

# Active Impedance Matched Dual-Polarization Phased Array Feed for the GBT

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**BYU**

BRIGHAM YOUNG  
UNIVERSITY



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- Marianna Ivashina, Rob Maaskant, and Stefan Wijnholds have been working hard at BYU on polarimetric calibration



# PAF Development Efforts

- 19 element very low loss active impedance matched array
  - Fabricated, sky noise measurements completed (Nov. 2009)
- 19 x 2 element dual-polarized array
  - Element design and fabrication
  - Room temperature 33 K LNAs
  - Four channel downconverter boards
  - 40 channel real time data acquisition system
- Cryogenic PAF – dewar and LNAs (R. Norrod, NRAO)
- Signal processing algorithms
  - Beamformers with high sensitivity and controlled beam shape
  - RFI mitigation algorithms for PAFs
  - Polarimetric calibration and beamforming
- PAF model performance simulations for PrepSKA
- Arecibo PAF feasibility study (G. Cortes)
- CASPER ROACH FBX engine (J. Landon @ Berkeley)

# System Noise Budgets

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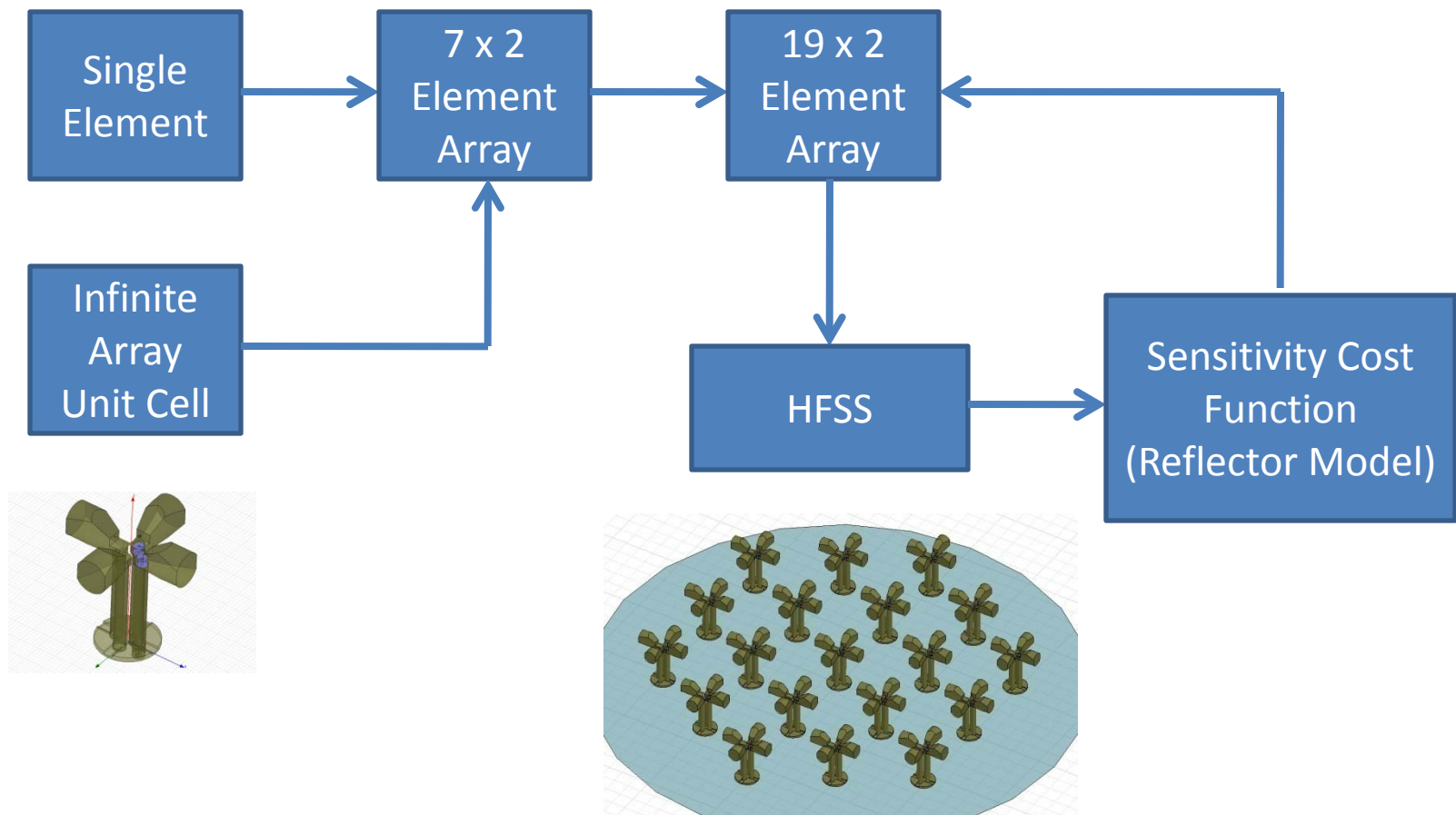
Radio Astronomy Systems  
Research Group

Component	2008 (Measured)	2009 (Target)	Cryogenic PAF (GBT)
Sky	4	4	4
Spillover	5	5	5
Antenna Loss	4	1	5
LNA Tmin	33	33	5
Mutual Coupling	20	3	1
<b>Total</b>	<b>66 K</b>	<b>46 K</b>	<b>20 K</b>

- Design goals:
  - Extremely low loss
  - Ground plane backed
  - Integrated balun
  - 300 MHz bandwidth (1 dB sensitivity)
  - Active impedance matched to formed PAF beams over FoV

