

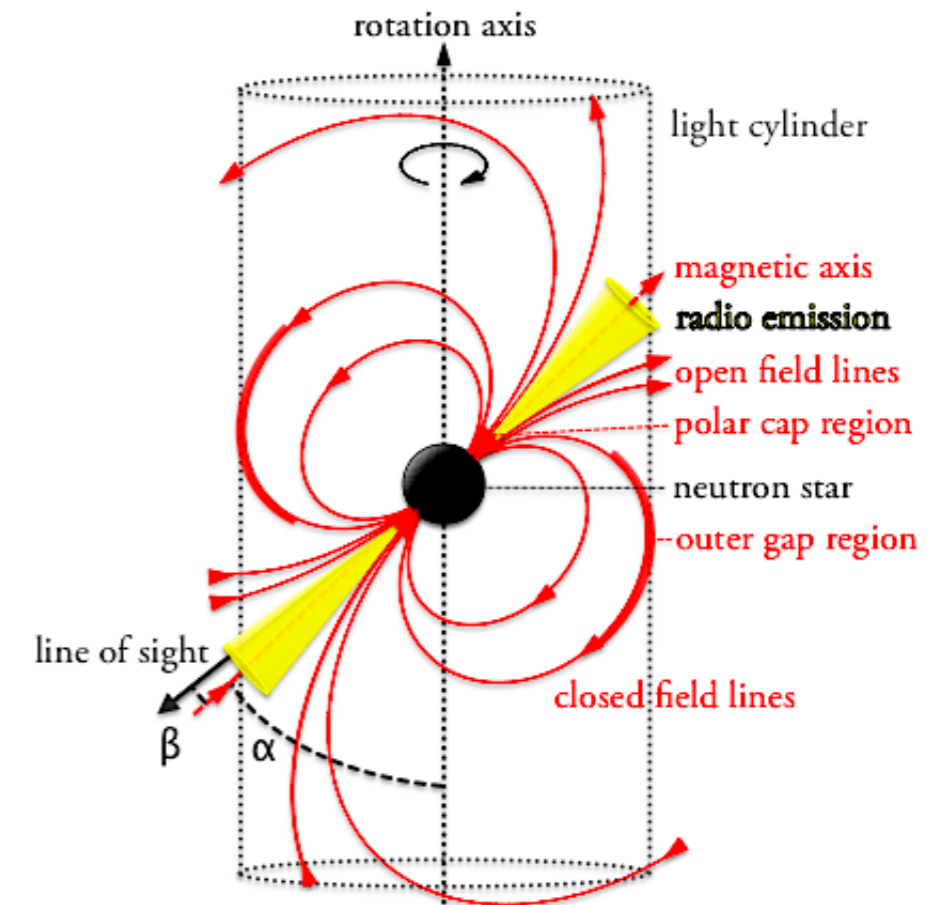
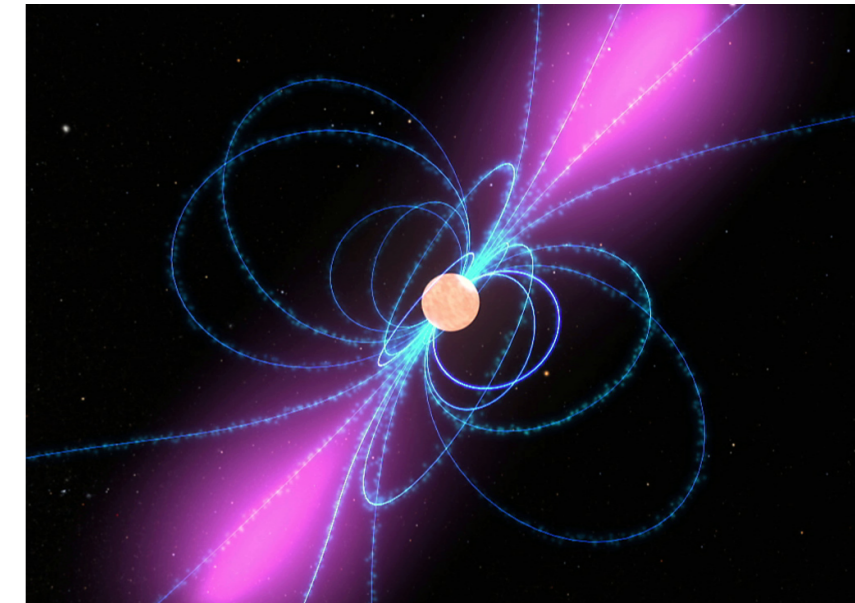
A plethora of emission characteristics from PSR B0823+26

Charlotte Sobey



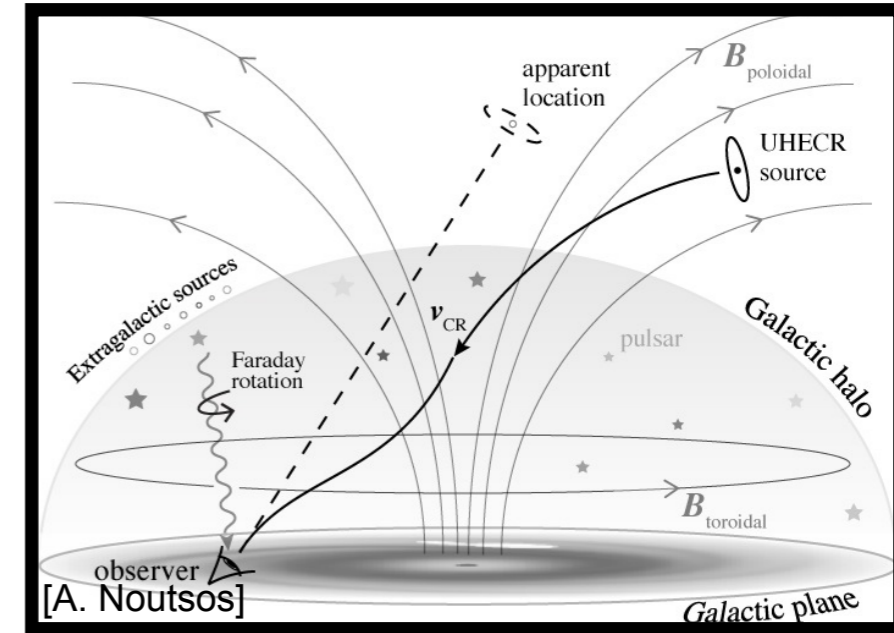
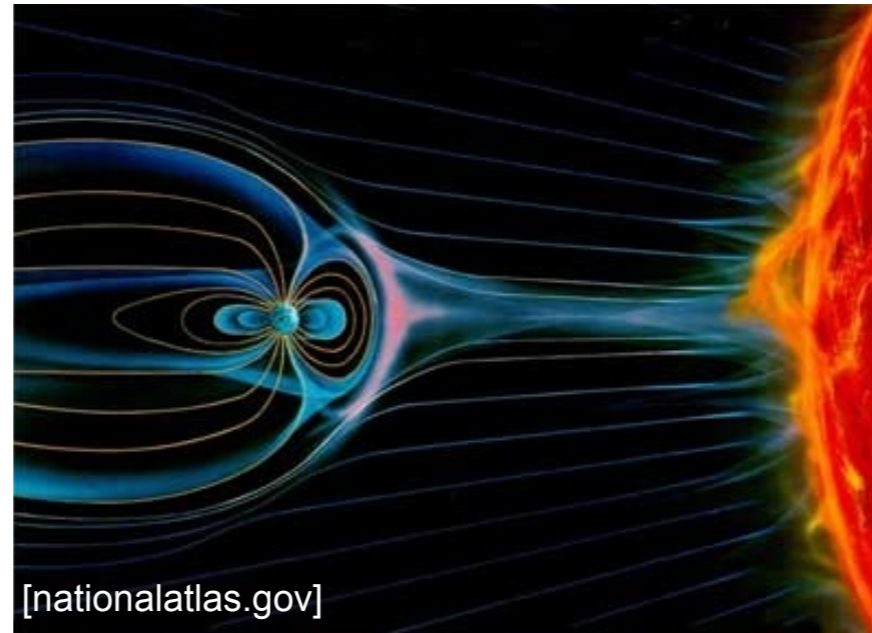
LOFAR

- Motivation & introduction:
 - Pulsar magnetospheric emission
 - PSR B0823+26
- Methods:
 - LOFAR stand-alone and simultaneous
 - Single-pulse studies
- Results
- Future prospects

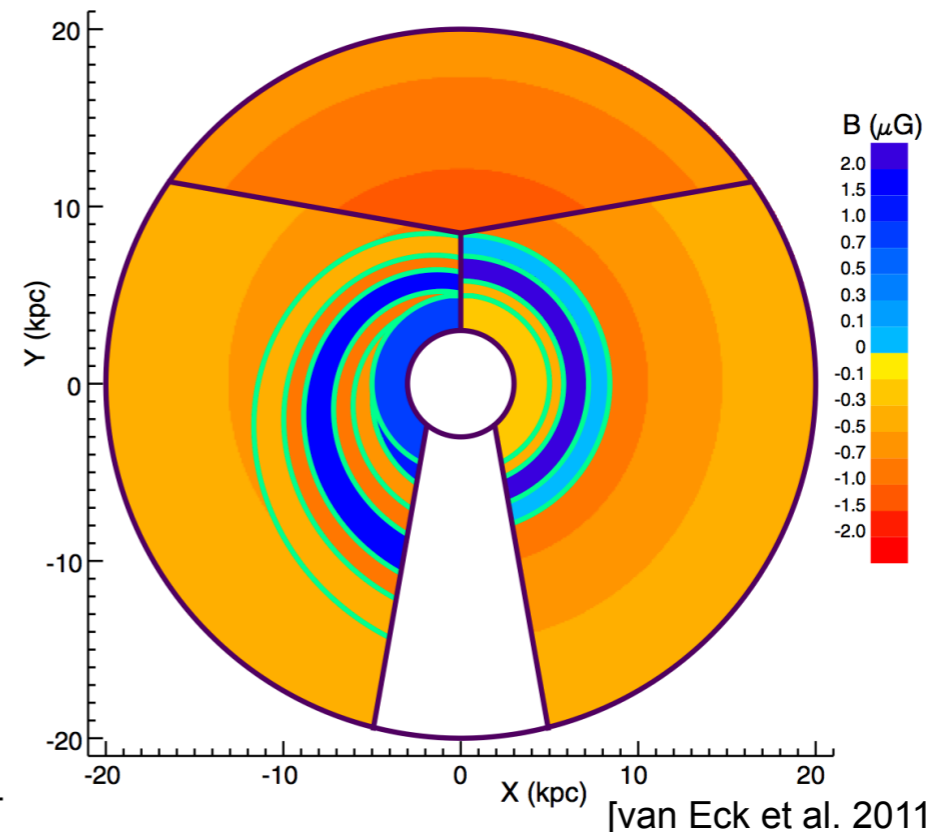
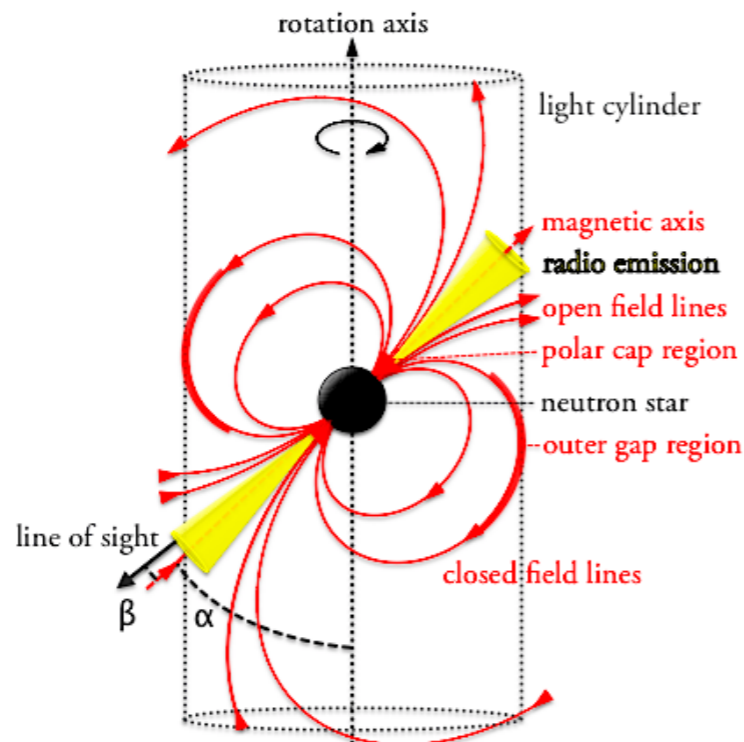


