Field Experiments in RFI Detection using an Array

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Steve Ellingson
ellingson.1@osu.edu

http://esl.eng.ohio-state.edu/rfse/argus/rfse-argus.html

Introduction

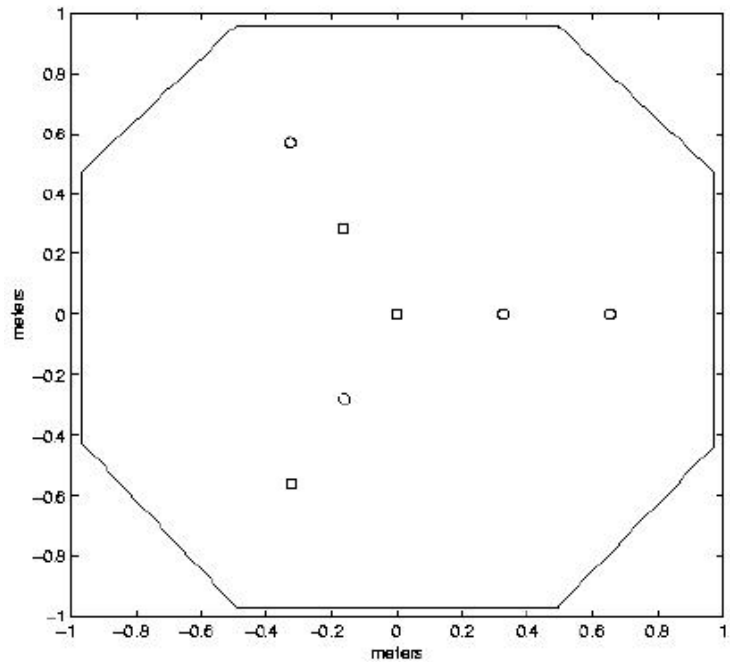
- Large array radio telescopes such as LOFAR, THEA, ATA will be the first radio telescopes designed from the beginning to include some form of “active” RFI mitigation
- So, what does this really entail?
- As a result of some experiments at OSU, we are developing some insights into the nature of the external RFI environment
- Types of experiments:
  - Angle of arrival (AOA) estimation
  - Patrolling
  - Deep Integration

Argus

- Testbed for developing omnidirectional microwave SETI technology
- Large array of elements with very broad patterns for nearly-hemispherical instantaneous field of view
- History:
  - Conceived by Bob Dixon in 1980's
  - Az-only experiment at 162 MHz in 1988
  - Various paper studies throughout the 1990's
  - Since 1998, a joint project of SETI Institute and OSU Dept. of Electrical Engineering
- Not a candidate SKA technology (sensitivity is sacrificed for FOV)
- Nevertheless, some interesting applications:
  SETI, transients, RFI monitoring and detection

460 MHz Az-Only Radio Source Localization (1999)

Y-shaped array of 7 quarter-wave monopoles on roof of ESL



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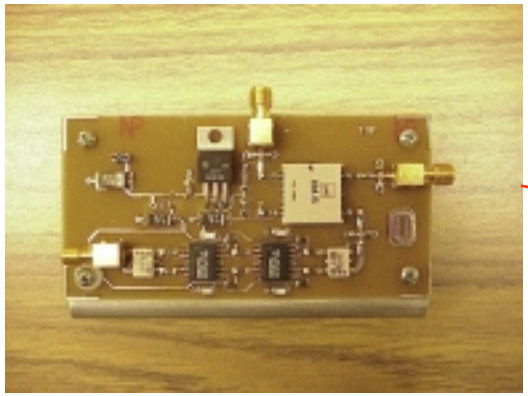
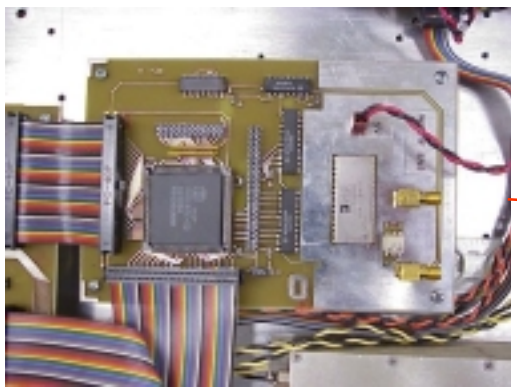
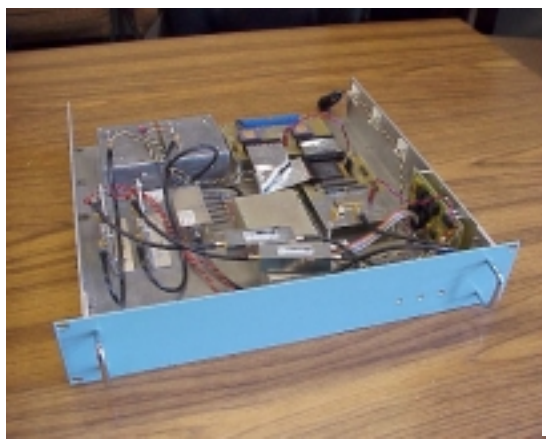
460 MHz Array Receiver



