32 GHz Celestial Reference Frame Survey for Dec < -45 deg

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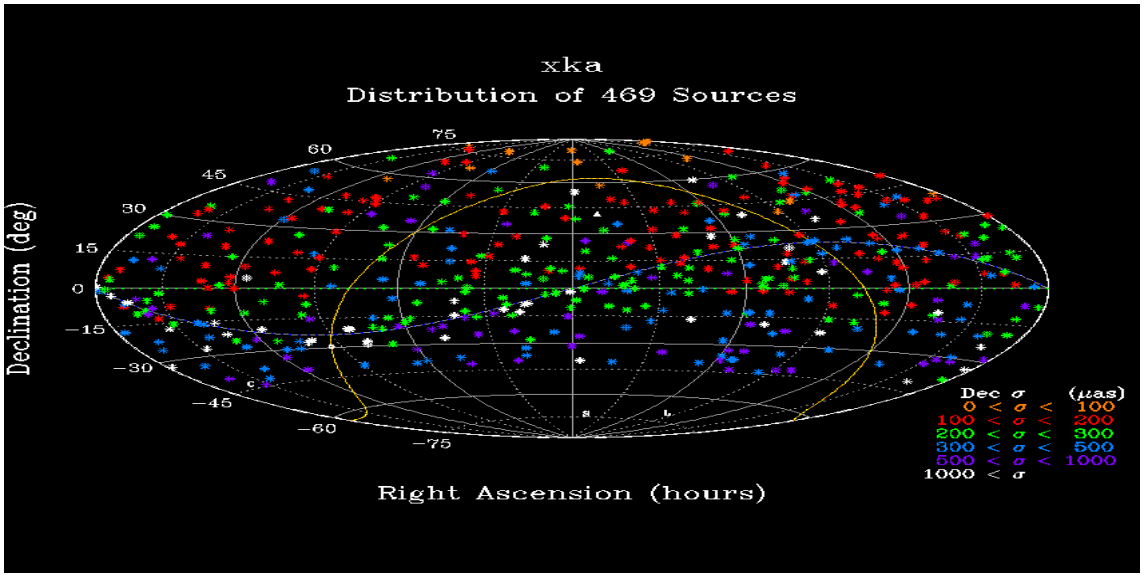
Outline

- Aim and Motivation
- Long Baseline Array (LBA), recent highlight, 32 GHz capability
- Source Selection
- Observational Strategy
  - Fringe test
  - Proposal
  - TAC review outcome
- Future challenges and plan

Celestial Frame needs the South

- Almost No current Ka sources meet ΔDOR accuracy goal south of equator!

Current DSN X/Ka Frame



- No coverage of South polar cap (-45 to -90 Dec)

- DSN weakly covers southern Ecliptic: only one strong baseline as California-Spain is weak in south

Declination 1-sigma Uncertainty

Orange: 0.5 nrad meets future ΔDOR spec
Red: < 1.0 current ΔDOR spec
Green: < 1.5
Blue: < 2.5
Purple: < 5.0
White: > 5.0

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Aim and Motivation

- DSN has also been developing a catalogue at 32 GHz (Ka-band) with its internal network of 34m Beam Wave Guide antennas that includes DSS-34 in Tidbinbilla (Jacobs et al. 2011). However, the DSN VLBI network alone can only cover limited part of the full sky, missing in the declination range from -45 to -90 degree.

