MITIGATION OF SELF-GENERATED INTERFERENCE WITH ASKAP PAF

To adopt RFI mitigation techniques, astronomers need to understand the effects of the algorithms on astronomical figures of merit.

L. Lourenço, and Chippendale, A., PAFAR2022, 2022

CURRENT RFI MITIGATION

- Corrupted data is flagged (discarded) in frequency and time, reducing sensitivity.
- Not using the spatial information in the system.
- Implementing spatial filtering algorithms can reduce the amount of flagged data

UNWANTED SIGNAL (STATIC)

- Due to clock signal in the ASKAP receiver electronics.
- Perform mitigation once at the start of an observation.

DYNAMIC CASE

- Intermediary use case to mitigating more pernicious forms of moving RFI including navigation satellite and aircraft.
- Mitigation performed continuously.

MITIGATION ALGORITHM

UNWANTED SIGNAL

BEAMFORMED WEIGHTS

RESULTS

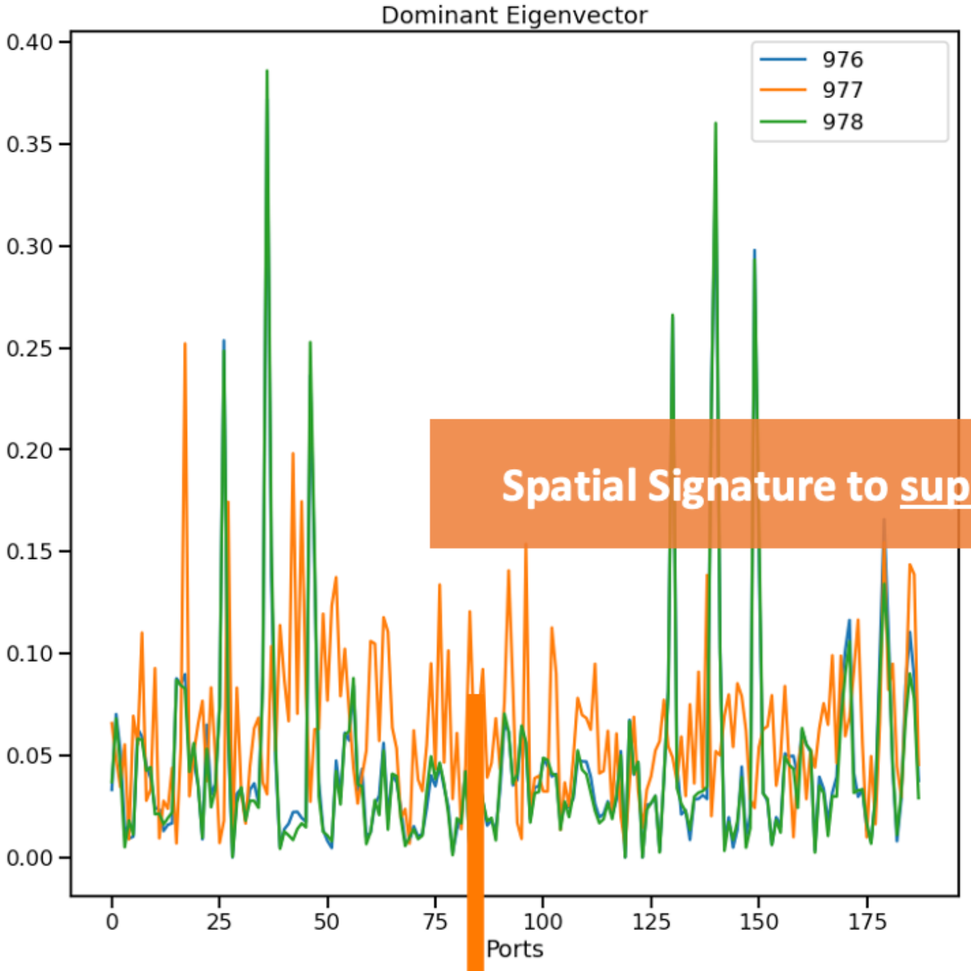
SIMULATED

OFFLINE

ON A SINGLE ANTENNA

OVERVIEW

Credit: CSIRO



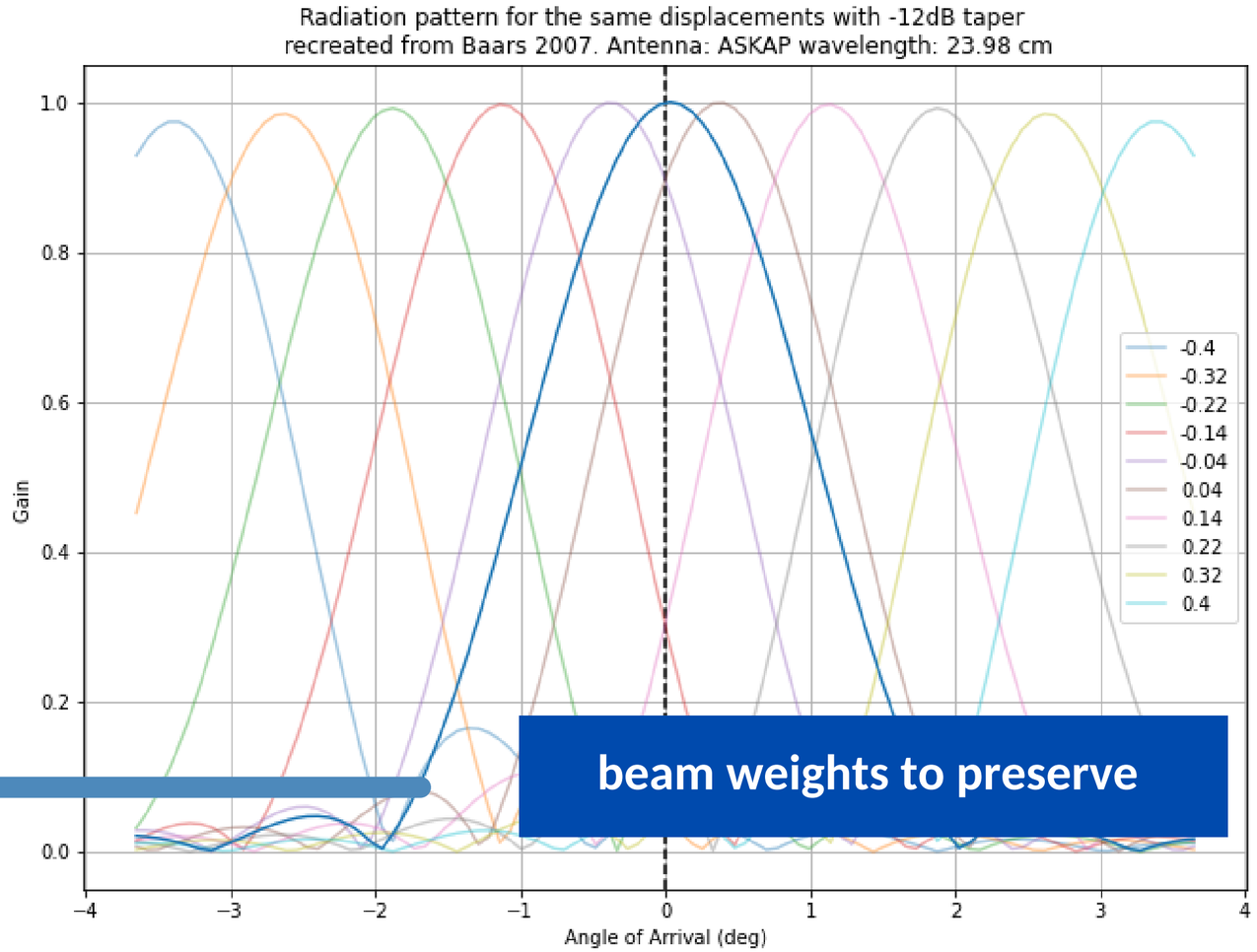
Spatial Signature to suppress

$$P_{ortho} = I - a_r (a_r^H a_r)^{-1} a_r^H$$

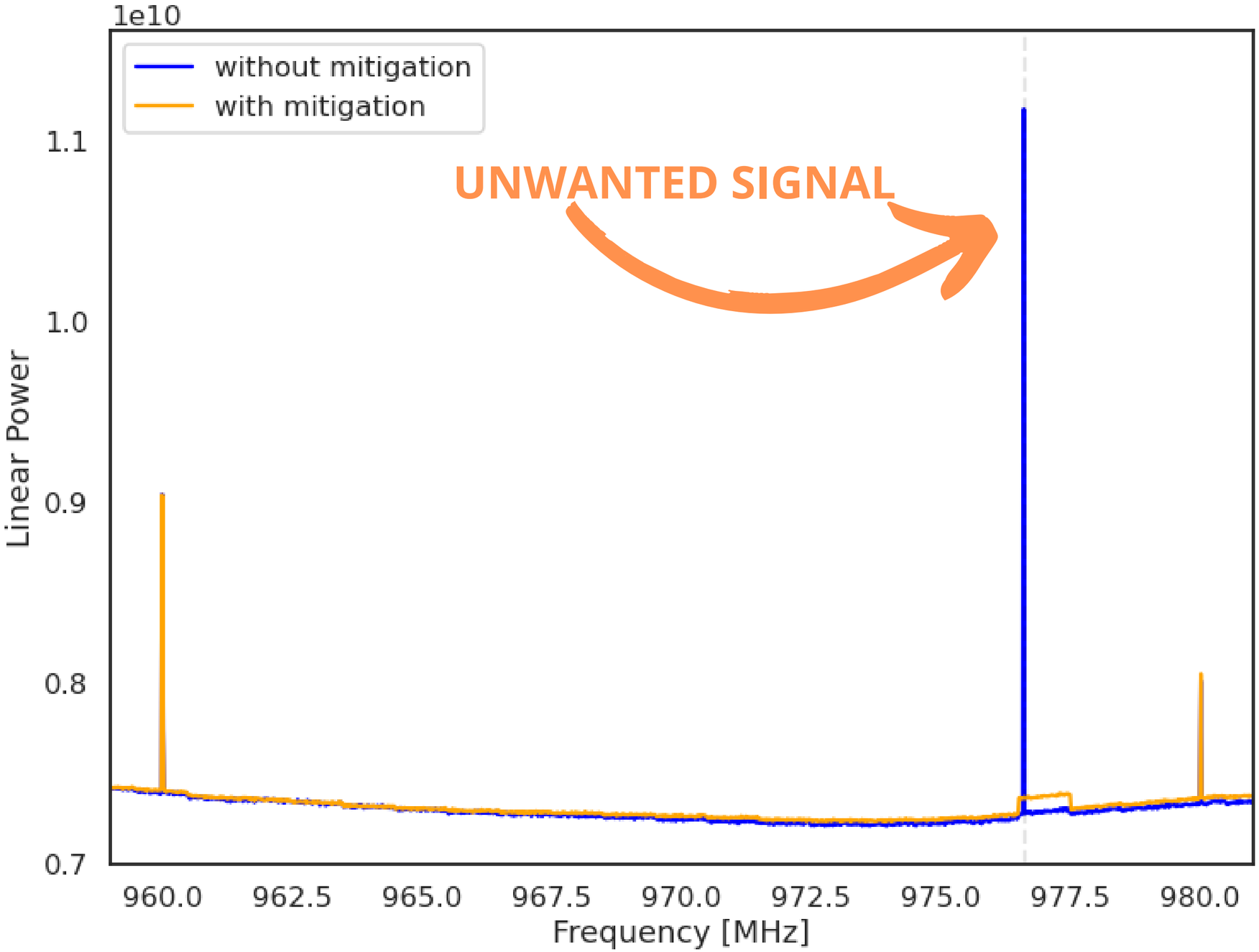
$$P_{obliq} = a_s (a_s^H P_{ortho} a_s)^{-1} a_s^H P_{ortho}$$

