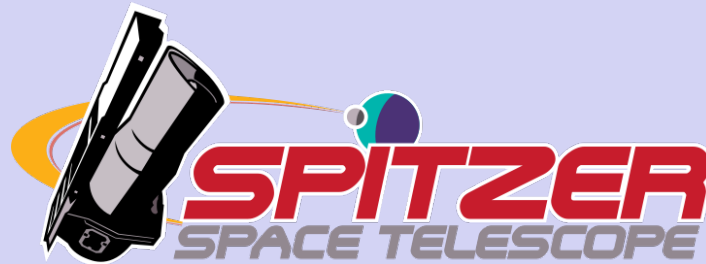


The Cosmic Evolution of AGN Feedback: Insights from Broad-band Radio Spectral Indices

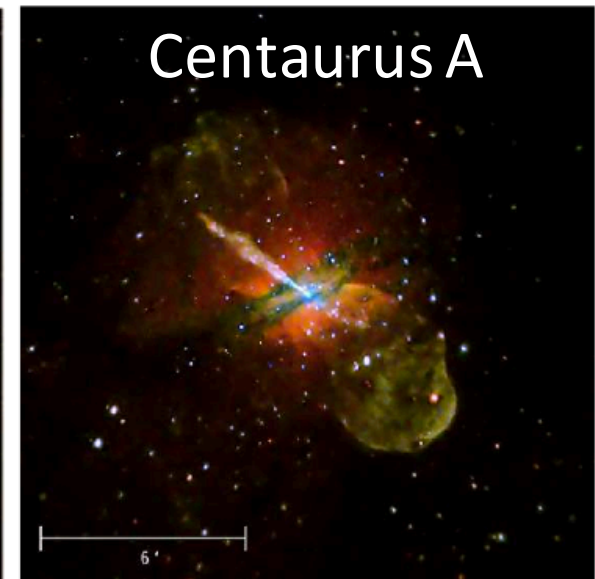
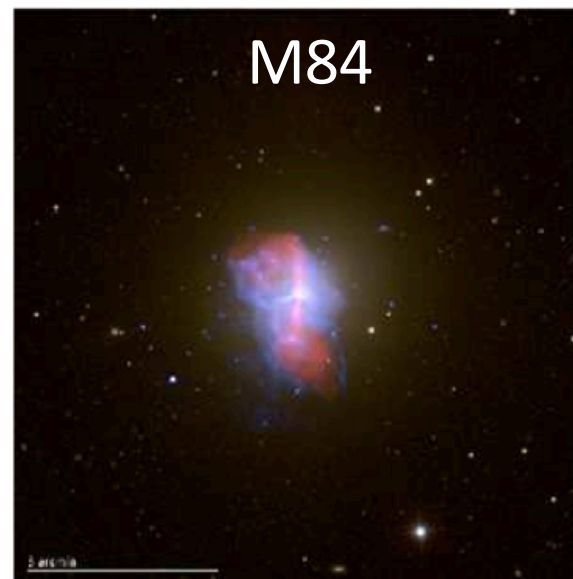
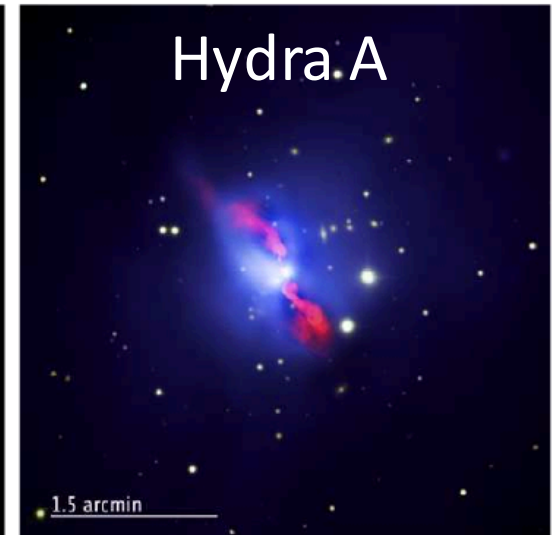
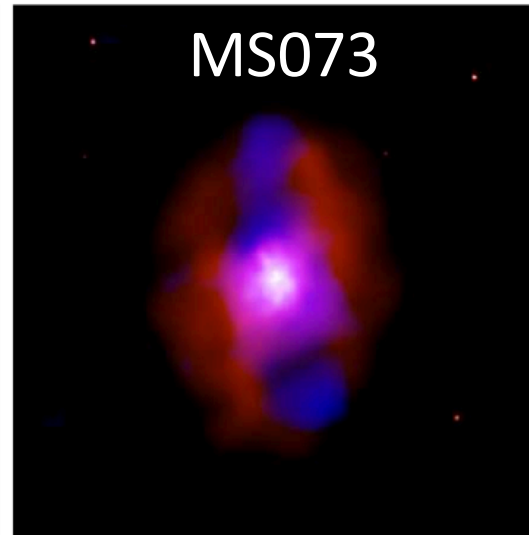
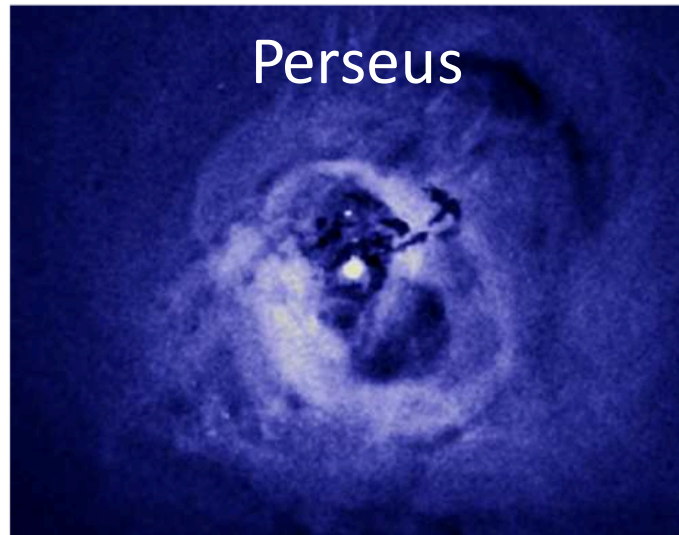


