

ACADEMIA SINICA  
Institute of Astronomy and Astrophysics

# Hawaii Fast Radio Burst Outrigger Station

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# Outline

- Introduction
- RFI Site Survey
- Antenna(s)
- Instrumentation
- Preliminary Test Results
- Status and Summary



# Introduction

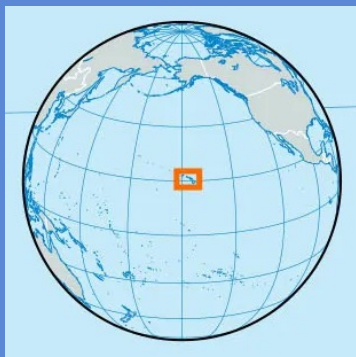
## ❑ ASIAA Hawaii Office

- Located in Hilo, Hawaii
- Support the following projects:
  - Smithsonian Submillimeter Array through 20% partnership
  - JCMT through East Asian Observatories
  - Greenland Telescope in partnership with Smithsonian Astrophysical Observatory
  - Subaru Telescope

## ❑ We are in the early stages of constructing an FRB outrigger array

- Plan for ten 6-meter dishes to perform VLBI with CHIME/FRB in Canada to increase localization precision for non-repeating FRB events
  - Other two outrigger stations are in Green Bank West Virginia (3333 km) and Algonquin Radio Observatory Canada (3000 km)
- Eight Log Periodic Antennas to perform VLBI with BURSTT in Taiwan

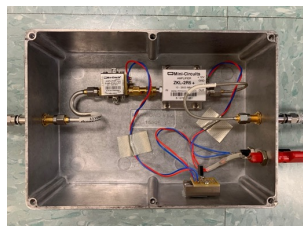
# RFI Site Survey





# RFI Site Survey

- Initial site survey was conducted with magnetic mount monopole antenna and LNA mounted to roof of vehicle
  - Band of interest is 400 to 800 MHz, identical to CHIME/FRB



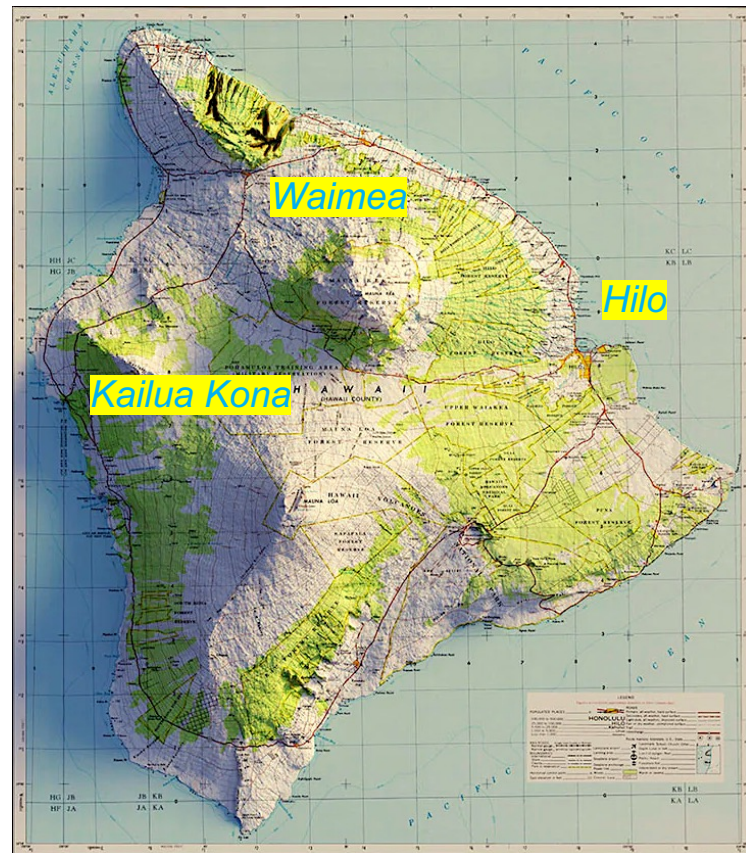
ASIAA LNA-001



TRAM UHF antenna  
410 to 490 MHz

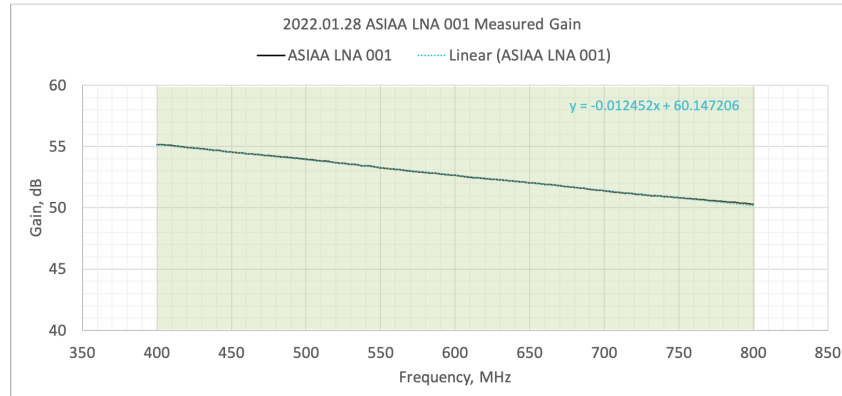
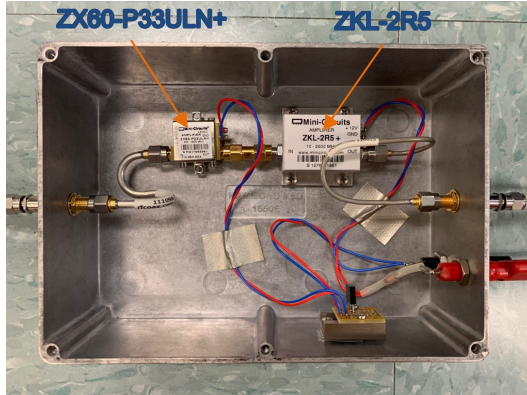
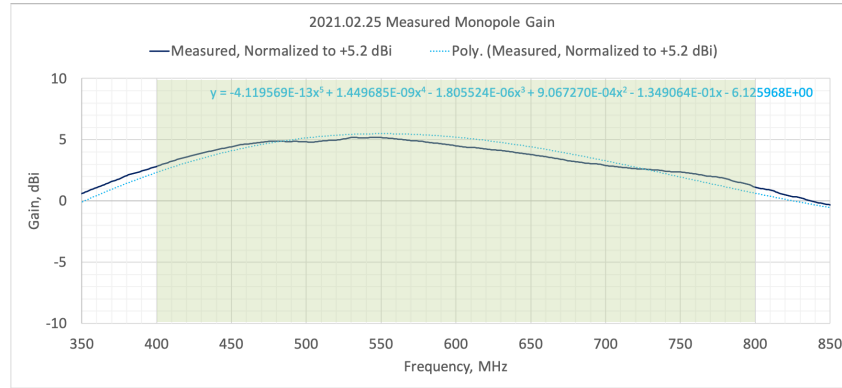
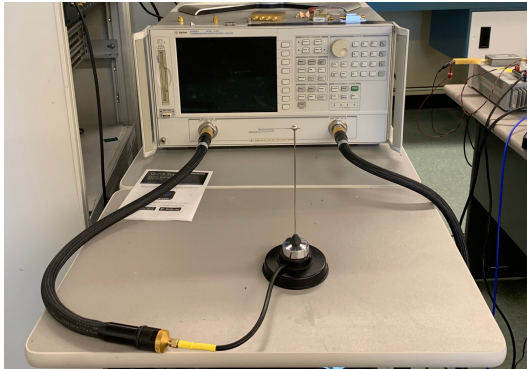


