The Search for Blazar Candidates in the Unidentified EGRET Error Boxes

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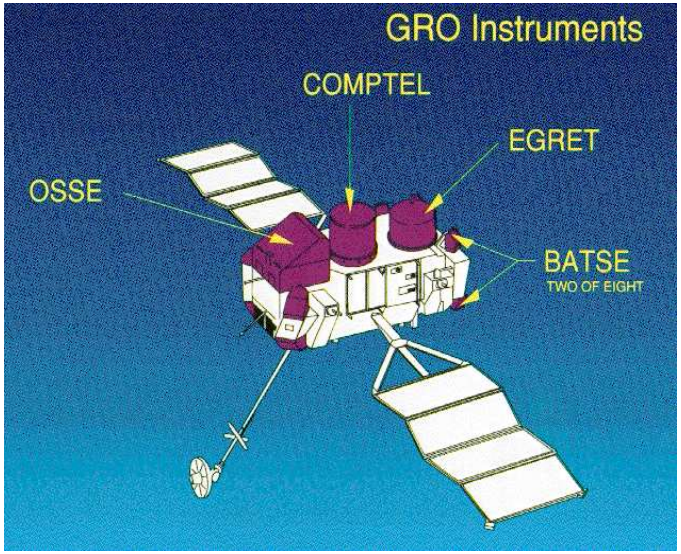
Thanks to the Organisers

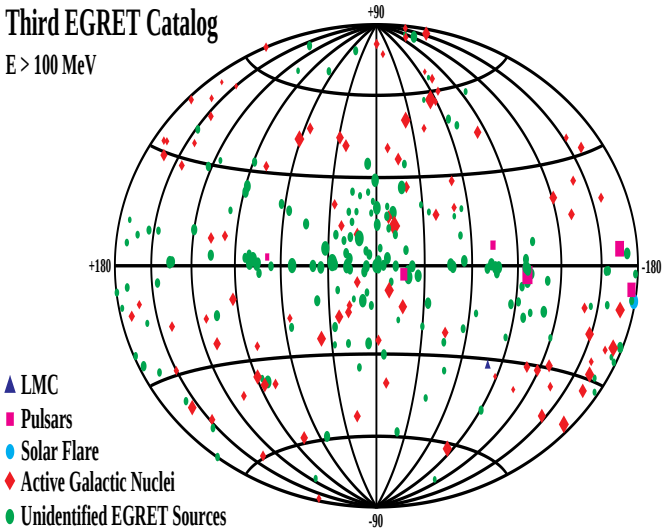
Travel to Delaware. Net flight: 20 hours 20 min

Contents

Before Fermi-LAT there was CGRO-EGRET

About 131 remained Unidentified





EGRET= Energetic Gamma-Ray Experiment Telescope

- Energy range: 20 MeV –30 GeV.
- Results: 271 objects with $E \geq 100\,\mathrm{MeV}$ (Hartman et al.1999). They may be 188 sources - Cassandrian et al. 2008.
- 101 sources identified by the EGRET team (91 % blazars (66 with HC and 27 with LC))
- About 39 sources were identified later by Sowards-Emmered et al. (2003, 2004)
- Unidentified: $\sim$ 131

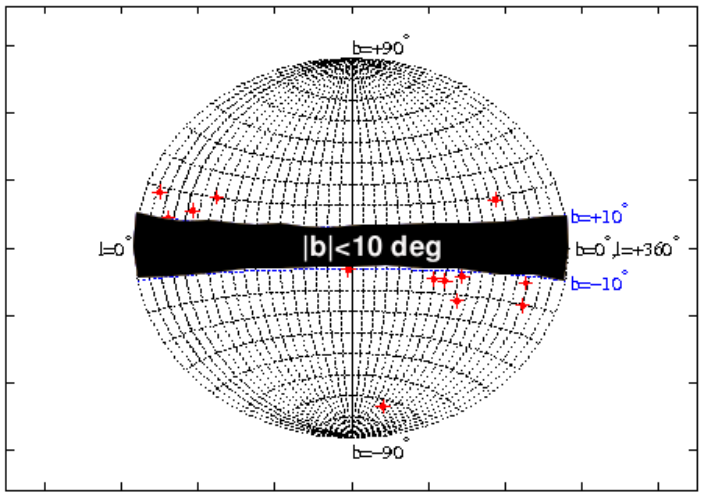
Are there blazars in the EGRET unidentified sources?

