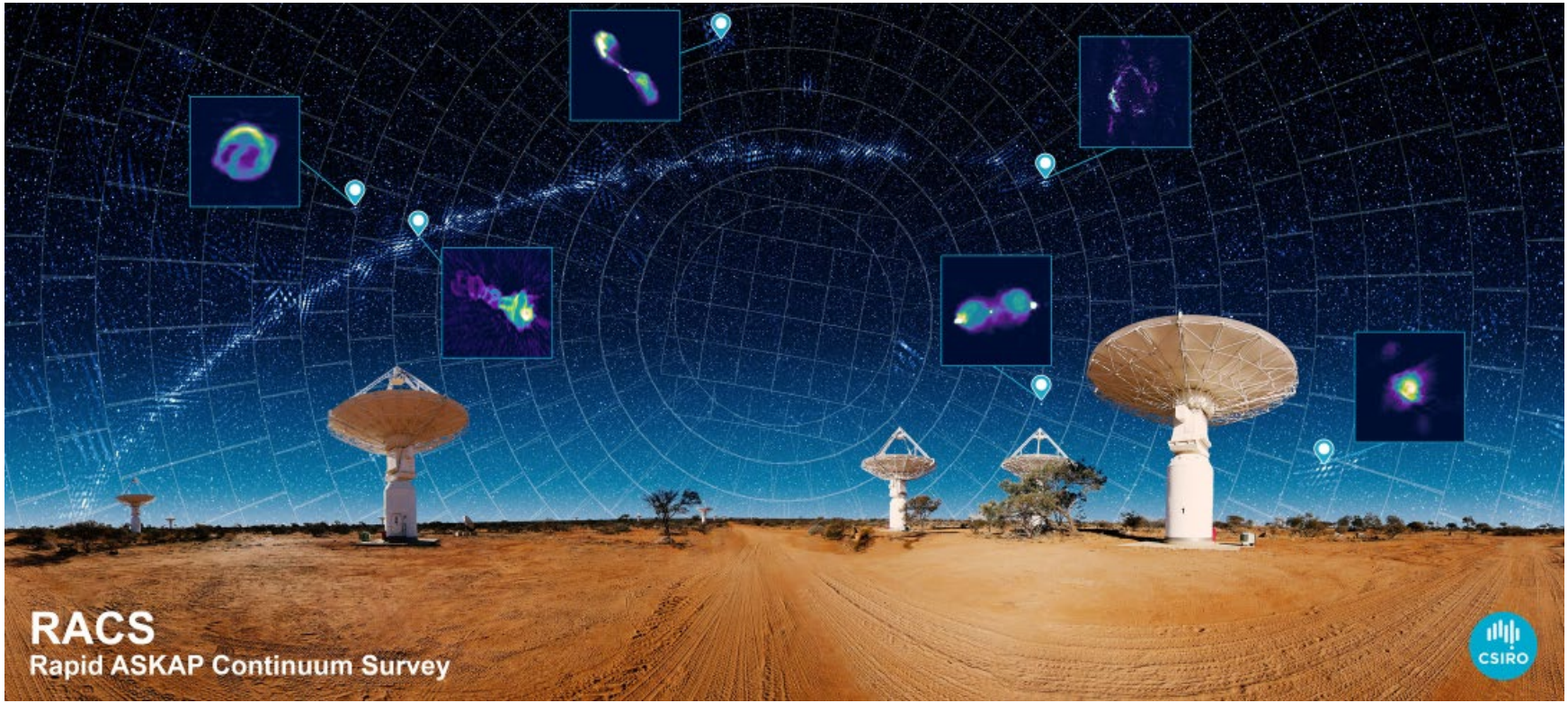


RACS: The Rapid ASKAP Continuum Survey

John Reynolds | 13th June 2023 - on behalf of the entire ASKAP and RACS teams

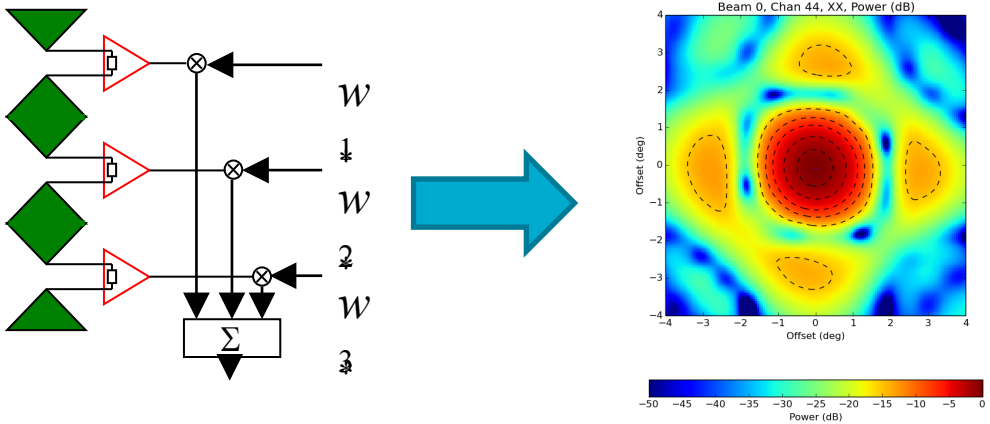
CSIRO

ASKAP – SKA precursor

Inyarrimanha Ilgari Bundara, CSIRO's Murchison Radio-astronomy Observatory

Phased Array Feeds

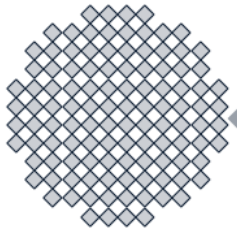
- ASKAP's most distinguishing feature
