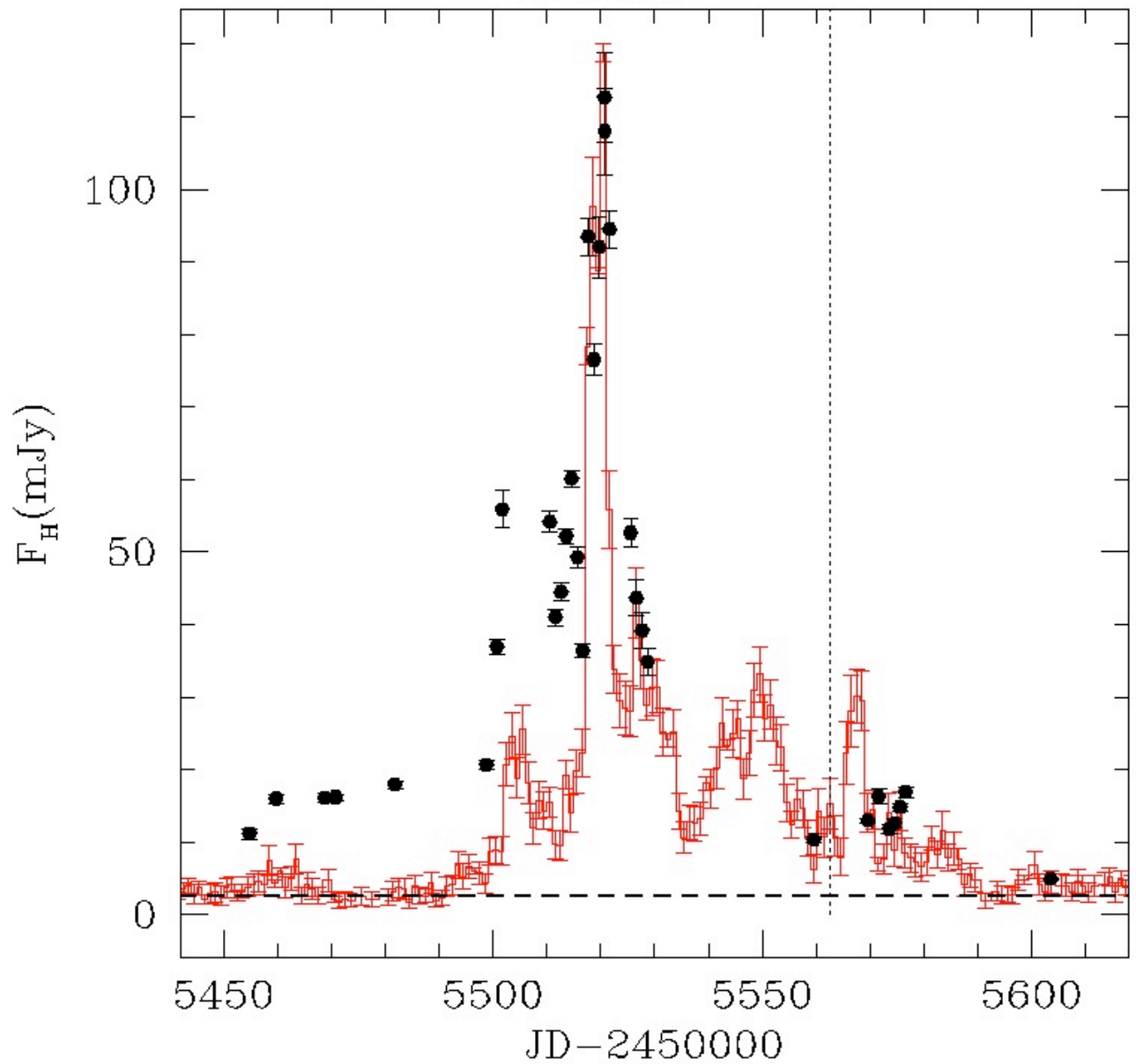


Canica H (1.6 μm)
Fermi (1-300 GeV)



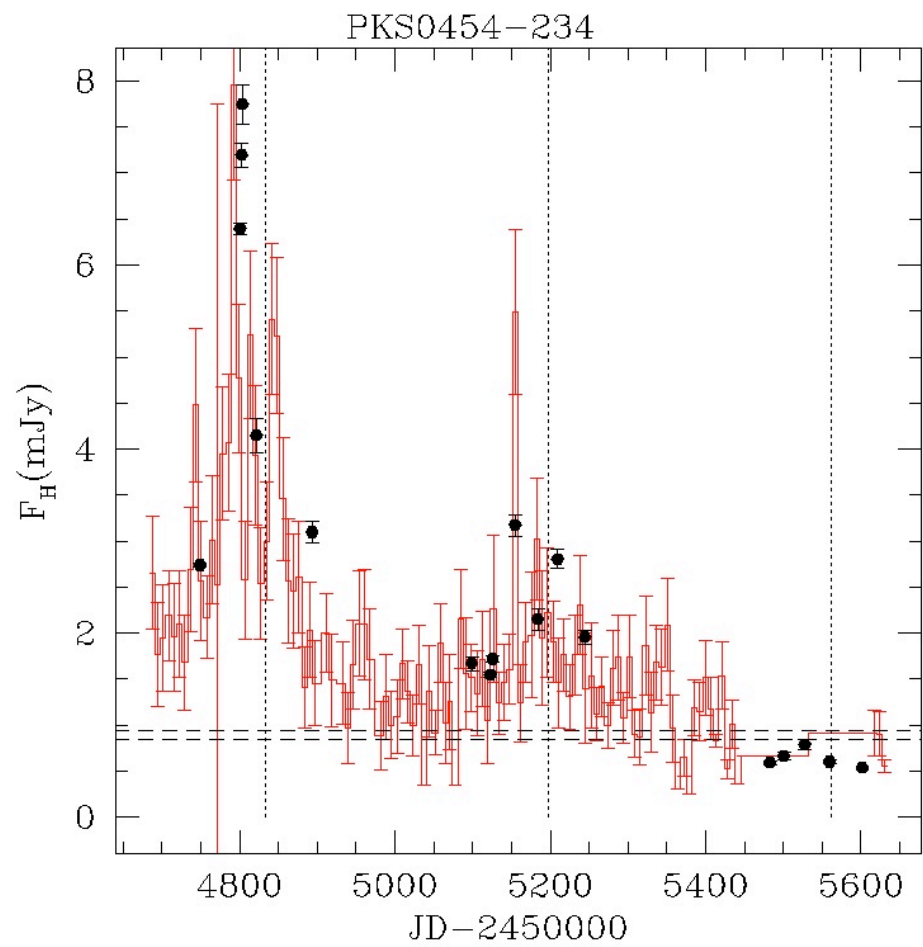
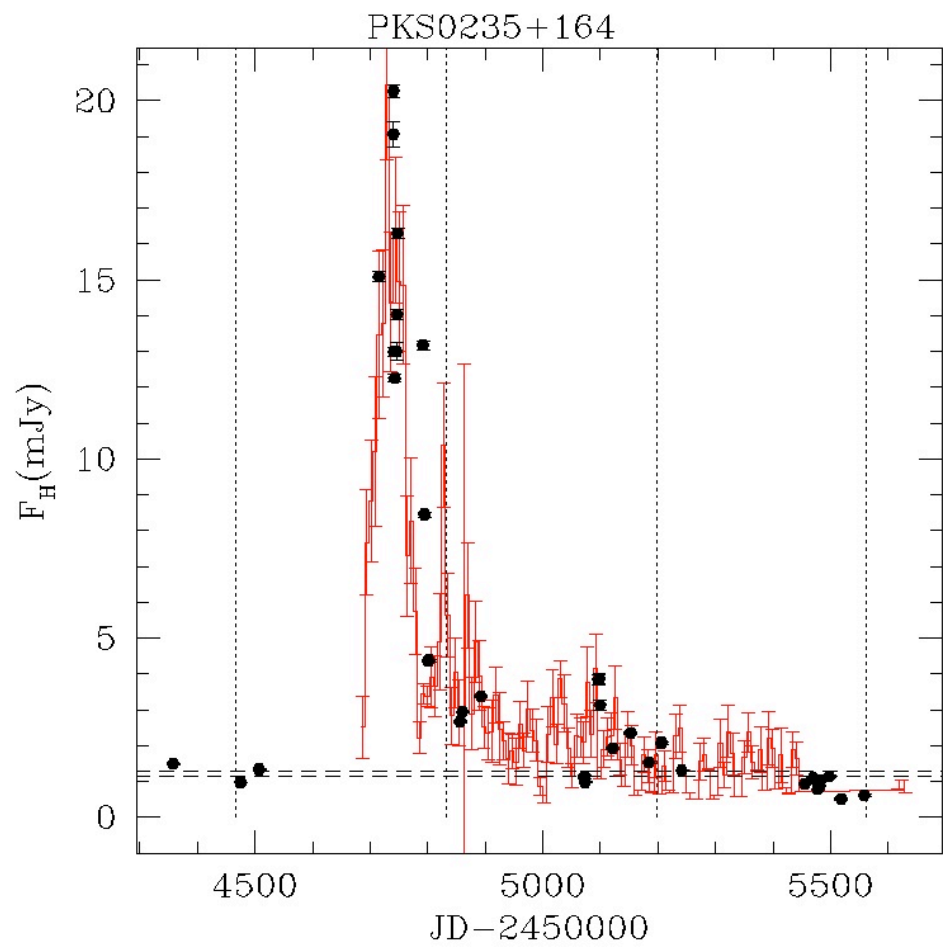
Prior to Nov 2010 flare

