



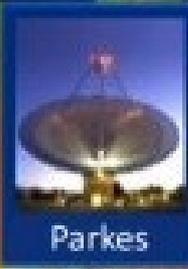
MRO



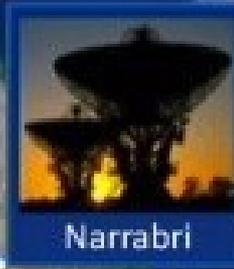
Ceduna



Hobart



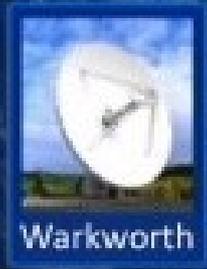
Parkes



Narrabri



Tidbinbilla



Warkworth

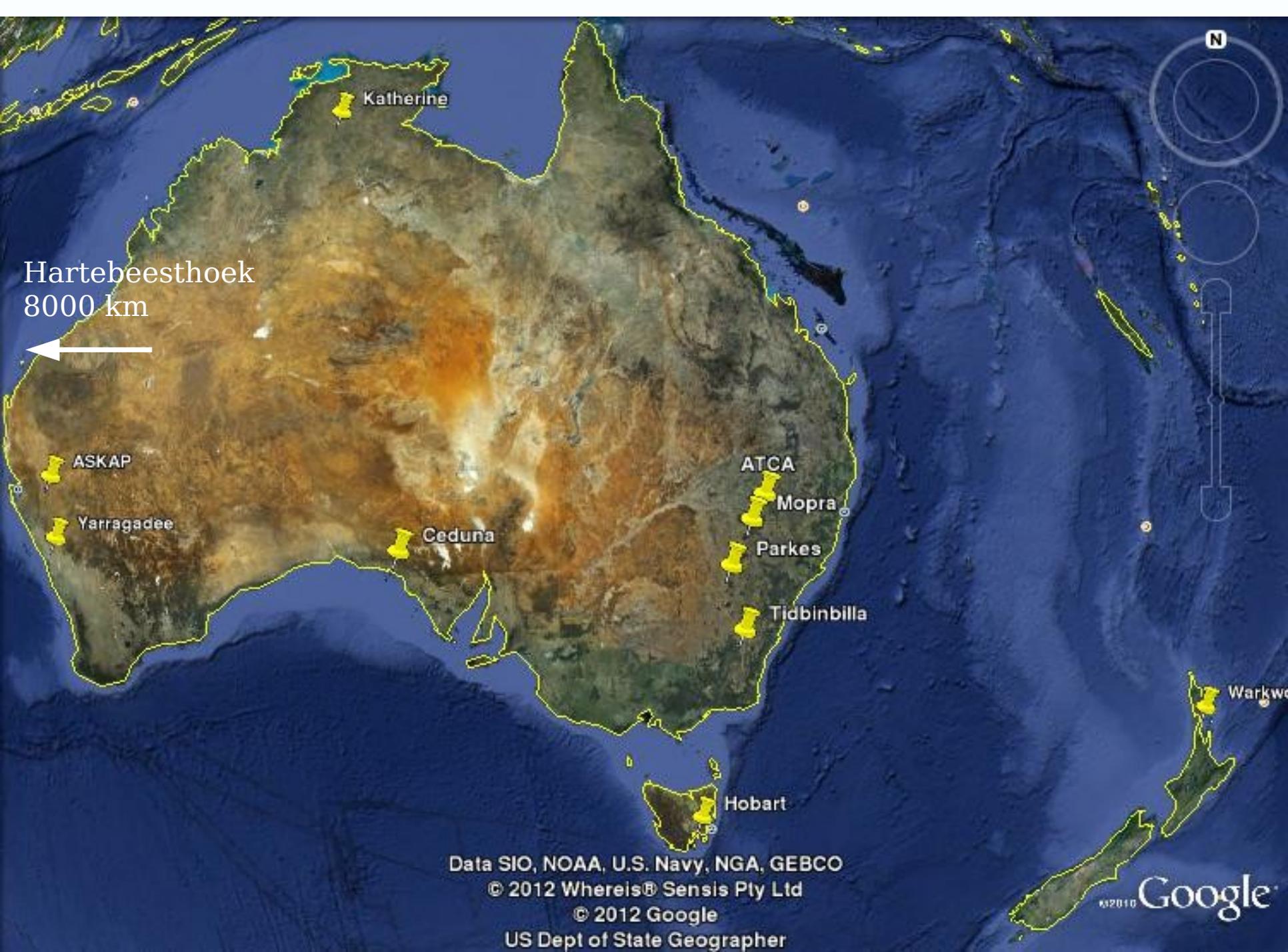


# LBA Operations

Cormac Reynolds, Chris Phillips, Phil Edwards + LBA Team  
19 November 2015

CSIRO ASTRONOMY & SPACE SCIENCE  
[www.csiro.au](http://www.csiro.au)