  - Driving all downstream requirements
- Primary beams defined by digital weights



ASKAP System Description (PASA Vol. 38 e009)

(per antenna) 3.5 Tb/s 1.3 Tb/s

Chequerboard Phased Array Feed



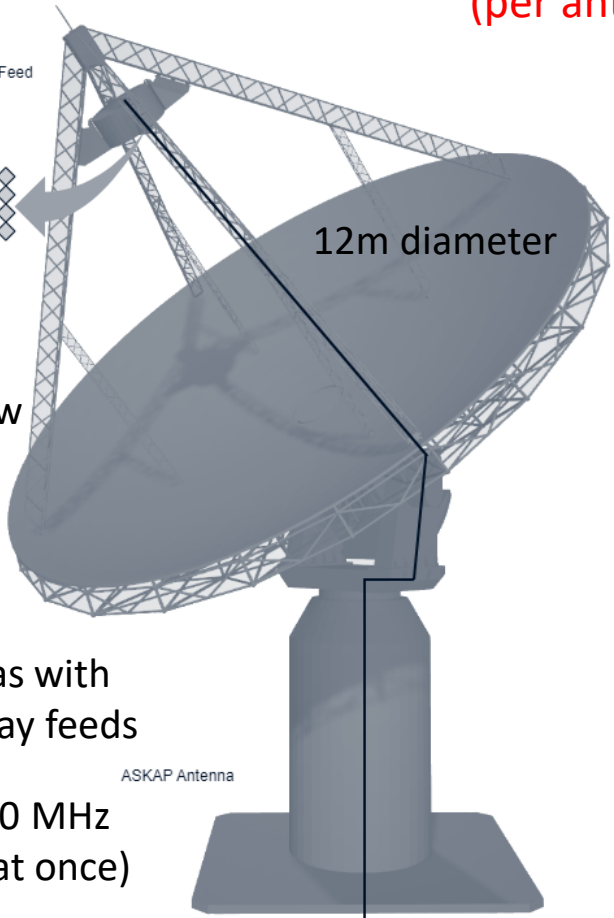
12m diameter

30 deg^2
field of view

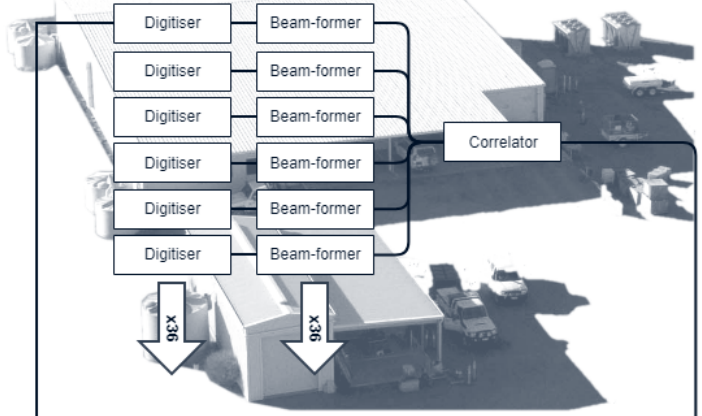
36 antennas with
phased array feeds

700 to 1800 MHz
(288 MHz at once)

