PROBING KINEMATICS OF AGN JETS WITH OPACITY EFFECTS

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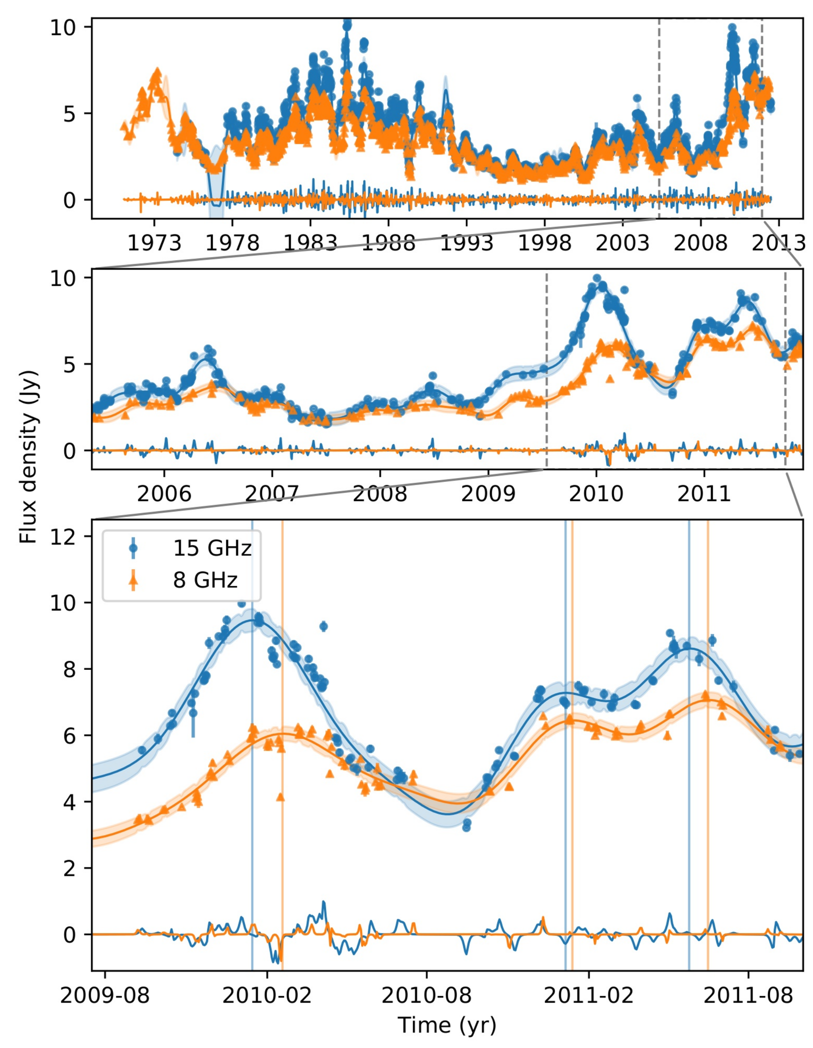
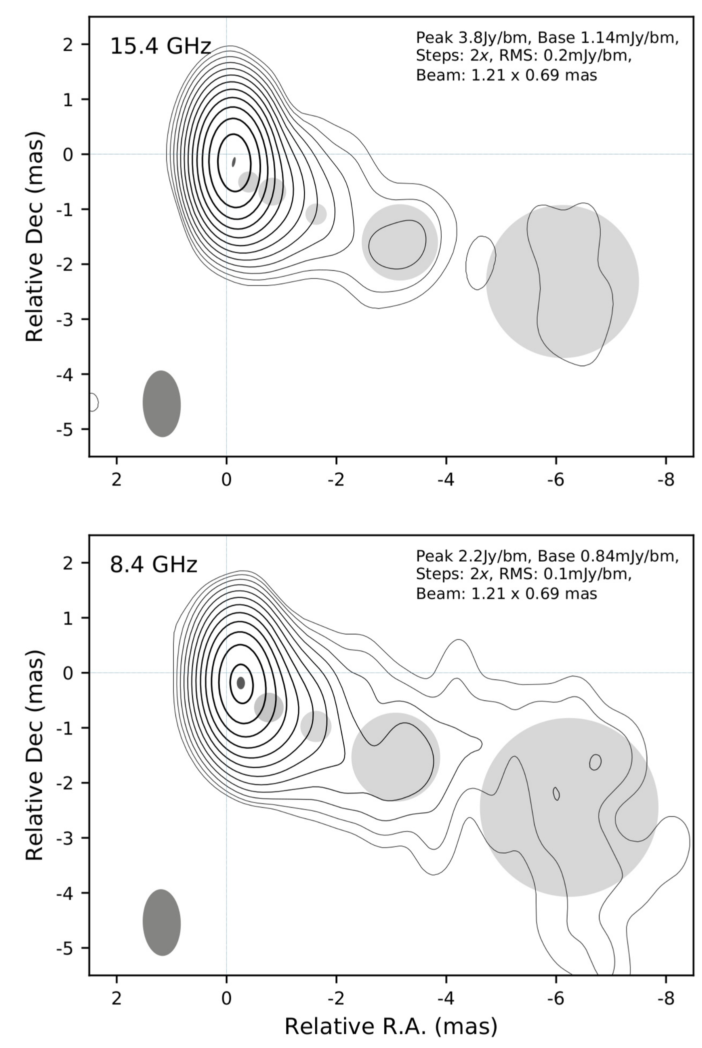
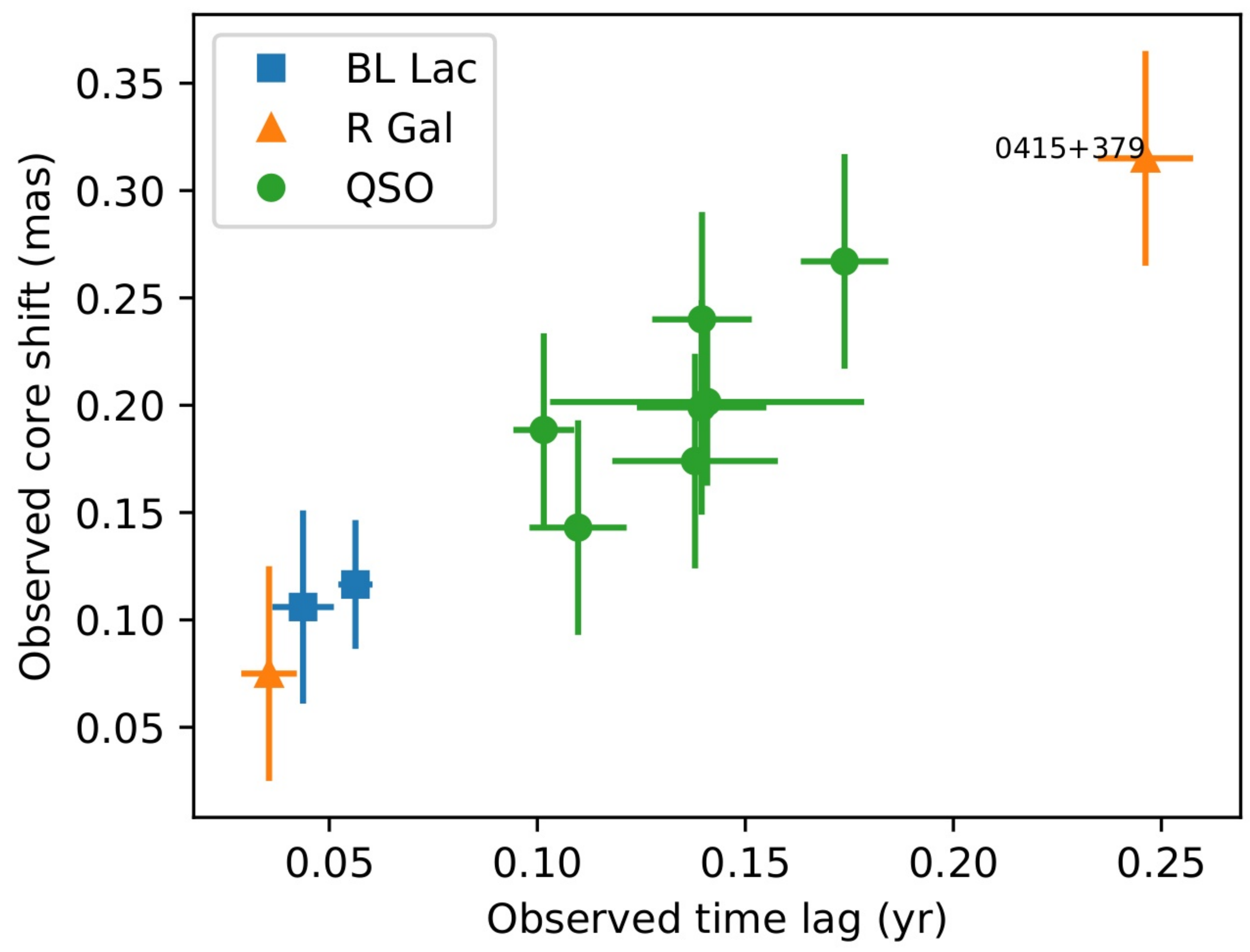
We report a strong correlation between the observed VLBI core shift and total flux density flares time delay at 15/8 GHz in 11 AGN. Our estimates of plasma flow speed in the jets are comparable with the apparent velocities of the fastest VLBI components. The results imply an acceleration of the jets with bulk motion Lorentz factor $\Gamma \propto R^{0.52\pm0.03}$ on de-projected scales R of 0.5−500 parsecs.

