

WEAVE-LOFAR: OVER 1 MILLION SPECTRA FOR LOW-FREQUENCY SELECTED RADIO SOURCES

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Leiden Observatory

HI Absorption 2018 @ ASTRON - 29-31st August 2018

THE LOFAR SURVEYS

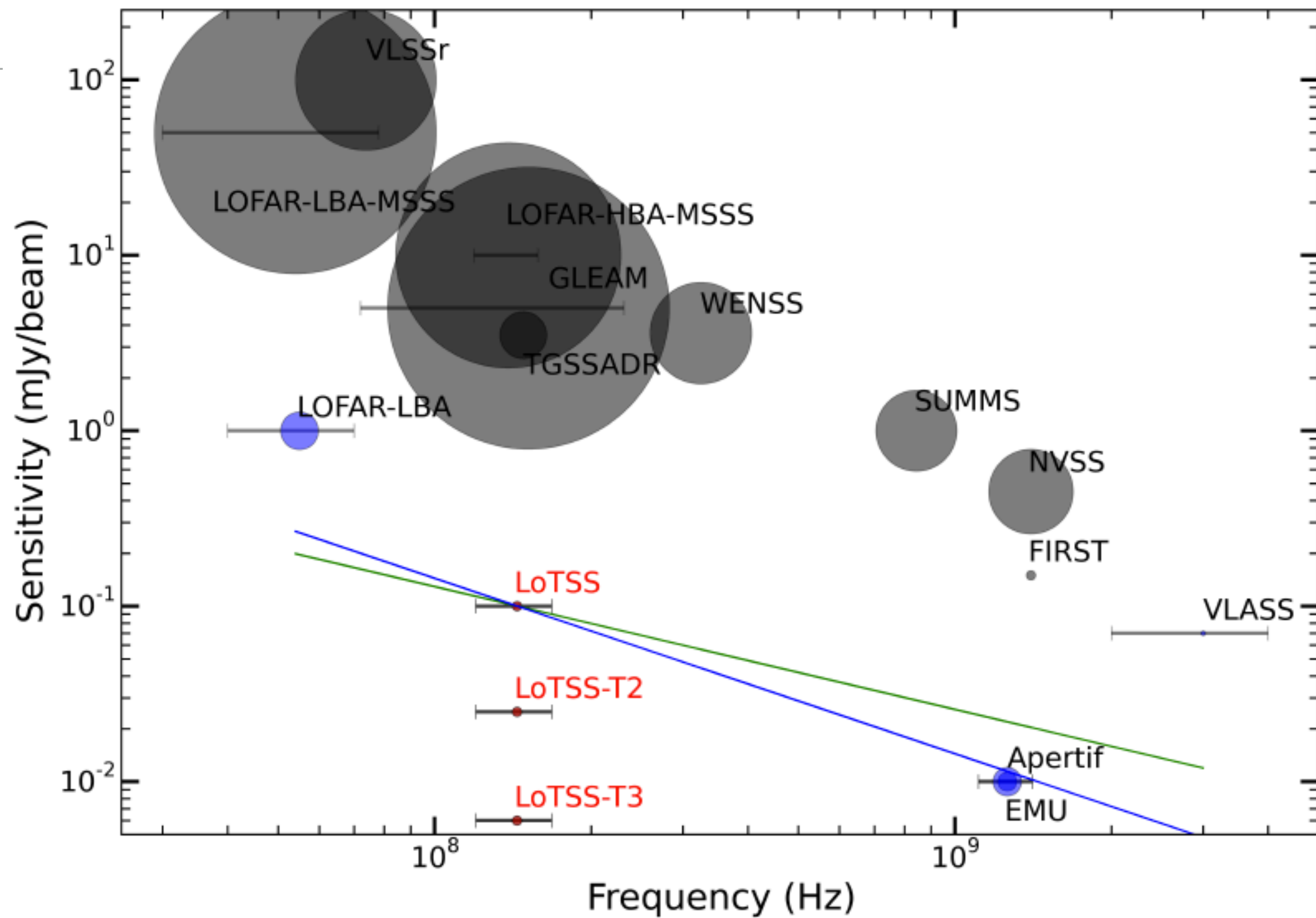
KEY SCIENCE DRIVERS FOR THE LOFAR SURVEYS KSP

- ▶ Formation of massive galaxies, clusters and black holes
- ▶ Intracuster magnetic fields using diffuse radio emission in galaxy clusters as probes,
- ▶ Star formation in the early Universe
- ▶ Exploration of new parameter space for serendipitous discovery.
- ▶ Magnetic fields and the interstellar medium in nearby galaxies
- ▶ Cosmology and the large scale structure of the Universe

LOFAR SURVEYS KSP

- ▶ **Tier-1** (or LoTSS): Will cover whole northern hemisphere
(0.1 mJy RMS at 150 MHz)
- ▶ **Tier-2** : ~100s of sq.deg to faint flux limits
(25 μ Jy RMS @ 150 MHz)
- ▶ **Tier-3** : ~10s of sq.deg to sensitivities > the deepest
existing imaging
(6 μ Jy @ 150 MHz)

Details: Röttgering et al. (2011), Shimwell et al. (2016)



