Using Sun Noise to Evaluate System Performance at VHF/ UHF and Microwave

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Using Sun Noise to Evaluate System Performance at VHF/ UHF and Microwave

- Discover What You can do with Measurements
- Discuss the Radio system and Instrumentation Needed to Make Measurements
- How to Make Measurements
- How to Interpret the Results
- Result Predictions & Actual Values

Introduction to Using Sun Noise to Evaluate System Performance

- **Most VHF/UHF Amateurs are Familiar with Noise Figure Measurements to Optimize Preamplifiers & RX Converters**
- **But Using the Sun as the Noise Source We can do Much More !**
- **This Presentation will Cover the Basics and Suggest Other Areas to Explore**

Introduction to Using Sun Noise to Evaluate System Performance

- **Measurements Can Be Used to :**
  - **Compare Overall System Sensitivity**
    - **How does one system perform relative to others?**
  - **Validate System Performance**
    - **Does it work as well as expected?**
  - **Measure Antenna Gains**
    - **Using a measured reference antenna**

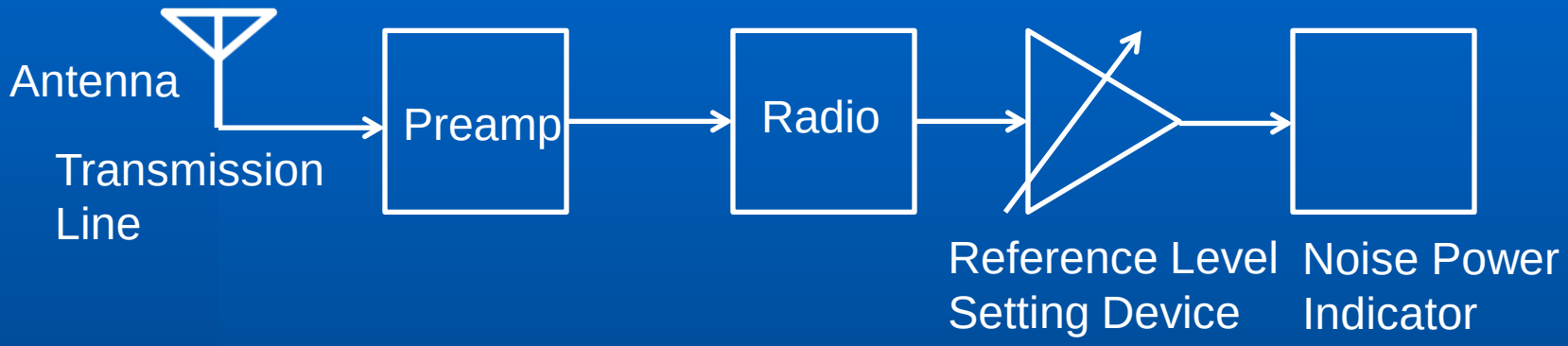
Noise Emissions from the Sun

- Sun Emits Noise from Optical spectrum down to ~30 GHz as a Black Body radiator of about 6000 deg K.
- Noise Between 100 MHz and 30 GHz Varies Greatly with Contribution from Corona and Chromosphere
- If Using Sun Noise for Long Term Comparisons, Must Note Solar Flux values and Compensate for Changes.

Noise Emissions from the Sky

- Sky Noise Also Varies with Frequency.
- Noise Between 1 and 10 GHz is About 3- 4 deg K from the Big Bang !
- Above 10 GHz Resonances of Oxygen and Water Vapor Increases Atmospheric Losses and the Sky Temperature Increases.
- Below 1 GHz the Noise Increases from Cosmic and Planetary Sources.

Measurement Technique

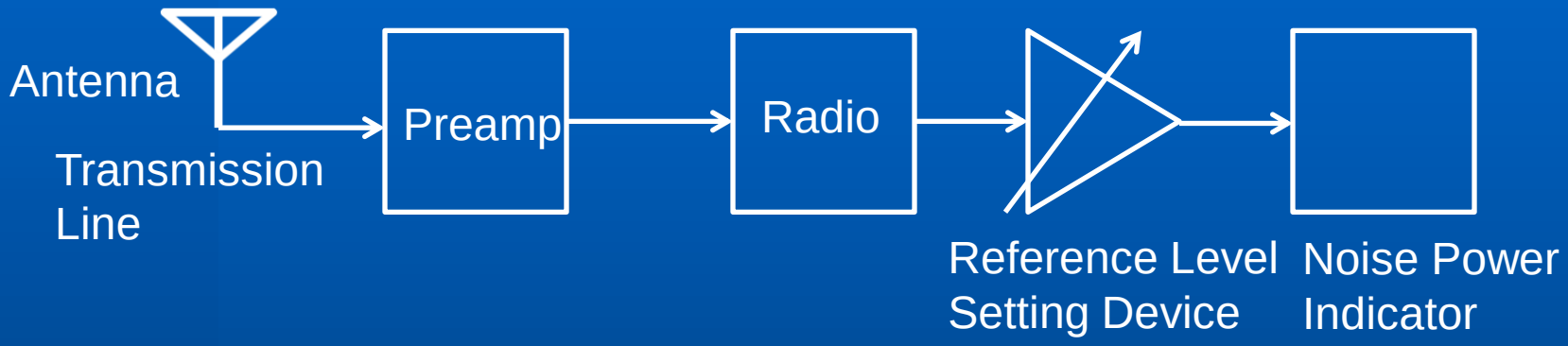


- **Need Antenna Capable of Pointing at Sun**
- **Take Noise Reading Pointed at Sun, Then Another at "Cold Sky"**
- **Noise Levels will Depend on Frequency, Antenna Gain, Preamp Sensitivity, etc.**

