CAASTRO
ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

Exploring the variable radio sky with the MWA

Tara Murphy
University of Sydney

13th November 2013

The Murchison Widefield Array

Frequency range	80 - 300 MHz
Number of receptors	2048 dual polarization dipoles
Number of antenna tiles	128
Number of baselines	16256
Collecting area	Approx. 2000 sq. meters
Field of view	Approx. 15 - 50 deg. (200 - 2500 sq. deg.)
Instantaneous bandwidth	30.72 MHz
Spectral resolution	40 kHz
Temporal resolution	0.5 seconds
Polarization	Full Stokes (I, Q, U, V)

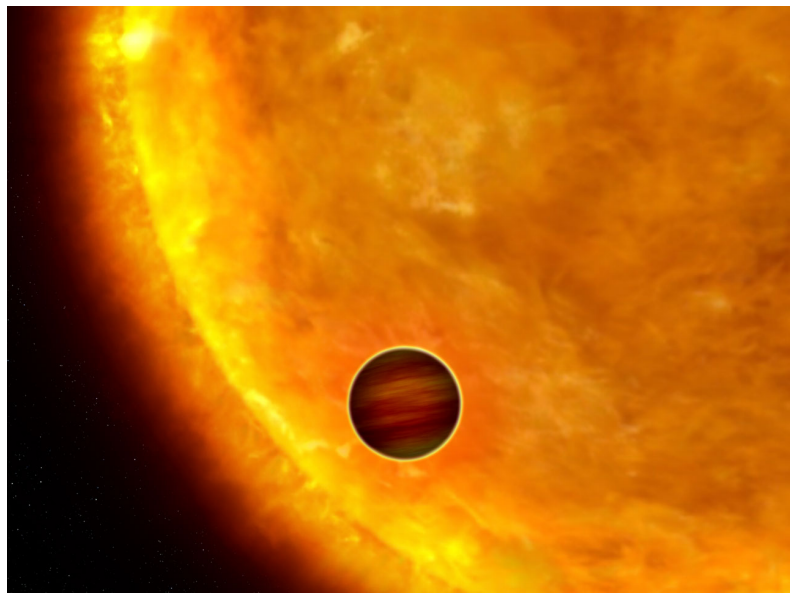
MWA 'slow transients' science goals

- **Low mass stars and brown dwarfs**
  Physical origin; incident rates; spectral characteristics
- **Magnetars**
  Flare properties; energetics; duty cycles of radio bright phases
- **X-ray binaries**
  Understanding the disc-jet connection; outburst statistics; burst luminosity function
- **Extra-solar planets**
  Independent radio detections?
- **Gamma Ray Bursts**
  Prompt emission; long term follow-up
- **New discoveries**

See Bowman et al. 2013, PASA, 30, 31

A hot Jupiter with the MWA?

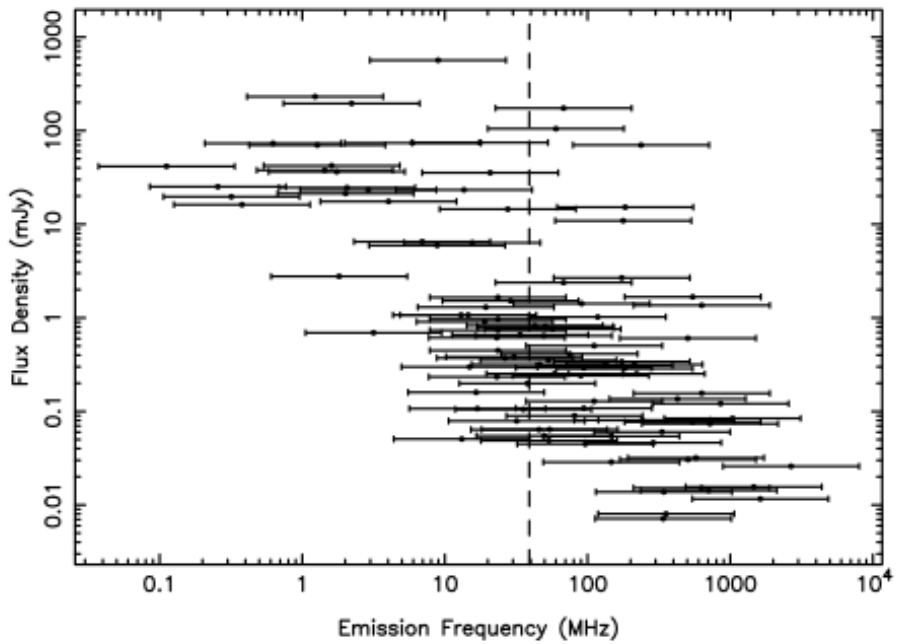
- Jupiter is a strong source of low-frequency radiation
- Caused by cyclotron maser processes in magnetosphere
- Many extra-solar Jovian planets have magnetic fields
- Potential for *direct* radio detection of extra-solar planets



Credit: NASA, ESA

A hot Jupiter with the MWA?

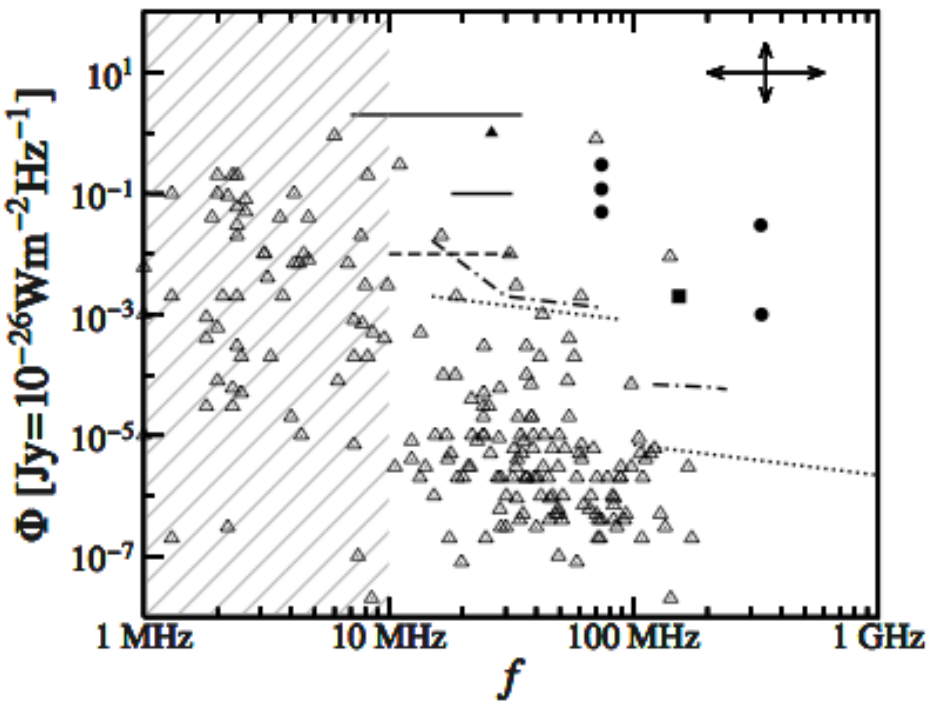
- Models predict μJy – mJy emission at MWA frequencies
- Results are model dependent
- MWA will help to constrain these models