Hartebeesthoek  
8000 km

ASKAP

Yarragadee

Ceduna

ATCA

Mopra

Parkes

Tidbinbilla

Hobart

Warkw

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

© 2012 Whereis® Sensis Pty Ltd

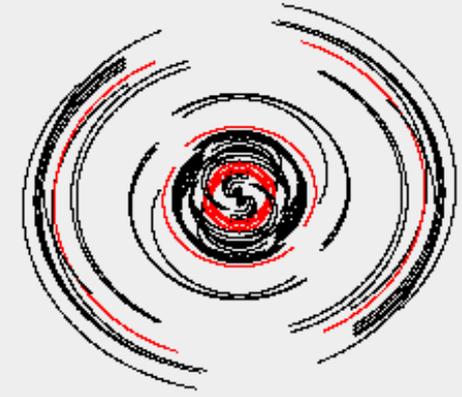
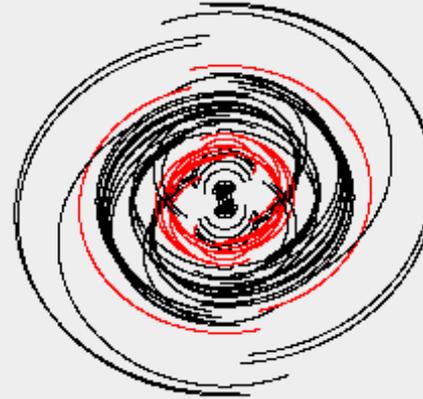
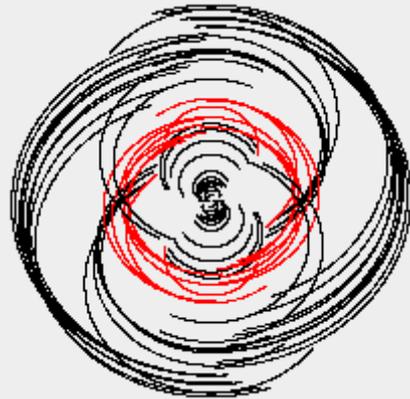
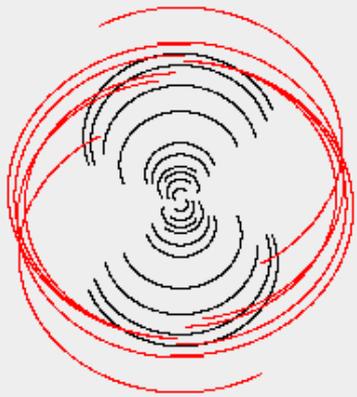
© 2012 Google

US Dept of State Geographer

©2010 Google

# Real-time e-VLBI





“LBA”  
6 ant  
1700km  
40  
ujy/beam  
(Ceduna)

+Auscope  
+ASKAP  
9 ant  
3450km  
110 ujy/beam

+NZ  
10 ant  
5360km  
110 ujy/beam

+South Africa  
11 ant  
10440km  
110 ujy/beam

# LBA Operations

- Frequency range: 1-22 GHz (3 stations at 32 GHz)
- Disks (XRAIDs) & eVLBI - up to 1Gbps (4 x 64 MHz)
- All (almost) data transfers electronically
- Software correlator(s) – DiFX
- e-VLBI correlators at ATNF (Parkes; ATCA)
- **Open VLBI network** - proposals 15 June & December
  - Joint application with EVN

# DAS/Recorder systems - existing

- **LBA DAS** (Developed for S2 VCR system)
  - Digital filtering – 2 x 64 MHz input IFs (2 pols) = 256 to 1024 Mbps
  - + COTS Computers + Disks
  - Remote disk recording + eVLBI
  - Obsolescent
- **Mk4/Mk5/VLBA DAS** + MK5A or MK5B recorders
  - Ho, Pk, Tid (older geodetic systems) – 16 MHz bands
- **DBBC + Mk5B** recorders
  - IVS systems – AuScope, NZ, SA – 16 MHz bands
- **ASKAP system** - (“Brucedas” Curtin recorder)
  - COTS computer, Commercial sampler card (Signatec PX1440)
  - 2 x 64 MHz bands = **512 Mbps** (could go x2)
- Flexibility of **DiFX** a decisive enabler for these heterogeneous systems

