

The LOFAR-LOTTS extragalactic survey: first data release and scientific results

Cyril Tasse

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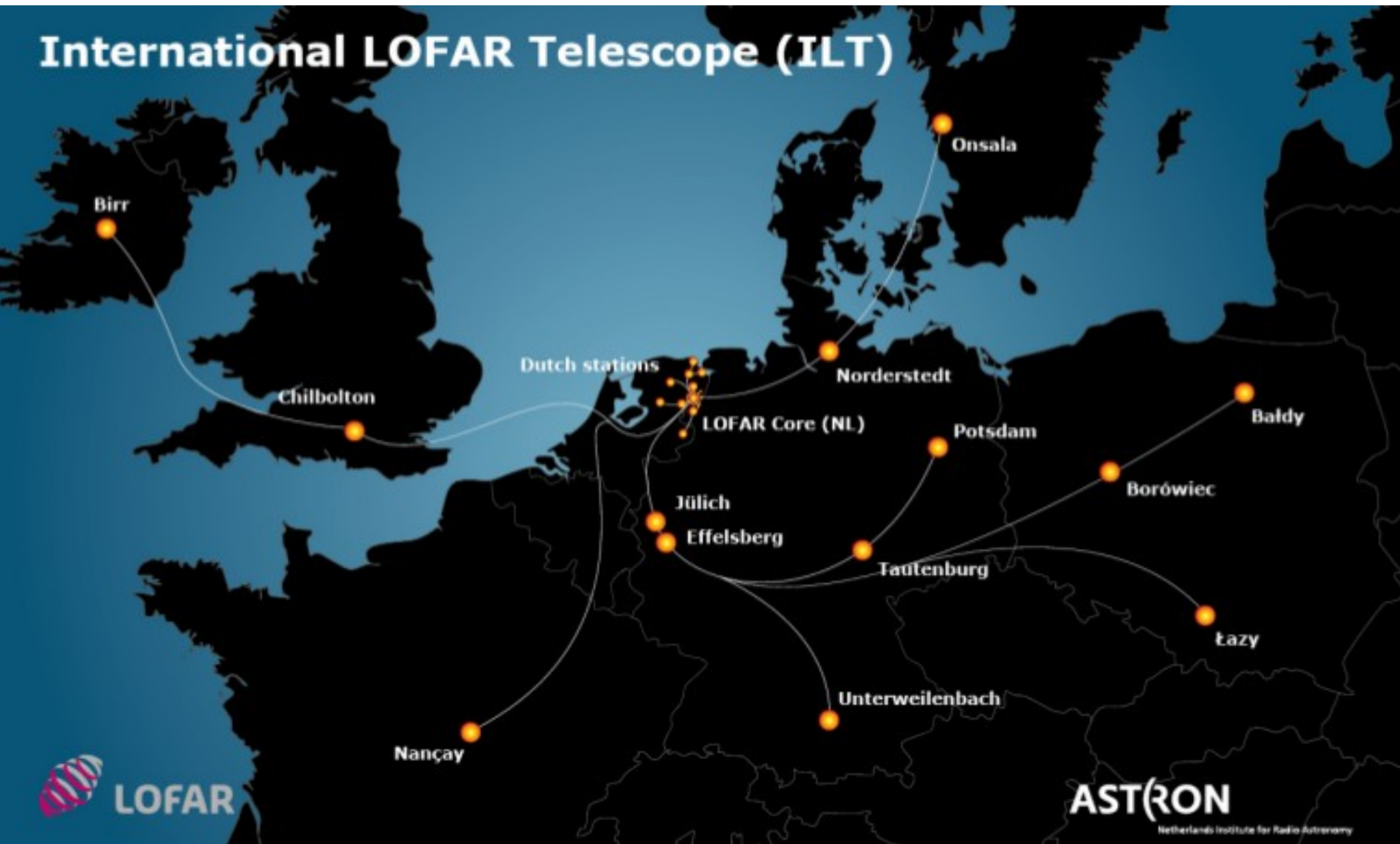
for the LOFAR Surveys KSP

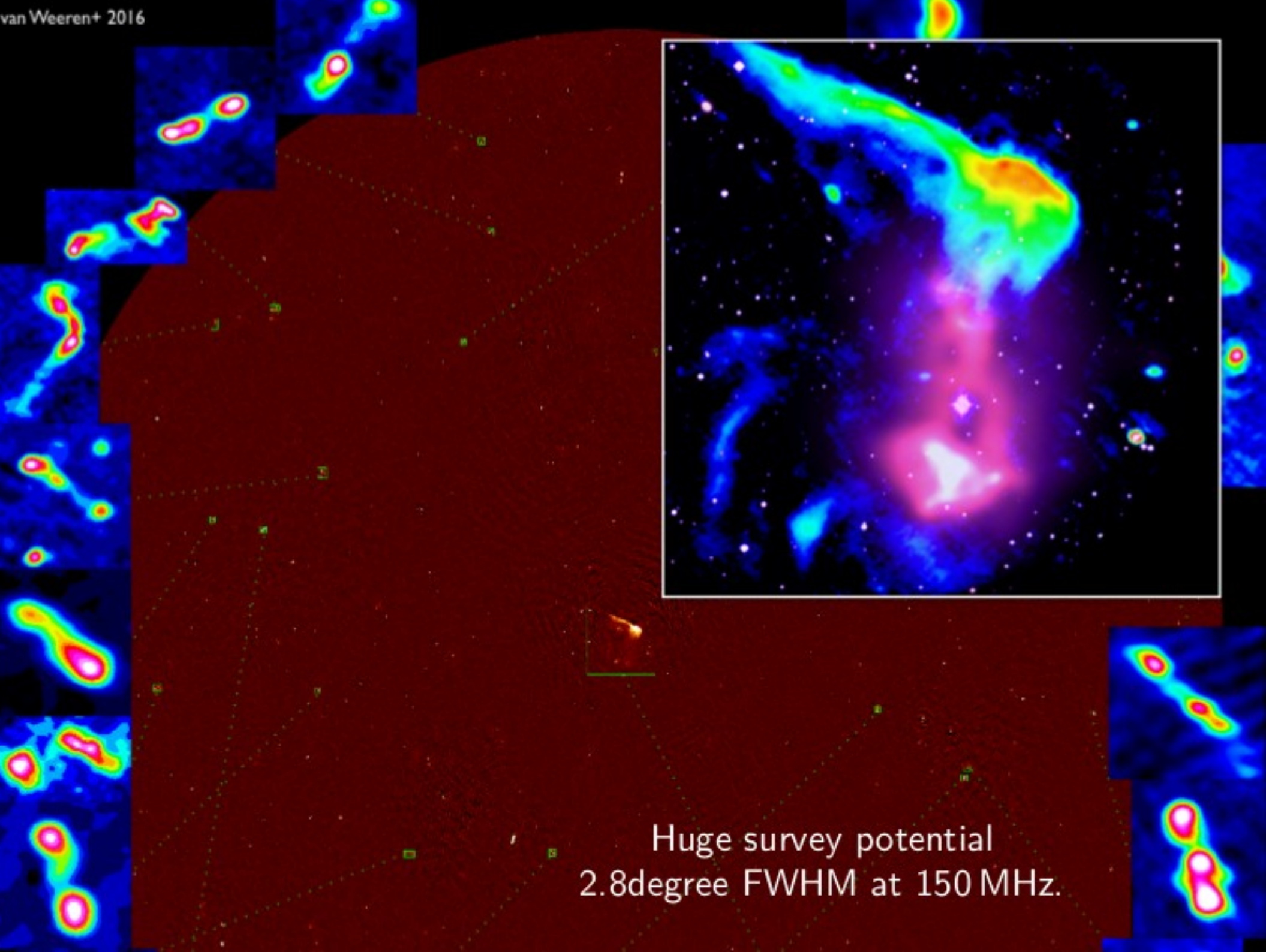
With many slides from :

Tim Shimwell, Reinout van Weeren, Federica Savini, Amanda Wilber, Shane O'Sullivan, Leah Morabito, Vijay Mahatma

LOFAR

International LOFAR Telescope (ILT)





Huge survey potential
2.8degree FWHM at 150 MHz.

The LOFAR extragalactic surveys

Key Science Project

PI: Röttgering

Core team: Best, Brüggen, Brunetti, Chyży, Conway, Haverkorn, Heald, Jackson, Jarvis, Lehnert, McKean, Miley, Morganti, Scaife, Tasse, White, Wise

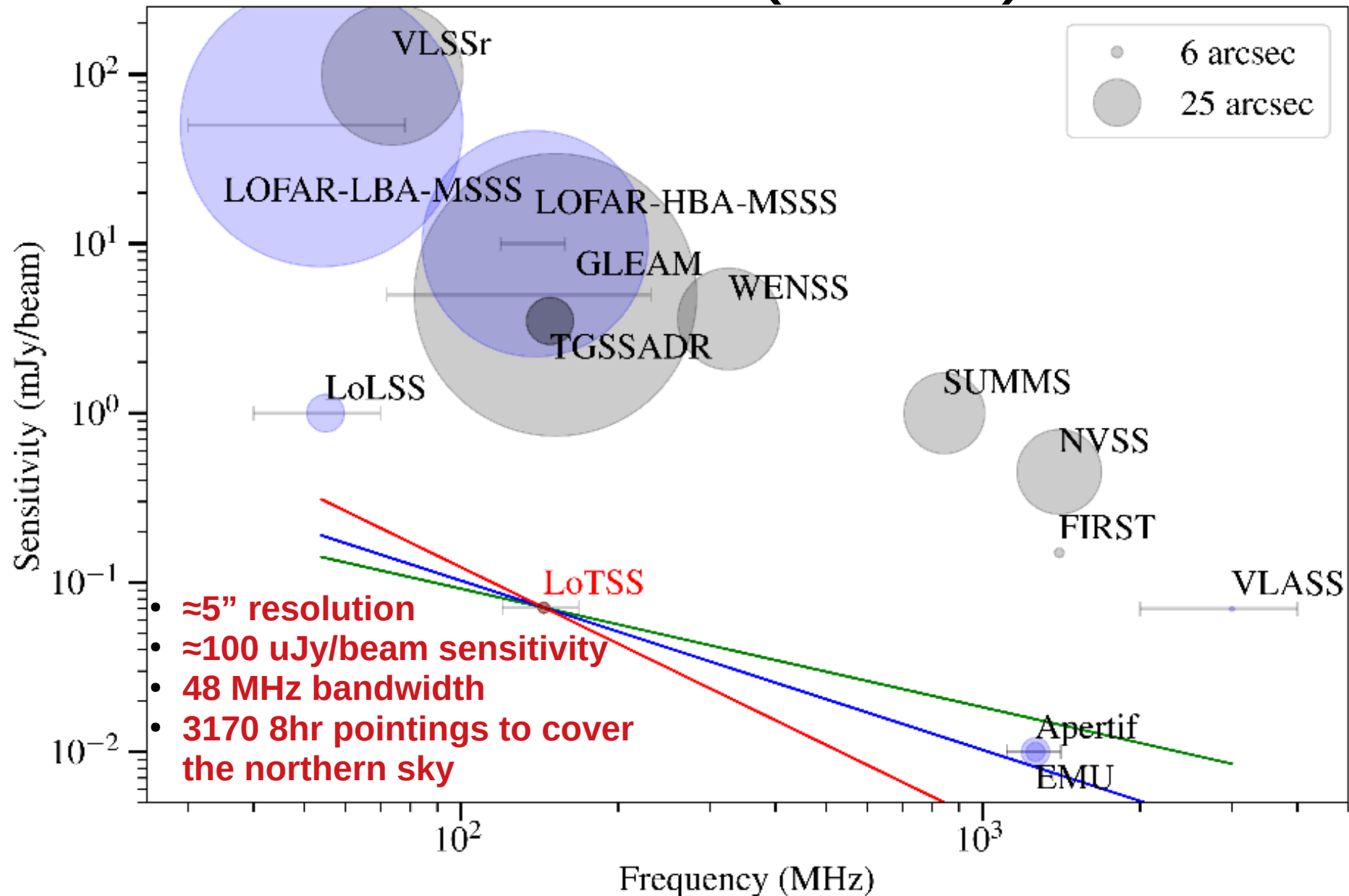
The 2018 « paper splash » :

More than 20 papers will be submitted together

Table of papers

Title	Lead author
The LOFAR Two-metre Sky Survey -- II. First Data Release	T Shimwell
The LOFAR Two-metre Sky Survey -- III. First Data Release: Optical identifications and Value-added catalogue	W.L. Williams
The LOFAR Two-metre Sky Survey -- IV. First Data Release: Photometric redshifts and rest-frame magnitudes	K. J. Duncan
The cluster chain Abell 781 as observed with LOFAR and XMM-Newton	A. Botteon
Elucidating the radio properties of Broad Absorption Line Quasars using the LOFAR Two-metre Sky Survey	L. Morabito
Ultra steep spectrum emission in merging galaxy cluster Abell 1914	S. Mandal
LOFAR Observations of the XMM-LSS field	C. Hale
LoTSS: Radio-loud AGN in the HETDEX field	M.J. Hardcastle
Systematic effects in LOFAR data: a unified LOFAR-LBA and LOFAR-HBA calibration strategy for calibrator fields	F. de Gasperin
Signatures from a merging galaxy cluster its AGN population: LOFAR observations of Abell 1682	A.O. Clarke
The LOFAR view on the merging galaxy cluster Abell 2069	A. Drabent
The low-frequency radio–SFR relation in nearby galaxies at 1-kpc scale with LOFAR	V. Heesen
Restarting radio galaxies in the HETDEX Spring field	V. H. Mahatma
Blazars in the LOFAR Two-Metre Sky Survey First Data Release	S. Mooney
A double radio halo in Abell 1430	C Dumba
A LOFAR study of non-merging massive galaxy clusters	F. Savini
LoTSS/HETDEX: Optical quasars -I. Low-frequency radio properties of optically selected quasars	G. Gurkan
The intergalactic magnetic field probed by a giant radio galaxy	S. P. O'Sullivan
The evolutionary phases of merging clusters as seen by LOFAR	A. Wilber
Exploring the properties of low-frequency radio emission and magnetic fields of a sample of compact galaxy groups using the LOFAR Two-Metre Sky Survey (LoTSS)	B.Nikiel-Wroczyński
<u>CHANG-ES XIV: A LOFAR and JVLA View of the Star-forming Galaxy NGC 3556</u>	A. Miskolczi
Radio observations of the merging galaxy cluster Abell 520	D. N. Hoang
A LOFAR view on the merging galaxy cluster Abell 2146	D. N. Hoang
The LoTSS view of radio-AGN in the local Universe. The most massive galaxies are always switched on	J. Sabater
LOFAR first look at the giant radio galaxy 3C 236	A. Shulevski

The LOFAR Two-meter Sky Survey : LOTSS (Tier-1)

