6th AGILE Workshop

AGILE results on Blazars

Stefano Vercellone INAF/IASF Palermo

on behalf of the AGILE AGN—WG

The Working Group

Bulgarelli A.	**(IASF Bologna)**
Chen A.W.	**(CIFS & IASF Milano)**
Donnarumma I.	**(IASF Roma)**
D'Ammando F.	**(IASF Roma & U. Tor Vergata)**
Longo F.	**(INFN Trieste)**
Giuliani A.	**(IASF Milano)**
Pacciani L.	**(IASF Roma)**
Pucella G.	**(ENEA & IASF Roma)**
Vercellone S.	**(IASF Palermo – *Chair*)**
Vittorini V.	**(CIFS & IASF Roma)**

The MW approach

MOJAVE	Radio imaging
Spitzer	IR
REM	IR-Optical
WEBT-GASP	Optical, radio, mm, IR
Swift	UV & Soft X-ray & Hard X-ray
Suzaku	Soft X-ray & Hard X-ray
INTEGRAL	Hard X-ray
Super-AGILE	Hard X-ray
AGILE/GRID	Gamma-rays
MAGIC	TeV
VERITAS	TeV
ARGO	TeV
HESS	TeV

Flaring AGN database

TABLE 1. List of the AGILE flaring blazars. References: 1. Chen et al., 2008, A&A, 489, L37; 2. Vittorini et al., 2009, ApJL, submitted; 3. Giommi et al., 2008, A&A, 487, L49; 4. Donnarumma et al., 2009, ApJL, 691, 13; 5. Maier et al., 2009, in preparation; 6. Pucella et al., 2008, A&A, 491, L21; 7. D'Ammando et al., 2009, in preparation; 8. Pucella et al., 2009, in preparation 9. Pacciani et al., 2009, A&A, 494, 49; 10. Giuliani et al., 2009, A&A, 494, 509; 11. Vercellone et al., 2008, ApJL, 676, 13; 12. Wehrle et al., 2009, in preparation; 13. Vercellone et al., 2009a, ApJ, 690, 1018; 14. Donnarumma et al., 2009, in preparation; 15. Vercellone et al., 2009b, in preparation; 16. Pucella et al., 2009, in preparation.

Name	**Period** *start : stop*	**Sigma**	**ATel #**	**Ref.**
S5 0716+714	2007-09-04 : 2007-09-23	9.6	1221	1, **2**
	2007-10-24 : 2007-11-01	6.0	-	3
MRK 0421	2008-06-09 : 2008-06-15	4.5	1574, 1583	4
W Comae	2008-06-09 : 2008-06-15	4.0	1582	**5**
PKS 1510−089	2007-08-23 : 2007-09-01	5.6	1199	6
	2008-03-18 : 2008-03-20	7.0	1436	**7**
	2009-03-01 : 2009-03-31	19.9	1957, 1968, 1976	**8**
3C 273	2007-12-16 : 2008-01-08	4.6	-	9
3C 279	2007-07-09 : 2007-07-13	11.1	-	10
3C 454.3	2007-07-24 : 2007-07-30	13.8	1160, 1167	11, **12**
	2007-11-10 : 2007-12-01	19.0	1278, 1300	13
	2007-12-01 : 2007-12-16	21.3	-	**14**
	2008-05-10 : 2009-01-01	15.0	1545, 1581, 1592, 1634	**15**
PKS 0537−441	2008-10-10 : 2008-10-17	5.5	-	**16**

Blazar flavours

AGILE detected at least one object for each blazar category:

FSRQ → 3C 454.3 **LBL → PKS 0537-441**

IBL → S5 0716+714 **HBL → MKN 421**

A few sources were detected more than once:

S5 0716+714; PKS 1510-089; 3C 454.3

Variability level could be very different:

Extr. Low (3C 279); Extr. High (PKS 1510-089)

Gamma-ray activity could vary on different time scale:

A few days (W Comae); Months (3C 454.3)

Published results

S5 0716+714

Chen et al., 2008, A&A, 489, L37

$\langle F_\gamma \rangle$ = (97 ± 15)E-8 ph/cm2/s E>100MeV

z = 0.31 ± 0.08 (Nilsson et al., 2008)

Total power transported in the jet is extremely high (L>3E45 erg/s).

This may exceed the max. power generated by a Kerr BH with M_{BH}~1E9 M_{Sun}.

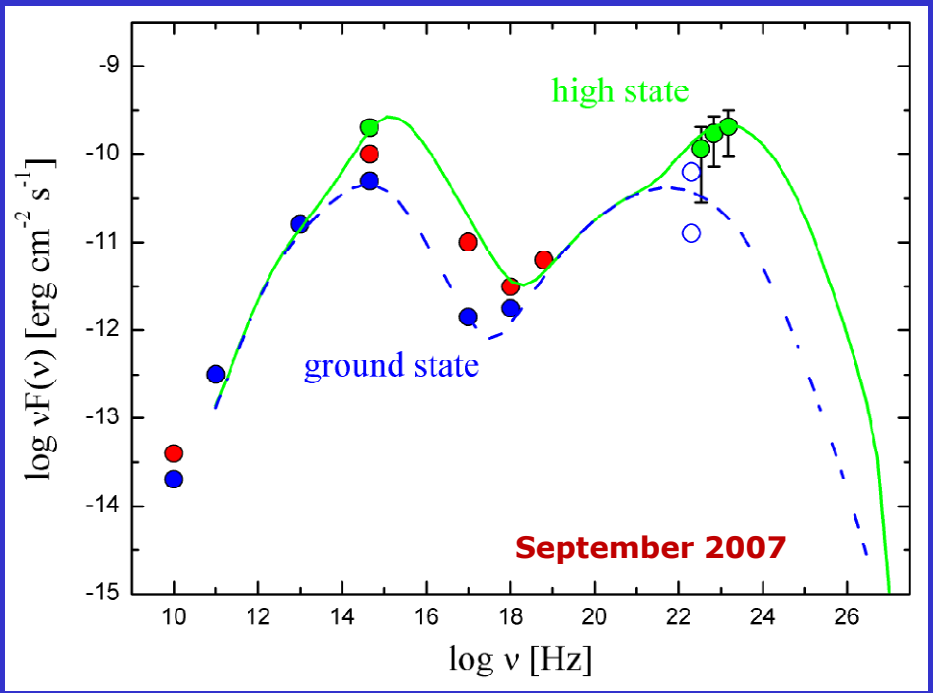
Giommi et al., 2008, A&A, 487, L49

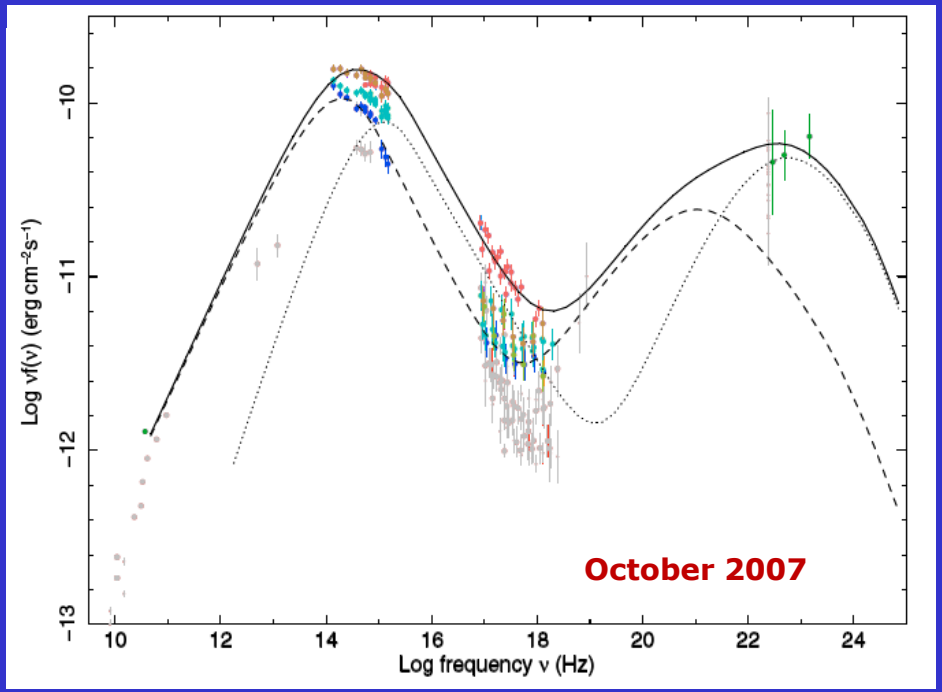
$\langle F_\gamma \rangle$ = (47 ± 11)E-8 ph/cm2/s E>100MeV

The γ-ray flux about a factor of 2 lower than in September.

