International Centre for Radio Astronomy Research

Low frequency VLBI on Pulsars

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THE GOVERNMENT OF WESTERN AUSTRALIA

THE UNIVERSITY OF WESTERN AUSTRALIA

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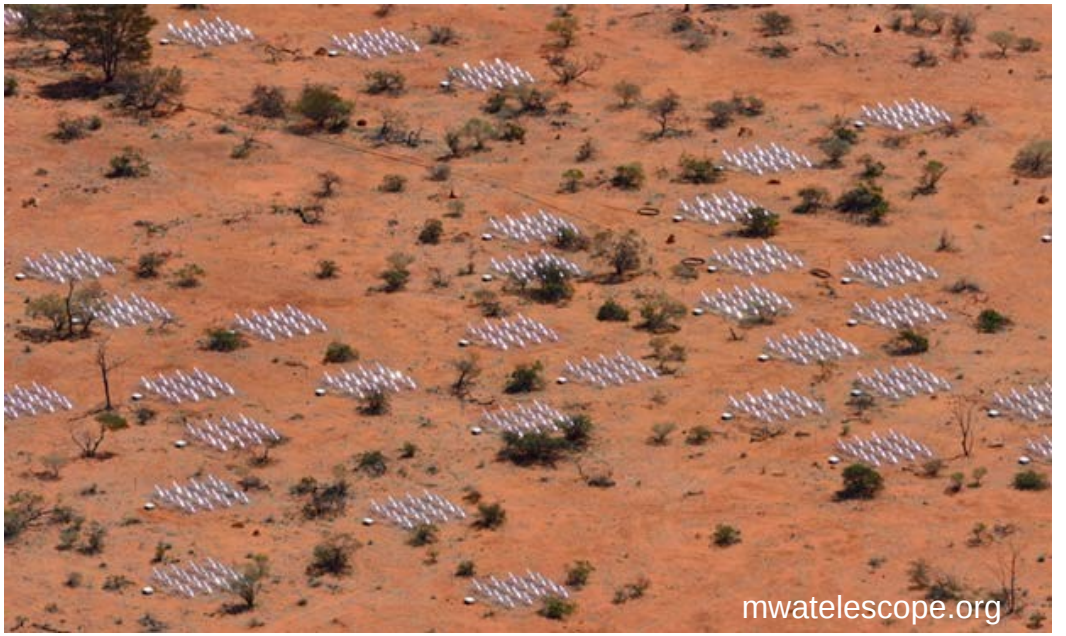
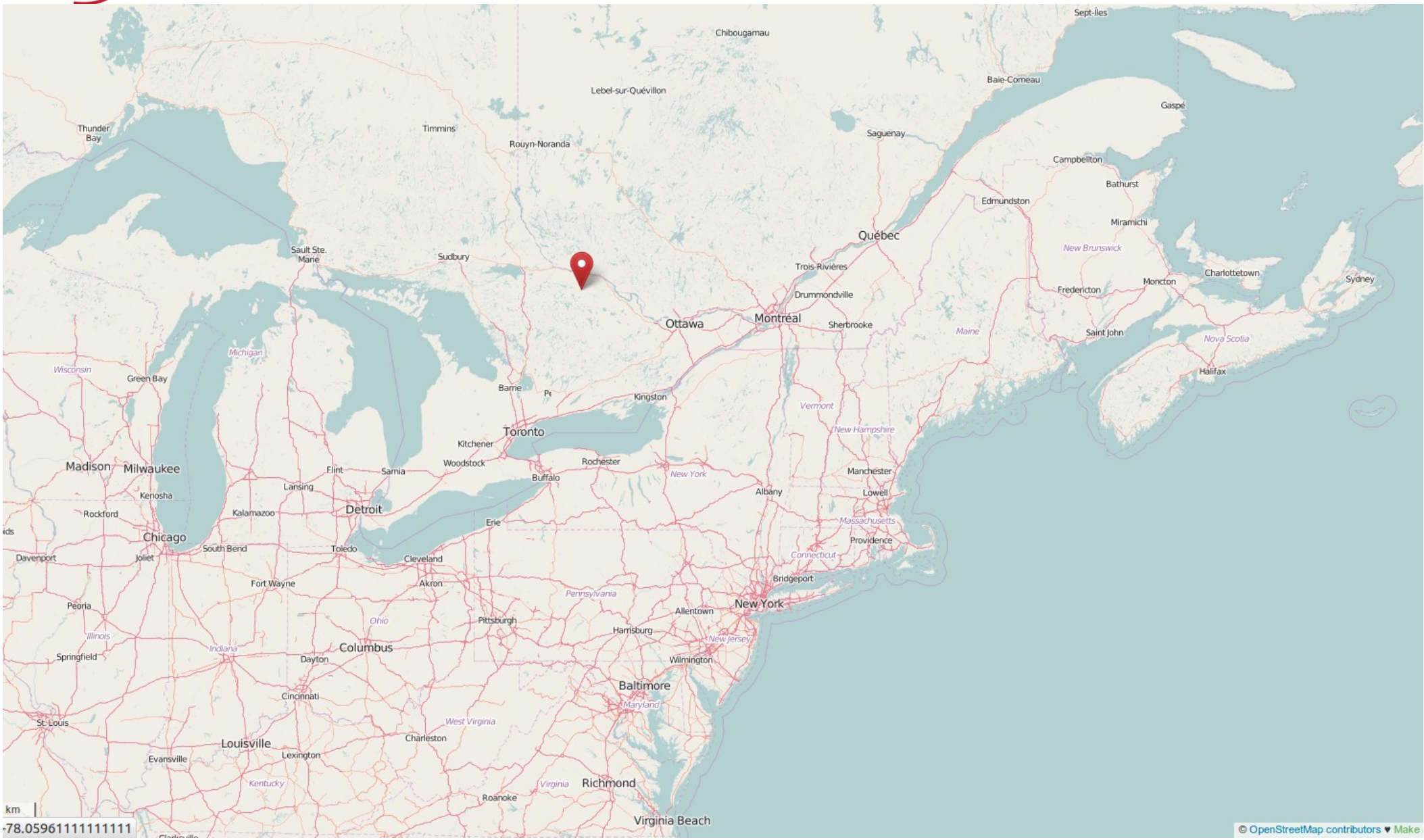
The Aim: Find Fringes!