- PhD supervisors: Michael Kramer, Aris Noutsos (MPIfR)
- Funded by DFG Research Unit 1254
 - “Magnetisation of Interstellar and Intergalactic Media: The Prospects of Low-Frequency Radio Observations”
- Pulsar Working Group for LOFAR:
 - J. Hessels (co-PI, ASTRON/UvA), B. Stappers (co-PI, Manchester University), A. Bilous, R. Breton, T. Coenen, S. Cooper, H. Falcke, J.M. Griessmeier, T. Hassall, A. Karastergiou, E. Keane, V. Kondratiev, M. Kramer, M. Kuniyoshi, J. van Leeuwen, A. Noutsos, M. Serylak, M. Pilia, M. Serylak, C. Sobey, S. ter Veen, J. Verbiest, P. Weltevrede, K. Zagkouris.
- Magnetism Key Science Project for LOFAR

- Magnetic fields are ubiquitous throughout the Universe:

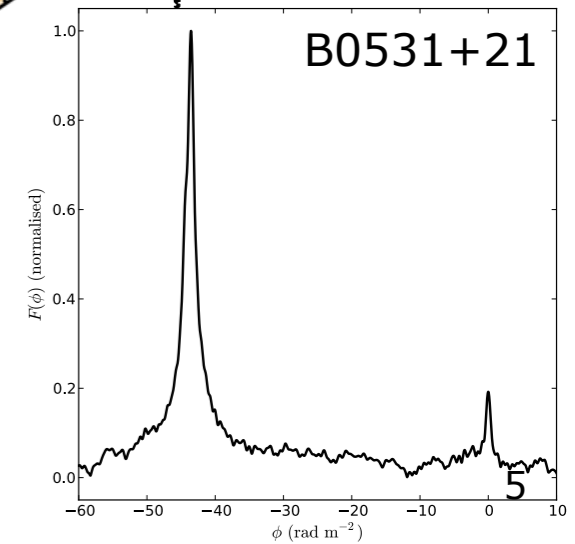
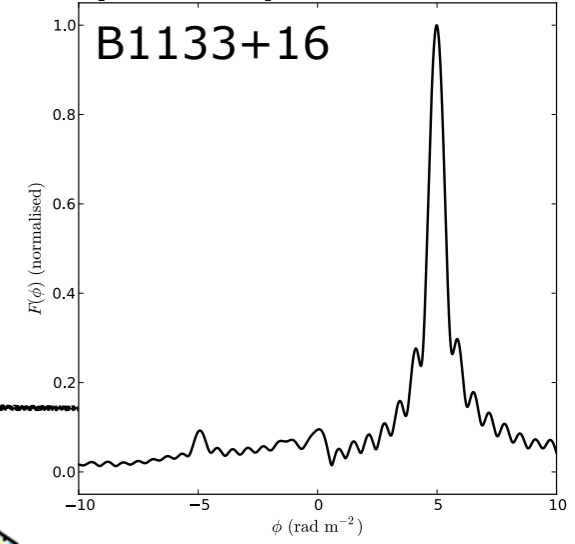
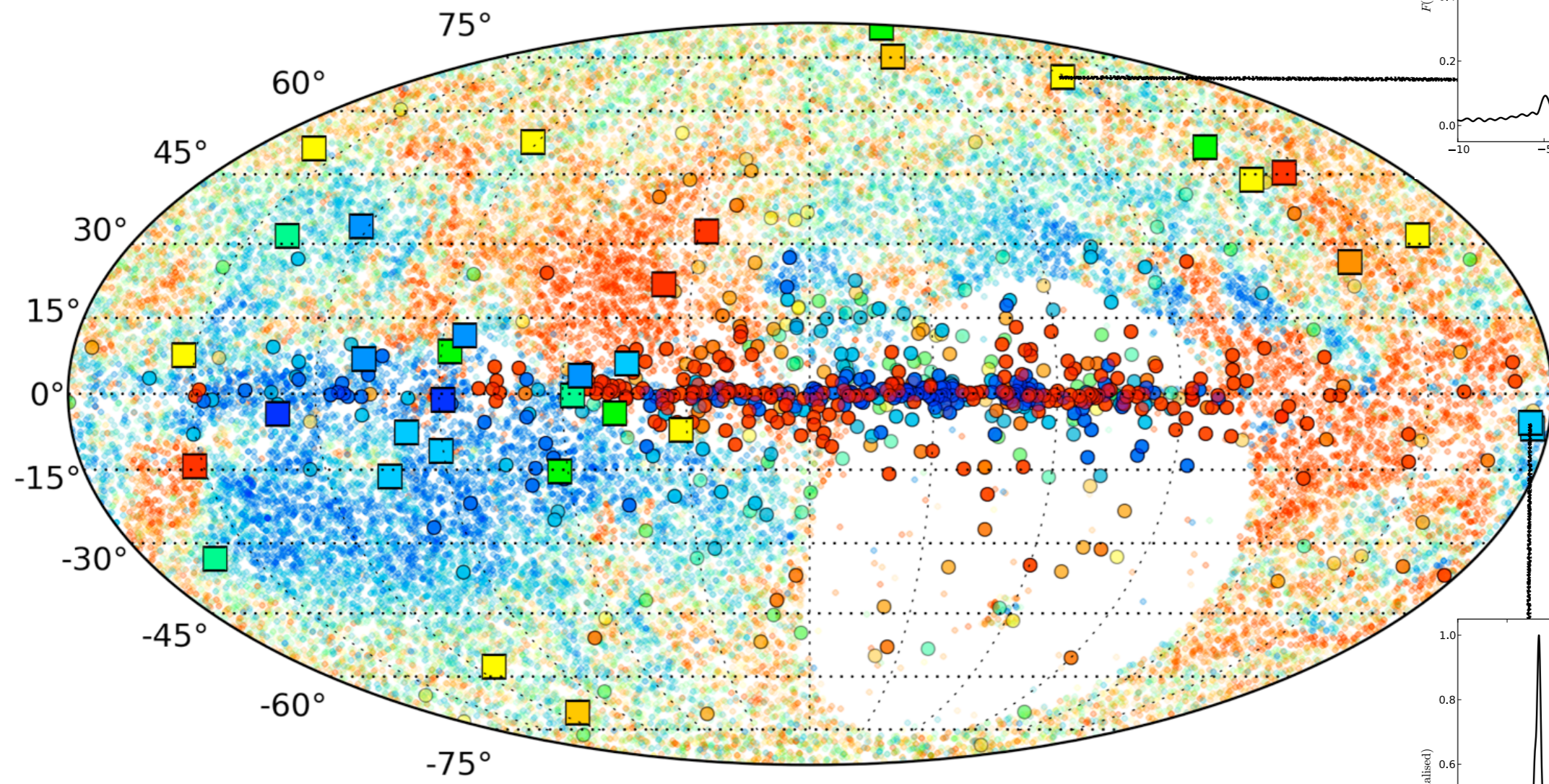


- Pulsars as probes, e.g., magnetosphere, ionosphere, GMF





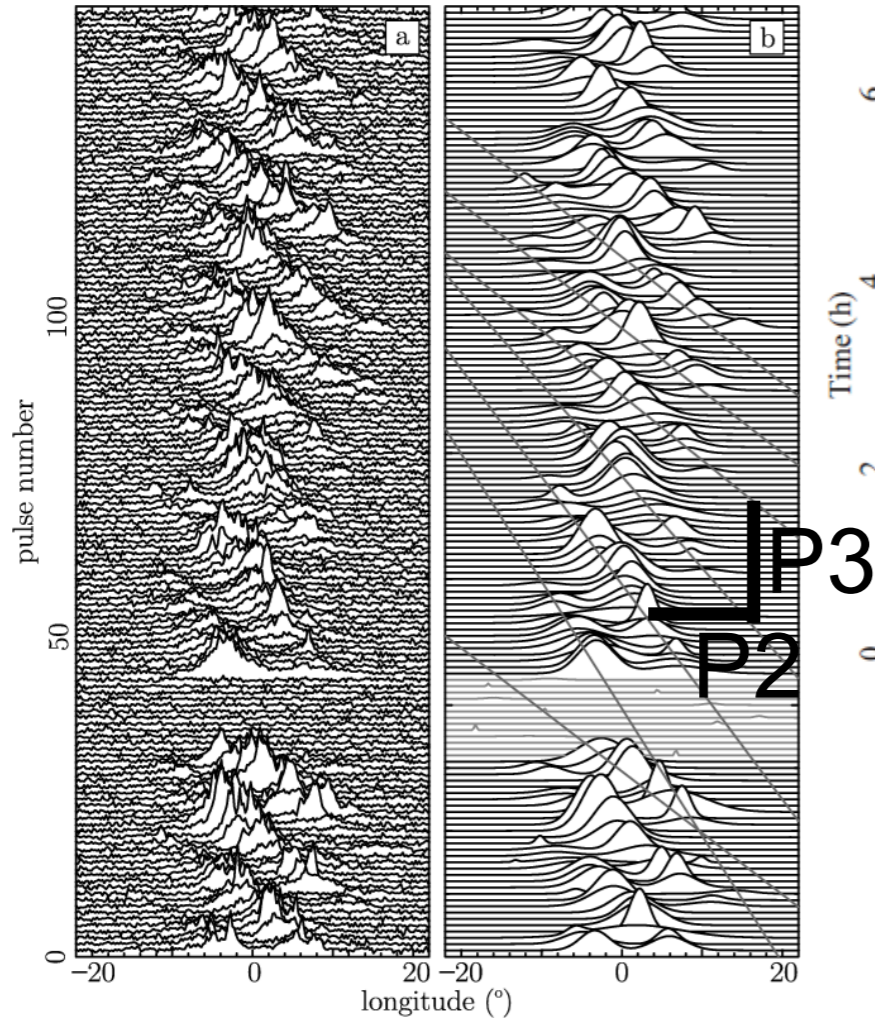
- Extra-galactic RMs (~40,000) + pulsar catalogue (674) + precise LOFAR RMs (squares, 35 to date!)



[Oppermann et al. 2011 and references therein, Manchester et al. 2005]

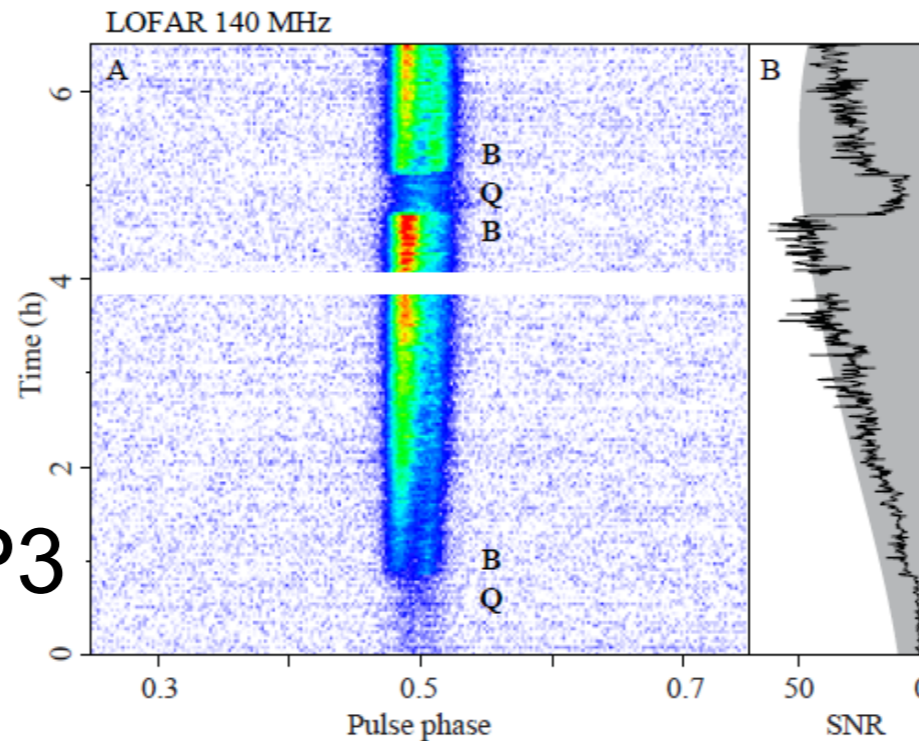
- Examples of emission characteristics on numerous timescales:

Nulling, subpulse drifting



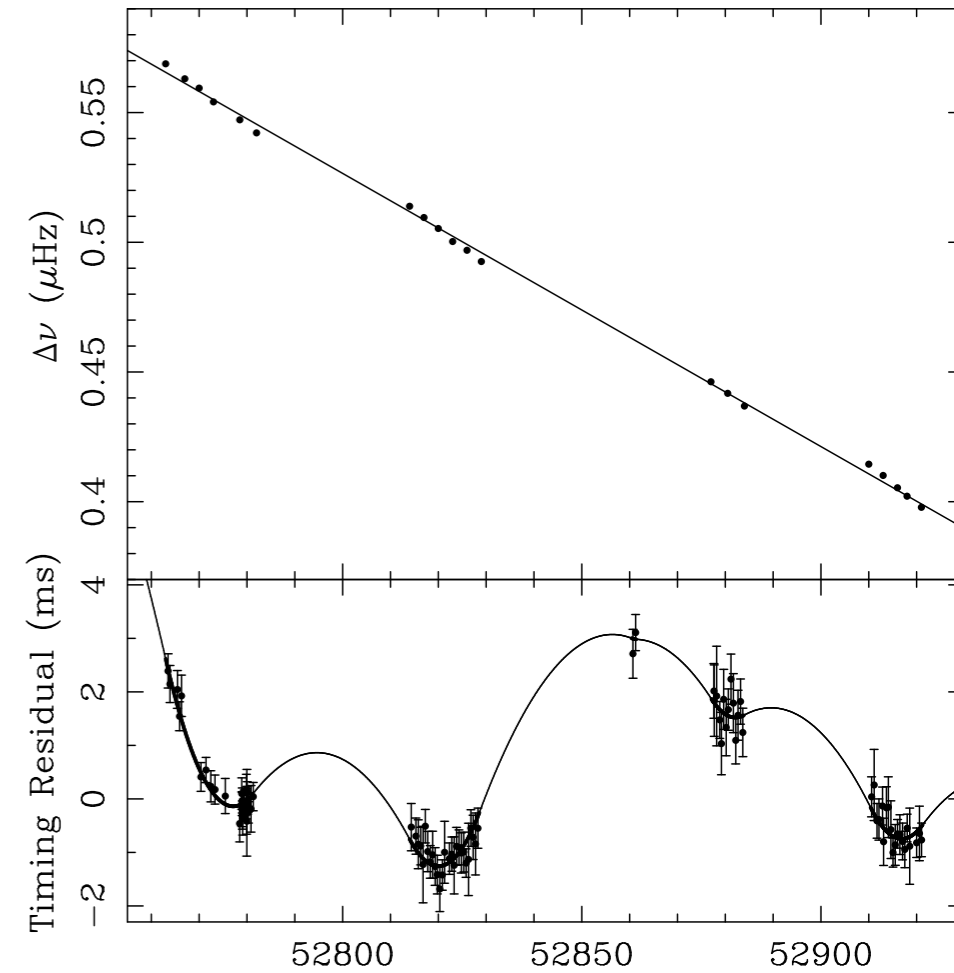
[van Leeuwen et al. 2003]

Mode-changing



[Hermsen et al. 2013]

Intermittency

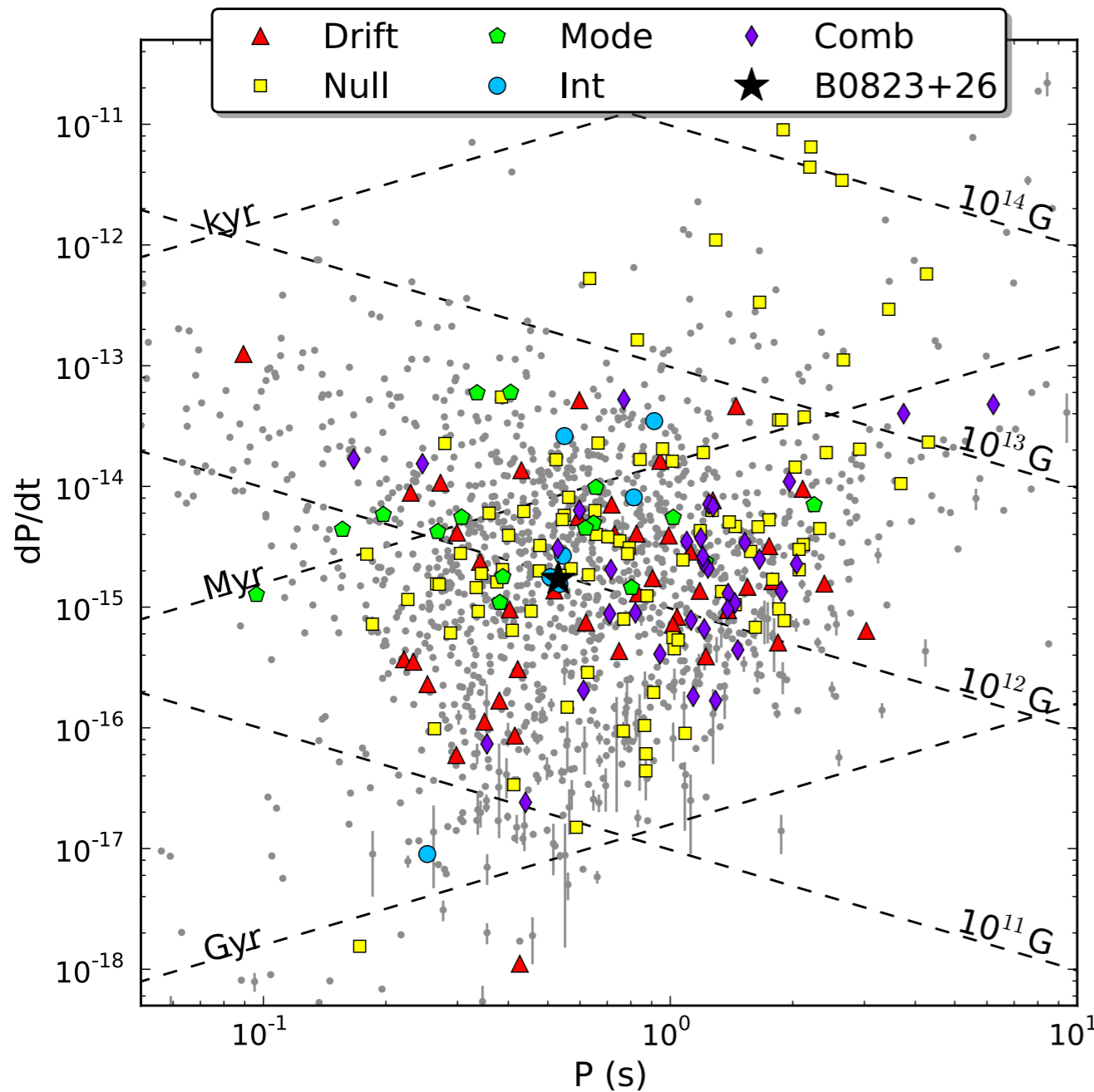


[Kramer et al. 2006]

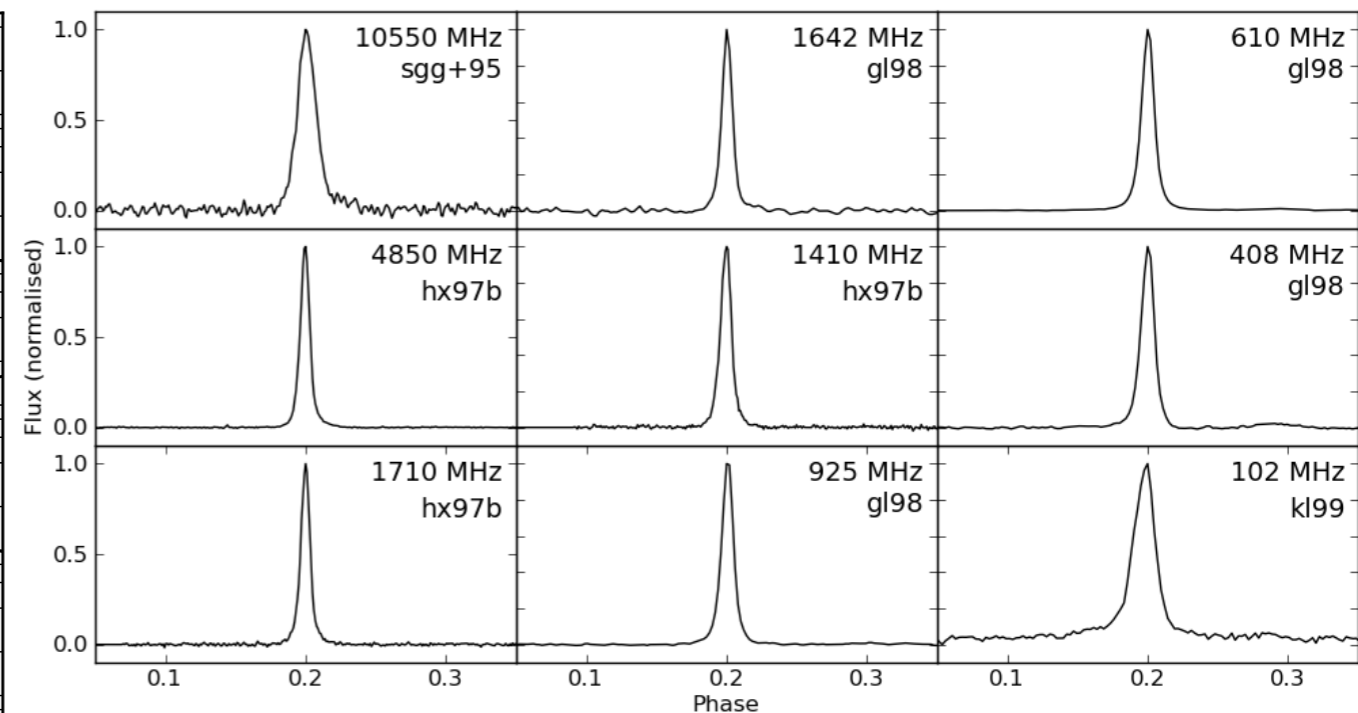
- Related to changes in current flows in pulsar magnetosphere

- Despite 'normal' parameters & long-term pulse stability:
 - nulling, sub-pulse drifting, mode-changing

P- \dot{P} diagram

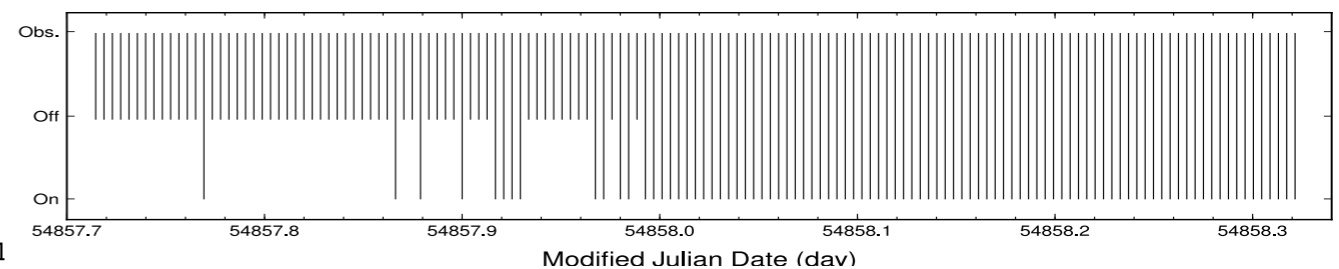


EPN pulse profiles



[<http://www.jb.man.ac.uk/research/pulsar/Resources/epn/>]