FieldFox N9918A



# RFI Site Survey, Hardware Setup

- ❑ Characterization of monopole antenna and ASIAA LNA-001 gain in lab





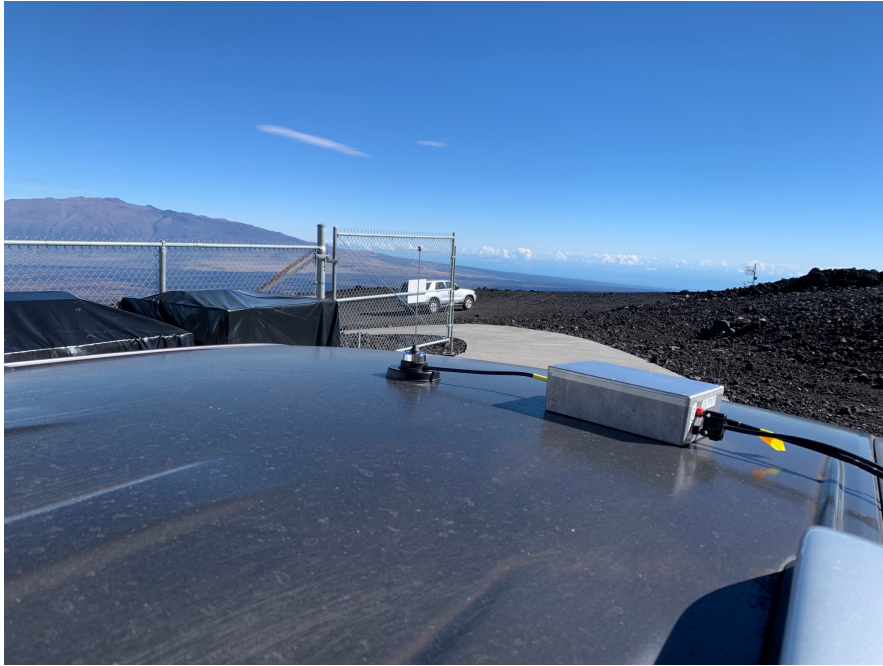
# RFI Site Survey

## ☐ Took measurements at several dozen sites

- 1 - Hamakua Energy at Honokaa
- 2 - Saddle Road 8 mile marker
- 3 - Mauna Loa AMiBA site
- 4 - Mauna Kea SMA site (log periodic antenna)
- 5 - Hawaiian Paradise Park
- 6 - Pahala



# Site Survey, Test Configuration

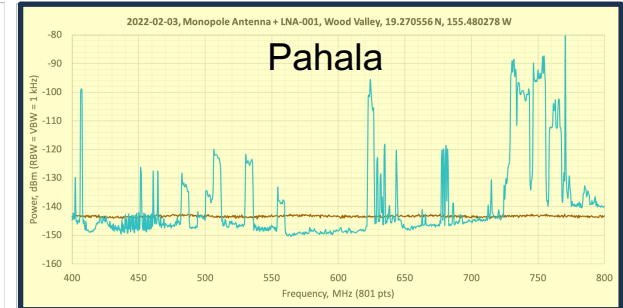
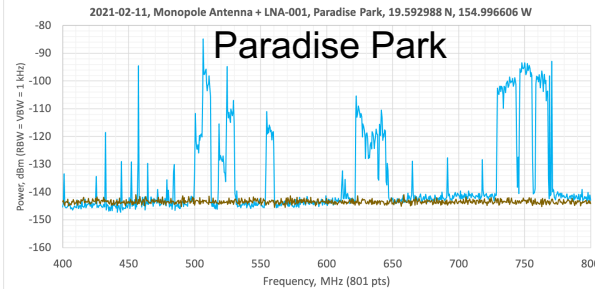
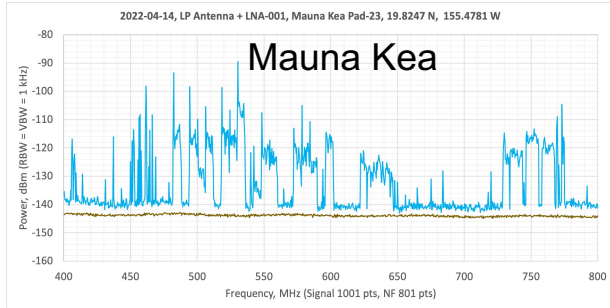
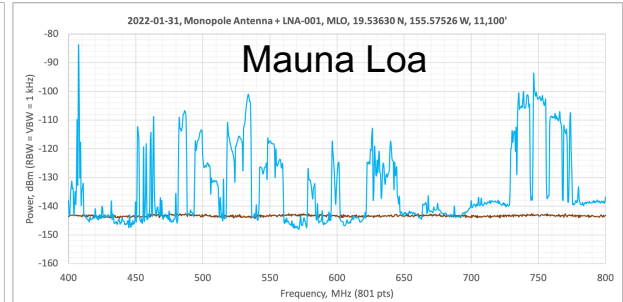
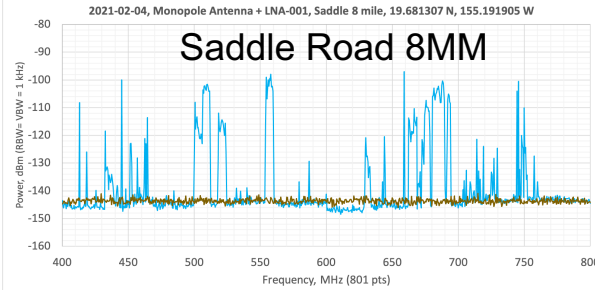
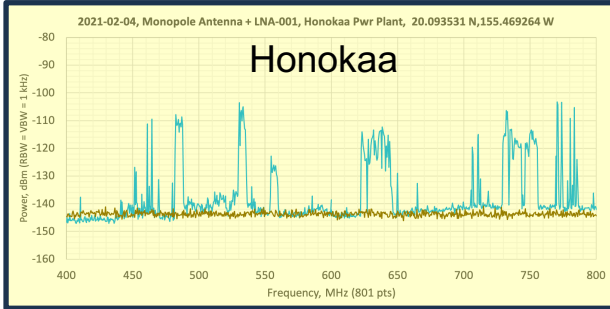