Antenna Requirements

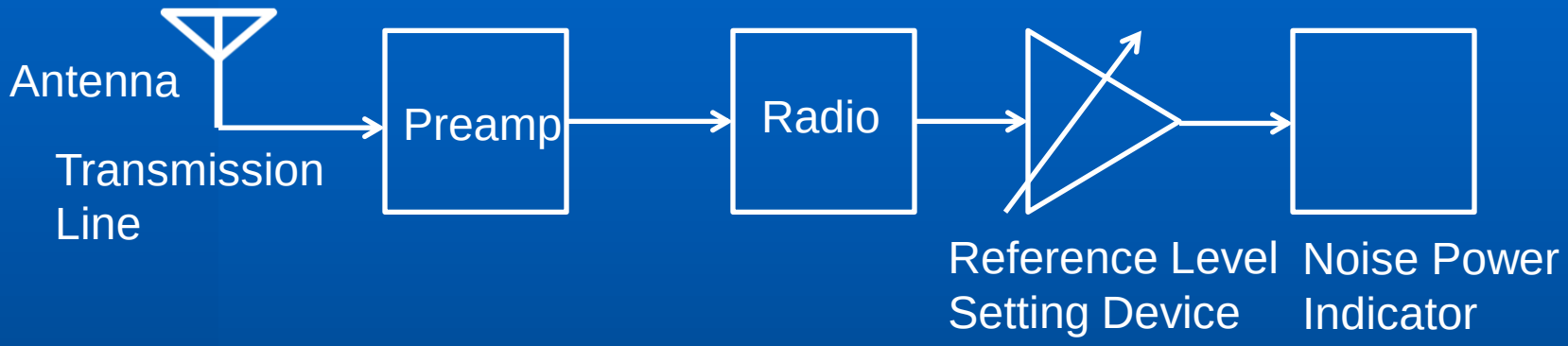
- Need Antenna “Sharp Enough” to Point at Sun and Away From Other Noise Sources
  - Ground, Man Made Emitters, Trees, Etc.
- Should have a Clean Pattern
  - Important Even for Terrestrial Operation!
- Antenna Gains Need to be Less than 50dBi
  - For a Beamwidth Less than 0.5 degrees the Sun/ Moon are No Longer Point Sources

Measurement Technique Cont'd



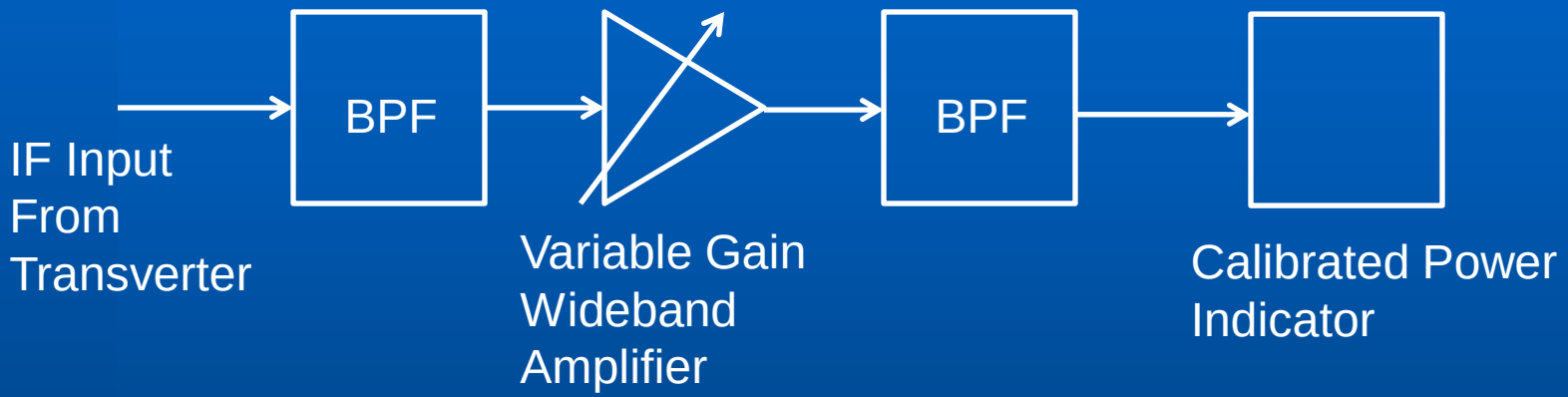
- **If Measuring Receive Audio, Must Disable the AGC, Unless Using "Precision" S meter**
- **Use Widest Bandwidth Possible to Average out Short Term Variations and Resolve Small Noise Level Changes**
- **Using < 3kHz BW Requires Some Averaging**

Measurement Technique Cont'd



- **Best Measurements Done by taking Wideband IF measurements, typically at the Output of a RX Converter or Transverter**
- **Care has to be taken to ensure that the Output is "Clean" of spurs or LO Leakage**

Measurement Technique Cont'd



- **Basic Indicator is a Wideband "Power Meter"**
  - **Need High Resolution and Stable Indication**
  - **Gain Stability of Whole System is Important !**
- **Need BP Filtered but Variable Gain Amplifier to Set Levels**
  - **>60 dB gain minimum**
- **Linear Dynamic Range must be 12 dB above nominal Noise level**

Many Ways to Build a System

- Use a Low Power microwave power meter with analog indicator (HP 432, 435, etc.)
- Use a True RMS Voltmeter
- Use a Noise Figure Meter or Selective Level Meter
- W1GHZ Has Described Several Level Meters
- GR1215 or 1236 IF Amplifiers
- Use a Receiver with “Precision” S Meter
- Use an RTL Dongle and Noise Software