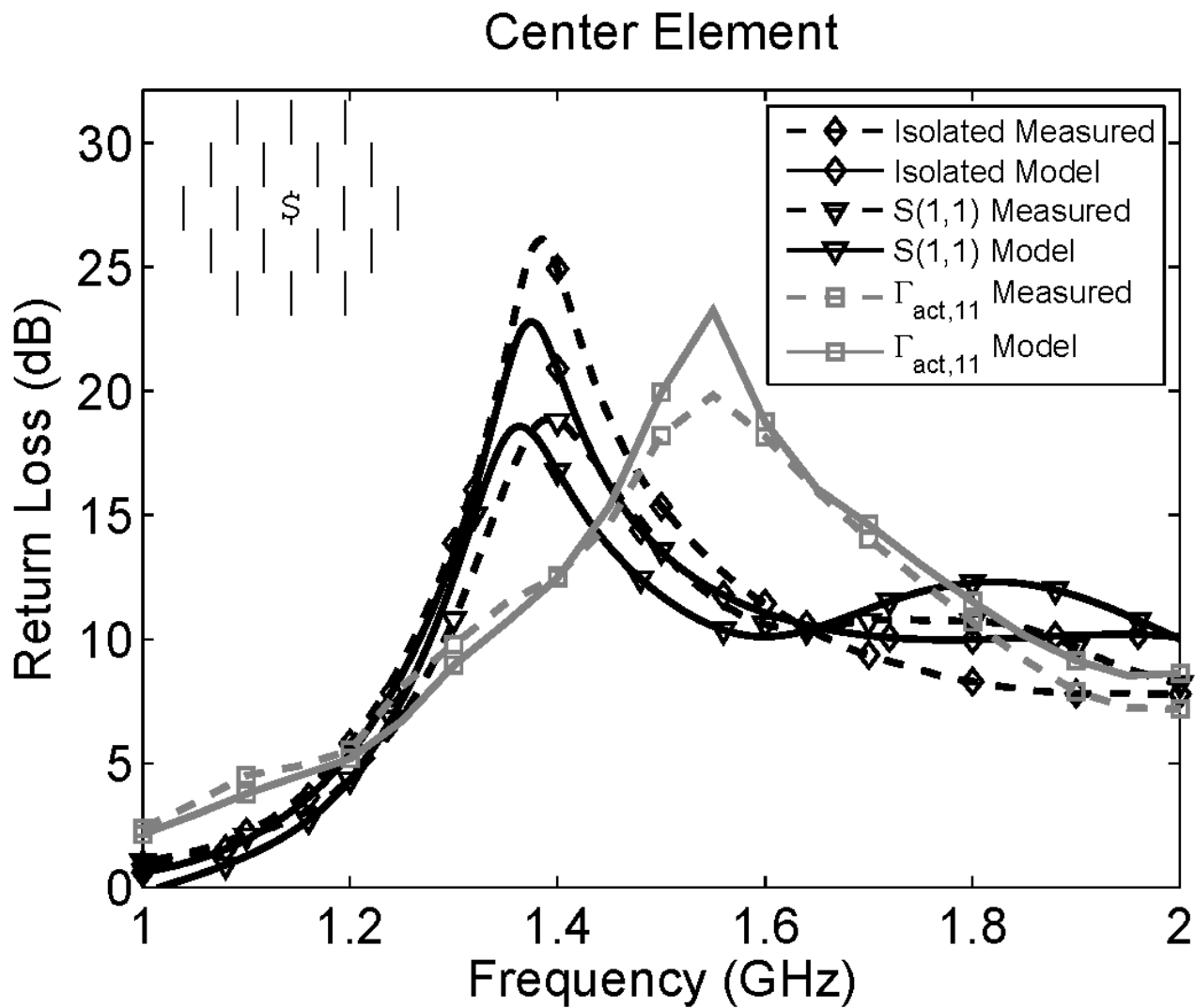
# Design Optimization Process

- Computationally challenging!
- Dave Carter, Taylor Webb (MS students)

