A Cryogenic Phased Array Receiver for the Parkes Radio Telescope

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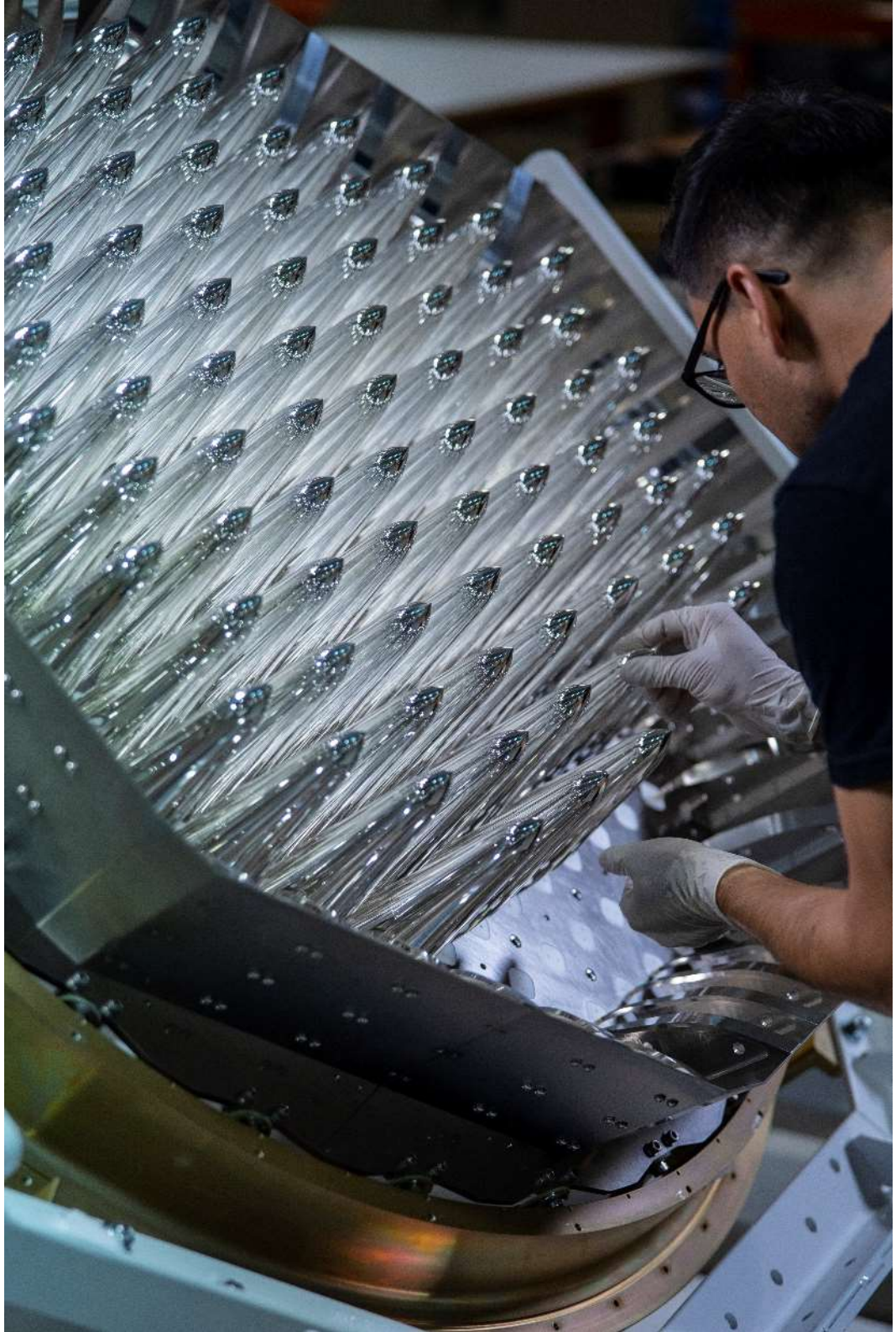
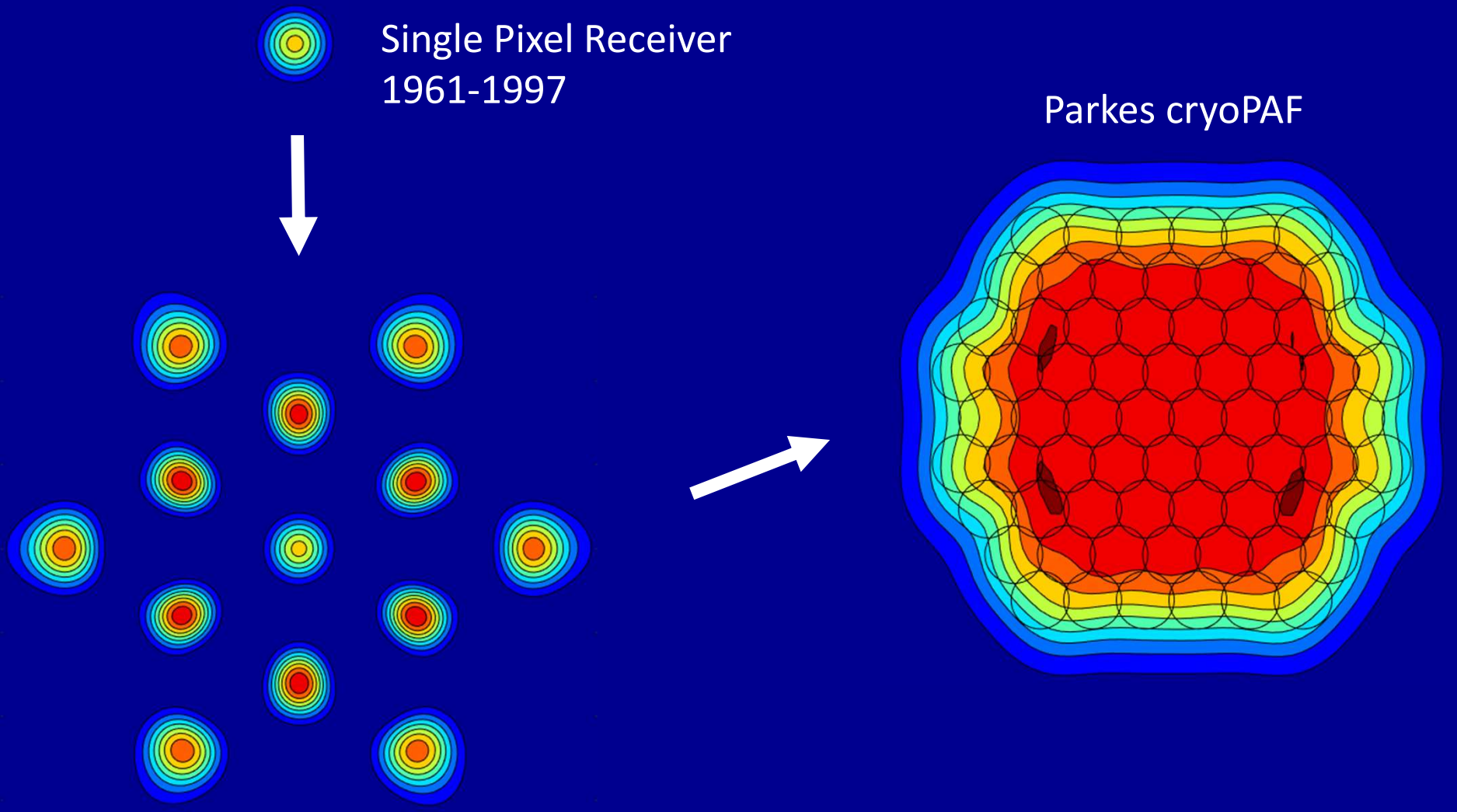
Australia's National Science Agency



