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

3mm GMVA observations of total and polarised emission from blazar and radio galaxy core regions

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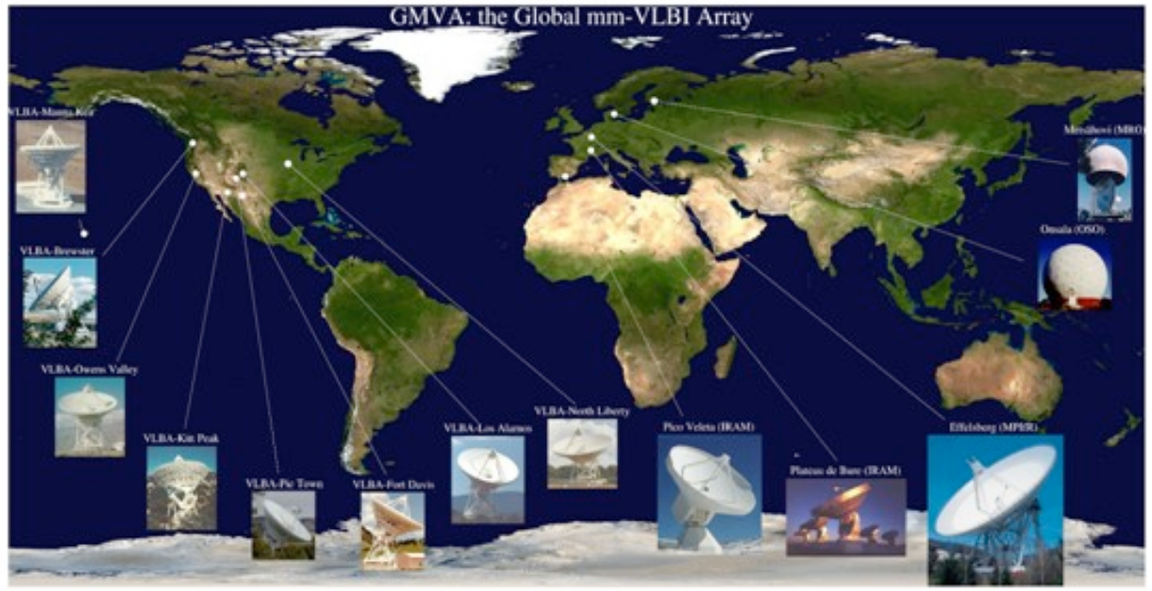
GMVA observations

THE SAMPLE

Half of the 37 gamma-ray bright and radio loud AGN:
24 FSRQ and BL Lacs, 3 radiogalaxies (3C 120, 3C 111 and 3C 84)

43 GHz VLBA (VLBA-BU-BLAZAR program) polarimetric obs.

- VLBA
- started in 2008, monthly obs.
- maximum resolution ~ 0.15 mas



86 GHz GMVA polarimetric obs. (PI: Prof. Marscher)

- VLBA, Green Bank, Effelsberg, Onsala, Yebes, Metsahovi, Pico Veleta, Plateau de Bure, KVN stations
- started in 2008.78, ~ every 6 months
- max resolution ~ 0.05 mas

PhD thesis of J. Hodgson - 2015 (http://www3.mpifr-bonn.mpg.de/div/vlbi/globalmm/)

GAINS and LOSSES with 3mm GMVA observations

GAINS

- 3 TIMES MORE RESOLUTION !
- observation of the regions optically thick at 43 GHz
- comparison of the linearly polarised and total intensity images between 86 and 43 GHz

Privileged sample to investigate the magnetic field in the very inner regions of AGN

LOSSES

- a lot of time in calibrating data
- data are noisy and many scans can be lost due to atmospheric fluctuations (atmospheric coherence time at 86 GHz ~ 10 - 20 sec), stations problems, etc..

↘

REDUCED PARALLACTIC ANGLE COVERAGE

Calibration of Polarisation

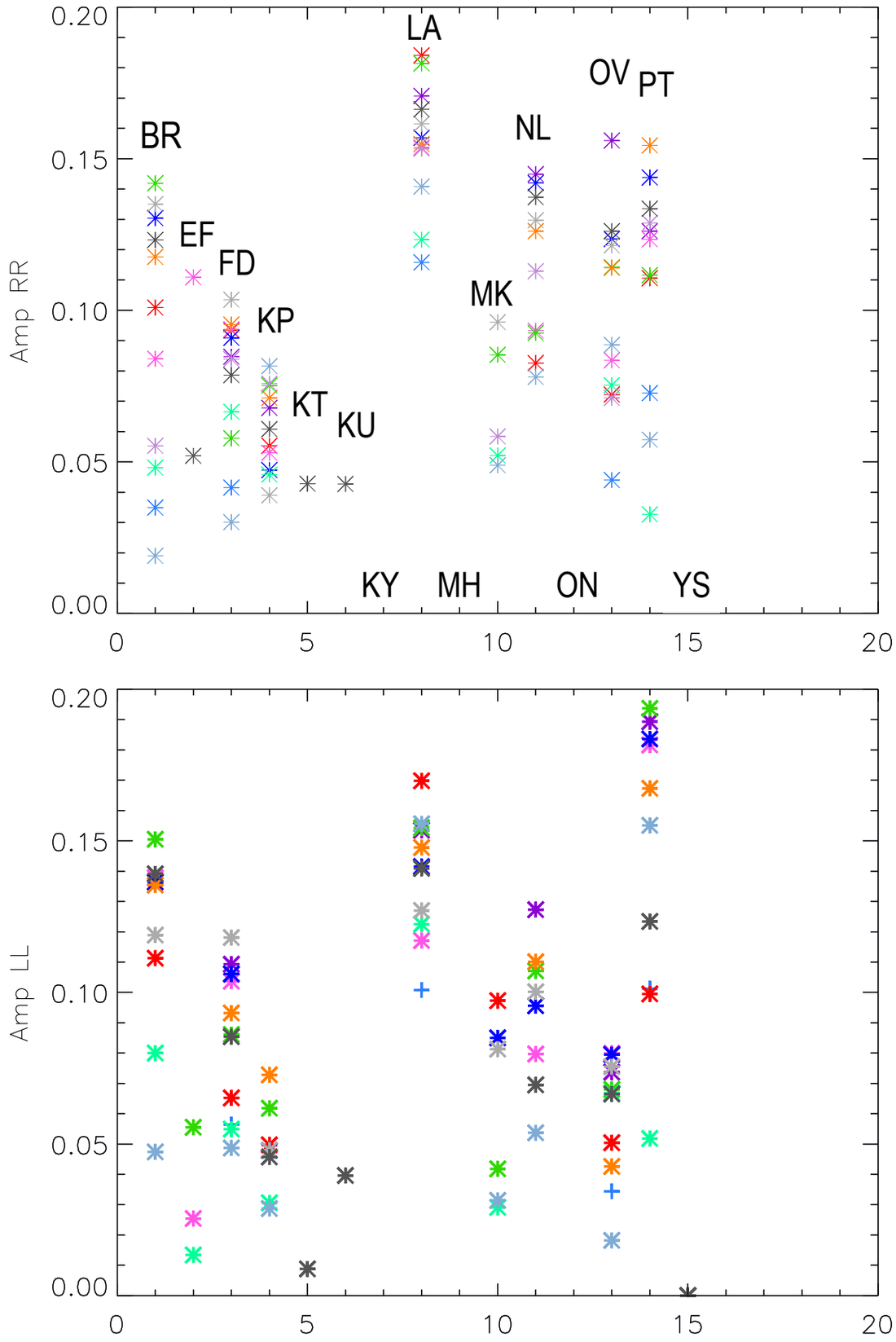
1) correction for the instrumental polarisation

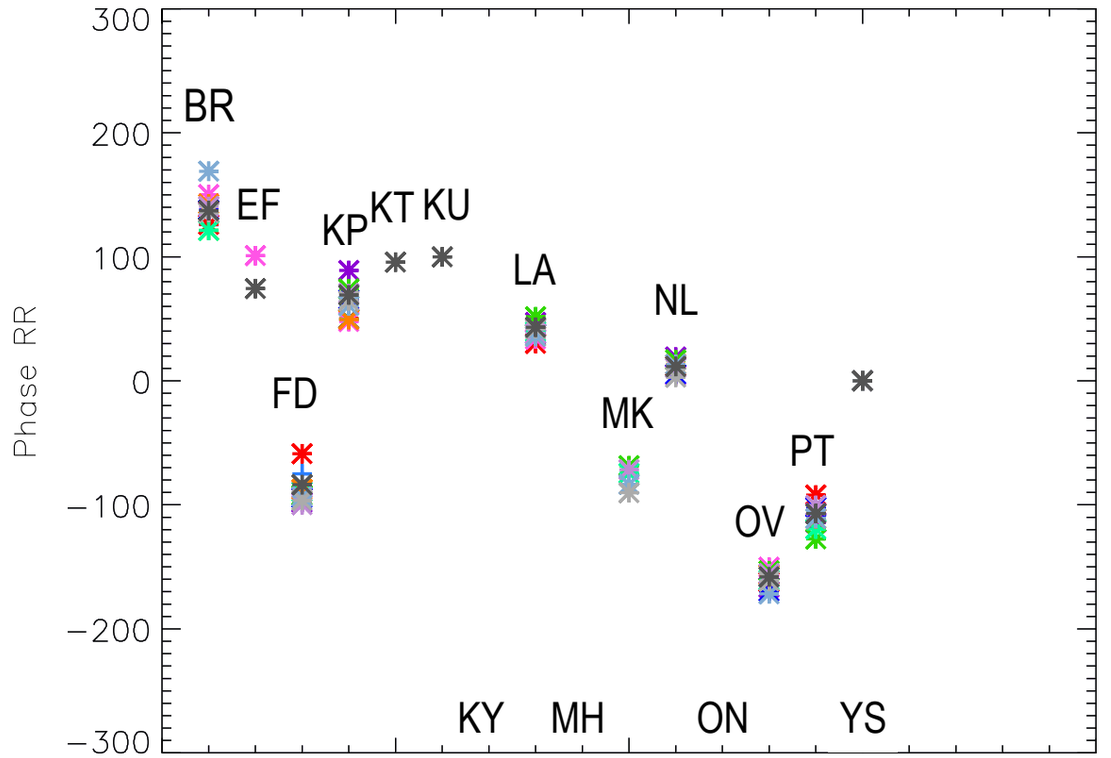
2) correction of the apparent orientation of EVPAs to the correct value

