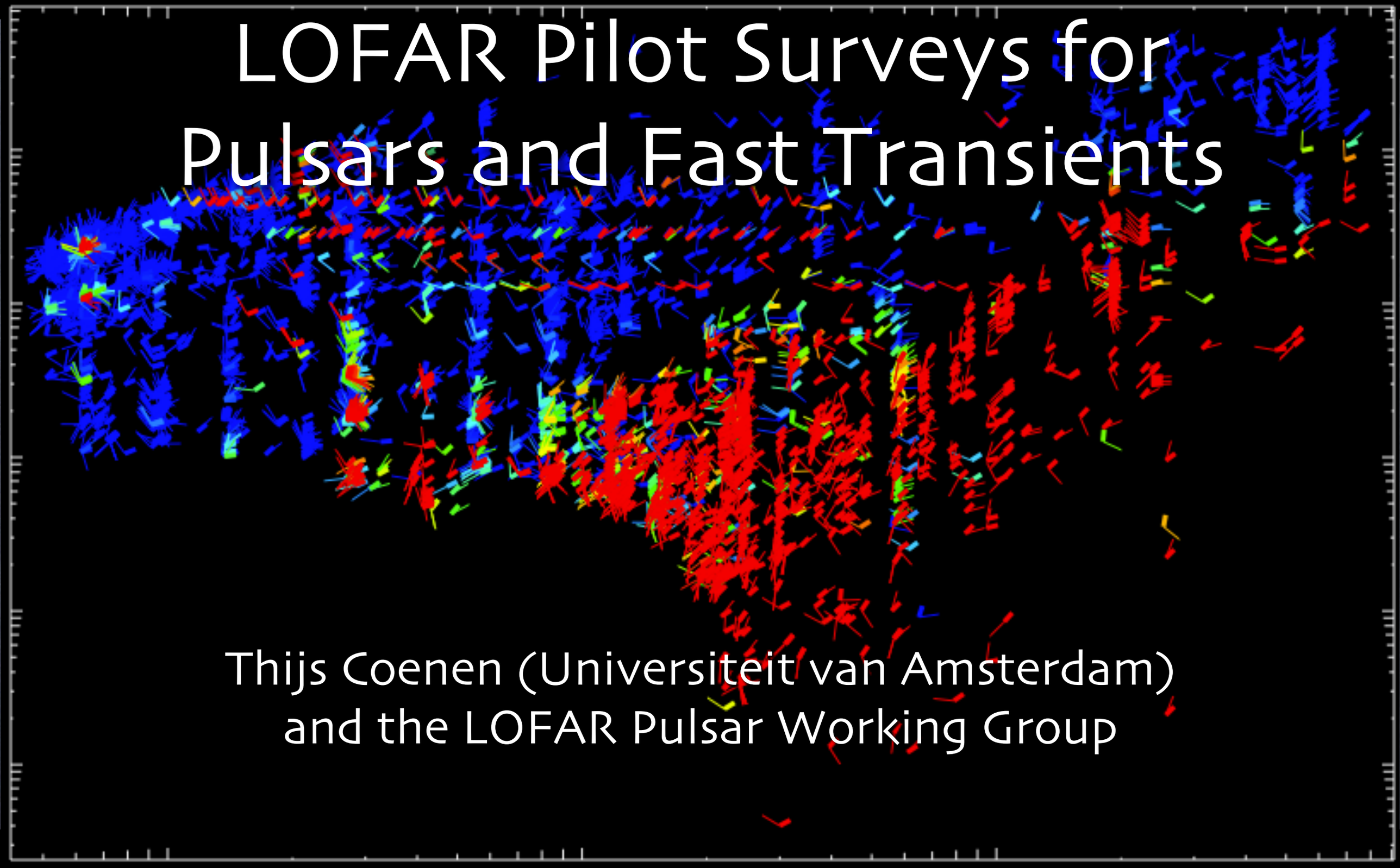
LOFAR Pilot Surveys for Pulsars and Fast Transients

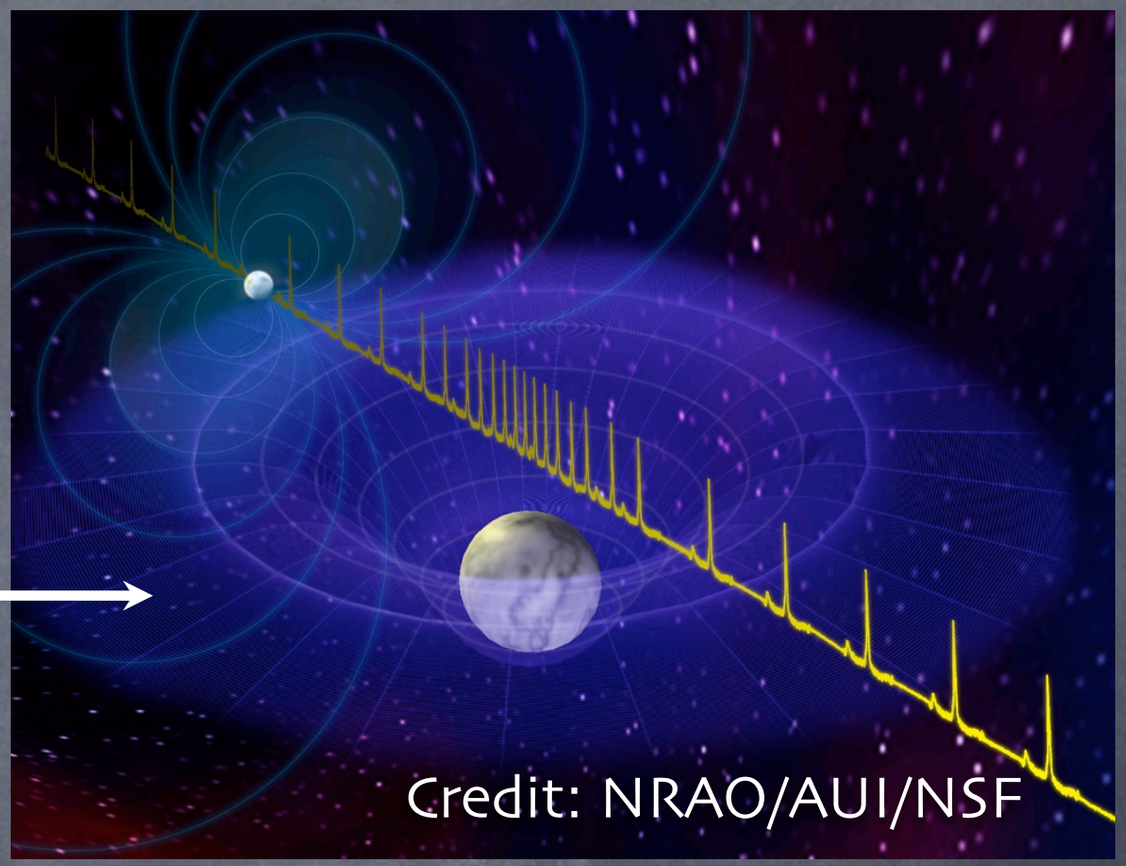


Thijs Coenen (Universiteit van Amsterdam)
and the LOFAR Pulsar Working Group

First Science with LOFAR - Dalfsen - 13 september 2011

Why survey for pulsars?

- With pulsars one can study:
  - Pulsars emission processes (cf. Vlad and Tom's talks).
  - Constrain dense matter Equation of State (e.g. Demorest et al 2010).
  - Look for gravitational radiation (indirect detection already with pulsar + NS system).
  - Inter stellar medium, earth's ionosphere, galactic magnetic fields etc.



Why with LOFAR?

