Some recent results from EoR observations of 3C196

Ger de Bruyn +

Maaijke Mevius, Pandey, Andre Offringa and the EoR team

- Some statistics on ionospheric effects in Cycle 3

- Observations of, and the use of, ‘flanking fields’

- Modelling of 3C196 with 0.3-0.45” resolution (8 IS)

1) From very Good to Ugly ionospheric nights

The ionosphere can have a big influence on imaging and calibration.
So the EoR team is faced with the following questions:

- What is the best method to classify or parameterize nights ?
- Which nights to include in initial EoR power spectra analysis ?
- How to model the sky (on long NL baselines) during mediocre nights ?

For the EoR project we need to know whether, and when, 'scintillation' noise (Vedantham & Koopmans, 2015) influences our power spectra at (say) 10-20' scales.

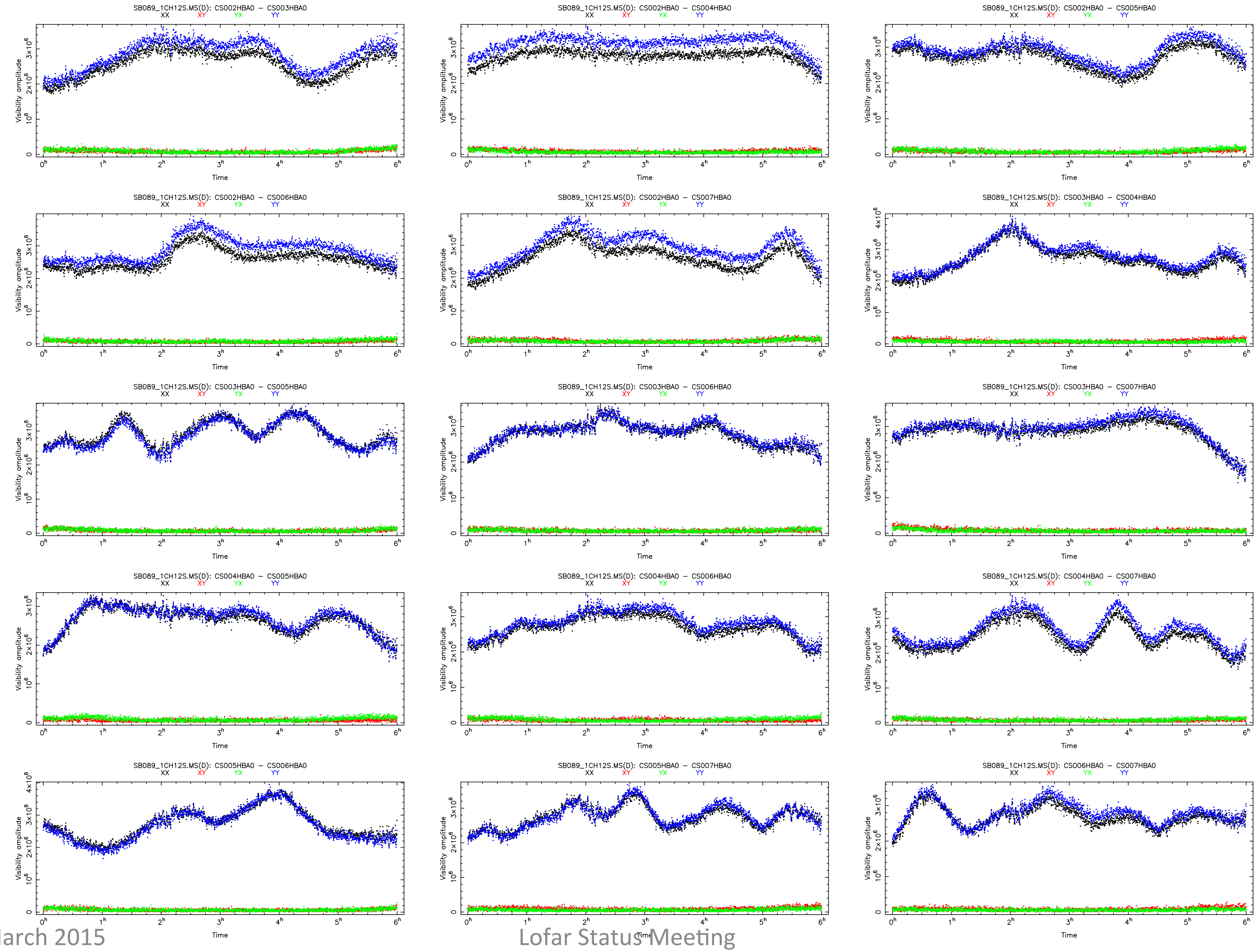
During Cycle 1 and Cycle 3 (Winter semesters) we found that weak scintillation is often (>30%) present at some level for some of the time (usually between UT 22-01h)

Various metrics can be constructed:

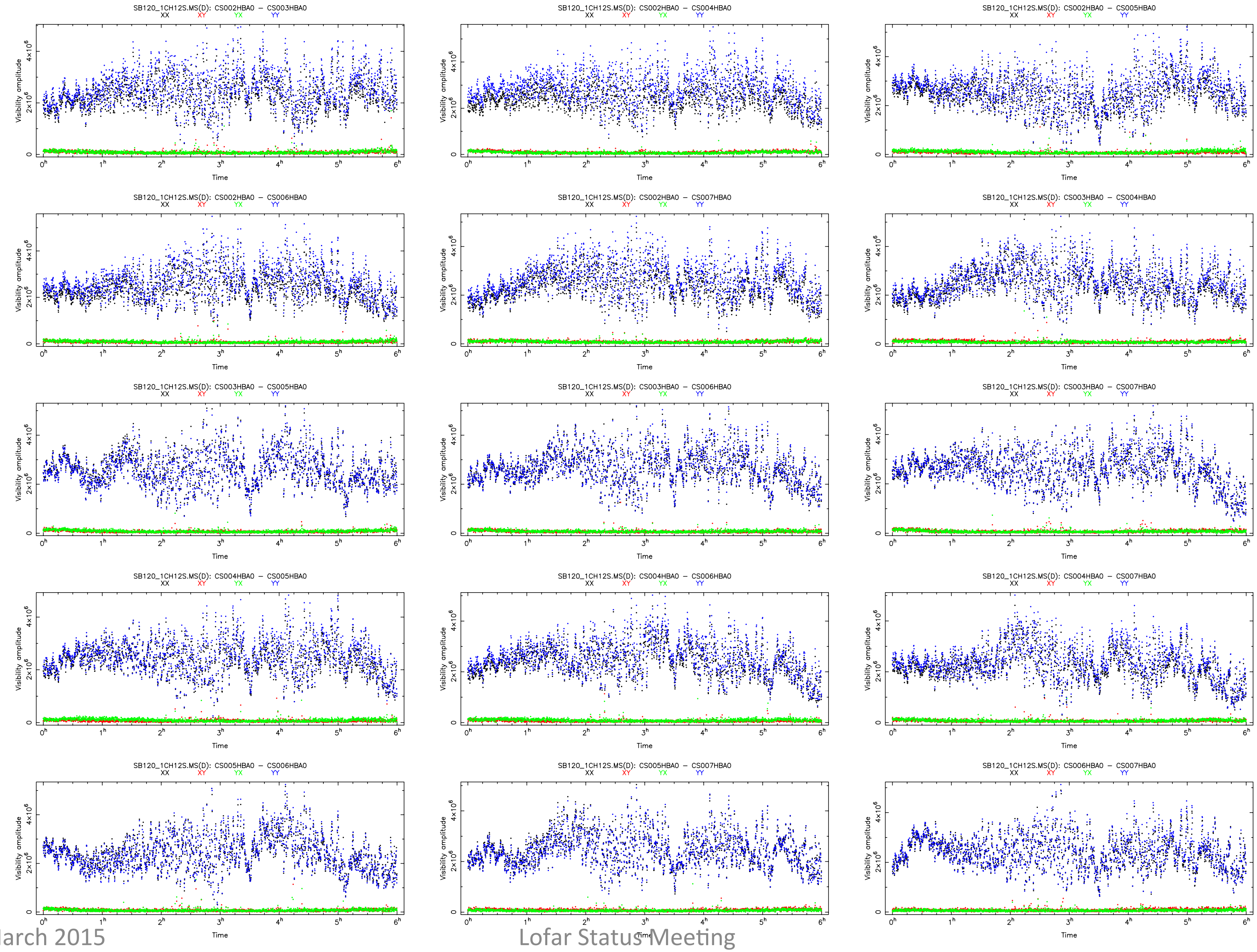
- one metric is the r_{diff} derived from ionospheric structure functions
- another metric may be the flux and position stability of sources.
  In the 3C196 field we have a 5 Jy source (J0814+4556) 2.3^{o} South of 3C196.

