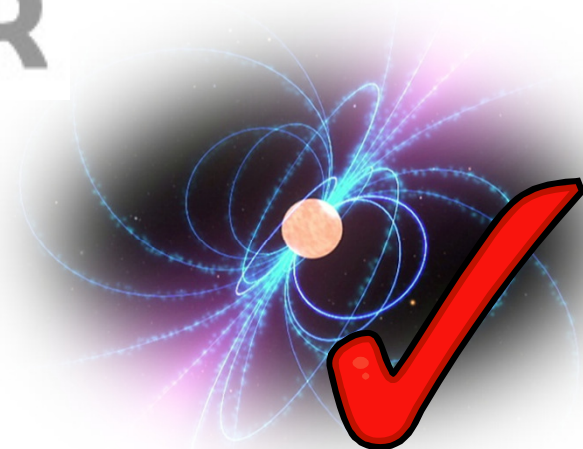


A year of pulsar polarimetry

with



LOFAR



Charlotte Sobey



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A year of pulsar polarimetry with LOFAR

Thursday 29th March 2012

Outline


- ④ Why polarisation?... In particular at low frequencies...
- ④ Current LOFAR polarised pulsar pipeline
- ④ Observations and results:
 - ④ Pulsar polarisation profiles & Rotation Measures (RMs)
 - ④ Tracking pulsar RM > ionospheric variations
 - ④ Giant pulses from the Crab pulsar > scattering
 - ④ Intermittent pulsar > magnetospheric phenomena
- ④ Future prospects for observations...

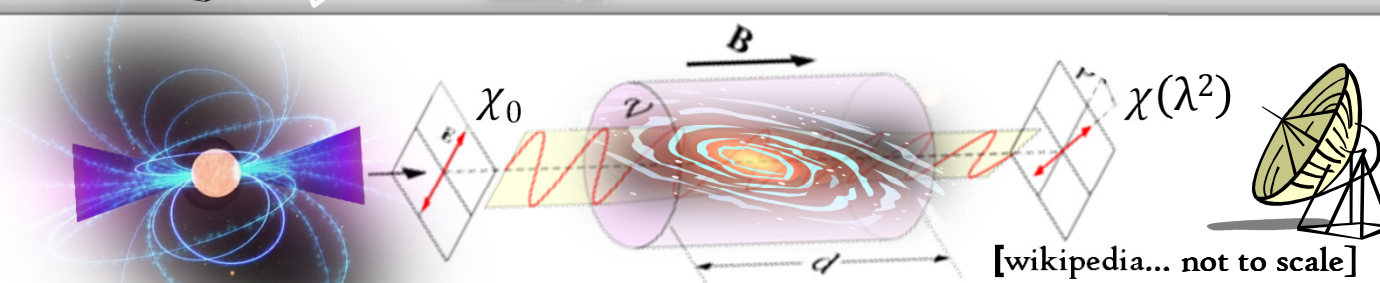
In collaboration with the Pulsar Working Group (TKSP) & MKSP

Why polarisation?

Ⓢ Extra information about emission and propagation... For example:

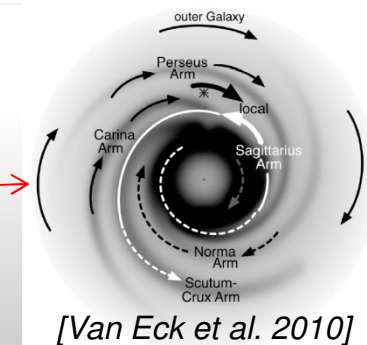
Ⓢ Faraday Rotation: Plane of linear polarisation rotated...

$$\chi(\lambda^2) = \chi_0 + RM \lambda^2 \quad \text{where} \quad \chi = \frac{1}{2} \tan^{-1} \frac{U}{Q}$$




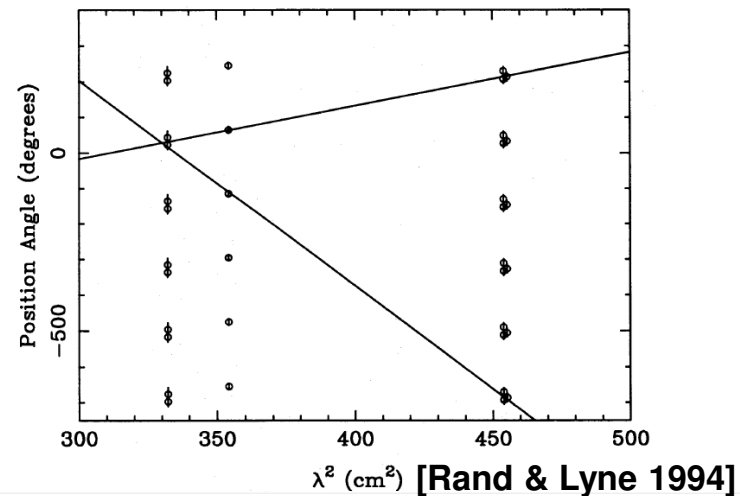
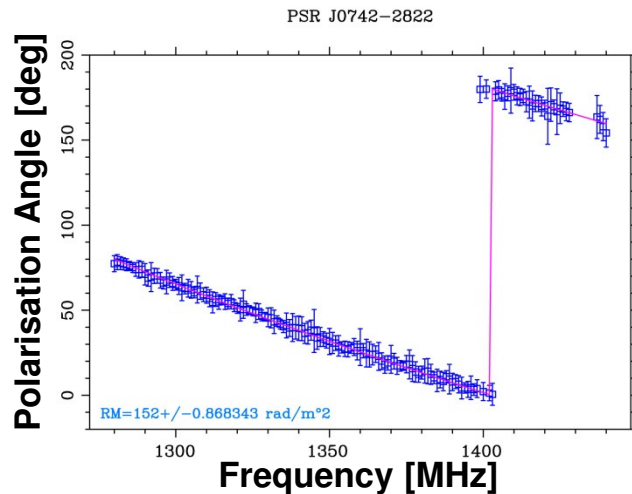
Ⓢ Rotation Measure (RM):

$$RM = 0.810 \int_{\text{source}}^{\text{receiver}} n_e(s) \bar{B}(s) \cdot d\bar{s}$$

Measuring RMs

Method 1: $\chi(\lambda^2)$



Method 2: RM synthesis (Burn 1966):

- ⊙ $\chi(\lambda^2)$ known to modulo π radians causing 'n π ambiguity'
- ⊙ Emission at multiple RMs in l.o.s
- ⊙ Sources with high RM undetectable in individual channels

