ASKAP Continuum Surveys

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SPARCS 2017

Image Credits:
Barnaby Norris (left)
Brett Hiscock (right)

Australian SKA Pathfinder

- 36-antenna multi-beam interferometer in a radio-quiet zone
  - Frequency range: 700 MHz – 1.8 GHz, 300 MHz bandwidth
  - Baselines: 23m to 6km, compact 2km core
- Survey instrument – wide instantaneous field of view
  - Phased-array feed (PAF) + flexible beamformer
  - 3-axis mount (whole antenna can rotate)
  - (Quasi) real-time processing
  - Service observing, science ready data products
- Early science with 12-antenna array is ongoing

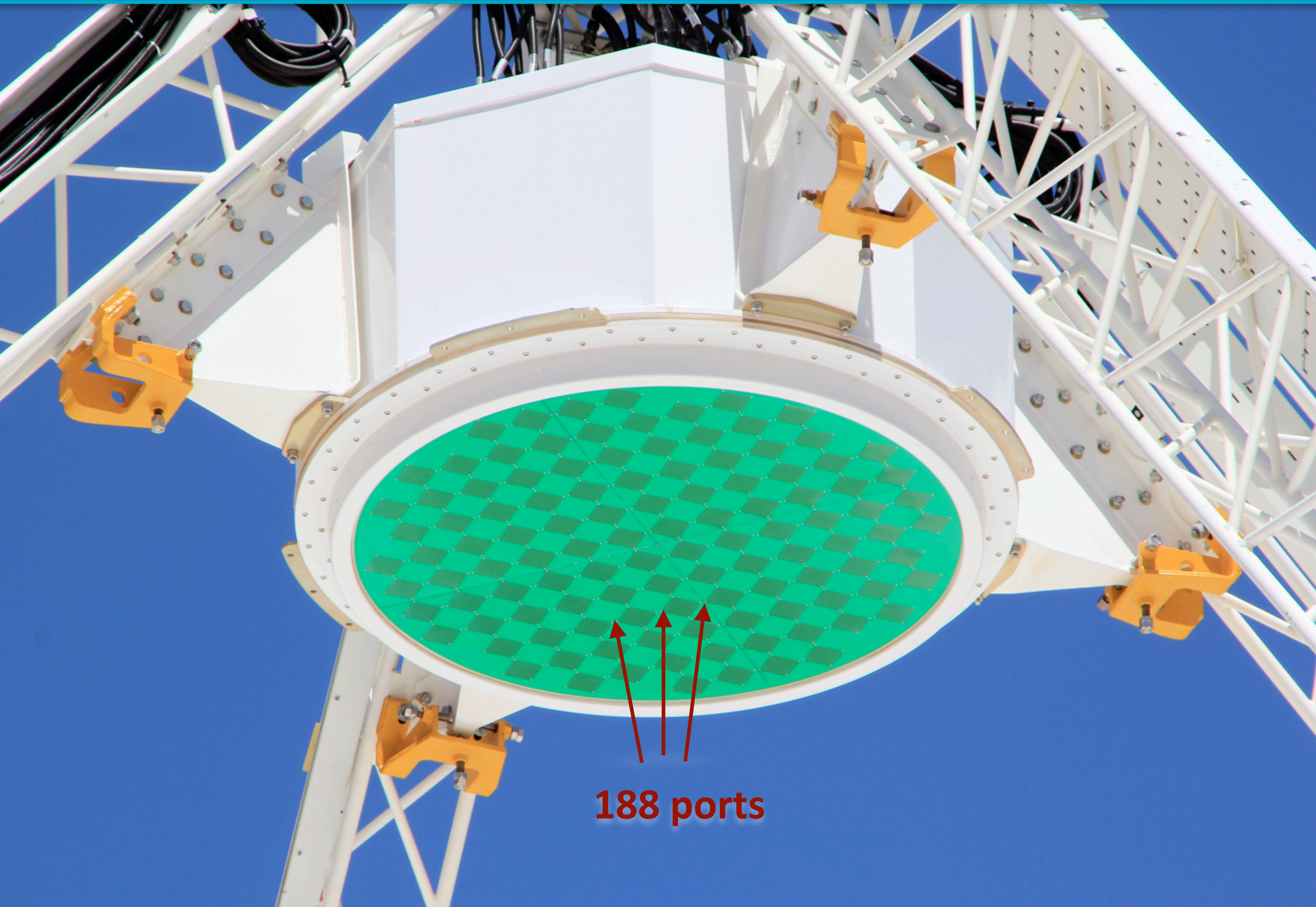

New Electronics

23 SEPTEMBER 2008

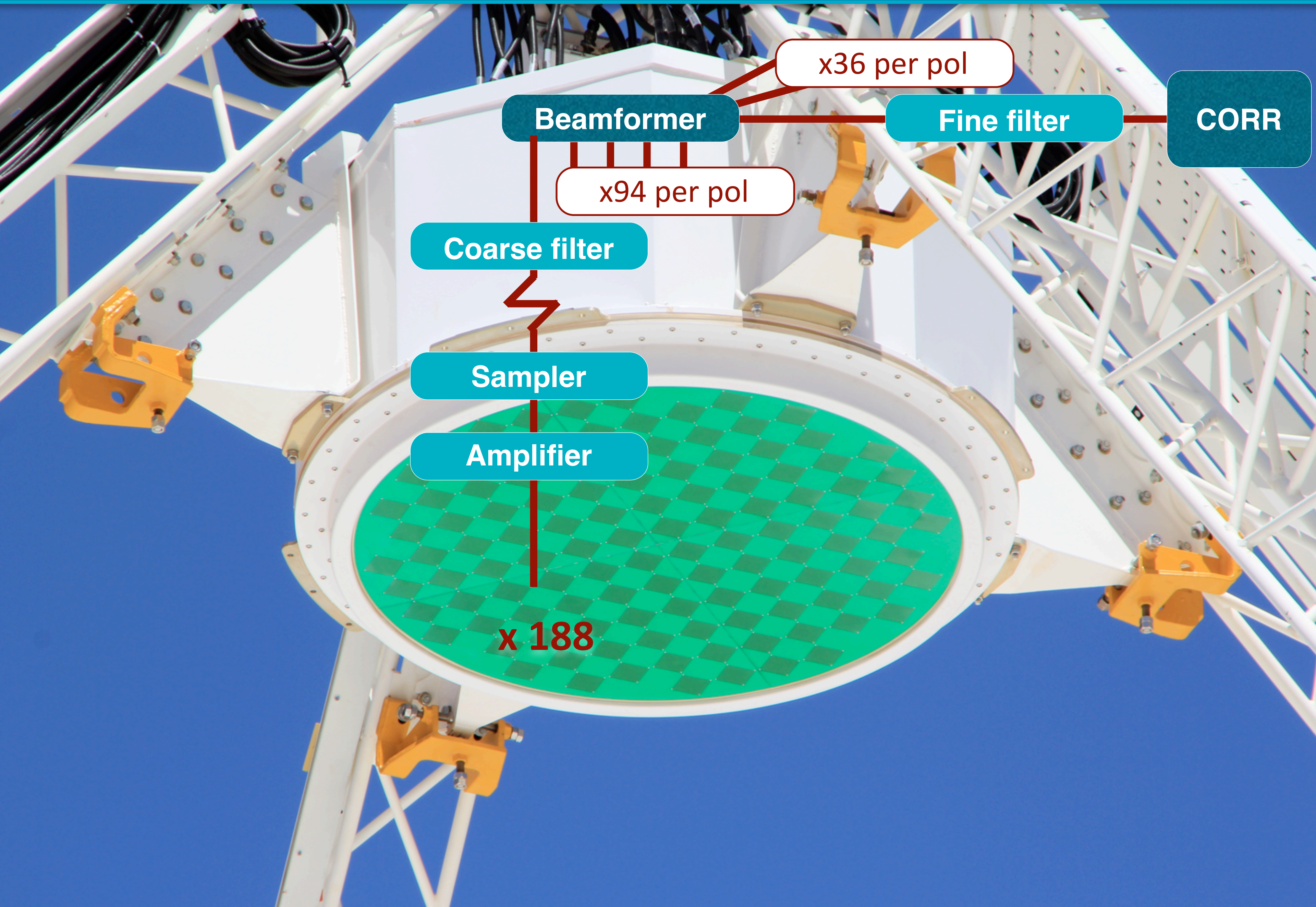
A better view of the skies

The Square Kilometre Array is set to provide astronomers with unprecedented views of what's out there – and opportunities for UK electronics.

ASKAP's Phased Array Feed (PAF)



ASKAP's Phased Array Feed (PAF)



Evolutionary Map of the Universe

Observe 75% of the sky (to dec +30)

