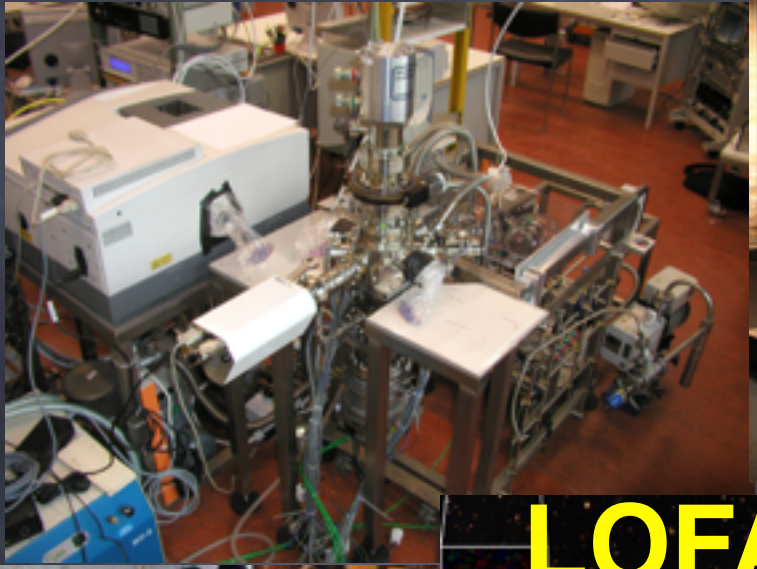


LOFAR surveys

Huub Röttgering



Members Core team Röttgering[12349](Leiden), Barthel[3456](Groningen), Best[12345] (Edinburgh), Brüggen[2] (Bremen), Brunetti[2] (Bologna), Chyży[236] (Kraków), Conway[56t] (Göteborg), Jarvis[1349] (Hertfordshire), Lehnert[36] (Meudon), Miley[1245] (Leiden), Morganti[45] (Dwingeloo), Wise[345] (ASTRON)

Regular members: Haverkorn[8] (ASTRON), Jackson[7] (Manchester), White[38] (Open University), Abdalla[9] (UCL London), Anderson (MPIfR Bonn), Arnaud[2] (Meudon), Bacon[79] (Portsmouth), Beck[6] (Bonn), Beswick[568] (Manchester), Brentjens [2] (ASTRON), Britzen[5] (Bonn), Conselice (Nottingham), Croston[2] (Southampton), Dettmar[6] (Bochum), Eales[6] (Cardiff), Edge[2] (Durham), Engels[4] (Hamburg), Enßlin[2] (Garching), Falcke[145] (Nijmegen), Feretti[2] (Bologna), Ferrari[2] (Nice), Franx[3] (Leiden), Garrett[37] (ASTRON), Génova-Santos[1] (IAC), Hardcastle (Hertfordshire), Hendry[9] (Glasgow), Hoeft[2] (Tautenburg), Horellou[256] (Onsala), Isral[6] (Leiden), Ivison[3] (Edinburgh), Jamrozy[45] (Krakow), Kassim[8] (Washington), Kauffmann[4] (Garching), Klein[6] (Bonn), Kuijken[7] (Leiden), Kunert-Bajraszewska[45] (Torun), Lobanov[5] (Bonn), Marecki (Torun), Marti-Vidal[6] (Onsala), Martinez-Sansigre (Portsmouth), McKean[17] (ASTRON), Merloni[45] (Garching), Middelberg[4] (Bochum), Murgia[45] (IAC), Nichol[9] (Portsmouth), Oliver[3] (Sussex), Oosterloo[6] (ASTRON), Otmianowska-Mazur (Krakow), Page[4] (London), Paragi (JIVE), Pentericci[13] (Rome), Percival[9] (Portsmouth), Peters[8] (Washington), Polatidis[5] (ASTRON), Prandoni[34] (IAC), Raychaudhury[2] (Birmingham), Reich[8] (Bonn), Schwarz[9] (Bieleveld), Simpson[14] (Liverpool), Steinmetz[5] (Potsdam), Strom[568] (ASTRON), Tadhunter[5] (Sheffield), Valentijn[26] (Groningen), van der Werf [3] (Leiden), van Driel[6] (Meudon), van Weeren[128] (ASTRON/Leiden), Varenius[6] (Gothenburg), Vink[8] (Amsterdam), White[4] (Garching), Wisotzki[4] (Potsdam), Wucknitz[7] (Bonn), Zarb-Adami[9] (Oxford), Zensus[5] (Bonn)

Postdocs: Asgekar[8] (ASTRON), Bertacca[9] (UWC), Birzan[235] (Leiden), Bonafede[2] (Bremen), Bonfield[9] (Hertfordshire), Cassano[2] (IAC), Deller (ASTRON), Dwelly[3] (Southampton), Faltenbacher[9] (UWC), Heald[6] (ASTRON), Heesen[56] (Hertfordshire), Heywood[9] (Oxford), Johnston[9] (UWC), Kapinska (Portsmouth), Kloeckner[34] (Oxford), Konig (Koln), Macario[2] (Nice), Mahony (ASTRON), Mauch[34] (Oxford), McKay (Chilboton), McKee[1] (Leiden), Oonk[8] (ASTRON), Orru[1235] (Nijmegen), Patel[9] (Portsmouth), Pizzo[2] (ASTRON), Raccanelli[9] (Portsmouth), Rafferty[235] (Leiden), Sabater Montes[4] (Edinburgh), Seymour[1] (Sydney), Smith[9] (Herts), Smith[9] (UWC), Stewart (Bonn), Tasse[4] (Meudon), Tudose (ASTRON), Vaccari[9] (UWC), van Bemmel (ASTRON), Zwart[9] (UWC)

PhDs: Batejat [56] (Gothenburg), De Gasperin[45] (Garching), Deane[3] (Oxford), Drzazga[36] (Krakow), Fielding[4] (Edinburgh), Guglielmino[45] (Bologna), Harwood[5] (Hertfordshire), Heidenreich[2] (Southampton), Israel[3] (Leiden), Junkelwitz[2] (Garching), Jurusik[6] (Krakow), Ker[134] (Edinburgh), Kuligowska[45] (Krakow), Lazell[2] (Birmingham), Lindsay[9] (Hertfordshire), Madhanpall[9] (UWC), McAlpine[9] (UWC), Morabito[1] (Leiden), Natt[8] (Open University), Ogrean[2] (Bremen), Rubart[9] (Bieleveld), Shulevski[5] (Groningen), Stroe[2] (Leiden), Temourian[1] (Hertfordshire), Trasatti[2] (Bonn), van Velzen[1] (Nijmegen), Williams[46] (Leiden).

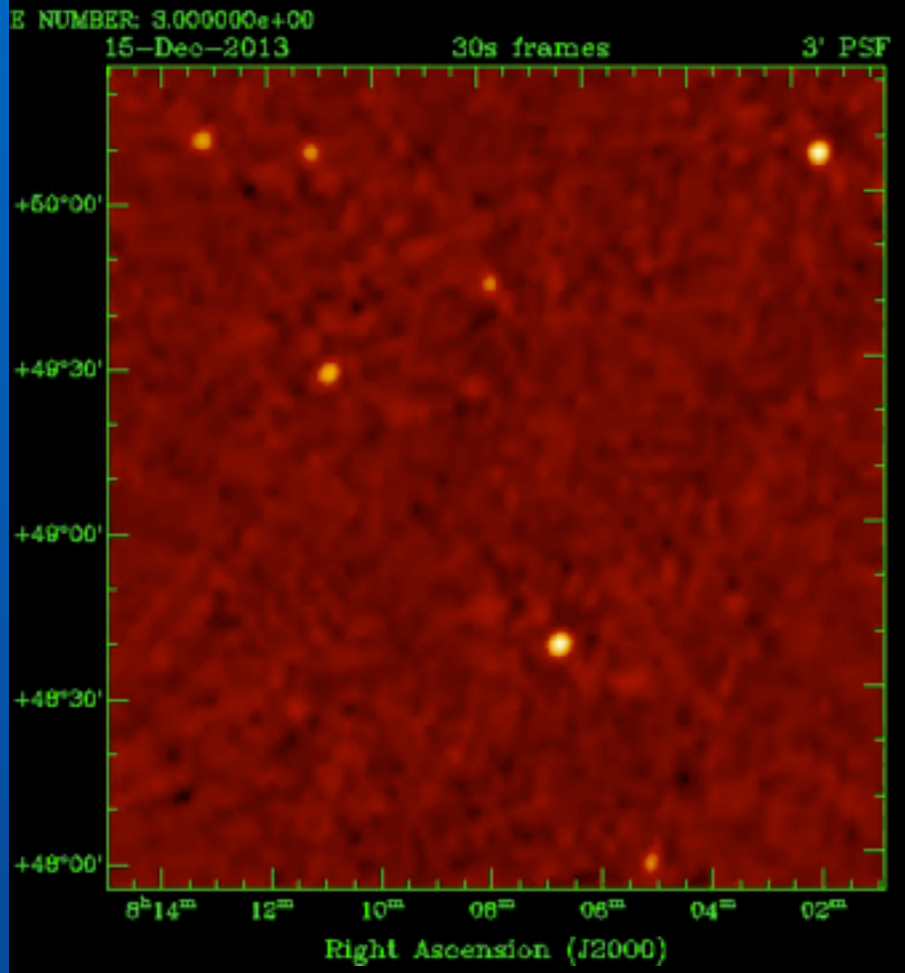
Science working groups with chairs:

1. High redshift radio galaxies - Miley
2. Galaxy clusters - Brüggen/ Brunetti
3. Cosmic Star-Formation - Lehnert/ Barthel
4. AGN and black hole evolution - Best
5. Physics of nearby AGN - Morganti
6. Nearby galaxies - Conway/ Chyży
7. Strong lensing - Jackson
8. The Galactic plane - Haverkorn/ White
9. Cosmology - Jarvis/ Bacon

