Phased Array Feed Calibration

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Beam Control

- Equal path lengths
- Attenuators
- Beam weights
- Beam footprint

Beam Chaos

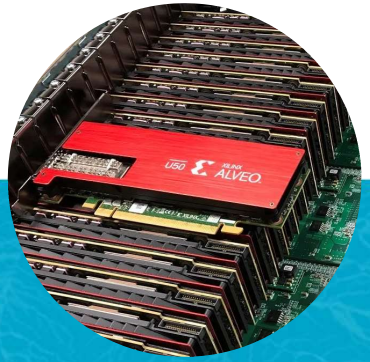
- Sensitivity loss
- Flux errors
- Polarisation leakage
- Position dependent bandpass
- Pointing errors
- ADC misalignment
- Gain drift
- Port Failures
- RFI

How we are

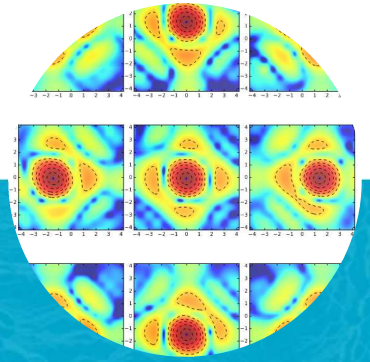
Improving Beam Calibration

External calibration

Internal calibration



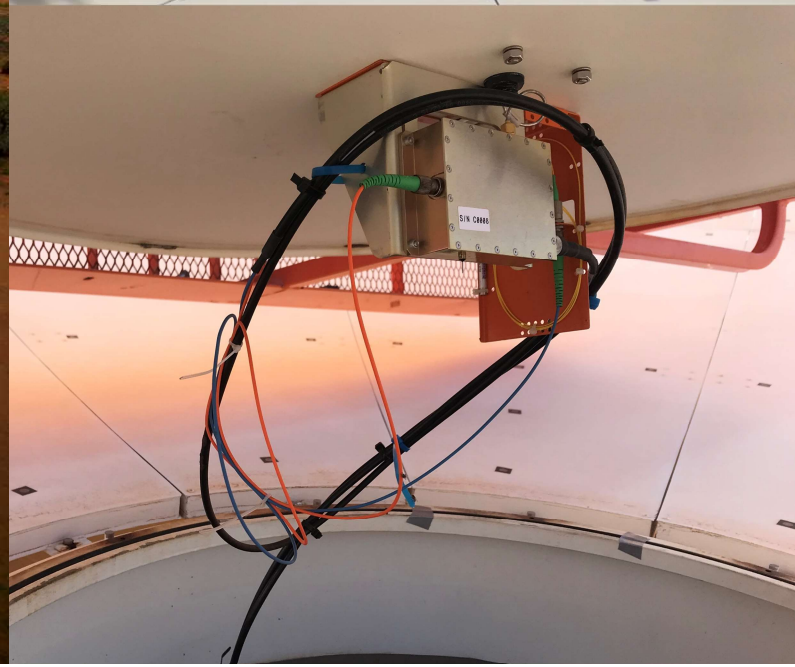
Beamformer improvements



Operational improvements

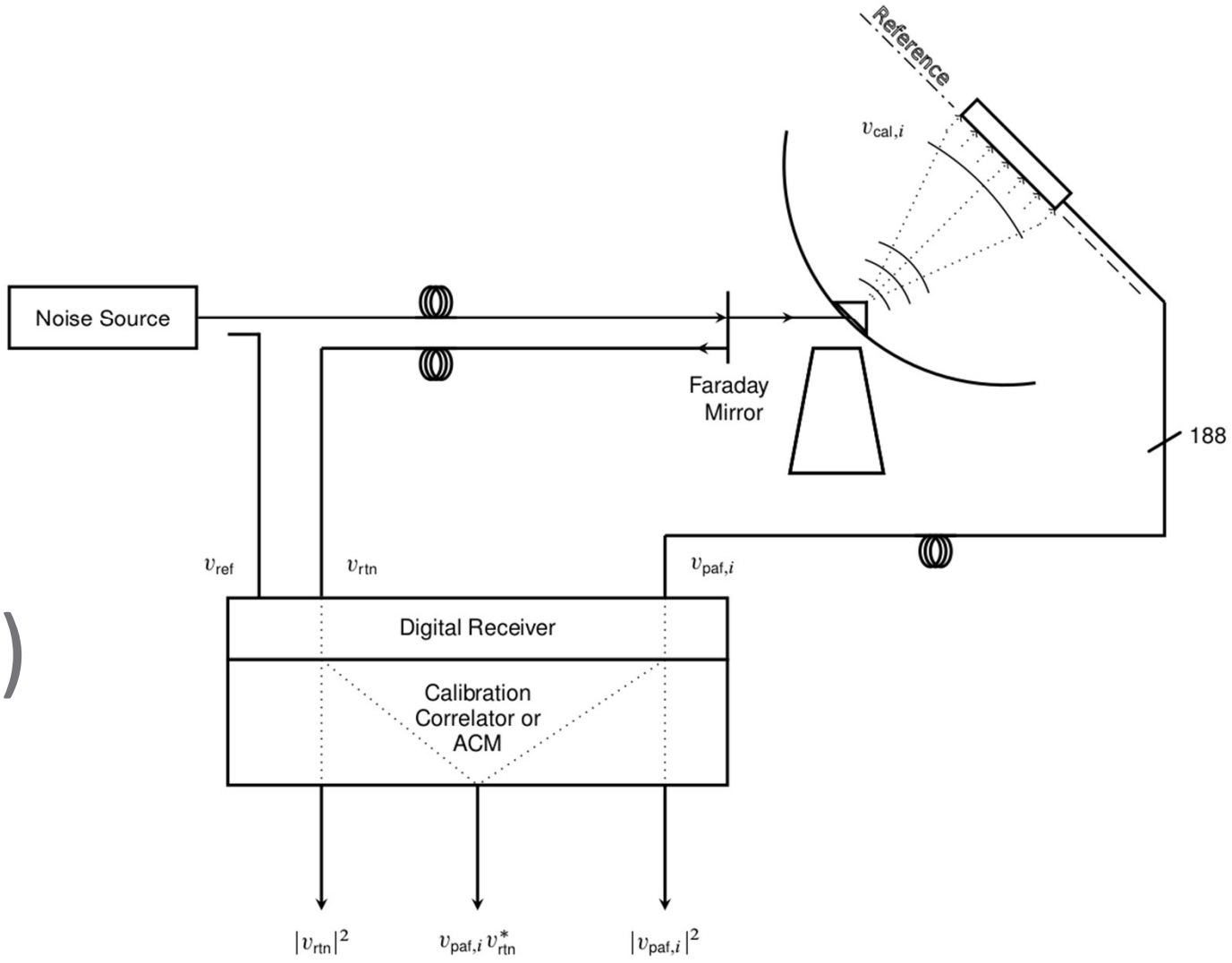
ASKAP On-Dish Calibration

with Beresford & Reay

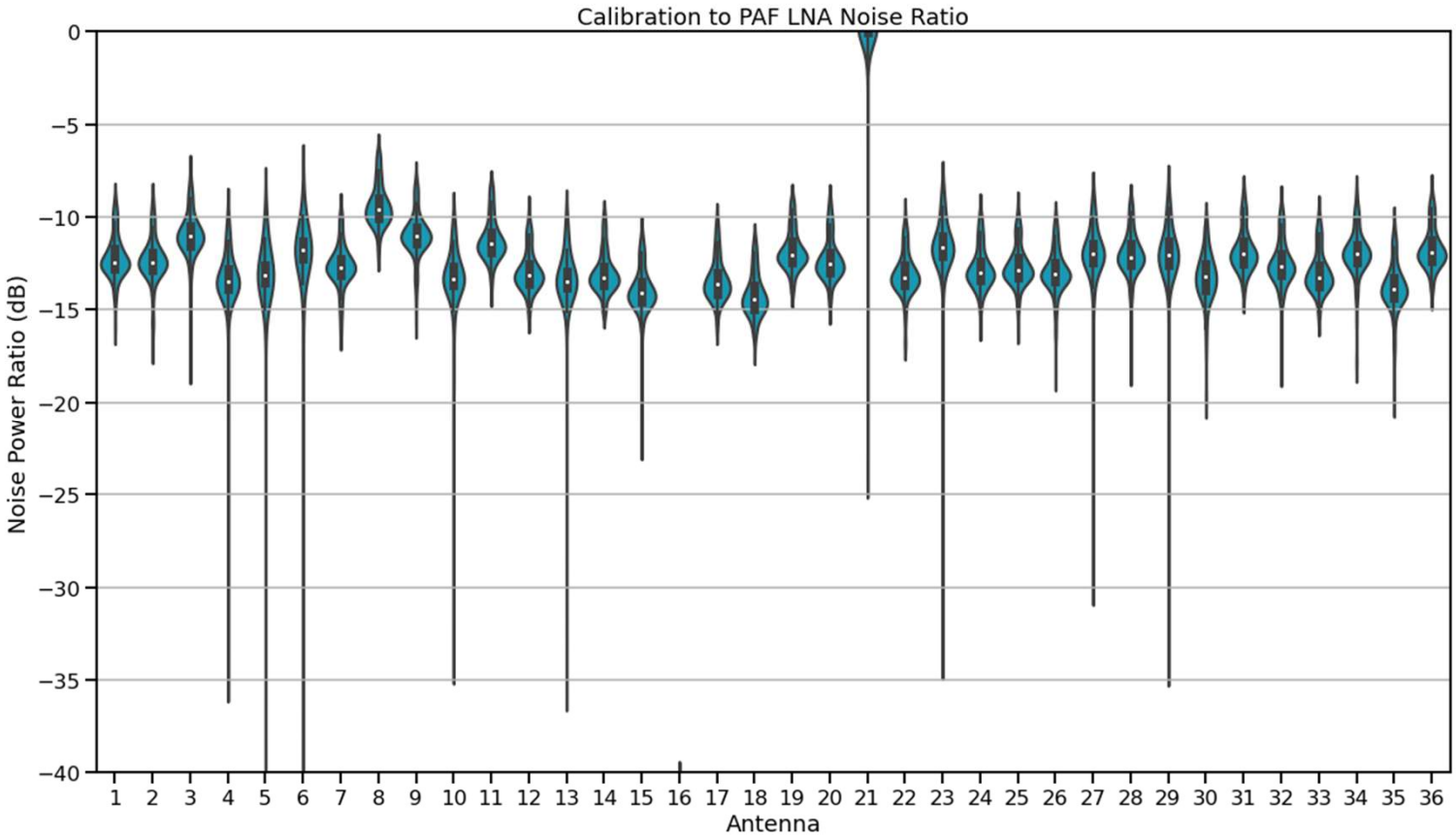


ASKAP On-Dish Calibration (ODC)

