OPTICAL POLARIMETRY &RADIO OBSERVATIONS OF PKS1510-089

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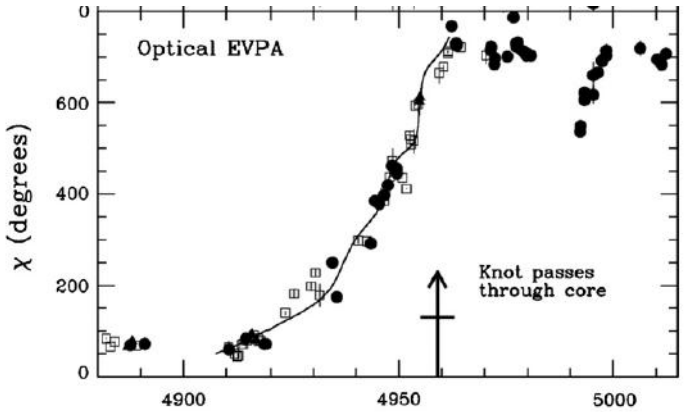
Polarised Emission from Astrophysical Jets
June 12-16, 2017, Ierapetra, Greece

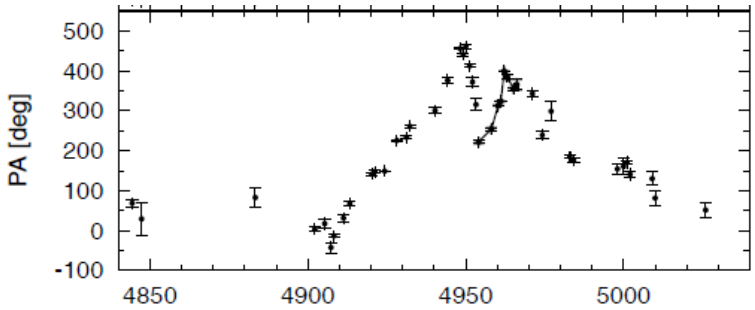
Introduction

- Monthly Basis Observations:
  - (OPD) Optical Polarimetric campaign: between 2009 and 2013
  - (ROI) Radio Monitoring: between 2011 and 2013
- Multi wavelength flaring Activity:
  - before 2008, a weak radio source 6 Jy at 37 GHz (Teräsranta et al. 2005)
  - After 2008, High γ-ray Activity. (eg. Abdo et al. 2010, Foschini et al. 2013; Aleksic et al. 2014)
- Activity of 2 Polarization Degree (PD) and Polarization Angle(PA) variability (Marscher et al. 2010, Sasada et al. 2011, Jermak et al. 2016)
- Activity of 2011 was follow by a radio increase reported in many telegrams (Beaklini et al. 2011, Nestoras et al. 2011, Orienti etl al. 2011, 2013).

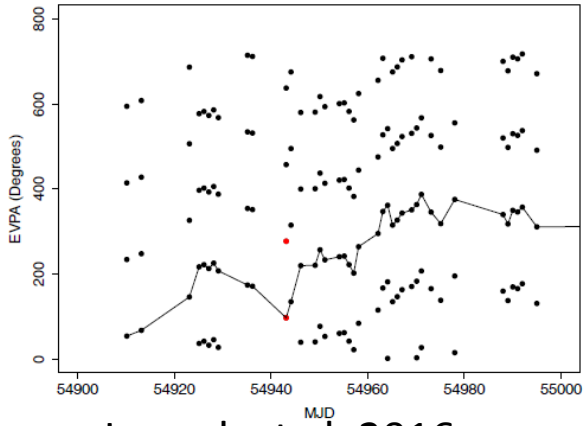
2009



Marscher et al. 2010



Sasada et al. 2011



Jermak et al. 2016

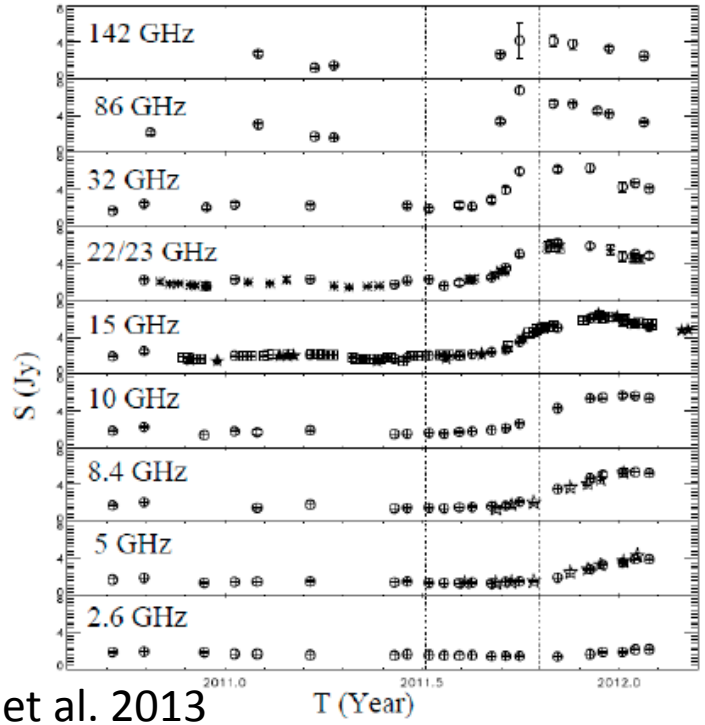
2011

Radio observations of PKS 1510-089 at 43 GHz during July 2011

ATel #3523; *P. P. Beaklini (IAG/USP), T. P. Dominici (MCT/LNA), Z. Abraham (IAG/USP)*
on 2 Aug 2011; 00:46 UT

