

**Not only typical flaring blazars  
in the Fermi gamma-ray sky.  
The strange cases of SBS  
0846+513 and PKS 0521-36**

**Filippo D'Ammando**

**(University of Perugia and INFN)**

and

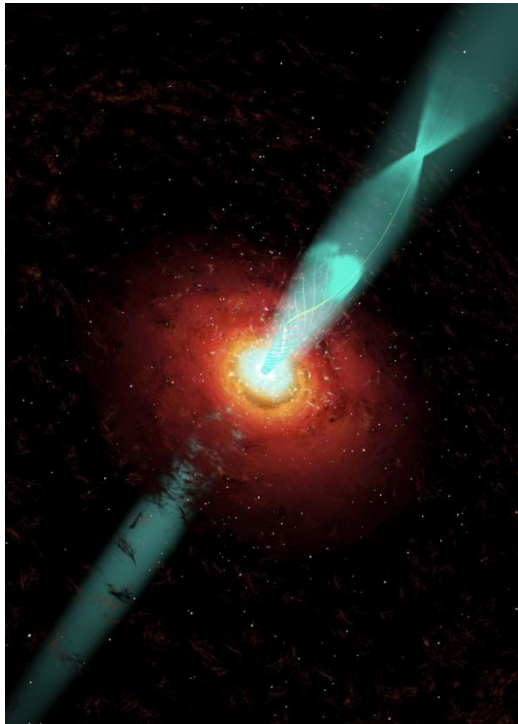
**M. Orienti (Univ. of Bologna and INAF-IRA)**

**J. Finke (U.S Naval Research Laboratory)**

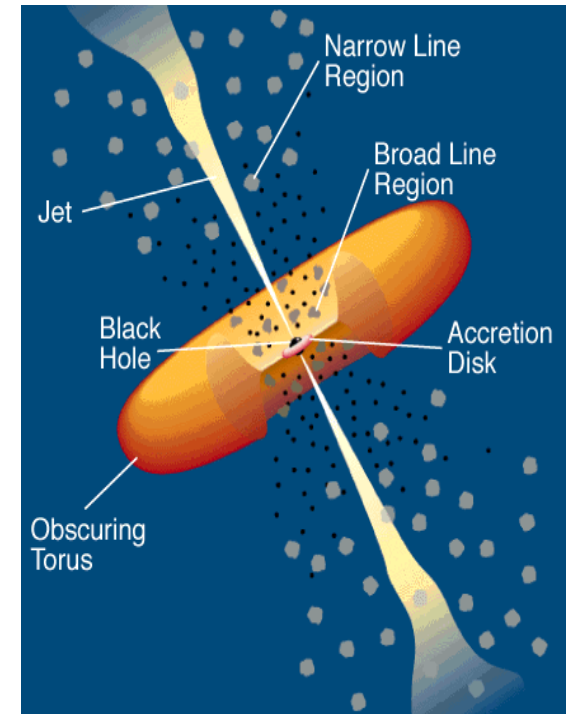
**M. Giroletti (INAF-IRA Bologna)**

**E. Torresi (INAF Bologna)**

**on behalf of the Fermi LAT Collaboration**



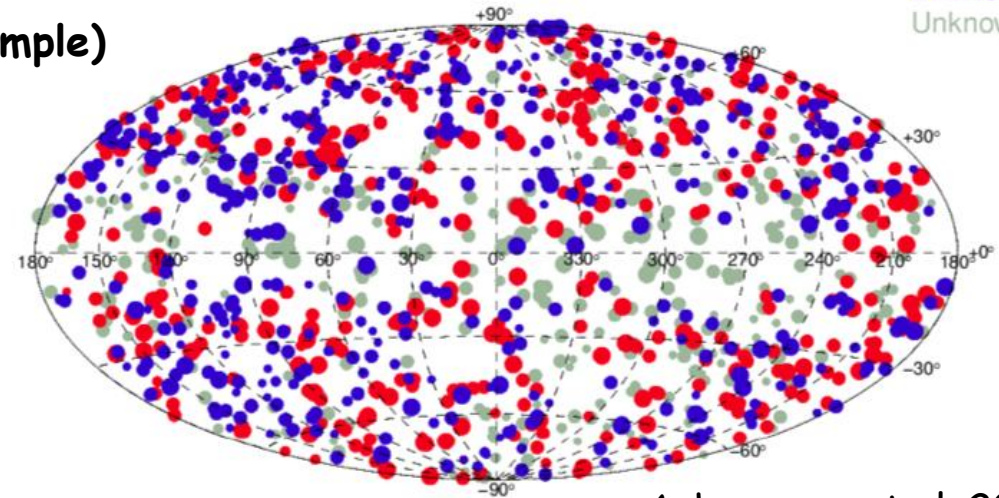
***Blazars are AGNs!!!***



Second LAT Catalogue (2LAC)  
TS>25, August 2008 – August 2010

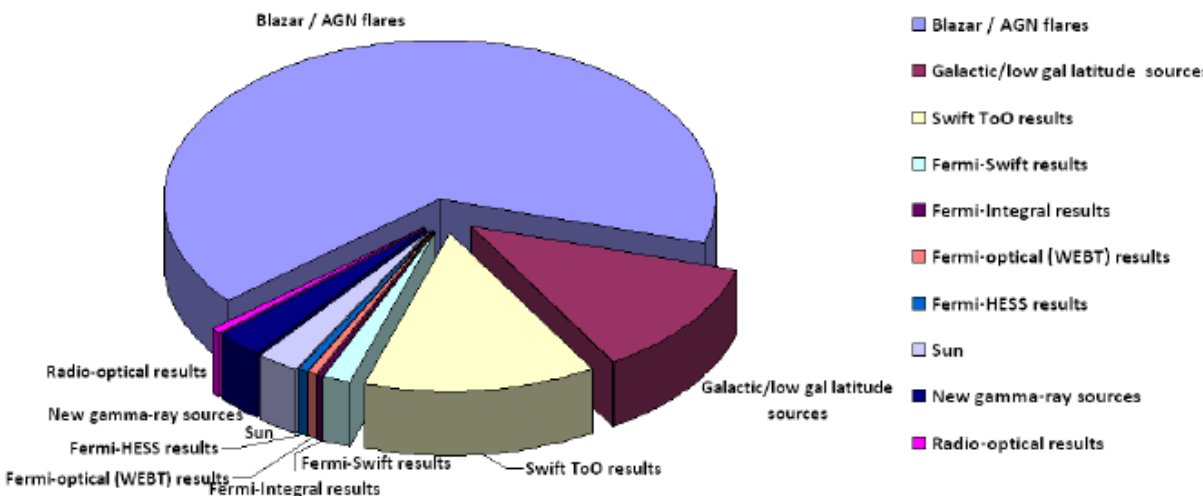
2LAC includes 886 AGNs (clean sample)

- 310 FSRQs
- 395 BL Lacs
- 157 of unknown type
- 24 other AGNs



Ackermann et al. 2011

203 Astronomer's Telegrams posted by the LAT Team for reporting gamma-ray flaring sources (up to 2012 August 28): most of them for AGNs





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## Fermi LAT detection of a GeV flare from the Radio-Loud Narrow-Line Sey1 SBS 0846+513

ATel #3452: [D. Donato \(CREST/UMCP/GSFC\)](#), [J. S. Perkins \(CREST/UMBC/GSFC\)](#), [on behalf of the Fermi Large Area Telescope Collaboration](#)  
on 24 Jun 2011; 16:13 UT

Credential Certification: [Davide Donato \(davide.donato-1@nasa.gov\)](mailto:davide.donato-1@nasa.gov)

Subjects: Gamma Ray, >GeV, AGN, Blazar, Transient

The Large Area Telescope (LAT), one of the two instruments on the Fermi Gamma-ray Space Telescope, has observed an increasing gamma-ray flux from a source positionally consistent with SBS 0846+513 (RA=08h49m57.9768s, Dec=+51d08'29.023", J2000, Kovalev et al. 2007, AJ, 133, 1236), a  $z=0.583715$  radio-loud narrow line Seyfert 1 galaxy (Zhou et al. 2005 ChJAA, 5, 41).

