A Wideband Receiver for FAST

Stephen Smith
Caltech

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Jin Chengin, Liu Hongfei, Cao Yang from BAO

Receiver for the FAST Telescope

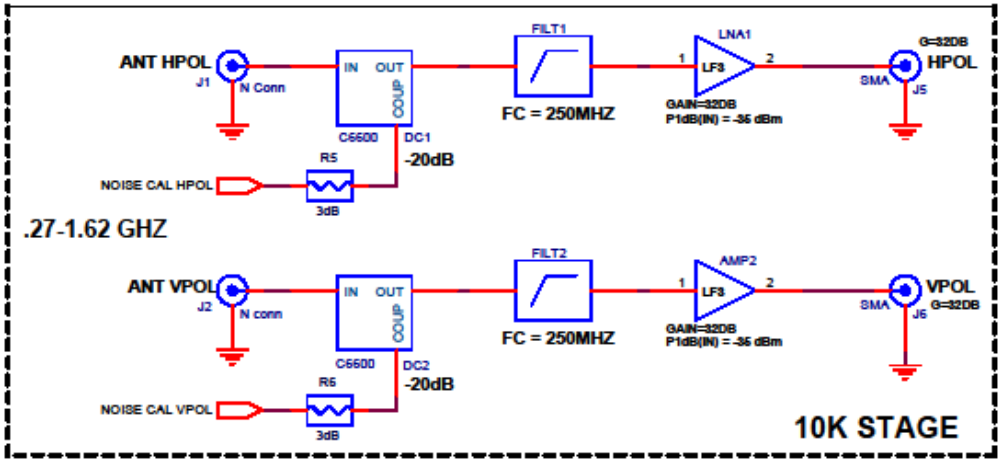
- Frequency range .27 to 1.62 GHZ
- Dual-linear polarization QRFH feed-uncooled
- Front end Receiver Cooled to 11K
  - Integrated Noise Sources for Stable Calibration
  - High pass filter for RFI mitigation
- Warm Back end electronics
  - 2 Bands-Full Band .27 to 1.62 GHZ-Reduced Band 1.3-1.62 GHZ (Requirement has chaged-Youling Yue)
  - Linear/Circular Polarization Selected by Switched Hybrid
  - 2 GHZ Fiber Optic Transmitters
  - RF Power Monitors
  - 5 bit Attenuators-1 dB/Step 31 dB total
  - Spectrum Analyzer-Rigol DSA1030
  - Warm Electronics Temperature Controller
  - Software control over Ethernet

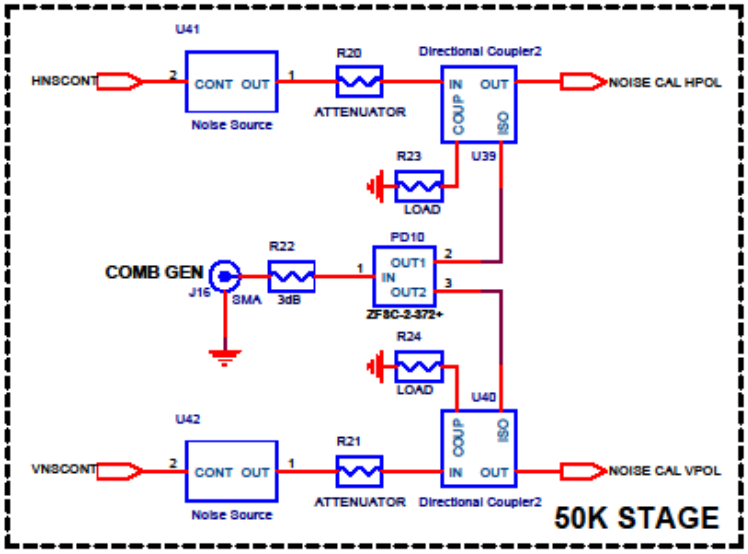
Receiver Design Goals

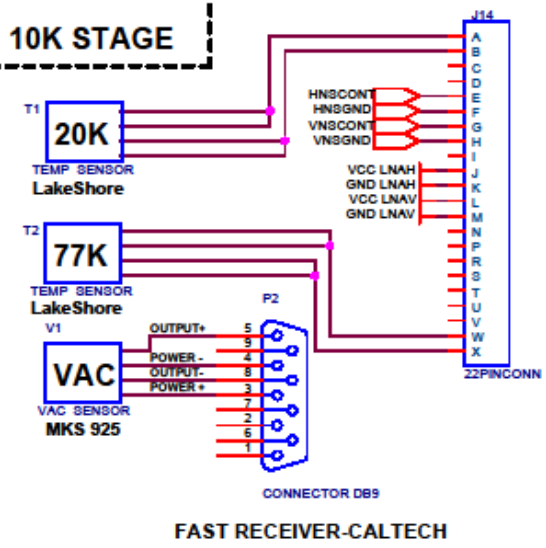
Frequency Band .27 to 1.62 GHz

- Feed Aperture Efficiency-Greater than 60% for F/D 0.46
- Feed Spillover Noise-Less than 10K
- System Noise Temperature < 35 Kelvin
  (including 9K Spillover and 6K sky noise)
- System Gain 65 dB Typ
- P 1dB Gain Compression >-35 dBm
- Noise Calibration Signal = 20 +/- 5 K
- System Mass < 100 Kg
- Feed Size = 1.45 m Square X 1.2 m long