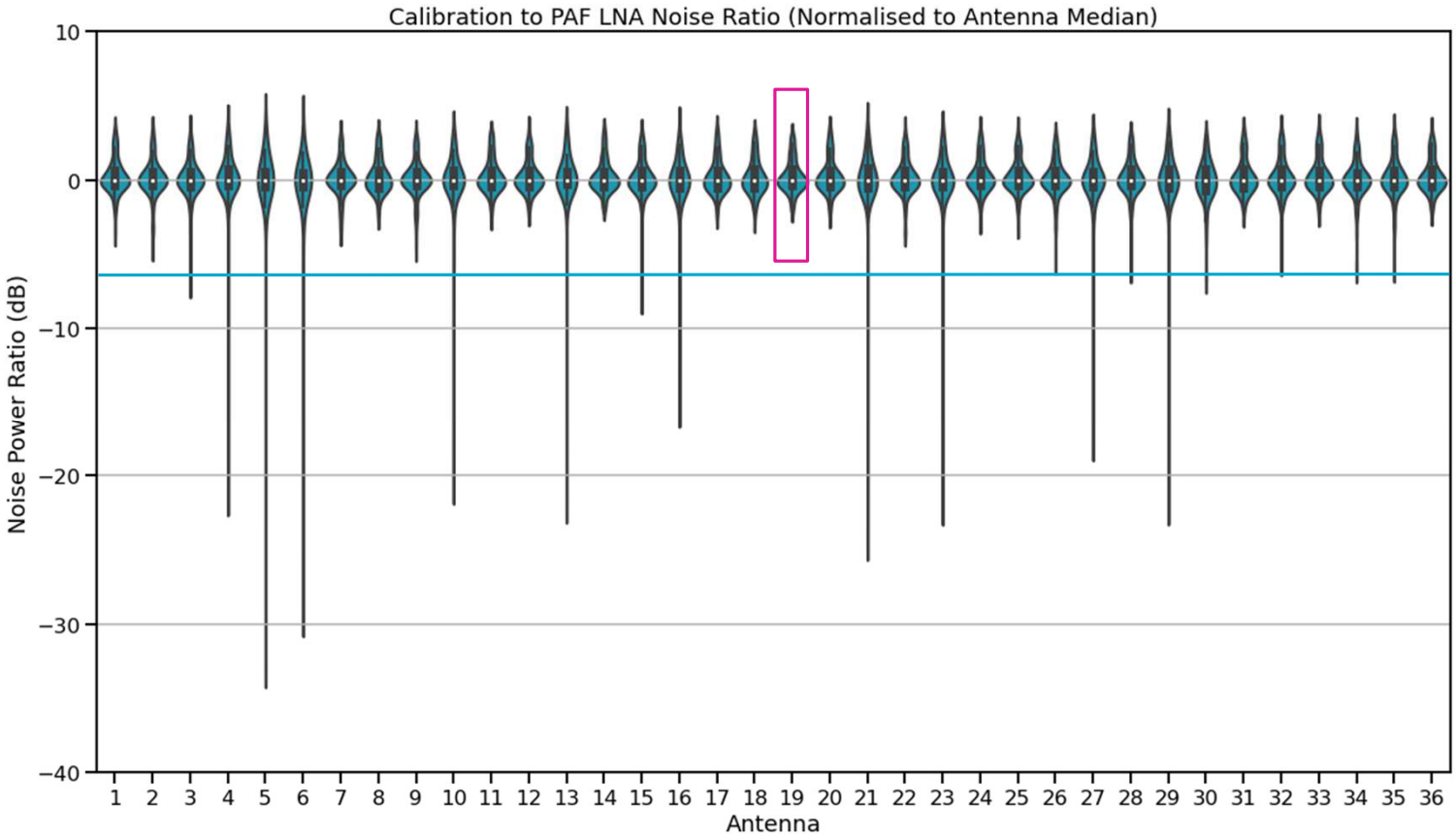
[Chippendale et al., 2017](#)
ACES memo 018