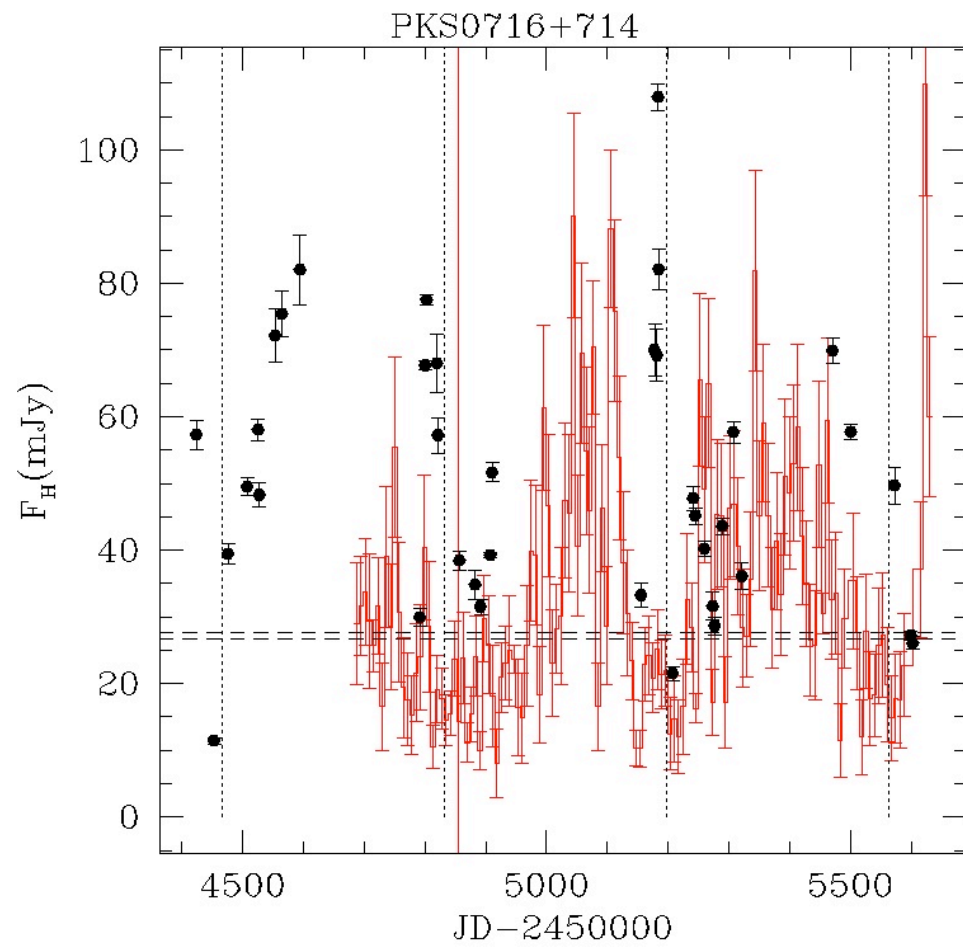
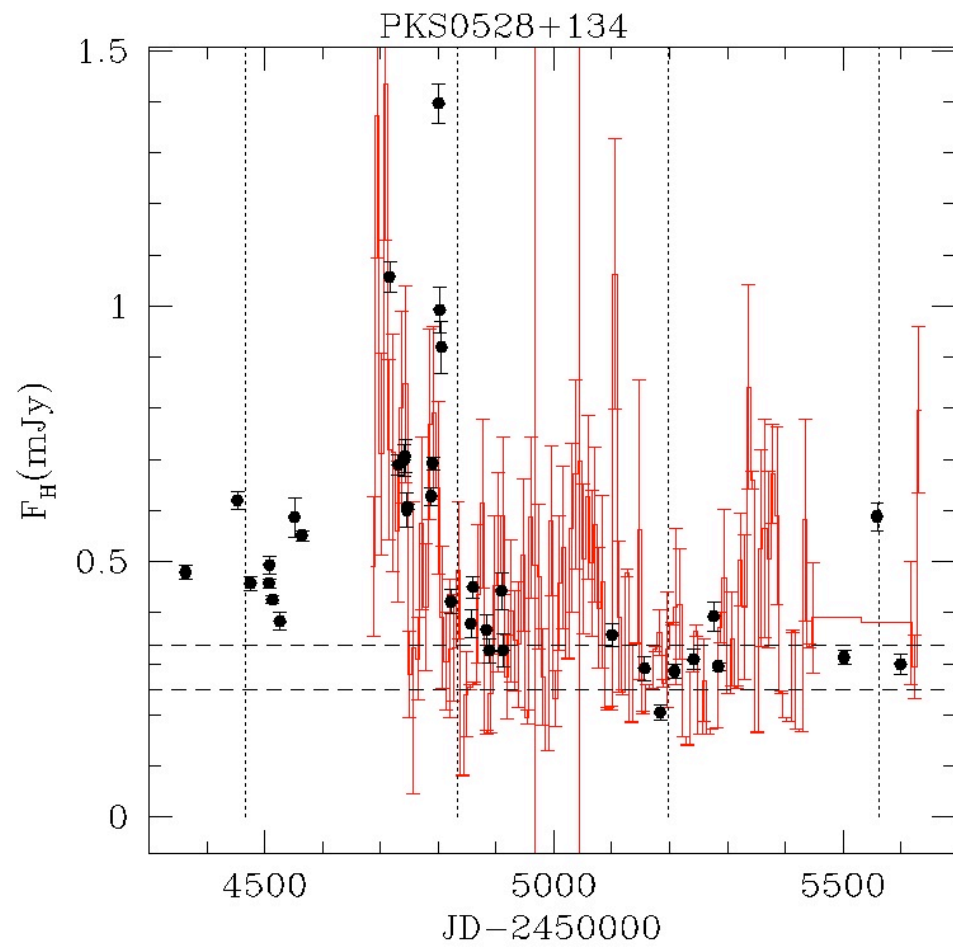
3C454.3

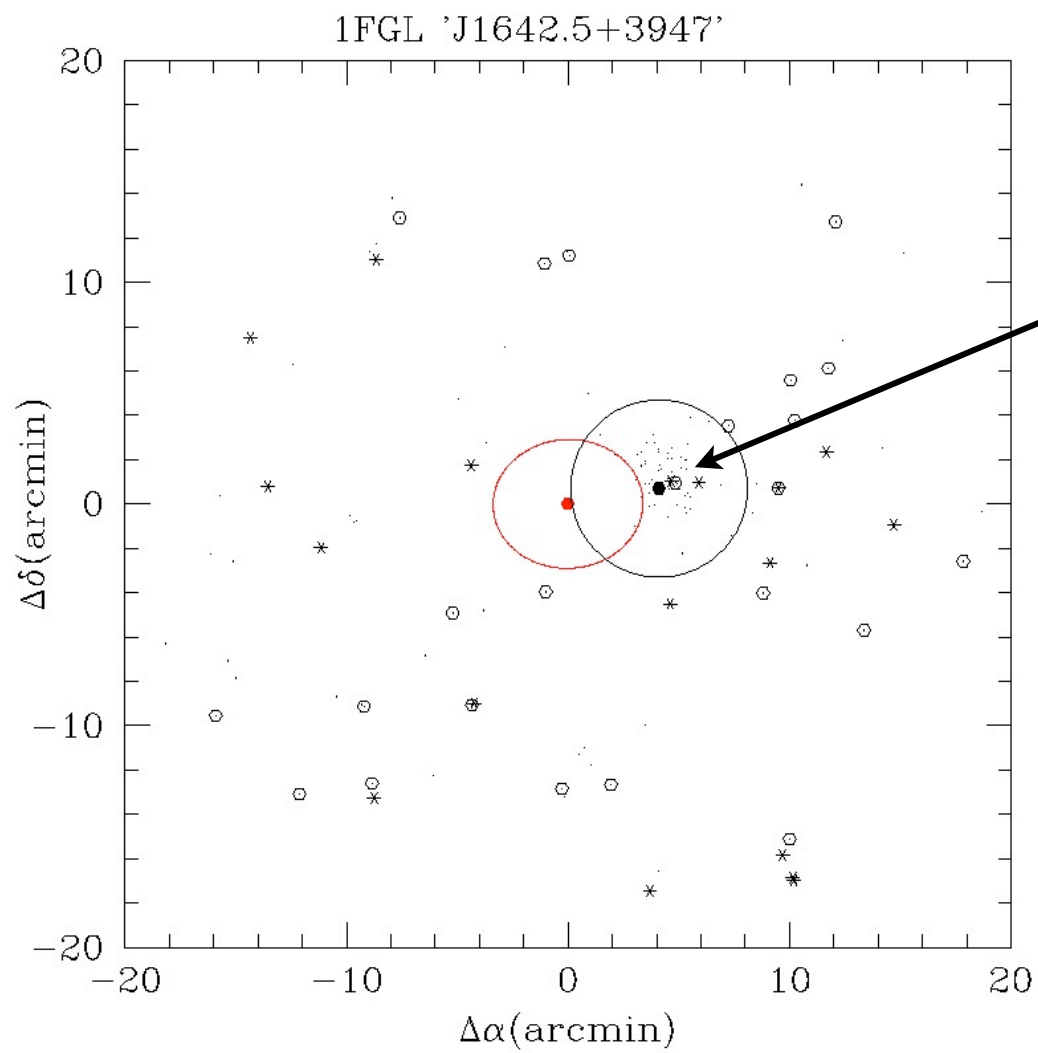


November 2010
flare day by day

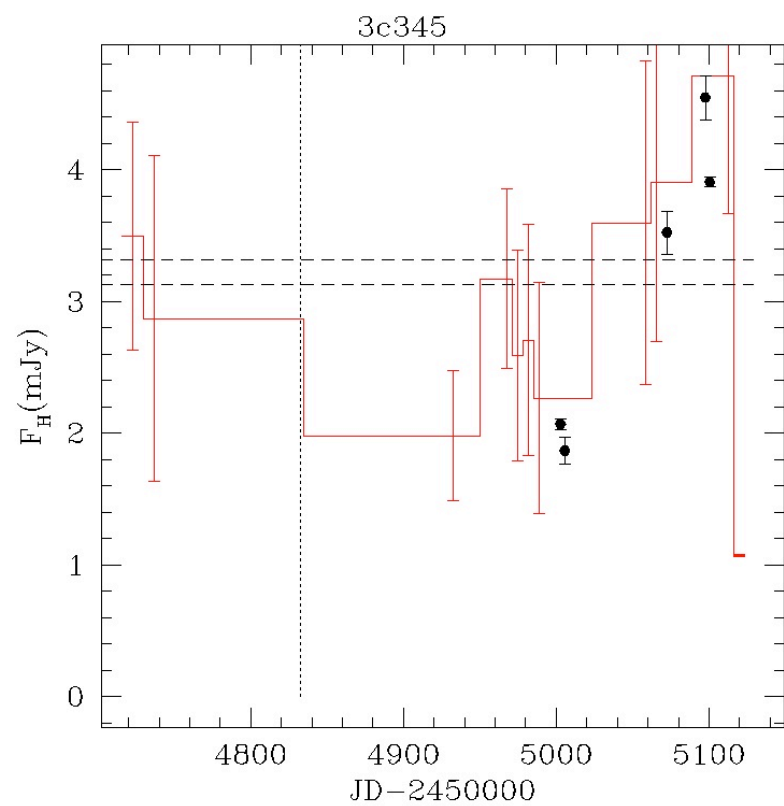
Canica H (1.6 μm)