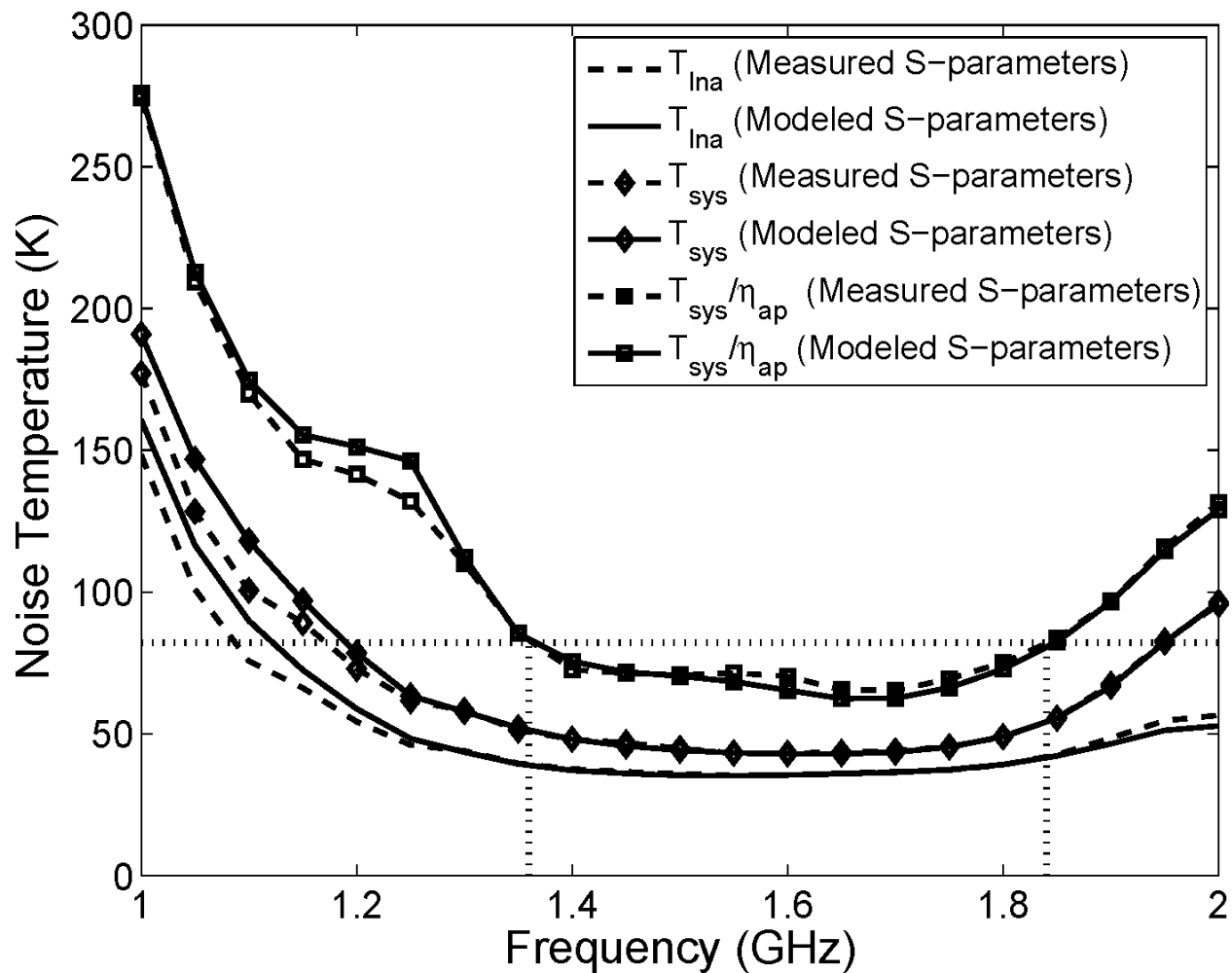


# Single-Pol Prototype



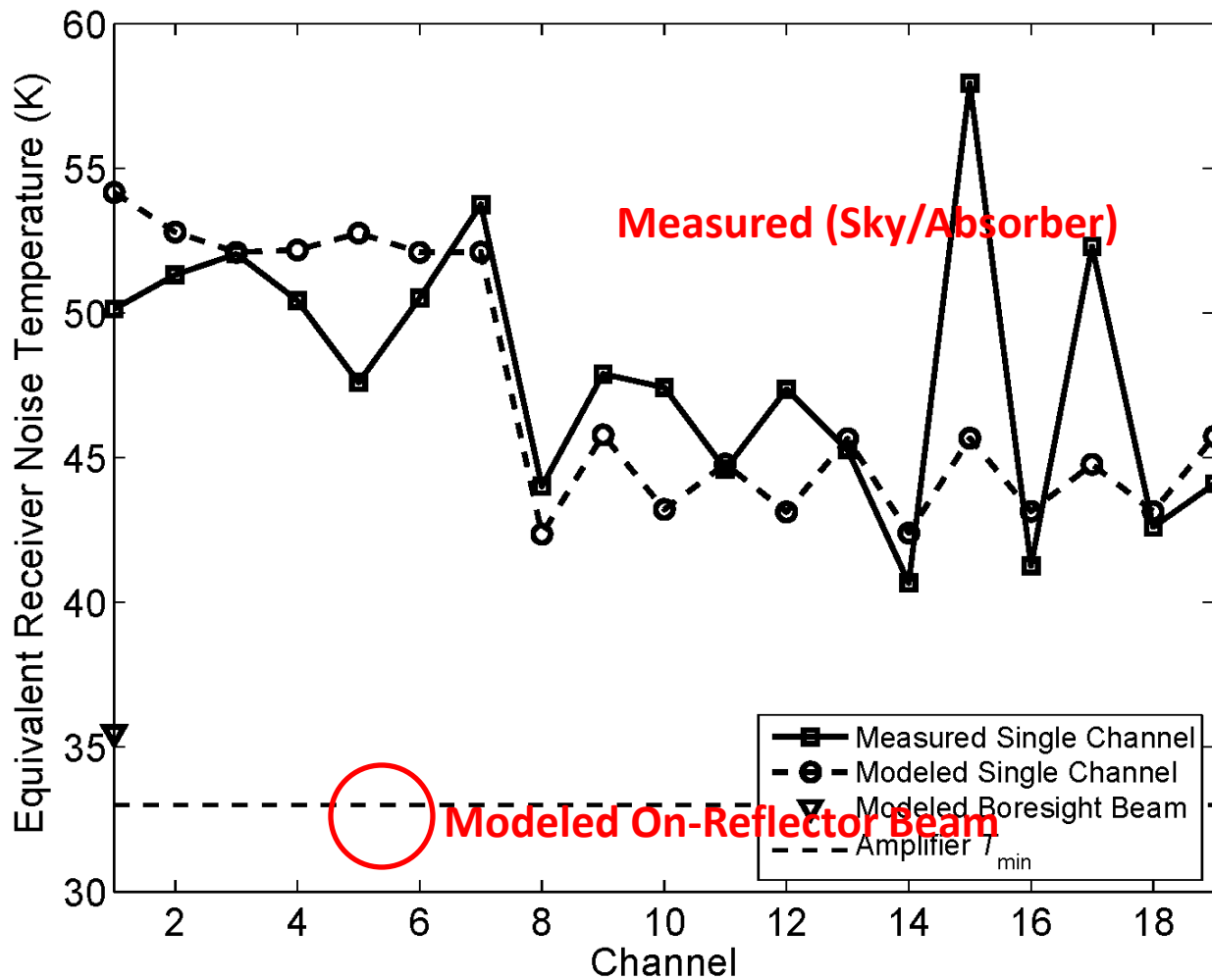