Lazio et al. 2004, ApJ, 612, 511

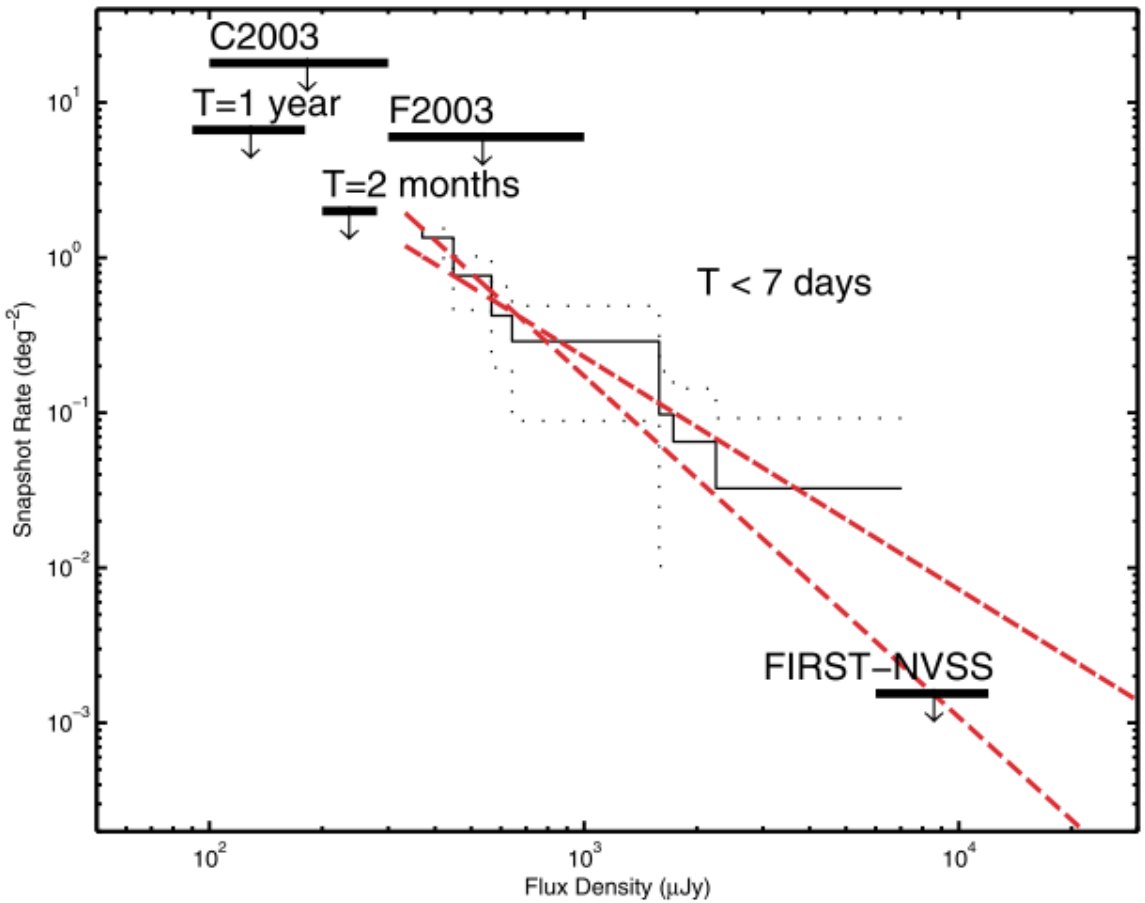
A hot Jupiter with the MWA?

- Searches have been carried out with VLA, GMRT, UTR-2
- No detections to date
- Emission is likely to be sporadic and bursty