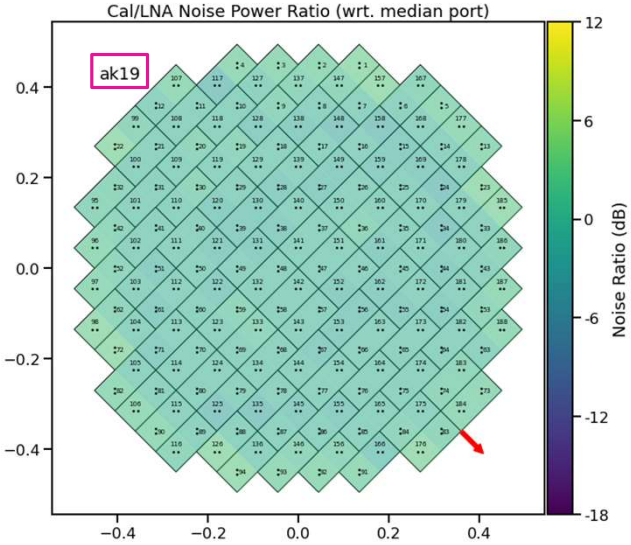
Finding Failed PAF Ports via ODC



Finding Failed PAF Ports via ODC



Normalised to median port



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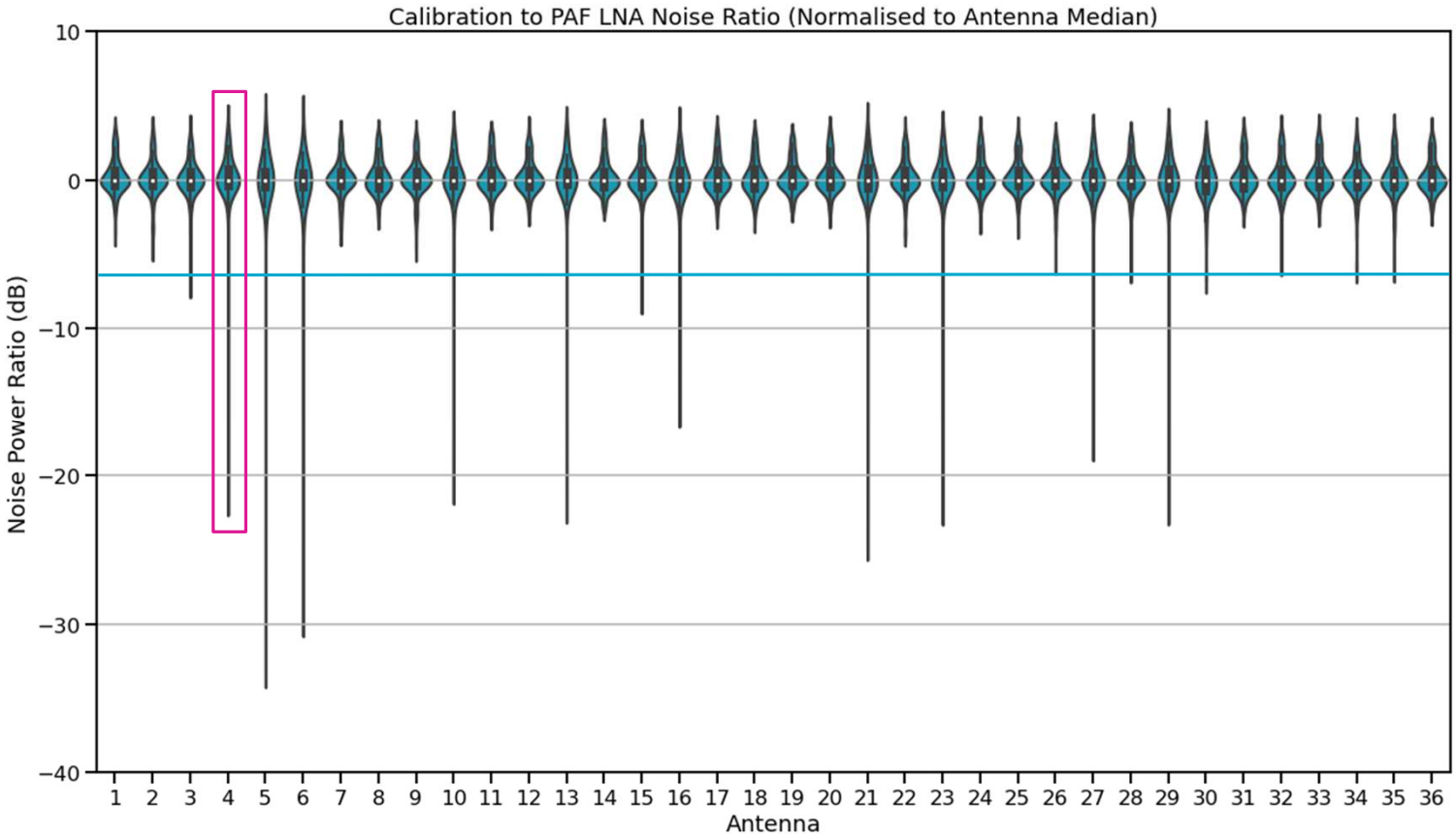
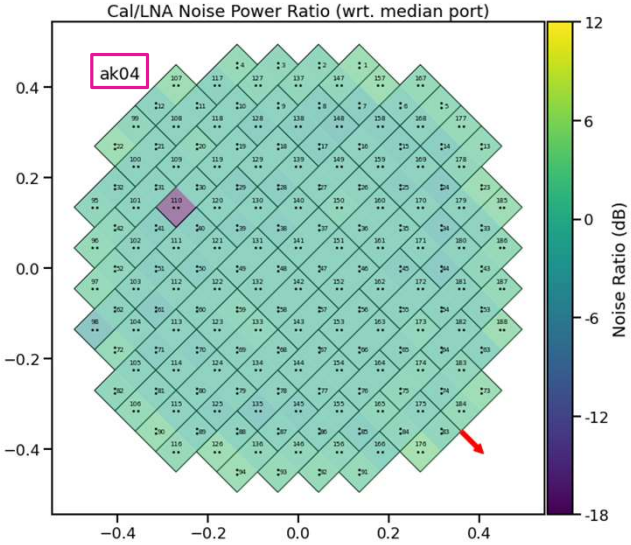
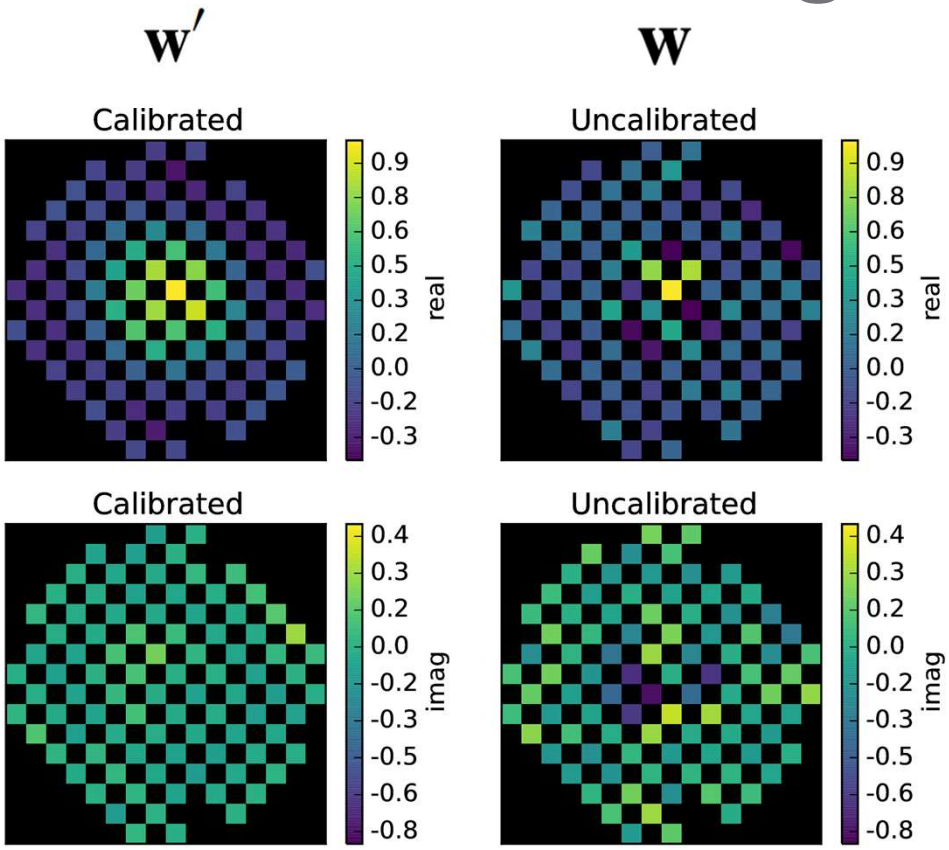


Normalised to median port



MaxSNR PAF Beam Weights at 835 MHz



Chippendale et al., 2016

PAF response to noise

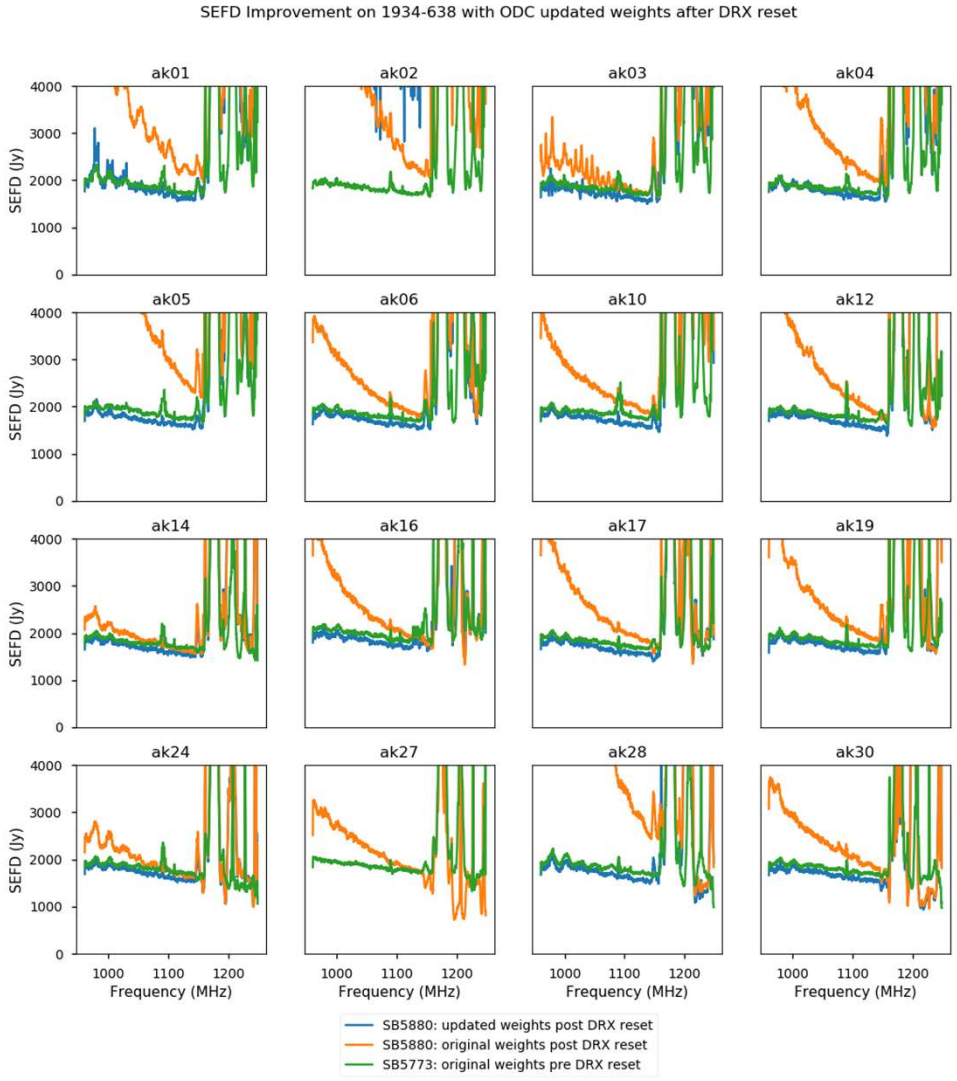
$$\mathbf{s}_{\text{cal}} = \left\langle \mathbf{v}_{\text{paf}} v^*_{\text{rtn}} \right\rangle$$