Cryogenics Dewar

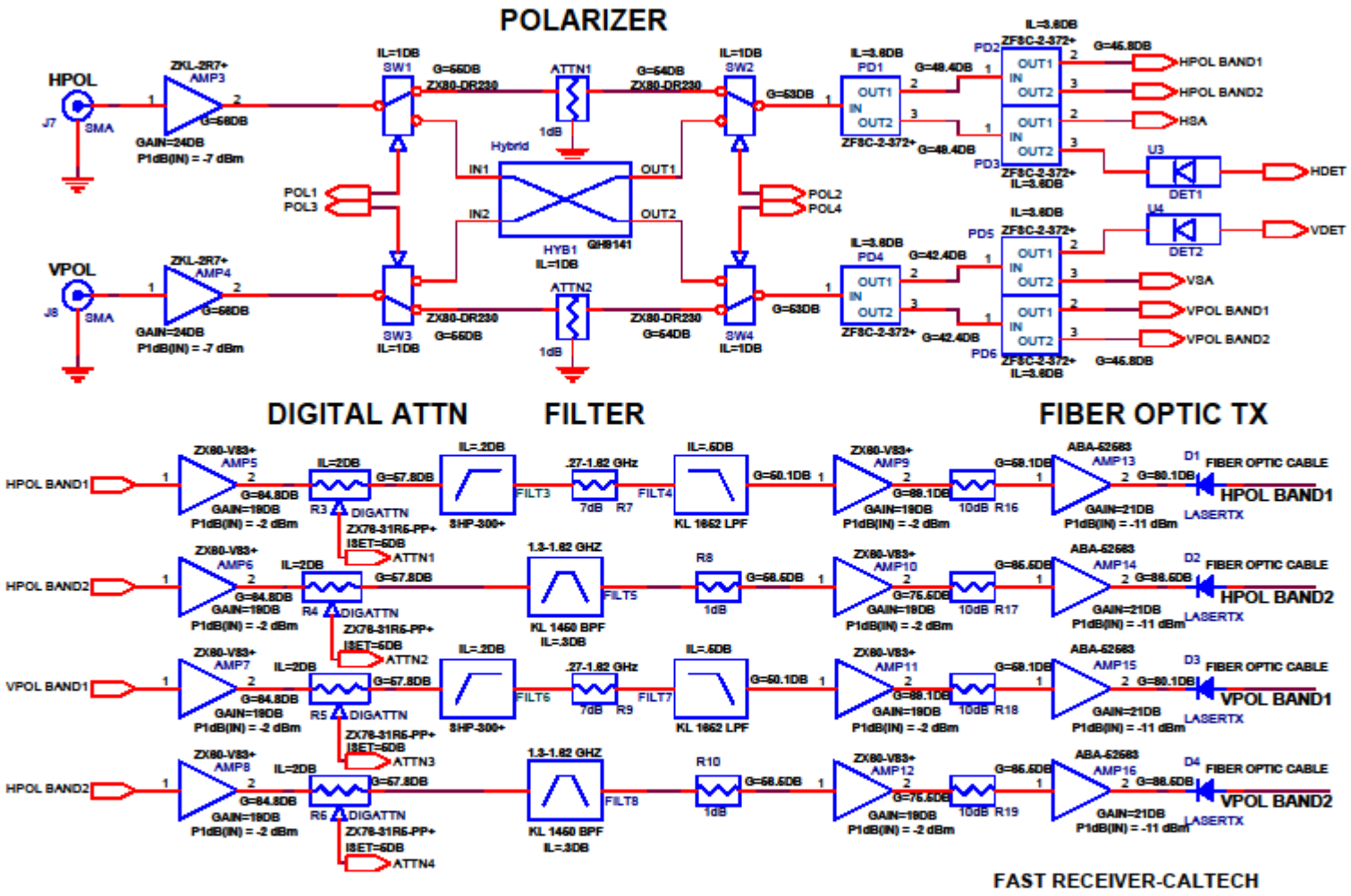




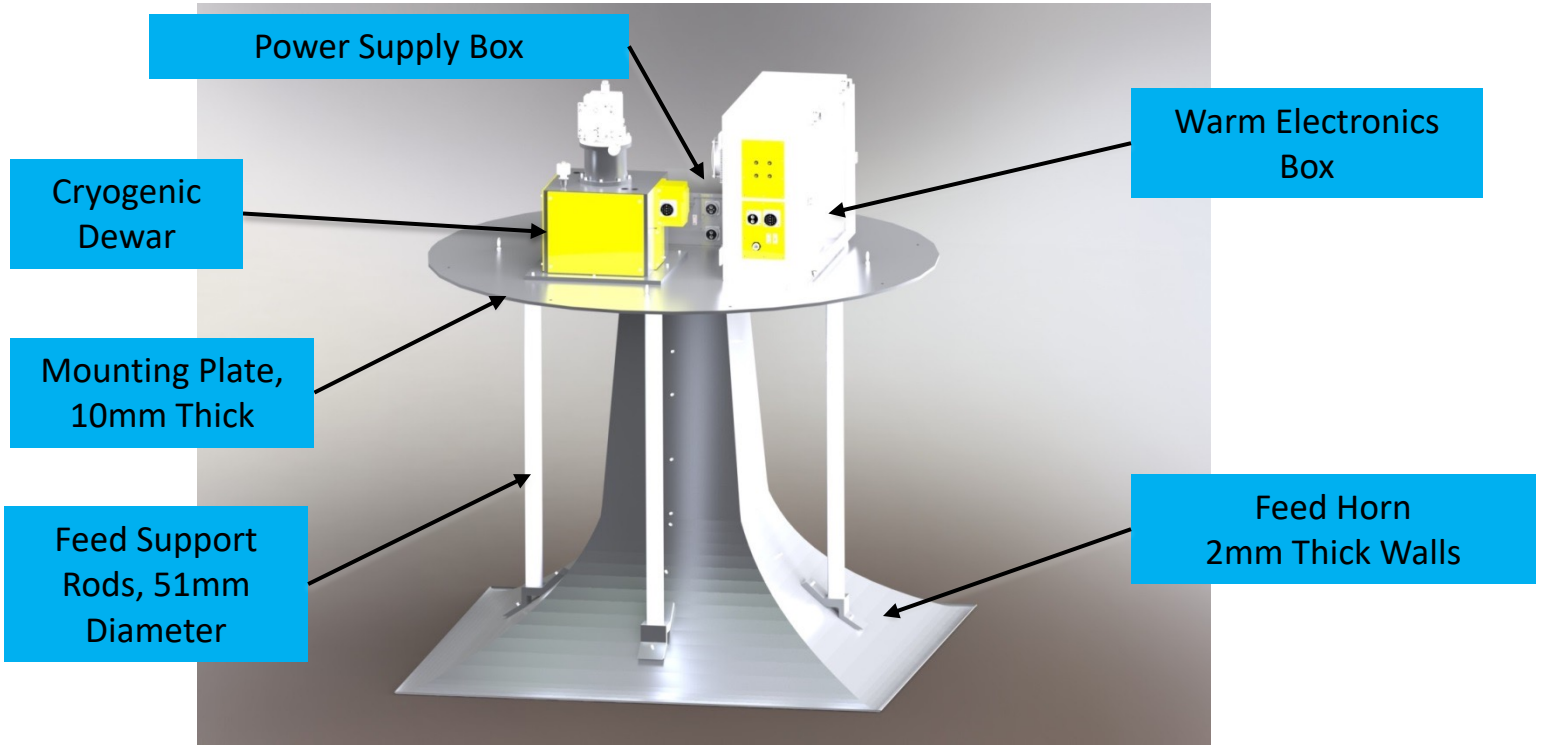


FAST RECEIVER-CALTECH

Warm Electronics



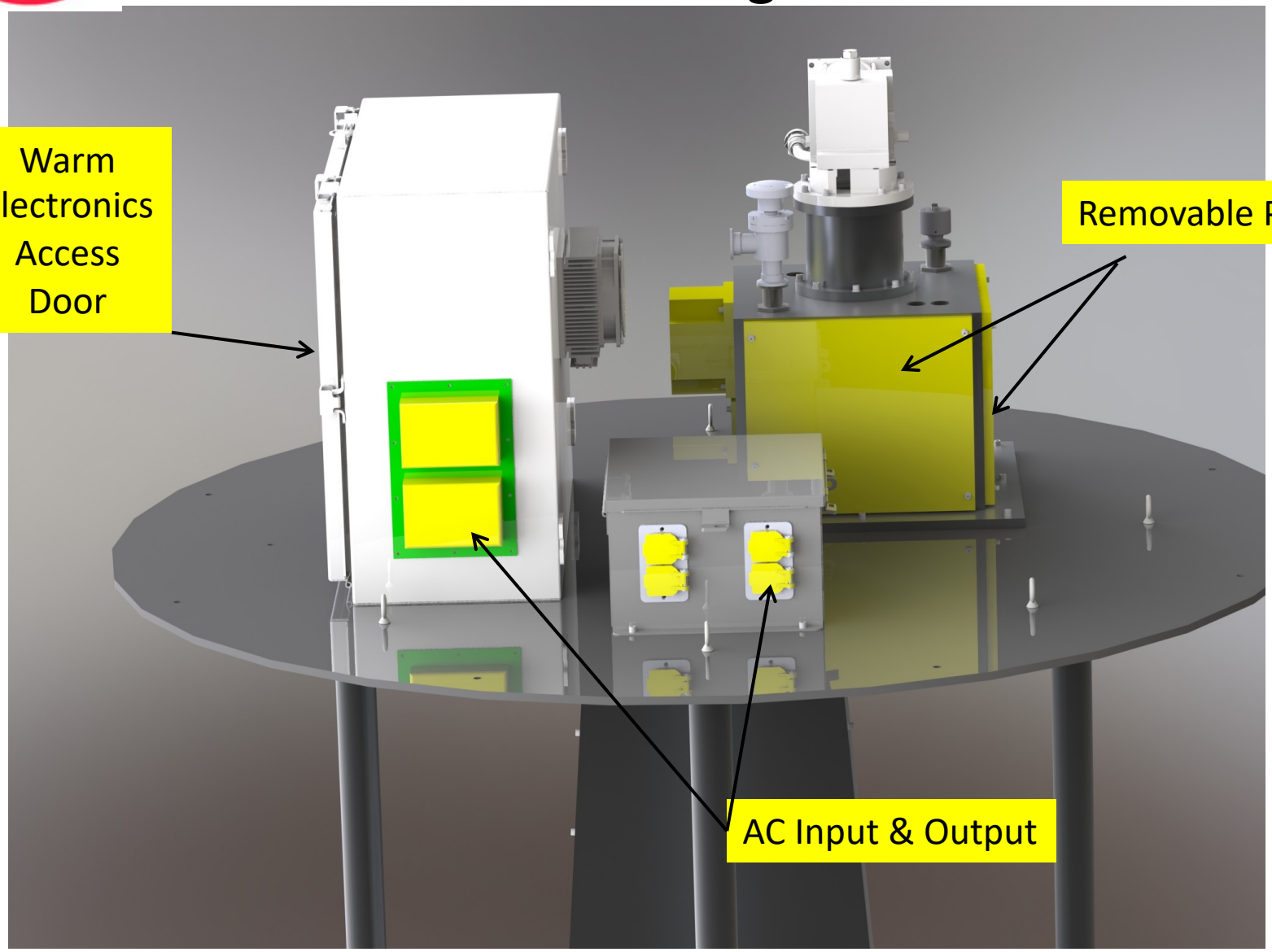
Overall View of the FAST Receiver

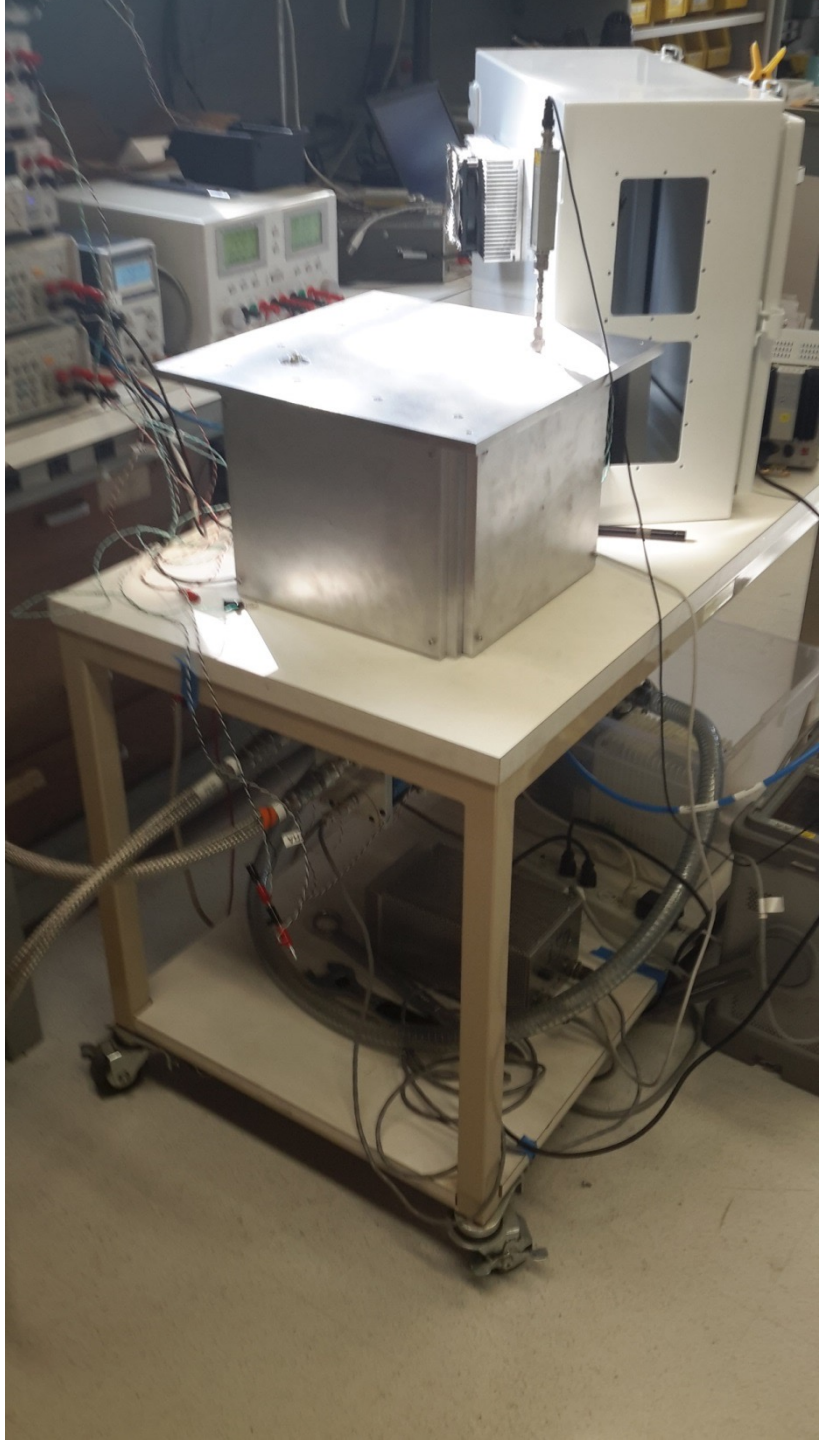


- Round mounting plate has diameter of 1.5m
- Feed is 1.453m square at the bottom
- Total height is 1.706m
- All boxes are RFI sealed and water sealed
- Weight estimate is 189 kg

