LOFAR imaging of the Galactic centre (GC)

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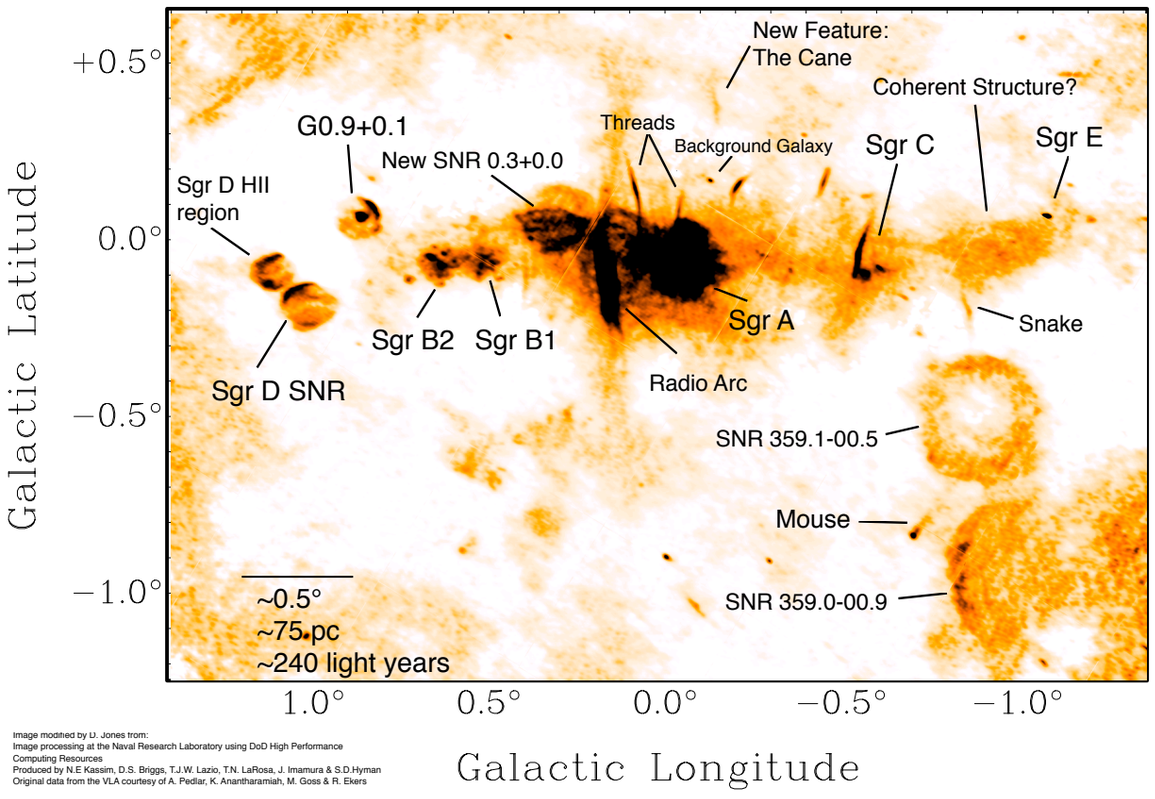
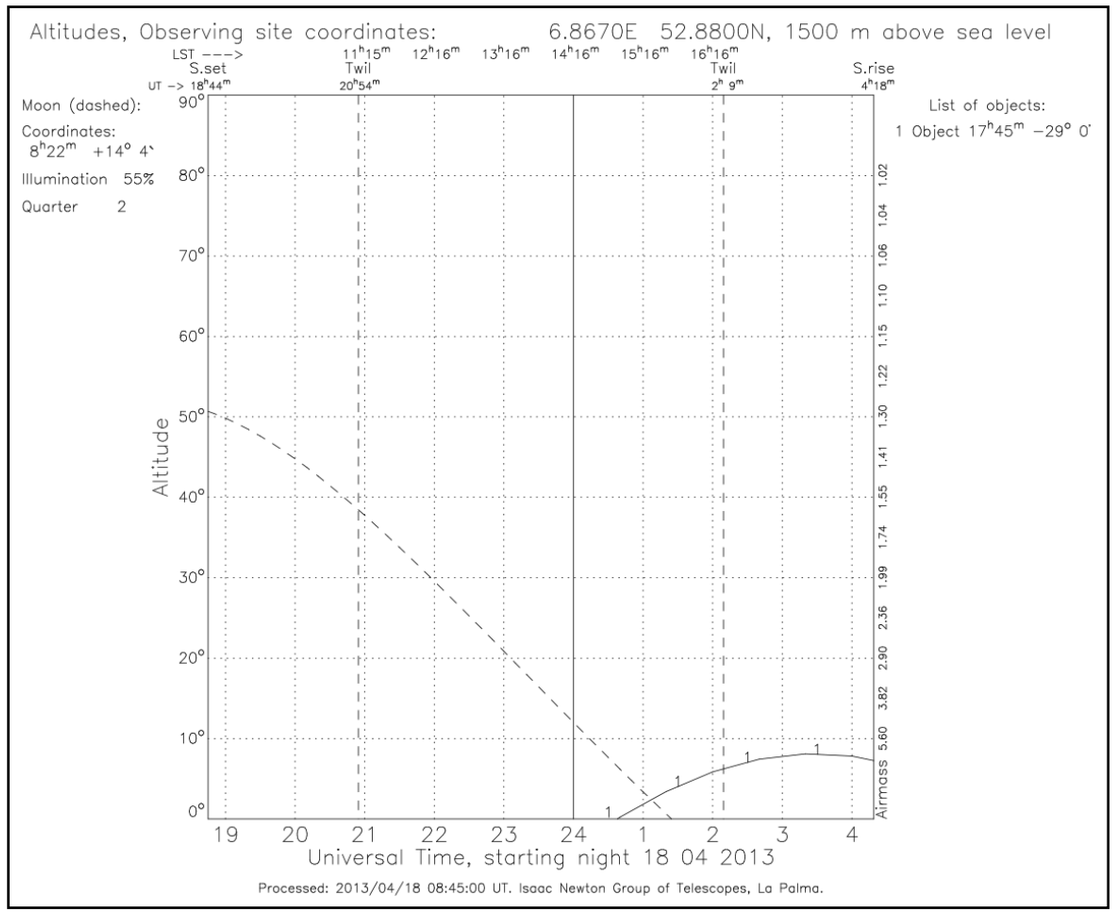
The Galactic centre

- For LOFAR, the GC is a very southerly source: RA=17 45 40.03599, DEC=-29 00 28.1699 (J2000). It peaks at an elevation of 8°.

- At 330 MHz it's a complex place.

