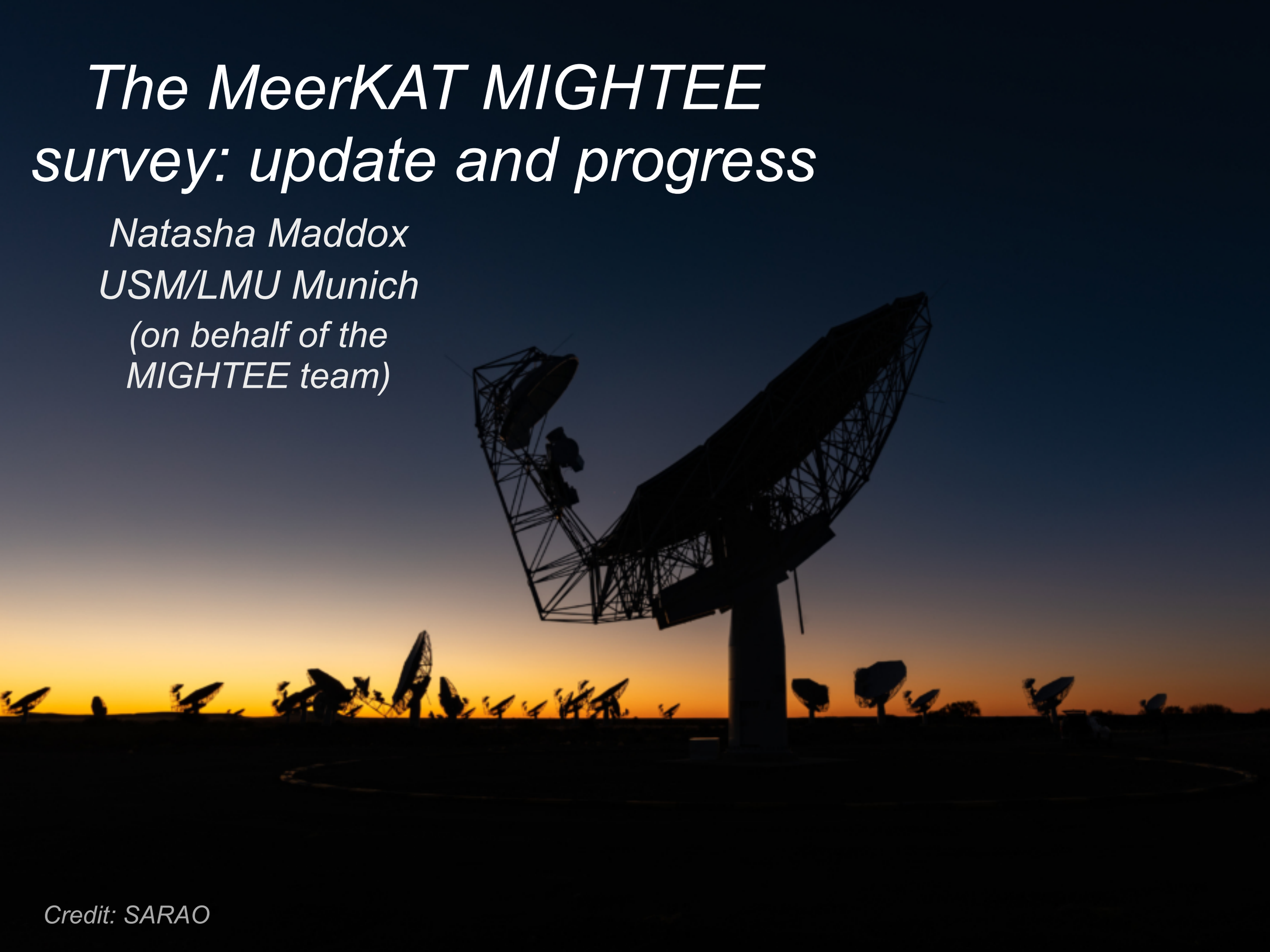
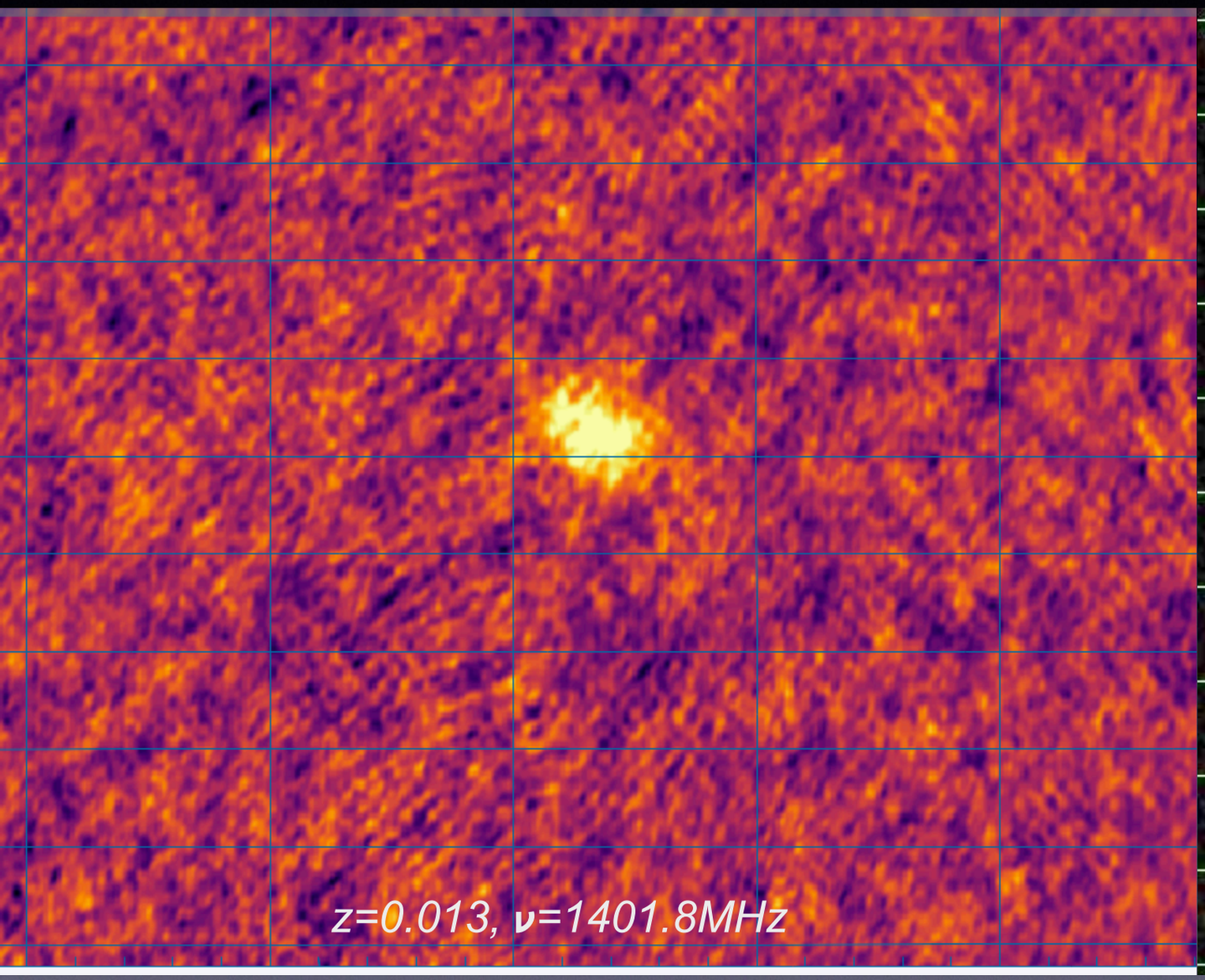
The MeerKAT MIGHTEE survey: update and progress

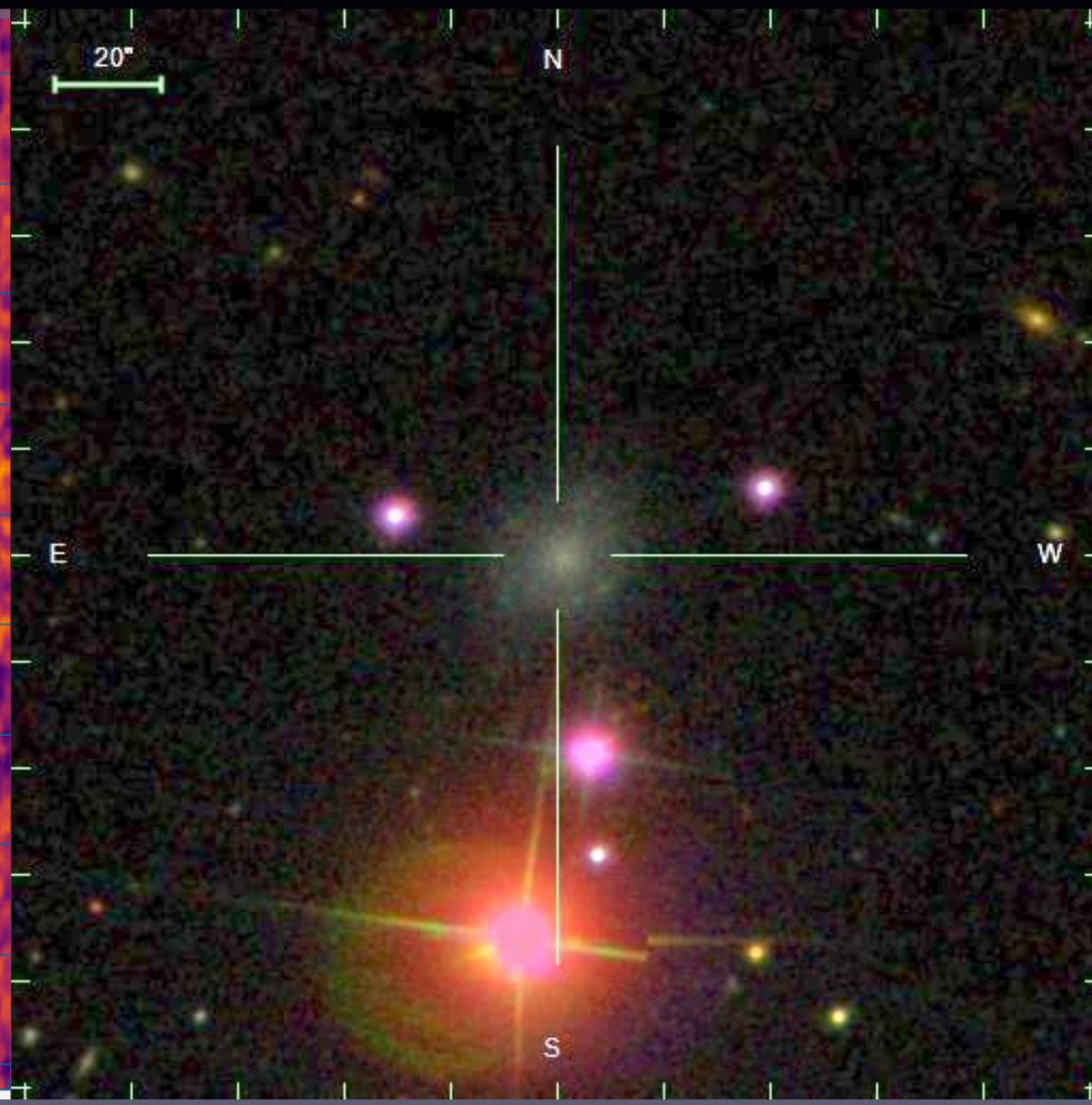
Natasha Maddox
USM/LMU Munich
(on behalf of the MIGHTEE team)