LOFAR TWO METER SKY SURVEY (LOTSS) PROGRESS

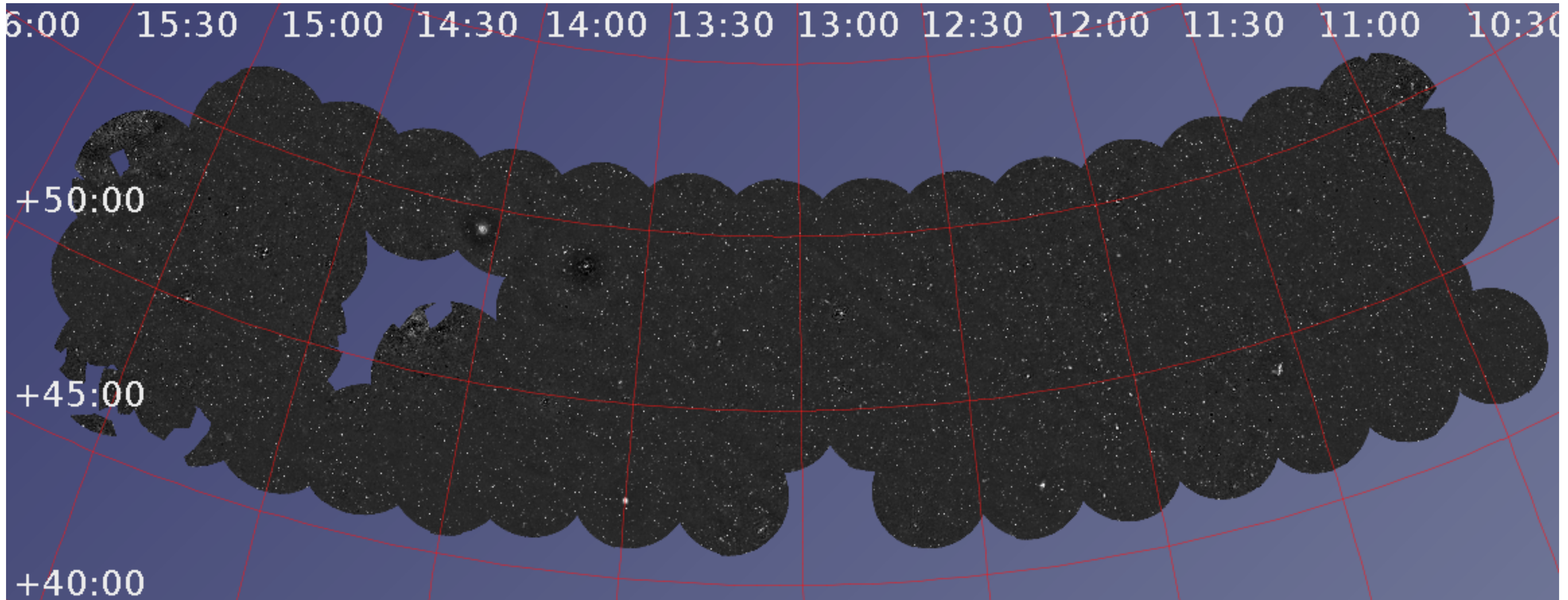
Red = Observed

Blue = Partially processed

Green = Fully processed

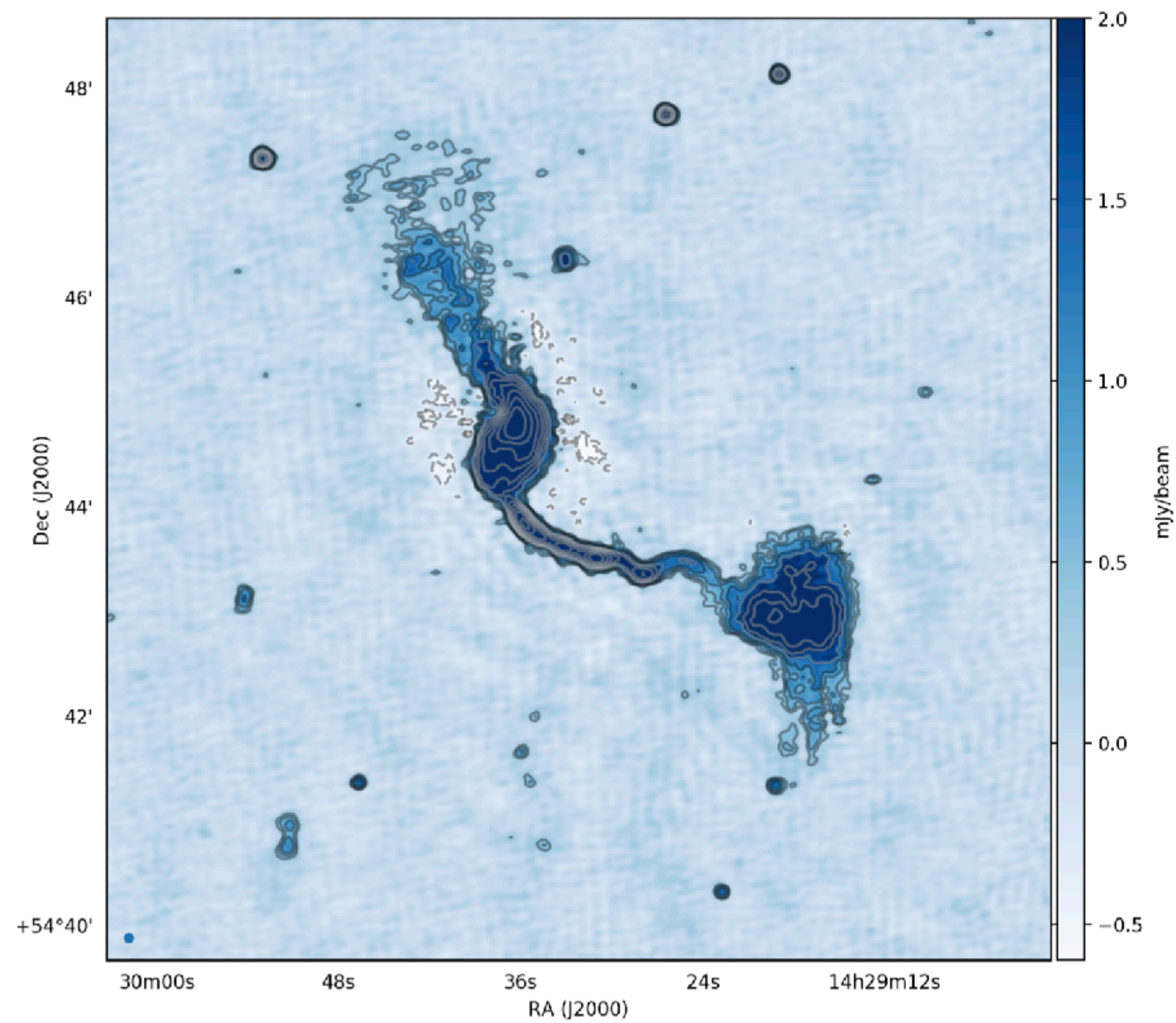
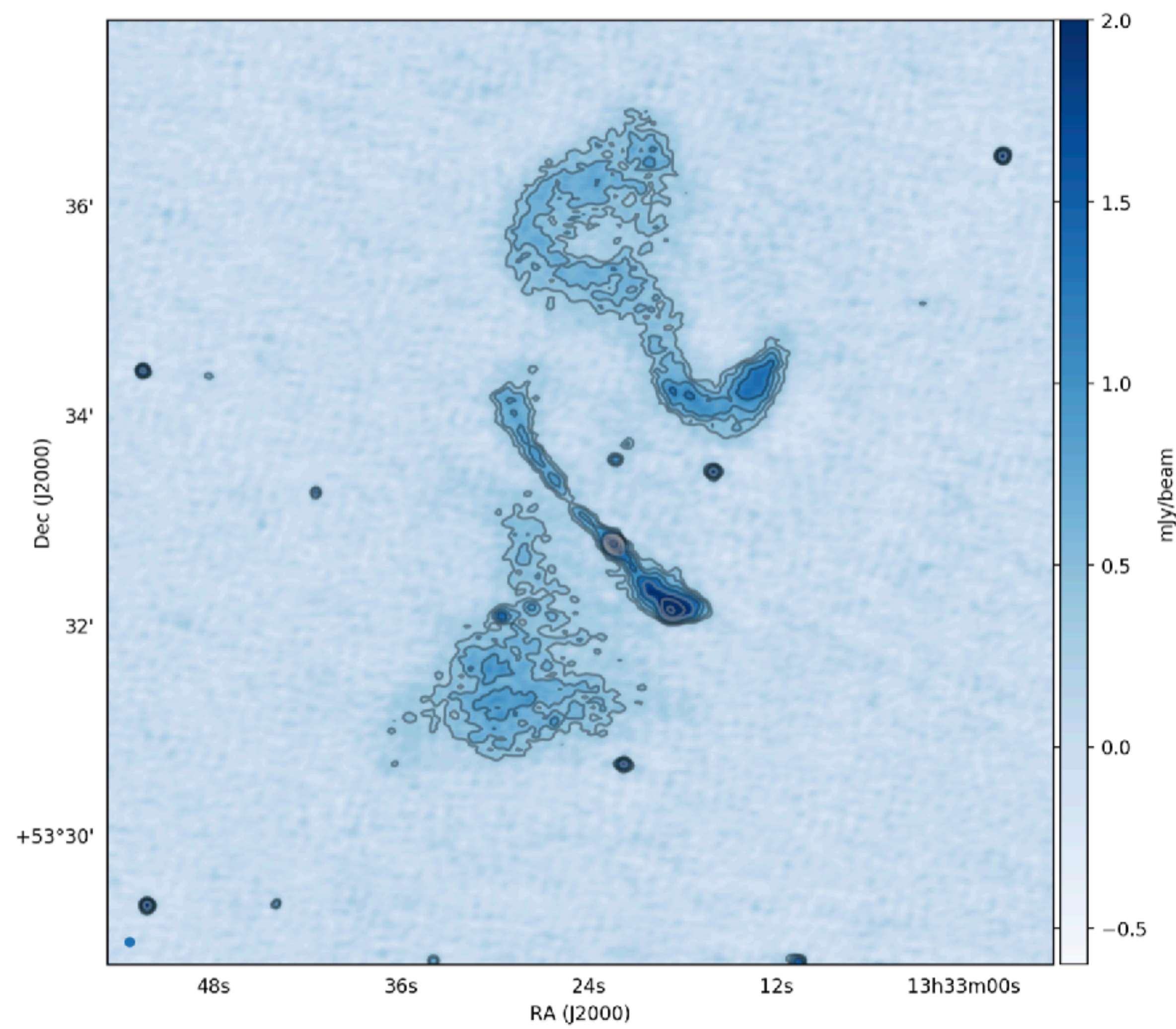
IMAGE: TIM SHIMWELL