Kristina Nyland
Postdoc at NRAO

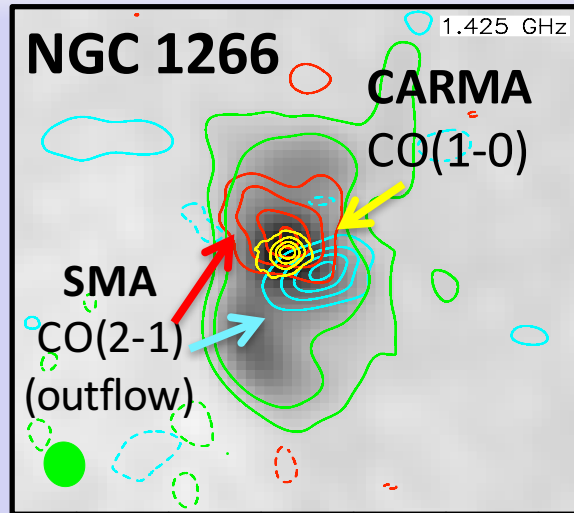


Collaborators: Mark Lacy + SERVS/Deepdrill team

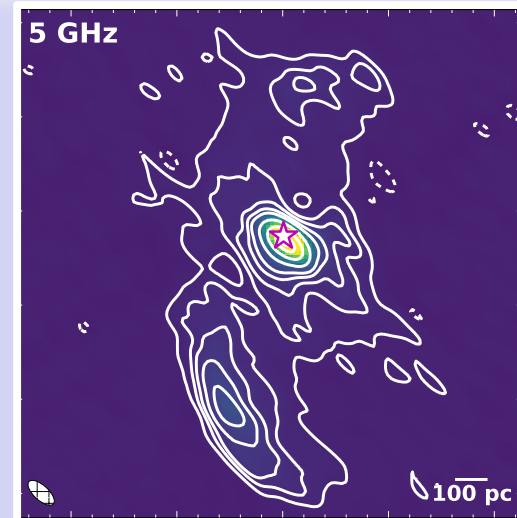
Radio AGNs and Galaxy Evolution



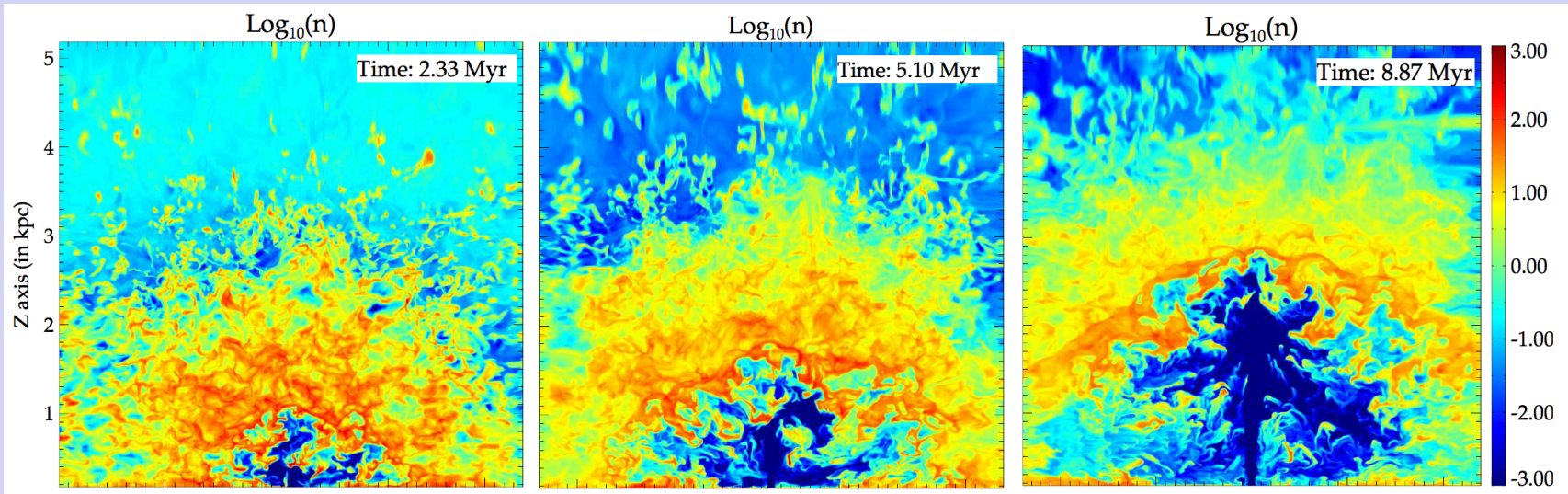
Radio AGNs and Galaxy Evolution



Nyland et al. 2013



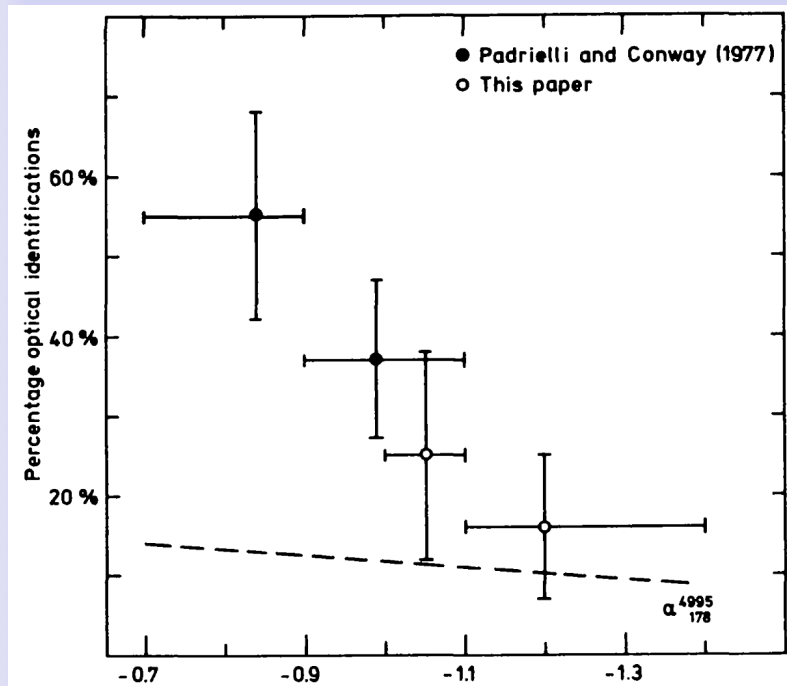
Nyland et al. 2016



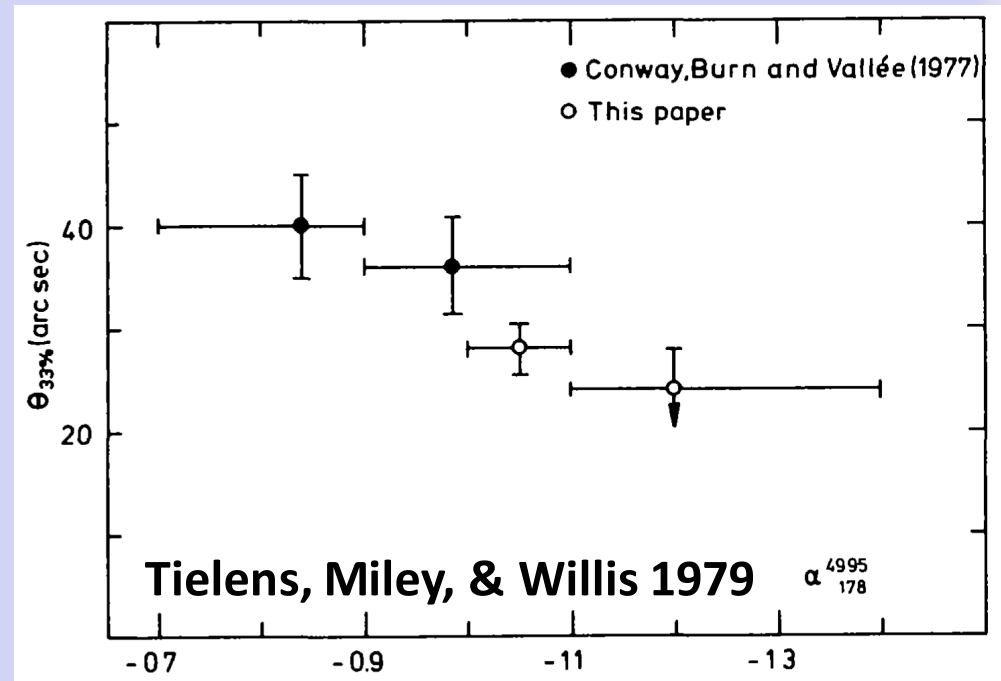
Mukherjee et al. 2016

Radio Spectral Indices and Redshift

Redshift evolution of radio spectral index?

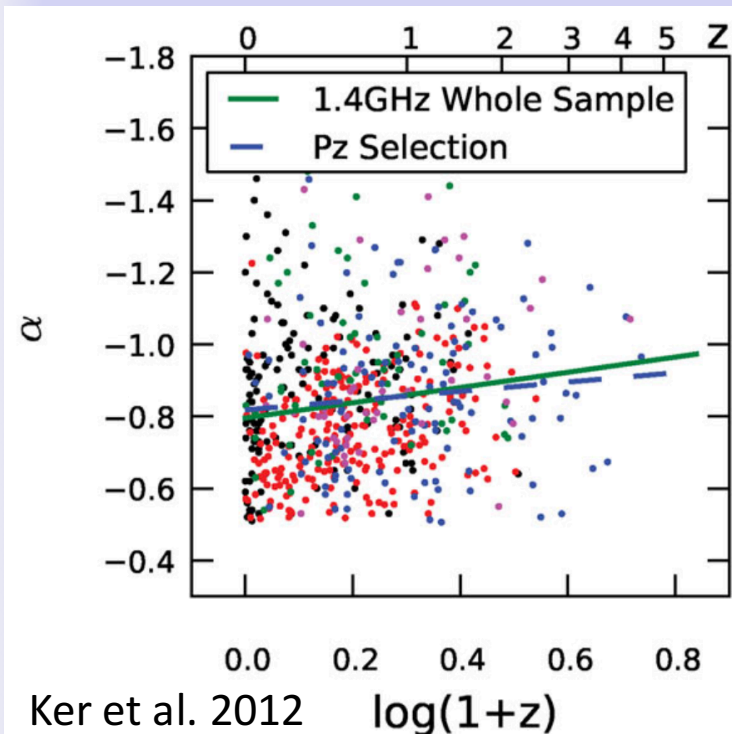
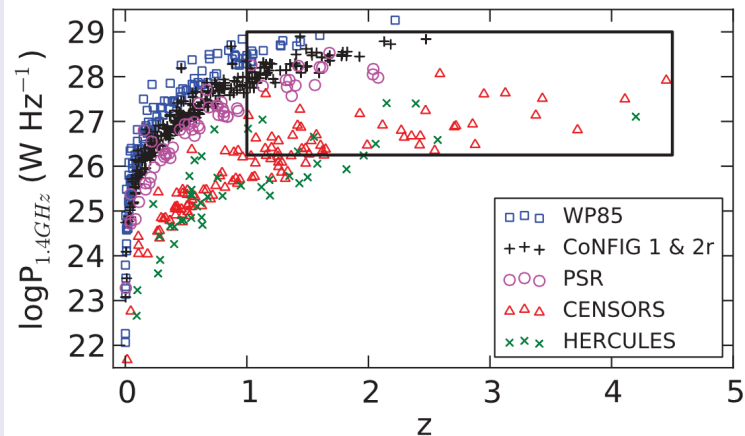


Steep spectrum radio sources are optically faint



Steep spectrum radio sources are small

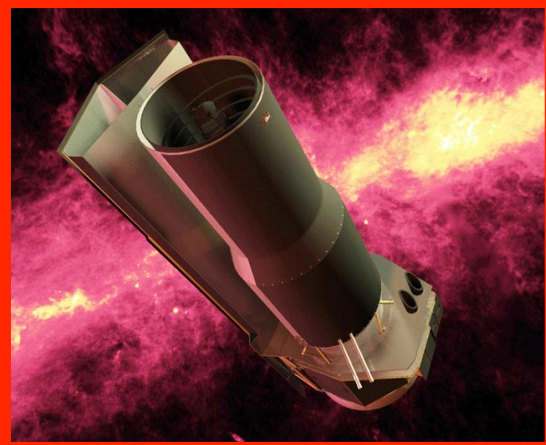
Origin of the α -z Correlation?



- Malmquist bias?
- Enhanced B-fields?
- Inverse Compton losses?
- Interaction with a dense ISM (“frustrated jet”)?