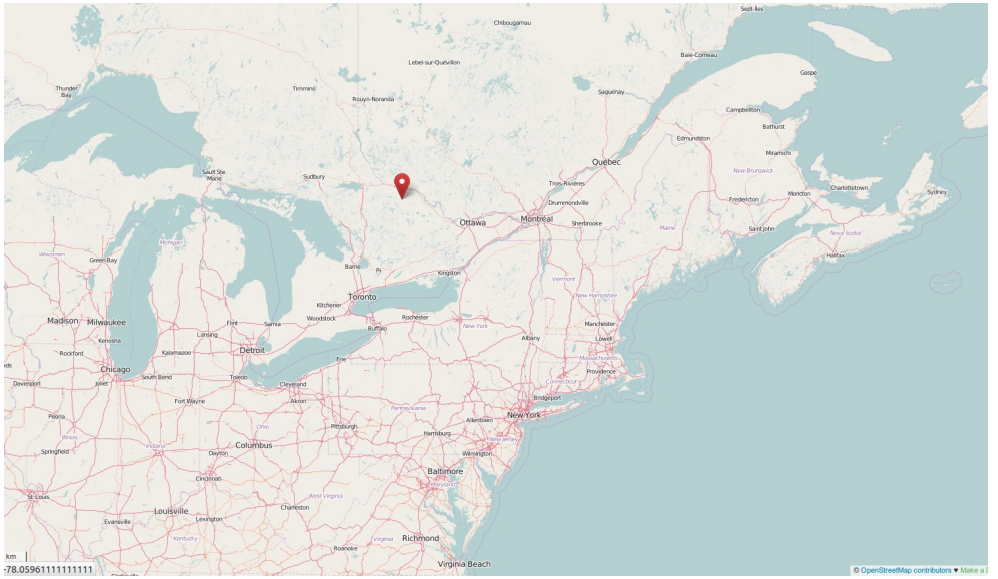


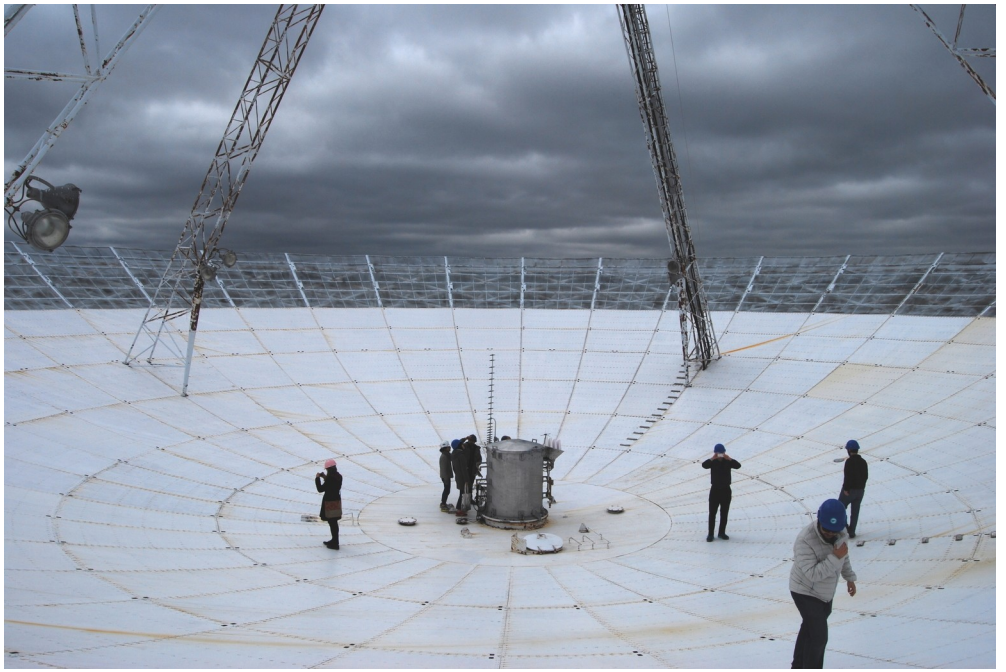
The Algoquin Radio Observatory



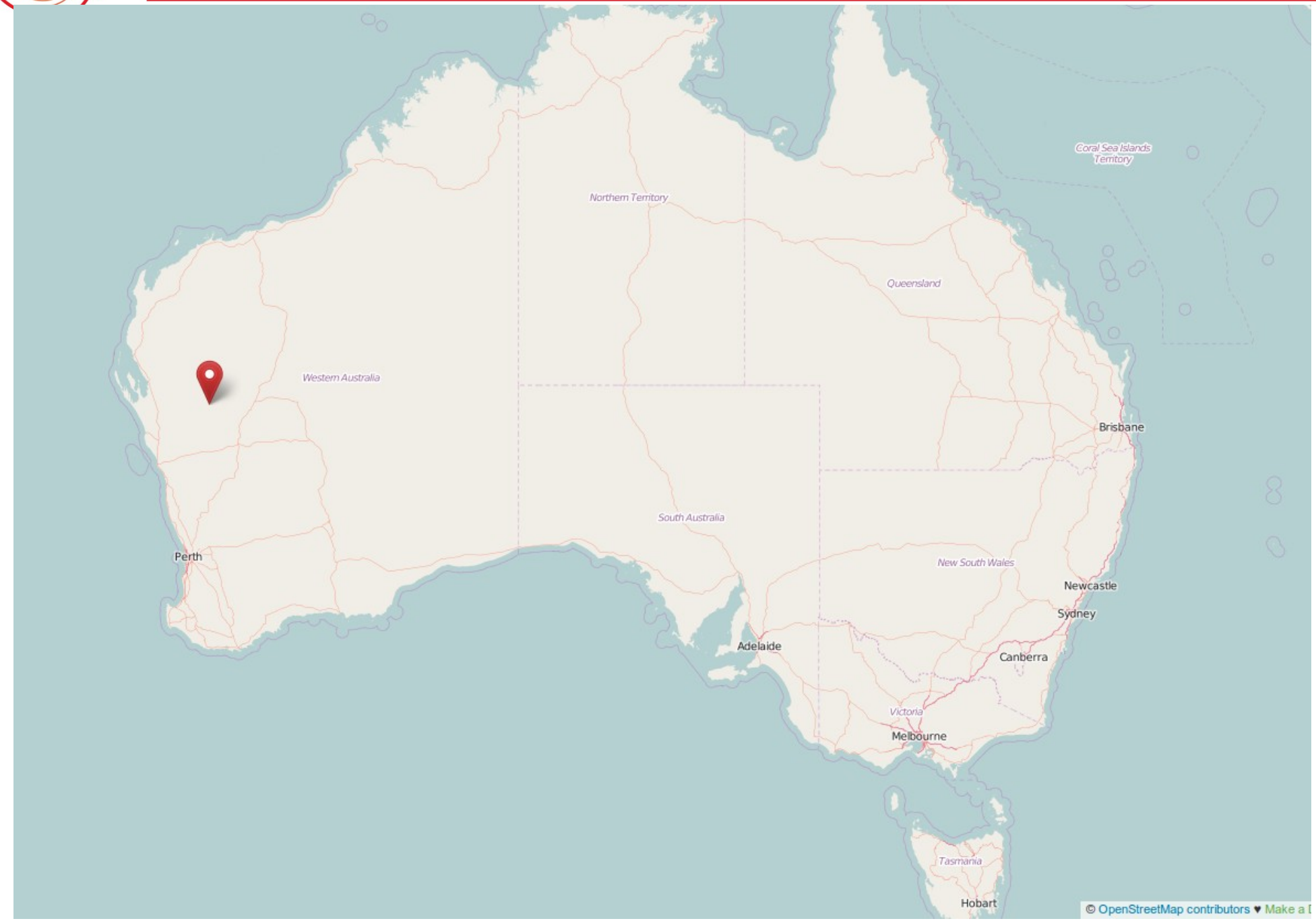
The Algoquin Radio Observatory

- Built in 1965, designed by Freeman Fox – also designed Parkes
- Geodetic dish until ???
- restoration as of 2008
- 46m diameter
- S-, X- L-band
- CHIME receiver mounted
- 400 – 800 MHz, 1024 channels
- Output is (non-standard) VDIF: 128 threads, 8 channels, 2 stations (one each pol), 4+4 bit complex
- Thread ID encodes freq
- Time not synchronised to GPS/atomic clock
- Observed the Crab at 600 MHz with GMRT and ARO





The MWA


Coral Sea Islands Territory
Northern Territory
Queensland
Western Australia
Brisbane
South Australia
Perth
New South Wales
Newcastle
Sydney
Adelaide
Canberra
Victoria
Melbourne
Tasmania
Hobart
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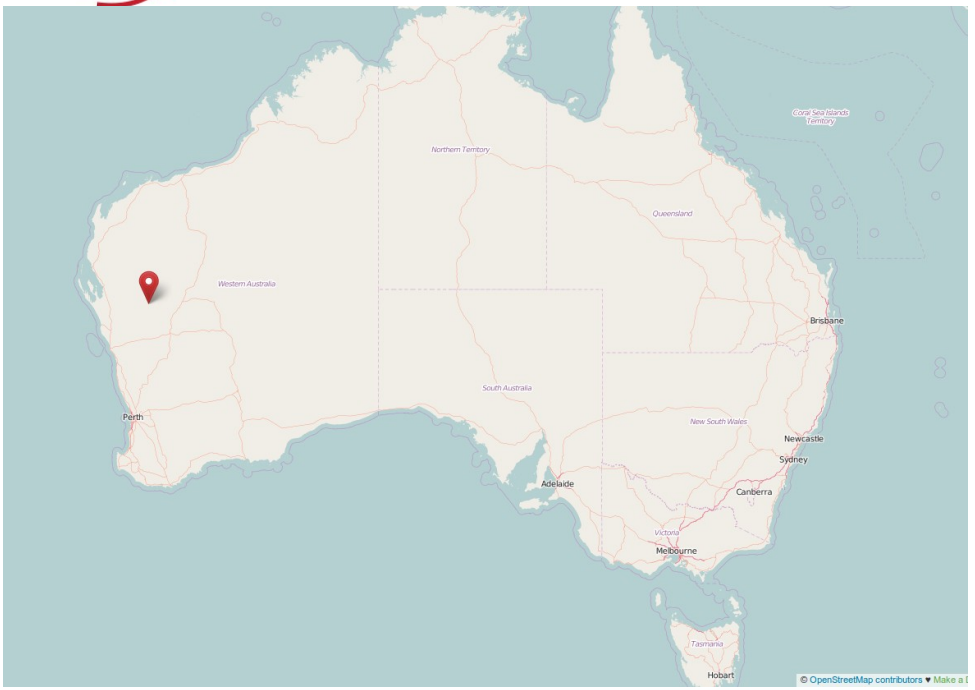
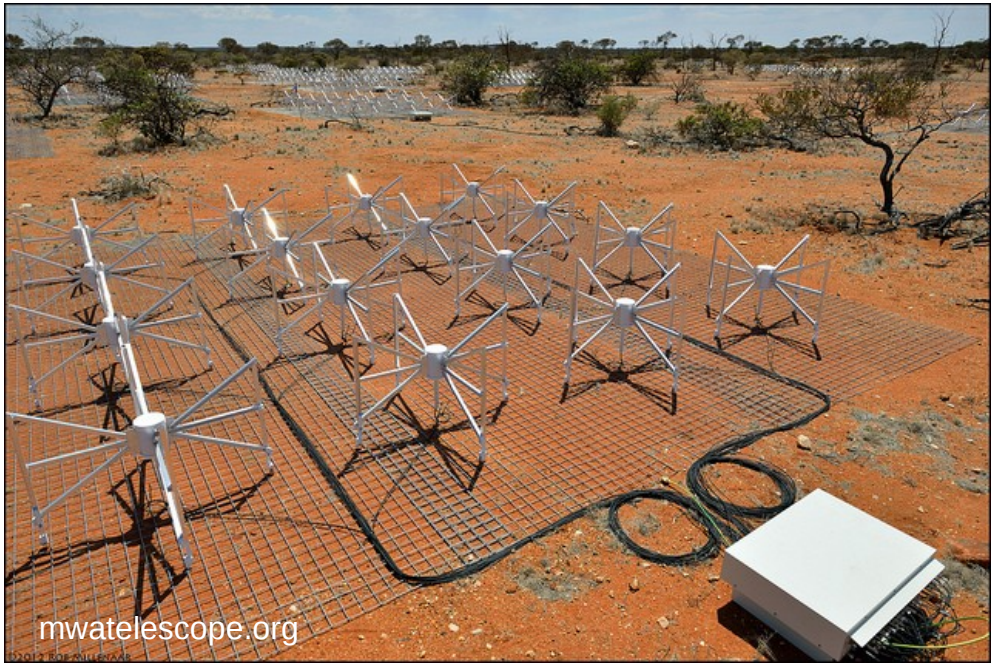
The MWA