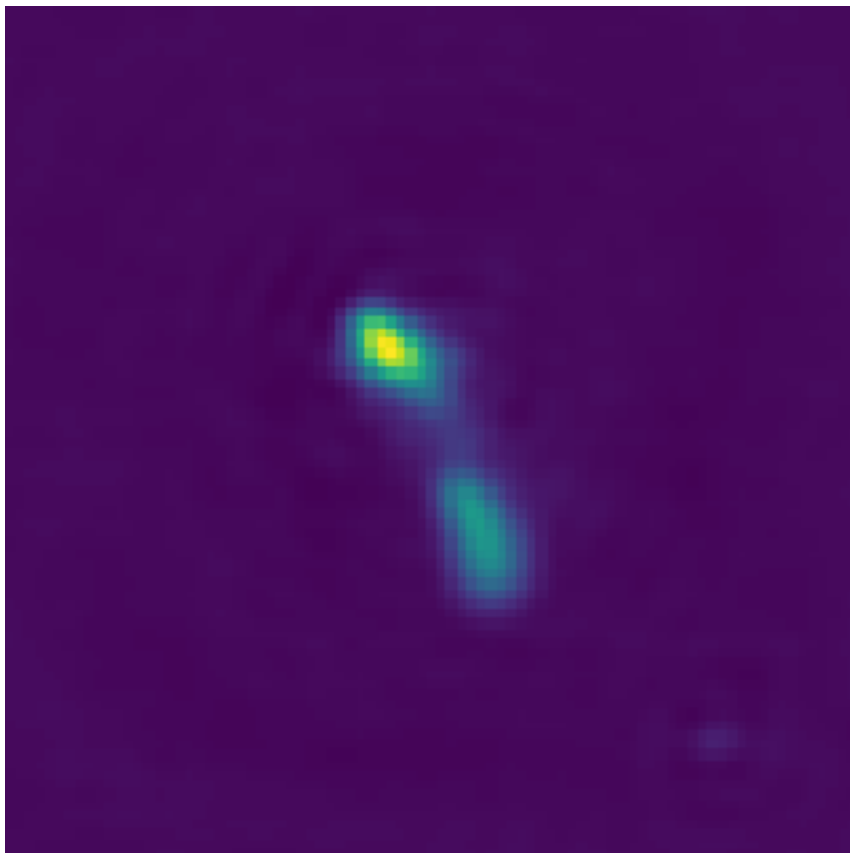
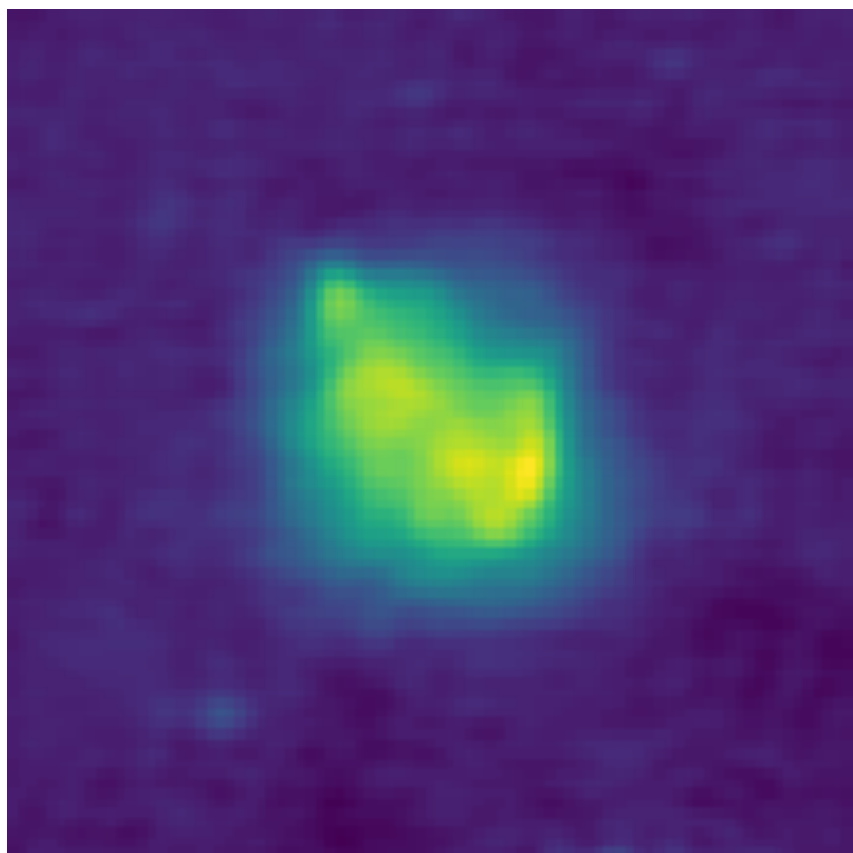
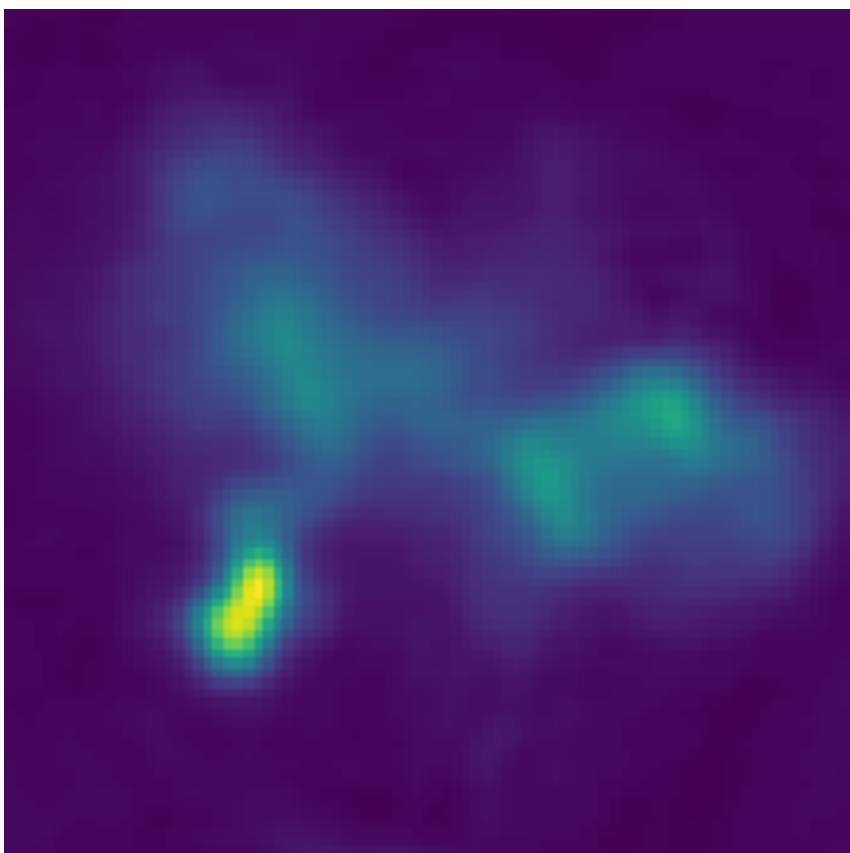
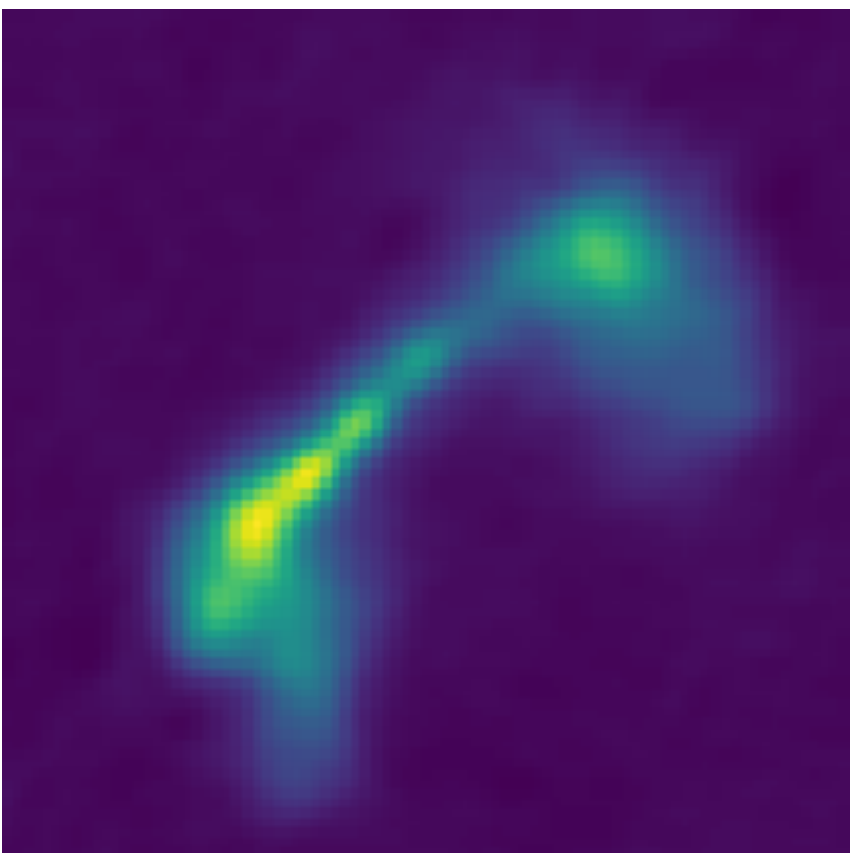
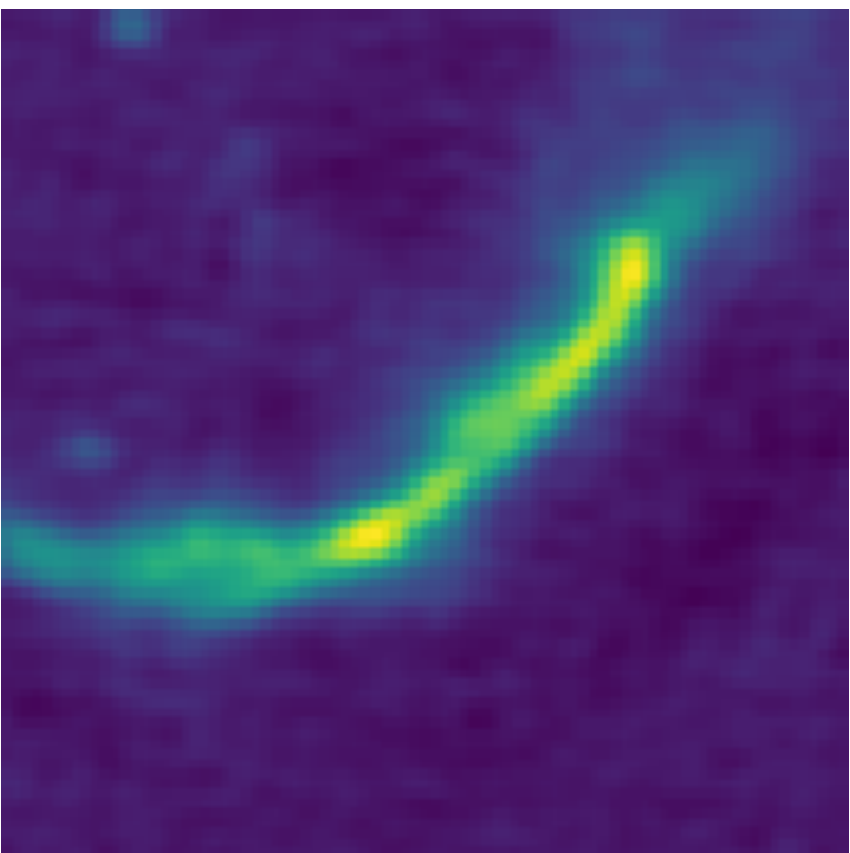
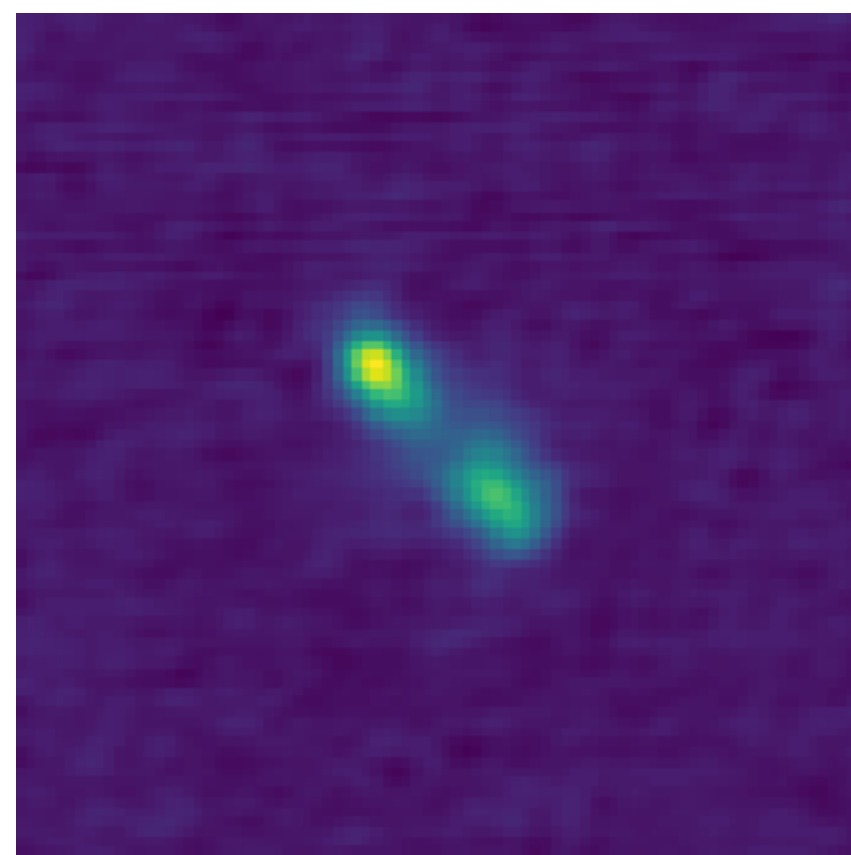
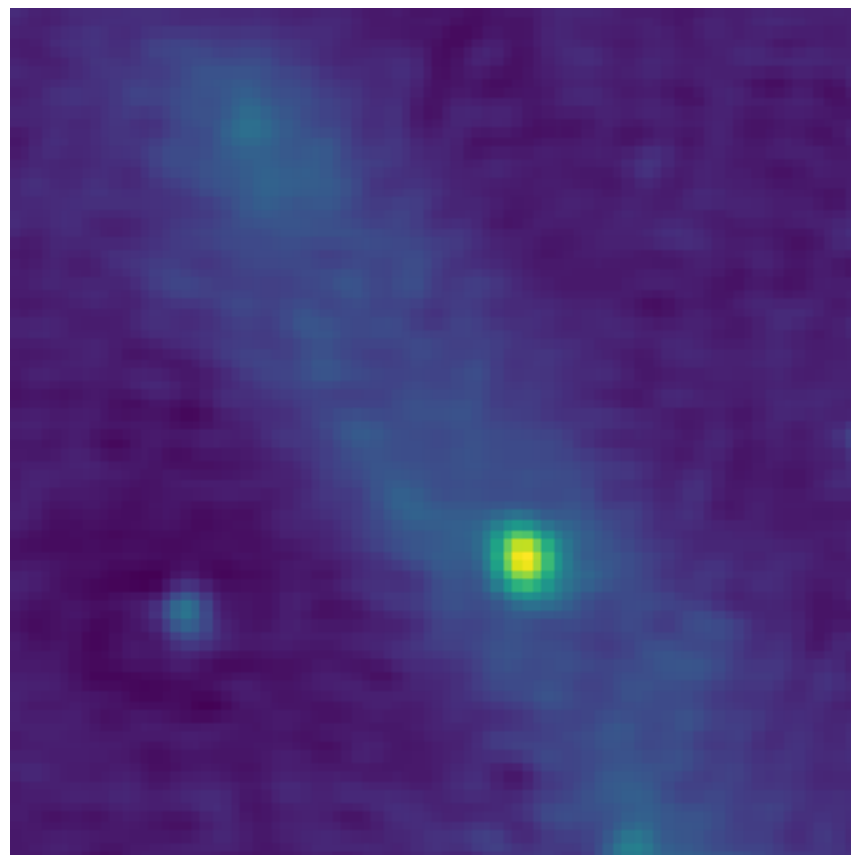
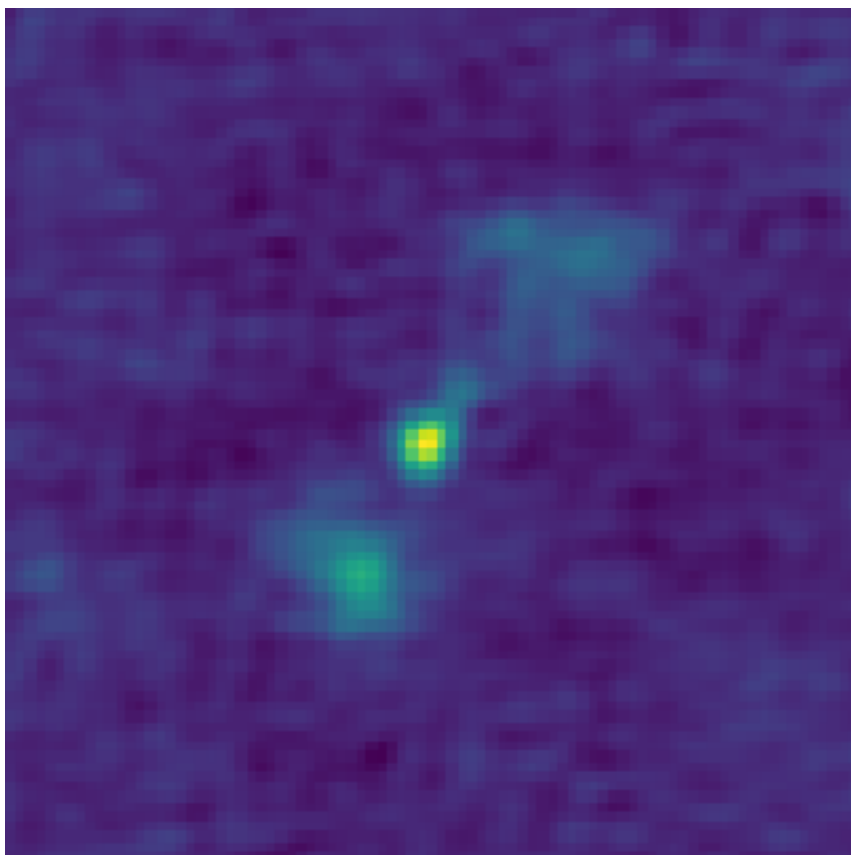