Calibrated weights

$$\mathbf{w}' = \mathbf{s}^*_{\text{cal}} \circ \mathbf{w}$$

Chippendale et al., 2019
ACES memo 19

Sensitivity Recovery via On-Dish Calibration



Original weights before digitiser reset

Original weights after digitiser reset

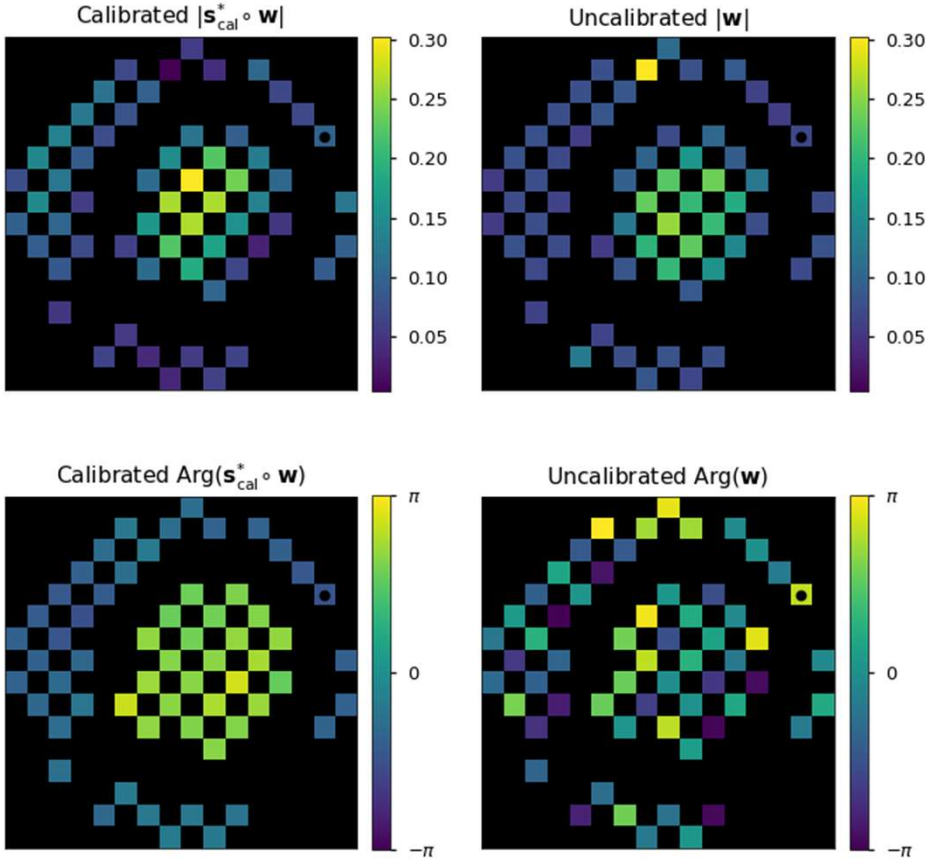
Updated weights after digitiser reset

Updated weights

$$\mathbf{w}_2 = \mathbf{s}^*_{\text{cal}1} \circ \mathbf{w}_1 \oslash \mathbf{s}^*_{\text{cal}2}$$

Chippendale & Lourenco, 2018
Unpublished

Calibrating XY-Phase On-Dish



Naïve method:

$$\mathrm{Arg}\left(\mathbf{w}_y^H \mathbf{R} \mathbf{w}_x\right)$$

- cal noise cancels
- works if noise off during beamforming

Solution:

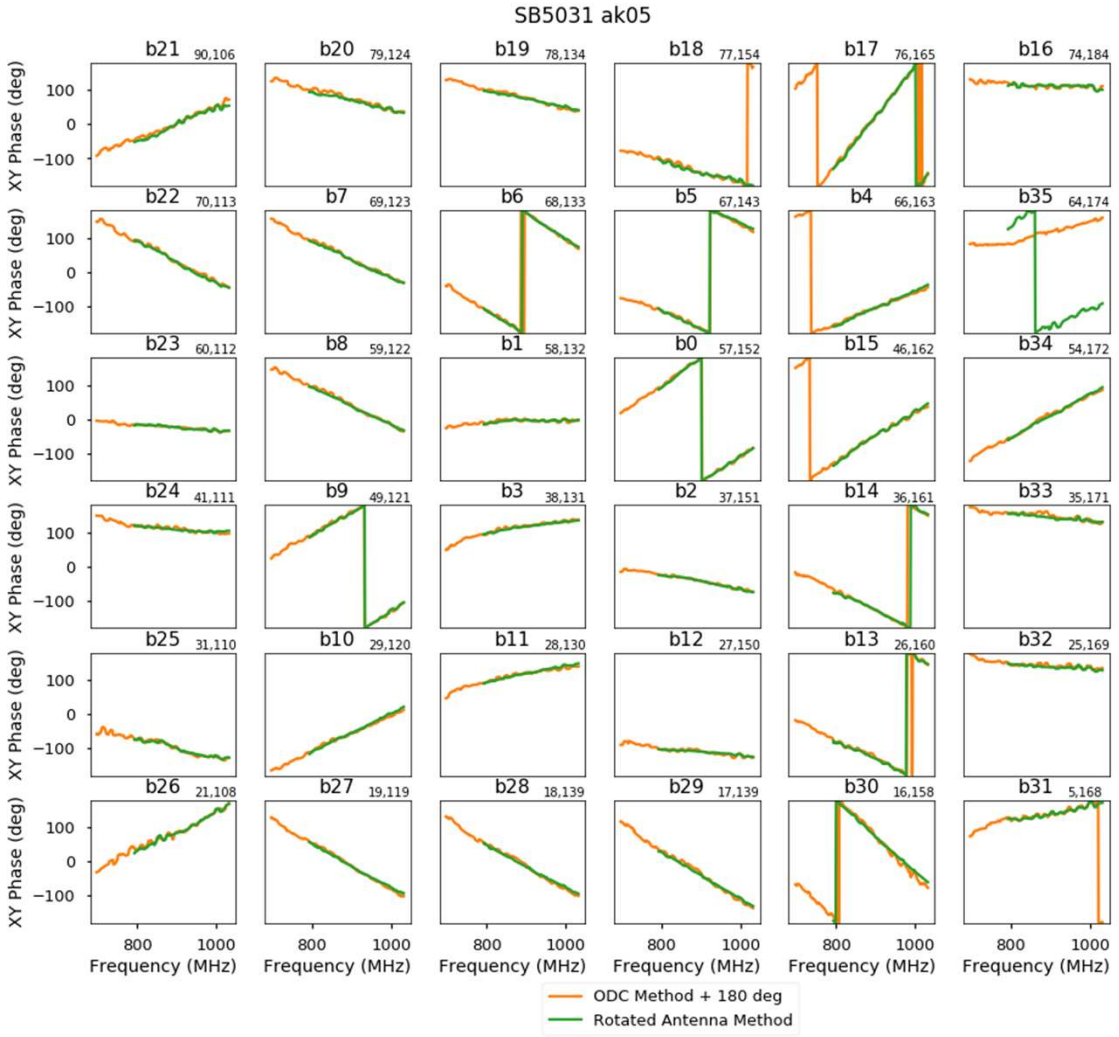
- Calibrate weights
- Divide vector averaged weight in main lobes (Ω)

$$\phi_{xy} = \mathrm{Arg}\left(\sum_{i \in \Omega_y} w'_{y,i} \Big/ \sum_{i \in \Omega_x} w'_{x,i}\right)$$

Chippendale & Anderson, 2019
(ACES Memo 19)

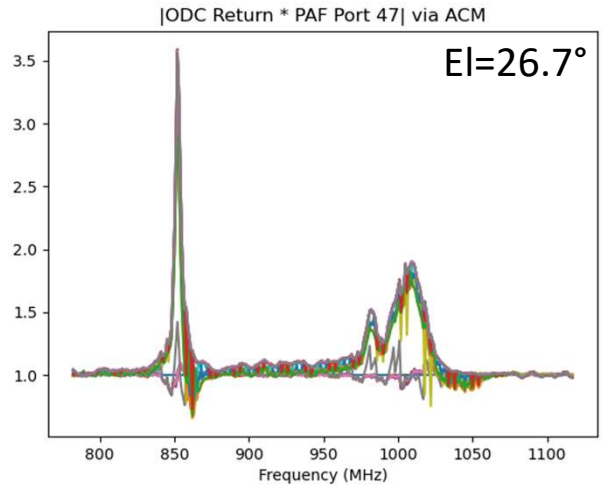
XY-phase: ODC Matches Rotated Antenna

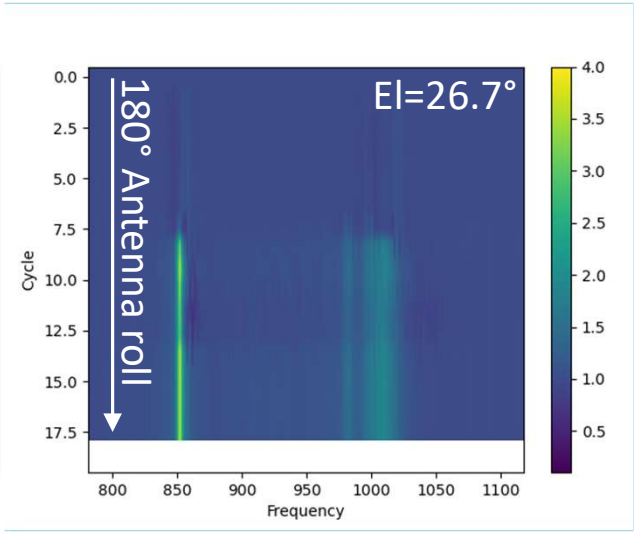
[Chippendale & Anderson, 2019](#)
(ACES memo 19)