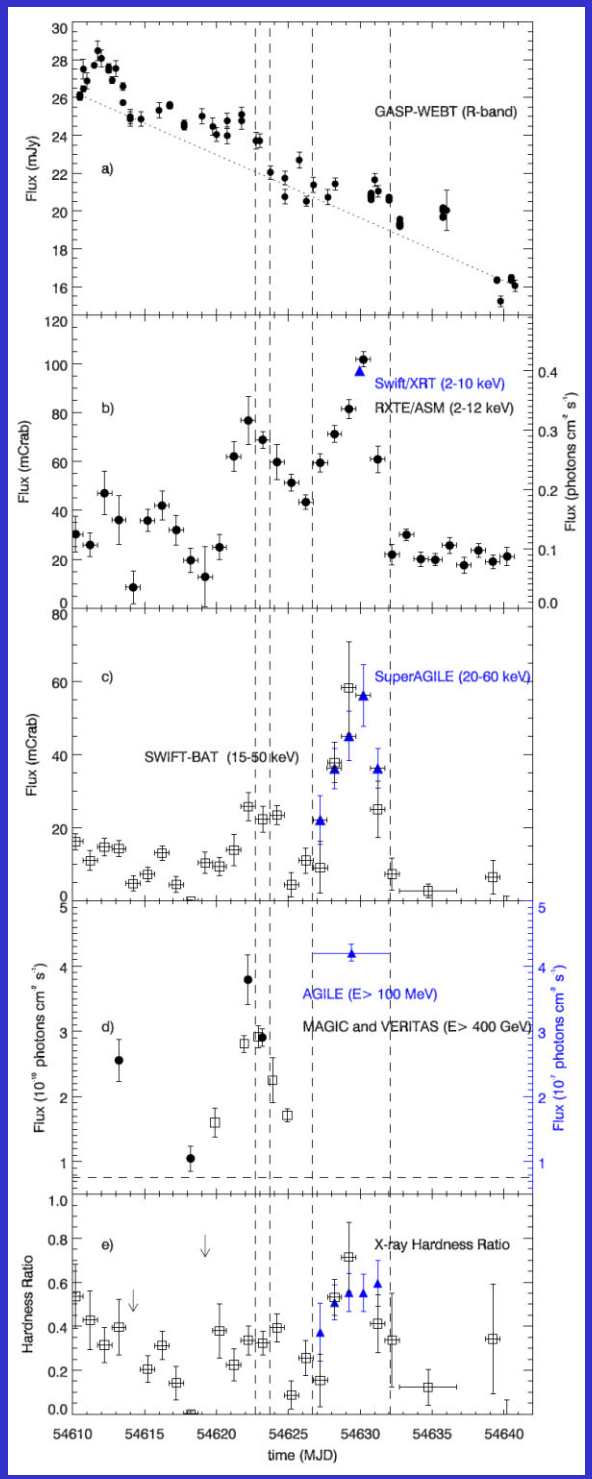
Swift observed different variability in opt/UV, soft X-ray, and hard X-ray.

The SED is consistent with a two—components SSC model.





MKN 421



Donnarumma et al., 2009, ApJL, 691, L13

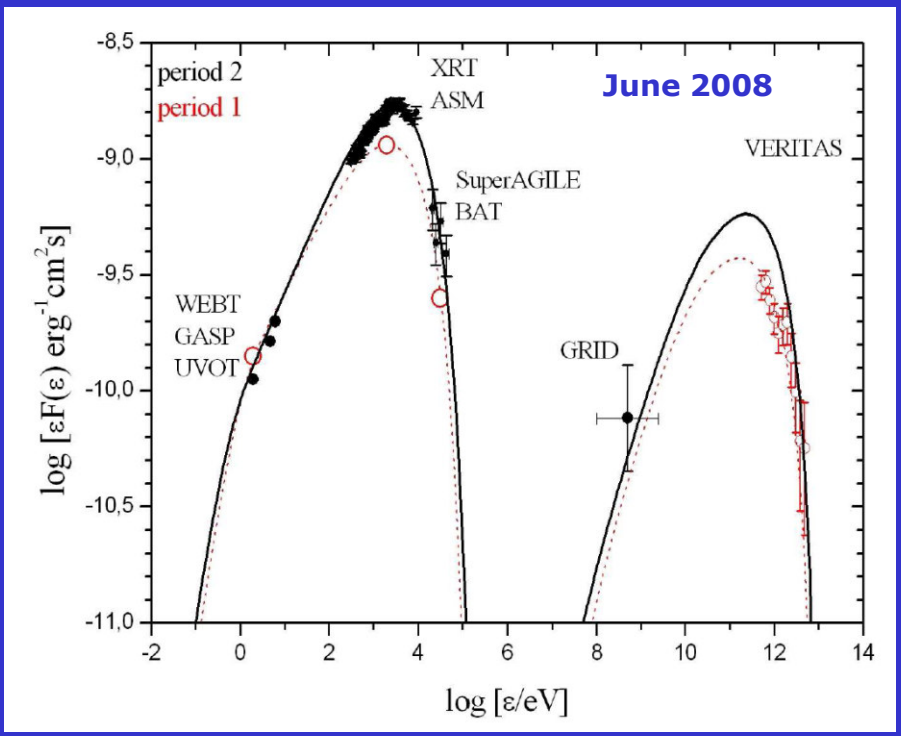
$\langle F_\gamma \rangle$ = (42 ± 13)E-8 ph/cm2/s E>100MeV

SA: 40mCrab (0.4 ph/cm2/s) 15—50 keV

Swift/XRT: 2.6E-9 ph/cm2/s 2—10 keV

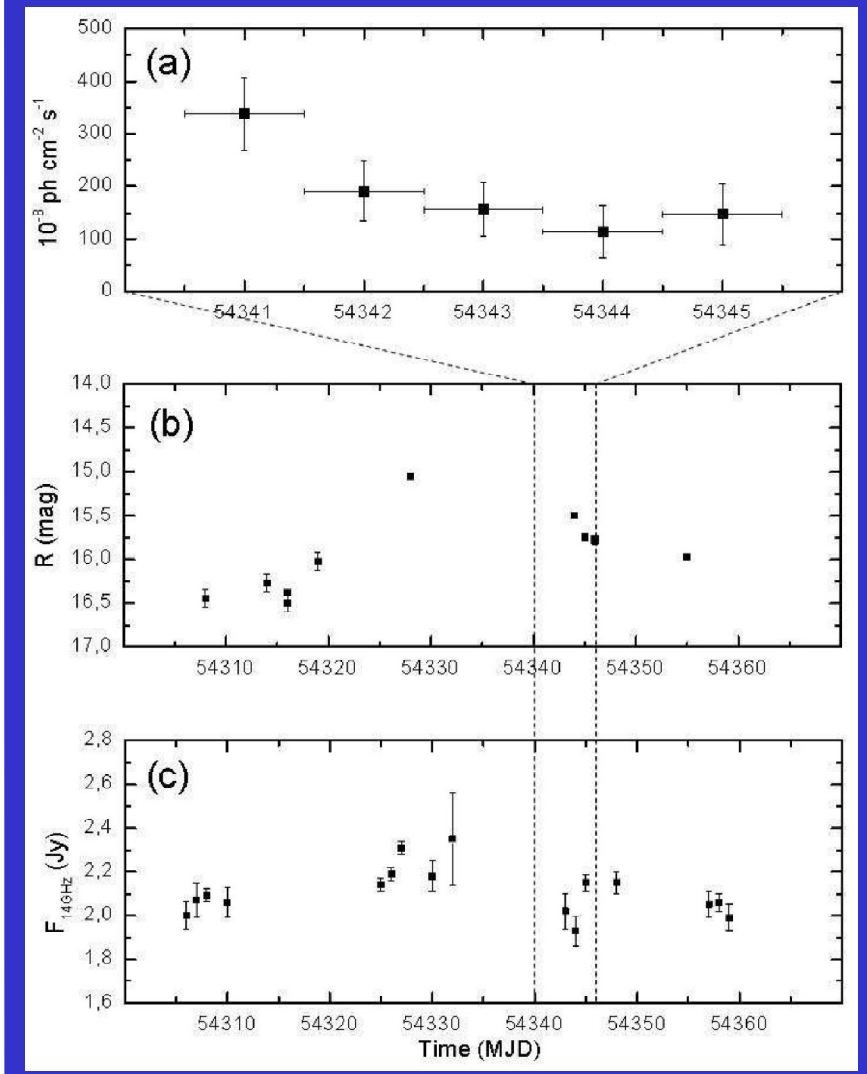
Correlated variability (optical, X-rays, HE, and VHE)

The γ-ray flare can be interpreted within the framework of the SSC model in terms of a rapid acceleration of leptons in the jet.