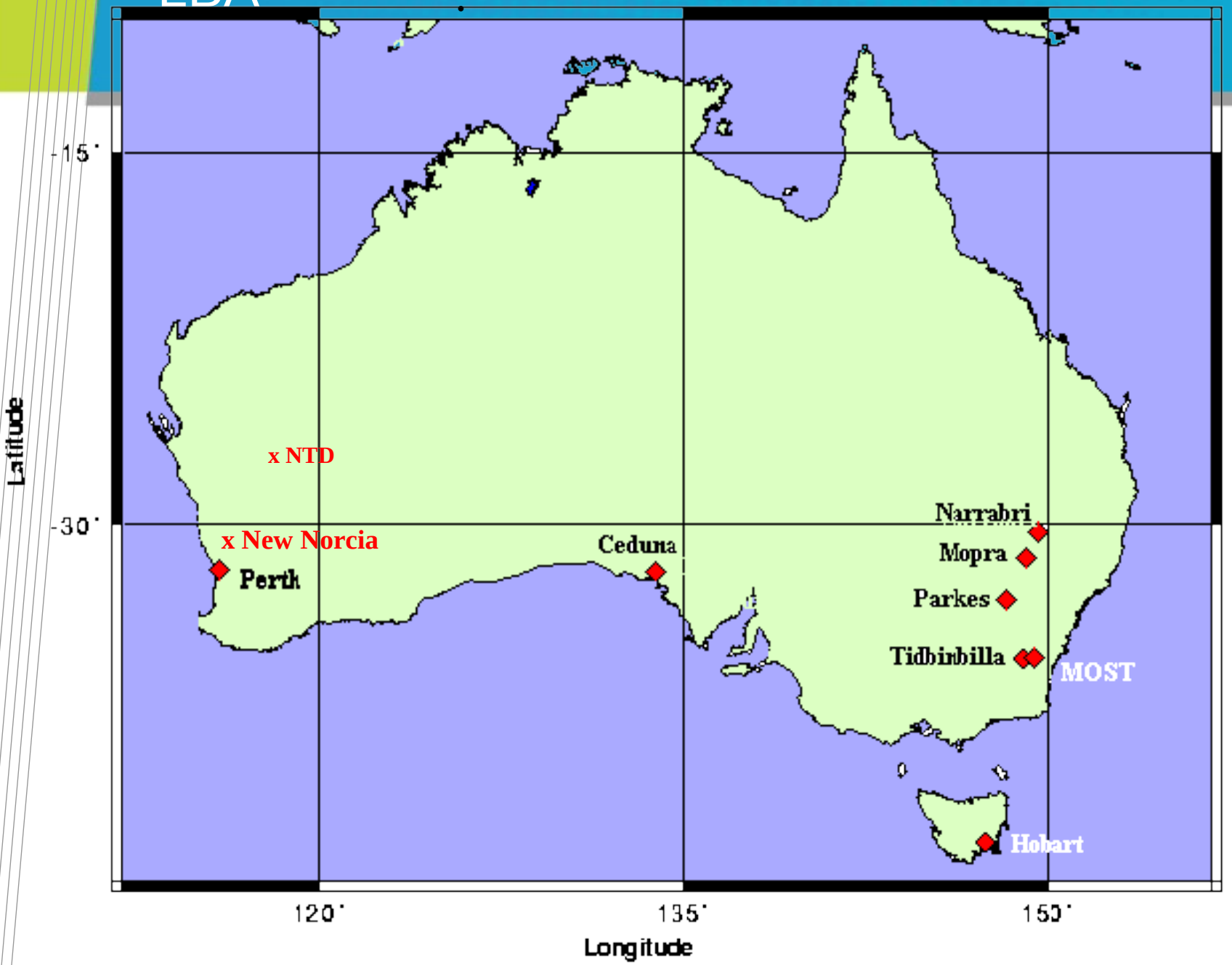
- The ultimate goal of our project is to establish a reference source catalogue at 32 GHz for the south polar cap region, which has never been covered in existing catalogues at that frequency.

- Toward this goal we need to first establish a list of sources that VLBI can detect fringes. A pilot survey within Australian baselines will allow us to select sources as well as obtain positions of sources to an order of 1 milli-arcsecond accuracy.