LOFAR

Survey project

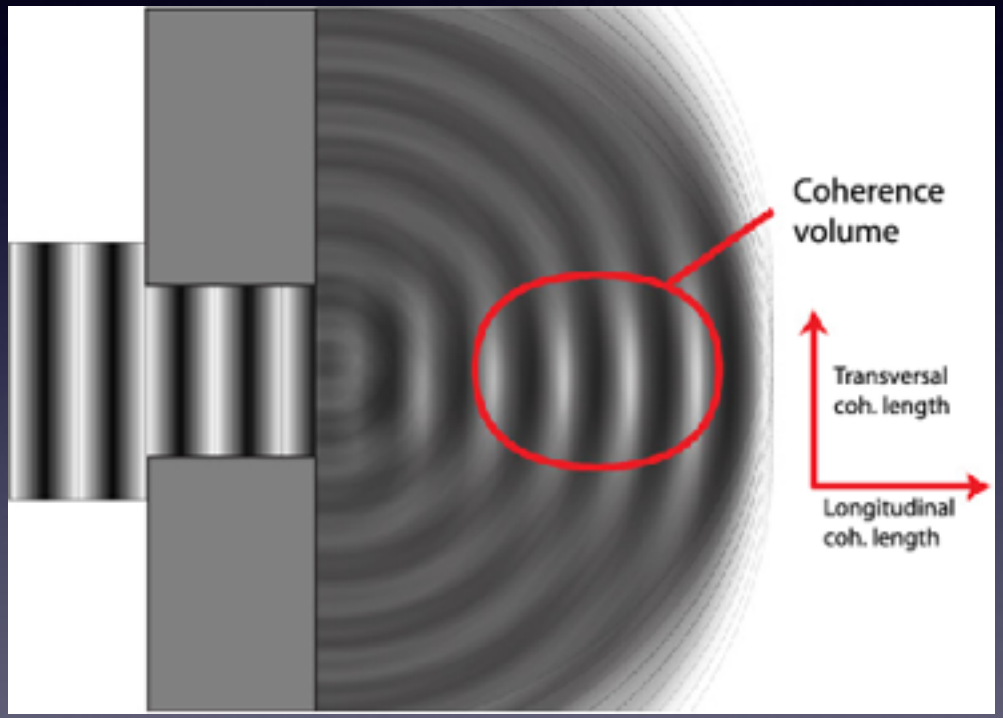
- Telescope design
- Survey design
- Data reduction
- (optical/IR) follow-up
- Scientific impact



images have only 3 arcmin resolution,
NL array has 5 arcsec resolution…
Courtesy: Ger de Bruyn+EOR team

Telescope design

- Angular resolution
  - resolve object for study
  - ~1 arcsec position accuracy for id'ing
- Calibratability
  - enough flux in coherence volume
  - good UV filling
  - Good sampling ionospheric
- Spectral range and resolution
  - RFI rejection
  - magnetism, recombination lines



Survey design

Science drivers + models luminosity functions

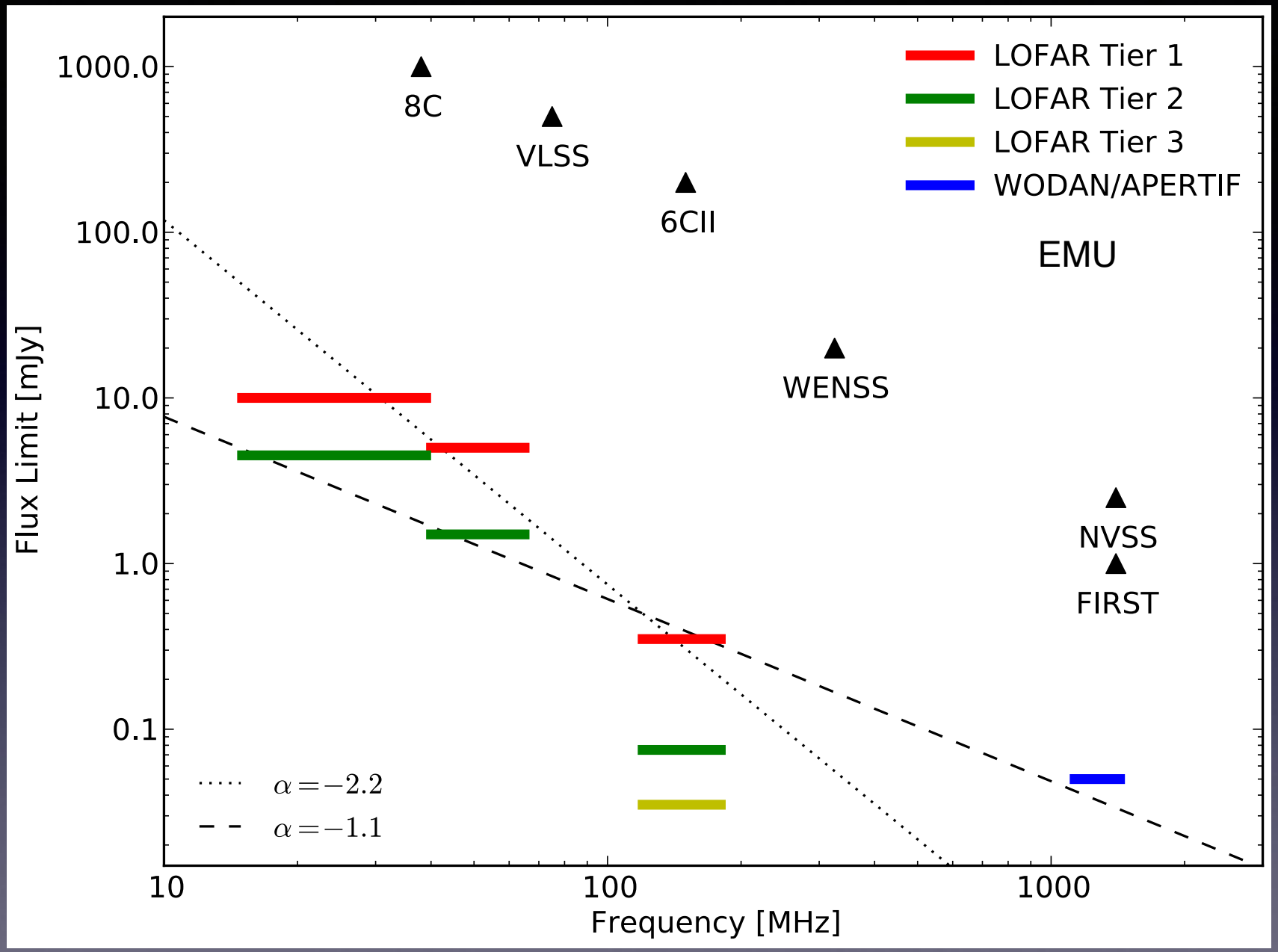
1. The highest redshift radio sources - George Miley: ~100 at z>6
2. Distant starforming galaxies: Philip Best 100 protoclusters at z>2
3. Clusters and cluster halo sources - Brüggen/ Brunetti: 100 @ z>0.6; 60 nearby clusters
4. AGN at moderate redshifts - Philip Best
5. Gravitational lensing - Neal Jackson
6. Detailed studies of low-redshift AGN - Raffaella Morganti
7. Nearby galaxies - John Conway/Krzysztof Chyzi
8. Cosmological studies - Matt Jarvis/David Bacon
9. Galactic radio sources – Marijke Haverkorn/ Glenn White