PKS 1510-089

23/08—01/09 2007

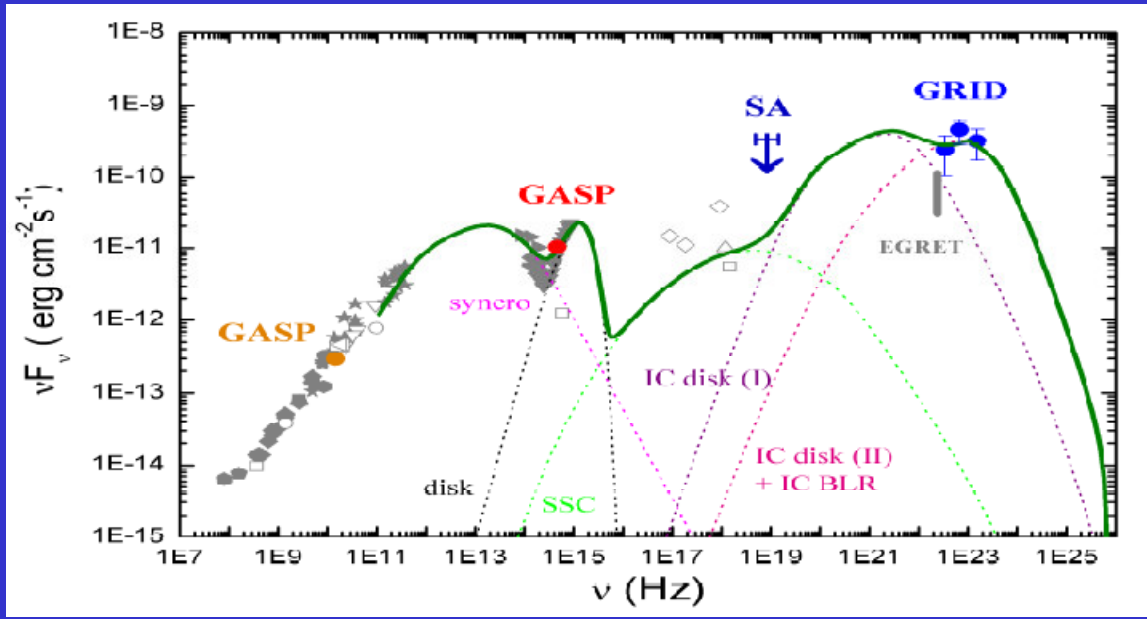


Pucella et al., A&A, 2008, 491, L21

$\langle F_\gamma \rangle$ = (195 ± 30)E-8 ph/cm2/s E>100MeV

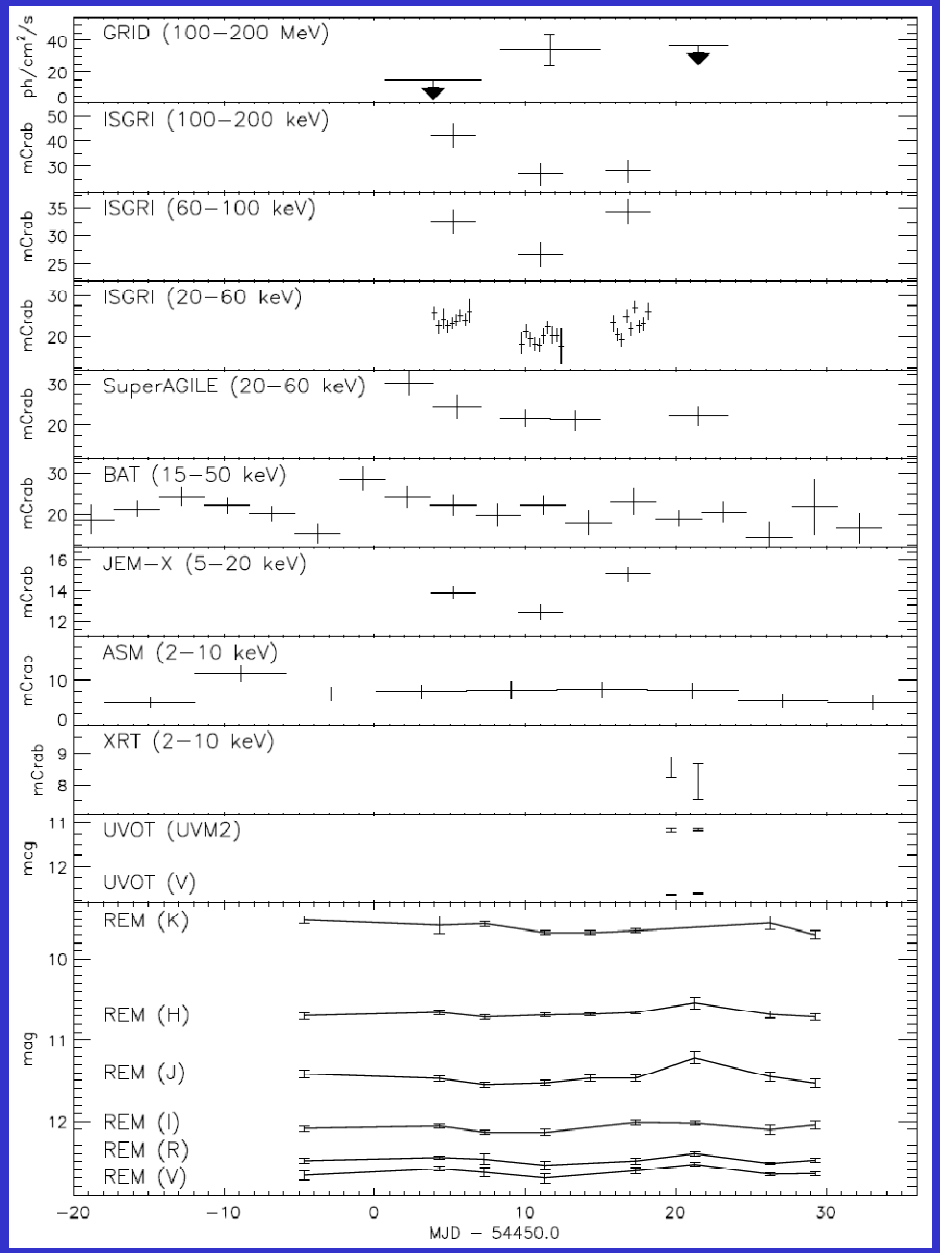
A common trend (fluxes decrease) in the optical and γ-ray LC seems to be present.

The overall SED can be fit by means of a leptonic model (SSC+EC on BLR clouds)



3C 273

16/12/2007 – 08/01/2008



Pacciani et al., A&A, 2009, 494, 49

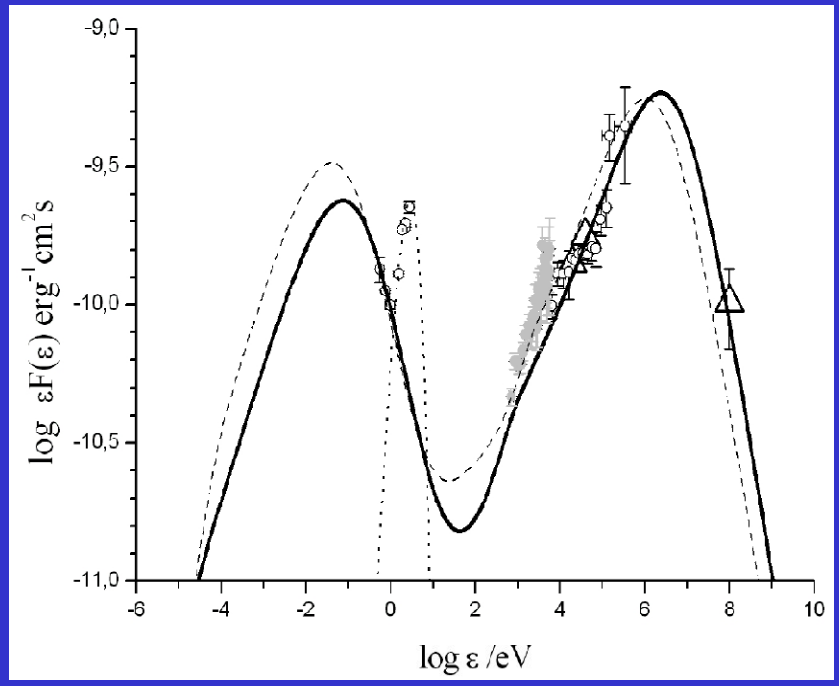
$\langle F_\gamma \rangle$ = (22 ± 6)E-8 ph/cm2/s E>100MeV

F_γ [peak] = (33±11)E-8 ph/cm2/s E>100MeV

First simultaneous detection by GRID & SA

No optical variability during the whole campaign (possible anti-correlation between the γ -ray and the X-ray light curves ?)

