



Supernova Remnant Searches with the Molonglo Telescope

Anne J. Green



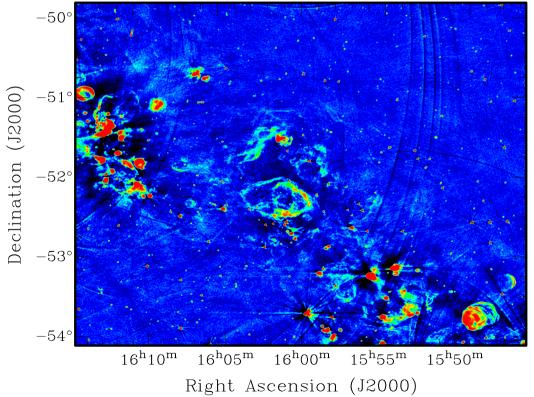


Overview of Talk

- Molonglo Galactic Plane Survey
- New supernova remnant candidates synergies between γ-ray & radio astronomy
- The UTMOST a telescope reborn
- What can we expect for the future?

^{2nd} Molonglo Galactic Plane Survey

Region covered: $245^{\circ} \le 1 \le 365^{\circ}$ for $|b| \le 10^{\circ}$ Area: 2400 deg² Resolution: ~43" Sensitivity: 1-2 m |y| beam (12 hours, 1σ)

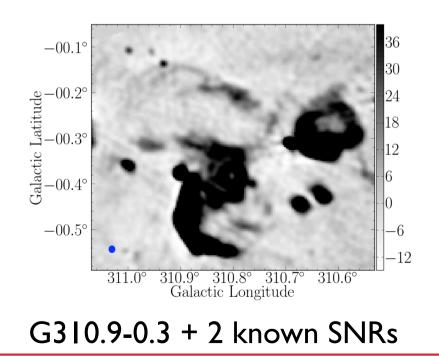


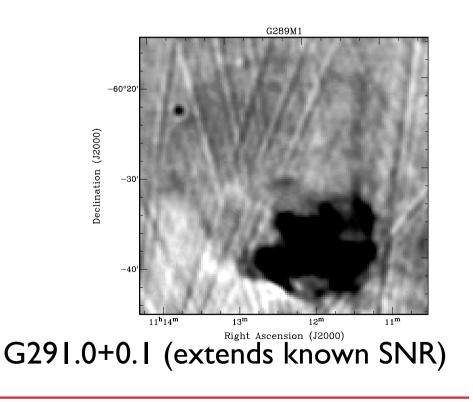
Mosaic J1600M52 (4° x 4°)

WINNEY MGPS-2 (new SNR candidates)

Selection Criteria:

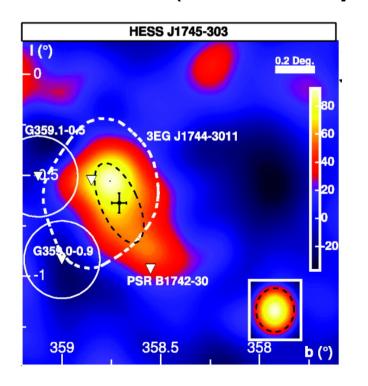
- Shell sources
- Angular diameter \geq 5 arcmin
- Absence of detectable MIR emission
- 23 Candidates identified





Synergy – correlate radio & γ-ray sources

- 30% TeV sources no identified counterparts
- Higher positional accuracy needed to match low frequency radio (synchrotron) and molecular cloud distribution (CO surveys) with γ-ray sources



Example: H.E.S.S. J1745-303 Aharonian et al. (2012)

SYDNEY What is the UTMOST?

- MOST is the largest radio telescope in Australia: 5xParkes, 4xASKAP
- Development work on digital back-end began around 2005: Polyphase Filterbank + correlator, 100 MHz BW, 700-1100 MHz
- August 2012 Swinburne collaboration proposed hybrid correlator solution: 33 parallel GPU cluster, with total data rate (22 Gbits/s)

SYDNEY UTMOST – technical details

Specfications

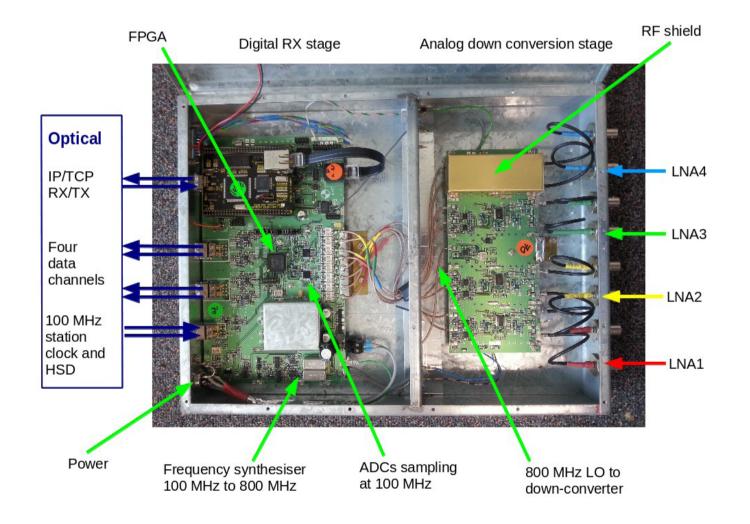
- Frequency range: 830 860 MHz
- Field of View $\approx 10 \text{ deg}^2$
- Angular resolution: 43" x 43" cosec $|\delta|$
- 256 µsec timescale RFI monitor & excision
- 15,000 spectral channels (0.5 km/s resolution)
- 1σ sensitivity per beam: 200 μJy in continuum

