Supernova Remnant Searches with the Molonglo Telescope

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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?

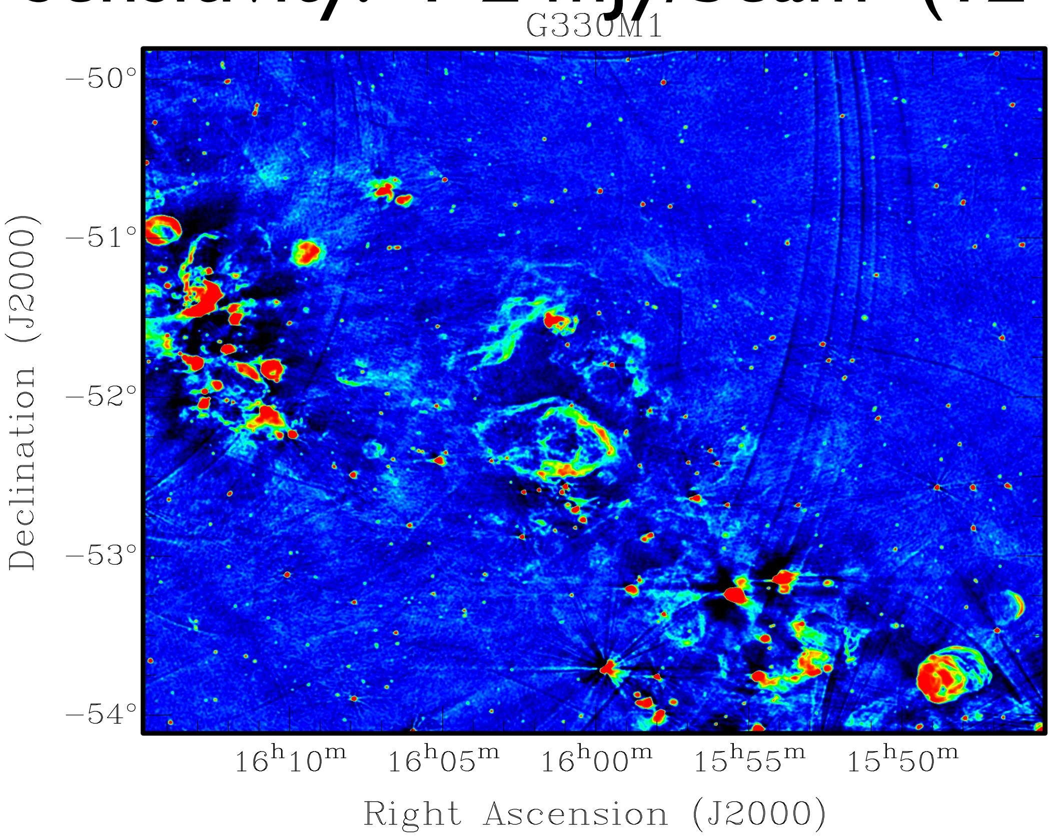
2nd Molonglo Galactic Plane Survey

Region covered: 245° ≤ l ≤ 365° for $|b|$ ≤ 10°

Area: 2400 deg^2

Resolution: ~43”

Sensitivity: 1-2 mJy/beam (12 hours, 1σ)

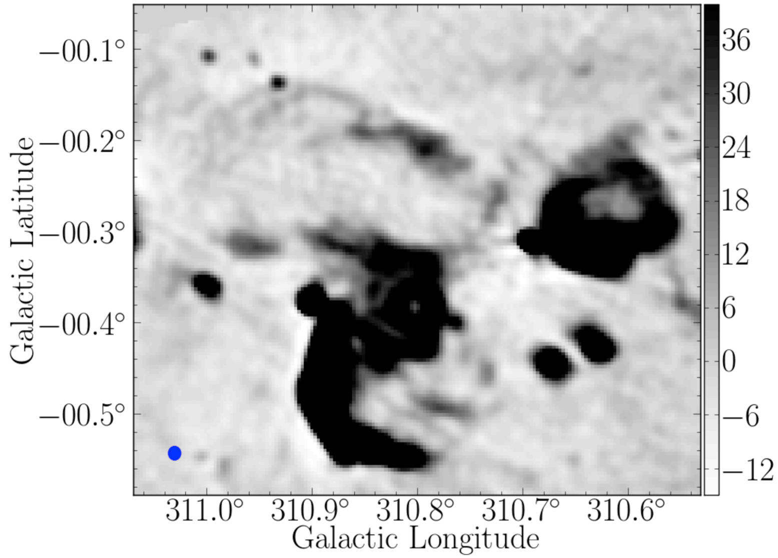


Mosaic J1600M52
(4° x 4°)

