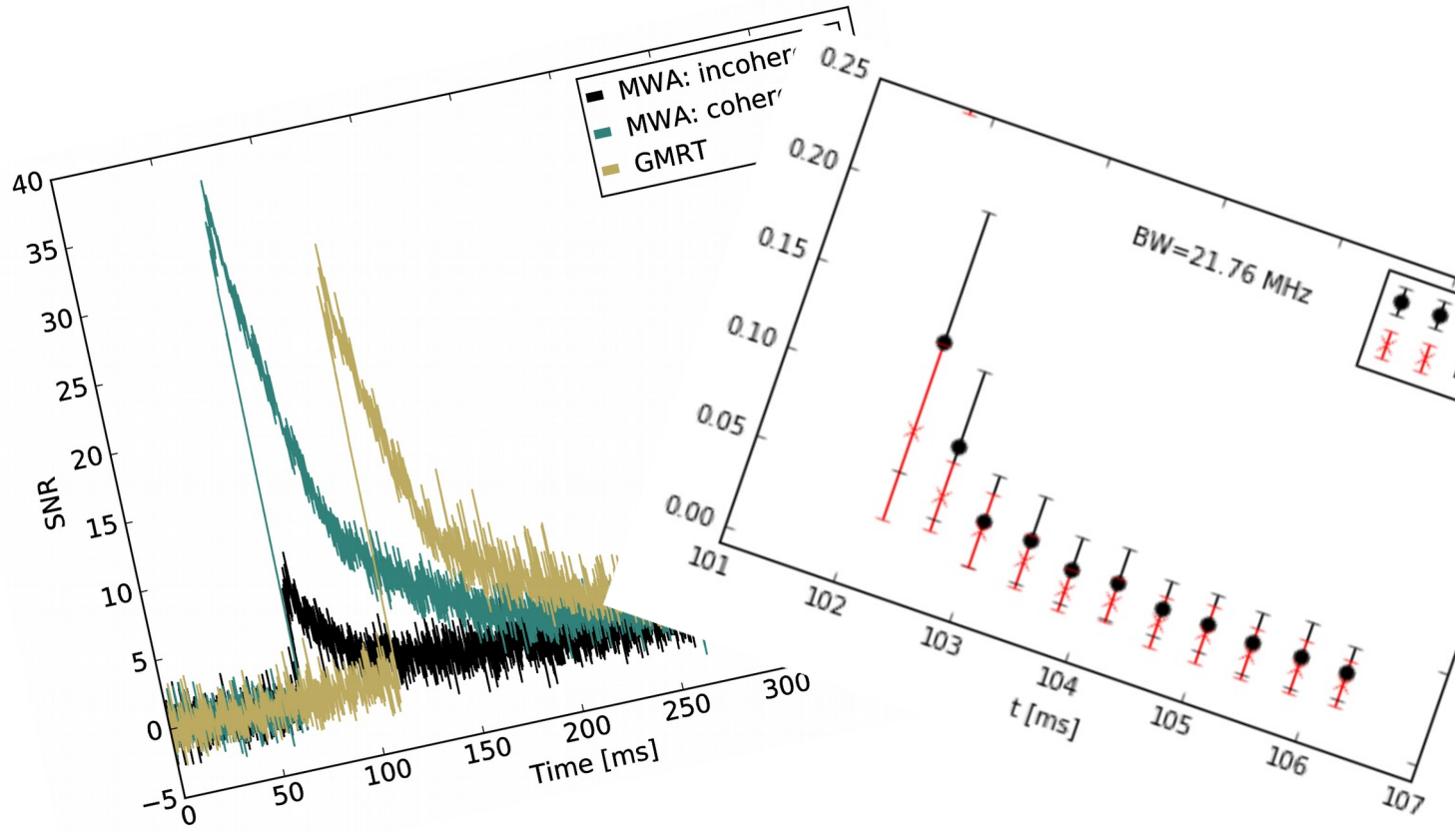


International Centre for Radio Astronomy Research

Low frequency VLBI: Fringes between the MWA and the GMRT

Franz Kirsten

Curtin University

The University of Western Australia

The broad impact of Low Frequency Observing, Bologna, 20 June 2017

A few words about me and my collaborators

- I work(ed) in Perth, Australia
- At ICRAR – Curtin
- Working on pulsar observations with the MWA
- And on pulsar scintillometry with VLBI

