The Position Stability of Four ICRF2 SOURCES (Observations and Results)

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Motivation

Two years ago we decided to monitor the structure and position of a few radio sources over a year in order to

1. Estimate the possible change of ICRF2 positions caused by source structure evolution and frequency dependence now that this error contribution is becoming significant with the improved ICRF2 catalog.

2. Expected accuracy and problems of tying radio ICRF2 grid to the optical GAIA/SIM grid using the precise location of the cores. Also, important information on jet physics.

We have had 10 VERA and VLBA sessions to determine the stability of the sources.

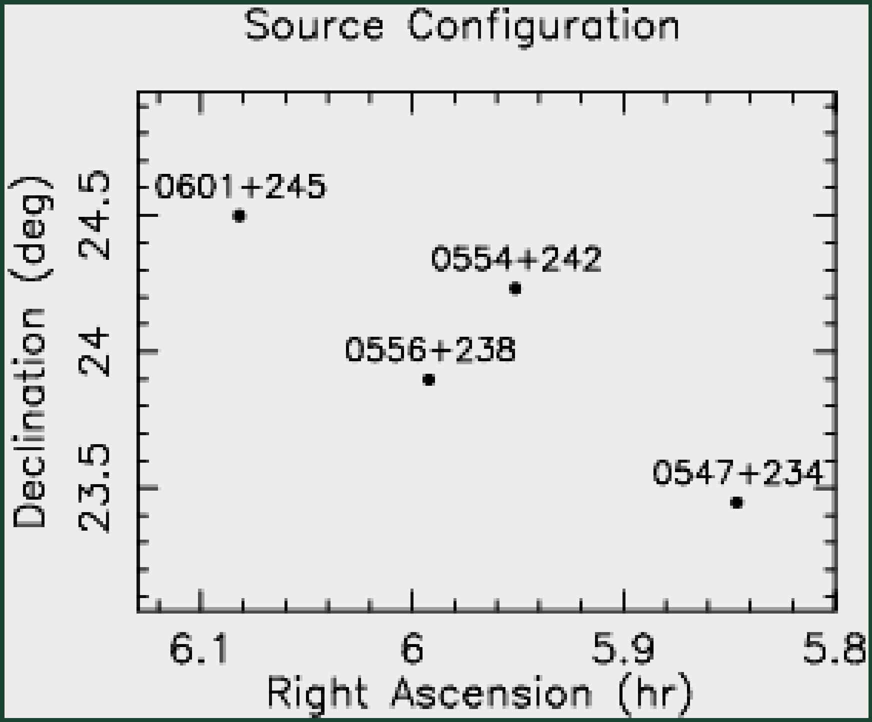
In 15 minutes, I can only give a quick overview of some tentative results.