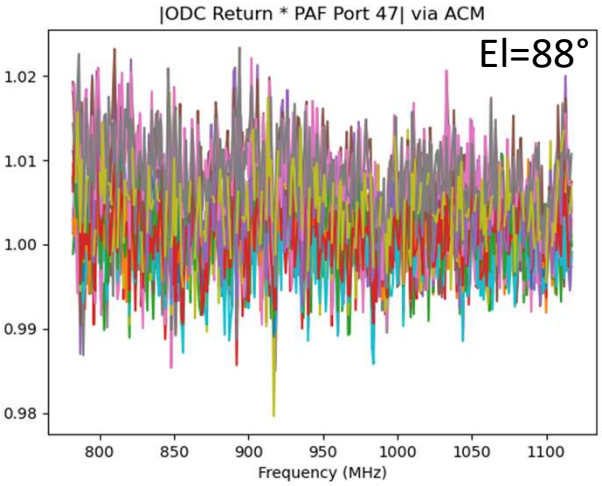


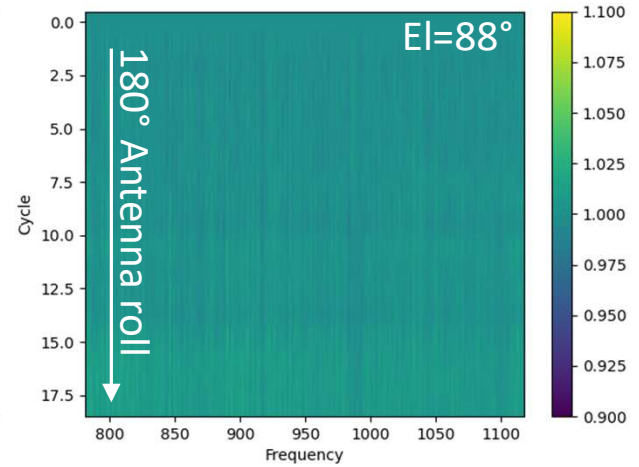
ODC Ripple and Motion Instability

ODC bandpass varies with antenna rotation at low elevation



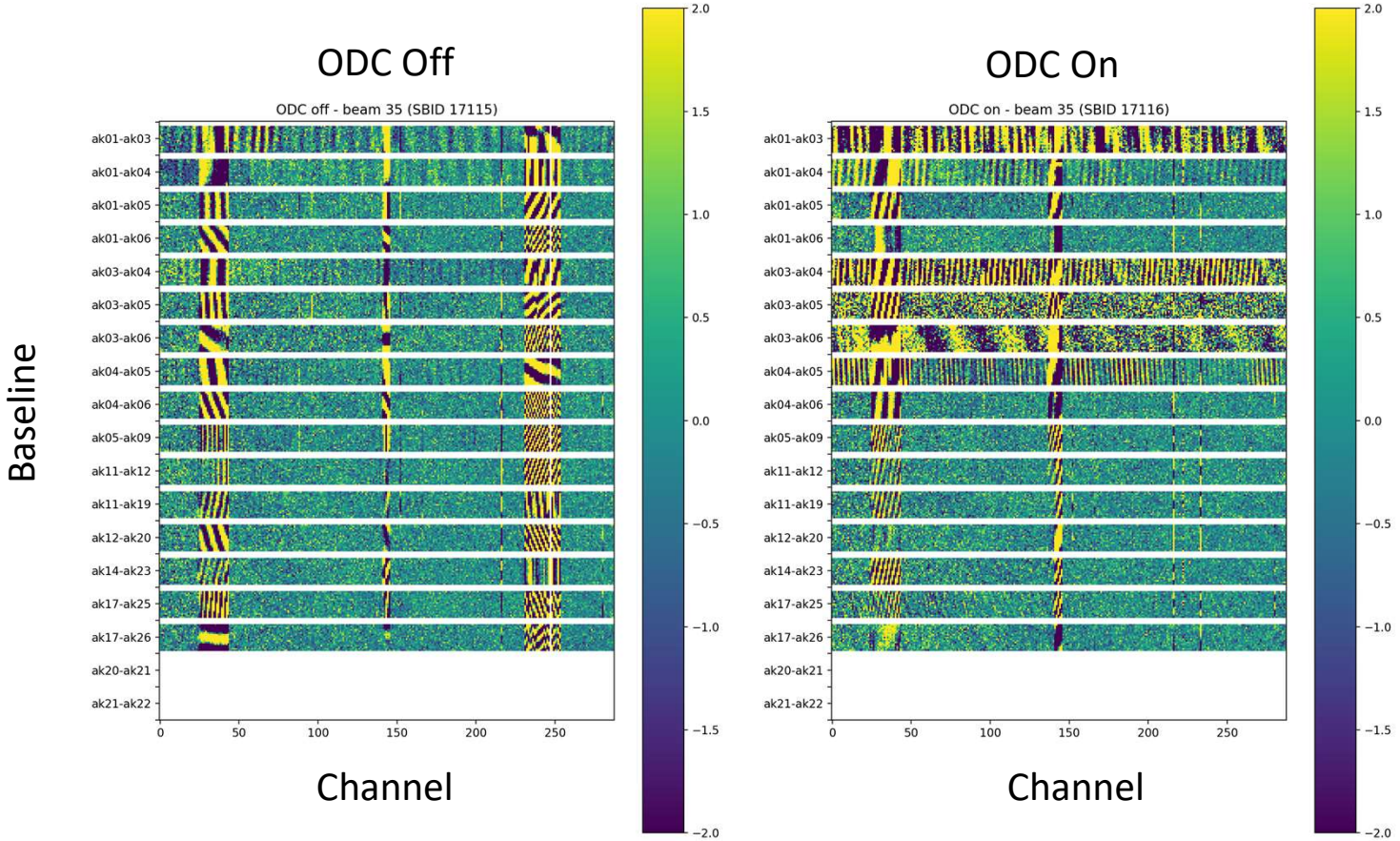






with Beresford & Reay

ODC Pollutes Short Baseline Visibilities



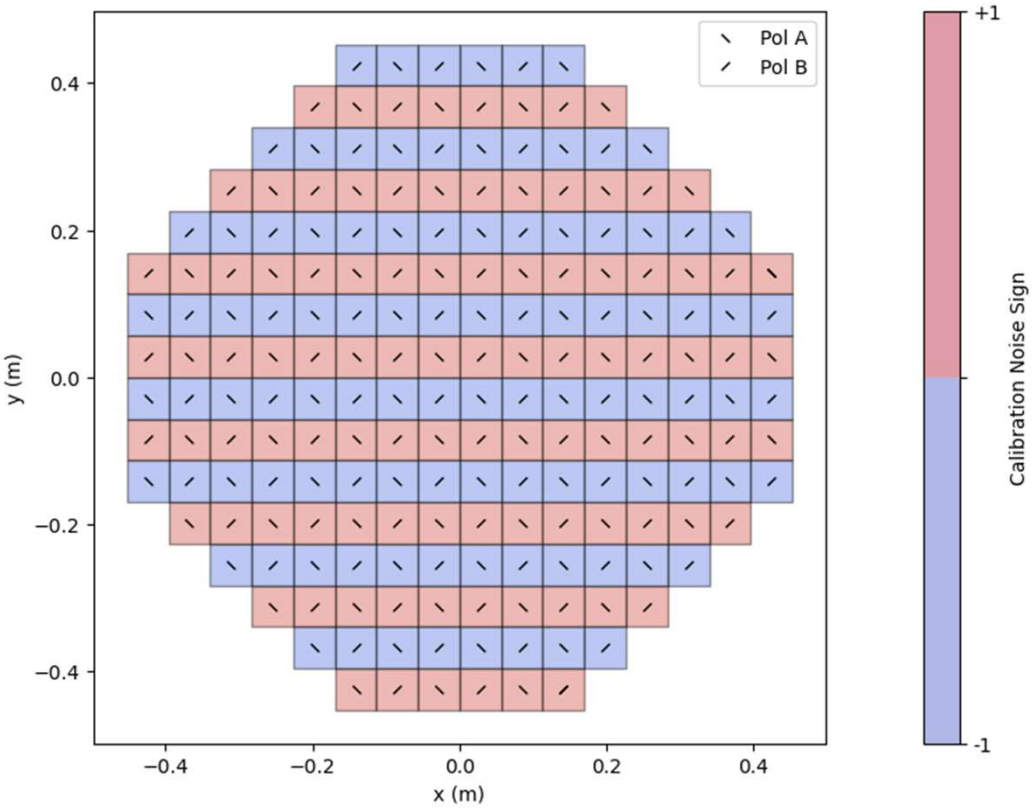
ASKAP ODC now:

- off for all observing
- on for first scan of all beamforming

E. Lenc,
Unpublished, 2020

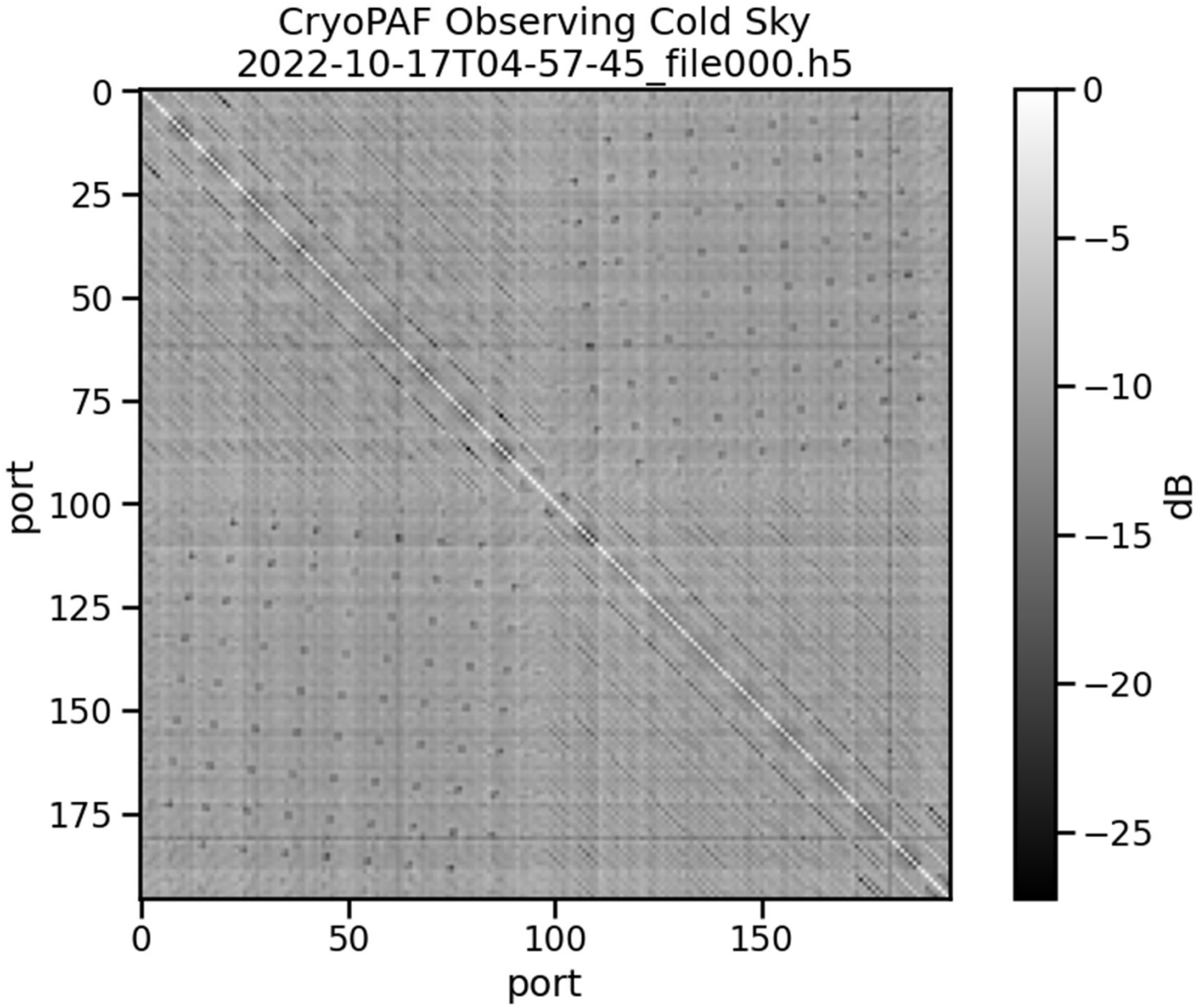
CryoPAF: Improved Internal Calibration

- Internal noise source
- Equal path length to all ports
- Alternating phase
- Adjacent ports:
  - opposite phase, or
  - orthogonal polarization.



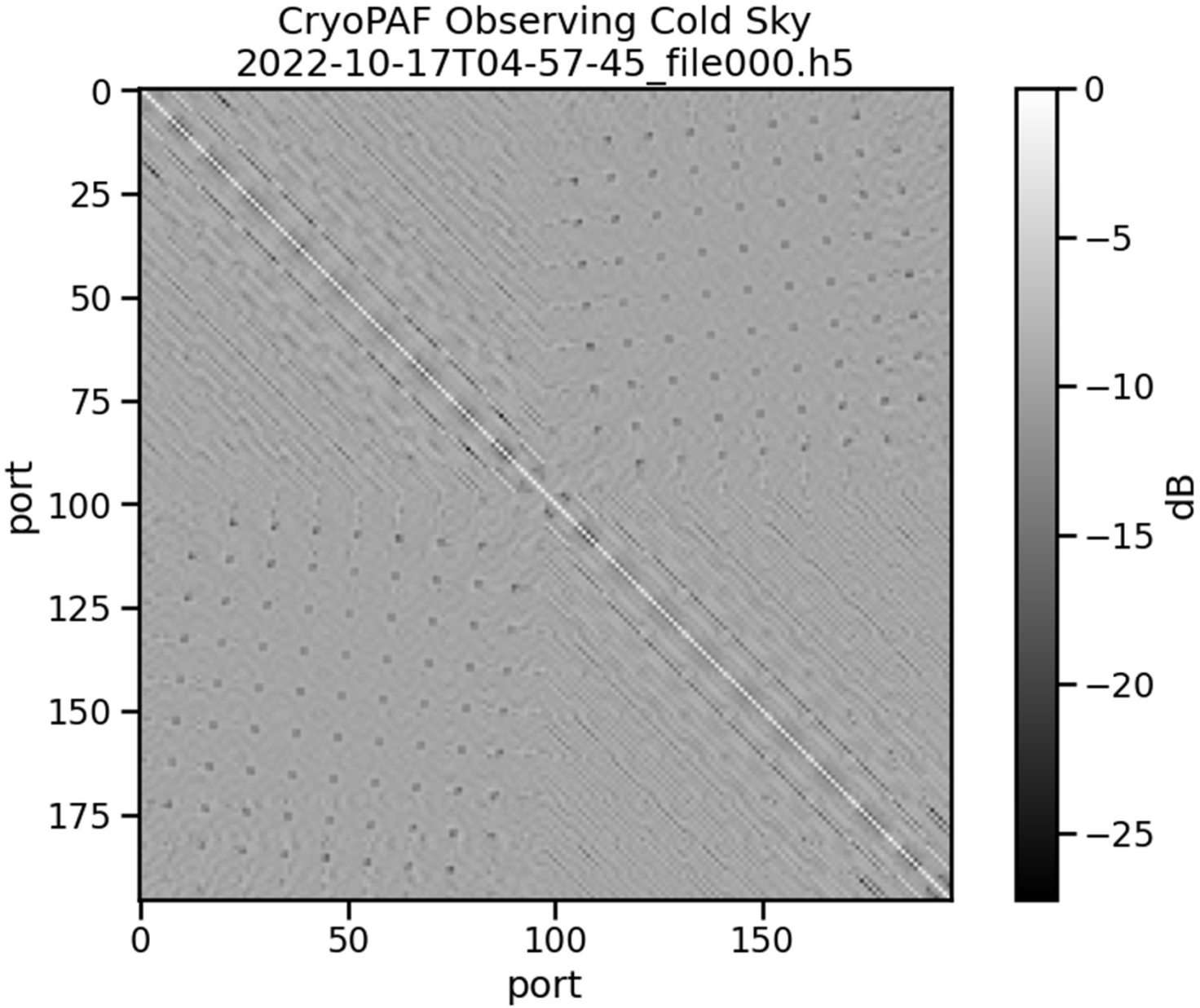
ACM

Raw

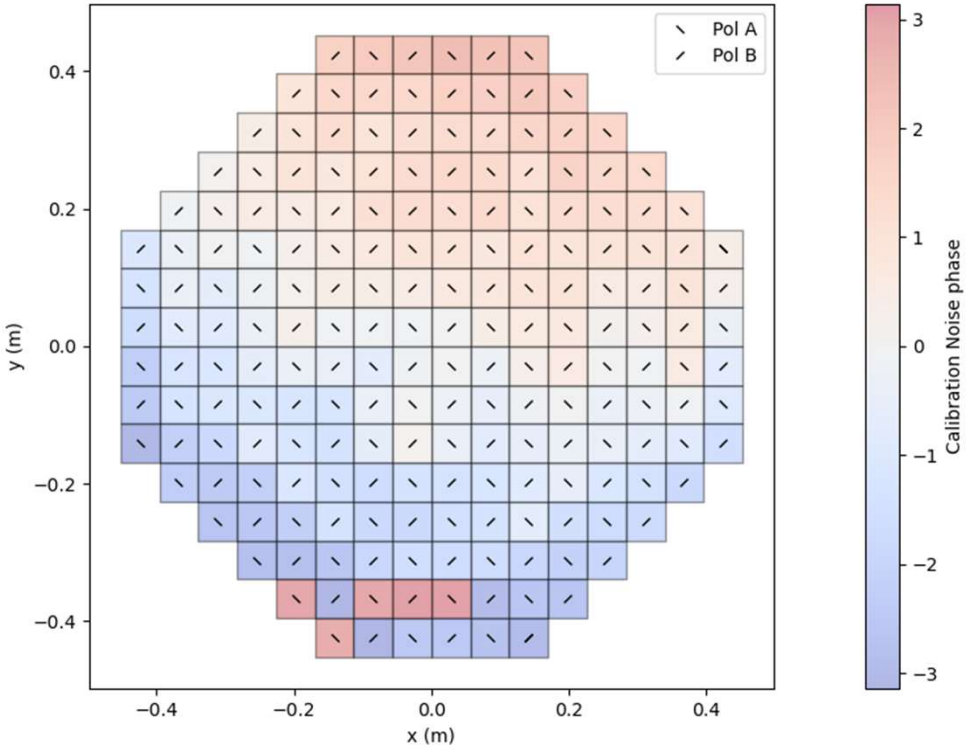

CryoPAF Observing Cold Sky
2022-10-17T04-57-45_file000.h5
port
0
25
50
75
100
125
150
175
0
50
100
150
port
0
−5
−10
−15
−20
−25
dB