Detection of an increase in the flux density at 43 GHz from blazar PKS 1510-089 since August, 2011

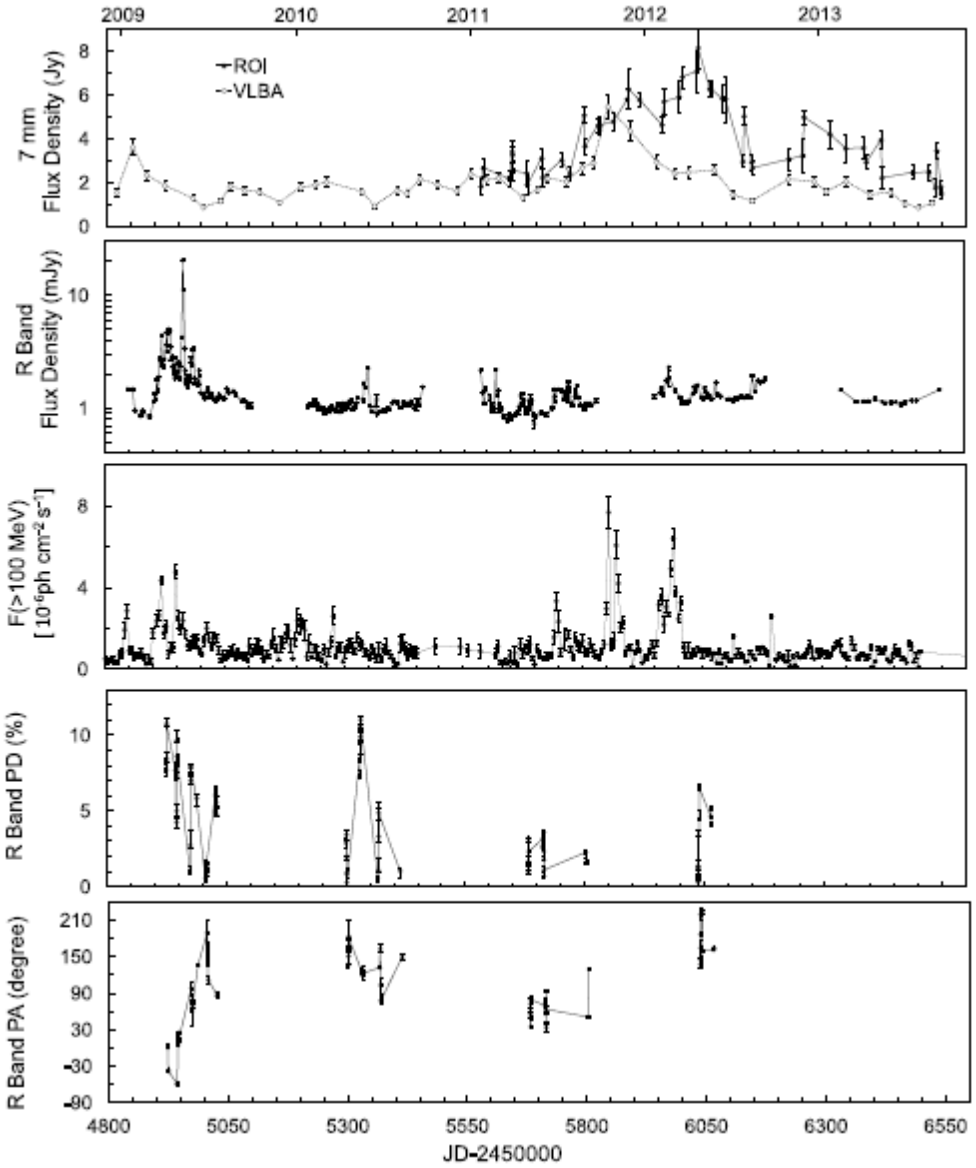
ATel #3799; *P. P. Beaklini (IAG/USP), Z. Abraham (IAG/USP), T. P. Dominici (MCTI/LNA)*
on 8 Dec 2011; 23:43 UT
Credential Certification: Tania Dominici (tdominici@lna.br)



