ASKAP and EMU

Andrew Hopkins

Australian Astronomical Observatory

Australian Government
Department of Industry
Innovation, Science, Research and Tertiary Education

AAO

ASKAP

EMU

Evolutionary Map of the Universe

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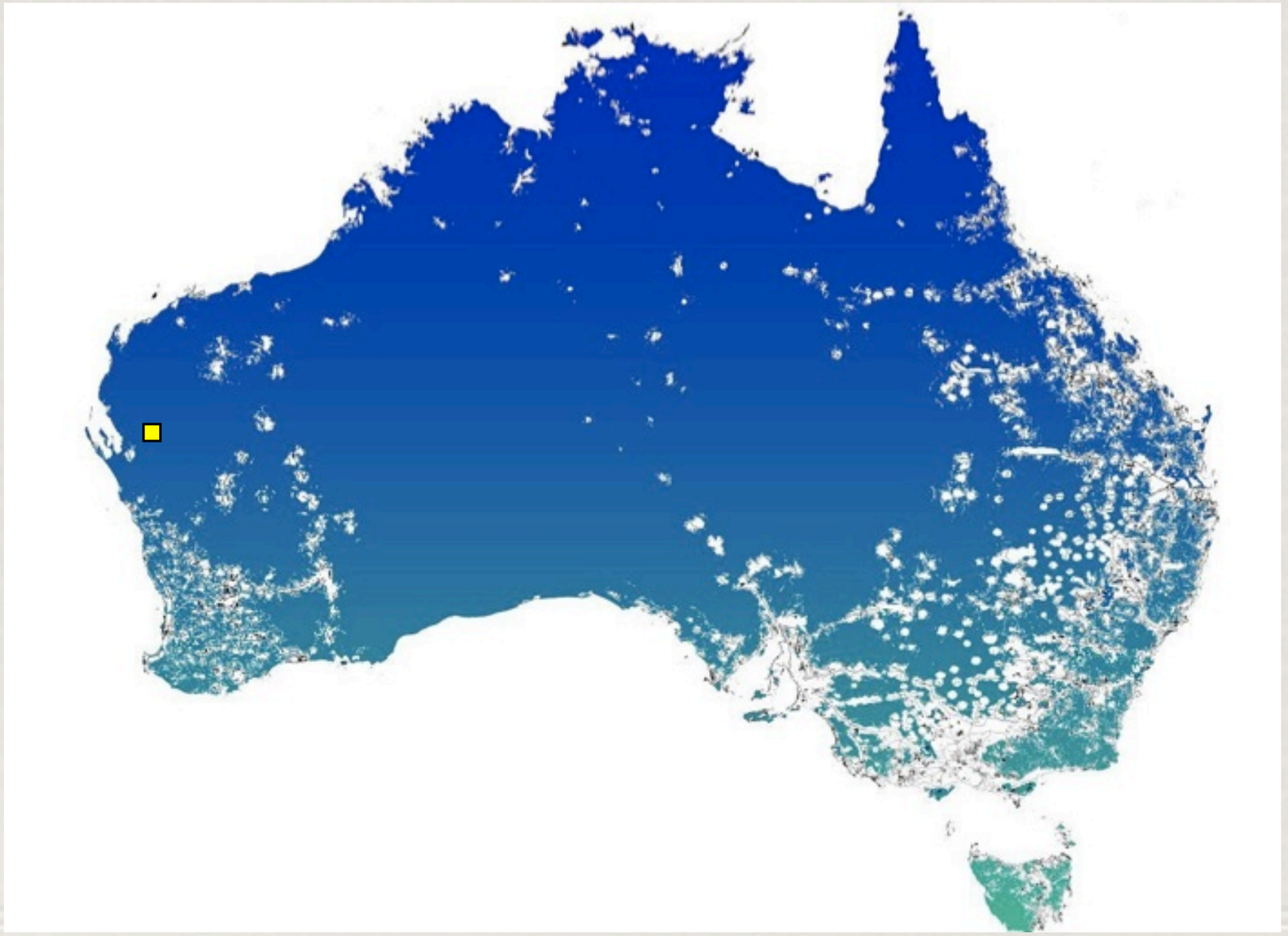
ASKAP

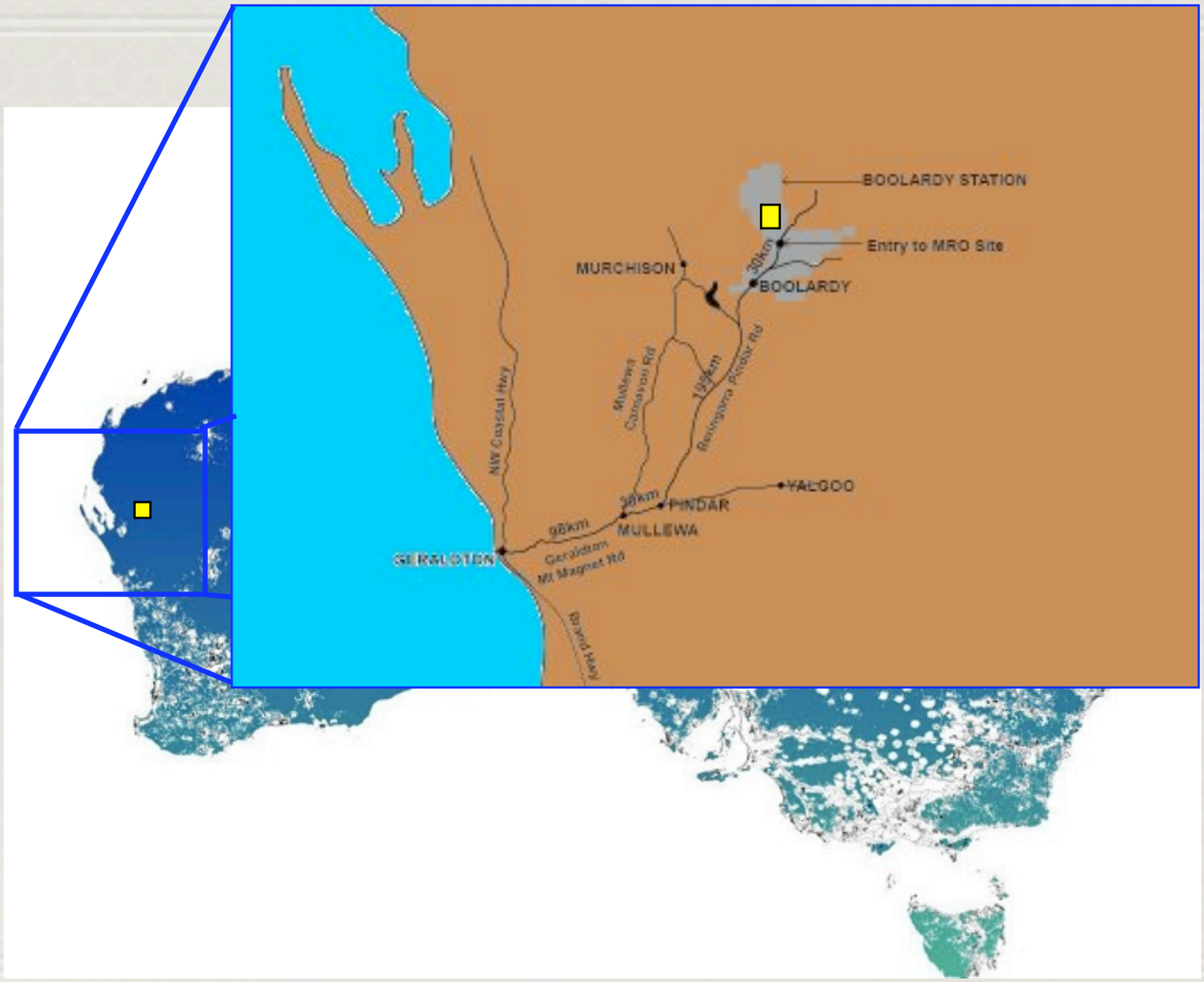
- *Australian SKA Pathfinder, completed late 2013, 36×12m antennas*
- *Antennas have a 100-pixel phased array feed (PAF), giving a 30 square degree FOV*
- *Being built in Murchison Shire, Western Australia*
- *All 36 dishes are already deployed*
- *18 PAFs are funded, 6 already deployed*
- *BETA (Boolardy Engineering Test Array) now taking data*

Image credit: Lisa Harvey-Smith

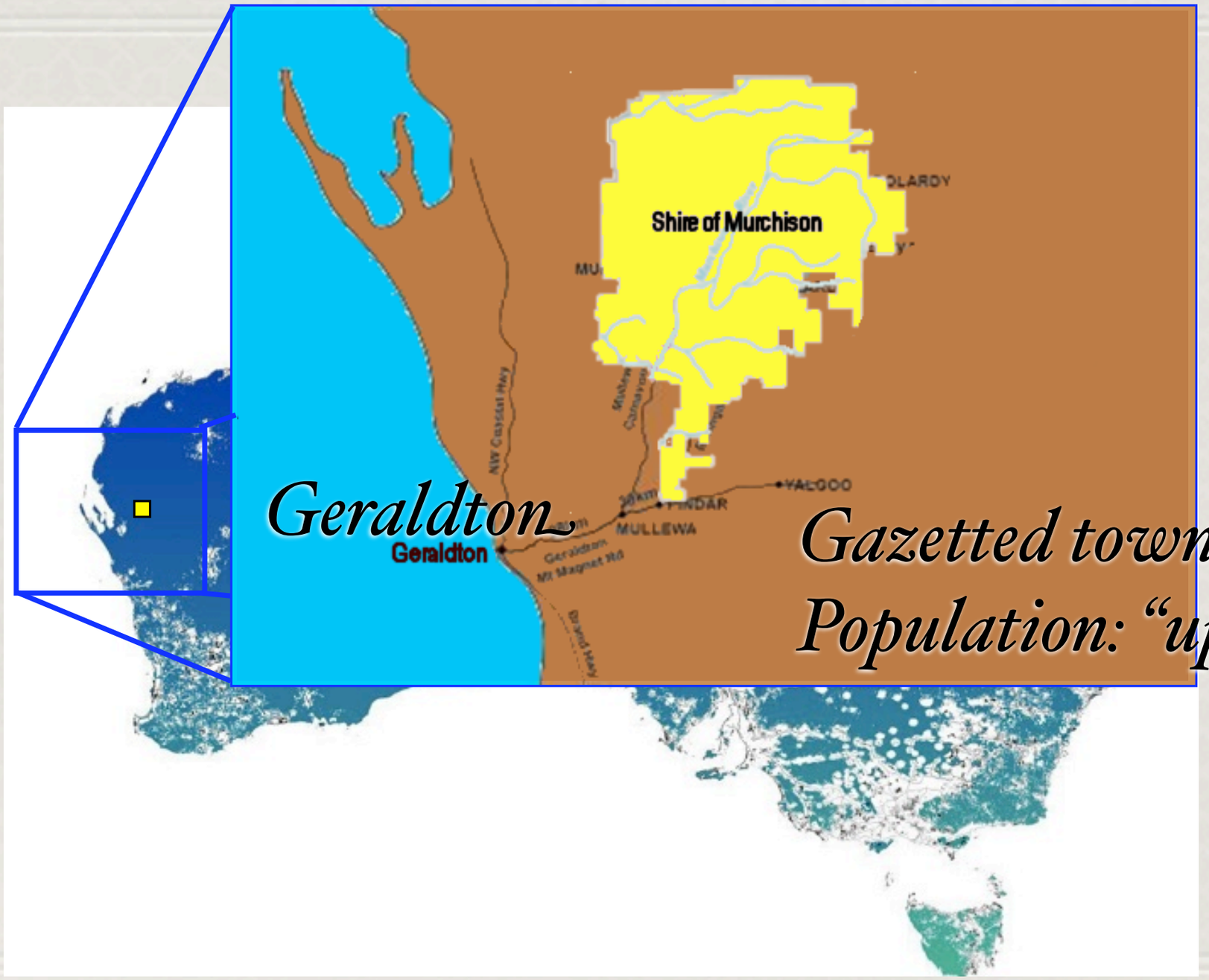
ASKAP



ASKAP


BOOLARDY STATION
Entry to MRO Site
MURCHISON
30km
BOOLARDY
NW Coastal Hwy
Mullewa Carnarvon Rd
135km
Geraldton Perenjori Rd
YALGOO
PINDAR
38km
98km
MULLEWA
GERALDTON
Geraldton Mt Magnet Rd
Great North Hwy