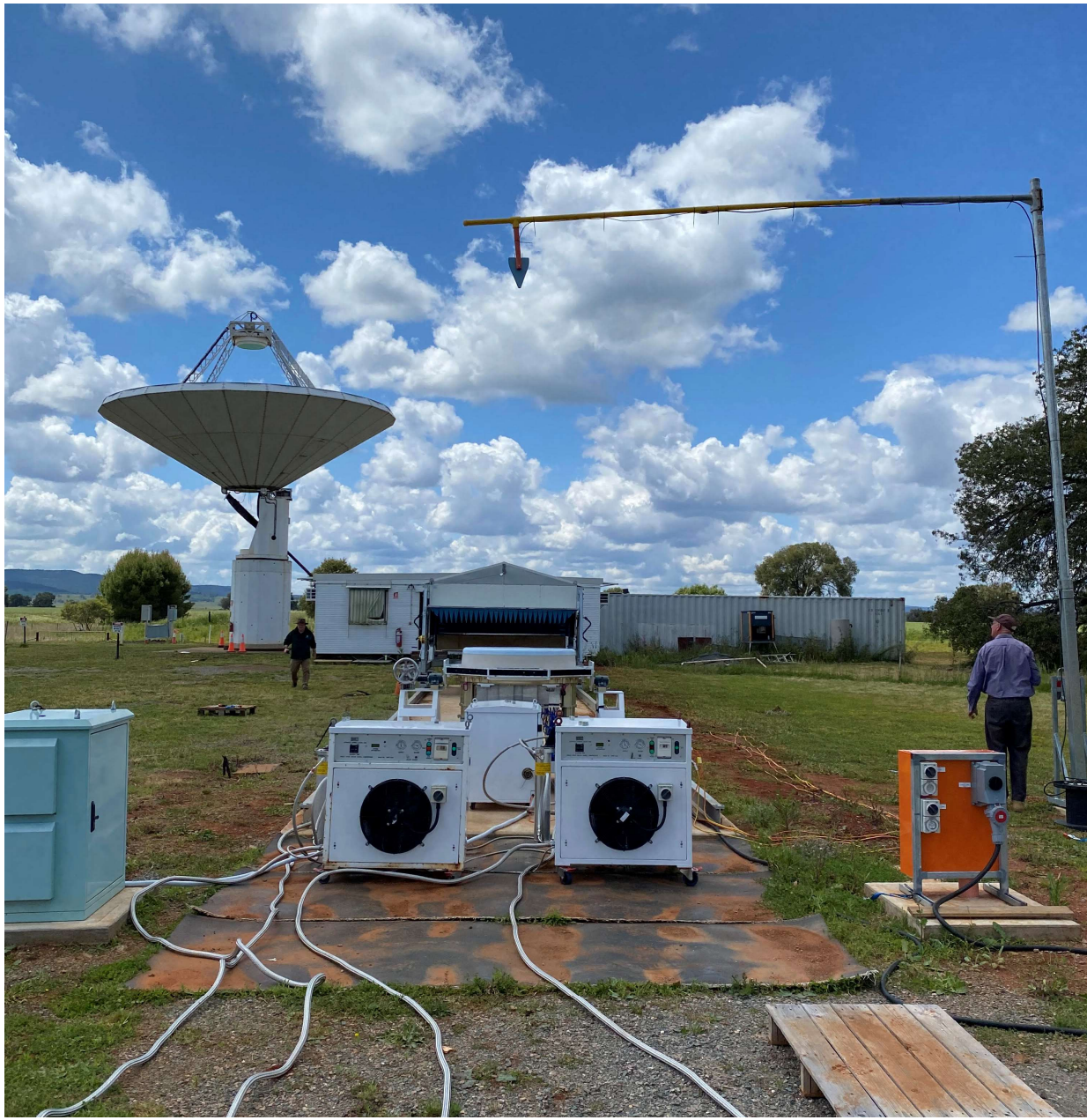
ACM

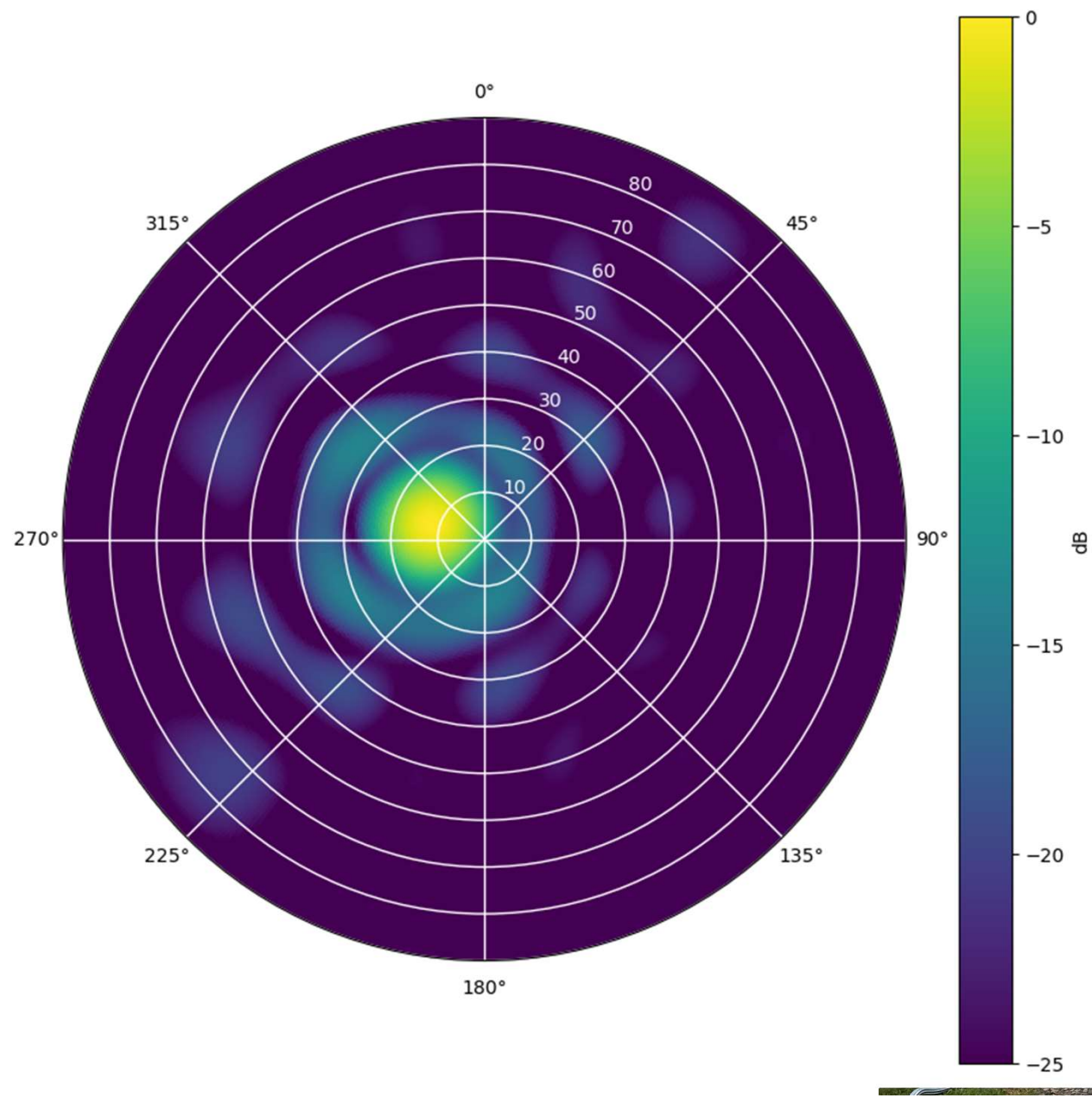
Calibrated

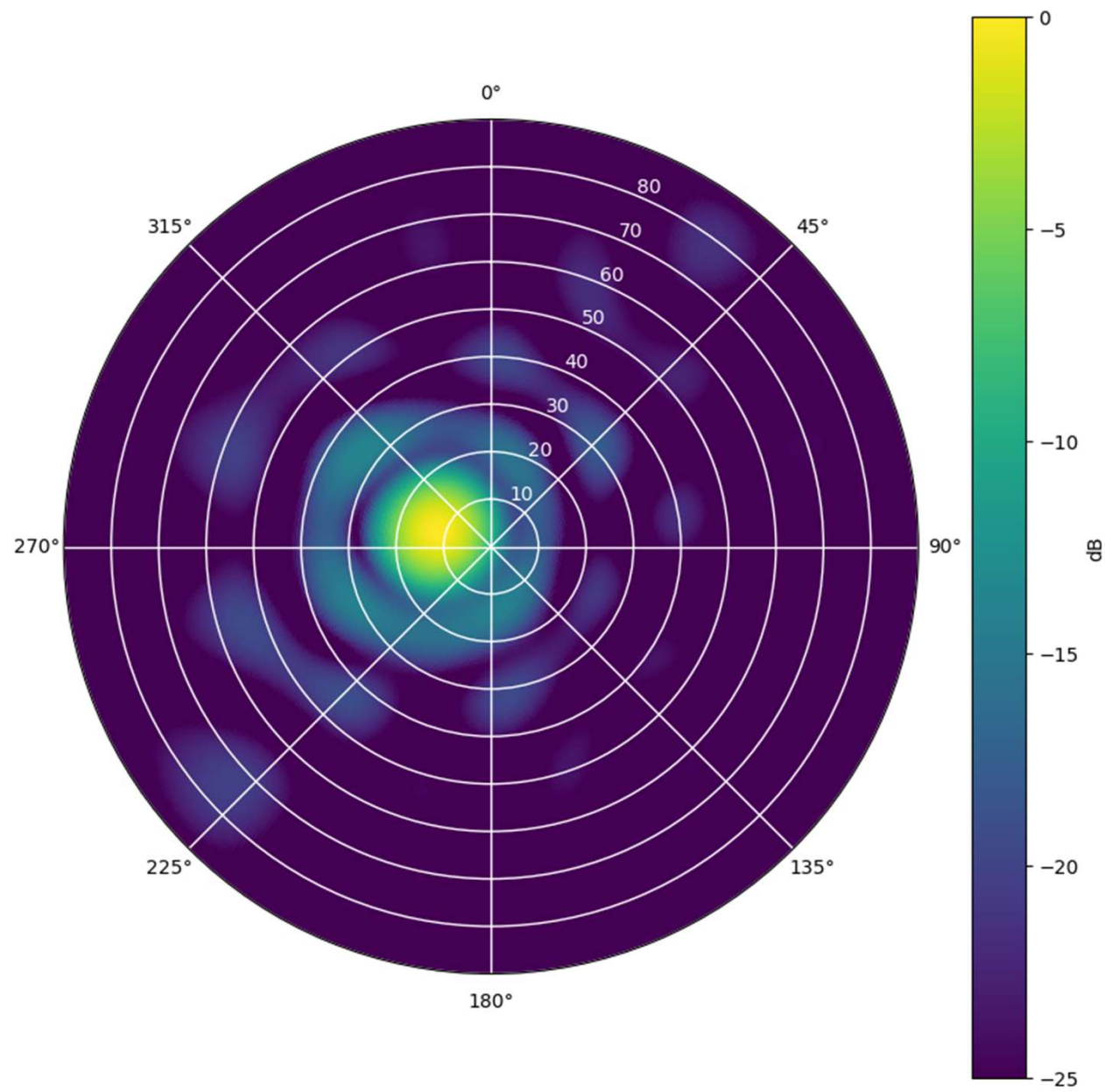


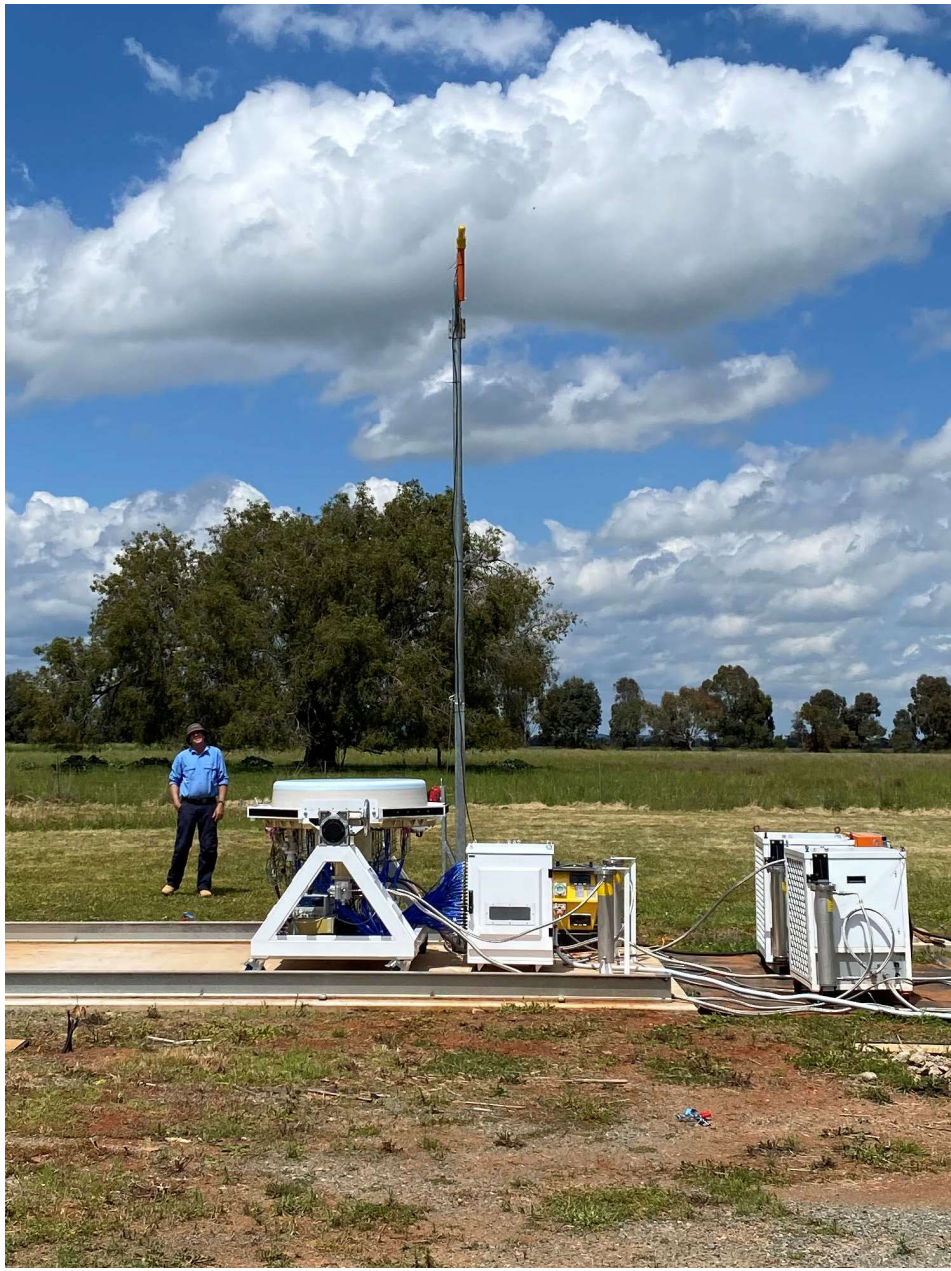
External noise referred to internal





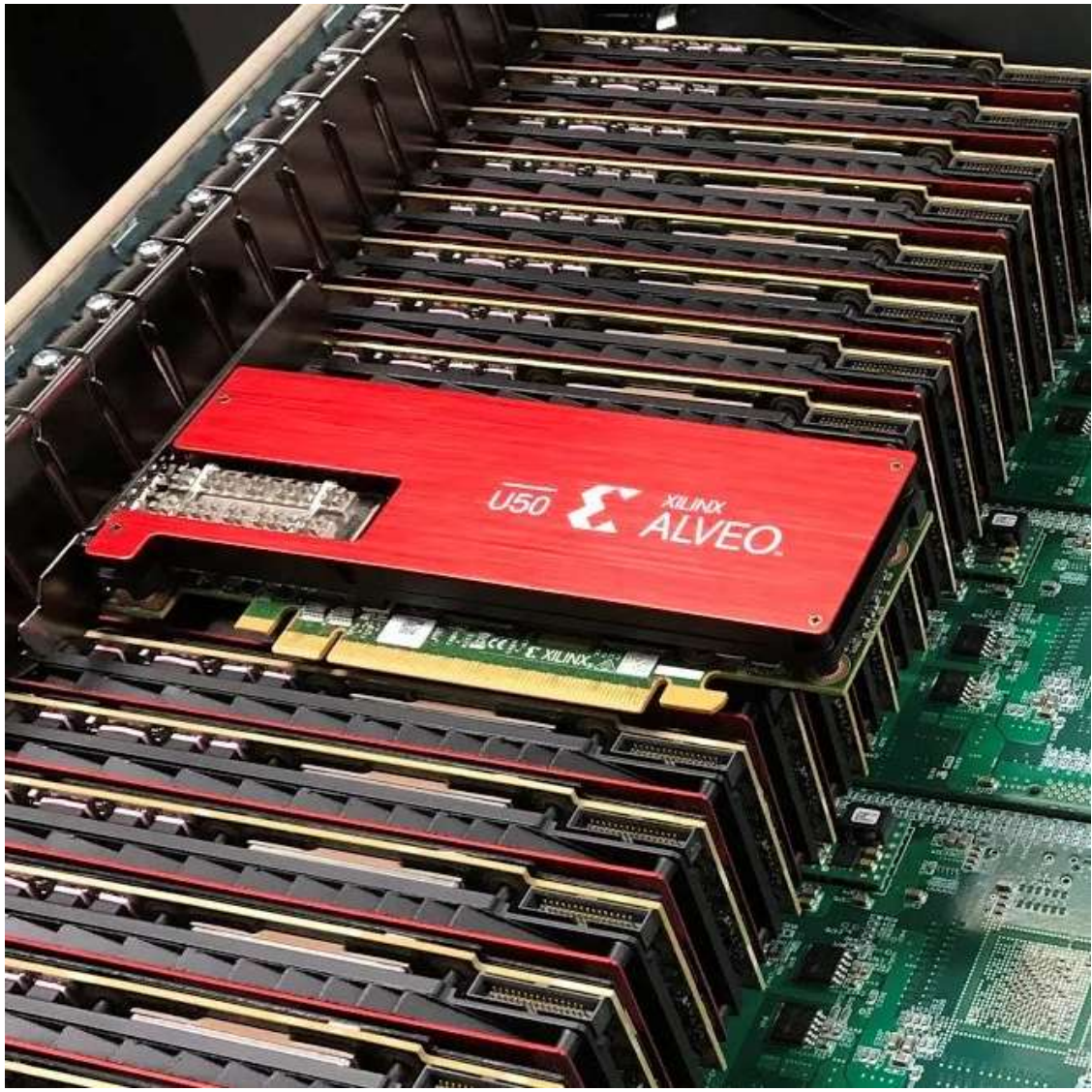

0°
45°
90°
135°
180°
225°
270°
315°
10
20
30
40
50
60
70
80
0
−5
−10
−15
−20
−25
dB


0°
45°
90°
135°
180°
225°
270°
315°
10
20
30
40
50
60
70
80
0
−5
−10
−15
−20
−25
dB



CryoPAF Beamformer Improvements

- Increased spectral resolution
  - 14.8 kHz (was 1 MHz on ASKAP)
- More ports per beam
  - All 196 ports (was 60 on ASKAP)
- More beams
  - 72 dual pol beams (was 36)



Thank you

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