RadioAstron 5-22 GHz observations of 3C 418 and 2013+370

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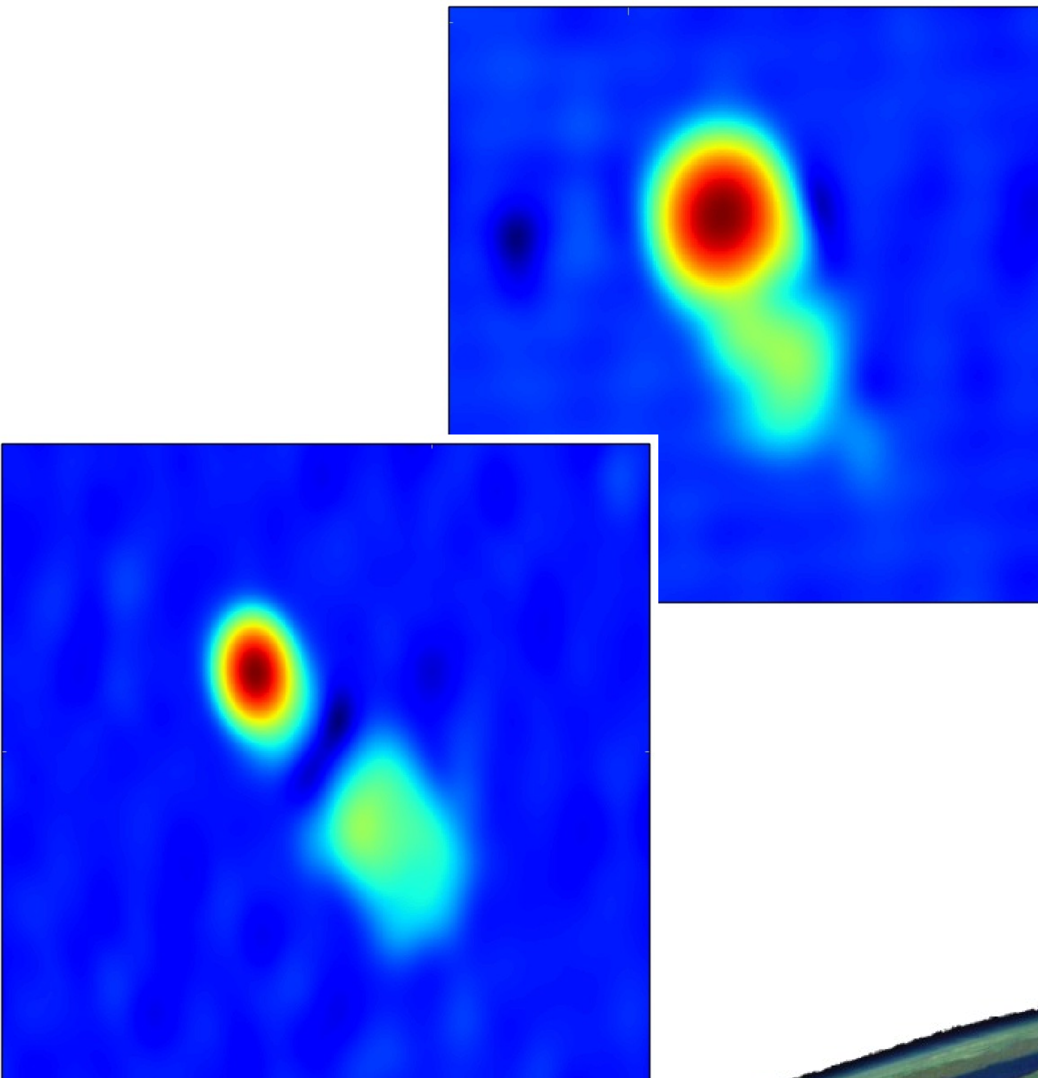
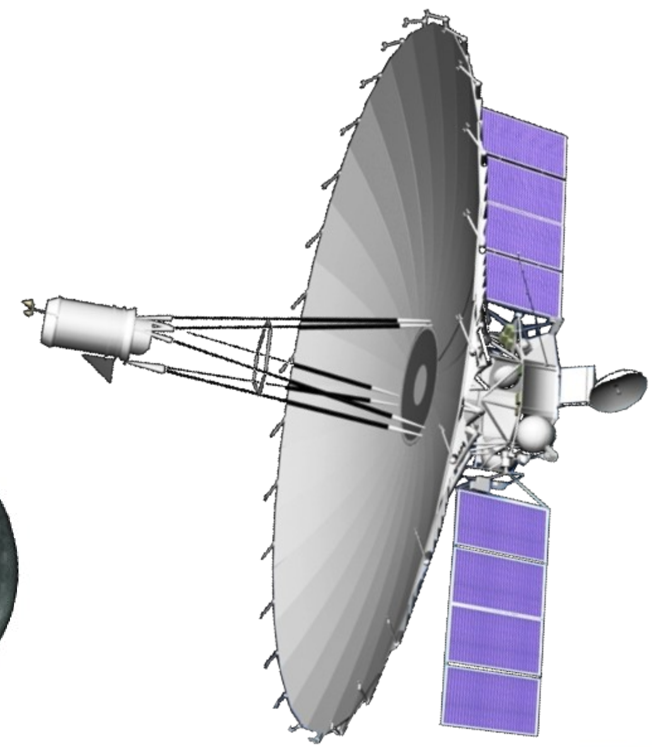
for the RadioAstron AGN team





Aims

Technical test

- Check amplitude calibration of the Space radio telescope through hybrid imaging

- Test RadioAstron's dual-band imaging capability at 4.8 and 22 GHz (simultaneously)

- Test RadioAstron's ability to image two nearby (15° apart) sources in one experiment

High-resolution imaging

- Determine *shape*, *size* and T_b of the most compact jet structures (optically-thick cores)