Survey parameters

1. Area
2. Depth
3. Frequencies

General use

1. Magnetism
2. Longbaselines
3. Recombination lines
4. Transient searches

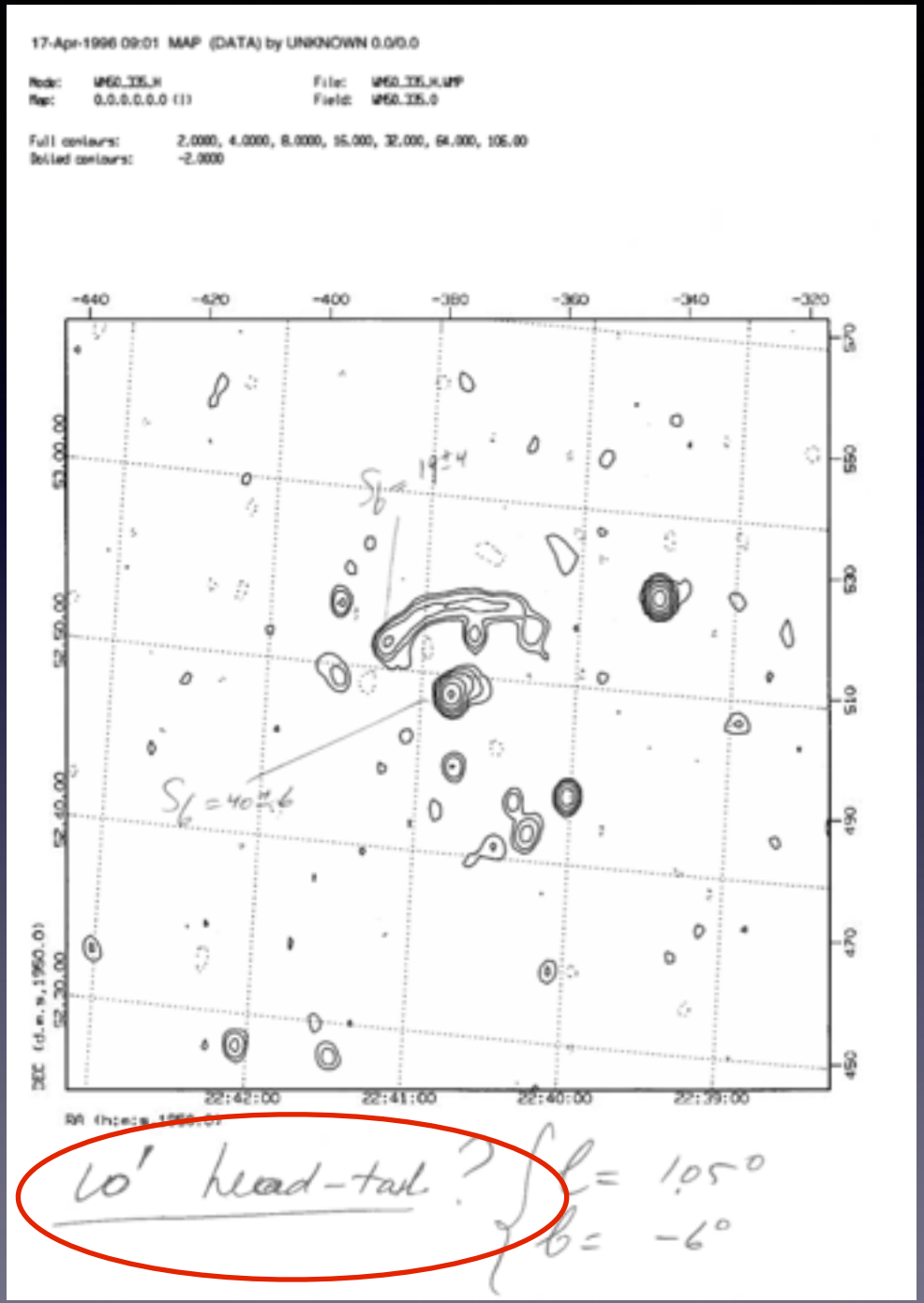


LoTSS: 48 MHz bandwidth (120–168 MHz), 16ch/sb and 1 s

van Weeren, Williams, Shimwell, Tasse, Hardcastle, Dijkema, van der Tol, de Gasparin, Offringa, Intema, Morabito, Mevius, Mechev, Oonk and many others…..

HBA Tier-1 LoTSS

Shimwell et al.