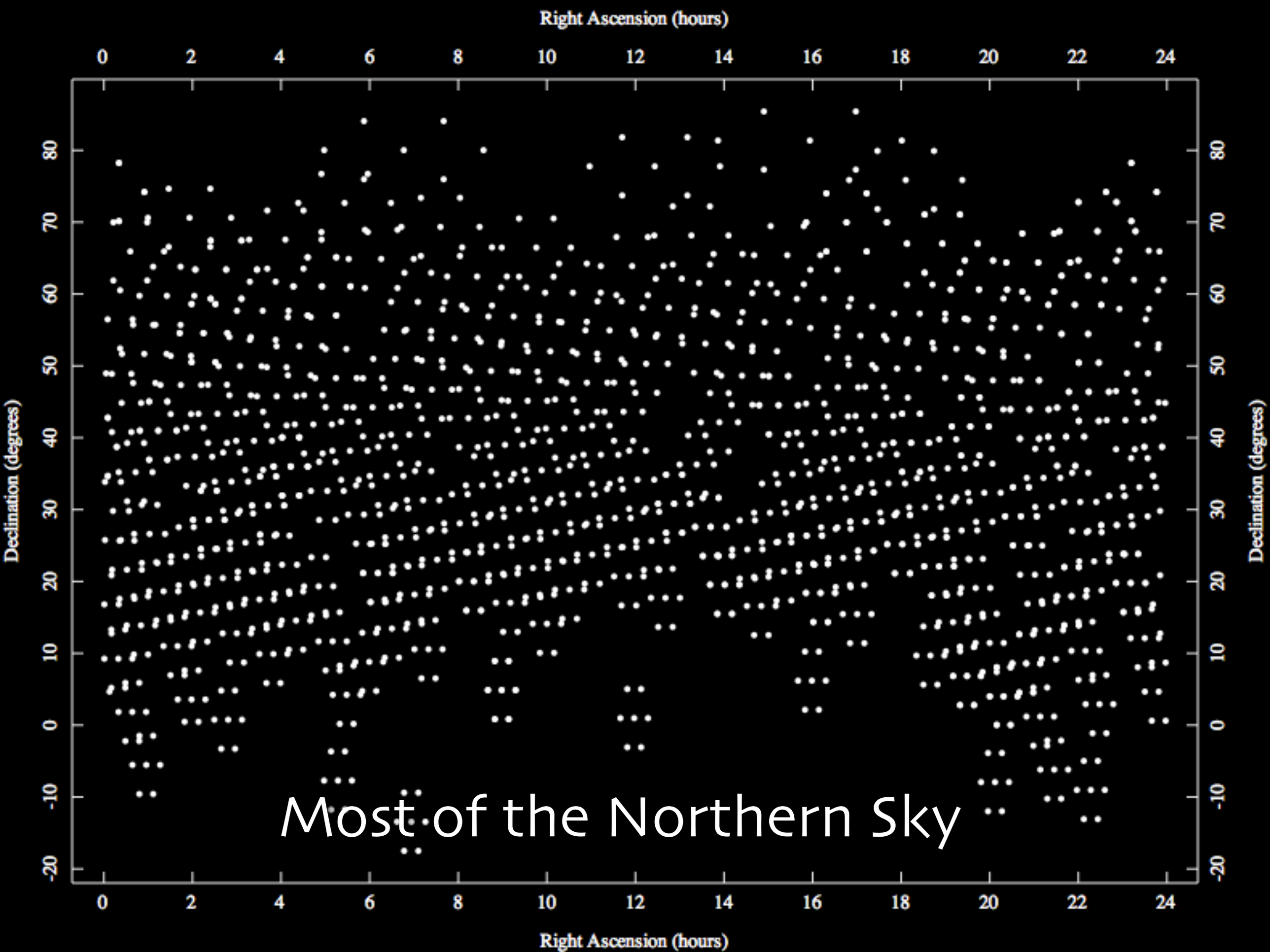
- Efficient, multiple beams, large field of view.
- Low-frequency radio relatively under-explored part of parameter space.
- Sensitivity, large collecting area, large bandwidth coverage.

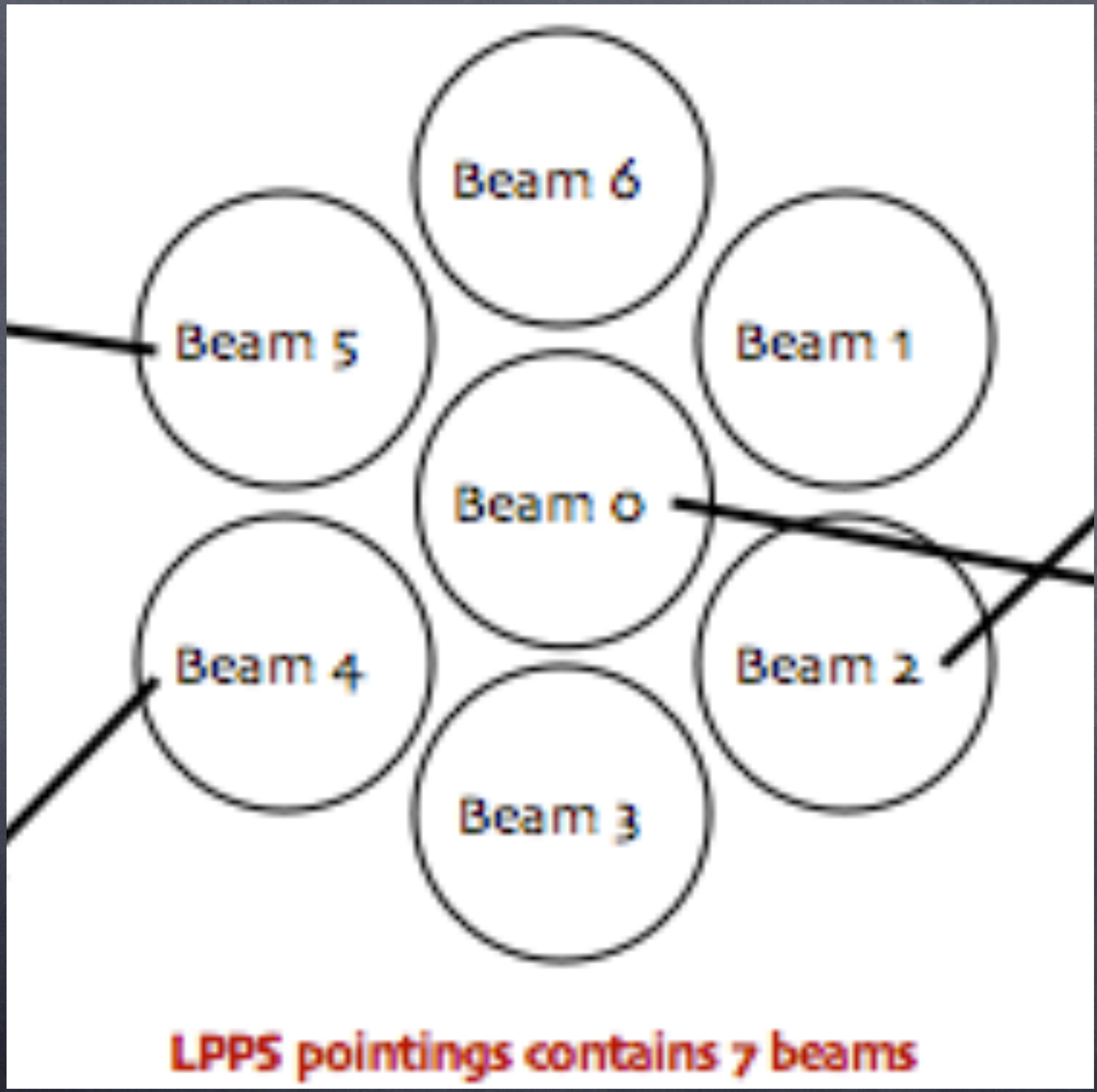
Pulsar Surveys

- Different types of surveys test different observing modes and probe different parts of parameter space.
- HBA
  - incoherent : LPPS
  - coherent : LOTAS
- LBA
  - incoherent : LoMASS

LOFAR Pilot Pulsar Survey (LPPS)

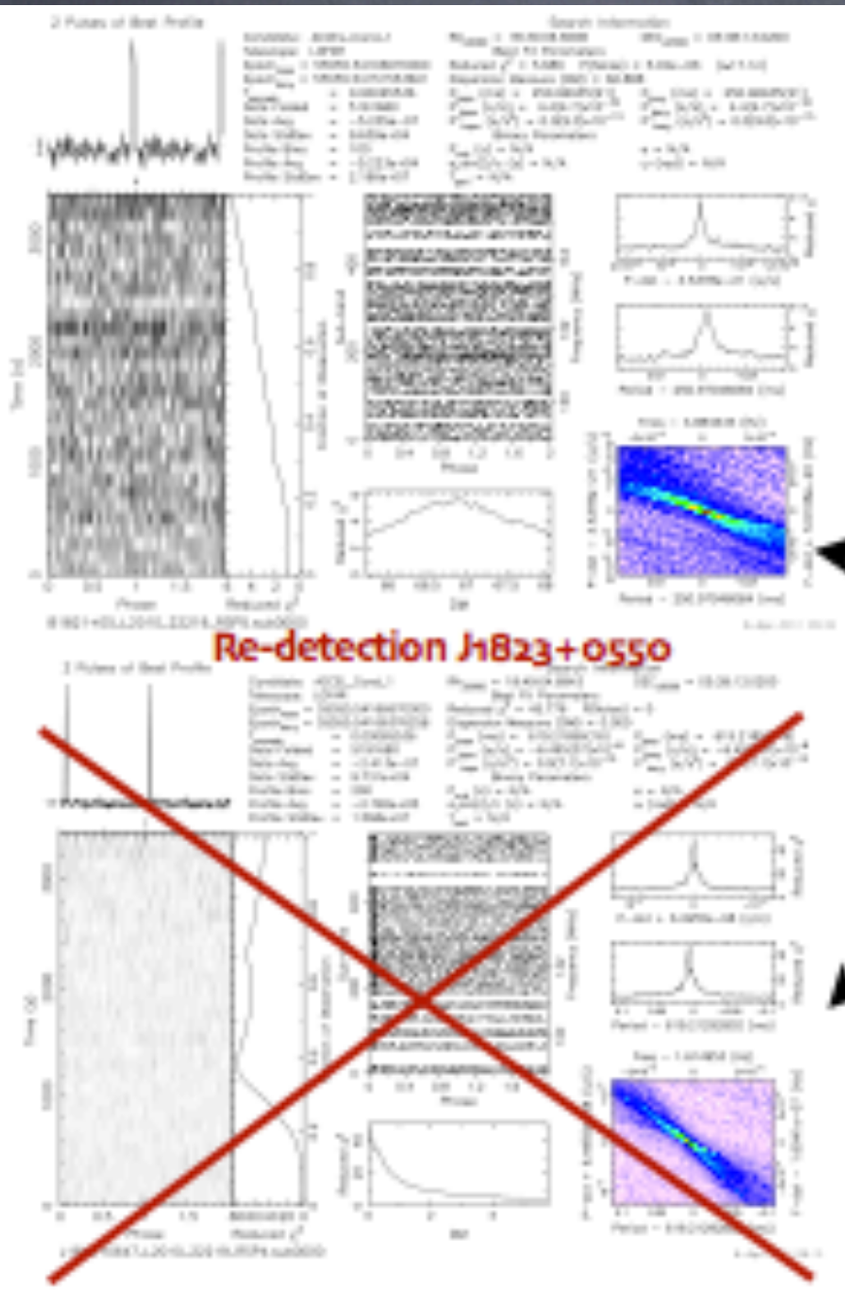
- Incoherent addition (about 20 stations).
- 7 beams, 7 MHz bandwidth per beam, 0.65 ms sampling time
- 57 minutes integrations
- 167 square degrees of sky
- Almost 250 observations taken around christmas 2010.