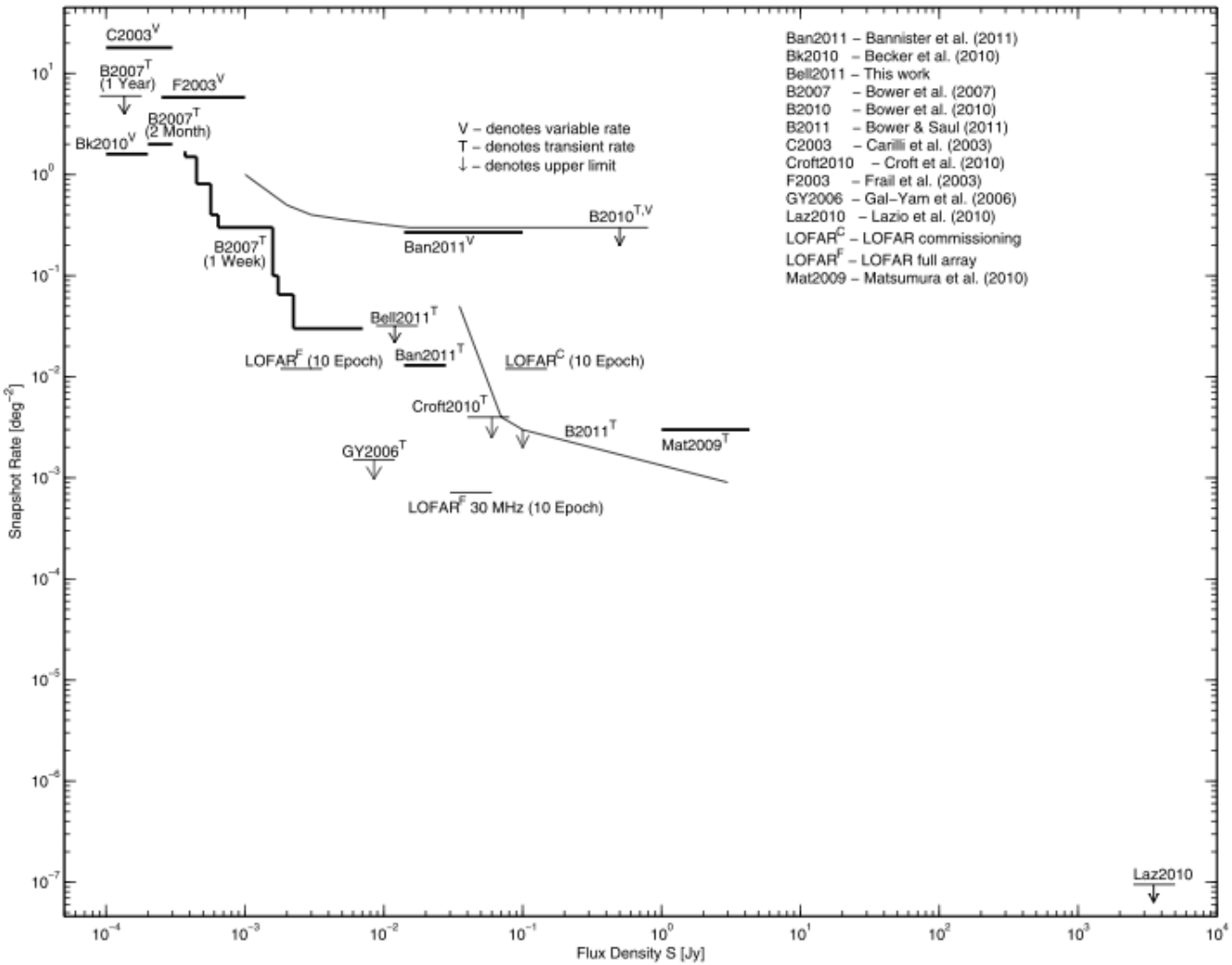
Greißmeier, Zarka & Spreeuw 2007, A&A, 475, 359

Transient snapshot rates (c. 2007)



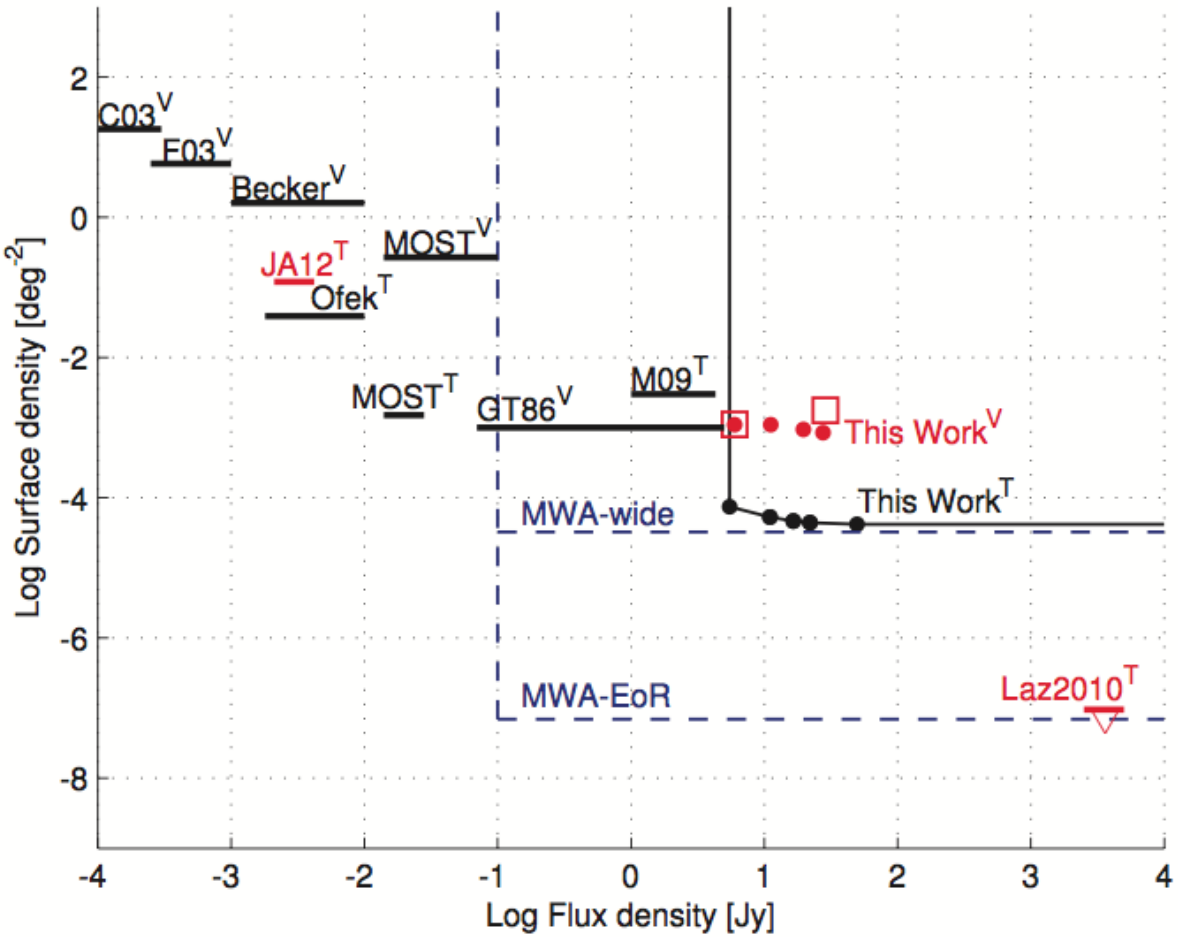
Bower et al. 2007, ApJ, 666, 346

Transient snapshot rates (c. 2011)