- SKA precursor
- ~ 80 – 300 MHz
- 128 tiles, 4x4 dipoles
- max 3km baseline
- 24 x 1.28 MHz = 30.72 MHz BW
- 10 kHz, 100 us resolution (raw voltages, VCS)
- regular pulsar observations → incoherent sum
- recently added beamformer, aka tied array
- Output: 24 x 1.28 MHz psrfits or VDIF
- VDIF: 2+2 bit complex, also 8+8 bit complex

Joint observations with the GMRT – the Crab

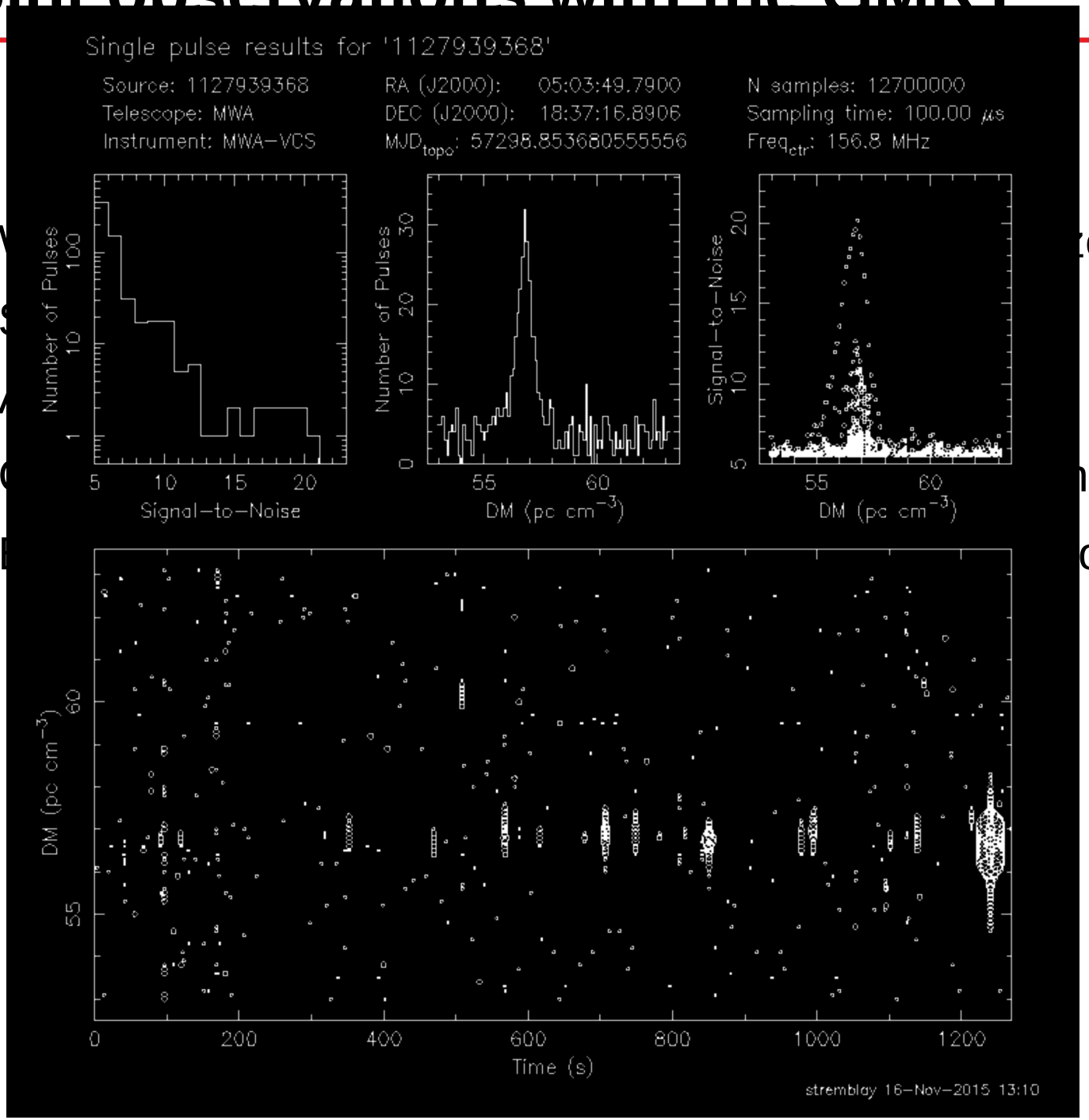
- GMRT: 33.33 MHz BW, 256 channels (136.67 – 170 MHz)
- MWA: 30.72 MHz BW, 24 channels (141.44 – 172.16 MHz)

- GMRT data format in phased array mode:
  - 5 files:
    - timestamps, 4 per second – tied to GPS before obs
    - 2 x left pol, each 1/8 of a second
    - 2 x right pol, same
- Times notorosly inaccurate, drifts (~1s a day apparently)
- XYZ coordinates of phase centre not exactly known

Joint observations with the GMRT – the Crab

- Want to make use of Crab giant pulses to synchronize clocks
- Scatter broadening ~15ms at 160 MHz
- Already found giant pulses at MWA
- Challenge to get data from GMRT – network slow, unstable
- Beamformer worked on 0437 – trouble getting it to work now