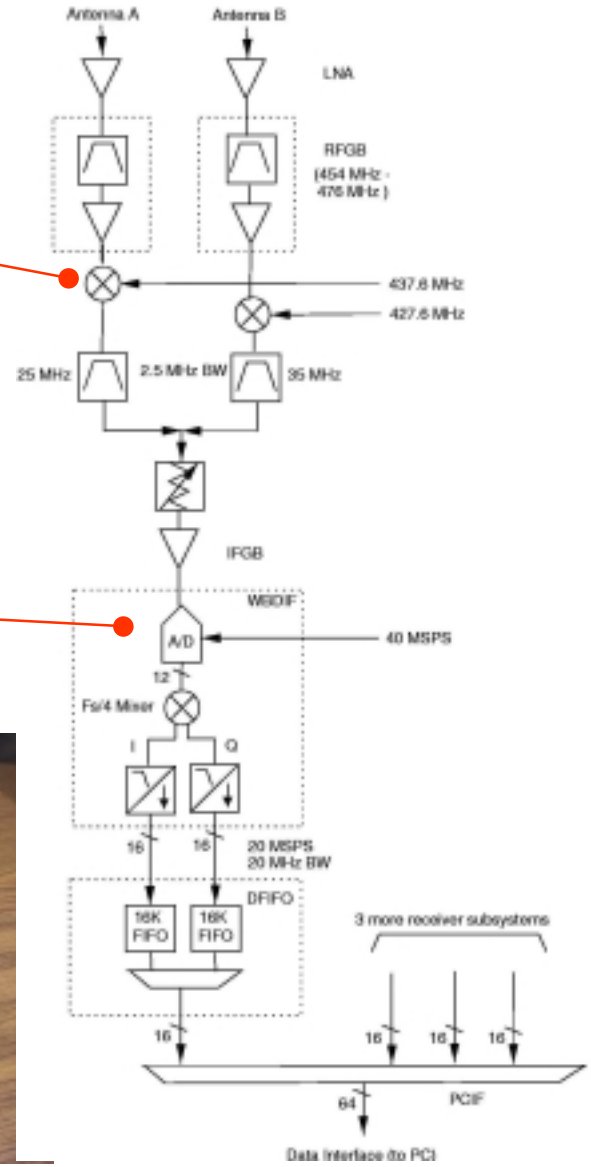
Active
FET mixer



40 MSPS A/D
& Fs/4 Digital
Downconverter



One of four
“dual receiver”
subsystems



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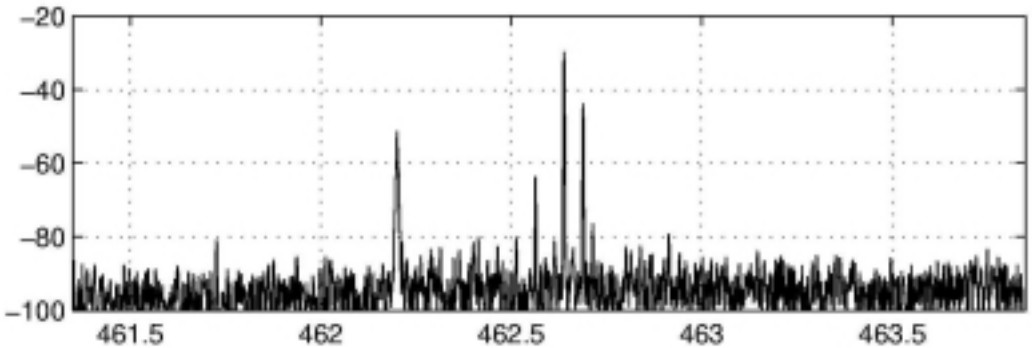
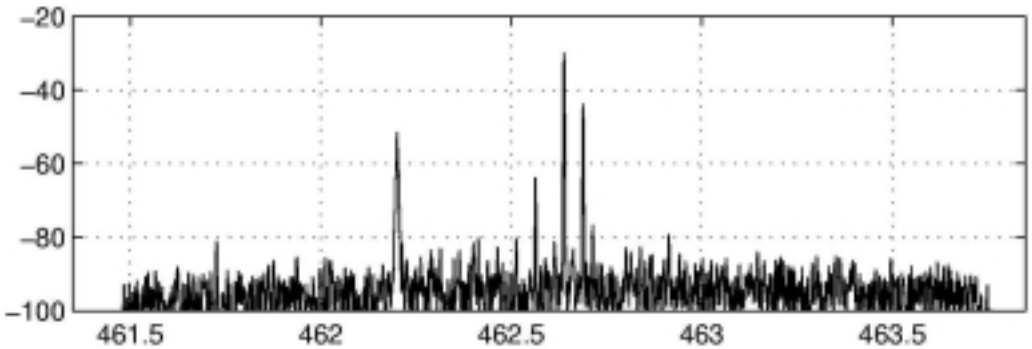
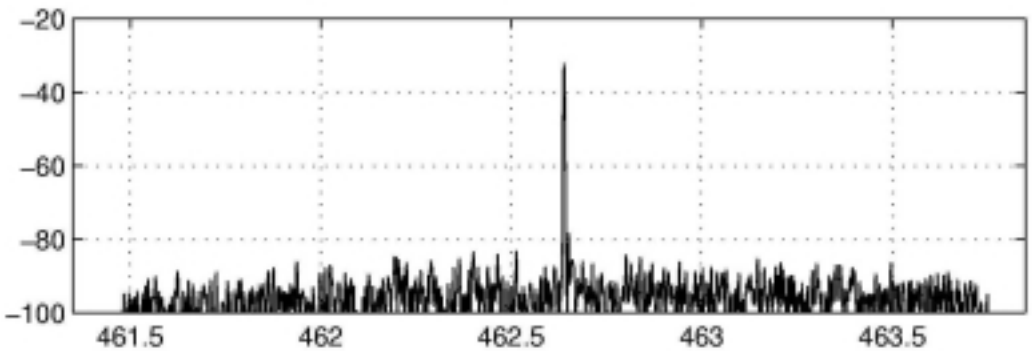
Digital IF Processing



A/D output
20 MSPS (bandpass)
16K samples



Filtered and decimated
5 MSPS (lowpass)
4K samples

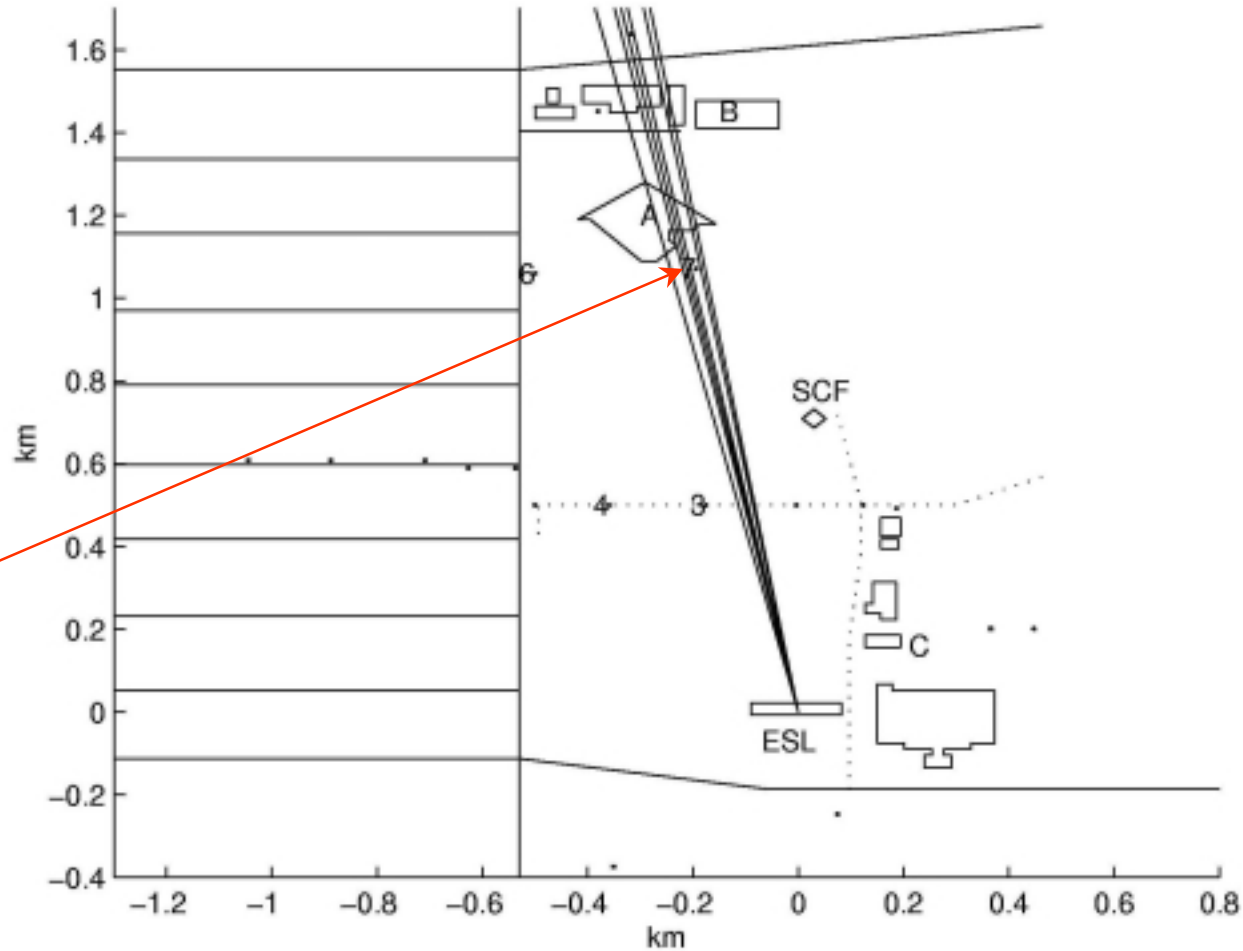


After removing all but signal-of-interest using a time-domain parametric estimation/ subtraction technique

Radio Source Localization

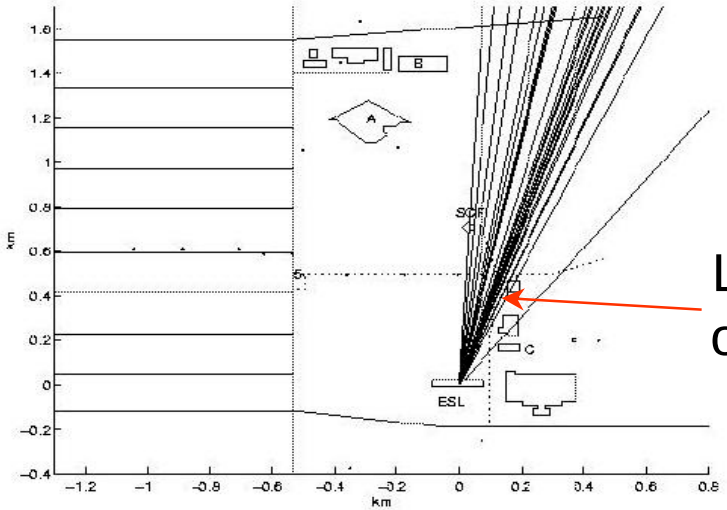
Lines of bearing estimated using "Maximum Likelihood" AOA estimation