Right Ascension (hours)
0
2
4
6
8
10
12
14
16
18
20
22
24
Declination (degrees)
80
70
60
50
40
30
20
10
0
-10
-20
Most of the Northern Sky

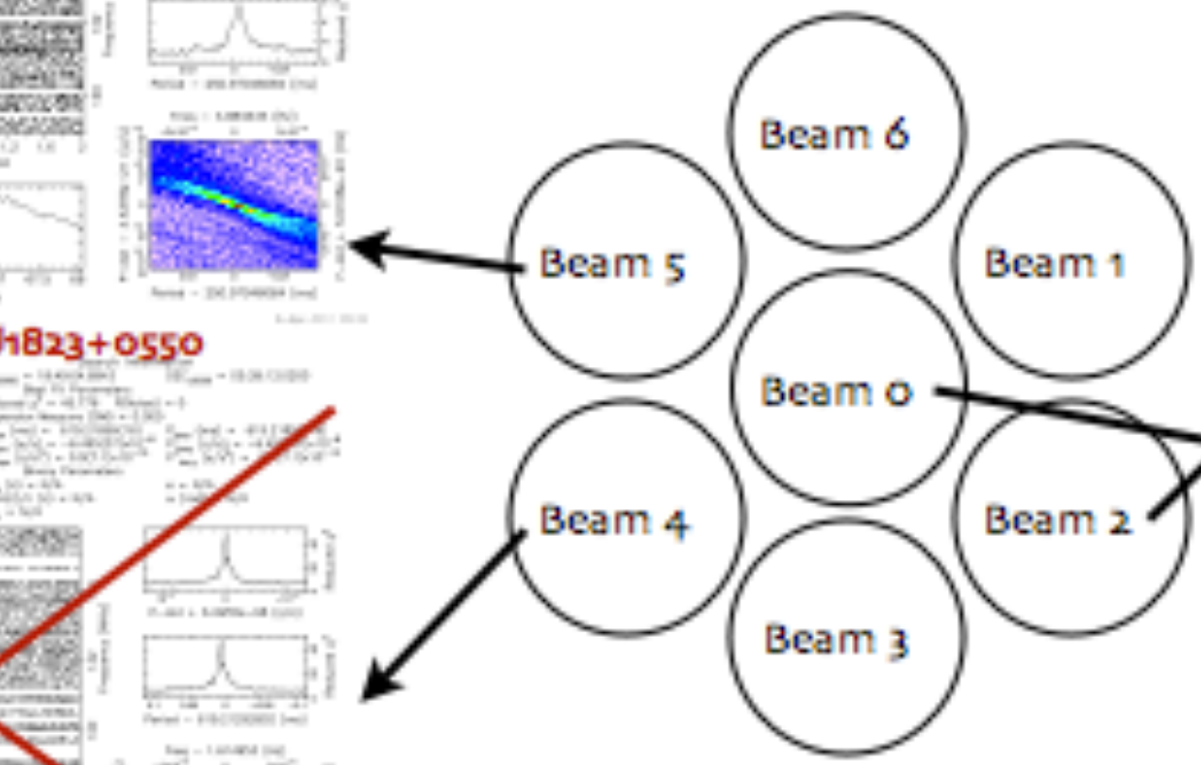


LPPS pointings contains 7 beams

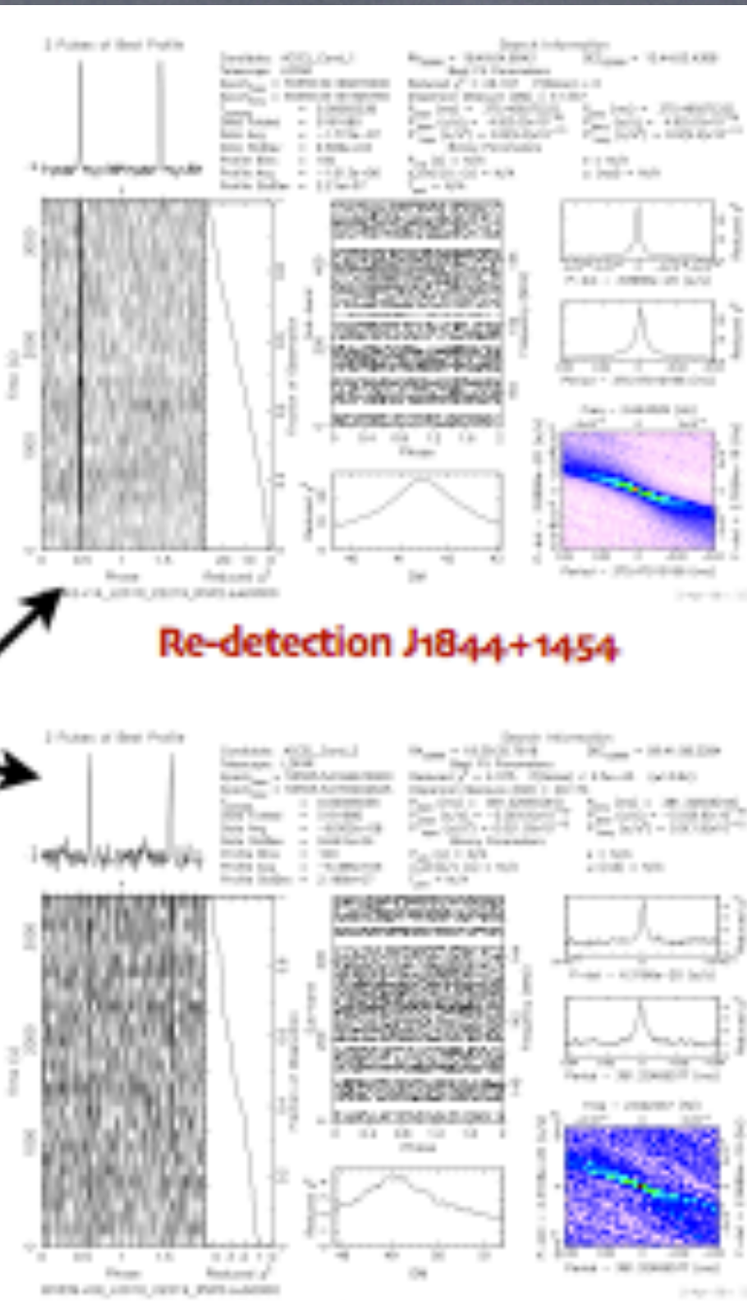
Blind re-detections in LPPS



Re-detection J1823+0550



LPPS pointings contains 7 beams



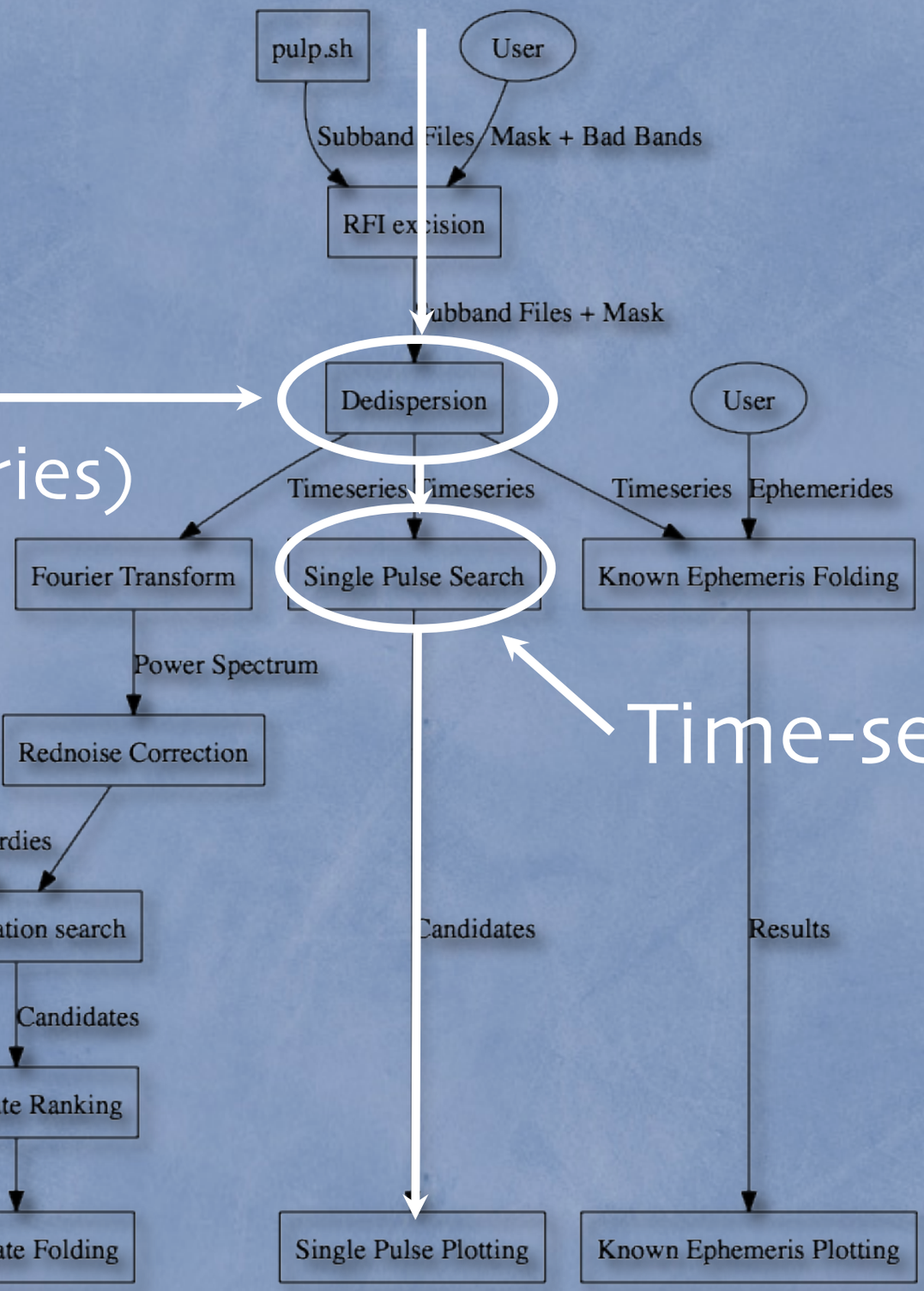