Fermi (1-300 GeV)







3C 345



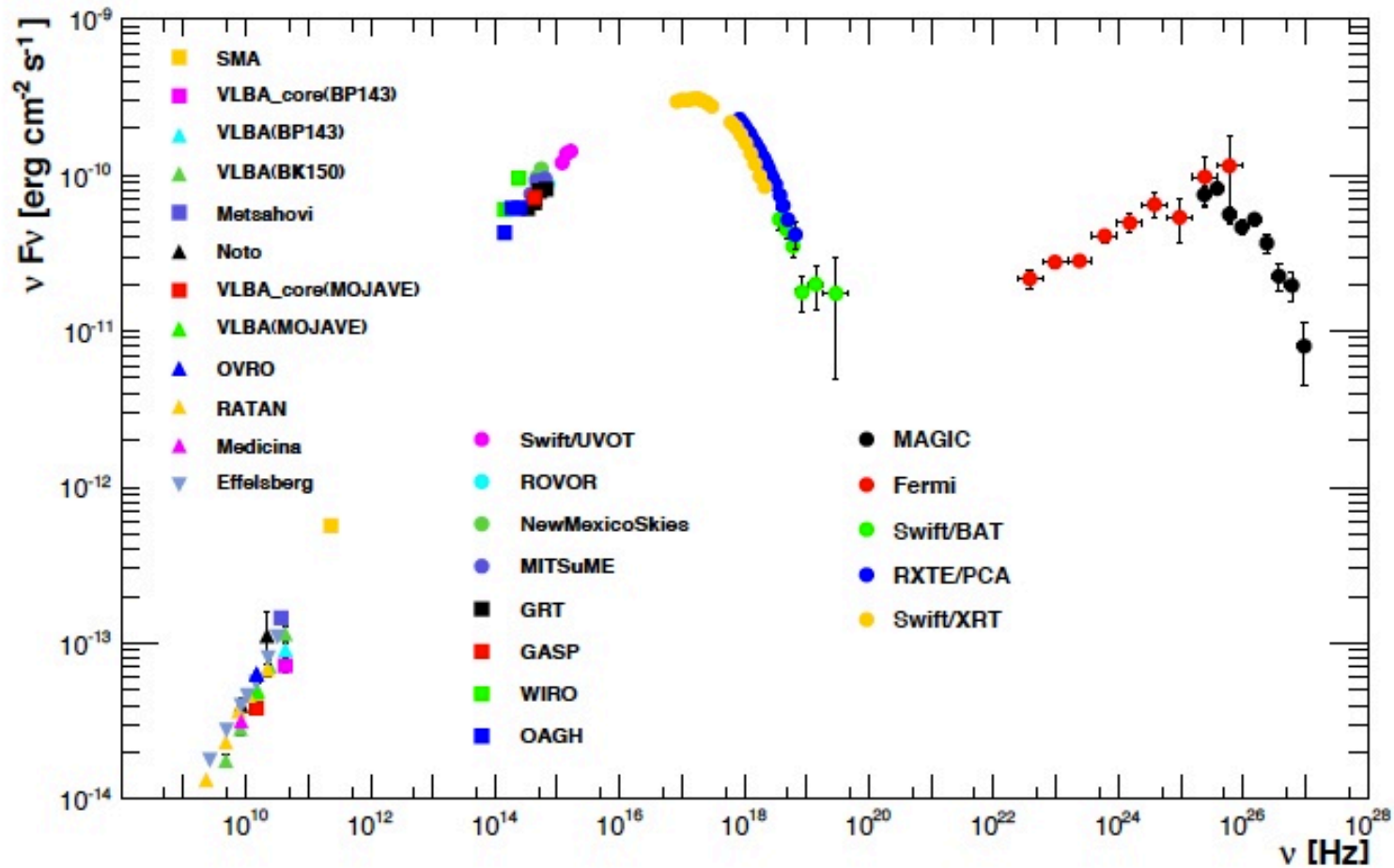
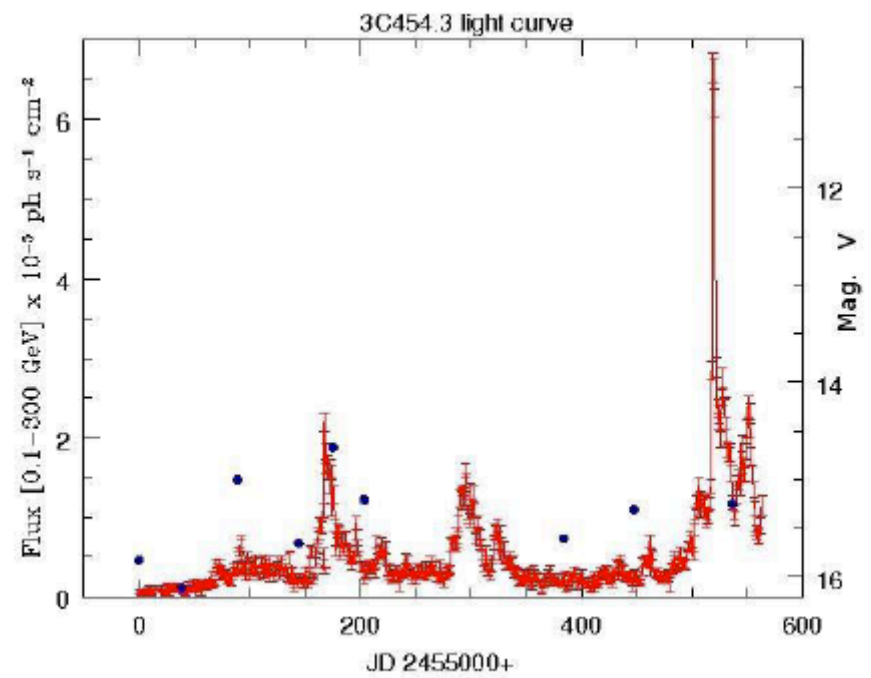
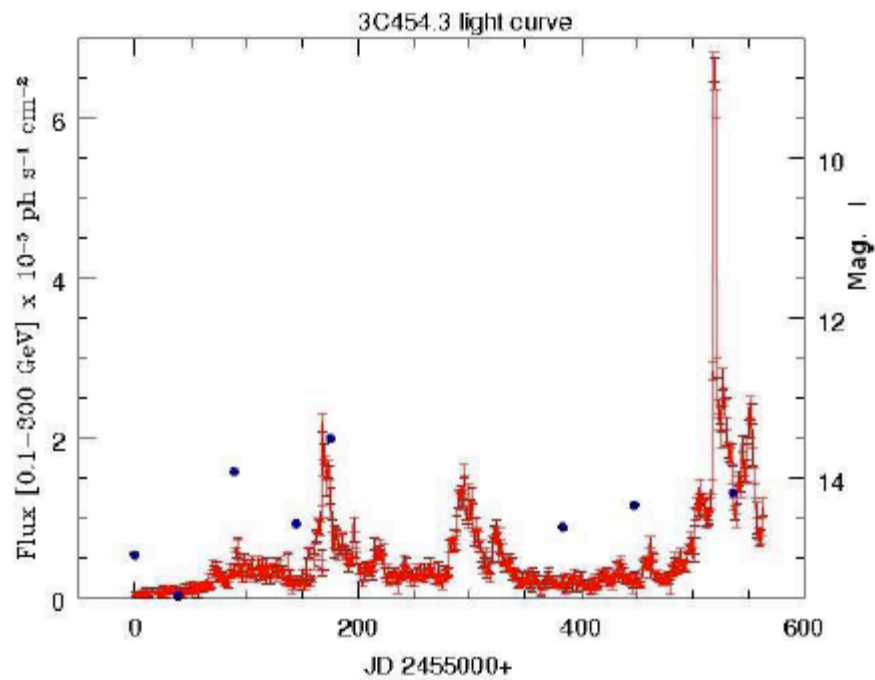
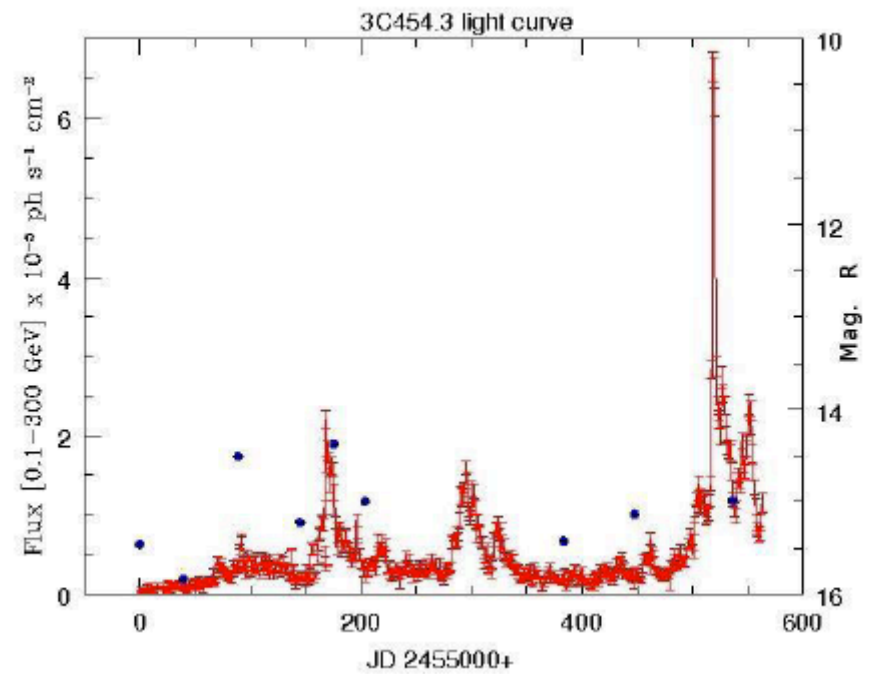
