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IMAGING, MODELFITTING & SOURCE STRUCTURE CORRECTIONS FOR THE K-BAND (24 GHz) CELESTIAL REFERENCE FRAME

ABSTRACT

The K-band VLBA celestial reference frame program, that is supported through the USNO's 50% timeshare allocation, has so far provided high-resolution VLBI images for more than 730 AGN sources at up to 87 epochs. A detailed analysis of the images has allowed us to determine several quantities that provide useful indicators of the quality of each image and the suitability of each source as a calibrator or reference source. In addition, modelfitting has allowed us to determine, for each image, the angular size and radial extent of the brightest and second brightest component and the position angle between them as well as estimates of the overall extent and direction of the source structure. While VLBI images of CRF sources show that, in general, they appear more compact at K-band (24 GHz) than at X-band (8.4 GHz), they can still exhibit measurable extended emission at K-band. We started a project to apply structure corrections directly to the data during the analysis process using updated models of the source structure. This is possible because of readily available VLBI images from our dedicated K-band CRF observing campaigns to map and monitor the source structure. We will present an overview of our image analysis and plans to investigate the impact of source structure using all available K-band CRF sources.

Current K-band CRF Status

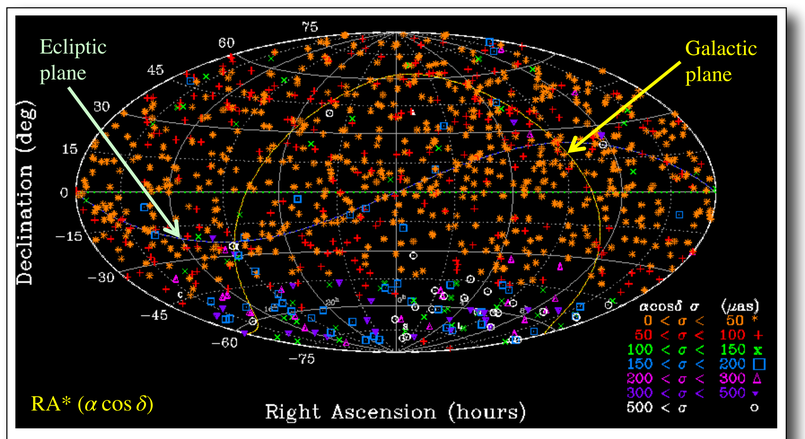


Fig. 1 Sky distribution of 1038 CRF sources from 2 million observations at 24 GHz
Median precision in RA/Dec is 47/80 μas (for 975 sources in common with S/X-band).
Astrometric solution D. Gordon: K-usno-230110 (2002-2023)

Current Imaging Status

> Imaged all K-band VLBA sessions between Jul 2015 and Jan 2023 *(de Witt et al., AJ, 2023)*

- 87 epochs, 1-2 x 24-hr sessions/month
- 1-3 scans/source, 90-120 sec integration time/scan
- about 250 sources/session, over 500 scans/session
- images for more than 730 sources

