Calibrating ASKAP's Phased Array Feeds

With External Noise Sources

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ASKAP ODC System

*On-dish Calibration*

**Functions:**
- Maintain beams
- Calibrate
  - XY-phase
  - beam delays
  - antenna delays

Photo: Mark Leach
On-Dish Calibration System

Chippendale et al., 2017
Calibrated MaxSNR PAF Beam Weights at 835 MHz

PAF response to noise

\[ s_{\text{cal}} = \langle v_{\text{paf}} v_{\text{rtn}}^* \rangle \]

Calibrated weights

\[ w' = s_{\text{cal}}^* \circ w \]

Chippendale et al., 2016

Chippendale et al., 2019
Sensitivity Recovery via On-Dish Calibration

SEFD improvement on 1934-638 with ODC updated weights after DRX reset

Original weights before digitiser reset

Original weights after digitiser reset

Updated weights after digitiser reset

Updated weights $\mathbf{w}_2 = \mathbf{s}_{\text{cal1}} \circ \mathbf{w}_1 \otimes \mathbf{s}_{\text{cal2}}$

Chippendale & Lourenco, 2018
Unpublished
ODC Level and Impact on Beam Sensitivity
Chippendale et al., 2018

Provided noise is on during beamforming:
• Calibration noise is mitigated by standard maxSNR beam weights
• Calibration noise raises $T_{sys}$ by less than 1% so long as calibration noise is less than 24% of single-port noise power.

Also:
• Measured ratio of calibration noise to single-port noise via Pearson correlation coefficient
• Set common noise level on all ASKAP antennas
Calibration Signal Level Validated on 36 antennas!
(22/2/2019)
Calibrating XY-Phase On-Dish

Chippendale & Anderson, 2019

Naïve method:
\[ \text{Arg} \left( \mathbf{w}_y^H \mathbf{R} \mathbf{w}_x \right) \]
- cal noise cancels
- works if noise off during beamforming

Solution:
- Calibrate weights
- Divide vector averaged weight in main lobes (\(\Omega\))

\[
\phi_{xy} = \text{Arg} \left( \sum_{i \in \Omega_y} w'_{y,i} / \sum_{i \in \Omega_x} w'_{x,i} \right)
\]
XY-phase: ODC Matches Rotated Antenna Method

Chippendale & Anderson, 2019
Fornax A by ASKAP

Anderson, 2019

Linearly polarised intensity

XY-phase calibrated via ODC
Residual leakage
Chippendale & Anderson, 2019

- Constant (PAF rotation)
- Ripple (PAF-ODC standing wave)
Residual Suppressed by Time Gating ODC Response

Chippendale, 2019 (Unpublished)
Thank you

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