Designed by Steve Smith

Another View Showing Access Panels

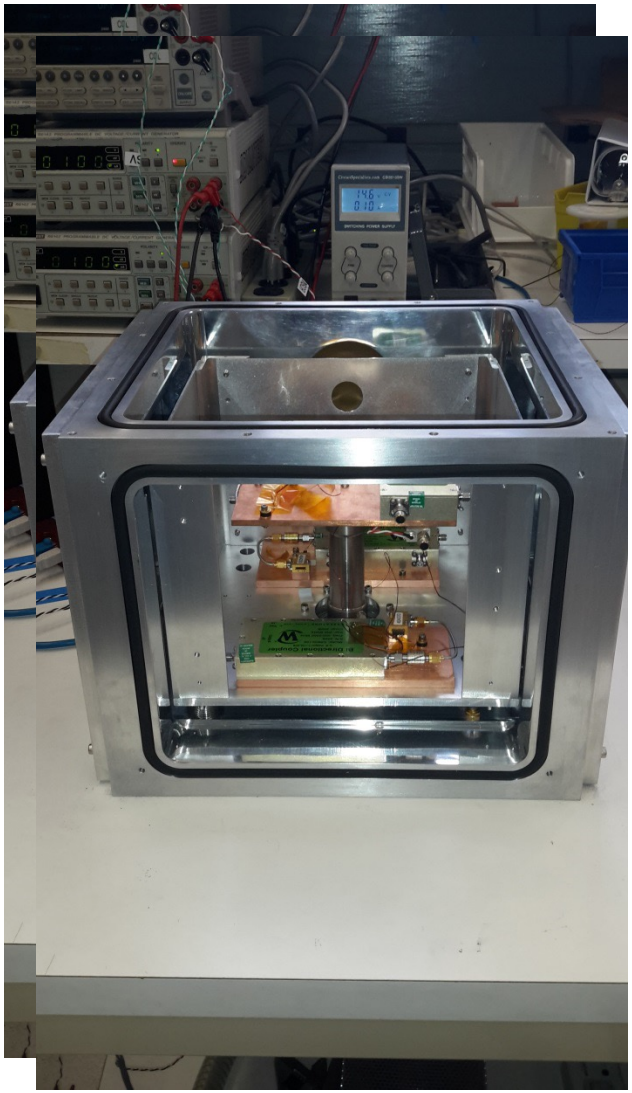




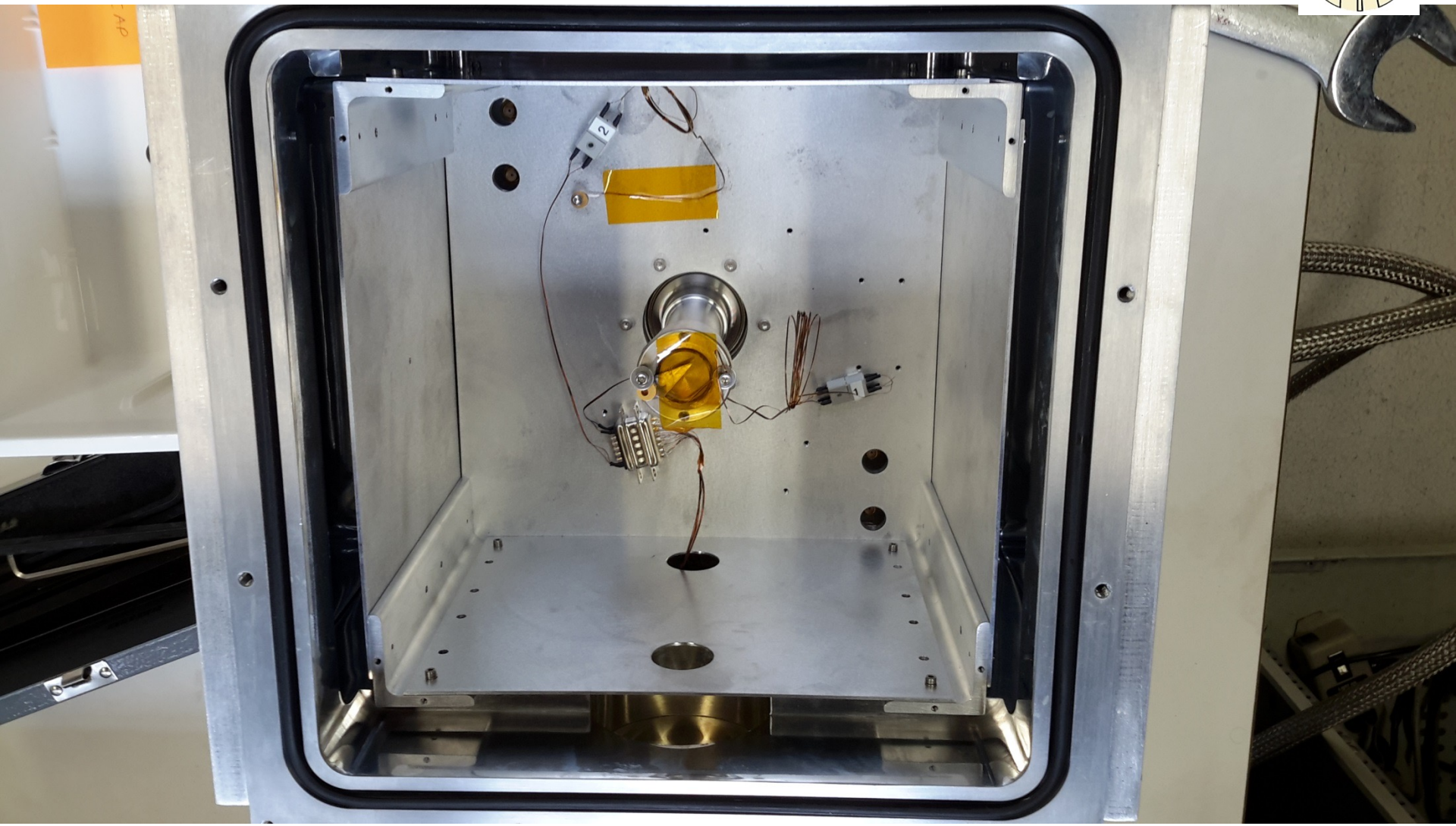

CRYODYNE

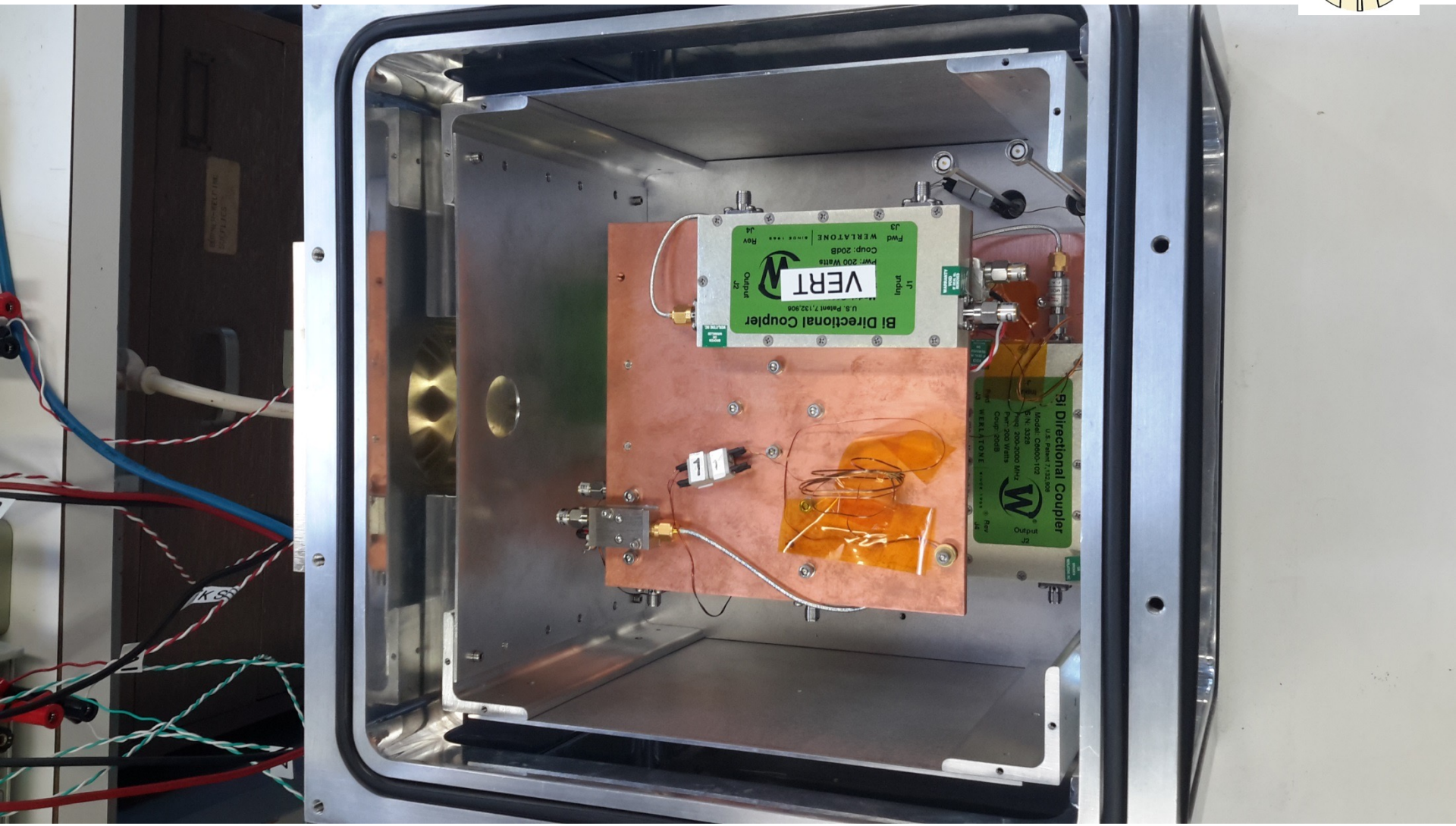
Cryogenic Dewar

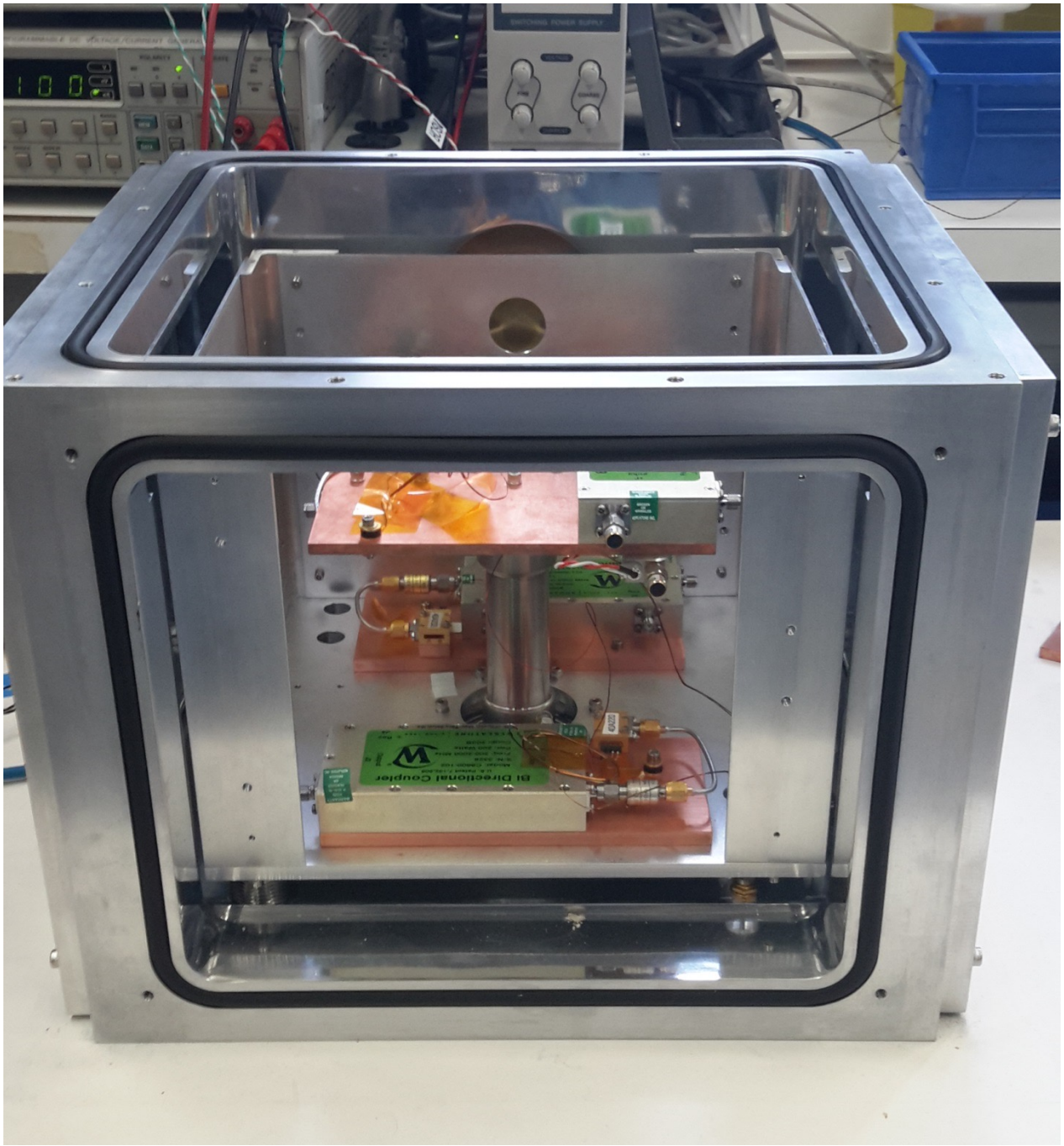
- CTI 350 2 stage Cryogenic Cooler
- 50K 1st Stage, 11K 2nd Stage
- Removable access panels on 3 sides of the Dewar for easy access
- Direction Couplers, High Pass Filters, LNAs on 2nd Stage
- Noise Sources, Directional Couplers on 1st Stage
- N Connector Input (2) from Feed
- SMA Connector Outputs (2) to Warm Electronics
- SMA Comb Generator Calibration Input (1)

