



Radio Pulsars and SKA Pathfinders

Simon Johnston

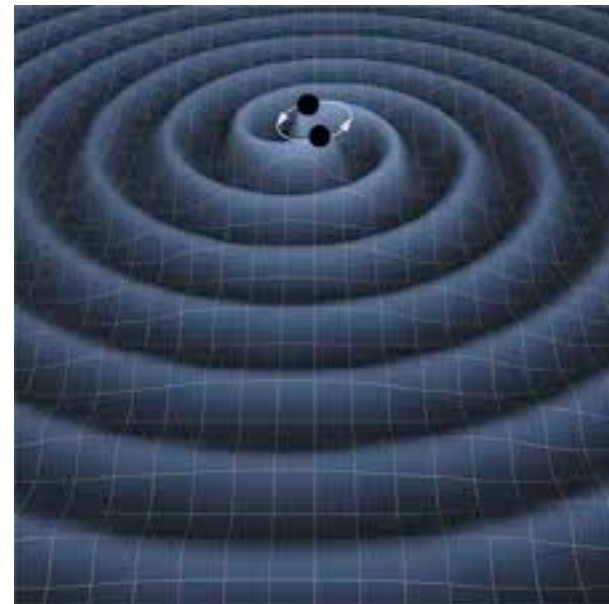
Head of Astrophysics, ex ASKAP Project Scientist
CASS

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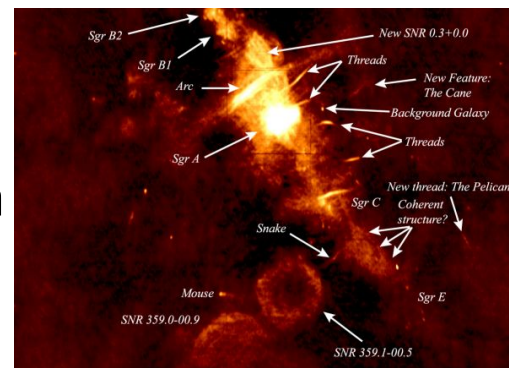


Pre-SKA Pulsar Science

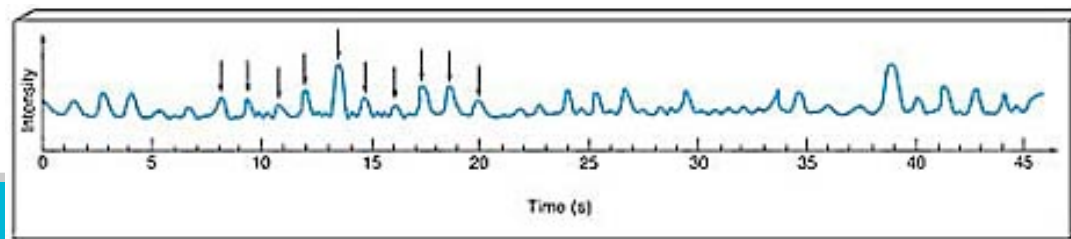
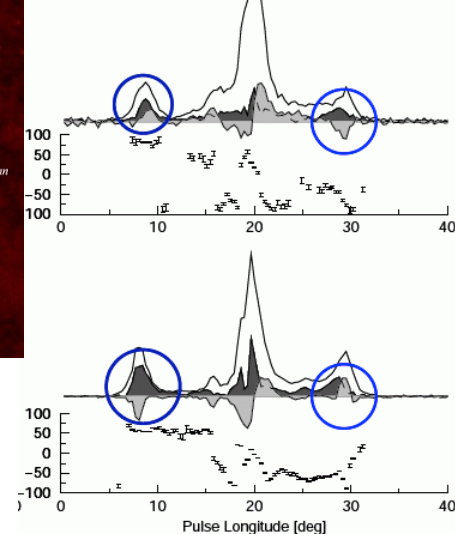
- High precision timing
 - Gravitational waves
 - Tests of GR
 - Binary formation and evolution
- Surveys
 - Finding MSPs and other exotics
 - Galactic Centre
- Other stuff
 - Galactic structure
 - Distance + proper motion
 - Understanding pulsars
 - Emission mechanism