Comparison with MOST

- Larger FoV, 10x bandwidth
- Short time domain physics & spectroscopy possible
- Simultaneous mapping, pulsar & burst mode, RFI excision



SYDNEY Down Conversion & Digital Receiver





Science goals

MAP: Imaging the radio sky

BURST: Fast radio bursts (FRBs) –

At full sensitivity, UTMOST should detect more than one FRB every 10 days.

TIME: Massive-scale pulsar timing –

At full sensitivity, UTMOST will time 500 pulsars daily, with up to 30 per FOV, coherently de-dispersed

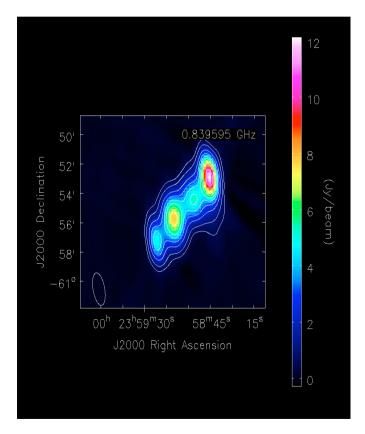


Image credit: Shivani Bhandari, Vikram Ravi

Fornax A – complex radio galaxy

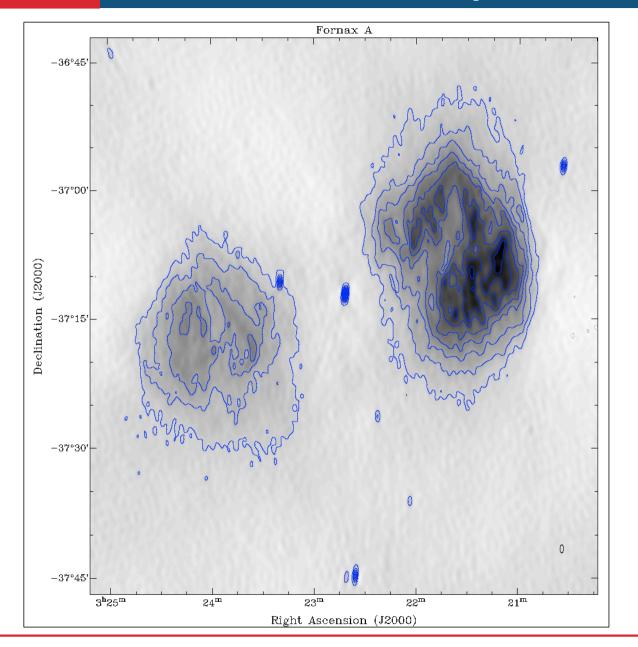
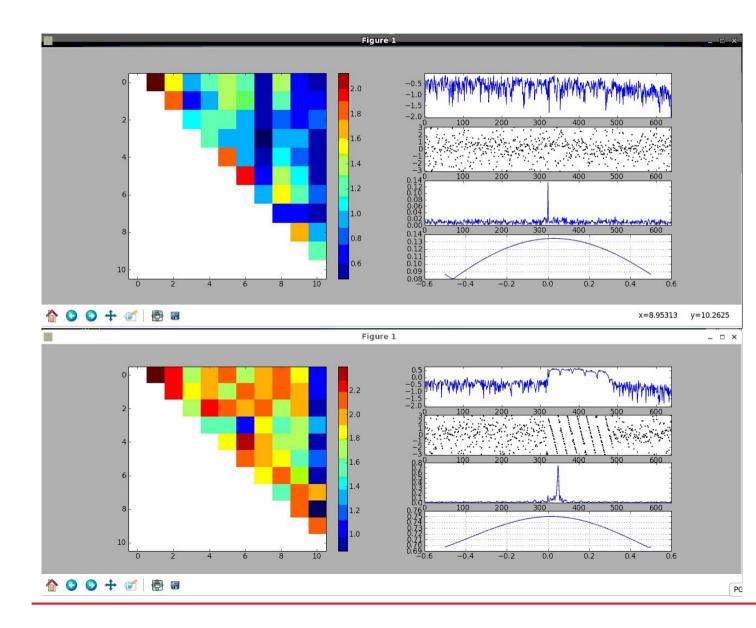