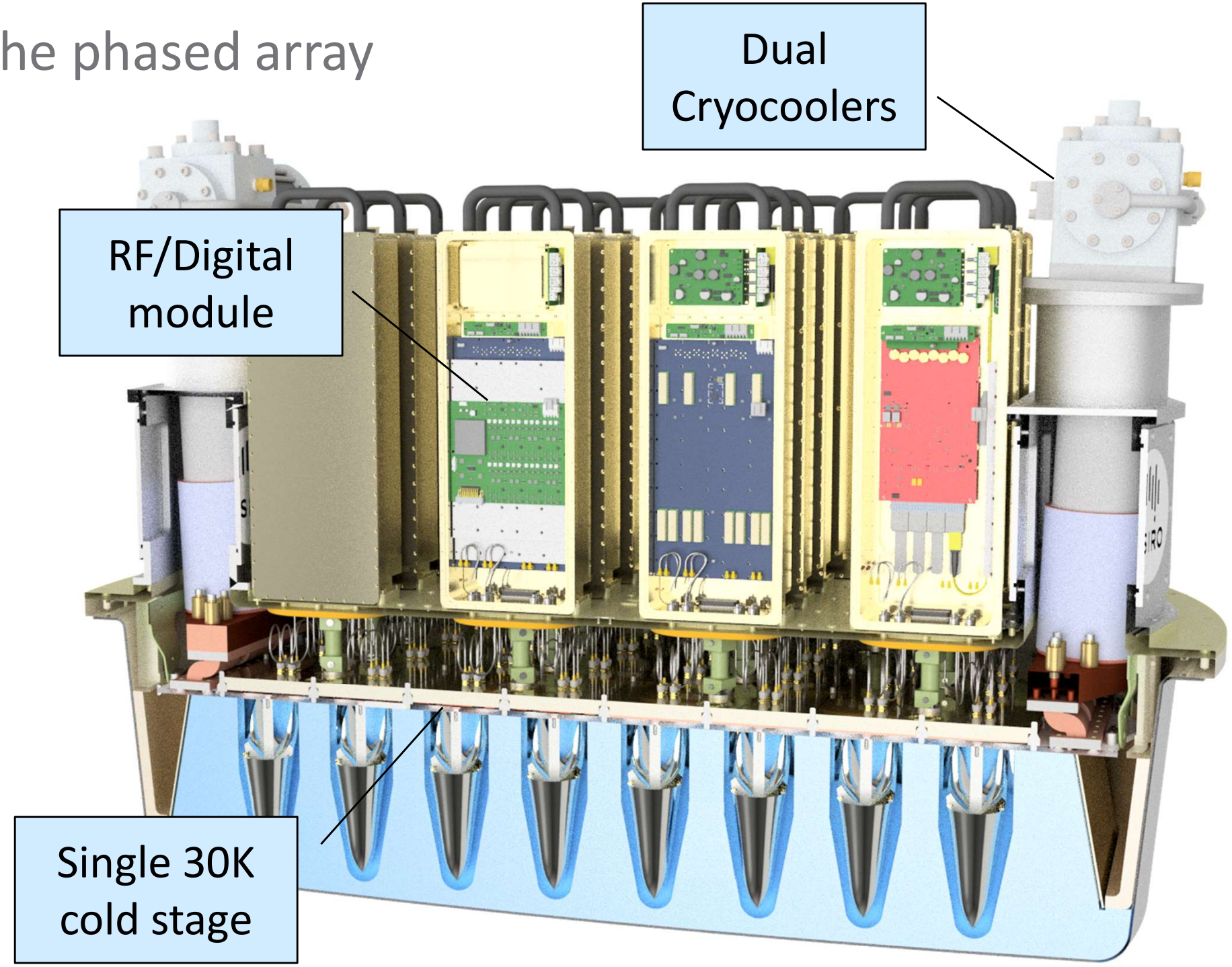
Parkes Radio telescope field of view

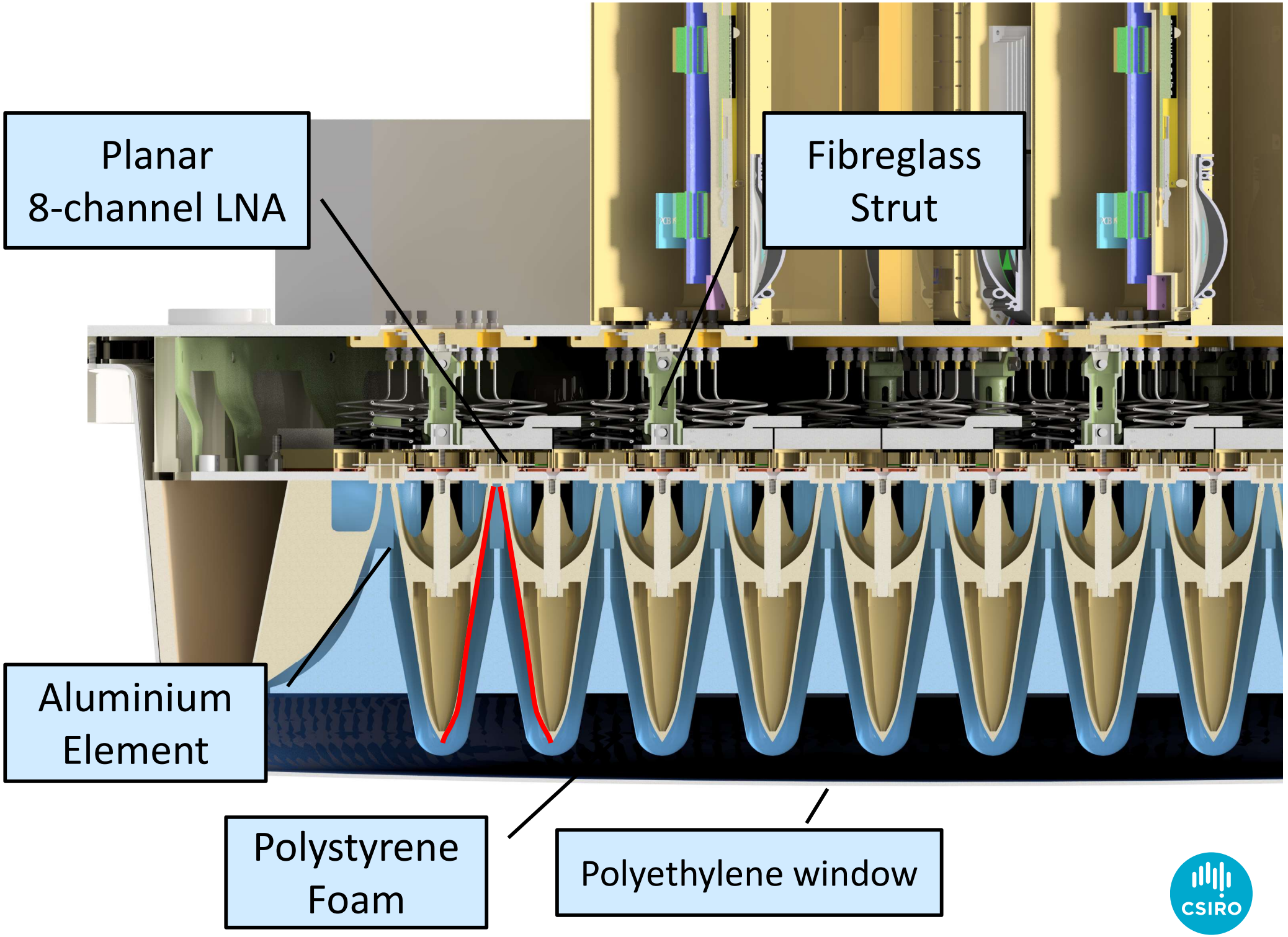


Parkes cryoPAF System Specifications:

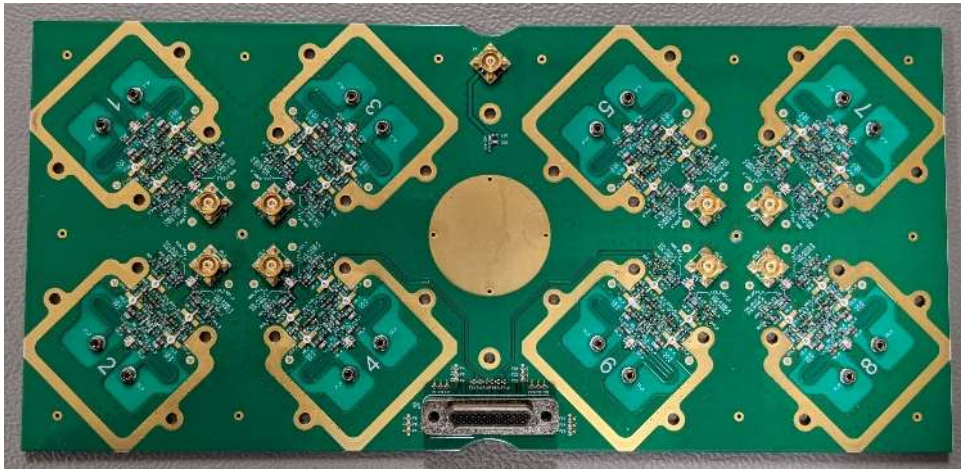
- Based on ‘Rocket’ elements
- Frequency: 700-1950 MHz (700-1200,1100-1950 MHz)
- Ports: 196 (98 vertical, 98 horizontal)
- Beams: 72 Dual Polarization
- System Temperature < 20K
- Digital data rate out of PAF: 7.8 Tb/s
- FPGA beamformer, GPU backend

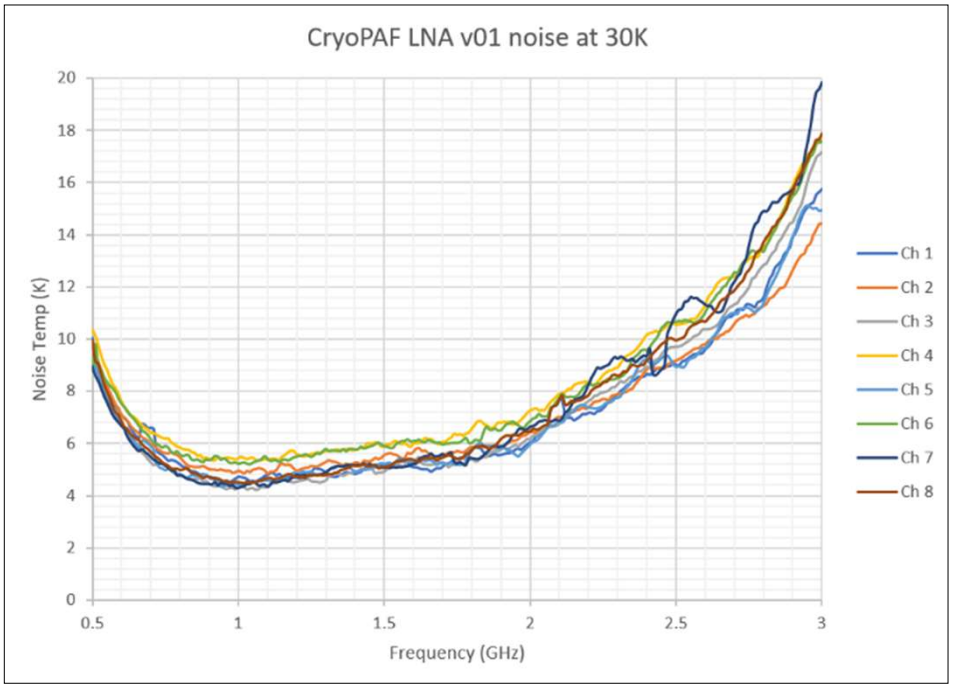
The phased array




Planar
8-channel LNA
Fibreglass
Strut
Aluminium
Element
Polystyrene
Foam
Polyethylene window

