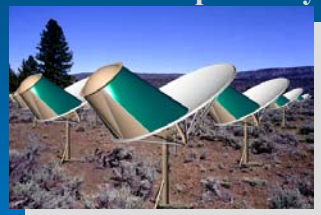
Allen Telescope Array



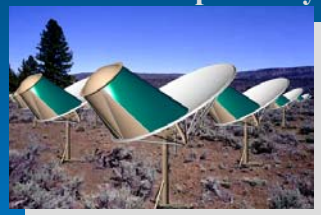
Antennas from an ATA Perspective

FASR Workshop

May 24, 2001

David DeBoer, Project Engineer/Deputy Project Manager, SETI Institute

Allen Telescope Array



Outline

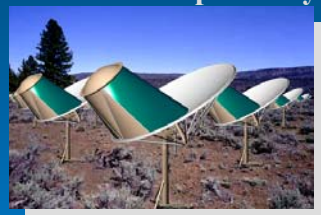
- ATA Overview
- Antenna
- Costing/timeline

Allen Telescope Array

ATA Team

- SETI Institute
  - Rob Ackermann
  - Larry D'Addario
  - Mike Davis
  - Dave DeBoer
  - John Dreher
  - Gerry Harp
  - Girmay-Keleta
- Other
  - Ed Ackermann
  - John Andersen
  - Charlie Cox
  - Niklas Wadefalk
  - Sandy Weinreb
- RAL
  - Robert Abe
  - Leo Blitz
  - Douglas Bock
  - Geoff Bower
  - Calvin Chang
  - Matt Dexter
  - Greg Engargiola
  - Ed Fields
  - Matt Fleming
  - Doug Thornton
  - Lynn Urry
  - Jack Welch
  - Dan Werthimer
  - Mel Wright
  - Daning Zhou

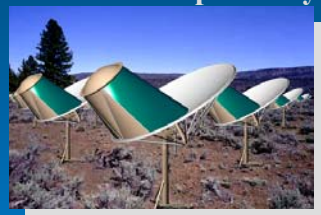
Allen Telescope Array



The Allen Telescope Array

A Joint Project Between the SETI Institute and UCB/RAL

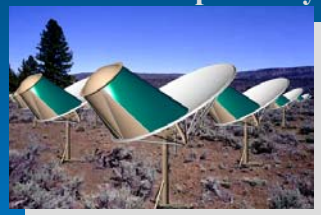
Allen Telescope Array



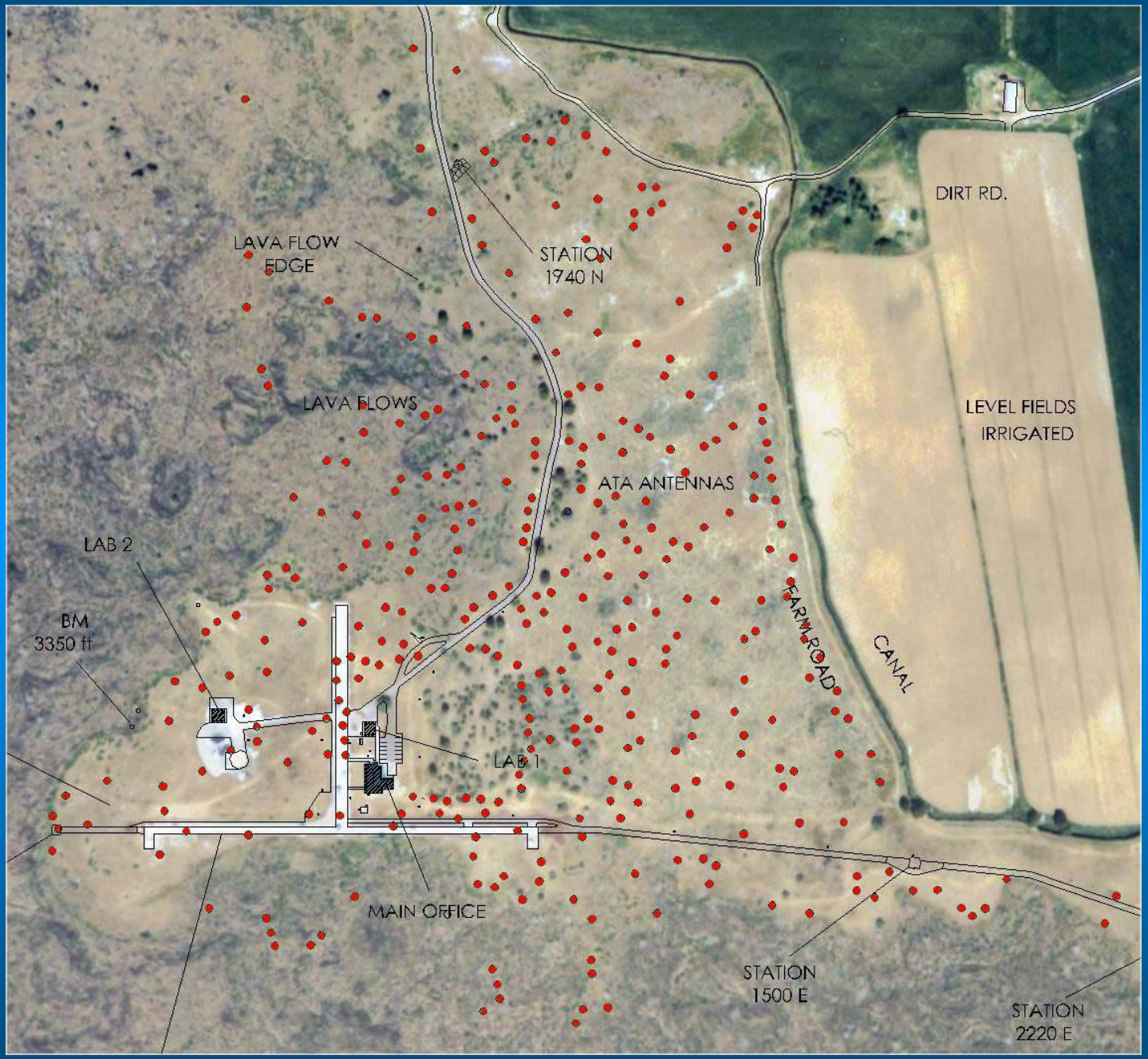
Design Goals for the ATA

Number of elements	350		
Element diameter	6.1	m	
Total geometric collecting area	10229	m^2	
	114	m	
Aperture efficiency	60%		
Effective area	6137	m^2	
	2.2	K/Jy	
System temperature	42	K	at 80 K
Ae/Tsys	146	m^2/K	~1% SKA
Effective diameter	700	m	natural weighting
Number of beams	16		
Frequency	0.5	11	GHz
FoV	7	0.3	deg
Synthesized beam	216	9.8	arcsec