Target selection

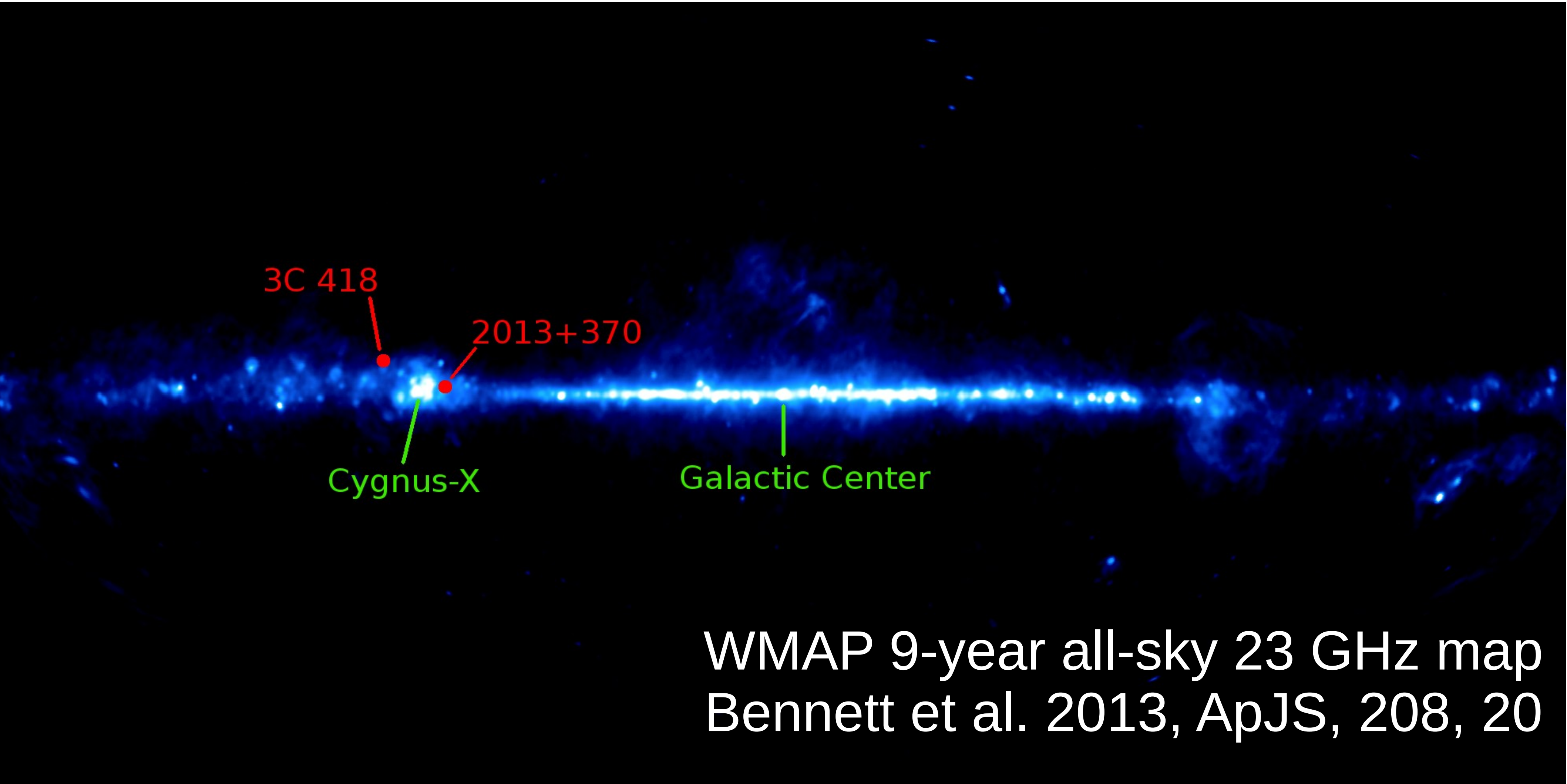
Bright VLBI sources with space-ground baselines crossing ground-ground baselines in October 2012

- TXS 2013+370 FSRQ at $z=0.859$, GeV-bright, 3mm VLBI detected (Lee et al. 2008, AJ, 136, 159), $\beta=12.5c$ (MOJAVE)

- 3C 418 FSRQ at $z=1.686$, no GeV detection, 3mm VLBI detected, $\beta=3.75c$

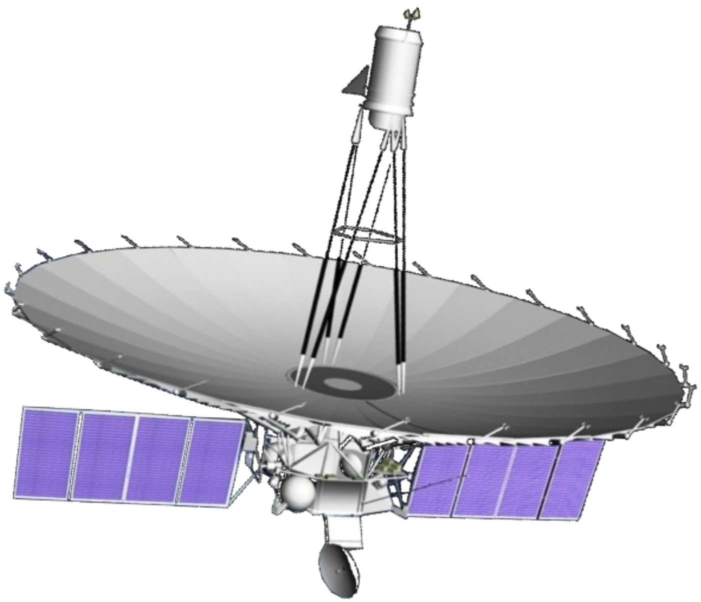
3C 418 and TXS 2013+370

are close to the Galactic plane at b=6.0° and b=1.2°.
Expect interstellar scattering.



Array configuration

EVN + Usuda 64m + Evpatoria 70m divided in two subarrays observing at 4.8 and 22 GHz, the Space telescope observing in two bands simultaneously