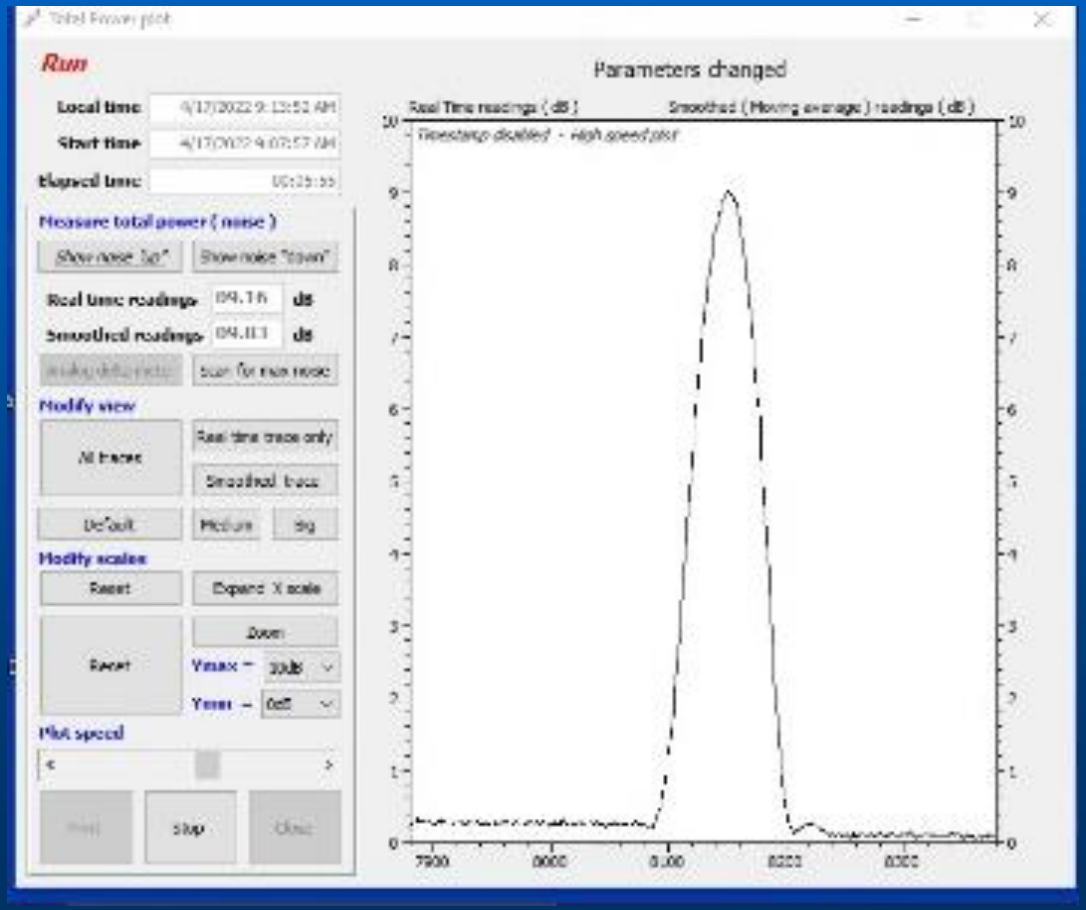
General Radio 1236 IF Amplifier

RTL Dongle & Noise Software

- **I0NAA Created "Total Power" software using RTL Dongle for receiver**
  - **Wide Band Frequency coverage**
  - **Up to 2.4 MHz Sampling Rate so Wide Bandwidth & Stable Readings**
  - **Wide Range of Operating Levels and Resolution**
  - **Many Features for Radio Astronomy Use**