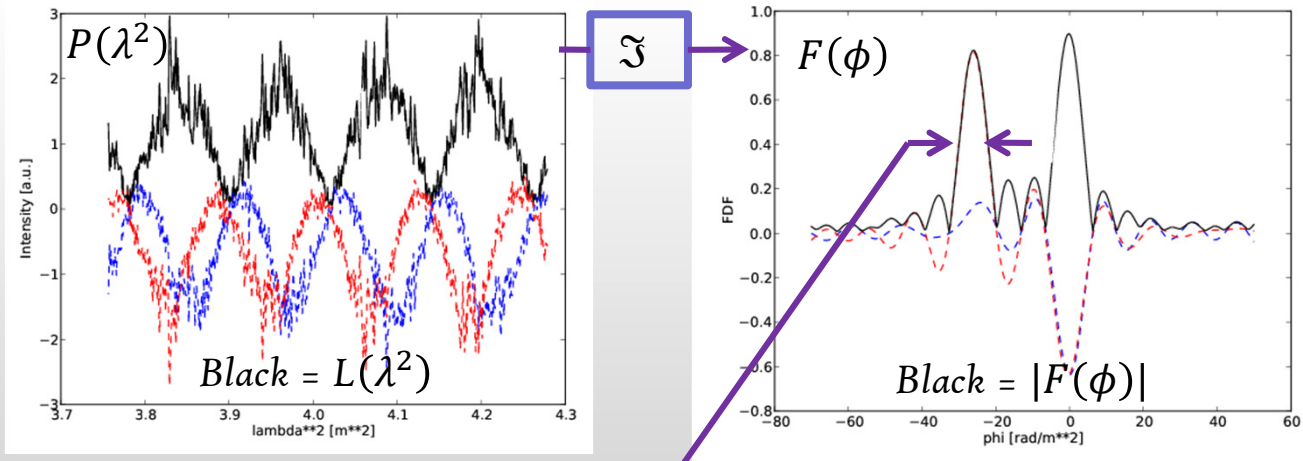
RM synthesis... Quick intro

Observed complex polarisation vector:

$$P(\lambda^2) = p l e^{2i(\chi_0 + RM\lambda^2)} = \int_{-\infty}^{+\infty} F(\phi) e^{2i\phi\lambda^2} d\phi$$

Fourier transform-like:

$$F(\phi) = \int_{-\infty}^{+\infty} P(\lambda^2) e^{-2i\phi\lambda^2} d\lambda^2$$



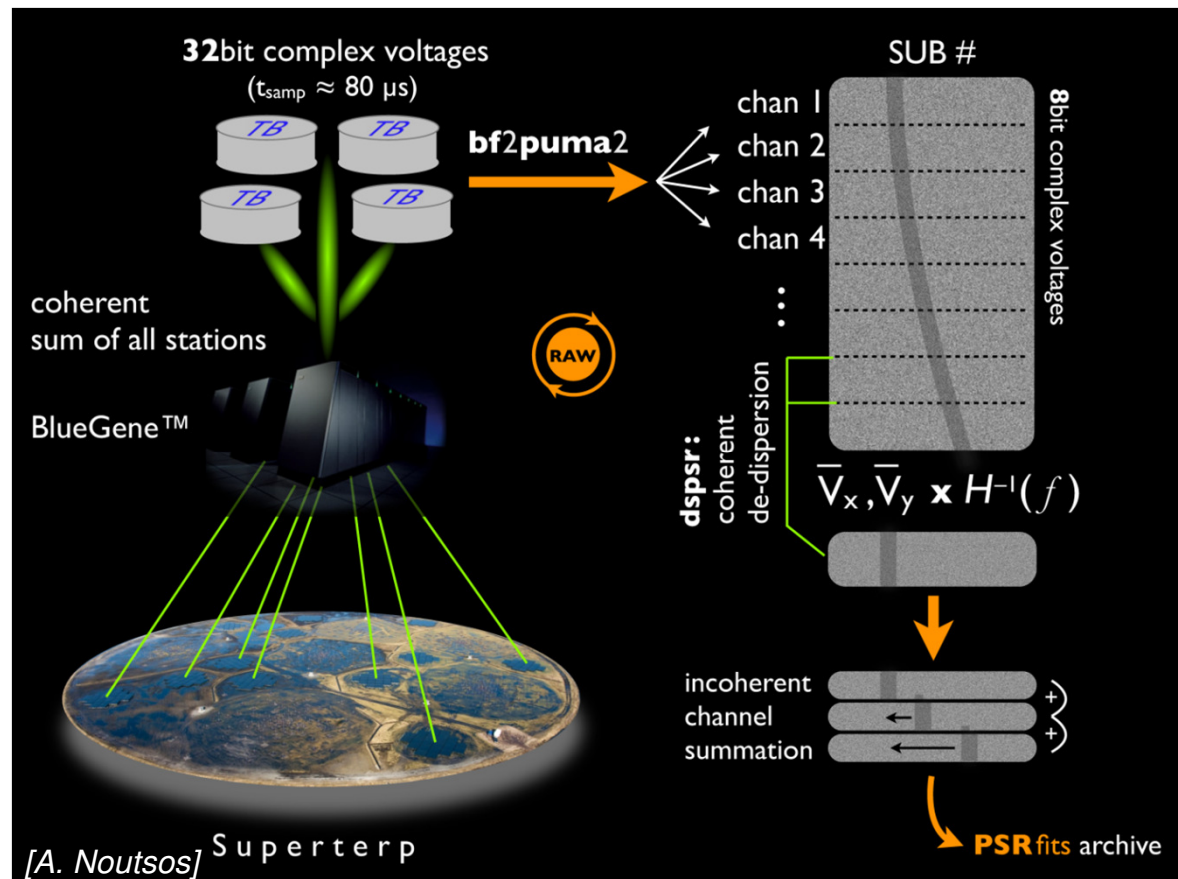
Important: $FWHM = \frac{3.8}{\lambda^2_{max} - \lambda^2_{min}}$ determines accuracy [Brentjens & de Bruyn 2005]

LOFAR: low frequency & large fractional bandwidth!



