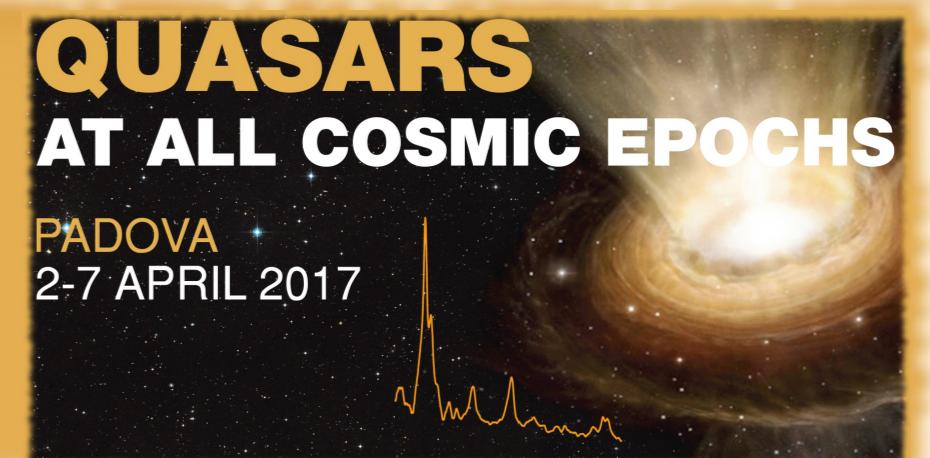


# Ultra-compact blazar AO 0235+164

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Y.Y. Kovalev<sup>1,4</sup>, A. Lobanov<sup>4</sup>, A. Ipatov<sup>5</sup>, M. Aller<sup>6</sup>, H. Aller<sup>6</sup>, A. Lahteenmaki<sup>7,8</sup>



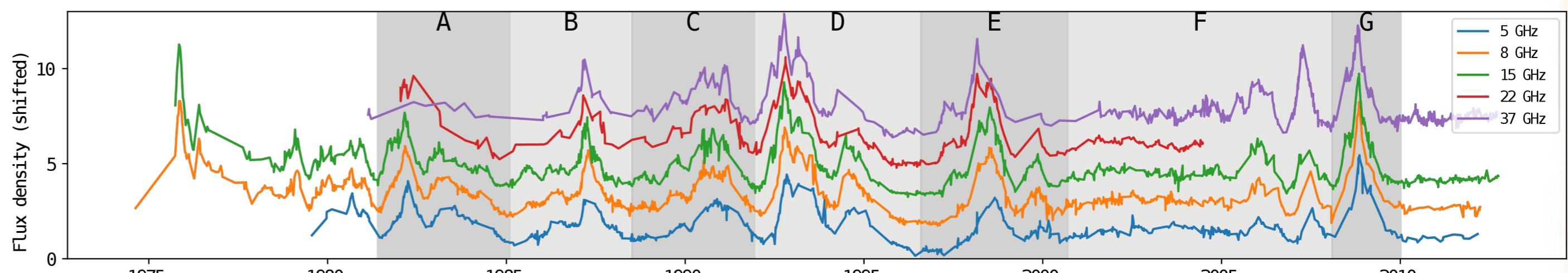
Based on multi-frequency VLBI and single-dish radio observations we find kinematical and geometrical parameters of the source, which suggest significant jet acceleration and collimation within 1 mas of the 7 mm core. The extremely high brightness temperatures measured with space interferometer indicate presence of an unresolved core substructure

## Observational data



- Single-dish light curves

Univ. of Michigan Radio Observatory (5, 8, 15 GHz)  
Metsahovi Radio Observatory (22, 37 GHz)  
Owens Valley Radio Observatory (15 GHz)



