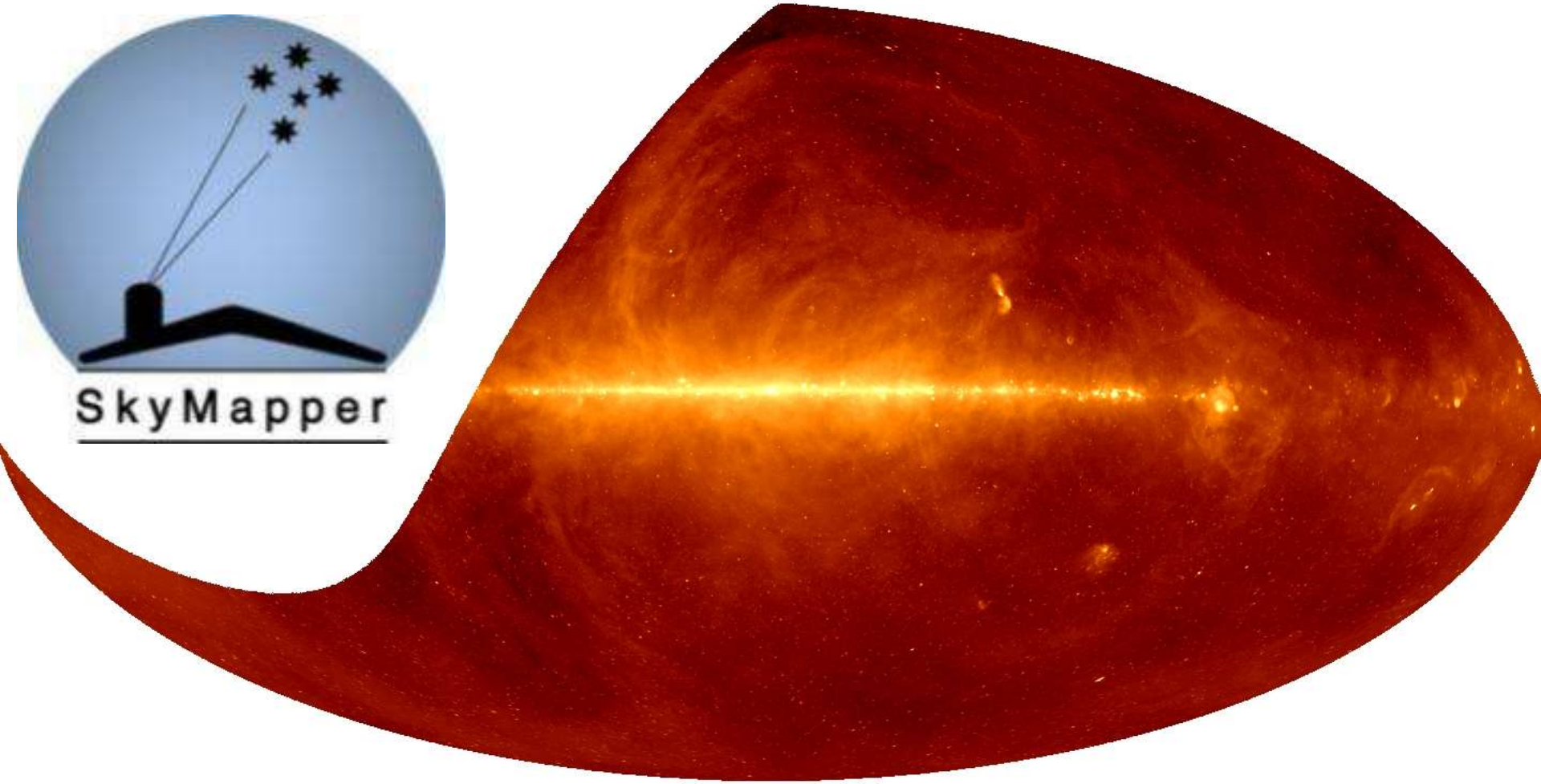


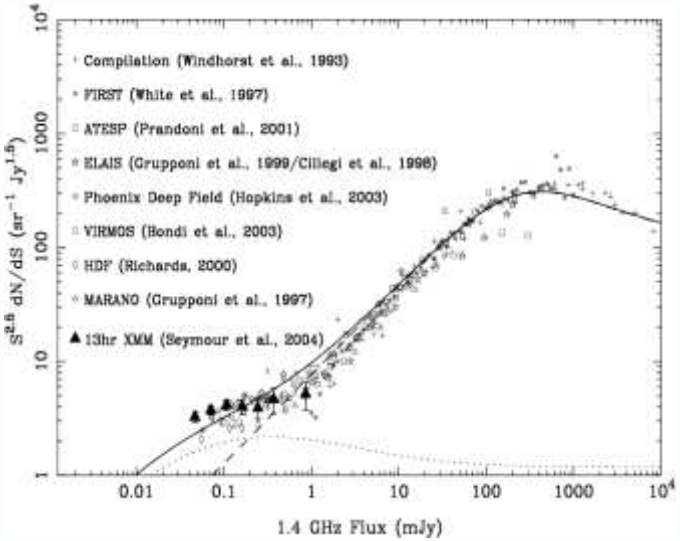
# ASKAP-EMU & Skymapper SYNERGY

CSIRO ASTRONOMY & SPACE SCIENCE
www.csiro.au

Nick Seymour (CASS) – ANU – 8th April 2014

Image: CHIPASS

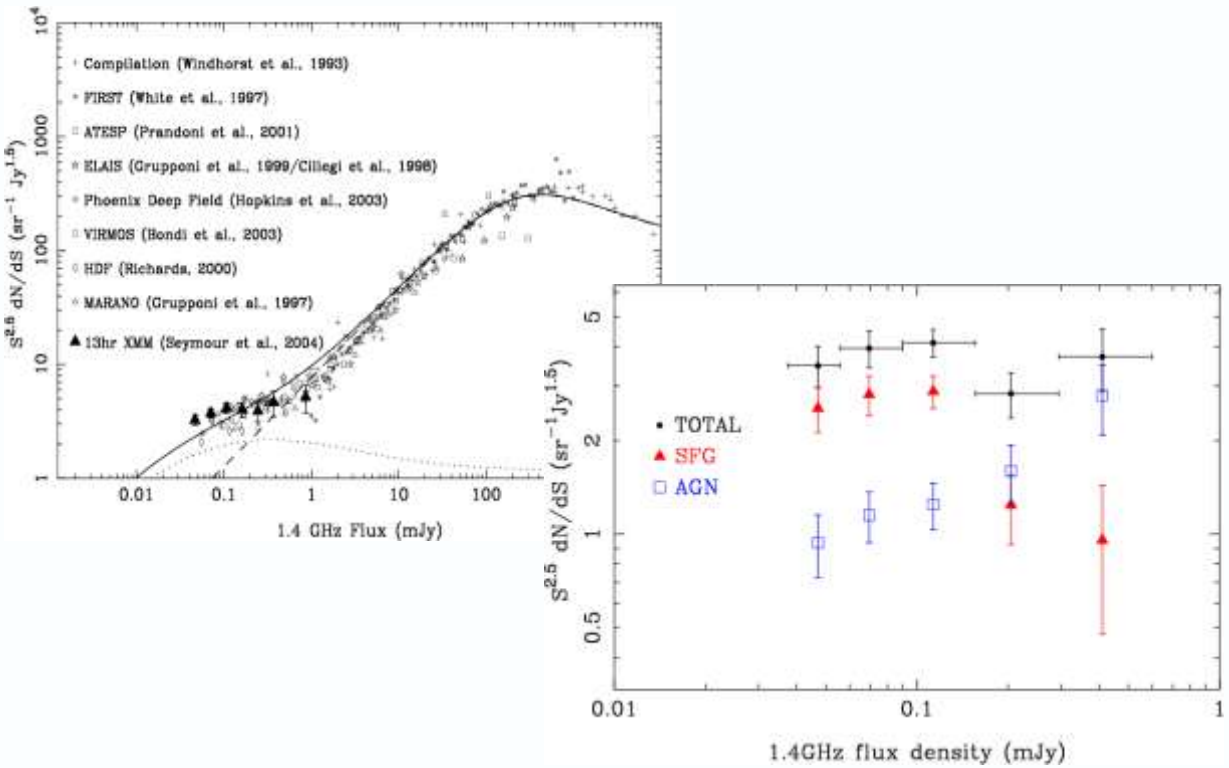
# Motivation: why radio surveys




- separate SFGs/AGN

Seymour et al. (2004)