Tremblay

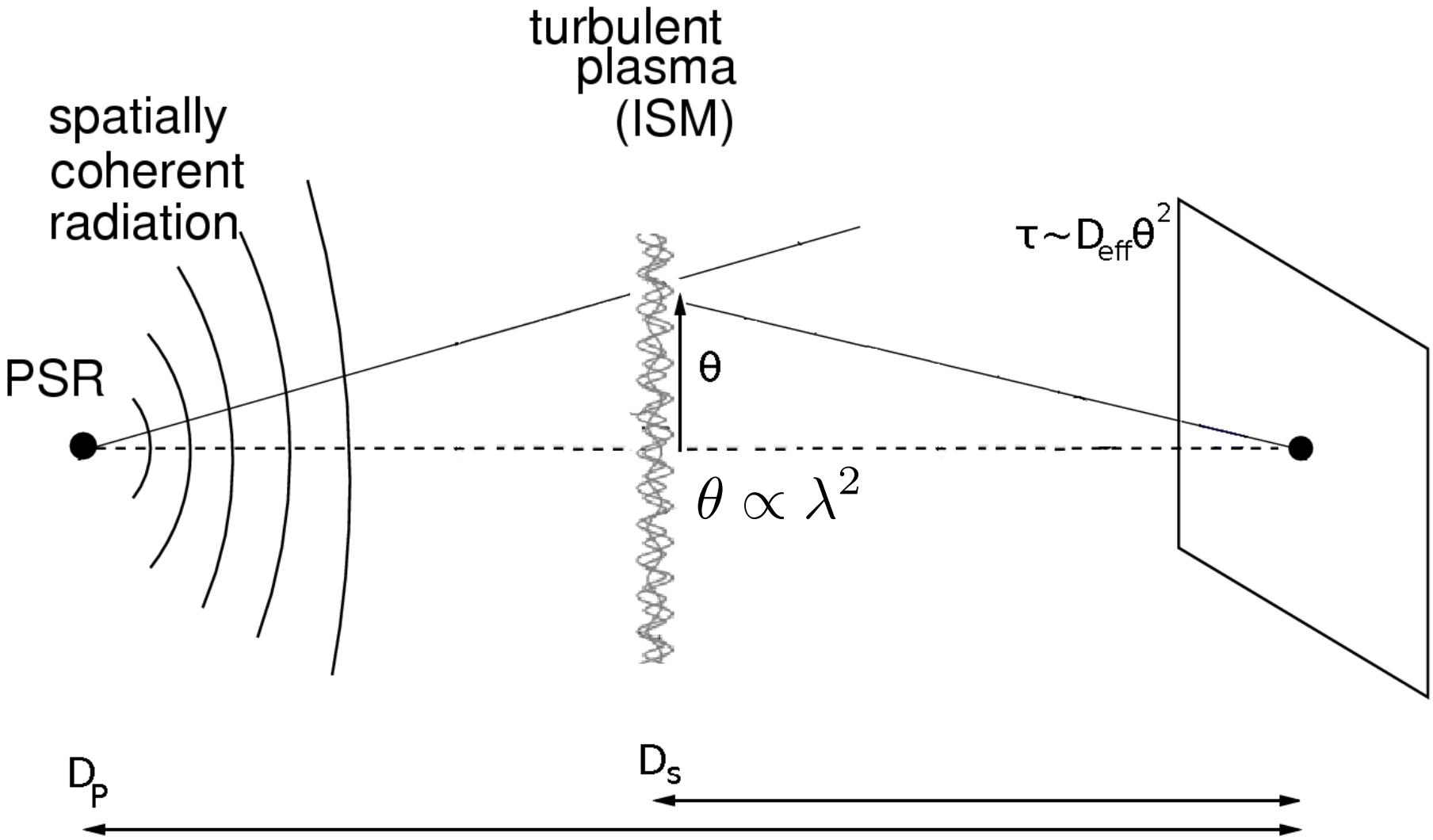
Bhat

Macquart

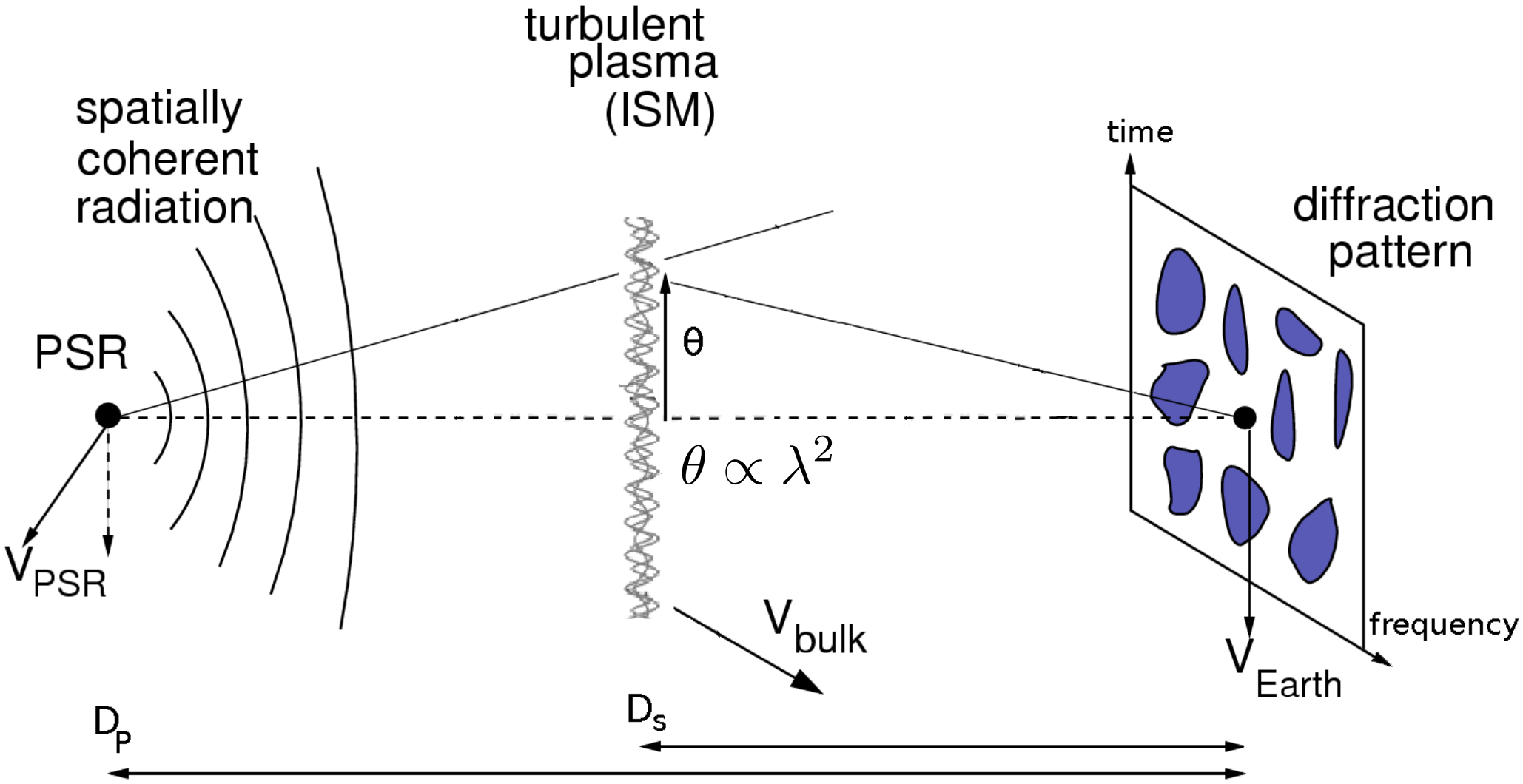
Pen

van Kerkwijk

Scintillation – in a nutshell

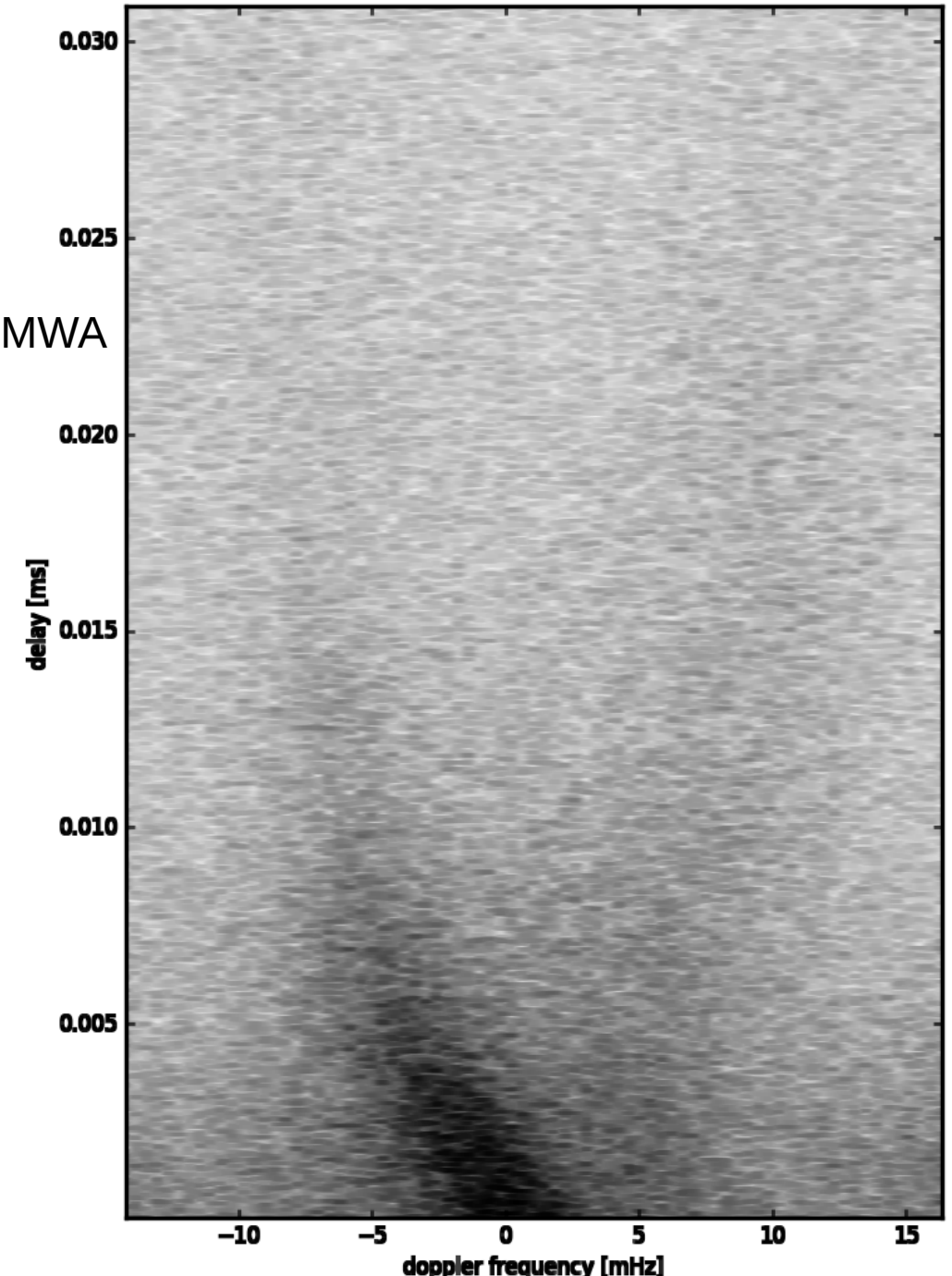


Scintillation – in a nutshell



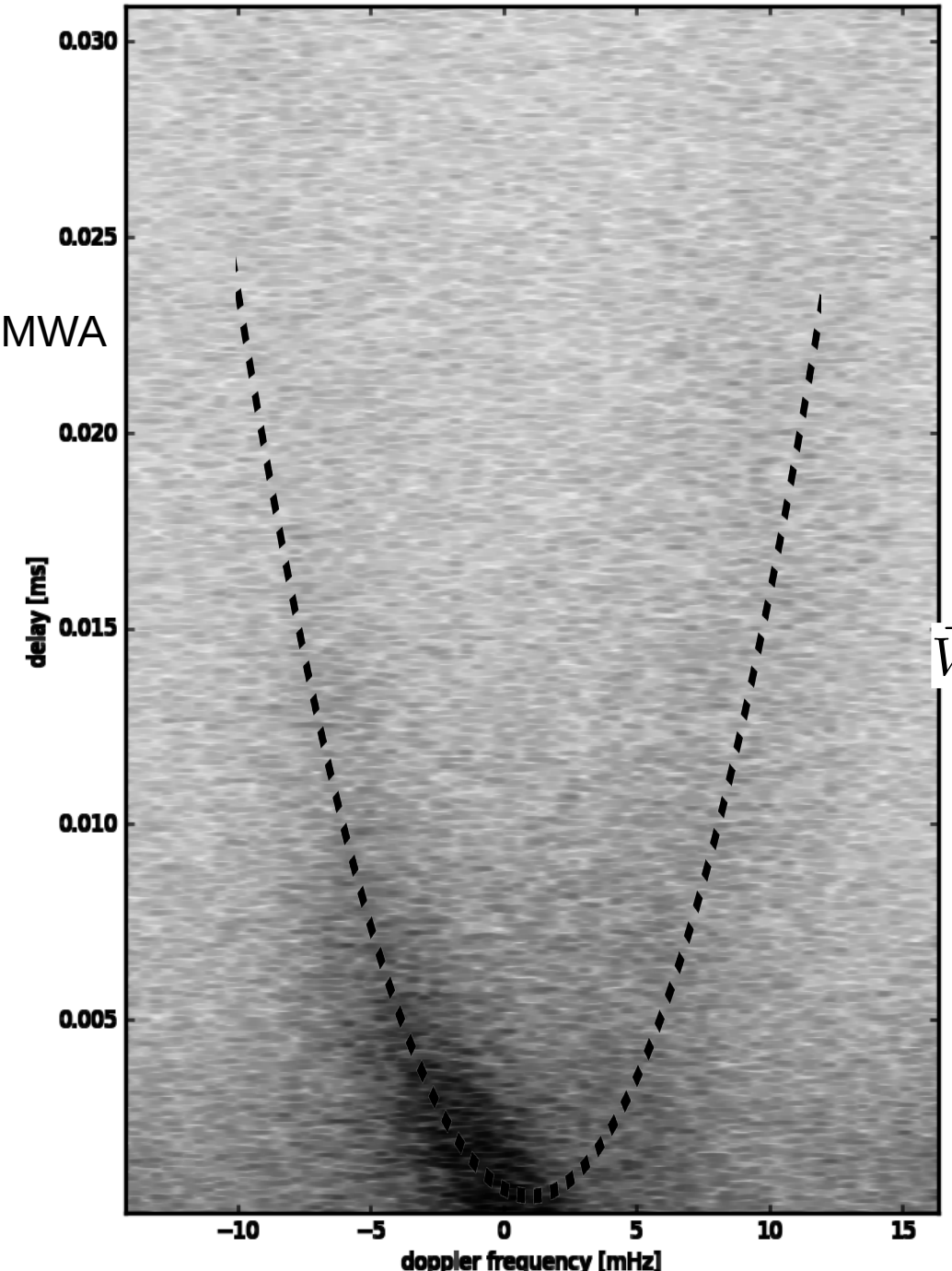
Secondary Spectrum: $|F(I(t,\nu))|^2$

PSR J1136+1551
As observed with the MWA



Secondary Spectrum: $|F(I(t,\nu))|^2$

PSR J1136+1551
As observed with the MWA



