VLBA monitoring of Mrk 421 at 15 and 22 GHz during 2011

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Abstract

We present a preliminary analysis of new high resolution radio observations of the nearby TeV blazar Markarian 421 (z=0.031). We consider data obtained with the Very Long Baseline Array (VLBA) at six epochs (one observation per month from January to June 2011) at 15 and 22 GHz. We investigate the inner jet structure, on parsec scale, through the study of model-fit components for each epoch. Almost all components seem to be stationary. More details will be obtained by means of the higher resolution data at 43 GHz. This study is part of a most ambitious multifrequency campaign, with observations in sub-mm (SMA), optical/IR (GASP), UV/X-ray (Swift, RXTE, MAXI), and γ rays (Fermi-LAT, MAGIC, VERITAS). The aim is to try to shed light on questions such as the nature of radiating particles, the connection between radio and γ emission, the location of emitting regions and the origin of the flux variability.

Introduction

Markarian 421 is one of the nearest (z=0.031) and one of the brightest BL Lac objects in the sky. It has been the first extragalactic source detected at Tev energies. The Spectral Energy Distribution (SED) of this object, dominated by non-thermal emission, shows two smooth broad components; one at low energies, from radio band to soft X rays domain, and one peaking at γ rays energies. Despite several and accurate studies on this source (*Abdo et al. 2011, ApJ 736,131*), details of physical processes responsible for the observed emission are still poorly constrained. Because of its strong variability and its broadband spectrum, multiwavelength long term observations are required for a good comprehension of the emission mechanisms.

Observations and goals

Mrk 421 has been observed for 12 epochs (one observation per month for the whole 2011) at 15, 22 and 43 GHz. In this work we present only a partial analysis of this data set, showing preliminary results of the analysis of the first six epochs at 15 and 22 GHz (see the table below). The main purpose of this ambitious multifrequency campaign is to obtain a complete physical understanding of these particular objects. Another important goal is to compare results obtained with our **VLBA** data (radio band), with **Fermi-LAT** observations (γ rays), to find the expected correlation between these two bands, and to confirm the Synchrotron Self Compton model (SSC).

Fermi - Large Area Telescope

VLBA network.