Extreme examples below refer to: -11-Jan-2015 (L256533) and 23-Jan-2015 (L258631)

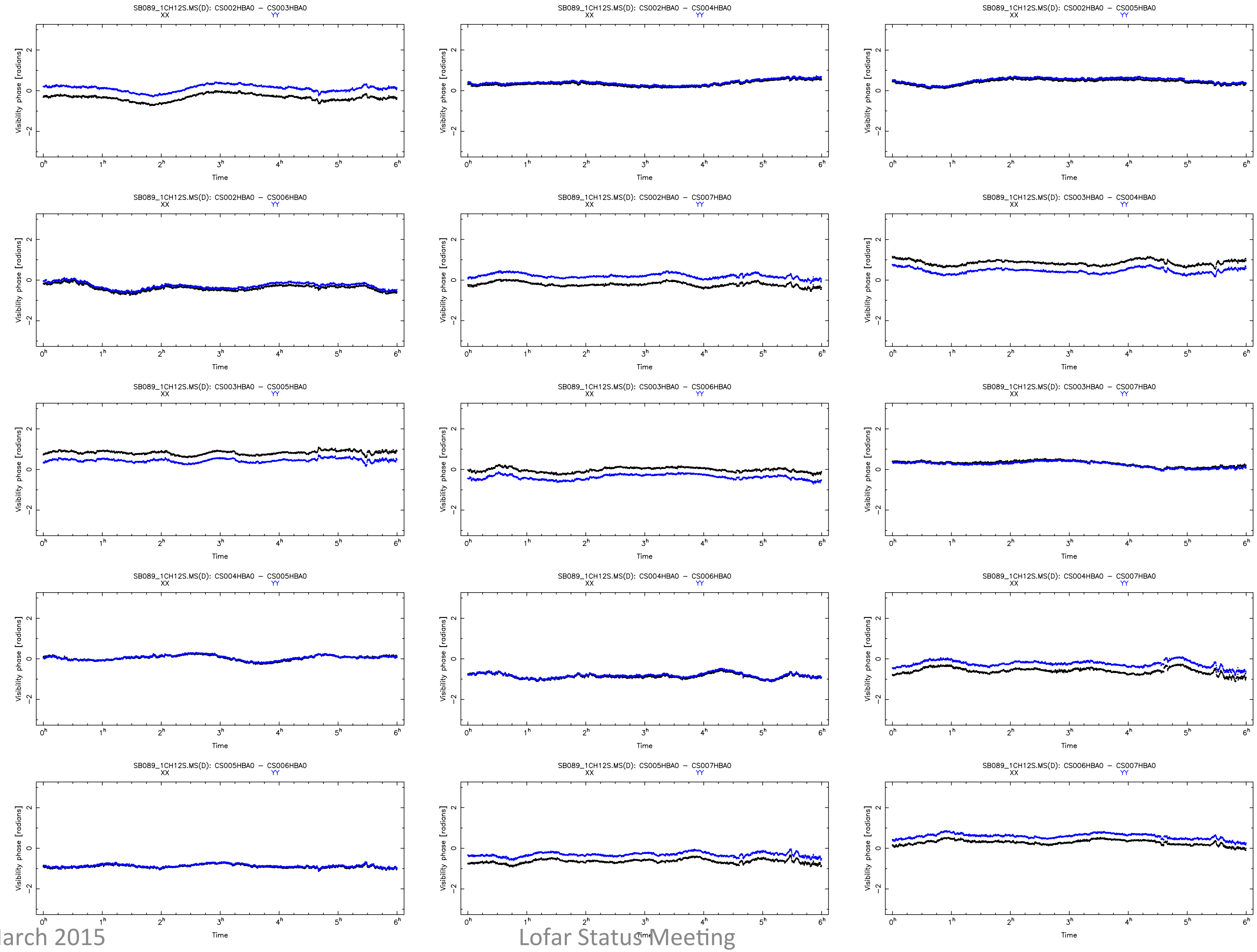
Superterp baseline visibility amplitudes on 3C196:   excellent night



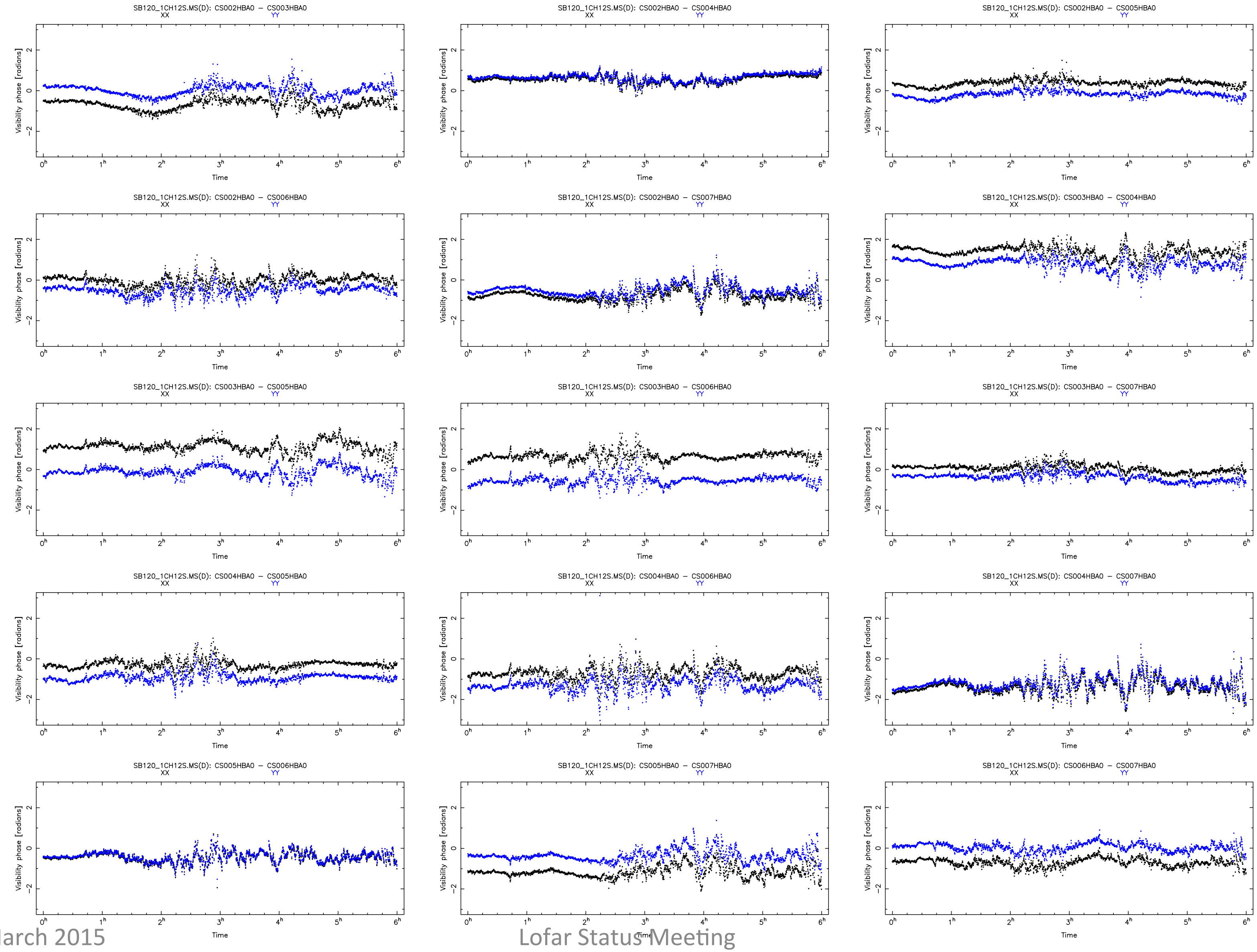
Superterp baseline visibility amplitudes on 3C196:   very bad night

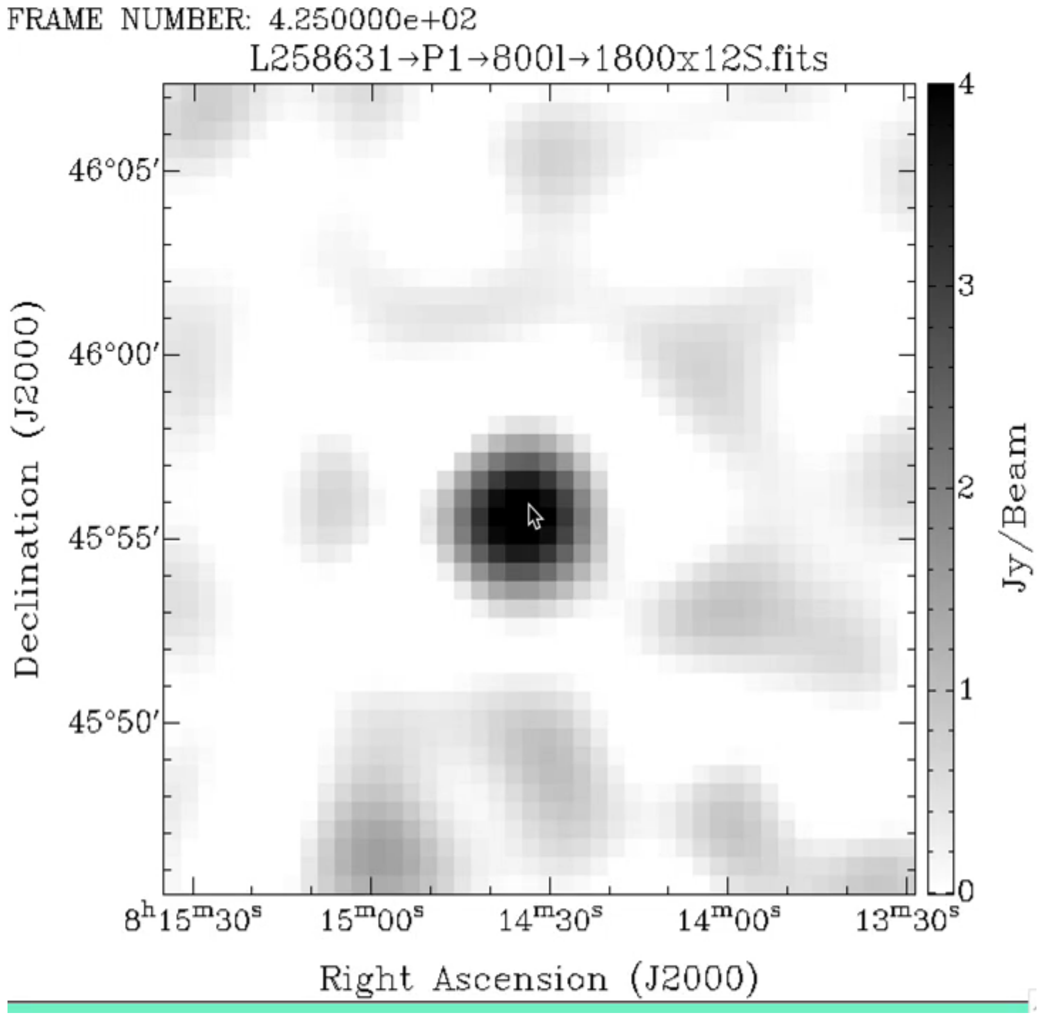


Superterp baseline visibility phases on 3C196:   very good night



Superterp baseline visibility phases on 3C196:   very bad night





1800 frames of 12s in 6h

using only core baselines.

