Antenna system – Status & progress report

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for the antenna work package group

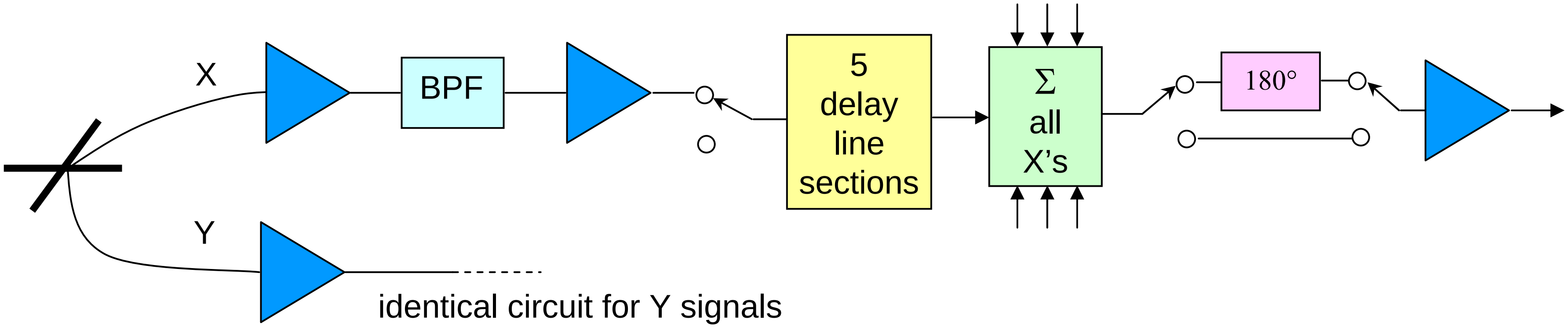
General specifications

Tunable frequency range	80-300 MHz
Instantaneous frequency range	≥ 32 MHz
Collecting area	≥ 10 m^2 over as much of frequency range as possible
Field of view	As wide as possible (within constraints of collecting area & physics)
Polarization	Dual linear
System temperature	Sky noise dominated

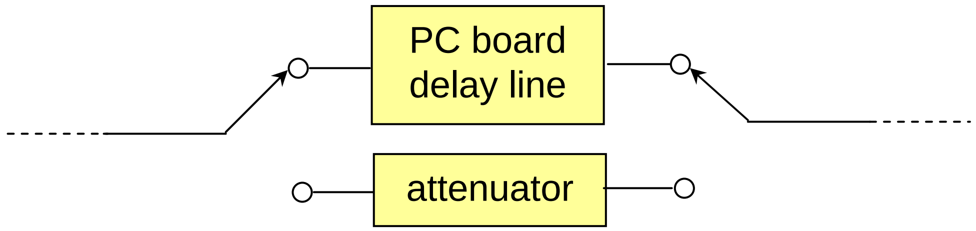
Key design features

- 16 dual-polarization, bowtie antenna elements over a ground screen
- Elements arranged in compact planar array with $\lambda/2$ spacing at 140 MHz (= 1.07 m)
- Low-noise amplification integral to each element
- Analog RF beamformer with PCB tapped delay lines

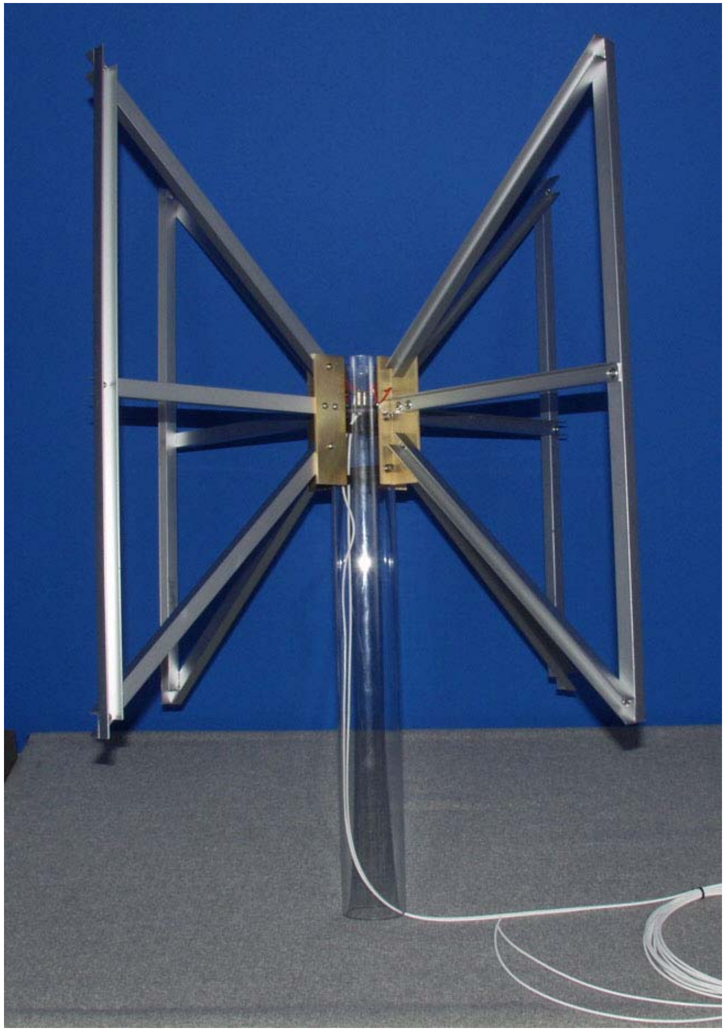
Block diagram of electronics for one tile