 LBA observations

Long Baseline Array (LBA)

LBA


VLBI Telescopes Within Australia
-15°
-30°
Latitude
x NTD
x New Norcia
Perth
Ceduna
Narrabri
Mopra
Parkes
Tidbinbilla
MOST
Hobart
120°
135°
150°
Longitude

The Australian Long Baseline Array (LBA)+






Parkes (64)

ATCA (5x22m)

Mopra (22m)

Hobart (26m)

Ceduna (30m)

Tidbinbilla (70m or 34m), all in Australia,

Hartebeesthoek (26m) , South Africa (Sep2008)

TIGO (6m), Chile

O’Higgins (9m), Antarctica, also NZ, AuScope, ASKAP as new elements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Standard LBA Mode

Supported LBA S2 Configurations for SCHED

Listed in the table below are the recommended standard configurations for LBA observations. All of these configurations are available as NRAO SCHED setup files on the ATNF UNIX machines. They are also available here: lba_setup.tar.gz. If the desired configuration is not present please contact the VLBI observers for help.

N.B. These S2 configurations are used with the disk LBADR system, until updated configurations can be ported into the SCHED software package.

Configuration				Antenna (y/n indicates if the configuration is supported).							
Name	Frequency range (MHz)	Bandwidth (MHz)	Polarisation	ATCA 6 x 22m	Mopra 22m	Parkes 64m	Tid 70m (DSS43)	Tid 34m (DSS45)	Hobart 26m	Ceduna 30m	Hartebeesthoek 26m
lba21cm-2p-1IF	1392 - 1408	16	dual	y	y	y	n	n	y	n	n
lba21cm-1p-2IF	1384 - 1416	2 x 16	LCP	y	y	y	n	n	y	n	n
lba18cm-2p-1IF	1642 - 1658	16	dual	y	y	y	n	n	y	n	y
lba18cm-1p-2IF	1634 - 1666	2 x 16	LCP	y	y	y	y	n	y	n	y
lba13cm-2p-1IF	2274 - 2290	16	dual	y	y	y	y	n	y	y	y
lba13cm-1p-2IF	2252 - 2284	2 x 16	RCP	y	y	y	y	y	y	y	y
lba6cm-2p-1IF	4808 - 4824	16	dual	y	y	y	n	n	y	y	y
lba6cm-1p-2IF	4800 - 4832	2 x 16	RCP	y	y	y	n	n	y	y	y
lba5cm-2p-1IF	6492 - 6508	16	dual	y	y	y	n	n	y	y	y
lba5cm-1p-2IF	6484 - 6516	2 x 16	RCP	y	y	y	n	n	y	y	y
lba3cm-2p-1IF	8417 - 8433	16	dual	y	y	y	y	n	y	y	y
lba3cm-1p-2IF	8409 - 8441	2 x 16	RCP	y	y	y	y	y	y	y	y
lba12mm-2p-1IF	22192 - 22208	16	dual	y	y	y	n	n	y	y	n
lba12mm-1p-2IF	22184 - 22216	2 x 16	LCP	y	y	y	y	n	y	y	n

Backend – LBADAS, LBA-DR (with AppleXraids) @ 256 MBps (512 MBps)
eVLBI is possible for some stations

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LBA observing time (in hrs) by year and band

	2004	2005	2006	2007	2008	2009	2010	2011
20cm	36	37	107	142	58	65	44	20
13cm	64	44	54	91	51	11	37	70
6cm	22	60	42	14	65	95	88	72
3cm	98	192	127	99	226	168	290	247
1cm	24	0	12	21	105	57	60	54
total	244	333	341	366	505	396	519	463