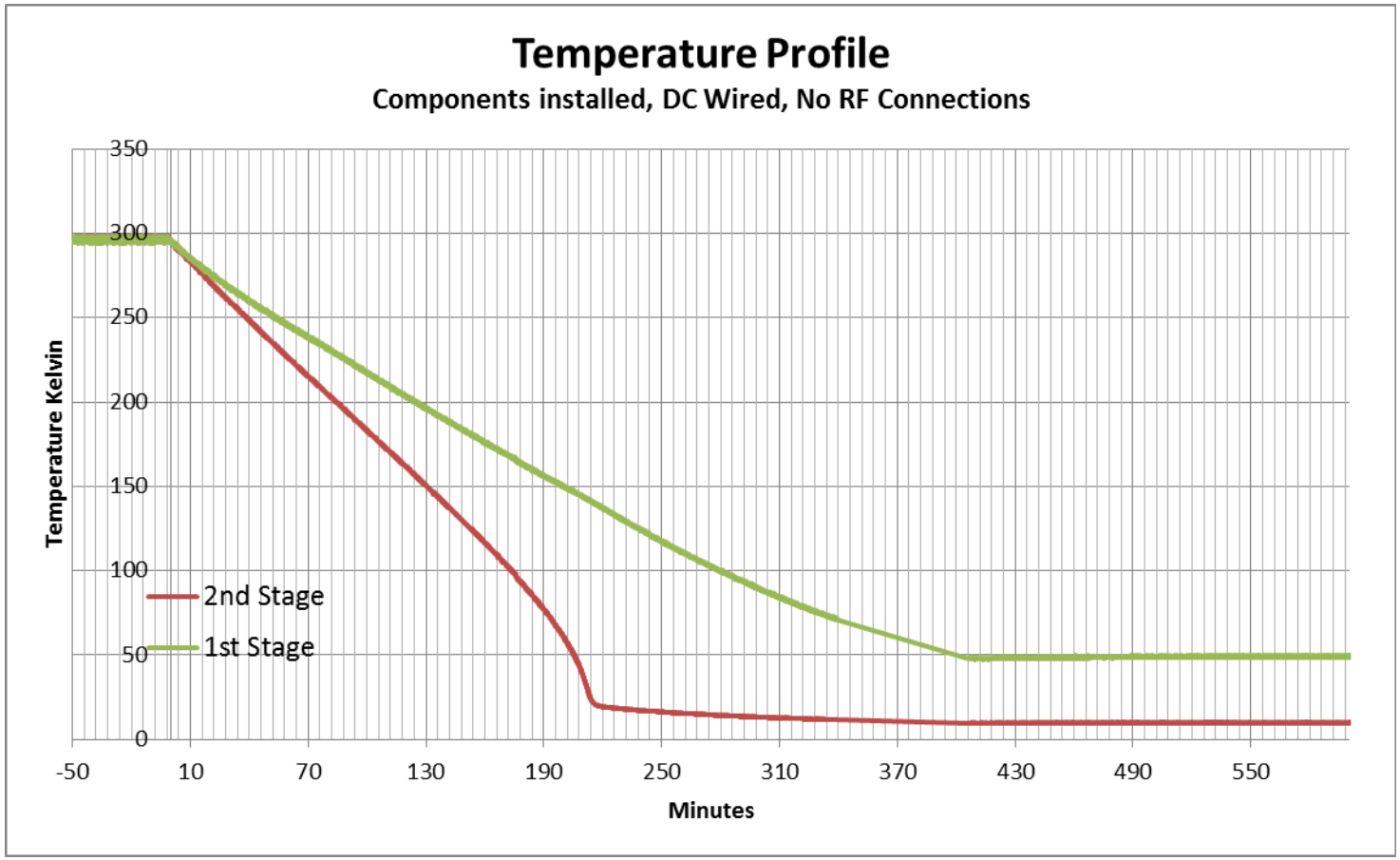


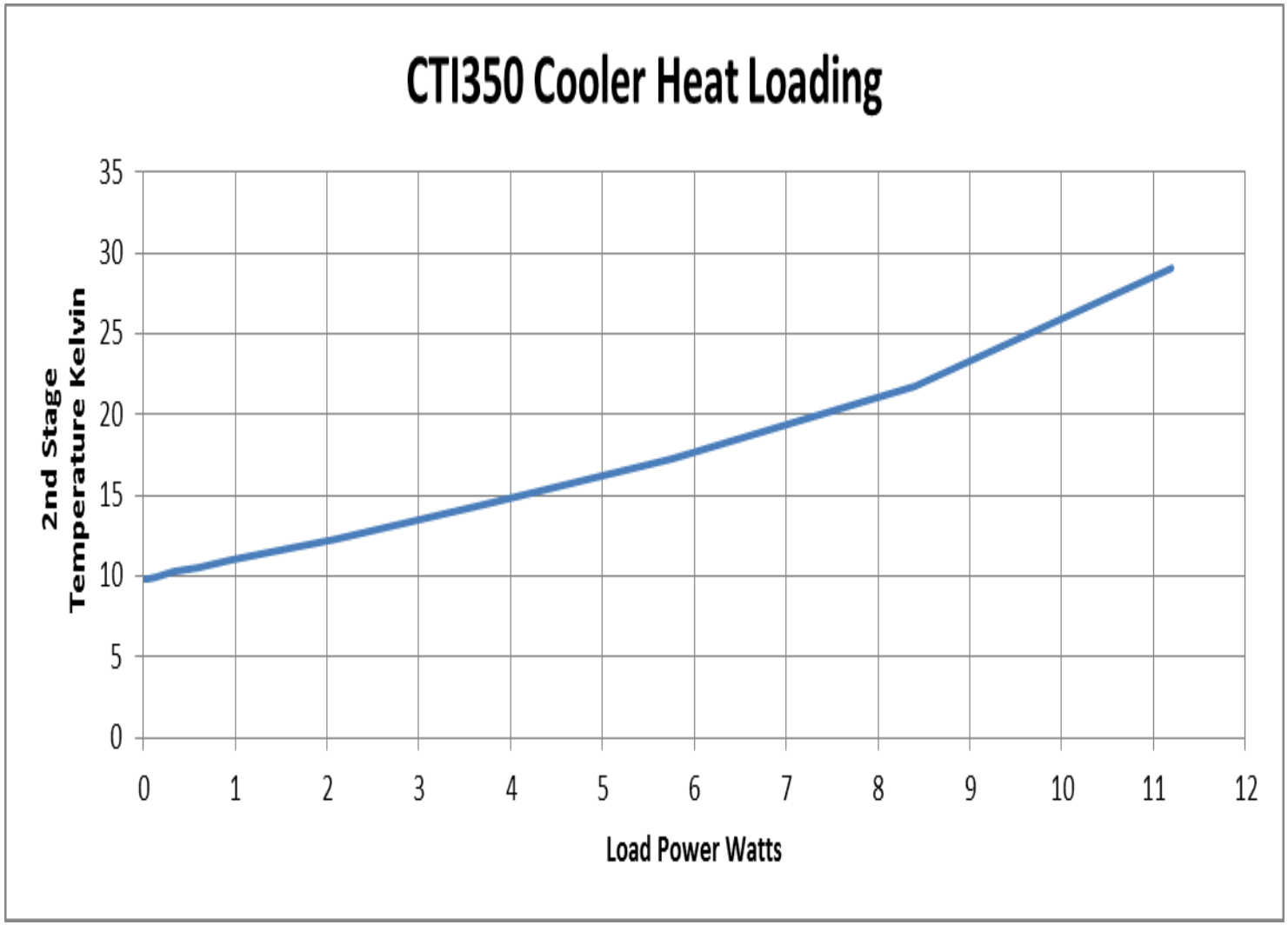
Designed by Steve Smith



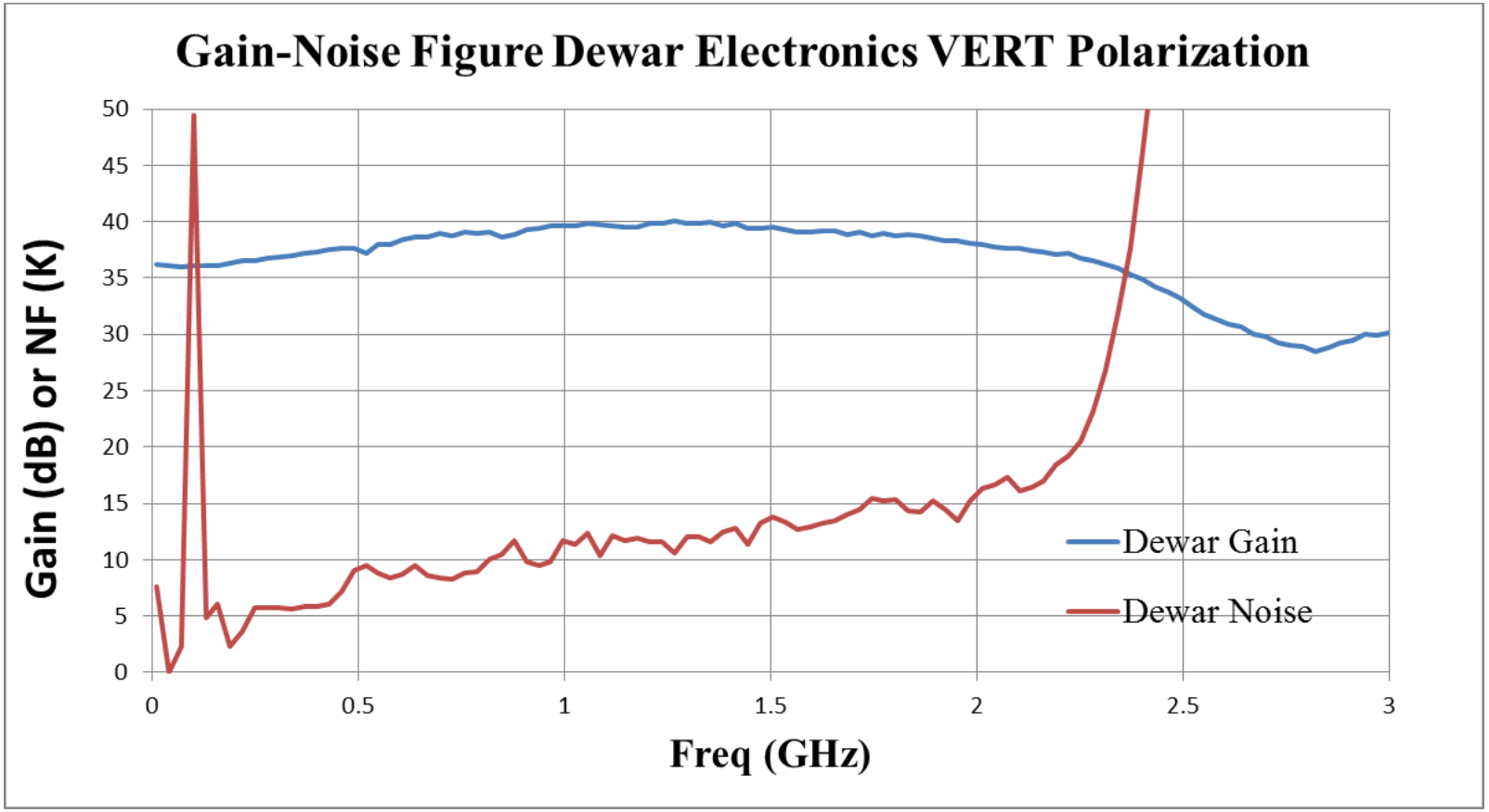

BI Directional Coupler
VERT
WERLATONE


Bi Directional Coupler


Temperature Profile
Components installed, DC Wired, No RF Connections
Temperature Kelvin
350
300
250
200
150
100
50
0
-50
10
70
130
190
250
310
370
430
490
550
Minutes
2nd Stage
1st Stage

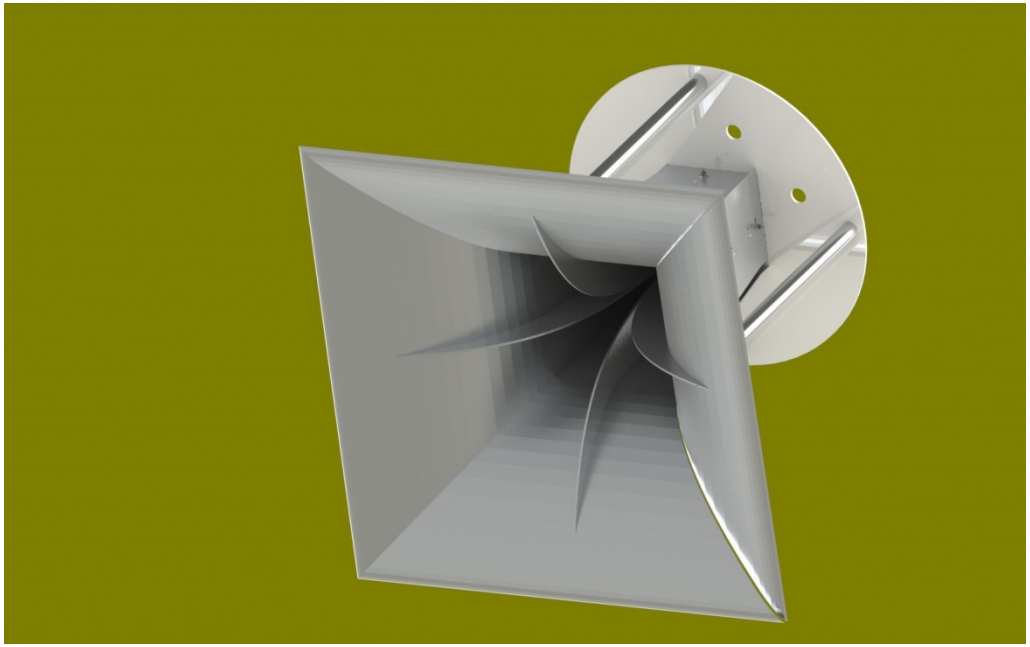

CTI350 Cooler Heat Loading
2nd Stage Temperature Kelvin
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Load Power Watts

Measured Dewar Performance



Antenna Feed

QRFH-Quad Ridge Flared Horn

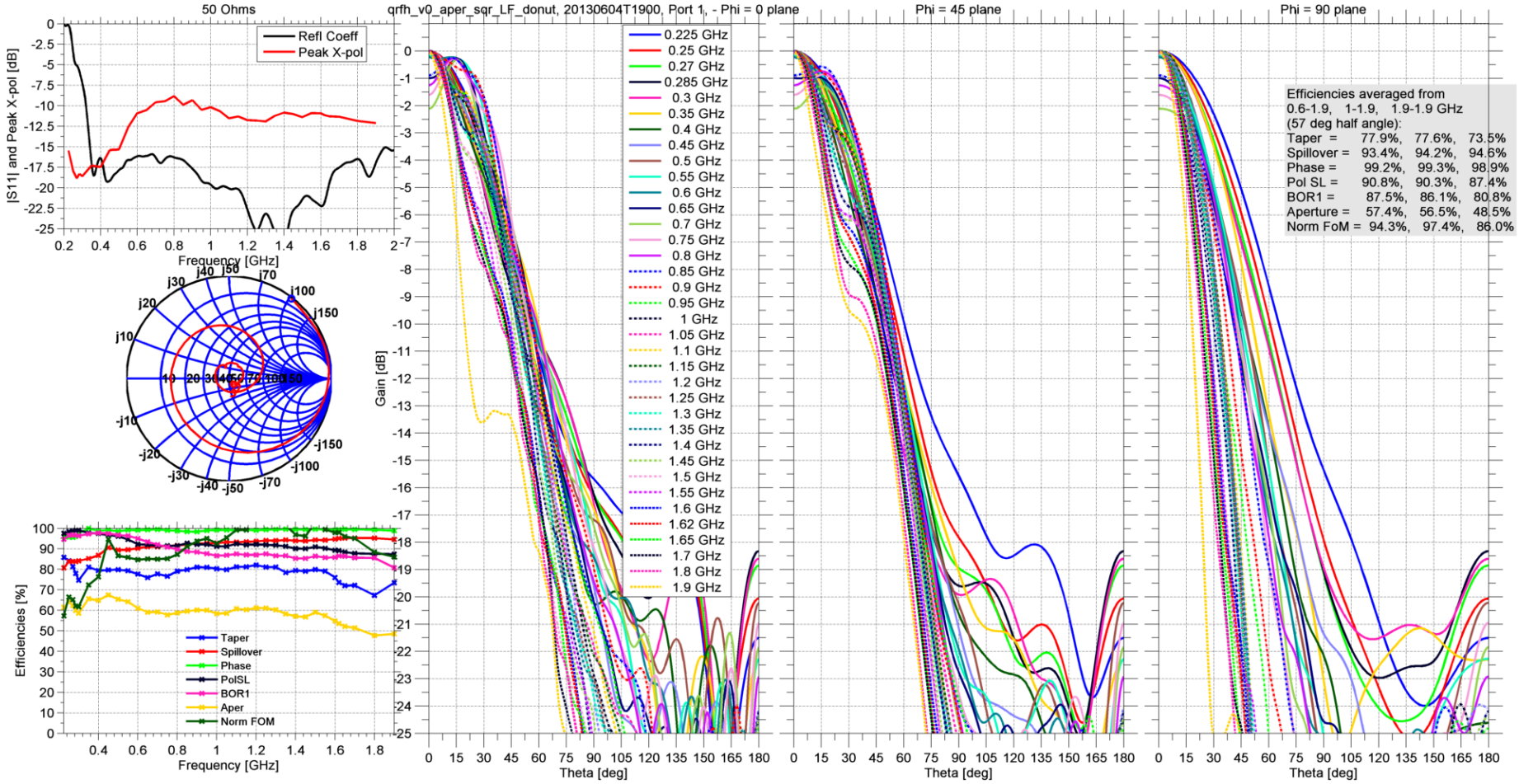


- Quad Ridge Flared Horn
- Constant Phase Center
- 3:1 Bandwidth
- 1.45m X 1.45m X 1.2m

Designed by Ahmed Akgiray, Caltech PHD Graduate
Fabrication Designed by Cao Yang, BAO

