

Multi-frequency VLBI and single-dish observations of the extremely variable TeV active galaxy IC 310

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PHYSICS

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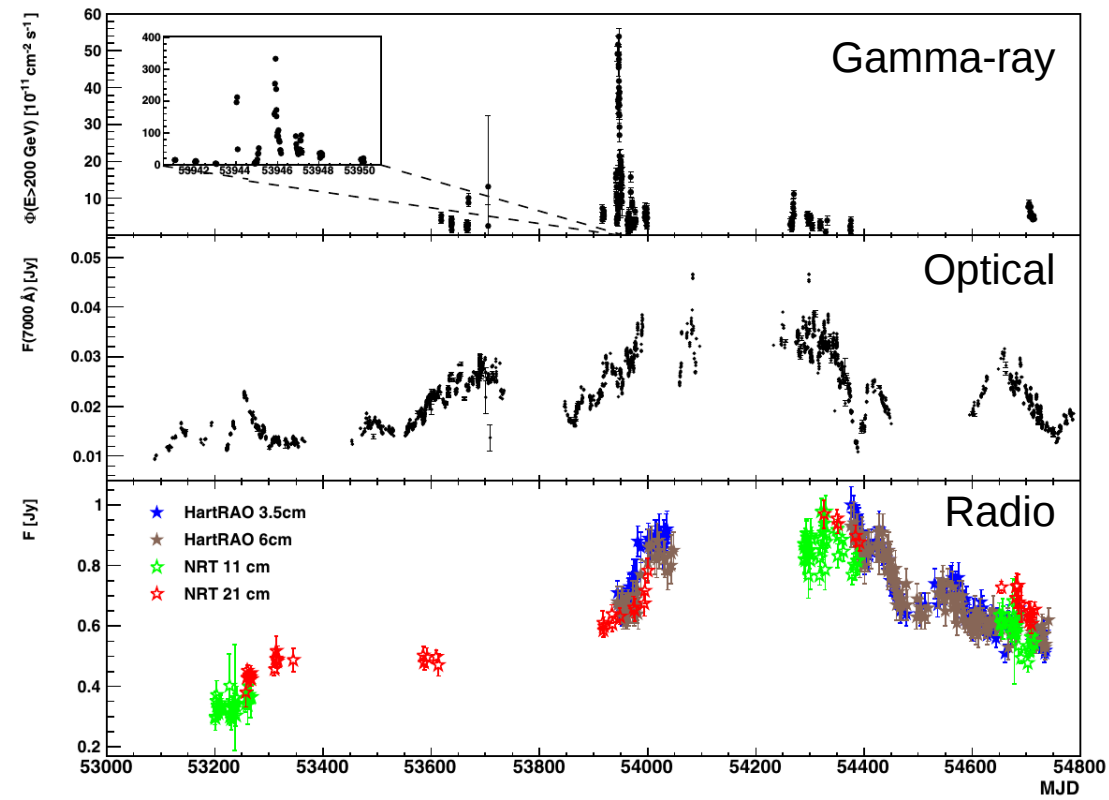
ASTRO WÜRZBURG

Gamma-ray emission of AGN

Majority of gamma-ray detected AGN are blazars
(e.g., Acero et al. 2015)

Strong radio-gamma-ray
connection

High-energy emission
usually related to the jet



PKS 2155-304, credit: H.E.S.S. Collaboration 2012, AJ

Radio classification under discussion

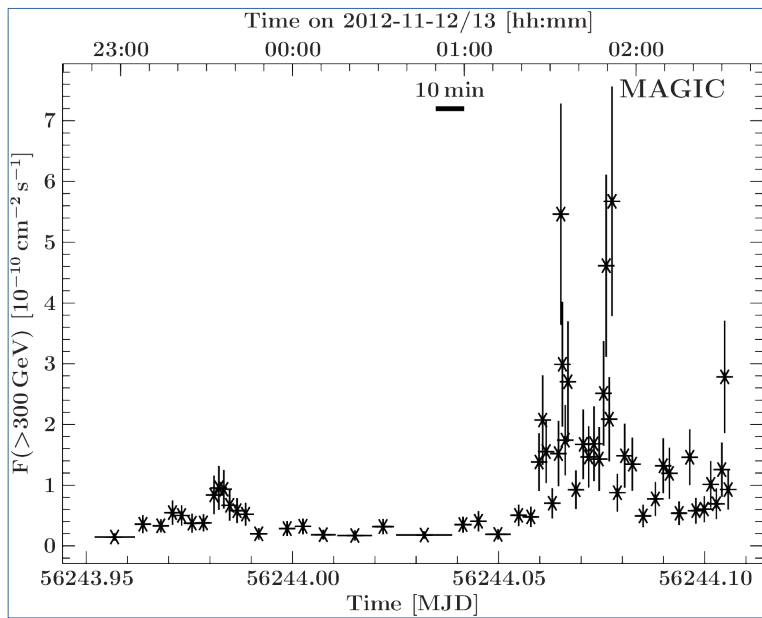
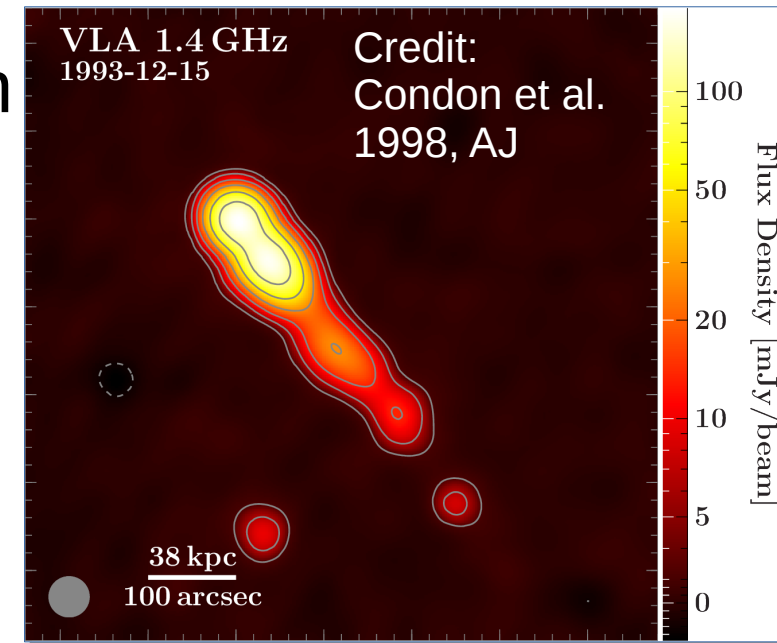
(e.g., Rhee et al. 1994, AJ; Sijbring et al. 1998, A&A; Sato et al. 2005, PASJ; Kadler et al. 2012, A&A)

Detected by Fermi/LAT and MAGIC

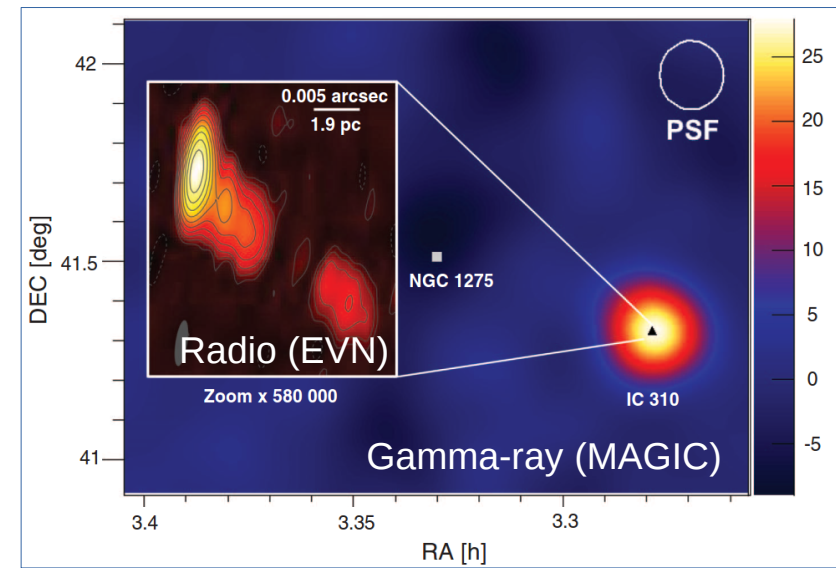
(Aleksic et al. 2010, ApJL; Aleksic et al. 2014, A&A)