# The LBA - Past 12 months

- 25 days observing
  - 4 ATNF Antennas (Parkes, ATCA, Mopra, ASKAP)
  - 5 UTAS antennas (Hobart x2, Ceduna, Yarragadee, Katherine)
  - Warkworth x2 antennas (AUT, NZ)
  - Tidbinbilla, Hartebeesthoek
  - Shanghai, Kunming, Tianma65
- Median data rate 512 Mbps
  - (Almost) all data e-transferred
- CUPPA cluster decommissioned
- Fully fledged remote obs
- Correlator ops returning to CSIRO
  - Pawsey Centre
  - CSIRO Pearcey Cluster



# LBA Correlator Facility at CSIRO

- DiFX on TBD hardware
- **Future plans (option 1)**
  - Pawsey Centre for SKA Supercomputing
  - 1488 x 12 core nodes
    - Cray Aries interconnect
      - 72 Gbps/node
      - 64 GB memory per node
      - 3 PB storage (~200 TB available for VLBI)
      - 300,000 CPU hours secured through merit allocation
- slurm control
- e-transfer only!



# LBA Correlator Facility at CSIRO

- **Future plans (option 2)**
  - CSIRO Pearcey Cluster
  - 142 node Dell Poweredge cluster (dual 10 core)
  - FDR infiniband interconnect
  - separate datastore (>200 TB reserved for VLBI ops).
- slurm control
- e-transfer only!



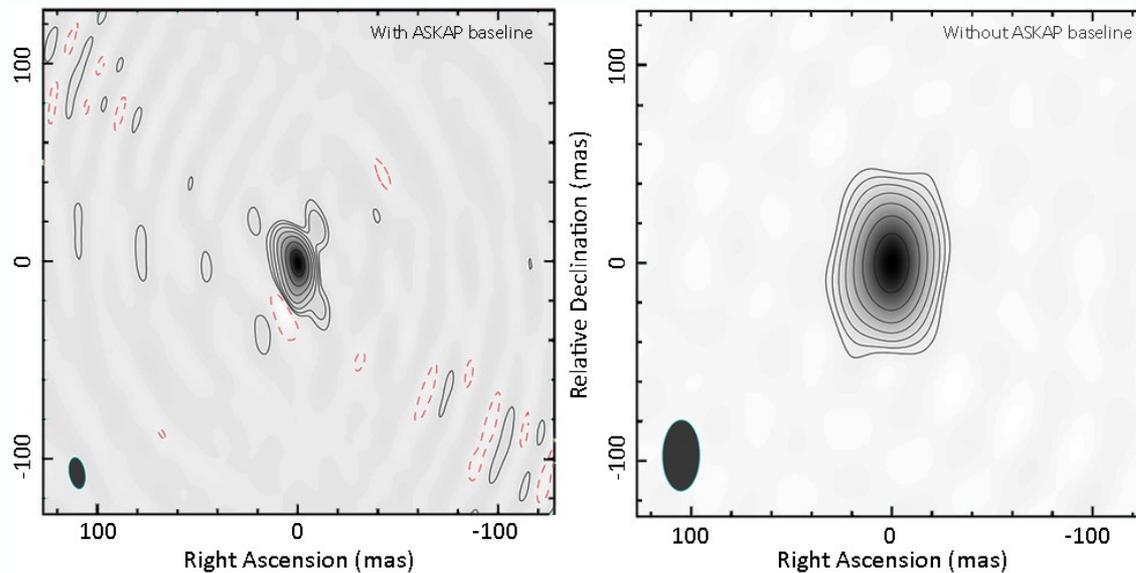
# ATNF Telescope Status

- Parkes: Large Receiver fleet
  - 700-764, 2600-3600, 1230-1530 (Multibeam), 1200-1800, 2150-2500, 5900-6800, 8100-8500, 12000-15000, 16000-26000 MHz, S/X
  - Limited Frequency Flexibility
  - Building 700-4000 MHz UWB Rx
  - Installing ASKAP PAF for 2016, prospects of permanent PAF
  - LBA DAS and Mark4/Mark5b backends
  - Limited receiver changes



# ATNF Telescope Status

- ASKAP – Single pixel 1 GHz and 8 GHz room temp receiver on two “unused” telescopes
  - 700-1800 MHz PAFs on all 36 telescopes by 2017
- Demonstrated first VLBI fringes on baseline to ASKAP PAF
  - Proof-of-concept only (though single-dish ASKAP VLBI routine)



