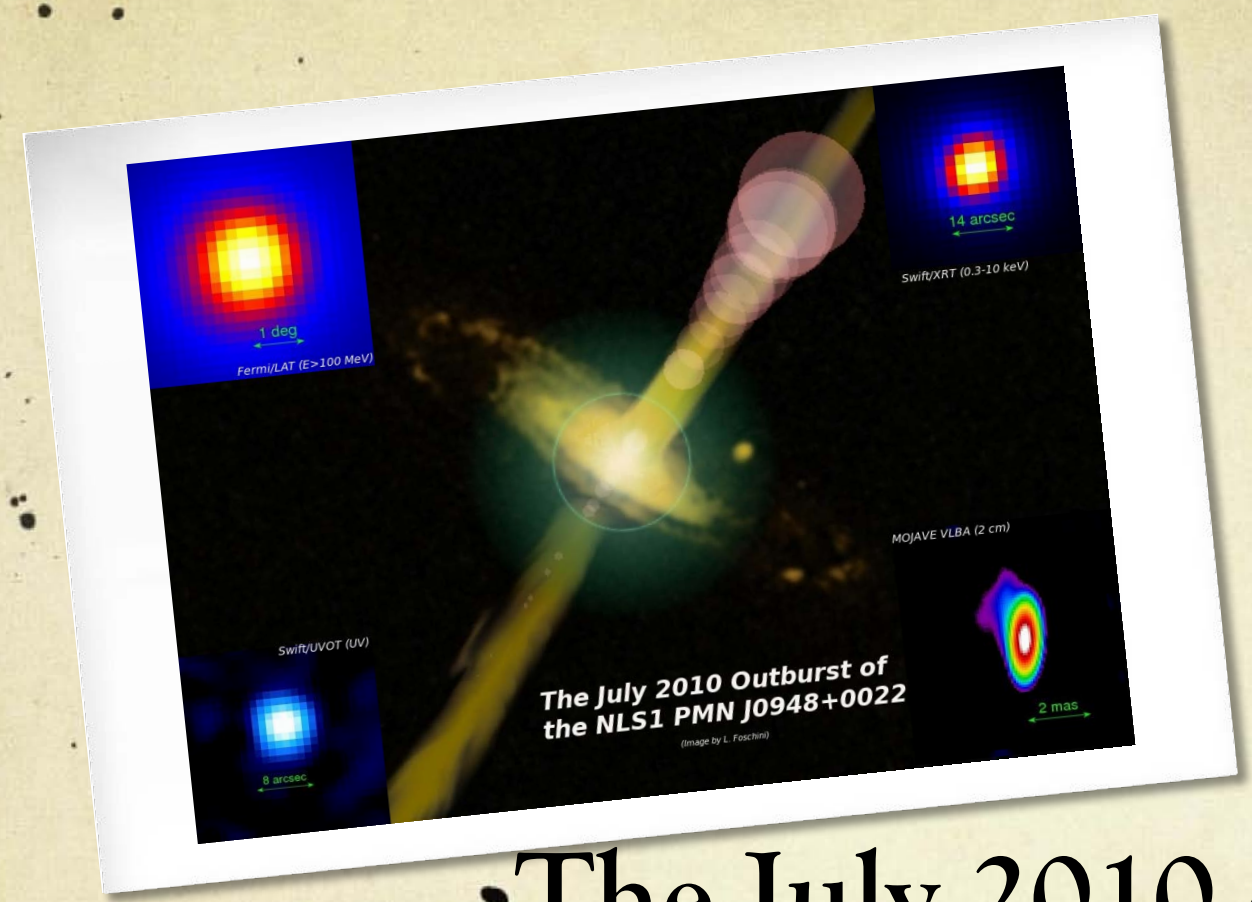
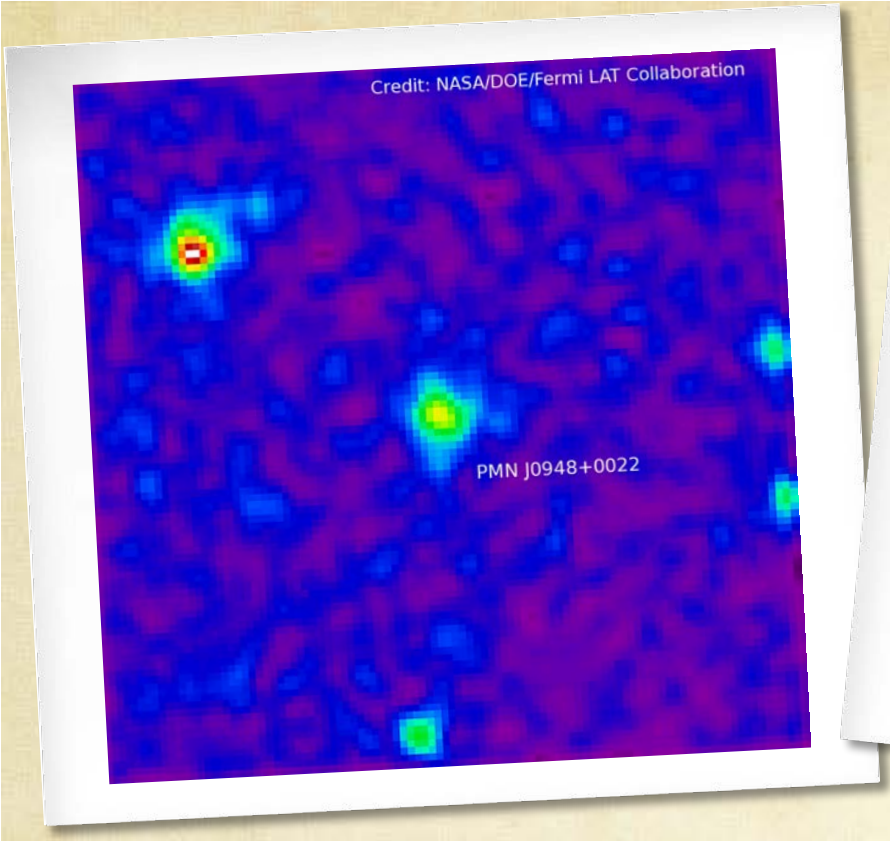
Third Fermi Symposium
Roma (Italy), 9-12 May 2011

