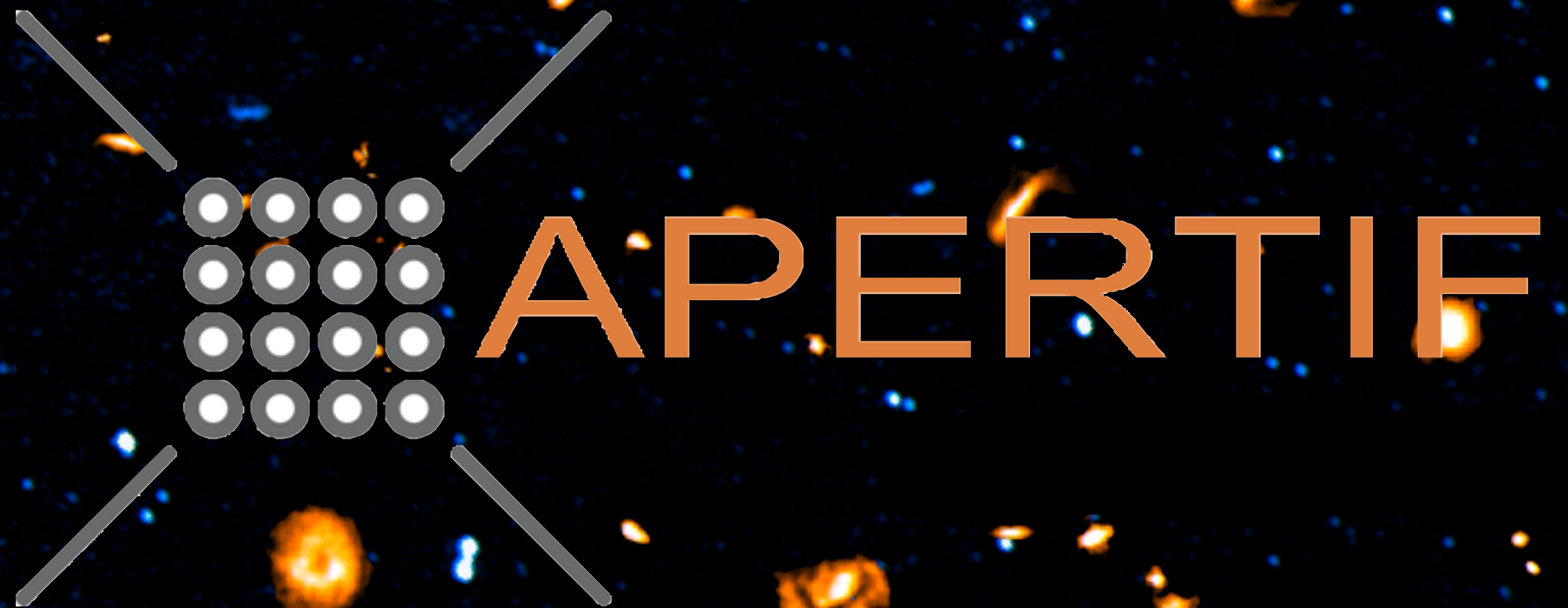


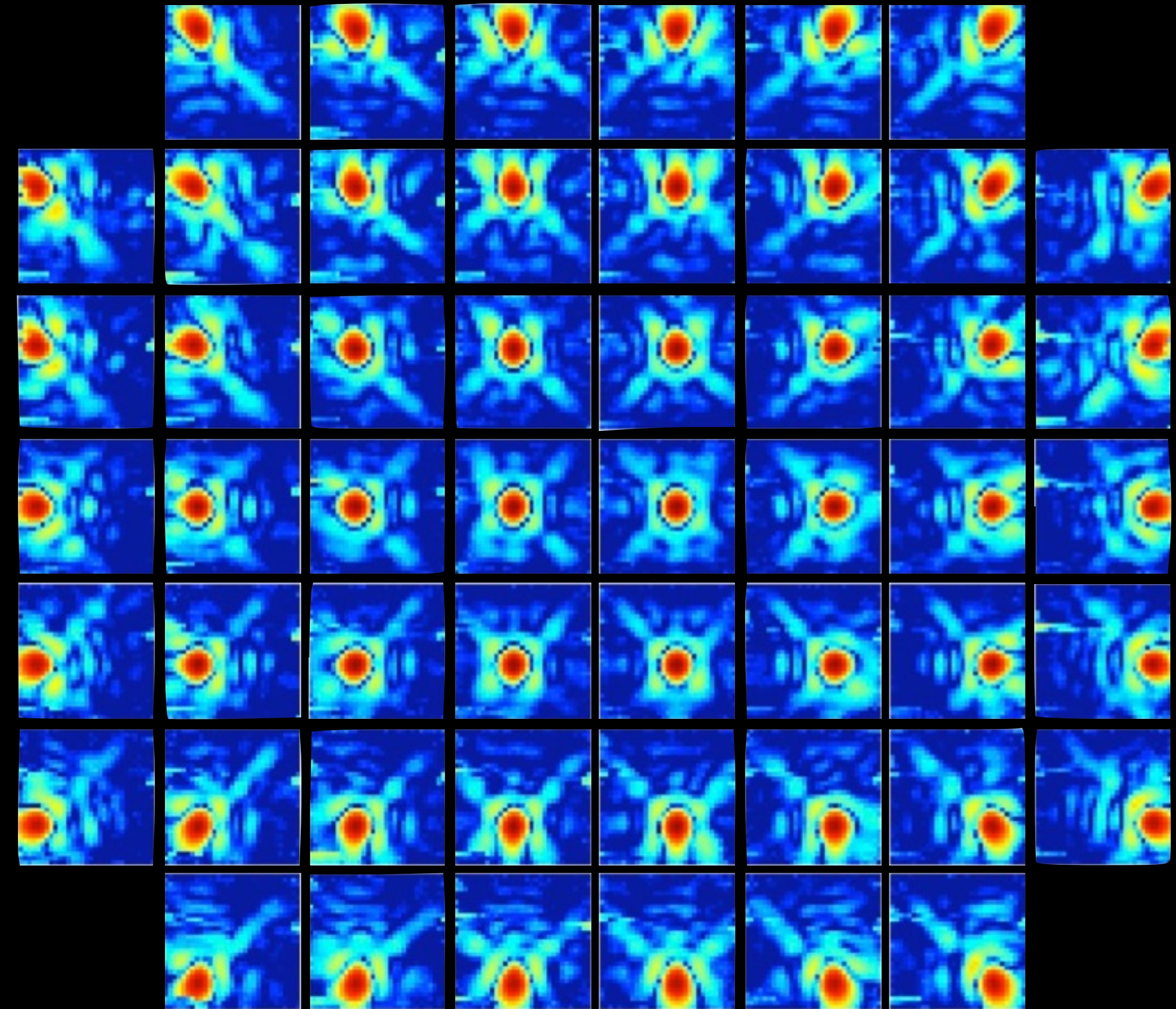


Apertif update

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Kapteyn Astronomical Institute, Groningen, NL

- ▶ Status
- ▶ Software
- ▶ Surveys



Array of densely packed Vivaldi receptors in each WSRT dish to **fully sample** focal plane

121 elements (60+61)

37 beams on the sky

FoV 8 deg²

Range ν : 1110 – 1700 MHz

T_{sys} 70 K

Aperture efficiency 75%

Bandwidth 300 MHz

16384 channels 4-5 km/s resolution

12 dishes

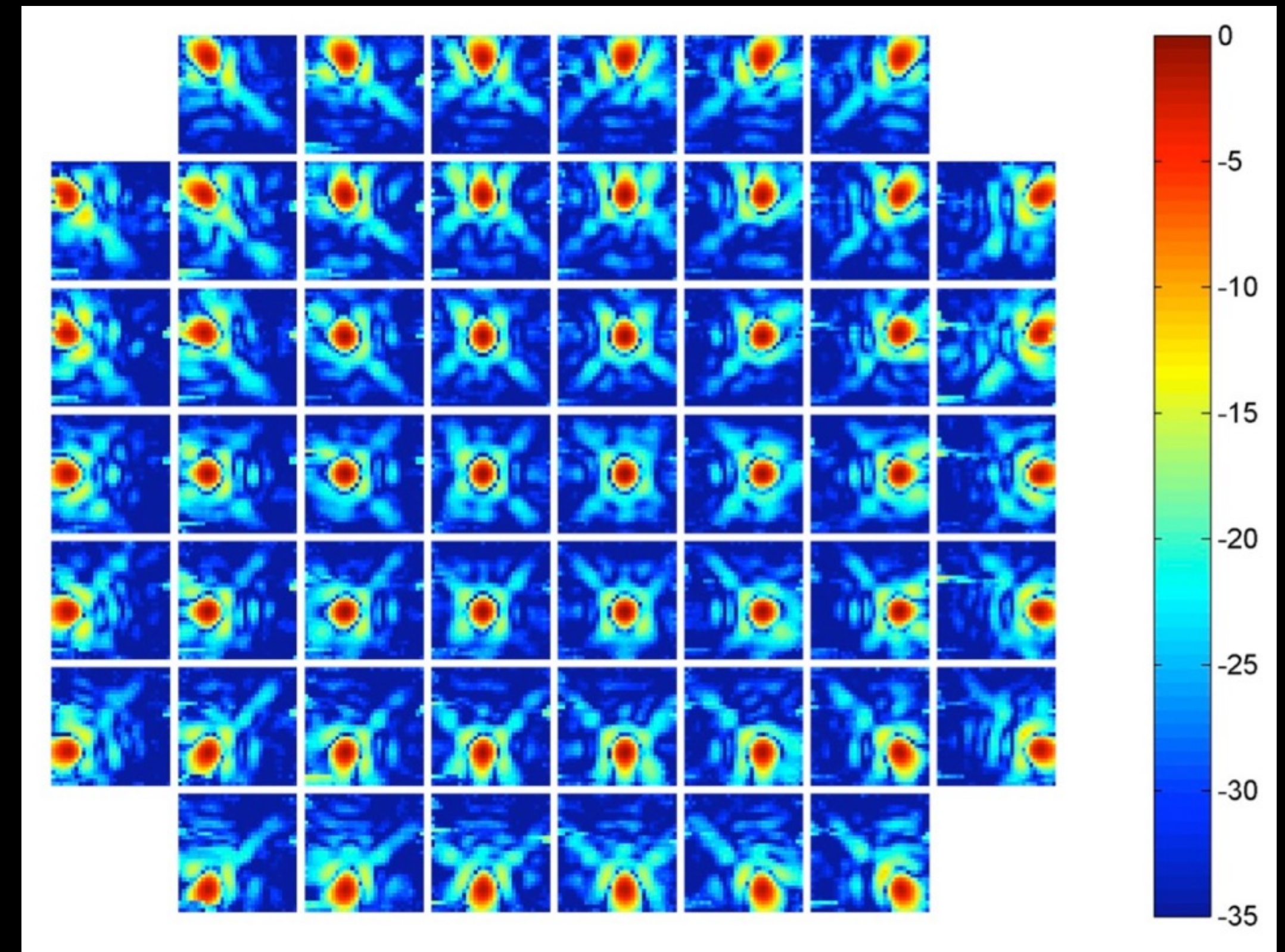
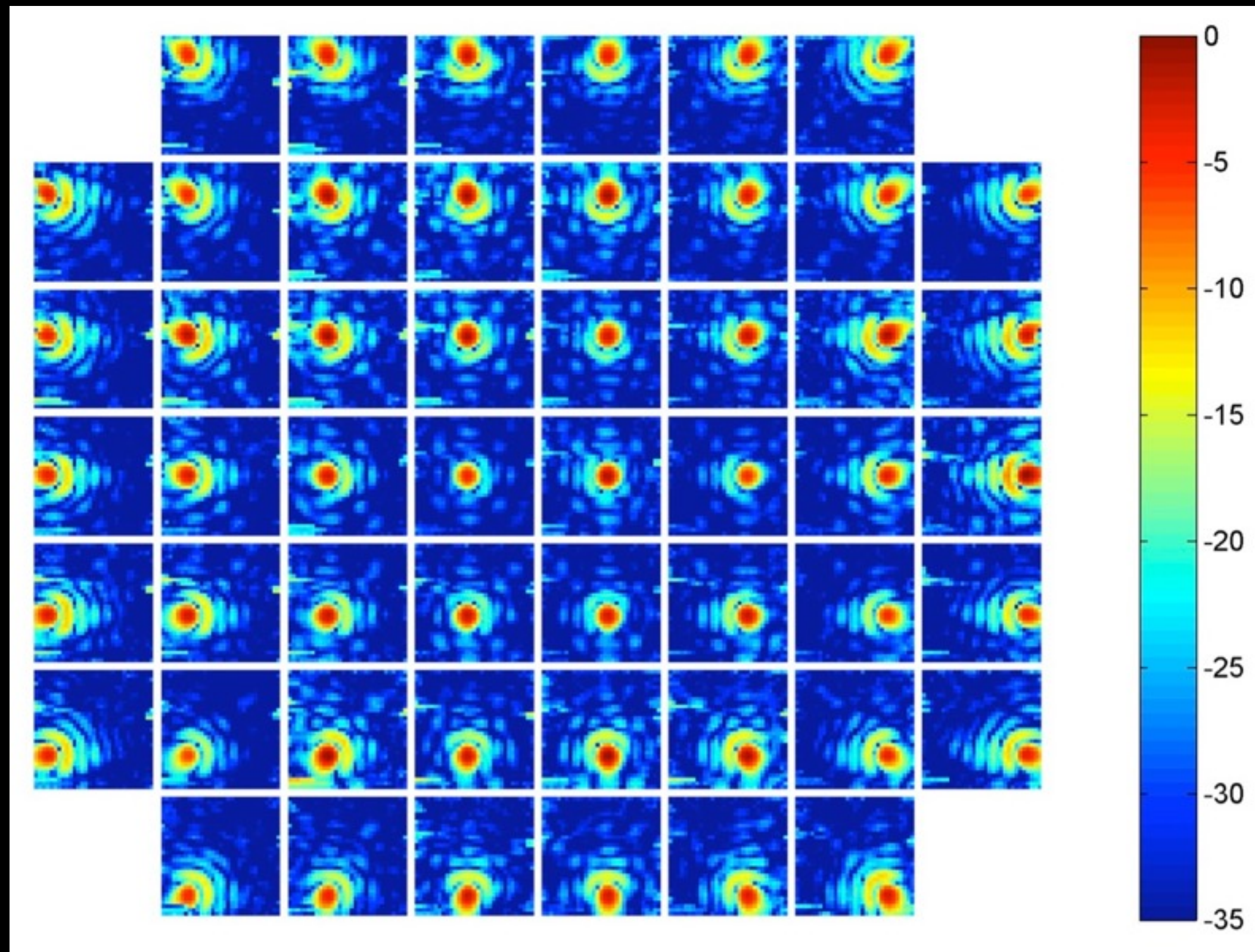