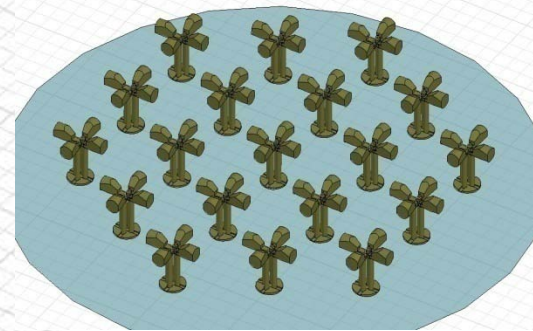
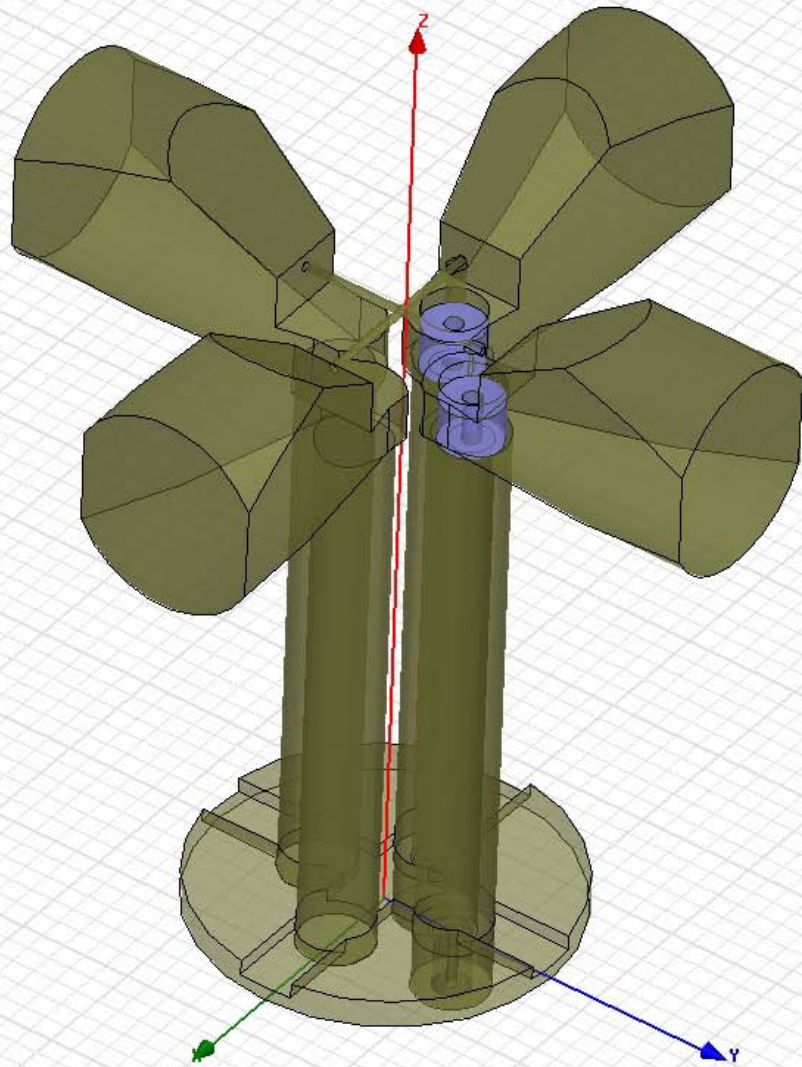