Results

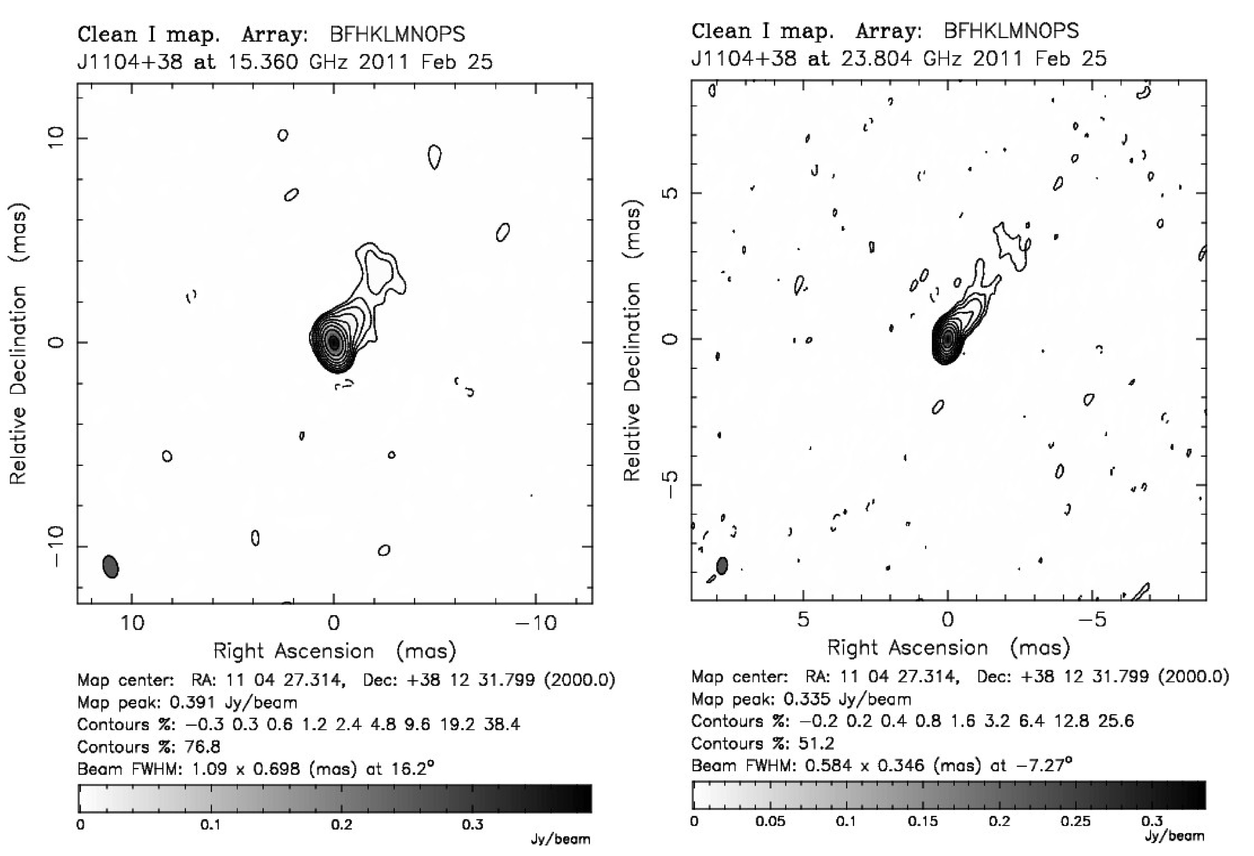

Fig 1. Cleaned maps of the February data-set at 15(left) and 22 GHz (right). At 15 GHz the rms is 0.438 mJy/beam (1σ), at 22 GHz the rms is 0.297 mJy/beam (1σ).

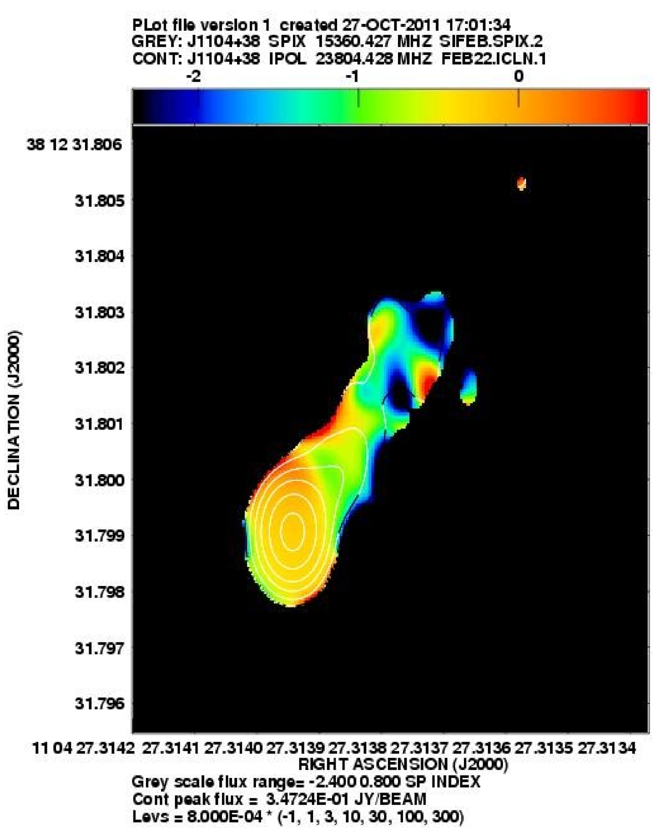

Fig 2. Spectral Index map obtained using observation of the second epoch data-set at 15 and 22 GHz.