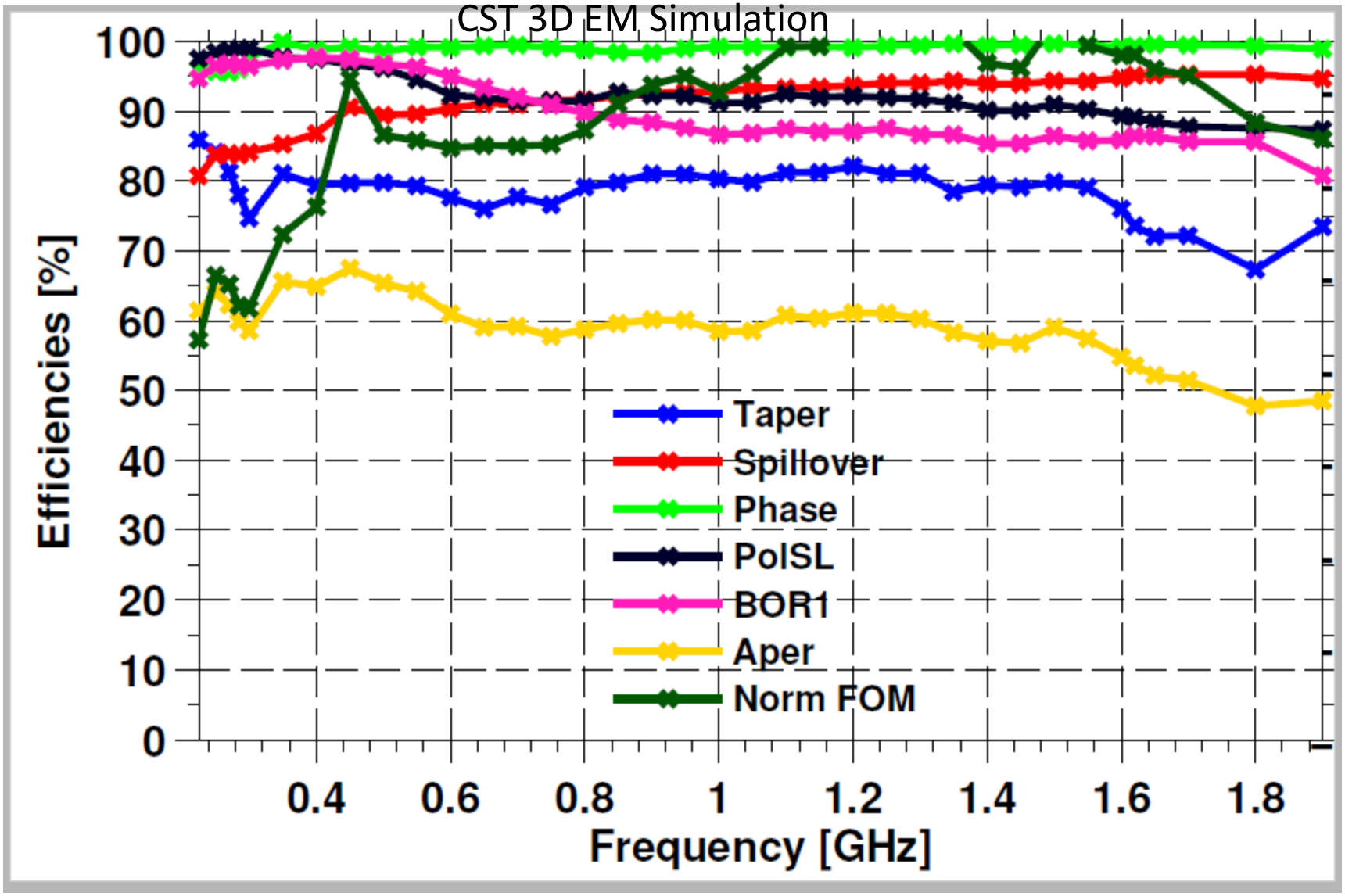
Antenna Feed

CST 3D EM Simulation



Antenna Feed

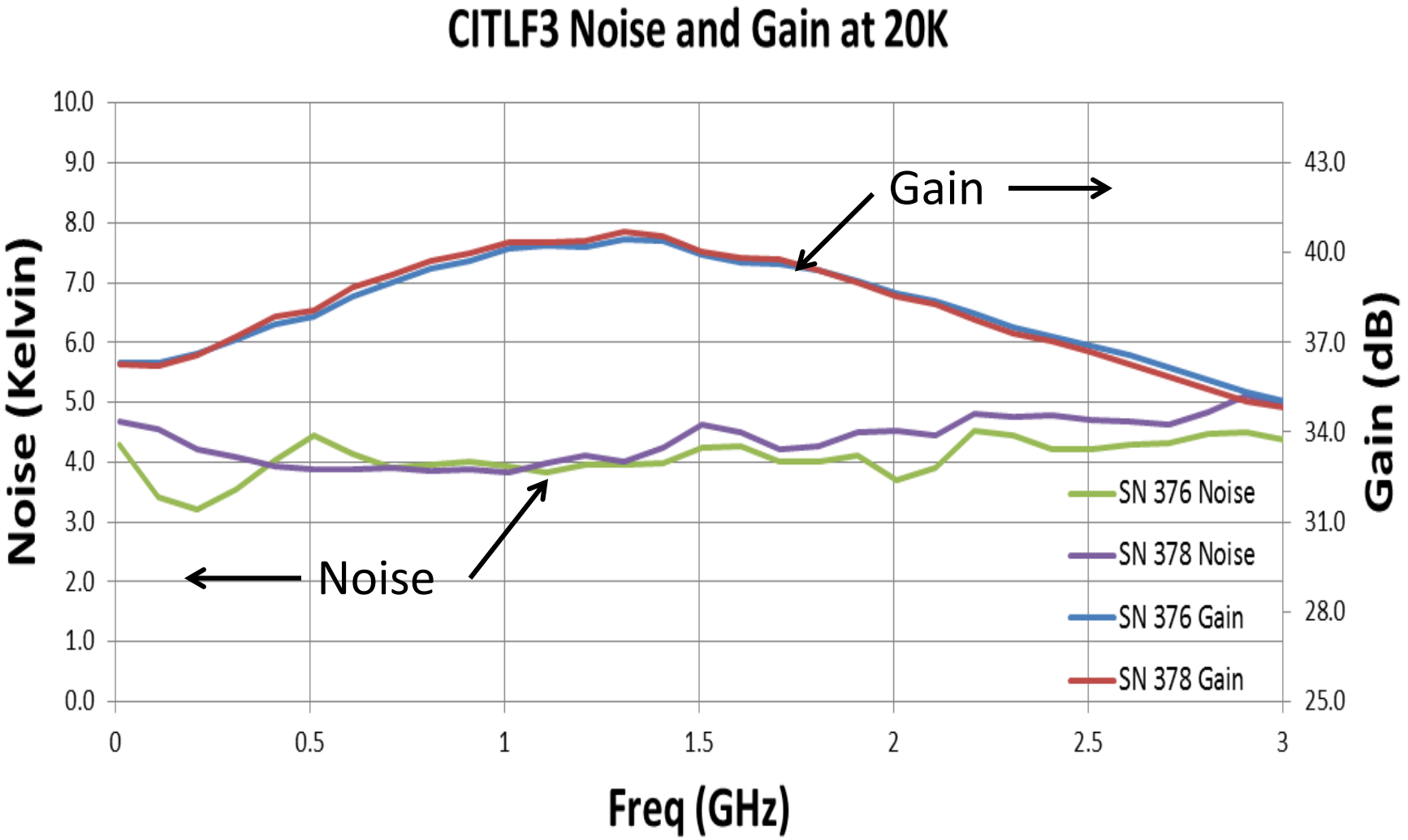
CST 3D EM Simulation



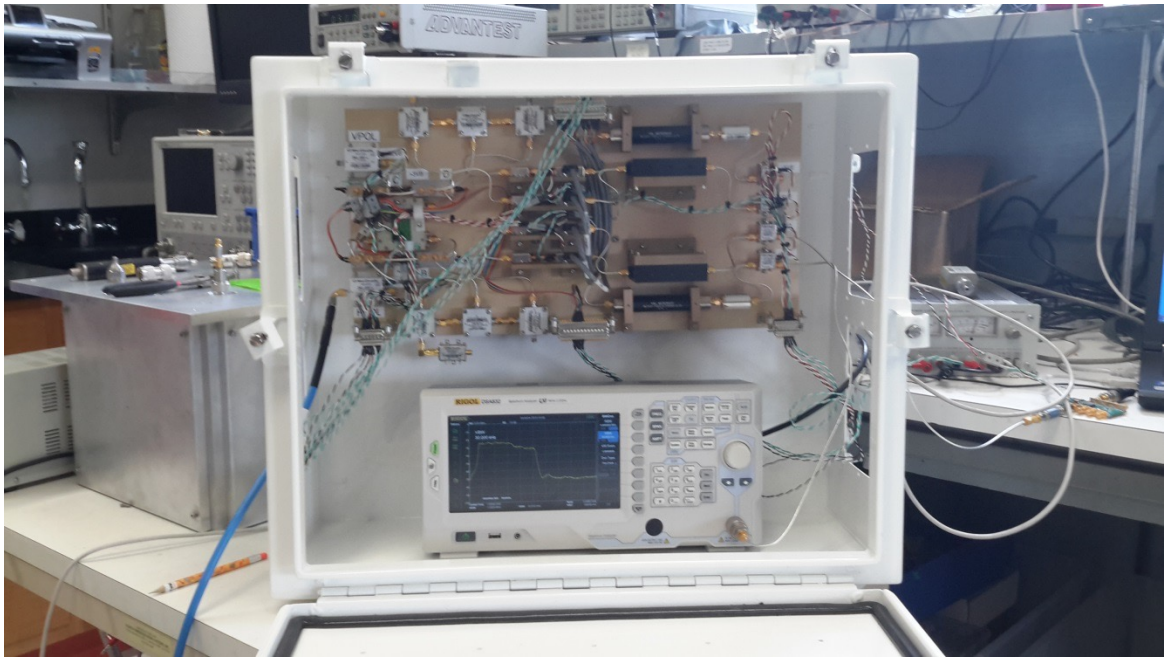
LF3 Cryogenic Low Noise Amp

Designed by Sandy Weinreb

Measured Cryogenic Performance of the LNA's

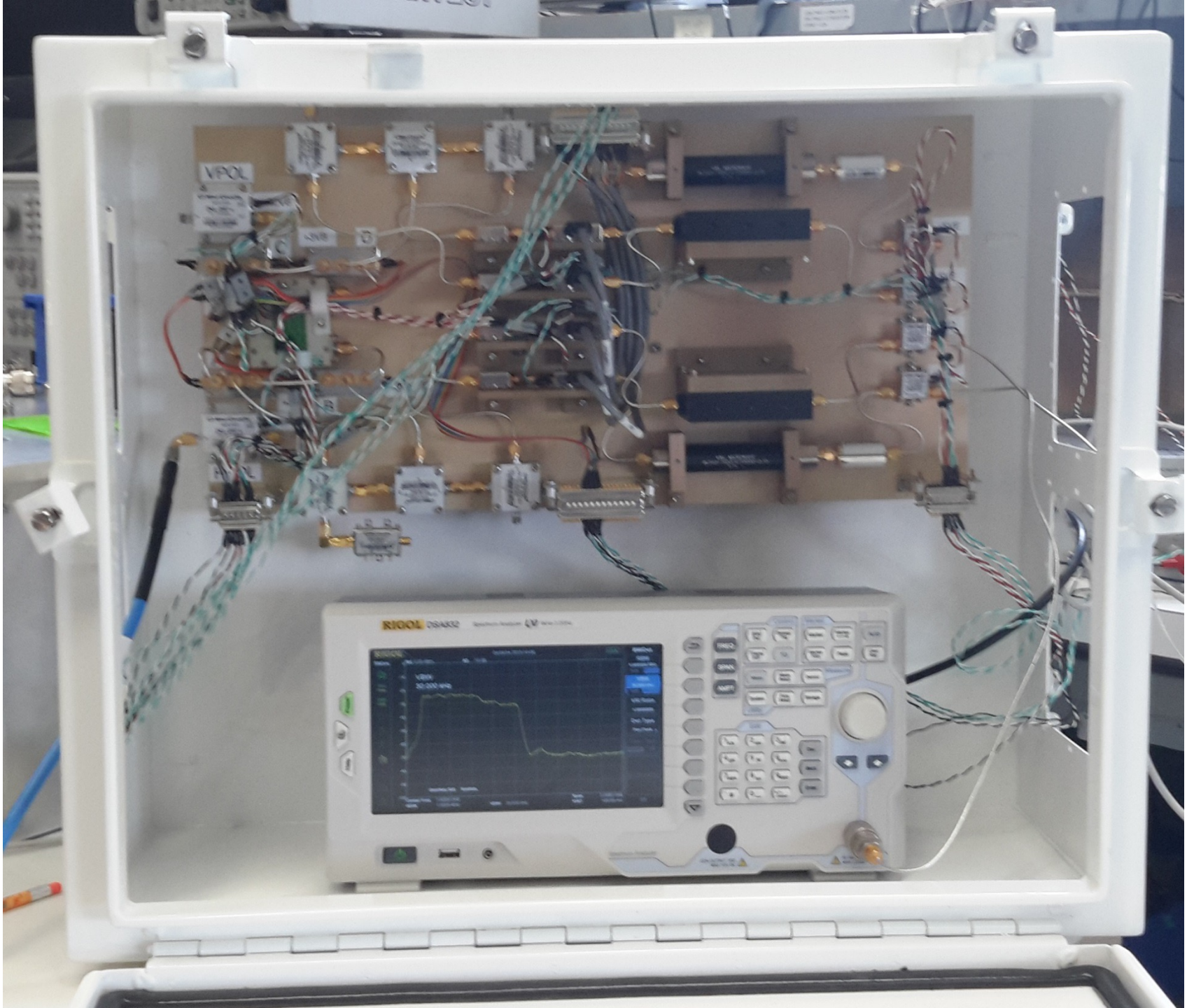


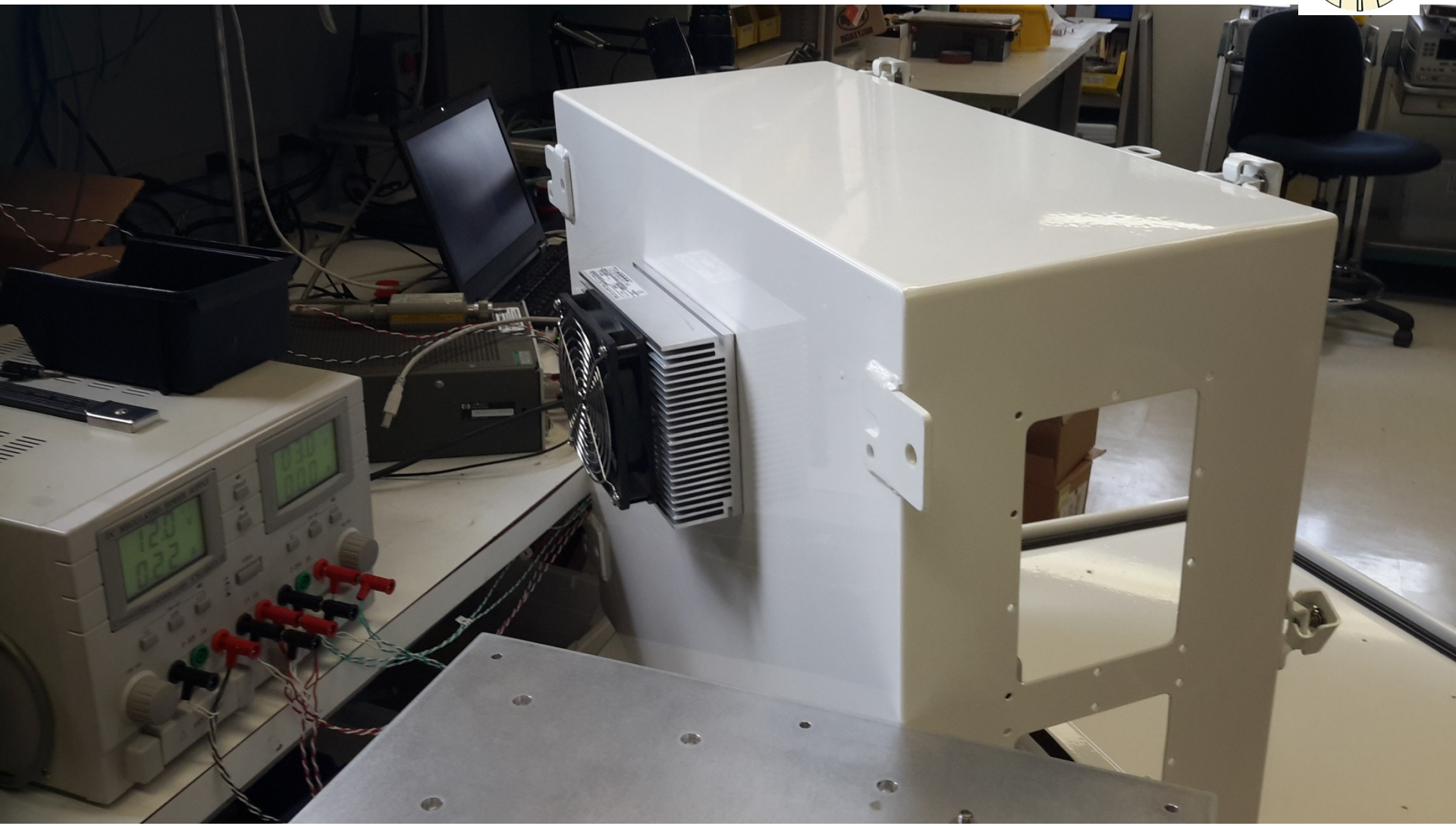
Warm Electronics



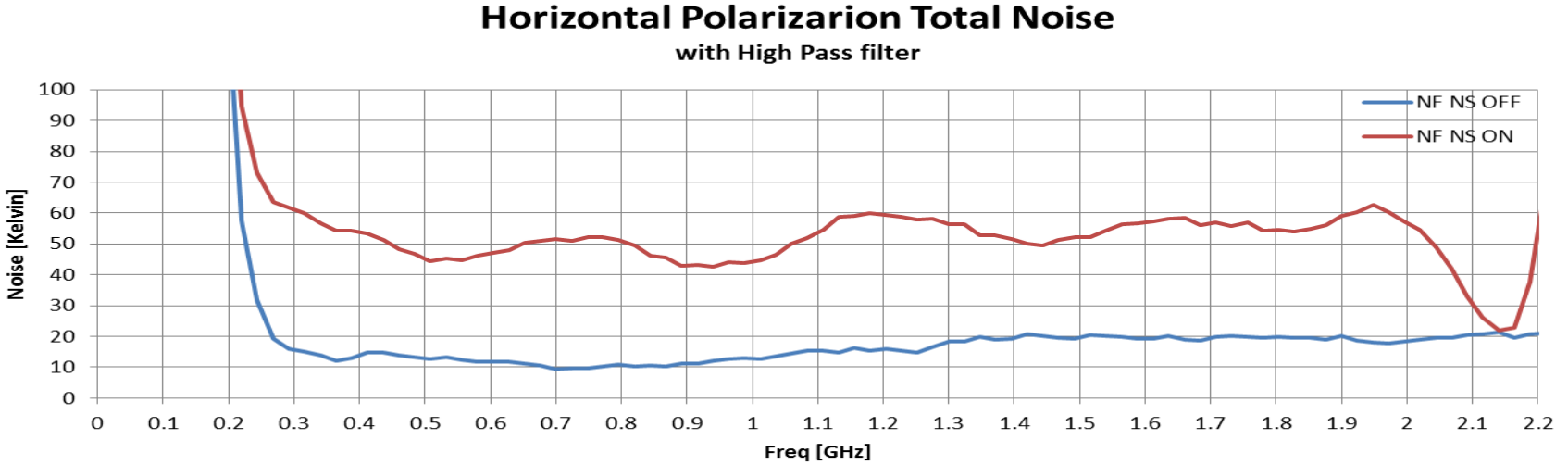
- Replaceable, Off-the shelf Components
- Components are field replaceable without a Soldering Iron
