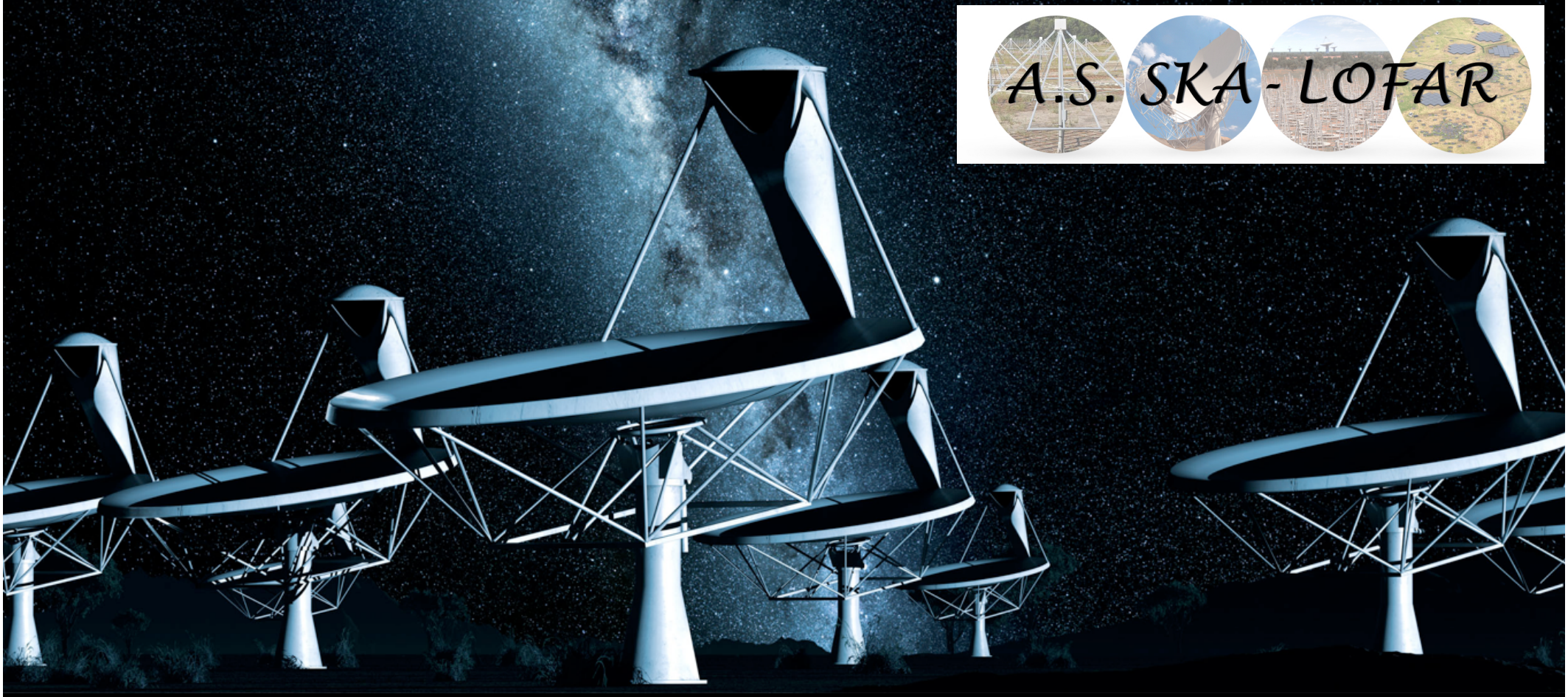
SKA PATHFINDERS & PRECURSORS

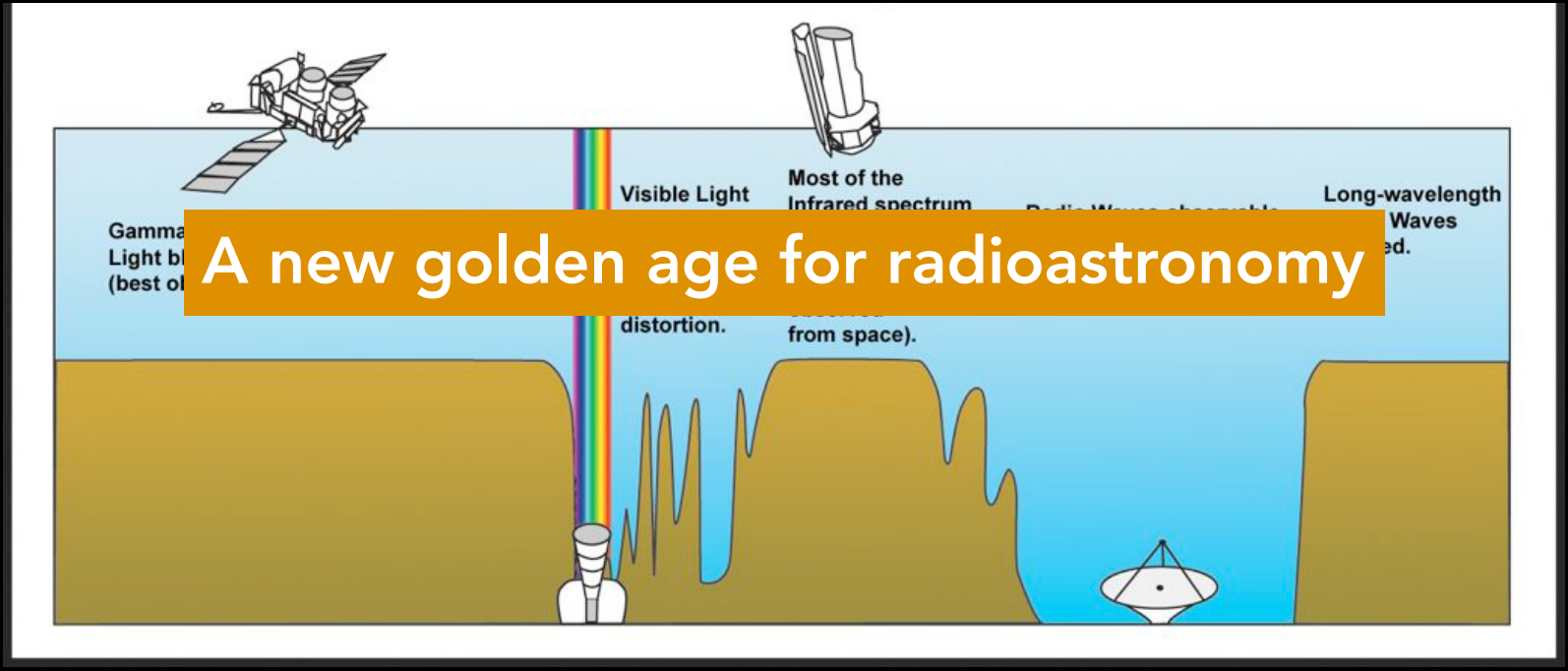
S. CORBEL (UNIV. P. DIDEROT & CEA SACLAY & OBS. PARIS)



FIRST RESULTS FROM LOFAR SURVEY @150 MHZ.

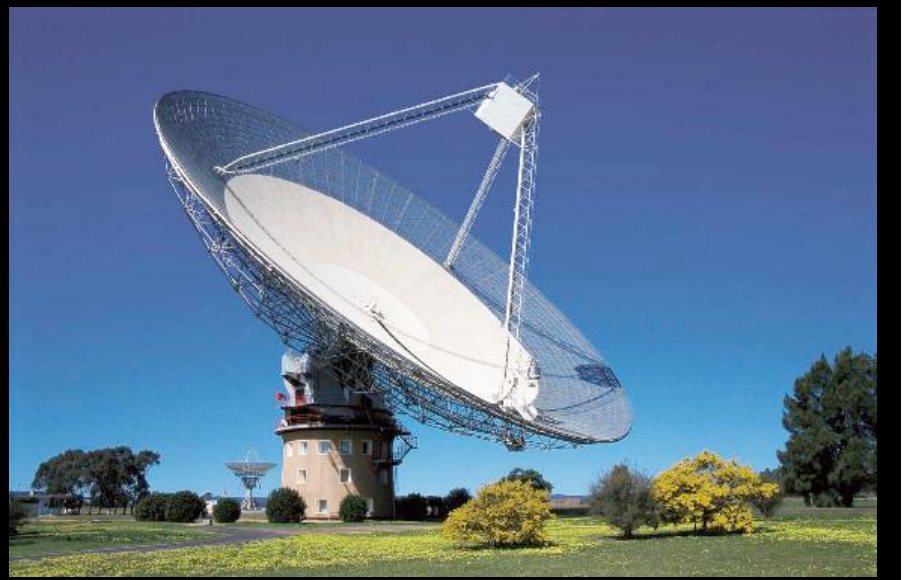
C. TASSE (OBS. PARIS/GEPI)

MINUTE BREAK: RADIOASTRONOMY



A new golden age for radioastronomy

Phased arrays v.s. **pointed telescope**



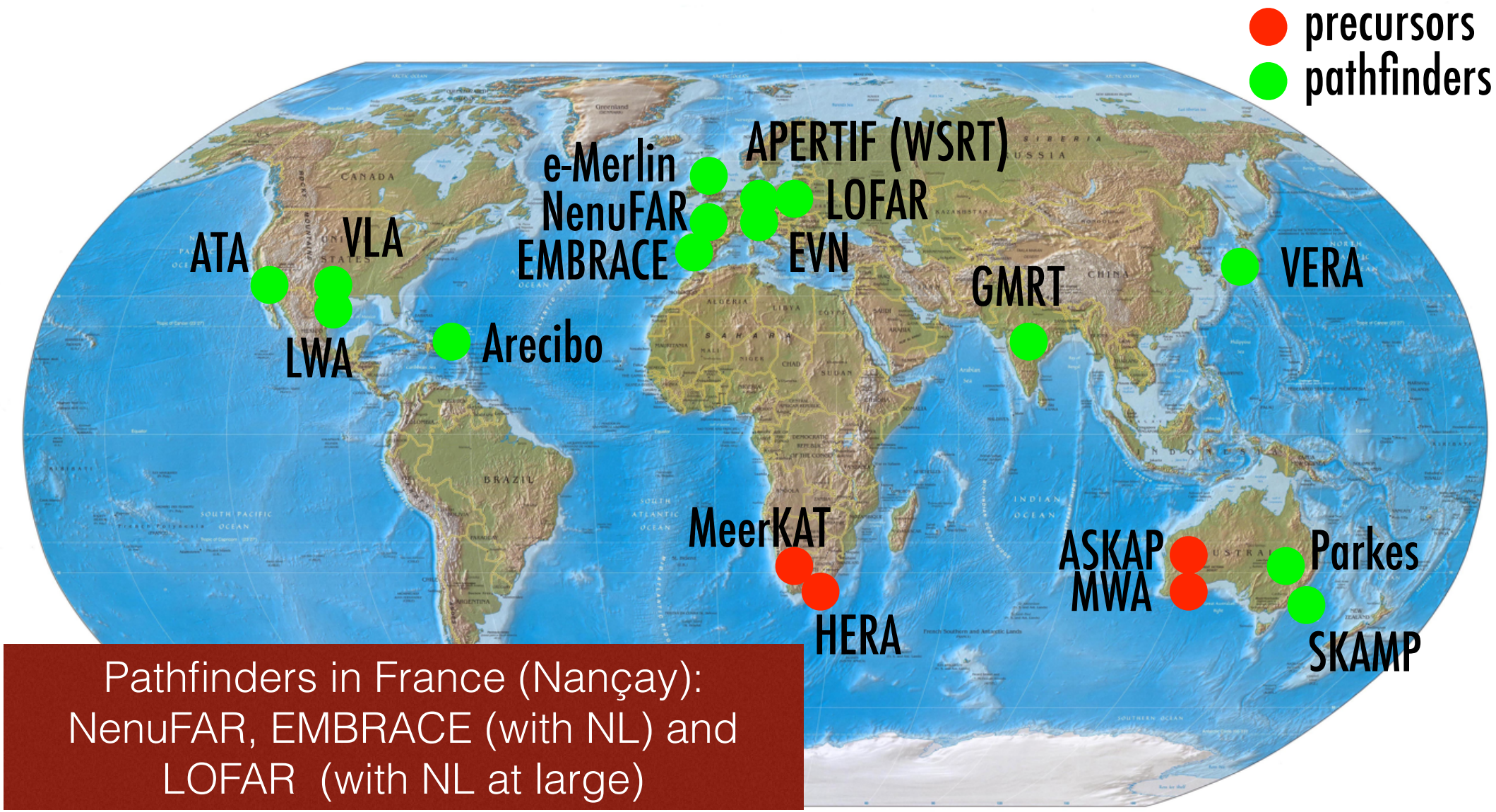
Science @ radio frequencies

- **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



Pathfinders in France (Nançay):
NenuFAR, EMBRACE (with NL) and
LOFAR (with NL at large)

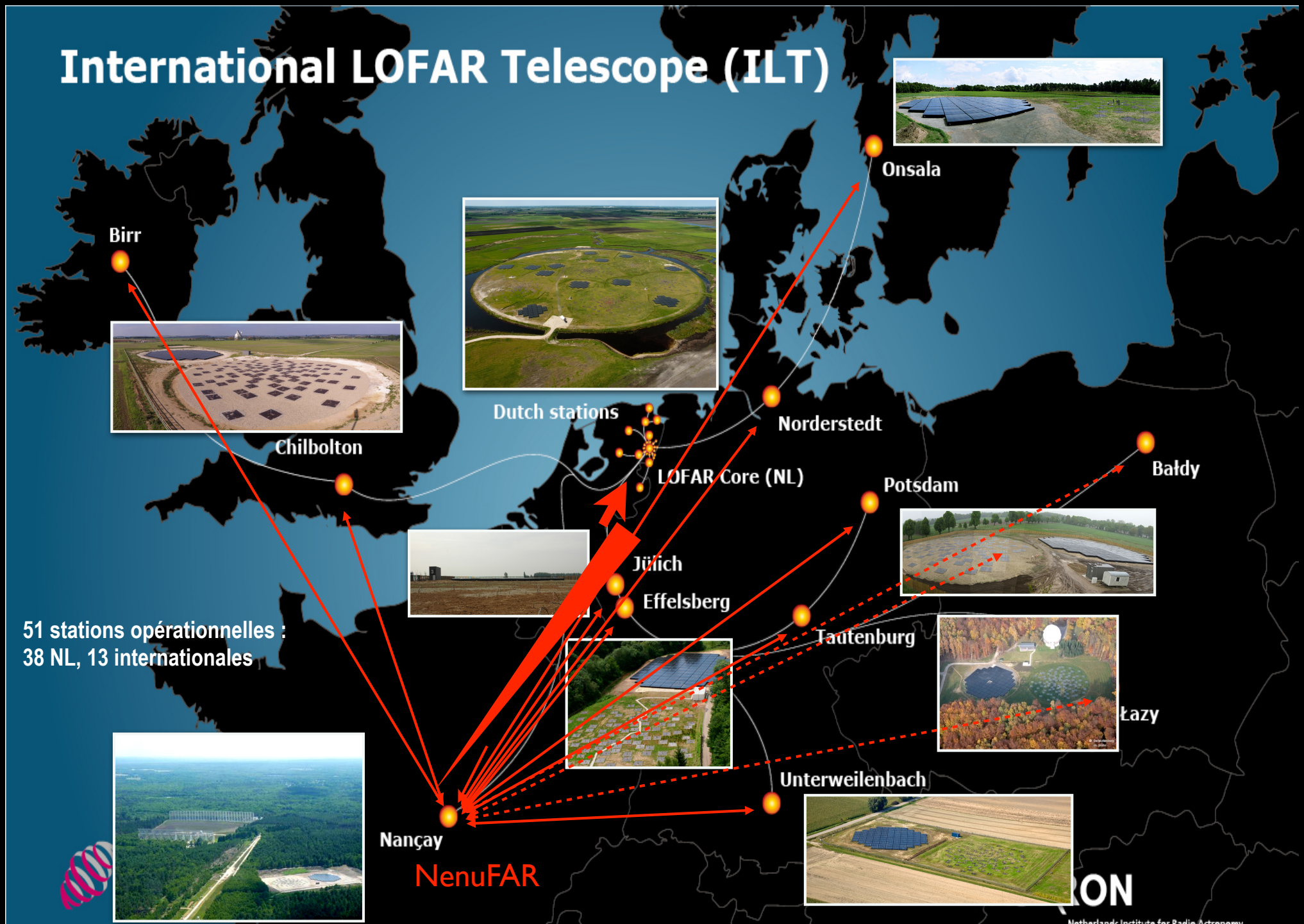
ULTIMATE GOAL: TOWARDS SKA

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


International LOFAR Telescope (ILT)
Onsala
Birr
Dutch stations
Chilbolton
Norderstedt
LOFAR Core (NL)
Potsdam
Bałdy
Jülich
Effelsberg
Tautenburg
51 stations opérationnelles :
38 NL, 13 internationales
Łazy
Unterweilenbach
Nançay
NenuFAR