Joint observations with the GMRT – the Crab



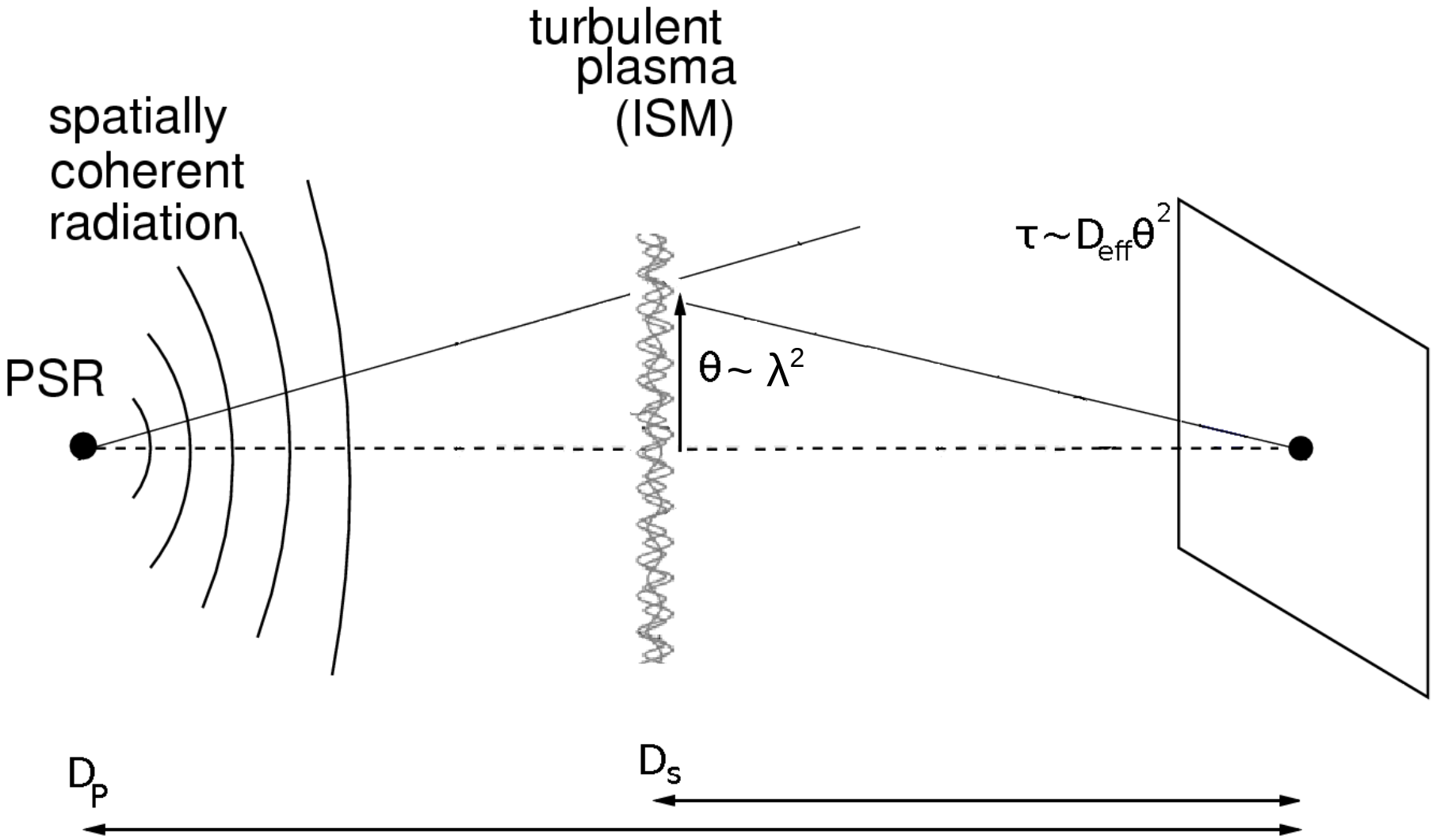
- V… …ze clocks
- S…
- A…
- C… …nstable
- P… …ork now

DiFX/SFXC install on GPC at Scinet

- General Purpose Cluster
- Linux Centos 6.4
- 3864 nodes (30,912 cores), 16/32/64/128 GB RAM
- QDR/DDR infiniband
- Have SFXC and DiFX running
- SFXC only gnu compiles, DiFX both intel and gnu compiles
- Moab scheduler
- Regularly correlate with ~800 cores

wiki.scinet.utoronto.ca

Apart from 'just finding fringes': Scintillometry



Adopted from Lorimer & Kramer 2005

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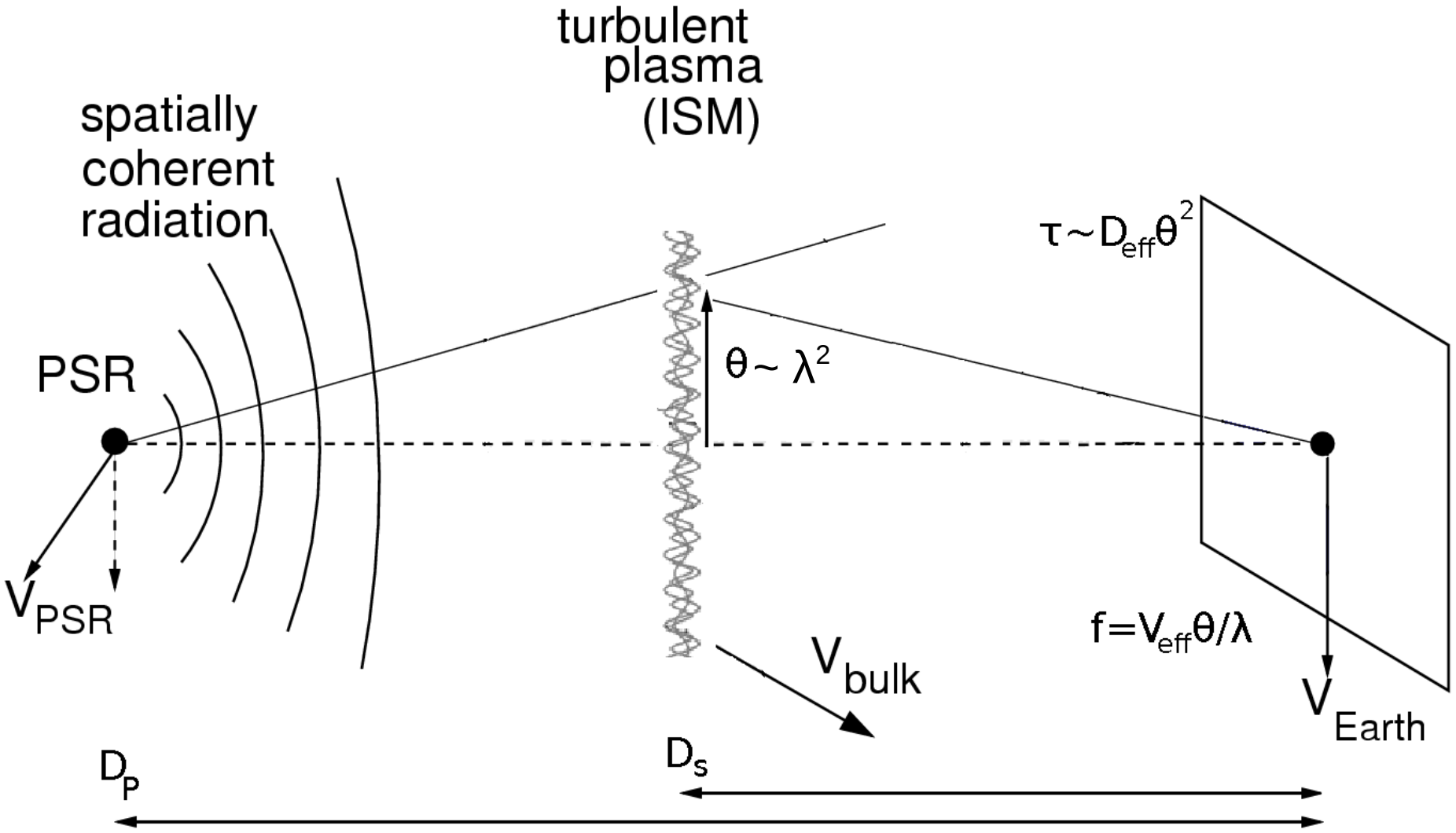

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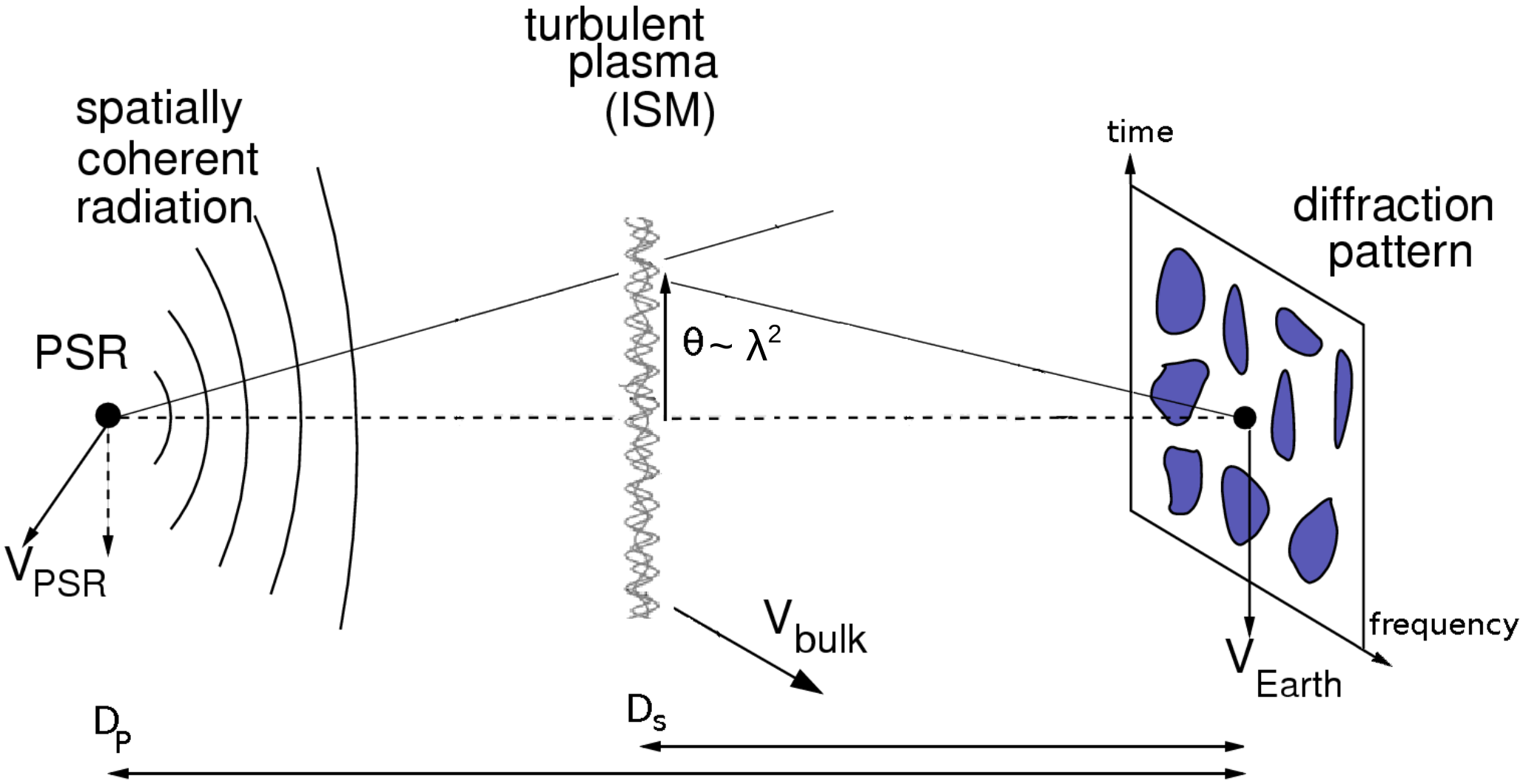

