LOFAR detection of extended polarized emission: Giant Radio Galaxies & Milky Way

Emanuela Orrú

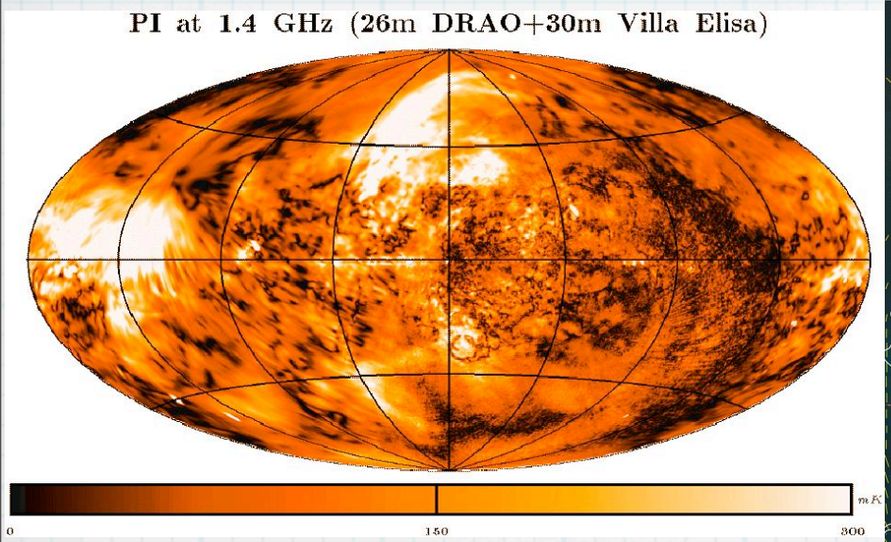
Radboud University Nijmegen

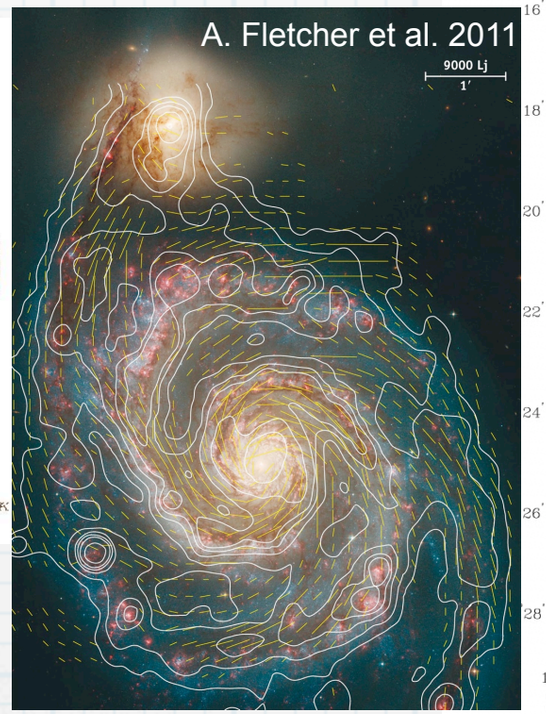
Commissioning team:
R. F. Pizzo(Astron) , M. Iacobelli(Leiden)
Group leaders:
G. De Bruyn(Astron), M. Haverkorn(Nijmegen)

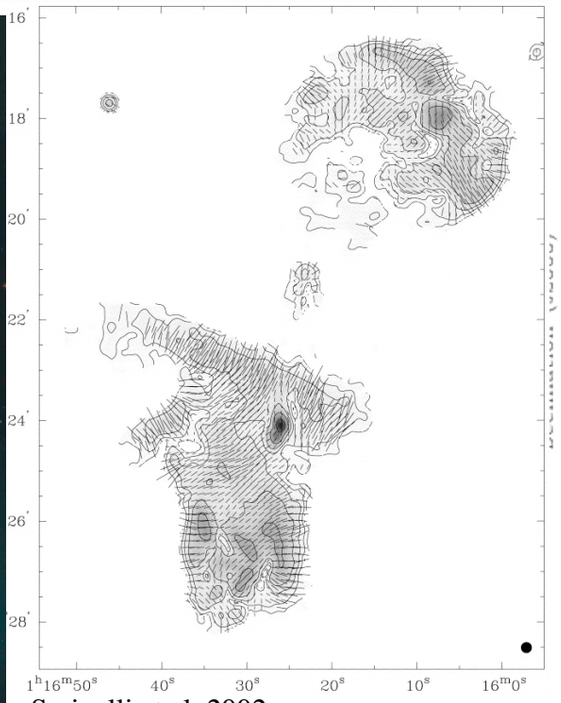
on behalf of the MKSP

Extended polarization

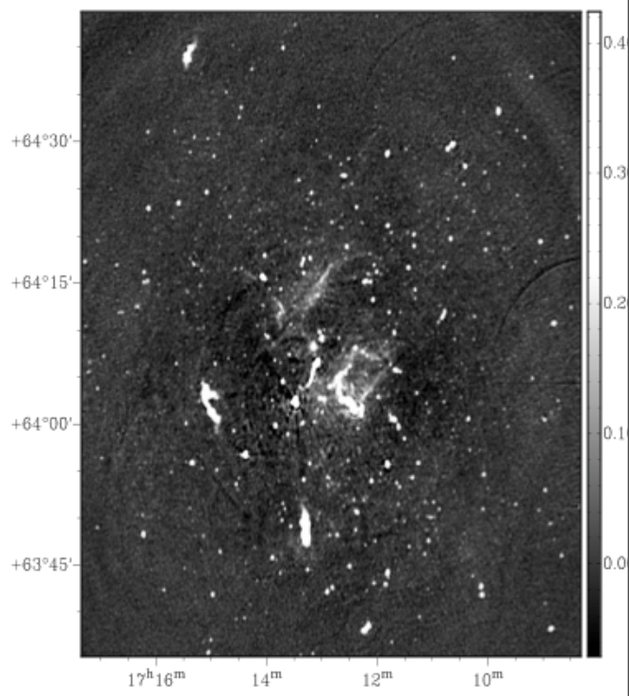
* Examples of extended polarization
  (MW, spiral galaxies, double radio galaxies AGN, clusters filaments)







Saripalli et al. 2002



Pizzo et al. 2011

* Which telescopes? Which objects?

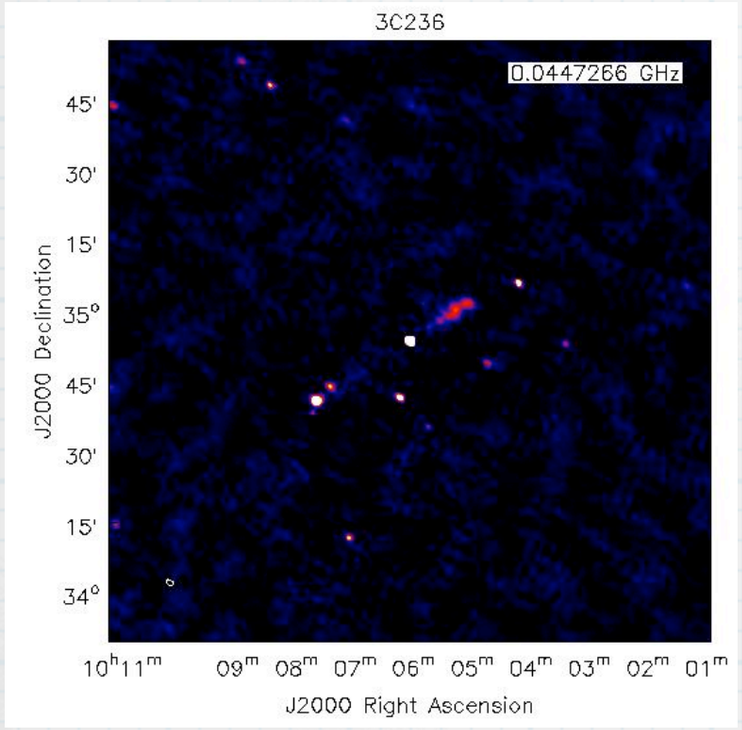
VLBI,ATCA,VLA...> 1 GHz
WSRT, GMRT (test) <1 GHz

High surface brightness total intensity

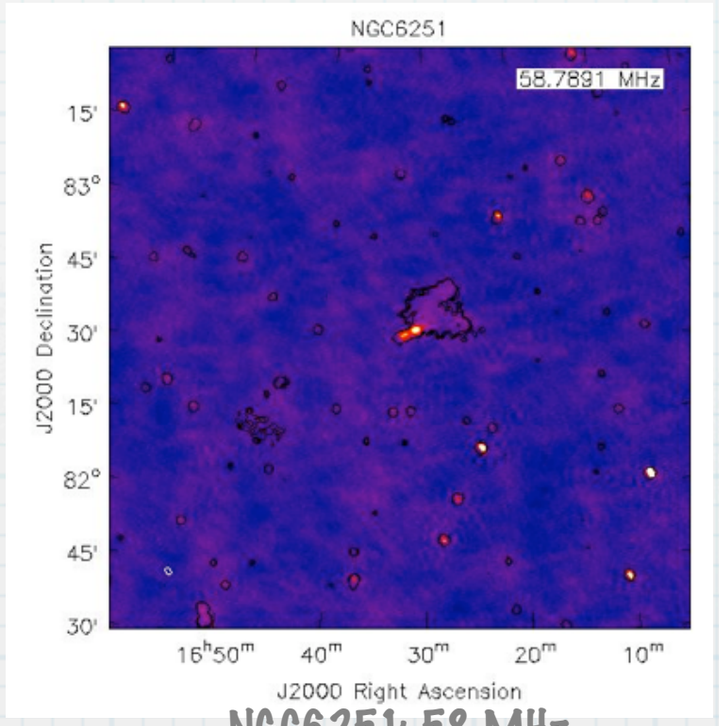
(Giant) Radio Galaxies:

* the group: G. De Bruyn (chair), E. Orrú, R. Pizzo
* the goal: characterization of polarized emission, calibrators
* the challenge: low surface brightness, difficult to model

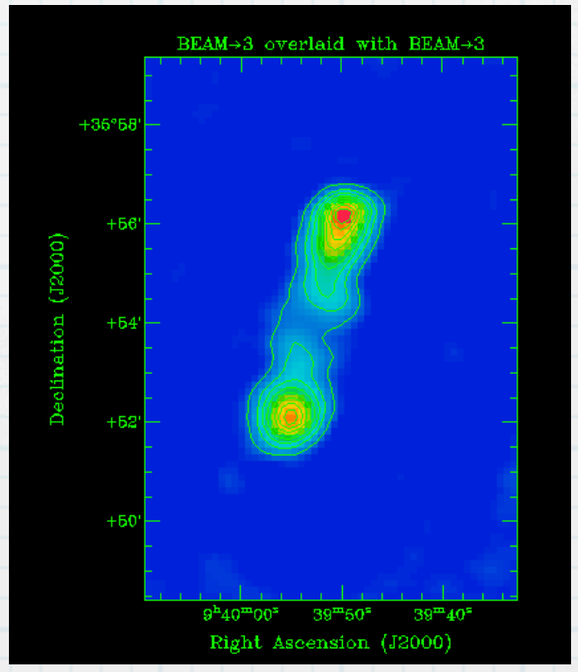
Members: P. Alexander, J. Anderson, T. Arshakian, J. Broderick, M. Jamrozy, R. Laing, E. Middelberg, E. Orru, R. Pizzo, J. Riley, A. Scaife