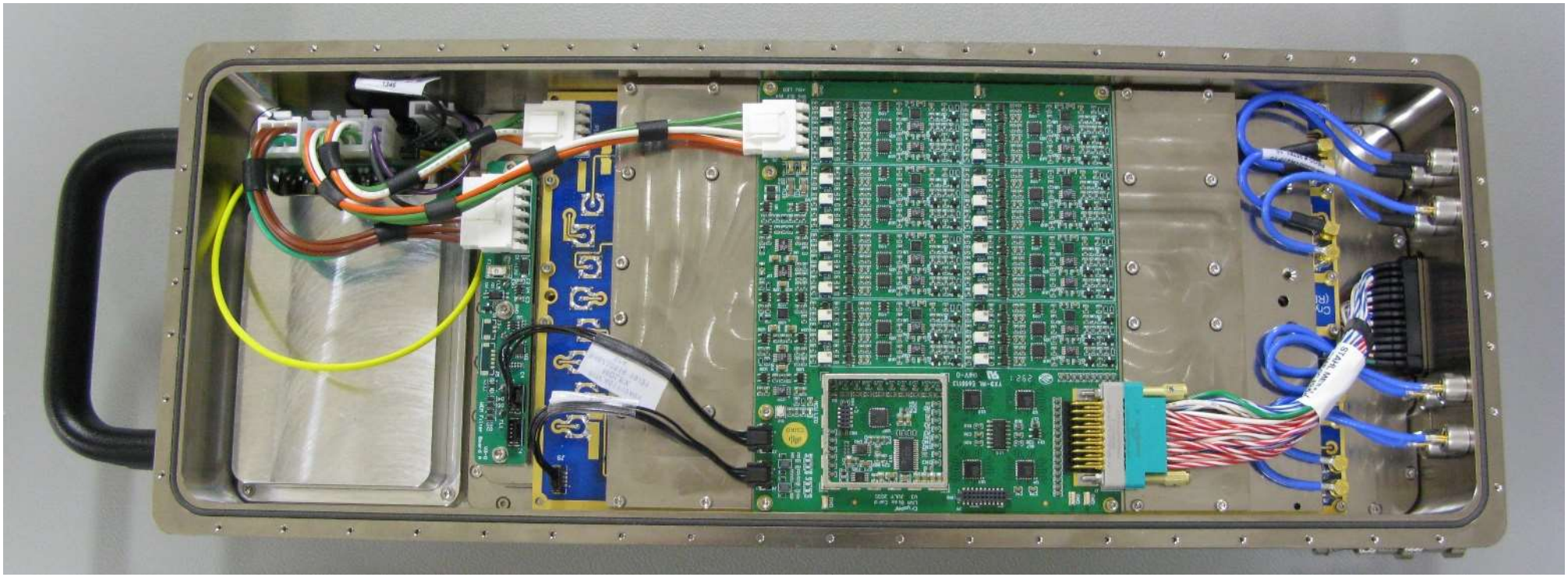
8-Channel Low Noise Amplifier

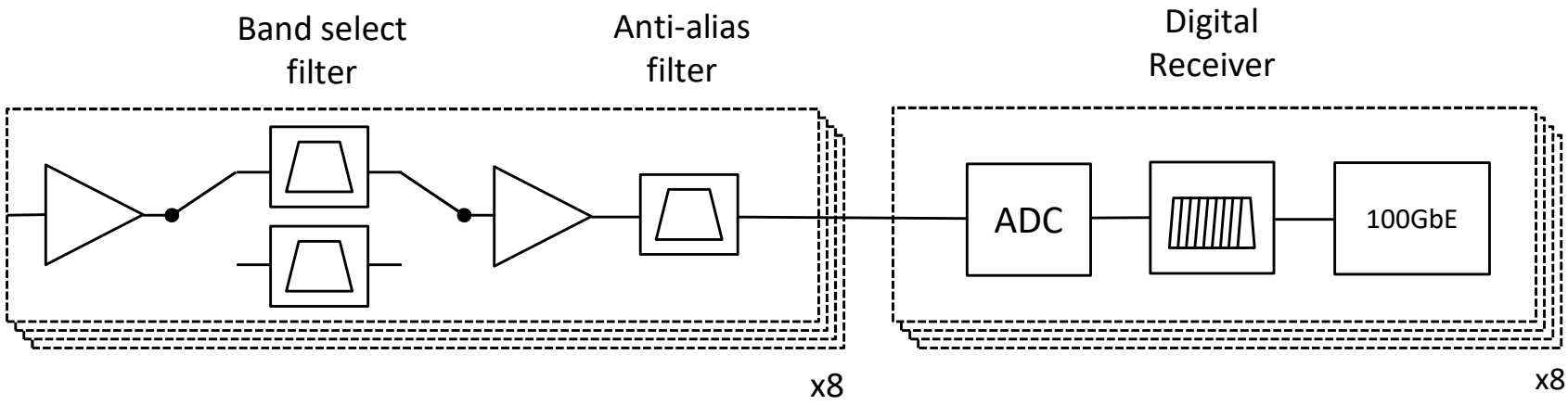




- Differential Architecture
- Discrete Transistors
- Integrated Noise Coupler
- To be upgraded with custom MMIC amplifiers when available

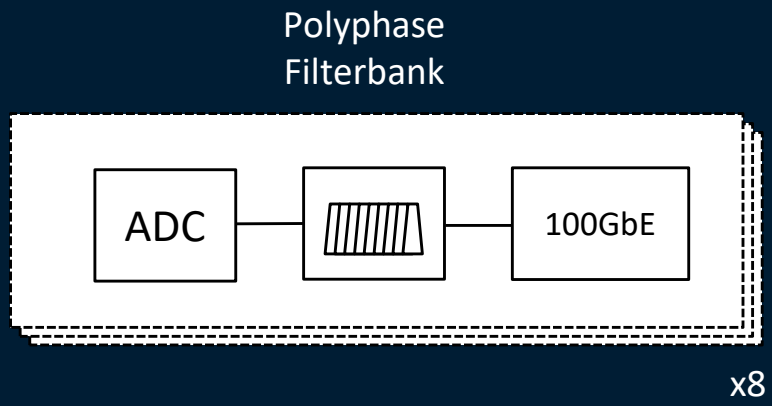
Warm Electronics Module

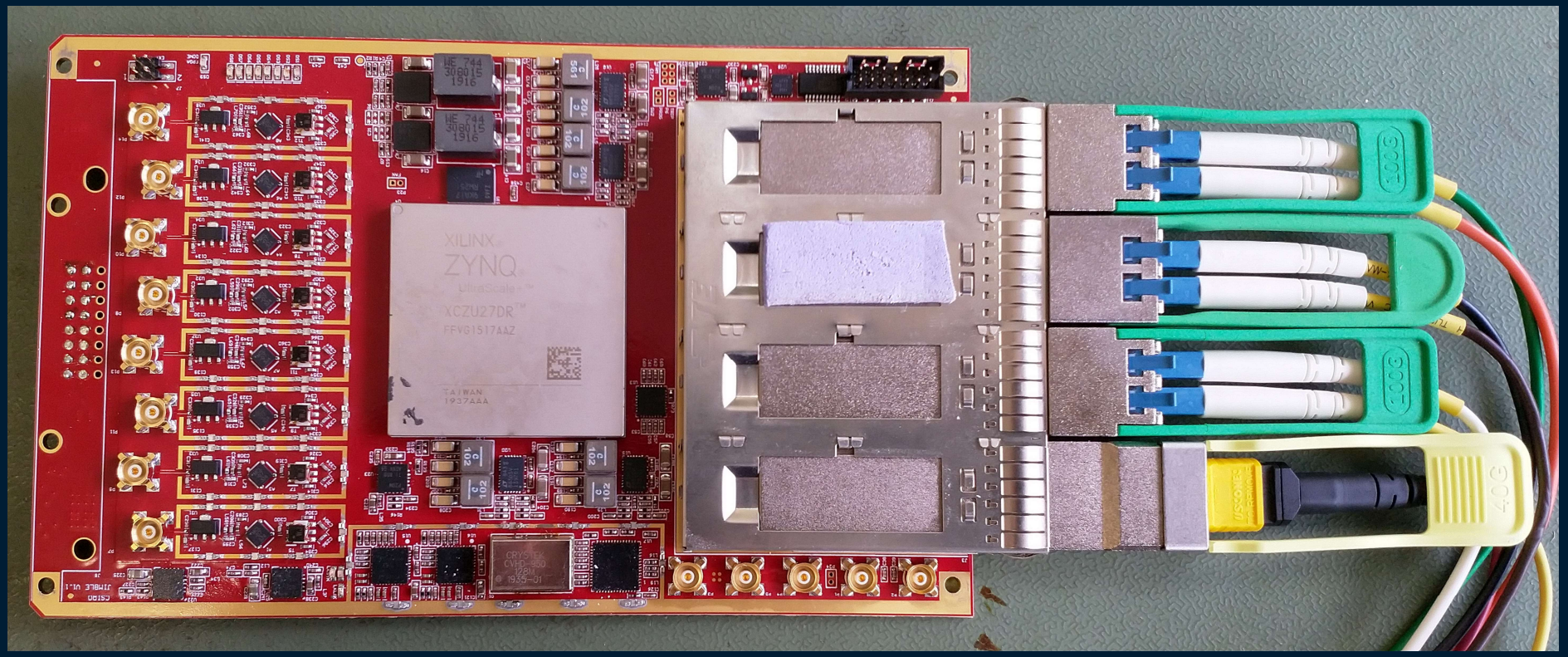




Digital Receiver

- 8x 4G samples/second ADC
- Integrated pre-processing
- 3x 100Gb Ethernet output