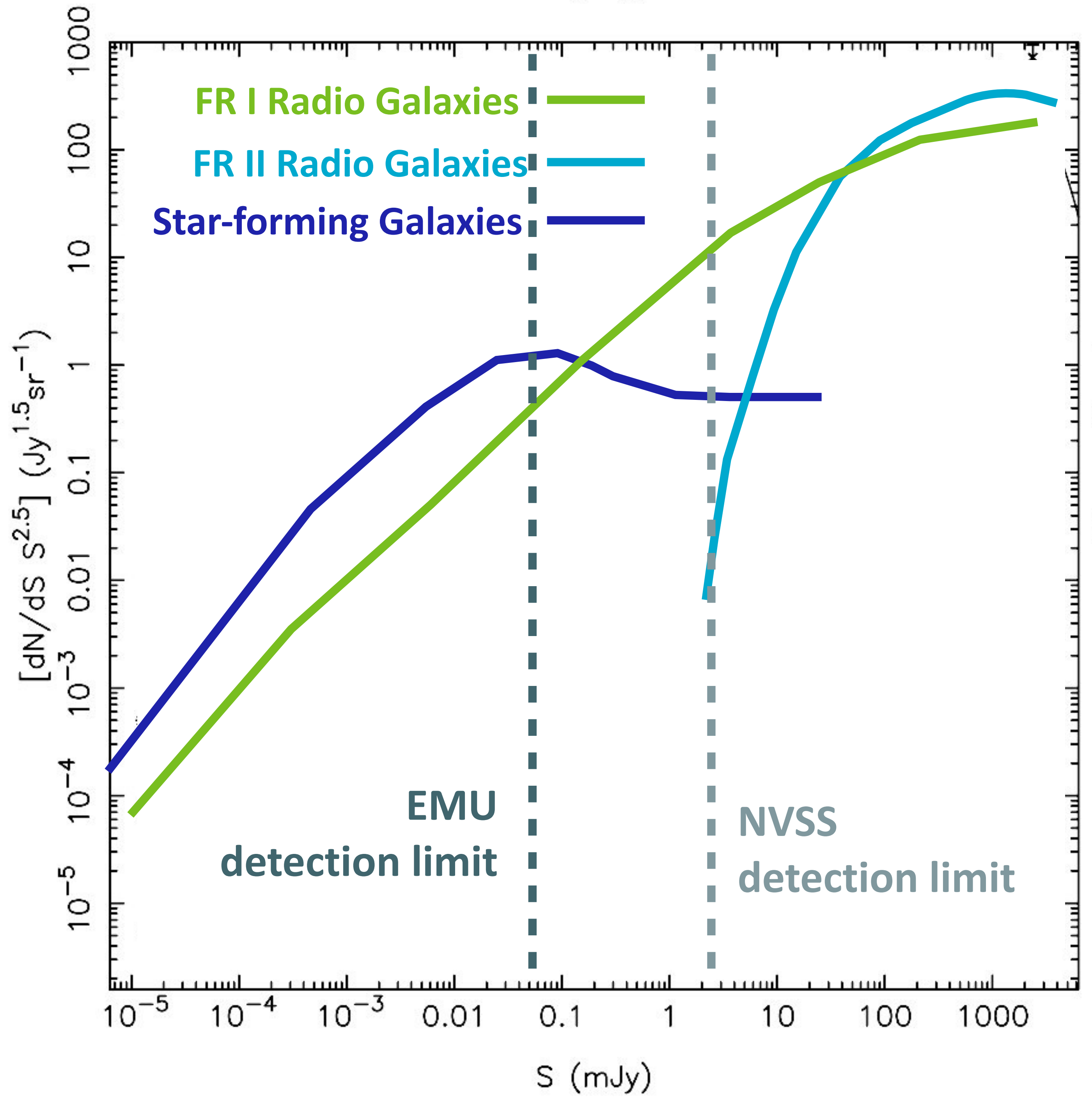
Frequency range: 1130-1430 MHz

10 uJy bm^{-1} thermal noise, 10^5 dynamic range

10 arcsec resolution,   >10 arcmin LAS

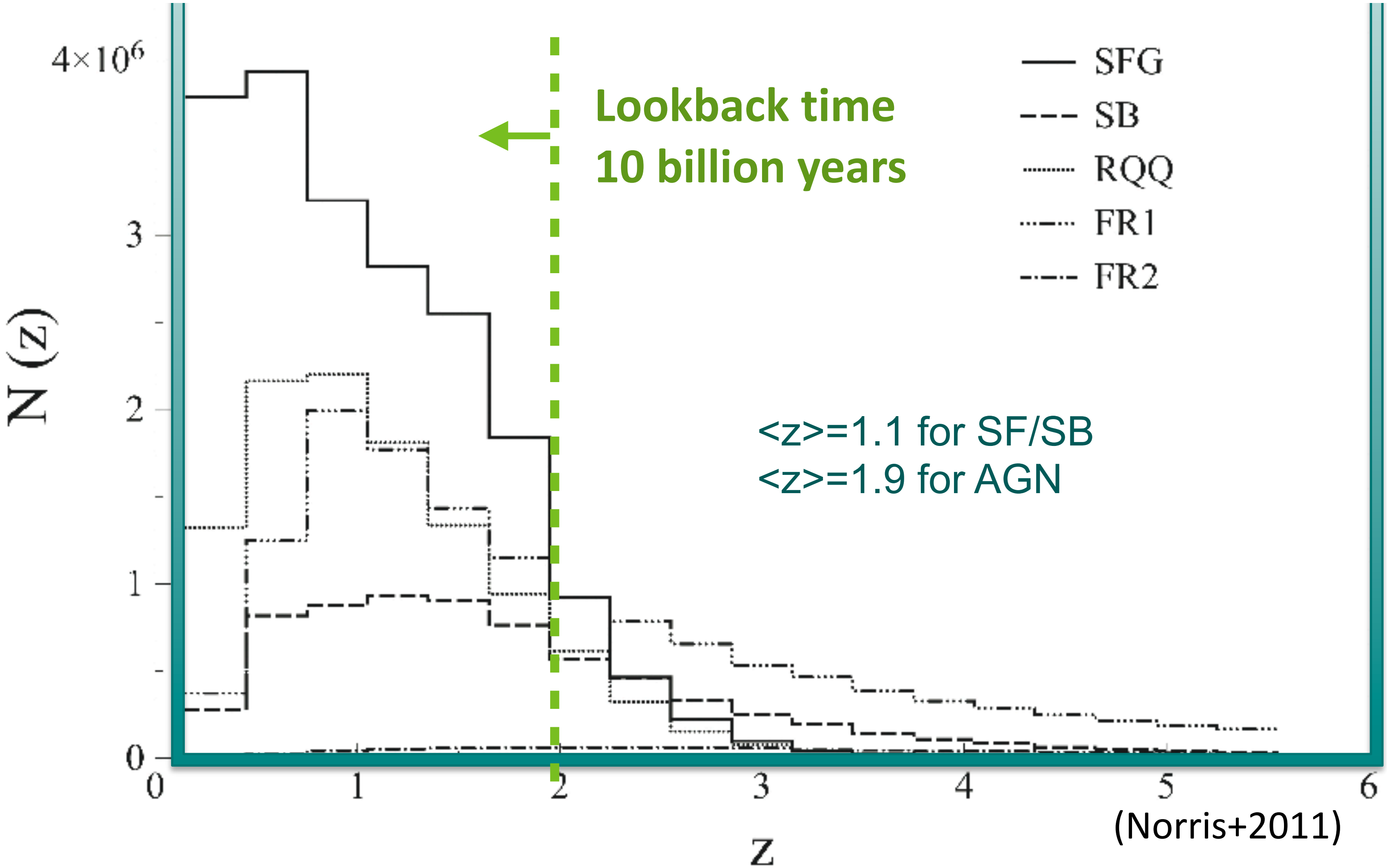
Will detect and image **70 million galaxies** at 20 cm

	SUMSS	NVSS	EMU
Frequency (MHz)	843	1400	1280
Sensitivity (uJy)	1000	450	10
Resolution (“)	43/cos δ	45	10
Declination (	< -30	> -40	< +30
Area (deg	8,100	34,000	31,000
# of Sources	2E+05	2E+06	7E+07



FR I Radio Galaxies
FR II Radio Galaxies
Star-forming Galaxies
EMU
detection limit
NVSS
detection limit
[dN/dS S^2.5] (Jy^1.5 sr^-1)
S (mJy)

Redshift distribution of EMU sources



(Norris+2011)

Based on SKADS (Wilman et al; 2006, 2008)

CSIRO

The EMU Survey

14 Key Science Projects

12 Collaboration Projects

14 Development Projects

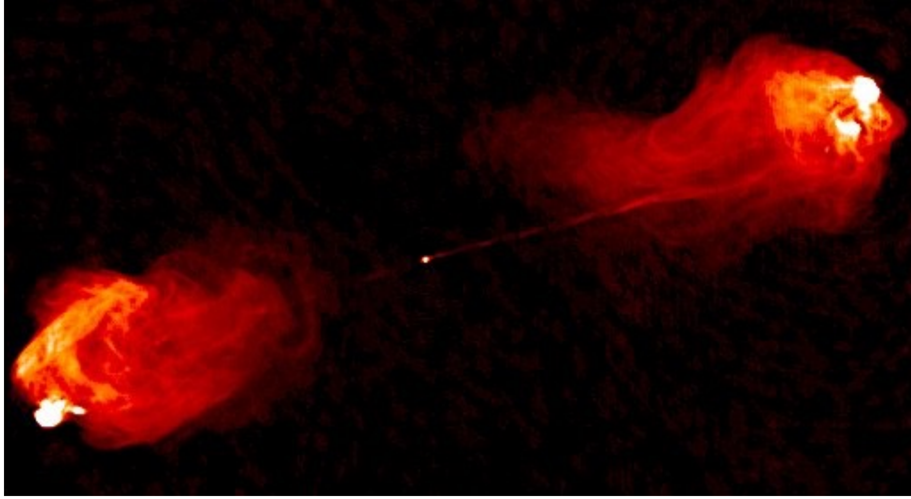
21 Early Science Projects

EMU Key Science Projects

How do galaxies form and evolve?

Active Galaxies

These KSPs are dedicated to radio galaxies and AGN:



Assemble RLFs and KLFs and determine how they evolve

Over time, with host galaxy properties, with BH accretion state

Investigate duty cycles, triggering and lifetimes and feedback

Identify RQ-AGN and study the origin of their radio emission

Study the highest redshift AGN and their role in the EOR

Discover new candidate binary black holes

Star formation

This KSP will measure the SFR of galaxies over cosmic time:

Combine radio data with UV to FIR star formation indicators

Improve SFR calibrations and SF-AGN classifications

Photometric colors, spectroscopic diagnostics, radio properties

Derive the cosmic SFH and growth of stellar mass

Test the dependence on mass, environment, color, etc.