The data at 15 and 8 GHz includes the total flux density single dish observations at UMRAO, VLBA observations, and core shift measurements from literature. The total flux density light curves are fitted with Gaussian process regression to locate the peaks and obtain the time scales. The core shift measurements are performed using Difmap.





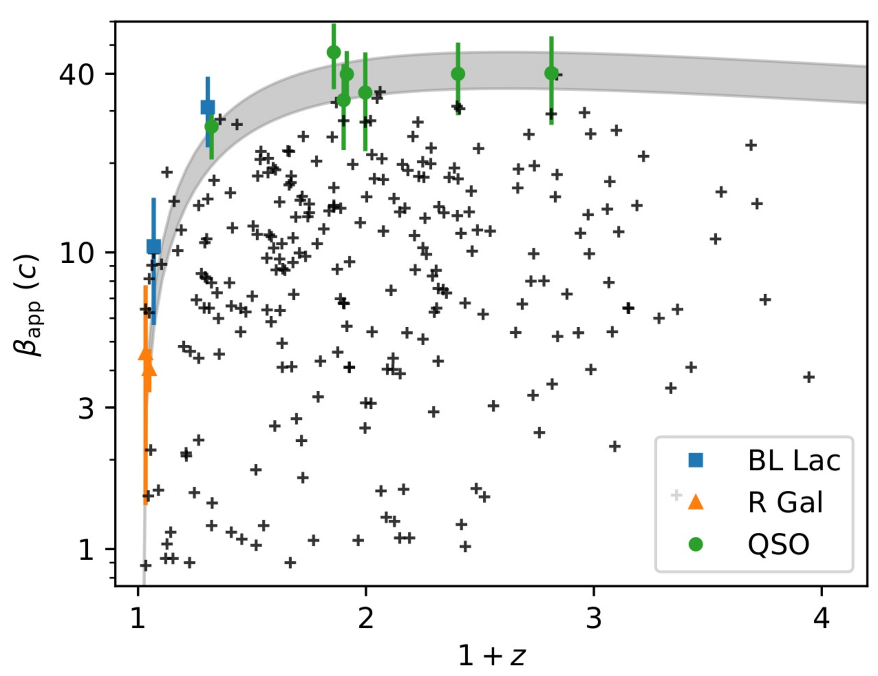


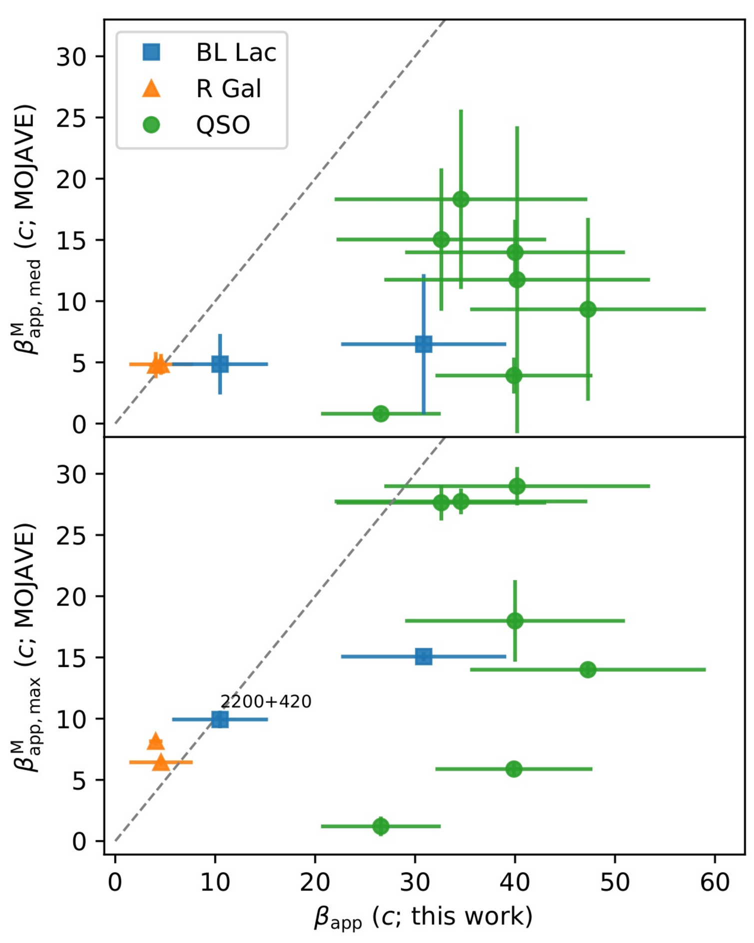
The observed core shifts and time delays do correlate with the slope of 1.5±0.1 mas/yr. This relation is used to estimate apparent speed and proper motion of the plasma in the jets. The estimates are consistent with the upper envelope of the highest apparent velocities measured by MOJAVE.

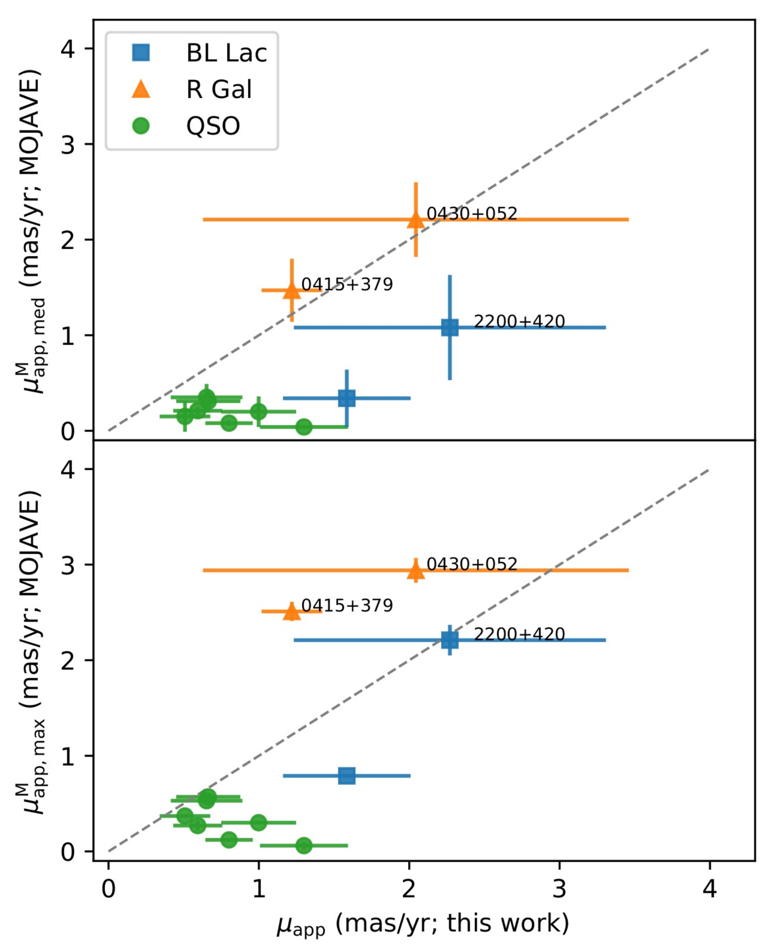
Source (1)	Name (2)	N (3)	$\Delta r_{\rm ang}$ mas (4)	Δt days (5)	$\mu_{\rm app}$ mas/yr (6)	$\beta_{\rm app}$ c (7)	τ days (8)	δ (9)	Γ (10)	θ deg (11)	R_{15} pc (12)	R_8 pc (13)