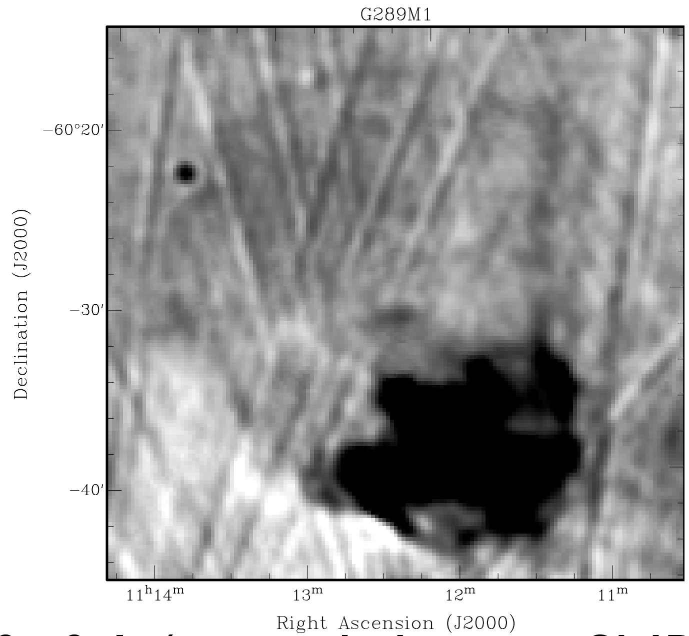
MGPS-2 (new SNR candidates)

Selection Criteria:

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



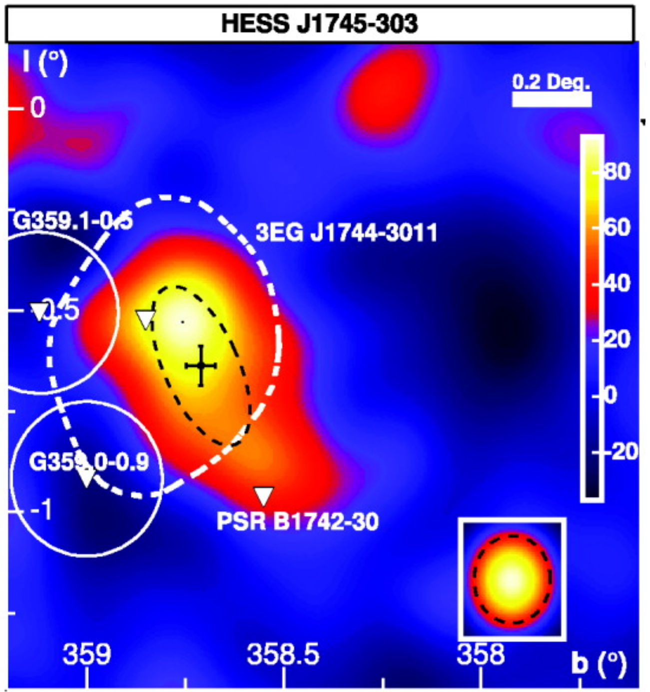
G310.9-0.3 + 2 known SNRs



G291.0+0.1 (extends known SNR)

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)

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)

UTMOST – technical details

Specfications

Frequency range: 830 – 860 MHz

Field of View ≈ 10 deg^2

Angular resolution: 43” x 43” cosec|δ|

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


DEMO ONLY
FPGA
Digital RX stage
Analog down conversion stage
Optical
IP/TCP RX/TX
Four
channels
100 MHz station clock and HSD
LNA4
LNA3
LNA2
LNA1
Power
Frequency synthesiser 100 MHz to 800 MHz
ADCs sampling at 100 MHz
800 MHz LO to down-converter