SPATIAL FILTERING EXPERIMENT WITH THE ASKAP BETA ARRAY

Gregory Hellbourg[1,2], *Keith Bannister*[2], *Aidan Hotan*[2]

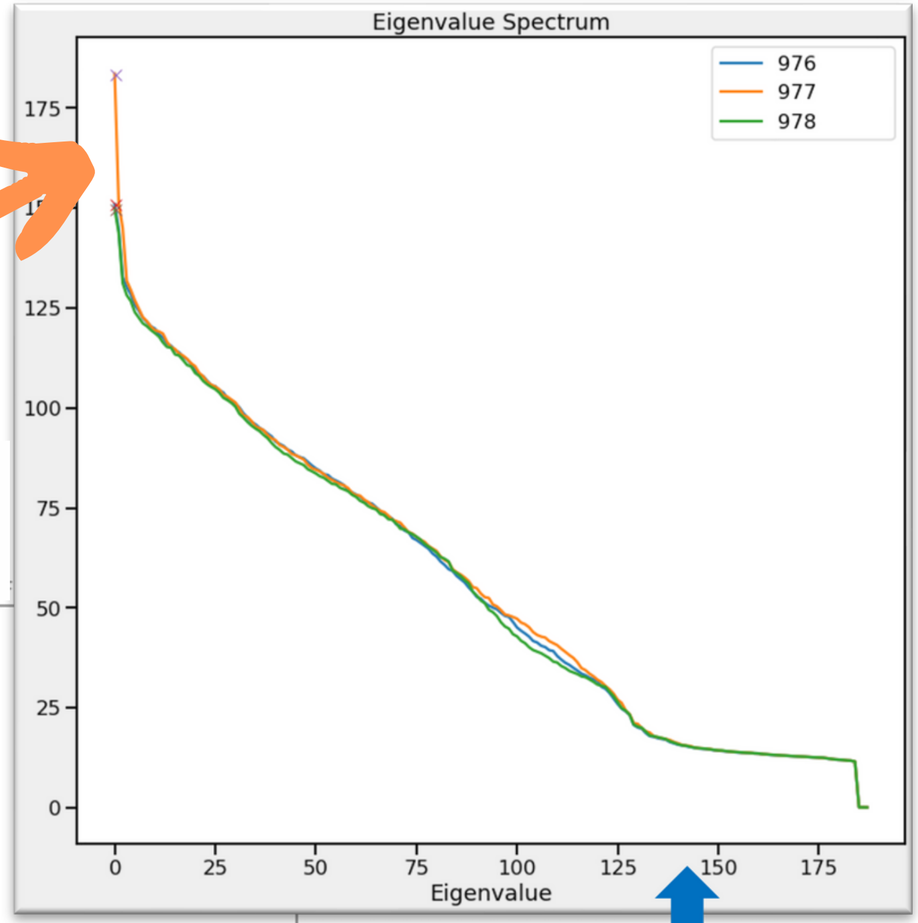


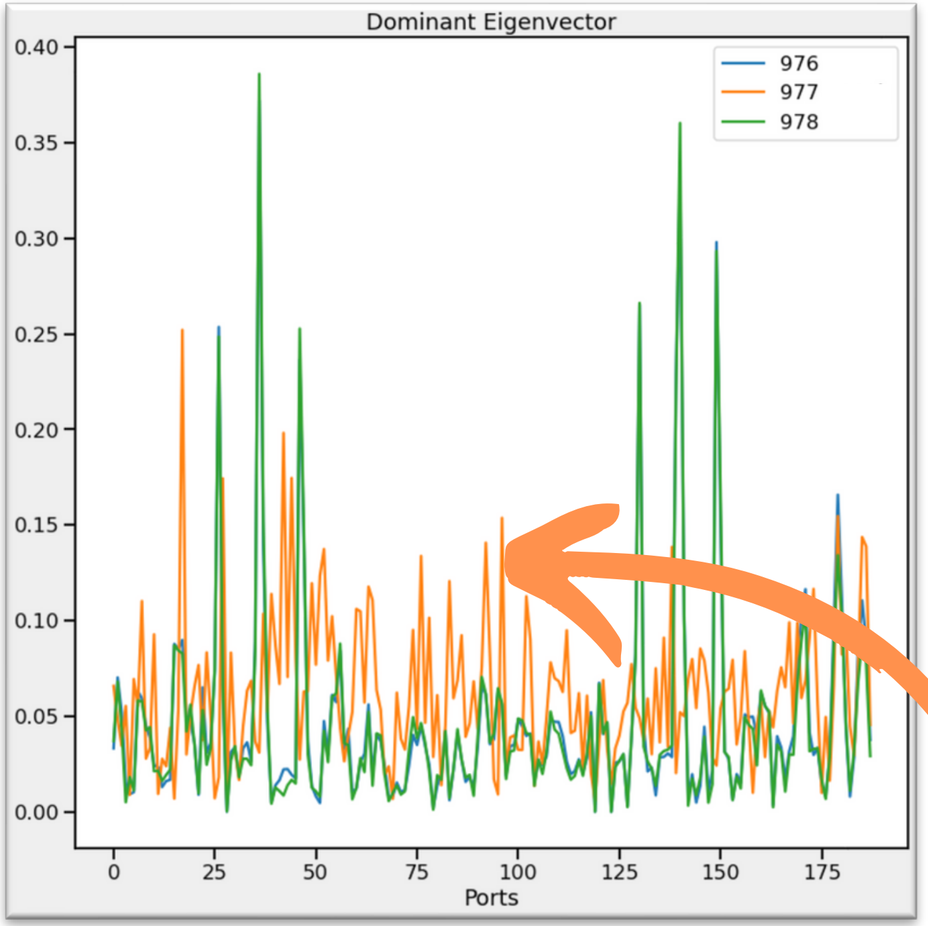
beam weights to preserve

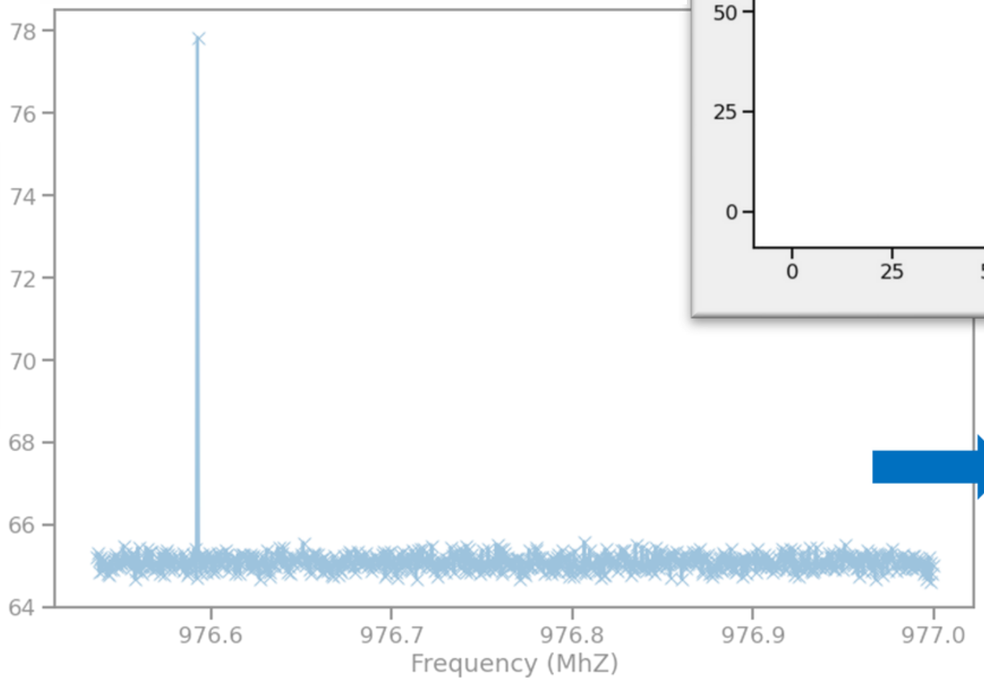

1e10
without mitigation
with mitigation
UNWANTED SIGNAL
Linear Power
1.1
1.0
0.9
0.8
0.7
960.0
962.5
965.0
967.5
970.0
972.5
975.0
977.5
980.0
Frequency [MHz]