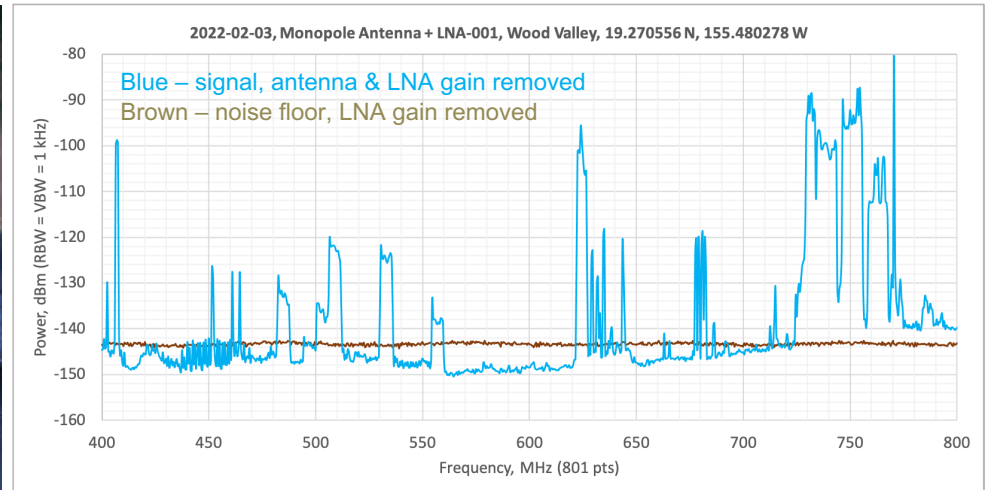
# RFI Site Survey – Sample of Results

Blue – signal, antenna & LNA gain removed

Brown – noise floor, LNA gain removed



# RFI Site Survey → Pahala





# Antenna, 6-meter Dish for CHIME/FRB

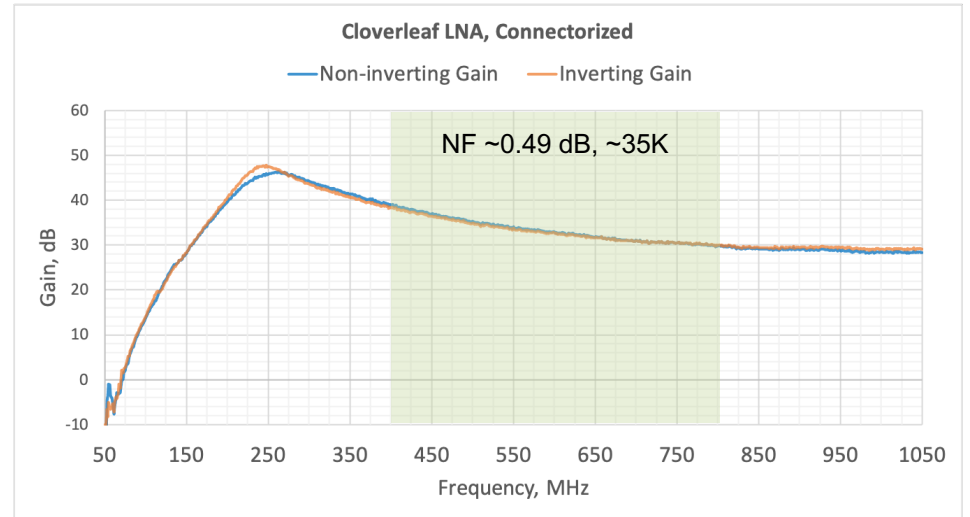
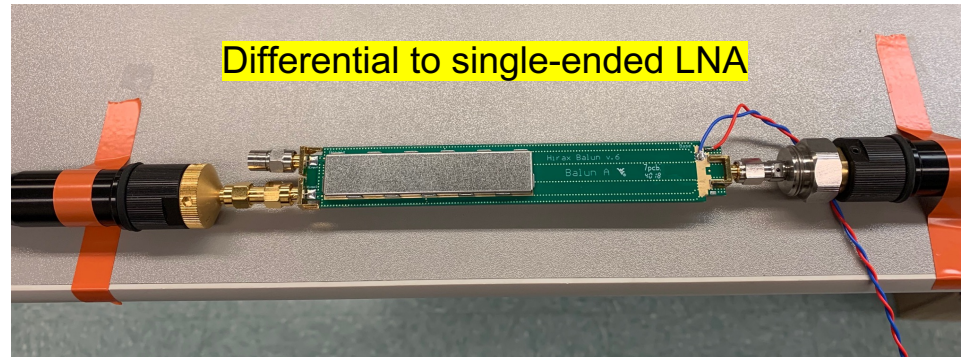


10 antennas – 283 m<sup>2</sup> collecting area  
CHIME – 8000 m<sup>2</sup>

Item No	GL-DYS600AM12PM	
Panel(Sector Divided)	12	
Aperture Diameter	600CM	
C-Band Gain@ 4GHz	46.75dB	
Ku-Band Gain@ 12.5GHz		
F/D Ratio	0.38	
Focus Length	231CM	
Material	aluminum	
Finish	painting	
Mounting Type	Pole/polar	
Elevation Alignment	0~90°	
Azimuth Alignment	0~360°	
Operational Winds	Able to receive	25m/sec
	Able to re-set	40m/sec
	Not broken & fly away	60m/sec
Ambient Temperature	-40°C~+60°C	
Relative Humidity	0~100%	

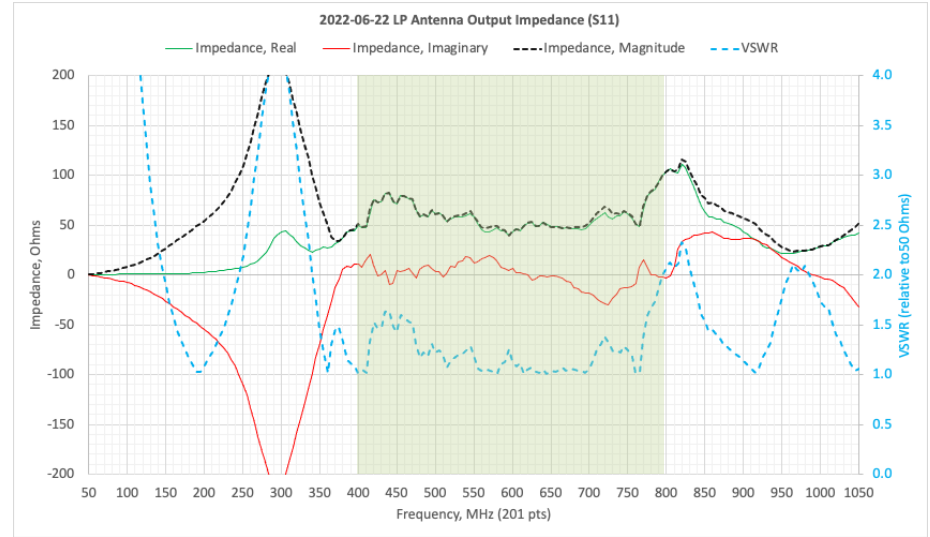
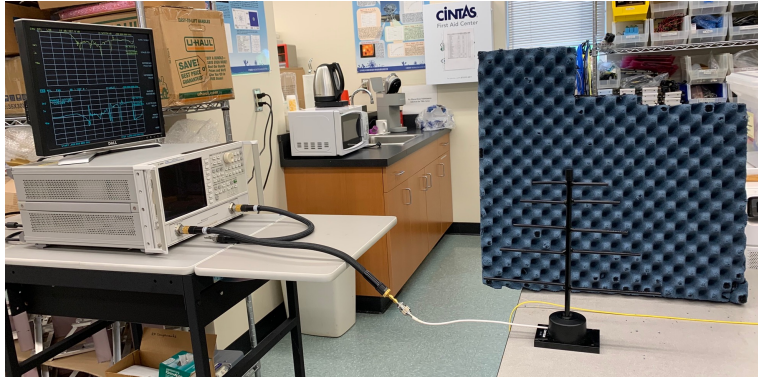
Gain at 600 MHz ~30 dB, beamwidth 5 degrees  
CHIME – 100 degrees N-S, 2 degree E-W