0415+379	3C 111	5	0.315	89.9 ± 4.2	1.2 ± 0.2	4.0 ± 0.7	46.2	5.3	4.3	10.5	1.9	3.6
0420−014		8	0.267	63.5 ± 3.8	0.8 ± 0.2	39.9 ± 7.8	47.9	70.2	46.4	0.7	198.7	372.6
0430+052	3C 120	7	0.075	13.0 ± 2.4	2.0 ± 1.4	4.6 ± 3.2	36.1	8.1	5.4	6.1	0.5	1.0
0607−157		7	0.240	50.9 ± 4.4	1.3 ± 0.3	26.6 ± 6.0	44.9	44.2	30.1	1.1	65.1	122.1
0851+202	OJ 287	18	0.116	20.5 ± 1.5	1.6 ± 0.4	30.9 ± 8.3	26.7	32.7	30.9	1.7	20.0	37.4
1308+326		8	0.143	40.1 ± 4.3	0.7 ± 0.2	34.6 ± 12.6	40.7	61.5	40.5	0.8	95.8	179.7
1633+382		3	0.201	51.4 ± 13.8	0.5 ± 0.2	40.2 ± 13.3	73.2	50.3	41.2	1.1	102.4	192.0
1730−130		3	0.174	50.3 ± 7.3	0.7 ± 0.2	32.6 ± 10.5	52.2	47.6	35.0	1.1	80.5	151.0
2200+420	BL Lac	13	0.106	15.9 ± 2.7	2.3 ± 1.0	10.5 ± 4.8	25.7	6.5	11.8	7.9	1.2	2.2
2223−052	3C 446	8	0.199	50.9 ± 5.7	0.6 ± 0.2	40.0 ± 11.0	54.7	80.8	50.3	0.6	198.8	372.8
2251+158	3C 454.3	9	0.189	37.1 ± 2.7	1.0 ± 0.2	47.3 ± 11.8	44.2	110.5	65.4	0.4	257.2	482.3