Location of source



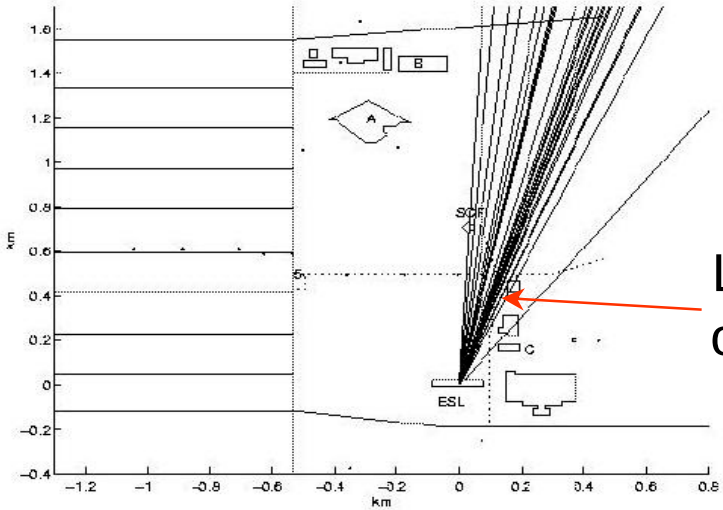
With about 10 dB S/N and 0.5 ms of data,
estimates possible with about 1º RMS error and negligible bias