Observation Date	Map Peak (mJy/beam)*		Beam (masxmas, deg)		Notes
	15GHz	22GHz	15GHz	22GHz	
14/01/11	340	316	0.89 x 0.52, 21.7	0.73 x 0.41, 13.5	No MK, no NL
25/02/11	391	335	1.09 x 0.70, 16.2	0,58 x 0.35. -7.27	NL snowing
29/03/11	384	358	0.93 x 0.55, -3.48	0.61 x 0.36. 0.18	No HK
25/04/11	358	305	0.89 x 0.50, -2.31	0.56 x 0.32, -1.15	No MK and NL
31/05/11	355	295	0.90 x 0.52, -3.02	0.58 x 0.34, -2.87	No MK and NL
29/06/11	260	200	0.87 x 0.49, -3.09	0.70 x 0.34, - 20,5	No LA

** Beam size with natural weigth.*

Jet Structure

Here we report cleaned maps for the first six epochs (*Fig 3*). The source shows a well defined jet structure at these frequencies. The jet extends for roughly 4.5 mas (2.67 pc), with a position angle slightly less than 45 deg. The core flux density at 15 GHz is roughly 0.35 Jy, and it decreases as we move outward along the jet. In particular we show the spectral index map (*Fig 2*) obtained from observations on February at 15 and 22 GHz (*Fig 1*). Here the spectral index α is defined such that $S(\nu) \sim \nu^{\alpha}$, *and it* is near flat at the core and steepens along the jet.

