VAST: exploring the dynamic radio sky

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(on behalf of the collaboration)
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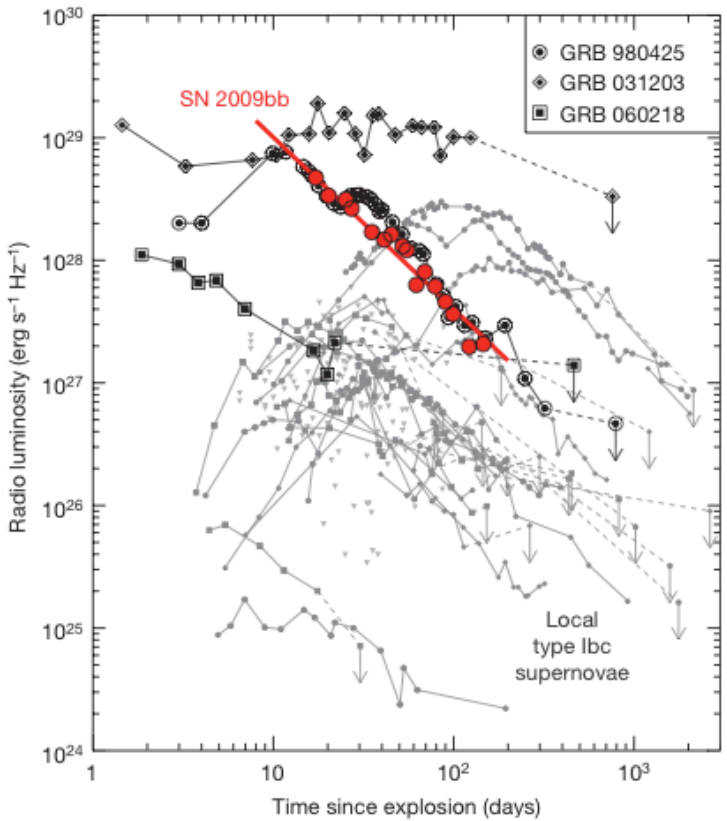
CAASTRO
ARC CENTRE OF EXCELLENCE FOR ALL-SKY ASTROPHYSICS

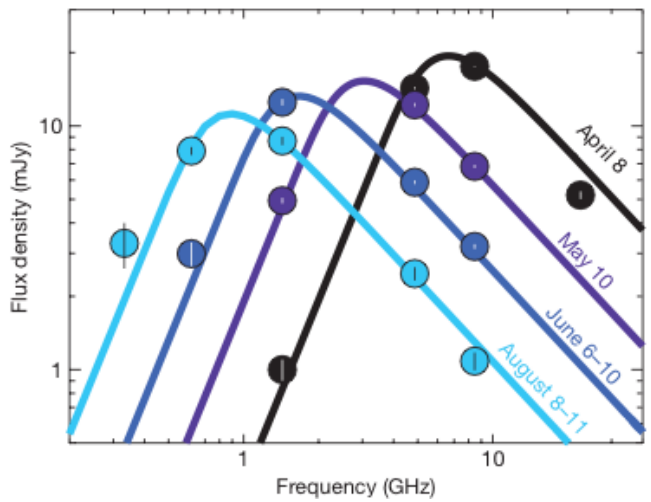
What causes radio transients?

1. **Explosions**
   - e.g. supernovae, Gamma-ray bursts, orphan afterglows
2. **Propagation**
   - e.g. extreme scattering events, intra-day variables
3. **Accretion**
   - e.g. neutron stars, black holes, quasars, X-ray binaries
4. **Magnetospheric**
   - e.g. magnetars, flare stars, planetary variability
5. **Unknown**
   - e.g. known unknowns, unknown unknowns...

Explosions: the search for orphan afterglows

- Highly beamed emission means most GRBs are undetected
- Afterglow can be detected in radio days to months later