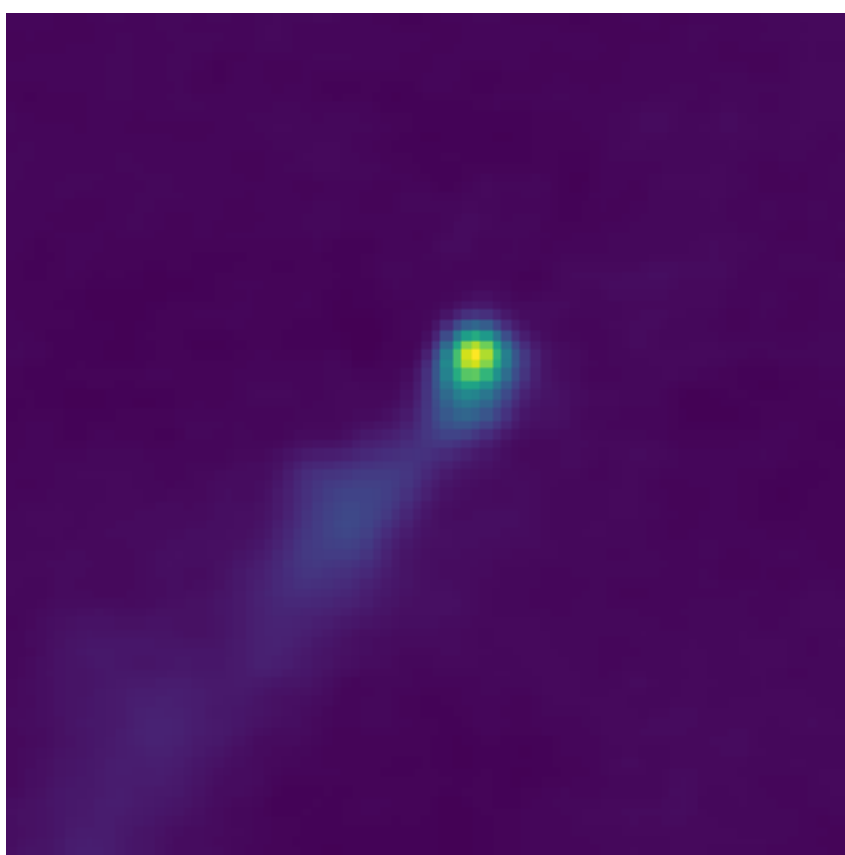
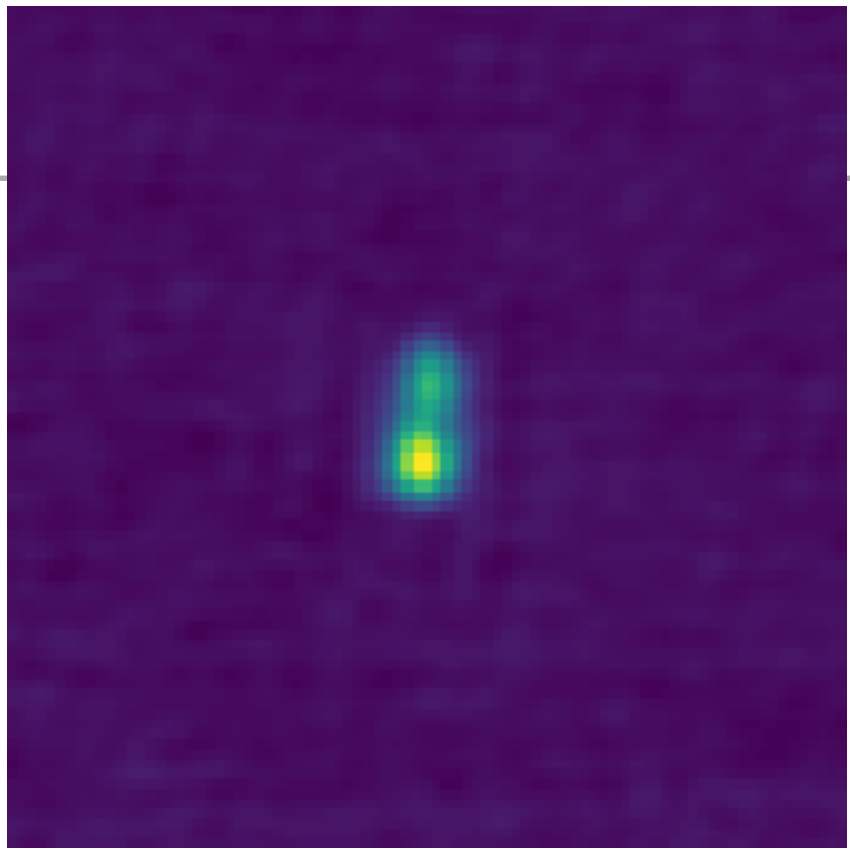
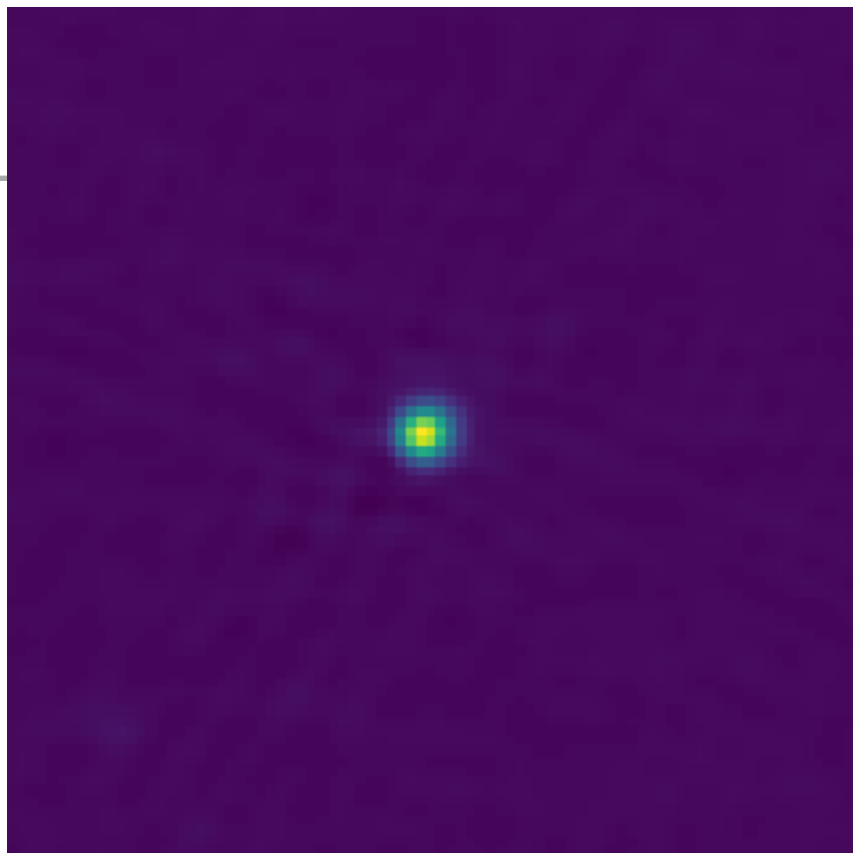
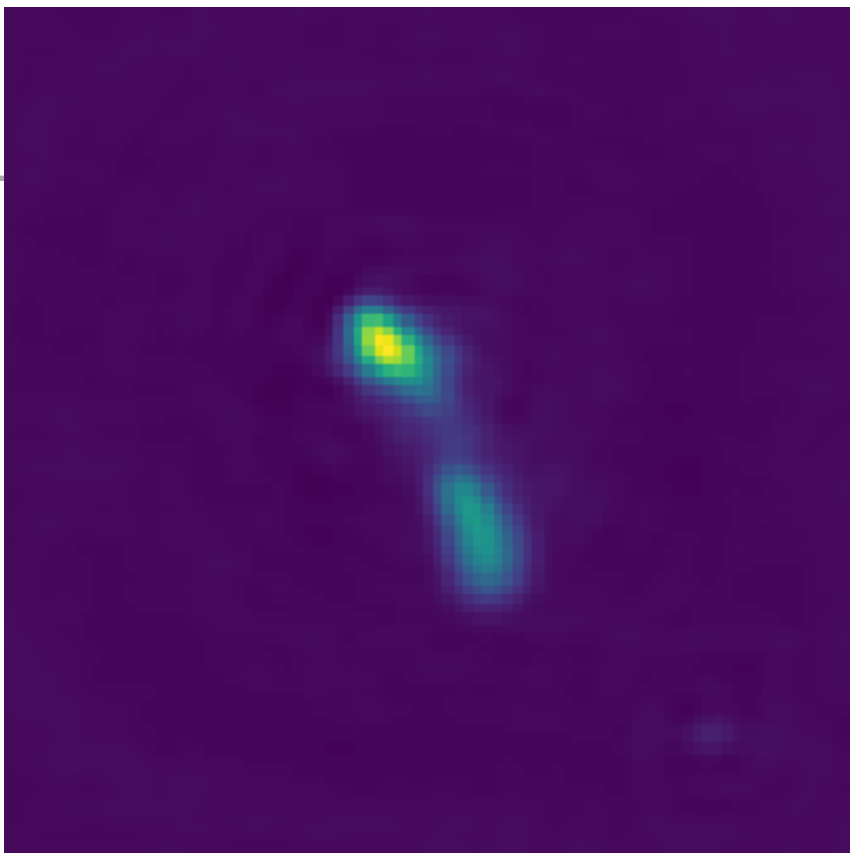
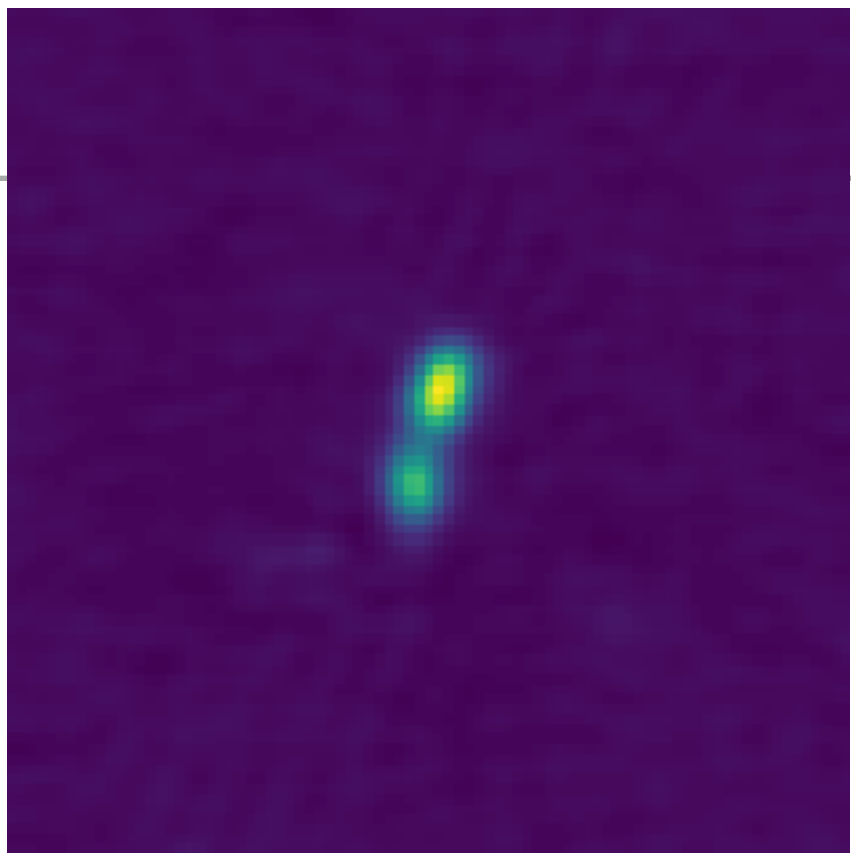
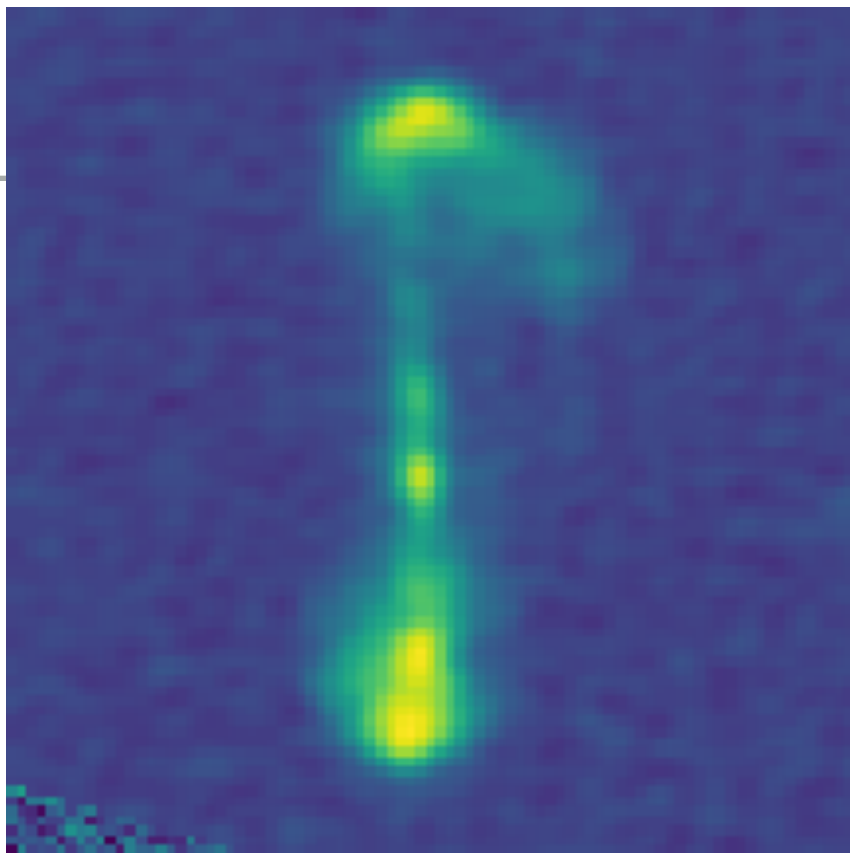
LOTSS FIRST DATA RELEASE – HETDEX SPRING FIELD