3C236: 45 MHz
rms= 100 mJy/beam



NGC6251: 58 MHz
rms=100 mJy/beam



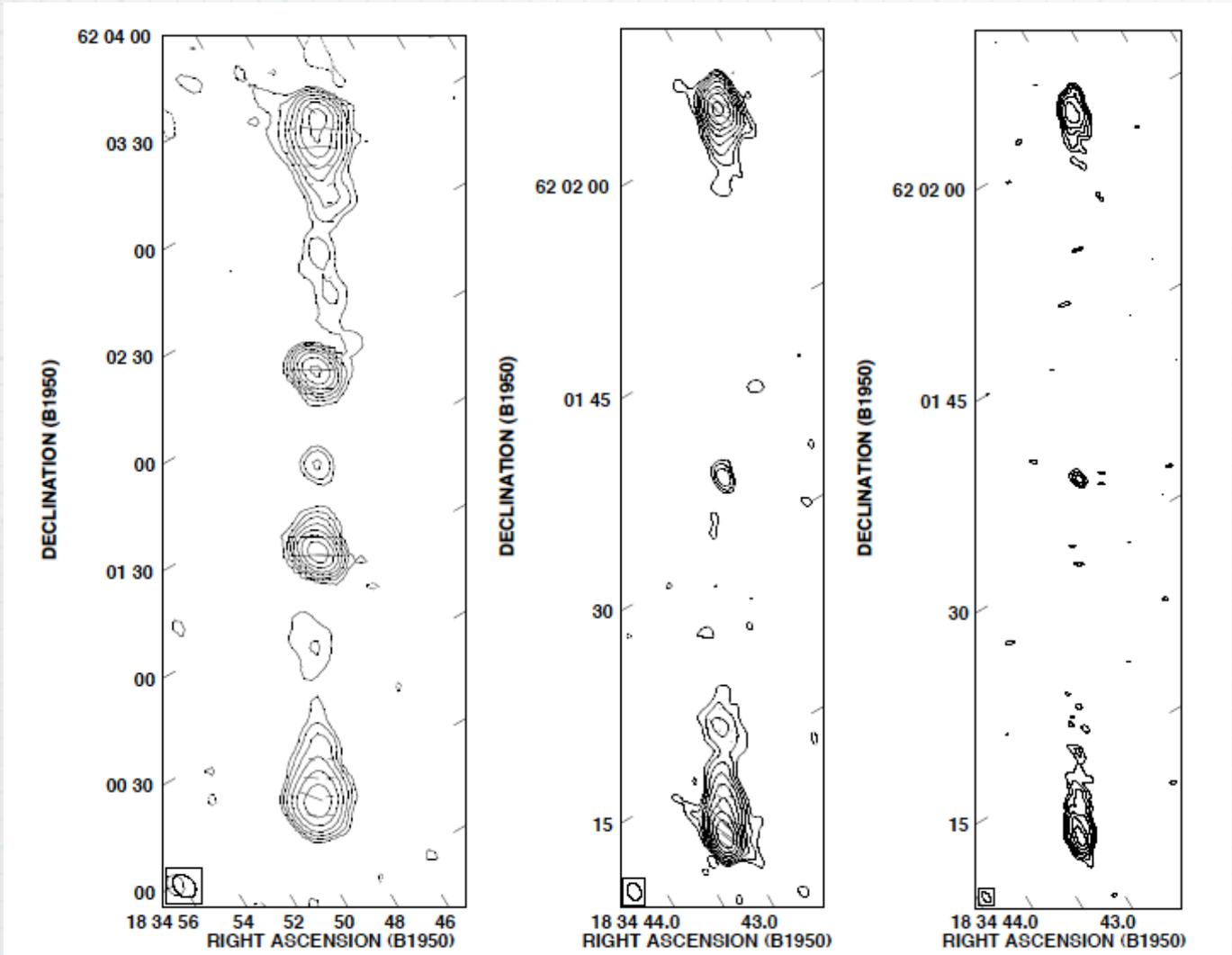
3C223: 58 MHz
rms=90 mJy/beam

LOFAR LBA

see Poster A. Shulevski

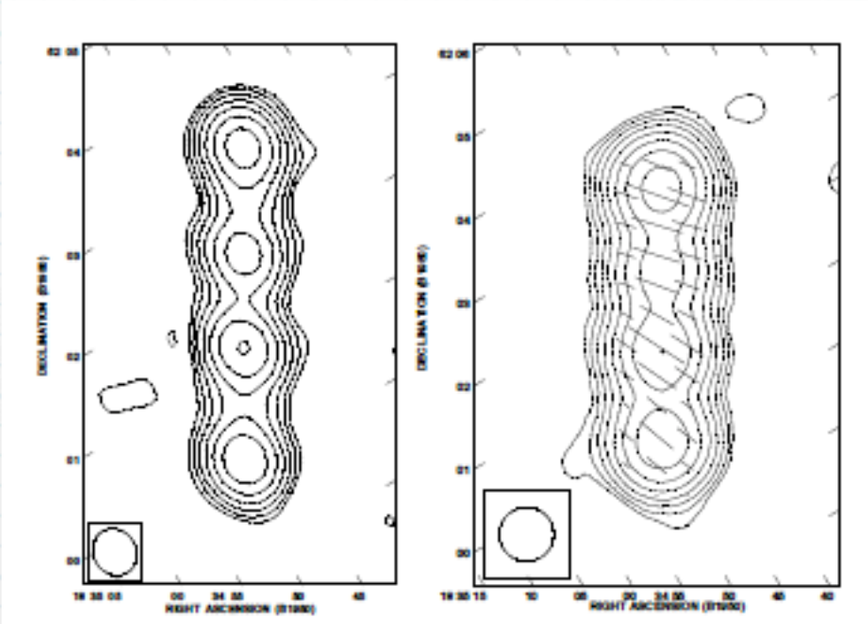
DoubleDoubleRG: B1834+620

Schoenmakers et al. 2000



VLA 8.4 GHz 1.4 GHz 5 GHz

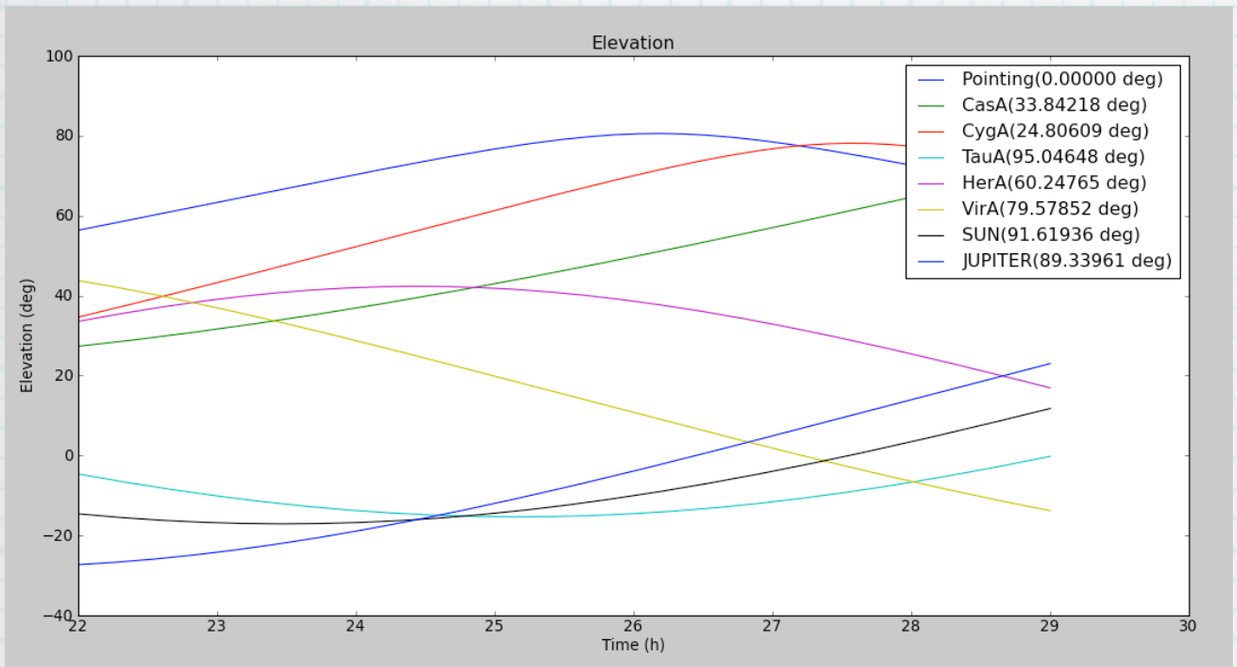
* known to be polarized at 150 MHz (Ger priv. com.)
* easy to model
* available WSRT model

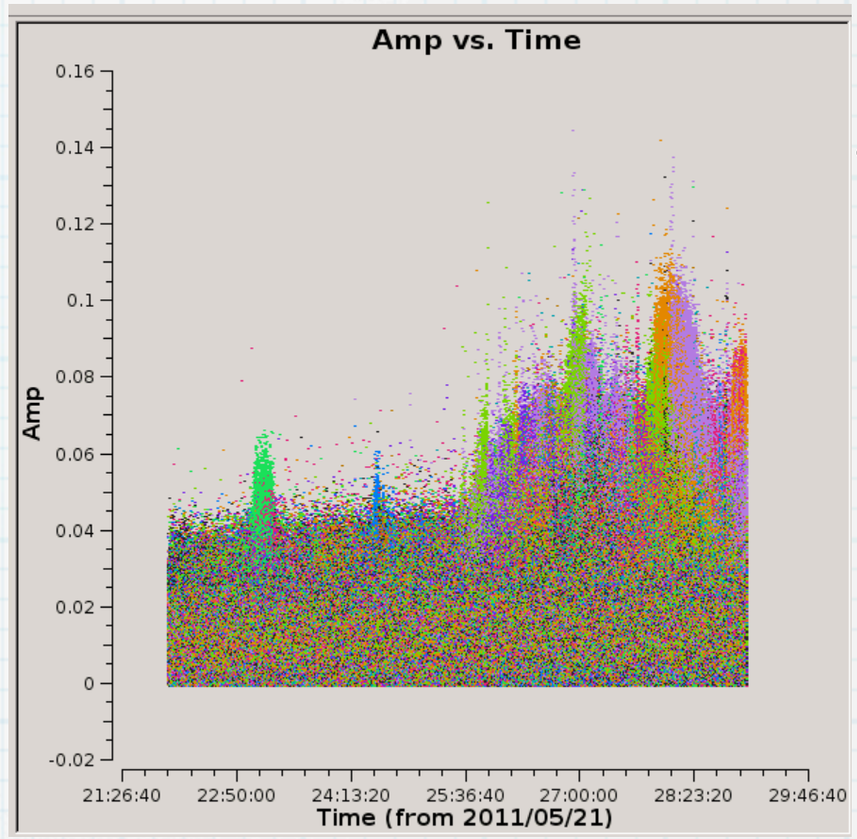


WENSS 610 MHz NVSS 1.4 GHz

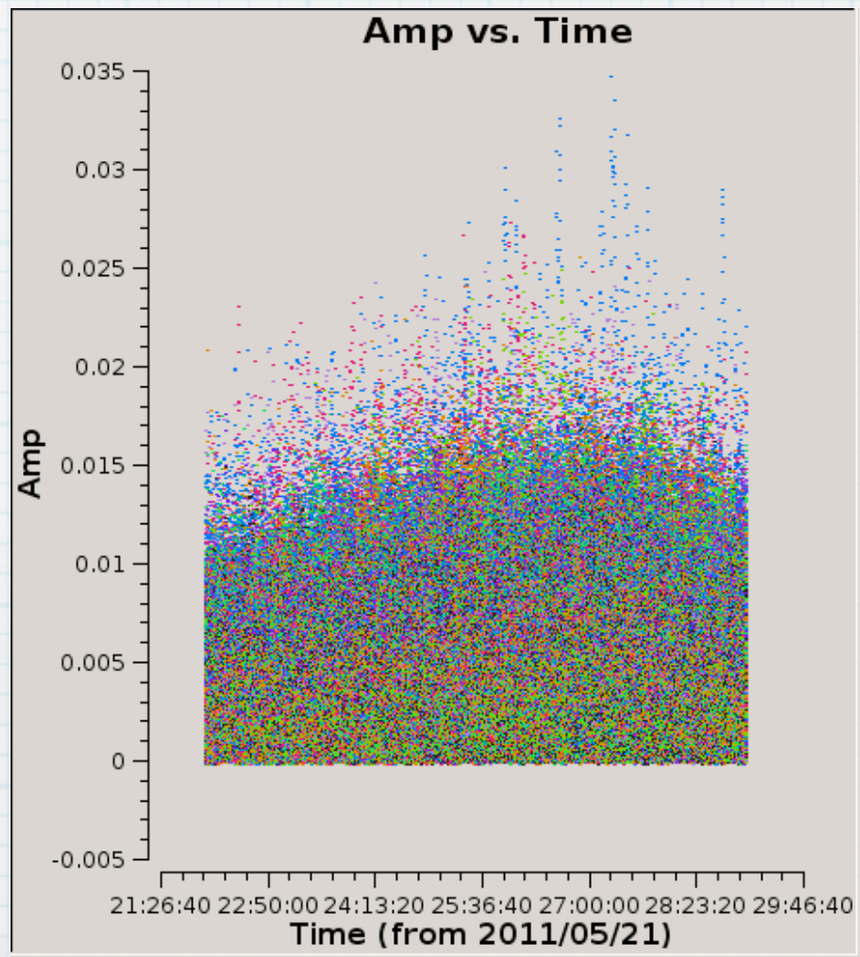
LOFAR HBA

* 21-22 May-2011: 7h
* freq. ~ 140 MHz
* 44 antennas IDE flagged + one with no data recorded



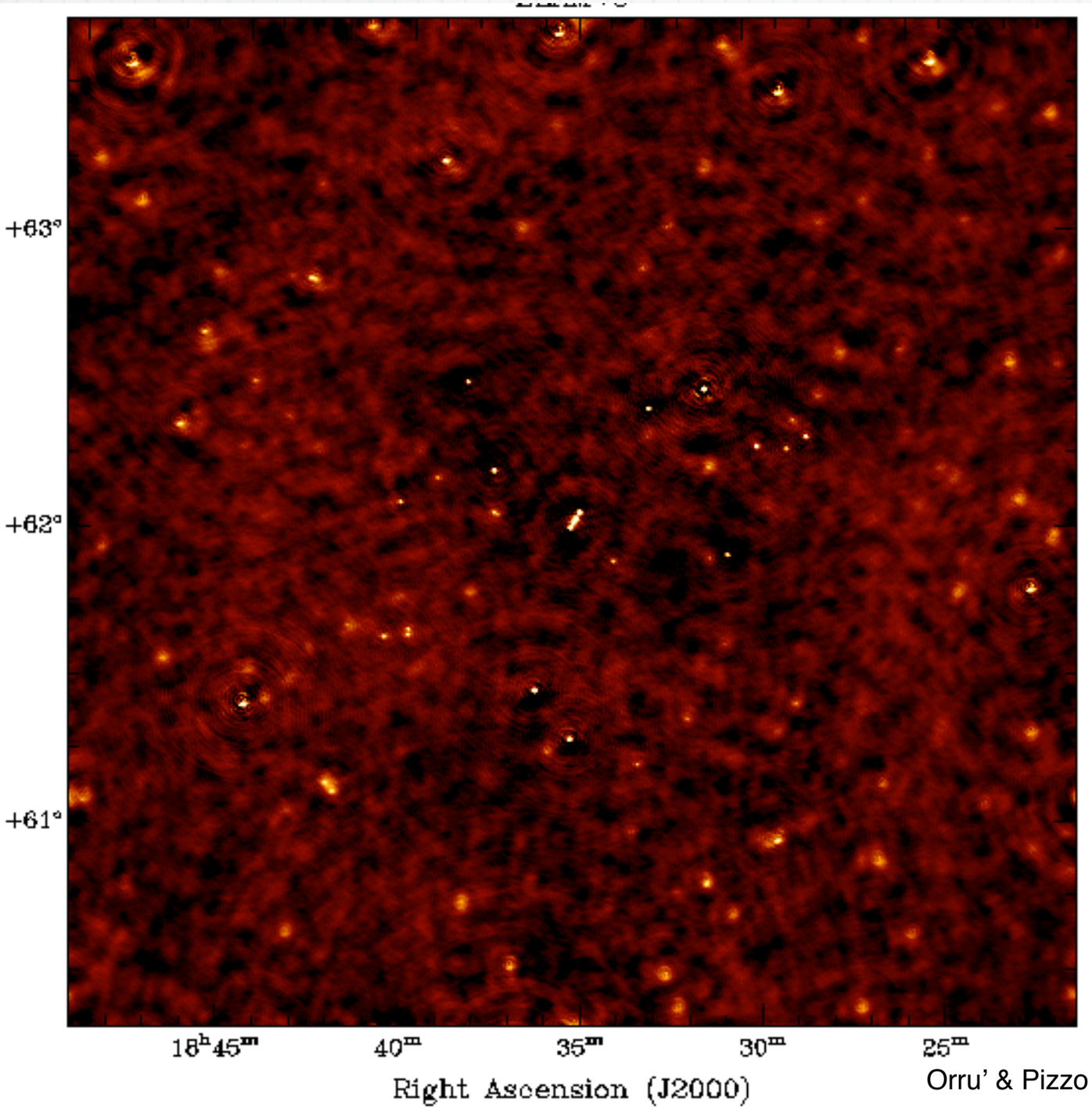


A-team?