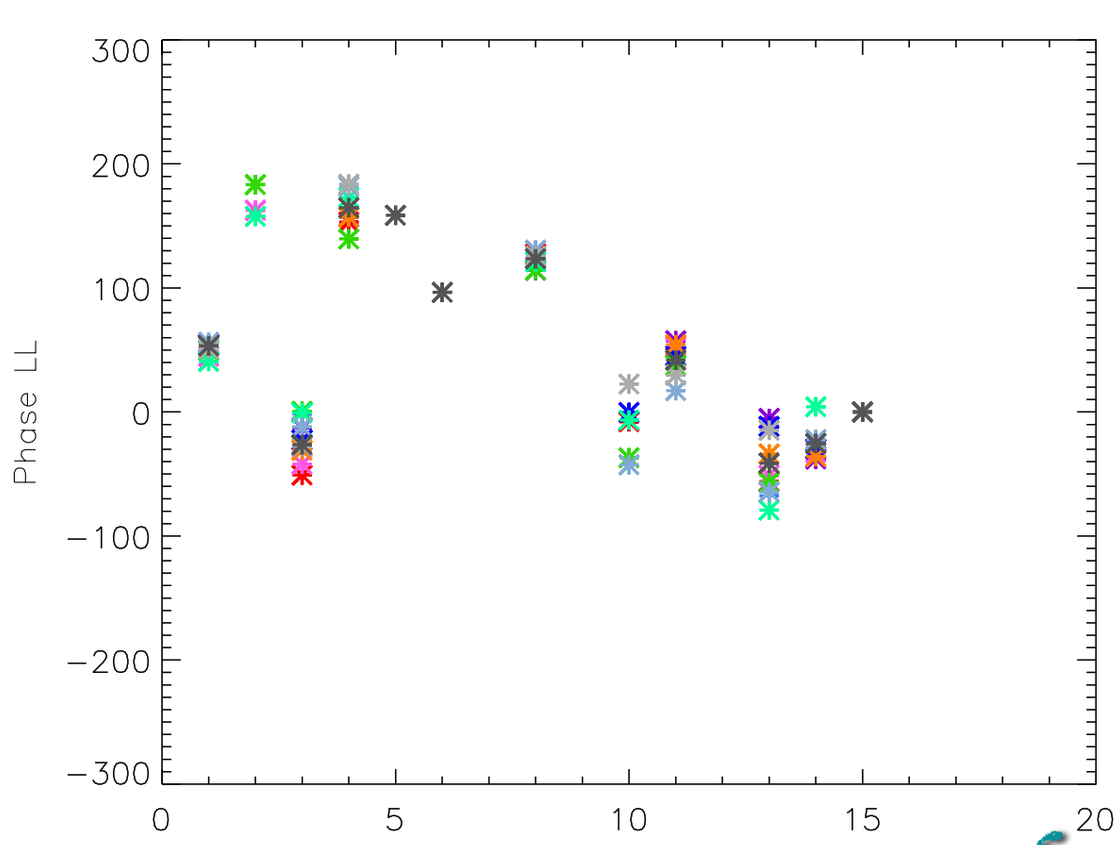
1) correction for the instrumental polarisation

21 May 2016 – GMVA obs.

3C111
3C120
3C273
3C345
3C454.3
0716+714
0954+658
1510
1633
BLLAC
CTA102
OJ287







1) correction for the instrumental polarisation

21 May 2016 – GMVA obs.

3C111
3C120
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3C454.3
0716+714
0954+658
1510
1633
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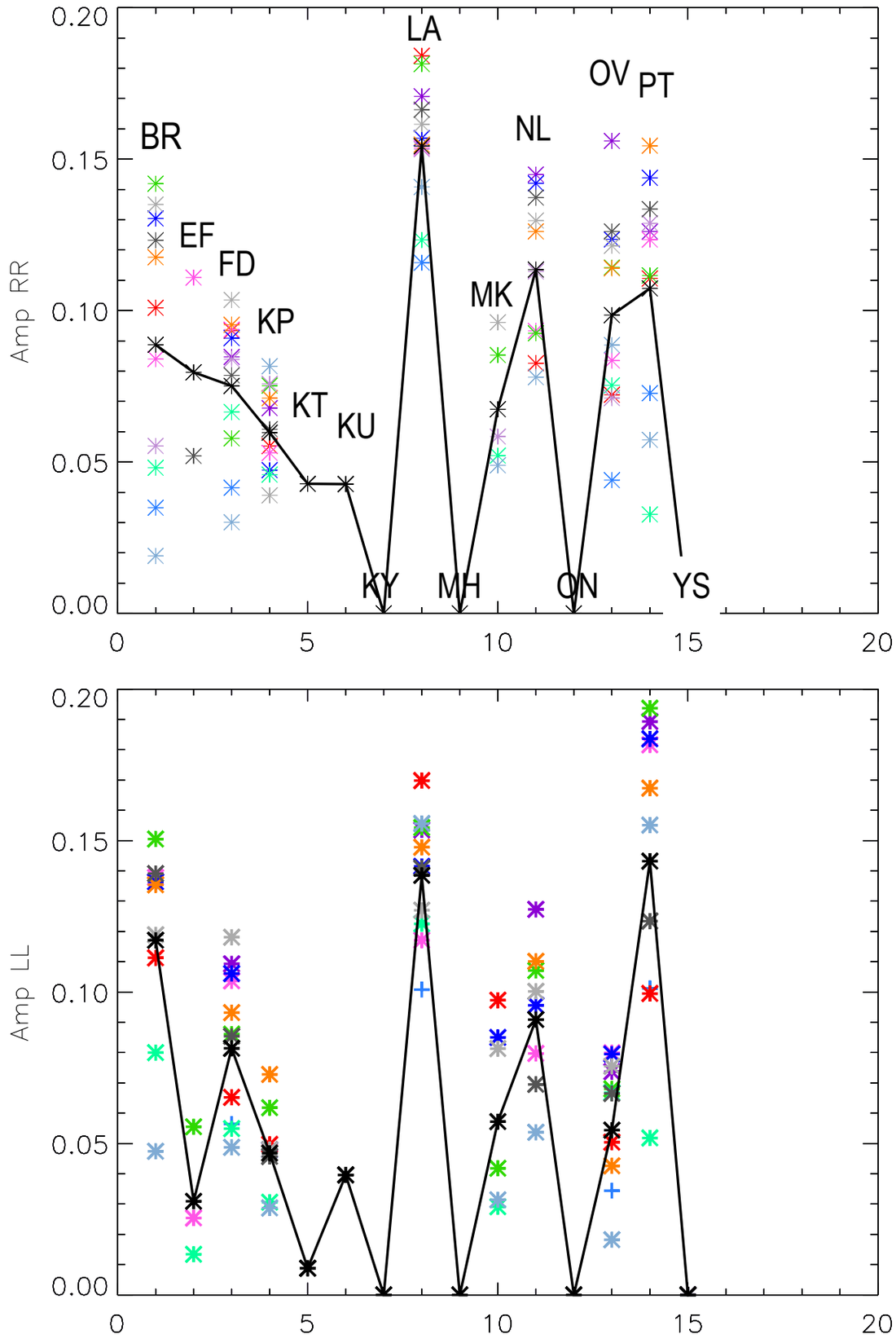
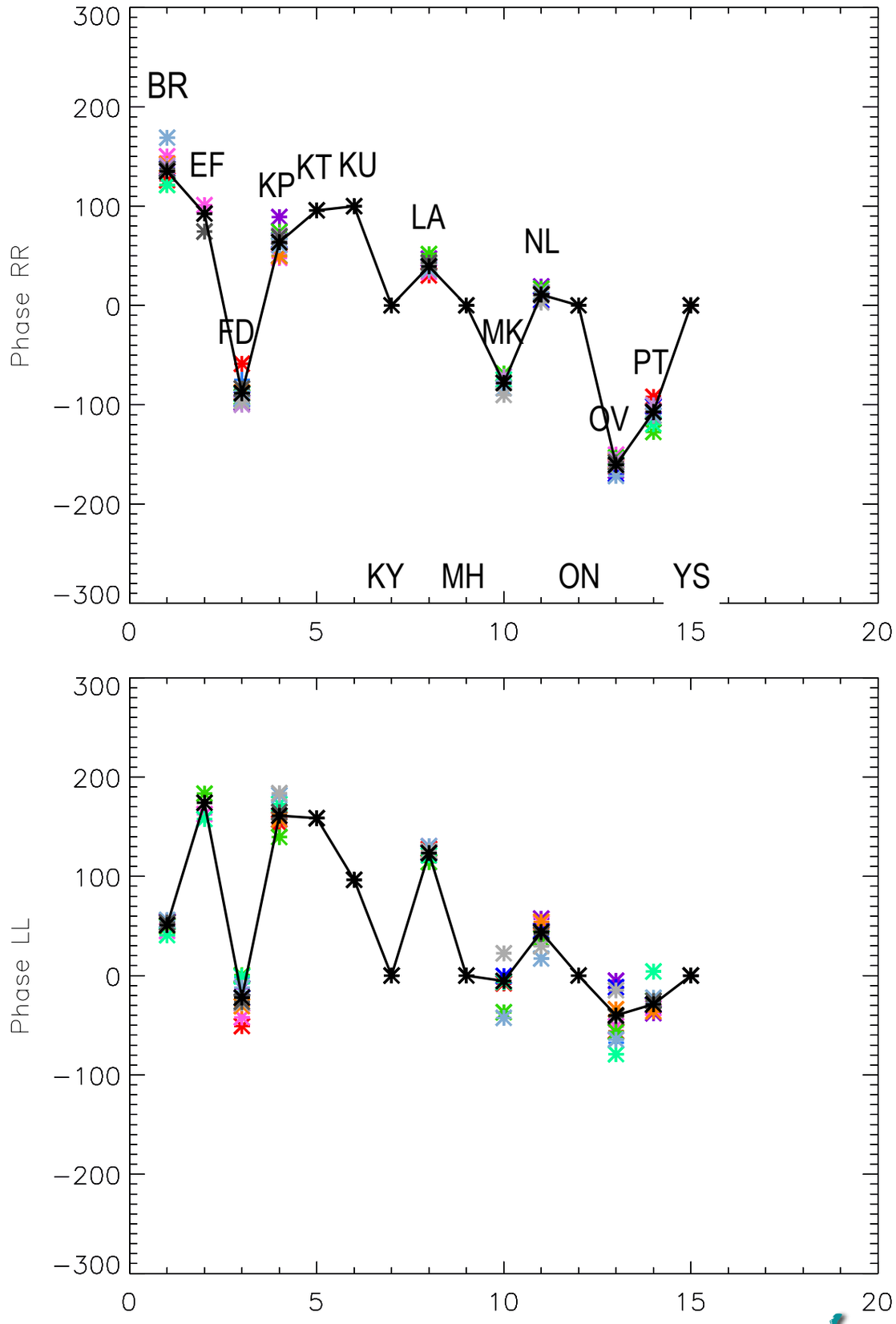
CTA102
OJ287

