Central parsec(s) of the quasar 0850+581

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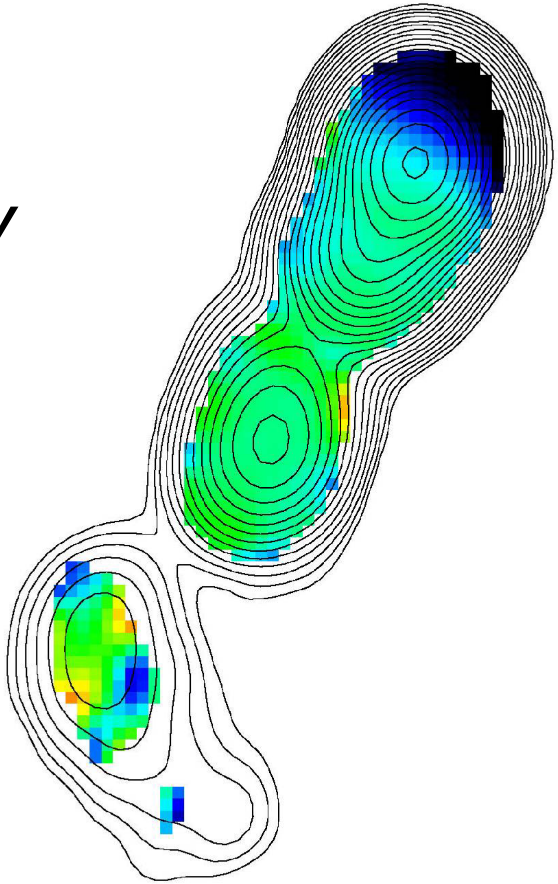
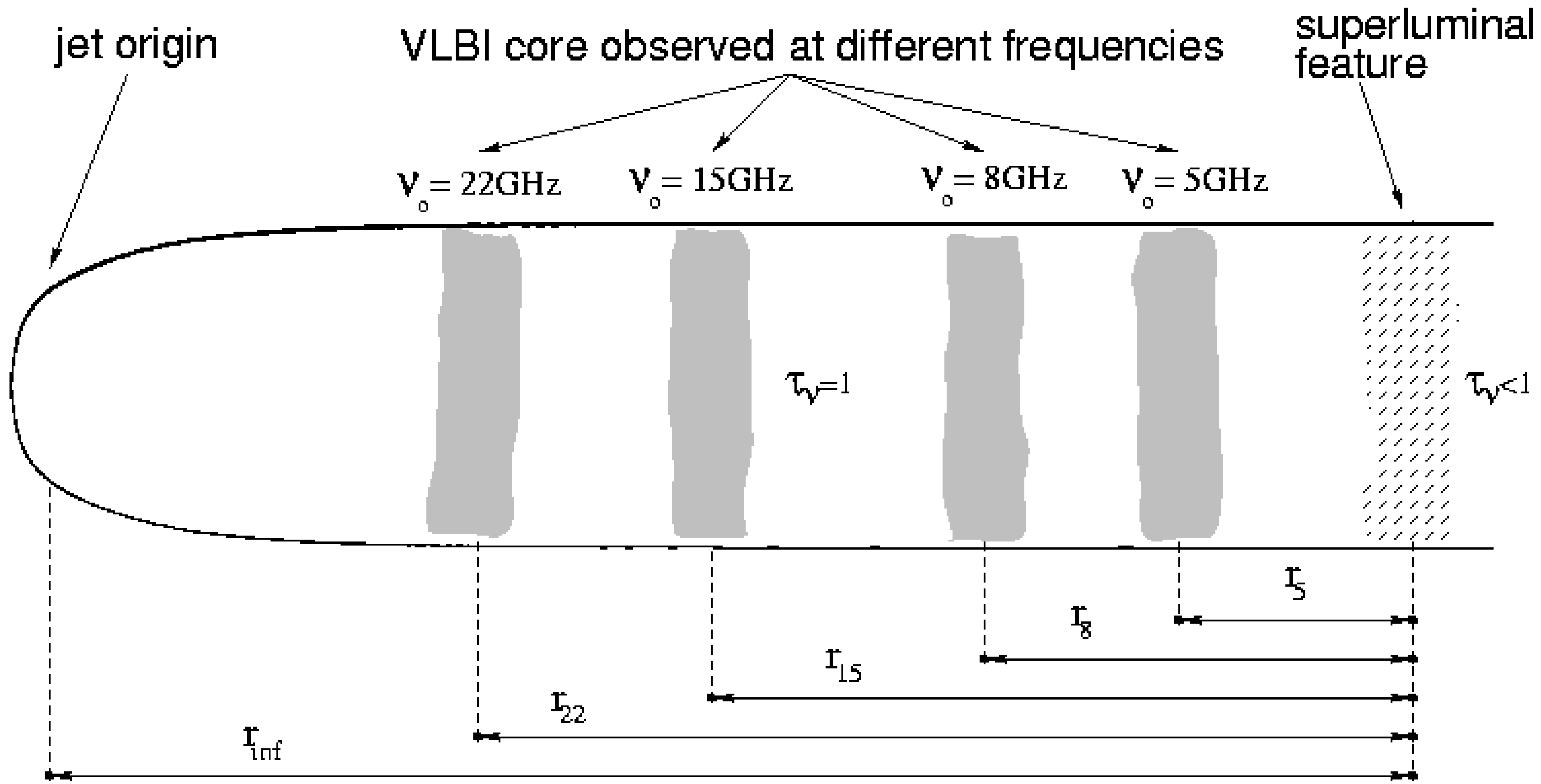


Outline

- Properties of the nuclear opacity in compact relativistic jets of active galactic nuclei
- Measuring the positional shift of the core ("core shift") due to the nuclear opacity
- Results of the first systematic study of the core shift
- Quasar 0850+581

Frequency dependent position shift of the VLBI core



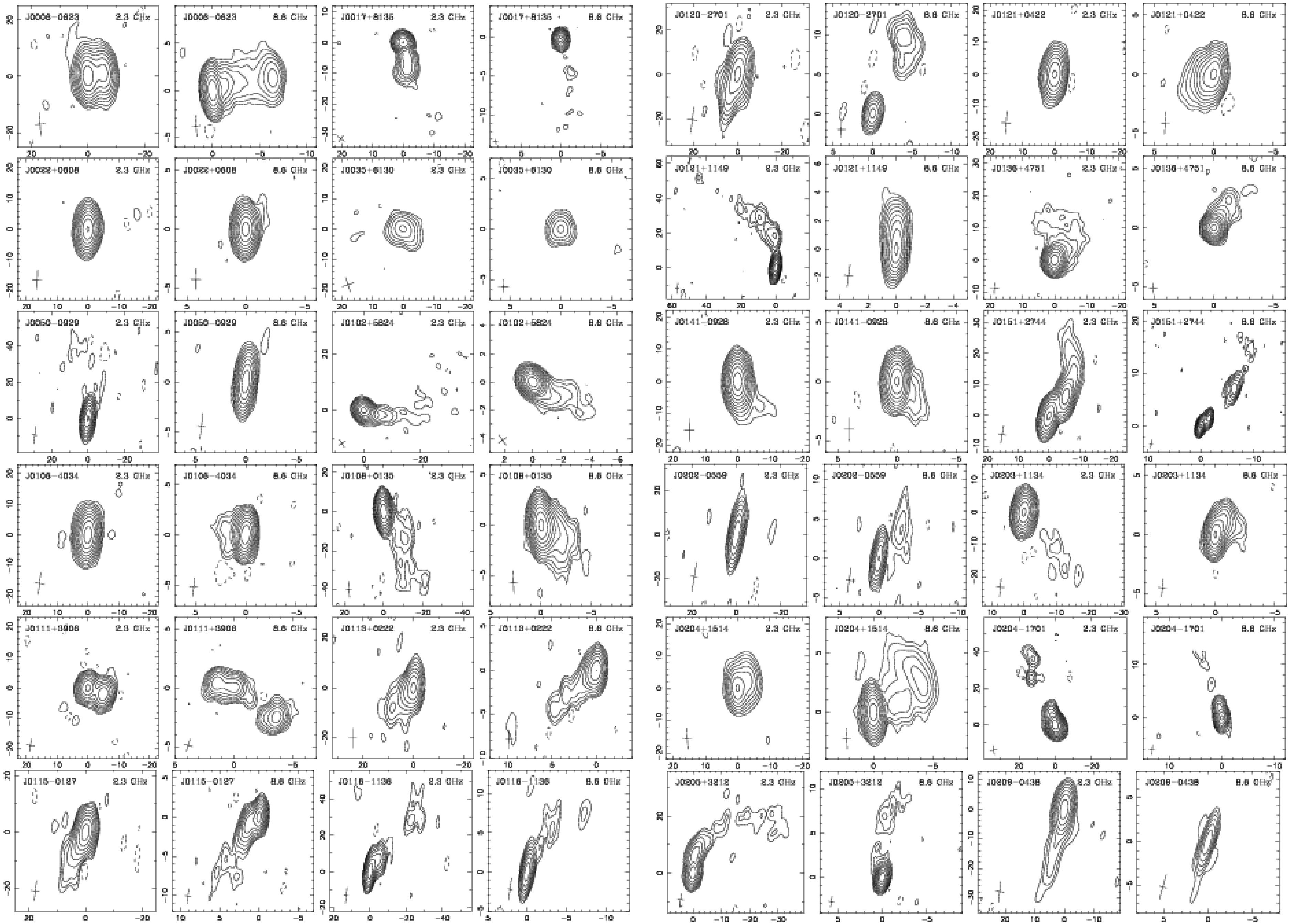
Lobanov 1998

The condition τ_ν=1 determines the variable location *r* of the core at different frequencies. Core location: $r \sim \nu^{-1/k_r}$.