Very high TeV-variability: ~ 4.8 min

(Aleksic et al. 2014, Sci)



Credit:
Aleksic et
al. 2014



Radio Campaign

VLBI observations:

EVN: quasi-simultaneous at 1.7, 5.0, 8.4 and 22.3 GHz

MOJAVE monitoring (Lister et al. 2016, AJ) at 15 GHz (VLBA)

Single-Dish observations

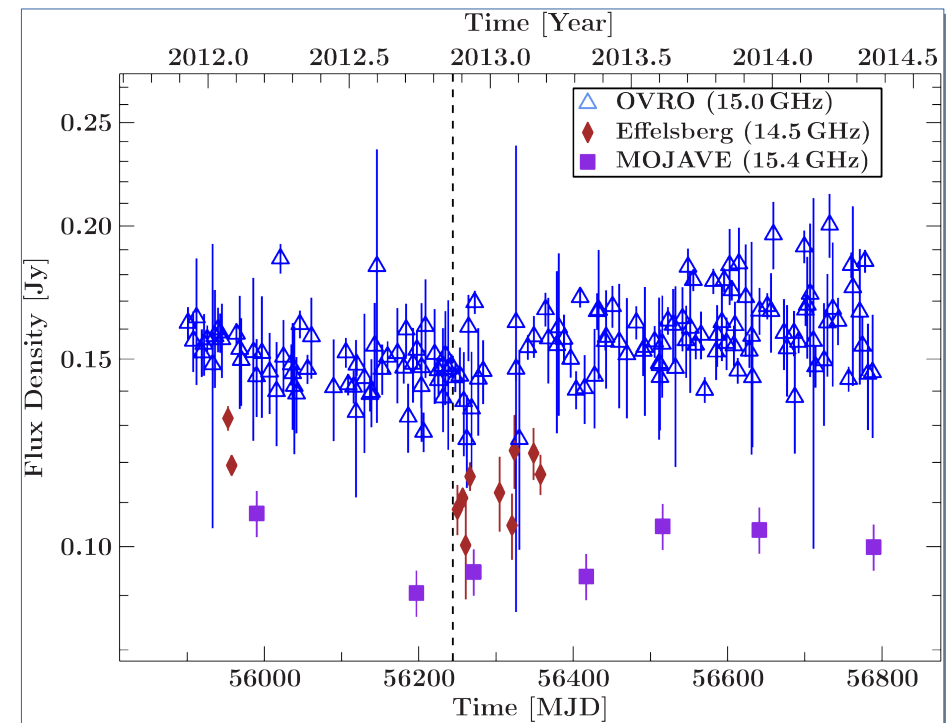
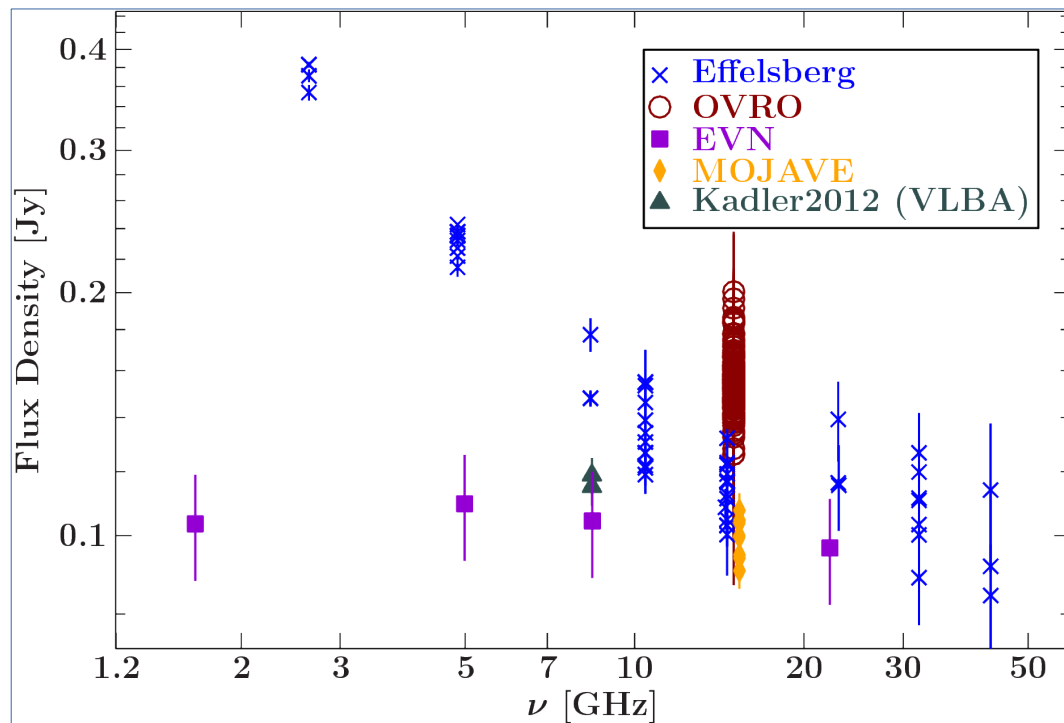
Effelsberg: 1.7 – 43 GHz