Galactic plane

These KSPs will explore continuum radio emission from our Galaxy:

Create an atlas of discrete radio continuum sources

Supernova remnants, pulsars and PWNe, HII regions, PNe,

flare stars, CSE, active binaries, ultra-cool dwarfs, LBV, WR

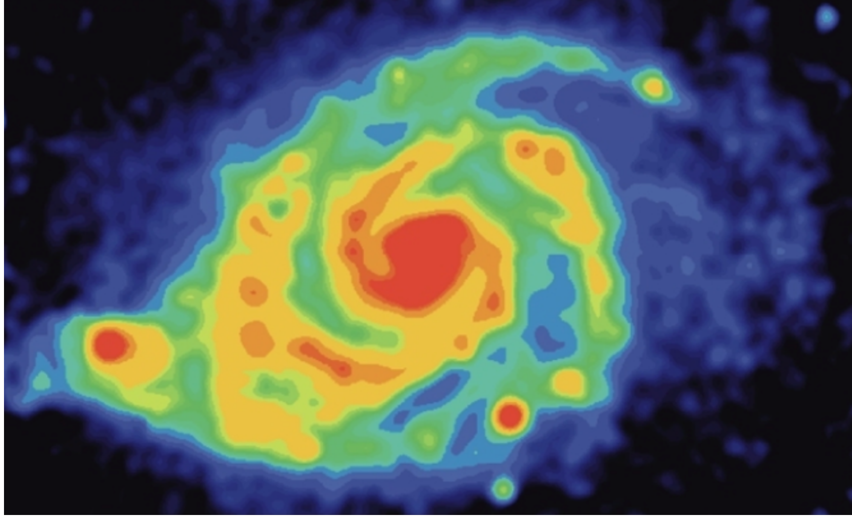
Cross match with stellar catalogs to discover new radio stars

Assemble an evolutionary sequence of HII regions

Detect the youngest and most compact SNRs

Local galaxies

These KSPs will focus on nearby galaxies and the Magellanic Clouds:



Resolve large angular size spiral disk galaxies

- Distribution of SFR tracers, radio spectral index, FRC
- Correlate with optical, IR morphology, HI kinematics

Search for extended continuum emission in edge-on galaxies

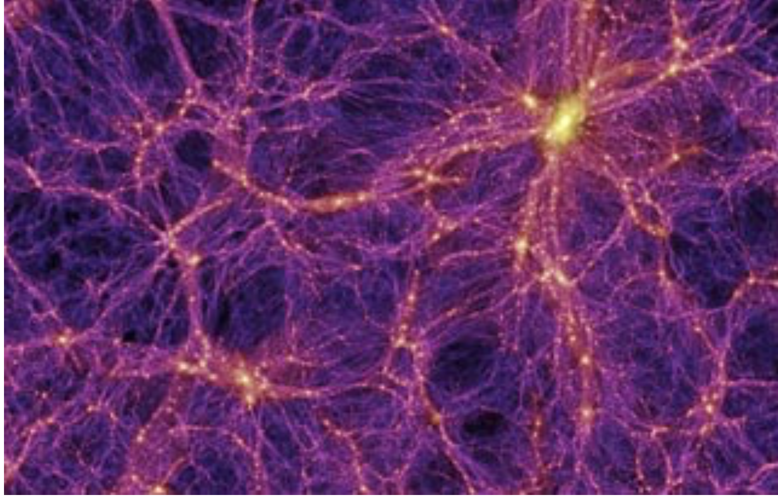
Build multi-wavelength SED templates

Complete sample of SNR, HII regions, PNe in MCs

Probe MC's ISM, B-field using background sources

Large scale structure

These KSPs will investigate galaxy clusters and the synchrotron cosmic web:



Direct search, stacking and cross-correlation of radio emission

Diffuse synchrotron, accretion shocks, dark matter annihilation

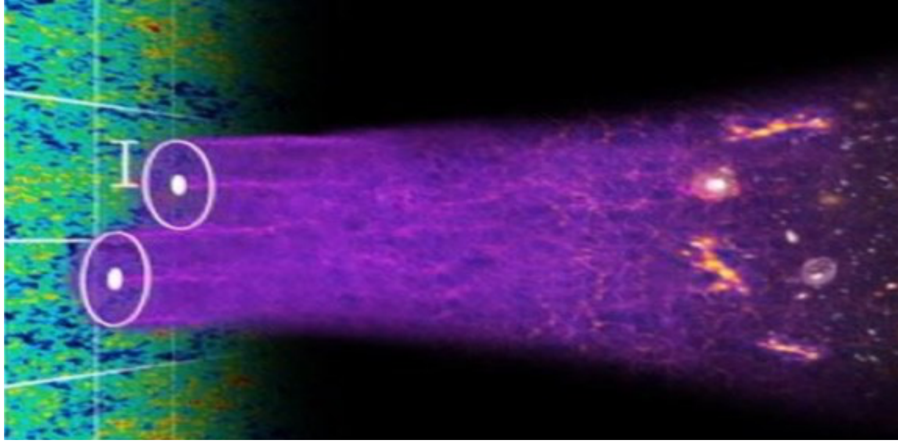
SFR vs redshift, merger state, richness of environment

Study halo generation, turbulence, B-field, X-ray luminosity

RLF of early and late type cluster members and radio relics

Distortion of radio galaxy tails by IGM weather

Cosmology



This KSP will place constraints on cosmological observables:

Cosmic Magnification of high-redshift EMU galaxies by low-redshift optical foreground galaxies

Cross correlation of EMU and (e.g. Skymapper or TAIPAN) sample

Cosmic Magnification of CMB by EMU galaxies

Cross-correlation between EMU density and CMB on small scales

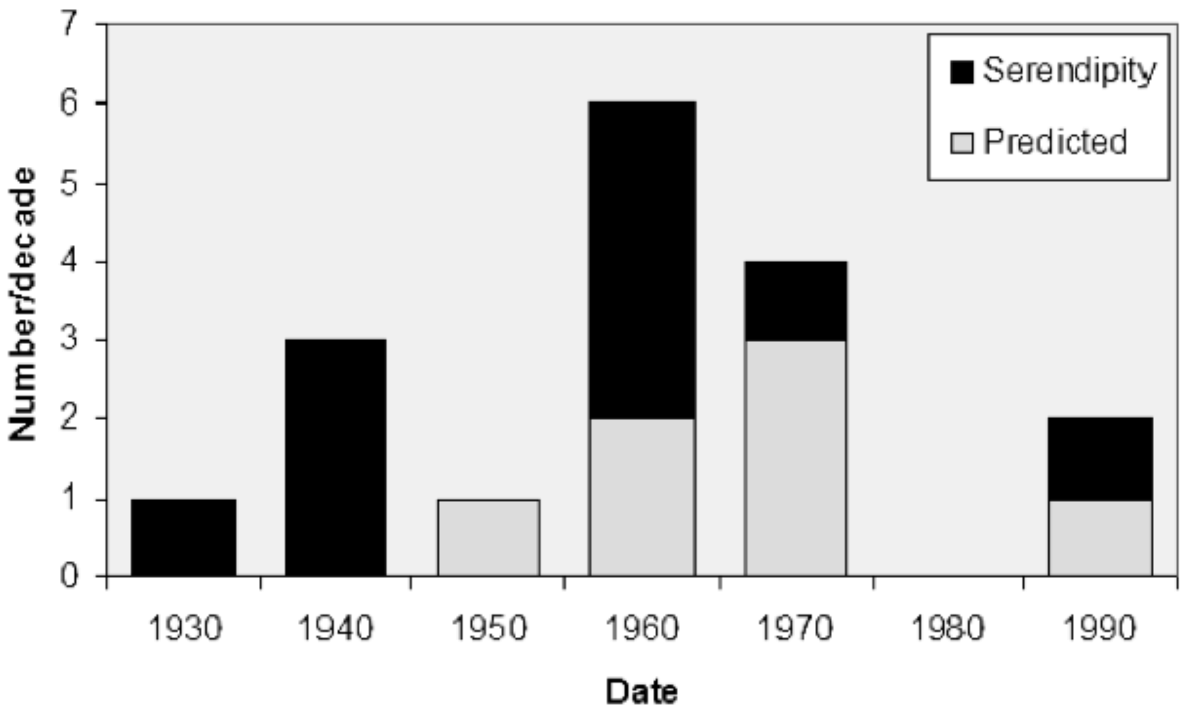
Integrated Sachs-Wolfe effect

Cross-correlation between EMU density and CMB on large scales

Angular correlation function of EMU galaxies

Unknown Unknowns

This KSP will search for rare and unusual types of objects:



Serendipity: 10
Predicted: 7

From Ekers (2009) PoS(sps5)007

See also:

- *Harwit(1981), Cosmic Discovery*
- *Kellermann(2009) PoS(sps5), 44*
- *Wilkinson et al.(2004), New Astr. Rev., 48, 1551 45*
- *Wilkinson(2007) the Modern Radio Universe, 144*
- *Wilkinson(2015) (AASKA14), 65*