Selection of the sample

Selection criteria of a radio counterpart within the EGRET error box:

1. Extragalactic (NED)
2. $|b| > 10°$
3. $S_{12.4} > 200\,\mathrm{mJy}$
4. $|\alpha| < 1$, $F_\nu \propto \nu^\alpha$
5. $V_{\mathrm{ind.}} > 1$
6. X-ray source

Outside the Galactic Plane



- Variability index (Nolan et al. 2003)
- Sowards et al. criteria: $S_{8.4GHz} > 100$ mJy

Selected Sample

- About 131 remain unidentified
- 13 (10%) Selected sources:

No	EGRET name (3^{rd} catalogue)	Counterpart PKS, PMN,...	α	$S_{12.4}$ (mJy)	$V_{\mathrm{ind.}}$	b (°)	Class	z
1	3EG J0159-3603	J0156-3616	-0.82	219		-73.04		
2	3EG J0500+2502	J0502+2516	-0.51	1541		-14.28	FSRQ	0.28
3	3EG J0702-6212	J0657-6139	-0.41	221	1.06	-22.56		
4	3EG J0706-3837	J0710-3850	-0.5	299		-13.76		
5	3EG J0724-4713	J0728-4745	-0.11	280		-14.38	FSRQ	2.28
6	3EG J0821-5814	J0820-5705	-0.64	369	2.02	-12.04		
7	3EG J1300-4406	J1302-4446	-0.85	202	1.05	18.74		
8	3EG J1659-6251	J1703-6212	-0.13	513		-12.47		
9	3EG J1709-0828	J1713-0817	-0.64	334		18.25		
10	3EG J1800-0146	J1802-0207	-0.96	240		10.39		
11	3EG J1813-6419	J1807-6413	0.61	-		-20.32	FSRQ	1.02
12	3EG J1822+1641	J1822+1600	-0.15	445	2.26	13.84		
13	3EG J1824+3441	J1827+3431	-0.07	411		20.14	FSRQ	1.81

- Selection criteria within the error box: Extragalactic, $|b| > 10°$, $S_{12.4} > 200$ **mJy**, $|\alpha| < 1$ $(F_\nu \propto \nu^\alpha)$, $V_{\mathrm{ind.}} > 1$

Multifrequency data collection

Data & Instruments

Source	Band/Instrument: Radio *26-m (HartRAO)* 1.6–24 GHz	Radio: Online	NIR: *2MASS* *J*, *H*, *K*	Opt. (Photom.): 1.0-m	Opt. (Photom.): 1.9-m	Opt. (Photom.): *SALT*	Opt. (Photom.): Online
				U, *B*, *V*, *R* and *I*			
3EG J0159-3603	x	x					x
3EG J0500+2502	x	x	x				x
3EG J0702-6212	x	x		x	x	x	x
3EG J0706-3837	x	x	x	x	x	x	x
3EG J0724-4713	x	x					x
3EG J0821-5814	x	x	x	x	x	x	x
3EG J1300-4406	x	x					x
3EG J1659-6251	x	x	x				x
3EG J1709-0828	x	x					x
3EG J1800-0146	x	x	x				x
3EG J1813-6419	x	x	x				x
3EG J1822+1641	x	x	x				x
3EG J1824+3441	x	x	x				x

Online: Vizier catalog:
`http://vizier.u-strasbg.fr/viz-bin/VizieR`

Multifrequency data collection (cont.)