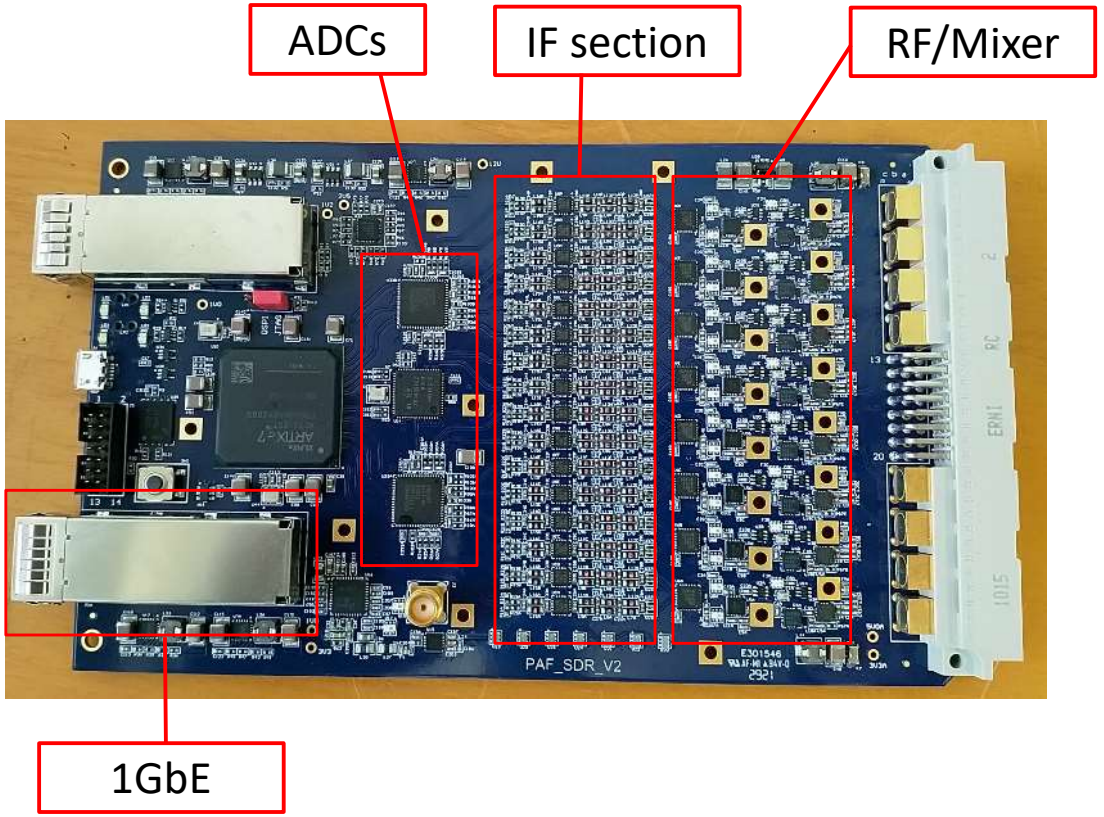


Managing the Thermal Load

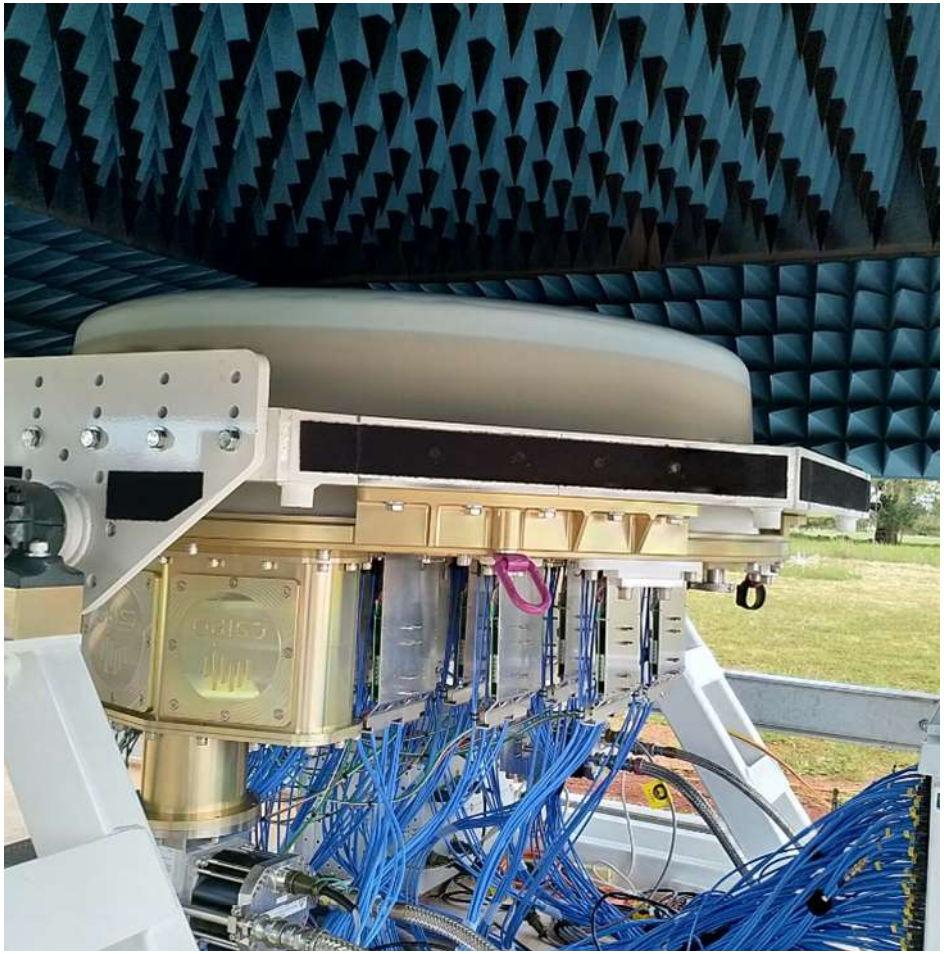
Plating	Radiation Load
Nickel	370mW
23K Gold	260mW
Pure Gold	240mW
Silver	80mW

Narrowband backend

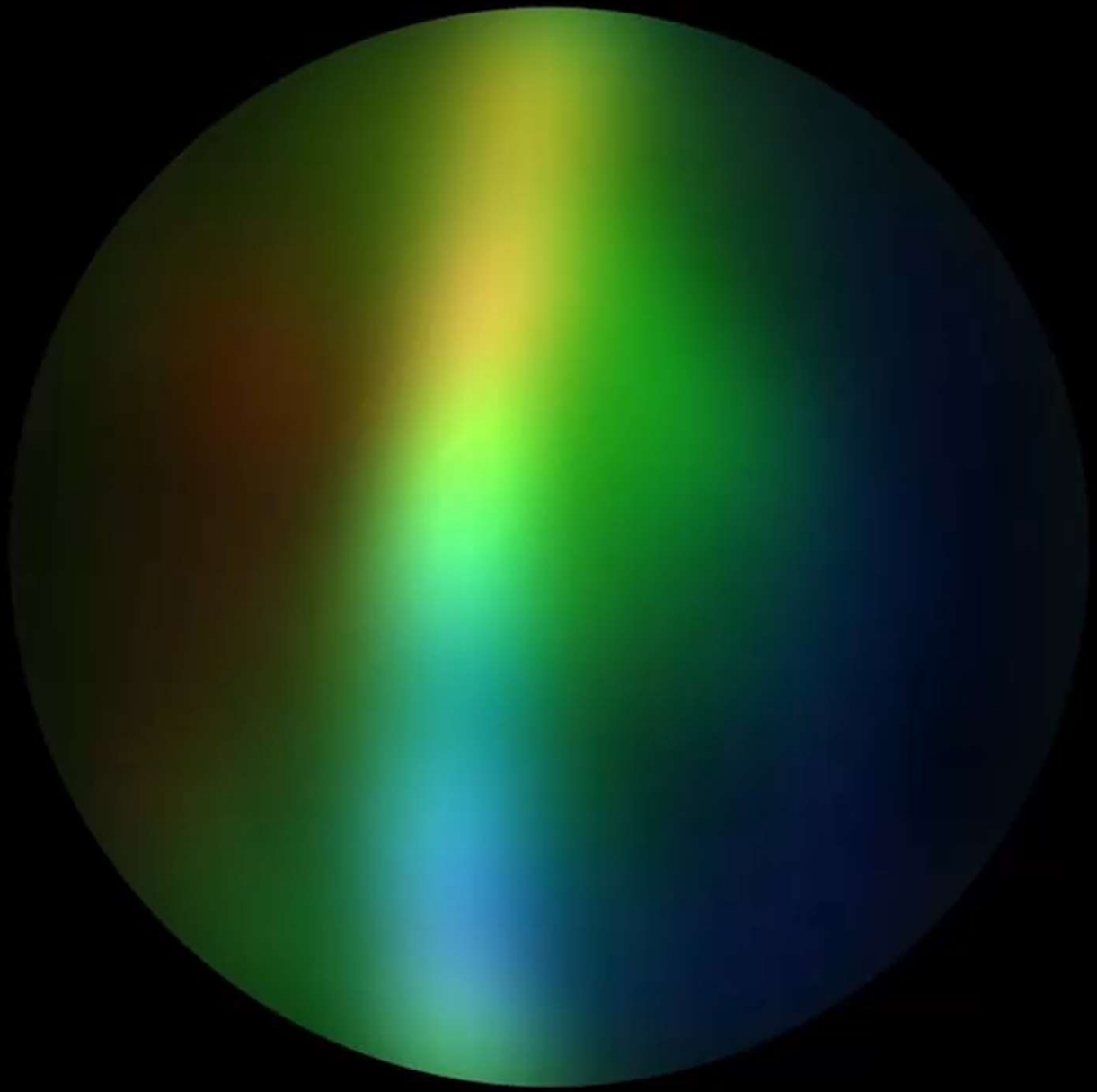
- 600-2500MHz swept RF bandwidth
- 2.5MHz instantaneous bandwidth
- Single GPU for covariance matrix computation