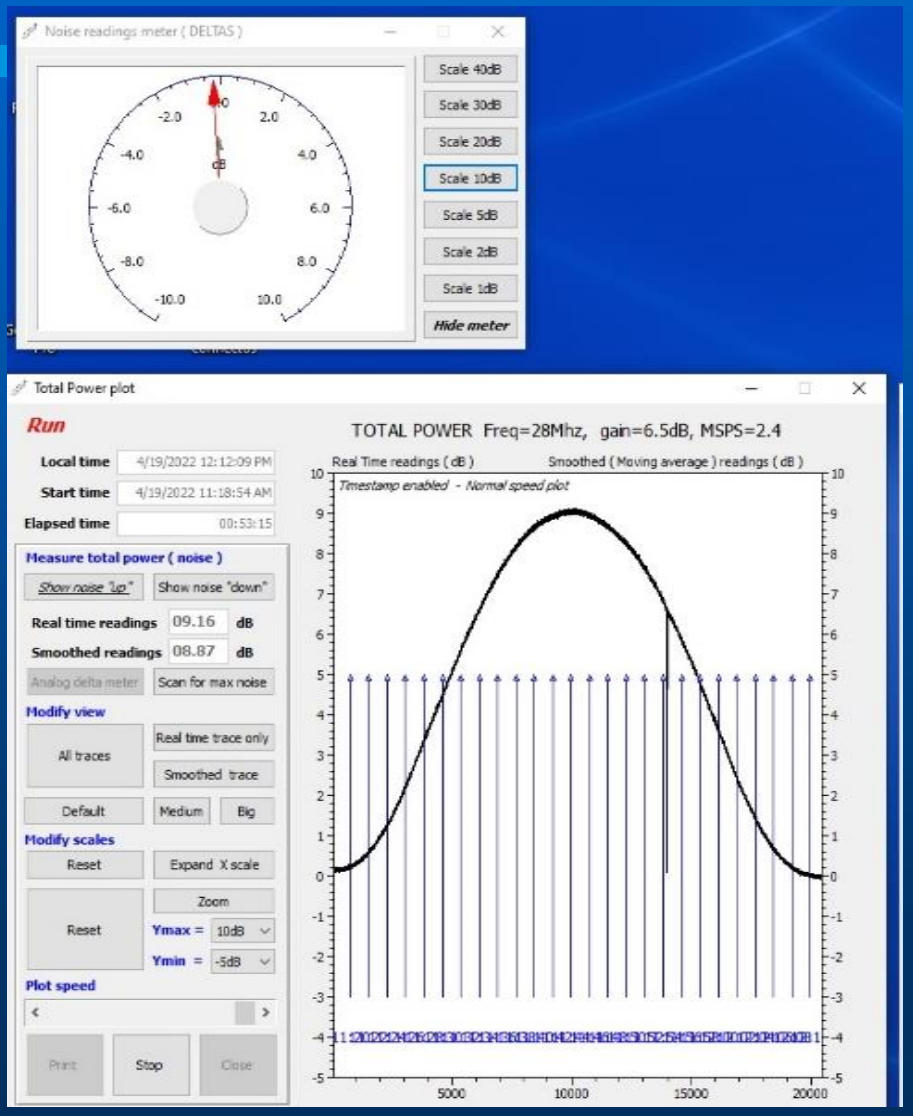
Total Power Software Example

- Sun Noise Response on Antenna Move
- Analog Meter available for Peaking Response



Total Power Software Example 2

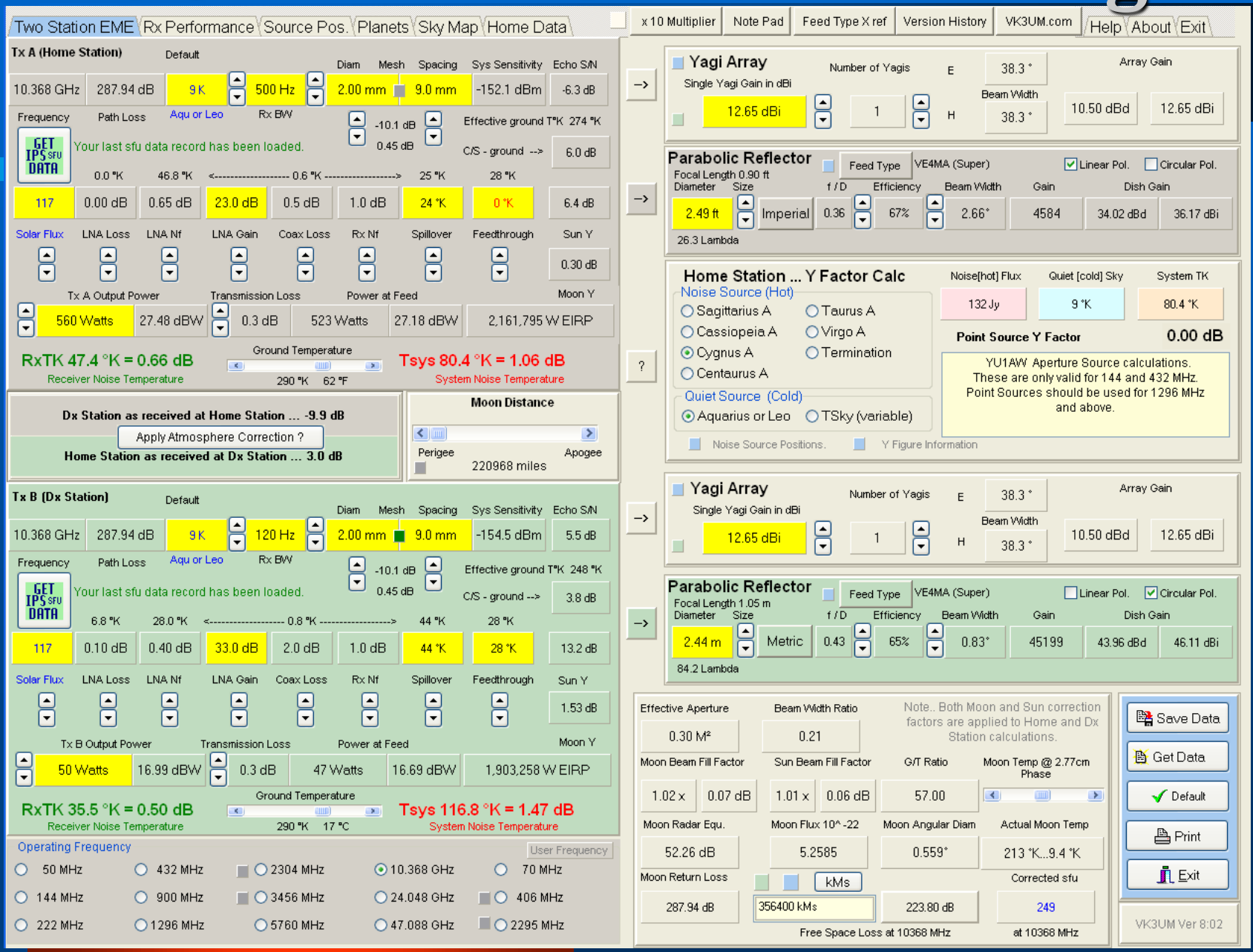
- Response as Sun Moves Across Antenna Beam
- Can Determine Beam width with Time Ticks



Taking Measurements

- System Must be Sensitive Enough to pick up Sun Noise:
  - Adequate Combination of Antenna Gain, System Noise Figure and Down conversion Gain
- Anticipated Performance can be Checked using VK3UM's EME Calculator program
- Expect Most Portable Terrestrial systems on 5.7, 10 & 24 GHz & Above should be good Enough to Use the Sun.