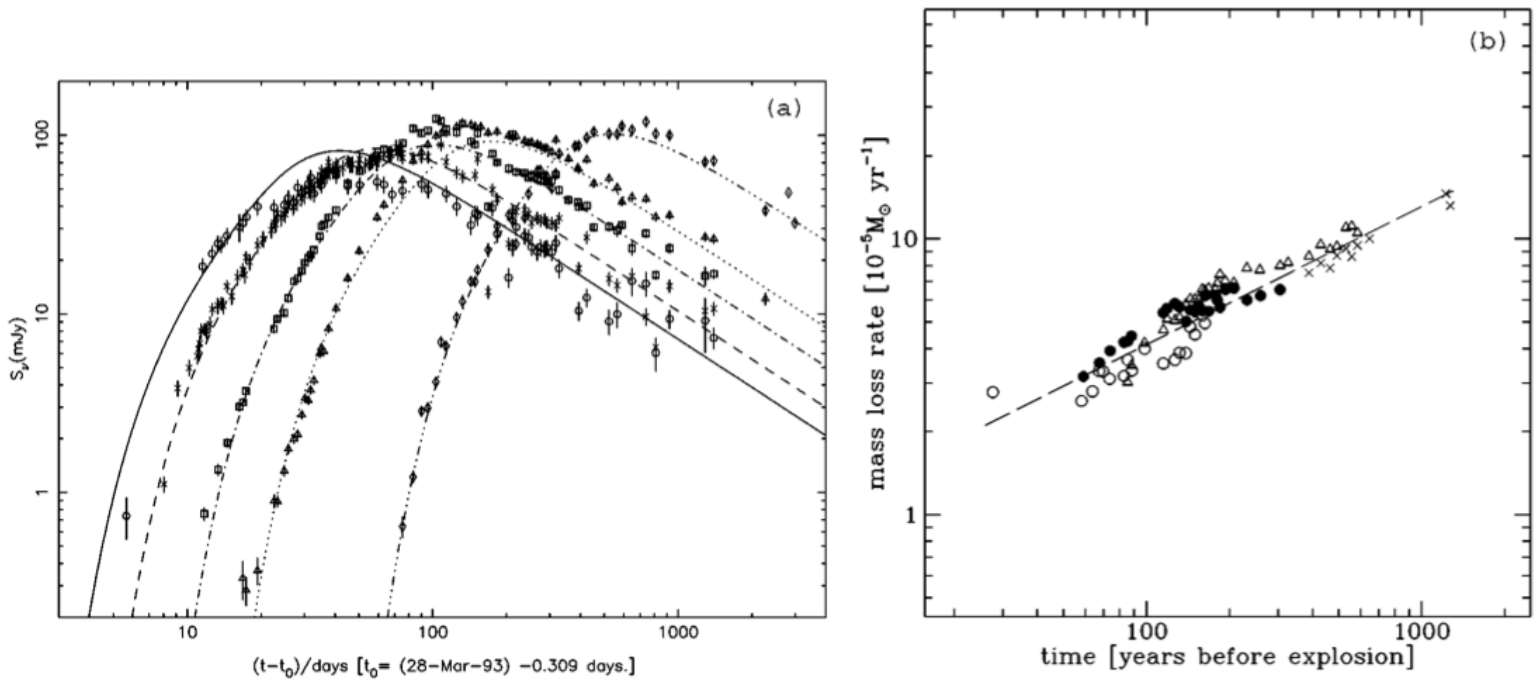




Soderberg et al. 2010, Nature, 464, 513

An unbiased census of supernovae

- Radio SNe probe the CSM and stellar mass outflow history
- We can detect new SNe that are obscured by dust



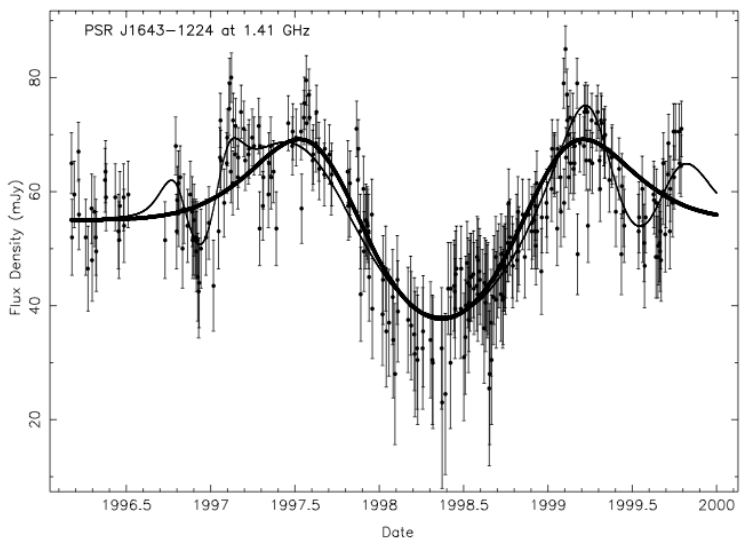
Weiler et al. 2002, ARA&A, 40, 387

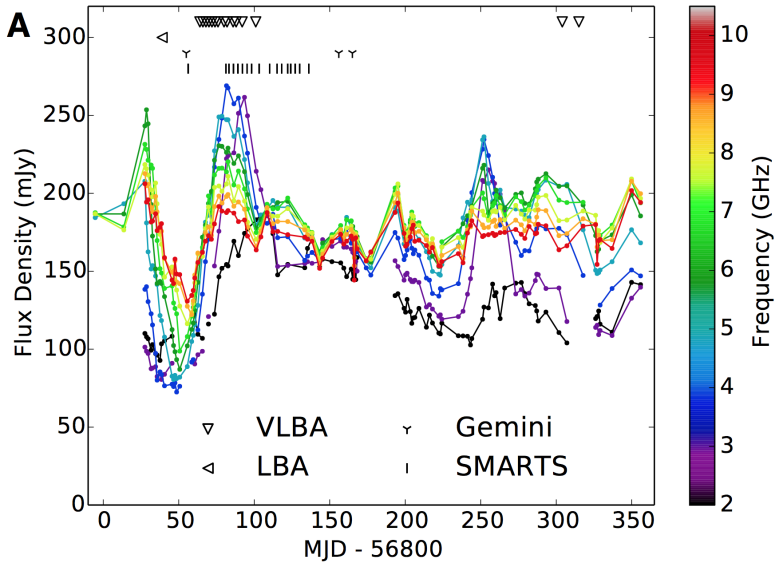
- No SNIa have been detected at radio wavelengths

(Hancock et al. 2011; Chomiuk et al. 2012)

The origin of extreme scattering events

- We will be able to characterise ESEs in real-time
- Map out dense neutral gas clouds in our Galaxy
- Could explain some fraction of baryonic dark matter