ASKAP

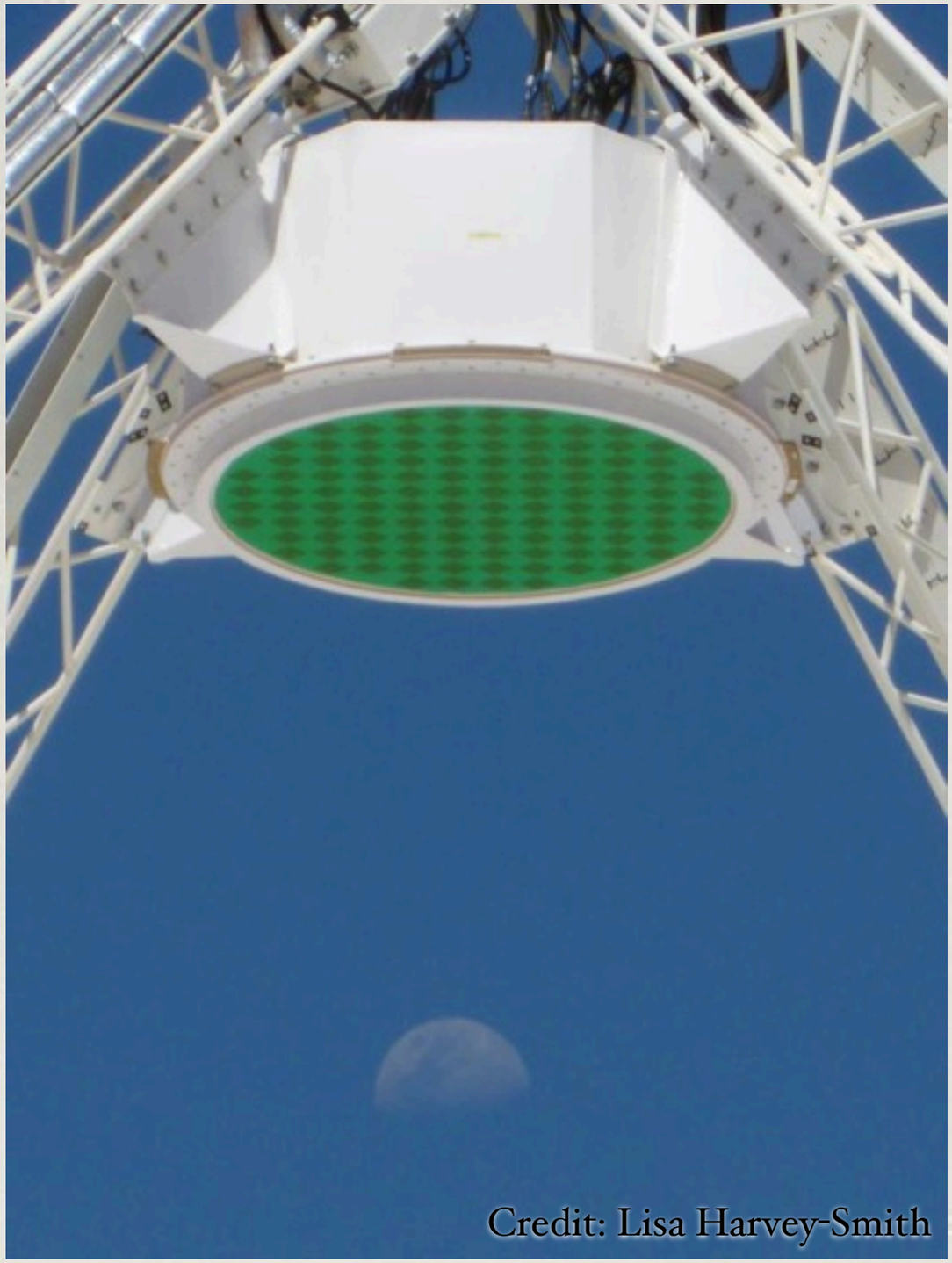


Geraldton

Gazetted towns: 0

Population: "up to 160"

ASKAP PAF



Credit: Lisa Harvey-Smith

Credit: Lisa Harvey-Smith

ASKAP surveys

- *EMU - radio continuum survey*
- *WALLABY - HI "all-sky" survey*
- *POSSUM - polarisation survey*
- *DINGO - deep HI survey, covering the GAMA regions*
- *VAST - variable/transient survey*
- *FLASH - HI absorption survey*

ASKAP surv

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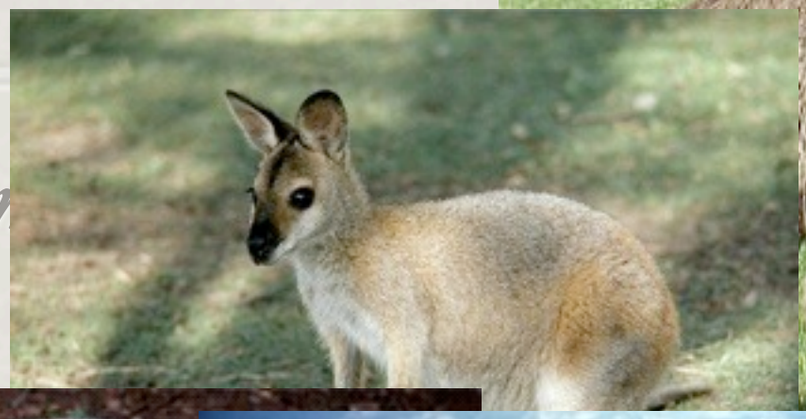

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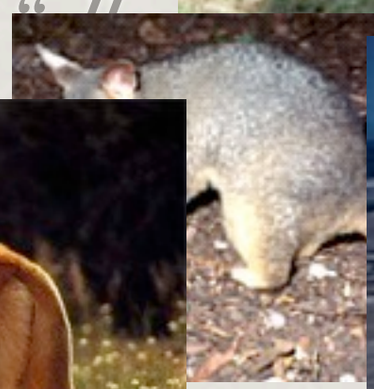

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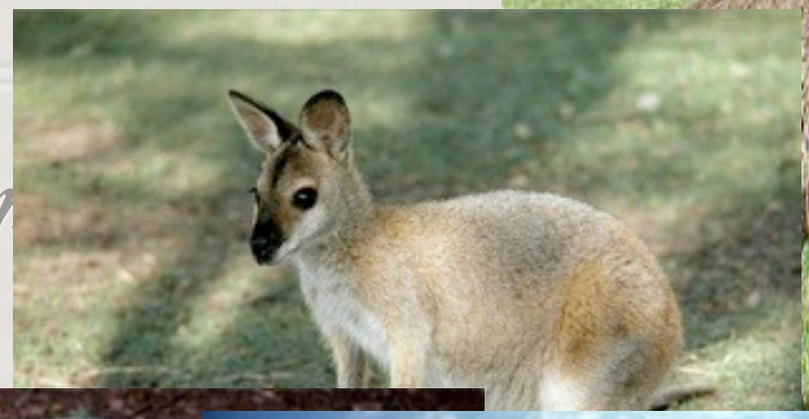
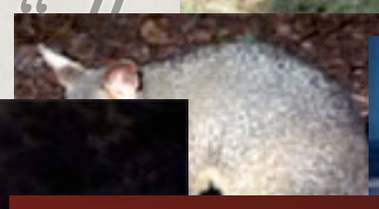