OVRO monitoring: 15 GHz

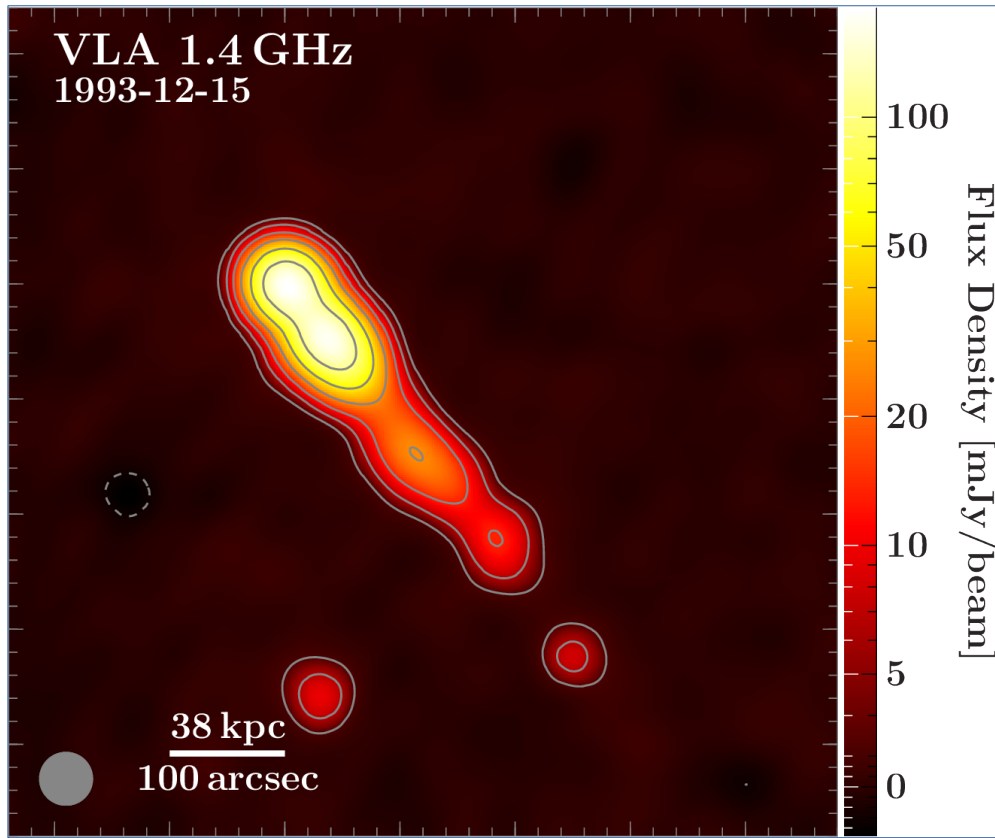
Radio Spectrum and Variability

Flat VLBI spectrum

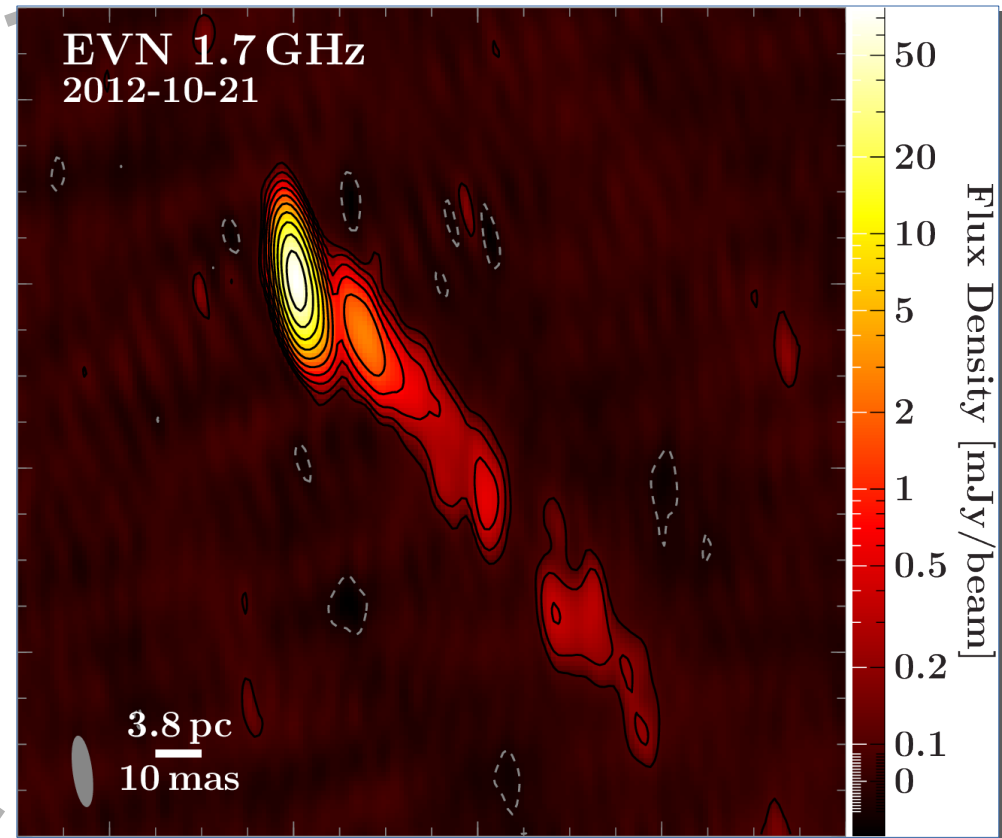
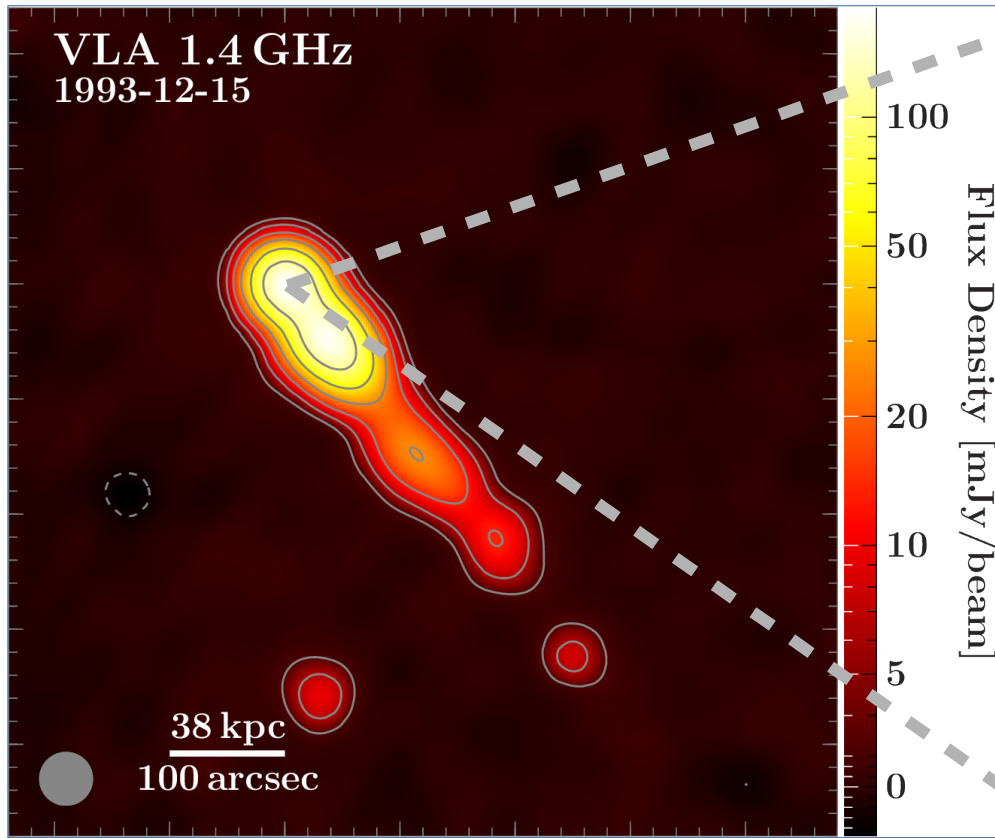
No significant variability