ASKAP Antenna

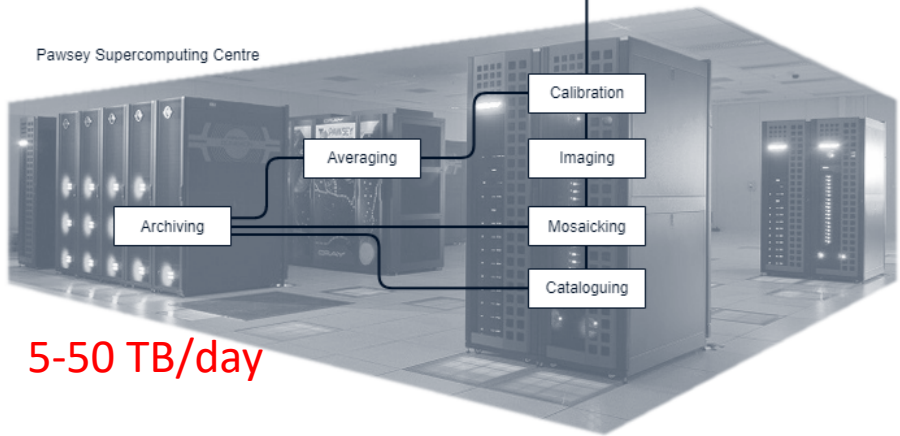


Murchison Radio-astronomy Observatory Site



20 Gb/s

Pawsey Supercomputing Centre



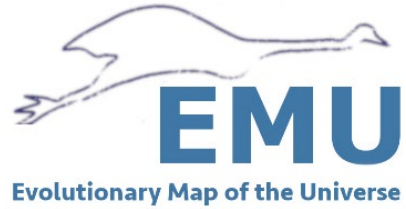
5-50 TB/day

ASKAP is a rapid radio survey national facility

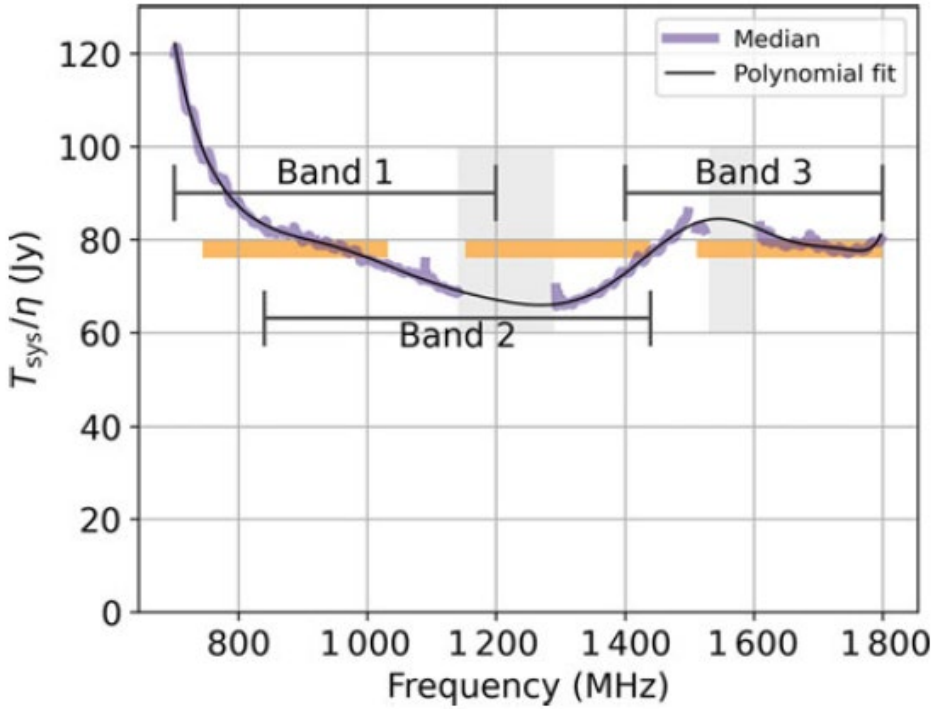
- Large instantaneous field of view (30 square degrees at 1 GHz)
- 15” resolution, good PSF and sensitive to extended emission
- Remote location avoids most terrestrial interference
- Autonomous scheduling allows high observing efficiency
- Dedicated supercomputer for imaging and calibration
- Produces science-ready data products in near real-time
- Wide range of commensal outputs per observation
- Public data archive CASDA makes results widely accessible

