

# Imaging VGOS observations and modeling source structure effects in VGOS

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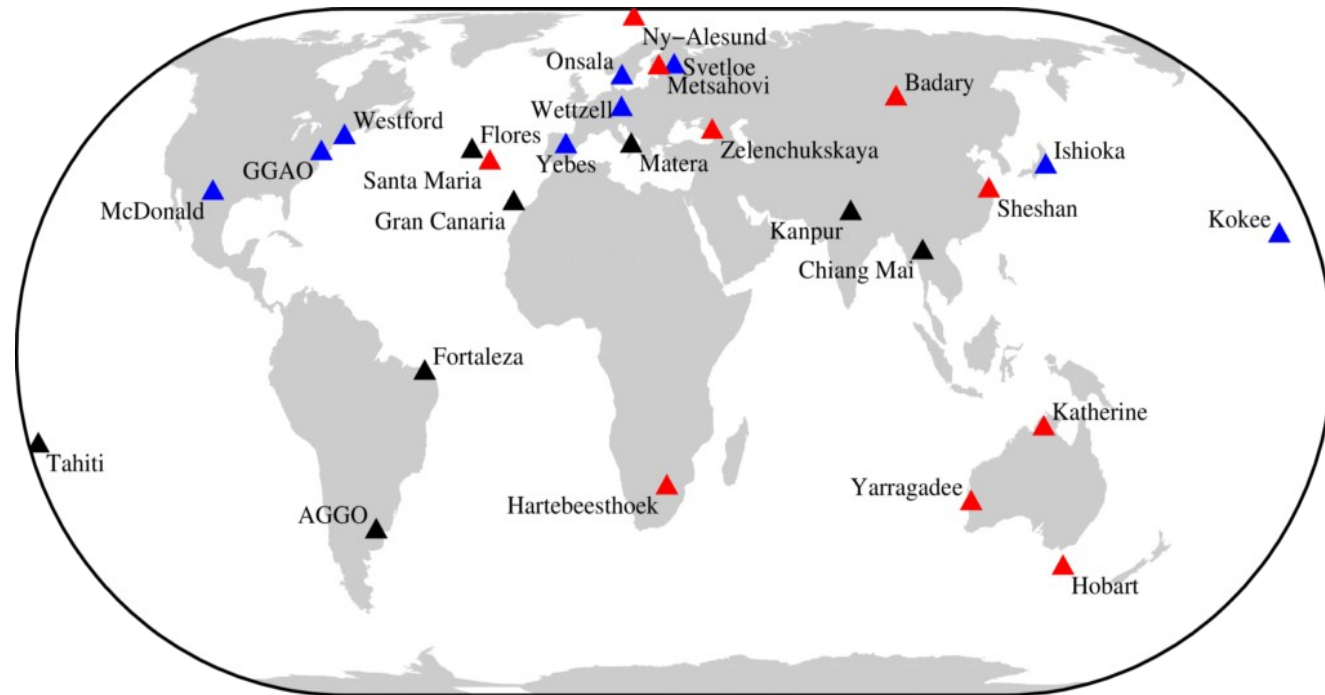
1. GFZ, Germany    2. Aalto Uni., Finland

16<sup>th</sup> EVN Symposium & Users' Meeting

Sep 2-6, 2024, Bonn

# Outlook

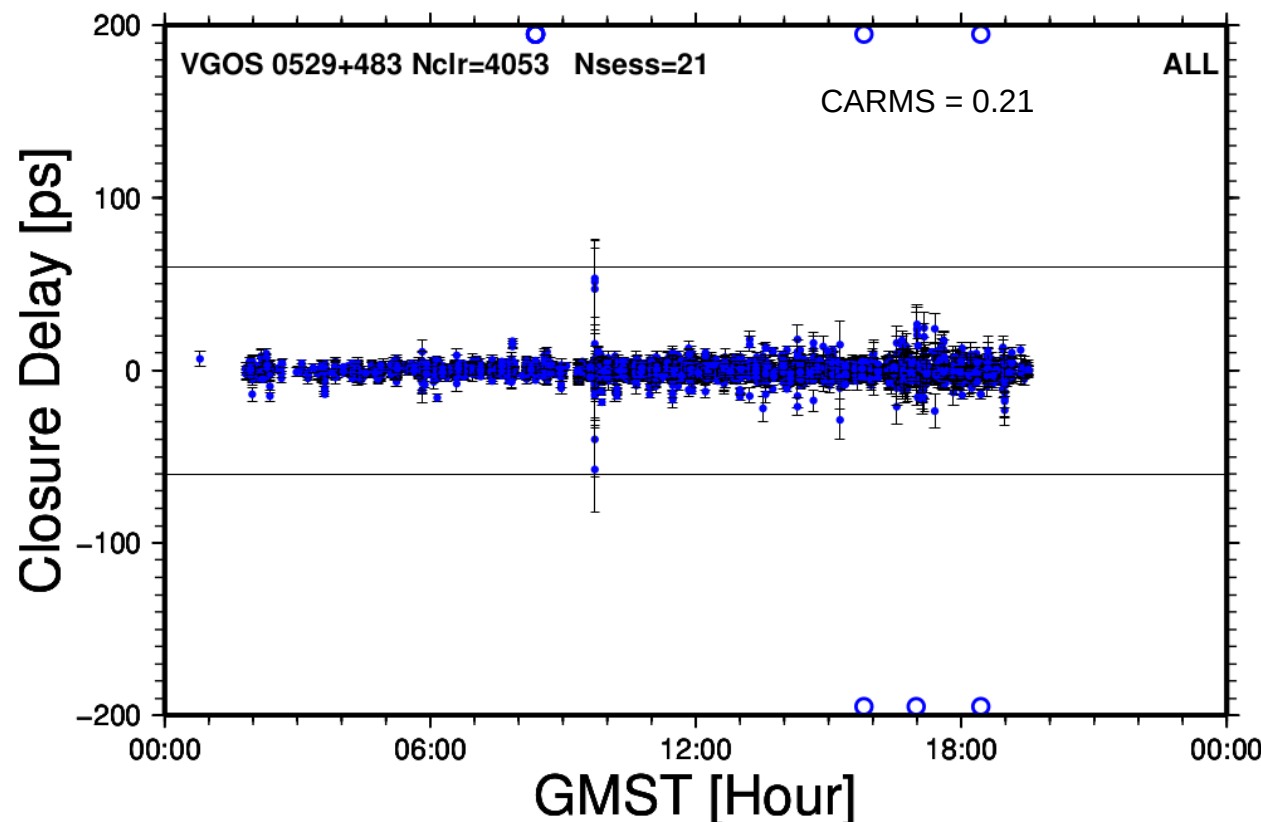
- 1) Geodetic VLBI/VGOS
- 2) Effects of source structure
- 3) Source position variation
- 4) Closure delays
- 5) Conclusion



VGOS network (Behrend, 2020)

# Geodetic VLBI/VGOS

- 177 24-hour experiments
- **Simultaneously** observing at
  - 3.0 – 3.5 GHz
  - 5.2 – 5.7 GHz
  - 6.3 – 6.8 GHz
  - 10.2 – 10.7 GHz
- 13 VGOS antennas/fast slewing
- **Short** scan lengths
  - 7 – 30 seconds
- 370 radio sources