Preliminary analysis indicates that on June 21, 2011 the source was in a high state with a gamma-ray flux ( $E>100\text{MeV}$ ) of  $(0.8 \pm 0.2) \times 10^{-6}$  photons  $\text{cm}^{-2} \text{s}^{-1}$ . During the first 2 years of the Fermi mission, this source was not detected, yielding an upper limit on the flux of  $4.0 \times 10^{-9}$  photons  $\text{cm}^{-2} \text{s}^{-1}$ . In the last 11 months this source has brightened to an average flux of  $(5.8 \pm 0.7) \times 10^{-8}$  photons  $\text{cm}^{-2} \text{s}^{-1}$ . Recently on June 17, SBS 0846+513 was detected in a single 24 hr timeframe with a gamma-ray flux of  $(0.4 \pm 0.2) \times 10^{-6}$  photons  $\text{cm}^{-2} \text{s}^{-1}$  (all errors are statistical only).

Since Fermi operates in an all-sky scanning mode, regular monitoring of this source will continue. In consideration of the ongoing activity of this source we strongly encourage multiwavelength observations. The Fermi LAT contact person for this source is D. Donato ([donato@milkyway.gsfc.nasa.gov](mailto:donato@milkyway.gsfc.nasa.gov)).

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.

## Fermi LAT detection of gamma-ray flaring activity from the radio galaxy NGC 1275

ATel #2737: [D. Donato \(NASA/GSFC\)](#), [D. Wood \(NRL\)](#), [C. C. Cheung \(NRC/NRL\)](#) [on behalf of the Fermi Large Area Telescope Collaboration](#)  
on 14 Jul 2010; 21:19 UT

Credential Certification: [Davide Donato \(davide.donato-1@nasa.gov\)](mailto:davide.donato-1@nasa.gov)

Subjects: Gamma Ray, AGN

Referred to by ATel #: [2916](#)

The Large Area Telescope (LAT), one of the two instruments on the Fermi Gamma-ray Space Telescope, has observed an increasing gamma-ray flux from a source positionally consistent with NGC 1275 (1FGL J0319.7+4130, Abdo et al. 2010, ApJS, 188, 405), a radio galaxy located at the center of the Perseus cluster (see also Abdo et al. 2009, ApJ, 699, 31).

Preliminary analysis indicates that the source began brightening on June 26, 2010 with a daily average gamma-ray flux ( $E>100\text{MeV}$ ) of  $(0.7 \pm 0.3) \times 10^{-6}$  photons  $\text{cm}^{-2} \text{s}^{-1}$  (errors are statistical only). Additional analysis revealed the same peak flux level was reached on several subsequent days, and as recently as July 14. The peak flux is a factor of  $\sim 3$  greater than its average observed during the first year of Fermi observations (Abdo et al. 2010), and is larger than the flare detected previously in April-May 2009 (Kataoka et al. 2010, ApJ, 715, 554).

Since Fermi operates in an all-sky scanning mode, regular monitoring of this source will continue. In consideration of the ongoing activity of this source we strongly encourage multiwavelength observations. The Fermi LAT contact persons for this source are J. Kataoka ([kataoka.jun@waseda.jp](mailto:kataoka.jun@waseda.jp)) and C. C. Cheung (Teddy.Cheung\_ctr@nrl.navy.mil).

## Fermi LAT further detection of a GeV flare from low redshift source PKS 0521-36

ATel #2683: [G. Iafrate \(INAF - OATS, Trieste\)](#), [F. Longo \(INFN Trieste\)](#), [F. D'Ammando \(INAF - IASF Palermo\)](#) [on behalf of the Fermi Large Area Telescope Collaboration](#)  
on 18 Jun 2010; 21:52 UT

Distributed as an Instant Email Notice Request For Observations  
Credential Certification: [Francesco Longo \(francesco.longo@ts.infn.it\)](mailto:francesco.longo@ts.infn.it)

Subjects: Gamma Ray, >GeV, Request for Observations, AGN

Referred to by ATel #: [2689](#)

The Large Area Telescope (LAT), on the Fermi Gamma-ray Space Telescope, has observed an increasing gamma-ray flux from a source positionally consistent with 1FGL J0522.8-3632, a source associated with PKS 0521-36 (RA: 05h22m57.98465s, DEC: -36d27m30.8509, J2000, Lambert et al. 2009, A&A, 493, 317) at  $z=0.055$ .

Preliminary analysis indicates that the source on June 17, 2010 was in a high state with a gamma-ray flux ( $E>100\text{MeV}$ ) of  $(1.0 \pm 0.2) \times 10^{-6}$  photons  $\text{cm}^{-2} \text{s}^{-1}$  (statistical uncertainty only), about 10 times the flux reported in the 1FGL catalogue (Abdo et al. 2010, ApJS, 188, 405).

This is the second time that Fermi is announcing activity on this source. It was already reported by Fermi at a slightly lower flux in its Gamma-ray sky blog on [January 29, 2010](#).

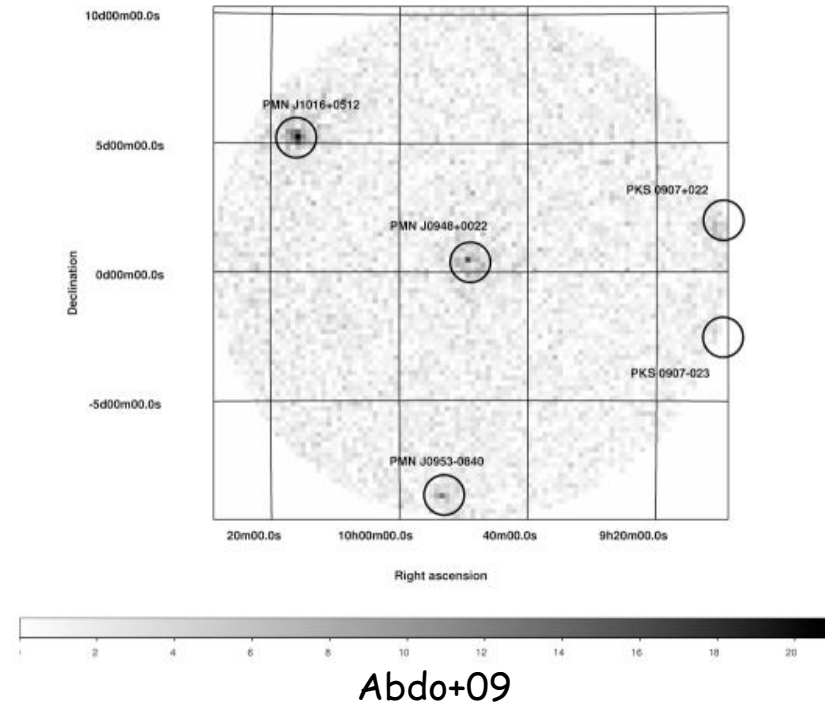
This source first classified as an N galaxy, and then as a BL Lac object, showed in optical and UV strong narrow and broad emission lines typical of Seyfert 1 galaxies (Ulrich 1981, A&A, 103, L1; Scarpa et al. 1995, A&A, 303, 730). Given the doubtful classification, the low redshift and in consideration of the ongoing activity of this source we strongly encourage multiwavelength observations. For this source the Fermi LAT contact person is Filippo D'Ammando