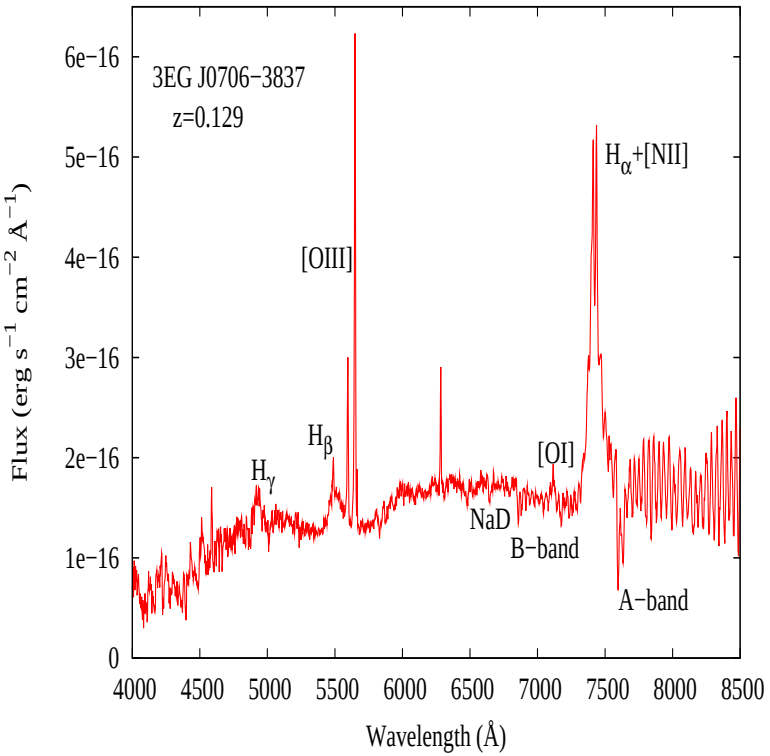
Data & Instruments

Source	Band/Instrument: Opt. (Spec.) *Goodman/SALT* *V*	X-ray *ROSAT* 0–2 keV	X-ray *XMM* 0.2–12 keV	X-ray *EINSTEIN* 0.2 –20 keV	γ-ray *EGRET* (*)	γ-ray *LAT* (**)
3EG J0159-3603	x				x	
3EG J0500+2502				x	x	
3EG J0702-6212					x	
3EG J0706-3837	x	x			x	
3EG J0724-4713					x	x
3EG J0821-5814	x	x	x		x	
3EG J1300-4406					x	x
3EG J1659-6251					x	x
3EG J1709-0828	x				x	x
3EG J1800-0146	x	x			x	
3EG J1813-6419					x	x
3EG J1822+1641					x	
3EG J1824+3441		x			x	

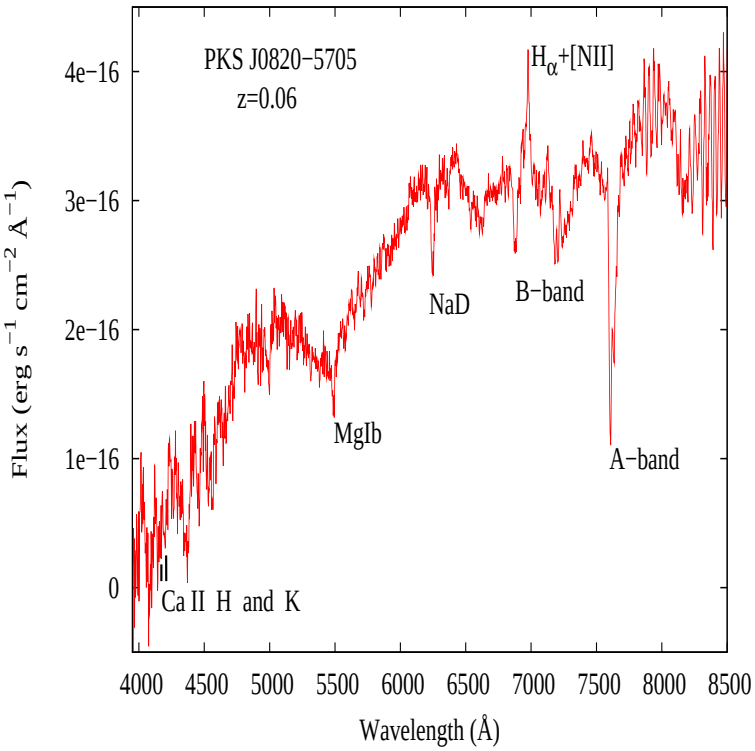
(*) EGRET: 30 MeV-20 GeV
(**) LAT: 100 MeV-300 GeV