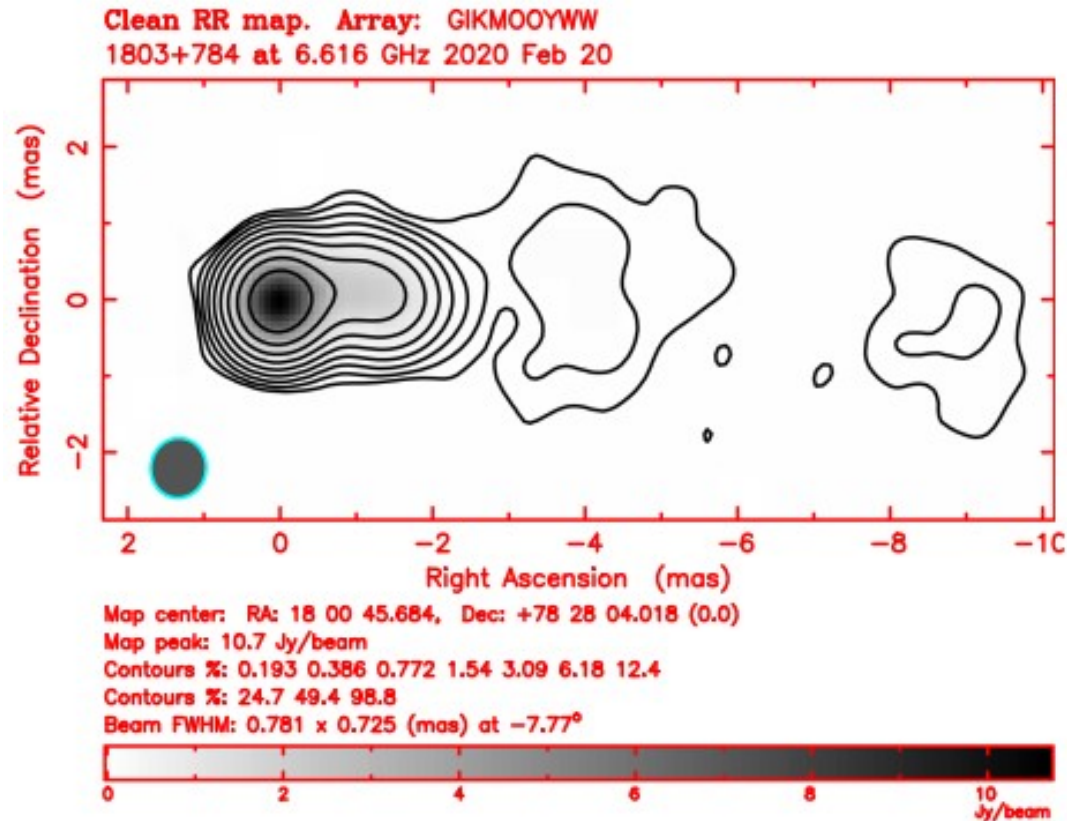


**All of the closure delays of source 0529+483 in 21 VGOS sessions. WRMS = 3.0 ps**

(Niell et al, 2018; Xu et al., 2021)

- **Imaging**
  - Closure phases
  - Closure amplitudes
  
- **Geodetic analysis**
  - Global solution
  - Absolute source positions
  - Position time series
  - Compare with ICRF3 S/X

# Radio loud AGNs observed by VGOS

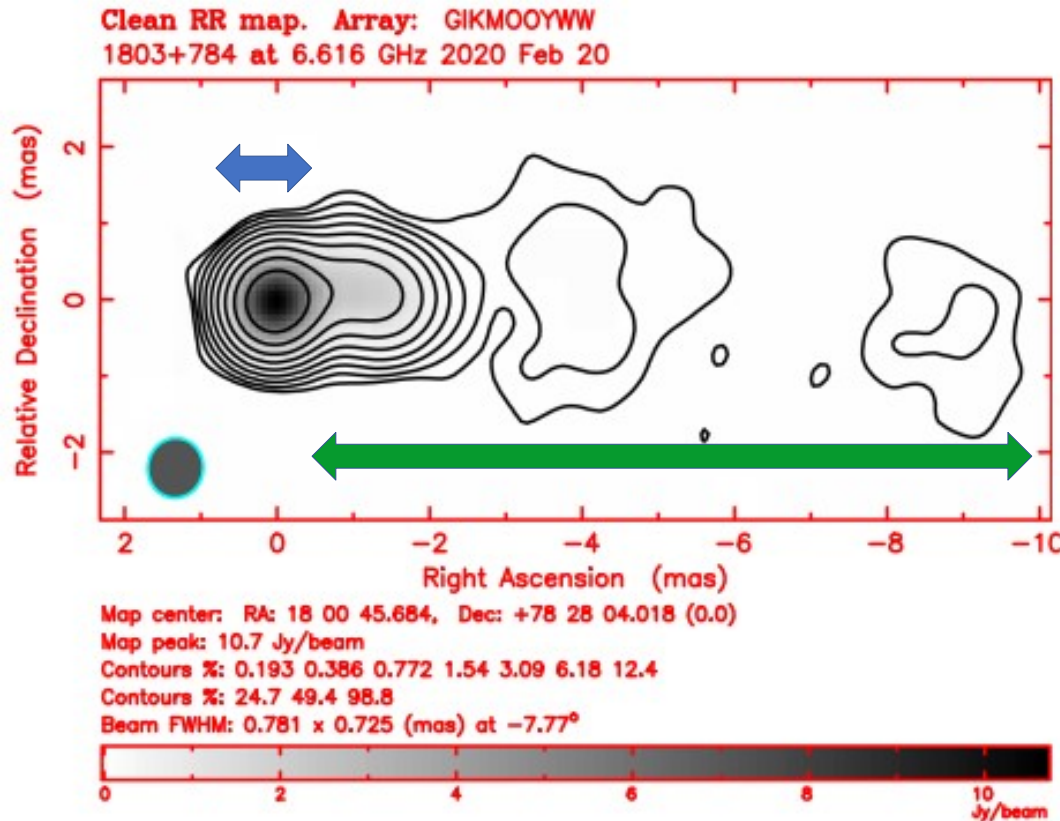


Goal of VGOS:

- Station position: 1 mm
- Source position: 30 micro-arcsecond

Source image of 1803+784 at 6.6 GHz from session VO0051  
(Xu et al., 2021)

# Effects of source structure



Structure causes two major effects:

## 1) Phase center shift

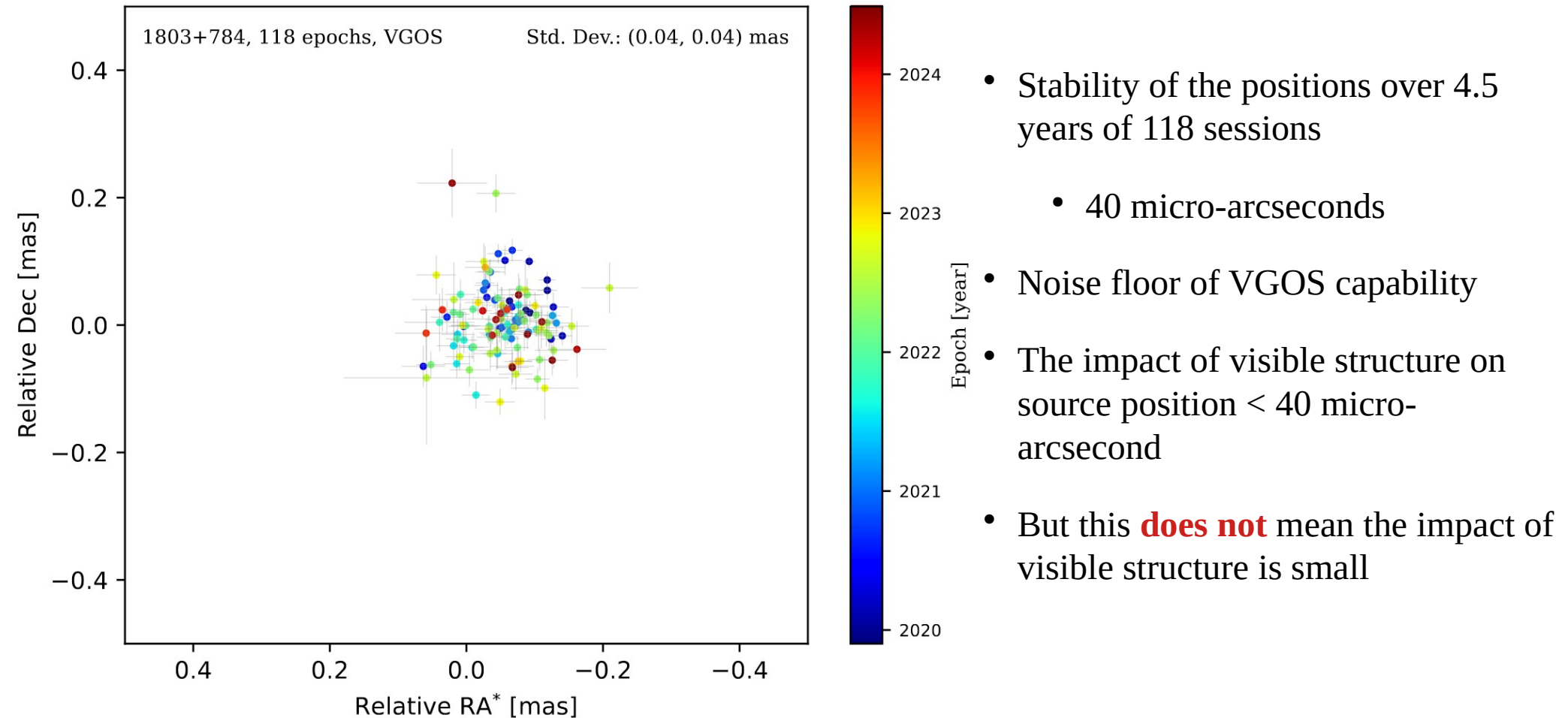
- Structure within the beam – “invisible” (Porcas 2010)
- Source position

## 2) Systematic delay errors

- Extended jet -- “visible”
- Closure delays
- Other geodetic parameters

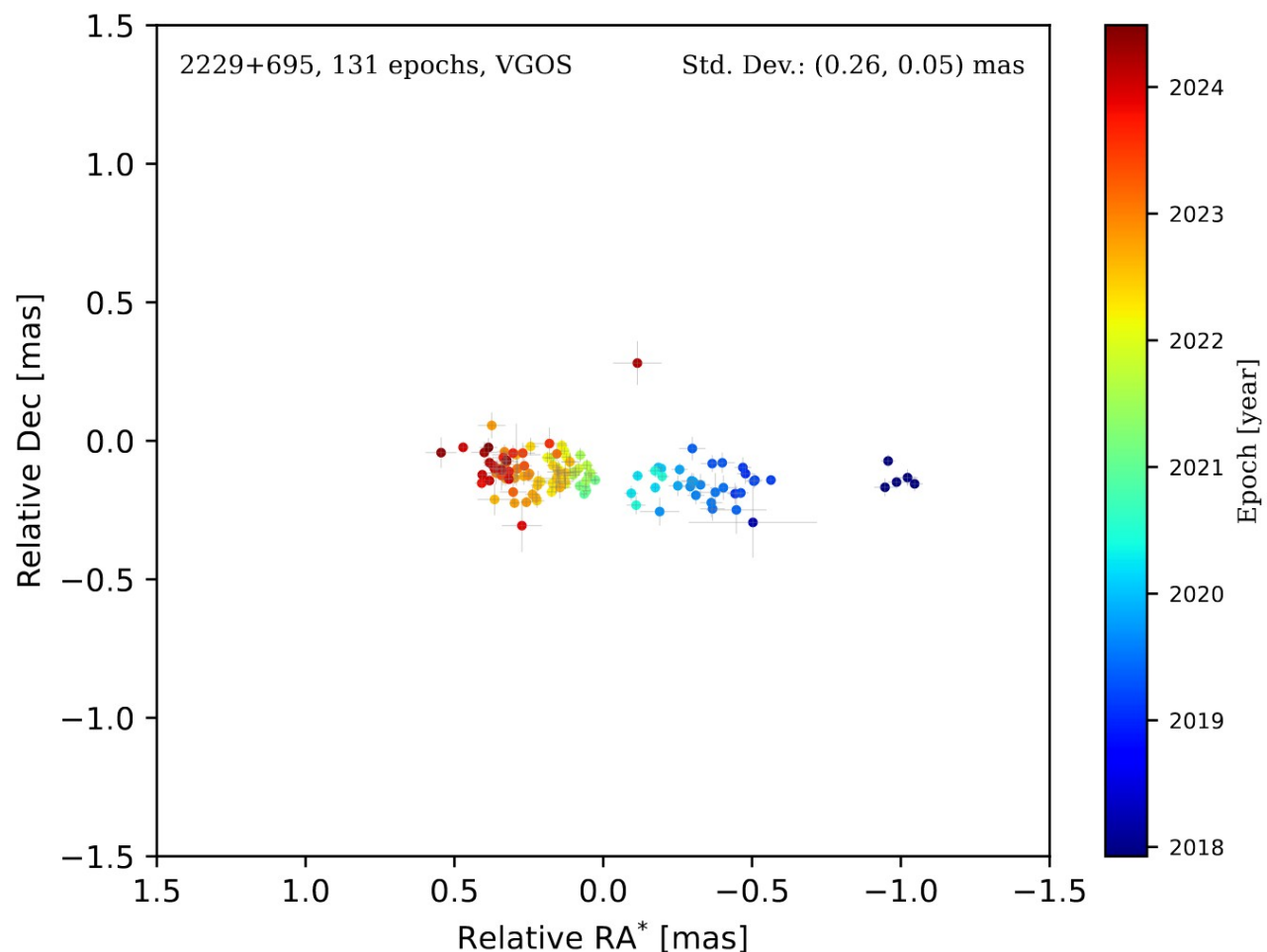
Source image of 1803+784 at 6.6 GHz from session VO0051  
(Xu et al., 2021)

# Source position estimates of 1803+784



Distribution of position estimates of source 1803+784 with respect to the ICRF3 S/X position (Xu, in prep)

# Moving of 2229+695



Source position changes in its jet direction

- Move continuously towards East from 2018 to 2024
- Angular difference 1.6 mas
- Jet dominant structure