Orienti et al. 2013

SMARTS

Fermi/LAT

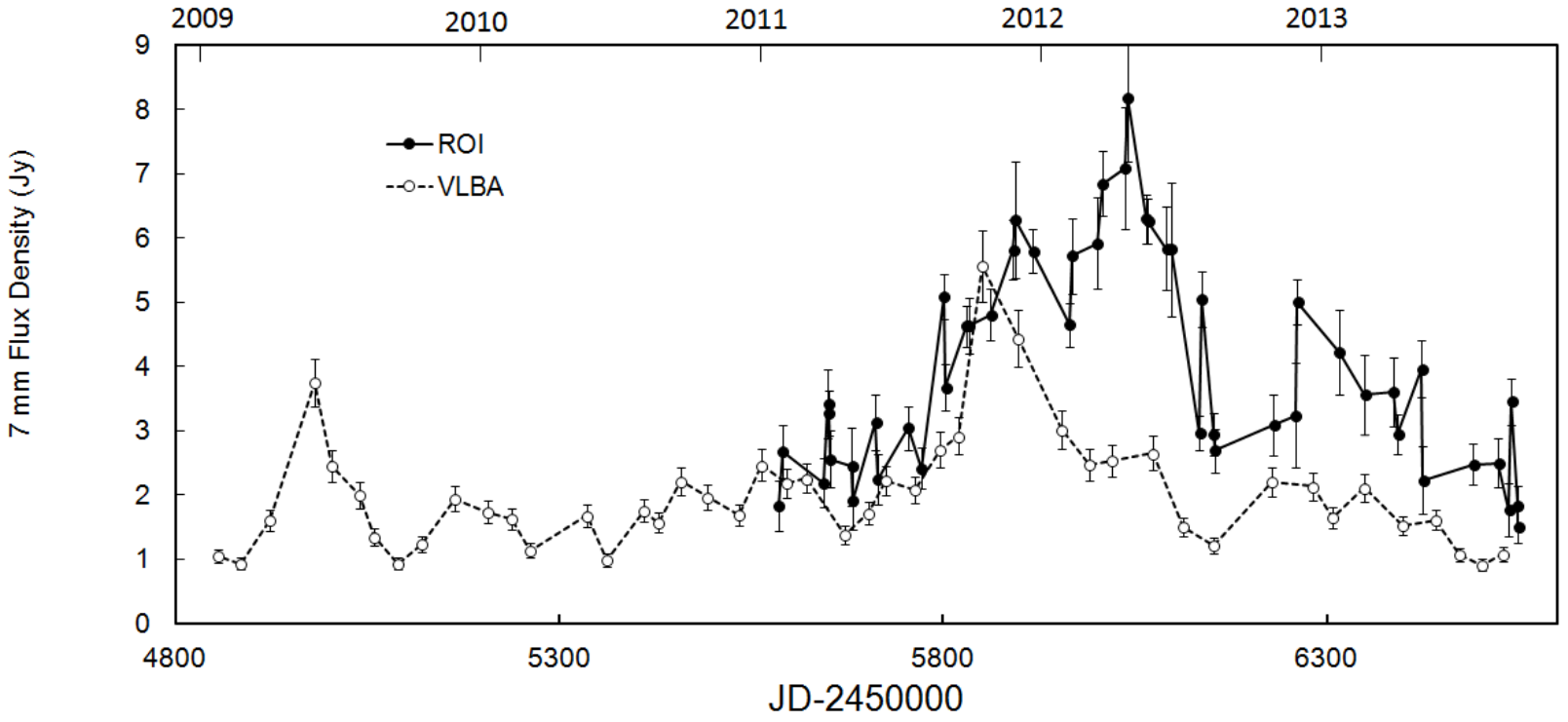


Beaklini et al.
Submitted

SMARTS: Small and Moderate Aperture Research Telescope System (Bonning et al. 2012)
Fermi/LAT: Large Area telescope (Atwood et al. 2009, Abdo et al. 2010)