Allen Telescope Array



Near final configuration of 350 antennas – surveying is underway



Allen Telescope Array

ATA Signal Path

RF: 0.5-11.2 GHz

IF: 1-2 GHz

from other antennas

optical fibers

digitize, track

detect

Antenna

Front End

RF to IF Converters

Tunable LOs

f_A

f_B

f_C

f_D

IF Processor

IF Processor

IF Processor

IF Processor

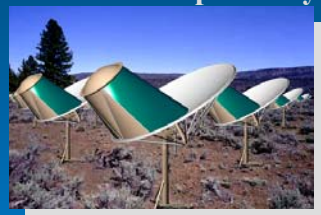
back ends

back ends

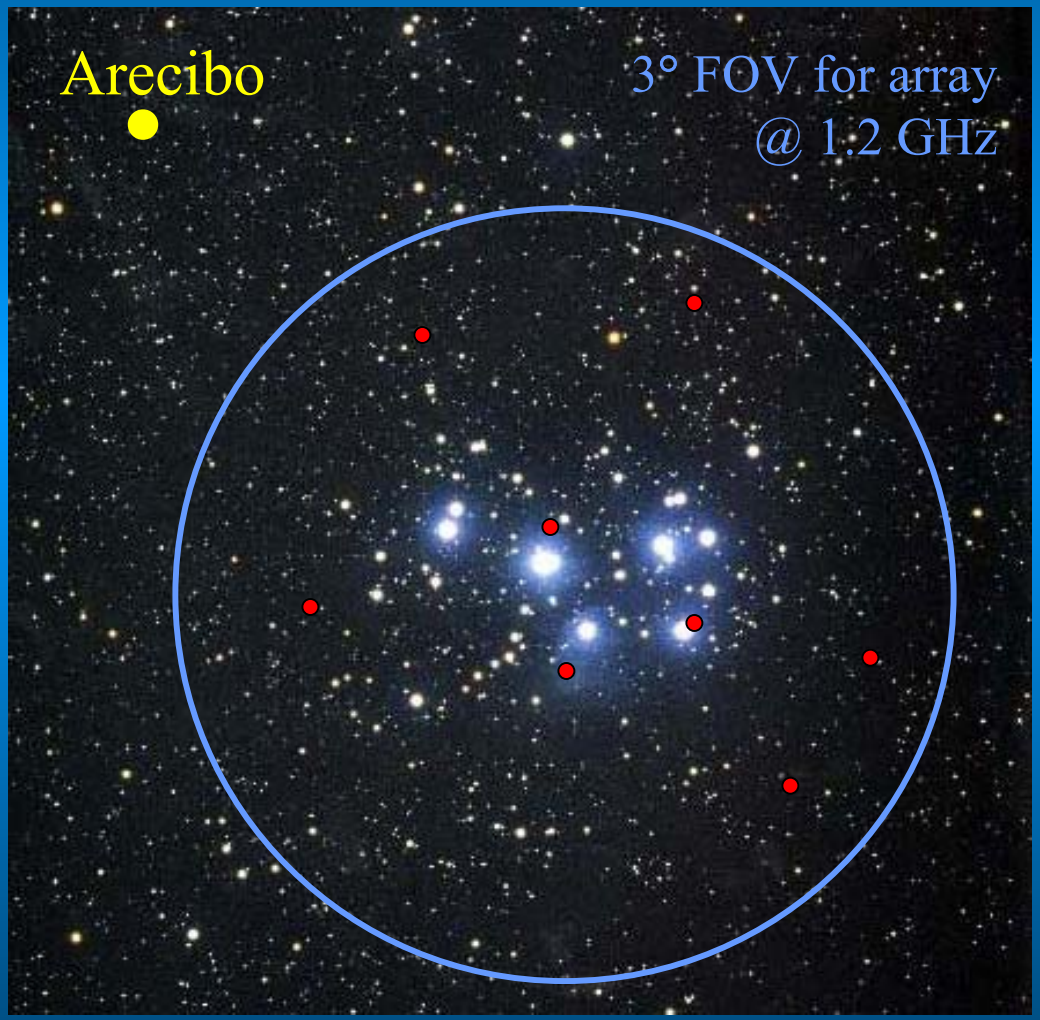
back ends

back ends

Allen Telescope Array



ATA IF Processor Design → Extremely Flexible Instrument



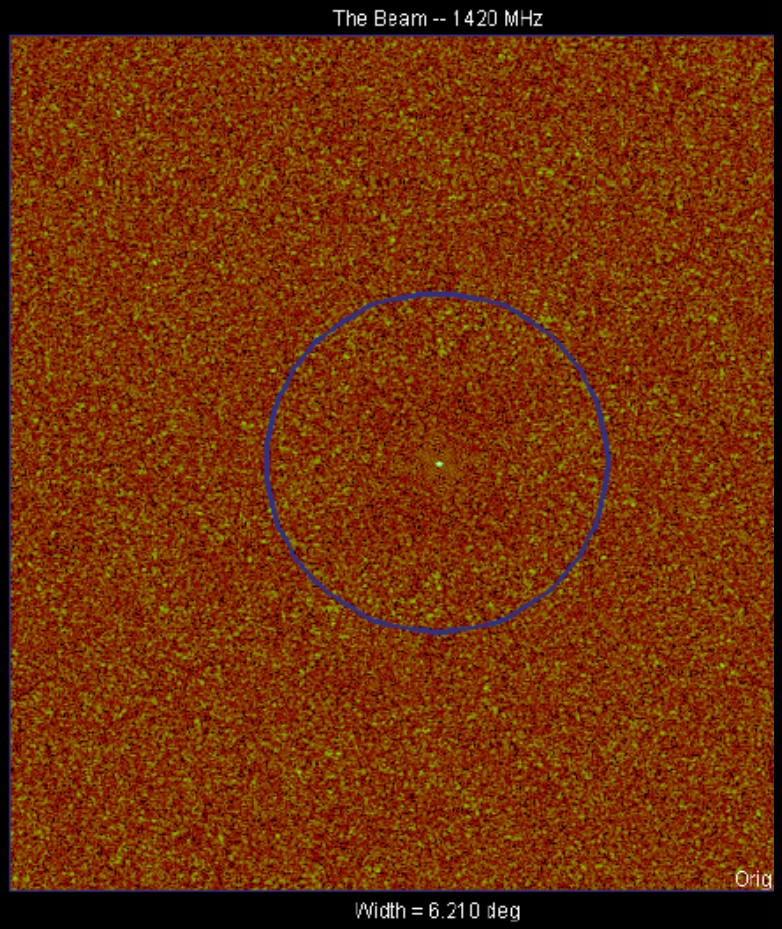
Beam former generates 16 dual-pol pencil beams anywhere in the sky (100 MHz)

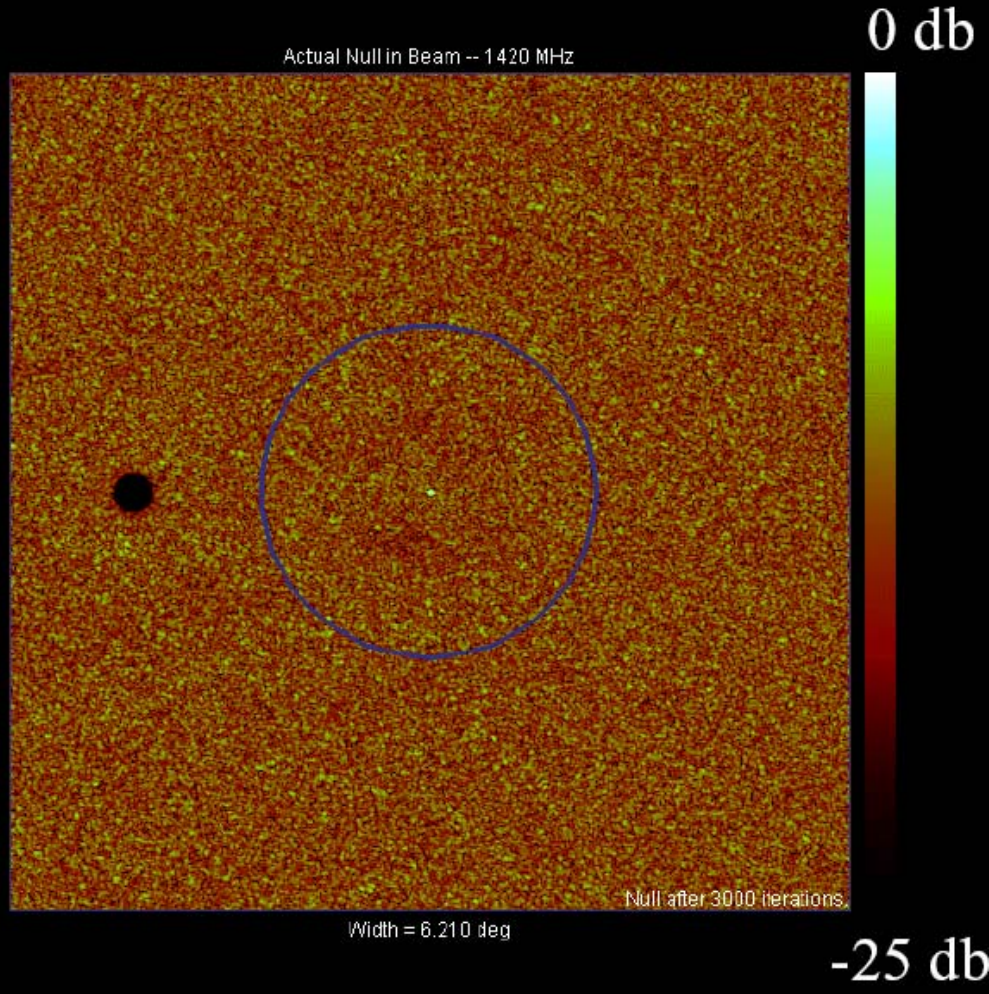
Correlator images the entire FoV (50-400 MHz)