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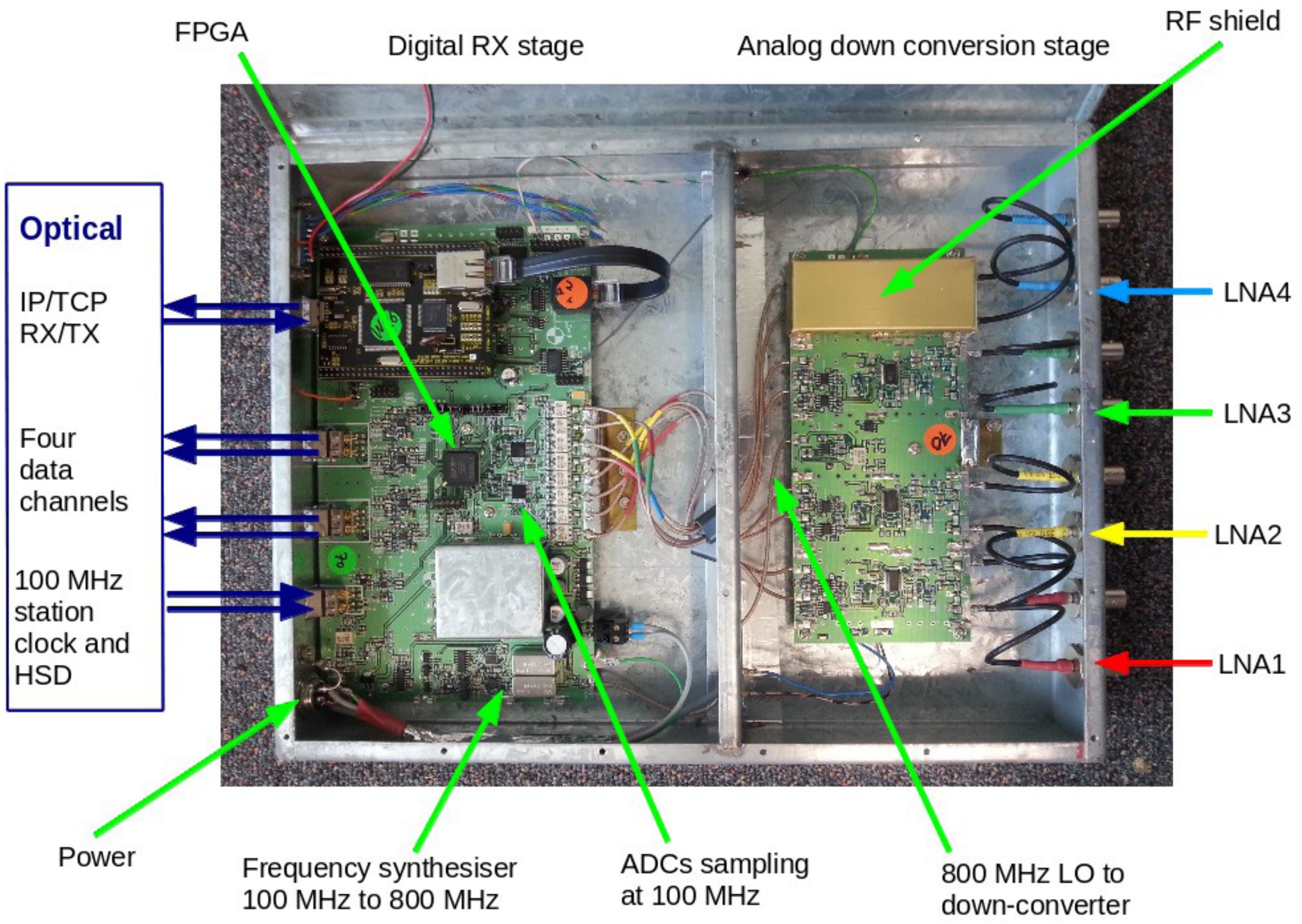
Down Conversion & Digital Receiver