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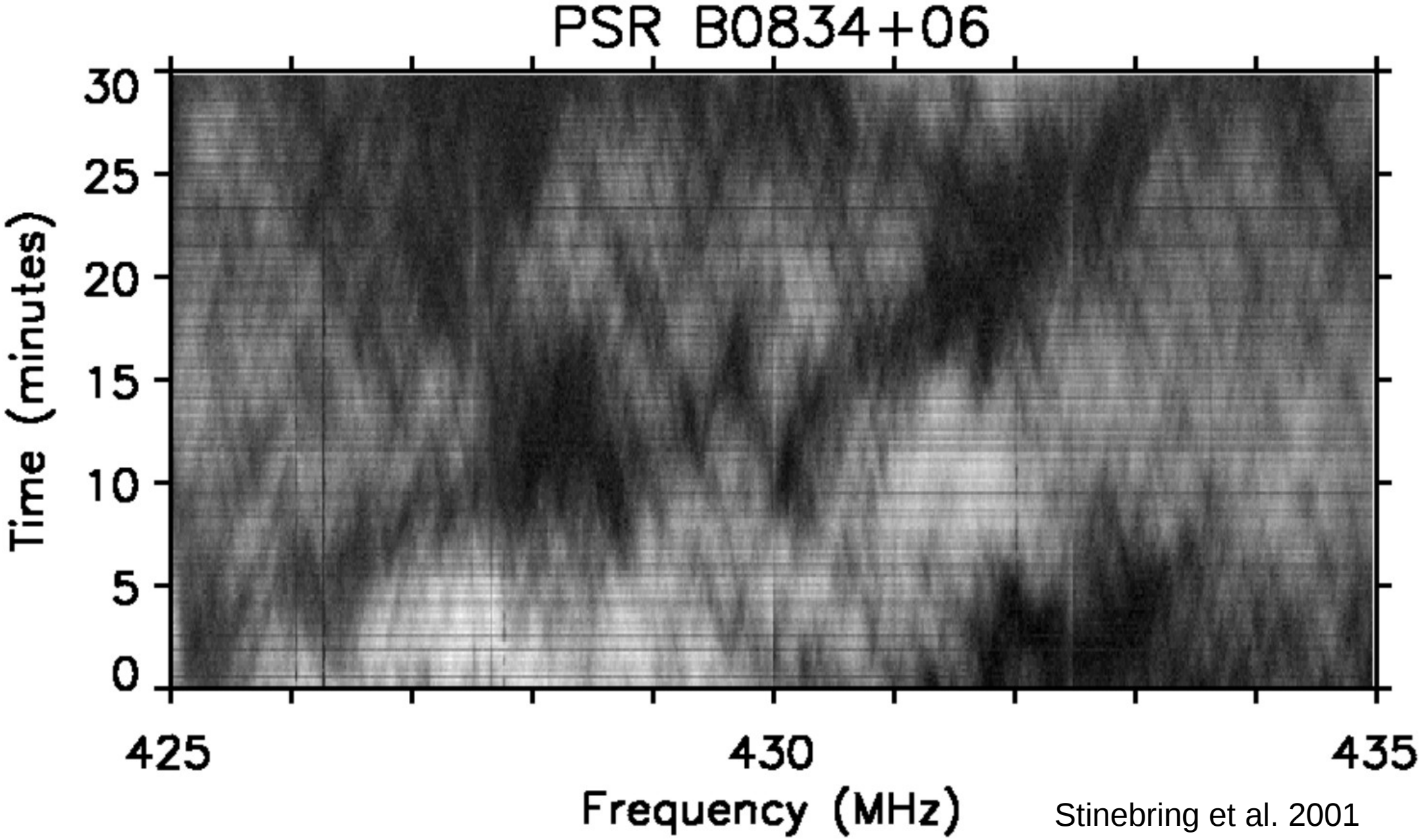

Stinebring et al. 2001

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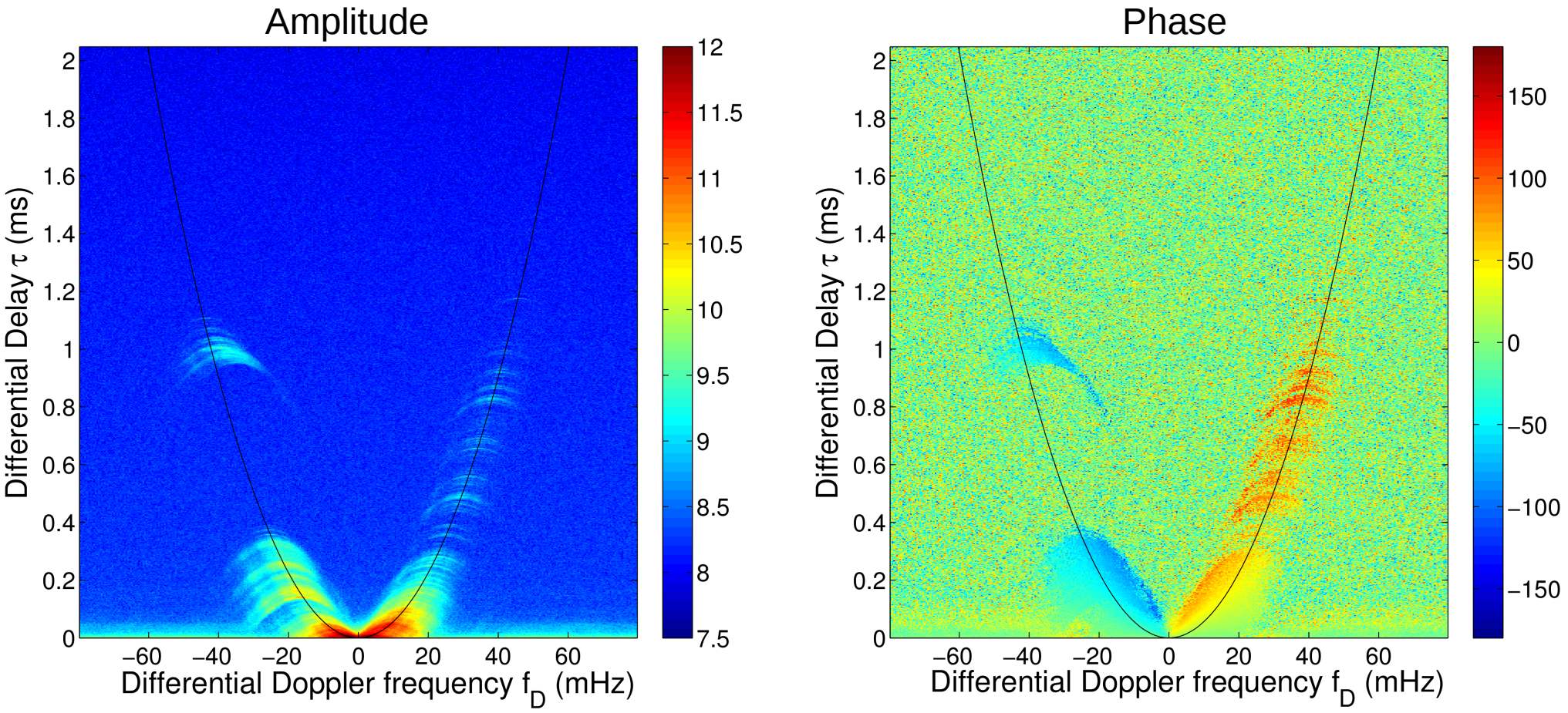