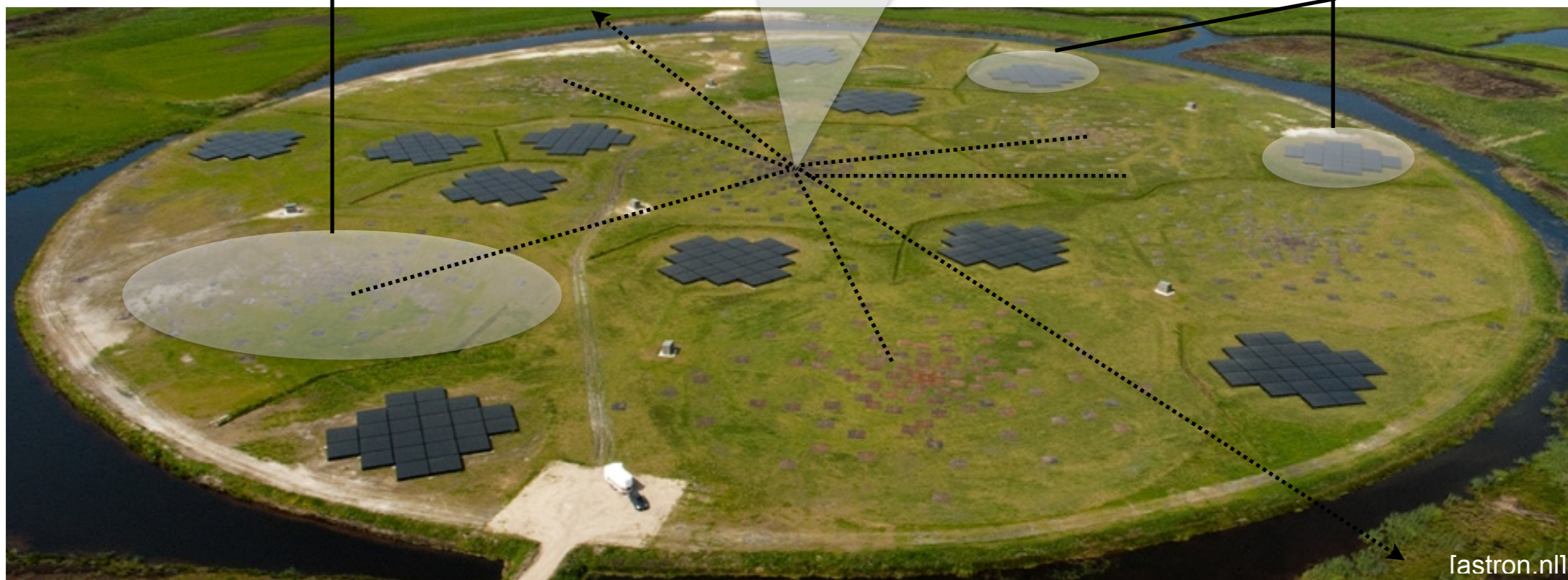
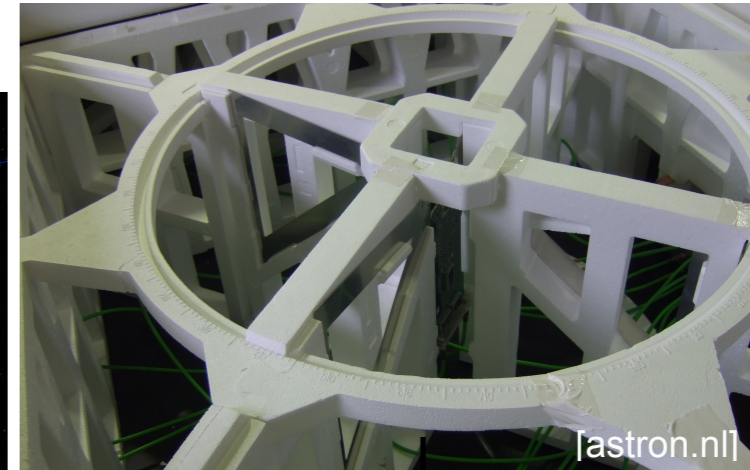
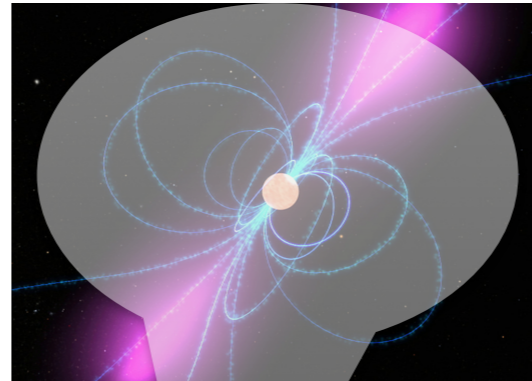
Long (<5 hr) 'nulls'!



[Young et al. 2012]

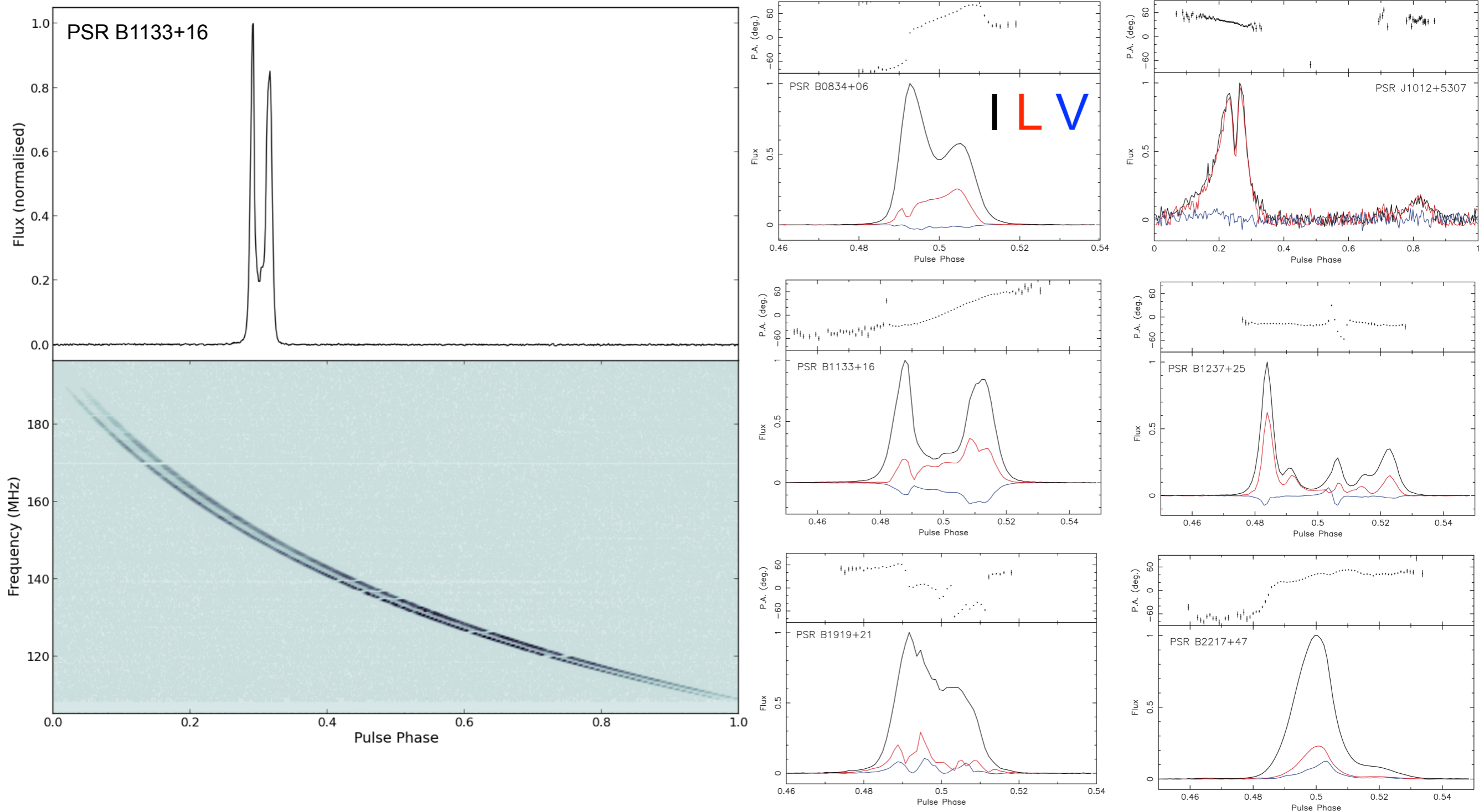
- Low Band Antennas (LBAs)
 - 10-90 MHz

- High Band Antennas (HBAs)
 - 110-240 MHz



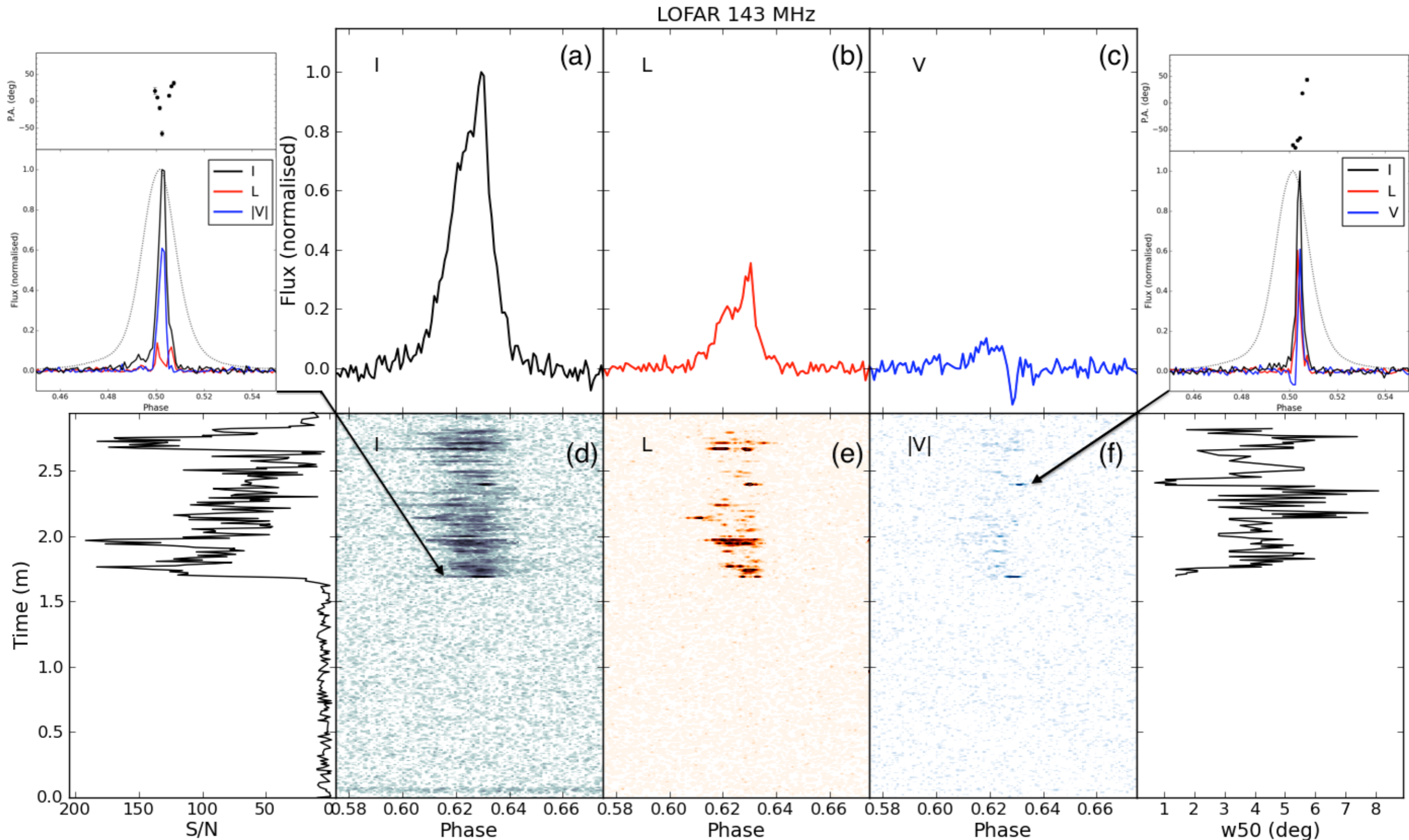
- Overview (van Haarlem et al. 2013), Pulsar modes (Stappers et al. 2011)