- *WALLABY - HI "*



- *POS*

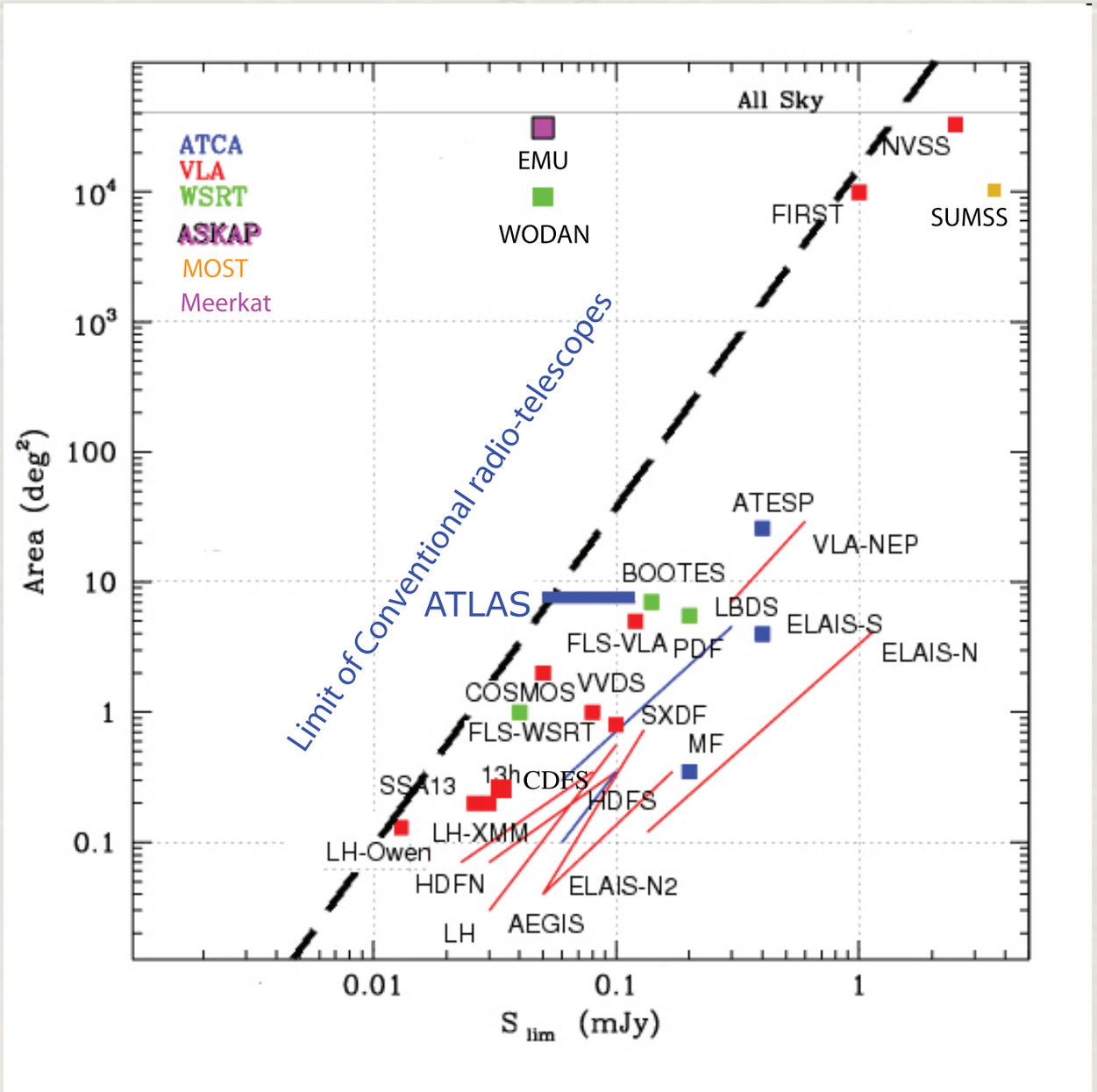
- *DIN*
- *VAST - variable/t*

- *FLASH - HI abso*

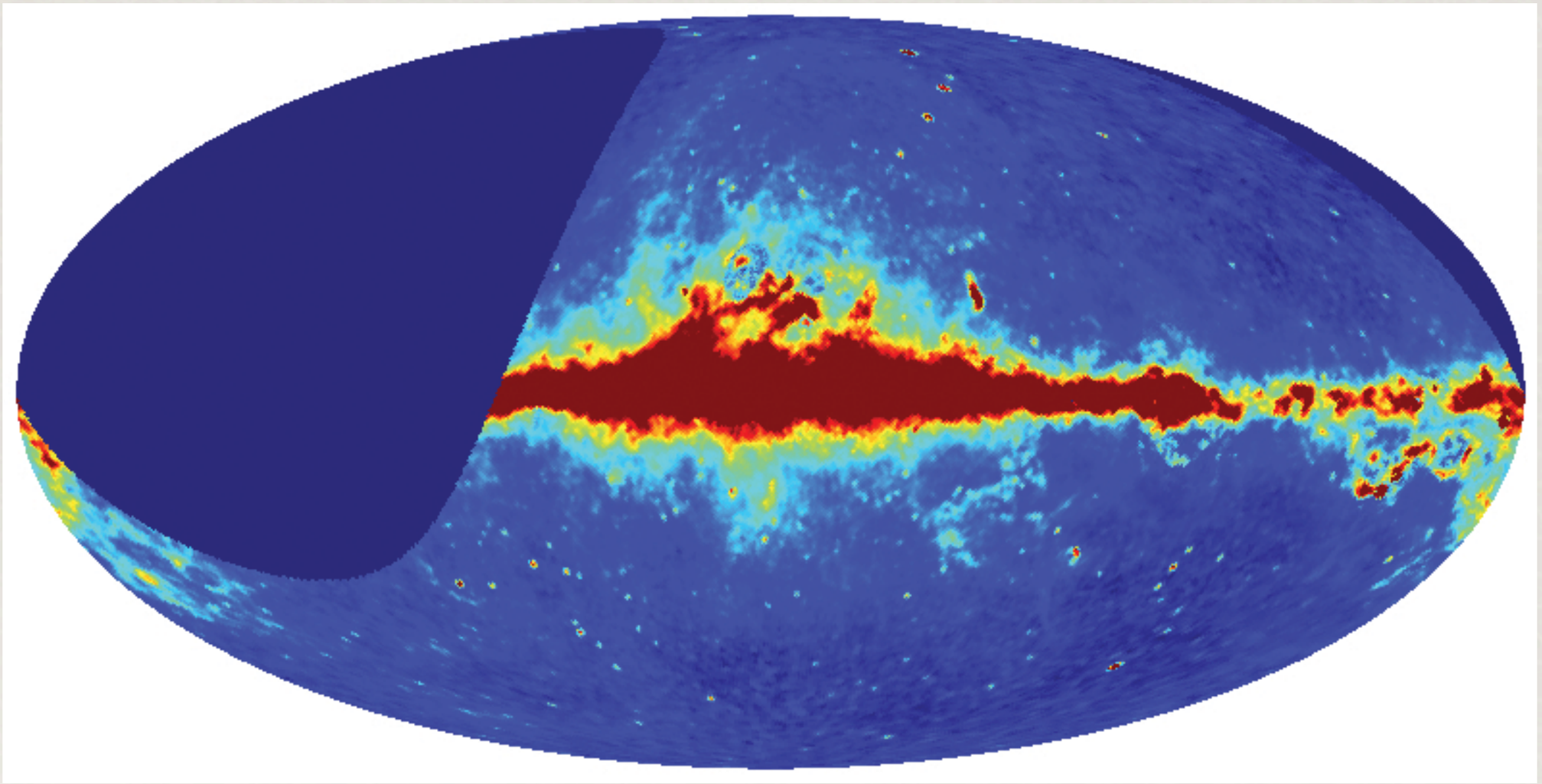
EMU Survey

- *All sky south of +30° declination*
- *Synthesized beam width: 10" FWHM*
- *Frequency range: 1100-1400 MHz*
- *RMS noise: 10 μJy*
- *Total integration time: ~1.5 yrs (12 hr per field)*
- *~70 million sources*

EMU Survey


All Sky
ATCA
VLA
WSRT
ASKAP
MOST
Meerkat
EMU
WODAN
NVSS
FIRST
SUMSS
Limit of Conventional radio-telescopes
ATESP
VLA-NEP
BOOTES
ATLAS
LBDS
ELAIS-S
FLS-VLA
PDF
ELAIS-N
COSMOS
VVDS
SXDF
FLS-WSRT
MF
13h
CDFS
SSA13
HDFS
LH-XMM
LH-Owen
HDFN
ELAIS-N2
LH
AEGIS
10^4
10^3
100
10
1
0.1
Area (deg^2)
0.01
0.1
1
S_{lim} (mJy)

EMU Survey



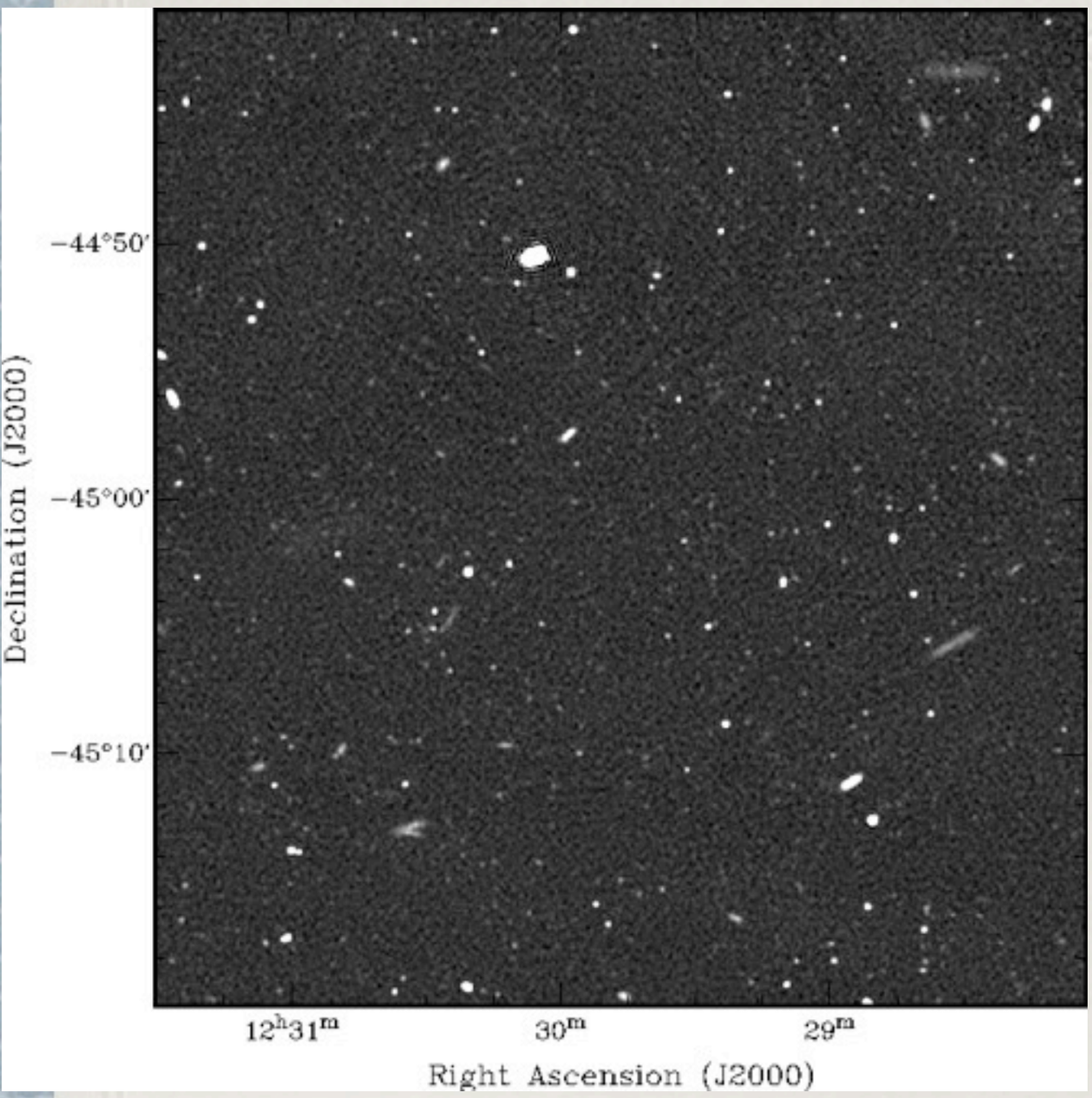
EMU team

- ***Project leader: Ray Norris***
- ***Project scientists:***
  - ***Andrew Hopkins***
  - ***Nick Seymour***

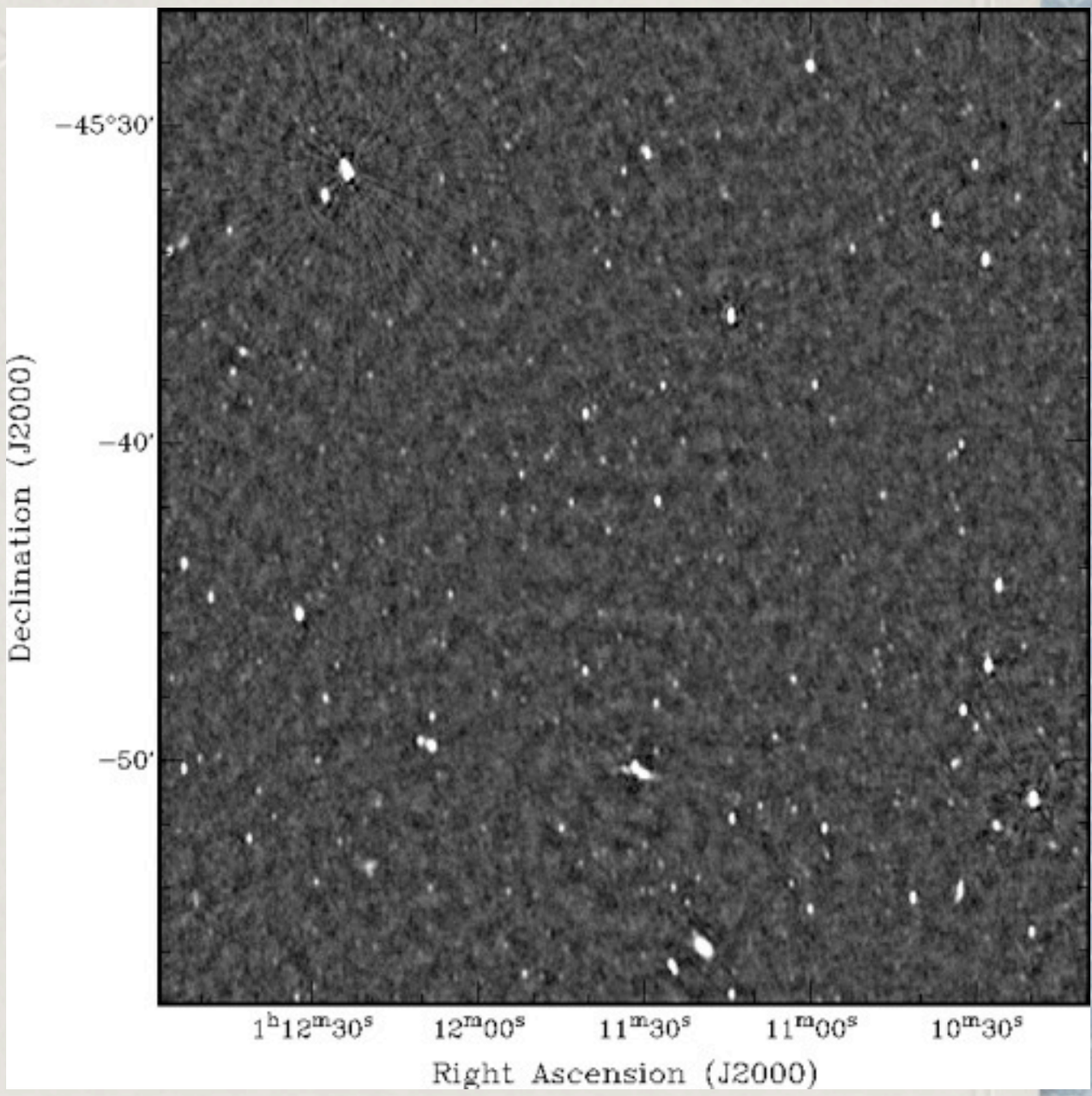
- *>220 members from 17 countries*
- *Split into ~15 working groups*
- *Cross-linkages with other major multiwavelength surveys*