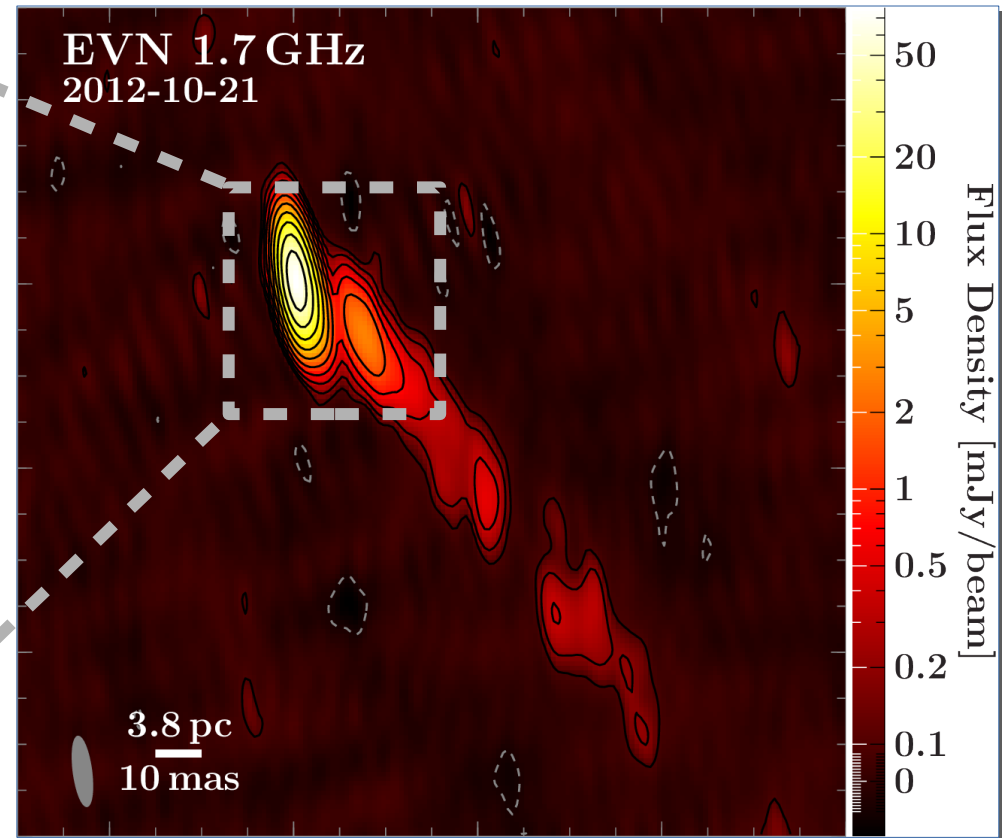
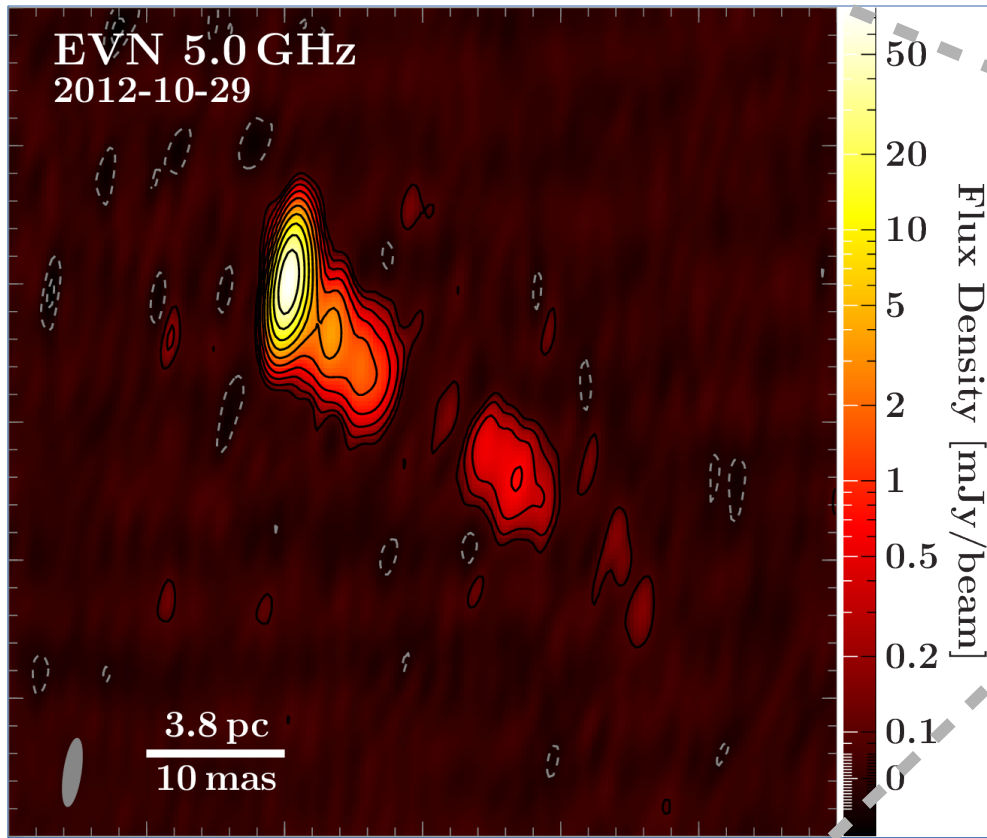
Zooming into IC 310