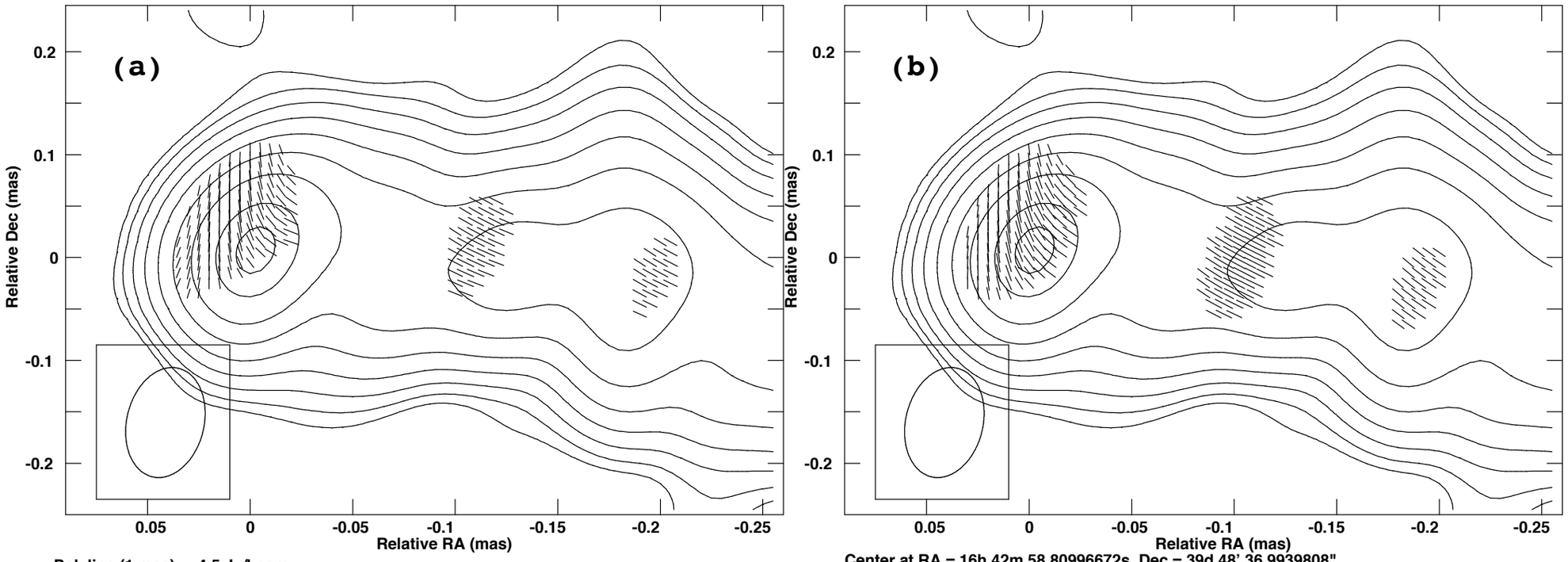




Average vs. Proper D-terms

3C 345

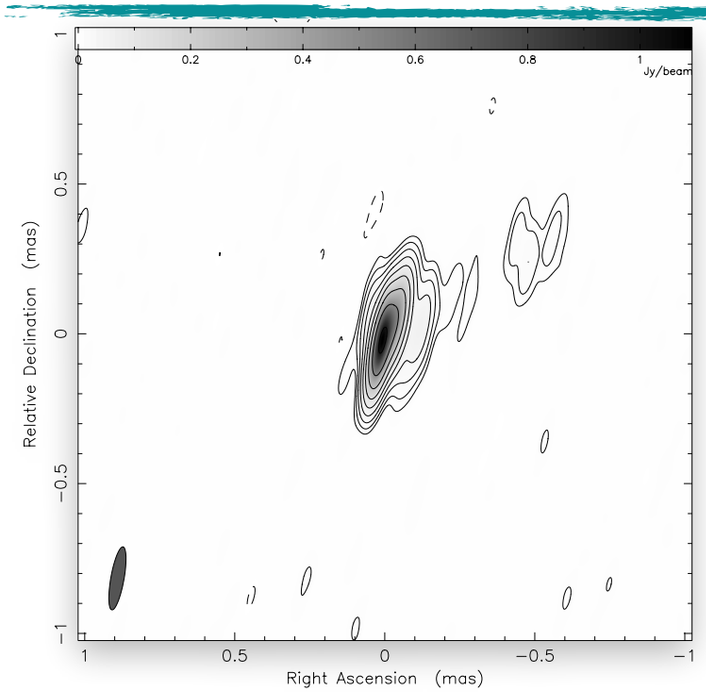
Martí-Vidal et al., 2012



Averaging the D-terms from 3C 345, BLLAC and 0716+714

D-terms from 3C 345

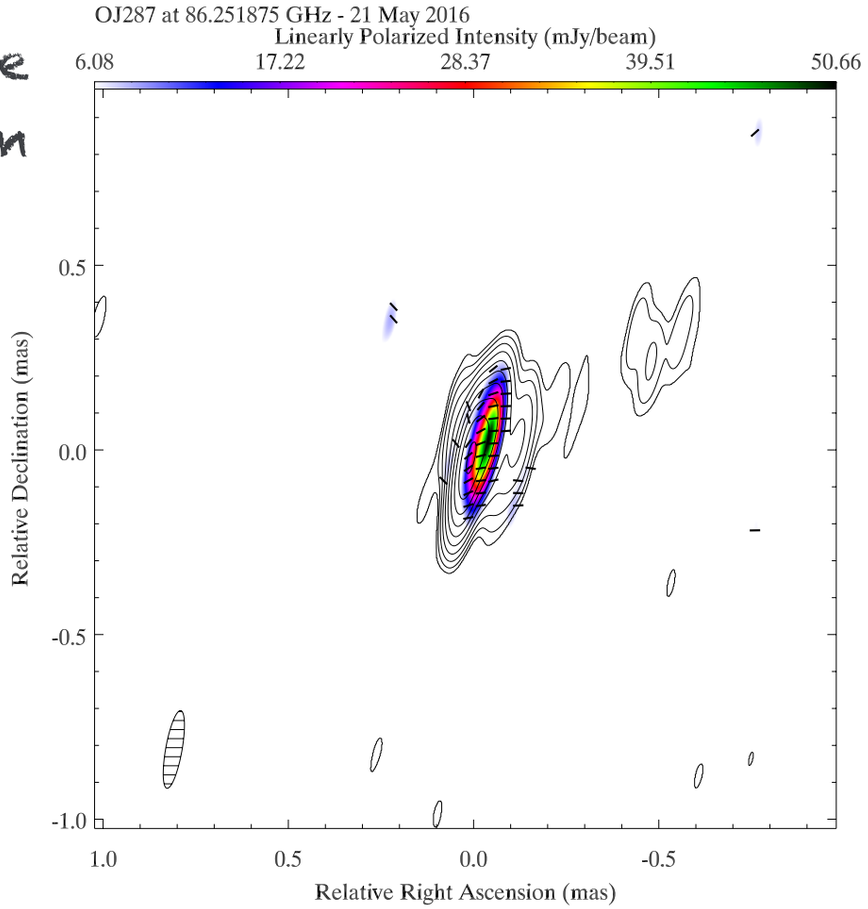
Average vs. Proper D-terms: the ideal case of OJ 287



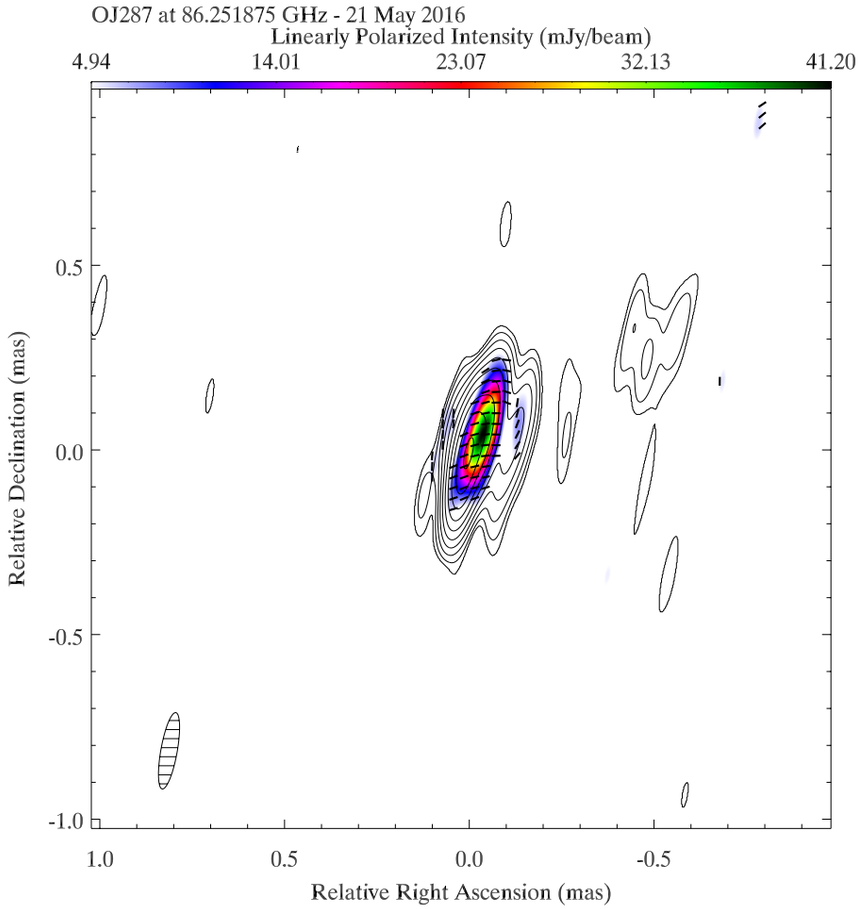
Ant.	#Vis.	Parallel	Cross-hand (Jy)	PA range (deg)
BR 1	13439	0.226	0.187	79.8
EF 2	5966	0.149	0.115	6.8
FD 3	14621	0.233	0.155	133.0
KP 4	14594	0.248	0.188	128.1
KT 5	406	1.209	0.817	118.2
KU 6	645	0.765	0.441	113.5
KY 7	250	0.543	0.351	0.5
LA 8	14526	0.203	0.169	118.5
MK 10	8490	0.215	0.167	21.1
NL 11	10157	0.377	0.332	105.1
OV 13	13485	0.223	0.169	109.9
PT 14	14083	0.287	0.252	122.1

Averaging the D-terms from

3C 111
3C 120
3C 273
3C 345
3C 454.3
0716+714
0954+658
1510-089
1633+382
BLLAC
CTA102
OJ287



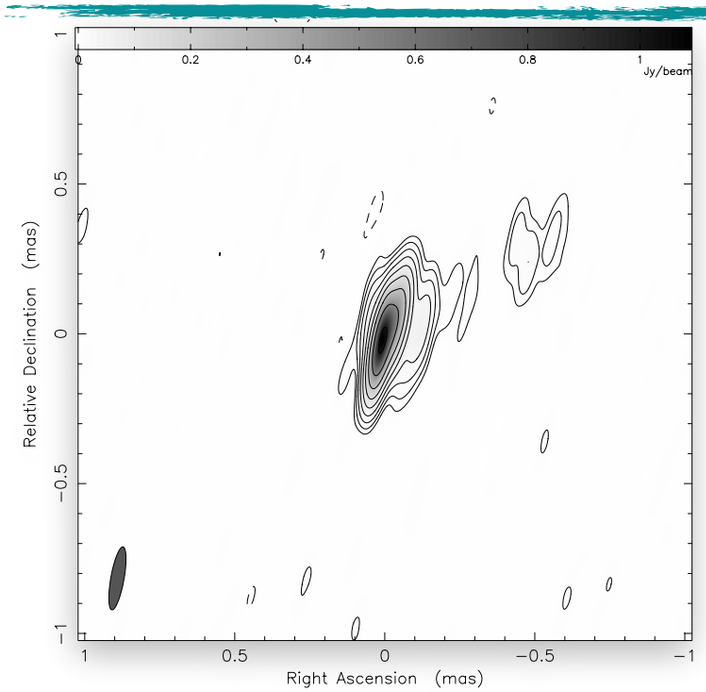
Peak Total Intensity 1.0944 Jy/beam (first cont. at 3.83 mJy/beam - Noise Pol. 12.0% peak)
Total Intensity Contours 0.35,0.65,1.20,2.23,4.12,7.64,14.15,26.22,48.58,90% of peak
Beam FWHM 0.21x0.04 mas at -10.06 deg.



Peak Total Intensity 1.0933 Jy/beam (first cont. at 3.83 mJy/beam - Noise Pol. 12.0% peak)
Total Intensity Contours 0.35,0.65,1.20,2.23,4.12,7.64,14.15,26.22,48.58,90% of peak
Beam FWHM 0.21x0.04 mas at -10.11 deg.