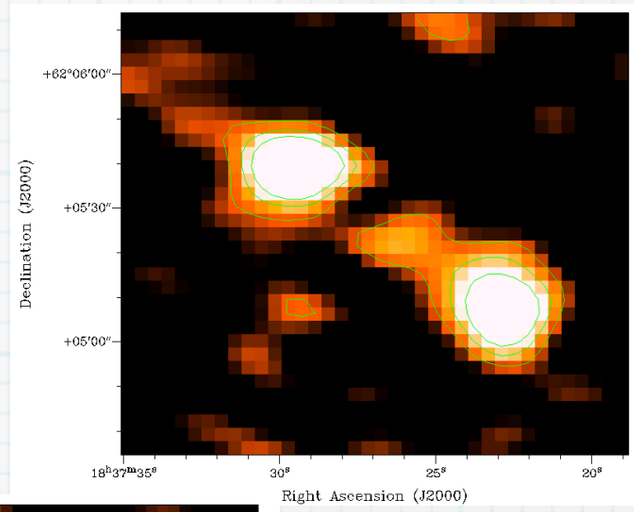


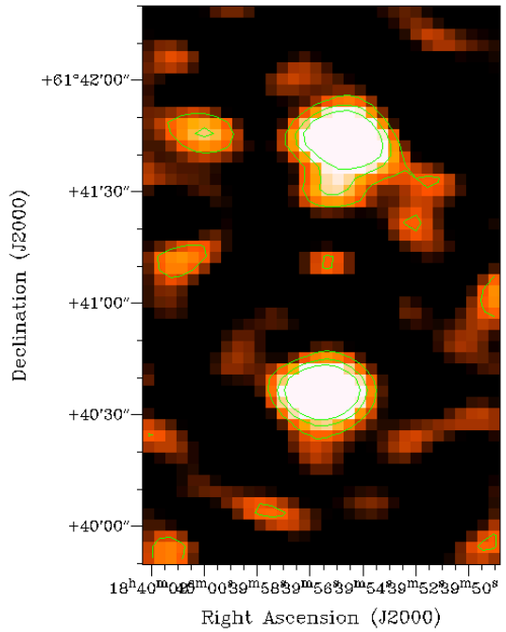
after "demix"

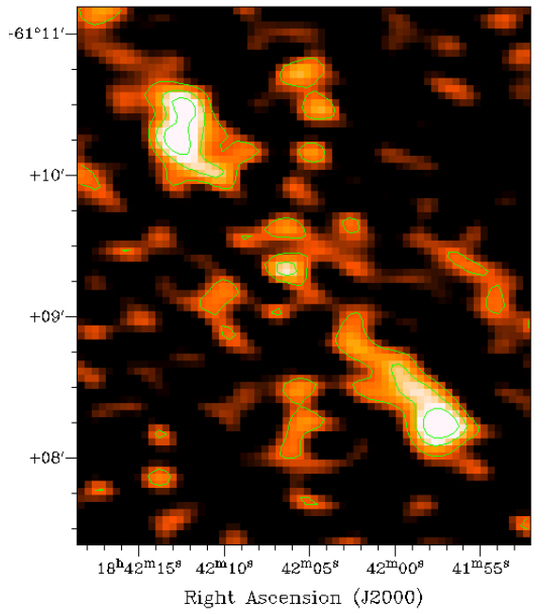
Double-double results:

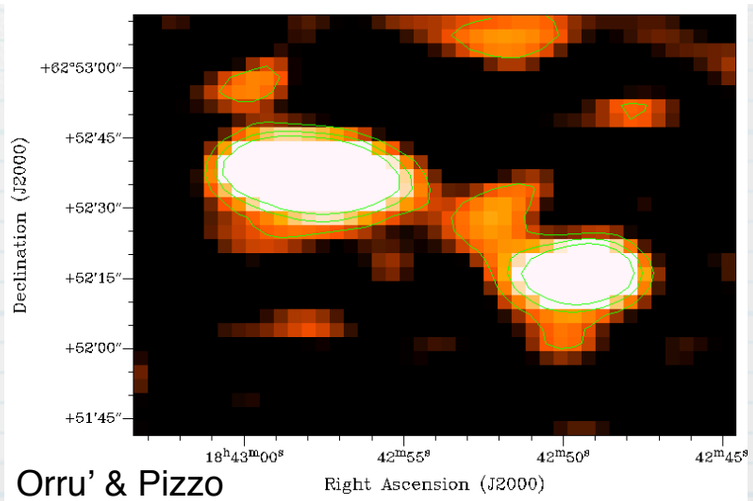


Orru' & Pizzo





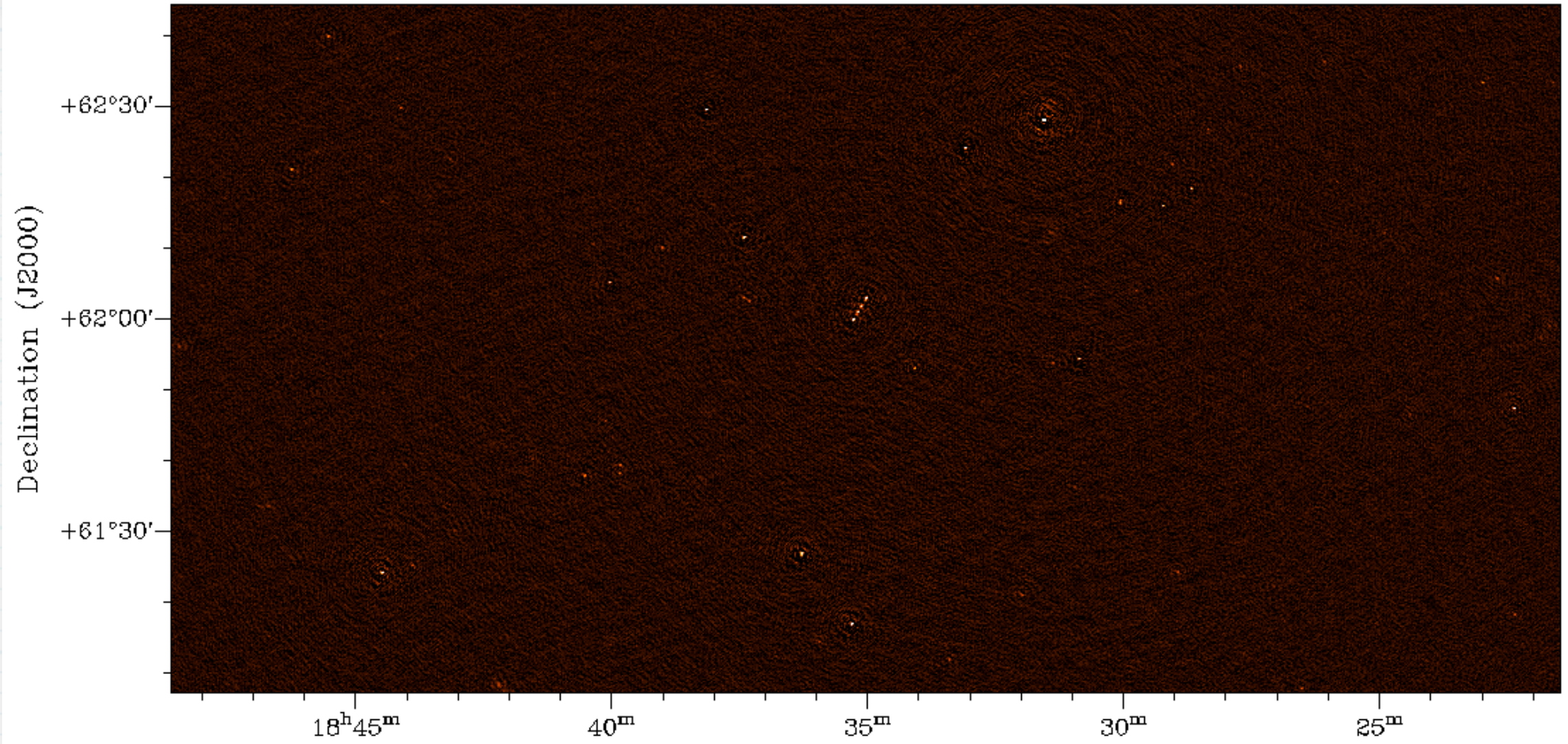




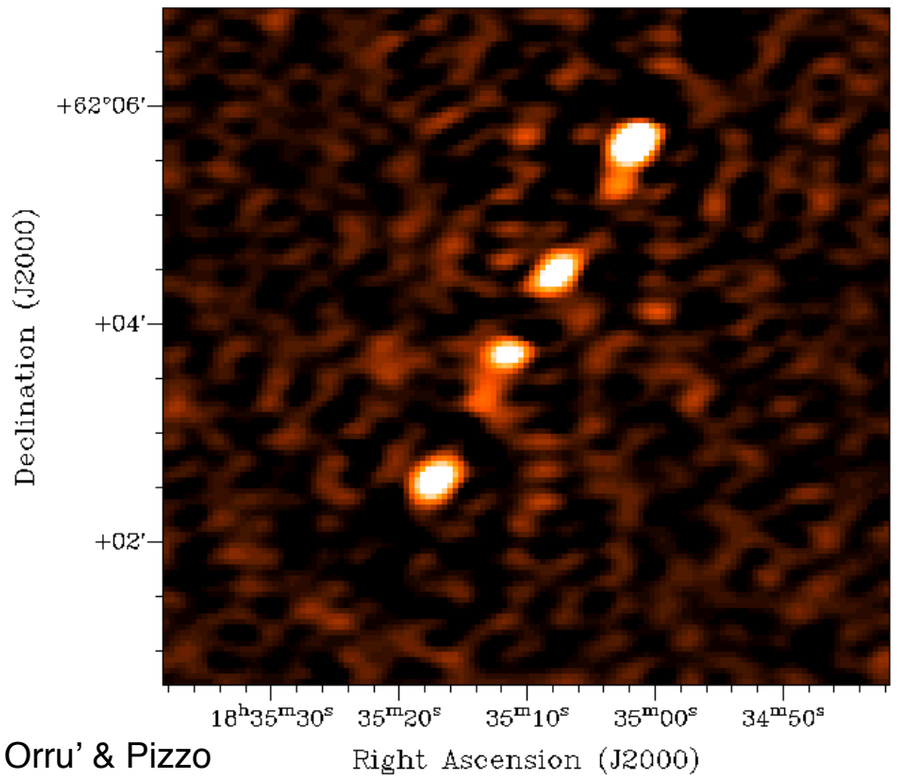
Orru' & Pizzo

5SBs ~ 1MHz
res=36"
rms=6.5 mJy/beam

FoV=4°



Orru' & Pizzo



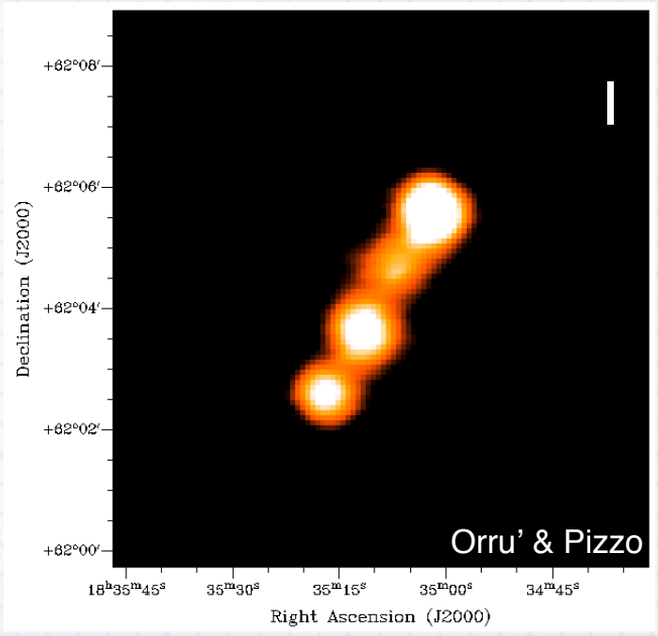
Orru' & Pizzo

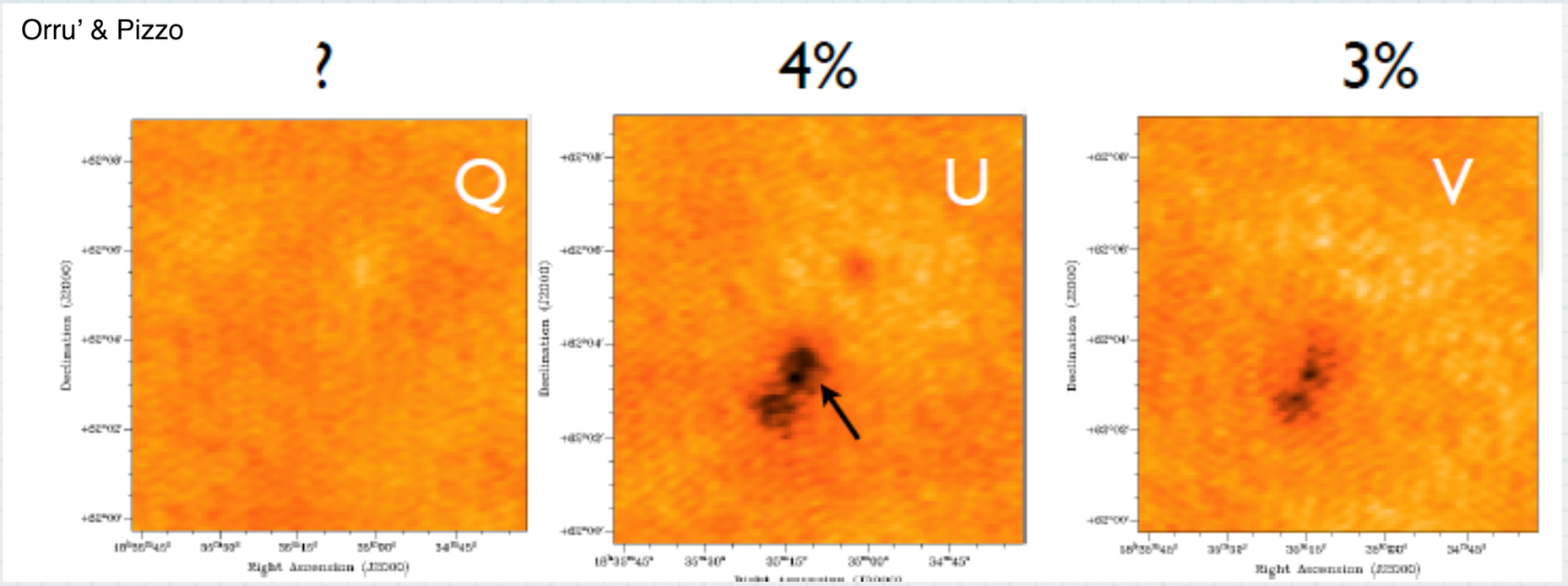
res=10"X15"
rms=7 mJy/beam

CS+RS
uniform

polarization?

* WSRT model same frequency I U Q V
* RM=+58
* polarization 5%
* 4 components





Milky Way

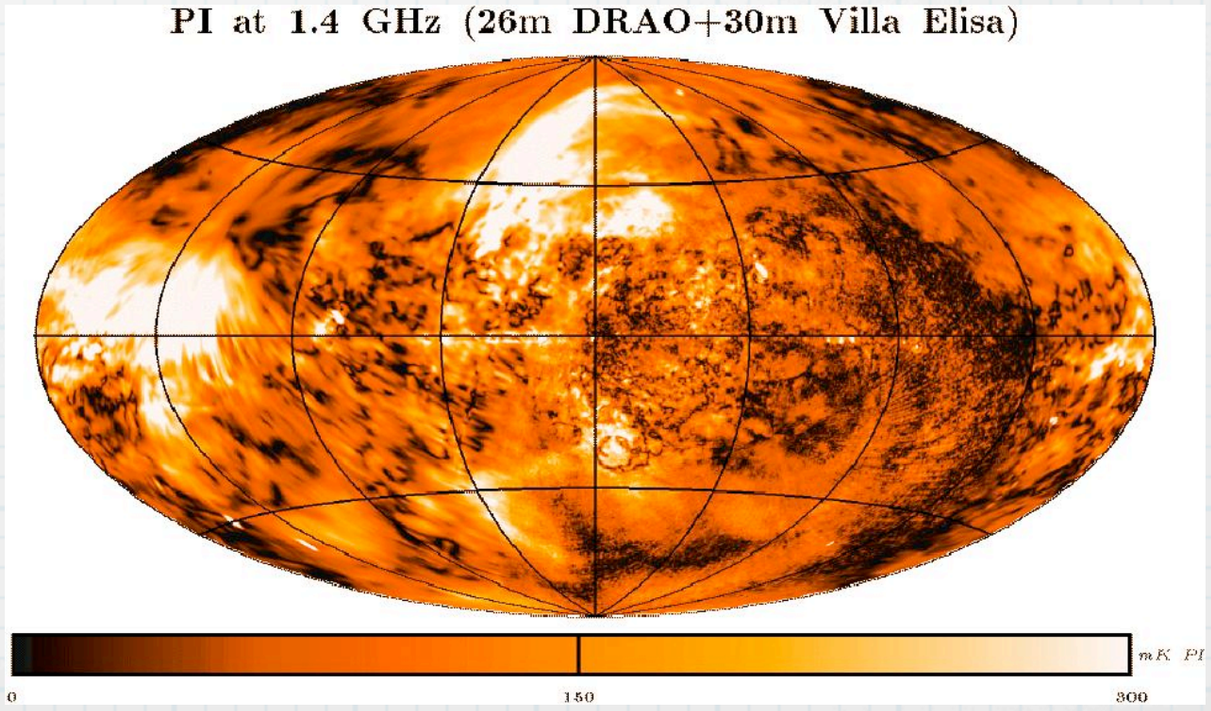
* the group: M. Haverkorn (chair), E. Orrú, M. Iacobelli, R. Pizzo

* the goal: 3D model of the gas and magnetic fields in the MW and characterize the low frequency galactic foregrounds affect extragalactic observations

* challenge: structures do not have Stokes I counterpart. Difficult to model.

* commissioning: FAN region

Members: Gianni Bernardi, Ger de Bruyn, Michiel Brentjens, Ettore Carretti, Katia Ferrière, Andrew Fletcher, Marco Iacobelli, Roberto Pizzo, Wolfgang Reich, Carl Shneider, Dominic Schnitzeler , E. Orrú



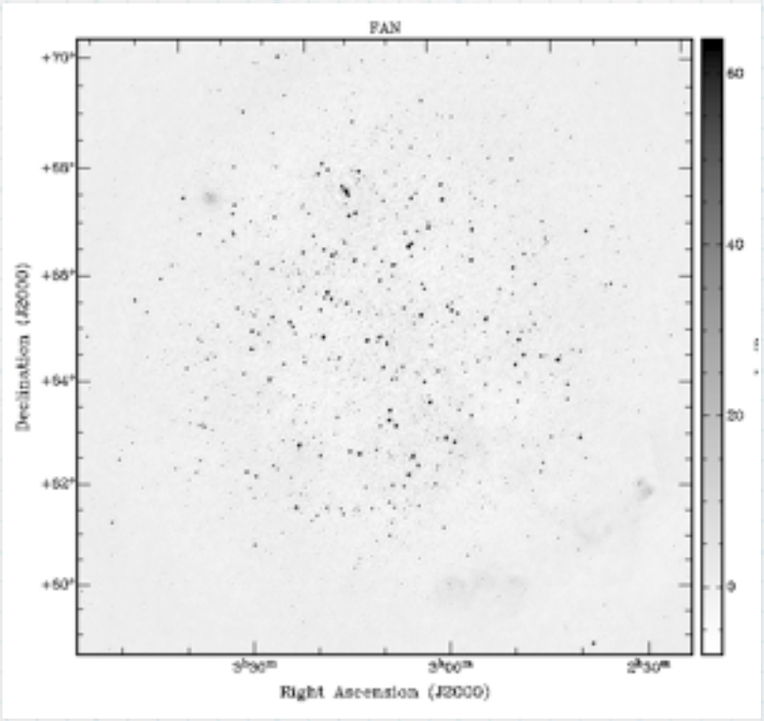
Fan Region

* Strongly polarized, then easier to detect without modeling
* available WSRT model

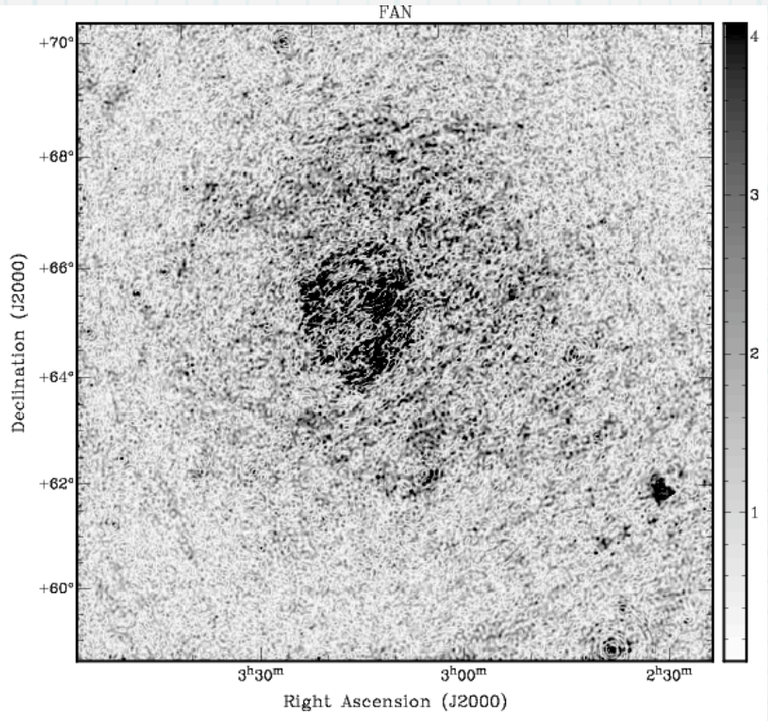
WSRT Observations of the Fan Region at 150 MHz (Bernardi et al 2009)