91 AGN detected in flare by LAT during the first 3.5 years of Fermi operation: 64 FSRQ + 16 BL LAC + 11 AGN

# Gamma-ray emitting NLS1s

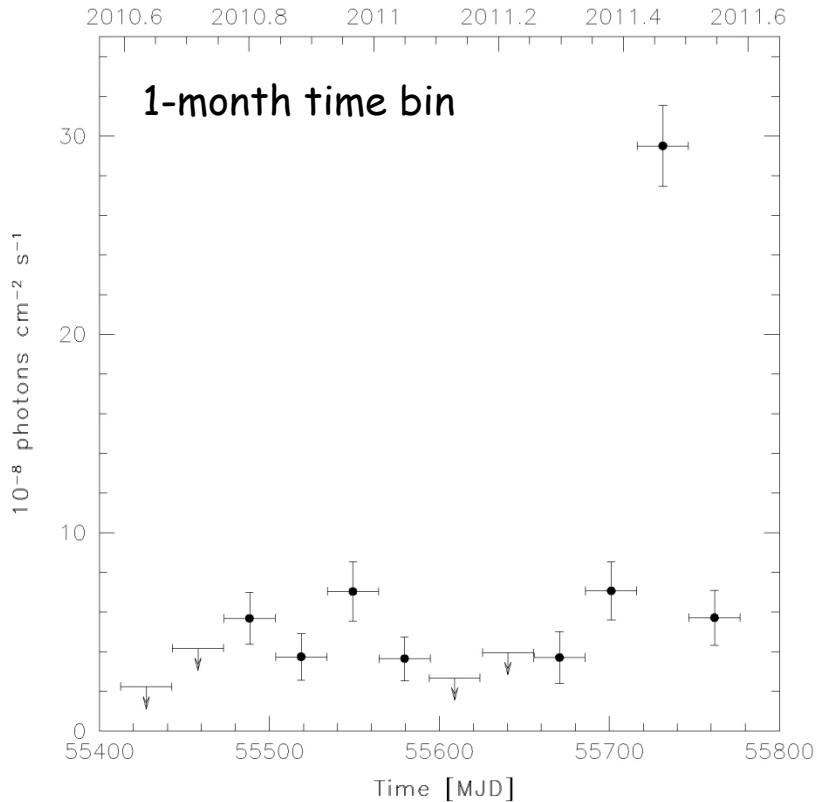
- Before the *Fermi* satellite  $\gamma$ -ray emitting AGNs are only blazars and radio galaxies
- *Fermi*-LAT first 2 years (1FGL and 2FGL) confirmed that the extragalactic  $\gamma$ -ray sky is dominated by those two classes but...

...first detection of a  $\gamma$ -ray emitting Narrow-line Seyfert 1 in 2008: PMN J0948+0022 and after that other 4 NLS1 were detected in gamma rays



## Confirmation of the presence of relativistic jets also in NLS1s

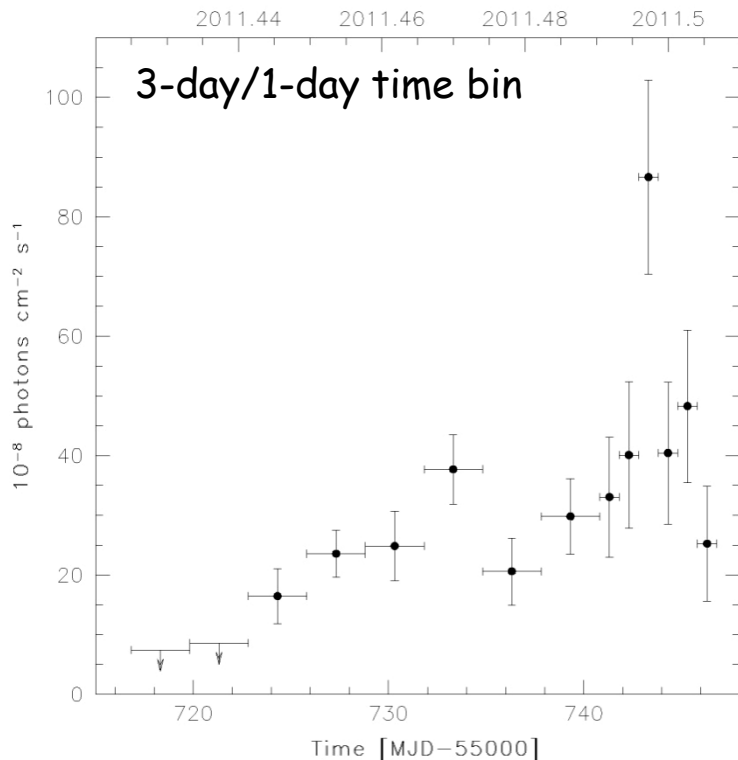
NLS1s are usually hosted in **spiral galaxies**, the presence of a relativistic jet in these objects seems to be contrary to the paradigm that the formation of relativistic jets could happen only in elliptical galaxies (e.g. Boettcher and Dermer 2002, Marcher 2009).



SBS 0846+513 was not detected in gamma rays with  $TS > 25$  during the first 2 years of Fermi operation. UL  $\sim 8.5e-9$  ph  $\text{cm}^{-2}$   $\text{s}^{-1}$

SBS 0846+513 clearly detected in gamma rays with  $TS = 653$  ( $\sim 25\sigma$ ) during the third year of Fermi operation. Flux  $E_{>100 \text{ MeV}} = (6.7 \pm 0.5)e-8$  ph  $\text{cm}^{-2}$   $\text{s}^{-1}$  and  $\Gamma = 2.23 \pm 0.05$

# A gamma-ray flare from SBS 0846+513

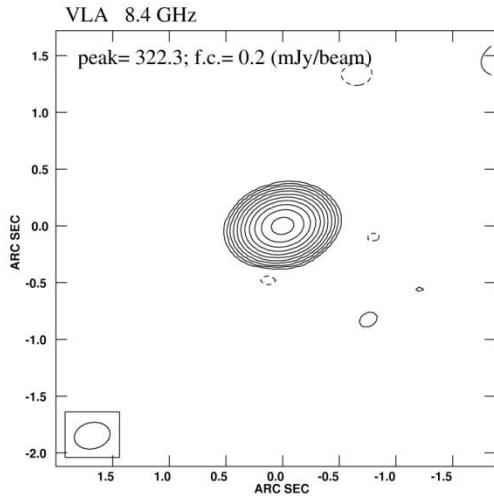


During the month of high activity there was spectral evolution in gamma rays, as already observed in other FSRQs

