Transient science with the Square Kilometre Array

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The dynamic radio sky

- Radio surveys have given us a largely static view of the sky
- A figure of merit for transient detection is

$$A\Omega \left(\frac{T}{\Delta t} \right) = \text{large}$$

$A =$ collecting area
$\Omega =$ solid angle coverage
$T =$ total duration of observations
$\Delta t =$ time resolution

- The SKA and pathfinders will allow us to explore transient phenomena in an unbiased way, for the first time

What causes transient phenomena?

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. . .

SKA Science

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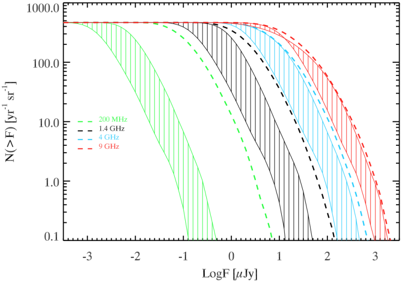
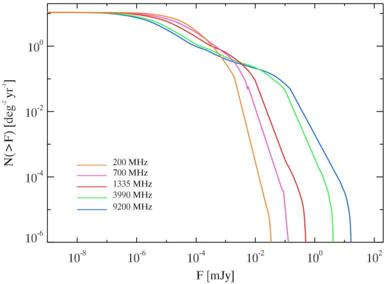
SKA: Gamma-ray bursts

- Long: collapse of massive star
- Short: merger of two neutron stars (or black hole)
- Trace cosmic star formation to high redshift
- SKA can observe large fraction of GRB afterglows
- Detect orphan afterglow emission

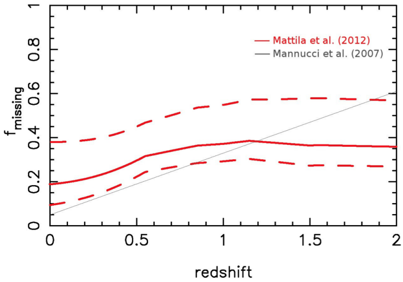


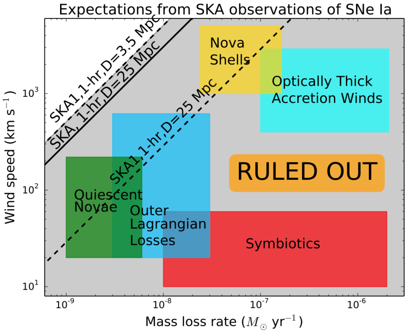


Burlon et al. 2015, arXiv:1501.04629

SKA: Supernovae

- Determine true CCSN rate in local Universe
- Bridge the gap between Type IIBc SNe and GRBs
- Determine progenitor scenario for Type 1a SNe

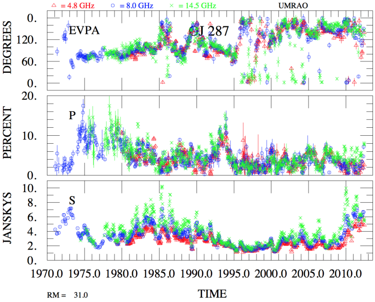


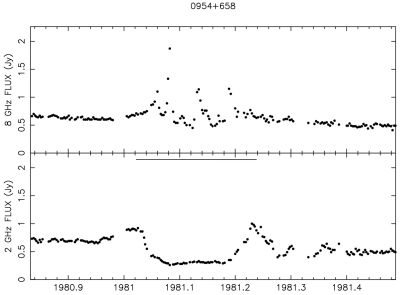


Pérez-Torres et al. 2015, arXiv:1409.1827

SKA: Active galactic nuclei

- Intrinsic variability: flares, shocks around SMBH
- Extrinsic variability: scattering in ISM, IGM
- SKA will allow monitoring of $\sim 10^5$ sources