Credit: SARAO

Third MIGHTEE-HI detection





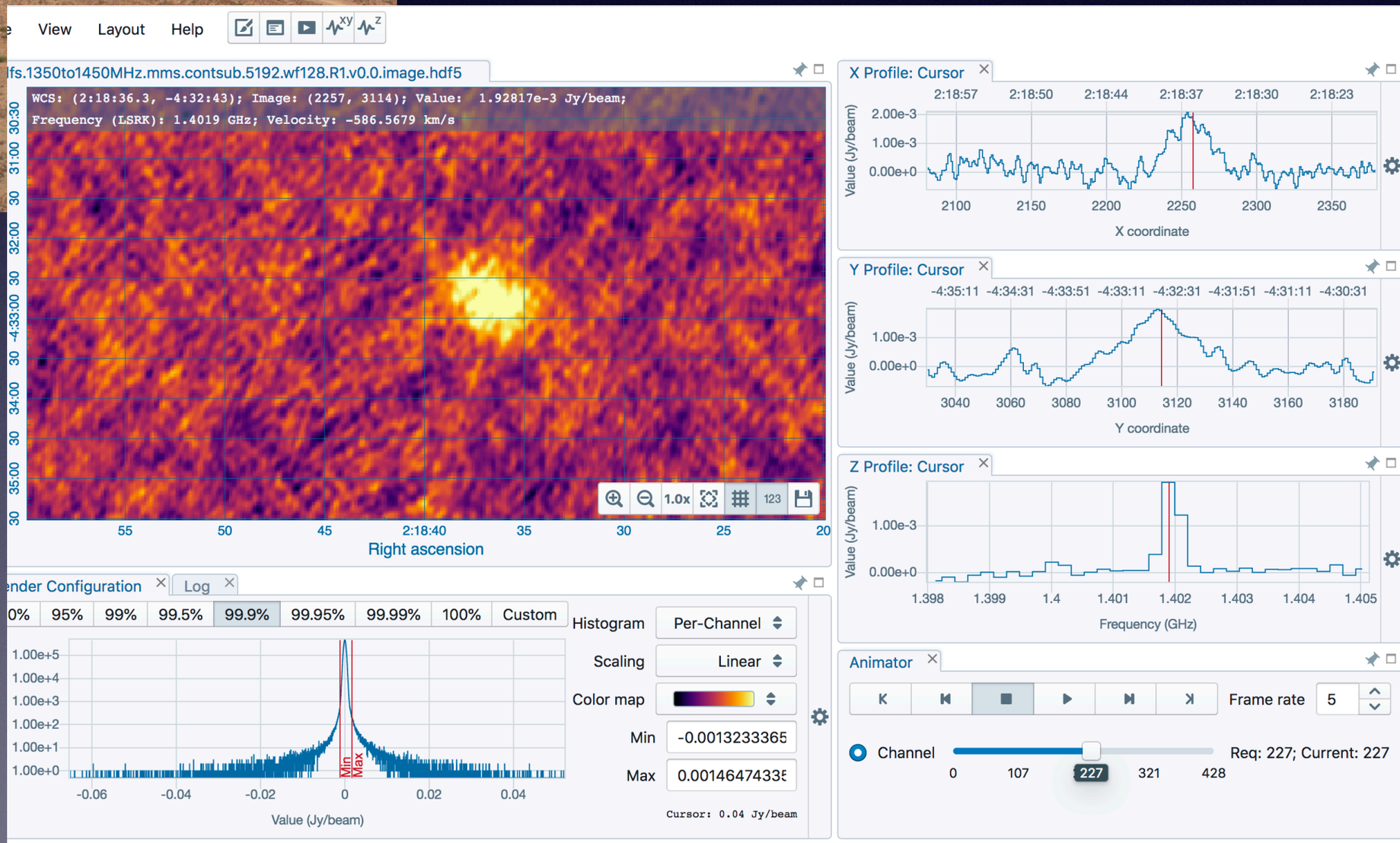
Credit: Brad Frank and IDIA Pipelines team

Evolution of MeerKAT

Image credit: SARAO

2013

CARTA: cartavis.github.io/
Hosted by IDIA

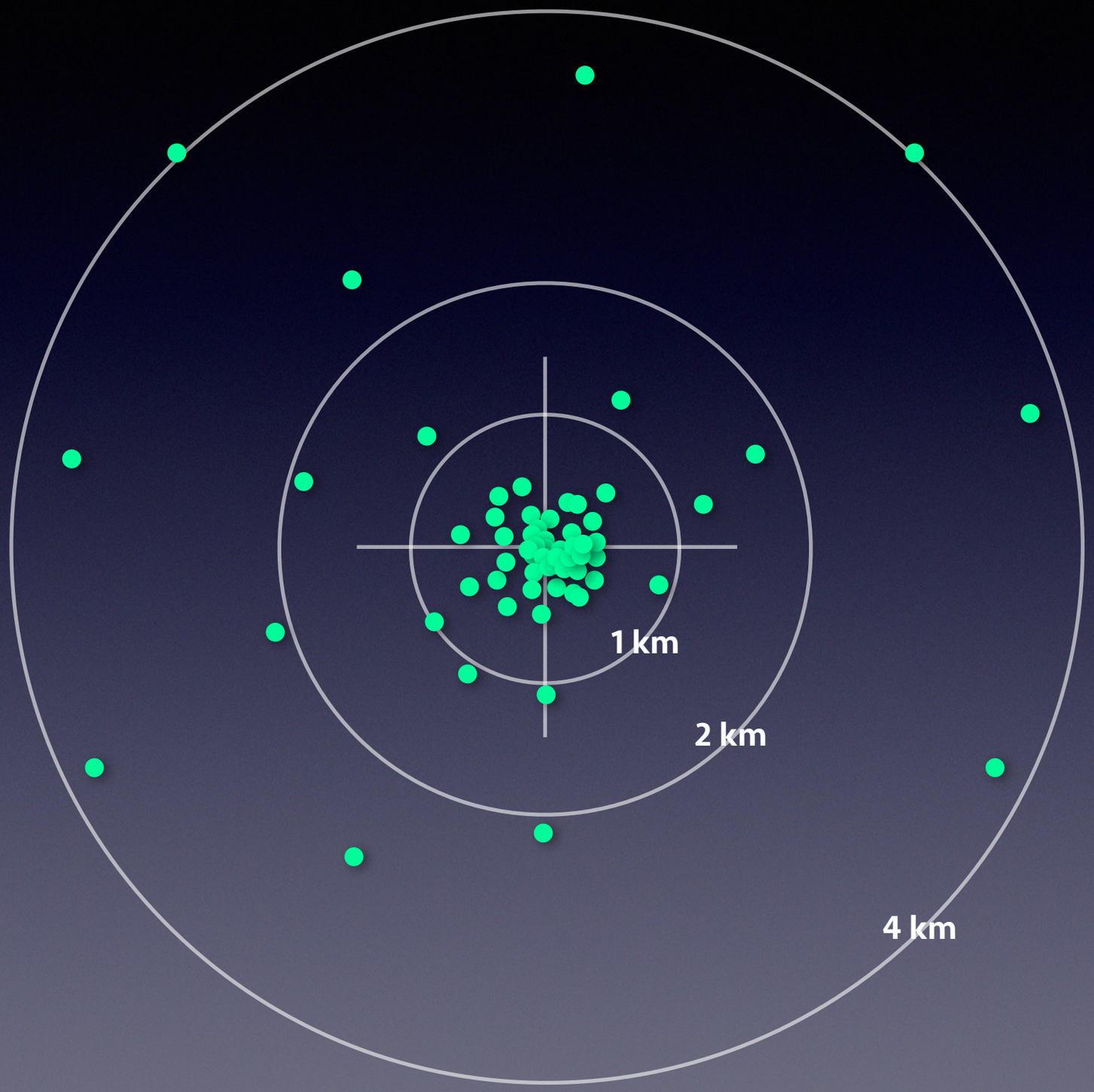


2019

MeerKAT

- 64 13.5m offset Gregorian dishes (larger FoV than VLA)
  - ~1deg^2 vs ~0.25deg^2 at 1420MHz
- 8km maximum baselines with compact core
  - 6arcsec resolution with good surface brightness sensitivity