Bell et al. 2011, MNRAS, 415, 2

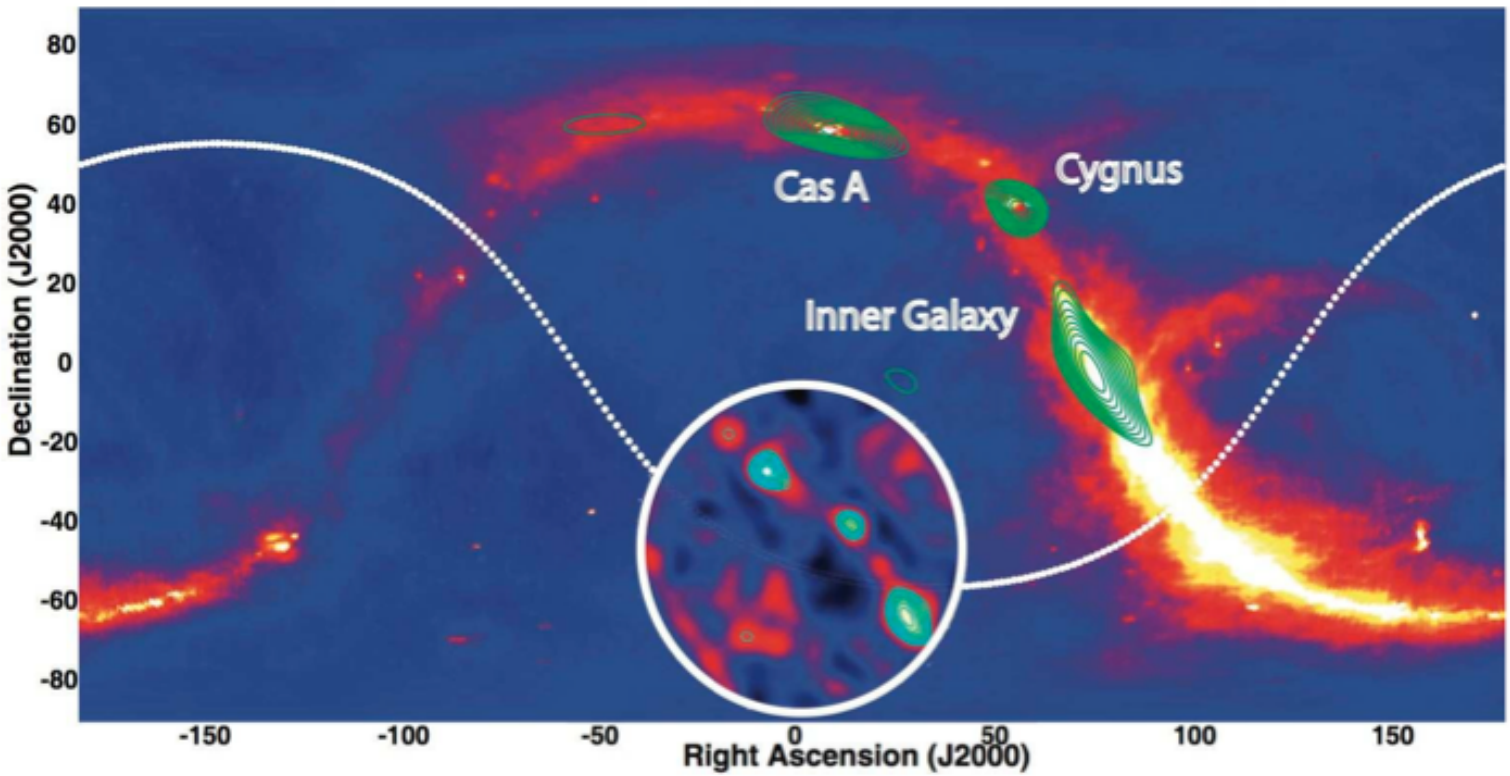
Transient snapshot rates (c. 2013)



Bell et al. 2013, MNRAS, *accepted (yesterday!)*

The LWDA all-sky survey

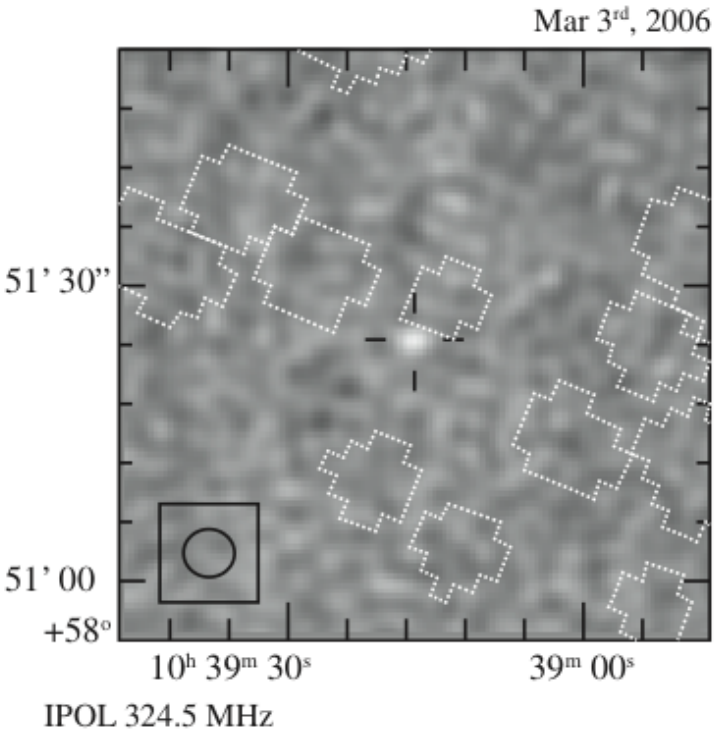
- 73.8 MHz all-sky survey, 106 hr of data with 2–5 min sampling
- No transients external to solar system at limit of 500 Jy