- Multi-frequency VLBI

VLBA (2008-09-02): 4.8 - 43 GHz  
EVN (2008-10-19): 1.6 - 8.4 GHz

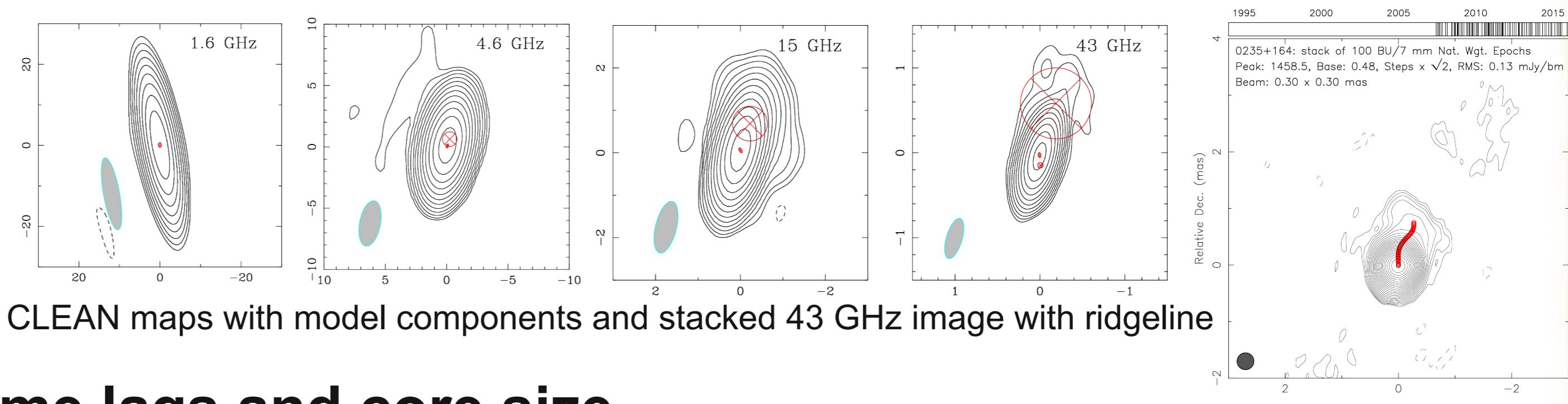
Light curves of 0235+164. The time lags of the flares depend on frequency as  $\Delta T \sim v^{-1.0 \pm 0.4}$

- Multi-epoch VLBA at 43 GHz

Data by Boston University blazar group (100 epochs)