A community partnership

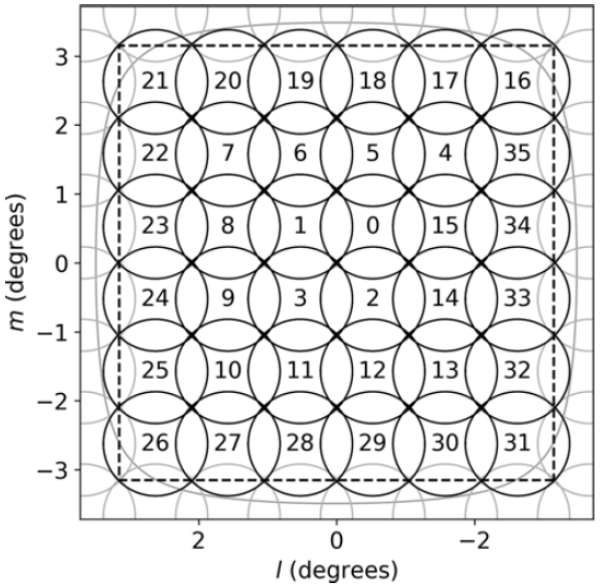
- Working with the ASKAP Survey Science Teams for 15 years
  - Contributing to commissioning and ongoing improvements
  - Feedback on data quality through formal validation
  - SSPs span all capabilities of ASKAP
  - Independent science review in 2022
  - **5-year survey program commenced!**



PAF performance



Footprint



RACS-low footprint:
square_6x6

RACS - the motivation

Observatory-led project with 3 main aims;

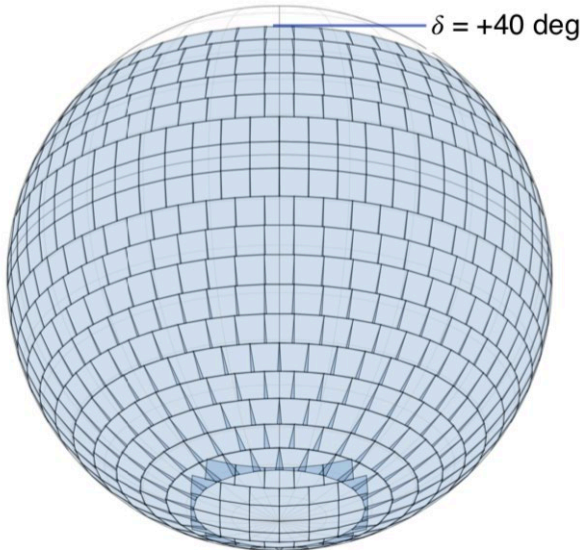
- Establish all-sky model required by the full ASKAP surveys
- Essential learning exercise before undertaking the larger surveys
- Valuable science product in its own right

RACS: Margaret Whitehurst

RACS-low : Initial Epoch

- Frequency: 887.5MHz / 288MHz BW
- Sky coverage: $-90^\circ < \delta < +41^\circ$ (34,240 deg^2)
- Tiling: 903 tiles x 15 minutes
- Footprint: square_6x6, spacing 1.05^o
- Epoch: mostly April 2019 (10 days)
- Processing ASKAPSoft s/w on *Galaxy* (Cray XC30)

- Resolution 15” (*)
- RMS (typical) 250 µJy/beam



Comparisons with Previous Surveys

	RACS-low	NVSS	SUMSS	FIRST	TGSS	GLEAM
Sky Coverage	Sky south of Dec +40 deg (~33000 sq. deg)	Sky north of of Dec -40 deg (~33000 sq. deg)	Sky south of Dec -30 deg (~9000 sq. deg)	North & South Galactic caps (~10000 sq. deg)	Sky north of of Dec -53 deg (~37,000 sq. deg)	Sky south of Dec +30 deg (~30,000 sq. deg)
Resolution (“)	~15	~45	~45	~5	~25	~100
Depth (mJy/beam)	~0.25-0.3	~0.5	~1	~0.15	~3.5	6-10
Depth at 1.4 GHz* (mJy/beam)	~0.2	~0.5	~0.7	~0.15	~0.7	~1-2
Frequency (MHz)	700 – 1800	1400	843	1400	150	74-231