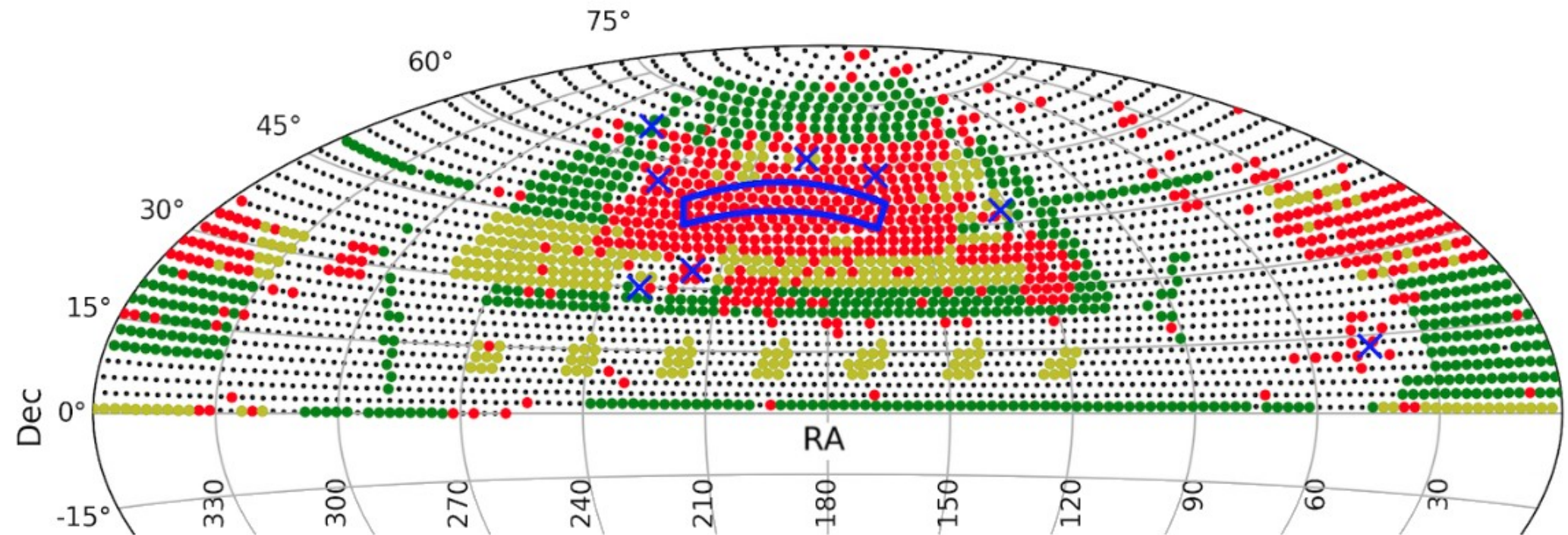


LOTSS : LOFAR Two-meter Sky Survey

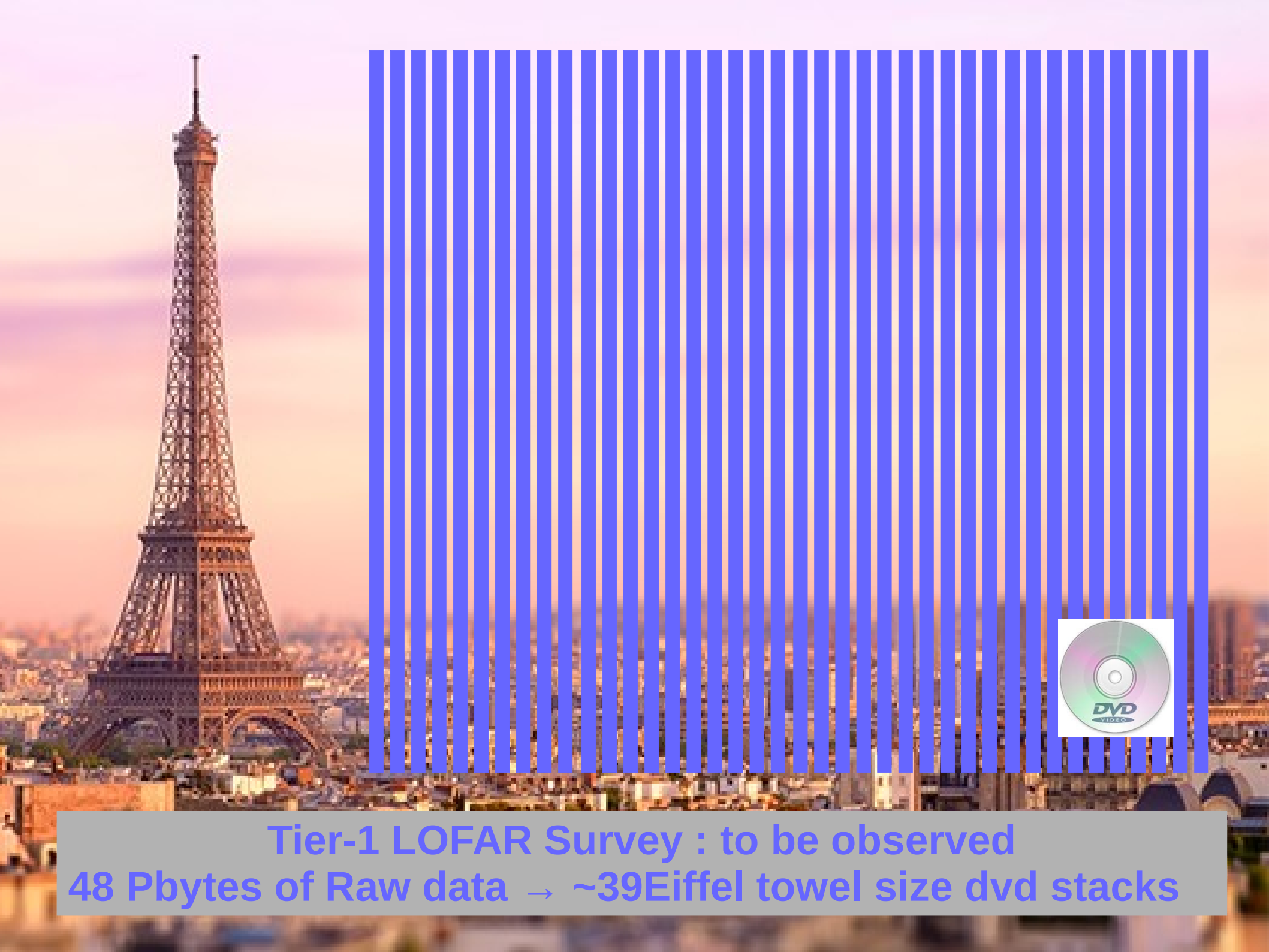
20% of the northern sky is observed.

50% of the observed data is partially processed.

Allocated 3750 hrs of observations to reach 50% completeness in 2 years



Red observed, yellow observed in next 6 months, green observed in next 2 years.

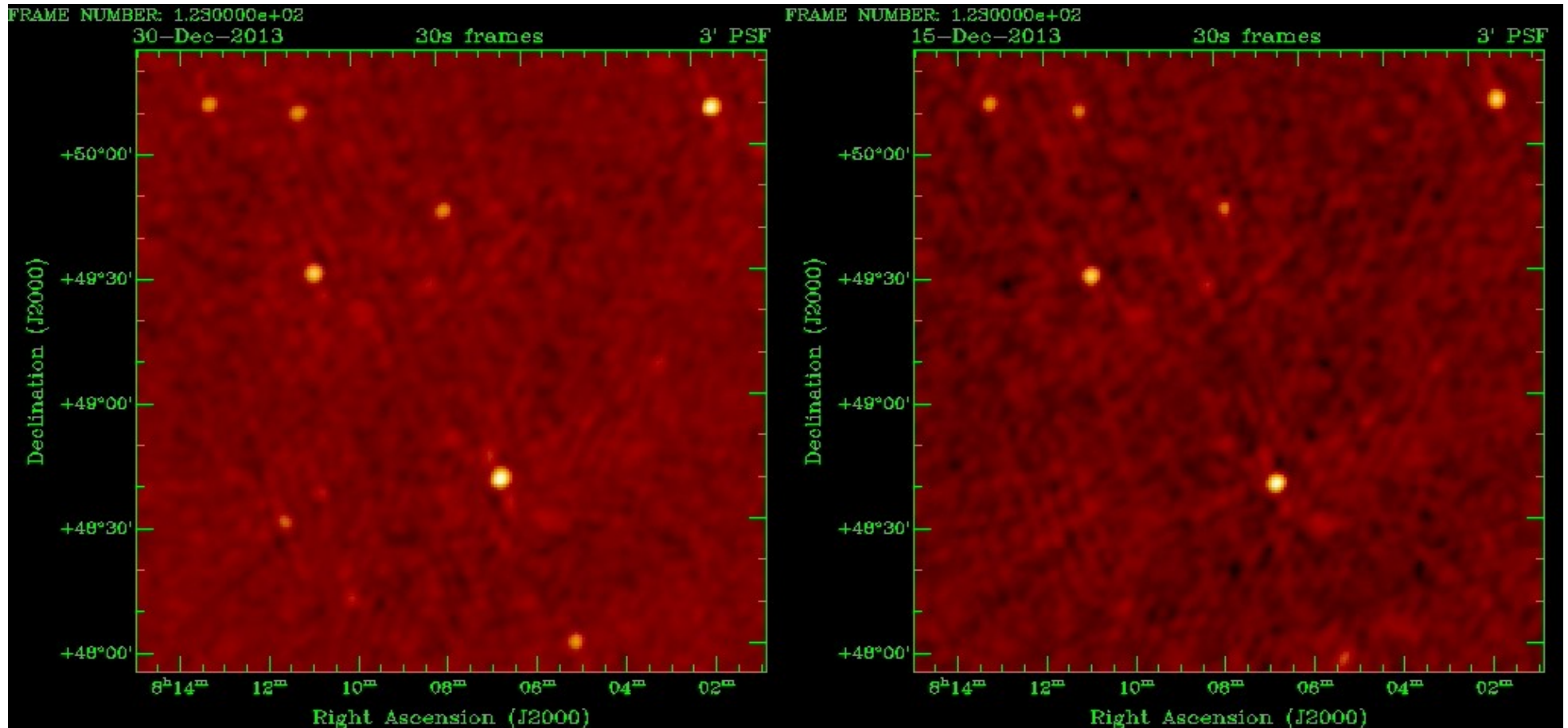


Tier-1 LOFAR Survey : to be observed
48 Pbytes of Raw data → ~39 Eiffel tower size dvd stacks

Ionosphere

Good ionosphere

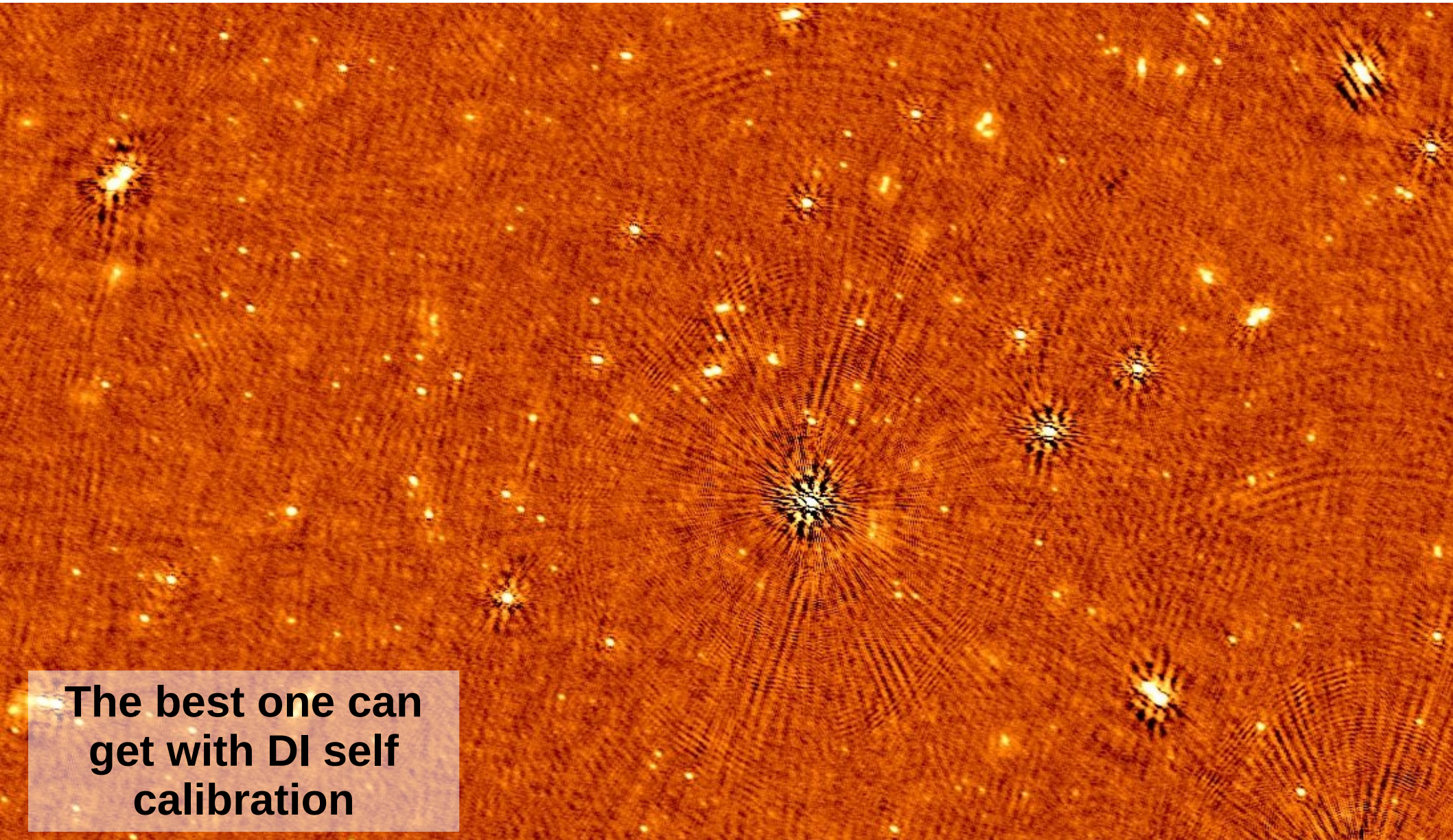
Bad ionosphere



Images have 3 arcmin resolution

Wirtinger calibration

Tasse 14, Smirnov&Tasse15, Tasse+ 17



The best one can
get with DI self
calibration

Wirtinger calibration

Tasse 14, Smirnov&Tasse15, Tasse+ 17

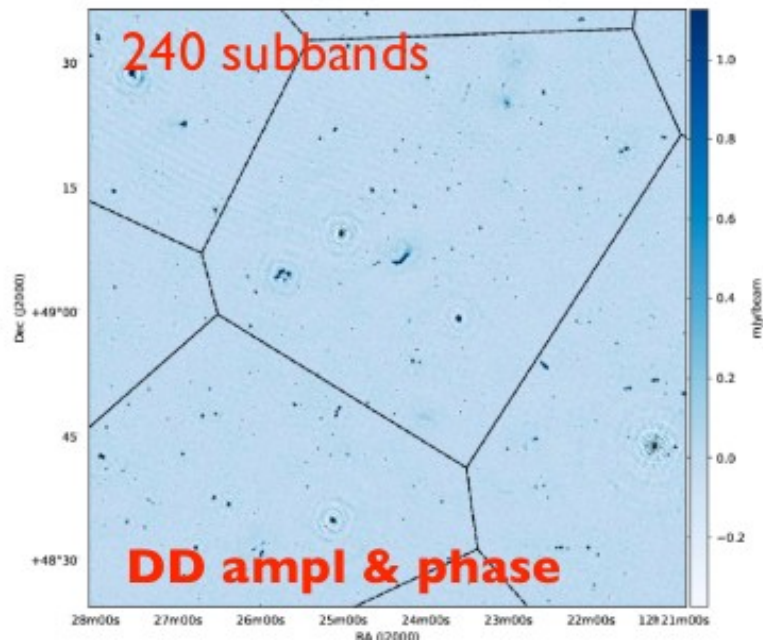
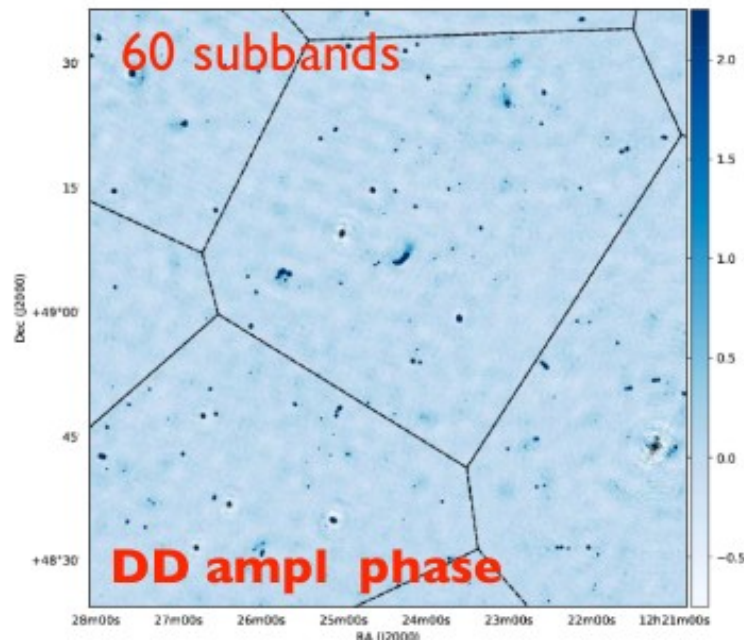
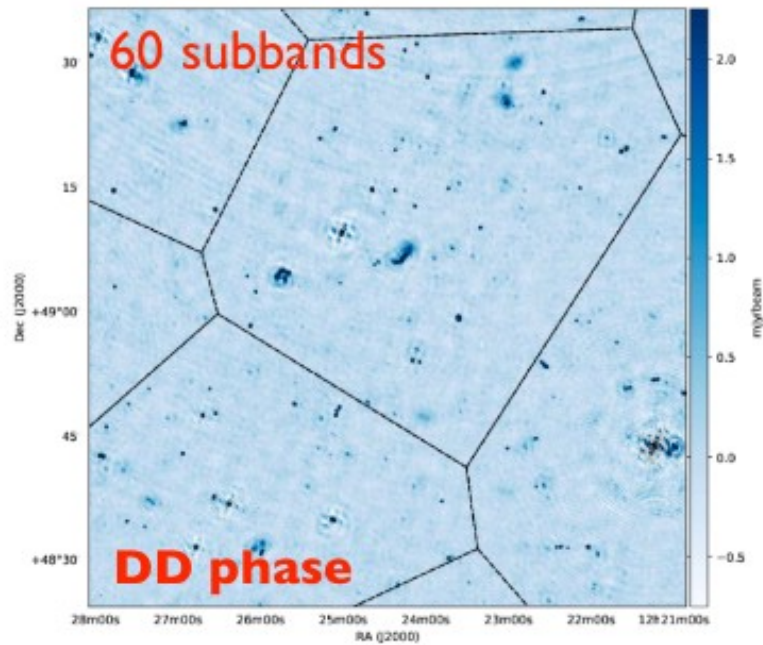
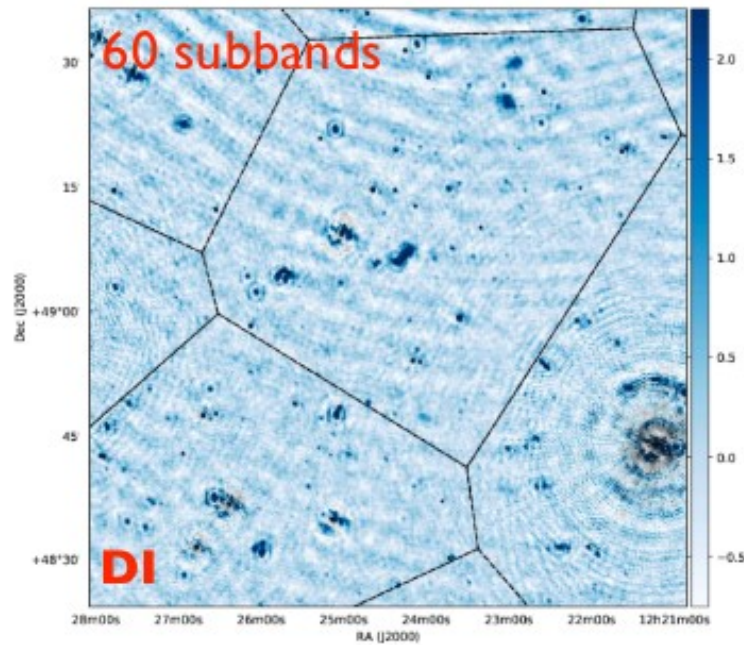