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

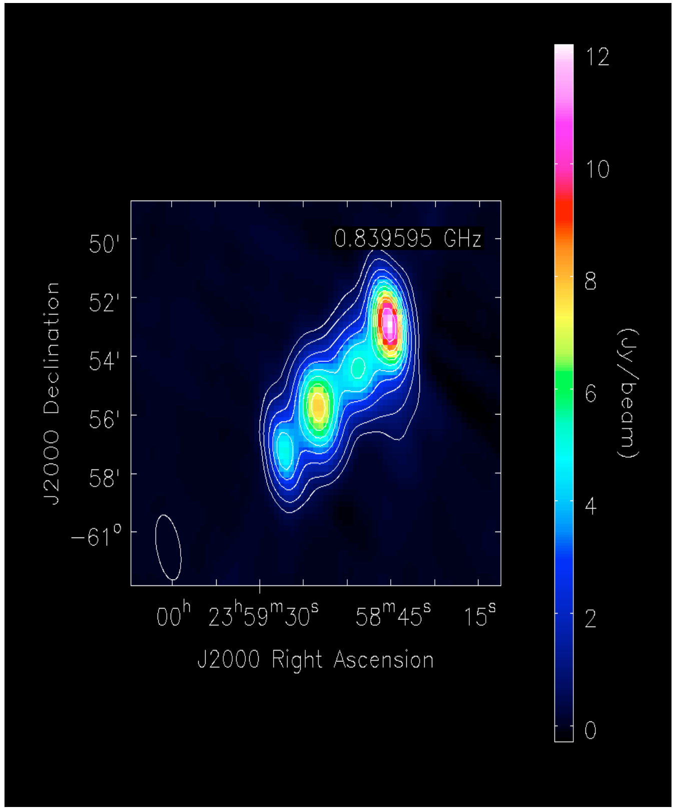


Image credit: Shivani Bhandari, Vikram Ravi