Source Sample

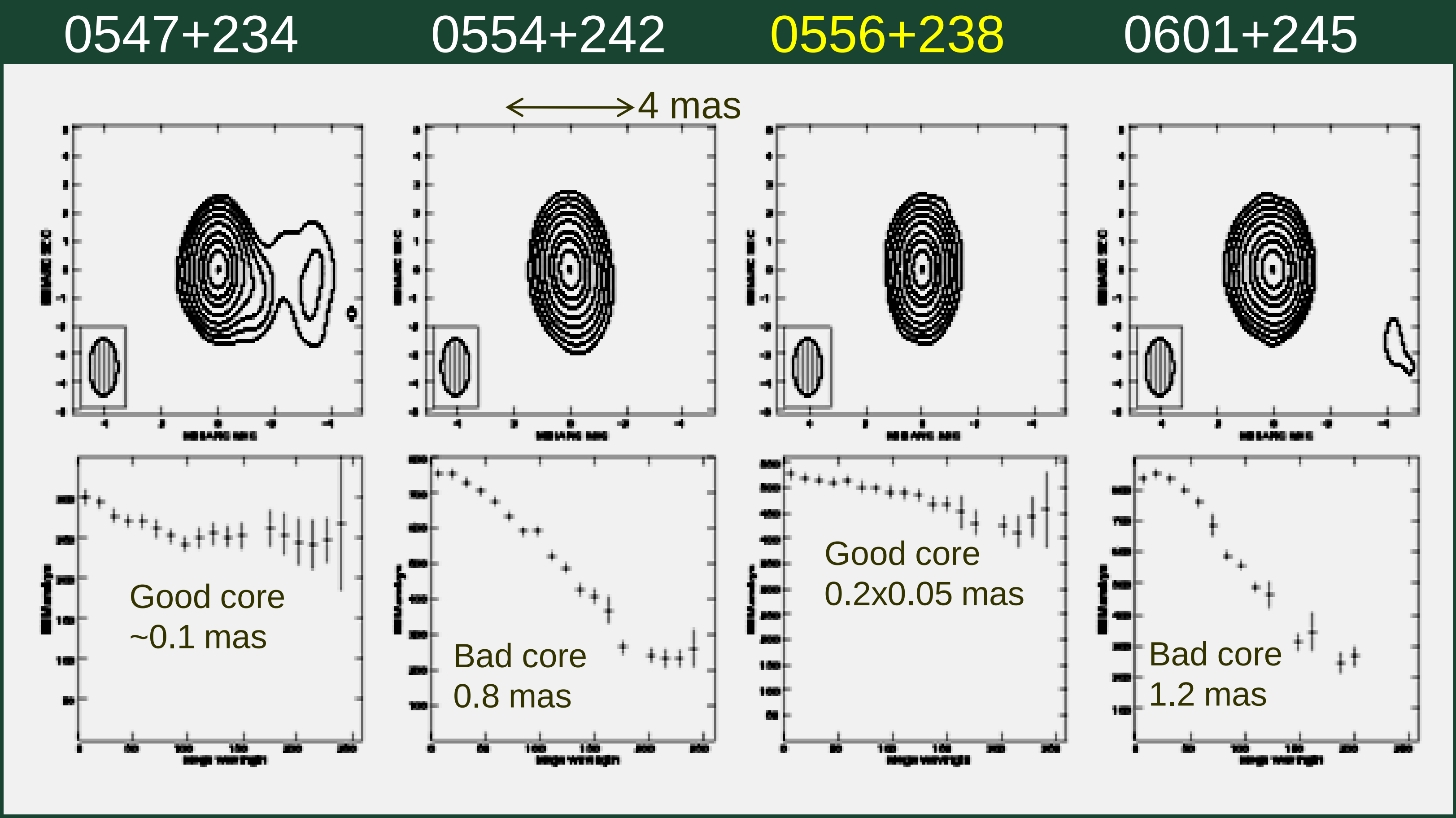
To obtain 0.02 mas positional accuracy and accurate structures with ~0.5 mas resolution, phase referencing was needed at high freq.

Four ICRF2 sources were chosen
-- Close enough for phase referencing (~3º)
-- Relatively strong (~0.4 Jy)
-- Not much source structure: SI = 1 or 2 (at X-band)
-- Used 23 and 43 GHz to probe deeply into the cores.

Fortuitously, the four have very different structure properties!



8.4 GHz images/uv from RDV 2005-Aug-26



0556+238 is nearly a point source, and will be the phase reference
0547+234 small core with faint jet and some large-scale emission
0554+242 and 0601+245 show significant resolution > 4000 km

VERA/VLBA Phase Referencing Observations

ARRAY	OBS. DATE	FREQ	RESOL (mas)
VERA	18Apr2008	K	1.0x1.0
VERA	24May2008	K	1.0x1.0
VLBA	20Dec2008	K,Q	0.5x1.0, 0.3x0.6
VLBA	22Dec2008	K,Q	0.5x1.0, 0.3x0.6
VERA	17Jan2009	K	1.0x1.0
VLBA	16Mar2009	K,Q	0.5x1.0, 0.3x0.6
VERA	20Apr2009	K	1.0x1.0
VLBA	08Jun2009	K,Q	0.5x1.0, 0.3x0.6
VLBA	14Sep2009	K,Q	0.5x1.0, 0.3x0.6
VLBA	12Dec2009	K,Q	0.5x1.0, 0.3x0.6

combine

Each session 6 hours

Geodetic 1 hr block to determine better troposphere model

VLBA: alternate 0556 with other sources
VERA: simultaneous 0556 with others in turn

--0556+238 was reference source/phase calibrator
--Images for other three sources made for each 6-hour session
--VERA at 23 GHz. Good agreement with VLBA results.
VLBA at 23 GHz and 43 GHz. Shown in this talk