# Antenna, Cloverleaf Feed



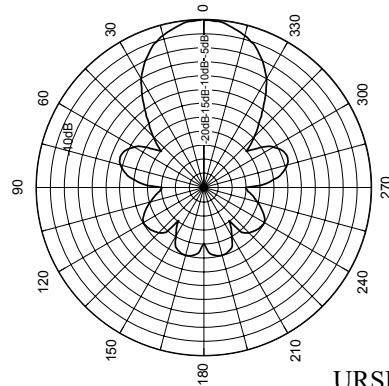
# Antenna, Log Periodic for BURSTT

MOBILEMARK Y42400WB



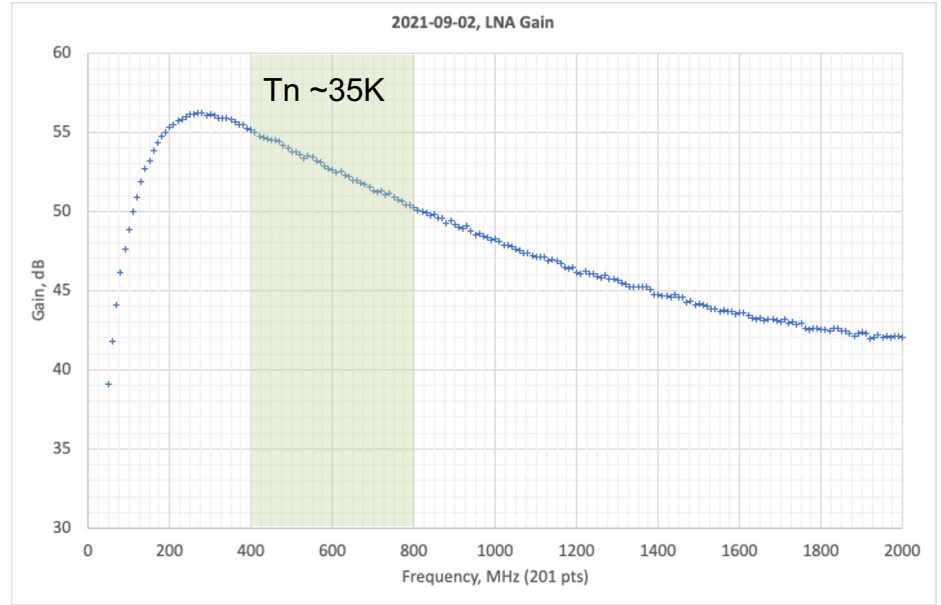
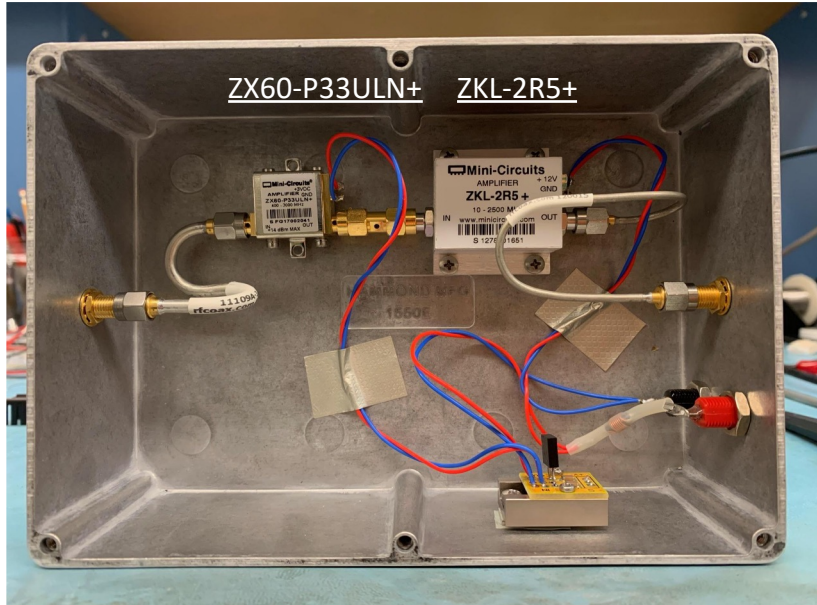
## ELECTRICAL SPECIFICATIONS

<b>GAIN:</b>	7dBd / 9dBi
<b>FREQUENCY@</b>	
<b>VSWR &lt;1.5:1</b>	400-800MHz
<b>&lt;2.2:1</b>	400-1000MHz
<b>F to B RATIO:</b>	20dB
<b>VERT BEAMWIDTH:</b>	35°
<b>HORIZ BEAMWIDTH:</b>	30°
<b>POWER RATING:</b>	150 watts
<b>IMPEDANCE:</b>	50 ohms

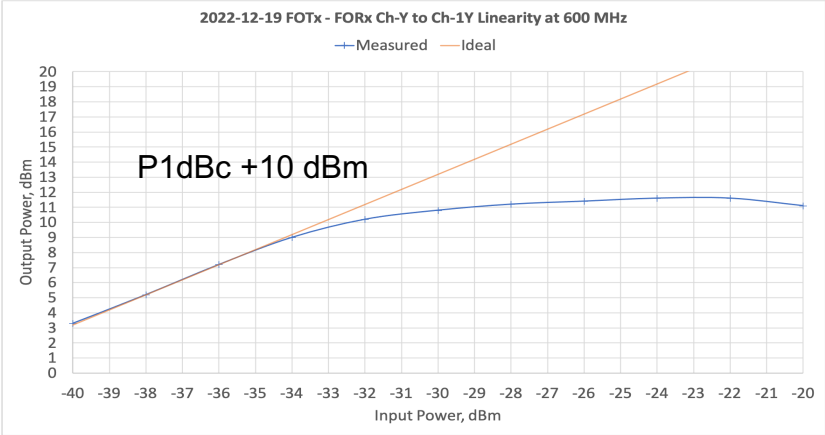
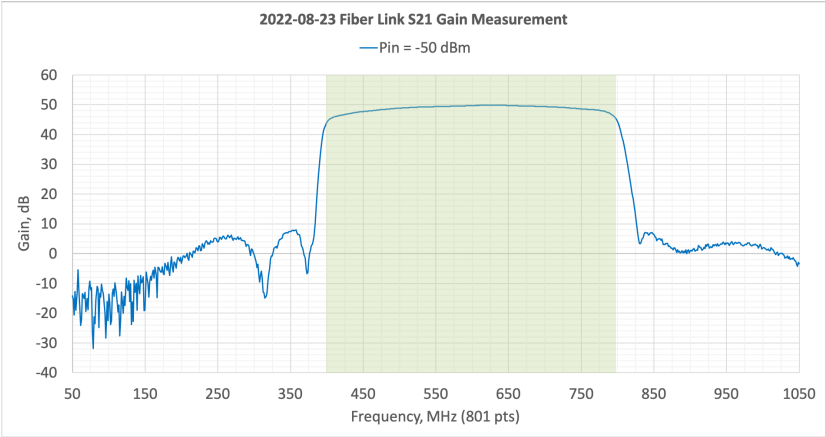
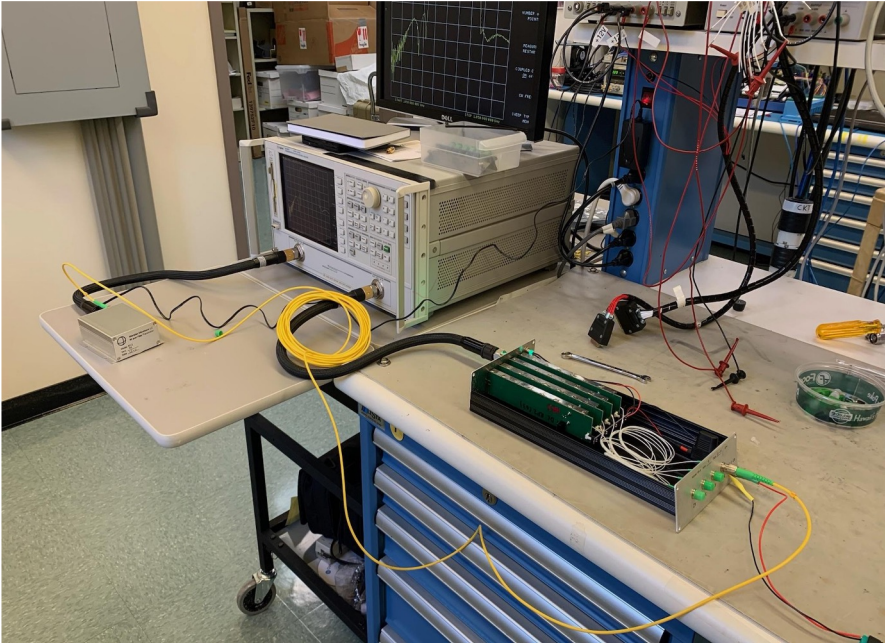