Maitia et al. 2003, ApJ, 582, 972
Bannister et al. 2016, Science, 351, 354

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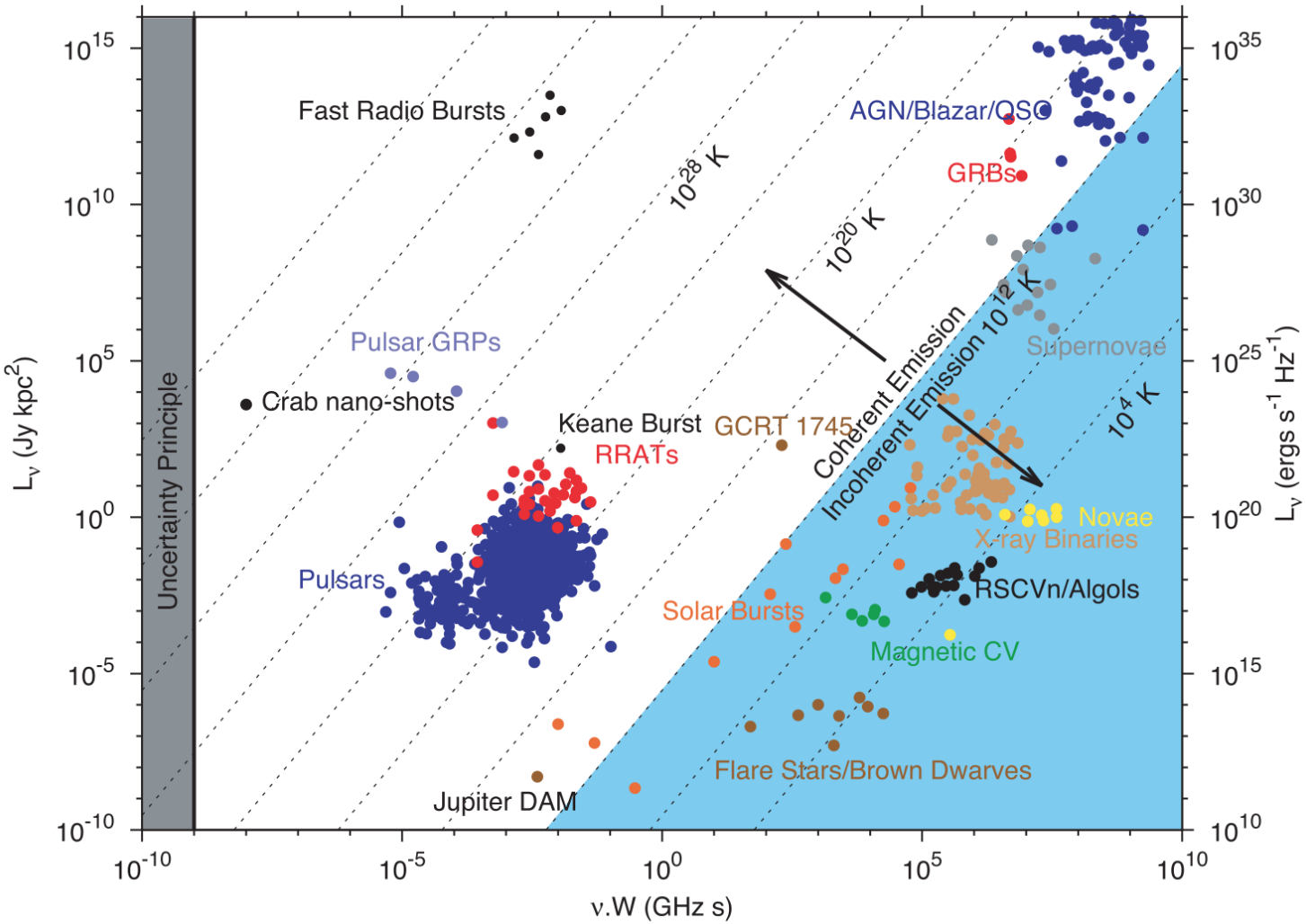
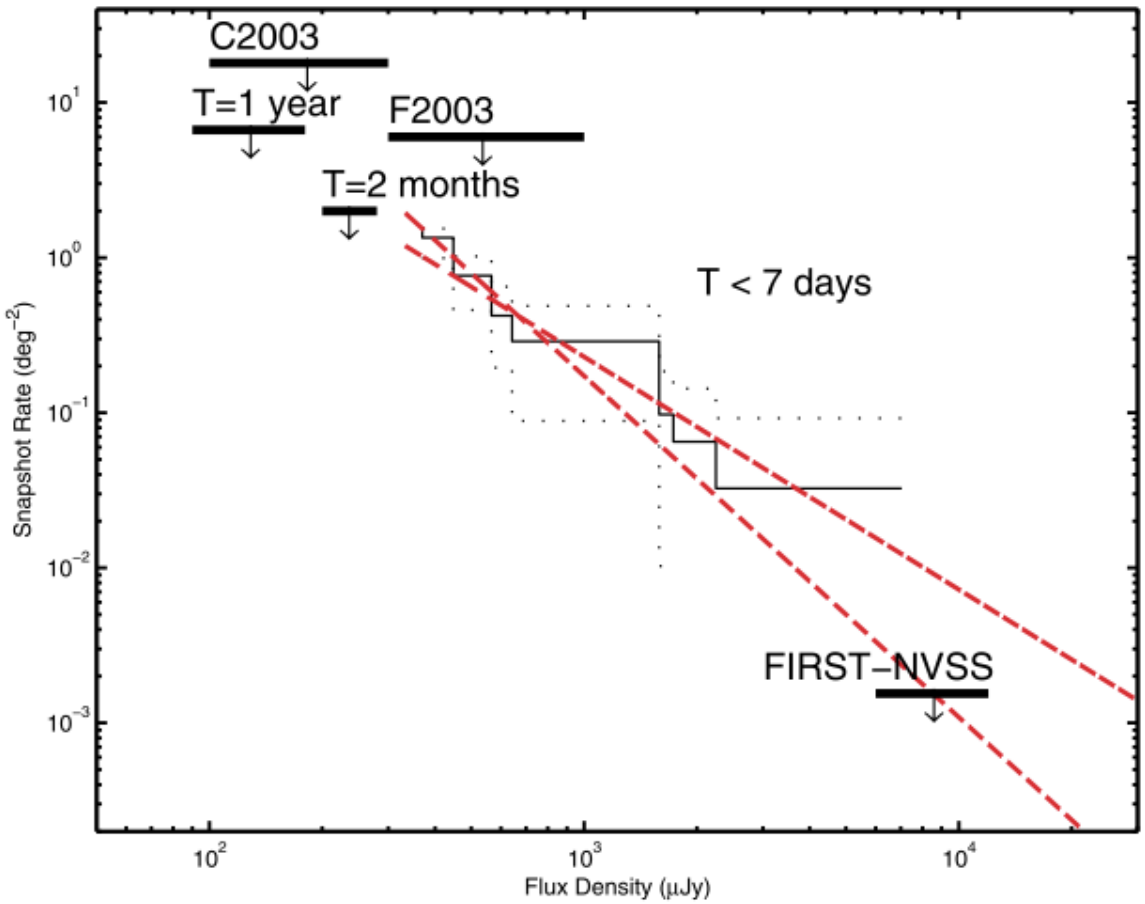
Exploring the unknown. . .