Allen Telescope Array

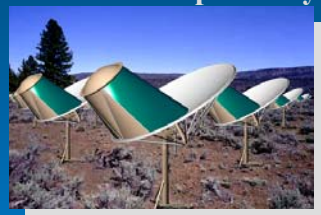
Null Formation

350 x 2 = 700 degrees of freedom

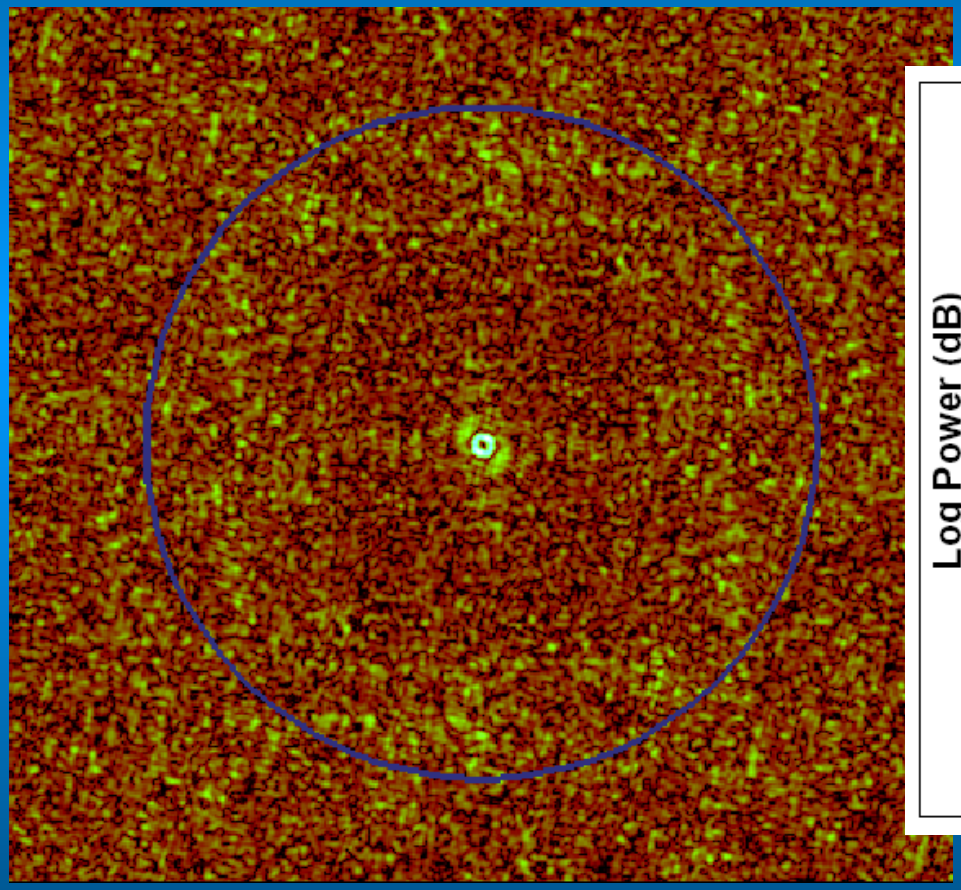


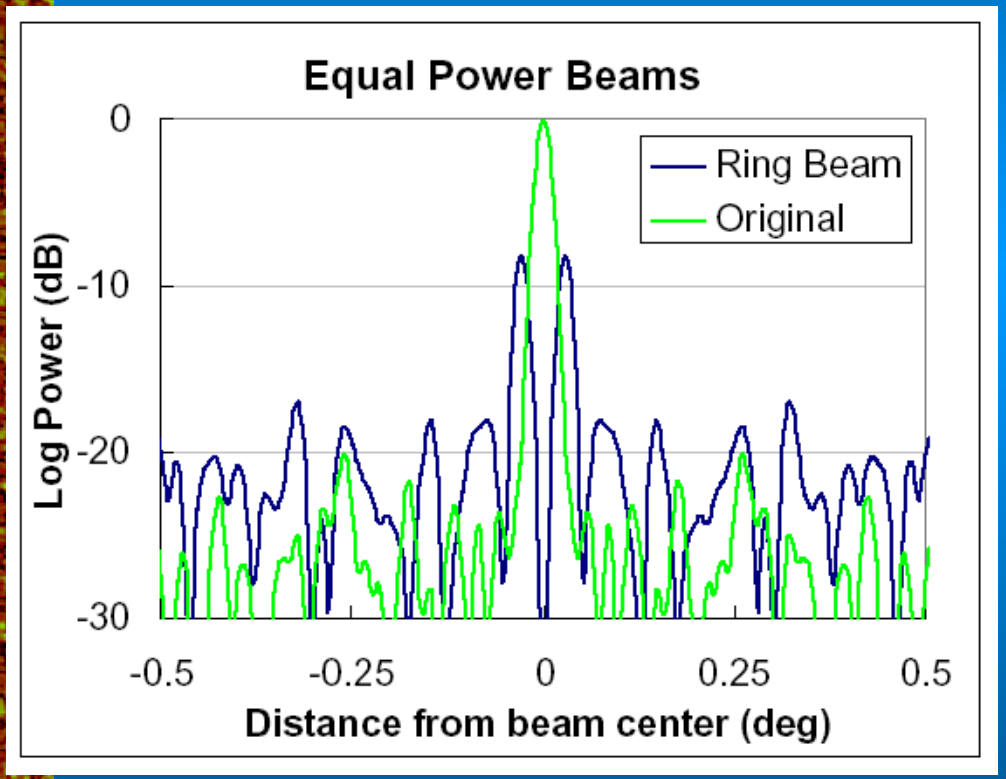


Allen Telescope Array

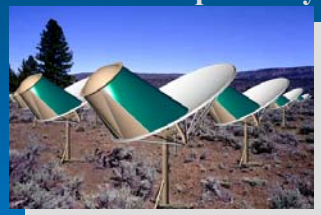


Ring Beam

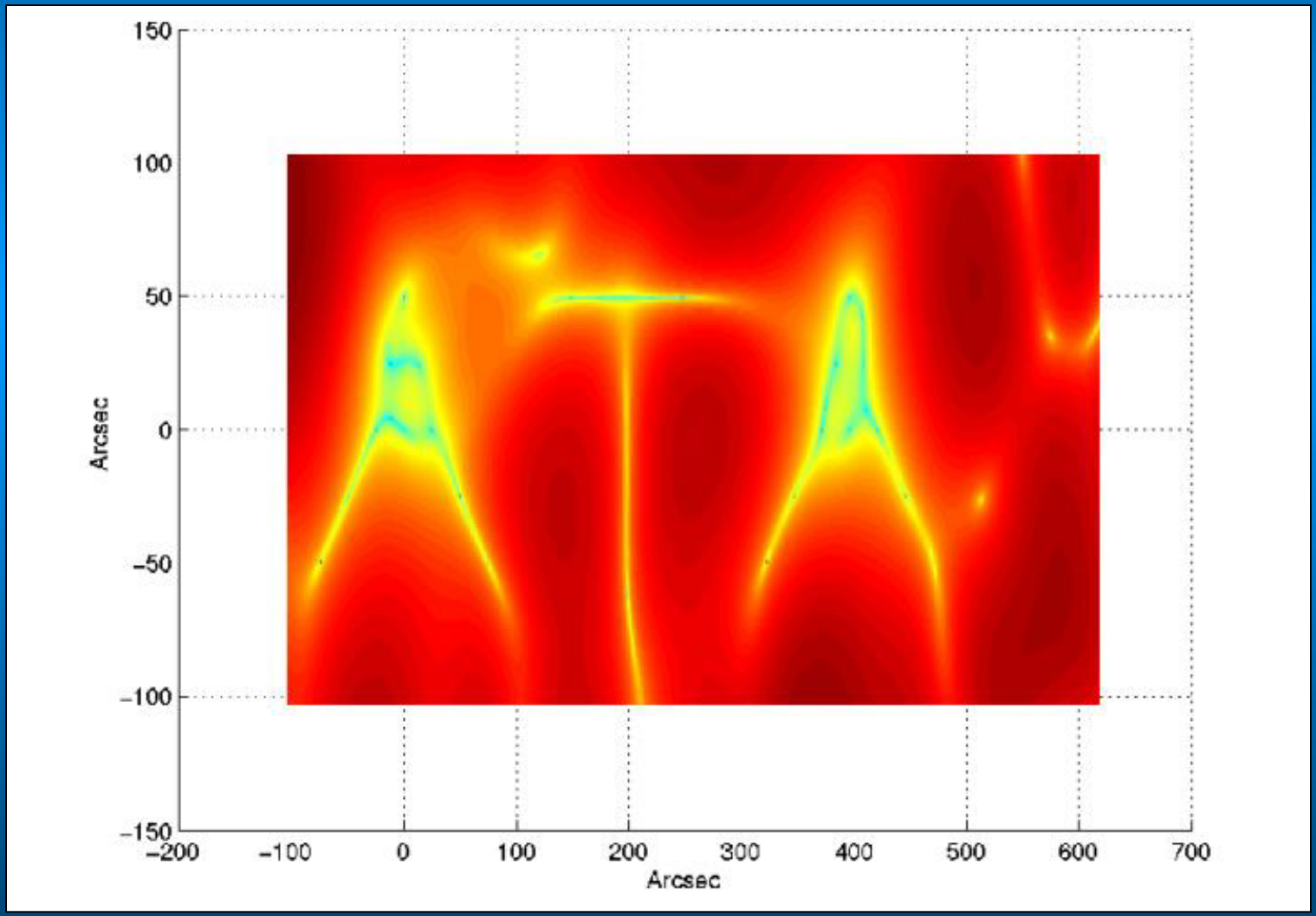


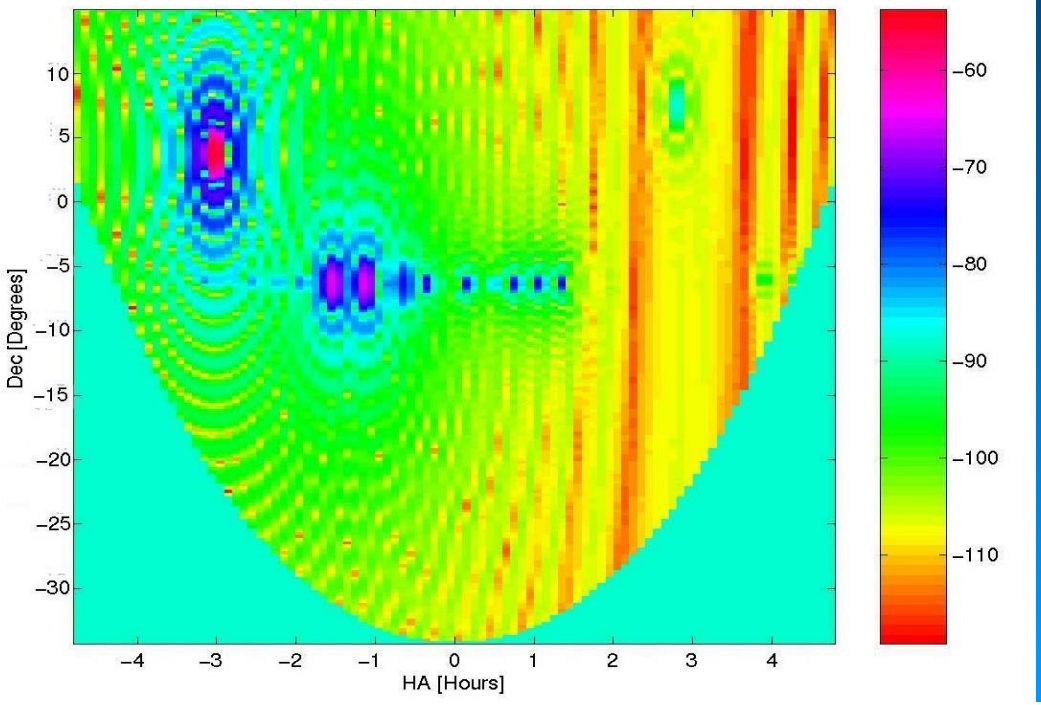


Allen Telescope Array



Complex Pattern Can Be Written With Nulls

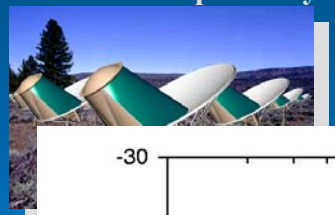