Raw voltage observations

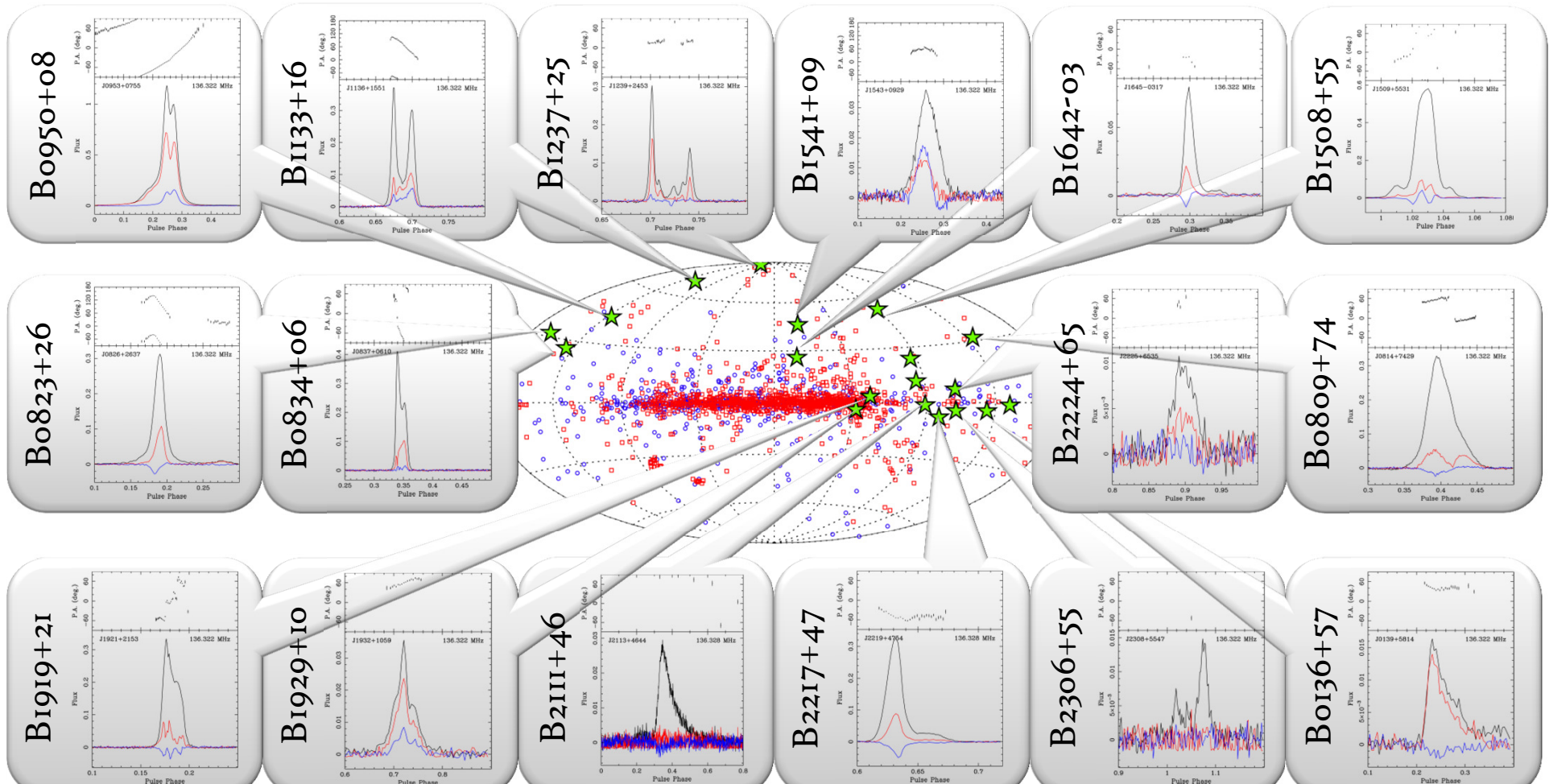
@ Tied array mode > raw voltages > coherent dedispersion > Stokes IQUV



March 2011
20 psrs, 10 mins

HBA 'Survey'...

freq=136 MHz
bw=6 MHz



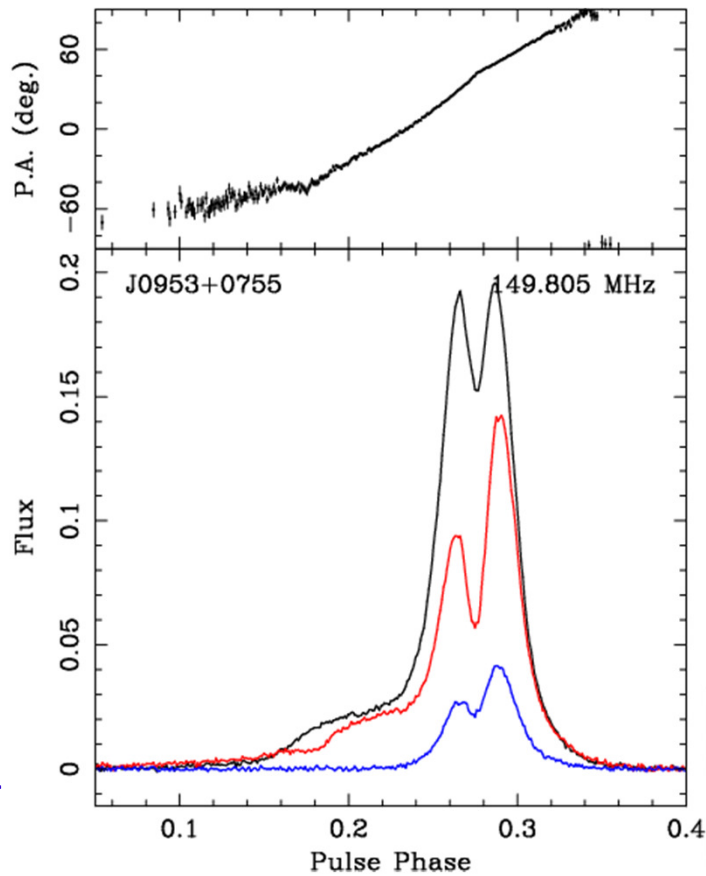
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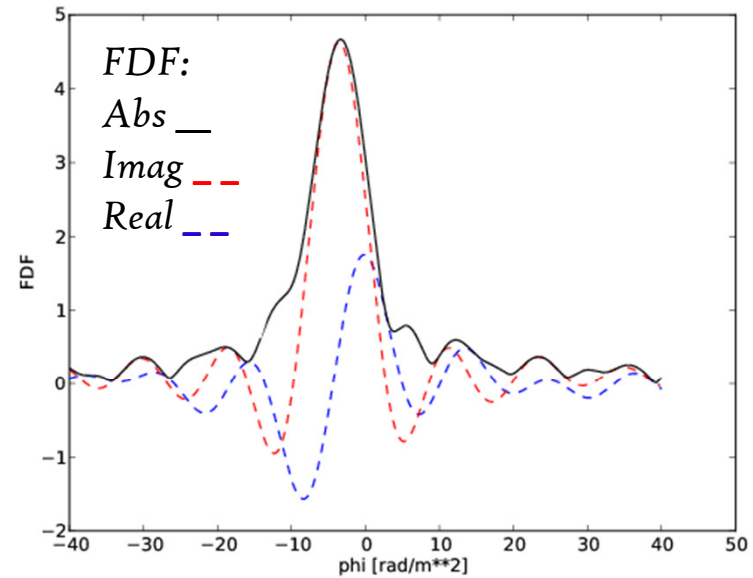
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HBA profile & RM example...