- Large fractional bandwidth and collecting area: high sensitivity

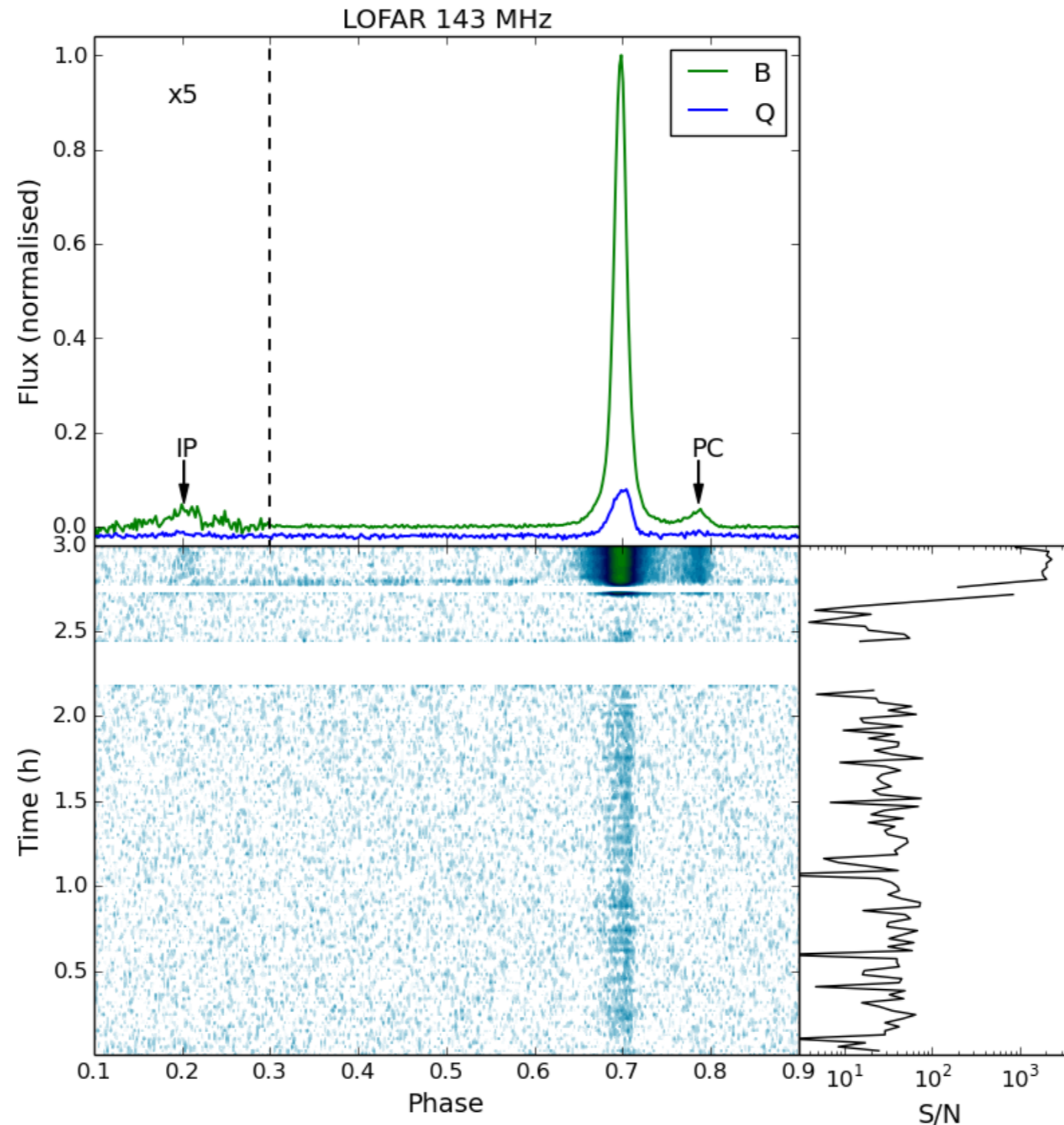


[A. Noutsos et al., in prep.]

- Mode-change **during** 3-min observation, within one single pulse!



- Long 'nulls' actually sporadic & **weak quiet-mode emission state**



- Mode-change **simultaneous & broadband** (105–2700 MHz)



Effelsberg 2630 MHz



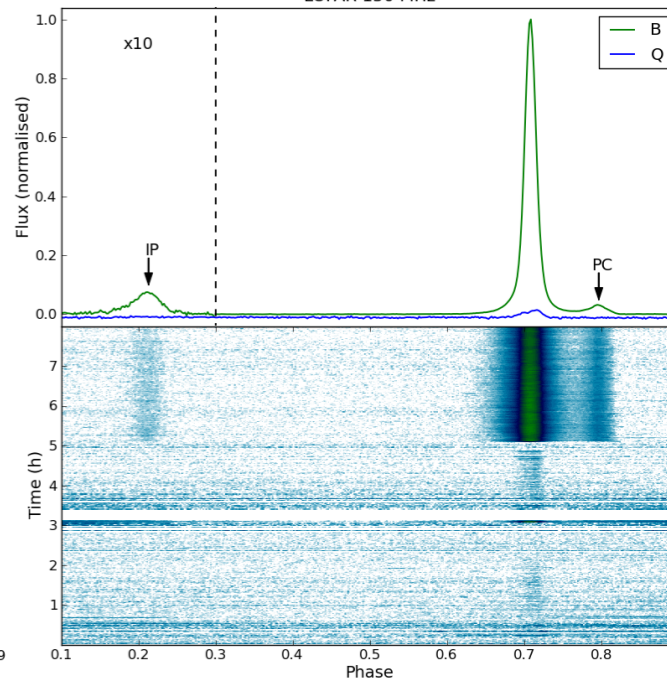
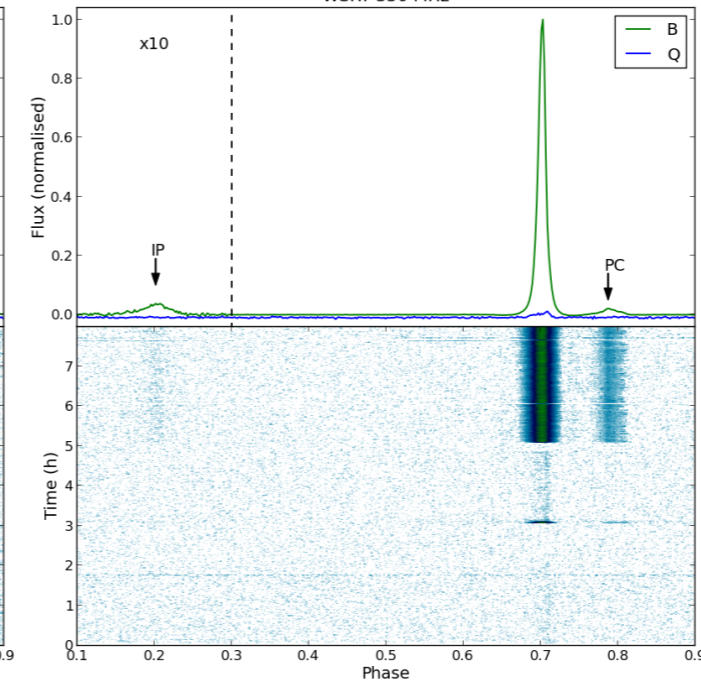
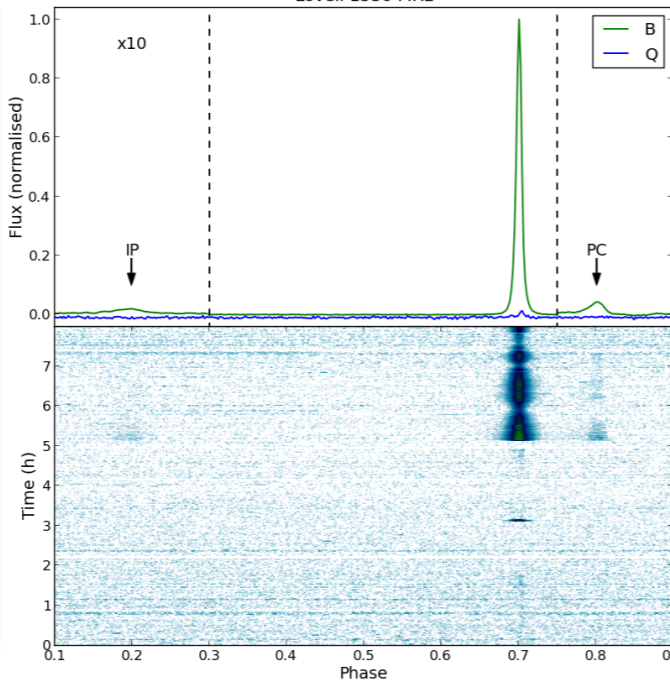
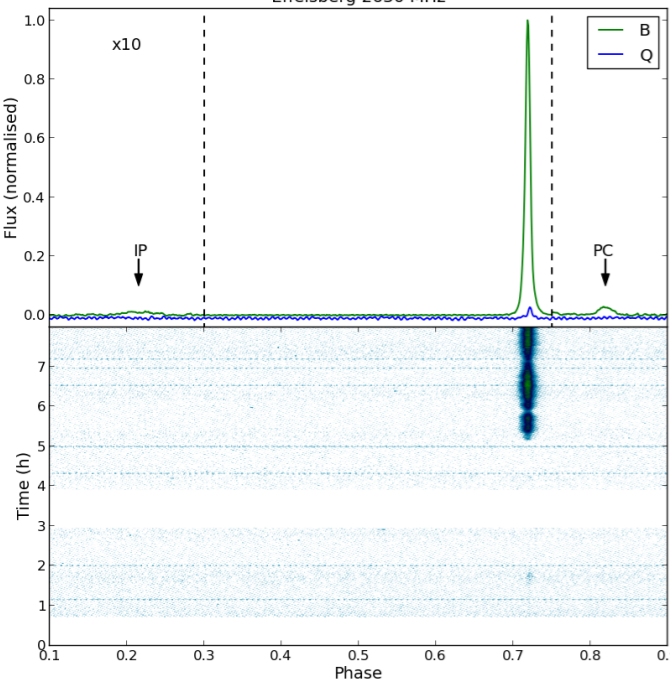
Lovell 1530 MHz