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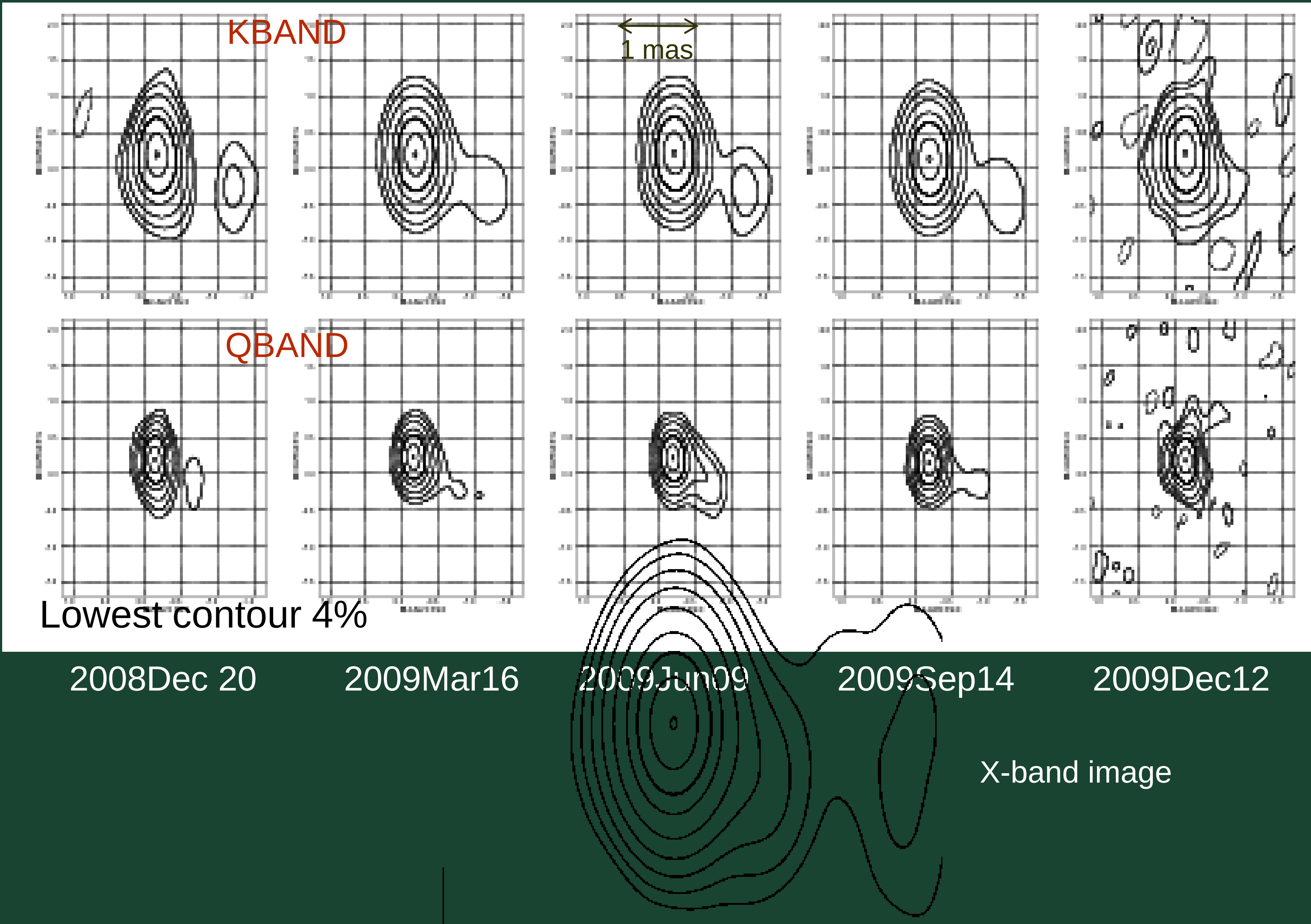
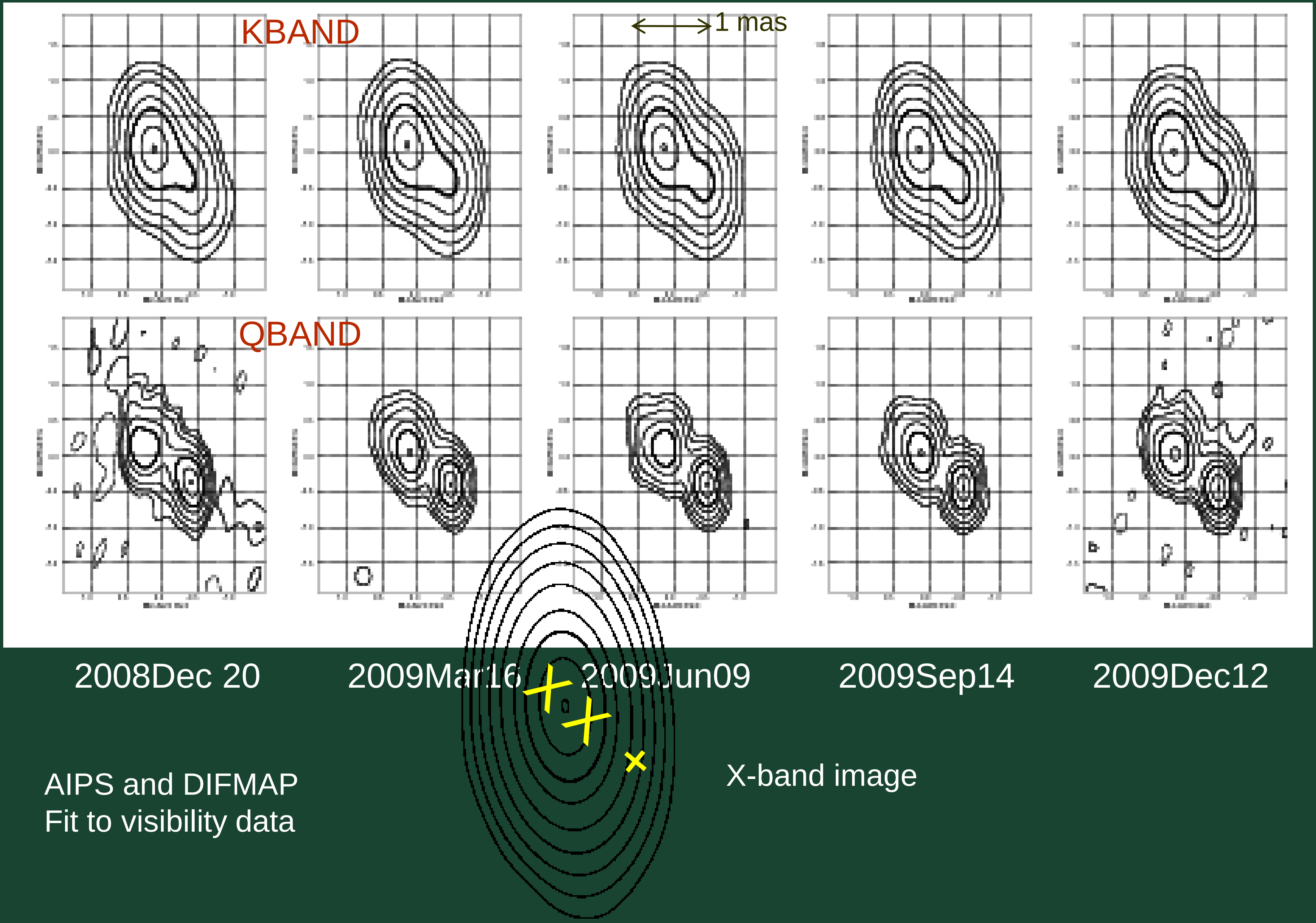
NOW, A WHIRL-WIND TOUR OF THE RESULTS:
(0556+238 not included since it defines the reference frame)