VK3UM EME Calculator Program



Program Predictions for 30 inch Dish

- 5.7 GHz with a 0.65 dB NF (EME) preamp
  ~ 5.7 dB Noise increase
- 1O GHz with a 0.65 dB NF (EME) preamp
  ~ 6.4 dB Noise Increase
- 24 GHz with a 1.5 dB NF (EME) preamp
  ~ 5.3 dB Noise Increase
- 10 GHz with 1.0 dB NF DEMI & 18 inch dish
  ~ 2.7 dB Noise Increase

Program Predictions for Yagi Antennas

- 144 MHz 2.12 WL M2 9SSB 11.96 dBi Gain with a 0.25 dB NF (EME) preamp
  - ~ 3.42dB Noise increase
- 432 MHz 6.5 WL K1FO 22 el 17.85 dBi with a 0.25 dB NF (EME) preamp
  - ~ 7.3 dB Noise Increase
- 1296 MHz 55el Directive Systems Loop'er with a 0.25 dB NF (EME) preamp
  - ~ 2.44 dB Noise Increase

Some Measured Dish Results

- 10 GHz 18 inch Dish 1.0 dB NF DEMI
  2.0 dB Noise Increase
- 10 GHz 32 inch Dish 0.65 dB (EME) preamp
  6.25 dB Noise Increase
- 24 GHz 39 inch Dish 1.5 dB (EME) preamp
  10.2 dB Noise Increase

Some Measured Yagi Results

- 432 MHz, 25el K1FO, 0.3 dB NF EME preamp
  ~6.0 dB Noise Increase
- 1296 MHz 55 el Looper 0.25 dB (EME) preamp
  3.5 dB Noise Increase
- Care Must be Taken to avoid Driven Element Being Too Close to Ground
- Of Course VHF/ UHF Antenna Must be Clear of Buildings, Trees, Etc. Note Large Beamwidths

Measurements of 5 ft TVRO Dish

- 2.3 GHz Offset Feed to Part of 10 ft Dish

Measured Results for 5 ft TVRO Dish

- 902 MHz ~ 22 dBi Gain, 0.5 dB NF
  7.0 dB Noise Increase
- 1296 MHz ~25 dBi Gain, 0.25 dB NF
  7.5 dB Noise Increase
- 2.3 GHz ~30 dBi Gain, 0.35 dB NF
  >8 dB Noise Increase
- 3.4 GHz ~ 34 dBi Gain, 0.45 dB NF
  9.0 dB Noise Increase
- 5.7 GHz ~ 38 dBi Gain, 0.5 dB NF
  9.5 dB Noise Increase
- 10 GHz ~43 dBi Gain, 0.65 dB NF
  Only 8.5 dB Noise Increase

Antenna Gain Can Be Too High !

- Tested 24 GHz Feedhorns from W1GHz with Increasing Gain to find Best G/T for 2.4 m 0.7 f/D dish
- Tests inconclusive ! ?

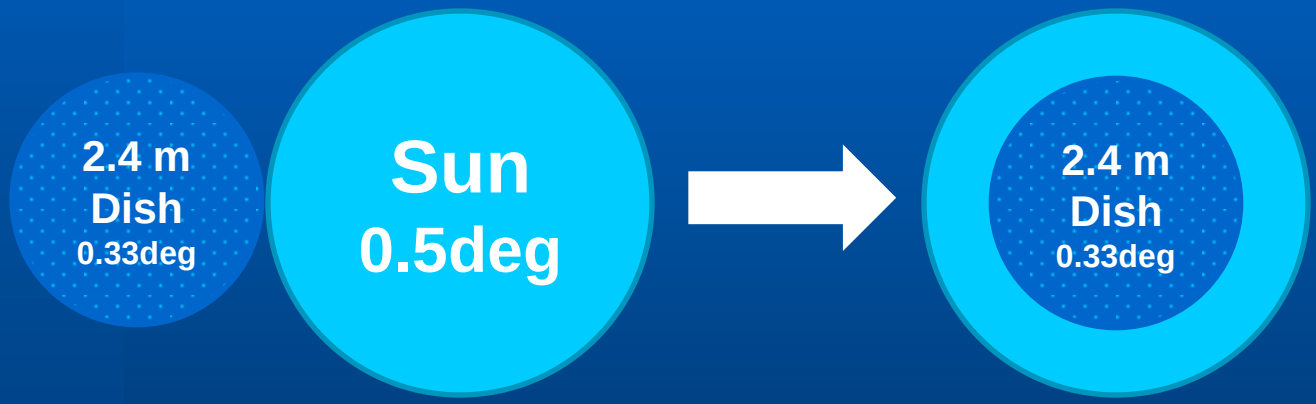
Antenna Gain Can Be Too High !

8 ft Dish 3.4 - 78 GHz

- Difficult to test in Mid November from VE4 due to low Sun and limited window before trees.
- Sun is 0.5 Deg Wide Dish BW ~ 0.3 deg, (54 dBi Gain)
- Needed to Re-Test on Smaller Dish