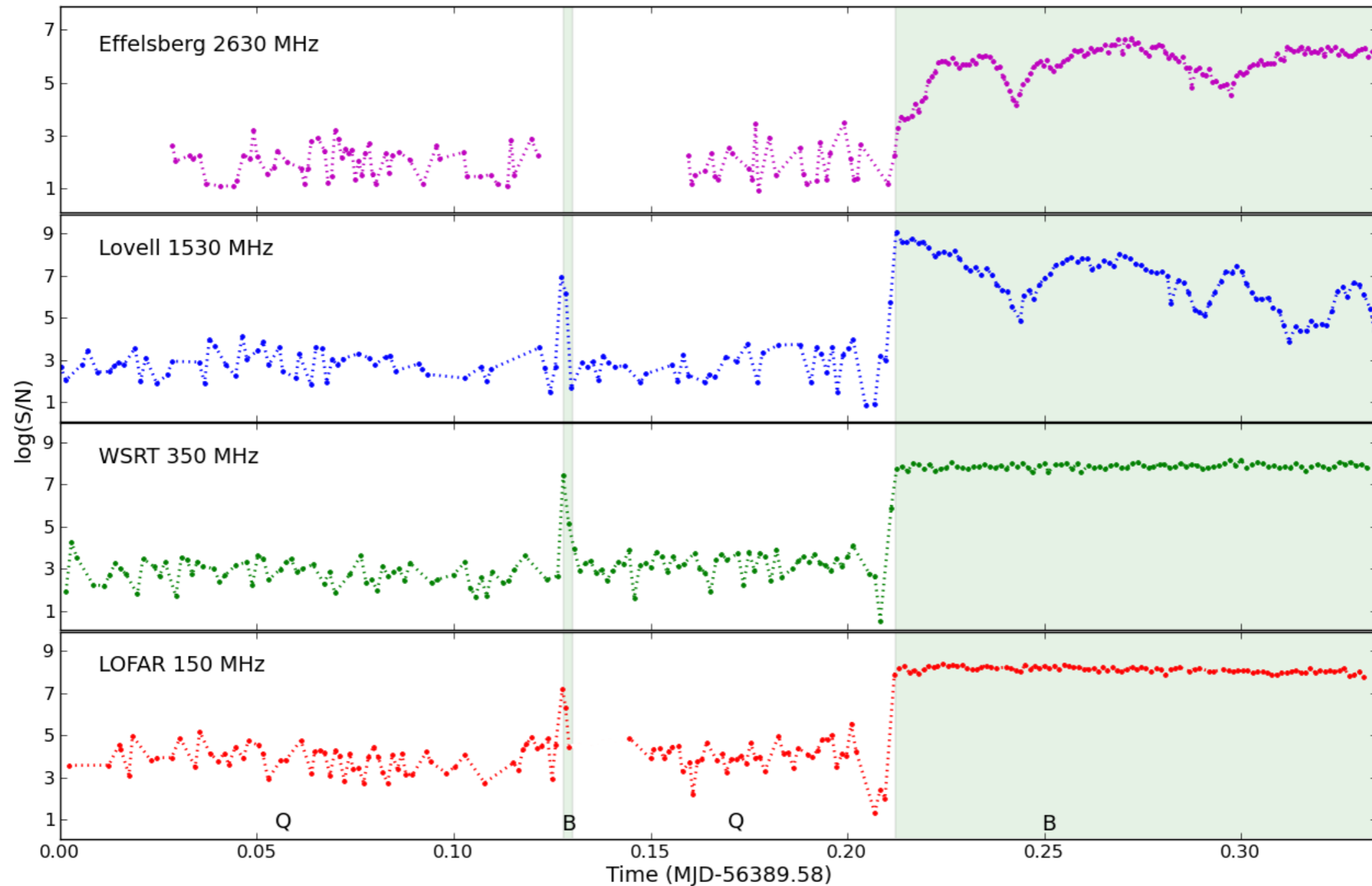
WSRT 350 MHz



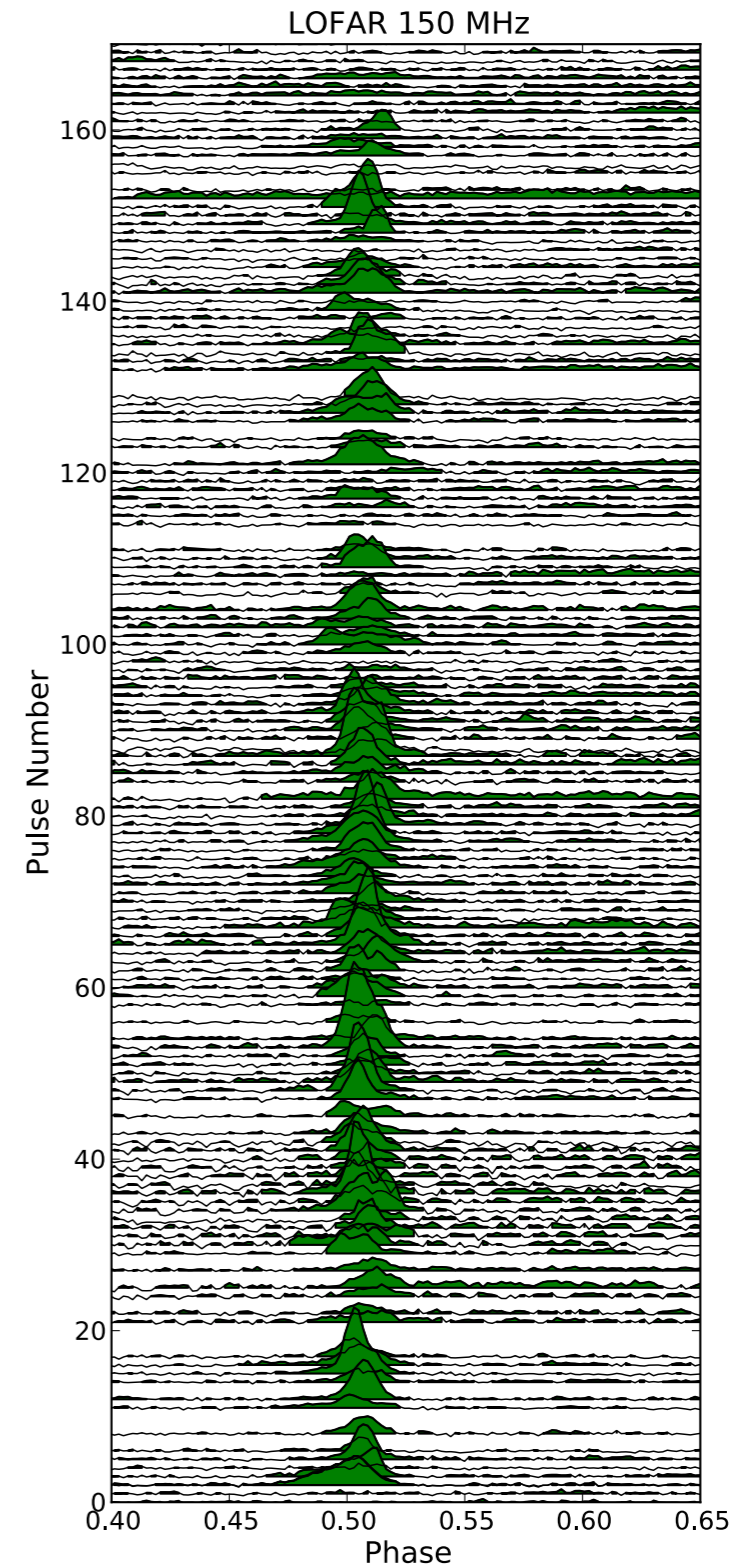
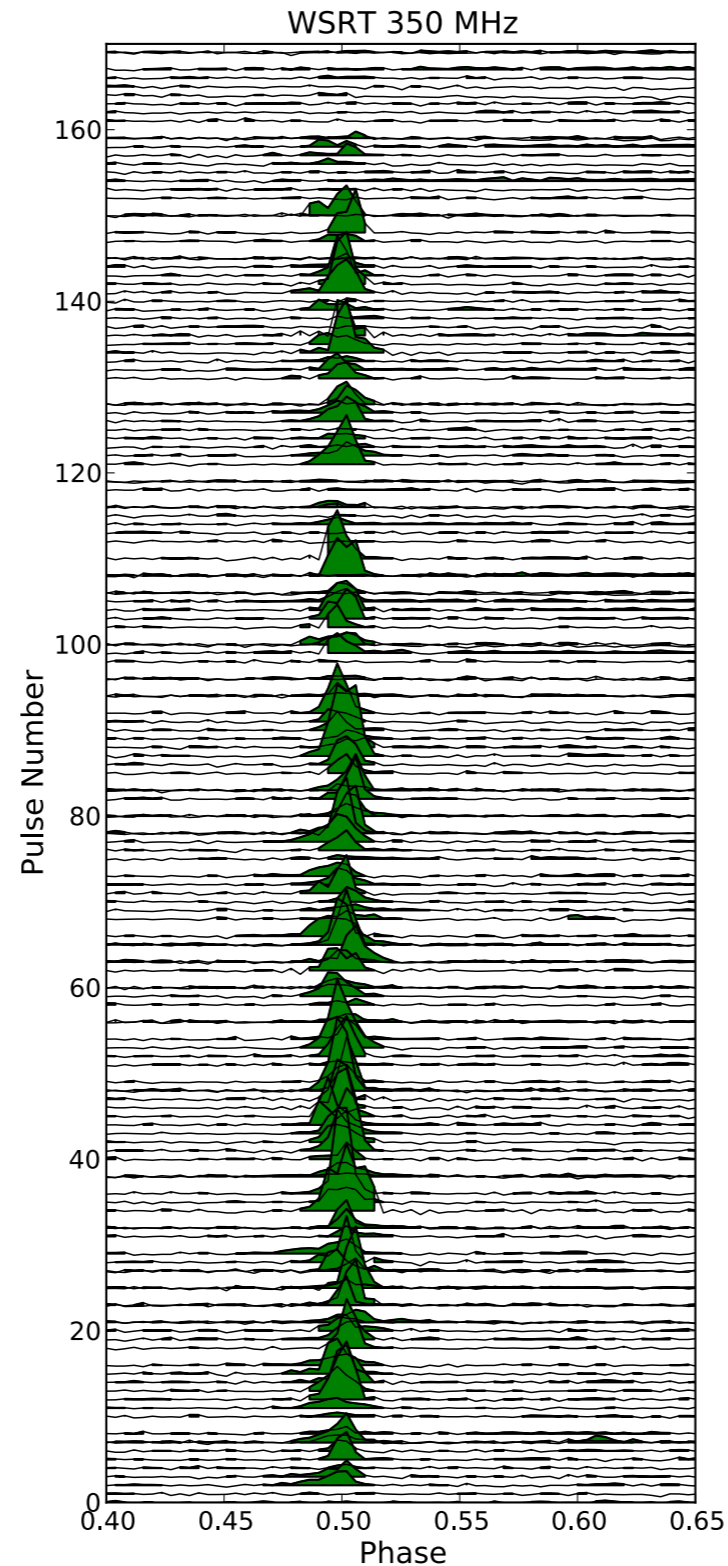
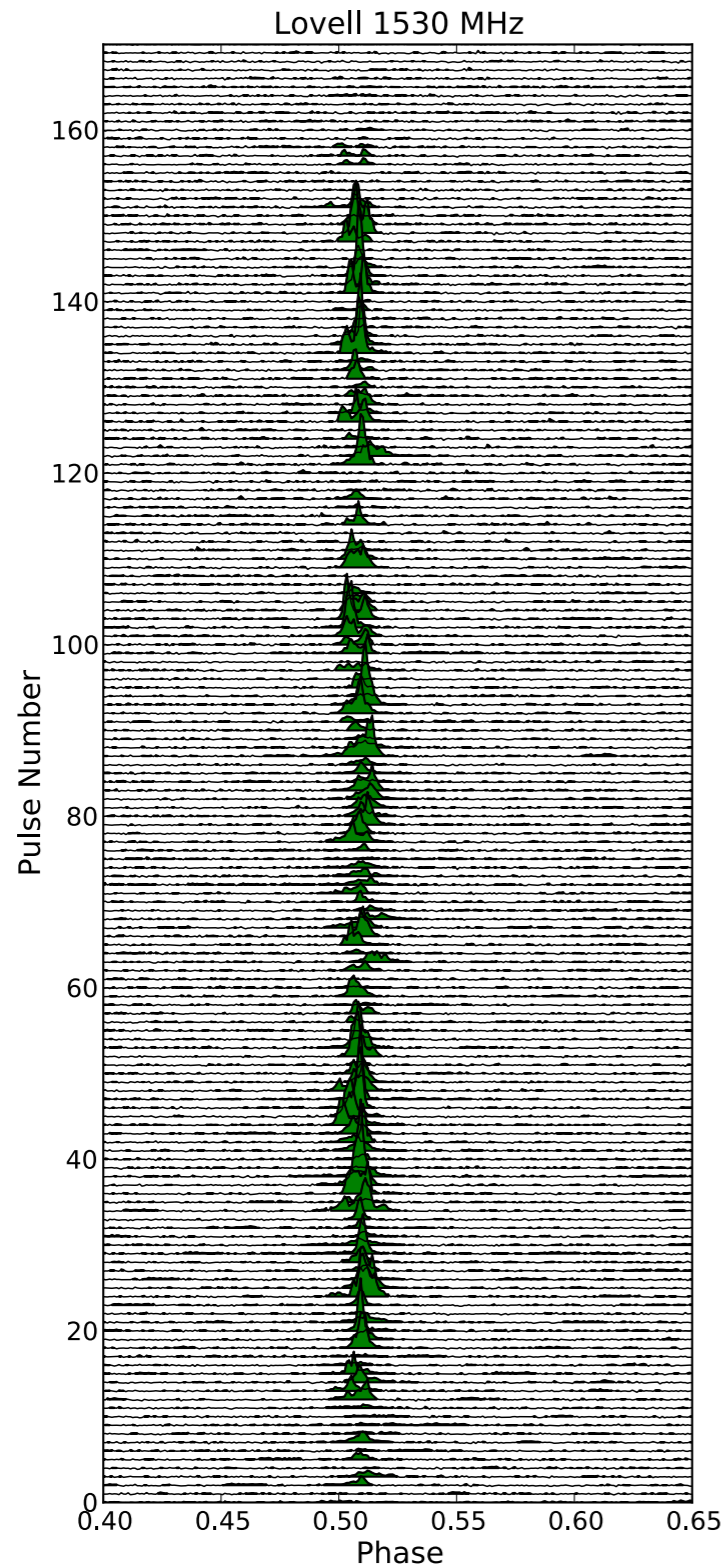
LOFAR 150 MHz