Evolution of 0547+234 (good)

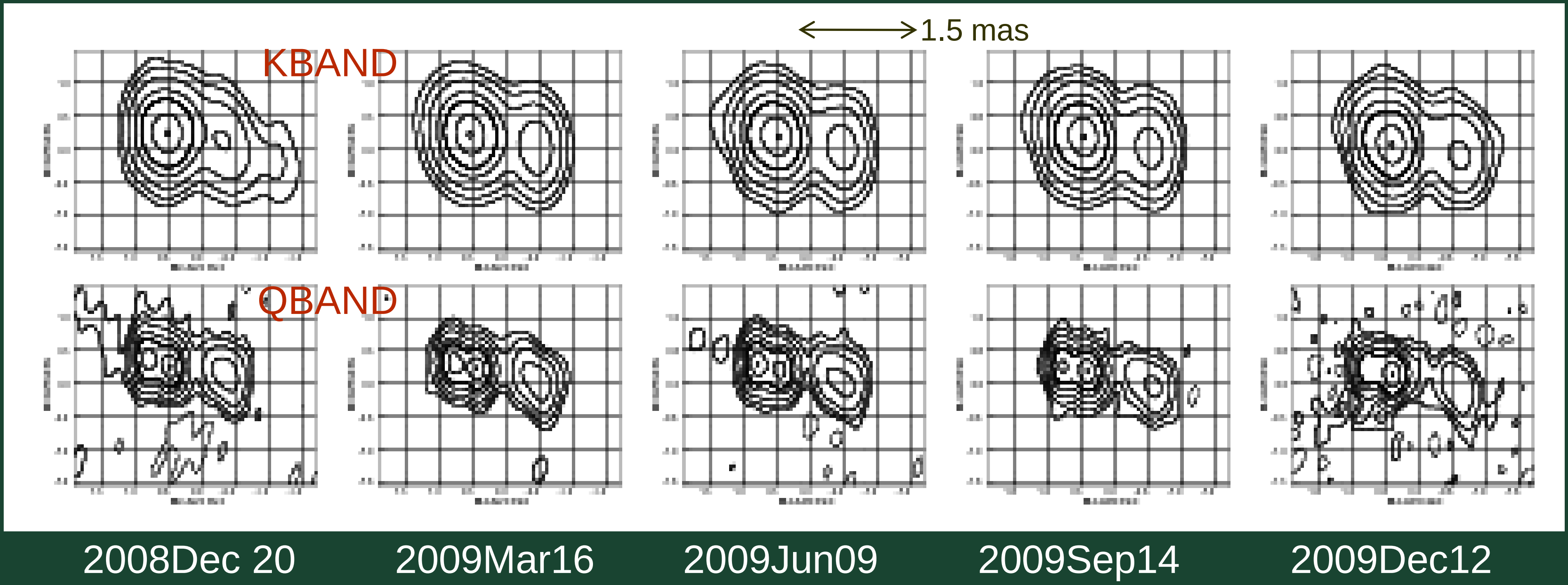


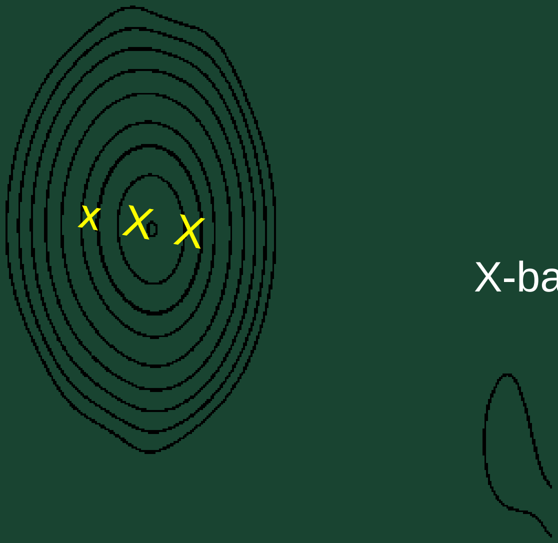
Evolution of 0554+242 (bad)



AIPS and DIFMAP
Fit to visibility data

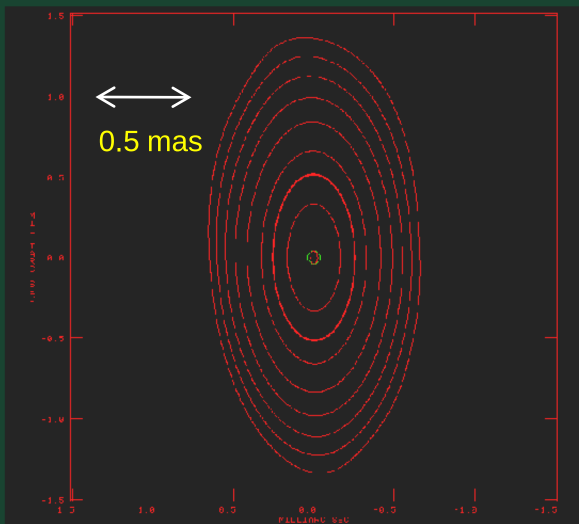
Evolution of 0601+245 (ugly)



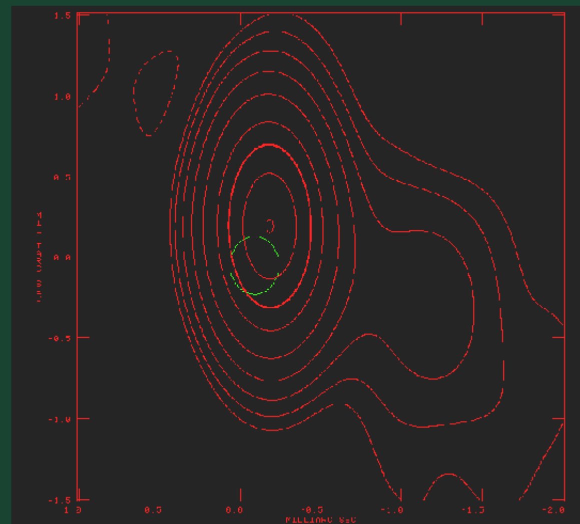


X-band image

K-BAND versus ICRF2 Position Comparison (Mar 16, 2009)