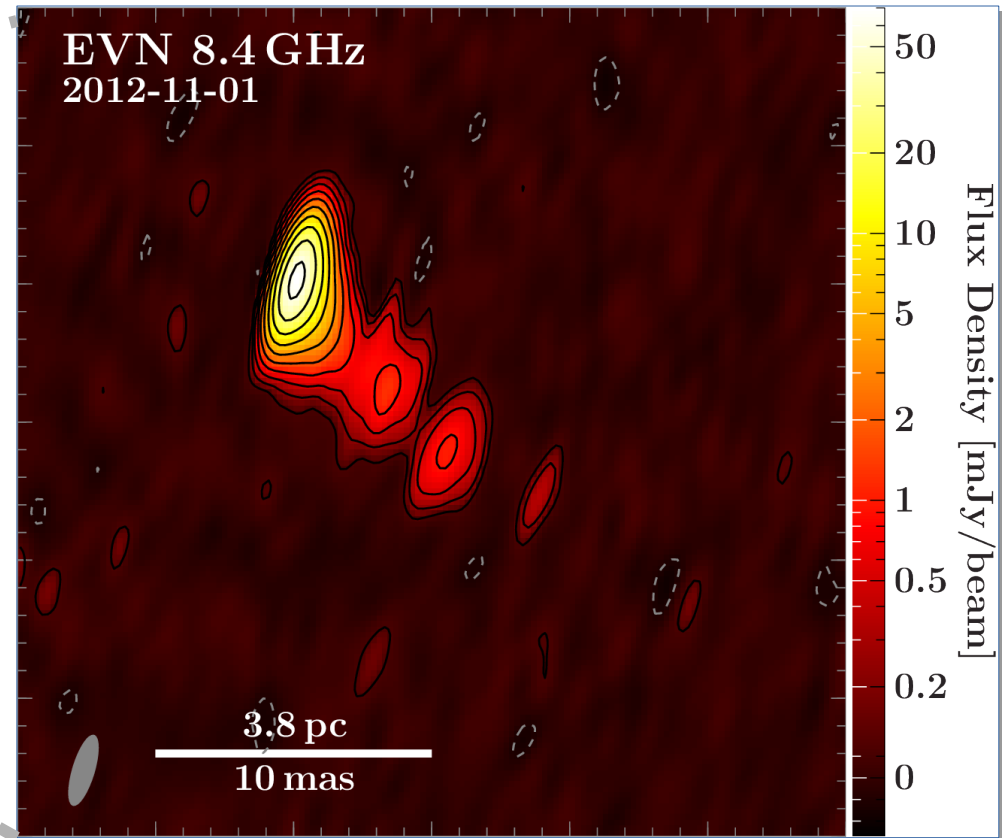
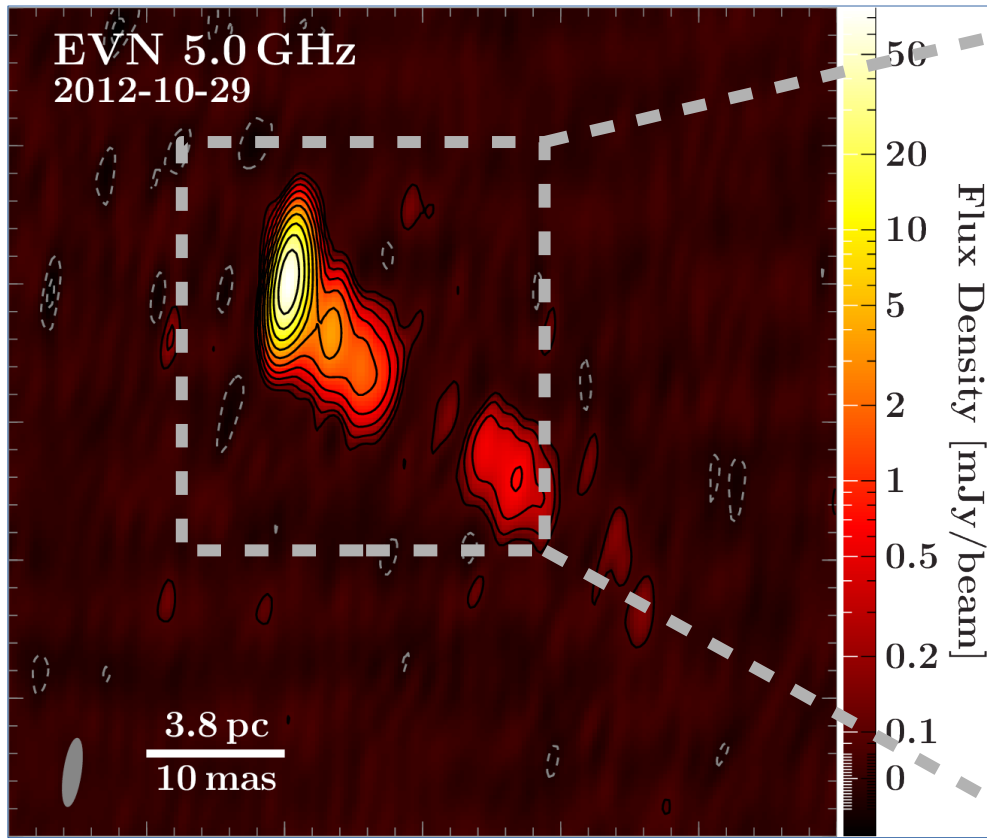
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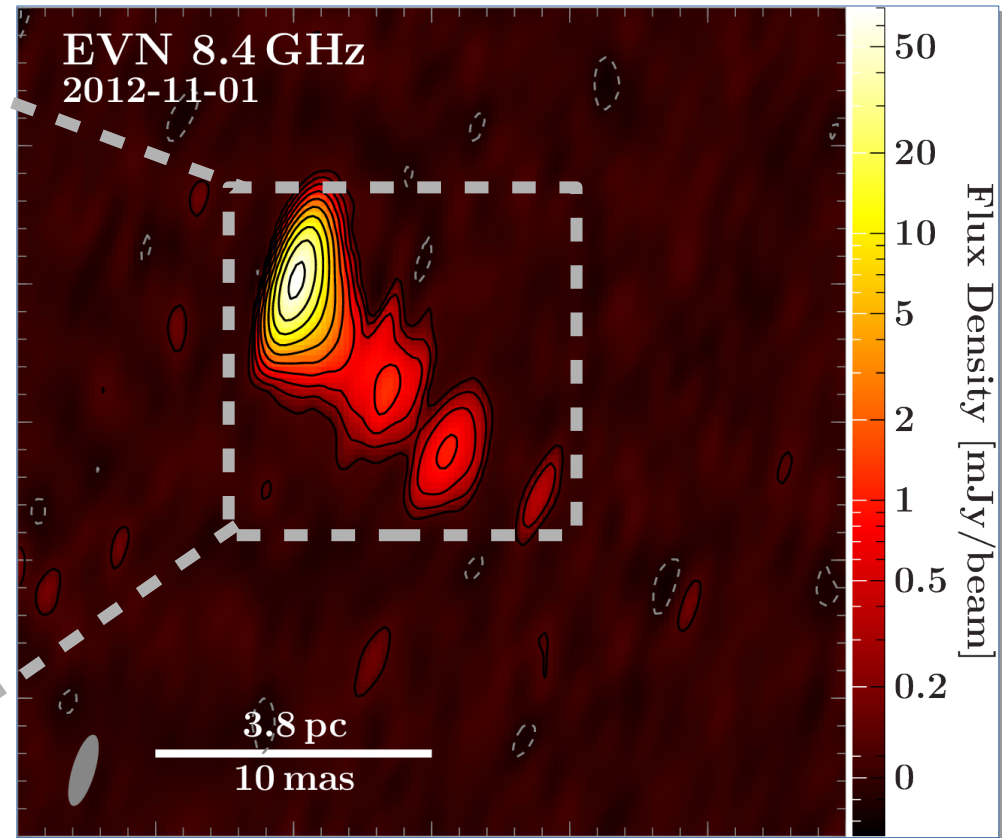
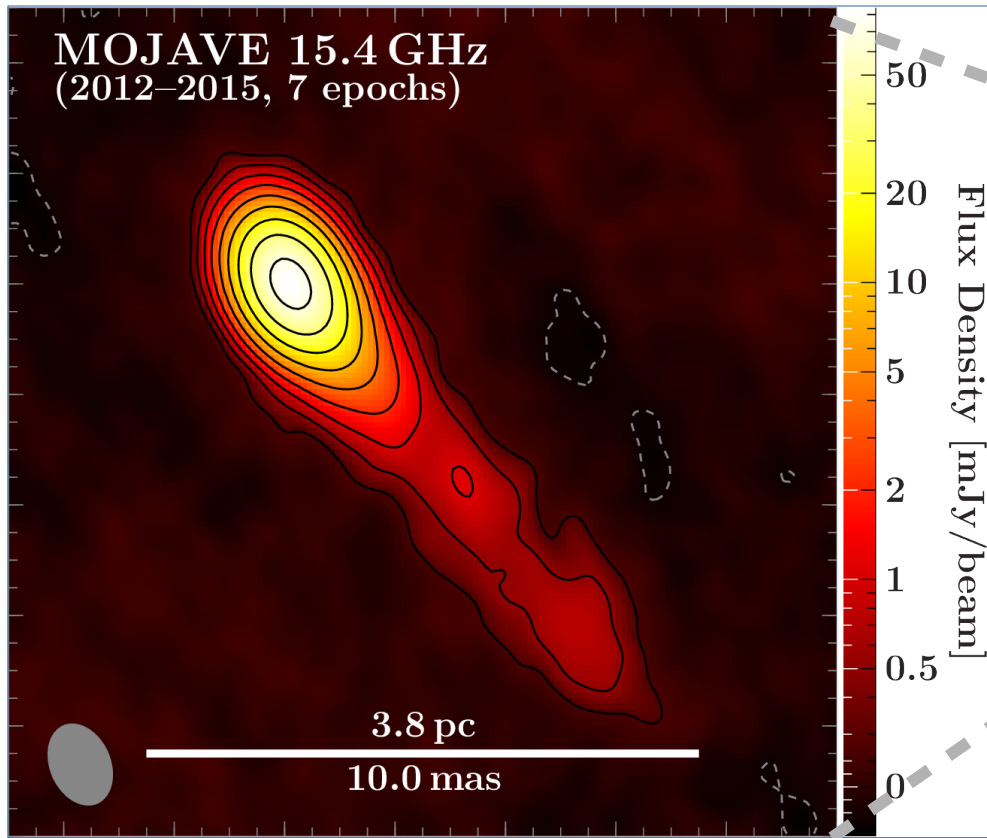
Zooming into IC 310