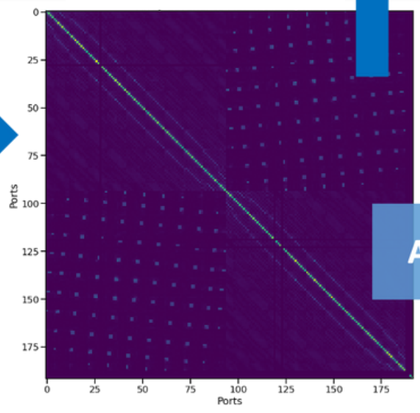
02

UNWANTED SIGNAL



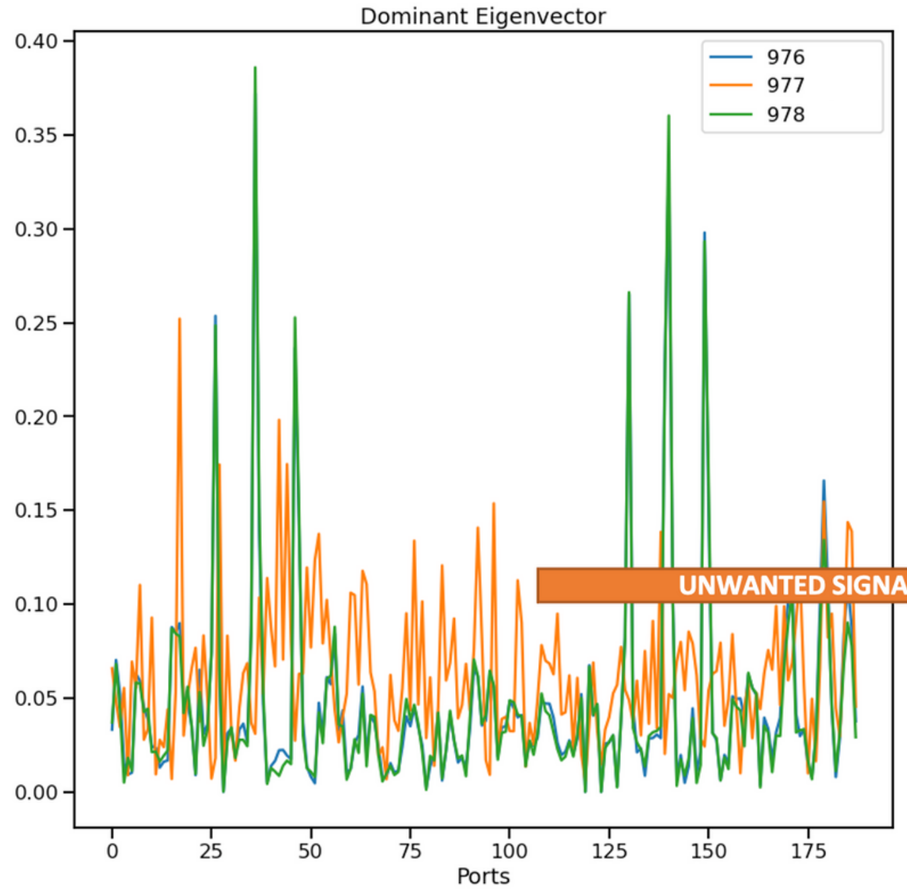




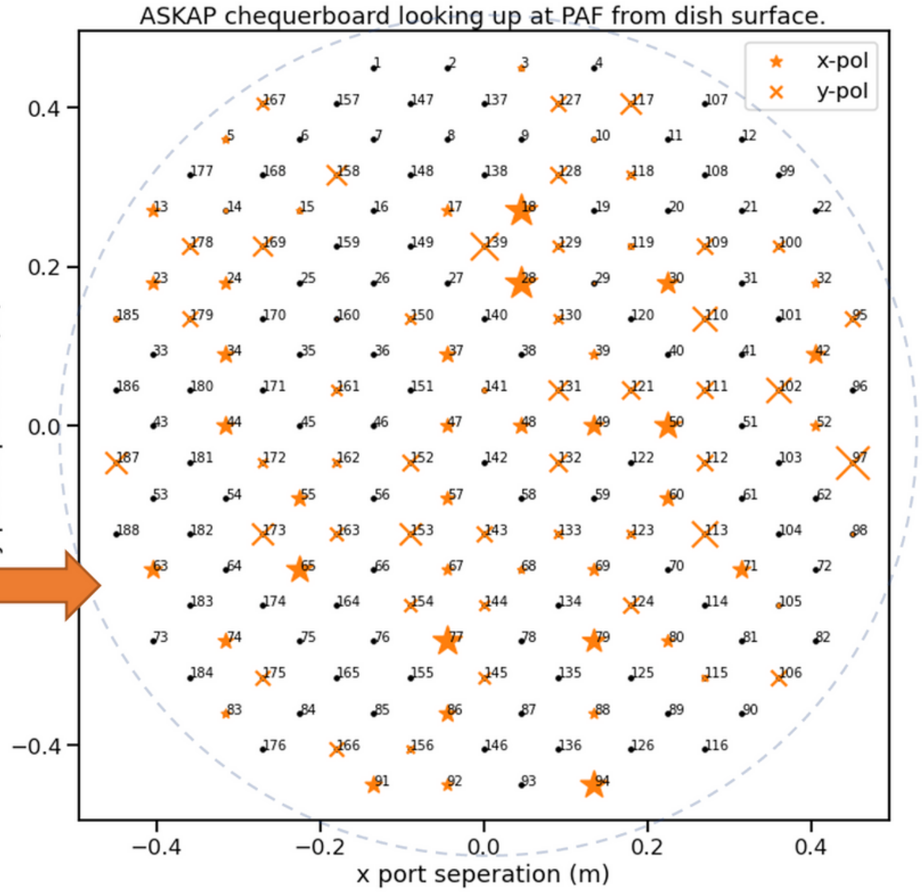


ACM

Eigenvalue decomposition
to isolate the 'direction' of the interferer



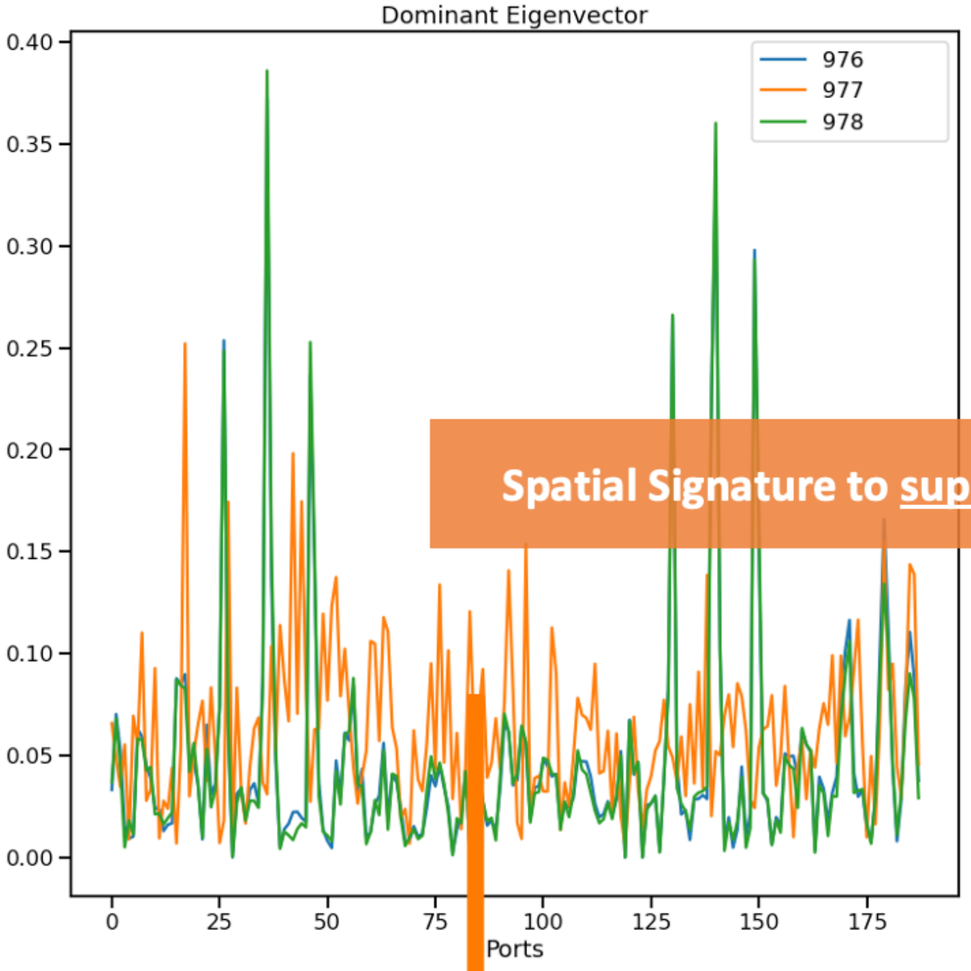
UNWANTED SIGNAL



Spatial signature to suppress