Profile:
 Total —
 Linear —
 Circular —

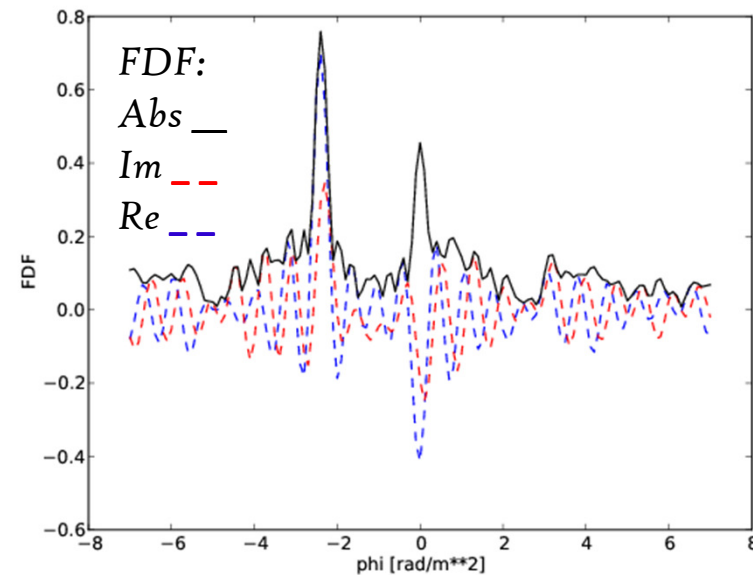
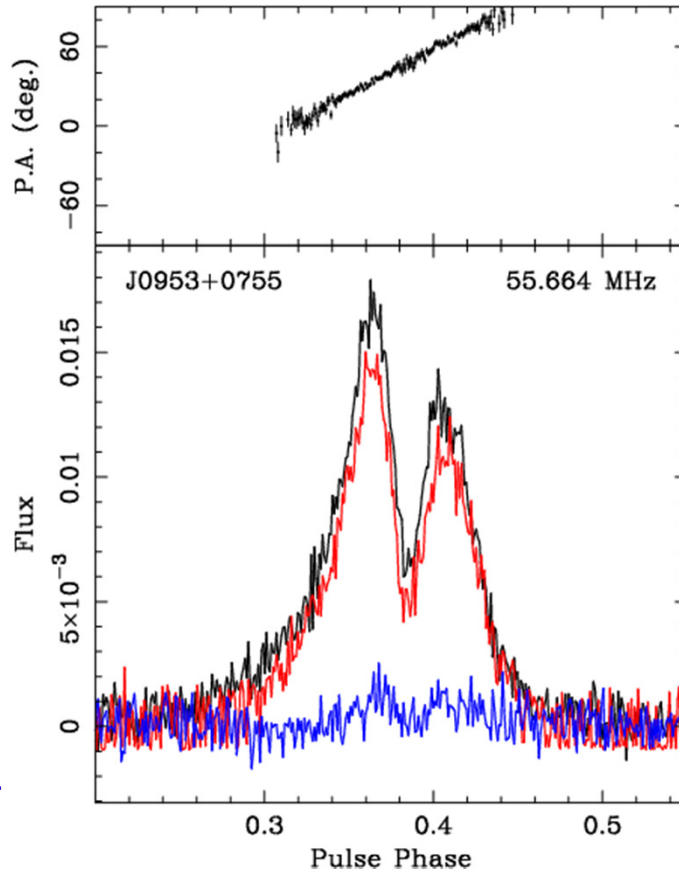


PSR B0950+08

freq = 149.8 MHz

$FDF_{FWHM} = 7 \text{ rad m}^{-2}$

LBA profile & RM example...

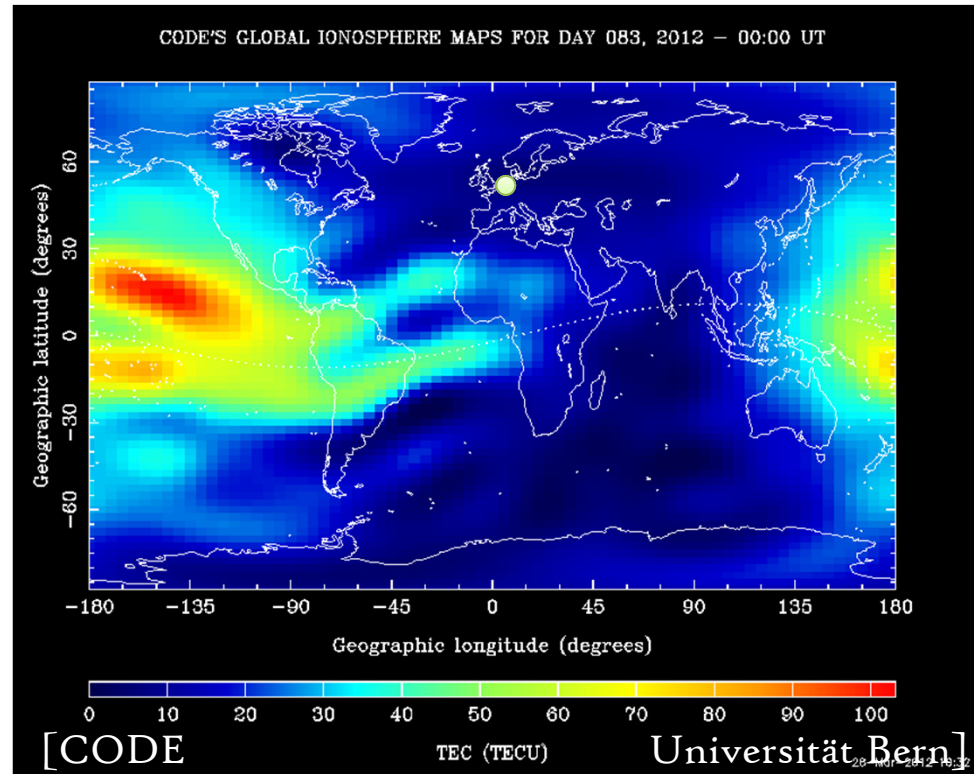
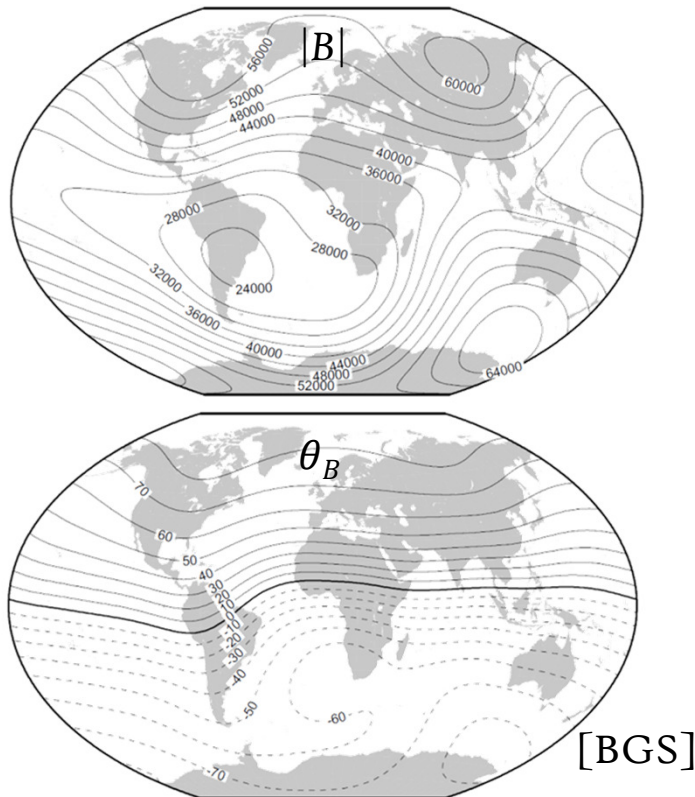


PSR B0950+08

freq = 55.6 MHz

$FDF_{FWHM} = 0.4 \text{ rad m}^{-2}$

The Ionosphere...



magnetic field + Total Electron Content (TEC)