0556+238 ICRF2 OFFSET

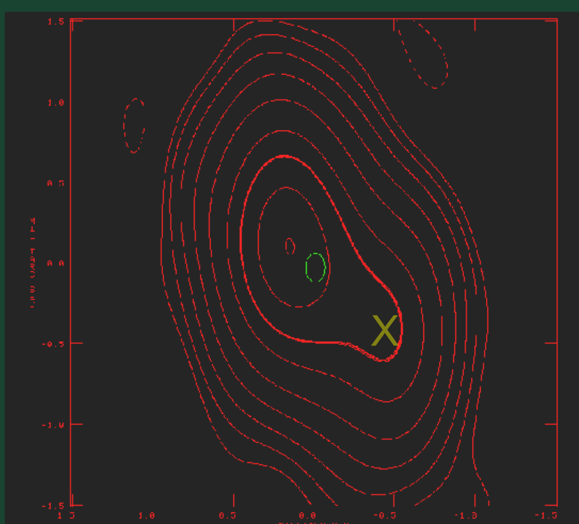


0547+234 ICRF2 OFFSET

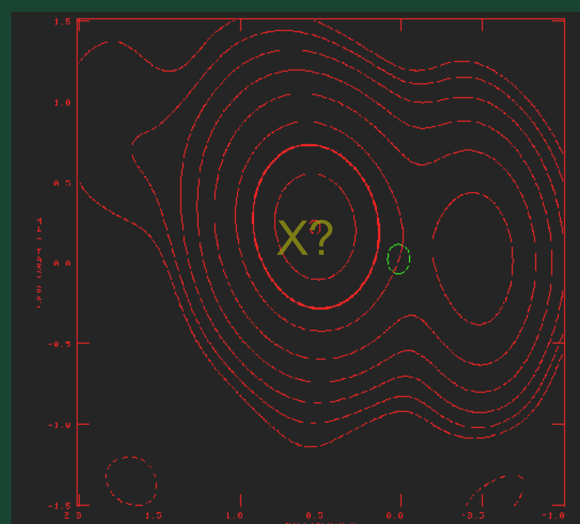
ICRF2-VLBA aligned
for 0556+238

Red: VLBA 23 GHz image
levs =-1,1,2,4,8,16,32
50,75,99.5%

Green ellipse:
ICRF2 position + error



0554+242 ICRF2 OFFSET



0601+245 ICRF2 OFFSET

3 of 4 source have structure

K-X Position difference:

0547 just outside error
0554 and 0601 X-band
position down jet
0.2 to 0.6 mas from
K-band peak

Effect on ICRF2 position

Emission within 1 to 2 mas of core, within about one resolution cell at X-band, is averaged to obtain the X-band position.

Porcas Law: You don't know what is happening within the core emission region that is contained within the resolution. Variability and motion of the core constitutents will lead to apparent position changes.

Guidelines:

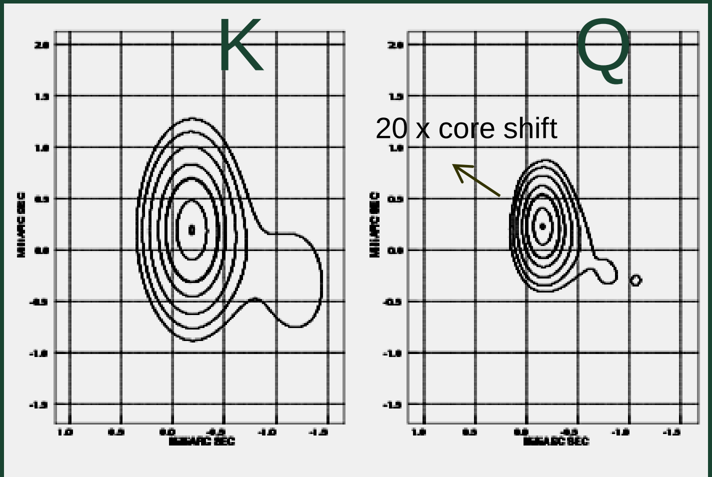
1. Determine angular size of core component. The approximate position variation could be as large as 0.2 x core size.
2. Additional extended structure more than 2 mas from core not a major problem. It is well separated and structure corrections can be made.
3. Higher resolution images (23 GHz) on a yearly basis may help define the 'best' astrometric sources for the ICRF2 and VLBI-2010 by resolving the X-band core.
4. Same problem occurs at 23 and 43 GHz, but resolution size is smaller, so the position changes are smaller.