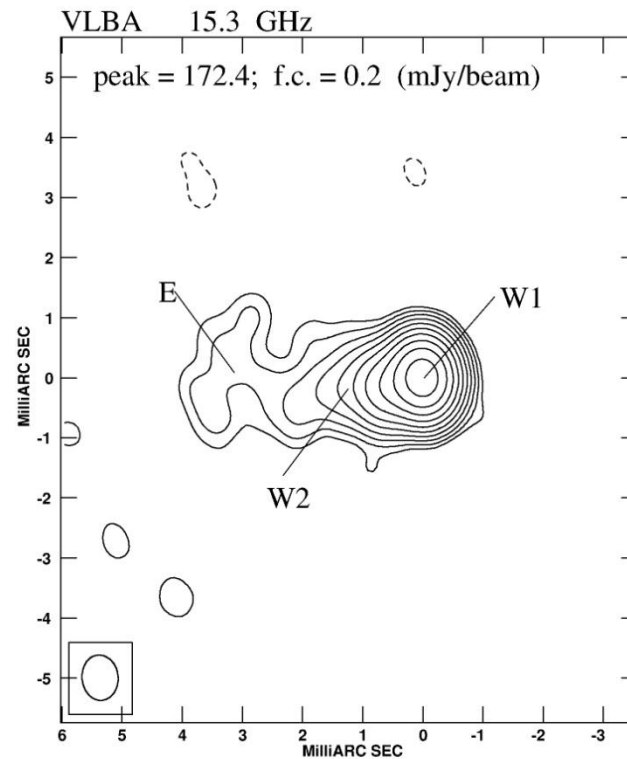
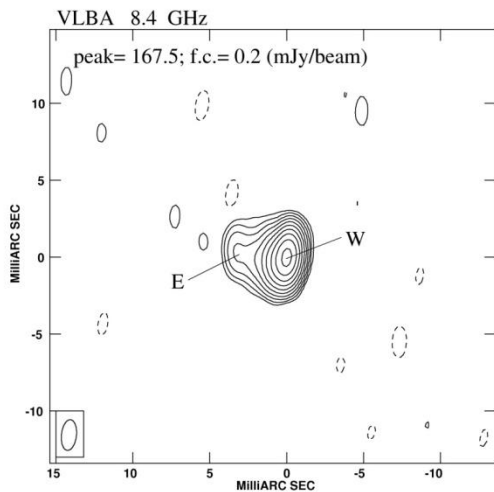
The gamma-ray peak with daily timescale on 29-30 June 2011 is  $(87 \pm 16)e-8$  ph  $\text{cm}^{-2}$   $\text{s}^{-1}$ , corresponding to an isotropic luminosity of  $\sim 10^{48}$  erg  $\text{s}^{-1}$ , comparable to that of the luminous FSRQs.

D'Ammando, Orienti, Finke, et al. 2012

# The radio view of SBS 0846+513



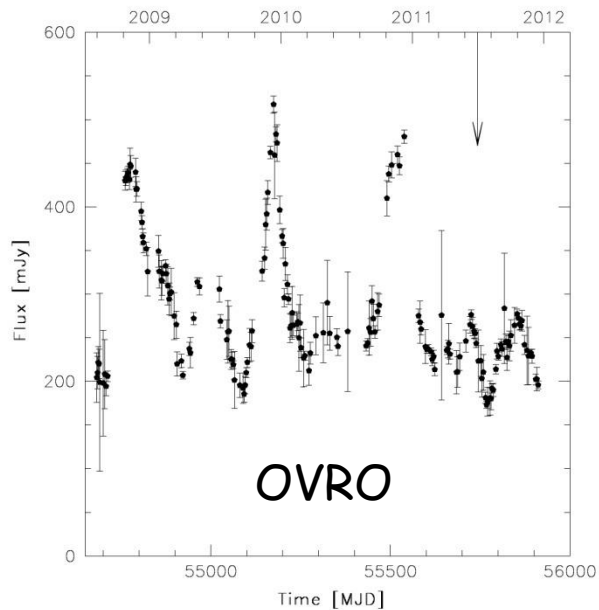
**Core-jet structure on parsec scale.  
Unresolved with the VLA.**



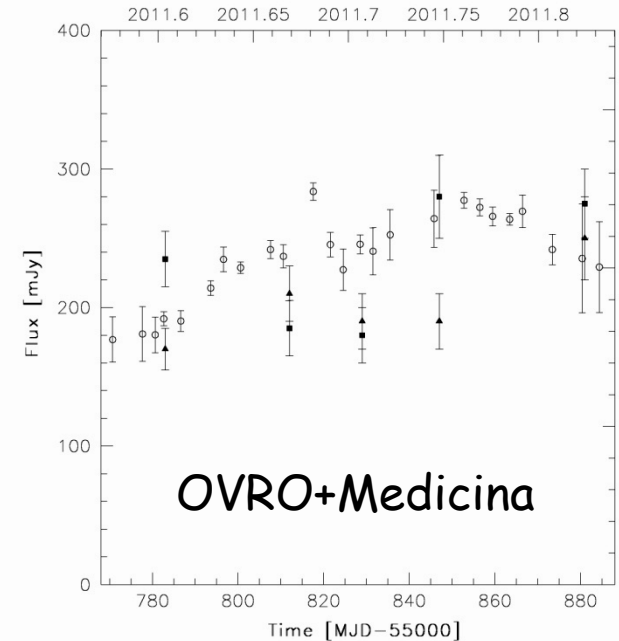
D'Ammando, Orienti, Finke, et al. 2012



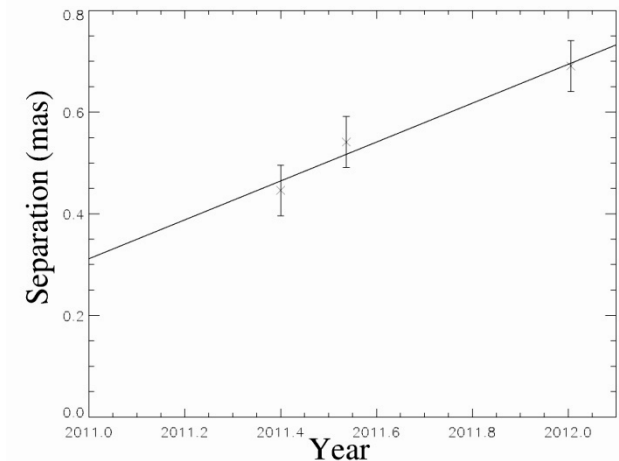
# The radio variability of SBS 0846+513



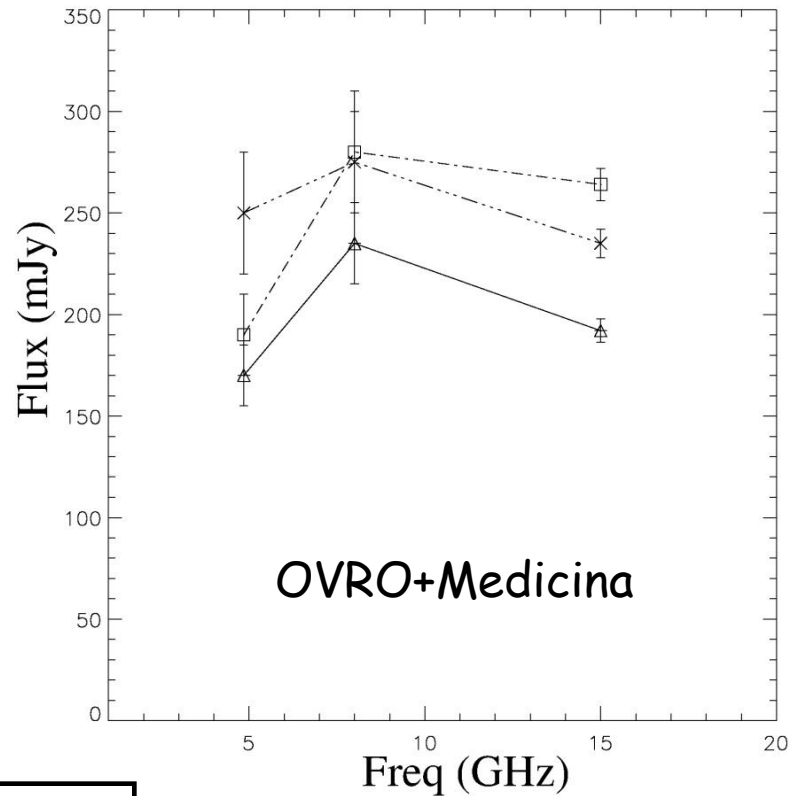
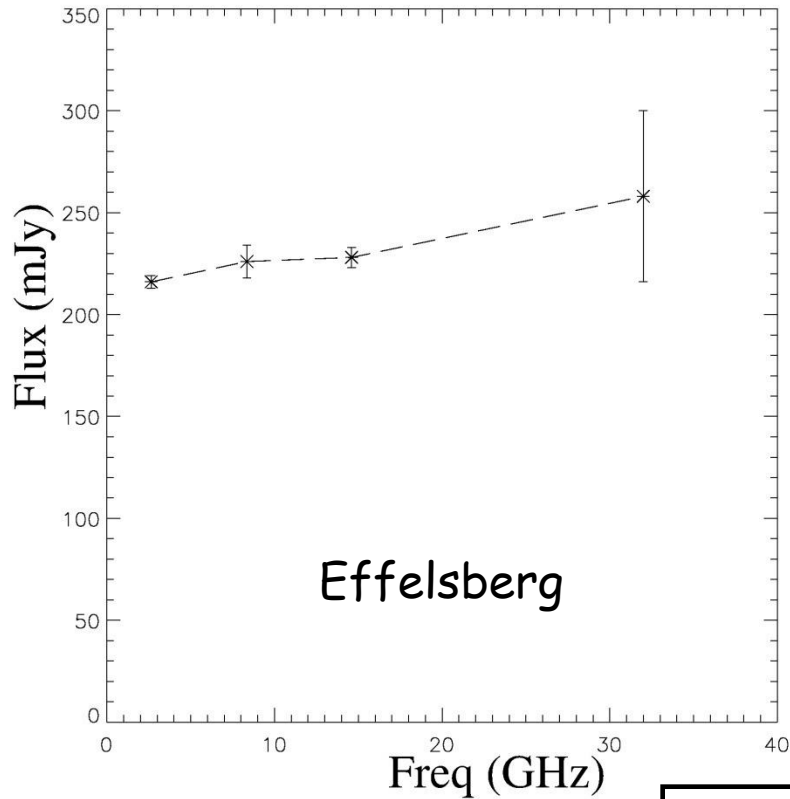
The OVRO light curve showed strong variability at 15 GHz, but not so high during the peak of the gamma-ray activity