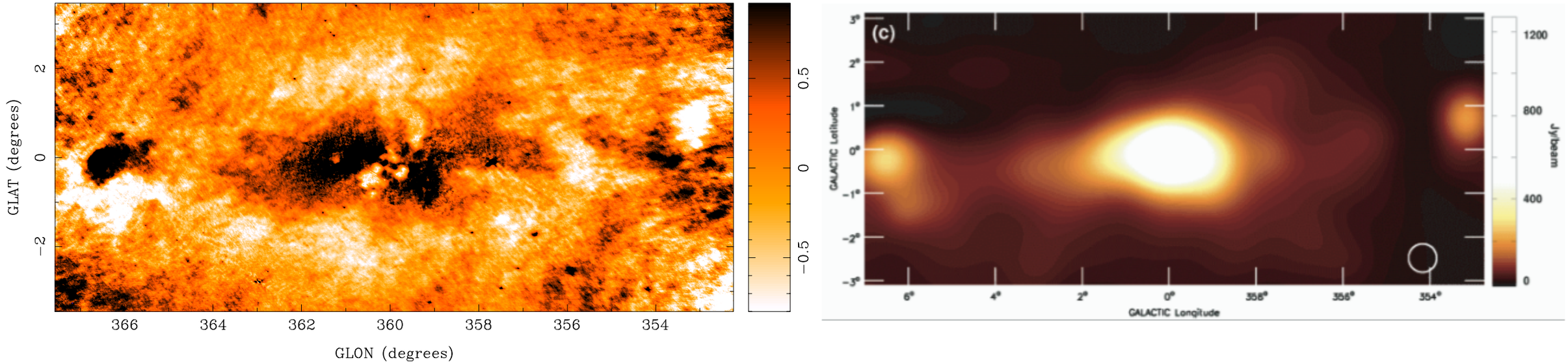




Large-scale structure of the GC

- In addition to small-scale sources, there is significant large-scale structure at low frequencies.

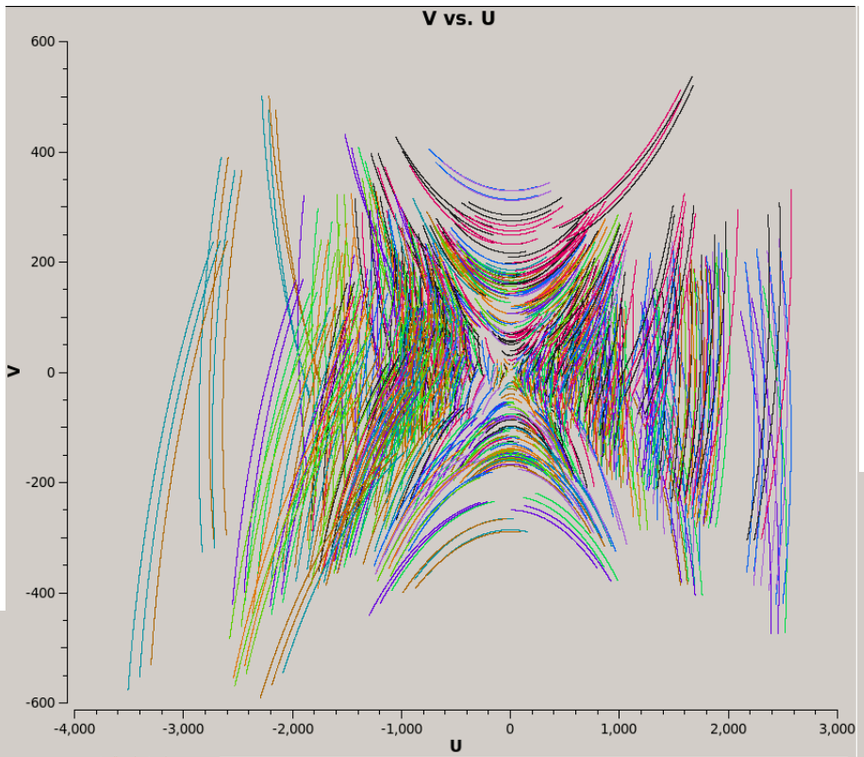
- The GC also suffers from self-absorption, especially at low frequencies.