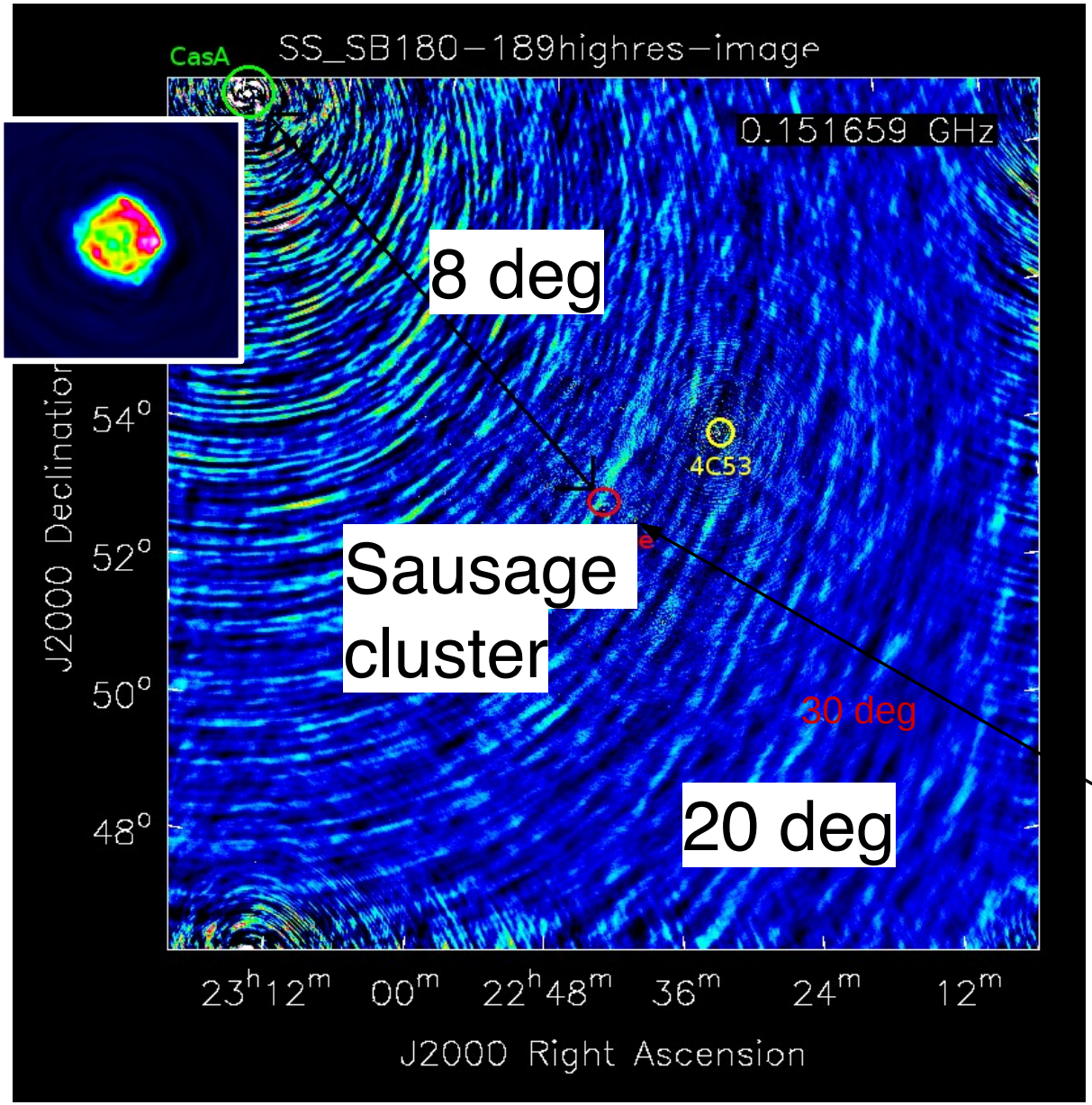


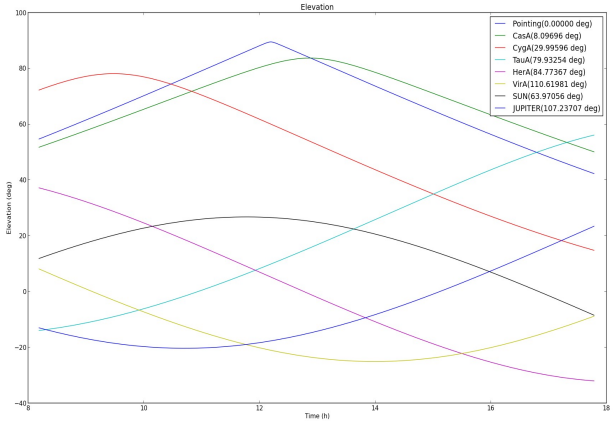
15 years earlier

WENSS survey
330 MHz

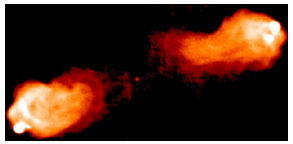
Ger de Bruyn

LOFAR observations of the Sausage -

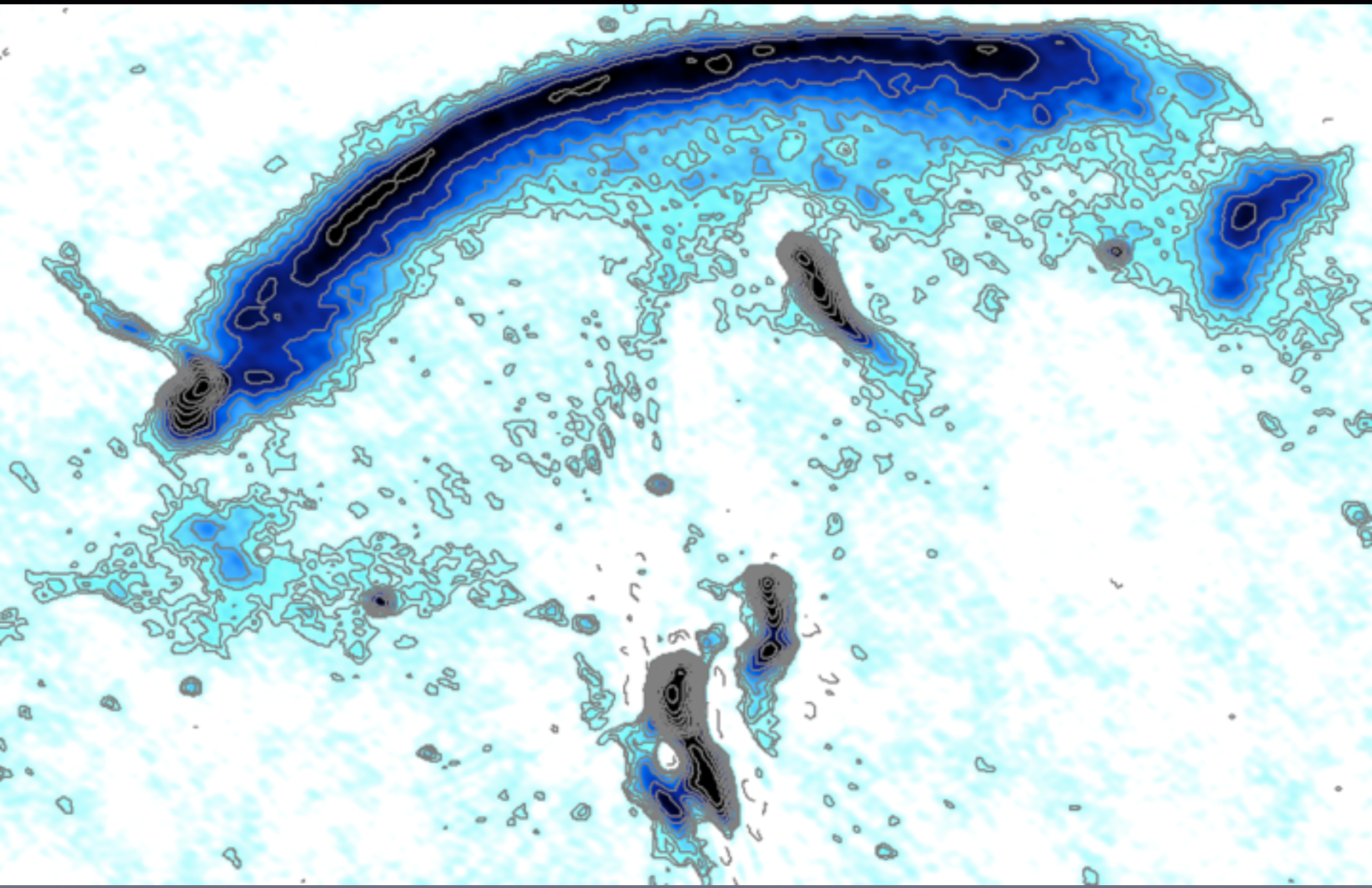


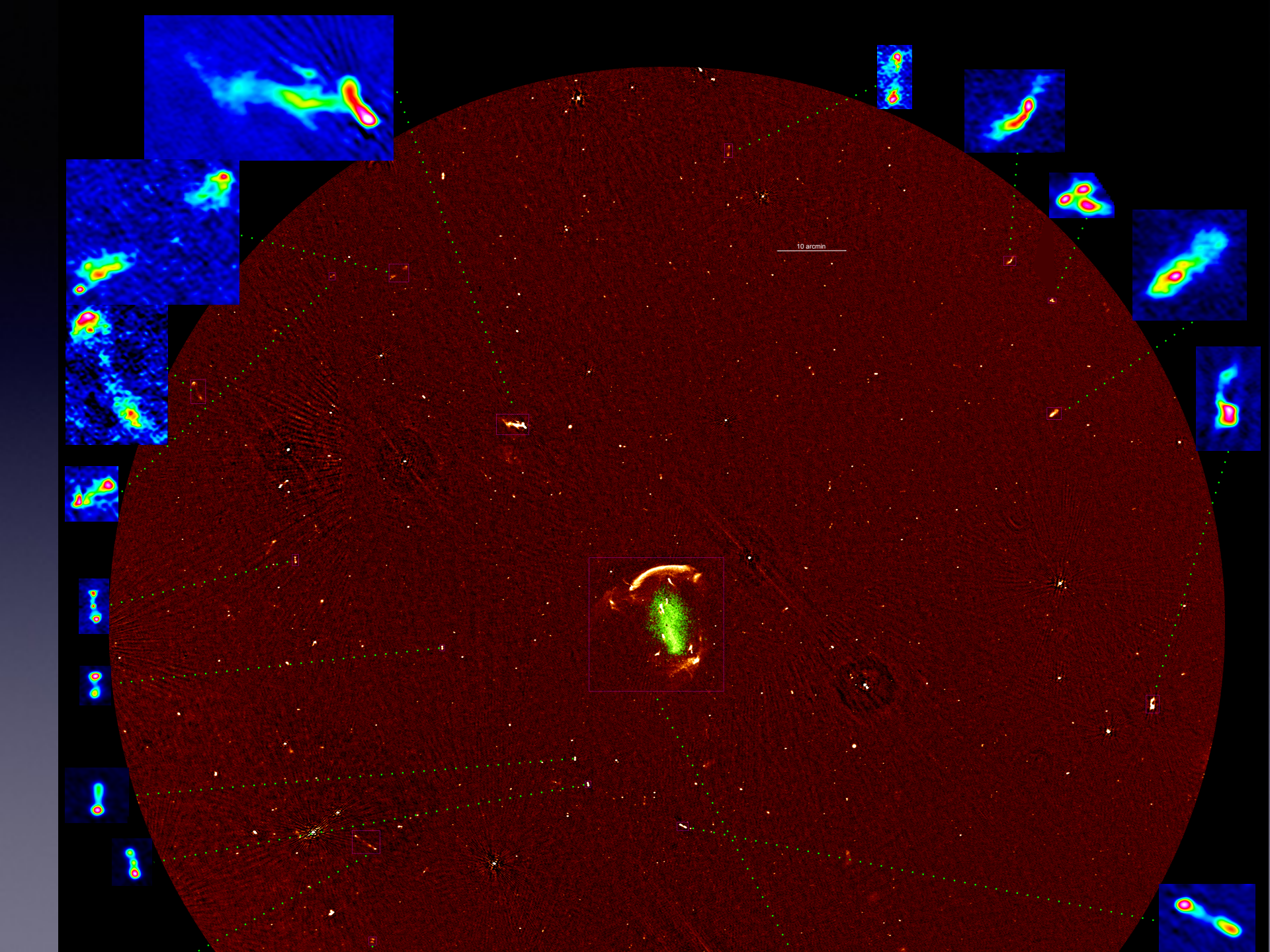


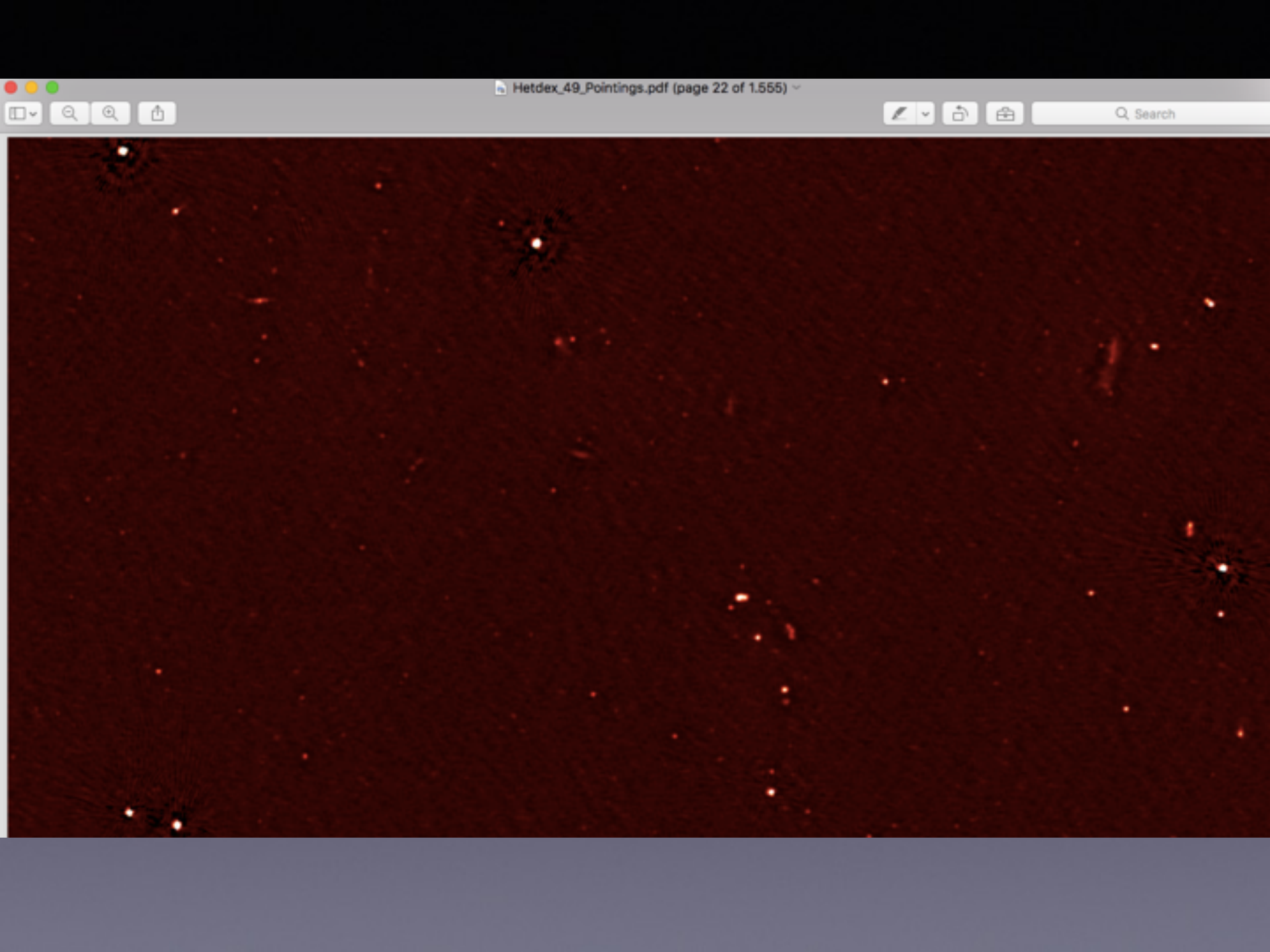
- CasA skymodel: 69MHz, 10” (Reinout van Weeren)
- Data resolution: 64ch, 1s
- Time step: 4s
- Freq. step: 16ch