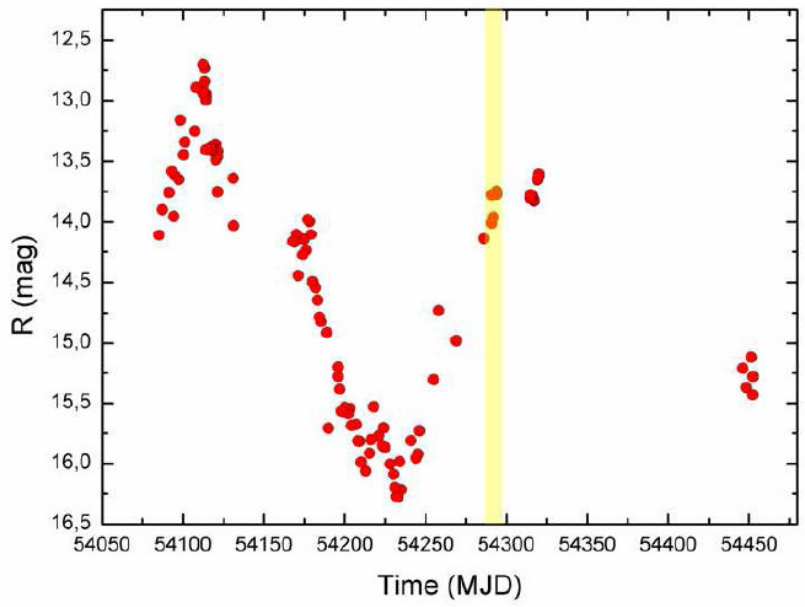
Soft X-ray: SSC + EC. Hard X-ray and γ –ray: EC from thermal photons of the disk.



3C 279

09—13/07 2007

Observation date	Flux 2-10 keV erg cm^{-2} s^{-1}	Spectral slope Γ	χ^2_r (d.o.f.)
10-Jul-2007	1.20×10^{-11}	1.42 ± 0.05	1.21 (73)
11-Jul-2007	1.17×10^{-11}	1.47 ± 0.07	0.86 (52)
12-Jul-2007	1.05×10^{-11}	1.47 ± 0.06	1.07 (57)
13-Jul-2007	1.13×10^{-11}	1.48 ± 0.06	0.96 (50)



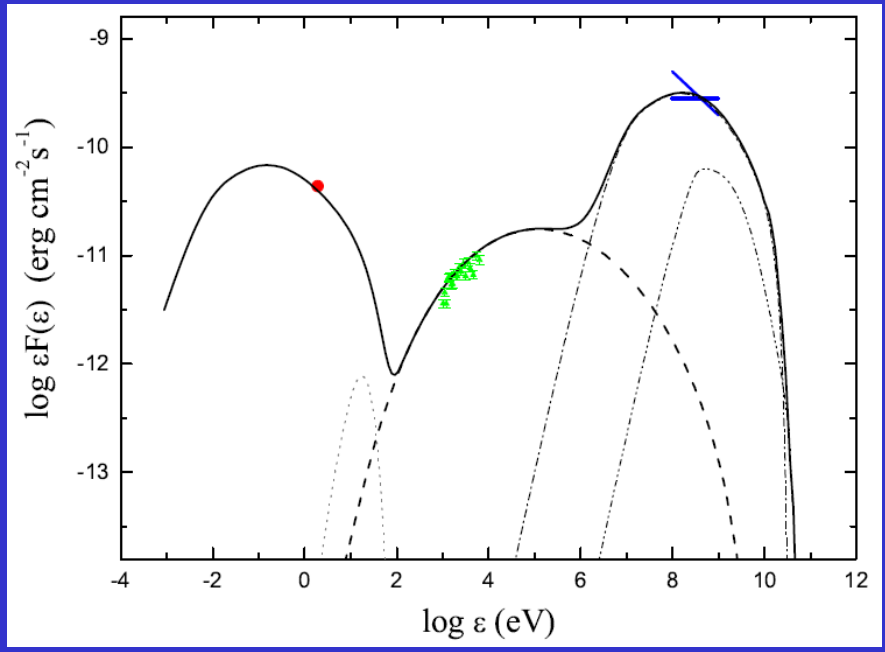
Giuliani et al., A&A, 2009, 494, 509

$\langle F_\gamma \rangle$ = (210 ± 38)E-8 ph/cm2/s E>100MeV

First extragalactic source detected by AGILE/GRID & first AGILE multi—λ campaign

Gamma—ray flux similar to the EGRET high state

Soft γ-ray spectrum (Γ = 2.22 ± 0.23): low state of the accretion disk before the γ-ray observations, suggesting a dominant contribution of the EC of direct disk radiation compared to the EC scattering of the BLR clouds.



3C 454.3

Vercellone et al, 2008, ApJ, 676, L13

AGILE repointing at 36 deg off—axis

$\langle F_\gamma \rangle$ = (280 ± 40)E-8 ph/cm2/s E>100MeV

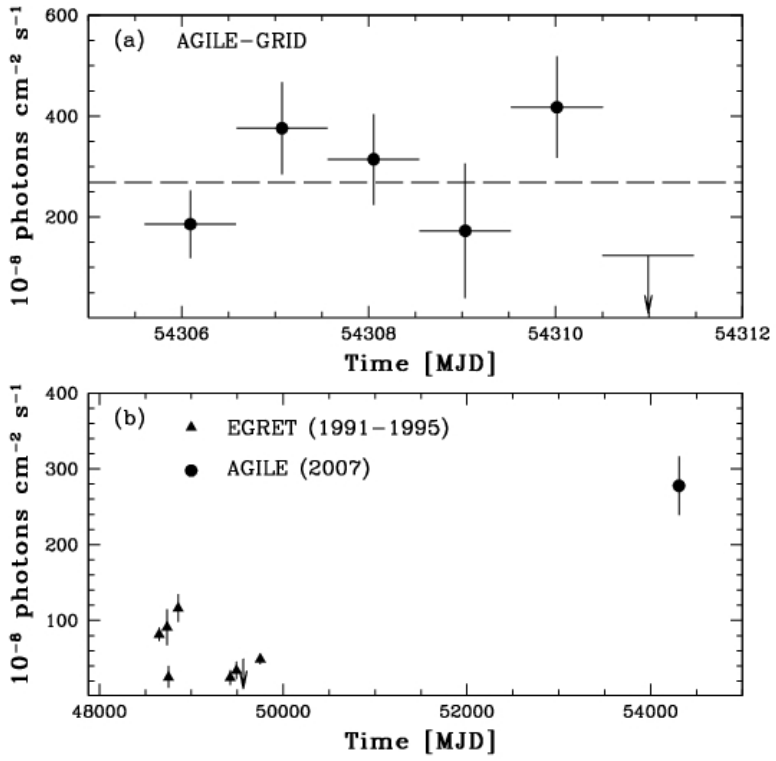
Highest published flux (till now … but see Fermi, Tosti et al., ATel #1628)

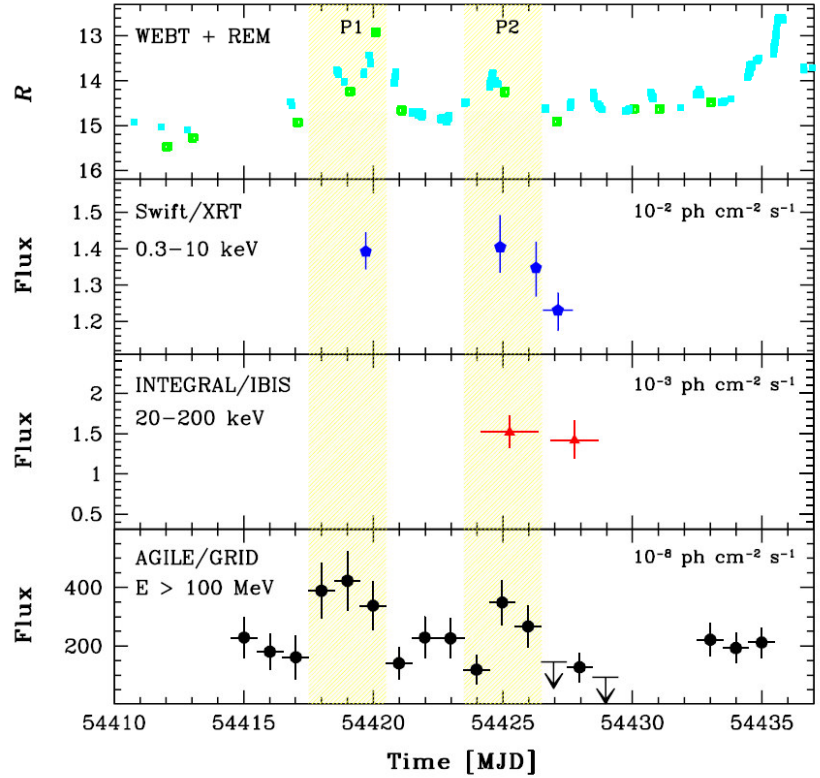
Vercellone et al., 2009, ApJ, 690, 1018

Result of a multi—λ campaign based on pre—approved ToOs and GI programs

$\langle F_\gamma \rangle$ = (170 ± 13)E-8 ph/cm2/s E>100MeV

Extremely variable behavior in the R band.