International LOFAR Telescope (ILT)

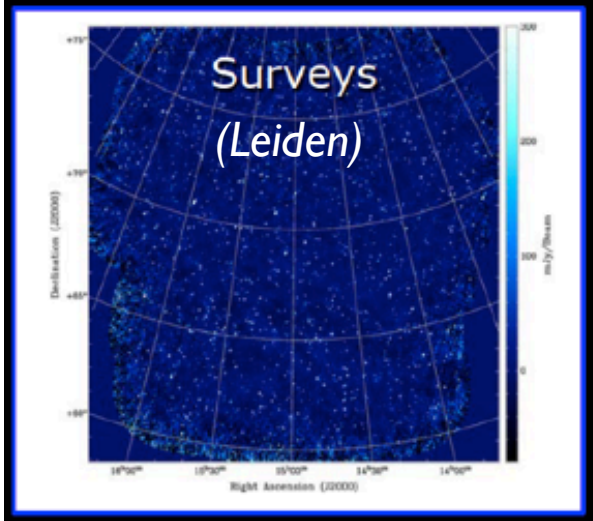
Onsala
Irbene
Birr
Dutch stations
Chilbolton
Norderstedt
Bałdy
Potsdam
Borówiec
Jülich
Effelsberg
Tautenburg
Łazy
Nançay
Unterweilenbach
Medicina

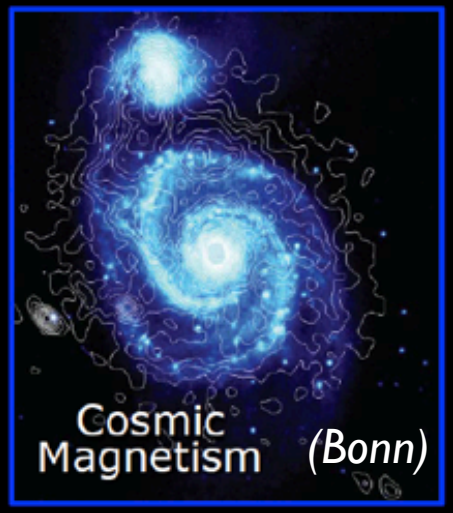
51 stati
38 NL, 1

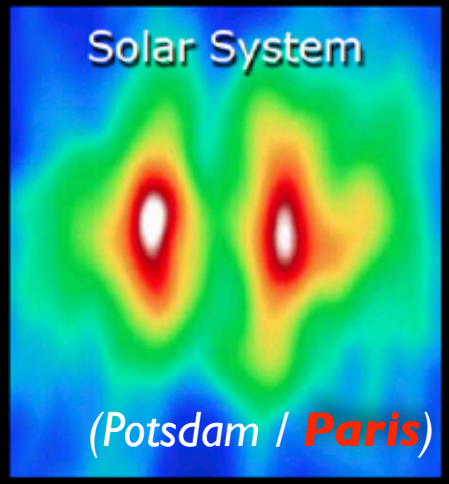
+2 new station in Latvia and Italy

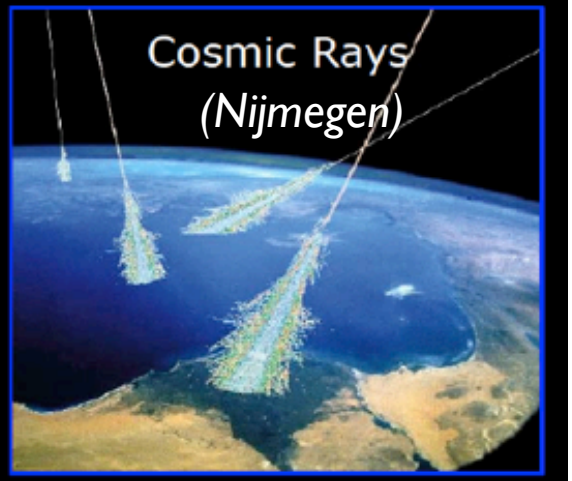
See more with C. Tasse

LOFAR KEY SCIENCE PROJECTS

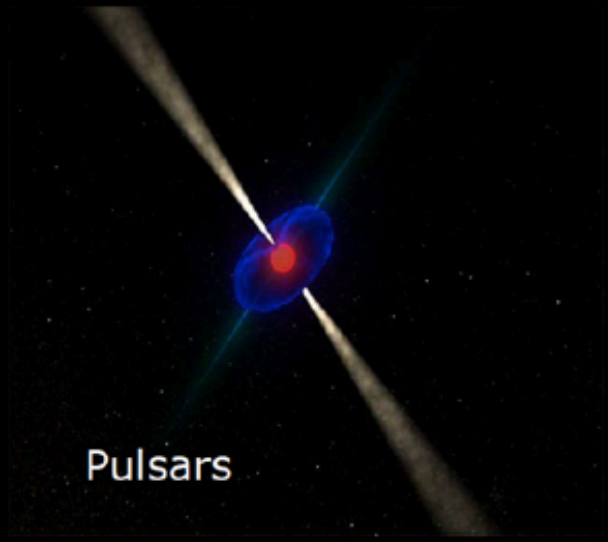




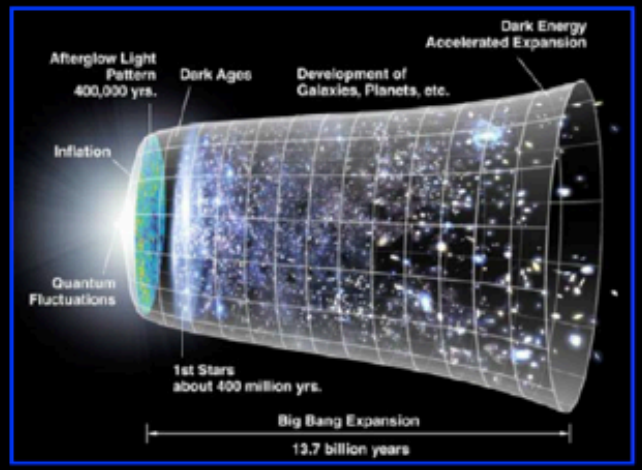




(Amsterdam)

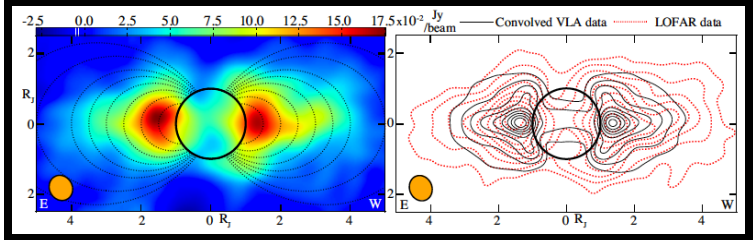


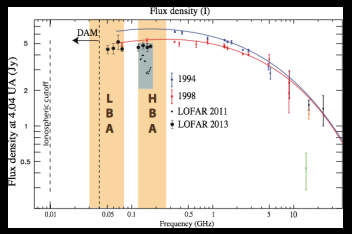
(Manchester / Dwingeloo)

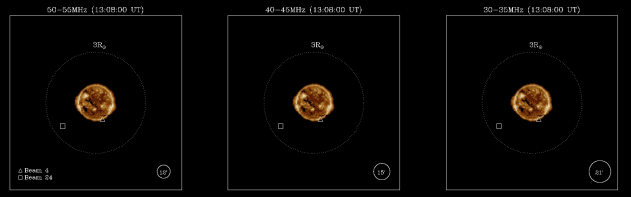


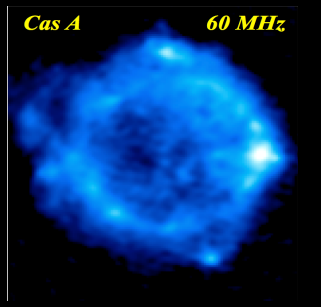
Epoch of Reionization
(Groningen)

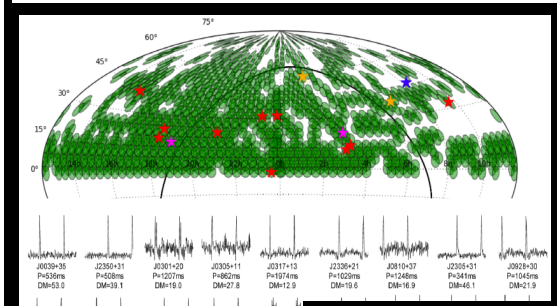
Some scientific results

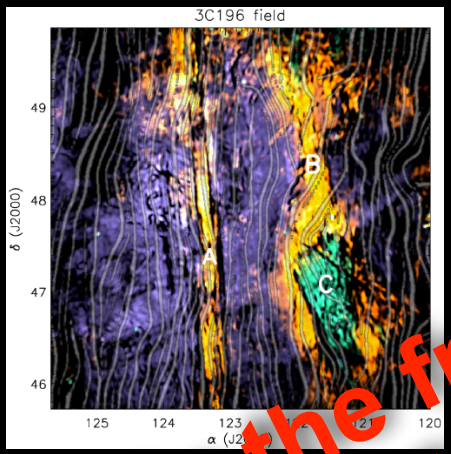


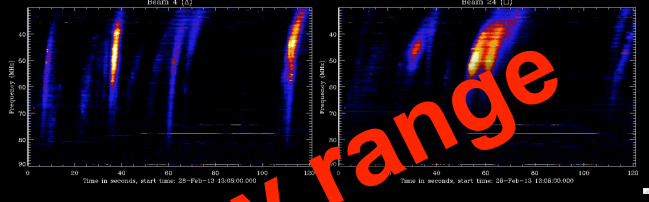


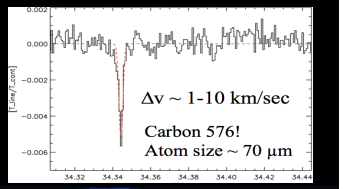


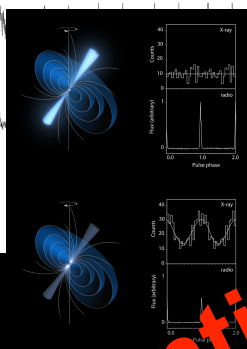


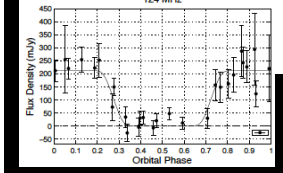




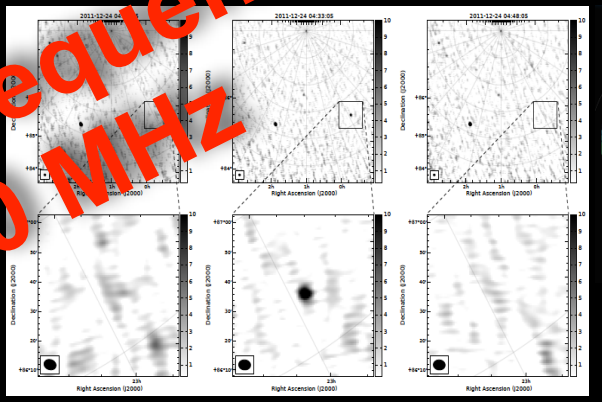


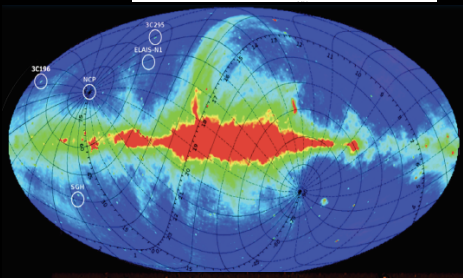


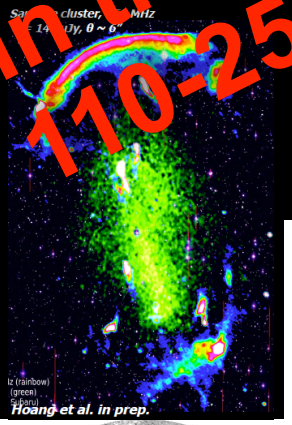


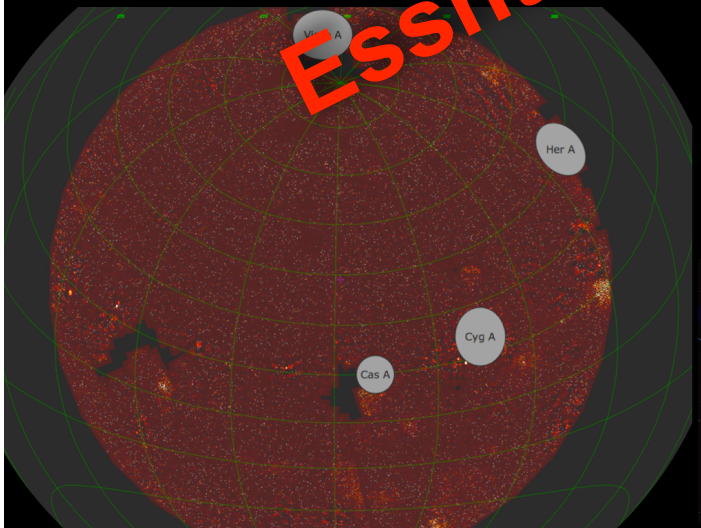


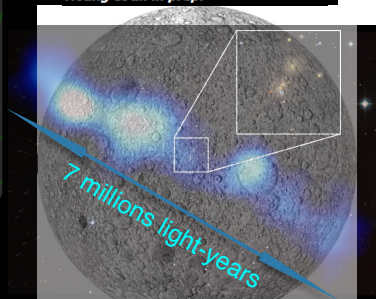
Esstntially in the frequency range 110-250 MHz