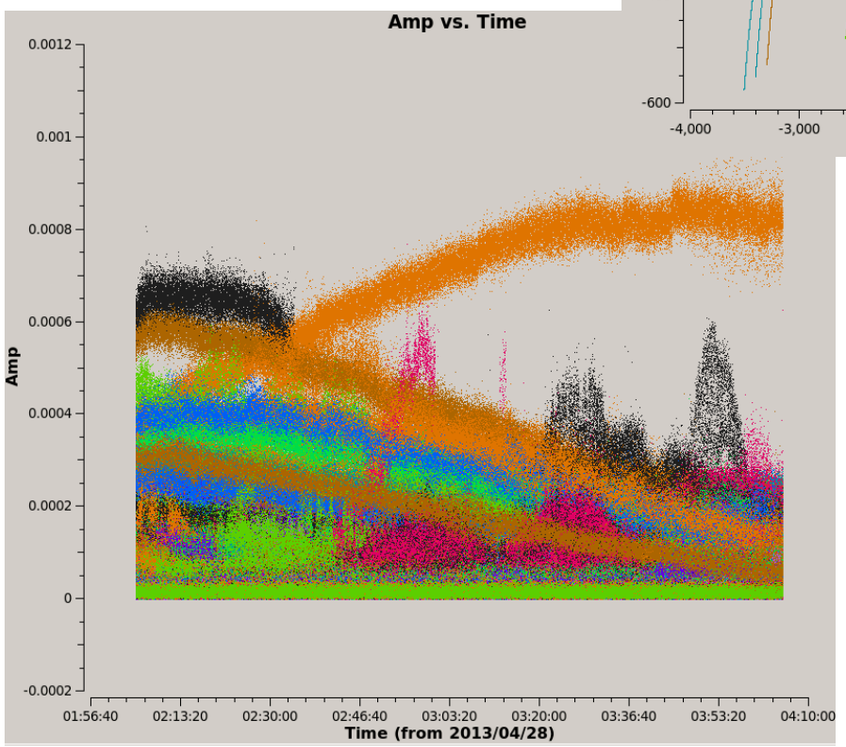


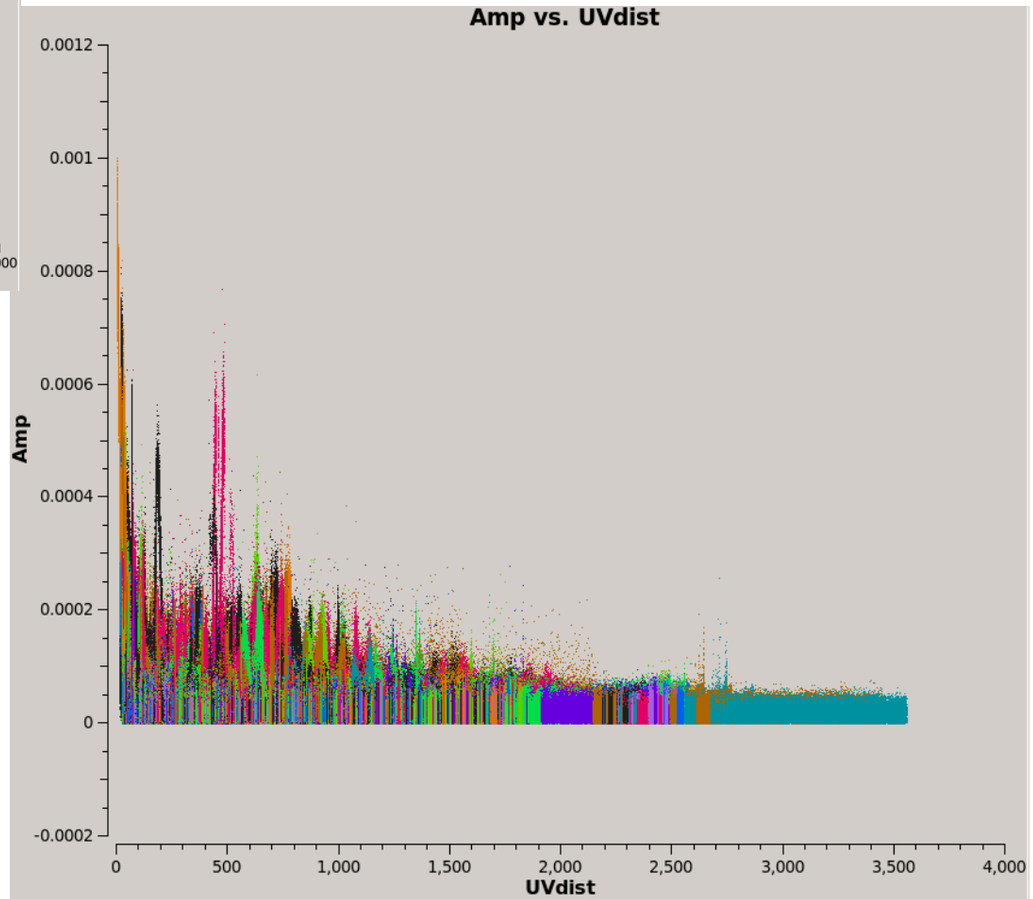
(Left: 74 MHz VLA; right 330 MHz GBT, source-subtracted image)

The data

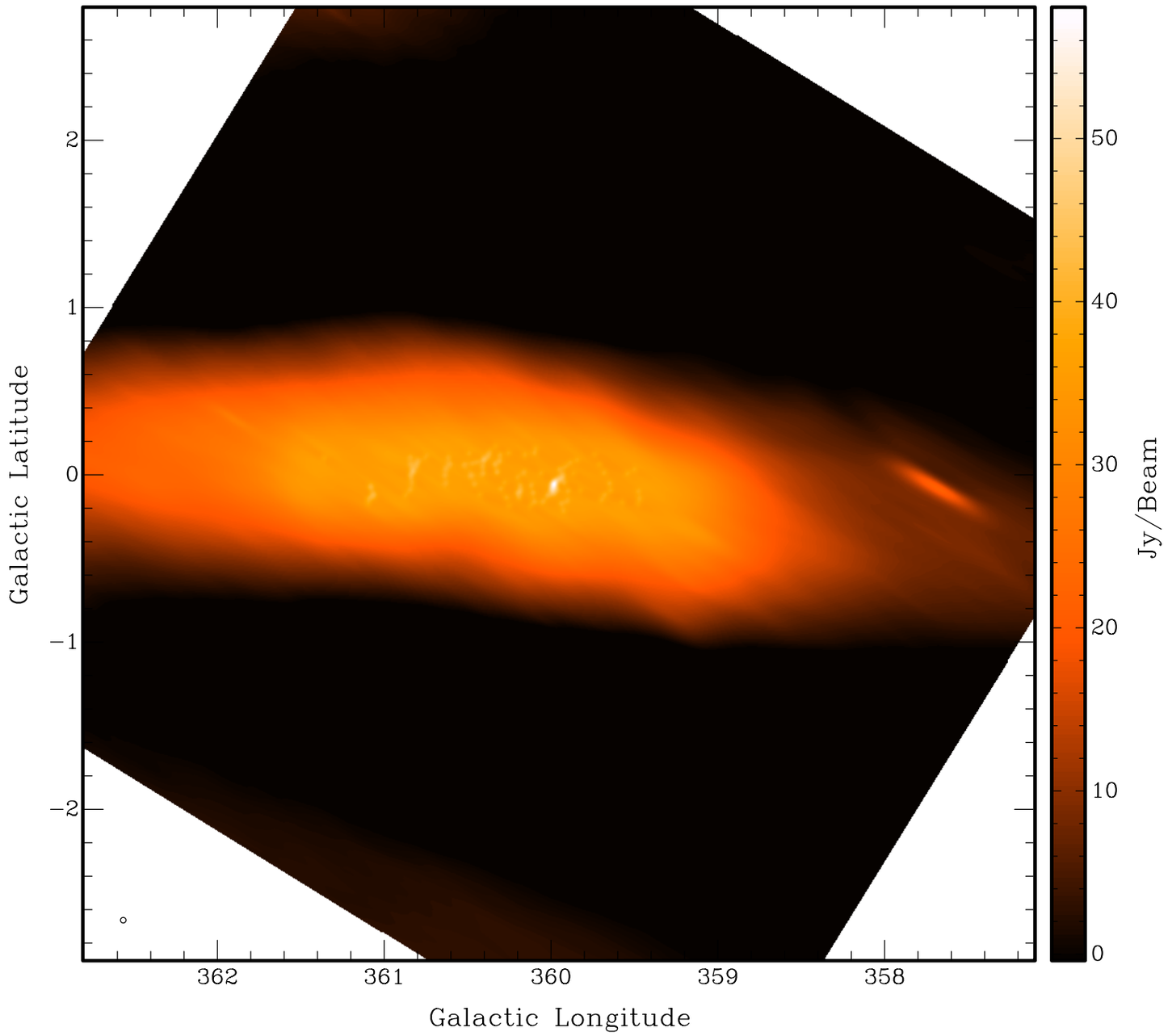
- After the observations (2 hours), the data are flagged and demixed (demix source is CasA).