Optical Spectroscopy

Redshift, BLR, NLR, etc

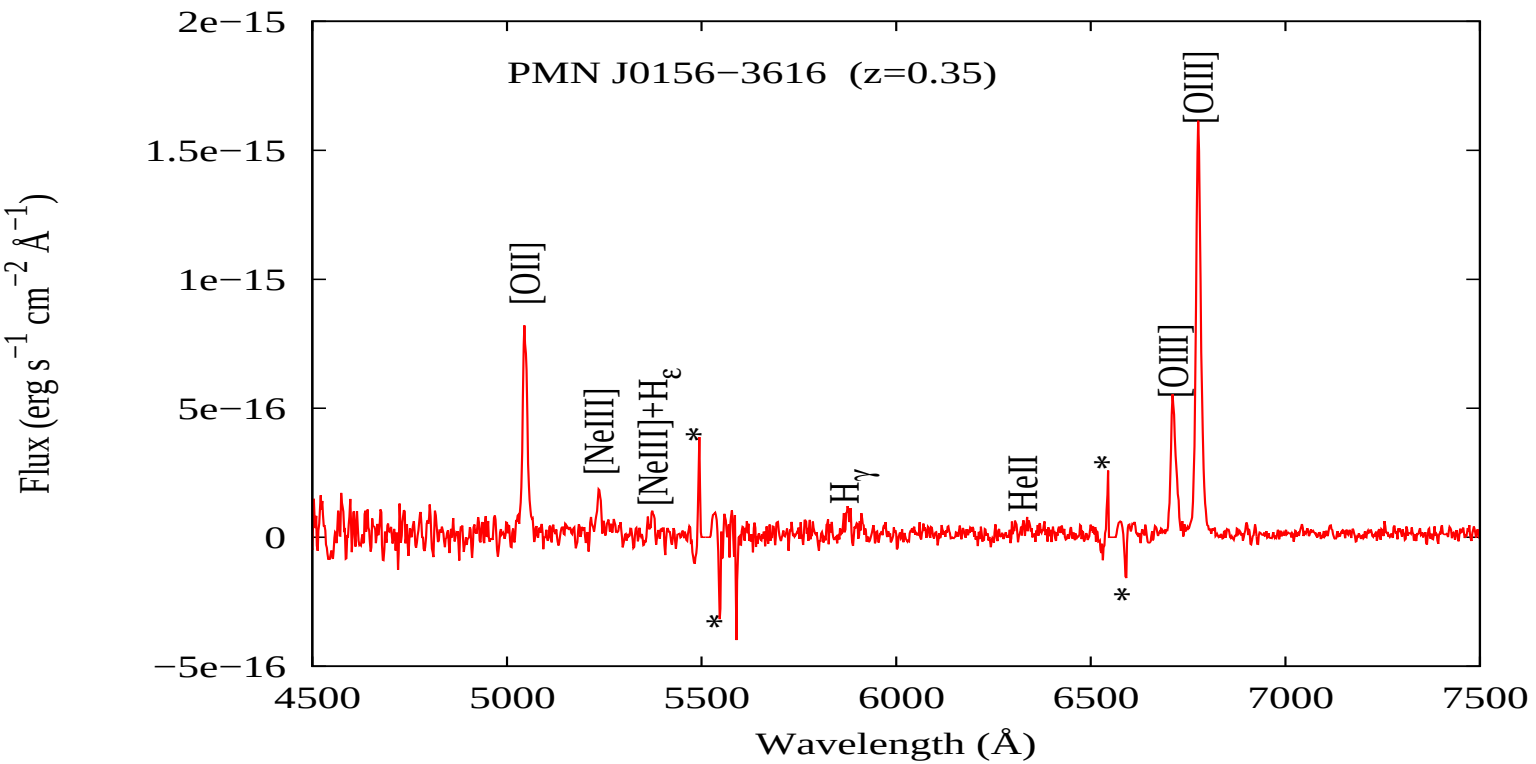


The measured FWHM of the broad lines is of typical Seyfert I galaxies.



The Ca H & K depression of 8.8% measured at 4000 Å is of typical blazars (less that 40% - Caccianiga et al.)

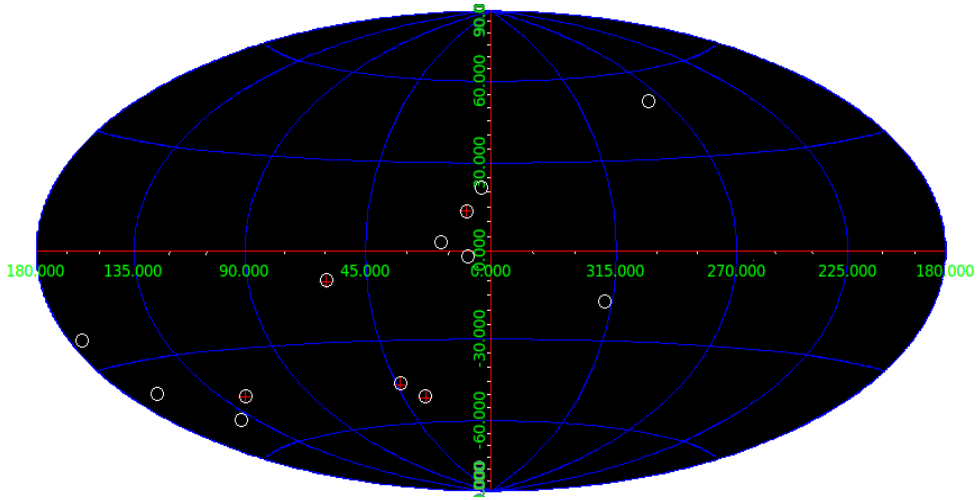
Optical spectroscopy (cont.)



Spectrum of 3EG J0159-3603 (SALT)

Emission lines at $z = 0.35$.

LAT detections in the selected sample



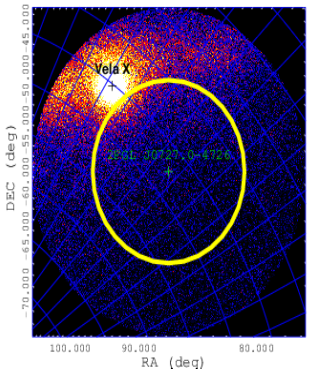
5 sources in 2FGL- 2 year data

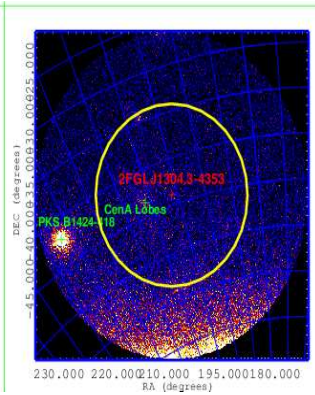
	2FGL source	EGRET counterpa
1	*2FGL J0727.0-4726*	*3EG J0724-4713*
2	*2FGL J1304.3-4353*	*3EG J1300-4406*
3	*2FGL J1703.2-6217*	*3EG J1659-6251*??
4	*2FGL J1709.0-0821*	*3EG J1709-0828*
5	*2FGL J1815.6-6407*	*3EG J1813-6419*