2011 Activity

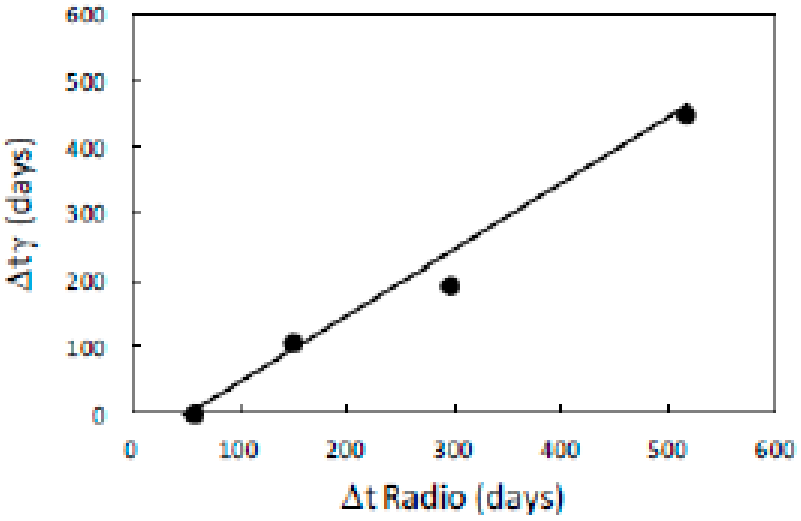
Radio Variability

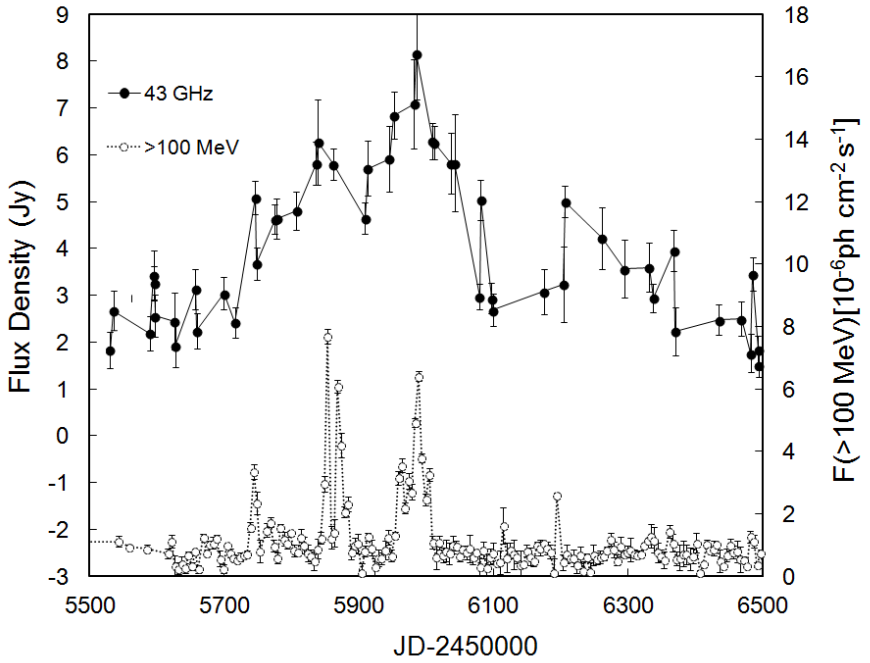


VLBA data from the VLBA-BU Blazar Monitoring Program (VLBA-BU-BLAZAR)
http://www.bu.edu/blazars/VLBAproject.html

Time Delay – Radio-Gamma:1510-089

2011 Event





Delay of ≅ 55 days

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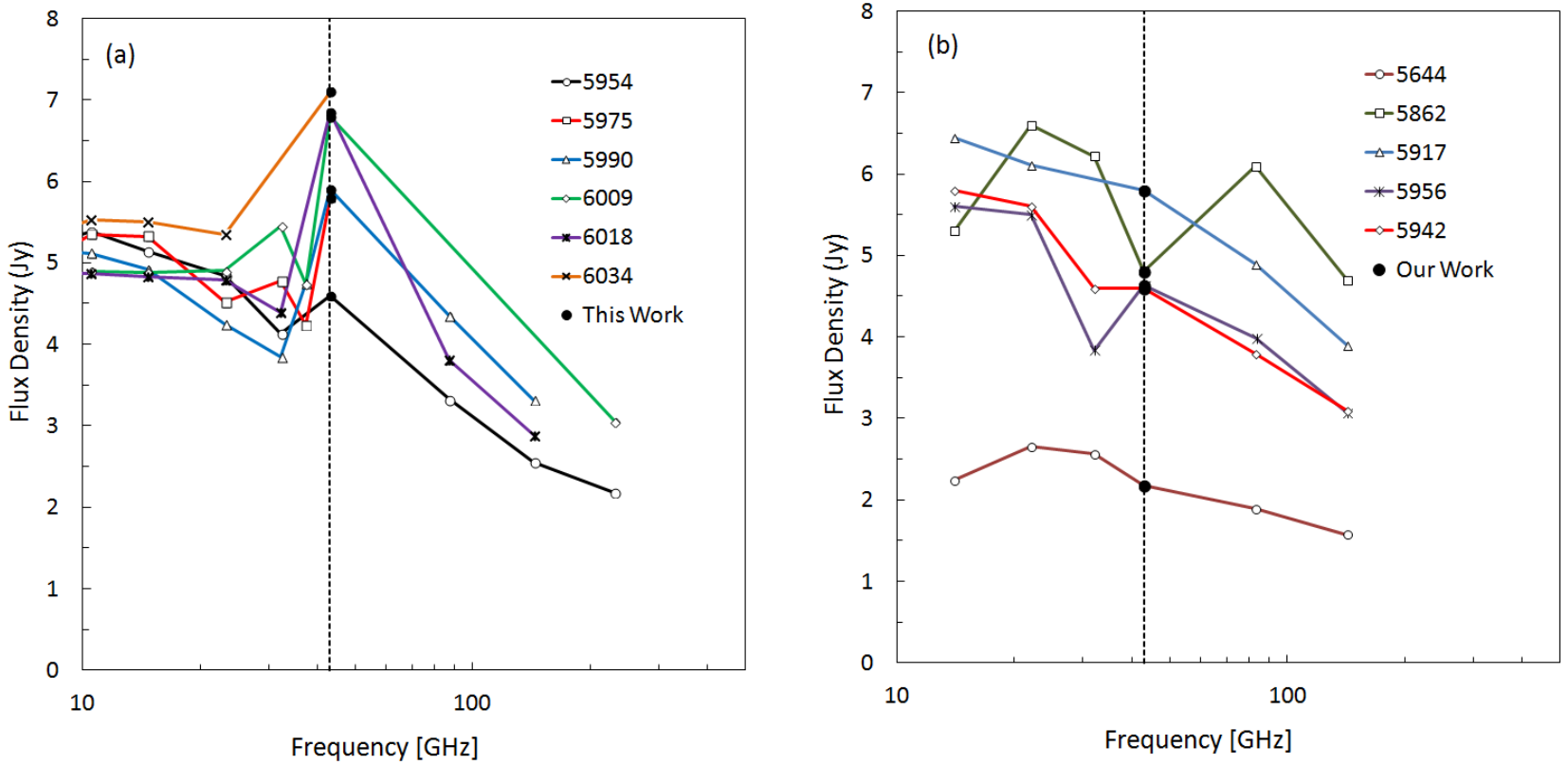
Evidences of a new jet component