k_r=1 ⟶ synchrotron self-absorption,

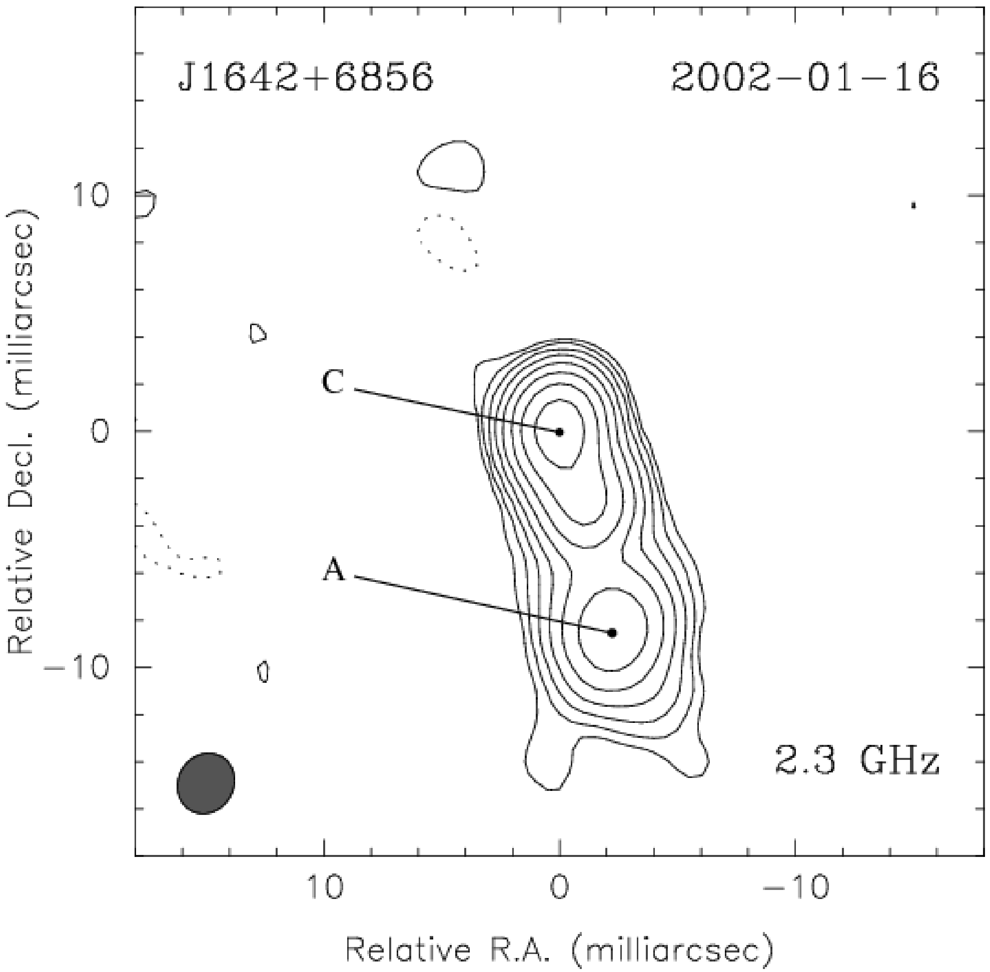
k_r>1 ⟶ synchrotron self-absorption+external absorption (i.e., free-free in BLR).

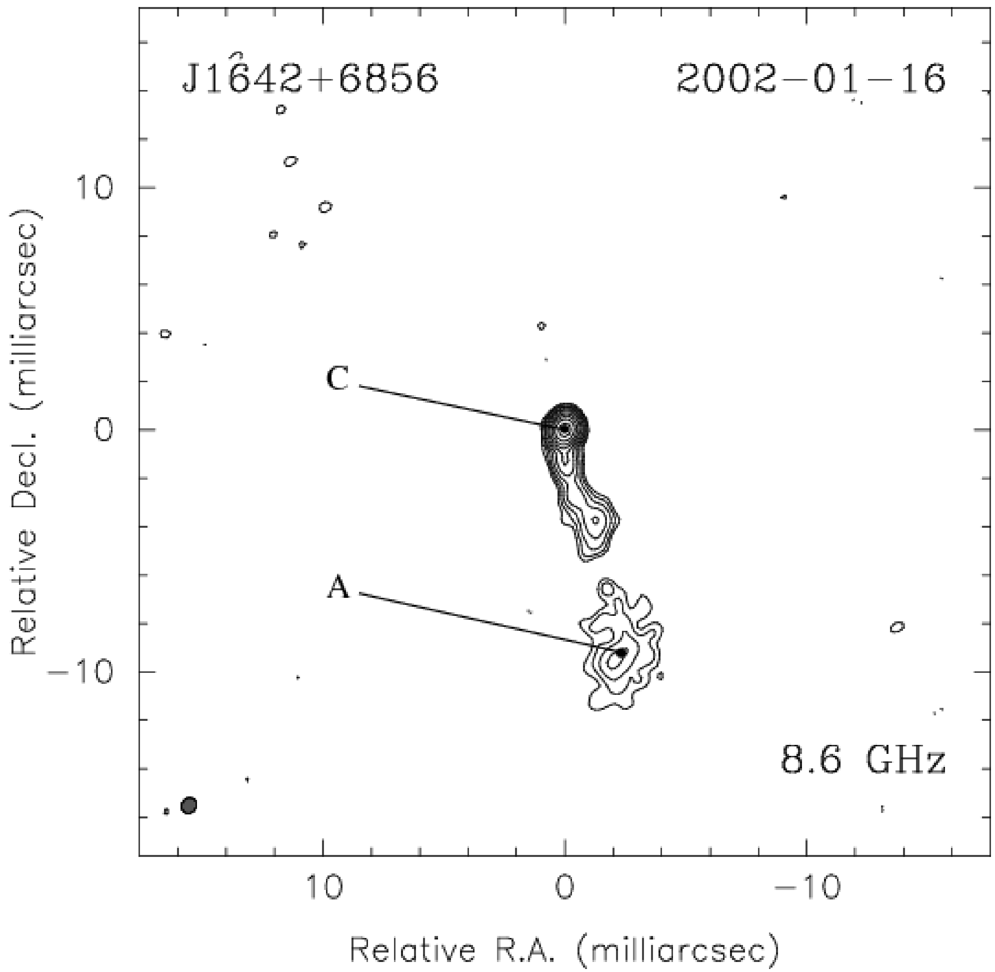
RDV data are used for the first systematic study of the core-shift effect: 2 & 8 GHz global VLBI



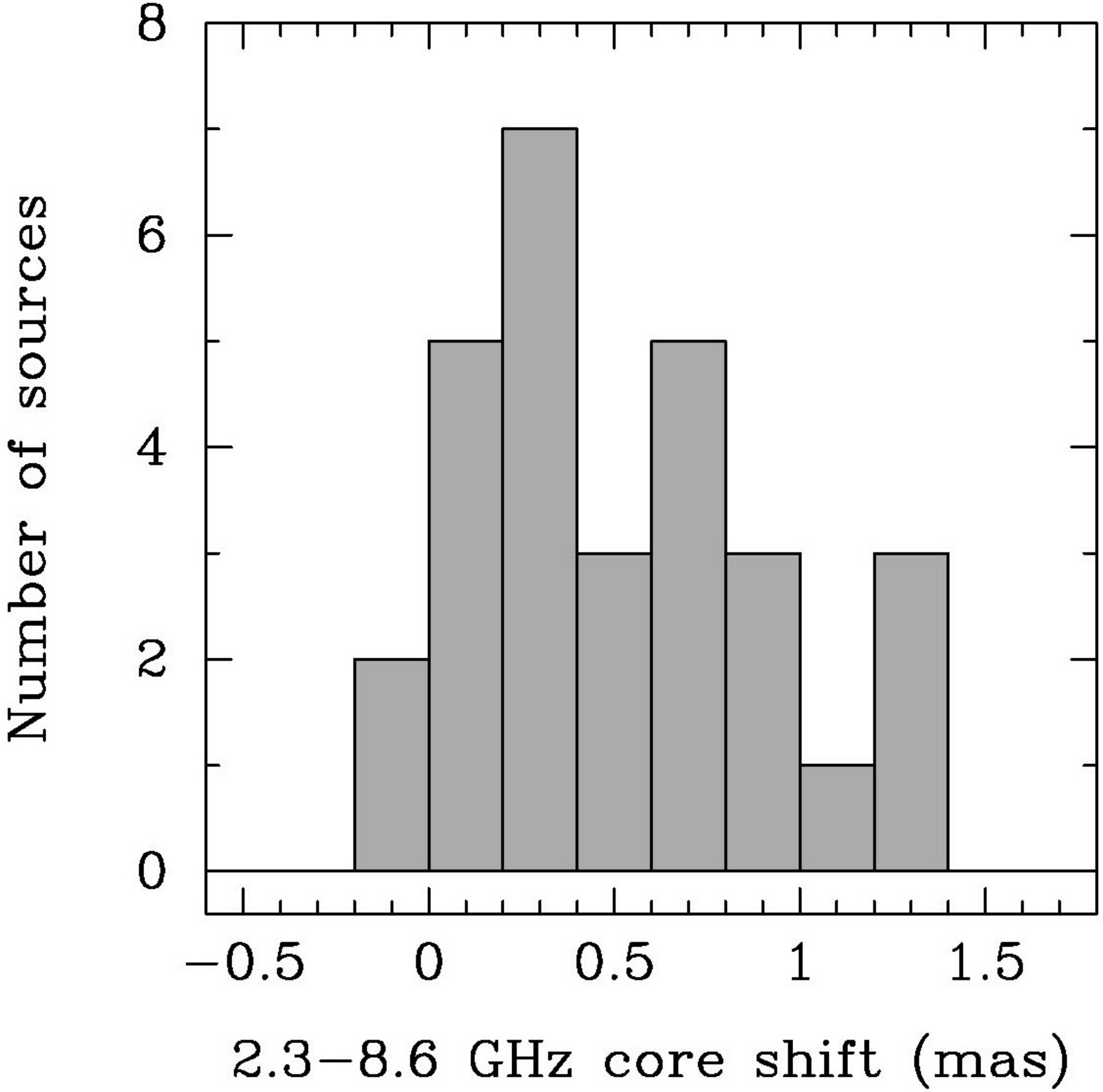
See poster by A. Pushkarev et al.

