Preparations for 78 GHz EME
The **NEXT** Final Frontier?

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Preparations for 78 GHz EME – The **NEXT** Final Front Frontier?

- **The Challenges**
- **The Technology**
- **Results to Date & Schedule**

Recall the First 47 GHz Echoes

- **RW3BP on July 24, 2004 “Outstanding! ”**
- **>100 Watts Output, 2.4 m Offset Dish, ~ 50 MW ERP!**
- **~4 dB NF “HB” Preamplifier, ~10 dB Sun, 1 dB Moon Noise**
- **Copied By AD6FP, VE4MA, VE7CLD, W5LUA**
- **But this was as good as it got !**

2.4 m Offset Fed Dish at RW3BP

78 GHz Feed on 2.4 m Dish at RW3BP

- First Tests in 2008
- 1 x UMS CHA1077 Preamp with a Fundamental Mixer ~ 6.5 dB DSB NF
- 5.8 dB of Sun Noise
- 0.53 dB of Moon Noise

EME Challenges at 78 GHz

- **Rough surface of moon produces very rough sounding note – like aurora**
- **Spreading can be several hundred Hz making the use of very narrow bandwidth IF filters impossible**
- **Doppler shift upwards of +200 kHz on rising moon and –200kHz on setting moon**
- **Antenna beamwidths less than half the 0.5º subtended angle of the moon**

Atmospheric Effects at 78 GHz

- **Unlike 24 GHz, but like 47 GHz , 78 GHz is not significantly affected by Humidity on an EME path**
  - **– it is a relatively thin slice of atmosphere**
- **Oxygen absorption is present at minimum levels**
- **Best EME conditions occur ????**

Best EME Conditions at 78 GHz

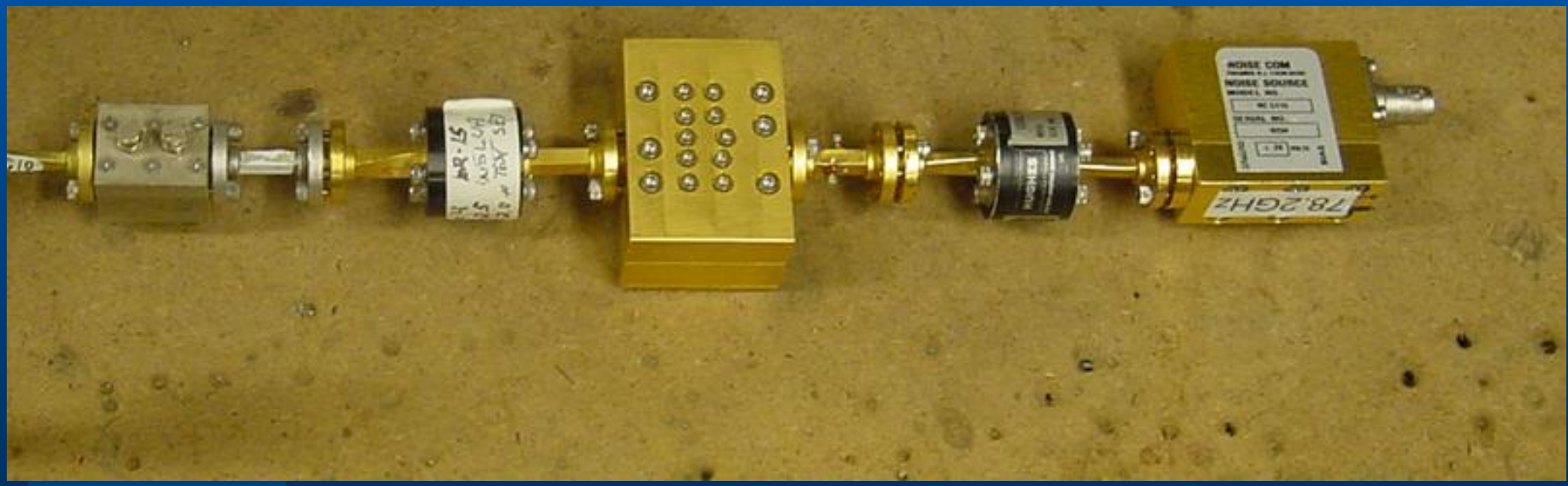
- Atmospheric absorption worst on horizon
- Doppler shift is extreme near horizon
  - Tracking programs calculate very closely
- Signal Spreading is more severe as moon moves to zenith
  - But now can be predicted using software

