

# India Australia Collaboration

# Team Eccentric @ TIFR

- ▶ *What we are pursuing?*
  - i) *General Relativistic constructs to search for nano-Hertz GWs, induced by individual sources, in IPTA/PPTA/IndPTA data sets*
  - ii) *Improved/New timing model for exotic pulsar binaries*
- ▶ *Deliverables & why*
  - i) Two detailed manuscripts & few more under preparation. Few codes are incorporated into Tempo2
  - ii) These constructs should be helpful to inaugurate the era of nano-Hertz GW astronomy during the next decade
- ▶ *Requirements*

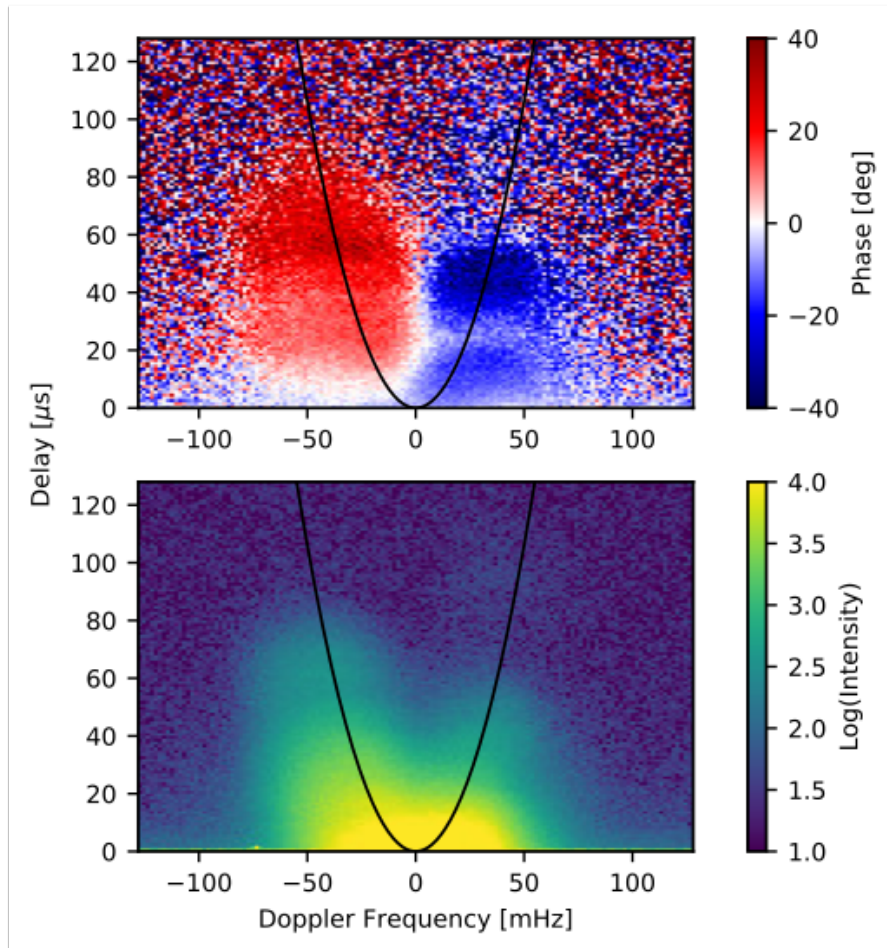
Funding to enhance exchange visits for graduate students, post-docs and researchers
- ▶ *Additional wish list*

Interoperability between researchers at TIFR-ATNF-FAST-Meerkat
- ▶ **Current Researchers**