Full 64-antenna MeerKAT array configuration



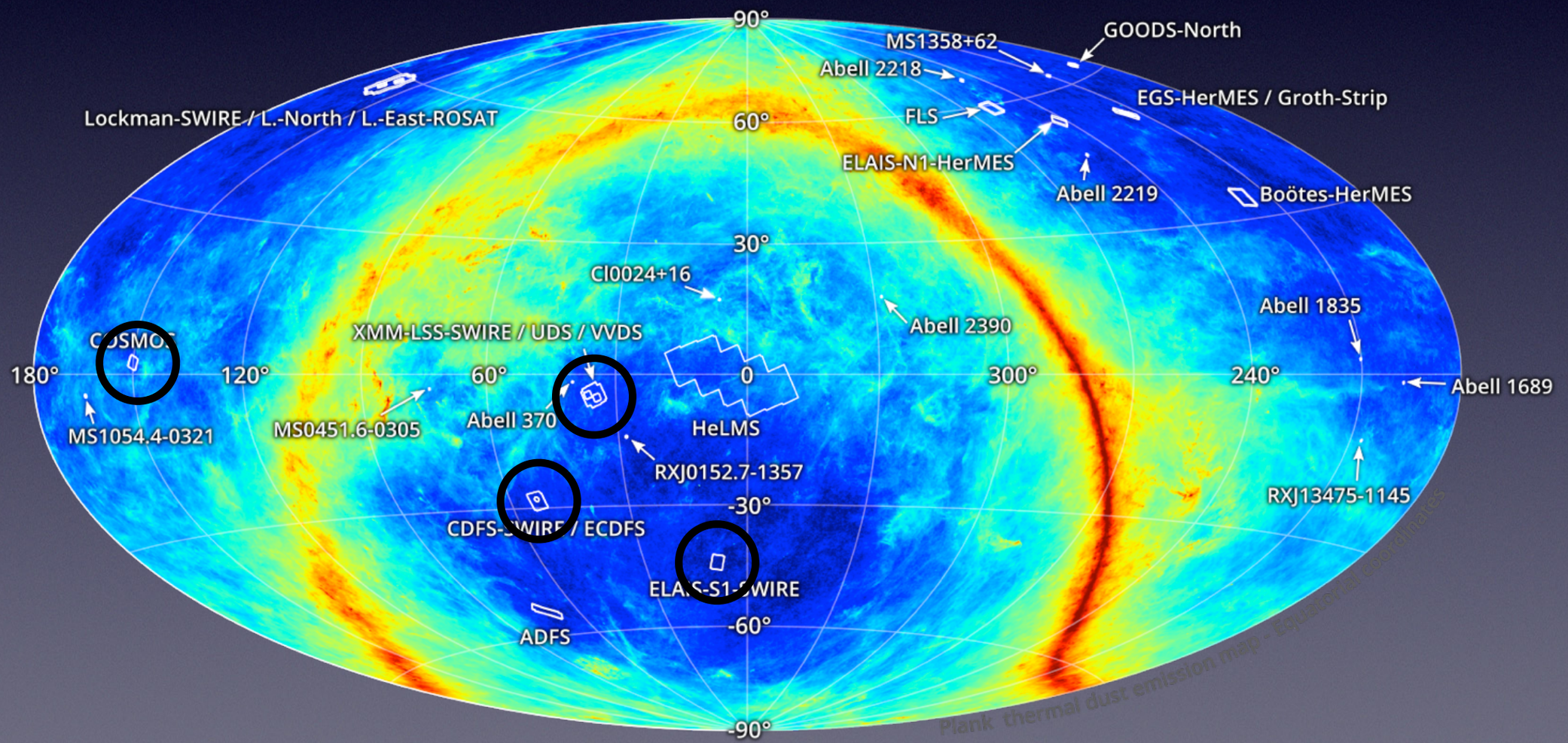
MeerKAT

- **L-band:** 900-1670MHz (HI 0<z<0.58, primarily HI emission)
- **UHF:** 580-1015MHz (HI 0.4<z<1.4, HI absorption but also emission)
- **S-band:** 1750-3500MHz

Image credit: SARAO

MIGHTEE: PIs Matt Jarvis, Russ Taylor

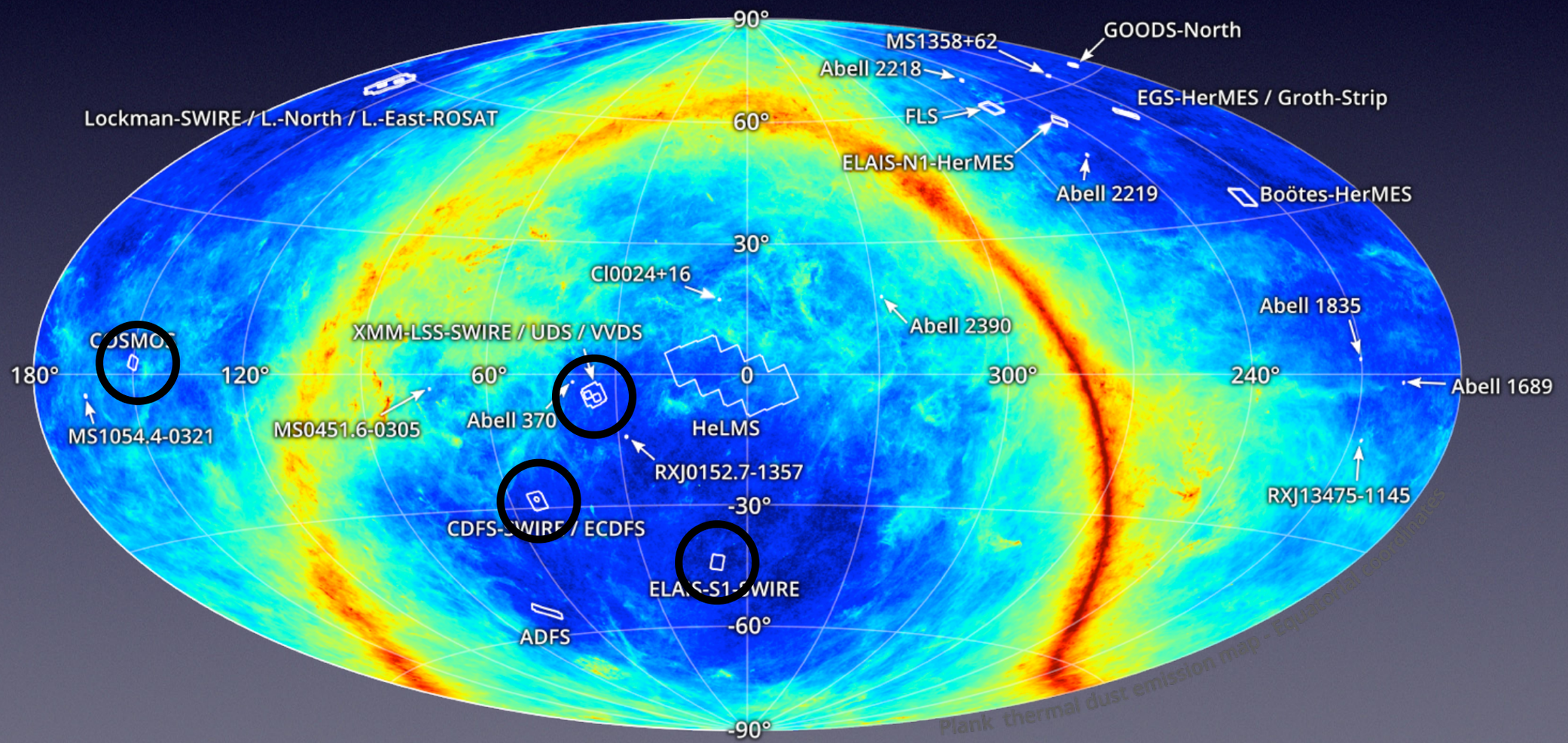
- MeerKAT International Giga-Hertz Tiered Extragalactic Exploration
- L-band and S-band medium-deep, medium-wide survey
- 20 deg^2, ~16 hours per pointing (20h effective) for ~few μJy sensitivity
- 0<z<3 for star forming galaxies, 0<z<6 for AGN



COSMOS (also the CHILES field), **XMM-LSS**, **ECDFS** (also the LADUMA field), **ELAIS S1**