Fornax A – complex radio galaxy

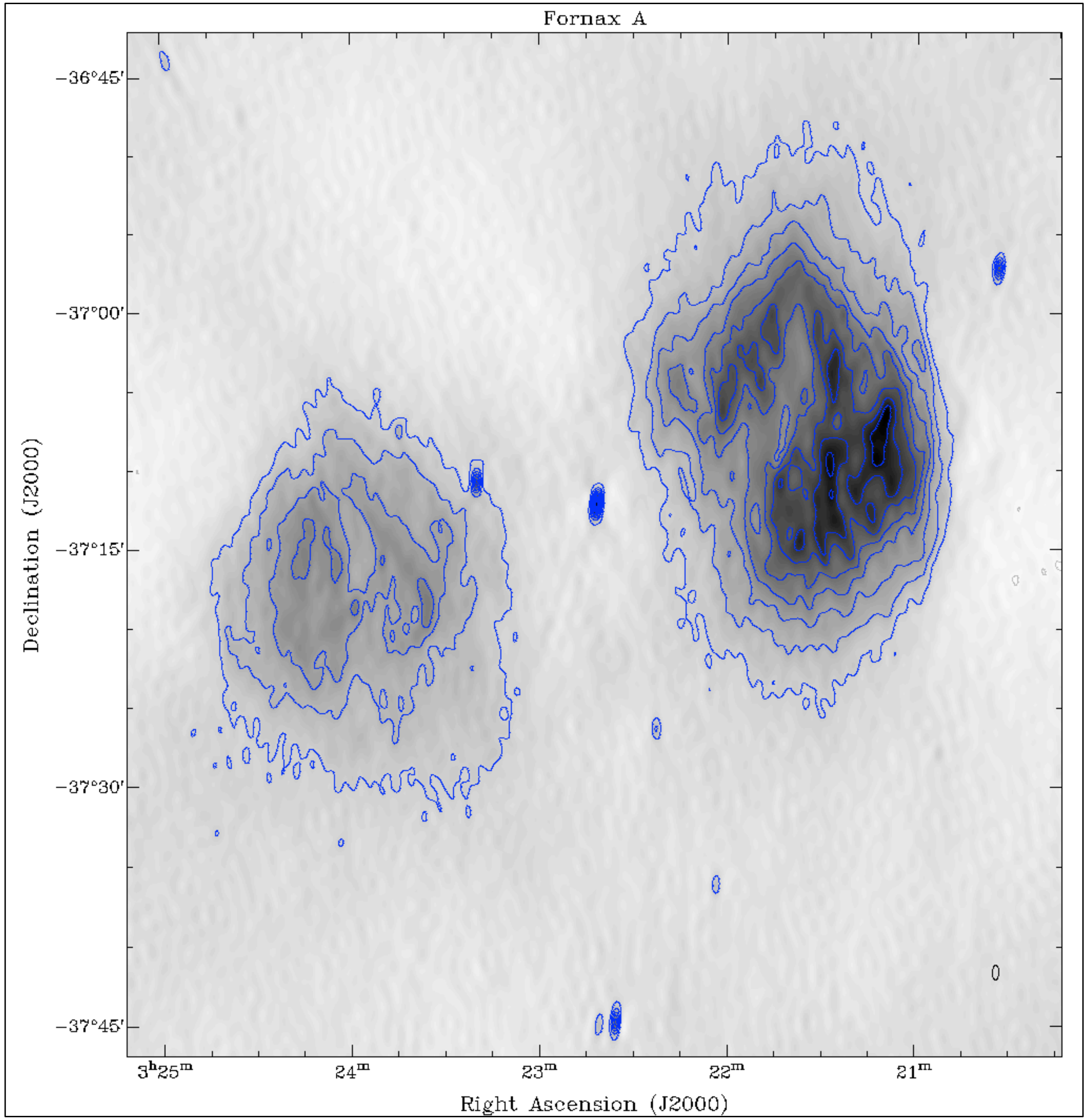


Image credit:
Vikram Ravi
Chris Flynn

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