$$\tau = \eta f^2$$

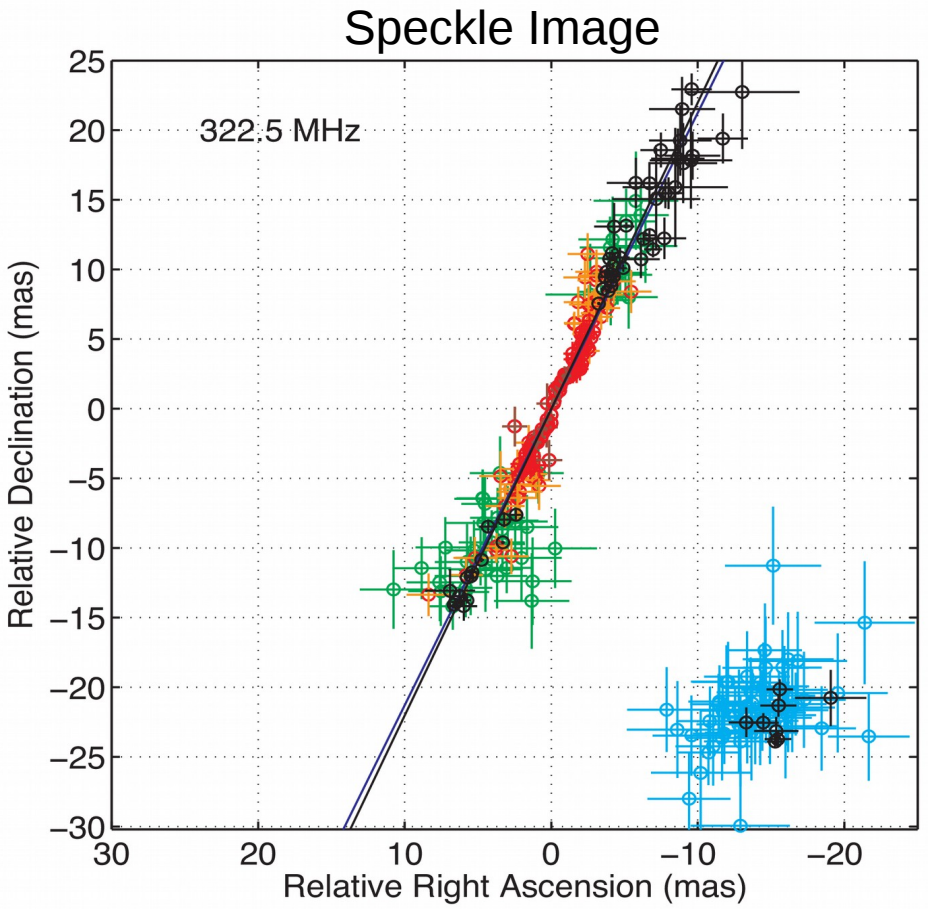
$$\eta = \frac{D_{\rm eff}\lambda^2}{2cV_{\rm eff}^2\cos^2\alpha}$$

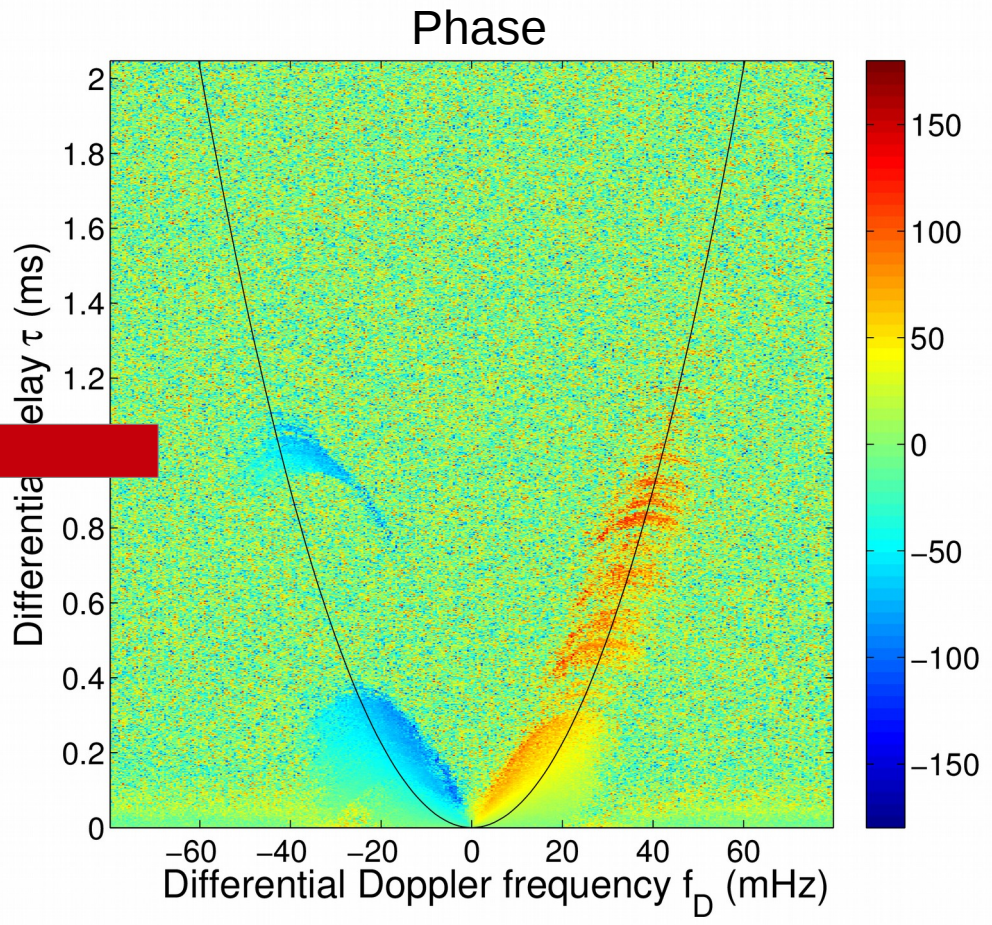
$$D_{\rm eff} = D_{\rm eff}(D_{\rm P},\ D_{\rm s})$$

$$\vec{V}_{\rm eff} = \vec{V}_{\rm eff}(\vec{V}_{\rm P},\ D_{\rm P},\ D_{\rm s})$$

Secondary Cross Spectrum

$$C(\tau,\ f,\ \vec{b}) = \tilde{V}(\tau,\ f,\ \vec{b})\ \tilde{V}(-\tau,\ -f,\ \vec{b})$$