New Surveys, New Opportunities

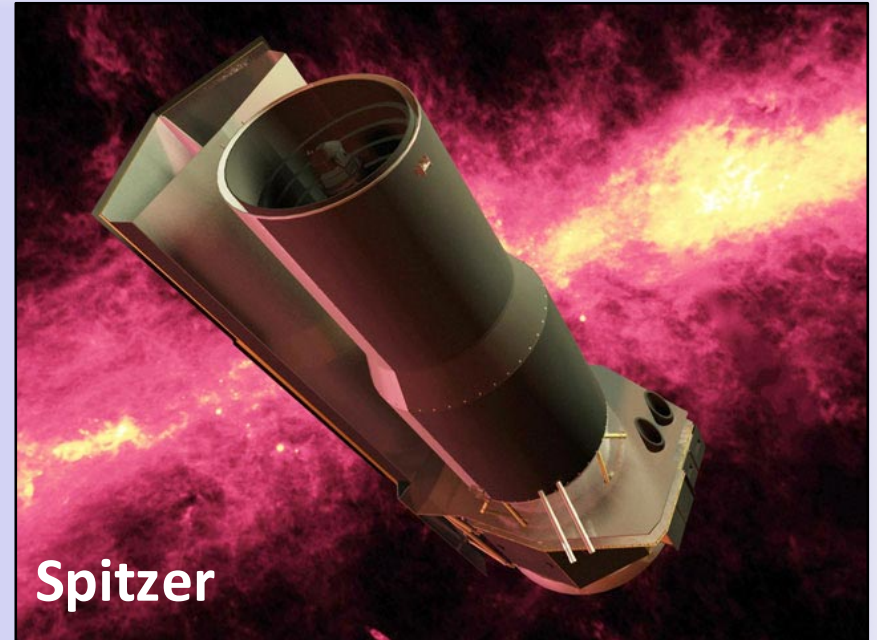
**Multi-band IR +
optical survey**



**Radio Continuum
Surveys**

SERVS

- “The Spitzer Extragalactic Representative Volume Survey” (P.I. Mark Lacy)
- Post-cryogenic 3.6 and 4.5 μm Spitzer observations of 5 deep fields to a depth of 2 μJy



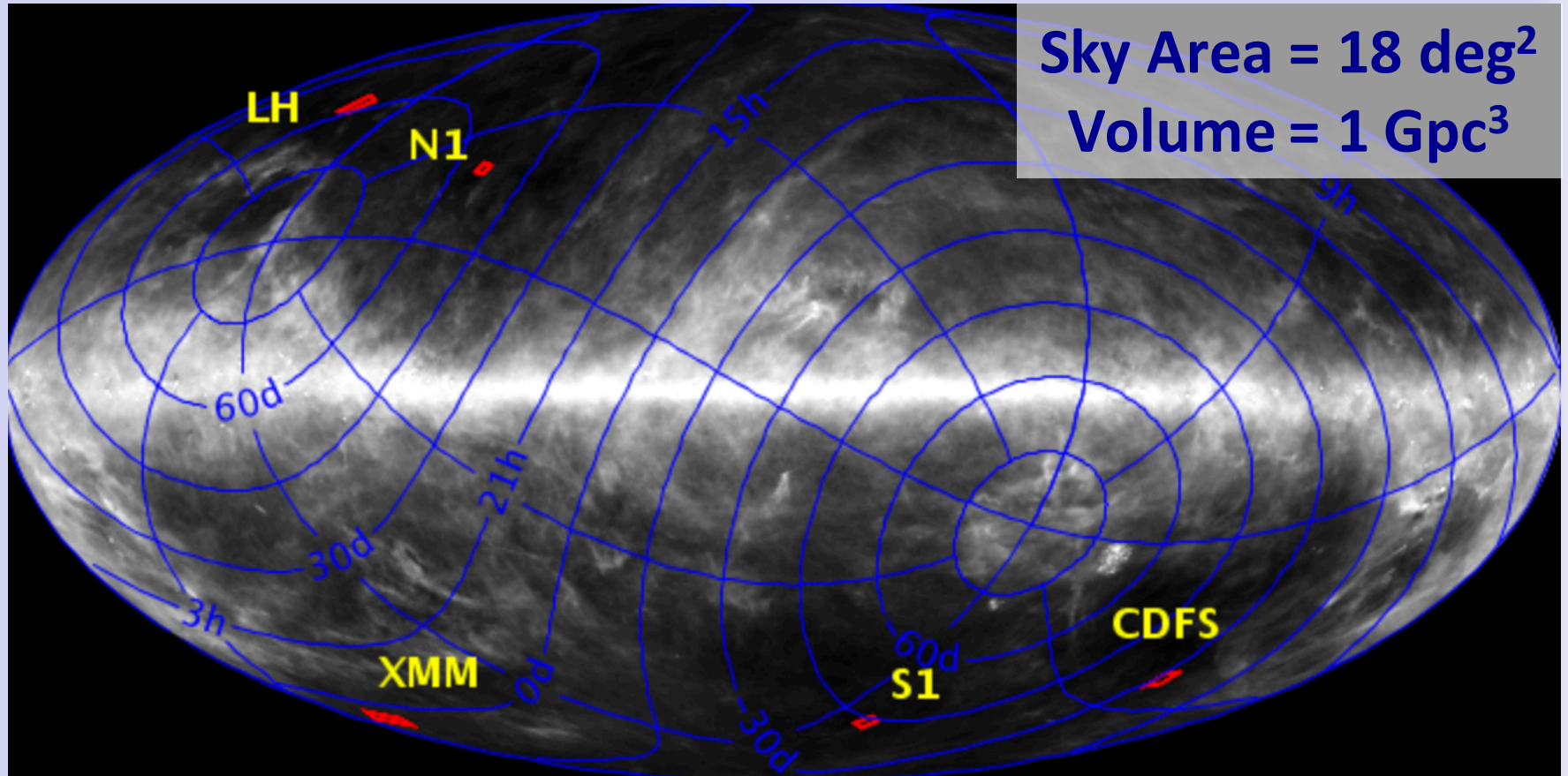
Goals: The study of stellar mass assembly, obscured star formation, the role of AGNs, the role of environment, and the highest redshift quasars