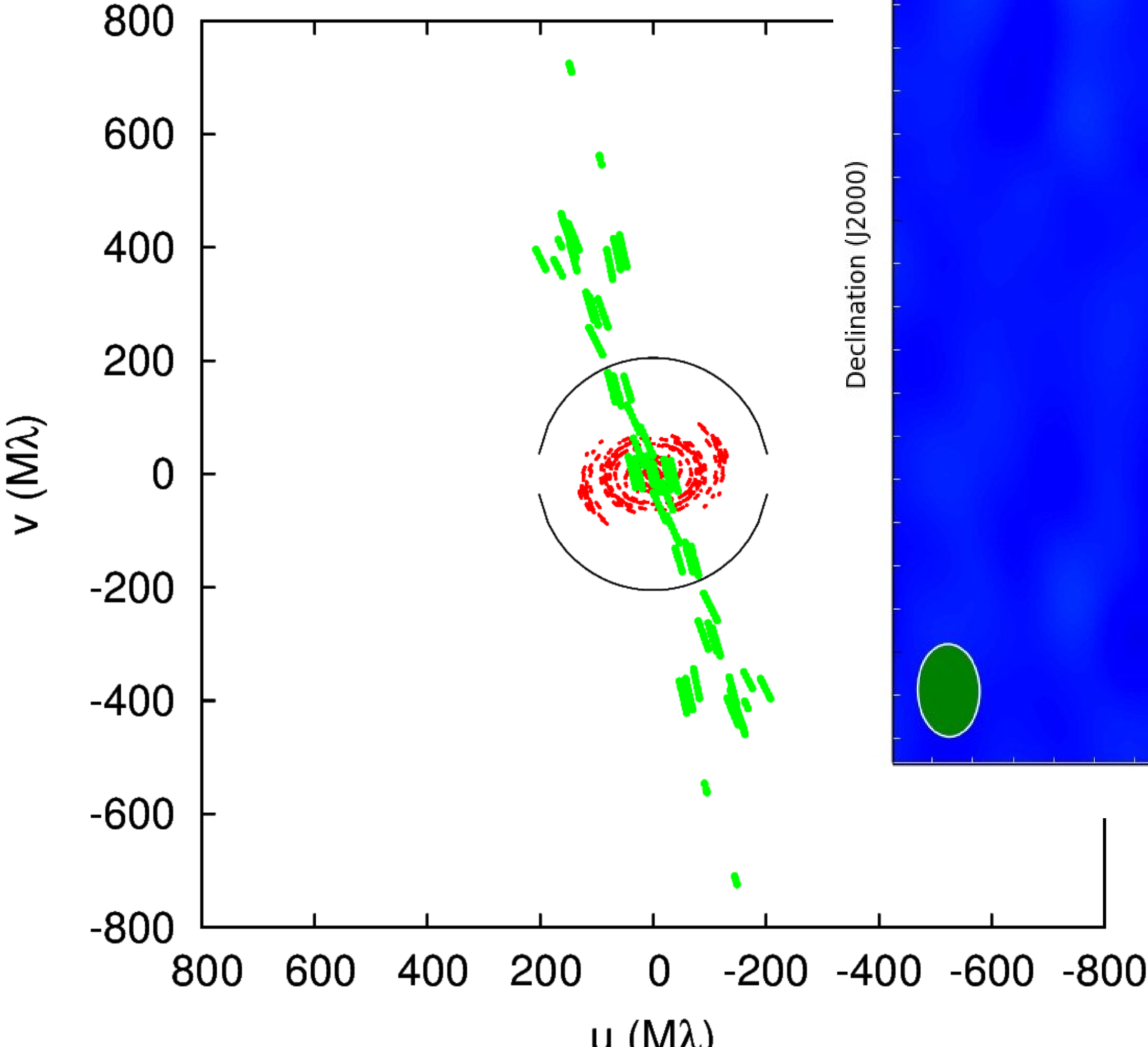
Space radio telescope

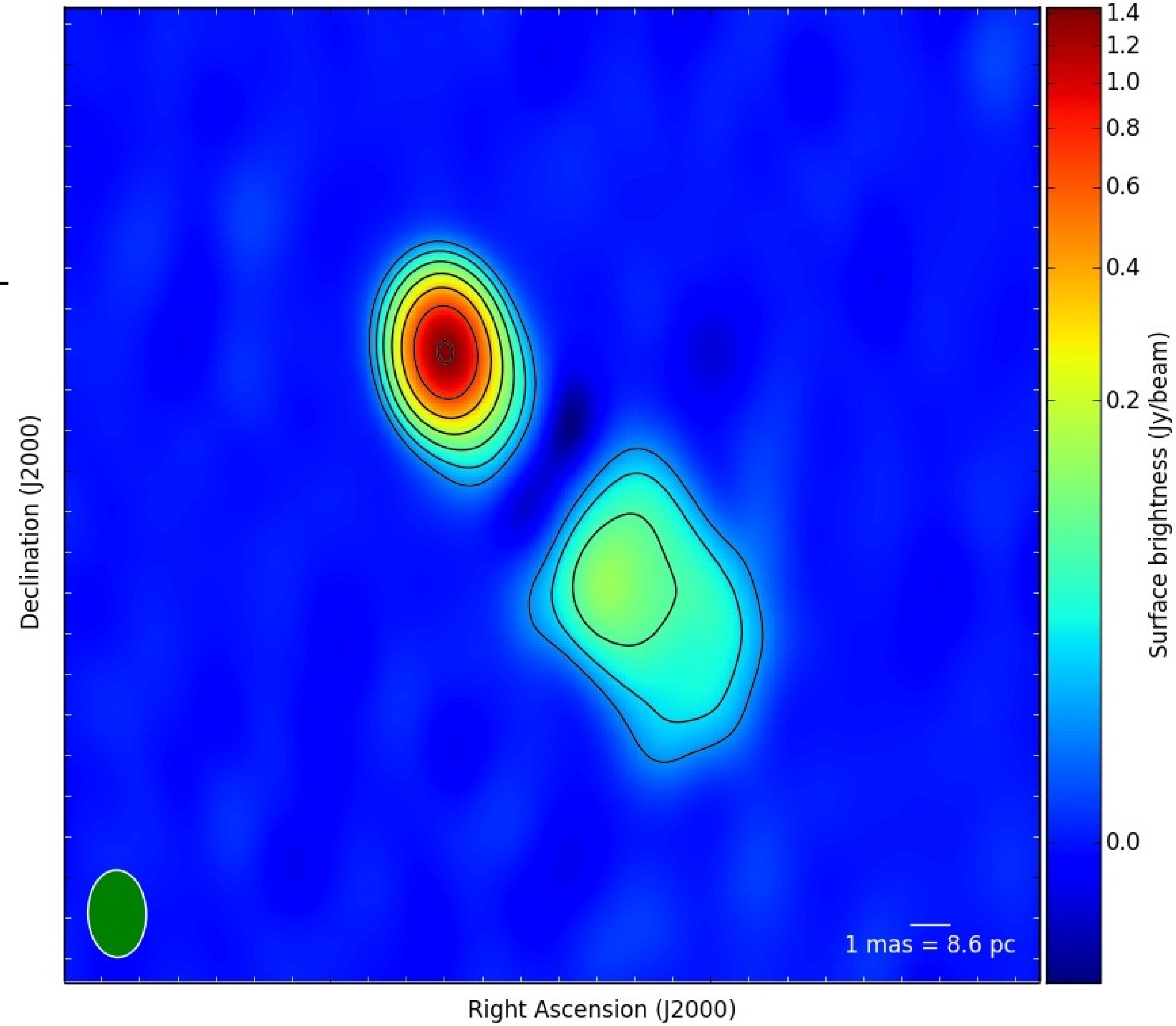
Evpatoriya

WSRT

3C 418 at 4.8 GHz