Re-detection J1844+1454

RFI (DM = 0 cm-3 pc)

Re-detection J1841+0912

Credit: Coenen

Fast Transients Search

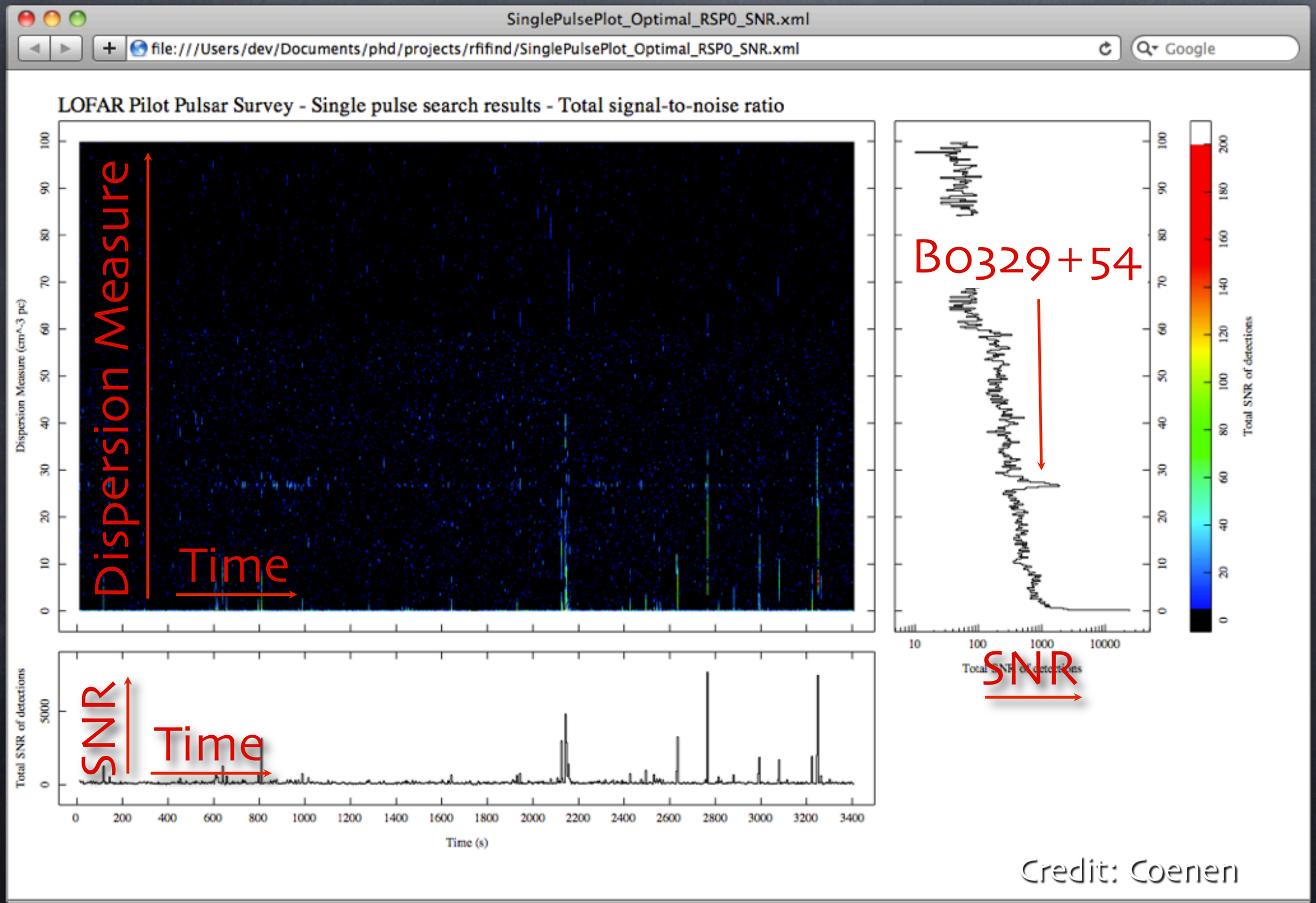


Dedispersion
(creates time-series)

Time-series search

Credit: Coenen

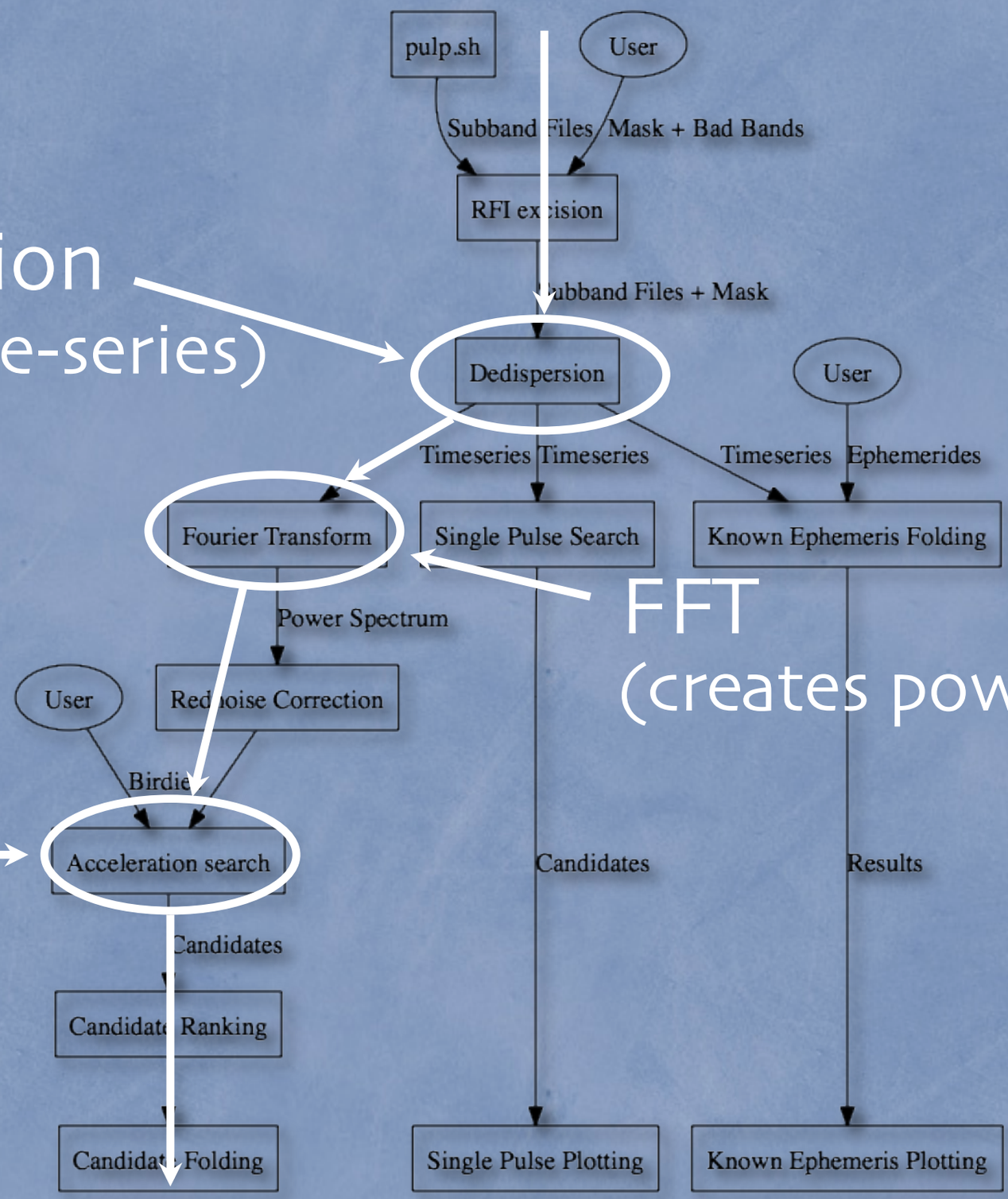
Fast Transients Search



Credit: Coenen

Periodicity search

Dedispersion
(creates time-series)