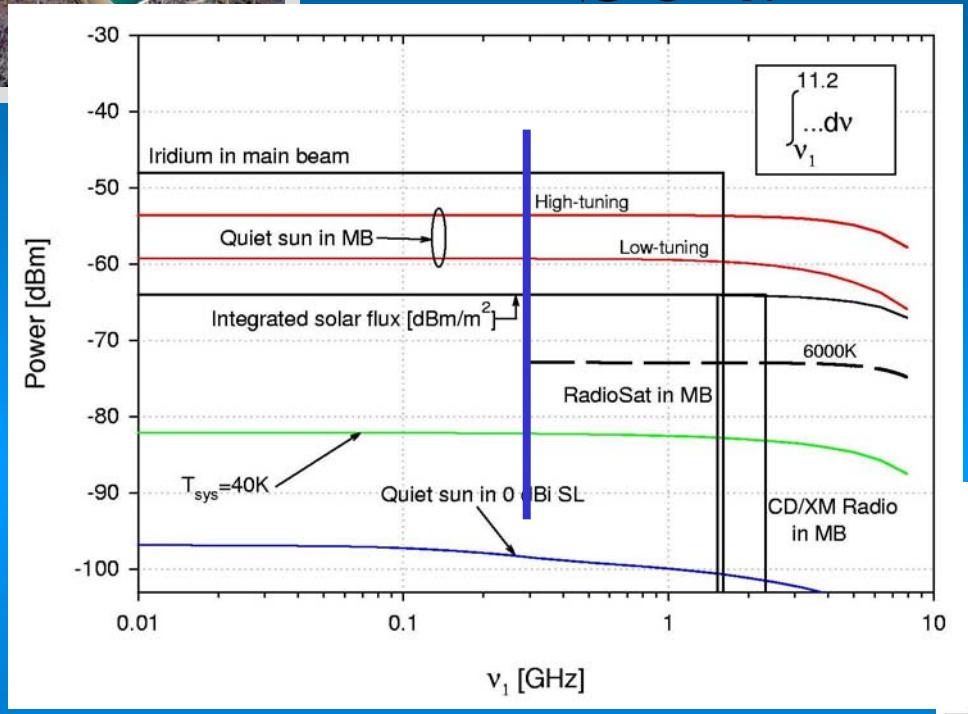
RFI

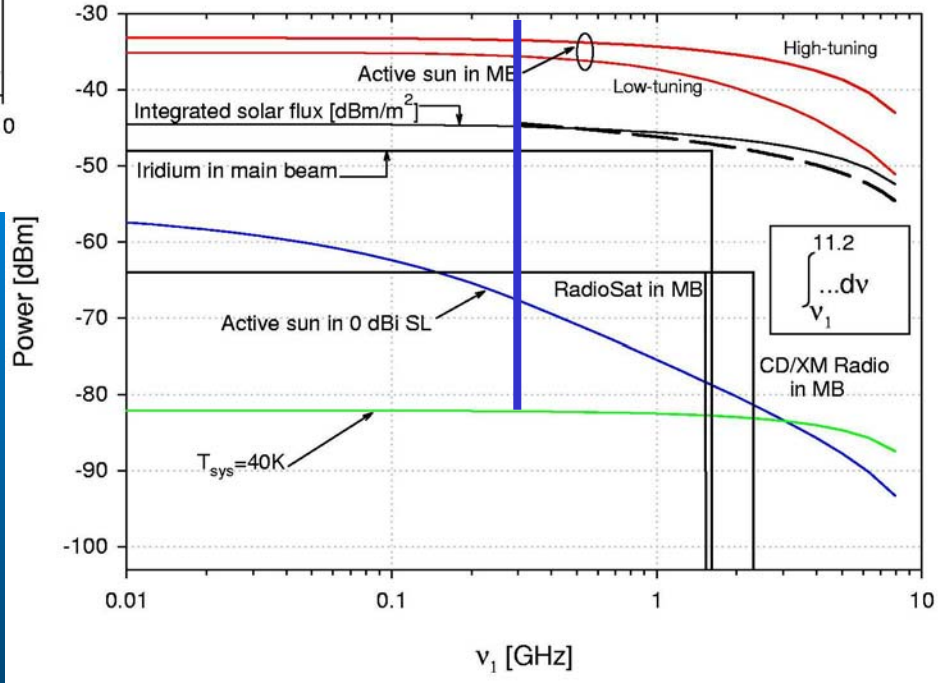
		GPS	Iridium	Satellite radio	Radarsat
Power density (dBm/m²)		-95	-60	-76	0
MB	**Power available at LNA (dBm)**	-83	-48	-64	+12
	Dynamic range (dB)	2.5	34	18	!!!
	Source equivalent in 11 GHz band	2.9 kJy 140 Hyd A	9MJy 3.5 Quiet Suns	230 kJy 212 Cas A	9 TJy 39k Active Suns
10dBi	**Power available at LNA (dBm)**	-110	-75	-91	-26
	Source equivalent in 11 GHz band	5 Jy	16 kJy 15 Cas A	455 Jy 5 Vir A	13 MJy 6 Active Suns