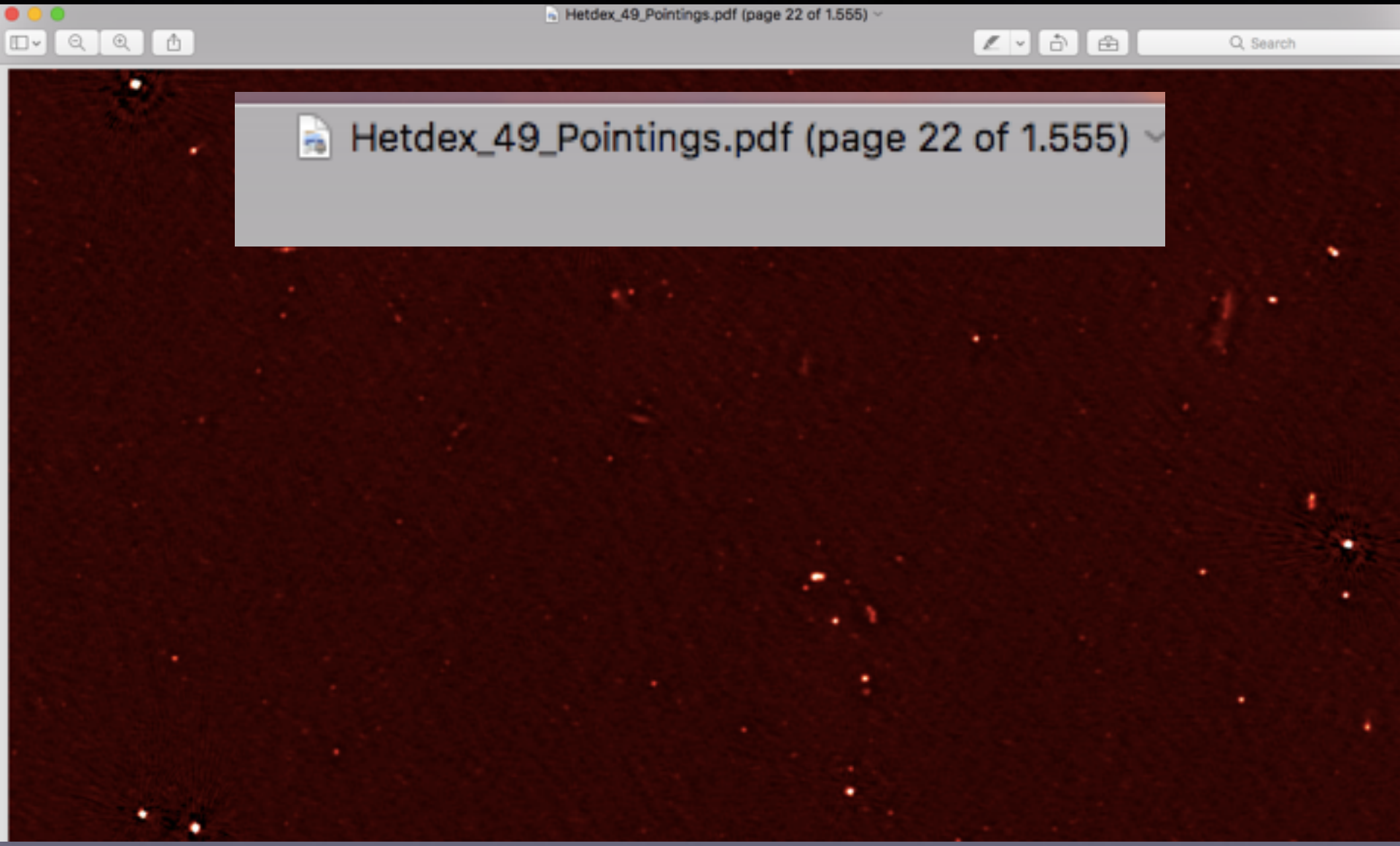


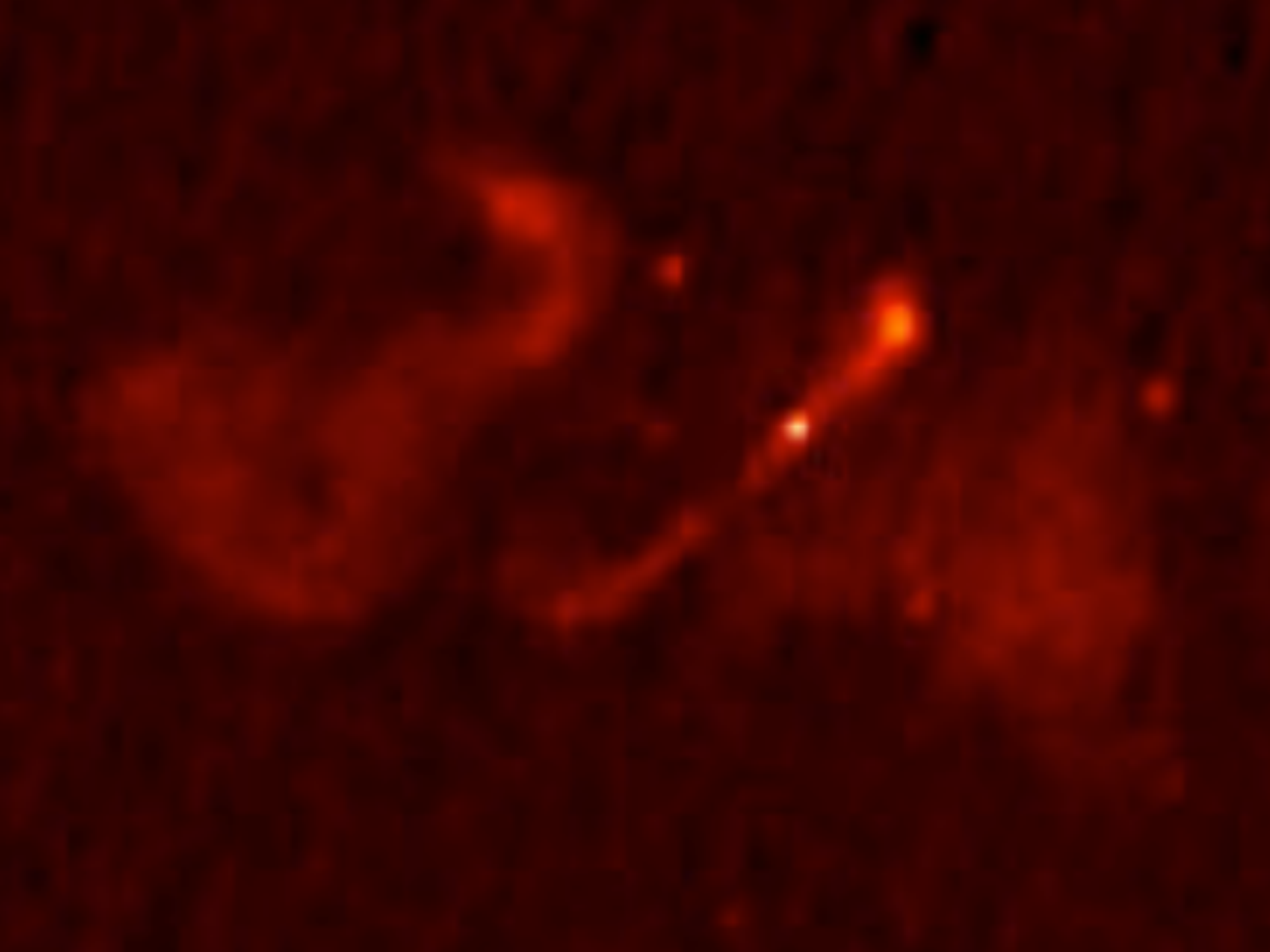
CygA

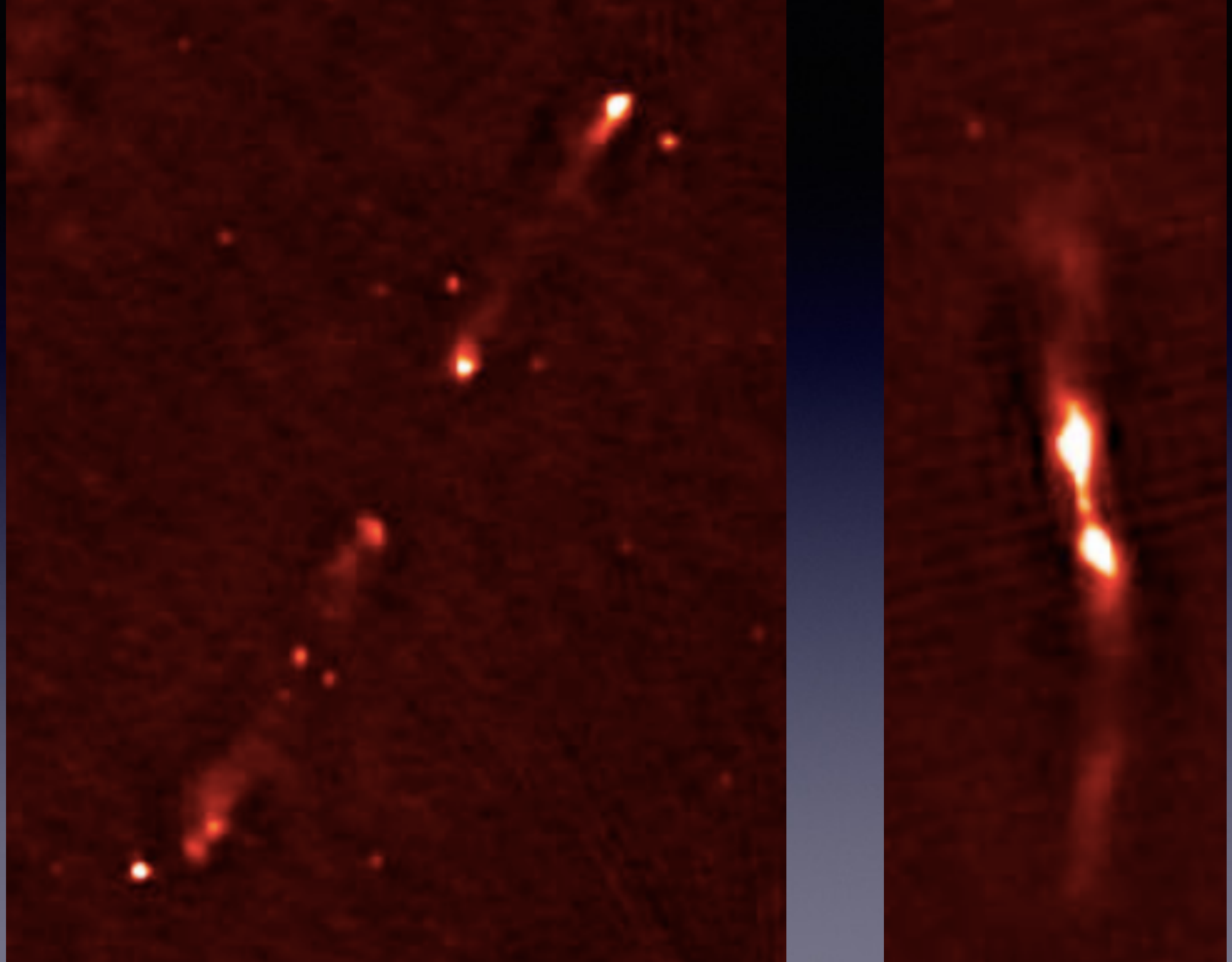


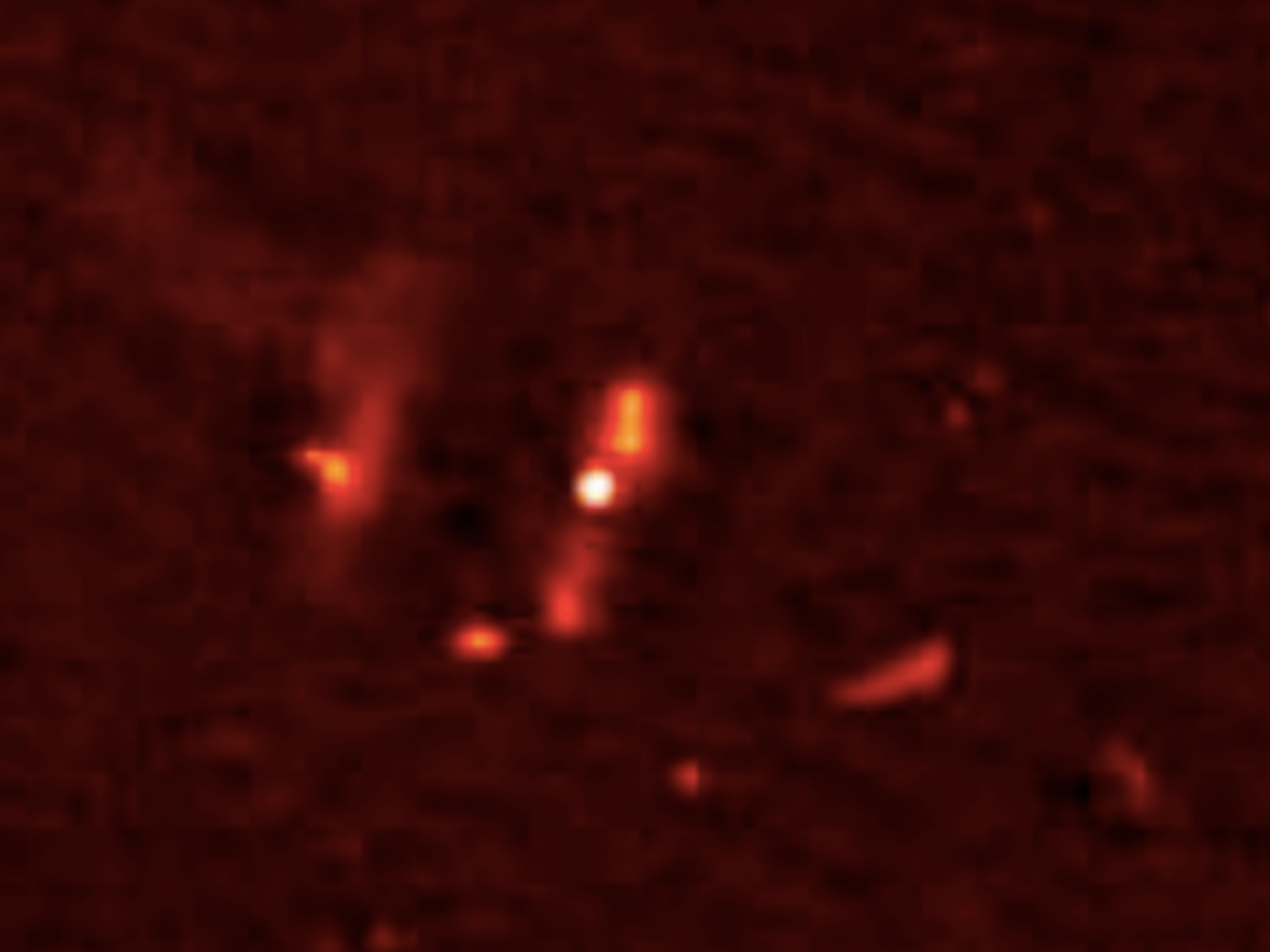

10 arcmin

