Detecting Radio Recombination Lines in LOFAR Imaging Data

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Fundamental Physics in Radio Astronomy

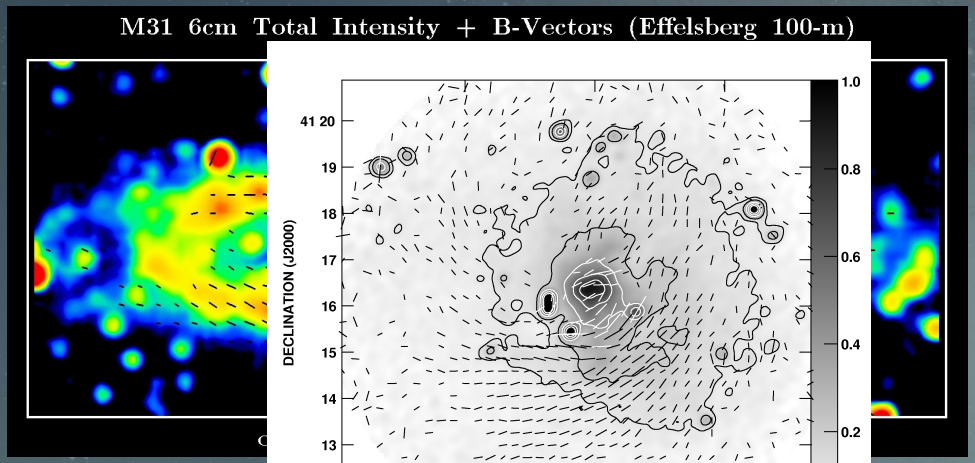
(Michael Kramer)

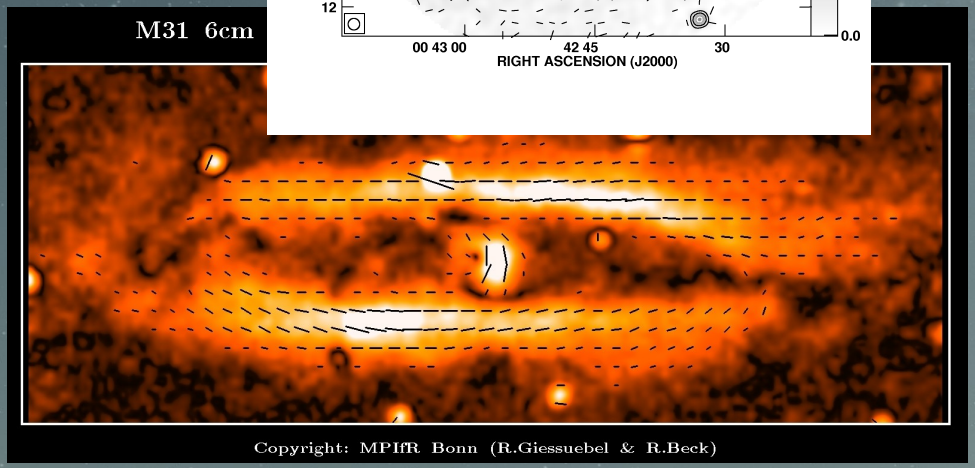
MAX-PLANCK-GESELLSCHAFT

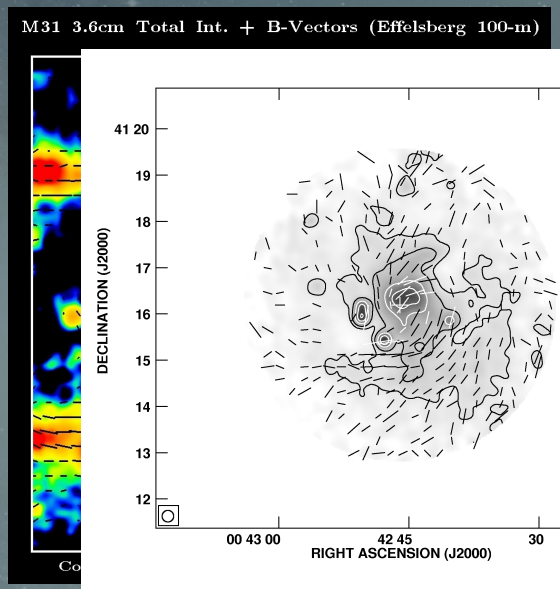
Max-Planck-Institut für Radioastronomie

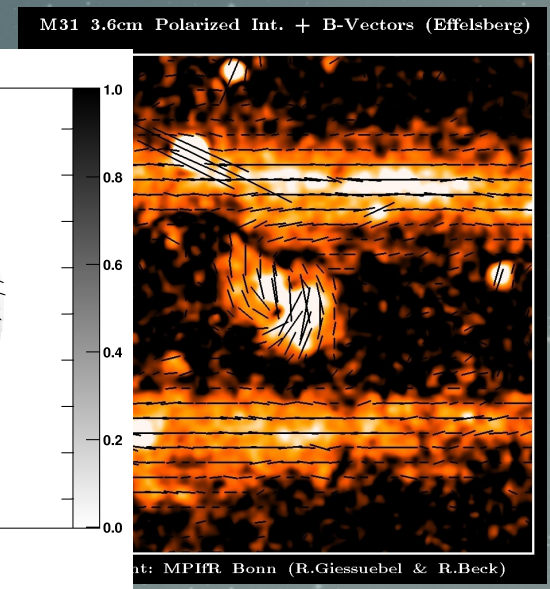
The magnetic field of M31

Rainer Beck, Elly M. Berkhuijsen









- deepest polarization maps obtained with Effelsberg
- VLA data at 8350 MHz and 4850 MHz
- WSRT observation at 350 MHz (A9 Pilot)
- future plans: LOFAR observation, APERTIF?

Detecting Radio Recombination Lines in LOFAR Imaging Data

Detecting Radio Recombination Lines in LOFAR Imaging Data

what?

why?

where?

how?

What are Recombination Lines?

electrons captured by ions
cascade down

radio (n>40): hydrogenic

nomenclature of lines:

atom n (end level) # of levels

C448α

$$(n + \Delta n) \rightarrow n$$

$$\nu = Z^2 \cdot R_X \cdot c \cdot \left(\frac{1}{n^2} - \frac{1}{(n+\Delta n)^2} \right) \quad \text{(GHz)}$$

Why are we interested in RRLs?