* Assuming $\alpha=0.7$, $S \propto \nu^{-\alpha}$

Comparisons with Previous Surveys

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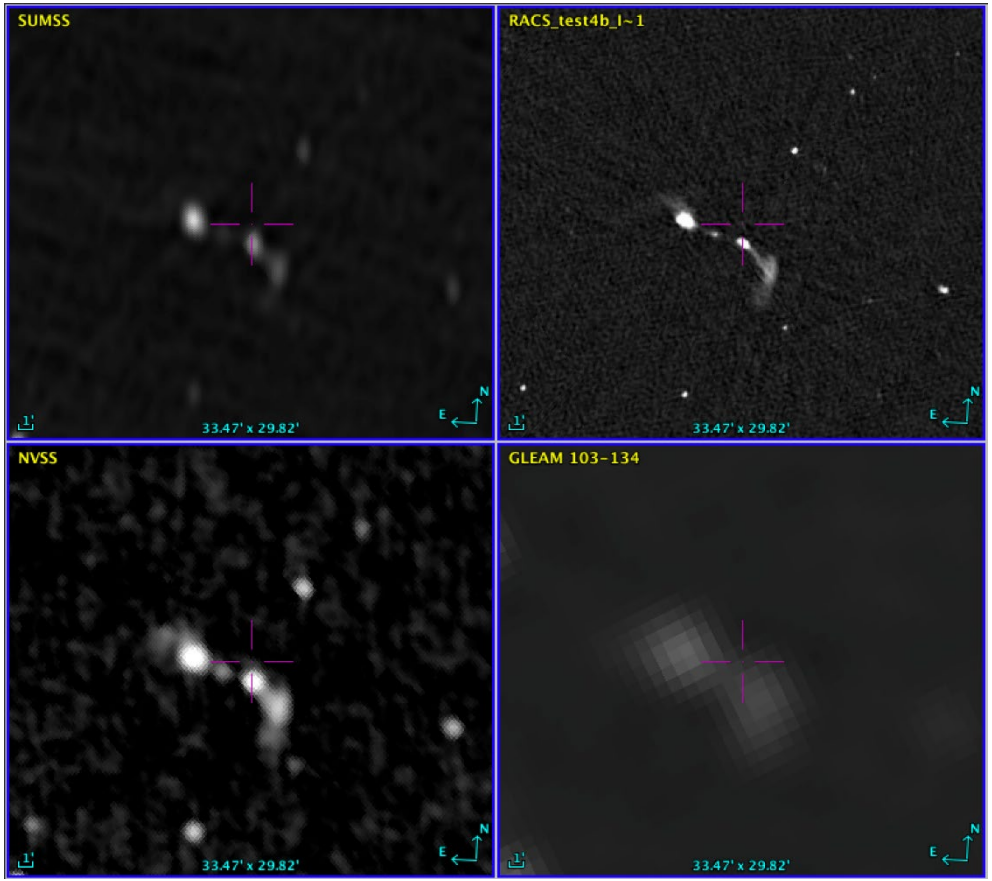
Comparisons with Previous Surveys

SUMSS
(Mauch+ 2003)



RACS

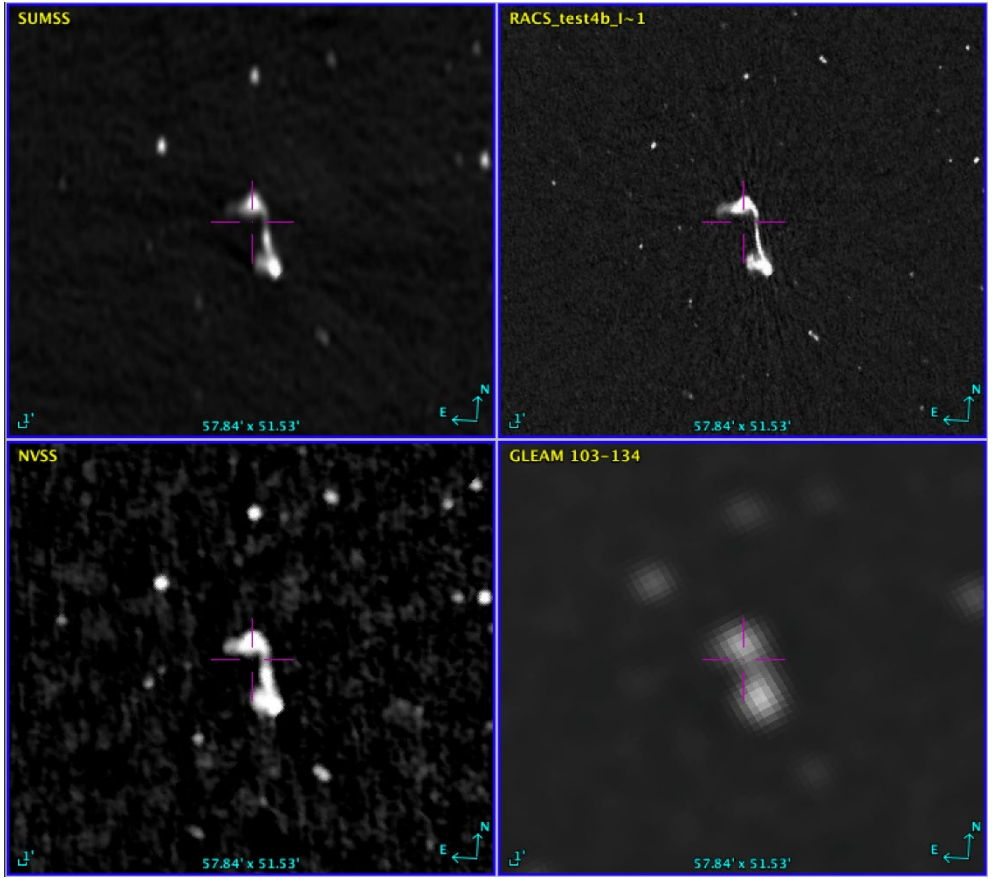
NVSS
(Condon+ 1998)