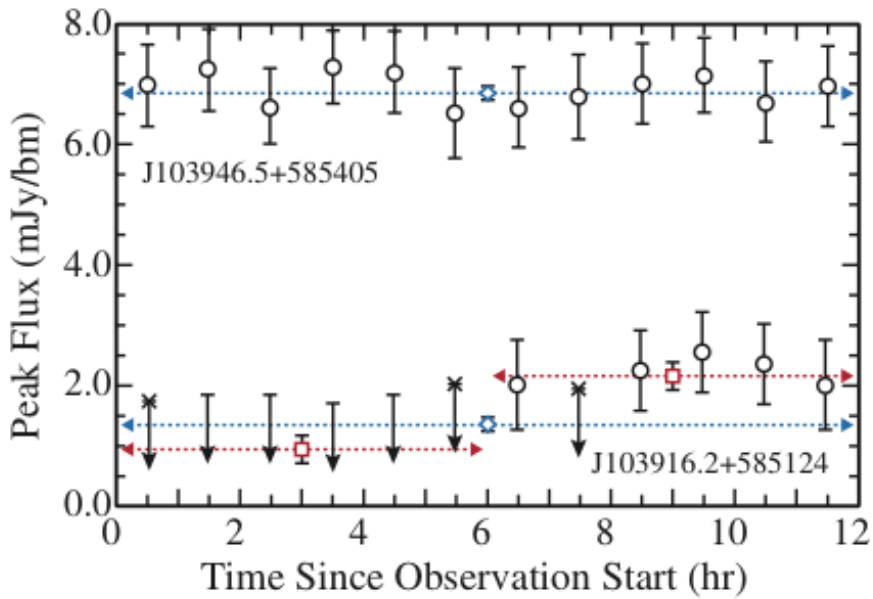


Lazio et al. 2010, AJ, 140, 995

VLA SWIRE Deep Field survey

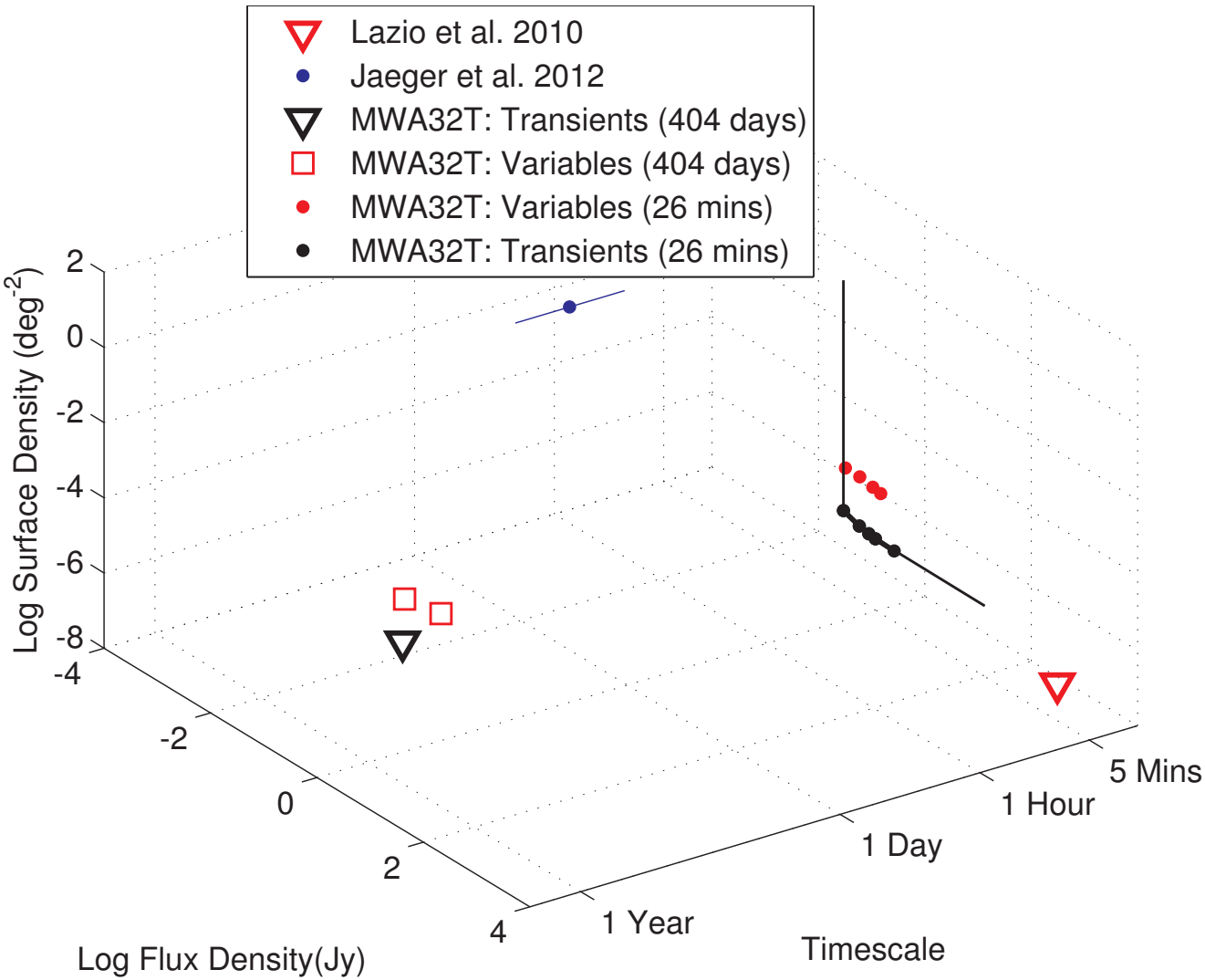
- Archival survey of 6×325 MHz observations
- Observations days to months apart; peak sensitivity 0.2 mJy
- Multiple variables, one transient source