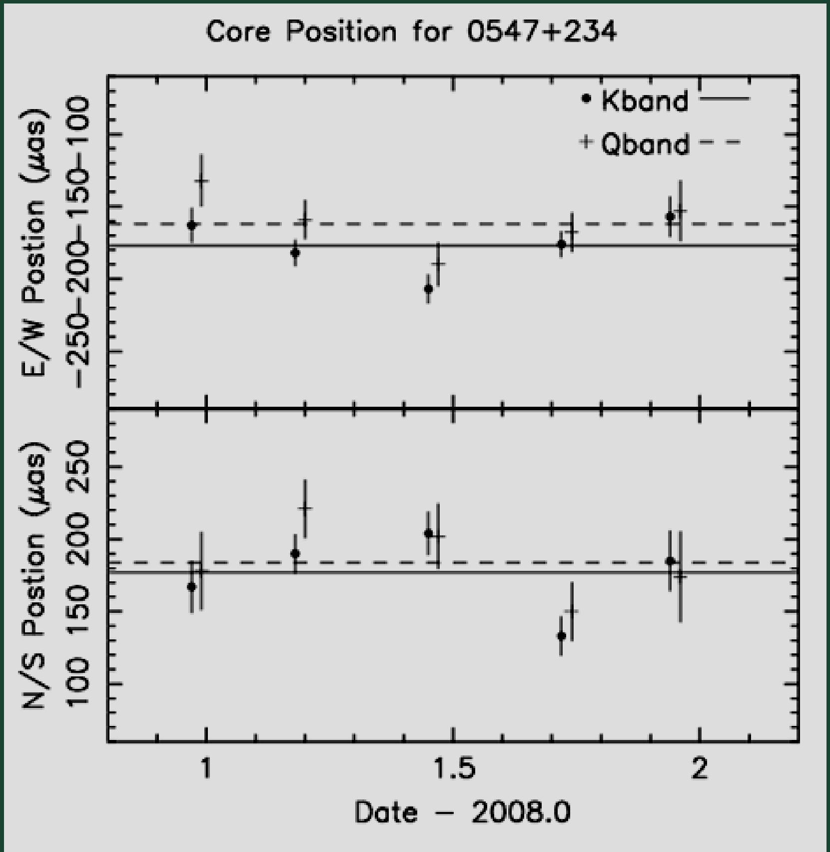
Now, a closer look at radio source stability

Can we easily find the cores?

What kind of motions and frequency changes do we see?

Core stability for 0547+234 over one year
Core size ~0.1 mas

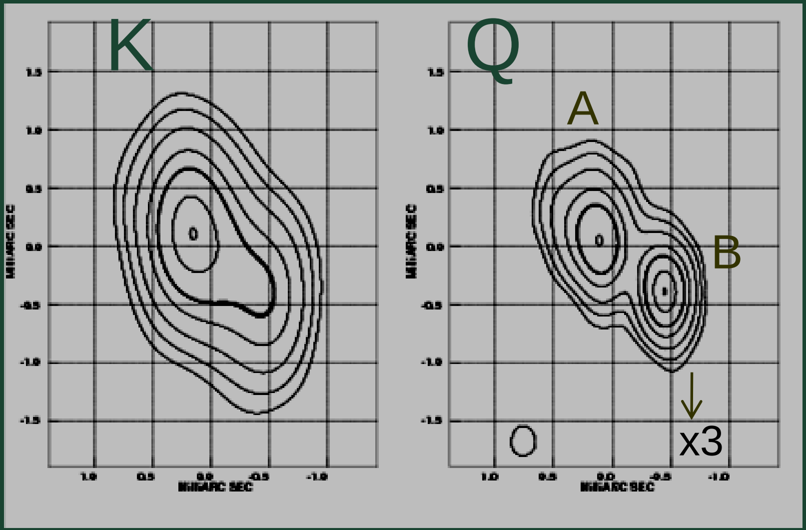




1. Kband and Qband peak position changes caused by residual troposphere errors
2. No secular change to about 20 microas
3. Qband – Kband difference somewhat independent of troposphere errors
4. Qpos – Kpos = (+18, +6) microas in direction away from faint jet.
5. Combination of core/shift and higher resolution
6. Using ‘lambda’ law of core shift, ‘real’ core is about 25 microsec ENE of Qband core.
7. This assumed no core shift in 0556+234.
8. Good ICRF2 position stability and accurate radio/optical core alignment to 20 microas

FOR COMPACT CORES, we can determine positions to about 20 microas

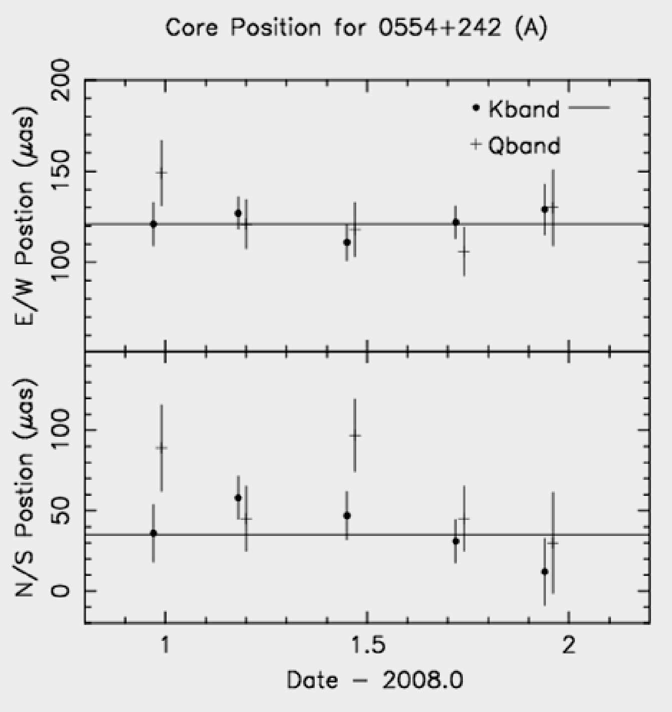
‘Core’ stability for 0554+242 over one year. Core size about 1.0 mas

