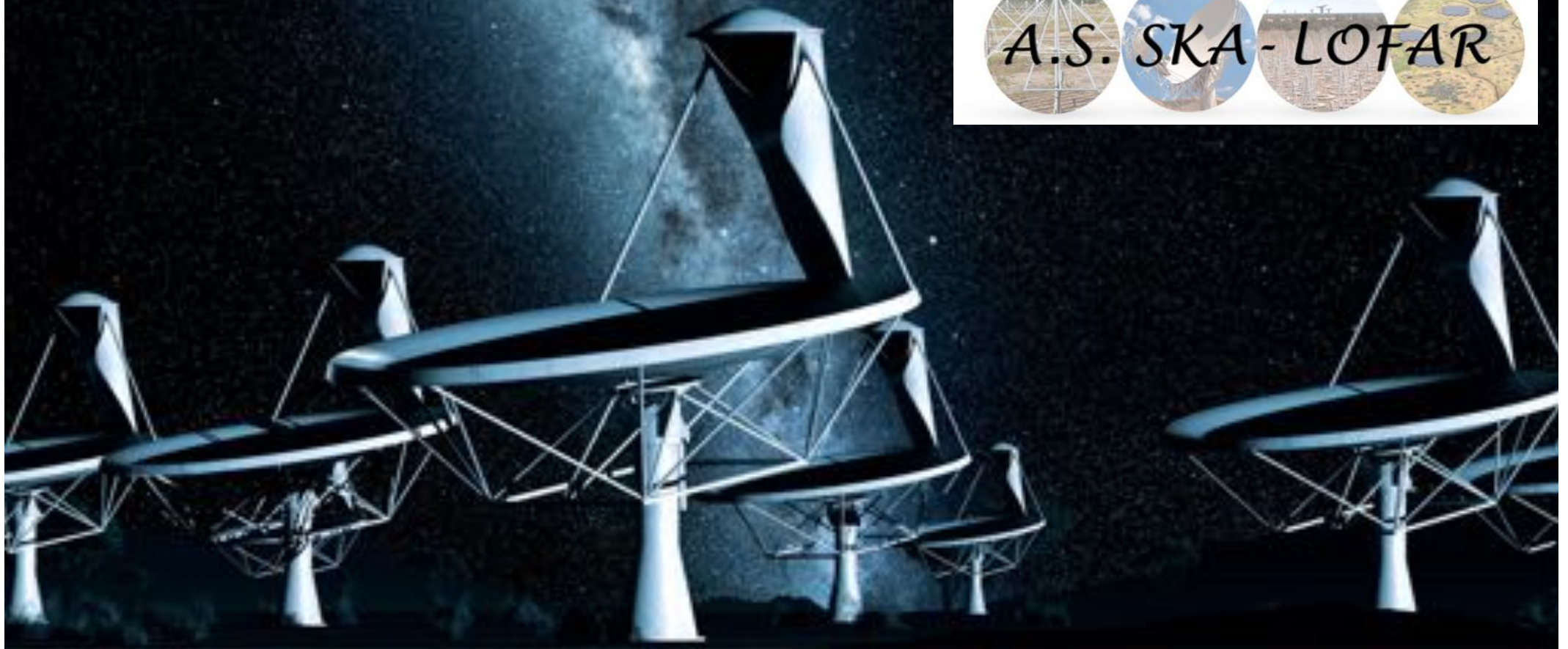


SKA PATHFINDERS & PRECURSORS

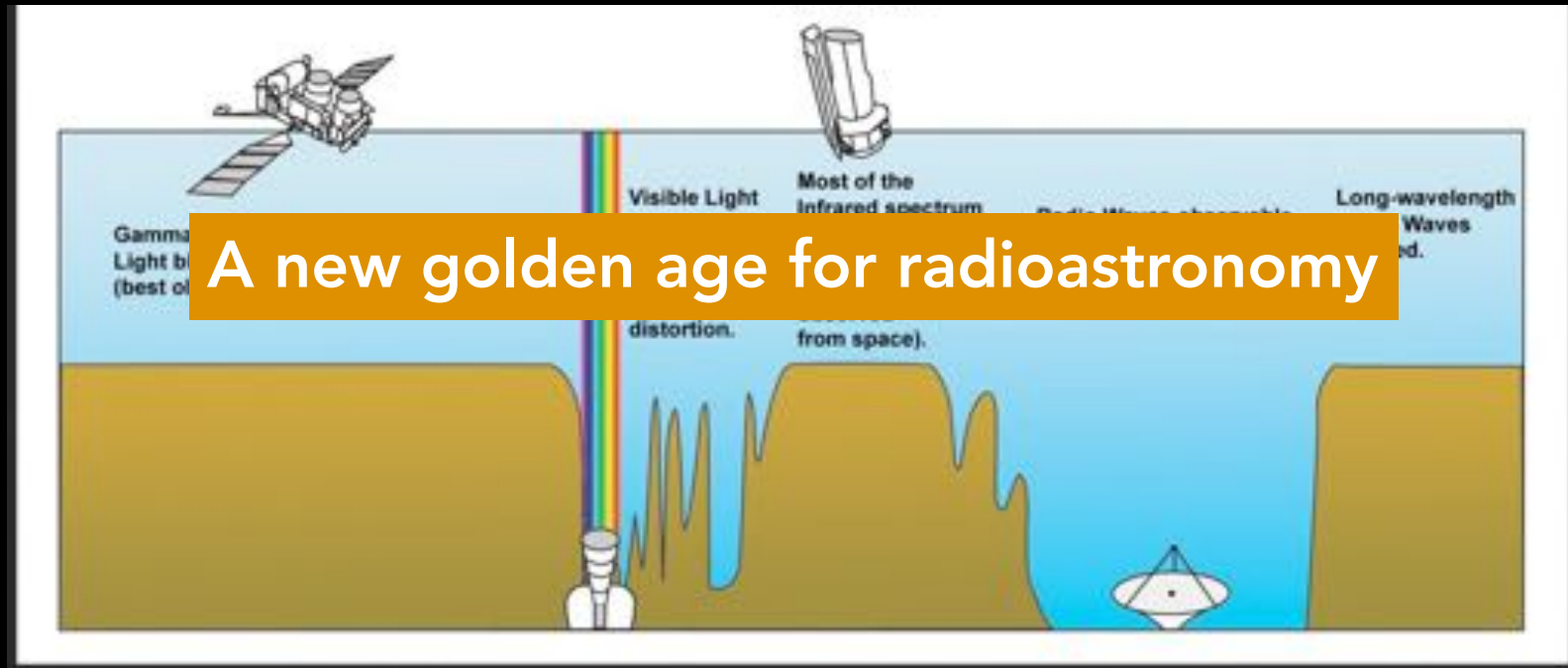
S. CORBEL (UNIV. P. DIDEROT & CEA SACLAY & OBS. PARIS)



FIRST RESULTS FROM LOFAR SURVEY
@150 MHZ.

C. TASSE (OBS. PARIS/GEPI)

MINUTE BREAK: RADIOASTRONOMY



Phased arrays

v.s.

pointed telescope



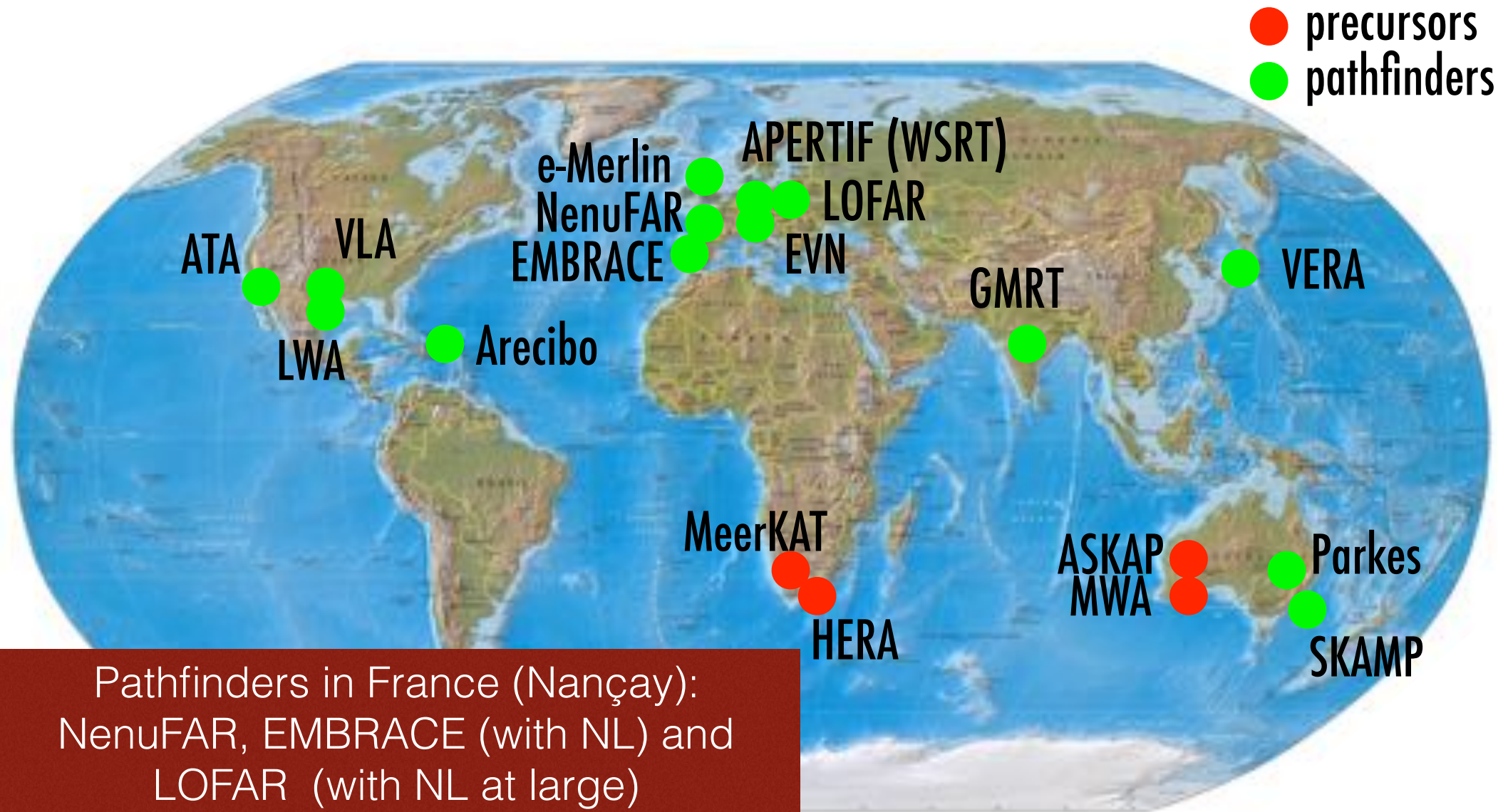
Science @ radio frequencies

- **Hydrogen signature @ 1420 MHz → early Universe, emission redshifted to low frequency:** probing the cosmic dawn, epoch of reionisation, galaxy evolution, ...
- HI for **mapping the evolution of the Universe** : towards 1 billion of galaxies in HI
- **Fundamental physics with pulsars** and detection of gravitational waves.
- Cosmic **magnetism** (from polarisation studies) and **ISM**
- **Planet**, the Sun, **stars** and **interactions**
- **Transients**
- **Multidisciplinary** fields, **Synergies**: ALMA, Euclid, JWST, SVOM, CTA, ...

SKA pathfinders & precursors

- **Precursor (=précurseur)**: A telescope on one of the two construction sites
- **Pathfinder (=éclaireur)**: SKA-related technology, science and operations activity
- To apply for a designation, **an “SKA Contribution” must satisfy** one or more of the **following criteria** in the areas of technology, science and operations:
 - it contains **new technical elements** that have not been tried before on the scale of a large telescope and which are part of the SKA Baseline Design – **technology**;
 - it will carry out **observational tests**, both simulated and real, that explore **new capabilities** at flux density and dynamic range levels similar to or scalable to the full SKA – **science**;
 - it tests **methods of scheduling and allocating** time similar, or scalable to, that needed for the SKA – **operations**.

SKA pathfinders/precursors



ULTIMATE GOAL: TOWARDS SKA

See presentation by C. Ferrari
of Maison SKA-France



**Please note, no financial contribution from France ~ no SKA data
So important to be involved NOW !**

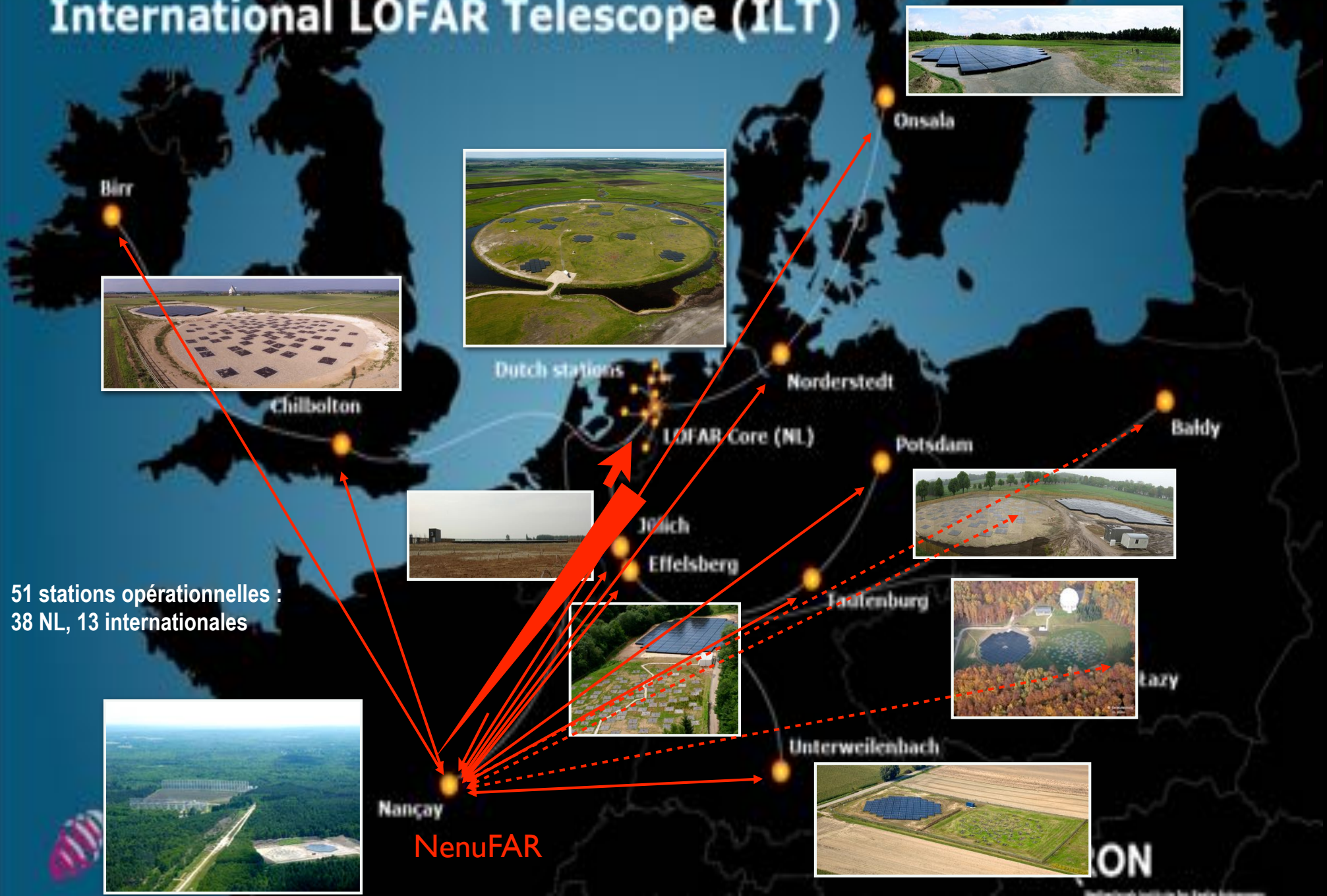
SKA pathfinders (=éclaireurs)