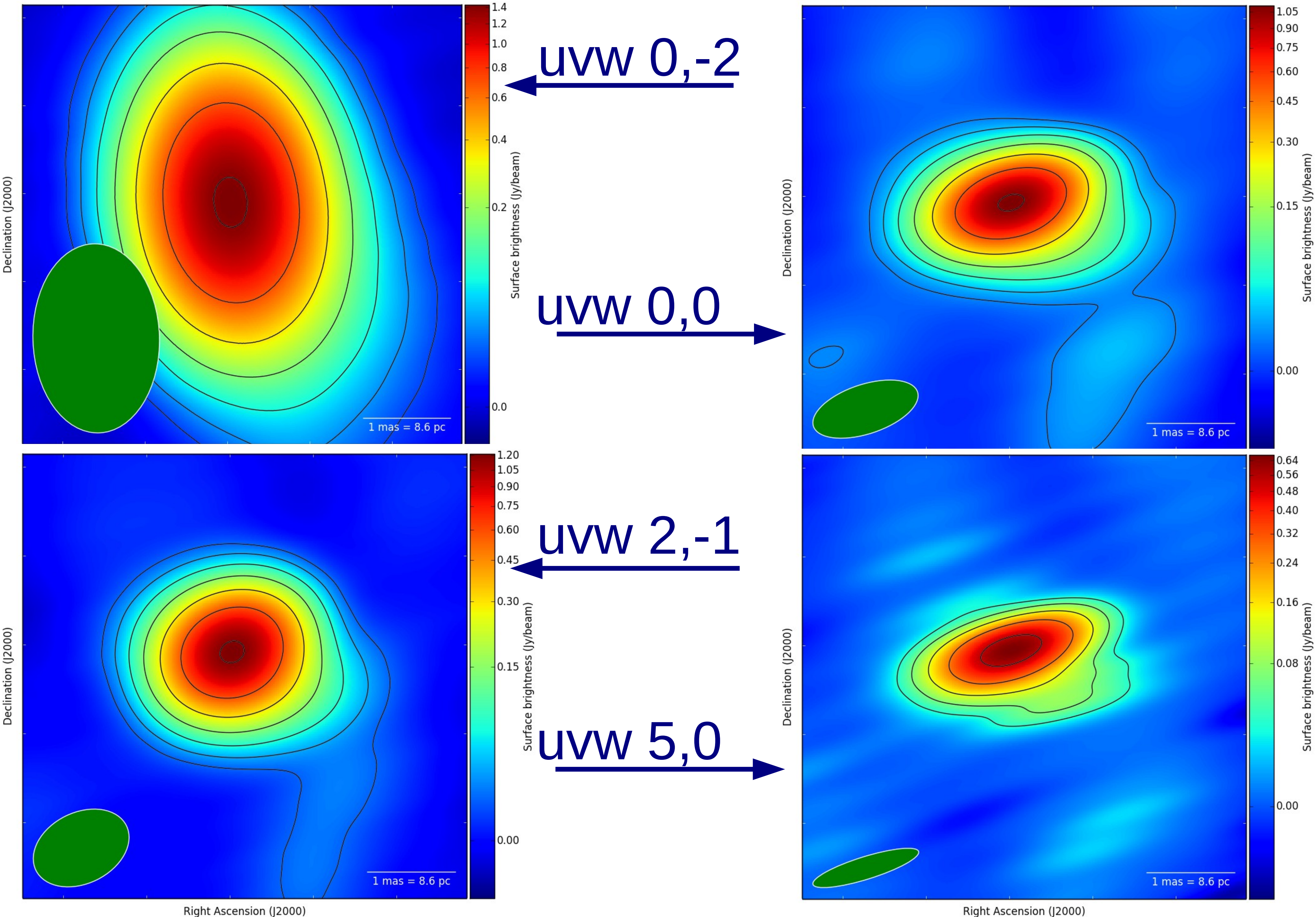
uv-coverage



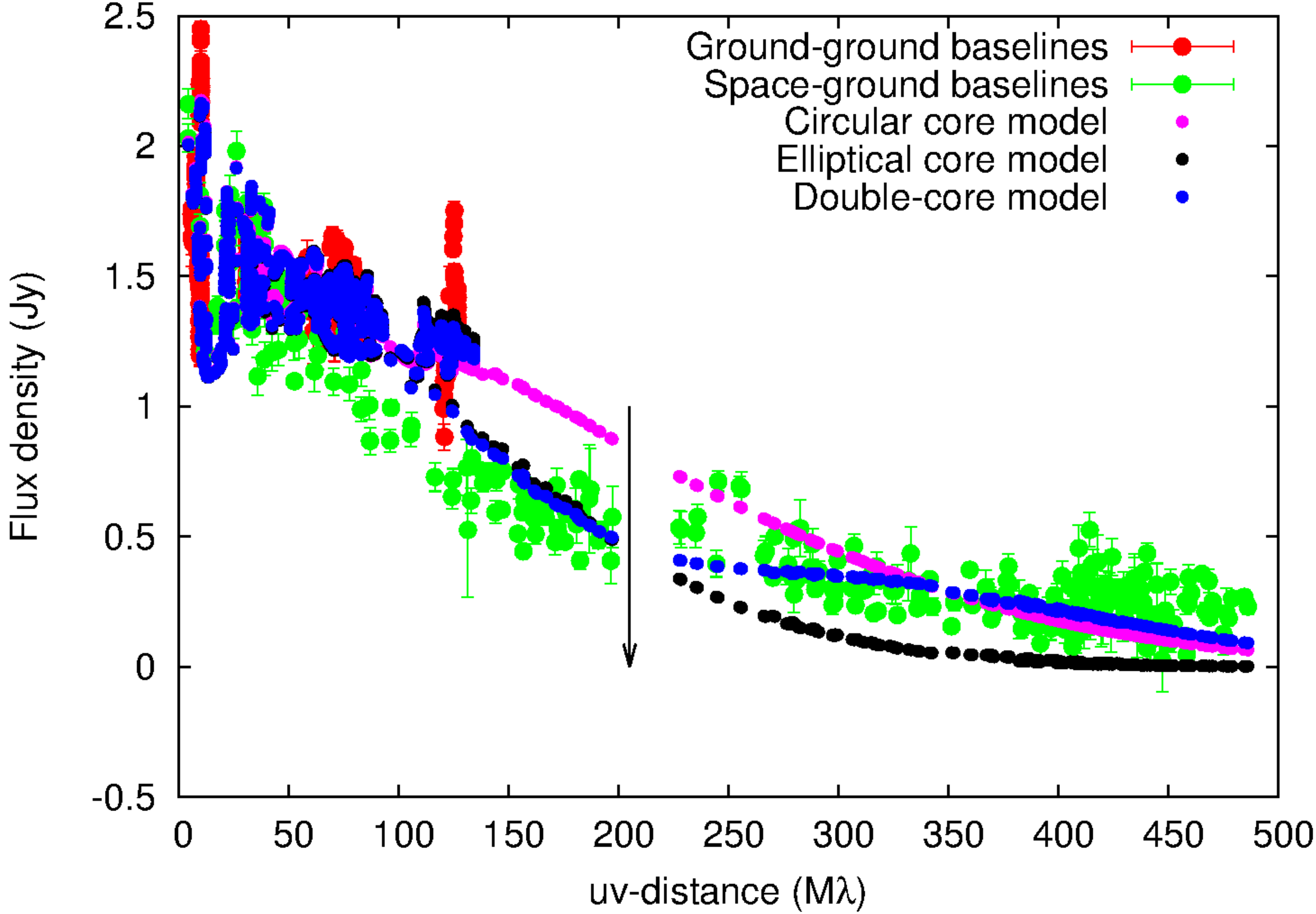


naturally-weighted image (uvw 0,-2)