FFT
(creates power spectrum)

Search

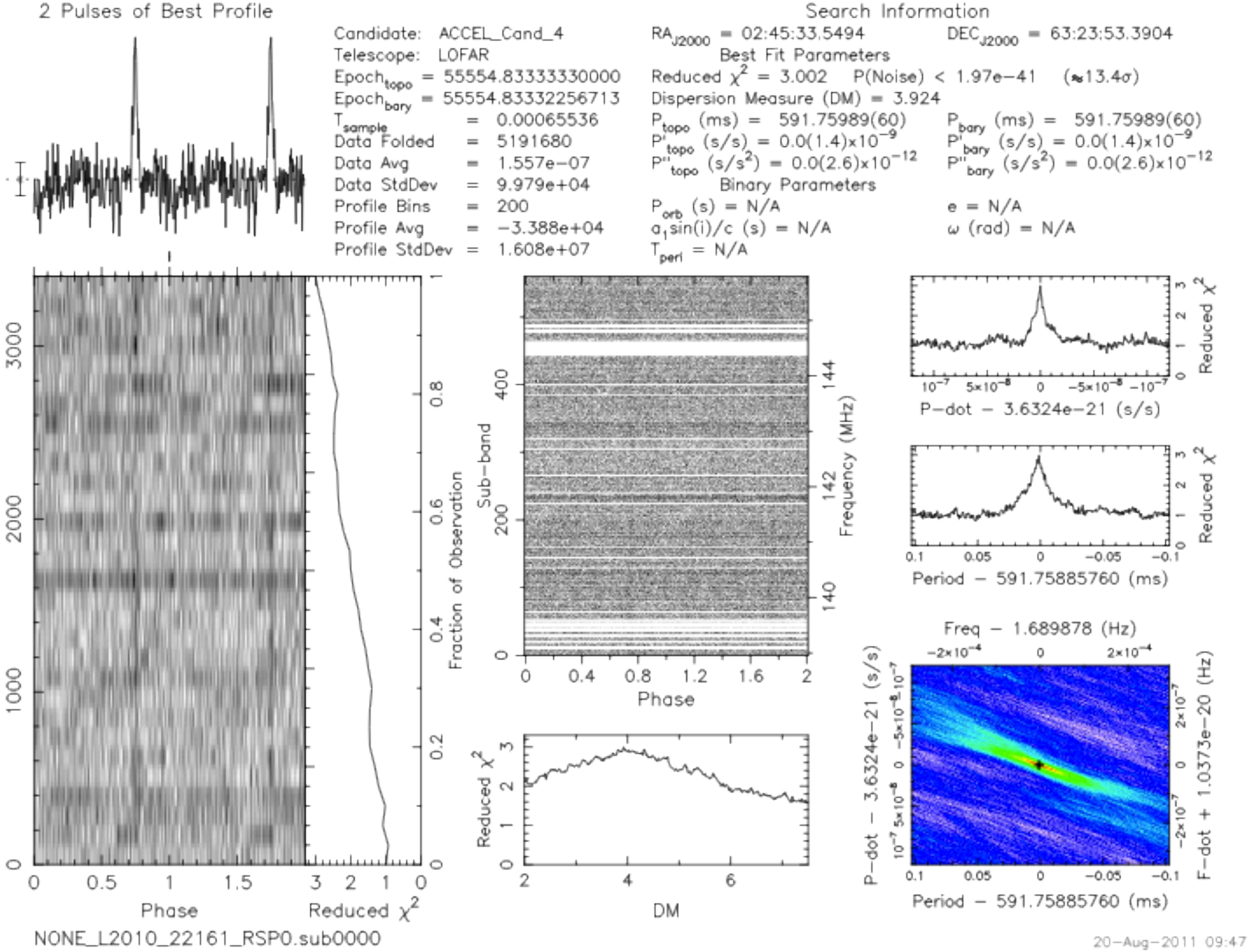
Credit: Coenen

Result: many pulsar candidates...

Neural Nets to the rescue!

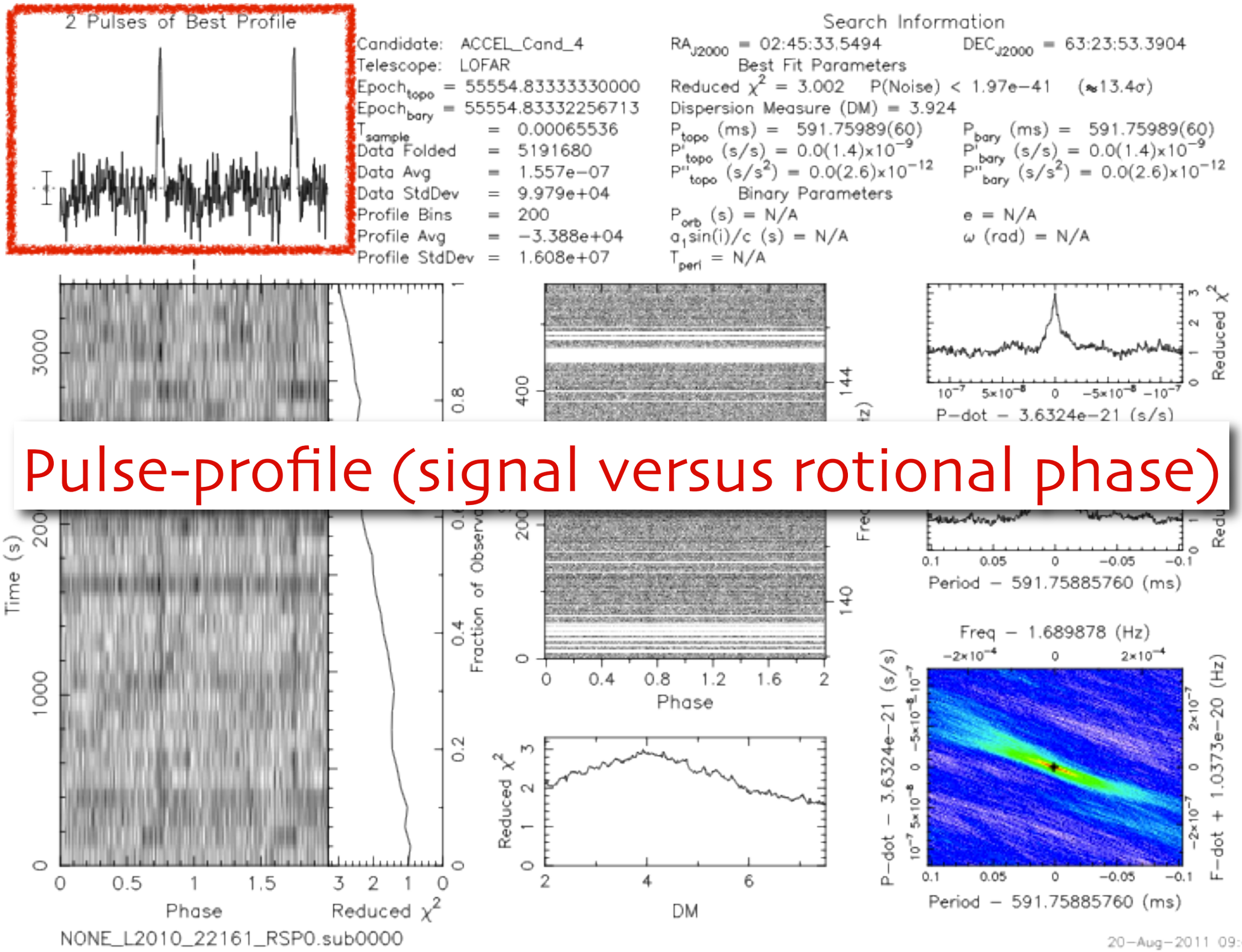
- Neural nets are machine learning algorithms.
- A new neural net was trained on LPPS data by Jenny Green (Manchester).
- Automatically finds about 100 known pulsars in LPPS data.
- Cuts back on inspection of candidate plots by 2 orders of magnitude!