Tracking RM at sunset

PSR B0834+06

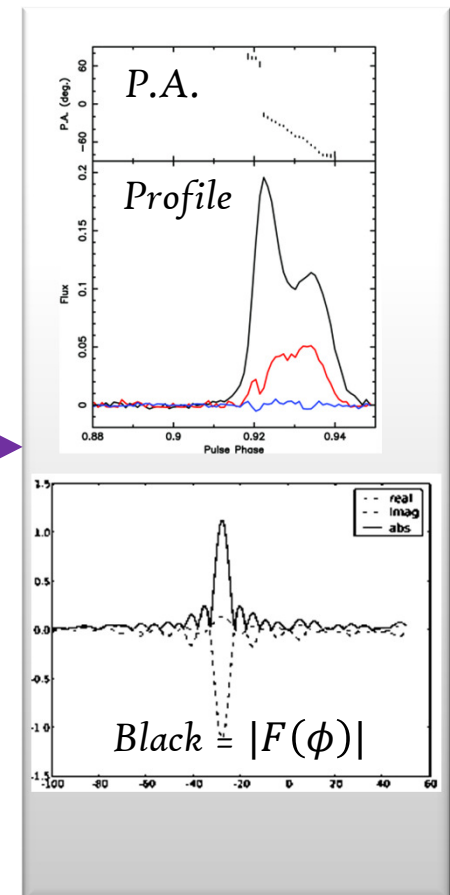
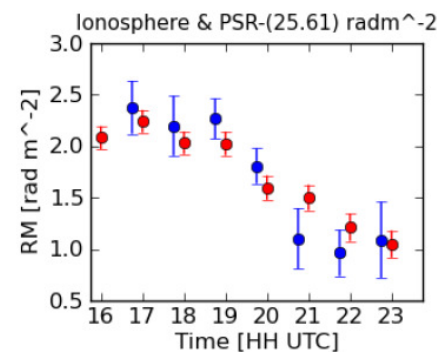
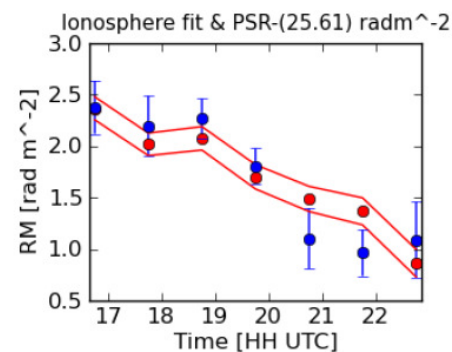
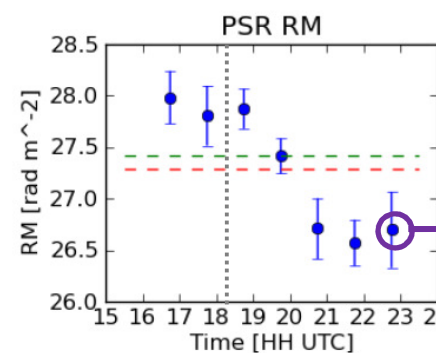
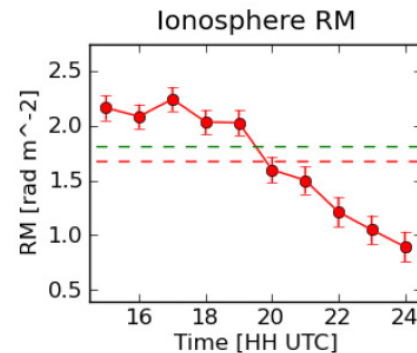
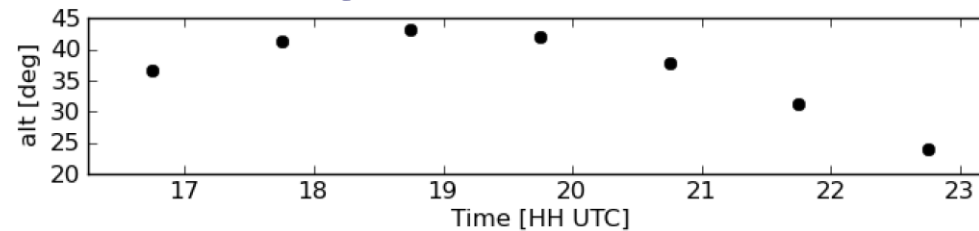
11th April 2011

10 minute obs
every hour

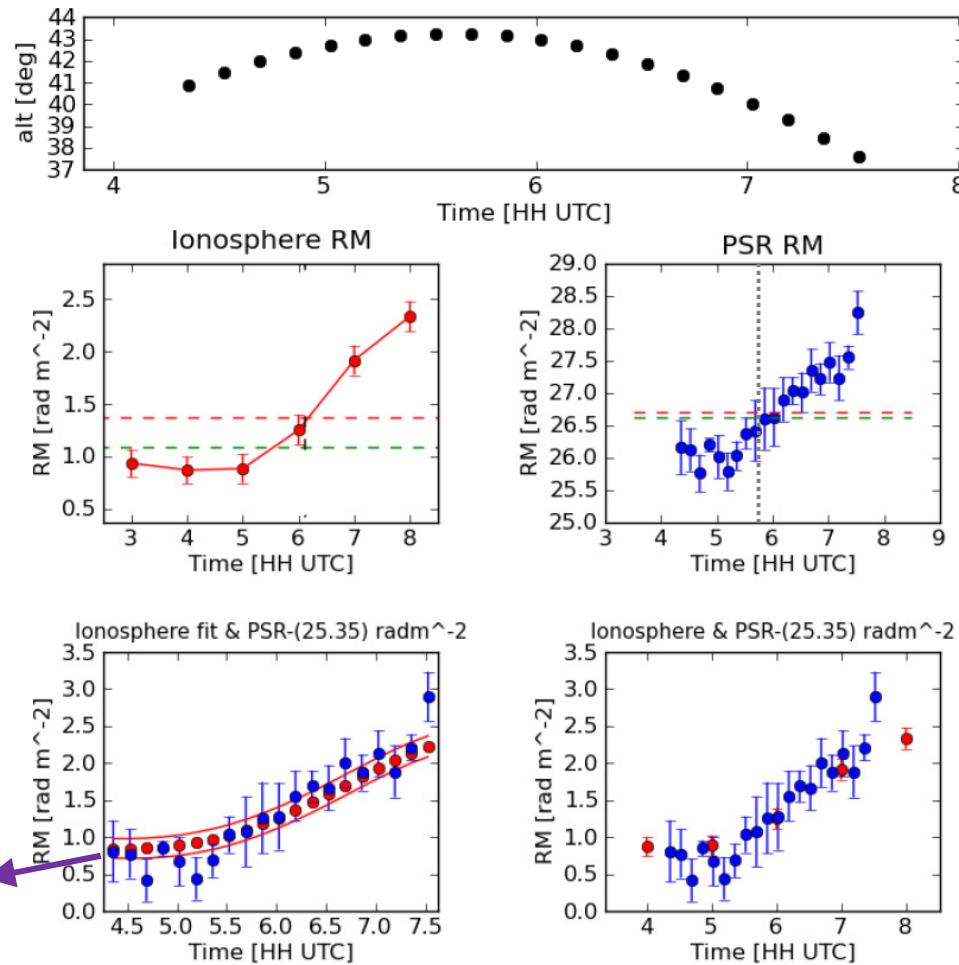
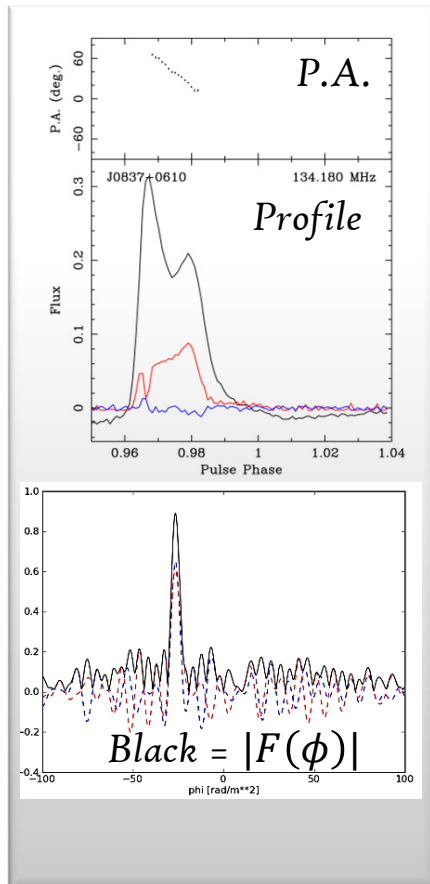
freq = 123 MHz
bw = 6.3 MHz