MIGHTEE-HI

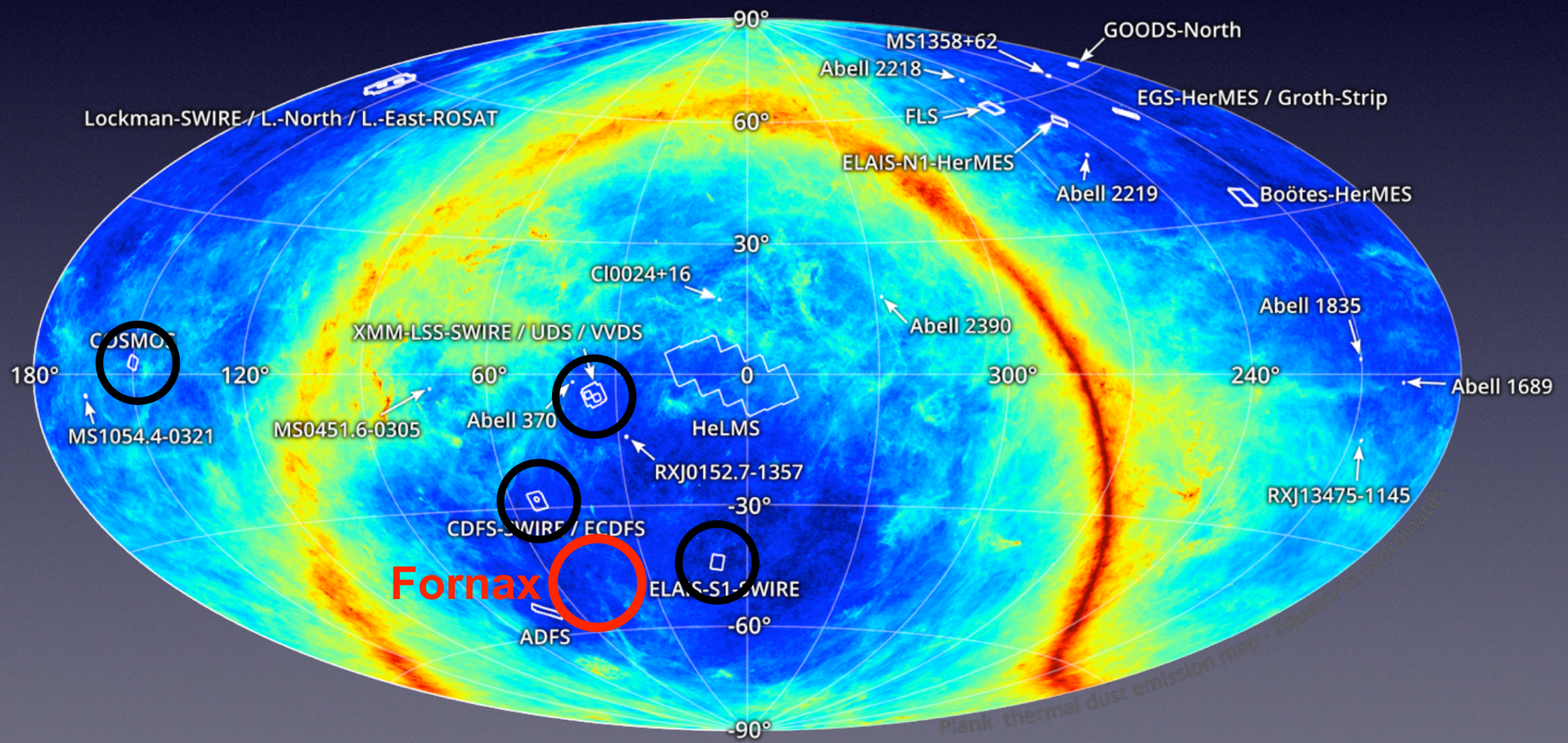
- Observations are taken in spectral line mode → commensal HI survey
- HI working group responsible for coordinating HI science from MIGHTEE (Focus session Thursday morning 09:30)
- Frequency coverage 1420<ν<900MHz, or 0<z<0.58 for HI
- (**note: a new >1deg^2 0<z<0.58 volume every 16 hours!)



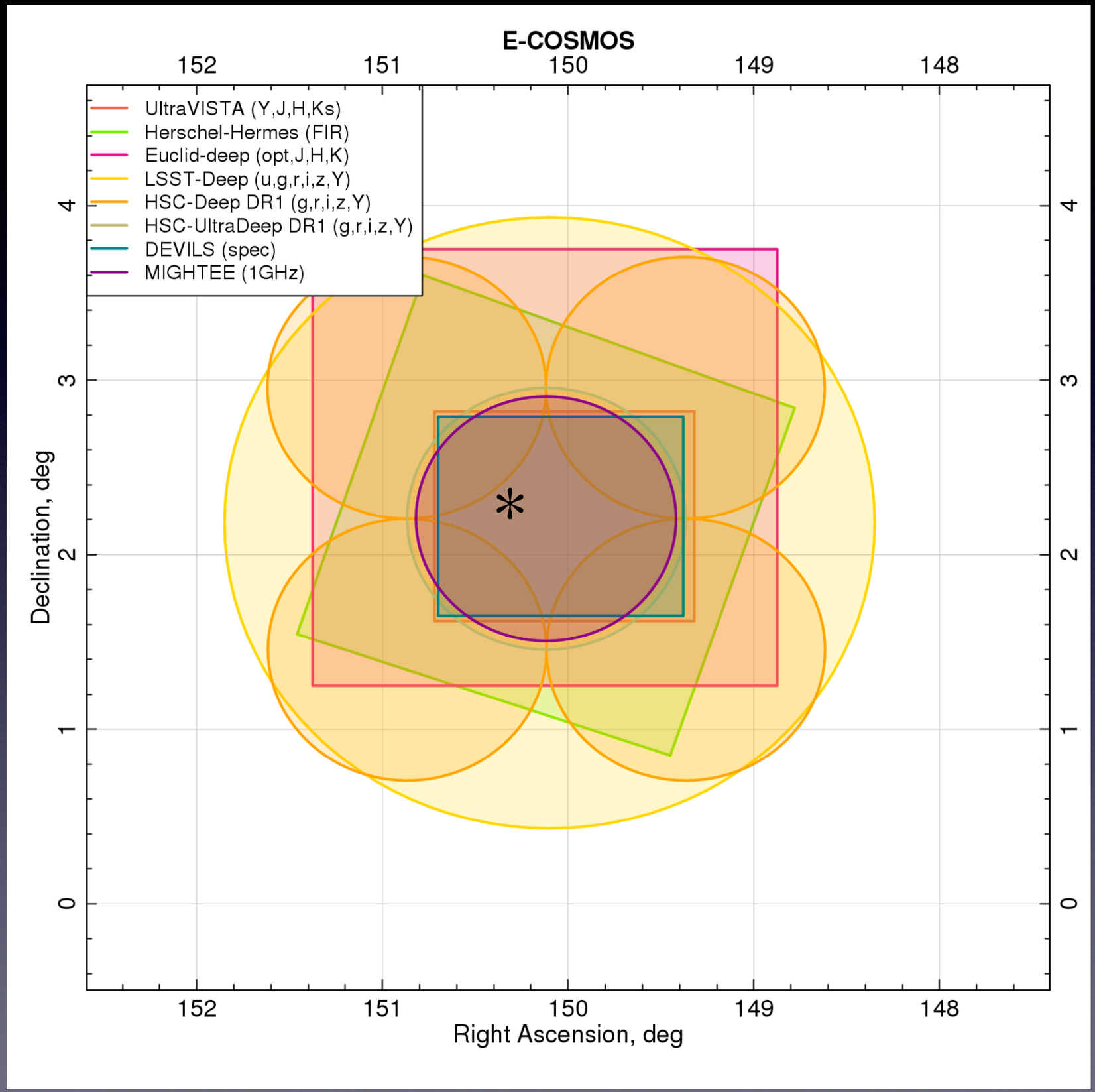
COSMOS (also the CHILES field), **XMM-LSS**, **ECDFS** (also the LADUMA field), **ELAIS S1**

MIGHTEE-HI

- An agreement between MeerKAT Fornax and MIGHTEE-HI designates the volume *behind* Fornax as MIGHTEE-HI volume
- ~~20~~ 32 deg², ~16 hours per pointing in L-band, with 12 extra deg² from the background volume of MeerKAT Fornax