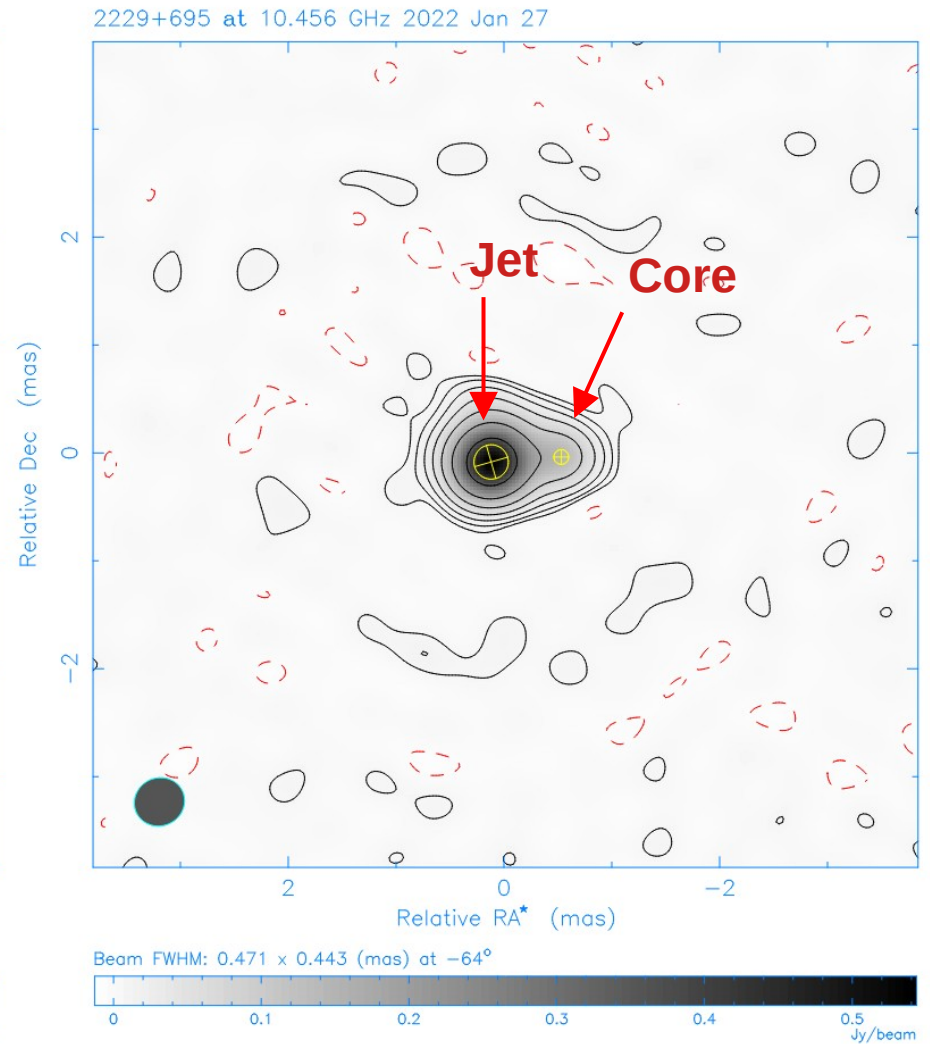
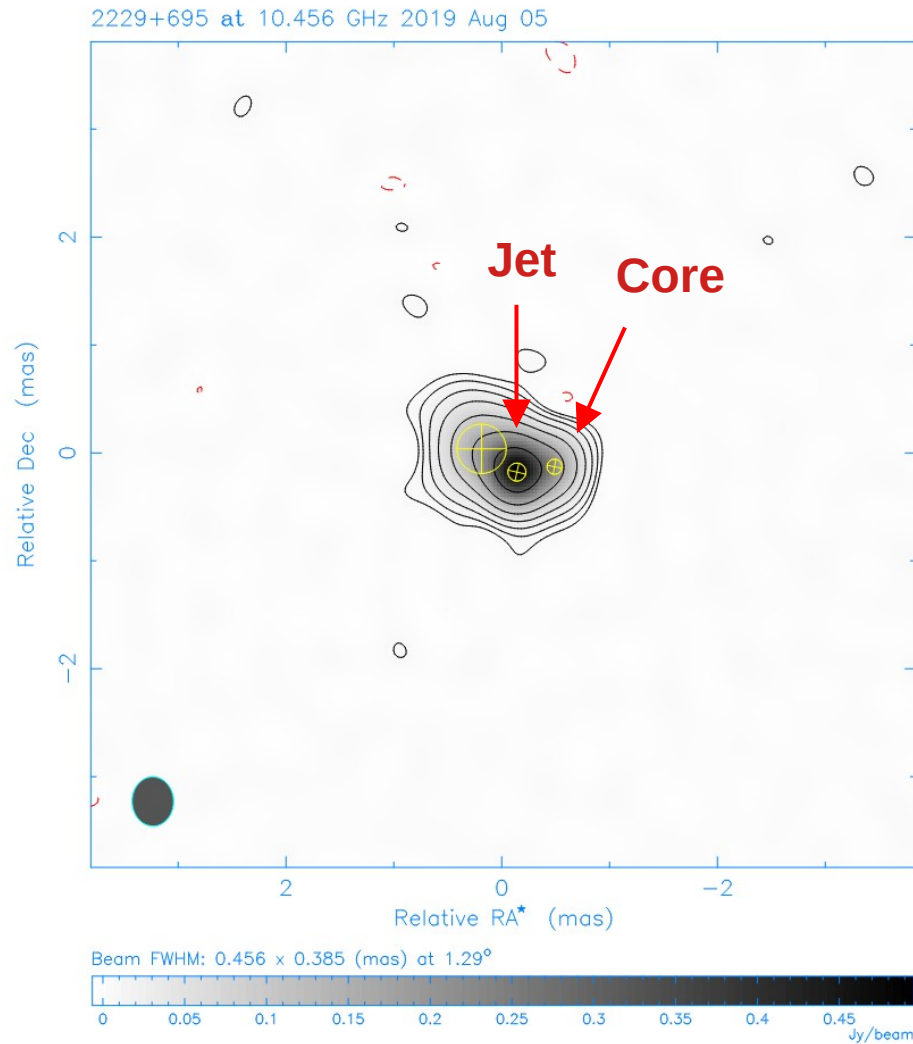
Distribution of position estimates of source 2229+695 with respect to the ICRF3 S/X position (Xu, in prep)