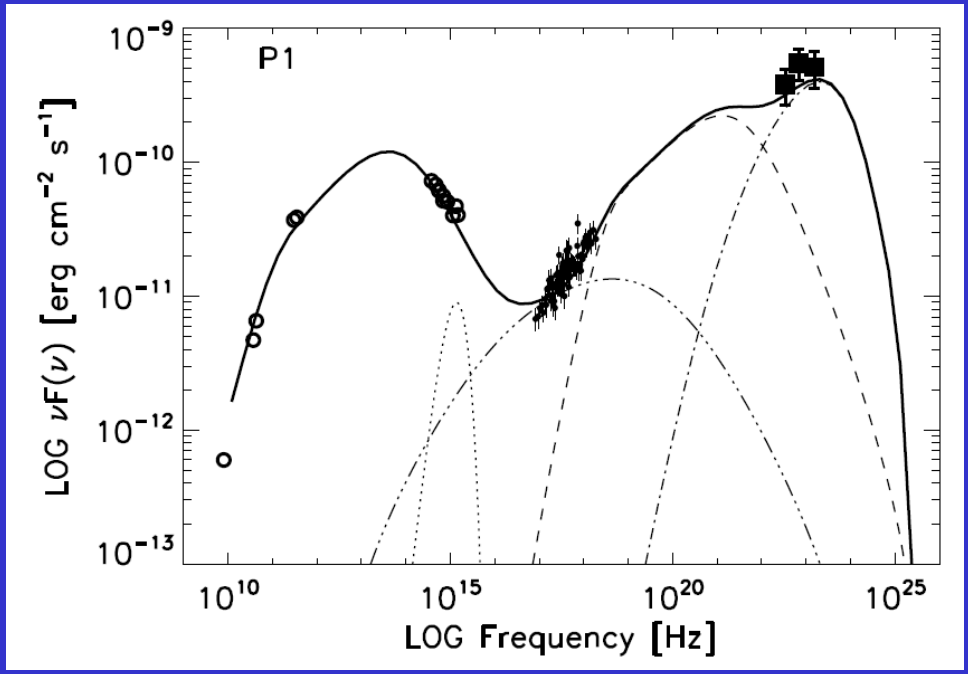
3C 454.3

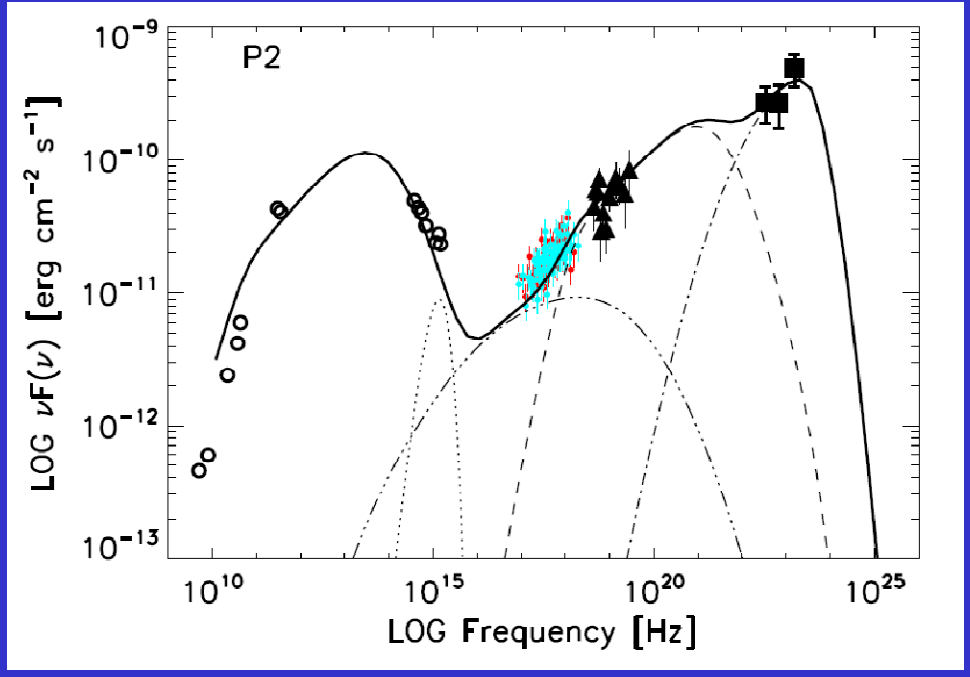
Parameter	SED P1	SED P2	Units
α_l	2.1	2.2	
α_h	4.5	5.0	
γ_{min}	10	10	
γ_b	500	500	
K	14	12	cm^{-3}
R	35	35	10^{15} cm
B	10	8	G
δ	14.64	14.64	
L_d	5	5	10^{46} erg s^{-1}
r	0.05	0.05	pc
Θ_0	2.6	2.6	degrees
Γ	8.4	8.4	

The average photon index ($\Gamma = 1.73 \pm 0.16$) is harder than the time–averaged one ($\Gamma = 2.22 \pm 0.06$) reported for EGRET.

During intense γ-ray flares, the ECC and ECD play a major role and the softness/hardness of the resulting spectrum is controlled by the dominant component.

The emission between 30 MeV and 30 GeV is dominated by IC scattering of relativistic electrons in the jet on the external photons from the broad line region.