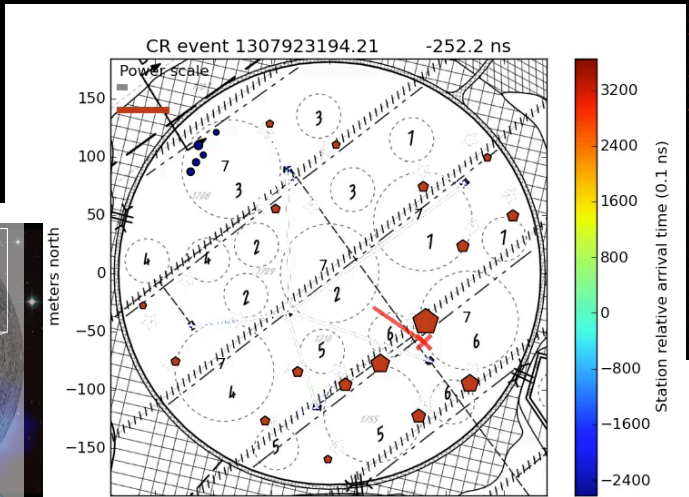


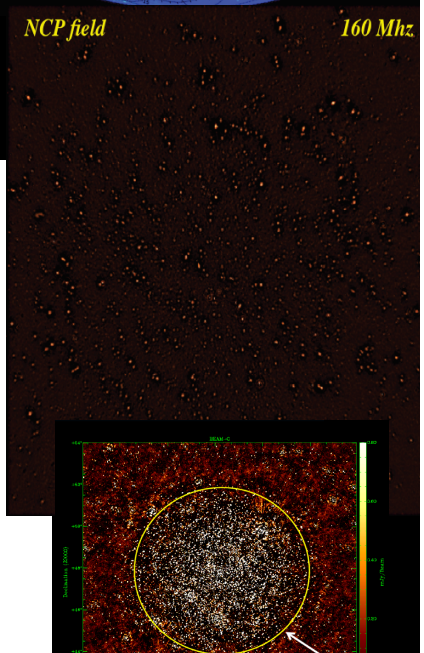








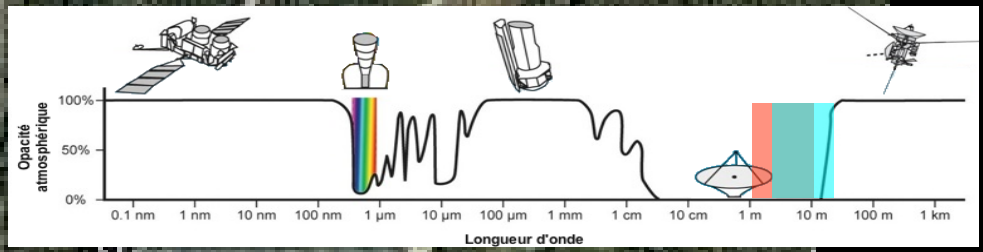




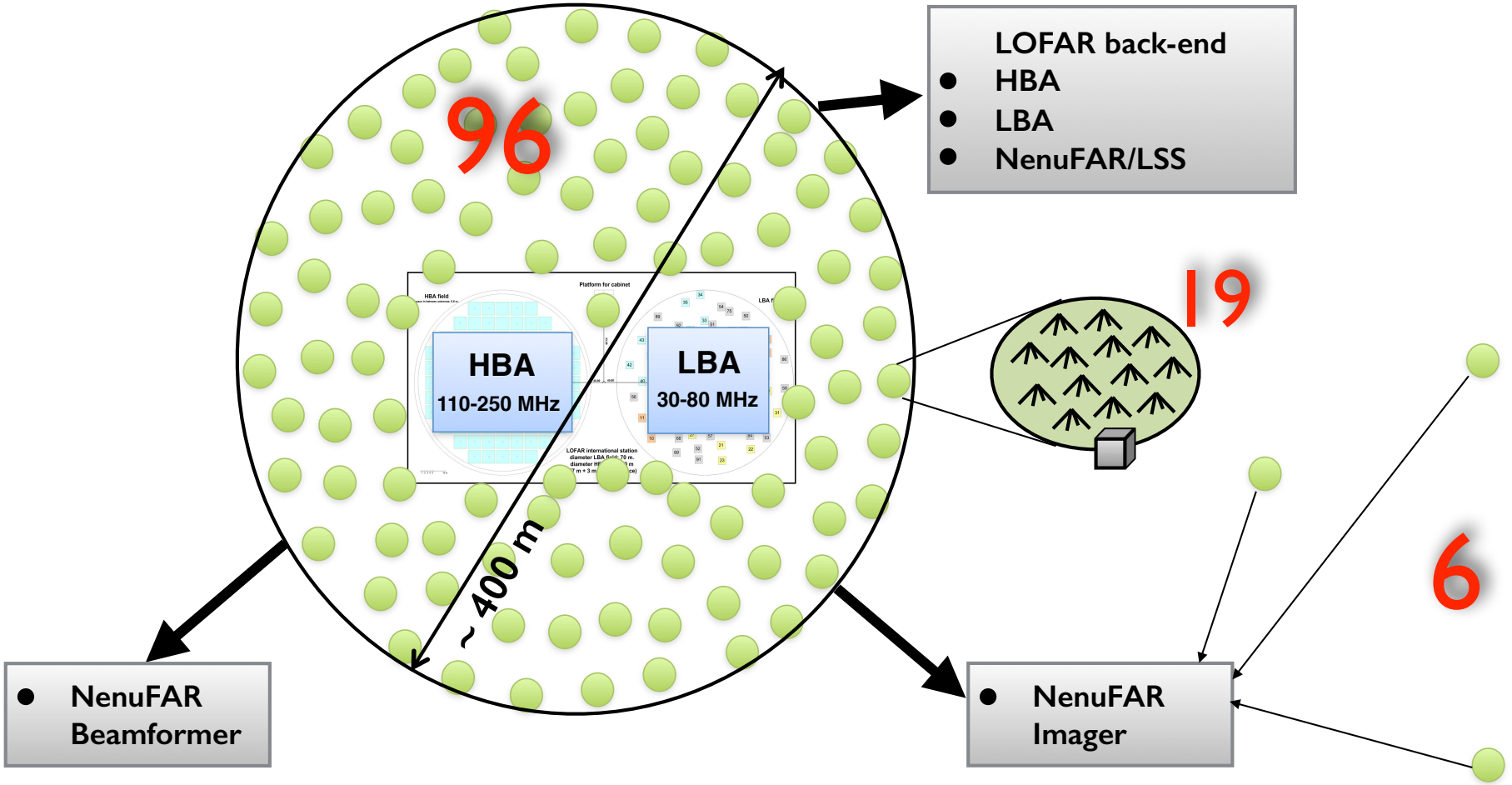
… NenuFAR

New extension in Nançay upgrading LOFAR

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



Le concept de NenuFAR



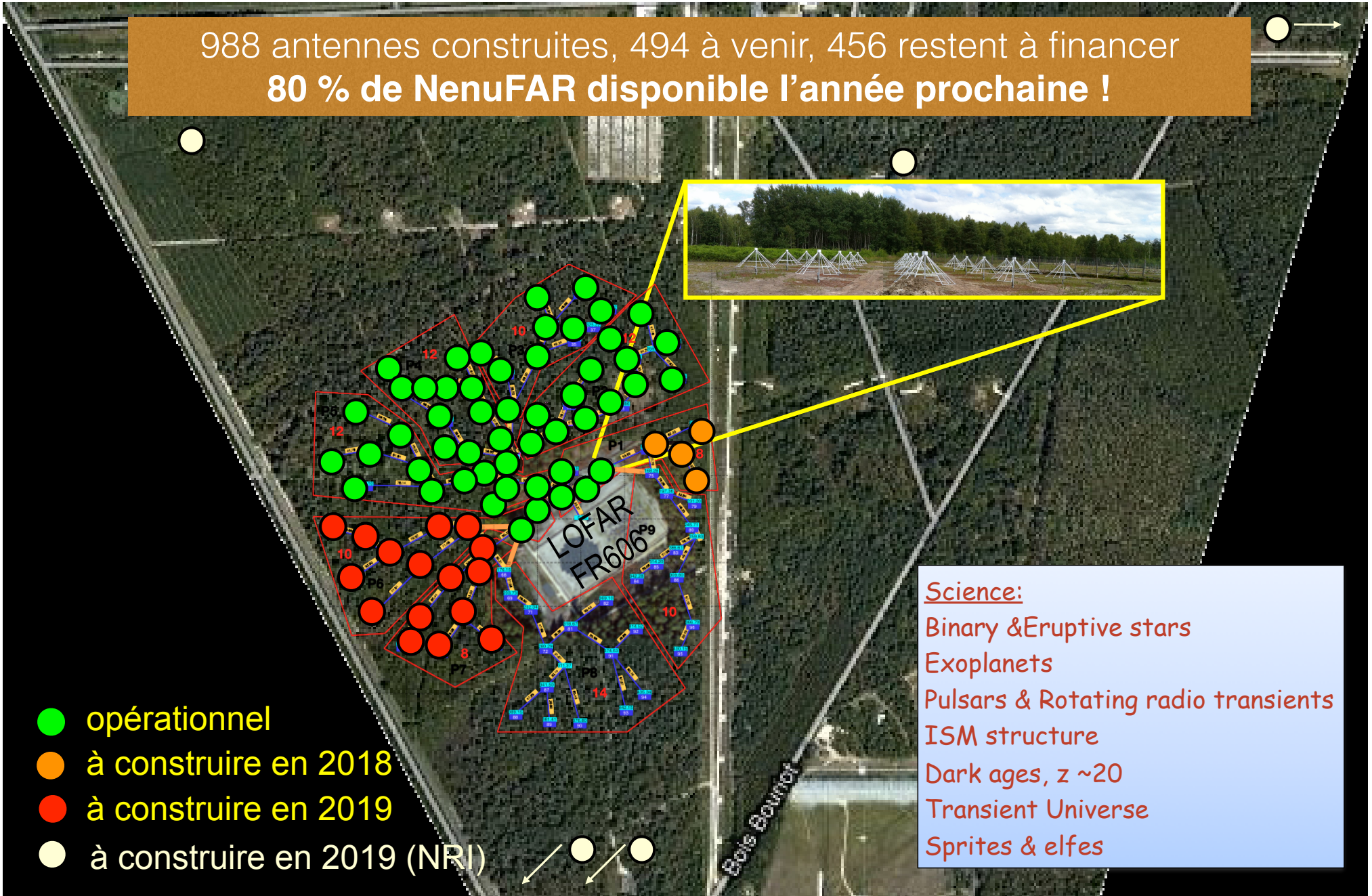
Beamformer, Imageur, Station géante LOFAR (Pulsar machine, SETI machine)

(96+6) Mini-Réseaux x19 antennes = 1938 antennes++

(> LOFAR), Sensibilité 2-8 x LOFAR, 10-85 MHz,

Déploiement

72 MR coeur financés, 52 construits & opérationnels



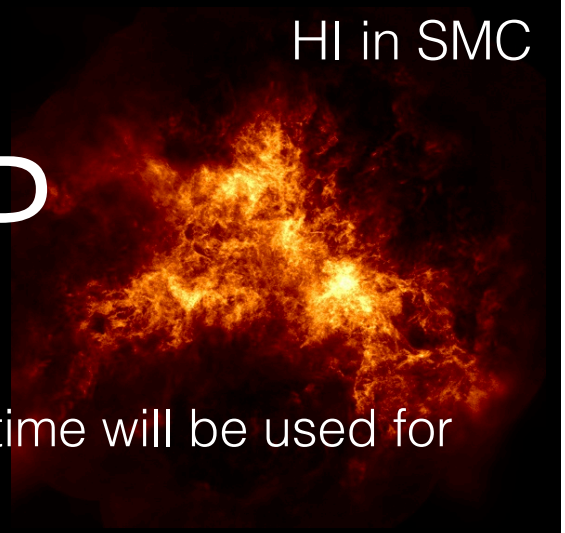
SKA precursors (=précurseurs)

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 deg^2 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 μJy/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. -

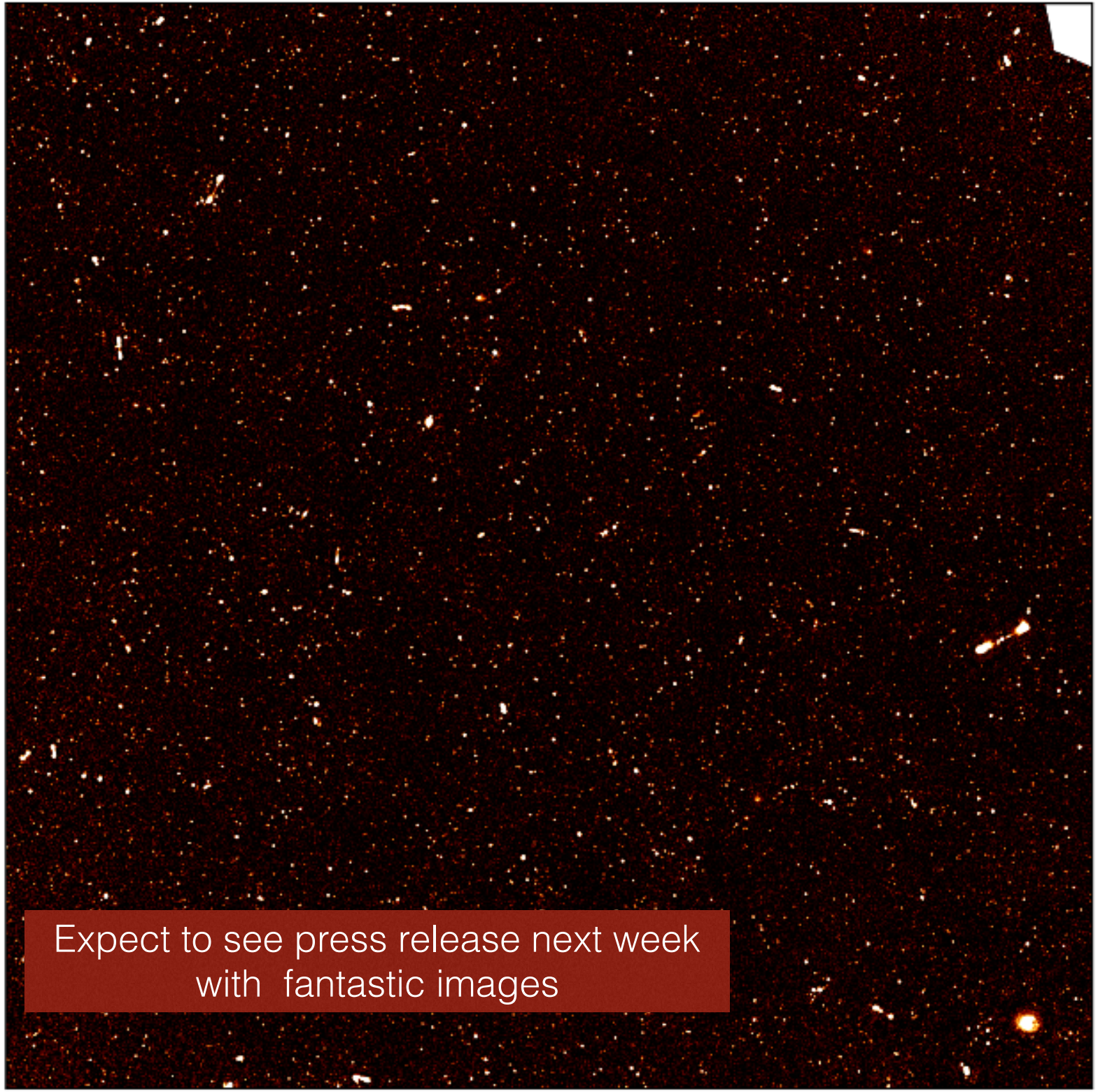
  + 30% for smaller PI driven proposals (of which 5% will be DDT). Call for Proposal expected at some point.

- 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, …



Expect to see press release next week with fantastic images

Commissioning image of MeerKAT

16 ant.
1.3° x 1.3°
1.4 GHz
rms ~ 6.5 μJy

Goal with full array ~1 μJy

Ref: Fender (private com)

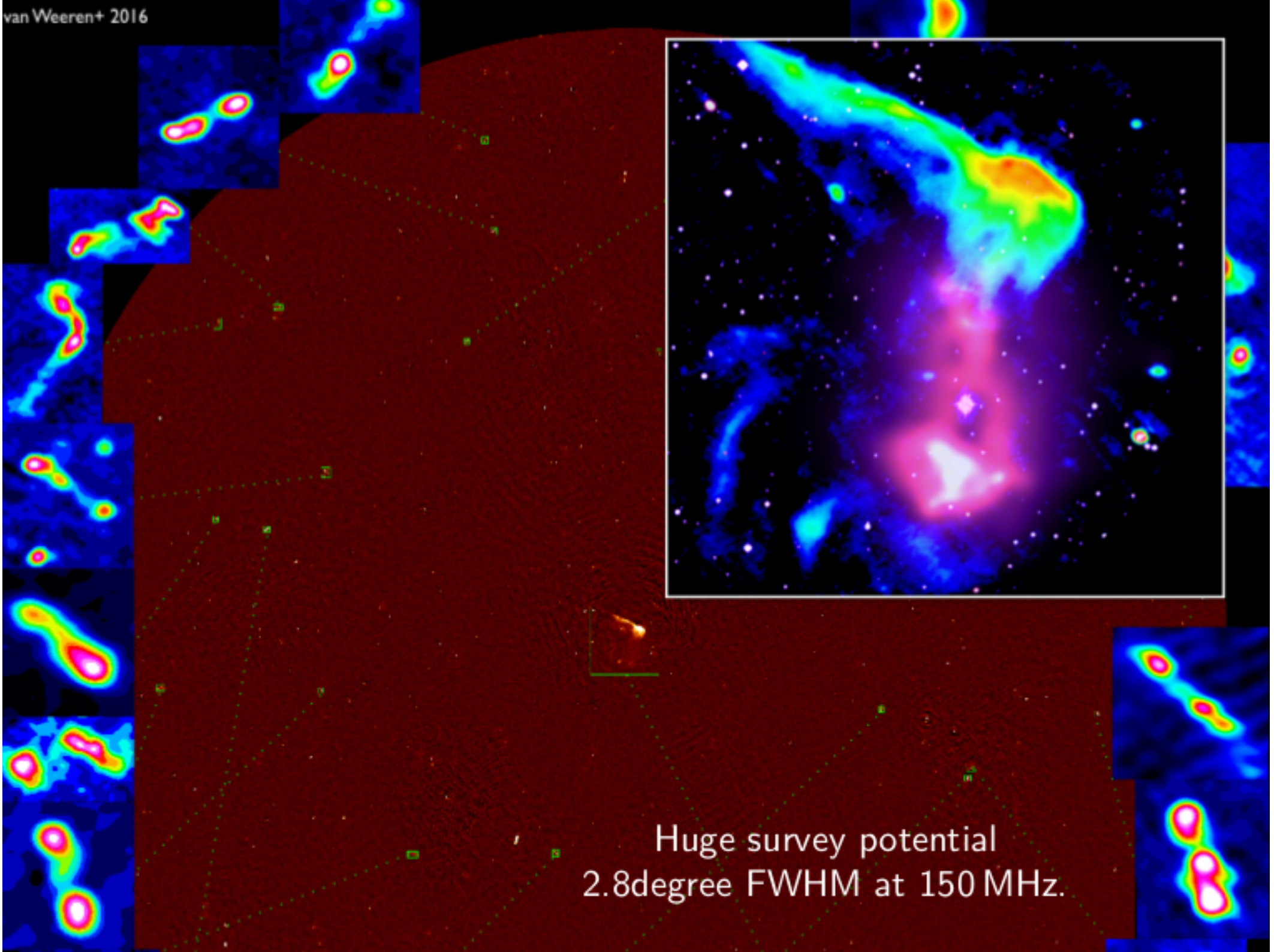
The LOFAR-LOTTS extragalactic survey: first data release and scientific results

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


van Weeren+ 2016
Huge survey potential
2.8degree FWHM at 150 MHz.