# LNA-001 Assembly



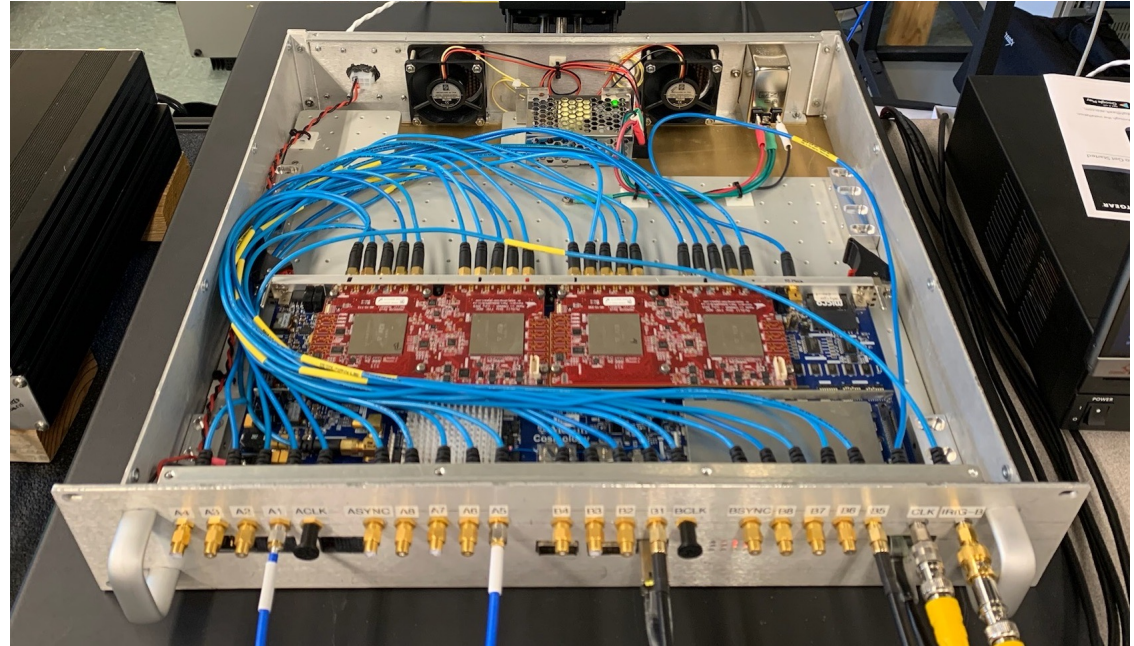
# Optical Link



# Digital Backend

## ❑ ICE board

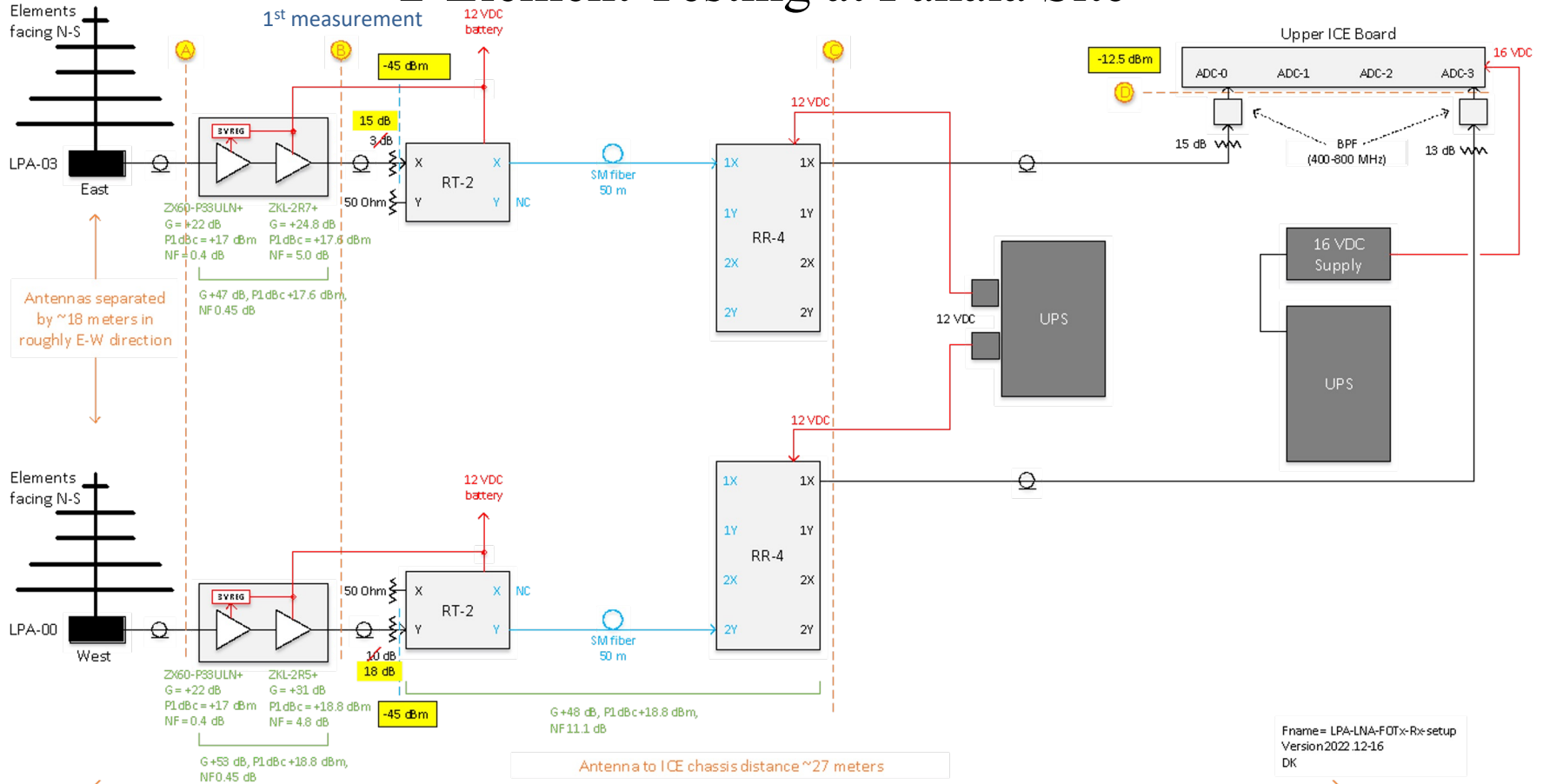
- Two ADC daughter boards
  - Four 4-channel ADC
  - 800 Msps, 8-bit
  - 16 total input channels
- 10 MHz input from GPS
- IRIG-B