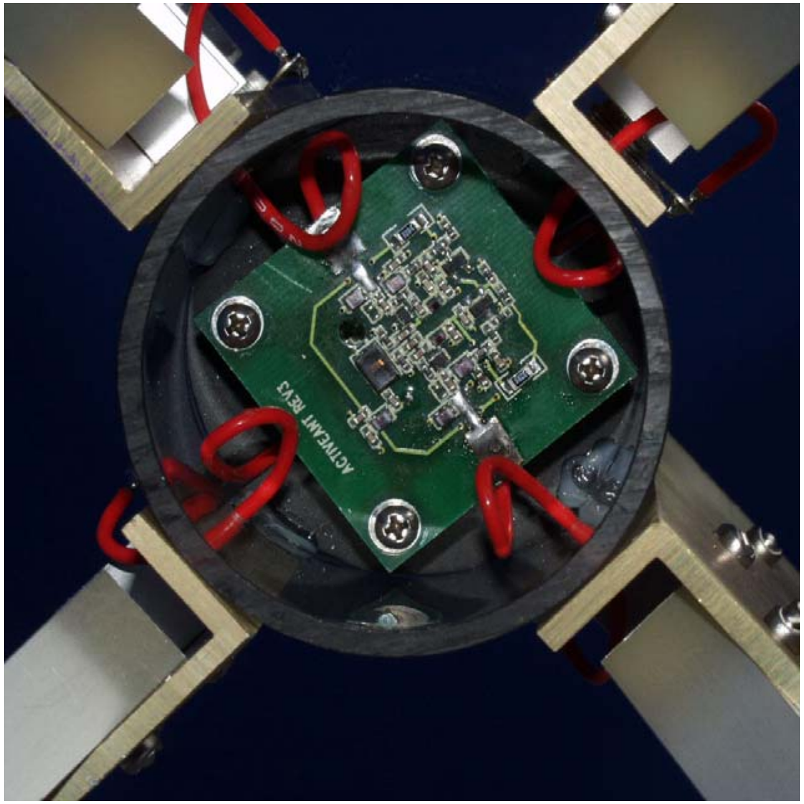


One section of 5 sections of switchable delay line –
lengths differ by factors of 2