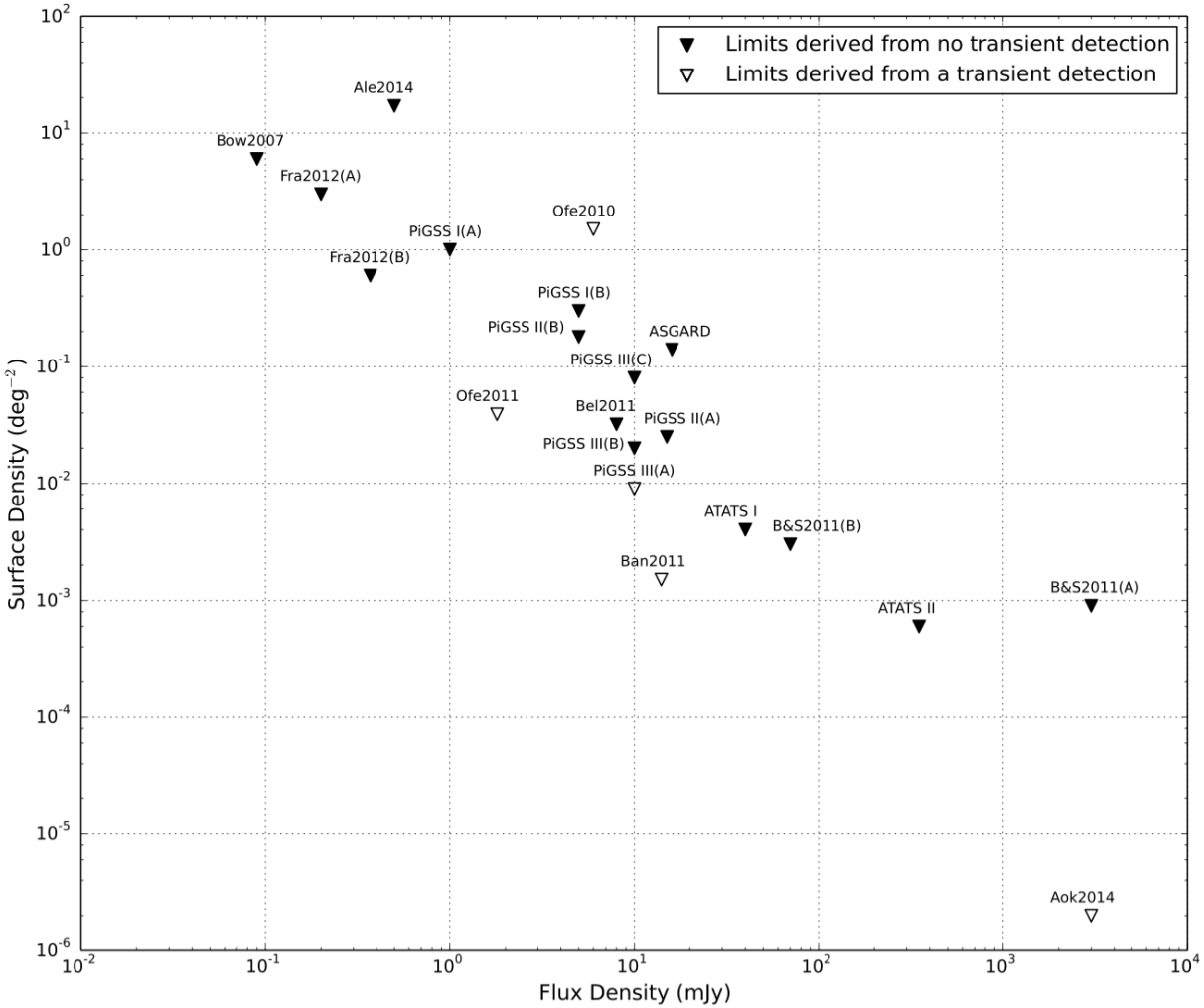
Pietka, Fender & Keane, 2015, MNRAS, 446, 3687

Transient snapshot rates (c. 2007)