Source flux is 5 Jy.

Image wander of 10’

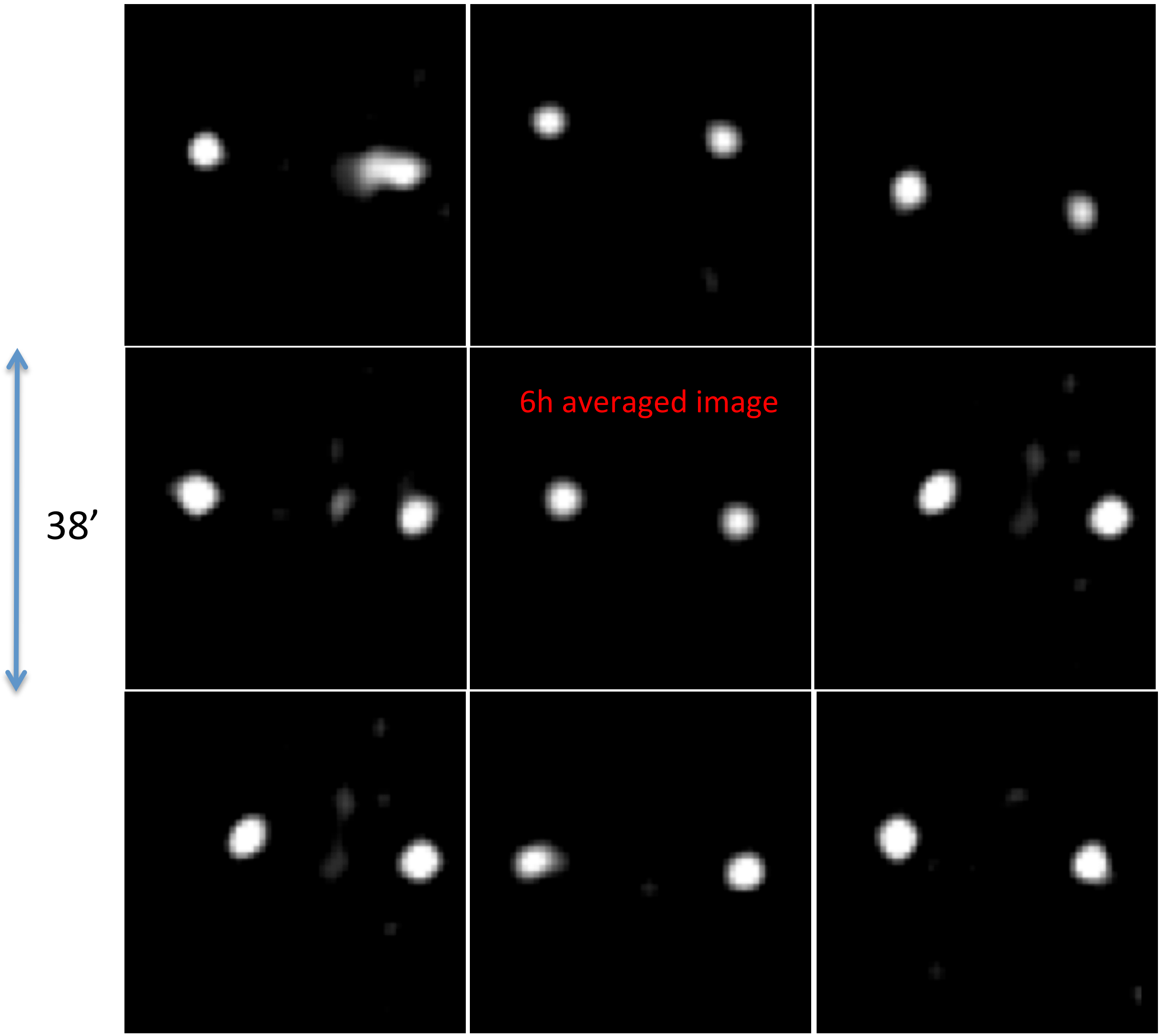
(frame is 20’x20’)

3C196 145MHz Dec 2013 Two 2-Jy sources near J0812+50

Sources are 19' apart. The PSF is ~ 4'

Shown are eight 30s frames from a 720-frame (6h) movie.

The 6h average is in the middle



2) Using data from 3C196 flanking fields

The flanking field data will be used to construct better sky models, enlarge the FOV for polarization images and improve ionospheric modelling

72 MHz (380 subbands) is allocated to the target field (115-189 MHz)

24 MHz (108 subbands) form 6 beams, each 18 subbands also covering 115-189 MHz

These socalled flanking fields are in a hexagon pattern at a radius of 3.75^{o}.

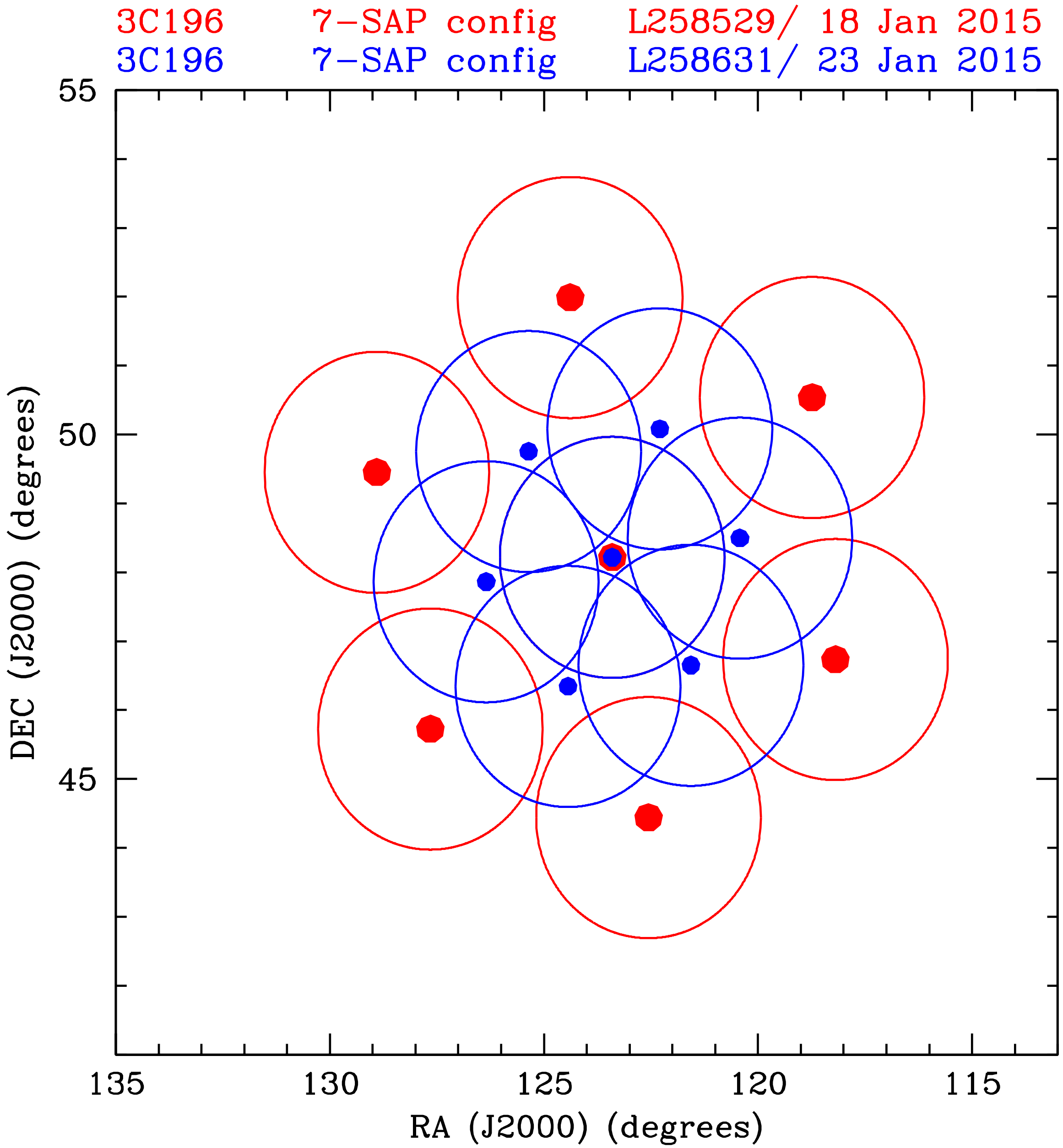
As of Jan 2015 the 6 flanking fields were moved inwards to a radius of 2^{o} (and rotated)

We also created 4 staggered frequency combs to combine data (from 4 nights) to provide better frequency coverage with lower RMSF sidelobes.