~500 MHz 1 dB Sensitivity Bandwidth

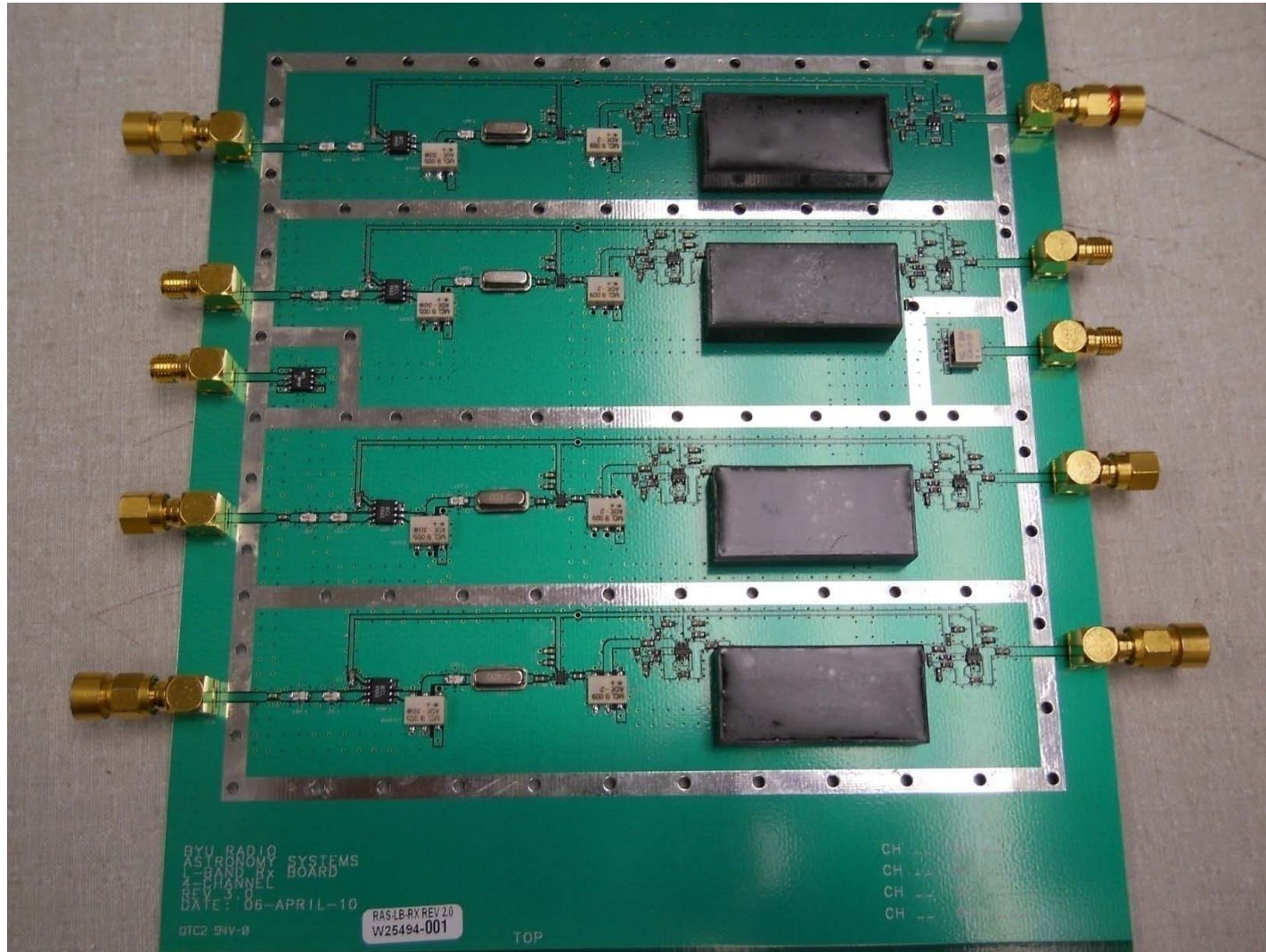
# Measured Single-Channel Noise Performance



# Dual-Polarized Element Design

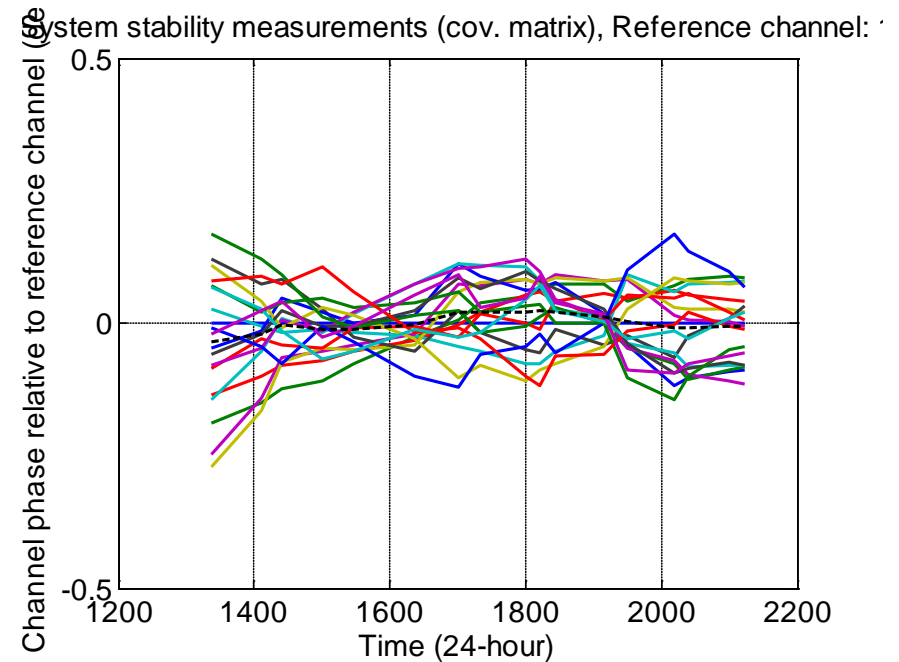
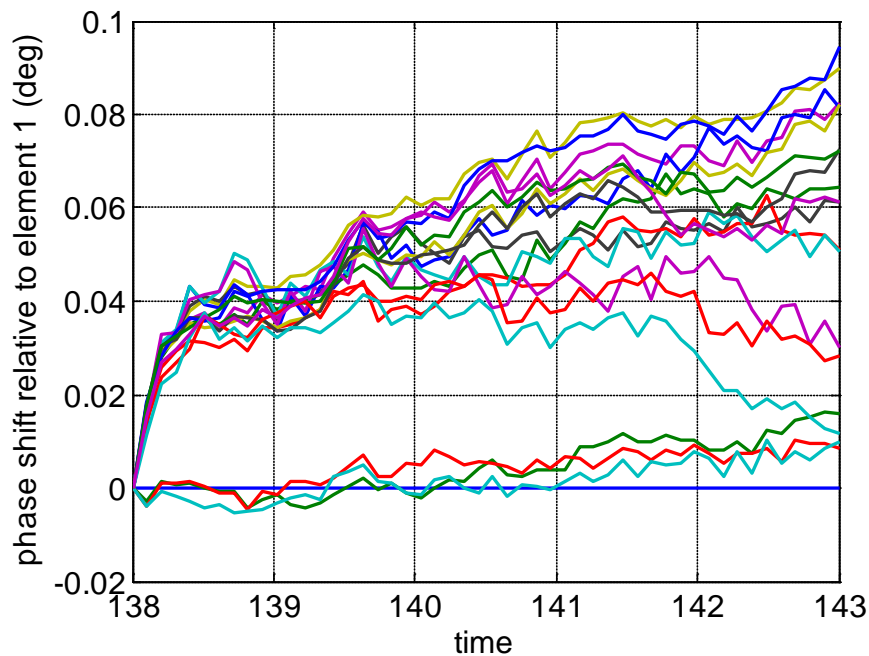


