New Zealand path to gamma-ray burst follow-up and transient observations

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Credit: Red Aurora - Alex Cherney

Abstract

Due to its fast slewing rates, the Warkworth 12m radio telescope can be on source in a short period after a gamma-ray burst (GRB) alert and conduct follow-up radio observations of GRB and other transient events.

We report on the work that is currently being undertaken to integrate the Field System with the GRB Coordination Network (GCN) alert system.

The aim is to undertake both single-dish (Warkworth) and interferometric (with Australian antennas) observations of these events.

In conjunction with this project work is taking place to utilize real-time autocorrelating spectrometer with the aim to handle dedispersion when observing pulsars and searching for transient events.

Acknowledgments

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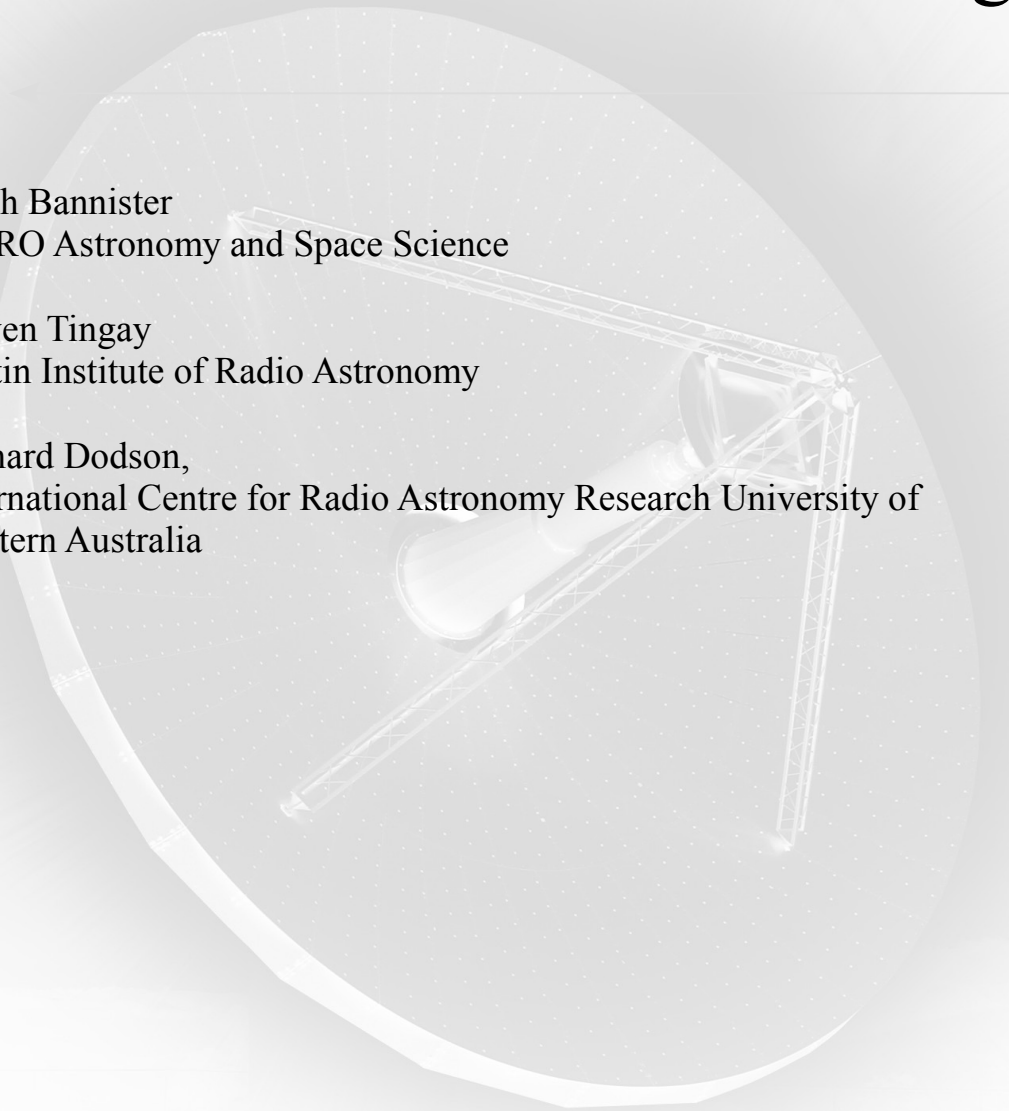

