VLBI with Indian facilities

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- **The Indian facilities and possibilities**
  - **The legacy GMRT – available now**
  - **The upgraded GMRT – getting ready**
  - **32-m antennas (ISRO's deep space network antenna; other communication antennas)**
    - **Used for VLBI – DDOR experiment** **(Manikantan Ramdas talk)**
  - **The Ooty Radio Telescope - available now**
  - **SWAN** **(Desh's talk)**
  - **Scintillometery – possible with both the uGMRT and the ORT**
    .
    (Viswesh's talk)

VLBI with Indian facilities

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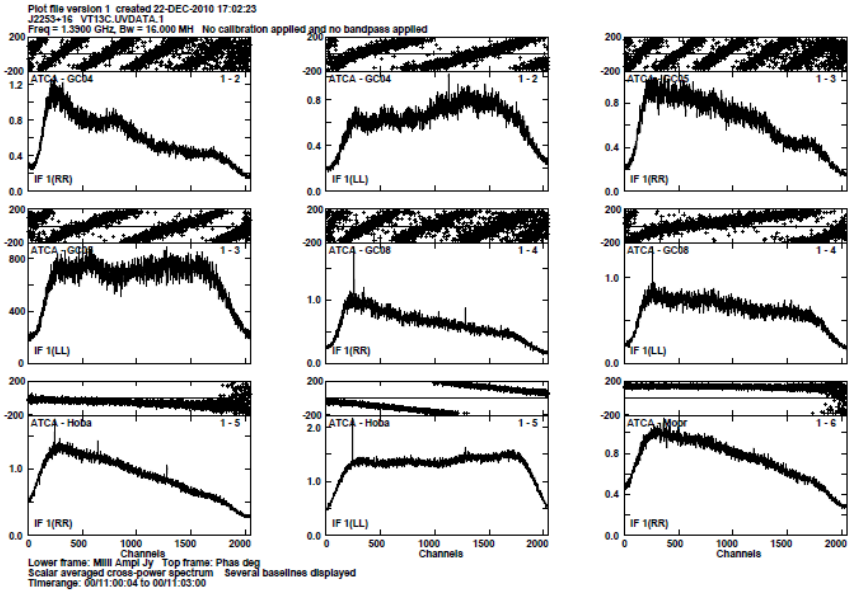
- **The addition of light collecting bucket - upgraded GMRT**
  - **Large collecting area - 9 antennas in a phased sub-array synthesizes a 120-m single steerable dish – high sensitivity Australasia VLBA**
  - **Wide sky coverage of GMRT, $-57^0 < Dec < 90^0$**
  - **Overlaps for Dec ~ -47^0 with Parkes (2.5 hours), ASKAP/MWA (6.0 hours)**
  - **New wideband feeds at Band 2, 3, 4 and 5 with a flexible digital backend allow overlaps at P and L band with Australian instruments**
  - **Newly commissioned active hydrogen maser provides stable frequency standard for increased coherence time**
- **The 32-m antennas**
  - **ISRO Deep space network 32-m antennas with $-75^0 < Dec < 90^0$ coverage**
  - **S Band - 2.2 – 2.3 GHz**
  - **X Band - 8.0 – 8.5 GHz**
  - **Astronomical tests with 16 MHz receiver successfully carried out**
- **The Ooty Radio Telescope**
  - **7000 m^2 collecting area at P Band with $-60^0 < Dec < 60^0$ with 9 hour tracks(larger overlap)**
  - **VLBI capable PONDER receiver providing 16 MHz in RDF, Mark 5C, VDIF formats**
  - **Newly commissioned active hydrogen maser frequency standard**

Previous efforts

- First try with Australian instruments
  - December 2010 experiment with GMRT-ATCA-MOPRA at 1390 MHz (Yashwant, Tasso, Ramesh and others)
  - Under a collaborative AISRF effort
  - Useful cross-spectrum between different telescope
  - Time-stamp, resampling, frequency stability problems
  - Time to do this again !!!
- Other experiments
  - ORT – GMRT P-band experiments May 2013
  - ORT – RA P-band experiments November 2013
  - GMRT - WSRT P-band experiment December 2018
  - All these efforts either with single antennas or legacy GMRT
  - Opportunity with the uGMRT



Possible science

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- **Pulsar proper motions**
  - Large proper motions can identify high velocity pulsars and can constrain supernova kick mechanisms
  - Interesting case of glitching pulsar PSR B1727-47 (Shternin et al. 2019)
  - Frequent glitches and timing noise in PSR B1721-47 introduce covariance in estimation of proper motion
  - Varying estimates of proper motion over the years - 104 to 224 mas per year
  - V_{tr} ~ 2000 km/s (50-700 km/s – Hobbs et al. 2005)
    - Precision distance and velocity measurements
    - Constraints on supernova physics
    - Constraints on ISM
  - Inter-continental VLBI with large light collecting buckets such as uGMRT and FAST needed for precision
- **ISM studies**
  - High spatial resolution studies with RA and GRT of PSR B0950+08 and B0329+54 reveal interesting ISM structures
  - In B0950+08,a cosmic prism was inferred at projected baseline of 220000 km (Smirnova,..,Joshi et al. 2014)
  - Two exponential scales for scatter-broadening with substructure of a resolved scatter broadened image of PSR B0329+54 was inferred from RA-GRT VLBI (Popov,…,Joshi et al. 2017)
- **Other VLBI science – AGN, Masers etc**