Prototype antenna element used in ED tiles

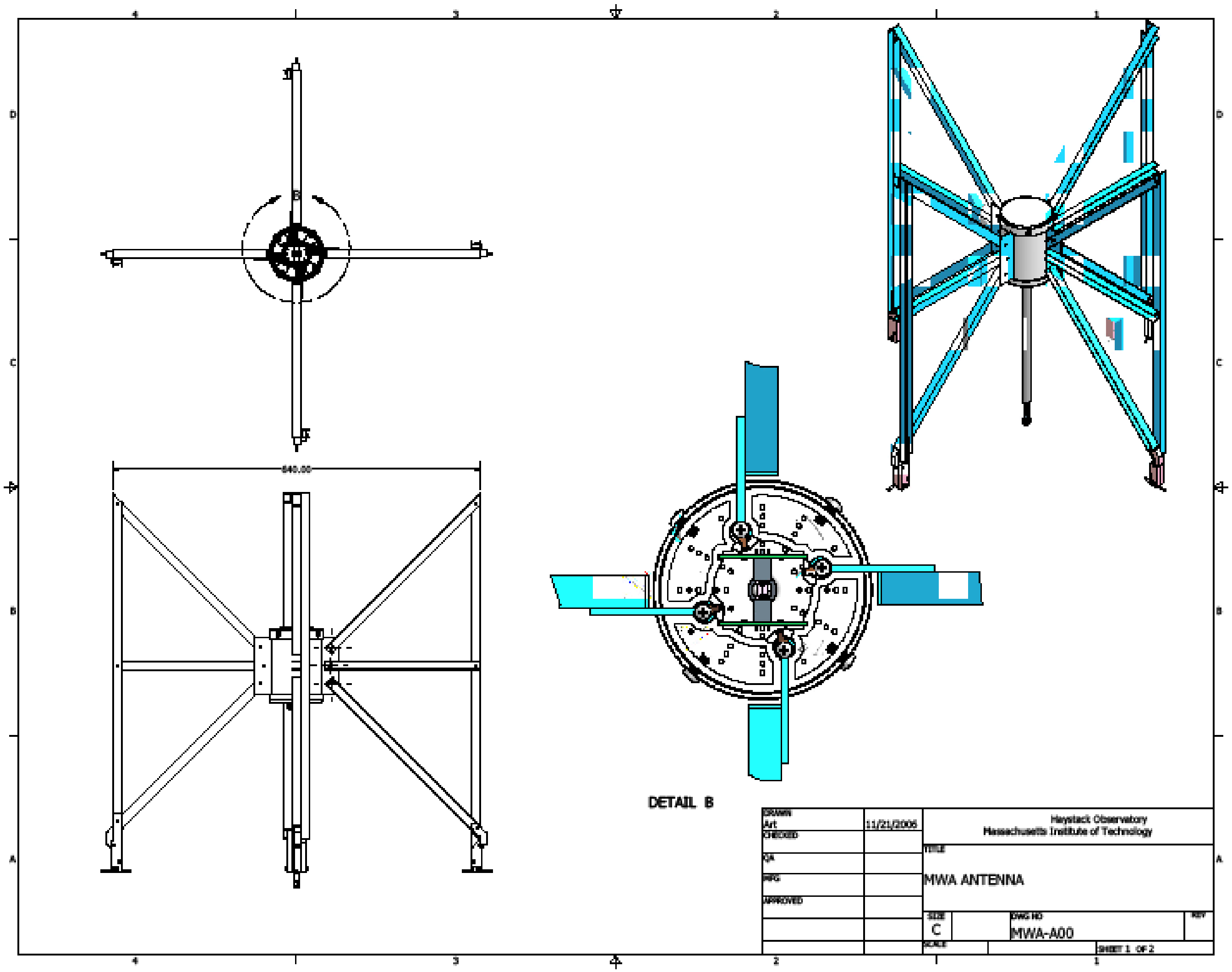




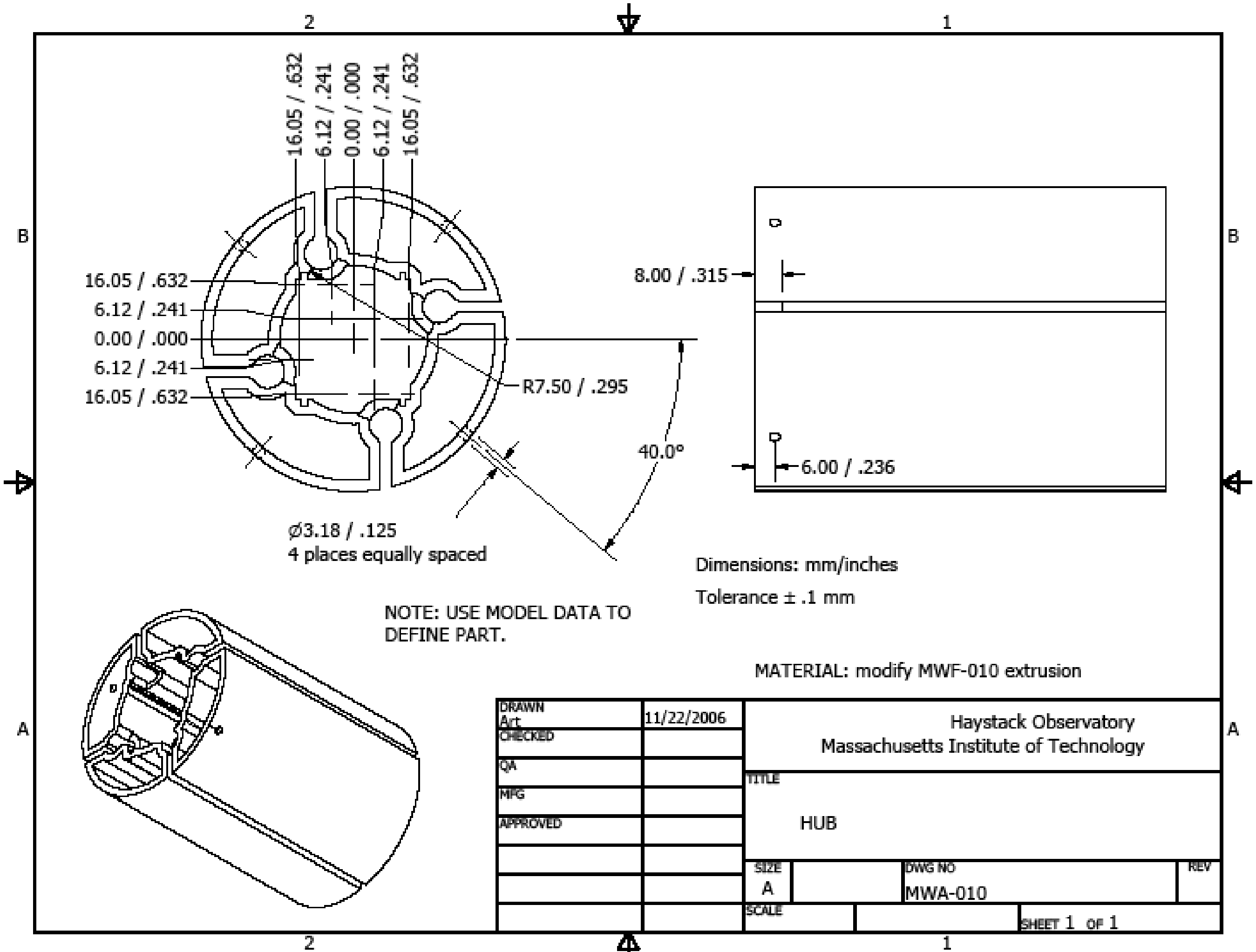
Antenna element redesigned for low-cost manufacture