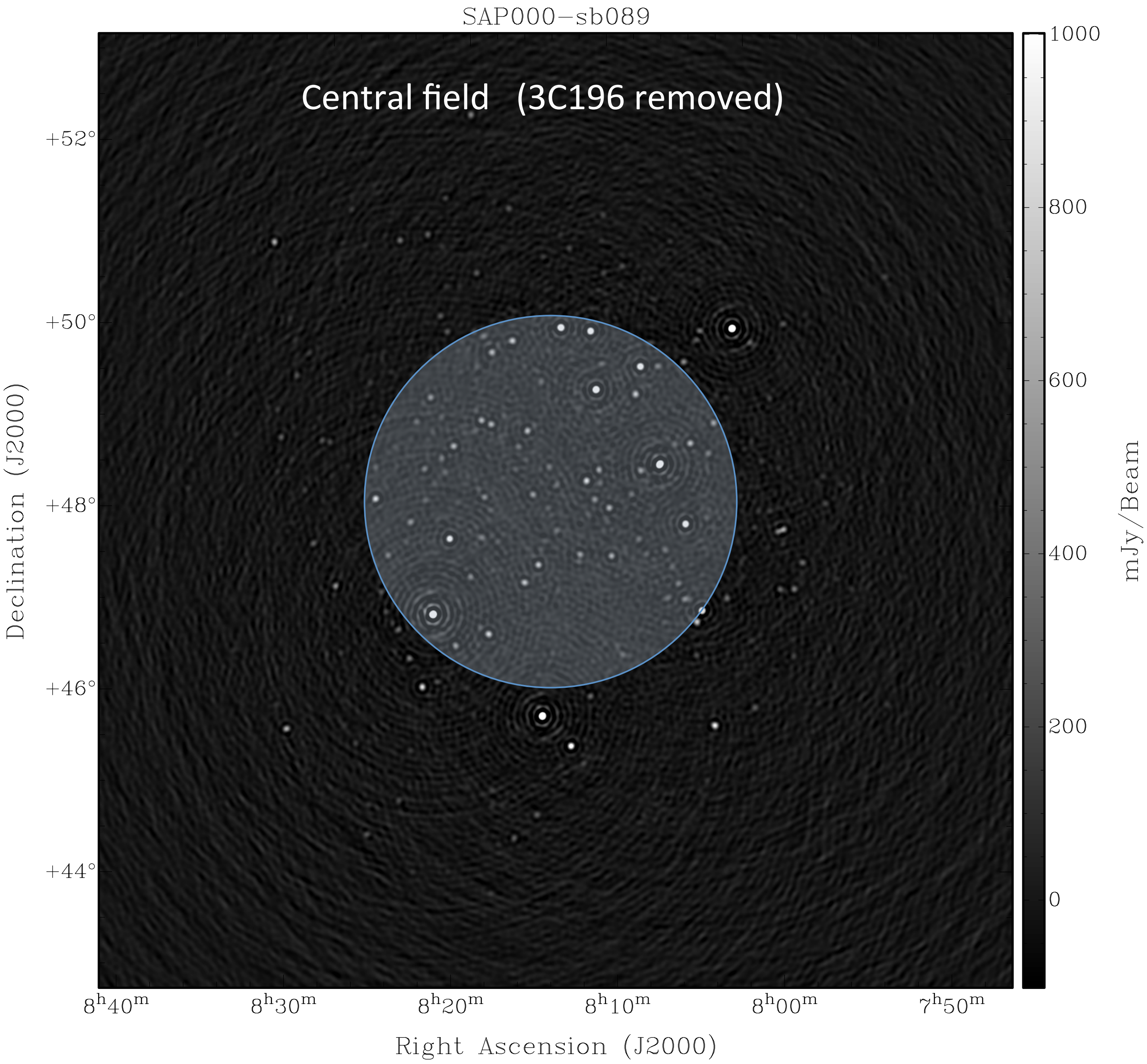
Hereafter we show 7 images of the flanking fields (still at 3.75^{o} from 3C196)

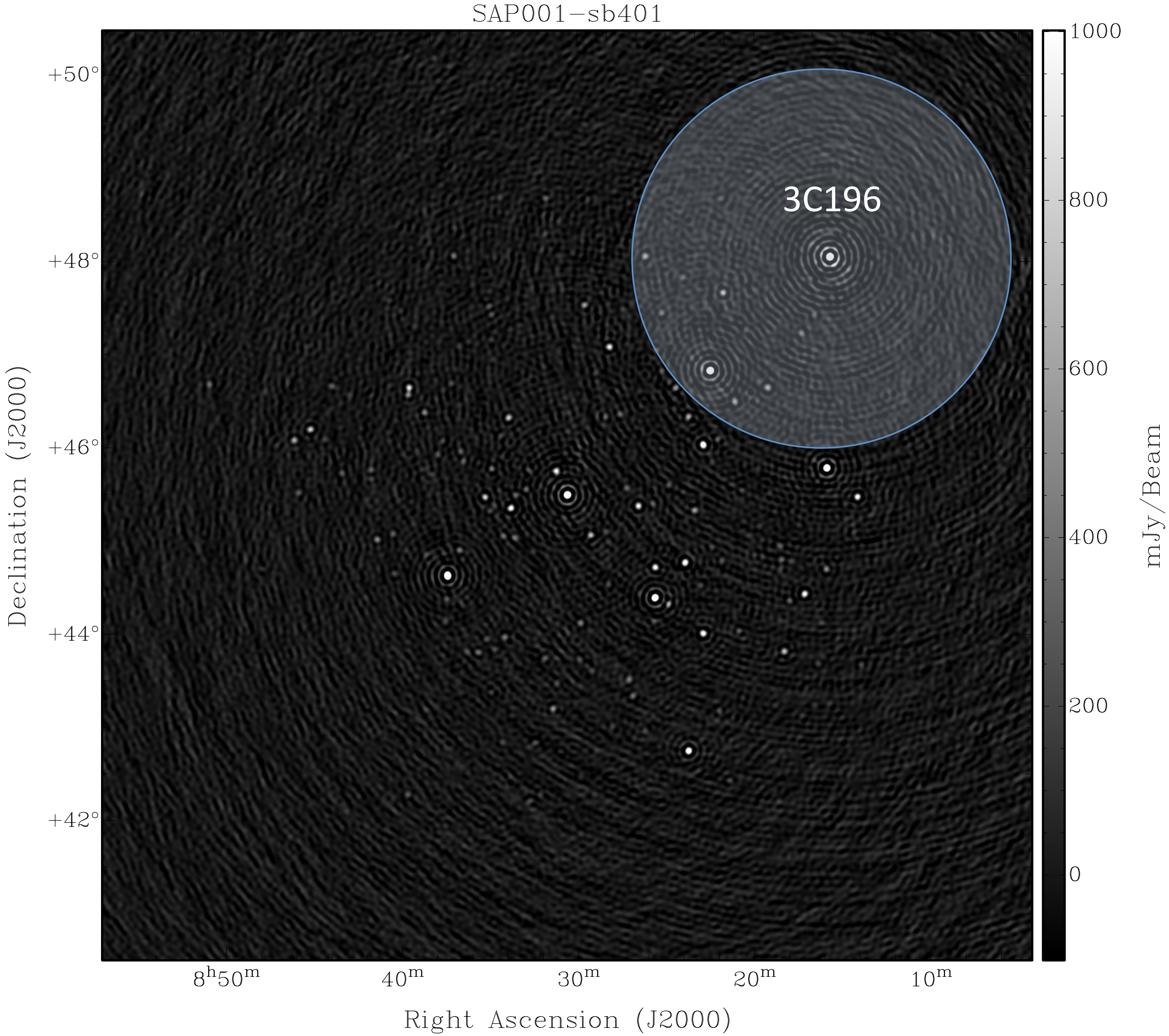
- SAP000 (the central beam) was calibrated with only the 3C196 4-comp model
- SAP001-006 data were calibrated using the gain transferred from SAP000