3C 418 at 4.8 GHz



3C 418 at 4.8 GHz

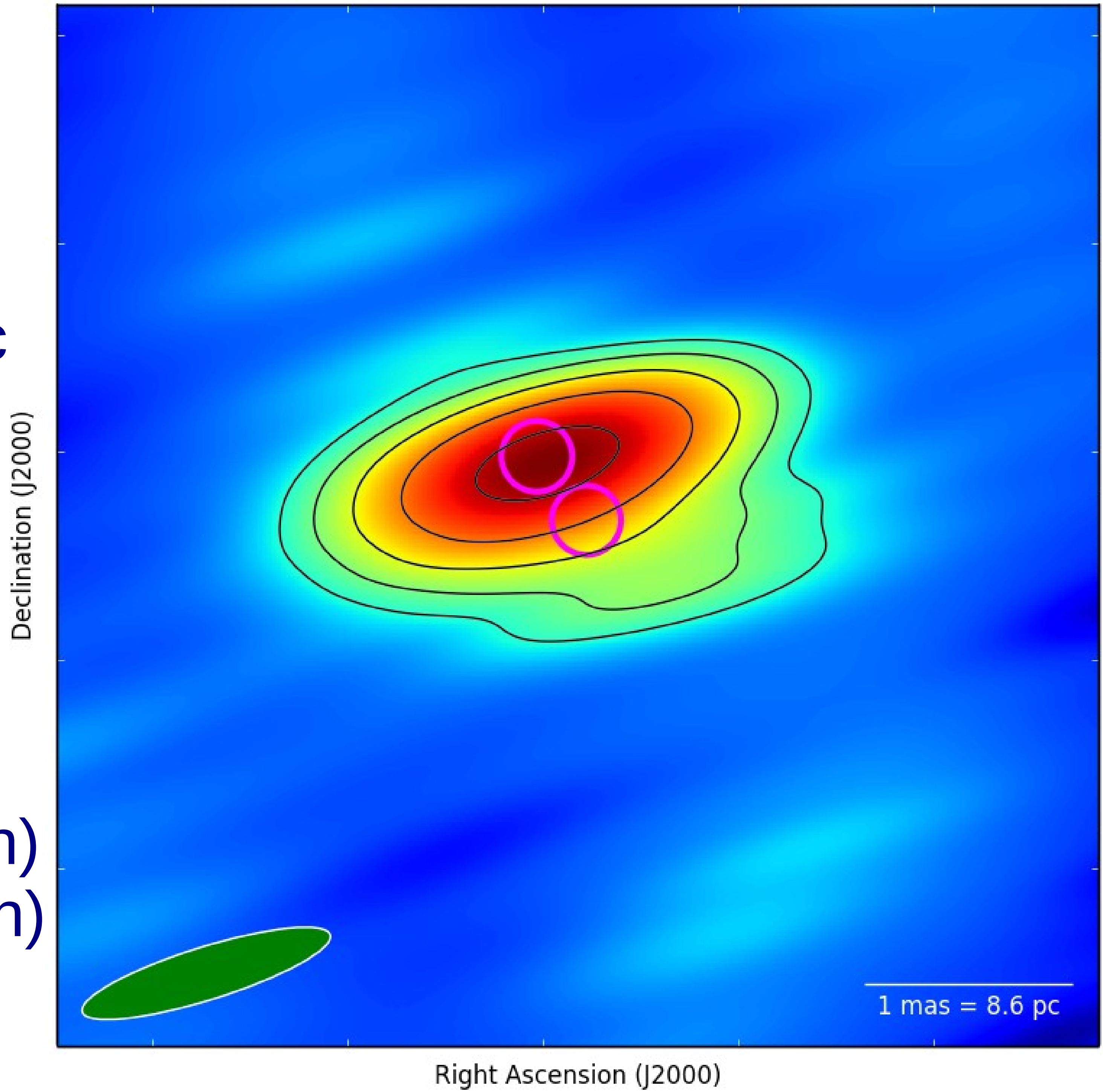


Two-component model of 3C 418's core

Size
0.3 mas = 2.6 pc
(each)