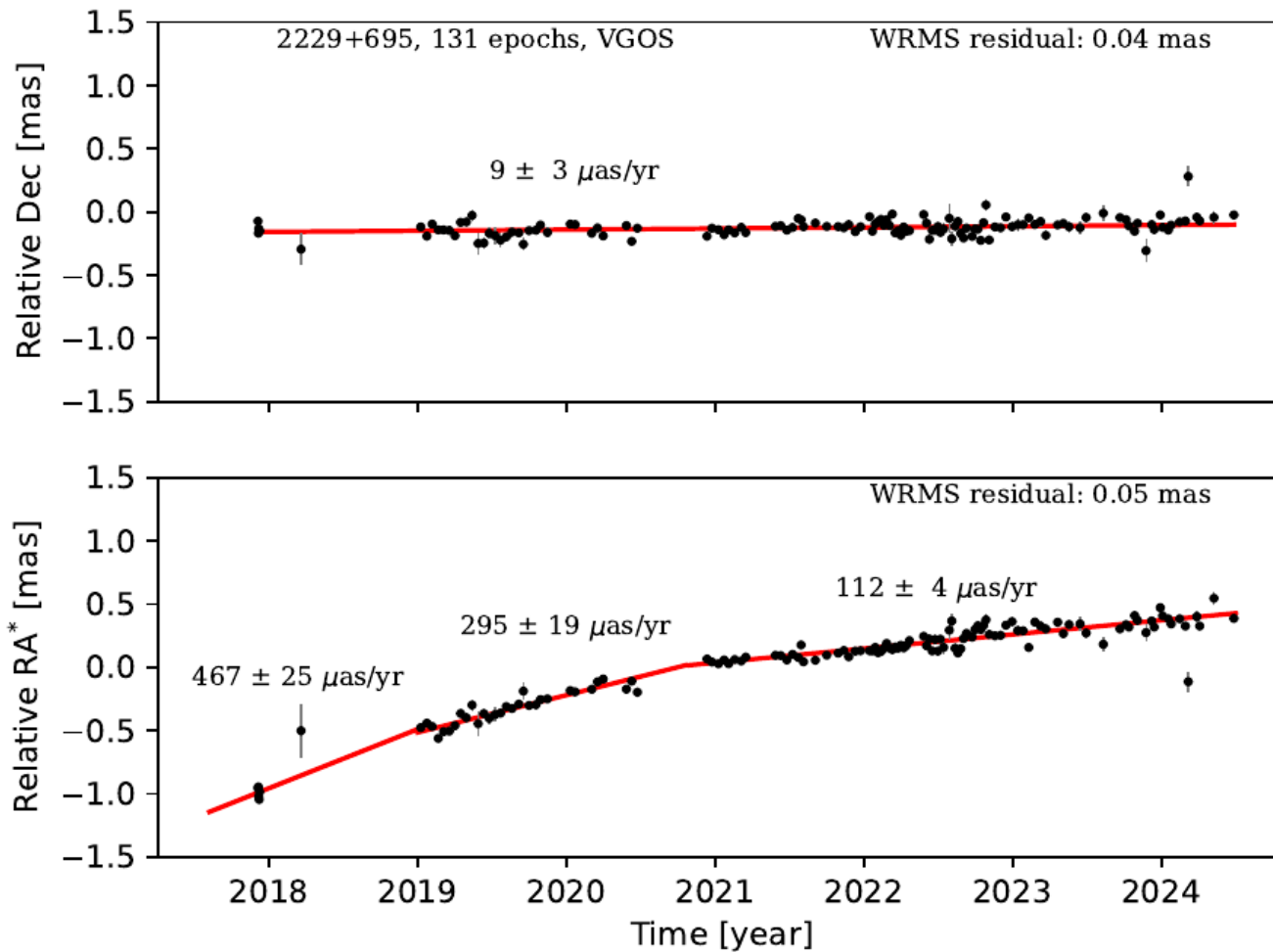
# VGOS Images of 2229+695 at two epochs

2019 AUG 05

2022 JAN 27



# Jet kinematics from absolute astrometry/geodesy



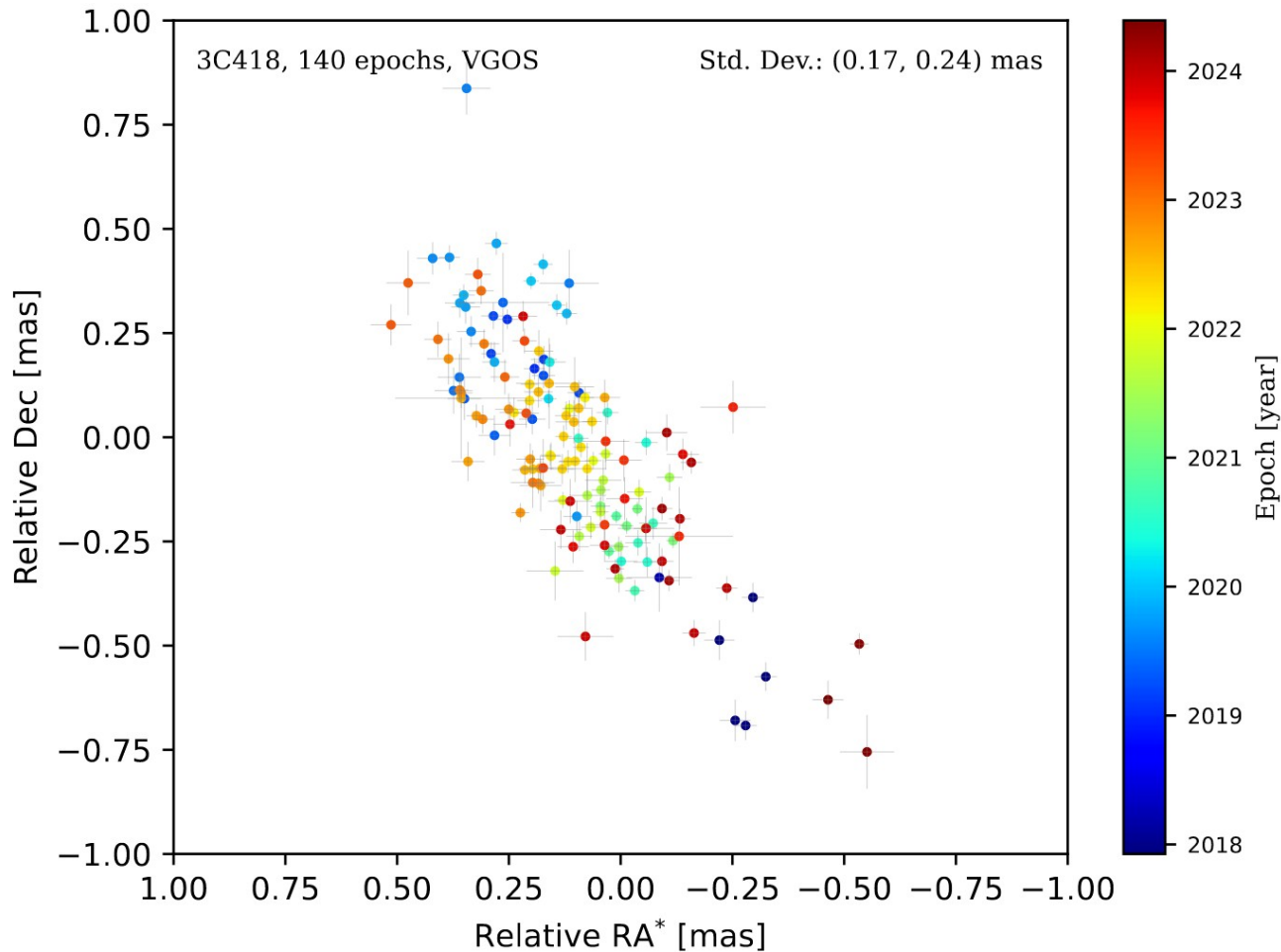
- It is **not** a MOJAVE source

- **Challenge:**  
Align images over time

Position time series of source 2229+695

(Xu, in prep)