tracer of ionized gas
and its properties

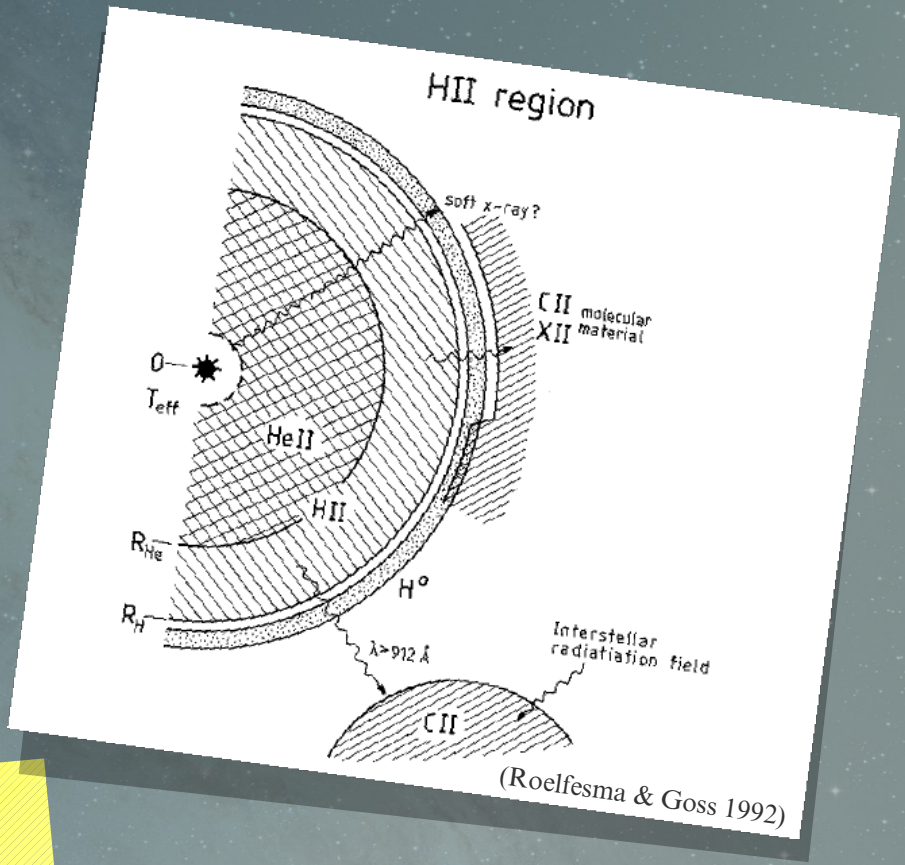
probe different regions
of the ISM

magnetic field strength
electron density

Why with LOFAR?

LOFAR frequency range
corresponds to n~300-850
low density regions

imaging!
but: sparse aperture array



(Roelfesma & Goss 1992)

n=766 => 1/13 mm

Detecting Radio Recombination Lines in LOFAR Imaging Data

what?

why?

where?

how?

low frequency → low density
→ strong background source

Cas A

want to have previous results

Payne et al. (1989), 93m & 43m NRAO Green Bank

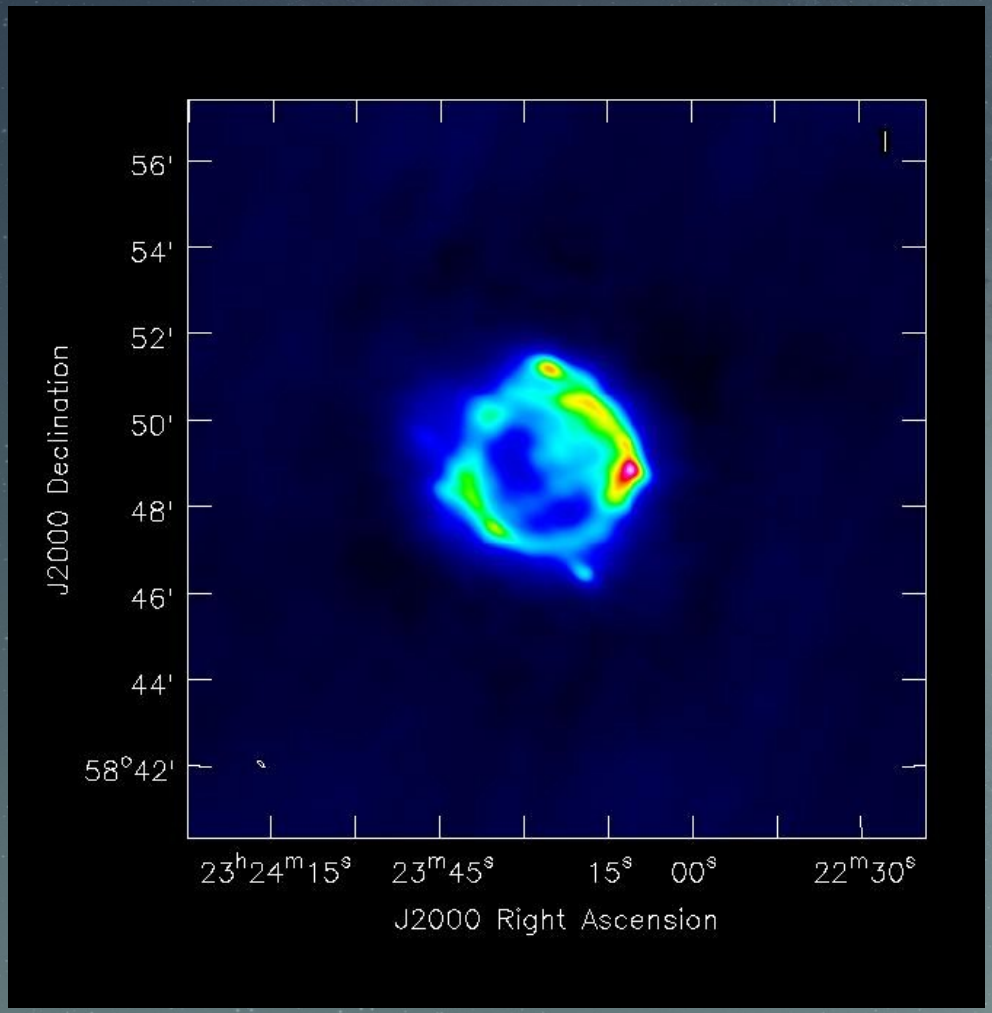
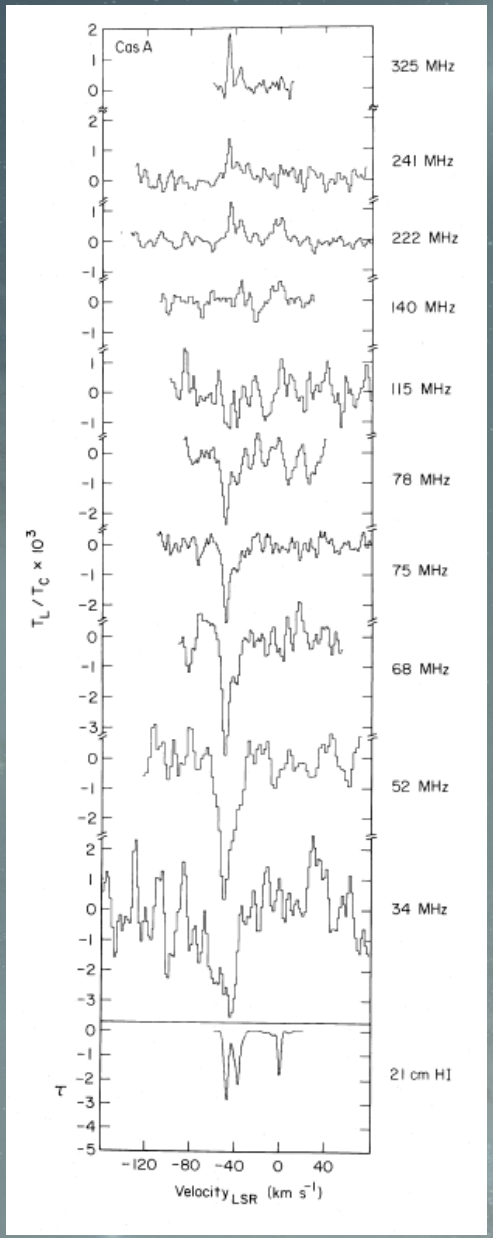


image by Sarod Yatawatta (ASTRON)