interference arrives at each port with different amplitude and phase

a unique spatial signiature



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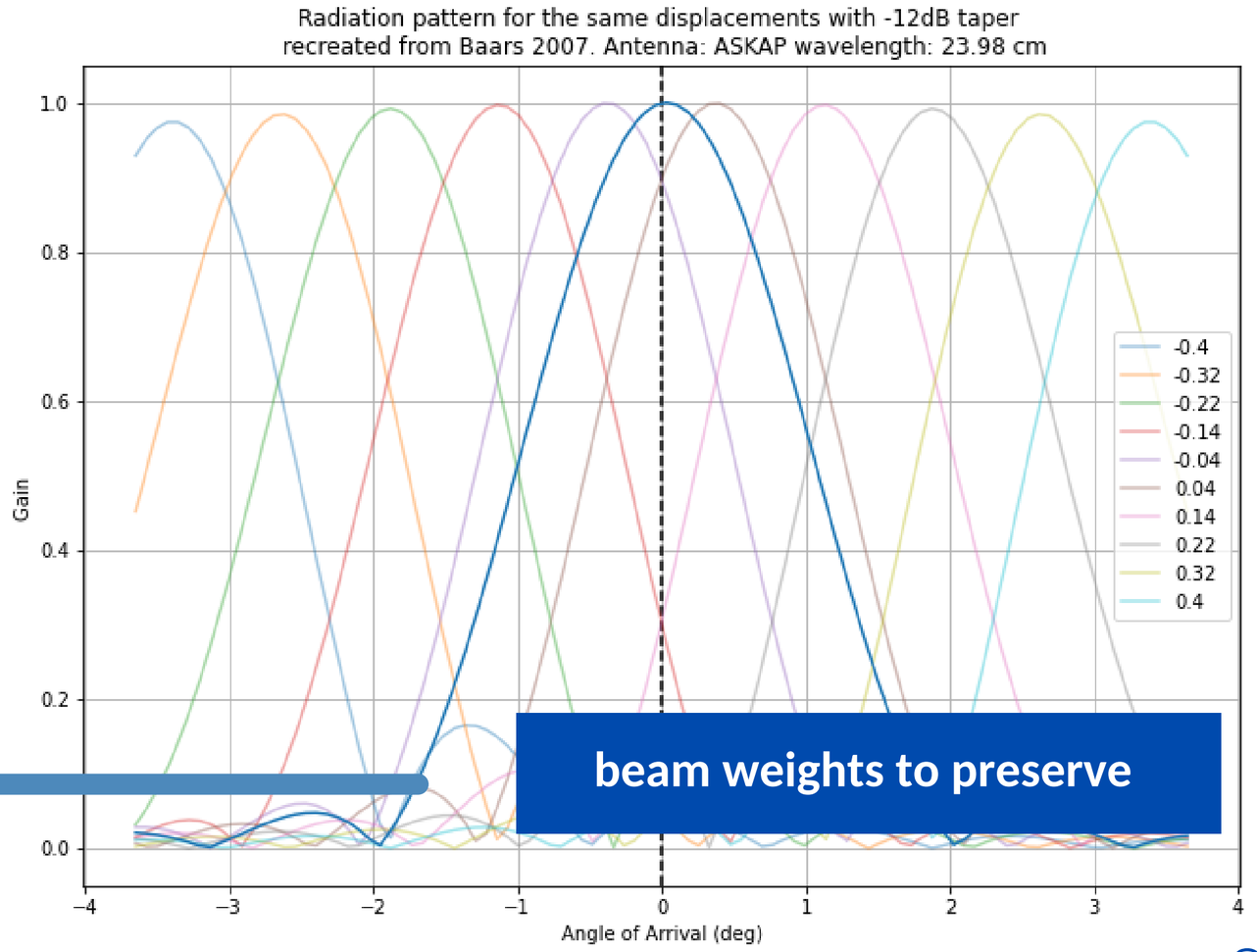
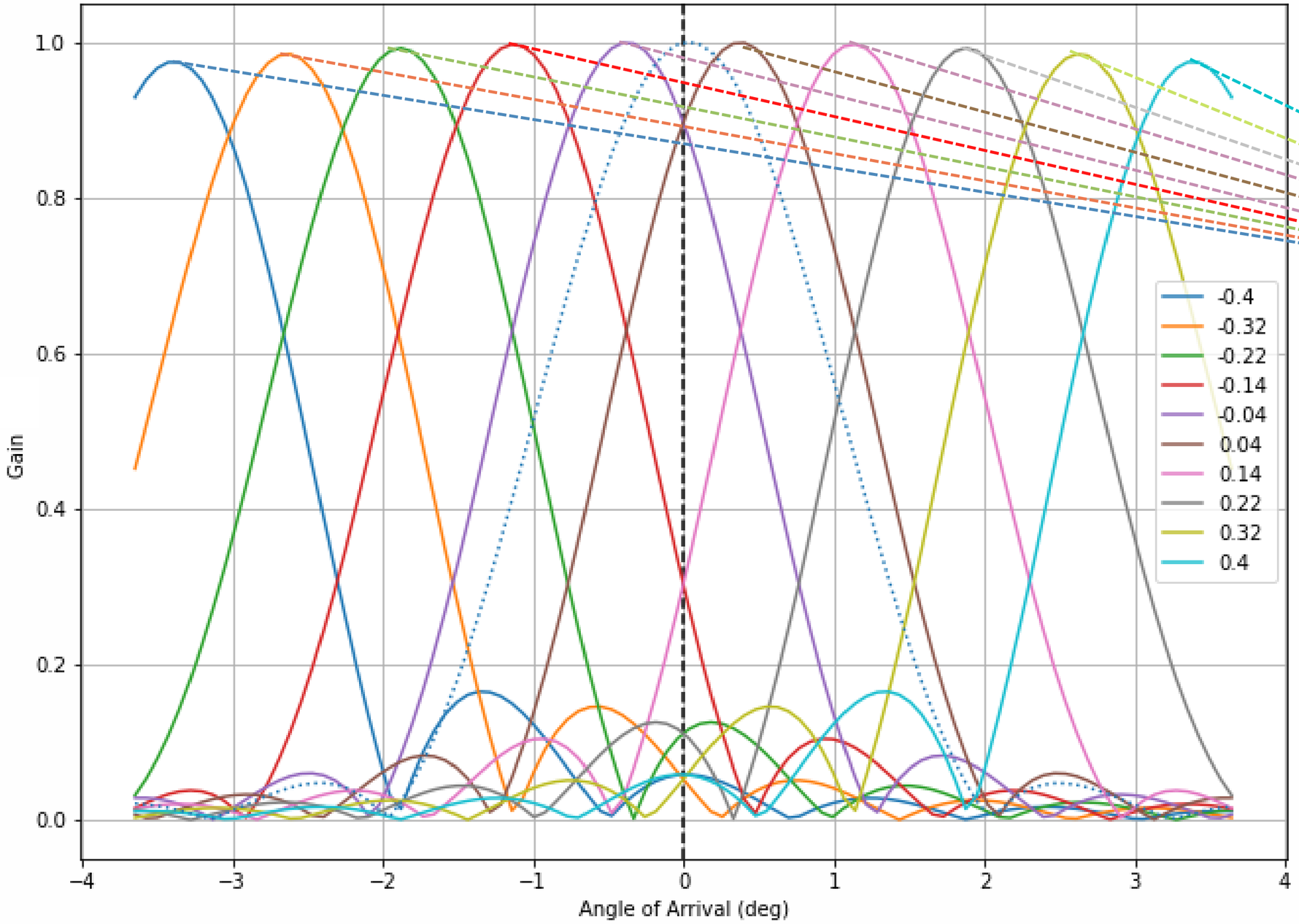
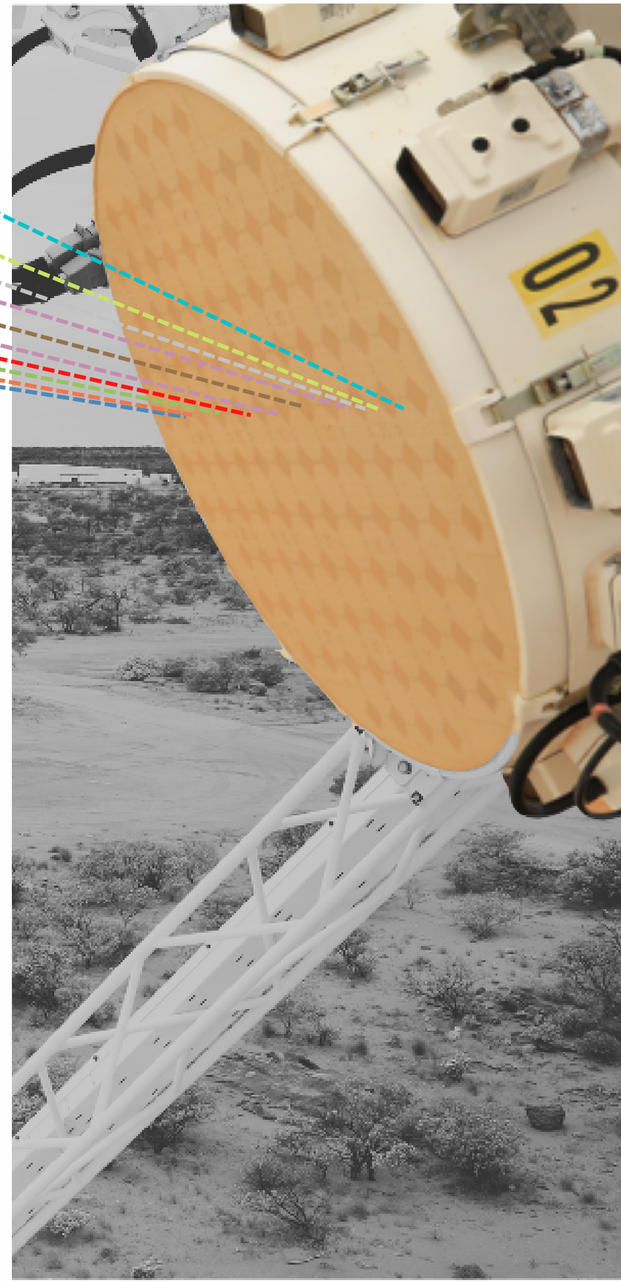
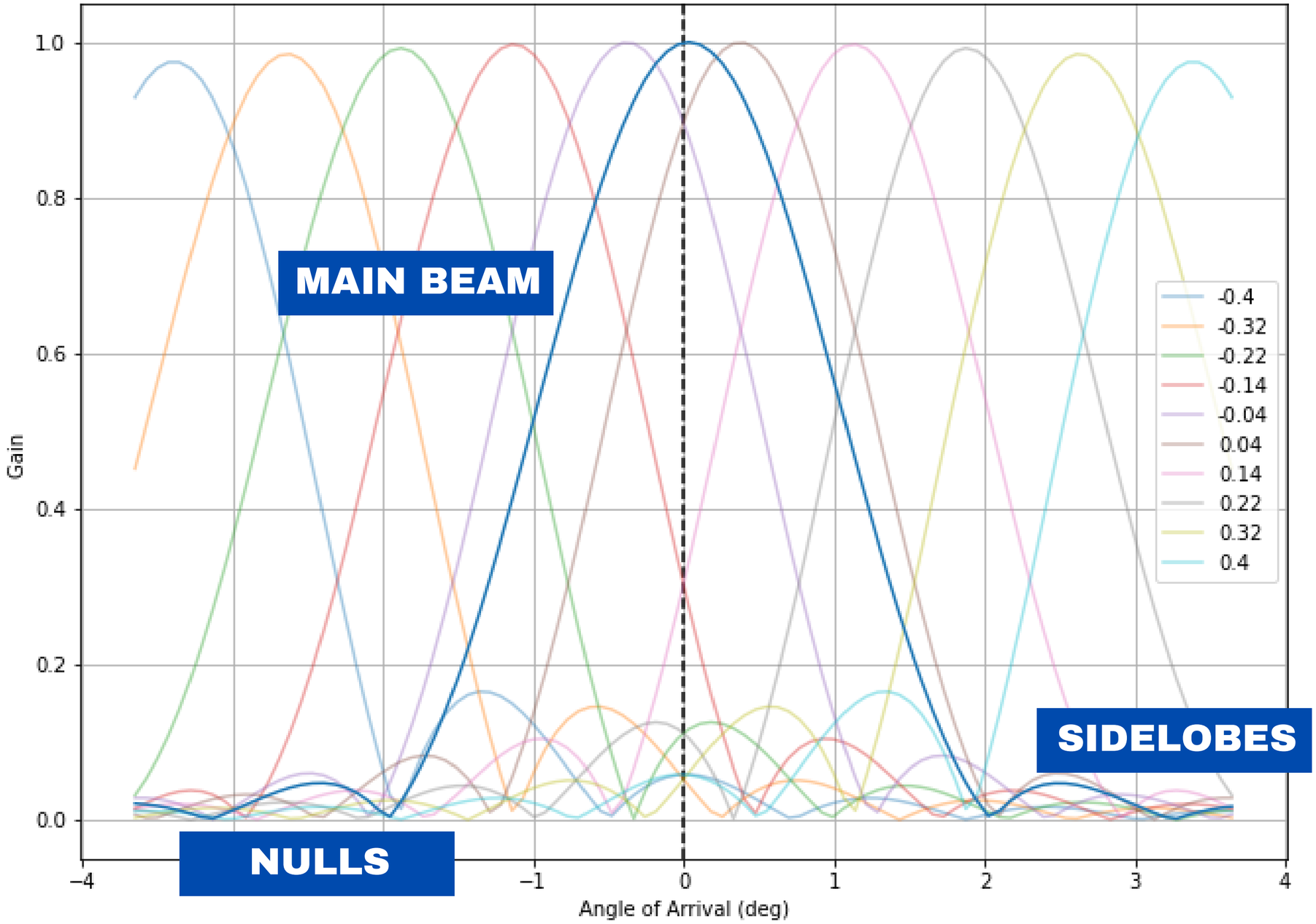
$$P_{obliq} = a_s (a_s^H P_{ortho} a_s)^{-1} a_s^H P_{ortho}$$