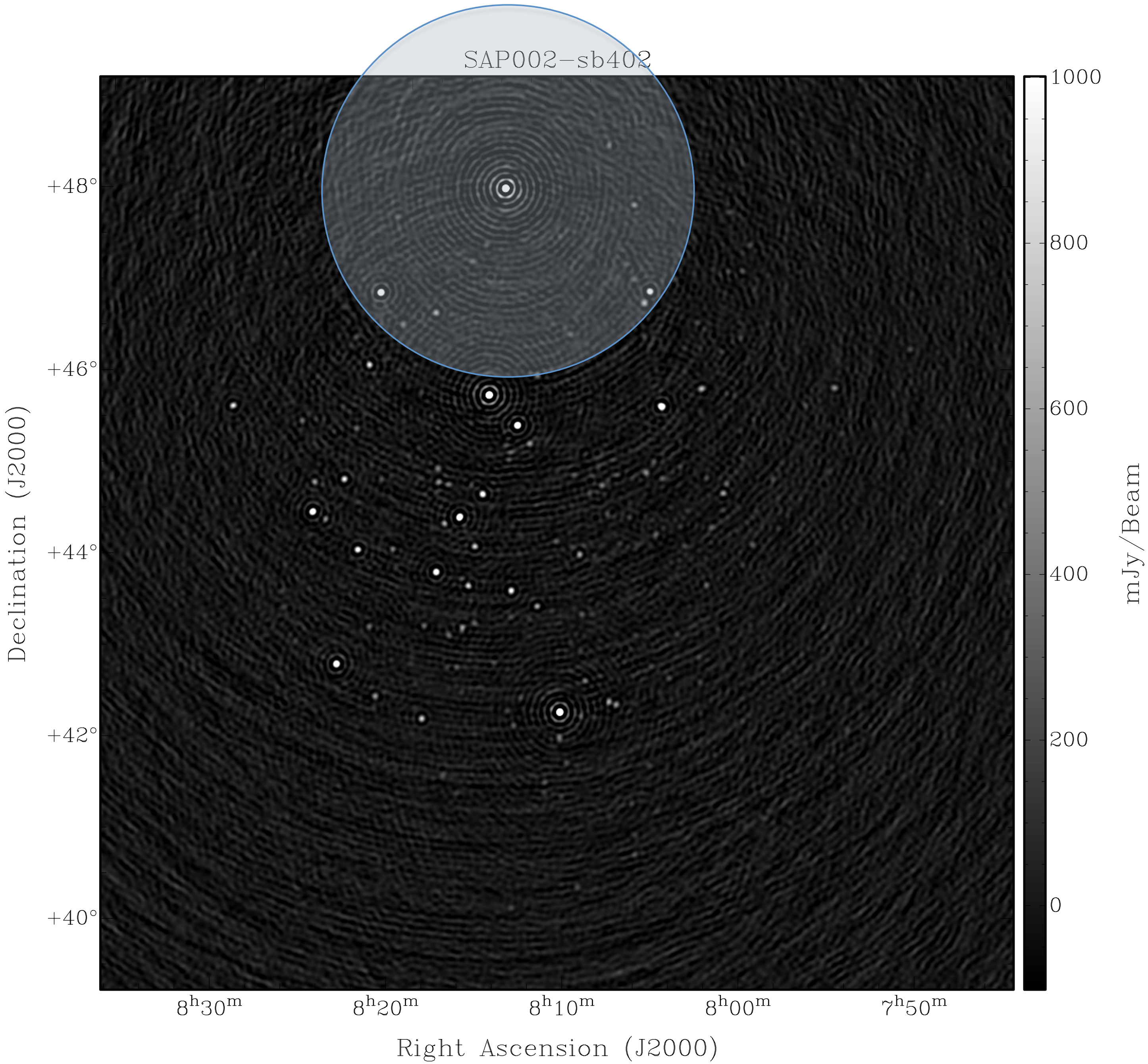
NB: SAP = Sub Array Pointing

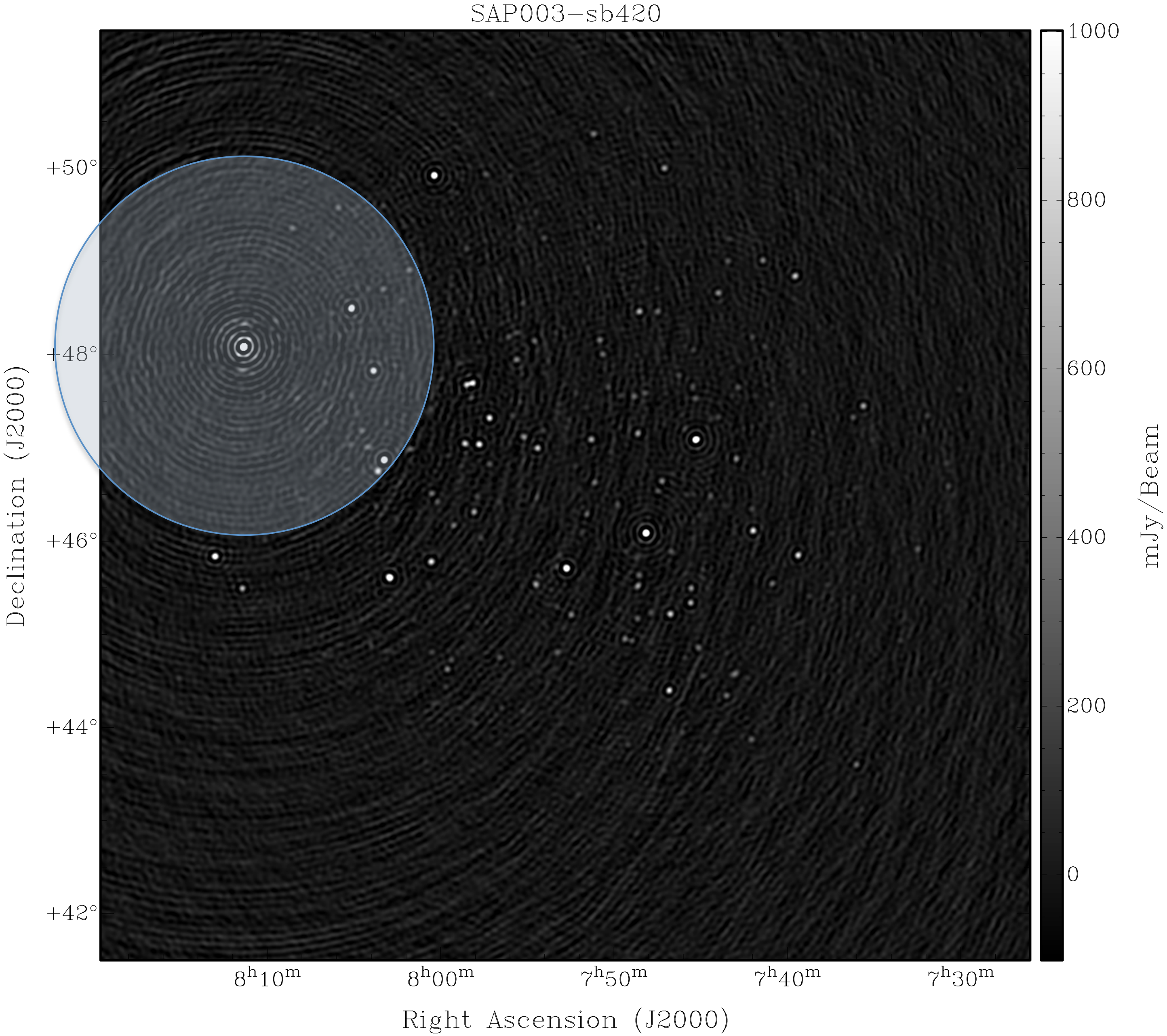


Inner and outer hexagons of flanking fields for the 3C196 window

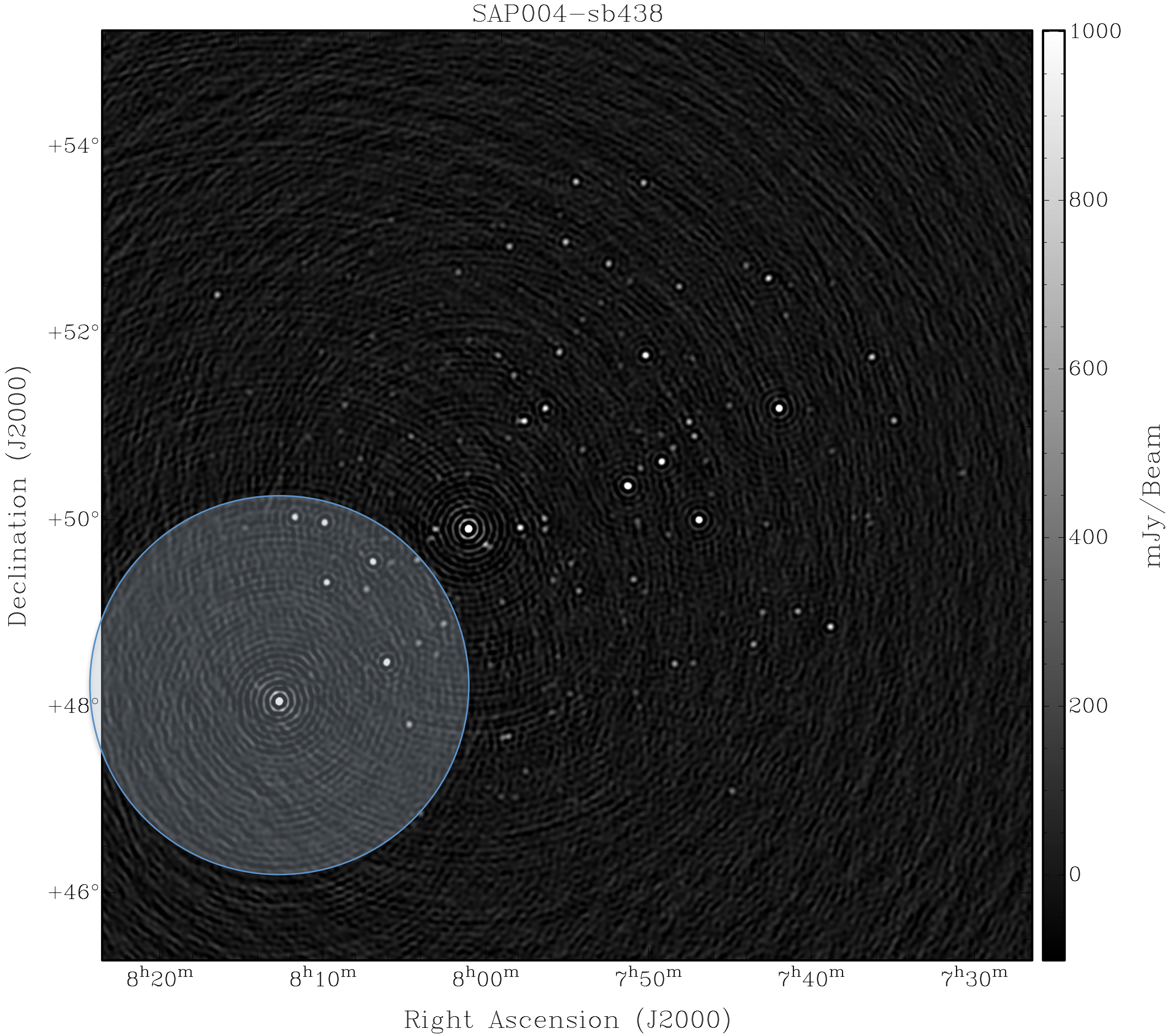

SAP000−sb089
Central field (3C196 removed)
+52°
+50°
+48°
+46°
+44°
Declination (J2000)
8h40m
8h30m
8h20m
8h10m
8h00m
7h50m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam

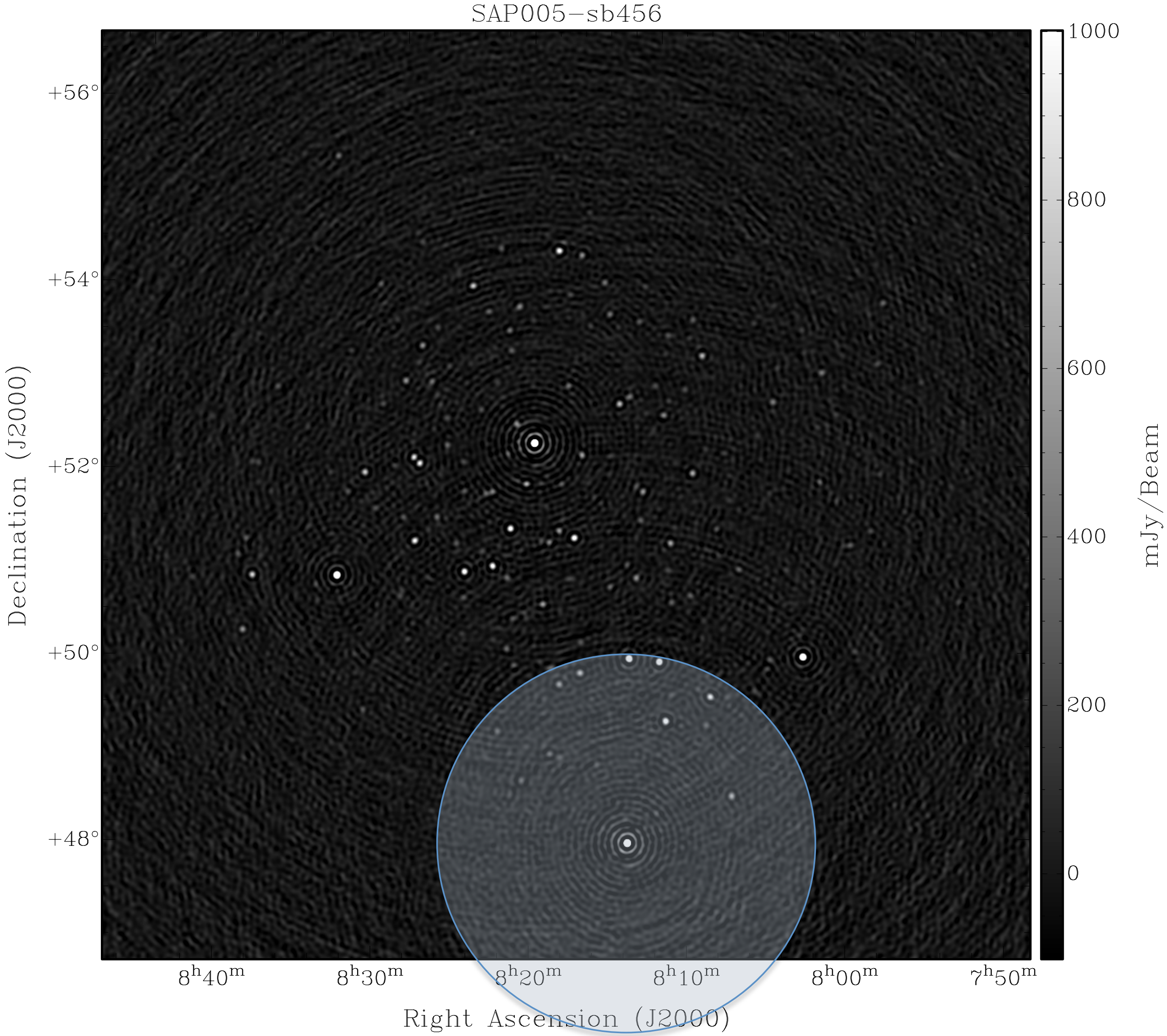

SAP001−sb401
3C196
+50°
+48°
+46°
+44°
+42°
Declination (J2000)
8h50m
40m
30m
20m
10m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam

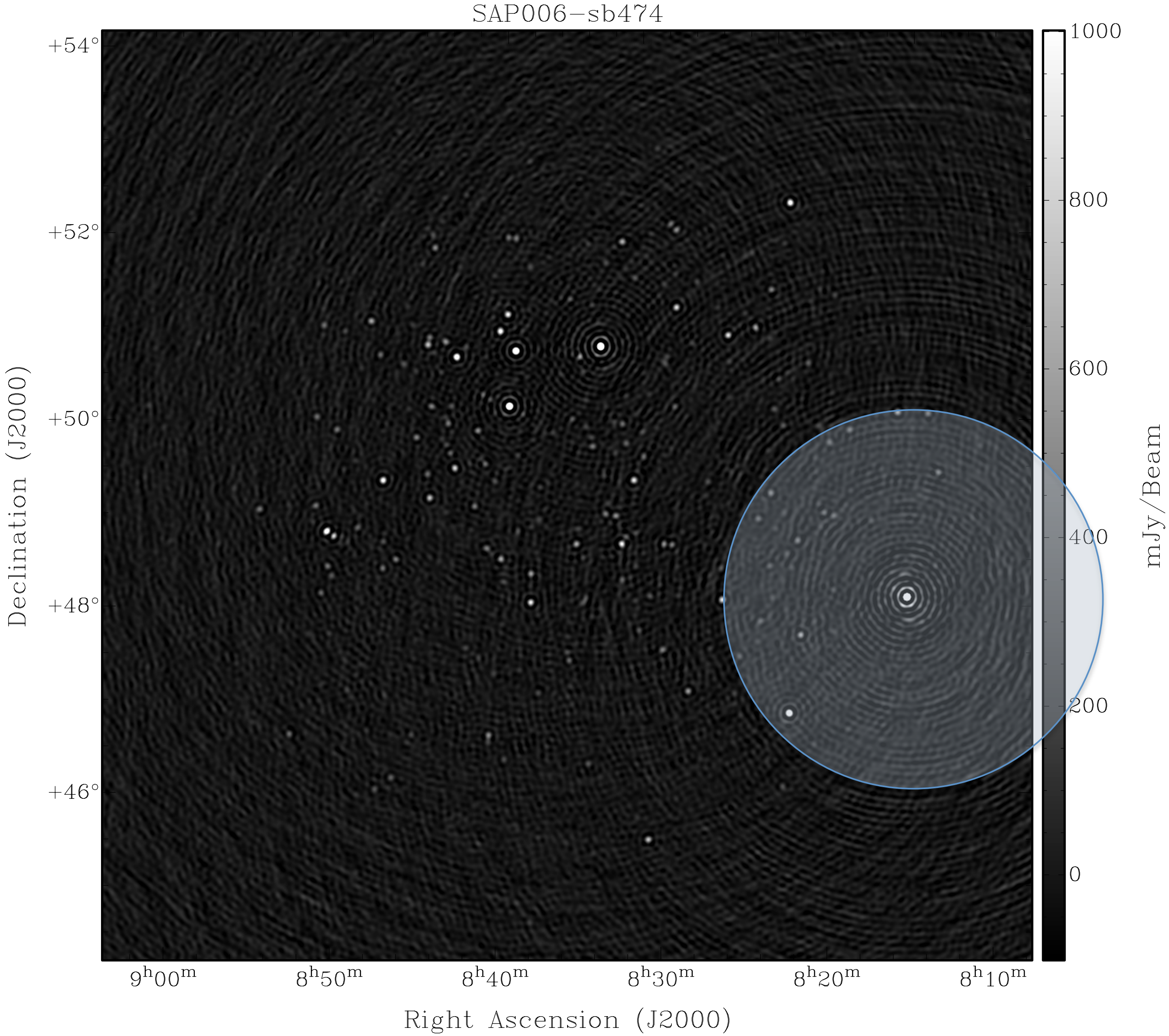

SAP002-sb402
+48°
+46°
+44°
+42°
+40°
Declination (J2000)
8h30m
8h20m
8h10m
8h00m
7h50m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam



SAP003−sb420
+50°
+48°
+46°
+44°
+42°
Declination (J2000)
8h10m
8h00m
7h50m
7h40m
7h30m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam


SAP004−sb438
+54°
+52°
+50°
+48°
+46°
Declination (J2000)
8h20m
8h10m
8h00m
7h50m
7h40m
7h30m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam


SAP005-sb456
+56°
+54°
+52°
+50°
+48°
Declination (J2000)
8h40m
8h30m
8h20m
8h10m
8h00m
7h50m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam



SAP006−sb474
+54°
+52°
+50°
+48°
+46°
Declination (J2000)
9h00m
8h50m
8h40m
8h30m
8h20m
8h10m
Right Ascension (J2000)
1000
800
600
400
200
0
mJy/Beam

3) Processing international station data on 3C196

Why? We need a (sub-arcsecond) model on NL baselines for ~ 5 sources

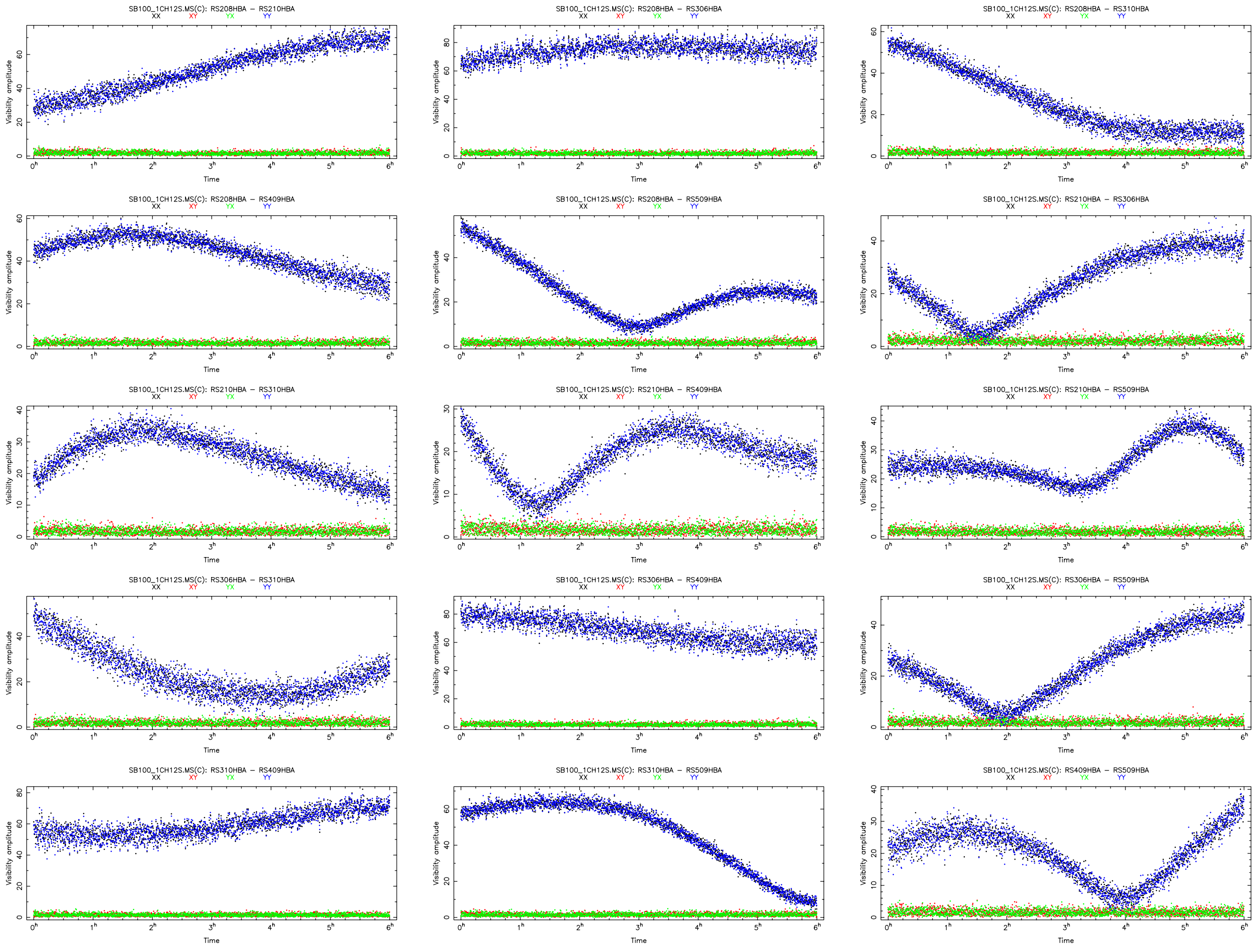
Data calibration/imaging/modelbuilding procedure:

- Start BBS with Pandey's 4 component Gaussian (spectral) model
- Use casapy-clean to generate model, FT → model visibilities
- Iterate
- Slowly bring in longer baselines

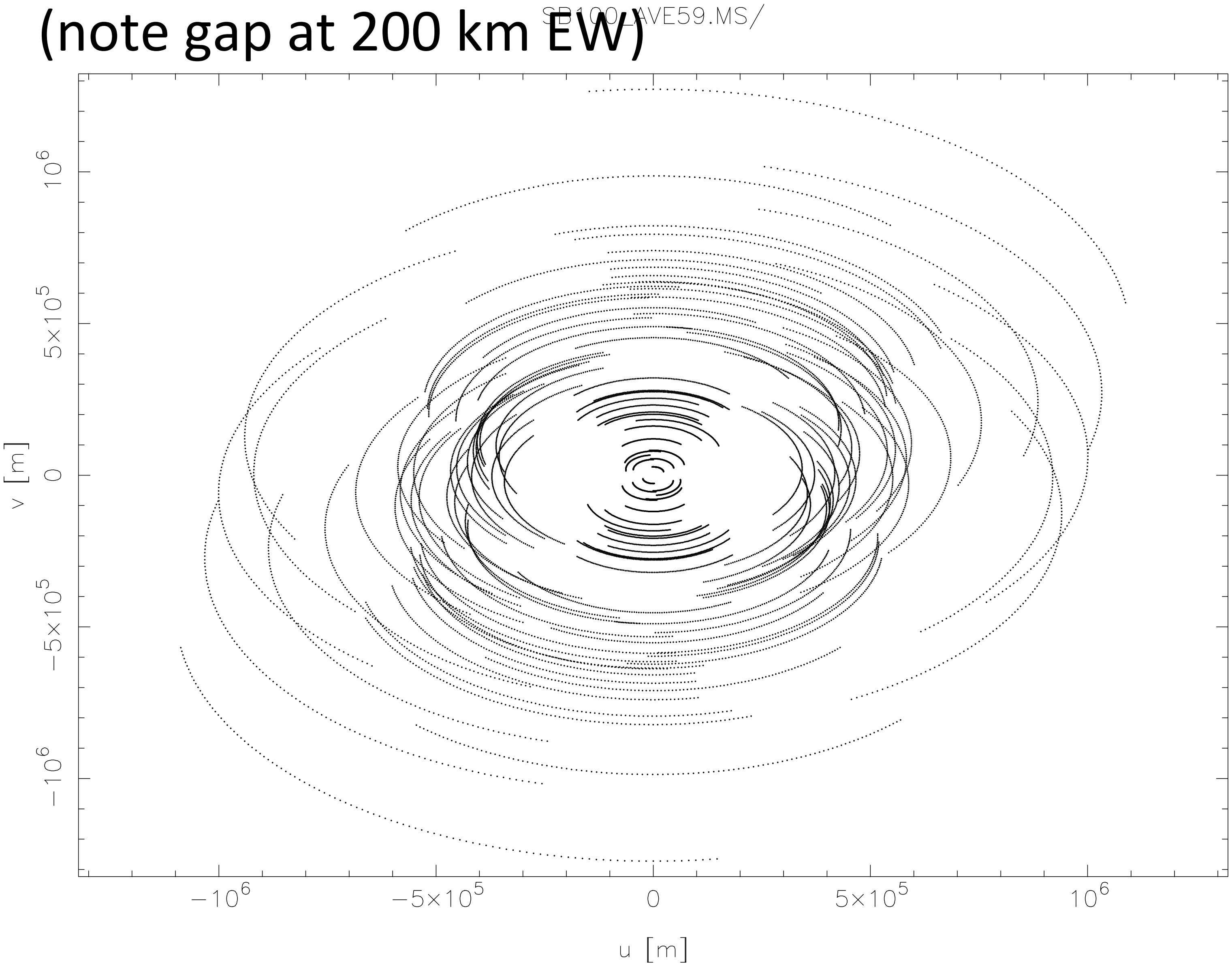
(if needed, smooth gain-amplitude solutions with 2d order polynomial)

NB:
- No use of coherent core needed (enough S/N)
- Use of data with 180 kHz acceptable (delays < 200 ns)
- Use of 12s integration acceptable (except for SE607 baselines ~ 10% of time)

Calibrated NL baselines → 3C196 barely resolved
To predict/subtract source requires arcsecond structure



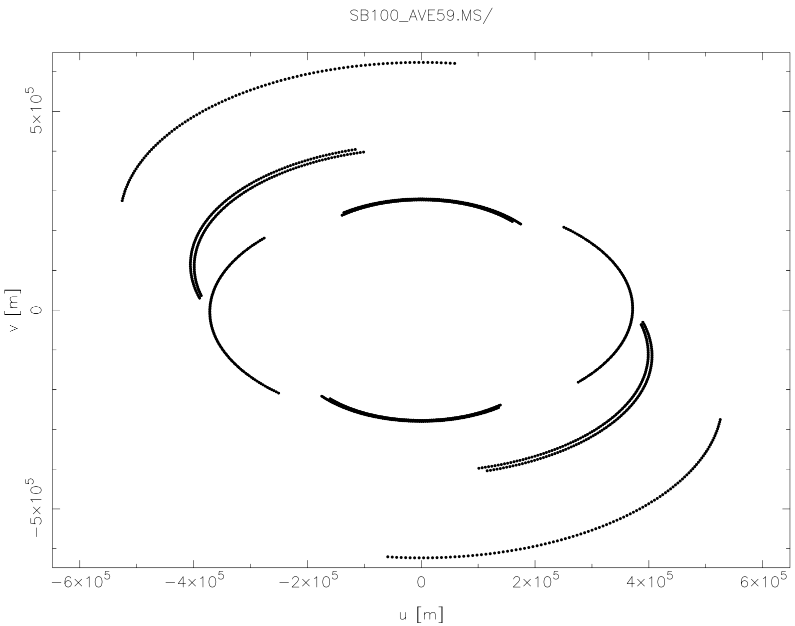
uv-coverage with 8 IS   3C196 - 6 hours
(note gap at 200 km EW)