Re-detection of PSR J0240+63



Credit: Stappers & Hassall

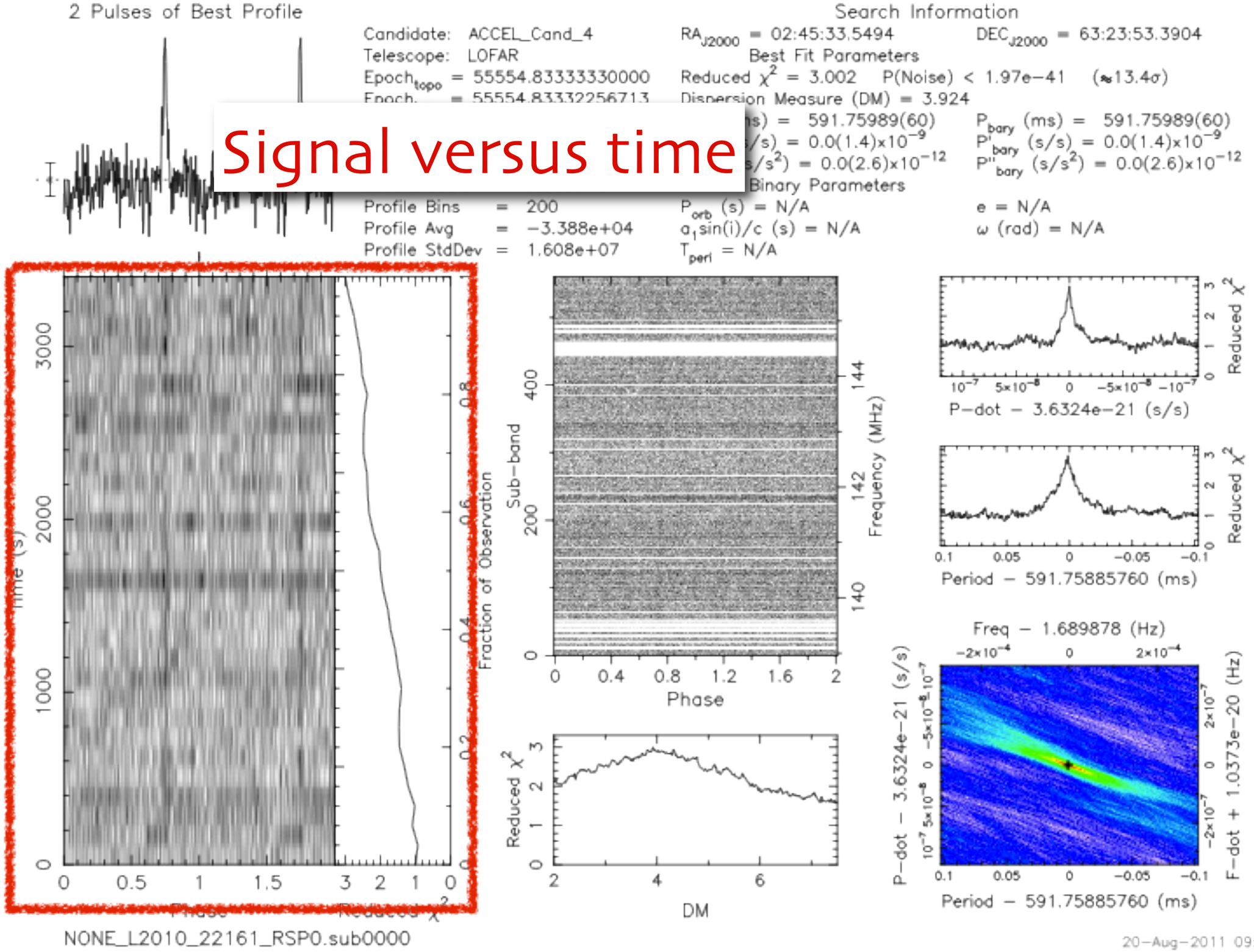
Re-detection of PSR J0240+63



Pulse-profile (signal versus rotional phase)