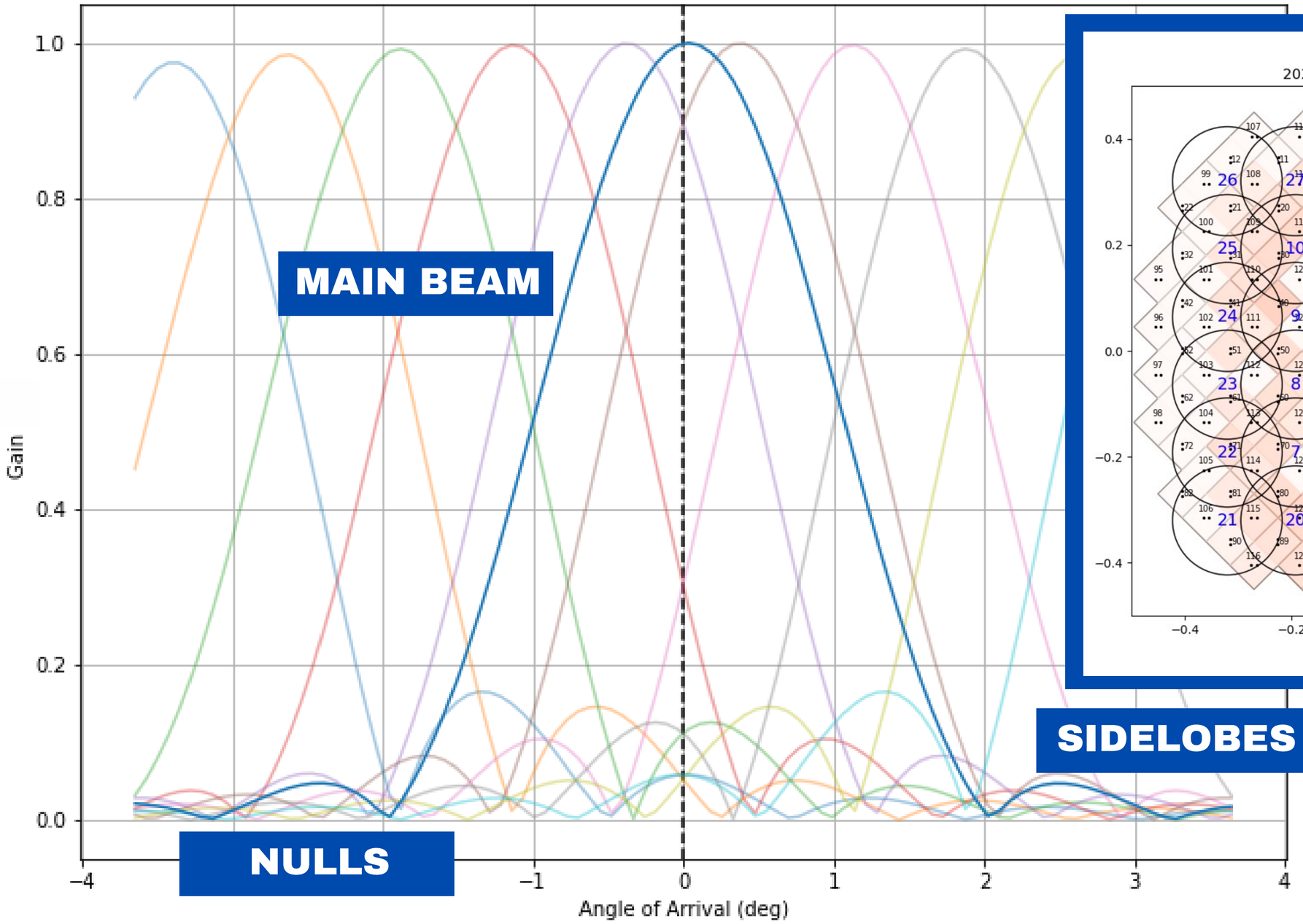
beam weights to preserve

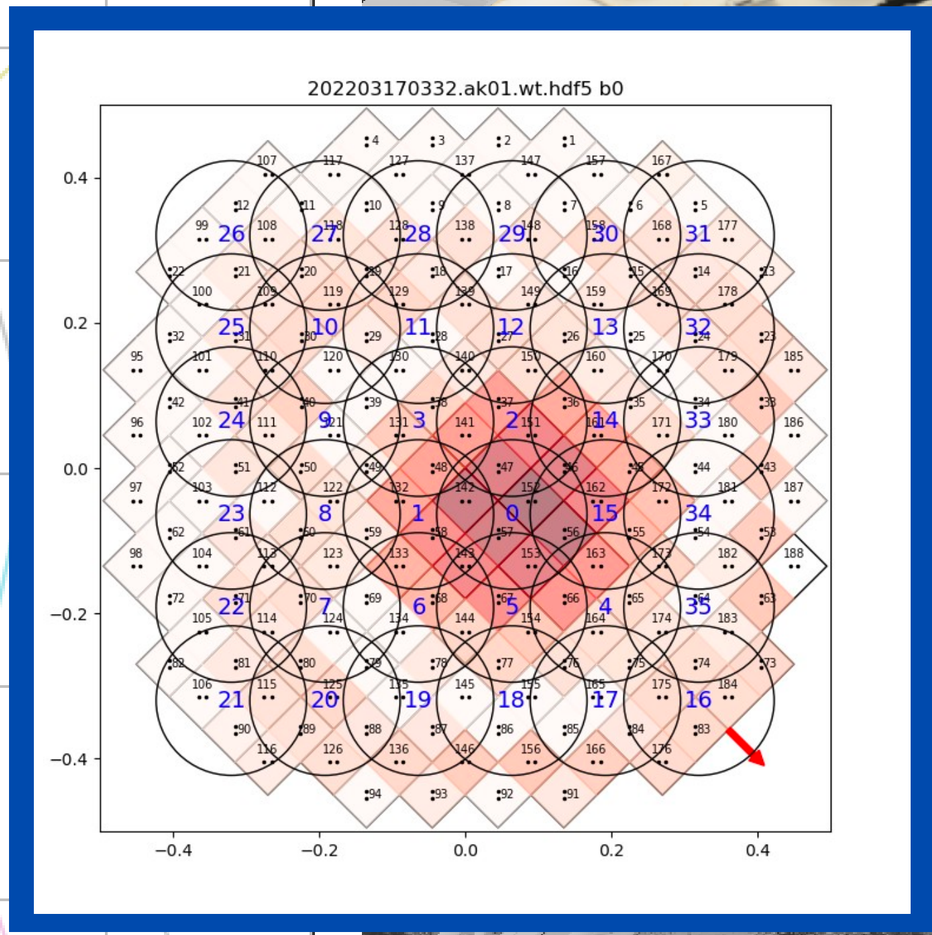

1.0
0.8
0.6
0.4
0.2
0.0
Gain
−4
−3
−2
−1
0
1
2
3
4
Angle of Arrival (deg)
-0.4
-0.32
-0.22
-0.14
-0.04
0.04
0.14
0.22
0.32
0.4