- Mechanical redesign done by Burns Industries of Nashua, New Hampshire, U.S.A., in collaboration with Haystack, in November 2006
- Primary change from ED prototype is to support antenna element at the bottom of the bowties rather than via a central column
- Changes should have minimal effect on electrical performance
- Prototype redesigned element delivered on 12 December
- Prototype 16-element tile to be built using final production processes (e.g., extruded central hub and bowtie keys, molded feet) in China, with delivery by late February 2007
- Projected cost of 16 elements + groundscreen, installed in WA, is <1K $US in 500-tile quantities
- To do:
  - Minor changes to LNA board layout
  - Determine required overlap between groundscreen pieces

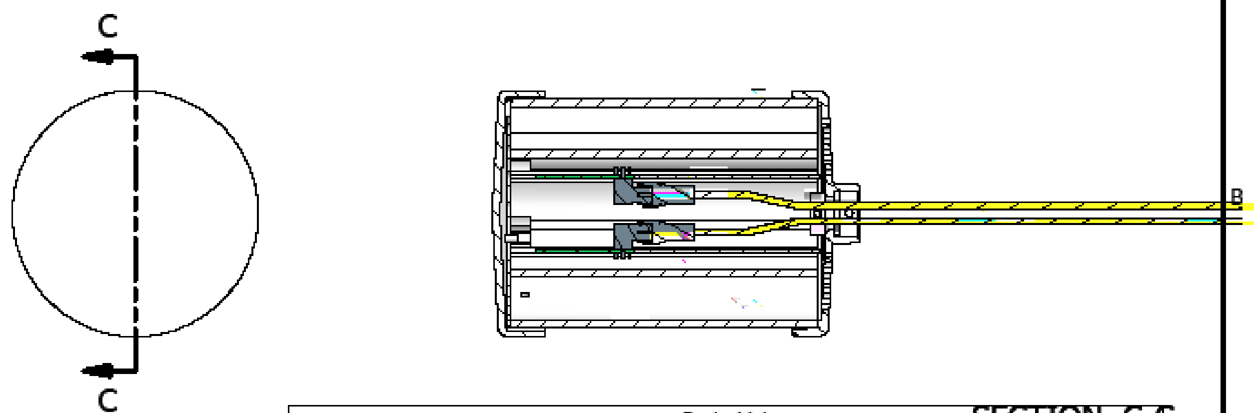
Redesigned antenna element details



Redesigned antenna element details – cont'd



Redesigned antenna element details – cont'd



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	LNA	
2	1	LNA LH	
3	1	MWA-009	TOP CAP
4	1	MWA-010	HUB
5	1	MWA-011	BOTTOM CAP
6	1	MWA-012	SEALING DISK
7	2	MWA-014	BOARD RETAINER
8	1	cable clamp	

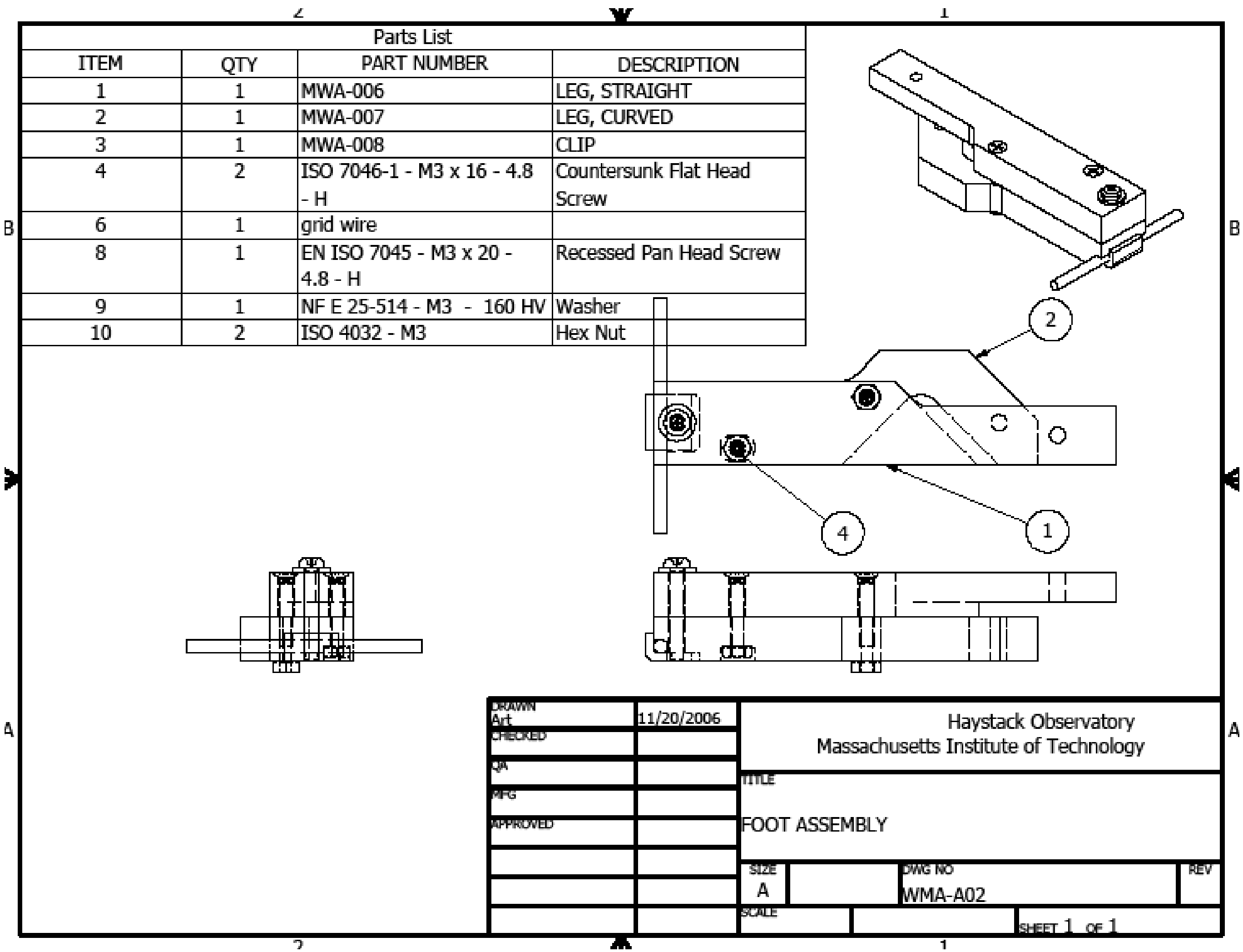
DRAWN Art 11/22/2006
CHECKED
QA
MFG
APPROVED