Two more from 3FGL catalog - 4 year data

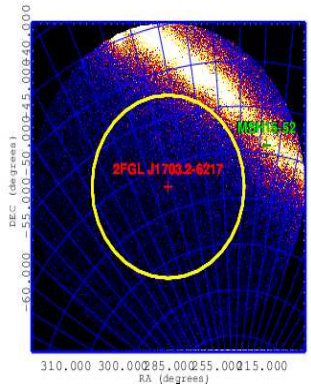
6	*3FGL J0700-6310*	*3EG J0702-6212*
7	*3FGL J0703.4-3914*	*3EG J0706-3837*

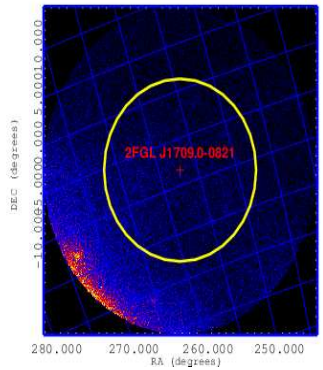
ROIs



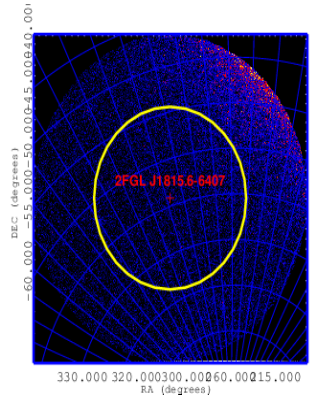


2FGL J0727.0-4726 (b=-14.32) and *2FGL J1304.3-4353* (b=18.94)





2FGL J1703.2-6217 (b=-12.40) and *2FGL J1709.0-0821* (b=18.67)



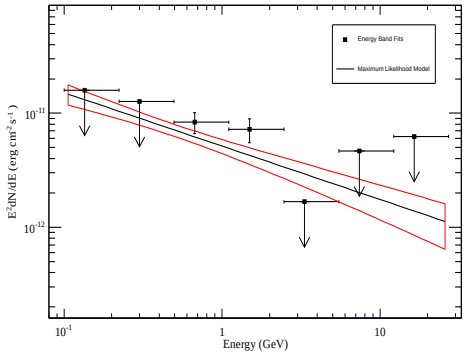
2FGL J1815.6-6407 (b=-12.40)

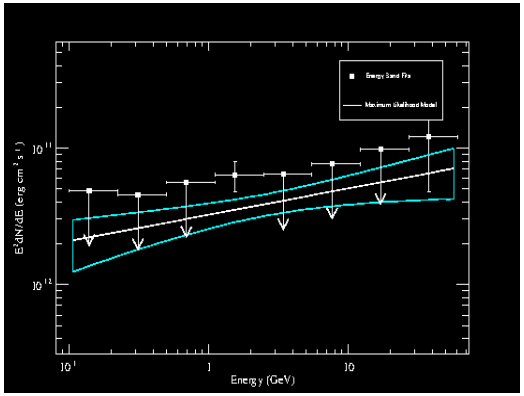
Contamination

- Galactic diffuse emission
- Extended objects: Vela-X (at 11 deg *2FGL J0727.0-4726*) , Cen A lobes (*2FGL J1304.3-4353*) and MSH52-12 at 10 deg of *2FGL J1703.2-6217* .

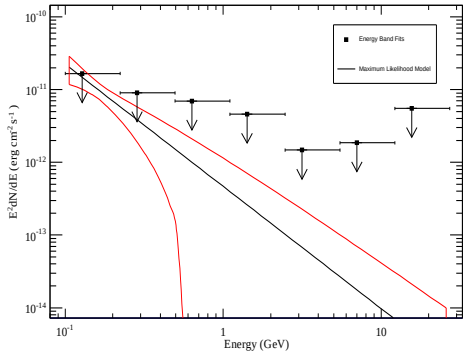
Energy fluxes (LAT)

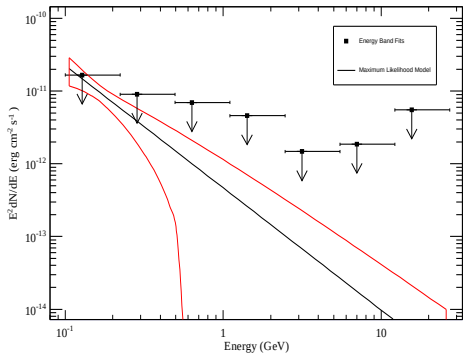
Thanks to the Fermi collaboration at Univ. of Wurzberg (Germany)