With Wirtinger
calibration and
imaging

~ 100 $\mu\text{Jy}/\text{Beam}$ rms

Wirtinger calibration

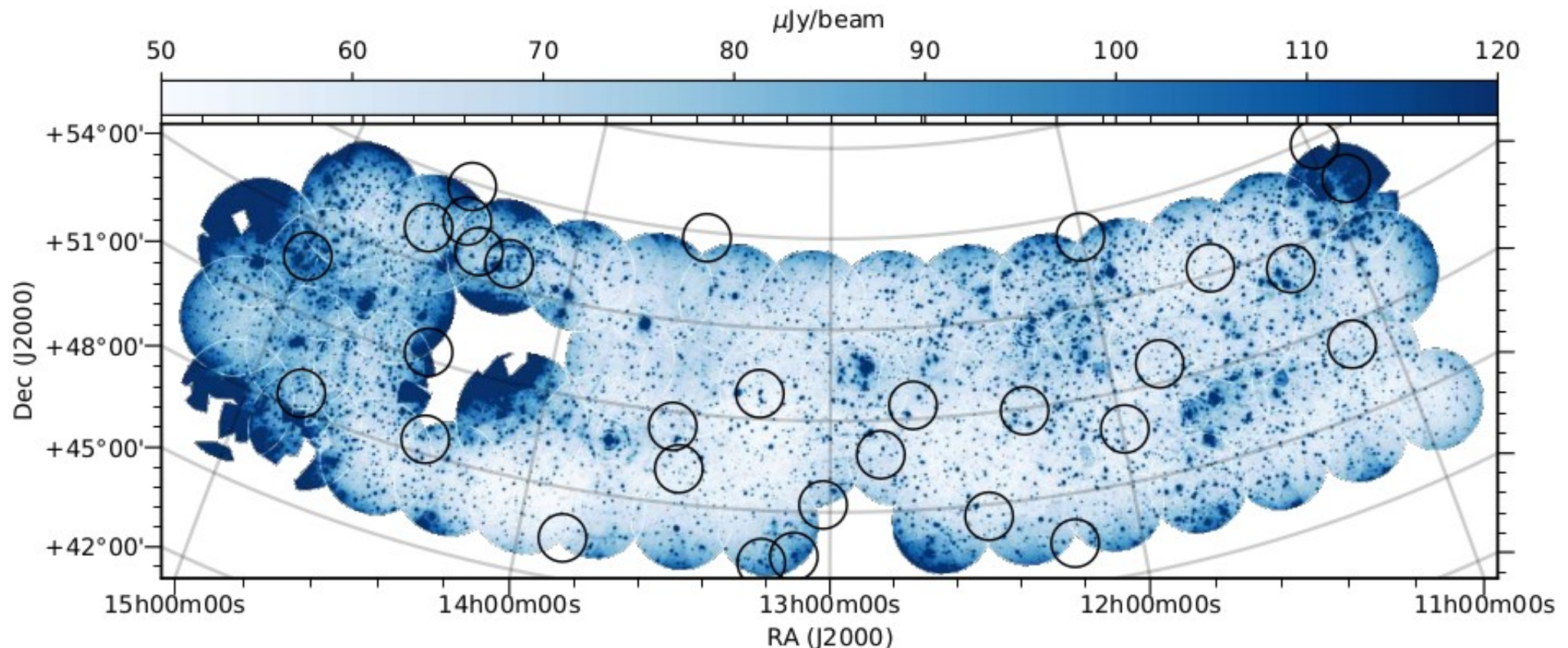
Tasse 14, Smirnov&Tasse15, Tasse+ 17



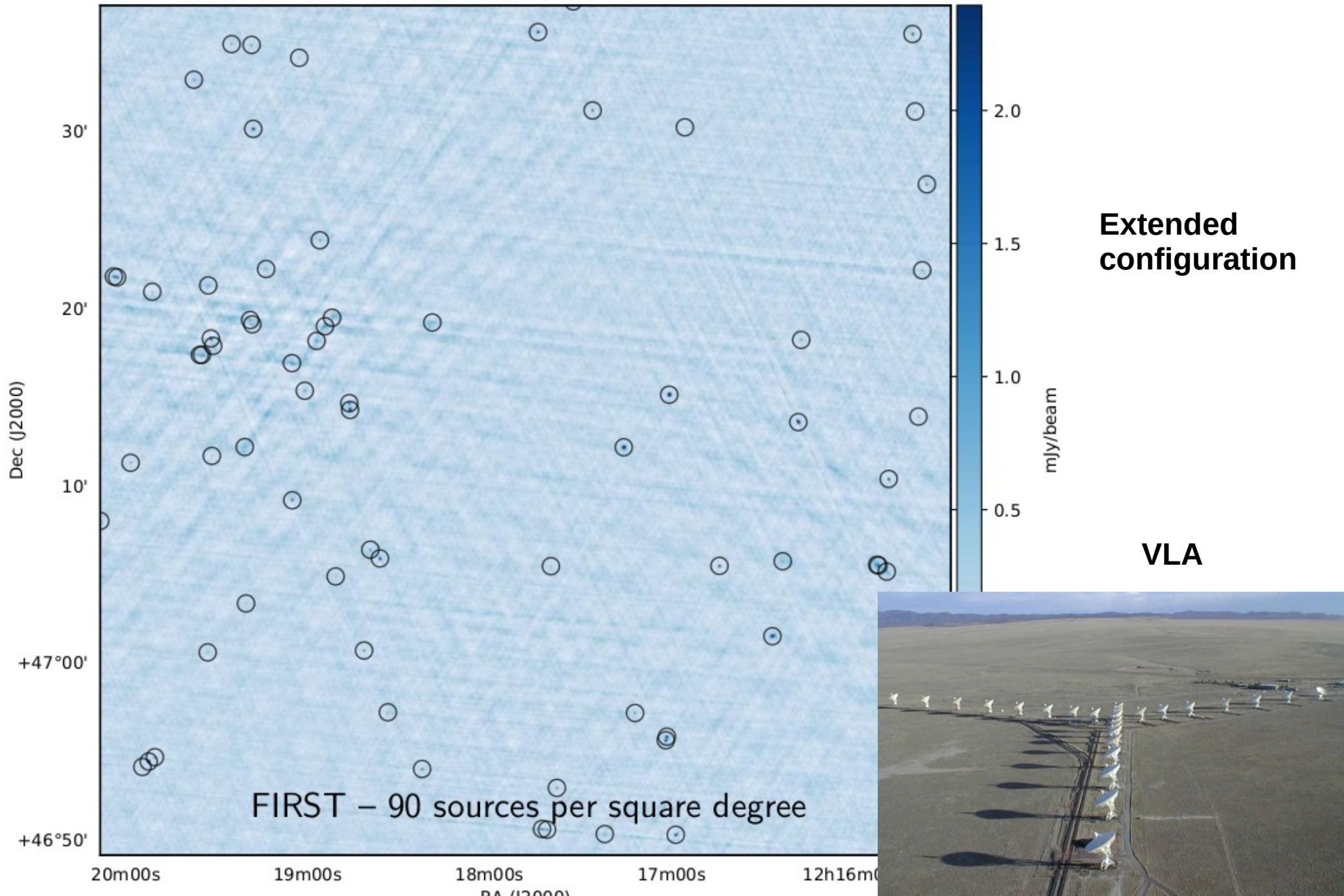
LOTSS – First Data Release

A data release of 6" resolution images with a sensitivity of $71\mu\text{Jy}/\text{beam}$ that covers 424 square degrees in the HETDEX Spring Field region.

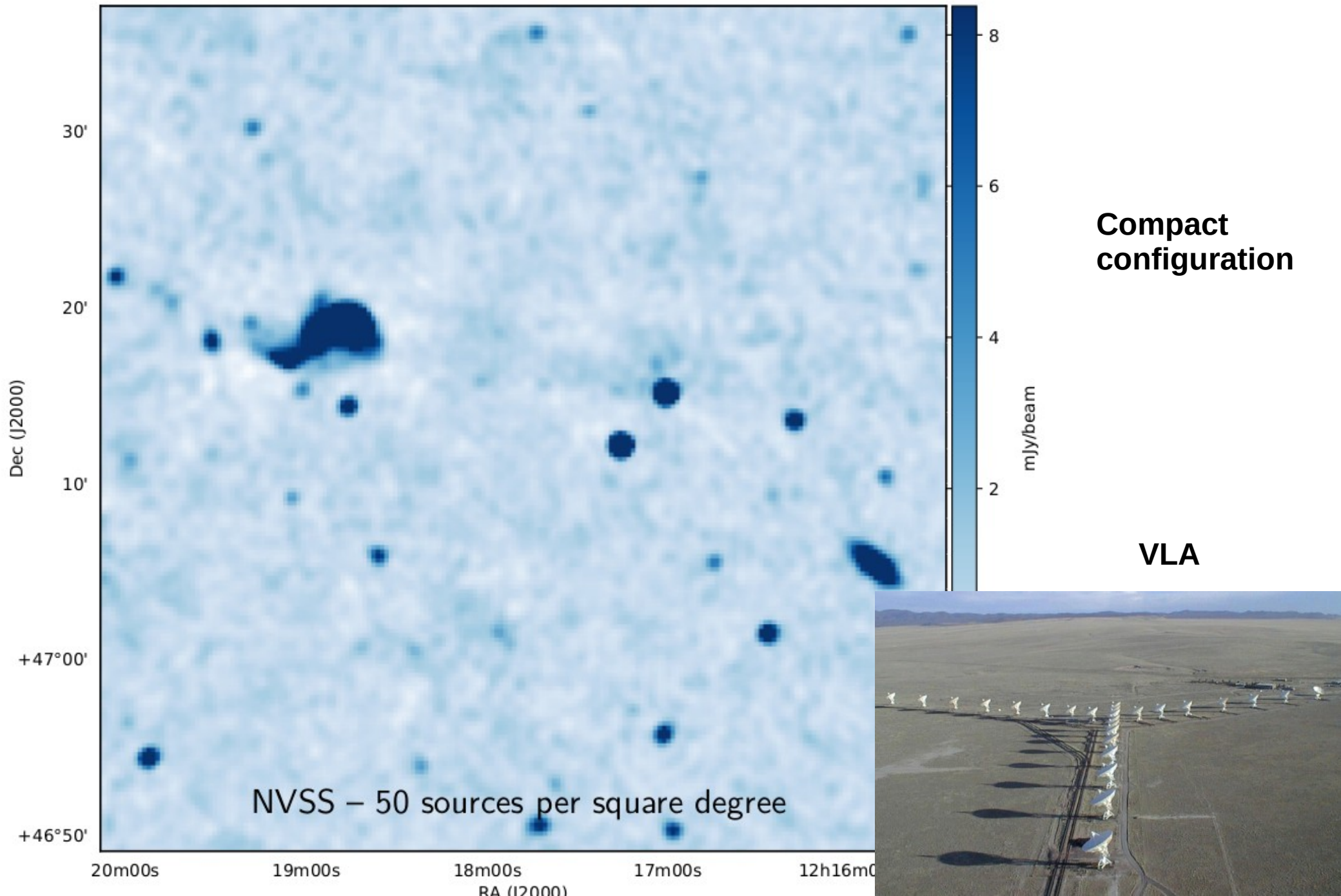
The catalogue contains 325,694 radio sources (Shimwell+ submitted), 225,457 optical identifications (Williams+ submitted) and 158,284 photometric redshift estimates (Duncan+ submitted)