Haystack Observatory
Massachusetts Institute of Technology

TITLE
HUB ASSEMBLY

SIZE A
DWG NO MWA-A03
REV
SCALE
SHEET 1 OF 1

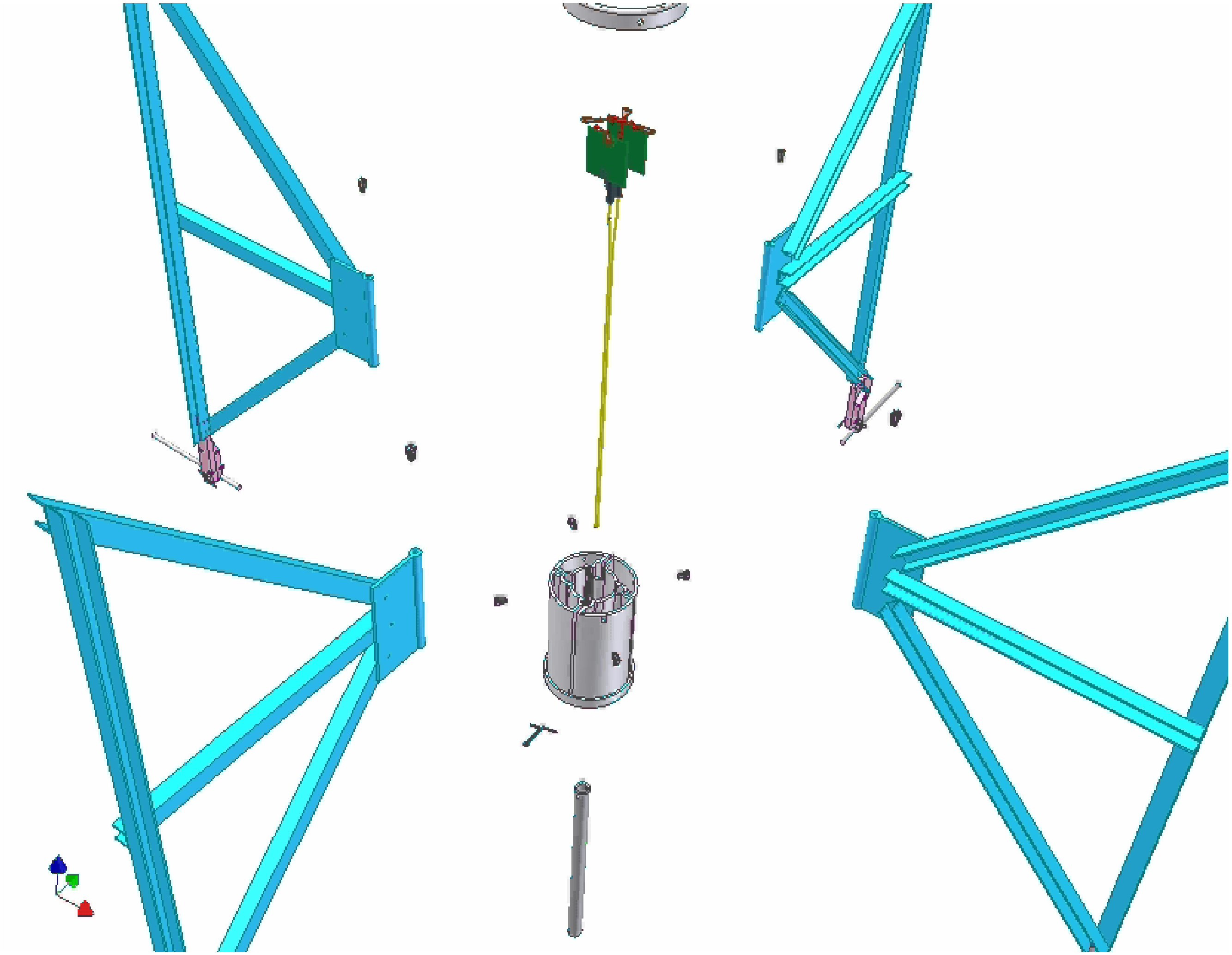
Redesigned antenna element details – cont'd