Allen Telescope Array

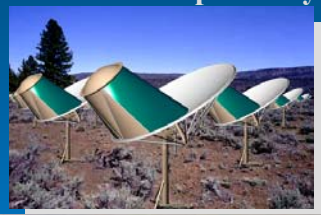


Solar "Mitigation"

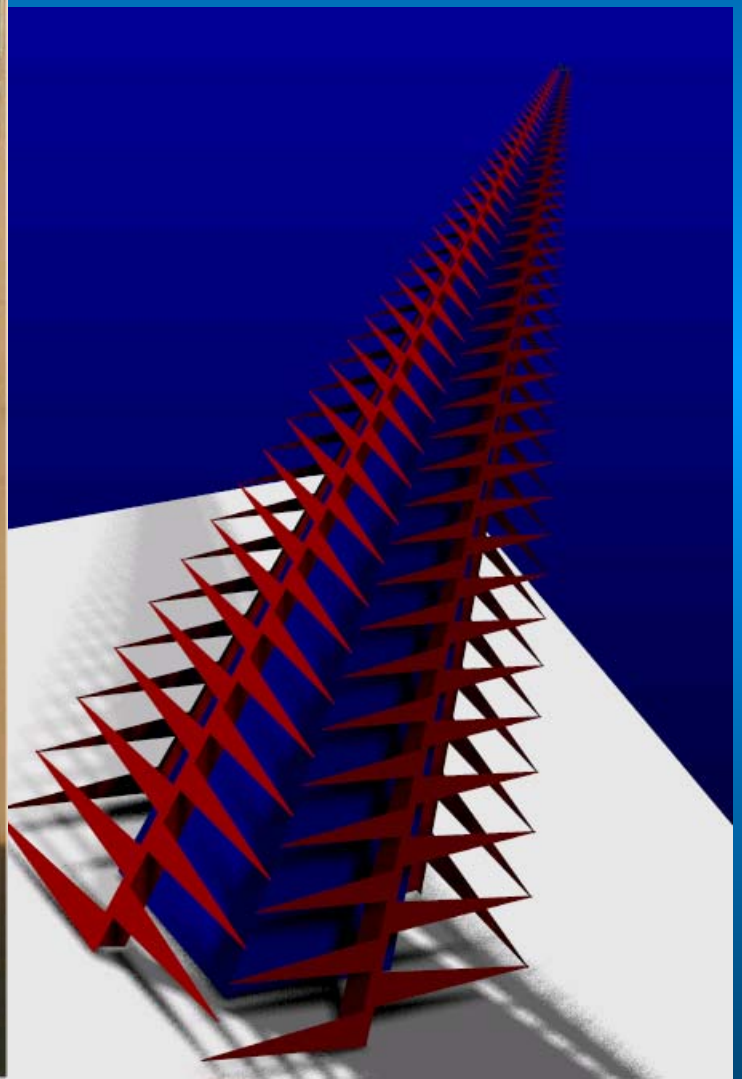




Allen Telescope Array



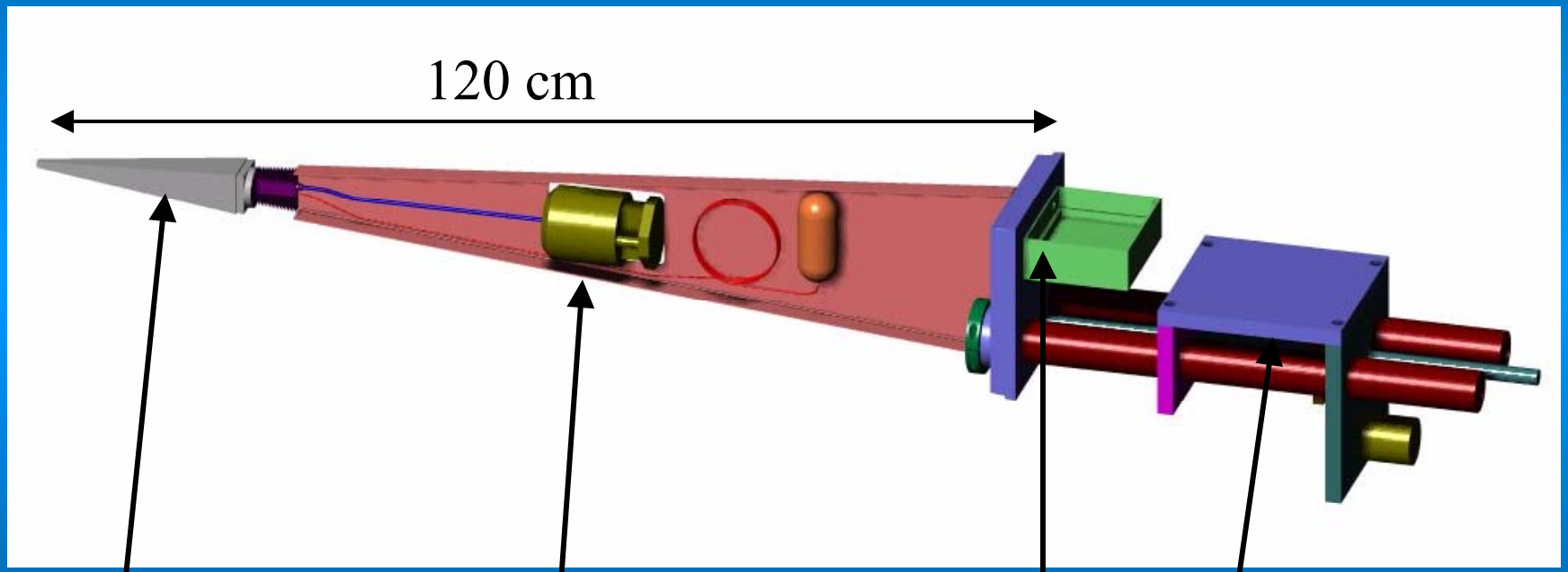
New Wideband Feed Design



- Dual-pol, log-periodic
- Covers 0.5–11.2 GHz
- 1.2 m long
- Metallic inner pyramid houses LNA and cryo