D-terms from OJ287

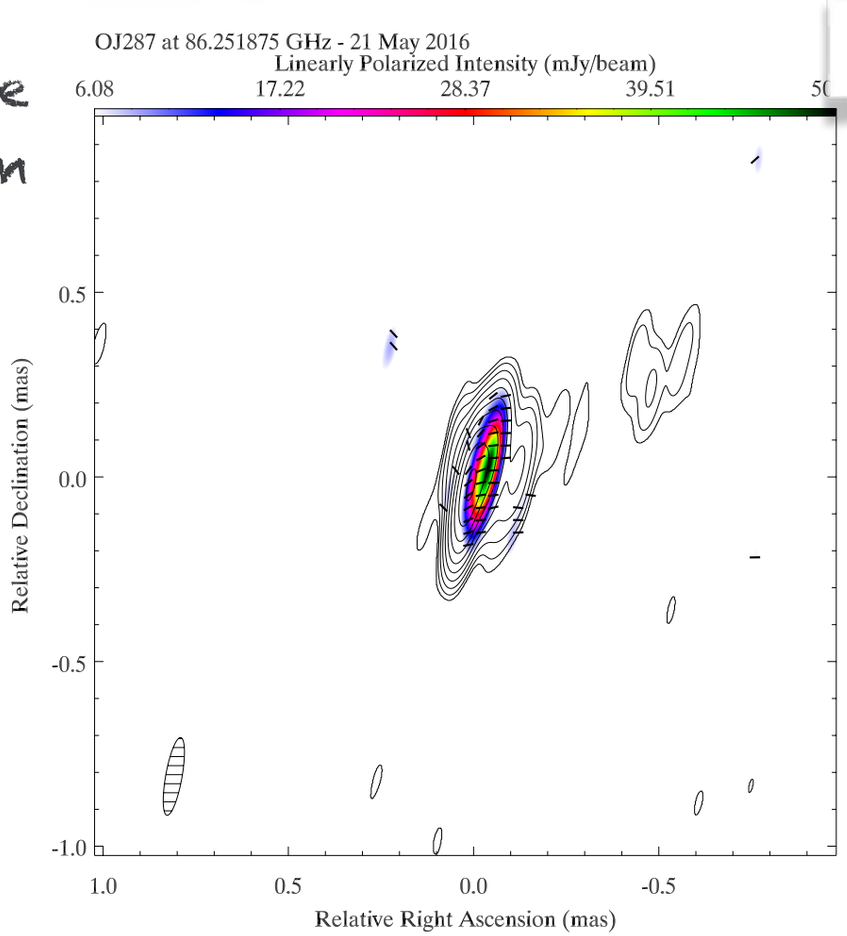
Average vs. Proper D-terms: the ideal case of OJ 287



Ant.	#Vis.	Parallel	Cross-hand (Jy)	PA range (deg)
BR 1	13439	0.226	0.187	79.8
EF 2	5966	0.149	0.115	6.8
FD 3	14621	0.233	0.155	133.0
KP 4	14594	0.248	0.188	128.1
KT 5	406	1.209	0.817	118.2
KU 6	645	0.765	0.441	113.5
KY 7	250	0.543	0.351	0.5
LA 8	14526	0.203	0.169	118.5
MK 10	8490	0.215	0.167	21.1
NL 11	10157	0.377	0.332	105.1
OV 13	13485	0.223	0.169	109.9
PT 14	14083	0.287	0.252	122.1

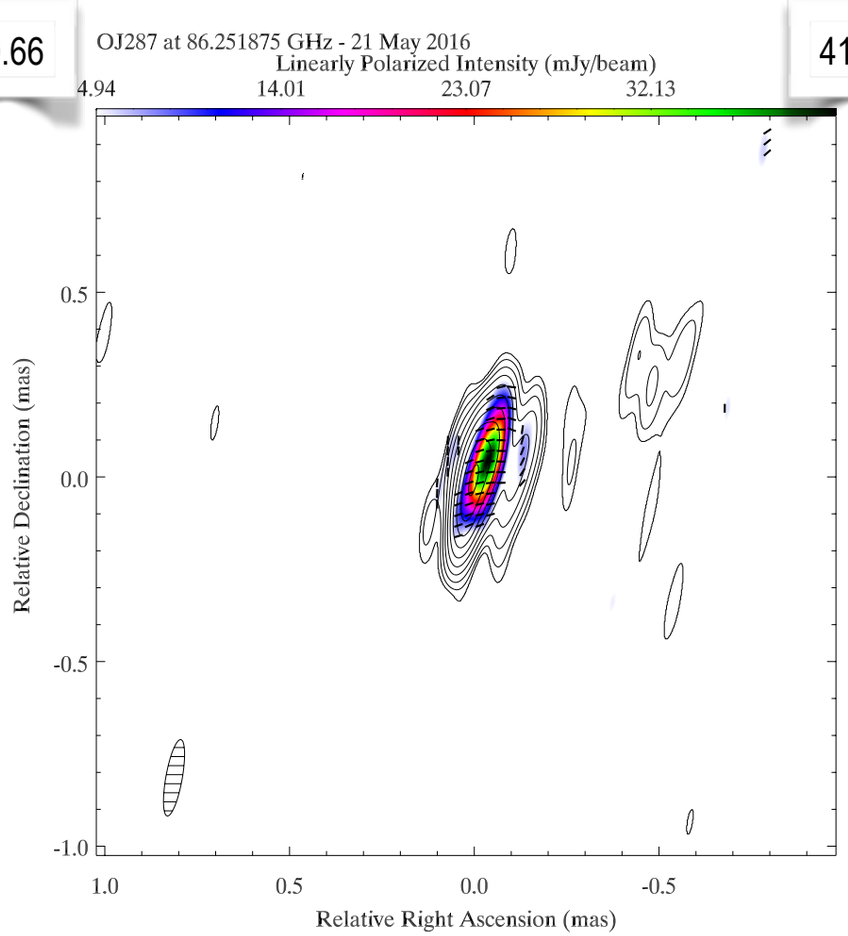
Averaging the D-terms from

3C 111
3C 120
3C 273
3C 345
3C 454.3
0716+714
0954+658
1510-089
1633+382
BLLAC
CTA102
OJ287



Peak Total Intensity 1.0944 Jy/beam (first cont. at 3.83 mJy/beam - Noise Pol. 12.0% peak)
Total Intensity Contours 0.35,0.65,1.20,2.23,4.12,7.64,14.15,26.22,48.58,90% of peak
Beam FWHM 0.21x0.04 mas at -10.06 deg.

50.66

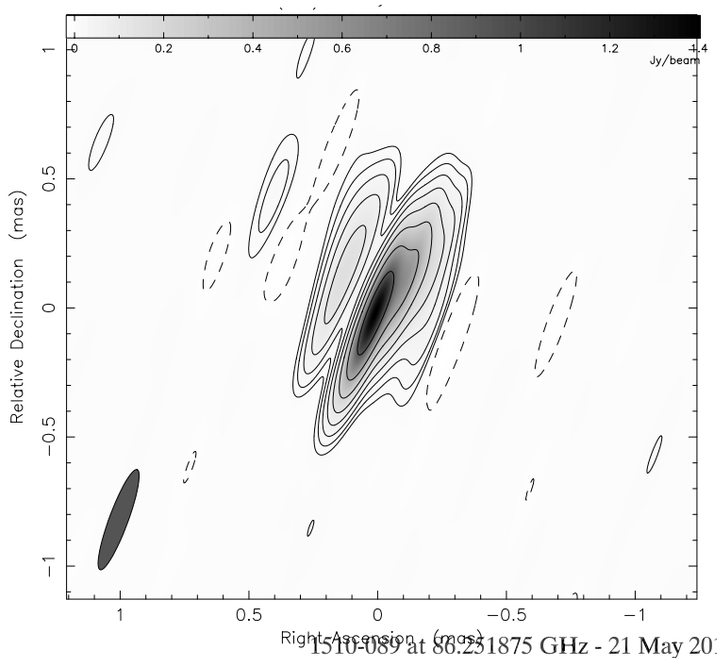


Peak Total Intensity 1.0933 Jy/beam (first cont. at 3.83 mJy/beam - Noise Pol. 12.0% peak)
Total Intensity Contours 0.35,0.65,1.20,2.23,4.12,7.64,14.15,26.22,48.58,90% of peak
Beam FWHM 0.21x0.04 mas at -10.11 deg.

41.20

D-terms from OJ287

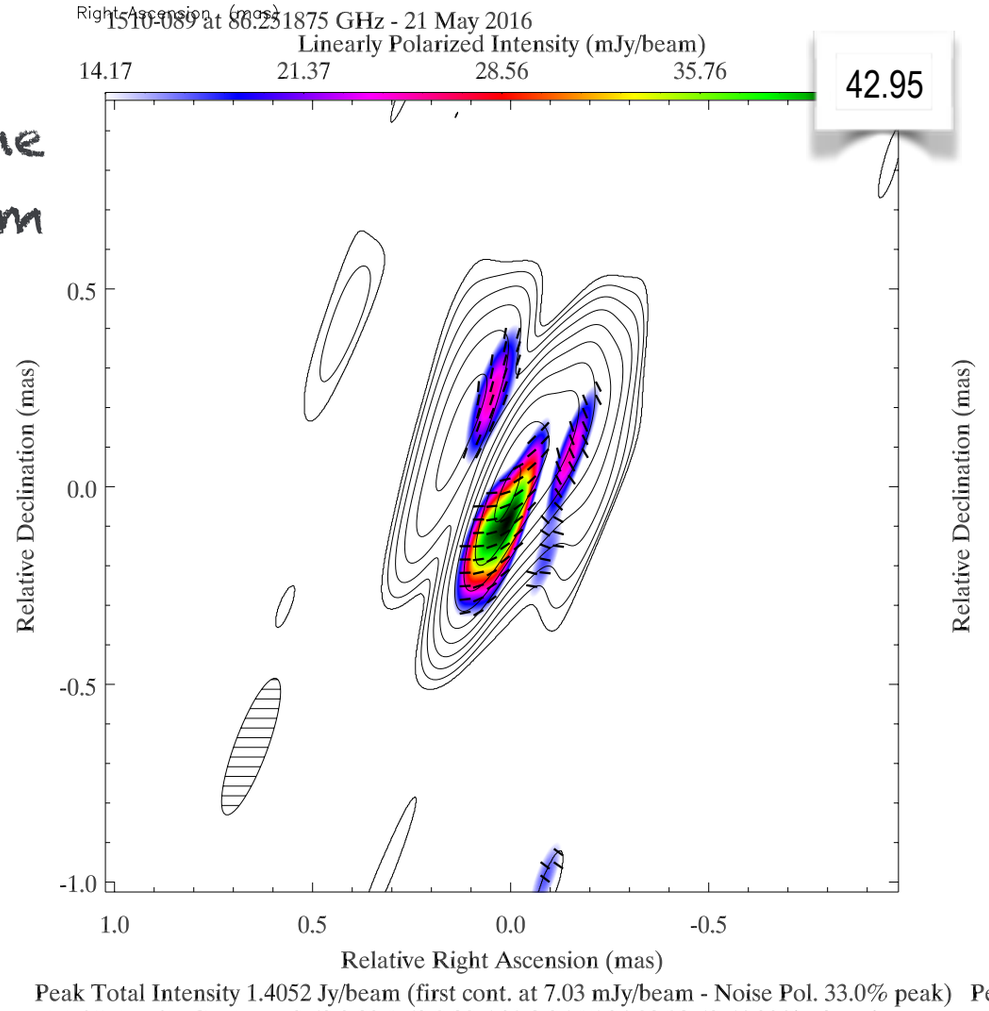
Average vs. Proper D-terms: the unlucky case of 1510-089