Method of the systematic core-shift study: self-reference





Result of the first systematic study: 29 objects out of about 250 imaged in 2002-2003



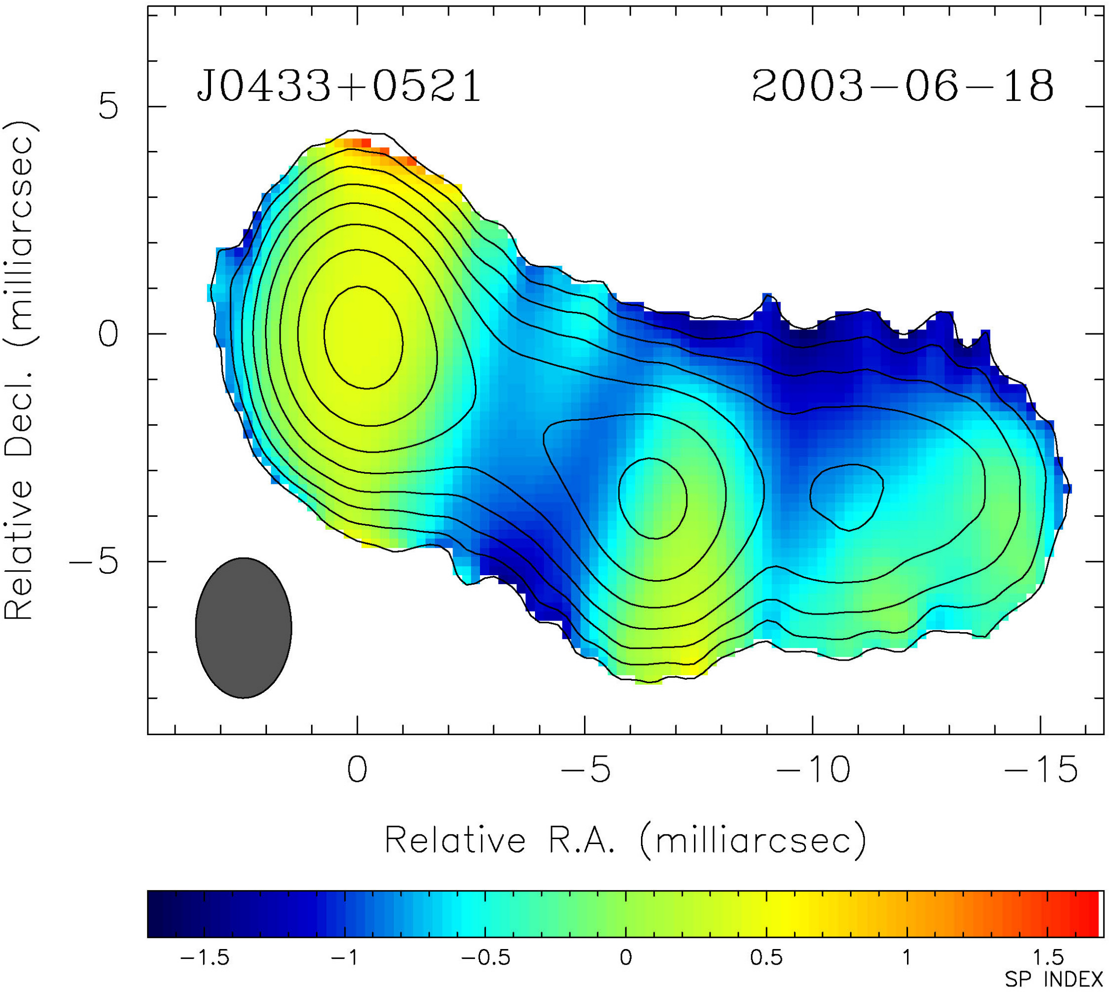
Median value:
0.44 mas

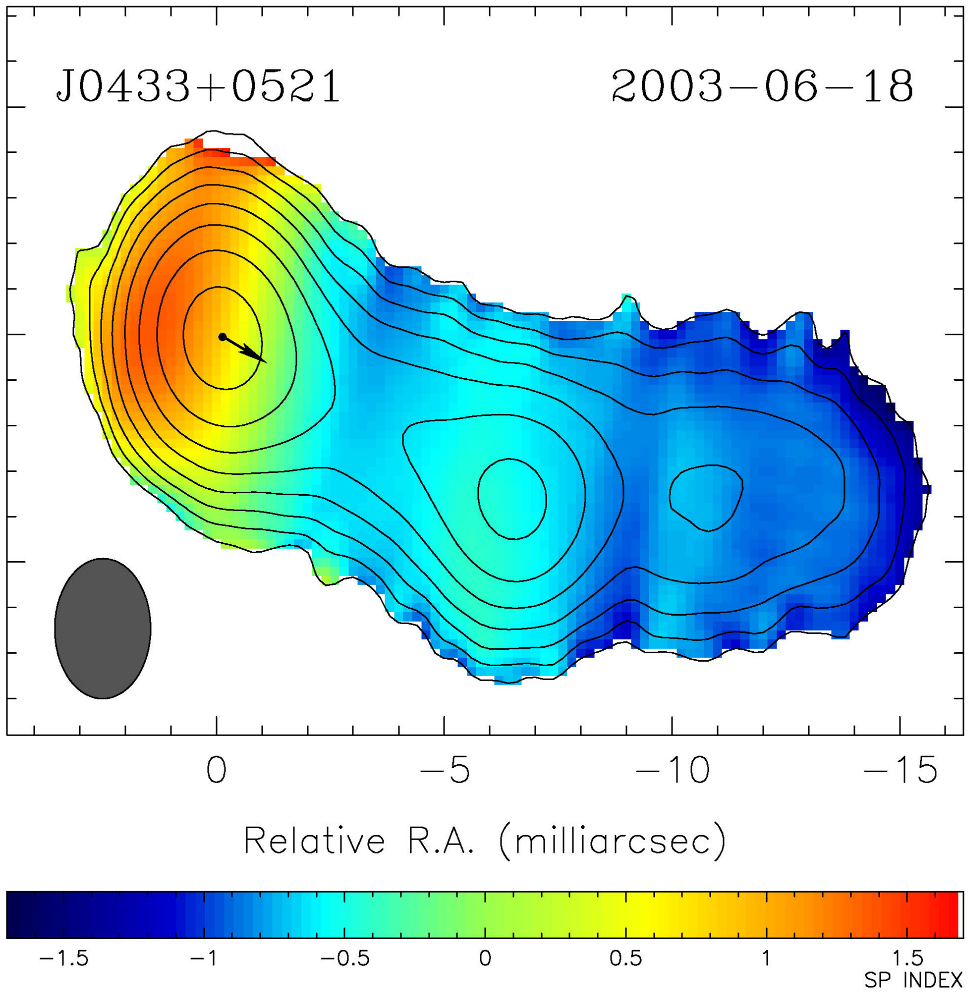
Theoretical predication for a complete sample: average value of the core shift between 2 and 8 GHz: ~0.3 mas

Kovalev et al. (2008)

