

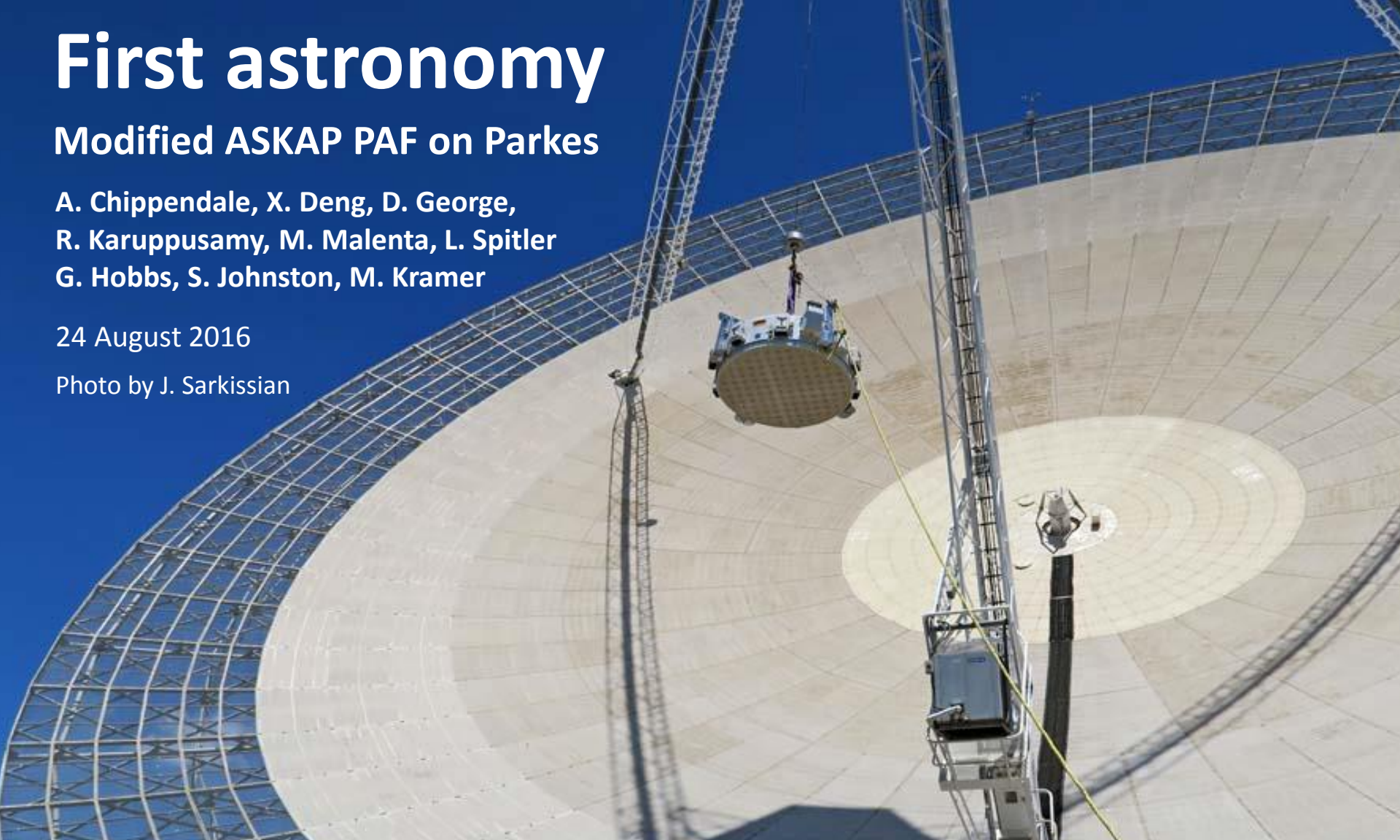
First astronomy

Modified ASKAP PAF on Parkes

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G. Hobbs, S. Johnston, M. Kramer

24 August 2016

Photo by J. Sarkissian



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Max Planck Institute
for Radio Astronomy

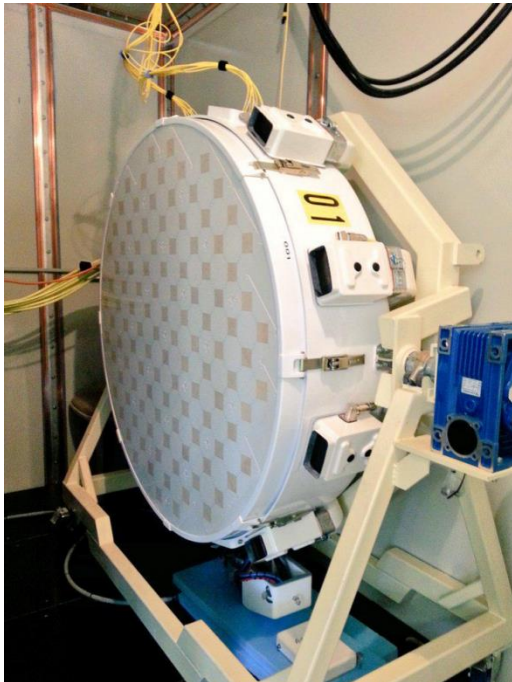


PAF Workshop
24 August 2016, Cagliari



MPIfR PAF System at Parkes

- 188 ports, 94 ports each polarization, 4 spare ports
- 36 beams x 2 pol x 336 MHz voltages streamed to GPUs (1 MHz resolution)
- 32 beams x 2 pol x 384 MHz spectra download (18 kHz resolution)
- Now testing 18 beams in streaming mode and 16 beams in spectral-line mode



PAF: 600 MHz



DRX: 600 MHz

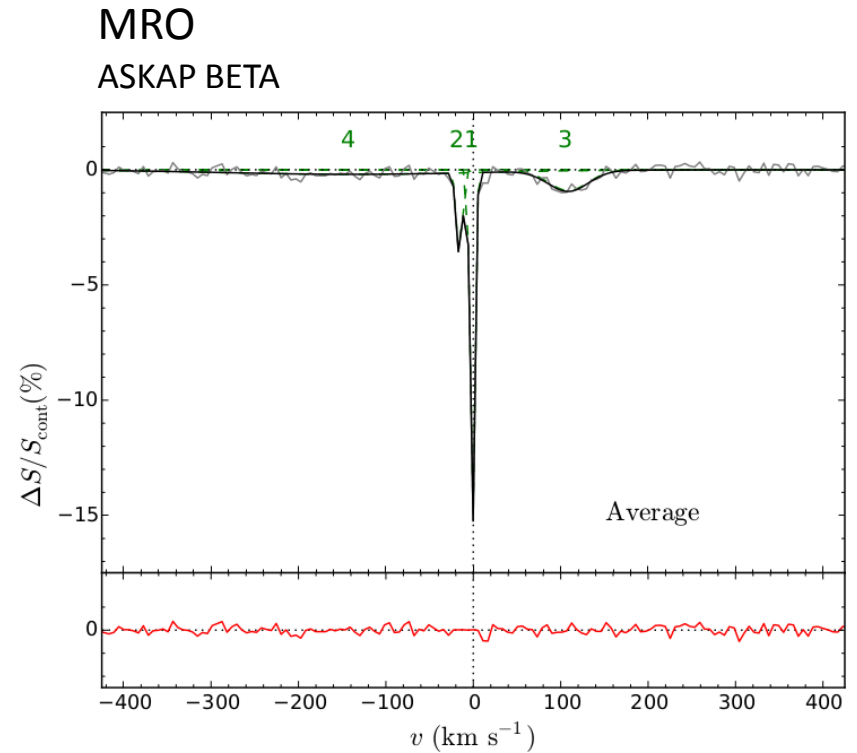
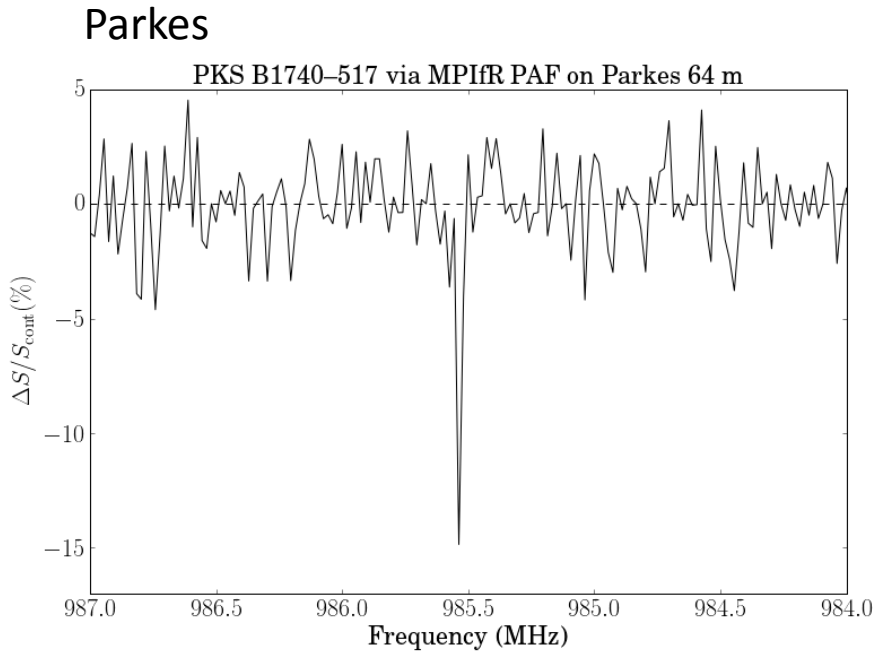