# Positions of 3C418

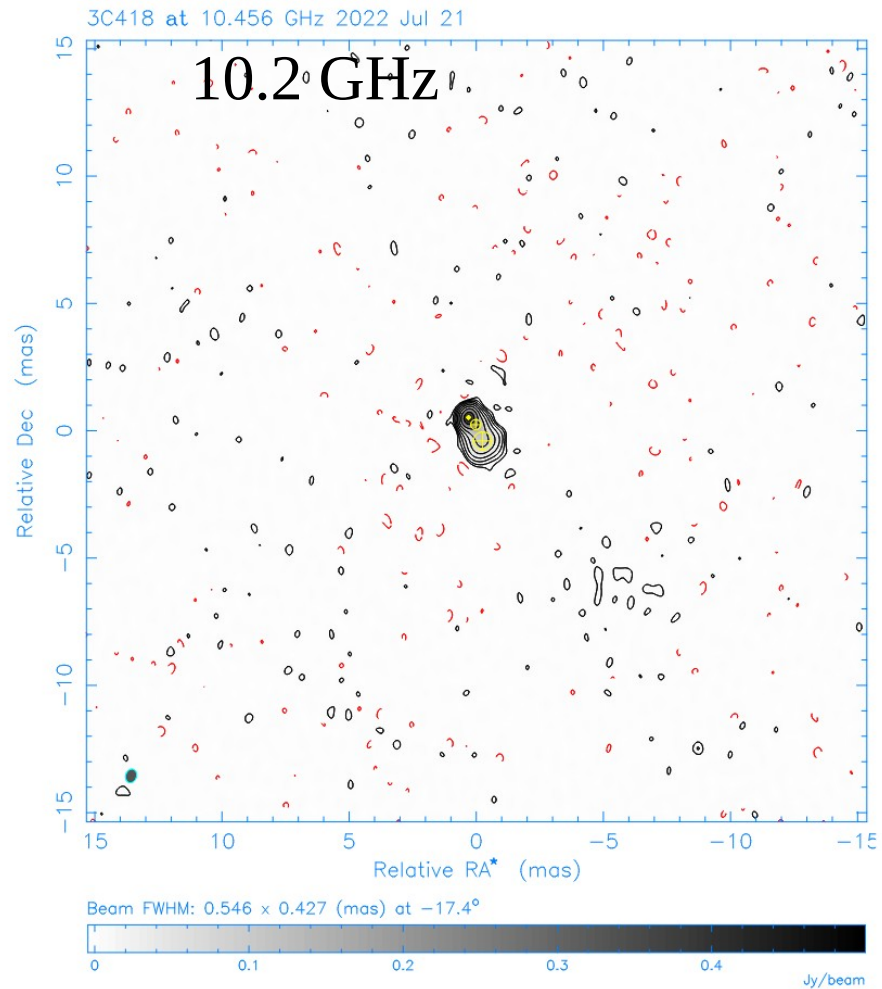
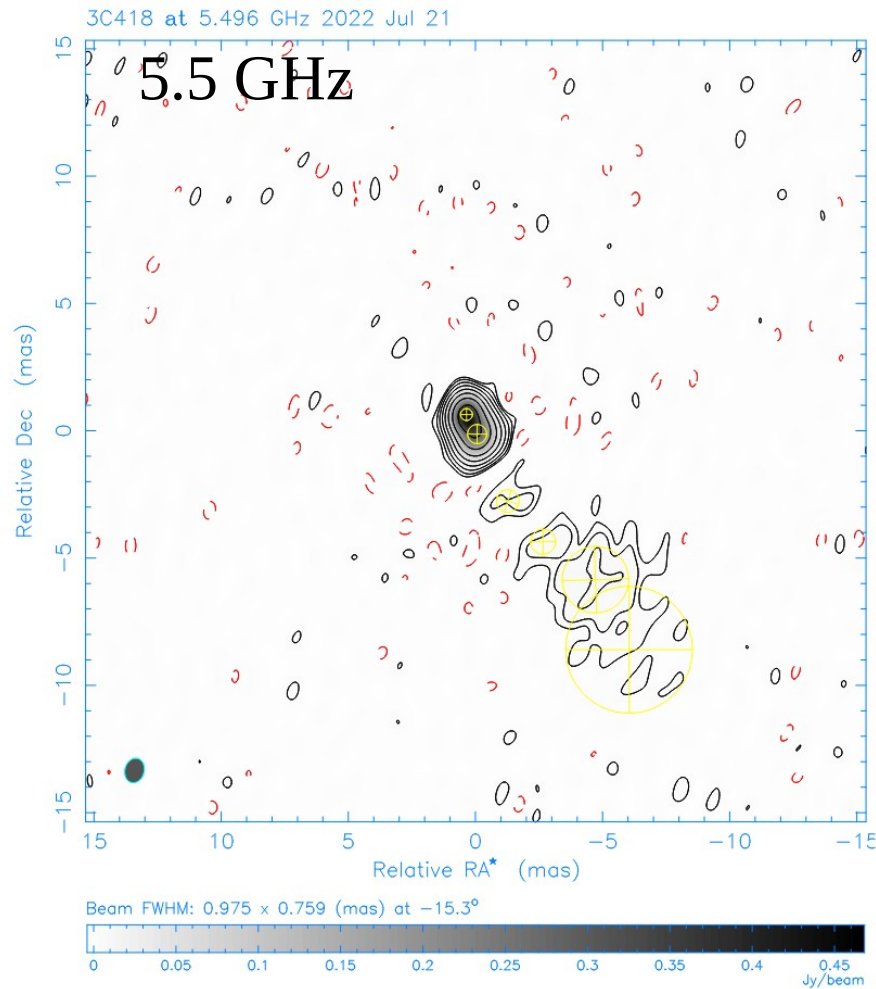


- Source position changes in its jet direction
  - Move towards east-north and west-south back twice from 2018 to 2024
  - Angular difference 1.1 mas
  - Typical behavior due to within beamsize structure

Distribution of position estimates of source 3C418 with respect to the ICRF3 S/X position

(Xu, in prep)