- Radioastron Space-VLBI

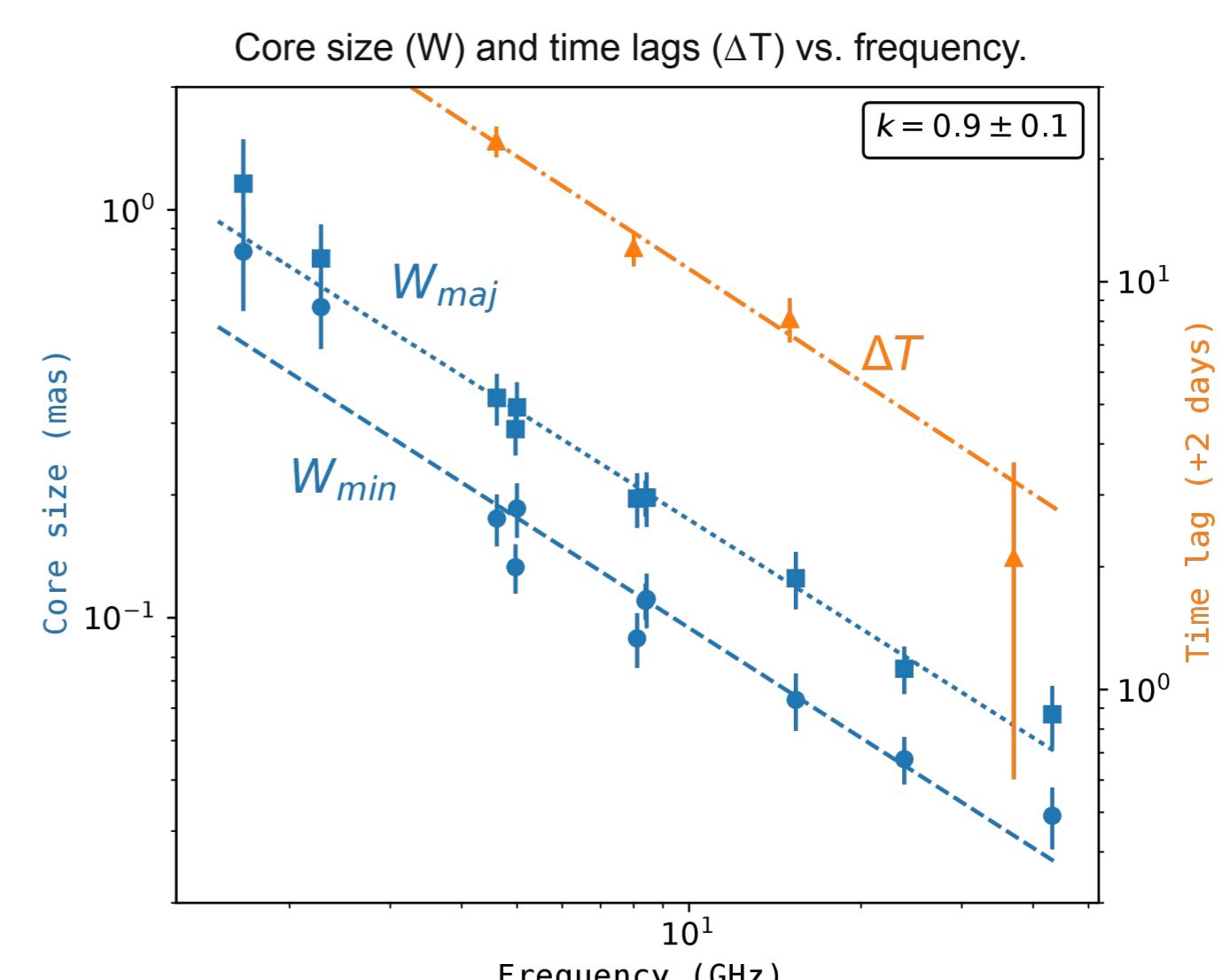
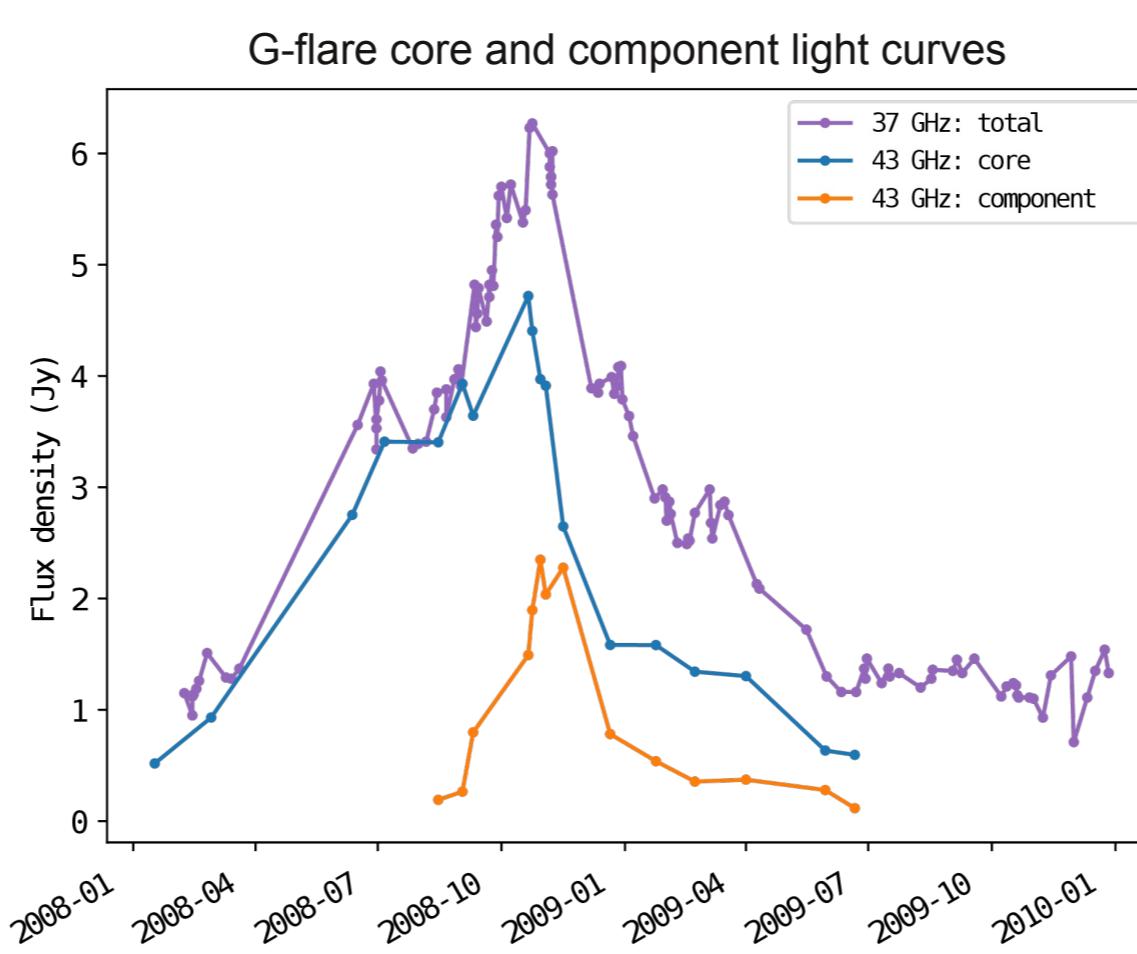