The LOFAR extragalactic surveys Key Science Project

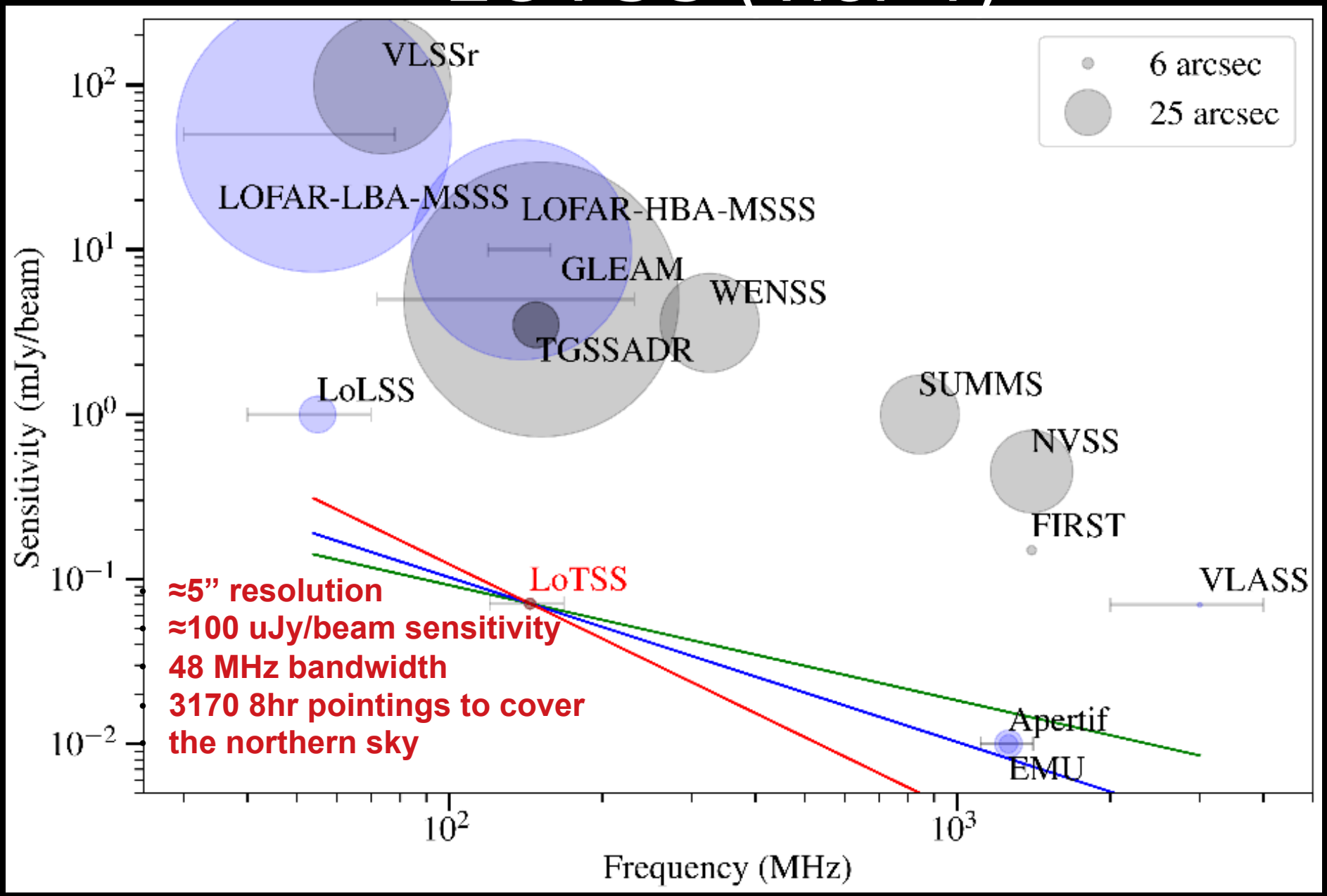
PI: Röttgering
Core team: Best, Brüggen, Brunetti, Chyży, Conway, Haverkorn, Heald, Jackson, Jarvis, Lehnert, McKean, Miley, Morganti, Scaife, Tasse, White, Wise

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 Skurvey (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)

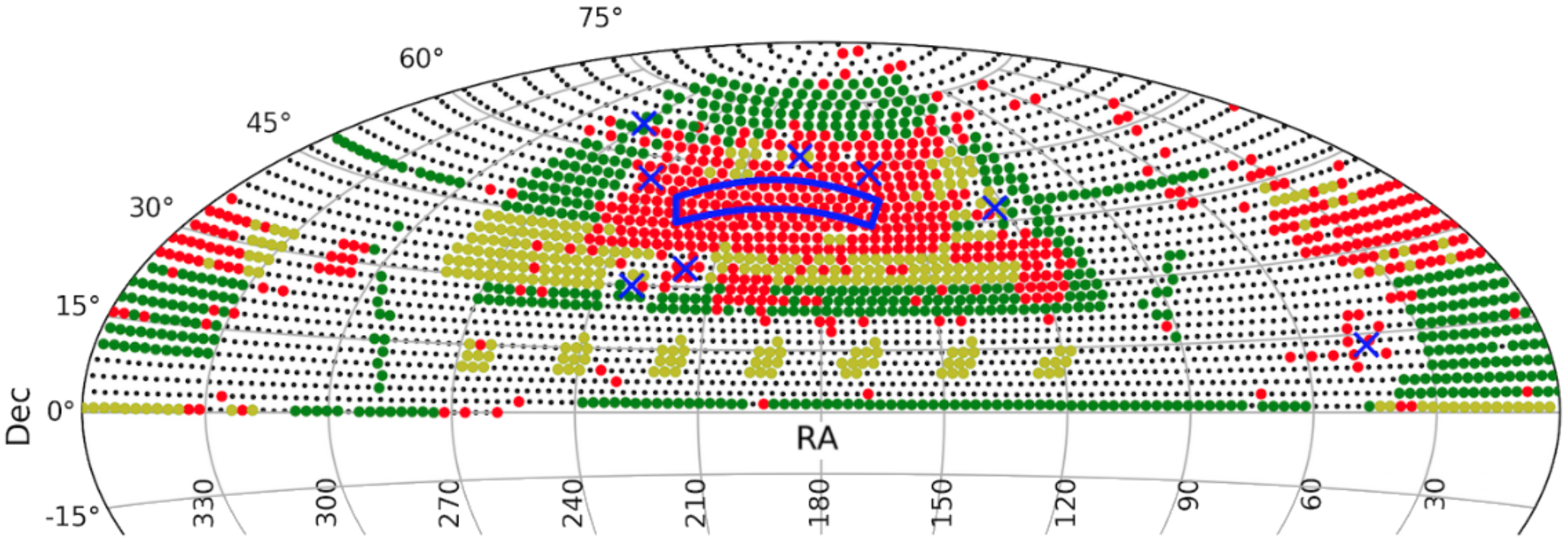


LOTSS : LOFAR Two-meter Sky Survey

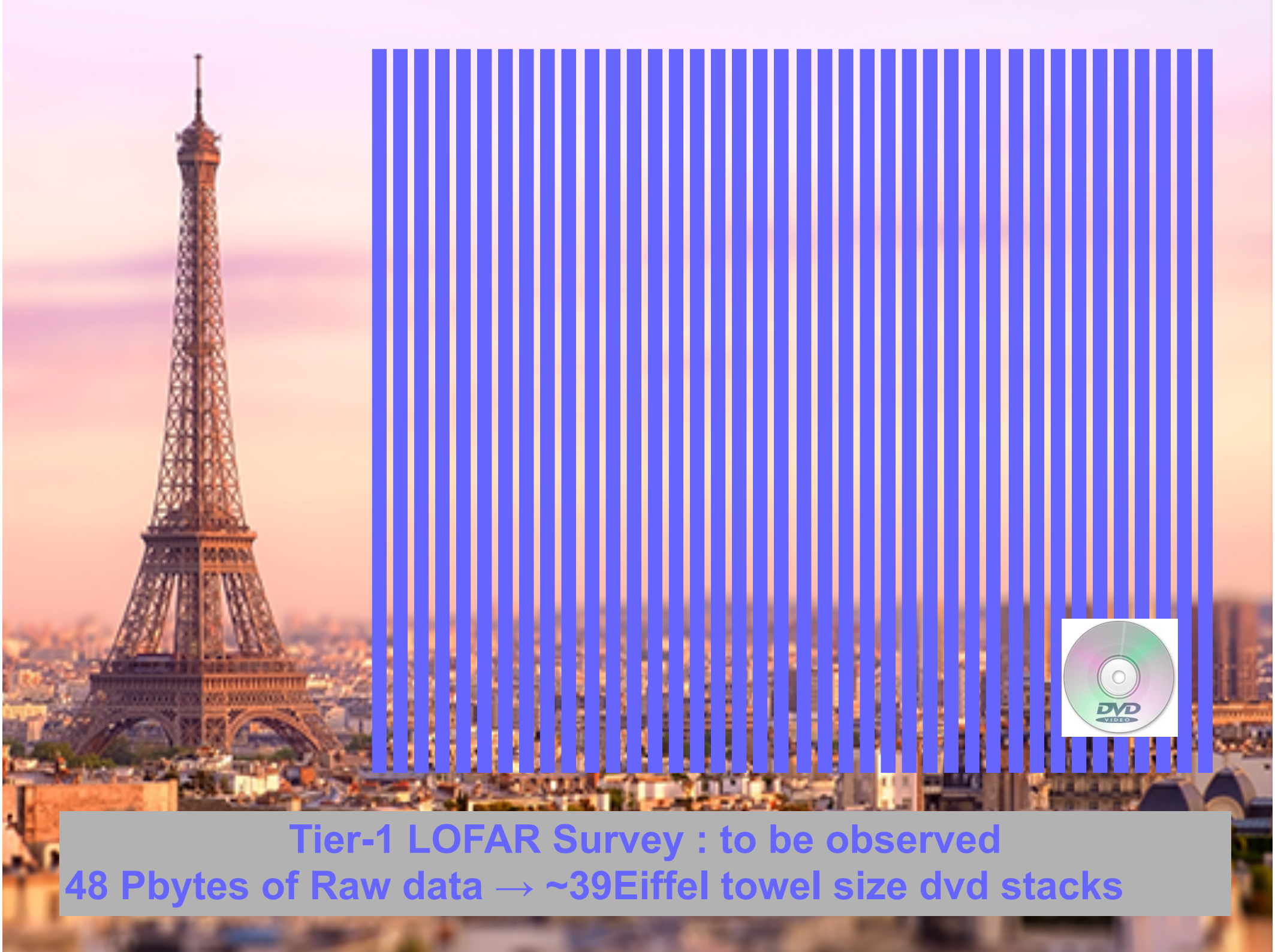
20% of the northern sky is observed.

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.