Brisken et al. 2010

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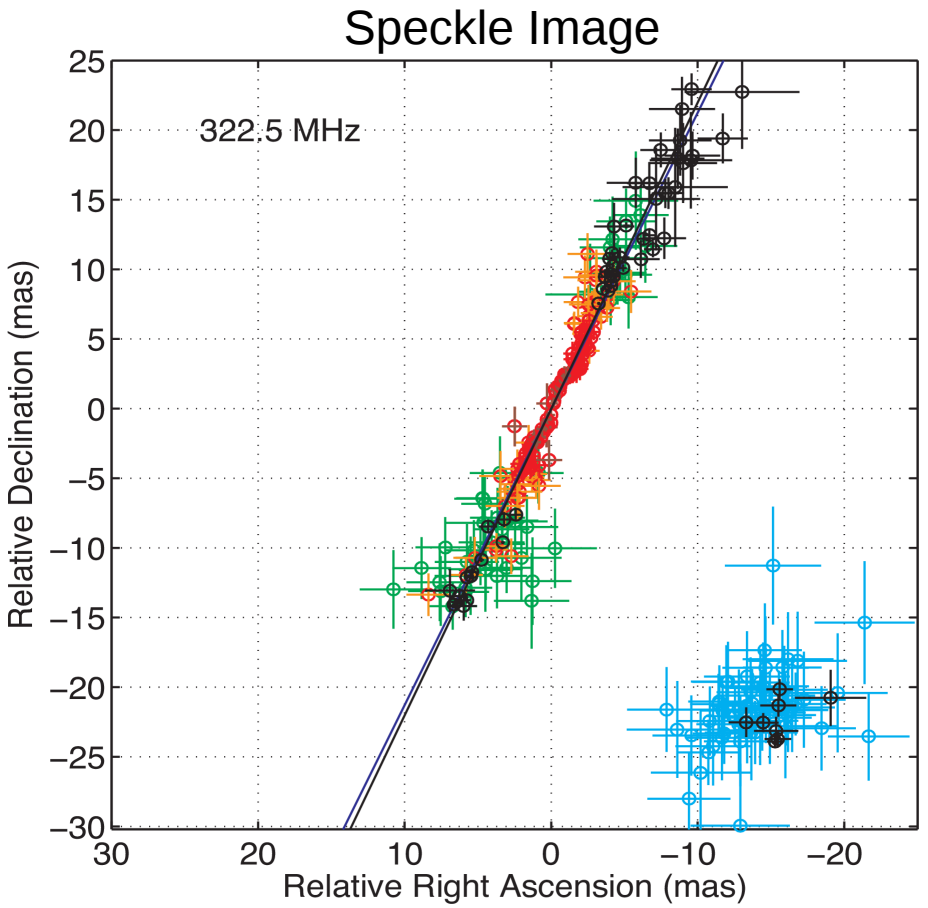
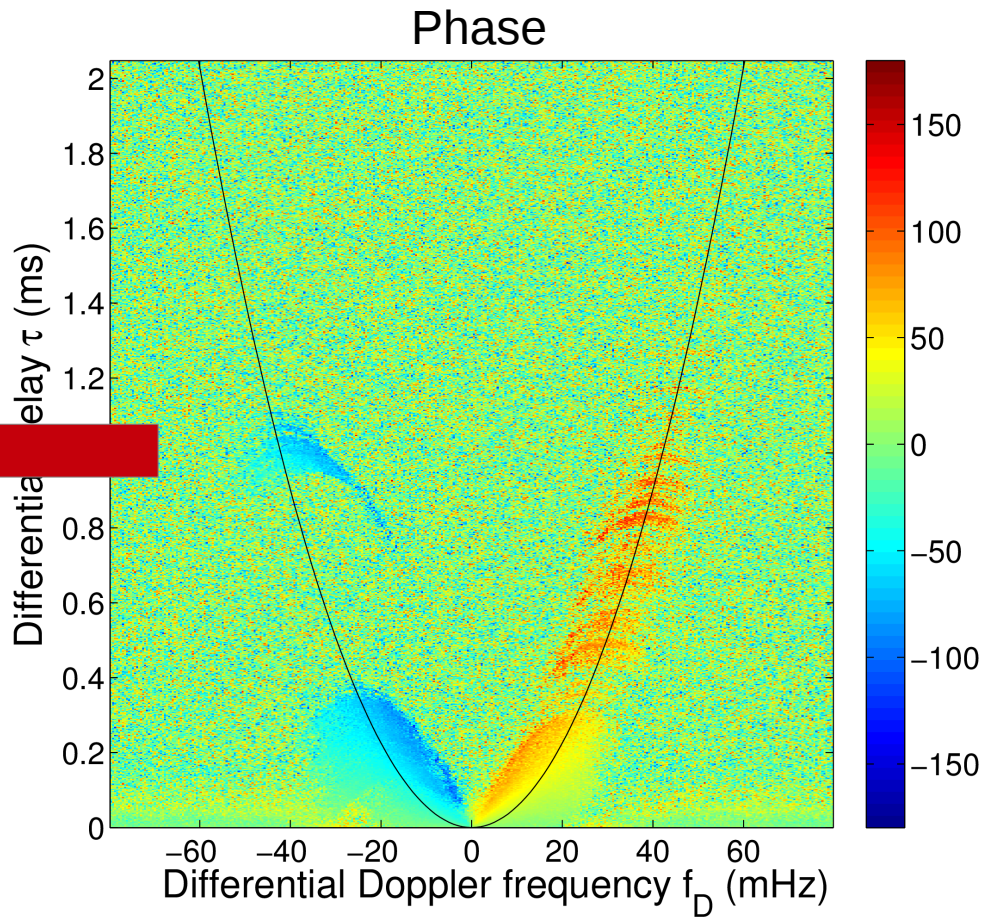
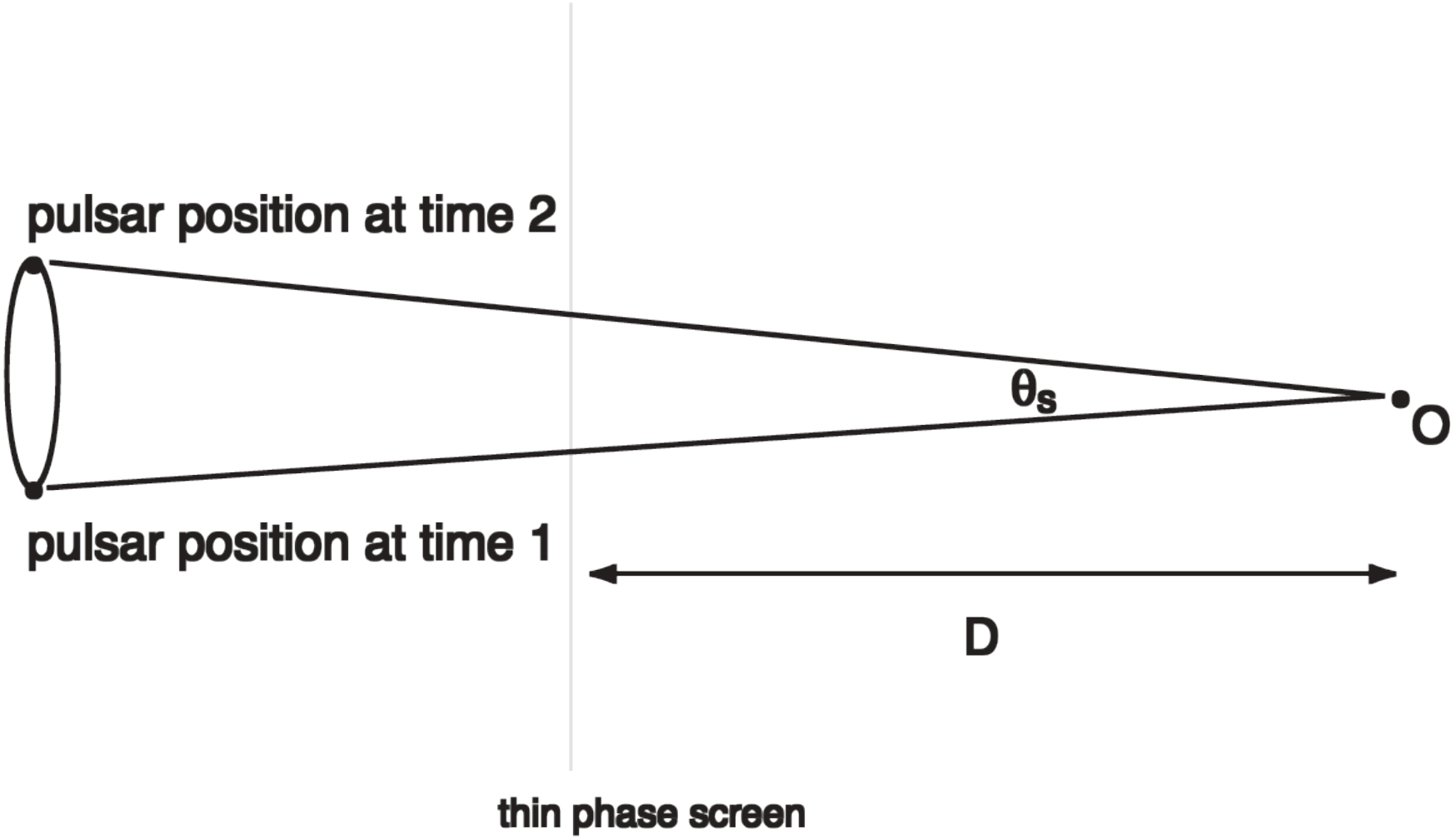