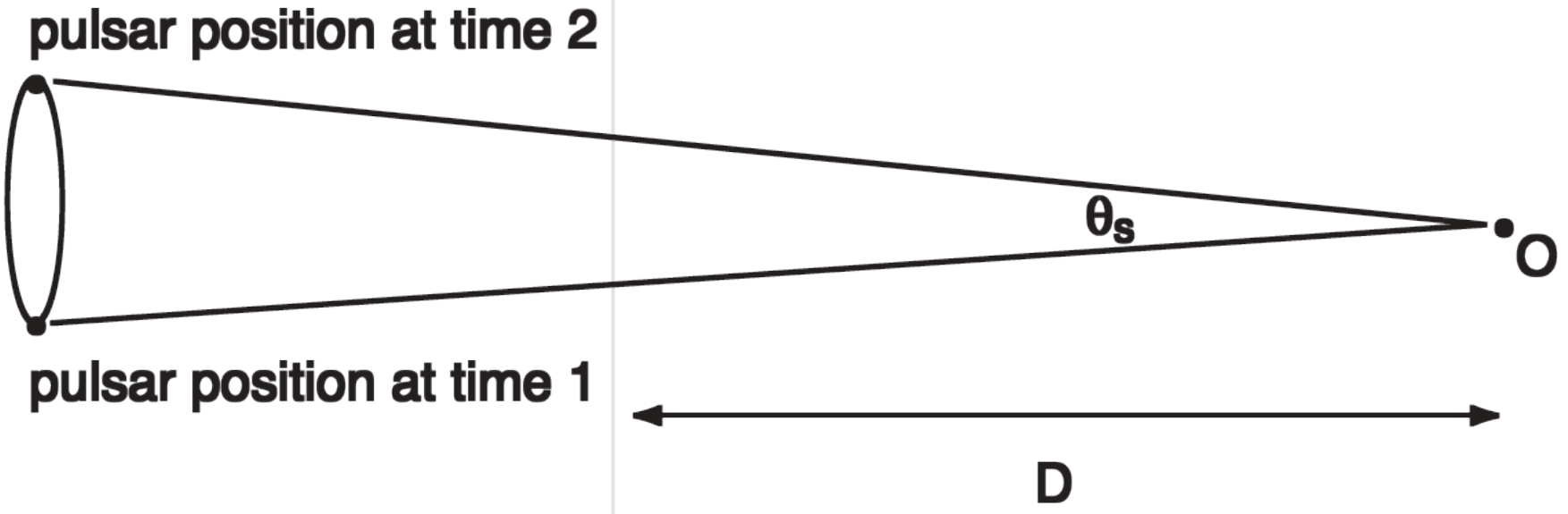


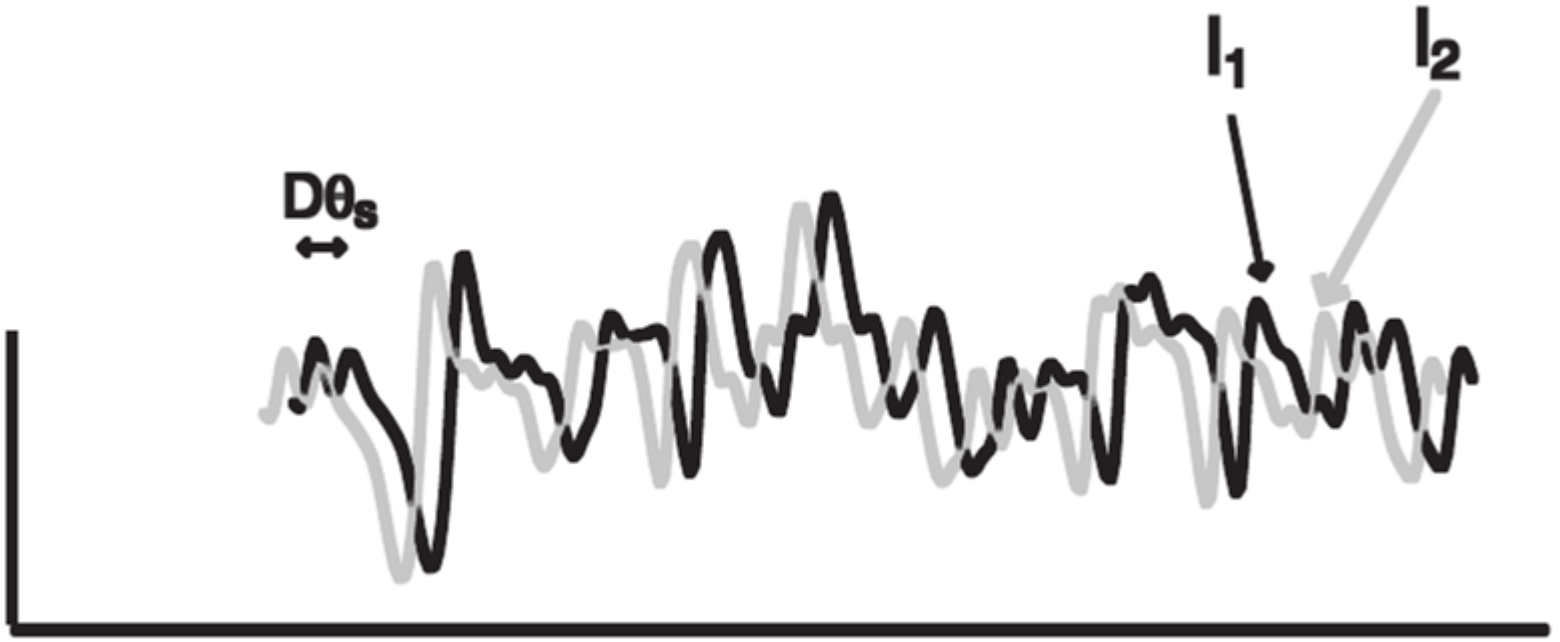


$$\tau = D_{\rm eff}\theta^2/2c$$

Brisken et al. 2010

Applications – Pulsar positions

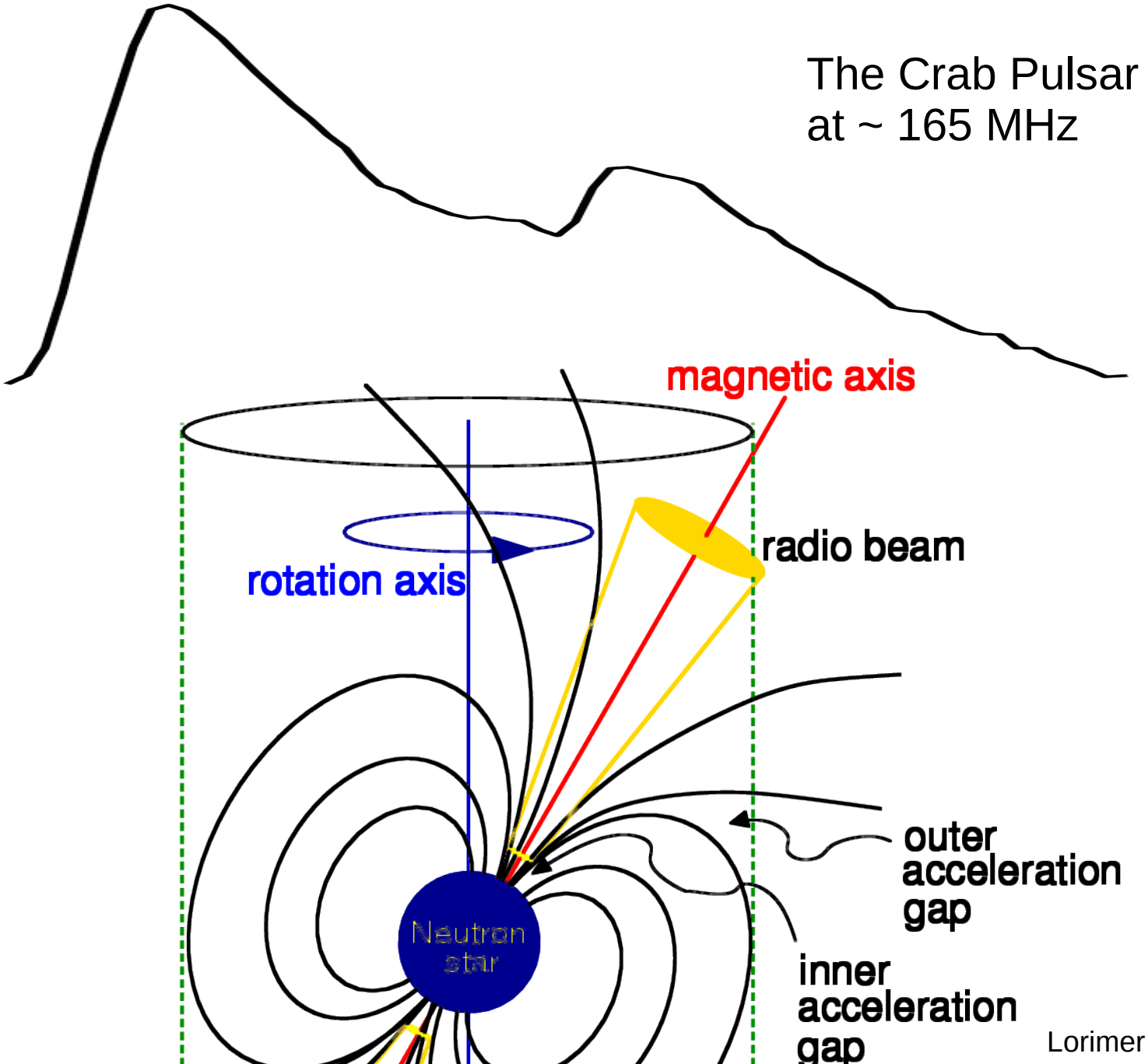




Courtesy of J-P Macquart

Applications – Pulse emission region

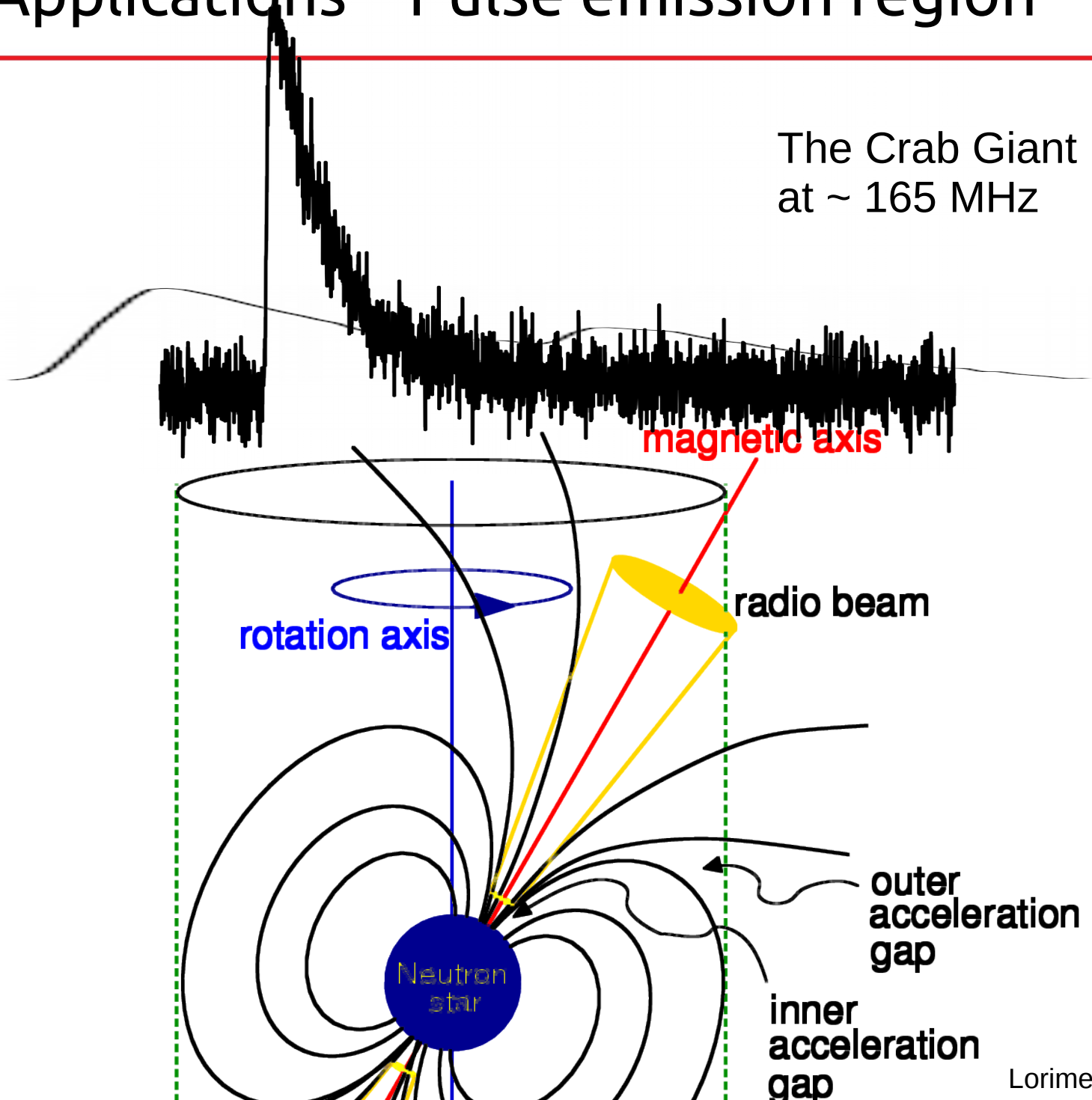
The Crab Pulsar Profile
at ~ 165 MHz



Lorimer & Kramer 05

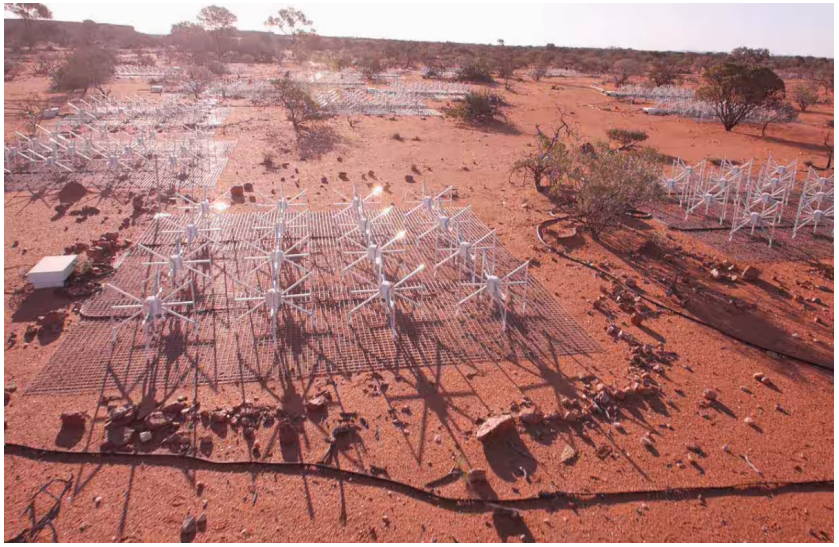
Applications – Pulse emission region

The Crab Giant Pulses
at ~ 165 MHz



Lorimer & Kramer 05

VLBI between MWA and GMRT



- MWA: 30.72 MHz BW,