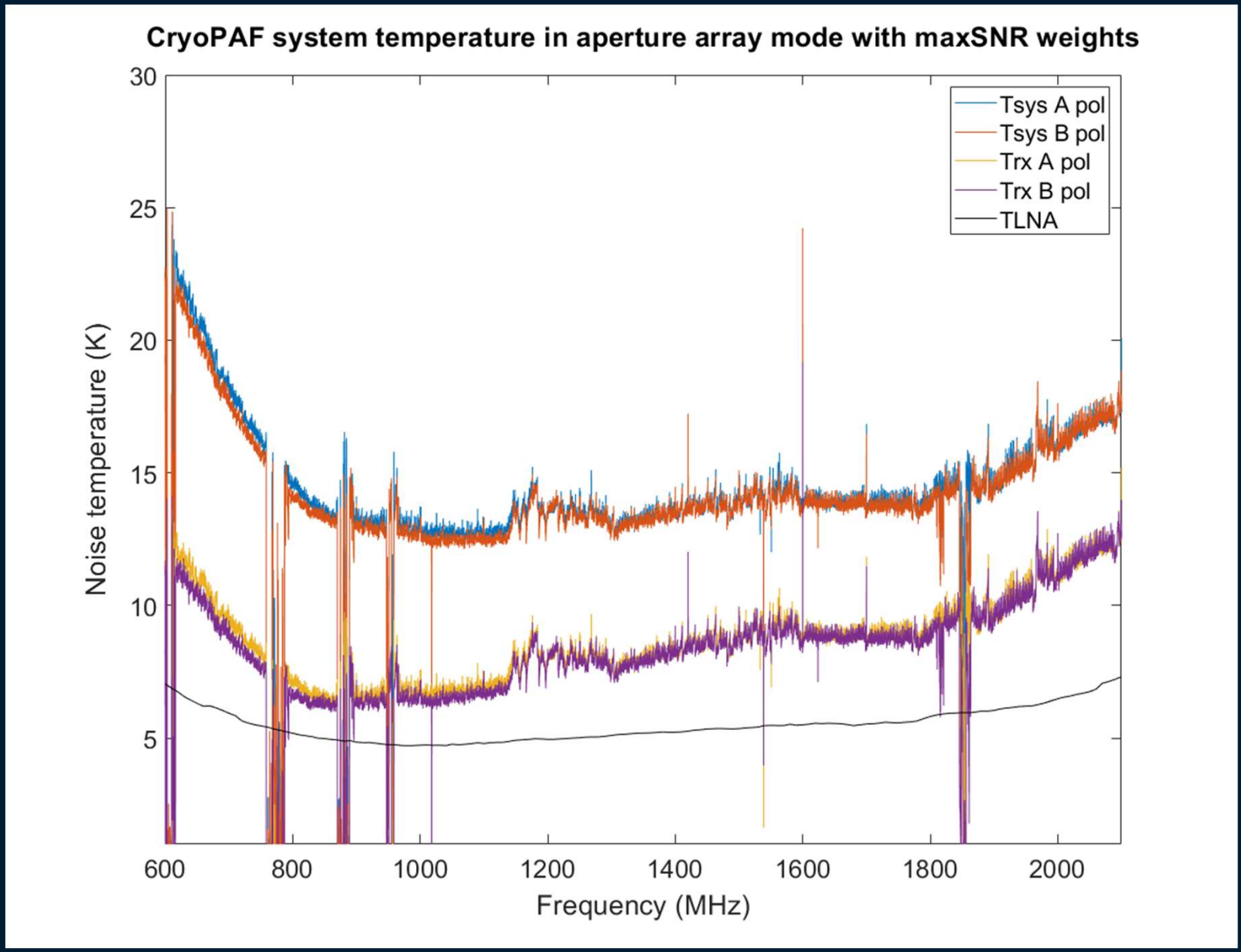
Aperture Array measurements



GLONASS Satellites

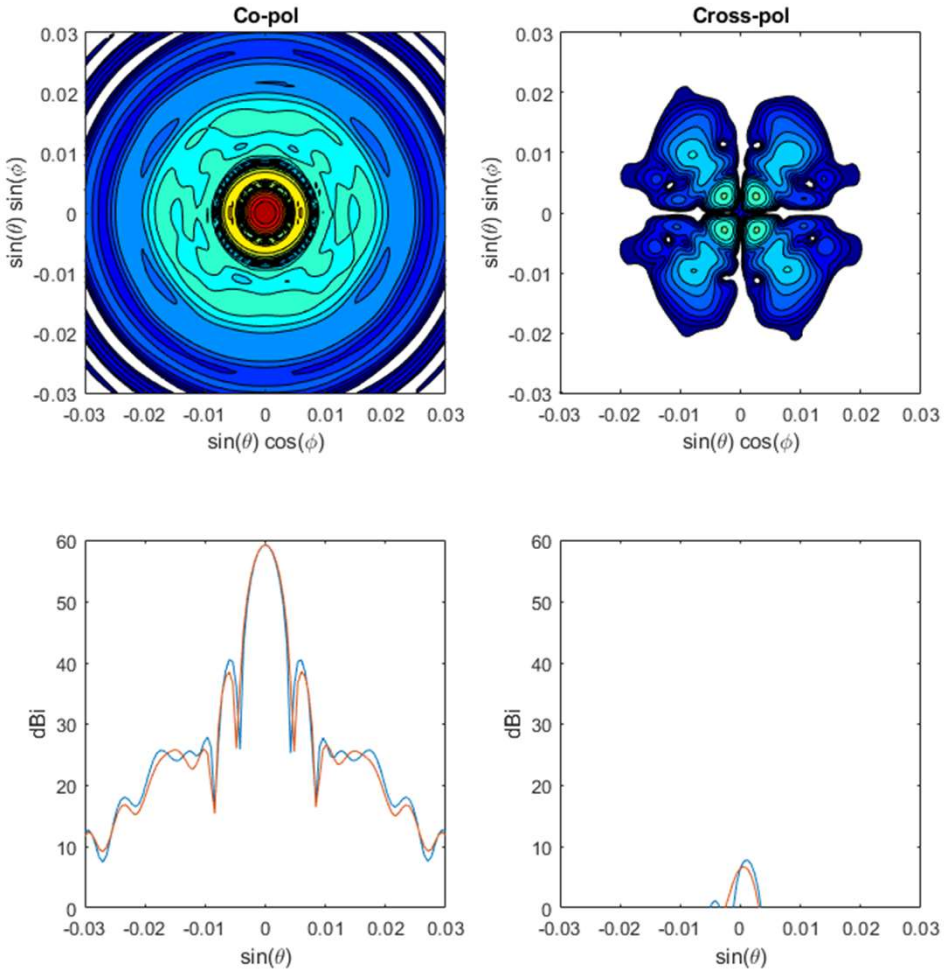


System Temperature in Aperture Array mode

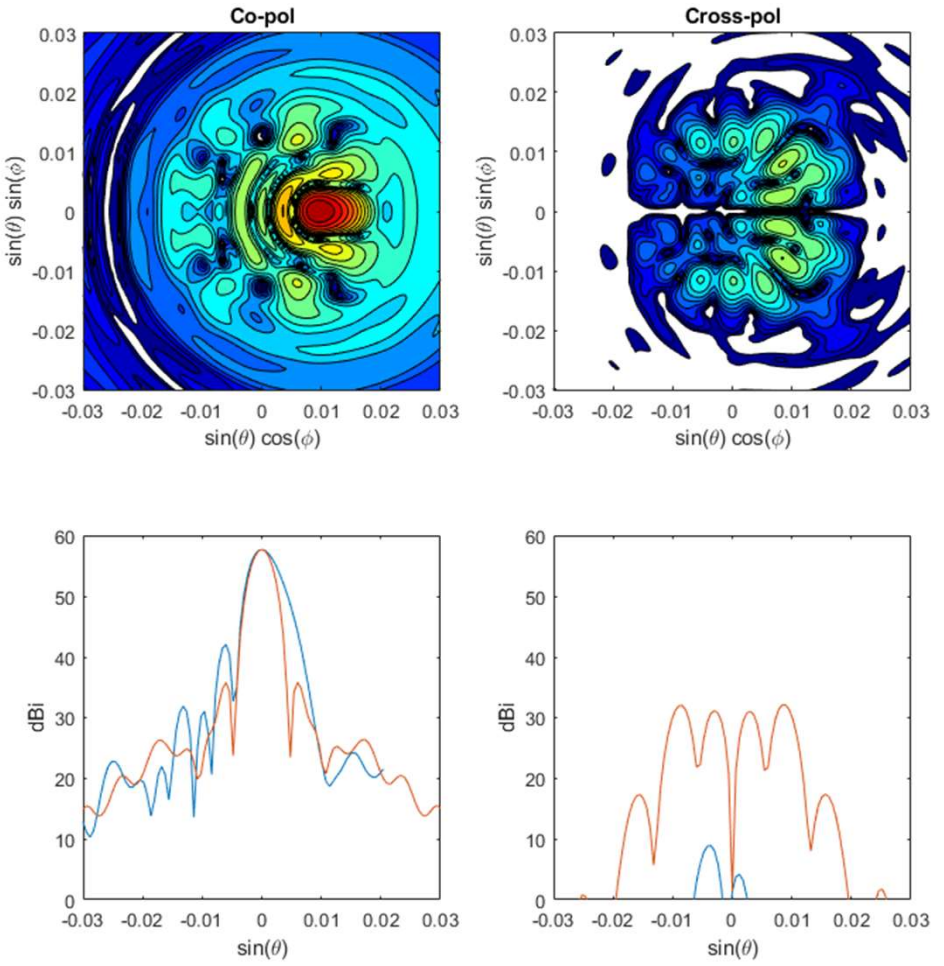


MaxSNR Antenna Patterns at 1.5GHz