- ***Radio***
  - *LOFAR*
  - *WSRT+Apertif / WODAN*
  - *NVSS*
  - *SUMSS*
  - *MWA*
  - *ATLAS*
  - *SPT*
  - *GMRT*
- ***Optical/IR***
  - *SDSS*
  - *LSST*
  - *Pan-STARRS*
  - *2MASS*
  - *HLA*
  - *VISTA/VIKING/VHS/VIDEO*
  - *GAMA*
  - *VST/KIDS*
  - *UKIDSS*
  - *Herschel ATLAS/HERMES*
  - *WISE*
  - *SkyMapper*
  - *TAIPAN*

ASKAP vs PDS



ASKAP Simulation



Phoenix Deep Survey

EMU Science

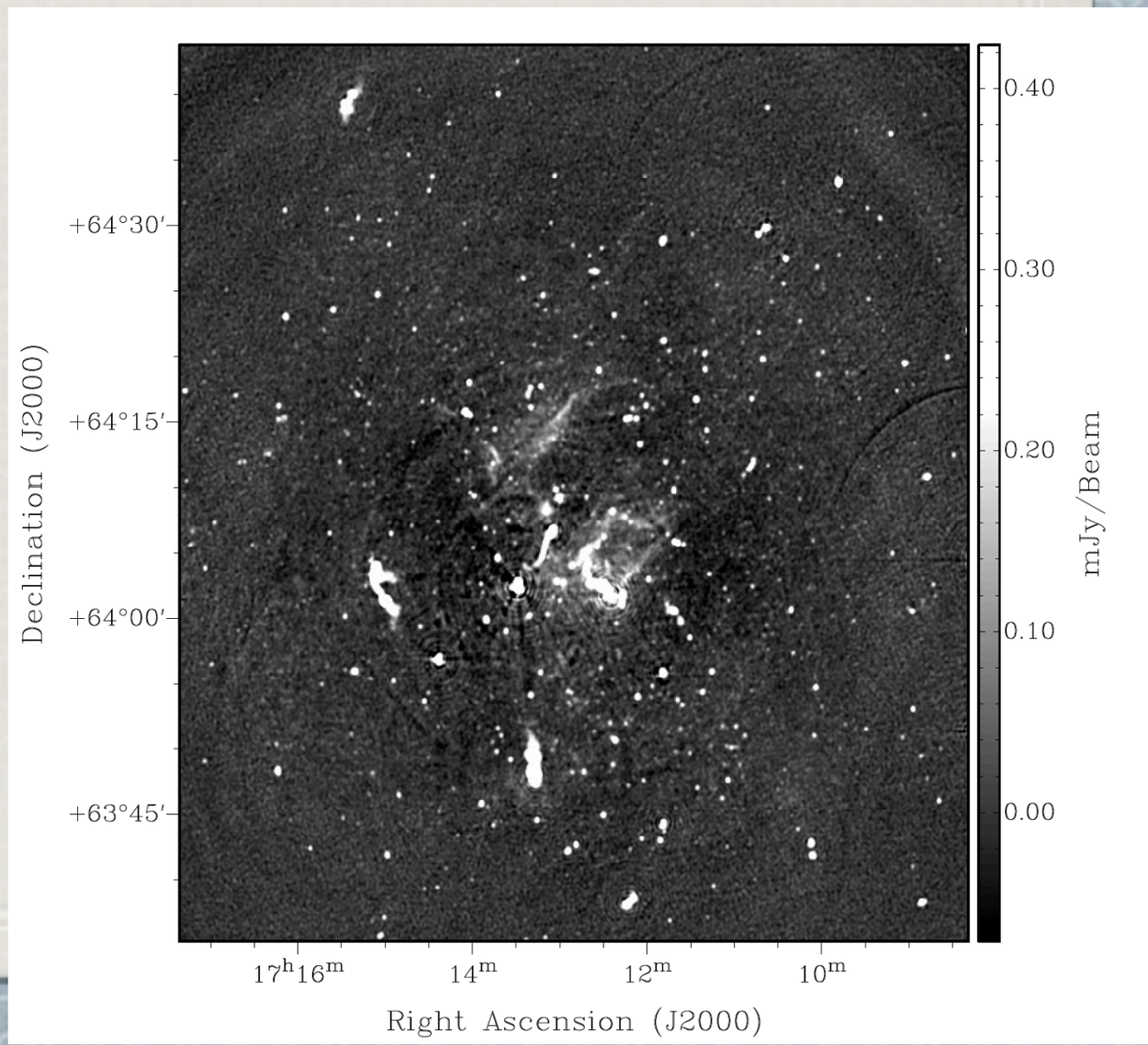
- *How did galaxies form and evolve?*

EMU Science

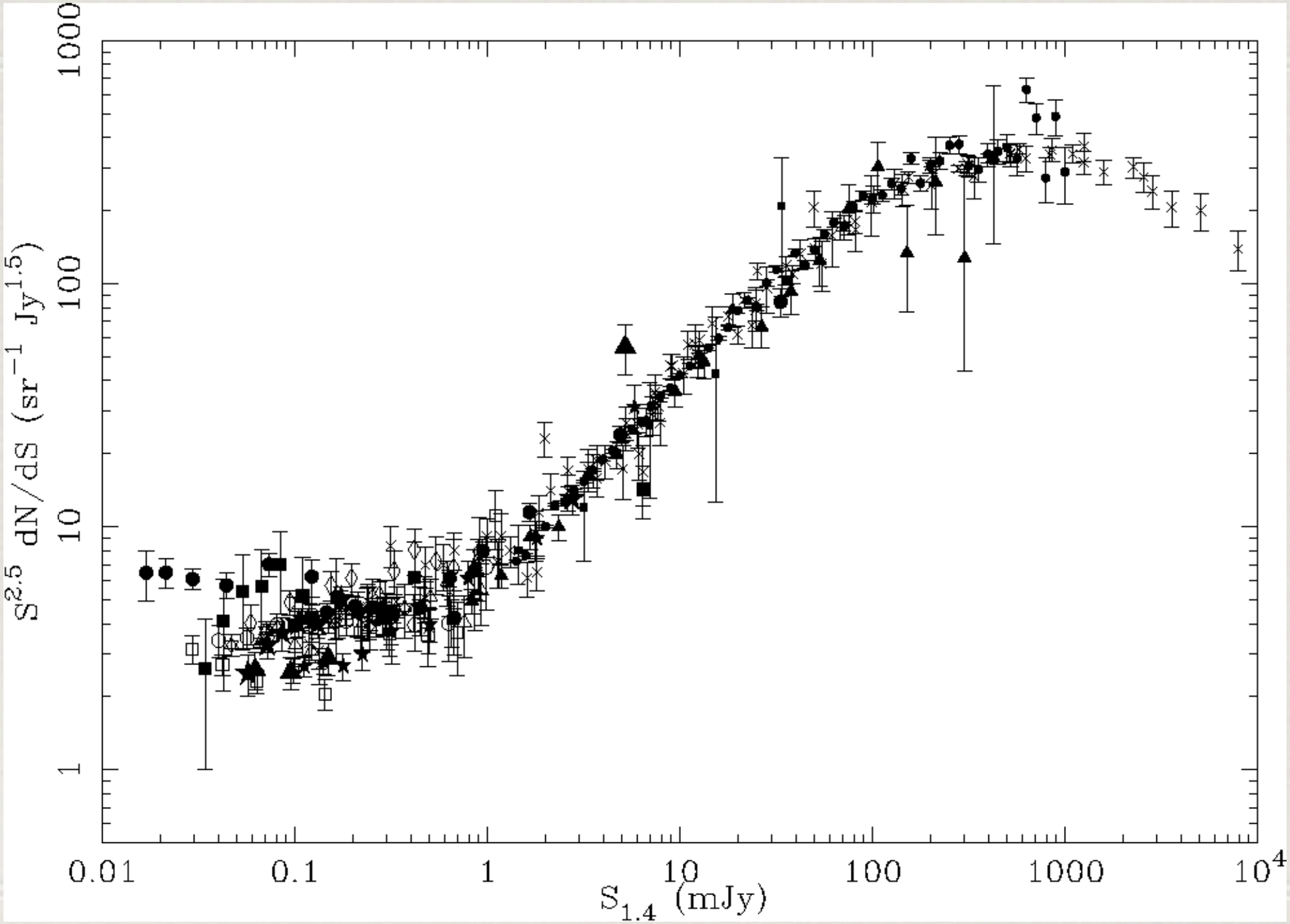
- *How did galaxies form and evolve?*
  - *Evolution of star formation over the past 10 Gyr (z<2)*
    - *using a wavelength unbiased by dust or molecular emission*
  - *Evolution of massive black holes*
    - *and understanding their relationship to star formation*
  - *Explore the large scale structure and cosmological parameters of the universe*
    - *including an independent measure of dark energy evolution*
  - *Explore an uncharted region of observational parameter space*
    - *almost certainly finding new classes of object*

Additional goals

- *Explore diffuse low surface brightness objects*
- *Generate an atlas of the Galactic Plane*
  - *star formation*
  - *supernovae*
  - *pulsars*
  - *Galactic structure*
- *Legacy value*
  - *Herschel*
  - *JWST*
  - *ALMA*
  - *ESO public surveys*