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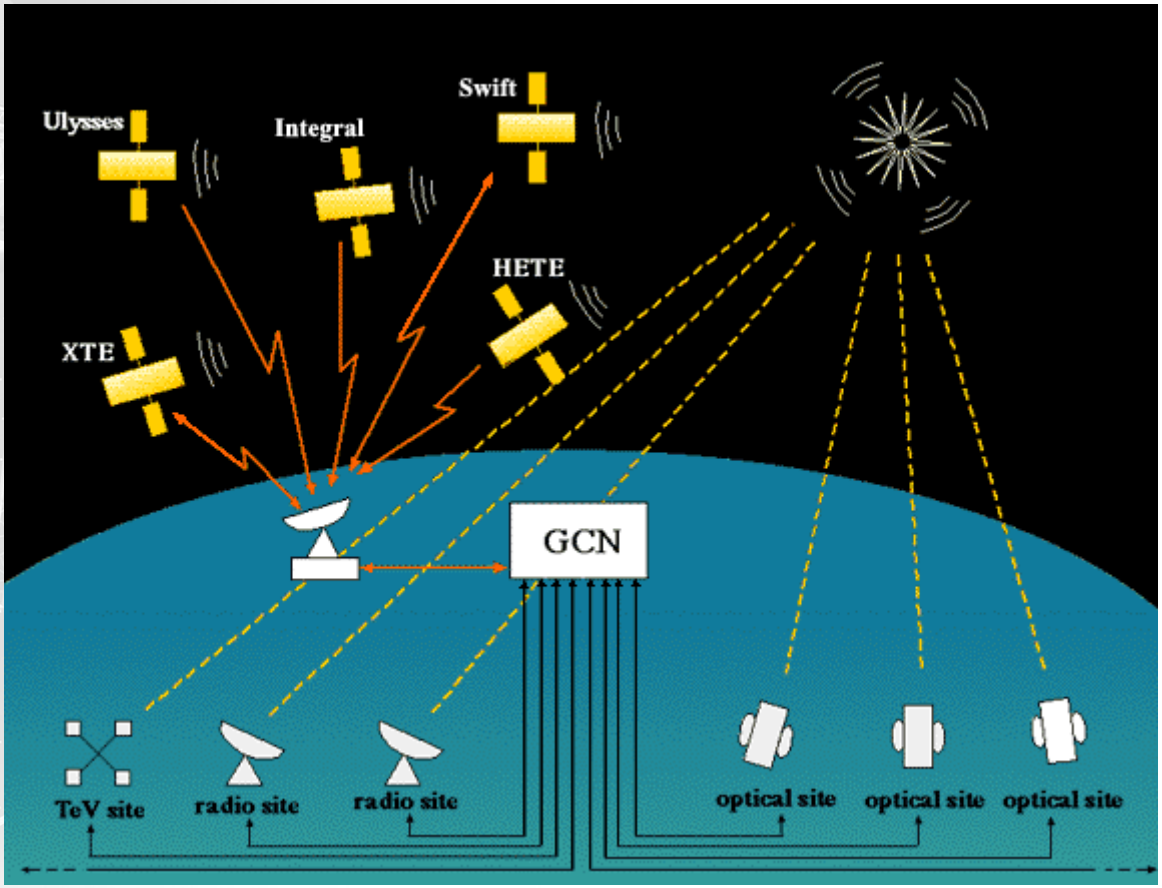
GCN: The Gamma-ray Coordinates Network

Locations of GRBs and other Transients (the Notices) detected by spacecraft (most in real-time while the burst is still bursting and others that are delayed due to telemetry down-link delays).

An alerts is transmitted to the receiving sites via several methods, such as E-mail, Phone/Modem, Pager and Internet Sockets.



http://gcn.gsfc.nasa.gov/

Example of alert received through GCN socket_demo

```
PKT INFO:    Received: LT Thu Dec  8 01:22:23 2011
   Type= 112   SN= 1    FERMI-GBM Gnd Position
   Hop_cnt= 0
   PKT_SOD= 0.00 [sec]   delta=44543.00 [sec]
   RECORD_NUM=      56
   TRIGGER_NUM=     344953038
   TJD=             15902
   SOD=             44236.20 [sec]   delta=306.80 [sec]
   RA=               166.8100 [deg] (J2000)
   Dec=              -18.9700 [deg] (J2000)
   ERROR=           10.58 [deg radius, statistical only]
   DATA_SIGNIF=     5.20 [sigma]
   DATA_INTERVAL=   1.024 [sec]
   PHI=              51.00 [deg]
   THETA=            28.00 [deg]
   E_RANGE=         44.032 - 279.965 [keV]
   LOC_ALGORITHM=   4143 (Gnd S/W Version number)
   This is a ground-generated Notice -- not flight-generated.
```

I have put socket_demo under "/usr2/st/gcn" on the Field System. As this will be a local station procedure. It has been modified to also communicate with the DBBC and Mark5B.