HBA
110-250 MHz

♫ ♪ ♫ ♪♪ ♫

LBA
10-90 MHz

the data (LBA)

07679

(used before for the high resolution image of Cas-A by Sarod)

6 hours observation time

18 Antennas (CS, RE and DE)
used only the 12 core stations (at least on of those flagged as well)

=> uv-distance ~600 λ

240 channels/subband

channel width ~762Hz

08409

(special observation for the project need sensitivity, not high resolution)

18 hours observation time

18 Antennas (only core stations)

=> uv-distance ~620 λ (~3 km)

240 channels/subband

channel width ~762Hz

Detecting Radio Recombination Lines in LOFAR Imaging Data

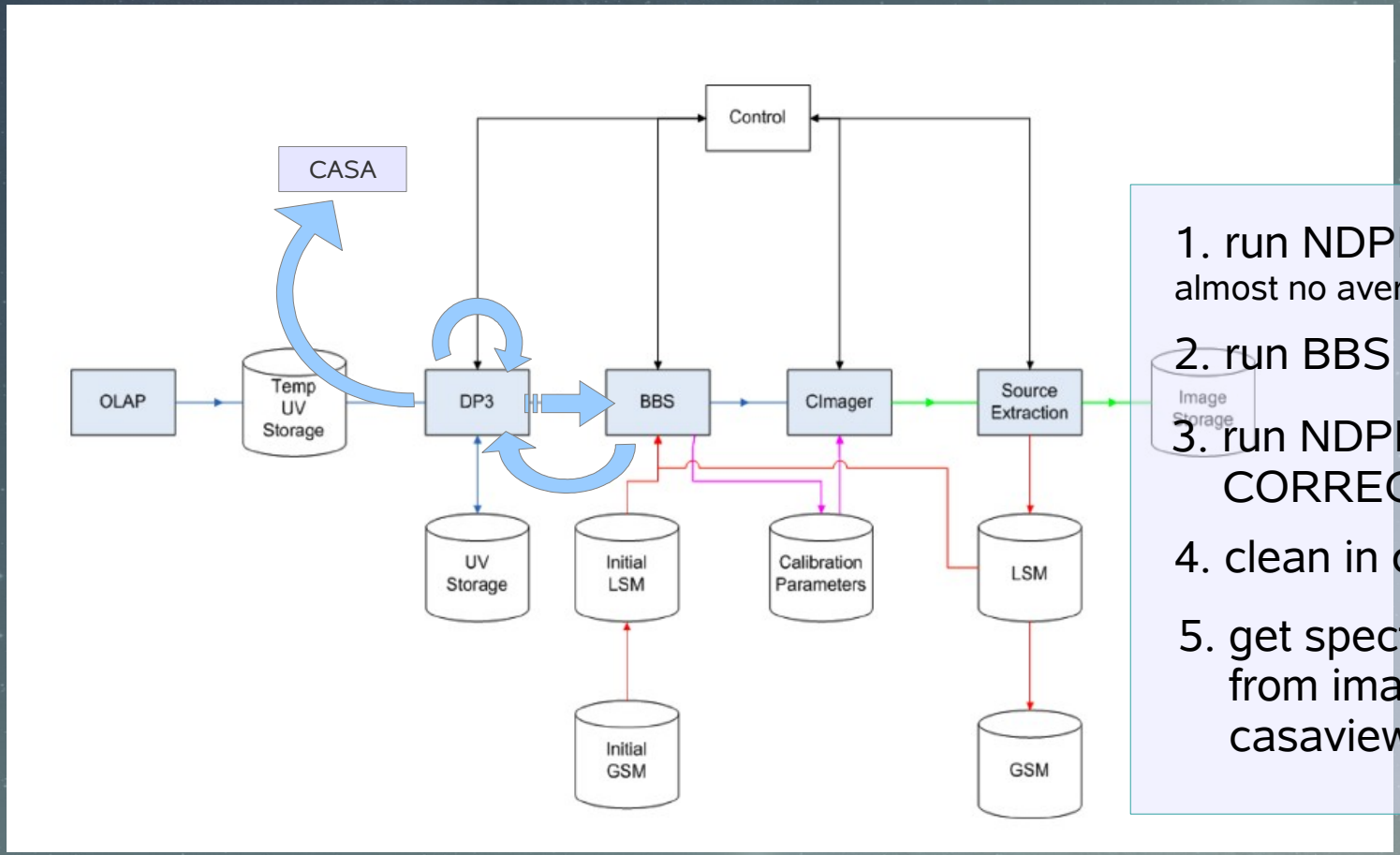
what?

why?

where?

how?

data processing



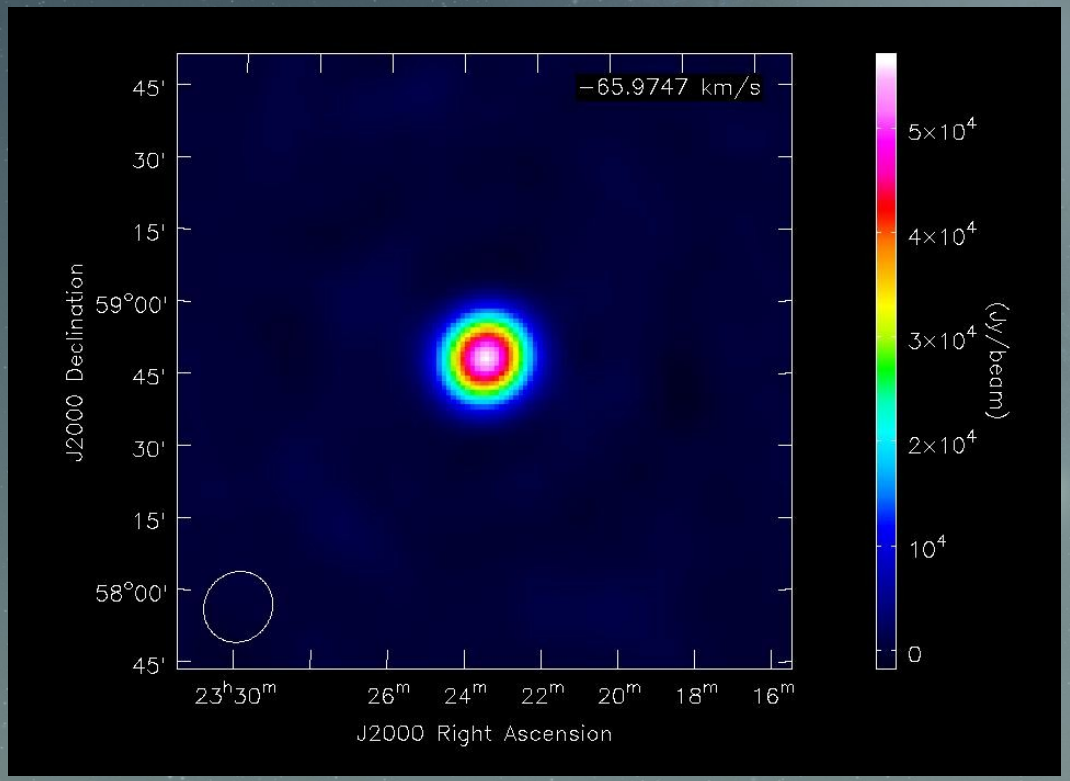
1. run NDPPP
almost no averaging!
2. run BBS
3. run NDPPP on CORRECTED_DATA
4. clean in casapy
5. get spectral profile from image cube in casaviewer