BMF: 384 MHz



9 GPU nodes

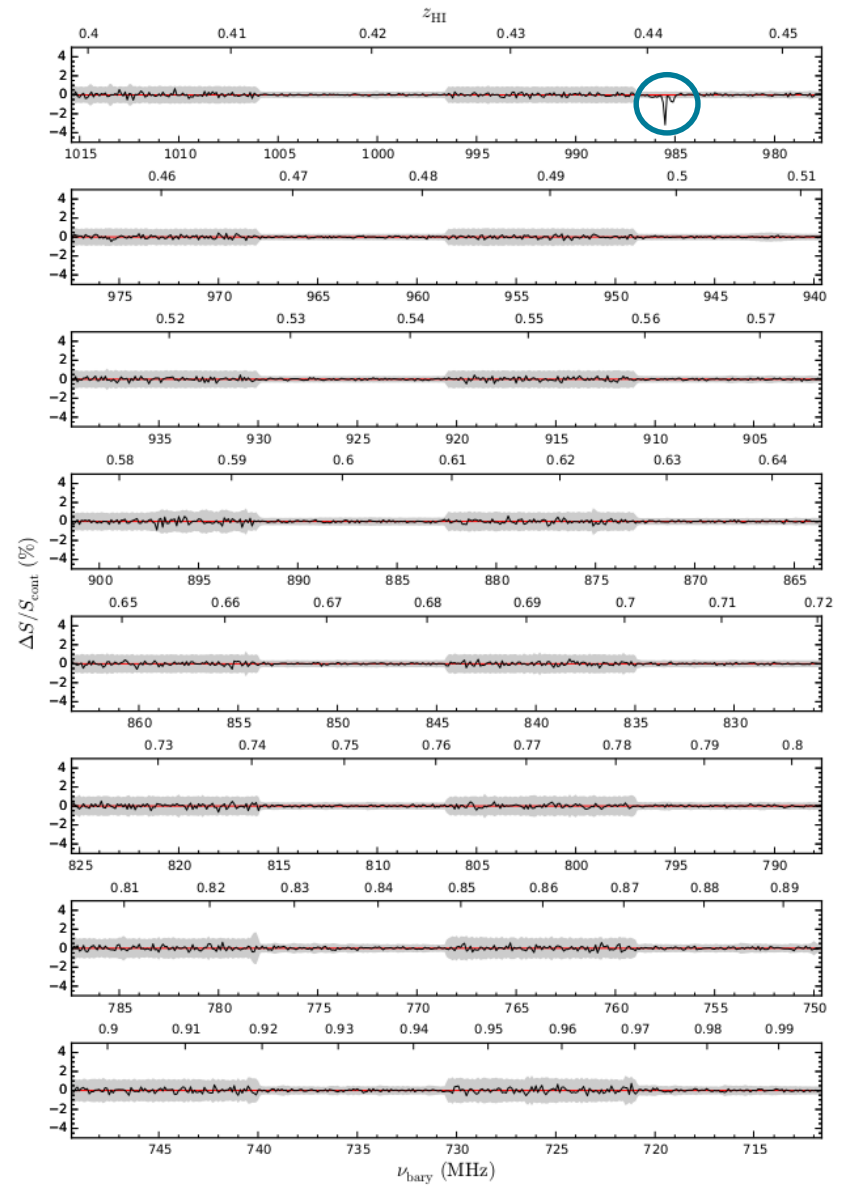
H_I gas in a young radio galaxy at z=0.44



(Allison et al., MNRAS 2015)

MRO

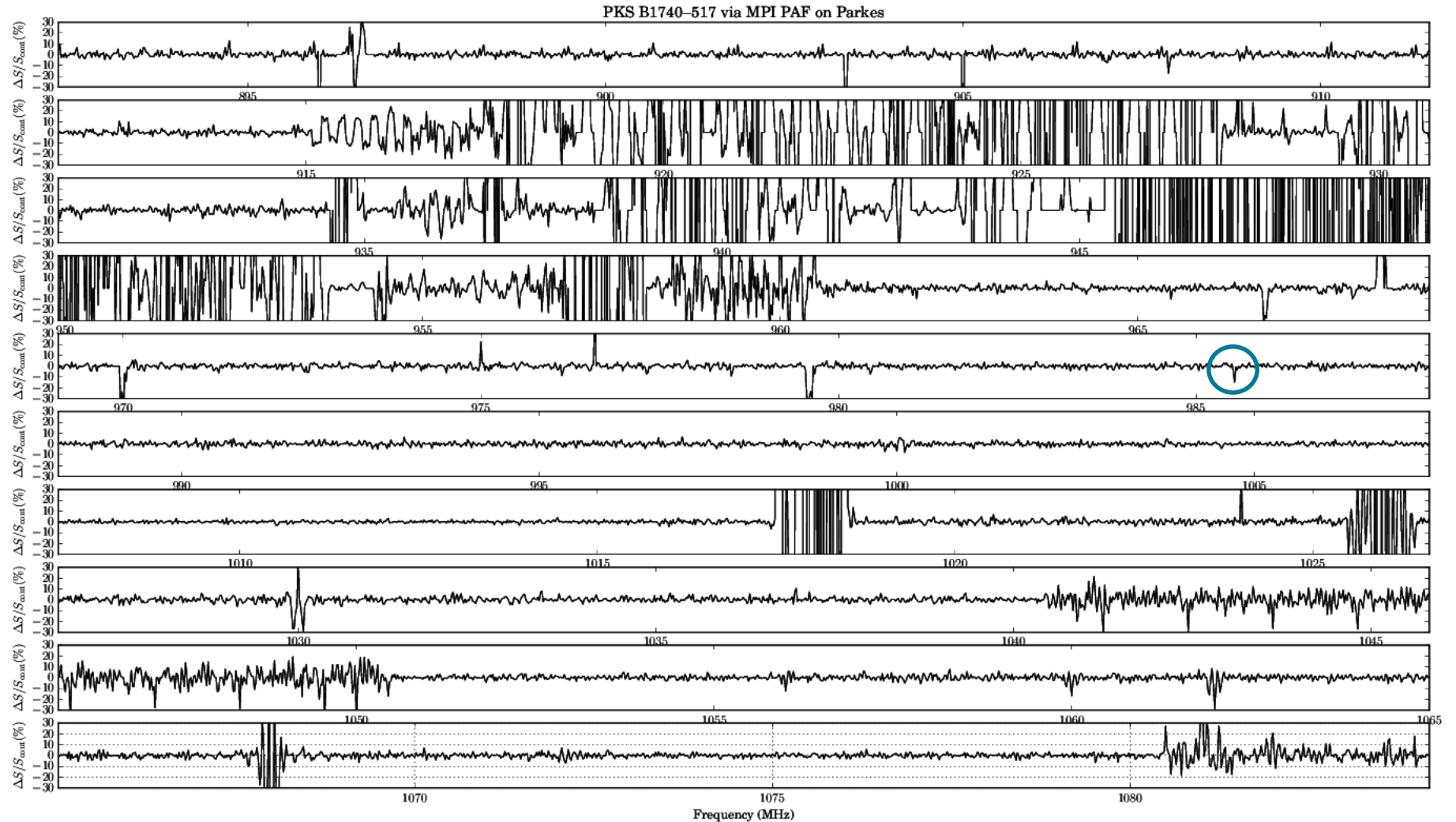
Population 113



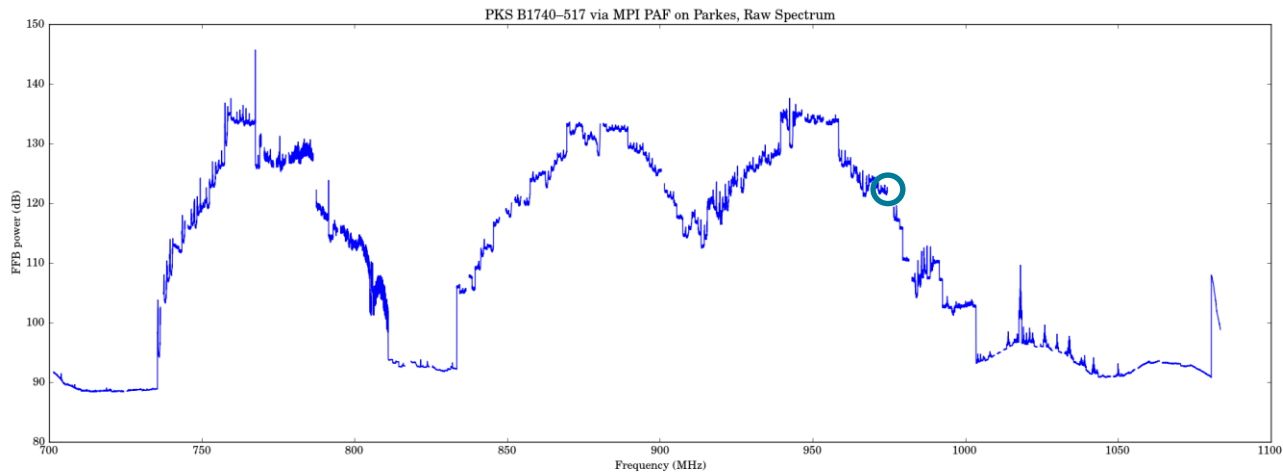
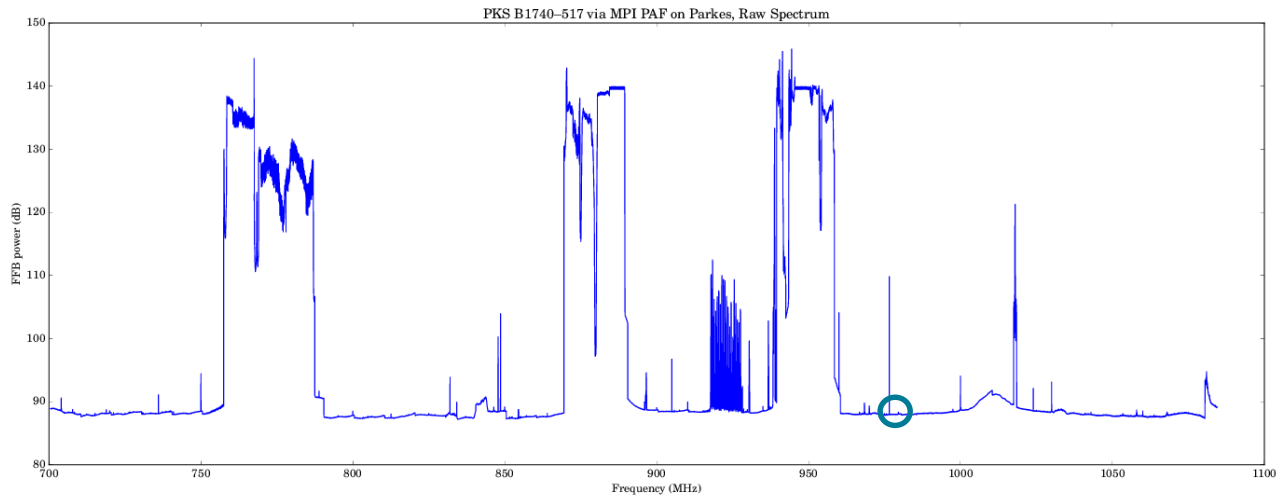
(Allison et al., MNRAS 2015)