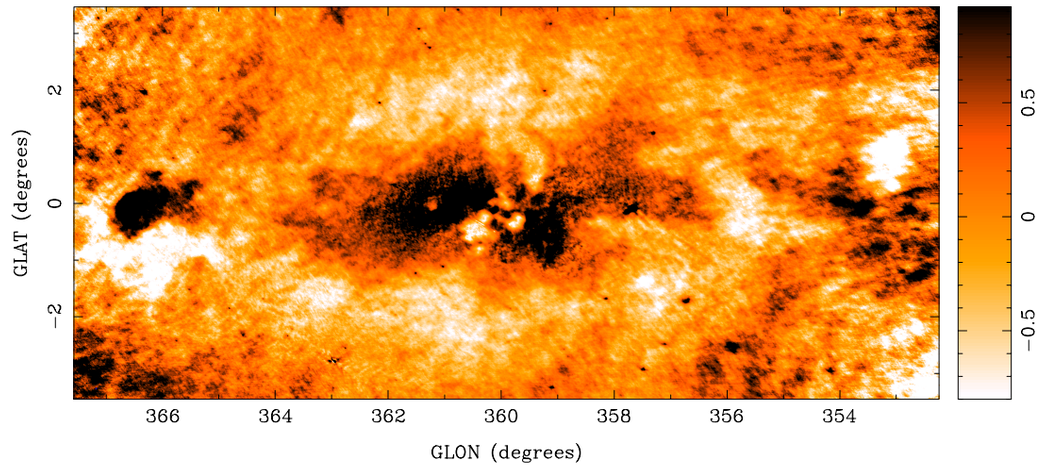


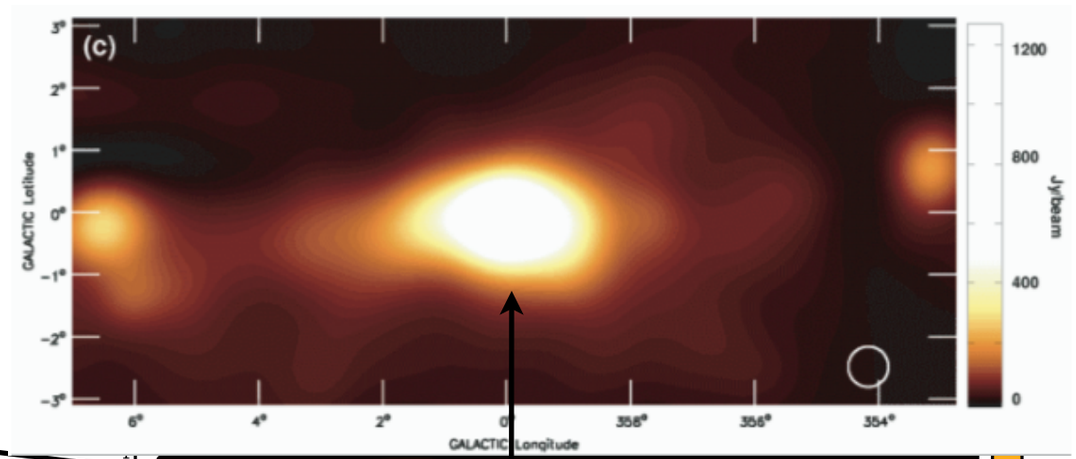
First LOFAR light on the GC

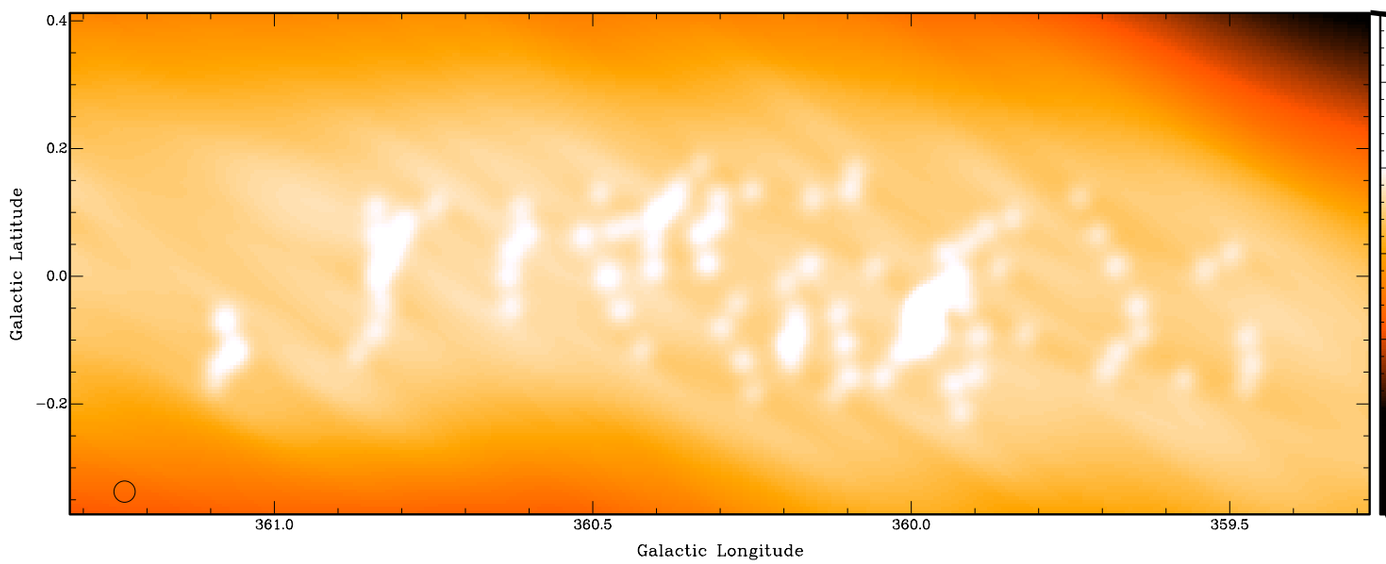


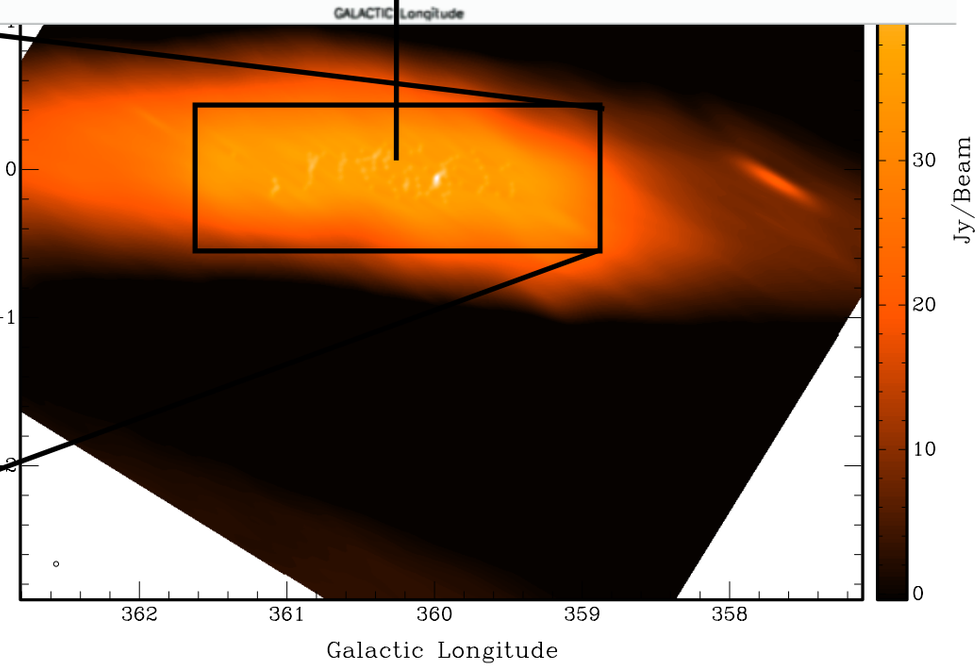
Imaging the GC at 148 MHz

- Using a light CLEAN of the data coming out of the pipeline, with only the core-stations, reveals an image with much large-scale structure: 148 MHz, 10 sub-bands (=~2 MHz BW), ~10 Jy noise (S/N~6)









