LBWG memo 17

Imaging with DDFacet

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DDFacet

As an alternative to Factor there is also the DDFacet imager currently used for the LoTSS processing. In this memo I explore the possibilities of wide-field mapping at high resolution with this imager. DDFacet is publicly available on github: `https://github.com/saopicc/DDFacet` and installing it should be a matter of following the instructions there. [1] If everything went correctly, `DDF.py -h` should print out the available options. No further setup needed.

Imaging with DDFacet

Compared to Factor, very little is needed to kick off the imaging, except a powerful computer (think 32 cores / 256 GB memory). I averaged down the data to 4 seconds and 4 channels per subband and concatenated it in groups of 10 before feeding it to the imager. The chosen time and bandwidth averaging was an arbitrary guess between not completely murdering the computer and still keeping some resolution in those dimensions, to prevent maybe over averaging the data. The data I used came straight from the long baseline pipeline, no further processing was done. To reach a significant sky area, the beam was also somewhat undersampled with 0.1"/px.

Cell size	0.1"/px
Image size [px]	40000×40000 px
Image size [deg]	1.11×1.11 deg
Weighting	Robust -1

Table 1: DDFacet imaging parameters

To produce the image (which took around 7 hours for the dirty image and 13 hours for the final cleaned image) the following command was used:

```
DDF.py --Data-MS mslist_200SB.txt --Image-Cell 0.1 --Image-NPix 40000
--Output-Mode Clean --Data-ColName DATA --Data-ChunkHours 5
--Output-Name=image_center_200SB_40k_robust_n1
--RIME-DecorrMode=FT --Deconv-Mode=SSD --Deconv-MaxMajorIter=1
--Deconv-MaxMinorIter=1000 --Mask-Auto=1 --Freq-NDegridBand=1
--Parallel-NCPU=20 --Beam-Model=LOFAR
--Facets-NFacets=11 --Output-Also onNeds --Weight-Robust -1.0
```

The cleaning was minimal and only done to get an image with the beam size. Beam "creation" in DDFacet isn't really stable, so it is better to force a certain beam size. From another run with the full 240 subbands with a forced restoring beam of 0.4" I get a map with a 380 μJy RMS noise level, detecting 59 sources so far in the dirty image, plus maybe a few more tentative ones. Many settings will probably need to be tweaked

[1] If your cluster/computer supports it, I also have it set up in a Singularity container, which I also use for my testing. Contact me if you'd want to try it.

still, but this run successfully produced an image. The full bandwidth memory issue was solved by splitting the data using `--Data-ChunkHours` (thanks for the tip, Etienne!). In Fig. 1 I show small postage stamps of all the sources found by manual cross-matching with the low-resolution 6" map. The image itself is too big and has too many pixels to display sensibly in a PNG, so if you are interested in scrolling around download it here:

1. Full image (6GB): `https://home.strw.leidenuniv.nl/~sweijen/img.fits`
2. Region file containing circles around the sources: `https://home.strw.leidenuniv.nl/~sweijen/img.reg`

Self-calibration

The previous data was imaged straight from the pipeline. I have now applied the phase-only and amp+phase self-calibration solutions of 4C43.15 (the central source) to the data and reimaged a (slightly smaller) new image of 36000 pixels squared. This took less than a day for the dirty image and about half a day for a major iteration of deconvolution. After a first major deconvolution iteration and some manual cross-matching, 103 sources are identified in the high-resolution map. Some are only tentative, but a large fraction is clearly identified.

1. Full image (4.8GB): `https://home.strw.leidenuniv.nl/~sweijen/img_ap.fits`
2. Region file containing circles around the sources: `https://home.strw.leidenuniv.nl/~sweijen/img_ap.reg`

An interactive overview showing a 6" DDF reduced image compared to a 0.3" long baseline image is here: `https://home.strw.leidenuniv.nl/~sweijen/aladin.php`. Source density is about a factor of 10 lower than LoTSS, seeing 313 sources in the low-resolution map, compared to 38 sources in the high-resolution map.

0.1 Current status

- Deconvolution works with images of 20000×20000 pixels, so it's more related to the image size in pixels rather than the physical sky area imaged.
- Currently putting together a directional imager to image "facets" of 20k by 20k pixels using DI solutions.