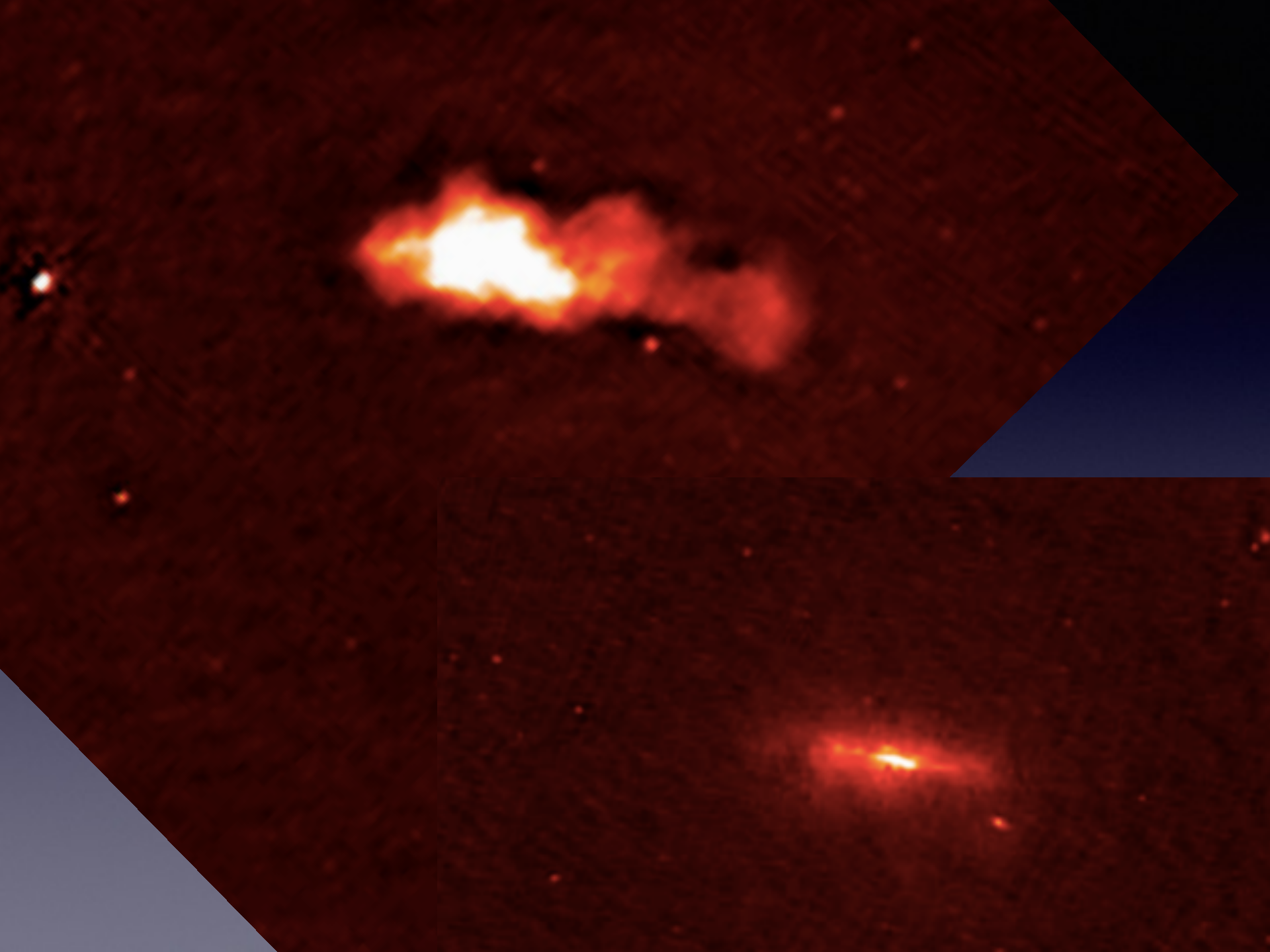

Hetdex_49_Pointings.pdf (page 22 of 1.555)
Search


Hetdex_49_Pointings.pdf (page 22 of 1.555)
Search
Hetdex_49_Pointings.pdf (page 22 of 1.555)