CSIRO

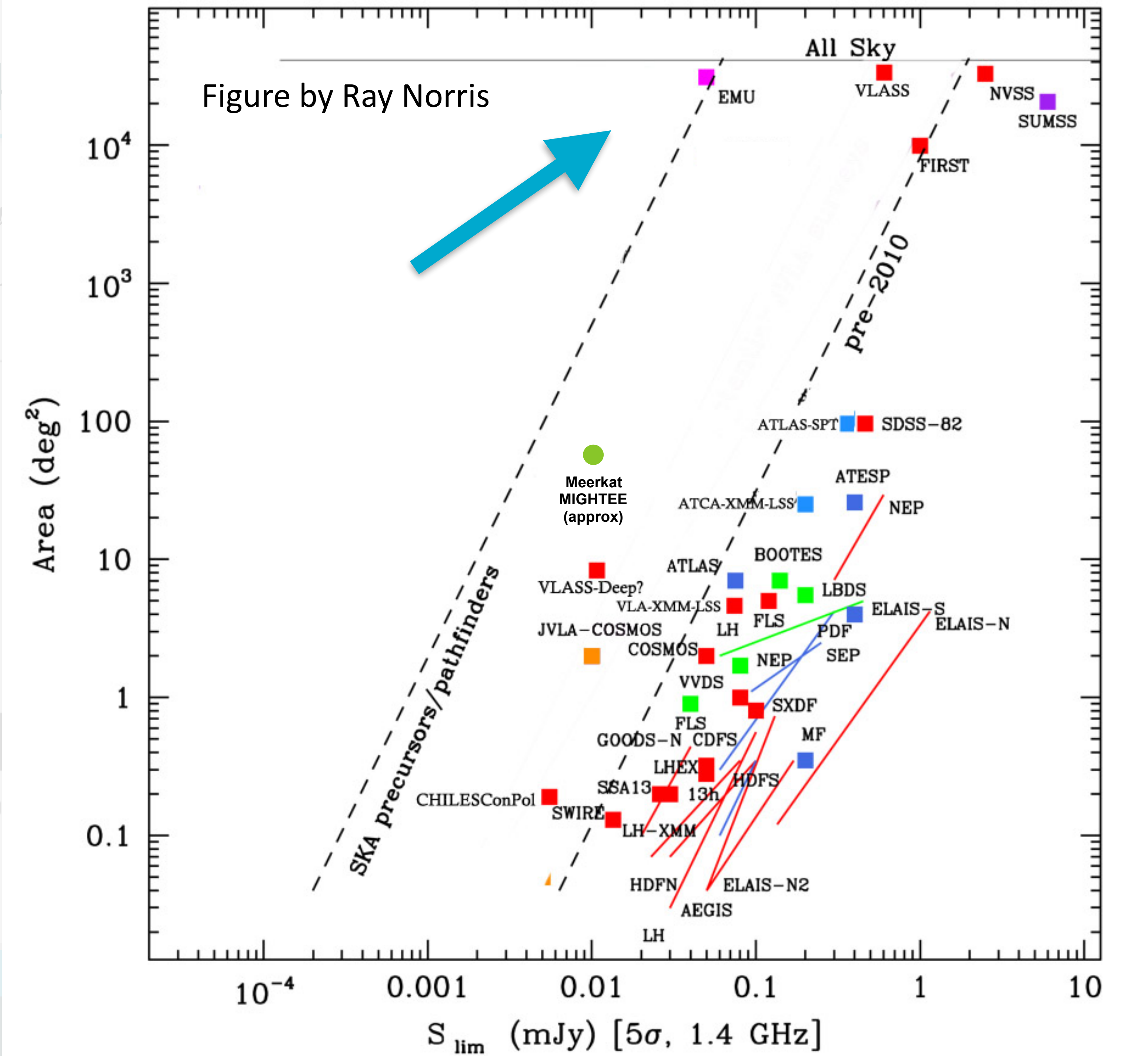


Figure by Ray Norris
All Sky
EMU
VLASS
NVSS
SUMSS
FIRST
pre-2010
SKA precursors/pathfinders
ATLAS-SPT
SDSS−82
Meerkat
MIGHTEE
(approx)
ATESP
ATCA-XMM-LSS
NEP
BOOTES
ATLAS
VLASS-Deep?
LBDS
VLA-XMM-LSS
FLS
ELAIS−S
ELAIS−N
JVLA−COSMOS
LH
PDF
COSMOS
SEP
NEP
VVDS
SXDF
FLS
GOODS−N
CDFS
MF
LHEX
SSA13
HDFS
13h
CHILESConPol
SWIRE
LH−XMM
HDFN
ELAIS−N2
AEGIS
LH
Area (deg^2)
S_{lim} (mJy) [5σ, 1.4 GHz]