424 sq.deg, 63 pointings @ average noise 71 μ Jy/beam

~325,000 sources





LOTSS FIRST DATA RELEASE – HETDEX SPRING FIELD

Radio Catalog - Shimwell et al. 2018 (A&A, submitted)

424 sq.deg, 63 pointings @ average noise 71 μ Jy/beam

~325,000 sources

Optical Cross-IDs - Williams et al. 2018 (A&A, submitted)

Combining statistical cross-matching for unresolved/small sources with detailed visual inspection for extended sources

Photometric Redshifts - Duncan et al. 2018 (A&A, accepted)

All optical sources in the region = ~20million+ PS1 and WISE sources

Novel hybrid photo-z technique to give good estimates for AGN and galaxies

PHOTOMETRIC REDSHIFT PRECISION OVER THE LOTSS FOOTPRINT

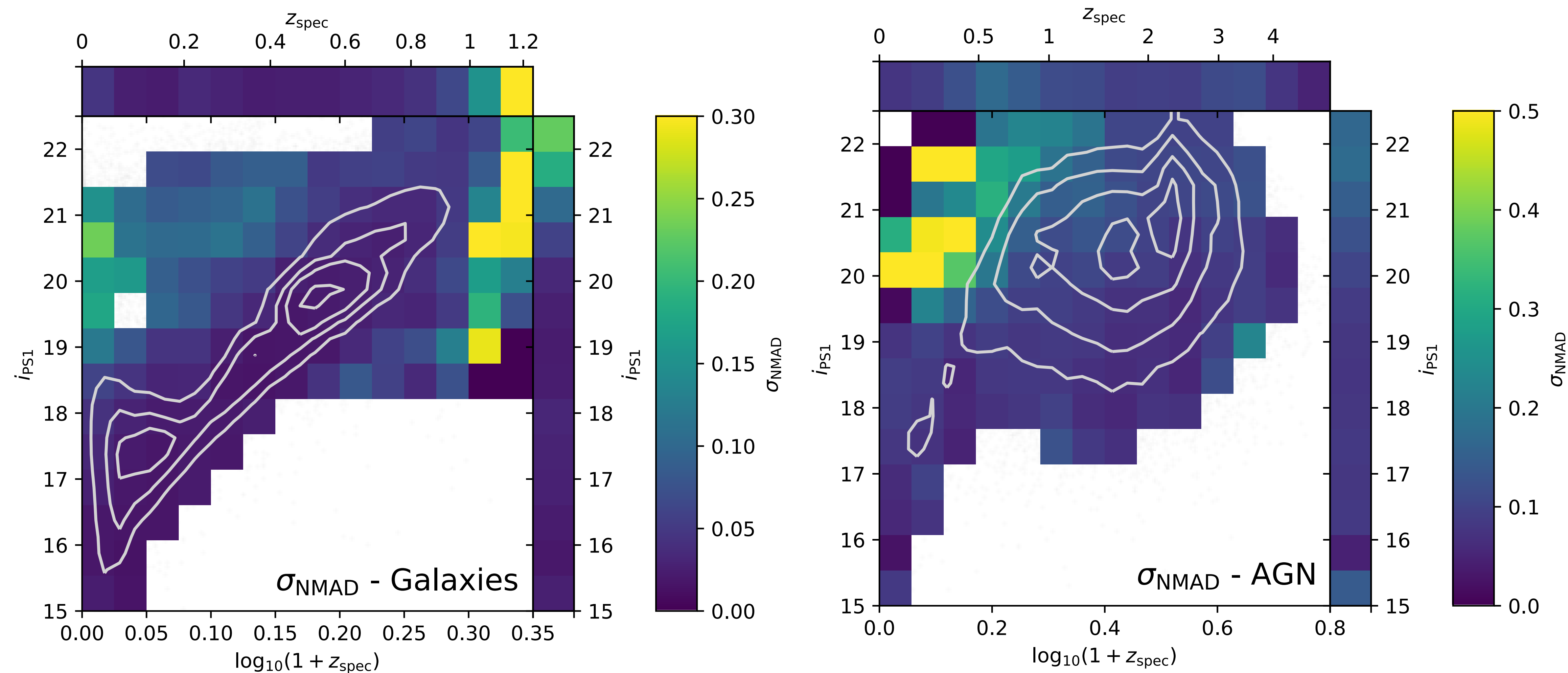


Photo-zs of comparable (or better) quality will likely be produced for all optically detected sources covered by LoTSS DR Footprints

WEAVE

WHAT IS WEAVE?

THE “WHT ENHANCED AREA VELOCITY EXPLORER”

- ▶ WEAVE is a ~1000 fibre multi-object spectrograph going on the 4.2m WHT
- ▶ 2 deg diameter field of view
- ▶ Complete wavelength coverage from 370–960nm at $R=5000$
- ▶ First light “Q2 of 2019” (stable-ish for last 12 months)