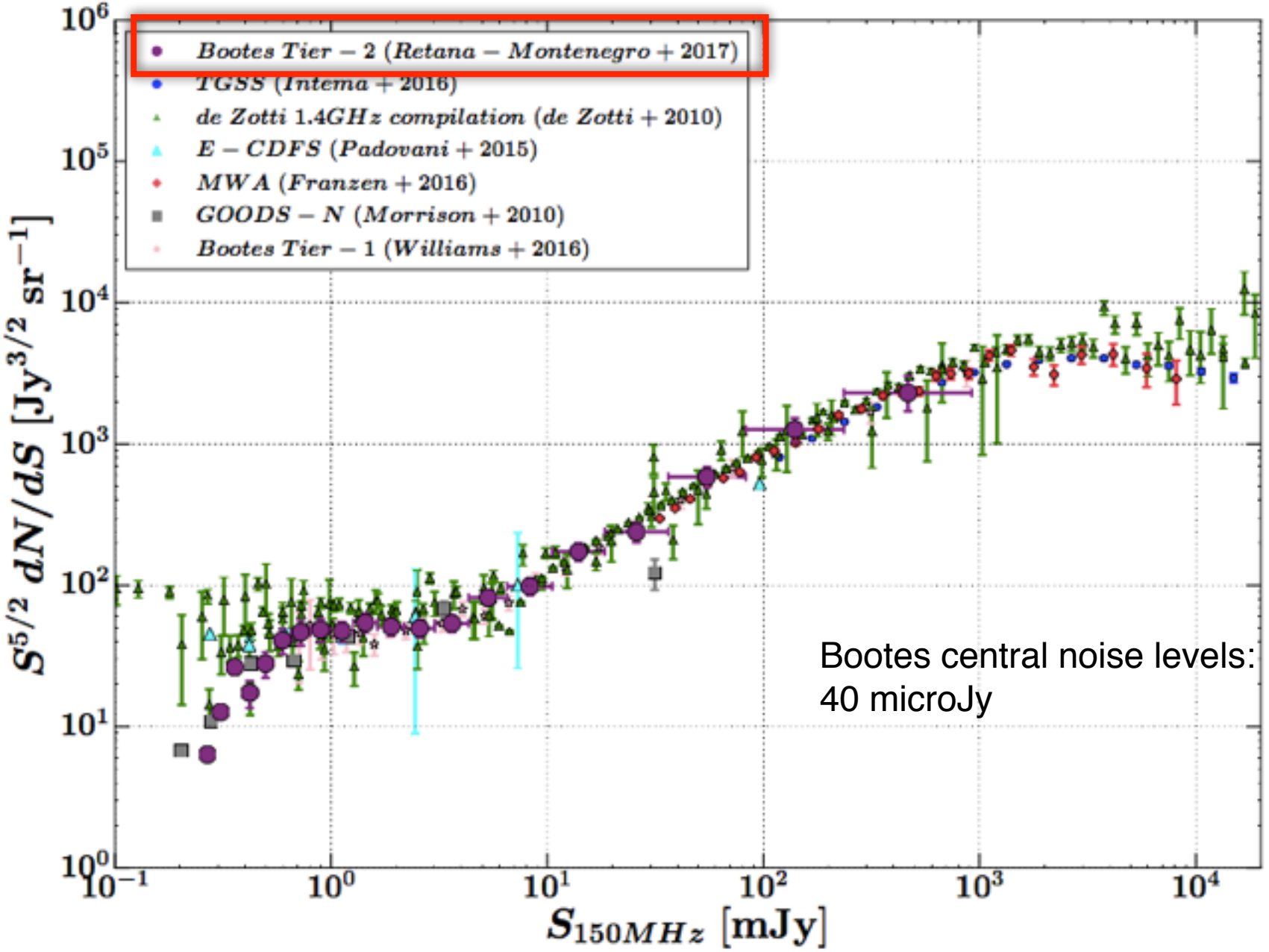


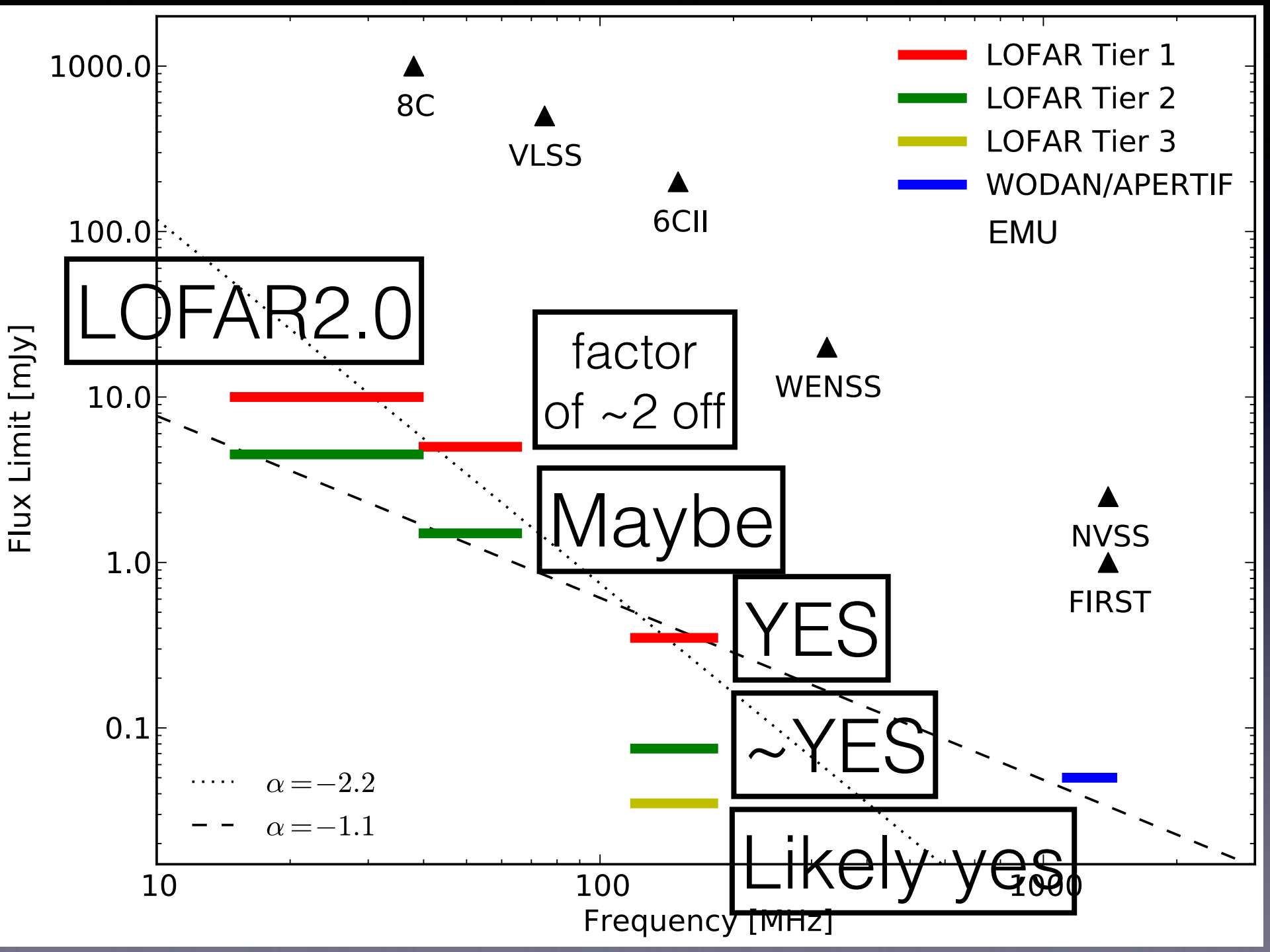




Tier2/3 status

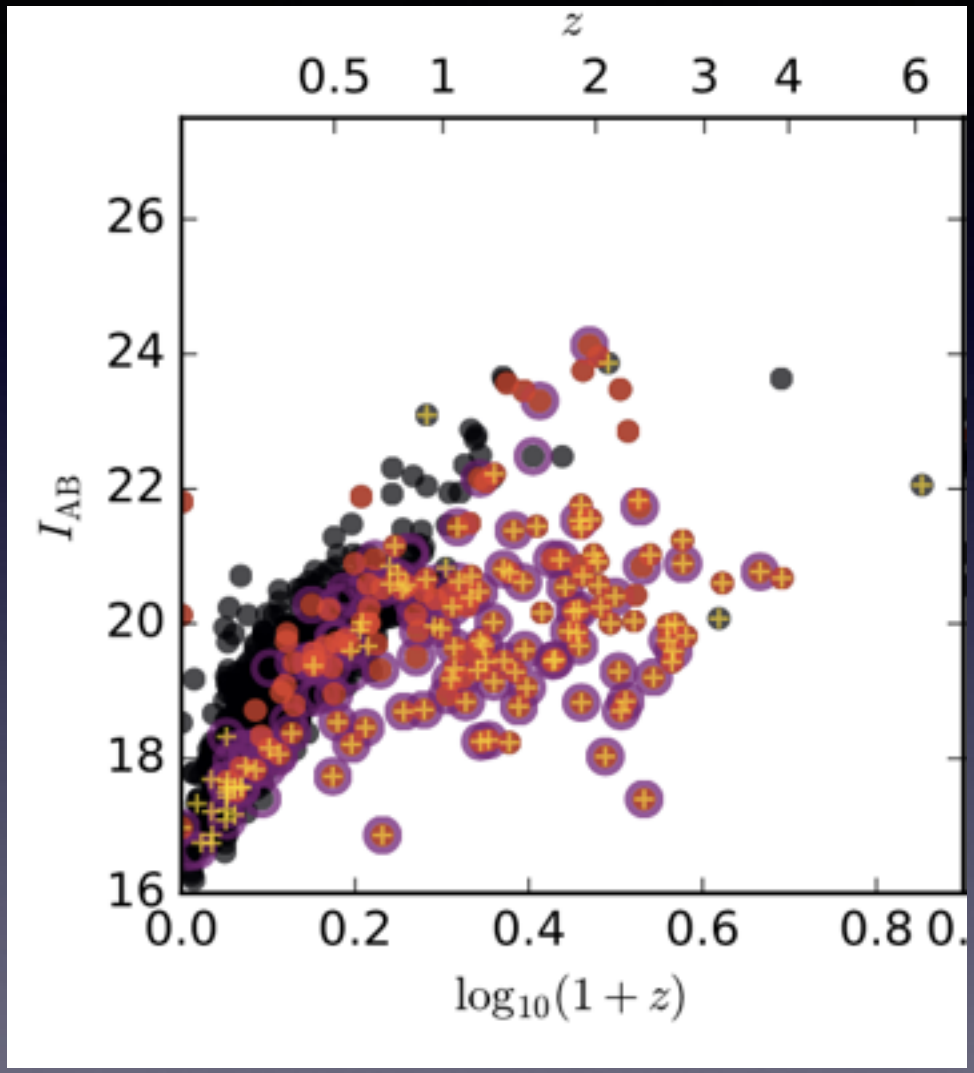
- HBA data famous fields
  - Goods North — ~60 hours
  - Groth Strip — existing just cycle 0 (~10hrs), cycle 2 (6x8hrs) — total ~58hrs
  - Herschel ATLAS — existing just cycle 0 (~10hrs)
  - Bootes — ~100hrs
  - Lockman — ~66hrs
  - Elias-N — 200hours