Identification of Multipath



Location of source

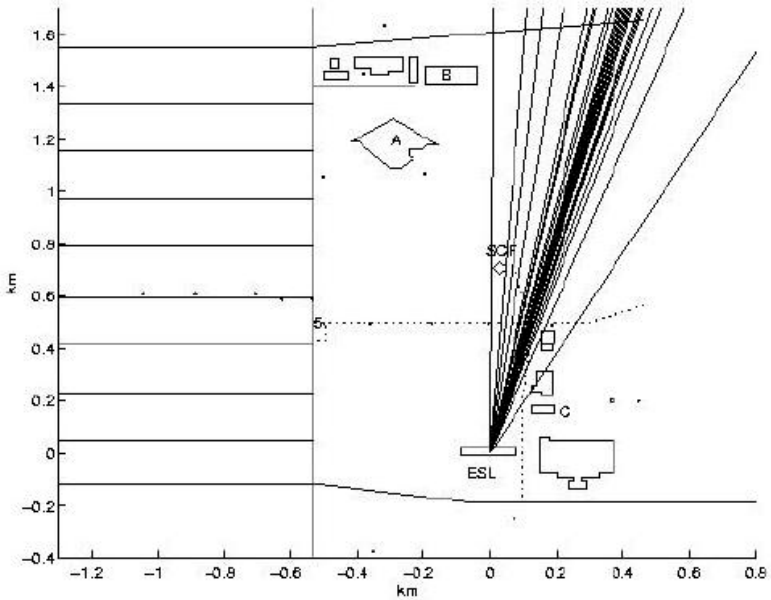
Identification of Multipath

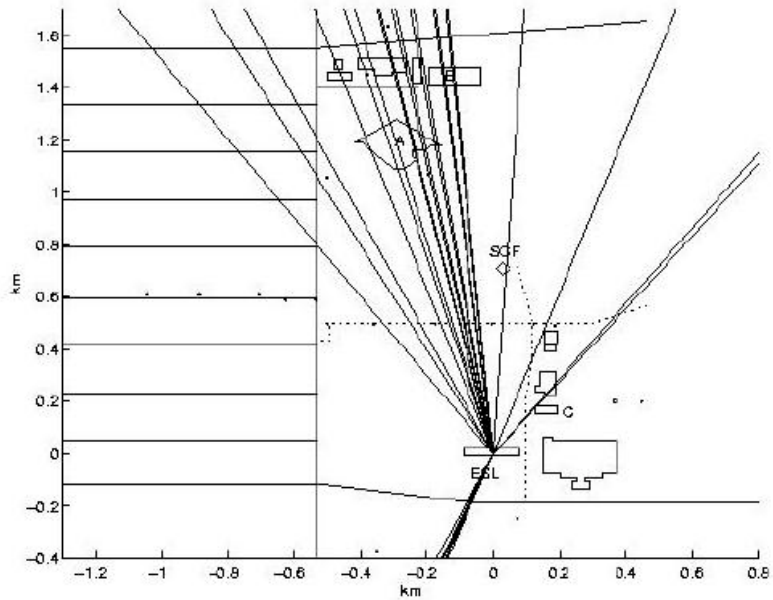


Estimation assuming 1 path

Location of source

Estimation assuming 2 paths





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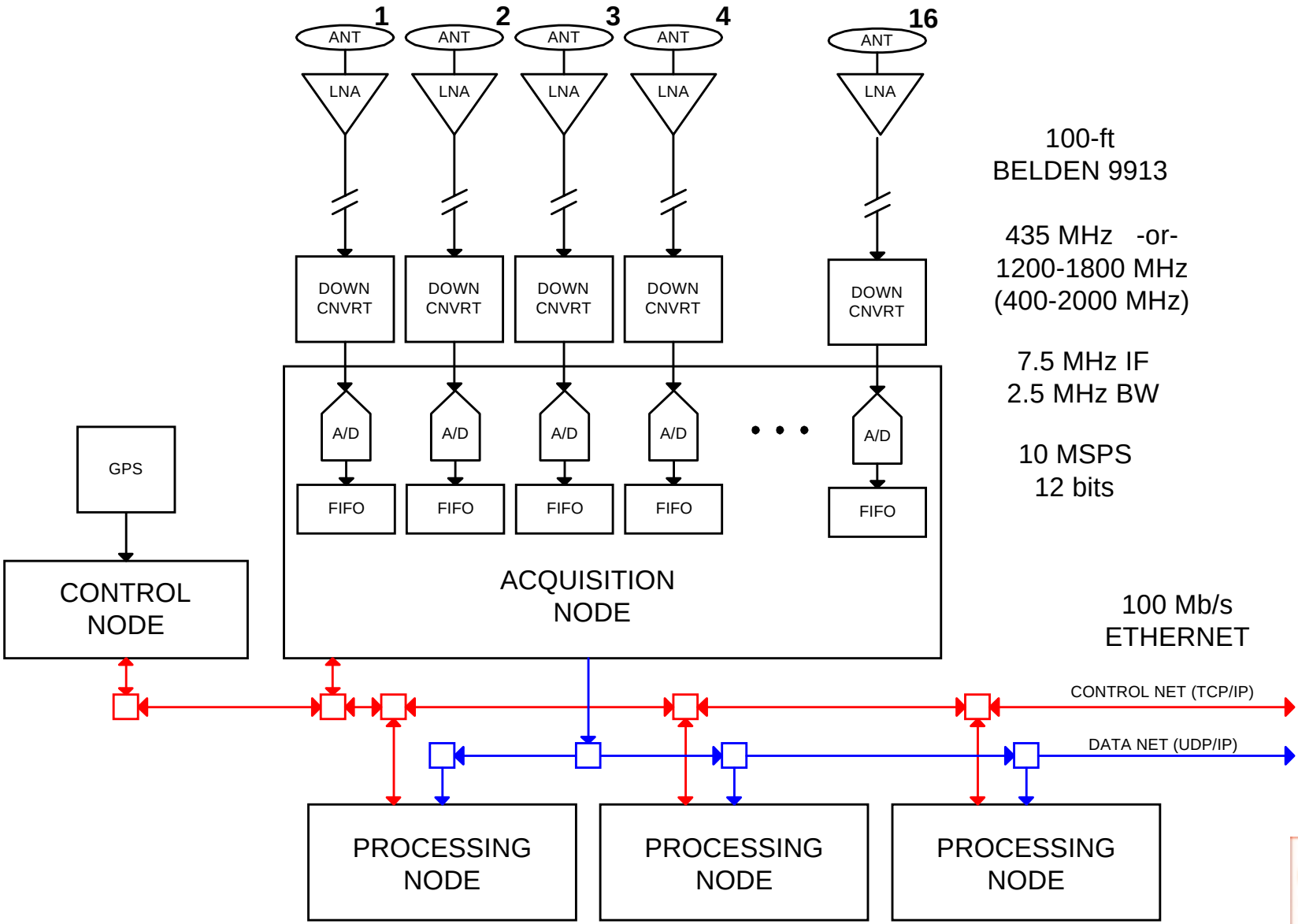
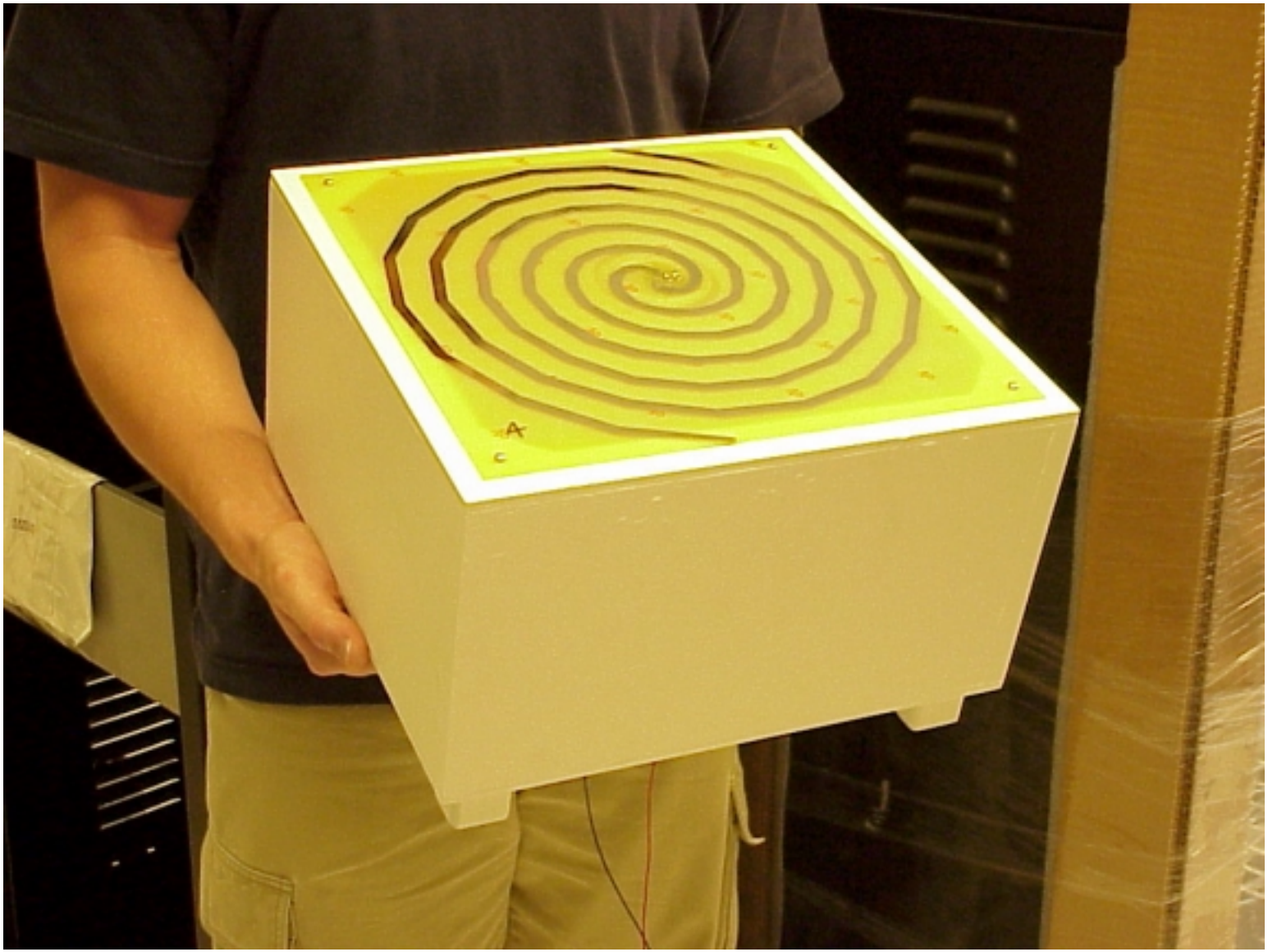
Argus System (as of July 2001)