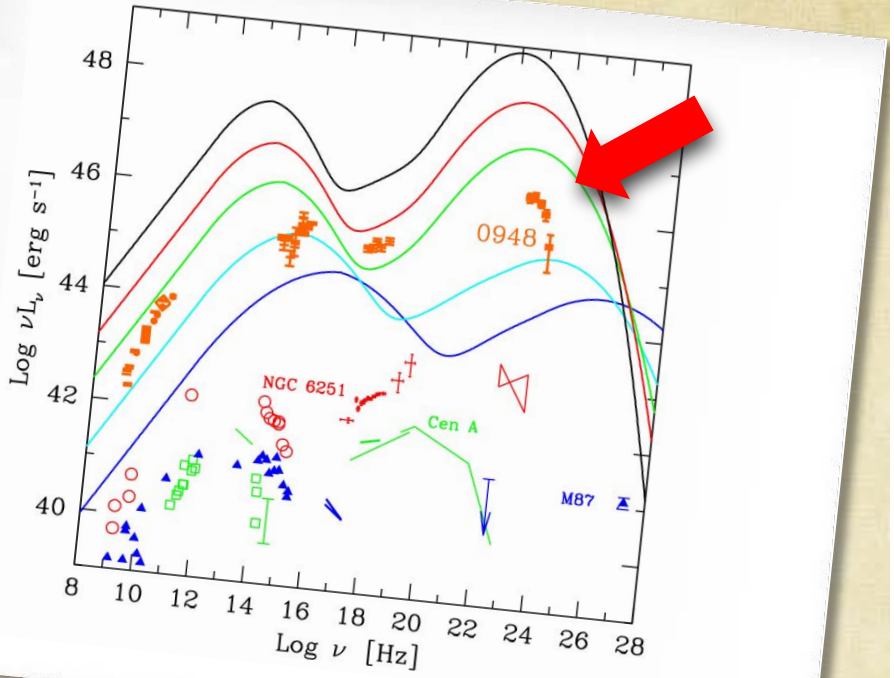


The July 2010 outburst of the NLS1 PMN J0948+0022

Luigi Foschini (INAF OA Brera, Italy)
and G. Ghisellini, Y.Y. Kovalev, M.L. Lister, F. D'Ammando, D.J. Thompson, A. Tramacere, E. Angelakis, D. Donato, A. Falcone, L. Fuhrmann, M. Hauser, Yu.A. Kovalev, K. Mannheim, L. Maraschi, W. Max-Moerbeck, I. Nestoras, V. Pavlidou, T.J. Pearson, A.B. Pushkarev, A.C.S. Readhead, J.L. Richards,
M.A. Stevenson, G. Tagliaferri, O. Tibolla, F. Tavecchio, S. Wagner



Blazar sequence from Fossati et al (1998) and Donato et al. (2001)
Radio galaxies from Ghisellini et al. (2005)



PMN J0948+0022 (0.585) a.k.a. SDSS J094857.31+002225.4

The first NLS1 detected at high-energy γ–rays (E > 100 MeV) - found after the first months of *Fermi* operations (17σ)

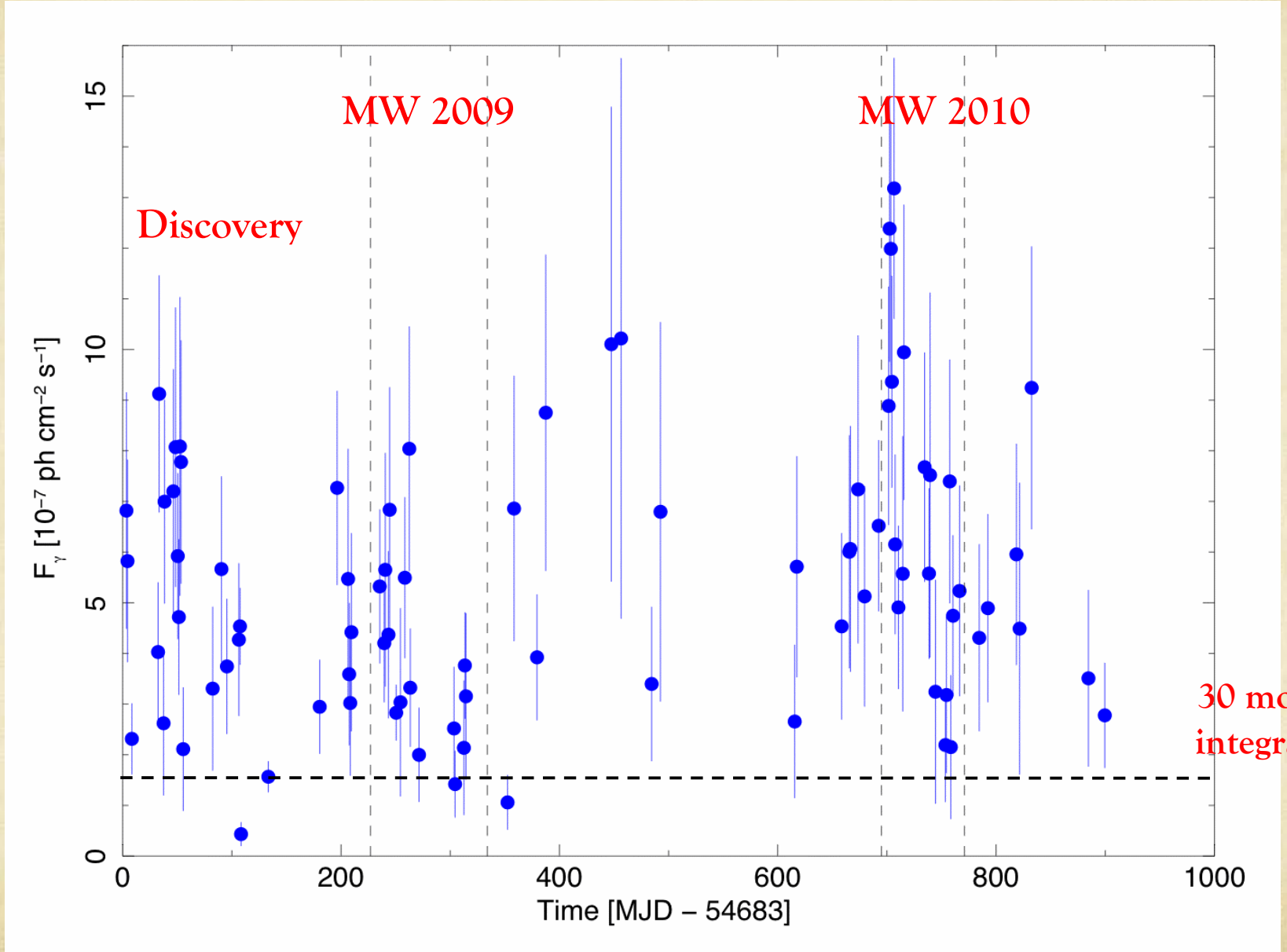
Abdo et al. (corresponding author L. Foschini), 2009, ApJ, 699, 976