1.4GHz Source Counts



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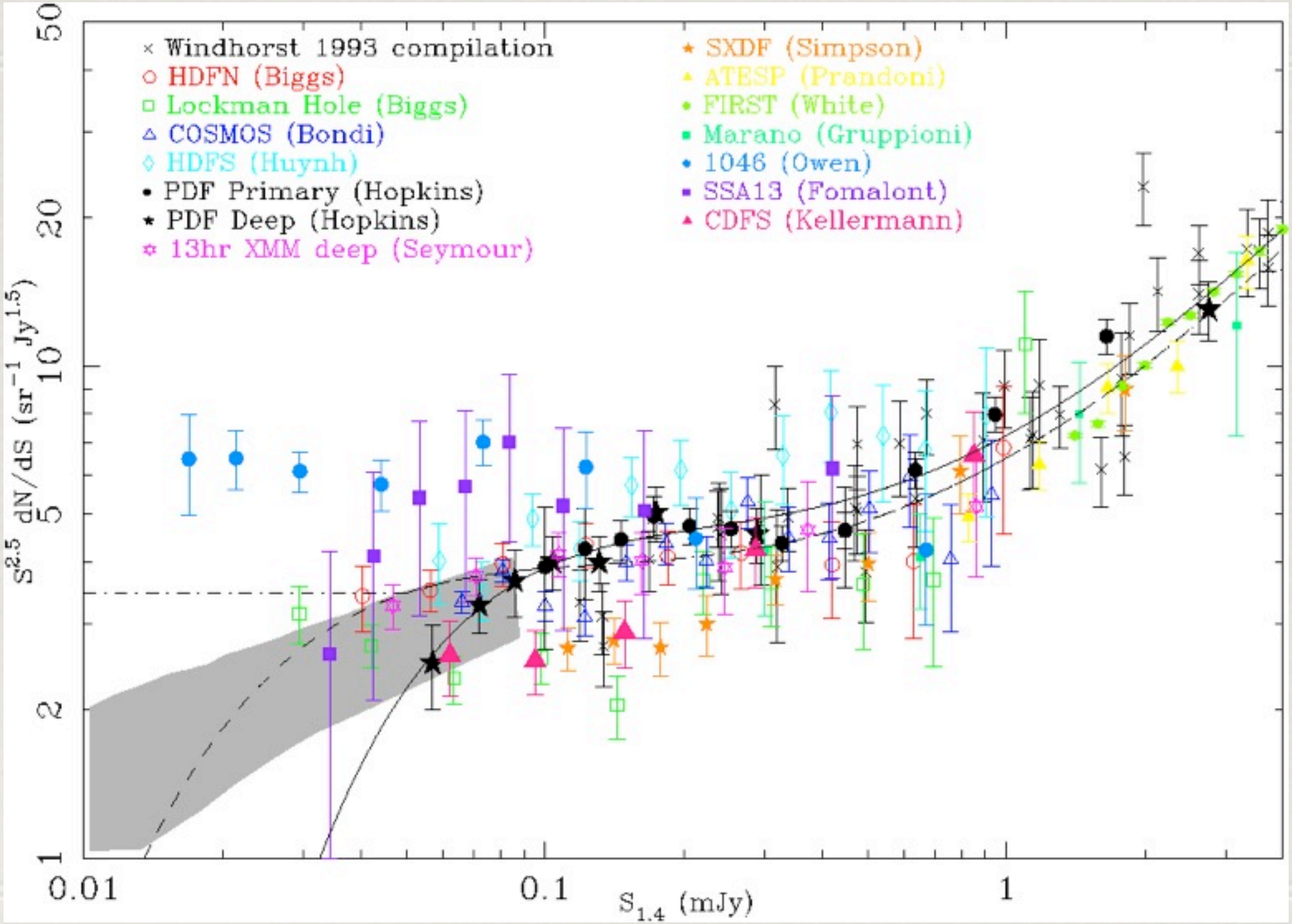

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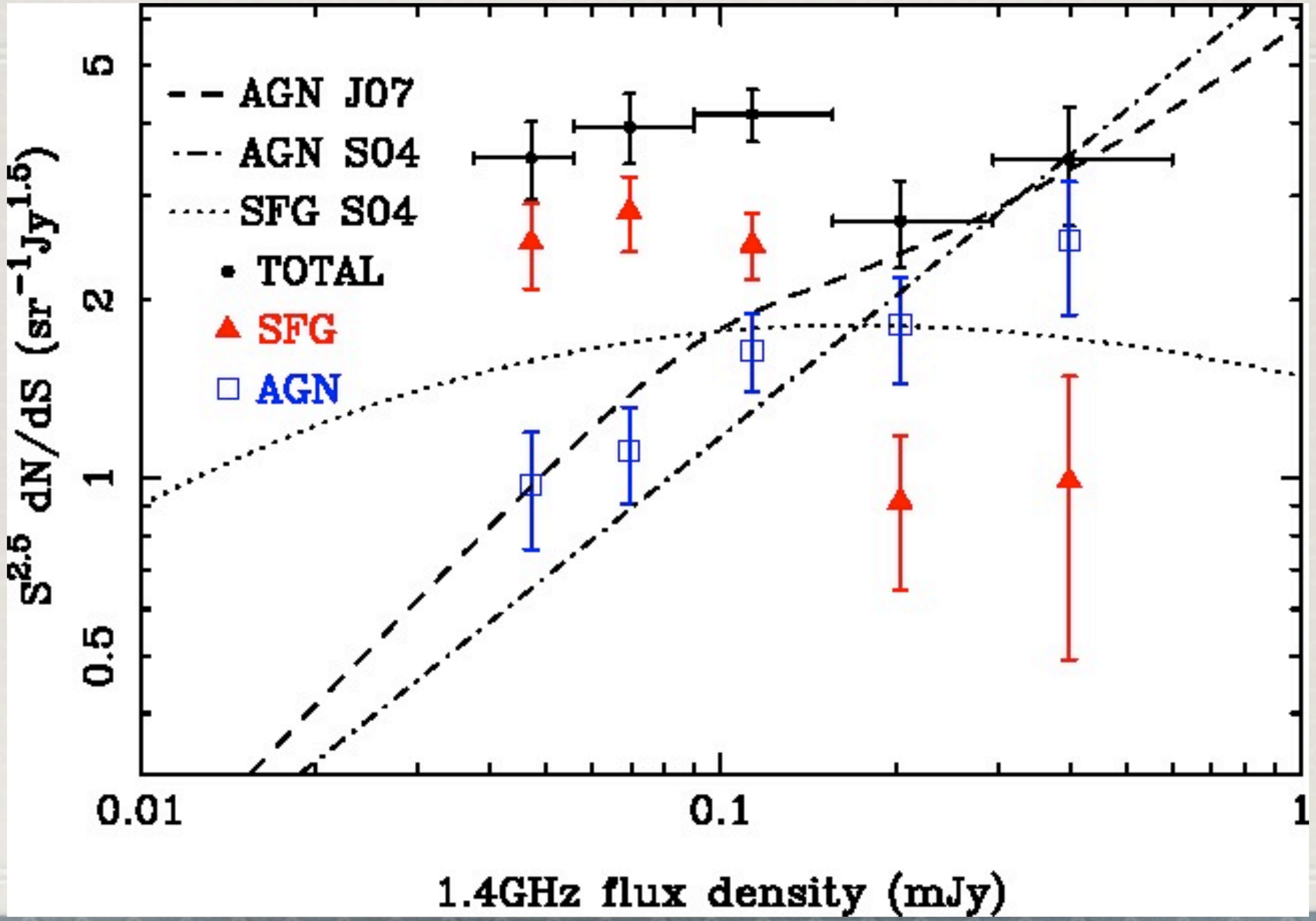

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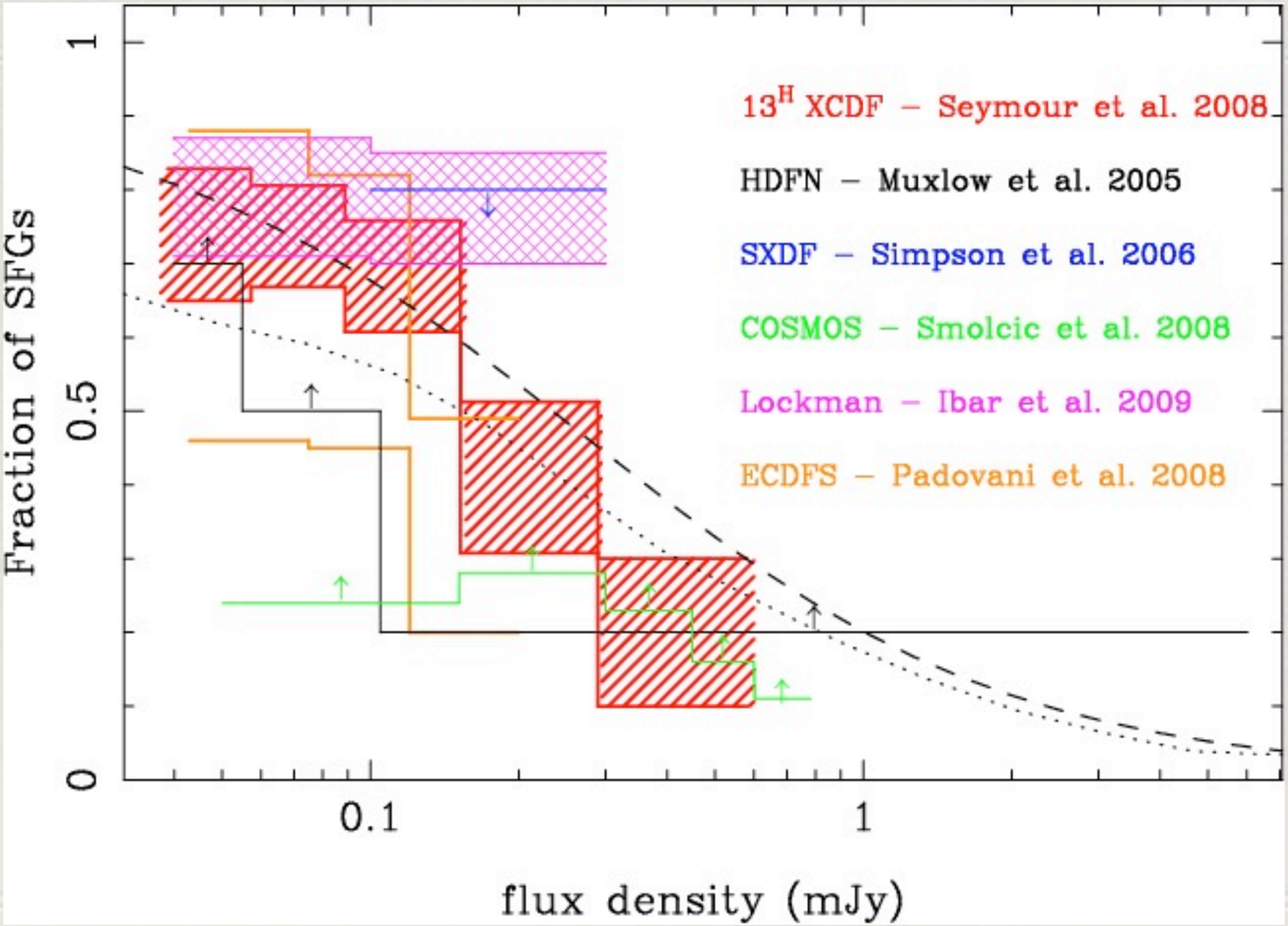
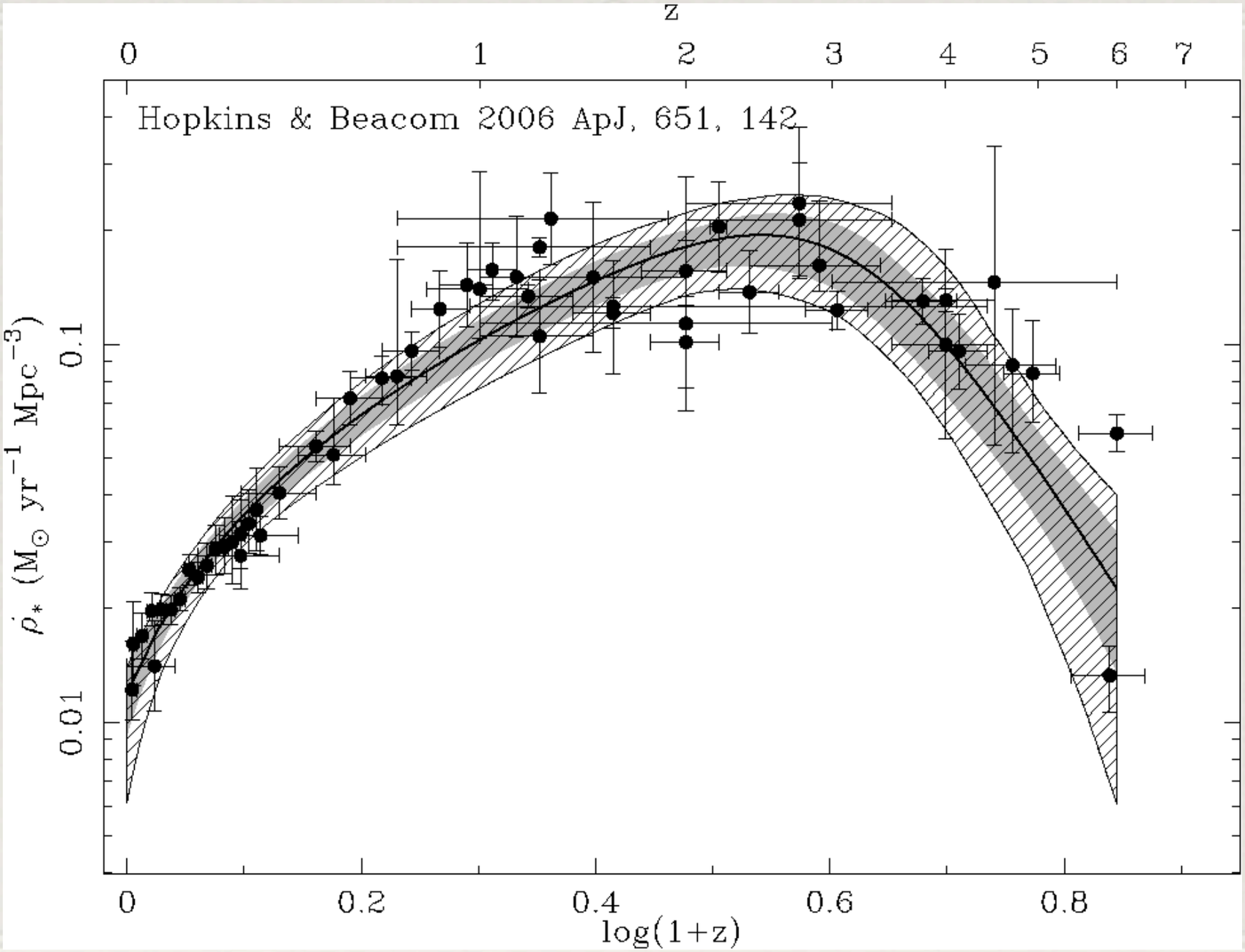