from LOFAR Imaging Cookbook

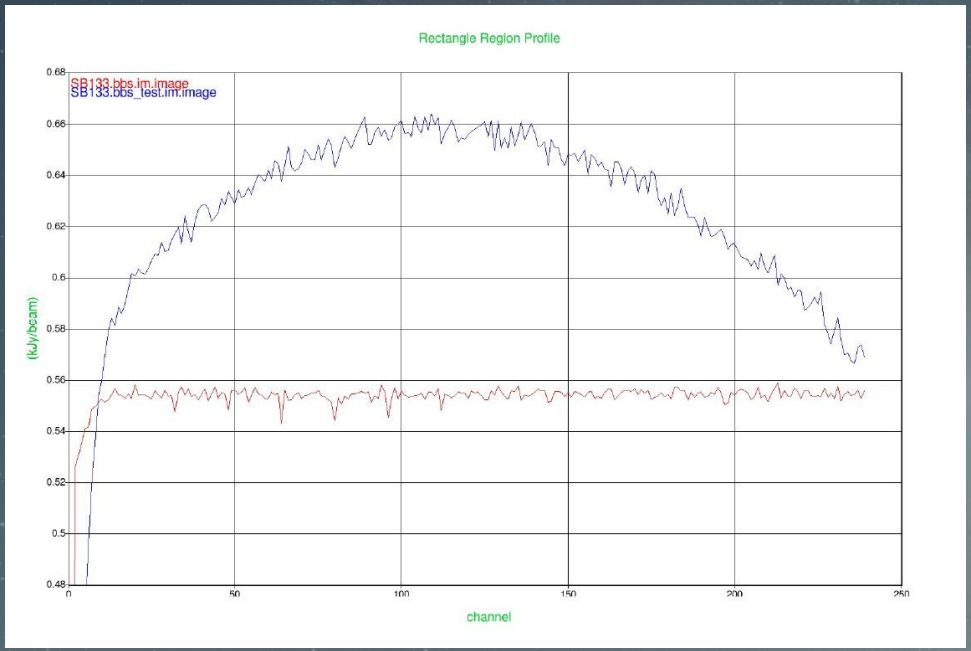
calibration with BBS

skymodel
single gaussian
(fit to smoothed image)

```
# (Name, Type, Ra, Dec, I, Q, U, V, ReferenceFrequency='60e6', SpectralIndexDegree='0', SpectralIndex:0='0.0', Major, Minor, Phi) = format
CasA, GAUSSIAN, 23:23:26.222, +58.49.04.719, 48147, 0.0, 0.0, 0.0, 55.0e6, 0, -0.7, 320.915, 297.061, 60.2319
```



calibration with BBS



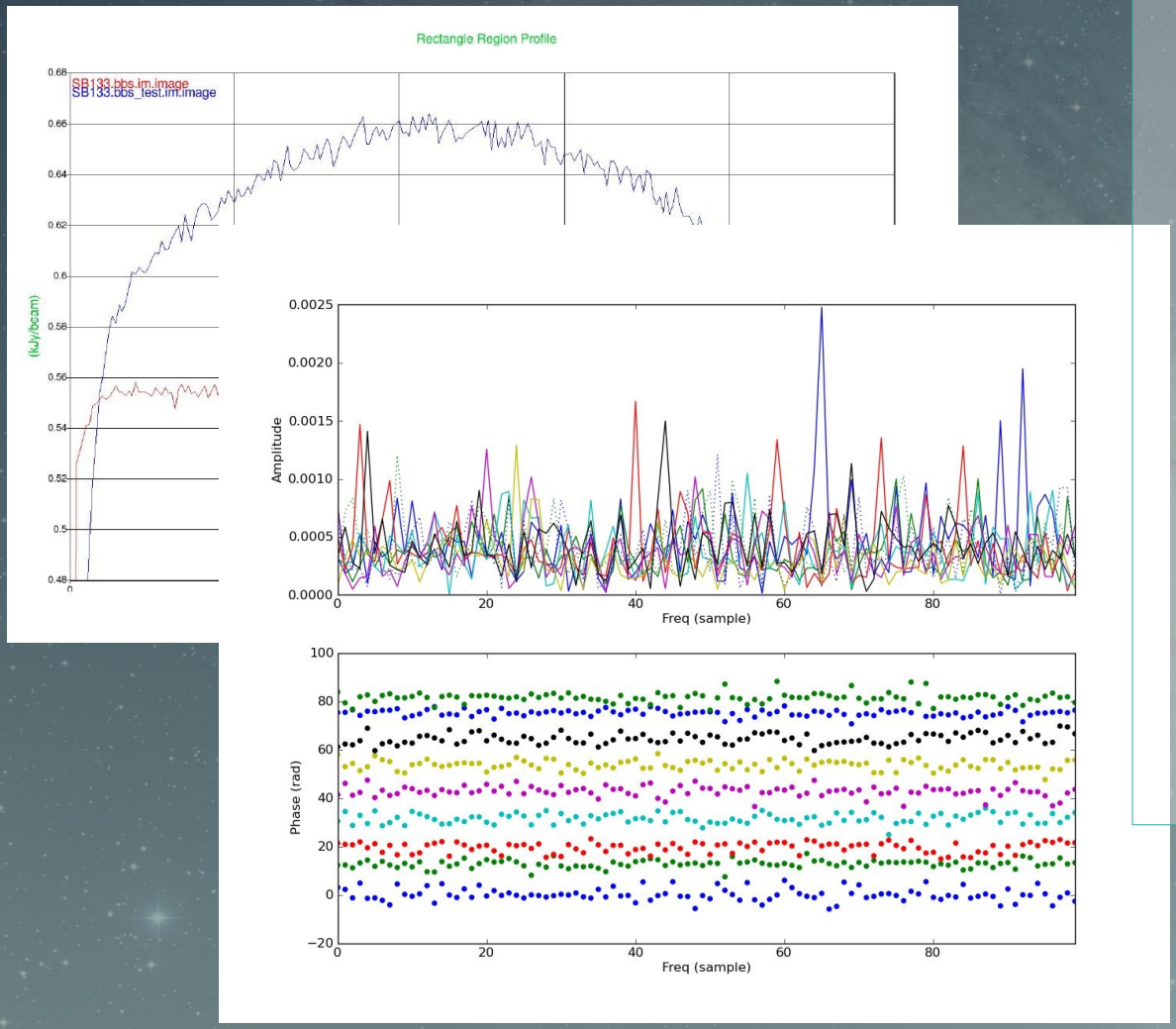
skymodel
single gaussian
(fit to smoothed image)

uv-plane-cal.parset
follow documentation
except:

```
CellSize.Freq = 1
```

calibrate each channel
seperately

calibration with BBS



skymodel
single gaussian
(fit to smoothed image)