Kassim et al. 1999

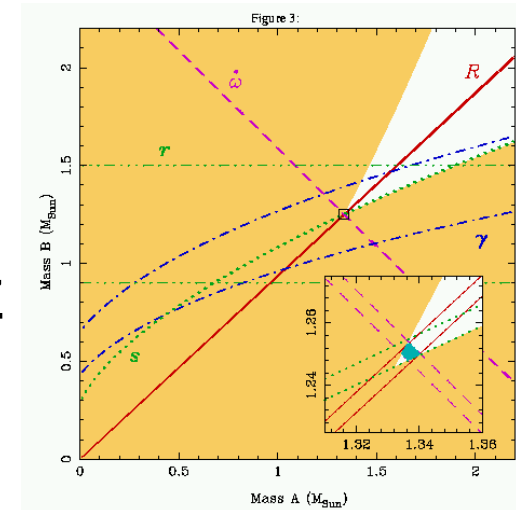


Karastergiou et al. 2001



What do we need for High Precision Timing

- Single Pixel Sensitivity
 - Lots of collecting area, low T_{sys}
 - Don't care how collecting area is distributed !!
- Frequency range 0.5 GHz to few GHz
 - Too low: run into ISM problems
 - Too high: pulsars become too weak
 - Wideband receiver ideal
- Regular and repeated observations
 - Lots of telescope time



Kramer et al. 2006

Image: M. Kramer

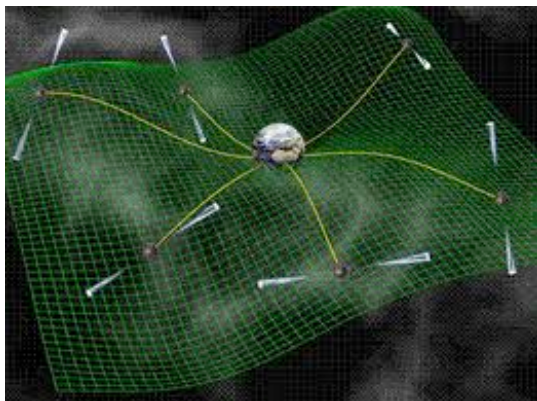
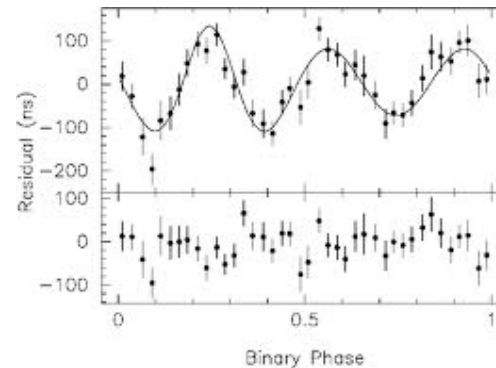
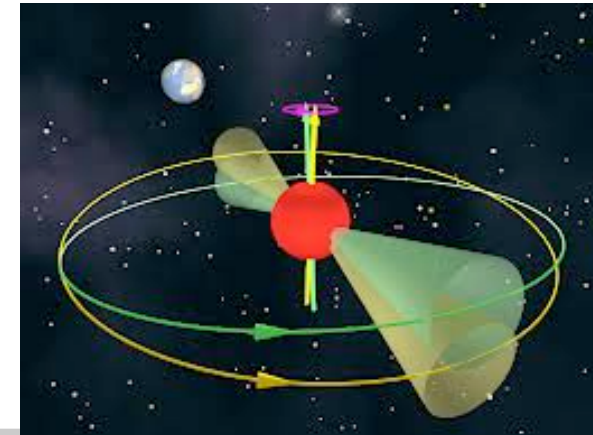


Image: SKA



van Straten et al. 2001



What do we need for Surveys

- Wide field of view
 - Multibeaming
 - Phased array feeds
- Good Sensitivity
 - Lots of collecting area, low T_{sys}
 - Collecting area must be in a compact region
- Frequency range 0.05 GHz to 2 GHz
 - Low: off-plane, all sky, MSPs are bright
 - Mid: on-plane, overcome scattering/ T_{sky}
- Frequencies to > 20 GHz
 - Galactic centre - GBT
- Lots of telescope time
- Lots of cpu time