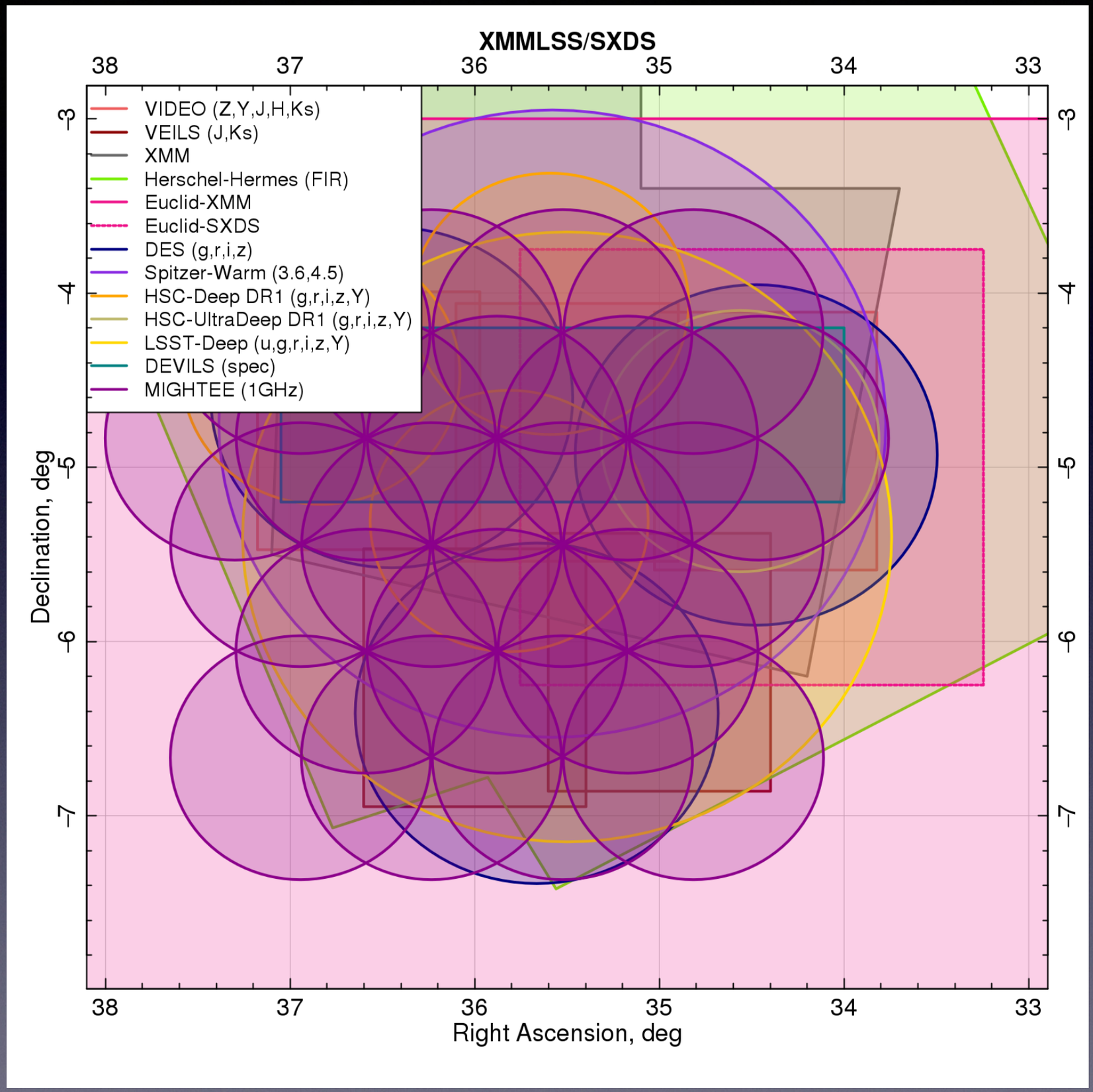


COSMOS



Epic figures from AstroMap, created by Luke Davies http://astromap.icrar.org/

XMM-LSS



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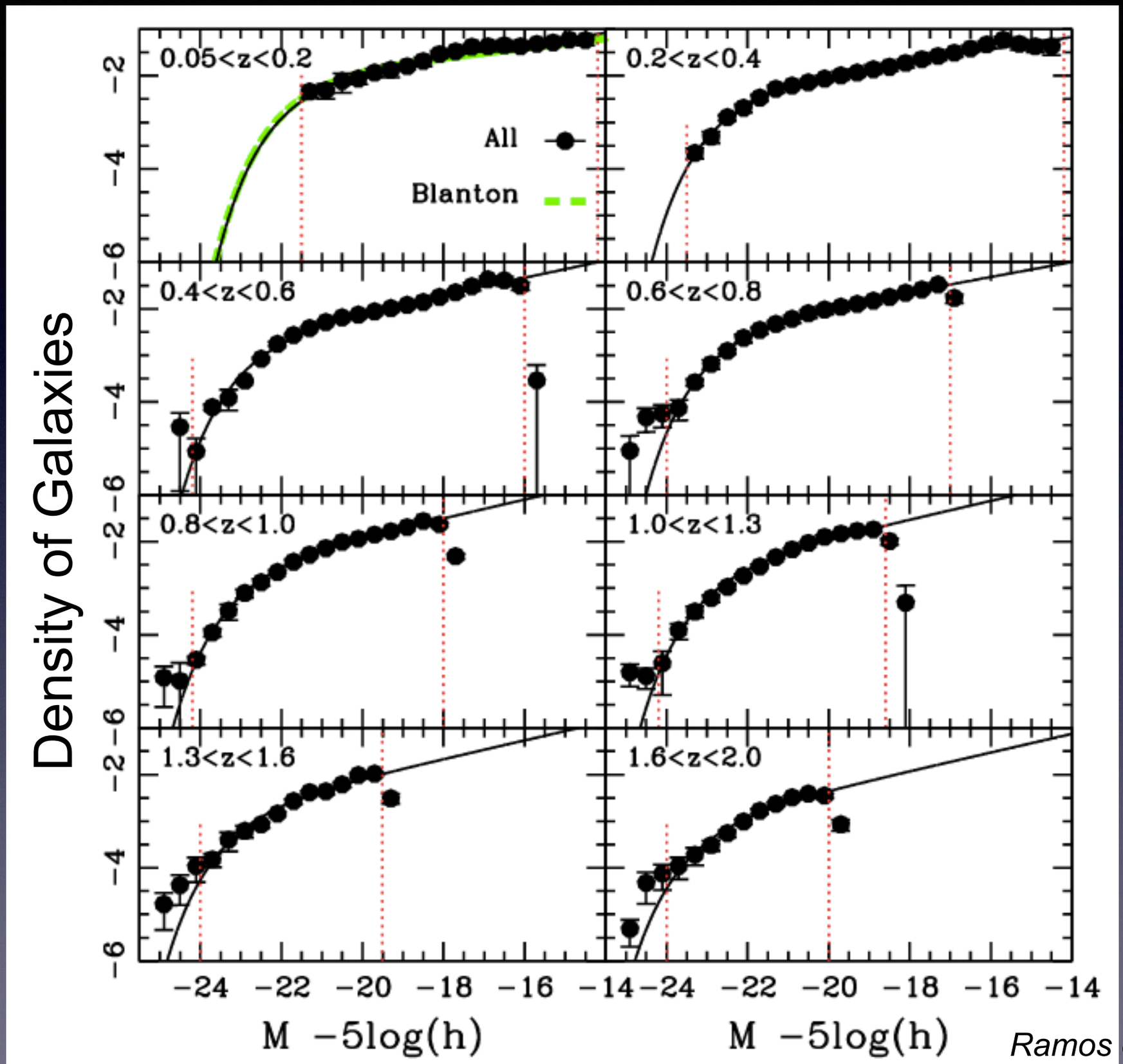
Science Cases for MIGHTEE (medium-deep, medium-wide)

- *MIGHTEE--LADUMA synergy* → HIMF, HI evolution
- *Resolved galaxies* → dynamics, TF relation
- *Low mass galaxies* → Too big to fail, too shy to shine
- *Continuum synergy* → HI-rich galaxies are also starforming
- *HI as a function of environment* → groups, clusters, filaments, voids
- *HI as a function of stellar properties* → star formation, stellar mass
- *Statistical techniques* → Stacking
- *Simulations/Modelling/Visualization* → HI cycle
- *HI and AGN* → emission, absorption, fueling, feedback
- etc...

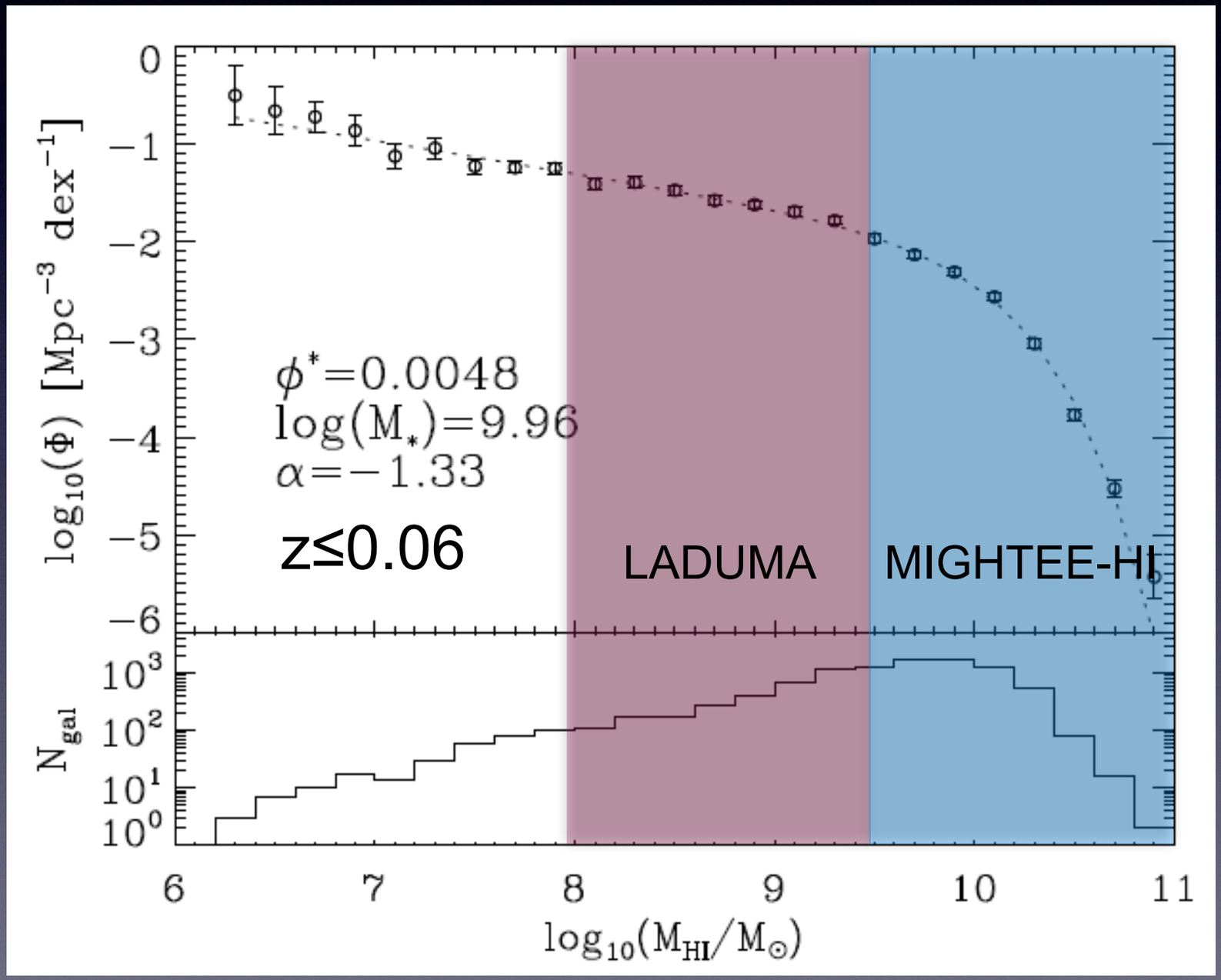
Galaxy Luminosity Function evolution



Ramos et al 2011

HIMF evolution

- Investigate the HI mass function at different redshifts, in different environments, to z≤0.4



How do normalisation, M^*_{HI}, and slope evolve with redshift?