Parkes

Population 15,000

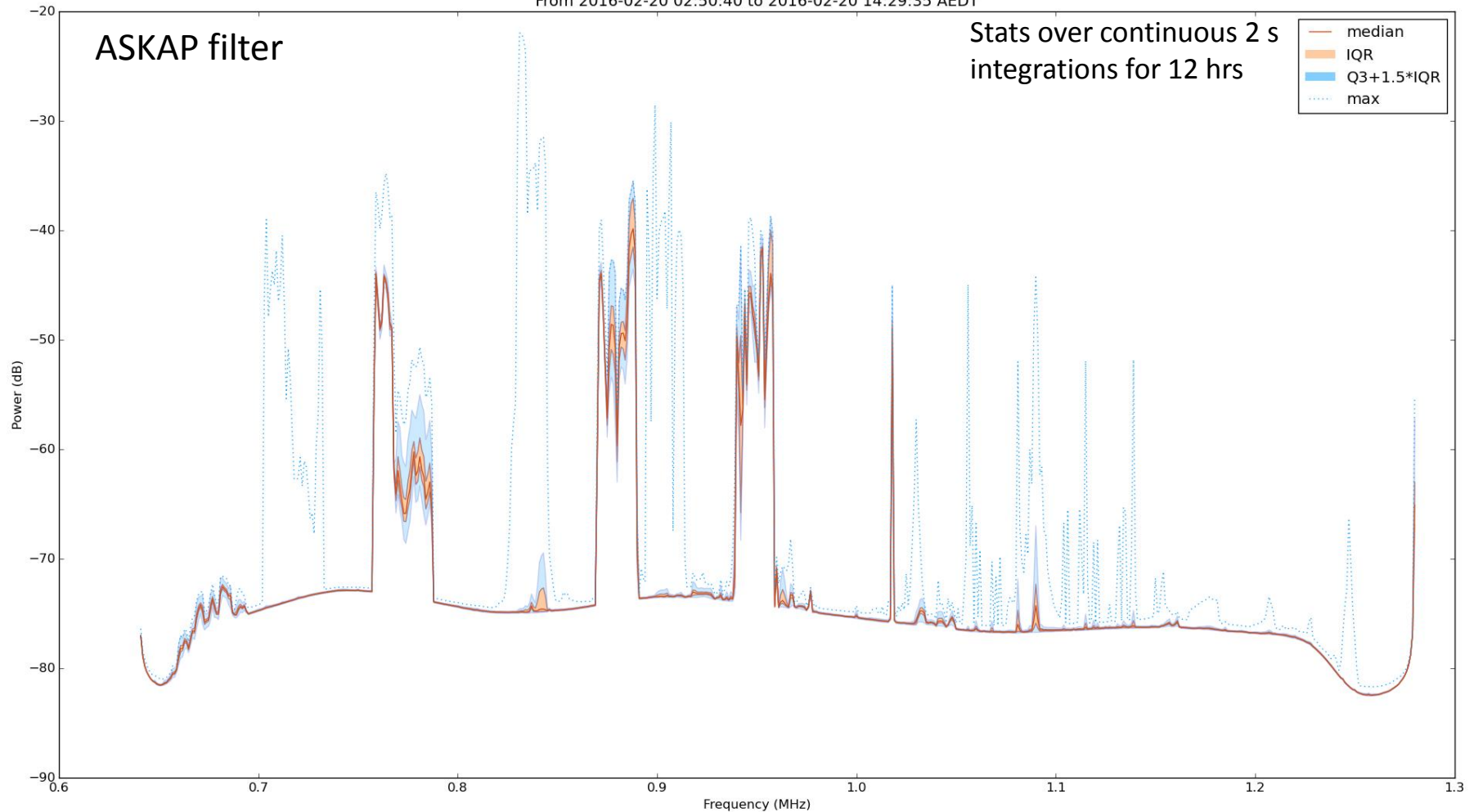


Just working versus blown out of the water...



Single port spectra at zenith (0.7-1.2 GHz)

MPIPAF on Parkes 64 m (az=29.76, ze=-0.56), PAF Port 47
From 2016-02-20 02:50:40 to 2016-02-20 14:29:35 AEDT

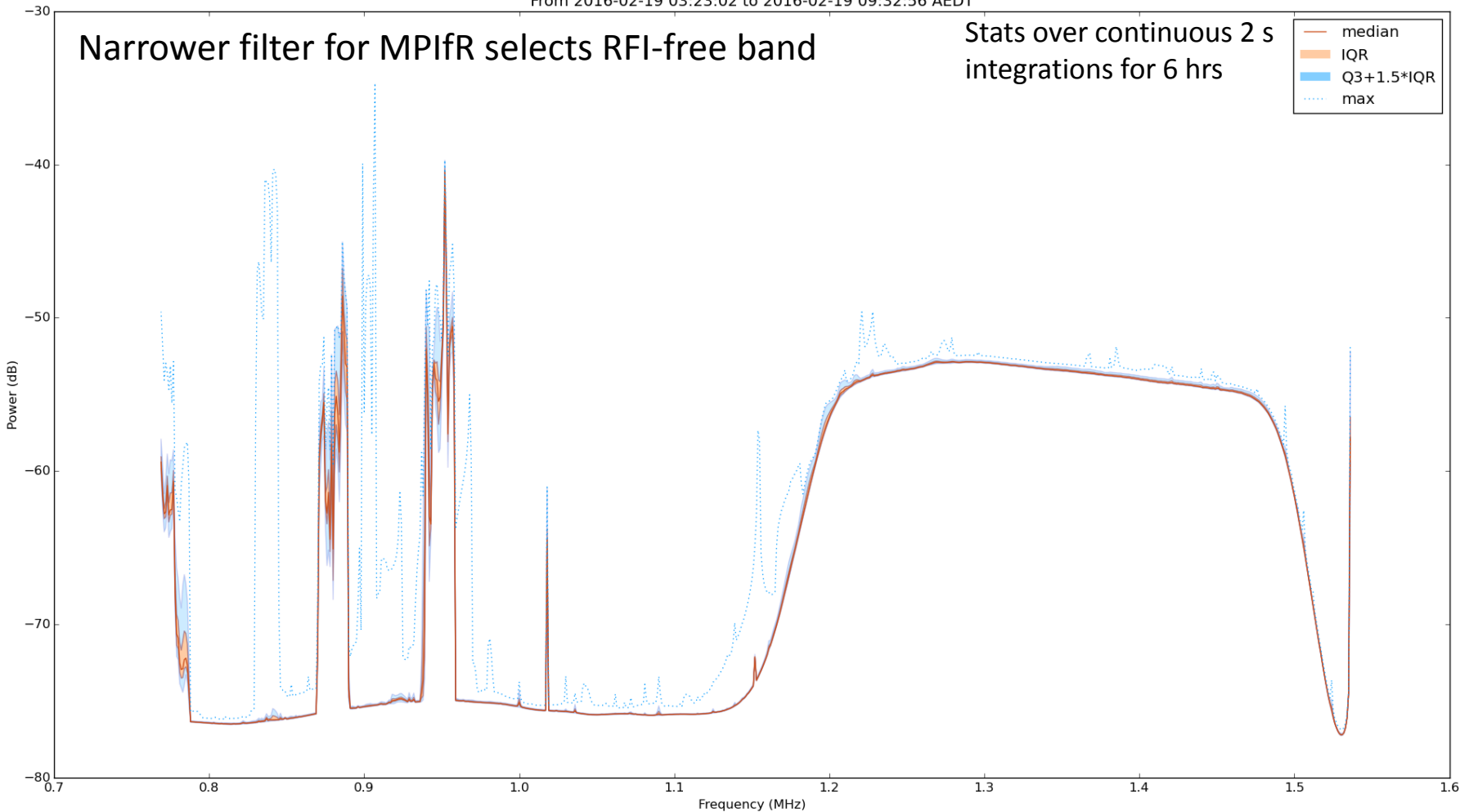
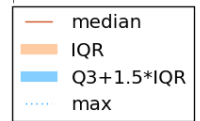


Single port spectra at zenith (1.2-1.5 GHz)

MPIPAF on Parkes 64 m (az=9.54 deg, ze=-0.55 deg), PAF Port 47
From 2016-02-19 03:23:02 to 2016-02-19 09:32:56 AEDT

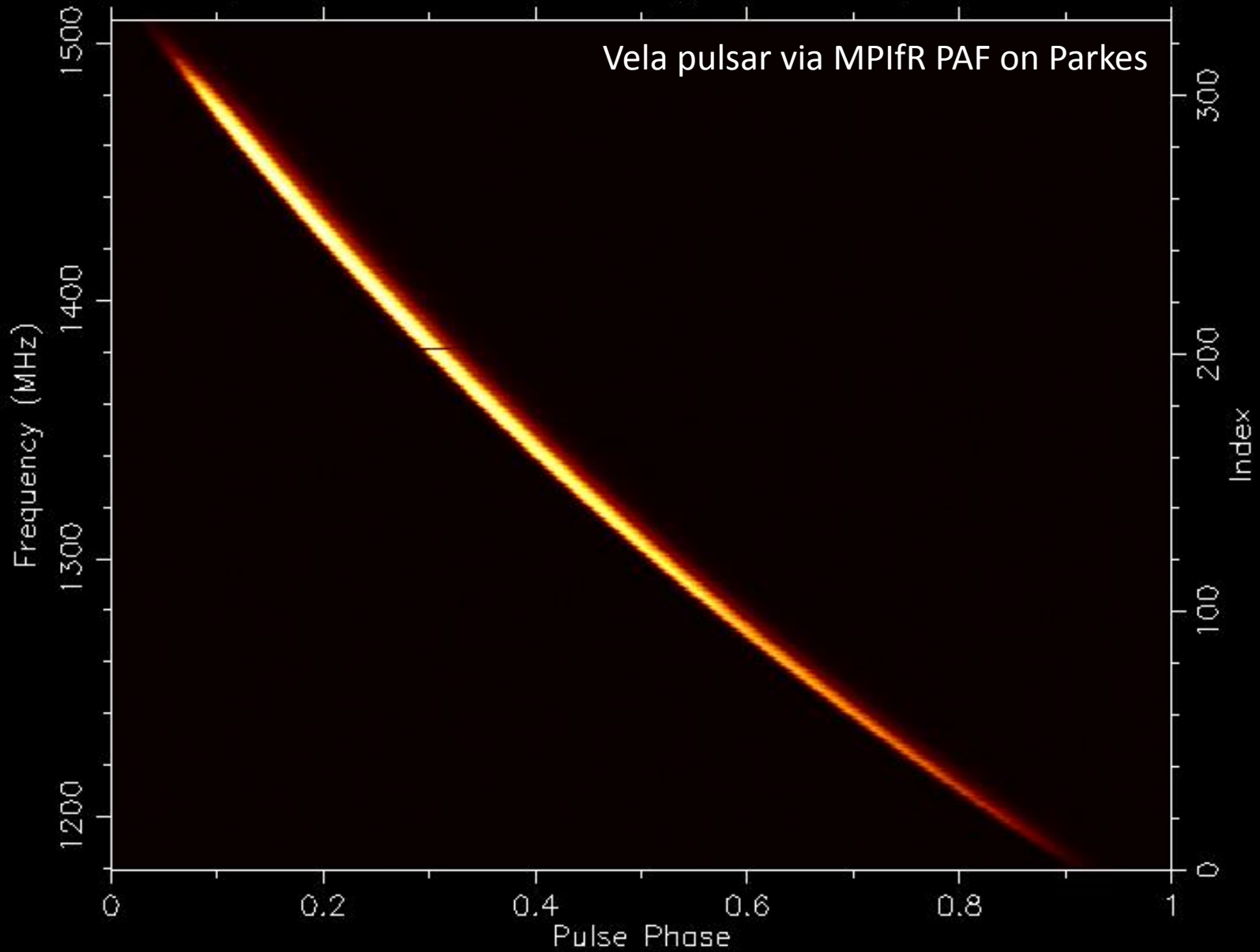
Narrower filter for MPIfR selects RFI-free band