From the model-fitting of 3-epoch MOJAVE data in 2010-2011 we found that W1 and W2 are separating with an **apparent velocity of  $(8.2 \pm 1.5)c$** . This value suggests the presence of boosting effect as well as in blazars.

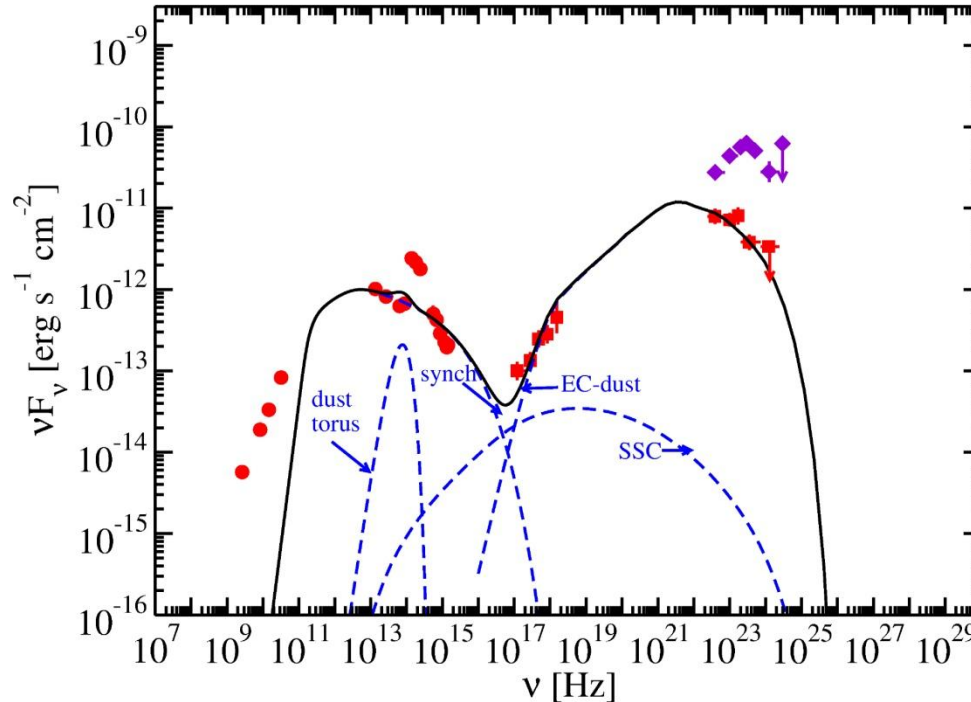


# The radio spectra of SBS 0846+513



D'Ammando+2012

A flat radio spectrum was observed on April 2011, before the high gamma-ray activity. After the gamma-ray flare (August-November 2011) also the radio shape changed, a quite typical blazar-like behaviour.



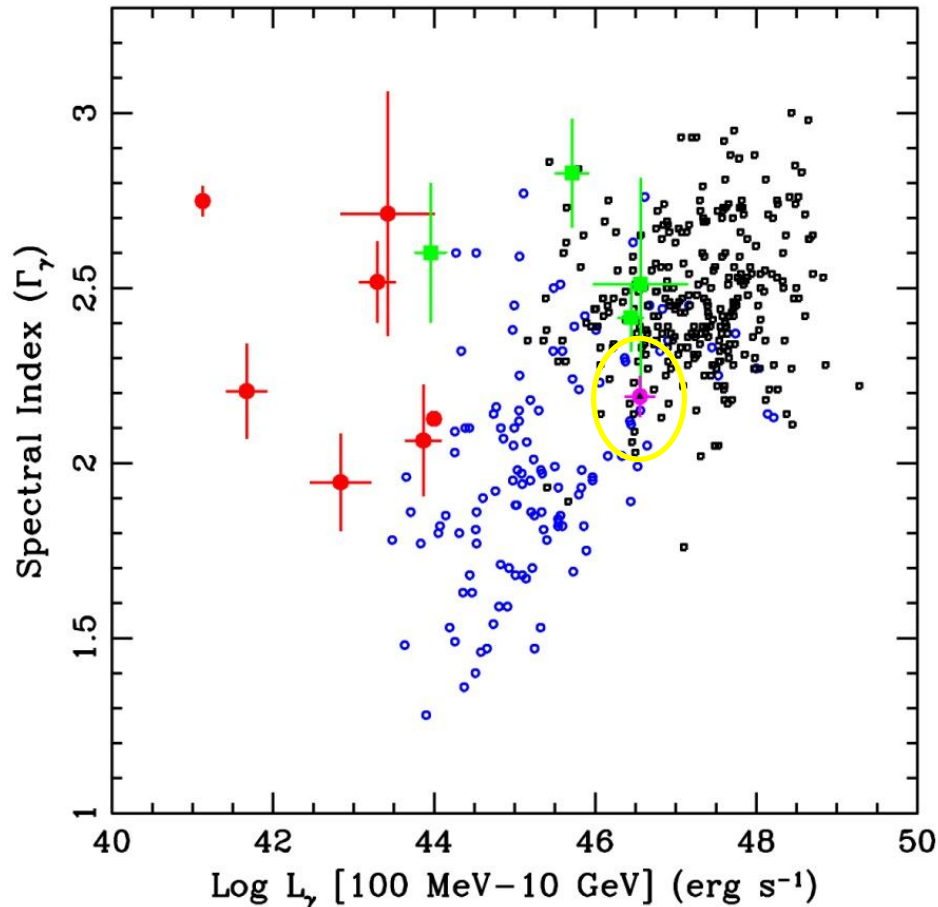
D'Ammando+2012

Modeling of the SED of the source in a low state with SSC+EC (dust).

$$\Gamma = 15, B = 1 \text{ G}, P_{\text{jet}} = 1.8 \times 10^{45} \text{ erg s}^{-1}$$

Magnetic field and electrons energies are nearly in equipartition.