# VGOS images of 3C418 at two frequencies

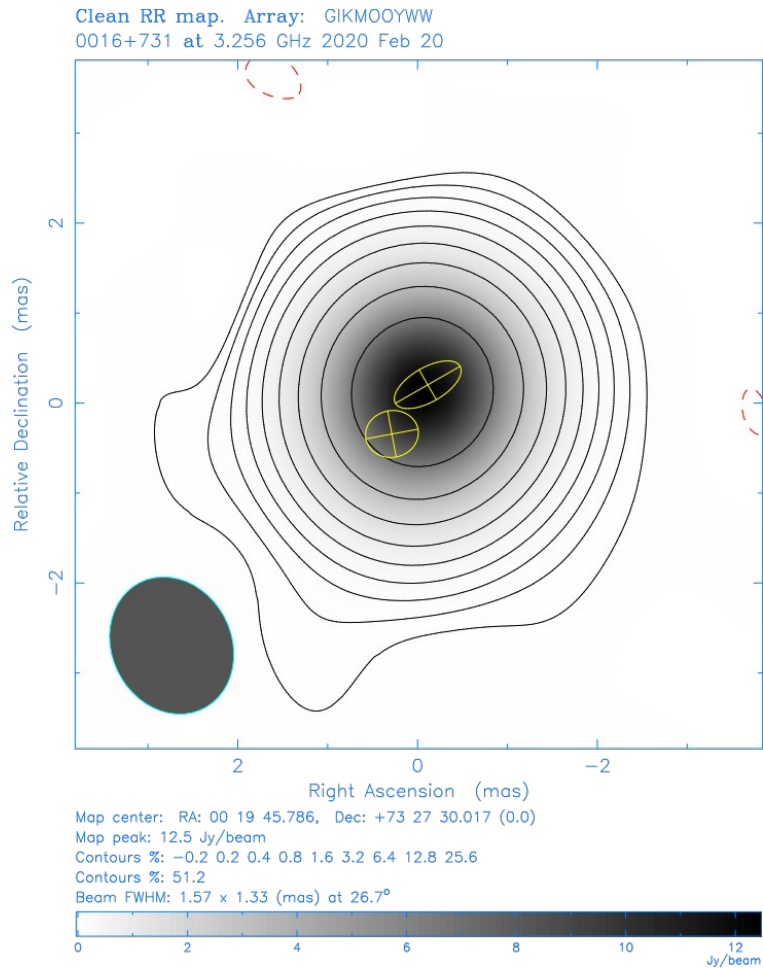


**Challenge: align images over four frequency bands**

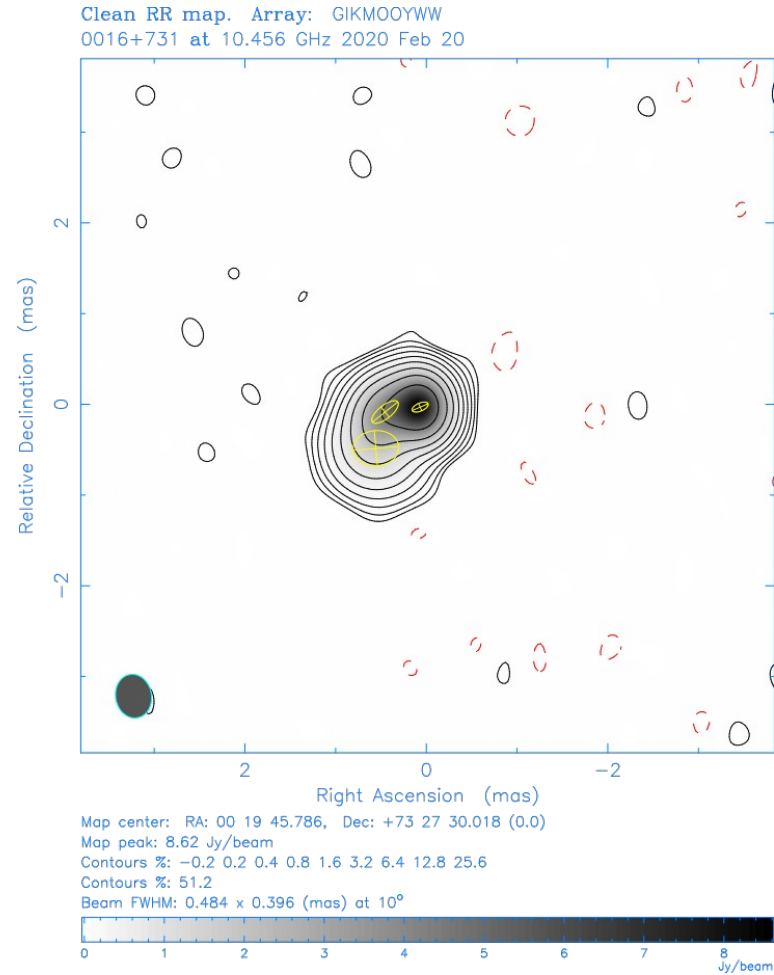
- **Beam size changes**
- **Core shift**

# VGOS images of 0016+731 at two frequencies

## 3.3 GHz



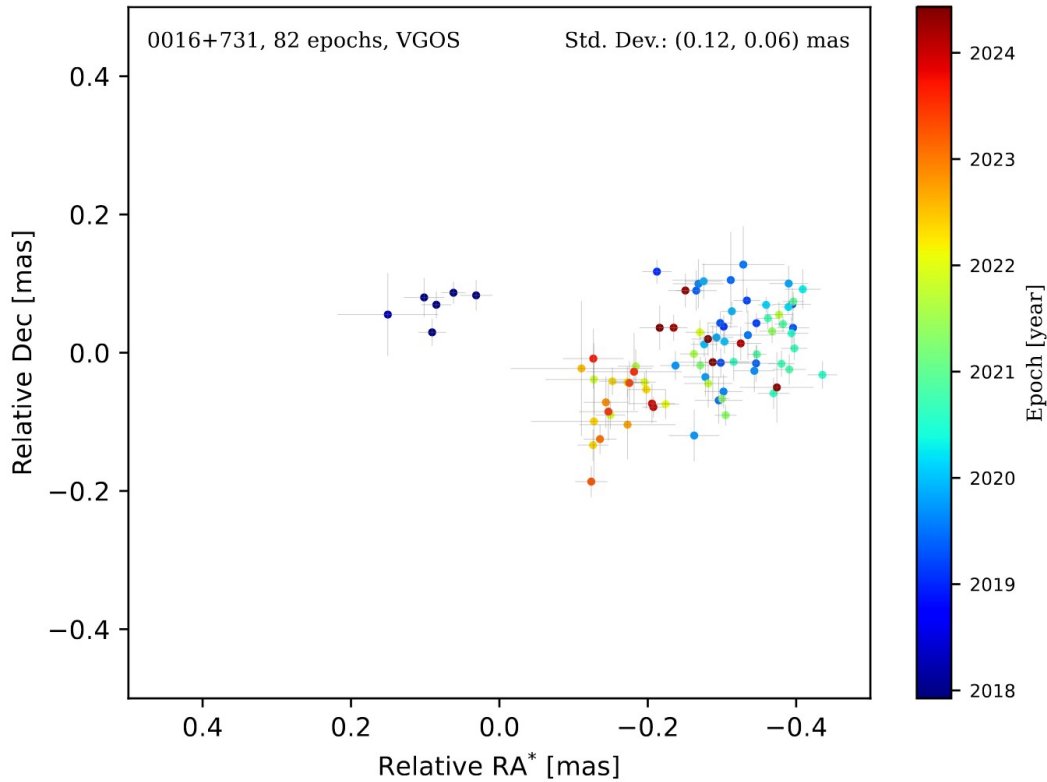
## 10.2 GHz



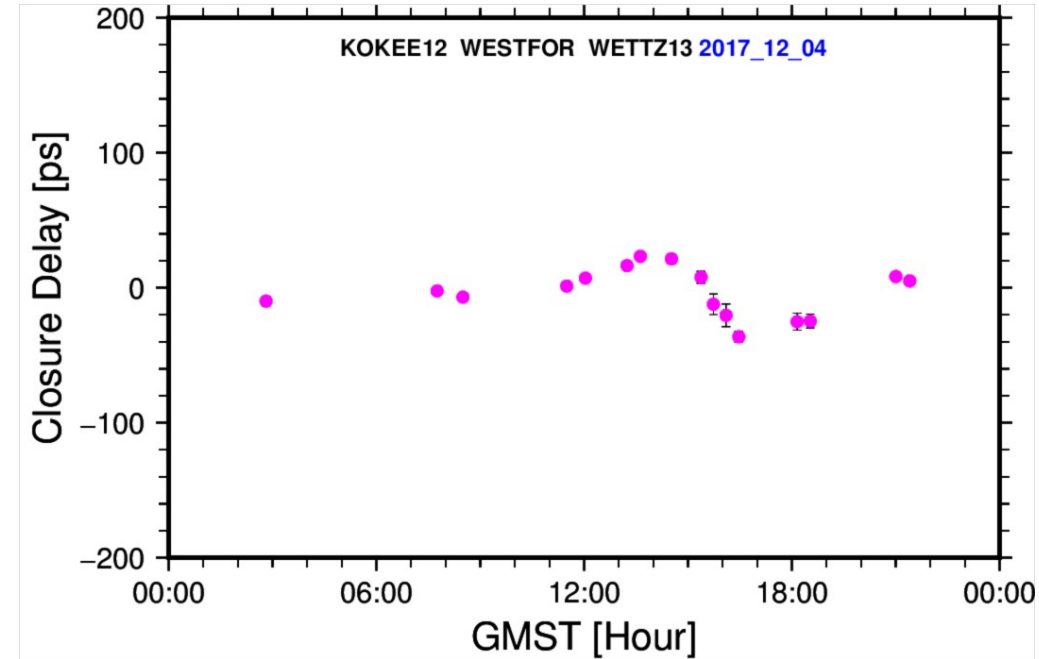
(Xu, et al., 2021)

# Two types of effects due to structure

## Impact of “invisible” structure



## Impact of “visible” structure



Source position variation @ 0.6 mas

Closure delays @ 100 ps

## Conclusion and outlook

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- 1) Source structure effects become more prominent
- 2) 40 micro-arcsecond @ source position from VGOS
- 3) Two major effects due to structure:
  - Source position variations
    - In-beam structure @ 0.2 – 0.6 mas
    - Jet dominant @ > 1 mas
  - Larger scale structure @ station-based parameters
- 4) We have a group at the GFZ to solve this challenge