Parts List

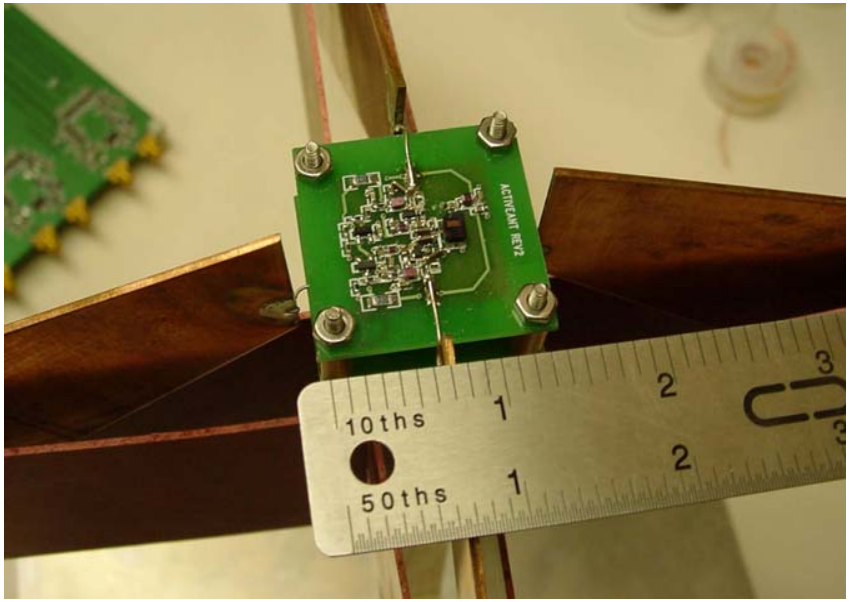
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	MWA-006	LEG, STRAIGHT
2	1	MWA-007	LEG, CURVED
3	1	MWA-008	CLIP
4	2	ISO 7046-1 - M3 x 16 - 4.8 - H	Countersunk Flat Head Screw
6	1	grid wire	
8	1	EN ISO 7045 - M3 x 20 - 4.8 - H	Recessed Pan Head Screw
9	1	NF E 25-514 - M3 - 160 HV	Washer
10	2	ISO 4032 - M3	Hex Nut

Redesigned antenna element – the movie



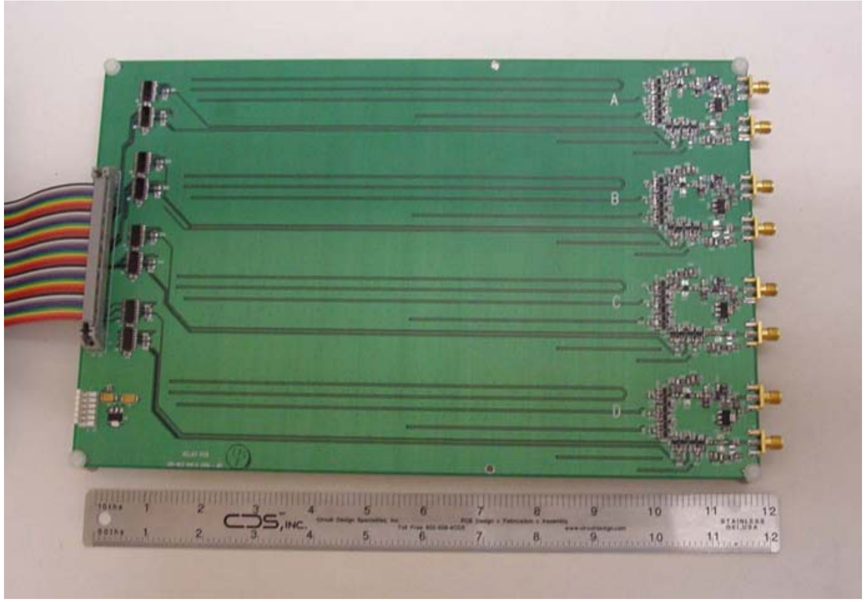
Low-noise amplifier

- Balanced design using two ATF-54143 HEMTs
- Measured noise temperature 14-17 K with 50 ohm loads on inputs, in agreement with simulation
- Measured OIP2 > +63 dBm, OIP3 = +27 dBm
- With LNA connected to prototype element, simulated noise temperature < ½ x sky temperature



RF analog beamformer, ED prototype

- 4-channel prototype board constructed using coplanar waveguide in 4-layer PCB with 10-ns max delay
- Isolation > 40 dB between channels and between switched lines within a channel
- Delay reproducible between channels to ~0.1 ns (1σ)
- Gain reproducible between channels to ~0.3 dB (1σ)
- Gain independent of delay selected to <1 dB