Compton dominance ( $\sim 7$ ) and X-ray spectral index consistent with FSRQs



D'Ammando+2012

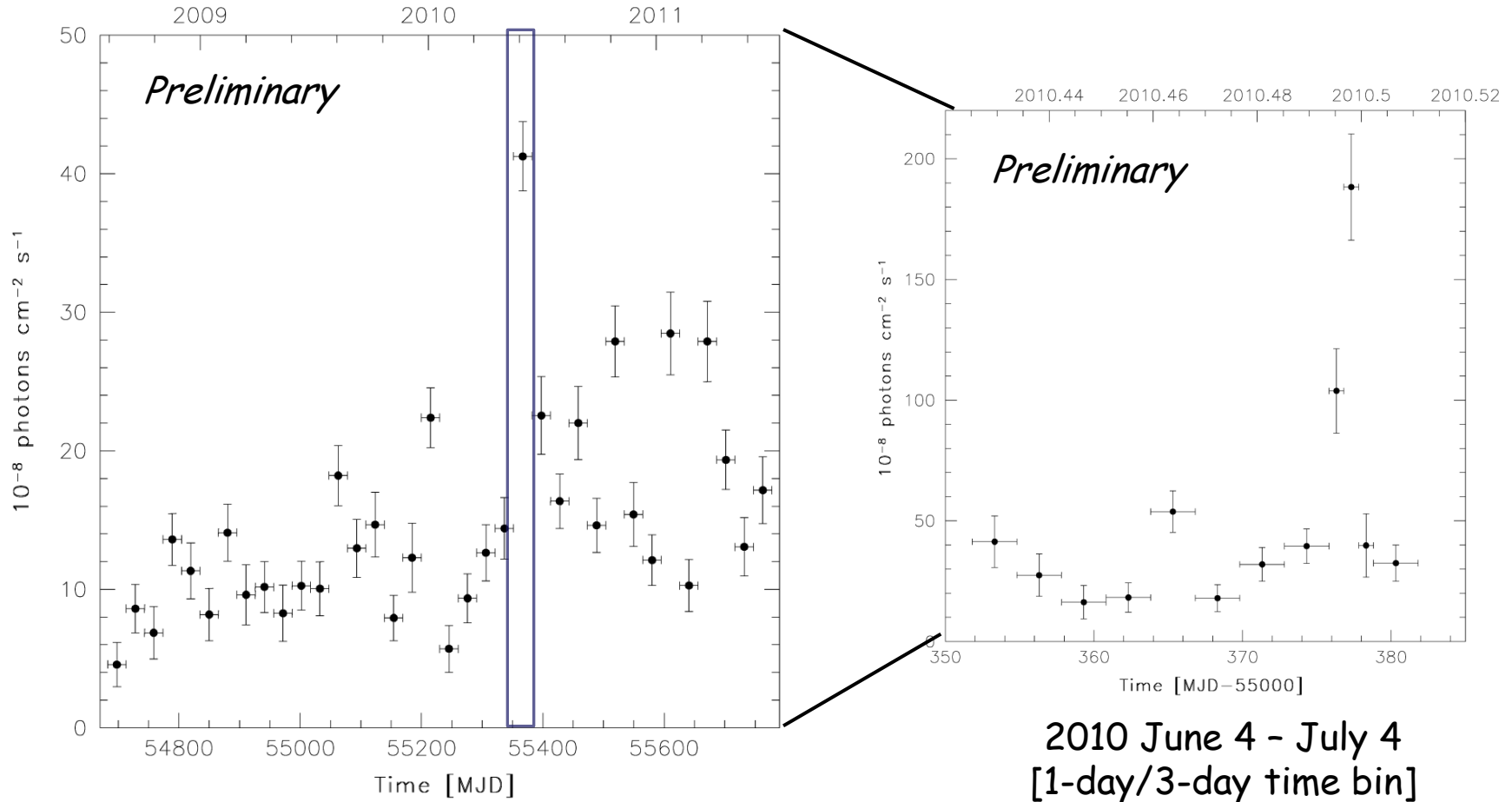
In the  $L_\gamma$ - $\Gamma$  plane SBS 0846+513 lies in the blazar region. This should reflect a similar viewing angle with respect to the jet axis and beaming factor.



- The power released by SBS 0846+513 during the flaring activity and the apparent superluminal velocity are strong indications of the presence of a relativistic jet as powerful as those of blazars
- Variability and spectral properties in radio and gamma rays bands indicate blazar-like behaviour
- The black hole mass of SBS 0846+513 was estimated from the H $\beta$  broad line, the [OIII] narrow line, and the host galaxy 's bulge luminosity in the range between  $8.2 \times 10^6$  and  $5.2 \times 10^7$  solar masses (Zhou et al. 2005)
- This source could be a blazar at the low end of the blazar's BH masses (possibly young), indicating that radio-loud AGNs can host relativistic jets as powerful as those of blazars, despite the BH mass
- *The discovery of relativistic jets in a class of AGN usually hosted by spiral galaxies was a great surprise but...*

...BH masses of radio-loud NLS1s are larger than the entire sample of NLS1s (Komossa et al. 2006). This could be related to prolonged accretion episodes that can spin-up the BH leading to the relativistic jet formation. Only for a small fraction of NLS1s the high accretion last sufficiently long to significantly spin-up the BH

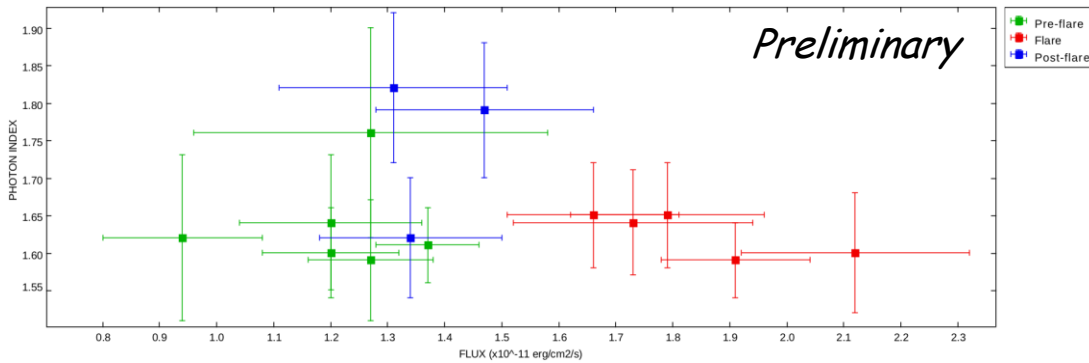
- First classified as a N galaxy (Bolton et al. 1965) then as a BL Lac object (Burdidge et al 1987, 1990)
- Strong narrow and broad emission lines typical of Seyfert 1 galaxies in optical/UV (Ulrich 1981, Scarpa et al. 1995)
- optical, NIR and radio jet (Scarpa et al. 1999, Falomo et al. 2009), detected also at X-rays (Birkinshaw et al. 2002)
- marginally detected by EGRET (Lin et al. 1995)
- No beaming effect is needed for the core brightness temperature, consistent with the non detection of superluminal motion (Tingay et al. 2002)
- viewing angle  $30^\circ$  and  $\delta \sim 1.2$  (Pian et al. 1996)
- VLBA image showed that the same Position Angle found on the parsec-scale jet is maintained, without any significant bending, over 3 orders of magnitude (Giroletti et al. 2004). This is consistent with a relatively large angle of view.
- knotty structure similar to the jet in M87