Can do in a day what now takes a month
Synergy with LOFAR

Use optimised beams

Each element sees a different part of the sky (it's a camera...).

Could make 60 primary beams on sky, but is better to make smaller number of *optimised* primary beams, using weighted sum of all 121 element beams for each optimised beam. Do this 37 times in parallel.

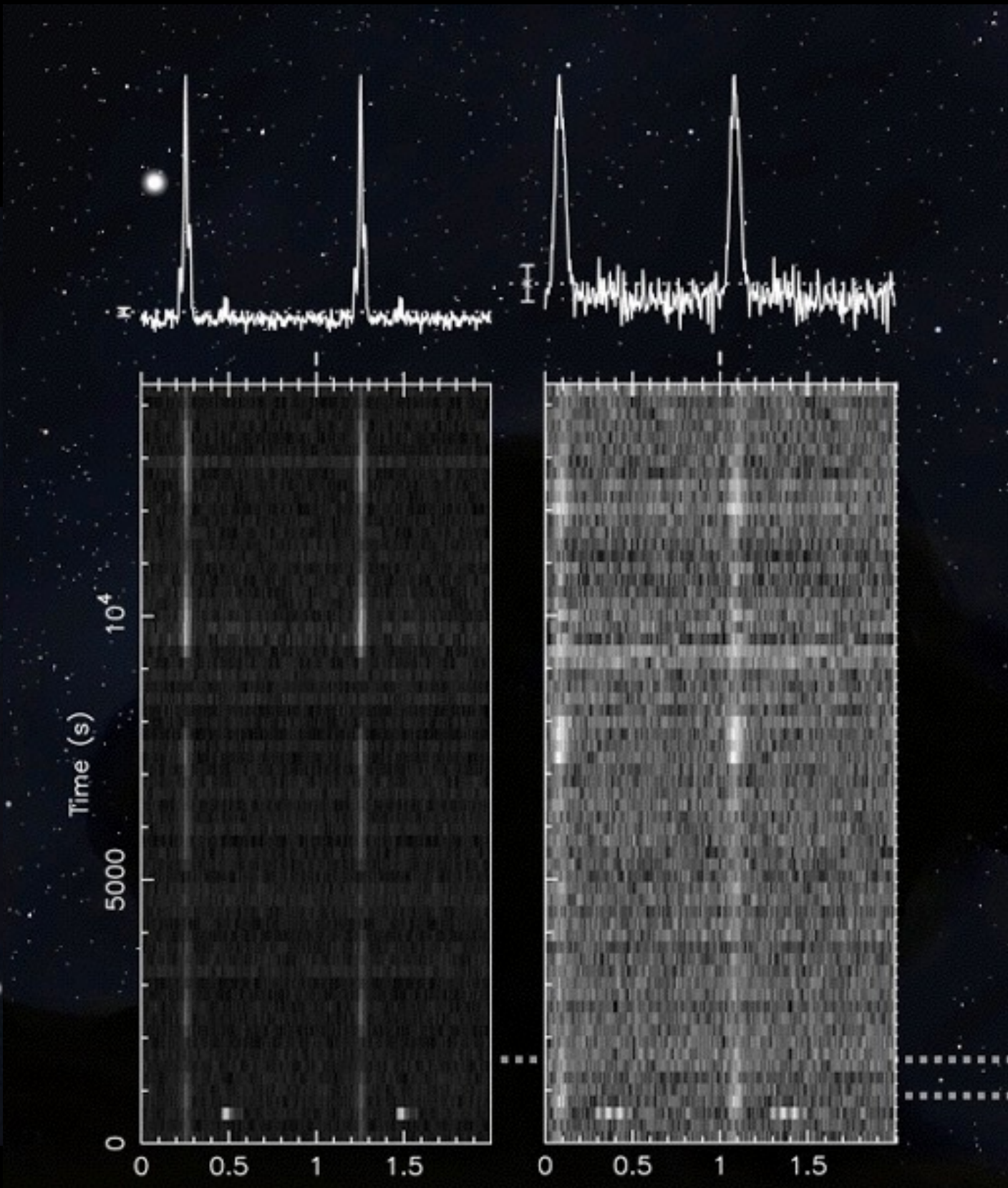


Element beams are ugly, but compound beams are very well behaved

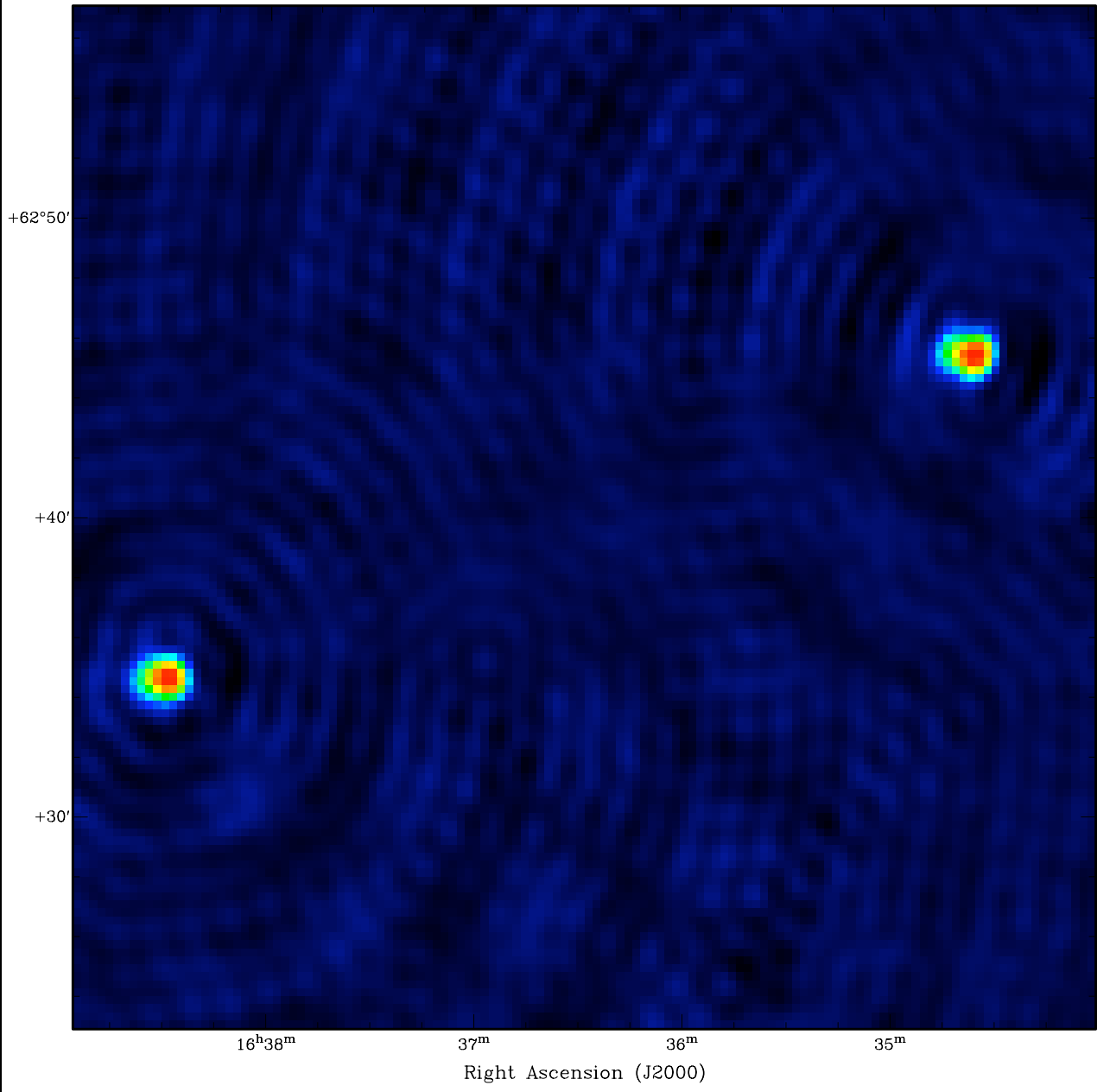
Since 2008: several generations of prototype PAFs in one WSRT dish (Digestif)