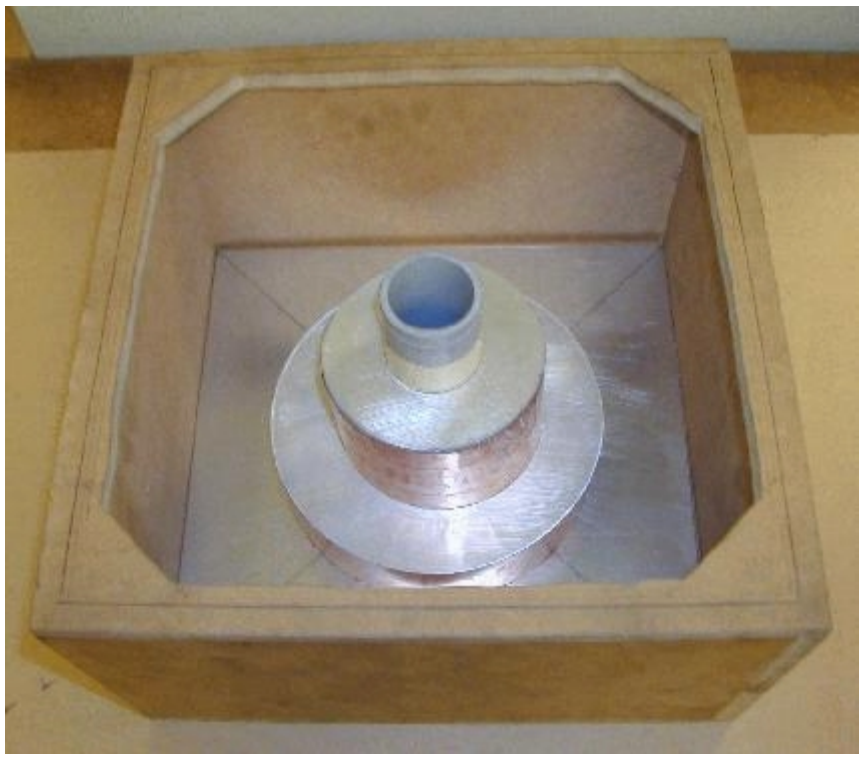
Site

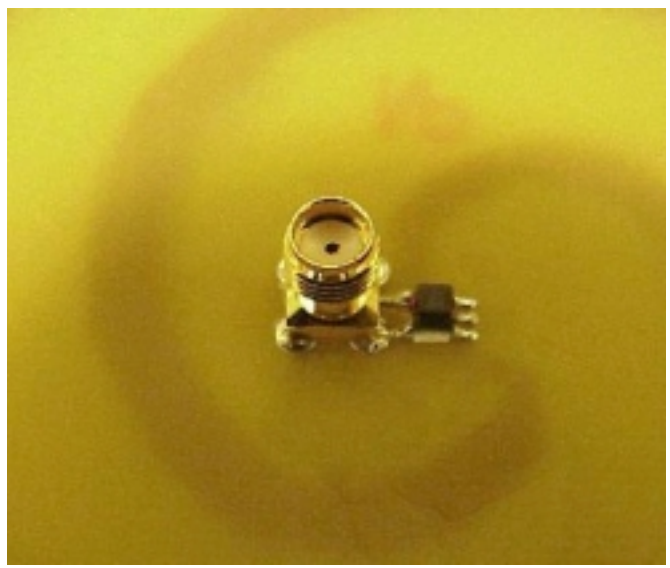
Antenna Arrays

Compact Spiral Antenna with Integrated LNA

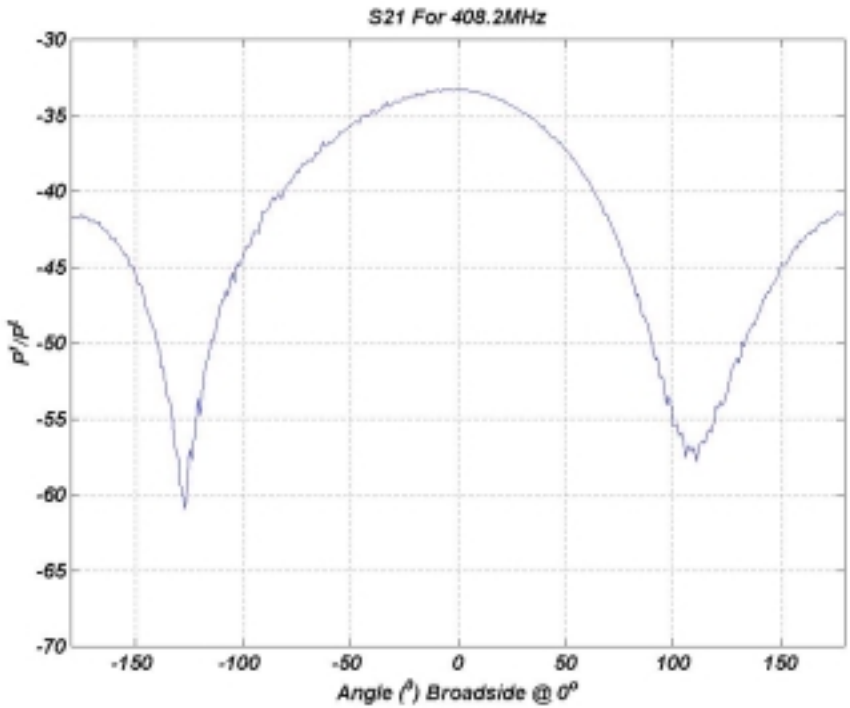


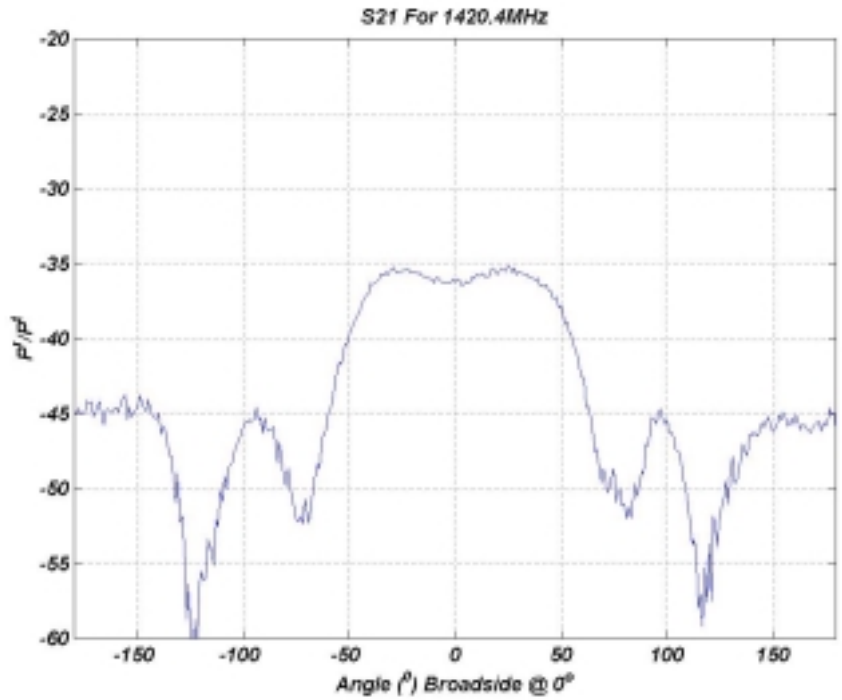
Spiral Antenna Contruction

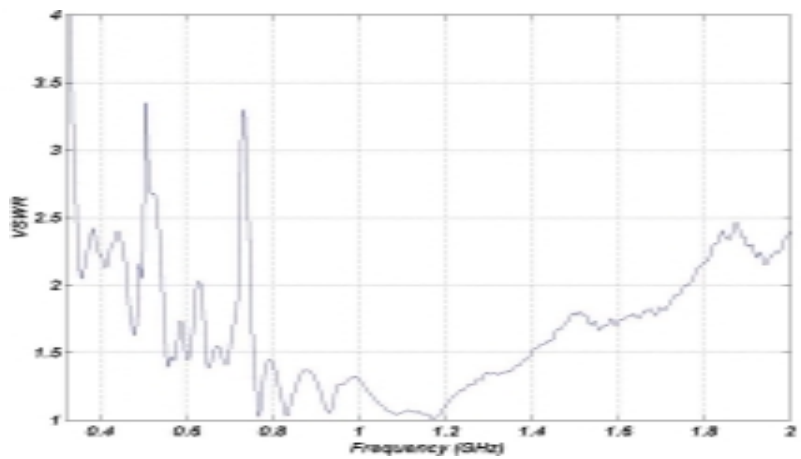




Spiral Antenna Performance







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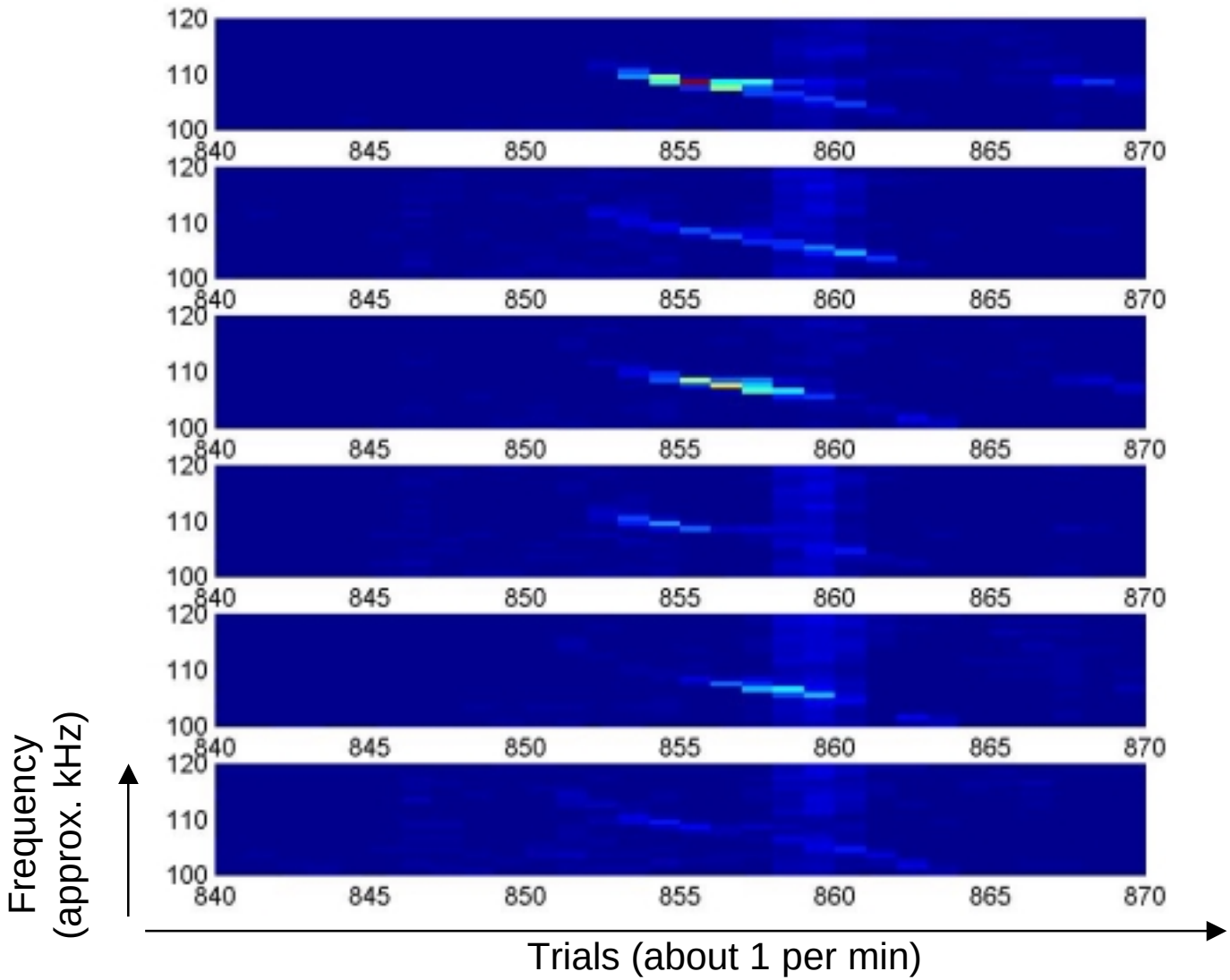
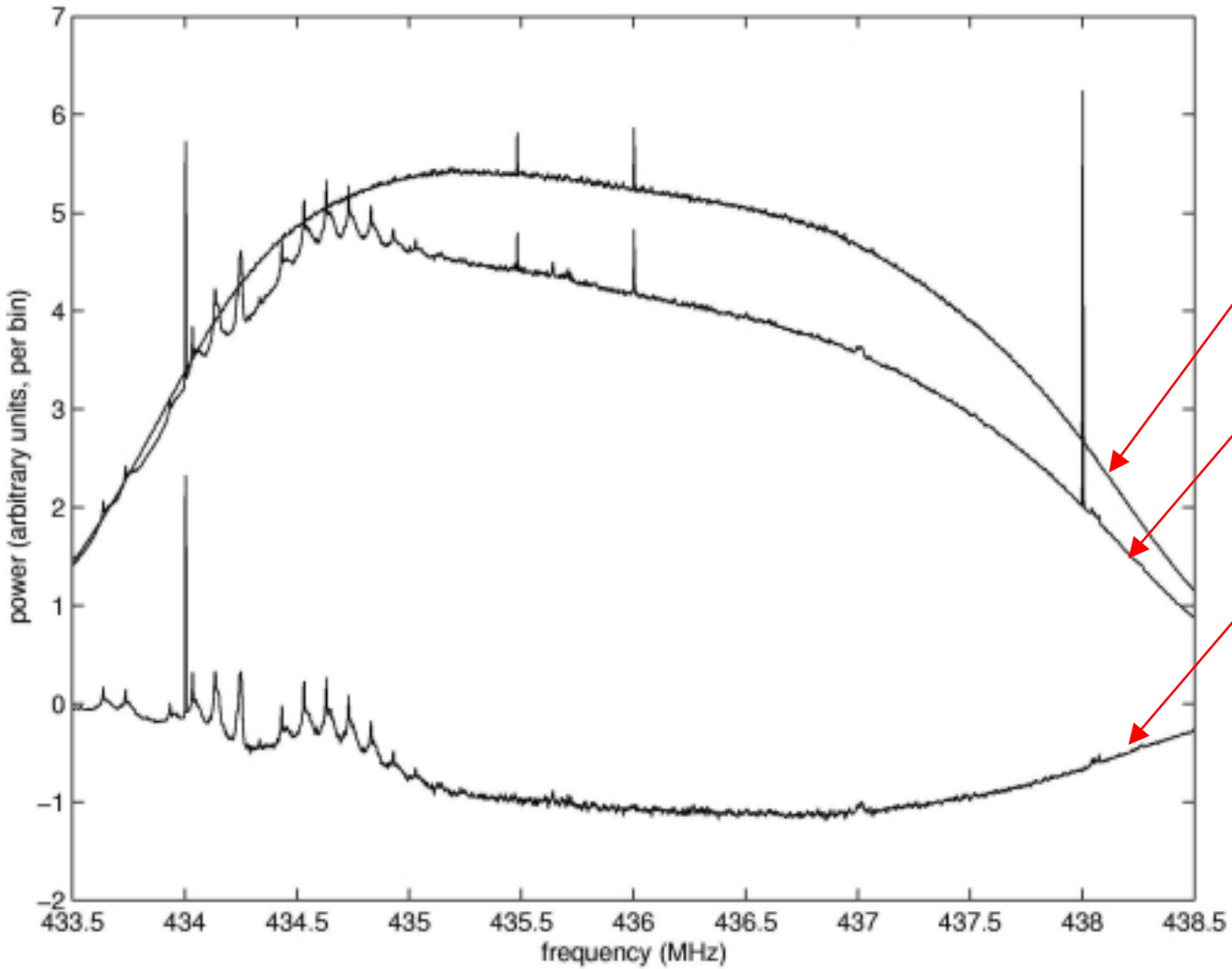
Some Specs