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Recent LBA publications

- The first resolved imaging of milliarcsecond-scale jets in Circinus X-1 (Miller-Jones et al. 2012 MNRAS 419, L49)
- e-VLBI observations of Circinus X-1: monitoring of the quiescent and flaring radio emission on AU scales (Moin et al. 2011 MNRAS 414, 3551)
- Dual-frequency VLBI study of Centaurus A on sub-parsec scales. The highest-resolution view of an extragalactic jet (Muller et al. 2011 A&A 530, L11)
- Maser maps and magnetic field of OH 337.705-0.053 (Caswell et al. 2011 MNRAS 415, 3872)
- First geodetic observations using new VLBI stations ASKAP-29 and Warkworth 12m (Petrov et al. 2011 PASA 28, 107)
- Magnetic fields from OH maser maps at 6035 and 6030 MHz at Galactic sites 351.417+0.645 and 353.410-0.360 (Caswell et al. 2011 MNRAS 414, 1914)
- First VLBI Detection of the Radio Remnant of Supernova 1987A: Evidence for Small-scale Features (Ng et al. 2011 ApJ 728, L15)
- The LBA Calibrator Survey of southern compact extragalactic radio sources - LCS1 (Petrov et al. 2011 MNRAS 414, 2528)
- Discovery of extended and variable radio structure from the gamma-ray binary system PSR B1259-63/LS 2883 (Moldon et al. 2011 ApJ 730, L1)

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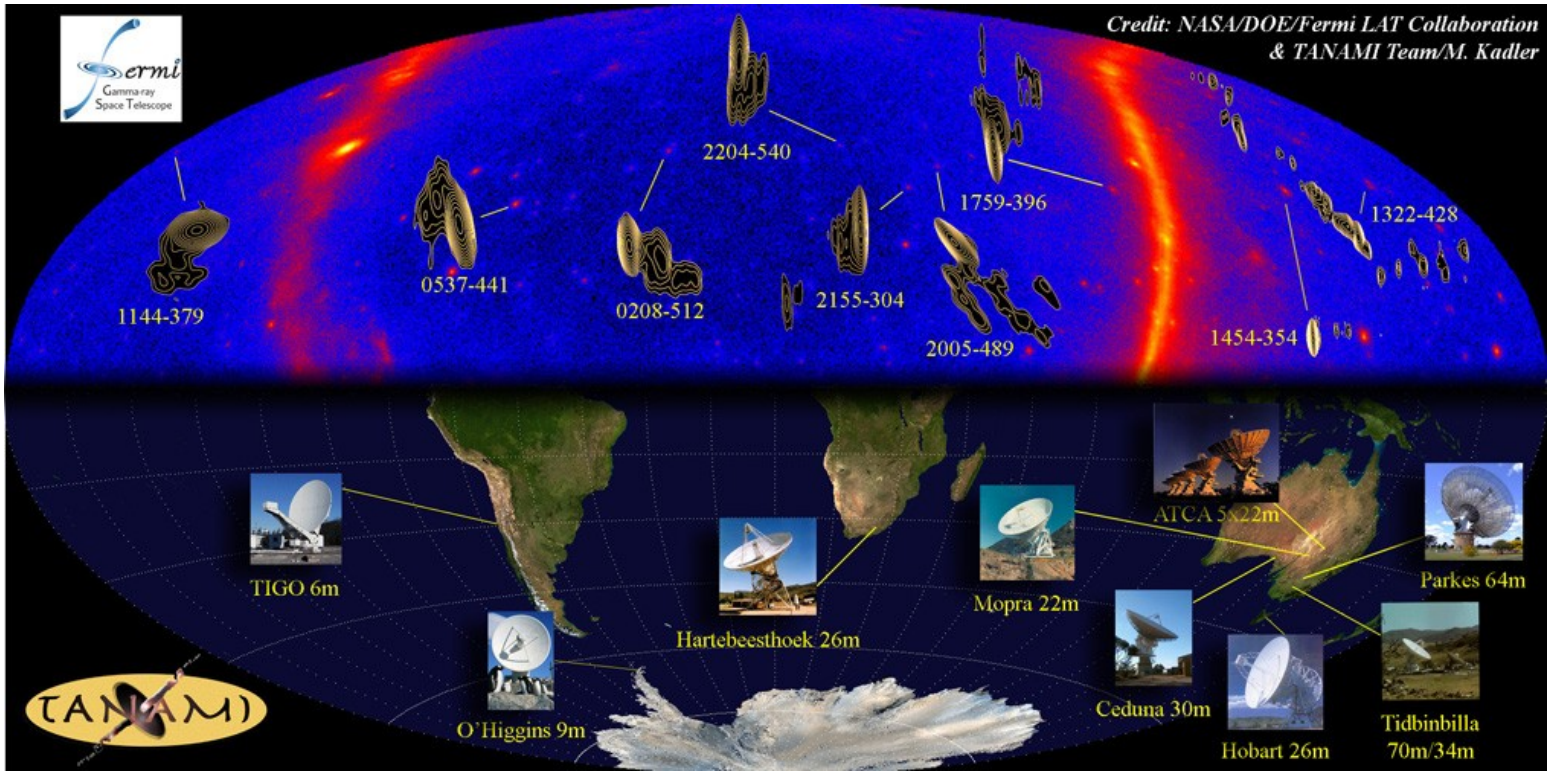
TANAMI-LBA project to track FERMI targets