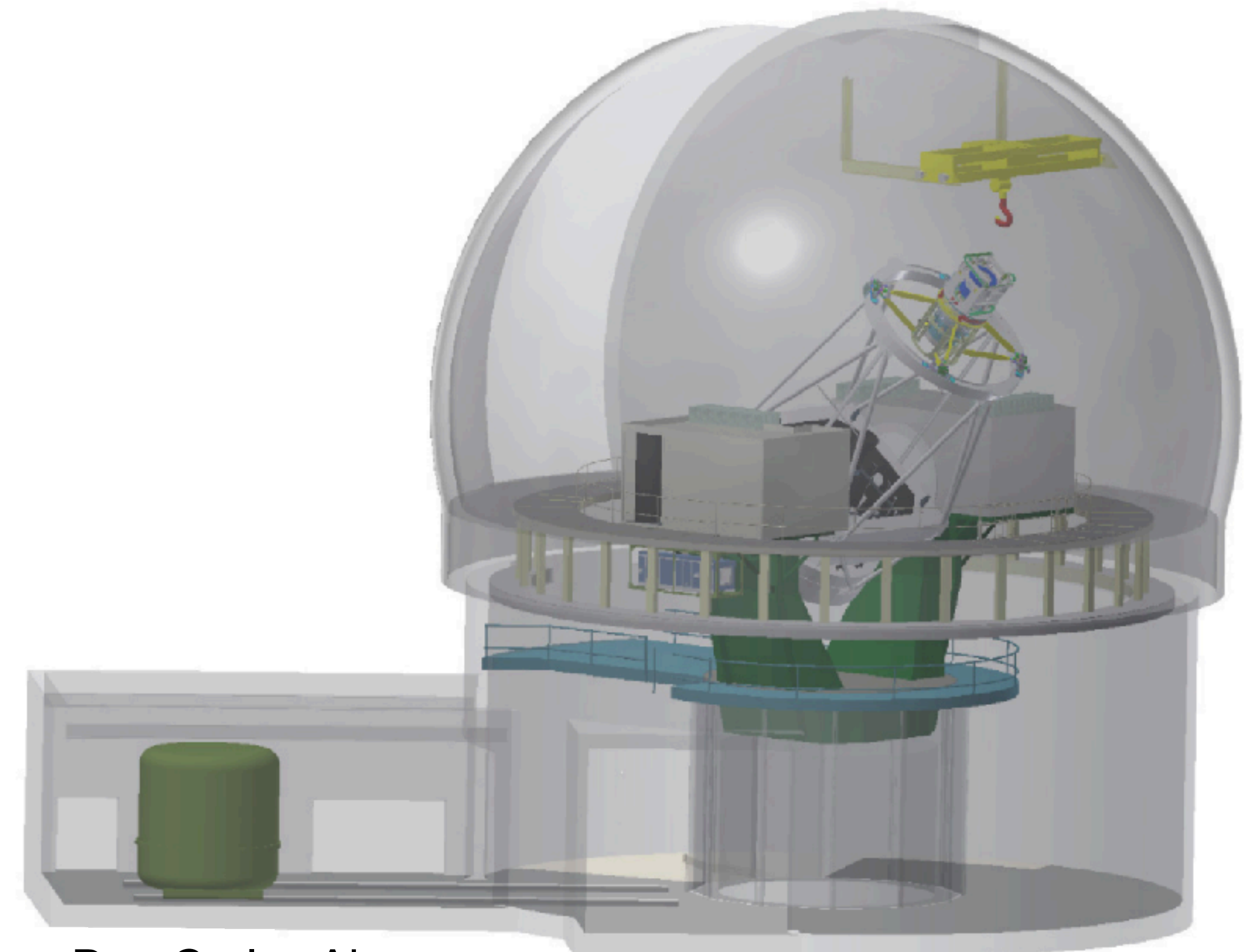


Image: Don Carlos Abrams



Photos: Dan Smith

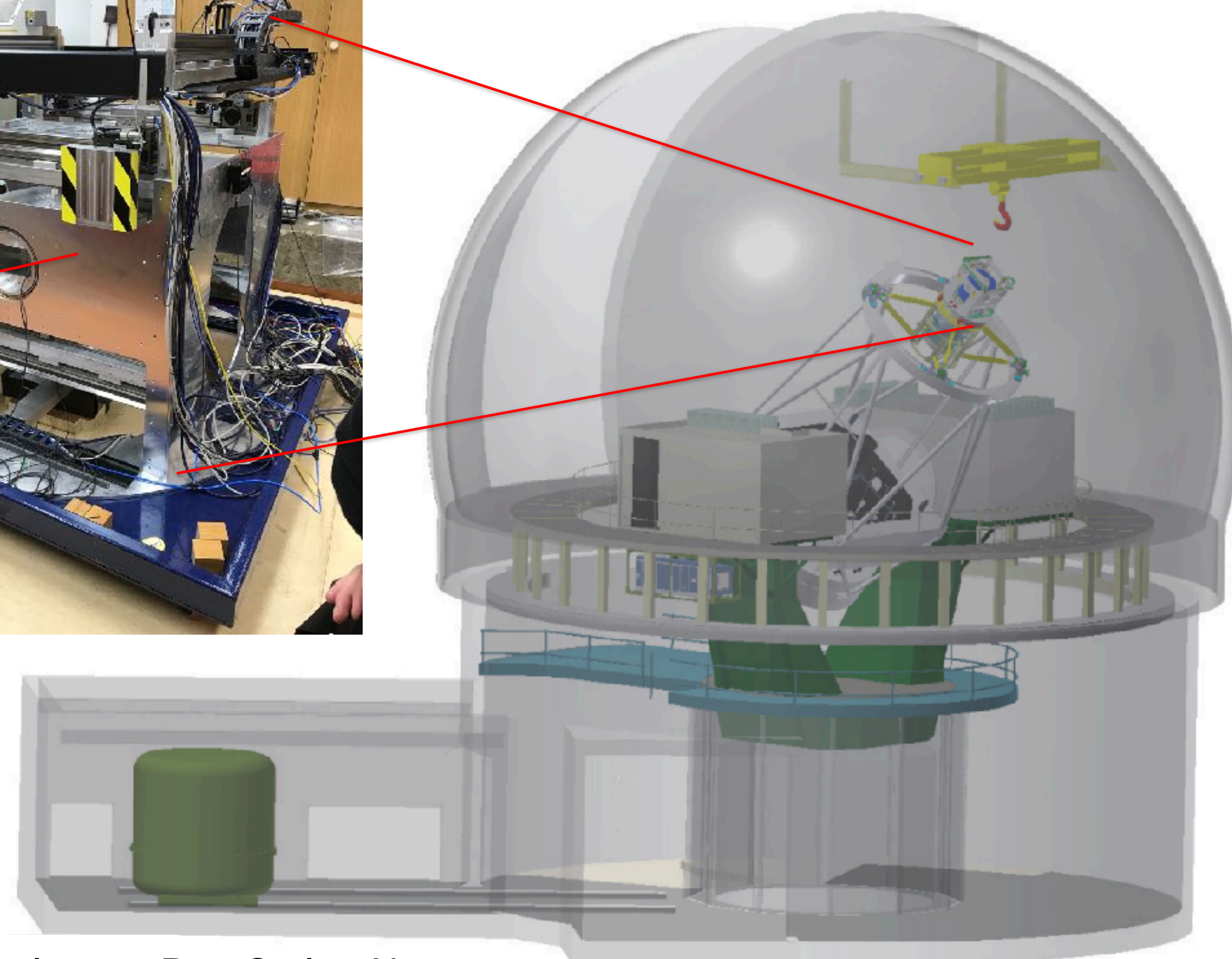
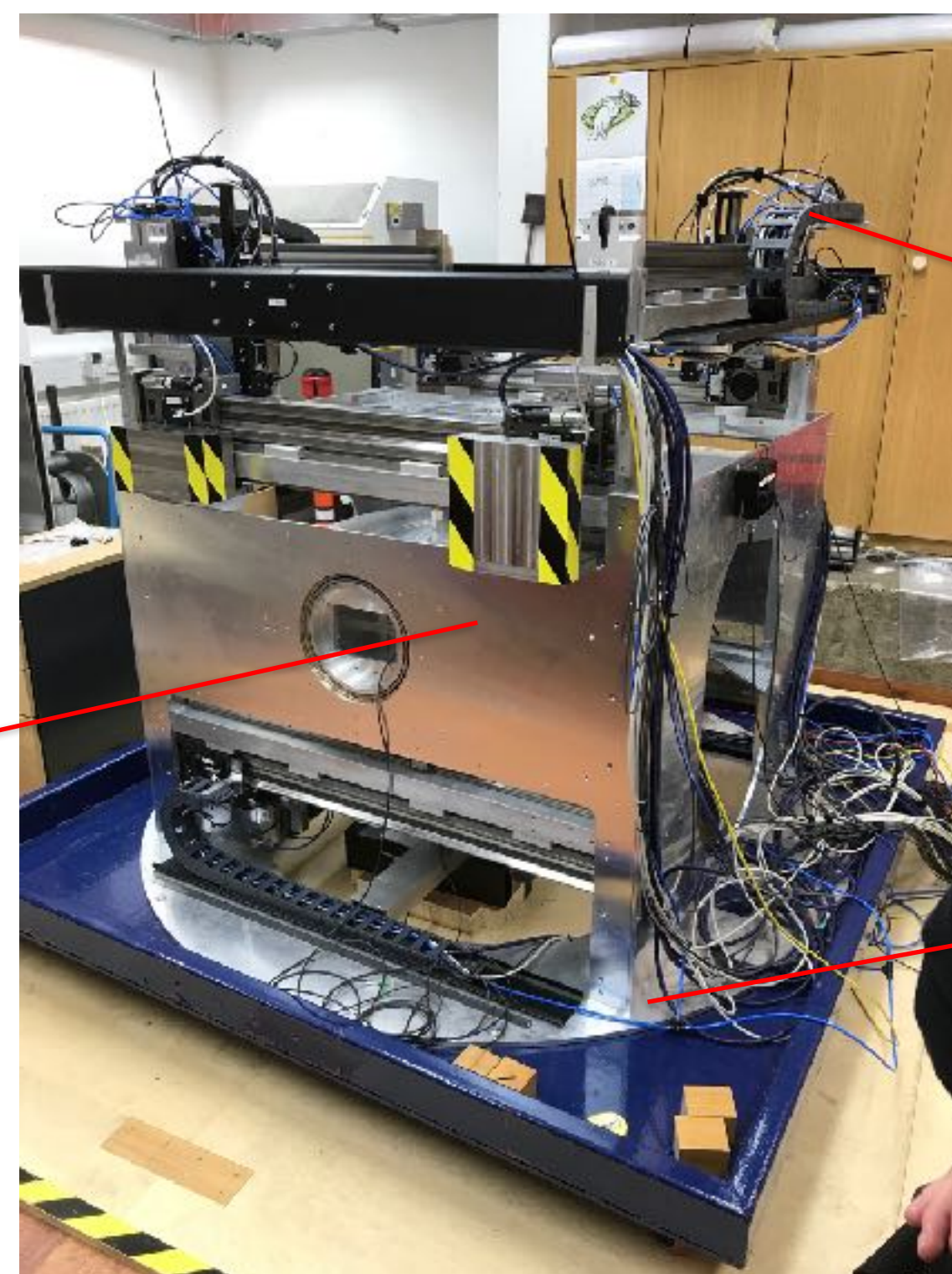
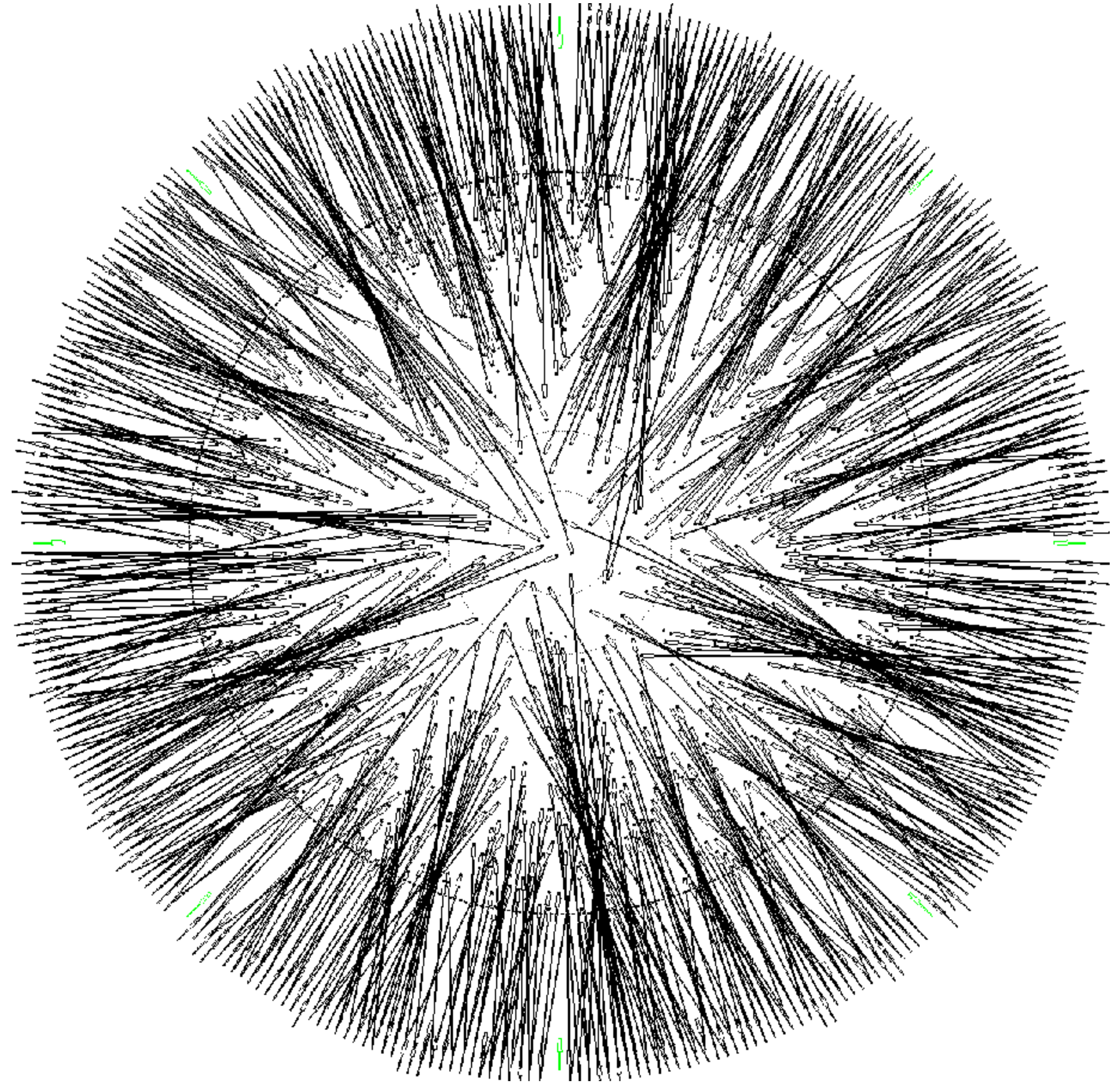