Iacobelli et al in prep. for the scientific interpretation

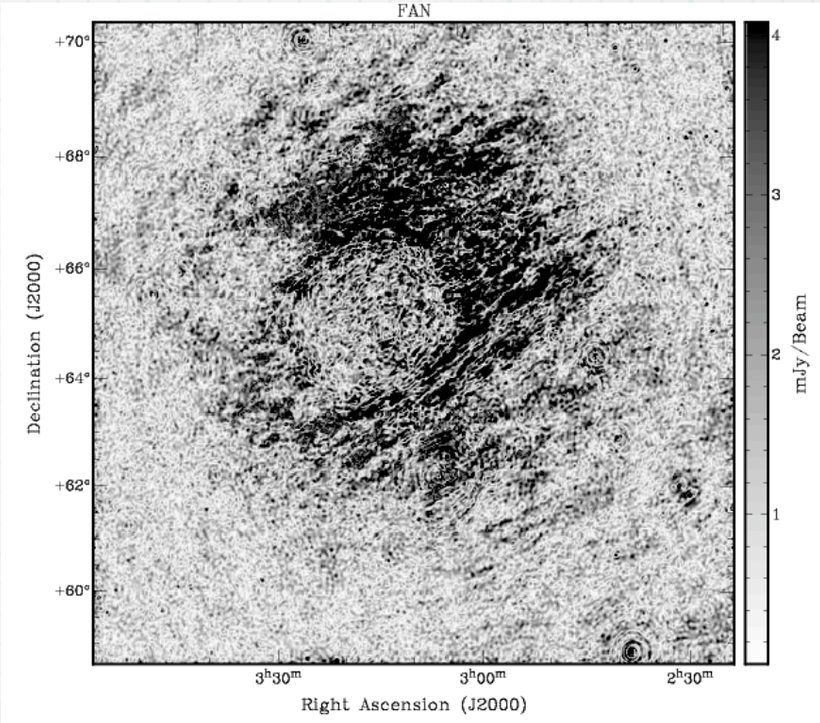
Stokes I



Polarized intensity
Fdepth = -6 rad m^{-2}

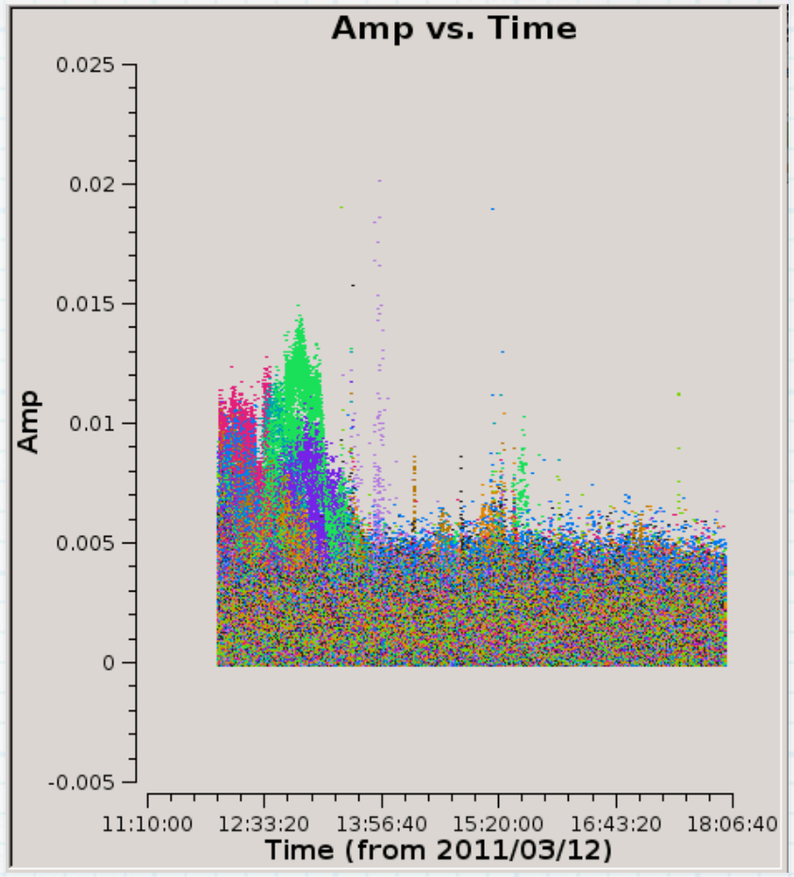


Polarized intensity
Fdepth = -2 rad m^{-2}

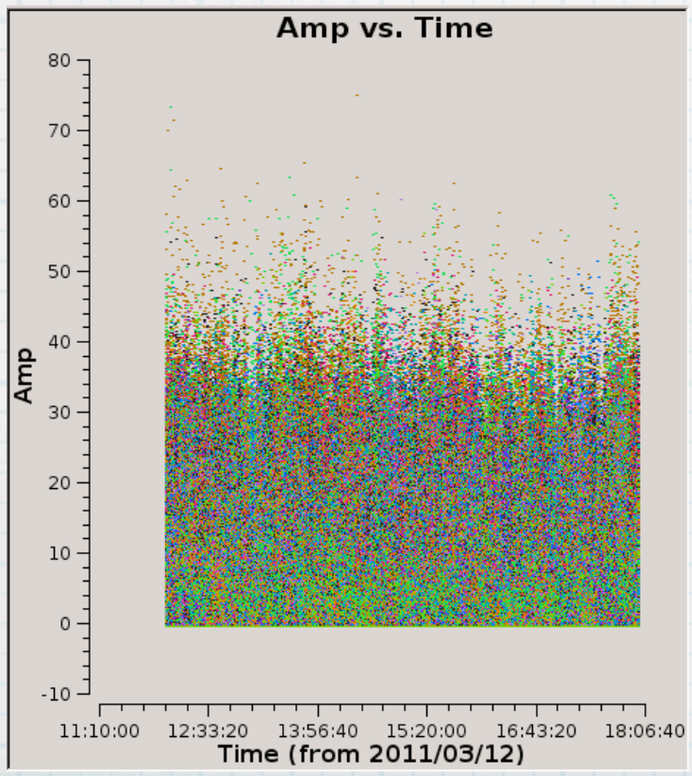


LOFAR HBA

* 12 March-2011: 6h
* 234 SB $\Delta\nu \approx 40$ MHz
* 44 antennas 2 flagged
* 2 calibration approaches

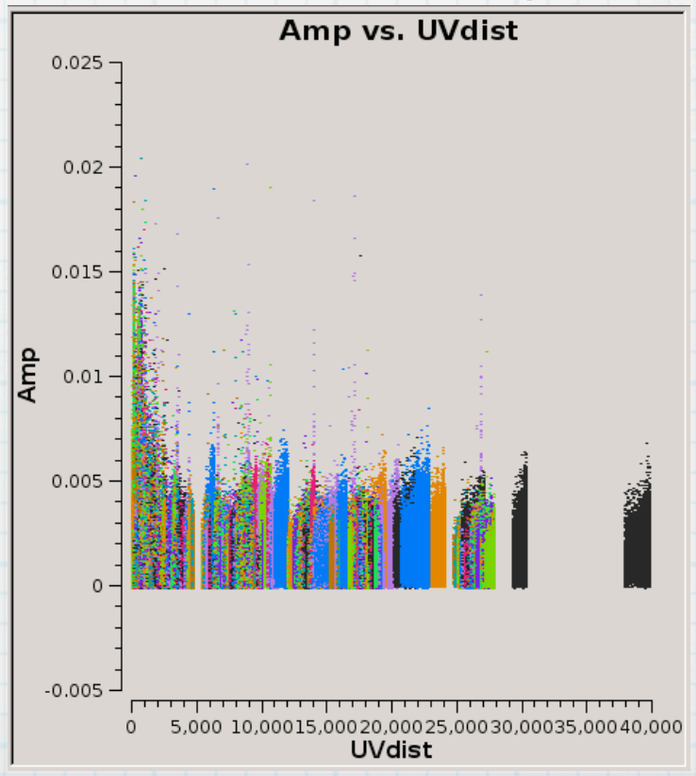


FAN-CasA
(but no beam!)

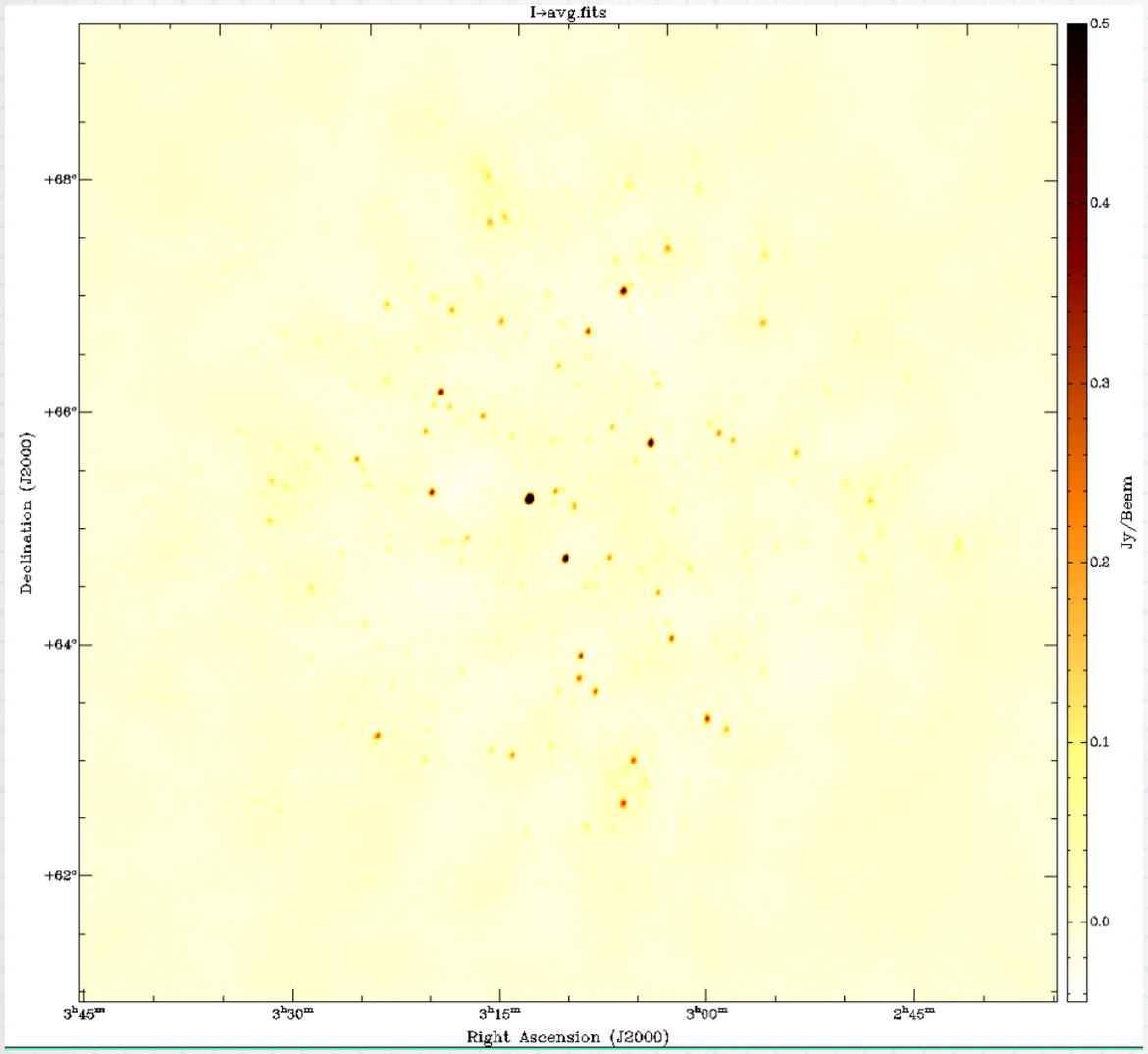


CS only

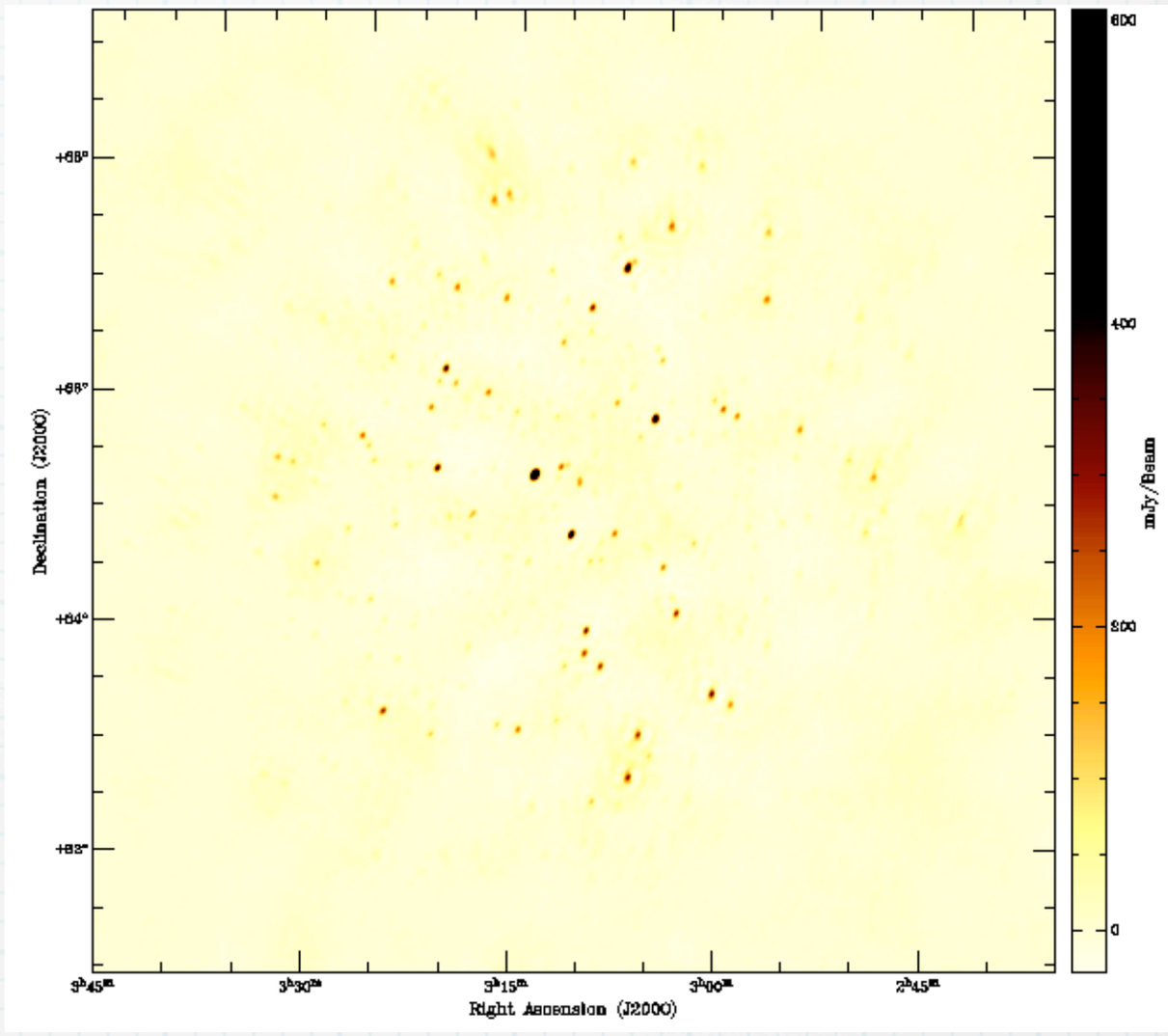
FAN-uv cut-time cut
(beam and leakage)