Stats over continuous 2 s
integrations for 6 hrs



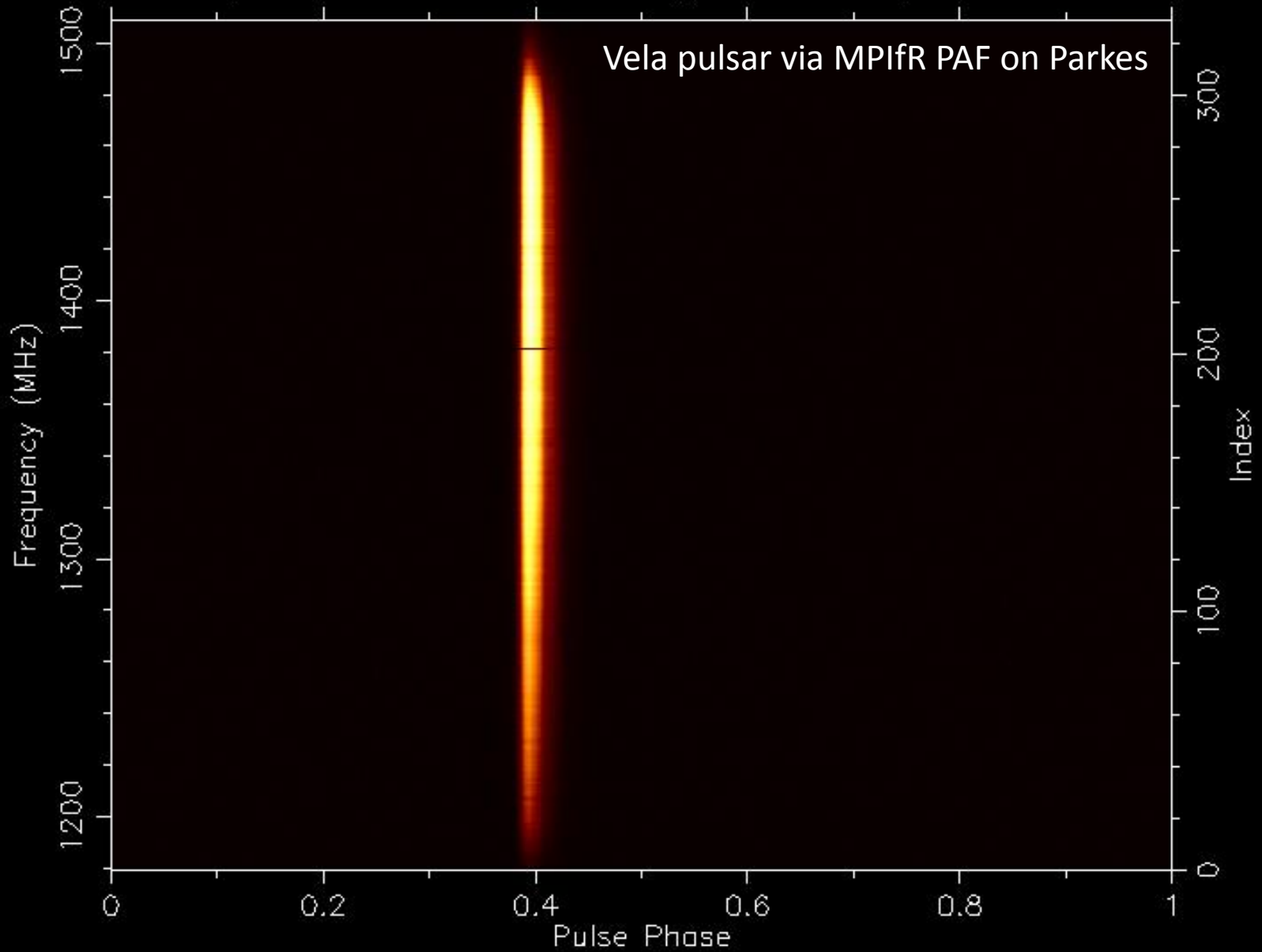
0833-45 add.ar

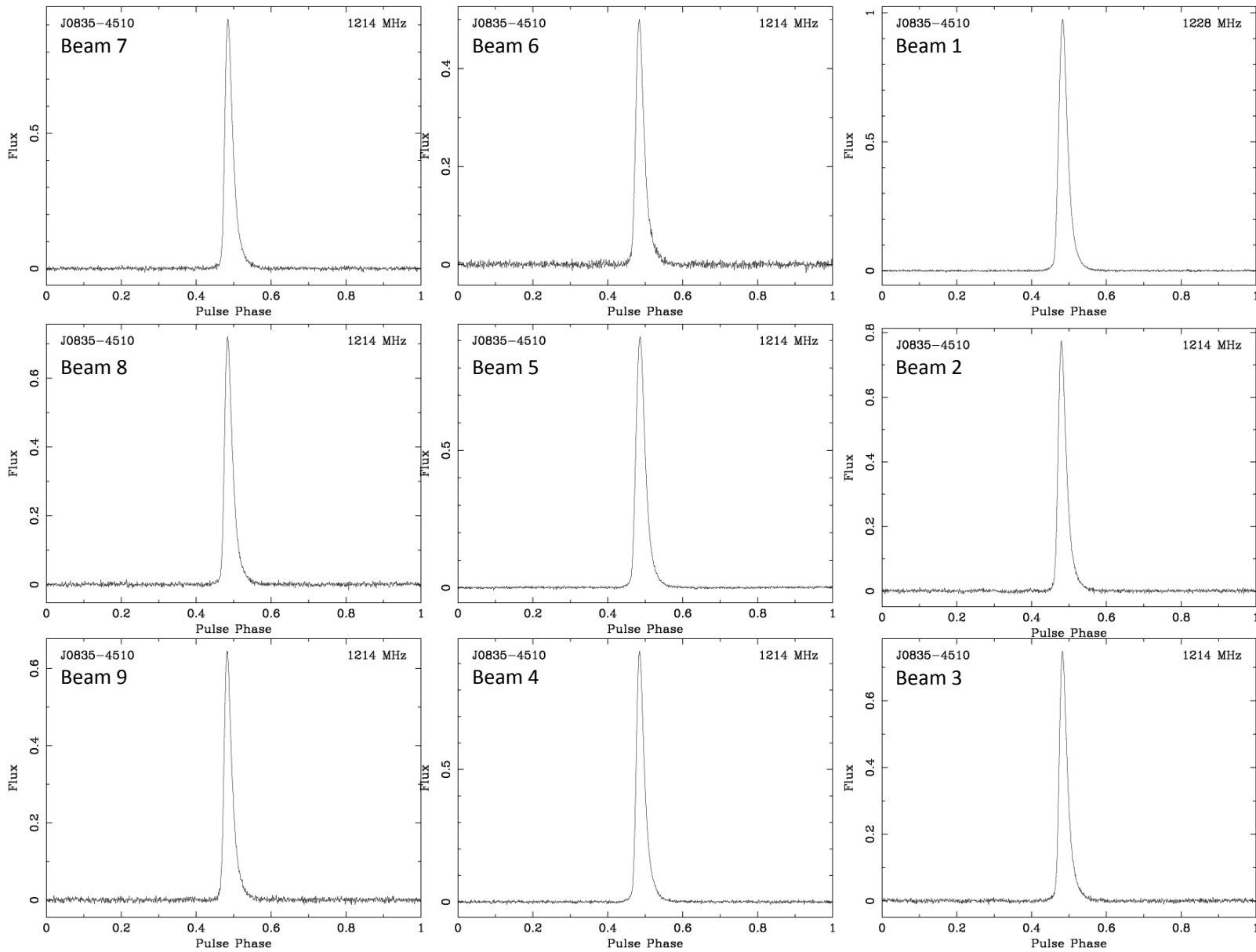
Freq: 1344.000 MHz BW: 329 Length: 599.880 S/N: 17046.143