LOFAR
NenuFAR



LOFAR: FIRST INSTRUMENT OF A NEW GOLDEN AGE OF LF RADIOASTRONOMY

International LOFAR Telescope (ILT)



International LOFAR Telescope (ILT)

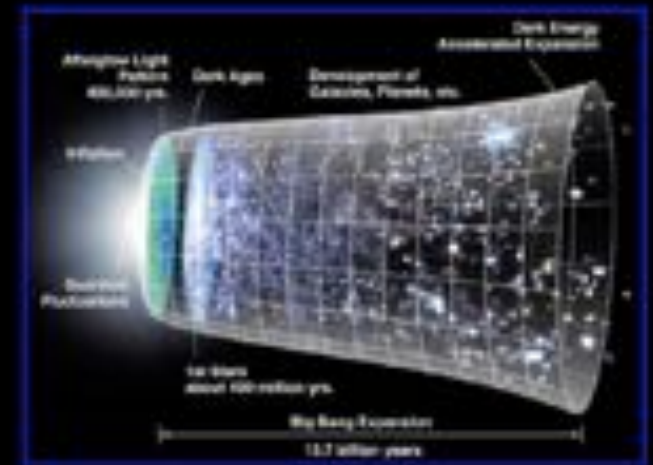
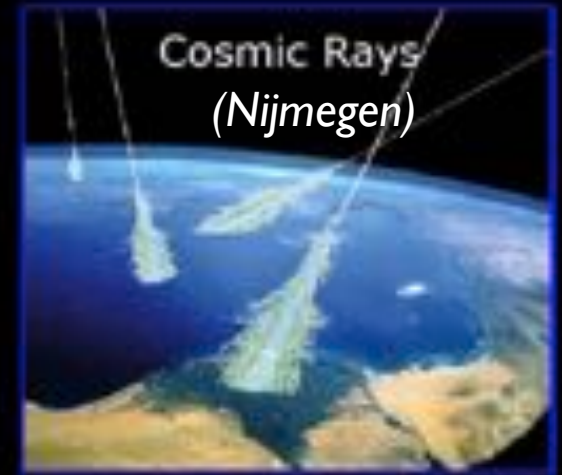
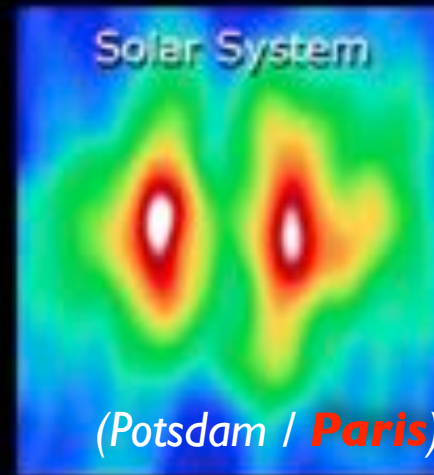
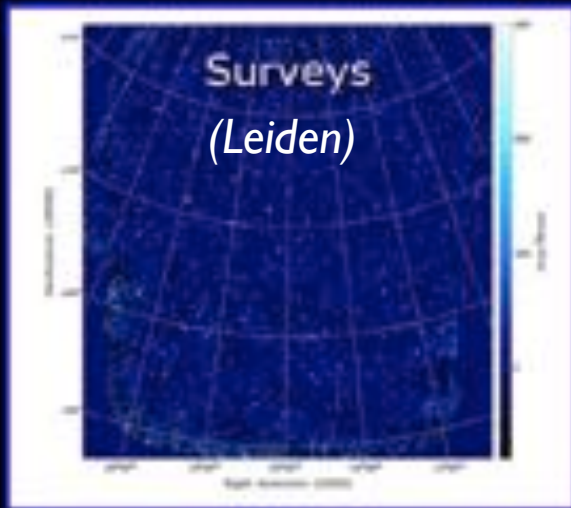


51 stations
38 NL, 13

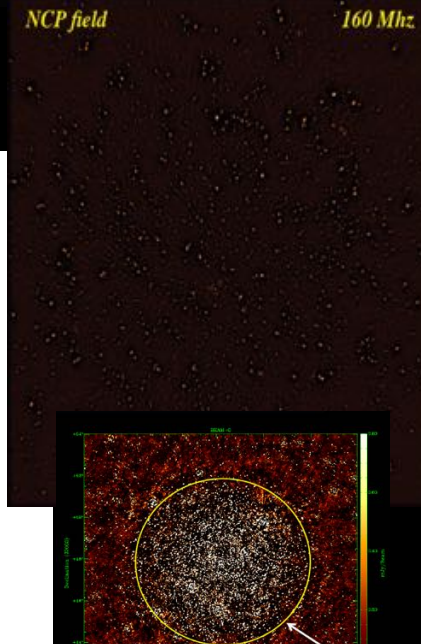
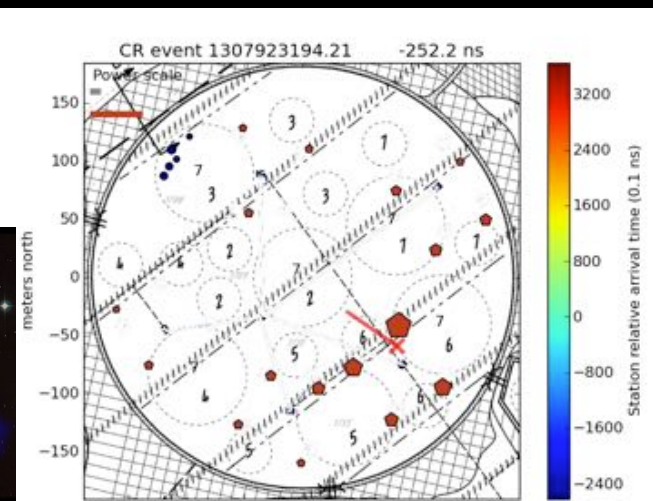
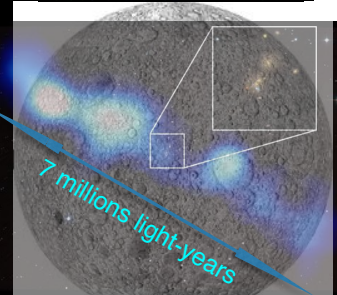
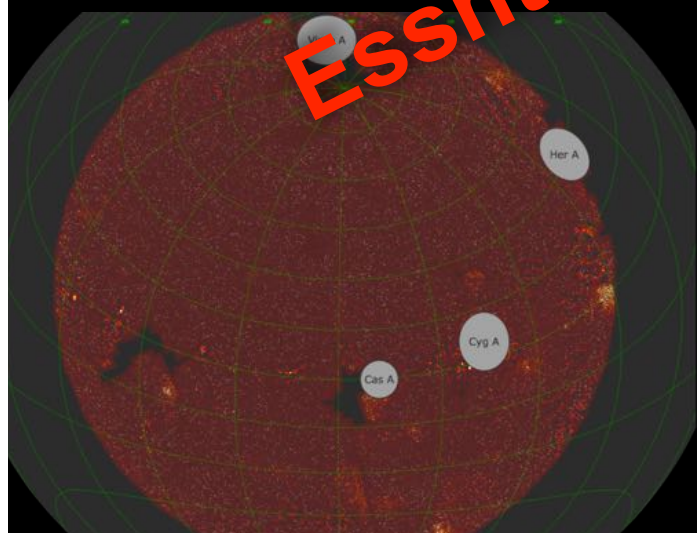
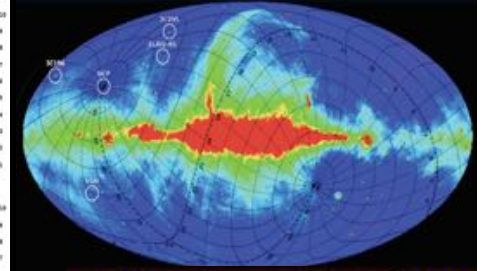
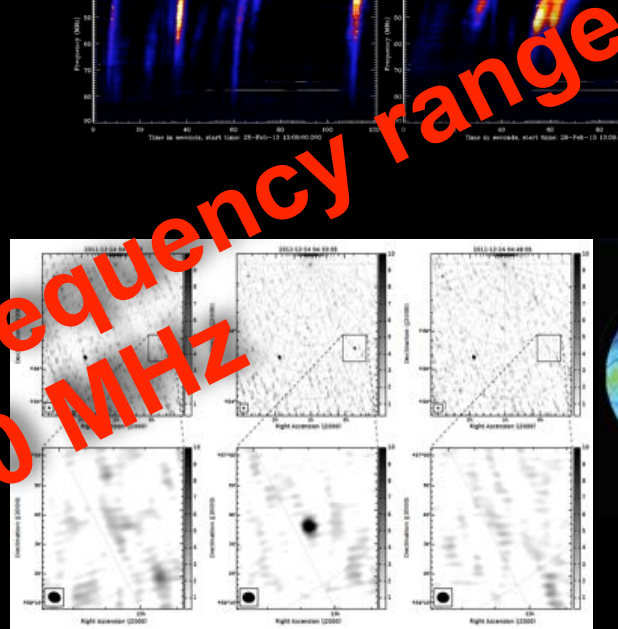
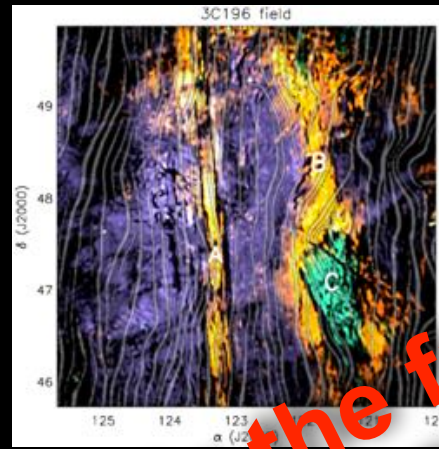
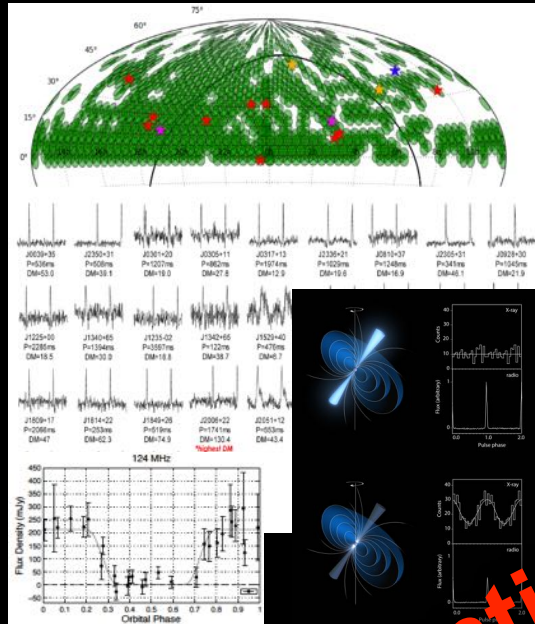
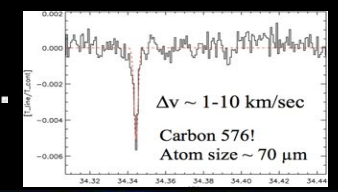
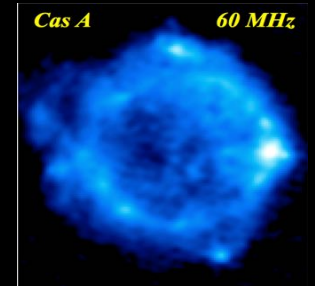
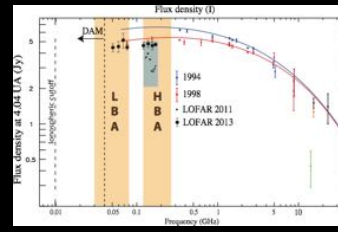
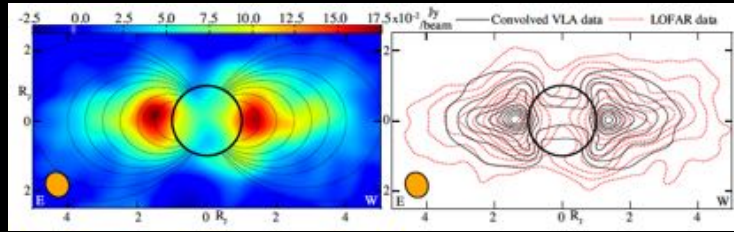
**+2 new station in
Latvia and Italy**