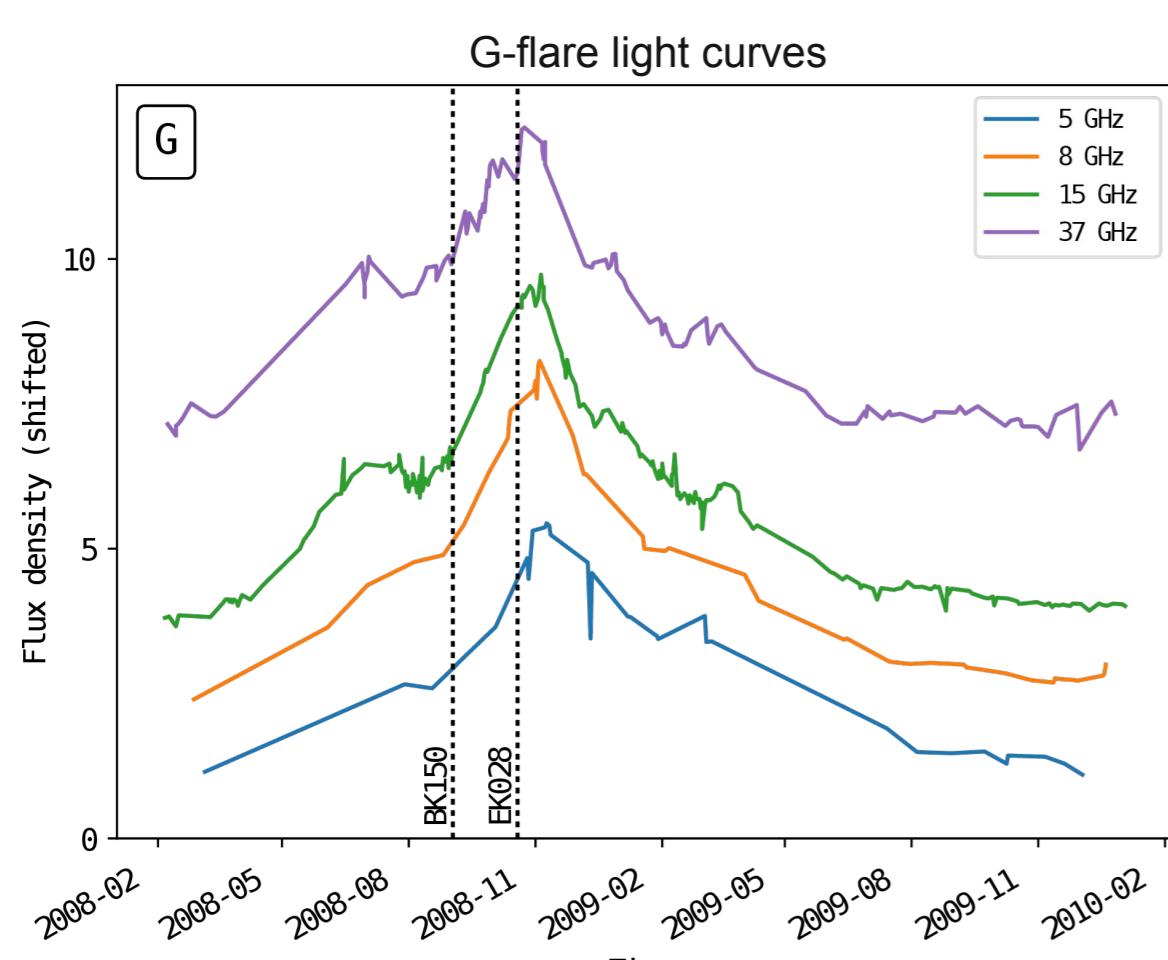
12 epochs, 1.6 - 22 GHz, baselines up to 14 G $\lambda$