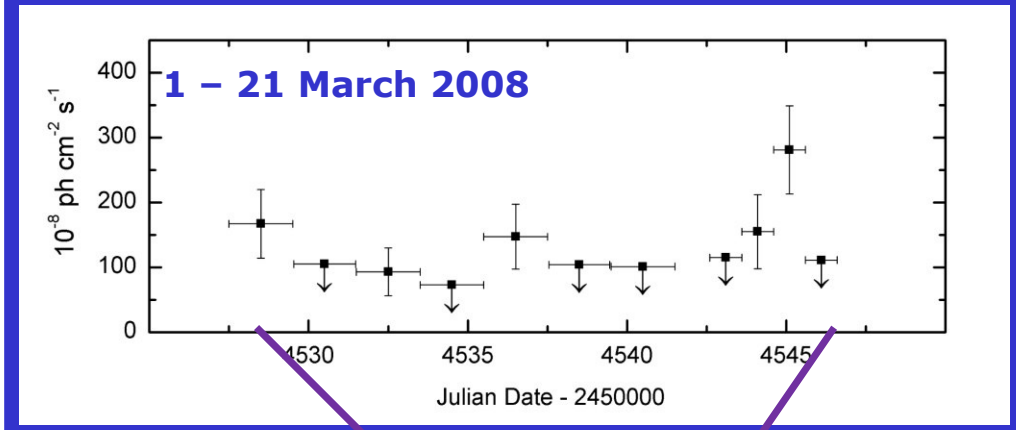




More to come…

News from the outback…

PKS 1510-089



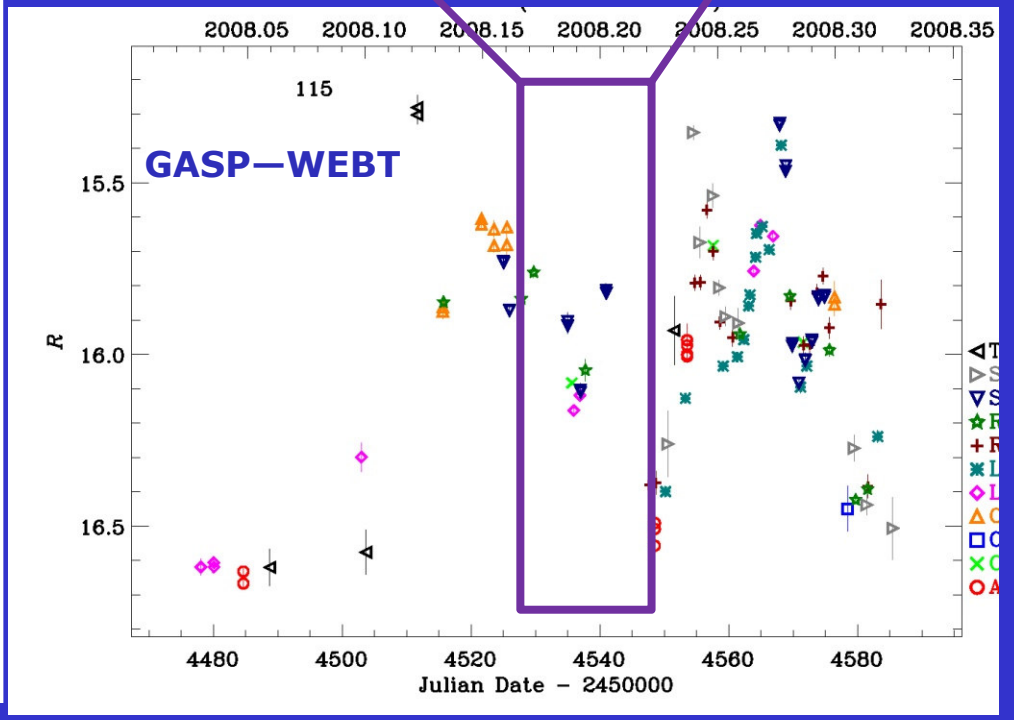
D'Ammando et al., submitted

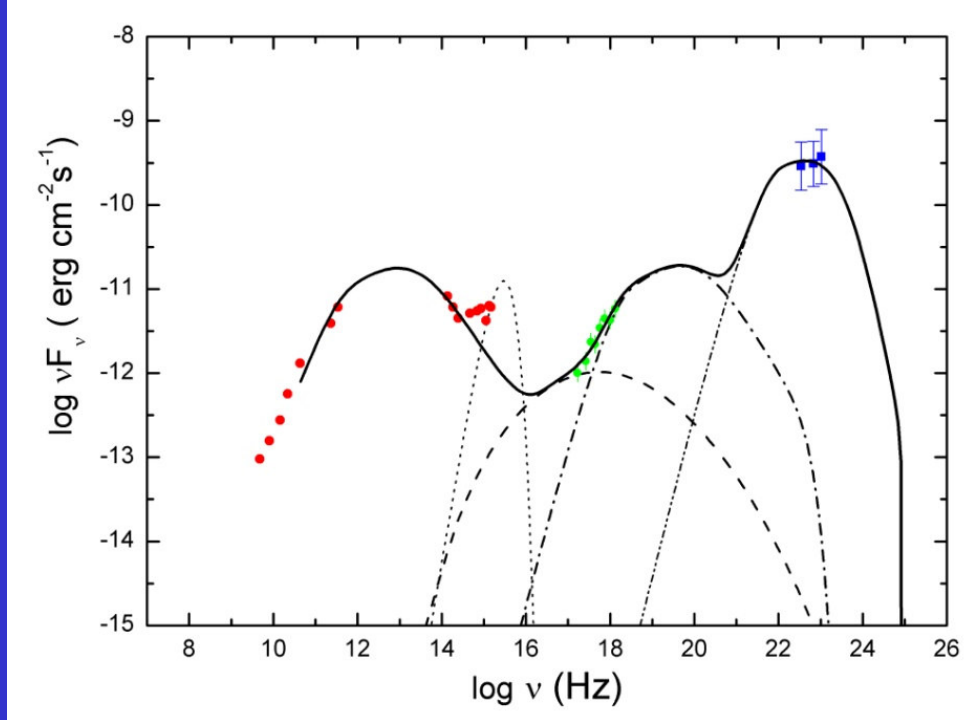
3 Optical flares: 15/02, 29/03, 11/04

The γ-ray photon index is Γ = (1.81 ± 0.34)

In the period March 17-21 the average flux was $<F_\gamma>$ = (170 ± 13)E-8 ph/cm2/s

The SED is modelled with a multi-component SSC+ECC+ECD+black body (disk) model

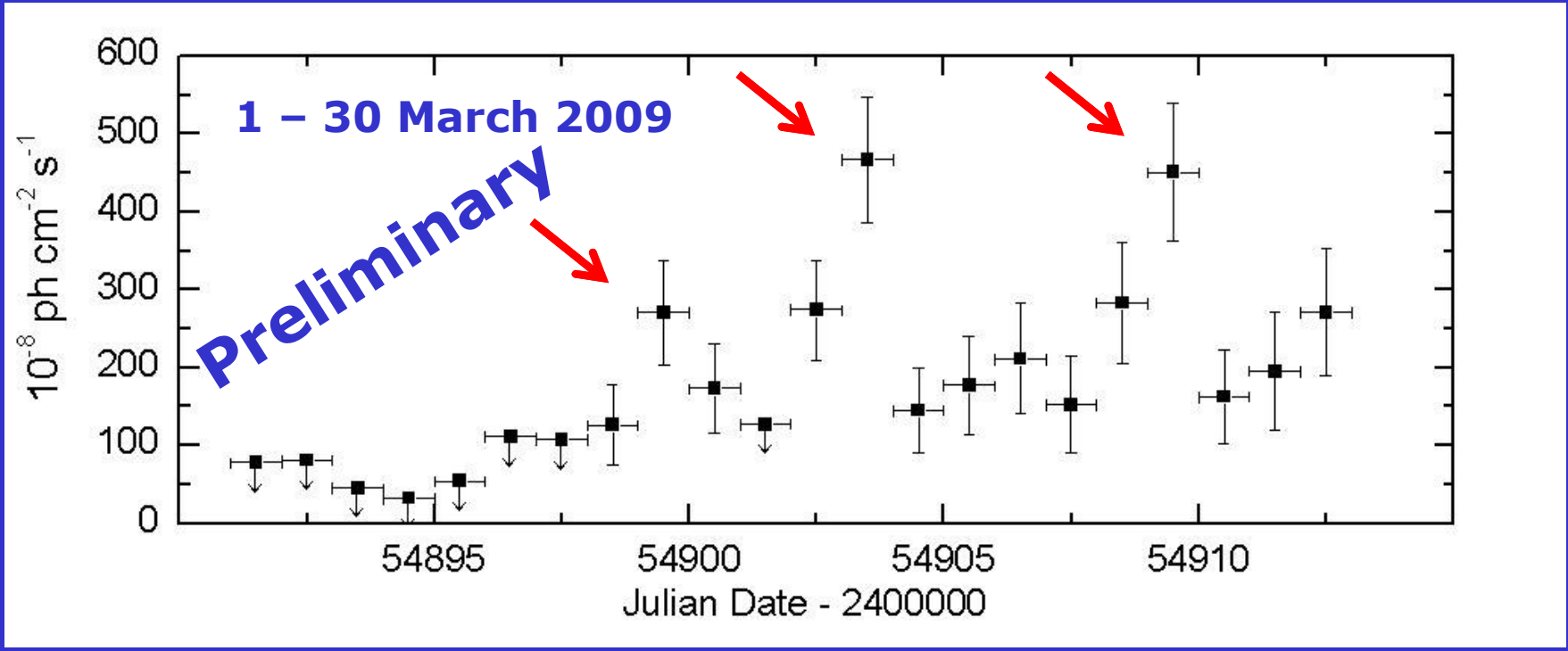




PKS 1510-089

Pucella et al., in preparation

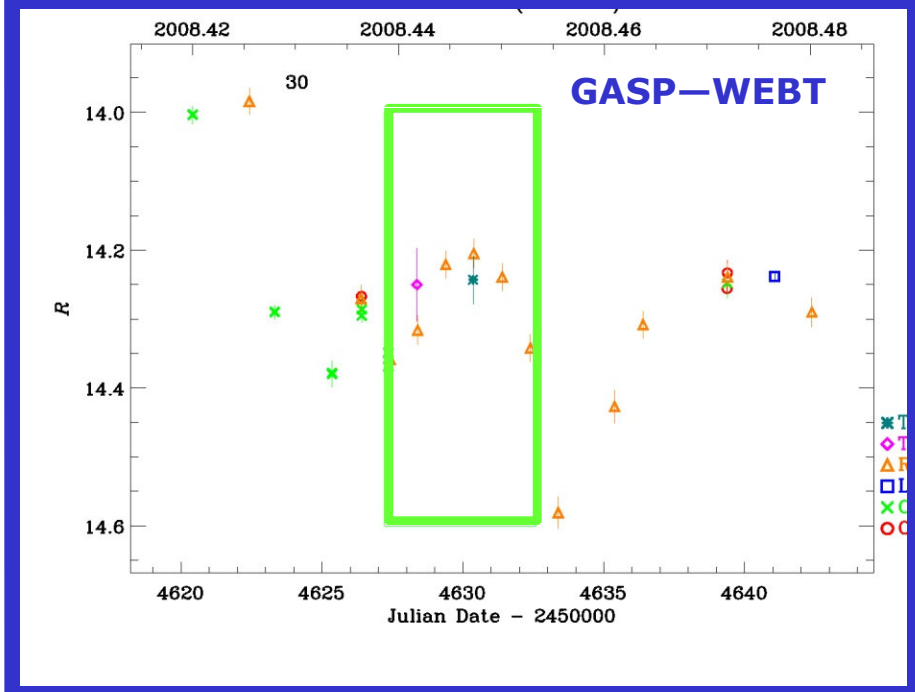
- **D'Ammando et al., ATel #1957, 2009-03-08 14:00 UT and 2009-03-10 4:00 UT flux in excess of 200 x 10^-8 ph cm^-2 s^-1.**
- **Pucella et al., ATel #1968, 2009-03-12 07:00 UT and 2009-03-13 05:00 UT flux in excess of 400 x 10^-8 ph cm^-2 s^-1.**
- **Vercellone et al., ATel #1976, 2009-03-18 05:45 UT and 2009-03-19 05:33 UT flux of about 400 x 10^-8 ph cm^-2 s^-1. This value represents an increase of more than a factor of 3 within 24 hours compared with the gamma-ray flux level detected during the previous three days.**