**See more with C.
Tasse**

LOFAR KEY SCIENCE PROJECTS



Some scientific results



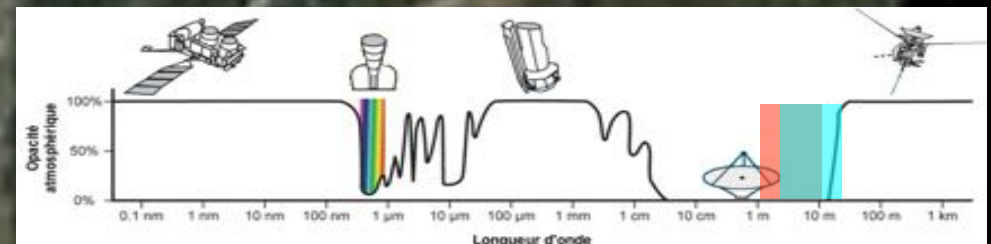


... NenuFAR

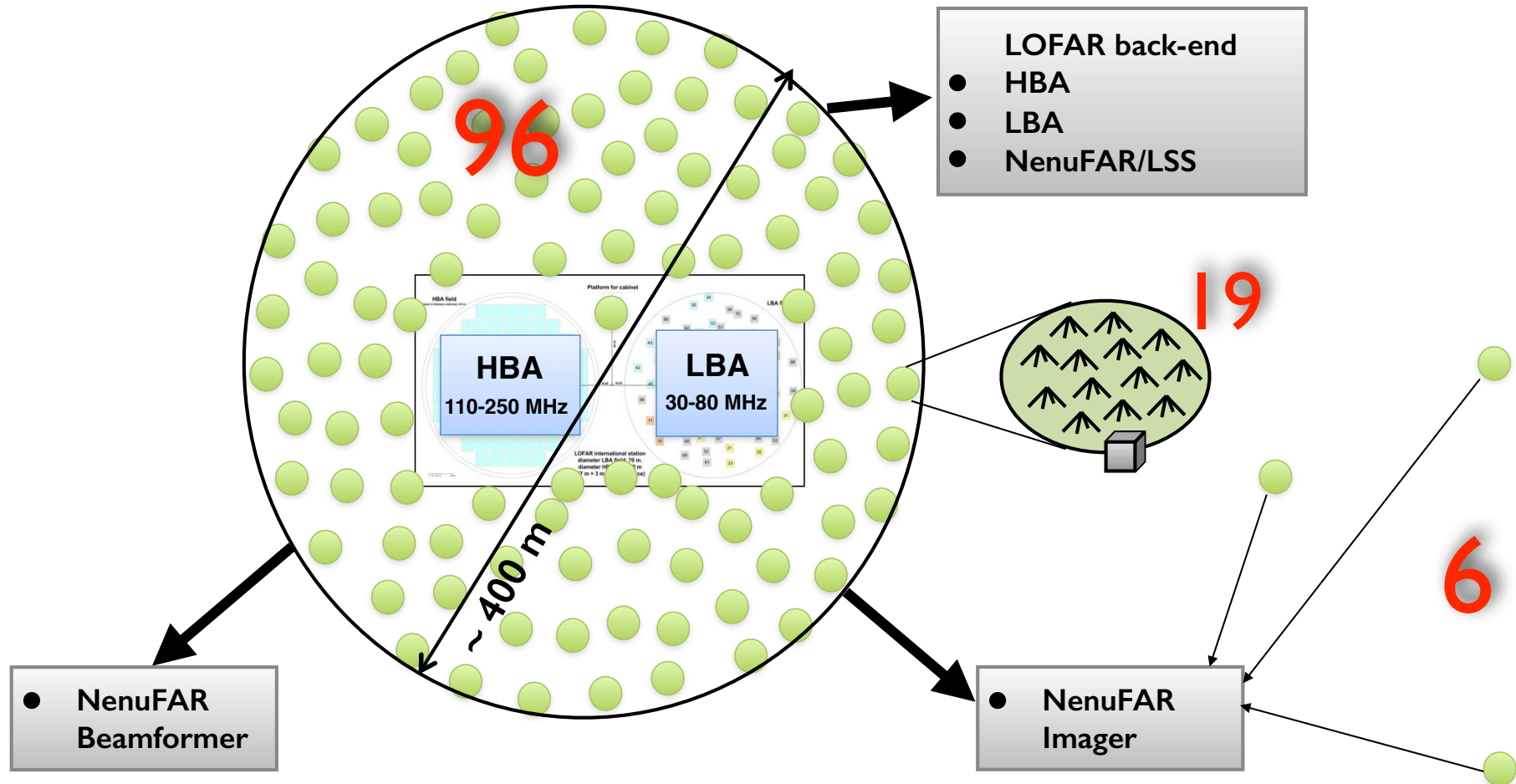
New extension in Nançay upgrading LOFAR



PI: P. Zarka/ M. Tagger
with L. Denis



Le concept de NenuFAR



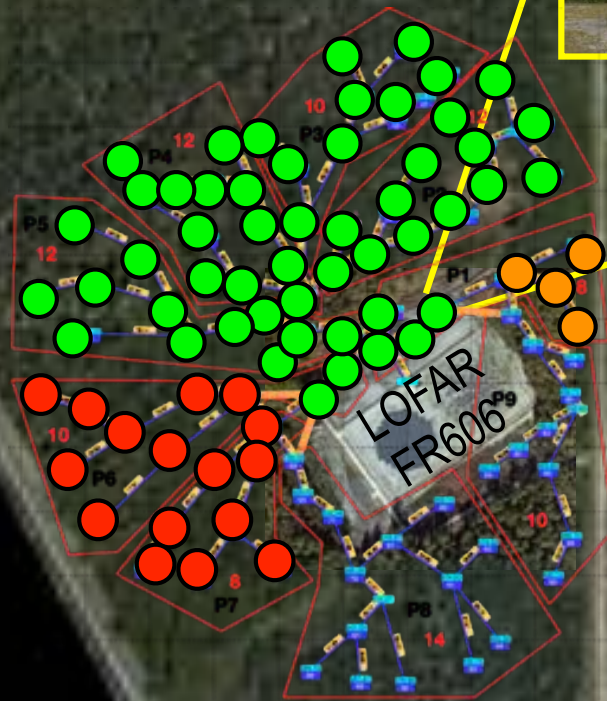
Beamformer, Imageur, Station géante LOFAR (Pulsar machine, SETI machine)

$(96+6) \text{ Mini-Réseaux} \times 19 \text{ antennes} = 1938 \text{ antennes}++$
($>$ LOFAR), Sensibilité 2-8 x LOFAR, 10-85 MHz,

Déploiement

72 MR coeur financés, 52 construits & opérationnels

988 antennes construites, 494 à venir, 456 restent à financer
80 % de NenuFAR disponible l'année prochaine !



- opérationnel
- à construire en 2018
- à construire en 2019
- à construire en 2019 (NRI)

Science:

Binary & Eruptive stars
Exoplanets
Pulsars & Rotating radio transients
ISM structure
Dark ages, $z \sim 20$
Transient Universe
Sprites & elves

SKA precursors (=précurseurs)

ASKAP
MeerKAT



SKA PRECURSORS: ASKAP

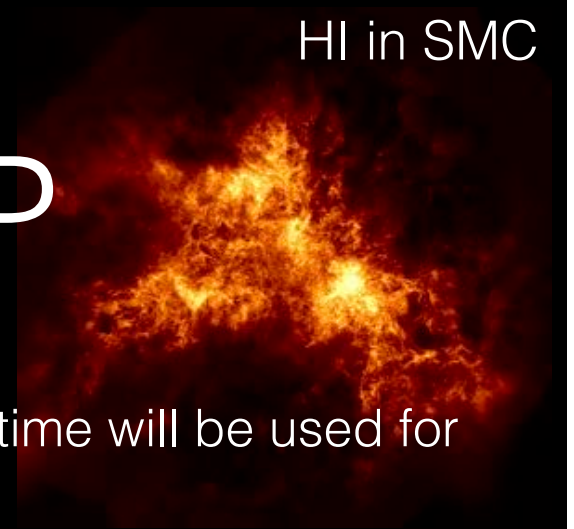


- Location: Australia
- Max Baseline : 6 km
- Frequency coverage: 0.7-1.8 GHz
- 36 antennas (12 m) with PAF (30 deg² FOV), 16 avail. —> 24 now integrated.
- Full ASKAP operational early 2019 at shared risk.



**Large FOV
—> Surveys**

Science with ASKAP



- During ASKAP's first five years of operation at least 75% of its time will be used for large Survey Science (>1500 hr).
- Selection of **ten projects** in 2009 (likely reassessments in the near future):
 - E.g. Evolutionary Map of the Universe (EMU), PI: Norris. —> deep (10 μ Jy/beam rms) radio continuum survey of 75% of the entire sky.
 - An ASKAP Survey for Variables and Slow Transients (VAST). PI : Murphy, Chatterjee
 - Polarization Sky Survey of the Universe's Magnetism (POSSUM), PI: Gaensler, McClure Griffiths & Heald
 - The Commensal Real-time ASKAP Fast Transients survey (CRAFT). PI : Hall
 - + VLBI, magnetism, galaxies, pulsars and fast transients...
- See: <https://www.atnf.csiro.au/projects/askap/science.html>

SKA PRECURSORS: MEERKAT

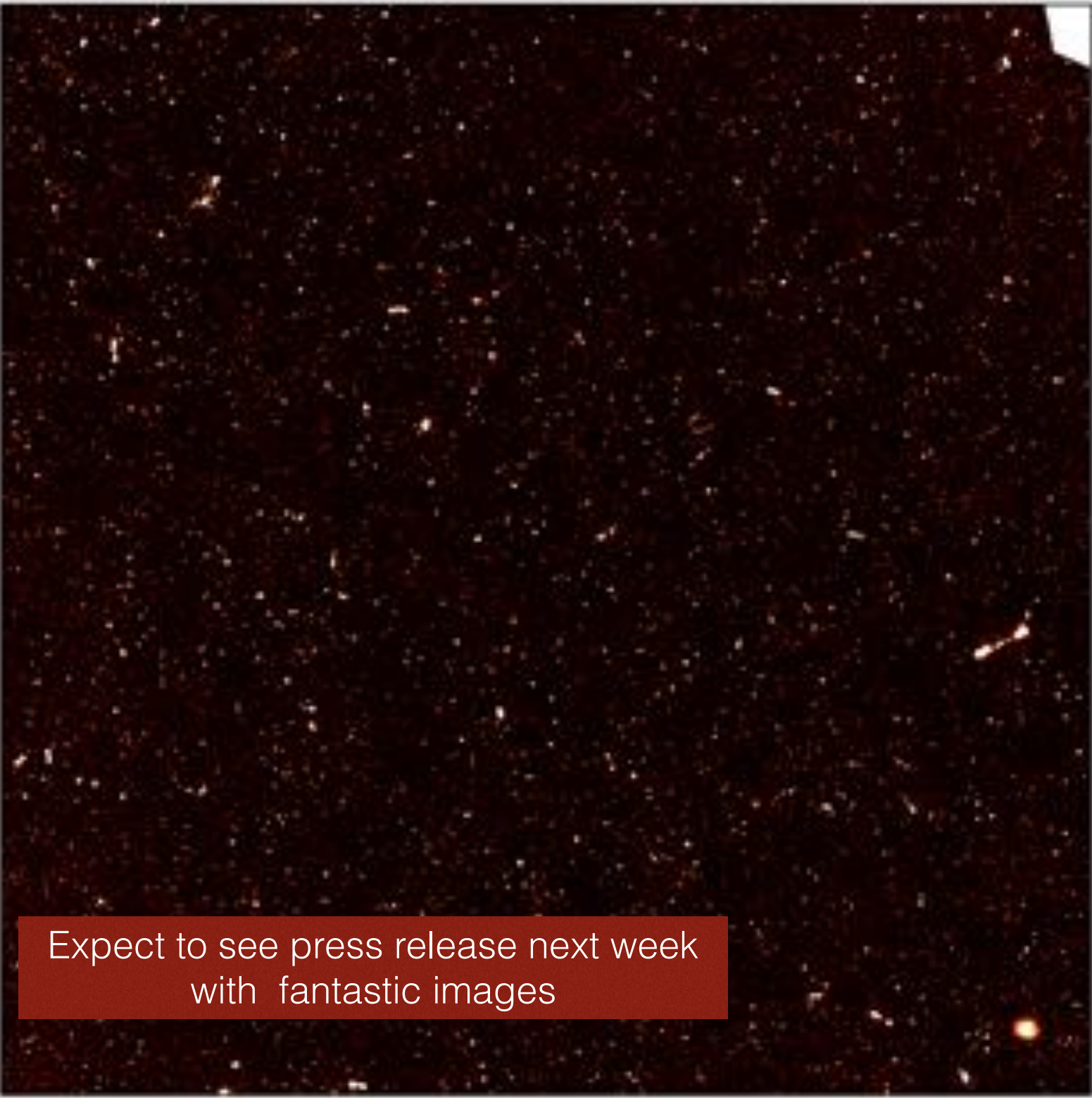


- Location: South Africa
- 64 antennas (13.5 m) over an 8-km baseline
- Frequency coverage: 0.5-10 GHz
- FOV: 1.69 deg^2 @ 1 GHz
- Fully deployed in March 2018 (32 in march 2017)
- Inauguration next week



Science with MeerKAT

- 2010: Call for large (> 1000 hr) survey projects (70% allocated). Good contribution from the French community. Updated in 2017. -
 - + 30% for smaller PI driven proposals (of which 5% will be DDT). Call for Proposal expected at some point.
- Priority 1 programmes:
 - **Radio pulsar timing** (PI: M. Bailes): Testing Einstein's theory of gravity and gravitational radiation - Investigating the physics of enigmatic neutron stars through observations of pulsars.
 - LADUMA (Looking at the Distant Universe with the MeerKAT Array) - An **ultra-deep survey of neutral hydrogen gas in the early universe**. PI: Blyth, Holverda, Baker.
- Priority 2 programs, e.g : transients, pulsars, radiogalaxies, galaxy formation, VLBI, ...



Commissioning
image of
MeerKAT

16 ant.
 $1.3^\circ \times 1.3^\circ$
1.4 GHz
rms $\sim 6.5 \mu\text{Jy}$

Goal with full
array $\sim 1 \mu\text{Jy}$

Expect to see press release next week
with fantastic images

Ref: Fender
(private com)

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

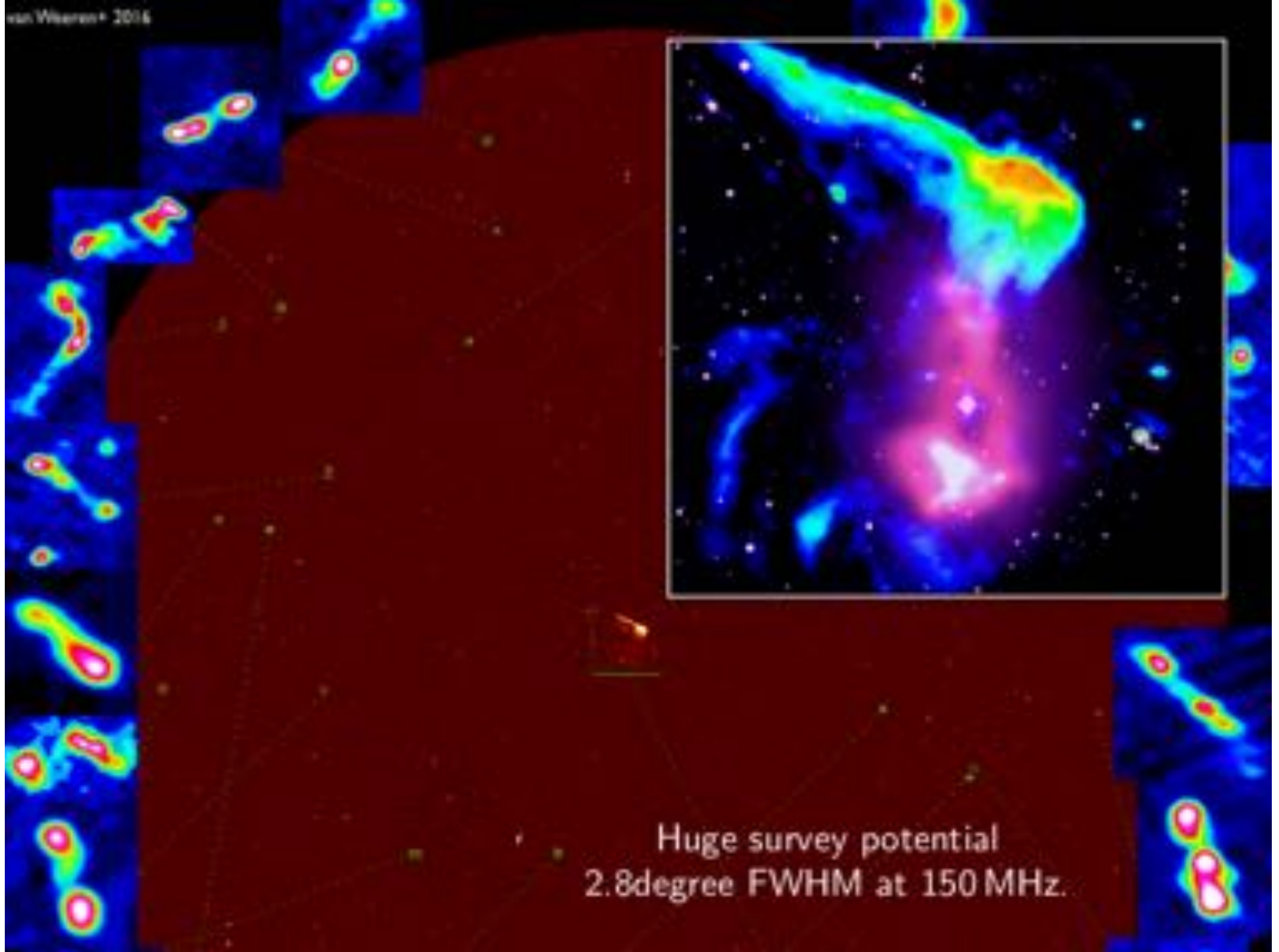
Cyril Tasse

*Observatoire de Paris – GEPI/USN
Rhodes University*

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



Huge survey potential
2.8degree FWHM at 150 MHz.