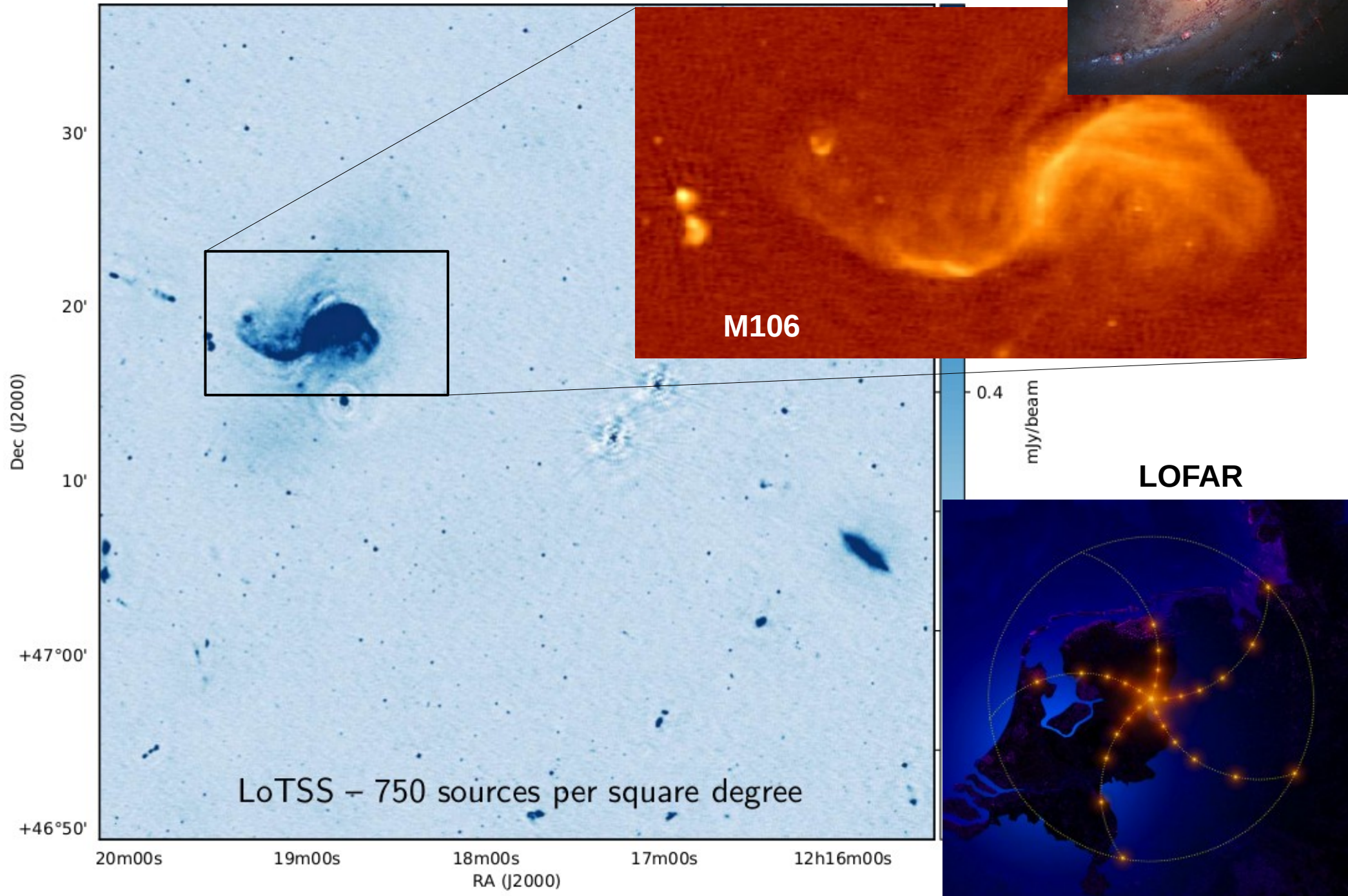
LOTSS – First Data Release



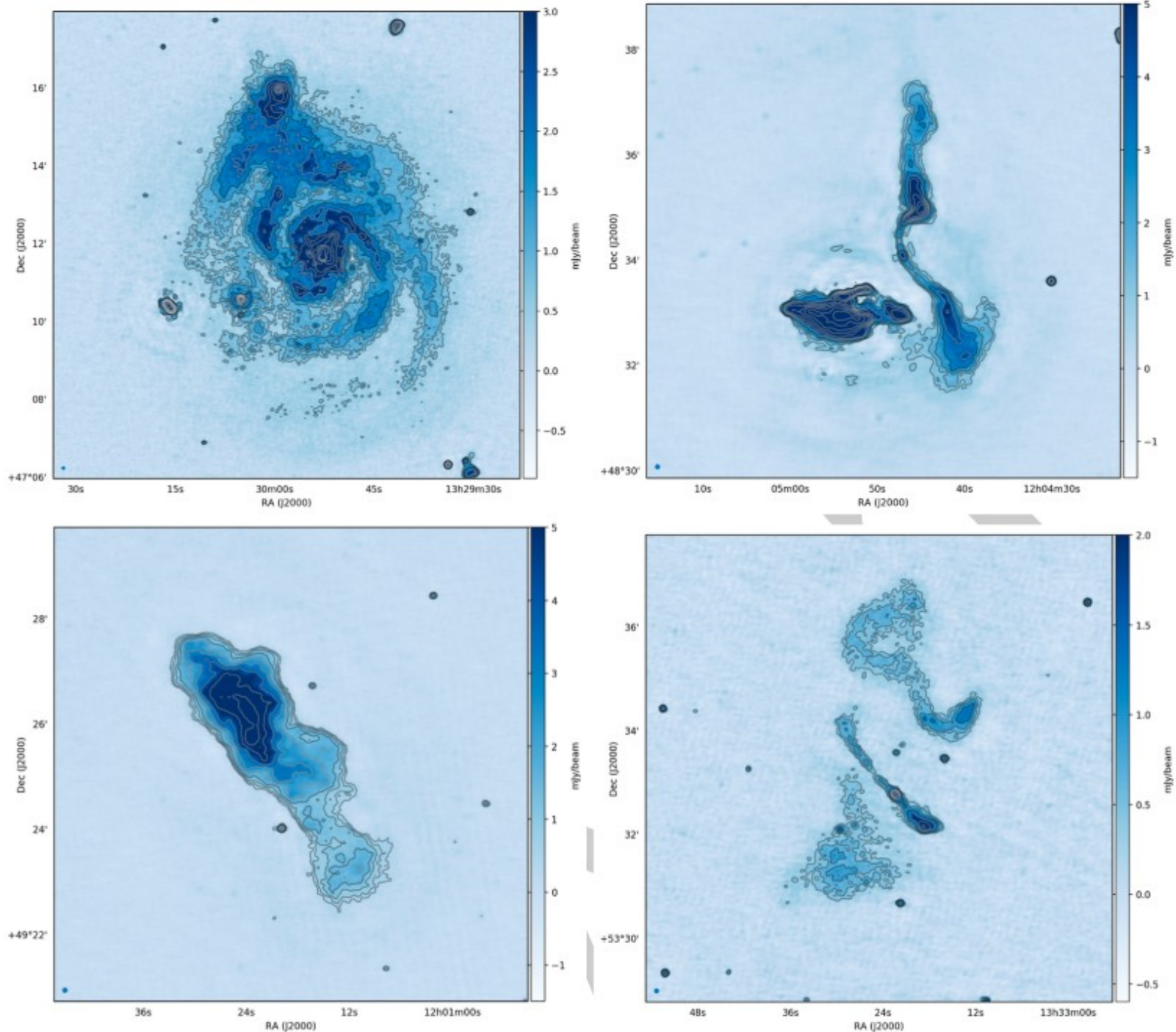
LOTSS – First Data Release

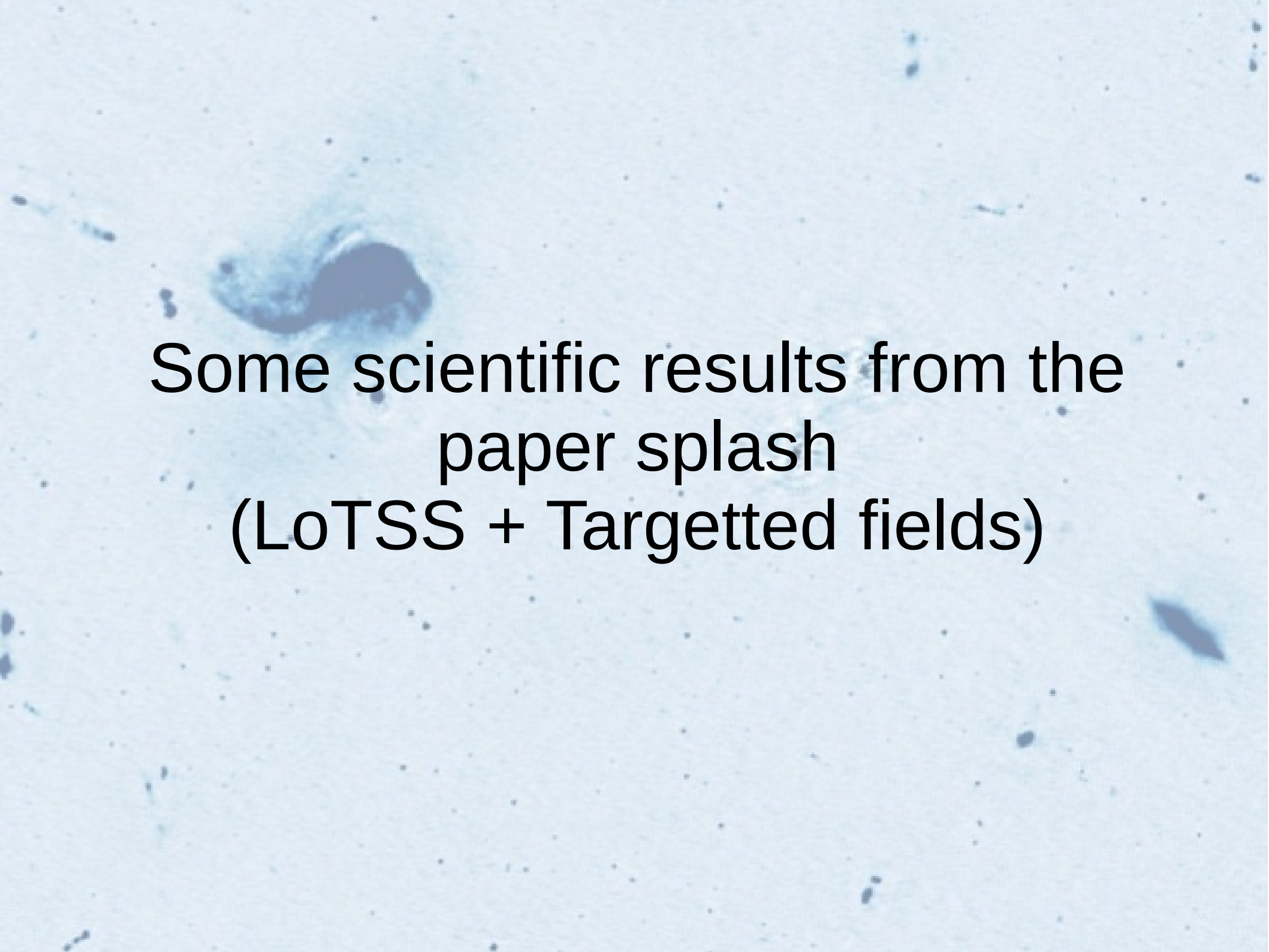


LOTSS – First Data Release



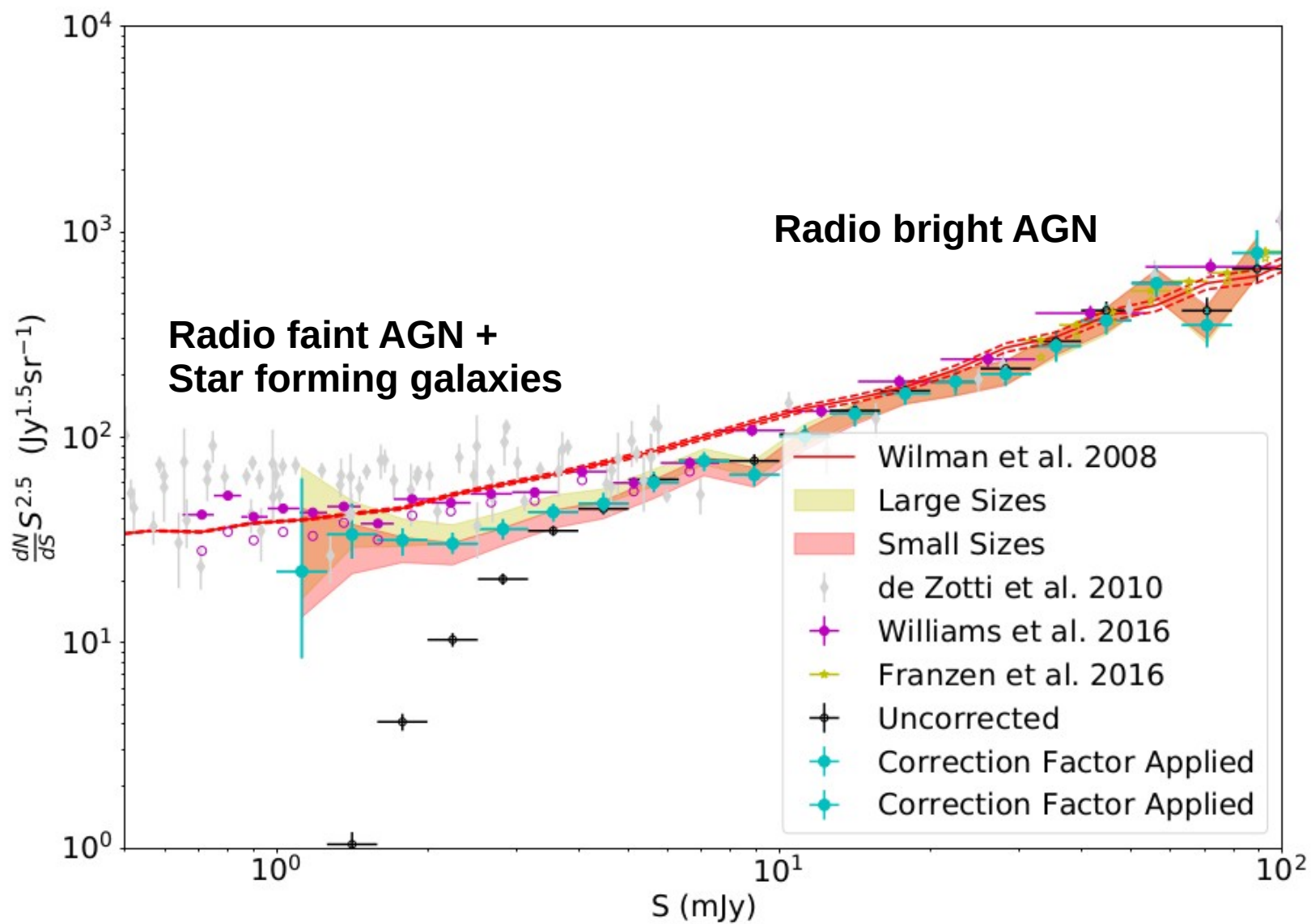
LOTSS – First Data Release





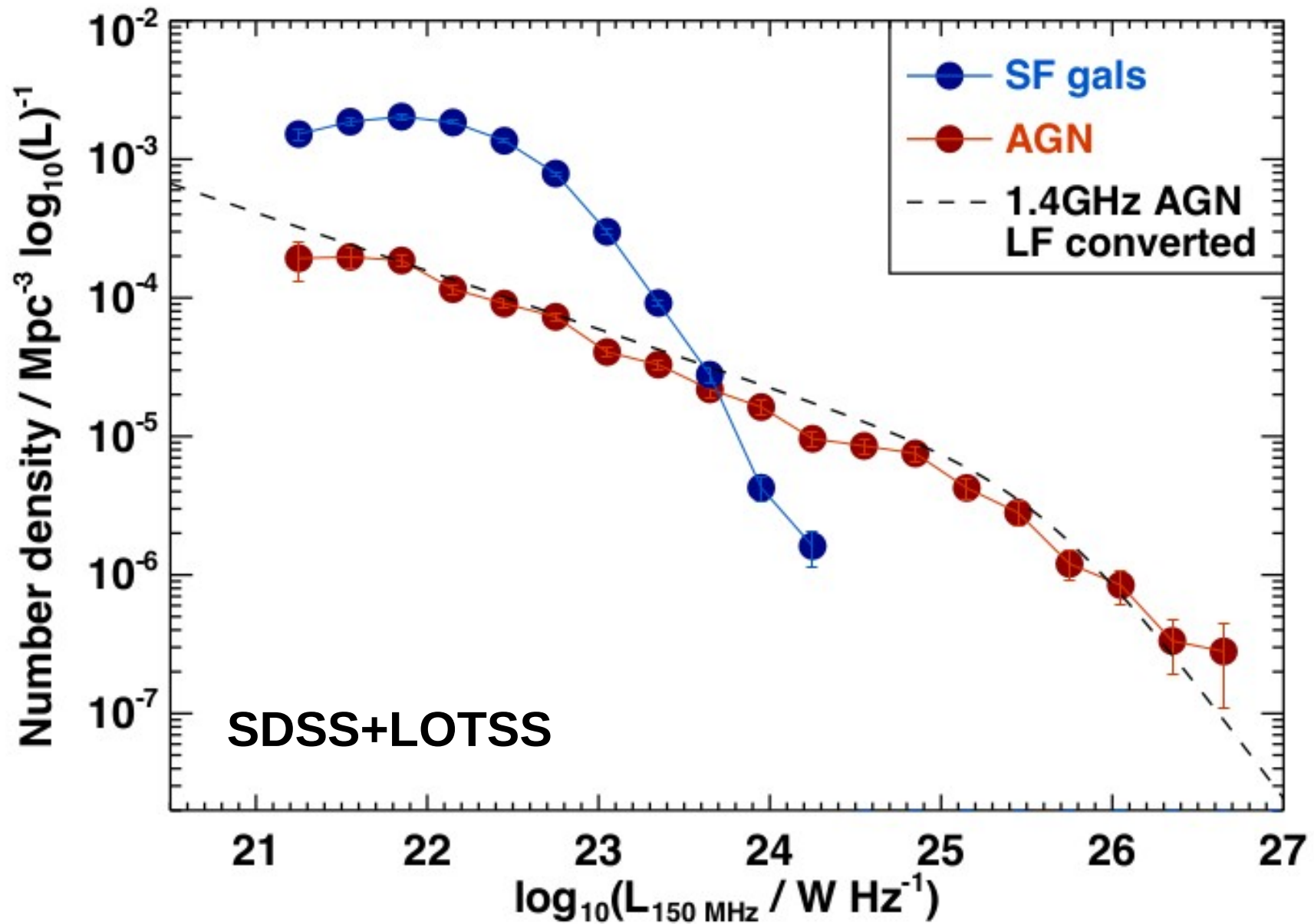
Some scientific results from the
paper splash
(LoTSS + Targetted fields)