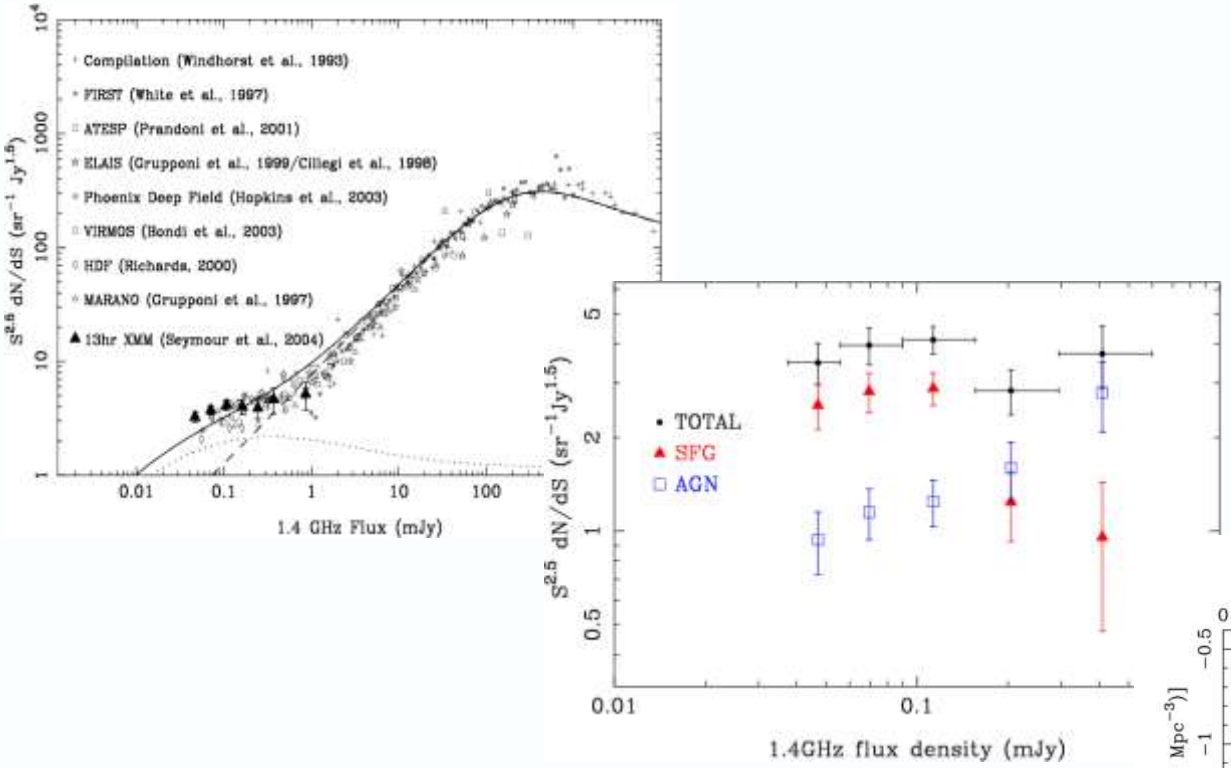
# Motivation: why radio surveys



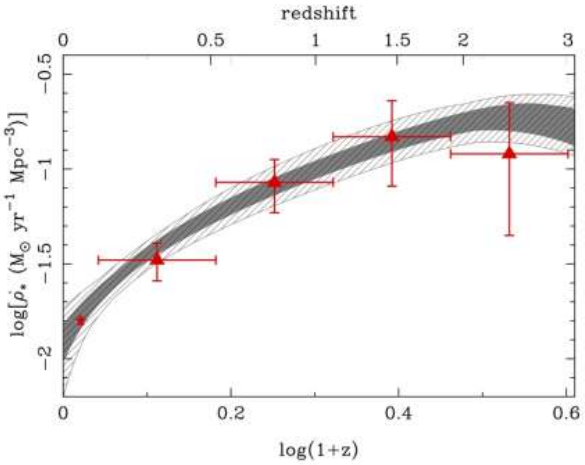

- separate SFGs/AGN
- obtain redshifts

Seymour et al. (2004, 2008)

# Motivation: why radio surveys




- separate SFGs/AGN
- obtain redshifts
- convert radio luminosity to SFRs (k-correction & conversion factor)



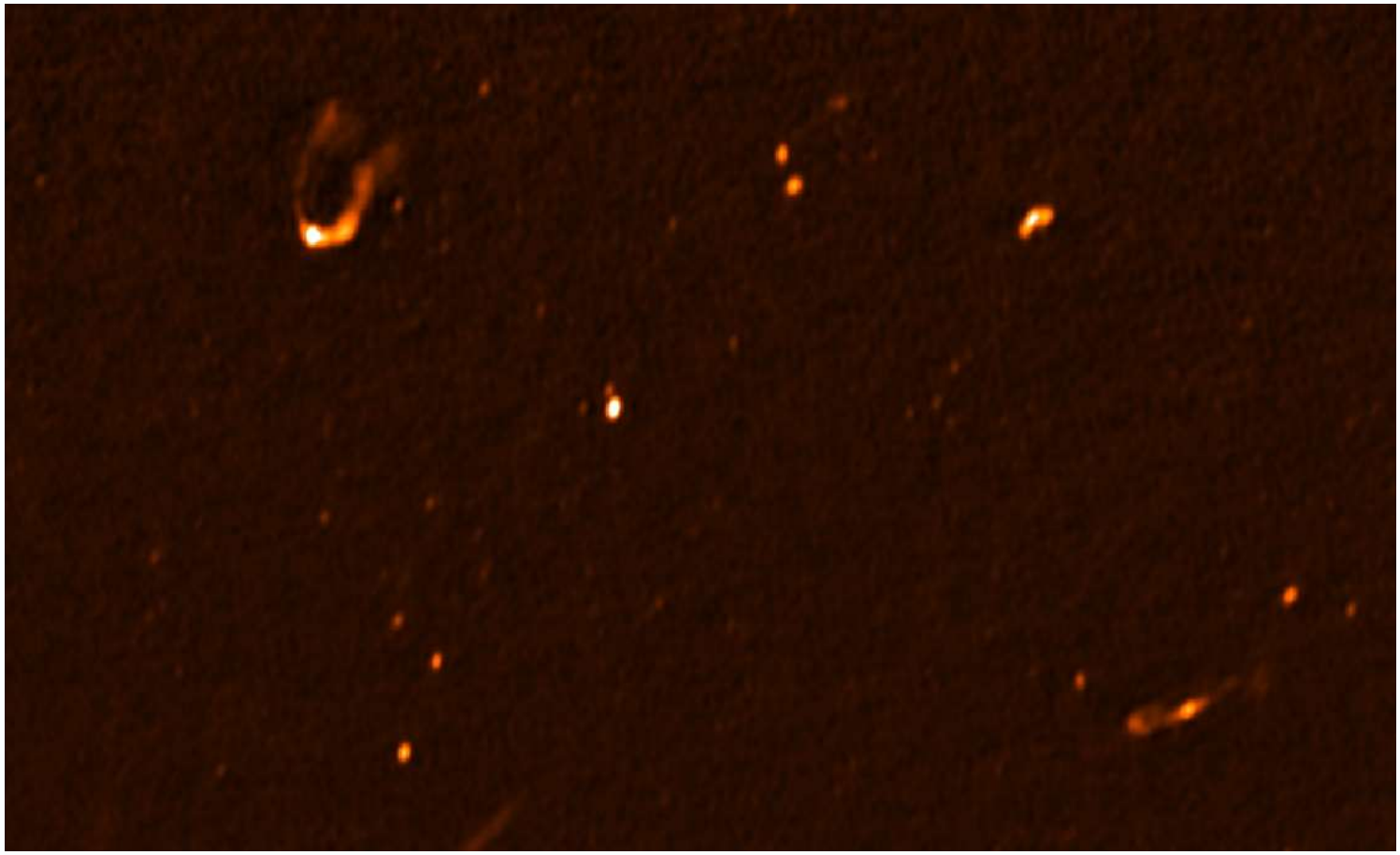

Seymour et al. (2004, 2008)

# ATLAS Survey

- 7deg$^2$
- ~15μJy/beam rms
- Widest 1.4GHz survey at this depth
- ECDFS and ELAIS S1
- Aim: trace build-up of galaxies and black holes across cosmic time
- Huge wealth of ancillary data:
  - *Chandra*/*XMM*/UV(*GALEX*)/optical/VIDEO/SERVS(Spitzer)/PEP+HerMES(*Herschel*)/radio
  - Spec-z's from literature (already compiled)

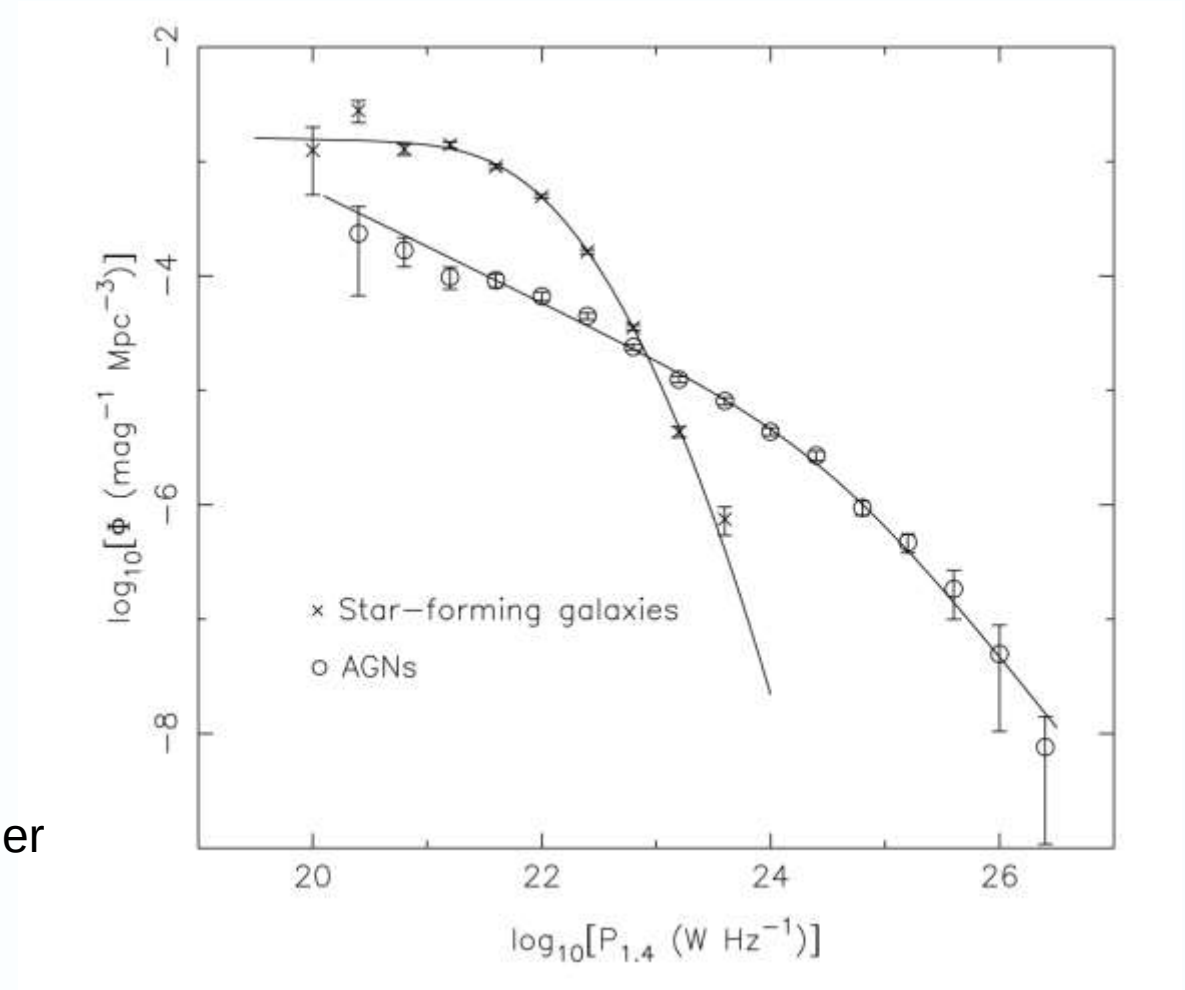
Image: NS

# Australian Telescope Large Area Survey (ATLAS)



Data Release 3: Banfield et al. (2014), Franzen et al. (2014)