Tracking Active Galactic Nuclei with Austral Milliarcsecond Interferometry



LBA Monitor at 8/22 GHz (vs. MOJAVE at 15 GHz with VLBA)

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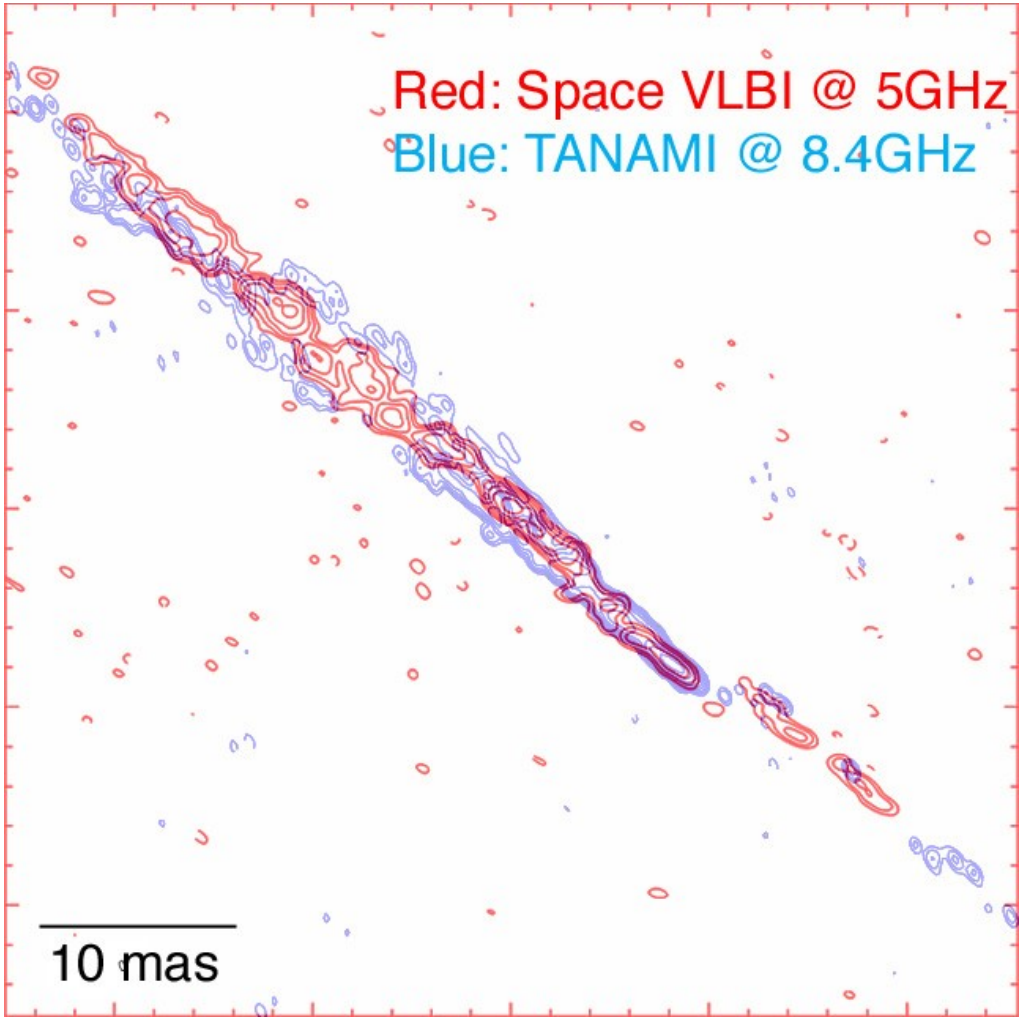
TANAMI subsample - Centaurus A