Foschini et al., 2010, in: "Accretion and Ejection in AGN: A Global View", ASP Conf. Proc. 427, p. 243

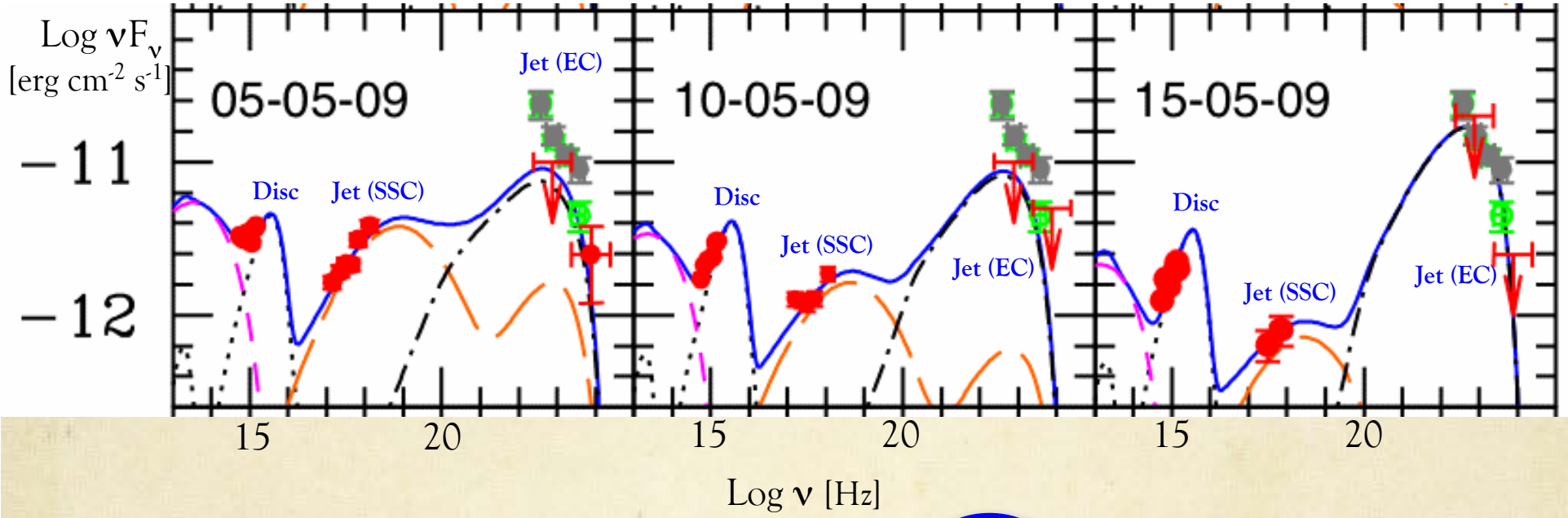
This NLS1 was already found to be radio-loud with flat spectrum and high brightness temperature by Zhou et al. (2003)

For a review on γ–NLS1 see: Foschini, *Evidence of powerful relativistic jets in NLS1*, `arXiv:1105.0772`
In: *Proceedings of the workshop "Narrow-Line Seyfert 1 Galaxies and Their Place in the Universe", (Milano, April 4-6, 2011)*
`http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=126`

Light curve at γ rays (1 day bin, 0.1-100 GeV)