## Time lags and core size

Time lags of the flares at different frequencies are found using Gaussian process regression.

VLBI structure is modeled with elliptical and circular Gaussian components.

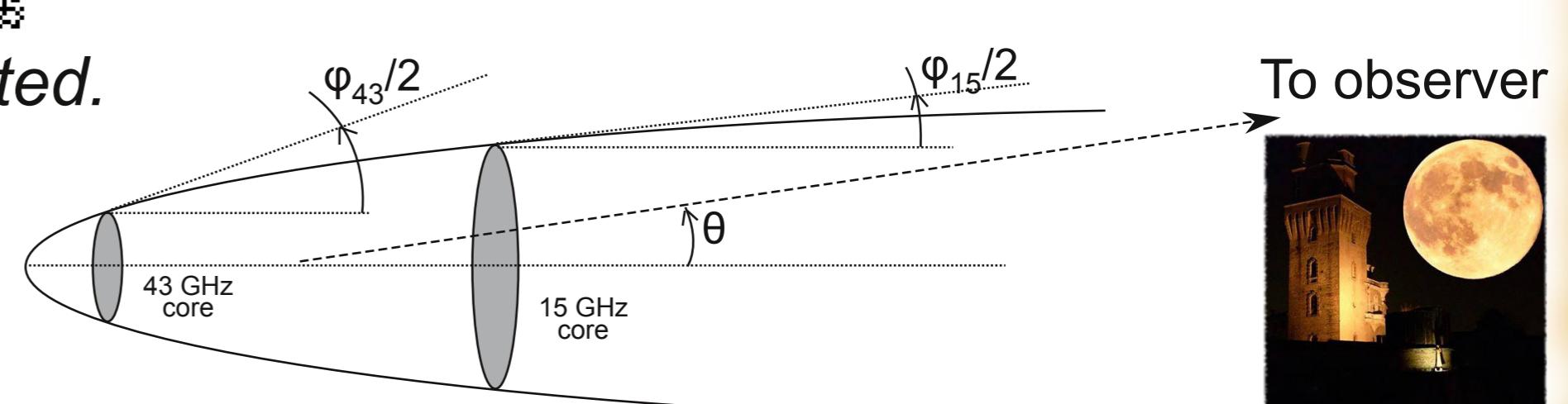
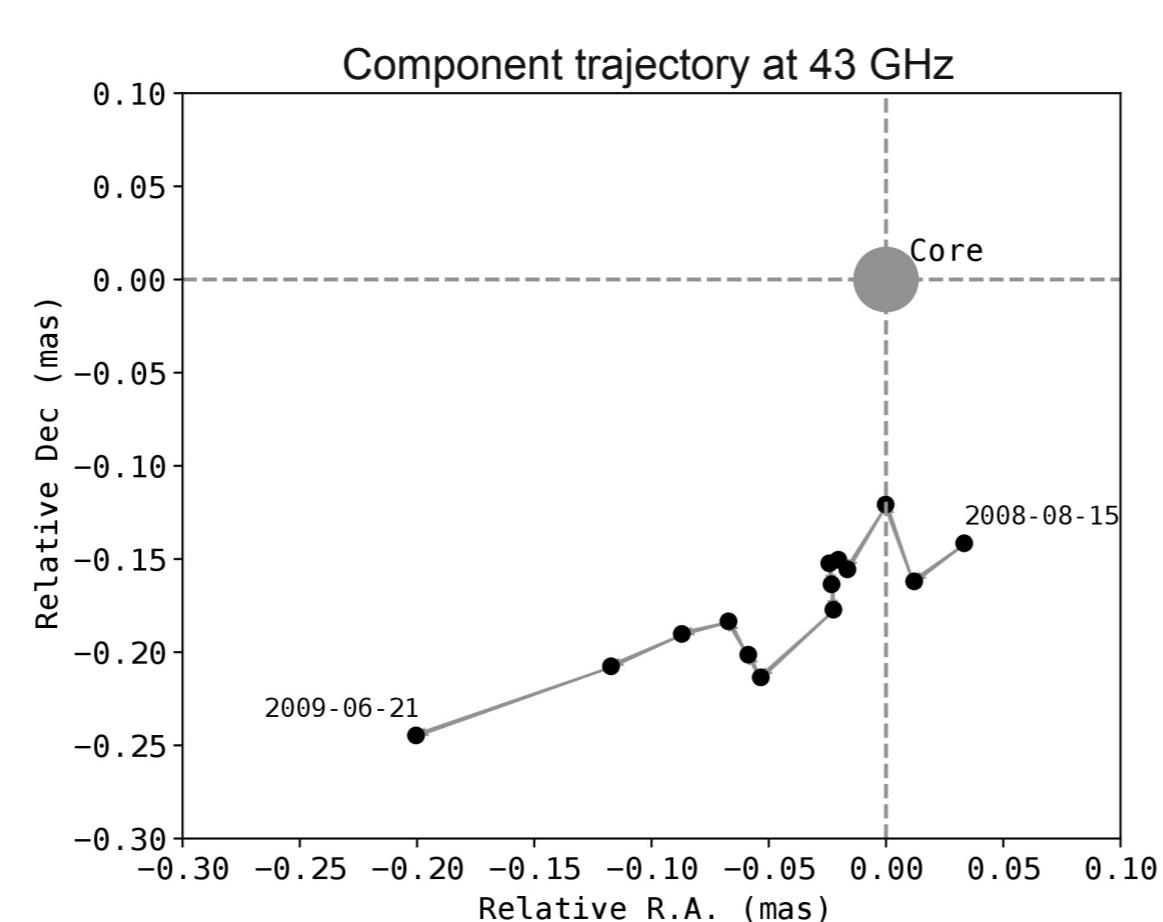
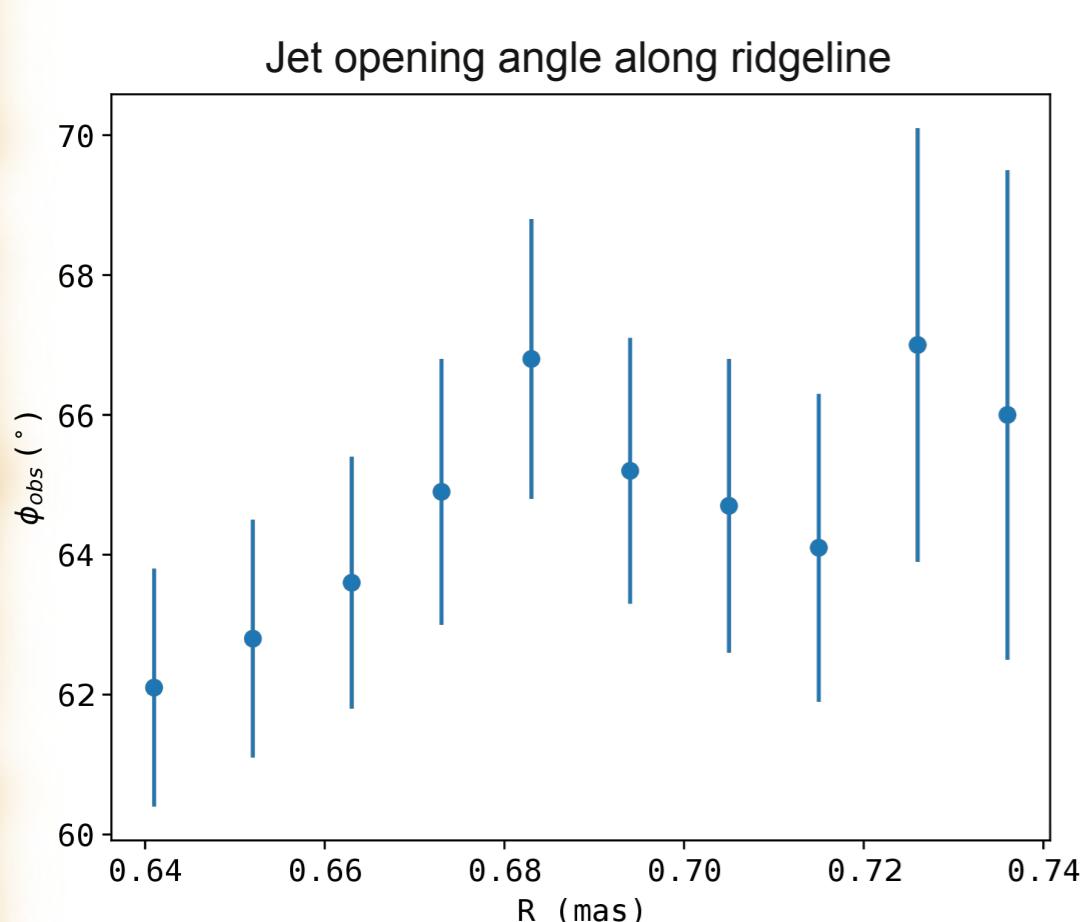


## Jet geometry and kinematics



Stacked image is used to find jet opening angle  $\phi$ .