FAN-CasA



FAN-uv cut-time cut

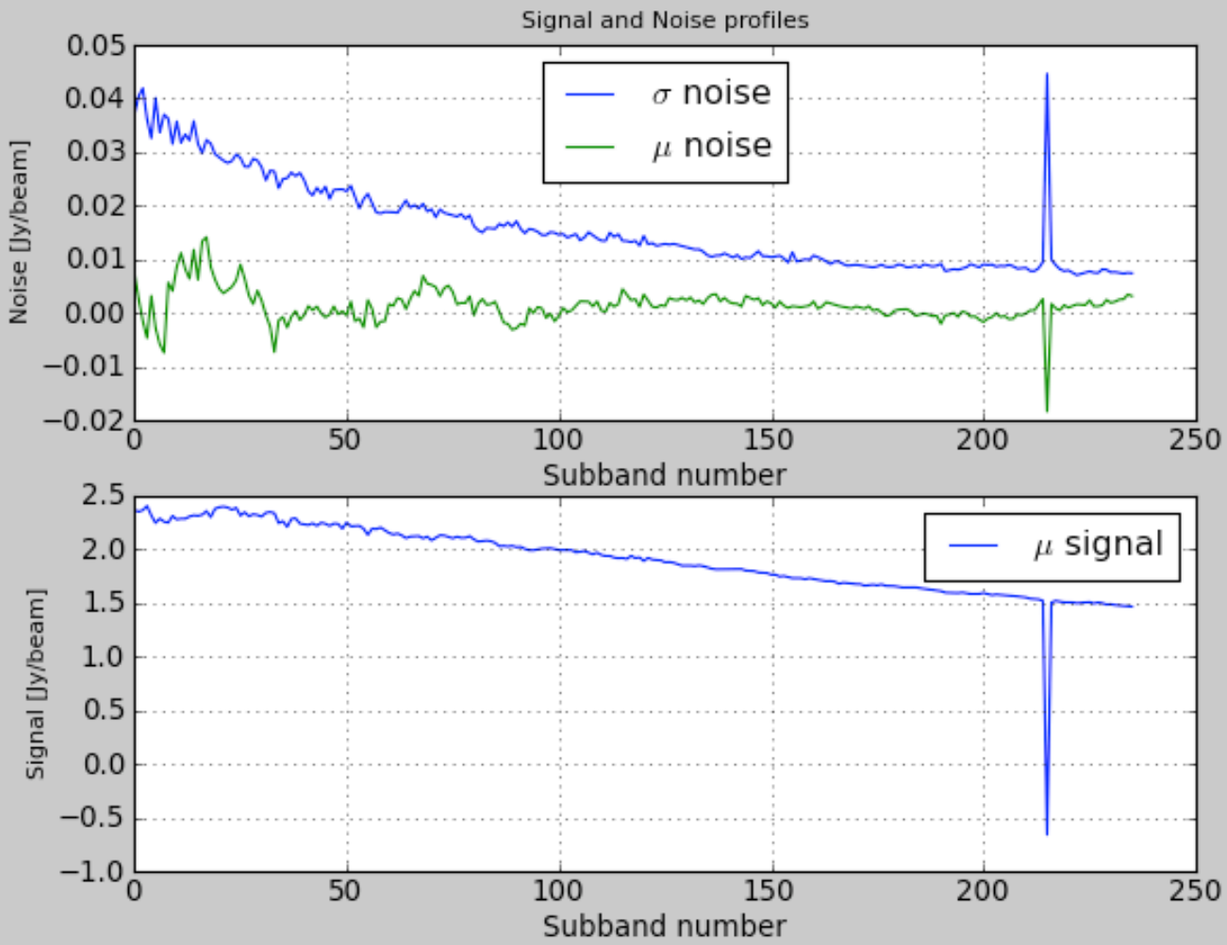


- 238 SB
- rms= 1.7 mJy/beam
- res= 74″×53″

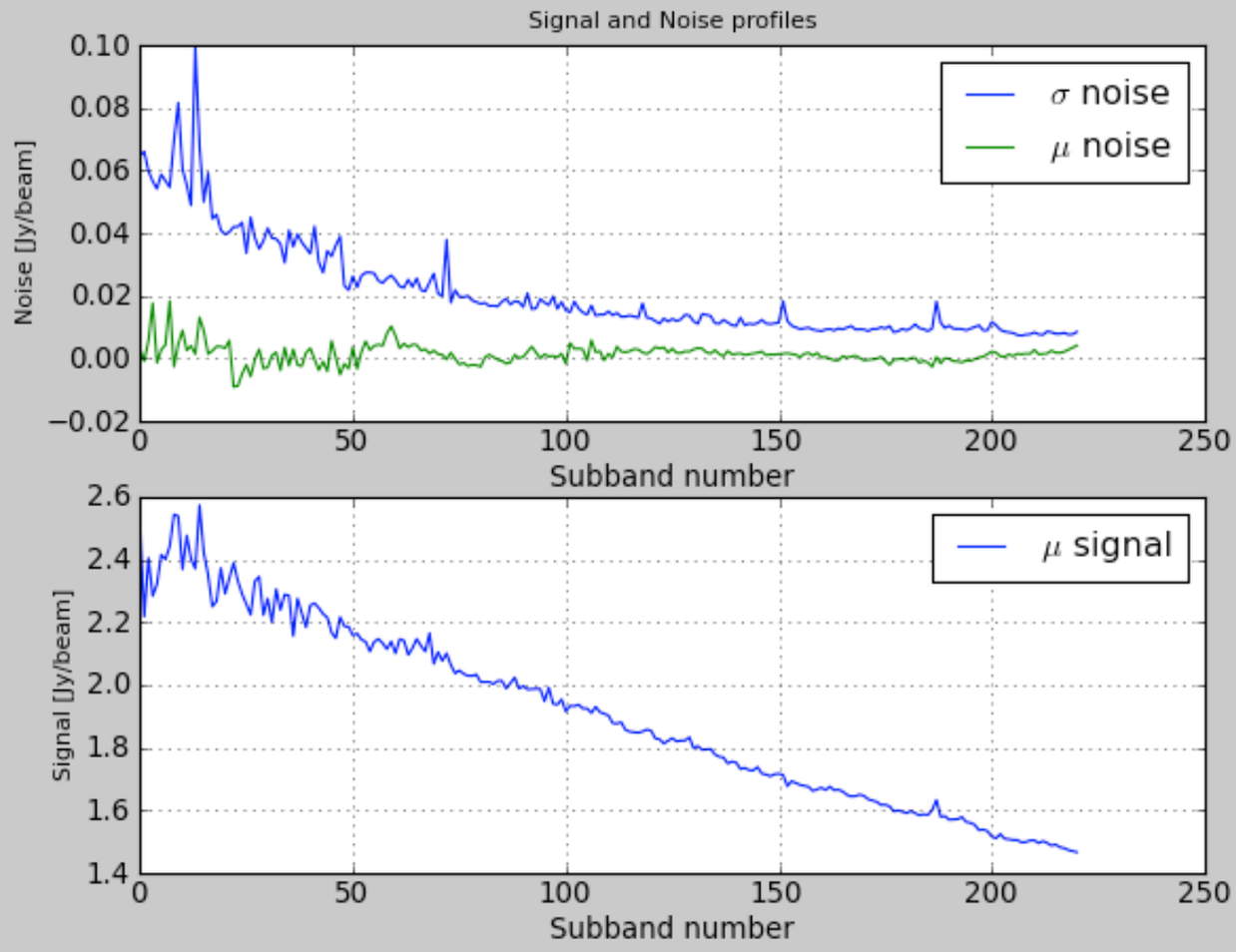
- 234 SB
- rms=1.8 mJy/beam
- res=74″×53″