uv-plane-cal.parset
follow documentation except:

```
CellSize.Freq = 1
```

calibrate each channel seperately

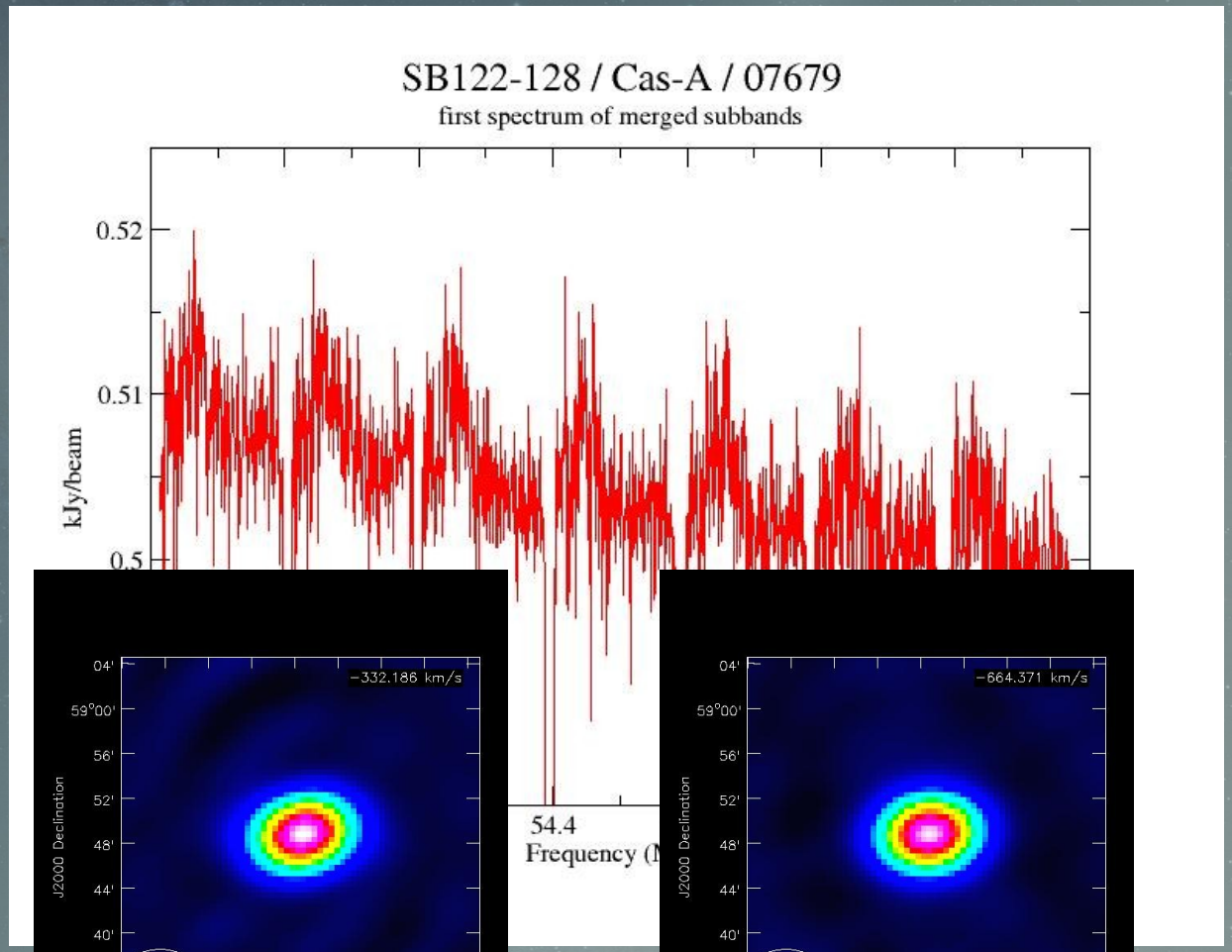
parmdbplot

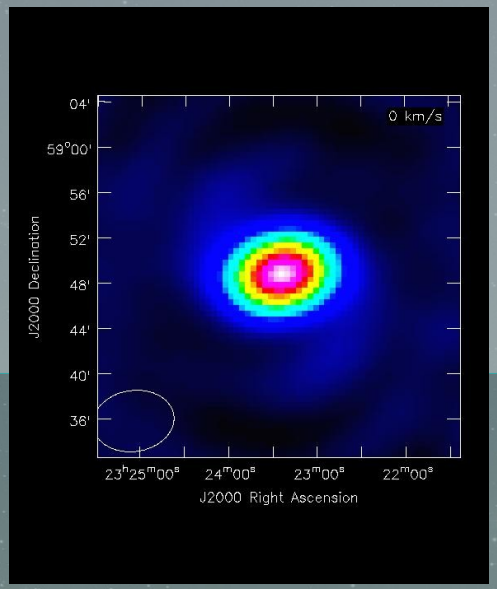
problematic or not?

effects of RFI

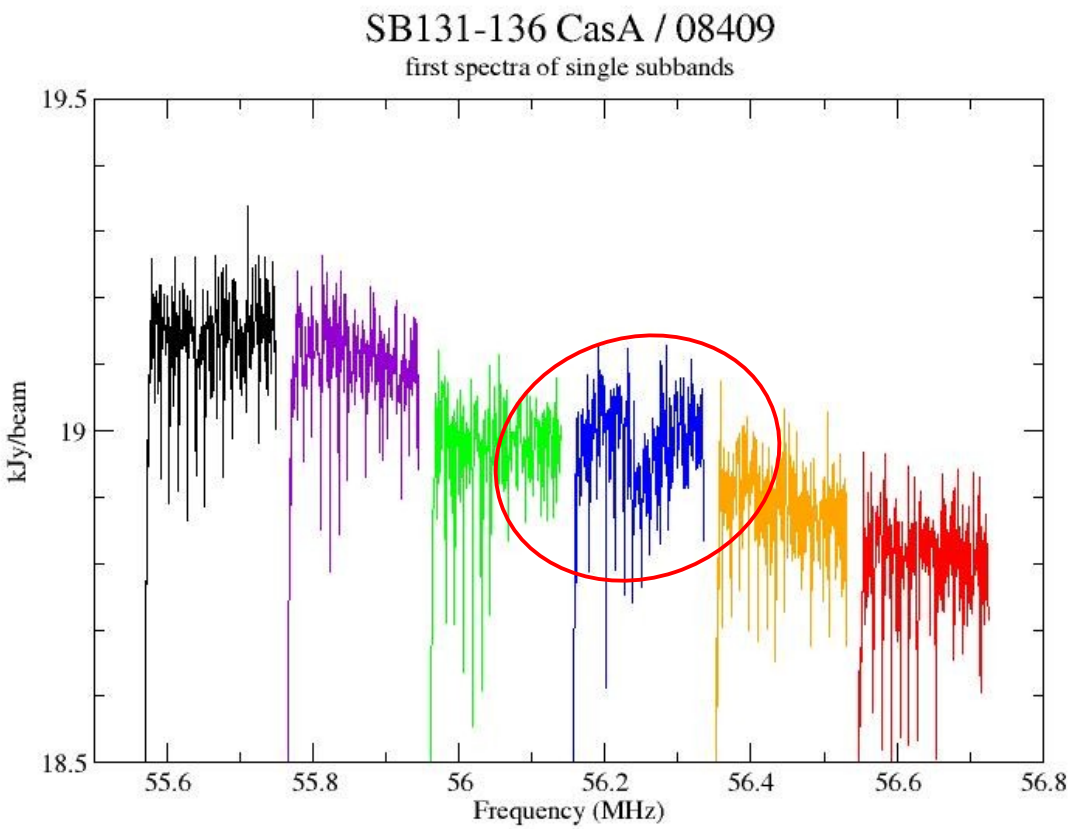
<u>very first results</u>

combined subbands:
baseline not flat
re-occuring wiggles
→ RFI
ionospheric scintillation?