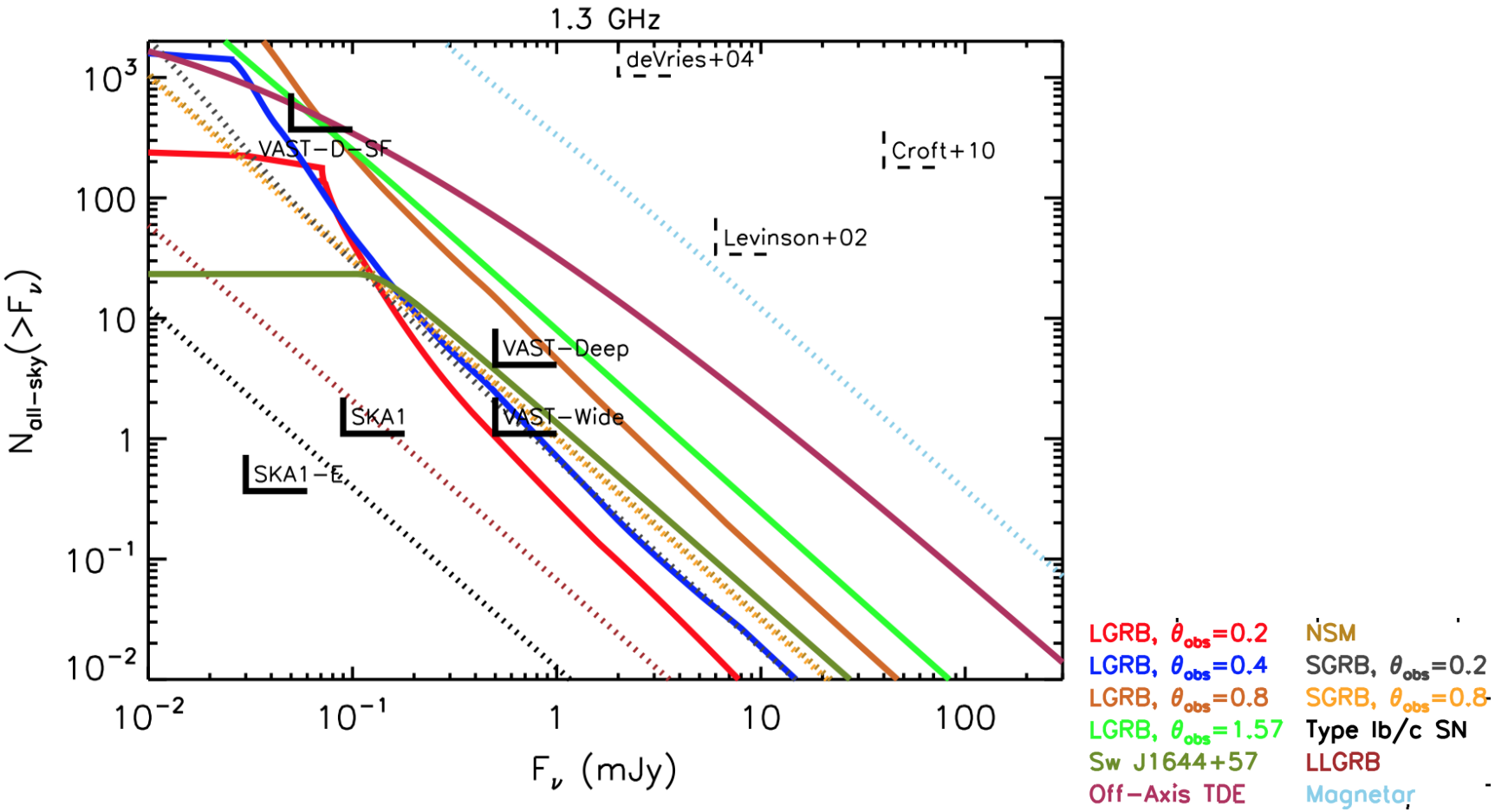
Bower et al. 2007, ApJ, 666, 346

Transient snapshot rates (c. 2015)