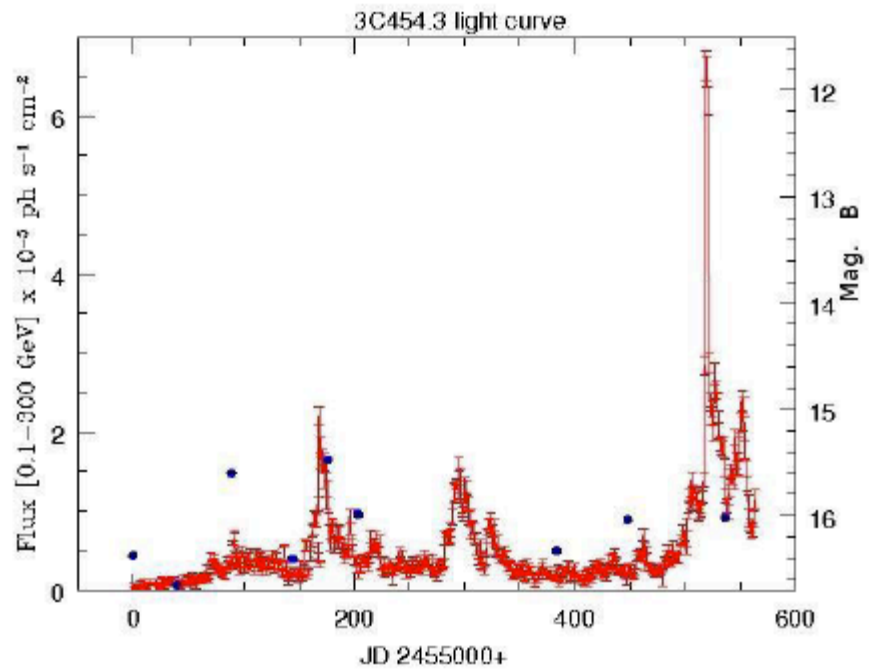
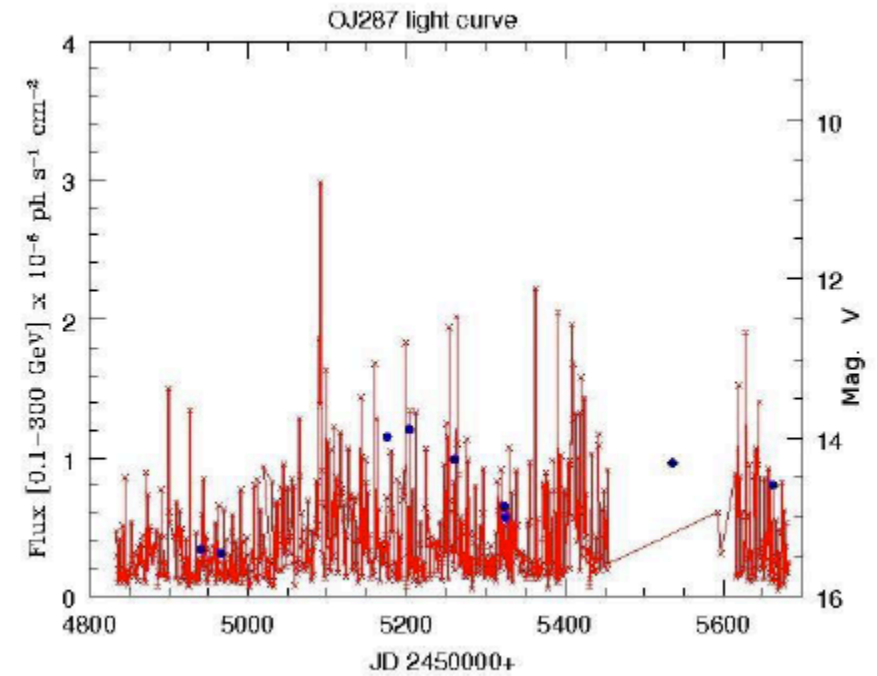
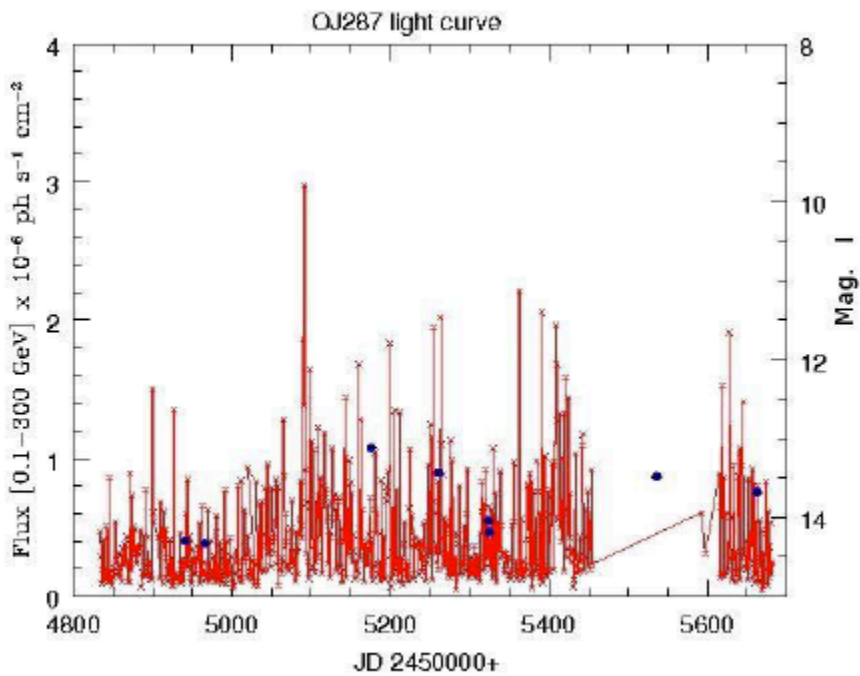
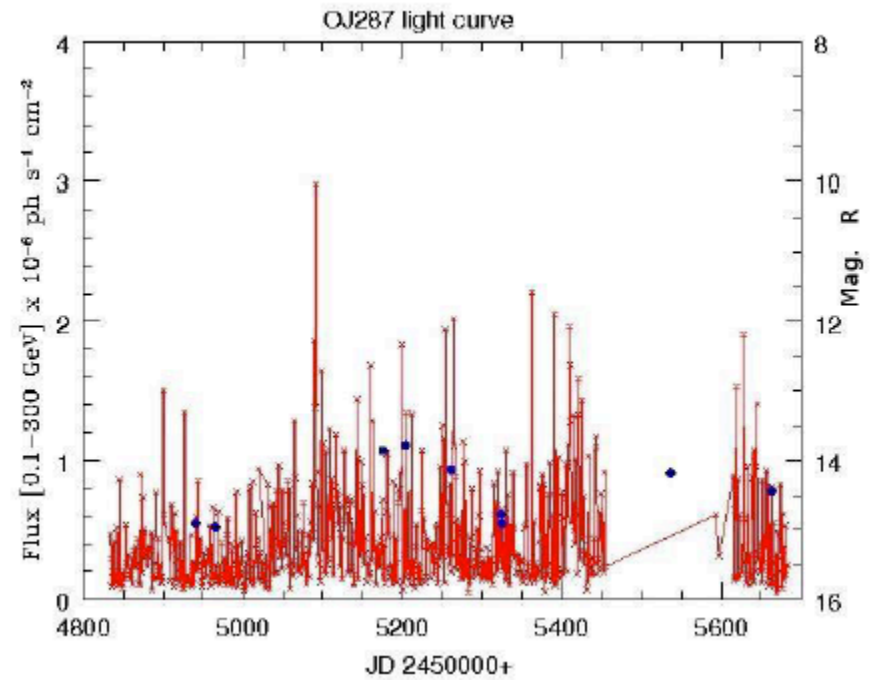
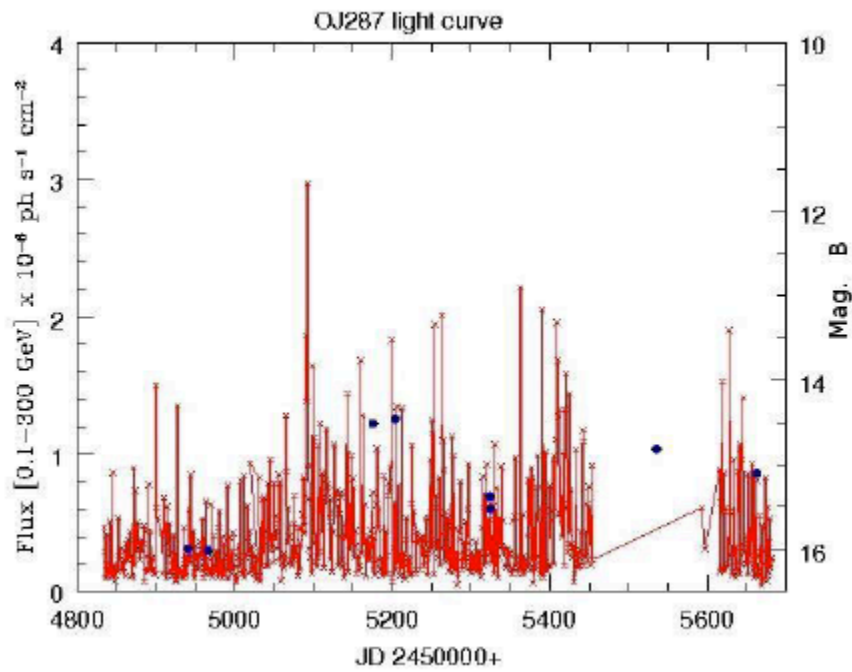