In the XMM-LSS field



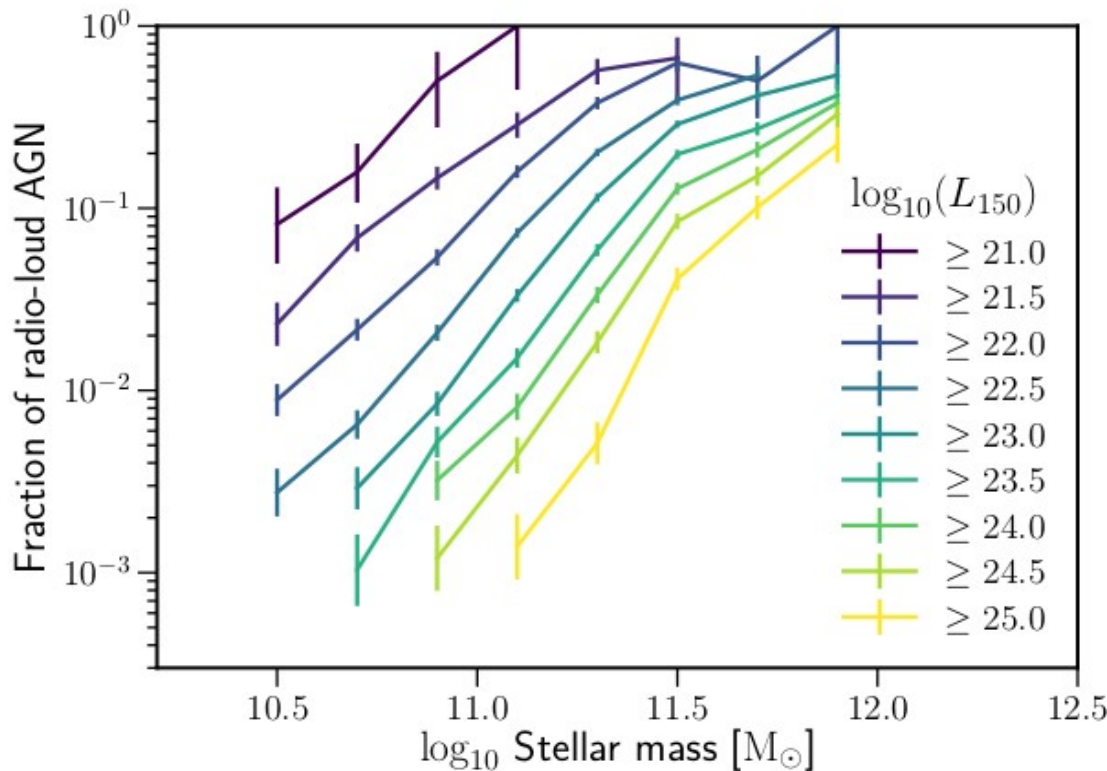
Hale et al. In prep

AGN In the local universe

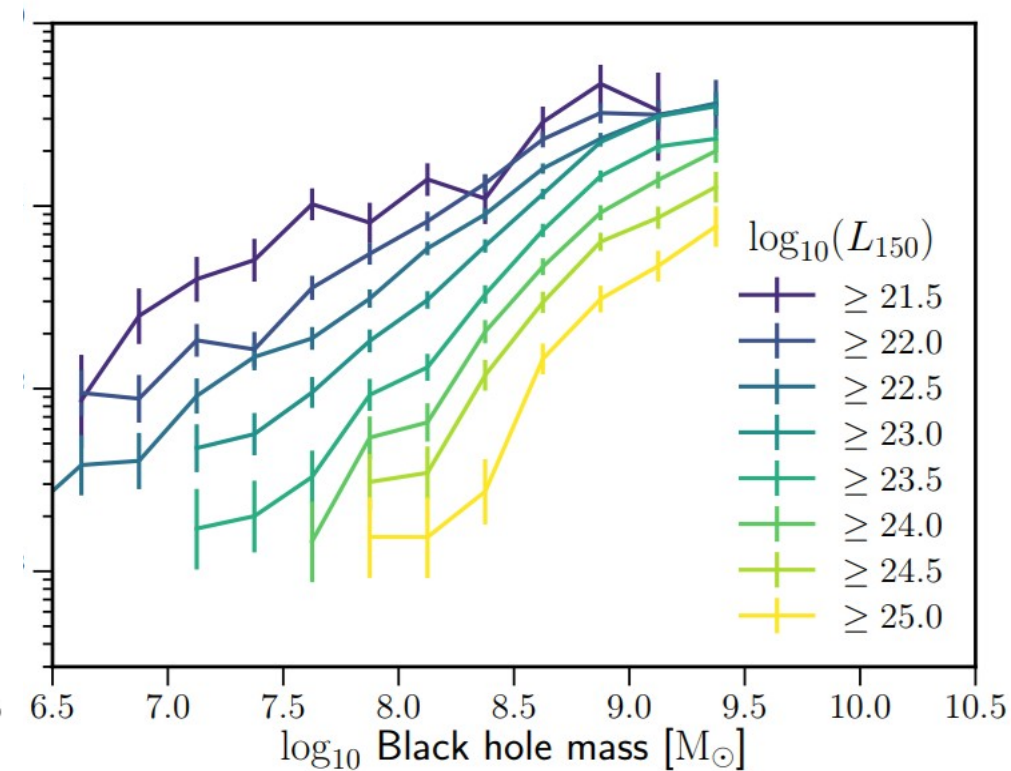


Sabater et al. In prep

In the local universe, AGN in massive galaxies *are always on*



Stellar mass



Black-Hole mass

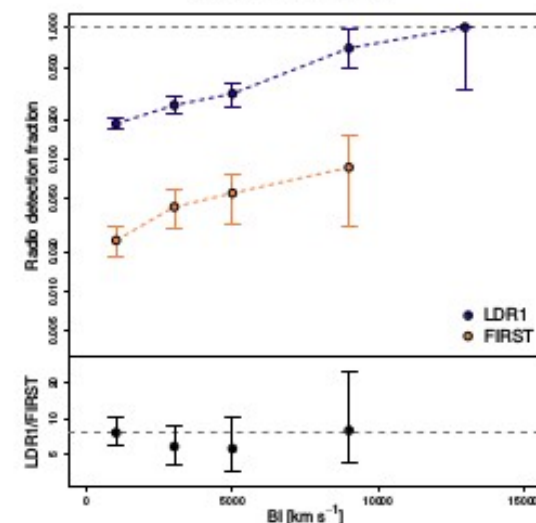
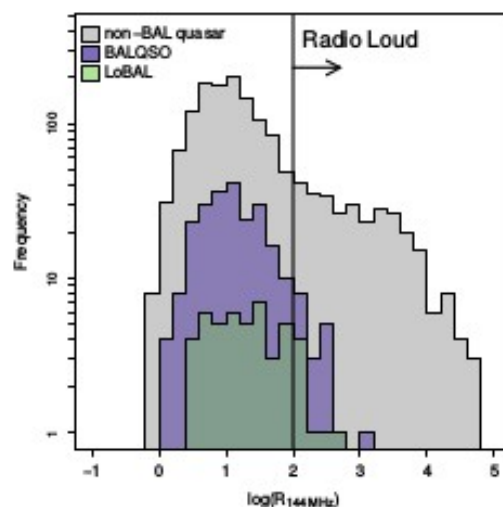
Elucidating the radio properties of Broad Absorption Line Quasars using the LOFAR Two-metre Sky Survey

L.K. Morabito et al.

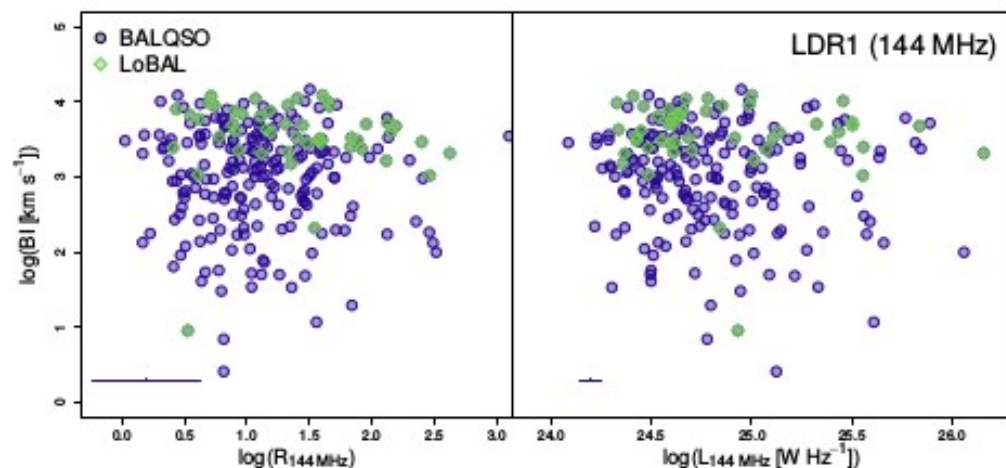
Broad **A**bsorption **L**ines (BALs) are evidence for fast outflowing winds in our line of sight to the centres of active galaxies

Only a few have 'loud' or bright radio emission when compared to the optical emission

The radio detection fraction is correlated with the strength of the BALs (measured by **B**alnicity Index, BI)

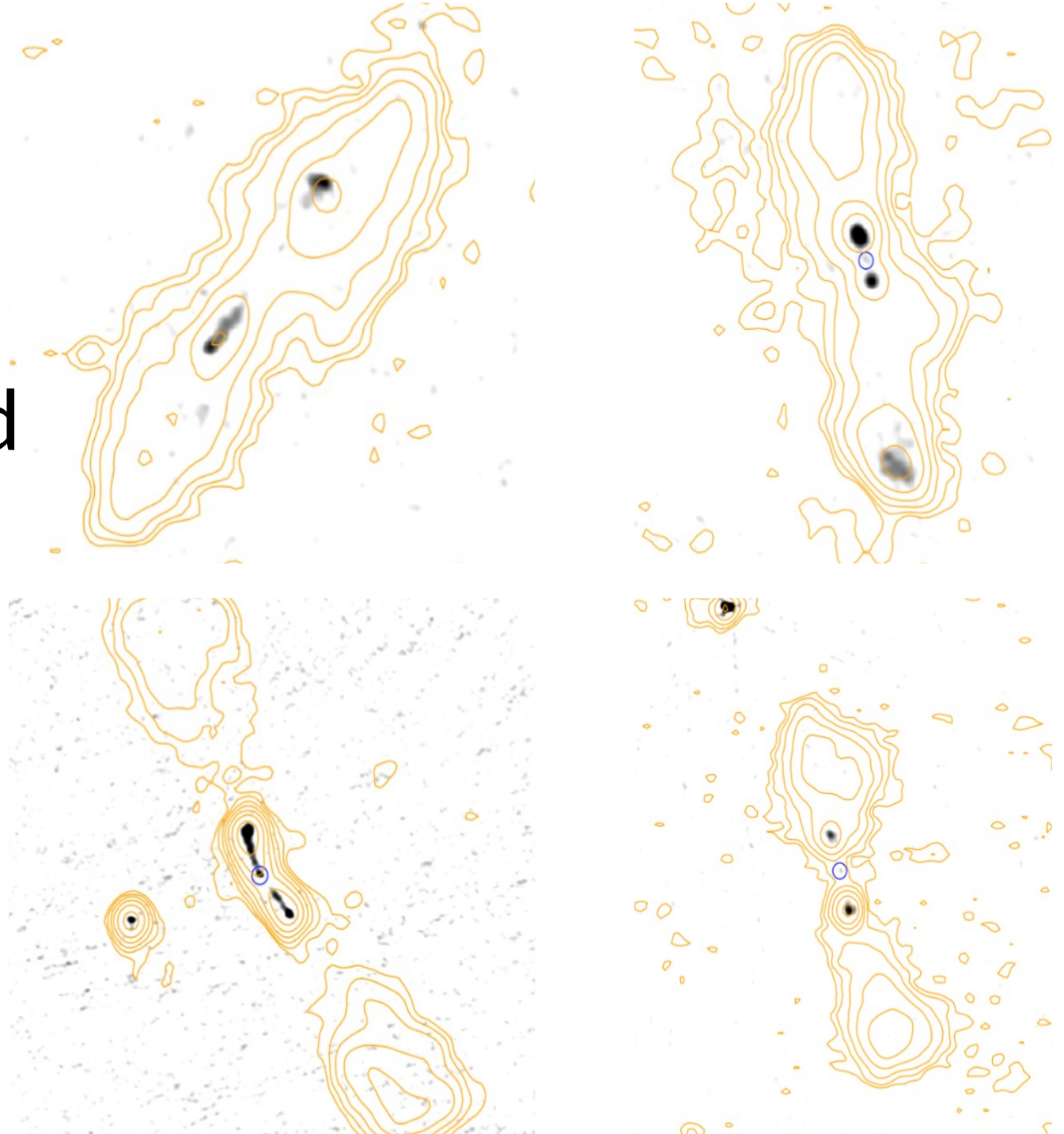


Although radio detections and BI are correlated, there is no other correlation between BI and radio properties. This means that BI and radio emission are linked to the same underlying process – the quasar – but are spatially separated



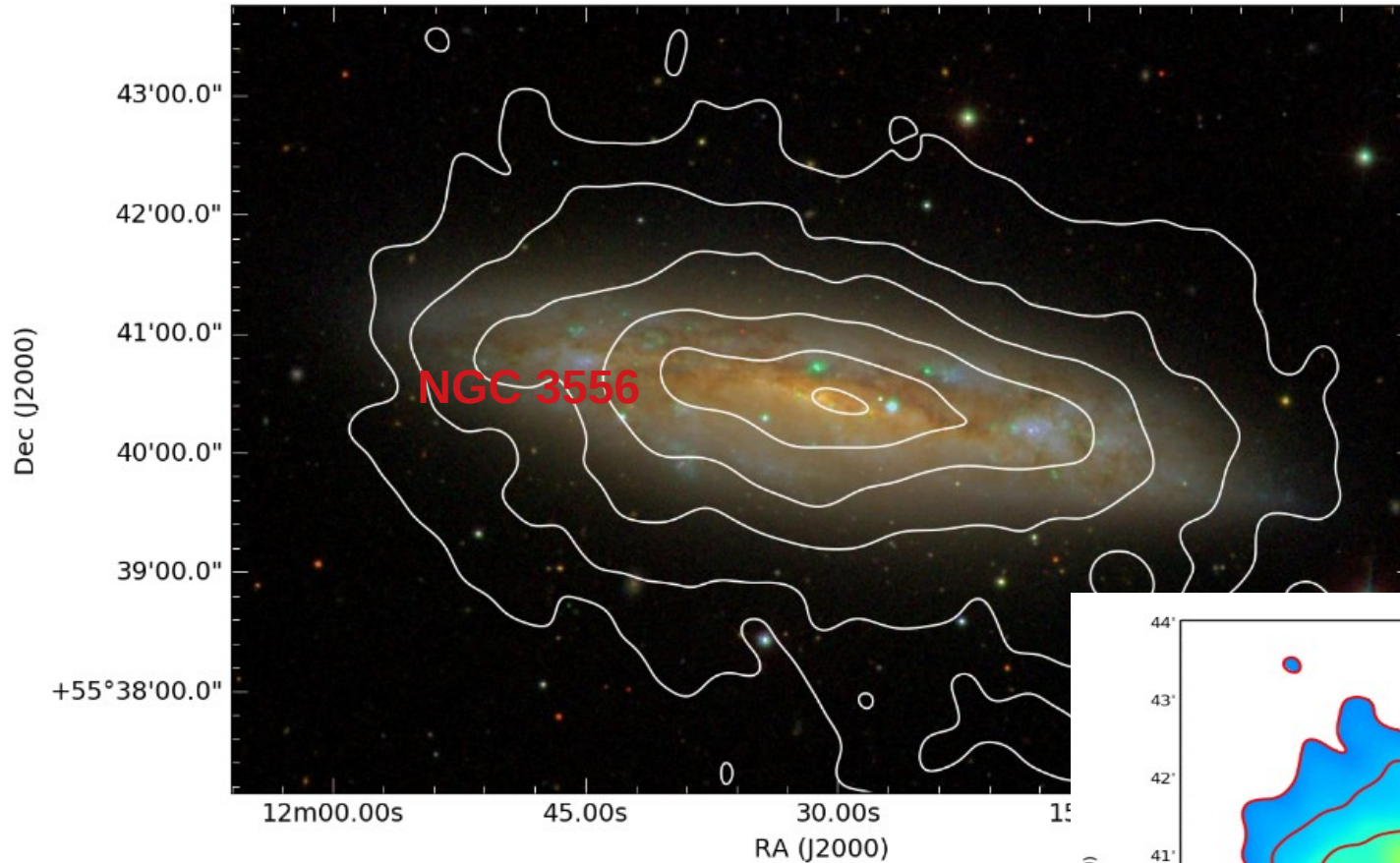
Relic AGN or restarted?