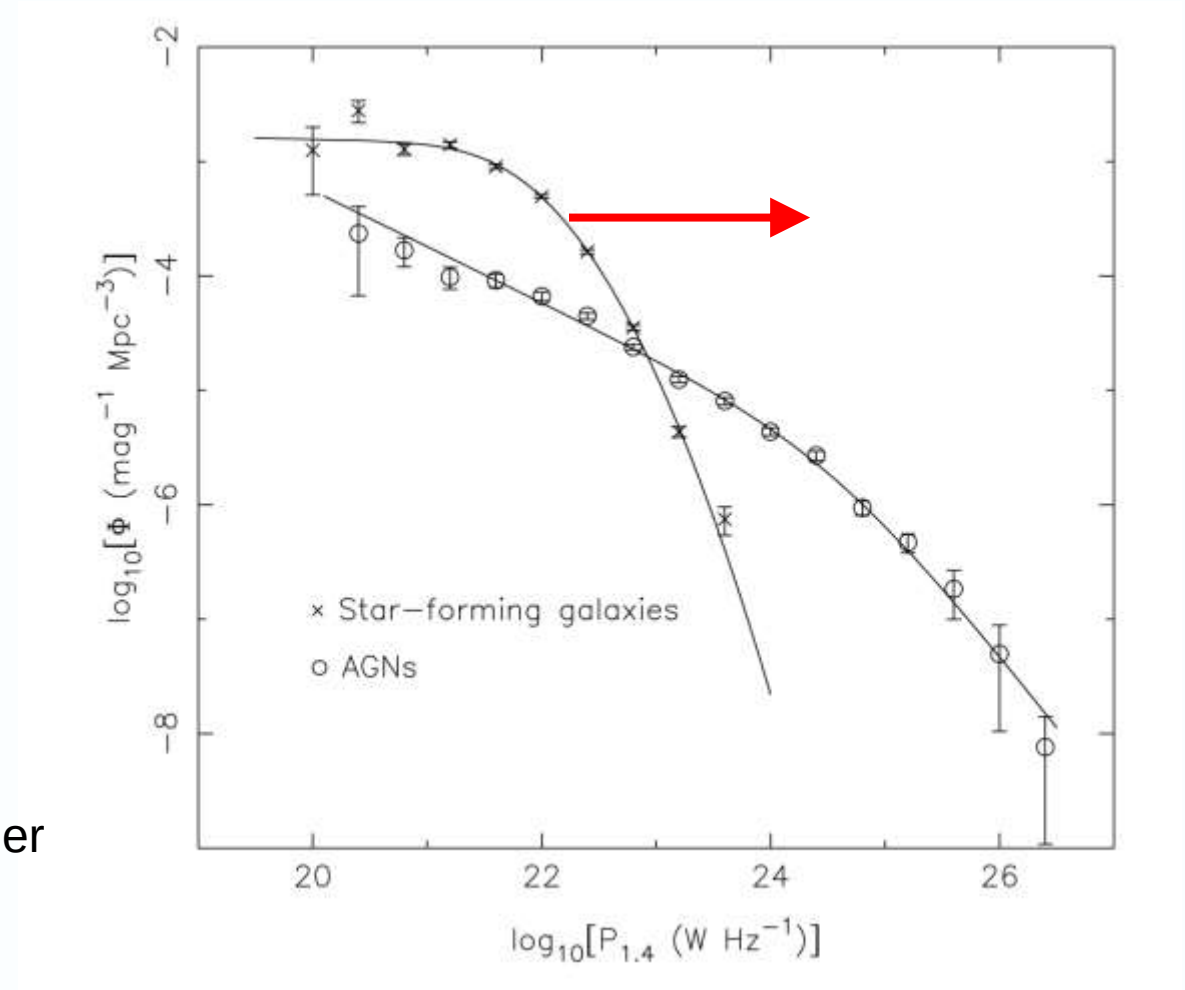
# Galaxy Evolution




Mauch & Sadler (2007)

6df + NVSS

# Galaxy Evolution

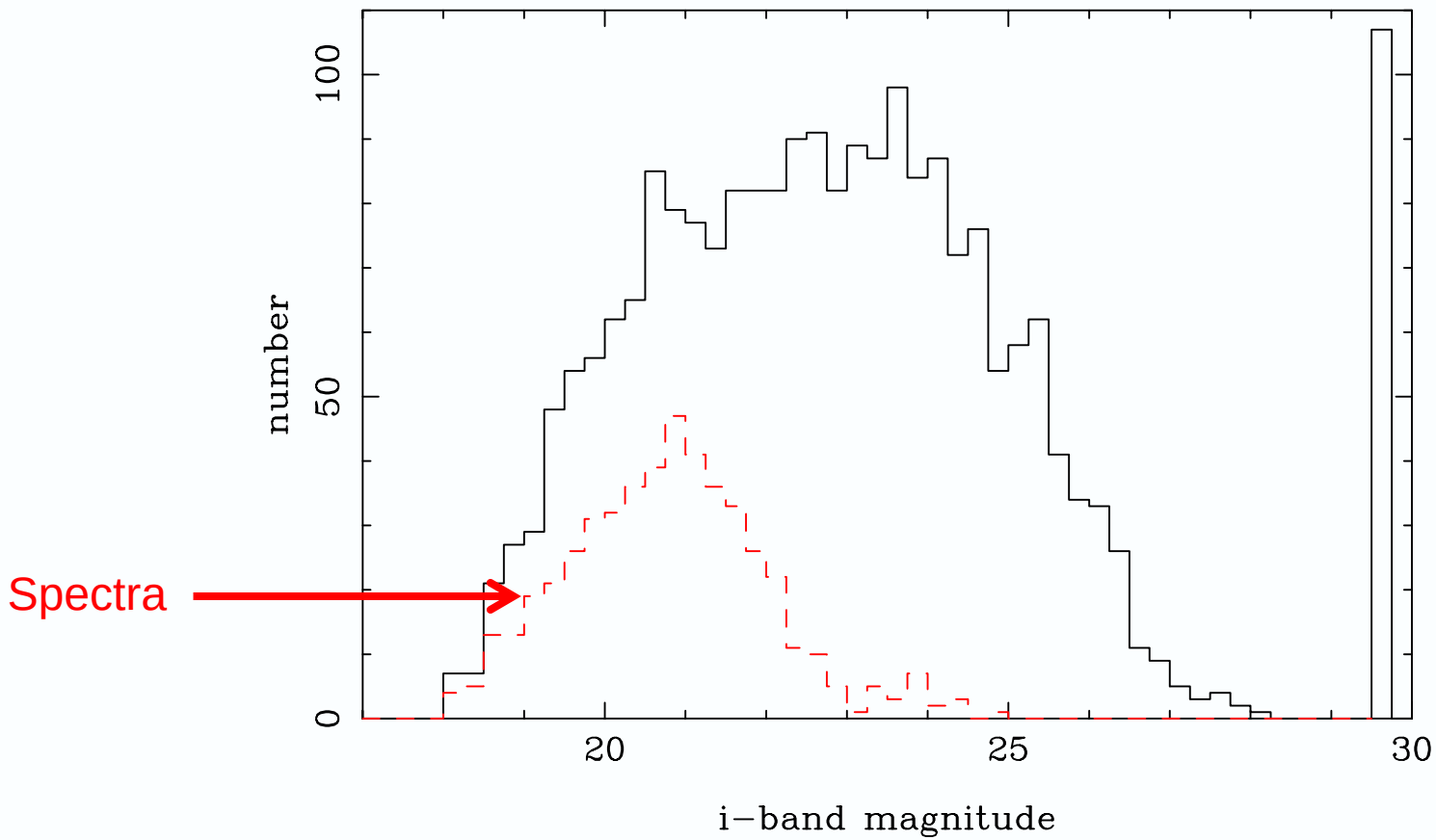



Mauch & Sadler (2007)