the new (08409) data



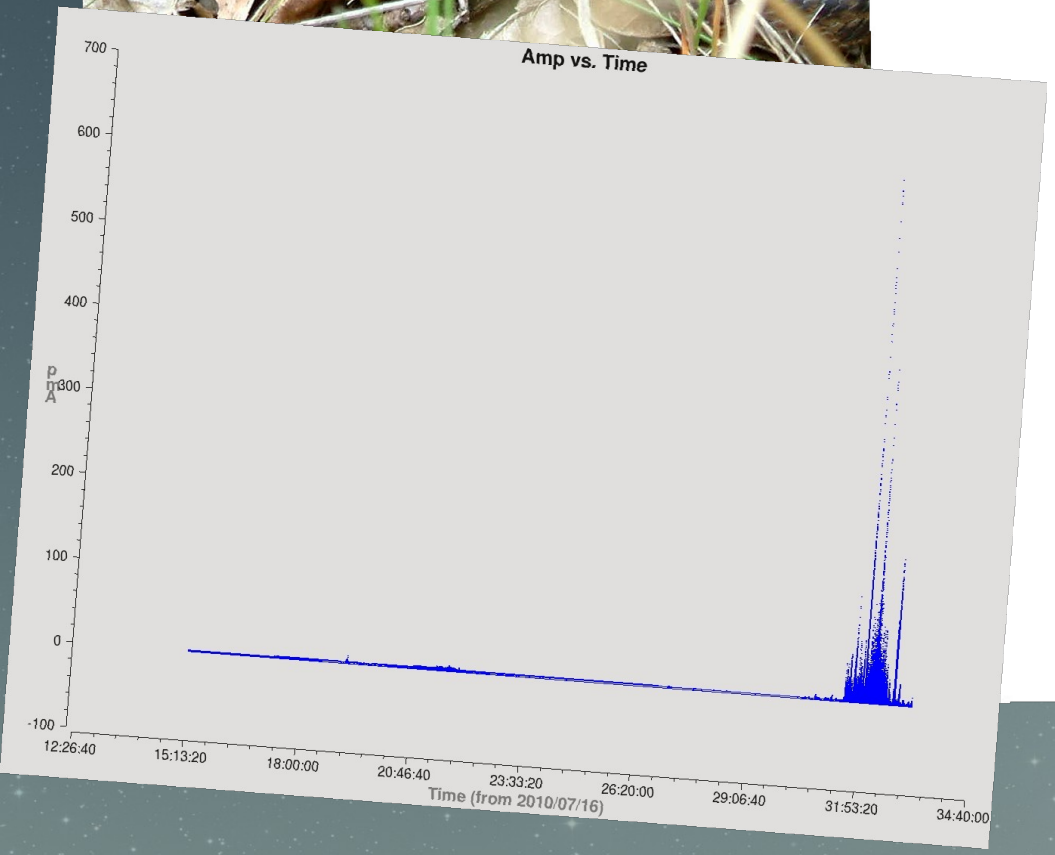
<u>very first results</u>

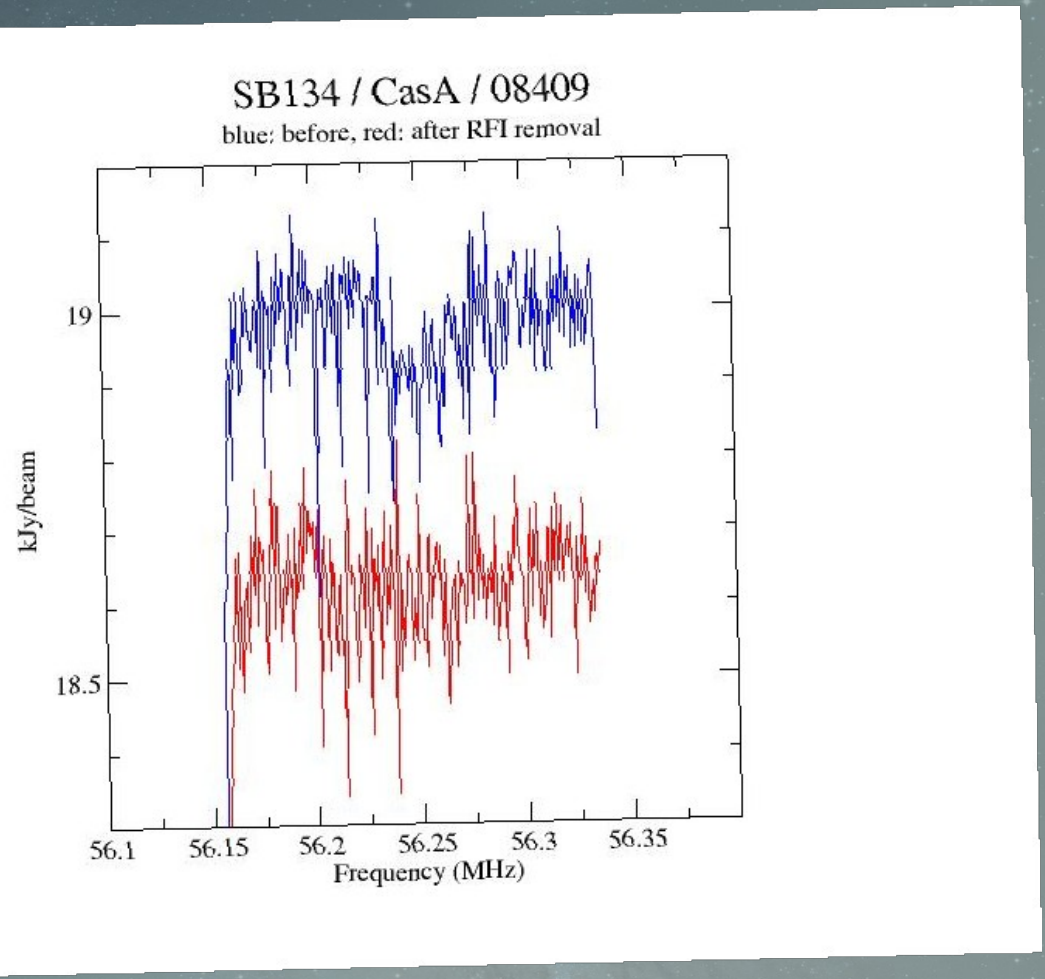
single spectra are smooth
(less RFI, better uv-coverage,
long observation time)

and ...

possible line detection
very broad (zeeman-splitted?)
quite strong!