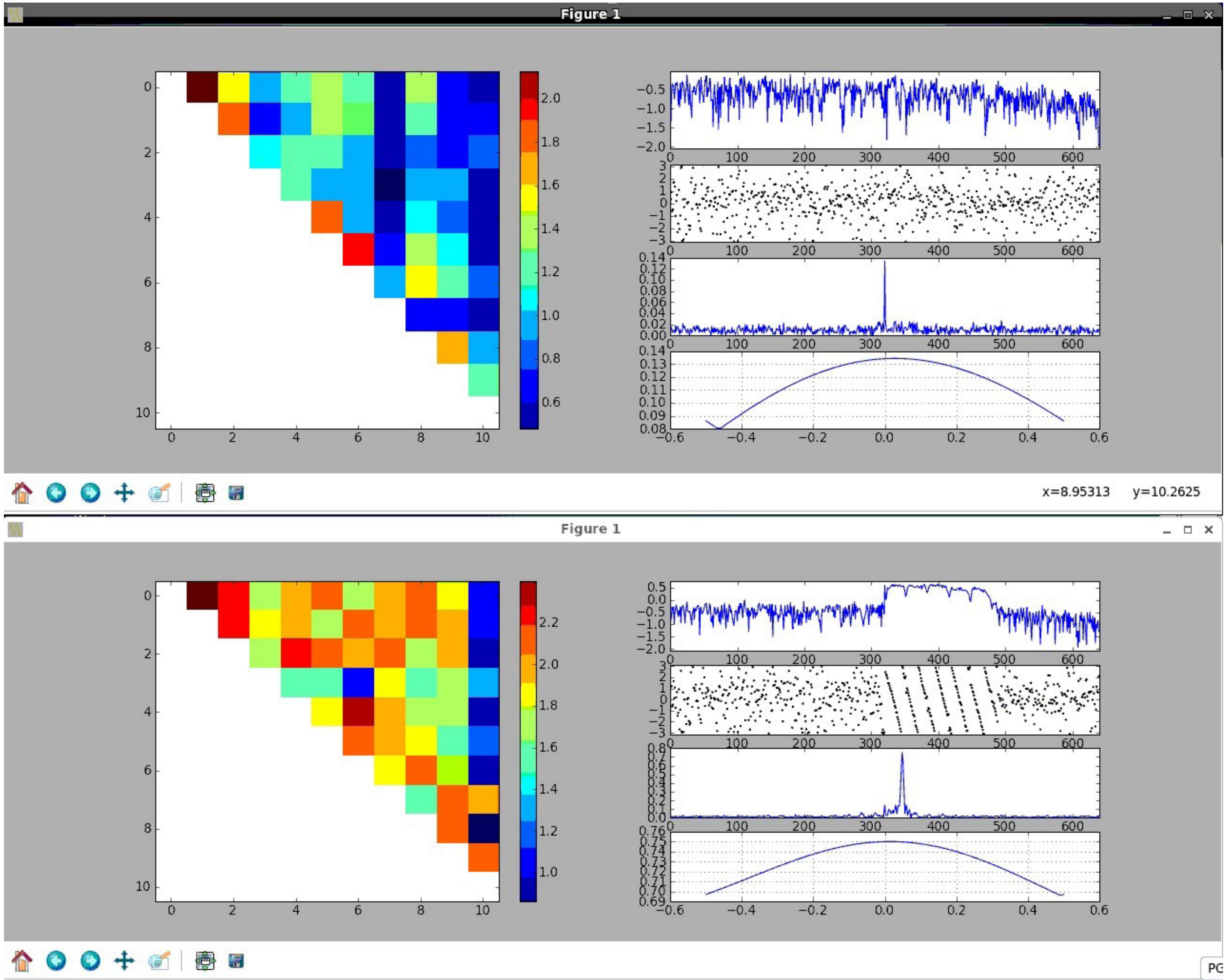
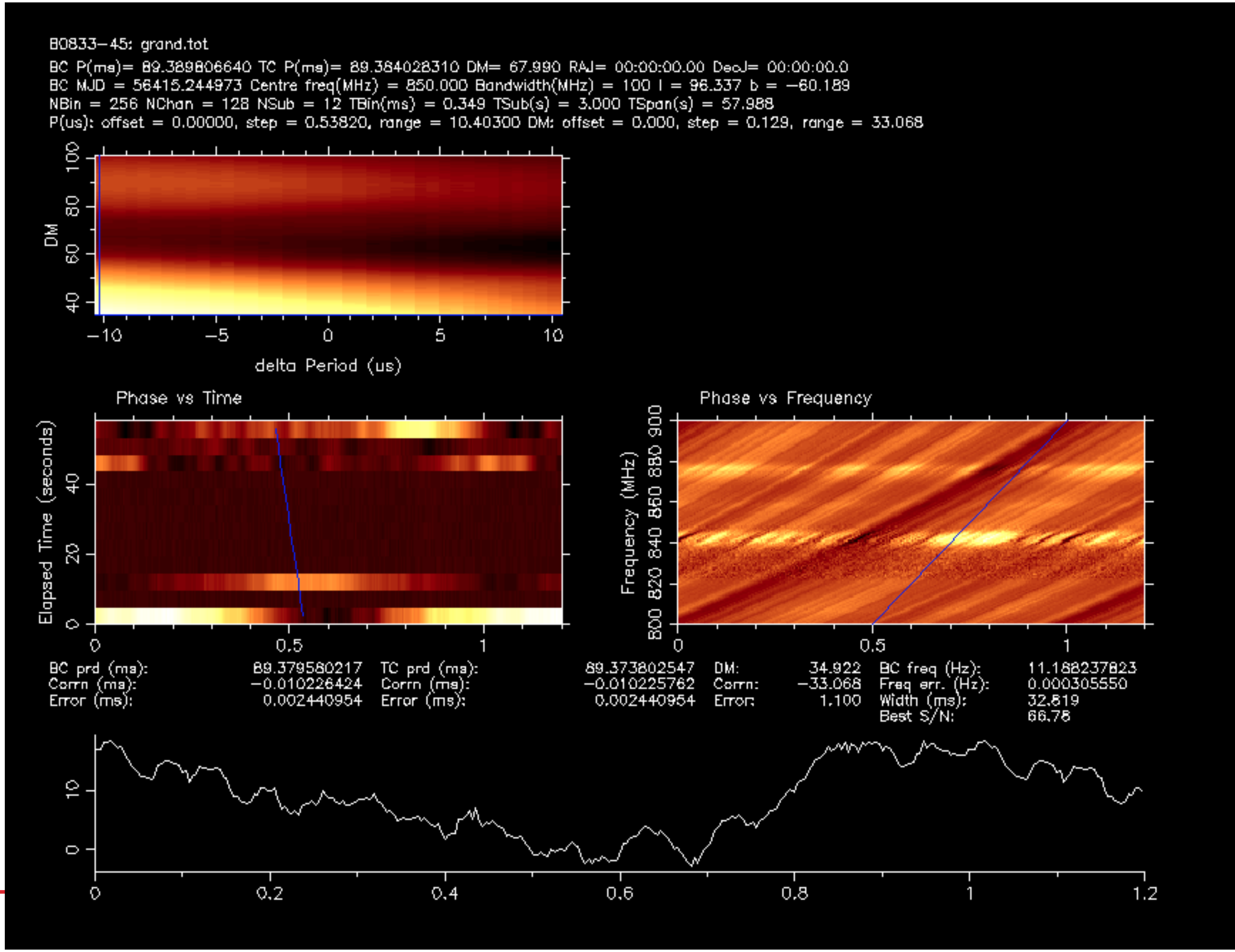
Phone calls & a quasar with 6% telescope