The LOFAR extragalactic surveys

Key Science Project

PI: Röttgering

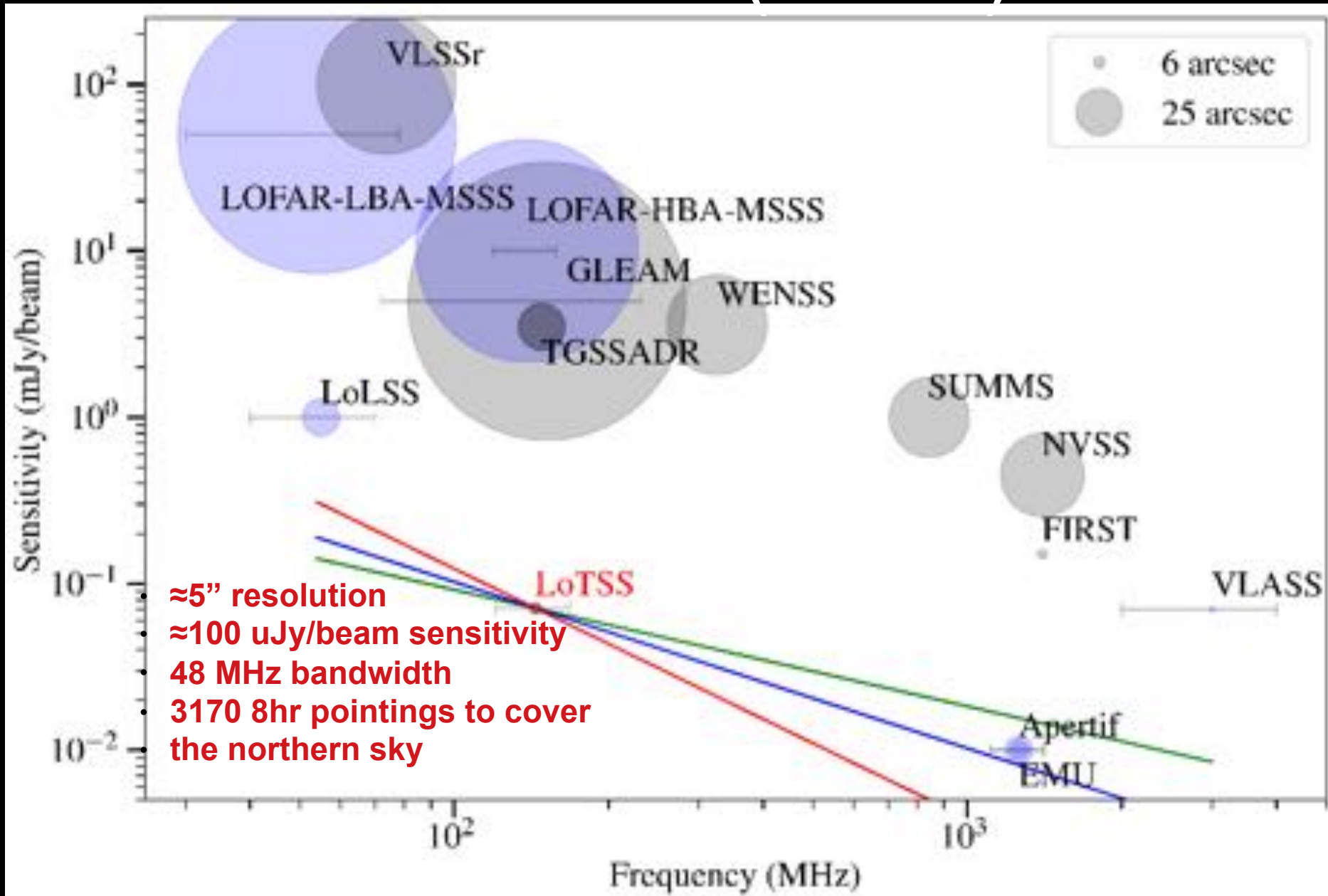
Core team: Best, Brüggen, Brunetti, Chyży, Conway, Haverkorn, Heald, Jackson, Jarvis, Lehnert, McKean, Miley, Morganti, Scaife, Tasse, White, Wise

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
CHANG-ES XIV. A LOFAR and JVLA View of the Star-forming Galaxy NGC 3556	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)

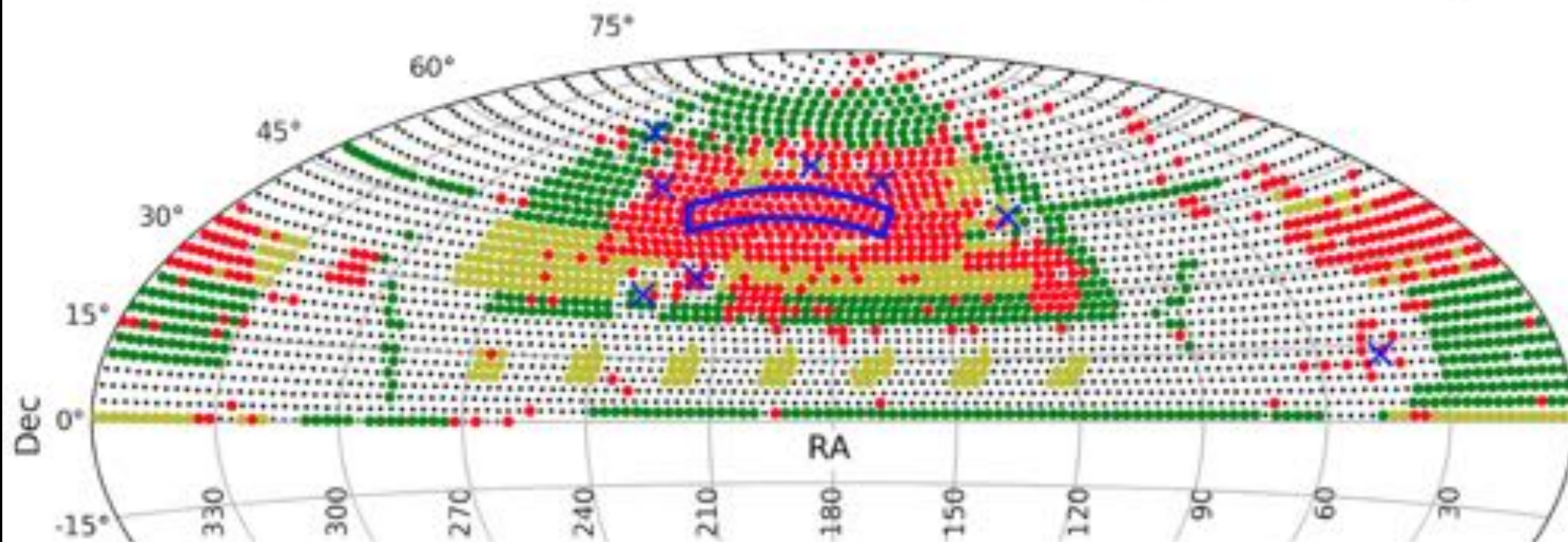


LOTSS : LOFAR Two-meter Sky Survey

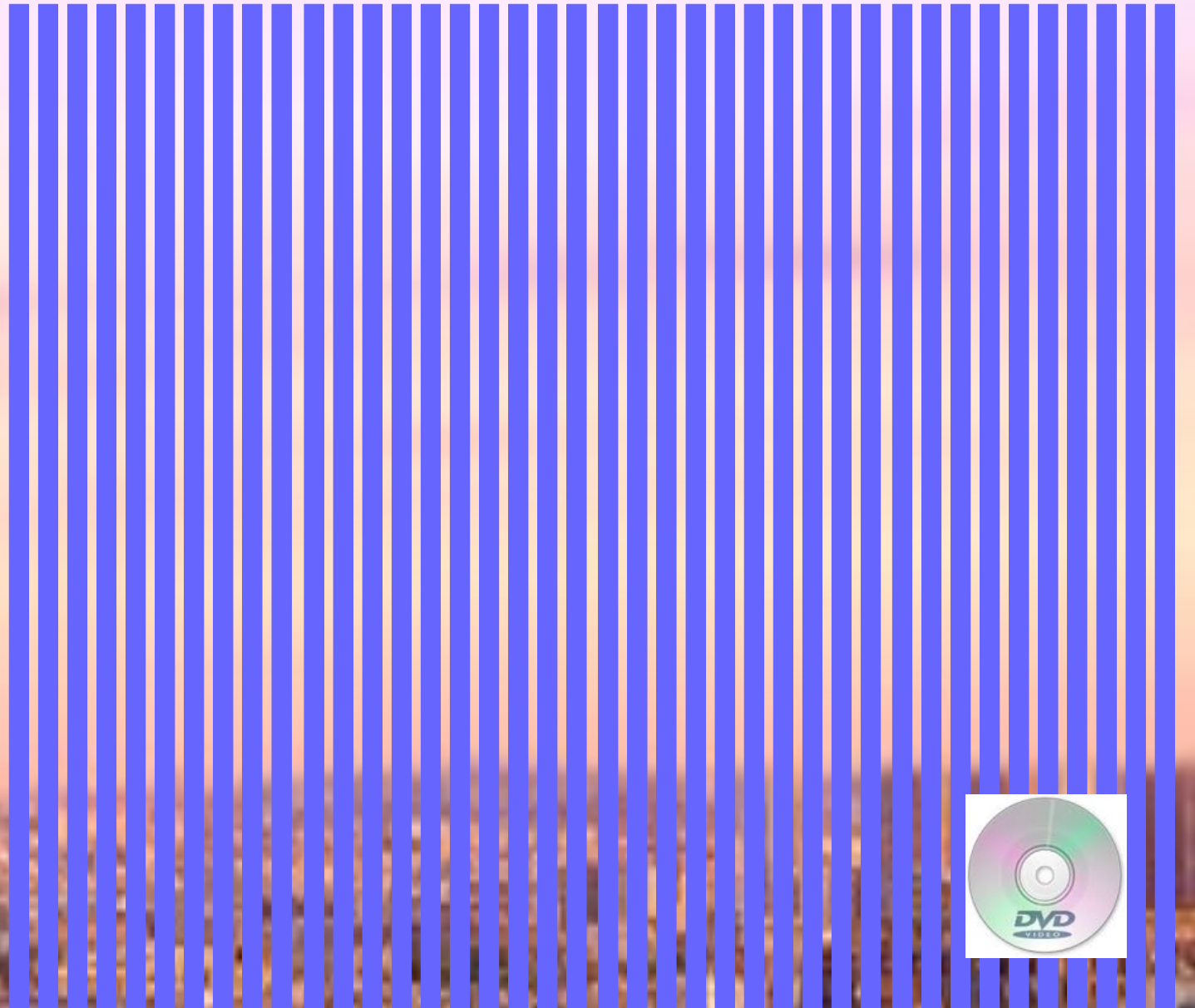
20% of the northern sky is observed.

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.