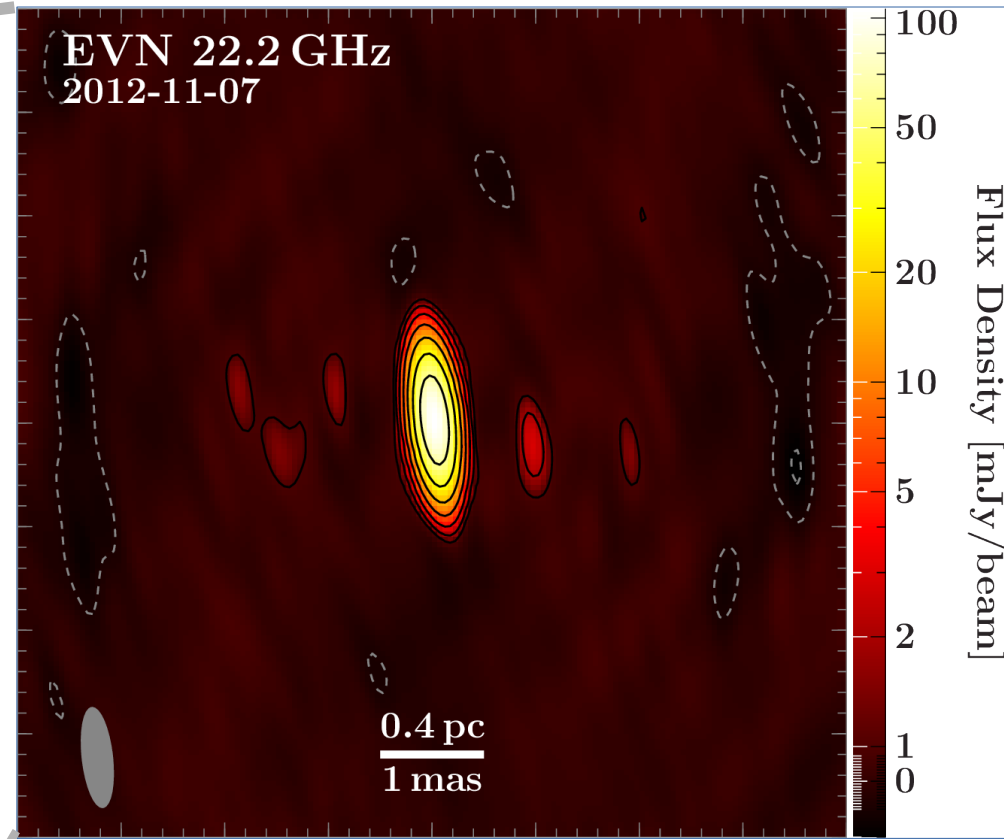
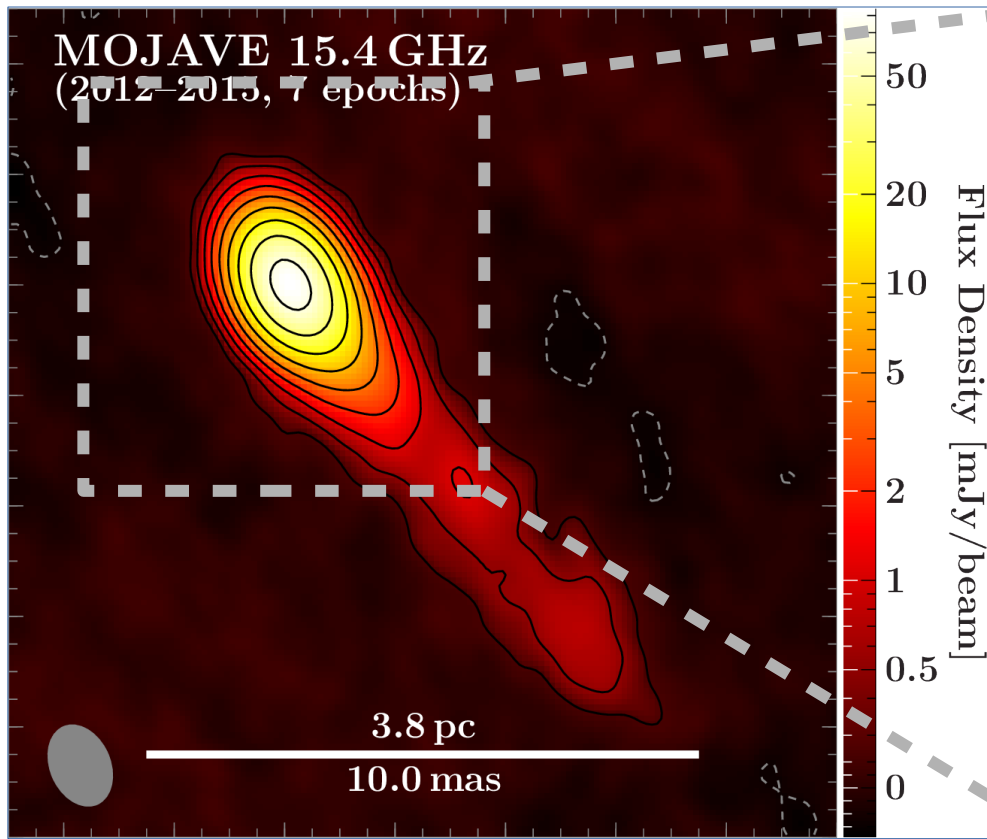
Zooming into IC 310



Zooming into IC 310

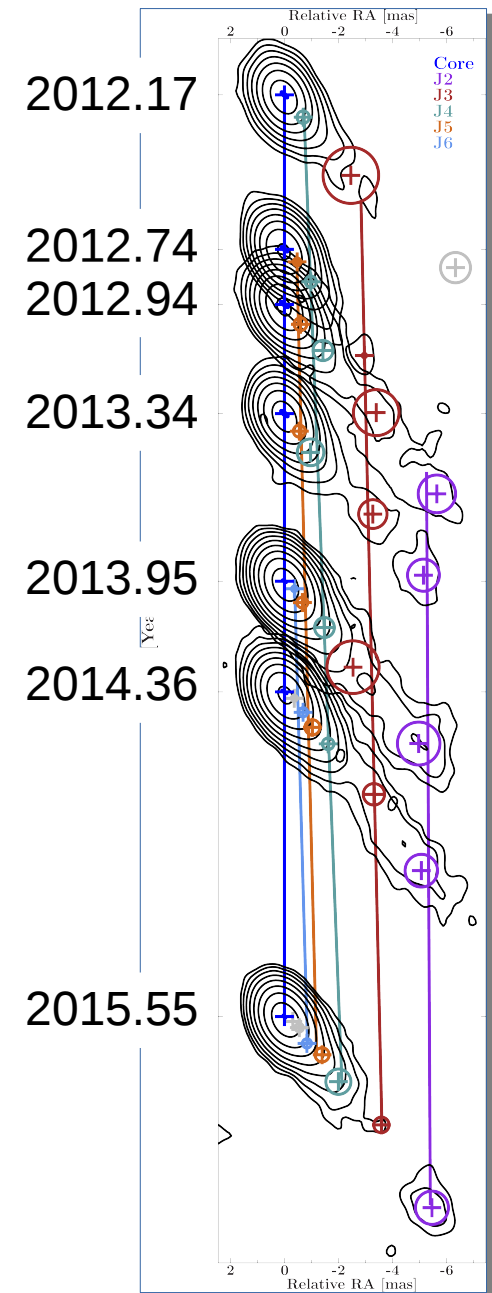
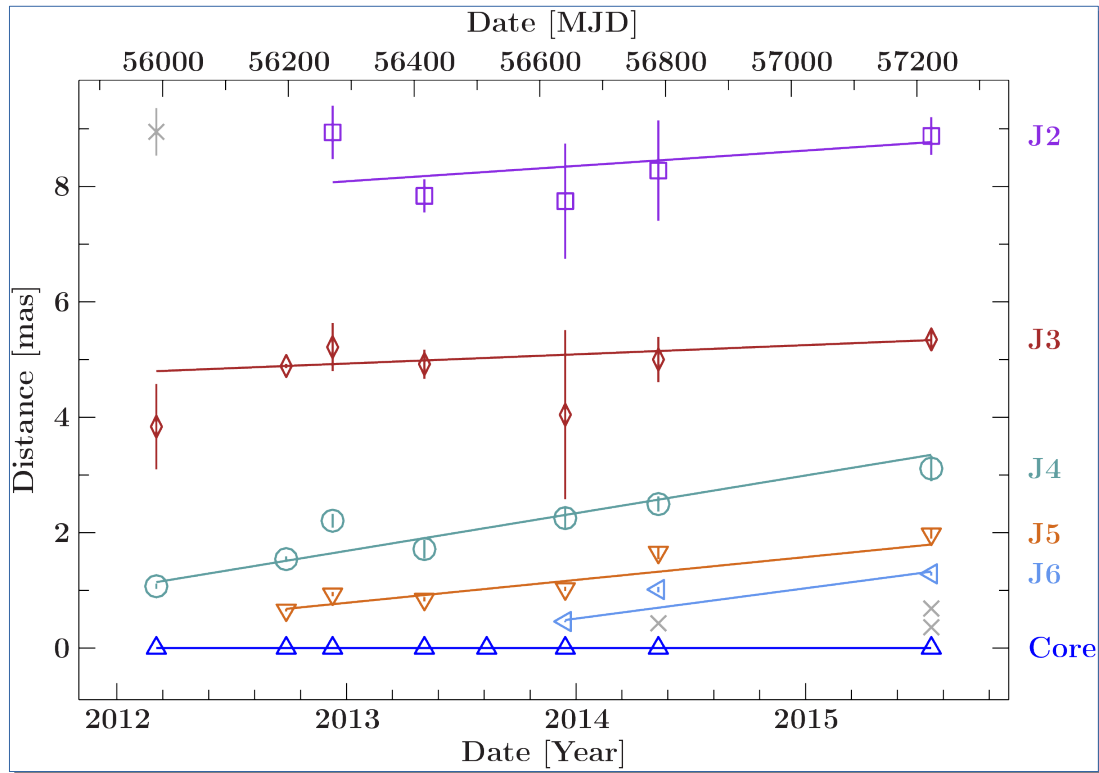