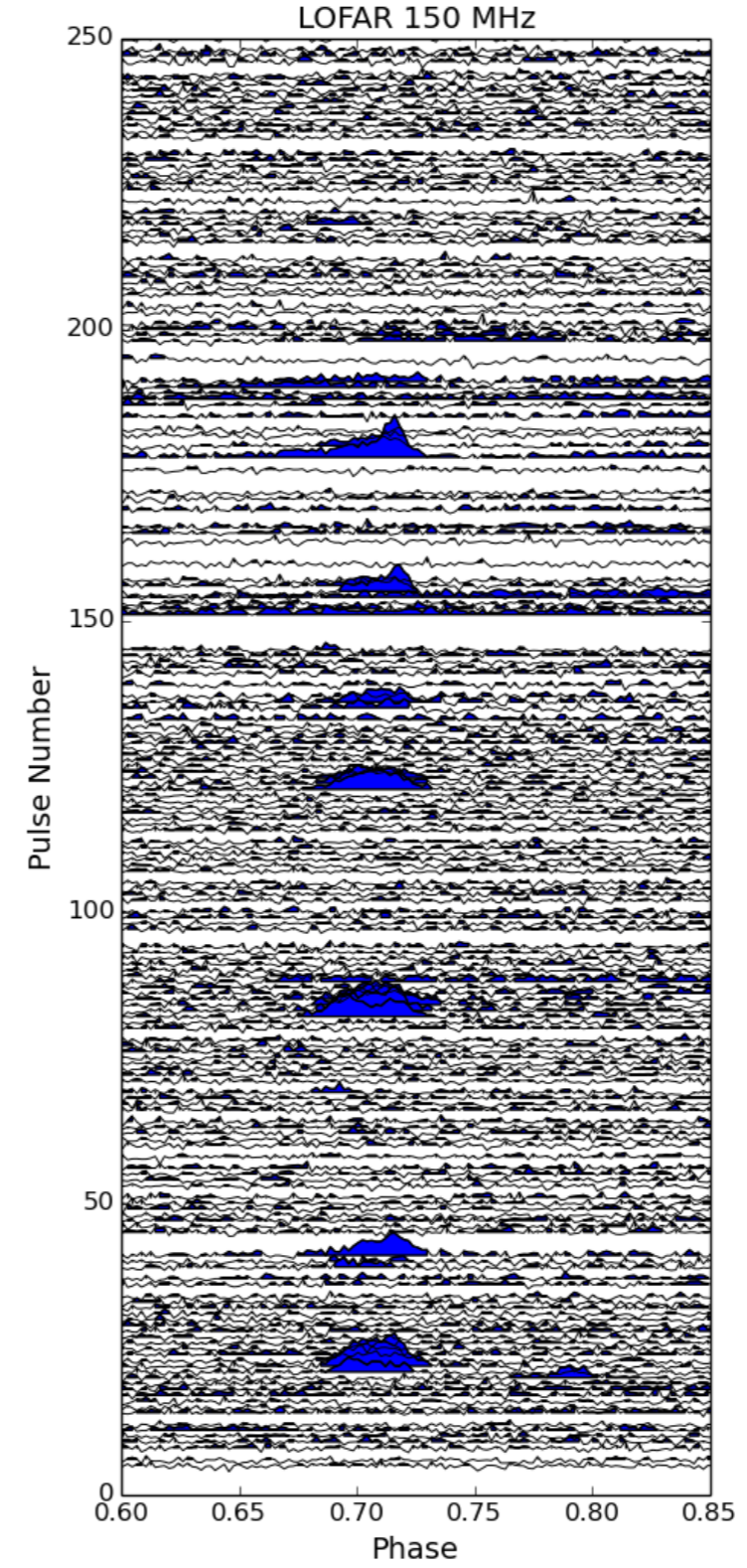
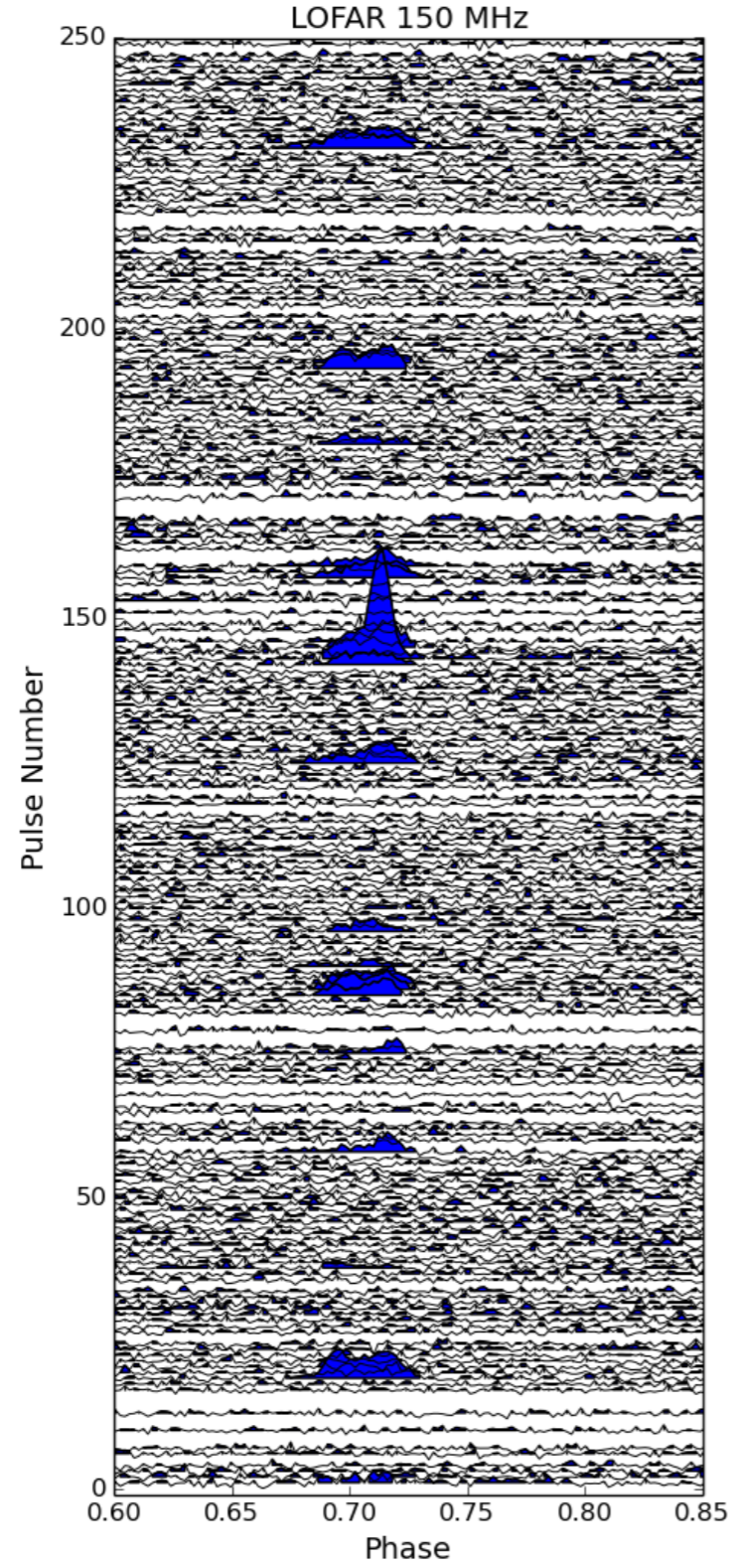
- Mode-change broadband behaviour & visible scintillation



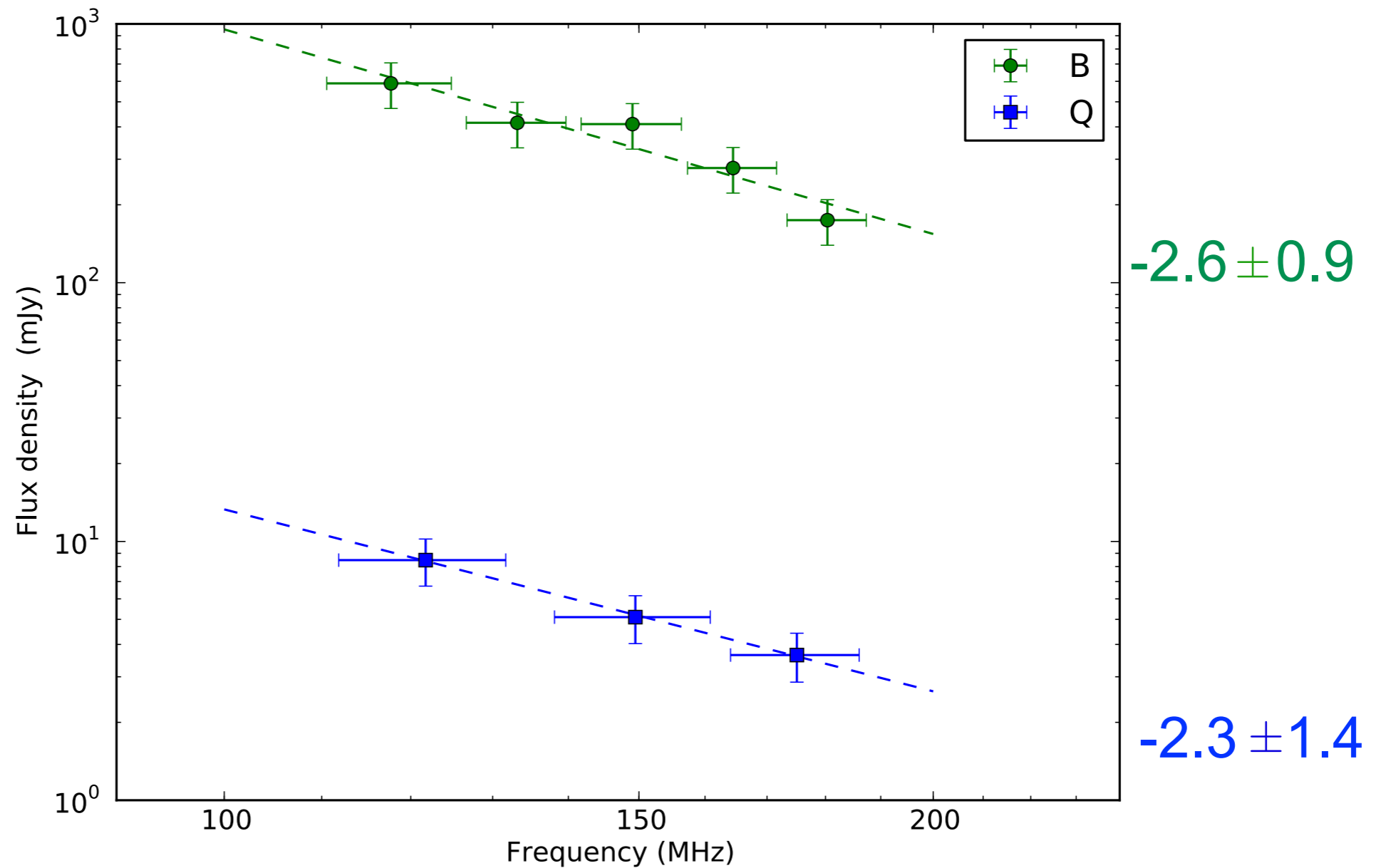
- Simultaneous mode-change & nulling (bright mode ~2%)



- Quiet emission: weak, sporadic, larger nulling fraction (~50%)