Image: Don Carlos Abrams

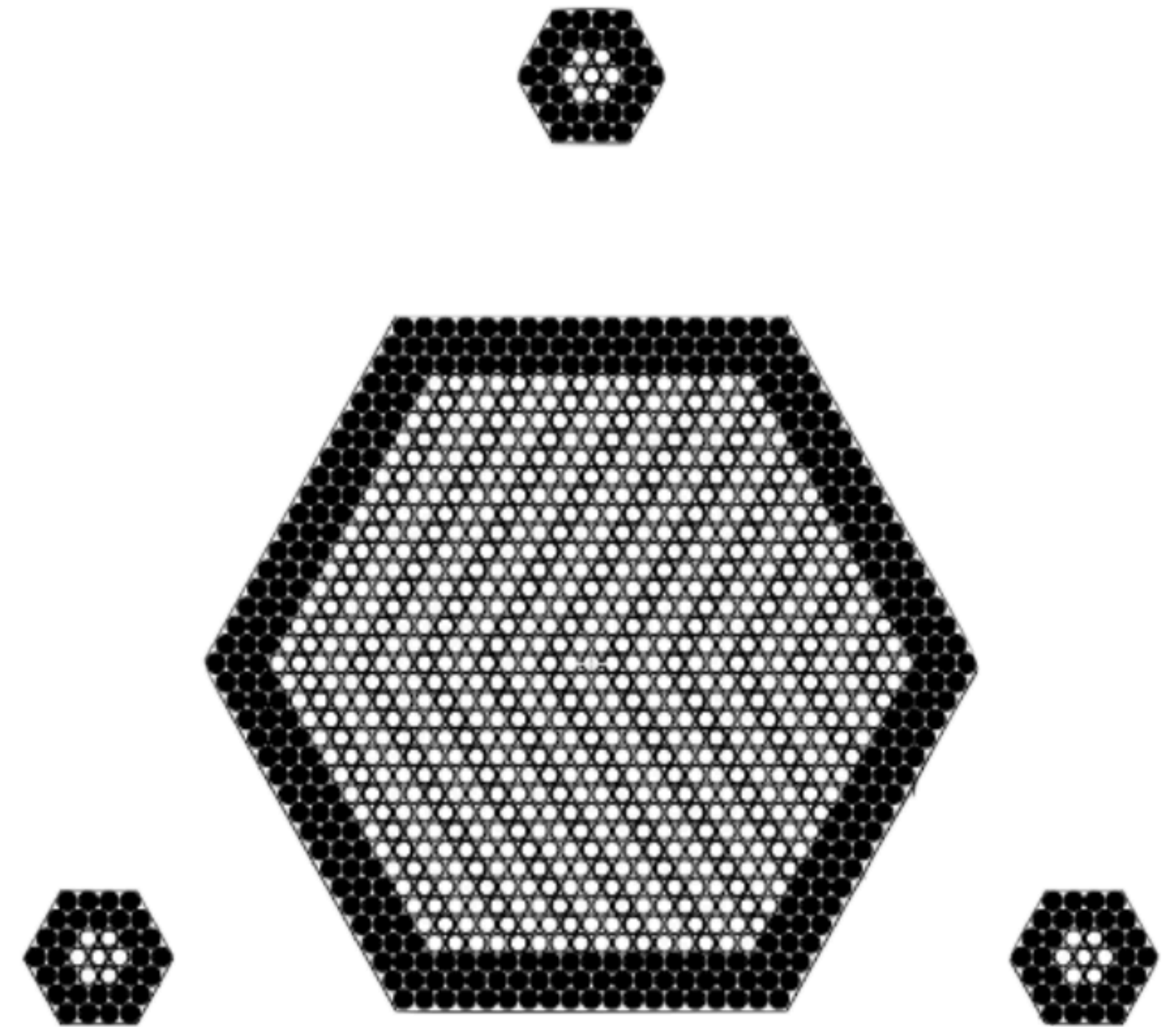
WEAVE MOS

- ▶ 960 (940) x 1.3" fibres
- ▶ Low-resolution mode: 370-960nm at R=5000
- ▶ High-resolution mode: R~20,000 in three windows
- ▶ Robotic pick and place fibre positioner



WEAVE IFU

- ▶ Large IFU
 - ▶ 84" x 97" - 2.6" spaxels
- ▶ Mini IFUs
 - ▶ 20 mini IFUs placeable around the field of view
 - ▶ 11" x 12" - 1.3" spaxels



WEAVE SURVEYS

GALACTIC:

- ▶ Galactic Archaeology
- ▶ Stellar Circumstellar and Interstellar Physics (SCIP)

EXTRAGALACTIC:

- ▶ Galaxy Clusters
- ▶ Galaxy Evolution
 - ▶ StePS (Stellar populations at intermediate redshifts survey)
 - ▶ WEAVE-APERTIF
- ▶ **WEAVE-LOFAR**
- ▶ WEAVE-QSO

WEAVE-LOFAR

Science Team Lead:

Dan Smith (University of Hertfordshire)

Survey Working Group representative:

Kenneth Duncan (Leiden Observatory)

WEAVE LOFAR...

Credit: Dan Smith

1) MOS Survey:

Spectroscopic follow-up of large numbers of LOFAR-selected sources in three tiers, to get a complete picture of SF and AGN co-evolution.

Deep
(up to 100 deg²)

Mid (1,250 deg²)

Wide (up to 10,000 deg²)

2) IFU Survey:

Resolved spectroscopy of large samples of protoclusters and targets with extended haloes - provide detailed studies of the relationship between galaxies/AGN and their environments



1) MOS Survey:

Spectroscopic follow-up of large numbers of LOFAR-selected sources in three tiers, to get a complete picture of SF and AGN co-evolution.

Current fibre hour envelope:
<1.6 million

Deep
(up to 100 deg²)

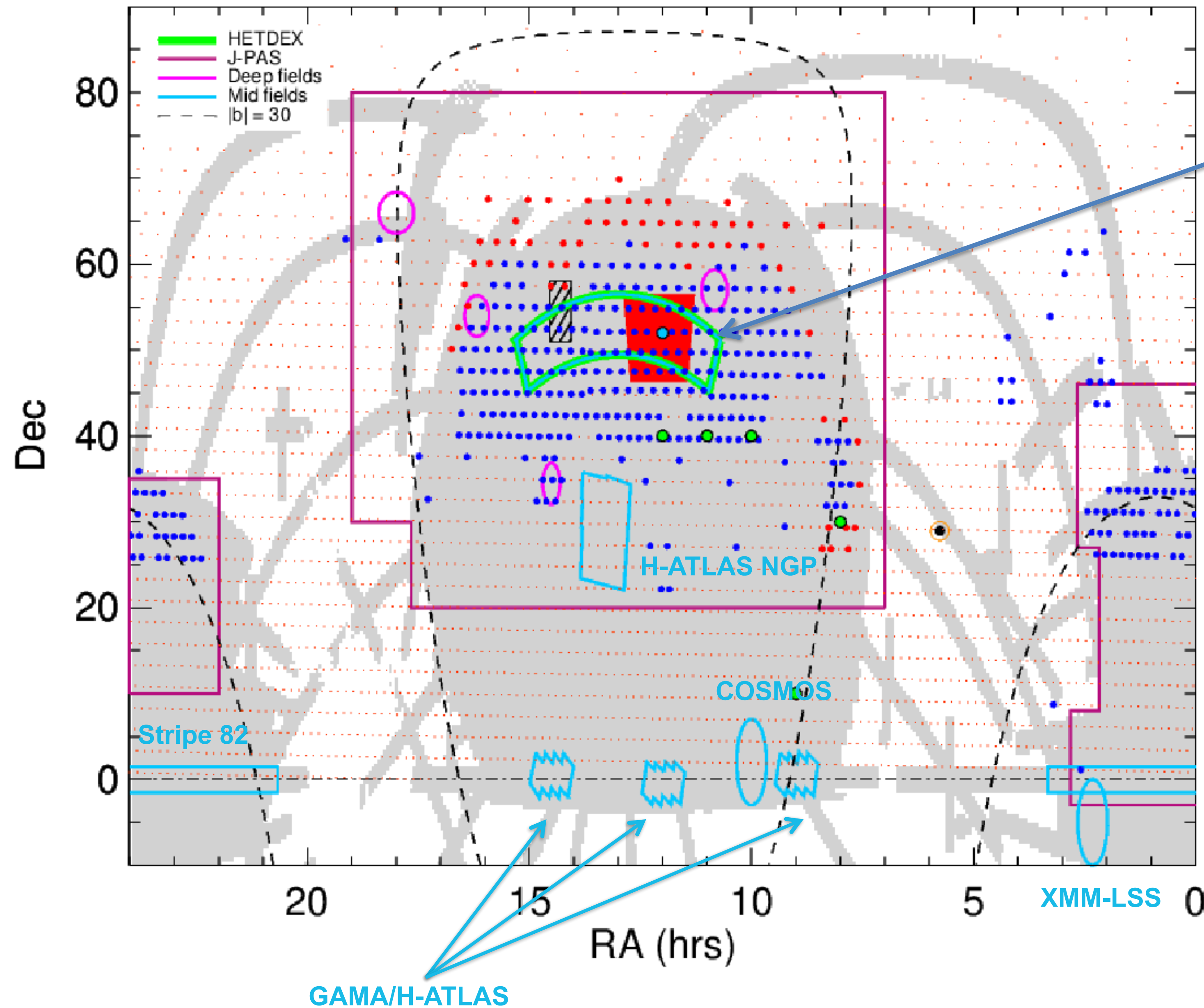
Targets > 100 μ Jy at 150 MHz
(Target density \sim 5,000/deg²)

Mid (1,250 deg²)

Targets > 1 mJy (500/deg²)

Wide (up to 10,000 deg²)

Targets > 10 mJy (55/deg²)



HETDEX Northern field

~100k sources based on current radio catalogs

Deep Fields:

Bootes

Lockman-Hole

ELAIS-N1

NEP

- ▶ The history of accretion and AGN driven feedback
- ▶ Un-biased cosmic star formation history
- ▶ Probing the epoch of reionization
- ▶ Cosmology
- ▶ Radio galaxies, Lyman alpha haloes and proto-cluster environments.