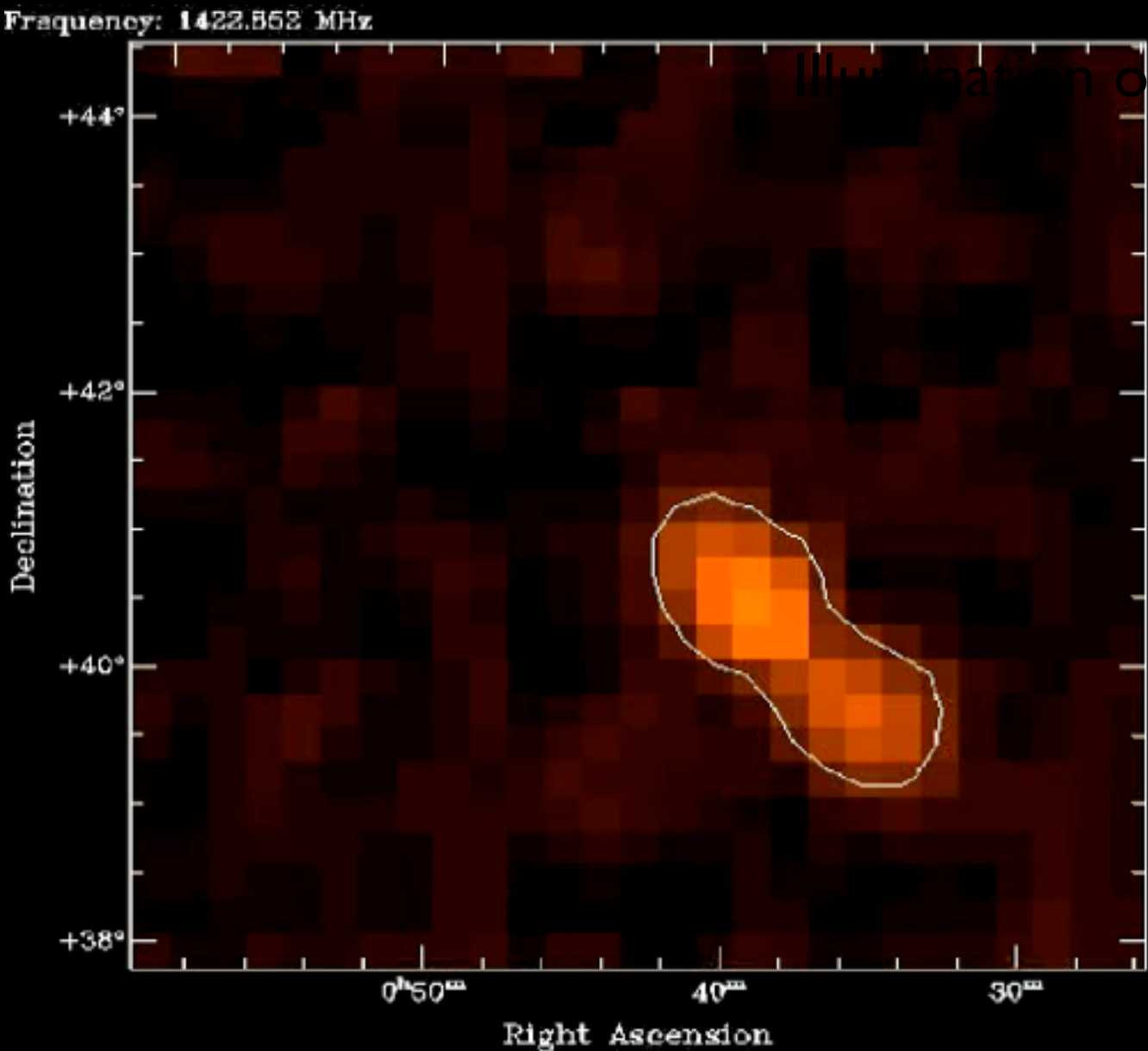
Dual beam pulsar detection



single dish M3I; 4 pointings covering 40 deg²



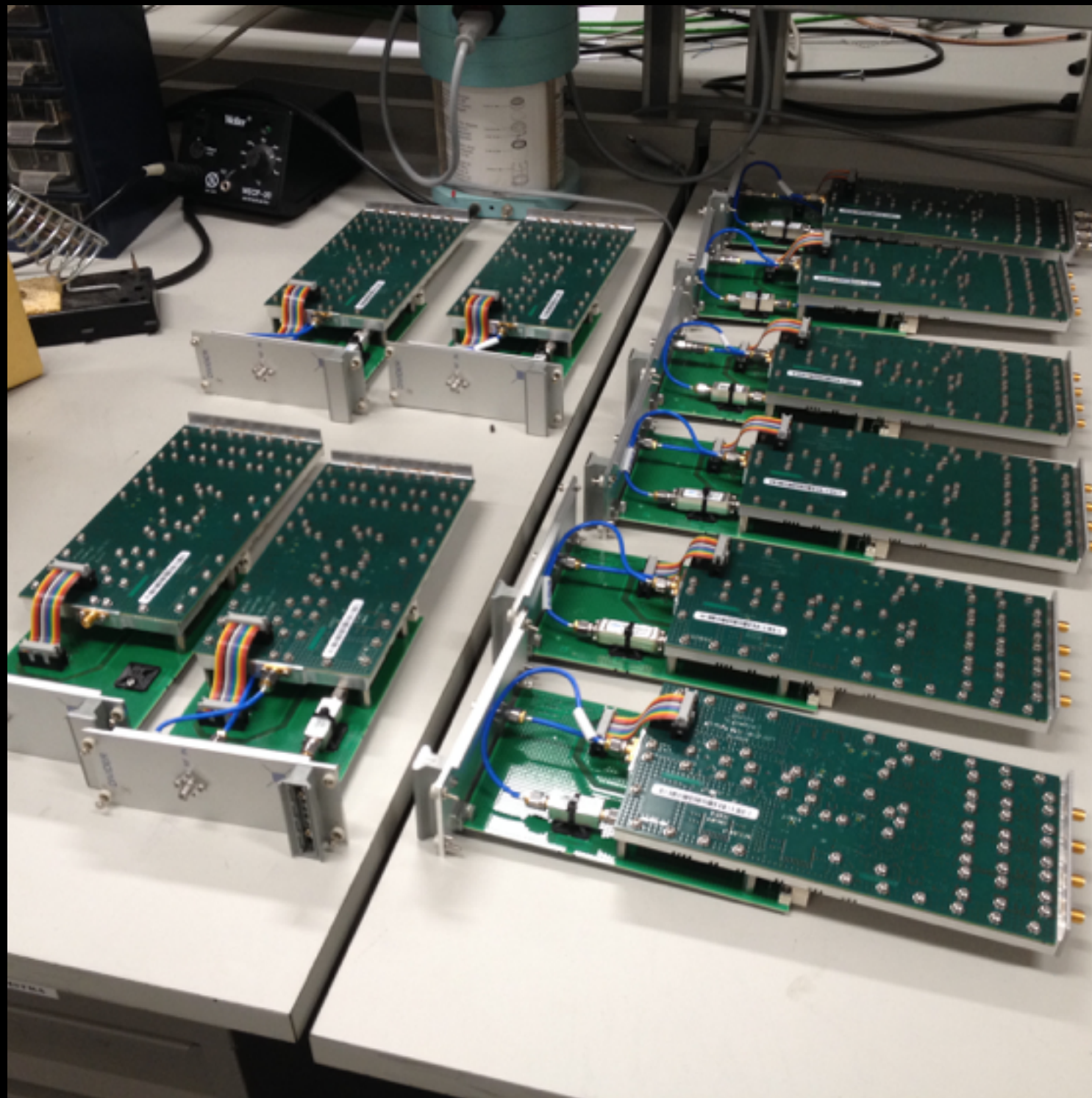
Interferometry on 3C343 & 3C343.1



Radio galaxy image

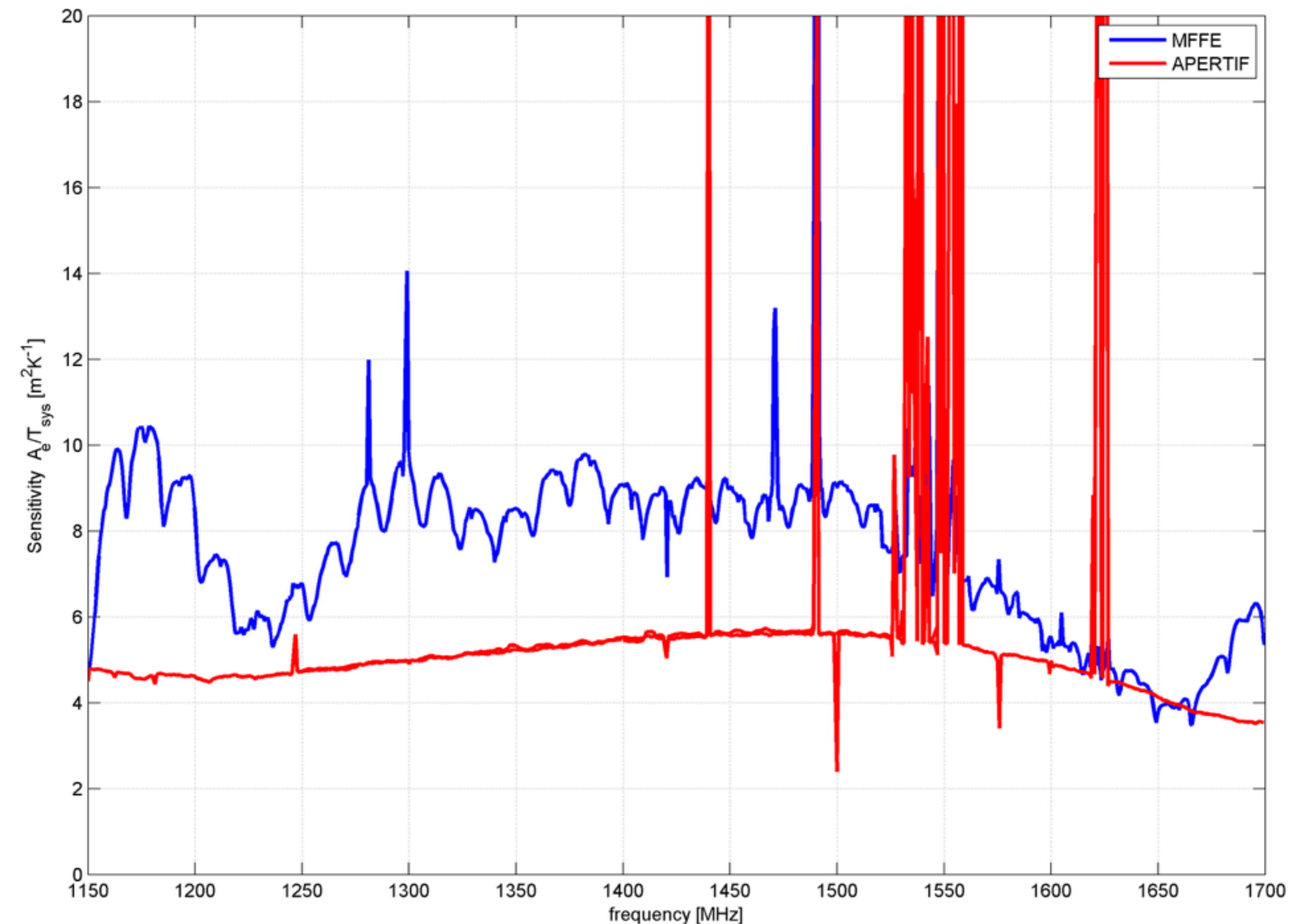
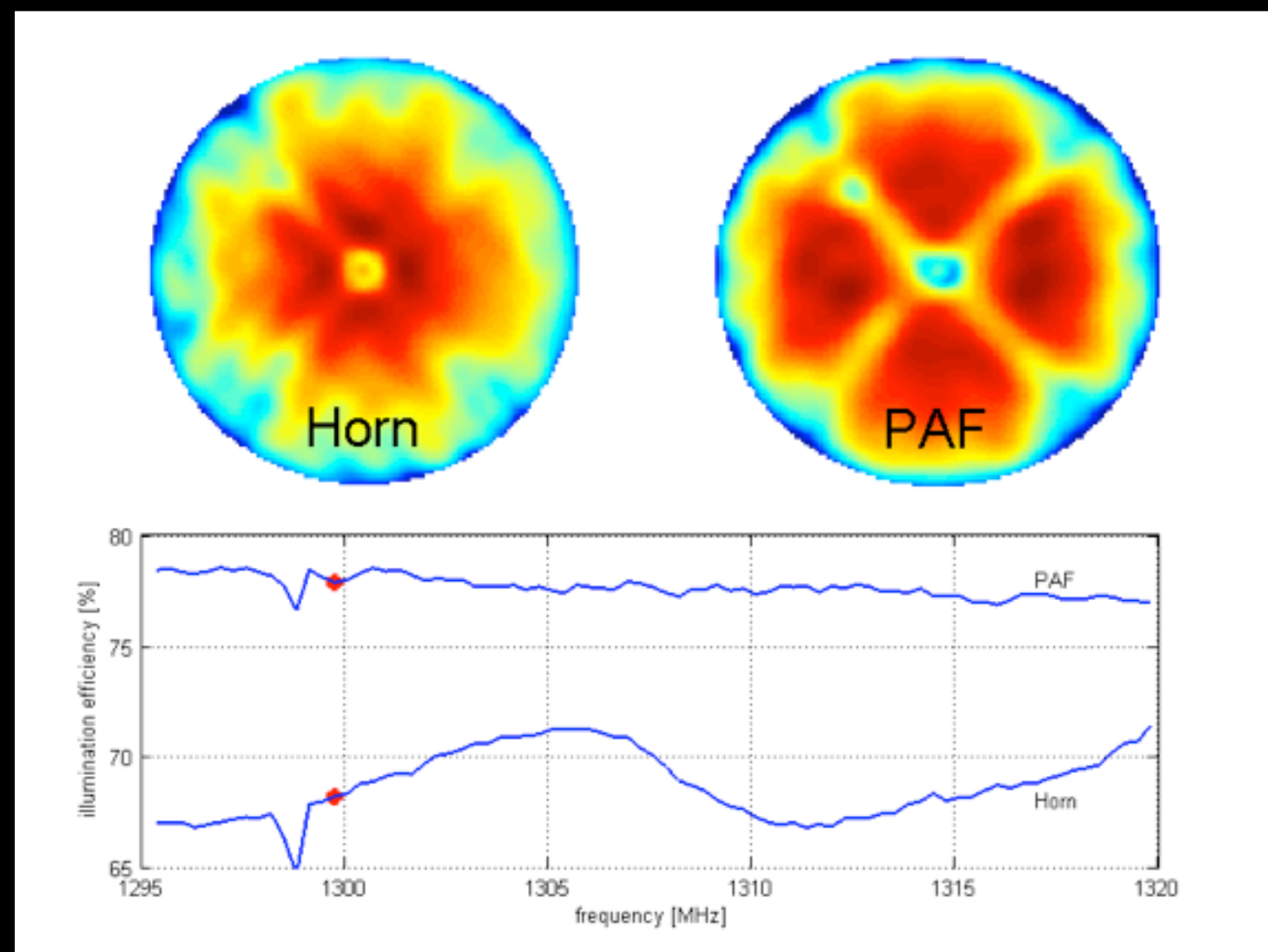
Status