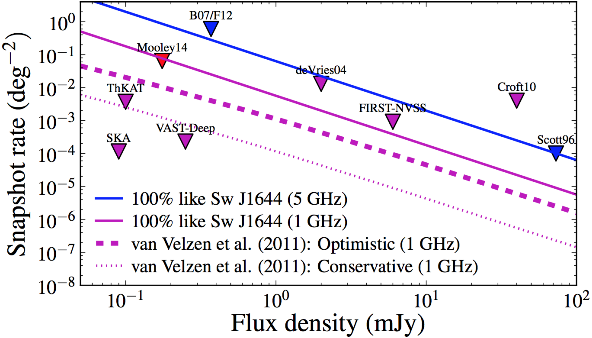




Bignall et al. 2015, arXiv:1501.04627

SKA: Tidal disruption events

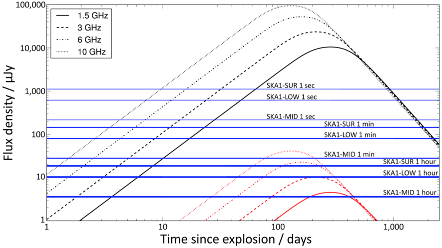
- Tidal disruption of stars by supermassive black holes:
  - Can discover quiescent supermassive black holes
  - Can study early stages of jet formation in AGN

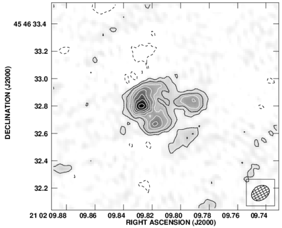


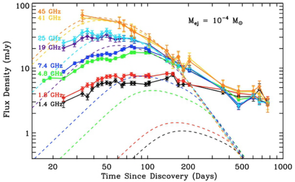
Donnarumma et al. 2015, arXiv:1501.04640

SKA: Novae and symbiotics

- Interacting binary star systems
- Hot white dwarf orbits a main-sequence/red giant star.
- Thermal emission traces outflows
- Can determine mass, kinetic energy

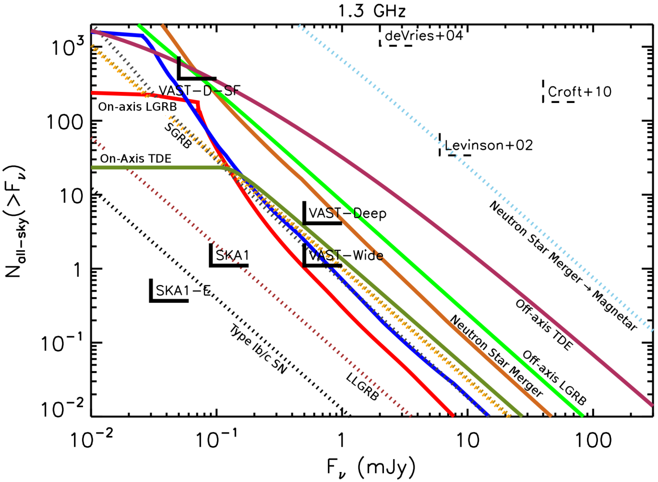






O'Brien et al. 2015, arXiv:1502.04927

What will the SKA see?



Metzger, Williams, Berger (2015, 1502.01350)