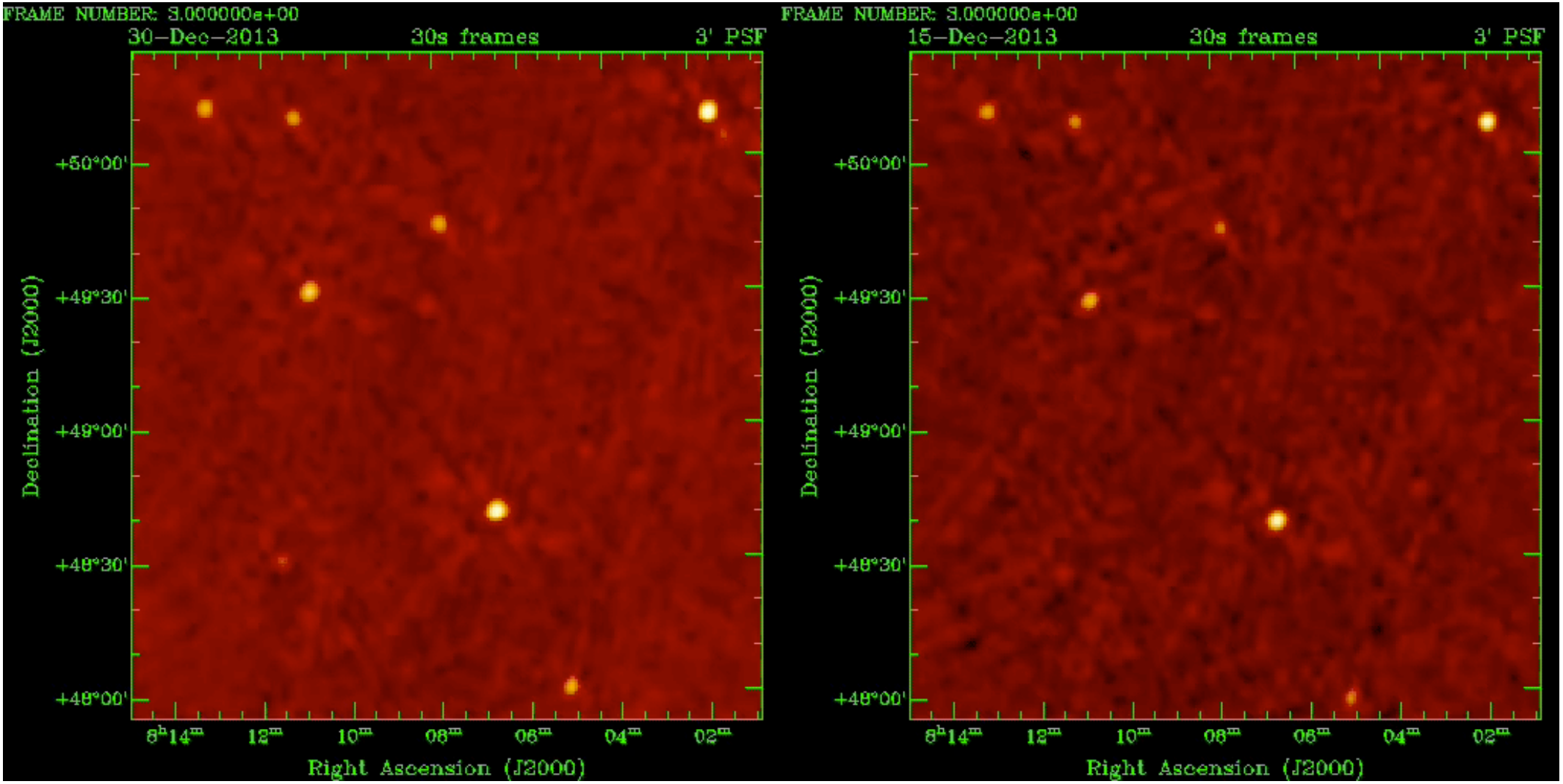
Tier-1 LOFAR Survey : to be observed

48 Pbytes of Raw data → ~39Eiffel towel size dvd stacks

Ionosphere

Good ionosphere

Bad ionosphere

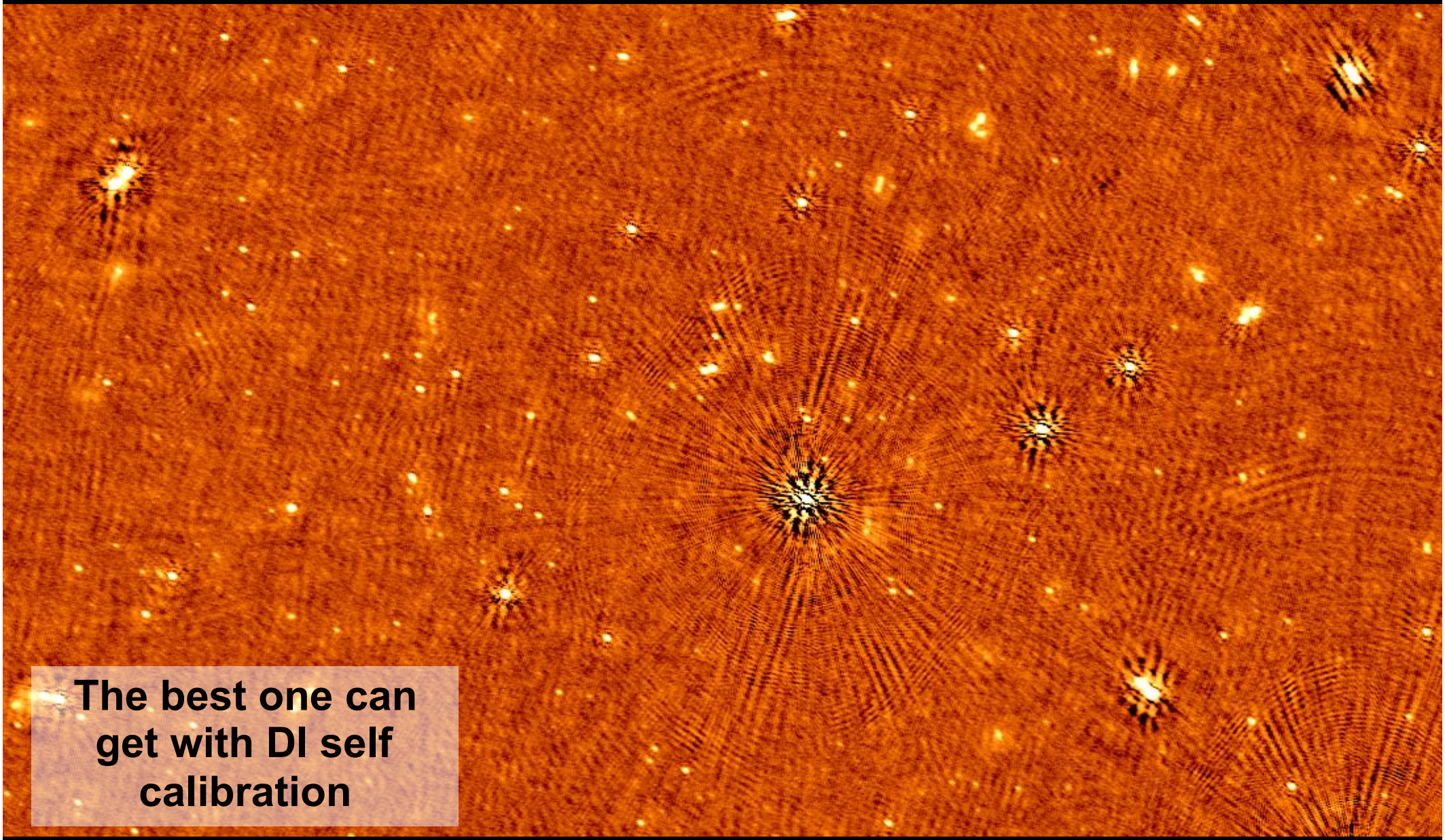


Images have 3 arcmin resolution

Ger de Bruyn & LOFAR EoR team

Wirtinger calibration

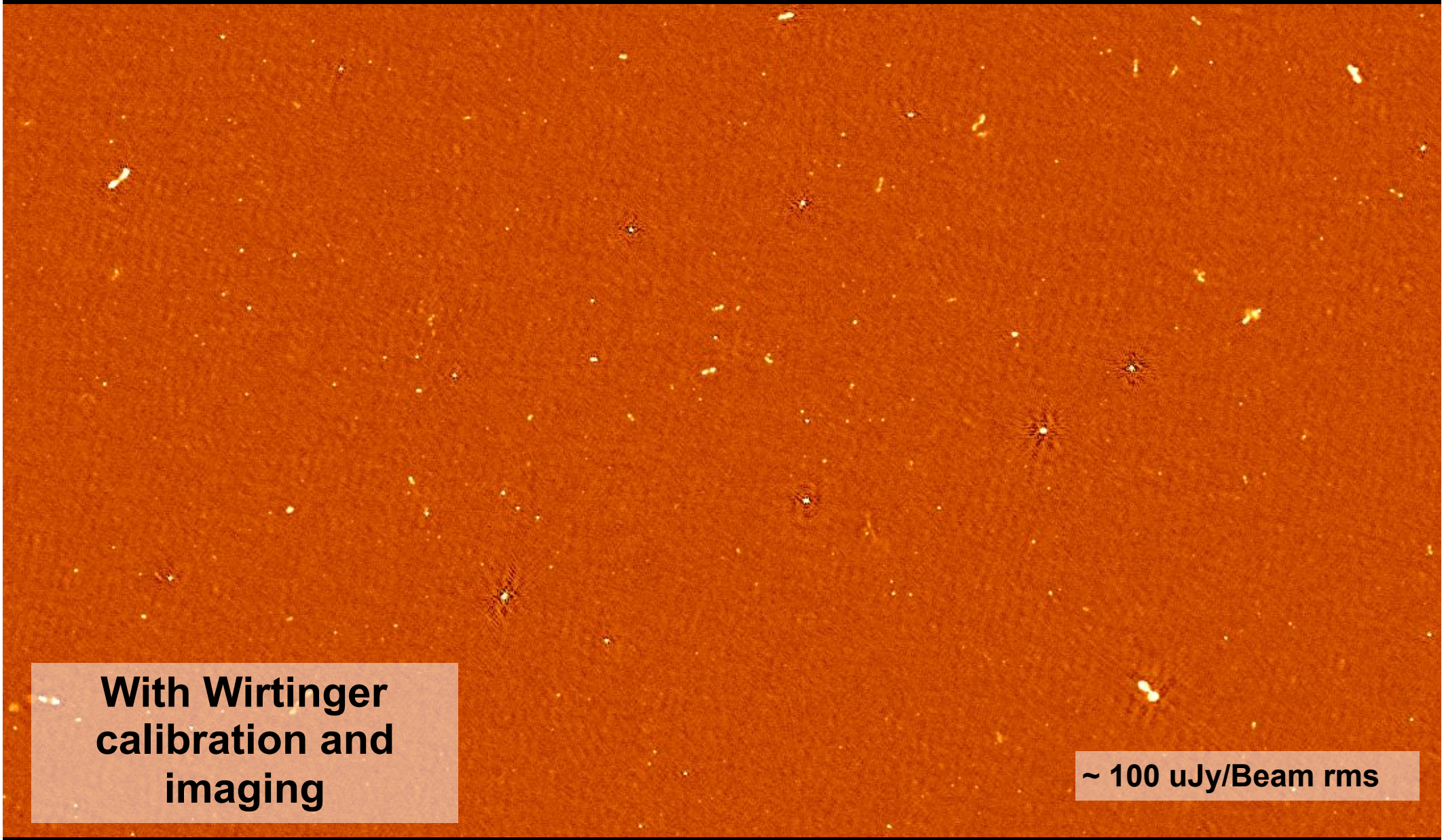
Tasse 14, Smirnov&Tasse15, Tasse+ 17



The best one can get with DI self calibration

Wirtinger calibration

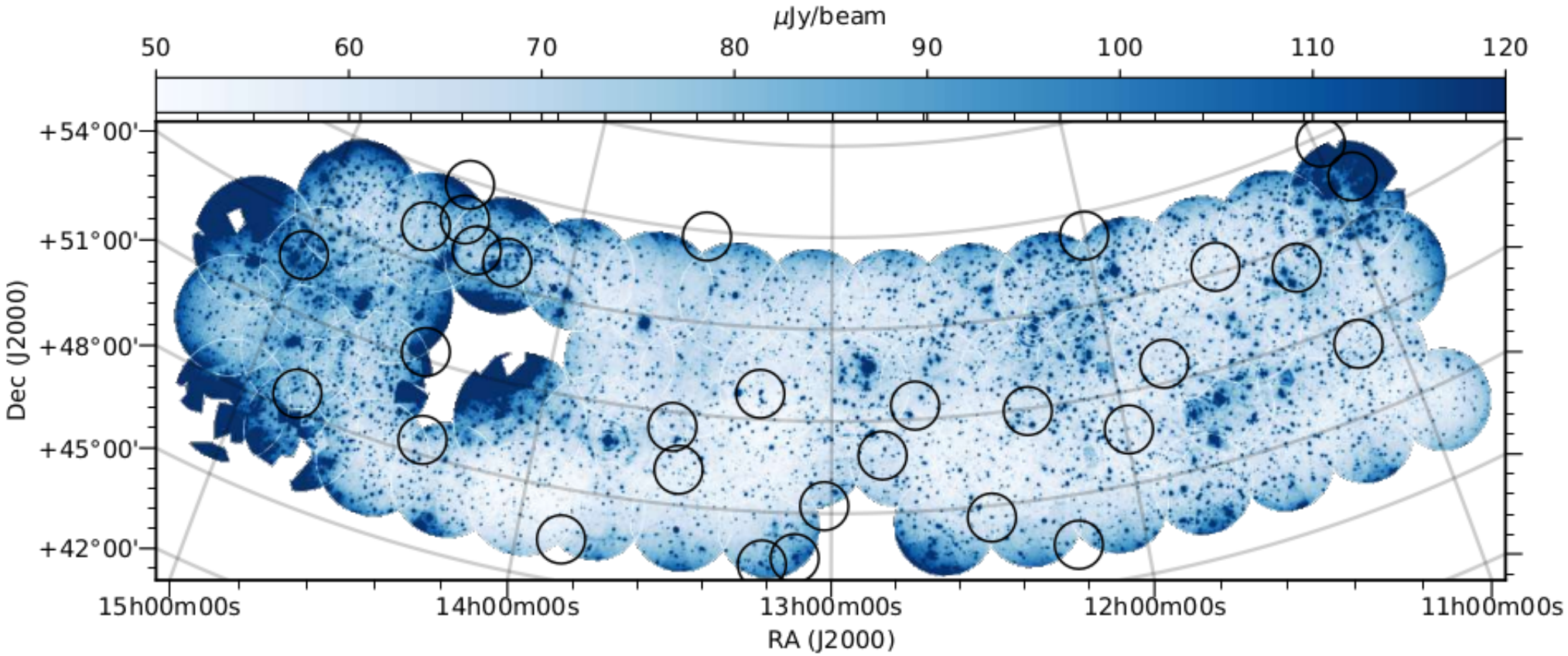
Tasse 14, Smirnov&Tasse15, Tasse+ 17



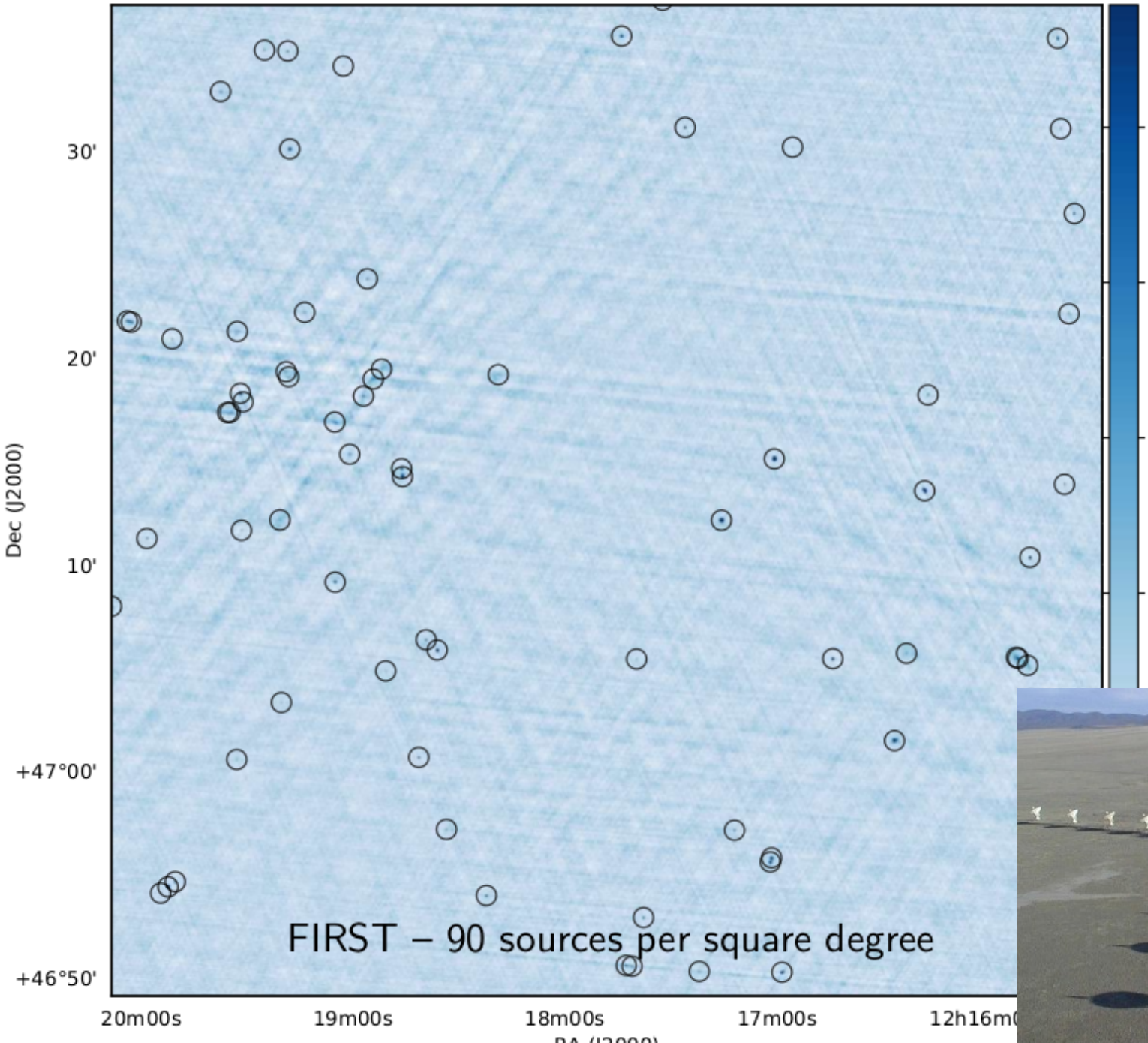
LOTSS – First Data Release

A data release of 6" resolution images with a sensitivity of 71μJy/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)