$RM = 25.61 \pm 0.15$

[Sotomayor in prep]
[Sobey et al. in prep]



Tracking RM at sunrise



PSR B0834+06

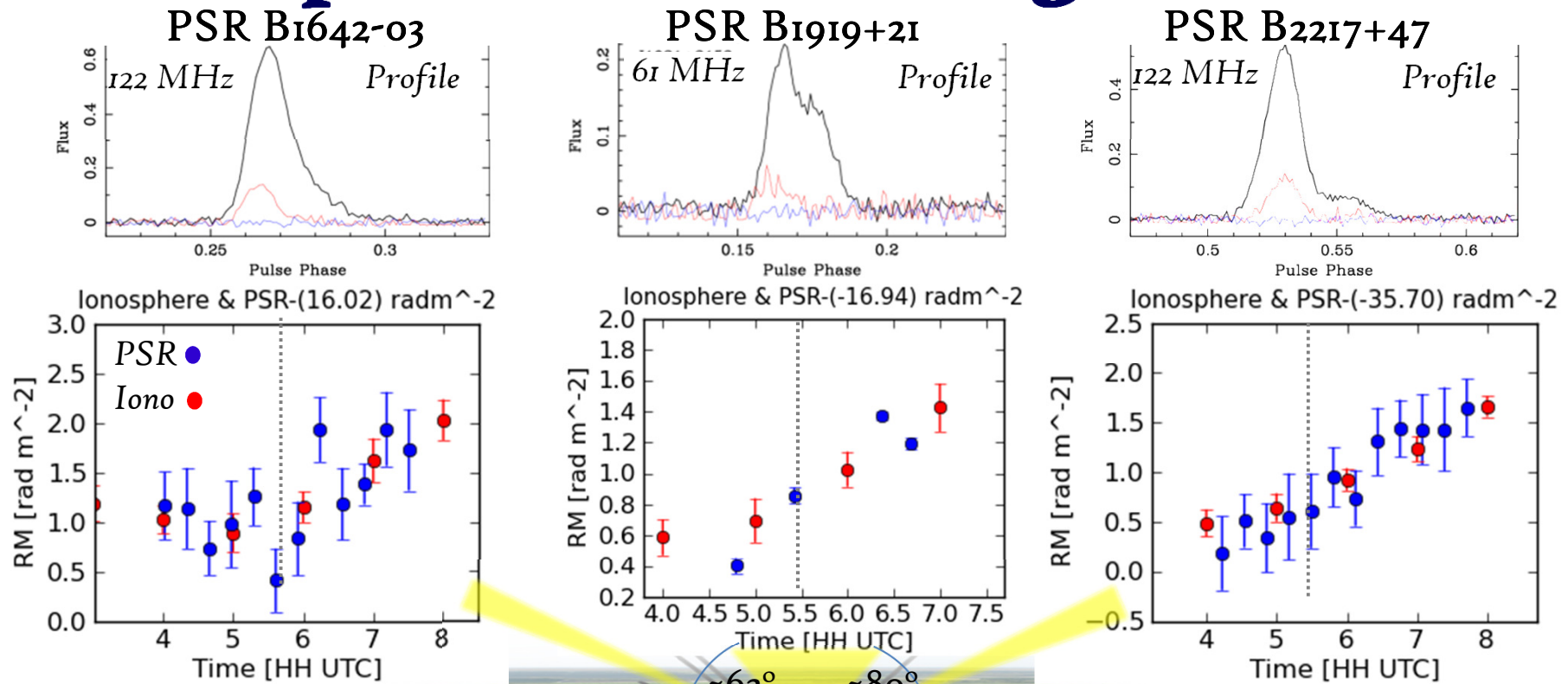
20th October 2011

3 minute obs
every 10 mins

freq = 134 MHz
bw = 9 MHz

RM = 25.34 ± 0.09

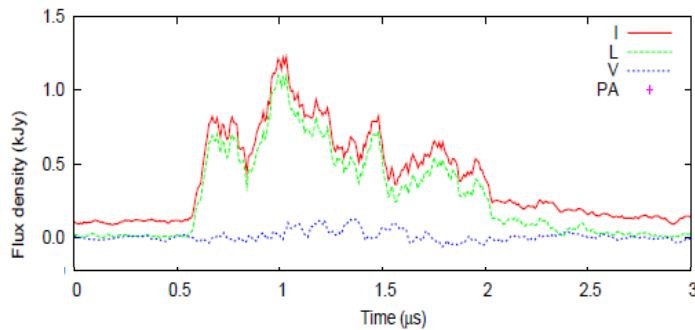
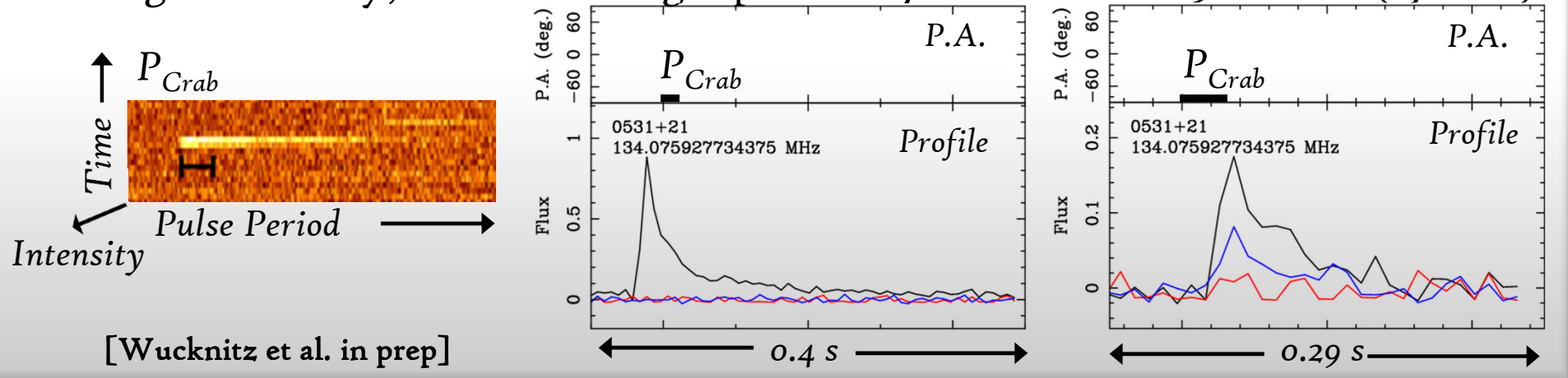
Multiple RM tracking at sunrise