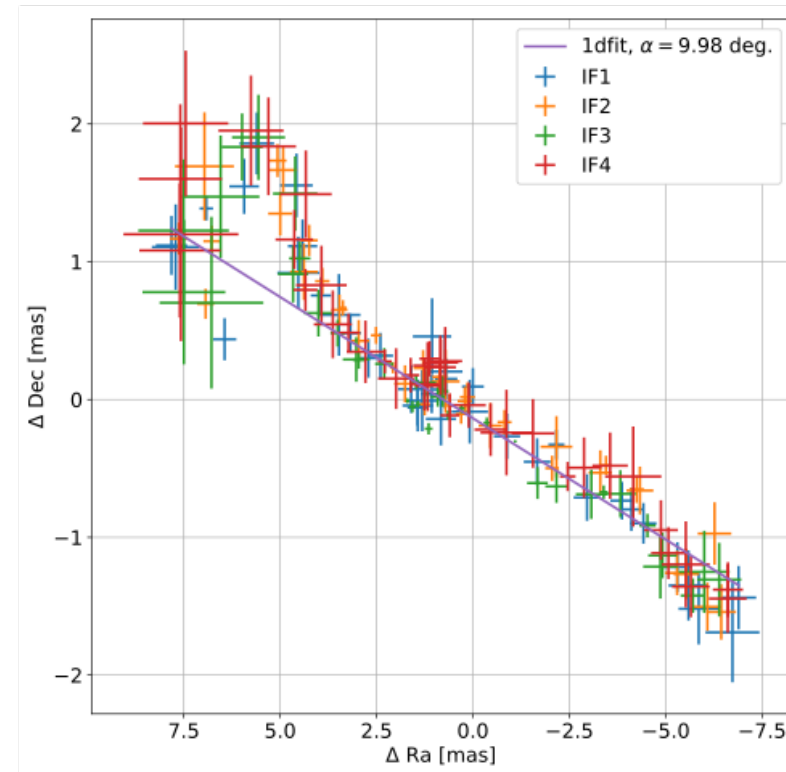
*Abhimanyu S, Lankeswar Dey, Xingjiang Zhu,  
George Hobbs, Bhal Chandra Joshi & A. Gopakumar*

# Pulsar Scintellometry

## GMRT— LBA/MWA pulsar speckle imaging



Speckle imaging of the Vela pulsar  
(Kirsten et al., in prep.)



**Figure 4.** Map of scattered image of the Vela pulsar.

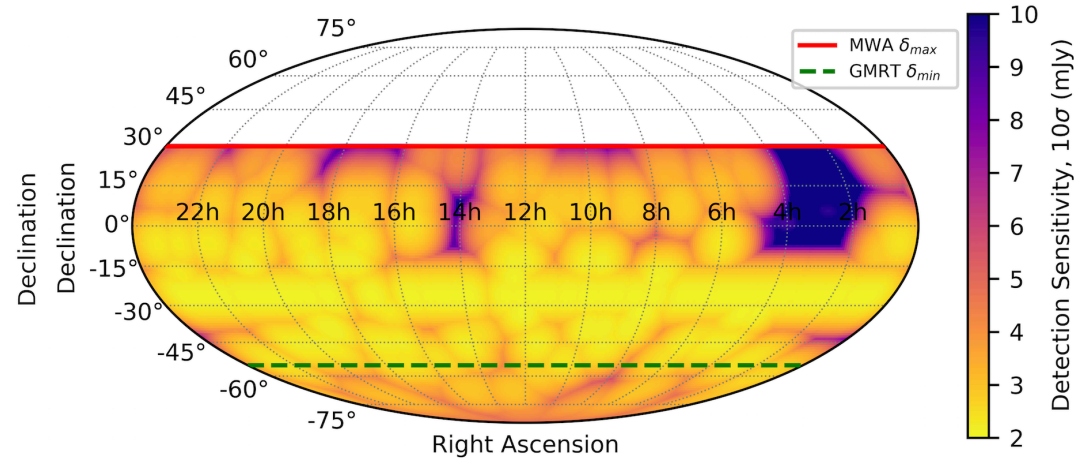
# uGMRT-Parkes-MWA



- **Key synergies**
  - Complementary Wide frequency coverage 70 – 4000 MHz
  - Imaging at MWA and uGMRT with high sensitivity high frequency time-series follow up at Parkes
  - Long Baseline ~ 9750 km on overlapping bands
- **Possible key projects**
  - **SKA Key science goal : detection of nano-Hz GW (Pulsar Timing Arrays)**
  - Measurements of variations in DM upto  $0.00001 \text{ pc-cm}^{-3}$  and scatter-broadening to improve ToA precision for PTA experiments (both InPTA and PPTA) + aux science
  - Testing frequency dependence on DM with implications for PTA
  - High cadence campaign monitoring of targeted GW searches (OJ287)
  - **SKA Key science goal : quadrupling pulsar population and discovering NS-BH binary**
  - Optimal design of SKA surveys by conducting scatter-broadening measurements for a large sample of pulsars from 70 – 4000 MHz covering maximally Galactic LoS
  - Imaging and time-series low frequency surveys with candidate follow-up at Parkes
  - **Applications to space exploration**
  - Exploration and development of Radio Pulsar Navigation (RPNAV)
- **Funding**
  - Data transfer media, computing, travel and exchange of students and scientist
  - AISRF proposal under umbrella of Australasia (Australia, India, Japan, Thailand .....)  
science and technology cooperation
  - Academia – industry collaboration on both Australian and Indian side?