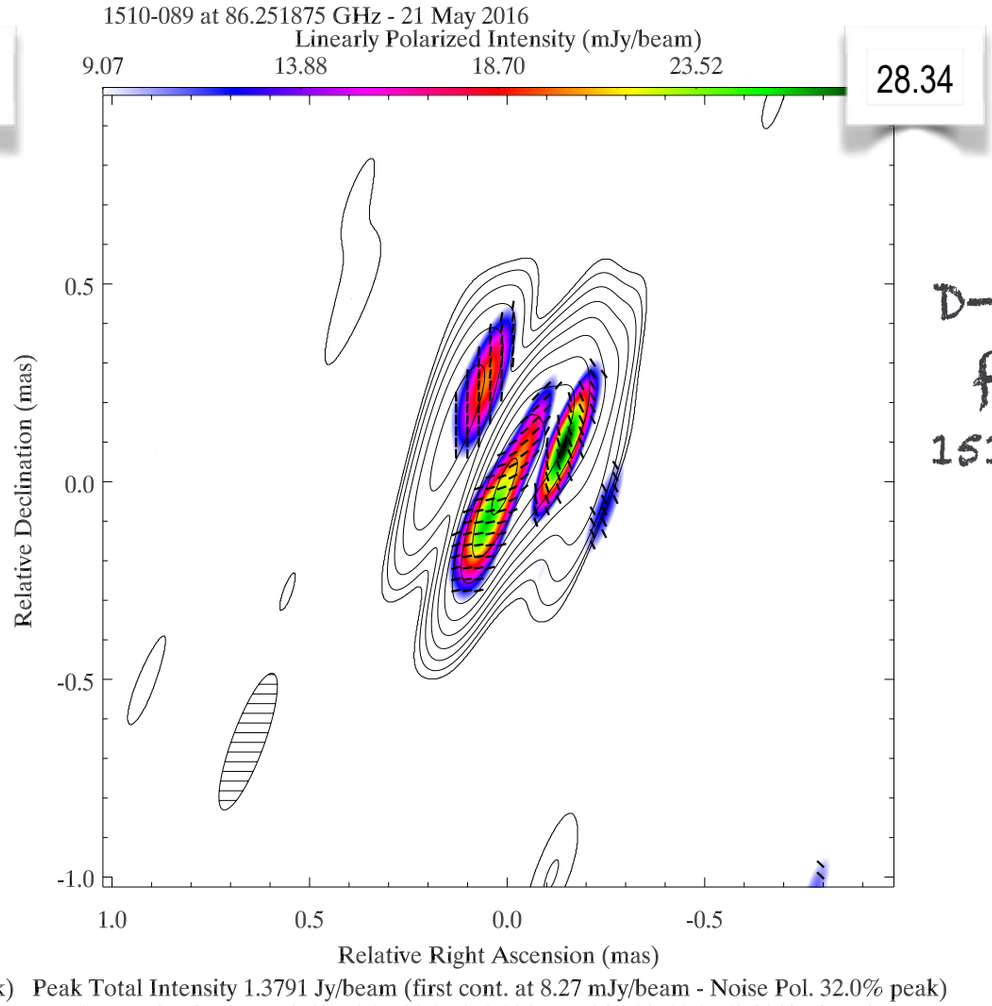
Ant.		#Vis.	Parallel	Cross-hand (Jy)	PA range (deg)
BR	1	1188	0.221	0.221	35.0
FD	3	3203	0.243	0.194	70.0
KP	4	3141	0.367	0.272	65.6
LA	8	3342	0.206	0.179	61.2
MK	10	2547	0.248	0.224	25.7
NL	11	3082	0.440	0.405	52.0
OV	13	3391	0.271	0.245	54.8
PT	14	3058	0.317	0.312	63.0

Averaging the D-terms from

3C 111
3C 120
3C 273
3C 345
3C 454.3
0716+714
0954+658
1510-089
1633+382
BLLAC
CTA102
OJ287



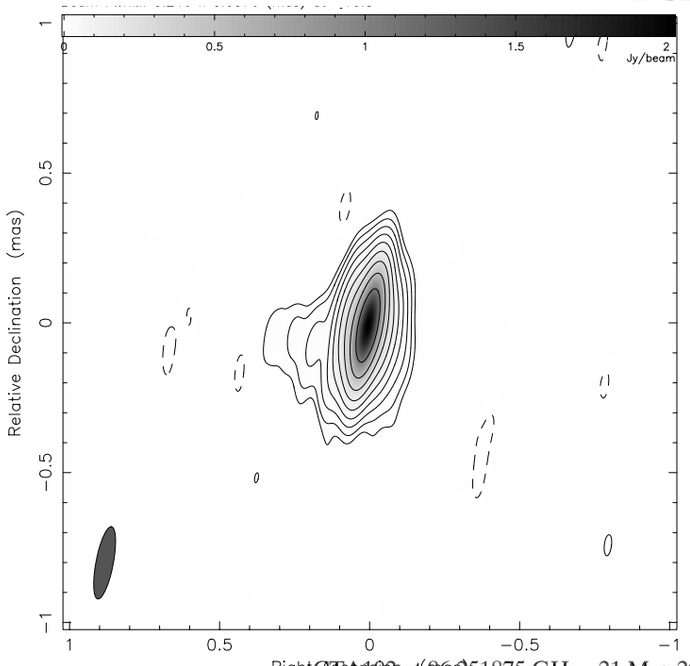
Peak Total Intensity 1.4052 Jy/beam (first cont. at 7.03 mJy/beam - Noise Pol. 33.0% peak)
Total Intensity Contours 0.50,0.89,1.59,2.82,5.03,8.95,15.94,28.38,50.54,90% of peak
Beam FWHM 0.37x0.08 mas at -20.30 deg.



Peak Total Intensity 1.3791 Jy/beam (first cont. at 8.27 mJy/beam - Noise Pol. 32.0% peak)
Total Intensity Contours 0.60,1.05,1.83,3.19,5.56,9.71,16.94,29.56,51.58,90% of peak
Beam FWHM 0.37x0.08 mas at -20.20 deg.

D-terms from 1510-089

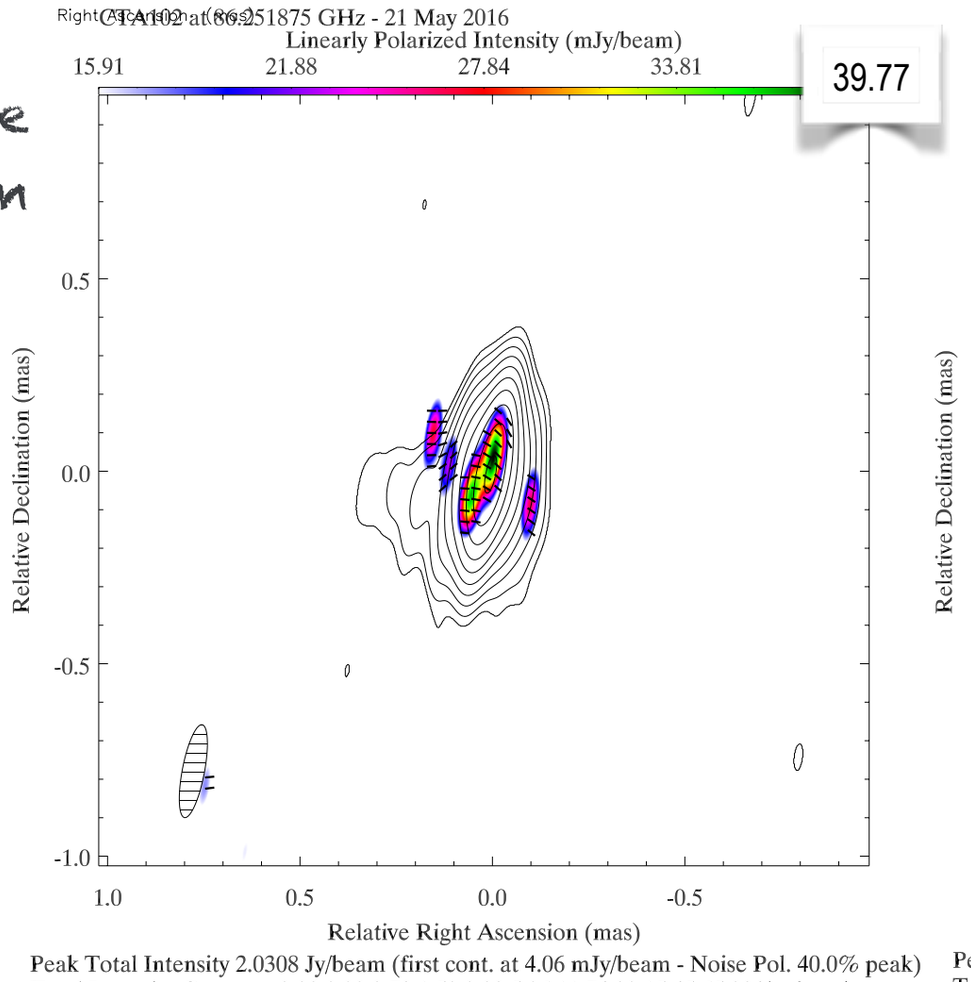
Average vs. Proper D-terms: the unlucky case of CTA 102



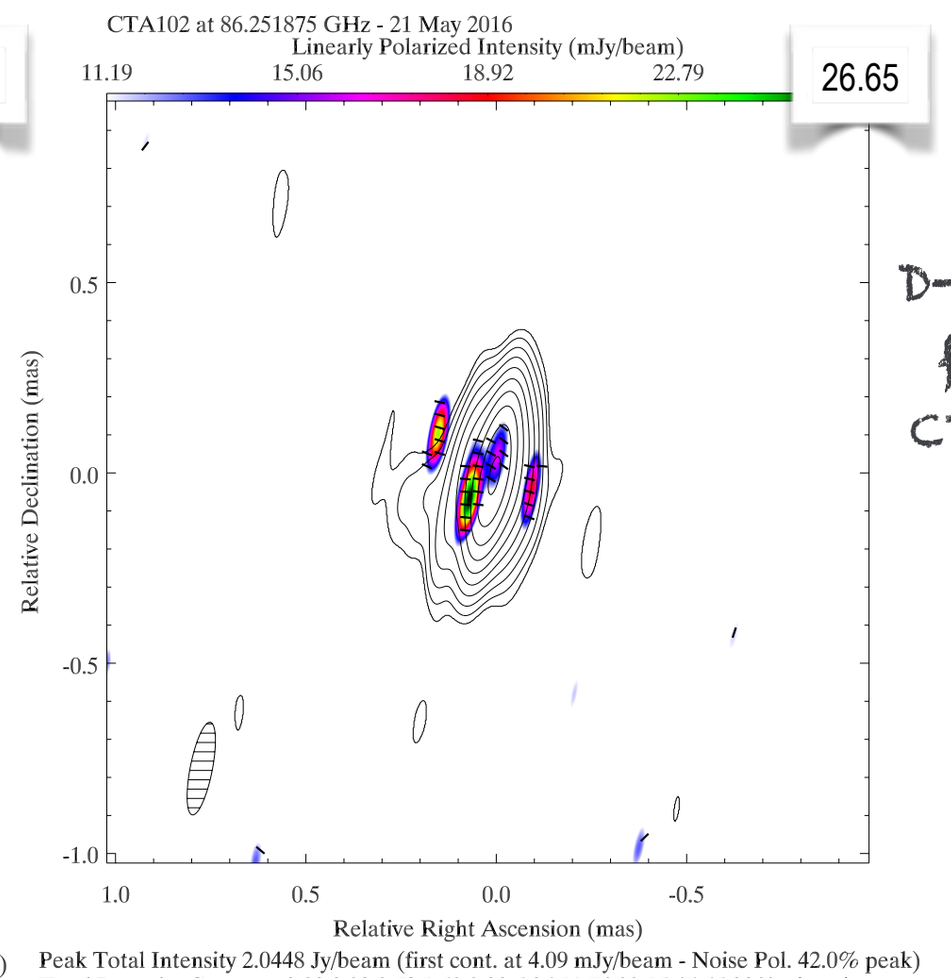
Ant.	#Vis.	Parallel	Cross-hand (Jy)	PA range (deg)
BR	1	7052	0.994	0.254	72.3
FD	3	7023	0.689	0.143	96.4
KP	4	7795	0.671	0.240	103.2
KT	5	1413	1.290	0.078	4.4
KU	6	1595	2.194	0.040	6.2
LA	8	7062	0.817	0.155	86.6
MK	10	7996	0.542	0.132	146.5
NL	11	5595	0.511	0.466	53.7
OV	13	7685	0.854	0.097	95.9
PT	14	7618	1.017	0.424	93.0