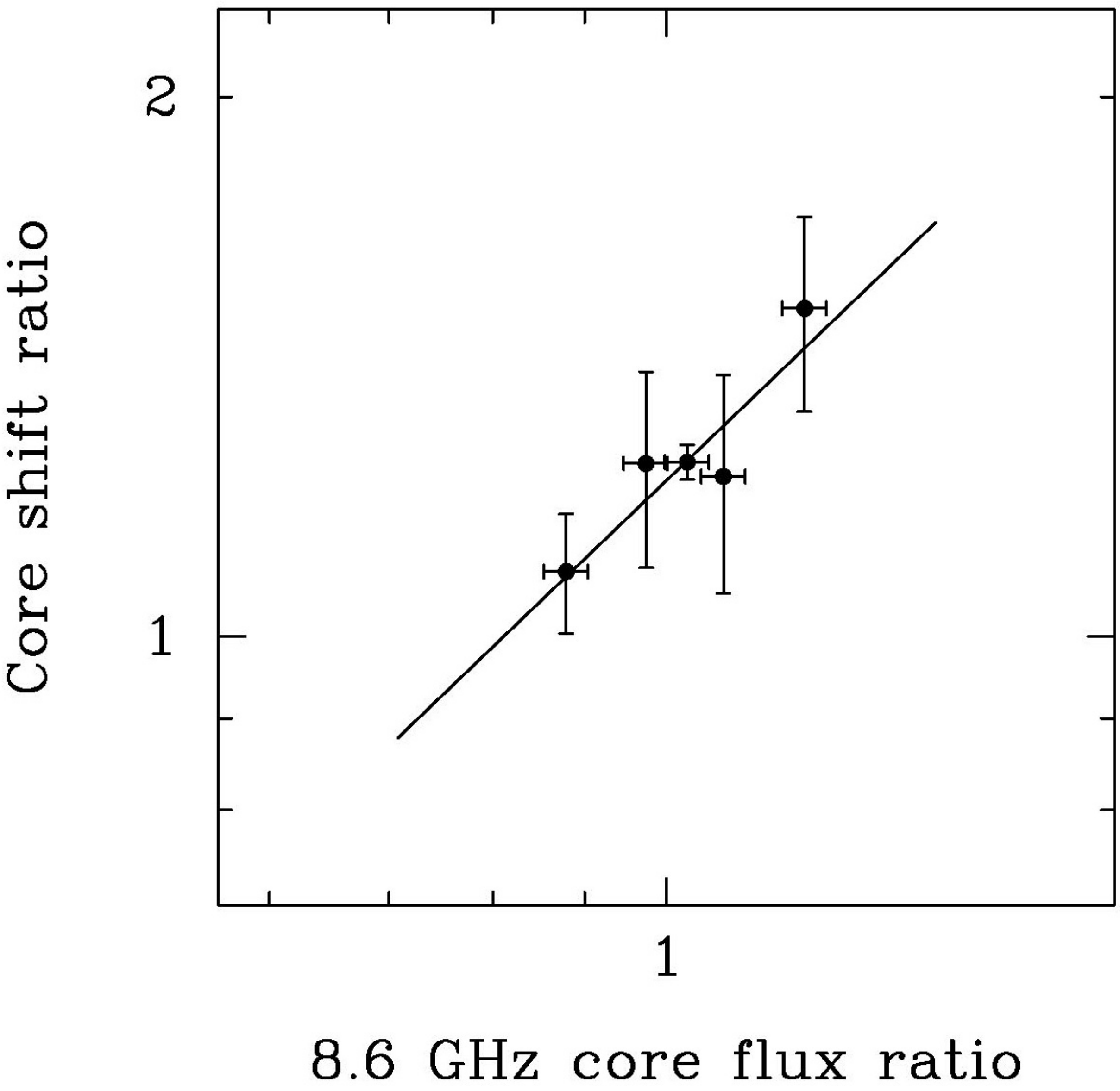
What happens if we do not take the core-shift into account (astrophysical analysis)?

$S \sim \nu^{\alpha}$





Core shift variability due to nuclear flares



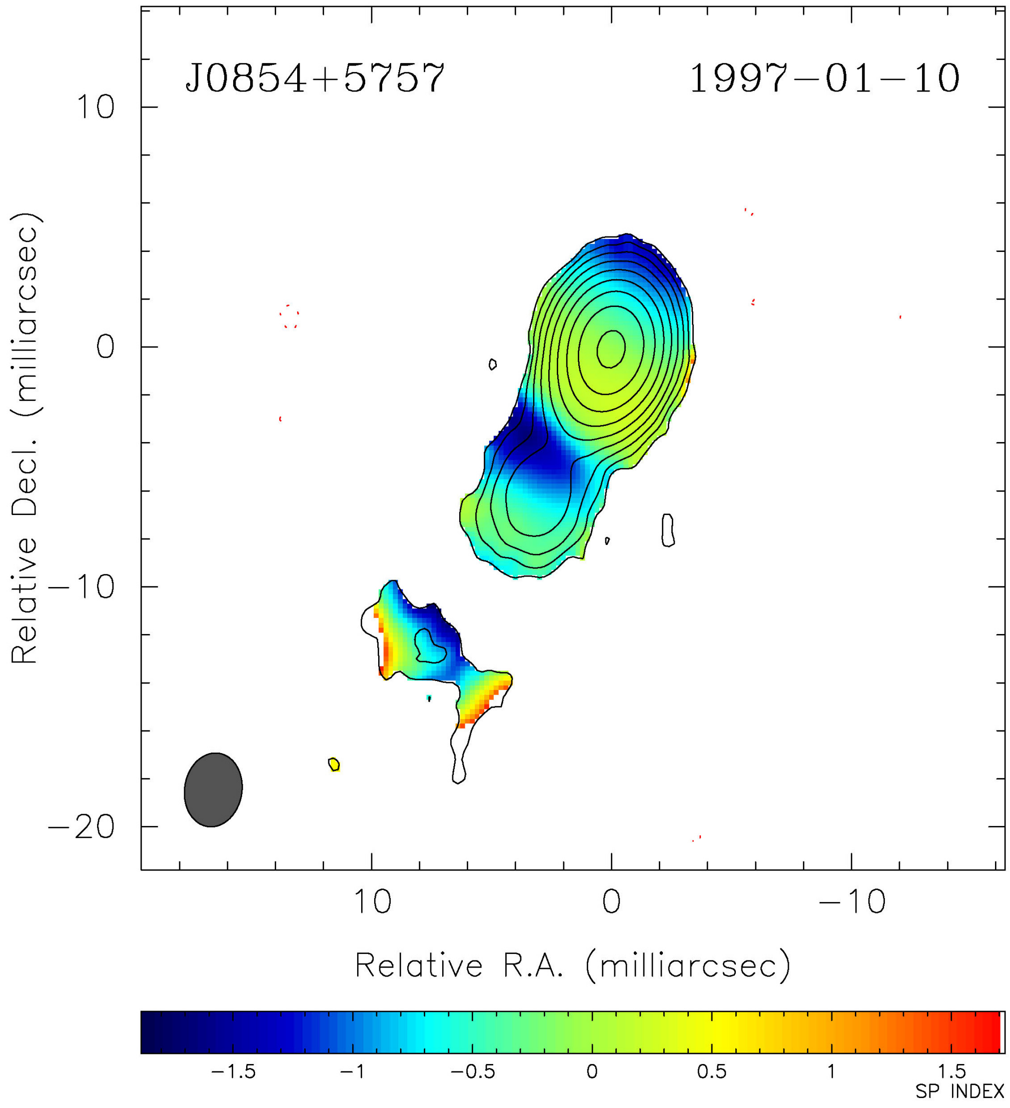
Slope: 0.96±0.18

Theoretically predicted slope for flares produced by particle density variations: **2/3**

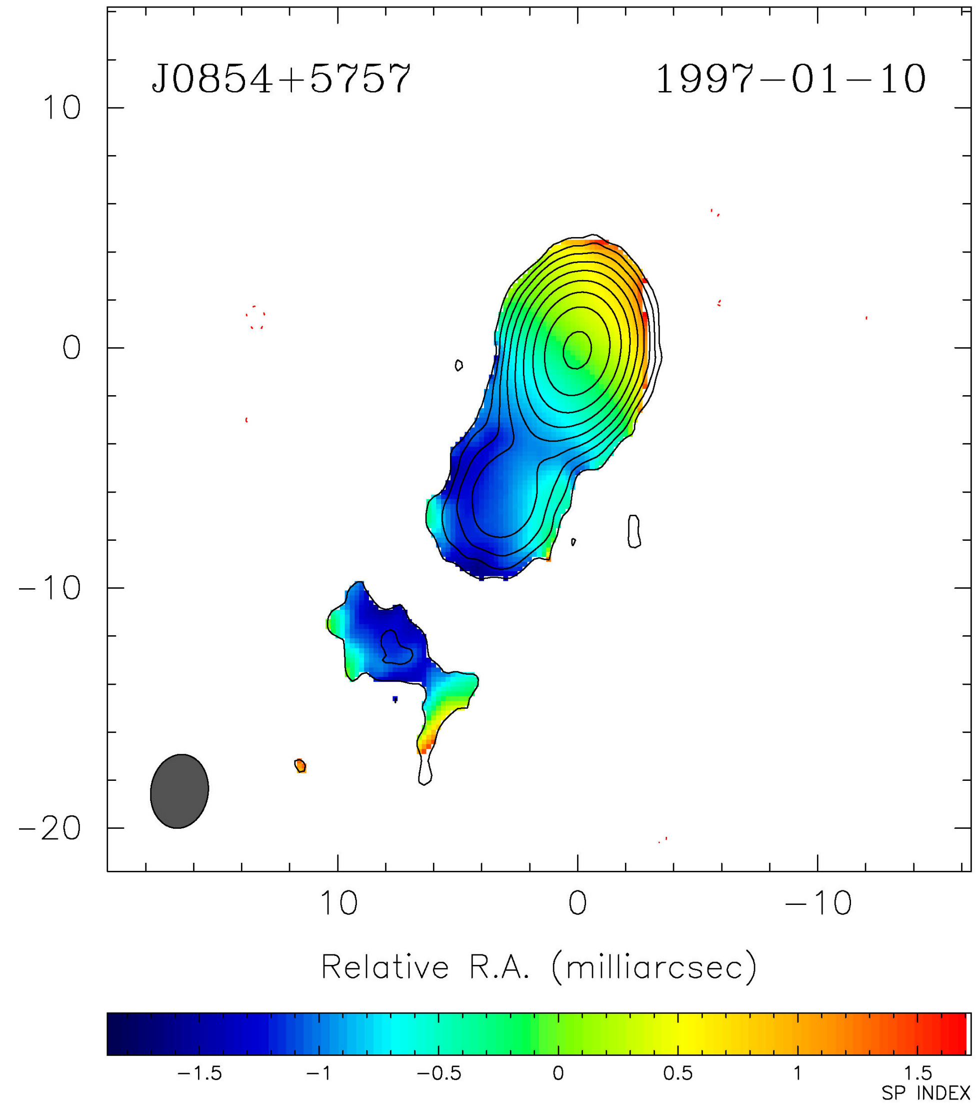
Kovalev et al. (2008)