- Effective Aperture: on the order of 0.1 m^2 (frequency dependent) per N=8 elements
- System Temp: < 300 K (night)
- Acq. Duty Cycle: ≈ 3% max. (depends on processing)
- Spectrometer: 2048 channels, ≈ 1 kHz/channel
- All processing following A/D - including beamforming, spectrometry, and RFI mitigation - is implemented in C on Linux
- Have achieved detection and localization of strong continuum sources as well as the SETI League's 1296 MHz EME beacon
- Currently running a rudimentary SETI program

All-Sky Multibeam Patrolling at 435 MHz



Integration: 3.6 min over 15 h at 435 MHz



Cold load at LNA input

Antenna at LNA input

Difference

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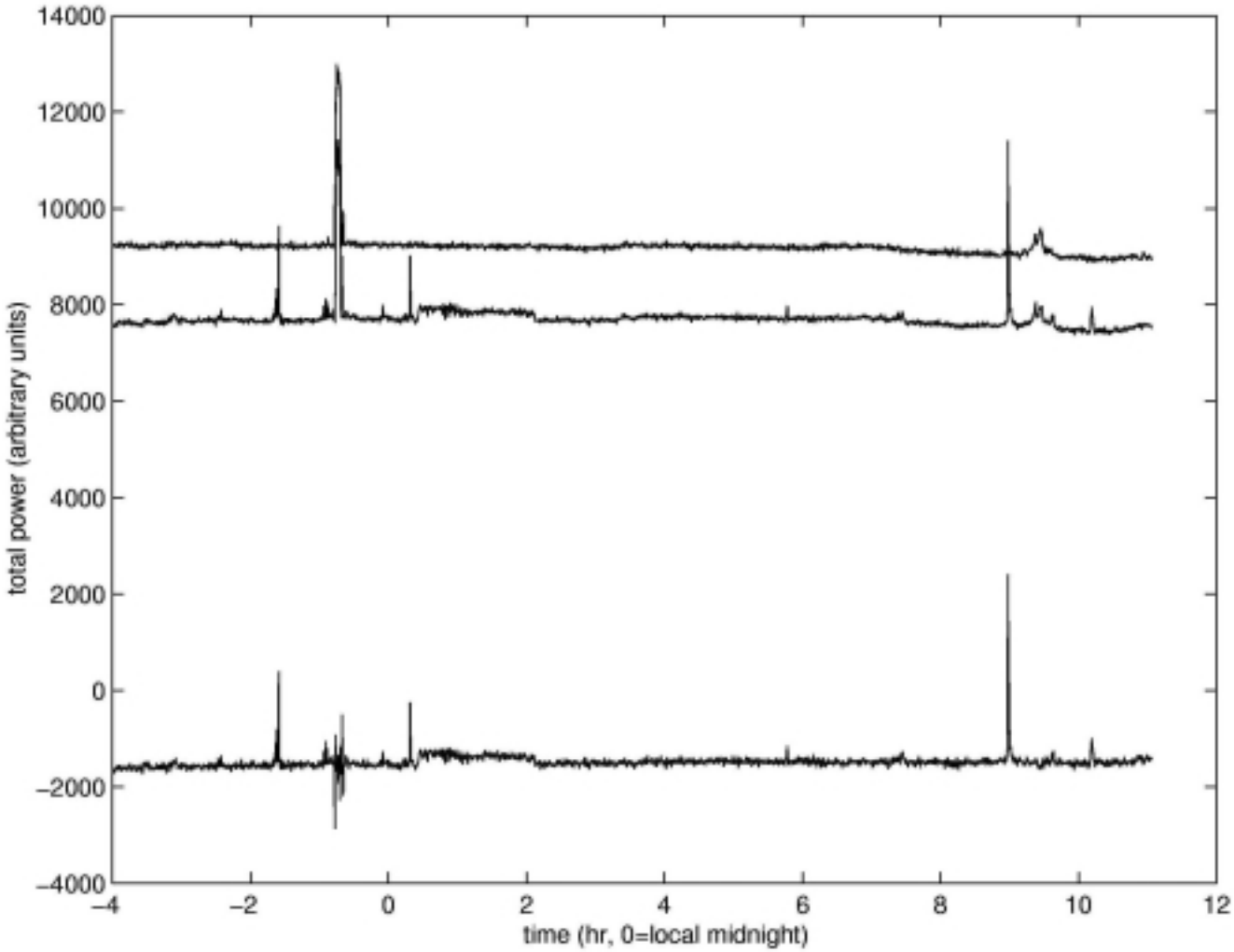
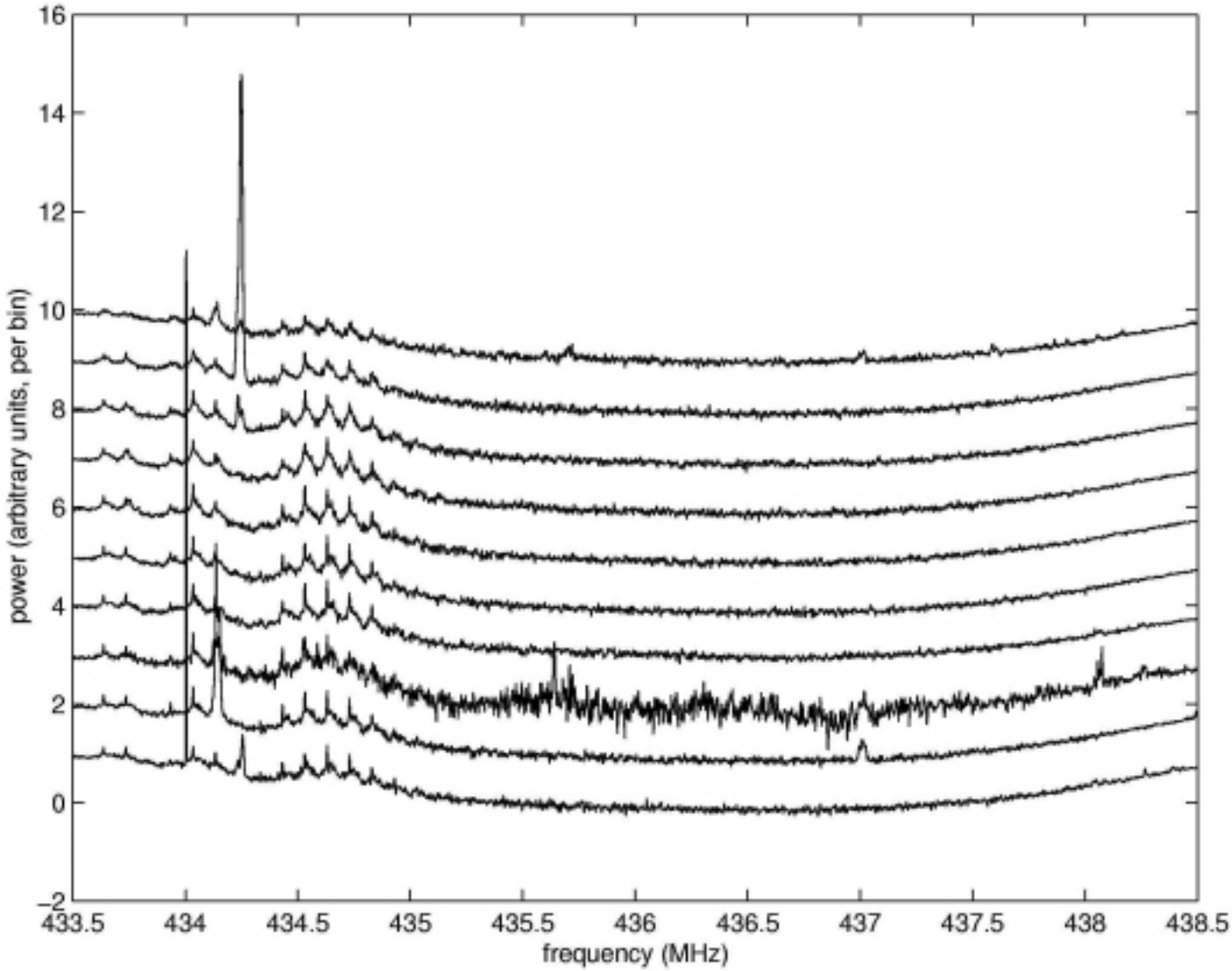
Same Experiment in Continuum/Time-Domain