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**Thank you very much!**

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**We are hiring!**

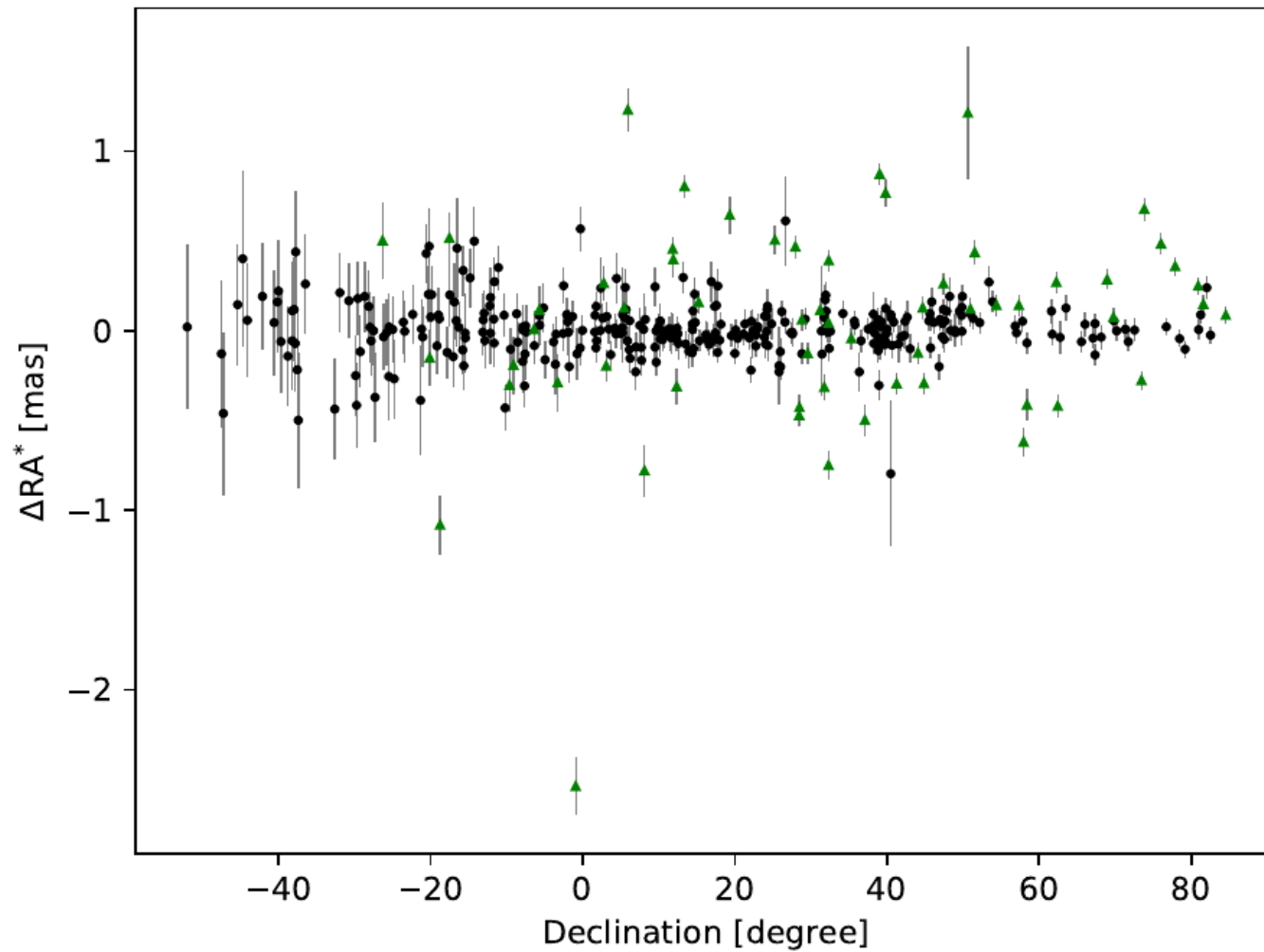
<https://www.gfz-potsdam.de/en/career/job-offers/details/9403>



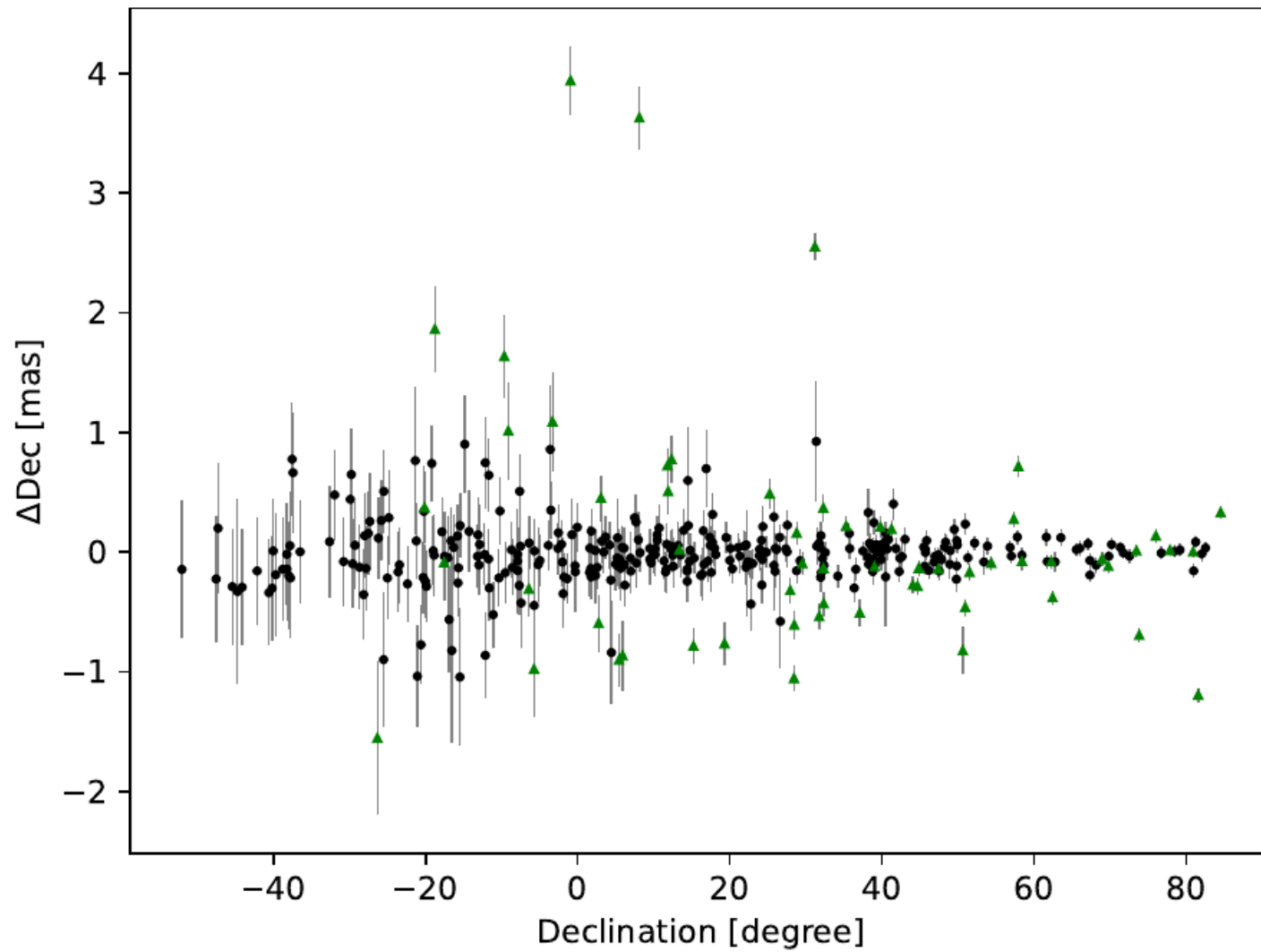
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Position differences in RA\* between VGOS and ICRF3



Position differences in Dec between VGOS and ICRF3