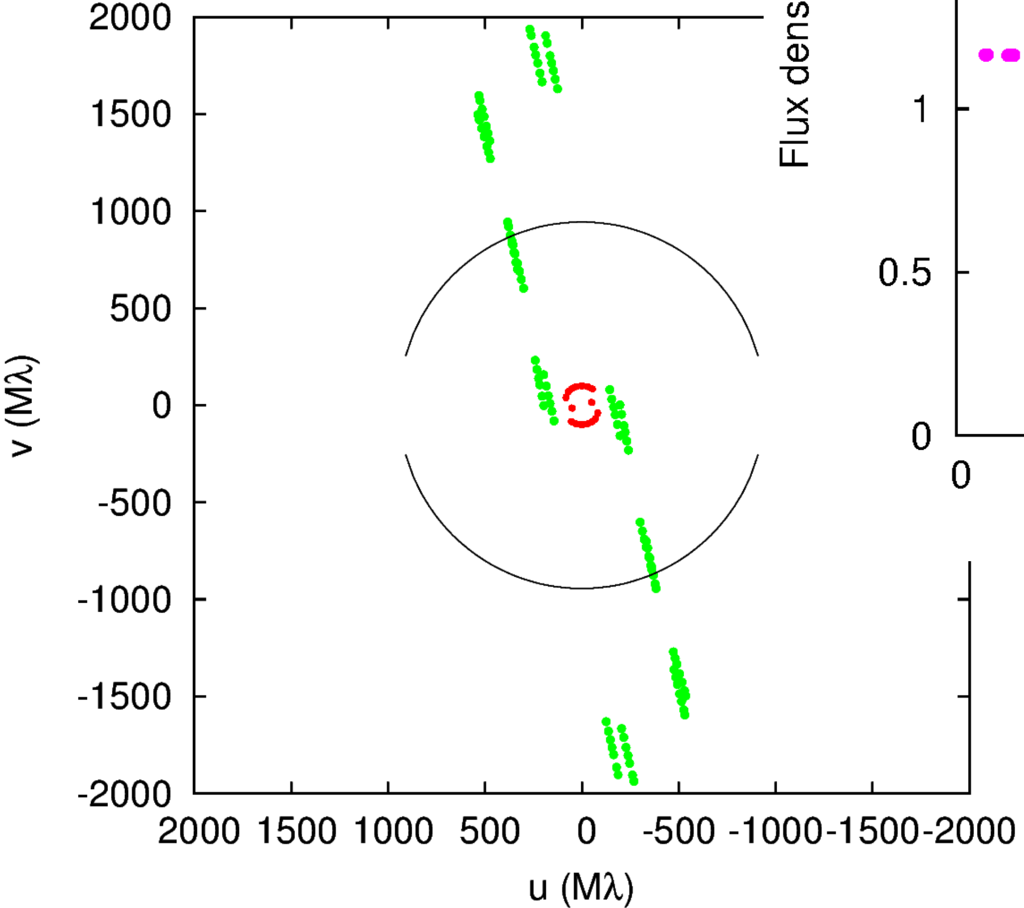
Flux densities
1.14 & 0.40 Jy

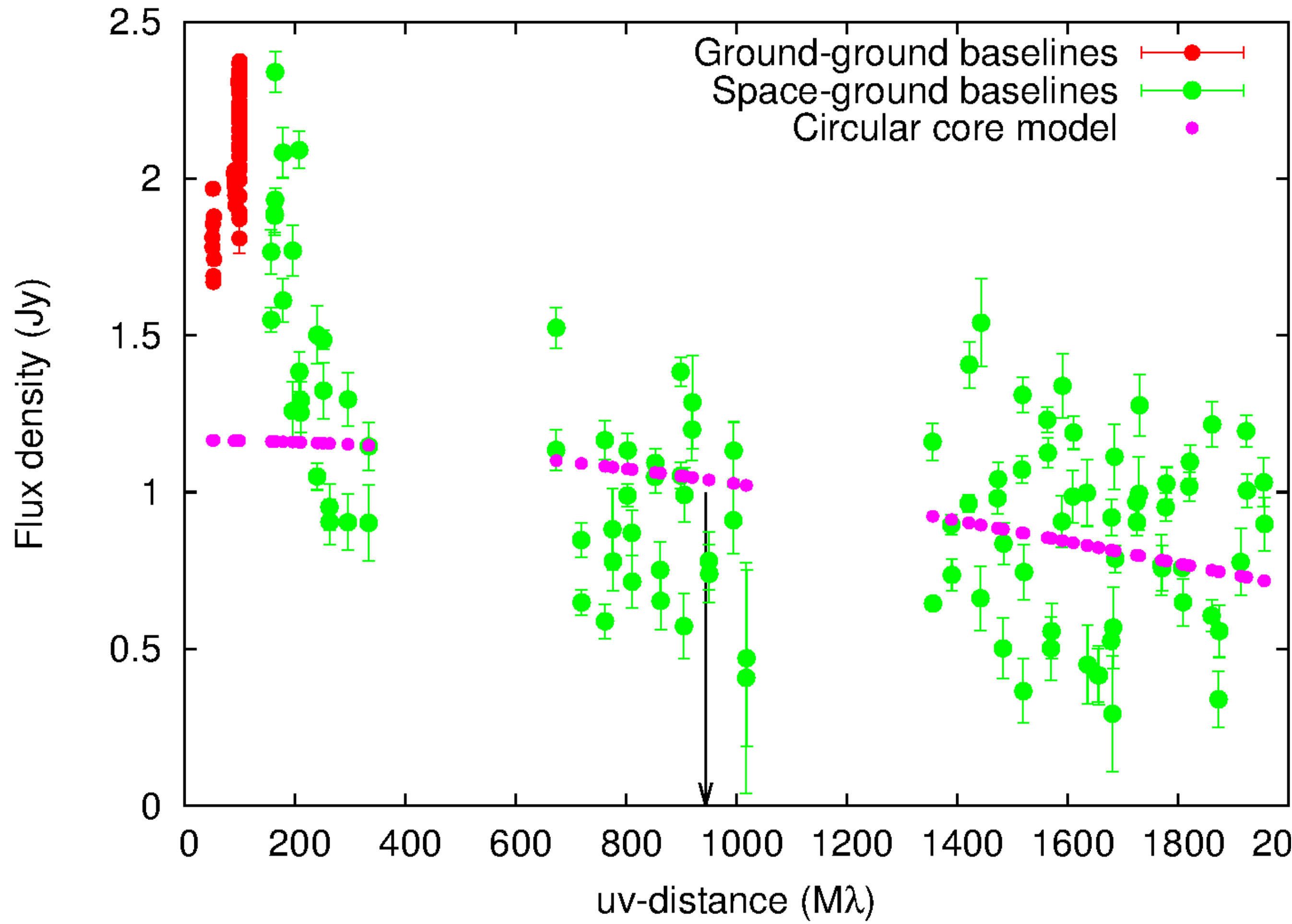
Tb
1x10^12 K (north)
4x10^11 K (south)