Martin et al 2010

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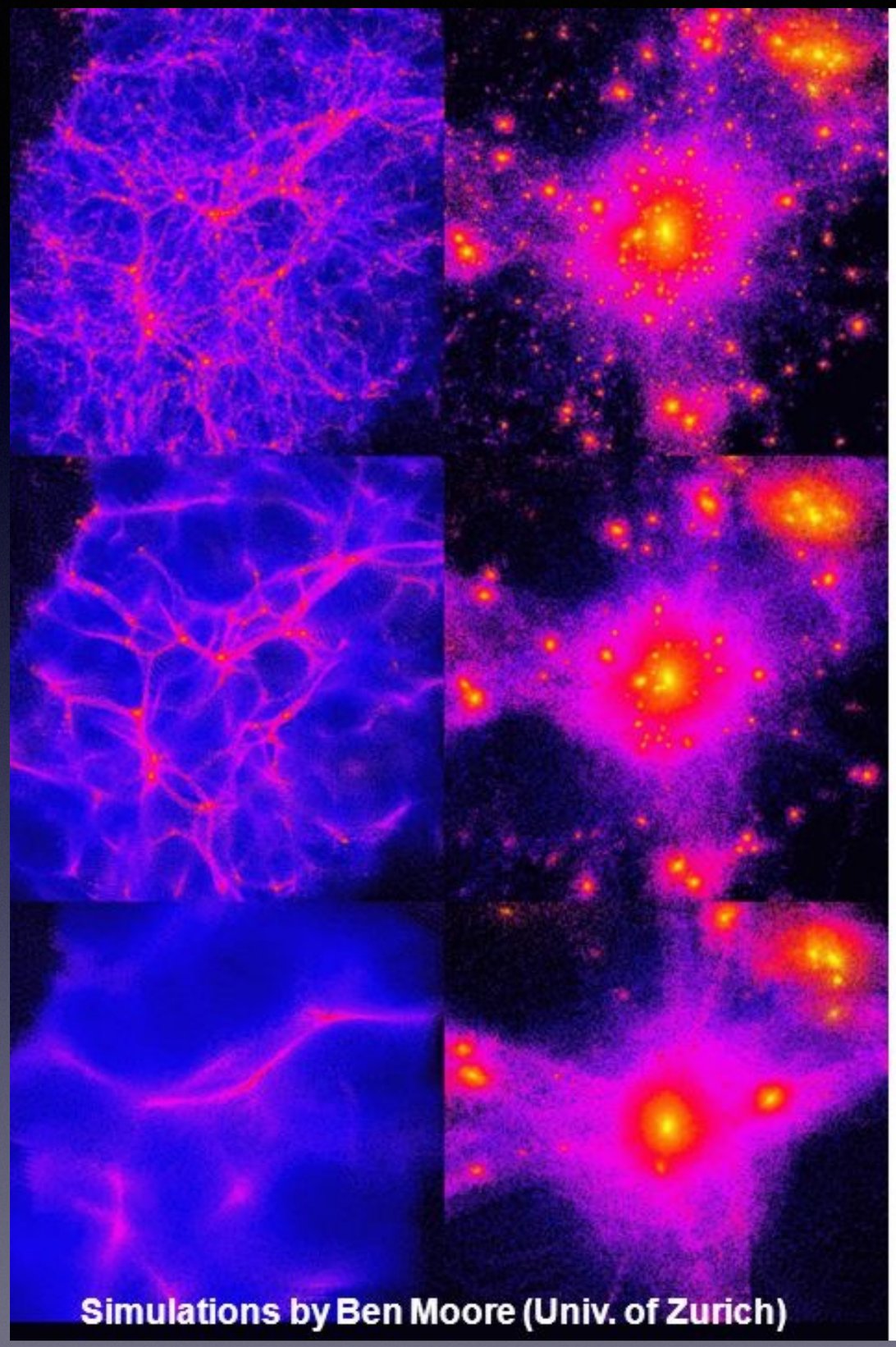
The missing satellites problem with LCDM



Cold Dark Matter (WIMPs)

Warm Dark Matter (mostly CDM but with some neutrinos as well)

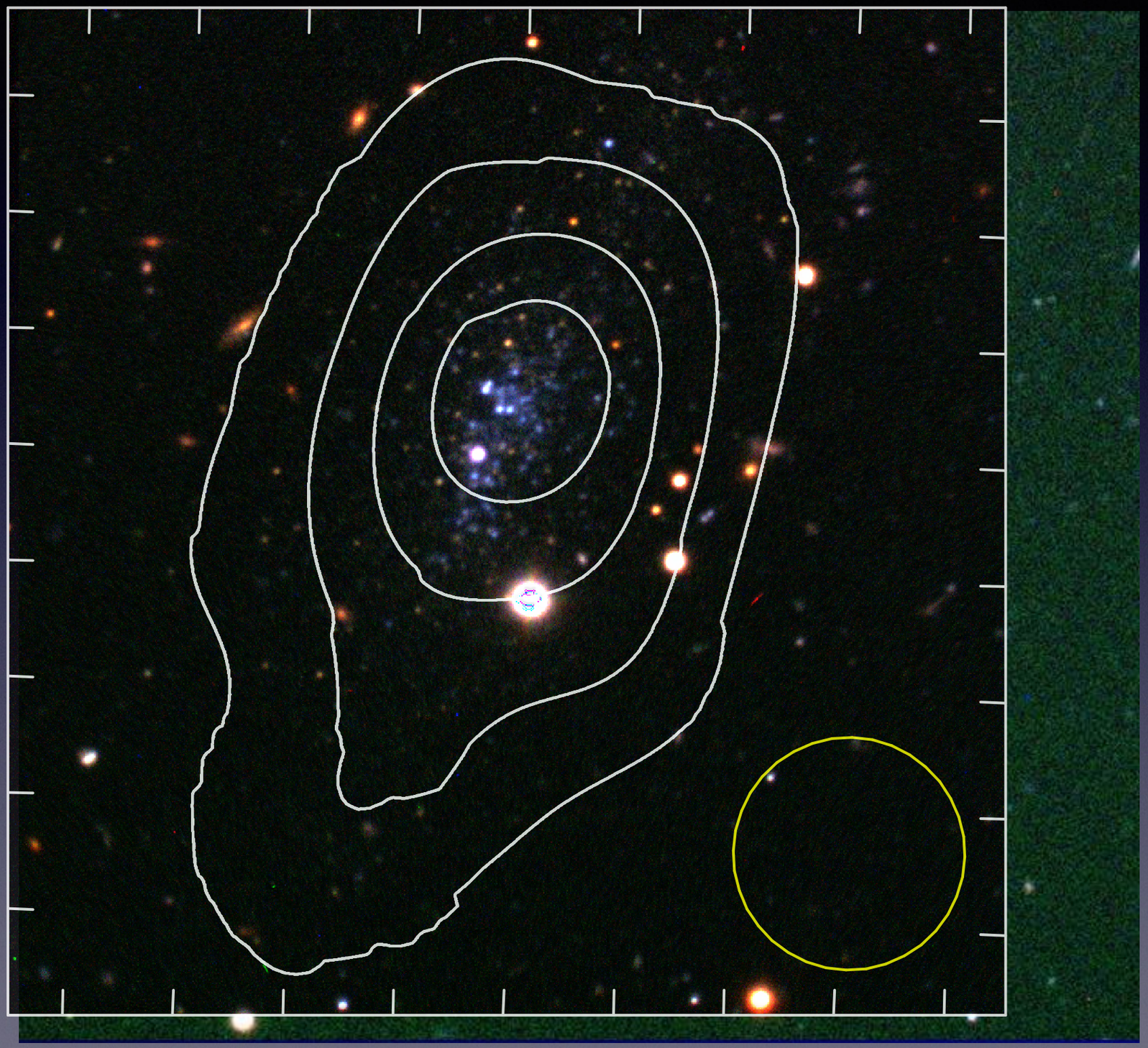
Hot Dark Matter (neutrinos)

Leo P - *Low mass galaxy in the Local Group*

$M_\star = 5.7 \times 10^5\ M_\odot$

$M_{HI} = 9.3 \times 10^5\ M_\odot$

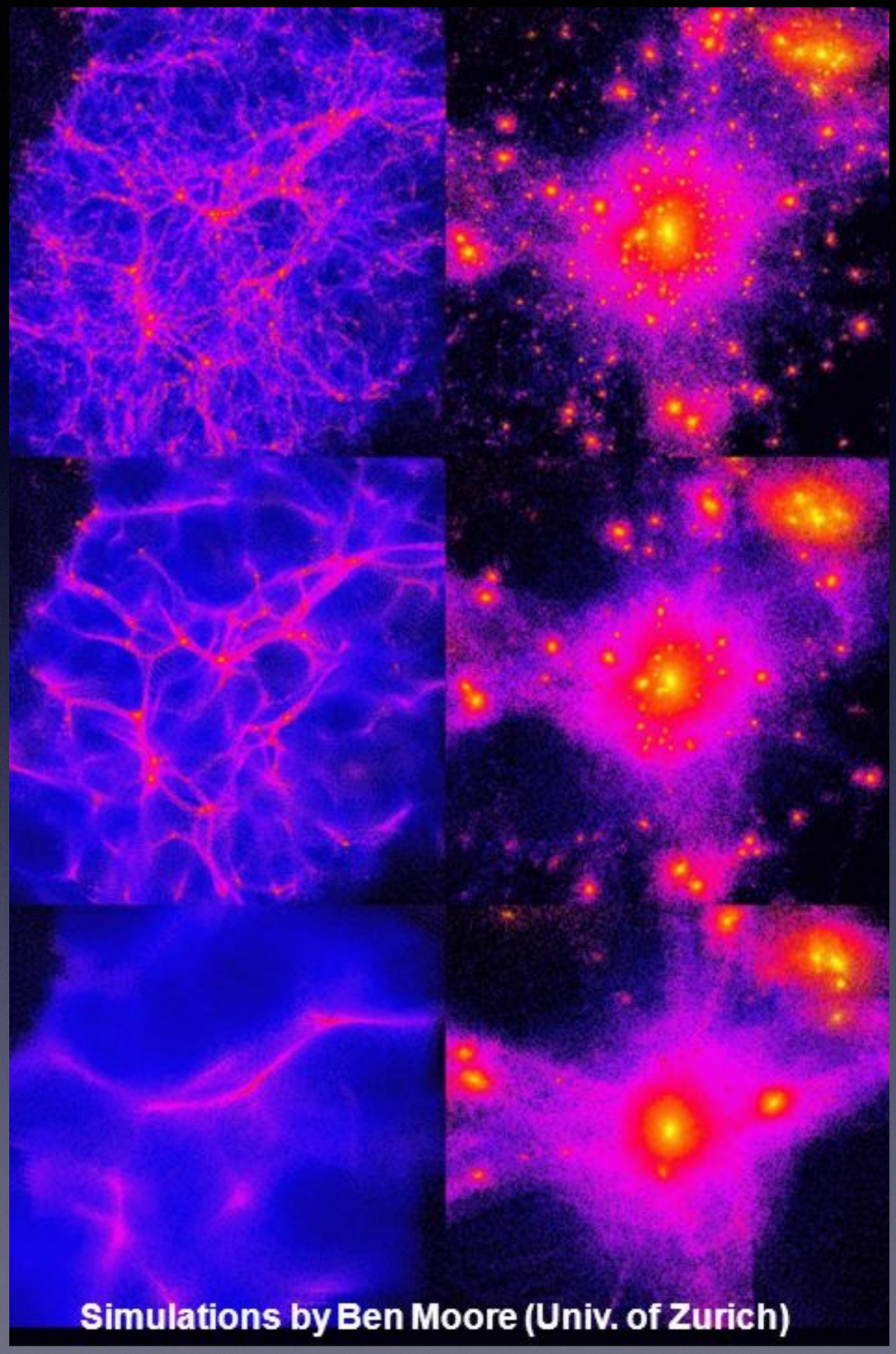
$\underline{M_{HI}/M_\star = 1.6}$



Rhode et al. 2013 (optical), Giovanelli et al. 2013 (HI)