78 GHz System Requirements

- **Experience from 47 GHz work**
- **Best Available Hardware was not Good Enough**
  - **~ 4 DB NF Preamps**
  - **1.8 - 2.4 m Offset Dishes (~57-60 dB Gain)**
  - **30 W output**
- **NO Signals Heard !**
- **Predictions Said “More System Gain Needed” (NF, Ant Gain, or TX Power)..6 dB Needed**

78 GHz System Hardware: Preamps

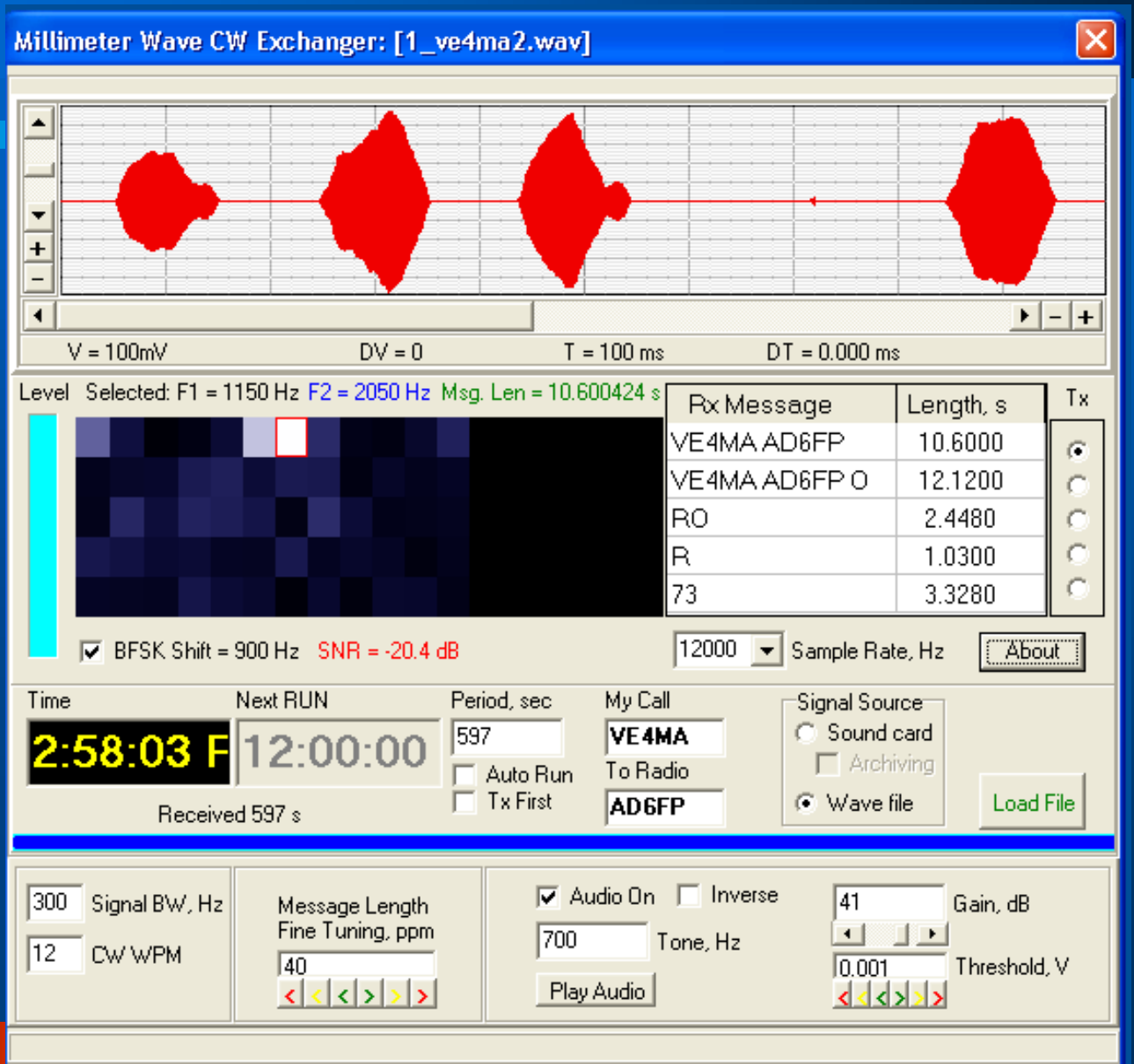
- **WA1MBA Preamplifier of course**
- **~ 3 dB NF Preamps so System NF ~3.5 dB**