# ATNF Telescope Status

- Mopra: 1.3-3, 4.5-6.7, 9-9.2, 16-27, 30-50, 76-117 GHz
  - Recovery from 2013 Bushfire complete
    - CSIRO no longer funding operations
- Collaboration funding (UNSW, UTAS et al.) for one year 7/3mm and VLBI operations
- Future uncertain



# ATNF Telescope Status

- ATCA: 1.1-3.1, 3.9-11, 16-25, 30-50, 83-105 GHz
  - Some split frequency capability with subarrays. 7/3mm used S/X possible
  - No Mark5 type backend
- No broadband VLBI capability currently
  - Plans to replace CABB with GPU-based system to provide this
- ATCA split array capability: 7mm/3mm obs with KVN
- Reliable 32 GHz fringes ATCA/Mopra/Tid-34m

# ATNF Telescope Status

Inclusion of UTAS AuScope antennas, when available

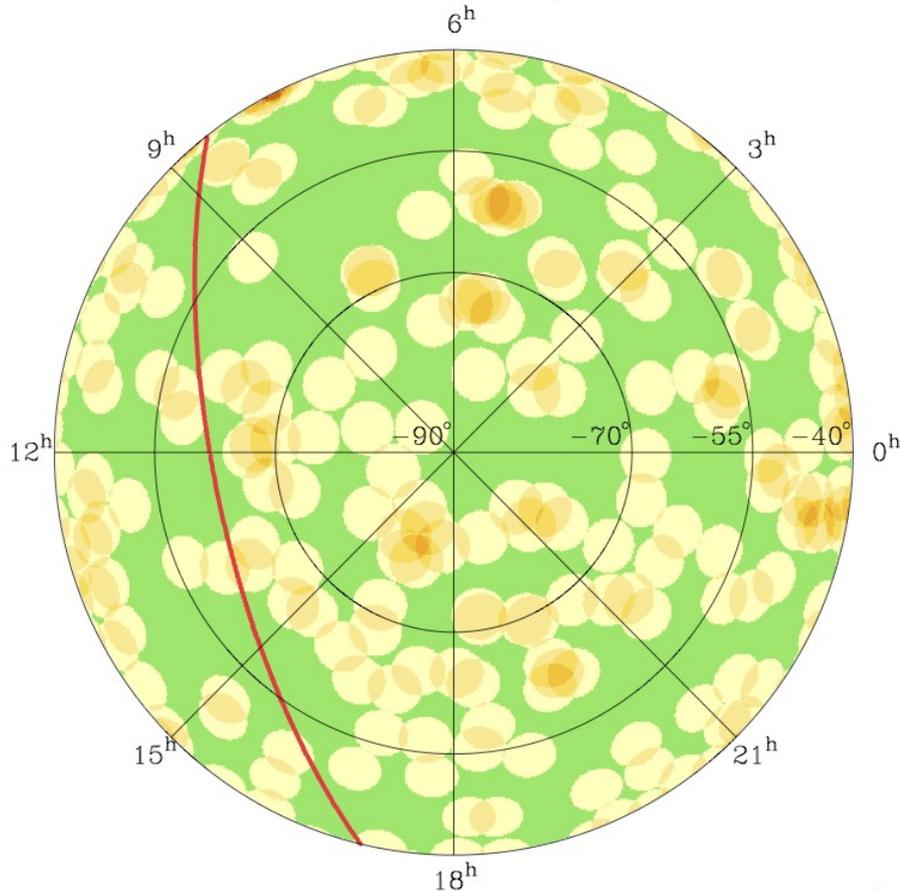
- Reduction in AuScope Geodetic operations for 2015

Warkworth 30m first fringes

Tidbinbilla: DSS-35 commissioned, DSS-36 under construction (both 34m)