Zooming into IC 310



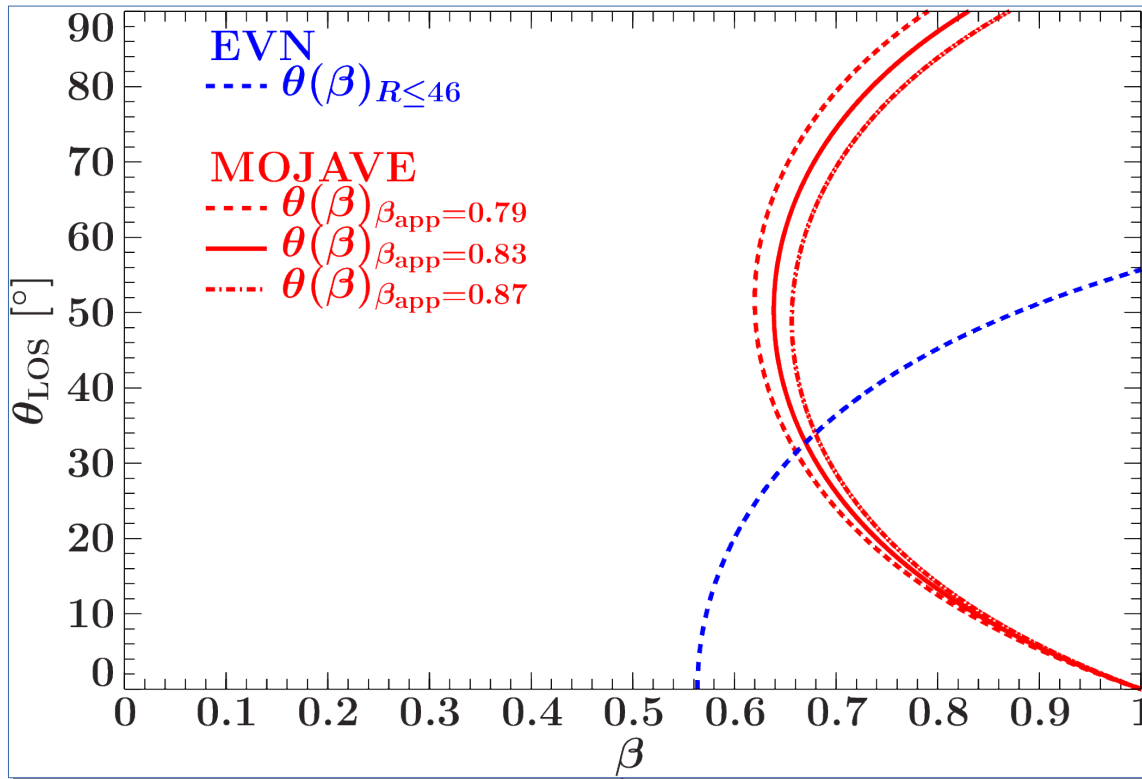
Jet Kinematics

MOJAVE 15 GHz monitoring



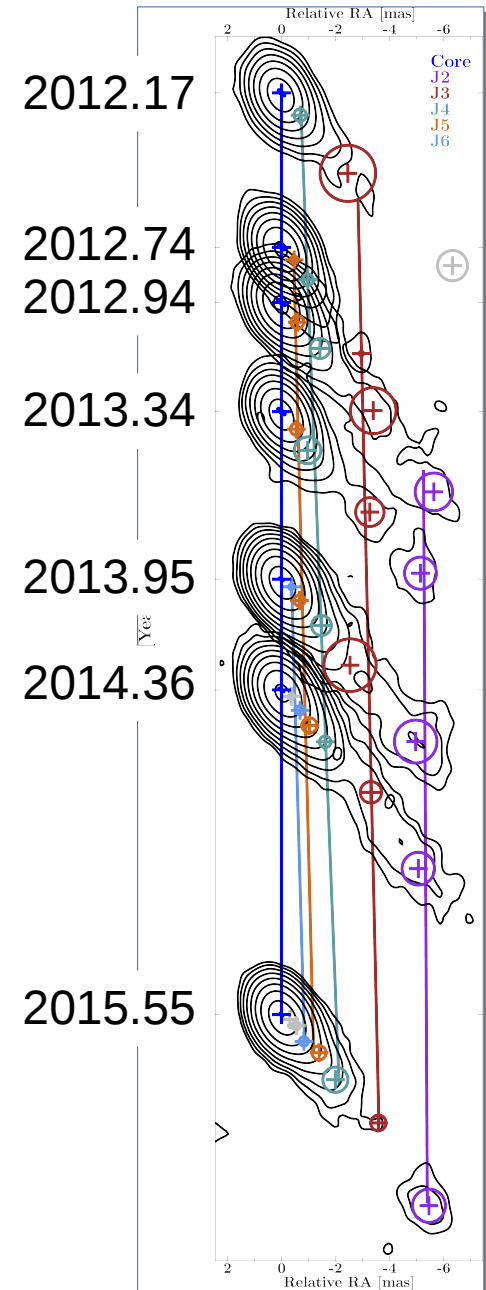
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MOJAVE 15 GHz monitoring