78 GHz EME RX Improvement?

- **RW3BP Software "Extends The Receive Threshold"**
  - **Signal Spread from 300 to 450 Hz Wide**
  - **Long Transmission Periods**
  - **CW Transmission**
  - **BFSK & "Special" CW Modulation**
- **Time Averaging Techniques to Extend Minimum RX Threshold**
- **CW Playback of Averaged Signal**
- **Newer Software JT4???**

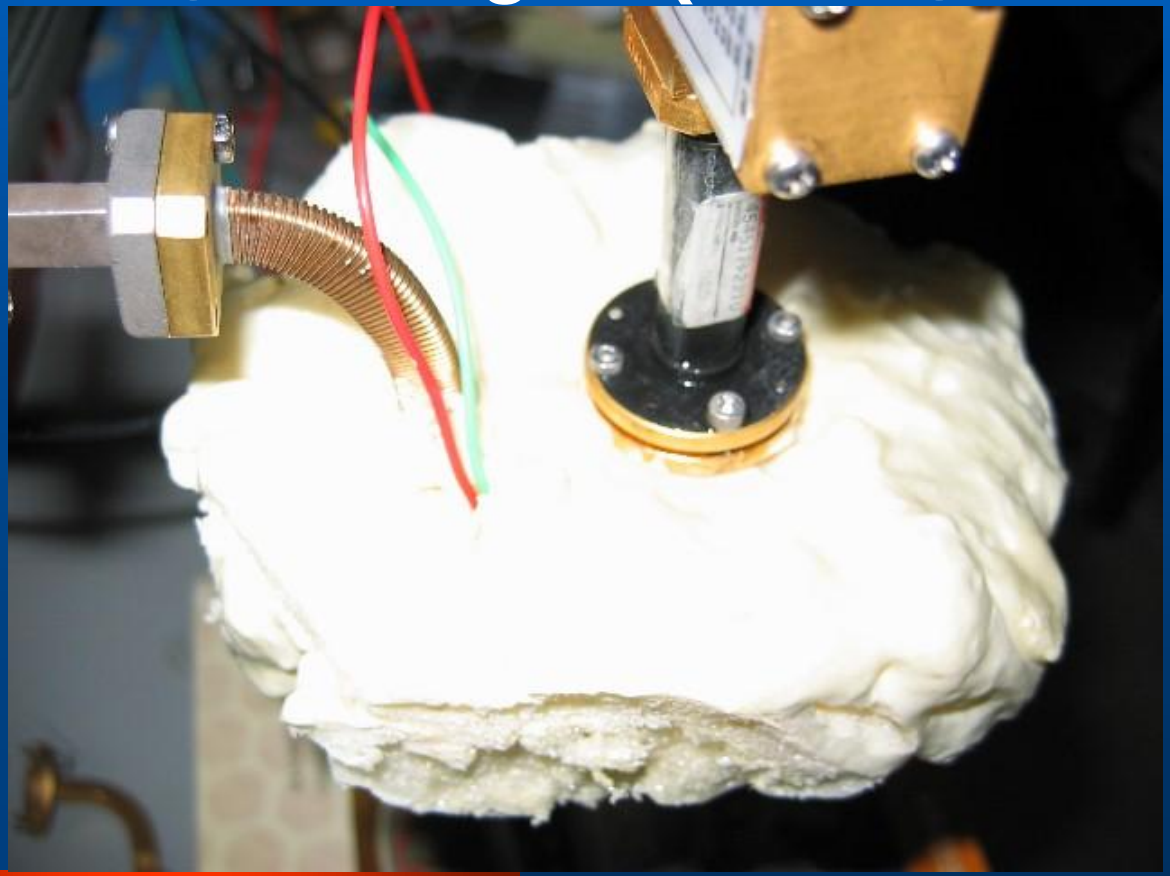
mmWave EME Software



Better RX Performance With Cooling?