$$\tau = D_{\mathrm{eff}}\theta^2/2c$$

Brisken et al. 2010

Applications – Pulsar positions



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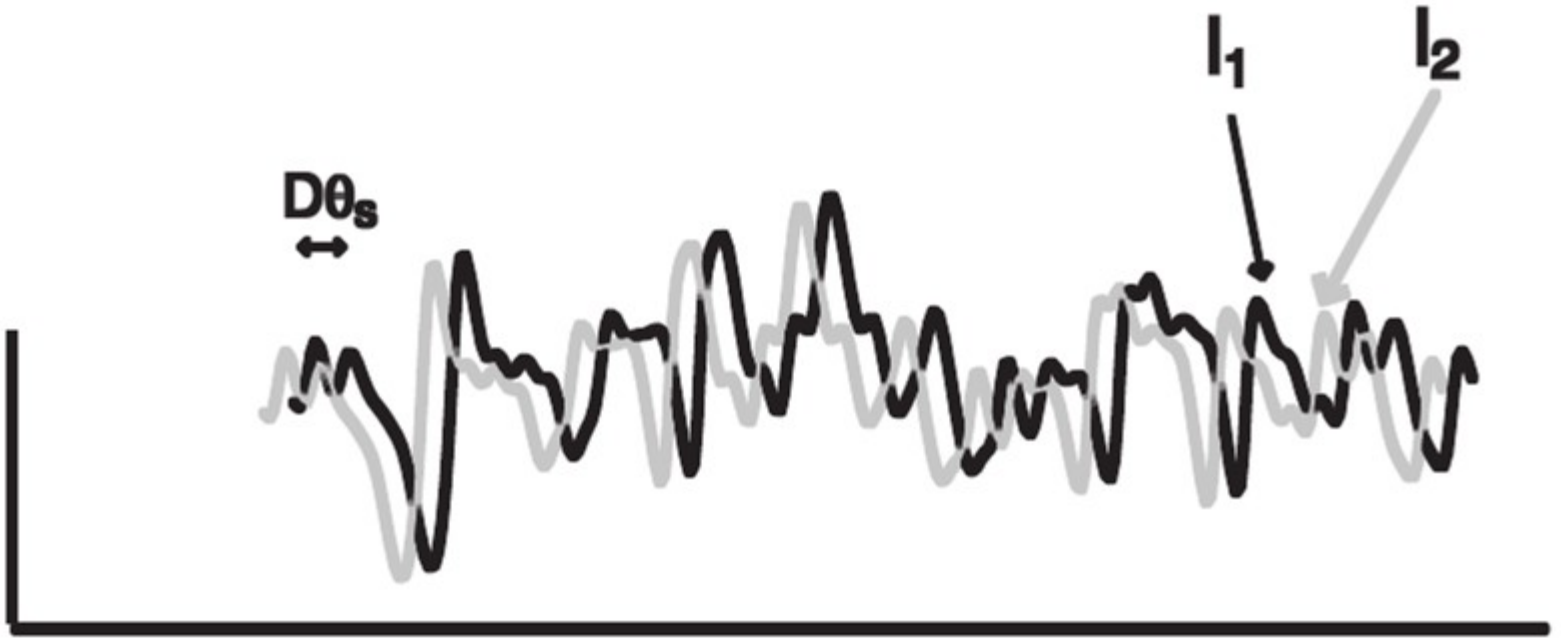
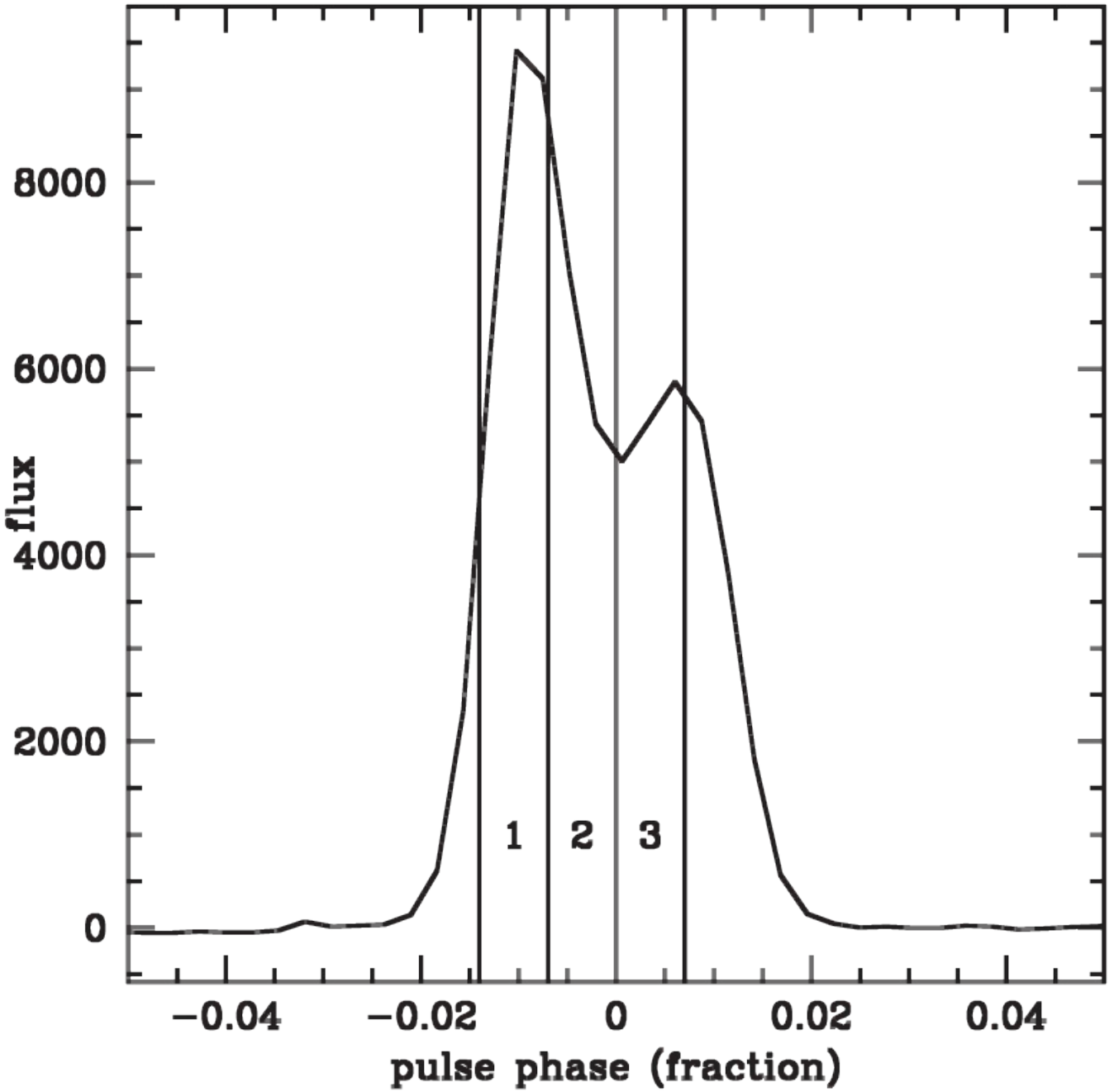