Time Evolution of Integrated PSD



Previous result divided into 10 21.6-s integrations

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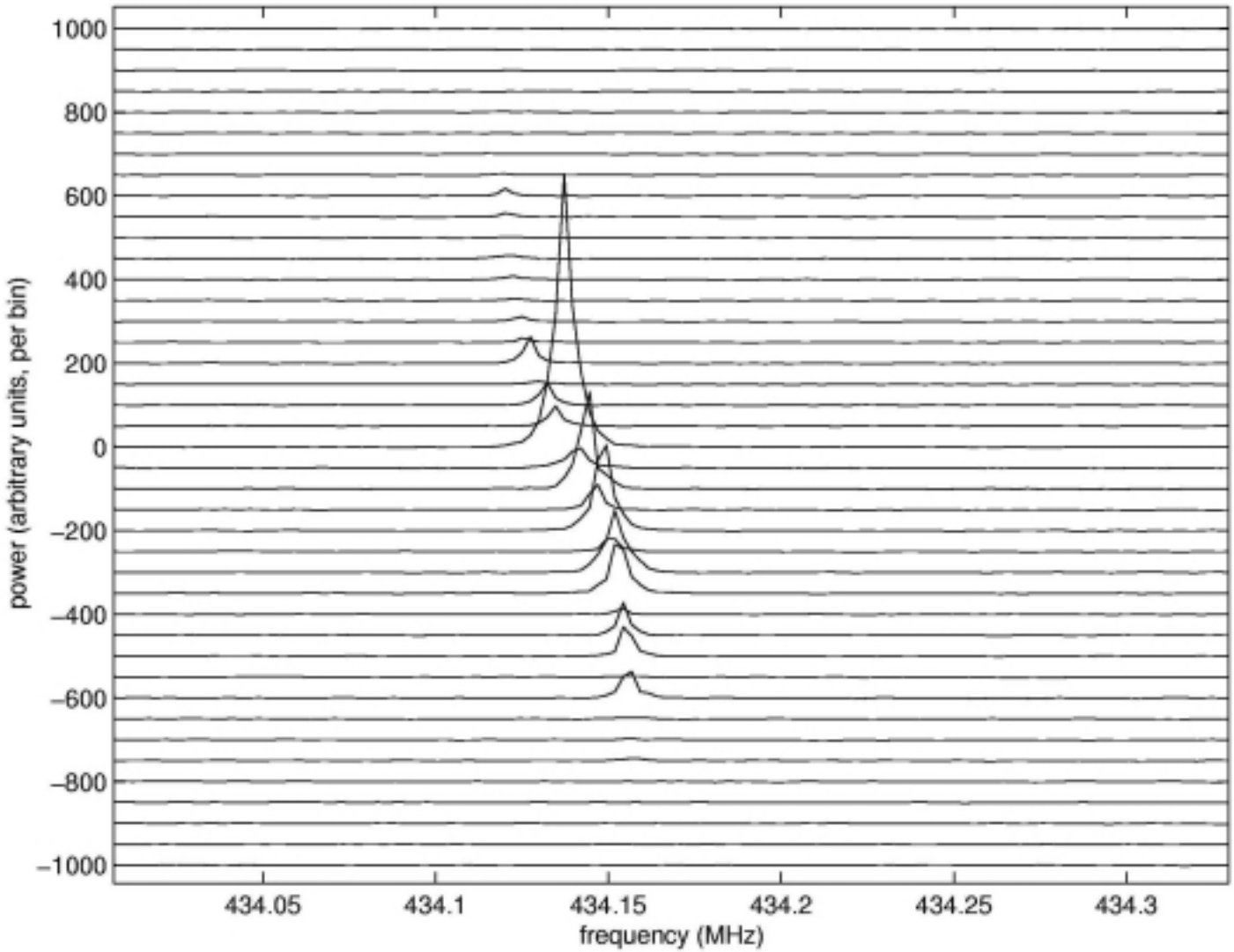
Identification of a LEO Satellite