6df + NVSS

# Galaxy Evolution

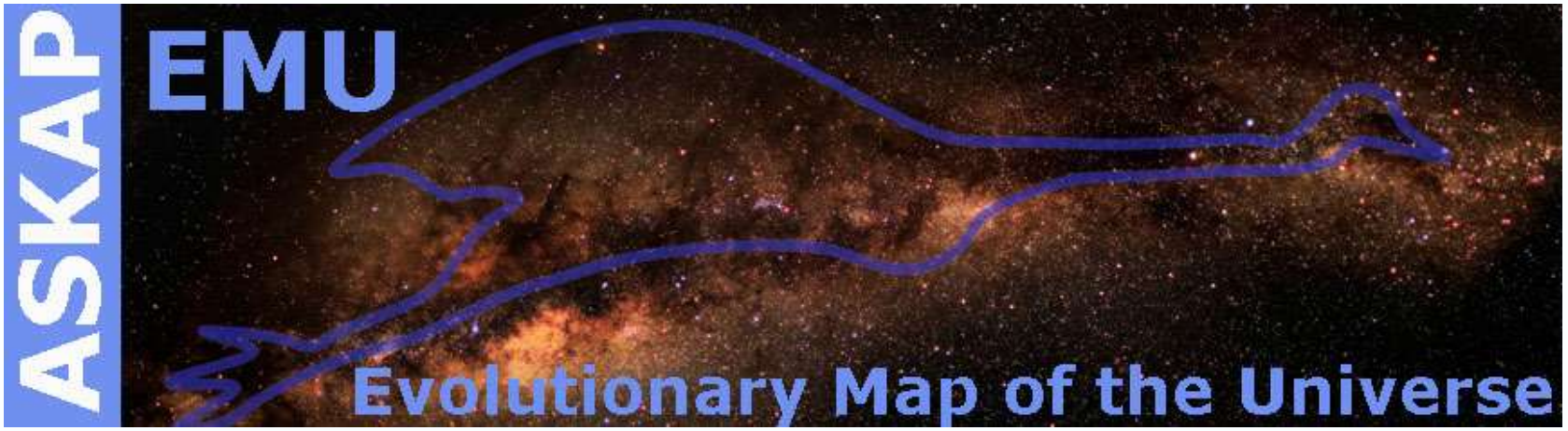
Optical counterparts to COSMOS VLA sources



# The Australian SKA Pathfinder

- 36x 12m dishes located in WA
- Distributed over 6km
- Novel tri-axial design for antennas
- Each antenna equipped with a phased array feed
- 300MHz bandwidth in 700-1800MHz range
- 1MHz channels
- Full Stokes data taken
- Data processing automatic
- Data released to public after quality control
- ASKAP early science Q2 2015

Image: Alex Cheney




- Deep, all-sky radio continuum survey (3π)
- Frequency range 1130-1430 MHz
- 10uJy/beam rms
- 40 x better sensitivity than NVSS
- 5 x better resolution than NVSS
- Better sensitivity to extended structures than NVSS
- Will detect and image ~70 million galaxies at 1.4GHz
- All data to be processed in pipeline
- Images, catalogues, cross-IDs, to be placed in public domain
- Total integration time: ~1.5 years
- Commensal with Polarisation and HI surveys

# EMU Science Goals

- **Galaxy Evolution**
  - SFGs to z=2-3, when & where did stars form?
  - AGN to the EoR, build up of earliest black holes?
- **Cosmology**
  - Integrated Sachs-Wolfe
  - Cosmological parameters
  - Cosmic magnification
- **Galactic Astronomy**
- **Local Galaxies**
  - Extended emission
  - Dwarf galaxies
- **Serendipity/Legacy**
  - New classes of objects

# EMU Science Goals

- **Galaxy Evolution**
  - SFGs to z=2-3, when & where did stars form?
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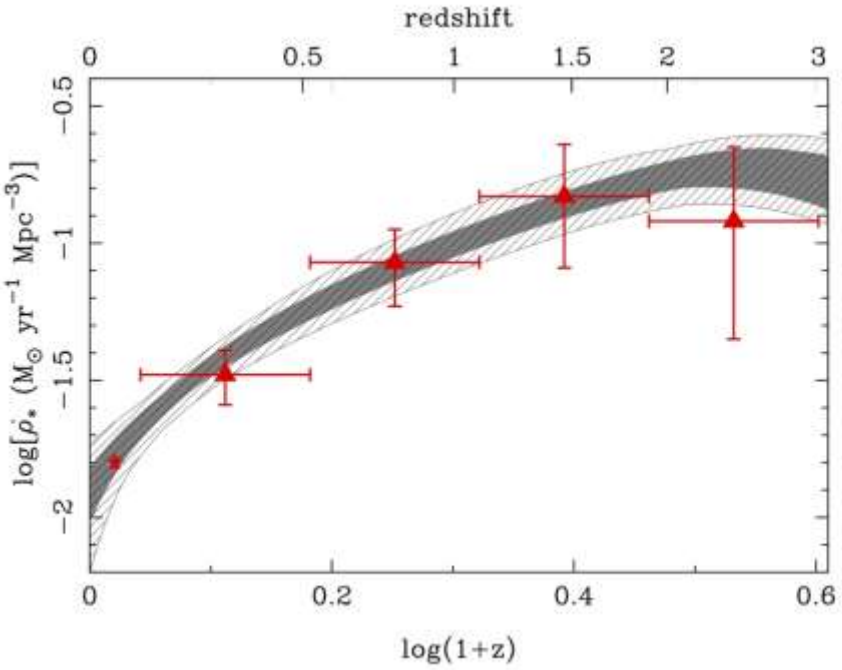
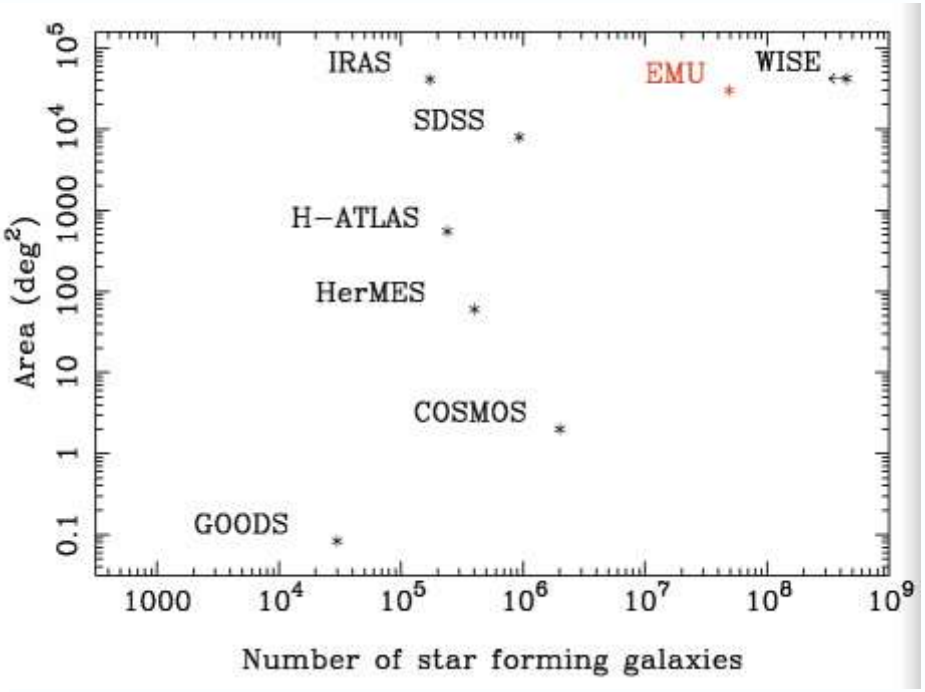
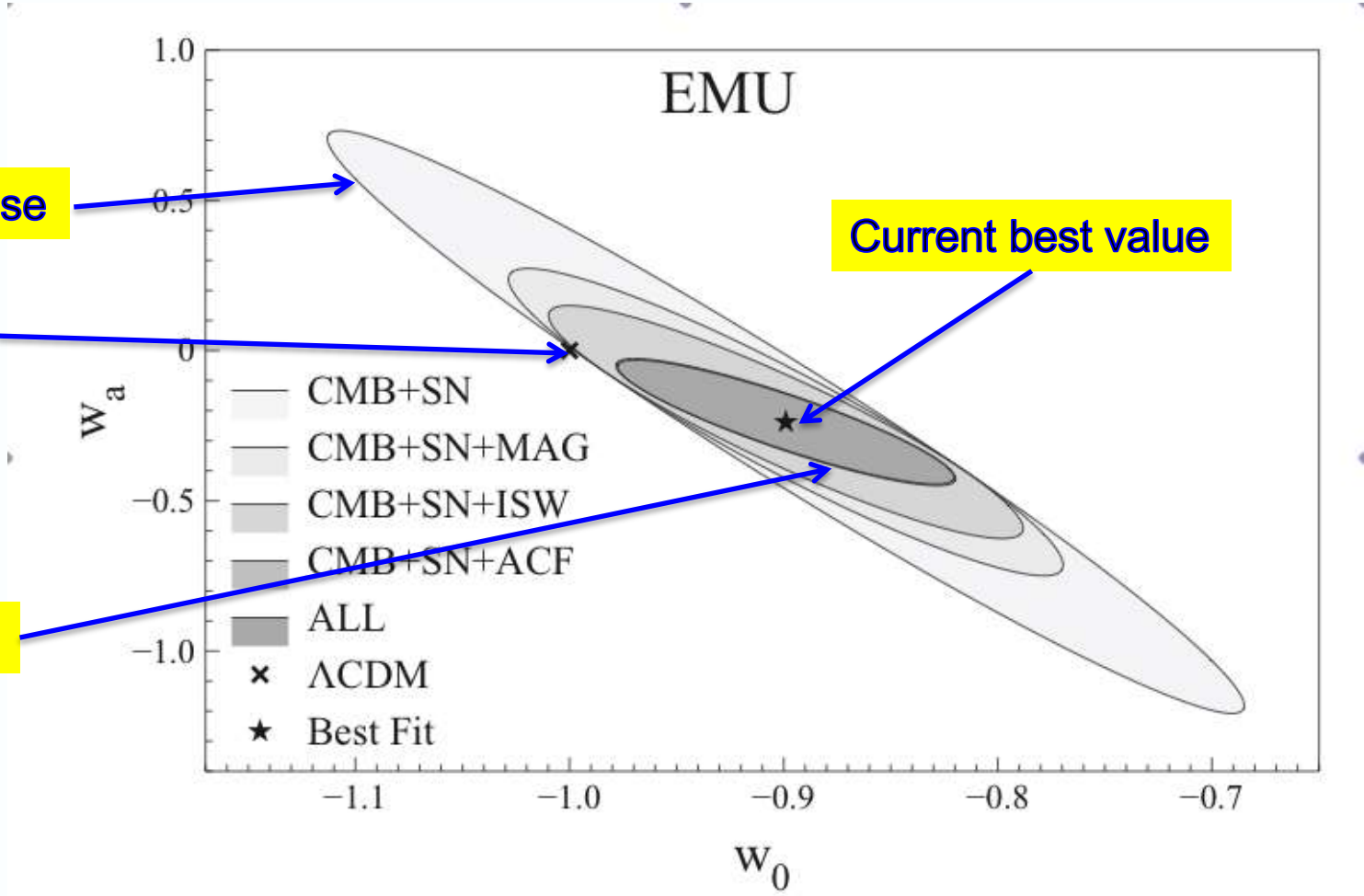