Evolution of Star Formation

- *To trace the evolution of the dominant star forming galaxies from z=5 to the present day*

- *EMU will detect ~45 million SF galaxies*
- *Milky Way type galaxies to z~0.3*
- *M82 types to z~1*
- *Arp 220 types to z~2*

Evolution of Star Formation



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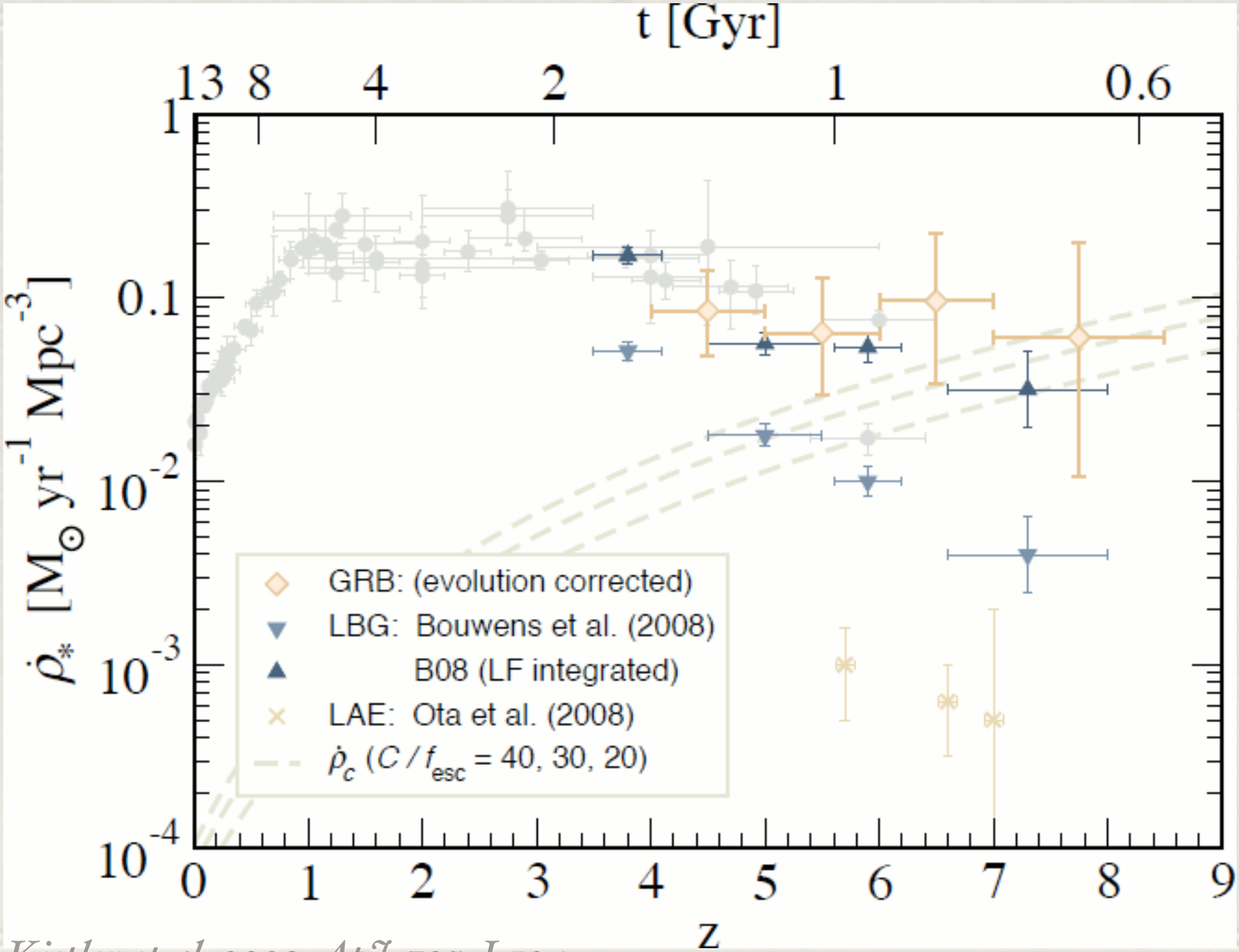
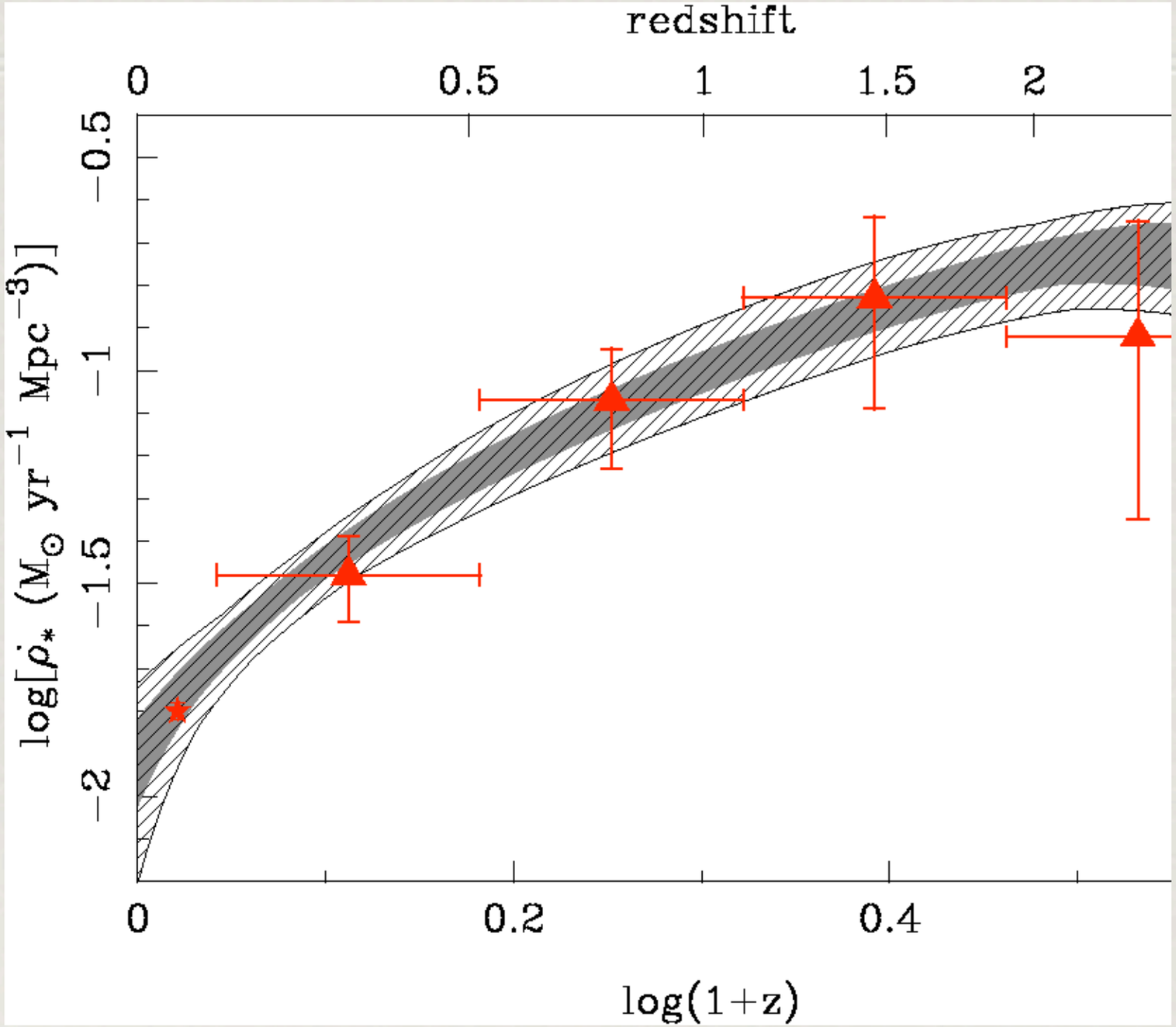