  24 channels (141.44 – 172.16 MHz)

  8+8 complex VDIF
- GMRT: 33.33 MHz BW,

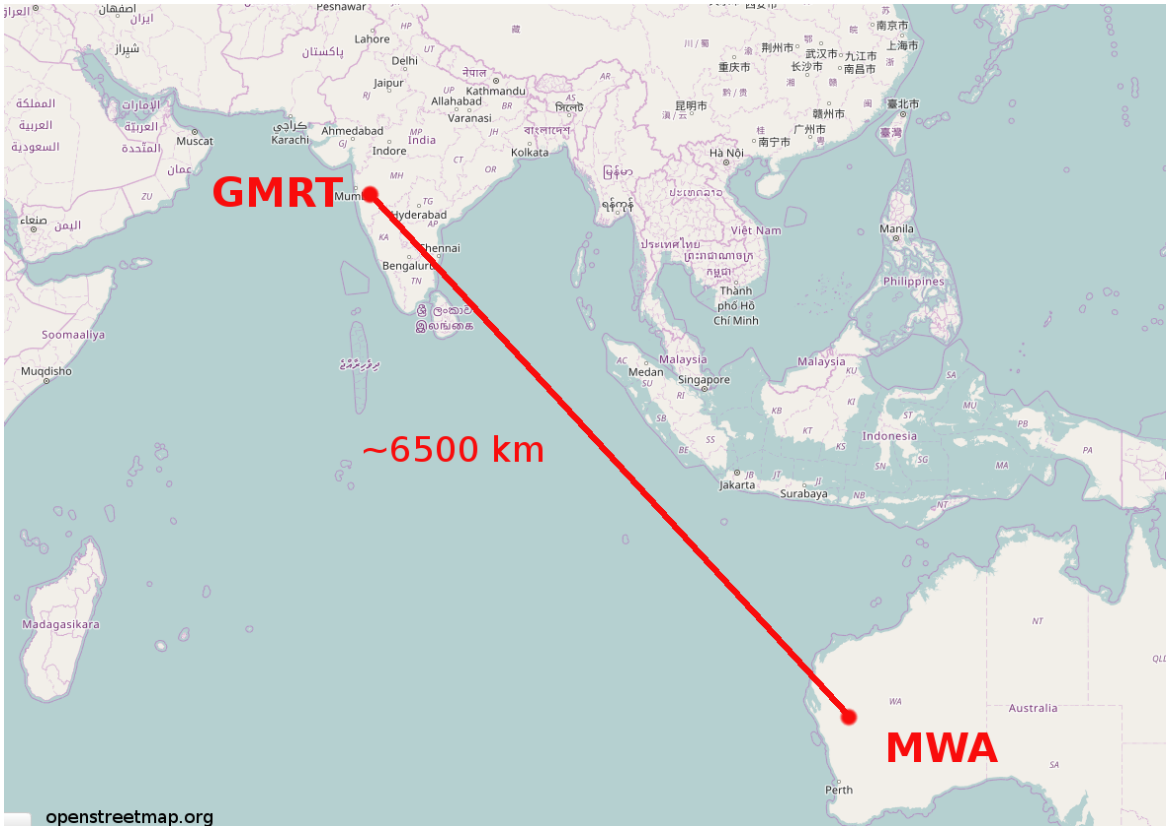
  512 channels (136.67 – 170 MHz)

  GMRT data format in phased array mode:
  - 5 files:
    - timestamps, 4 per second
    - 2 x left pol, each 1/8 of a second
    - 2 x right pol, same
- Time offsets a priori unknown
- XYZ coordinates of phase centre

  not exactly known

Use Giant pulses of the Crab to align clocks!

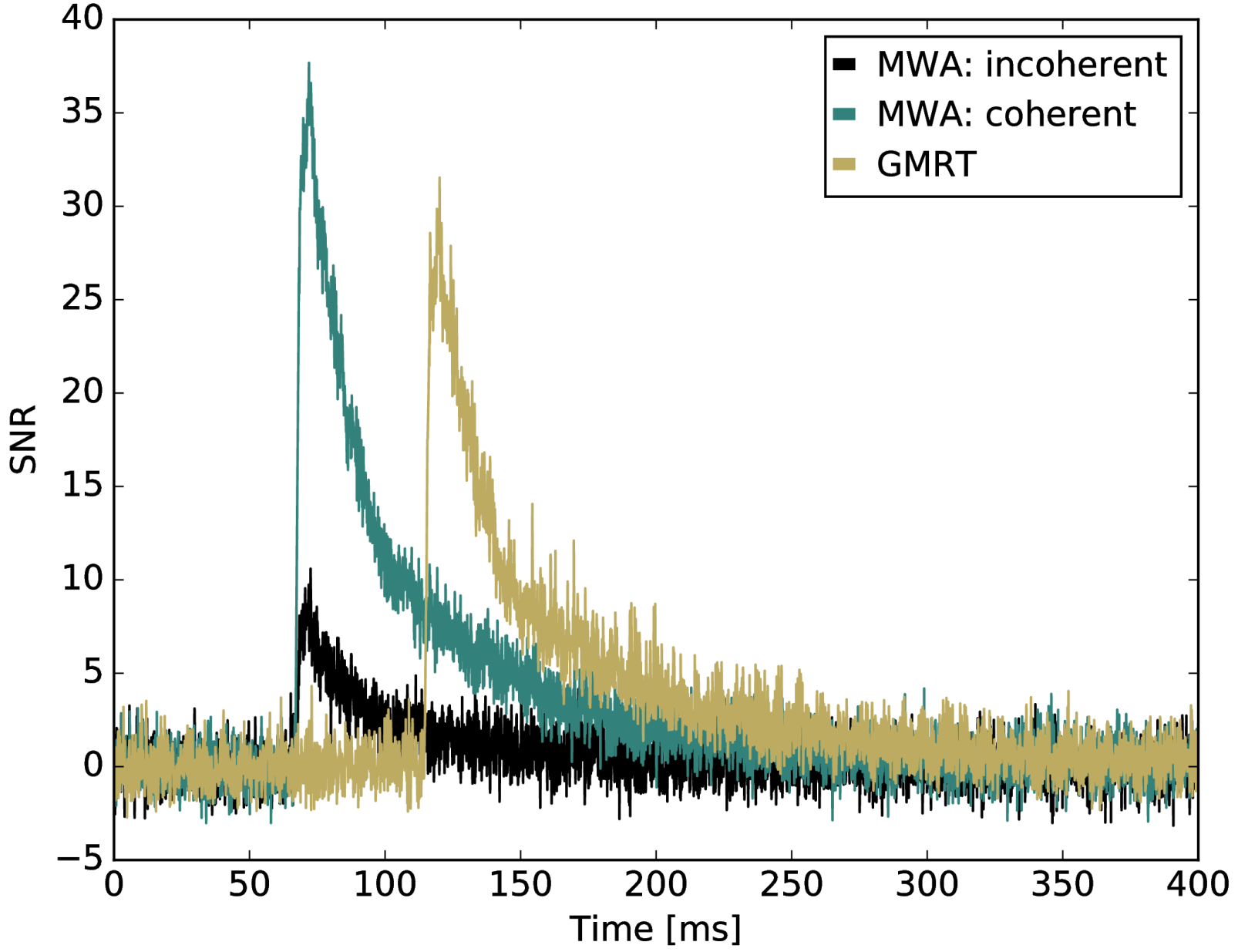
VLBI between MWA and GMRT



FWHM ~ 60 mas @ 160 MHz

Expected angular broadening due to scattering ~ 100 mas (NE2001)