SERVS

Lockman Hole

ELAIS-N1

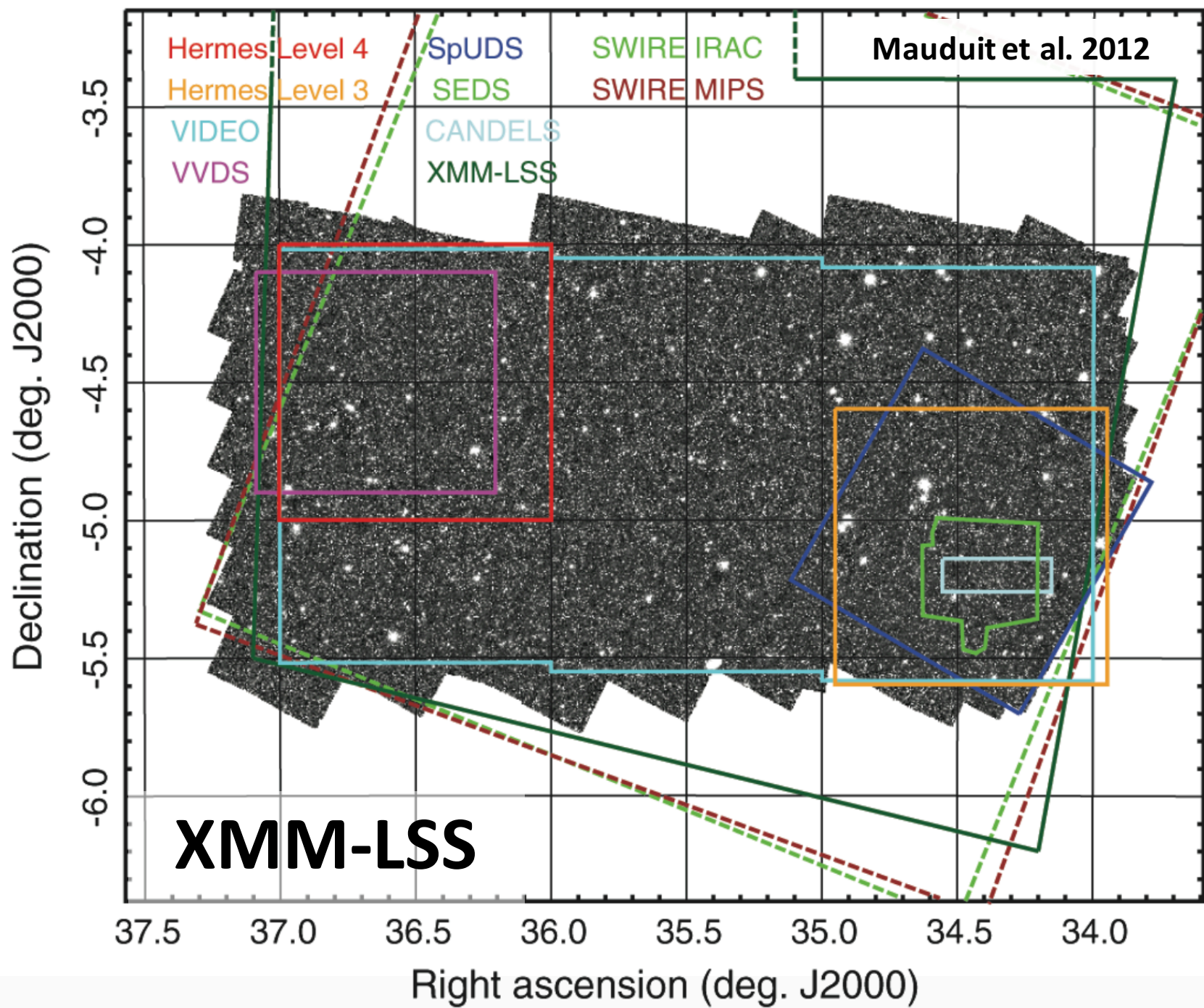


Sky Area = 18 deg²
Volume = 1 Gpc³

XMM-LSS

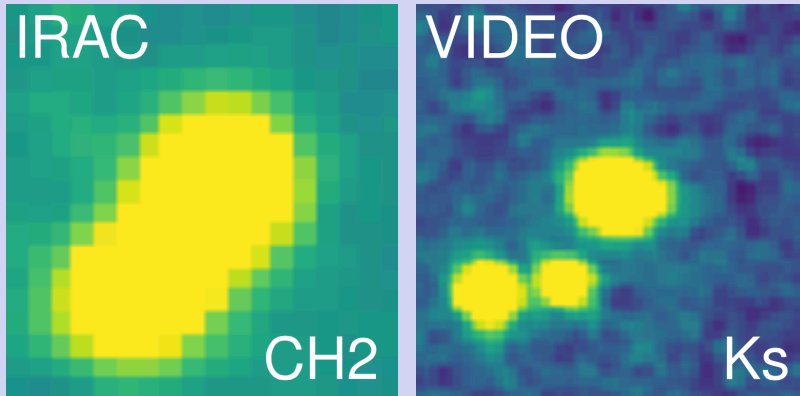
ELAIS-S1

Chandra Deep
Field South

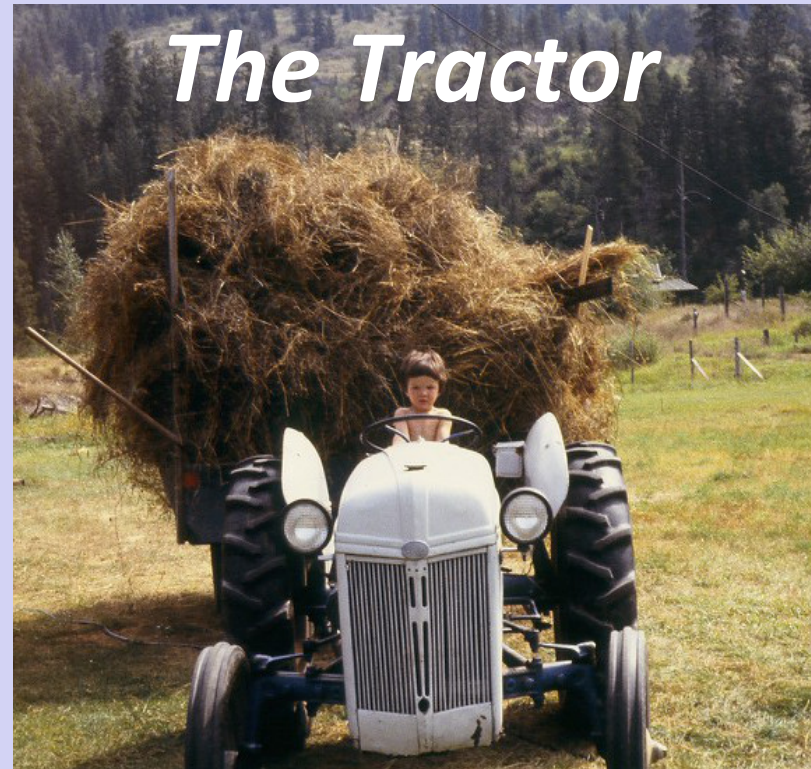
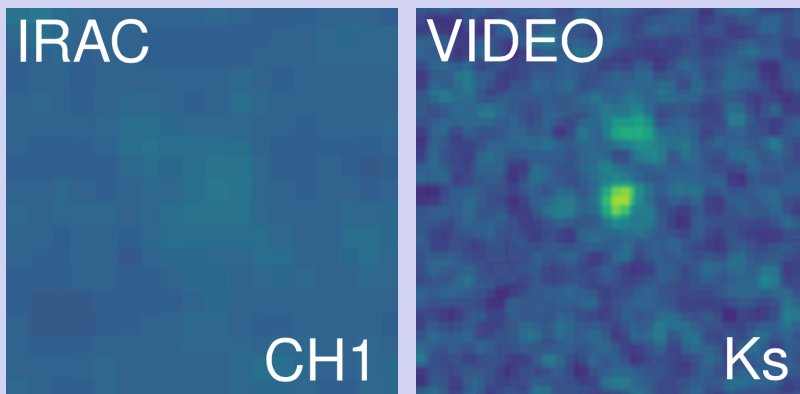