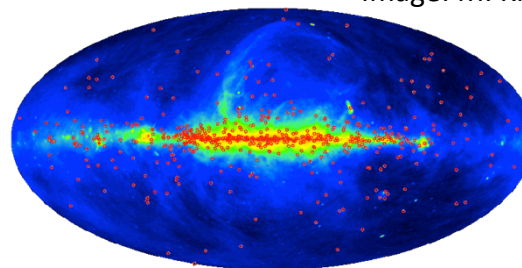
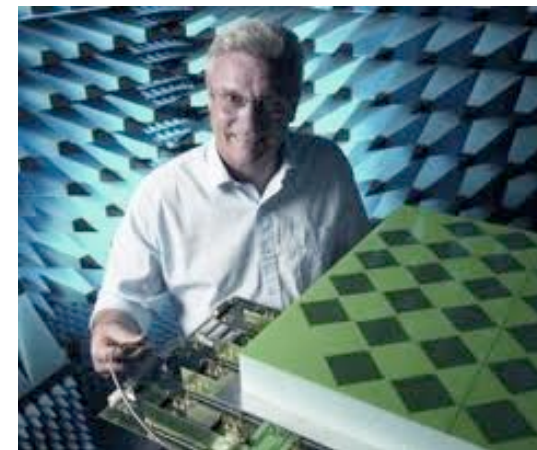


Image: M. Kramer



Images: CSIRO



What do we need for ... Other Stuff

- Sensitivity
 - Multibeaming
 - Phased array feeds
- VLBI scale baselines
 - Parallax / proper motion
- Frequency range large as possible
 - Emission physics
- Lots of telescope time

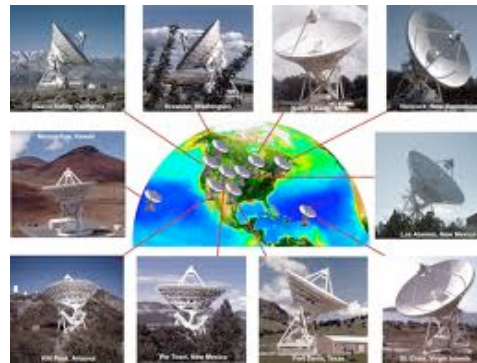
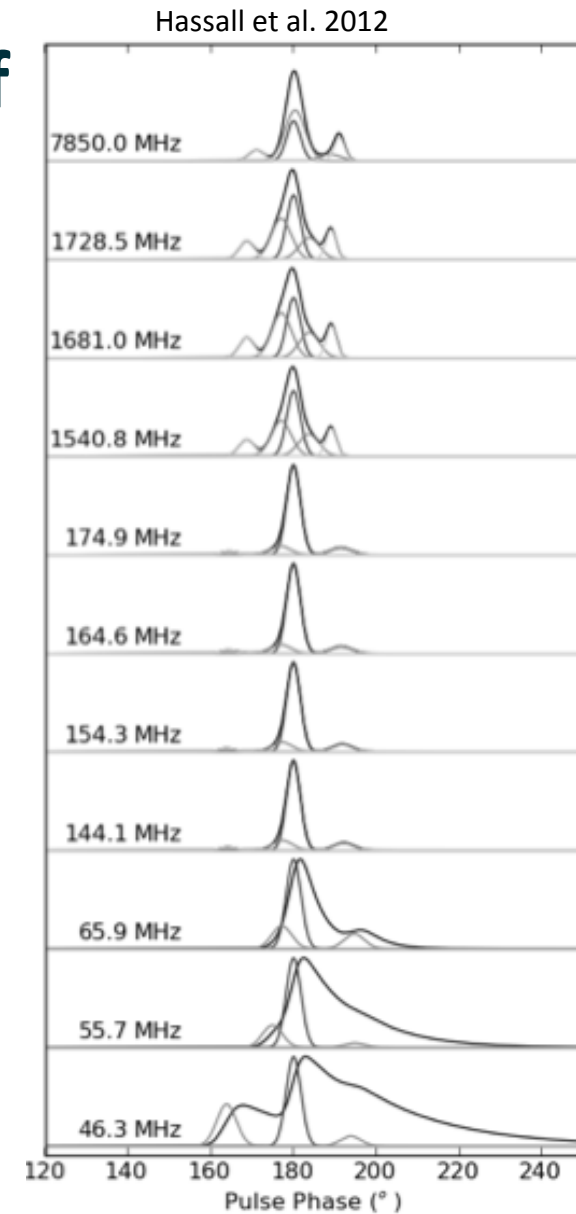