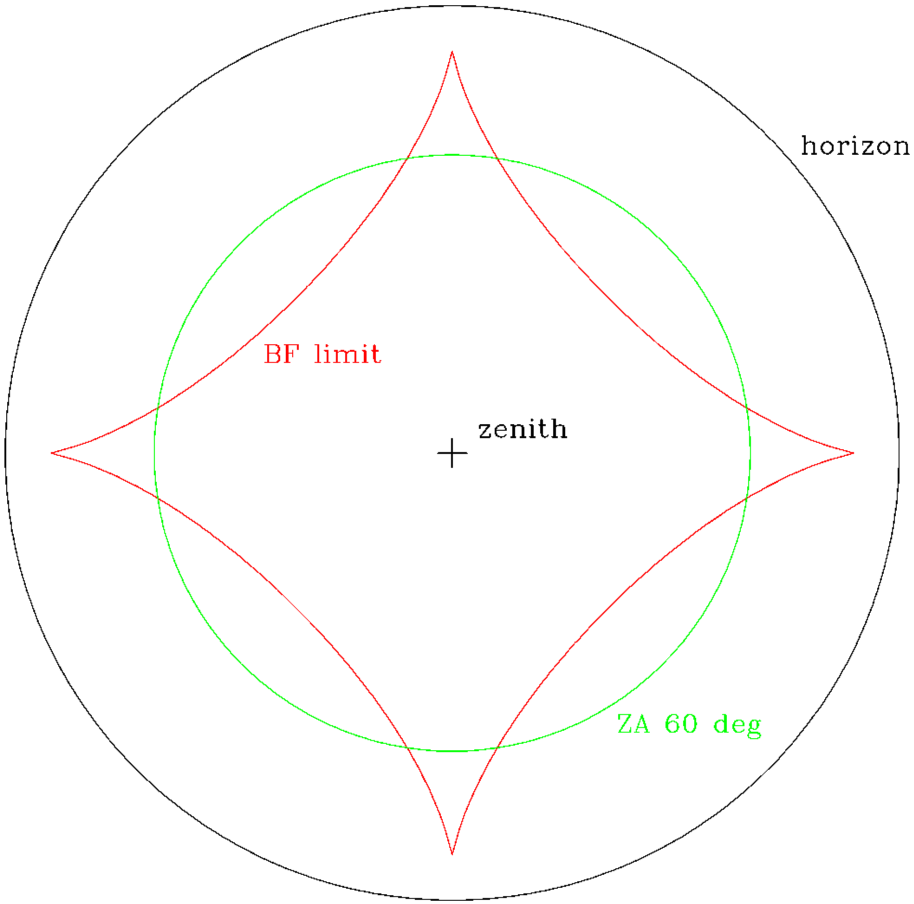


RF analog beamformer, version 2

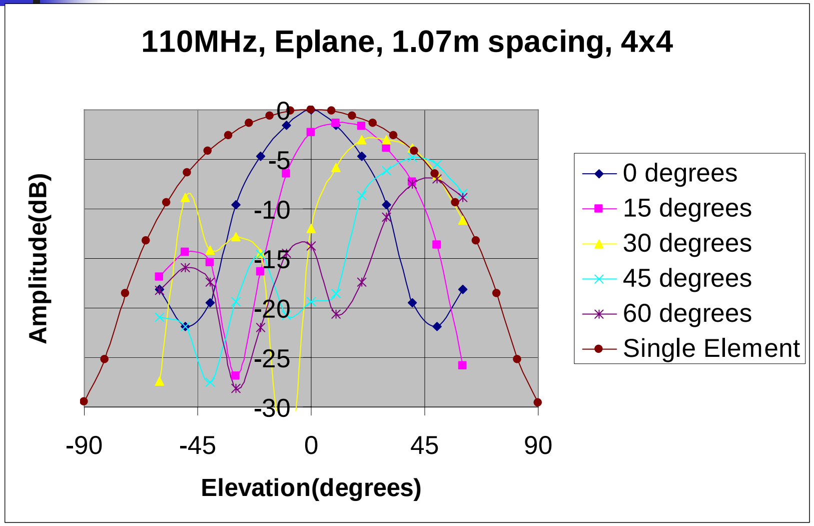
- Test board with different pitches between delay line traces shows >40 dB isolation for pitch of 0.200 inch (prototype board value), 0.100 inch, and 0.075 inch.
- Expect therefore to be able to put delay lines for 16 channels on one, or perhaps two, boards, rather than the four required in the prototype ED beamformer.
- Lengthening the lines to increase the max delay from 10.6 ns (ED prototype) to 13.1 ns may drive cost point to favor two boards per polarization.
- Most of M/C logic will go on delay line boards, rather than on a separate interface board as in the ED prototype, to reduce interconnect costs.