Improving Multi-band Photometry

Blended IRAC Source



Faint IRAC Source



<http://thetractor.org>

SERVS Photometry with *The Tractor*

VIDEO



Bands: Ks, H, J, Y, Z

CFHTLS Deep



Bands: I, R, G, Z, U

SERVS

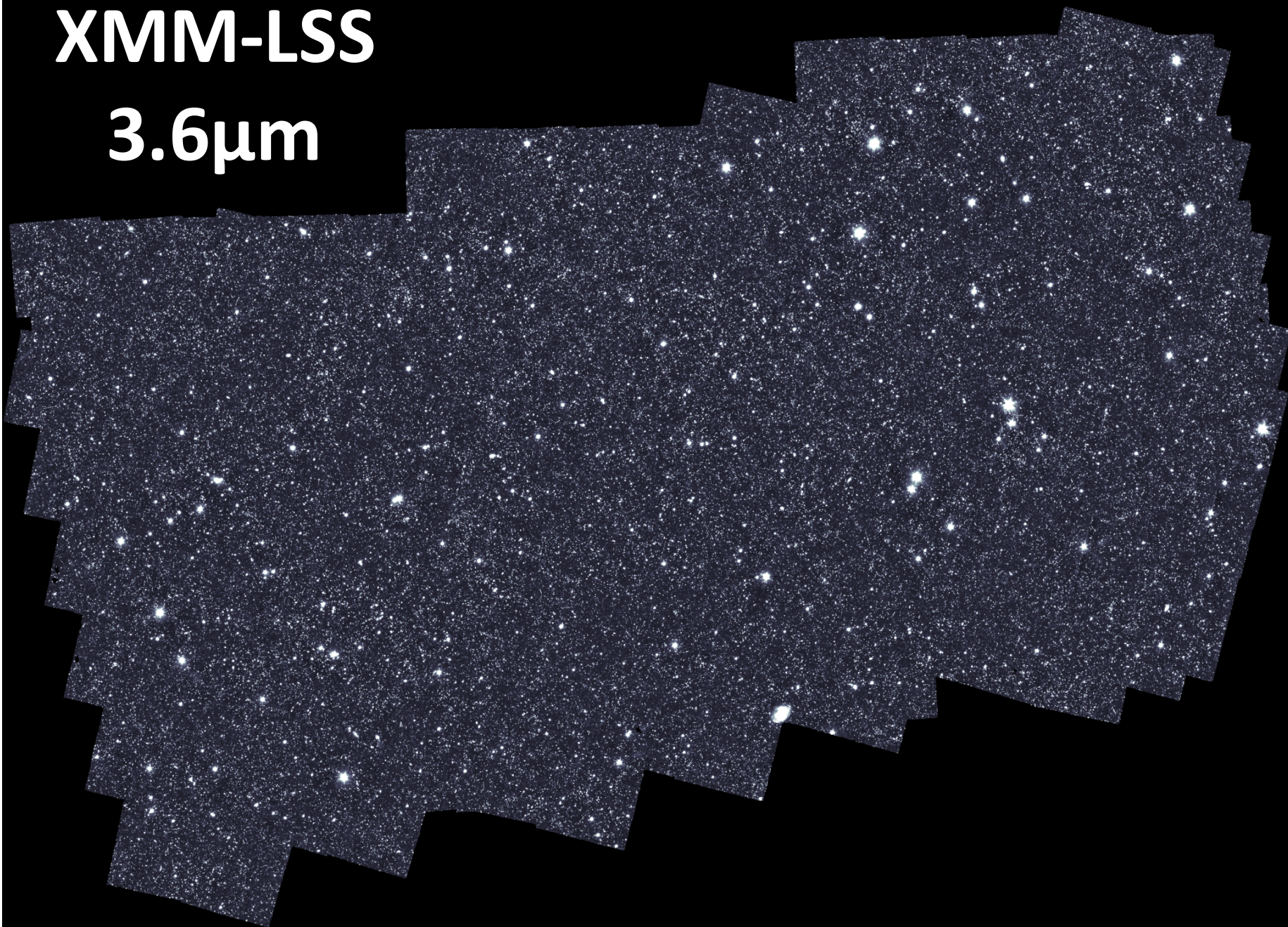


Bands: 3.6, 4.5 μm

**Fiducial band for initial
source model selected
from VIDEO**

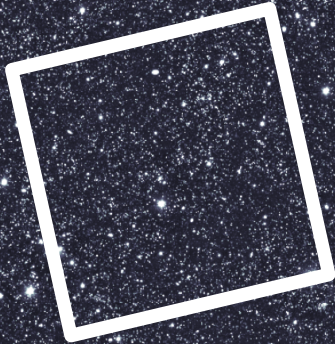
XMM-LSS

3.6 μ m



XMM-LSS

3.6 μ m

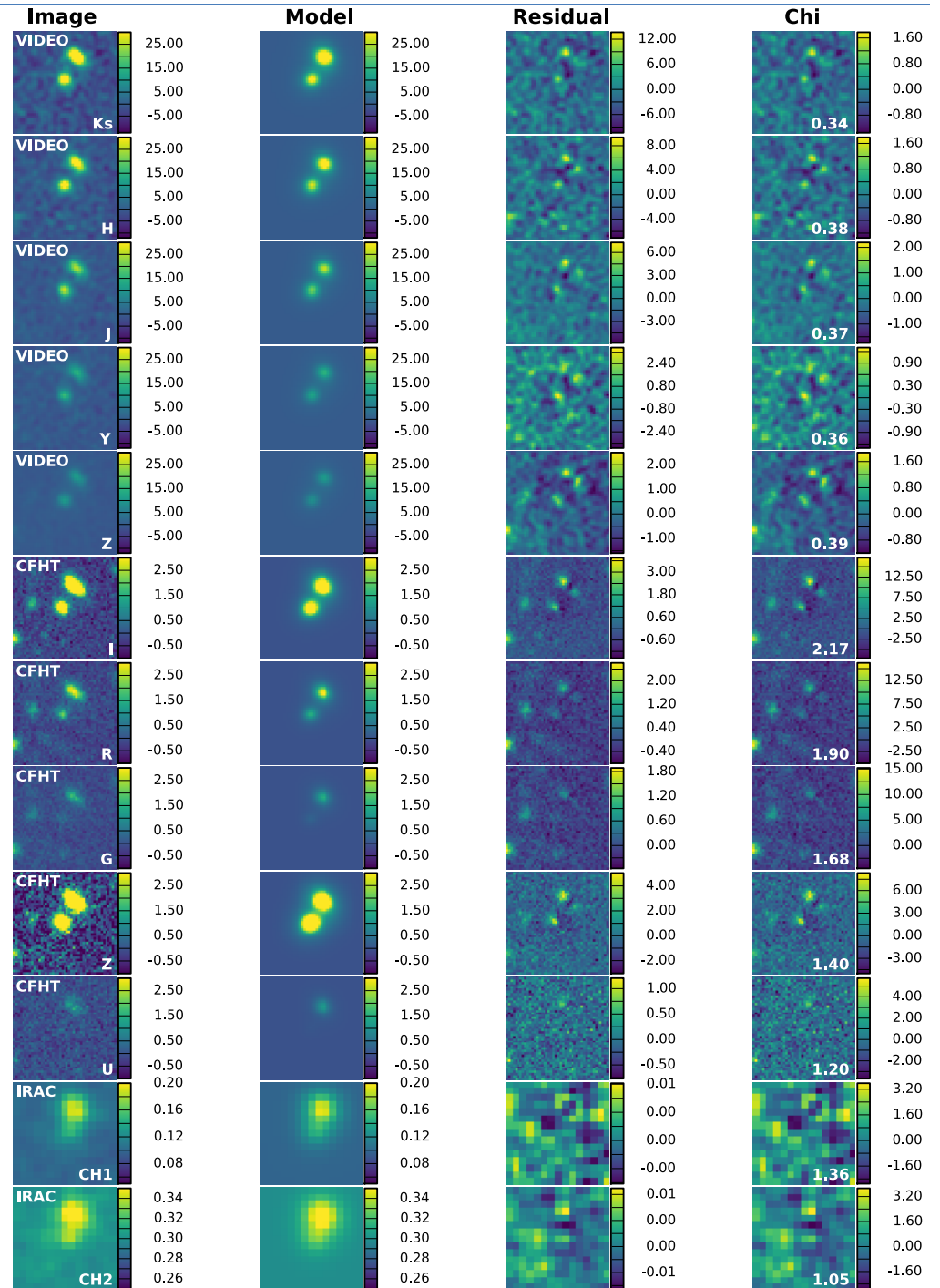


**XMM CFHTLS
Deep Square
Degree Field**

Multi-band SERVS Photometry with *The Tractor*

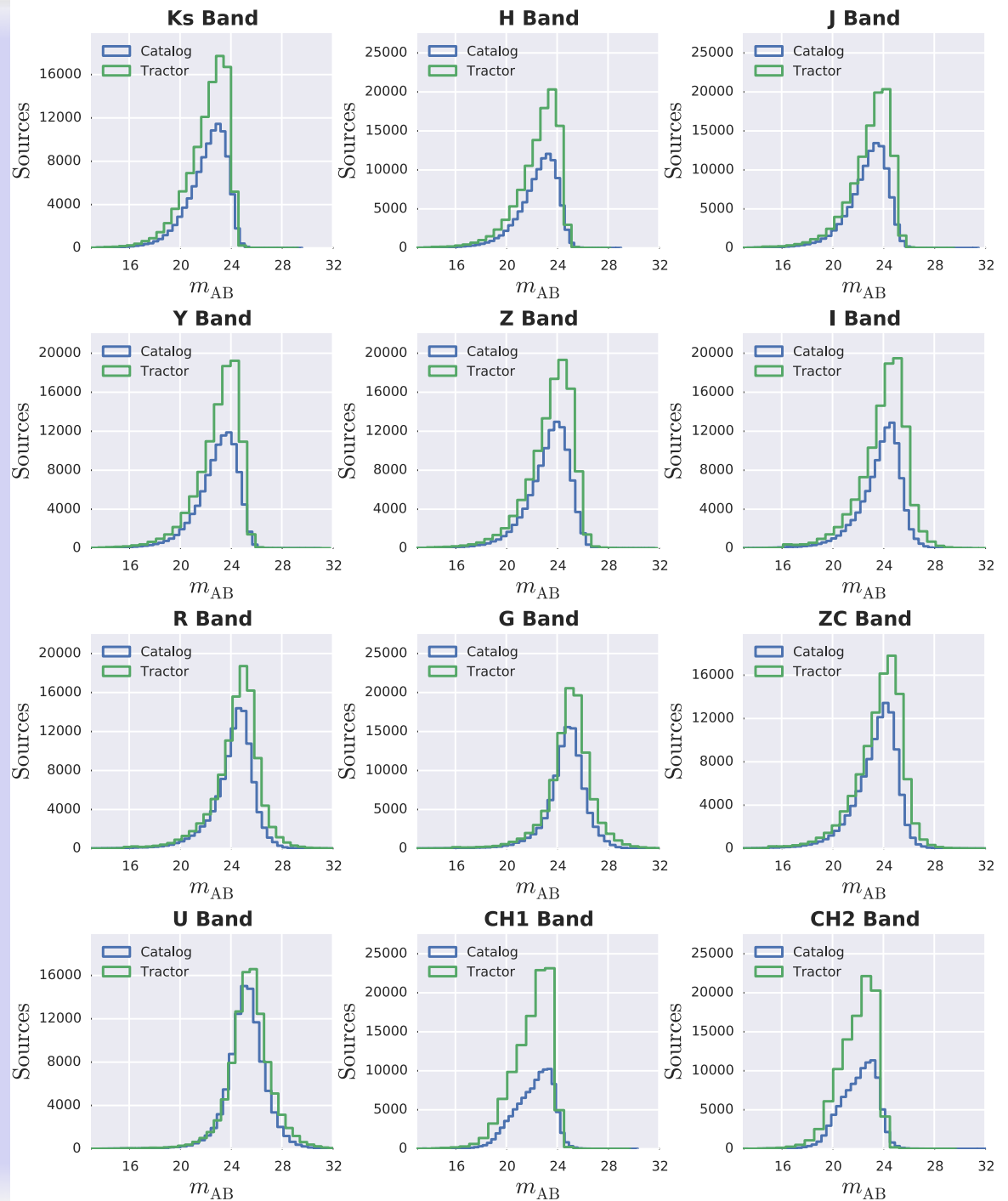
- Create initial source model
- Convolve model with source PSF + calibration params
- Fit the model to the real image

Nyland et al. in prep.



***The Tractor* recovers
more faint sources
than original
SExtractor catalogs**

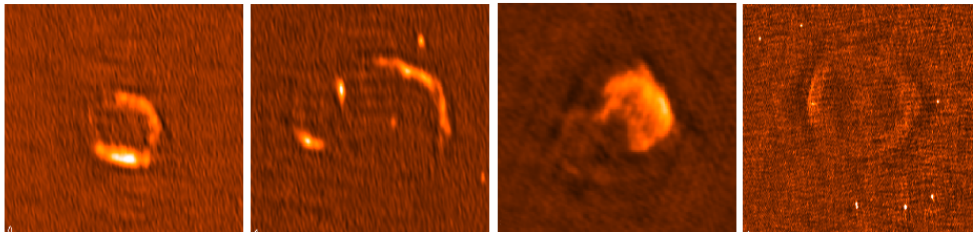
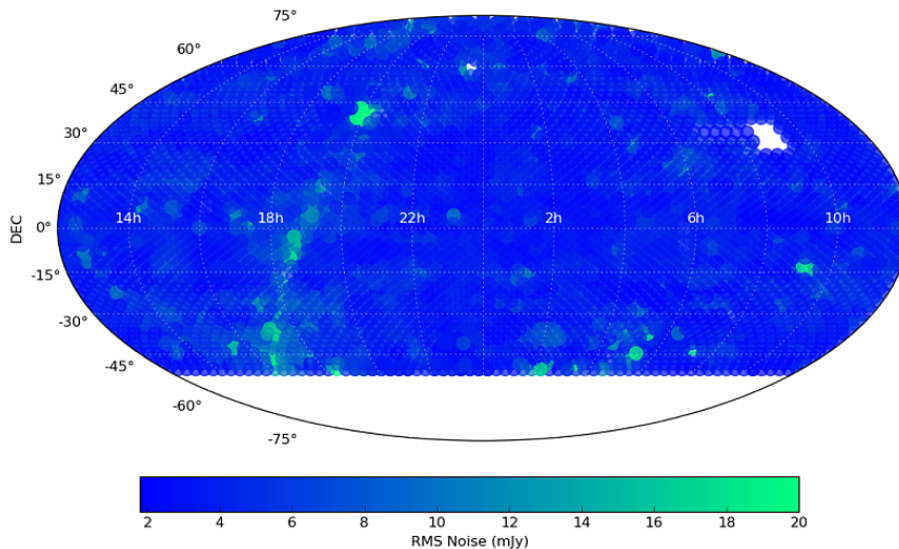
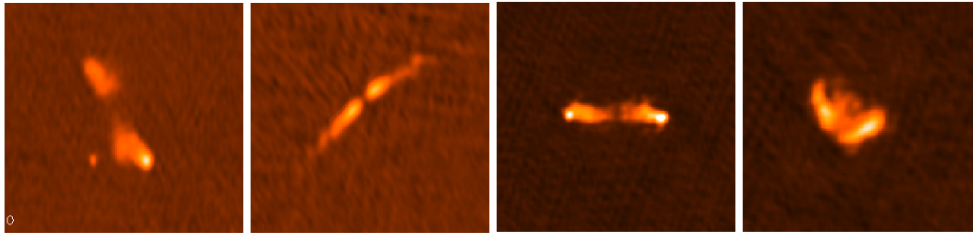
Nyland et al. (in prep)