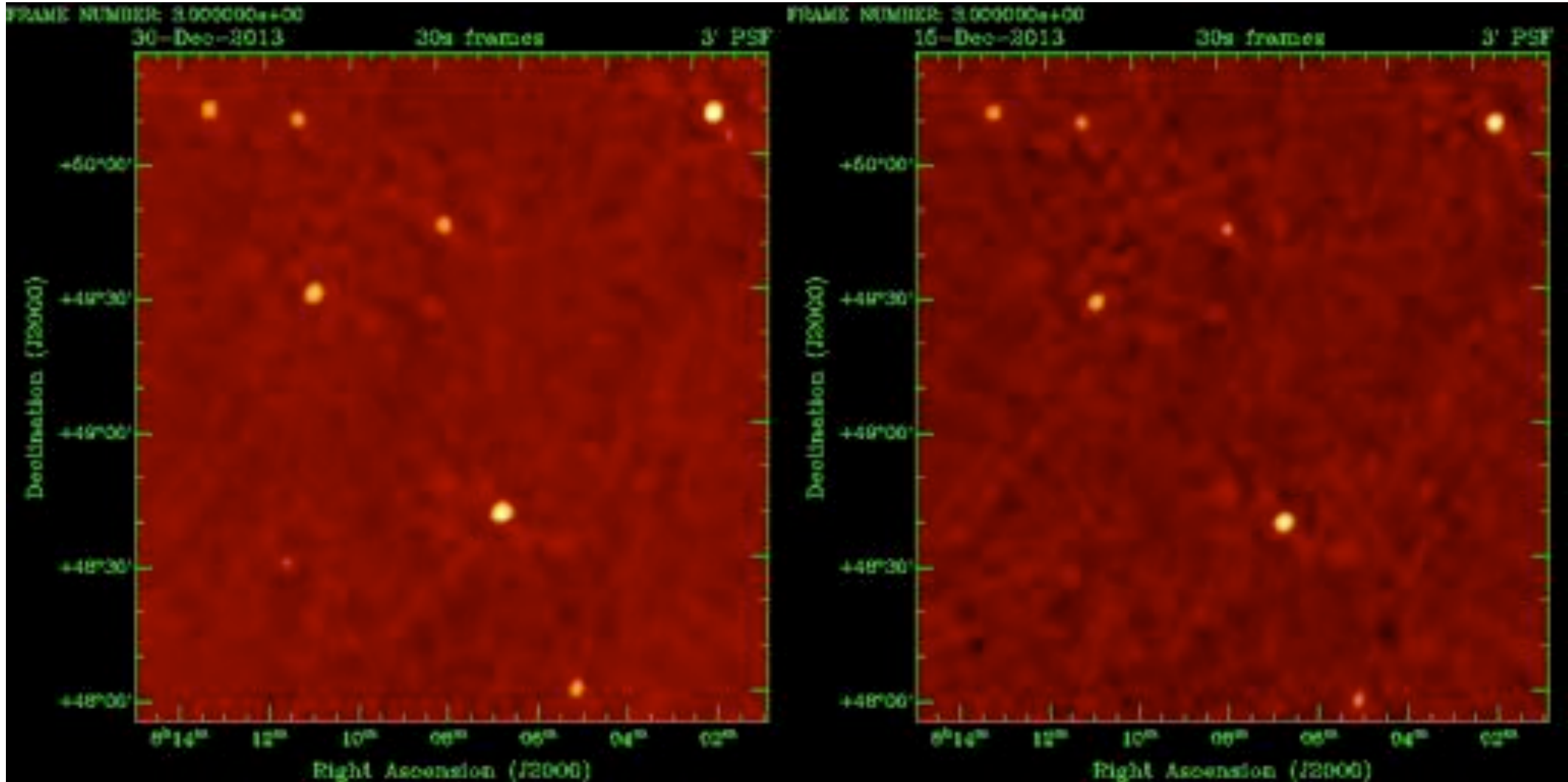


**Tier-1 LOFAR Survey : to be observed
48 Pbytes of Raw data → ~39 Eiffel tower size dvd stacks**

Ionosphere

Good ionosphere

Bad ionosphere

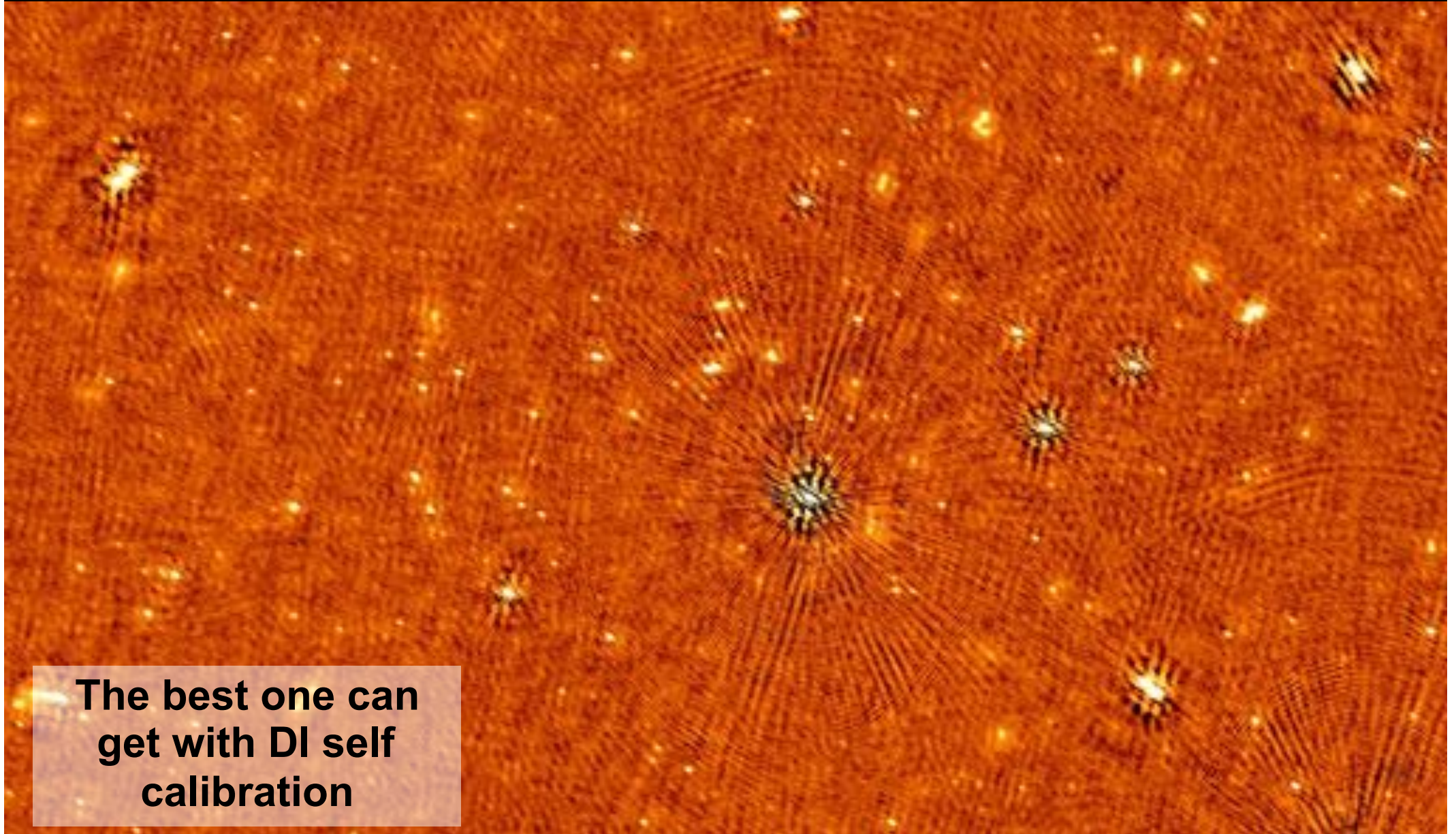


Images have 3 arcmin resolution

Ger de Bruyn & LOFAR EoR team

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

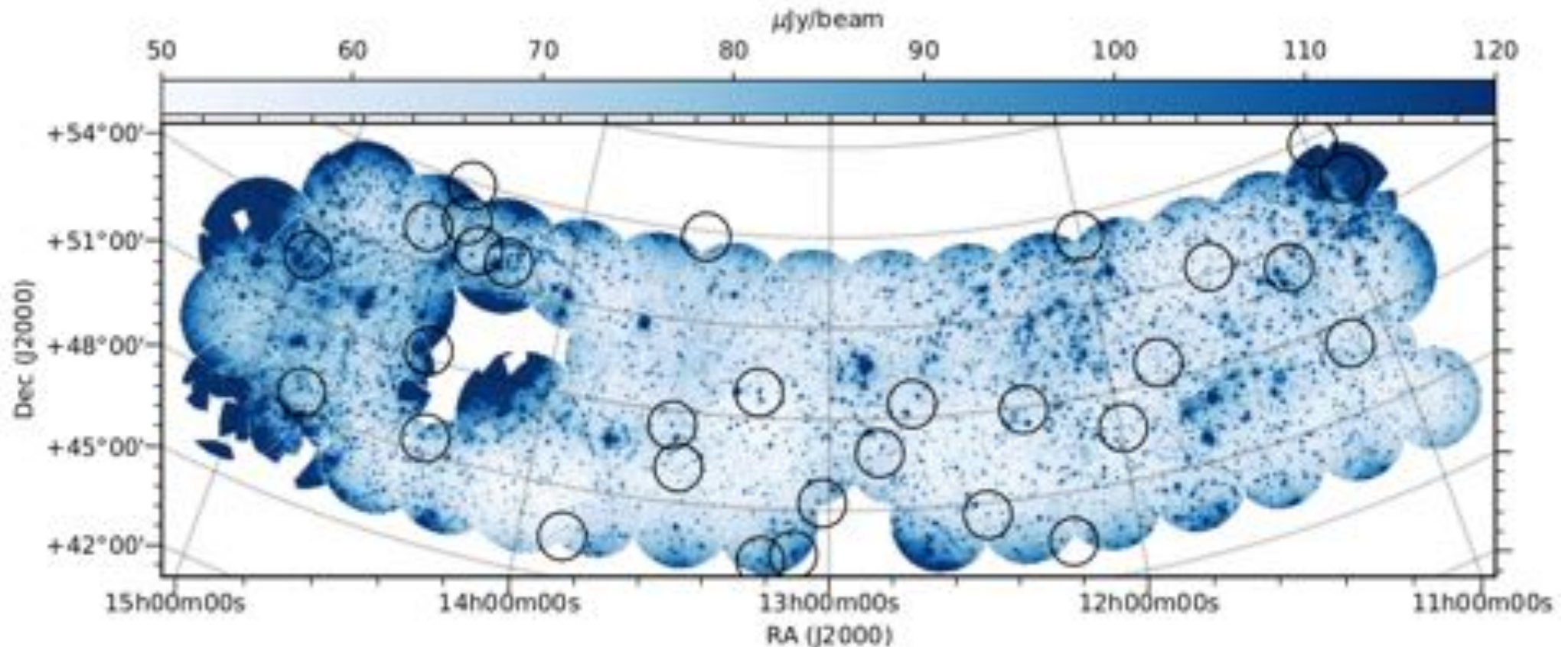
**With Wirtinger
calibration and
imaging**

~ 100 μ Jy/Beam rms

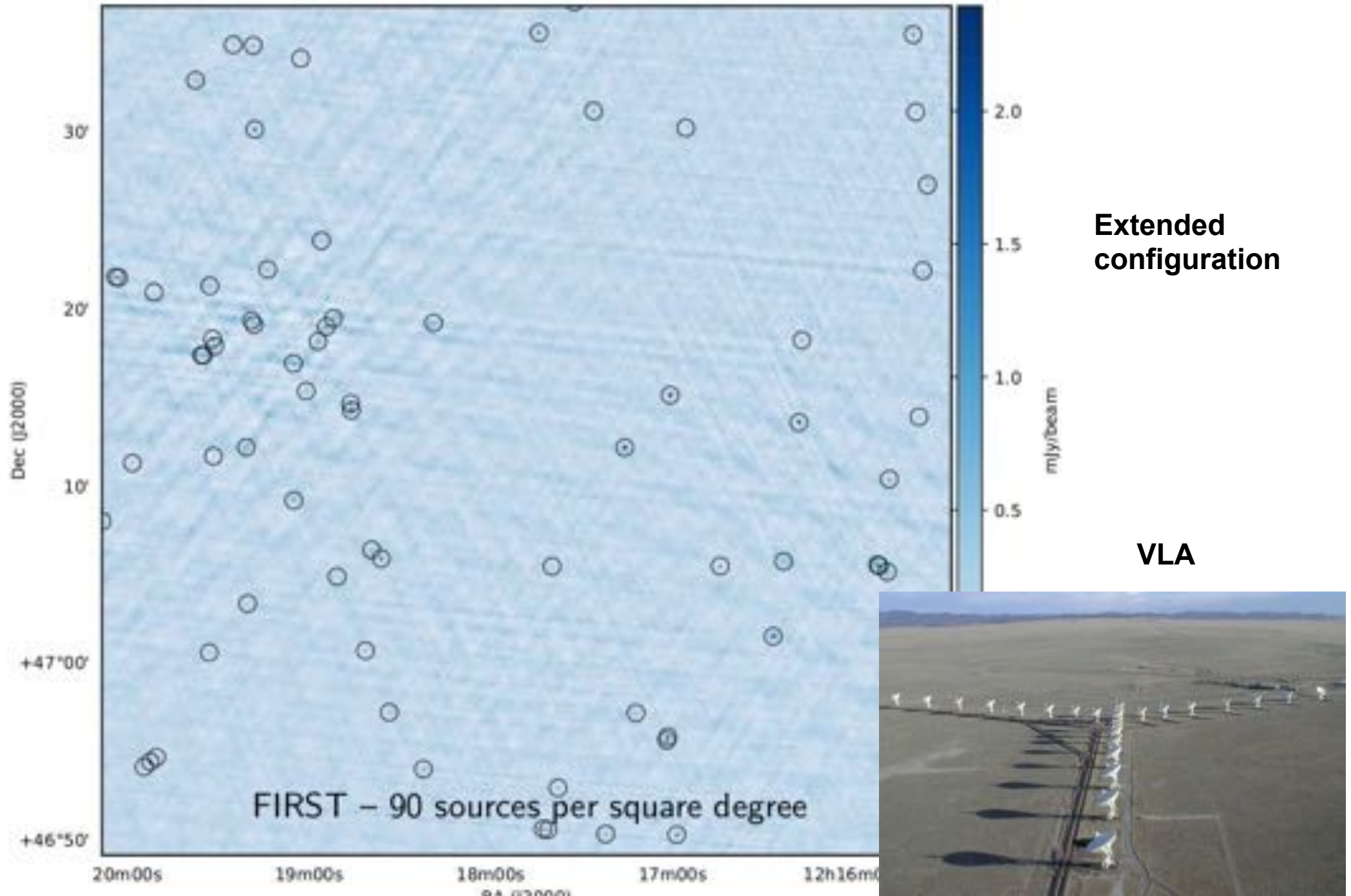
LOTSS – First Data Release

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.

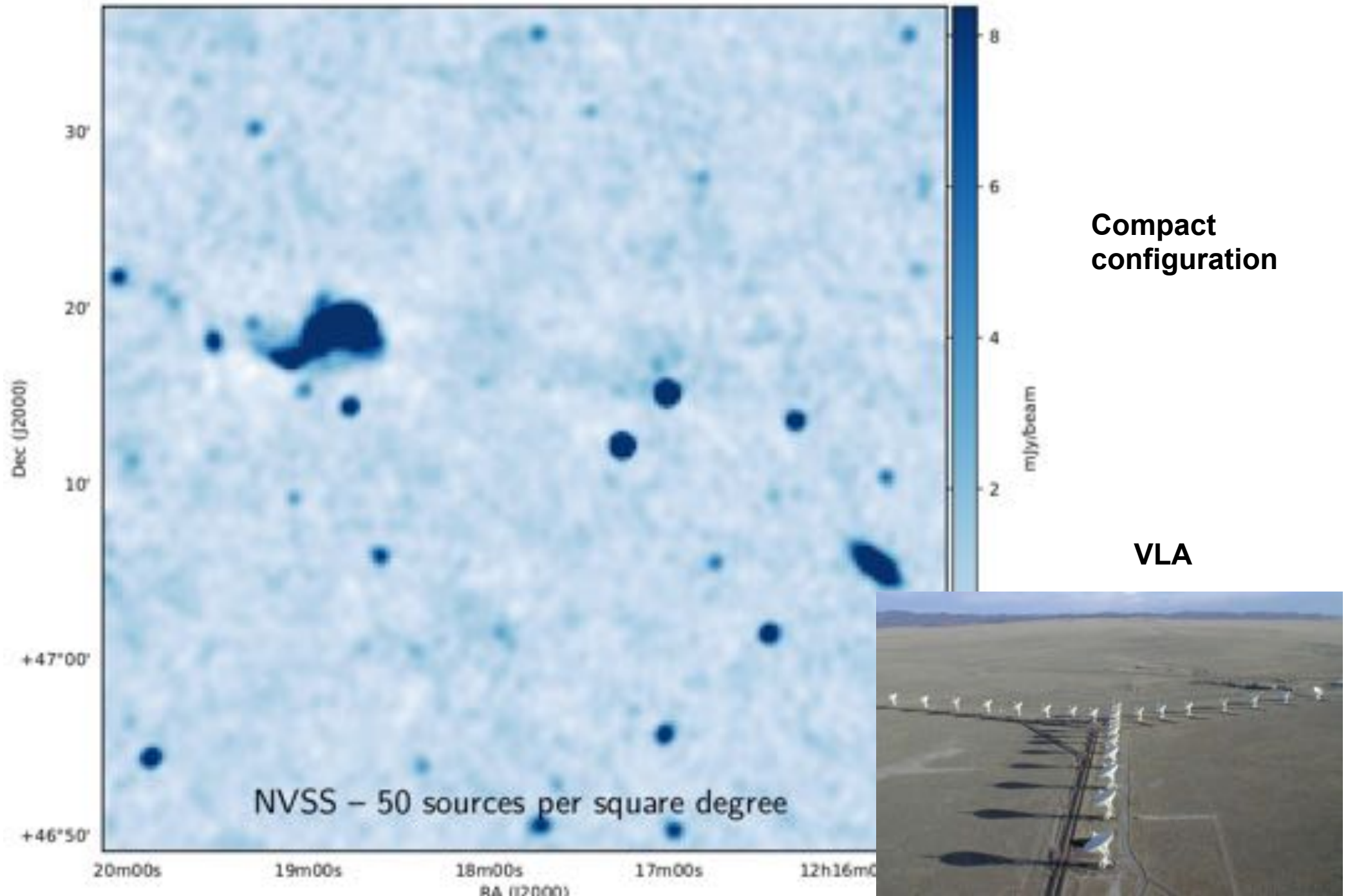
The catalogue contains 325,694 radio sources (Shimwell+ submitted), 225,457 optical identifications (Williams+ submitted) and 158,284 photometric redshift estimates (Duncan+ submitted)