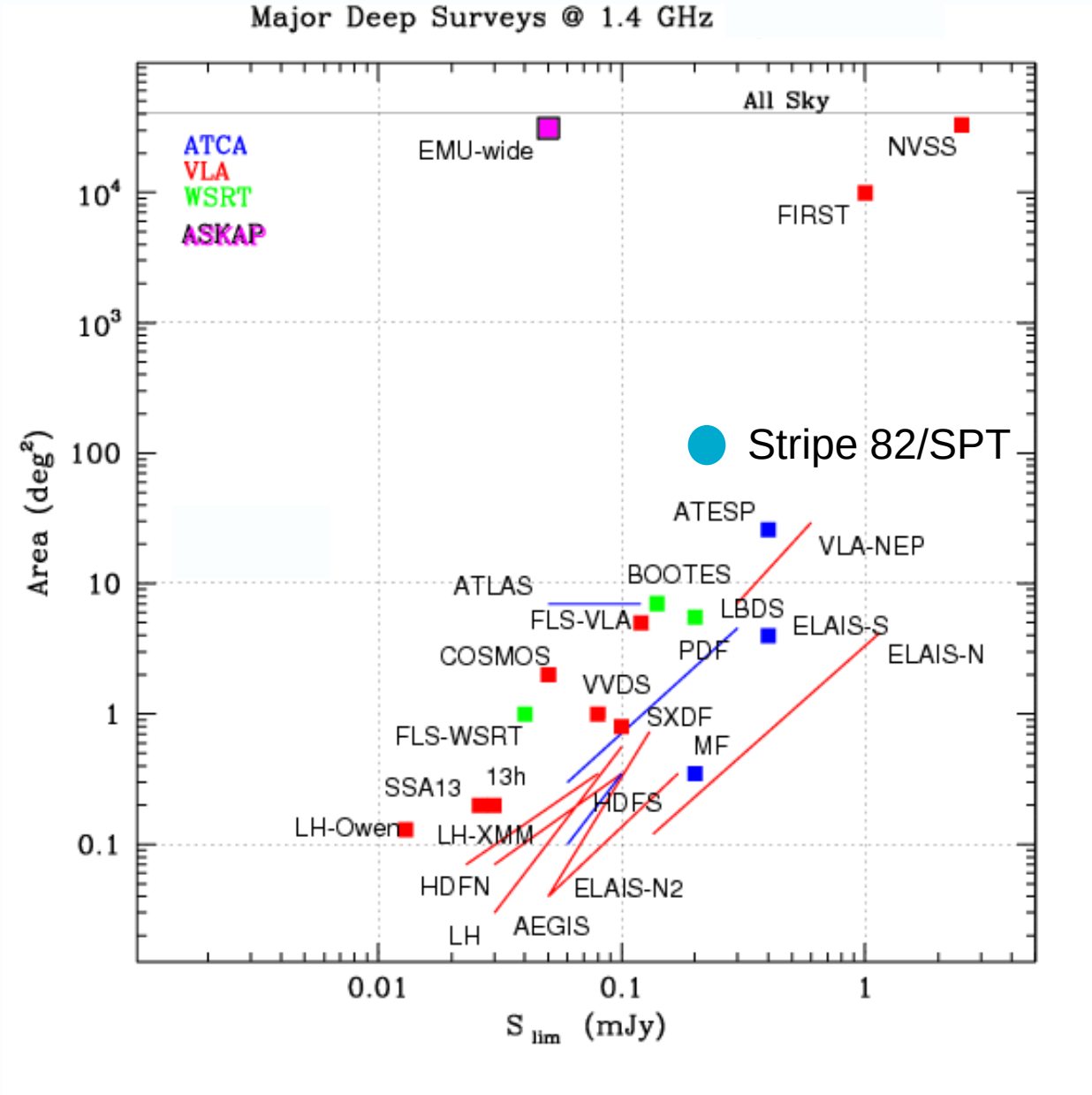



# Cosmology – Dark Energy




See Raccanelli et al. 2011

"Current error ellipse" is based on Amanullah et al., 2010, ApJ, 716, 712, plus Planck data


Major Deep Surveys @ 1.4 GHz
All Sky
ATCA
VLA
WSRT
ASKAP
EMU-wide
NVSS
FIRST
Stripe 82/SPT
ATESP
VLA-NEP
ATLAS
BOOTES
LBDS
ELAIS-S
FLS-VLA
PDF
ELAIS-N
COSMOS
VVDS
SXDF
FLS-WSRT
MF
13h
SSA13
HDFS
LH-Owen
LH-XMM
HDFN
ELAIS-N2
AEGIS
LH
Area (deg²)
S lim (mJy)
10⁴
10³
100
10
1
0.1
0.01
0.1
1

Major Deep Surveys @ 1.4 GHz

All Sky

ATCA
VLA
WSRT
ASKAP

EMU-wide
NVSS
FIRST

ASKAP12+

Stripe 82/SPT

ATESP
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BOOTES
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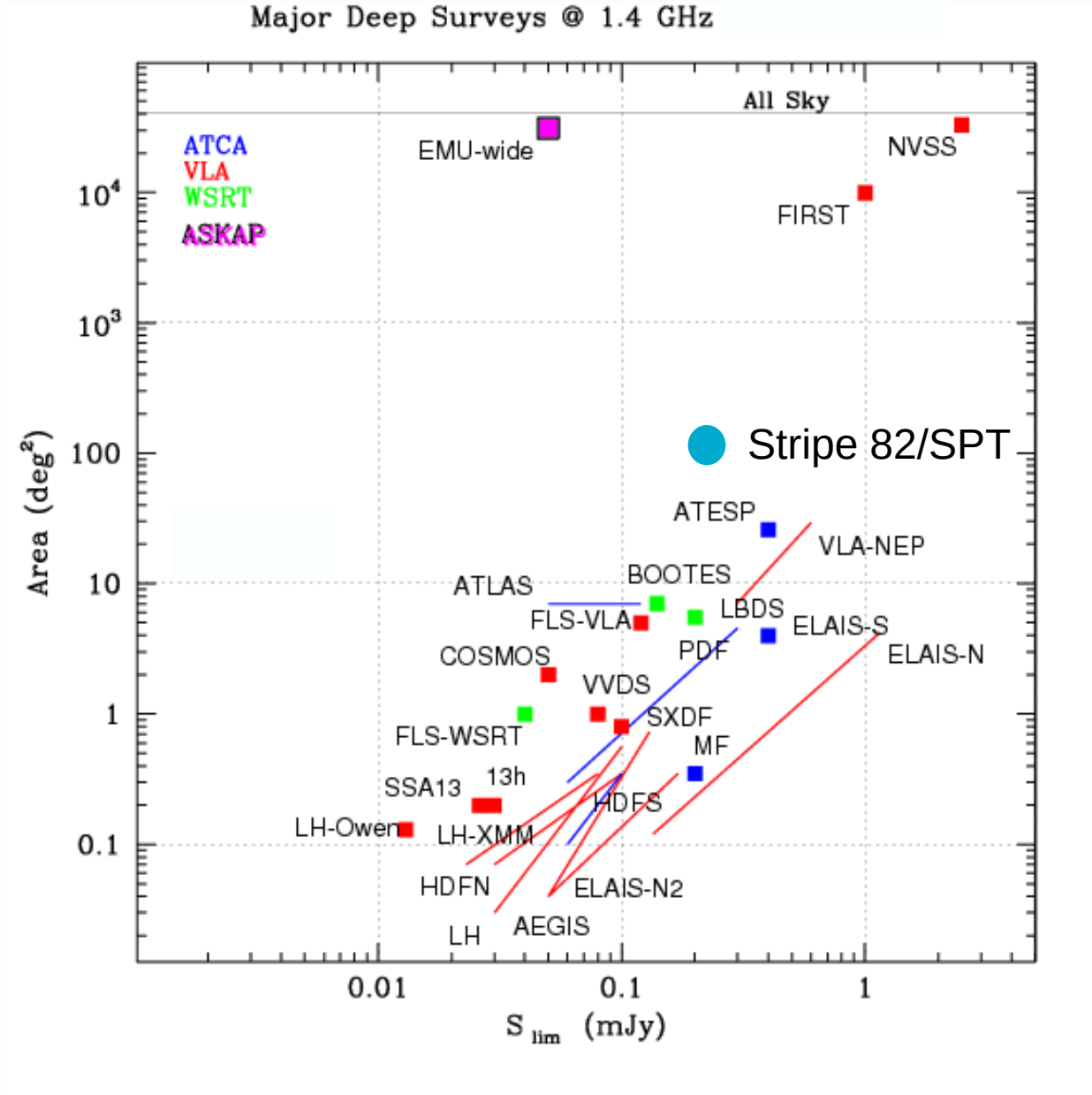
ELAIS-N2
LH
AEGIS