# Four Channel Downconverter Board



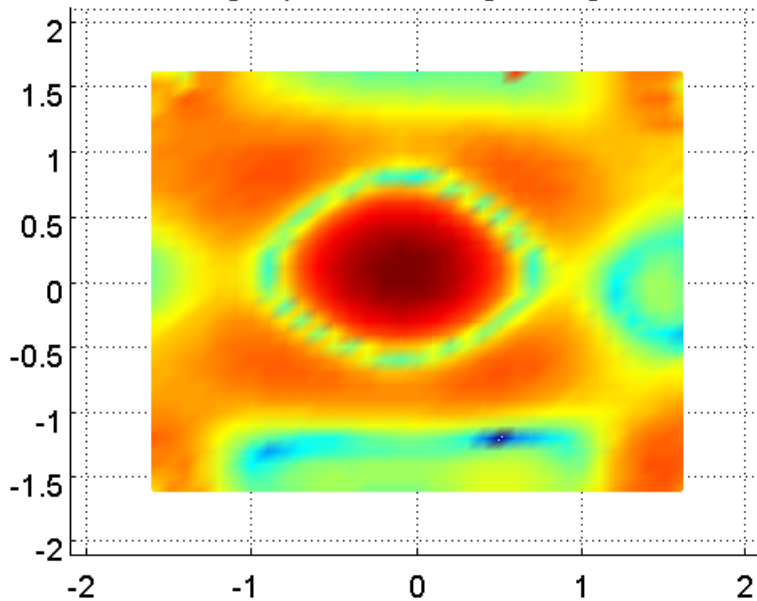
# Gain and Phase Stability

- BYU/NRAO goal: beam response stable to one part in  $5e-4$  (one hour integration at 1 kHz bandwidth)
- PAF model simulations: this corresponds to 0.3 degrees relative drift