Kistler et al, 2009, ApJ, 705, L104

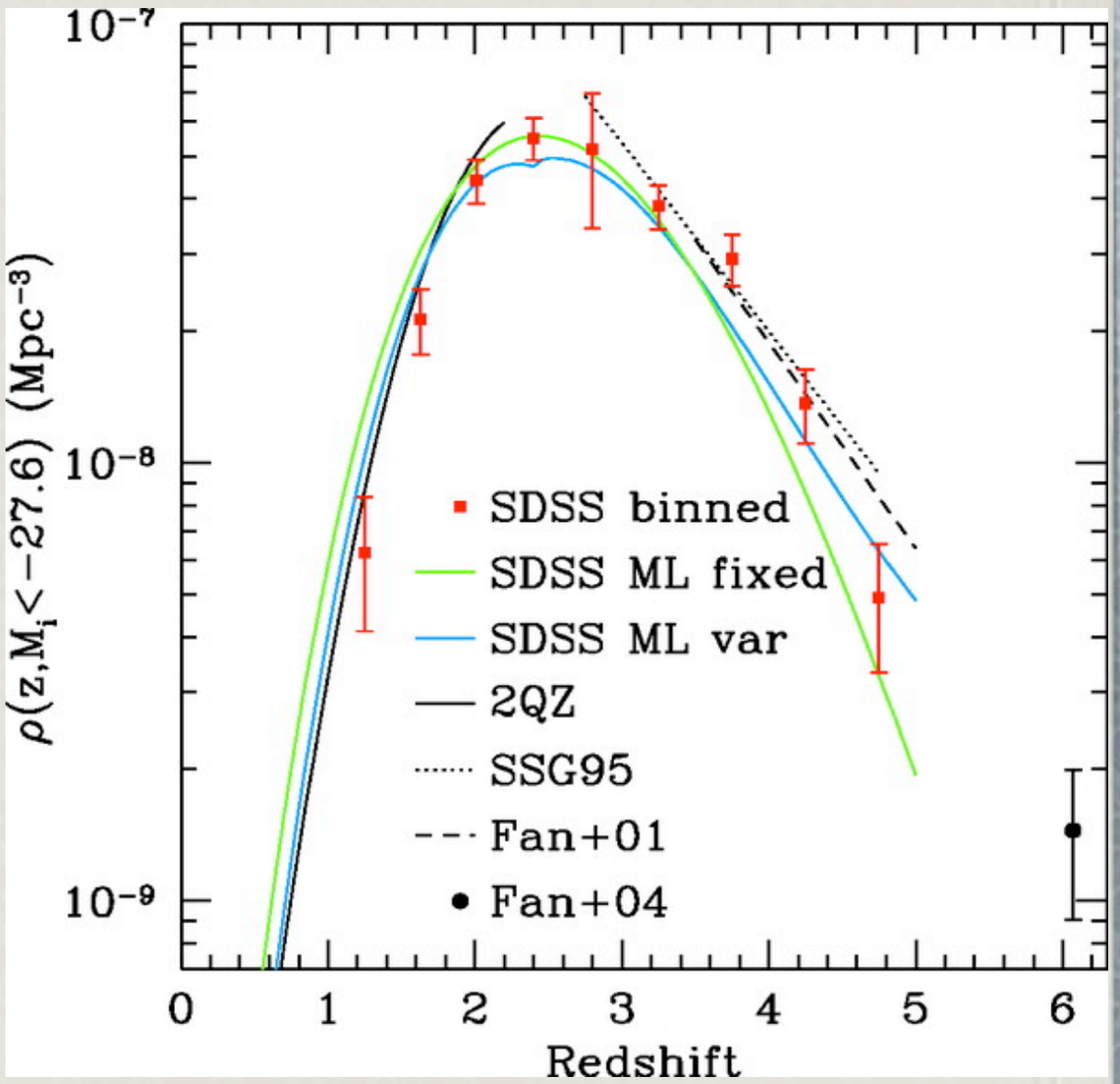
Evolution of Star Formation



Seymour et al, 2008, MNRAS, 386, 1695

Evolution of AGN

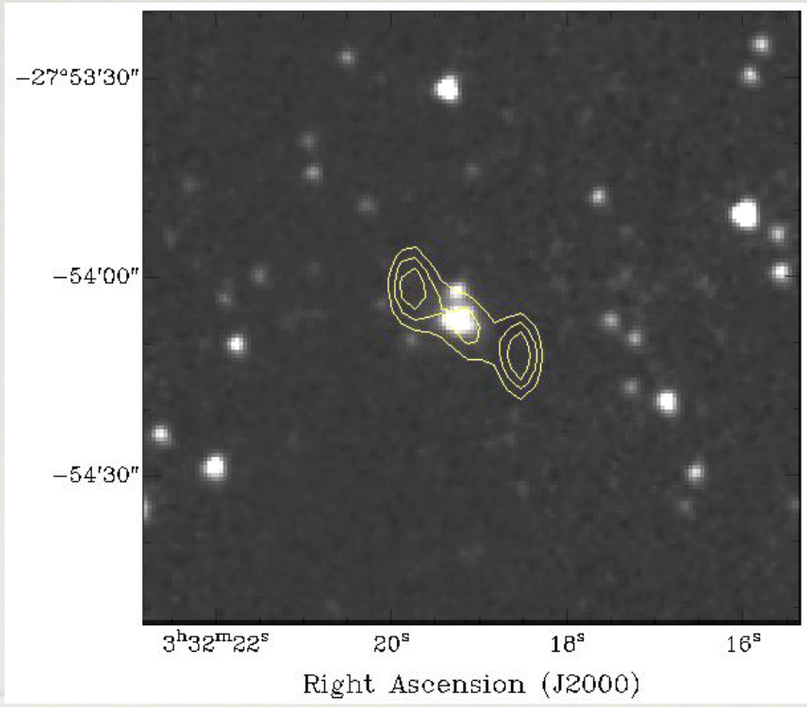
- *Compare the number of different types of radio AGN as a function of cosmic time (FRI vs FRII, radio-quiet QSO vs radio-loud, etc)*
- *Look for connections between star formation rate and numbers of AGN*

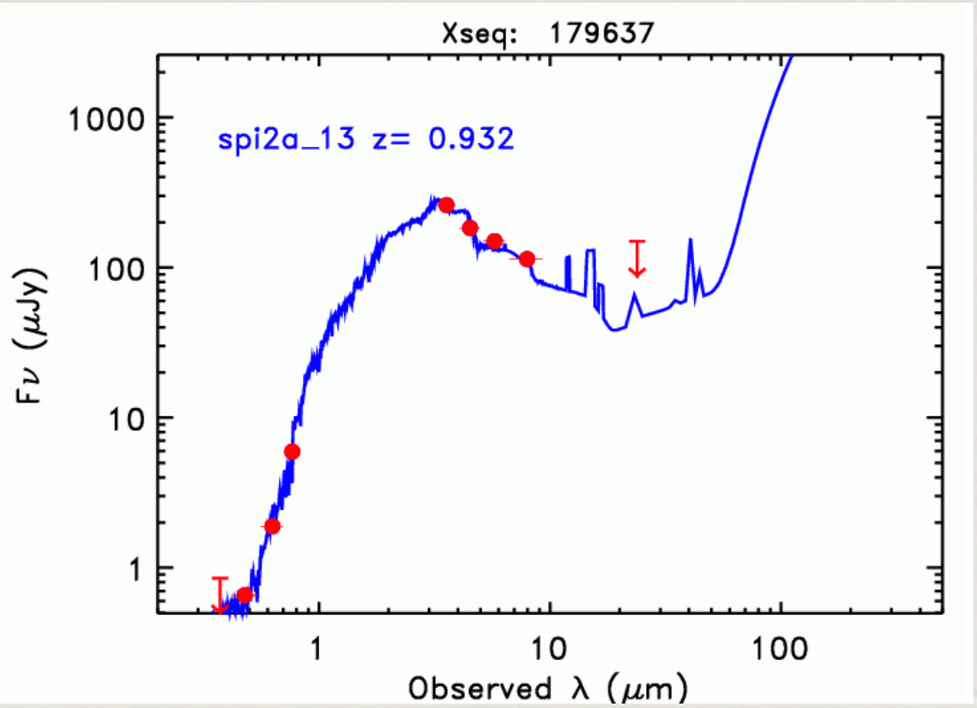


Richards et al, 2006, AJ, 131, 2766

Evolution of AGN

- *EMU will detect about 25 million AGN*
  - *High-z AGN*
  - *Composite AGN/SF galaxies*
  - *Galaxies in a brief transition phase from quasar-mode to radio-mode accretion*





Norris et al, 2008, arXiv:0804.3998; Mao et al, 2010, MNRAS, 406, 2578

4MOST and EMU

- *20 million extragalactic redshifts to r<22 is a good start.*

- *Perhaps 50% of these will be EMU counterparts (based on existing spectroscopy of similarly deep radio surveys).*

- *4MOST can increase spectroscopic completeness of EMU from 1% to ~10%.*

4MOST and others

- *SKA Phase 1 will be built (maybe) by 2019, so well-matched in time to 4MOST.*
- *LSST will be operational around the same time.*
- *SKA Phase 1 will be an order of magnitude larger in terms of survey sizes, than ASKAP and other pathfinders.*
- *Even with 4MOST we will still not be keeping up with the demand for spectroscopic redshifts.*

TAIPAN

- *Transforming Astronomical Imaging-surveys through Polychromatic Analysis of Nebulae*
- *Survey with the UK Schmidt Telescope at Siding Spring, following in the footsteps of the 6dF Galaxy Survey (Jones et al., 2004, 2009)*
- *All southern sky multi-object spectroscopic survey, ~0.5 million galaxies, r<~17 (but NIR selected, as with 6dFGS), 3-5 yr survey starting in ~2015.*
- *10-12 December, workshop in Sydney:* **http://physics.mq.edu.au/astronomy/workshop_2012**

MACQUARIE UNIVERSITY
ASTRONOMY, ASTROPHYSICS AND ASTROPHOTONICS RESEARCH CENTRE

The next generation of hemispheric redshift surveys and the prospects for TAIPAN

10-12 Dec 2012, Sydney, Australia

SOC

Prof. Quentin Parker (Chair, MQ/AAO)
Prof. Andrew Hopkins (Co-Chair, AAO)
Prof. Lisa Kewley (ANU)
Prof. John Peacock (Univ. Edinburgo)
Dr. Heath Jones (Monash)
Prof. Bryan Gaensler (Univ. Sydney)

LOC

Prof. Quentin Parker (MQ/AAO)
Dr. Lee Spitler (MQ/AAO)
Dr. Michelle Cluver (AAO)
Dr. Maritza A. Lara-Lopez (AAO)
Dr. Borja Anguiano (MQ)
Travis Stenborg (MQ)
Amanda Manypeny (MQ)

Invited Speakers

Joss Bland-Hawthorn
Simon Driver
Lister Stavely-Smith
Baerbel Koribalski
Matthew Colless
Tom Jarrett
Jon Lawrence
Fred Watson
Florian Beutler
Ray Norris

Major topics: Synergies with ASKAP galaxy surveys, precision cosmology, galaxy evolution, the connection between gas and stars, the impact of environment and mergers, large scale structure, stellar and halo mass functions, star formation and AGN, and the intergalactic magnetic field.

http://physics.mq.edu.au/astronomy/workshop_2012

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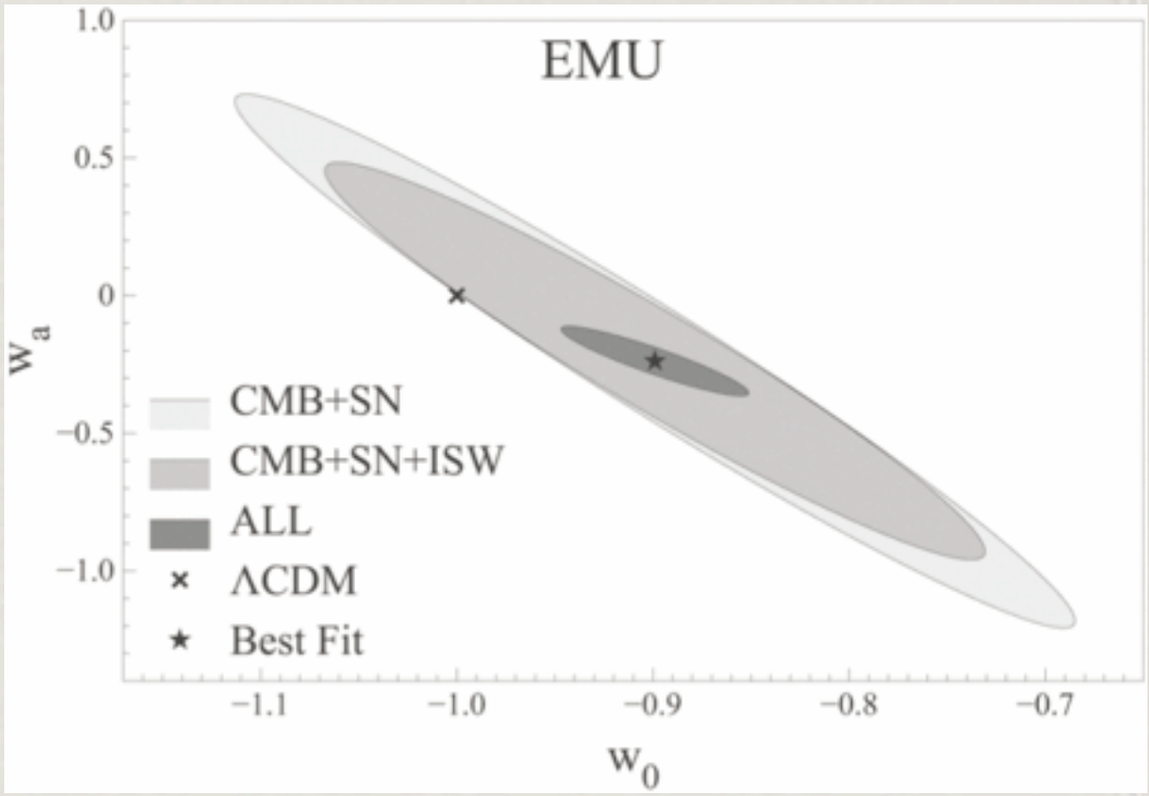
AAO
CSIRO
CAASTRO ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