Jaeger et al. 2012, AJ, 143, 96

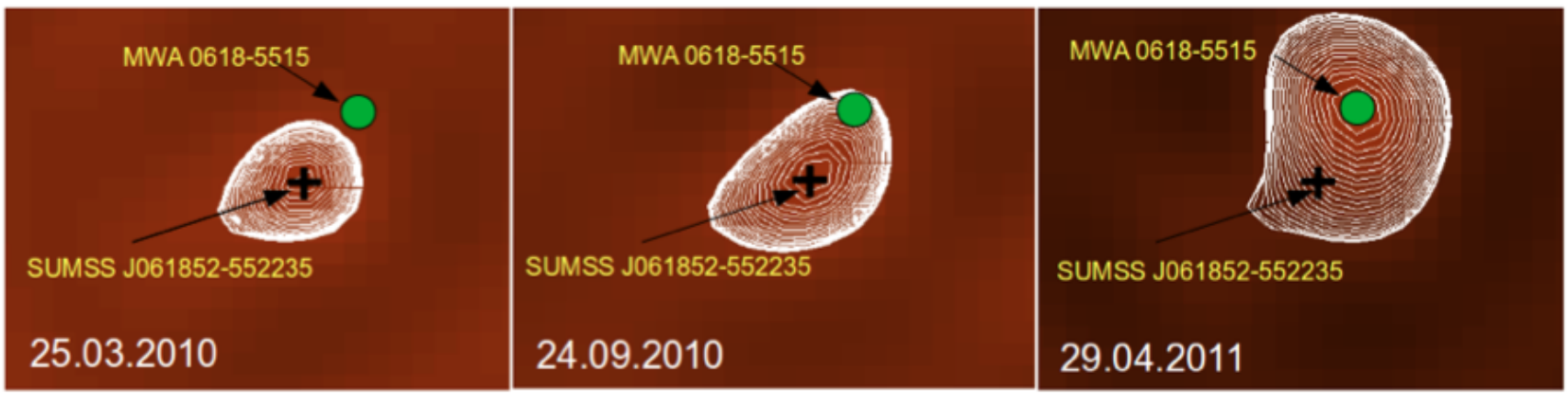
MWA 32T Hydra-A field survey



Bell et al. 2013, *accepted* *(yesterday!)*

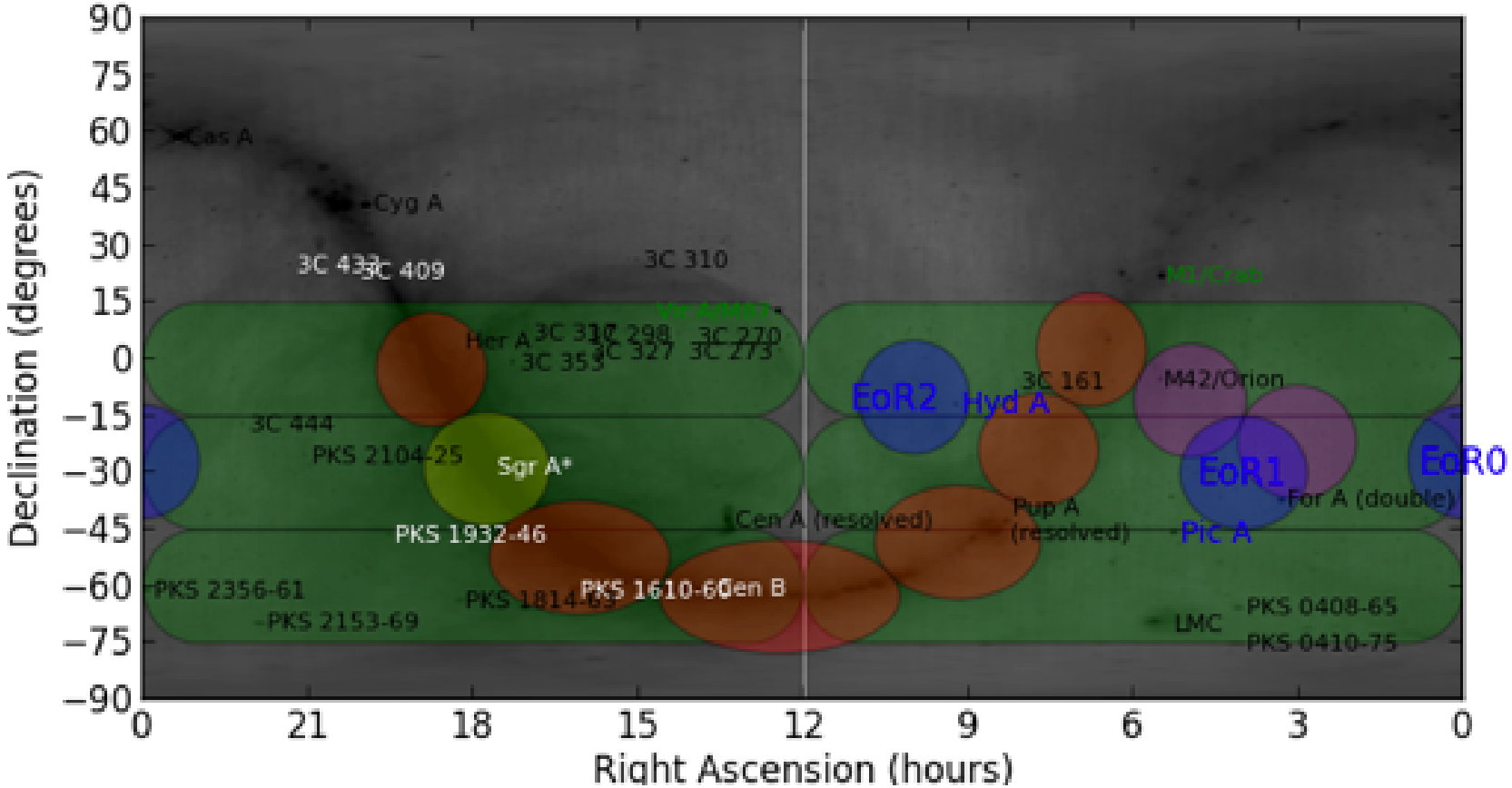
MWA 32T Pictor-A field survey

Expedition	Epoch	Date	Frequency	N_{snap}	T_{tot} [min]
13	Epoch 1	22-28 Mar 2010	154 MHz	11	55
			185 MHz	11	55
14	Epoch 2	24-25 Sep 2010	154 MHz	22	110
			185 MHz	9	45
15	Epoch 3	29-30 Apr 2011	154 MHz	44	153
			185 MHz	–	–