Current Results

MWA 128T transients surveys

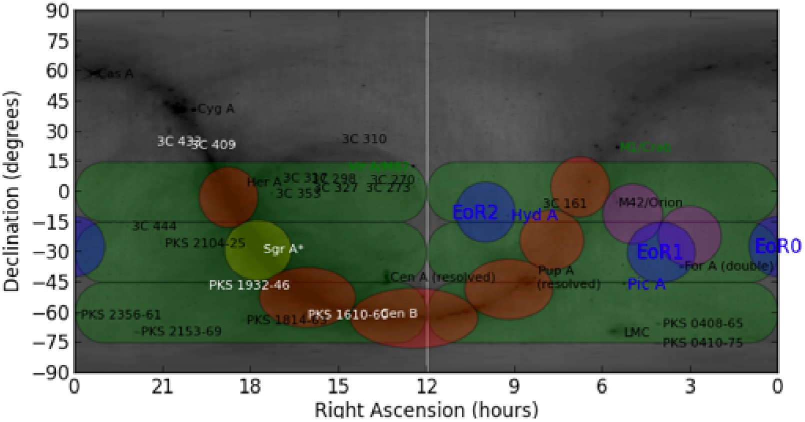


Image credit: David Kaplan

MWA survey results

- Cadences from 4 seconds – months
- Searching for pulsars (Bell), FRBs (Tingay, Trott, Rowlinson)
- Blind searches (Bell, Rowlinson)

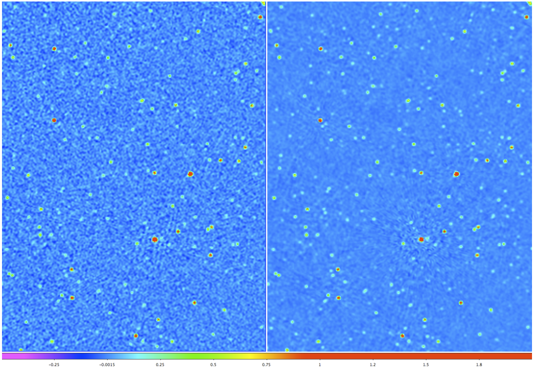
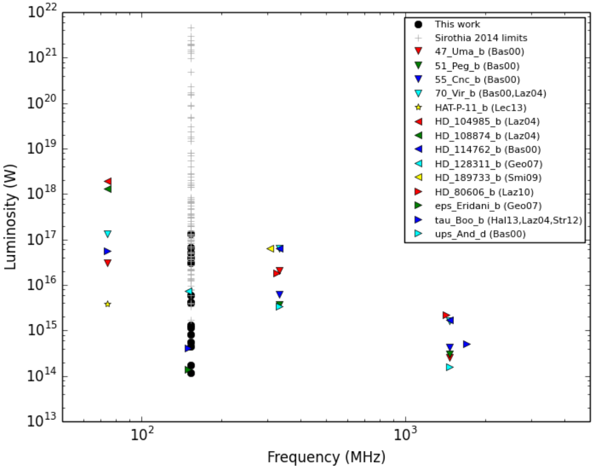


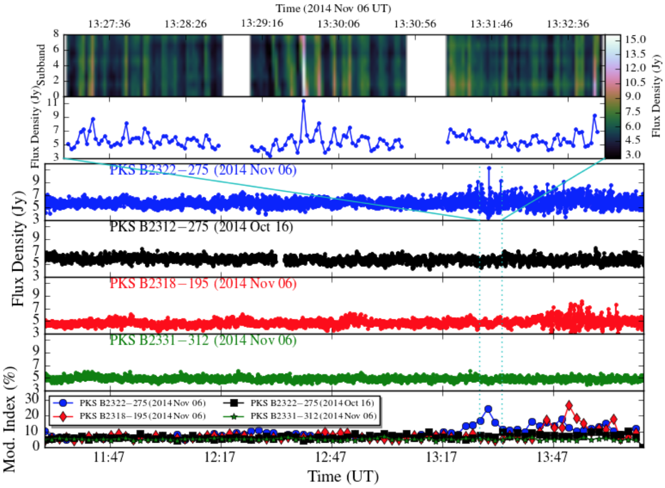
Image credit: Antonia Rowlinson

Radio emission from exoplanets?