- TEC Thermal Electric Cooler keeps component temperature @ 40C
- 2 GHz Laser Pair (Designed by Sandy) for IF Output
- Rigol Spectrum Analyzer for RFI monitoring (SA has Ethernet interface)
- Voltage, Current Monitors
- Control of Receiver thru Ethernet

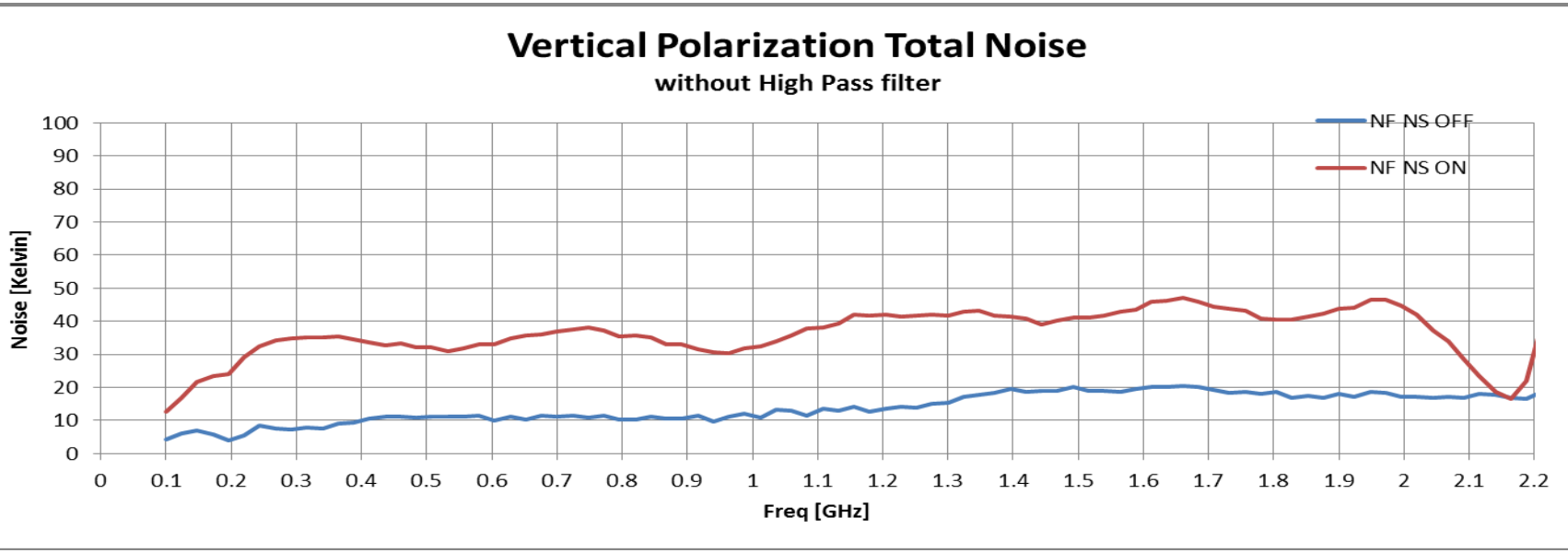
Designed by Steve Smith, Sandy Weinreb


VPOL
RIGOL DSA832



Measured Dewar Performance





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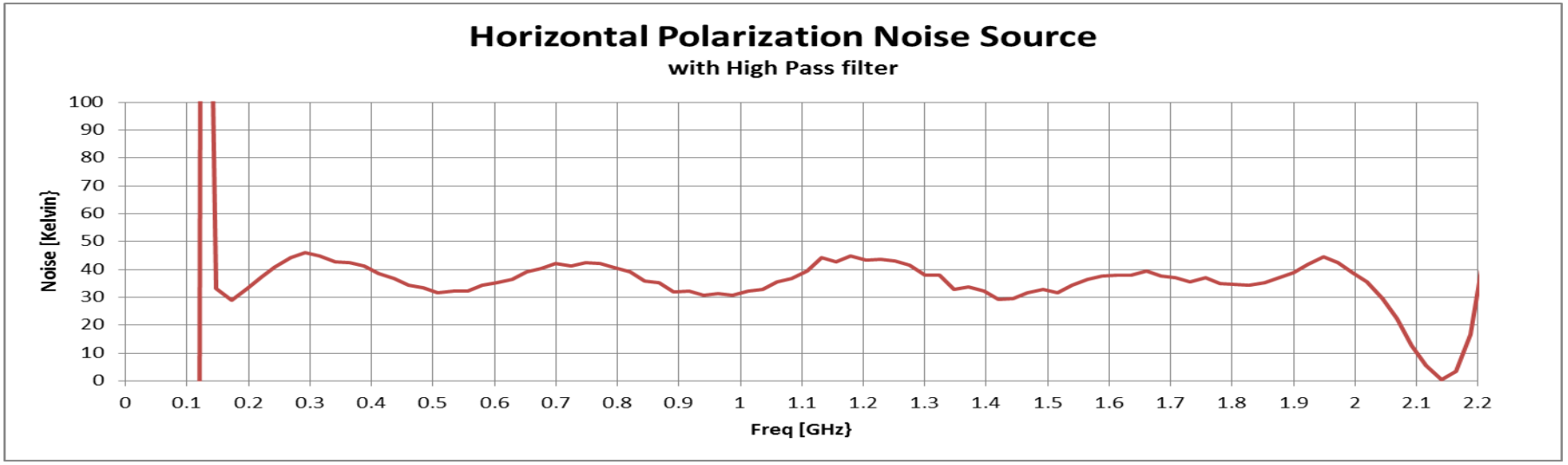
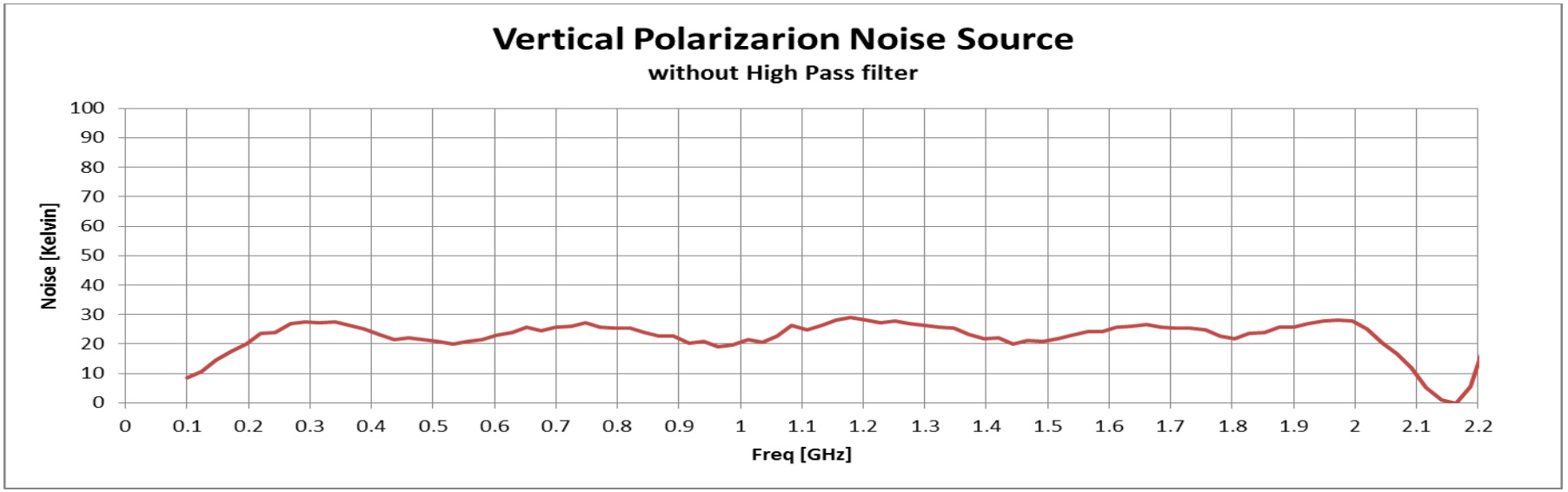
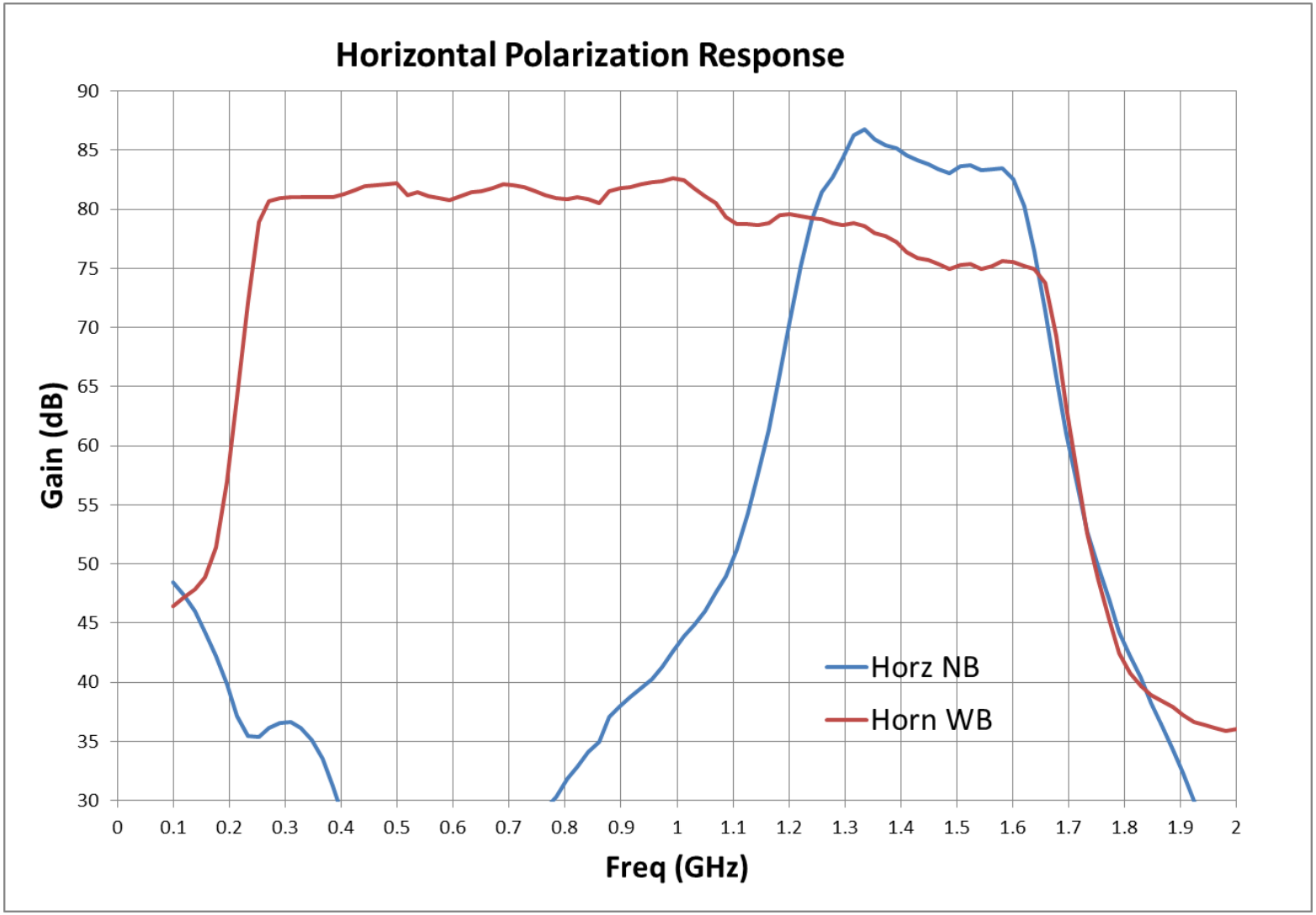