The low-mass, nearby universe

- Expect to find ~270 galaxies with $M_{HI}<10^8\ M_\odot$ in 20 deg^2
- 3-σ column density of ~$5x10^{20}$ cm^{-2} at 10” resolution (at 16 km/s resolution), or
  - ~$1x10^{19}$ cm^{-2} at 1’ resolution, for a 10 hour observation



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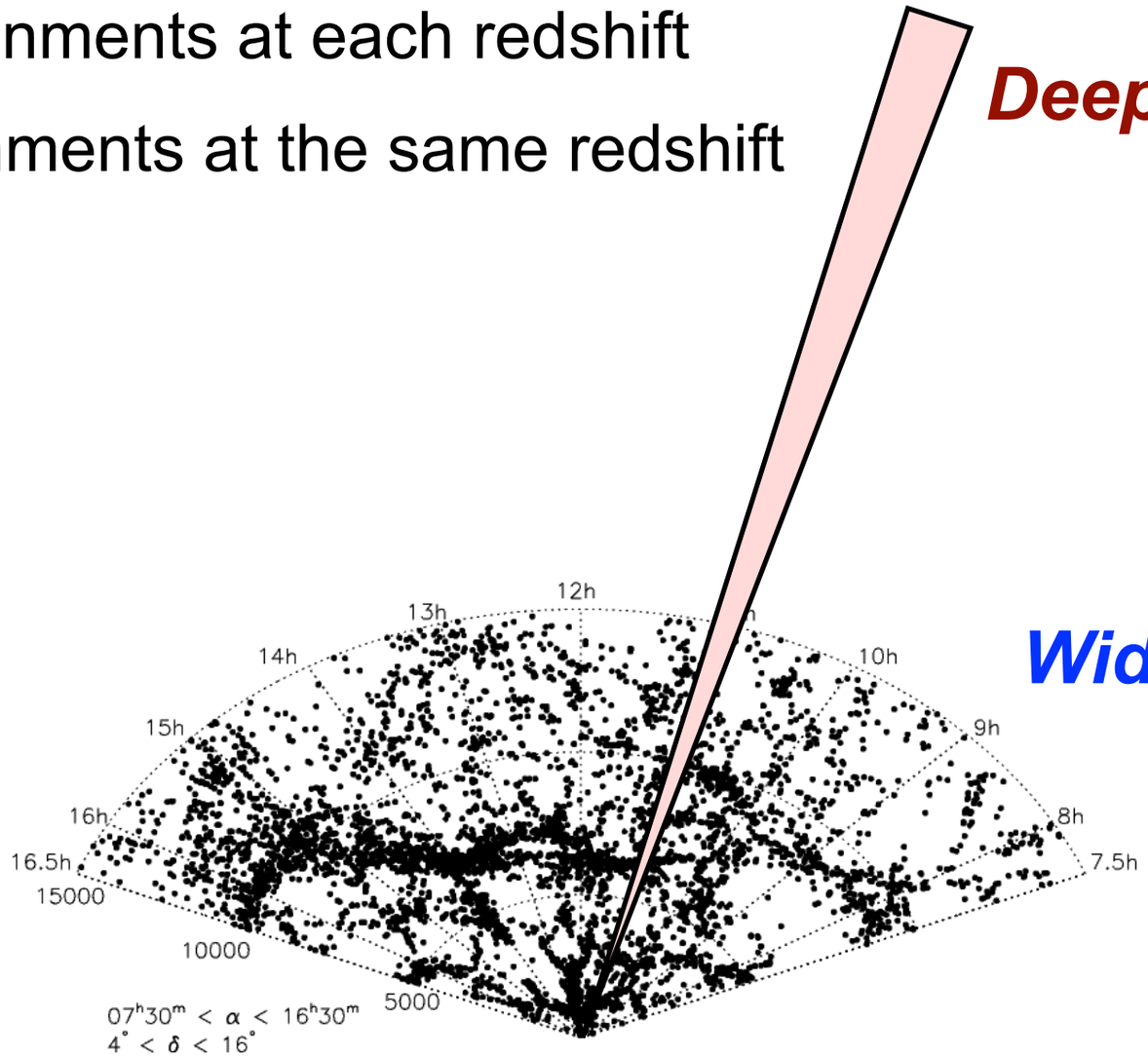
The benefits of different survey tiers

- Explore both high and low mass ends of the HI mass function
- Many more detections, improved population statistics
- Explore a wider variety of environments than available in one tier

Deep: Different environments at each redshift

Wide: Various environments at the same redshift



Deep (LADUMA)

Wide (MIGHTEE-HI)

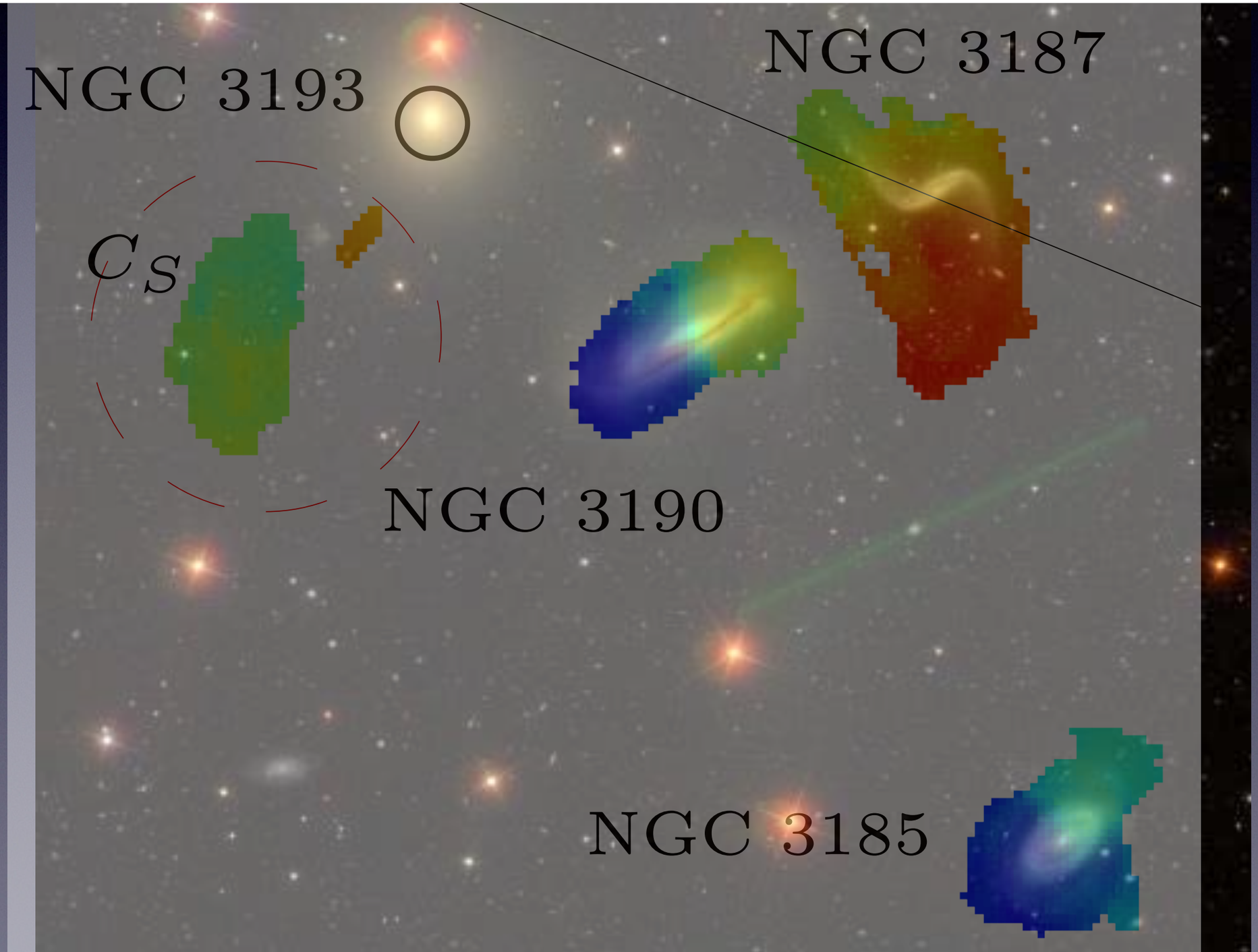
***not to scale*

DEVILS

DEEP EXTRAGALACTIC VISIBLE LEGACY SURVEY

PI Luke Davies (ICRAR)
https://devilsurvey.org/

- Spectroscopic survey with 95% completeness 0.3<z<1
- Targeting interacting, pairs and groups of galaxies