Shortest time scale for doubling/halving flux: < 0.8 days

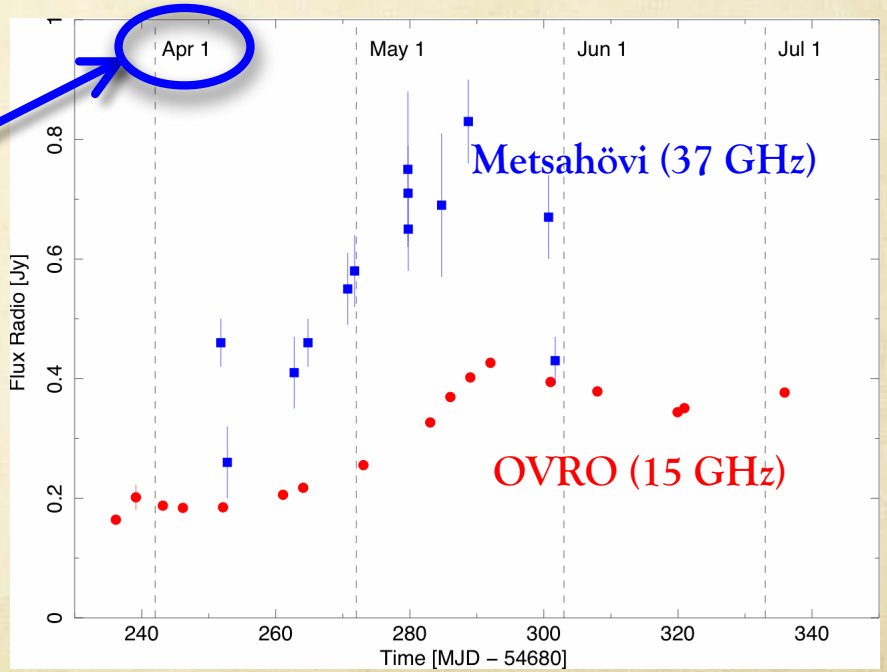


2009 MW Campaign on J0948+0022

γ-ray activity in early April 2009 (peak ≈ 4×10^{-7} ph cm^{-2} s^{-1}), drop of the MW fluxes, followed by an increase of radio emission after less than 2 months;

correlation between optical, X- and γ rays

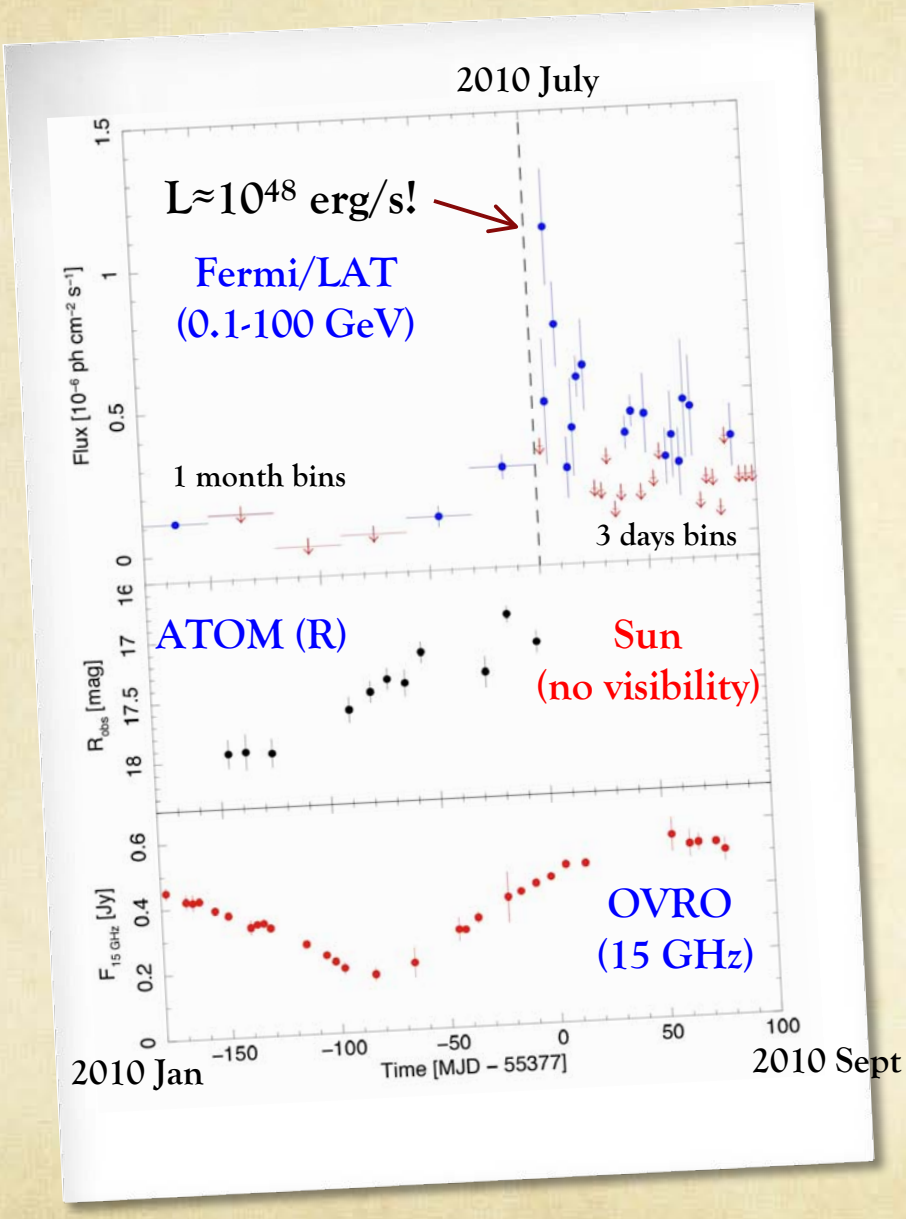
jet emission, confirmation of the association



NEW! Recently confirmed by detection of strong optical (V) polarization (19%) with Kanata telescope (Ikejiri et al. 2011, `arXiv:1105.0255`)

Abdo et al. (contact author: L. Foschini), 2009, ApJ, 707, 727.

2010 July-September Campaign



2010 MW Campaign

Triggered by the first γ-ray outburst:

peak γ–flux ≈ 10^{-6} ph cm^{-2} s^{-1}

☞

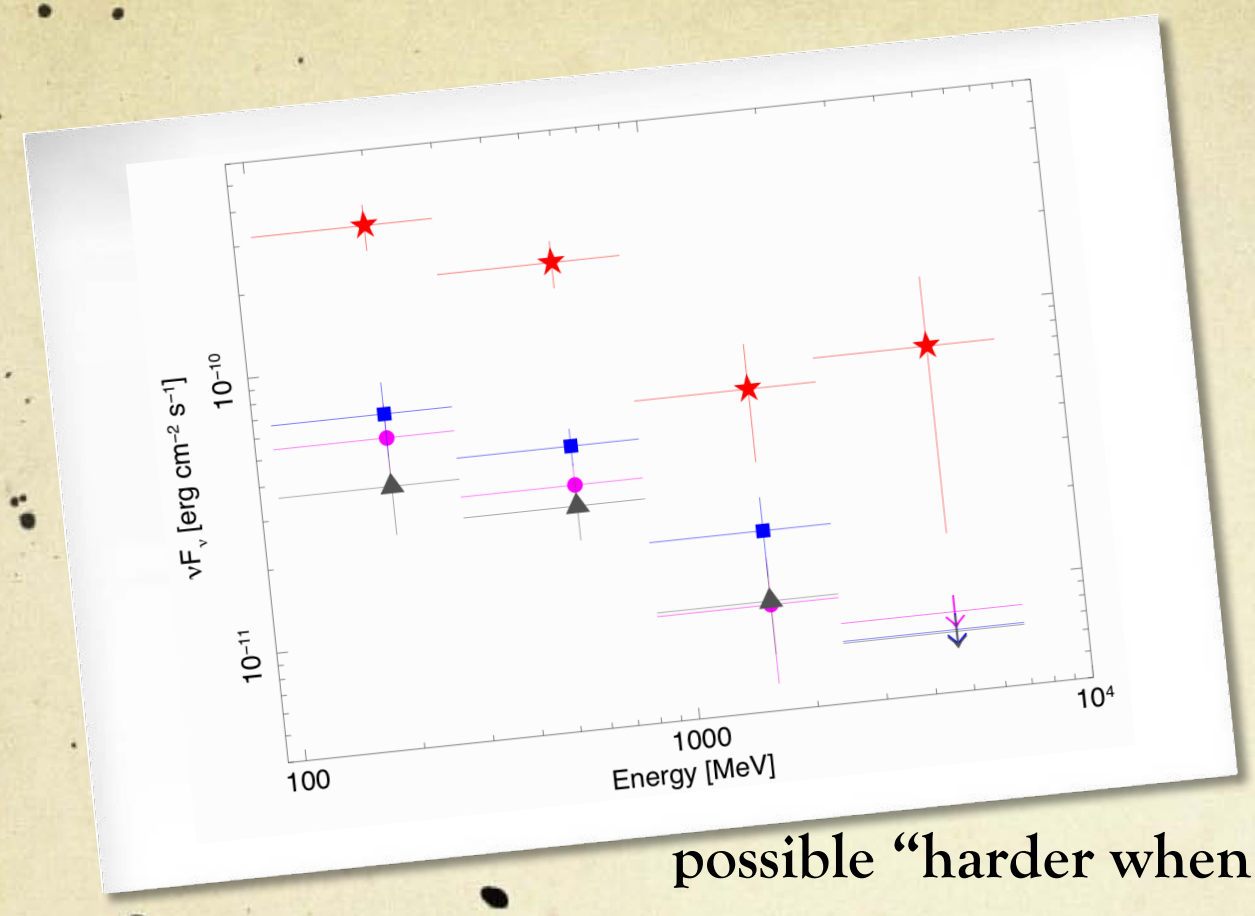
L ≈ 10^{48} erg/s!

(Donato et al., 2010, Atel 2733; Foschini, 2010, Atel 2752)

~1 day time scale of variability

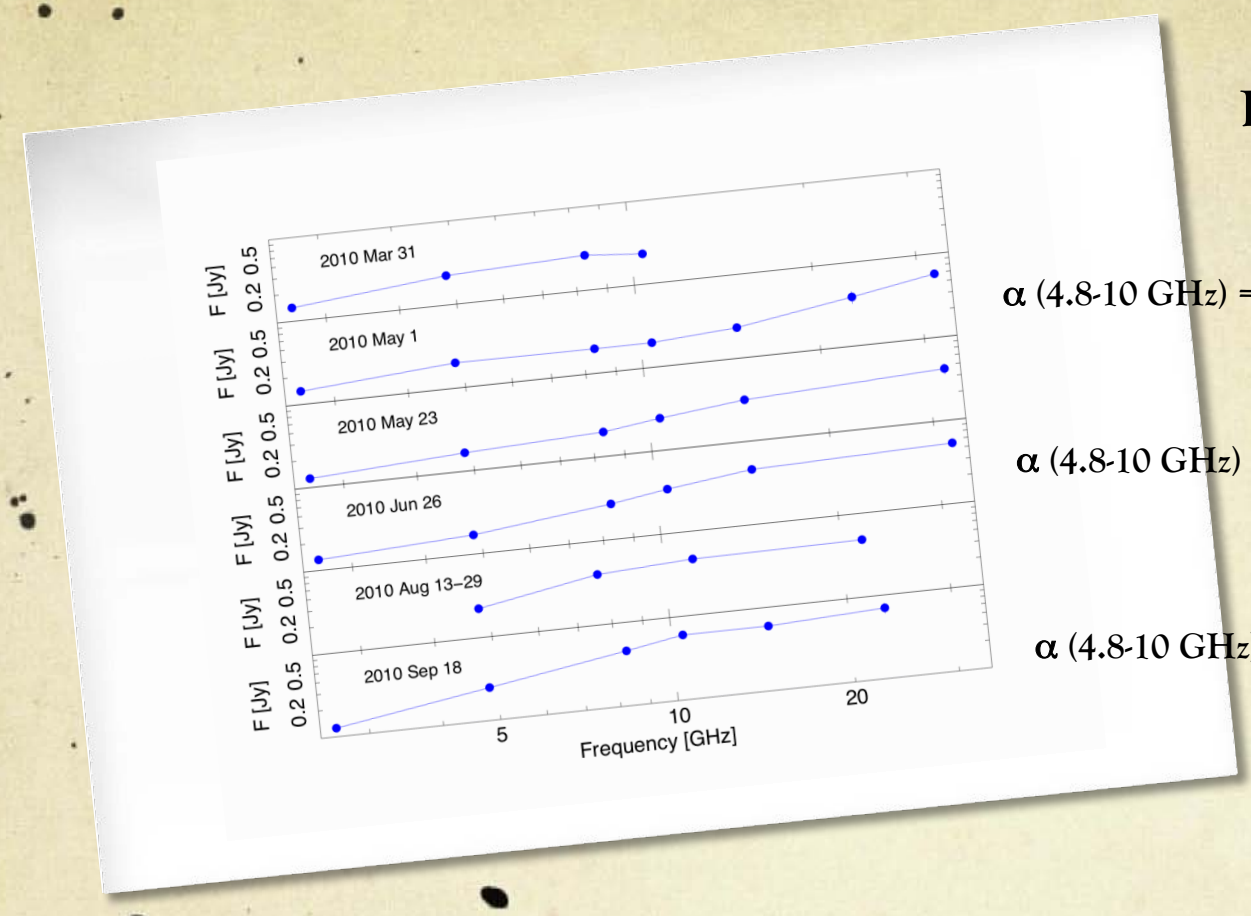
Facilities involved:

Fermi, *Swift* (XRT+UVOT), ATOM, Effelsberg (F-GAMMA Project), RATAN, VLBA (MOJAVE Project), OVRO



γ-ray spectrum: possible "harder when brighter" behavior

Time Period	Flux E >100 MeV [ph cm^{-2} s^{-1}]	Γ	TS
June 1-30	$(0.23\pm0.01)\times10^{-6}$	2.77±0.06	98
July 7-10 (burst)	$(1.02\pm0.02)\times10^{-6}$	2.55±0.02	140
Aug 1 – Sept 14	$(0.26\pm0.01)\times10^{-6}$	2.74±0.03	140



$F_\nu \propto \nu^{-\alpha}$

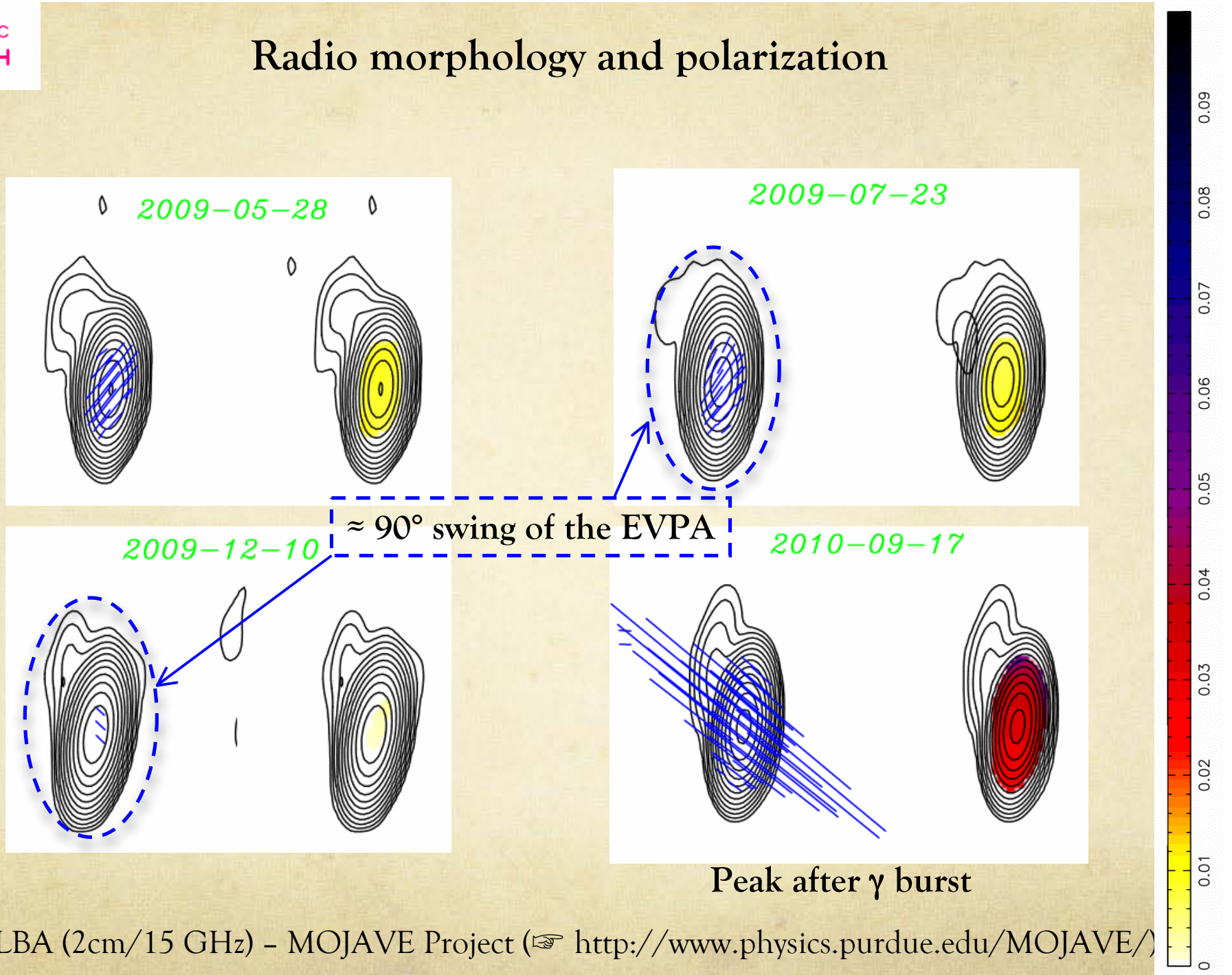
α (4.8-10 GHz) = 0.02±0.03 (flat)

α (4.8-10 GHz) = -0.81±0.02 (inverted)

α (4.8-10 GHz) = -1.0±0.1 (inverted)

Spectral evolution at radio frequencies
(from Effelsberg and RATAN radio telescopes)