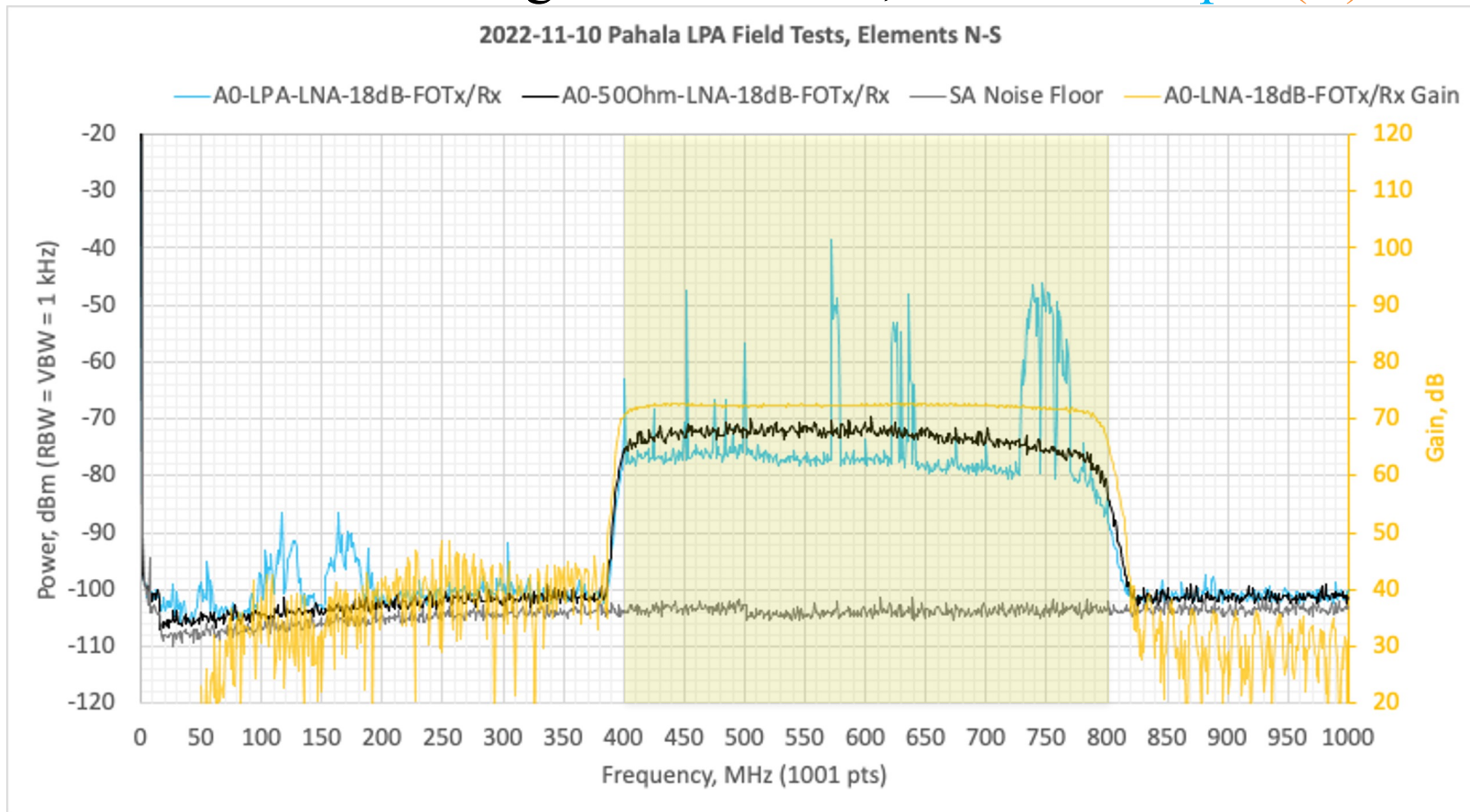
*Special thanks to Nina Gusinskaia at Algonquin Radio Observatory for helping us with software*