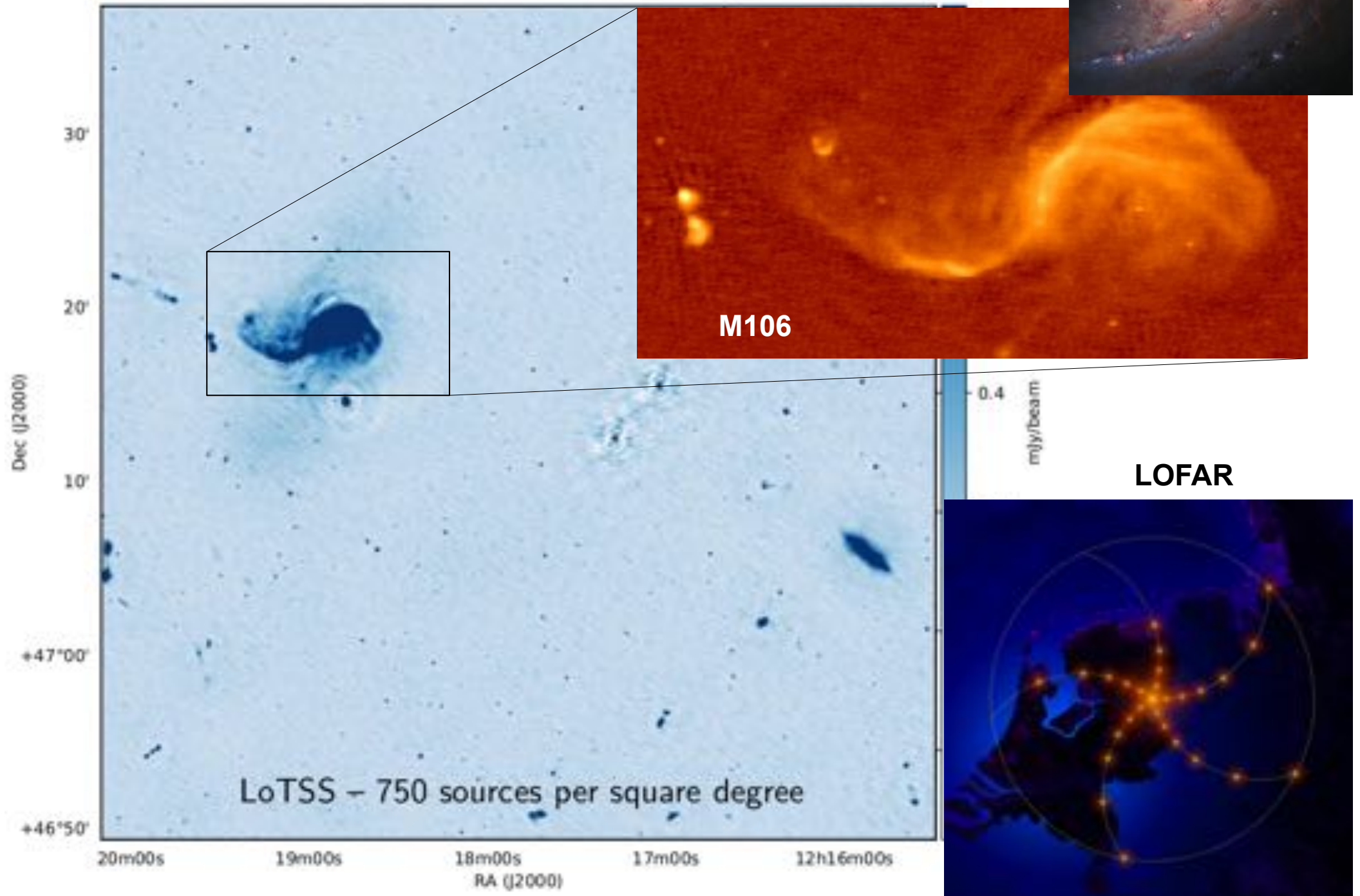
LOTSS – First Data Release



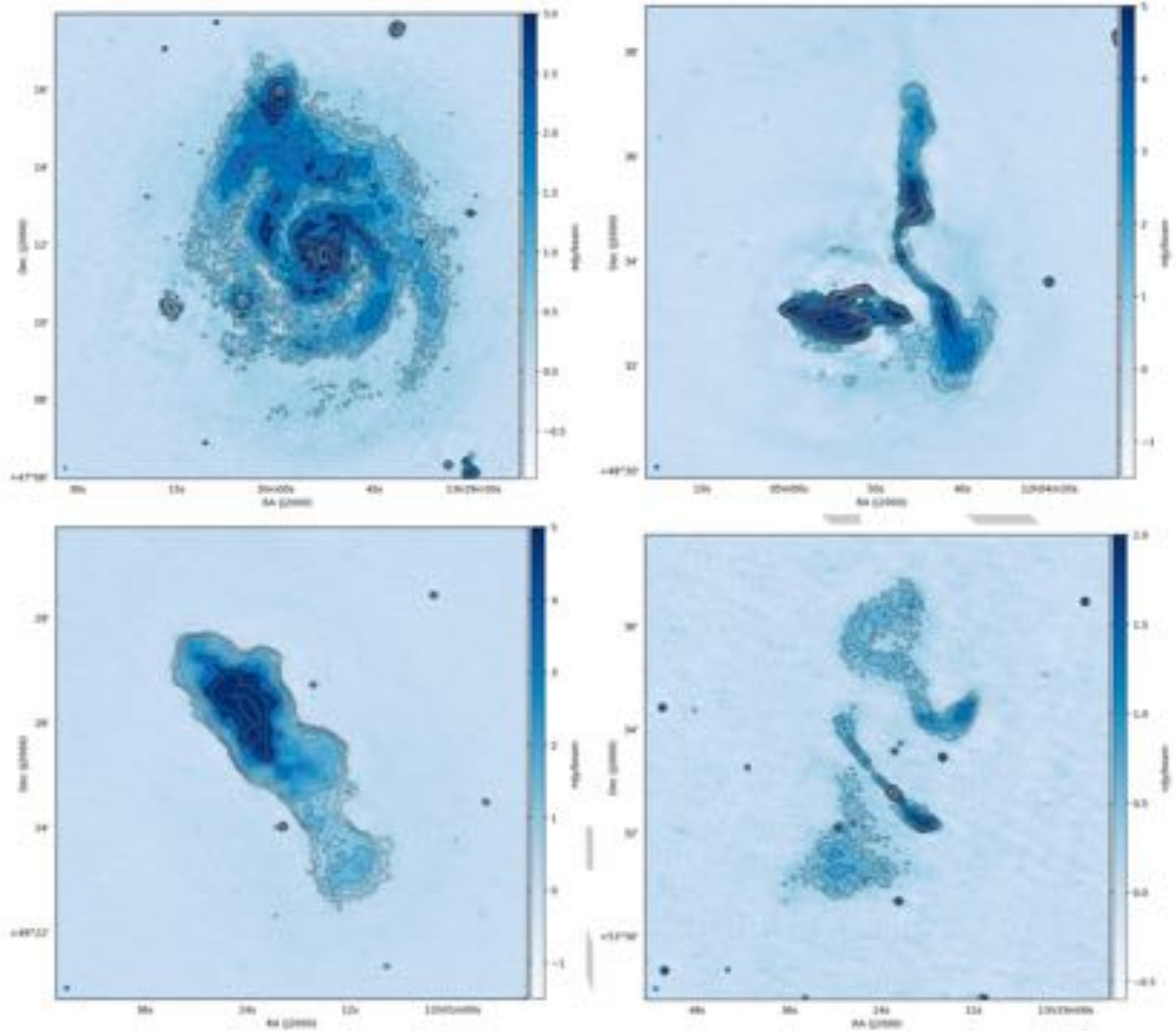
LOTSS – First Data Release

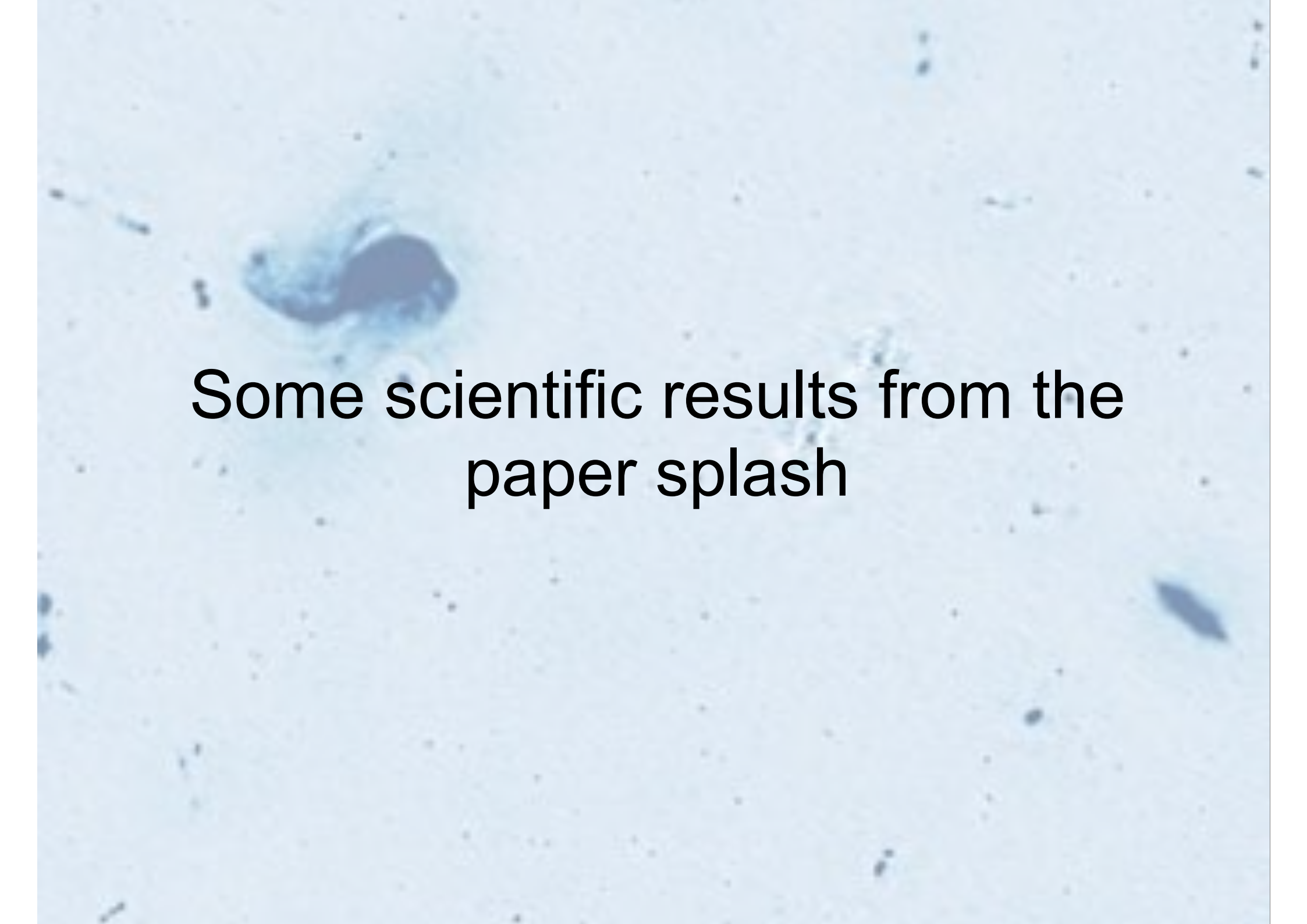


LOTSS – First Data Release



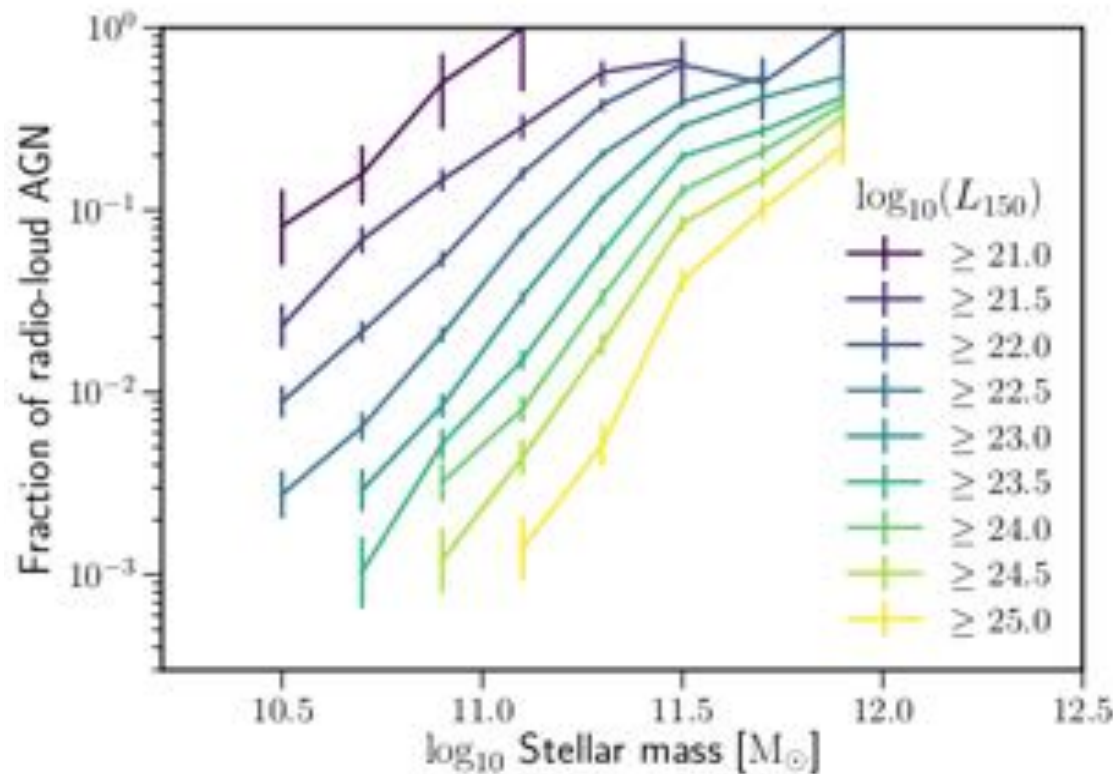
LOTSS – First Data Release



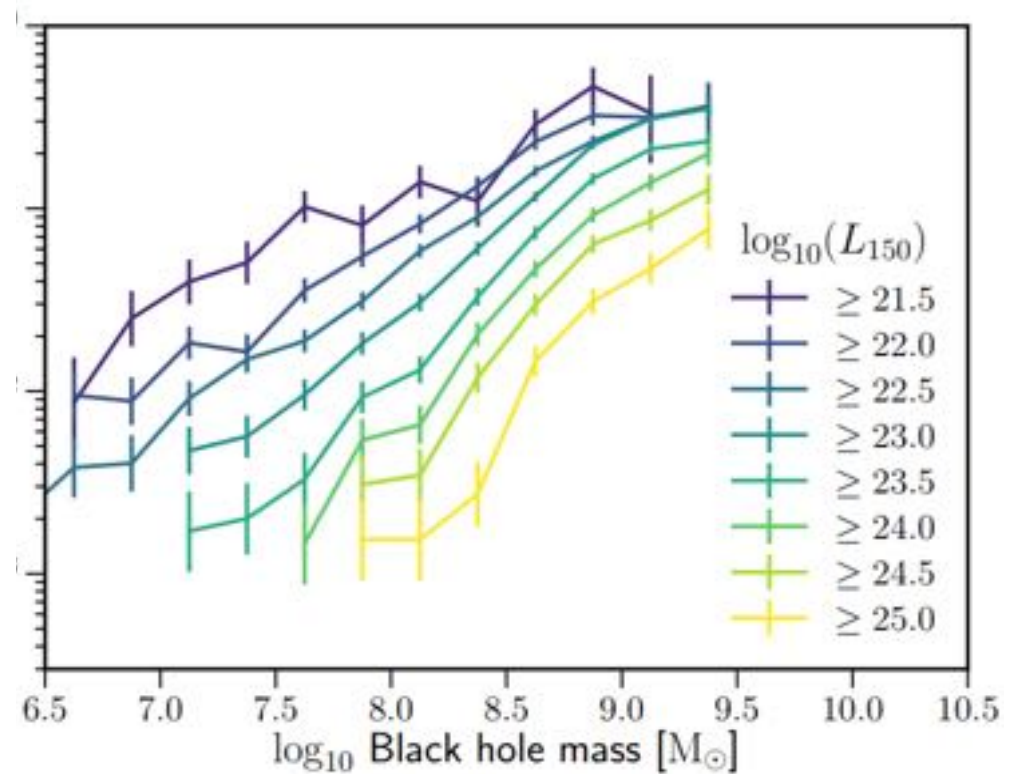
A microscopic image of a cell, likely a lymphocyte, showing a large, dark, round nucleus and a surrounding blue-stained cytoplasm. The background is light blue with some smaller, less distinct cells.

Some scientific results from the
paper splash

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



Stellar mass