Image credit: Vikram Ravi Chris Flynn

Phone calls & a quasar with 6% telescope

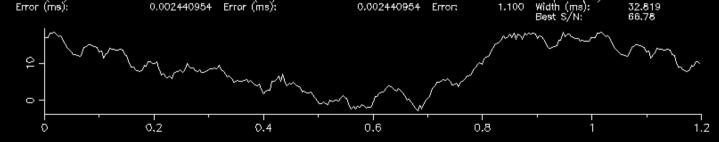


Use kurtosis of the raw voltage signal to remove RFI

Radio Frequency Interference

80833-45: grand.tot BC P(ms)= 89.389806640 TC P(ms)= 89.384028310 DM= 67.990 RAJ= 00:00:00.00 DecJ= 00:00:00.0 BC MJD = 56415.244973 Centre freq(MHz) = 850.000 Bandwidth(MHz) = 100 I = 96.337 b = -60.189 NBin = 256 NChan = 128 NSub = 12 TBin(ms) = 0.349 TSub(s) = 3.000 TSpan(s) = 57.988 P(us): offset = 0.00000, step = 0.53820, range = 10.40300 DM: offset = 0.000, step = 0.129, range = 33.068 80 MOB 40 -5Û 5 -1010 delta Period (us) Phase vs Time Phase vs Frequency 900 Elapsed Time (seconds) Frequency (MHz) 820 840 850 880 (MHz) 40 20 800 0 Ó 0 0.50.5BC prd (ma): Corrn (ma): Error (ma): 89.379580217 TC prd (ms): -0.010226424 Corrn (ms): 0.002440954 Error (ms): 89.373802547 -0.010225762 34.922 BC freq (Hz): -33.068 Freq err. (Hz): 1.100 Width (ms): DM: 11.188237823 0.000305550 Corrn: 0.002440954 Error:

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Kurtosis zapping

80833-45; grand.tot BC P(ms)= 89.389806613 TC P(ms)= 89.384028283 DM= 67.990 RAJ= 00:00:00.00 DeaJ= 00:00:00.0 BC MJD = 56415.244974 Centre freq(MHz) = 850.000 Bandwidth(MHz) = 100 I = 96.337 b = -60.189 NBin = 256 NChan = 128 NSub = 11 TBin(ms) = 0.349 TSub(s) = 2.533 TSpan(s) = 57.341P(us): offset = 0.00000, step = 0.54427, range = 12.32308 DM: offset = 0.000, step = 0.129, range = 33.068 80 MO OS 40 -5 5 10 -10Û delta Period (us) Phase vs Time Phase vs Frequency 900 Elapsed Time (seconds) 880 (MHz) 40 350 Frequency 820 840 20 800 0 ò 0.50.5 Ω 89.390895225 TC prd (ms): 0.001088612 Corrn (ms): 0.000880334 Error (ms): BC prd (ma): Corrn (ma): Error (ma): 89.385116824 DM: 0.001088541 Com BC freq (Hz): Freq err. (Hz): Width (ms): 11.186821627 68.505 0.515 0.000110169 Corrn: 3.143 24.32 0.000880334 Error; 0.391Best S/N: 2 - - Mar man man man man and a start and a MMMmy Mary Mr 0.2 0.4 0.6 0.8 1.2



What's next?

- Install second half of supercomputer
- High-speed internet link to site
- Commission remote control for sub-systems
- Full program of FRB search
- Implement imaging survey program

Watch this space!

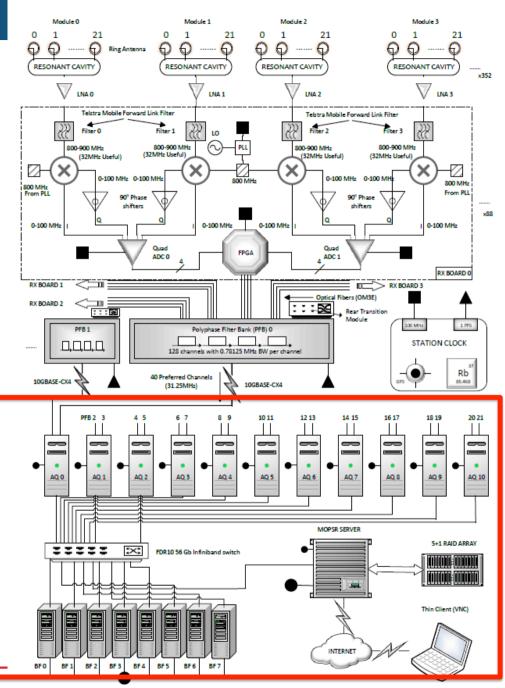


The Molonglo Correlator

I2 AQ servers with 6 CPUs and 2 GPUs (I x GTX690 graphics card) each
72 CPU cores and 24 GPUs
22 PFBs handling I6 modules each – 40 frequency channels
22 GiB/s data rate
Server cost approx \$76k

Other Swinburne contributions

GPS station clock ~\$10k
InfiniBand Switch \$10k
RAID server \$16k
UPS (2 units) \$3.4k
2 x retired Cisco switches (in kind contribution)



What are some future options?

- Radio frequency bremsstrahlung from CR and γ-ray atmospheric showers
- Relativistic beamed pulses from CR and γ-ray atmospheric showers
- Radio synchrotron emission from secondary electrons
- Detection of GRB prompt emission & (orphan) afterglows – wide field of view & storage buffers needed
- Future large radio telescopes with time link to particle detectors for source filtering and storage buffer to search backwards – radio Cerenkov?