Averaging the D-terms from

3C 111
3C 120
3C 273
3C 345
3C 454.3
0716+714
0954+658
1510-089
1633+382
BLLAC
CTA102
0J287



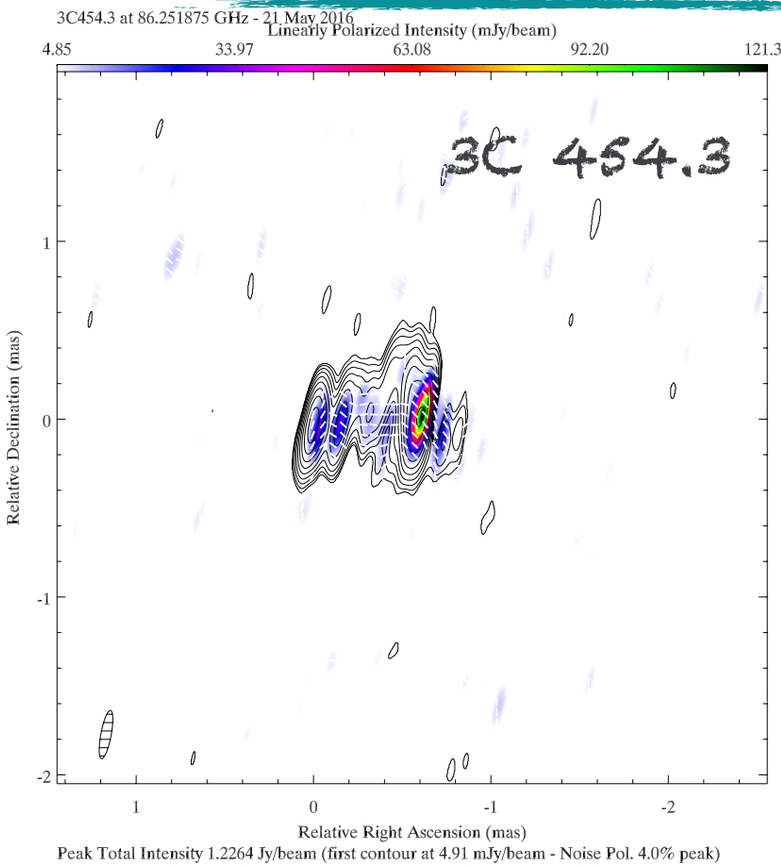
Peak Total Intensity 2.0308 Jy/beam (first cont. at 4.06 mJy/beam - Noise Pol. 40.0% peak)
Total Intensity Contours 0.20,0.39,0.78,1.53,3.02,5.96,11.74,23.15,45.65,90% of peak
Beam FWHM 0.25x0.06 mas at -10.79 deg.



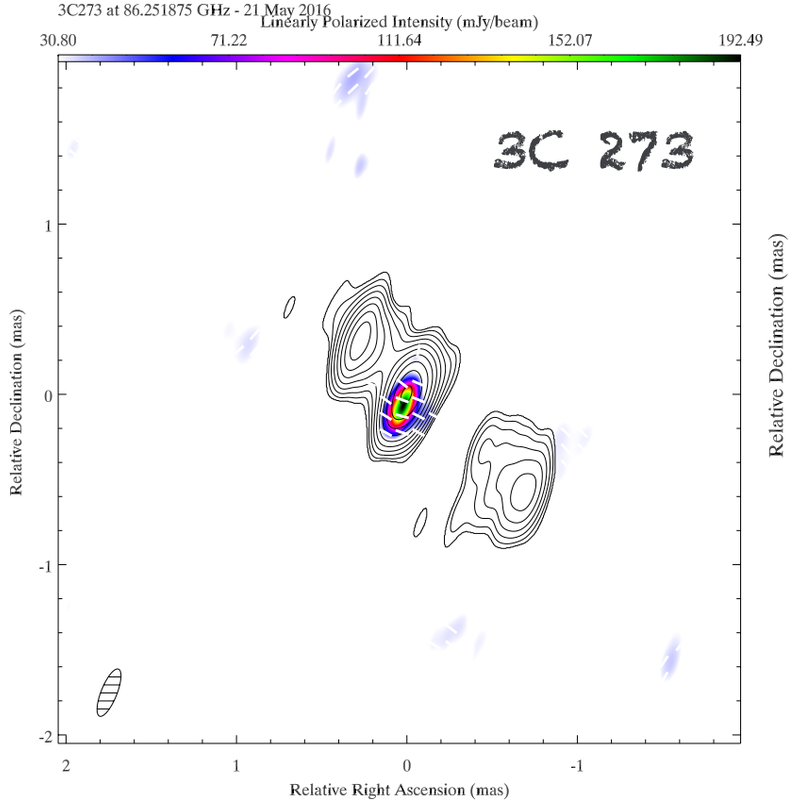
Peak Total Intensity 2.0448 Jy/beam (first cont. at 4.09 mJy/beam - Noise Pol. 42.0% peak)
Total Intensity Contours 0.20,0.39,0.78,1.53,3.02,5.96,11.74,23.15,45.65,90% of peak
Beam FWHM 0.25x0.06 mas at -11.08 deg.

D-terms from CTA 102

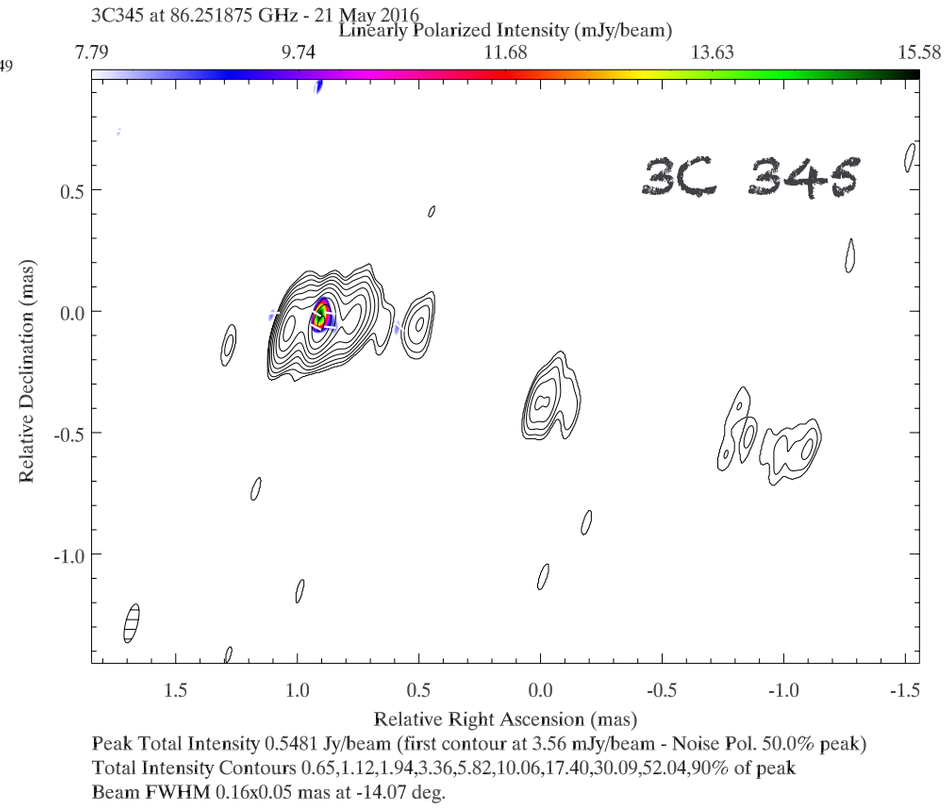
GMVA polarised and total intensity images



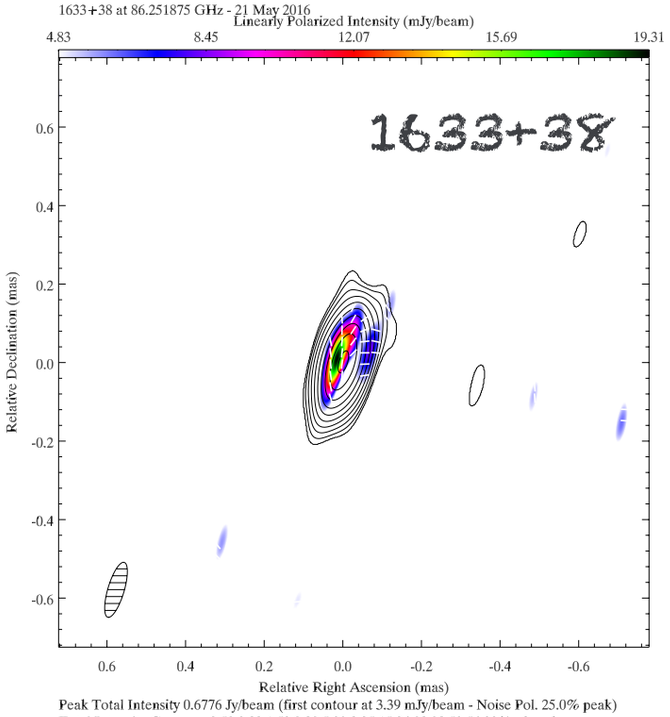
Peak Total Intensity 1.2264 Jy/beam (first contour at 4.91 mJy/beam - Noise Pol. 4.0% peak)
Total Intensity Contours 0.40,0.73,1.33,2.43,4.44,8.11,14.80,27.01,49.30,90% of peak
Beam FWHM 0.28x0.06 mas at -10.67 deg.



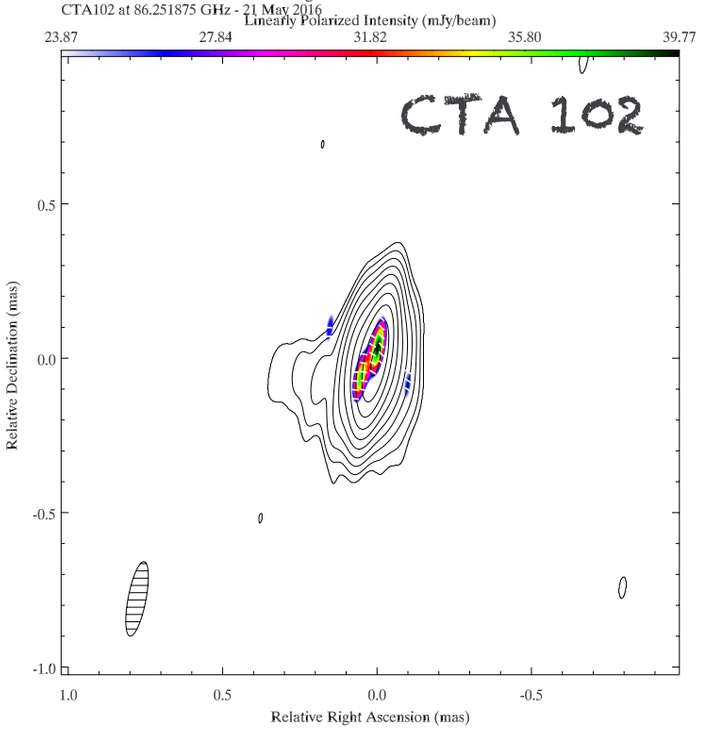
Peak Total Intensity 2.9360 Jy/beam (first contour at 11.74 mJy/beam - Noise Pol. 16.0% peak)
Total Intensity Contours 0.40,0.73,1.33,2.43,4.44,8.11,14.80,27.01,49.31,90% of peak
Beam FWHM 0.30x0.09 mas at -21.90 deg.