Radio morphology and polarization

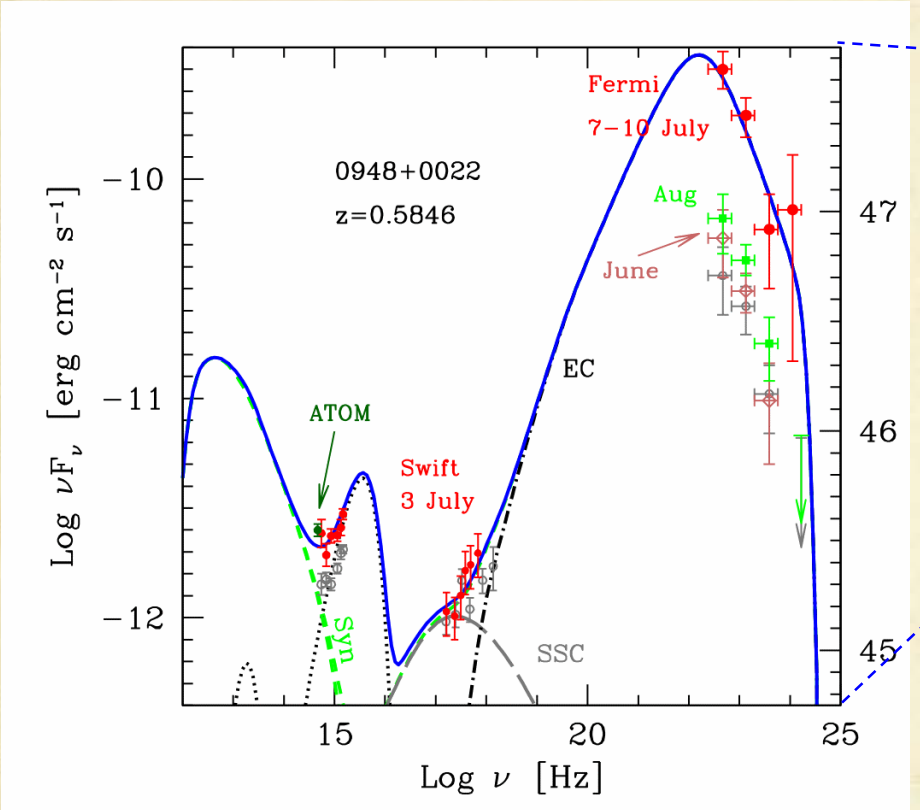


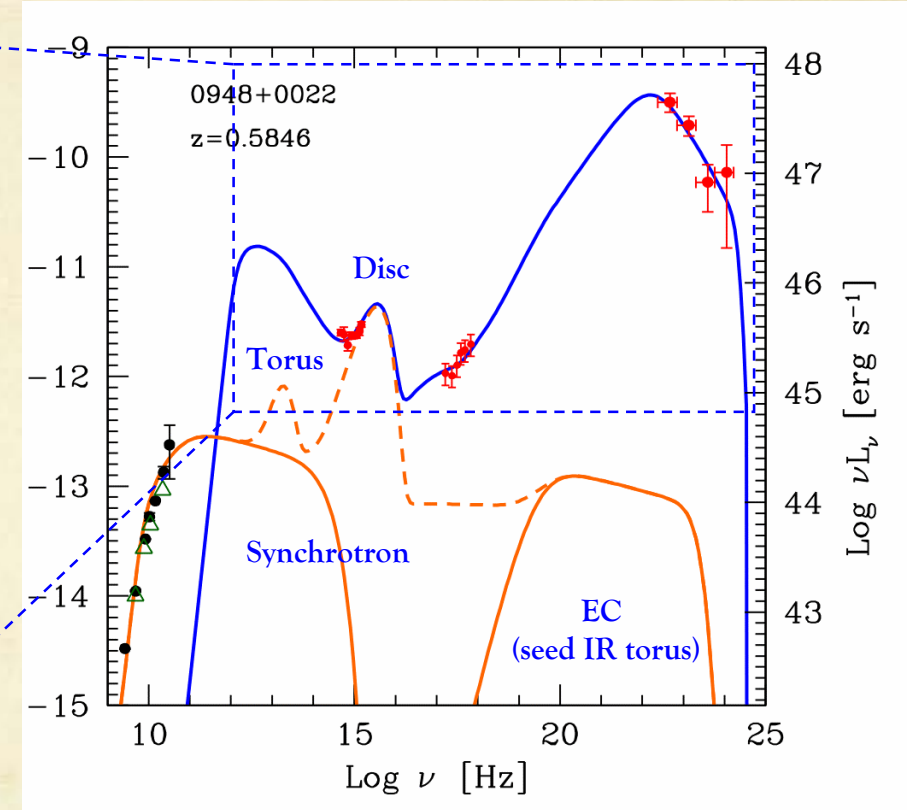
Peak after γ burst

VLBA (2cm/15 GHz) – MOJAVE Project (☞ http://www.physics.purdue.edu/MOJAVE/)

Spectral Energy Distribution (SED)

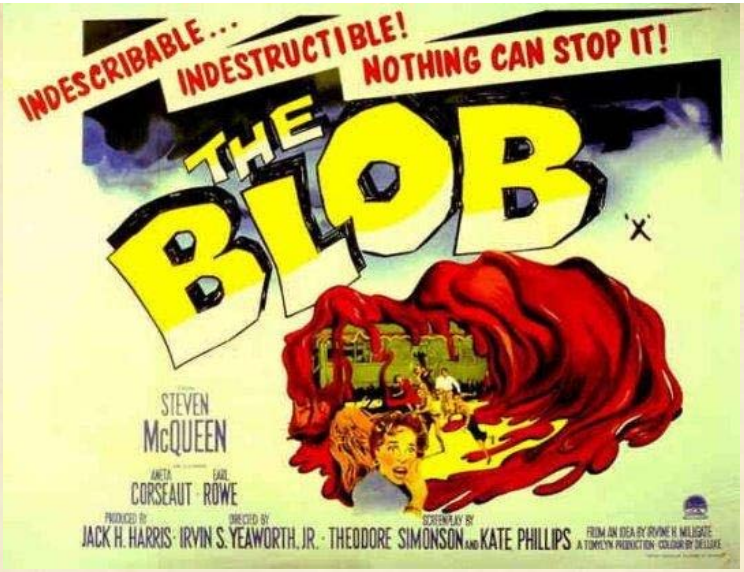
SED model described in detail in Ghisellini & Tavecchio (2009), MNRAS, 397, 985