Kudryavtseva et al. 2013, *in prep*

MWA 128T transients surveys



Credit: David Kaplan

Proposal abstracts: `http://mwatelescope.org/index.php/Astronomers`

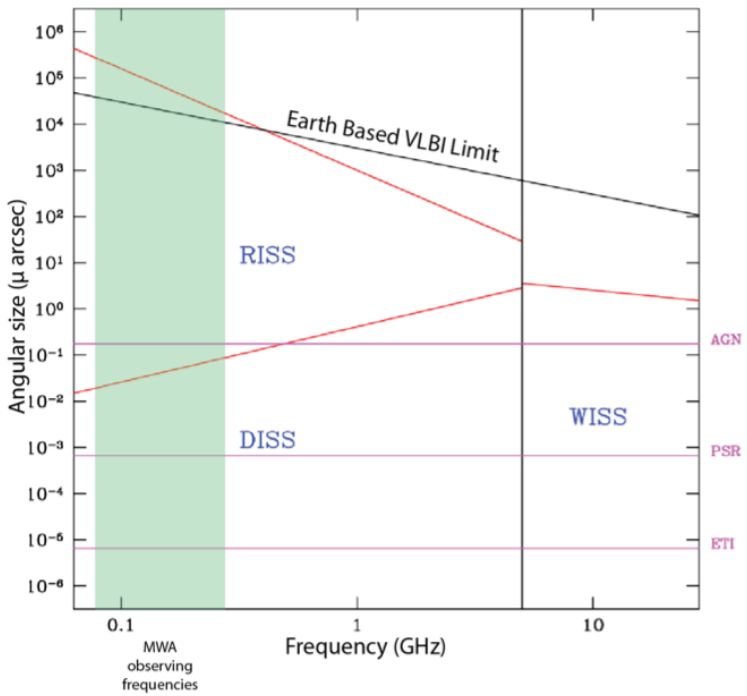
1. EOR fields commensal survey

- **PIs: Kudryavtseva & Feng (G0005, 353 hours)**
- Leverage 'Epoch of Reionisation' survey
  - EOR0: (0h, $-27°$)
  - EOR1: (4h, $-30°$)
  - EOR2: (11.3h, $-10°$)
- 30 flux measurements per night for 10^4 sources above 100 mJy
- Science goals
  - Spectral index of brown dwarfs and low-mass stars
  - Low frequency flares of AGN
  - Behaviour of magnetars
  - Tidal disruption events?
  - Detection of extra-solar planets?

2. Scintillation and turbulence

- **PIs: Hancock, Kaplan & Miller-Jones (G0003, 21 hours)**
- 24 weekly observations of a few fields
- Galactic fields with a range of latitudes

- Science goals:
  - Low frequency monitoring of AGN
  - Investigate RISS
  - Spatially resolved map of turbulence in the ISM

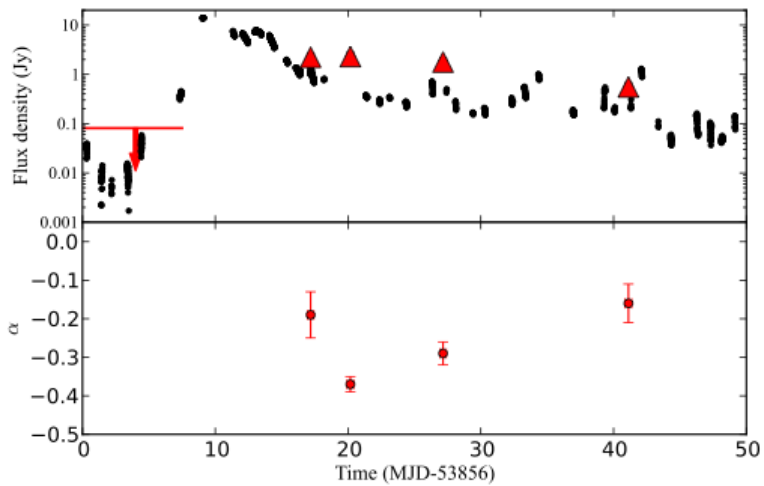


Credit: Paul Hancock

3. Monitoring the Galaxy

- **PIs: Kaplan & Miller-Jones (G0004, 36 hours)**
- Regular monitoring of the GP including the Galactic Centre
- Weekly and fortnightly observations; 5 minutes per field; over months

- Monitoring G2 as it orbits Sgr A*
- High cadence lightcurves of X-ray binary outbursts
- Serendipitous Galactic sources