Radio Continuum Data: 150 MHz

TGSS

Alternative Data Release



**Huib Intema
(Leiden)**



**Preshanth
Jagannathan
(NRAO)**

**Intema, Jagannathan,
Mooley, & Frail 2016**

Sky coverage: 90%

Radio Continuum Data: 1.4 GHz

FIRST

Faint Images of the Radio Sky at
Twenty-one cm



SERVS Fields: XMM, LH, EN1

$\text{RMS} = 150 \mu\text{Jy beam}^{-1}$

$\theta_{\text{FWHM}} = 5''$

ATLAS

The Australia Telescope
Large Area Survey



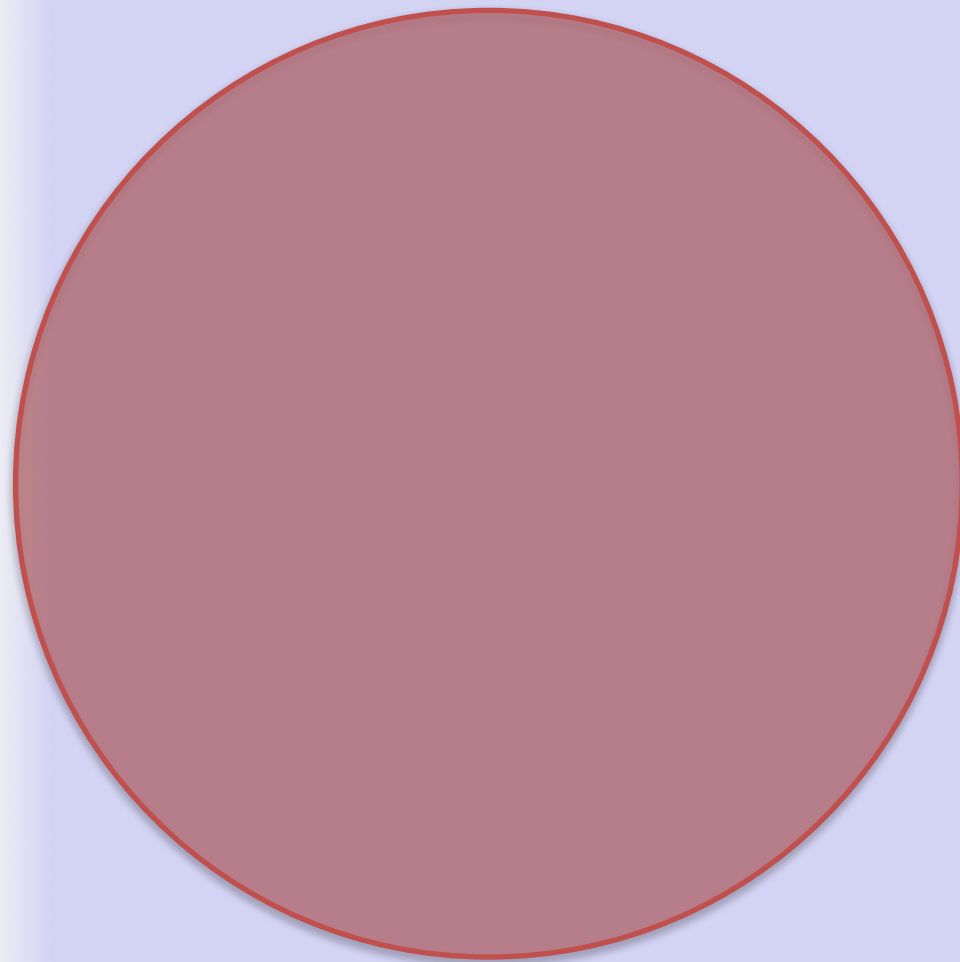
SERVS Fields: CDFS, ES1

$\text{RMS} = 15 \mu\text{Jy beam}^{-1}$

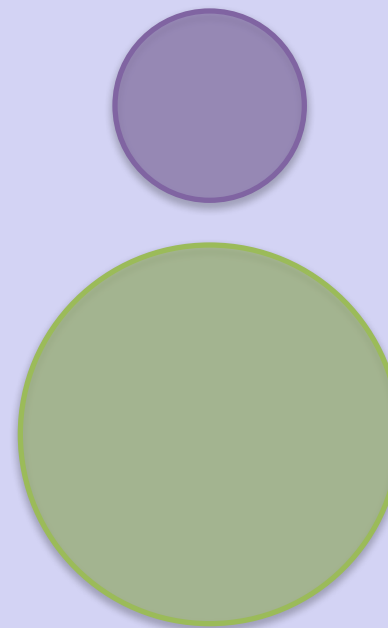
$\theta_{\text{FWHM}} = 10''$

Catalog Matching: Resolution

TGSS



FIRST
ATLAS

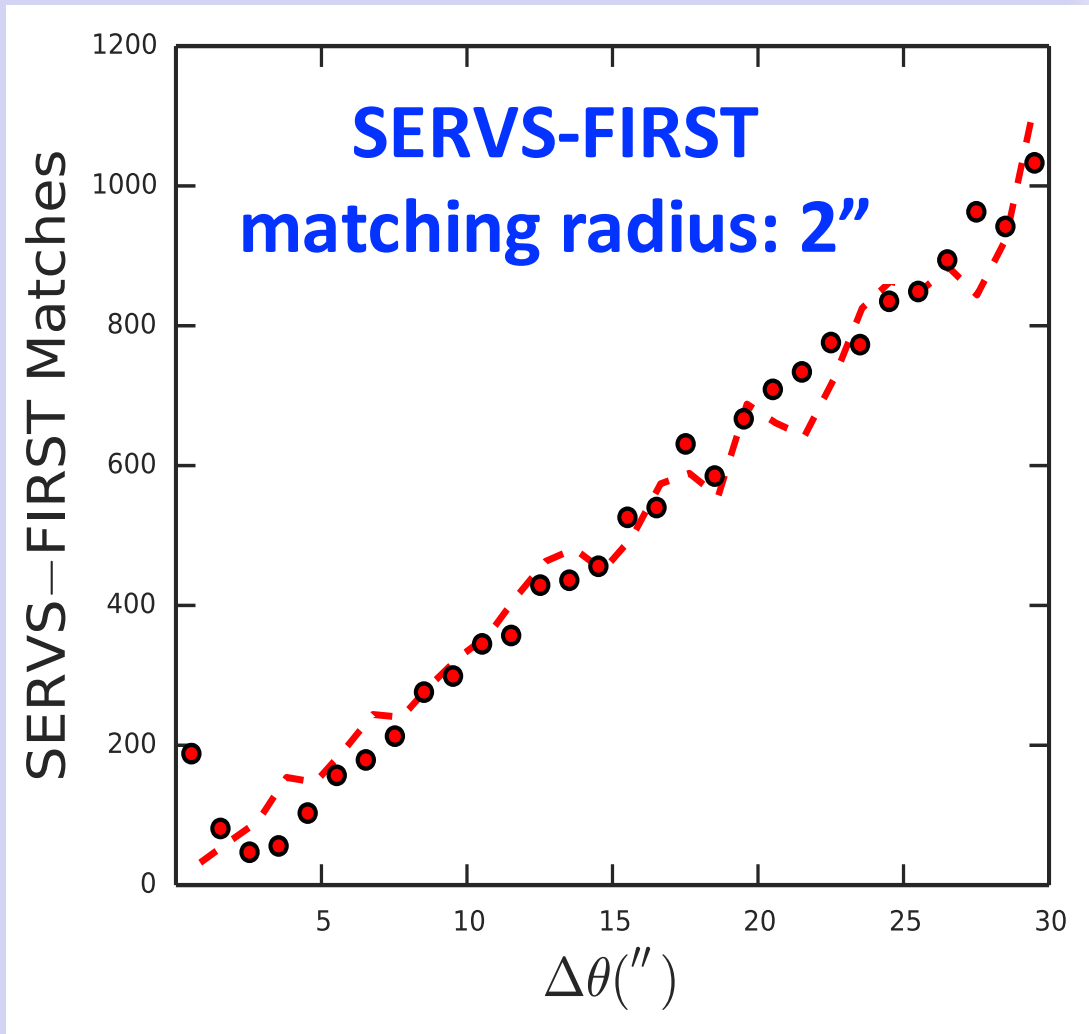
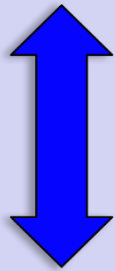