- Installation of Apertif is in full swing





- ▶ Sensitivity of final final frontend measured on sky in the dish
- ▶ T_{sys} around 70 K
- ▶ Note much smoother behaviour



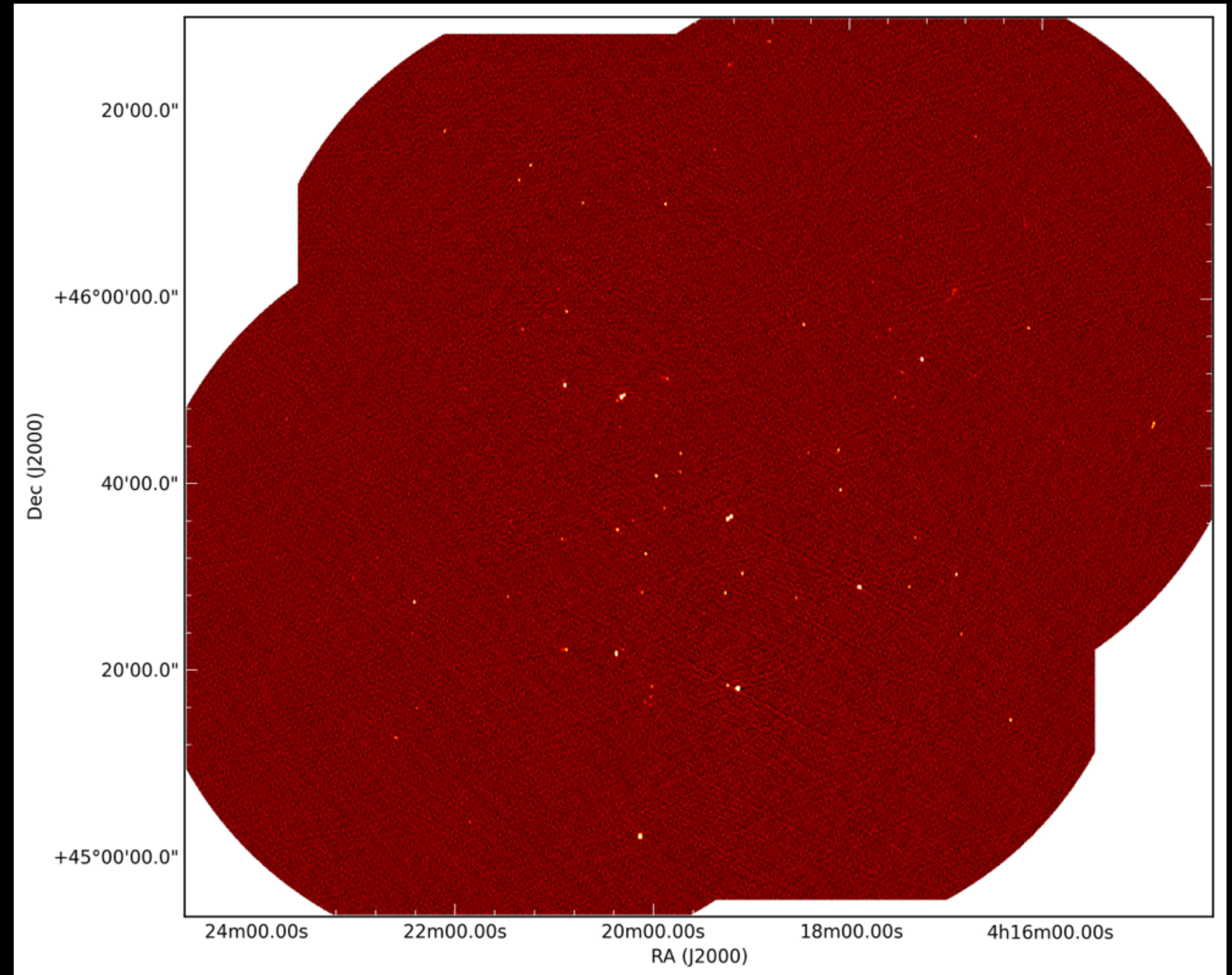
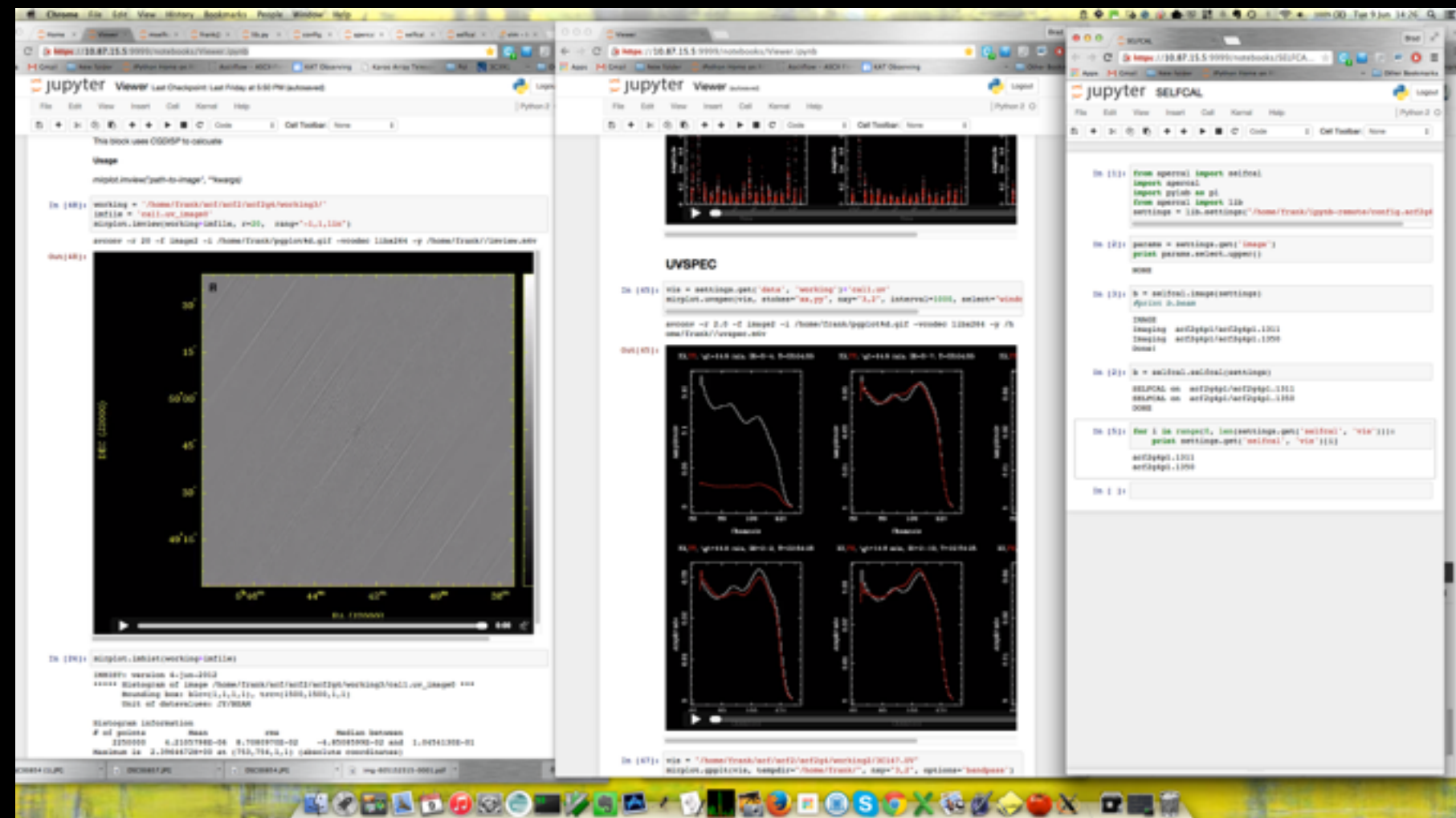
Underlines the merits of PAFS - major benefit for calibration