SED at the γ burst (7-10 July 2010)
(blue model)

SED at the radio peak (Sept 2010)
(orange model)



Typical relativistic jet
e.g. Blandford & Königl (1979)

Corona

Accretion disk

BLR

Molecular Torus

BH

JET

Blue model:
compact blob
γ rays: high
Radio: opt. thick
R << 1 pc

< 2 months

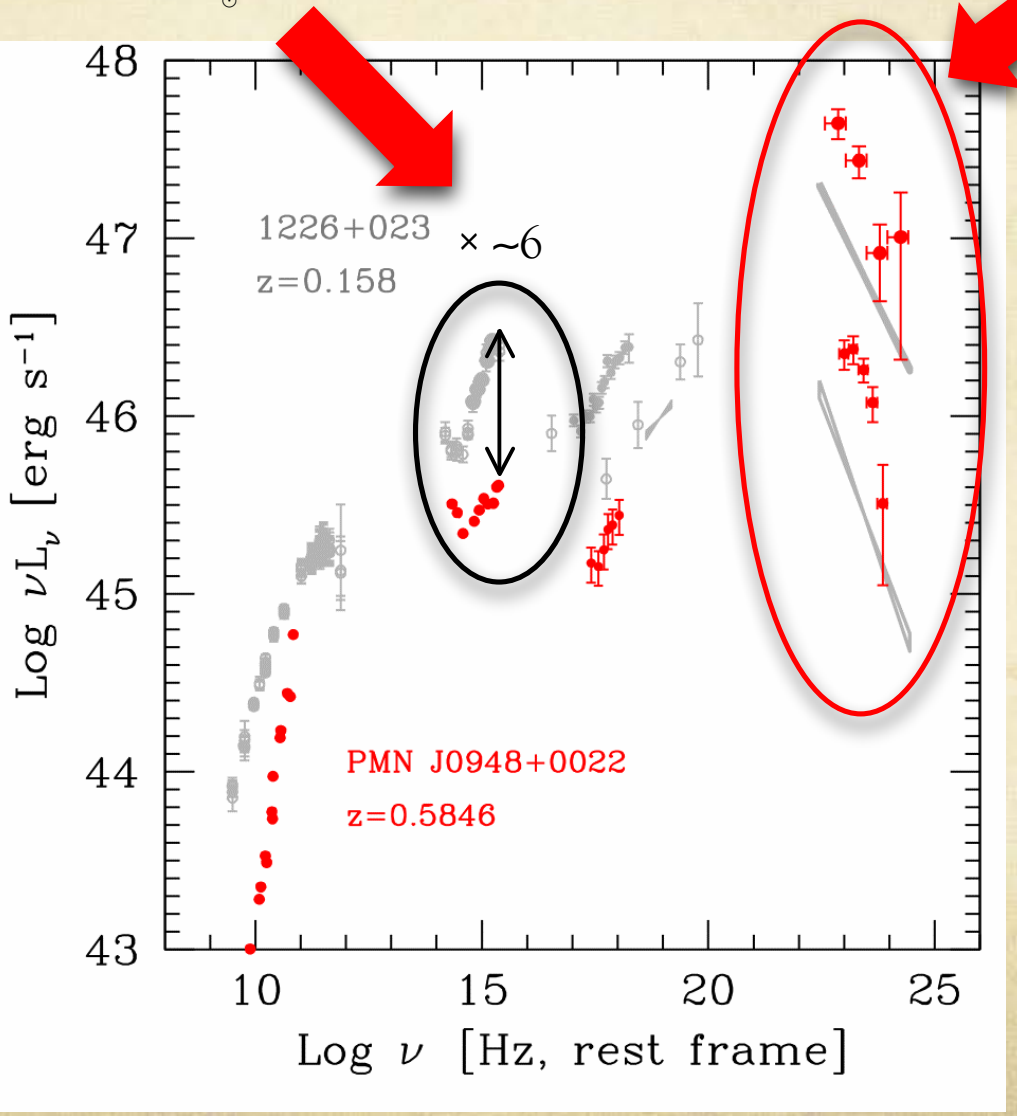
Orange model:
expanded and cooled blob
γ rays: low
Radio: opt. thin
R >> 1 pc

Comparison of PMN J0948+0022 with 3C 273

Factor × ~6: Difference in mass of the BH?

3C 273 ~ 8×10^8 $M_\odot$

J0948 ~ 1.5×10^8 $M_\odot$



Compton dominance in J0948+0022 stronger than in 3C 273: probably due to different jet viewing angle (larger in 3C 273)

CONCLUSIONS

Observational Facts

- *First outburst at high-energy γ rays of a NLS1 (PMN J0948+0022)*
- *Peak power ≈ 10^{48} erg/s!*
- *Day scale variability; some "harder when brighter" spectral behavior;*
- *Typical jet behavior: observed correlated multiwavelength activity*
- *Very compact radio morphology (pc-scale), despite the huge power released at γ rays;*
- *The outburst was preceded by a swing of the EVPA of about 90° at some time between 2009 July and December, similarly to what occurred at the blazar PKS 1502+106 (*). Increase of linear polarization from < 1% to > 3%.*
- *Comparison with the typical blazar 3C 273 shows that the Compton dominance is more extreme in PMN J0948+0022*
- *More details in: Foschini et al., 2011, MNRAS, in press (*`arXiv:1010.4434`*)*

(*) Please do not make confusion with the PKS 1502+036, which is a γ-NLS1 at z=0.41, while the blazar PKS 1502+106 is a flat-spectrum radio quasar with z=1.8.