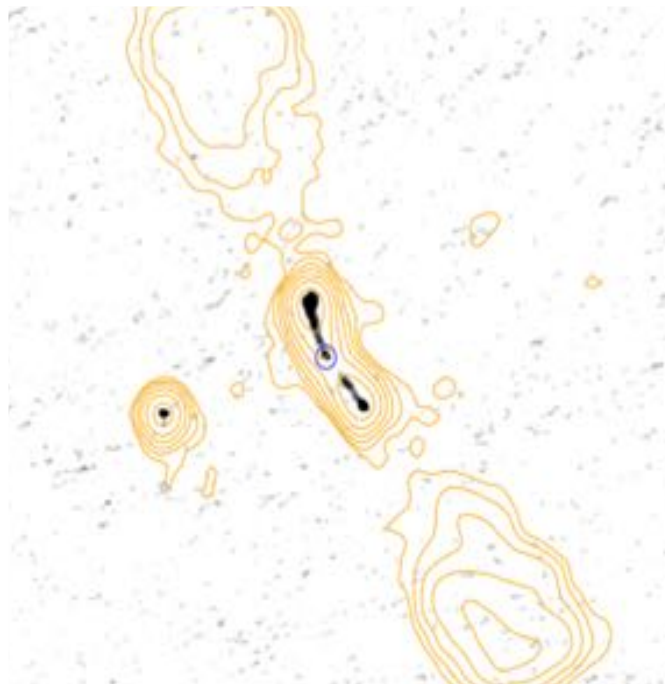
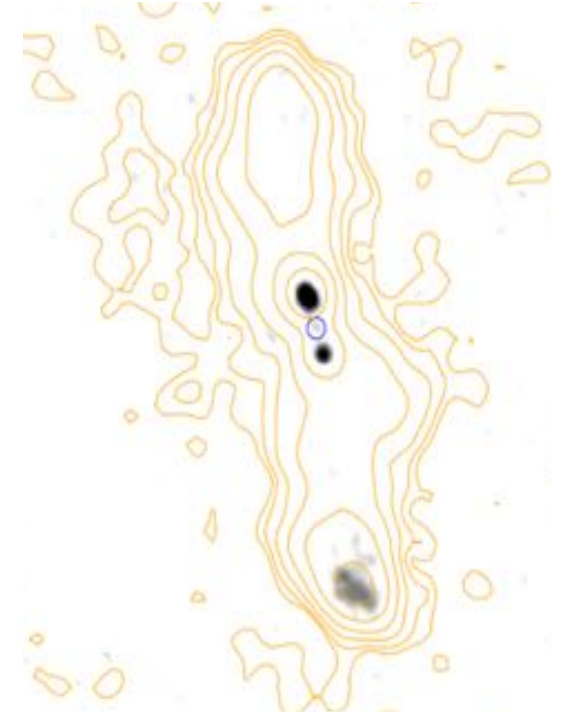
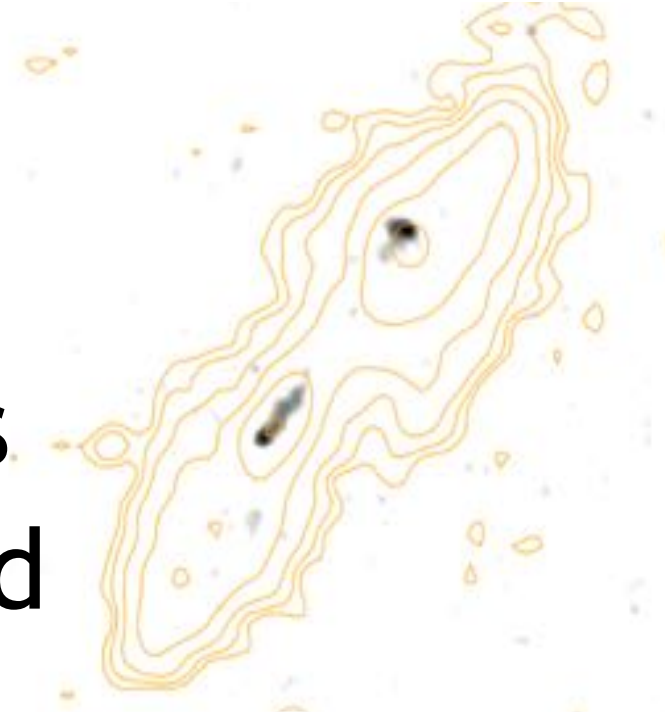


Black-Hole mass

Sabater et al.

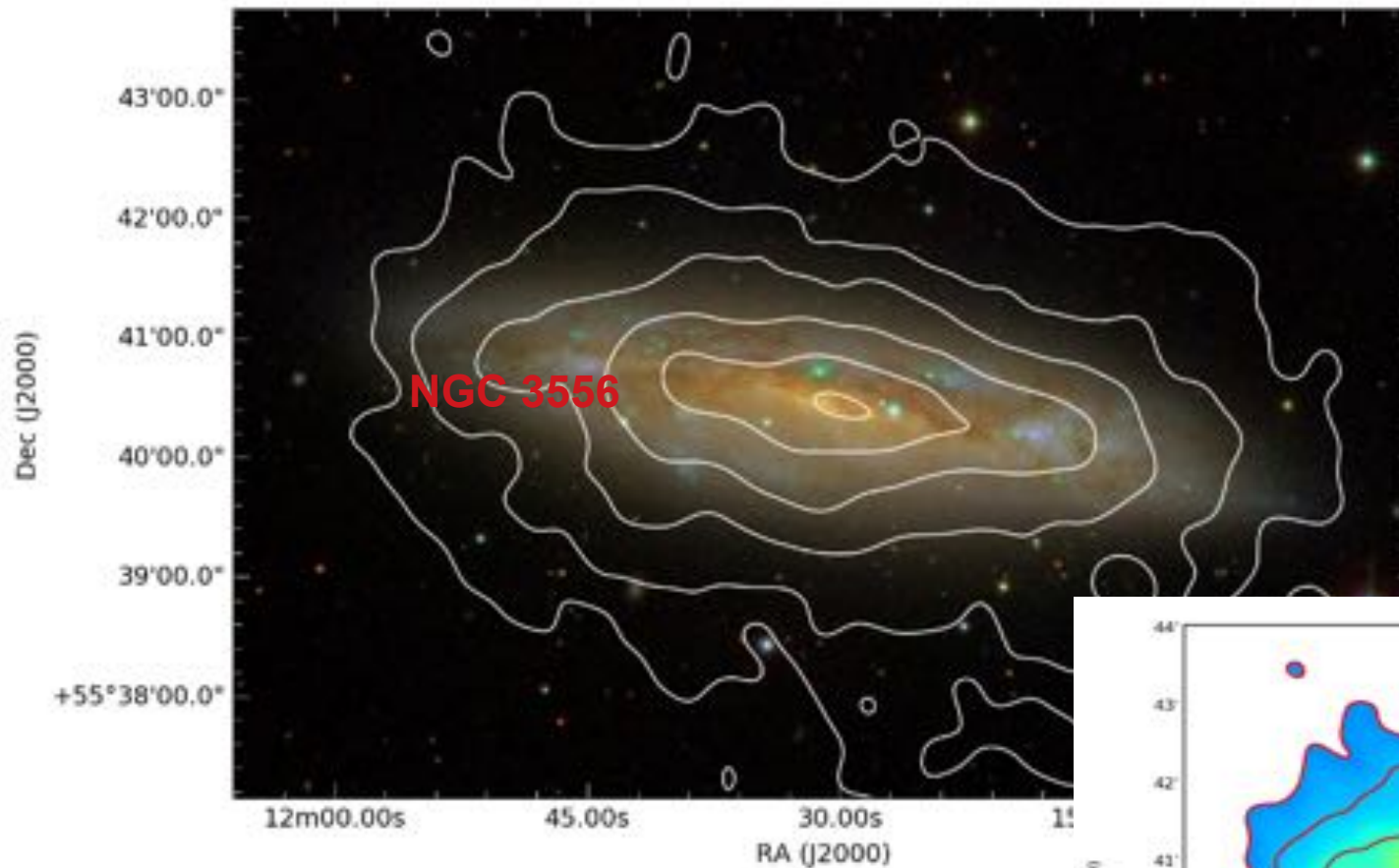
Relic AGN or restarted?

Jet dynamics
Feedback and
duty cycle



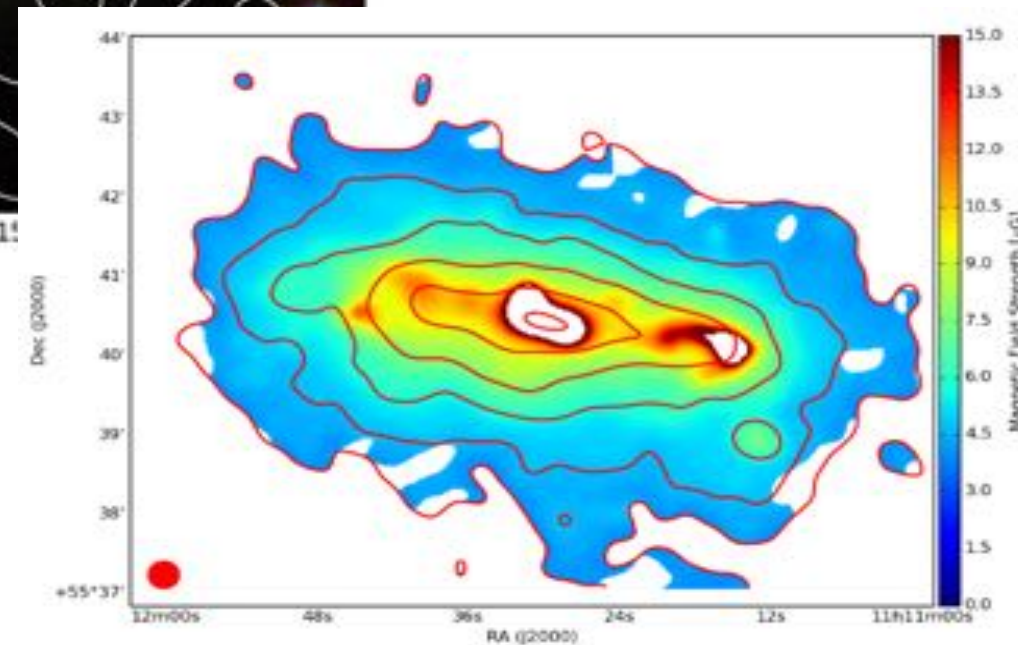
Mahatma et al.

Nearby galaxies



Miskolczi et al.

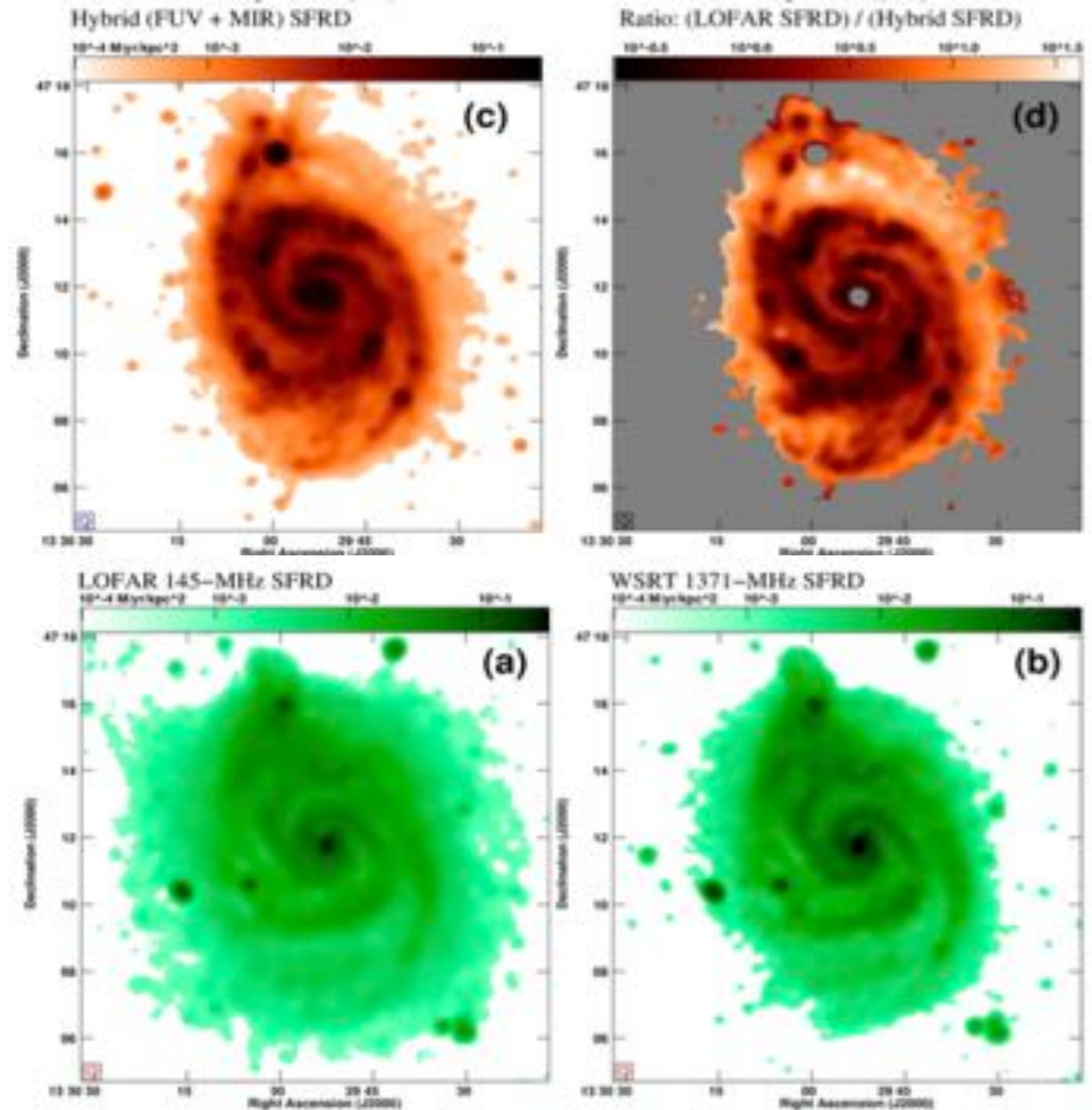
- Cosmic rays emitting synchrotron in a galactic Halo
- Constrains on CR Energy, magnetic field and galactic winds speed



Nearby galaxies

- Study the Radio to Star Formation relation (FIR & UV)

- Cosmic ray electron transport



Heesen et al.