Jet dynamics
Feedback and
duty cycle



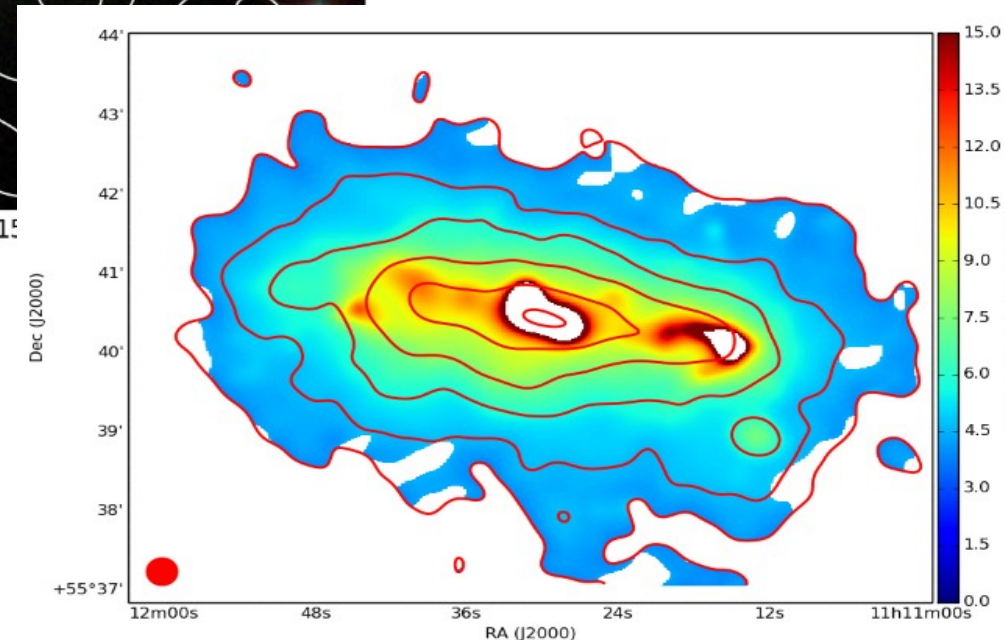
Mahatma et al. In prep

Nearby galaxies



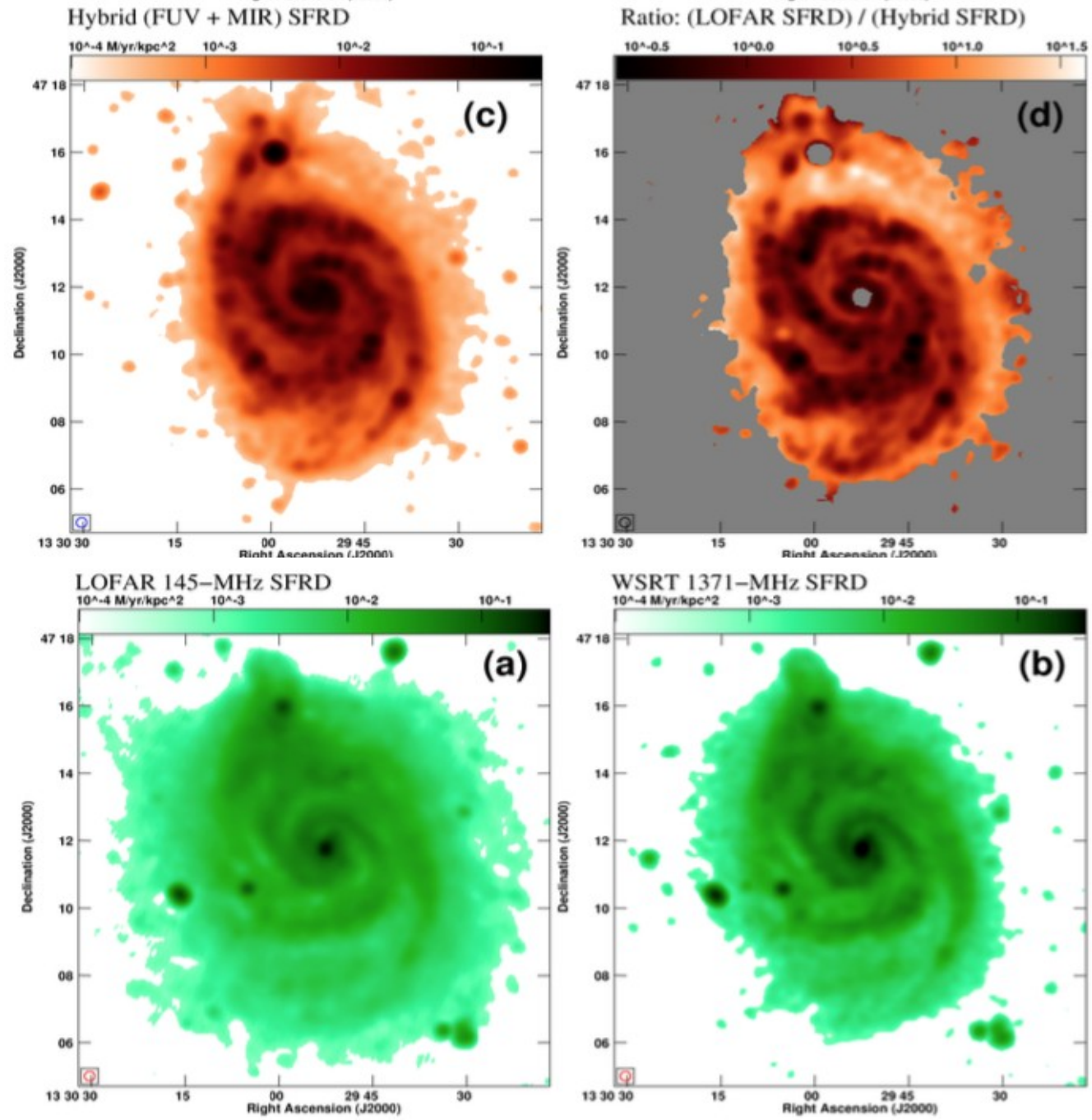
Miskolczi et al. In prep

- Cosmic rays emitting synchrotron in a galactic Halo
- Constrains on CR Energy, magnetic field and galactic winds speed



Nearby galaxies

- Study the Radio to Star Formation relation (FIR & UV)
- Cosmic ray electron transport



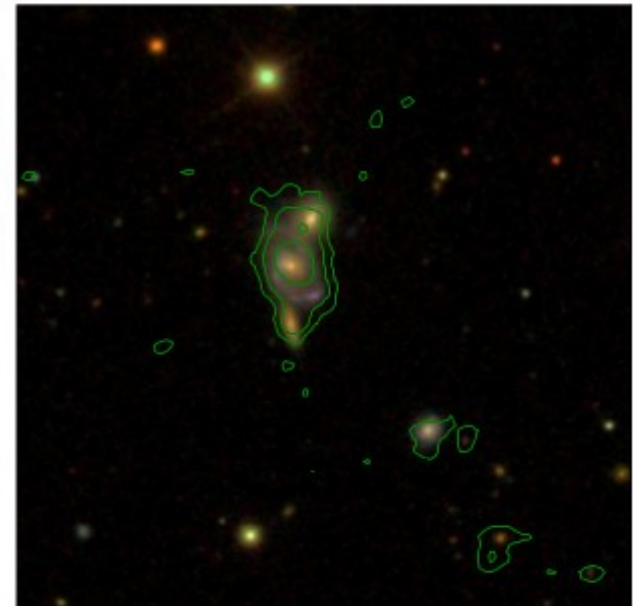
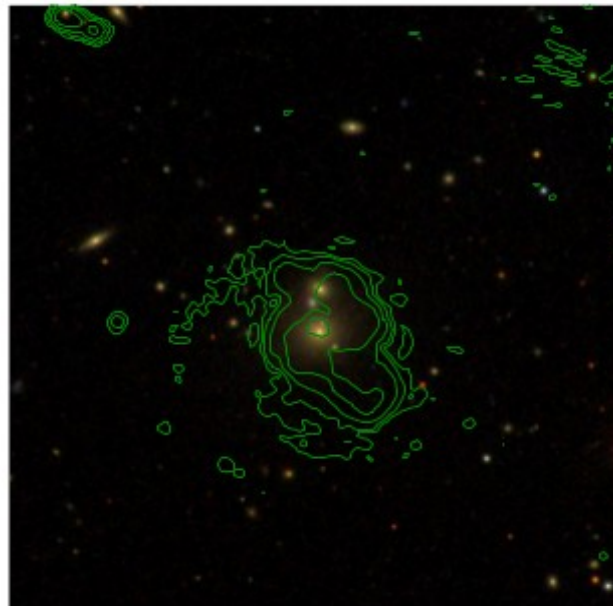
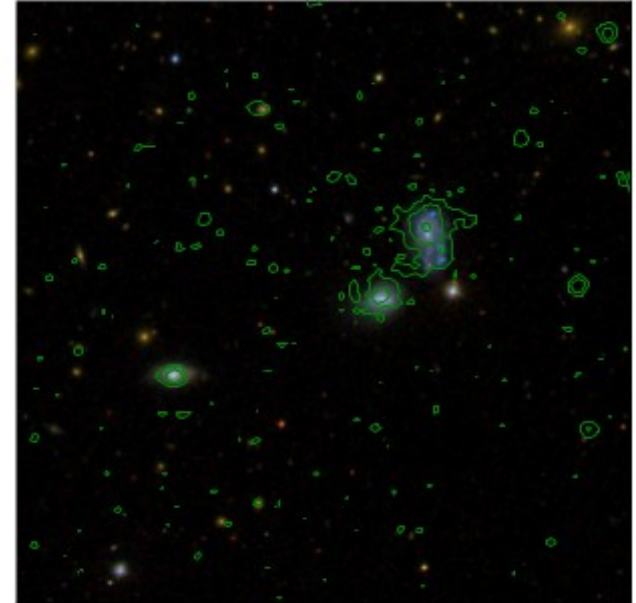
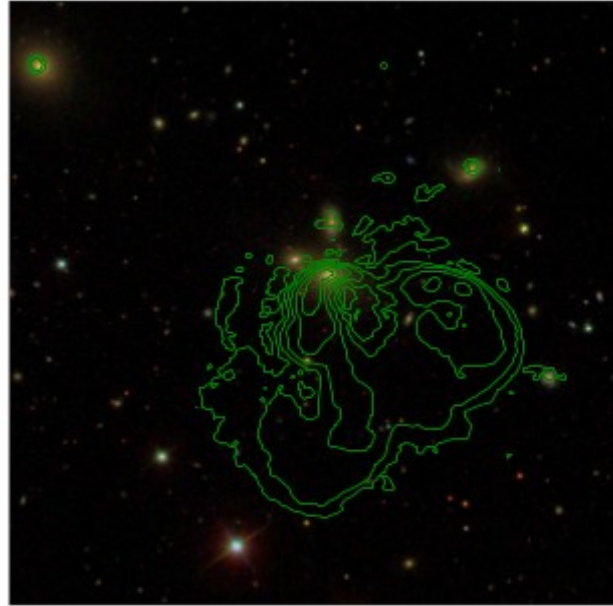
Nearby galaxy groups

Nikiel-Wroczyński et al. In prep

Using

- SDSS
- NVSS
- FIRST

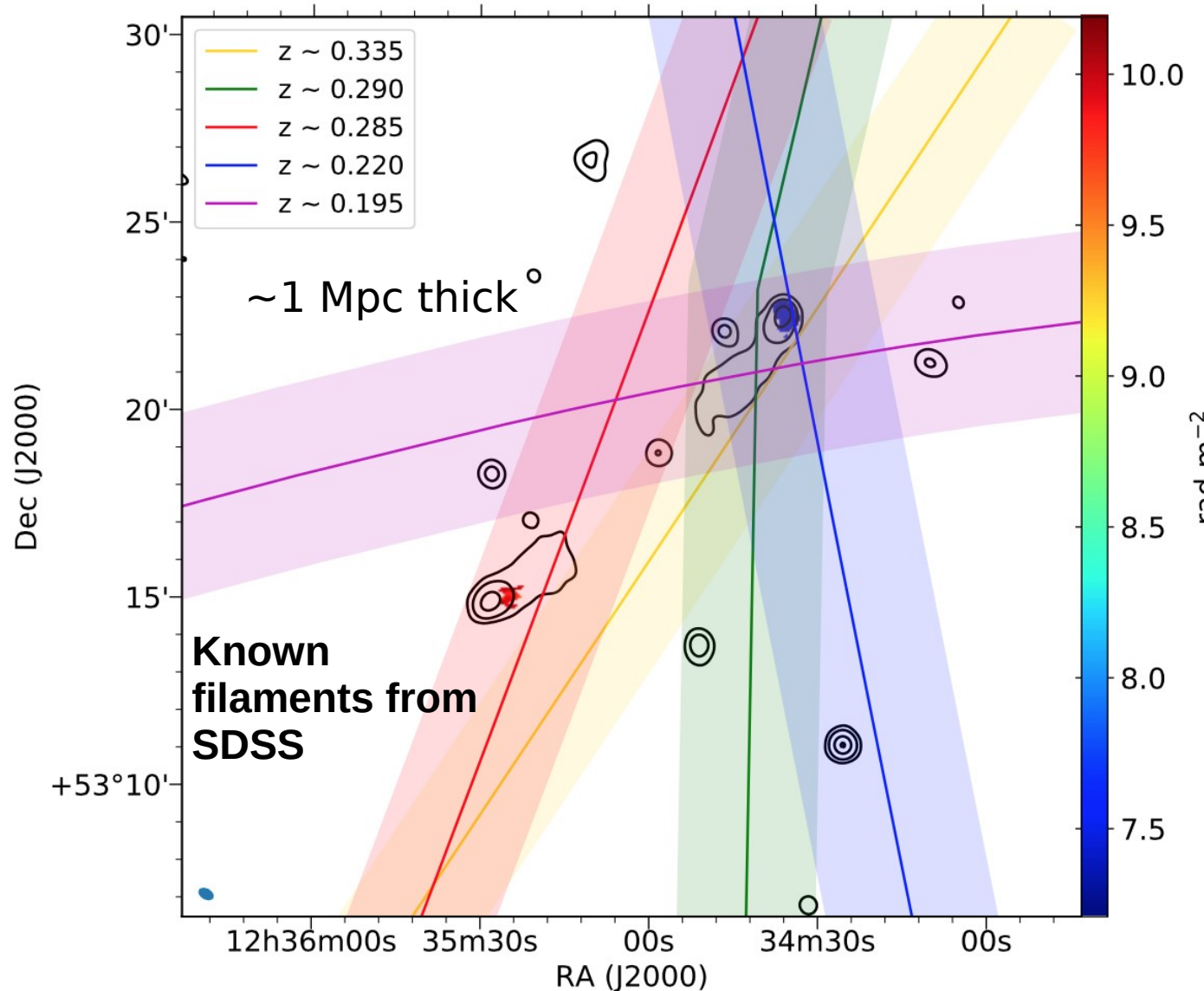
- 17/107 show signs of intergalactic structure
- Study of the magnetic field of the IGM