nope ... effects of RFI

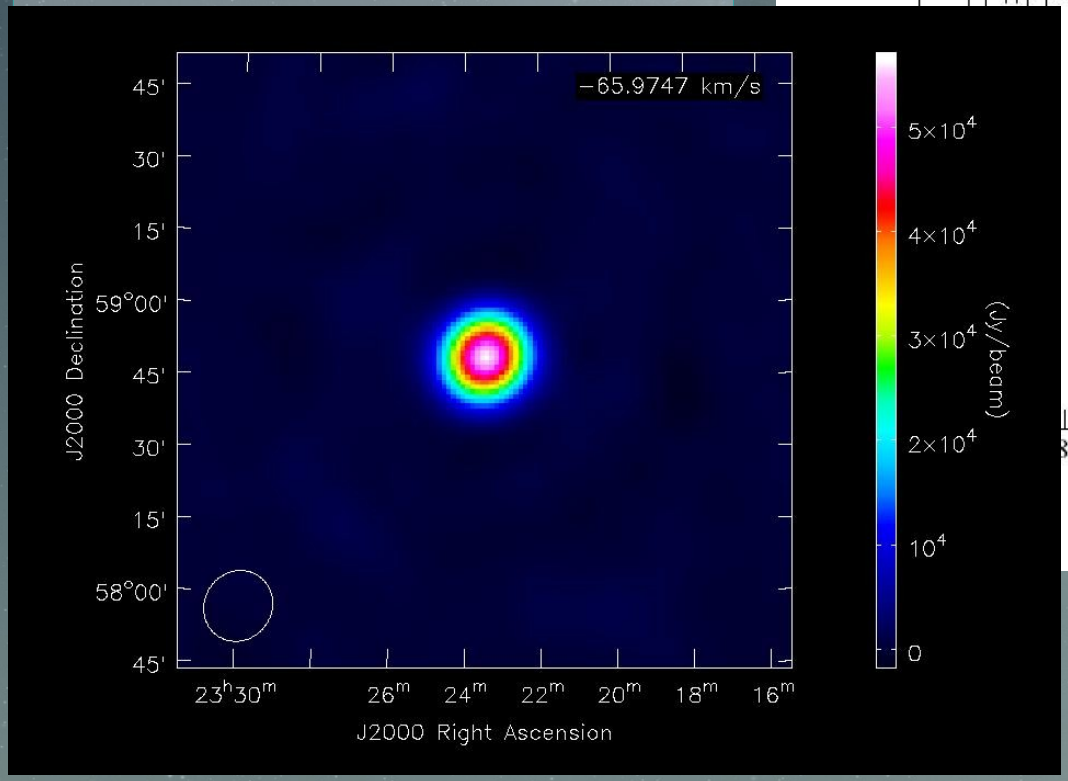


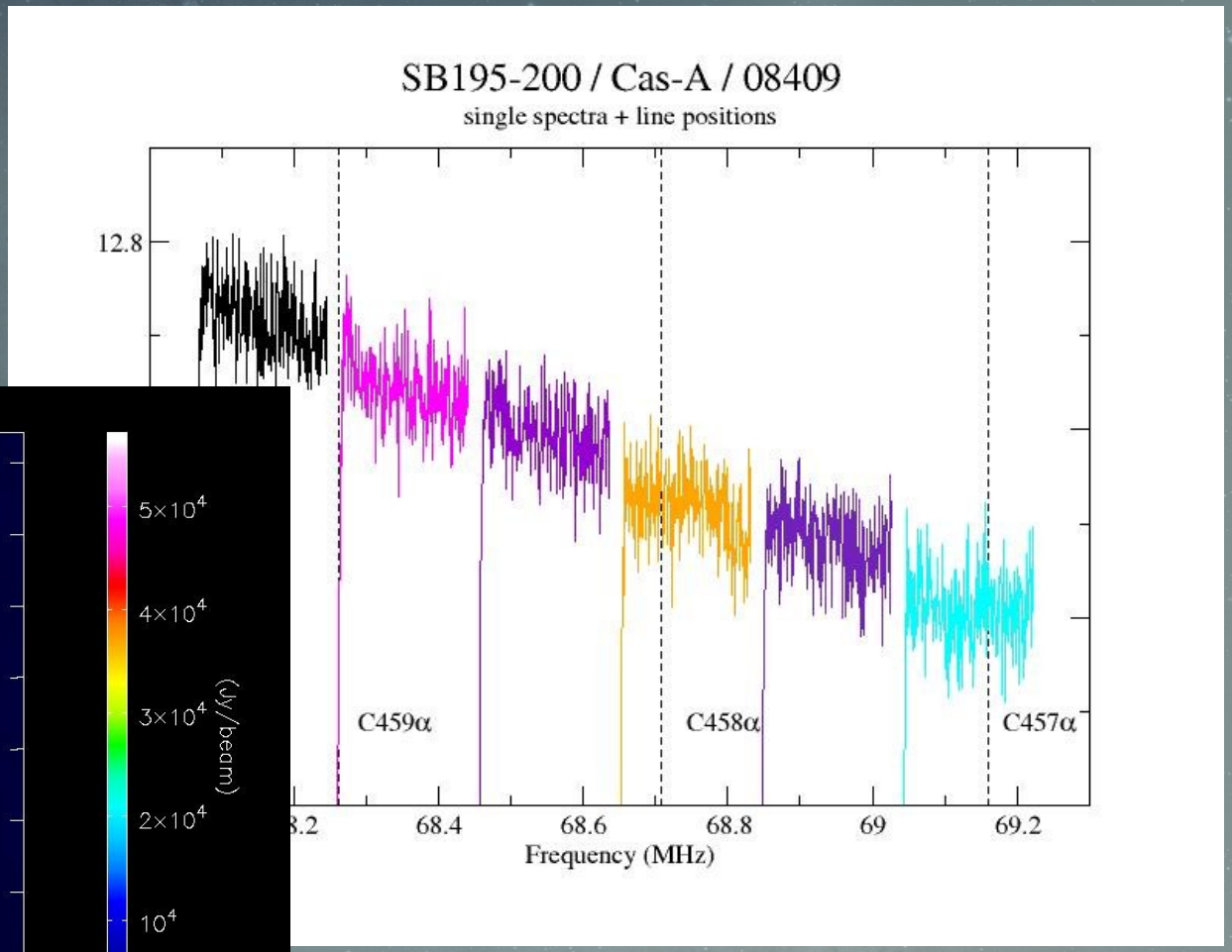


we're getting there ...

here we are:

very strict flagging!
“good” spectra





we're getting there ...