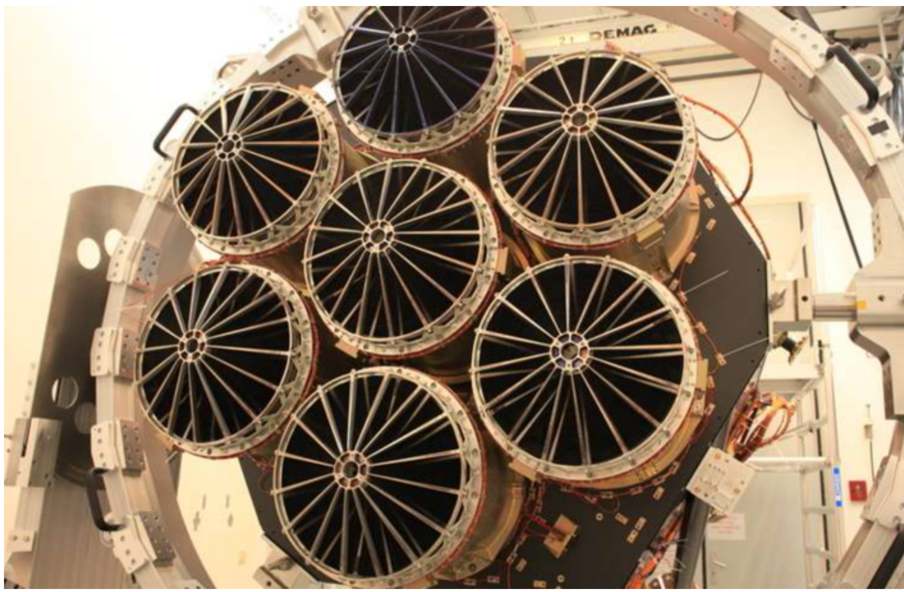
EMU Collaboration Projects

Multi-wavelength connections

EMU Collaboration projects

eROSITA

the whole sky in X-rays



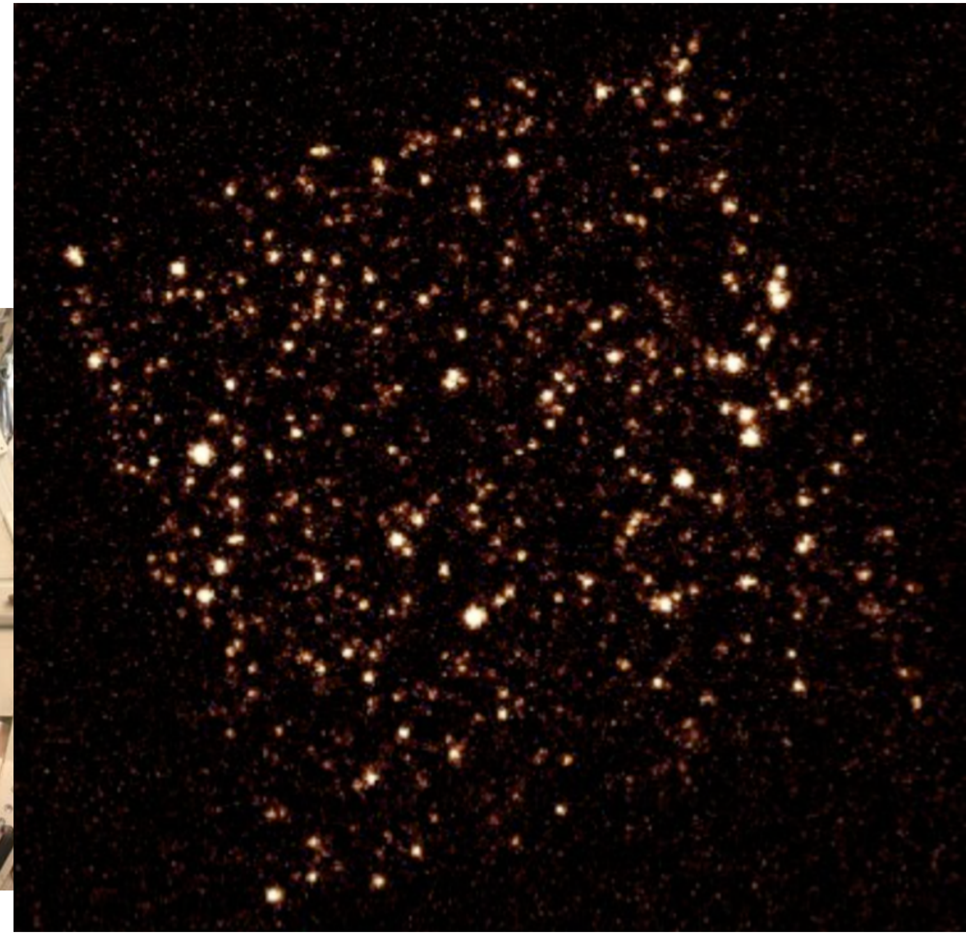


Image Credits: Max Planck Institute for Extraterrestrial Physics

EMU Collaboration projects

VISTA

WISE

THE DARK ENERGY SURVEY

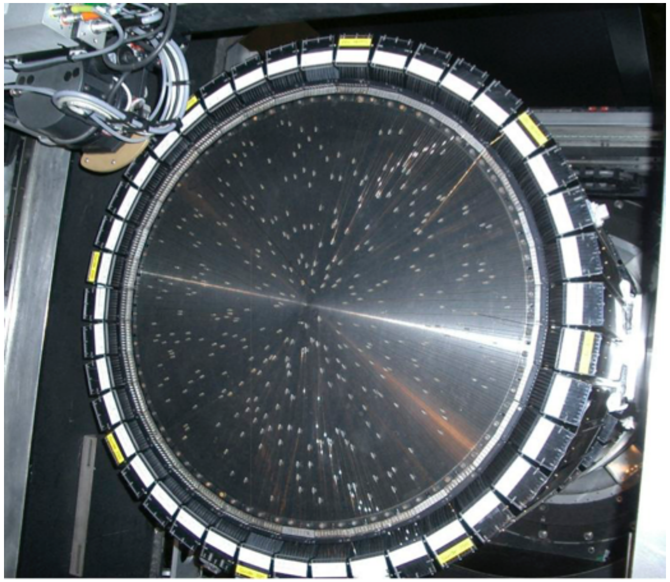
LSST

SkyMapper

EMU Collaboration projects

OzDES

TAIPAN



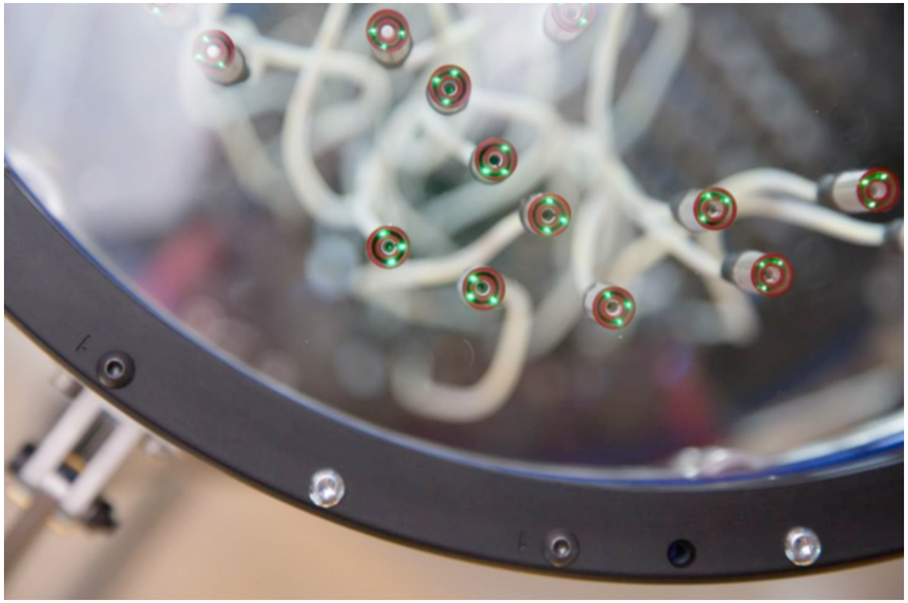


Image Credits: Australian Astronomical Observatory

EMU Collaboration projects

VLA SKY SURVEY

WALLABY

MWA
MURCHISON
WIDEFIELD
ARRAY

ASKAP-FLASH

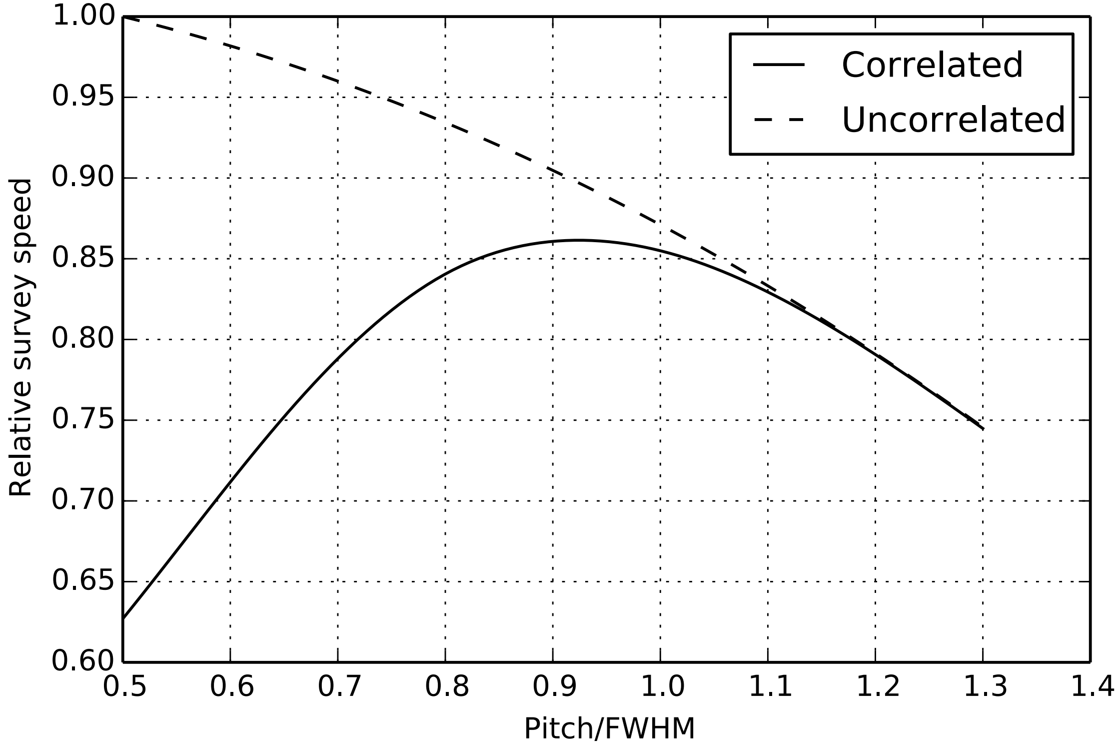
POSSUM
POLARISATION SKY SURVEY OF THE UNIVERSE'S MAGNETISM

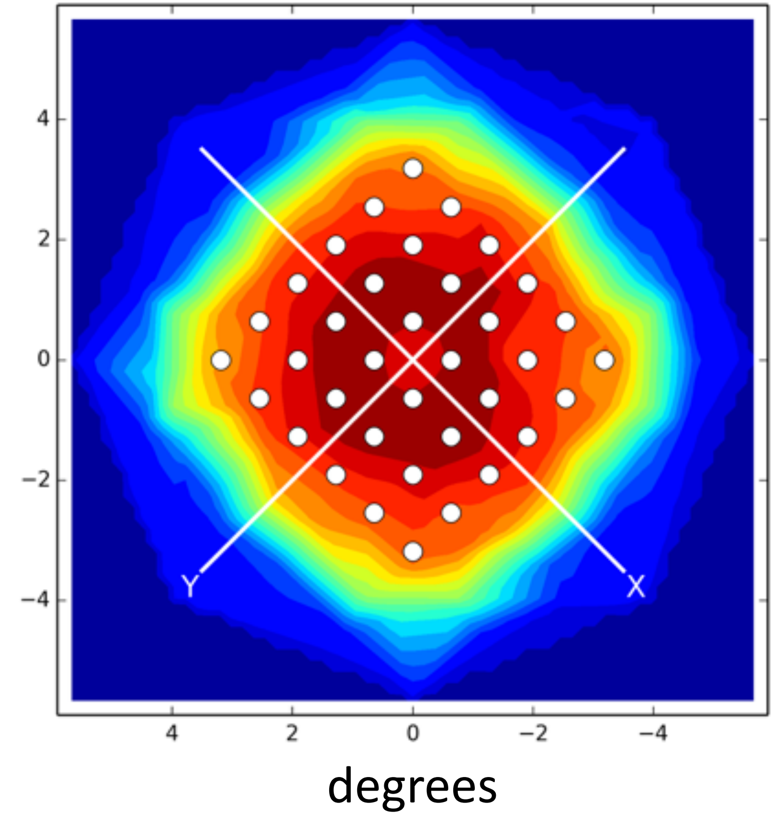
EMU Development Projects

Next-generation techniques

Observing strategy

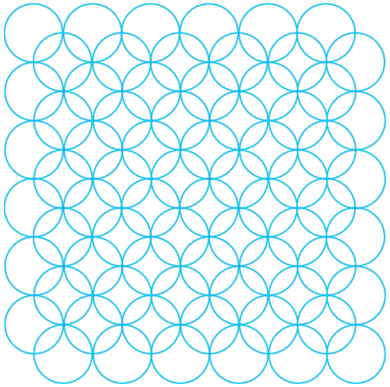
$$SS_s = \frac{B\,N_p\,N_a^2\,\sigma_s^2}{(\mathrm{SEFD}_0)^2}\iint_{FoV} A^2(l,m)\,dl\,dm$$

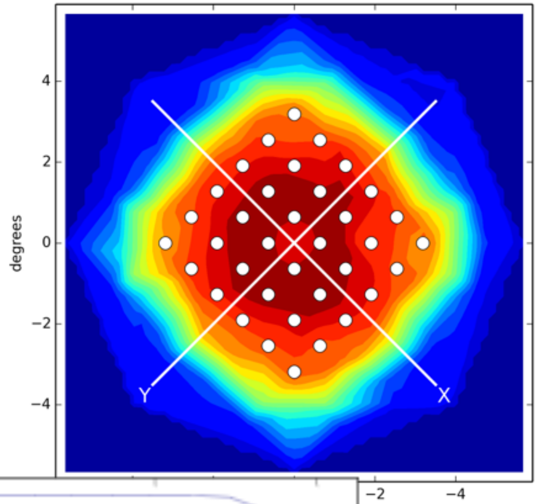




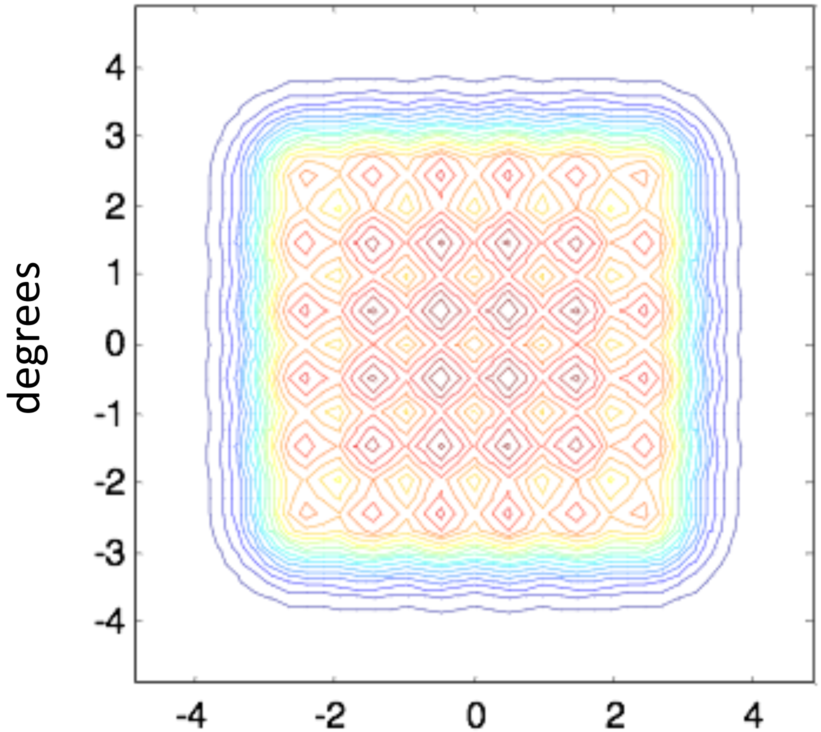
(McConnel 2016, ACES Memo #14)

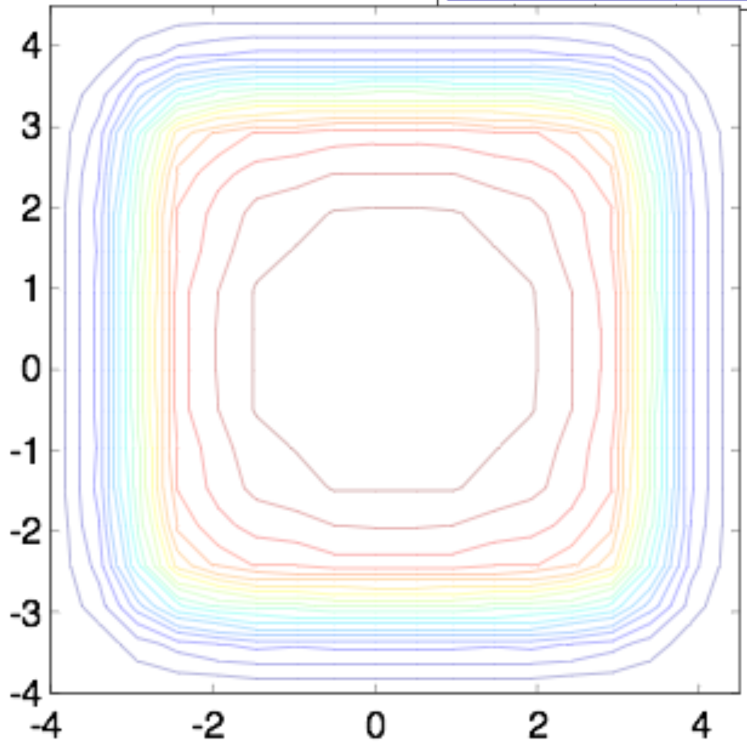
Observing strategy





5% sensitivity contours





(Bunton & Hay 2010)