Fender et al. 2015, Proc. of Science

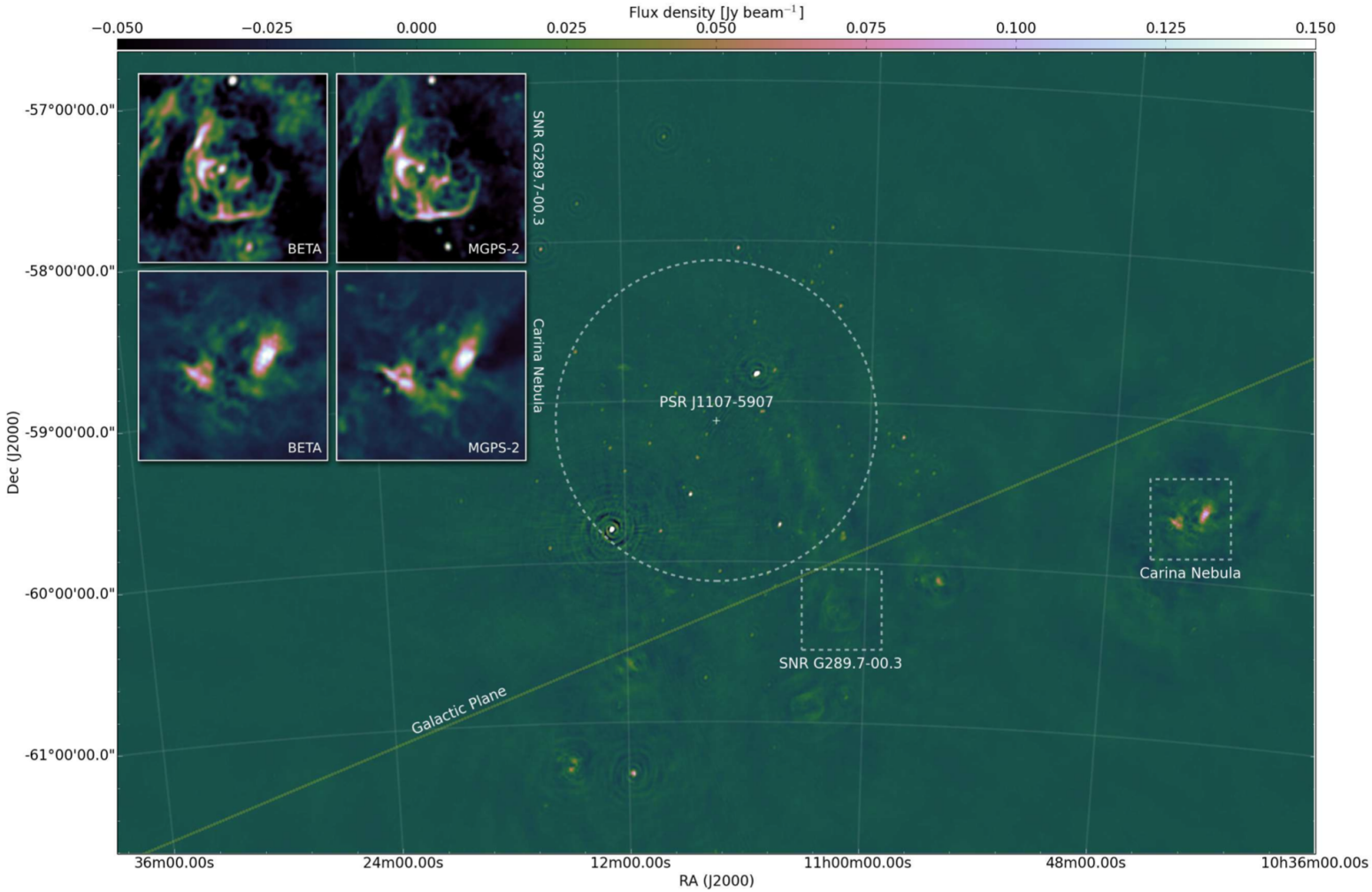
Approaching the detection threshold



Metzger, Williams & Berger 2015, ApJ, 806, 224

Results from BETA

Intermittent pulsar PSR J1107–5907



Hobbs et al. 2016, MNRAS, 456, 3948

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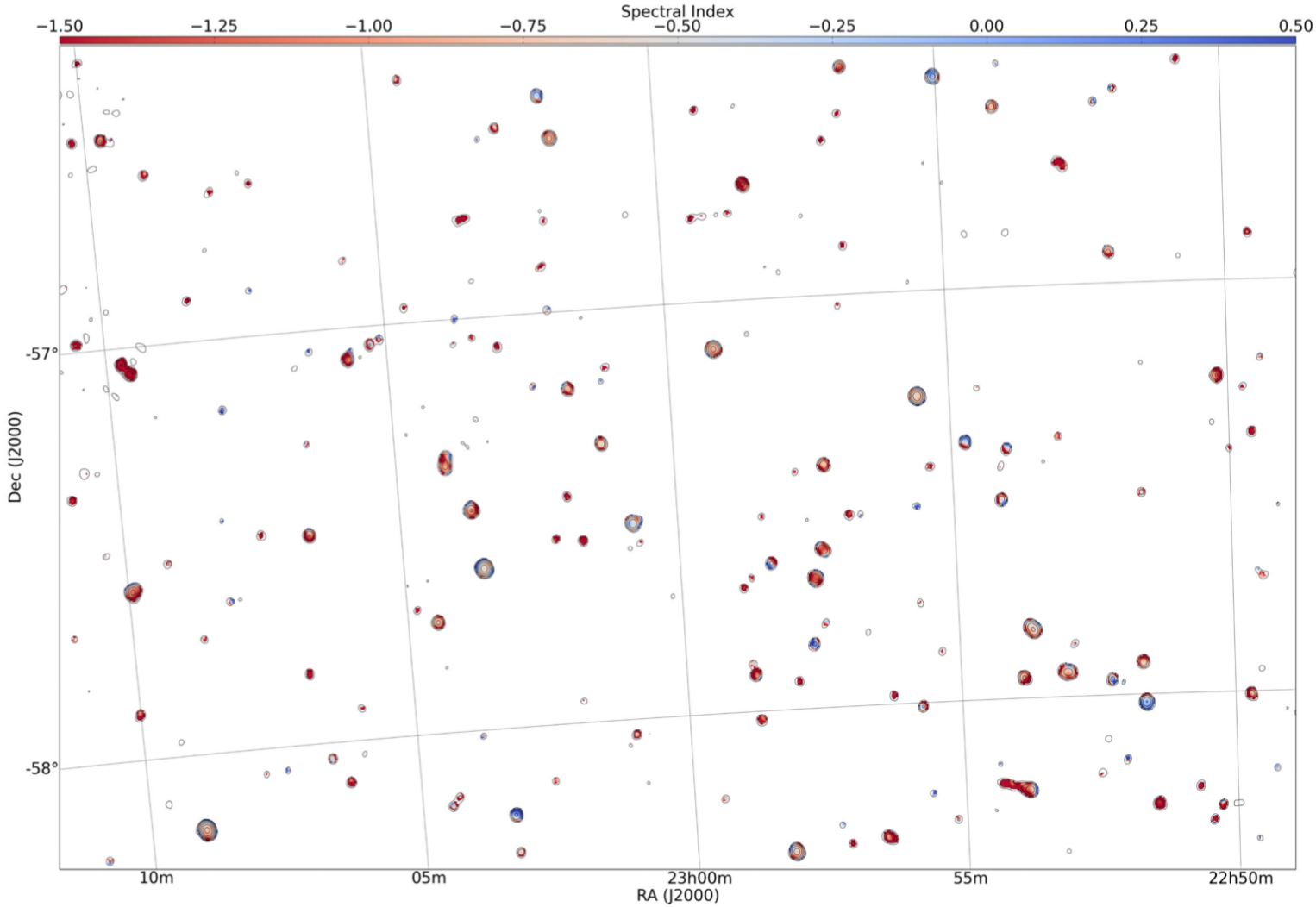
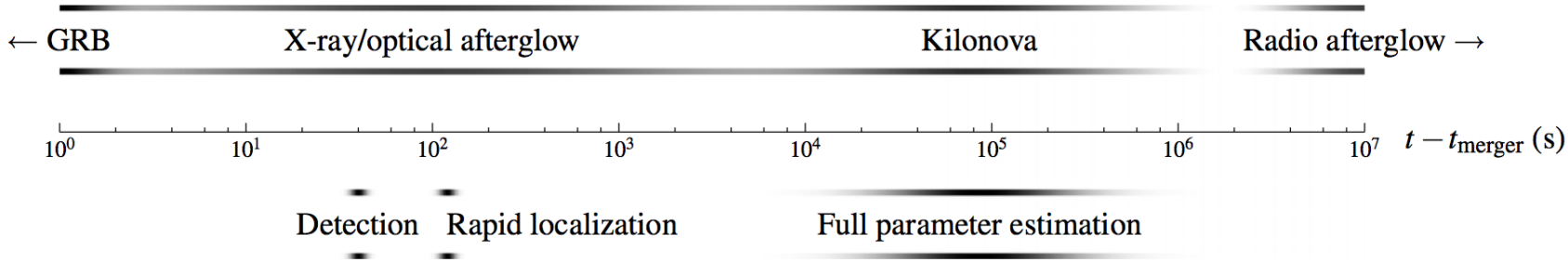
Multi-epoch continuum survey