# LBA Calibrator Survey

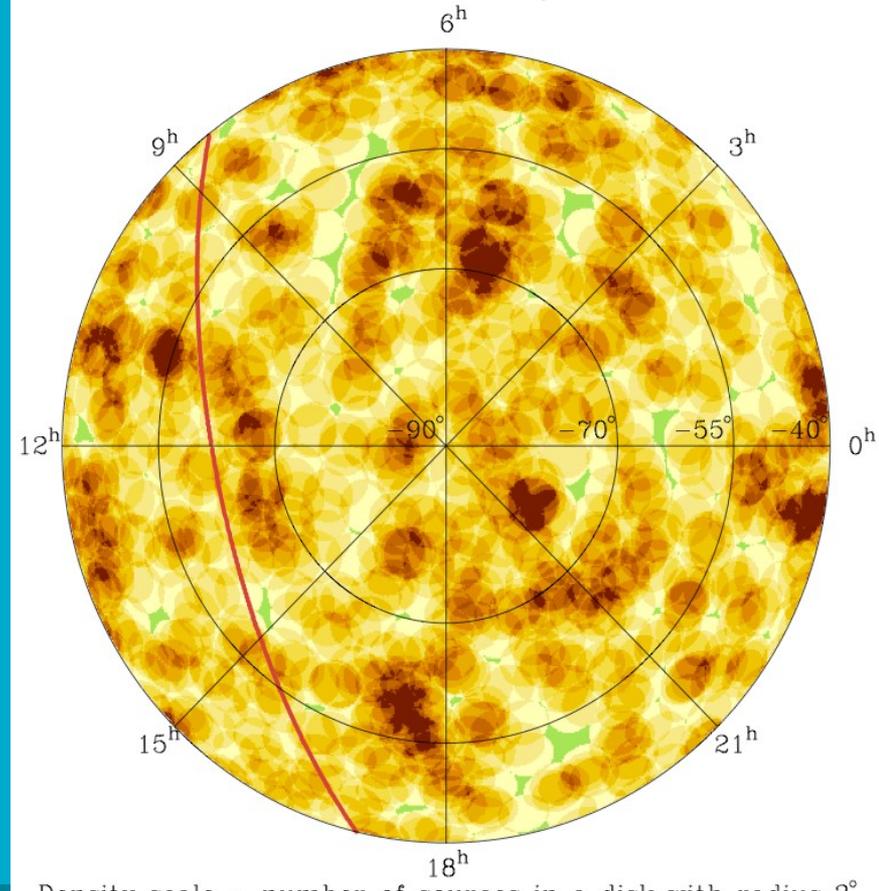
VLBI source density in 2007



Density scale - number of sources in a disk with radius 3°

[www.csiro.au](http://www.csiro.au)

VLBI source density in 2013



Density scale - number of sources in a disk with radius 3°

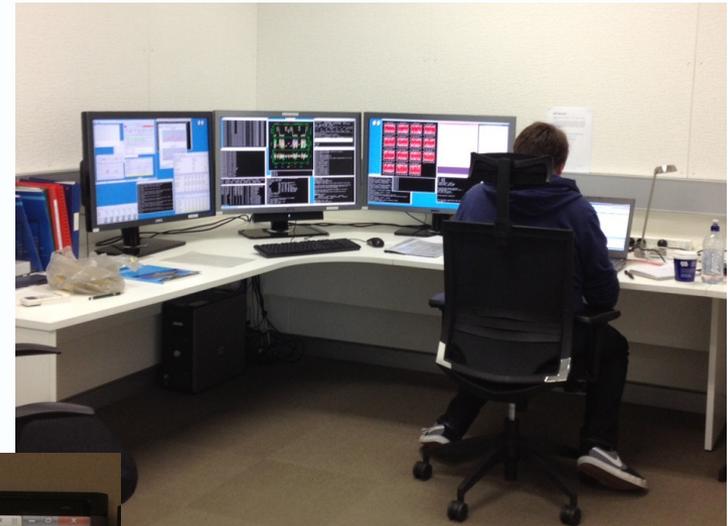
Petrov et al. 2011 MNRAS, 414, 2528

<http://astrogeo.org/lcs/>



# Remote Operations

- Development of TPS at the venerable Parkes telescope means entire array is now remotely operated