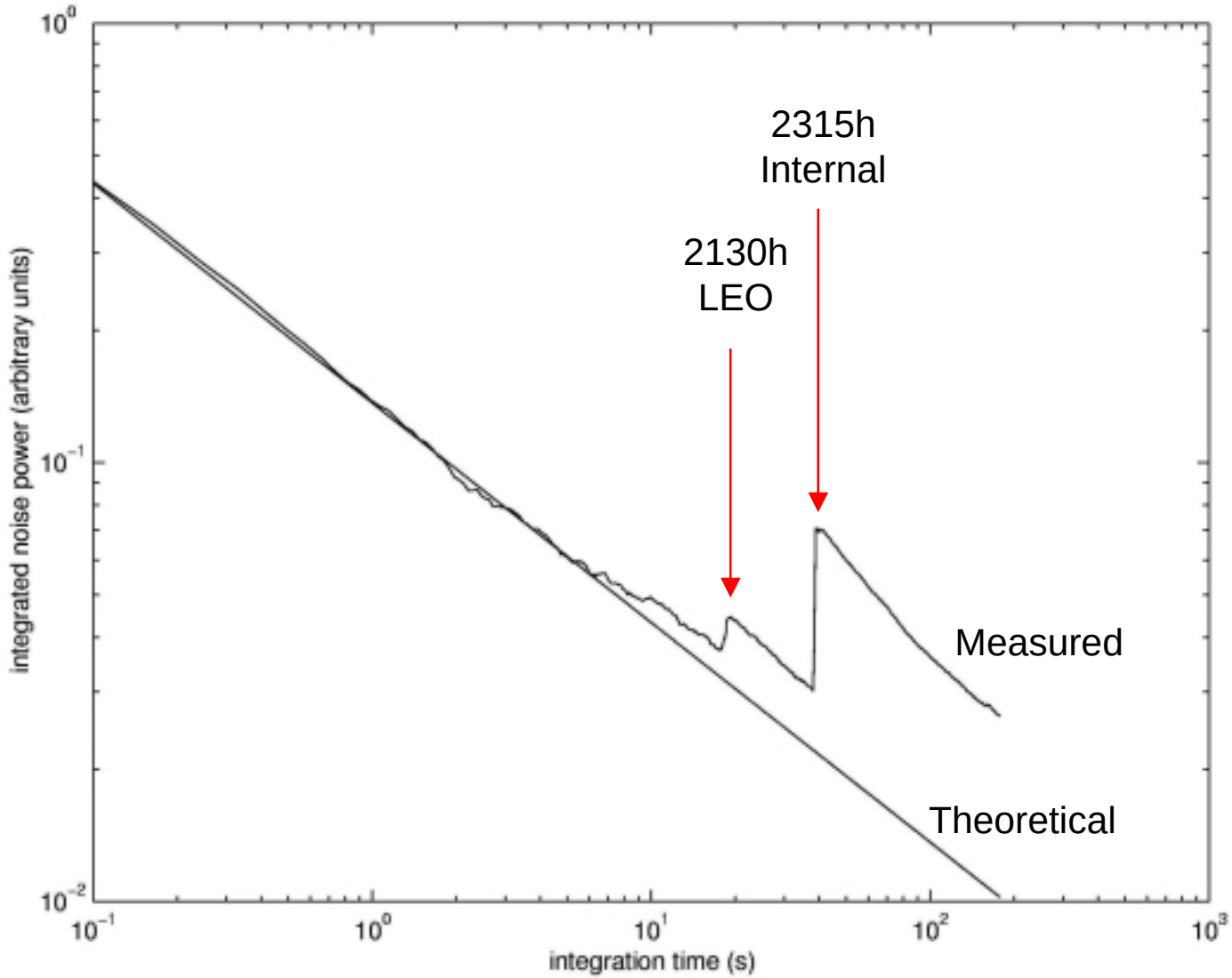


PSDs from 82-ms integrations, taken every 20 seconds

A Few of the LEO Satellites near 435 MHz

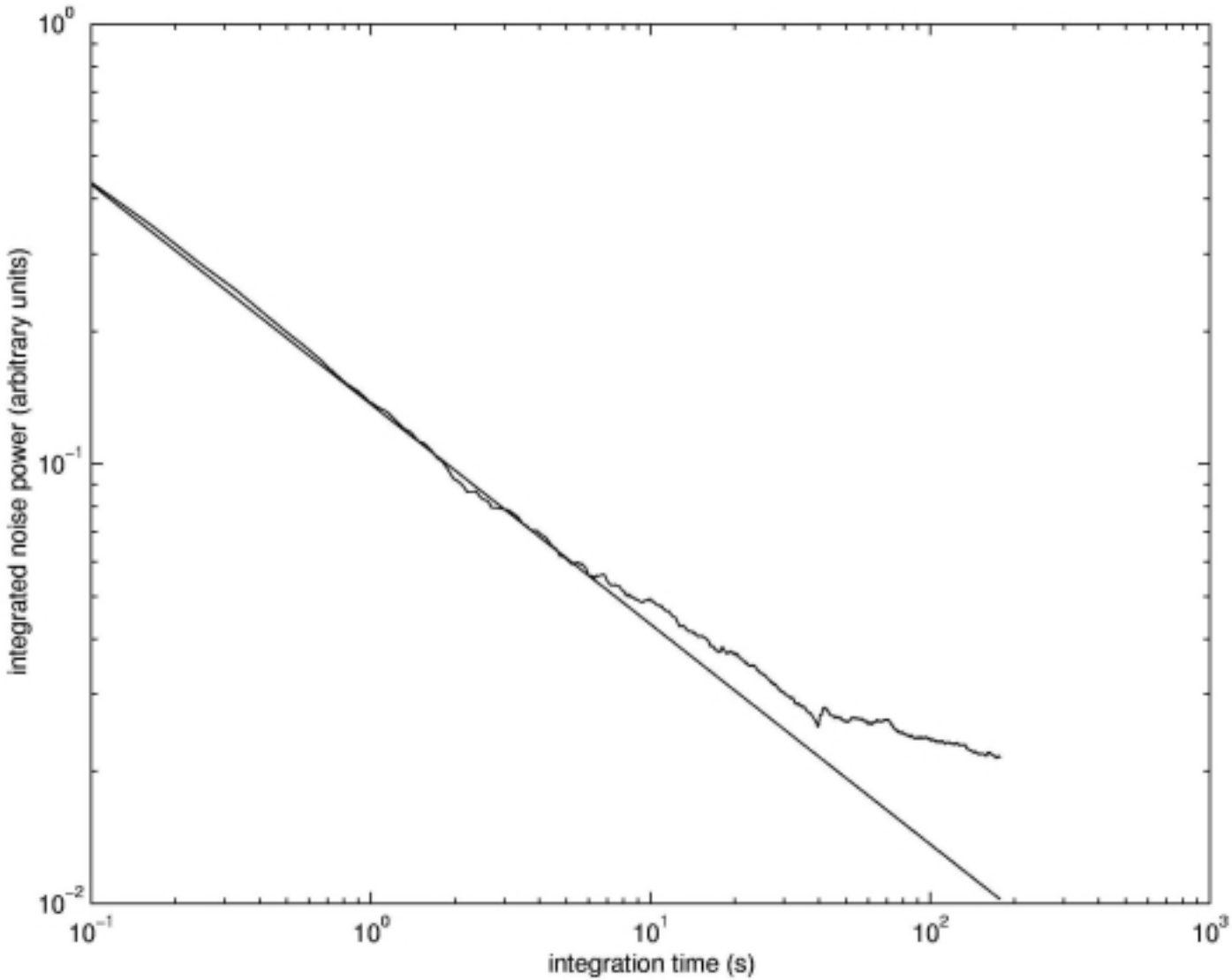
435.070 MHz	FM	UOSAT (UO-14)
435.12	FM	UOSAT (UO-22)
435.8-9	CW/USB(JA)	JAS-1b (FO-20)
435.8-9	CW/USB	JAS-2 (FO-29)
435.822	SSB	ITAMSAT (IO-26)
436.5	FM	KITSAT (KO-25)
436.792	FM	AO-27
436.925	FSK	TMSAT-1 (TO-31)
437.0,4	FSK	UOSAT-12 (UO-36)
437.025	SSB/PSK	PACSAT (AO-16)
437.12	CW	LUSAT (LO-19)

Effect on Sensitivity



Using 1.3-MHz "sweet spot" in measured spectrum

Same Experiment with Blanking



Concluding Remarks

- For more information on the AOA experiments, see paper in the June 2001 *IEEE Trans. Antennas & Propagation*

- Argus web site:
  http://esl.eng.ohio-state.edu/rfse/argus/rfse-argus.html

- Acknowledgements: Brian Baertlein, Gene Whipps, Ken Ayotte, Jim Hetrick, Emarit Ranu, Bob Dixon