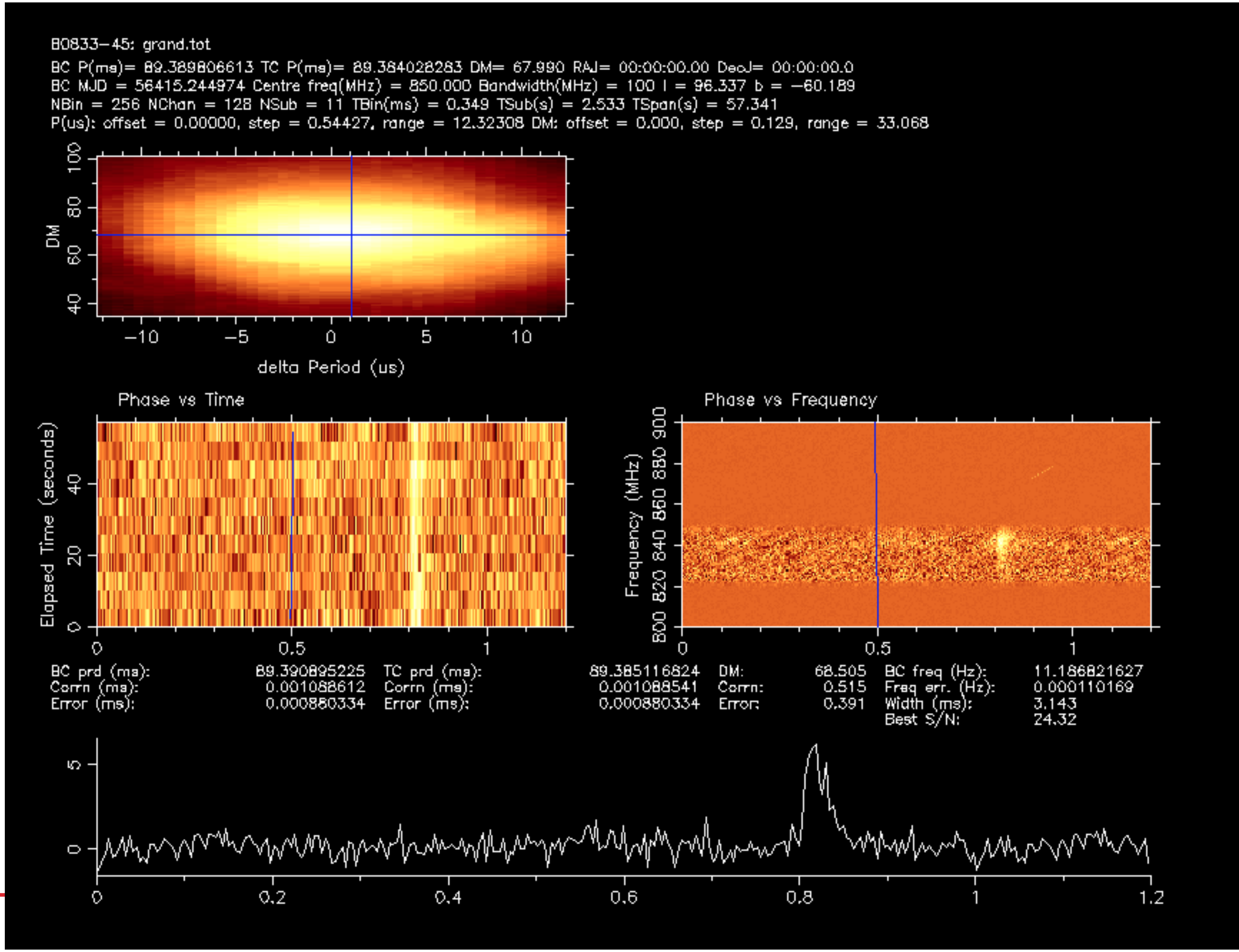


Use kurtosis of the raw voltage signal to remove RFI

Radio Frequency Interference



Kurtosis zapping



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

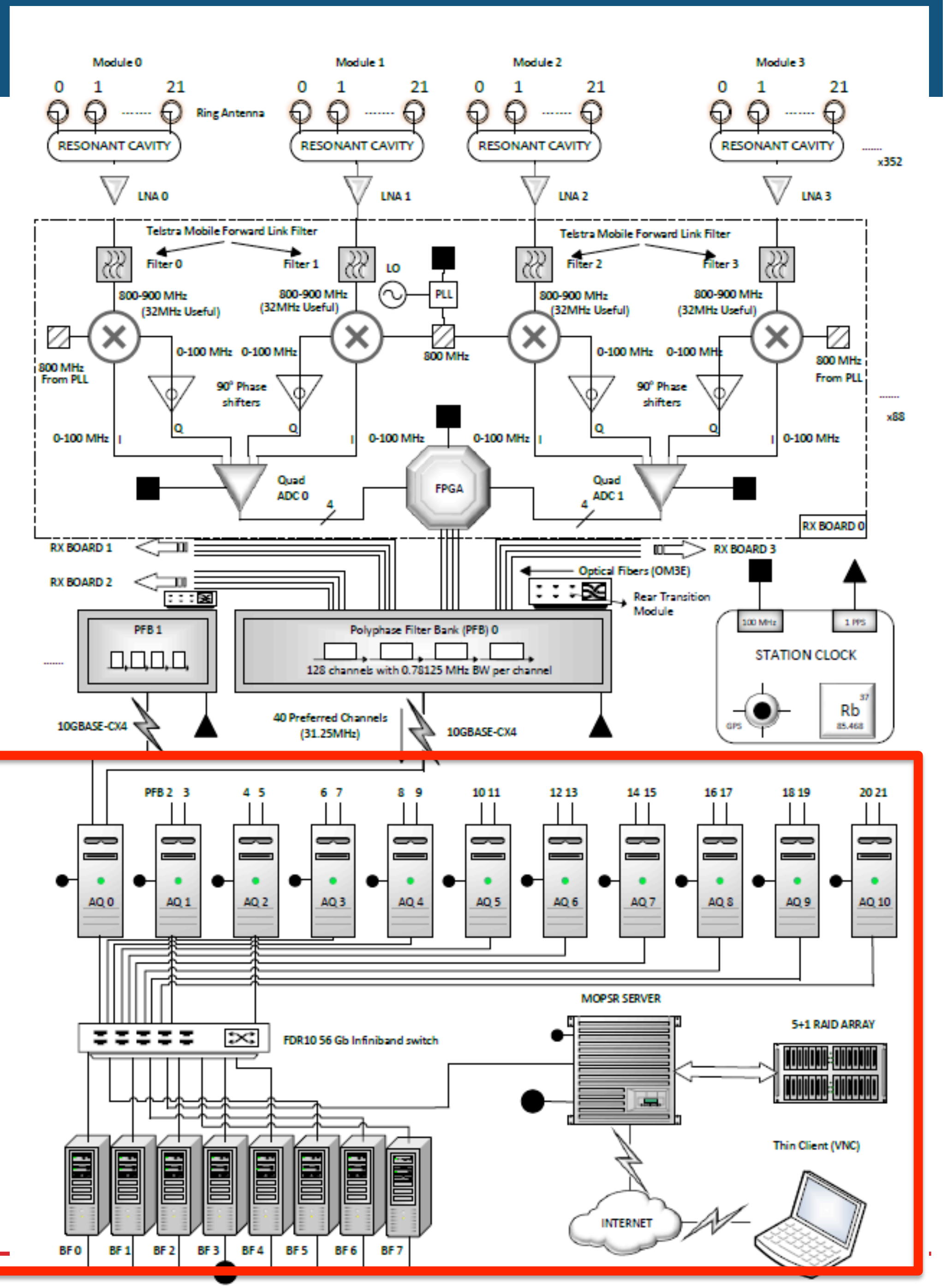
Watch this space!

The Molonglo Correlator

- 12 AQ servers with 6 CPUs and 2 GPUs (1 x GTX690 graphics card) each
- 72 CPU cores and 24 GPUs
- 22 PFBs handling 16 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)



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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?