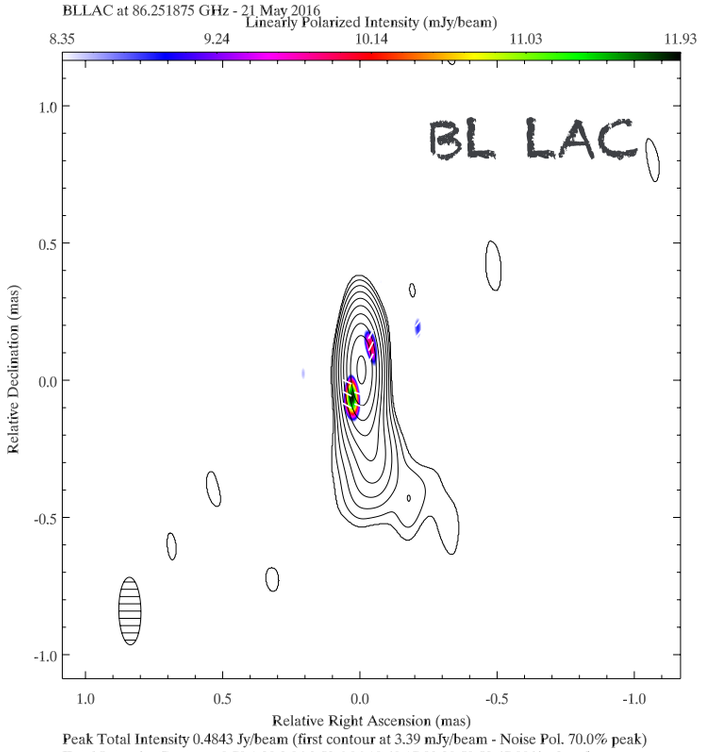
Peak Total Intensity 0.5481 Jy/beam (first contour at 3.56 mJy/beam - Noise Pol. 50.0% peak)
Total Intensity Contours 0.65,1.12,1.94,3.36,5.82,10.06,17.40,30.09,52.04,90% of peak
Beam FWHM 0.16x0.05 mas at -14.07 deg.



Peak Total Intensity 0.6776 Jy/beam (first contour at 3.39 mJy/beam - Noise Pol. 25.0% peak)
Total Intensity Contours 0.50,0.89,1.59,2.82,5.03,8.95,15.94,28.38,50.54,90% of peak
Beam FWHM 0.15x0.04 mas at -16.65 deg.

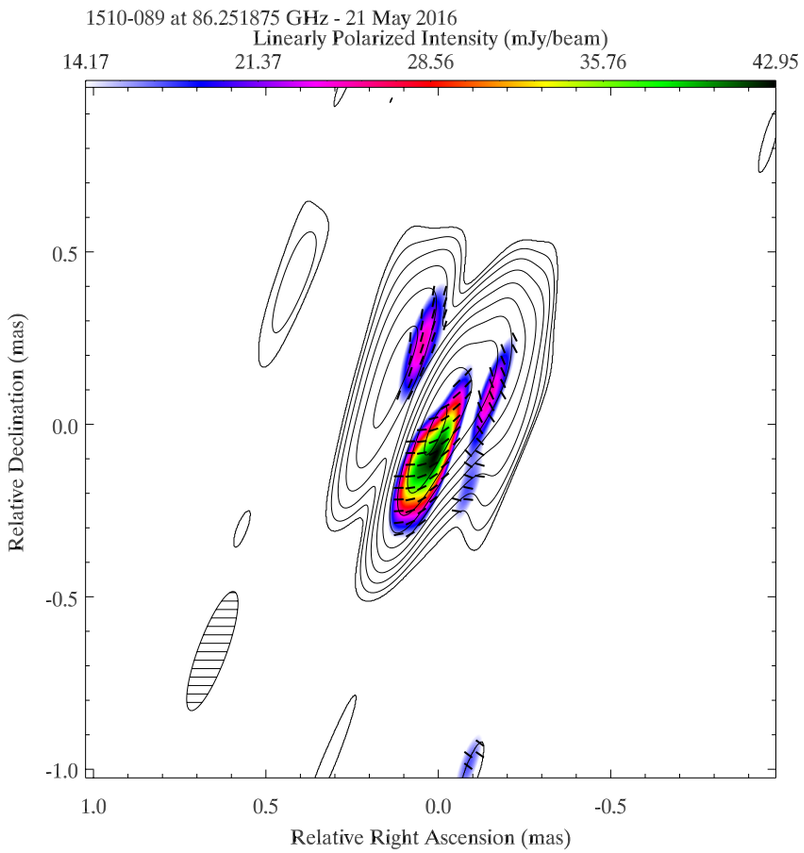


Peak Total Intensity 2.0308 Jy/beam (first contour at 4.06 mJy/beam - Noise Pol. 60.0% peak)
Total Intensity Contours 0.20,0.39,0.78,1.53,3.02,5.96,11.74,23.15,45.65,90% of peak
Beam FWHM 0.25x0.06 mas at -10.79 deg.

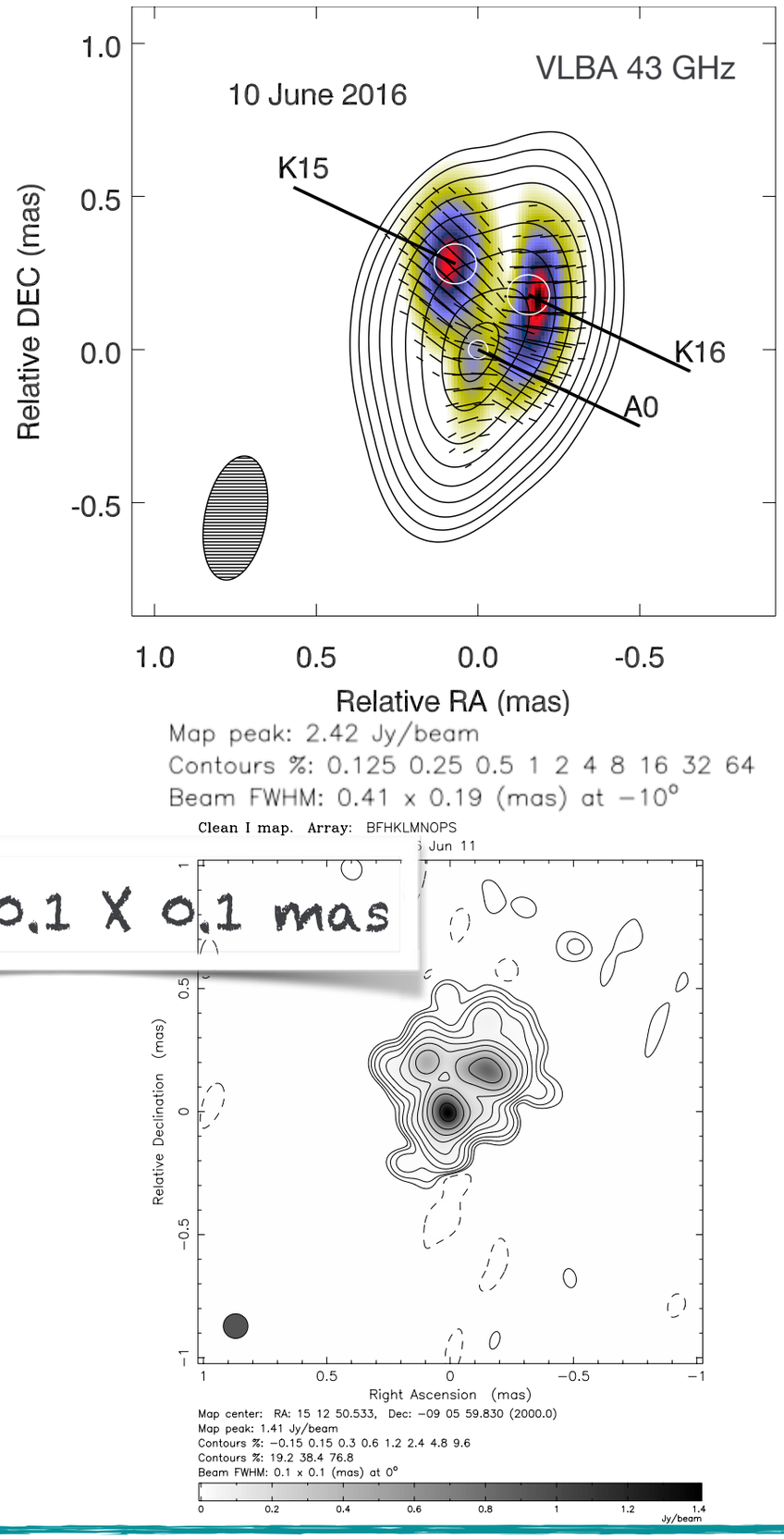


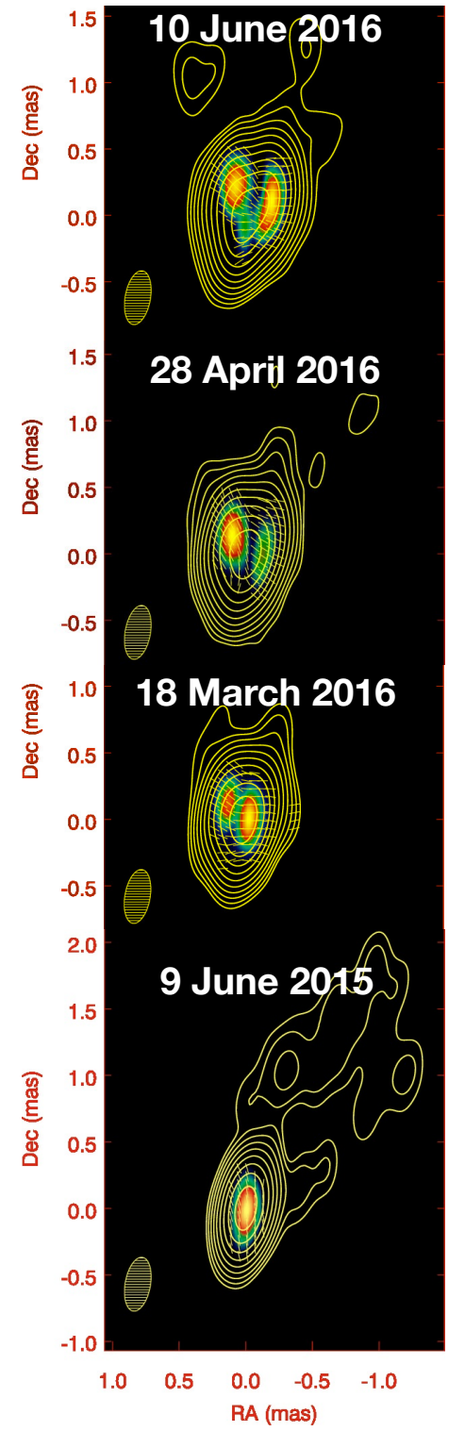
Peak Total Intensity 0.4843 Jy/beam (first contour at 3.39 mJy/beam - Noise Pol. 70.0% peak)
Total Intensity Contours 0.70,1.20,2.06,3.53,6.06,10.40,17.83,30.59,52.47,90% of peak
Beam FWHM 0.25x0.08 mas at 0.96 deg.