Quasar 0850+581 (z=1.3, β=9c): the largest core shift detected at 2-8 GHz to be 1.3 mas

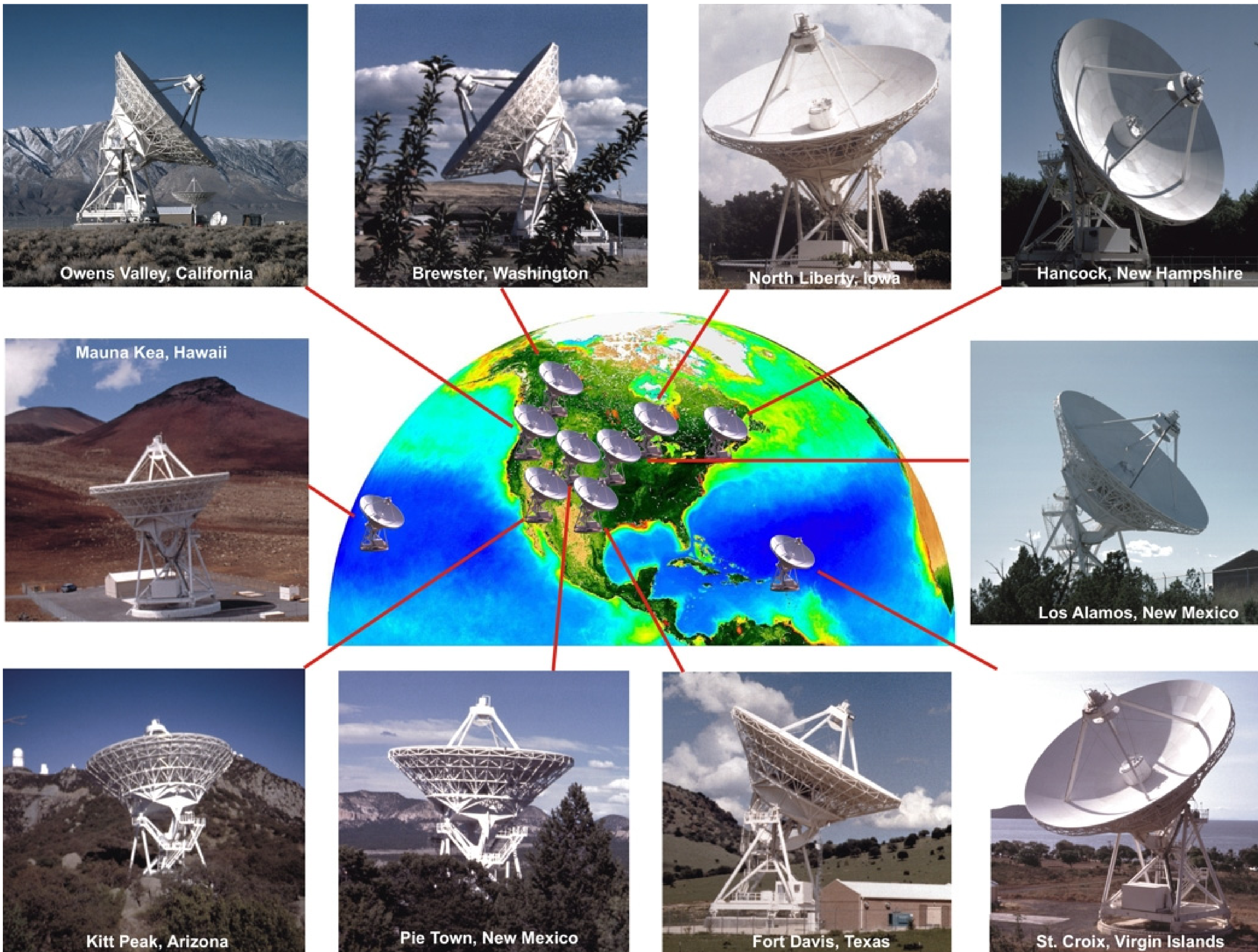
Not corrected for the shift:



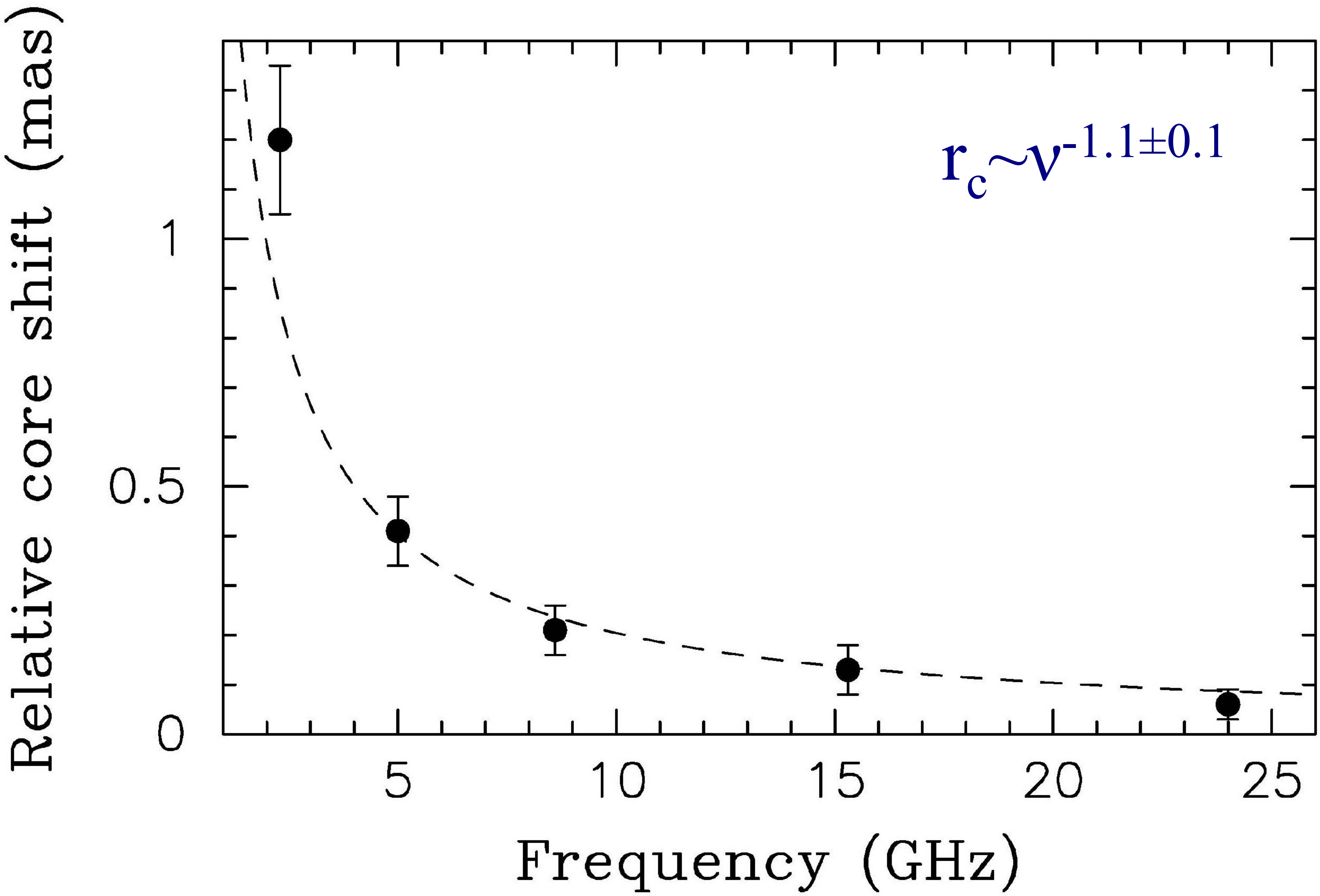
Corrected for the shift:



VLBA multi-frequency 5-43 GHz dual-polarization phase referencing experiment



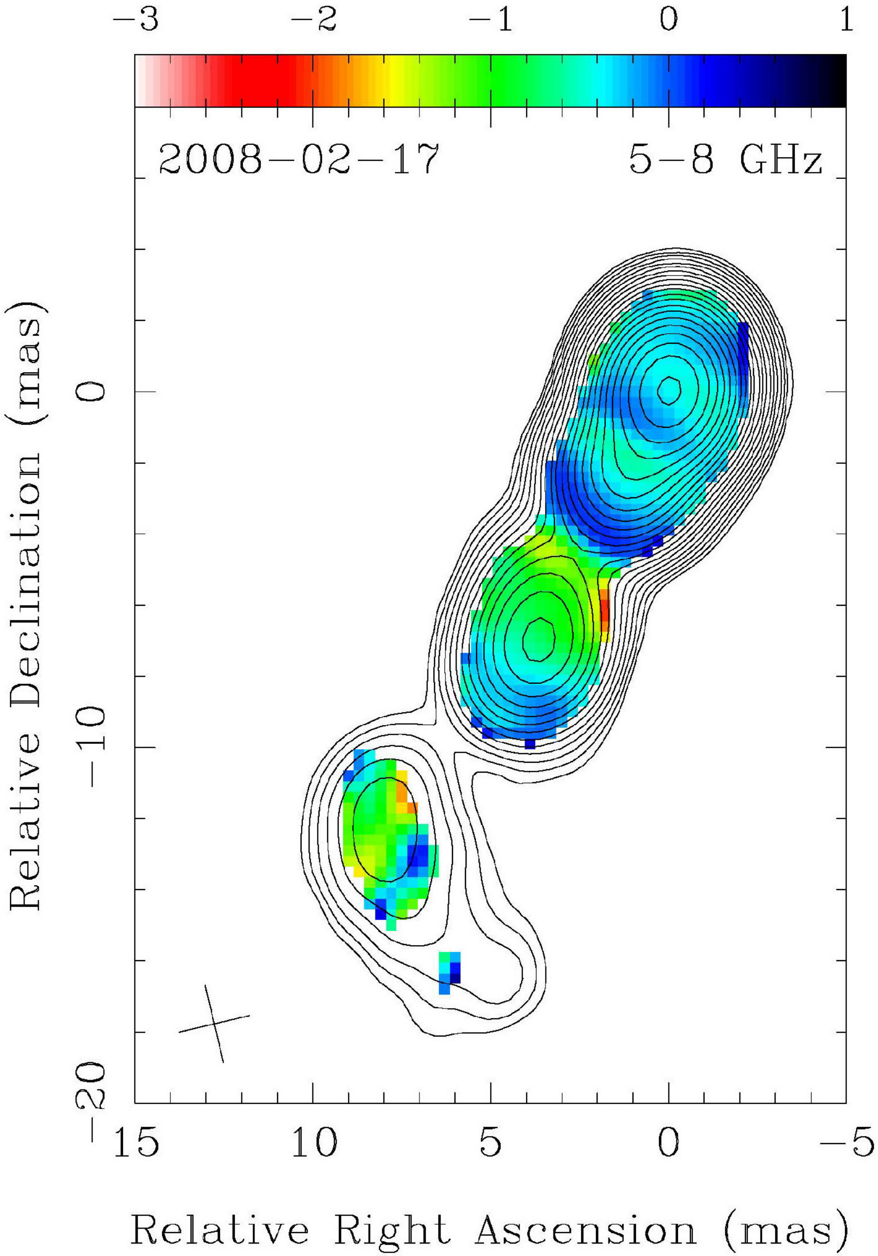
Quasar 0850+581
5-43 GHz first results (February 2008)



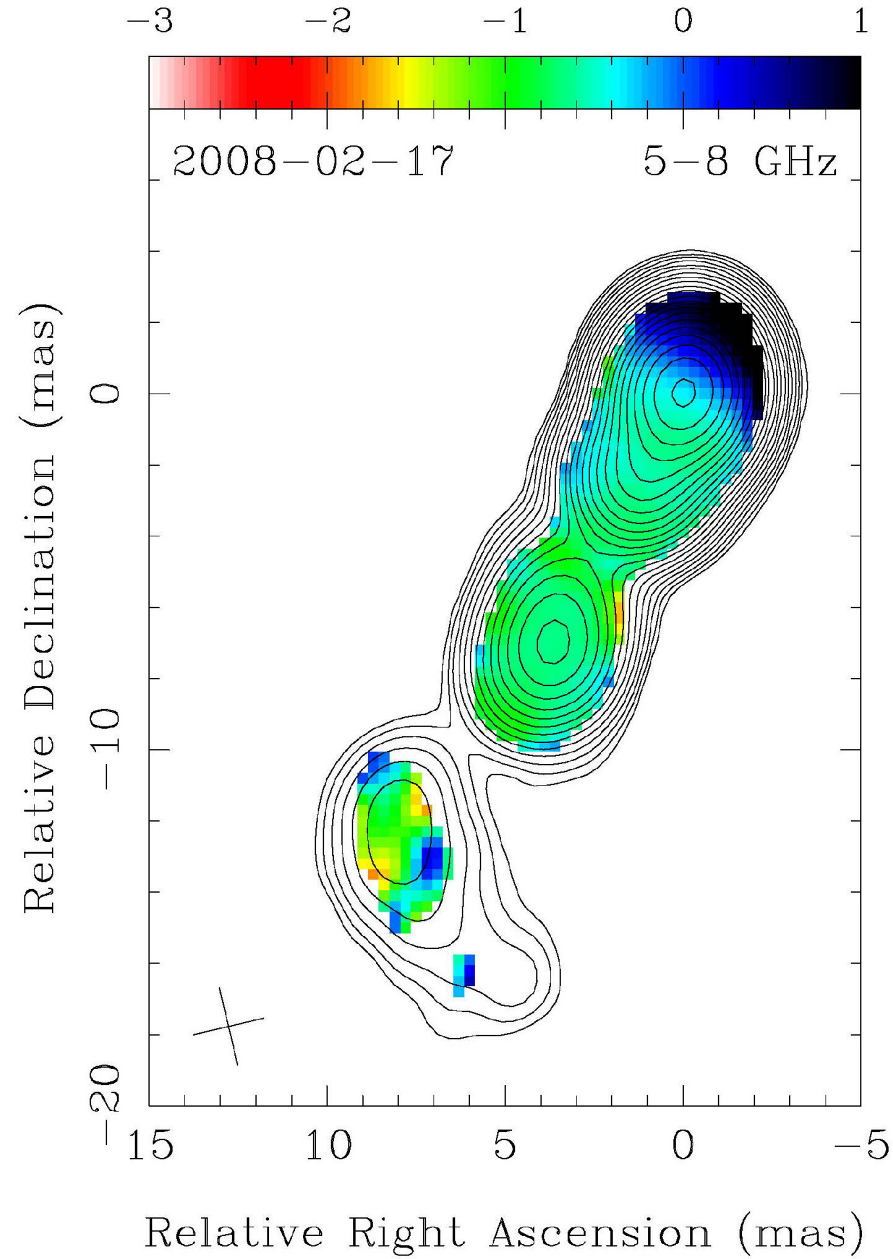
Reference frequency: 43 GHz

Quasar 0850+581: 5-8 GHz

Not corrected for the shift:



Corrected for the shift:



Quasar 0850+581
Intrinsic parameters: first preliminary results

- Distance from the observed core to the black hole: from 17 pc to 5 pc (corresponds to 5-24 GHz)

- Magnetic field at a distance of 1 parsec from the nucleus: B=3.1±0.2 (N_e [cm^{-3}]/1000) G, B_{eq}=2.9±0.7 G.

- Magnetic field in the observed 24 GHz core: B=0.2±0.4 G.