Current System Configuration

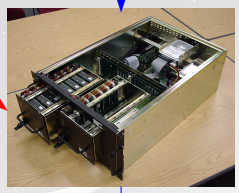
GCN Alert

tcp/ip packet

Field System

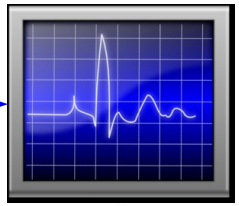
DBBC

Warkworth 12m



Mark5B

Post Processing IBM Blade



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AUT 12m Antenna

Antenna type	: Fully steerable dual shaped Cassegrain
Main dish Diam	: 12.1 m
Slewing rates	: (5 deg/s in azimuth and 1.25 deg/s in elevation)
Acceleration	: (1.3 deg/s/s)
Secondary Refl Diam	: 1.8m
Focal Length	: 4.538 m
Surface precision	: 0.35 mm (RMS)
Wavelength	: S-Band and X-Band
Mount	: alt-azimuth

Field System log for Alert

```
2012.038.09:19:59.37;Log Opened: Mark IV Field System Version 9.10.4
2012.038.09:19:59.37;location,WARKWRTH,185.34,-36.43,132.0
2012.038.09:19:59.37;horizon1,0.,10.,360.
2012.038.09:19:59.37;antenna,12.0,300.0,60.0,-180.0,360.0,8.0,88.0,azel
2012.038.09:19:59.37;equip,none,mk5b_bs,none,none,500.10,3,a/d,101,60,20,none,40,0,in,8bit,cdp,3,return
2012.038.09:19:59.37;time,-5.459,1.011,rate
2012.038.09:19:59.37;flagr,200
2012.038.09:19:59.37;source=134595401,000000.00,-350000.00,2000.0,

2012.038.09:19:59.40#antcn#Commanding to a new source
2012.038.09:19:59.41#antcn#/case1/Position Requested. RA: 0.154267, DEC: -34.934311

2012.038.09:19:59.41#antcn#/pmodl/azcor = -0.514445

2012.038.09:19:59.41#antcn#/pmodl/elcor = 1.183612

2012.038.09:19:59.41#antcn#/pmodl/AzEl:239.505301 20.071473
2012.038.09:19:59.41#antcn#/case1/Pointing Model Corrections -0.514445 1.183612

2012.038.09:19:59.41#antcn#/case1/Corrected RA & DEC         1.083632 -35.965338

2012.038.09:19:59.41#antcn#Turning power ON.
2012.038.09:20:00.10#flagr#flagr/antenna,new-source
2012.038.09:21:17.21#flagr#flagr/antenna,acquired
2012.038.09:25:07.56;log=station
```

1min 18 secs to be on source and tracking

GPU's the next step in compute power!

Future System Configuration

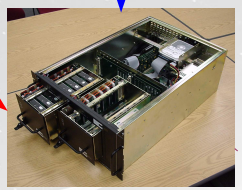
GCN Alert

tcp/ip packet

Field System

DBBC

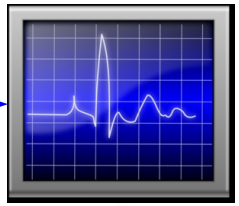
Warkworth 12m



Mark5C

10GBit

Real Time Processing GPU



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Real-time autocorrelating spectrometer

Stream-based approach using hardware accelerators for radio astronomy applications,
Mahmoud Mahmoud, AUT

Future work is to link this with the Field System

Also to accept real-time streaming of data either from the DBBC or Mk5C

We are also working with Richard Dodson and another GPU Autocorrelator
(http://sourceforge.net/projects/g-auto/)

This has been tested real-time over the network from Warkworth (via KAREN) to Perth (via AARNET).