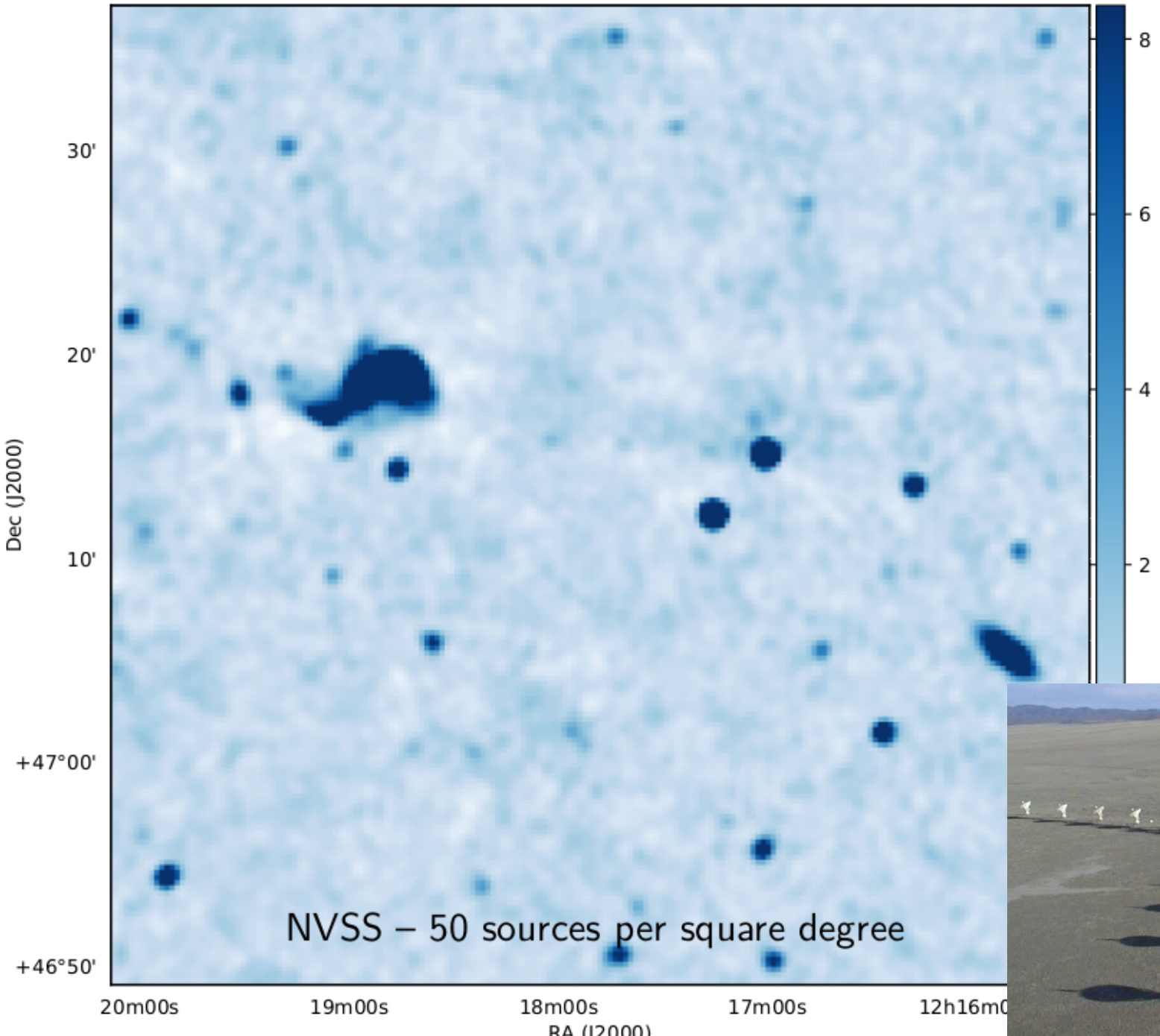
LOTSS – First Data Release



Extended configuration

VLA

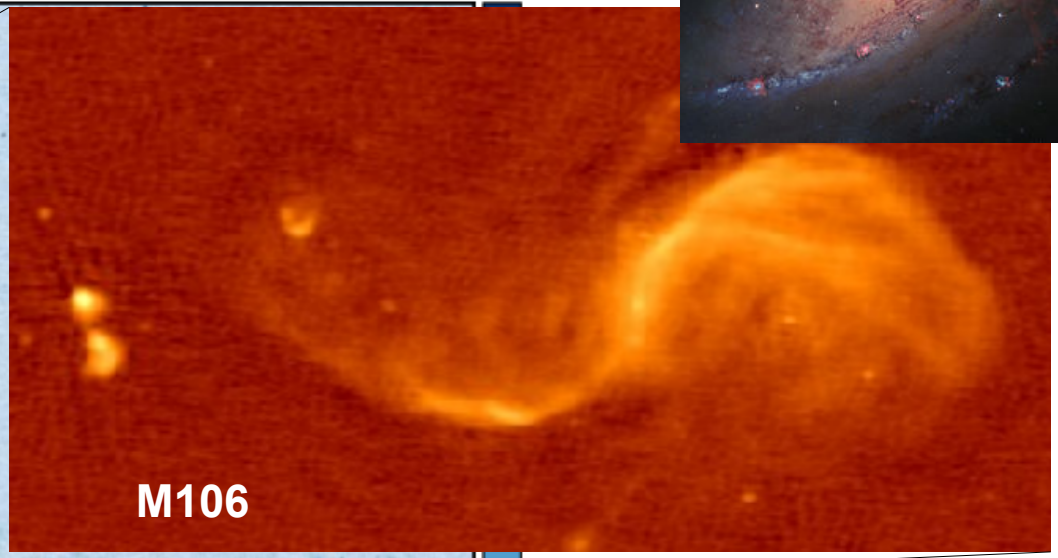
LOTSS – First Data Release

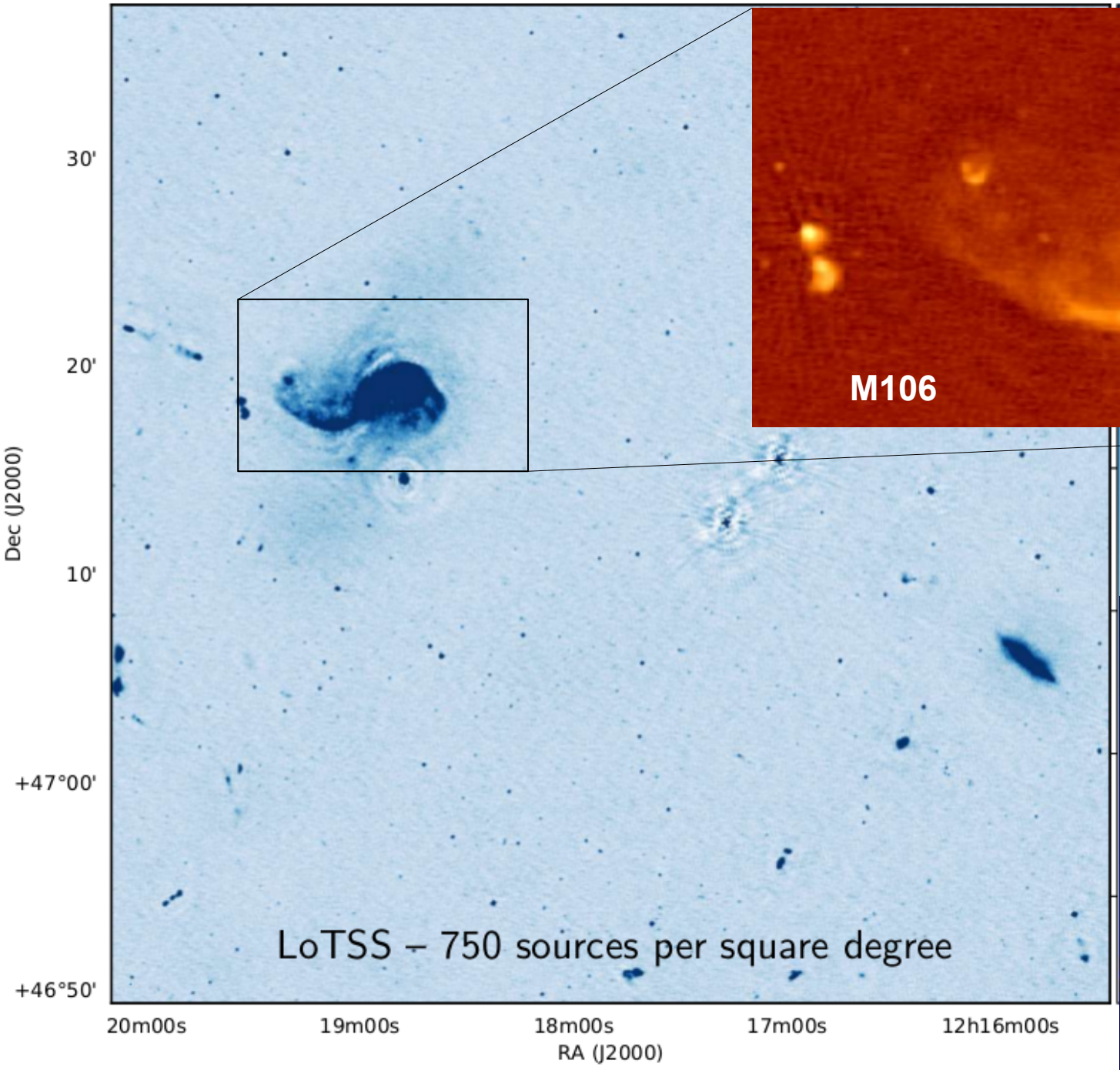


Compact configuration

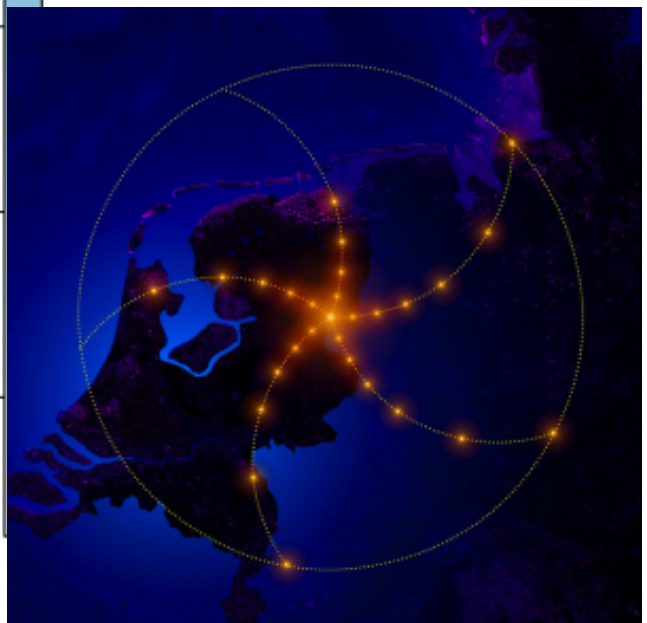
VLA

LOTSS – First Data Release

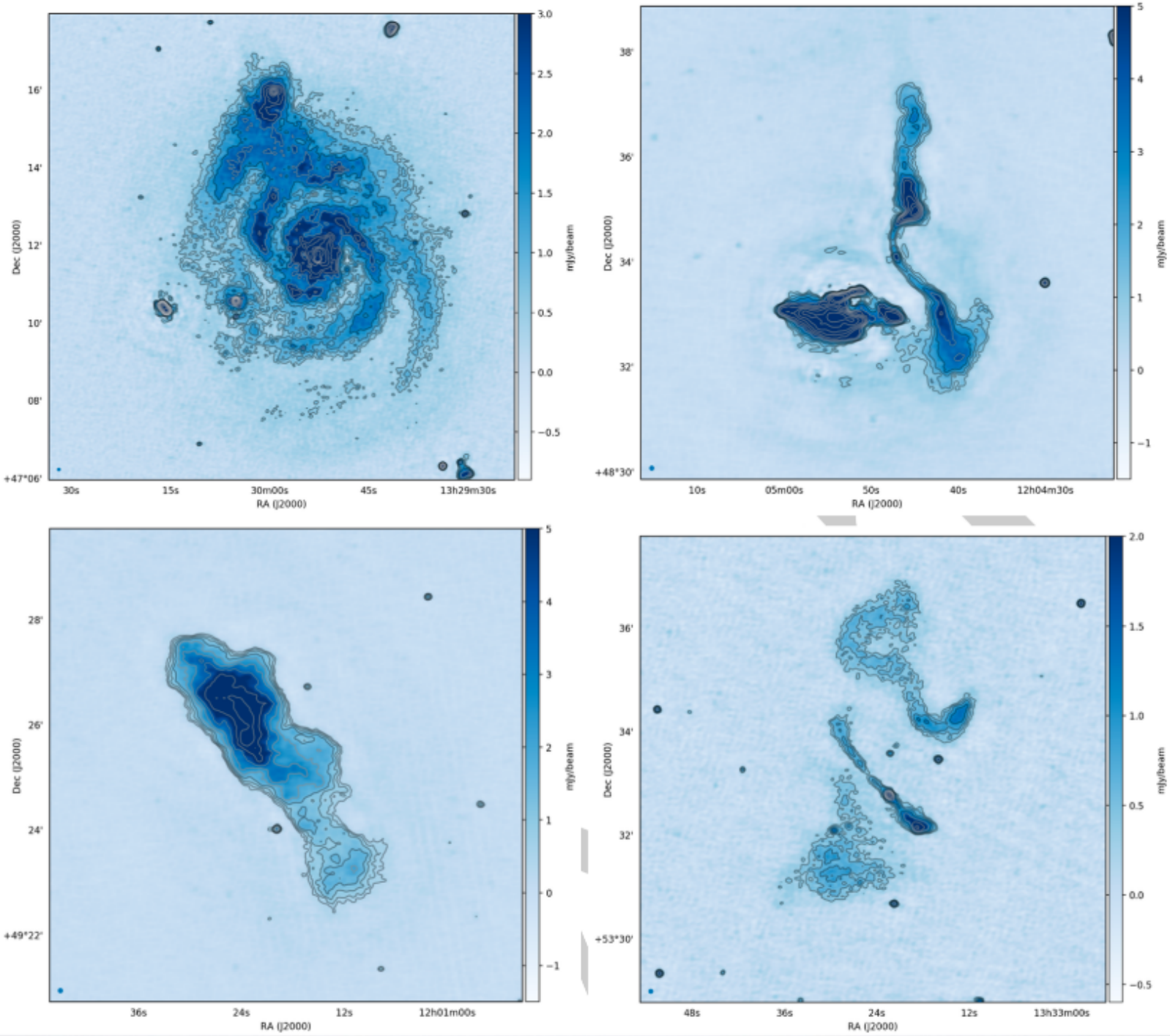


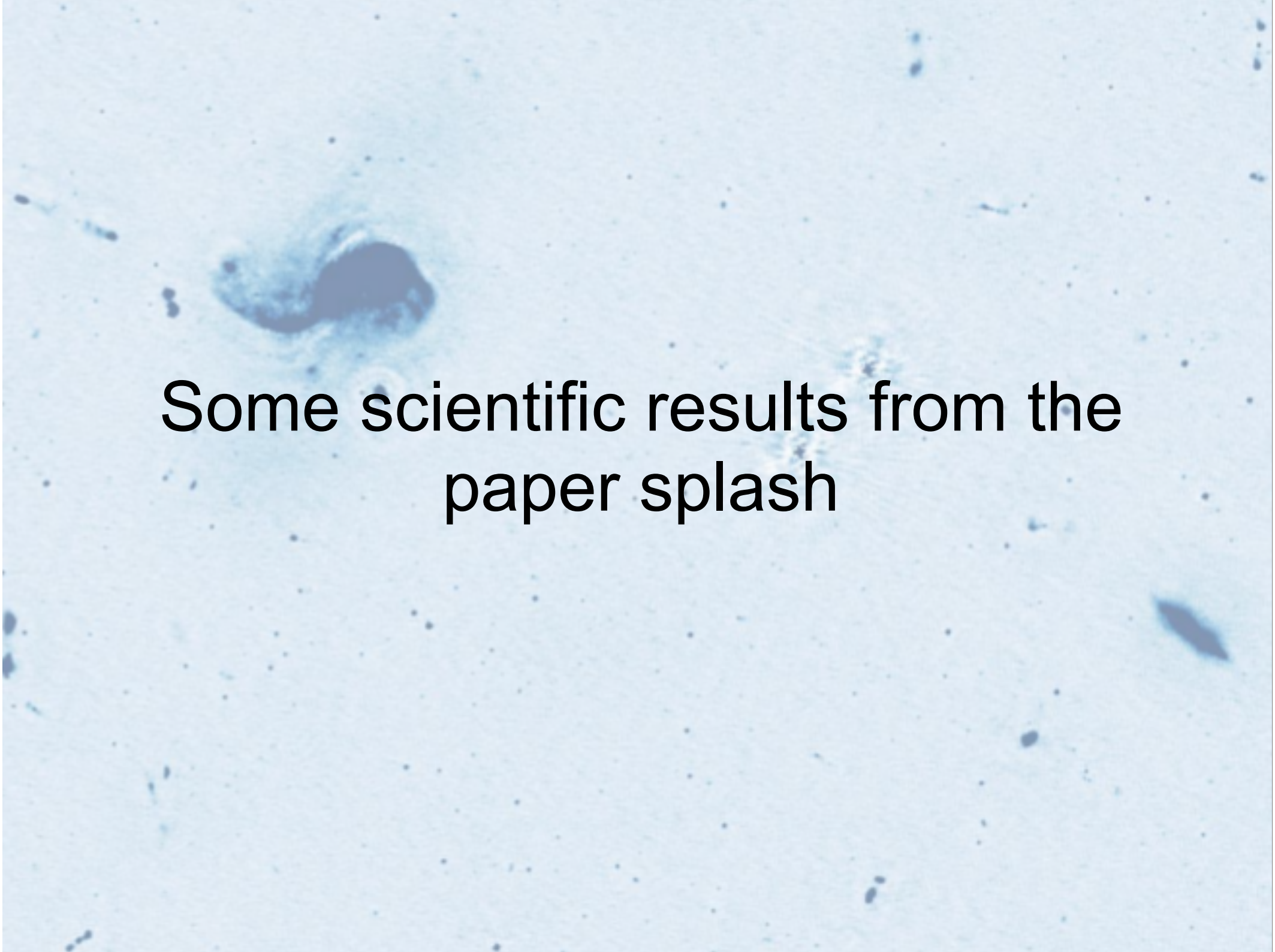


LOFAR

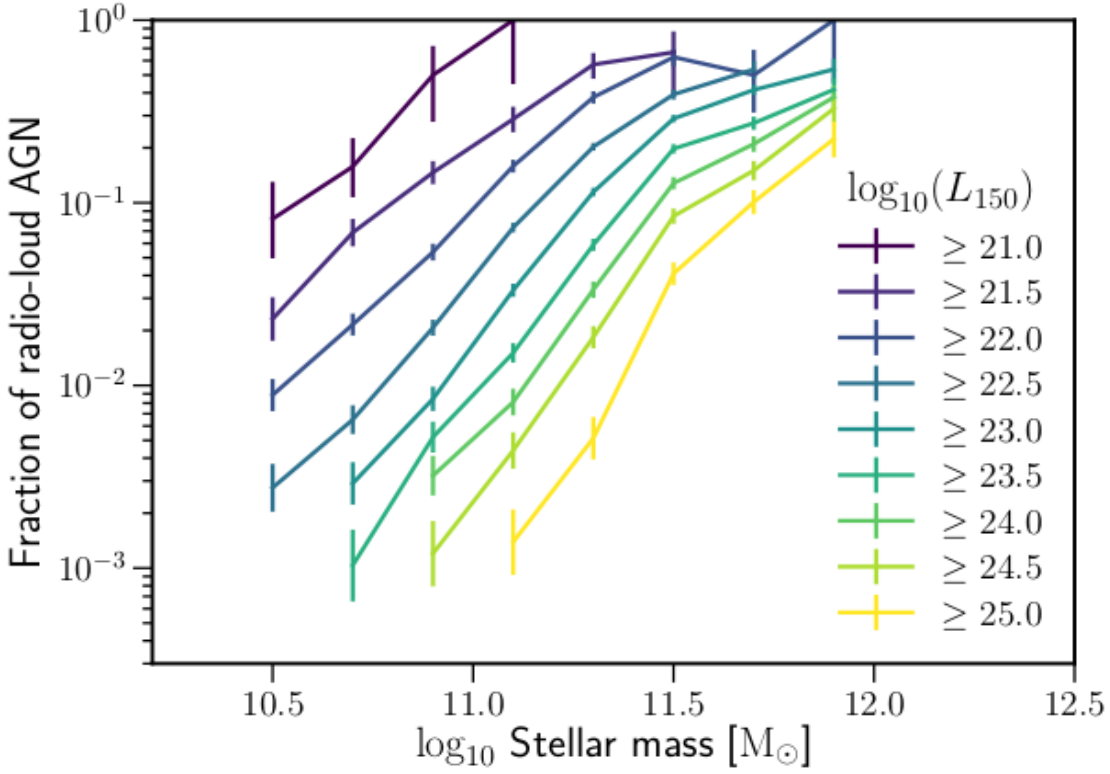


LOTSS – First Data Release