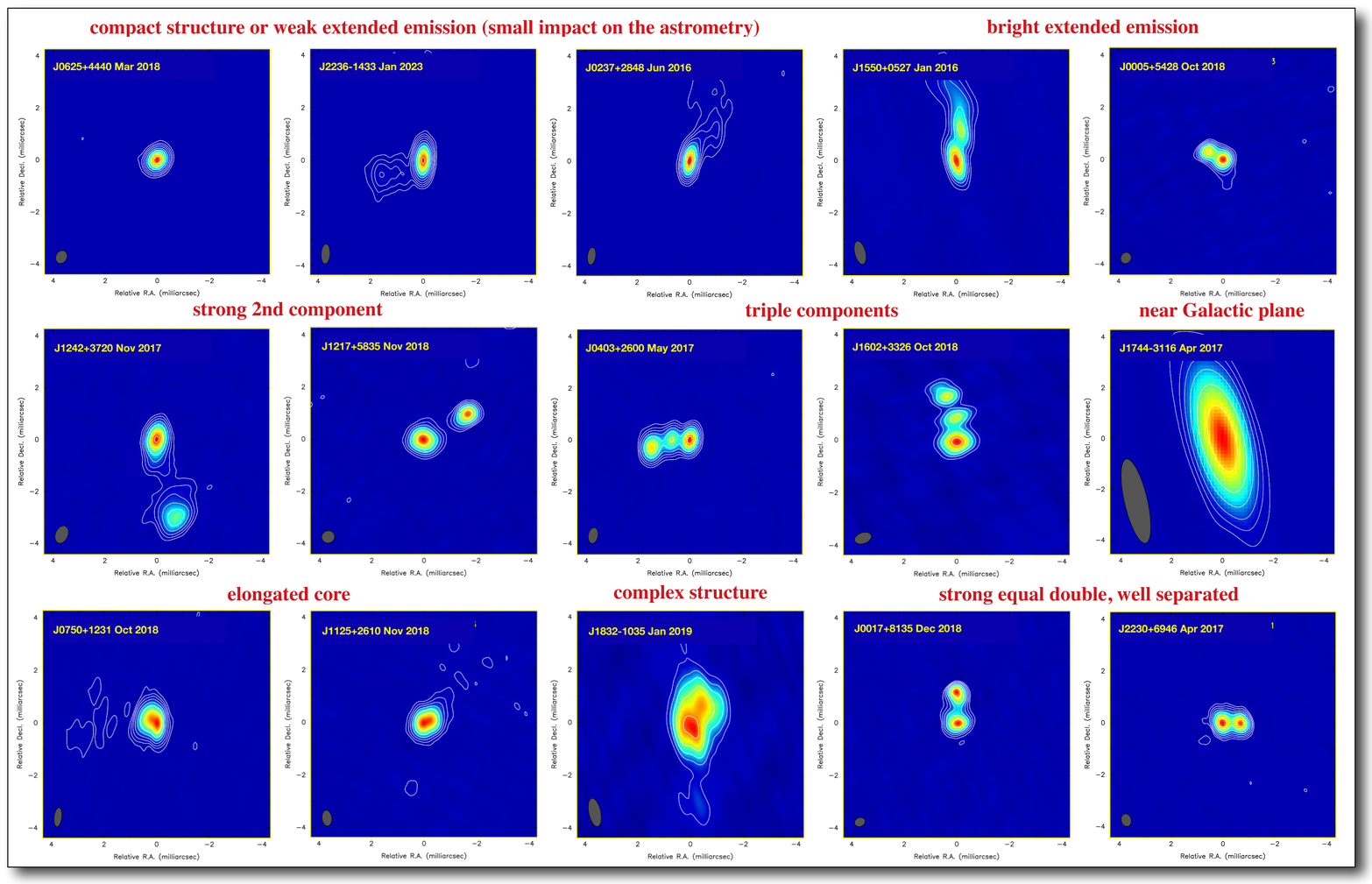
KP down from 2022 Nov 18 to 2023 Jan 06 due to wildfire