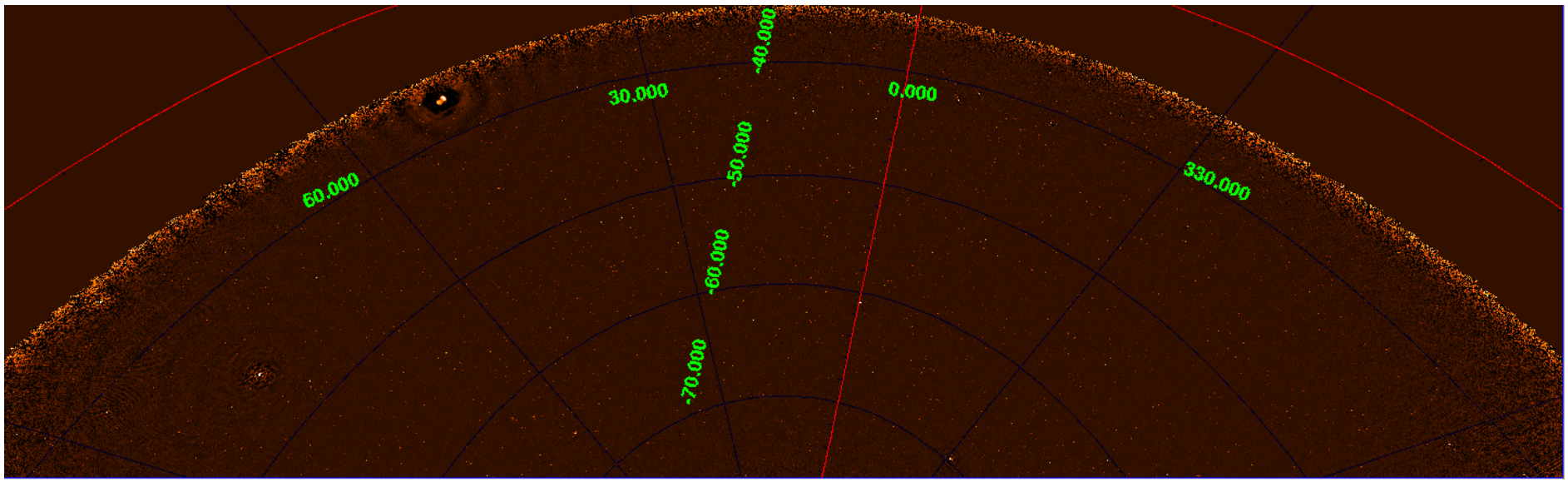


Cygnus X-3 outburst: 15 GHz and 150 MHz (Credit: Kaplan)

4. Longterm Radio Sky Monitor

- **PIs: Bell, Murphy & Kaplan (G0001, 50 hours)**
- Wide-field (20 000 sq deg)
  $\sim$ 7876 sq deg observed 5 times
- Long timescales (monthly observations)
- Sensitive (1 $\sigma = 10$ mJy)
- 10 hours observing in a night, 1 night per month, 6 months
- Science goals
  - AGN variability
  - Brown dwarfs, ultra cool dwarfs
  - Microquasars
- Variability catalogue on day–month timescales

Initial 128T transients results



(See RSM drift scan movie; Martin Bell)

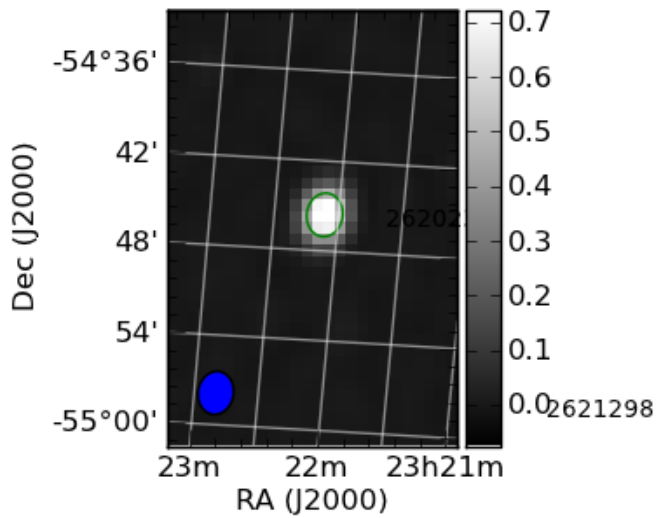
(See GP sneak preview; David Kaplan)

Transient detection pipeline

Source 200201 MWA_232206-544535

RA 23:22:06.69 Dec -54:45:37.07 search SIMBAD NED
Cross-match this source with the imported survey catalogues. View position plot.

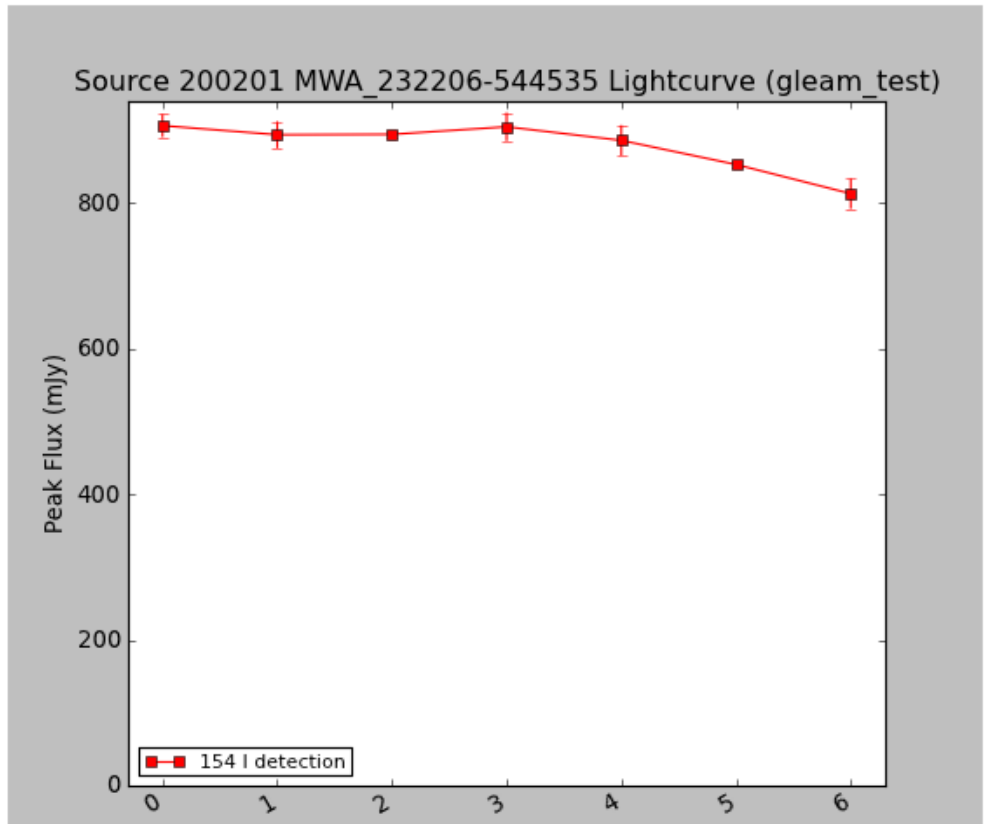
Quality source: None [set to True | False | Remove]



First Detection

Bands: 154

Polarisations: I



CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

Future challenges

1. Understanding confusion-limited surveys
2. Characterising ionospheric fluctuations
3. Incorporating full polarisation information
4. Reducing errors in source finding
5. Considering variability across full spectral range
6. **Running imaging and transient detection in real time**