Calibration pipeline works



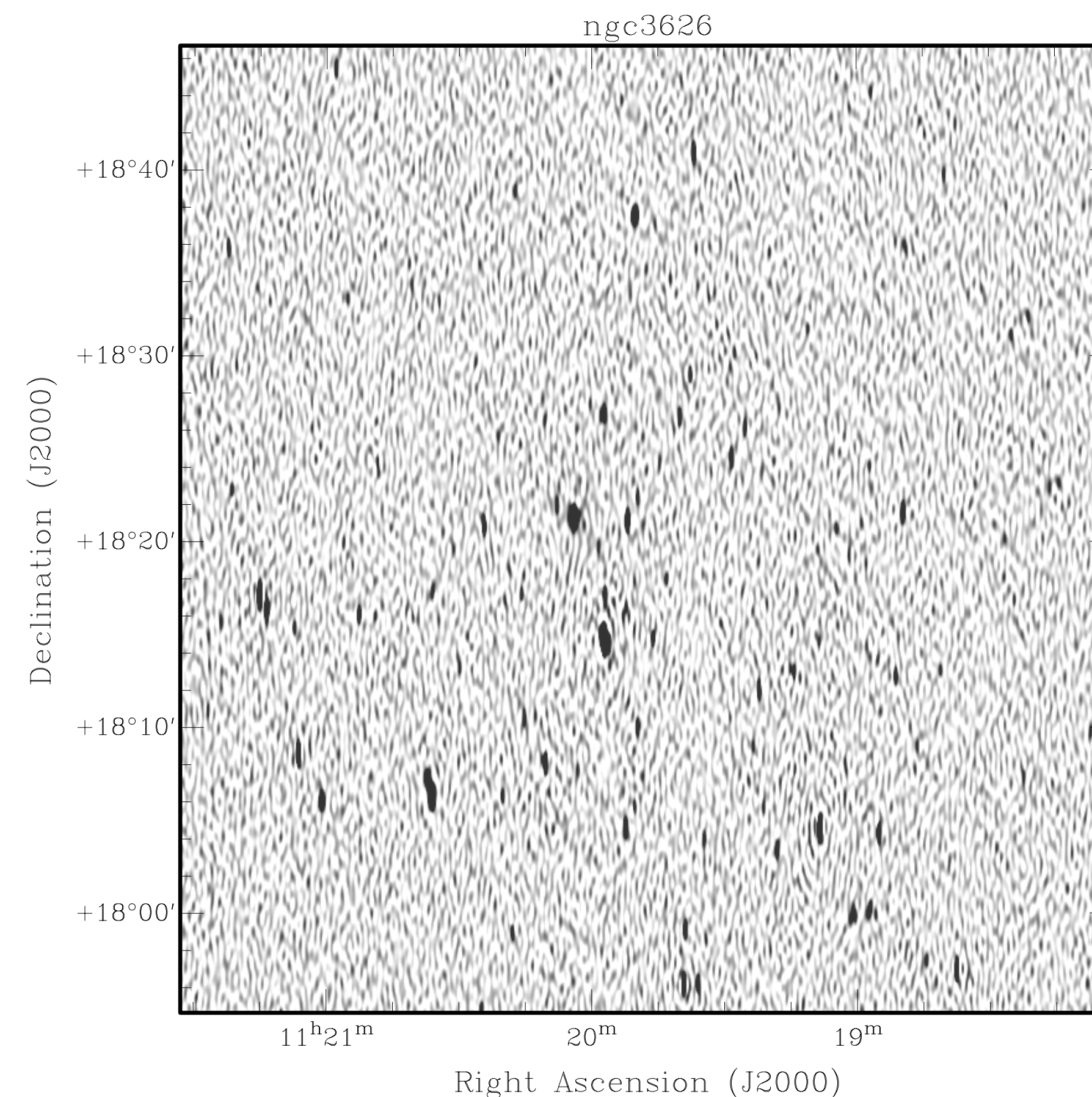
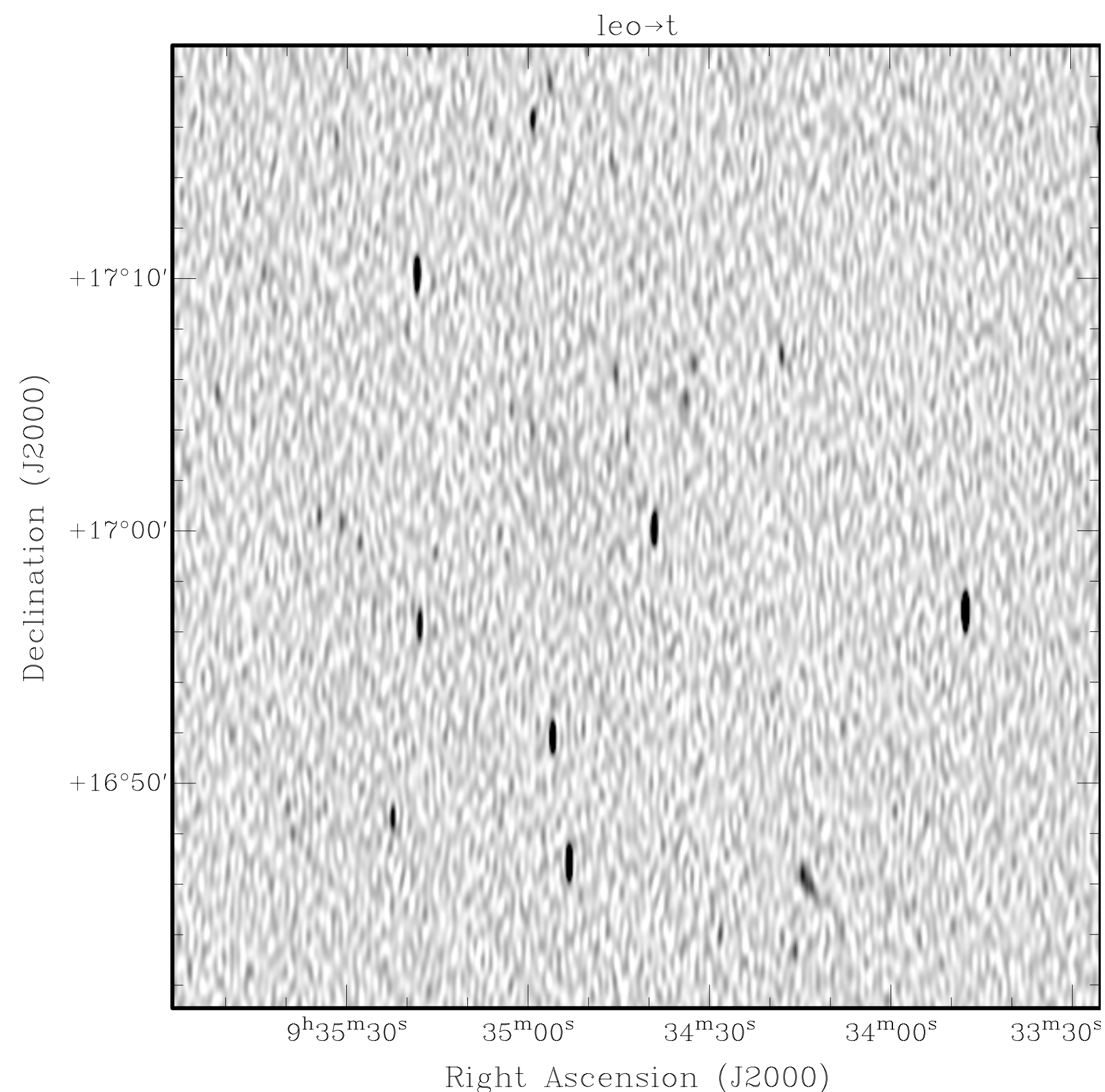
Off-line calibration is basically the same as of the old WSRT: selfcal on continuum (real-time cal very different)

Based on *miriad* for a number of reasons using Python Notebooks as interface



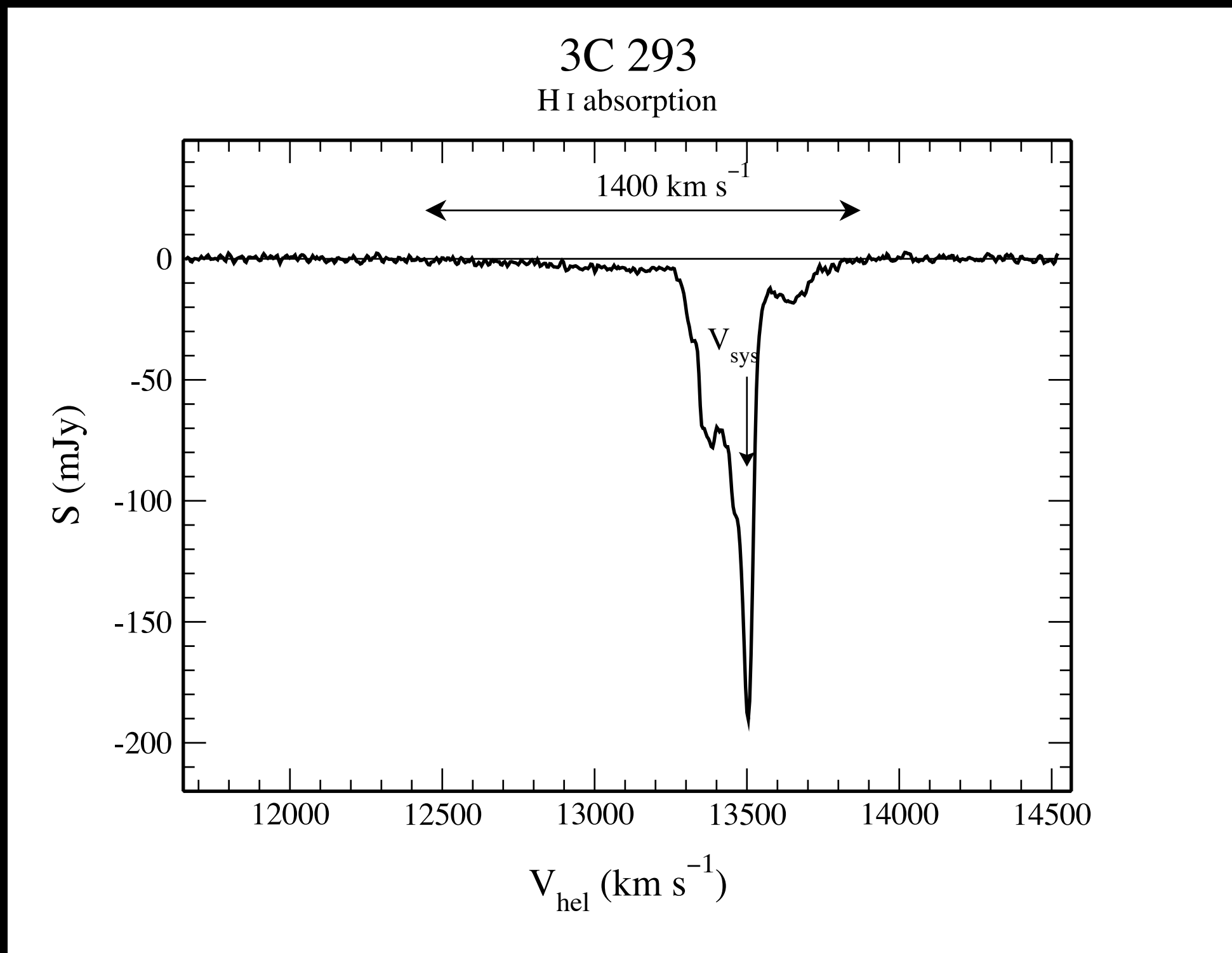
Pipeline-processed image of one of the Apertif reference fields