Long Baseline Array Monitoring Page

URC#	04:54:53	Warkworth	ATCA	Mopra	Parkes	Hobart	Ceduna	ASKAP	Start
LMS7	14:12:32	12:32:05	12:30:17	12:26:56	12:23:38	11:29:07	10:20:26	04:24:37	
R.A. (J2000)	13:02:47.64	13:02:13.7	13:02:47.7	13:02:47.4	13:02:47.3	13:37:45.5	13:00:52.487	06:35:46.6	
Dec. (J2000)	-63:10:23.66	-63:09:02.6	-63:10:29.6	-63:10:29.7	-63:20:33.0	-23:46:14.0	-64:37:09.200	-79:16:14.3	
Azimuth	195.46	174.196	175.277	172.25	166.132	89.195	156.929	169.393	
Elevation	60.79	55.75	56.934	58.51	66.133	87.997	44.415	37.93	
State	TRACKING	SLDRNG	TRACKING	TRACKING	TRACKING	IDLE	TRACKING	TRACKING	
Receiver	6750a	6750a	6750a	6850 (Dns)					
Freq 1 (MHz)	8425.0						8425.0	3.5ca	
Freq 2 (MHz)	8489.0								
TX Power (dB)	1.45	0.7	-0.75	0			-1.55	1.53	
Wind Speed (m/s)	3.528	16.1	17.71	14.49	28.4		35.1	4.22	
Temperature (°C)	12.9	20.2	16.0	17.1			16.8	6.2	
VSWR Cable	803	803	803	803					
Recording	Recording (1 & 2)	Recording	Recording						
Experiment	v4850 / v485b	v4850 / v485b	v4850 / v485b	v4850_2A01 / v4850_2A02	v485b	v485b			
Rec. Time	10:44:03 of 17h	10:44:03 of 17h	10:05:23 of 17h	10:06:27 of 17h	05:35:25 of 750h	00:35:42 of 450h			
Free Time	06:45:27 / 06:06:15	06:45:27 / 06:06:15	21:11:11 / 06:06:15	06:06:15	06:06:15	06:06:15	06:06:15	06:06:15	
BIGUP	485 MB (100%) / 485 MB (100%)	485 MB (100%)	485 MB (100%)						
TPS Skips	0 From 100 / 0 From 100	0 From 100	0 From 100						
Latest Update (UTC)	2013-08-16 04:54:53	2013-08-16 04:54:53	2013-08-16 04:54:53	2013-08-16 04:54:53	2013-08-16 04:54:53	2013-08-16 04:54:53	2013-08-16 04:54:53	2013-08-16 04:54:53	

Science Operations Centre, Sydney

# LBA Monitoring

- All ATNF telescopes are operated remotely
  - Single observers monitors all 4 telescopes
  - Observers are staff, PhD students or astronomers
  - Wide range of observing experience
    - Some only do VLBI observing 1-2 times per year
  - Observing from from VNC sessions
  - Every observatory different observing software!
- Enabled LBA wide web based monitoring of recorders and telescopes

# LBA Monitor

- All ATNF telescopes use “MoniCA” software
  - Designed for ATCA – polls and logs 1000’s monitor points every second
  - Available via web interface

<https://github.com/davidbrodrick/open-monica>

- Javascript based monitor page
  - Client polls MoniCA every 2 seconds for MoniCA enabled telescopes
  - Telescopes without MoniCA publish JSON format file with current parameters
  - Shows antenna location, expected location, windspeed etc

[http://www.narrabri.atnf.csiro.au/vlbi/lba\\_monitor.html](http://www.narrabri.atnf.csiro.au/vlbi/lba_monitor.html)

# Long Baseline Array Monitoring Page

<b>Experiment:</b>	v493b
<b>Time until end:</b>	18h 30m 24s

**Show:**
 Wark12m
  Wark30m
  ATCA
  Mopra
  Tidbinbilla
  Parkes
  Hobart
  Ceduna
  ASKAP
  Hart15m

UTC: 22:29:35	ATCA	Parkes	Hobart	Ceduna
LMST	12:18:22	12:13:13	12:09:55	11:15:24
R.A. (J2000)	17:18:22.3	17:18:22.31	17:18:22.6	17:18:22.0
Dec. (J2000)	-43:59:35.4	-43:59:35.7	-43:59:32.0	-43:59:28.0
Azimuth	126.113	125.12	119.867	129.687
Elevation	30.558	31.23	35.972	20.882
State	TRACKING	TRACKING	TRACKING	TRACKING
Receiver	20/13cm	GALILEO_B		
Freqs. (MHz)	2285 / 2285			
Tick Phase (µs)	-0.22	0.43		
Wind Speed (km/h)	6.44	3.22	15	23.2
Temperature (°C)	27.8	30.4		
VSIC Cable	Unknown	Unknown		
Recording	Not recording	Not recording	Not recording	Not recording
Experiment	N/A	N/A	N/A	N/A
Rec. Time	N/A	N/A	N/A	N/A
Free Time	N/A	N/A	N/A	N/A
BIGBUF	N/A	N/A	N/A	N/A
PPS Skips	N/A	N/A	N/A	N/A
VEX Check	OK	OK	OK	OK
VEX Expected	1714-439 (No0080)	1714-439 (No0080)	1714-439 (No0080)	1714-439 (No0080)
VEX Scan End	22:33:09	22:33:09	22:33:09	22:33:09
Latest Update (UTC)	2015-11-18 22:29:35	2015-11-18 22:29:35	2015-11-18 22:29:35	2015-11-18 22:29:35