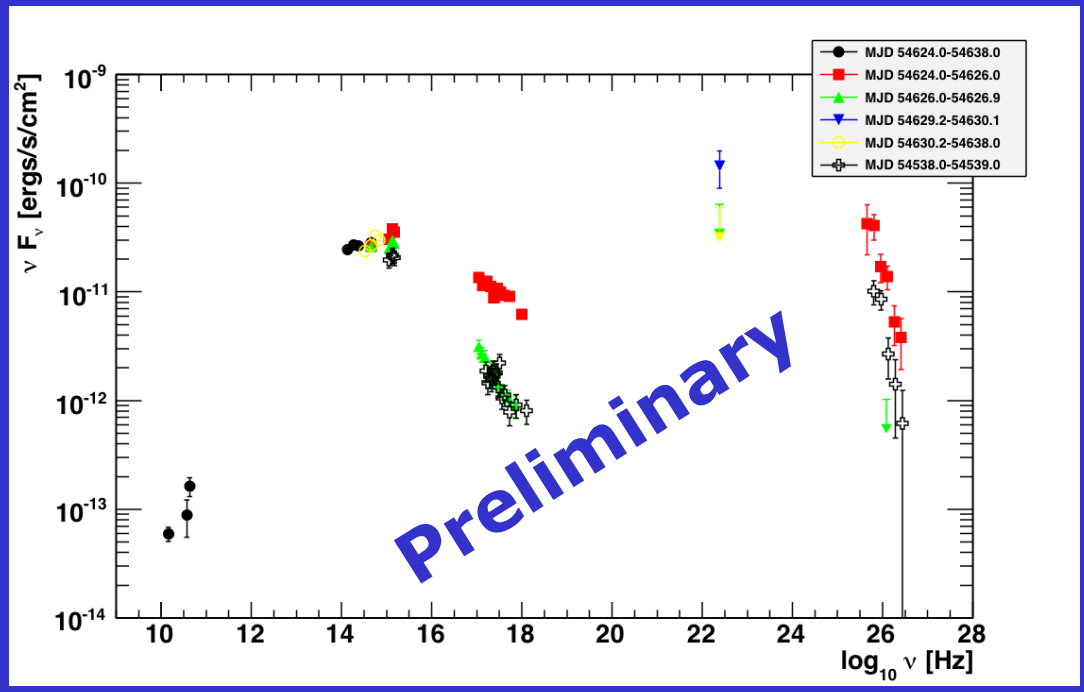


W Comae

Maier, Pian et al., in preparation

- **Detection by VERITAS (Swordy et al., ATel #1565) on 2008-06-07 at a flux double w.r.t. the flux detected in March 2008.**
- **AGILE ToO and subsequent detection (Verrecchia et al., ATel #1582)**
- **Multi-λ campaign, involving GASP—WEBT, Swift, AGILE and VERITAS**
- **This source belongs to an AGILE AO—1 GI (Pian).**

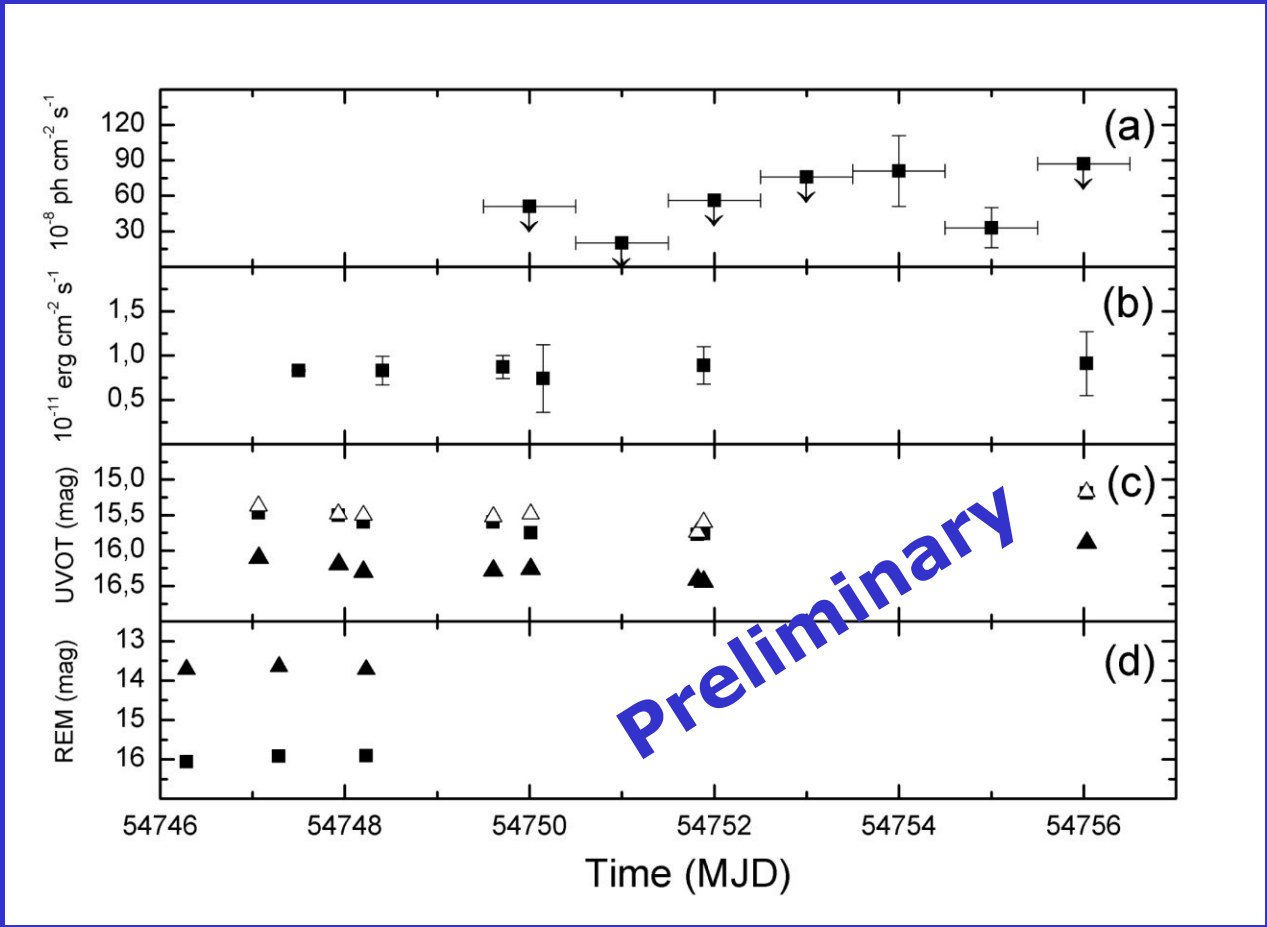




PKS 0537-441

Pucella et al., in preparation

- **Fermi/LAT detection (Tosti, ATel #1759) between 2008-09-15 and 2008-10-02, at a flux level of the order of 100E-8 ph/cm2/s.**
- **AGILE ToO with almost simultaneous Swift and REM observations.**