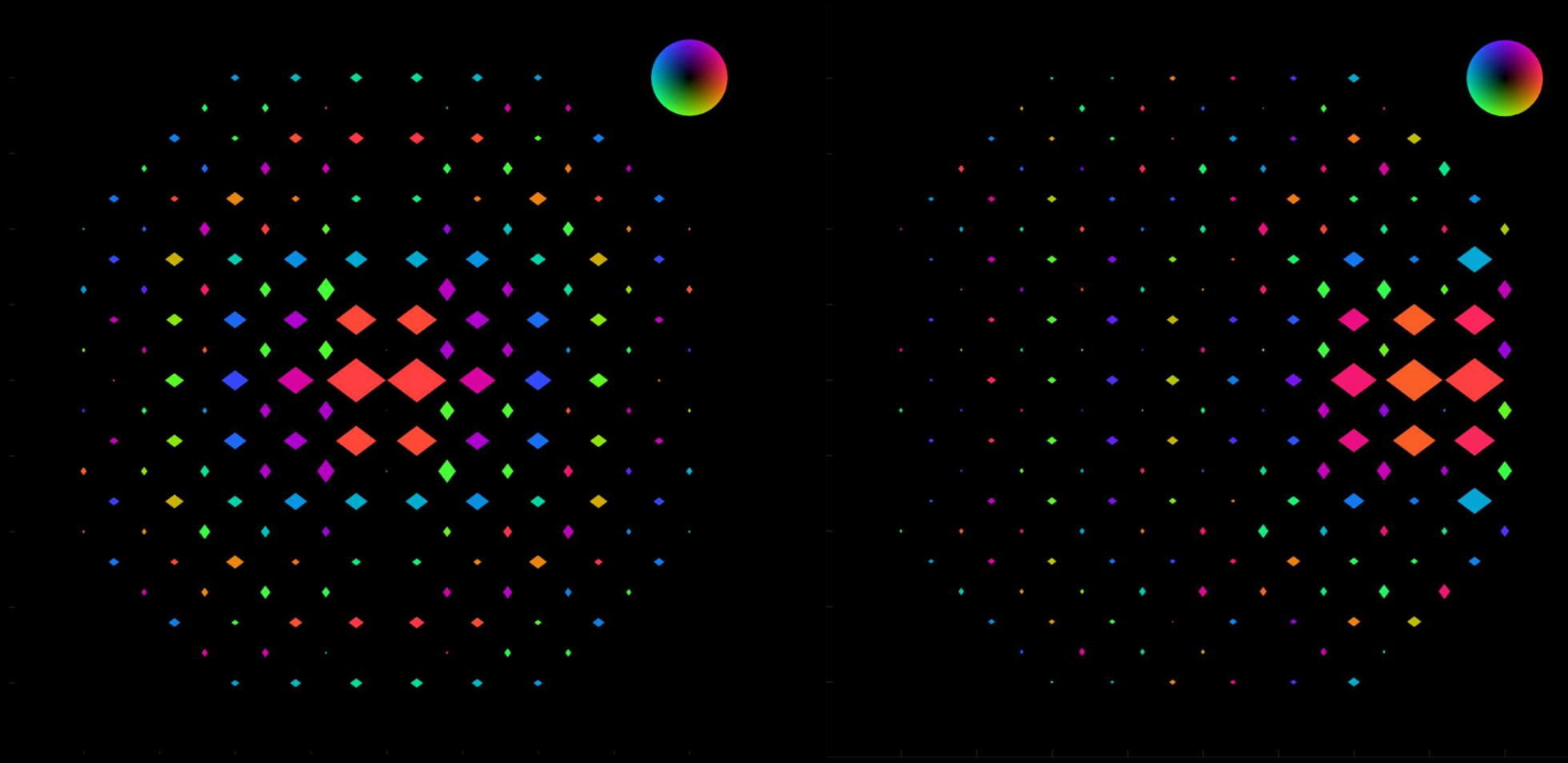
Boresight Efficiency=0.76 Tsys=15.6K



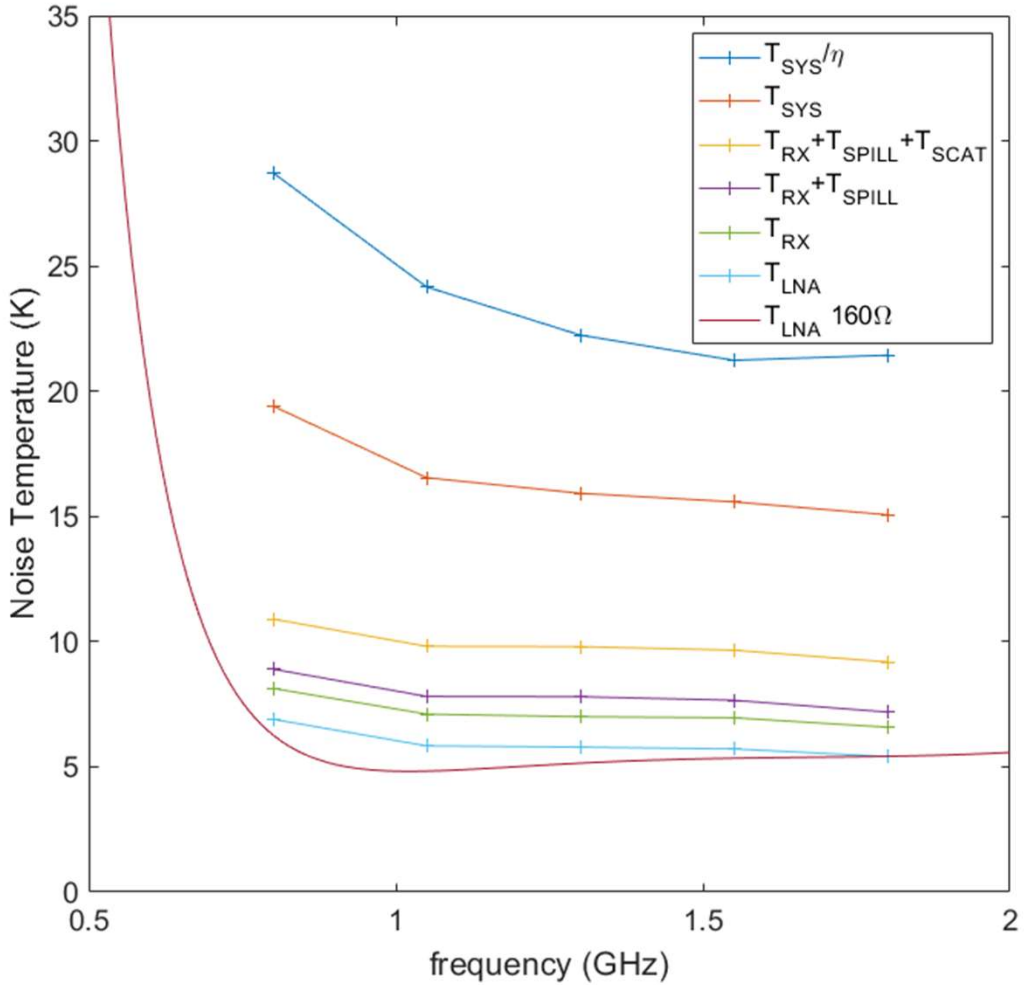
0.6deg offset Efficiency=0.45 Tsys=16K



Beam Weights



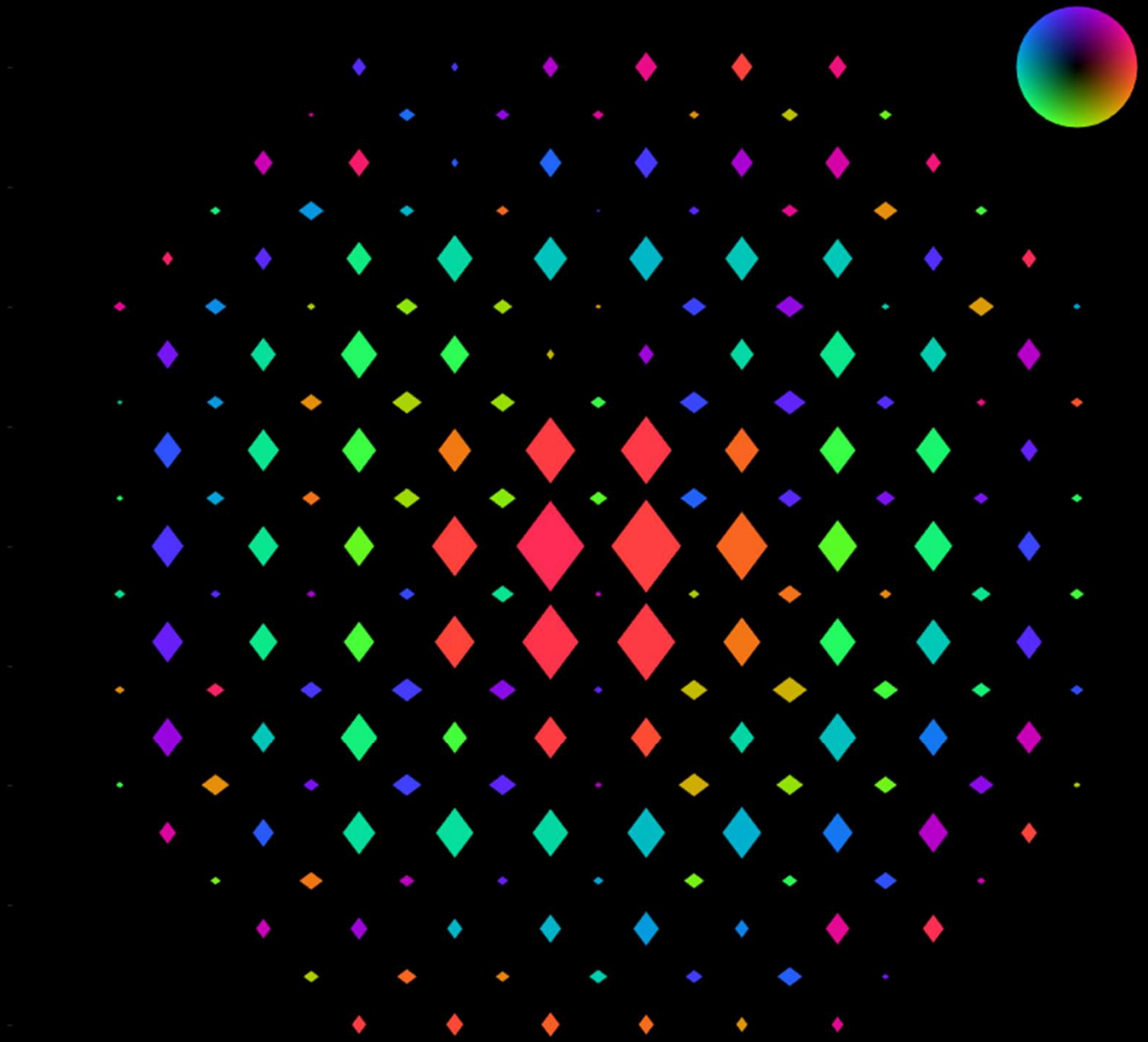