Measured System Performance



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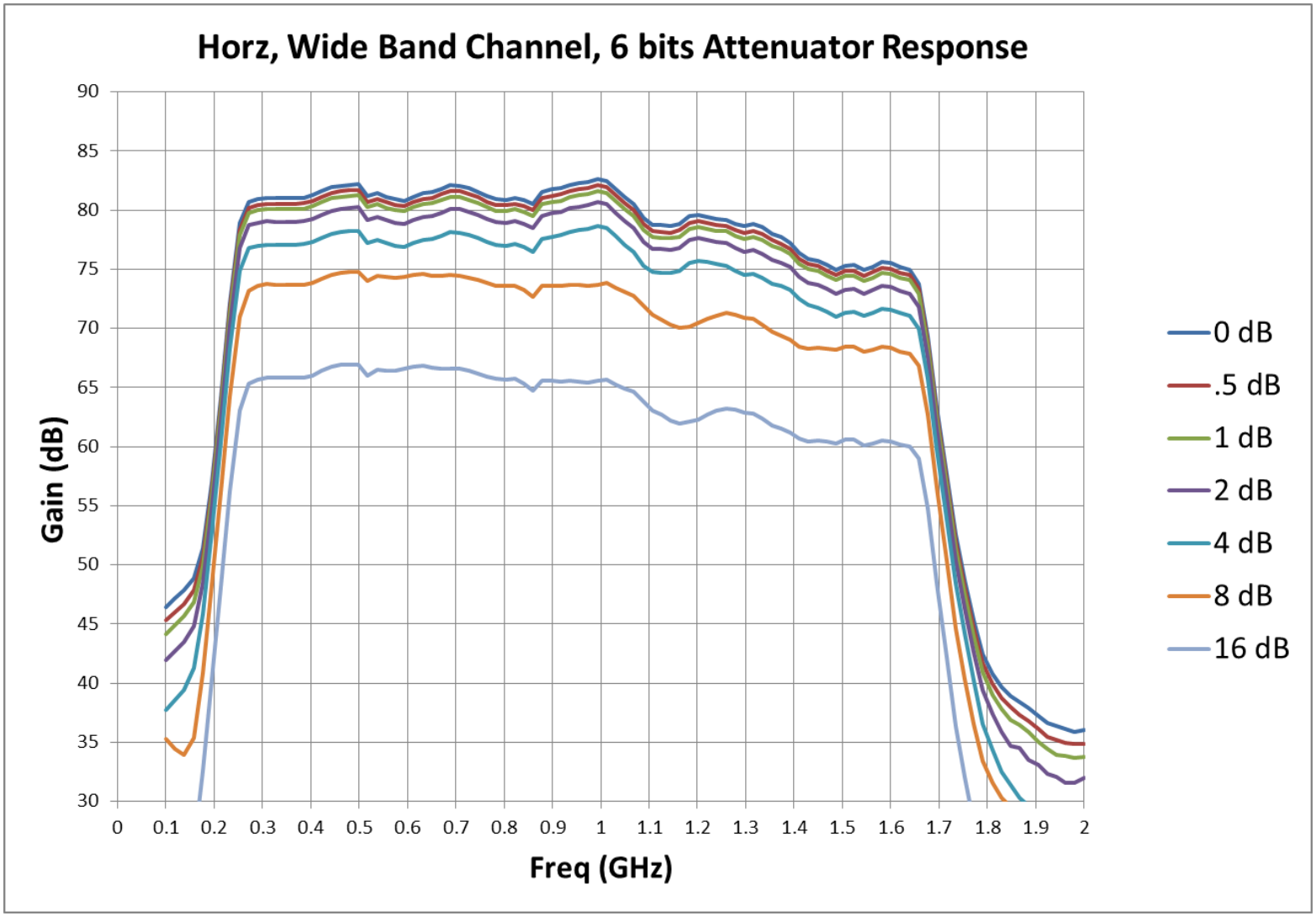

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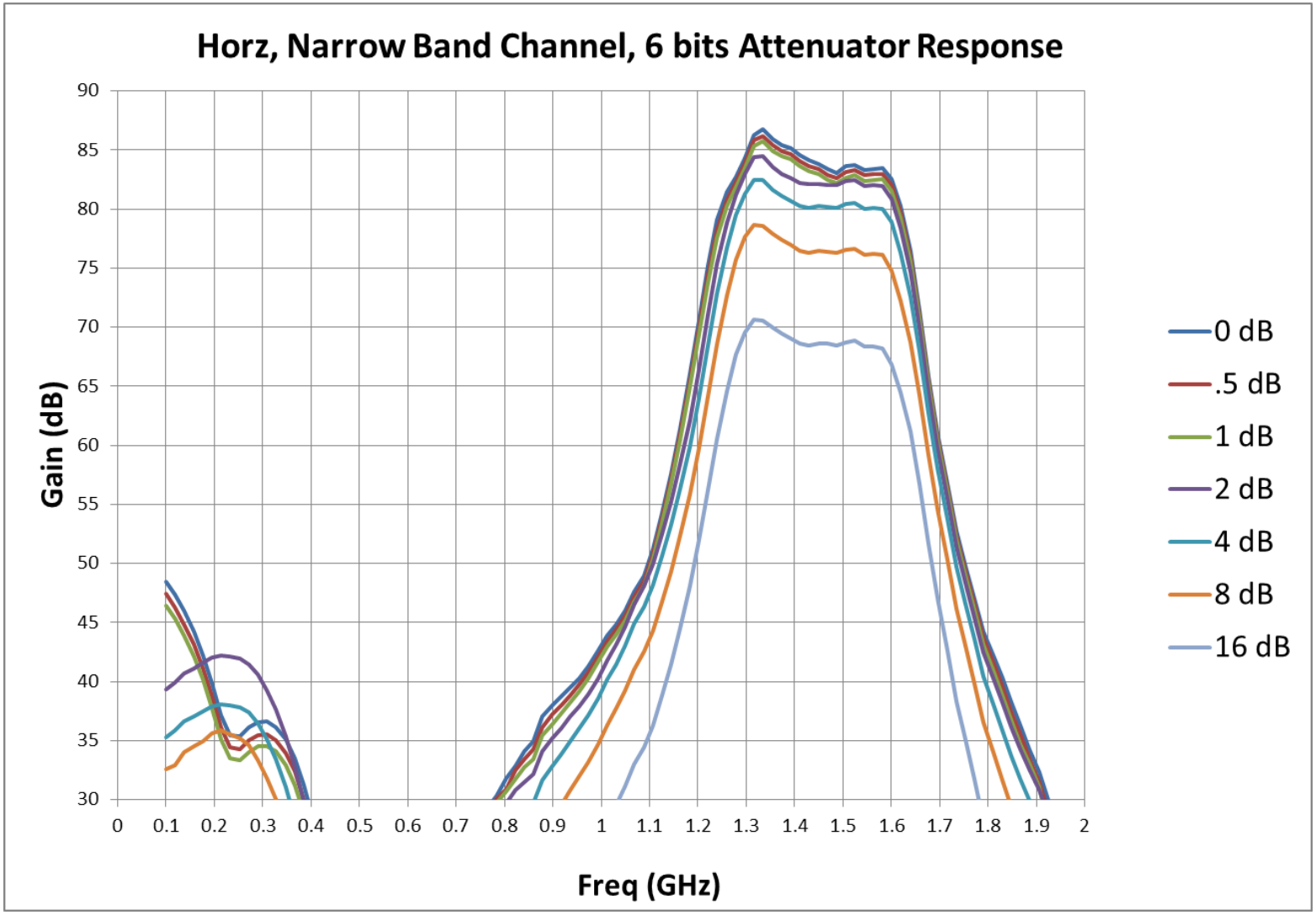

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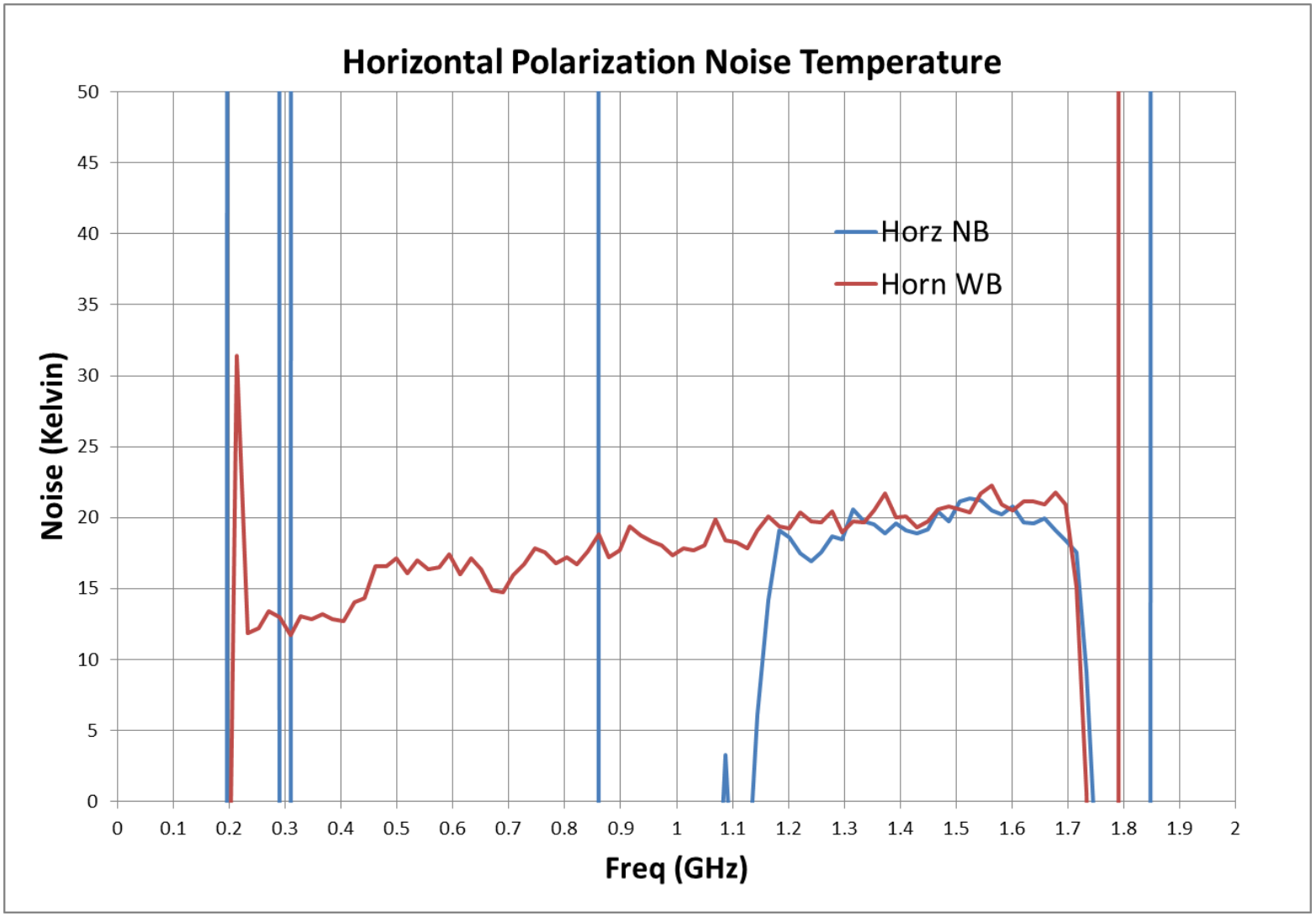