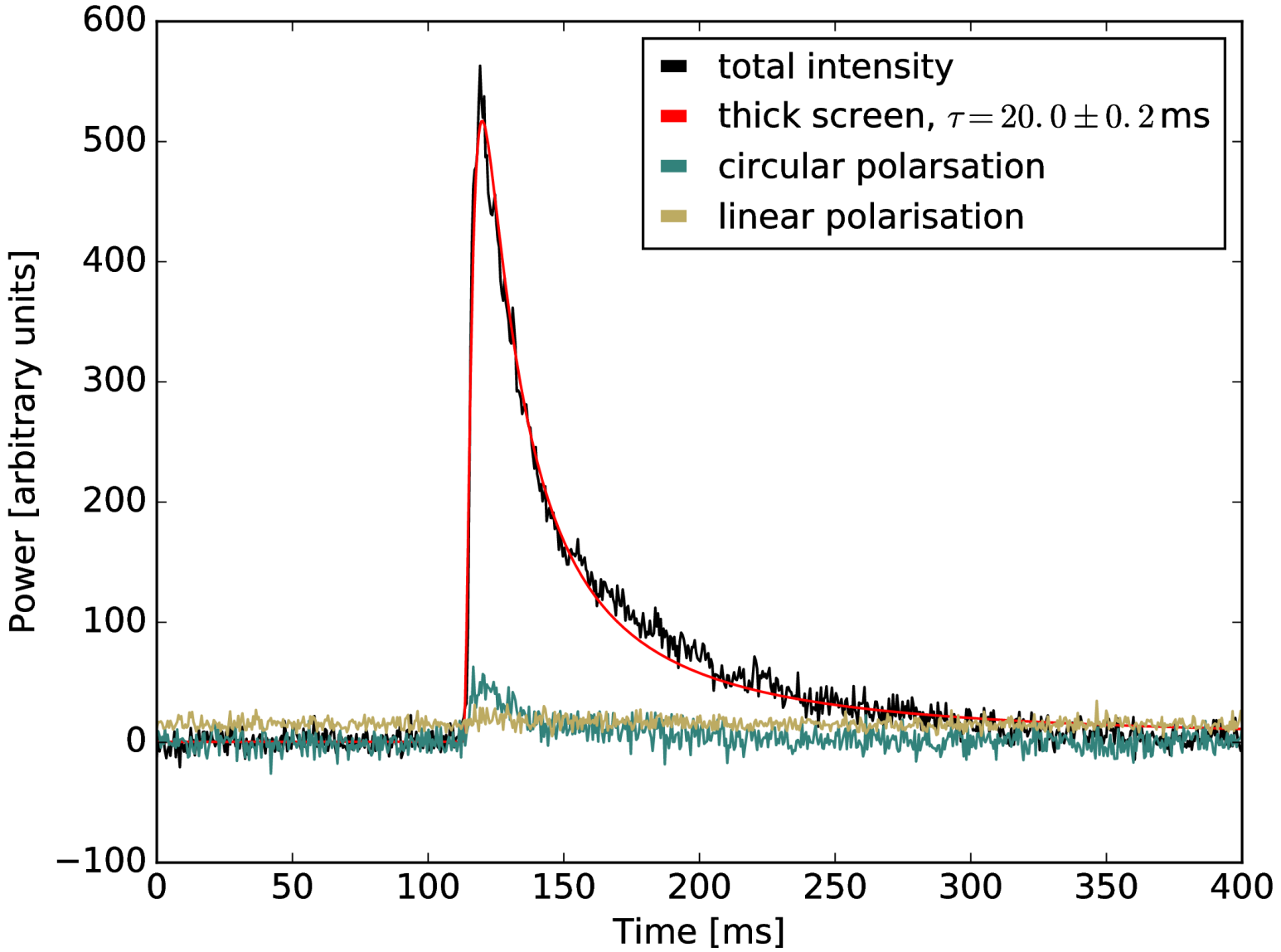
The Pulse...



Δτ = 1.15s

FK+, in prep

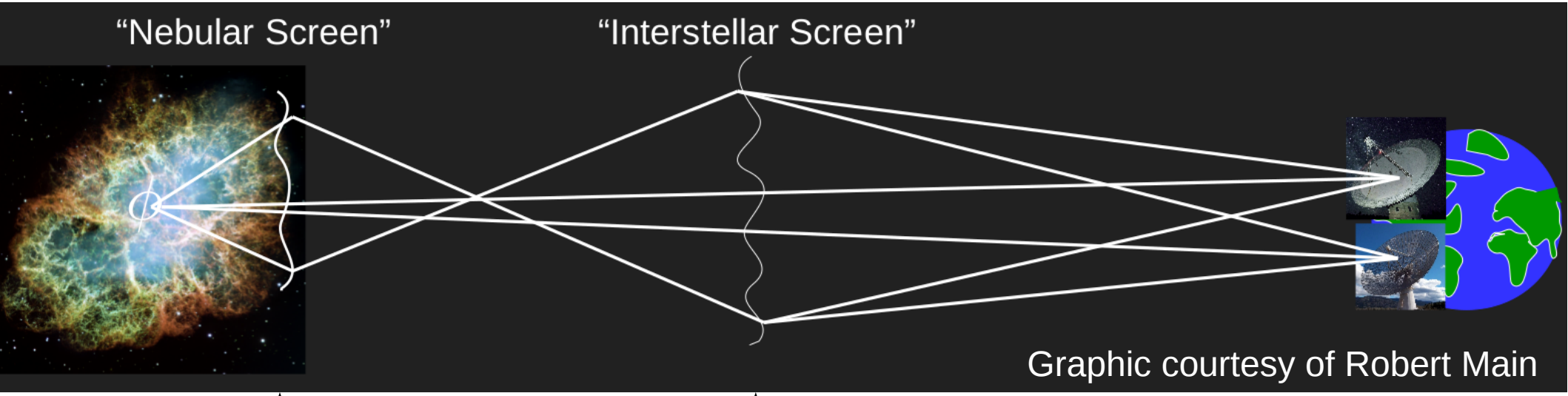
The Pulse...



FK+, in prep

The Crab Scattering Screens

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



Temporal broadening

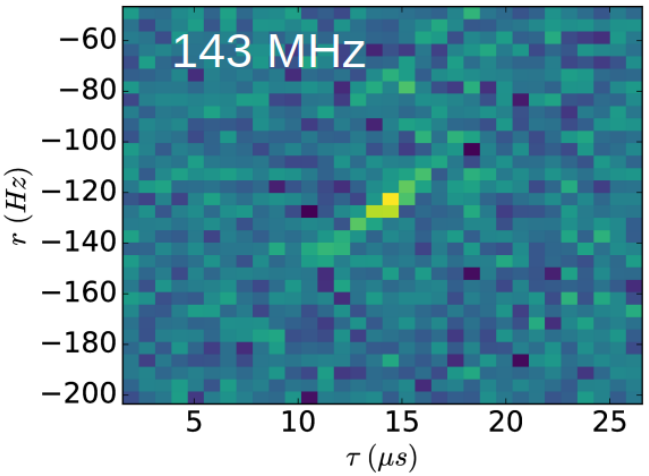
~ 20 ms
→ screen size ~ 4.4E-7

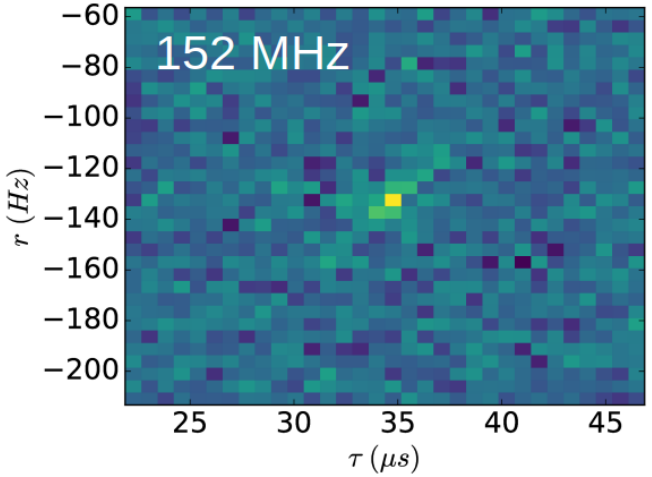
Angular broadening

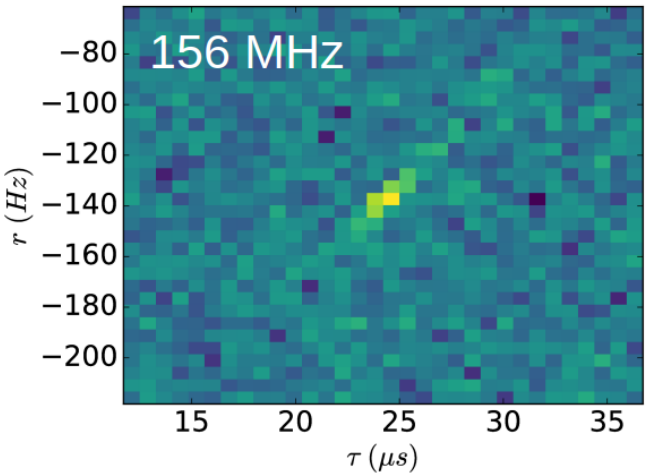
Assuming ~10AU cell size
→ screen resolution ~ 1.3E-12