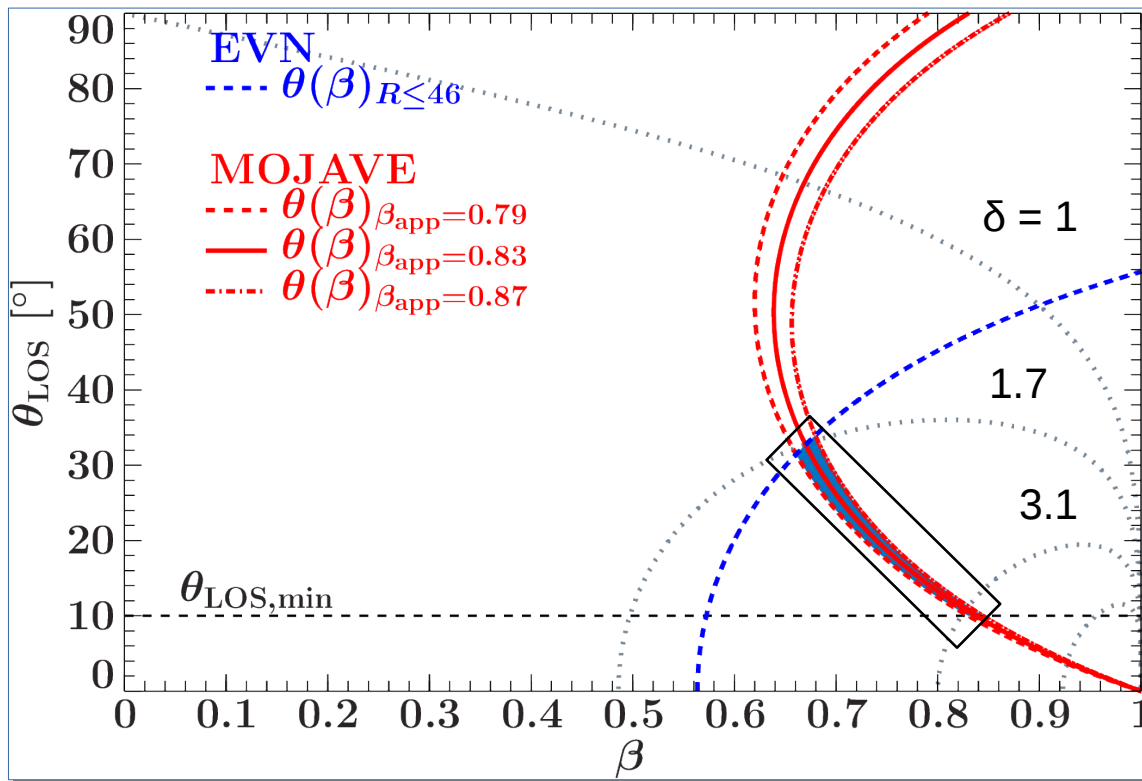
$$R = \frac{S_{jet}}{S_{cjet}} = \left(\frac{1 + \beta \cos \theta_{LOS}}{1 - \beta \cos \theta_{LOS}} \right)^n$$

$$\beta_{app} = \frac{\beta \sin \theta_{LOS}}{1 - \beta \cos \theta_{LOS}}$$



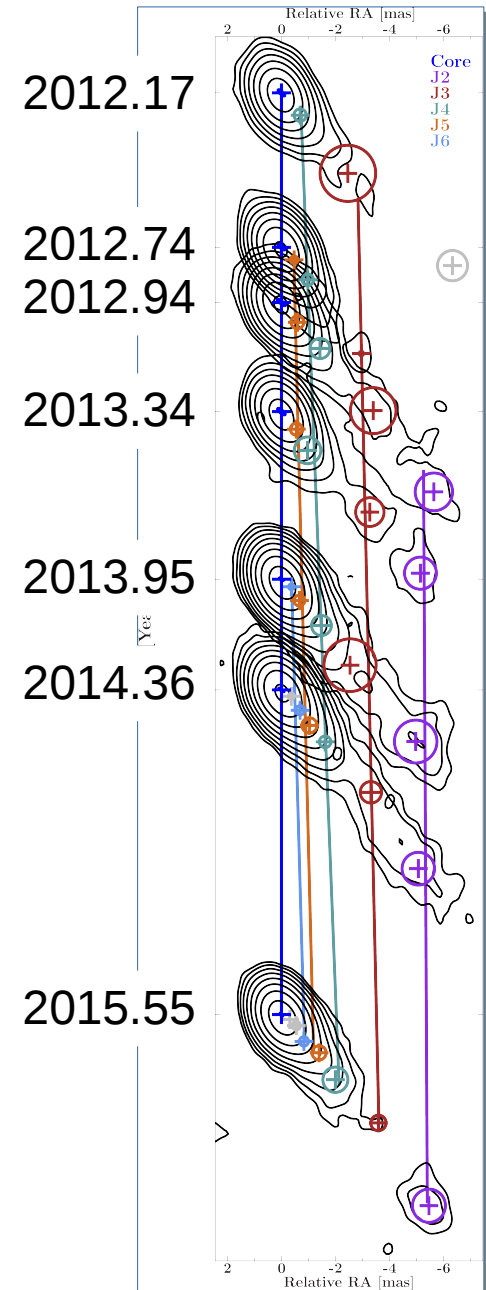
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$$\beta_{\text{app}} = \frac{\beta \sin \theta_{\text{LOS}}}{1 - \beta \cos \theta_{\text{LOS}}}$$



Jet Parameters

Lorentz factor: 1.4 – 1.8

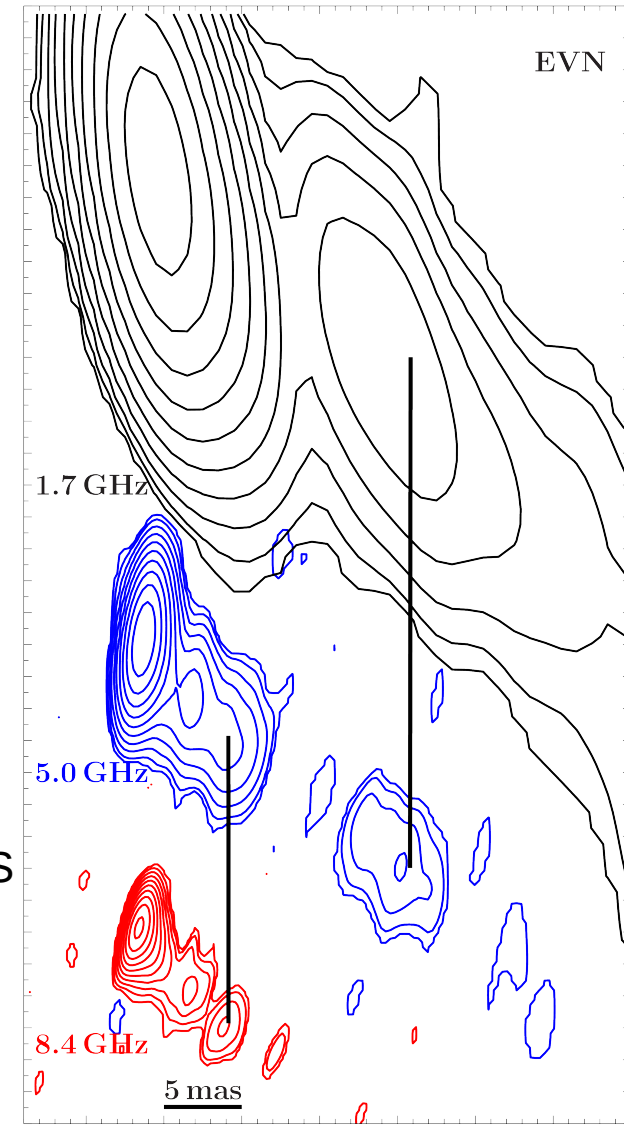
Intrinsic half-opening angle: $\lesssim 4^\circ$

Combined with core-shift measurements:

(following e.g., Lobanov 1998, A&A; O'Sullivan & Gabuzda 2009, MNRAS)

Distance: VLBI core – Jet base: $> 10^4 R_S$

Magnetic field at $1 R_S$: $> 10^3$ G



Summary

High TeV variability

No strong radio variability

Only moderately relativistic jet

High magnetic fields close to BH