CRAFT

Fast Radio Bursts with ASKAP
Thanks!

- Andrew Brown
- John Tuthill
- Aidan Hotan
- Maxim Voronkov
- Ryan Shannon
Fast Radio Bursts

After 9 years, we still don’t know what they are
CRAFT - The near future

- Fast autocorrelations from beamformers:
  - 1 ms x 336 x 1 MHz channels x 36 beams x 2 polarisations x 2 polarisations x 12 antennas
- Commensal
- Write spectra to disk
- Search offline

<table>
<thead>
<tr>
<th></th>
<th>Fluence Sensitivity (Jy ms $8 \sigma$)</th>
<th>FoV (deg$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASKAP-12 Fly’s eye</td>
<td>20</td>
<td>360</td>
</tr>
<tr>
<td>ASKAP-12 Incoherent</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>UTMOST (current)</td>
<td>1.3</td>
<td>8</td>
</tr>
<tr>
<td>Parkes</td>
<td>0.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Vela Folded
Vela
Vela
CRAFT - The next step

• Real-time detection
• Stop transient voltage buffer
• Dump voltages to disk
• Correlate to get positions
• High time-frequency resolution
Transient Buffer

- Each beam former FPGA has 2 GB of memory for saving 8 MHz of bandwidth
- Native resolution is 32 bits (16 bits complex)
- Configurable truncation & rounding down to 16, 8, 4, 2 bits to increase buffer duration (no level setting)
- Configurable number of dual-pol beams: 36 or 1
- Full buffer download time: 96 s @ full rate
- Total Memory: 84 GB per antenna. 1.1 TB per 12 antennas
- Can choose a time range to download, aligned with BAT.
- Max dispersion time: 1000 pc/cm³ = 1.6s assuming band 2 = 1-1.3 GHz.
- Say we download 2 s of data.

### Example transient buffer modes

<table>
<thead>
<tr>
<th>Nbits</th>
<th>Nbeams</th>
<th>Buffer Duration (s)</th>
<th>Download size 2s (GB)</th>
<th>Time to download 2s* (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>36</td>
<td>0.75</td>
<td>1100</td>
<td>91**</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>3</td>
<td>733</td>
<td>61</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td>27</td>
<td>81</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>108</td>
<td>20</td>
<td>2</td>
</tr>
</tbody>
</table>

* Assumes 200 MB/sec disk write speed
** To download 0.75s of data
CRAFT - the next step

- To Correlator
- Capture & reorder
- Scale, offset & requantise

- Fine Filterbank
- Square & Accumulate

- DADA Ringbuffer

- Capture & reorder
- FRB Search
- Candidates
- Capture & reorder

- 336x1 MHz
- 84 GB Voltage Ringbuffer
- Dribble

- Coarse Filterbank
- Digital receiver
- Beamformer
- CRAFT Box

- Ethernet
- Disk
UTMOST and ASKAP-12

- The UTMOST FoV will cover slightly more than 1 ASKAP beam.
- UTMOST \( \sim 1.3 \) times more sensitive than coherent ASKAP-12 (assuming 30 MHz, 300 K).
- 13 sigma @ UTMOST = 10 sigma @ ASKAP-12.
- AKSAP-12 instantaneous beam: 19”x17” (uniform weighting, -30 dec).
- Localisation in 2D: \( \sim 2" \) (10 sigma).
UTMOST detects & ASKAP locates

UTMOST shadows ASKAP pointing

**Trigger**
- DM
- Time (BAT)
- S/N
- 1D Position
- Pulse width
Conclusions

- CRAFT team is gathering pace after a long hiatus.
- Firmware works well!
- Commissioning on-going.
Coming Clean on Commensal
CRAFT

• Design a dedicated tied-array mode for the ASKAP hardware correlator/beamformer

• A lot like a zoom mode - only not a zoom mode

• Dedicated to tied-array / transients

• But sheesh, you’d get FRBs a go-go. If you could make all the beams: 6x improvement over standard CRAFT. 1.3x better than Parkes sensitivity with 50x the FoV

• More thought needed: Swallowing the data is a huge challenge, and may (in fact) be impossible

• e.g. For parity with the data rate of the current correlator, (6 GB/sec) we can only make ~20 tied-array beams
Parkes detects & ASKAP locates

- FRB
- Visibilities
- Trigger
- DM
- Time (BAT)
- S/N
- Beam position
- Beam #

Trigger (VOEvent)

Visibilities

Offline correlation

Imaging

Position

Calibration