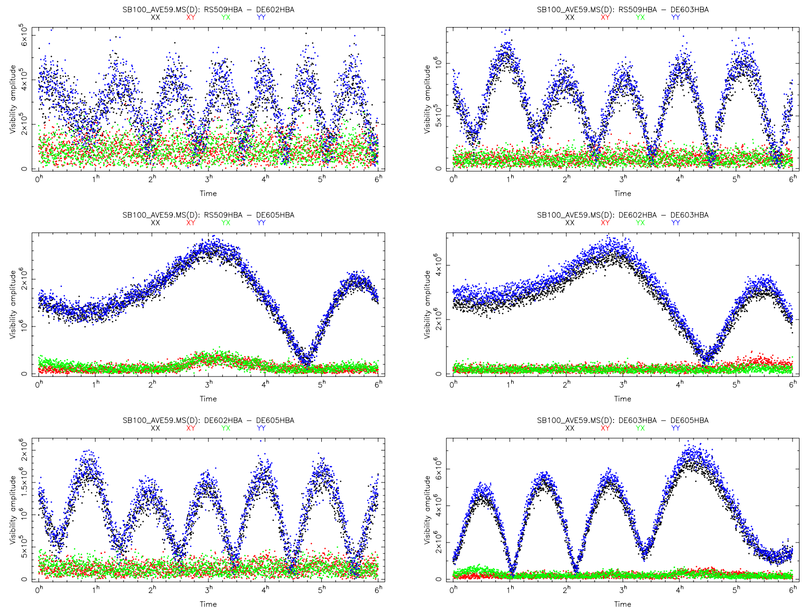


Interesting baseline coincidences

RS509-DE605 ~ DE602-DE603

RS509-DE603 ~ DE605-DE602

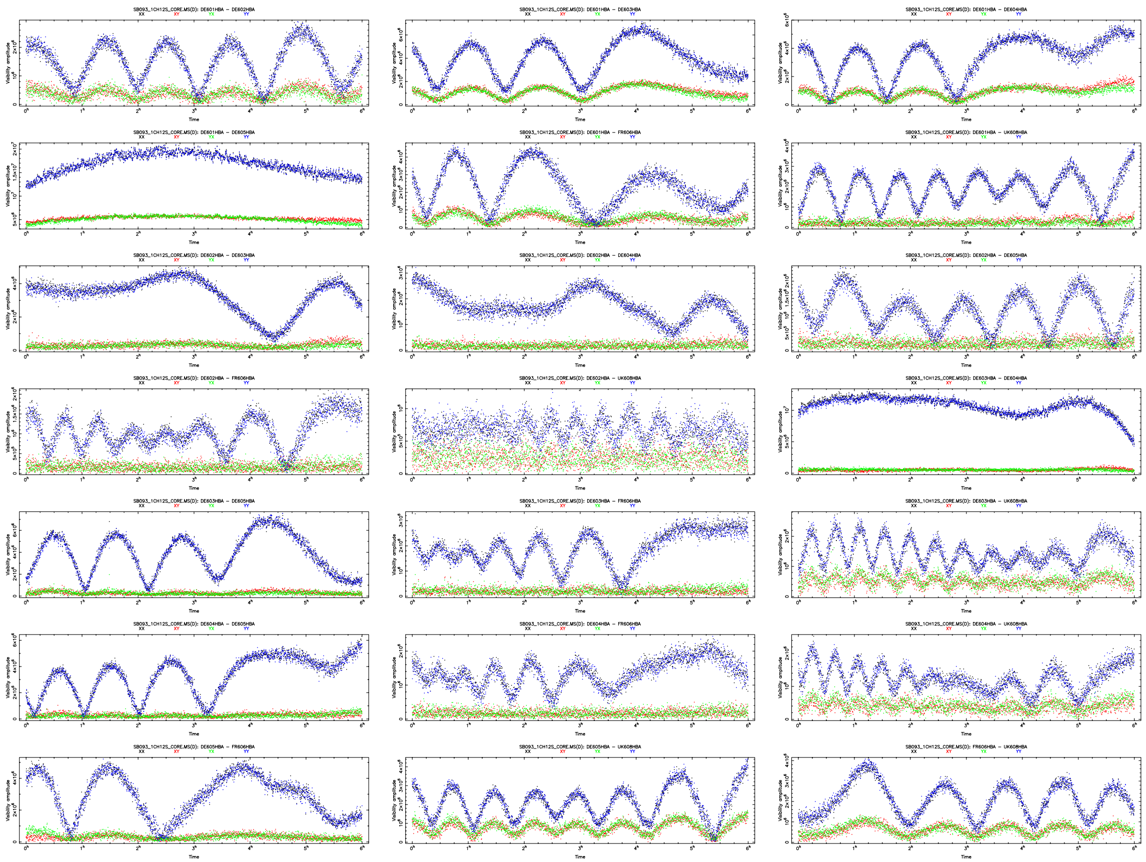




7 IS (DE601….DE605, FR606, UK608)   → 21 baselines

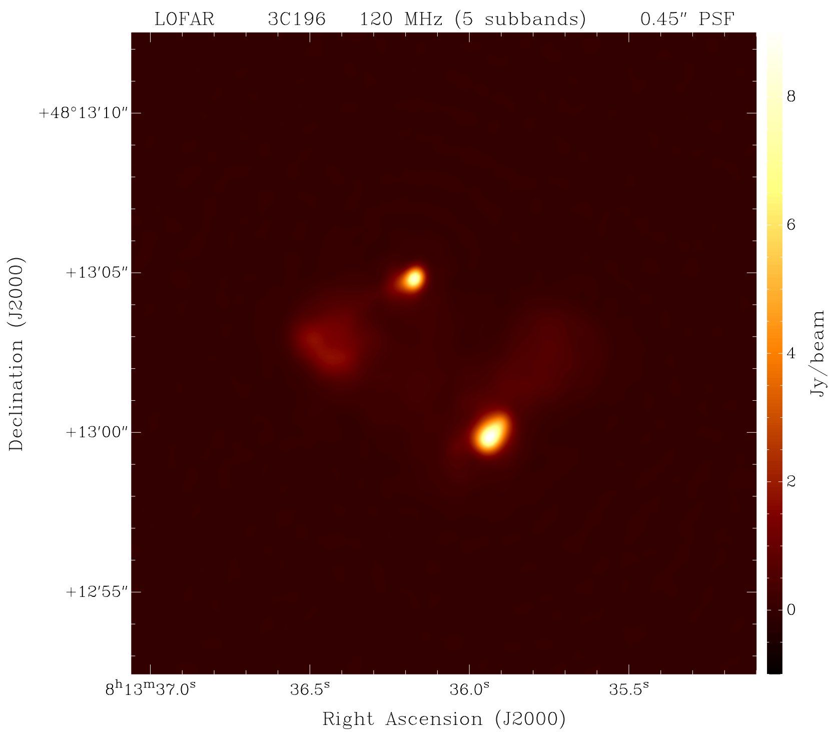
Note the strong Stokes U signals on many IS baselines

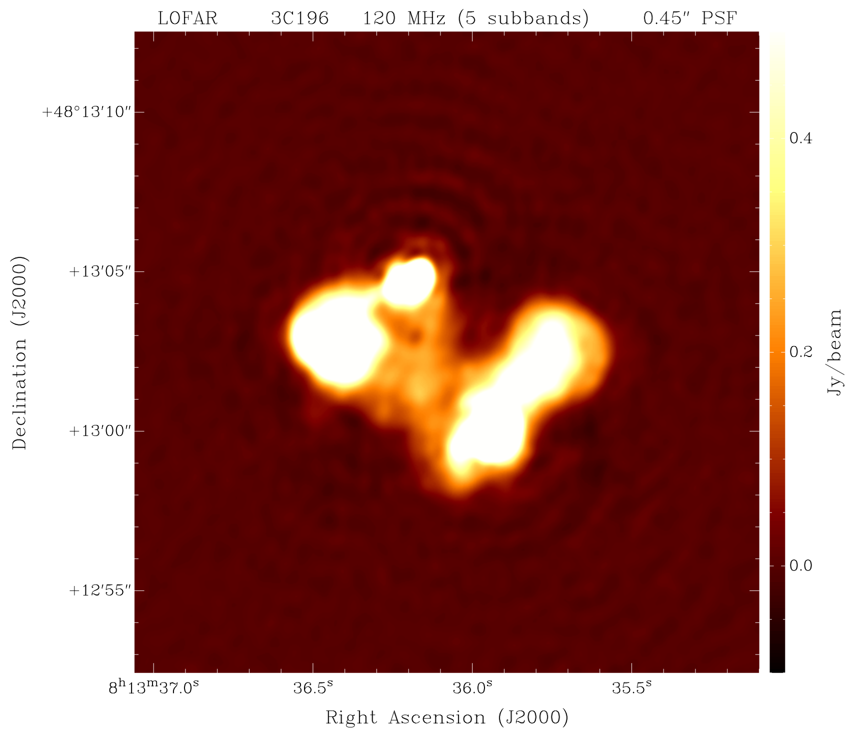
(even on DE601-DE605; 40 km)



3C196 0.45” images 28 Jan 2015, 6 hour synthesis
(6 RS + 7 IS, excluding SE607) 5 subbands (in 115-125 Mhz)

peak 9.5 Jy off source noise 2.5 mJy





3C196 observed morphology affected by lensing !?

3C196 QSR z=0.87

'barred' spiral z=0.44

116 F. H. Briggs et al.: Kinematics of a $z = 0.44$ spiral Galaxy

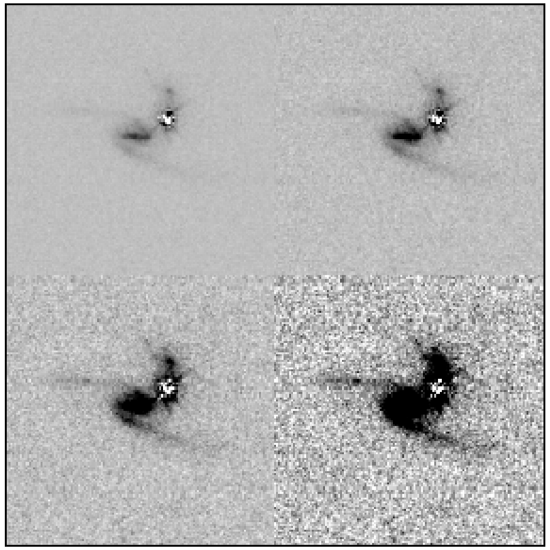


Fig. 4. HST image of 3C 196 after PSF subtraction (Ridgway & Stockton 1997) shown for four contrasts.

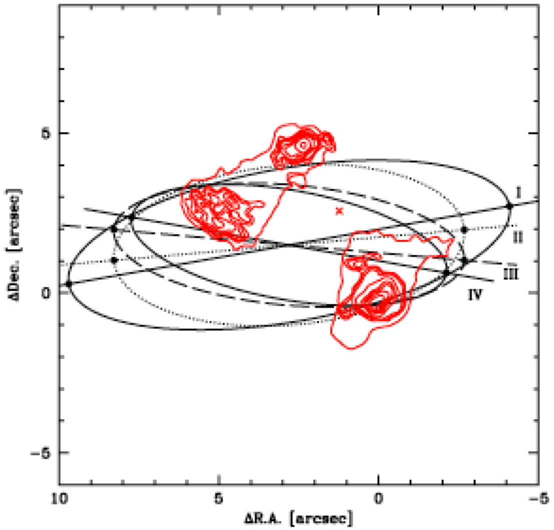


Fig. 5. Orientations and sizes of the four disk models overlaid on radio continuum contours. The representative models are labeled (I, II, III, IV) next to their major axes. The outer radio contour is taken from the 5 GHz map of Oren as shown by Cohen et al. (1996); the higher contours are 1666 MHz MERLIN data from Lonsdale & Morison (1983). The position of the optical quasar and radio nucleus is marked with an ×.

center ΔRA (measured eastward) and ΔDec with respect to the origin defined in the 1666 MHz maps of

Briggs, de Bruyn & Vermeulen (2001)

Next steps in sub-arcsecond EoR-processing:

1) Create broad band images/models using CASA’s MFS

2) Add DE609 → fills large gap in UV-plane on ~200 km EW baselines

3) Transfer gain solutions to flanking fields to image other bright sources

4) Verify the improvement in subtracting bright sources

5) Image polarized radio galaxies at sub-arcseconds

6) Get new observations with 0.5 s resolution (~ 90 TB/6h)

7) Do all of the above for some sources in the NCP window