0833-45 add.ar

Freq: 1344.000 MHz BW: 329 Length: 599.880 S/N: 17046.186

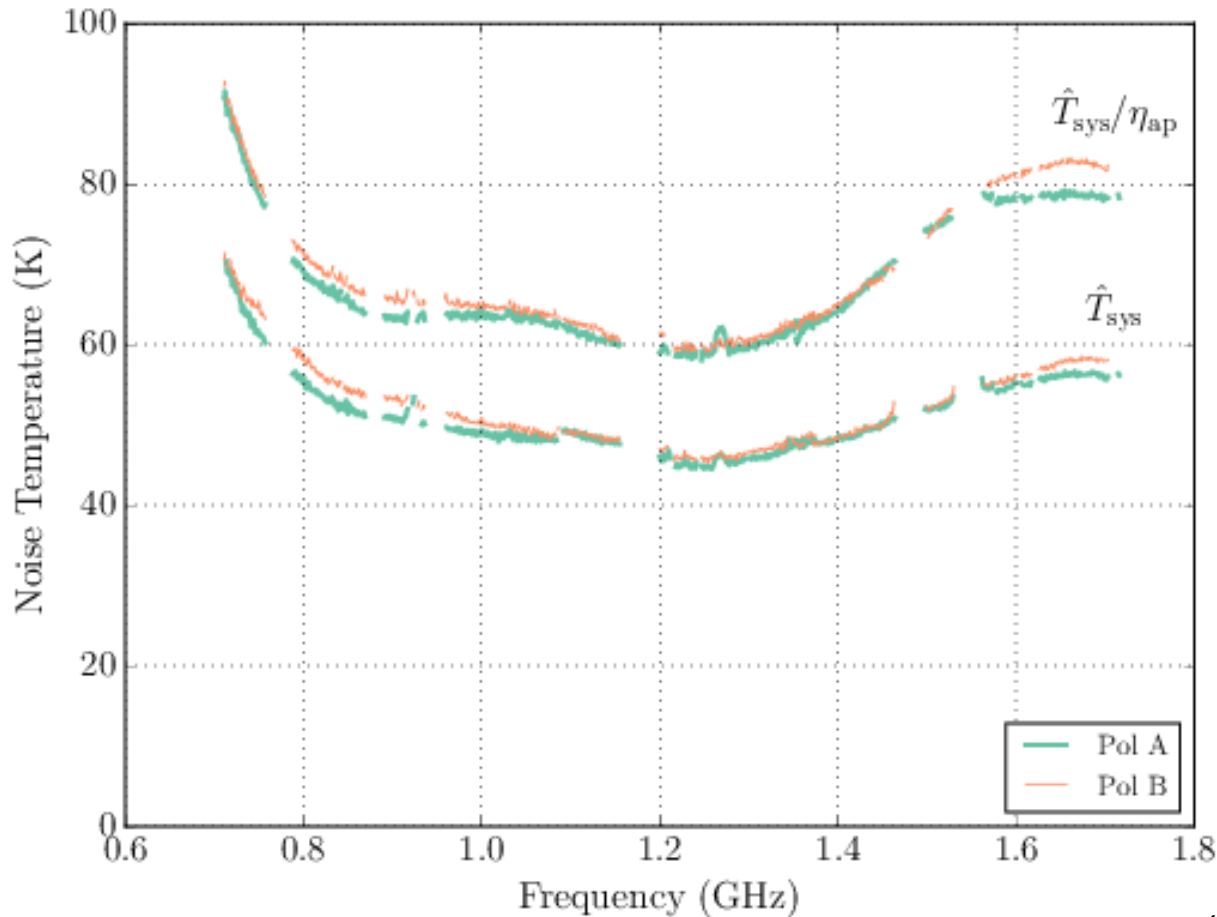




Vela Pulsar (J0835-4510): 3x3 Square Footprint on 0.215° Pitch, S1400 = 1.1 Jy

Noise Temperature of MPIfR PAF on Parkes 64 m

maxSNR beam at boresight



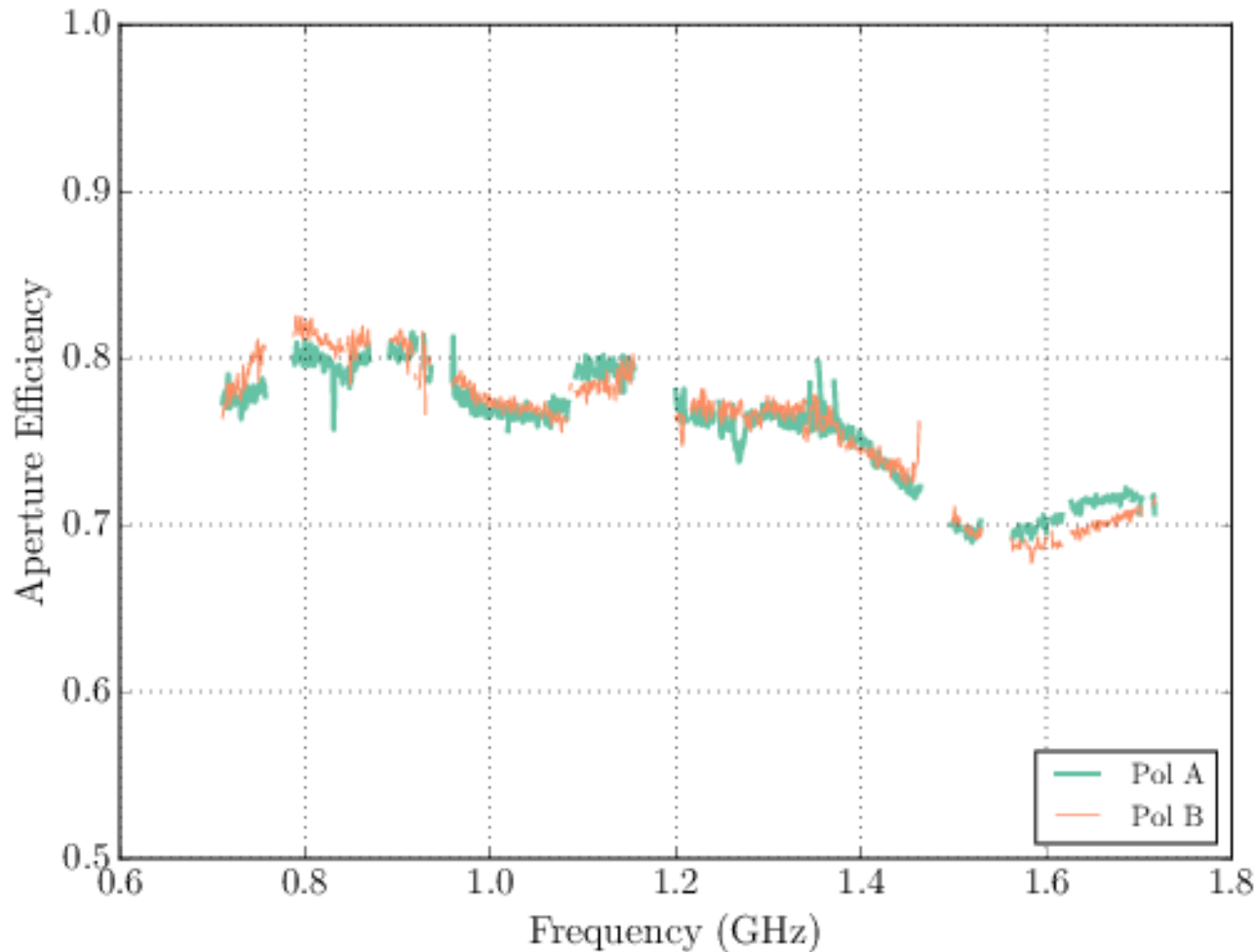
Measured via Virgo A
Flux model from (Ott et al., 1994)
Off-source $-1^{\circ}46'30''$ arc length RA offset

Measured via microwave absorber

RFI affected data removed

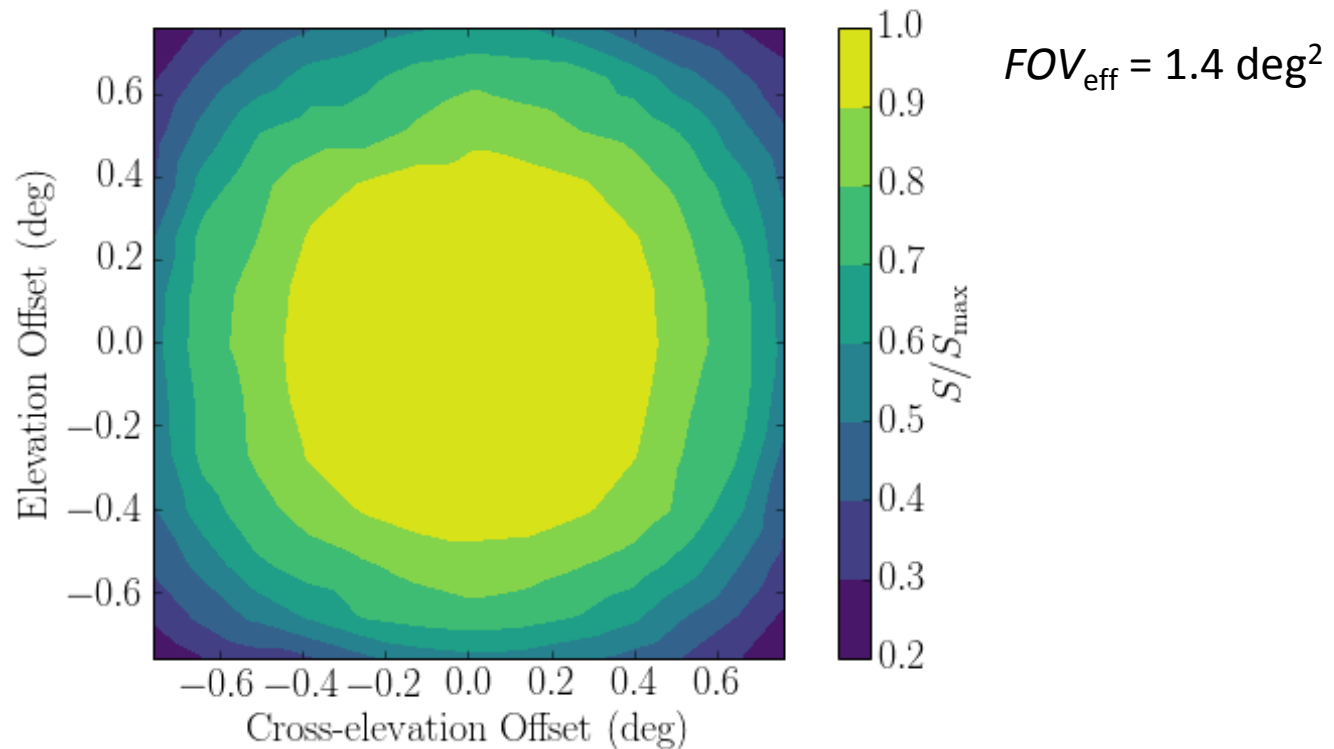
(Chippendale et al., ICEAA 2016)

Aperture Efficiency of MPIfR PAF on Parkes 64 m



(Chippendale et al., ICEAA 2016)

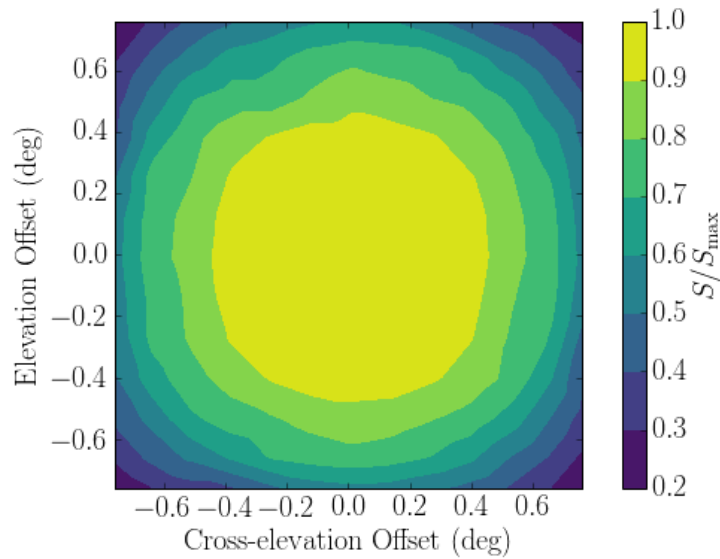
Relative Sensitivity of MPIfR PAF over FOV