Future work is to link this with the Field System

Comparison between a multi-core CPU (IBM blade) server and one GPU.

IBM Blade -m5spec 16MHz Band with 32767 channels, 12 mins
GPU – autocorrelator same data file but with 524290 channels, 9.8 secs

Xming :10.0

Applications Places System 11:19 AM

Computer

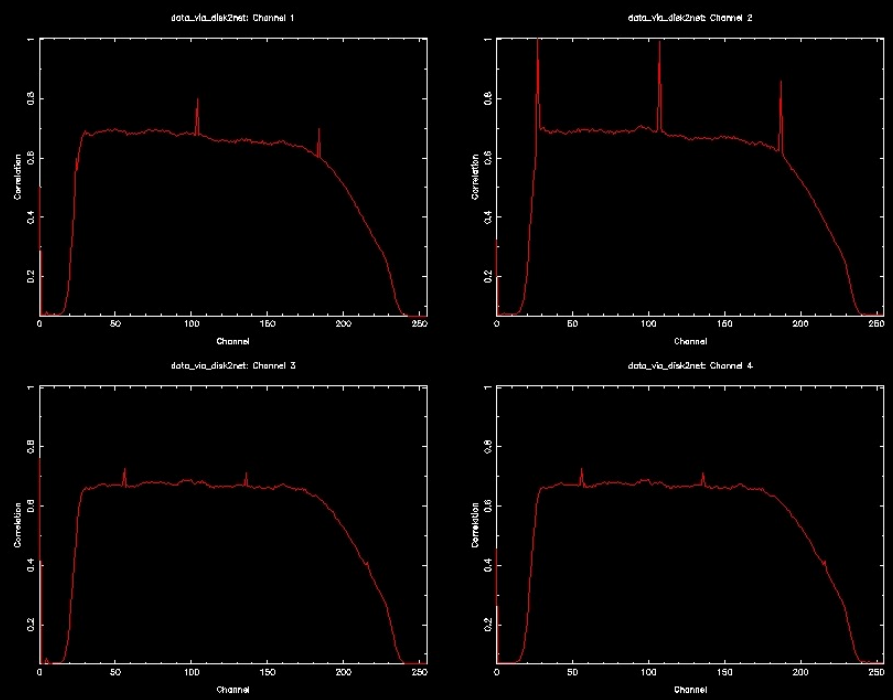
sweston's Home

Trash

Terminal

evince

PGPLOT Window 1




```
fdwriter: writing to fd=11
fiforeader: starting
fdwriter: stopping. wrote 21885091840 (20.3821Gbyte)
fiforeader: stopping
compute_theoretical_ipd: 4013us
Setting sokopt
fdwriter: writing to fd=11
fiforeader: starting
```

vlbi@astro-556: ~

File Edit View Terminal Tabs Help

```
Mark5B format: Mark5B-512-4-2
bind(): Address already in use
vlbi@astro-556:~$ /usr/local/cuda/rdodson/autocorrelator/autocorrelator -m -p 26
30 -f Mark5B-512-4-2 d ?
Accepting disk2net data
Mark5B format: Mark5B-512-4-2
Bound to port 2630
Accepted connection from [::8083:3601:0:0]:44719

file_bytes = 0
file_title = data_via_disk2net
header information:
headersize = 1024
nchan = 4
numbits = 2
bandwidth = 32.000000
encoding = NONE (0)

Parameter constraints:
a >= 1 (20)
b >= 0 (11)
a > b
g >= 0 (0)
```

sweston@ska-blade1:~

File Edit View Terminal Tabs Help

```
net_protocol
!syntax = 7 : Not a command or query;
net_protocol?
!net_protocol? 0 : tcp : 4194304 : 131072 : 8 ;
mode?
!mode? 0 : ext : 0x00000f0f : 2 ;
in2net=connect:localhost
!in2net=  0 ;
in2net=on
!in2net=  0 ;
in2net=off
!in2net=  0 ;
mode?
!mode? 0 : ext : 0x00000f0f : 2 ;
mode=ext:0x00000f0f:1
!mode= 4: cannot change during in2net ;
in2net=disconnect
!in2net=  0 ;
mode=ext:0x00000f0f:1
!mode= 0 ;
in2net?
!in2net?  0 : inactive ;
in2net=connect:localhost
!in2net=  0 ;
in2net=on
!in2net=  0 ;
```

vlbi@astro-556: ~ | oper@mark5-730: ~/jive5ab | vlbi@astro-556: ~ | sweston@ska-blade1:~ | [pgxwin] | PGPLOT1