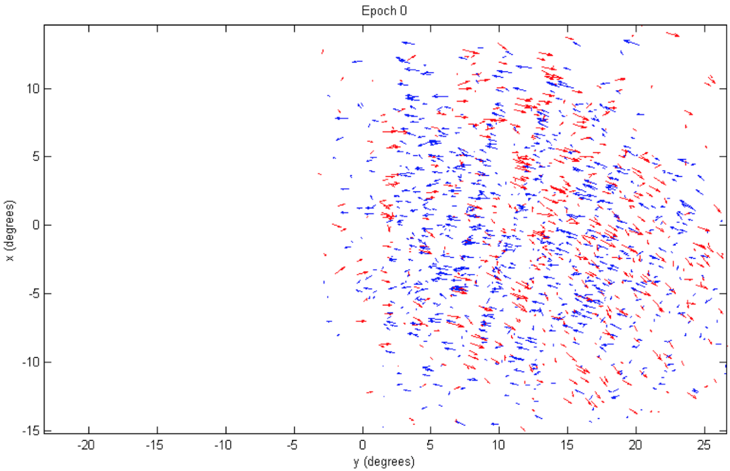
Murphy et al., 2015

Interplanetary scintillation



Kaplan et al. 2015, *in prep*

The ionosphere: direction field



Loi et al. 2015, *submitted*

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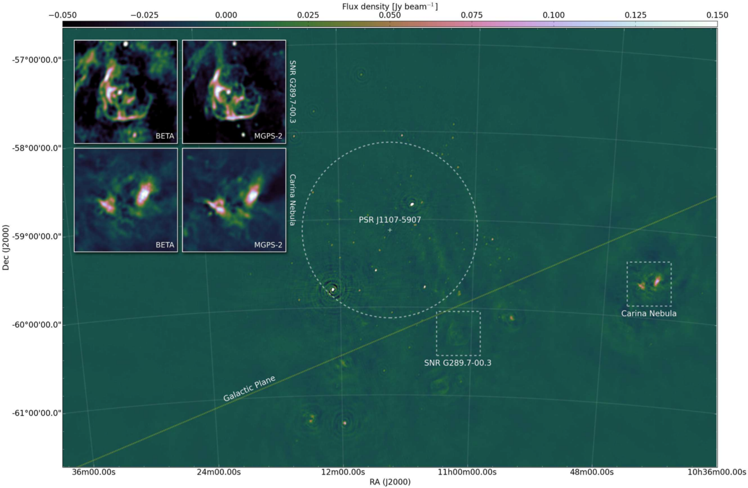
First results from BETA

150 sq deg to 1 mJy in 12 hours

Credit: Bannister & Heywood (CASS)

Intermittent pulsar PSR J1107–5907



Hobbs et al. 2015, *in prep*

First results from UTMOST

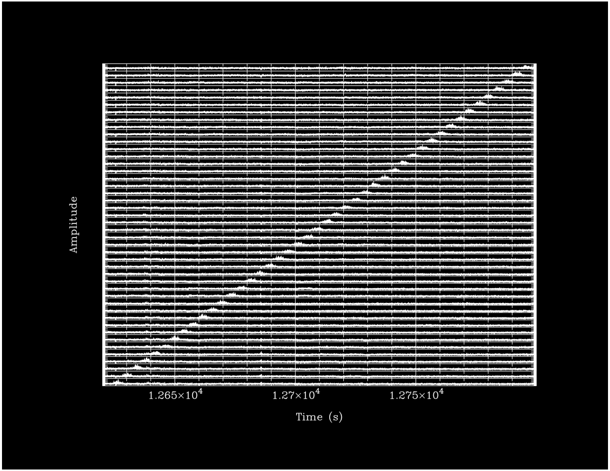


Image Credt: Ravi, Bailes et al

Future Challenges

Technical challenges

- Source finding (Hancock et al.)
- Source classification (Lo et al., Farrell et al.)
- Transient detection pipeline (Murphy et al.)
- Characterising rates and detection statistics (Trott et al.)
- Data storage and processing

- 'Real time' processing
- Triggering and follow-up

Summary: what we have learnt so far

- Large scale transients surveys open us new parameter space
  ...but increases the data/technical challenges
- Commensal surveys will produce great science
  ...however ability to do targeted follow-up is important
- Rapid processing and follow-up is critical
  ...follow-up on slower timescales than the events is limited
- Australia is leading lots of the scientific and technical efforts
  ...need to make sure this feeds into SKA