ASKAPsoft

Purpose-built data reduction package

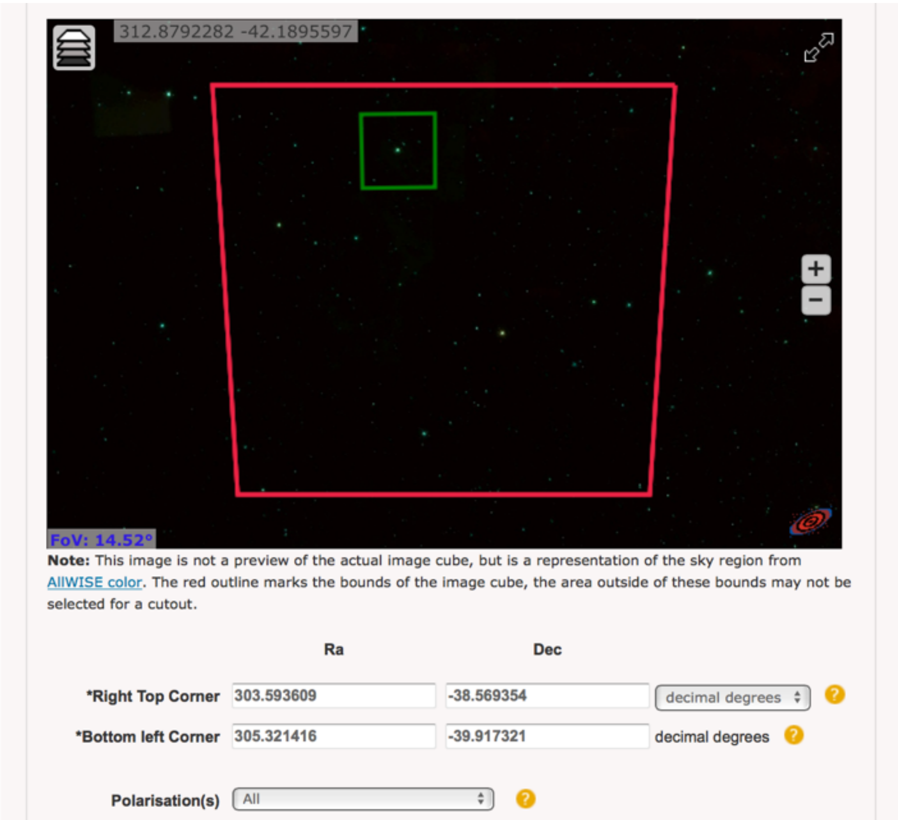
Highly scalable in HPC environments

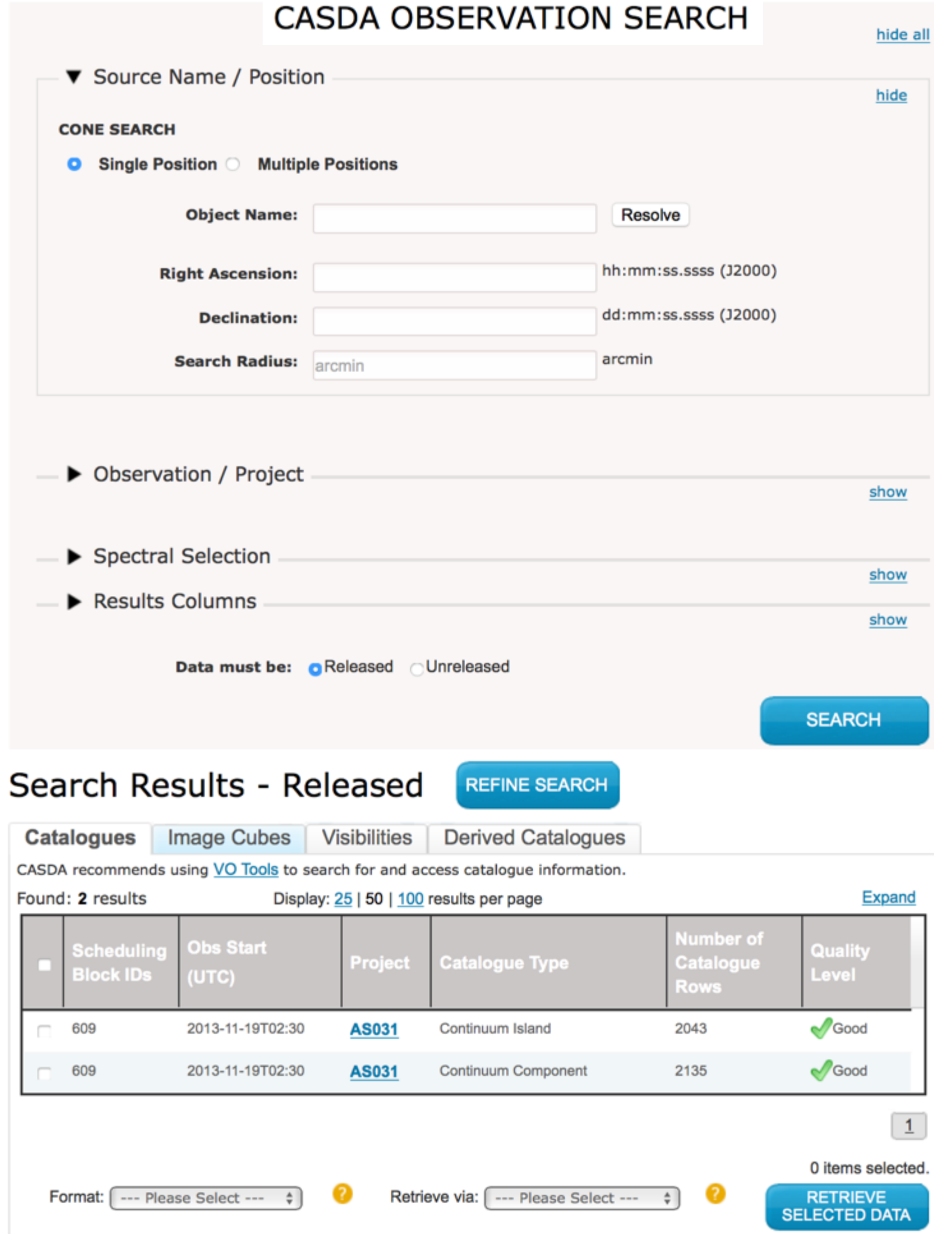
Preconditioned image weights

OTF calibration via global sky model

CASDA

- Science-ready data products
- GUI-driven access portal
- VO services (TAP, ADQL)
- Upload value-added products



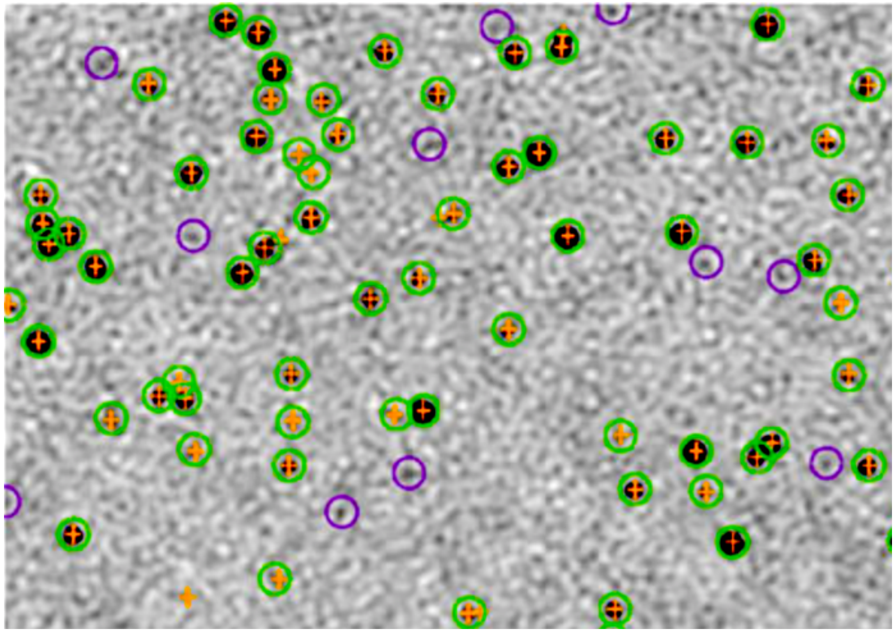


Source Extraction

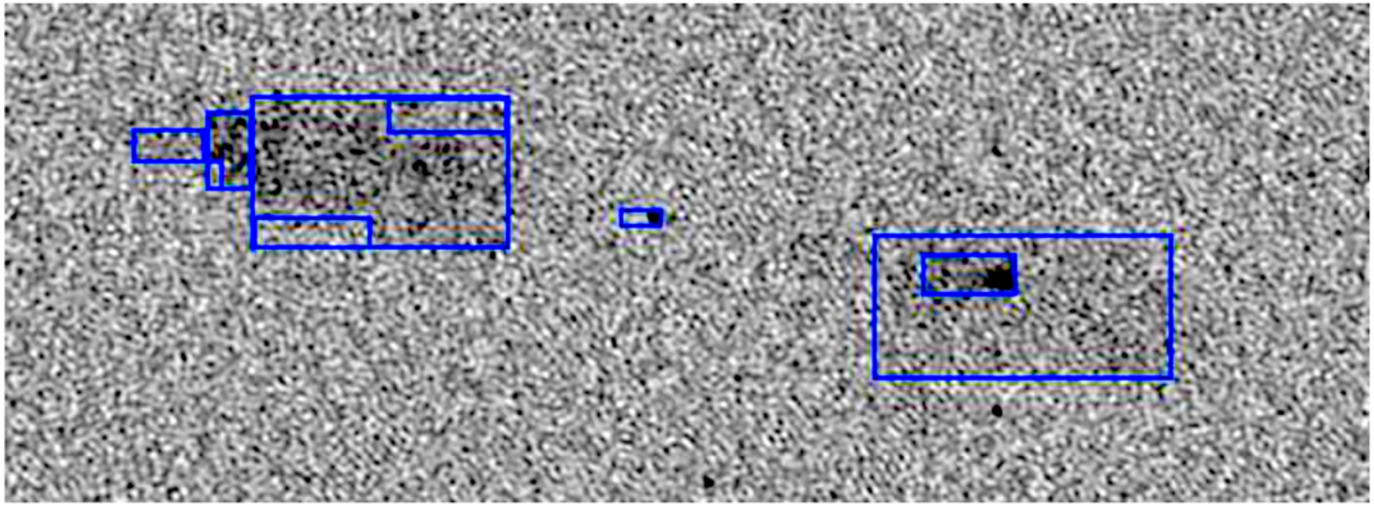
Generate simulated datasets

Compare algorithms

- Completeness
- Reliability
- Extended sources



(Hopkins+2015, PASA)