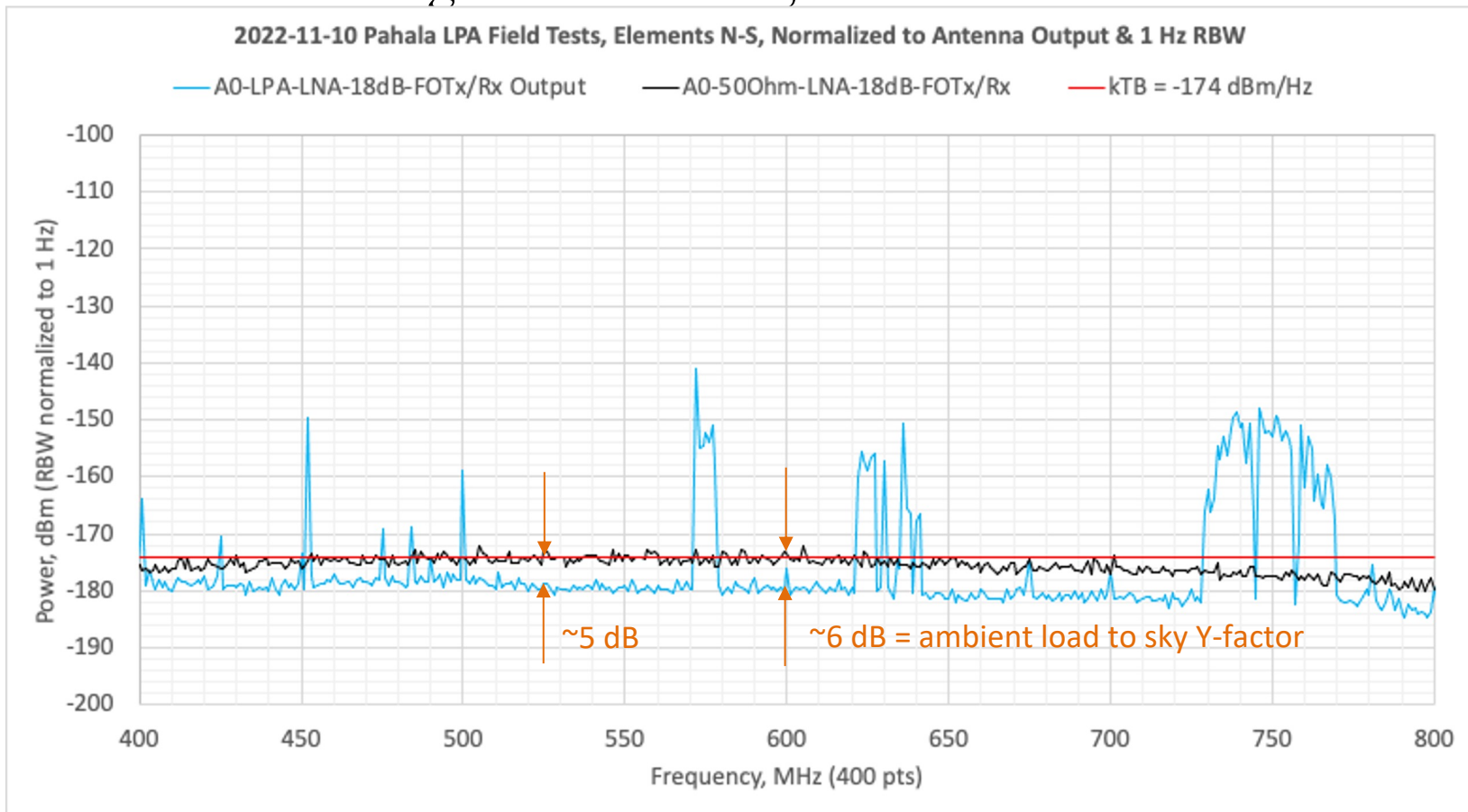
# 2-Element Testing at Pahala Site



# 2-Element Testing at Pahala Site, FORx-0 Output (C)

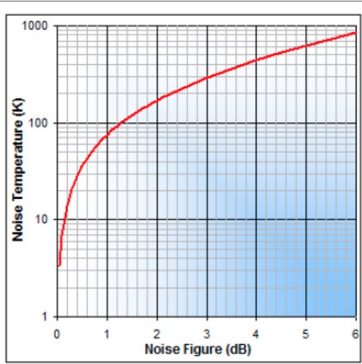


# 2-Element Testing at Pahala Site, FORx-0 Measured Y-factor





## 2-Element Testing at Pahala Site, FORx-0 Y-factor



$$T_{\text{load+rx}} = 300 + T_{\text{rx}}$$

From table 0.5 dB NF,  $T_{\text{rx}} = 35\text{K}$

$$T_{\text{sky+rx}} = T_{\text{sky}} + T_{\text{rx}}$$

$$T_{\text{sky}} = 46.5 \text{ K}^1$$

$$Y_{\text{factor}} = 10 * \text{Log}(T_{\text{load+rx}} / T_{\text{sky+rx}}) = 10 * \text{Log}[(300 + 35) / (46.5 + 35)]$$

$$= 10 * \text{Log}(335 / 81.5)$$

$$= \underline{6.13 \text{ dB}} \quad \text{verses measurement of } 6 \text{ dB}$$

NF(dB)	T <sub>N</sub> (°K)	NF(dB)	T <sub>N</sub> (°K)
0.1	7	2.1	180
0.2	14	2.2	191
0.3	21	2.3	202
0.4	28	2.4	214
0.5	35	2.5	226
0.6	43	2.6	238
0.7	51	2.7	250
0.8	59	2.8	263
0.9	67	2.9	275
1.0	75	3.0	289
1.1	84	3.1	302
1.2	92	3.2	316
1.3	101	3.3	330
1.4	110	3.4	344
1.5	120	3.5	359
1.6	129	3.6	374
1.7	139	3.7	390
1.8	149	3.8	406
1.9	159	3.9	422
2.0	170	4.0	438

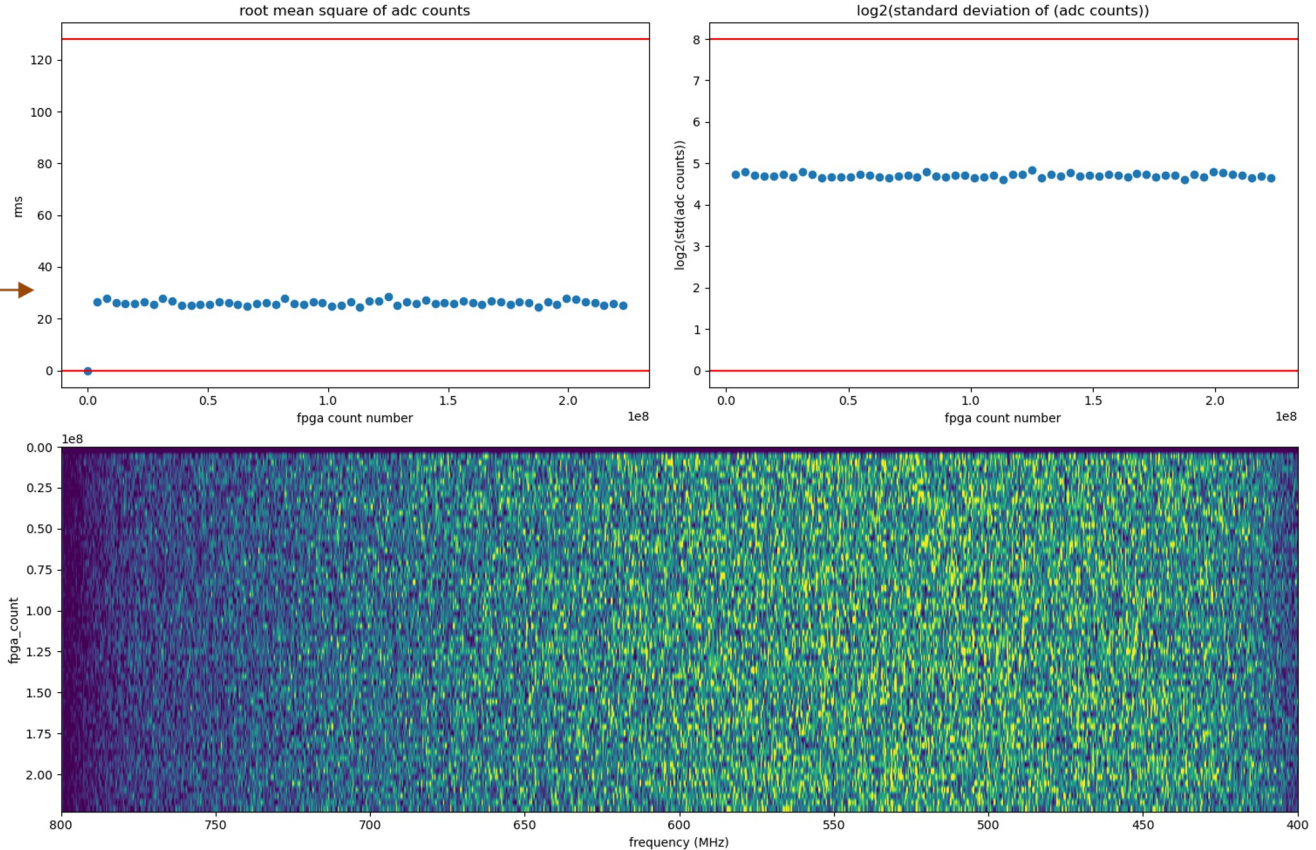
<https://www.rfcafe.com/references/calculators/noise-figure-temperature-calculator.htm>

<sup>1</sup>[The absolute temperature of the sky and the temperature of the cosmic background radiation at 600 MHz](#)