GLEAM
(Hurley-Walker+ 2017)

Visualisation using Aladin (http://aladin.u-strasbg.fr)

Comparisons with Previous Surveys

SUMSS
(Mauch+ 2003)



RACS

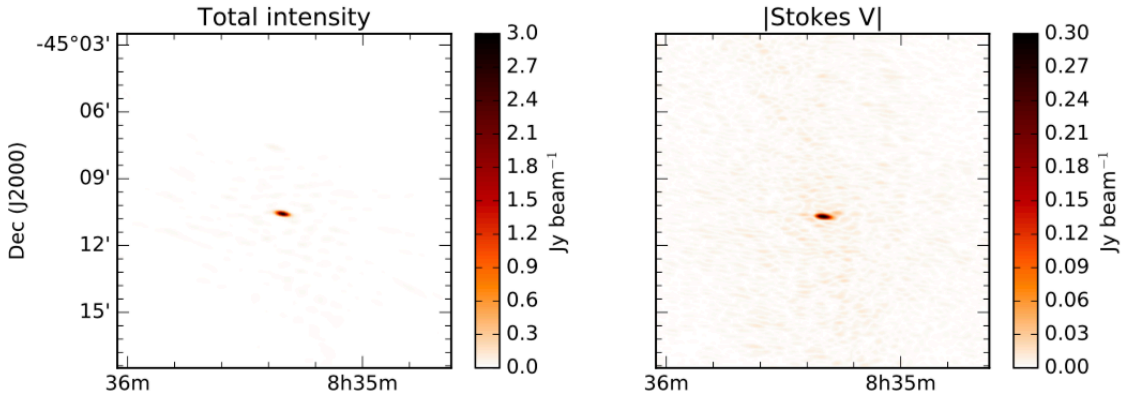
NVSS
(Condon+ 1998)

GLEAM
(Hurley-Walker+ 2017)

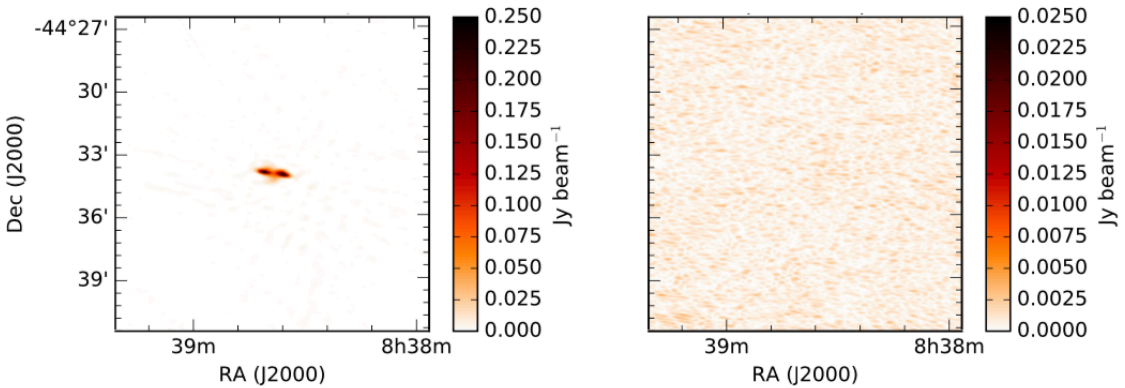
Visualisation using Aladin (http://aladin.u-strasbg.fr)