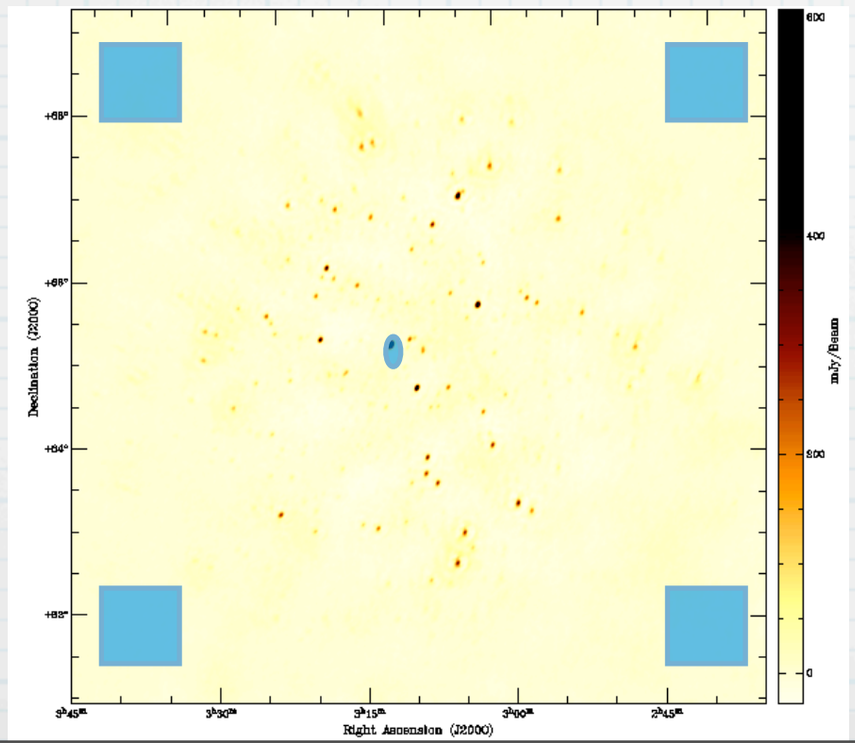
$\sigma \sim 20 \times \sigma_{therm}$

FAN-CasA



FAN-uv cut-time cut





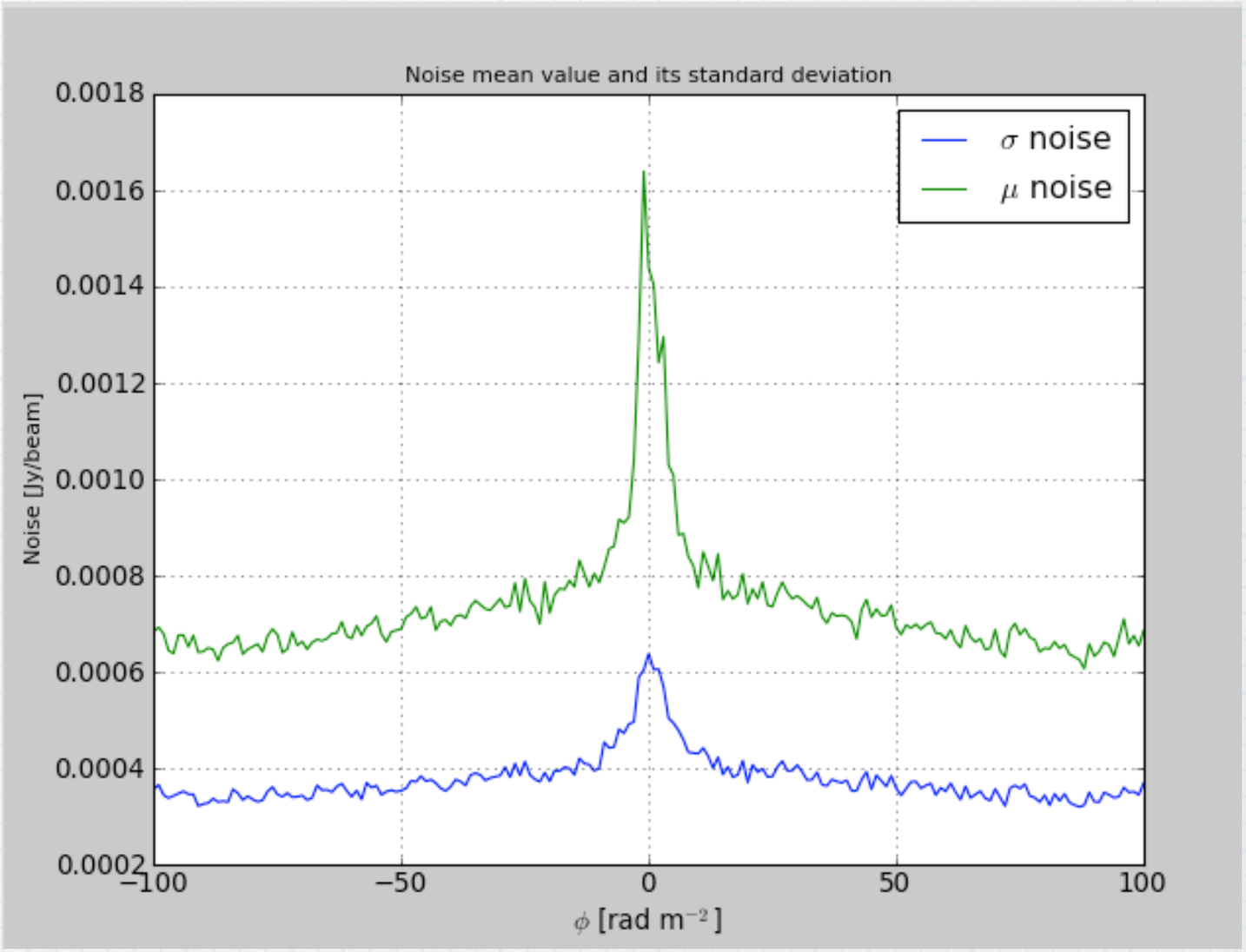
S/N ~ 1000

2 S/N FAN-CasA wrt FAN-uv cut-time cut

we used FAN-uv cut-time cut

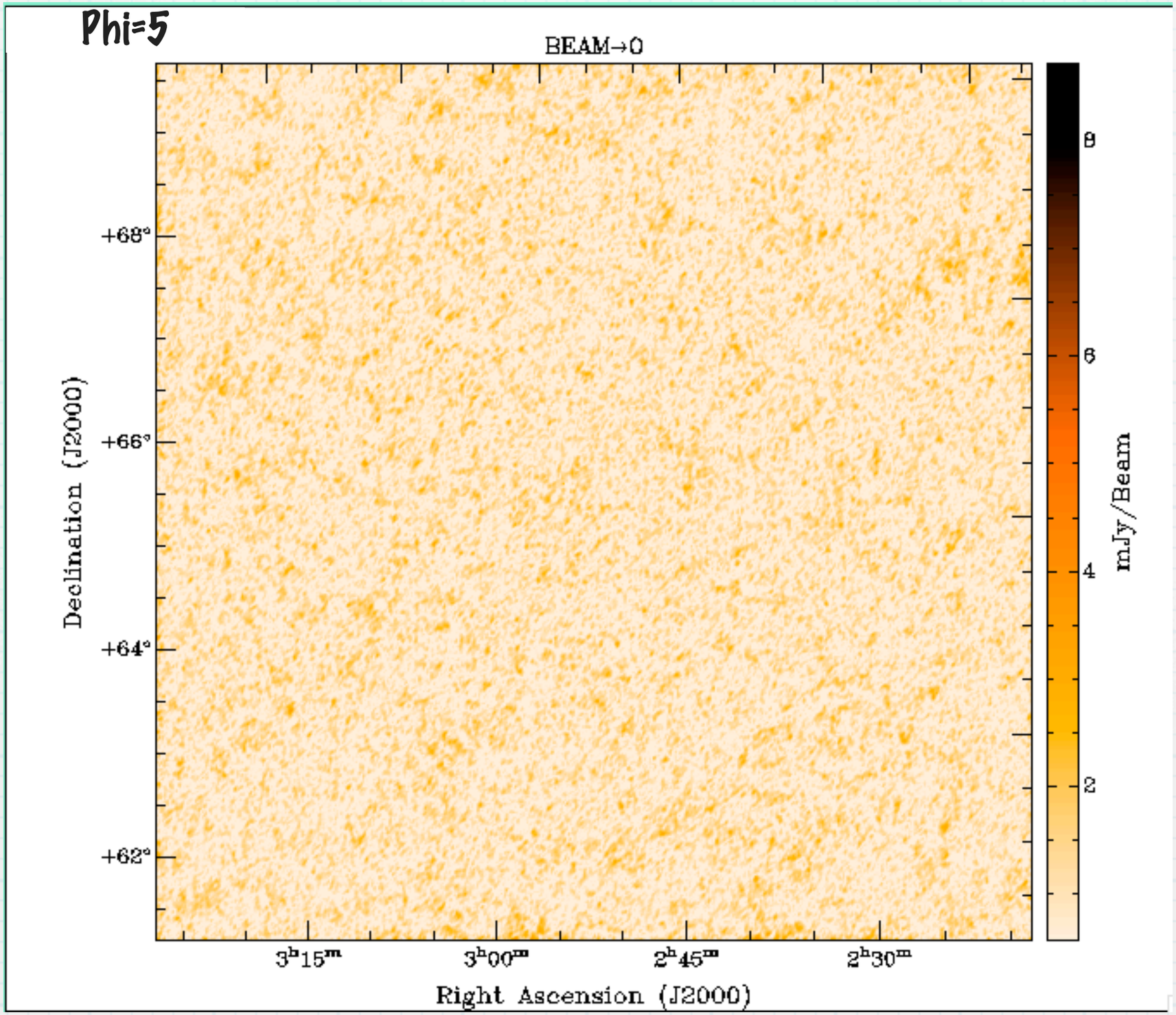
Rotation Measure Synthesis*

* SB 234
* phi = -100 - 100
* average instrumental polarization 4%
  * center ≈ 1%,
  * 1^0 ≈ 4.3%
  * 2^0 ≈ 3.7%