Area (deg$^2$)

$10^4$
$10^3$
100
10

0.01
0.1
1

$S_{lim}$ (mJy)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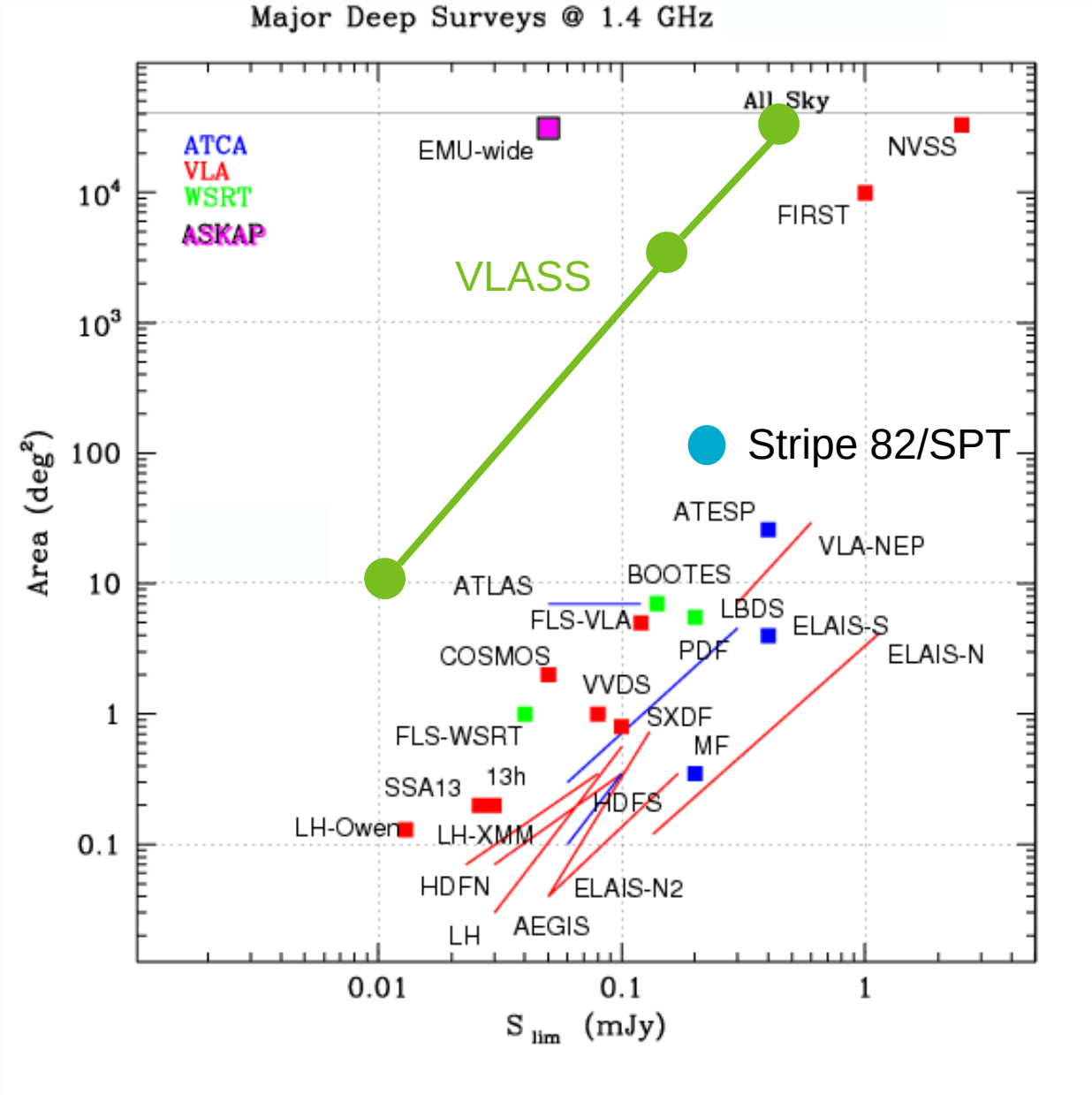
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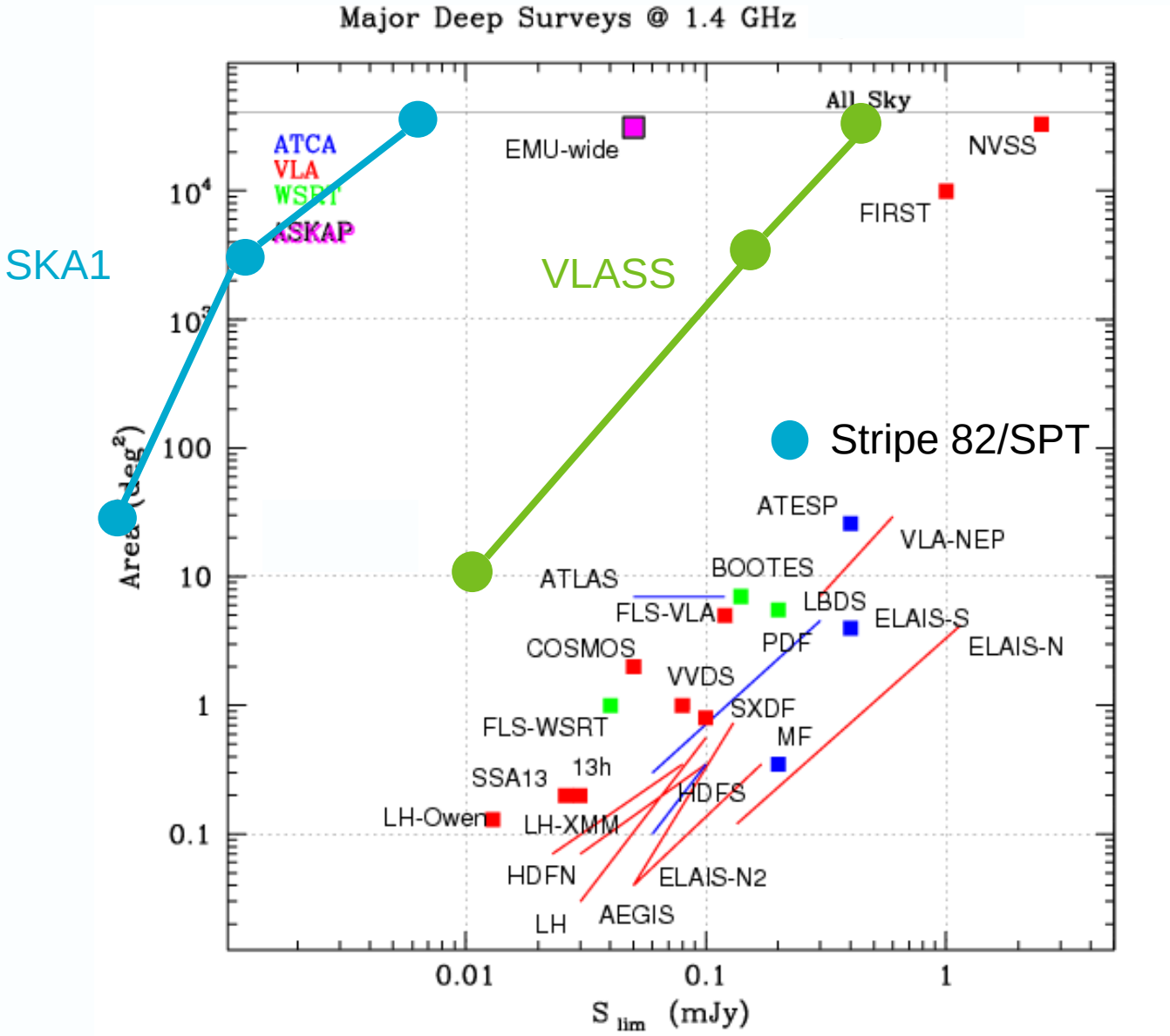
Major Deep Surveys @ 1.4 GHz
SKA1
ATCA
VLA
WSRT
ASKAP
VLASS
All Sky
EMU-wide
NVSS
FIRST
Stripe 82/SPT
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Area (deg²)
S lim (mJy)
10⁴
10³
100
10
1
0.1
0.01
0.1
1

# Optical XIDs

Beyond nearest neighbour:

- Likelihood Ratio: The ratio of the probability that two sources are associated to the probability that the same two sources are unrelated. (Sutherland and Saunders, 1992). Adapt for double radio sources.