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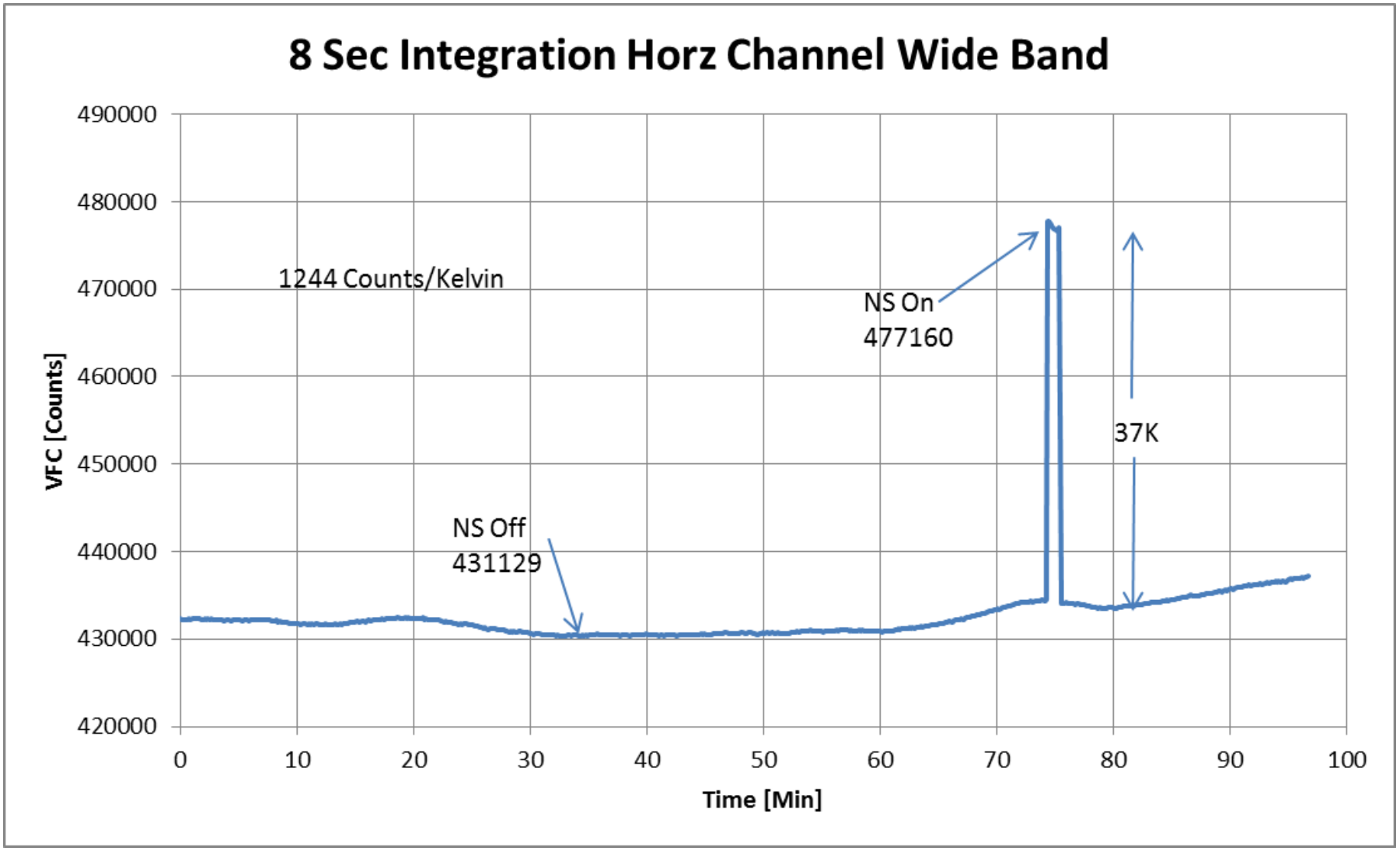

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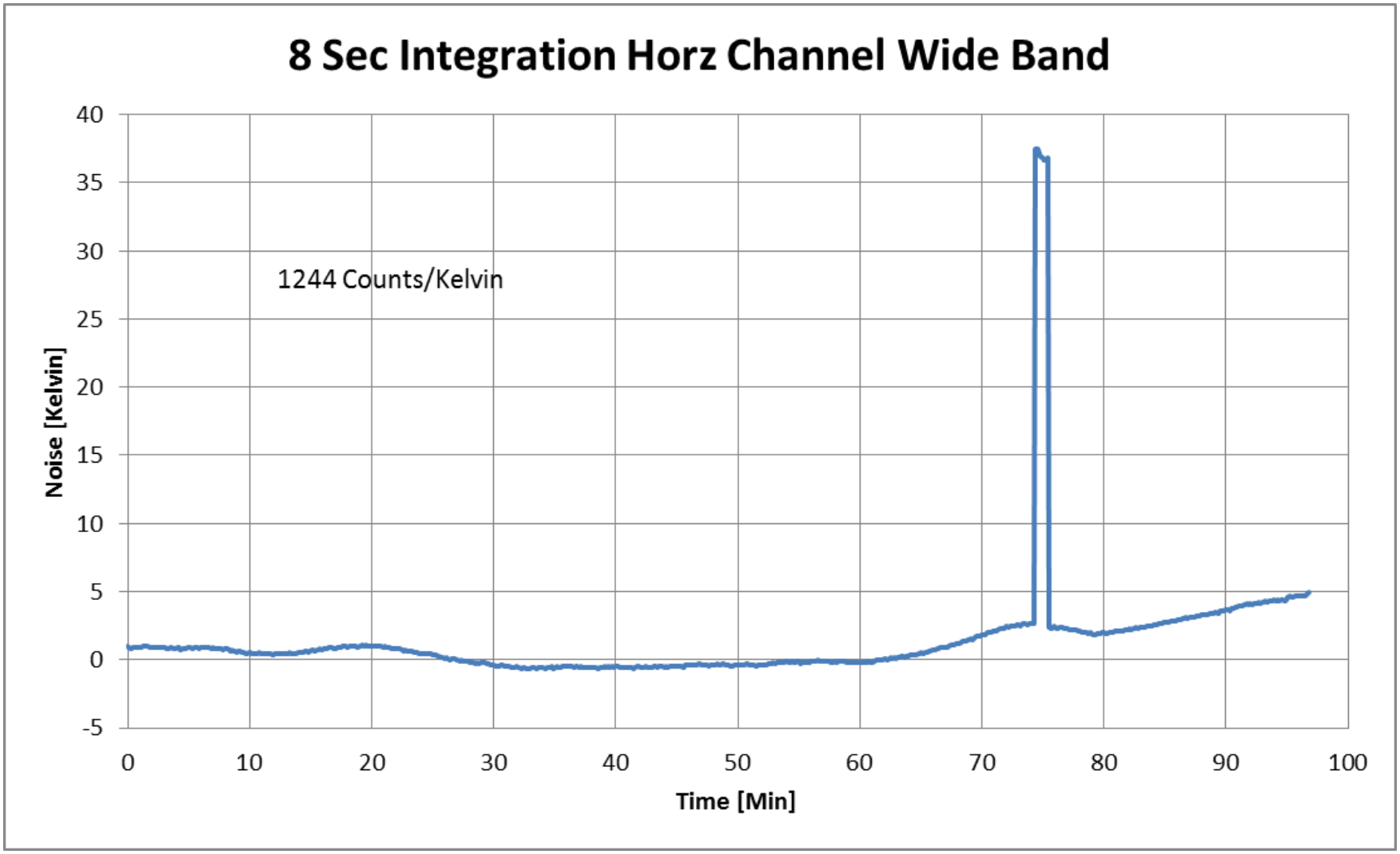

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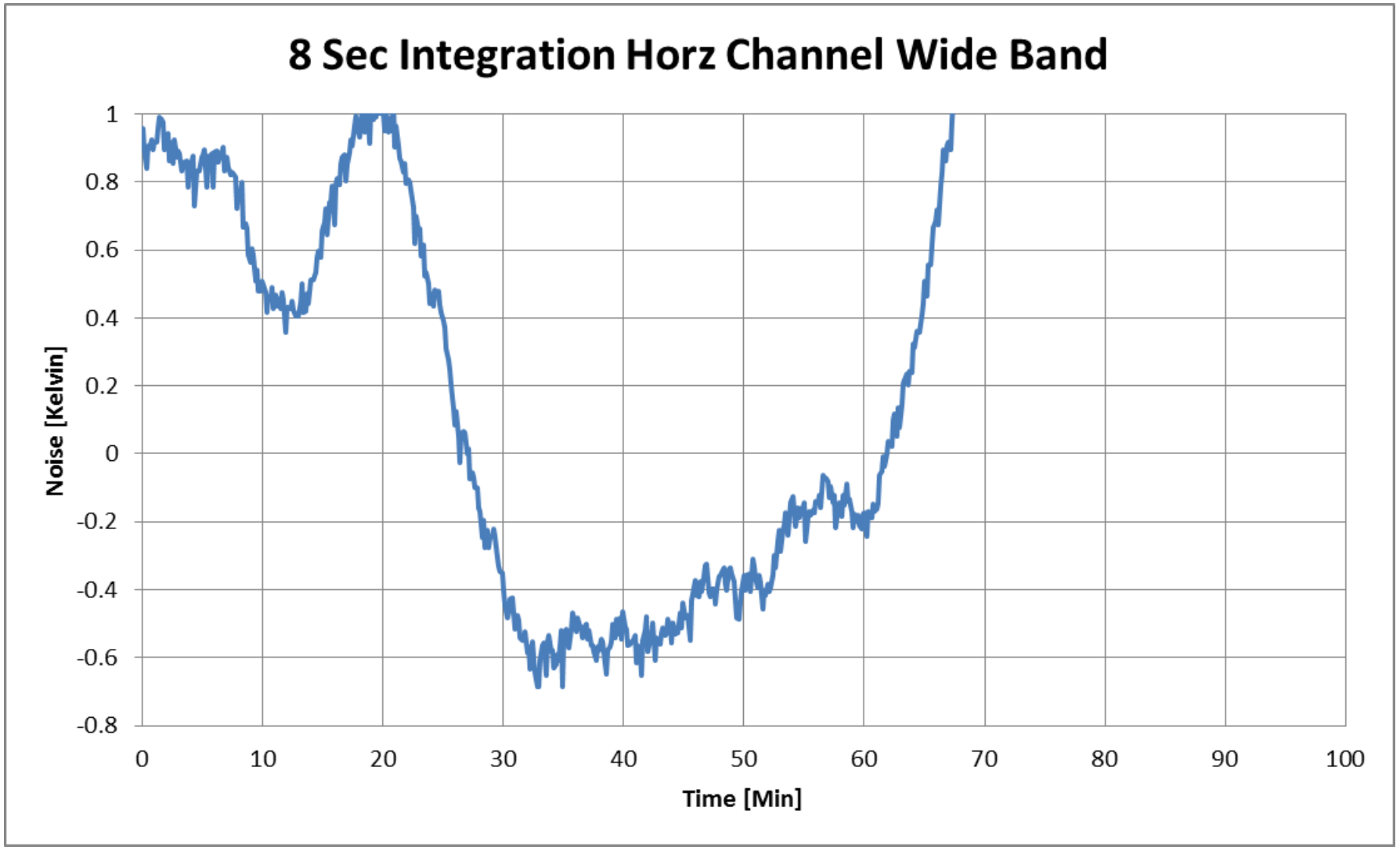

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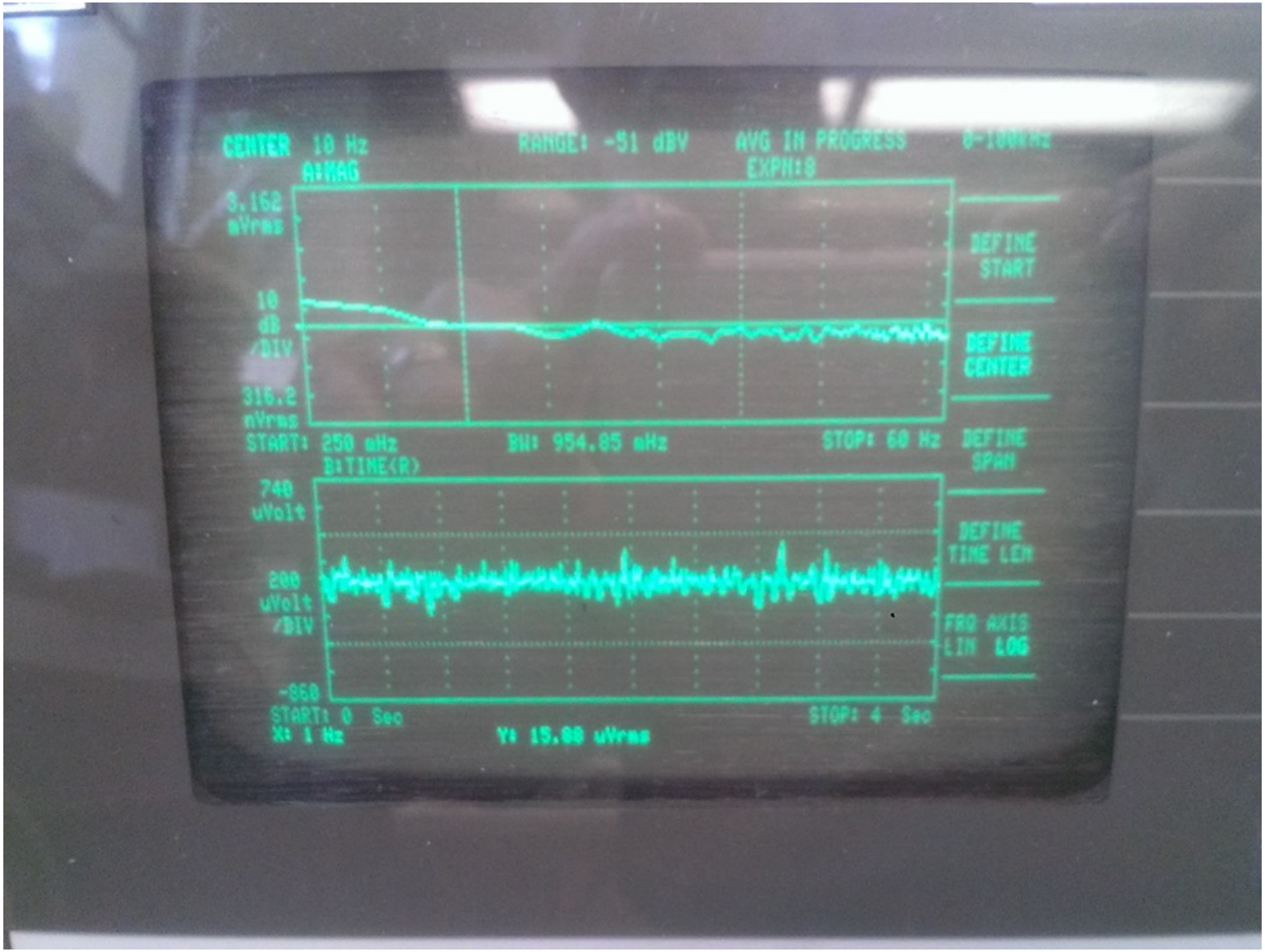

Control Software

- Python Language
- Controls all Receiver functions
- Voltage and Current Monitor
- Monitor for 1st and 2nd stage Cooler Temperature
- Monitors Warm Electronics Temperature
- Total Power Detectors
- Spectrum Analyzer
- Control Receiver with Ethernet Connection

Five hundred meter **A**perture **S**pherical radio **T**elescope

as of Oct 10, 2015