SERVS



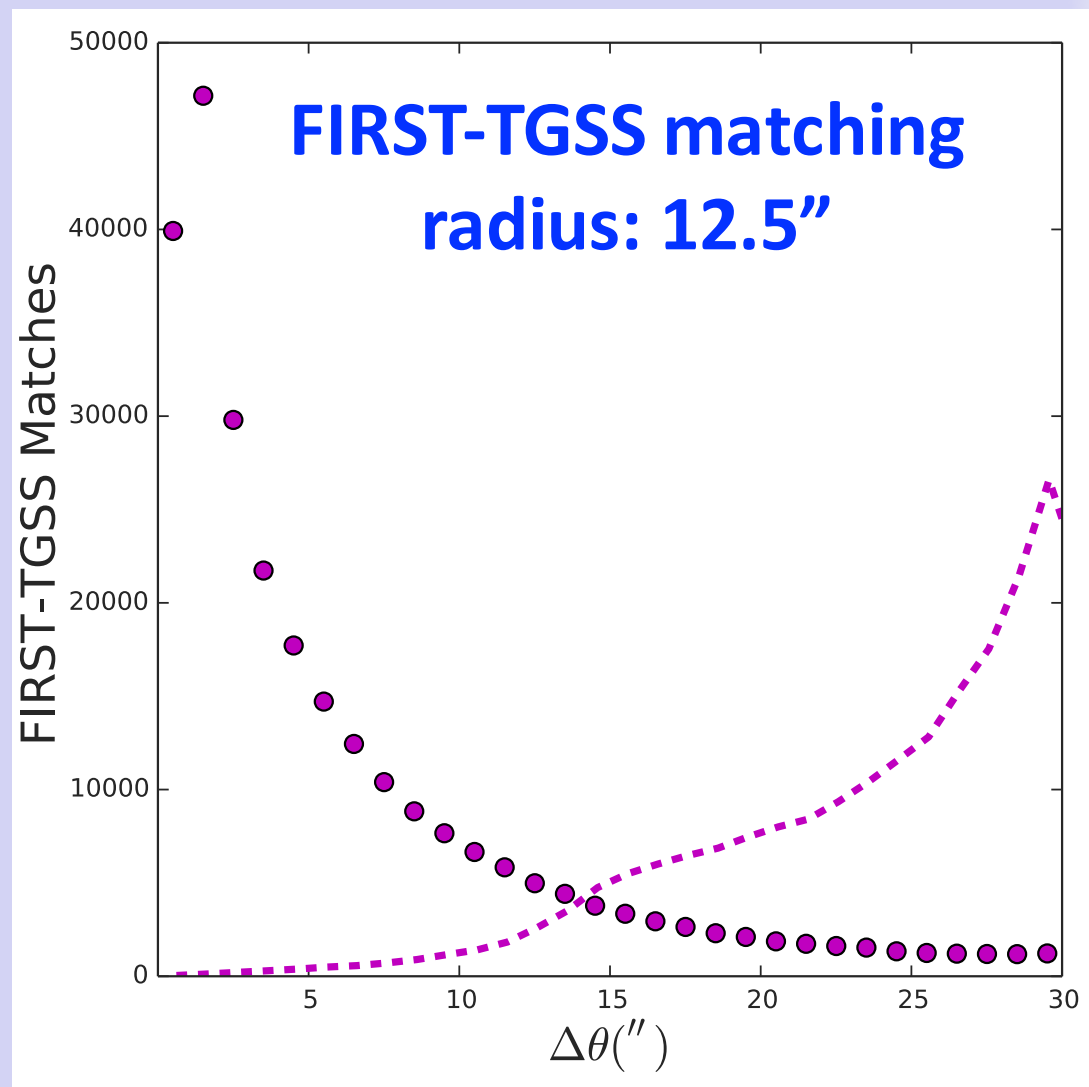
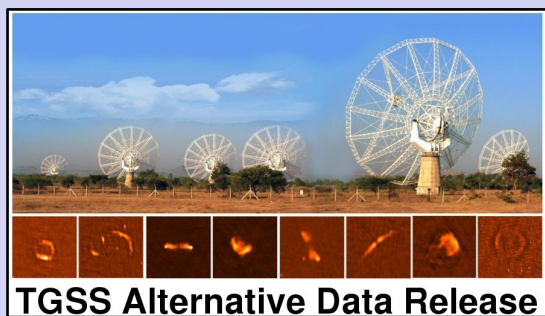
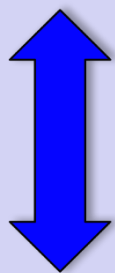
1.4 GHz Point Source Matching

Nyland et al. (in prep)

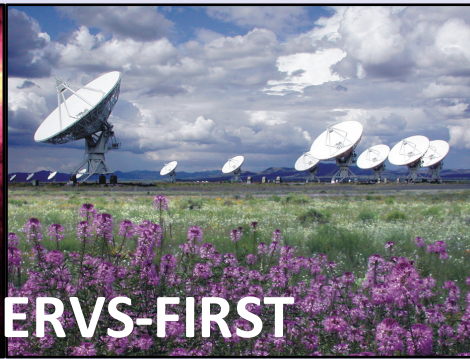


150 MHz Point Source Matching

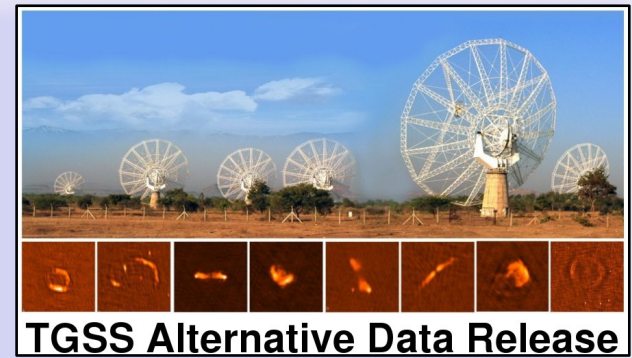
Nyland et al. (in prep)



150-1400 MHz Matches



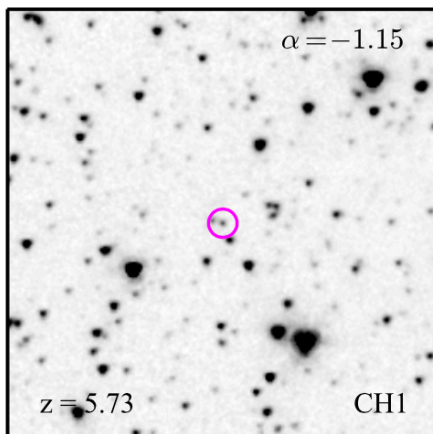
12.5"
183
matches!



$z = 5.73$

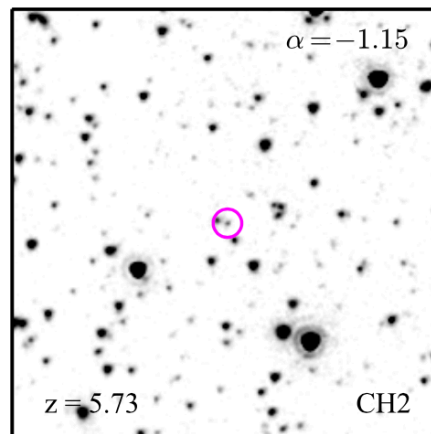
$\alpha = -1.15$

J104741+584812



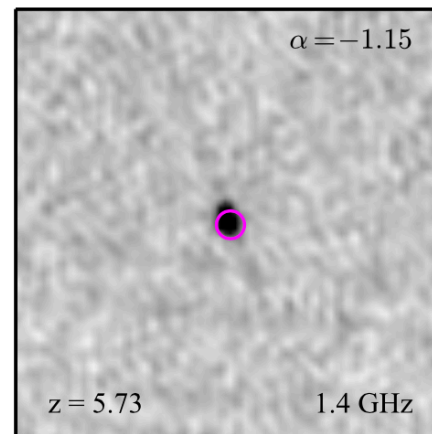
3.6 μm

J104741+584812



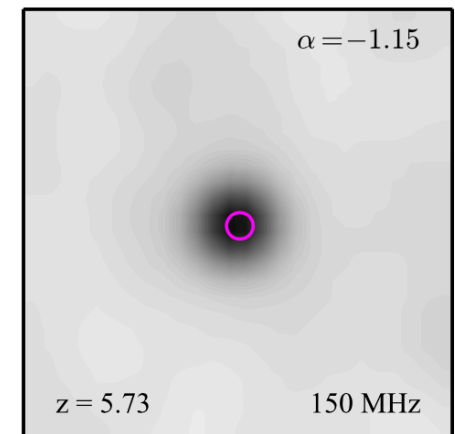
4.5 μm

J104741+584812



FIRST

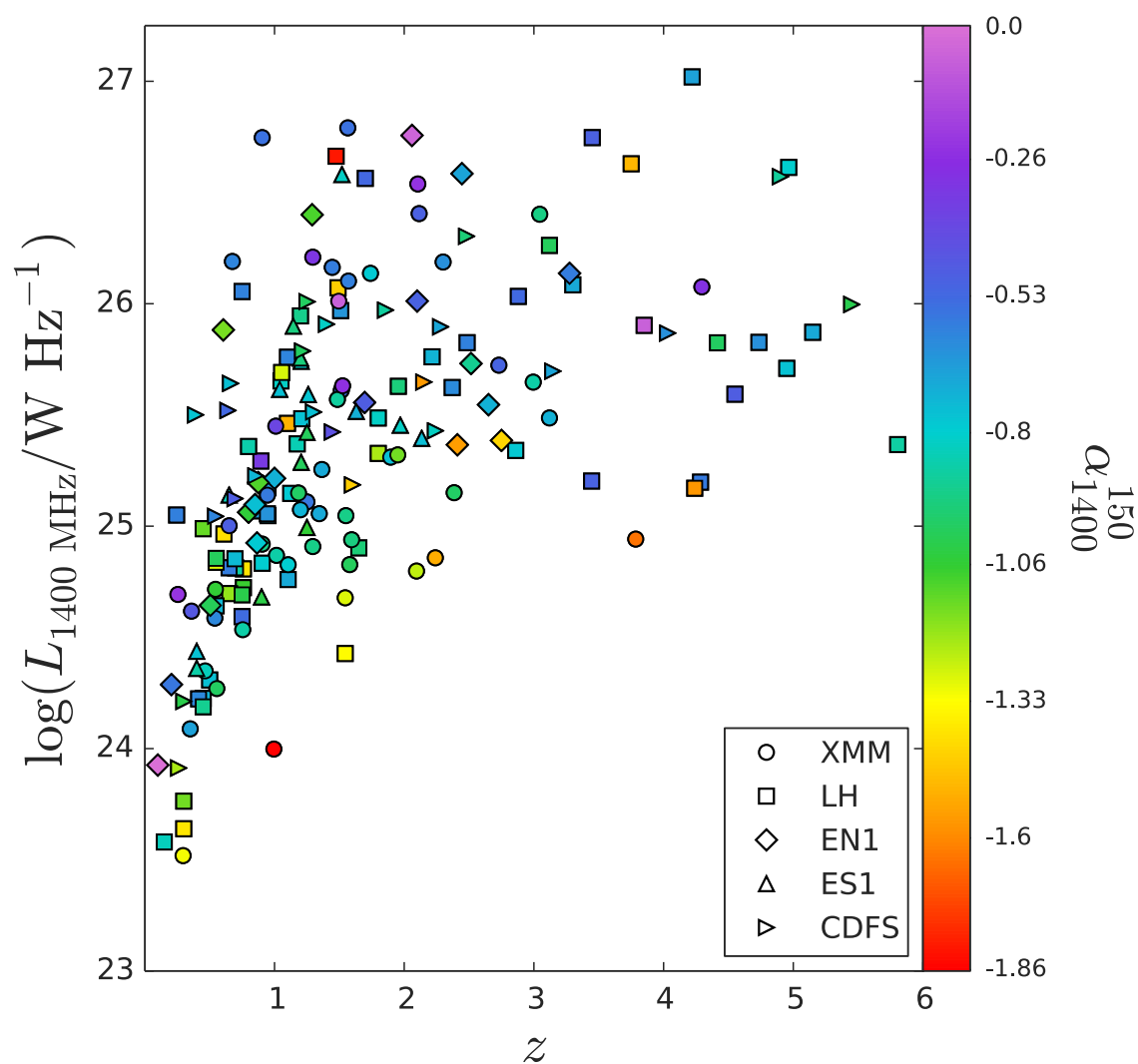
J104741+584812



TGSS

Redshift Distribution

Nyland et al. (in prep)