(1-2) source B1950 and alternative names; (3) number of cross-identified flares between 15 and 8 GHz; (4) mean 15-8 GHz core shift; (5) weighted averaged 15-8 GHz time delay; (6) apparent proper motion; (7) apparent speed in units of speed of light; (8) weighted averaged variability time scale of the flares at 15 GHz; (9) estimated Doppler factor; (10) estimated Lorentz factor; (11) estimated viewing angle; (12–13) de-projected distance from the jet base to the core at 15 and 8 GHz.

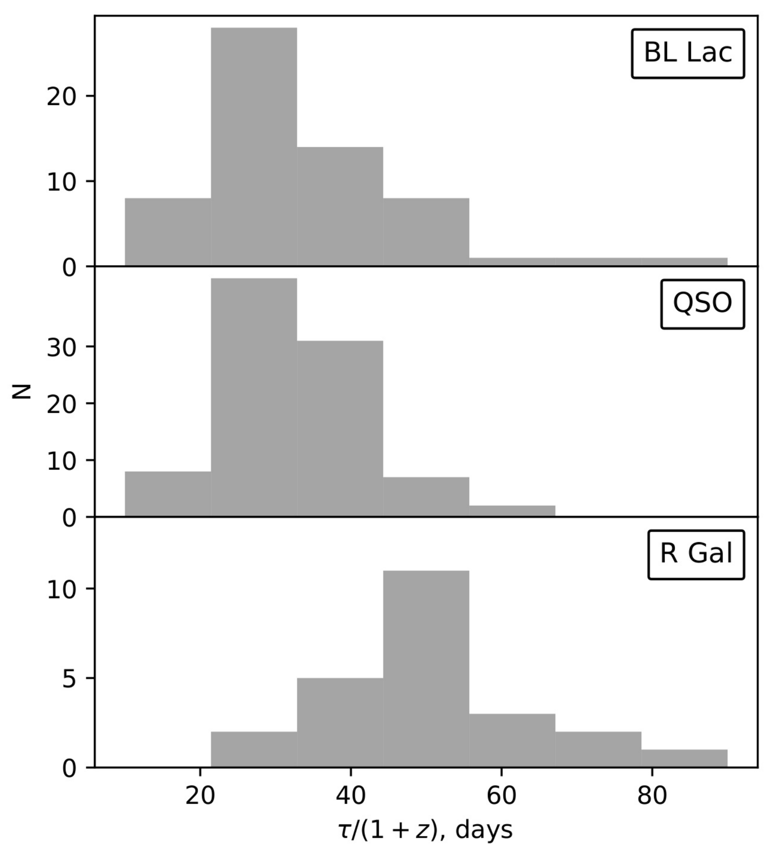
We estimate Doppler factors using the averaged variability time scale and the averaged core size for each source. Further we estimate viewing angles and Lorentz factors.