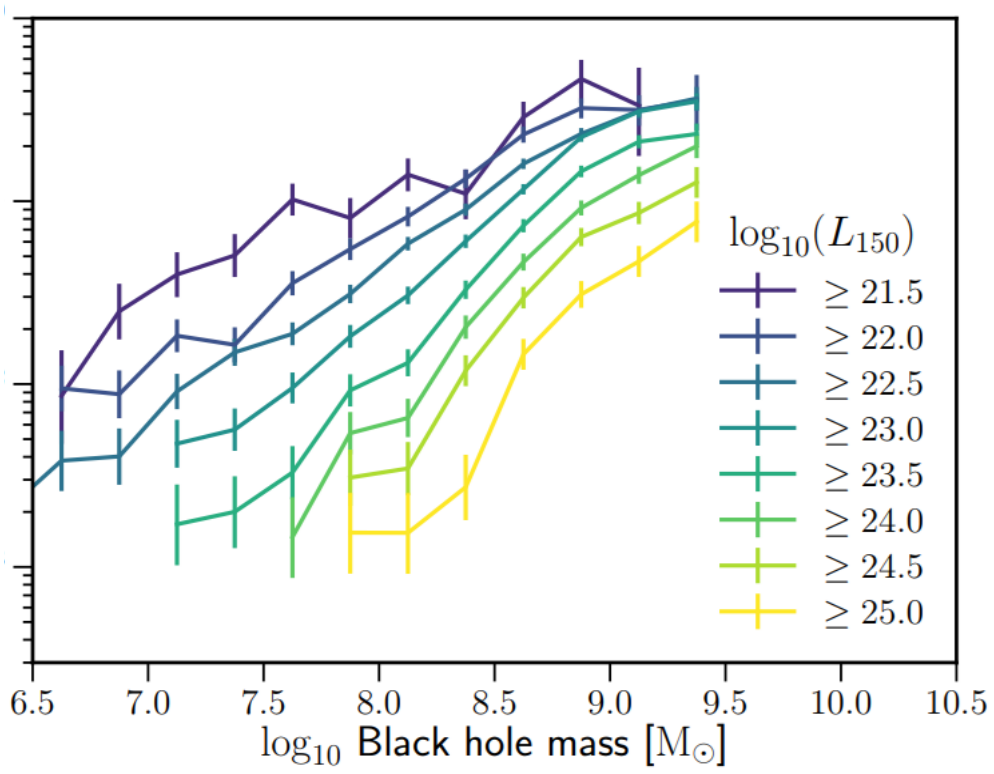



Some scientific results from the paper splash

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



Stellar mass



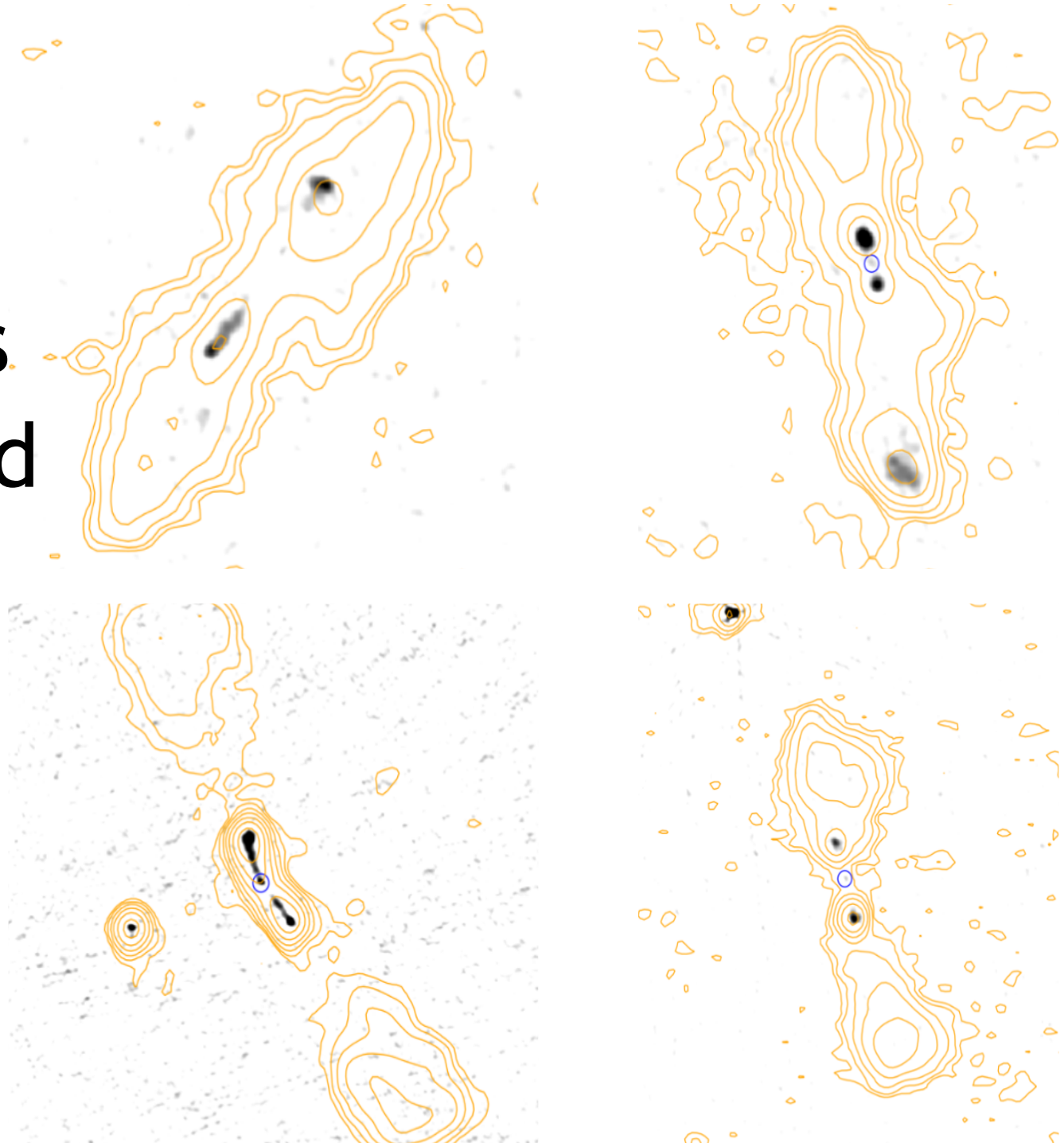
Black-Hole mass

Sabater et al.

Relic AGN or restarted?

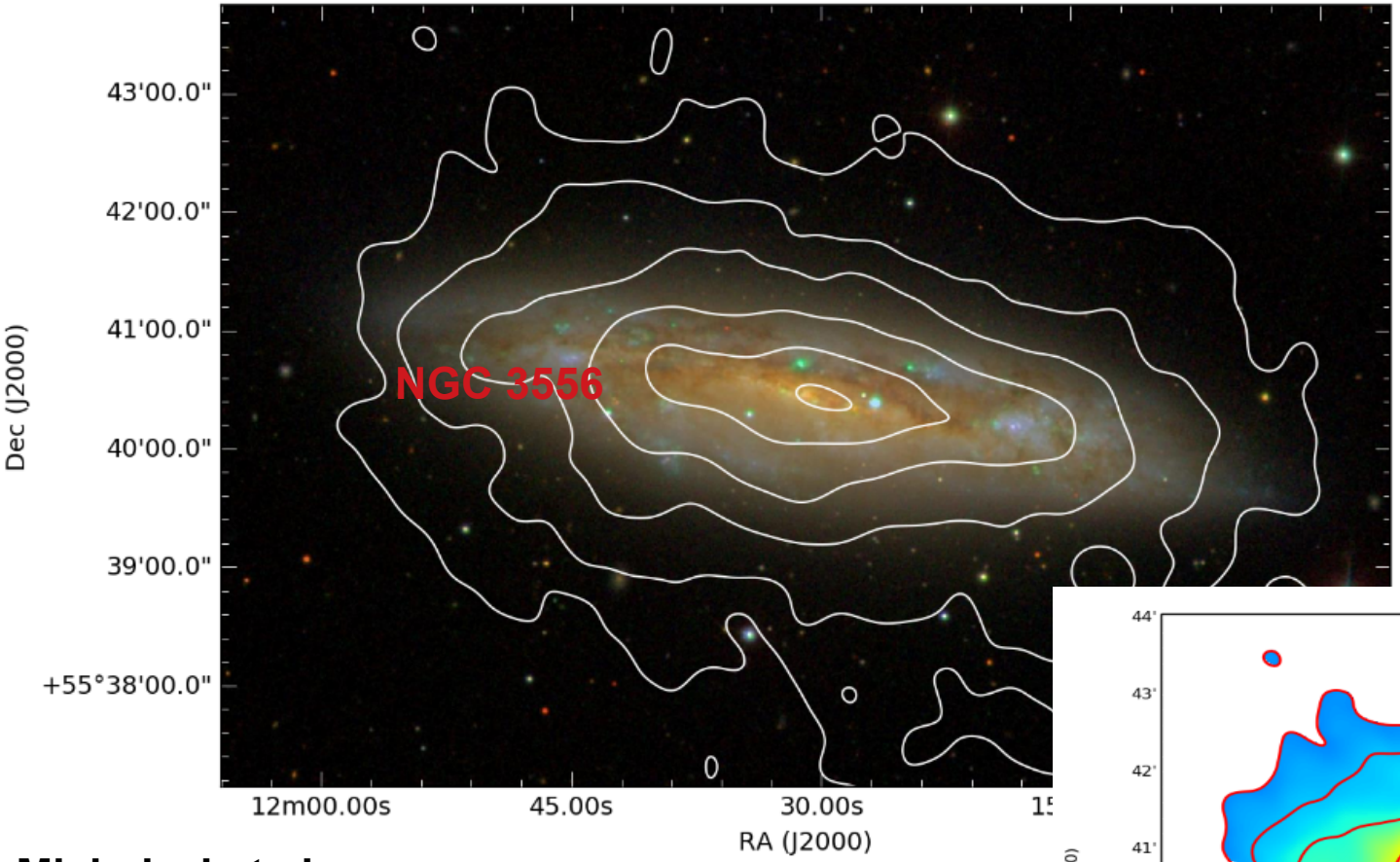
Jet dynamics

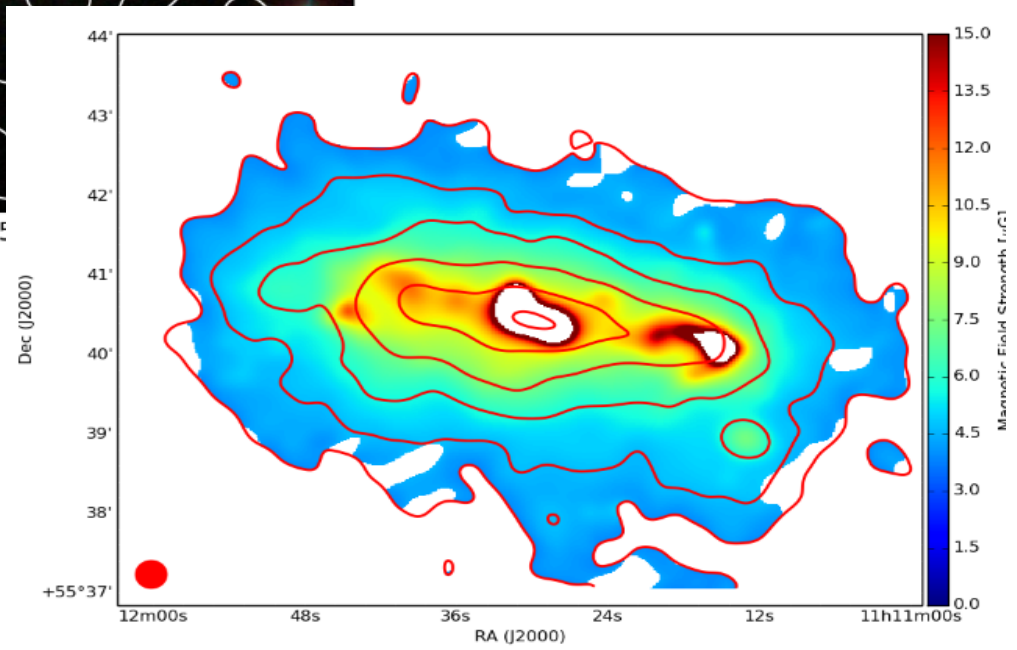
Feedback and duty cycle



Mahatma et al.

Nearby galaxies





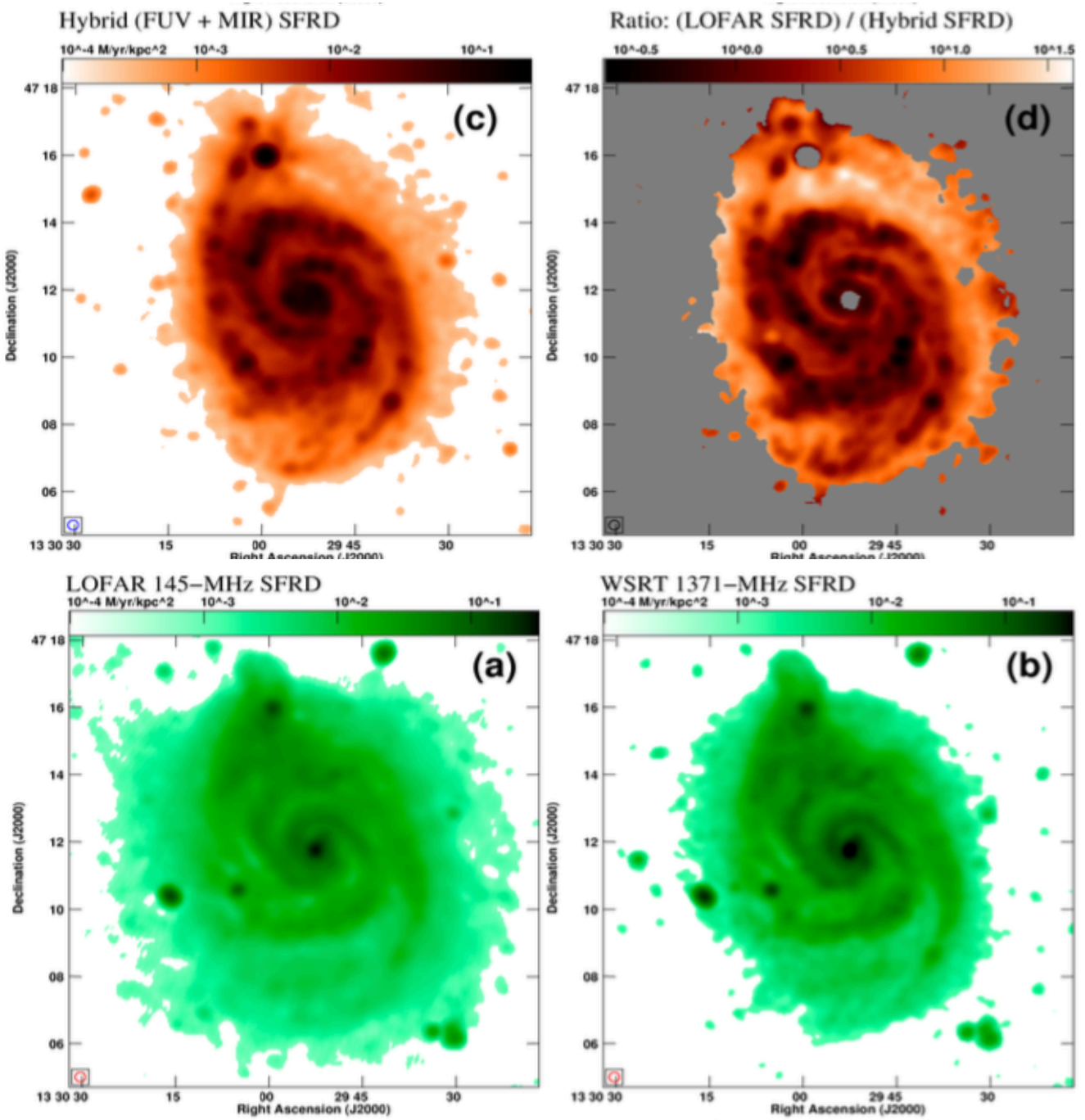
Miskolczi et al.