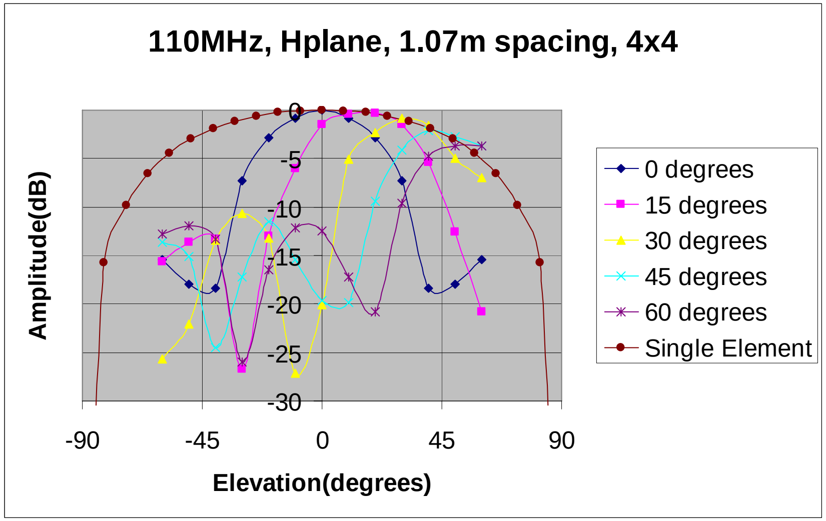
Beamformer: sky coverage of ED prototype

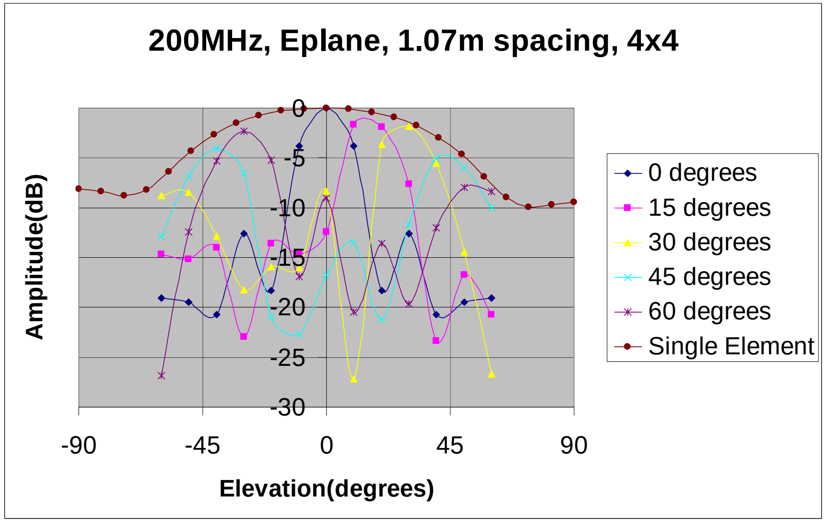
- Should the max delay be increased from 10.6 ns to 13.1 ns, to allow observations with all 16 elements down to 60° ZA for all azimuths?

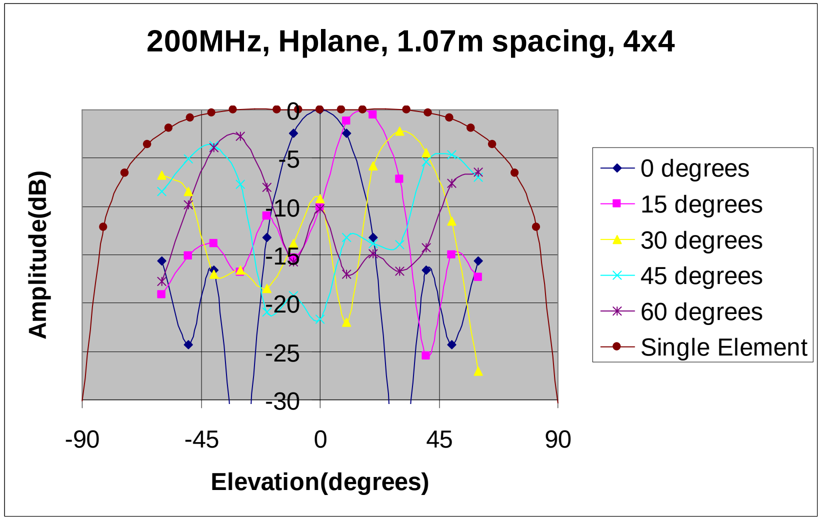


Measured antenna tile patterns for five steering directions









Monitor/control: functions

- Monitor functions:
  - Beamformer internal temperature
- Control functions:
  - For each polarization of each antenna element (32 per tile), set:
    - 5 sets of delay line switches
    - on/off switch
  - For each polarization (2 per tile), toggle 180° phase shift with Walsh function
- To monitor health of LNAs and beamformer, rely on:
  - Instrumental calibration
  - Satellite transmissions

Monitor/control: implementation

- To minimize interference problems, BF digital circuitry that controls delay line switches will be active only when switch settings are being changed.
- Four RS-485 lines from node to BF:
  - Clock
  - Data
  - xWalsh
  - yWalsh
- Two RS-485 lines from BF to node:
  - Clock
  - Data (acknowledgement with BF temperature)

Miscellaneous issues

- Is RoHS compliance a requirement?
- How far must the BF chassis be located from the tile to avoid degrading the beam patterns appreciably? Check with simulations.