(a) Our data (black dot) superposed with the Aleksic et al. (2014) data
(b) Our data (black dot) superposed with the Orienti et al. (2013) data

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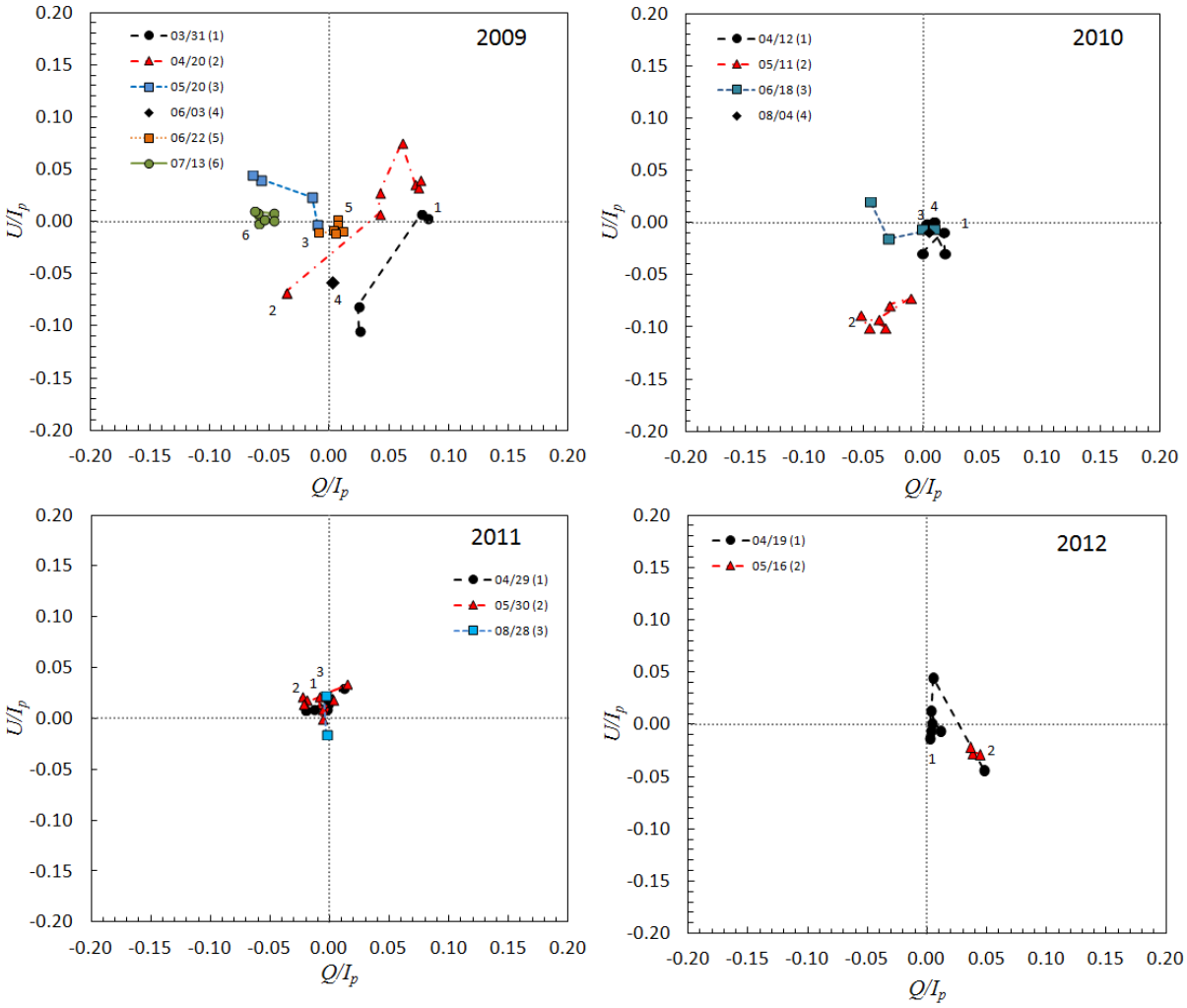
2009 Activity