Better 47 GHz RX Performance With Liquid Nitrogen Cooling?

- **1.5 NF @ 77 deg K (4 dB @ 290 K)**



78 GHz System Hardware: Preamps

- **Preamps will not withstand LN2….but Dry Ice?**
- **Noise Figure of RX Mixer still needs to be Very Good ~6 dB SSB**
- **Standard Subharmonic Mixer ~13 dB NF , so must use Fundamental mixer**

78 GHz System Hardware: Antennas

- **2.4m dishes were Marginal at 47 GHz**
- **1.8m dish of AD6FP provided best performance**
- **Test Big and Small Dishes at 78 GHz**
- **Even 1m dish has ~57 dB gain and 0.5 deg BW**
- **Perfect 2.4 m dish has 63 dB gain & 0.11 BW**
- **The moon is only 0.5 degrees wide**

AD6FP 47 GHz 1.8 Meter Dish

78 GHz Dish Tests at W5LUA

- Tests on 2.4 m & 1m Dishes
- Best Results from a 1m TV mini-dish
- 7 dB Sun Noise, 0.75 dB Moon Noise
- 50 Ohm/ Cold Sky 1.2 dB Ta = 133K
- Still Room to Optimize

78 GHz Dish Tests at VE4MA

- Better results from a 2.4m TV dish than W5LUA, but only have 6.1 dB NF so far
- 3.5 dB Sun Noise on 2.4m
- Only 2.8 dB on 33 inch mini-dish mounted like W5LUA

78 GHz Dish Tests at VE4MA

- Best Results from a 1.2m Satellite dish
- 4.8 dB Sun Noise, still 6.1 dB NF
- Dish was old Hughes DirecWay “KA” dish with aluminum foil added

78 GHz System Hardware: Transmitter

- **In 2008 we said 100 W tubes on market , but custom built and cost of about $100K….so unlike available to amateurs**

78 GHz System Hardware: Transmitter

- **“I WON the LOTTERY !”**
- **73 Watt Klystron Oscillator**
- **Tested on 78160 MHz +/- 82 MHz**
- **This Tube was One of Four**
- **The Search Continues for a Companion Tube**

78 GHz System Hardware: Transmitter

- **Needs 9 kV Power Supply and Really Good Water Cooling system**
  - **Have HV Extension Cable**
  - **Water Cooling in Sub Freezing Temperatures?**
- **Will need to be Phase Locked and FSK'd for Modulation**

RW3BP Software Technical Requirements

- **Hold Frequency Within 200 Hz for 10 Min**
  - **Need to Correct for Doppler ….Exactly and correct at ~700 Hz / minute**
- **Phase Locking Simple Now?**
- **Use Reflock or ??…Simple Plug & Play??**
- **Need Interface to HVPS for Phase Lock**

Varian 13 kV Power Supply Mods

(2006) The First 80 GHz EME QSO ?

- **80 GHz Will Be MORE Difficult !**
- **CPI Canada makes 80 W Tubes ~$100K!**
- **5 dB NF Preamplifier Chips Available**
- **Dish Performance Questionable?**
- **80 GHz EME QSOs….Unlikely**

The First 78 GHz EME Work?

- Echoes within a year ???
- Have 1 Tube …need second one for a QSO
- Or can we send one Tube back and forth???
- Good Dish Preamp & Dish Performance
- Stations working toward 78 GHz EME , RW3BP, VE4MA & W5LUA
- Lots of Work Still Required to Make it Happen!

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- **Questions ???**