Design and Demonstration of an Antenna for a New 27-49 MHz Radio Telescope Array

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http://www.ece.vt.edu/swe/eta

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**Eight meter wavelength Transient Array (ETA)**

- Array of 12 38-MHz resonant dual-polarized dipoles ($A_e \sim 476 \text{ m}^2$)

- Continuous, all-sky, low-frequency, “source agnostic” search for single pulses attributable to suspected but never-before-detected transient sources

- Located at Pisgah Astronomical Research Institute (PARI), a rural & mountainous site in Western North Carolina (35N 83W)

- Project started August 2005, regular operation expected to begin Fall 2006

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**ETA System Design**

- Dipole Array
  - Active Balun
  - Long Coax

- A/D-IF
  - RF

- 2 Gb/s Serial Interconnect Matrix
  - Node

- 125 MSPS x 12-bit (Digital Receiver, Channelization, RFI Mitigation, Calibration)

- 432 Mb/s Serial LVDS

- Reconfigurable Computer Cluster (RCC)
  - (Beamforming, RFI Mitigation, Dedispersion)

- Parallel LVDS

- 4-Node PC Cluster (Really part of RCC)

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ETA Antenna Array

16 m diameter (2λ @ 38 MHz)

~ 10 “Patrol Beams”

Beamwidth: ~ 30°
(38 MHz @ zenith)

Continuum sensitivity: 48 Jy
(Δν = 1 MHz, τ = 1 min, 5σ)

“Long” pulse sensitivity: 861 Jy
(Δν = 18 MHz, τ = 10 ms, 5σ,
incoherent dedispersion, 10-100 pc cm⁻³)

Pattern of One Patrol Beam

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“Low Frequency” Radio Astronomy

Ionosphere Becoming Opaque

Galactic Noise-Dominated $T_{sys}$

Instrument-Dominated $T_{sys}$

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Antenna Temperature due to Galaxy: $T_{sky}$

- $\sim 300,000$ K at 10 MHz
- $\sim 800$ K at 100 MHz

Galactic Noise Density for Constant VSWR

Preamplifier (“Active Balun”)

- Two Mini-Circuits GALI-74 MMICs in differential configuration
- Transformer for balun
- Measured Performance
  - T: about 250 K
  - Gain: 24 dB
  - $P_{1\text{dB}}$: -2.8 dBm @ 38 MHz
  - BW: < 5 MHz to > 95 MHz
  - 160 mA @ 12V (per dipole)
  - About $45 (small quantities)

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Inverted V-Shaped Thin Dipole

Dipole arms constructed from \( \frac{3}{4}'' \times \frac{3}{4}'' \) aluminum angle stock

Resonant at approximately 38 MHz

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What an ETA Dipole + Active Balun Sees:

http://www.ece.vt.edu/swe/eta
What an ETA Dipole Sees - RFI

At Antenna Terminals, $\Delta v = 300$ kHz

- Ubiquitous HF Hash
- ETA Search Bandwidth
- TV4
- TV3
- TV2
- FM

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GNL Diurnal Variation Test (Simulation)

Courtesy E. Polisensky & P. Ray, NRL
Summary

- A simple antenna + amplifier combination has developed and tested for use in a low frequency radio telescope array.

- Despite having narrow bandwidth in terms of VSWR, the antenna + amplifier combination is Galactic noise-limited from 29 MHz to 47 MHz.
  - Best possible sensitivity – any further improvement can be achieved only by increasing number of antennas.

- Main consideration after amplifier noise (250K) is dipole thickness. ¾” angle bracket material met our Galactic noise-limited sensitivity requirement.

- Verified Galactic noise-limited operation using both the known spectral and diurnal variations of the Galactic background.

- Good agreement with predicted results.

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