EMU: http://askap.pbwiki.com/

EMU Cosmology

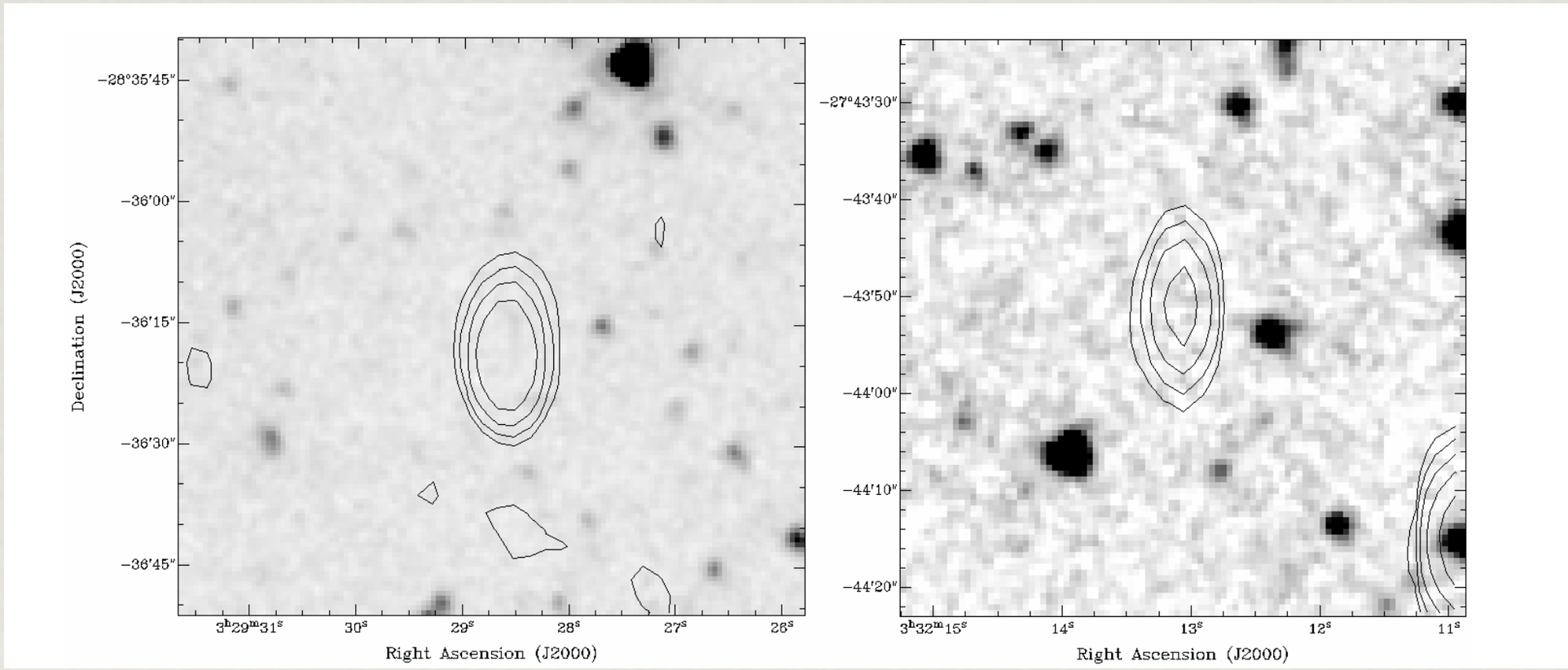
- *Uses the distribution of radio sources to measure the large scale structure and cosmological parameters of the universe*
- *ISW effect, cosmic magnetism, modified gravity*



Norris et al., 2011, PASA, 28, 215

Opening up parameter space

- *New classes of object, such as IFRSs*



E.g., Huynh et al, 2010, ApJ, 710, 698

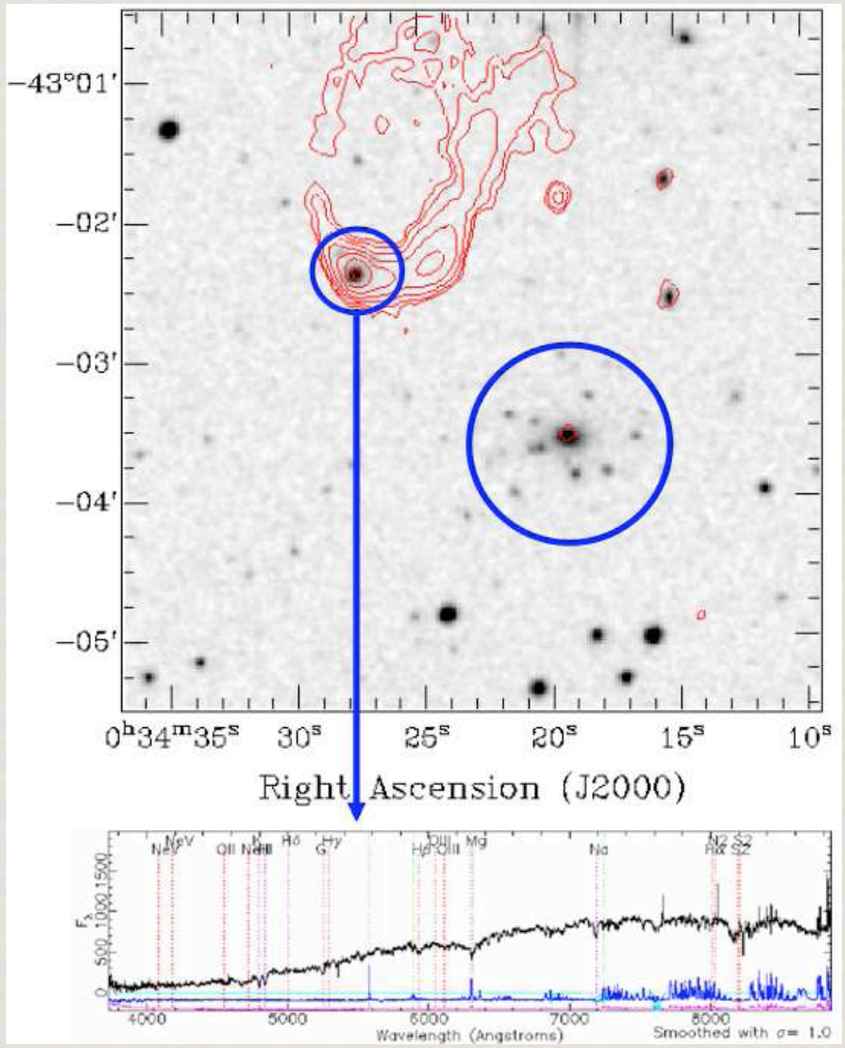
Diffuse structures

- *Determine luminosity function of relics and shocks, and how this evolves with redshift*

- *How do bent radio sources depend on environment, and can we use them to detect clustering at high redshift?*

- *How common are low luminosity radio galaxies?*

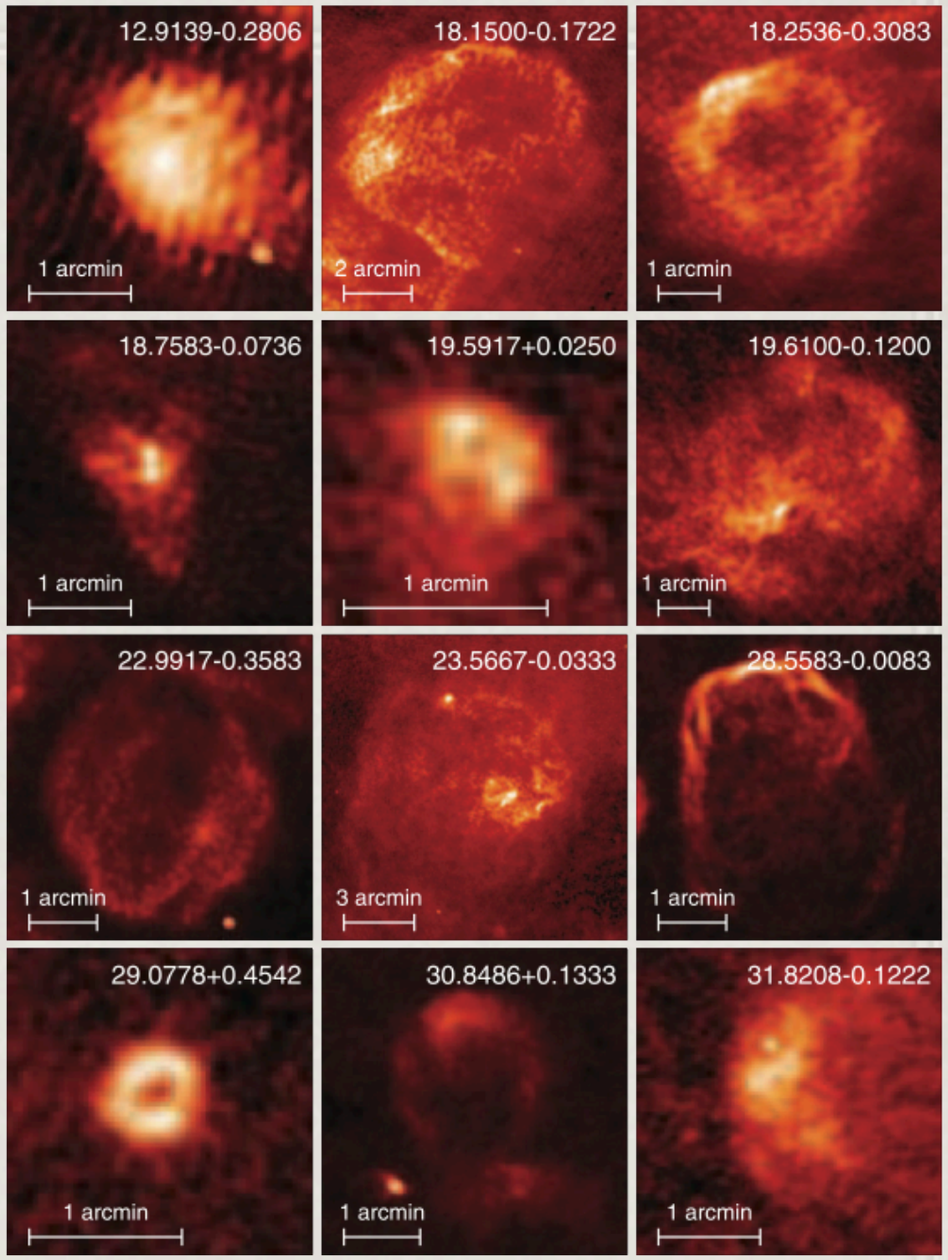
- *Do diffuse structures end at z~1 because of inverse Compton cooling? If not, why not?*



Mao et al, 2010, MNRAS, 406, 2578

The Galactic Plane

- *Deeper and higher resolution than existing surveys*
  - *CGPS: arcmin, few mJy, 73° of northern plane*
  - *SGPS: arcmin, 35 mJy, most of southern plane*
  - *MAGPIS: 6", 1-2 mJy, 27° of northern plane*
  - *EMU: 10", 50 μJy, most of plane (all when combined with WODAN/APERTIF)*
- *Complete census of:*
  - *All phases of HII region evolution*
  - *Most compact and youngest supernova remnants*
  - *Radio emitting PNe, to constrain Galactic density and formation rate*



Helfand et al, 2006, AJ, 131, 2525