(Butler-Yeoman+2016, ADASS XXV)

Self- and Cross-identifications

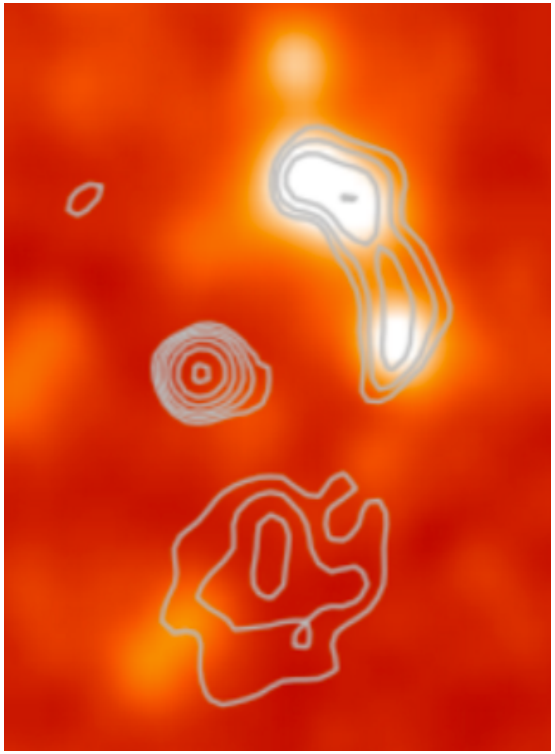
Expert manual cross-ID

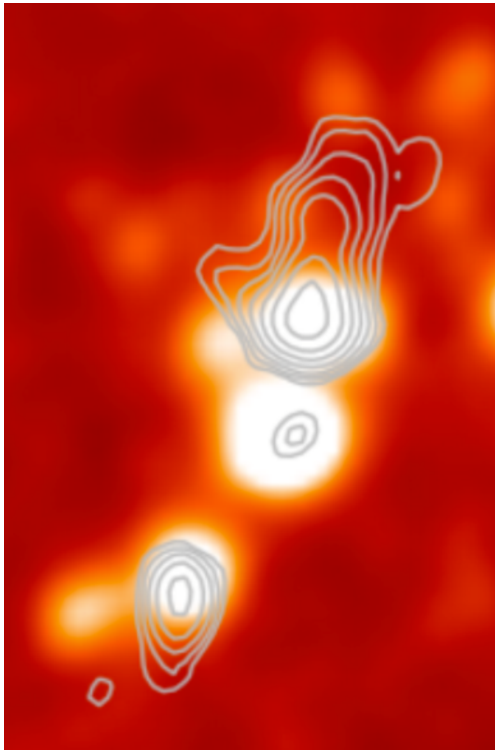
Radio Galaxy Zoo

Likelihood ratio

Machine learning

Bayesian techniques





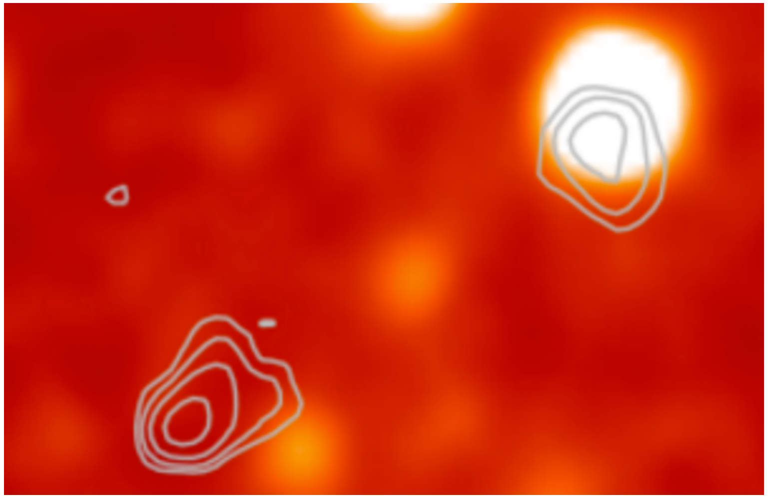


Image credit:
Larry Rudnick

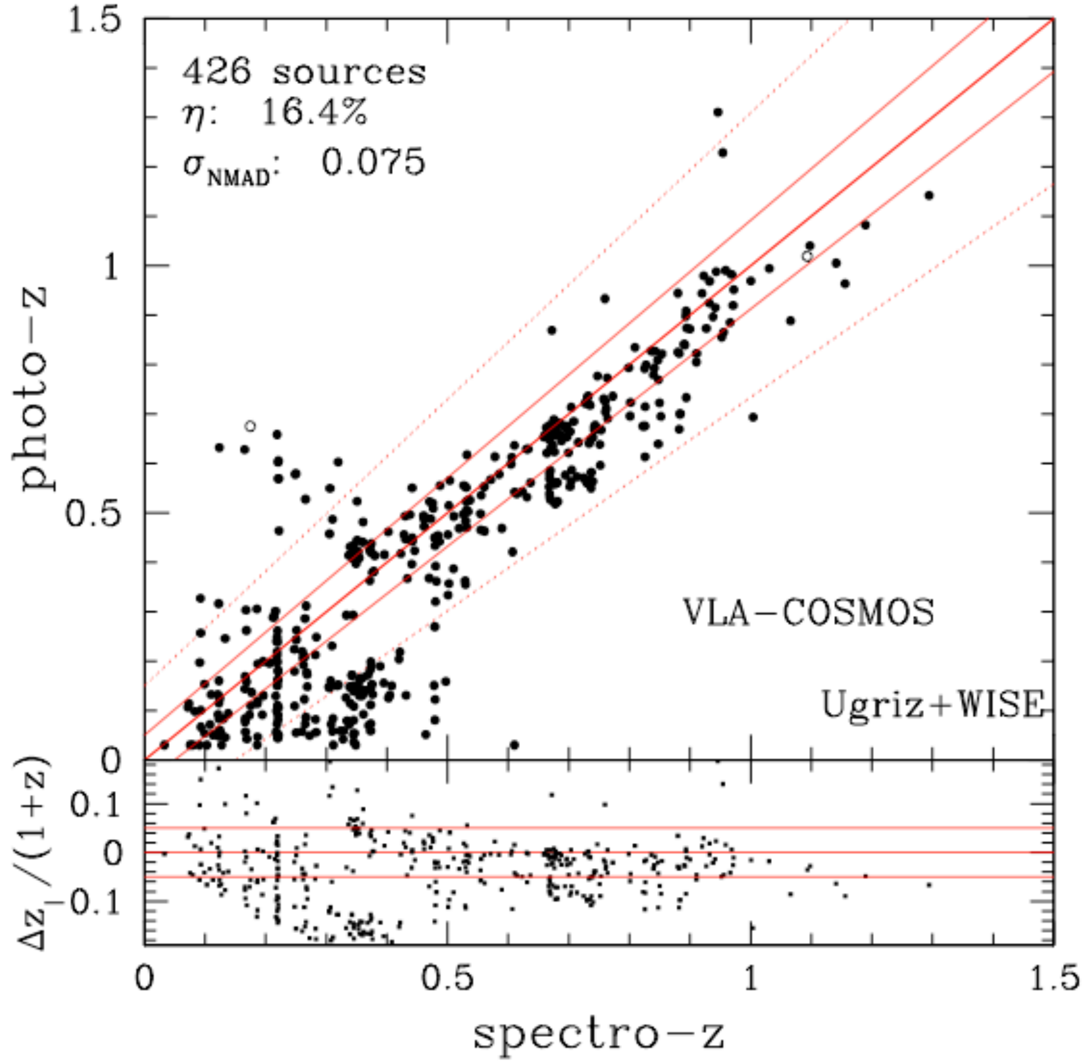
Redshifts

∼ 2% spectroscopic-z

∼ 70% photometric-z

Want to use non-detections together with other data → statistical-z

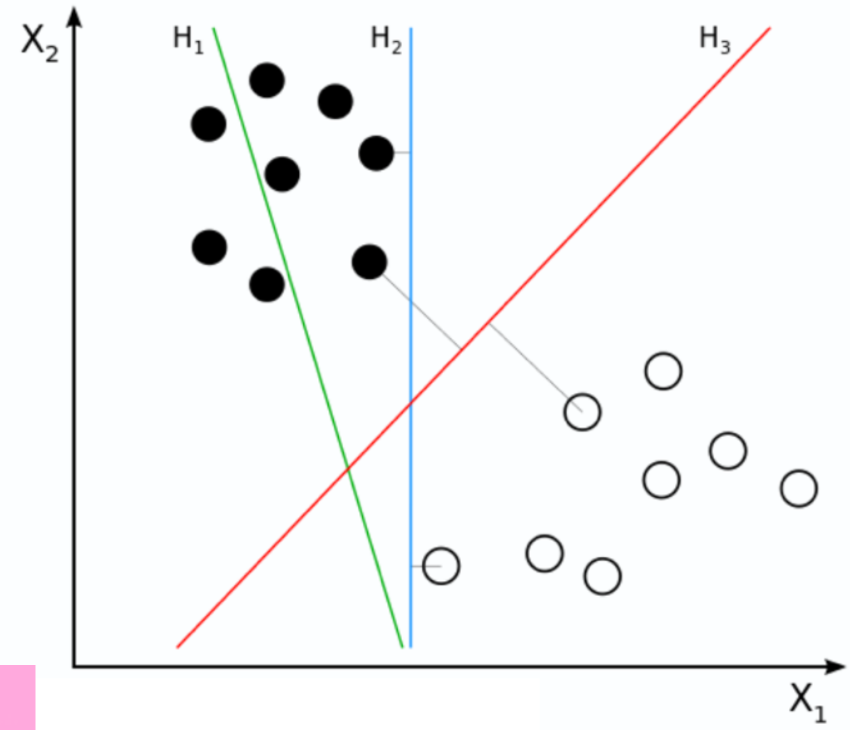
Coarse bins often suffice
e.g., <0.5, 0.5-2, >2



(Salvato, Zinn+, in preparation)

Data Science

Neural networks
k nearest neighbors
Self-organized maps
Support vector machine
Random forest