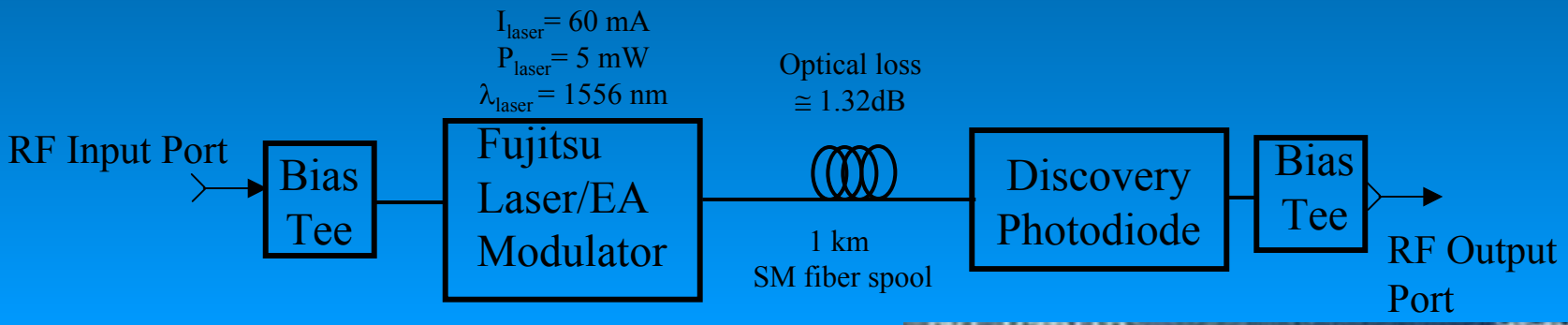
Allen Telescope Array

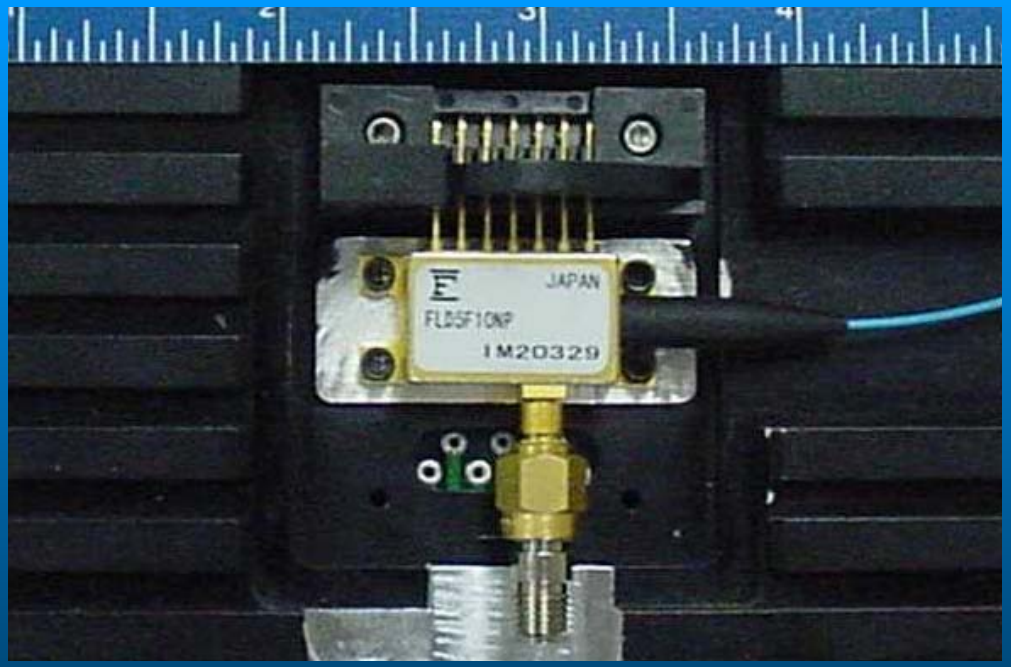
Cryogenics Inside Feed

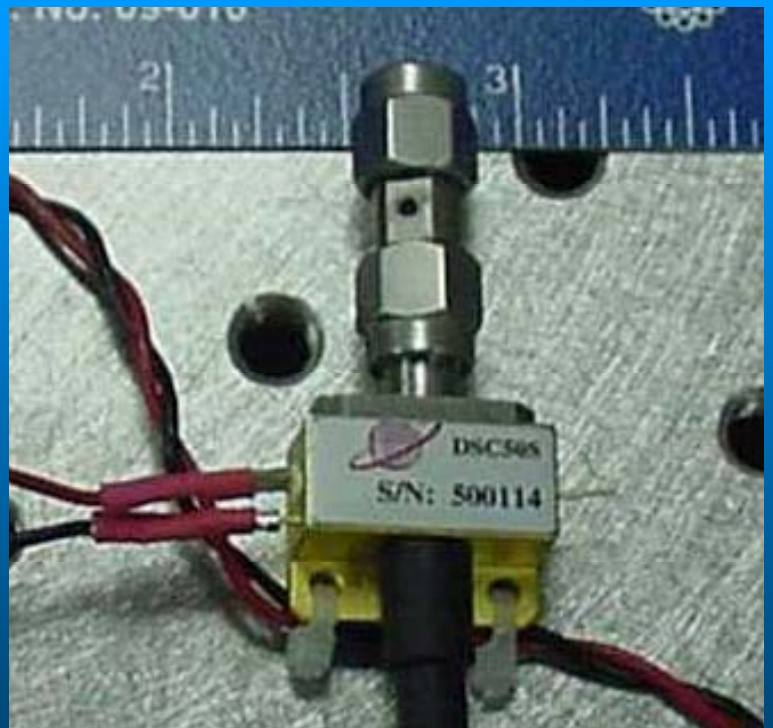


Allen Telescope Array

F/O Link – Commercial Unit







Allen Telescope Array

ATA Optimization

Lots of *A*

Good *eff* ~42 K

$$\max\left[\frac{A_{eff} / T_{sys}}{\$ / BW}\right]$$

Cheap

11 GHz

Allen Telescope Array

Offset Gregorian design

– confocal rotationally symmetric conic sections for no cross-polarization (Tanaka/Mizusawa).