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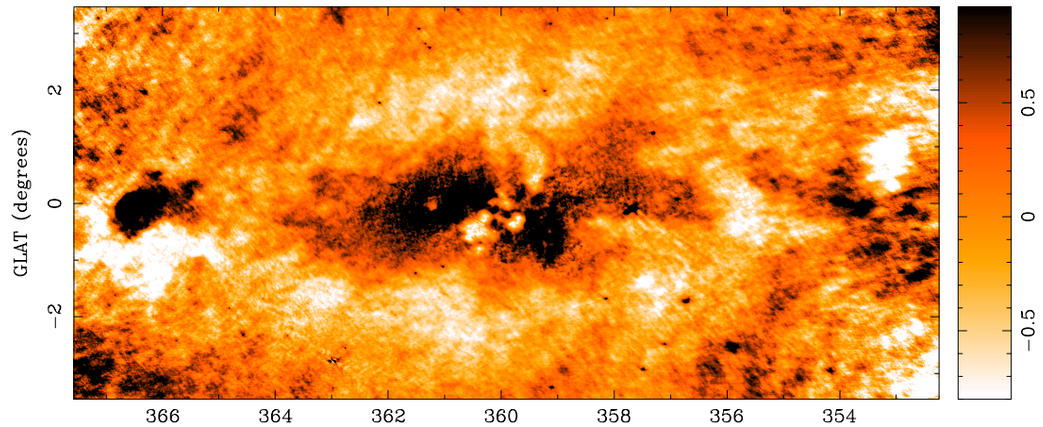
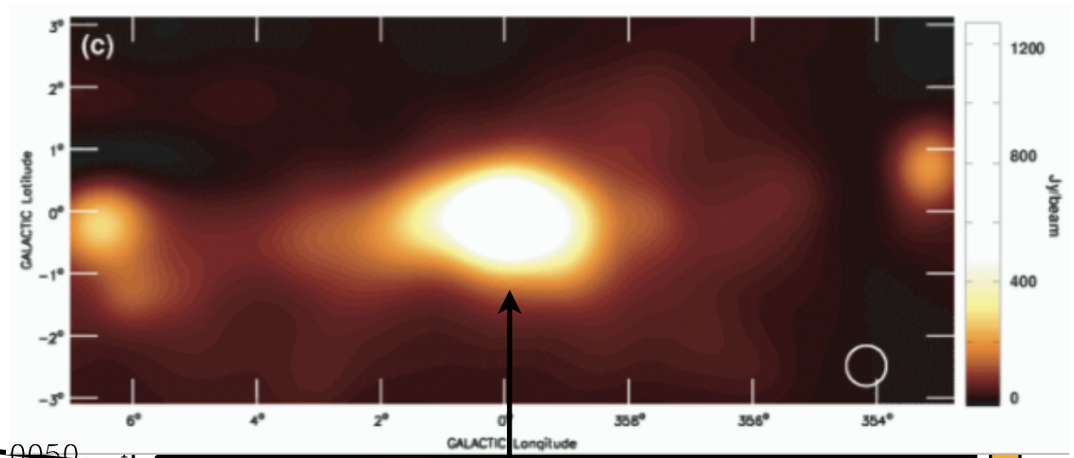
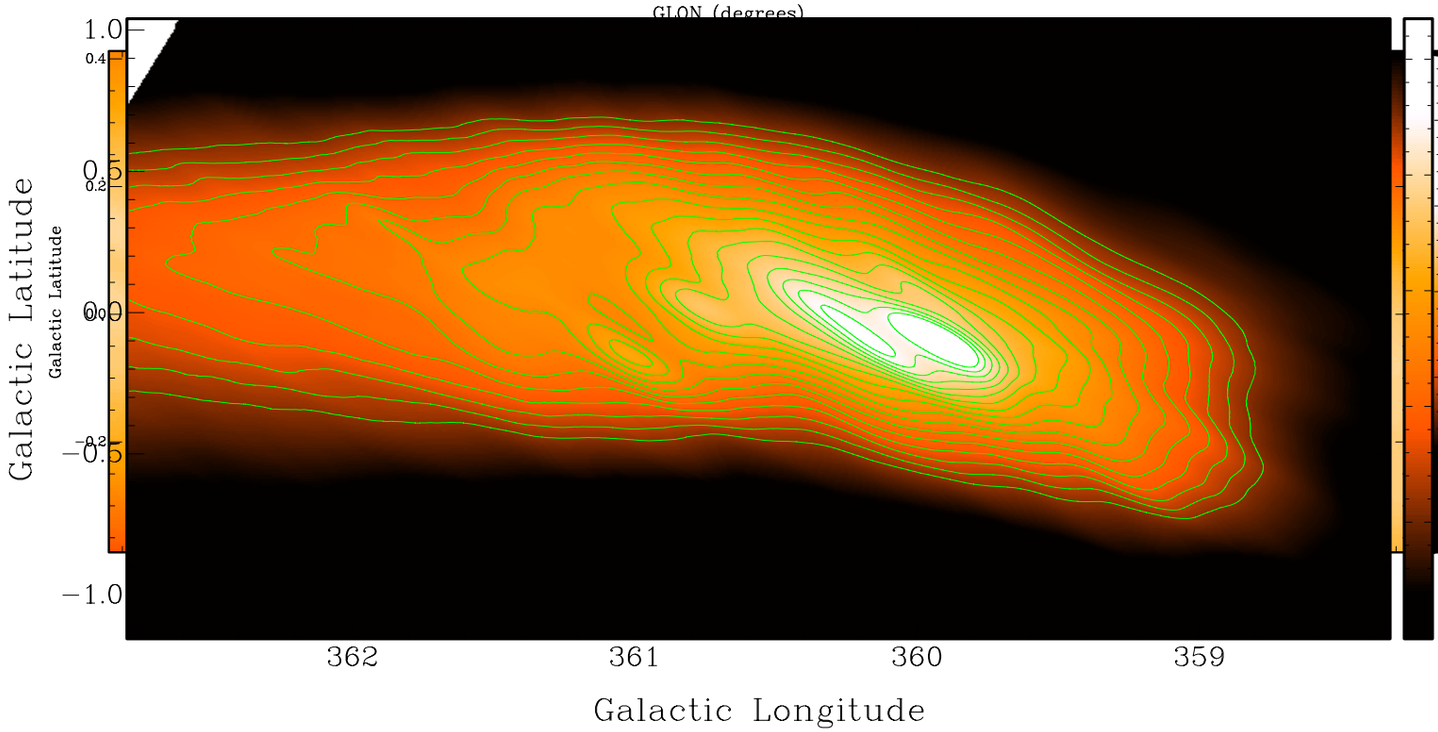
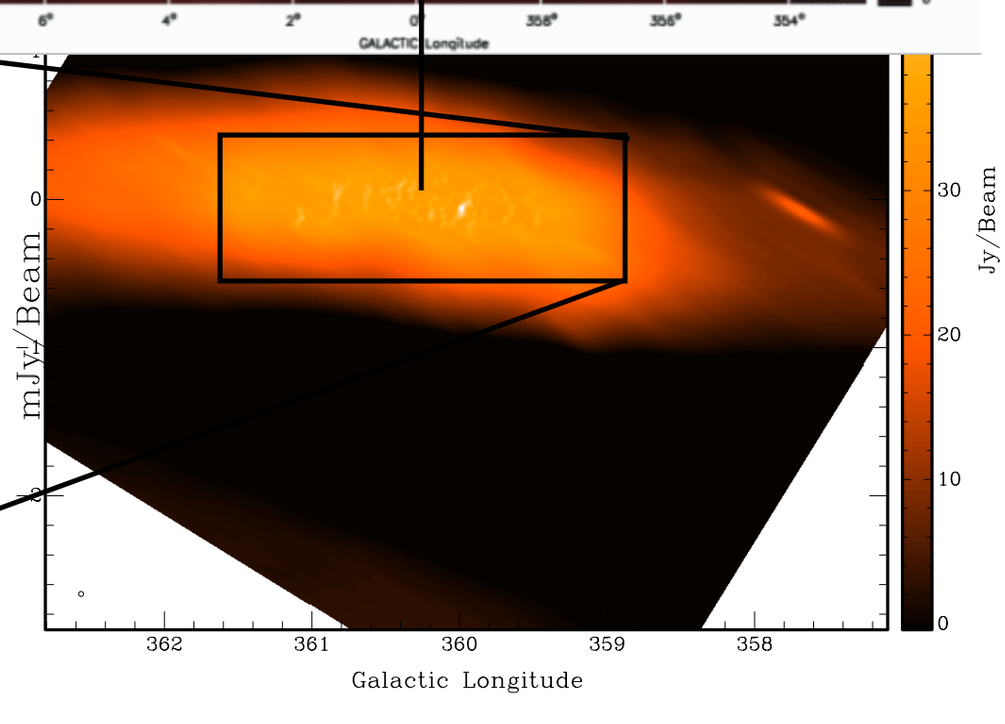