Examples of output of pipeline on old WSRT data

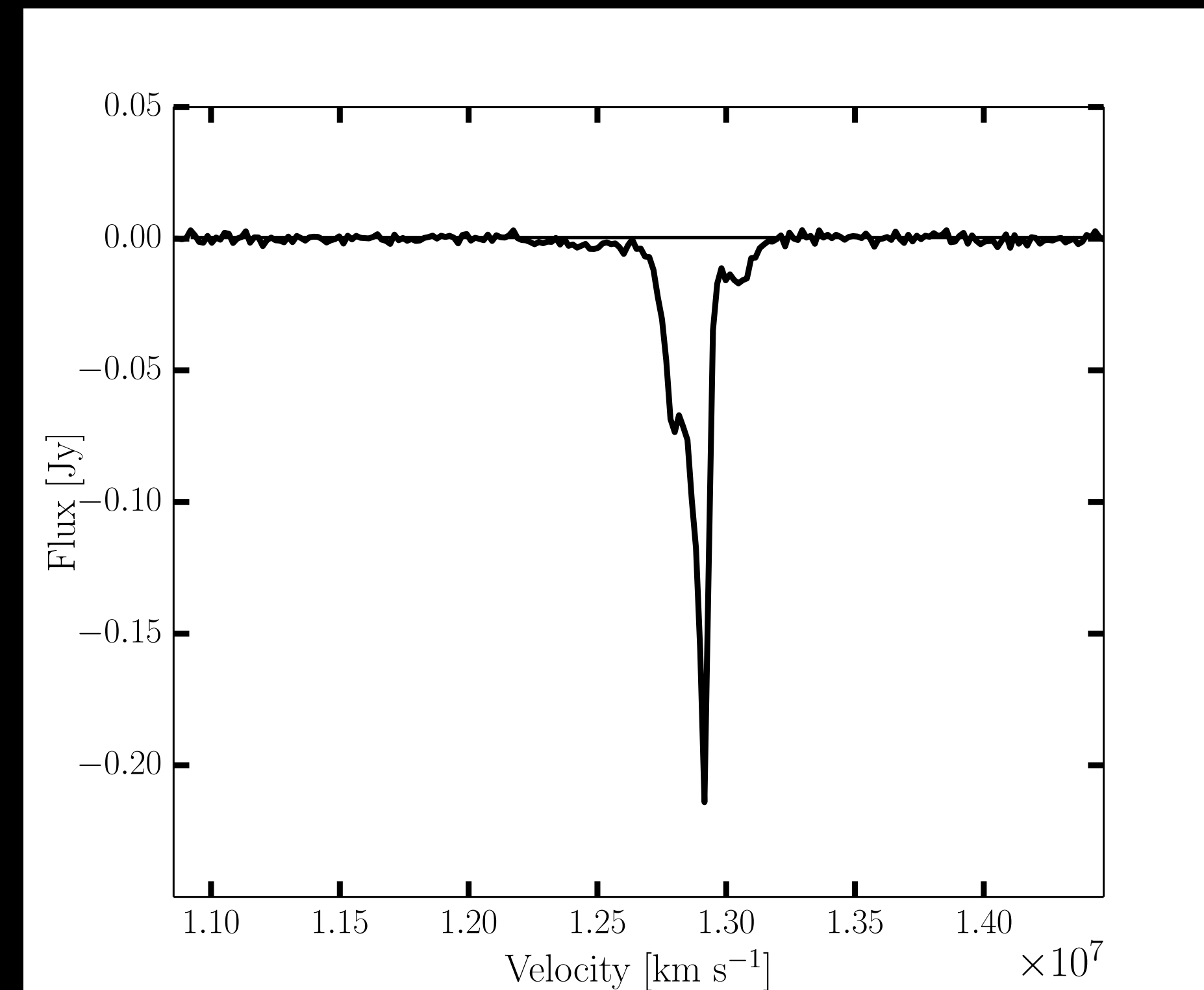


Reach dynamic range of few 1000 in a fairly robust way
Final pipeline will do >10x better (clean based vs parametric sky model)

Examples of output of pipeline on old WSRT data



Old



New

Spectrum of
3C293

3 Jy

Performance looks good



```
#####  
End of Selfcal for major cycles: 6  
#####  
#####  
Time elapsed : 102.160176992 seconds  
#####  
#####  
[5.71e-08, 5.759e-08, 5.704e-08, 5.64e-08, 5.495e-08  
[1.88, 1.81, 1.85, 1.84, 1.91]  
[150.0, 450.0, 750.0, 1050.0, 1350.0]  
[0.062, 0.031, 0.020666666666666667, 5e-05, 5e-05]  
#####  
Time elapsed : 102.160176992 seconds  
#####  
dakota:~/apertif/n4278> █
```

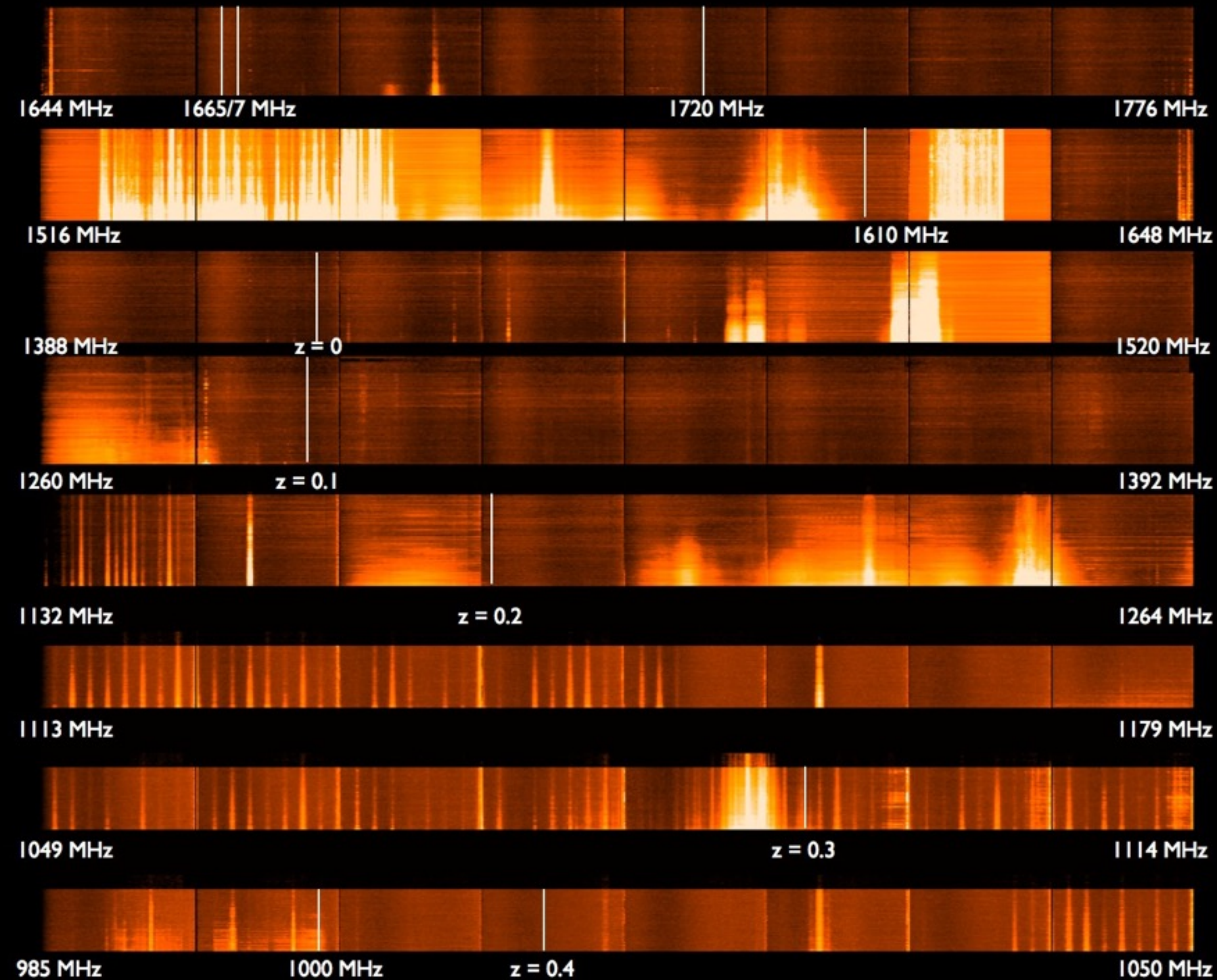
takes < 2 minutes to calibrate
1 beam over 20 MHz

```
#####  
Time elapsed : 67.0114068985 seconds  
#####  
█
```

Even less on a Mac....

Can calibrate 12-h observation in ~ 1 hr

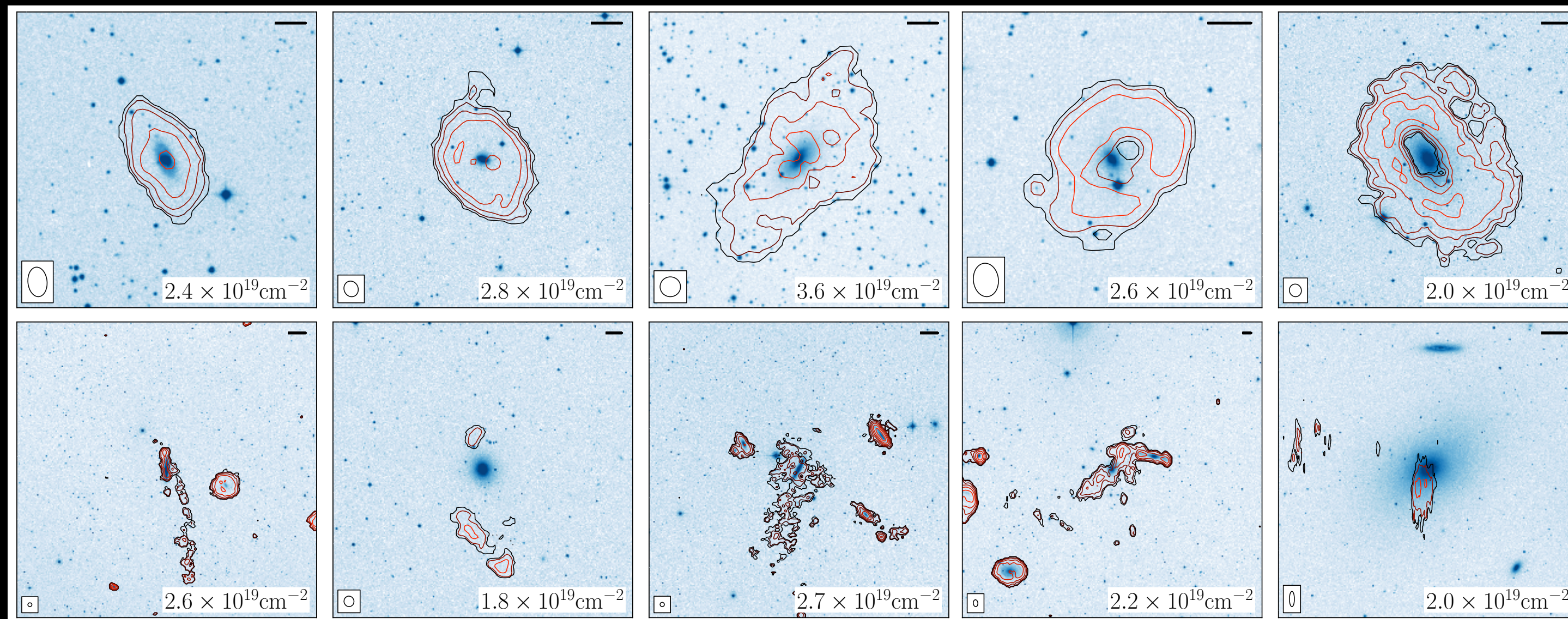
► RFI...



► Need good tools to inspect (and flag) data before pipeline is run....