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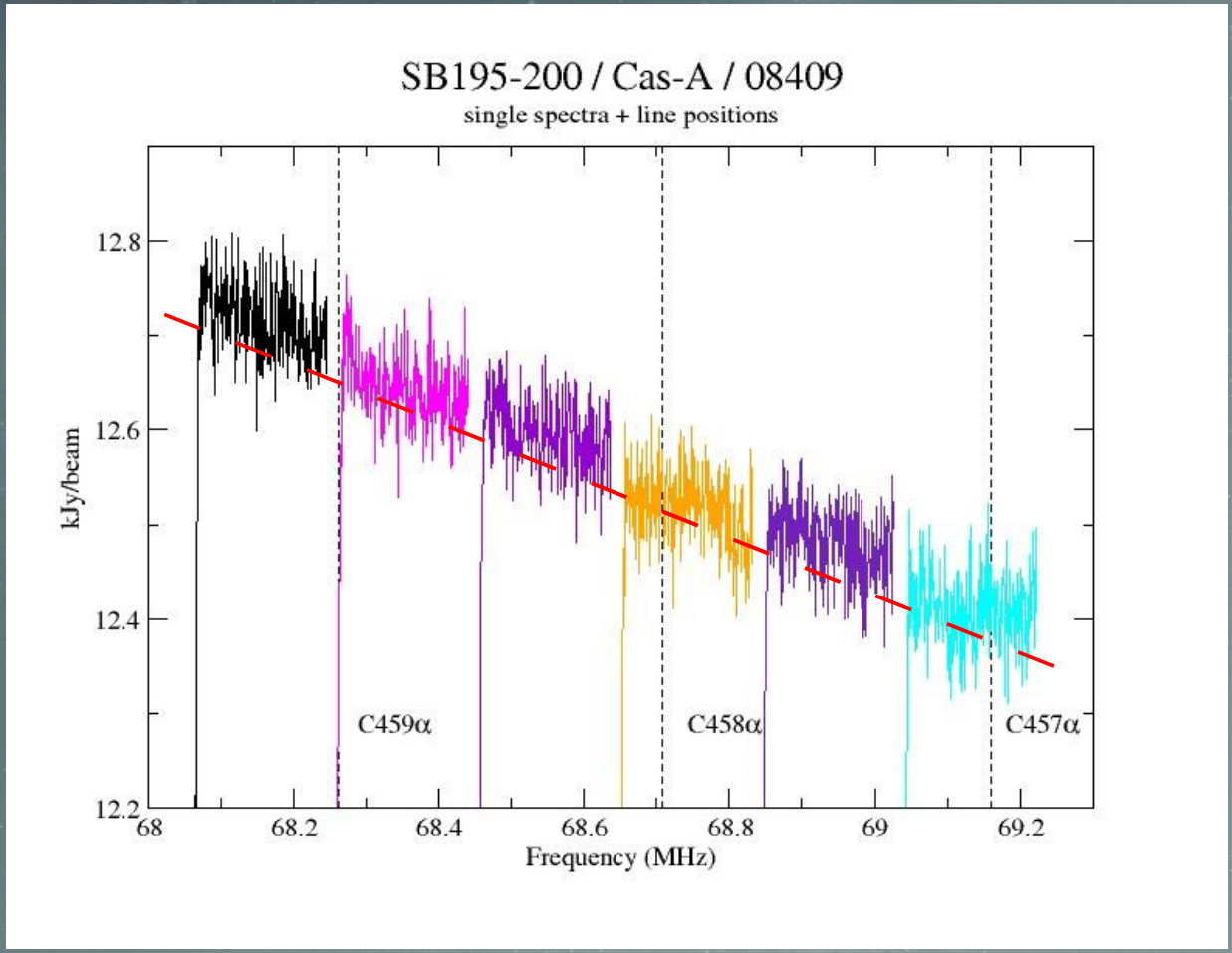
very strict flagging!
“good” spectra

some global bandpass
(probably due to slightly
inaccurate spectral index)



we're getting there ...

here we are:

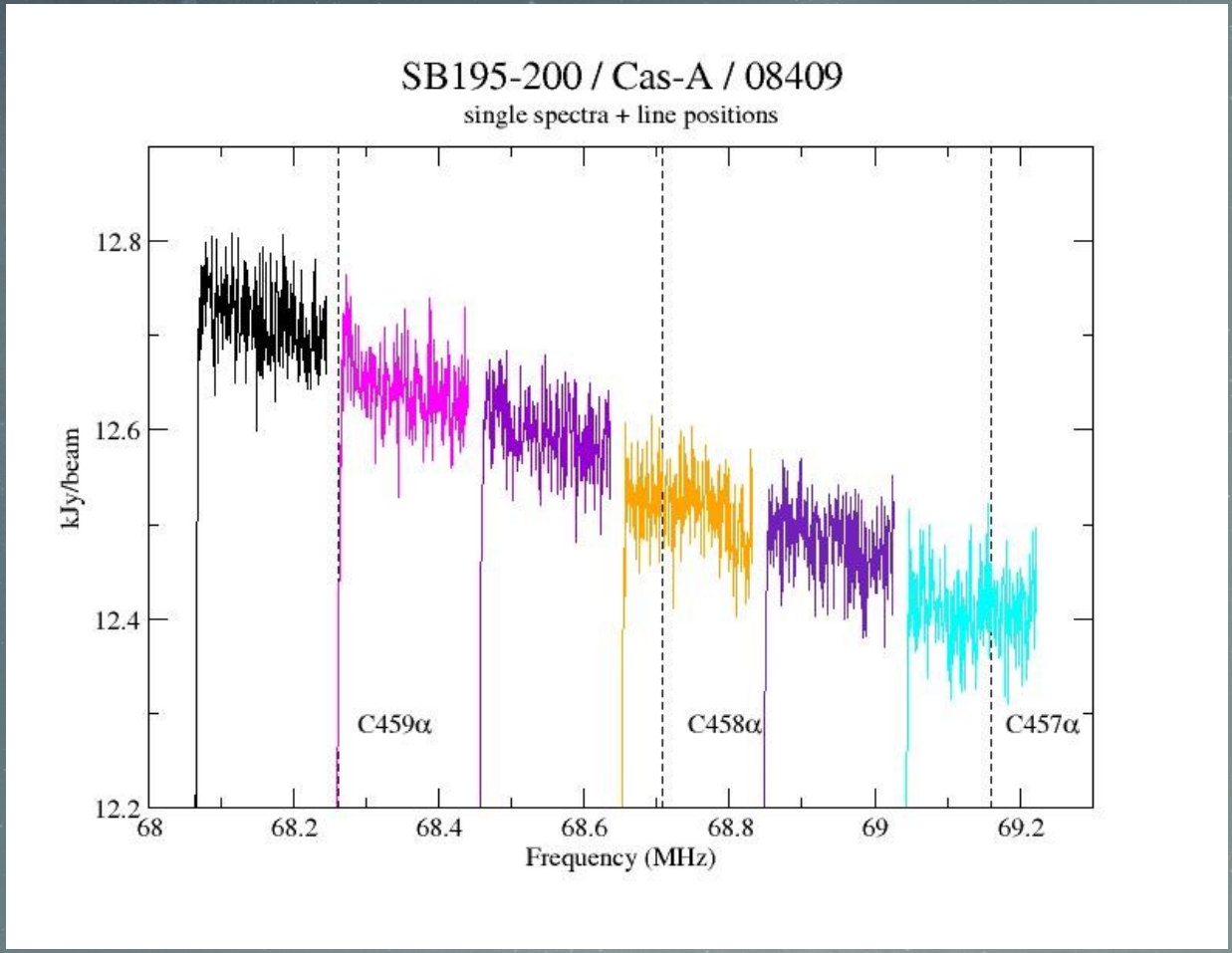
very strict flagging!
“good” spectra

some global bandpass
(probably due to slightly
inaccurate spectral index)

no lines in the single spectra.
actually not expected

need to average over multiple
line-positions

SB10-28: no detection



summary

<u>status</u>
- we (think we) know what to do
- can produce stable image-cubes
- scripts, parsets → basic building blocks for a pipeline

<u>main issues</u>
- run in distributed fashion
- disk space/resources
- errors/crashes
- time

<u>to do</u>
- doppler tracking
- testing, testing and testing
- redo subbands 20-45MHz
- get a detection

Thank you!