LSS Filaments

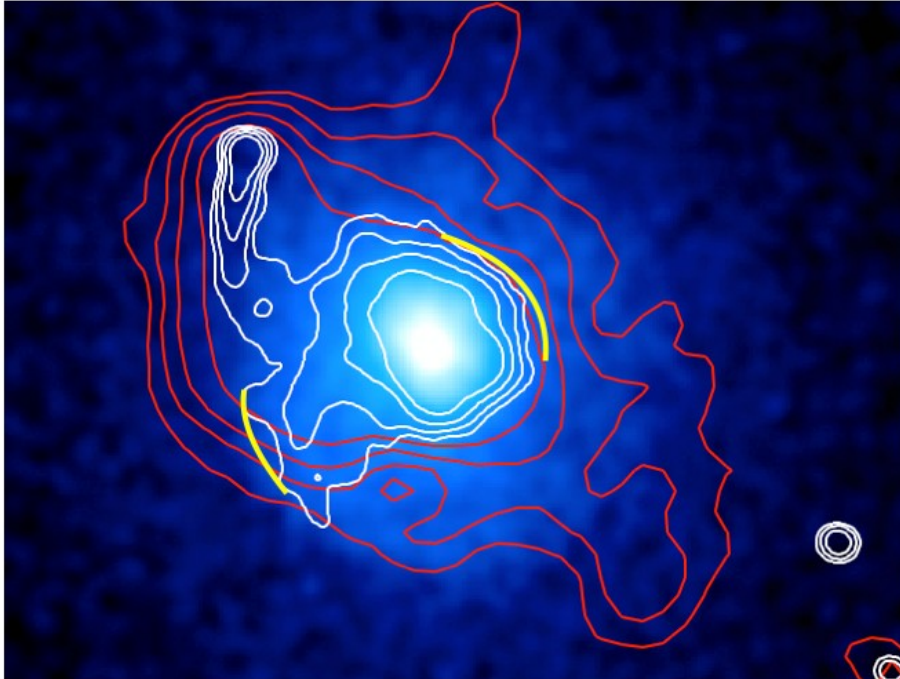
- Relativistic electrons don't do RM
- How large? 3.4 Mpc
- Lobes expanding in an empty region
- Large-scale structure filaments ? from SDSS by Chen+15, 16
- Excess of 3 filaments for North lobe

O'Sullivan et al.
In prep

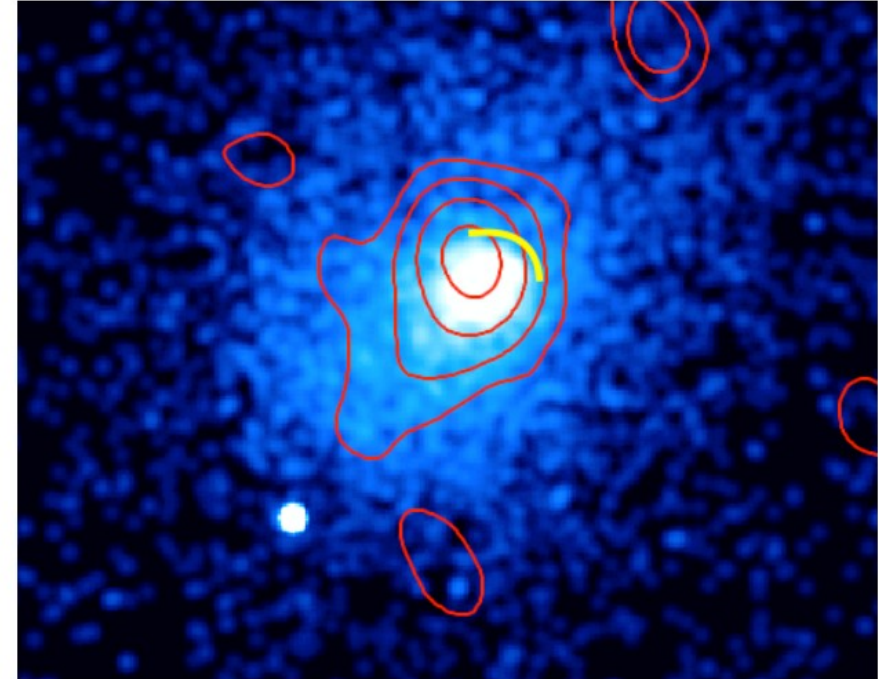


Cool-core clusters: MH+USSH

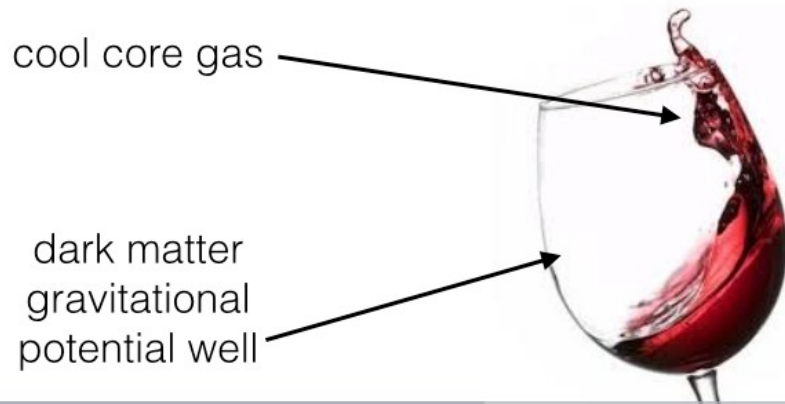
RXJ1720.1+2638



PSZ1G139.61+24.20



Gas sloshing & minor mergers



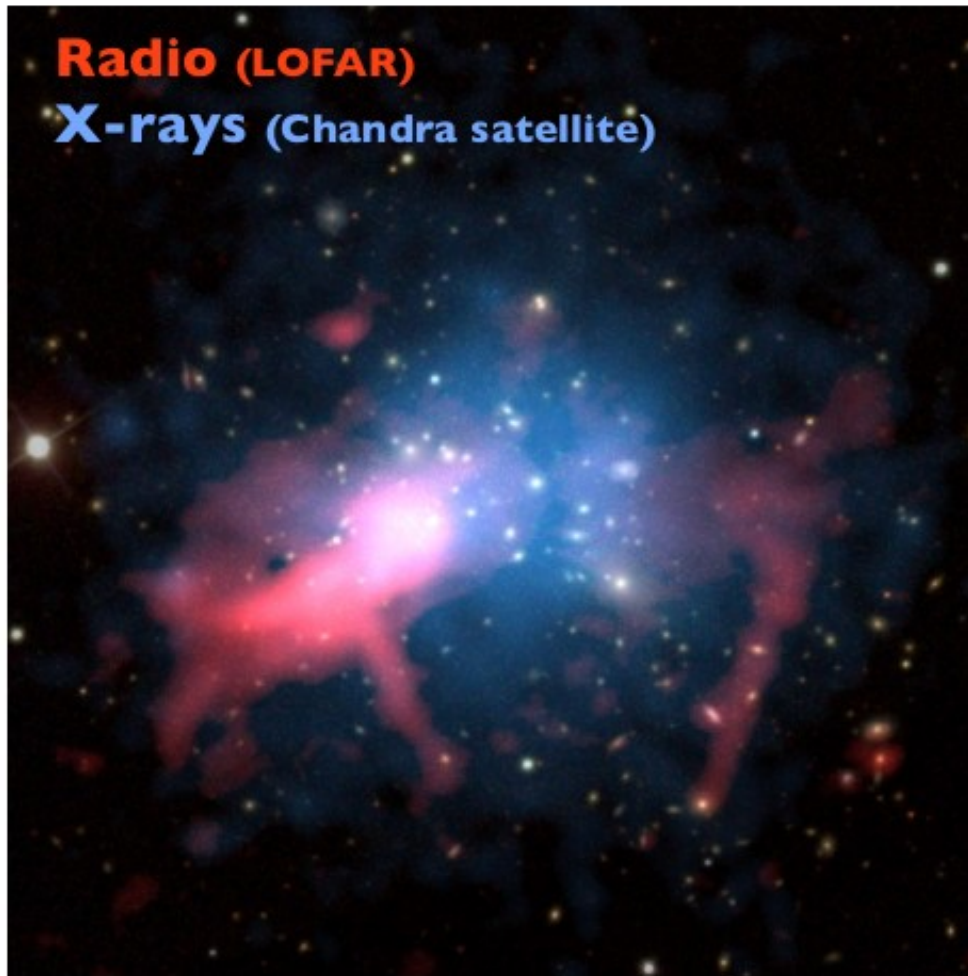
**Savini et al. In
prep**

Galaxy clusters

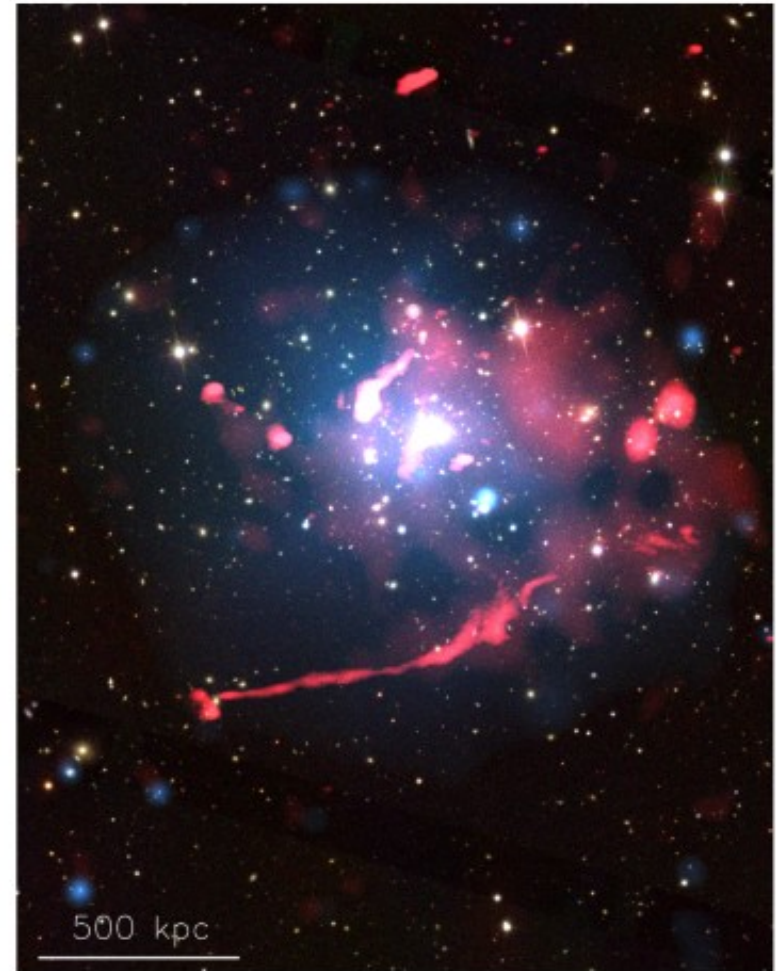
See Chiara Ferarri talk

Abell 1914

Abell 1132

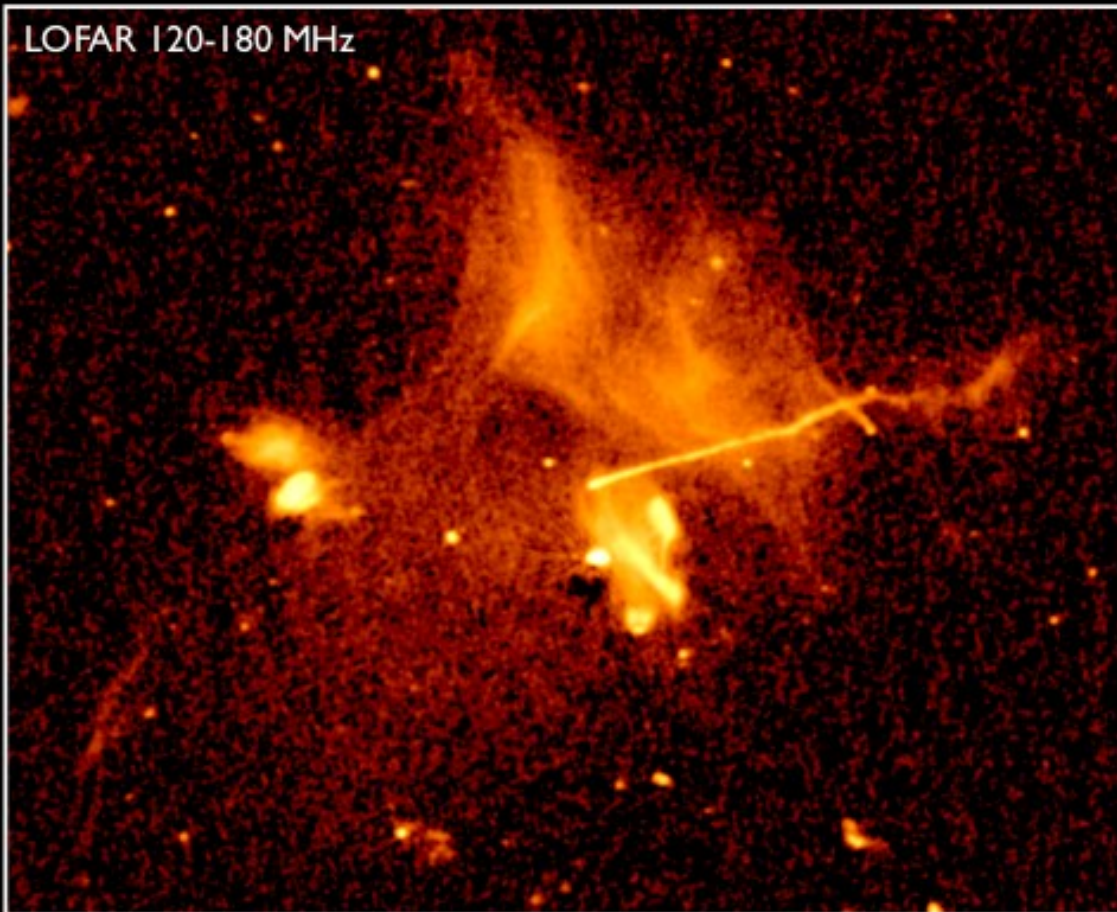


Mandal+ (2018, in prep)

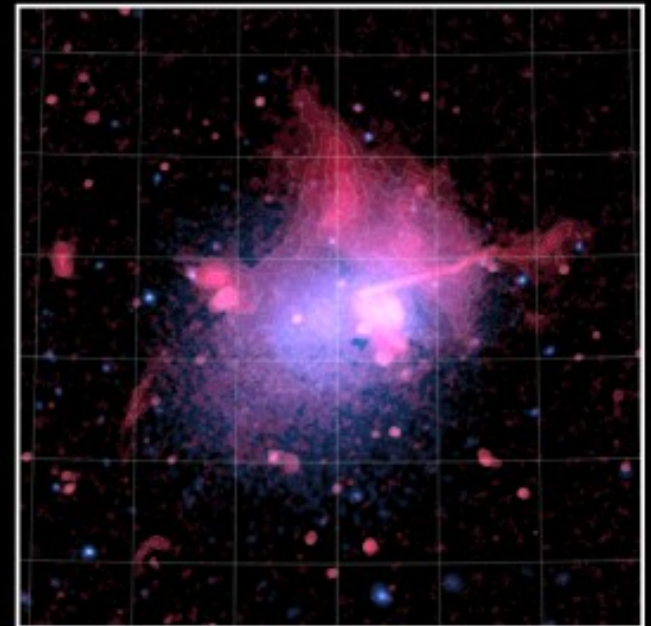


Wilber+ (2017)