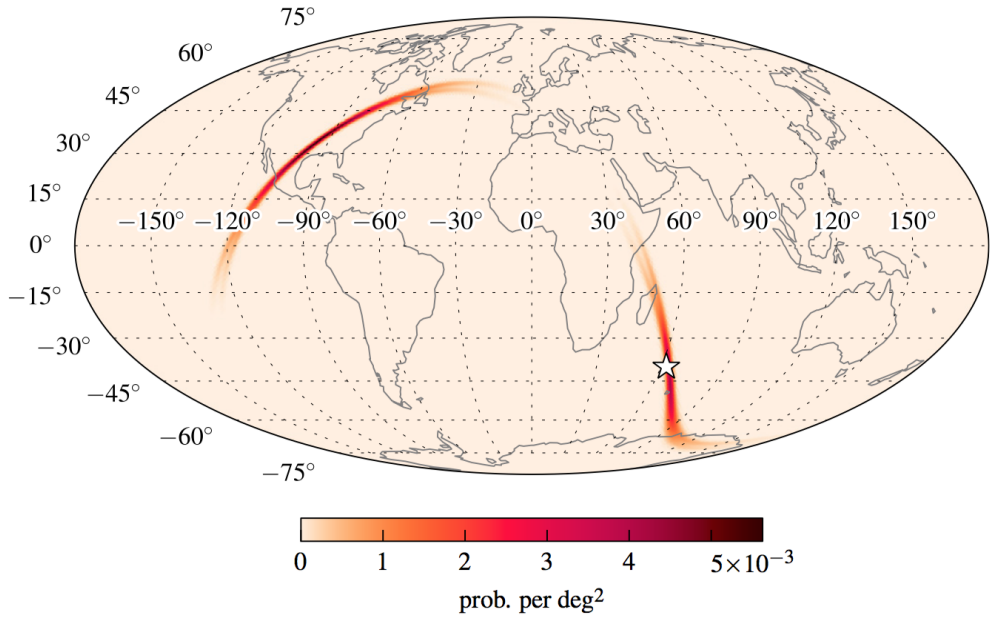


Heywood et al. 2016, MNRAS, 457, 4160

Radio follow-up of GW events



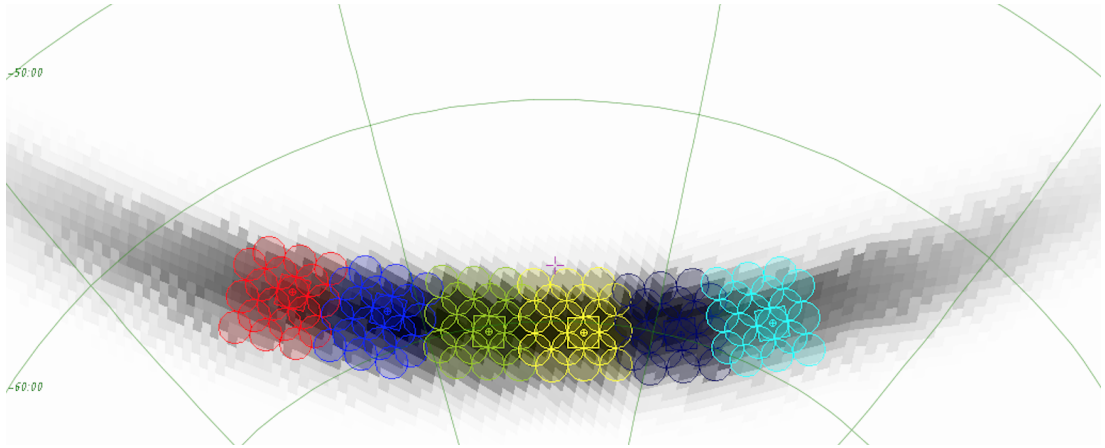
★ See talk by Tsvi Piran on Thursday



Singer et al. 2015, ApJ, 795, 105

ASKAP-BETA GW150914 results

- Northern region (4 pointings 100 square degrees)
- Southern probability maxima (9 pointings, 200 square degrees)
- Mosaic observations: 300 MHz, 9 beams, 5 antennas
- Southern region covered with 1 mJy/beam rms
- Looked for transients compared with SUMSS = no detections
- Covered 82% of the original constrained probability region 27% of the final probability region.