# Recorder Monitor

- LBADR recorder controlled by daemon which allows remote monitoring of state
  - Sampler stats, free disk space, various errors etc
- PHP script polls recorders and saves state into SQL database
  - Retains permanently list of recorder experiments and location
- PHP webpages display current state of recorder
- Sounds alarm if various conditions “bad” for a period of time
  - Can enable/disable individual recorders

# LBA Recorder Monitor

vlbi is logged in

Logout

- Monitor
- Disk Labels
- Configuration
- Recorders
- Alarms
- Delete

	pkvsi1	pkvsi2	cavsi1	cavsi2	mpvsi1	mpvsi2	hovsi	cdvsi	tidvsi	cira10
<b>Monitoring On</b>	<span style="color: green;">Monitoring On</span>	<span style="color: grey;">Not Monitoring</span>	<span style="color: green;">Monitoring On</span>	<span style="color: grey;">Not Monitoring</span>	<span style="color: grey;">Not Monitoring</span>	<span style="color: grey;">Not Monitoring</span>	<span style="color: green;">Monitoring On</span>	<span style="color: green;">Monitoring On</span>	<span style="color: grey;">Not Monitoring</span>	<span style="color: green;">Monitoring On</span>
<b>Location</b>	Parkes	Parkes	ATCA	ATCA	Mopra	Mopra	Hobart	Ceduna	Tidbinbilla	ASKAP
<b>System Time</b>	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30	2015-11-17 02:32:30
<b>Status</b>	Recording	Not Recording	Recording	Not Recording	Not Recording	Not Recording	Recording	Recording	Not connected	Recording
<b>Logged Time</b>	2015-11-17 02:32:20	2015-11-17 02:32:20	2015-11-17 02:32:20	2015-11-17 02:32:21	2015-11-17 02:32:21	2015-11-17 02:32:21	2015-11-17 02:32:21	2015-11-17 02:32:22		2015-11-17 02:32:22
<b>Recorder Time</b>	2015-11-17 02:32:03	2015-11-17 02:32:13	2015-11-17 02:32:16	2015-11-17 02:32:11	2015-11-17 02:32:13	2015-11-17 02:32:02	2015-11-17 02:32:06	2015-11-17 02:32:02		2015-11-17 02:32:23
<b>Experiment</b>	v541a		v541a				v541a	v541a		v541a
<b>Recorder</b>	<u>pam_store</u>		<u>xcube</u>				<u>Flexbuf</u>	<u>local</u>		<u>local</u>
<b>Output Disk</b>	/data		/data2				/disk1/	/exports/xraid/Ar_1		/mnt/raid_2
<b>Disk Label</b>	N/A		N/A				N/A	ATNF V021		raid_2
<b>Time to End</b>	09:36:57		11:11:44				12:08:29	11:44:37		10:32:00
<b>Time Remaining</b>	2d 23:40:58		10d 12:27:21				9d 13:01:44	13:17:49		20:27:46
<b>Channel Stats</b>	<b>Ok</b>		<b>Ok</b>				<b>Ok</b>	<b>Ok</b>		<b>Ok</b>
<b>Bigbuf</b>	100%		100%				100%	100%		100%
<b>1PPS Signal</b>	Ok		Ok				Ok	Ok		Ok
<b>1PPS Missed</b>	0/100		0/100				0/100	0/100		0/100
<b>Channels</b>	4		4				4	4		2
<b>Bandwidth</b>	16		16				16	16		64
<b>Bits</b>	8		8				8	8		16
<b>Bit Rate</b>	256		256				256	256		512
<b>Compression</b>	xxxx		xxxx				xxxx	xxxx		xxxx