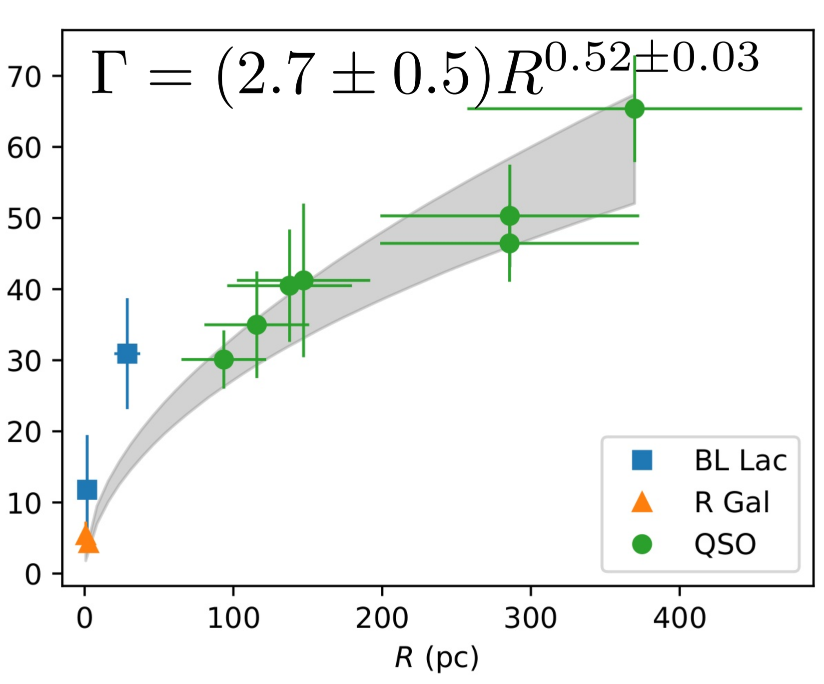


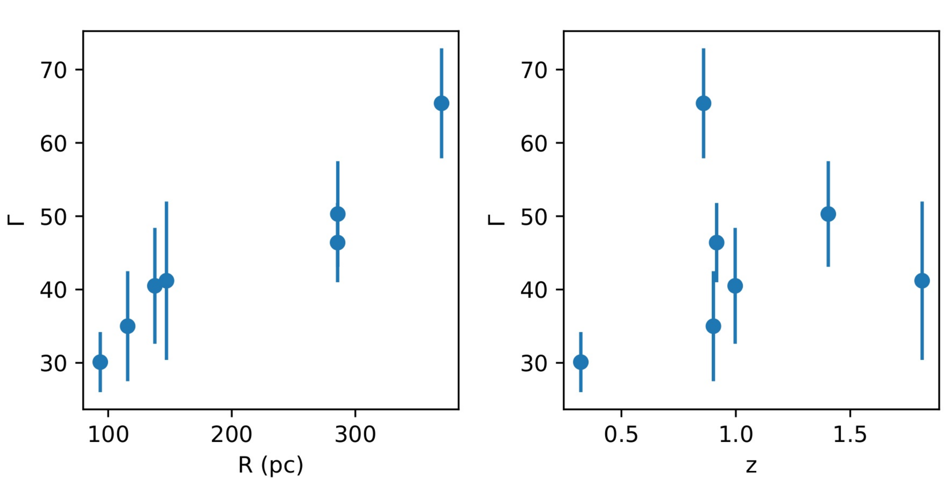




The variability timescale in radio galaxies is twice as long as that in quasars and BLLacs:







The de-projected core apex distance varies from 0.5 to 500 parsecs implying acceleration of the jets from Lorentz factors of ~few to 65. In an accelerating jet viewed at a given angle the Doppler factor changes and has maximum at some region.

The evidence for a common nature of the core shift and time delay in AGN is obtained. It provides a validation of the new method to probe the kinematics of AGN jets on sub-pc to kpc scales, based on measuring the opacity effects. Our sample contains the extremely variable AGN having Doppler factor maximized in the core region. We discuss the nature of stationary and moving VLBI components in accelerating jets. And more...

See ArXiv:1809.05536 for details.