Simulated Boresight Noise Contributions

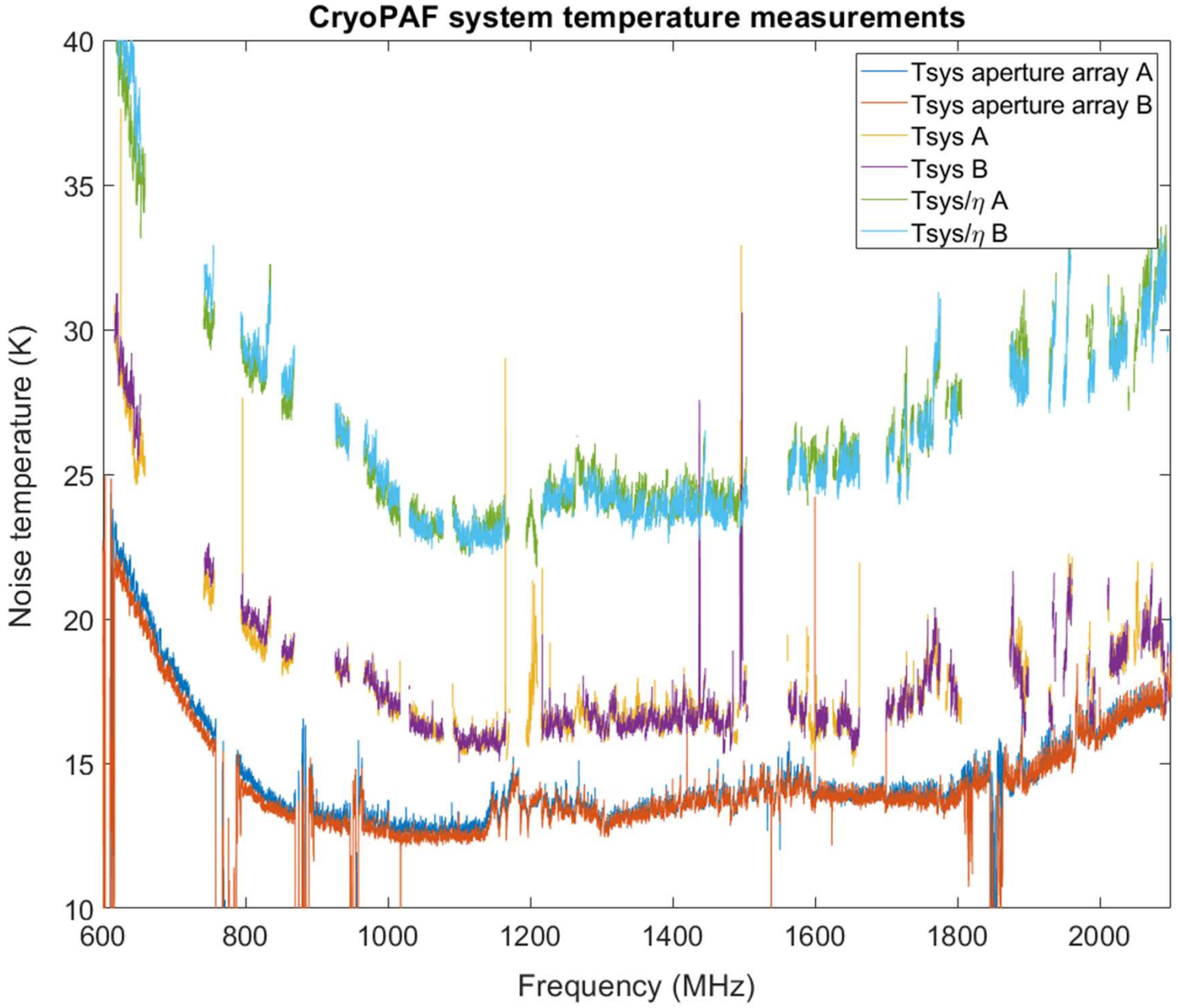


Element	1.55GHz Noise Contribution
LNA	5.7 K
Receiver (excluding LNA)	1.2 K
Spillover	0.7 K
Scatter	2 K ?
Sky + CMB	5.9 K
Tsys	15.6 K
Aperture Efficiency	73%
Tsys/Efficiency	21 K