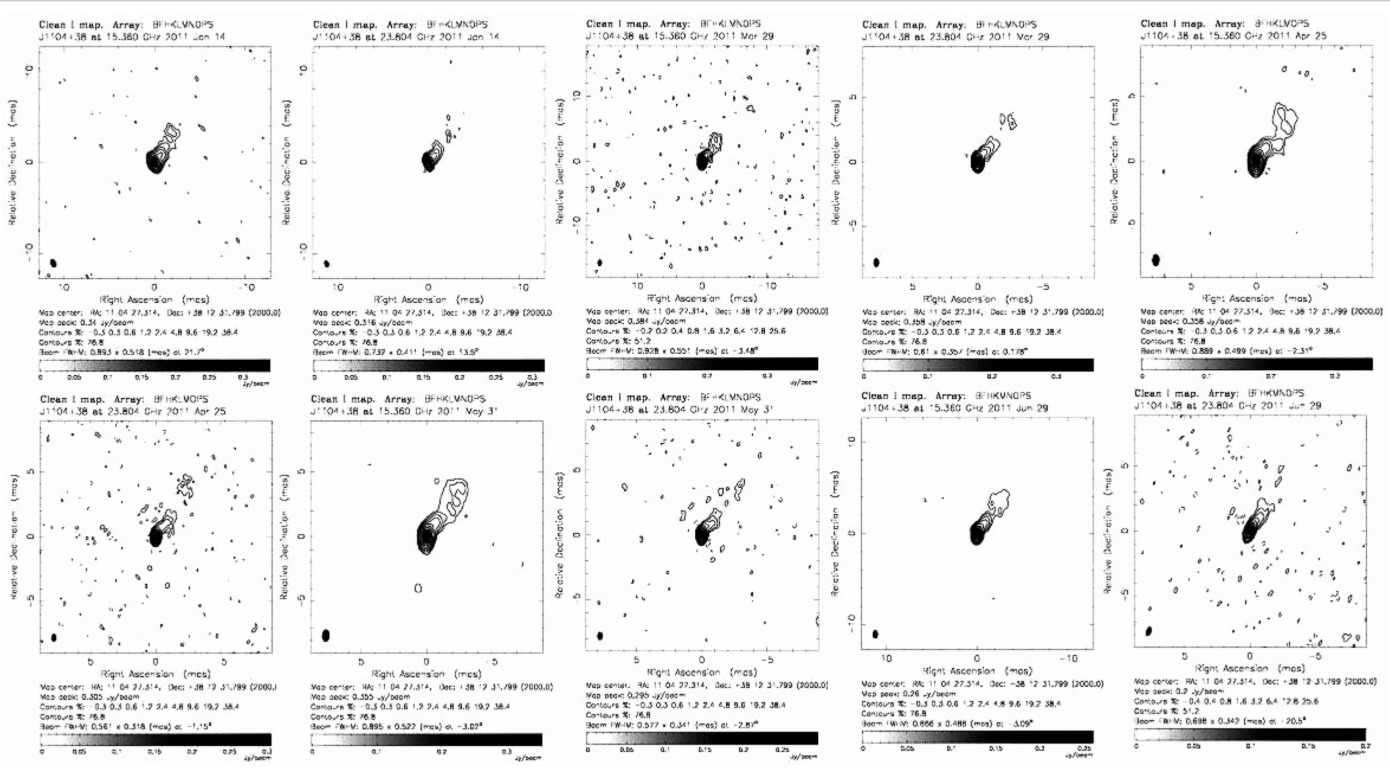

Fig 3. Cleaned maps of the first six epochs at 15 and 22 GHz.

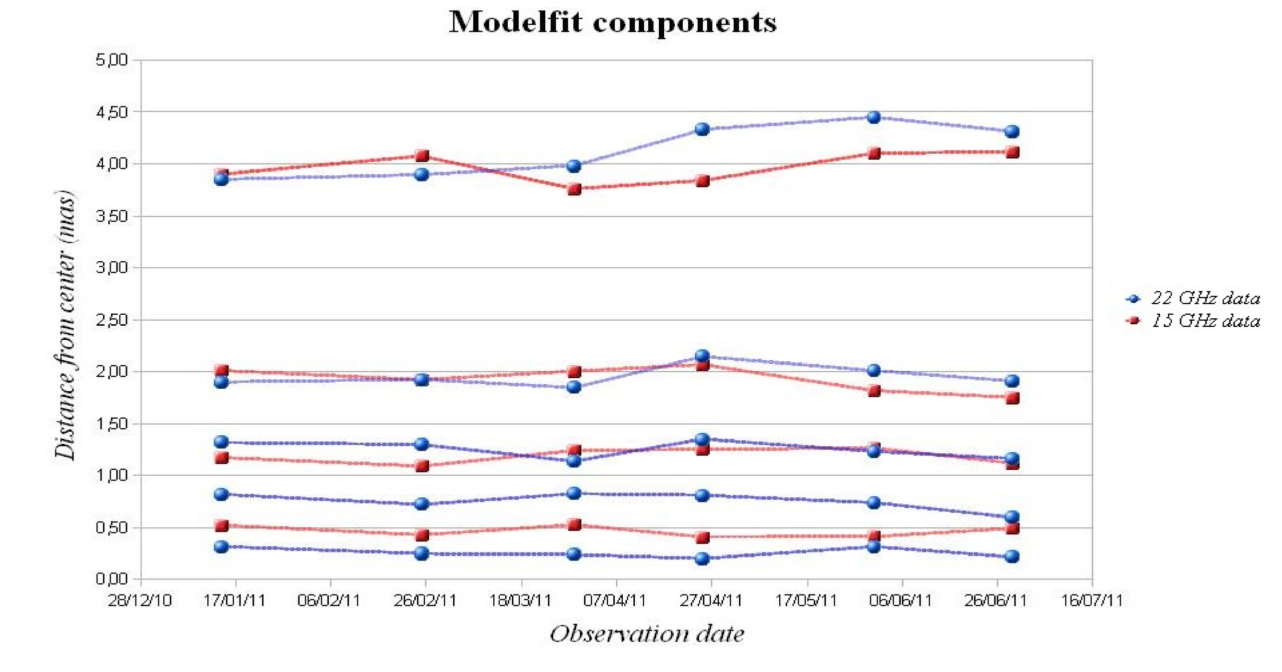

Fig 4. Results of the model-fit analysis of the first six epochs of observation. red squares and blue spots represent the position of gaussian components at 15 and 22 GHz respectively. Lines between data are only for guidance.

Modelfit

We have investigated in detail the inner jet structure by means of modelfit in the visibility plane (*Fig 4*). At 15 GHz a good fit is represented by five Gaussian components, which seem to be stationary from this preliminary analysis. At 22 GHz the first component near the core is resolved into two components. This feature is due to the high resolution at 22 GHz, and we will investigate it in more detail in a further analysis of data at 43 GHz.

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