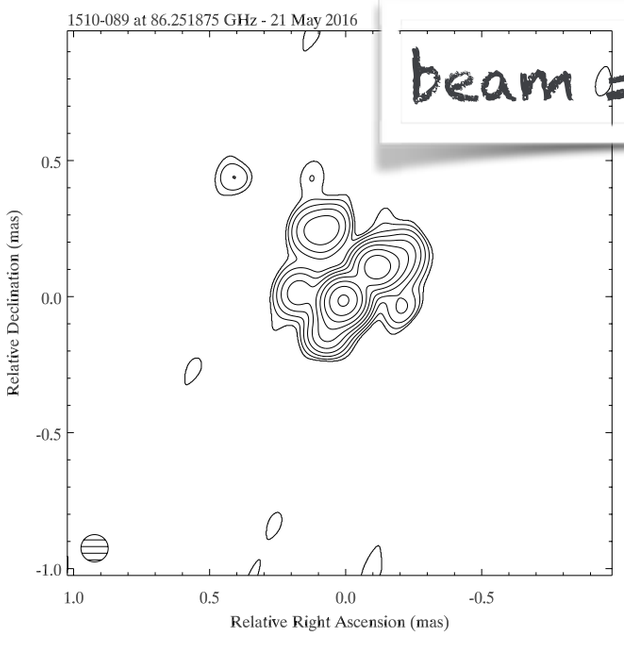
86 GHz GMVA / 43 GHz VLBA - 1510-089



Peak Total Intensity 1.4052 Jy/beam (first cont. at 7.03 mJy/beam - Noise Pol. 33.0% peak)
Total Intensity Contours 0.50,0.89,1.59,2.82,5.03,8.95,15.94,28.38,50.54,90% of peak
Beam FWHM 0.37x0.08 mas at -20.30 deg.



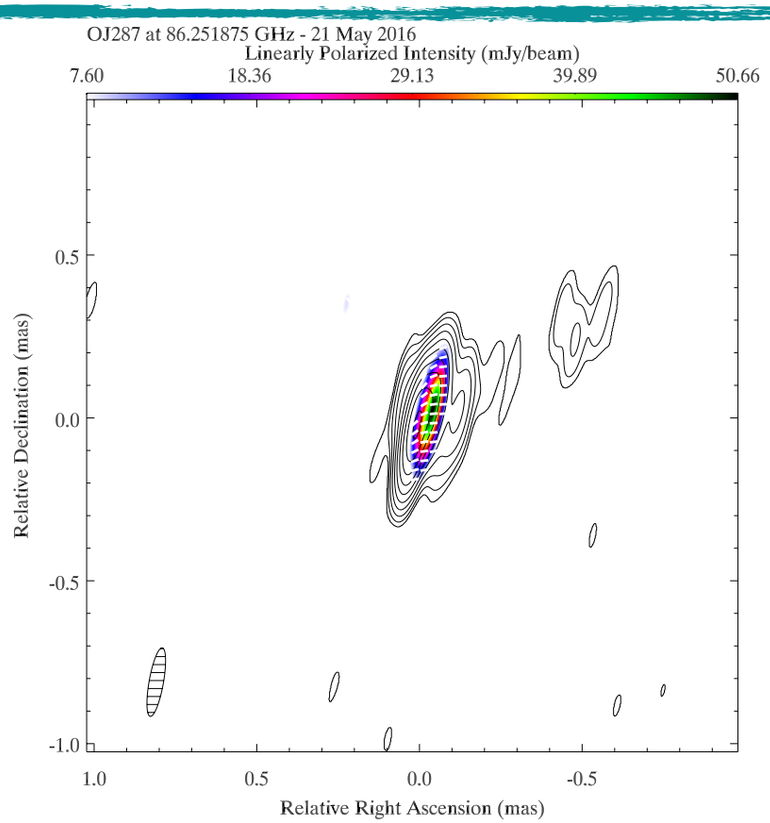




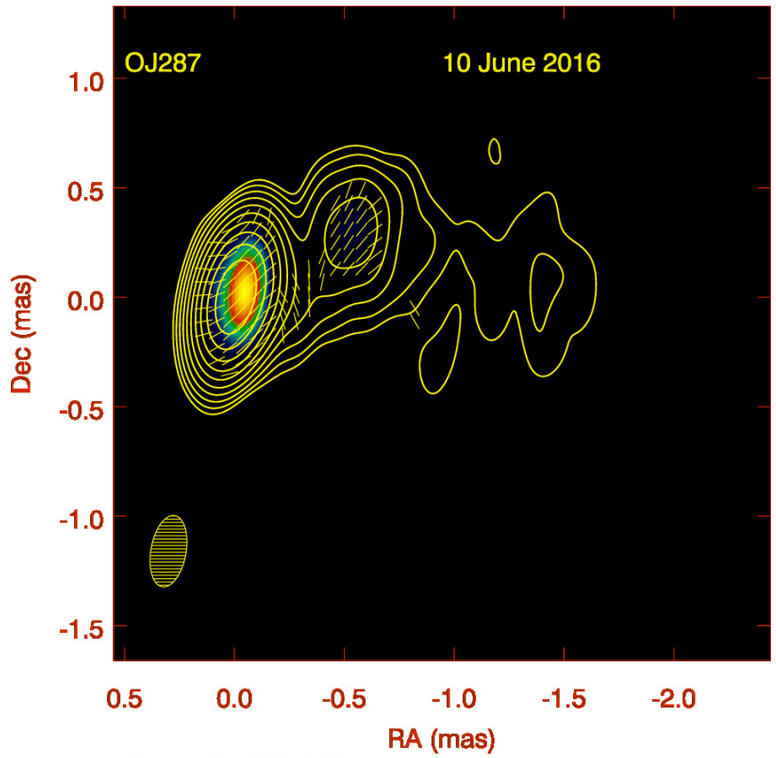
beam = 0.1 X 0.1 mas

VLBA 43 GHz

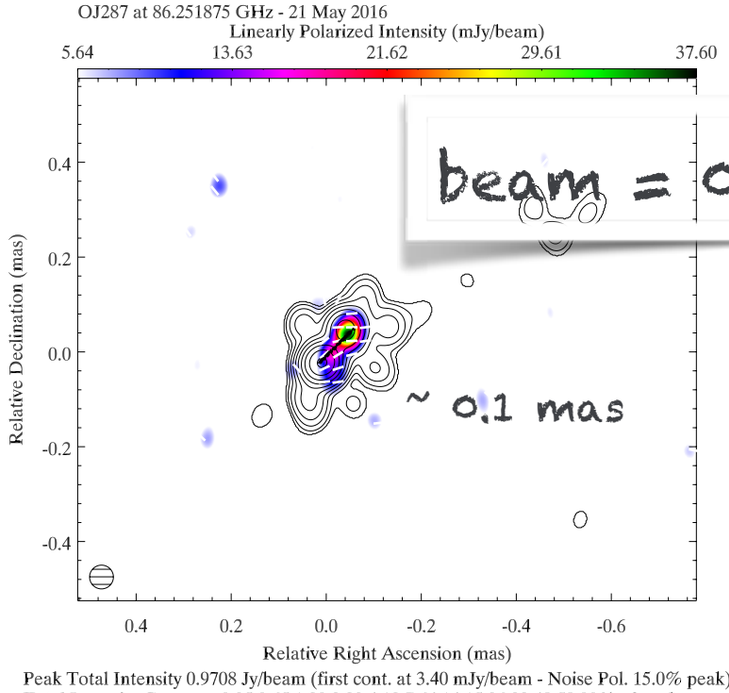
86 GHz GMVA / 43 GHz VLBA - OJ 287



Peak Total Intensity 1.0944 Jy/beam (first cont. at 3.83 mJy/beam - Noise Pol. 15.0% peak)
Total Intensity Contours 0.35,0.65,1.20,2.23,4.12,7.64,14.15,26.22,48.58,90% of peak
Beam FWHM 0.21x0.04 mas at -10.06 deg.

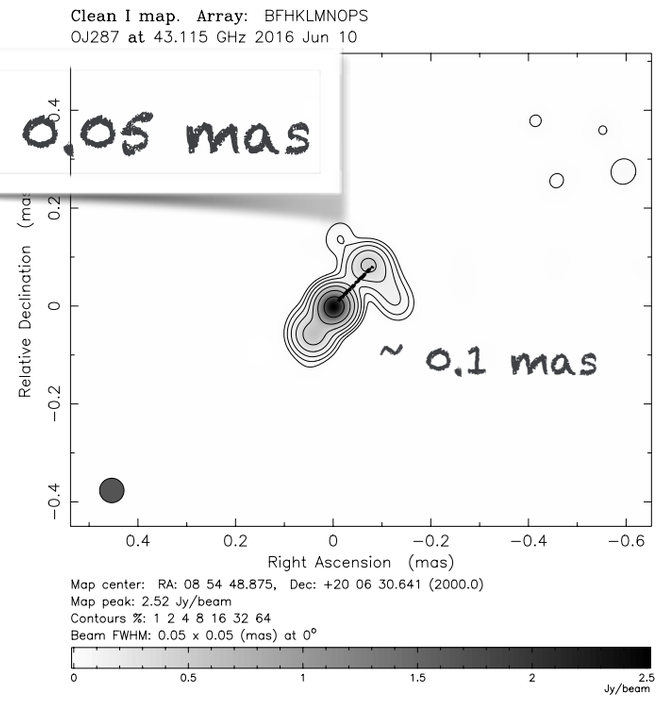


Map peak: 3.7 Jy/beam
Contours %: −0.0625 0.0625 0.125 0.25 0.5 1 2 4 8
Contours %: 16 32 64
Beam FWHM: 0.33 x 0.16 (mas) at −10°



Peak Total Intensity 0.9708 Jy/beam (first cont. at 3.40 mJy/beam - Noise Pol. 15.0% peak)
Total Intensity Contours 0.35,0.65,1.20,2.23,4.12,7.64,14.15,26.22,48.58,90% of peak
Beam FWHM 0.05x0.05 mas at 0.00 deg.

beam = 0.05 X 0.05 mas



Conclusions

We present the most complete sample, so far, of polarised images at the highest possible resolution;

3mm GMVA observations are a powerful tool to investigate the central region of distant blazars and radiogalaxies: the reduced opacity at 3mm and improved angular resolution (~ 50 μarcseconds) allow us to distinguish features not visible in VLBA 43 GHz observations (e.g., 1510-089 and OJ287)

Calibration of instrumental polarisation

The D-terms of a source are well defined only in case of good coverage of the parallactic angle (PA) for all the antennas;

If the coverage of the PA is not good enough, the morphology of the polarised emission can vary and, in general, the polarised flux is lower;

Applying the D-terms obtained from the average of all the sources is a more stable method that gives more reliable polarised maps and also permits us to investigate the stability of the D-terms at 86 GHz (GMVA) among epochs.

Thanks!