- VSOP (Horiuchi et al. 2006)
- TANAMI (Müller et al. 2010)
- observations separated by 10 years
- similar structure!
- previous apparent velocity ~ 1.4mas (Tingay et al. 2001)
- detailed velocity information from TANAMI monitoring



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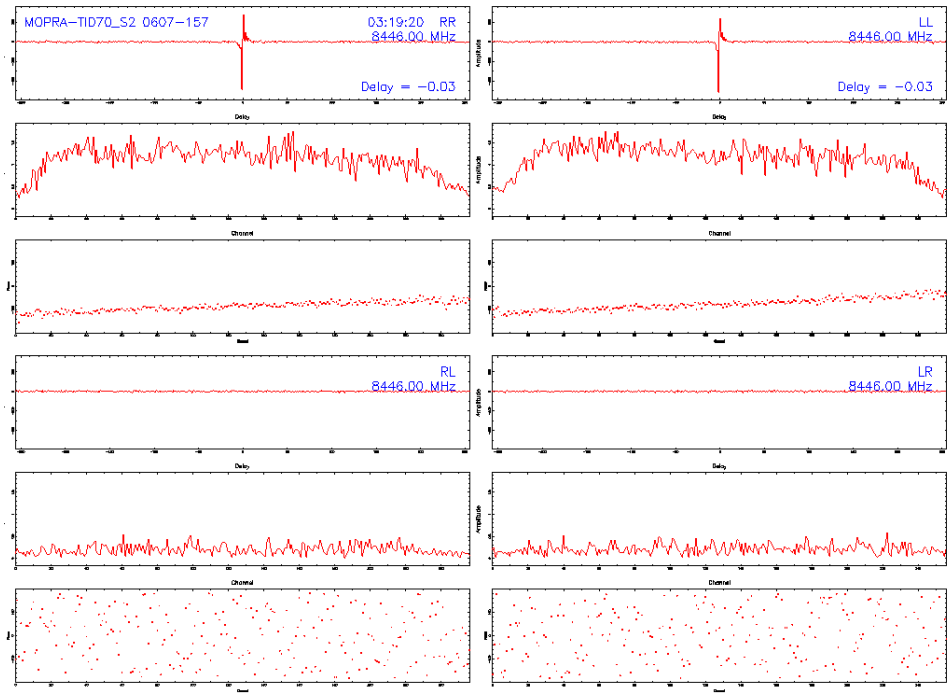
eVLBI Connectivity to Tidbinbilla

- 2009 June 15, the first real-time VLBI fringes to Tid (with Mopra, 32Mbps, 16MHz/1ch BW, correlated at Parkes)
  First ever eVLBI fringes to DSN!
- Current network speed and download limit are not good for practical eVLBI
- 1Gbps AARNET link to CDSCC is proposed



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LBA 32GHz capability – to be tested

- Mopra is also available for observations in the 15-mm (16-27 GHz) 7-mm (30-50 GHz) and 3-mm (76-117 GHz) bands.

- ATCA Observing is possible with the standard 15-mm (16-25 GHz) and 7-mm (30-50 GHz) systems on all six antennas, and 3-mm systems (83.5-106 GHz) on five antennas.

- DSS-34 Ka-band coverage is 31.910 - 32.190 GHz.