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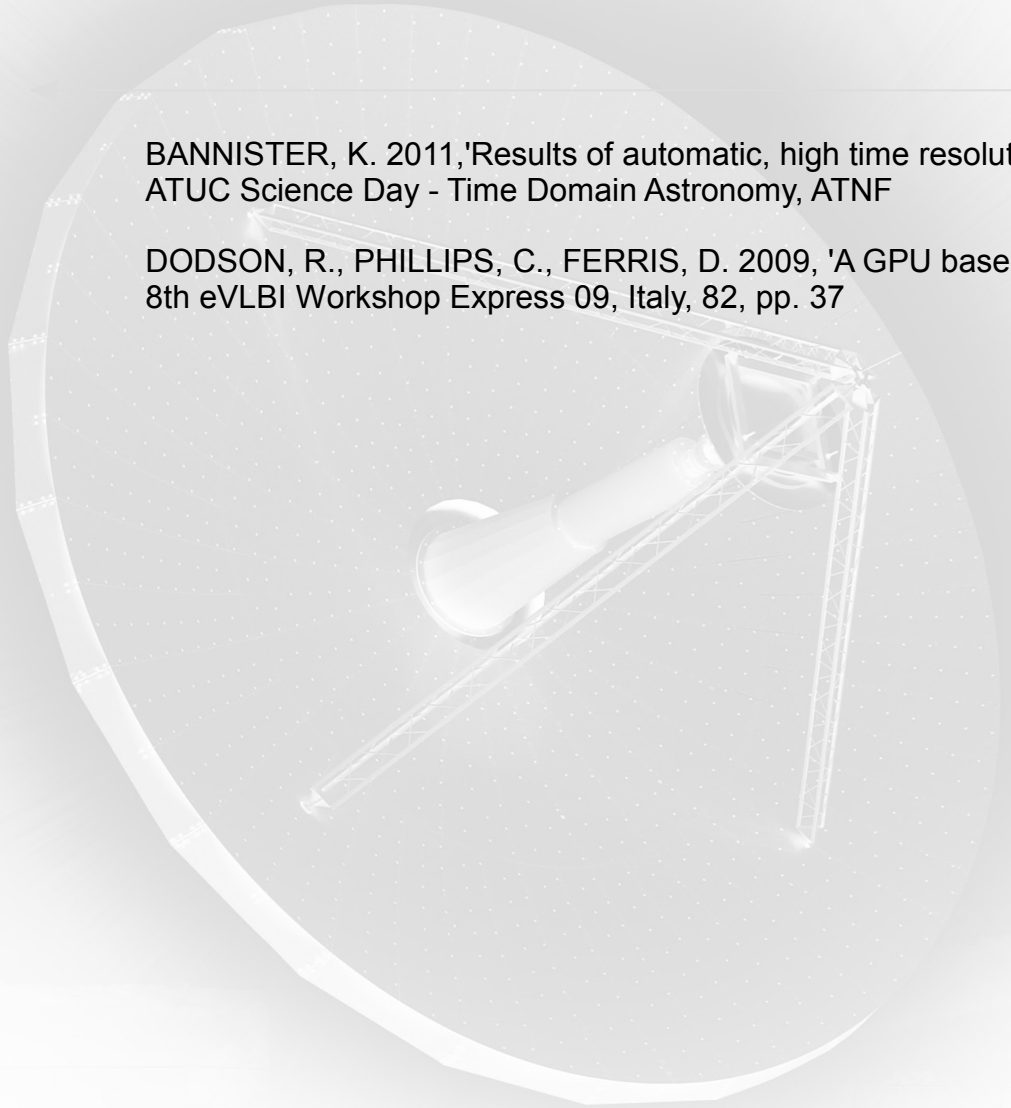
Conclusions

- Good things can be done with a small dish
- We can be on source within 2 minutes
- GPU's provide a significant leap forward for real-time processing

References

BANNISTER, K. 2011,'Results of automatic, high time resolution GRB follow-up with the Parkes 12 m', ATUC Science Day - Time Domain Astronomy, ATNF

DODSON, R., PHILLIPS, C., FERRIS, D. 2009, 'A GPU based solution for distributed FX correlation', 8th eVLBI Workshop Express 09, Italy, 82, pp. 37



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Thank You