Let $$\xi = 2\frac{f}{D}\tan\left(\frac{\theta_H}{2}\right)$$

and $$\zeta = \frac{y_c / D}{f / D}$$

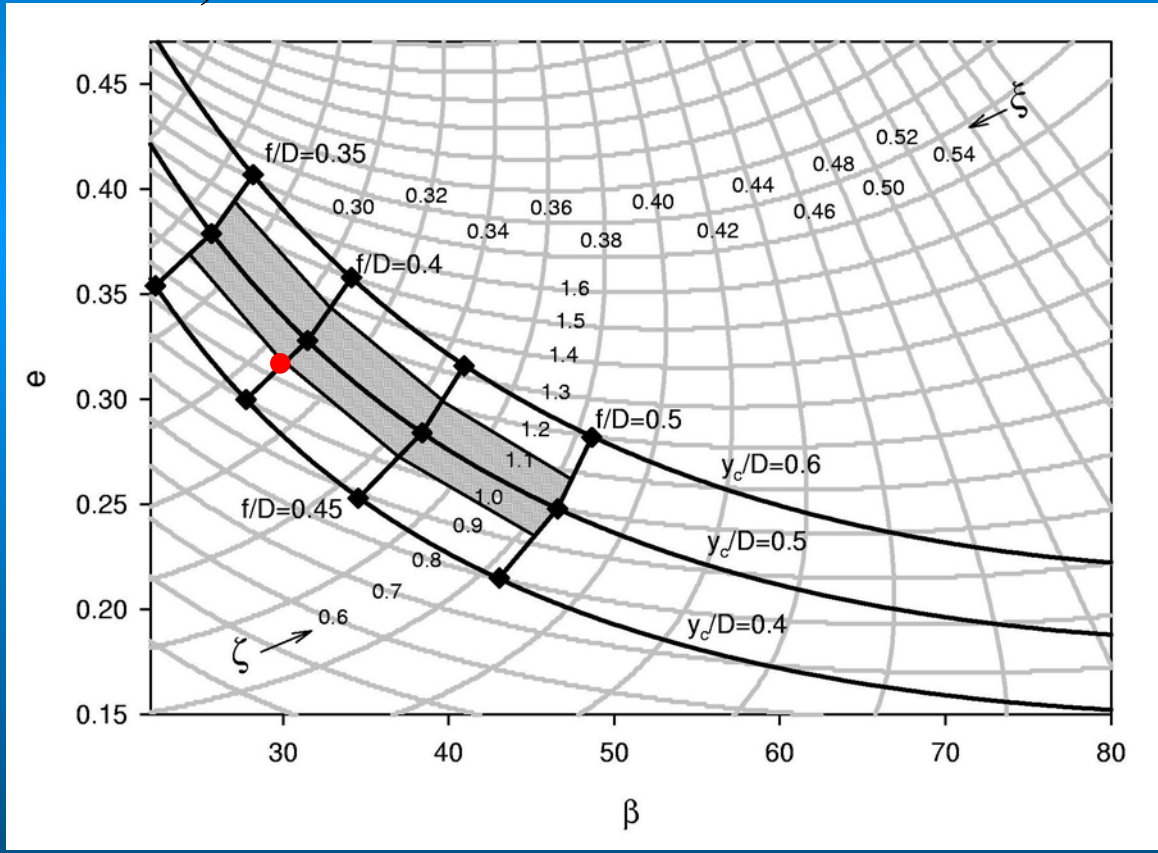
where

f *focal distance*

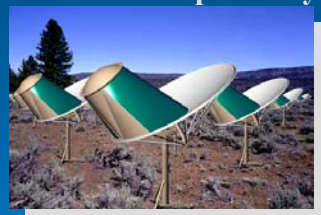
D *primary diameter*

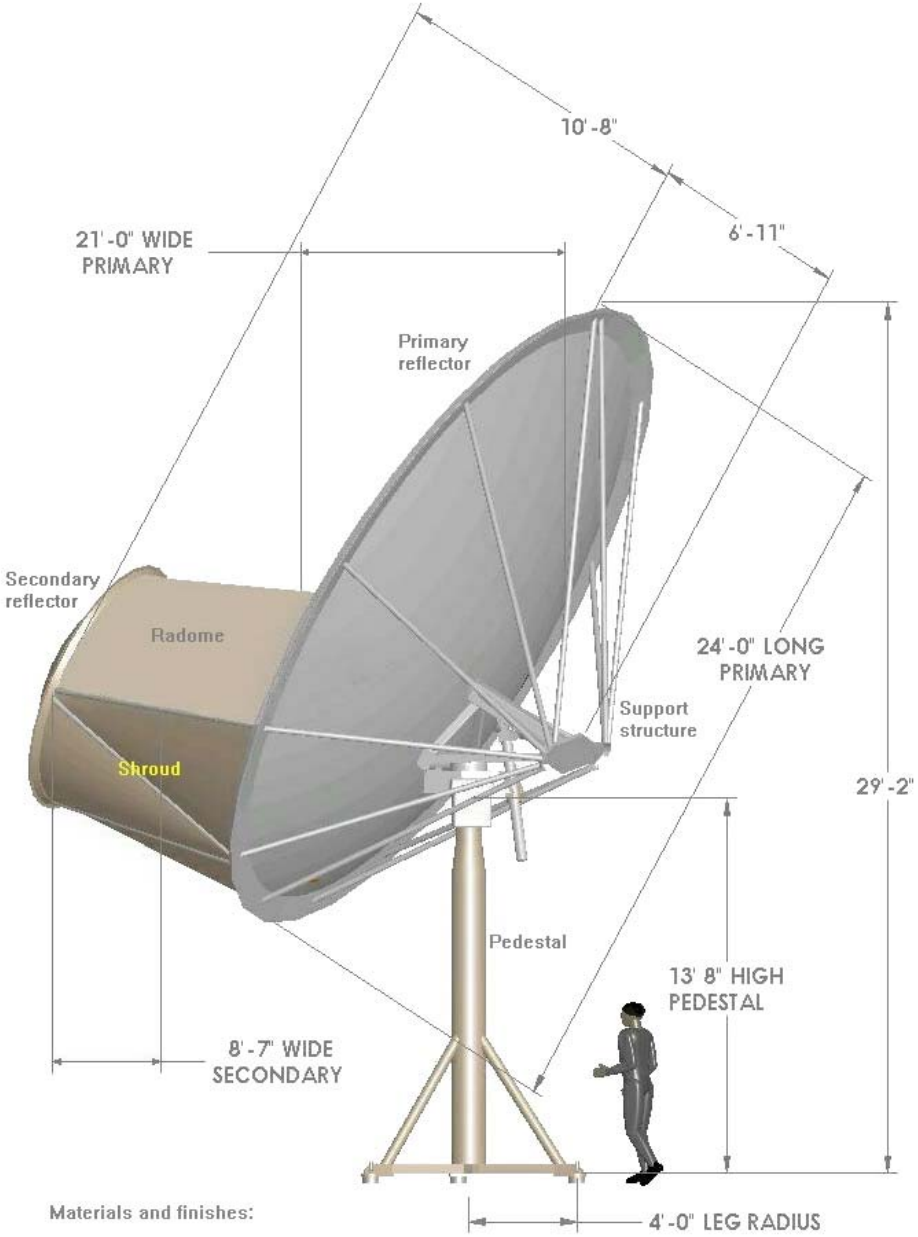
θ_H *semi-flare angle*

y_c *primary/secondary separation*



Allen Telescope Array

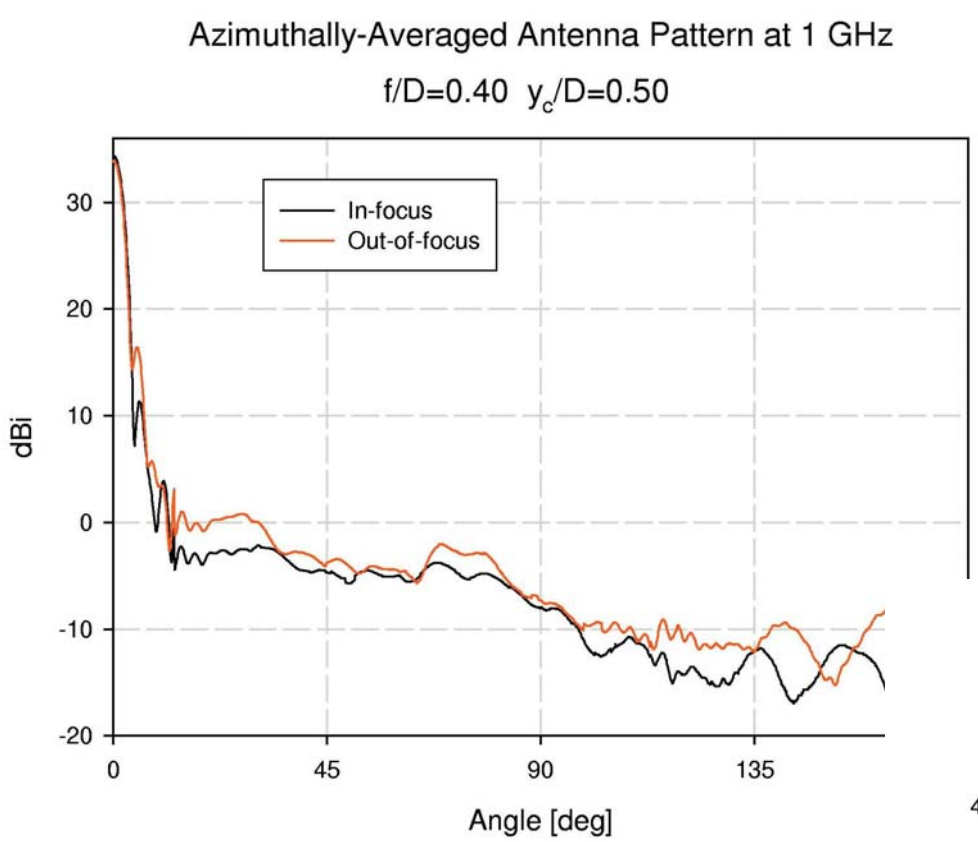


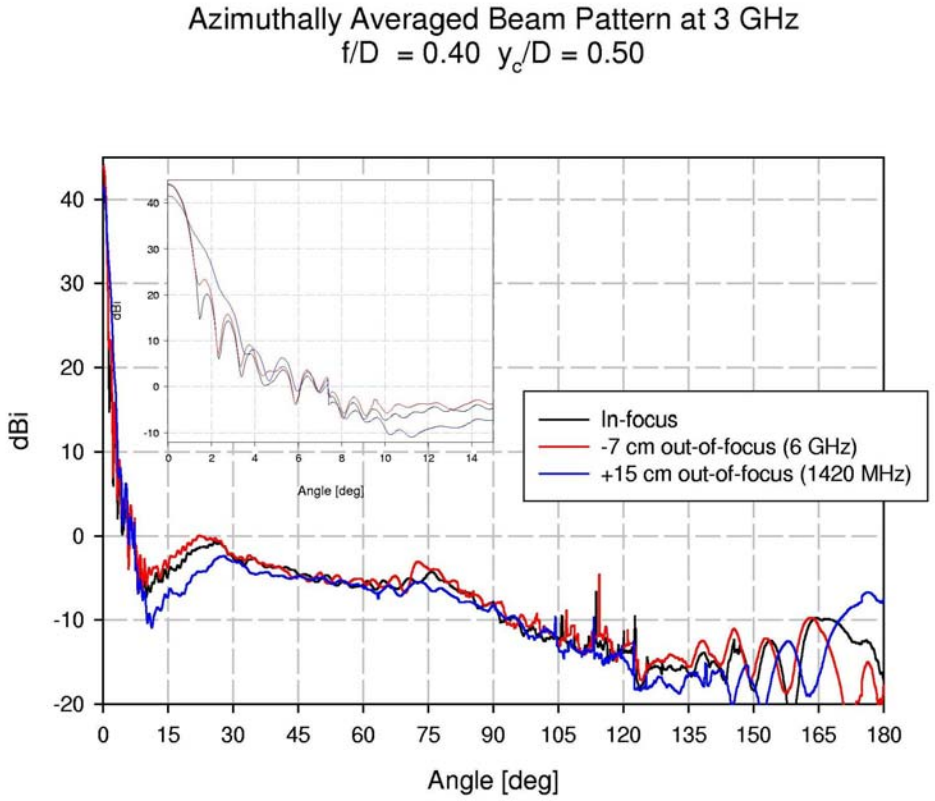


Materials and finishes:

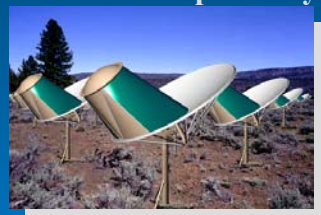
Primary and secondary reflectors: soda-blasted aluminum (minimizes reflectivity)
Pedestal and support structure: galvanized or painted steel
Shroud: galvanized or painted sheet metal
Radome: fabric awning
Foundation: three 12" concrete piers (6" exposed, depth range 4'-15')
and steel rock anchors