AGILE

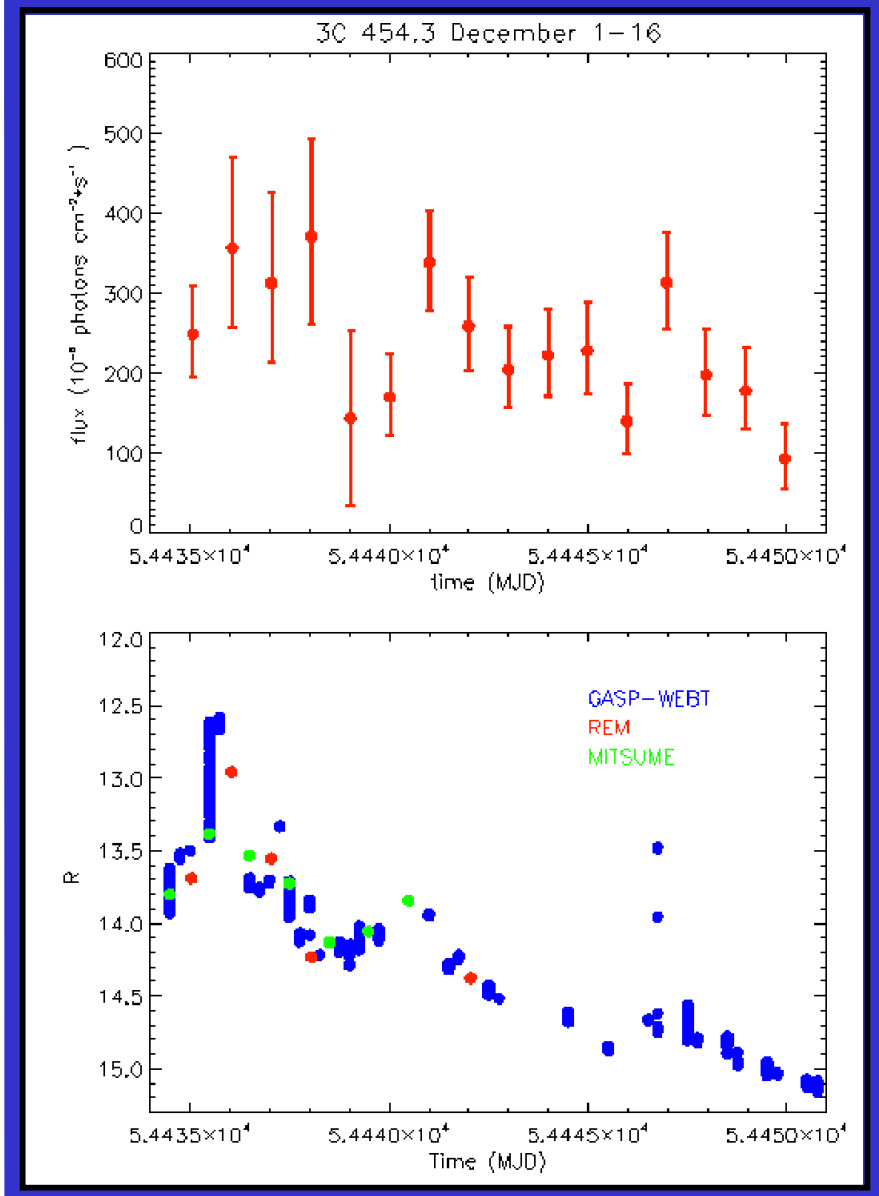
Swift/XRT

Swift/UVOT

REM

3C 454.3

December 2007

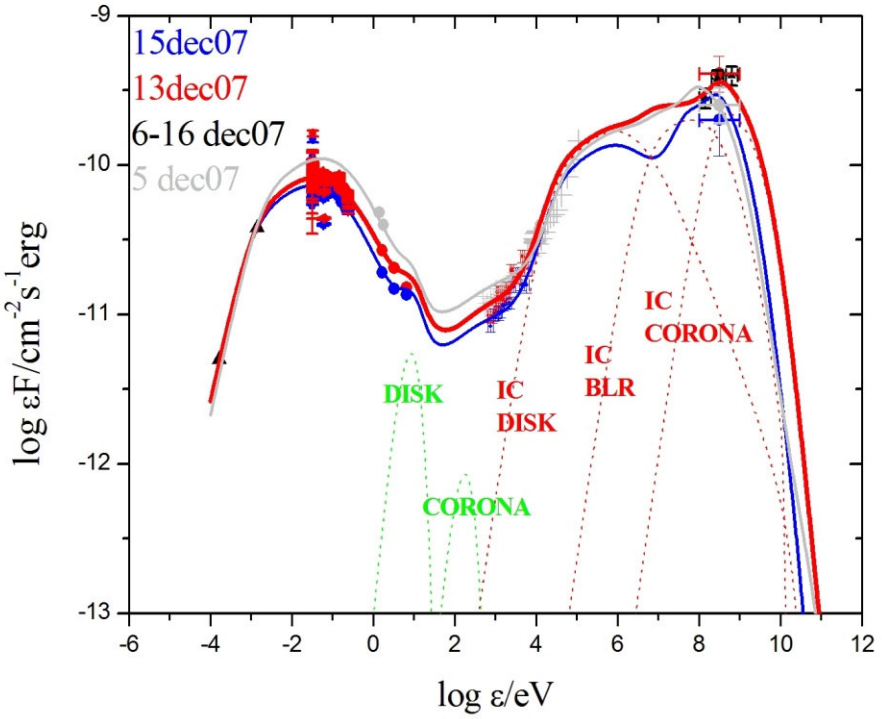


Donnarumma et al., submitted

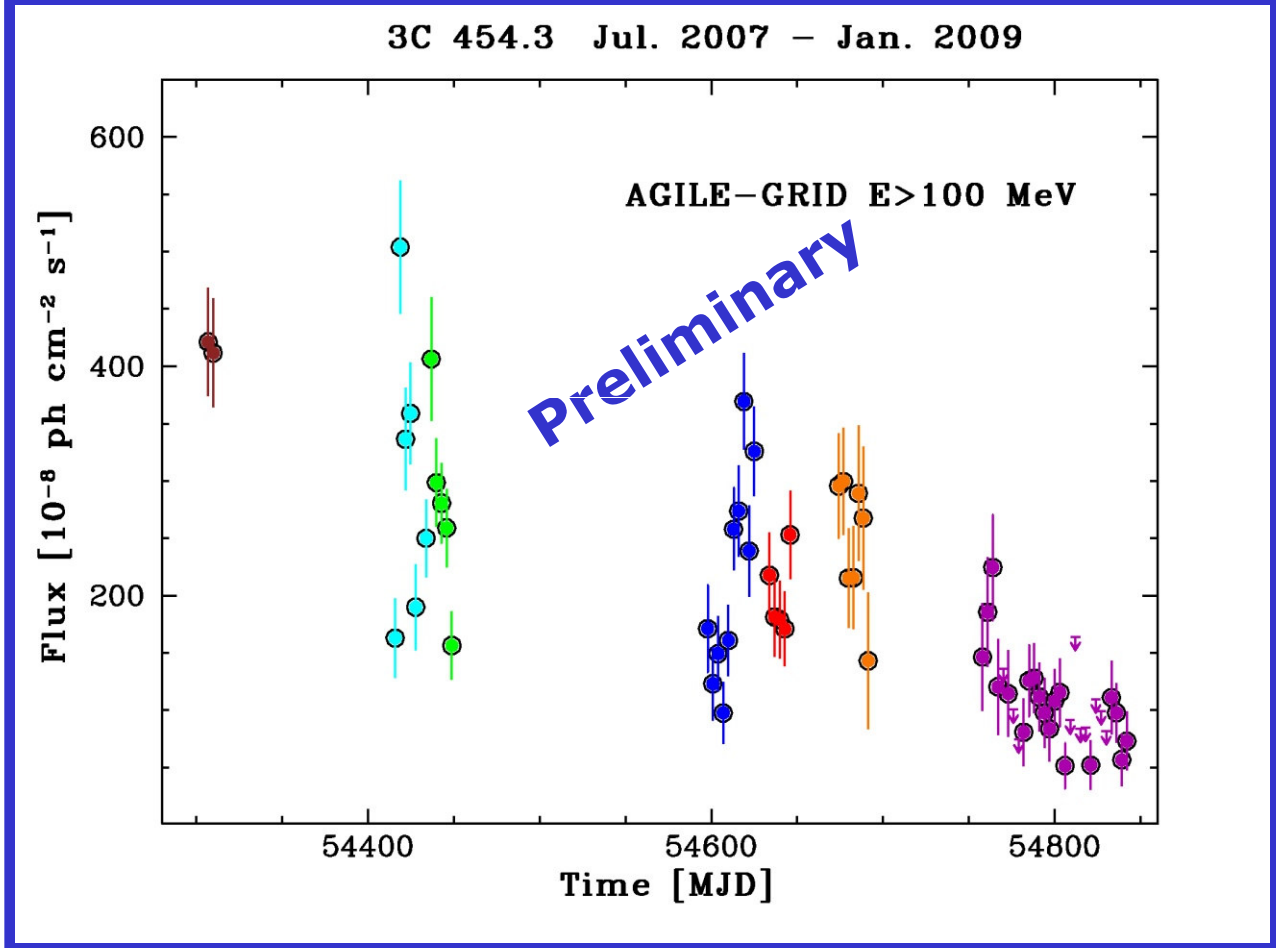
Multi-λ campaign with the contribution of Spitzer, REM, WEBT, MITSuME, Swift, Suzaku and AGILE

$\langle F_\gamma \rangle$ ~ 250 x 10^{-8} ph cm^{-2} s^{-1} E > 100 MeV

The SED may require EC emission of seed photons from a hot corona with T = 10^6 K



3C 454.3



Vercellone et al., in preparation

The longest monitoring so far of a γ-ray blazar.

A factor of about 10 in dynamic range in about 2 years (if considering also the Fermi data).

AGILE & blazars : a summary

- **The *AGILE* strength lies in its name:**
  - **it promptly reacts to external alerts (e.g., 3C 454.3, W Comae, PKS 0537-441)**
  - **it triggers ATels and ToOs with other Observatories.**
- **Several multi—λ papers are already printed, and others are ready-to-go.**
- **Archival data analysis is in process, in order to detect dim and steady sources.**
- **For any blazar request: stefano@ifc.inaf.it**