Image: NRAO

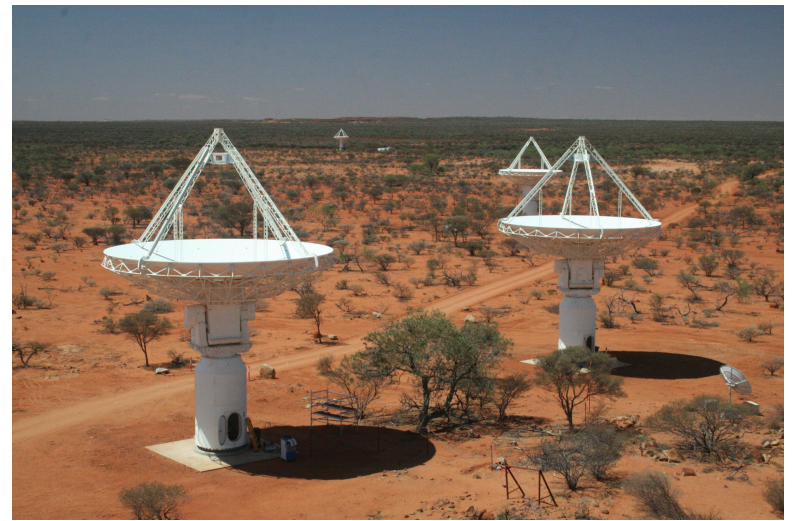


Pre-SKA “Pathfinders”

- ASKAP (2014) and Apertif (2015)
 - In Australia / In Netherlands (HI and continuum surveys)
- MeerKAT (2016)
 - In South Africa (deep imaging)
- LOFAR (2012) and MWA (2013)
 - In the Netherlands – talk by Kondratiev / In Australia (EoR)
- FAST (2016)
 - In China – talk by Di Li
- GBT, Arecibo, Parkes, LEAP, [JVLA] (now)
 - GBT, PKS, AO, Effelsberg: pulsar surveys
 - EPTA, PPTA, Nanograv: high precision timing programs

What is ASKAP

- Located in Western Australia
- 36 x 12m antennas
- 188 element phased array feed
 - 30 square degree field of view
 - 30 tied array beams
- Tsys ~ 55 K
- Frequency range 0.7 – 1.7 GHz, 300 MHz BW
- 30 antennas within 2 km core



Images: CSIRO



- Pulsar timing ok
- Pulsar searching tough
- COAST (PI Stairs)
- Great for transients
 - VAST (PI Murphy/Chatterjee)
 - CRAFT (PI Hall)

What is MeerKAT

- Located in the Karoo in South Africa
- 64 x 13.5 m gregorian offset antennas
 - $\sim 220 \text{ m}^2/\text{K}$
 - 8 km maximum baseline
 - 70 % in $< 1 \text{ km}$ diameter core
- 0.9-1.726 GHz cryogenic single-pixel receiver (L-band)
- Full 826 MHz RF bandwidth digitized and processed
- Phase 2: 580-1000 MHz
- Phase 3: 8-14.5 GHz



Image: Jonas



- Pulsar timing excellent
 - Best in the south
 - Frequency coverage?
- Timing: PI Bailes
- Pulsar survey tough
- Trappum: PI Stappers

What is LOFAR

- Located in NL and other EU
- Low frequencies
- Multi-beaming
- Up and running !