Serra et al 2013

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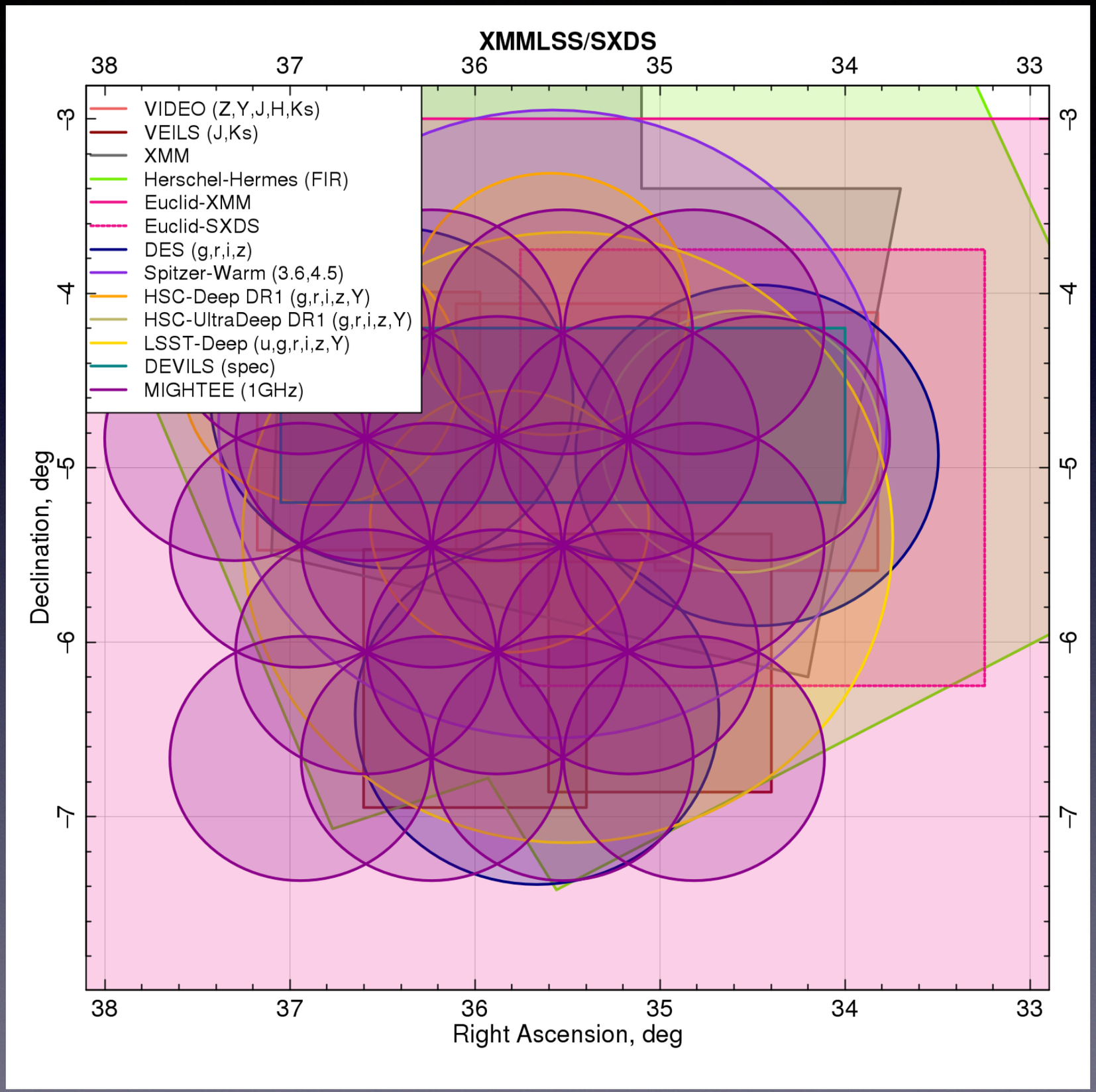
Scaling relations → ancillary data



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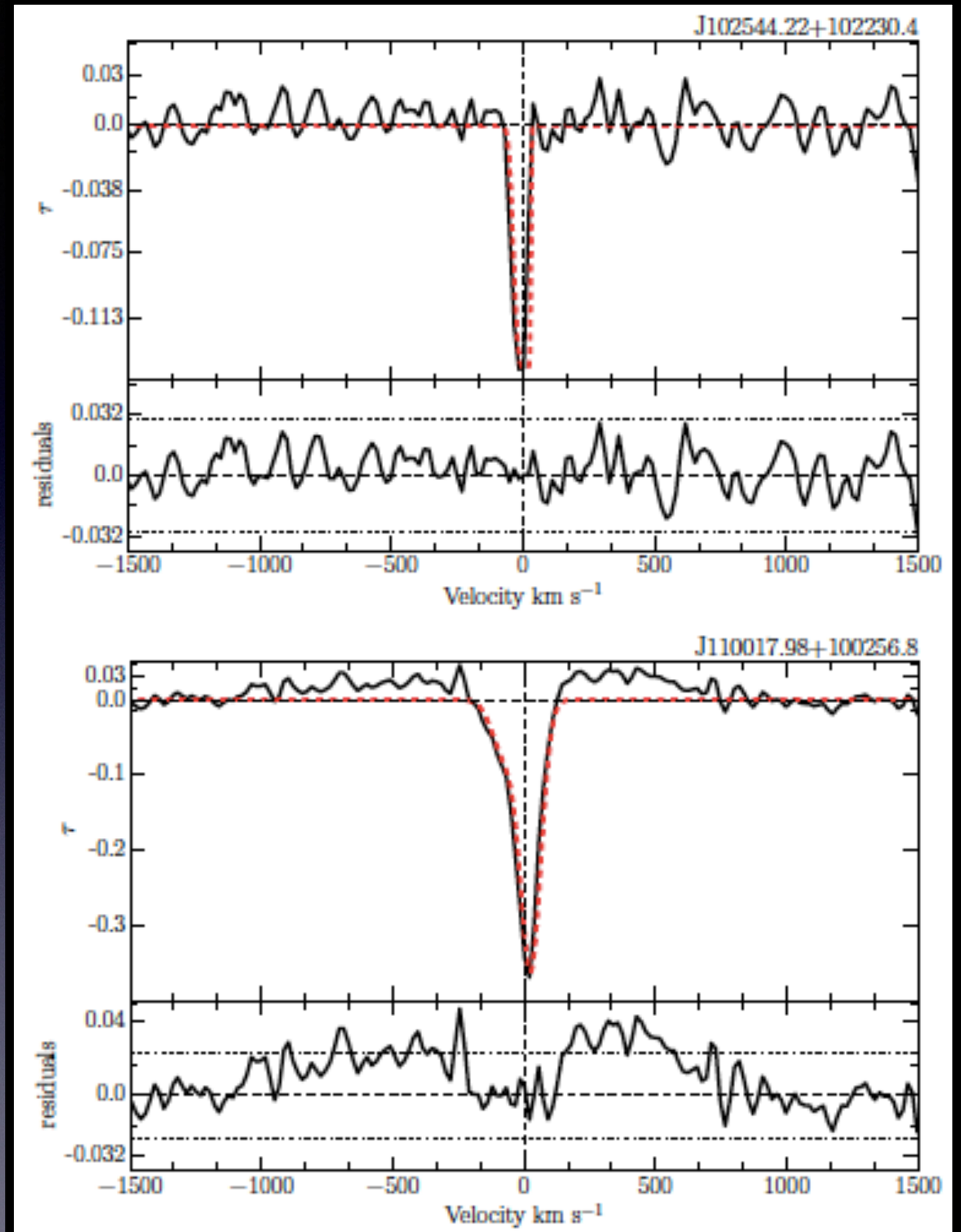
HI in absorption

- Detect HI in *absorption* toward background radio sources
- Sensitivity independent of redshift, provides another probe of HI content
- Gives details of nuclear environment
- MIGHTEE-Absorption working group, talk to James Allison



Maccagni et al 2017

The Data Flow

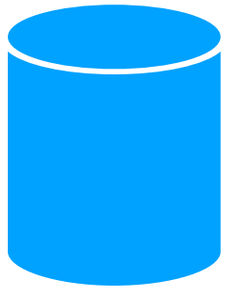
Courtesy of Brad Frank

- MIGHTEE: 32k/856MHz
- df = 26.75kHz, dv = 5.6km/s.
- Typical dataset ~10TB (6-hr @ 8s)

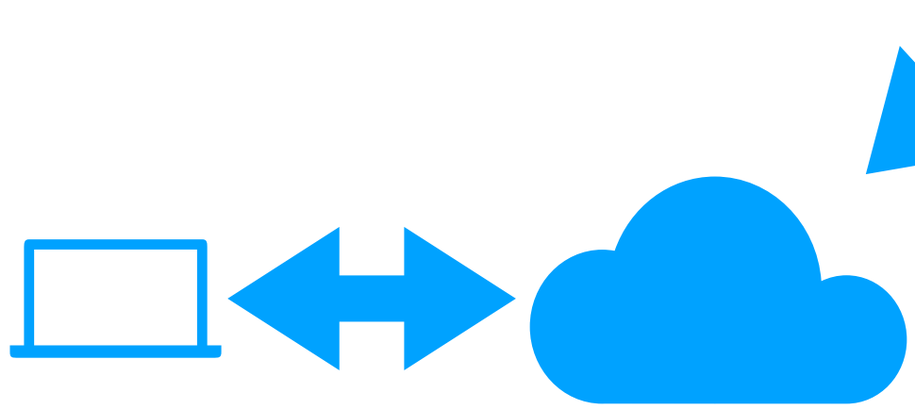
MeerKAT

Correlator SDP Cal (L0) (Site/Karoo)

Archive (L0+L1) (CHPC/Cape Town)



Data Transfer Node(s) (CHPC/Cape Town)



IDIA*

*Or any other 3rd-Party Data Centre (in theory).

MIGHTEE: medium-deep, medium wide MeerKAT survey

- MIGHTEE is underway, and has continuum images and HI detections
  - ➡ Early science imminent!
- Excellent multi-wavelength data already in place, with more to come
  - ➡ Add the crucial HI component into the galaxy census
- Data processing is currently manageable, and nearly finalised
  - ➡ Fast turnaround from telescope to science product
- MIGHTEE has the combination of area and depth to impact many science cases
  - ➡ MeerKAT will be transformational for HI science