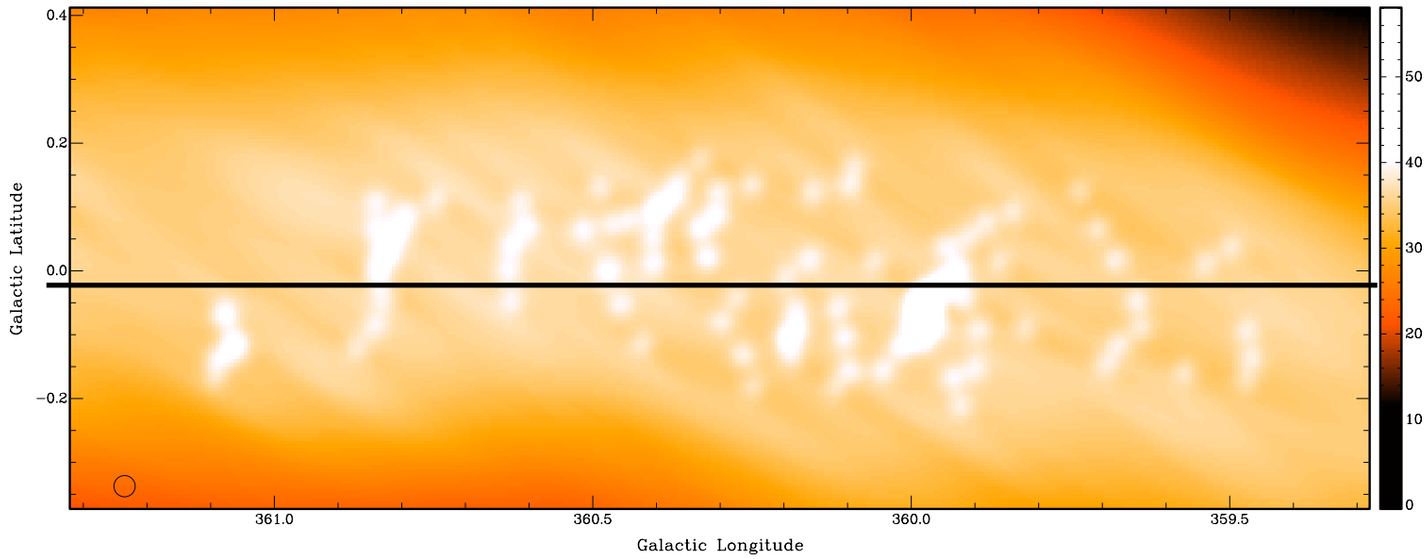


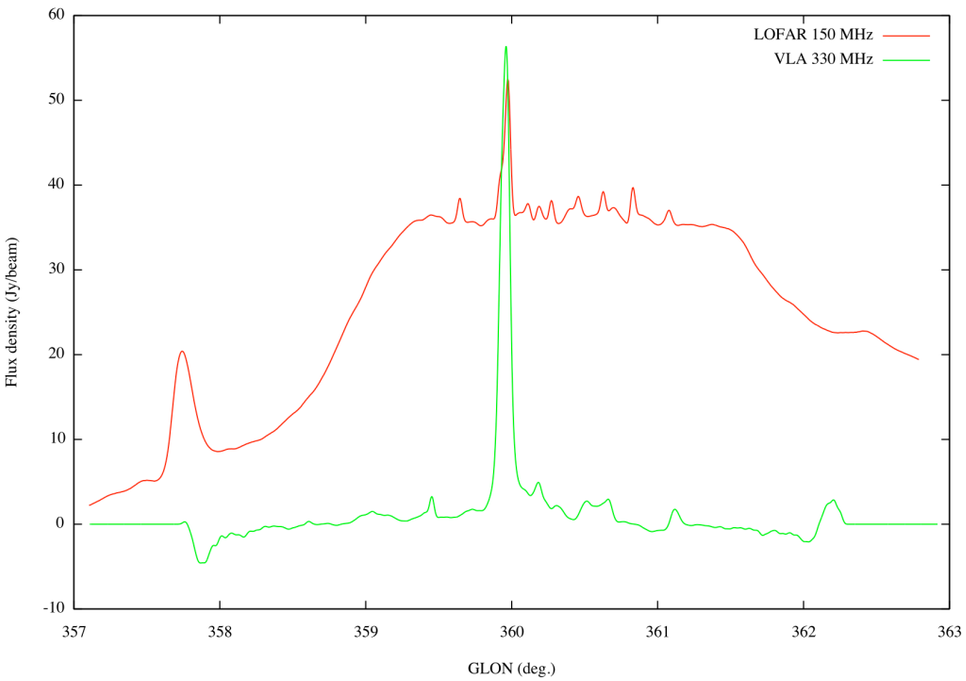




Quality control: Flux level and phase calibration

- Plot below shows a cross-section of the LOFAR data (red) and the VLA 330 MHz data at 2 arcminutes resolution.
- The position of Sgr A* (the peak) “seems” correct. Flux seems a little high...
- (“Small scale”) Structure definitely seems wrong... (Over-resolved)



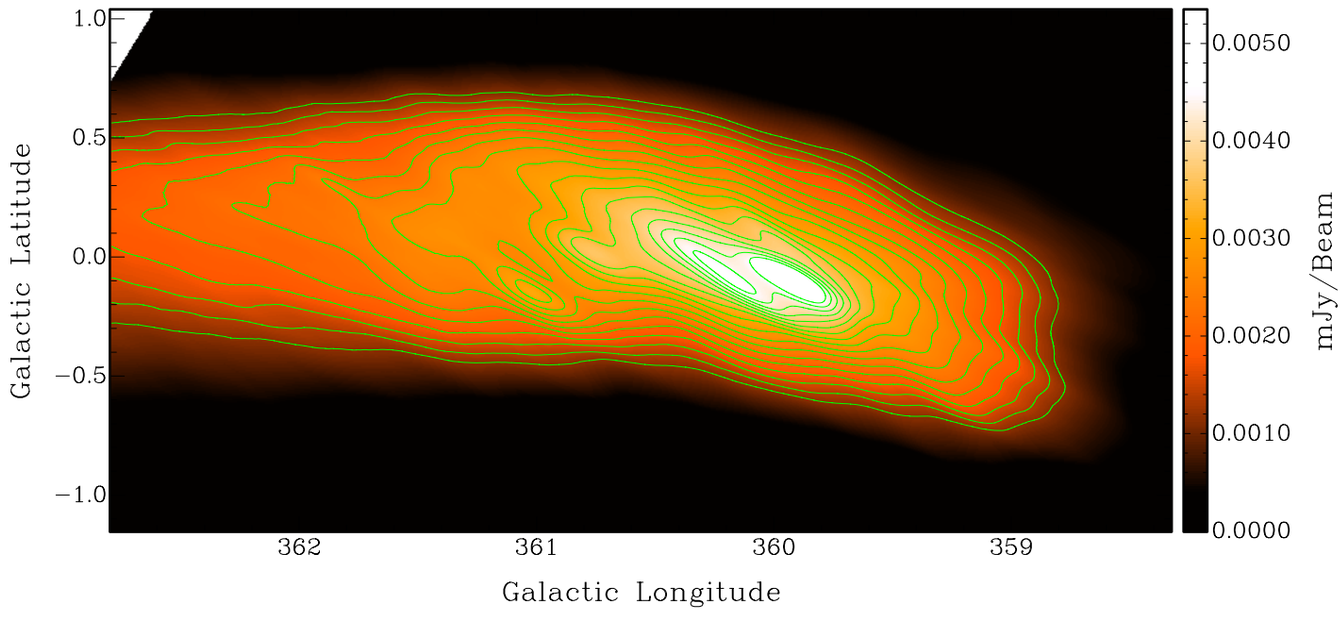