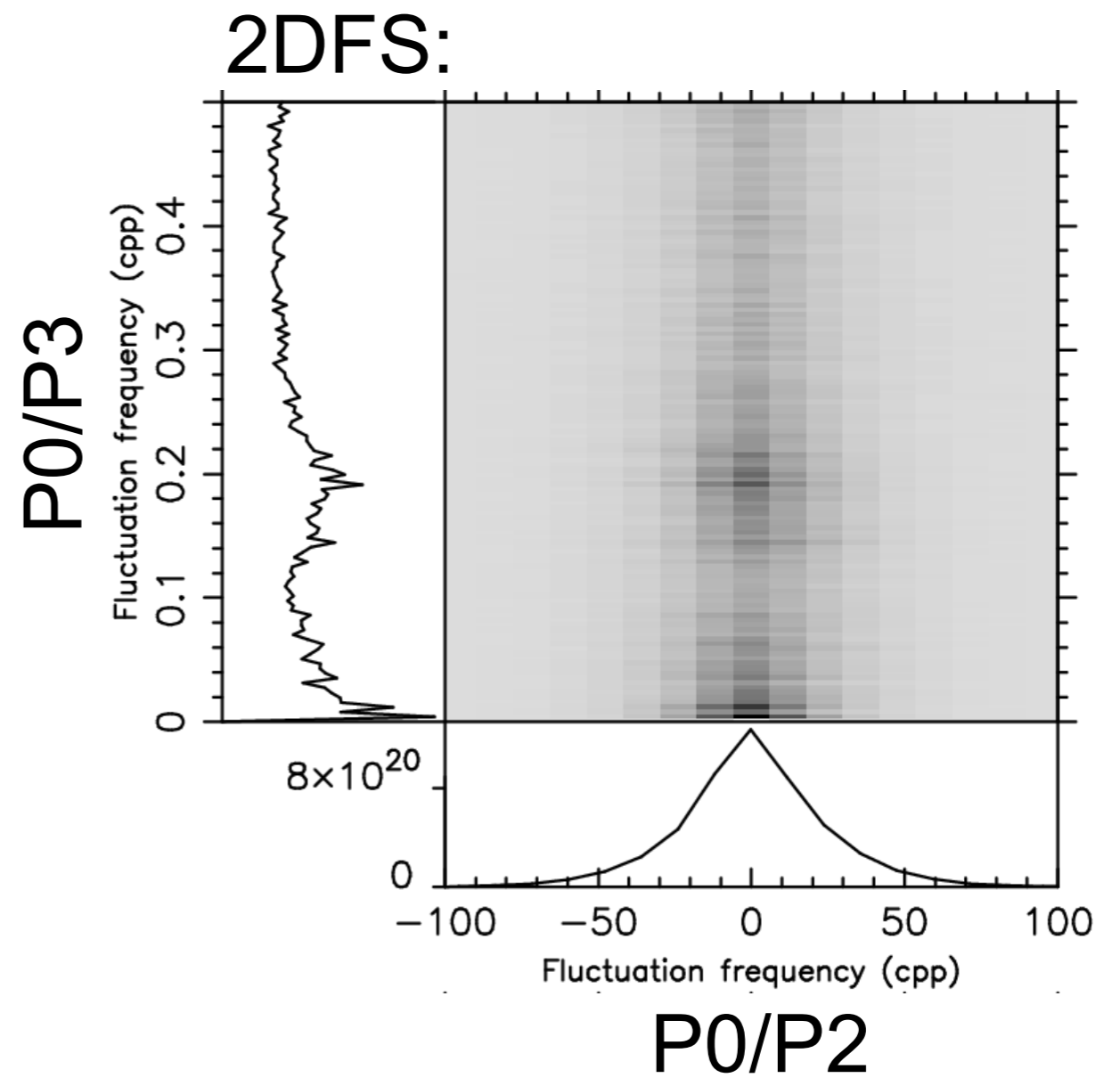
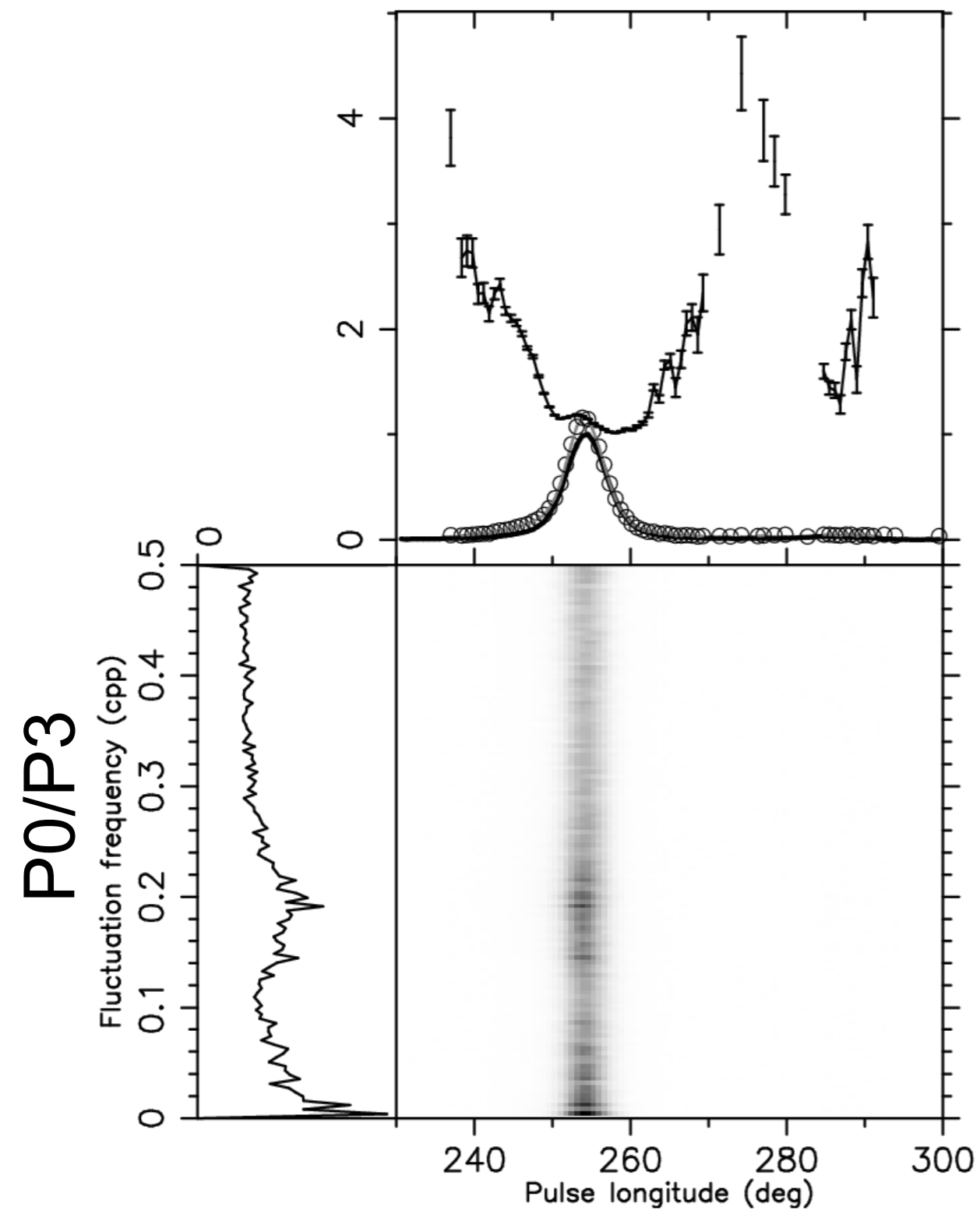


- Mode-separated LOFAR spectra: $S \propto \nu^{-\alpha}$

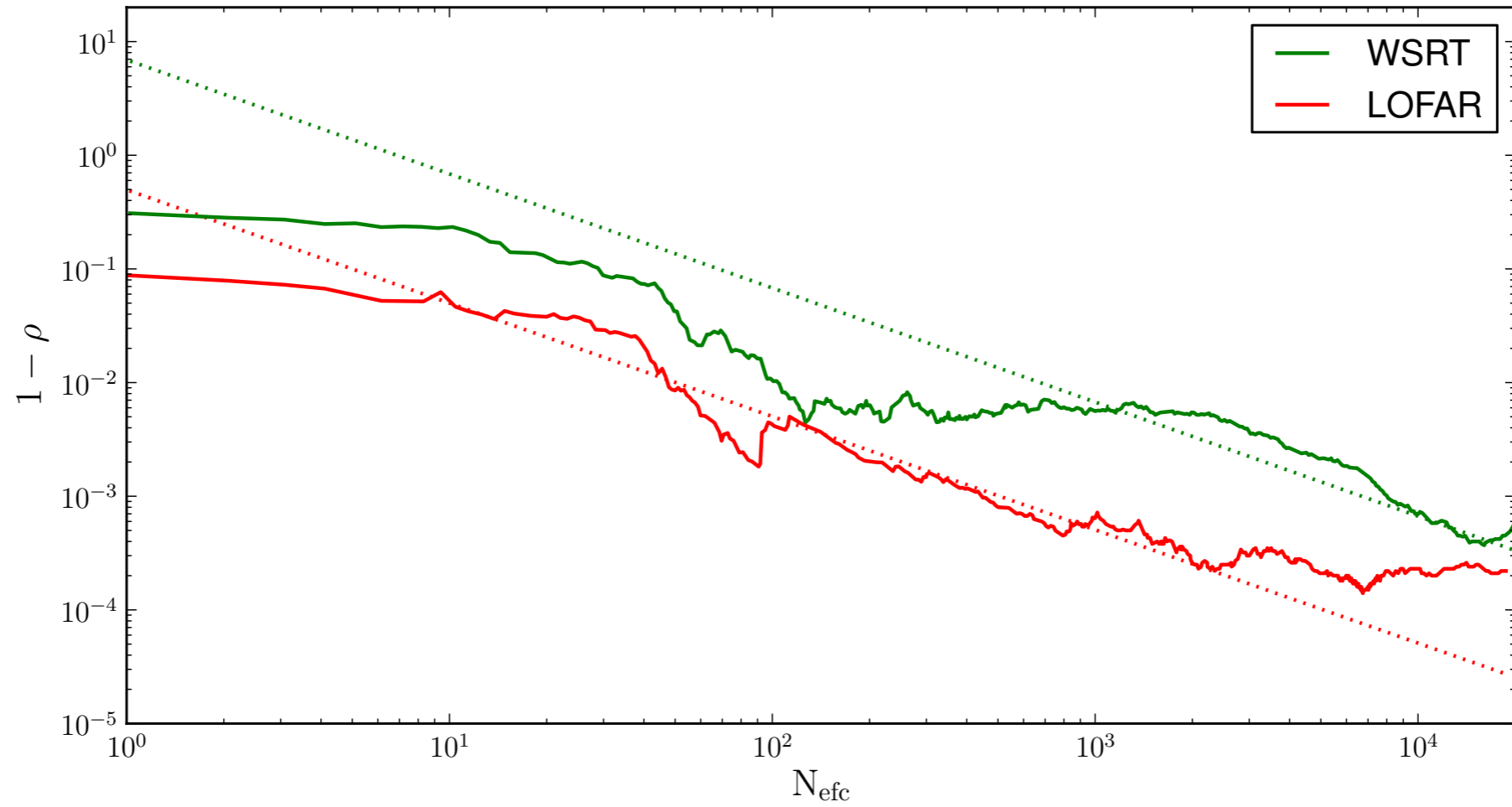


[pulsar spectra with LOFAR: T. Hassall et al., in prep.]

- Bright mode LRFS: $P3=5.26P0$ (Good agreement w/ Weltevrede+2007)

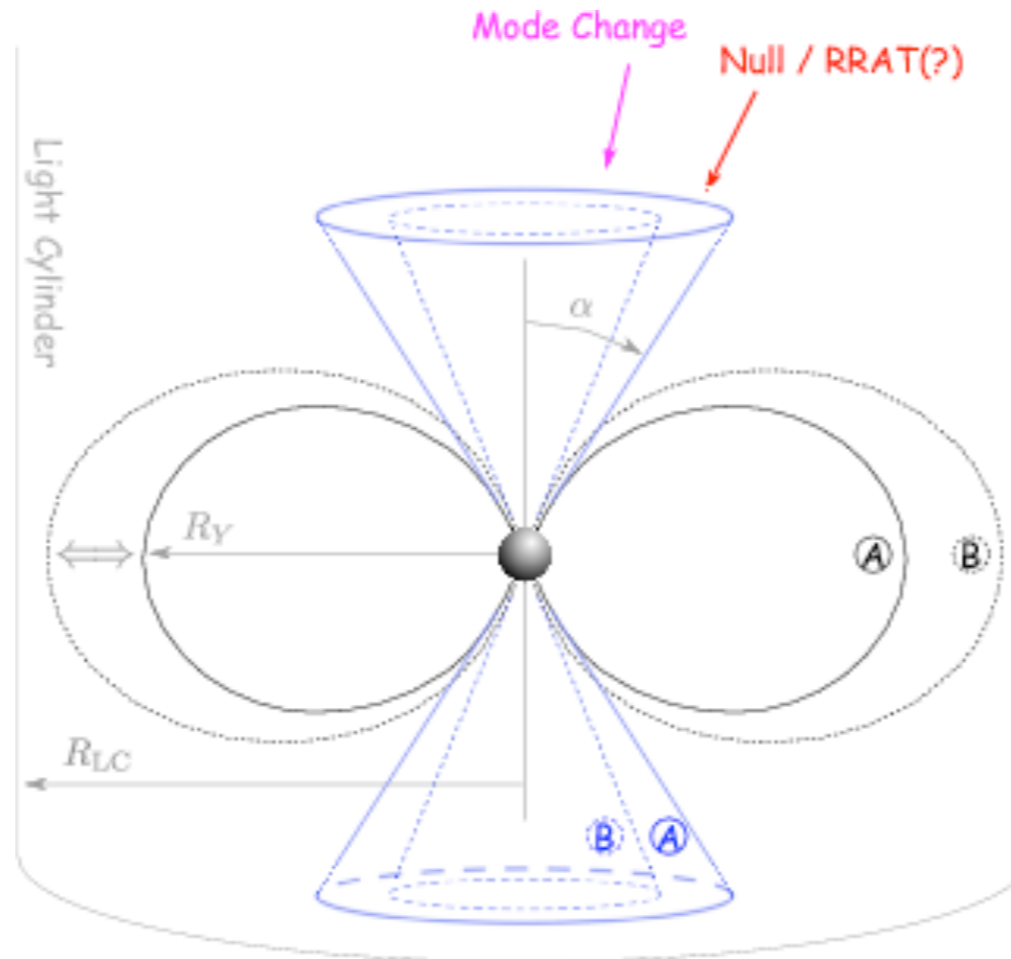


- Bright mode: pulse number - correlation coefficient



- Many effects to take into account when modelling magnetosphere

- Probing meta-stable states with mode-changers



[Timokhin 2010]

- Argument for multi-pass pulsar surveys, e.g., RRATs, etc.

- LOFAR observations of B0823+26:
 - Longer polarisation observations (RM, RVM)
 - LBA observations (spectra)
- LOFAR observations of extreme nulling/mode-changing
 - Similar to B0823+26, or line-of-sight geometry important?
- More interesting discoveries in multi-pass surveys, e.g., LOTAAS (c.f. S. Cooper's talk, T. Coenen PhD thesis, 2013)

- Pulsars are useful tools for studying magnetic fields in astrophysical plasmas - over many orders of magnitude
- LOFAR provides high quality pulse profiles and precise RMs
- Pulsars show plethora of magnetospheric emission phenomena
- **Thank you for listening!**