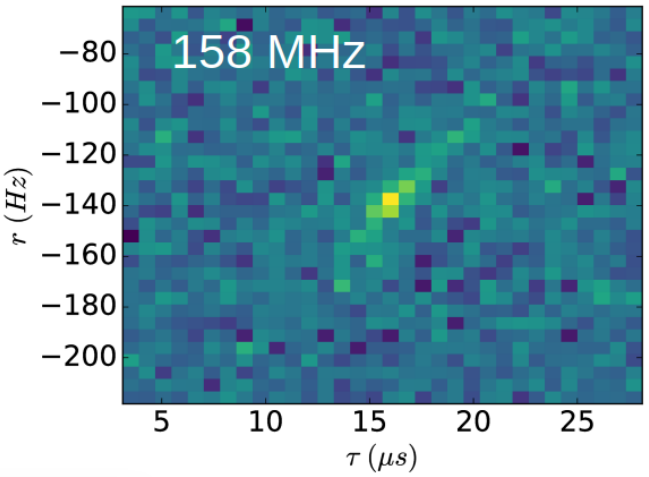
→ scattering disk of nebular resolved out

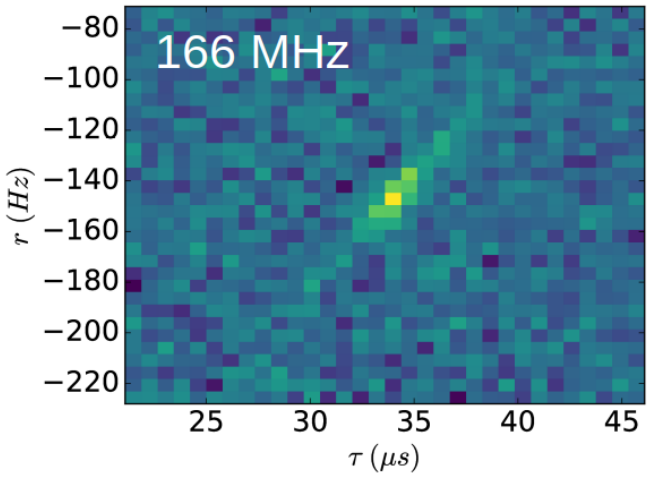
...and the fringes!