Summary

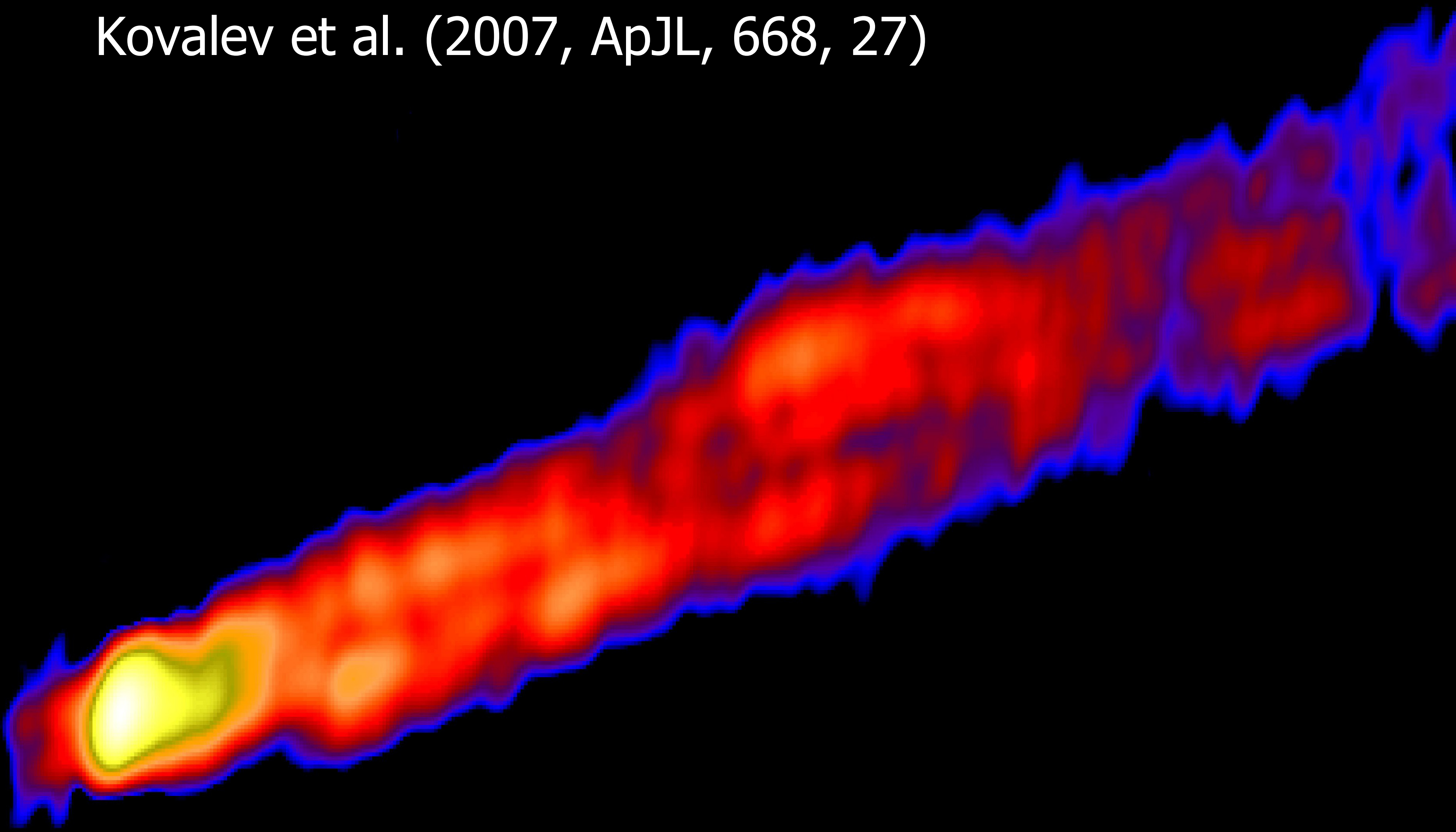
- The nuclear opacity in relativistic jets significantly affects observed positions of compact radio sources. The effect should be taken into account in astrophysicsal applications. Provides a tool to study physics of the compact jet nuclei.

- Application of this effect to the quasar 0850+581 allowed to determine geometry and physics of the inner parsecs of the compact jet.

More to come…

Inner jet of M87 at 15 GHz (VLBA+VLA)

Kovalev et al. (2007, ApJL, 668, 27)



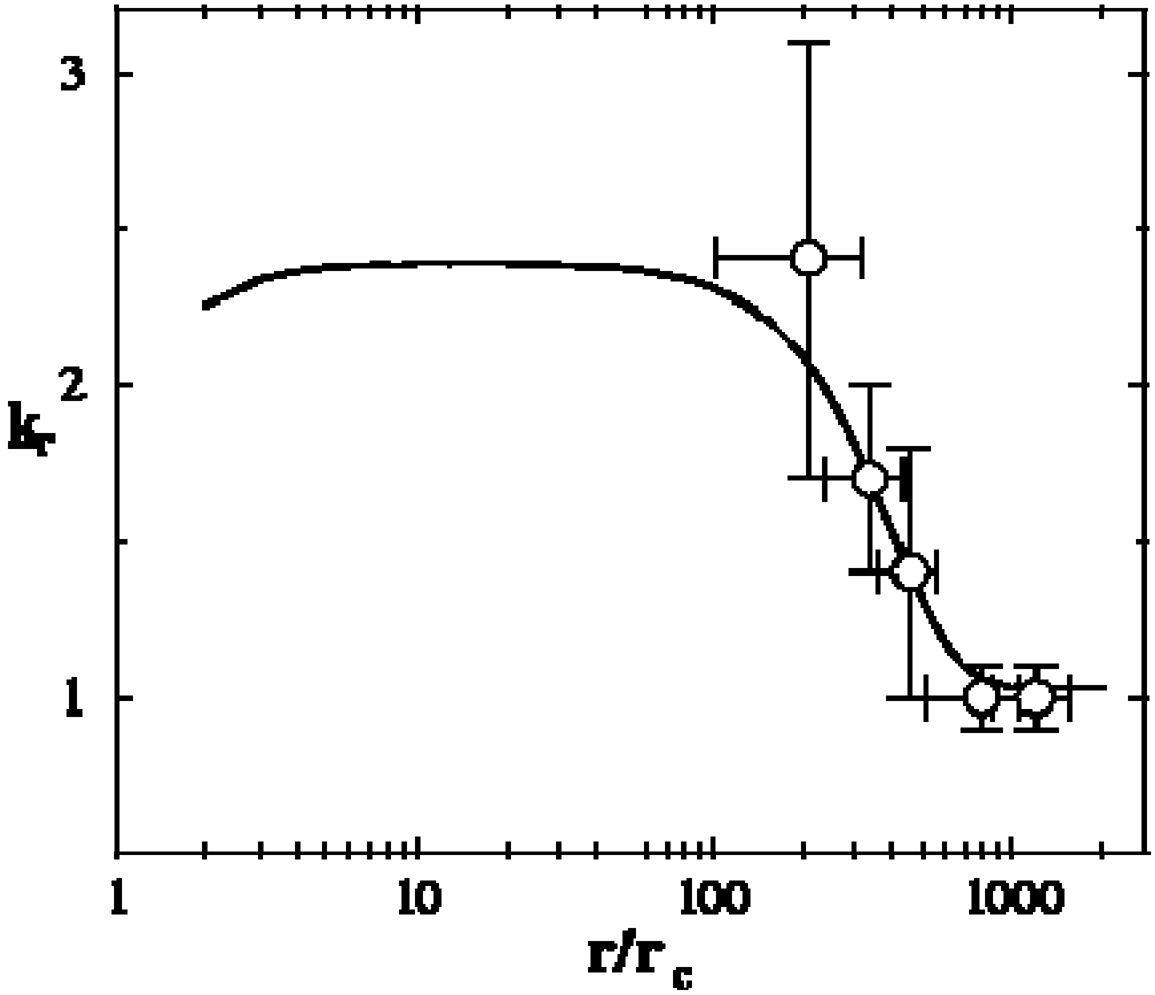

Thank you

Astrometry applications and the core shift

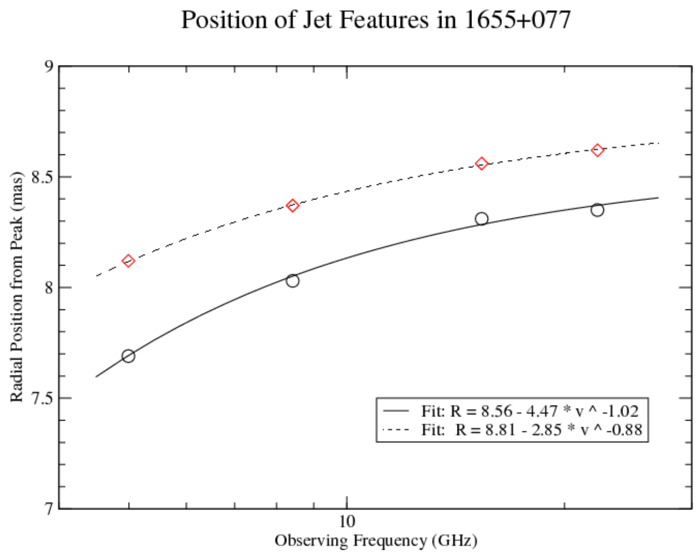
radio-optical reference frame alignment

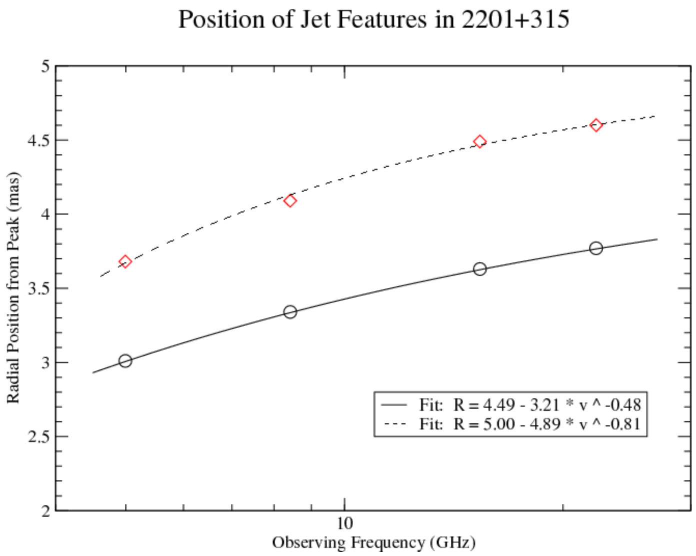
There is potentially a problem.
We have *theoretically* estimated an average shift between the radio (8 GHz) and optical (6000 Å) positions to be around 0.1-0.2 mas for a complete sample of radio selected active galactic nuclei.
The estimated shift exceeds the positional accuracy of GAIA and SIM. It implies that the core shift effect should be carefully investigated, and corrected for, in order to align accurately the radio and optical positions.