24 GHz Sun Noise with 2.4 m Dish

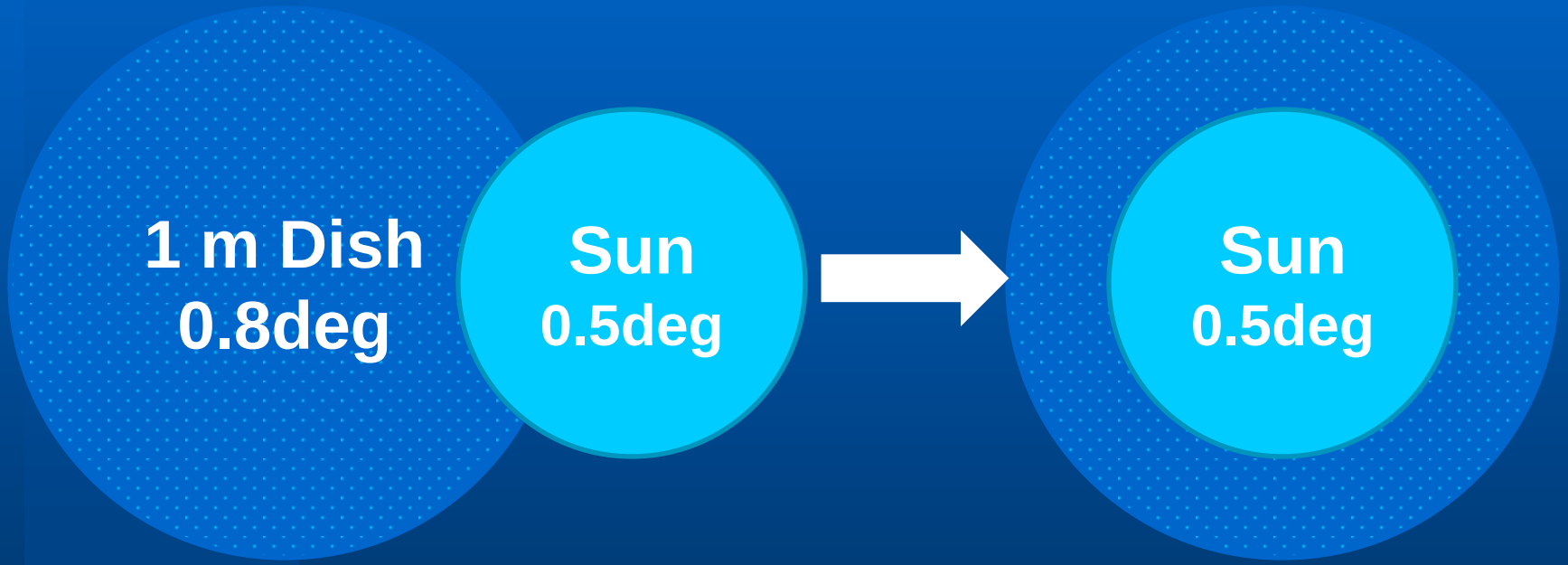
- **Antenna BW less than Sun/Moon Diameter**



- **Increasing Antenna Gain Does Not Increase Noise!**

24 GHz Sun Noise with 1m Dish

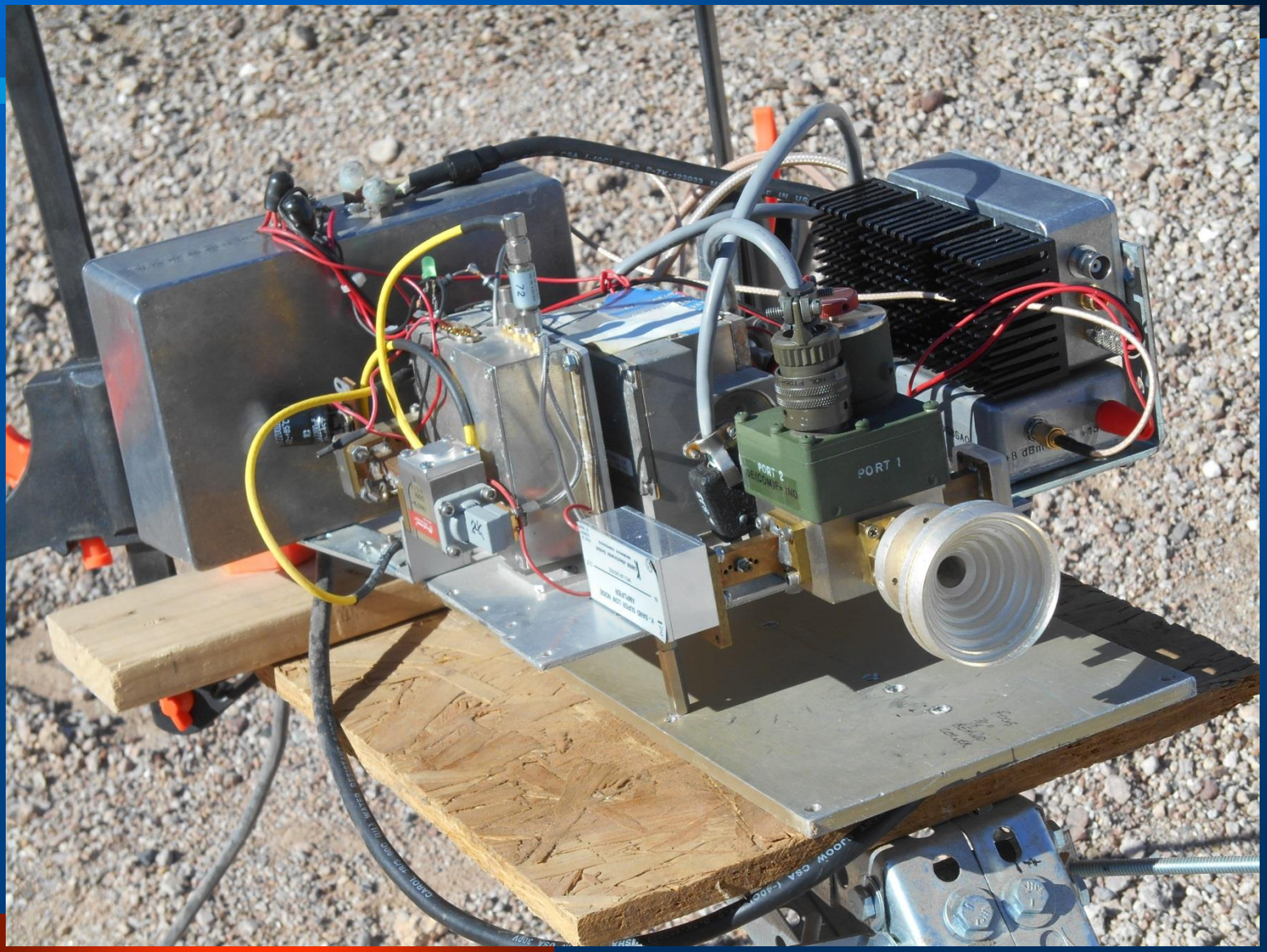
- Antenna BW Larger Than Sun Diameter



- Increasing Antenna Gain WILL Increase Noise Until BW Equals Sun Diameter

24 GHz Sun Noise on 1 m Dish

24 GHz Sun Noise on 1 m Dish



24 GHz Sun Noise on 1m Dish

- **Best Sun Noise was 10.2 dB ~46 dB Gain**

  (I see 14 -16dB at home with 2.4 m dish ~54 dBi Gain)