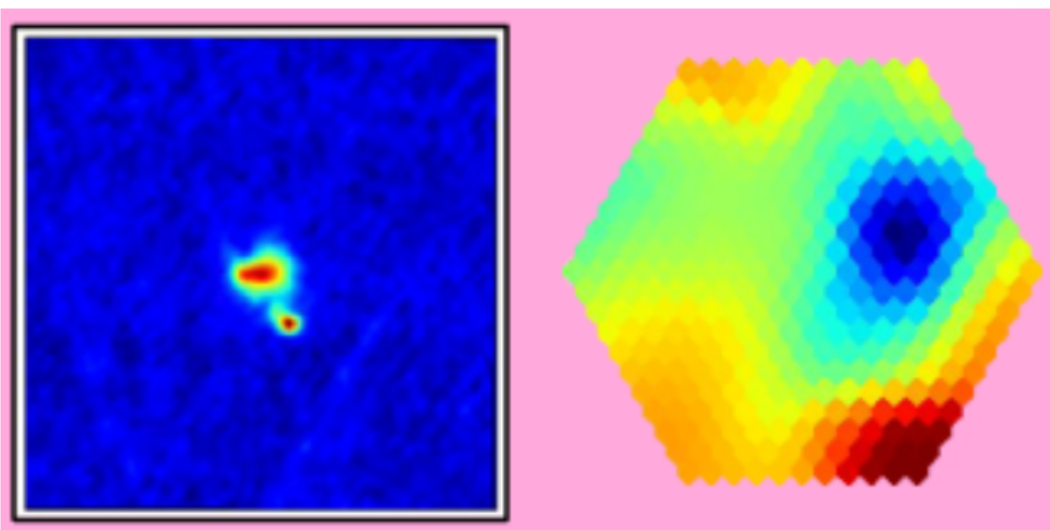


Image credit:
Kai Polsterer,
Enno Middelberg

ASKAP Continuum

Early Science

ASKAP - Current Status

- 36x 12-meter antennas
- 30 receivers installed - final 6 EOY
- Full beamforming capabilities (36 dual pol)
- 18 antennas accepted into main array
- Hardware for up to 240 MHz bandwidth
- System equivalent flux density $\lesssim$ 2000 Jy

ASKAP - Commissioning Activities

FPGA firmware / digital hardware
Antenna drives and pointing
Refinement of antenna locations
Primary beam measurements
Improved beamforming algorithms
On-dish PAF calibration system
Phase tracking / fringe rotation

ASKAP - Commissioning Activities

Support for higher data rates

Polarization calibration

Astrometric validation

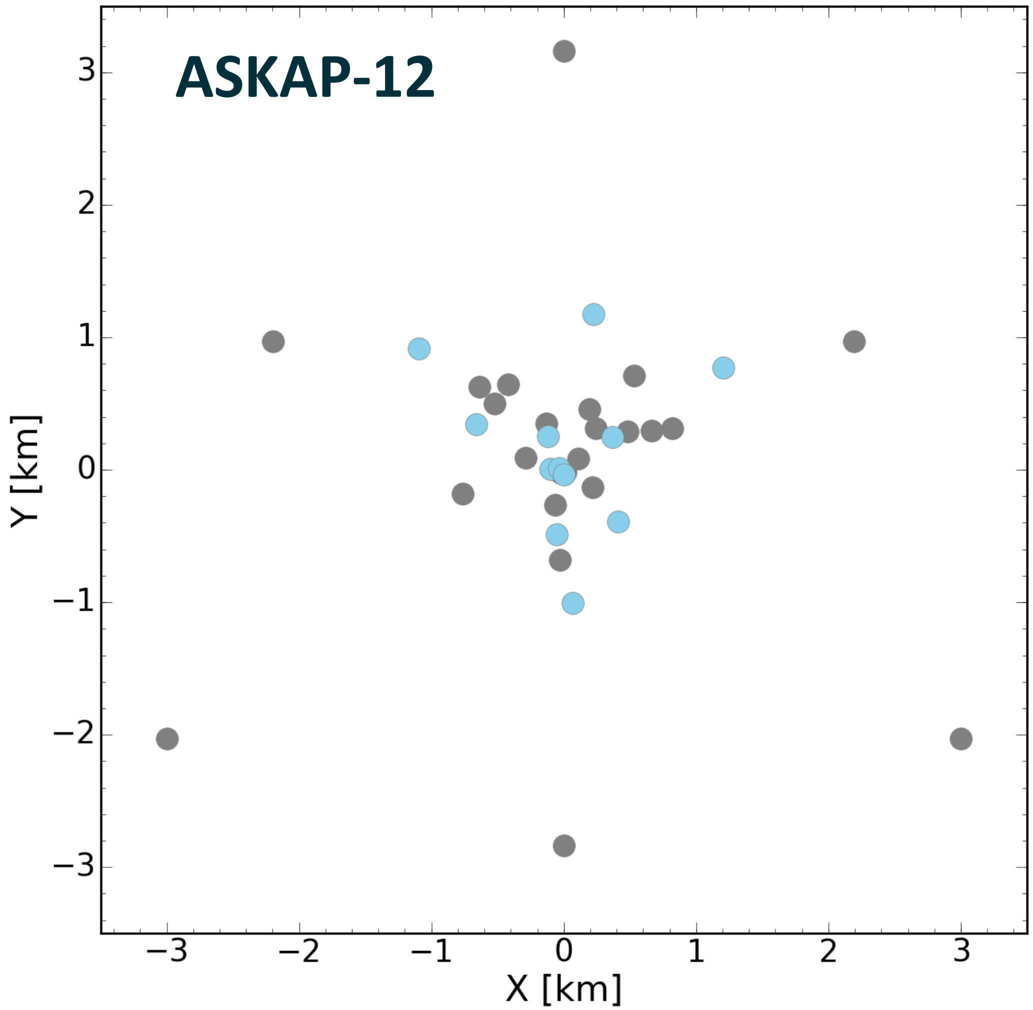
ASKAPsoft testing and verification

End-to-end software pipelines

Interface with the data archive

Priorities for ASKAP early science:

- Demonstrating the unique capabilities of ASKAP
- Providing data sets to the astronomy community to facilitate the development of analysis and interpretation techniques
- Providing a mechanism for feedback to CASS on the performance and characteristics of the system and opportunities for improvement
- Achieving high scientific impact



Early Science Array:

12 antennas

Baselines: 60 m - 2.3 km

Up to 36 formed beams

Phase tracking per field

Data rate limitations

Early Science Observations

600 hours on selected high-impact fields

- Broadband (700-1800 MHz), sensitive (40 uJy)

200 hours on a large contiguous area

Narrow-band (800-1100 MHz), shallow (100 uJy)

Early science fields include:

GAMA-23

SCORPIO

SMC

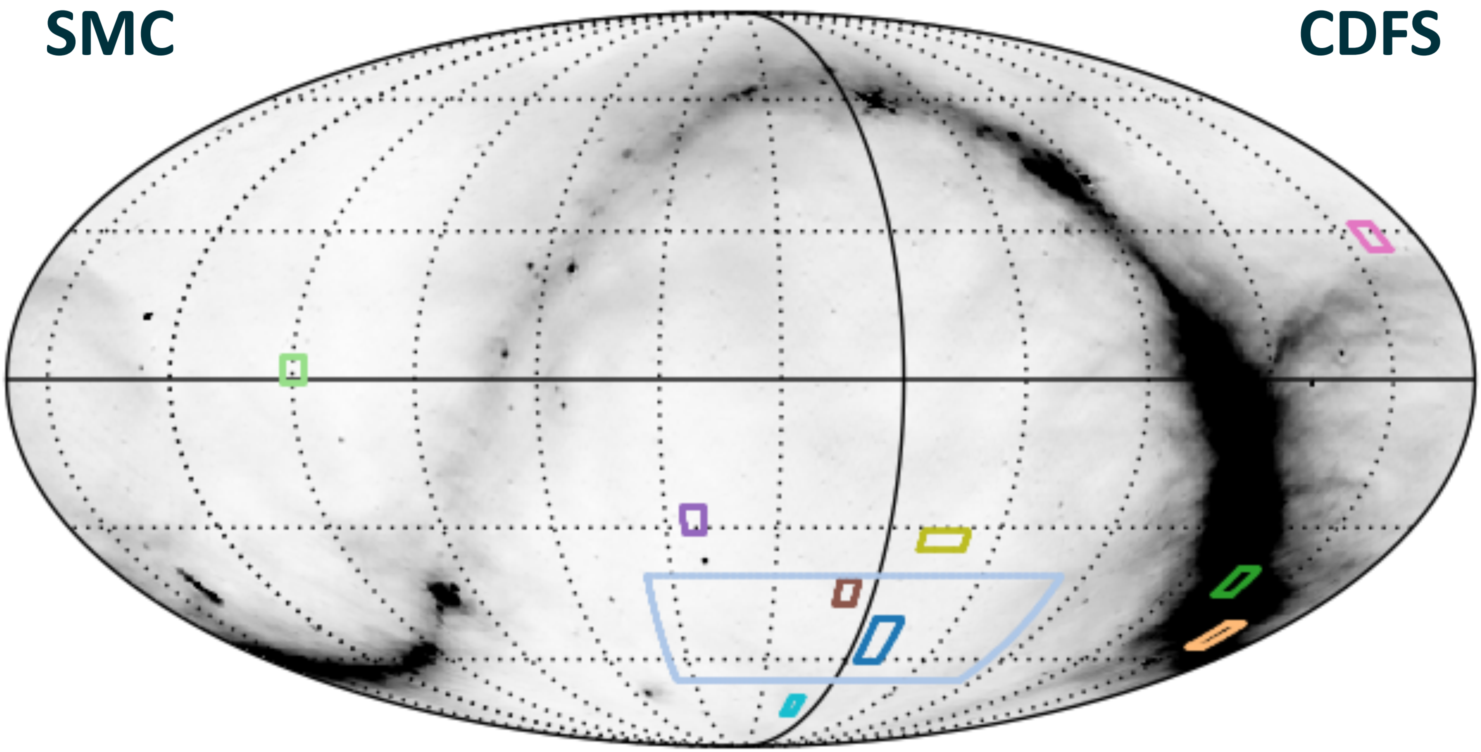
ELAIS-S1

SPT

SPARCS

COSMOS

CDFS




NGC 7232 group
Image by Ian Heywood
Data available at casda.csiro.au

Thanks for your attention!

We acknowledge the Wajarri Yamatji people as the traditional owners of the Observatory site