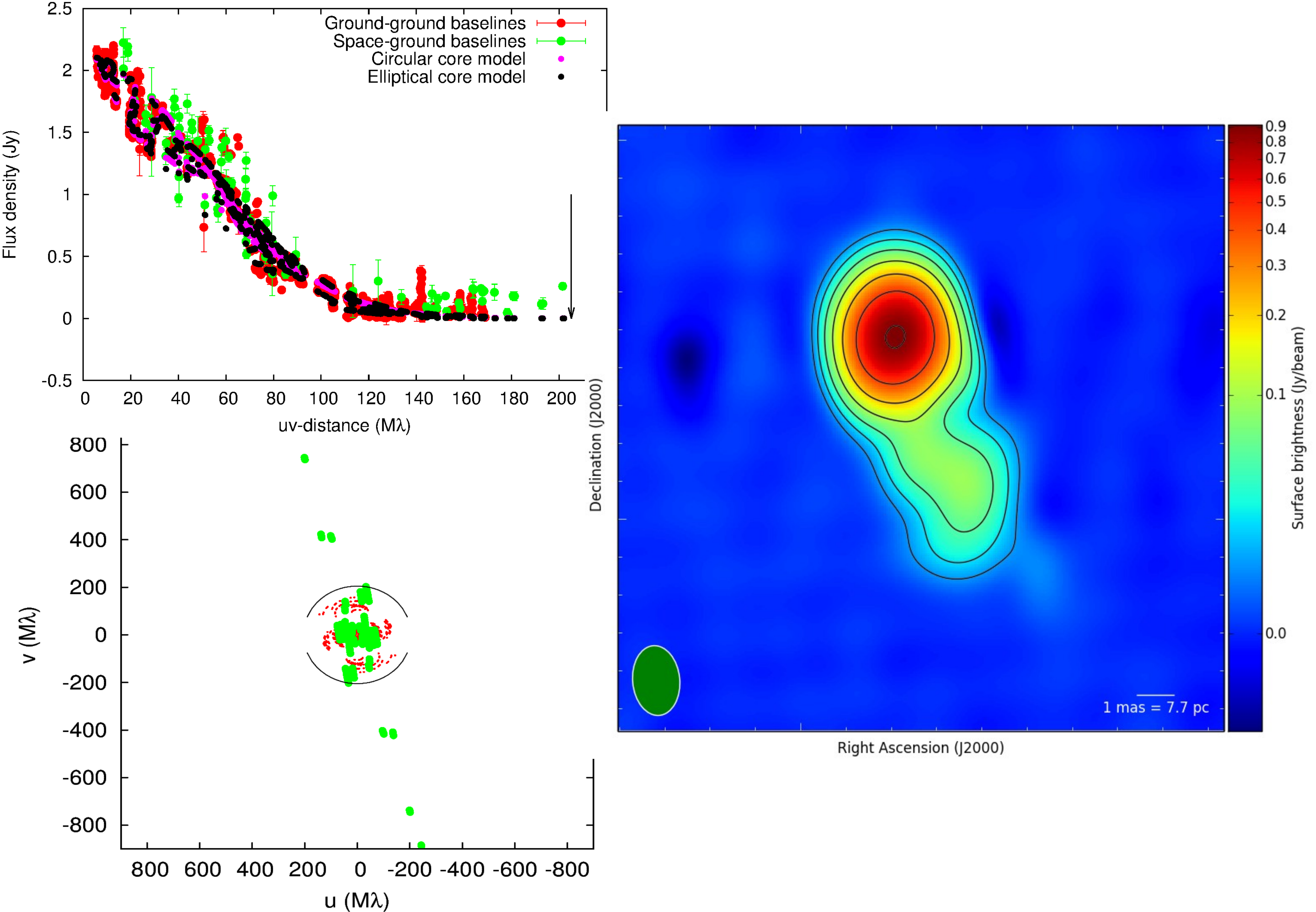
3C 418 at 22 GHz

0.039 mas = 0.33 pc, 1.17 Jy, Tb=5x10^12 K

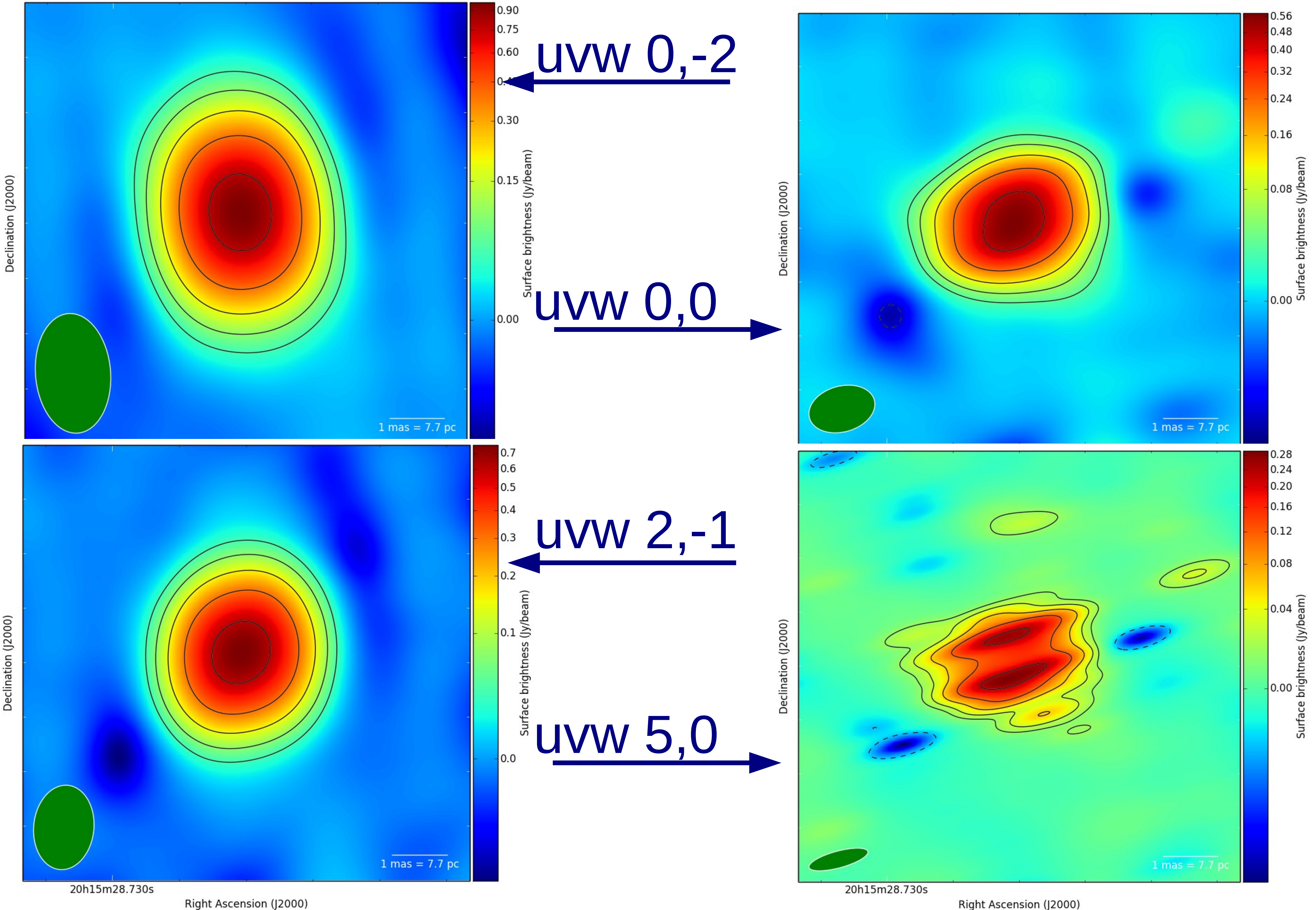




2013+370 at 4.8 GHz



2013+370 at 4.8 GHz

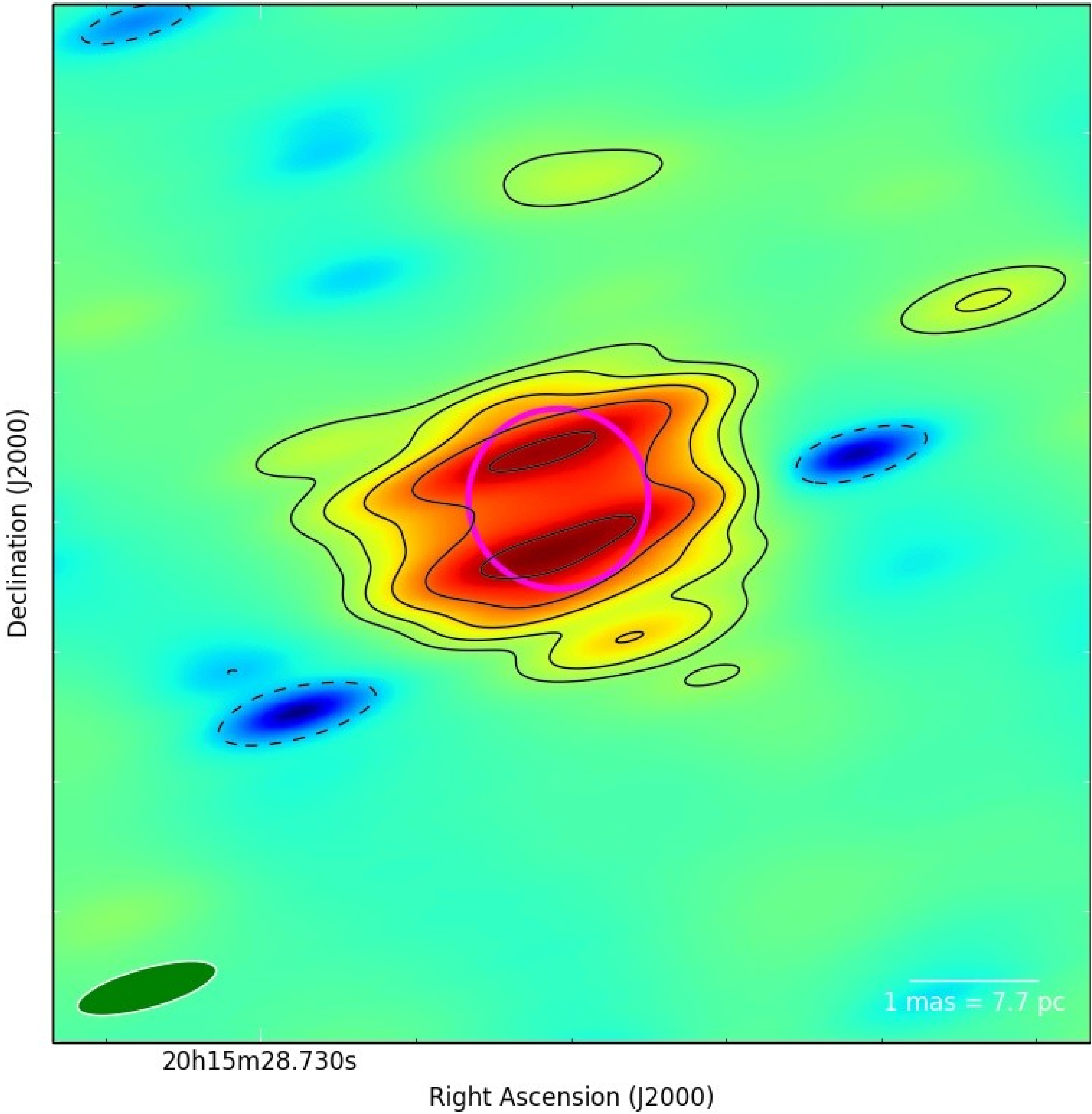


2013+370 4.8 GHz core model

Size
1.5 mas = 12 pc

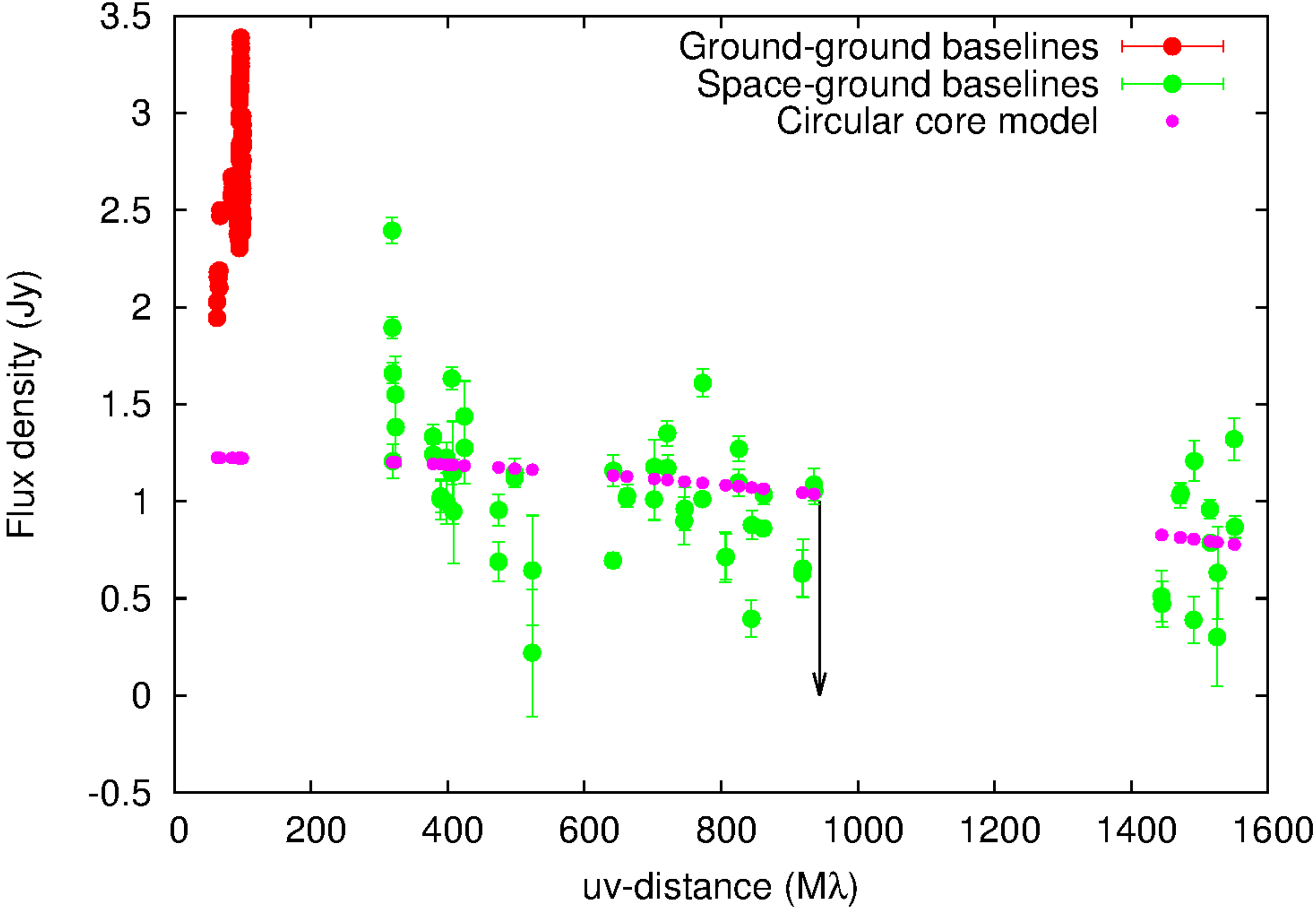
Flux density
1.86 Jy

Tb
8x10^10 K



2013+370 at 22 GHz

0.047 mas = 0.37 pc, 1.22 Jy, Tb=2.5x10^12 K



Conclusions

- Both sources resolved down to tens of mJy level
- Cores of both sources are likely scatter-broadened (4.8 GHz core size 9-30 times larger than 22 GHz size)
- 3C 418 – complex core structure that cannot be recovered with ground-only obs. at 4.8 GHz
- Tb >10^12 K found at 22 GHz

Backup slides...

Structure or scattering?

- If the source size is fully determined by scattering, it's size is expected to scale as λ^2
- If the scattering is not important, the core size is expected to scale as λ^1 (BK-type jet with SSA)
- 6.2cm/1.35cm = 4.6,   (6.2cm/1.35cm)^2 = 21.1
- 3C 418:   0.37mas/0.039mas = 9.5
- TXS 2013+370:   1.53mas/0.047mas = 32

Array configuration

Space + 9 (8 for 3C 418 invisible for Hh) ground telescopes collected useful 4.8 GHz data

C-band ground subarray baseline lengths (km)

	Wb	Jb1	On	Tr	Sv	Bd	Ur	Sh	Hh	Ev	Ud
Wb	0	599	601	799	1634	5786	5565	8090	8239	2097	8347