Polarisation as a tool for transients

Vela Pulsar



Typical AGN



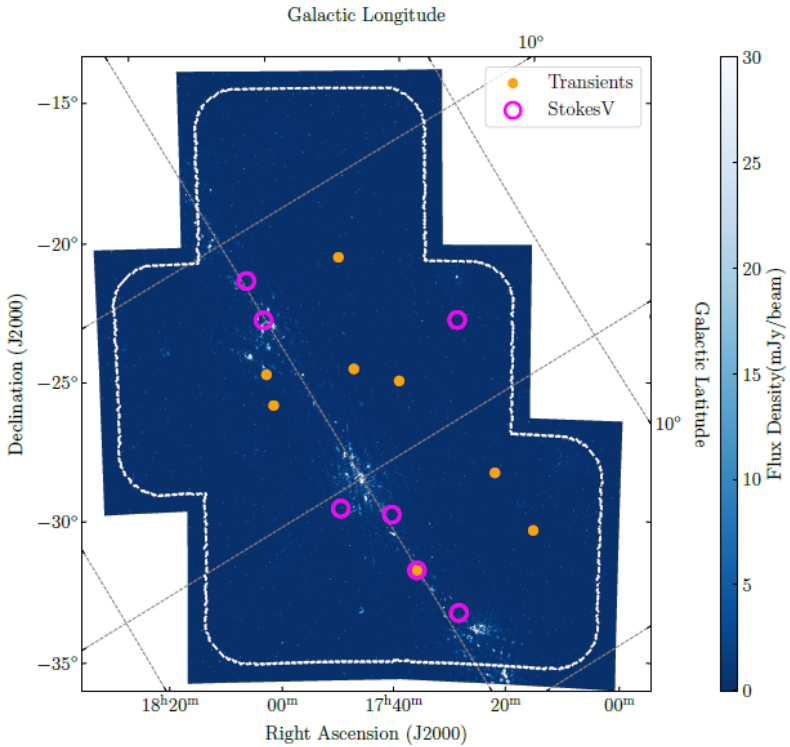
Slide credit: D. McConnell

Images by Emil Lenc

A pilot ASKAP survey for radio transients towards the Galactic Centre
Ziteng Wang et al. (2022)

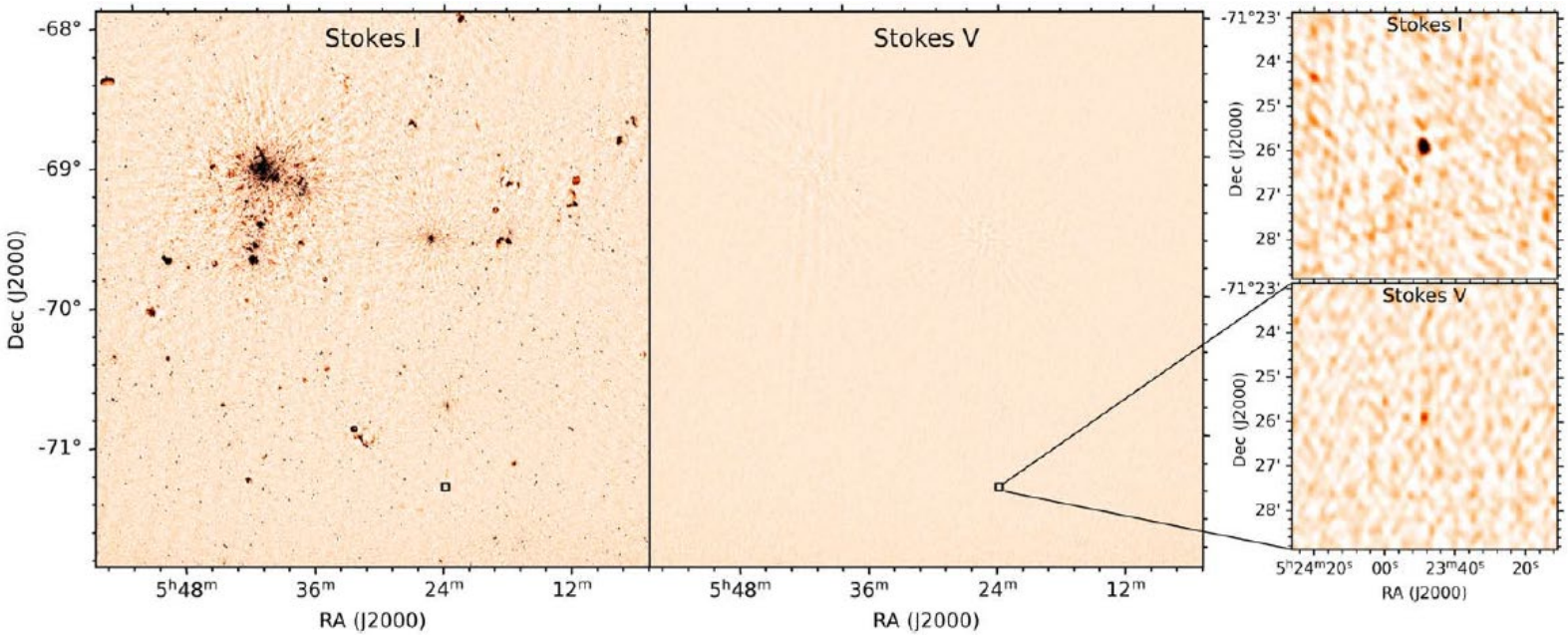
Used;
- RACS-low images in Stokes I,V
- Overlapping VAST images at multiple epochs