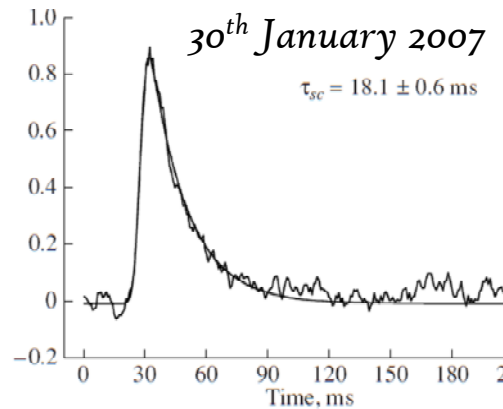
23rd March 2012, 3 minute obs every 19 mins, bw = 6 MHz

Crab giant pulses

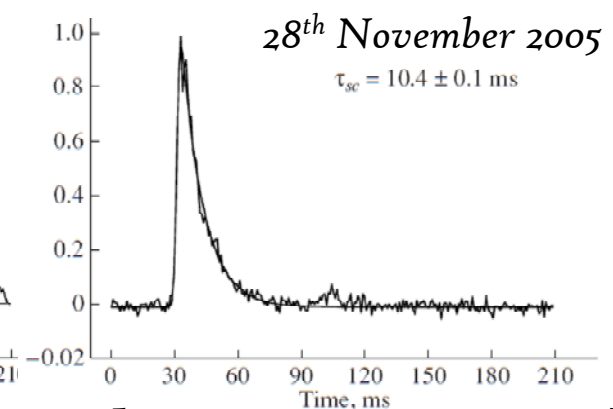
High intensity, scattered single pulses: 27+ detected in 30 mins! (27.10.11)



15.1 GHz at Effelsberg [Jessner et al. 2010]



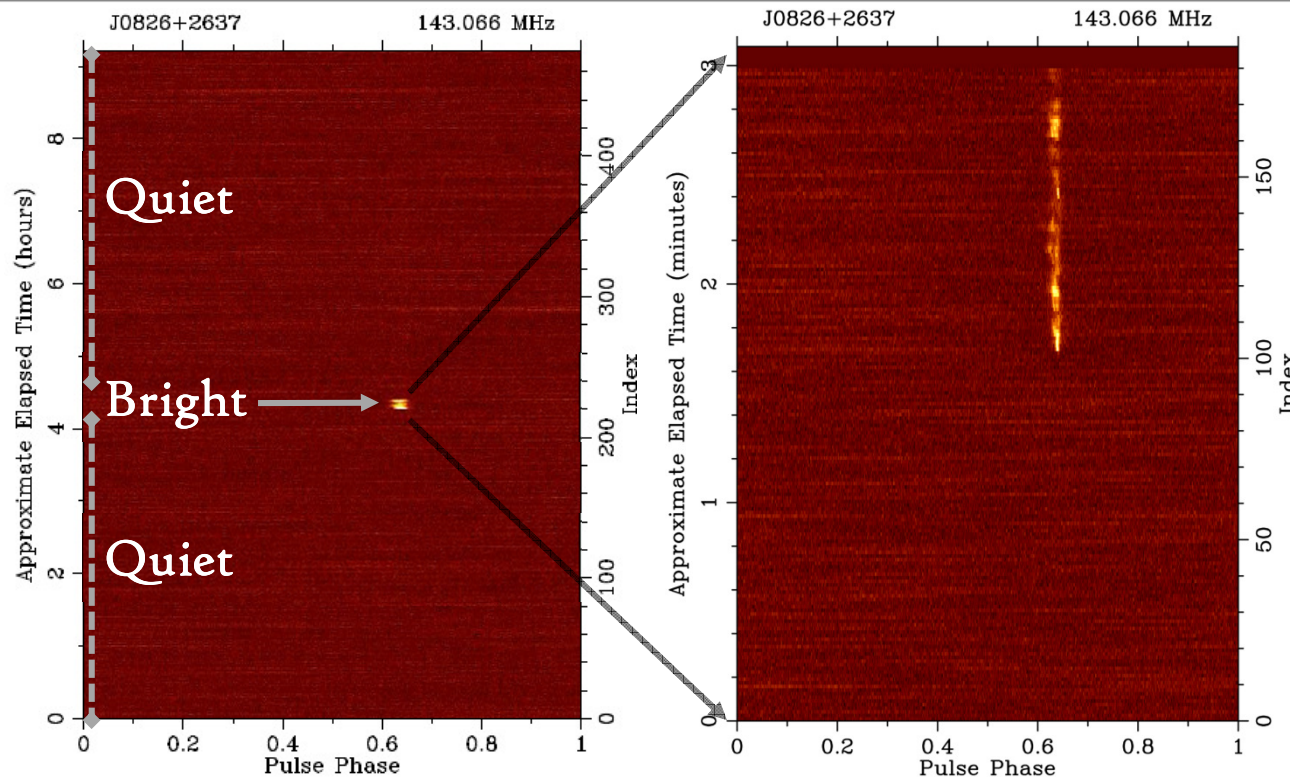
III.88 MHz at LPA



[Smirnova & Logvinenko 2008]

Intermittent pulsar

- ⊙ A class of pulsar discovered relatively recently (Kramer et al '06)
- ⊙ First discovered PSR B1931+24 switches 'on' and 'off'...