- **Best Result from**

  Corrugated Horn and

  1.8 WL W2IMU Feedhorn

How to Compare Sun Noise Readings?

- At Low Ratios the measurements are actually Signal plus Noise……???
- Consider a Reading of 3 dB…..the Sun Noise is the same level as the Noise (0 dB each)
- To convert to Signal to Noise, must convert dBs to Ratios then substitute into equation

  S/N = (S + N)/ N + 1

  So in our example S/N = 1

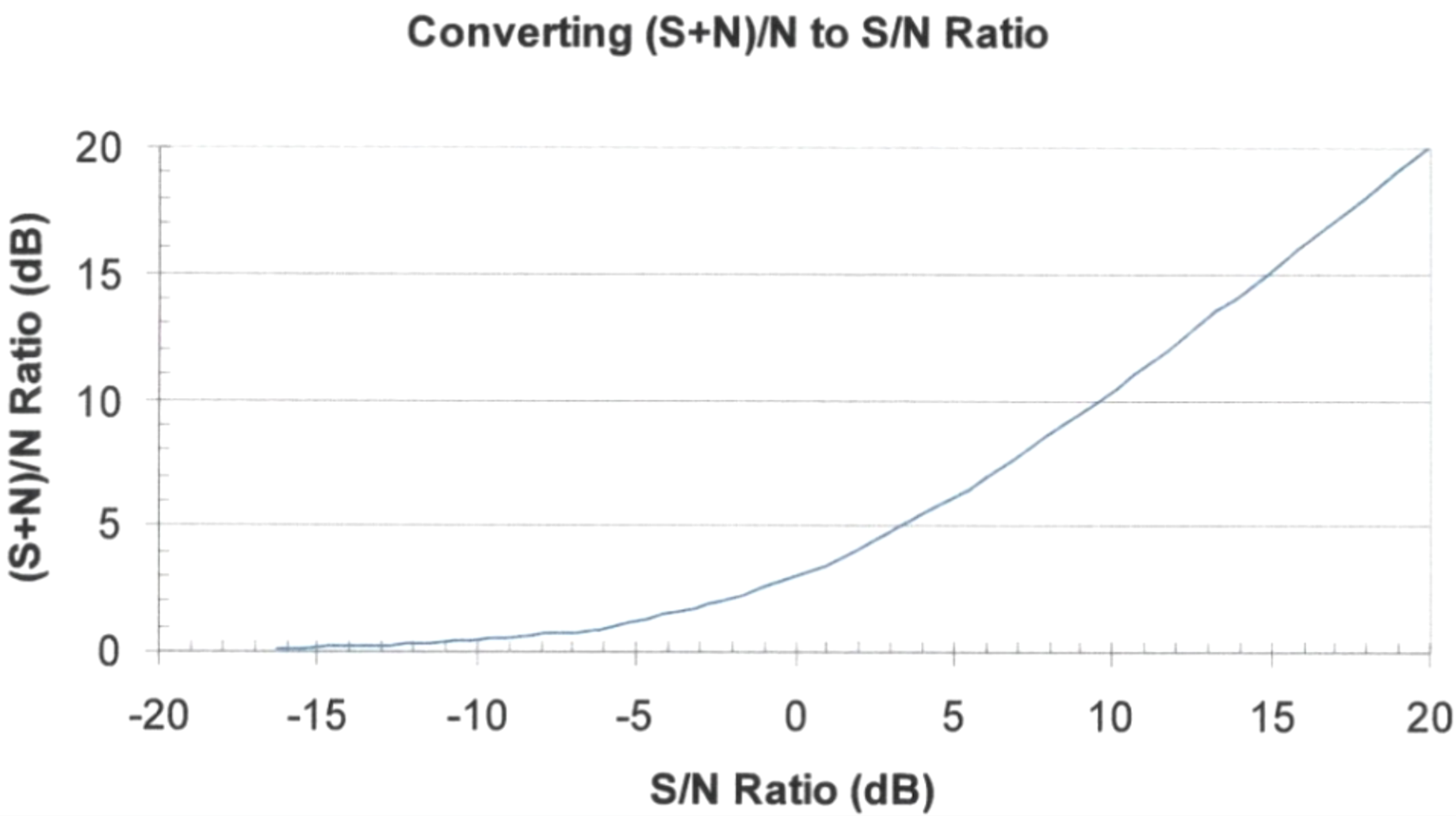
Converting (S+N)/N to S/N Ratio

S+N/N	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
S/N	-19.4	-16.3	-13.3	-11.5	-10.2	-9.1	-8.3	-7.7	-6.9	-6.4