WEAVE-LOFAR: $>10^6$ SPECTRA = IMMENSE STATISTICAL POWER

Mass

Environment

With huge statistical samples, we can study the population in detail as a function of parameters & processes of interest

Redshift

Star formation

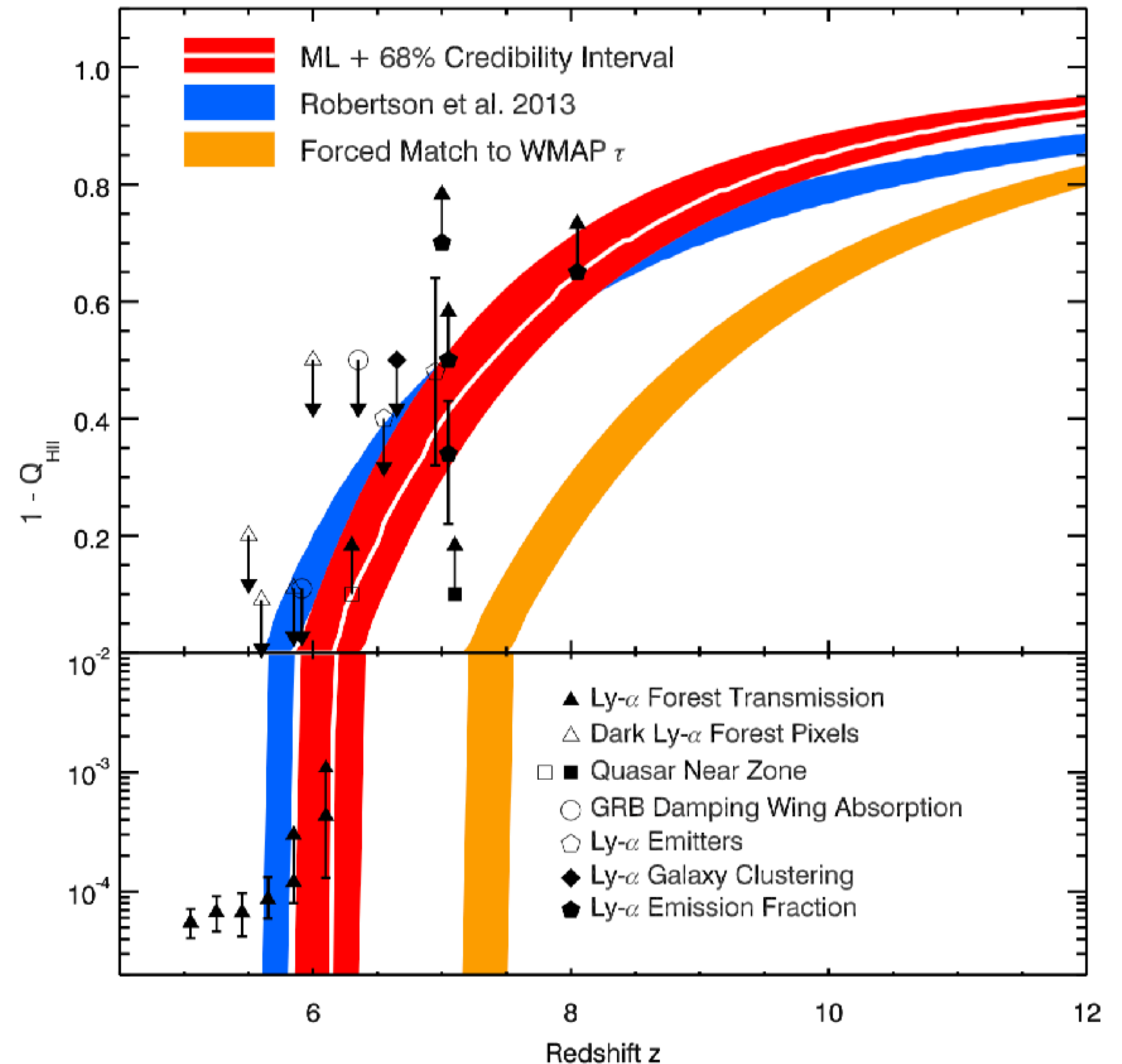
AGN activity

Accretion mode

WEAVE-LOFAR SCIENCE CASE : RADIO GALAXIES IN THE EOR

Lyman alpha forest rapidly becomes opaque - no longer a good probe of the details of the EoR

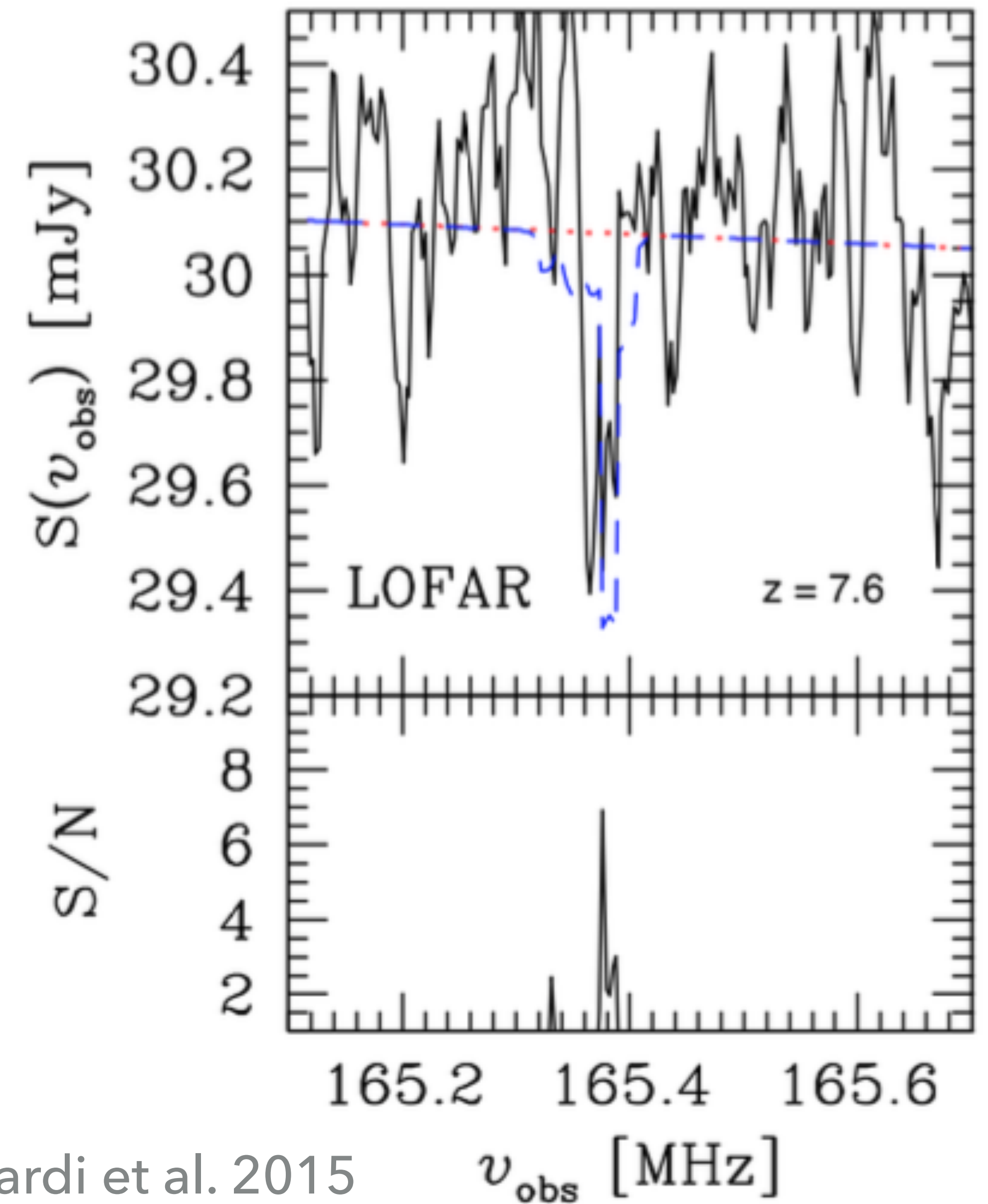
The opacity at 21cm is much lower, meaning that with 21cm you can see the details of reionization as a process, and how it evolved.



WEAVE-LOFAR SCIENCE CASE : RADIO GALAXIES IN THE EOR

This science doesn't have to wait until the SKA, for bright sources LOFAR can do this now...

Bright background sources giving multiple sightlines through the EoR are required; this is where WEAVE-LOFAR is ideal!



Ciardi et al. 2015

WEAVE DATA POLICY

From the WEAVE publication policy:

“WEAVE participants include any researcher at an astronomy institute in a WEAVE Project partner country or institute”

“At the time of writing, the partner countries are the United Kingdom, the Netherlands, Spain, Italy, and France, and the partner institutes are INAOE (Mexico) and Konkoly Observatory (Hungary). An updated list will be maintained on the WEAVE Publication Wiki.”

WEAVE-LOFAR data are proprietary to the WEAVE partner community

Public release will take place annually after the first 18-24 months (TBD).

“individual external (i.e. non-partner) collaborators are permitted to have access to data on specific projects, but they must first be proposed and accepted by the executive”

If you're interested, come and talk to me, or drop myself (duncan@strw.leidenuniv.nl) or Dan Smith (d.j.b.smith@herts.ac.uk) an email.

SUMMARY

LOFAR

- ▶ The LOFAR Two-metre Sky Survey is progressing well – public data release and paper splash imminent

- ▶ A key release product for LoTSS is high quality photo-z estimates for all radio sources with optical IDs (but estimates for all optical sources in the field are also available)

- ▶ More than 1 million optical spectra of LOFAR selected sources

- ▶ Huge scientific potential - ranging from constraints on cosmic SFR and accretion histories, the connection between AGN and SF and providing unique probes for the Epoch of Reionization

- ▶ **For more details, see arXiv:1611.02706**

WEAVE-LOFAR

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