Scintillometery with ORT

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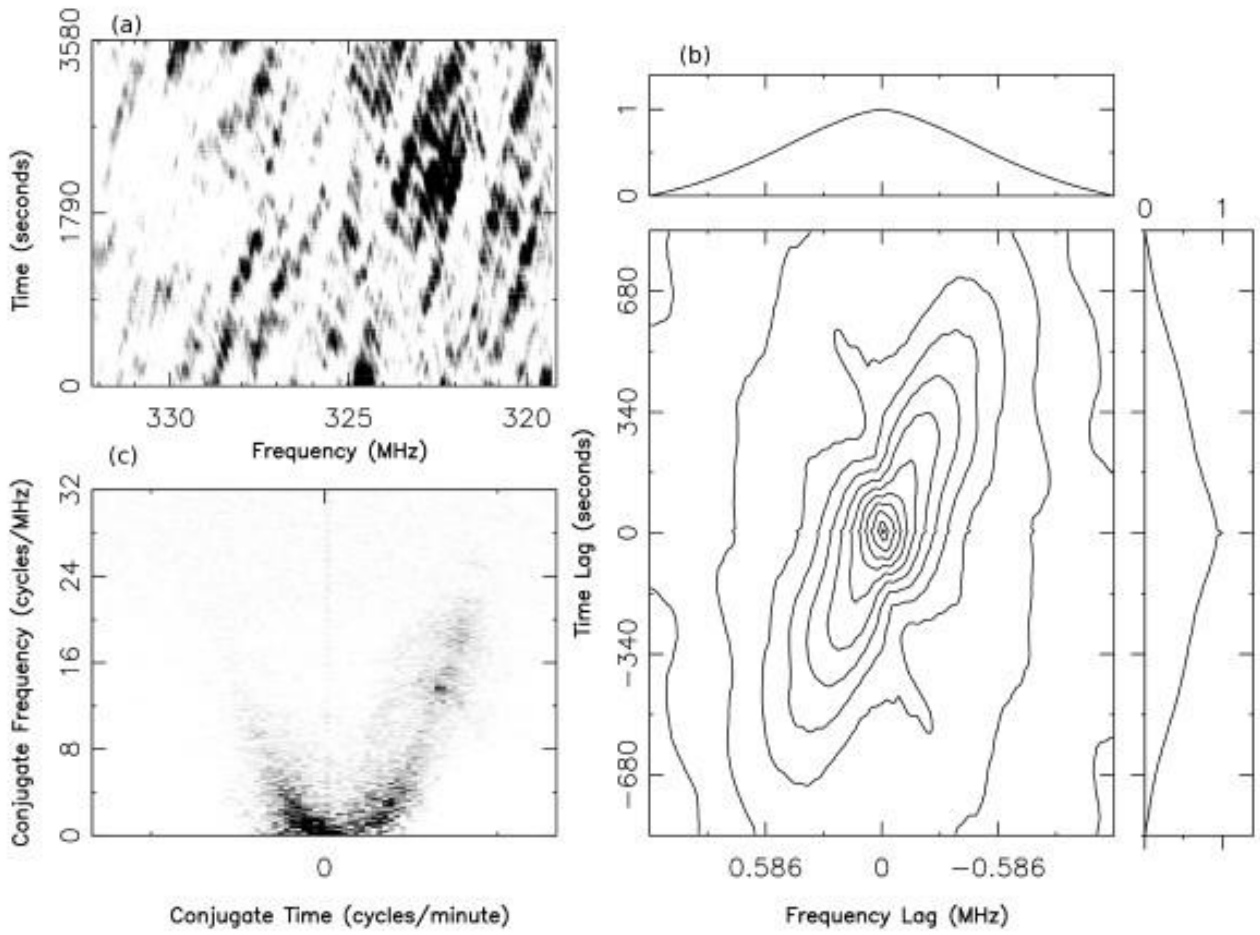
- **PSR B0834+06 secondary spectrum with PONDER at ORT**



Naidu, Joshi et al 2019

Indo Australian(Asian) VLBI

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- **Provides unique opportunity for VLBA with large sensitivity in Asia – Pacific region**

- **uGMRT-ASKAP-Parkes array**
  - **700 – 800 MHz VLBI**
  - **L band VLBI**
  - **Australasian VLBI with FAST, Urumqi, Tian Ma, 40-m Thai telescope**
  - **Antenna separations**
    - **9800 km (Parkes)**
    - **6800 km (ASKAP),**
    - **3500 km (E-W – FAST)**
    - **3900 km (N-E – Urumqi)**

- **uGMRT – MWA P band array**
  - **300 MHz 6800 km**
  - **Australasian VLBI with 40-m Thai telescope, FAST, QTT**
  - **ISM instrument**

- **4 – 22 mas**

Current efforts in India

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- **Technical developments at the uGMRT and the ORT to enable VLBI**
  - **VLBI capable receiver and recorder at the ORT – PONDER (Naidu,Joshi et al. 2015)**
  - **New active Hydrogen Masers have been commissioned as frequency standards at both the ORT and the uGMRT**
  - **Baseband data recording at the uGMRT for VLBI mode is in development (Ajith's talk)**
  - **DiFX correlator implemented and working at NCRA**
- **Pan – India VLBI network involving college students – SWAN (Desh' talk)**
- **Using Other large dishes in India**
  - **D32 and Arvi dishes**
  - **Astronomy tests were conducted in May this year successfully**
  - **These antennas are tuned for spacecraft communications, so some work is required for useful astronomical work**
  - **Already used in VLBI mode for DDOR experiment (Manikantan's talk)**

P

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