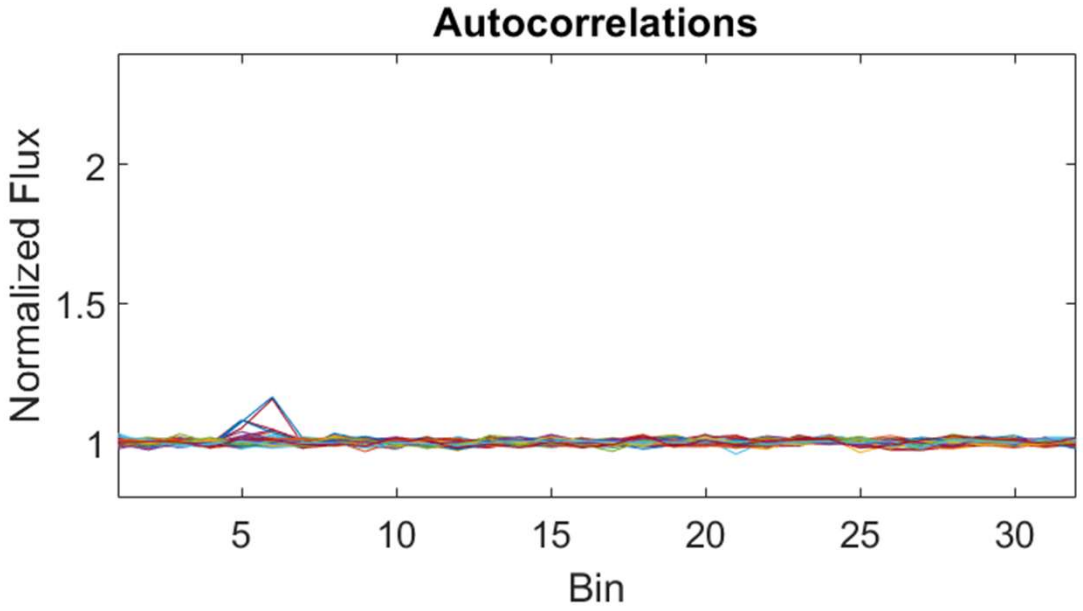
Early On Dish Tests

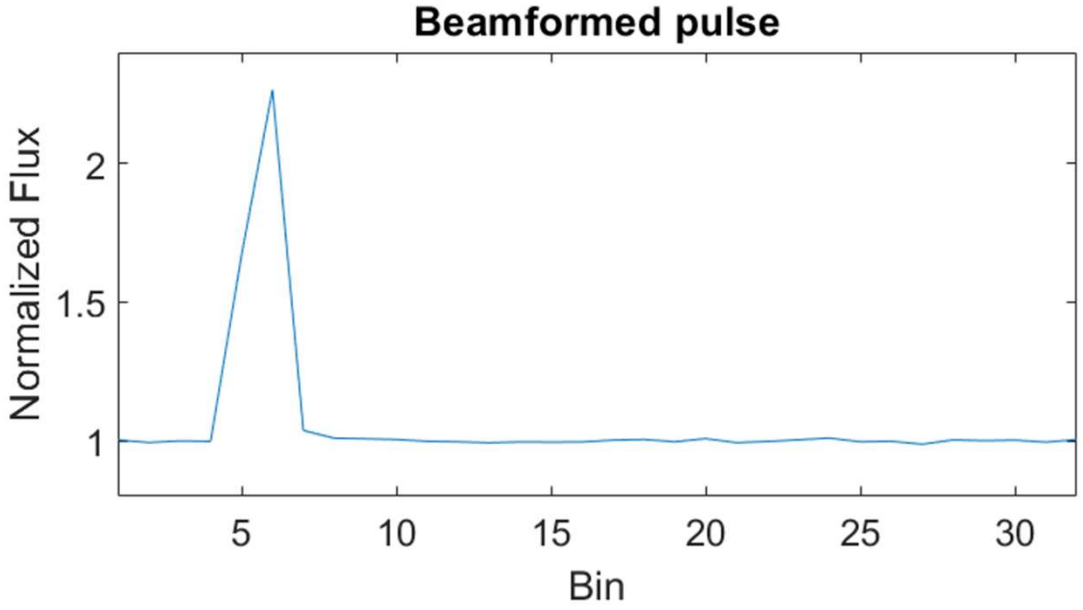
Measured MaxSNR weights

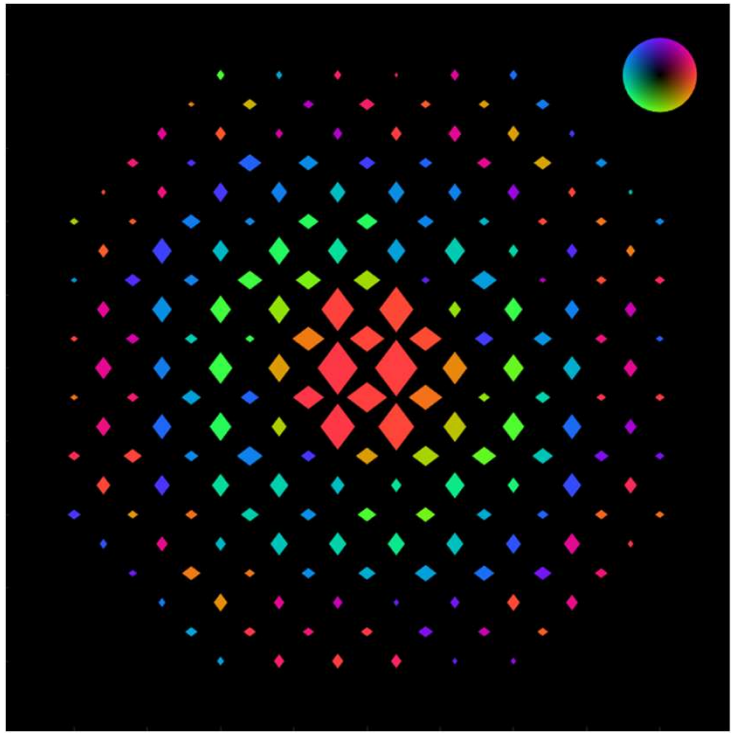



CryoPAF system temperature measurements
Tsys aperture array A
Tsys aperture array B
Tsys A
Tsys B
Tsys/η A
Tsys/η B
Noise temperature (K)
Frequency (MHz)
40
35
30
25
20
15
10
600
800
1000
1200
1400
1600
1800
2000

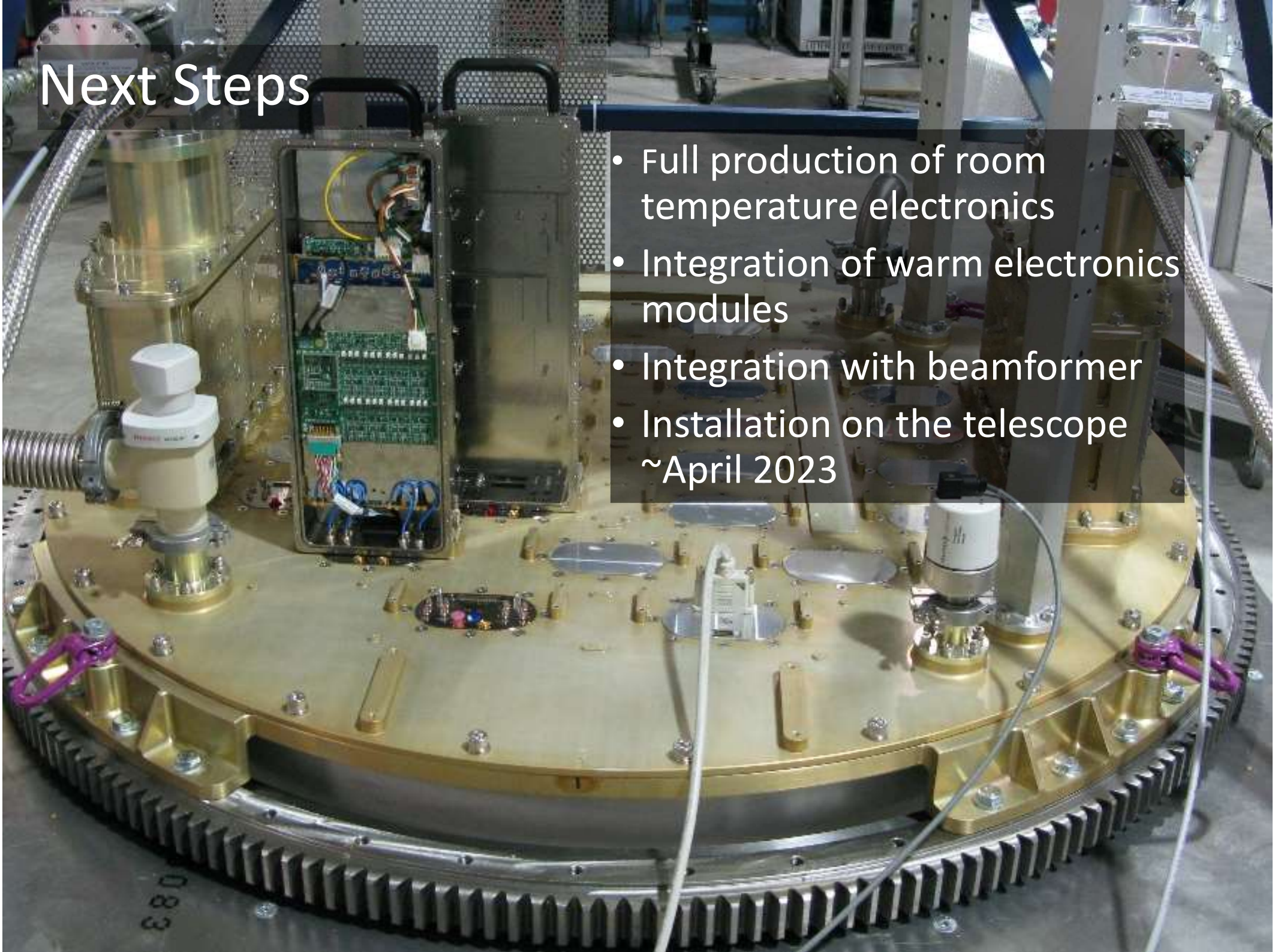
Beamforming with the Vela Pulsar



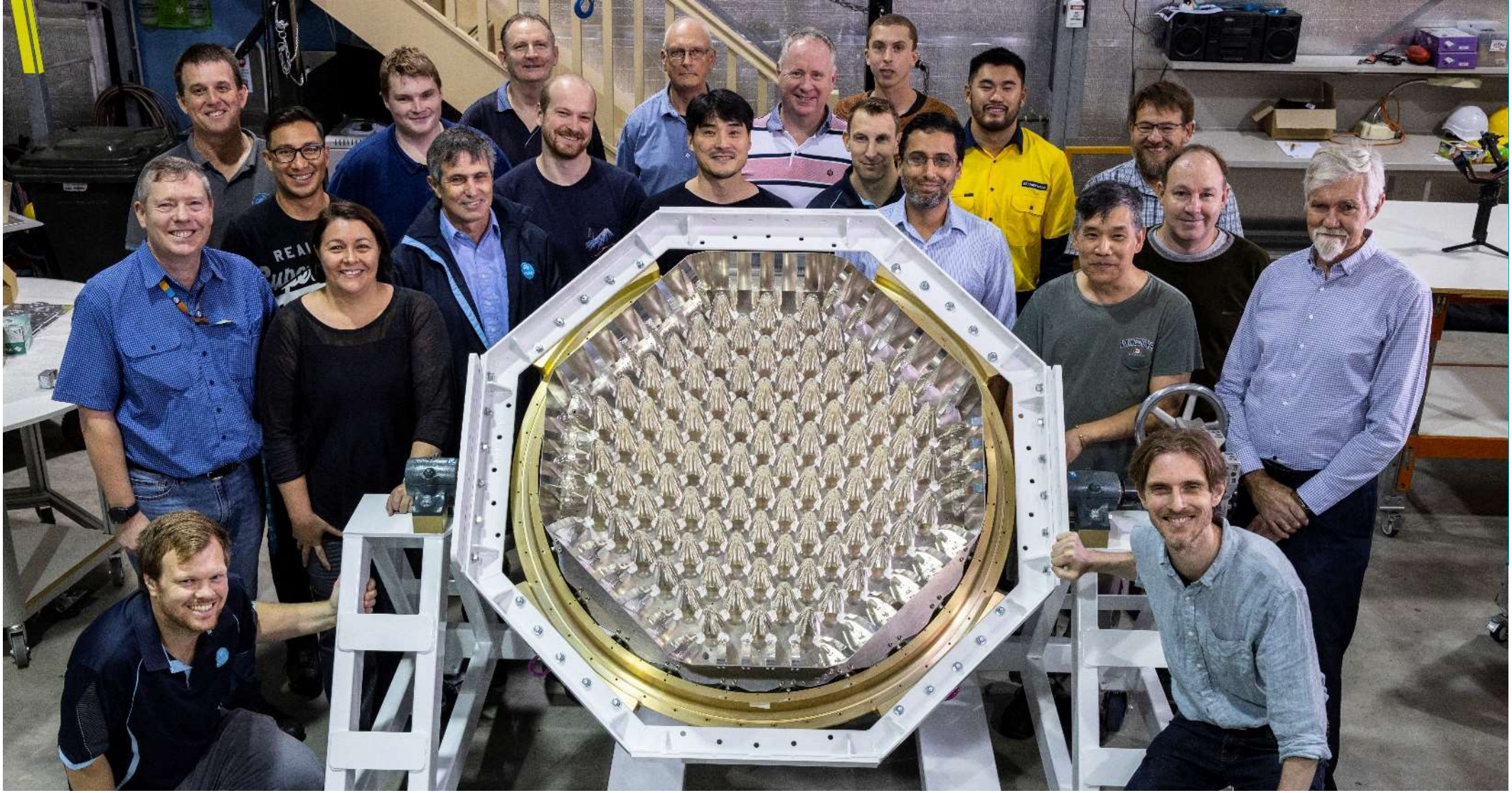




Next Steps



- Full production of room temperature electronics
- Integration of warm electronics modules
- Integration with beamformer
- Installation on the telescope ~April 2023



Thank you

CSIRO Space and Astronomy
Alex Dunning