Applications – Pulsar emission region



Pen et al. 2010

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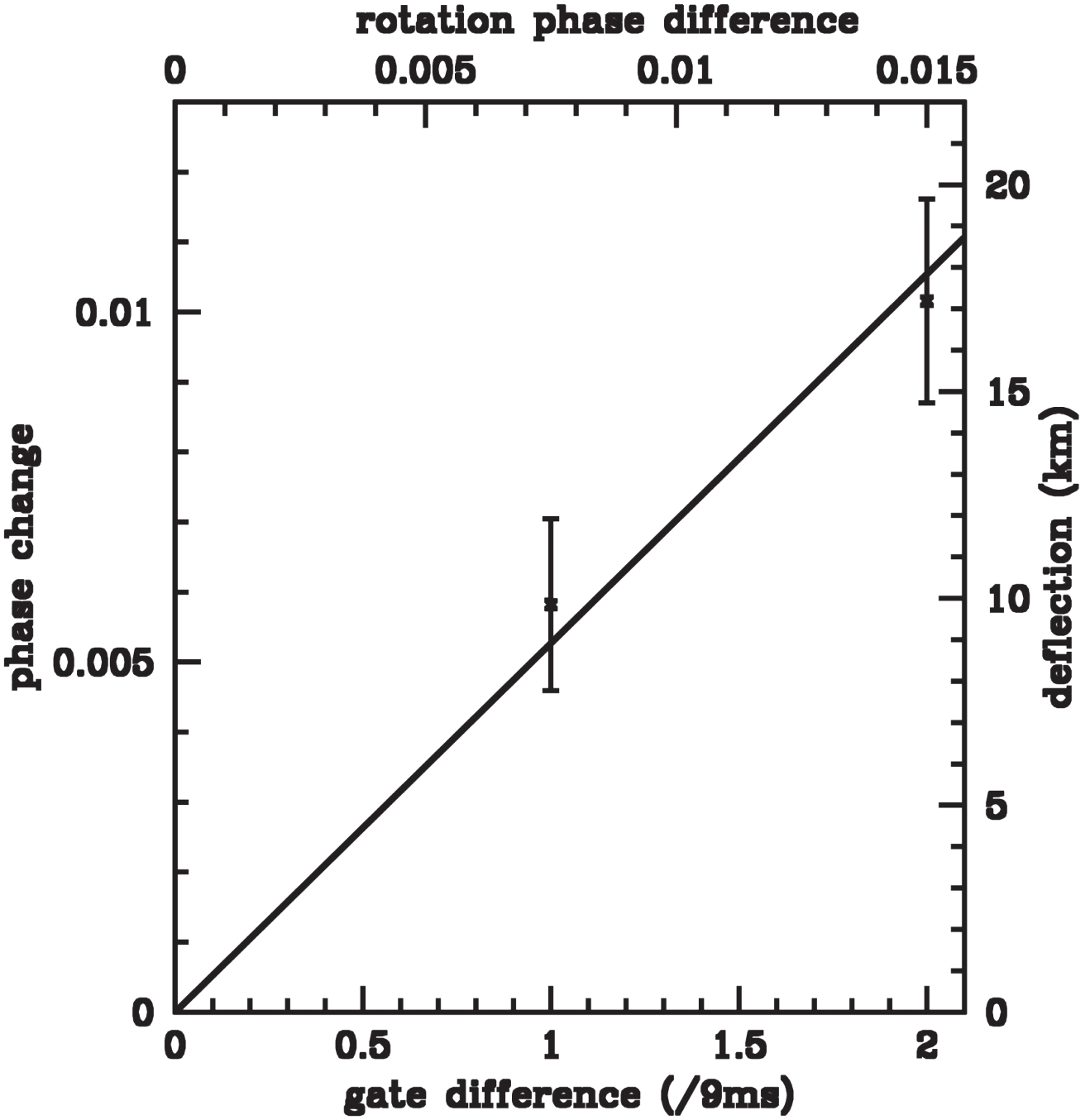


Pen et al. 2014

Current projects

http://chandra.harvard.edu

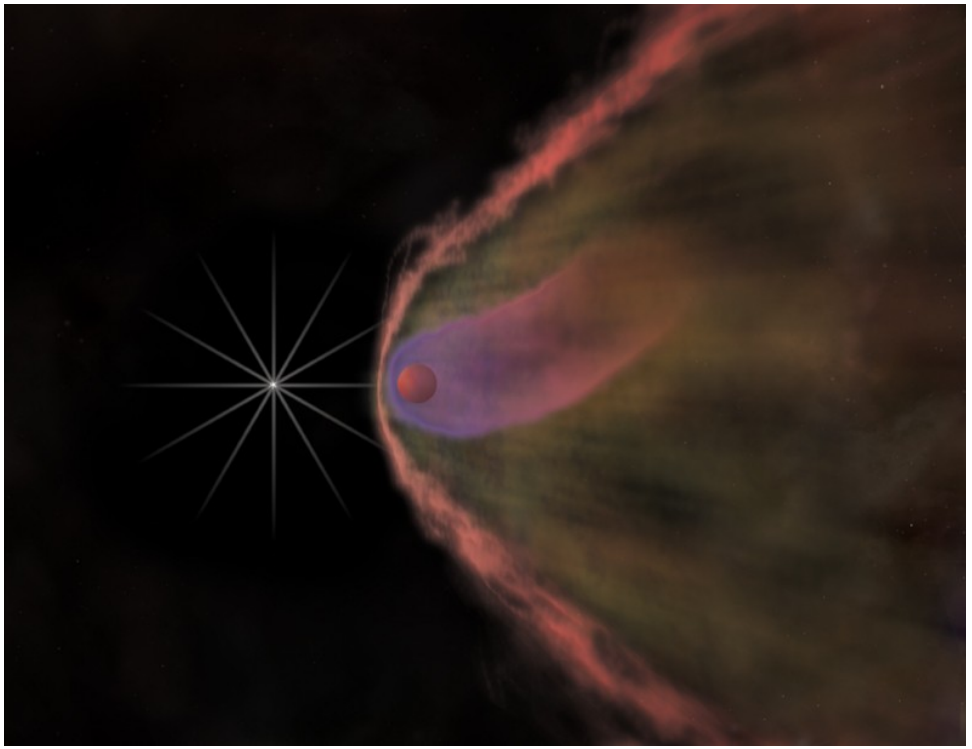
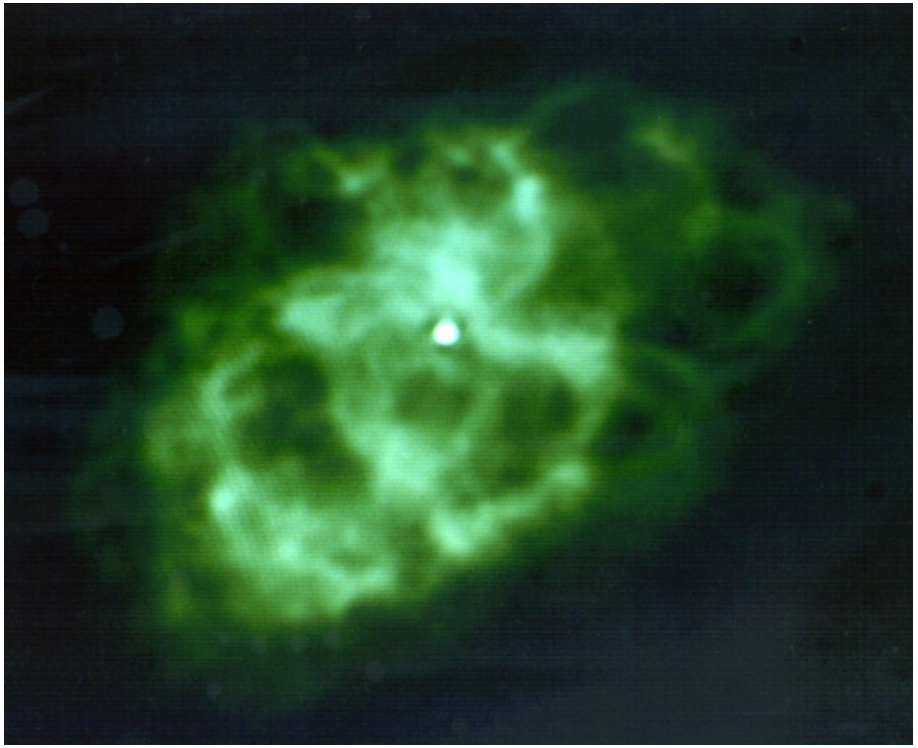


Image courtesy of NRAO/AUI



- B1957+20, aka 'Black Widow Pulsar
- Measure size of projected orbit and get inclination
- Measure mass of the pulsar (could be as high as 2.4 M_sol (van Kerkwijk 2011)

- B0531+21, aka 'The Crab'
- Measure deflection between components
- Measure deflection between normal and 'Giant' pulses
- Determine emission height