SC down from 2017 Sep 17 to 2018 Mar 03 due to hurricane damage

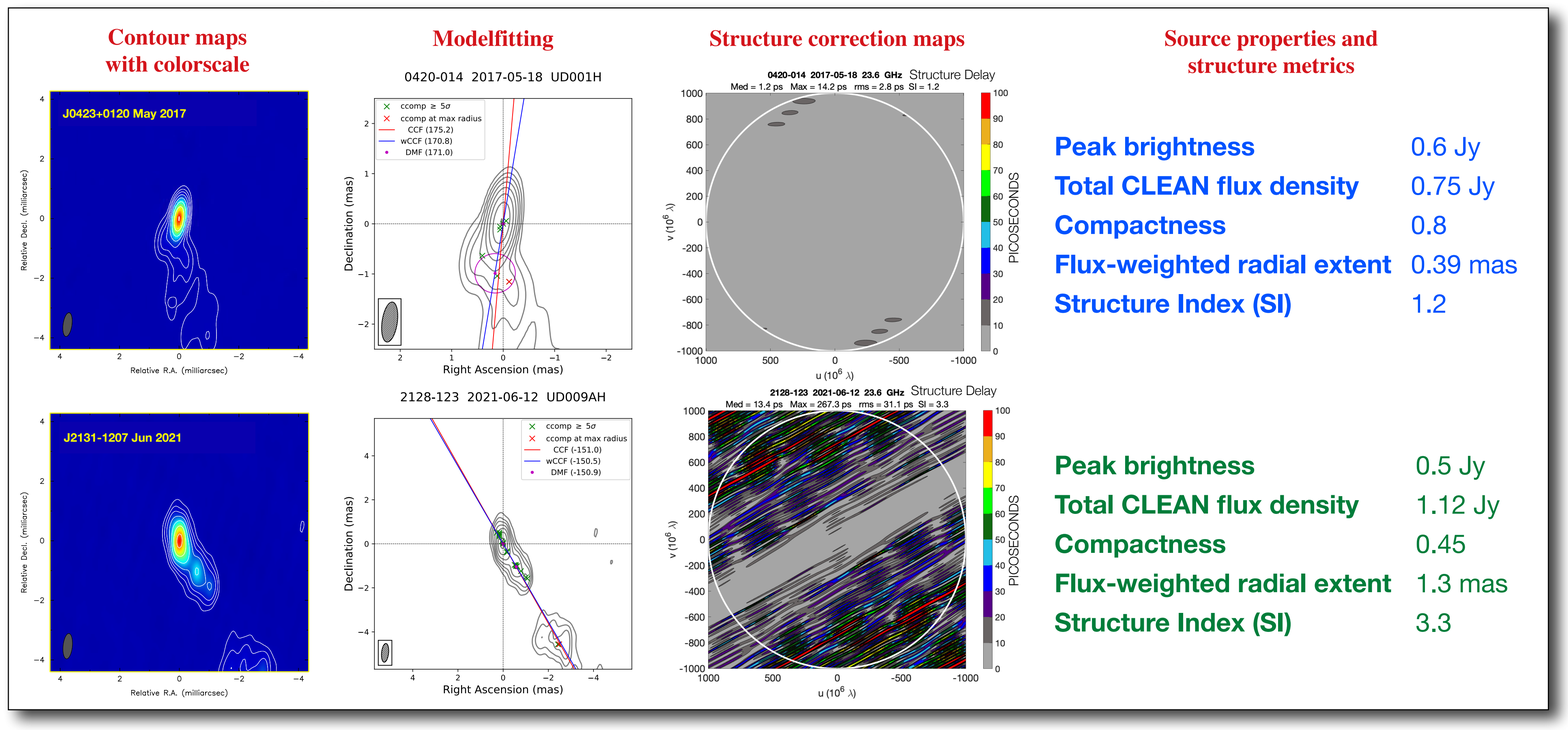
Fig. 2 Distribution of the ten 25-m antennas of the Very Long Baseline Array (VLBA)
http://www.vlba.nrao.edu/

K-band Source Structure

VLBA images of ICRF sources at K-band (24 GHz)
(First 28 epochs, de Witt et al., AJ, 2023)



Modelfitting & Structure Metrics



Peak brightness	0.6 Jy
Total CLEAN flux density	0.75 Jy
Compactness	0.8
Flux-weighted radial extent	0.39 mas
Structure Index (SI)	1.2

Peak brightness	0.5 Jy
Total CLEAN flux density	1.12 Jy
Compactness	0.45
Flux-weighted radial extent	1.3 mas
Structure Index (SI)	3.3

- **Calibration and imaging:** AIPS *(Greisen 2003)* & DIFMAP *(Shepherd 1997)*
- **Modelfitting to calibrated visibilities:** fit core & 2nd brightest comp. by least squares using DIFMAP
- **Modelfitting to CLEAN comp. locations:** estimate overall extent & direction of structure by fitting a line through CLEAN comp. locations using PYTHON
- **Structure analysis:** determine compactness, radial extent, structure index and the variability of each over time
- **Source structure corrections:**
  1. quantify structure & variability of K-band sources
  2. quantify effect of source structure on K-band CRF
  3. implement model in VieVS to correct for source structure

Producing a CRF with structure corrections applied to all sessions would be a worldwide first!

Source Variability

NRAO140 variability plots over 73 epochs