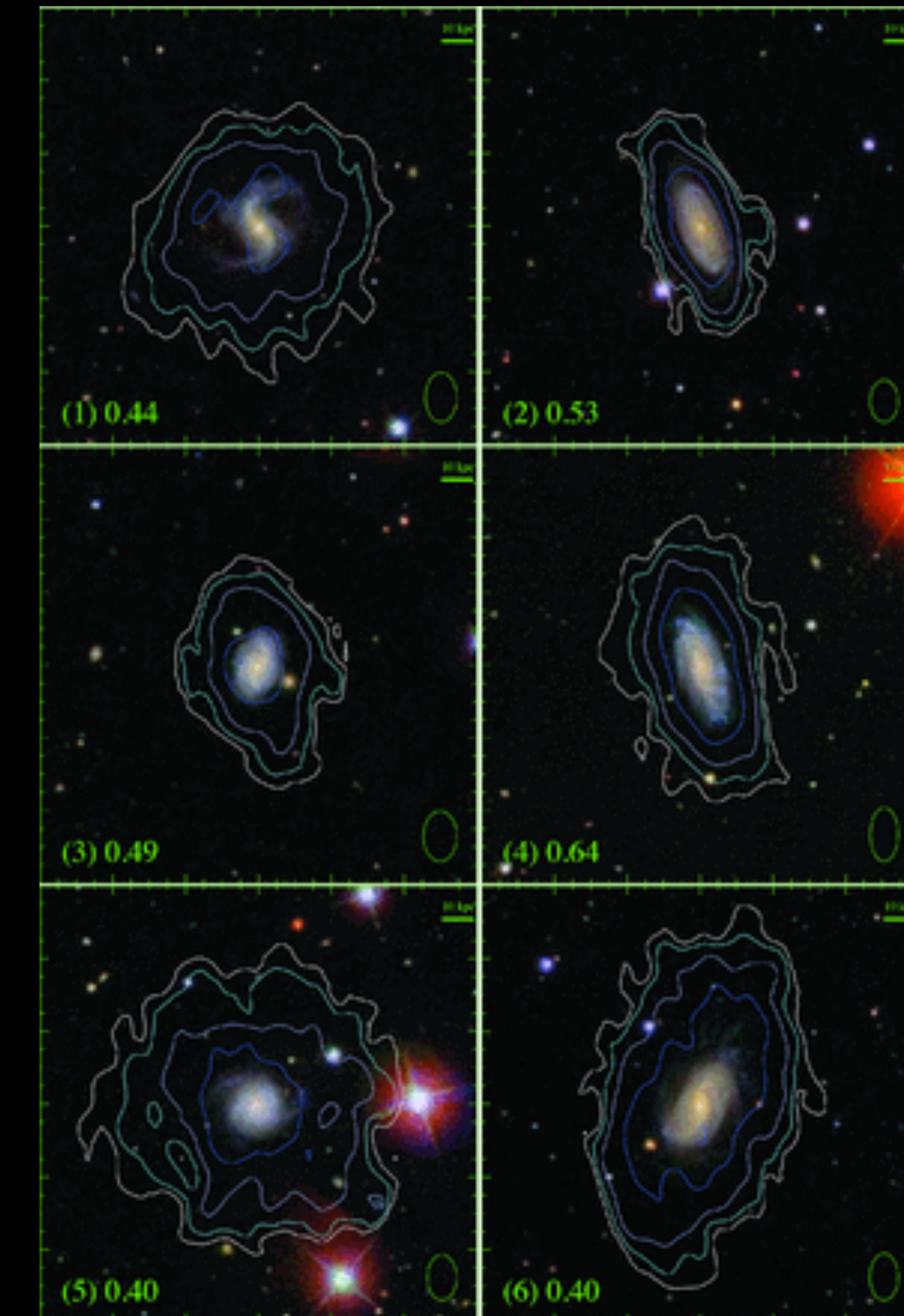
HI science

- ▶ Sensitivity is such that with a single 12-h synthesis detects column densities (just) below 10^{20} cm^{-2}
- ▶ Shallow survey will detect $\sim 100,000$ galaxies out to $z \sim 0.1$
- ▶ Deeper survey over 500 deg^2 will detect $\sim 15,000$ galaxies out to $z \sim 0.2$ and the fainter 10^{19} cm^{-2} gas in outer regions and in between.
- ▶ Key progress: *RESOLVED* HI studies of galaxies in the local Universe
- ▶ Study the role of the environment on galaxy properties



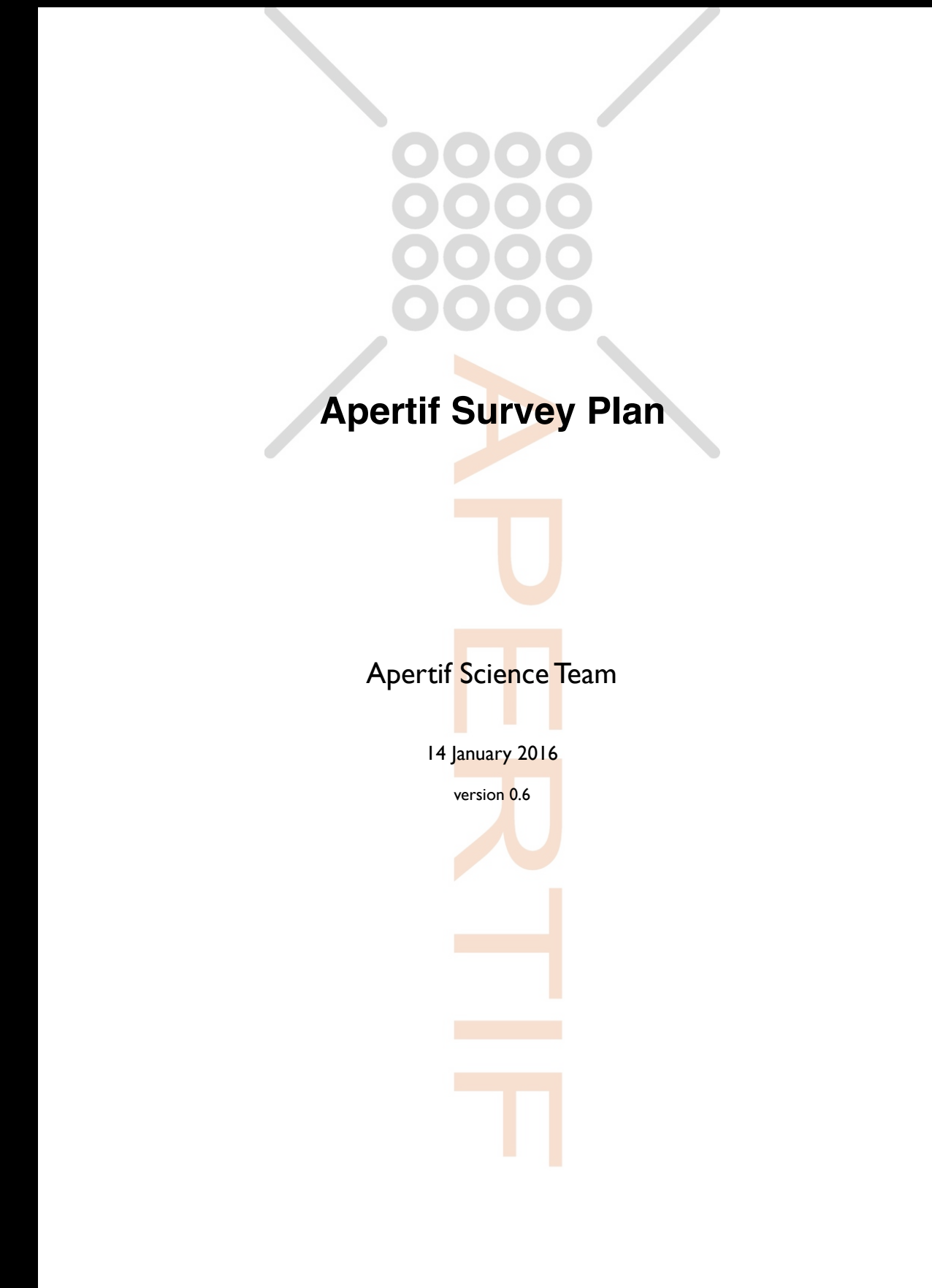
ETG in low-density field

ETG in high-density field

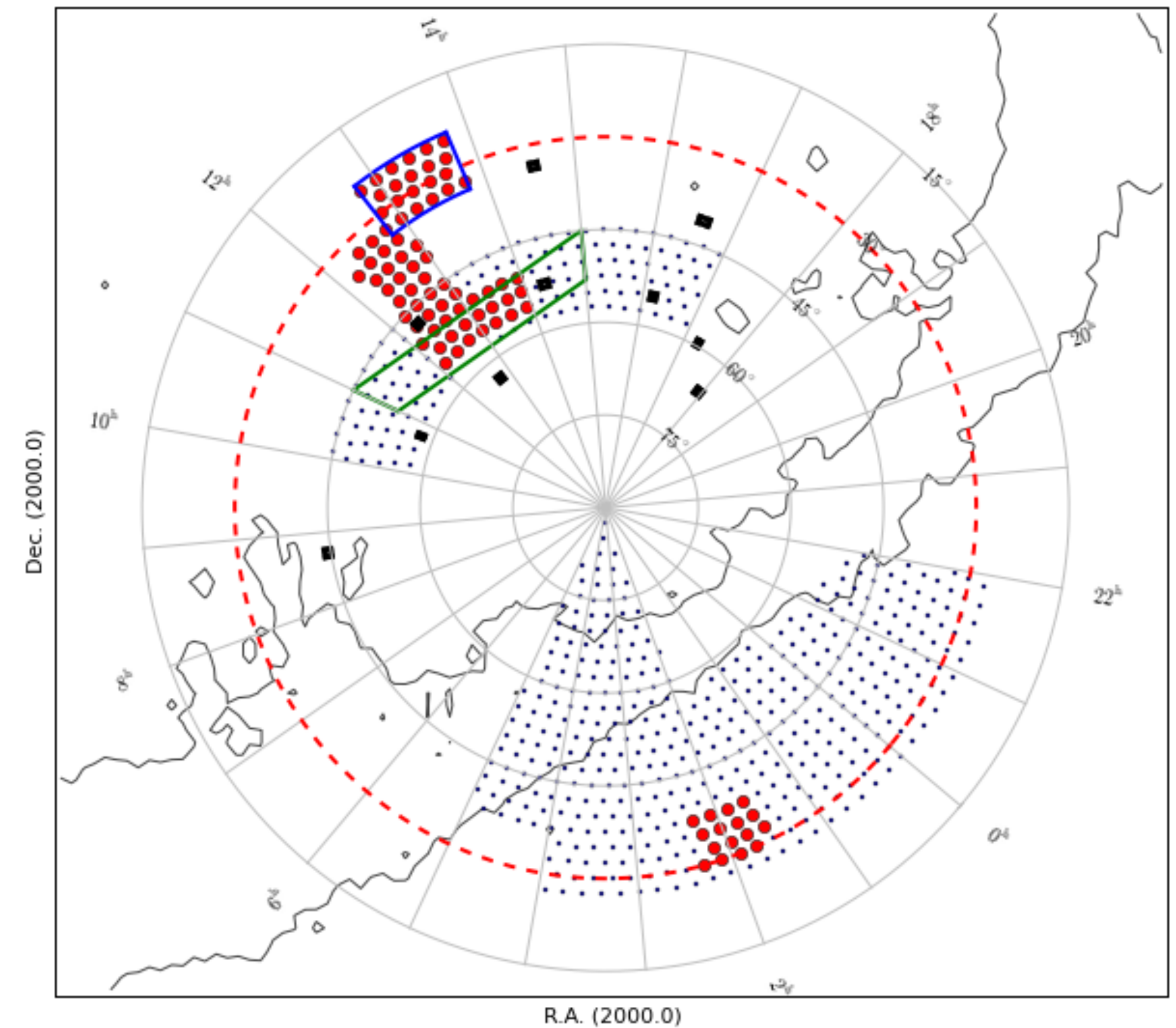
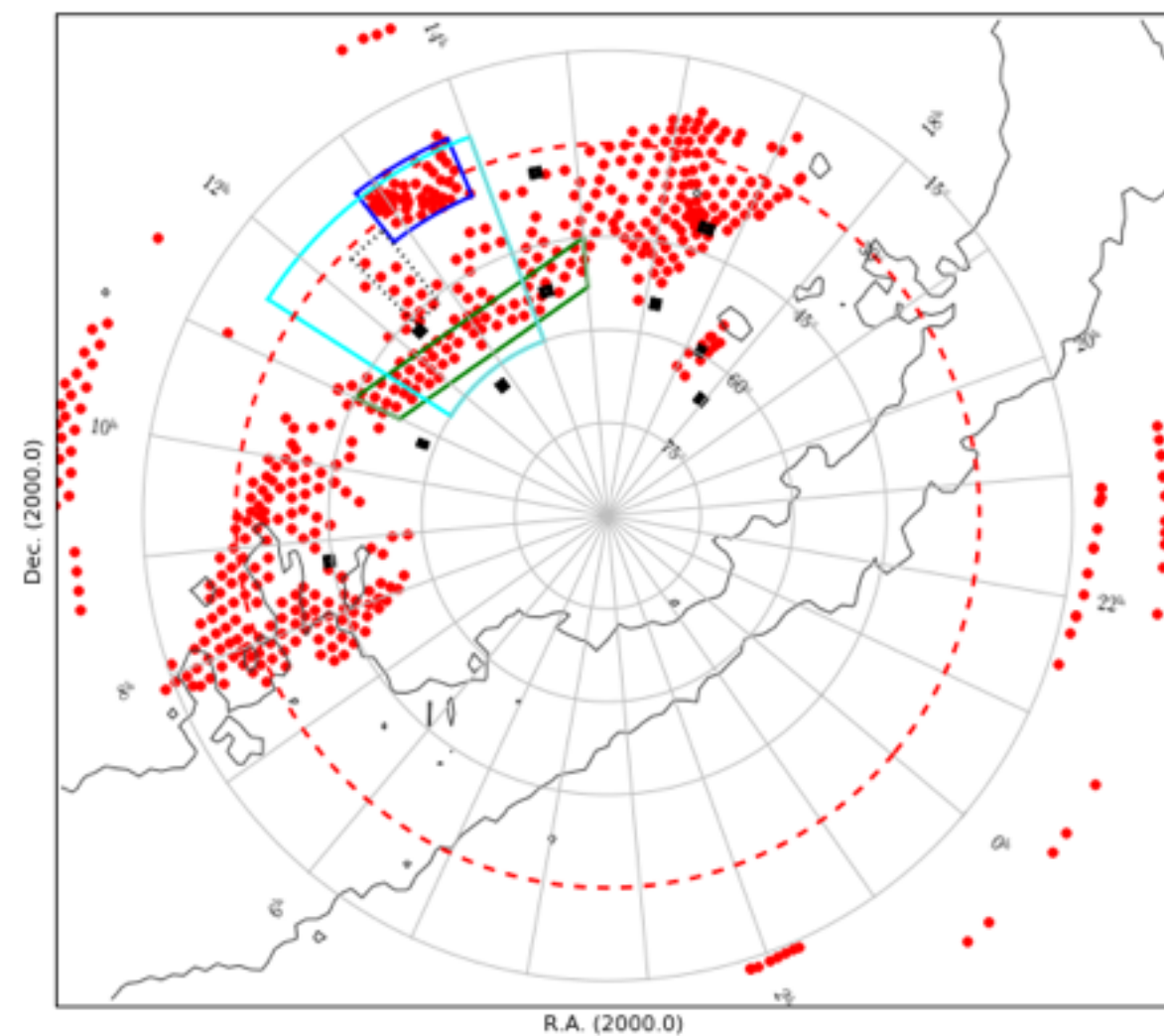