# Kotekan Software, ADC-1, Input-A1, LNA-00 Terminated

crate number.slot number.input\_number = 0.0.0

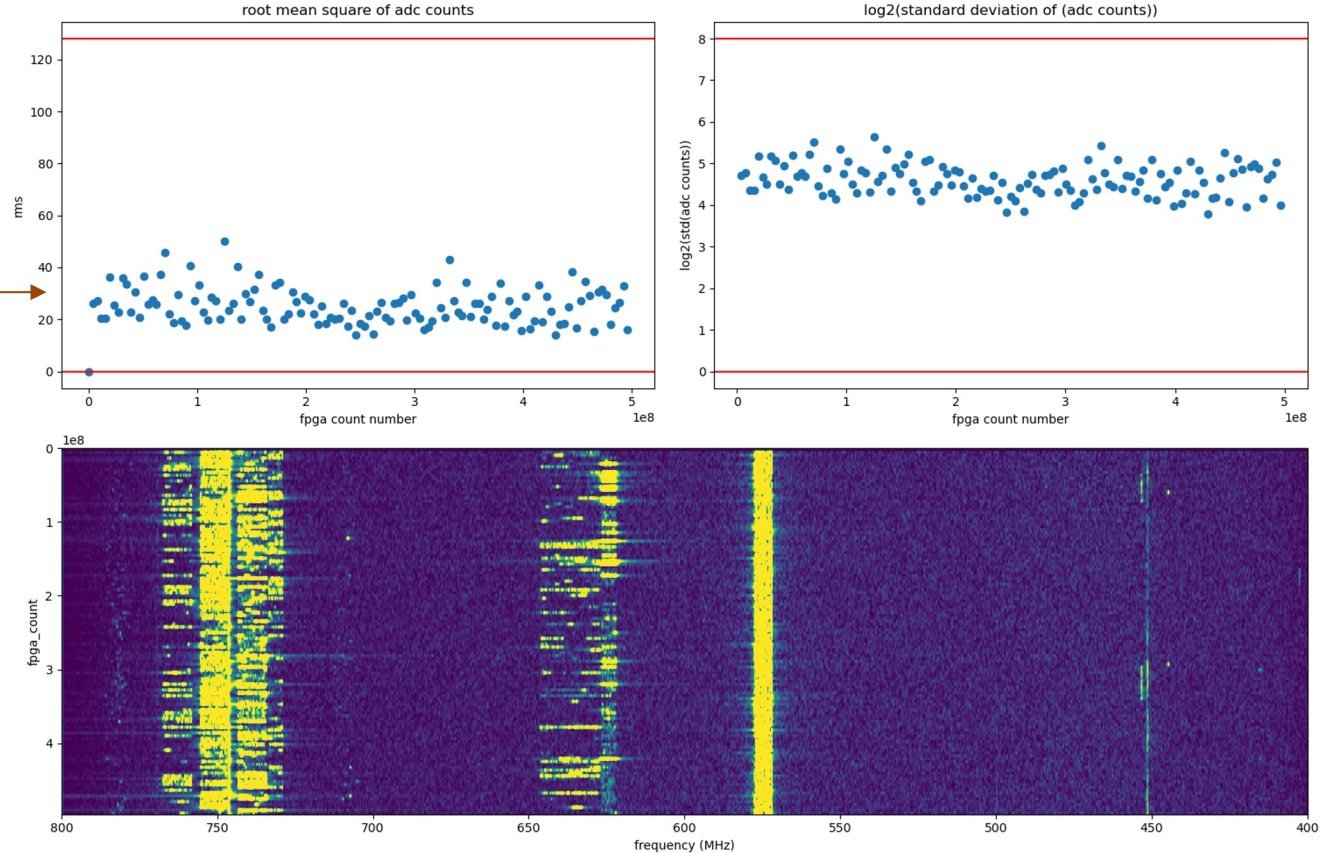
Optimal drive 32



# Kotekan Software, ADC-1, Input-A1, LPA-00

crate number.slot number.input\_number = 0.0.0

Optimal drive 32 →  
Difficult to set  
because of AM-ing

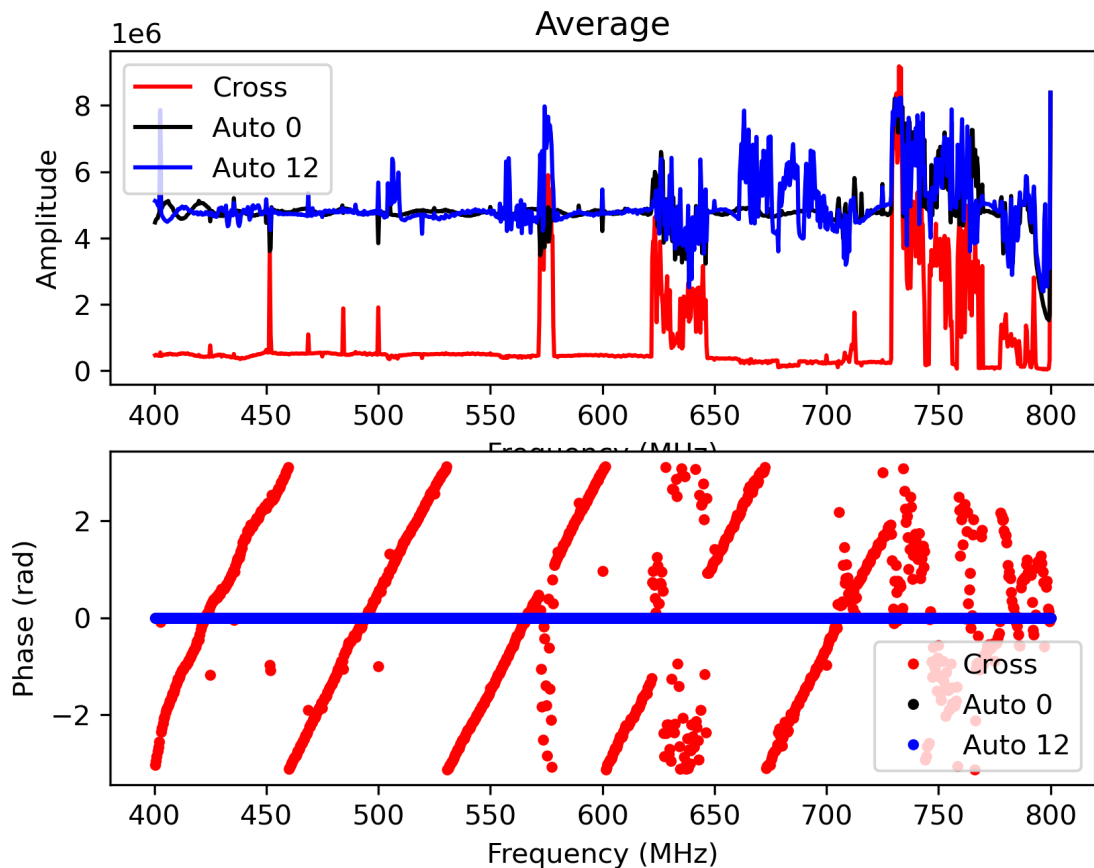




# Kotekan Software, Cross Correlation Detection of Sun

Pahala site

Integration time 2.684 sec



# Status and Summary

- ❑ Received permit to construct infrastructure and antennas on 2 acre site in Pahala
  - Need to grade, gravel and fence property
  - Deliver 20 foot shipping containers to site
  
- ❑ Preparing three 20 foot containers as electronics, power and storage facilities
  - Li-ion batteries + generator at first
  - Add PV panels later
  
- ❑ Procured and received the 6-meter dishes, cloverleaf/LNAs, fiber optic links, ICE boards, GPS\*, Starlink terminal
  - \*Need to improve timing precision for VLBI
  
- ❑ Need to implement and test detection trigger from CHIME
  
- ❑ Assembly of 6-m antennas on site to begin in January 2024