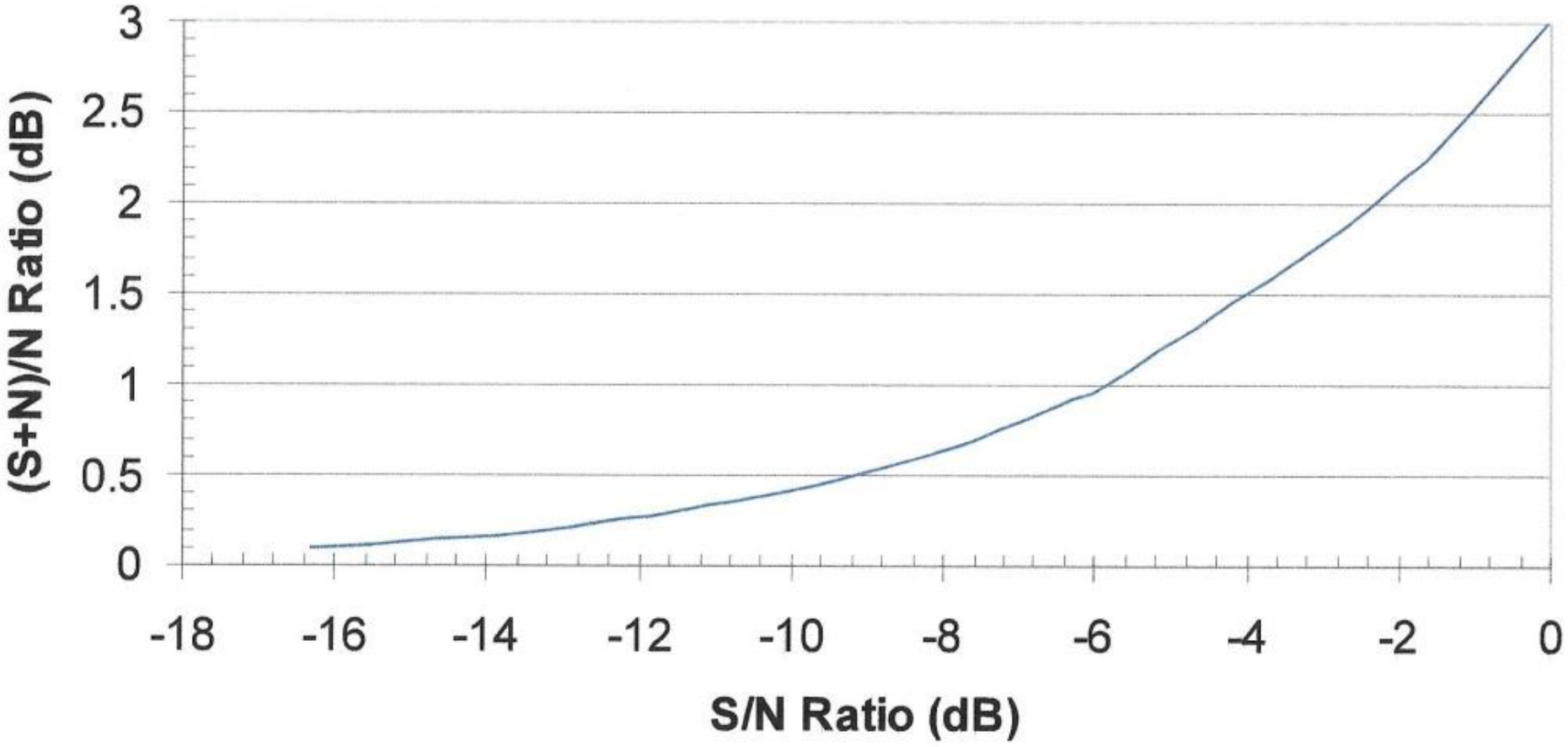
S+N/N	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
S/N	-5.9	-2.3	-0.0	1.8	3.3	4.7	6.0	7.3	8.4	9.5

S+N/N	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
S/N	10.6	11.7	12.8	13.8	14.9	15.9	16.9	17.9	18.9	20.0

Converting (S+N)/N to S/N Ratio



Converting (S+N)/N to S/N Ratio Expanded Scale



Measurement Method of Procedure

- Use the Graph or Table Values to convert S+N / N Readings to S/N values
- Use S/N Values to Determine Antenna Gain using Reference Gain Antenna
- Use S+N/ N Values to Evaluate System Performance Relative to VK3UM Predictions
- Use S/N Values to Compare Different Antennas

Sample Measurement Results

Callsign	Antenna Used	Sun Noise S+N/N (dB)	Signal to Noise (dB)	Comments
W0ZQ	24 in Offset	3.0	0.0	Best Measured
W0AUS	18 in Offset	2.0	-2.2	Loaner Rig
KC0IYT	18 in Offset	2.0	-2.2	Dish Network
WA2VOI	24 in Prime	1.5	-4.0	
WB0LIC	18 in Offset	1.5	-4.0	
W0ZQ	20 dB Horn	~0.05	~-18	Tiny Rig
K0KFC	32 in Offset	3.25	~+1	Arizona
K0KFC	32 in Offset	6.25	~+5	AZ EME Preamp

For Further Enlightenment

- See W1GHz's "Antenna Measurement Using the Sun" at http:www.qsl.net/n1bwt/chap10.pdf
- See W5LUA's "Using Sun Noise to Evaluate System Performance" at http://www.ntms.org/files/sun.pdf
- See VK3UM's "Sun Noise Measurements" at http://www.vk3um.com/SunNoise_Measurements.pdf

For Further Enlightenment Cont'd

- See UA3AVR's " Solar Flux and Temperature at Millimetre Wavelengths" in DUBUS 3/2016
- See I0NAA's "Total Power" software at http://i0naa.altervista.org/index.php/downloads

Using Sun Noise to Evaluate System Performance at VHF/ UHF and Microwave Summary

- Discover What You can do with Measurements
- Discuss the Radio system and Instrumentation Needed to Make Measurements
- How to Make Measurements
- How to Interpret the Results
- Result Predictions & Actual Results
- Questions?