- Cosmic rays emitting synchrotron in a galactic Haloe
- 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



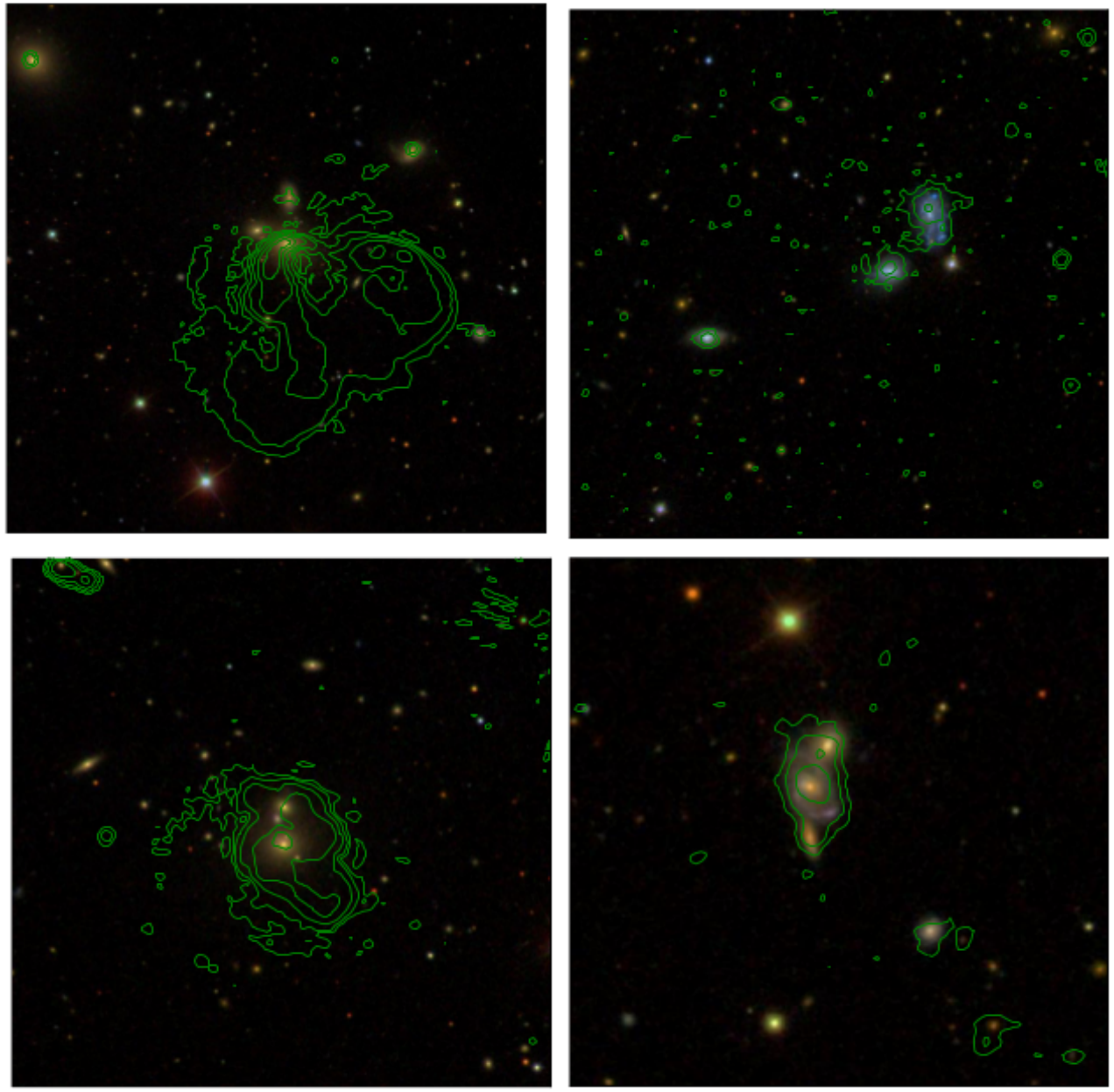
Heesen et al.

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

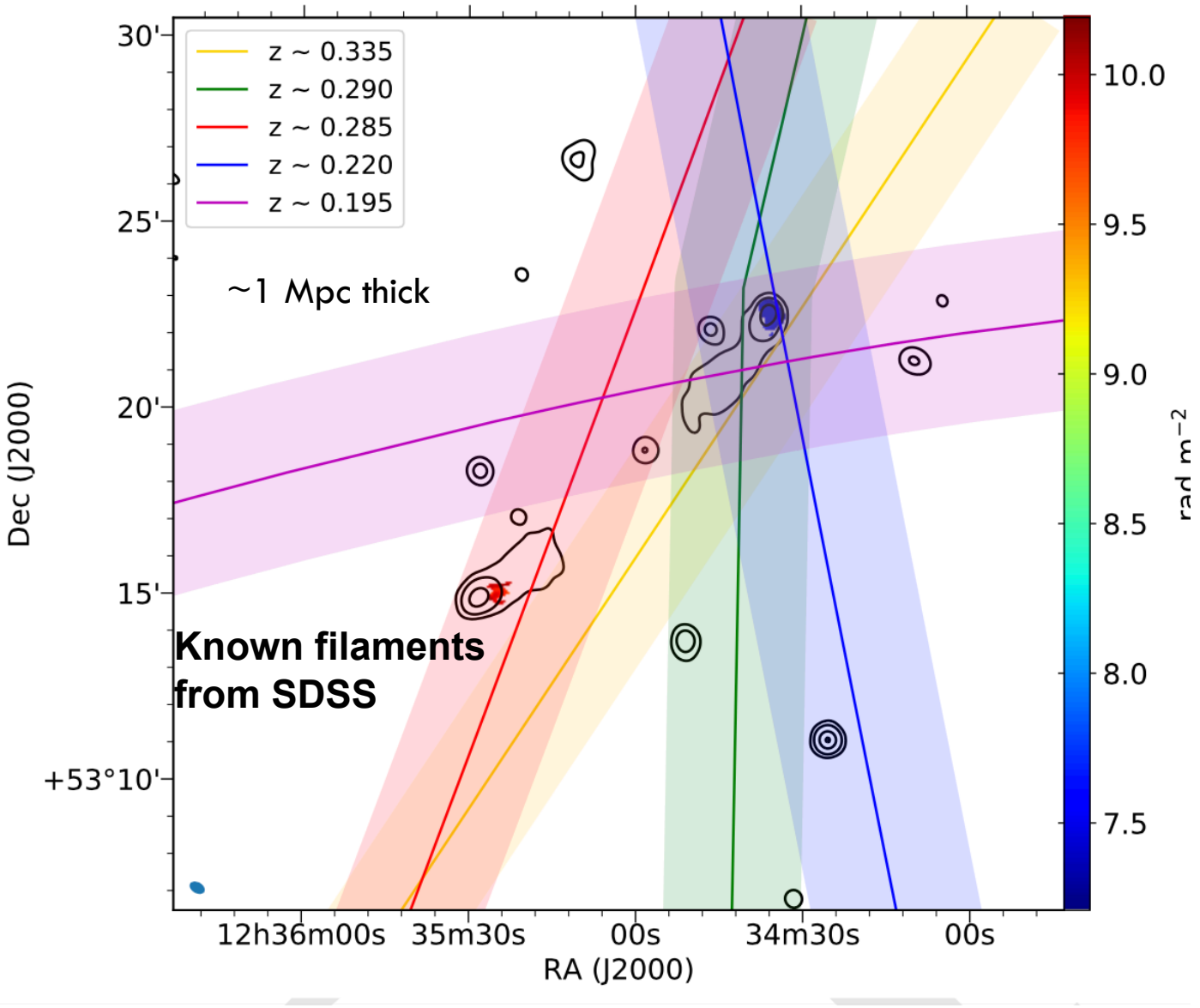


LSS Filaments

- 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

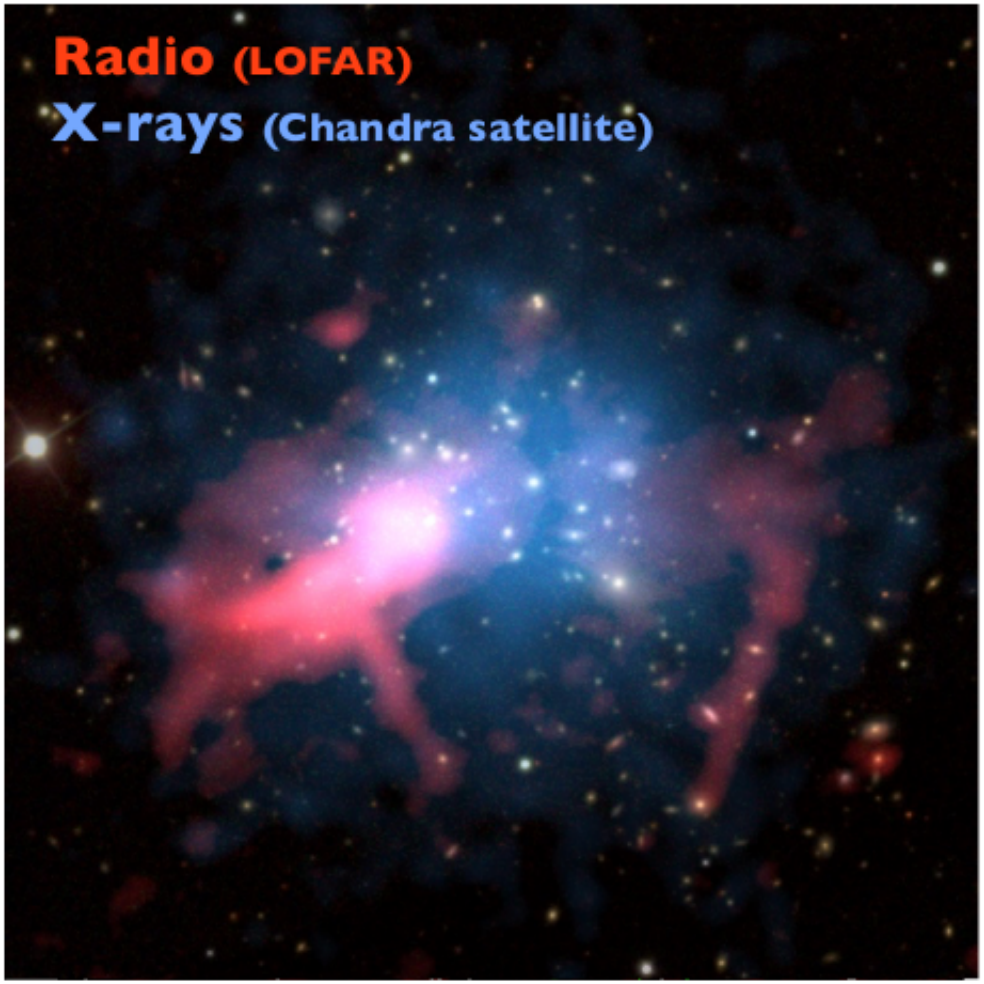
Excess of 3 filaments for North lobe

O'Sullivan et al.



Galaxy clusters

Abell 1914

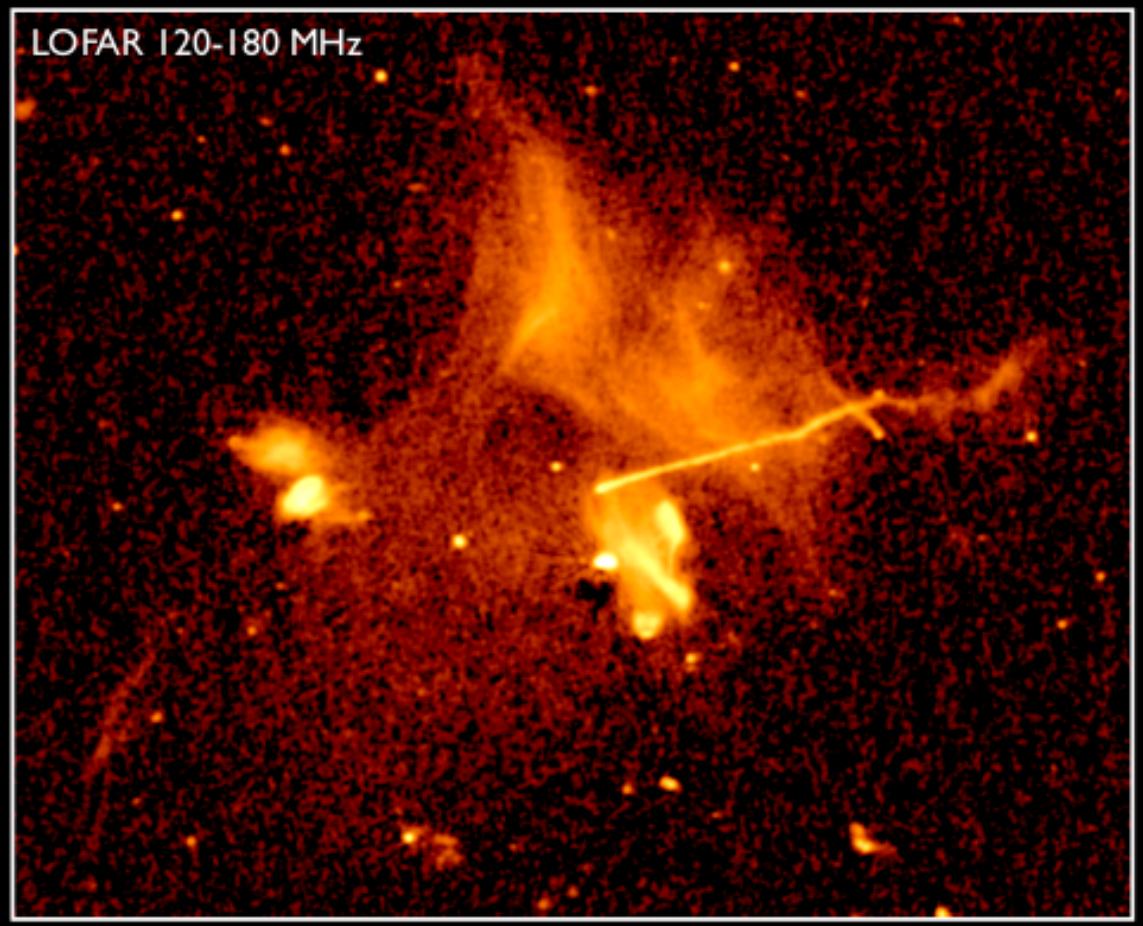


Mandal+ (2018, in prep)

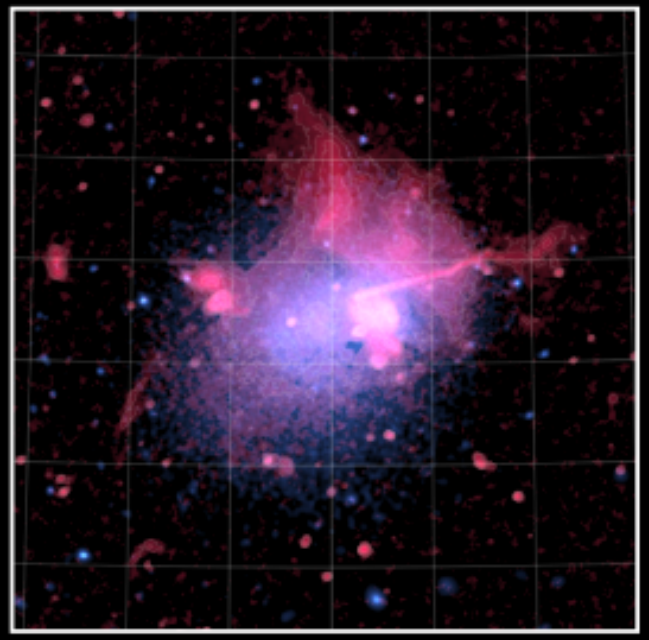
Abell 1132

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