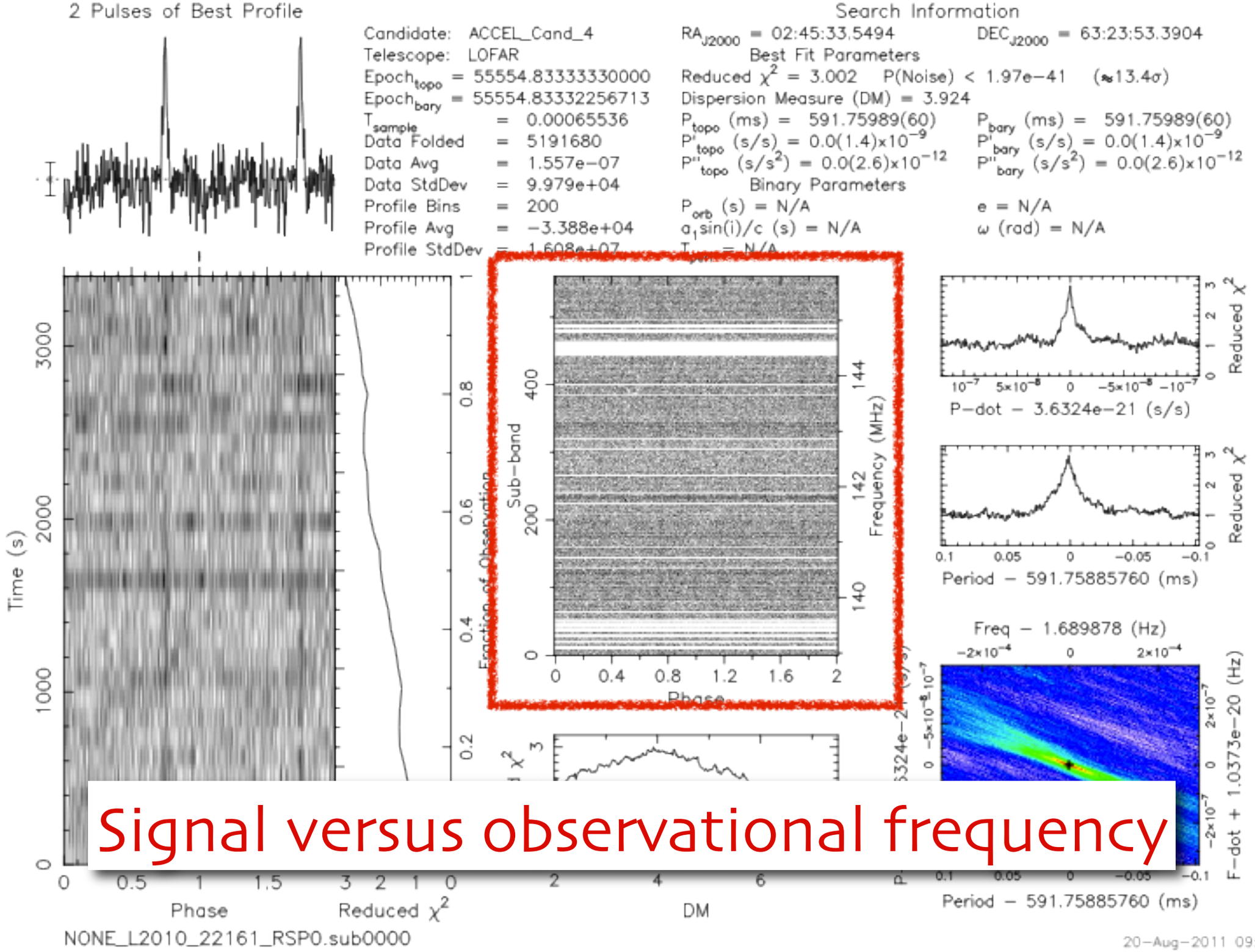
Credit: Stappers & Hassall

Re-detection of PSR J0240+63



Credit: Stappers & Hassall

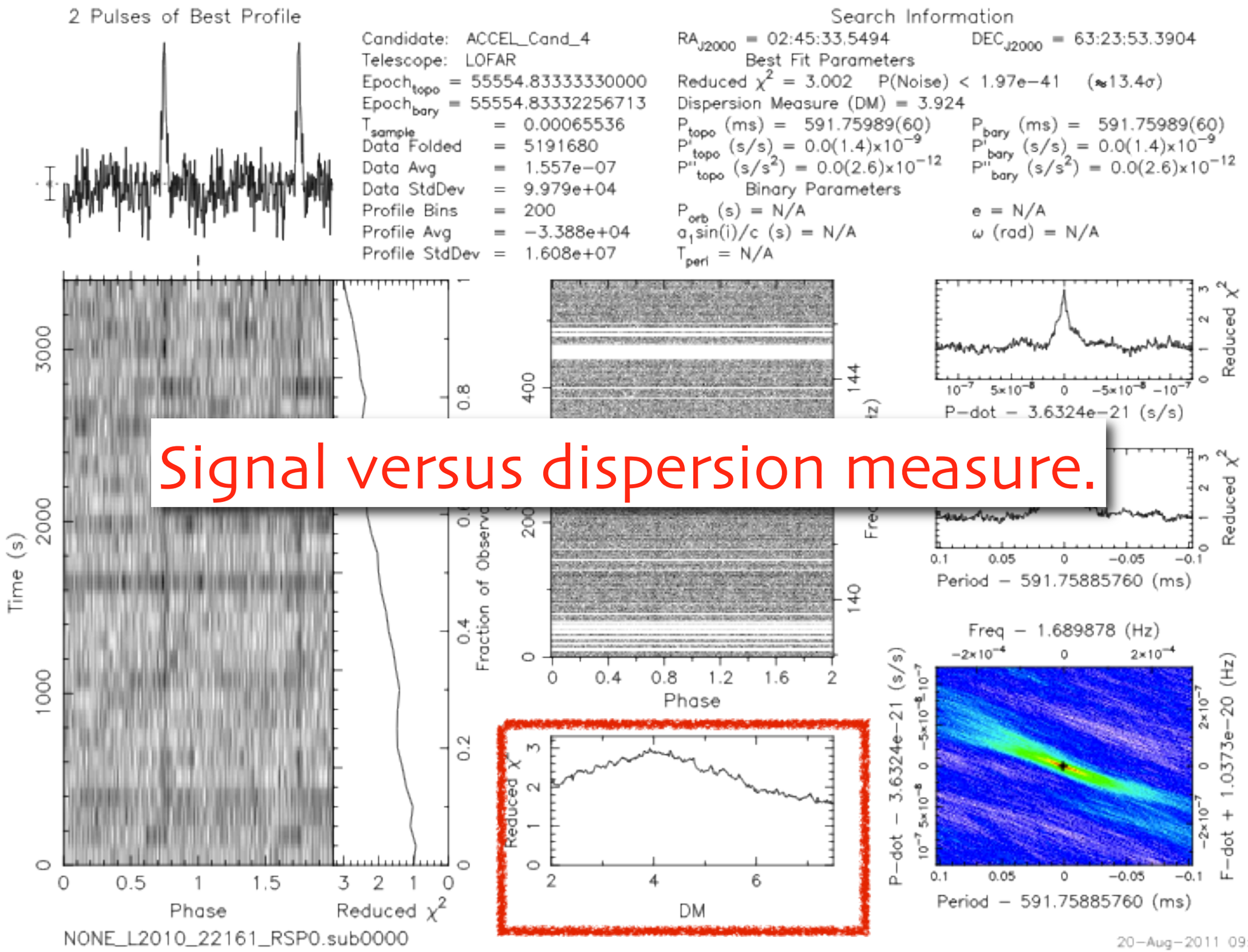
Re-detection of PSR J0240+63



Signal versus observational frequency

Credit: Stappers & Hassall

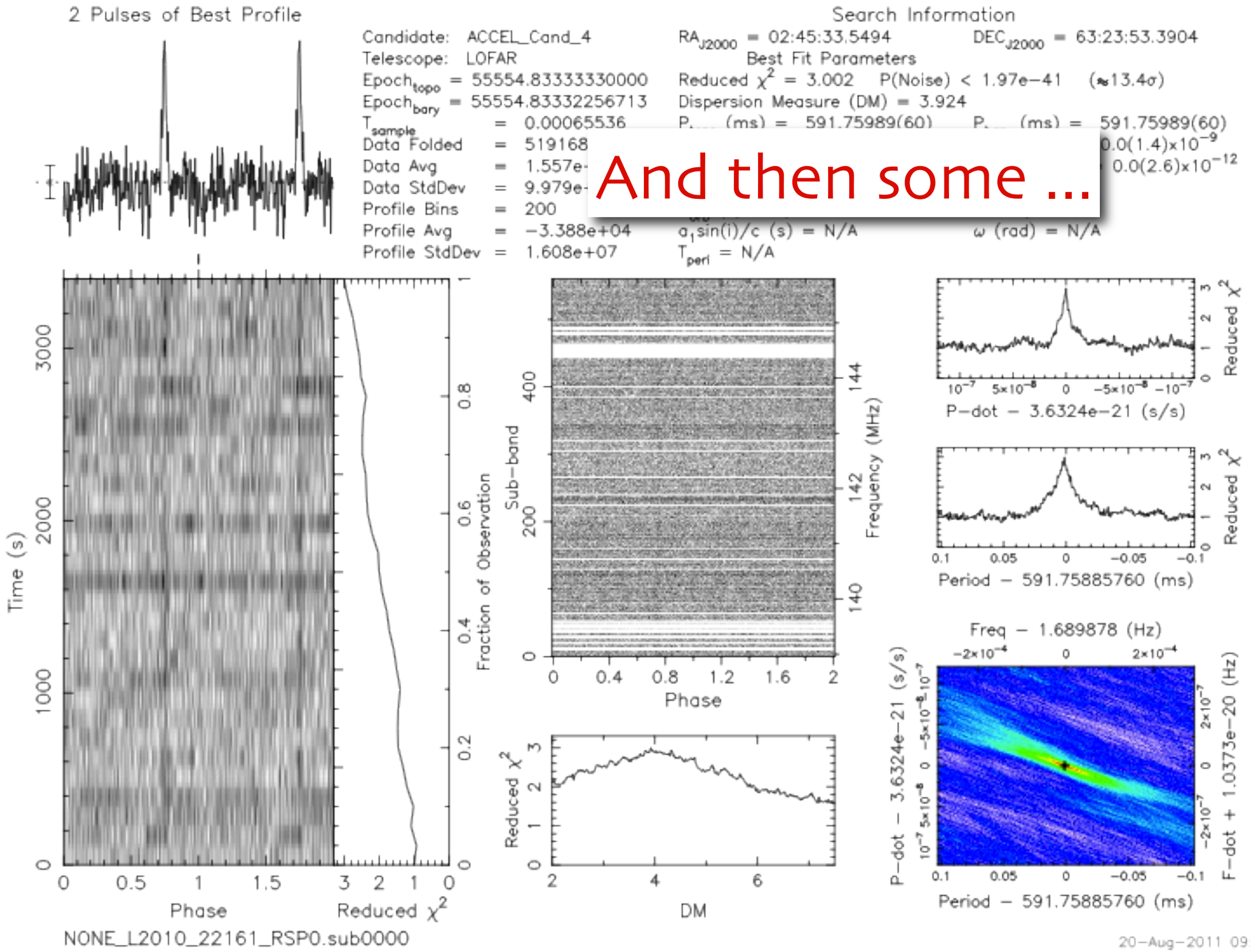
Re-detection of PSR J0240+63



Signal versus dispersion measure.