Bootes Tier − 2 (Retana − Montenegro + 2017)
TGSS (Intema + 2016)
de Zotti 1.4GHz compilation (de Zotti + 2010)
E − CDFS (Padovani + 2015)
MWA (Franzen + 2016)
GOODS − N (Morrison + 2010)
Bootes Tier − 1 (Williams + 2016)
$S^{5/2}\,dN/dS$ [Jy$^{3/2}$ sr^{-1}]
S_{150MHz} [mJy]
Bootes central noise levels:
40 microJy


LOFAR Tier 1
LOFAR Tier 2
LOFAR Tier 3
WODAN/APERTIF
EMU
8C
VLSS
6CII
WENSS
NVSS
FIRST
LOFAR2.0
factor
of ~2 off
Maybe
YES
~YES
Likely yes
$\alpha = -2.2$
$\alpha = -1.1$
1000.0
100.0
10.0
1.0
0.1
10
100
1000
Flux Limit [mJy]
Frequency [MHz]

Characterization

- classifying of radio sources
  - classic source finder (pybdsm) + visual inspection (Williams et al. 2016)
  - machine learning
- id'ing
- phot-z's (Duncan et al. 2017)
- characterisation
  - mass, sfr, environment, accretion mode

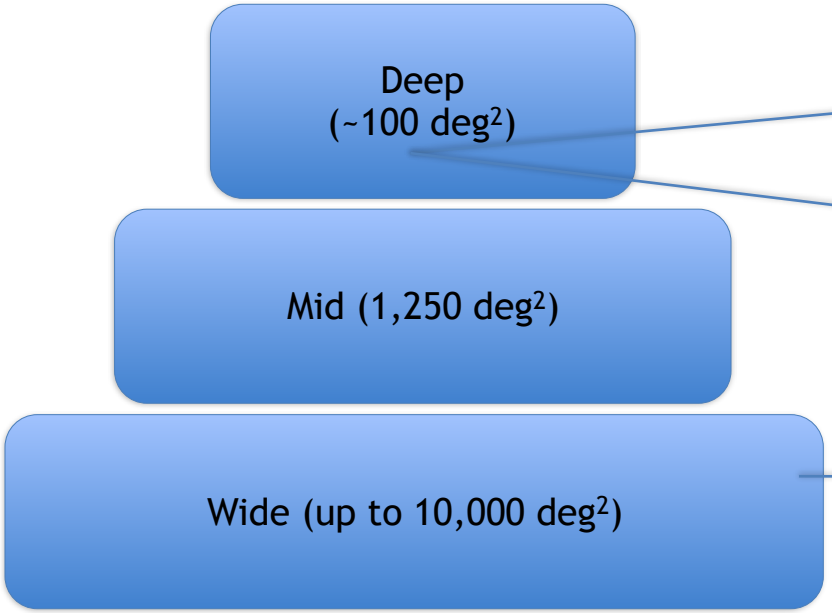


Duncan et al. 2017

WEAVE-LOFAR
Huge spectroscopic survey using
WEAVE multi object spectrograph on the 4.2 WHT La Palma
Start: 2019

Three tiers:
complete picture of SF and AGN co-evolution.

Current fibre hour envelope:
1.6 million



Targets > 100 uJy; ~50% of all time

Targets > 1 mJy; ~25% of all time

Targets > 10 mJy; ~25% of all time

Find z>6 radio galaxies for LOFAR 21 cm absorption spectroscopy

Results in all areas!

Science drivers

1. The highest redshift radio sources - George Miley: ~100 at z>6
2. Distant starforming galaxies: Philip Best 100 protoclusters at z>2
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General use

1. Magnetism
2. Longbaselines
3. Recombination lines
4. Transient searches

Evolution radio-IR correlation

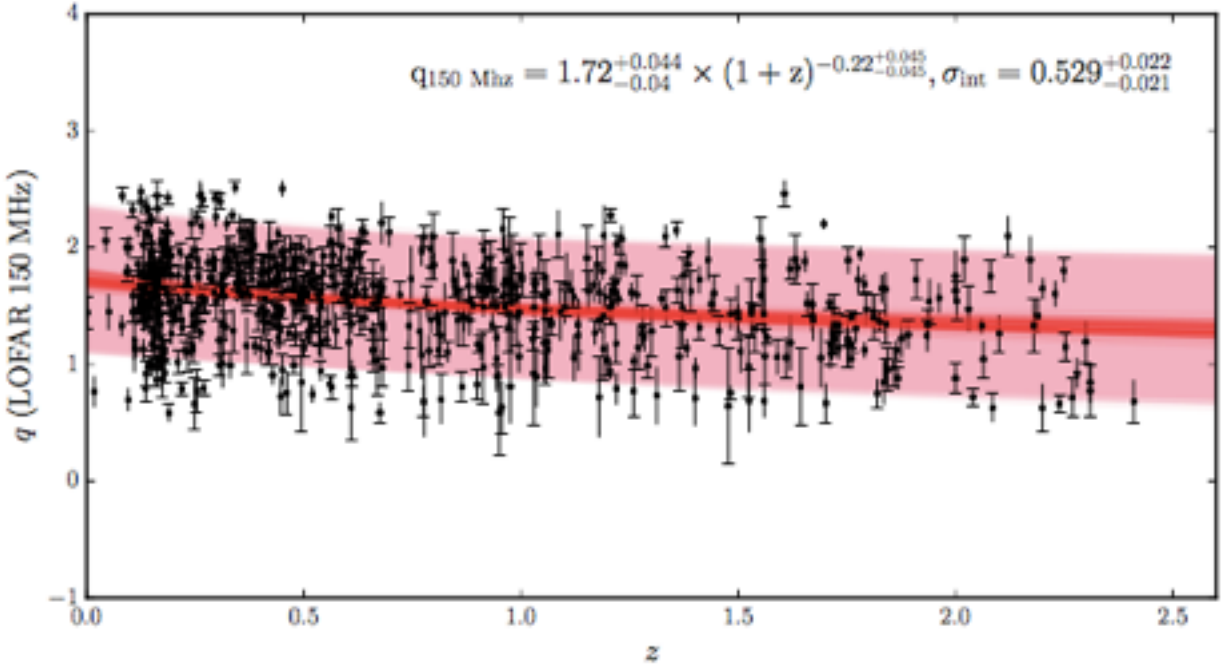
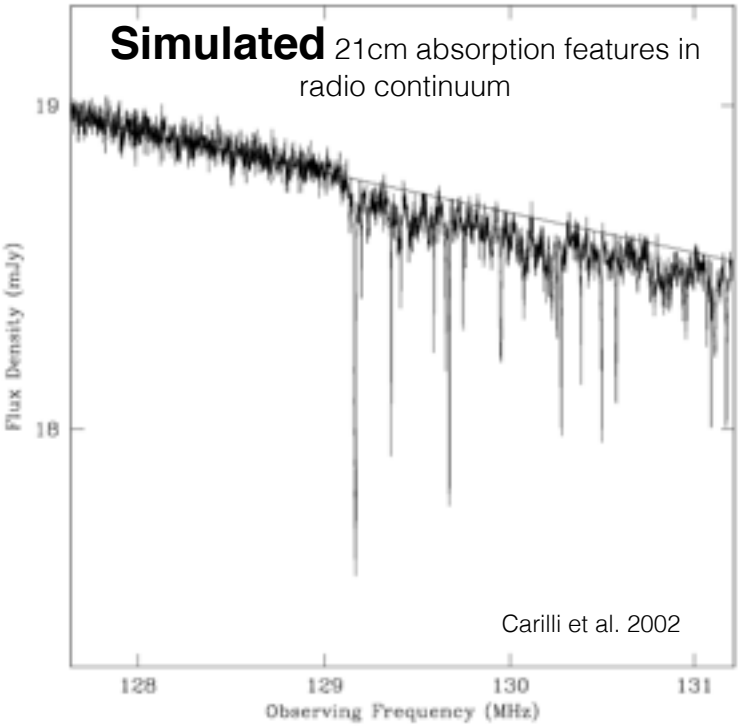
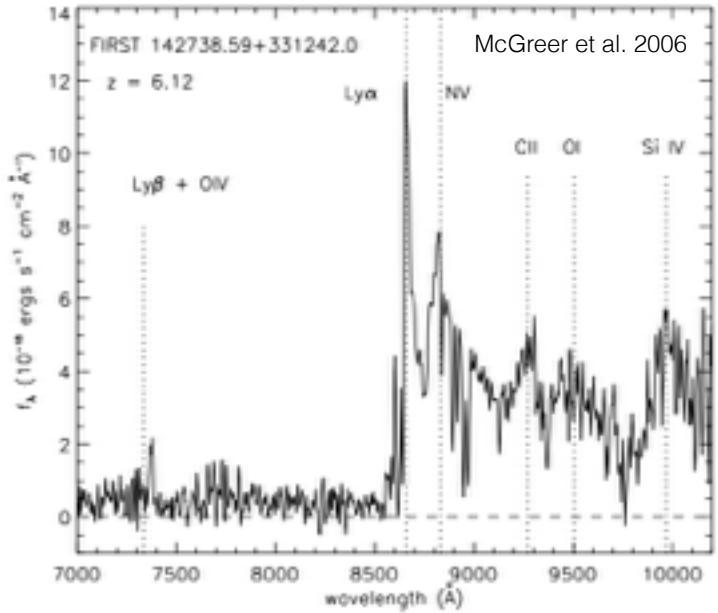


Figure 14. q-value for the IRC corresponding to radio luminosities at 150 MHz plotted against redshift. Black error bars depict the observed values, while red lines correspond to the fitted q-values inferred by the equation in the legend, taking into account uncertainties on the parameters calculated through MCMC sampling. The pink shaded area correspond to the fitted intrinsic scatter of the correlation.

Calistro-Rivera et al. 2017

z = 6.12 Radio Loud QSO as seen in Bootes field





Williams, Retana, Saxena, Duncan


A1914: Jit Mandal et al. in prep

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