14 sources of interest (variable/large V);
- 7 known pulsars
- 1 known LMXB
- 3 probable radio stars
- 3 likely GCRT



Discovery of PSR J0523-7125 as a Circularly Polarized Variable Radio Source in the LMC

Yuanming Wang et al. (2022)



Value of large ASKAP field of view

Used RACS-low data plus additional VAST epochs

Extremely luminous pulsar identified by large Stokes V.

The RACS family

- RACS-low 888MHz/288 : April 2019 to Jan 2020
  - Stokes I images, calibrated visibilities, source catalogue (in CASDA)
- RACS-mid 1368MHz/144 : Dec 2020 to Jun 2021
  - Stokes I,V images – *just accepted!*
- RACS-high 1656MHz/200 : Dec 2021 – Mar 2022
- RACS-low2 888MHz/288 : Mar 2022 – Jun 2022
- SPICE-RACS : Q,U images and analysis from RACS-low
  - Thomson et al. (2023, submitted)

Comparison of existing/underway radio surveys

Survey	Frequency (MHz)	Bandwidth (MHz)	Resolution (arcsec)	Sky coverage (deg^2)	Sensitivity (mJy PSF^{-1})	Polarization	$N_{sources}$ [a] ($\times 10^6$)
VLSSr	73.8	3.12	75	30 793	100	I	0.93
GLEAM	87, 118, 154, 185, 215	30.72	$\sim$ 140–196 [b]	27 691	$\sim$ 10–28 [b]	I,Q,U,V	0.33
GLEAM-X [c]	87, 118, 154,185, 215	30.72	$\sim$ 75–110 [a]	30 954	$\gtrsim$ 1.2 [b]	I,Q,U,V	$\sim$ 1.5
LoTSS & V-LoTSS [d]	144	48	6	5 634	0.095	I,Q,U,V	4.4
TGSS	150	16.7	25	36 900	2–5	I	0.62
RACS-low	887.5	288	15–25	34 240	0.2–0.4	I	2.1
RACS-mid [e]	1 367.5	144	$\gtrsim$ 8	36 449	$\sim$ 0.15–0.4	I,V	$\sim$ 3.0
RACS-high [f]	1 667.5	288	$\gtrsim$ 8	$\sim$35 955	0.2–0.4	I,V	$\sim$ 3.0
SUMSS & MGPS-2	843	3	45	10 300	1.5	RC	0.2
NVSS	1 346, 1 435	42	45	33 800	0.45	I,Q,U	2
FIRST	1 346, 1 435 & 1 335	42 & 128	5	10 575	0.13	I	0.9
VLASS	3 000	2 000	2.5	33 885	0.07	I,Q,U	5.3
AWES & AMES [g]	1361.25	137.5	$\geq$ 11	$\sim$ 1000	$\sim$ 0.04	I,V	$\sim$ 0.25

Thank you!

John Reynolds

Head of ATNF Operations

CSIRO Astronomy and Space Science
John@Reynolds@csiro.au

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