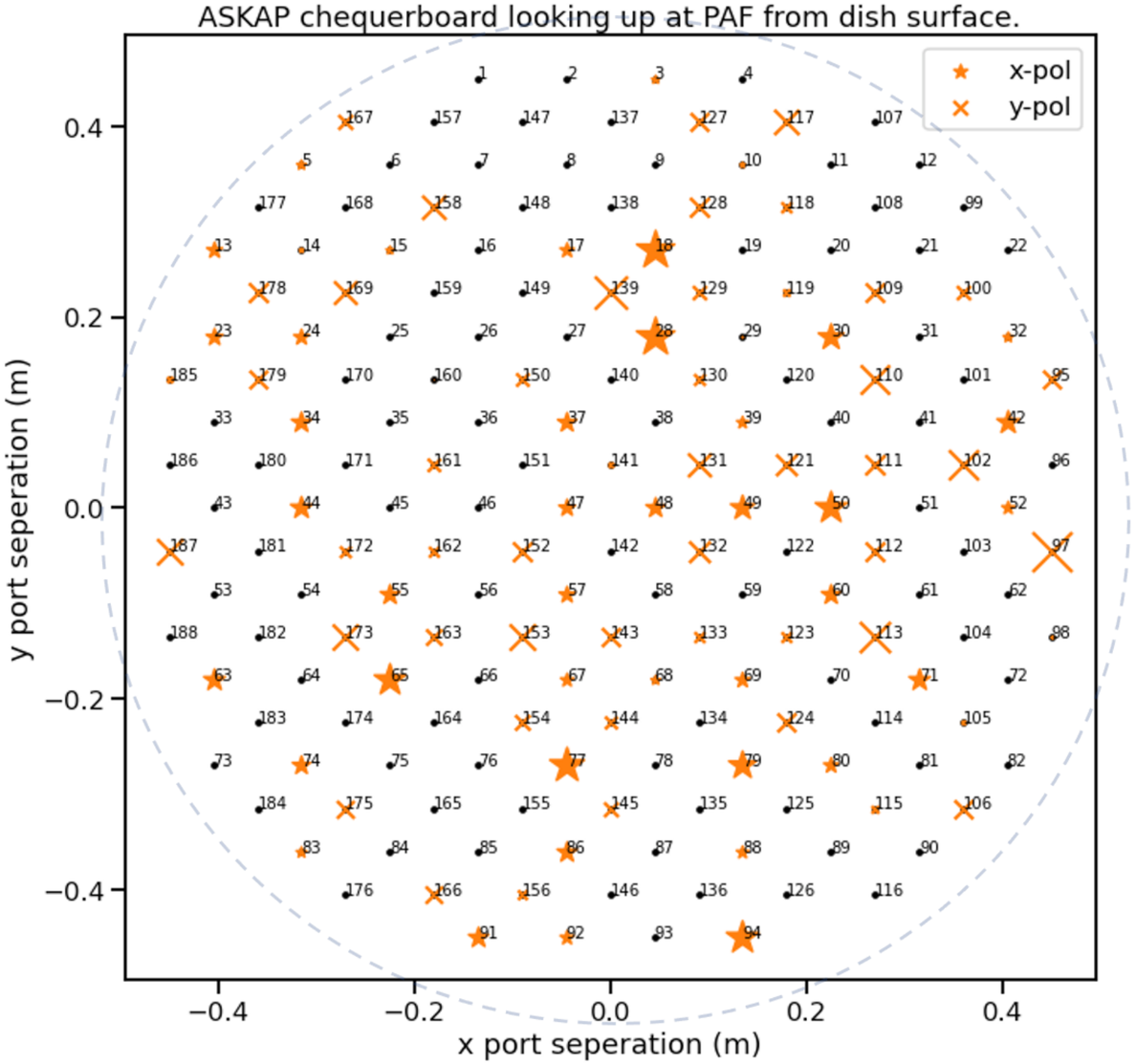

02

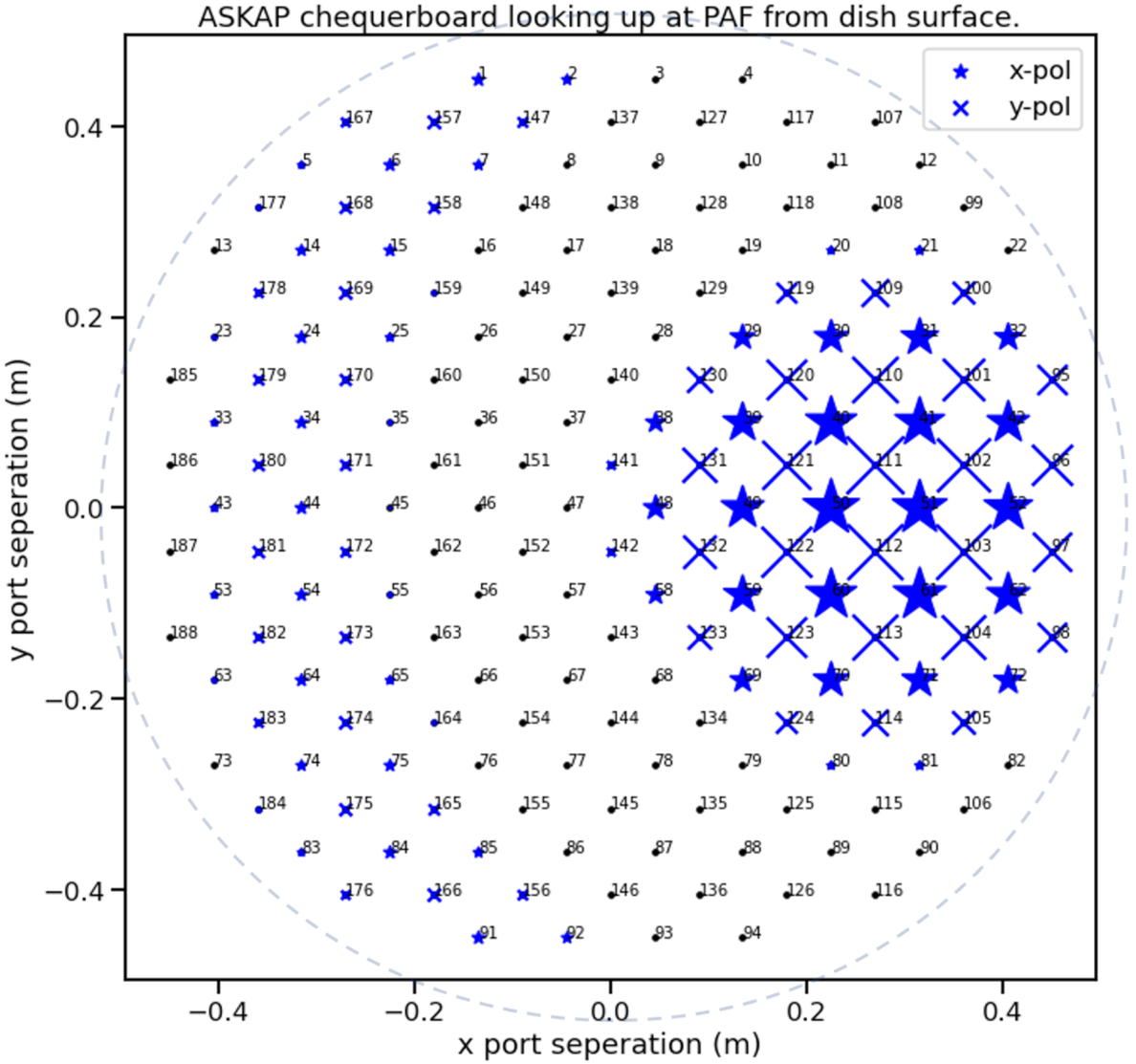

MAIN BEAM
SIDELOBES
NULLS
Gain
Angle of Arrival (deg)
1.0
0.8
0.6
0.4
0.2
0.0
−4
−1
0
1
2
3
4
-0.4
-0.32
-0.22
-0.14
-0.04
0.04
0.14
0.22
0.32
0.4

02


MAIN BEAM
NULLS
SIDELOBES
Gain
Angle of Arrival (deg)
1.0
0.8
0.6
0.4
0.2
0.0
−4
−1
0
1
2
3
4