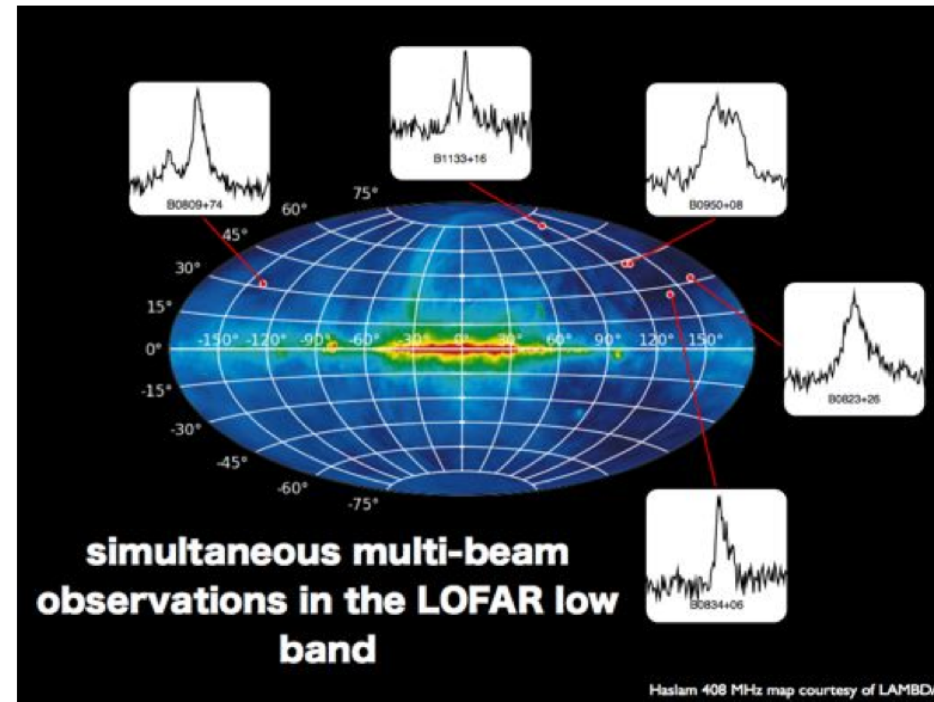
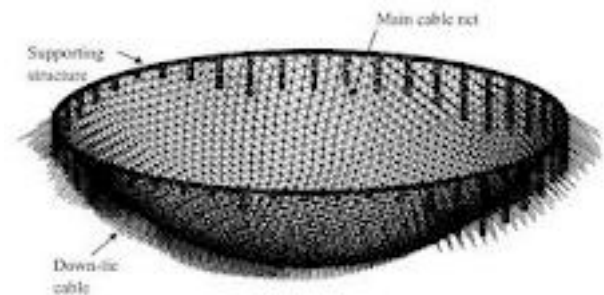


Image: Hassall, Hessels, Stappers

- Great for surveys
 - locally
- Great for pulsar physics
- Great for ISM physics
- Great for transients

What is FAST

- Located in China
- Single 500m aperture
- Built 2016



- Great for surveys
 - Needs multibeam/PAF
- Great for timing
- Limited sky coverage

Frustrating times ...



- We all recognise the fantastic science that will be done with SKA Phase I and the full SKA
- But pathfinders and the SKA are running on delayed timescales compared to e.g 2007 predictions
- And current (single dish) pulsar facilities face uncertain futures even in the short term
- LOFAR will be exciting over the next 5 years
- Let's gaze into the future ...



The Times: 1 July 2017

**Breaking
Astro
News**



The Times: 1 July 2017

Cherry Ng finds Black Hole pulsar in HTRU.
“Searching 4 billion candidates
worthwhile” she claims.



The Times: 1 July 2017

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Norbert Wex is “mildly excited”.
Sharpens pencil for further
gravity theories

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Cherry Ng finds Black Hole pulsar in HTRU.
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Scott Ransom says “man, this is
freaking awesome”



The Times: 1 July 2017

LOFAR find its 1000th pulsar!



The Times: 1 July 2017

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Joeri gets Hollywood role!

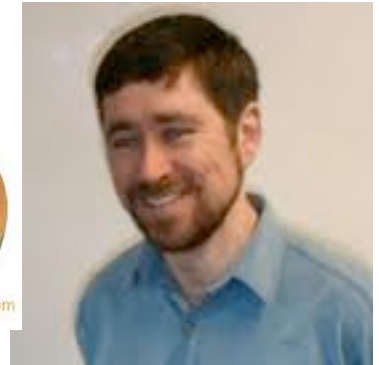
The Times: 1 July 2017

LOFAR find its 1000th pulsar!



Joeri gets Hollywood role!

Matthew Bailes loses bet: Forced to eat Dutch cheese



The Times: 1 July 2017

George Hobbs publishes another upper limit on GW strain. Makes himself another cup of tea.

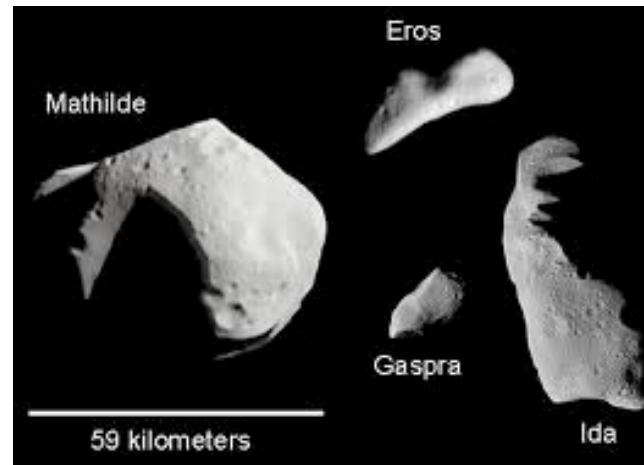


The Times: 1 July 2017

George Hobbs publishes another upper limit on GW strain. Makes himself another cup of tea.