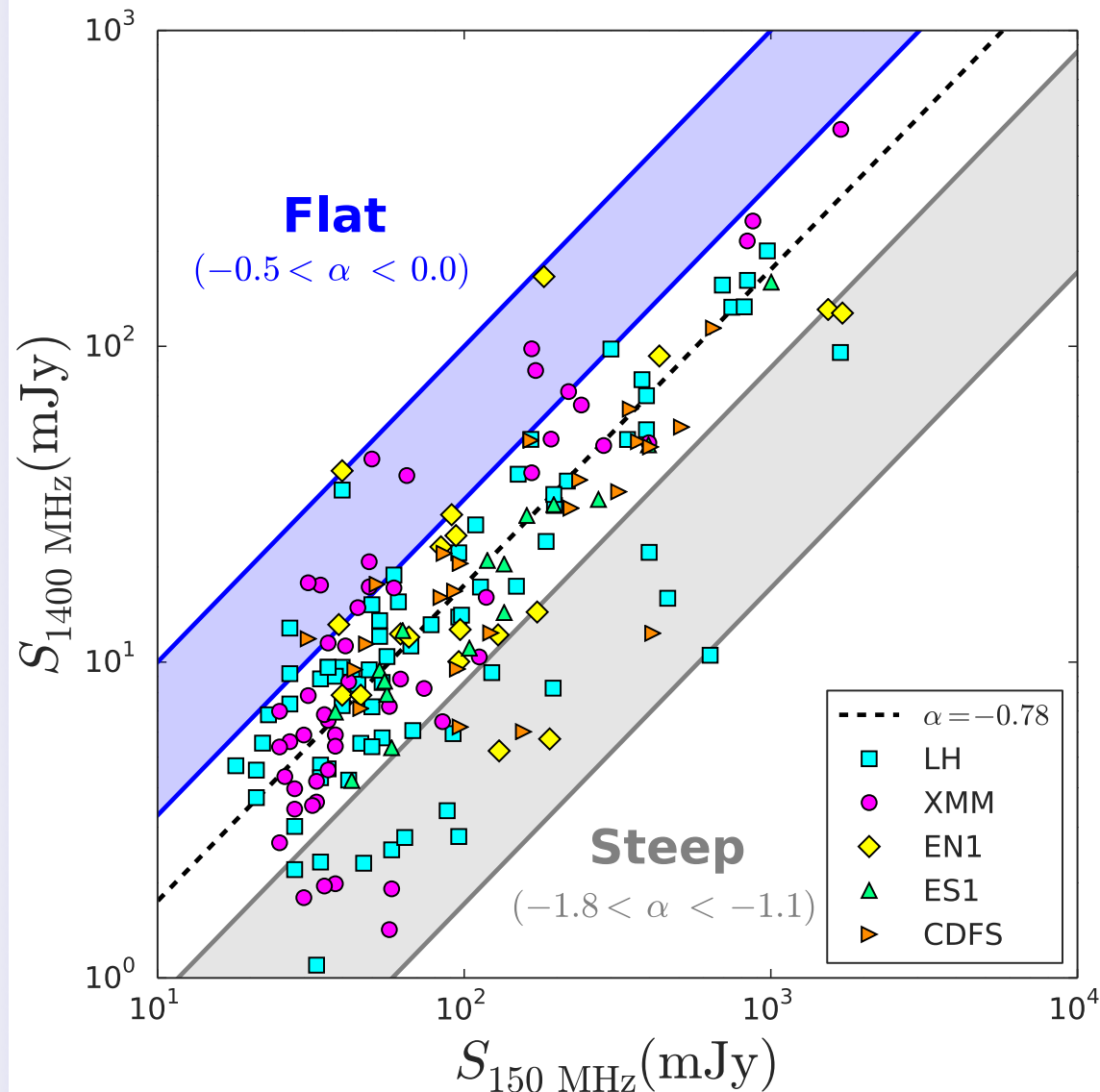


redshifts out
to $z = 6$

$0 < \alpha < -1.86$

150-1400 MHz Radio Spectral Indices

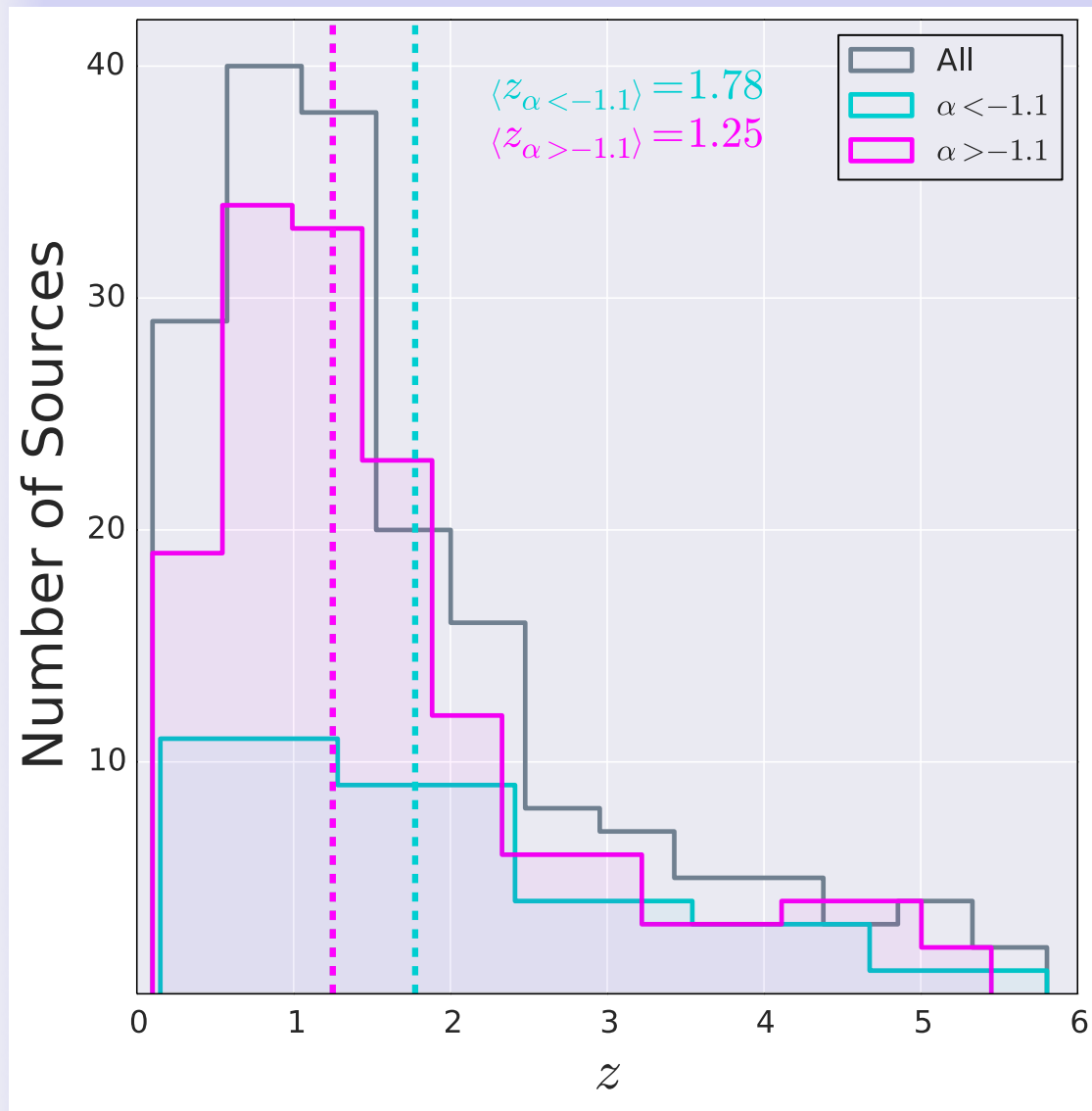
Nyland et al. (in prep)



**29 candidate
steep-spectrum
sources**

Radio Spectral Index Evolution?

Nyland et al. (in prep)



**Median z offset
between $z < -1.1$
and $z > 1.25$: 0.53**

**PRELIMINARY only .
.. additional
analysis in progress!**

Future Work

- ***Tractor* photometry for all SERVS fields (in progress)!**
- **Improved redshifts using new *Tractor* photometry**
- **Detailed statistical analysis of the α -z relation**
- **Follow-up ALMA observations to test “frustrated jet” scenario?**
- **Extension to additional surveys?**

Summary

- New multi-band SERVS catalogs using *The Tractor* will provide:
 - IRAC source de-blending
 - Faint source detection
 - More accurate photometric redshifts!
- SERVS + TGSS + existing 1.4 GHz surveys → study the cosmic evolution of radio spectral indices and the radio AGN-galaxy evolution connection
- Preliminary study of the 150-1400 MHz radio spectra of 183 sources in SERVS is in progress