Jb1	599	0	1011	1388	2082	6155	6028	8419	8441	2683	8578
On	601	1011	0	637	1080	5272	5119	7647	8525	1987	7885
Tr	799	1388	637	0	1070	5199	4874	7552	8108	1375	7925
Sv	1634	2082	1080	1070	0	4281	4127	6760	8697	1716	7074
Bd	5786	6155	5272	5199	4281	0	1452	2749	9832	4839	3293
Ur	5565	6028	5119	4874	4127	1452	0	3249	8852	4152	4303
Sh	8090	8419	7647	7552	6760	2749	3249	0	10160	7067	1680
Hh	8239	8441	8525	8108	8697	9832	8852	10160	0	7391	11085
Ev	2097	2683	1987	1375	1716	4839	4152	7067	7391	0	7721
Ud	8347	8578	7885	7925	7074	3293	4303	1680	11085	7721	0

Array configuration

Space + 3 ground telescopes collected useful 22 GHz data

K-band ground subarray baseline lengths (km)

	Ef	Jb2	Ys	Nt	Gb	Ro
Ef	0	699	1352	1644	6335	1413
Jb2	699	0	1411	2247	5719	1427
Ys	1352	1411	0	1616	6124	99
~~Nt~~	~~1644~~	~~2247~~	~~1616~~	~~0~~	~~7446~~	~~1711~~
~~Gb~~	~~6335~~	~~5719~~	~~6124~~	~~7446~~	~~0~~	~~6049~~
~~Ro~~	~~1413~~	~~1427~~	~~99~~	~~1711~~	~~6049~~	~~0~~

Correlation and post-processing

- RA-enabled `DiFX` (J. Anderson)
- Preliminary correlation done in MPIfR-Bonn
- Fringe search in `PIMA` (L. Petrov)
- Final `DiFX` correlation in ASC (slow but flexible)
- Fringe fitting in `PIMA` including accel. term (rate-rate)
- Imaging/modeling in `Difmap`
- TODO: repeat correlation using the `ASC` correlator and `SFXC` (JIVE), compare results