Aris Karastergiou still to unravel the pulsar emission problem even with simultaneous observations from 10 MHz to 100 GHz



The Times: 1 July 2017

George Hobbs publishes another upper limit on GW strain. Makes himself another cup of tea.



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Jim Cordes promises NE2017 “any day now”.

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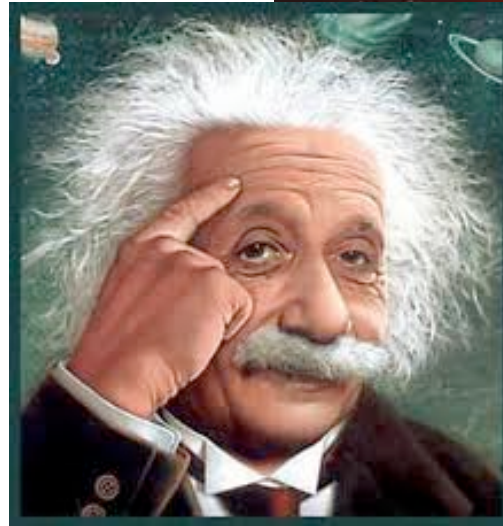
Anatoly Spitkovsky says “Theorists need more funding”.



Jim Cordes promises NE2017 “any day now”.

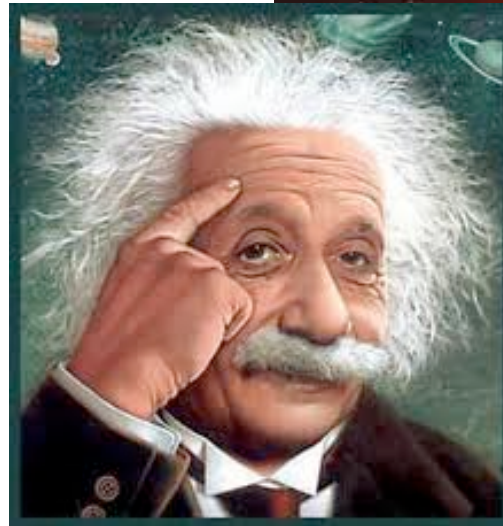
The Times: 1 July 2017

Einstein fails double pulsar test in the 6th decimal place!



The Times: 1 July 2017

Einstein fails double pulsar test in the 6th decimal place!

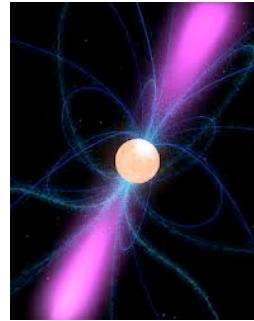


“Mein Gott”

A new era of
Stairs-Kramer Gravity emerges

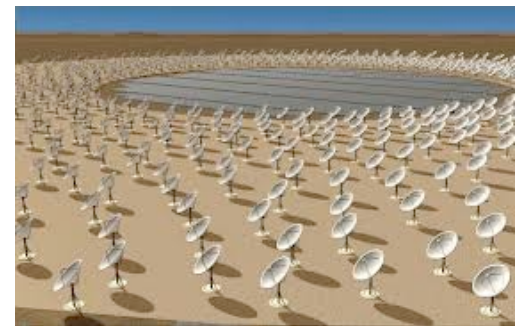
The Times: 1 July 2017

ASKAP, MeerKAT and FAST
operational: Pulsar timing and
surveys underway.



What will we be doing in 2017?

- Large surveys complete
 - HTRU N-S, PALFA, GBT
- LOFAR census of the local Galaxy ~1000 pulsars
- PAFs and WBFs on large single dishes (PKS, GBT, Eff)
- MeerKAT starts timing southern MSPs
- FAST starts timing northern MSPs
- Ensuring SKA does not design out pulsar timing/surveys
- Agitating to keep large single dishes alive



Thank you

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