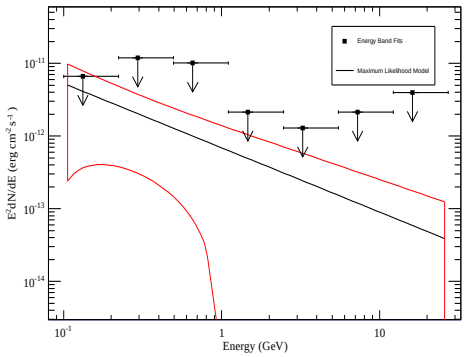


2FGL J0727.0-4726 and *2FGL J1304.3-4353*





2FGL J1703.2-6217 and *2FGL J1709.0-0821*

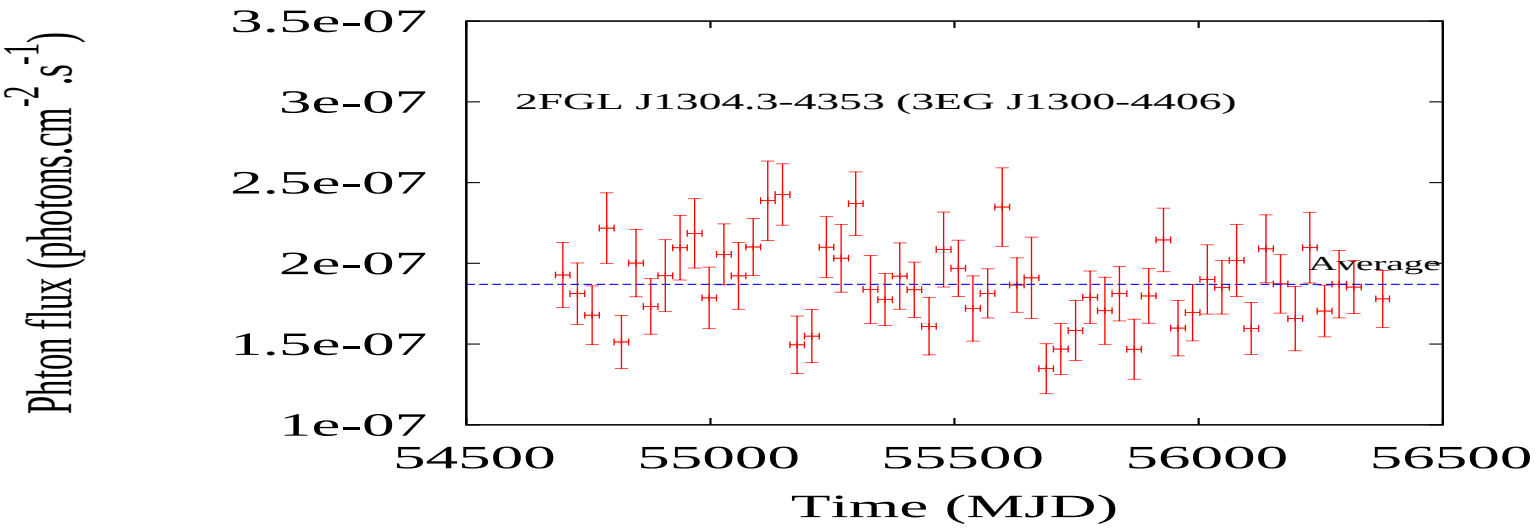


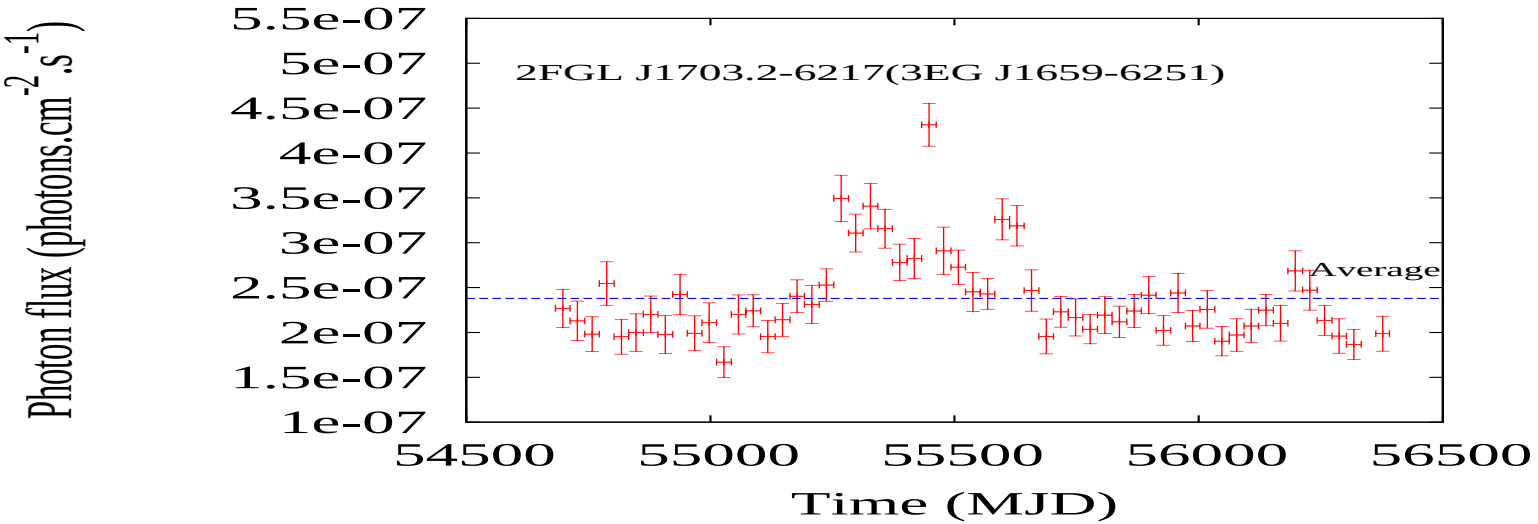
2FGL J1815.6-6407

2FGL J1304.3-4353