Doppler factor  $\delta$ , Lorentz factor  $\Gamma$  and viewing angle  $\theta$  are estimated.

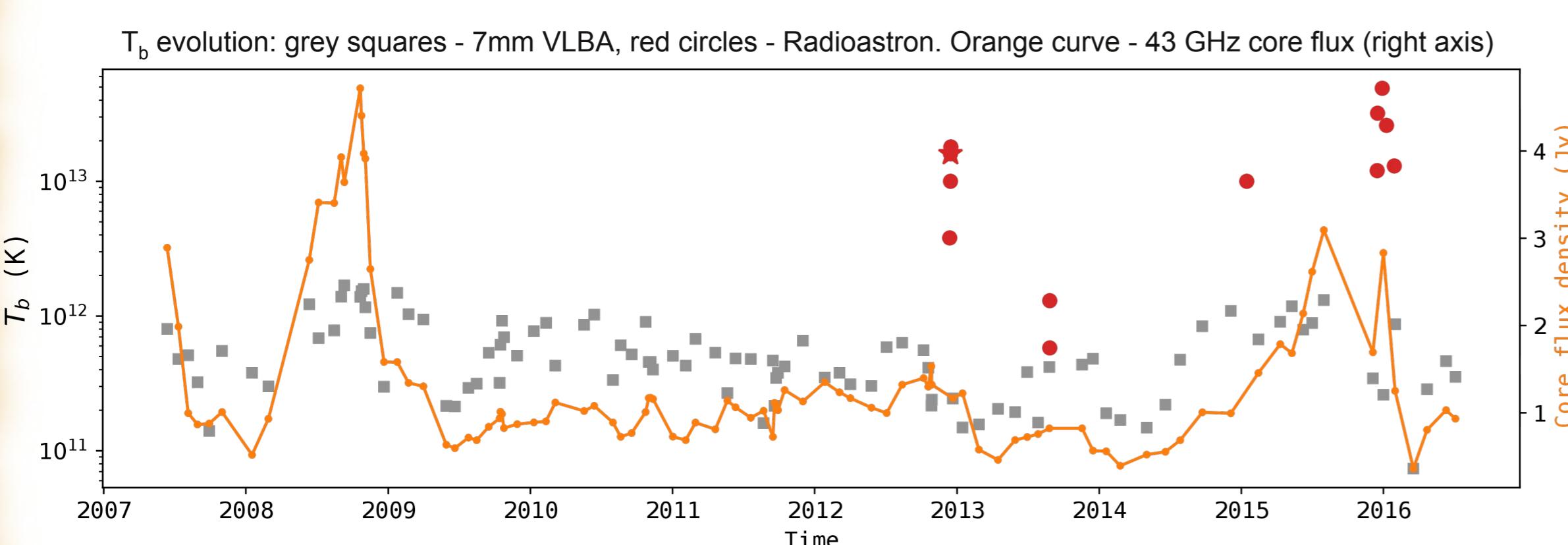


Schematic illustration of collimated jet with  $\phi_{15\text{GHz}} < 2\theta < \phi_{43\text{GHz}}$

## Brightness temperatures

measured using VLBI models

and visibility amplitudes on longest RadioAstron baselines



- Core is resolved (with mean axes ratio  $\sim 0.5$ )
- Core size and flares time lags  $\sim v^{-0.9}$
- Core  $\delta \sim 10$ ,  $\Gamma \sim 5$ ,  $\theta \sim 1.2^\circ$ ,  $T_{b,\text{int}} \sim 10^{11} \text{ K}$
- Component  $\delta \sim 30$ ,  $\Gamma \sim 18$ ,  $\theta \sim 1.2^\circ \Rightarrow$  acceleration
- Jet  $(\phi_{\text{obs}})_{7\text{mm}} = 65^\circ > (\phi_{\text{obs}})_{2\text{cm}} = 30^\circ \Rightarrow$  collimation
- $T_b \sim 10^{13} \text{ K} \Rightarrow$  unresolved core substructure

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