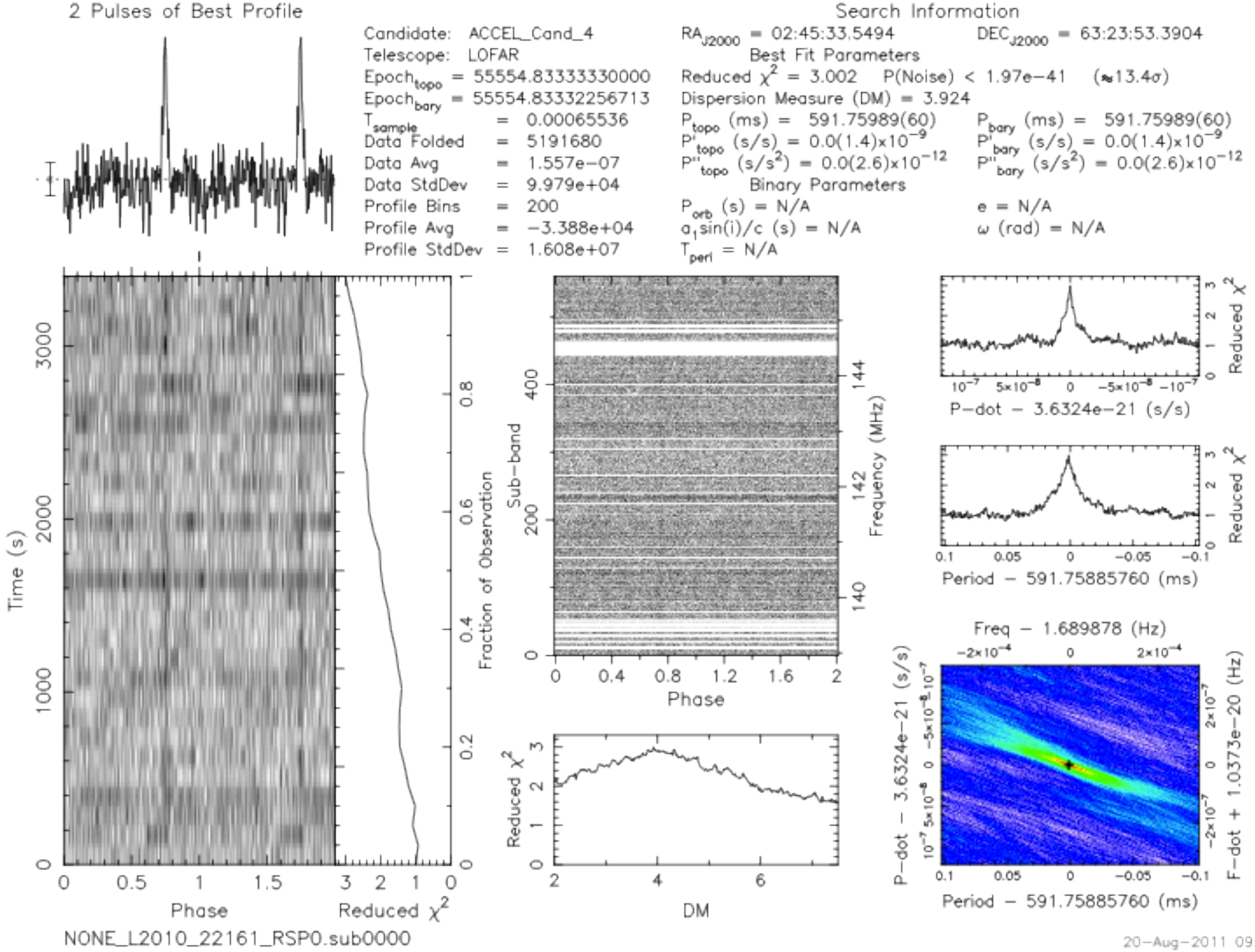
Credit: Stappers & Hassall

Re-detection of PSR J0240+63



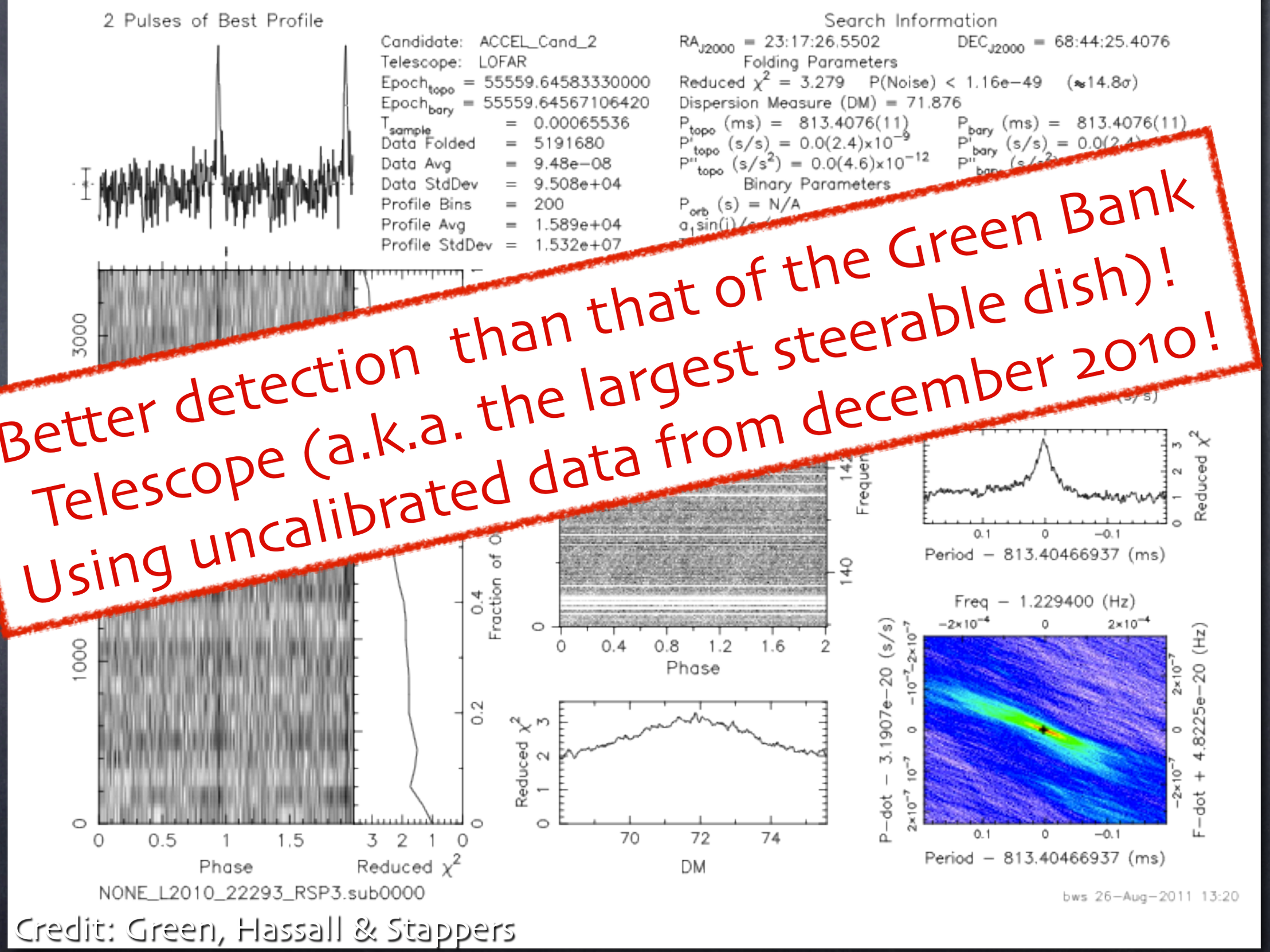
Credit: Stappers & Hassall

Re-detection of PSR J0240+63



Credit: Stappers & Hassall

Independent discovery J2317+68



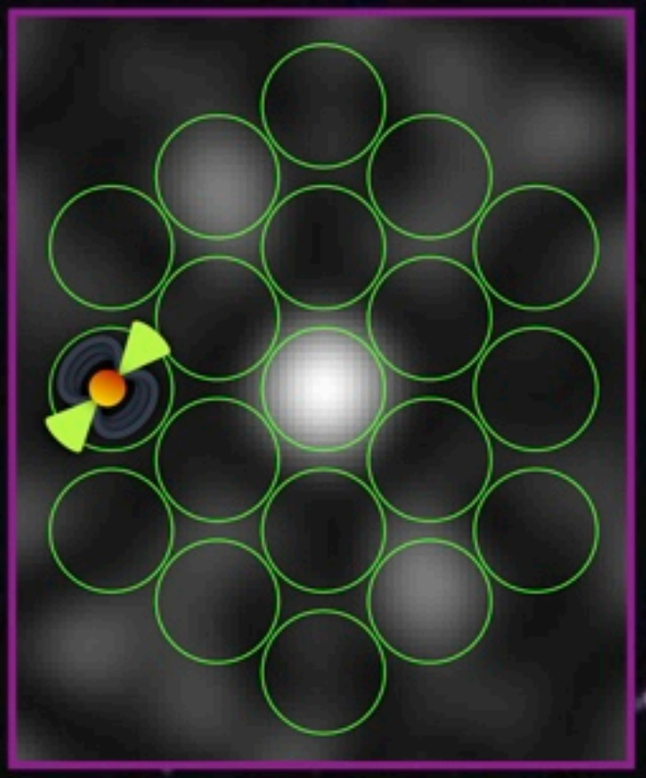
Better detection than that of the Green Bank Telescope (a.k.a. the largest steerable dish)!
Using uncalibrated data from december 2010!

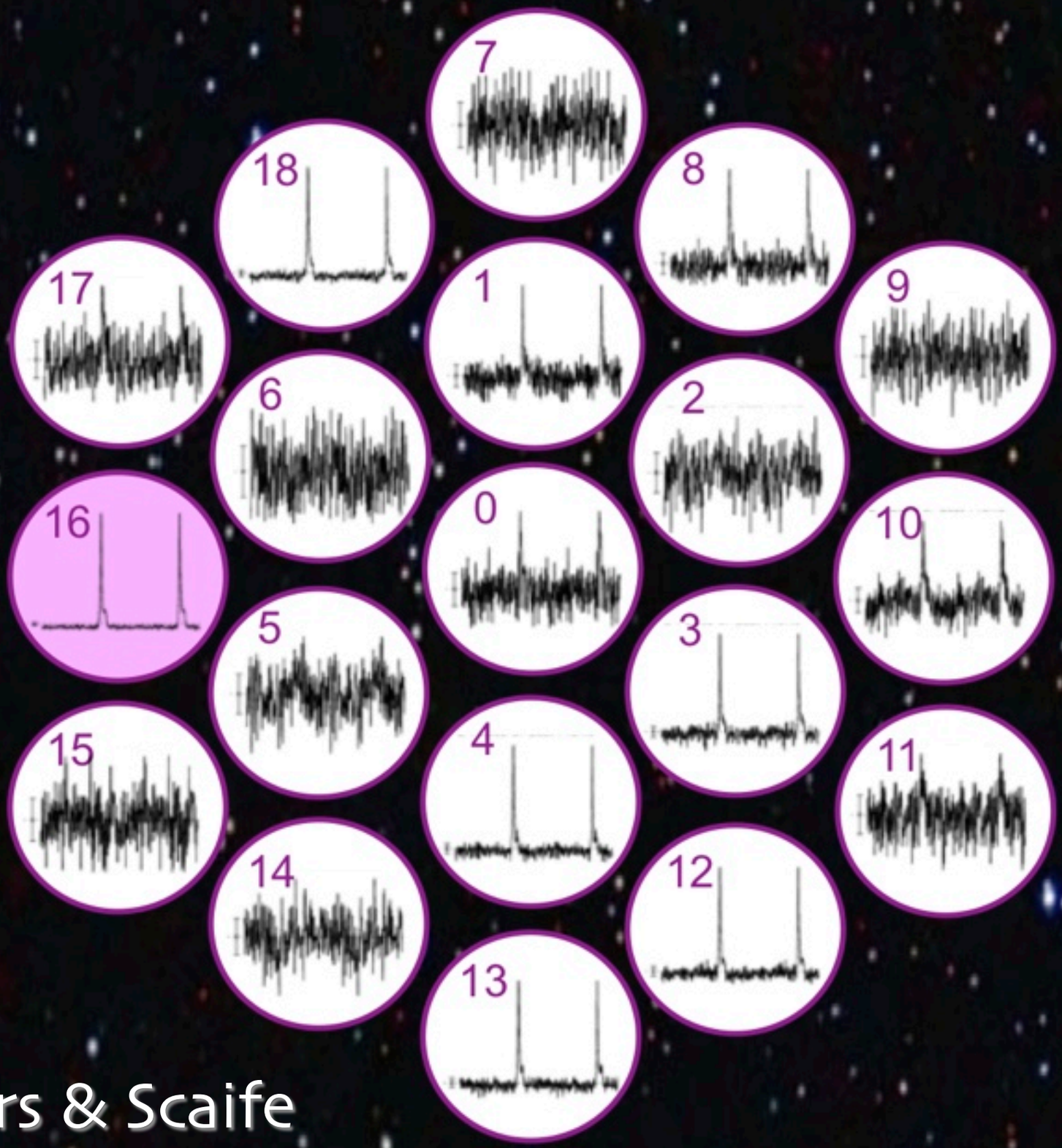
Credit: Green, Hassall & Stappers

LOTAS

- Coherent addition of LOFAR Superterp.
- 19 beams, 48 MHz bandwidth per beam, 1.3 ms sampling time.
- 17 minutes integrations.
- 3.7 square degrees of sky per pointing.
- Almost 200 observations taken so far.
- 10 times the sensitivity of LPPS

LOFAR Tied-Array Multi-Beam





Credit: Hessels, Stappers & Scaife

Future

- LPPS re-processing:
  - Mostly automated!
  - Will likely find new pulsars.
- LOTAS processing:
  - Re-use search software.
  - 10x more sensitive than LPPS
- Bet: 256 new pulsars by 12-12-2012