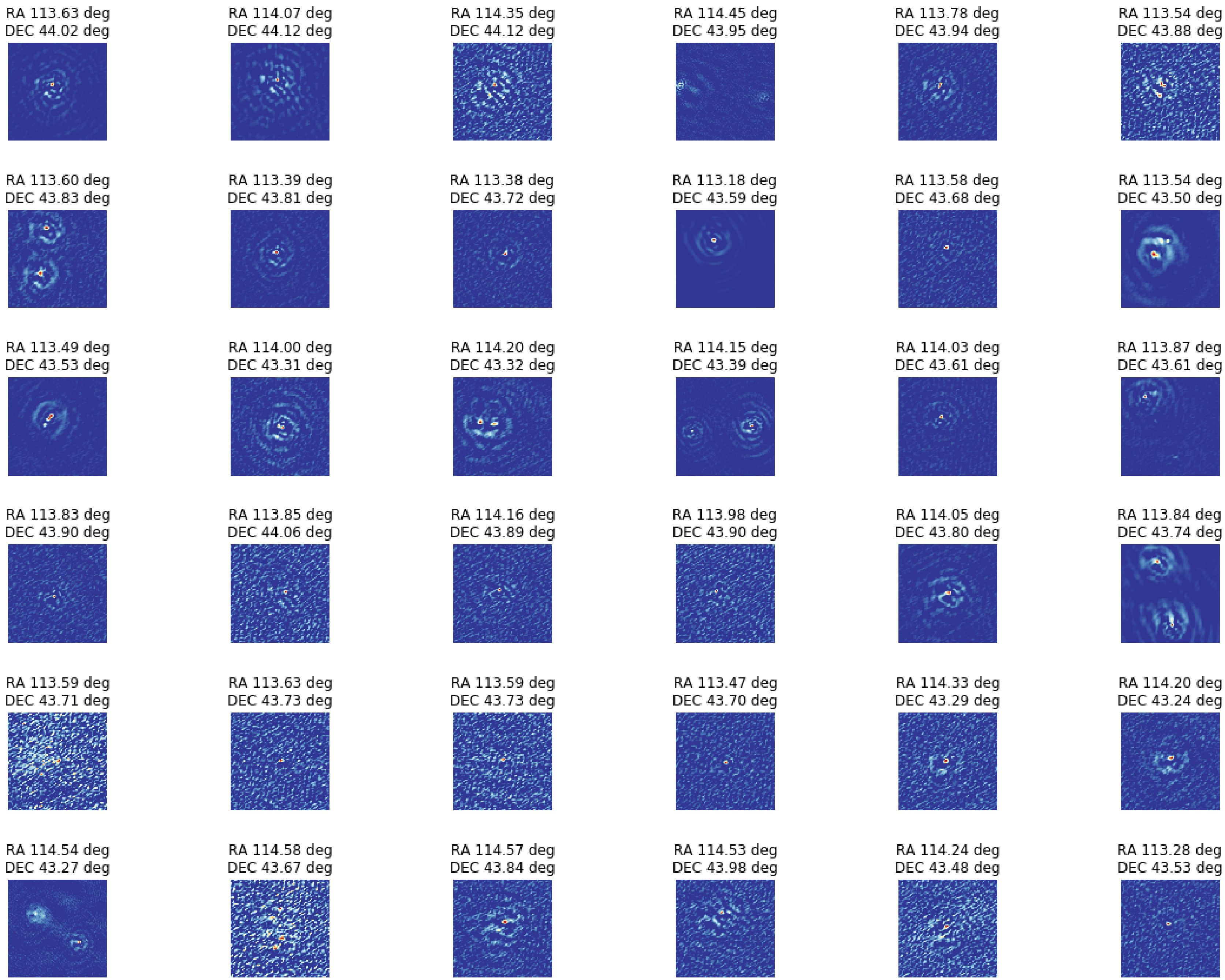

Figure 1: 36 sources found in the DDFacet image of a 1.11×1.11 degree image centered on 4C43.15. Most boxes are 15" $\times$ 15", with the exception of numbers 4, 16 and 31, which are 60" $\times$ 60", 25" $\times$ 25" and 30" $\times$ 30".