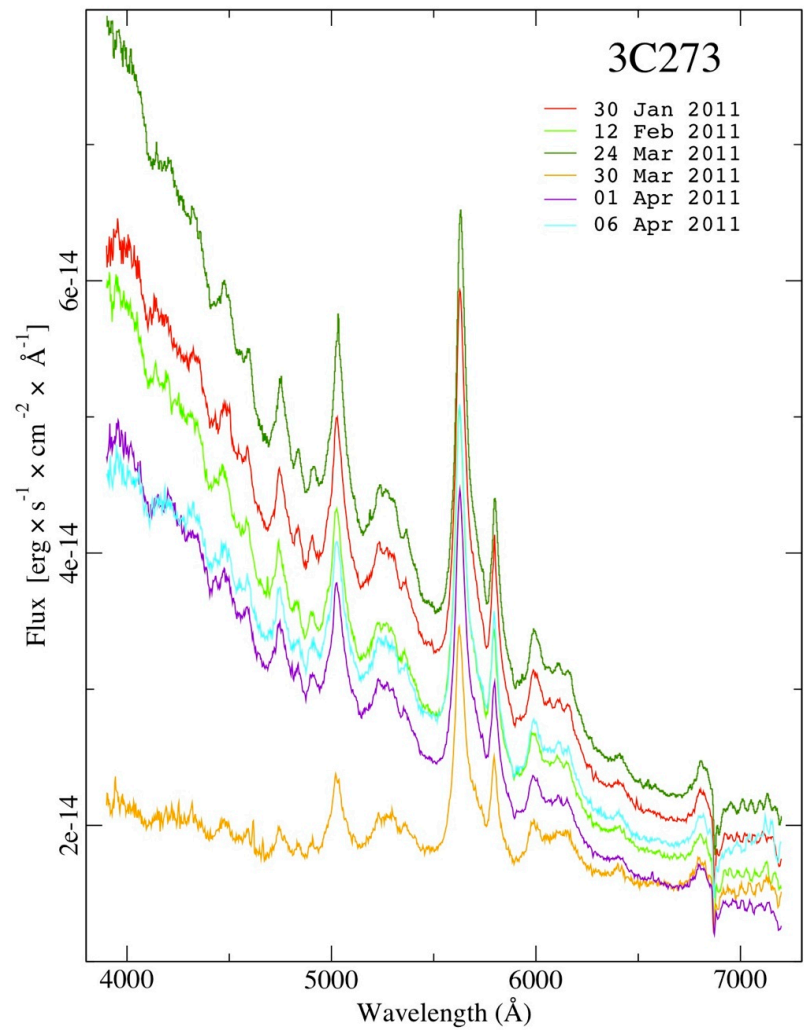
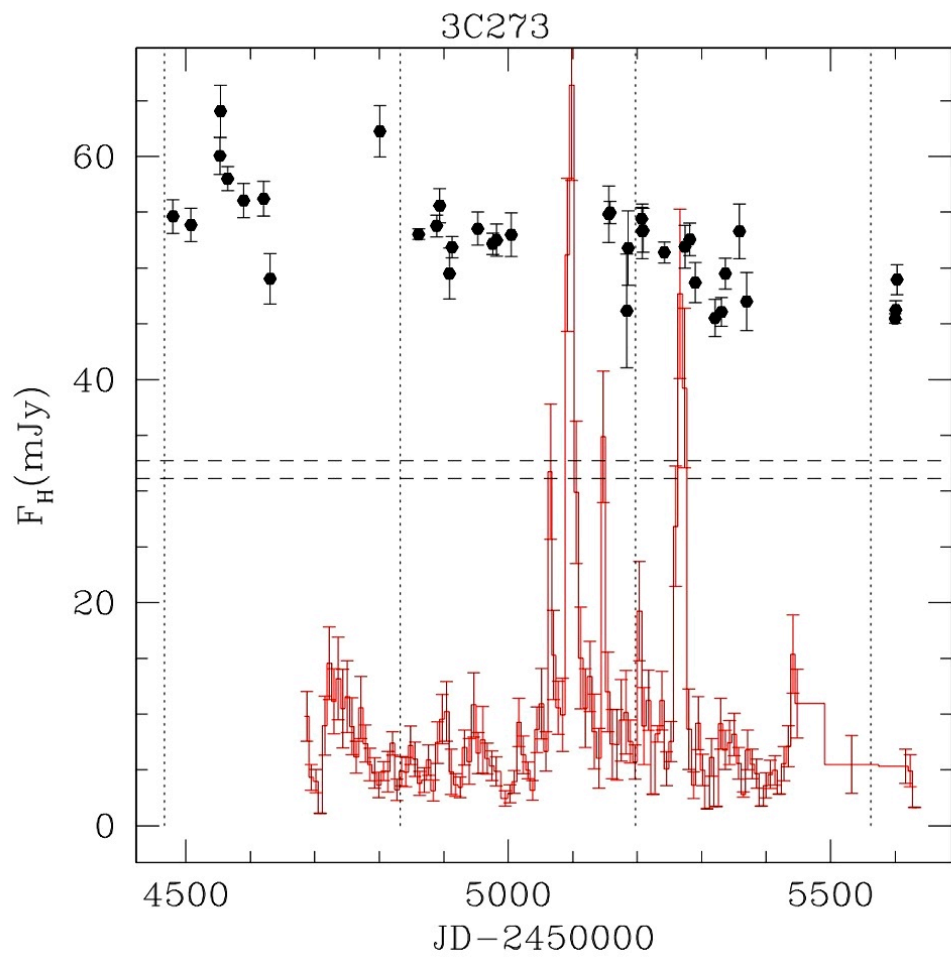


Fig. 8.— Spectral energy distribution of Mrk 421 averaged over all the observations taken during the multifrequency campaign from 2009 January 19 (MJD 54850) to 2009 June 1 (MJD 54983). The legend reports the correspondence between the instruments and the measured fluxes. The host galaxy has been subtracted, and the optical/X-ray data were corrected for the Galactic extinction. The TeV data from MAGIC were corrected for the absorption in the extragalactic background light using the prescription given in Franceschini et al. (2008).







Spectrum by Vahram Chavushyan

Work in progress

- NIR data reduced
- Comparative γ -NIR in progress
- Optical data pending reduction
- Class separated analysis TBD
- Incorporating spectroscopy
- Sub-sample $z < 1$ -- HAWC