ABELL 2256



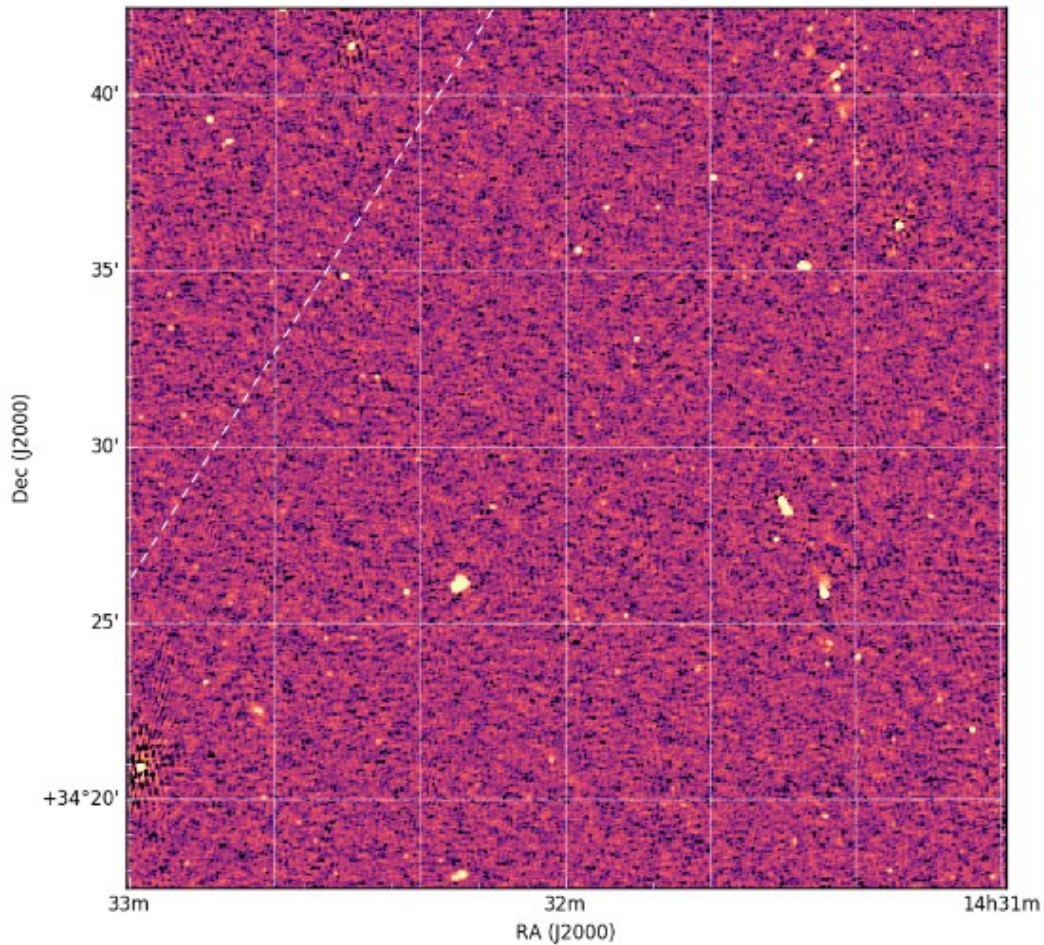
Radio (LOFAR)
X-rays (XMM)



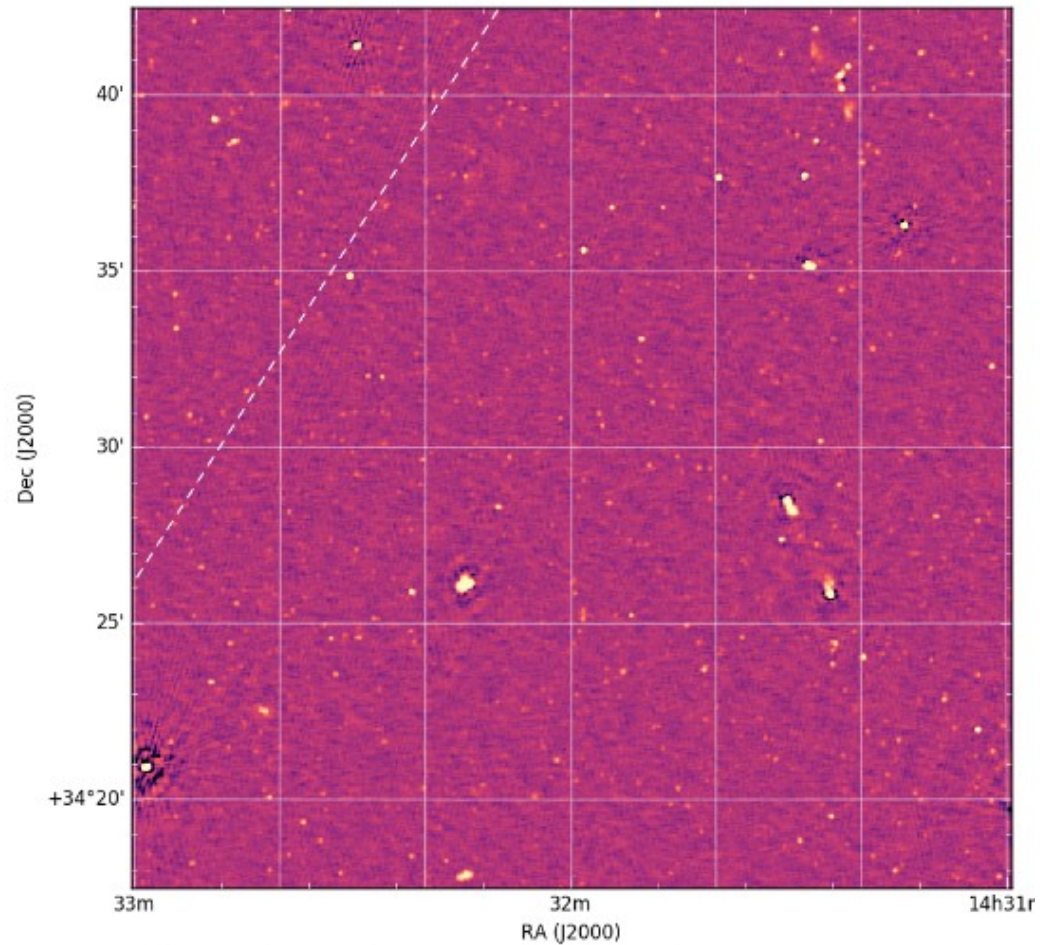
- Merging cluster
- $z = 0.05$

Van Weeren et al. In prep

Tier-2 deep fields



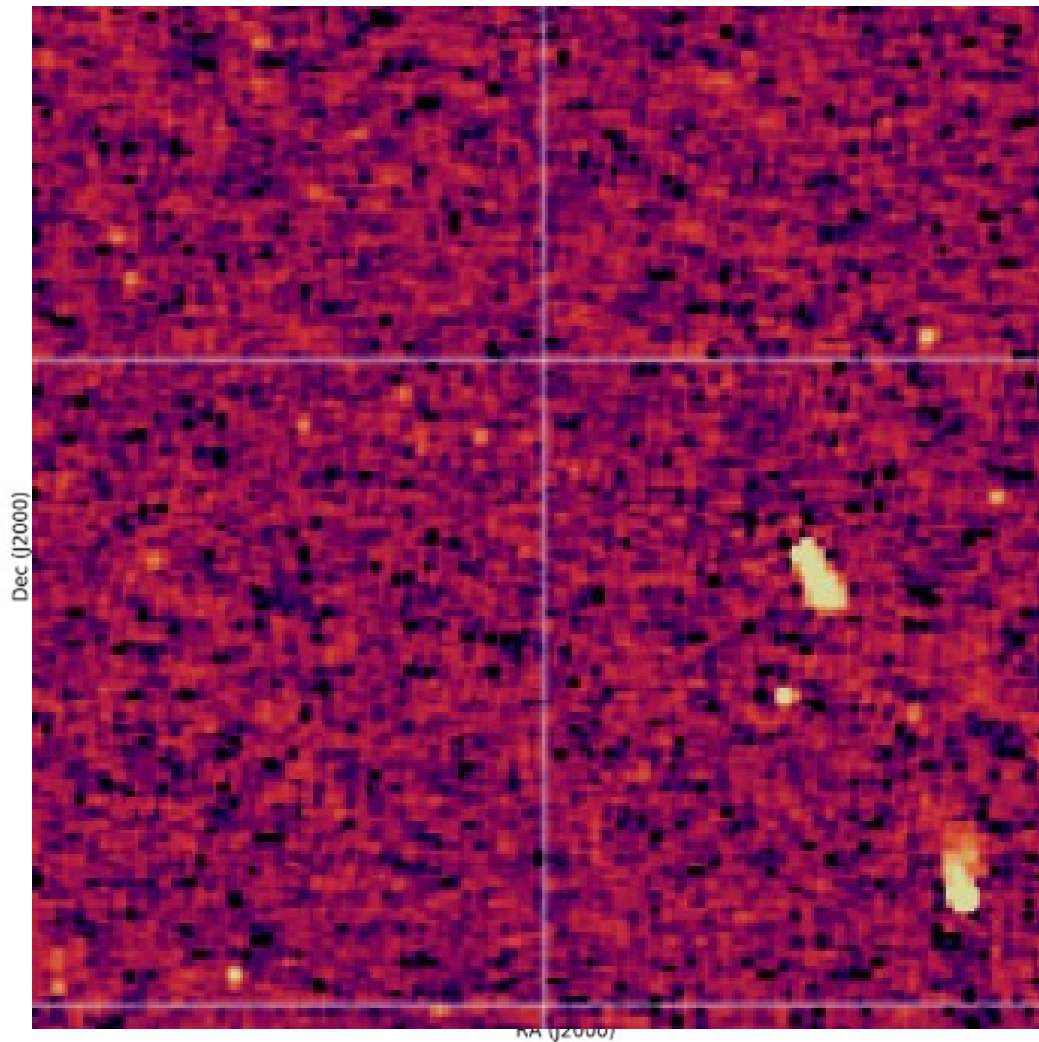
8 hours



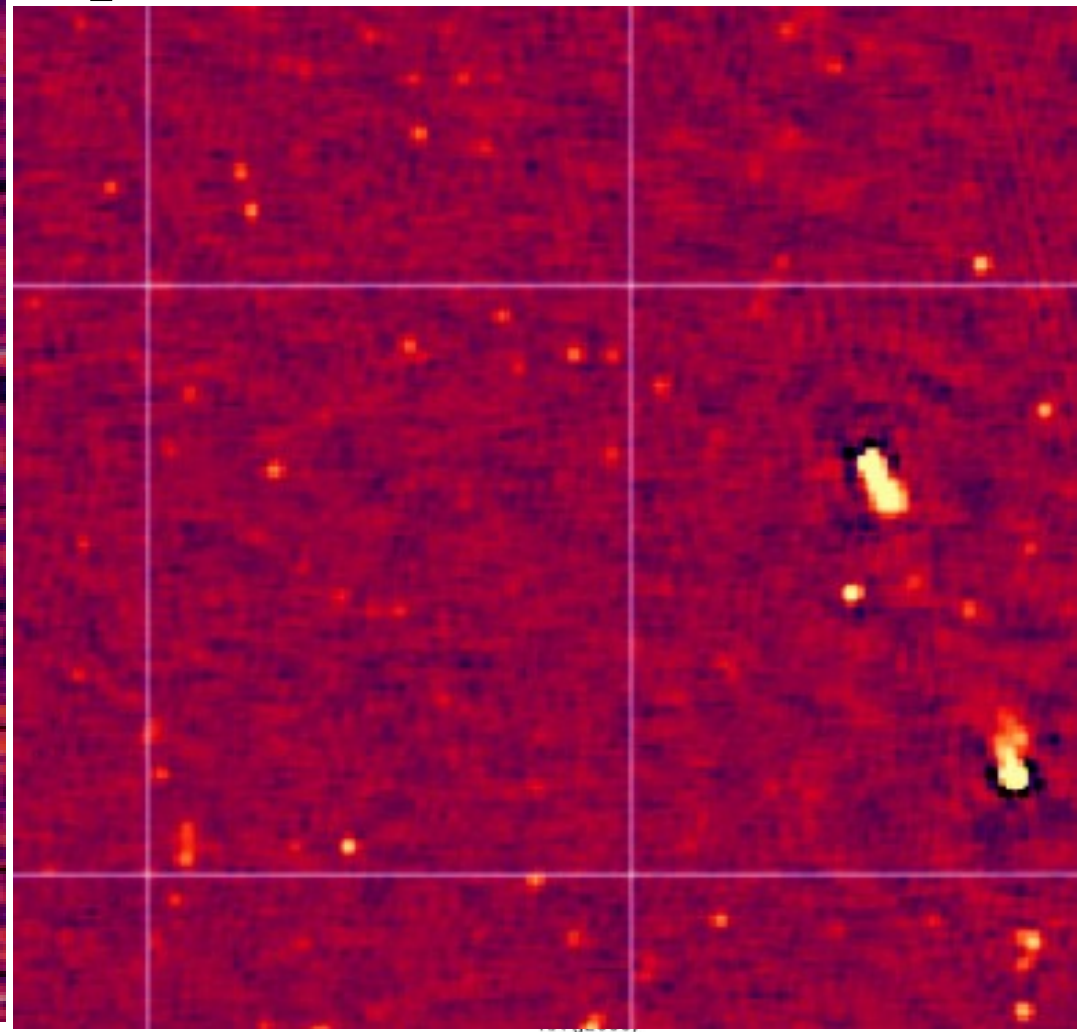
80 hours

Tasse et al. in prep
Mandal et al. In prep

Tier-2 deep fields



8 hours

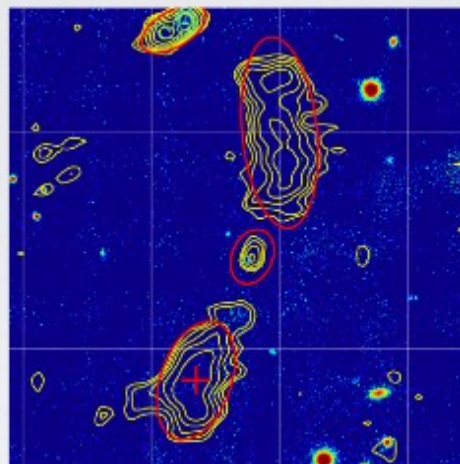


80 hours

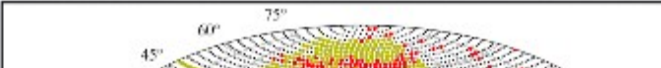
Tasse et al. in prep
Mandal et al. In prep

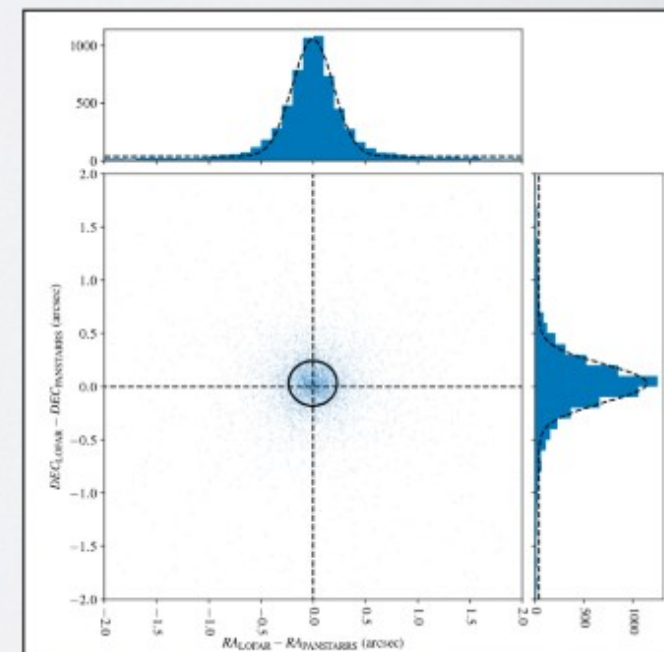
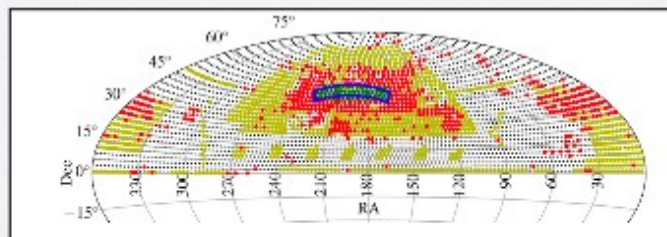
Conclusion

- LOTSS is 1-2 orders of magnitude deeper than any comparable surveys (major contribution from Paris Observatory)
- Value added is released together with the radio maps and catalogs :
 - multiwavelength cross matches
 - Photo-z
 - Host classification
- We also produce polarisation products
- Dynamic spectra (@AlanLoh)
- Lot of new science to be done
 - AGN & star formation history
 - AGN Feedback and duty cycle
 - Magnetism (galactic and extragalactic)
 - Galaxy cluster & large scale structure
 - Cosmology
 - Transiant universe

[illegible]

WISE
LOFAR contours
radio source components

- value added catalog:
 - 73 % of radio sources has optical counterpart
 - Automatic matching
 - LOFAR Galaxy Zoo for complex sources
 - 318,542 radio sources
 - 424 deg²
 - positional accuracy: 0.2 arcsec
- 



Shimwell+ (2018); Williams+ (2018); Duncan+ (2018)