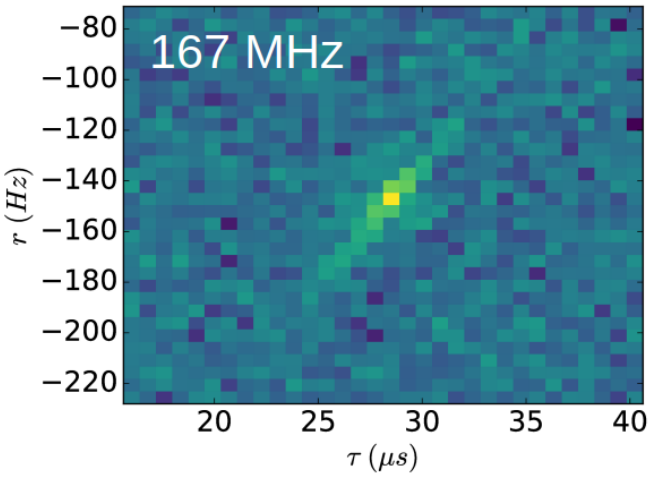




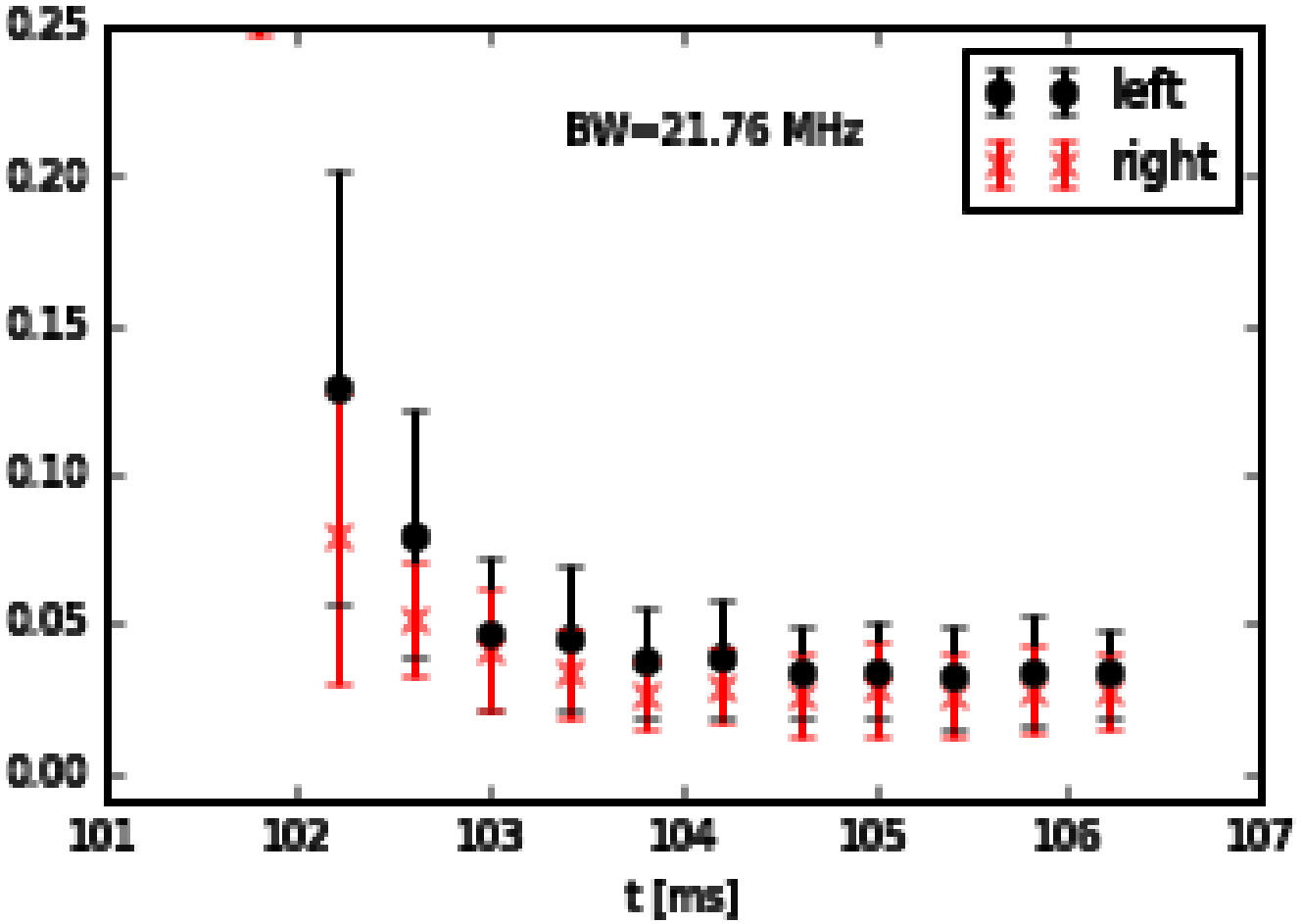








Visibility Amplitudes



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

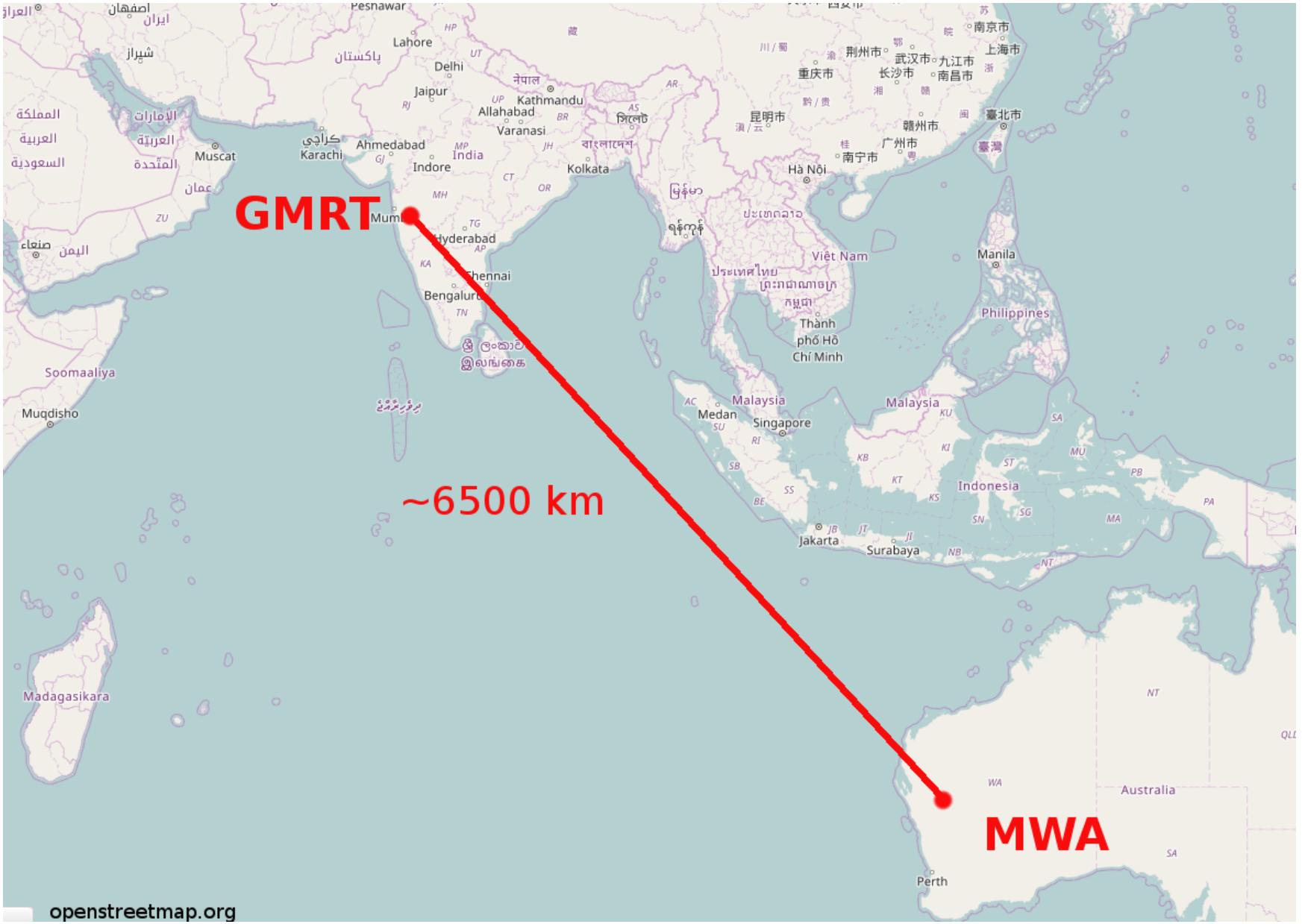
$$400\mu s \leq \tau \leq 800\mu s$$

$$13\text{mas} \leq \theta \leq 26\,\text{mas}$$

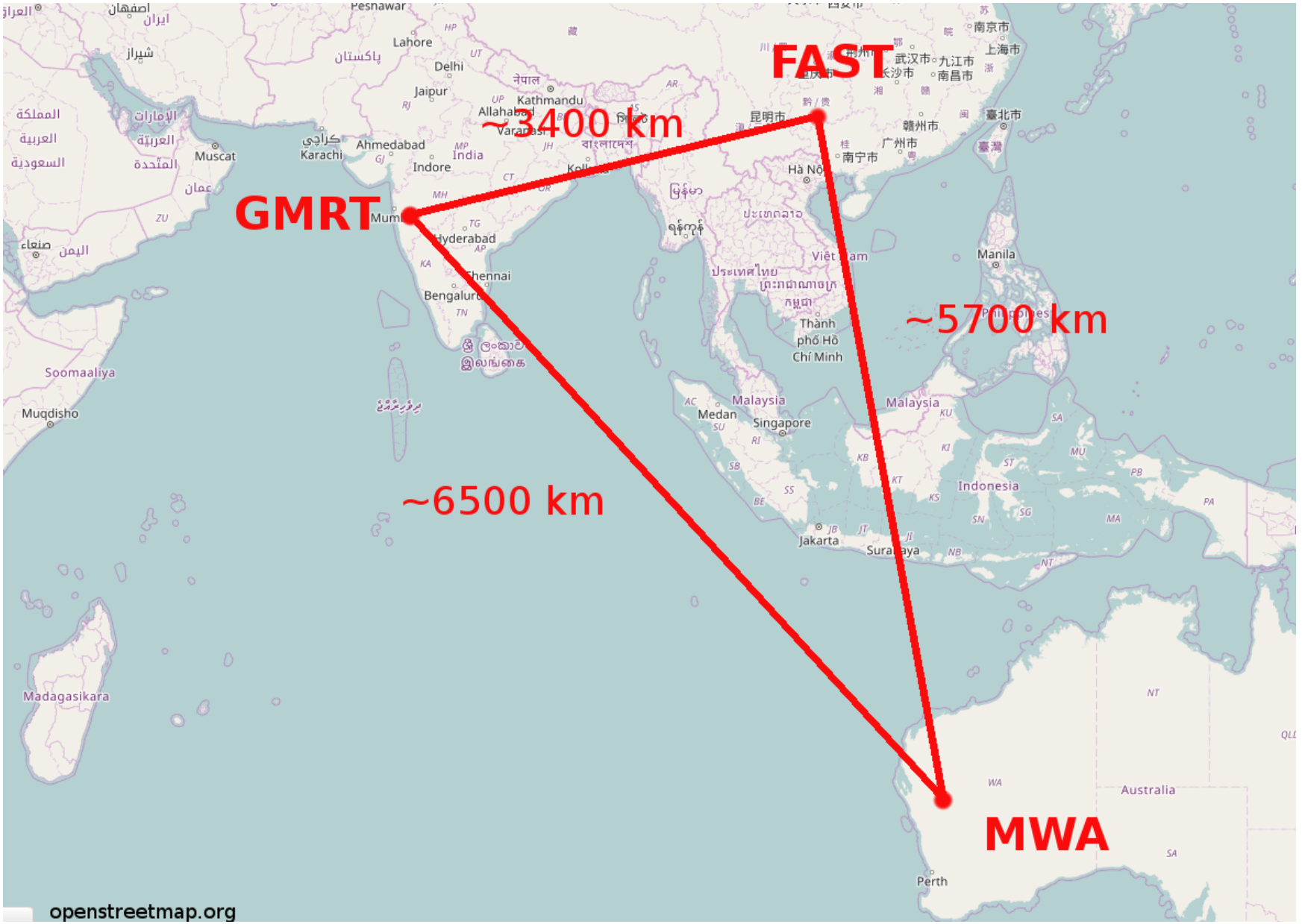
$$13\text{AU} \leq \text{disk} \leq 26\,\text{AU}$$

FK+, in prep

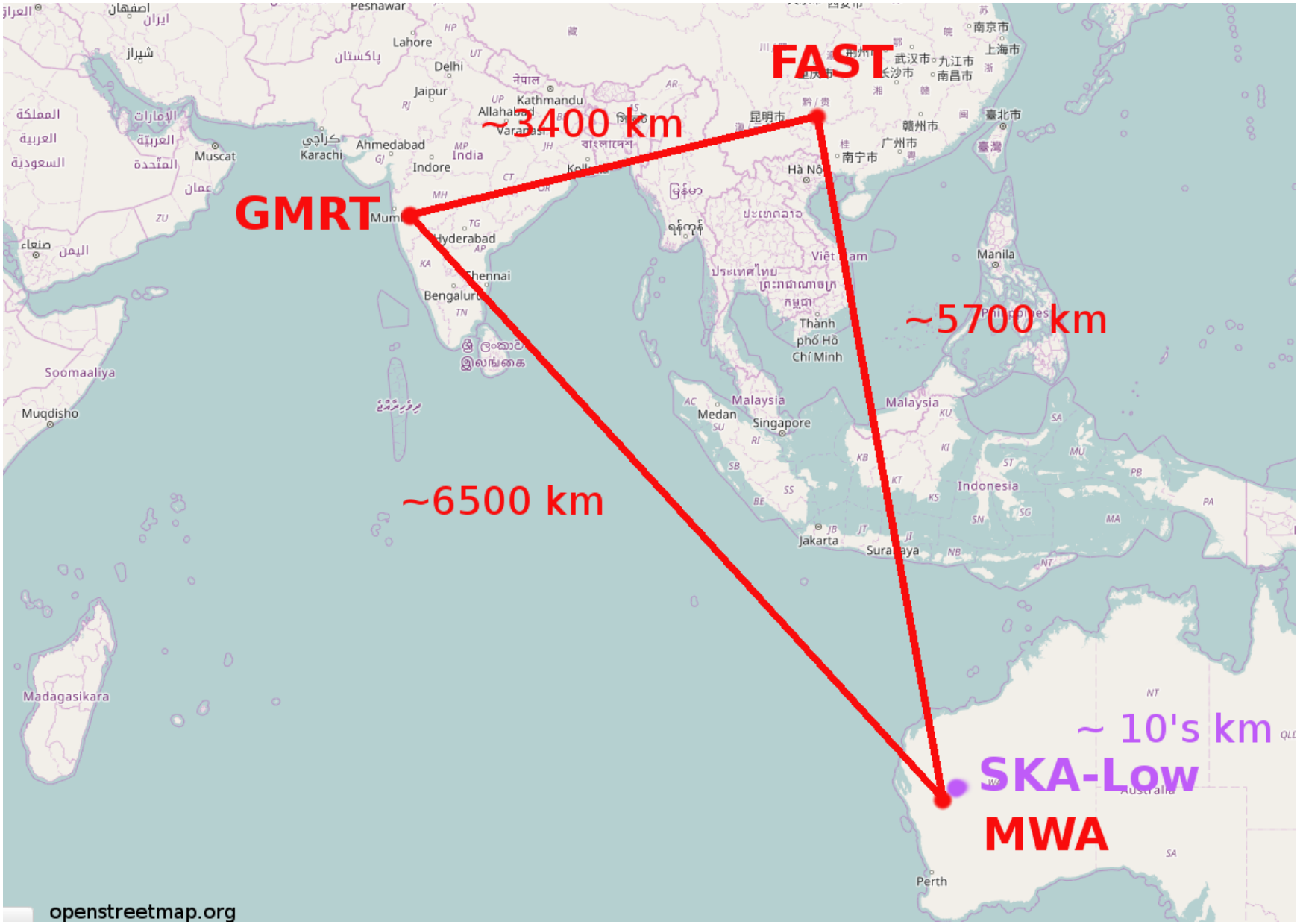
The current `array‘



The very close future: Phase Closure at 160MHz !!!



The distant (still close) future?



Thank you!

Delays/Rates across the band