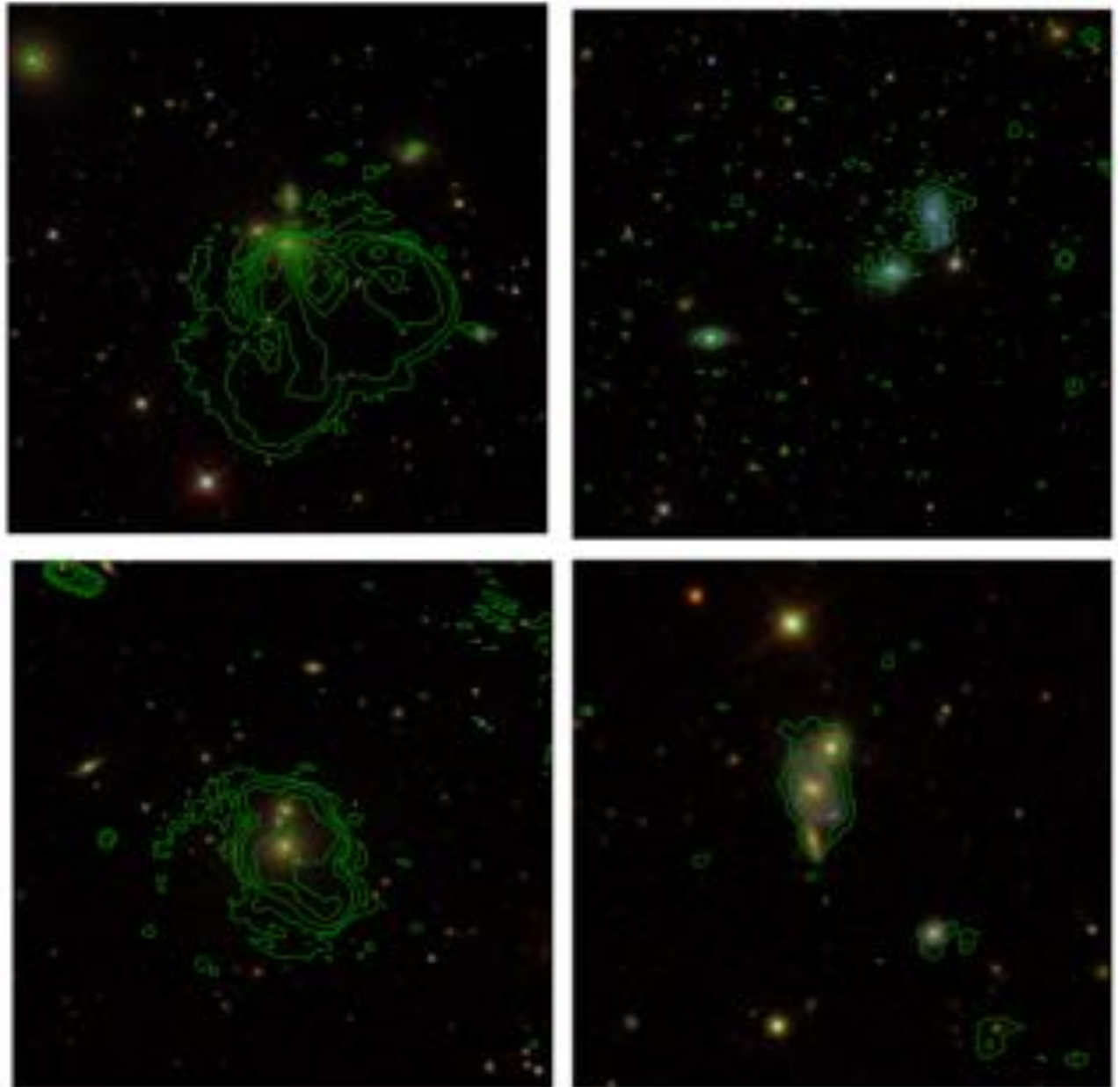
Nearby galaxy groups

Nikiel-Wroczyński et al. In prep

Using

- SDSS
- NVSS
- FIRST

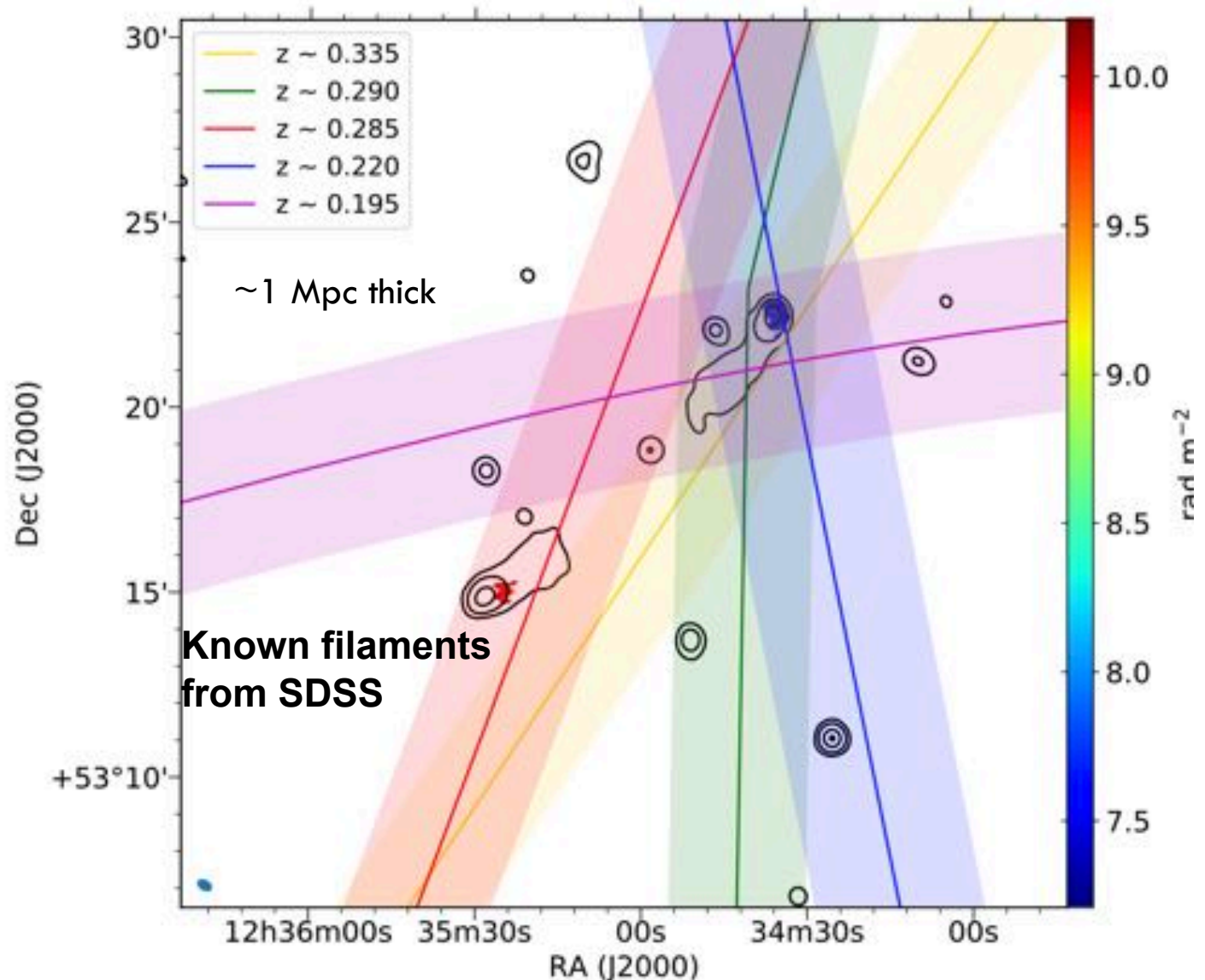
- 17/107 show signs of intergalactic structure
- Study of the magnetic field of the IGM



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.



Galaxy clusters

Abell 1914



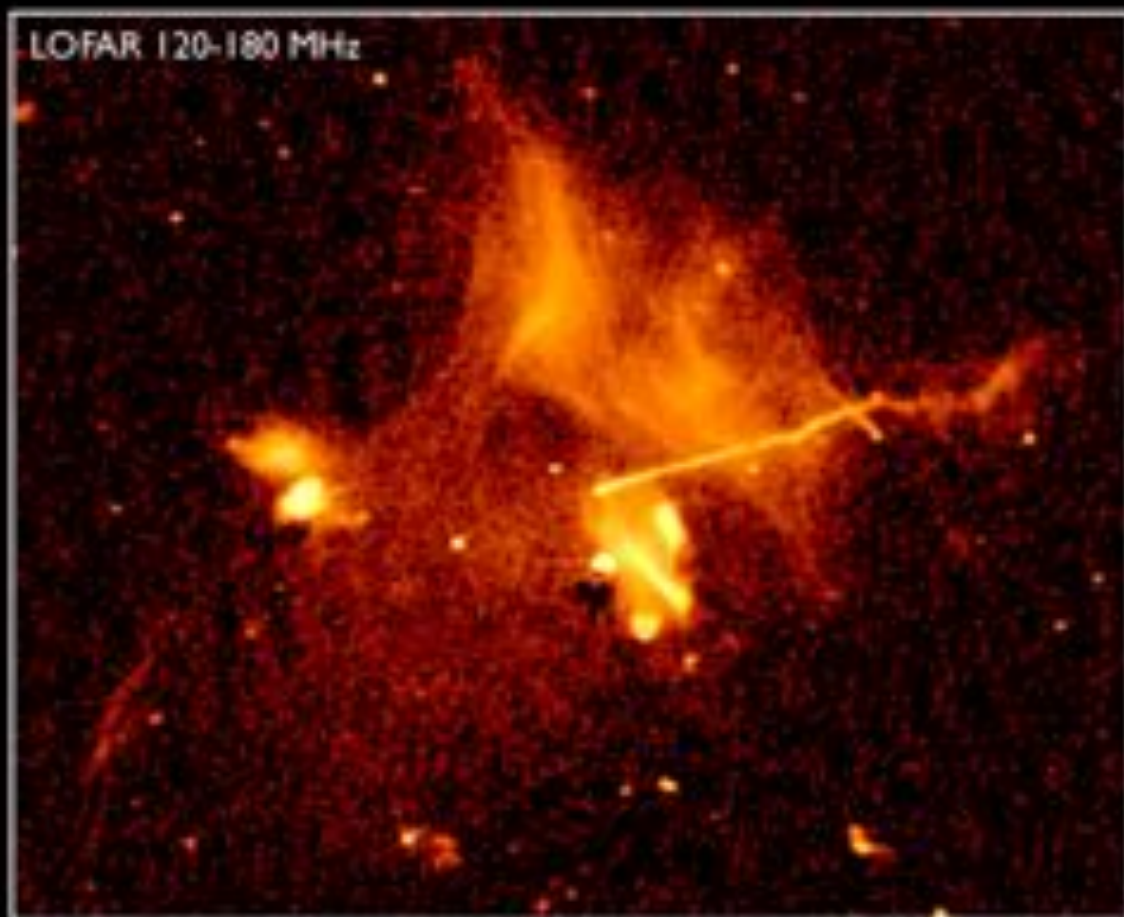
Mandal+ (2018, in prep)

Abell 1132

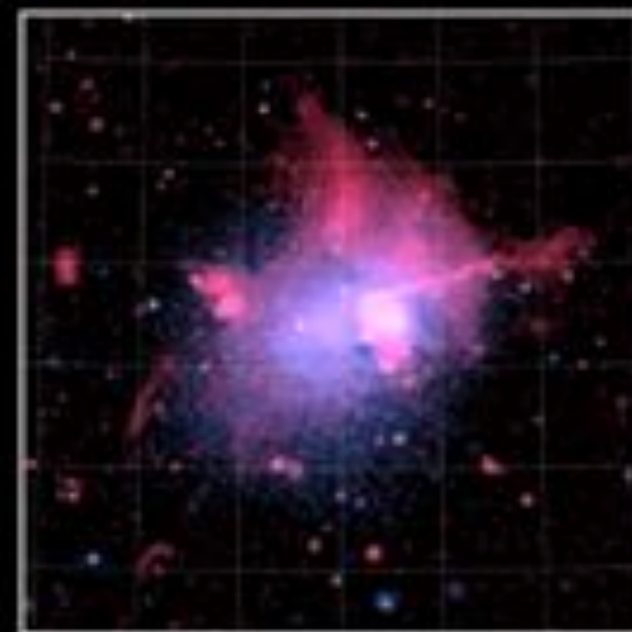


Wilber+ (2017)

ABELL 2256



Radio (LOFAR)
X-rays (XMM)



- Merging cluster
- $z = 0.05$

Van Weeren 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, Philippe Zarka)
- 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
 - Transient universe
- Also processing deep fields - 100+ hours of integration

AS SKA-LOFAR

- Nouveau Conseil Scientifique
- Nouveau site web (fermé pour l'instant): **as-ska-lofar.fr**
- Ateliers en cours de définition avec Maison SKA-France pour préparer la prospective INSU.
- Contact AS SKA-LOFAR (stephane.corbel@cea.fr) if interested to use any of the precursors/pathfinders
- **Liste de diffusion :**
 - Pour s'abonner : envoyer un courriel à sympa@services.cnrs.fr contenant dans l'objet du message:

subscribe as.ska-lofar@services.cnrs.fr PRENOM NOM