QxU StokesParameters



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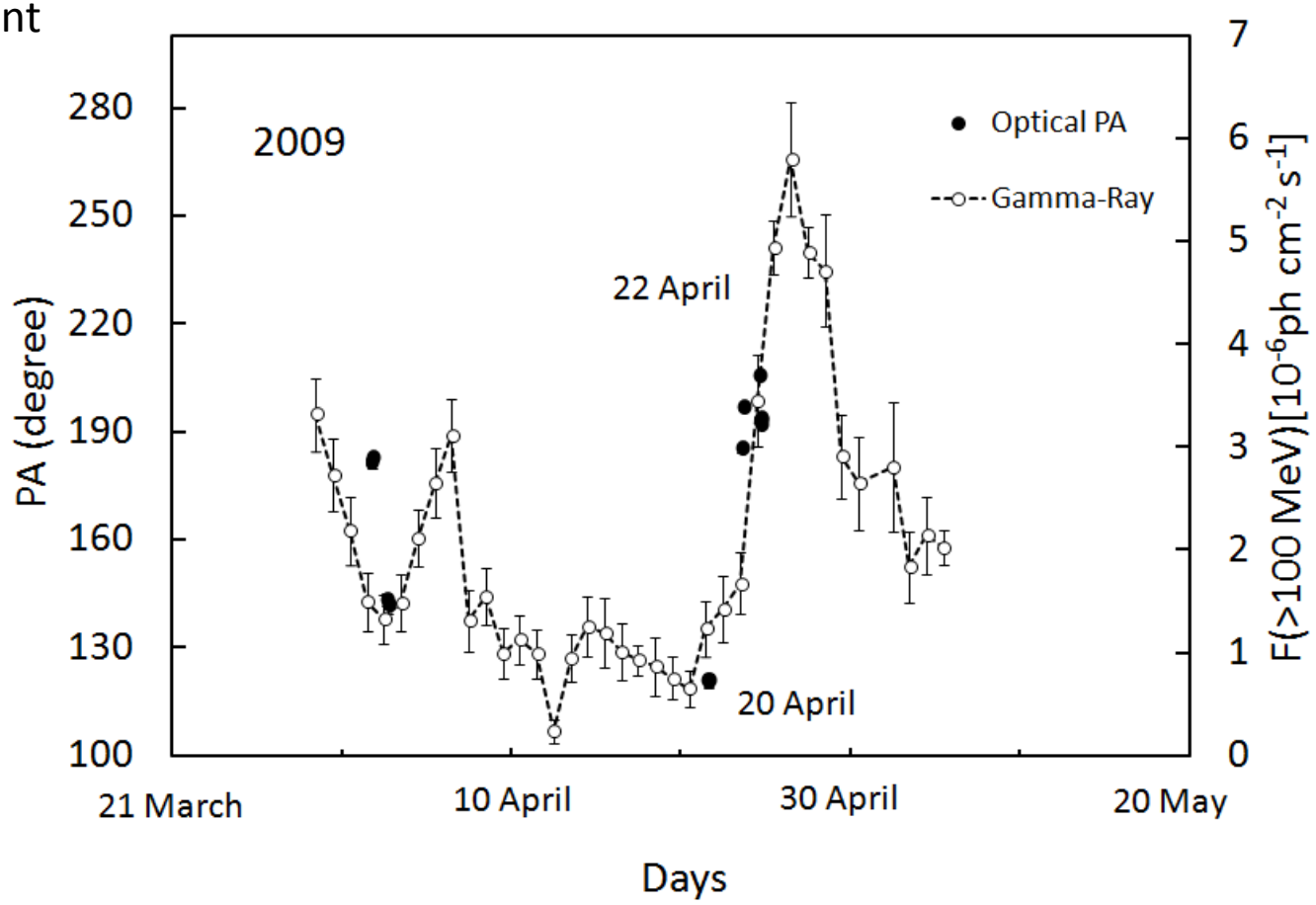
Polarimetry:1510-089

2009 Event



60° rotation of PA in 2 days interval

Depolarization at same time of rotation

Day	MJD	Q/I	U/I	Flux (mJy)	Error	PolFlux	Error	PD (%)	Error	Theta (deg)	Erro
20/04/09	4942.65	-0.0430	0.0640	2.29771	0.68931	0.17722	0.05886	7.713	0.248	120.8	0.9212
22/04/09	4944.63	0.0420	-0.0074	1.67956	0.50387	0.07172	0.02559	4.27	0.243	185.1	1.6304

On a 2 days interval, PA change for 65 ^{o} while PD decrease from 7.7% to 4.2%

How could an ejection of a new jet component produce such effects?

New Component

$$Q_{final} = Q_{jet} + Q_{new}$$

$$U_{final} = U_{jet} + U_{new}$$

$$I_{0(final)} = \sqrt{Q^2_{final} + U^2_{final}}$$

$$\cos 2\theta_{final} = (I_{0(jet)} \cos 2\theta_{jet} + I_{0(new)} \cos 2\theta_{new})/I_{0(final)}$$

$$\sin 2\theta_{final} = (I_{0(jet)} \sin 2\theta_{jet} + I_{0(new)} \sin 2\theta_{new})/I_{0(final)}$$

$$I^2_{0(final)} = I^2_{0(jet)} + I^2_{0(new)} + 2I_{0(jet)}I_{0(new)} \cos 2(\theta_{new} - \theta_{jet})$$

Can we obtain information about the new jet component using the Stokes Parameters before and after start the flare activity?