Bo823+26

13th November 2011

26 x 3 minute obs with
19 mins break,

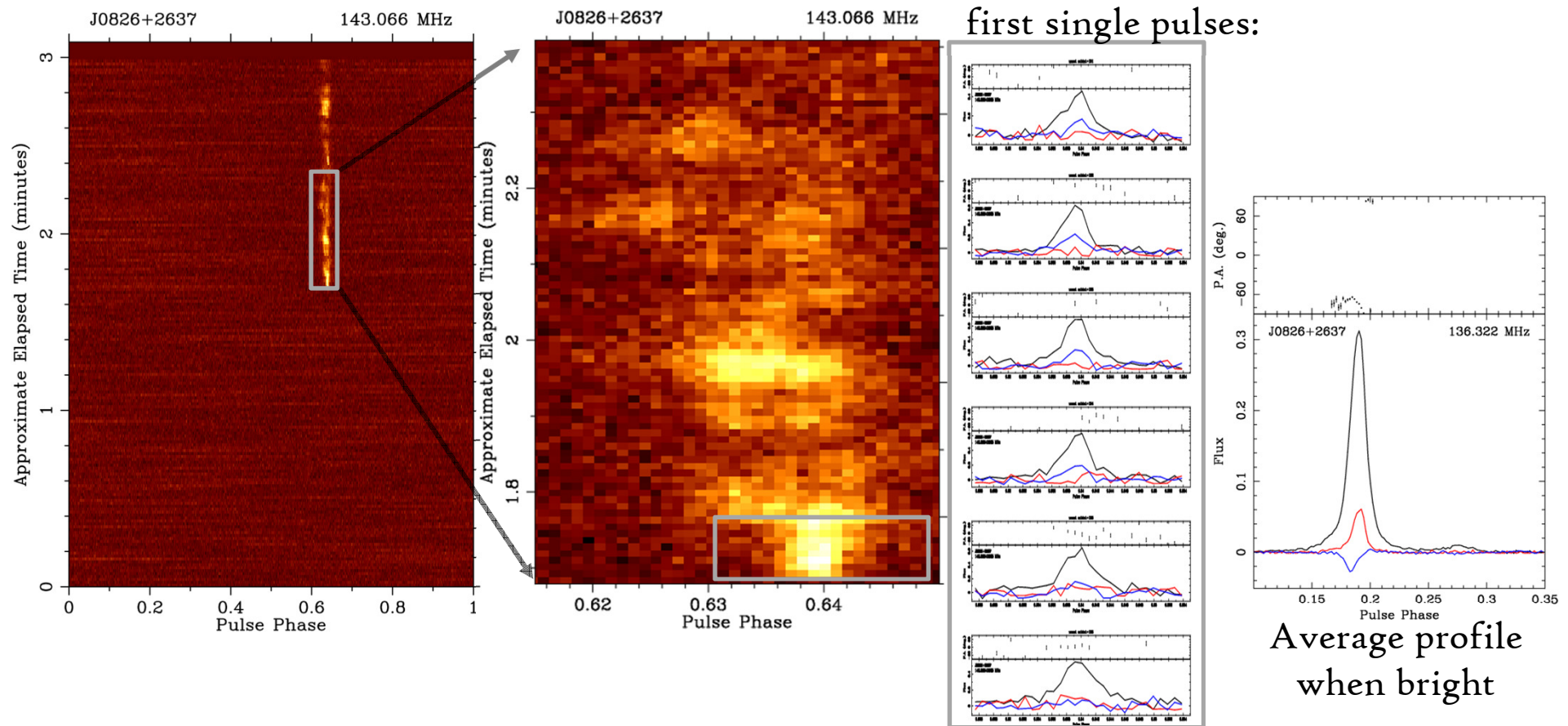
freq = 143 MHz

bw = 9 MHz

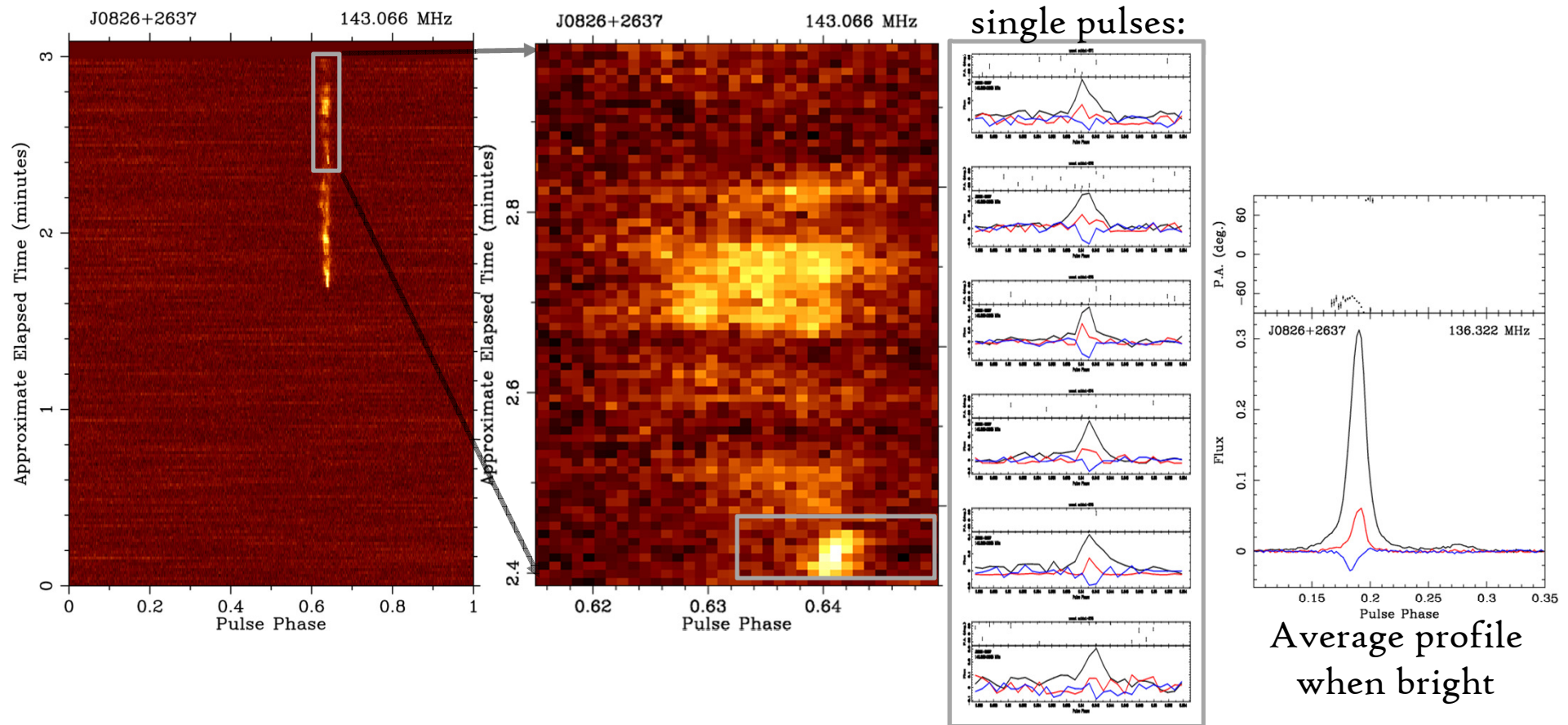
LOFAR –

great for monitoring!

B0823+26 single pulses... I



B0823+26 single pulses... II



The future looks bright...

The logo consists of a solid orange square above the word "orange" in a white, lowercase, sans-serif font, with a small trademark symbol (TM) to the upper right of the text.

- ⊙ Past observations have proven interesting in many ways...
 - ⊙ Low frequency polarisation profiles
 - ⊙ RM achieved with high precision > Ionosphere
 - ⊙ High sensitivity great for single pulse studies
 - ⊙ Interesting results from the Crab and intermittent Bo823+26
- ⊙ Future observations planned include:
 - ⊙ Near - more ionospheric studies... including joint BF-IM obs
 - ⊙ Continue observing pulsars in pol > B-field of Milky Way

$$E = mc^2$$



[German Wings in-flight magazine Oct/Nov 2011]

Thank you for listening!

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