Ka-Baseline Sensitivity (for 1min integration), Max Resolution

- ATCA-Mopra (120 km): 10 mJy, 20 mas
- ATCA-DSS-34 (569 km): 5 mJy, 4 mas
- Mopra-DSS-34 (456 km): 10 mJy , 5 mas

(cf. http://www.atnf.csiro.au/vlbi/calculator_2009/)

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Source Selection

Source selection for South Pole pilot survey

- Based on ATCA Survey at 20,8.6, and 4.8 GHz (AT20G by Murphy et al. 2010) – 5890 sources
- 531 sources with X-band flux density > 200mJy with percentage of unresolved component > 70 percent
- Among the 531 sources, 268 were detected at 20 GHz
- Finally, total number of south pole (Dec<-45 deg) candidate sources is 144.
- This includes 46 ICRF2 sources (with 29 “Defining” objects)

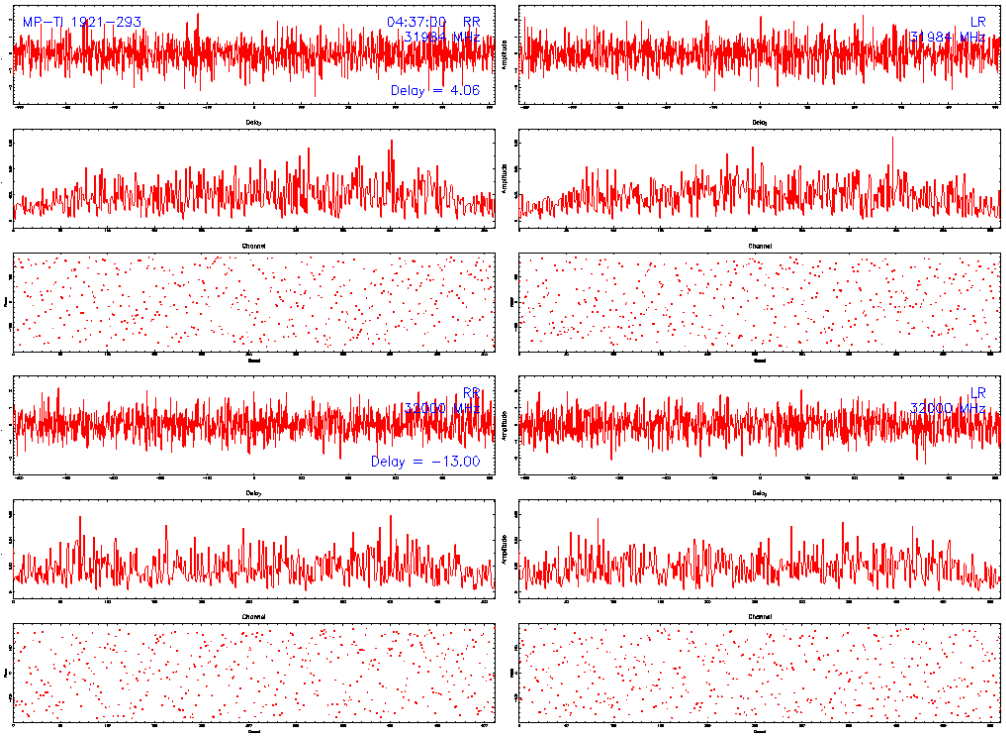
Fringe Test

First fringe test – 2011 Dec 02, 1921-293

- Mopra – DSS-34 Canberra
- Central frequency- 32000.00MHz
- 2 IF x16MHz bandwidth
- single polarization