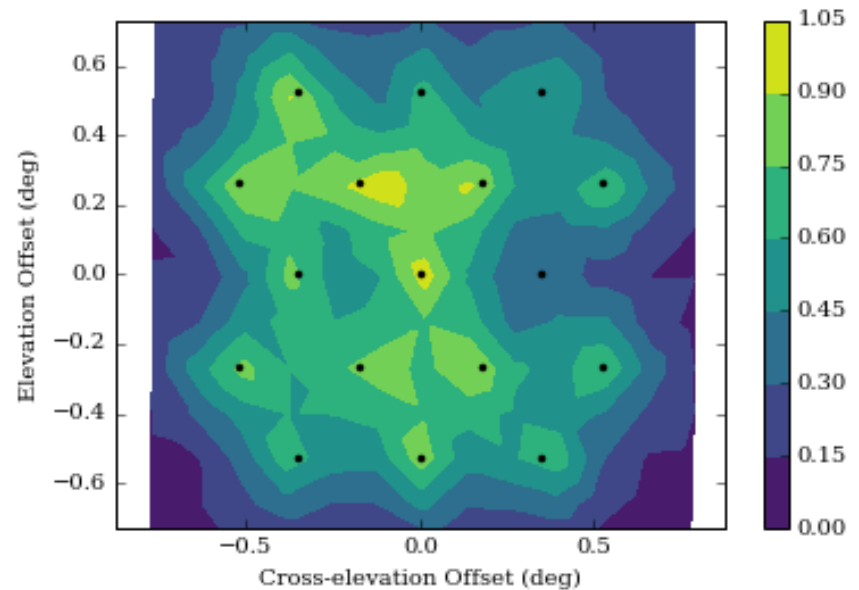
(Chippendale et al., ICEAA 2016)

Relative sensitivity over FOV

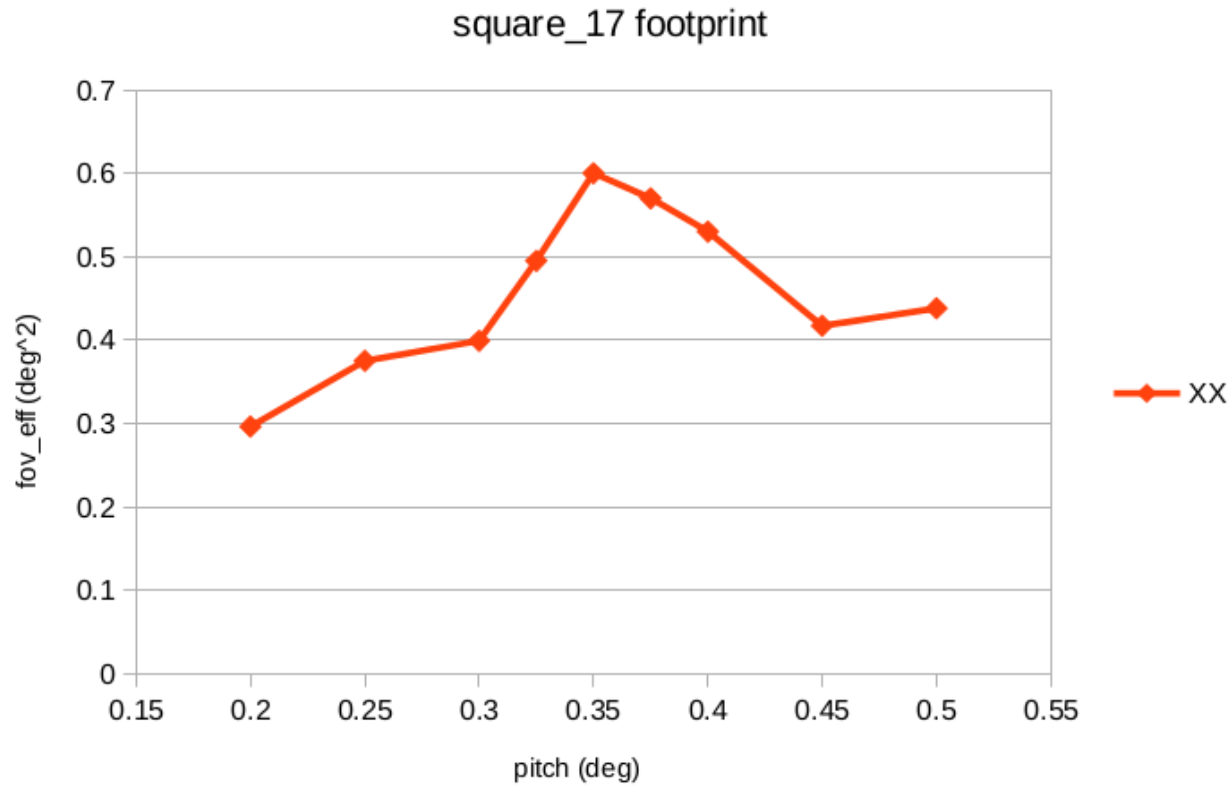
Infinite beams



17 beams (preliminary)



Effective FOV versus beam pitch (17 beams)

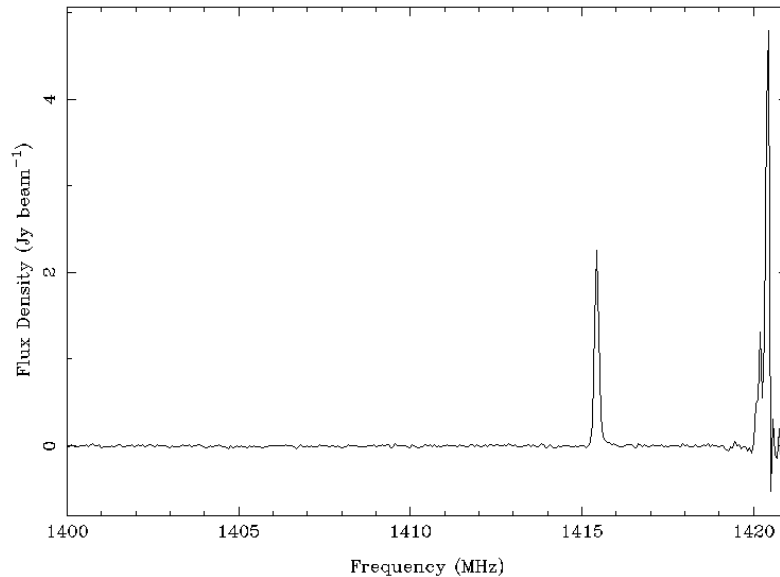


21 cm spectrum of another galaxy

HIPASS J040-48

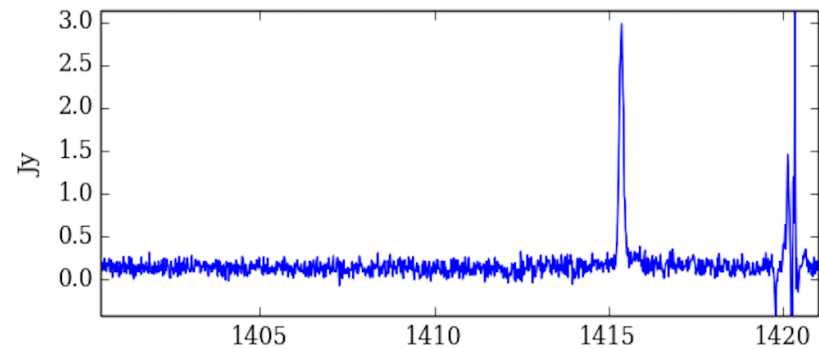
Parkes 20 cm Multibeam
(HIPASS public data release v1.2,)

Object: H088
Requested: 10:40:18.70 -48:34:00.00
Actual: 10:40:25.78 -48:37:47.84
Equinox: J2000.0
HIPASS public data release - v1.2 May 13 2000 (south)



MPIfR PAF on Parkes

(credit: L. Staveley-Smith and J. Rhee, 18 kHz res.)



“Nice flat baseline”

Polarisation calibration

Instrument modelled by single Jones matrix \mathbf{J}

$$\mathbf{c}_o = \mathbf{J} \otimes \mathbf{J}^* \mathbf{c}_i$$

where

$$\mathbf{c} = \text{vec}(\mathbf{R}_{\bar{E}}^*) = \begin{bmatrix} \langle |E_u|^2 \rangle \\ \langle E_u E_v^* \rangle \\ \langle E_u^* E_v \rangle \\ \langle |E_v|^2 \rangle \end{bmatrix}$$

Solve for \mathbf{J} that minimises square of difference between PAF measurement and PPTA reference measurement

$$\mathbf{J} = \mathbf{J}_{\text{gen}} \mathbf{J}_{FA} \mathbf{J}_{\psi}$$

Rotation by parallactic angle ψ and feed angle FA

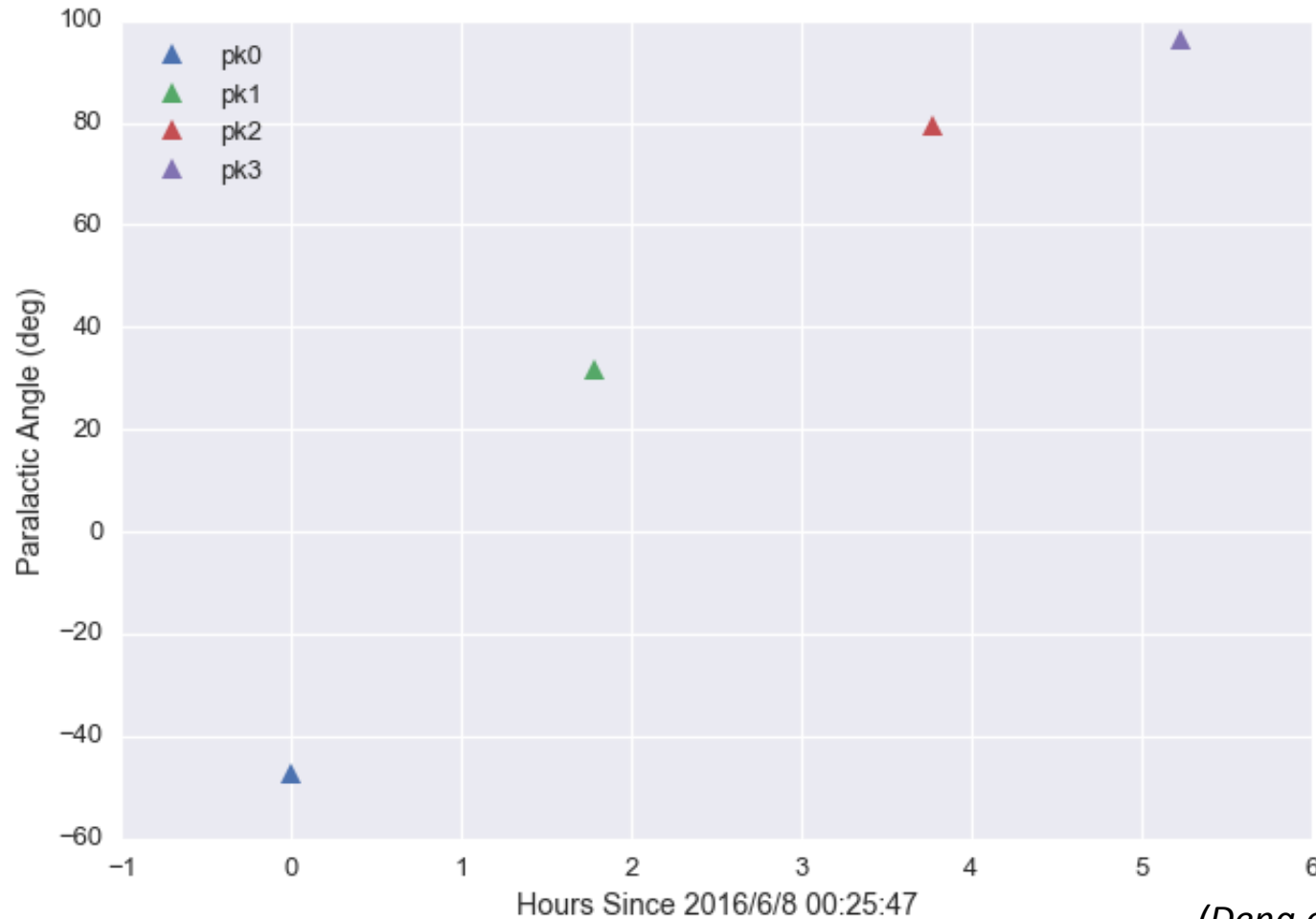
$$\mathbf{J}_{\psi} = \begin{bmatrix} \cos \psi & \sin \psi \\ -\sin \psi & \cos \psi \end{bmatrix}$$