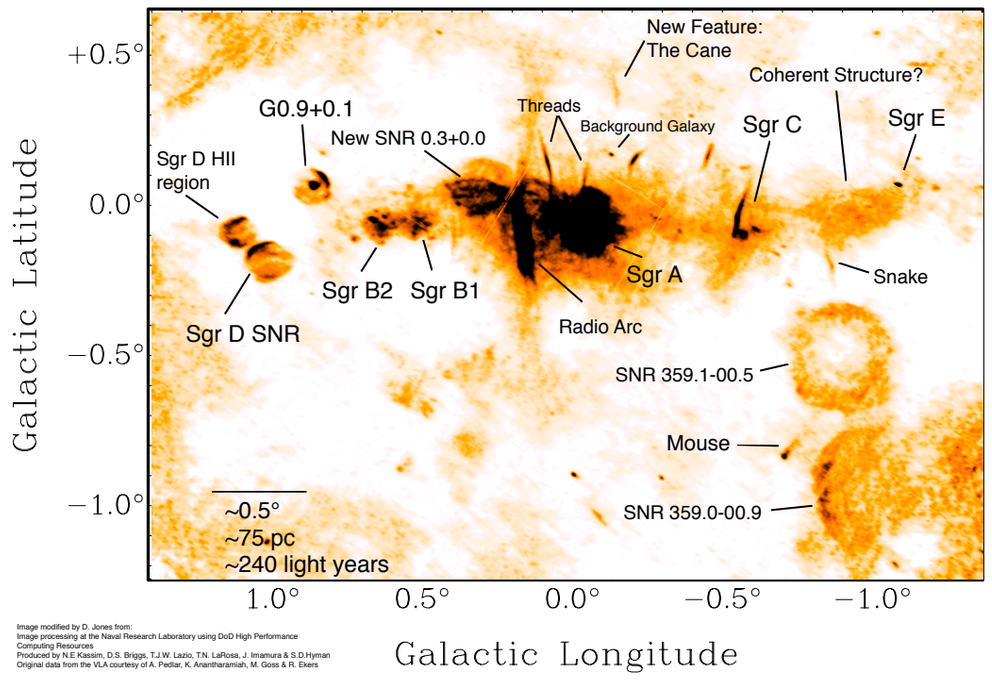
Test Case: Sagittarius B2

- One of the largest star-forming regions in the Galaxy. Very bright at all wavelengths (thermal, molecular-line, dust, x-ray and gamma-ray).

- Can we see it with LOFAR easily? VLA at 330 MHz sees it easily. At 74 MHz it's absorbed (actually there's evidence that it's absorbed even at 843 MHz; Jones, D., et al, 2011, AJ)

- First look is promising: but should we see it?