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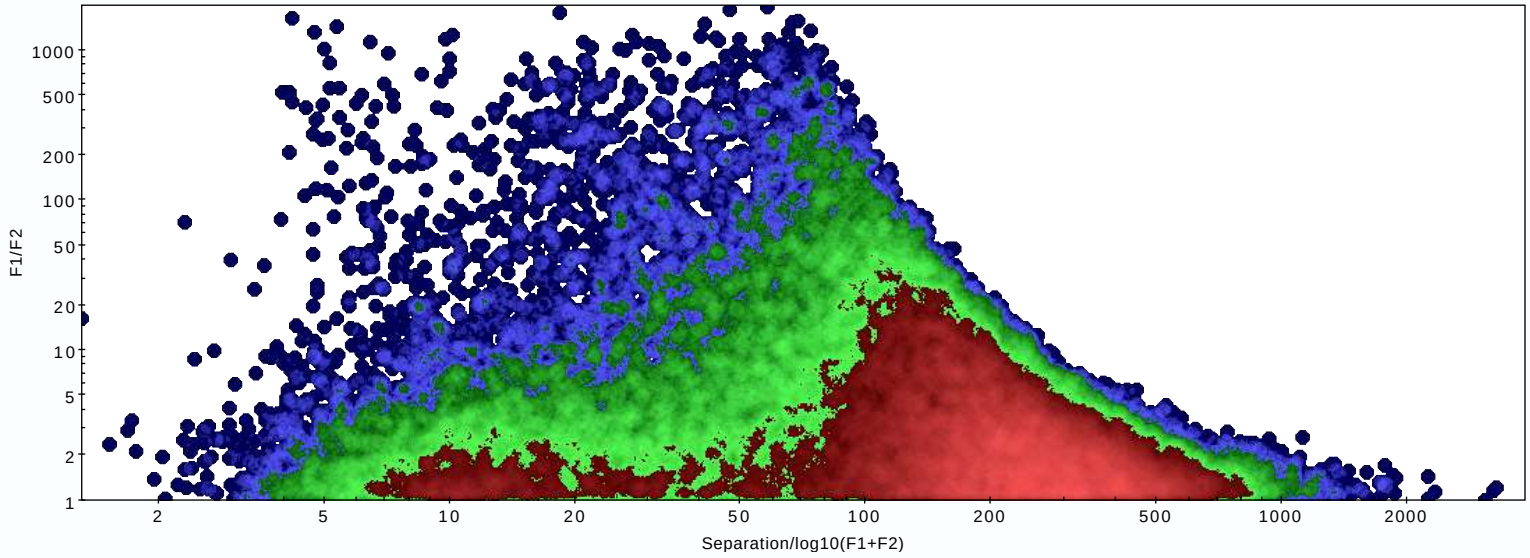
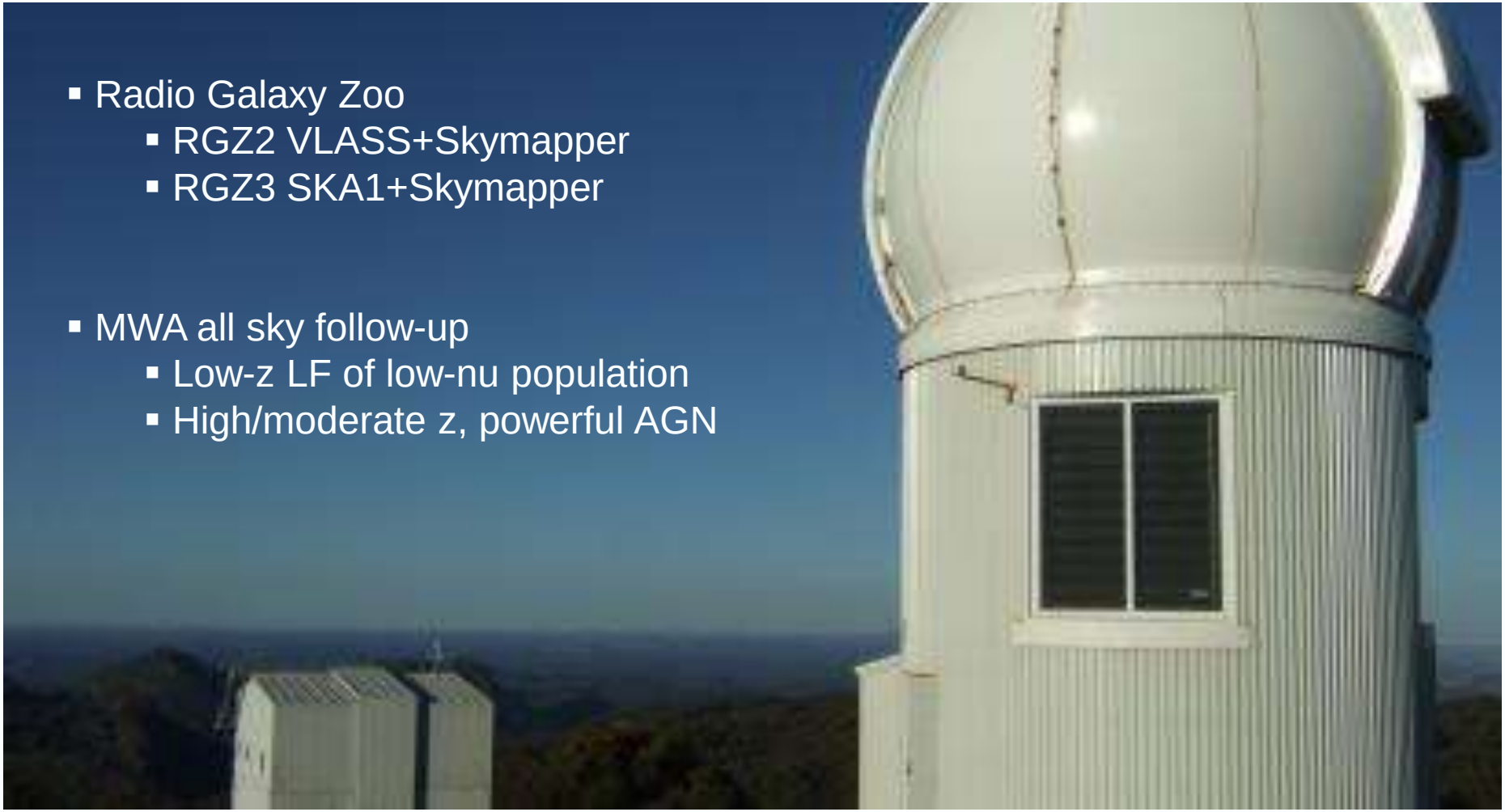


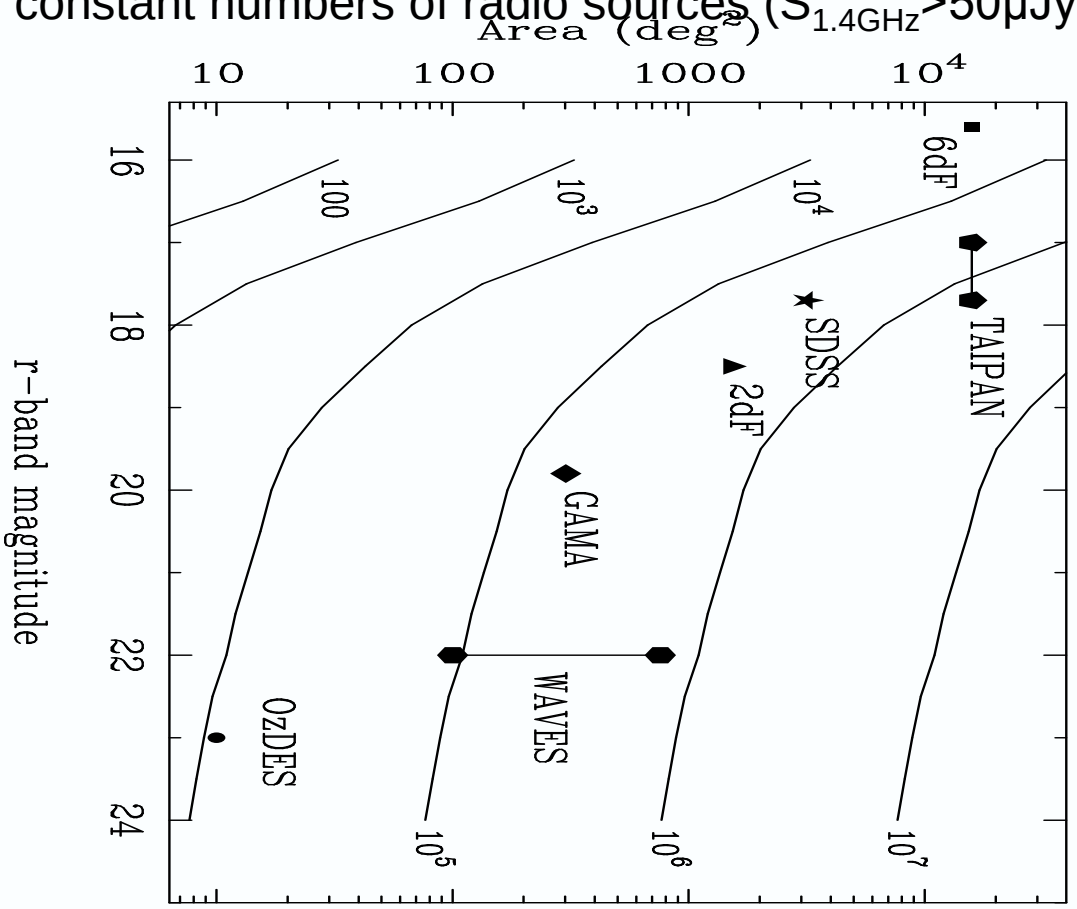
# Other Skymapper uses



- Radio Galaxy Zoo
  - RGZ2 VLASS+Skymapper
  - RGZ3 SKA1+Skymapper
- MWA all sky follow-up
  - Low-z LF of low-nu population
  - High/moderate z, powerful AGN