Generic instrumental response

$$\mathbf{J}_{\text{gen}} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

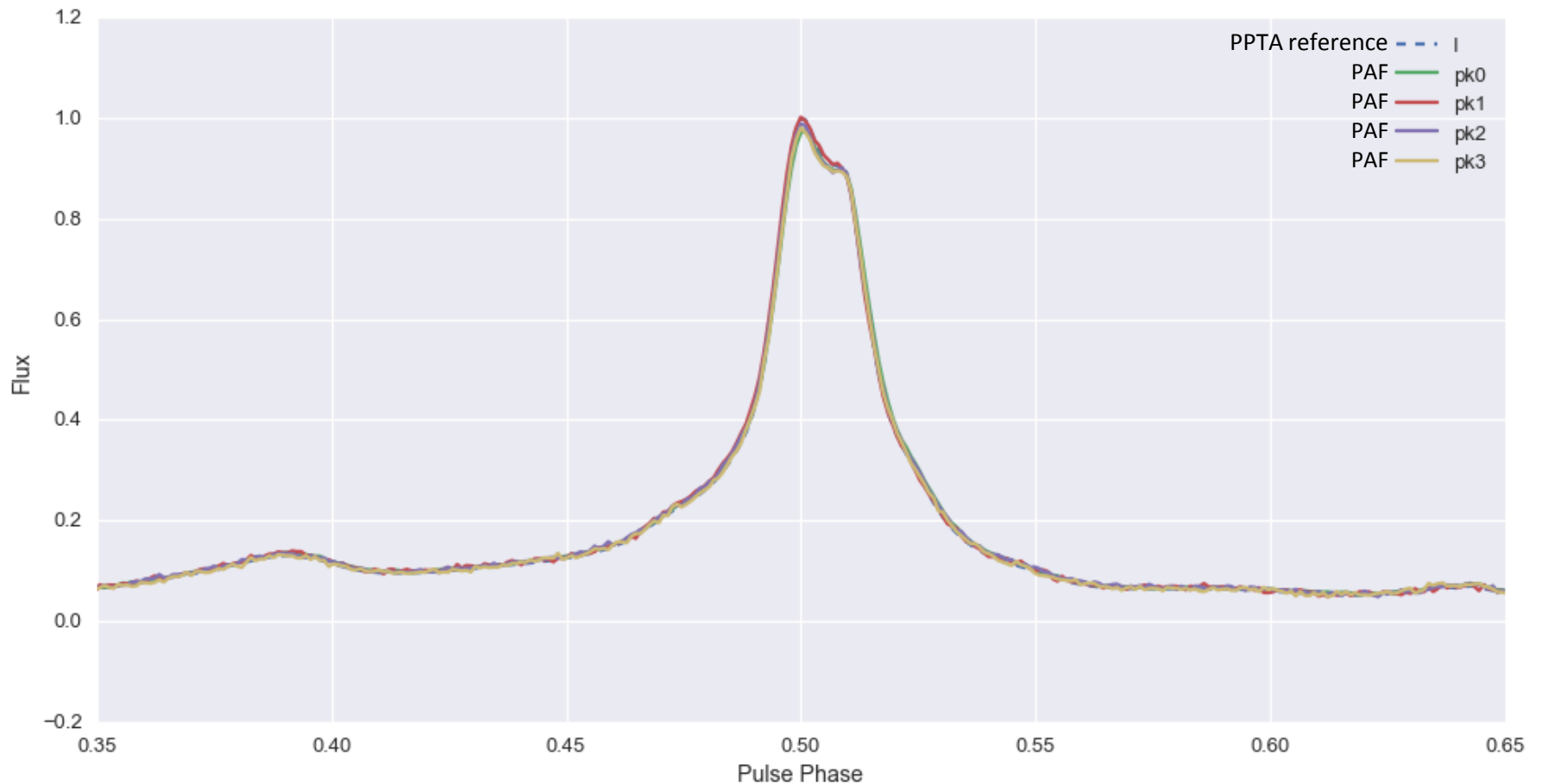
Multi-epoch PAF observation of PSR J0437-4715

Offset beam ($-0.215^\circ, -0.215^\circ$) in (cross-elevation, elevation)



(Deng et al. in prep.)

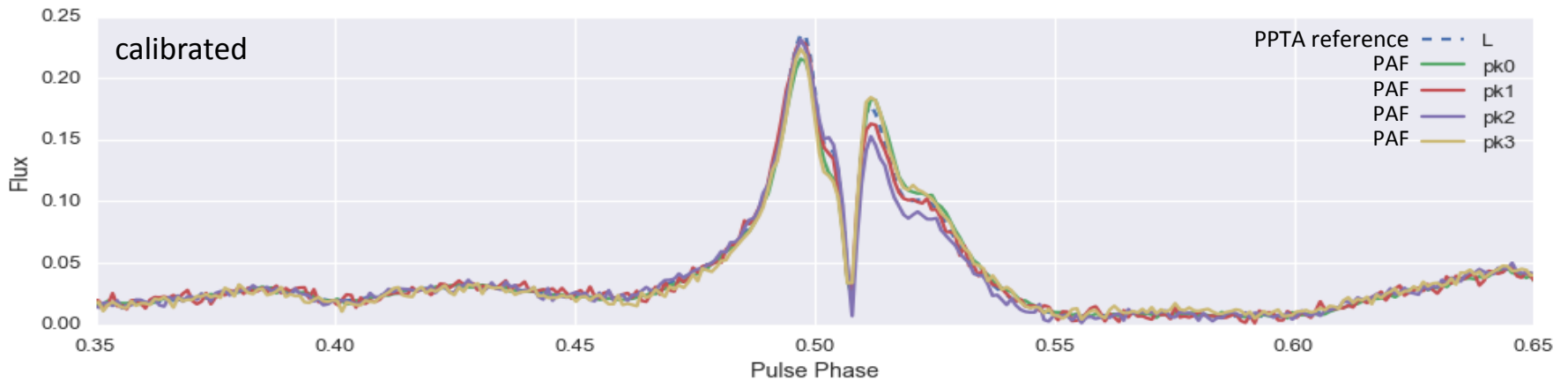
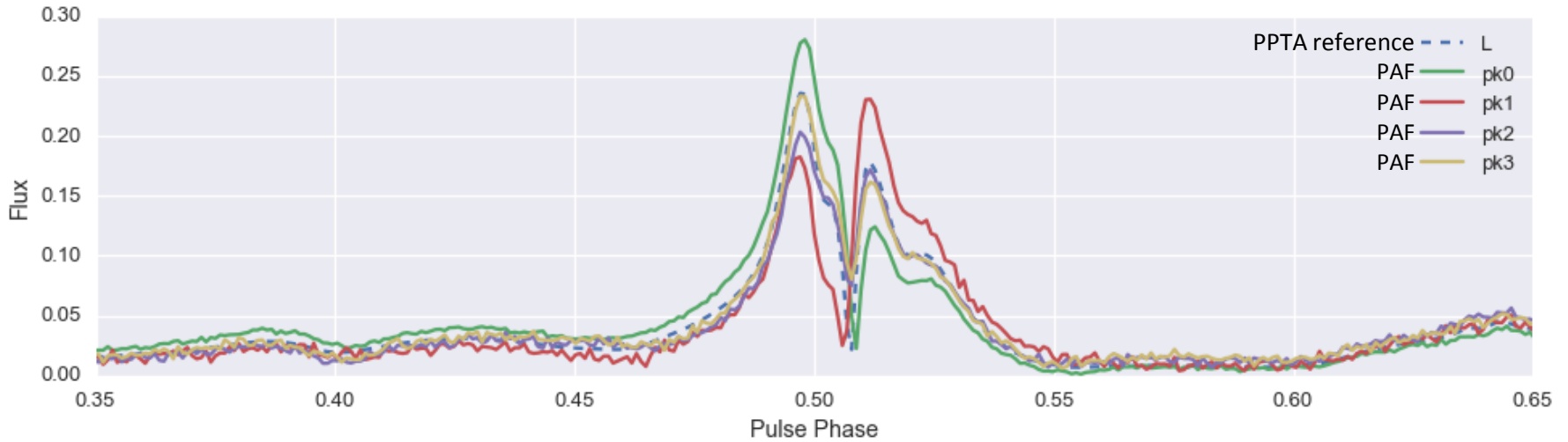
PSR J0437-4715: normalised Stokes I



PPTA reference from Dai et al., MNRAS 2015

(Deng et al. in prep.)