- No fringe

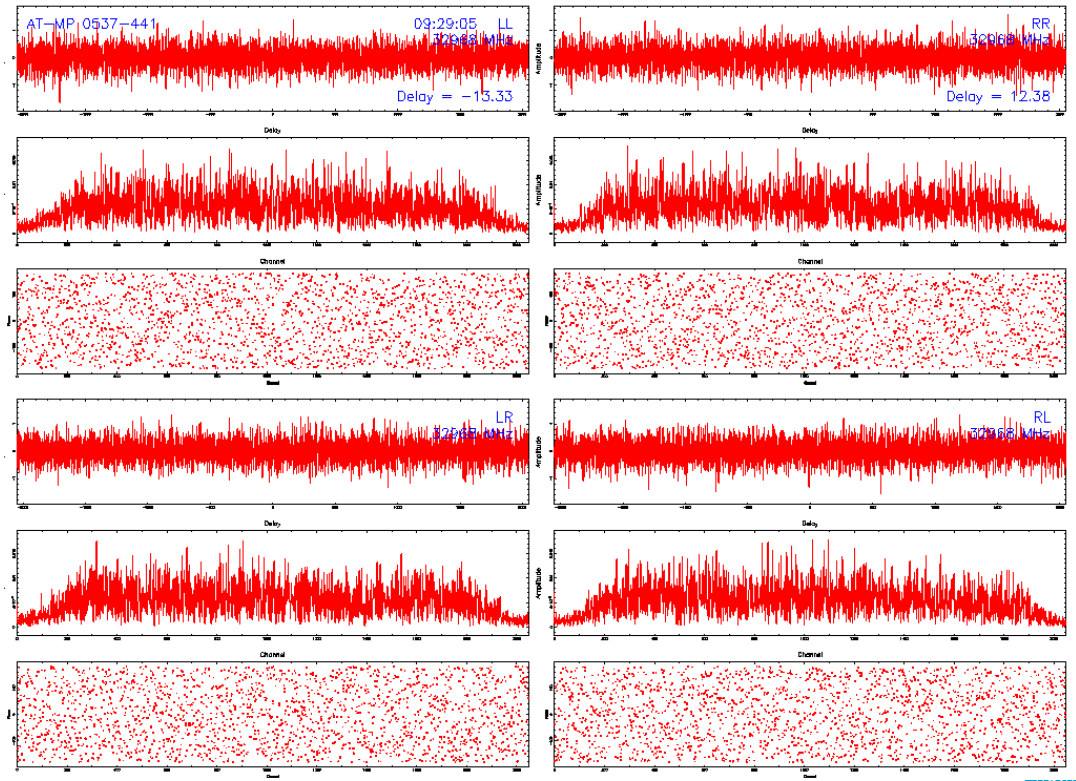
was detected



2nd fringe test - 2012 Feb 7 & 9, 0537-441

- ATCA – Mopra & DSS-34 - Mopra
- Central frequency- 32000.00MHz
- 2 IF x64MHz bandwidth
- Dual polarizations (except DSS-34)

No fringe
was detected



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However, LBA Proposal

LBA Proposal (submitted 15 Dec 2011)

32 GHz Celestial Reference Frame Survey for Dec < -45 deg.

P.I. Shinji Horiuchi, Co-Is: Chris Jacobs, Chris Phillips, Ioana Sotuela, Cristina Garcia-Miro

Requested time: 24 hour ATCA – Mopra + DSS-34

Time Assignment Committee (TAC) Outcome (came last week)

TAC Rate: 4.3/5.0

TAC Comments:

"A good reference frame at 32 GHz is needed for spacecraft navigation and a high precision GAIA frame-tie. This proposal is an initial step in the south by using AT-Mp to filter candidate sources for further study: a sensible first step."

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Future challenges

- Toward first fringes
  - Because 32 GHz is not yet a standard LBA mode we need to establish the way to get fringes before the pilot survey
  - Schedule gaps during and outside of regular LBA sessions are utilised
- The first LBA 24 hour session (if scheduled during a normal LBA session)
  - Hold as much as possible DSS-34 schedule to overlap with ATCA-Mopra observation
- Future ATNF operational change may affect
  - To seek funding to complete ASKAP, Mopra may not be available in near future…..(so as Parkes S/X for IVS community!)
- Toward establishing new Ka-band global network

  See poster by Chris Jacobs et al. (2.18)

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The Potential for a Ka-band (32 GHz) Worldwide VLBI Network (poster 2.18)

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Thank you!