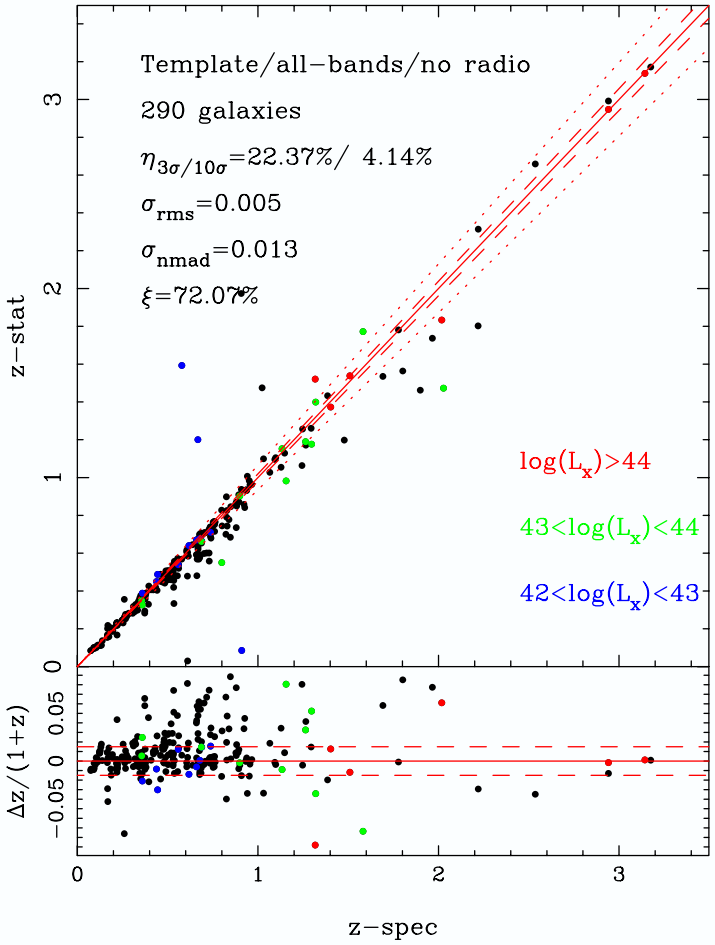
# Optical XIDs

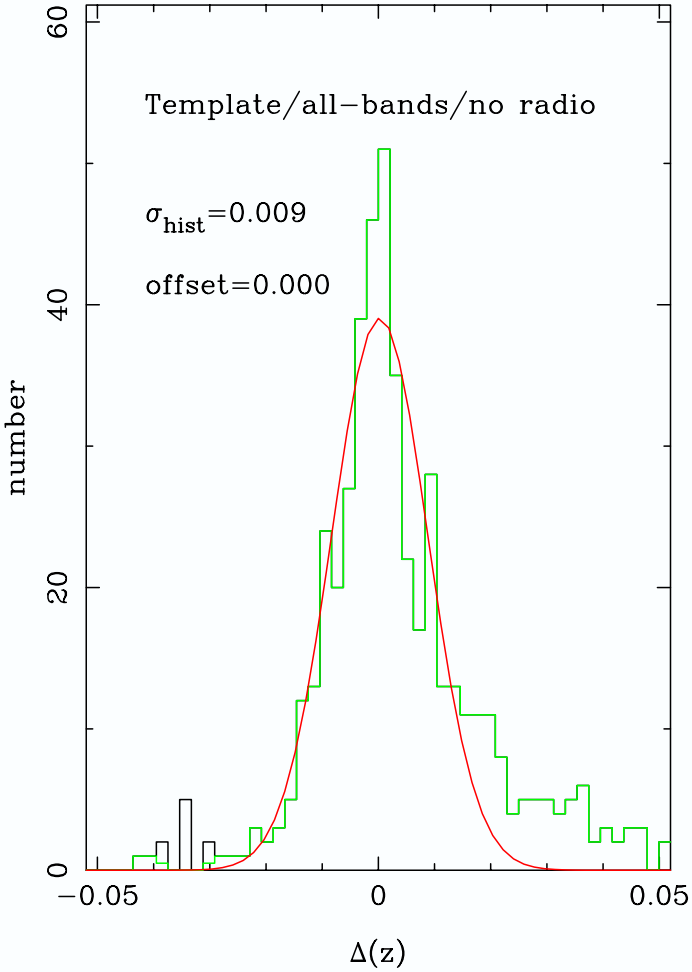
Lines of constant numbers of radio sources ($S_{1.4GHz}$>50μJy) with spectroscopy



# Galaxy Evolution

Photo-z's of COSMOS VLA sources




Salvato, Seymour et al. (in prep)

# EMU Value-added Catalogue

- **Philosophy**
  - To provide an enhanced data product to maximise the scientific return from the EMU survey
  - Enhanced data products include cross-IDs at other wavelengths, estimates of redshift/class of source etc.

Table 1: Straw-man plan for EVACat releases

| # | time of release | products included |
|---|---|---|
| 1 | ASKAP+9 months | first hundred(?) tiles, EMU Self-XID[a], basic EMU POSSUM and WALLABY products[b] and XID with existing surveys at other wavelengths[c] |
| 2 | ASKAP+18 months | first 500(?) tiles, zEMU1 redshifts based on EVACat1, WTF1 |
| 3 | ASKAP+30 months | all ~ 1000 tiles, RGZ1[d], zEMU2, WTF2 and XID with DES |
| 4 | ASKAP+42 months | all tiles, RGZ2, zEMU3, WTF3, and XID with data from non-commensurate ASKAP projects (e.g. FLASH and VAST) |
| 5 | ASKAP+54 monts | final release: RGZ3, zEMU4, WTF4, and XID with eROSITA |

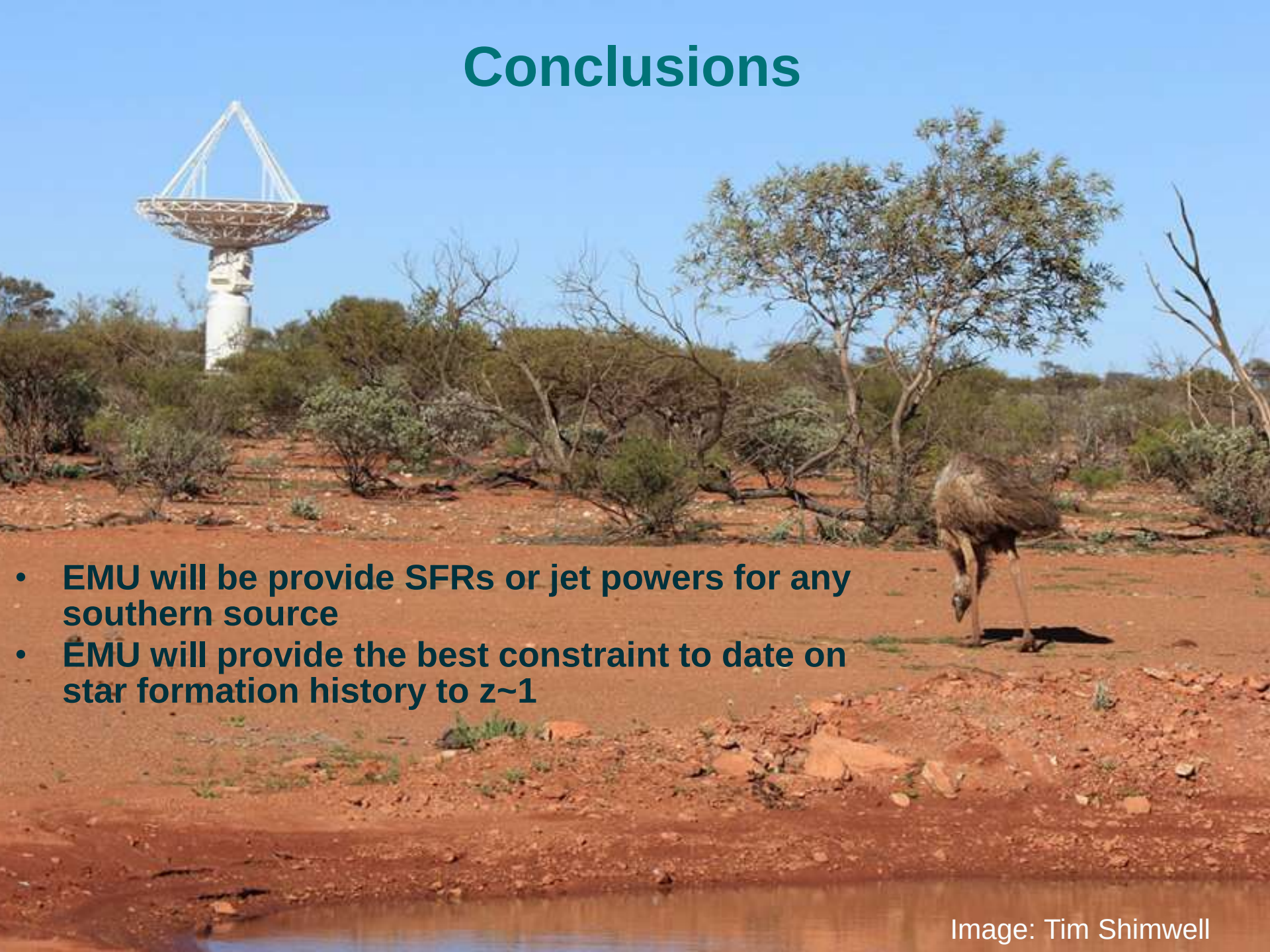
[a] EMU Self-XID is the identification of the probable multi-component sources by an algorithm based on work on ATLAS DR3

[b] EMU may require products from POSSUM and WALLABY which are not part of the general release from those projects

[c] these are likely to include current surveys: SUMMS, SDSS, *WISE*, *Akari*, 2MASS, DENIS and the VISTA surveys (VHS, VST-ATLAS, Viking); as well as surveys which will be complete around the end of 2015: PanSTARRS, Skymapper, SDSS-III

[d] see EMU Memo #16

# Conclusions



- **EMU will be provide SFRs or jet powers for any southern source**
- **EMU will provide the best constraint to date on star formation history to z~1**

Image: Tim Shimwell

# How do Redshifts Help?

These results made the conservative assumption that no redshifts are available for EMU sources (Raccanelli et al. arXiv 1108.0930)

But even imperfect photo-z's make a big difference (*Camera et al, arXiv 1205.1048)

(e.g polarised sources have <z>=1.8,
unpolarised sources have <z>=1.1)

Implications of statistical redshifts

1) "tomographic cosmology"
   - EMU samples much larger volume of space than DES etc

2) Further reduce the error ellipses in all above tests

# EMU Value-added Catalogue

- **Philosophy**
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  - Enhanced data products include cross-IDs at other wavelengths, estimates of redshift/class of source etc.