# Low-frequency high-time resolution archives

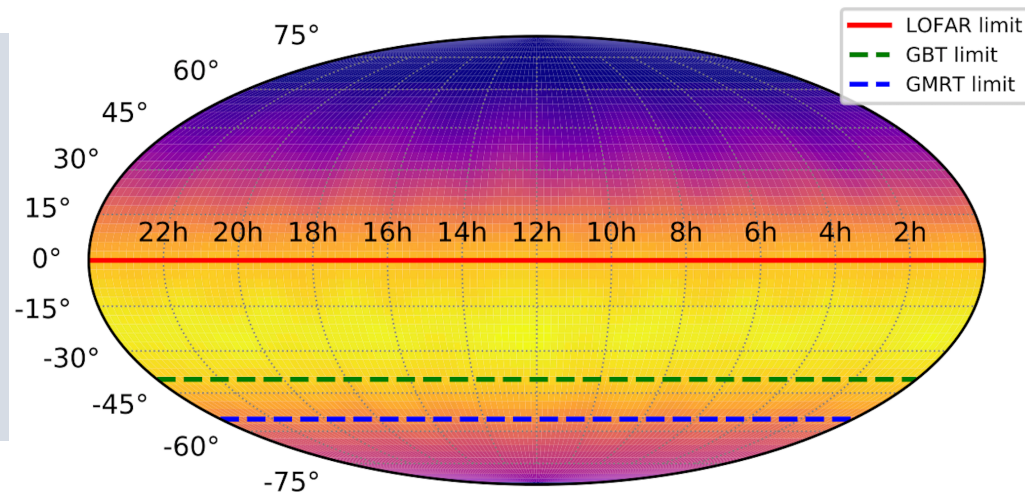
~ **mid 2019**



- Low-frequency detections
- Targeted pulsar searches
- Follow-ups of sources
- Will serve as a reference survey for SKA1-Low pulsar searches

~ **end 2021**

- Current archives ~ 170 – 200 MHz
- SMART survey obs ~ 140 – 170 MHz
- Dwell time ~ 3600 – 4800 seconds
- 100 us, 10 kHz resolutions
- VCS (voltage) data!



By ~ end 2021, MWA VCS archives (100us, 10kHz) will span the entire southern sky at in the ~ 140 – 200 MHz, band, down to ~2-3 mJy limiting sensitivity





# Simultaneous MWA + GMRT + Parkes observations

## Advantages:

- Can observe simultaneously
- Can cover very wide bandwidths
- Can observe relatively far South
- Telescopes all have proven pulsar observing modes

## Science goals:

- Comprehensive census of pulse profiles (shape, scattering, scintillation, **DM variations** ...)
- High cadence observing of millisecond pulsars (GW burst detection)
- Scatter broadening** models for future survey predictions
- Can look for molecular lines/environment

## Challenges:

- Telescope proposal deadlines and scheduling
- Links with ongoing pulsar projects at all three telescopes
- Radio frequency interference
- Determining the “key” science case
- Pulsar catalogue not ideal for wide-band properties of pulsars
- Getting “follow-up” observing time



# Low-Mid imaging survey specifically for relativistic pulsar systems (MWA, GMRT, ASKAP [and Parkes])

## Advantages:

Pulsars are point sources, steep spectrum, polarized and \*scintillate\*

Imaging techniques not biased against highly relativistic binaries

Update imaging techniques to optimize pulsar detection

GMRT to confirm ASKAP candidates at lower frequencies

Parkes telescope as confirmation/follow-up

## Science goals:

Discovering highly relativistic binary pulsars

Pulsar – black-hole systems

Direct targeting of regions of interest to PTAs

Can such techniques simplify pulsar searching with SKA?

## Challenges:

Telescope proposal deadlines and scheduling

Developing new pipelines

VLBI on likely sources

# A-ARISE: Asian-Australian Radio Initiative for the SKA era

## To start:

Prepare a short document describing the aims and scope and requesting input and support from the Asian-Australian radio community

Have Australia-China link for pulsar/GW research  
Have Australia-Japan link for pulsar/GW research  
Have Australia-India link for pulsar/GW research  
Have India-China link for pulsar/GW research  
Have Japan-China link for pulsar/GW research

....

Have large number of ongoing projects with existing telescopes

Can use SKA as the overall umbrella

- Linked with SKA regional centres
- Key SKA science projects
- SKA pathfinders
- Outreach/education and creating scientific community for SKA
- Role of existing telescopes in the SKA era?
- Training new scientists to maximise the Asia/Australian involvement in the key pulsar SKA science cases

Use this initiative to

- fund students travelling between Asian/Australian sites
- focus Asian/Australian community on SKA science
- provide justification for many detailed collaborations.
- focus on the future – will not disrupt existing projects on existing telescopes.