Bluedisk Apertif pilot

- ▶ Apertif surveys will be executed, calibrated and reduced by a single Apertif Science Team
 - Observatory is only responsible for technical operations!!!
 - participation in survey team requires significant commitment, financially or with people (nobody else will do the work)
 - yearly data releases
- ▶ Fall 2015: framework of surveys presented to community, with invitation to participate
- ▶ Dec 2015: participating teams defined final survey setup; sent to Review Panel
- ▶ Feb 2016: approval of surveys by Review Panel and by Astron's Science Advisory Committee (this week!!)



- definition driven by science AND efficiency
 - large-area shallow imaging survey 3500 deg²
 - smaller medium-deep imaging survey 450 deg²
 - transient survey
 - some details to be filled in (e.g. MaNGA)
(more on this later by Marc)



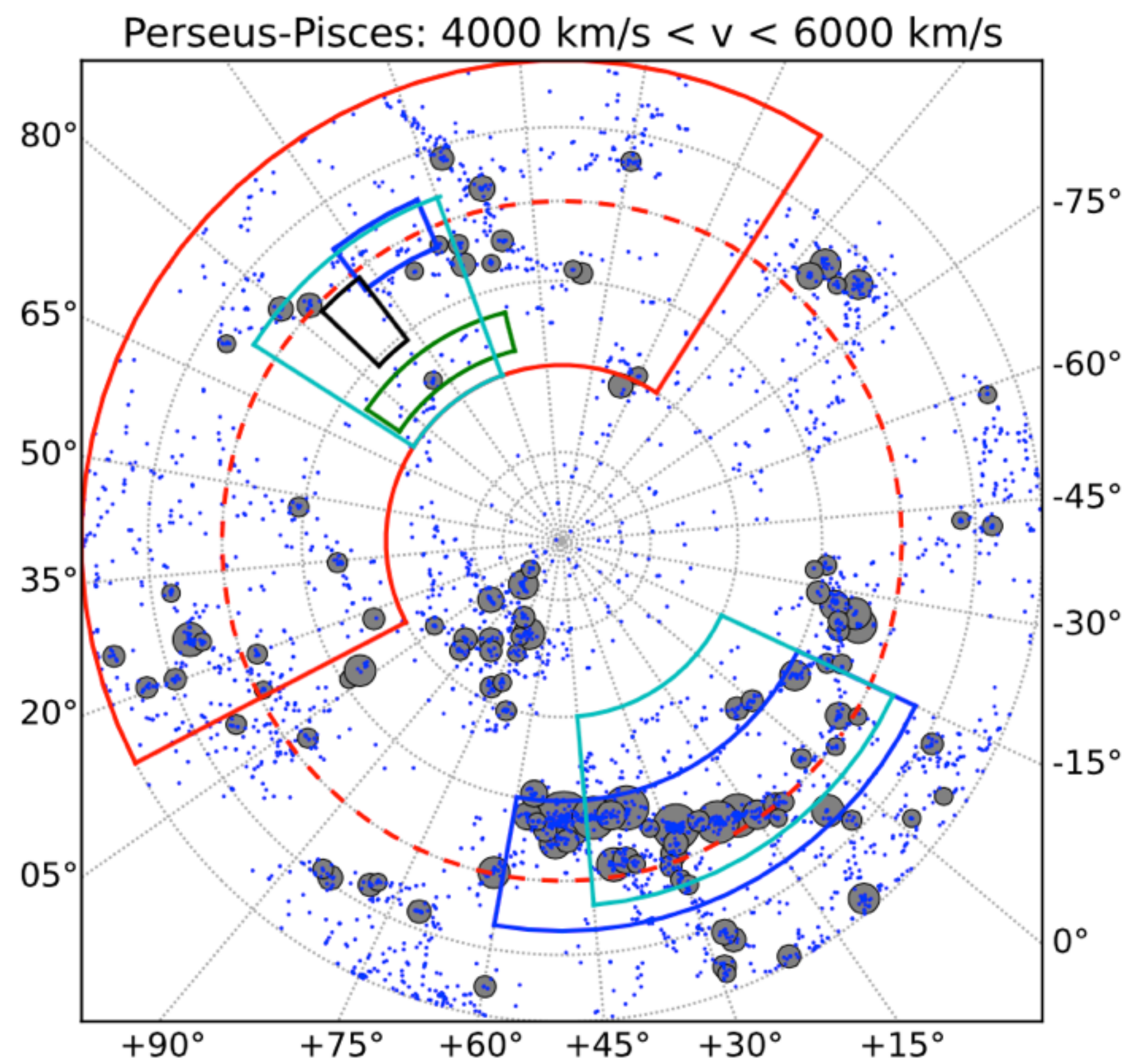


Figure 2: A slice highlighting the Perseus-Pisces cluster (5100 km/s) + filament. HI mass sensitivity: $10^8 - 10^{8.3} M_{\odot}$ at $cz = 4000 - 6000 \text{ km s}^{-1}$ (56 – 84 Mpc).

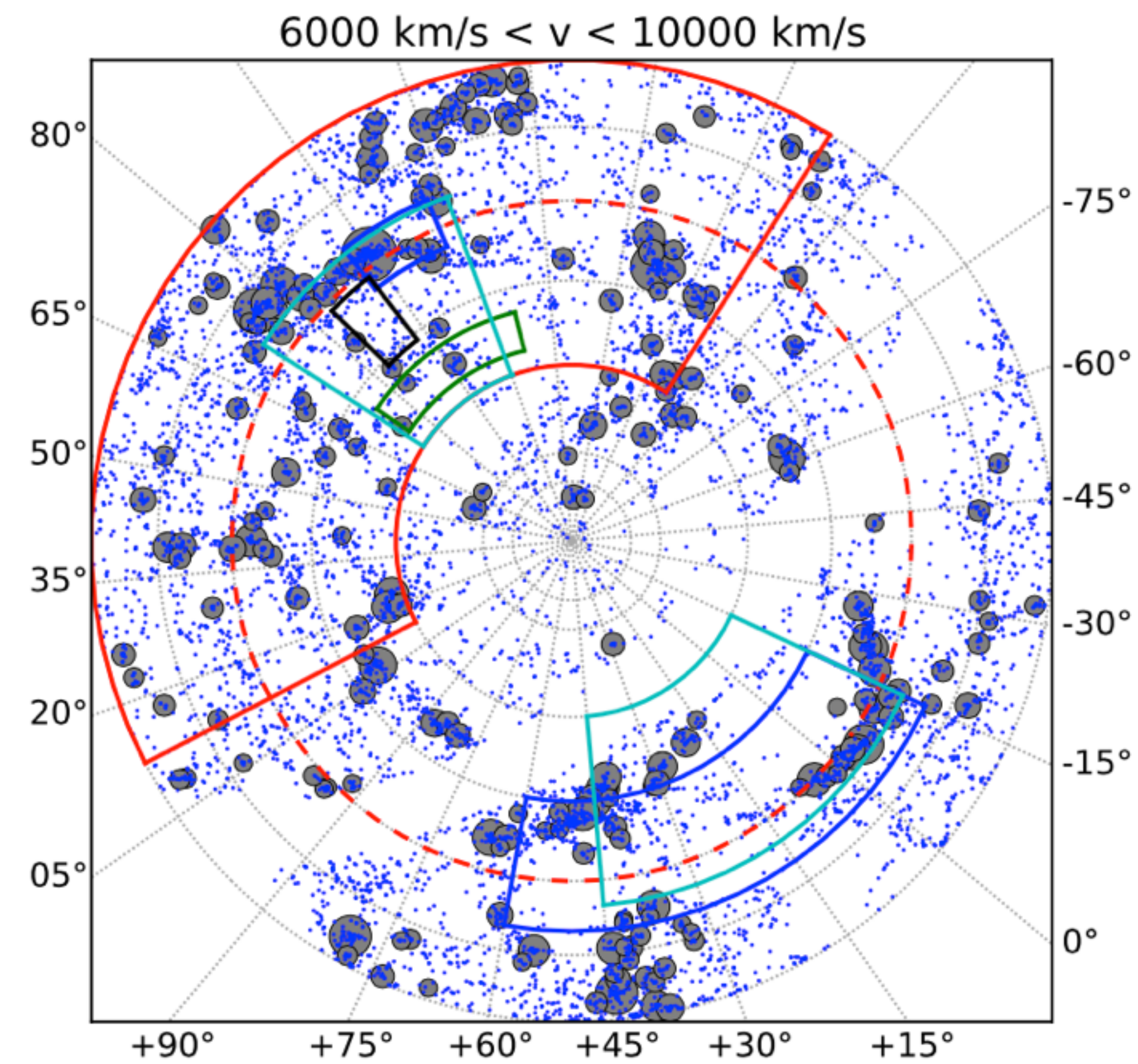


Figure 3: HI mass sensitivity: $10^{8.3} - 10^{8.8} M_{\odot}$ at $cz = 6 - 10000 \text{ km s}^{-1}$ (84 – 138 Mpc)

- ▶ Installation underway
 - 6 PAFs installed
 - commissioning starting
 - full Apertif i August

- ▶ Software looks good, but still some work to do

- ▶ Survey plans (almost) finalised