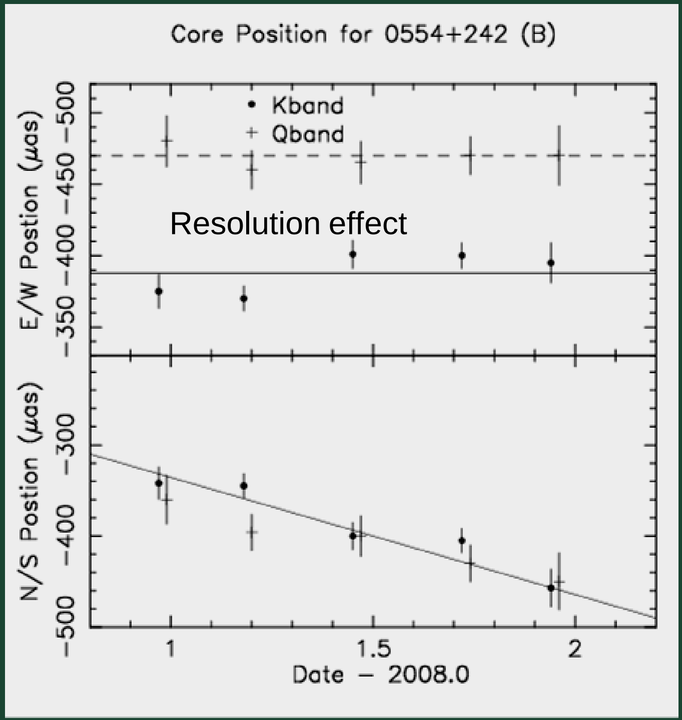


Component A is stationary to about 20 microas

Surprise!

Component B is MOVING SSW 0.15 mas/yr even though it is an opaque component

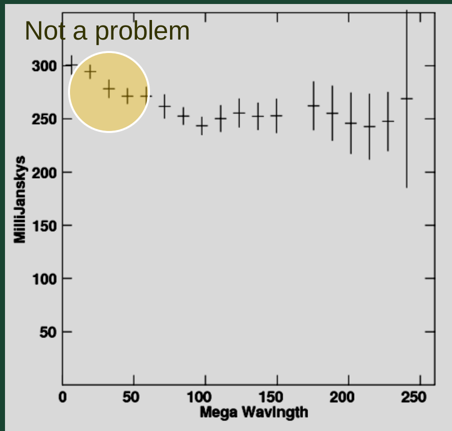




Motion of B is Puzzling.

Where is the core? In A?

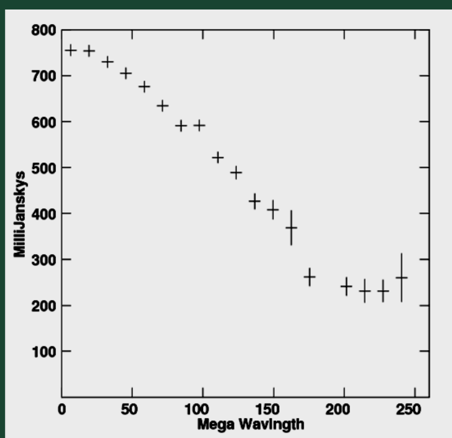
Thoughts and Suggestions



Do a good amplitude calibration and look at correlated flux density vs uv spacing plot. Related to Structure Index.

If size of core < 0.1 mas, then position stability of 0.02 mas can be obtained.

This implies accurate radio/optical alignments can be obtained



If core is resolved (~1.0 mas in size), then ICRF2 position jitter could approach 0.2 mas and the location of the 'true' core may be uncertain by more.

Long term 23 and 43 GHz monitoring may be needed to determine location of core for radio/optical comparisons.

--About 50 ICRF2 sources have very compact cores. Prefer to use these. Include compact VCS and southern sources as well not yet well known.

--Occasional (yearly) high frequency (23, 43 GHz) imaging is useful.

--Of course, this decade's 'compact' core may become next decade's extended core.