Depolarization

We investigate the possibility that $I_{0(final)} < I_{0(jet)}$ simultaneously with a large change in PA, as detected during the γ-ray flare of 2009 April, in which $I_{0(jet)} = (0.18 \pm 0.07)$ mJy and $\theta_{jet} = -59° \pm 2°$ in April 20, and $I_{0(final)} = (0.08 \pm 0.02)$ mJy and $\theta_{final} = +11° \pm 2°$ in April 22. From equation 8, this condition is satisfied if:

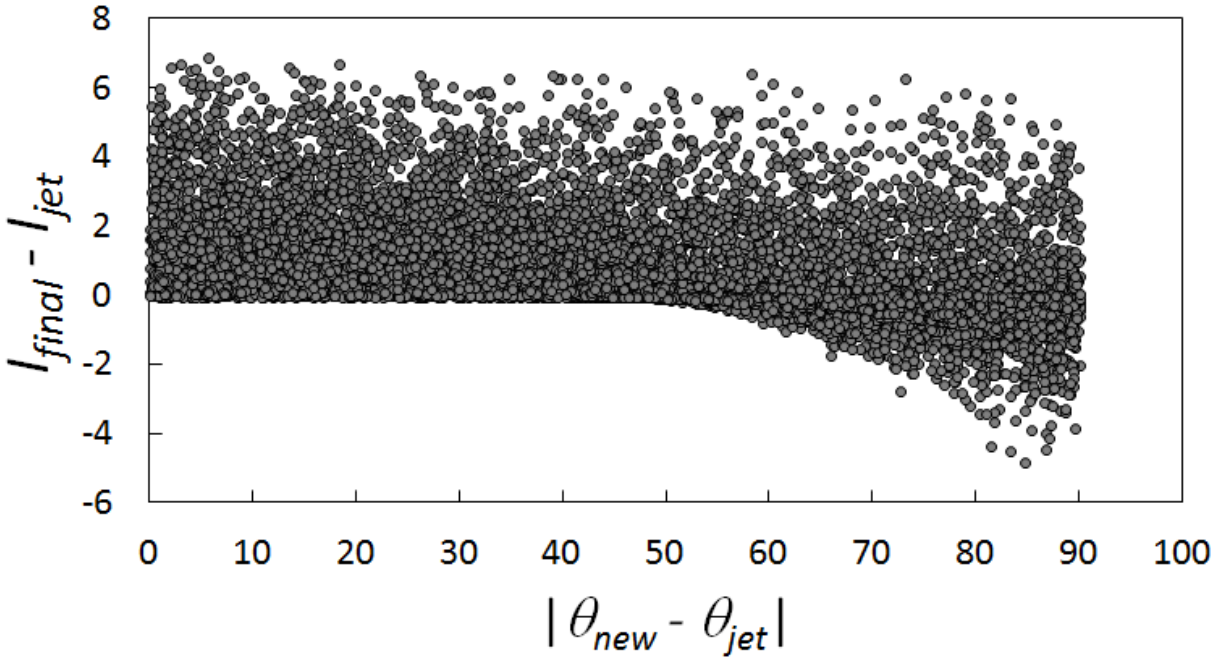
$$I_{0(new)} < -2I_{0(jet)} \cos 2(\theta_{new} - \theta_{jet}), \quad (9)$$

or

$$| (\theta_{new} - \theta_{jet}) | > 45°. \quad (10)$$

We used equations 6 to 8 to estimate the polarimetric properties of the ejected component and found $\theta_{new} = 23.^{\circ}7^{+2.^{\circ}8}_{-3.^{\circ}3}$ and $I_{0(new)} = (0.23 \pm 0.10)$ mJy, resulting in $(\theta_{new} - \theta_{jet}) = 83° \pm 4°$, in agreement with the requirement of equation 10.

How often a depolarization induced by a new component occurs?



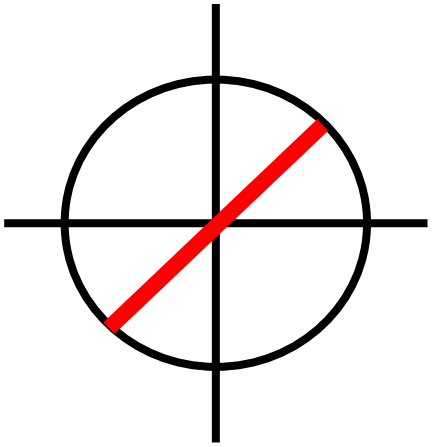
Flux:7mJy
PA: 0-180
PD:0-100

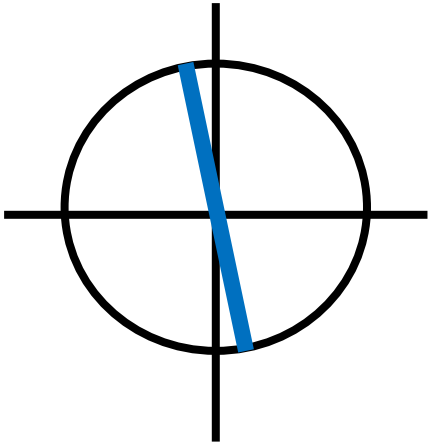
10000 combinations

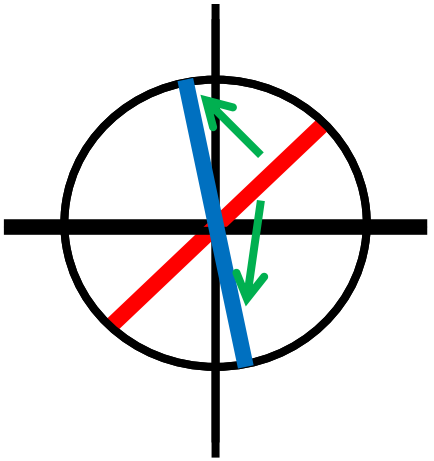
Combining

- Marscher et al.(2010)
- Sasada et al. (2011)
- Jemark et al. (2016)
- Our data

180° Multiplicity







Observation Day 1:

45° or 225° or…n x 180°

Observation Day 2:

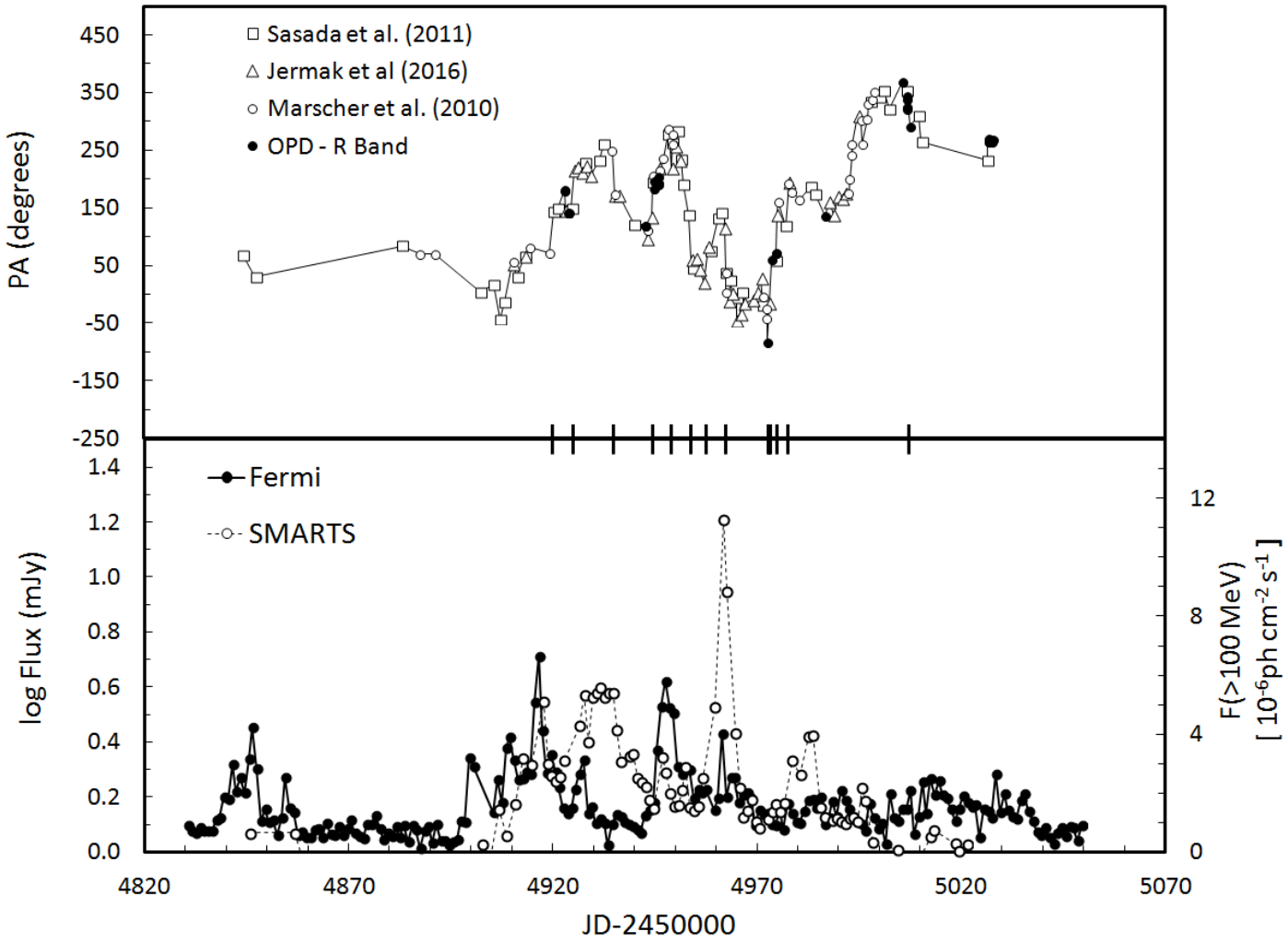
95° or 275° or…n x 180°

Difference:

40° or 140°

Let's do the simplest assumption?

PA variability



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Acknowledgements

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- This study makes use of 43 GHz VLBA data from the VLBA-BU Blazar Monitoring Program (VLBA-BU-BLAZAR; http://www.bu.edu/blazars/VLBAproject.html), funded by NASA through the Fermi Guest Investigator Program. The VLBA is an instrument of the National Radio Astronomy Observatory. The National Radio Astronomy Observatory is a facility of the National Science Foundation operated by Associated Universities, Inc.

- This paper has made use of up-to-date SMARTS optical/near-infrared light curves that are available www.astro.yale.edu/smarts/glast/home.php.

- This research has made use of data from the MOJAVE database that is maintained by the MOJAVE team (Lister et al., 2009, AJ, 137, 3718).

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