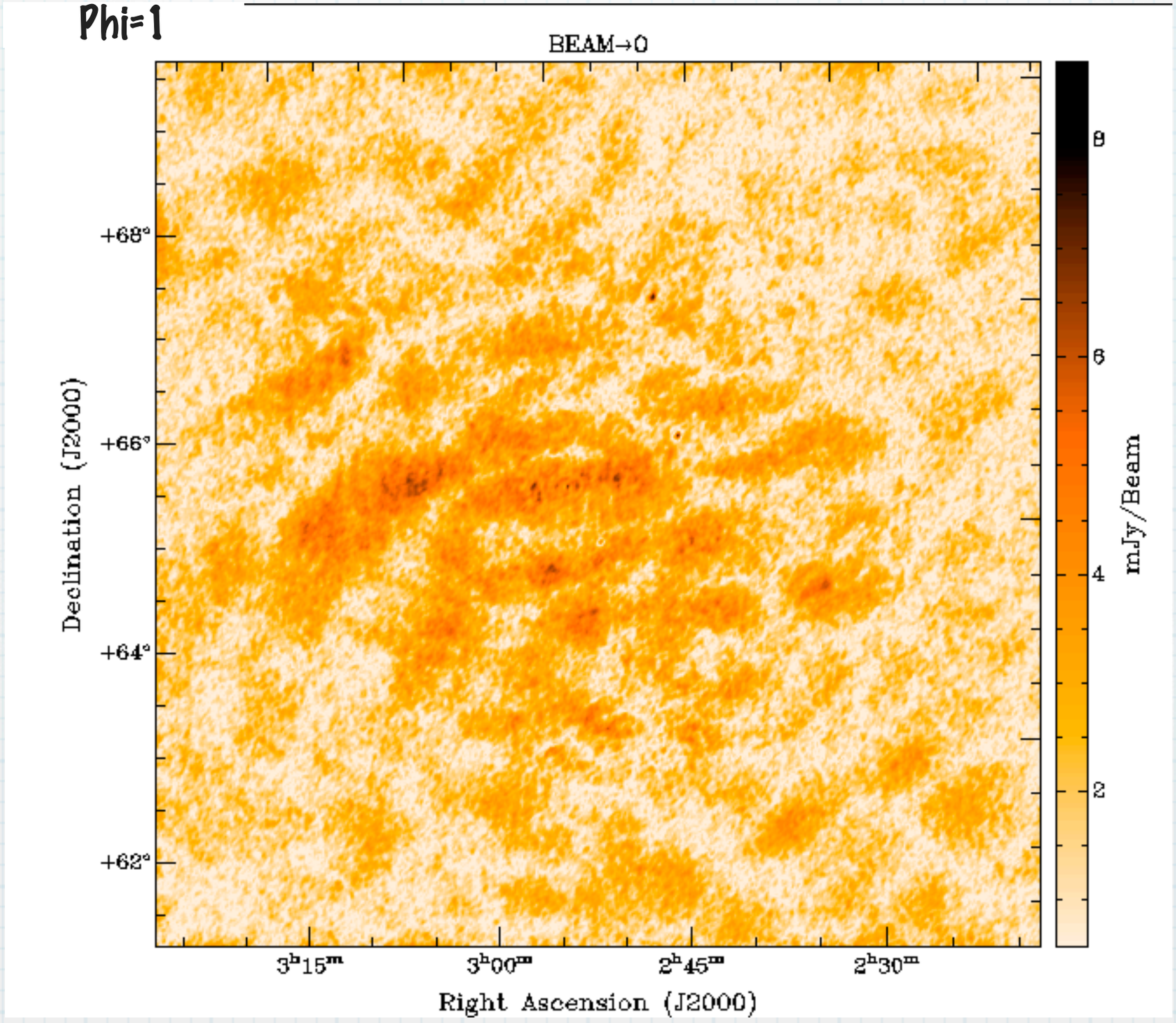


* Special thanks to M. Bell

Phi=5


BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

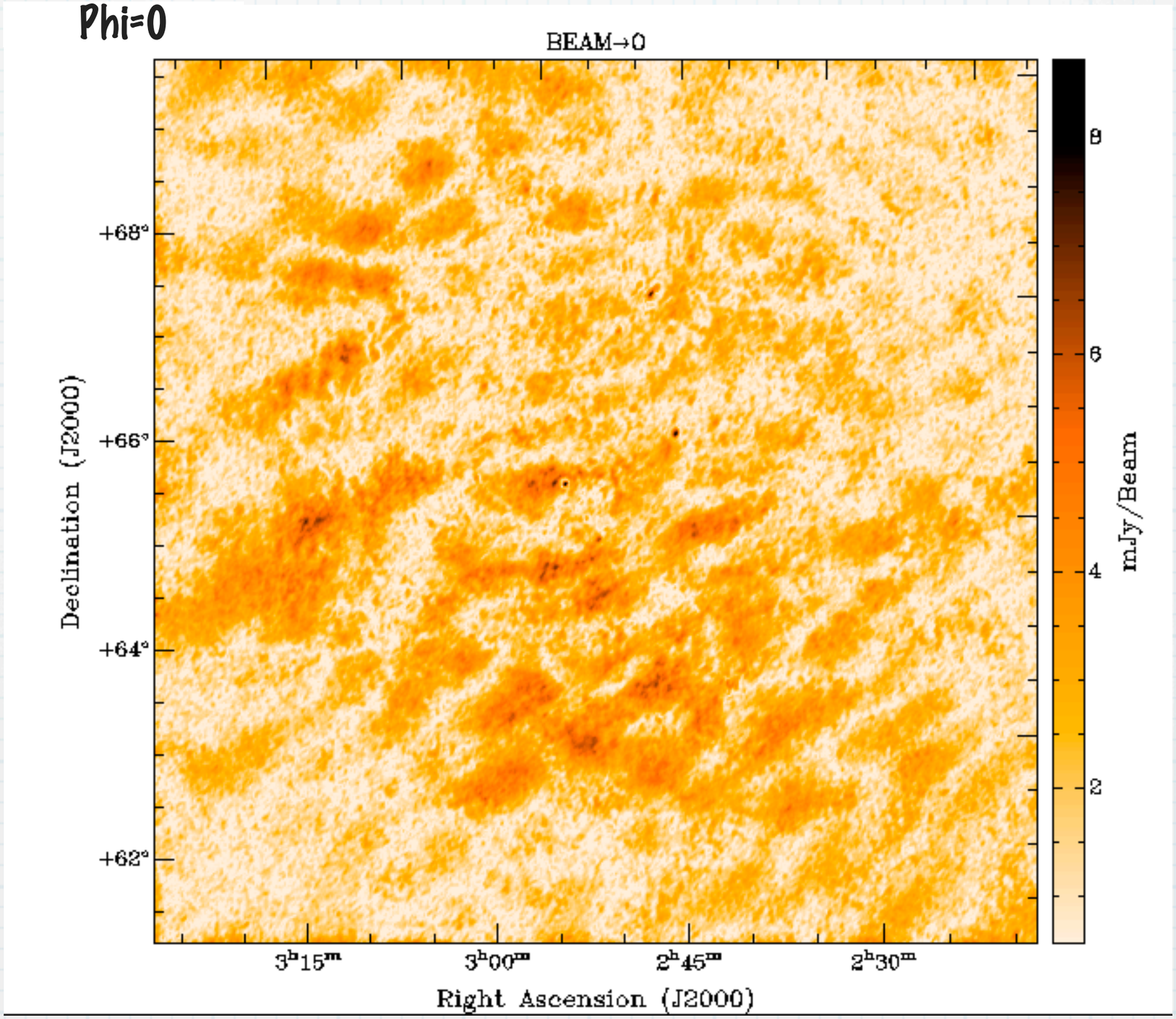
Phi=1


BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

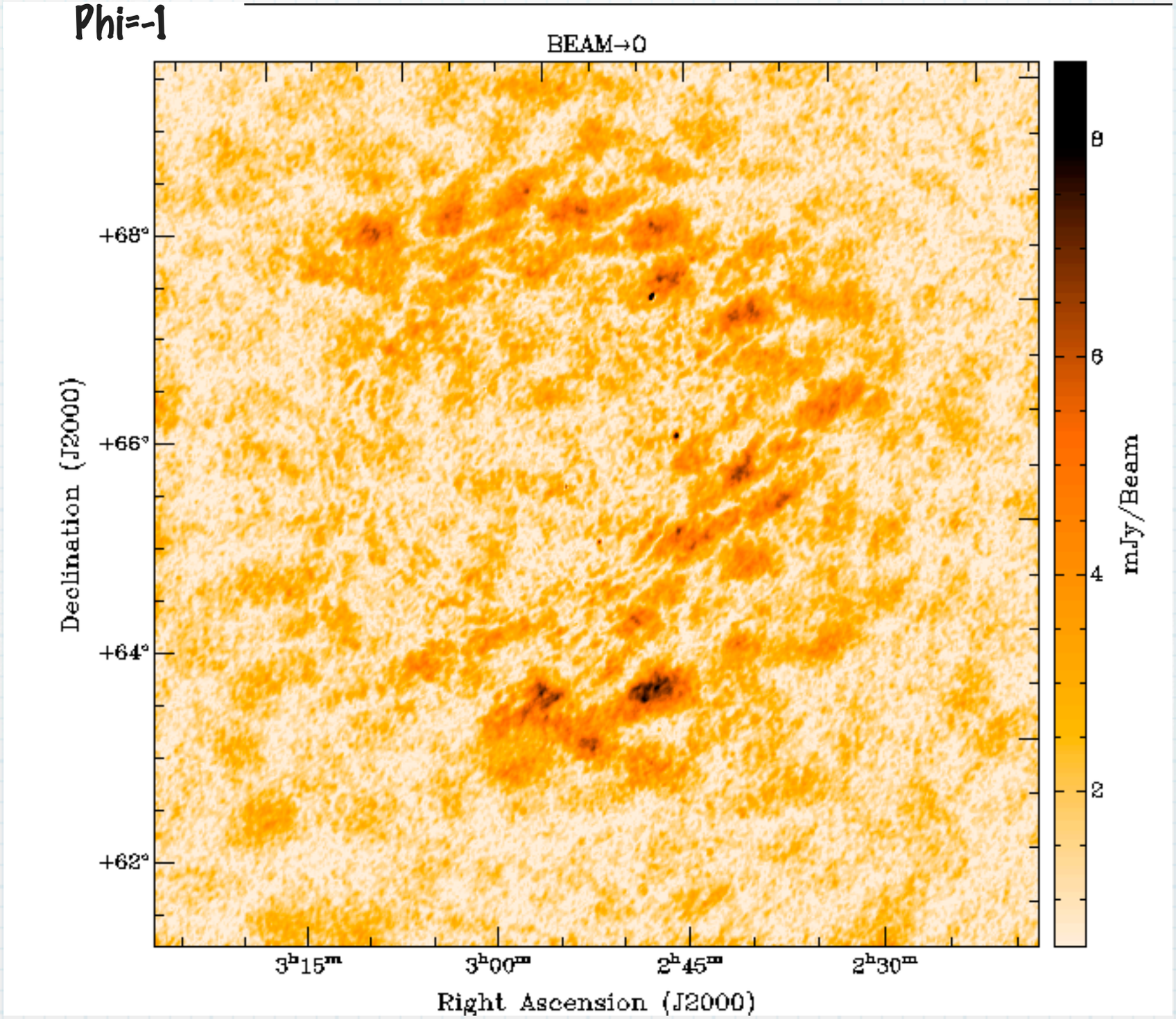
screen

screen

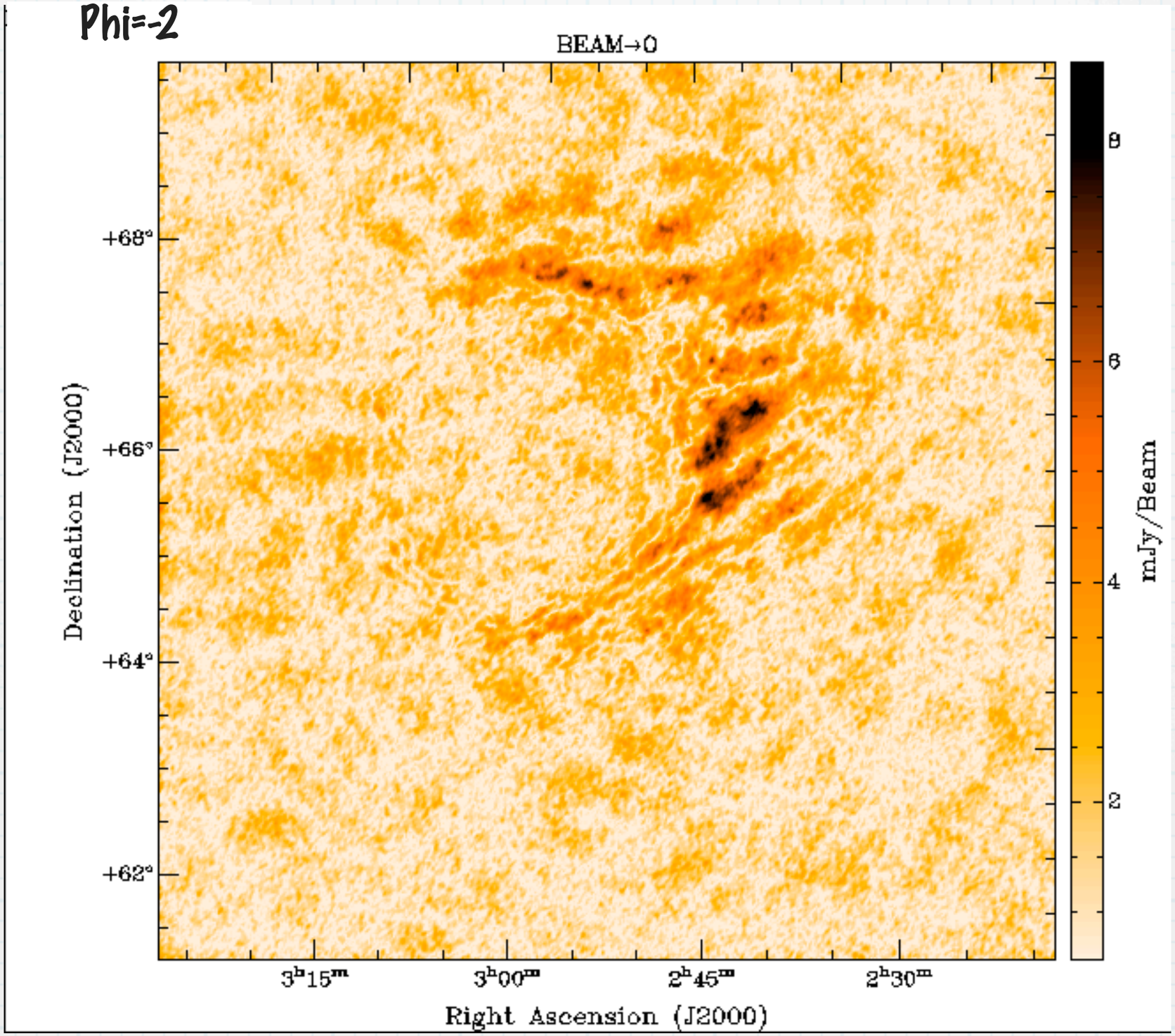
Phi=0


BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

ring

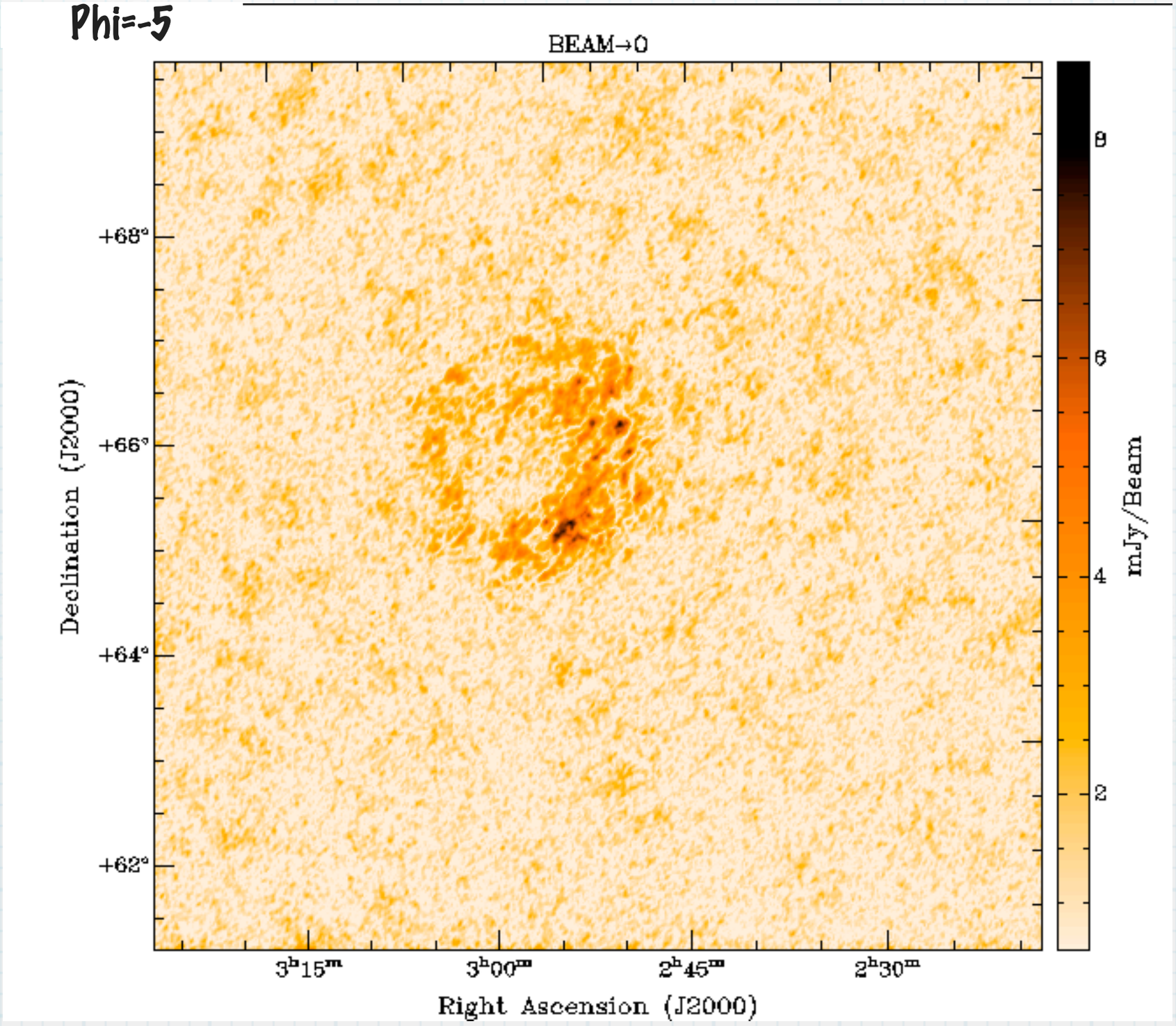

Phi=-1
BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

ring

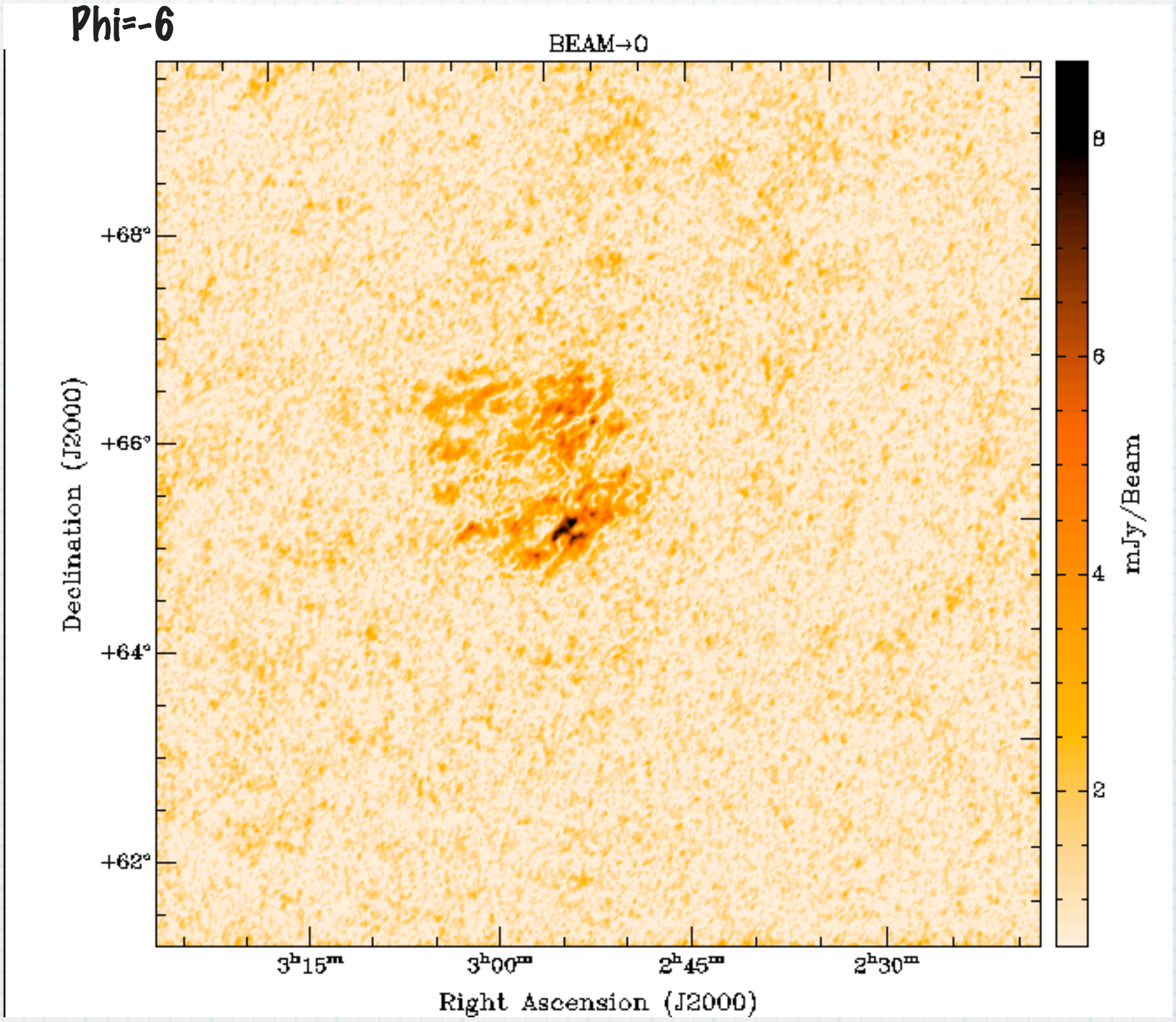

Phi=-2
BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

bubble

Phi=-5


BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

bubble


Phi=-6
BEAM→0
+68°
+66°
+64°
+62°
Declination (J2000)
3h15m
3h00m
2h45m
2h30m
Right Ascension (J2000)
8
6
4
2
mJy/Beam

Conclusion

* preliminary results of commissioning working groups: giant radio galaxies (B1834+620 DDRG) and MW (Fan region)

* FUTURE: run the full pipeline on B1834+620, run the demixing on FAN region data (new observation)..

* high sensitivity and spectral resolution allow RM-synthesis

* large polarized structures no counterpart Stokes I...is UNIQUE!