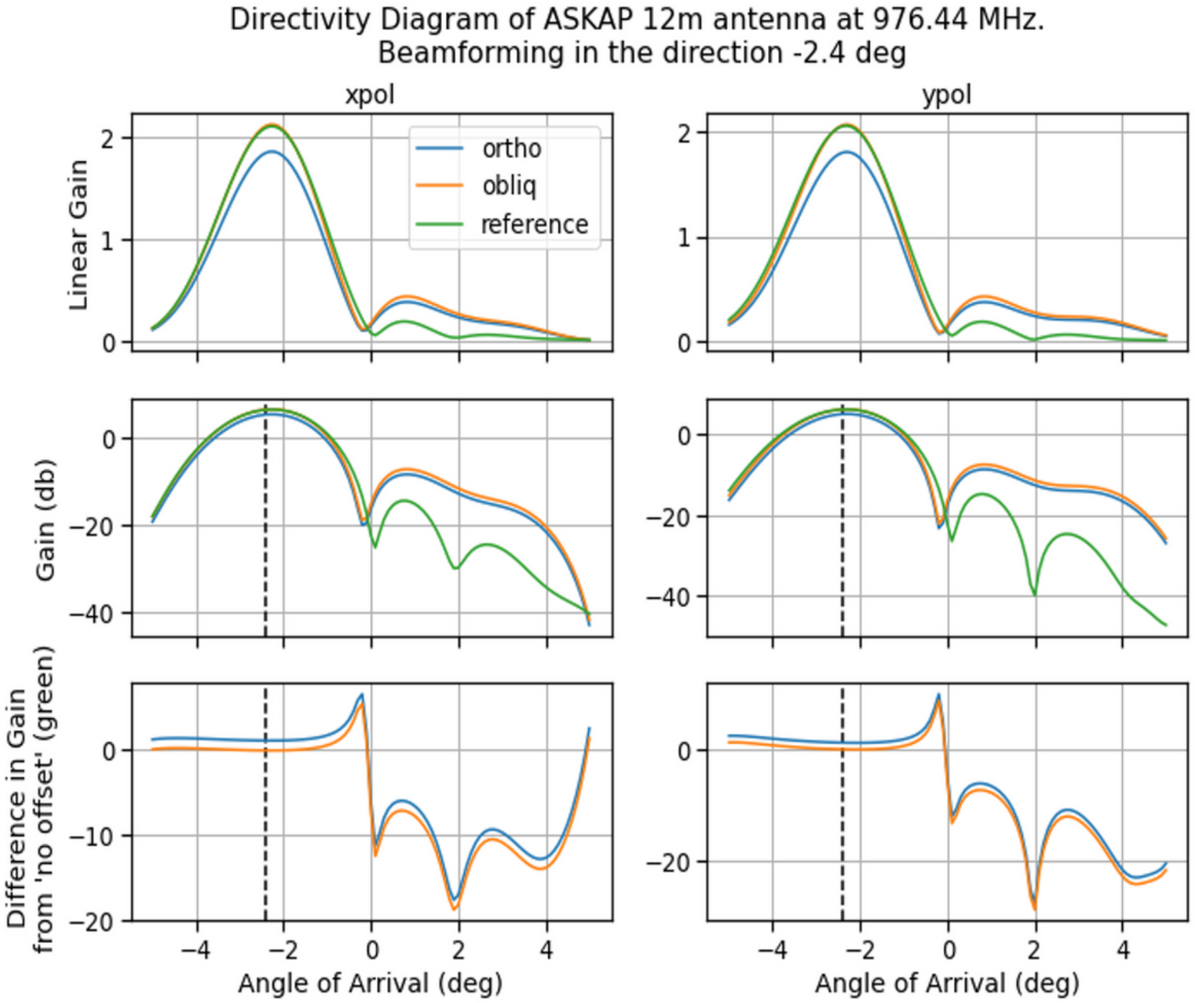

202203170332.ak01.wt.hdf5 b0
0.4
0.2
0.0
−0.2
−0.4
−0.4
−0.2
0.0
0.2
0.4



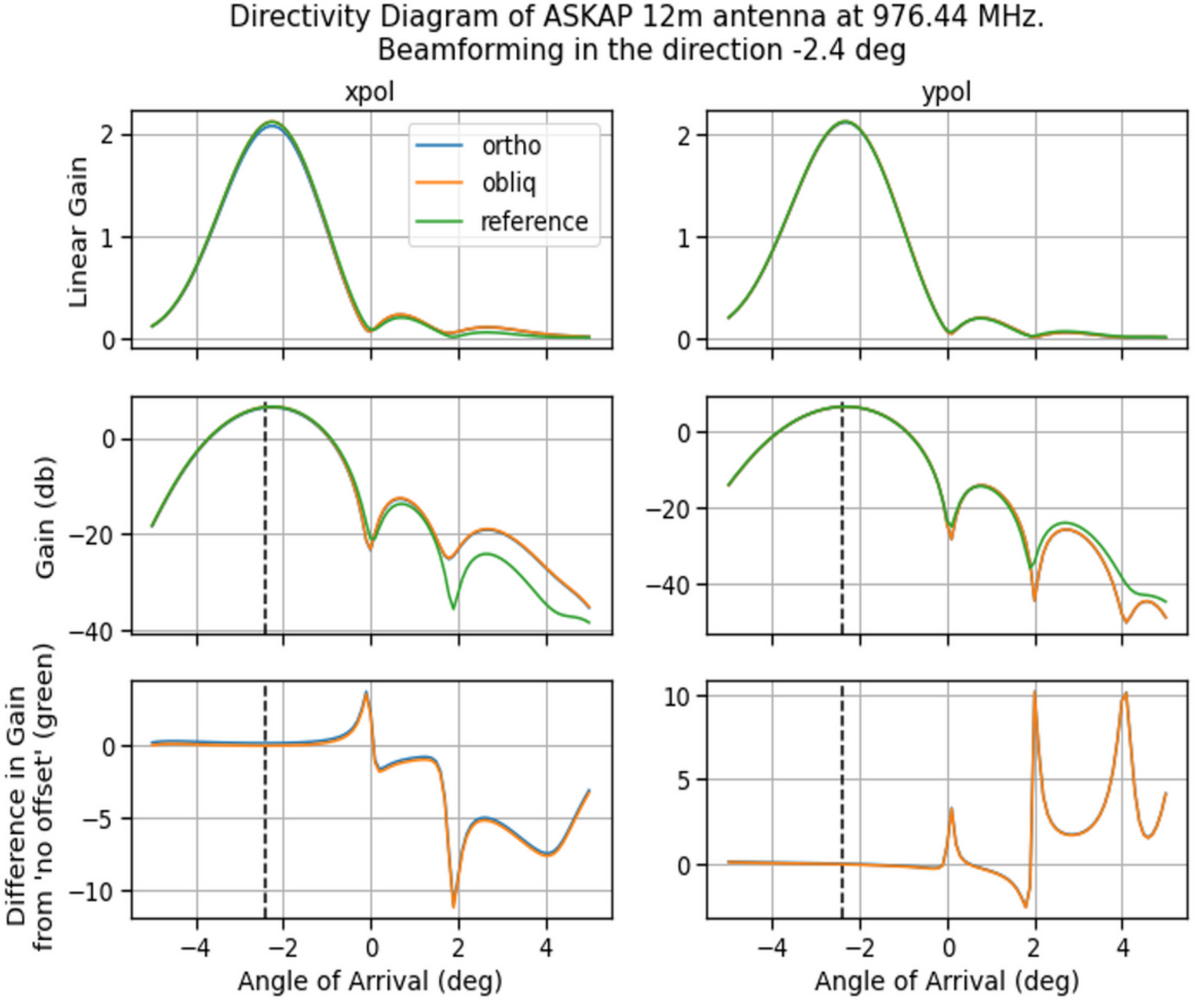


spatial signature to supress

beamweights to preserve



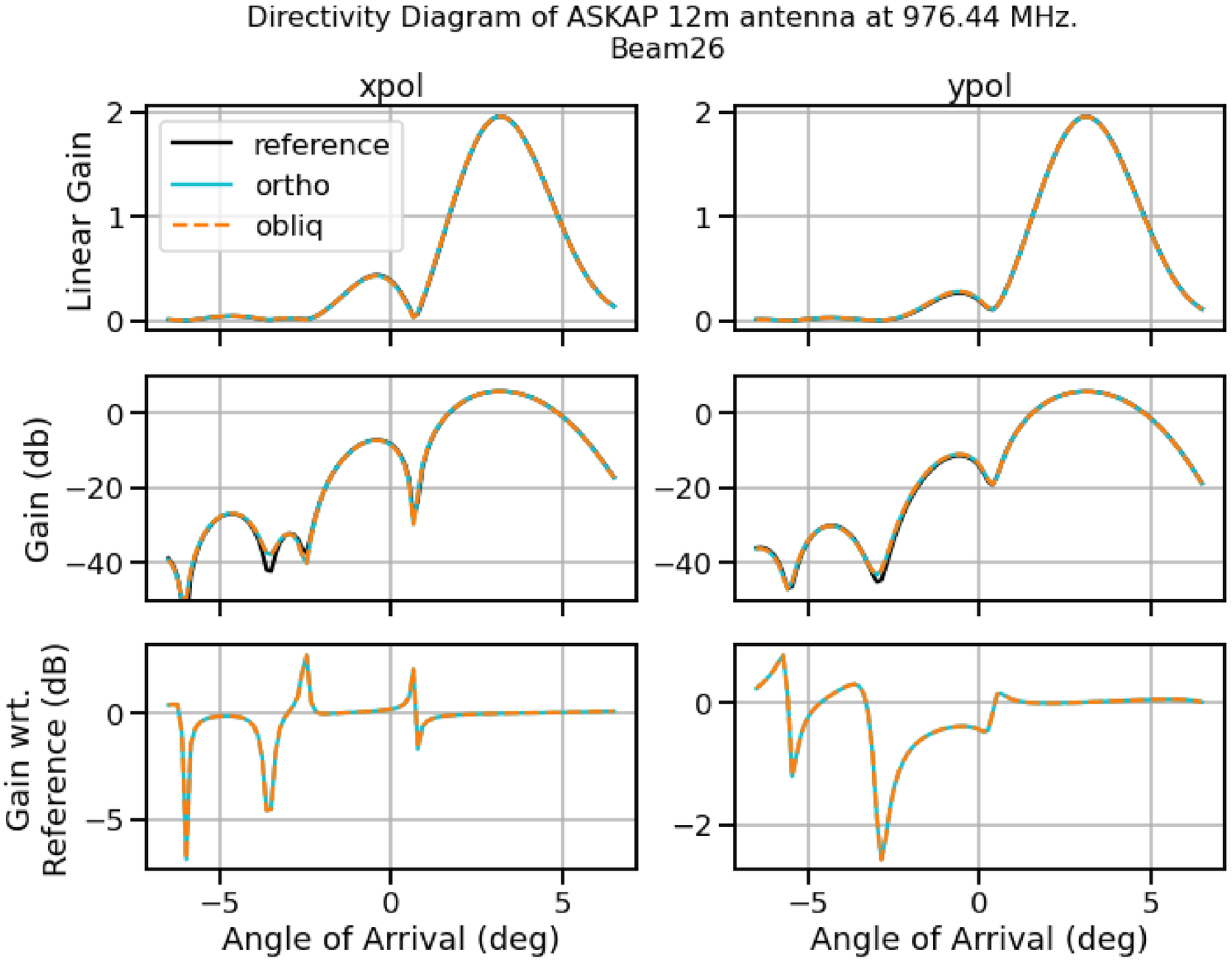
Coherent Phase on all ports

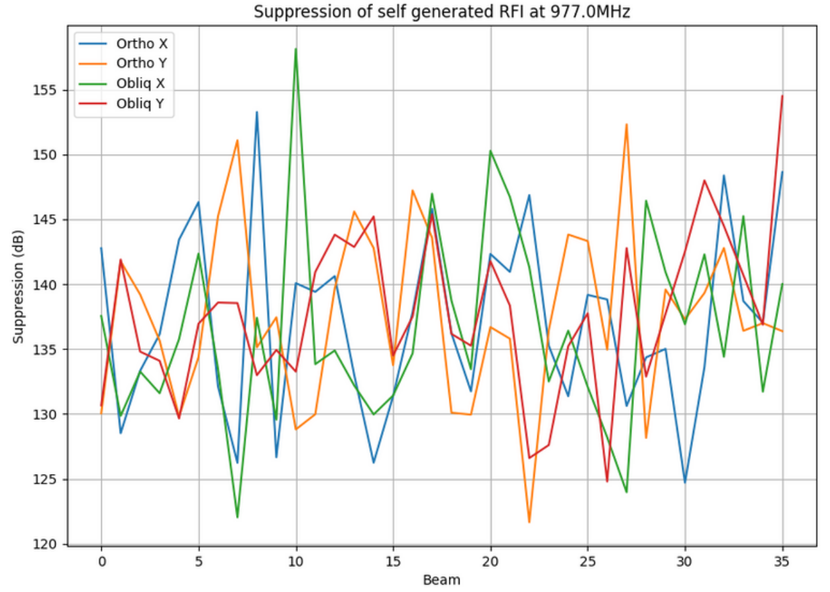


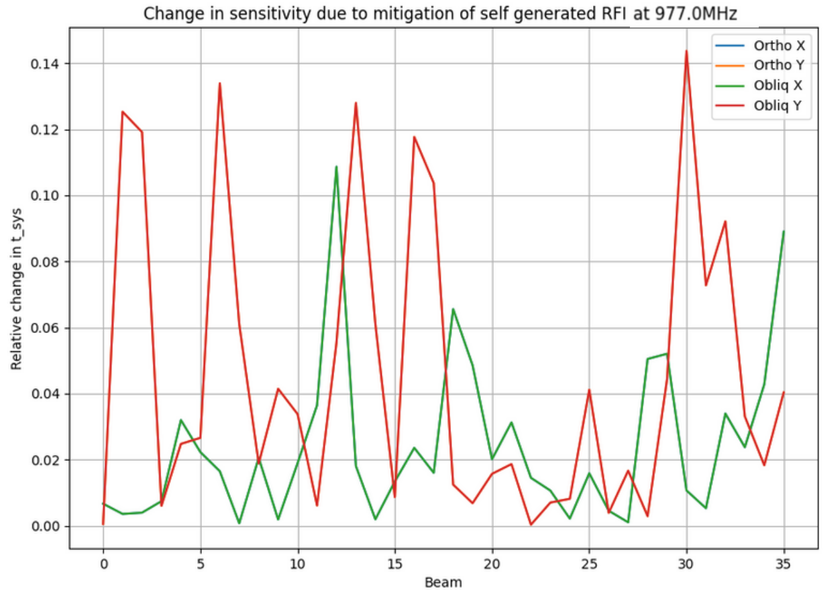
Different Phase on all ports

Variations to the beampatterns are reduced when the phase of the generated signal is randomize, particularly in the sidelobes.