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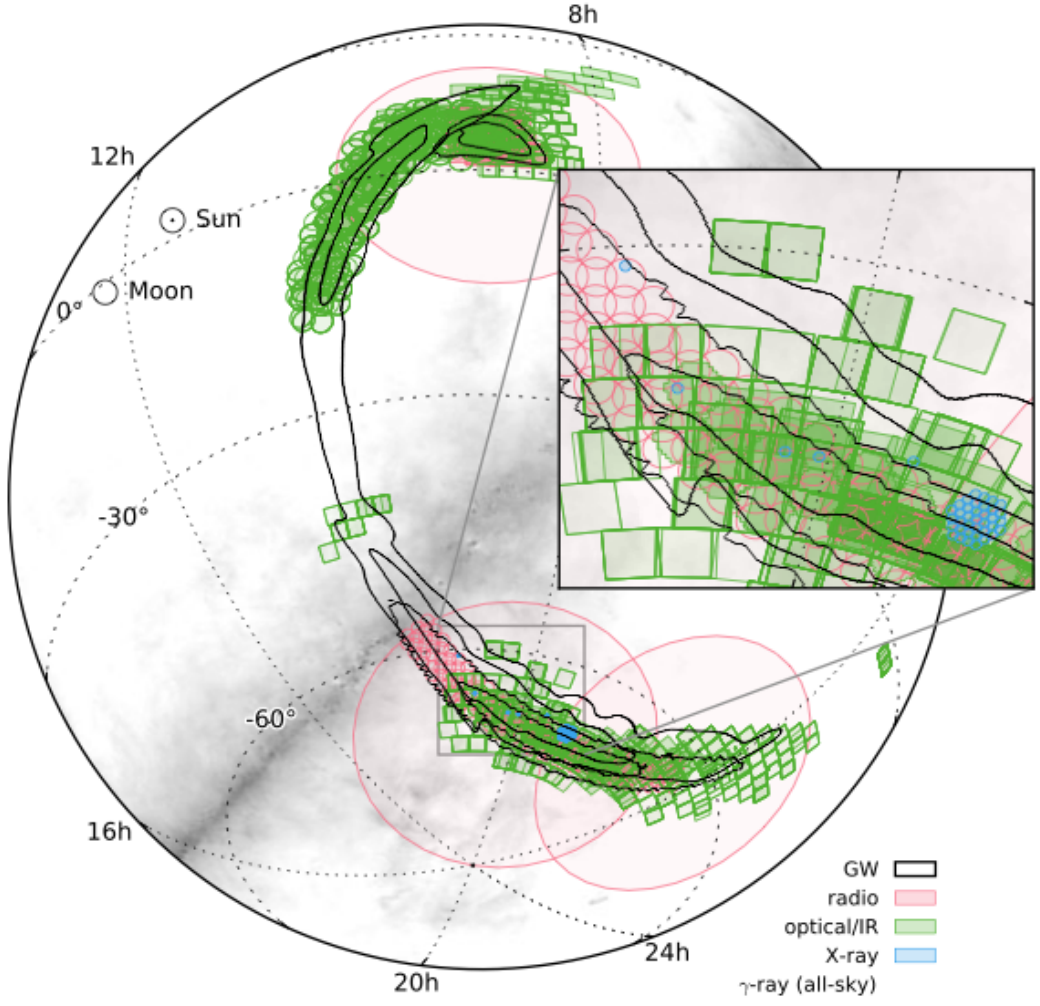
ASKAP-BETA GW150914 results



Abbott et al. 2016, ApJL, arXiv:1602.08492

Early Science

ASKAP-VAST Survey Strategy

	VAST-Wide	VAST-Deep		VAST-GP
Observing time (hrs)	4380	3200	400	600
Survey area (deg sq)	10 000	10 000	30	750
Time per field	40 s	1 hr	1 hr	16 min
Repeat	daily	7 times	daily	64 times
Observing freq (MHz)	1150–1450	1150–1450	1150–1450	1150–1450
Bandwidth (MHz)	300	300	300	300
RMS sensitivity	0.5 mJy/bm	50 μJy/bm		0.1 mJy/bm
Field of view (sq deg)	30	30	30	30
Angular resolution	10″ (Maximum possible)			
Spectral resolution	$\sim$ 10 MHz			
Time resolution	5 seconds (Maximum possible)			
Polarisation products	IQUV	IQUV	IQUV	IQUV

Murphy et al. 2013, PASA

VAST plans for early science

1. Commensal observing
   - $\sim$ 800 hours of EMU
   - $\sim$ 800 hours of WALLABY: 120 hours $\times$7 fields
   - DINGO & FLASH
2. $\sim$ 100 hours (TBD) of LIGO follow-up
3. Trial ASKAPSoft imaging on short timescales
4. Improve transient detection pipeline

VAST technical/software highlights

- Hancock et al. (2012)
  Continuum source finding for radio surveys
- Lo et al. (2014)
  Online classification for time domain astronomy
- Lo et al. (2014)
  Automatic classification of time variable X-ray sources
- Farrell et al. (2015)
  Automatic classification of variable 3XMM sources
- We have also been using pipeline in MWA transients projects

VAST science highlights

- Murphy et al. (2013)
  VAST science case and transient pipeline
- Ghirlanda et al. (2014), Burlon et al. (2015)
  GRB orphan afterglows in radio transient surveys
- Bell et al. (2015)
  5.5 GHz transient survey in Chandra Deep Field South
- Bannister et al. (2016)
  Real-time detection of ESEs
- Hobbs et al. (2016)
  Radio transient events around intermittent pulsar PSR J1107−5907
- Heywood et al. (2016)
  Multi-epoch continuum survey with BETA
- Abbott et al. (2016)
  Broadband follow-up of gravitational-wave transient GW150914