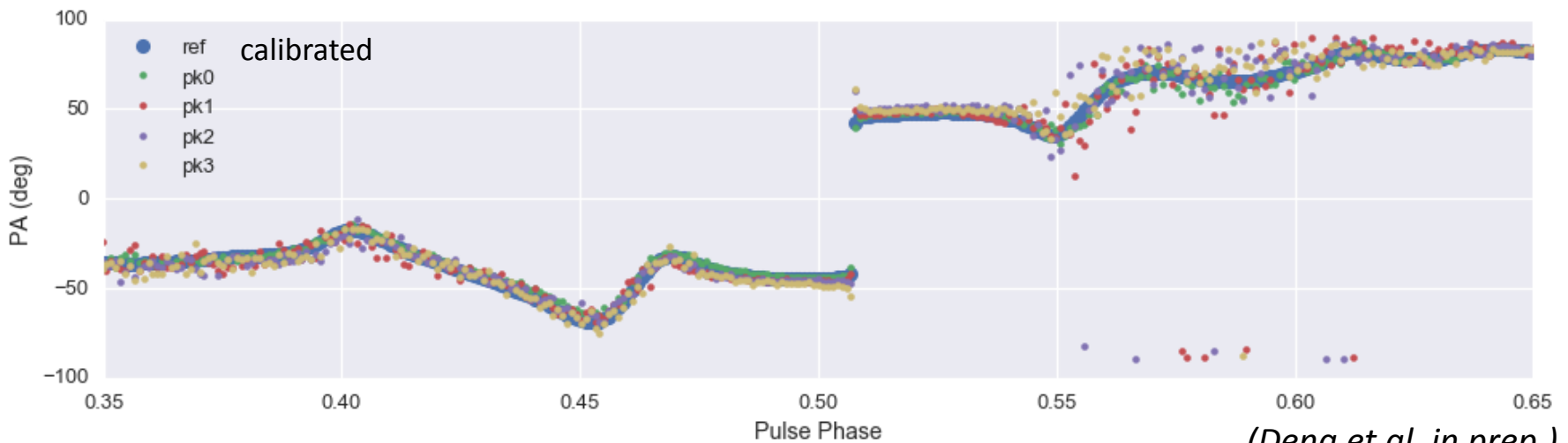
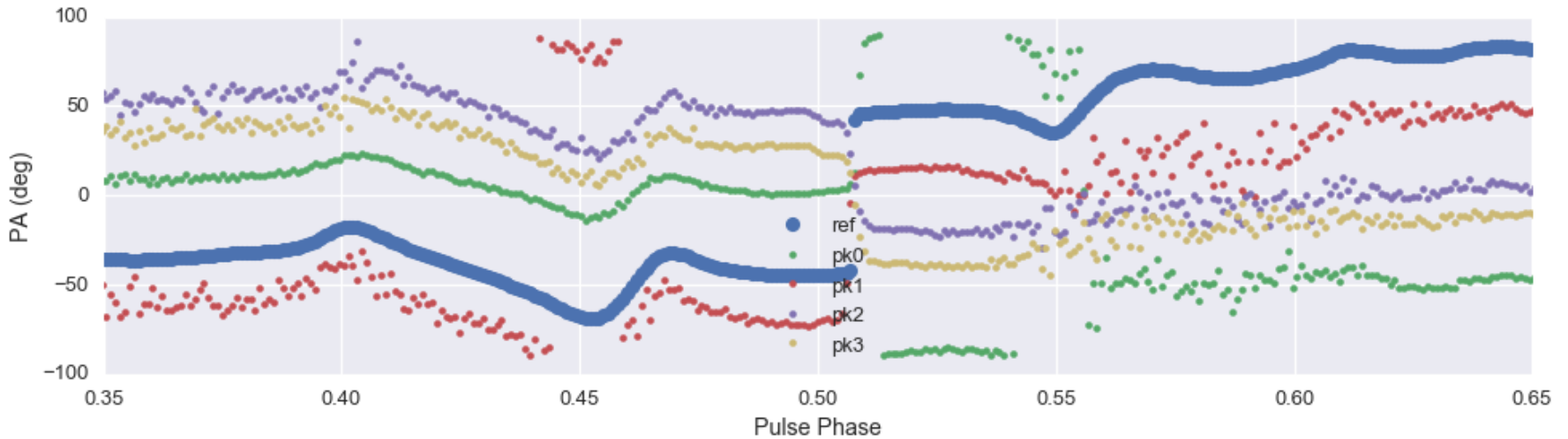
PSR J0437-4715: degree of linear polarisation



PPTA reference from Dai et al., MNRAS 2015

(Deng et al. in prep.)

PSR J0437-4715: position angle



PPTA reference from Dai et al., MNRAS 2015

(Deng et al. in prep.)

Jones matrix parameters

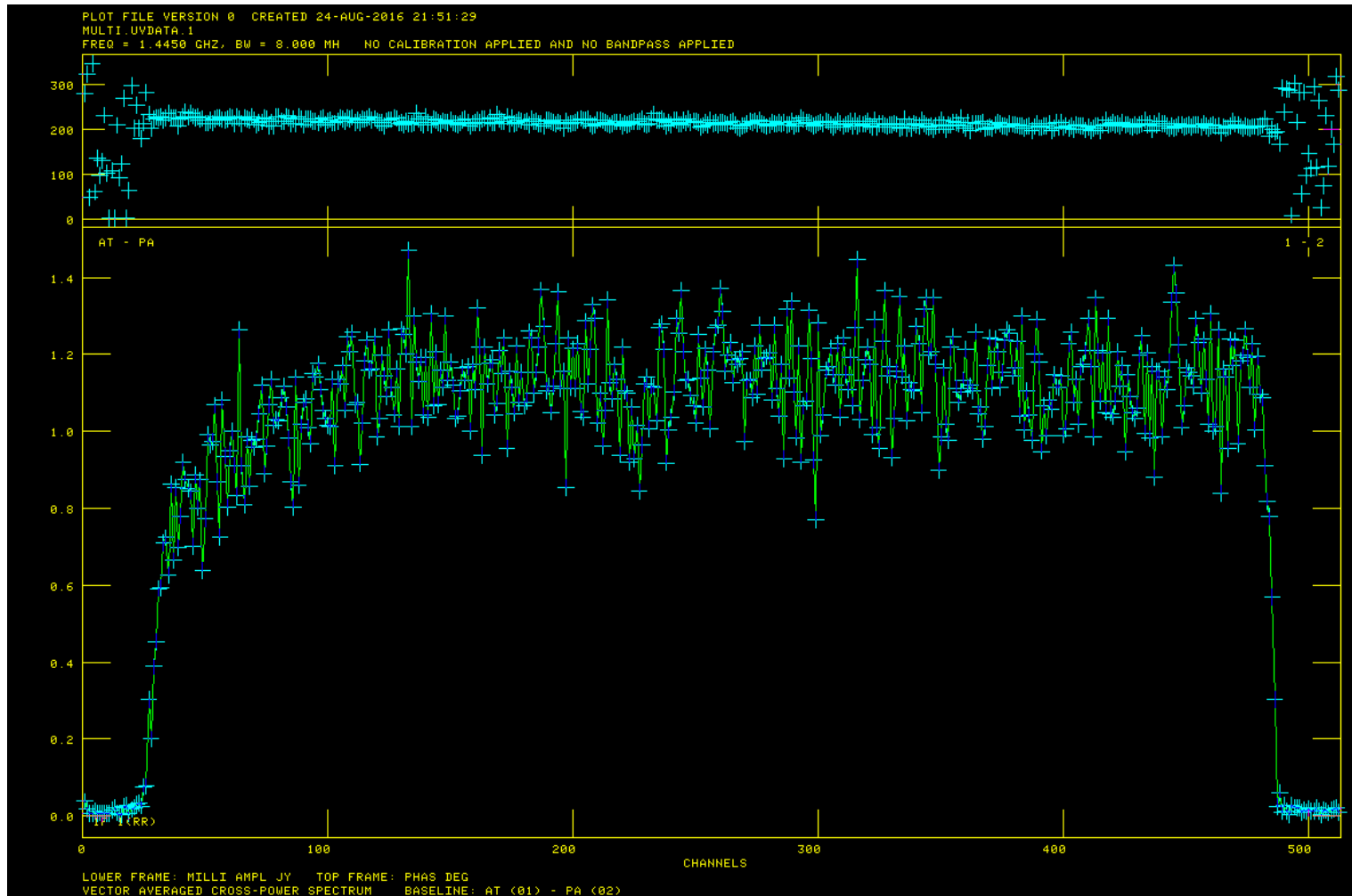
Single J works reasonably
for 336 MHz band

abs_gain:	1.05	
sys_phase:	-2.72 deg	
diff_gain_mod:	0.929	
diff_gain_arg:	9.16 deg	
leak_a_b_mod:	-35.7 dB	← Low leakage
leak_a_b_arg:	71.7 deg	
leak_b_a_mod:	-34.7 dB	←
leak_b_a_ar:	-30.0 deg	
feed_angle:	-2.0 deg	

VLBI between PAF on Parkes and ATCA

(credit: Chris Phillips)

3C273



Next

- Get more beams working at full bandwidth
- Simultaneous timing of multiple pulsars
- Push polarisation calibration into beam weights
(after Warnick et al, TAP 2012)
- Refer beam weights to on-dish calibration source

Longer term (supporting science)

- Reducing beam calibration overheads
- Direction of arrival (DOA) estimation
- Sky de-rotation via beamforming
- Beamforming with noise-field whitening
- Beamforming and performance measurements via pulsars
- RFI detection and mitigation

Thank you

Astronomy and Space Science

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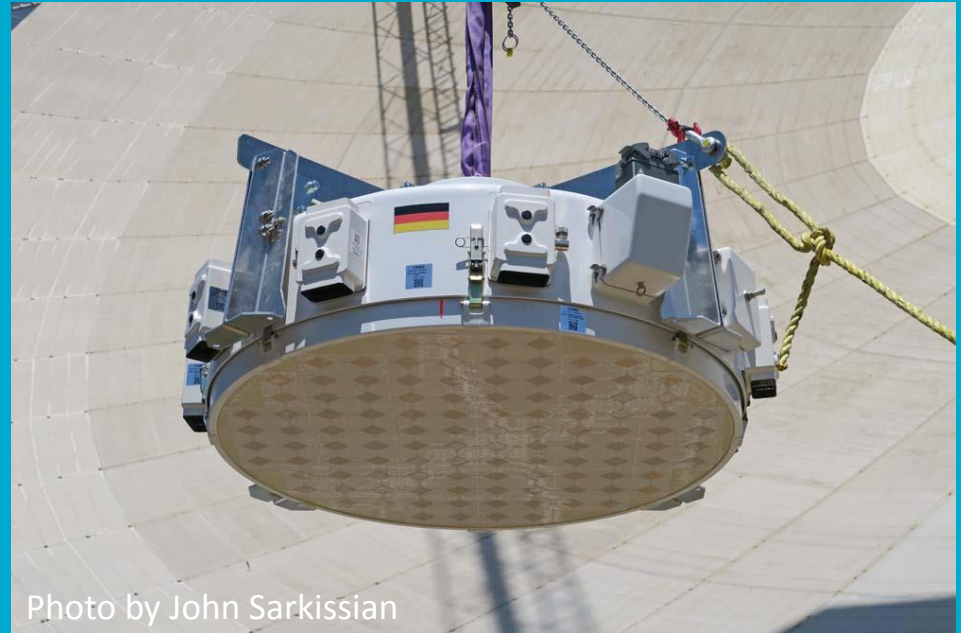


Photo by John Sarkissian

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