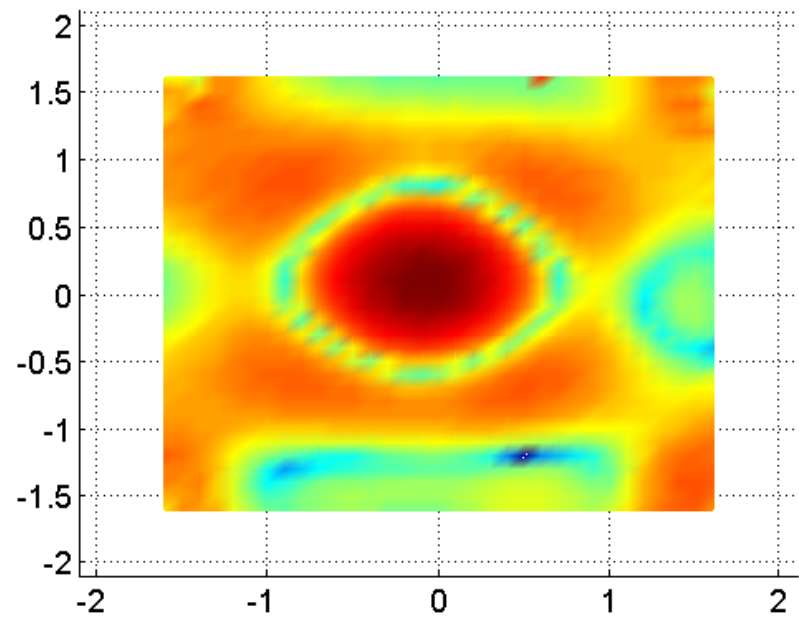


- Beam pattern with fresh and stale (2 days) calibrations

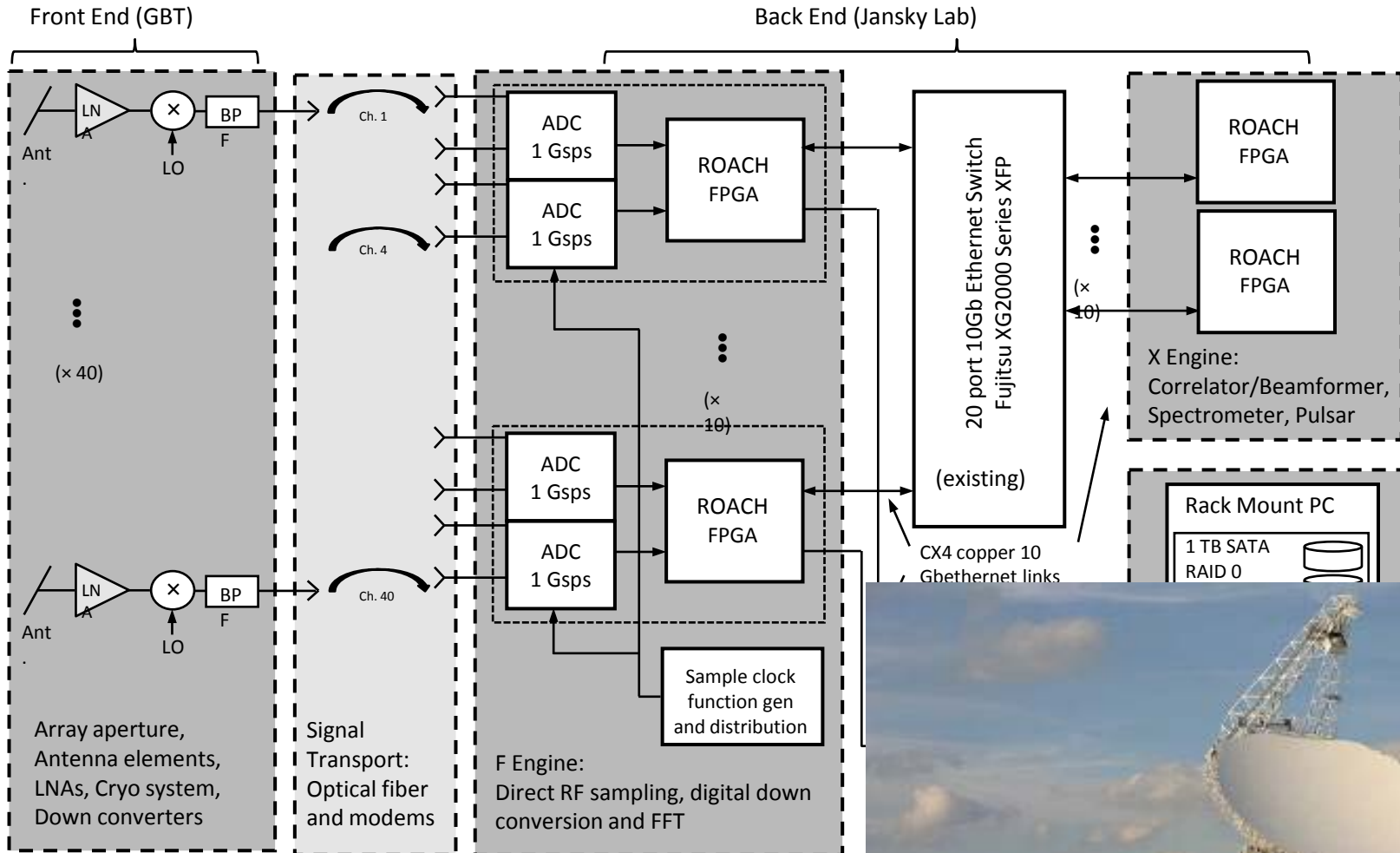
Aug. 6 pattern with Aug. 4 weights



Aug. 6 pattern with Aug. 4 weights

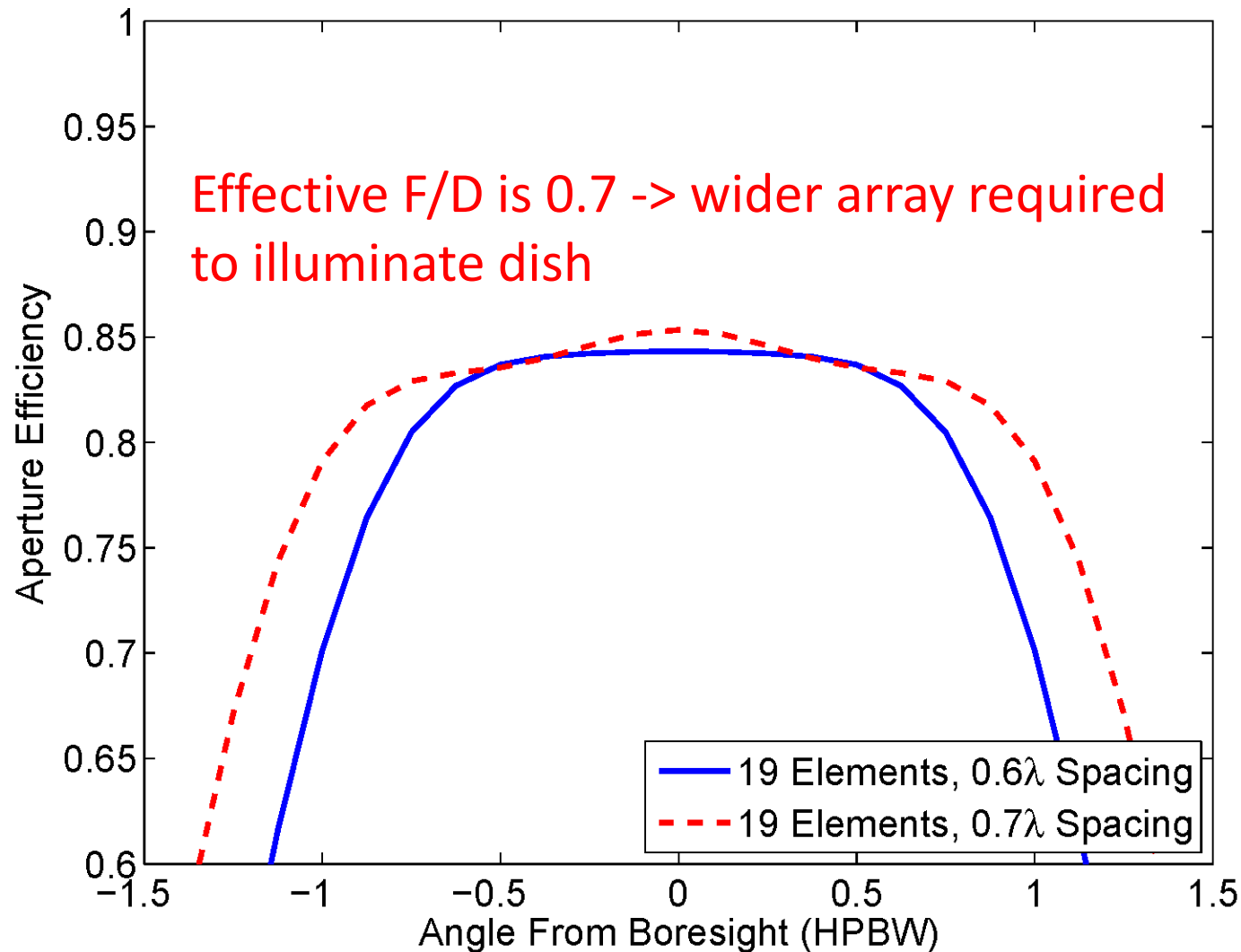


# Focal L-band Array for GBT (FLAG)

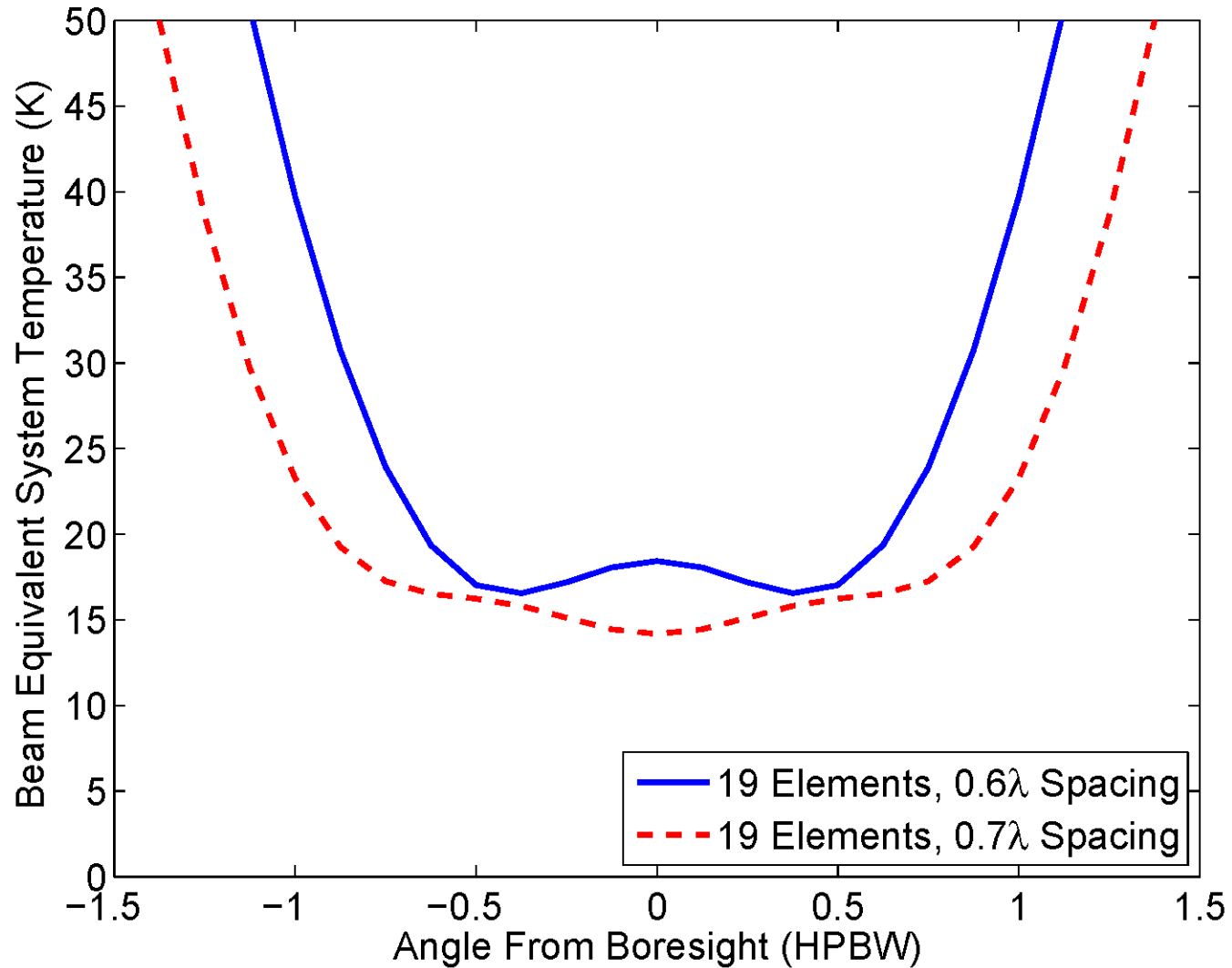


## Modeled GBT PAF Performance

Goal: One HPBW steering radius, 7 pulsar search beams







- PAF element design
- Cryostat, LNAs
- Signal transport (new fibers installed)
- Multichannel receivers
- Signal processing backend
  - Calibration and beamforming algorithms
  - Pulsar search engine
- Control software and data storage