L. Lourenço, and Chippendale, A., URSI RFI2022, 2022


Directivity Diagram of ASKAP 12m antenna at 976.44 MHz.
Beam26
xpol
ypol
Linear Gain
Gain (db)
Gain wrt. Reference (dB)
reference
ortho
obliq
Angle of Arrival (deg)
Angle of Arrival (deg)

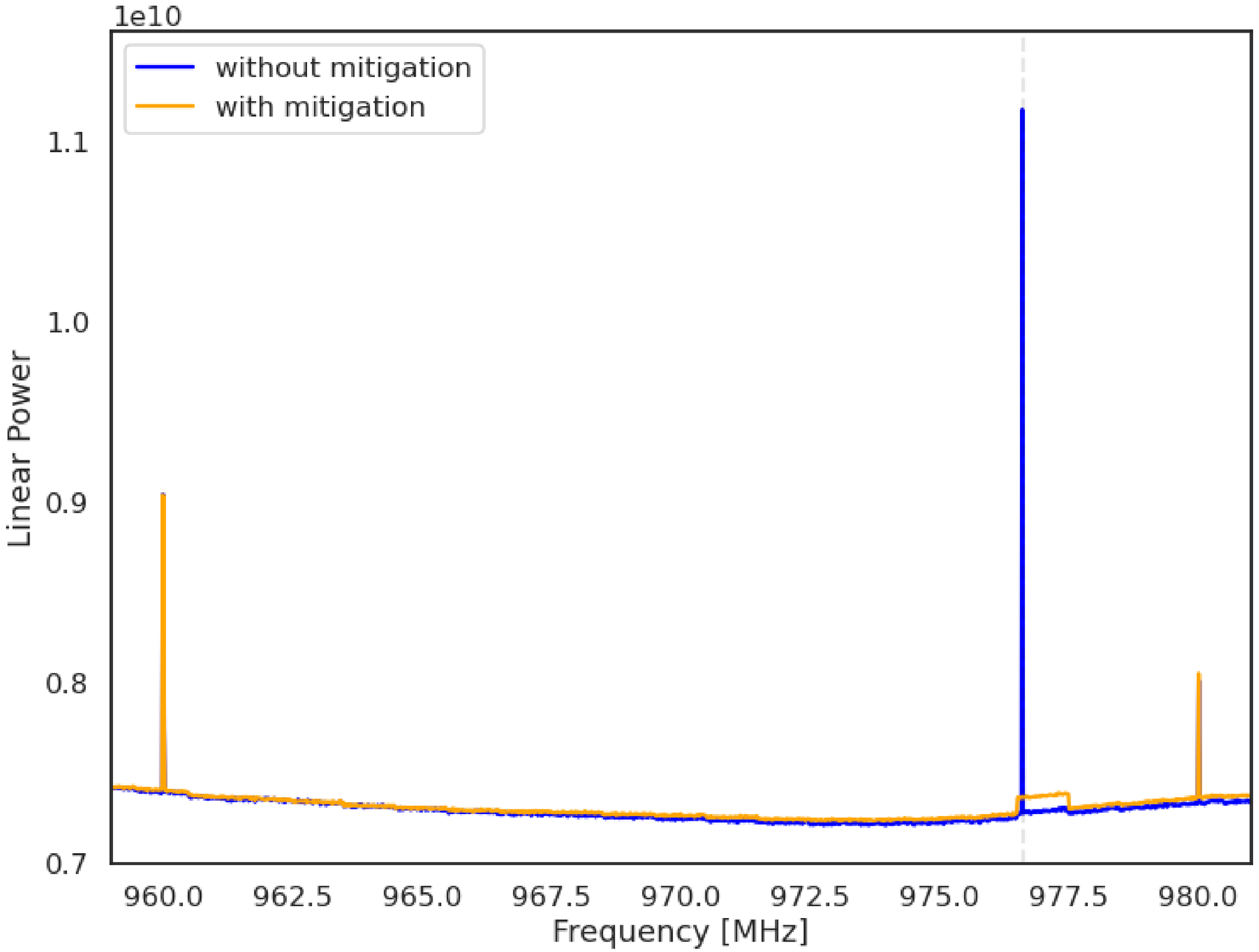

Suppression of self generated RFI at 977.0MHz
Ortho X
Ortho Y
Obliq X
Obliq Y
Suppression (dB)
Beam


Change in sensitivity due to mitigation of self generated RFI at 977.0MHz
Ortho X
Ortho Y
Obliq X
Obliq Y
Relative change in t_sys
Beam

SUPPRESSED OF UNWANTED NARROWBAND SIGNAL BY OVER 31 DB, TO THE NOISE FLOOR

REDUCTION IN SENSITIVITY OF JUST 1.5 %.

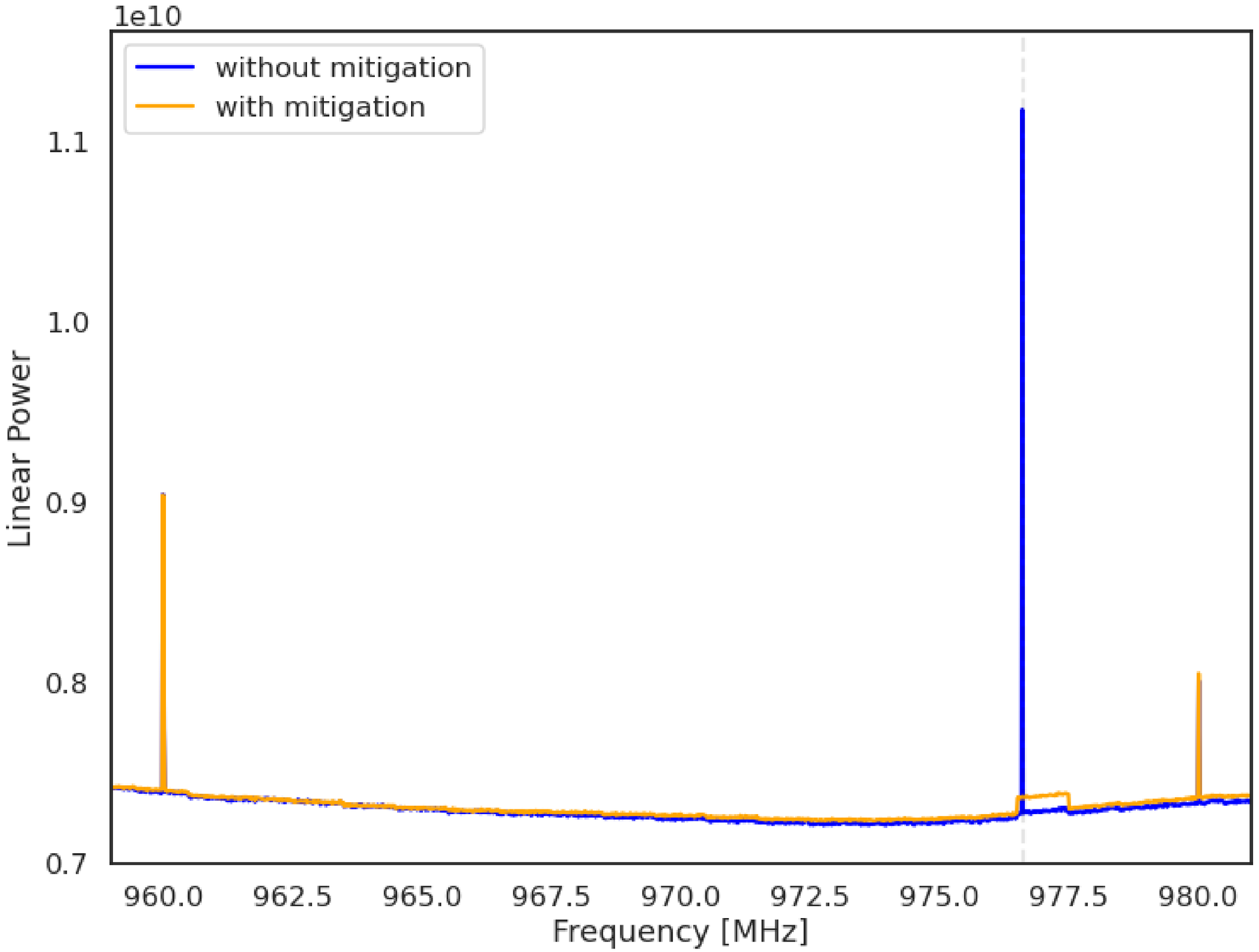
NO SIGNIFICANT EXPECTED CHANGE TO THE GAIN IN THE MAIN BEAM AND FIRST SIDELOBE.



GIVEN THIS KIND OF INFORMATION,

ASTRONOMERS ARE BETTER POSITIONED TO UNDERSTAND WHAT THE MITIGATION ALGORITHM IS DOING,

AND DECIDE ON THE USE OF THIS RFI MITIGATION TECHNIQUE BASED ON THEIR SCIENTIFIC GOALS.



Questions?

Next Steps:

- Measure sensitivity across the array and do holography of static use case on ASKAP.
  - Imaging and absorption/emission spectra, with and without mitigation.
- Model, implement and evaluate the dynamic case:
  - adjusting beam weights continuously throughout the observation.
  - shortlist suitable candidate RFI.
  - mitigate more pervasive RFI from moving sources, e.g. signals from satellites & aircraft.
    - starting with slower moving interferes
- Parkes CryoPAF

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Dr. Aaron Chippendale – CSIRO, Space and Astronomy

Other: Dr. Greg Hellbourg – California Institute of Technology