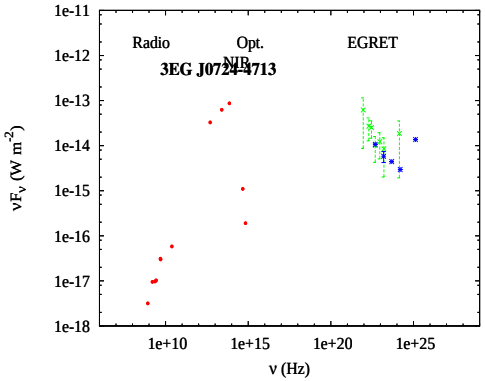
- Increasing slope beyond 300 GeV.
- Many upper limits but the 30 GeV point is significant (TS=25).
- *2FGL J1304.3-4353 is a potential TeV source.*

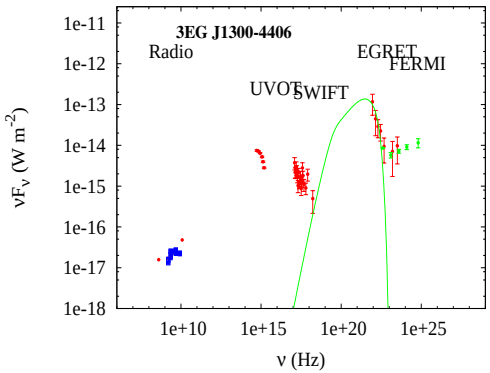
γ-ray variability (cont.)