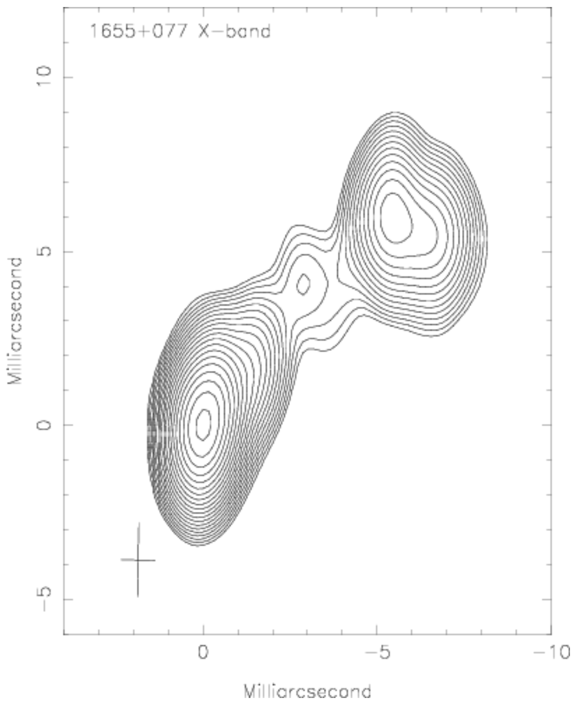
Frequency dependent position shift of the VLBI core: 3C309.1 (Lobanov 1998)

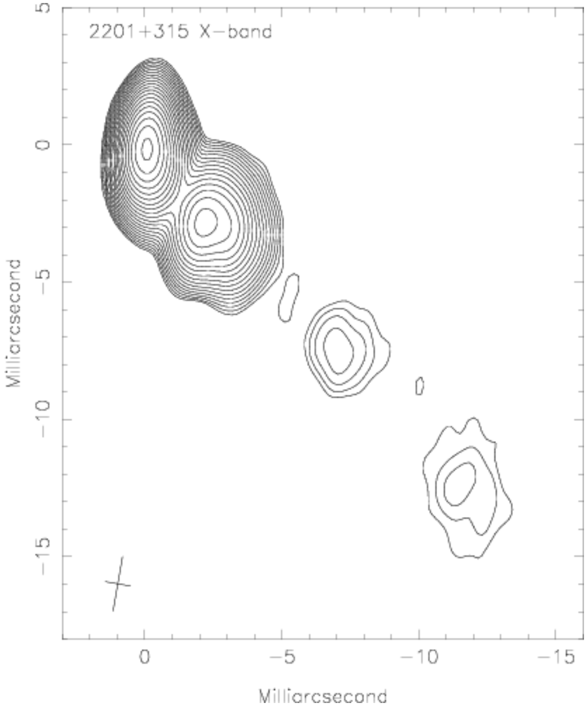


Core-jet separation vs. frequency: 1655+077 and 2201+315



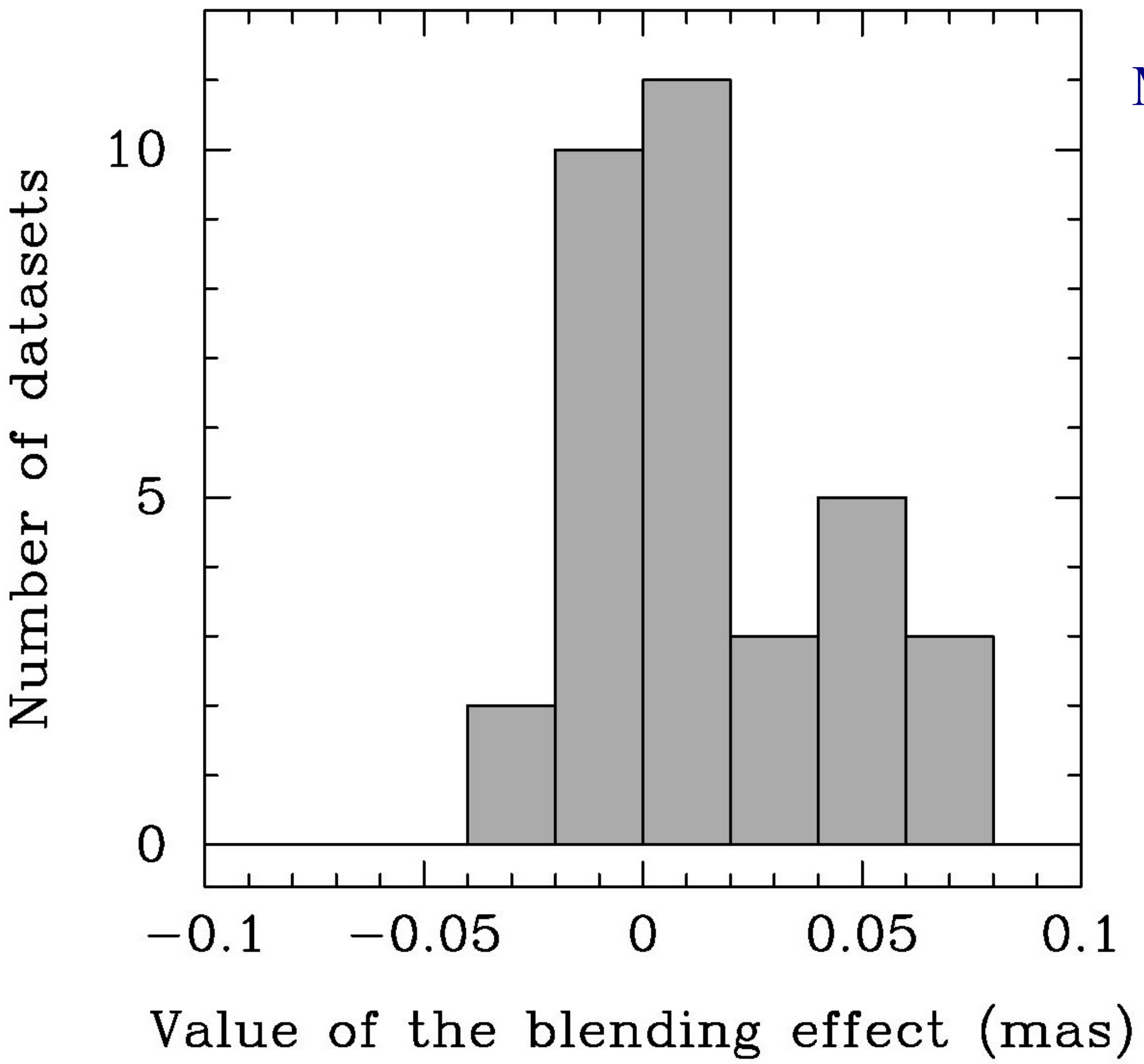






Homan & Kovalev: relative astrometry
+
self-referencing

Blending effect



Median: 0.006 mas

Radio-optical alignment: how to correct for the shift?

1. Multi-frequency VLBI measurements performed simultaneously with GAIA/SIM can be used for calculating the projected optical positions, assuming that the radio and optical emission regions are both dominated by the same spatially compact component. The discrepancies between the measured optical and radio positions can then be corrected for the predicted shifts, and the subsequent alignment of the radio and optical reference frames can be done using standard procedures.

2. A more conservative approach may also be applied, by employing the VLBI observations to identify and including in a Primary Reference Sample only those quasars in which no significant core shift has been detected in *multi-epoch* experiments.

Either of the two approaches should lead to substantial improvements of the accuracy of the radio-optical position alignment.

VSOP-2 nuclear opacity measurements

Goal: to study geometry and physical properties of the jet origins, BLR region, dominating mechanism of flare production, to test radio-optical alignment.

Suggested: (2/5 GHz ground), 8/22/43 VSOP-2, (90 GHz ground) VLBI observations of the nuclear opacity effect.

Targets: best cases selected on the basis of previous results.

Type of measurements: self-referencing and relative astrometry(?).

Type of observations: one epoch vs. monitoring.

Gain from the higher VSOP-2 resolution: higher accuracy. Critical for studies of free-free absorption in BLR regions and flares. Improves accuracy of radio-optical alignment.

By-product: Faraday RM.

Core shift: current study

1. Confirm the measured core-shift values plus get better idea about its variability. A dedicated VLBI experiment is currently underway: deep 1.4, 2.3, 5, 8.4, & 15 GHz VLBA observations of 20 targets. Estimate relativistic jet geometry and intrinsic parameters.

2. Continue to measure core-shifts on the basis of the high dynamic range high quality RDV S/X data. Investigate variability data and dominating mechanism of the flares.

3. Use 4-frequency MOJAVE VLBA observations in 2006 (8.1, 8.4, 12, & 15 GHz) to estimate core-shift values or their upper limits for a complete sample of ~200 bright extragalactic radio sources.