RecMon Ver 2.3.2  
Web Development

Alarm Test

Mute

Volume

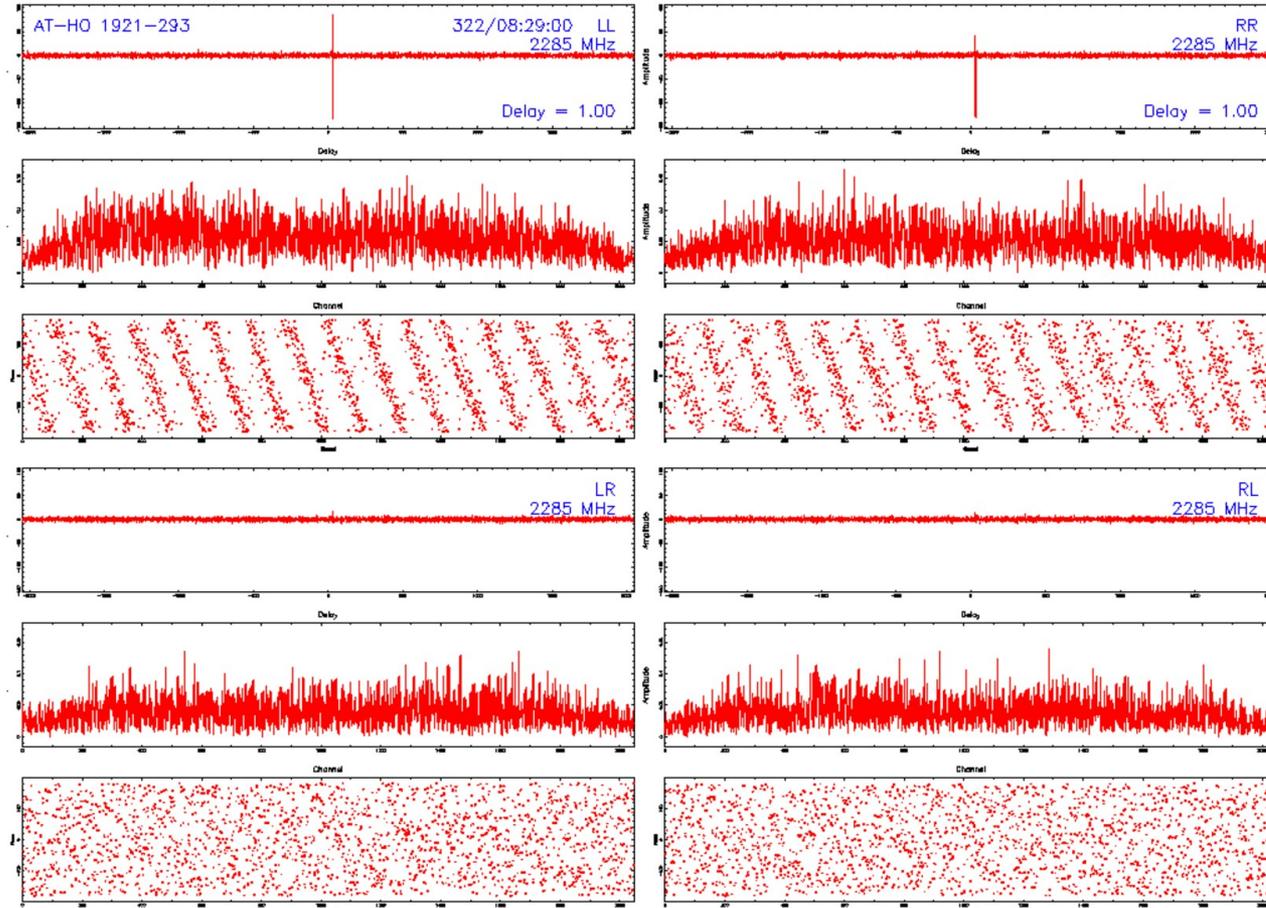
Next update



# Real Time Fringe Tests

- Interactively test fringes at start of every experiment
- Supports LBADR and Mark5
- Grab data then automatically correlate using DiFX a small chunk of data ( $\sim 1$  second) and display on web
- Relatively easy to automate

	At	Cd	Ho	Km	Pa	T6	Ti
At	<a href="#">2269, 2285</a>	<a href="#">2269, 2285</a>	<a href="#">2269, 2285</a>	-	<a href="#">2269, 2285</a>	-	-
Cd		<a href="#">2269, 2285</a>	<a href="#">2269, 2285</a>	-	<a href="#">2269, 2285</a>	-	-
Ho			<a href="#">2269, 2285</a>	-	<a href="#">2269, 2285</a>	-	-
Km				-	-	-	-
Pa					<a href="#">2269, 2285</a>	-	-
T6						-	-
Ti						-	-



Next proposal deadline December 15 (for obs from Apr 2016)

<http://www.atnf.csiro.au/vlbi/>

# Thank you

**CASS/ATNF**

Philip Edwards

Head of Science Operations

**t** +61 2 9372 4717

**E** [cormac.reynolds@csiro.au](mailto:cormac.reynolds@csiro.au)

**w** [www.atnf.csiro.au](http://www.atnf.csiro.au)

**CSIRO ASTRONOMY & SPACE SCIENCE**

[www.csiro.au](http://www.csiro.au)