Test Case: Sagittarius B2

- Using higher frequency data, I plot here the ~60 known HII regions of Sgr B2.
- This shows that most of the HII emission is gone under 1 GHz, even with diffuse thermal emission modelled using $NH_3(1,1)$ inversion transition observations (Protheroe, Ott, Ekers, Jones, et al., 2008)

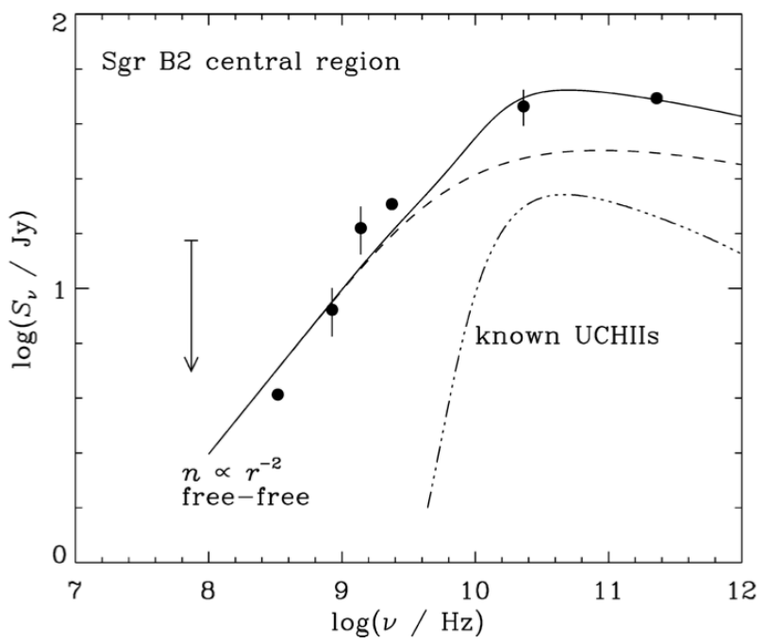
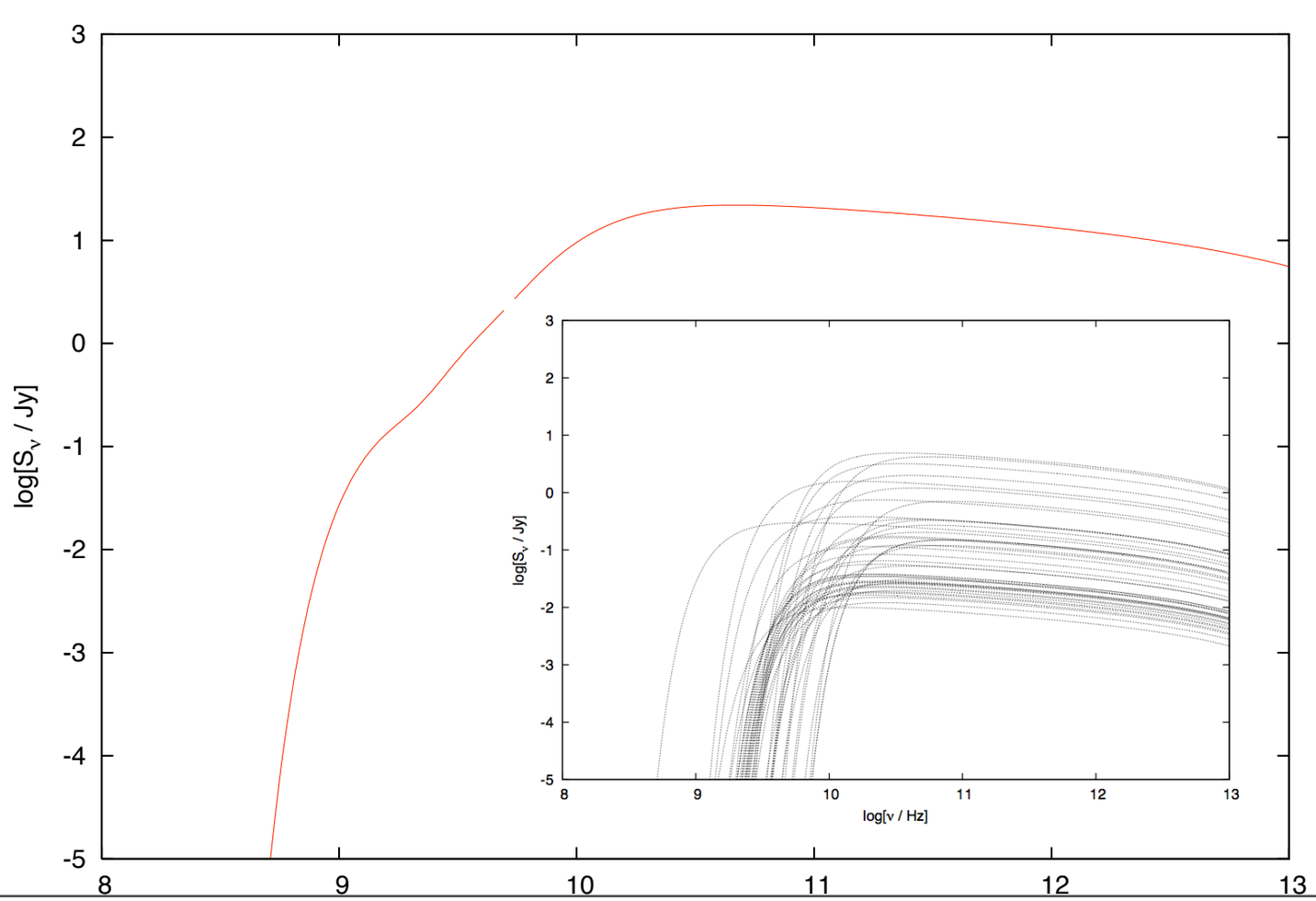


Figure 9. Observed fluxes summarized by Jones et al. (2008a) from the central region of Sgr B2 complex including the major H II regions but excluding the Southern Non-Thermal Source. The flux from the known UCHII regions is indicated (chain curve), and the best-fitting model of free–free emission from a constant temperature spherical envelope or wind with $n \propto r^{-2}$ is shown by the dashed curve, and the solid curve gives the sum of the two thermal components.



Conclusions

- Observations of the Galactic centre have been performed with LOFAR.
- Given that this extremely southerly source (Dec = -29°) is so bright, it is encouraging that so much known structure is recovered with relatively little effort.
    - It is well known that the sources sit on a “bed” of extended emission that LOFAR is reproducing well.
- It is obvious that the small-scale structure is not reproduced well by simple analysis of the data: much work needs to be done to explore the small-scale emission from the GC at these frequencies.
- A flux-calibrated image from these data is still being processed here in Nijmegen (hopefully I will have this image soon).