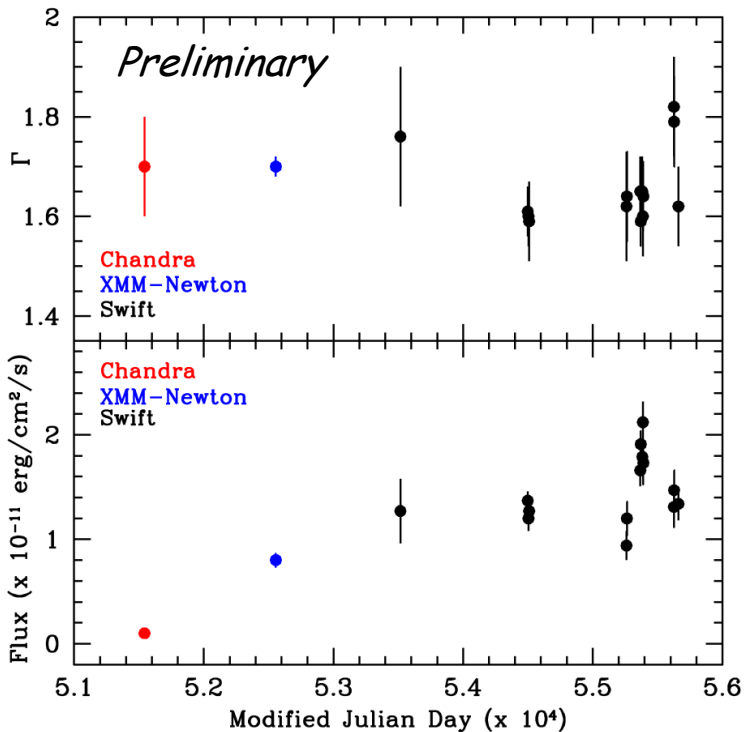
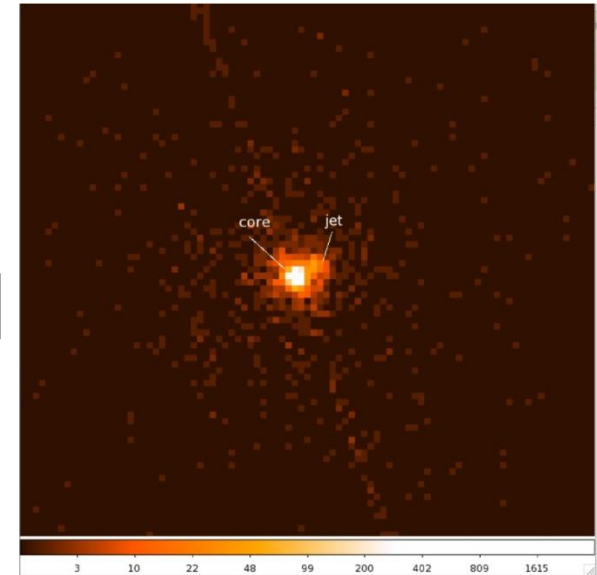
2008 August - 2011 August  
[1-month time bin]

D'Ammando, Torresi, Orienti et al. in prep

# X-ray observations of PKS 0521-36



Unresolved core, a diffuse halo and a jet feature

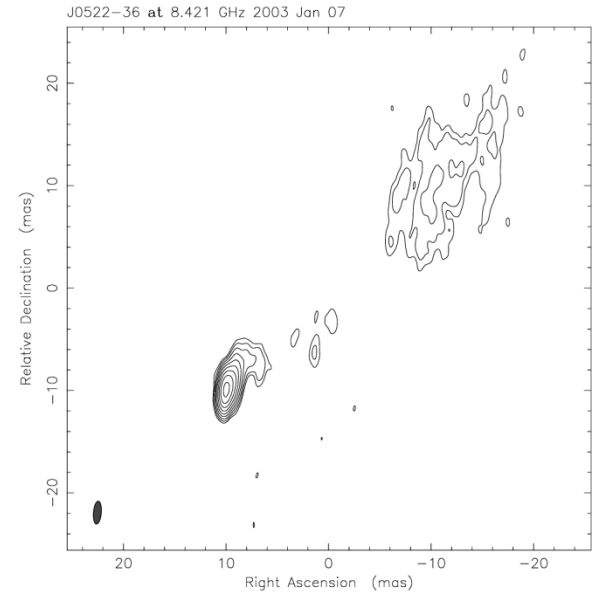
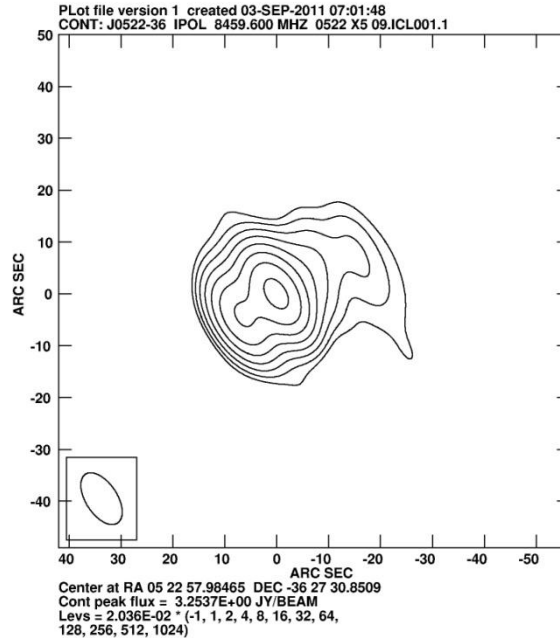
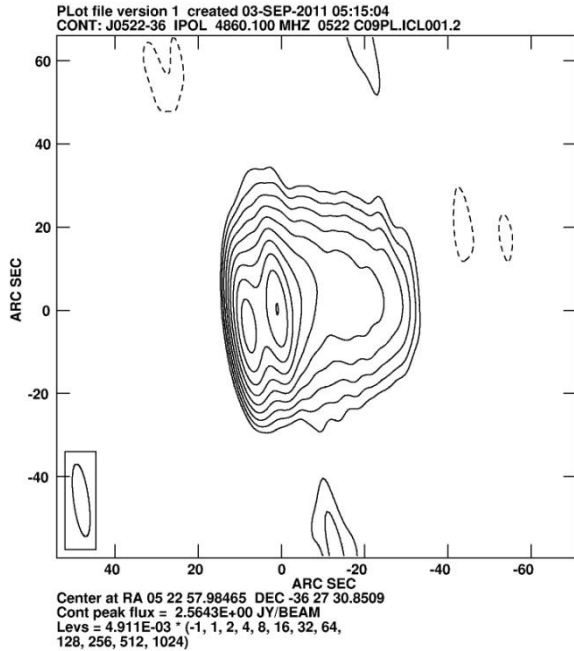


D'Ammando et al. in prep

Swift/XRT observed an increase of a factor of 2-3 of the X-ray flux during the gamma-ray flaring activity.