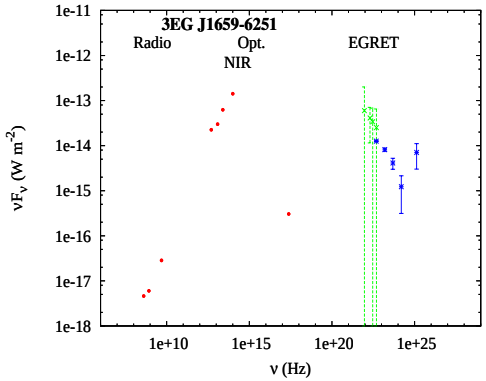


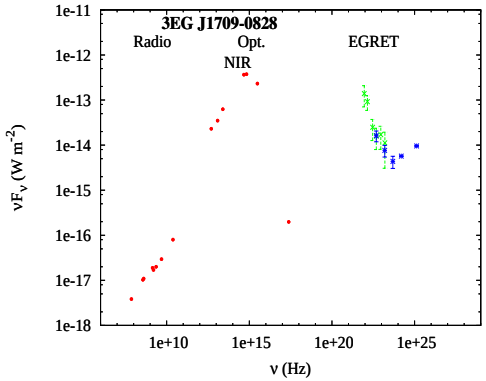
Overall SEDs



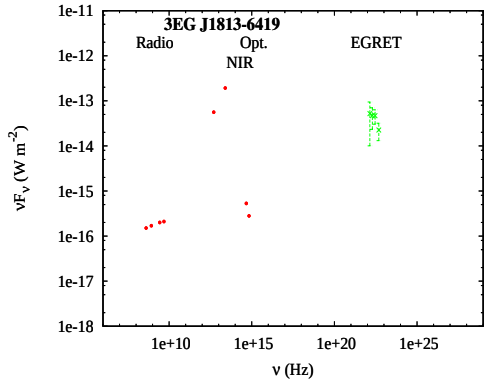


2FGL J0727.0-4726 and *2FGL J1304.3-4353*





2FGL J1703.2-6217 and *2FGL J1709.0-0821*



2FGL J1815.6-6407

Most of the cases you don't have enough data

Modelling the H.E emission from Blazars

models description

Models are used to

- **Interpret the SED**
- **Identify the involved radiation mechanisms**

but they require ⇳

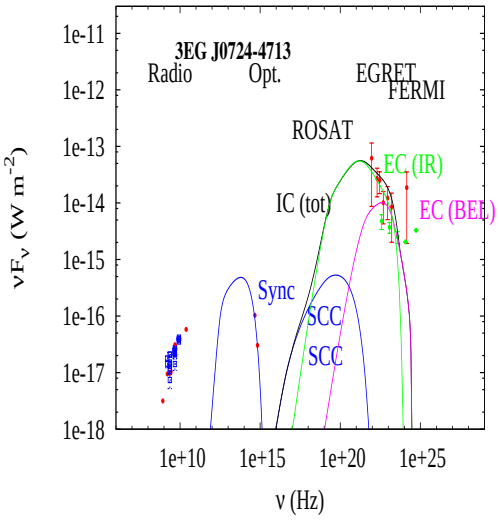
- **High quality of the data (sufficient points in all bands) to allow the constraint on the parameters** (10 - Markos's lecture))

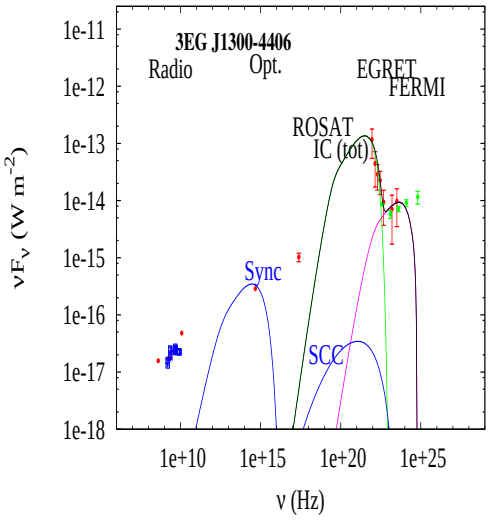
Two models were applied (Thanks to Markos for a new code):

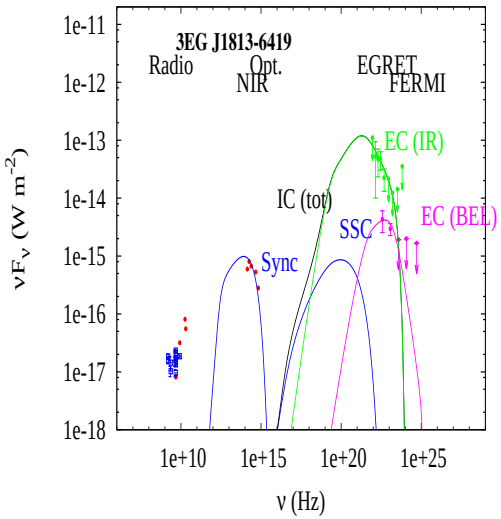
- Model of the homogeneous SSC emission (Katarynski et al. 2001)
- Model of the External Compton (Moderski et al.)

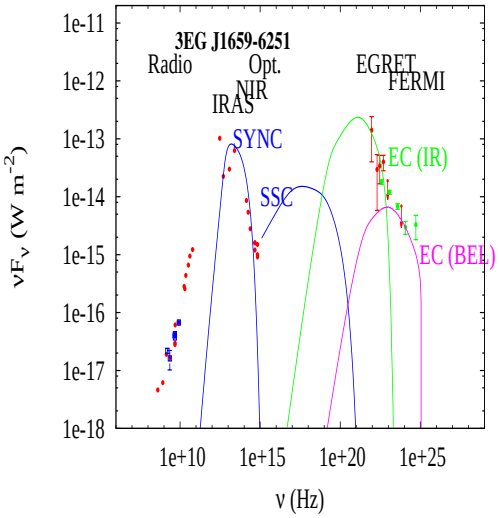
Modelling the emission mechanisms

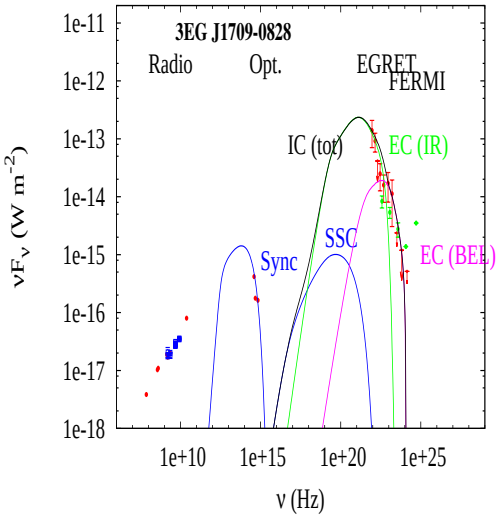
on going work











Features

- Radio synchrotron emission happens in outer parts of the jet
- Gamma-ray emission is explained by the EC (IR+ BEL)
- !! Data are not enough to constrain all the parameters

Way forward

Fermi contribution

Fermi is allowing a continuous monitoring of these sources

- The Not Yet detected may be ON sometime,
- Long lightcurves gives details on the phases of the source etc)

Thank you for your attention