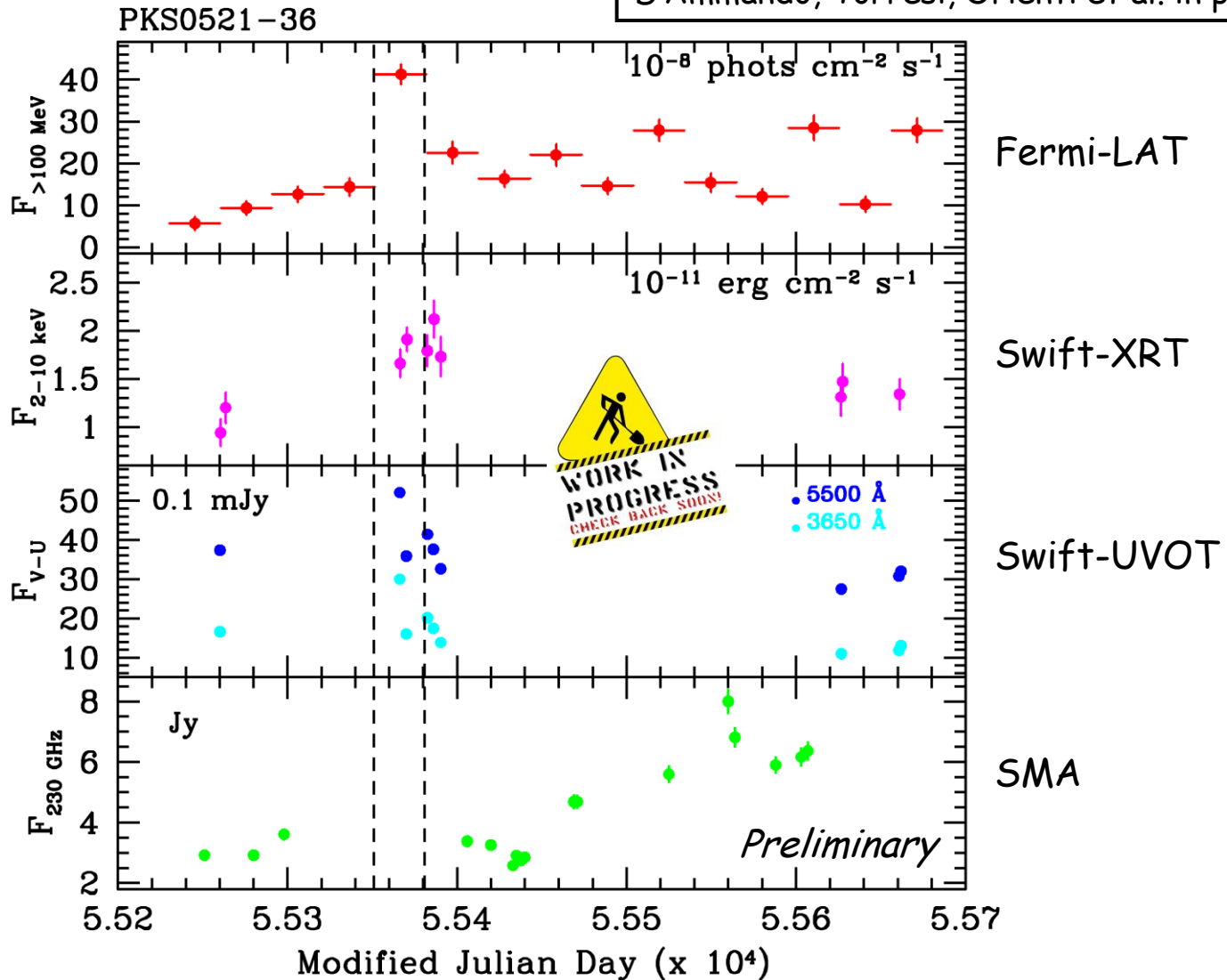
# The radio view of PKS 0521-36



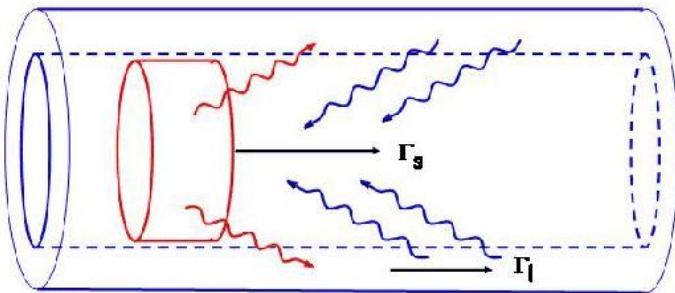
The brightness profile along the jet axis decreases rapidly with increasing distance from the core, but suddenly rises again at  $\sim 30$  mas. Similarly to radiogalaxies M87 and 3C 120

# MWL observations of PKS 0521-36

D'Ammando, Torresi, Orienti et al. in prep



- How to conciliate the knotty jet structure observed in radio with the intense activity and high luminosity observed in gamma rays?
- Emitting jet not closely aligned w.r.t to the line of sight. It is possible to model the SED of the gamma-ray flare with a low Doppler factor as suggested in the past for this source?
- Structured jet with spine or layer region active in different epochs?



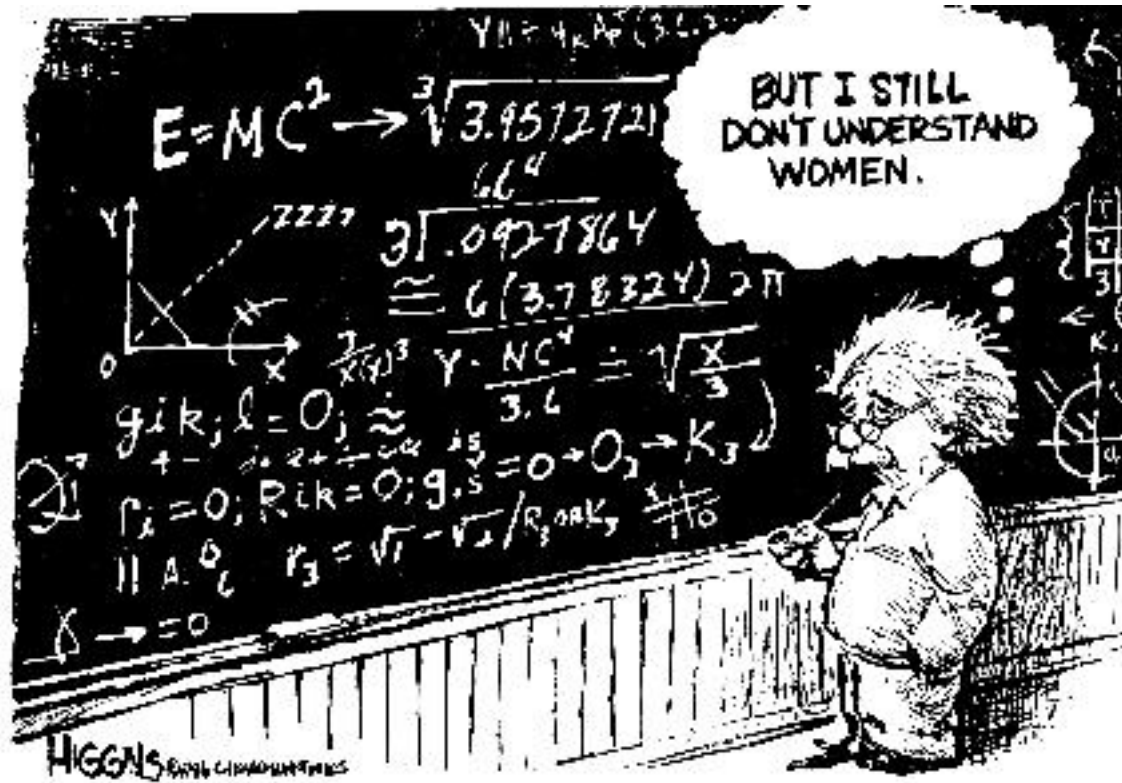
RGs may be "misaligned" blazars

- low power **FR I**
  - high power **FR II**
- ↔
- BL Lacs**
  - FSRQs**

SED modeling on-going

- Spine dominated ..... **Blazars**
- Layer dominated ..... **RGs**





Thanks for your attention!!!