Patterns

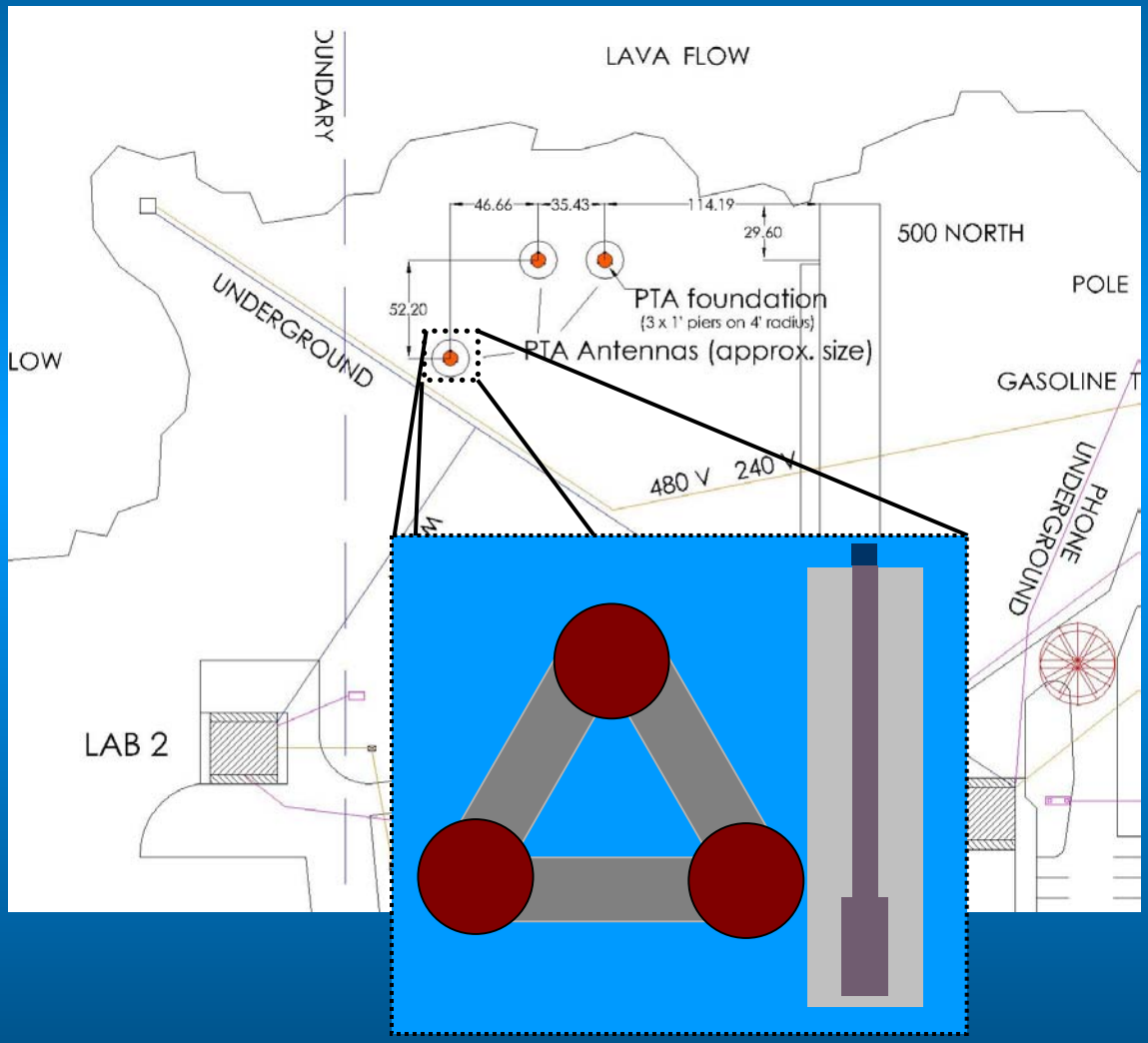

Azimuthally-Averaged Antenna Pattern at 1 GHz
f/D=0.40 y_c/D=0.50
In-focus
Out-of-focus
dBi
30
20
10
0
-10
-20
0
45
90
135
Angle [deg]


Azimuthally Averaged Beam Pattern at 3 GHz
f/D = 0.40 y_c/D = 0.50
In-focus
-7 cm out-of-focus (6 GHz)
+15 cm out-of-focus (1420 MHz)
dBi
40
30
20
10
0
-10
-20
0
15
30
45
60
75
90
105
120
135
150
165
180
Angle [deg]

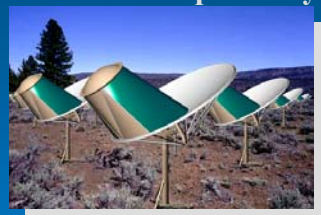
Allen Telescope Array

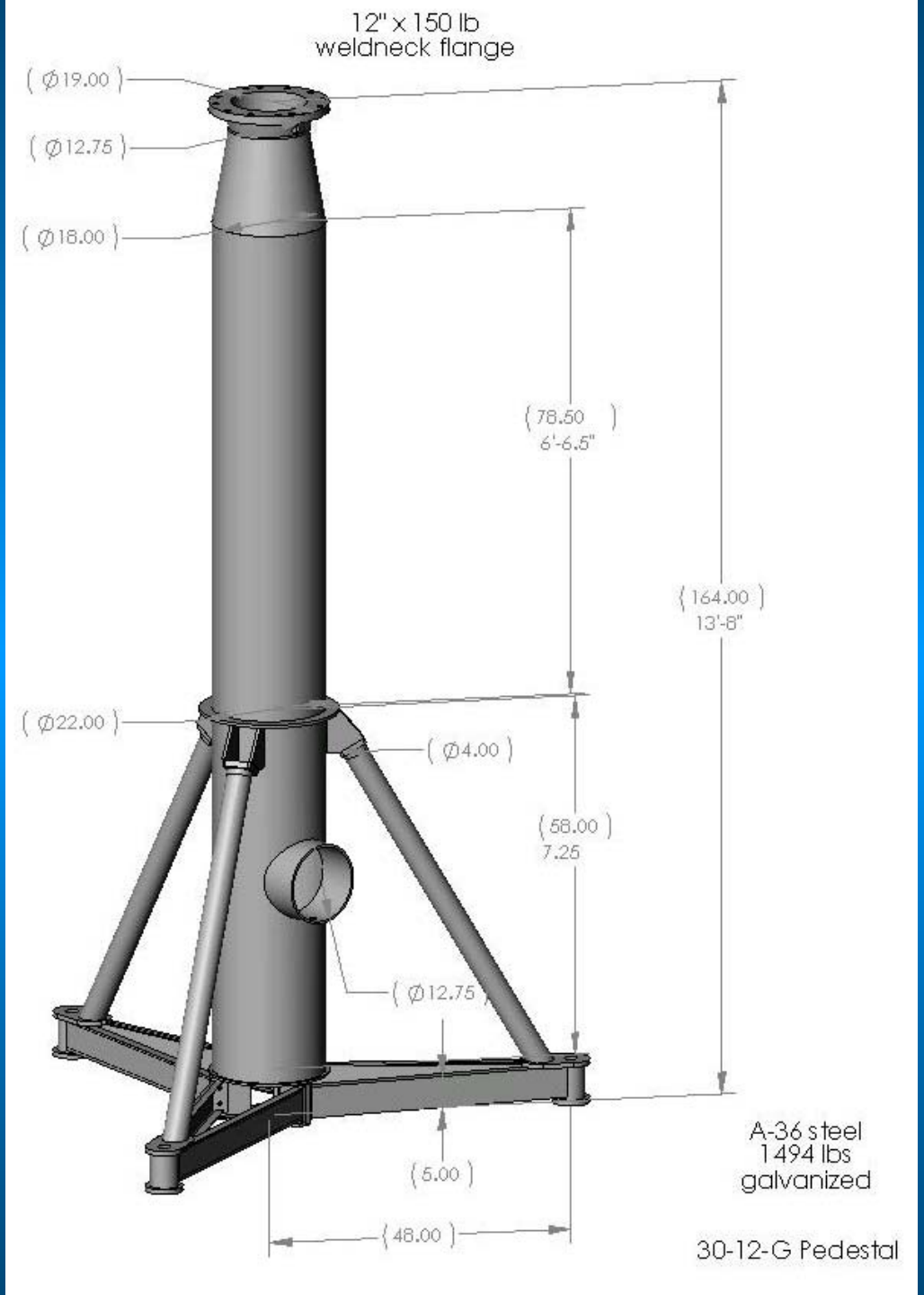


Foundation

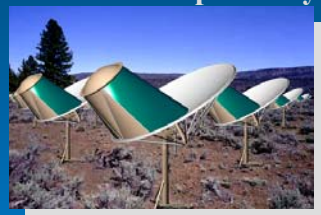


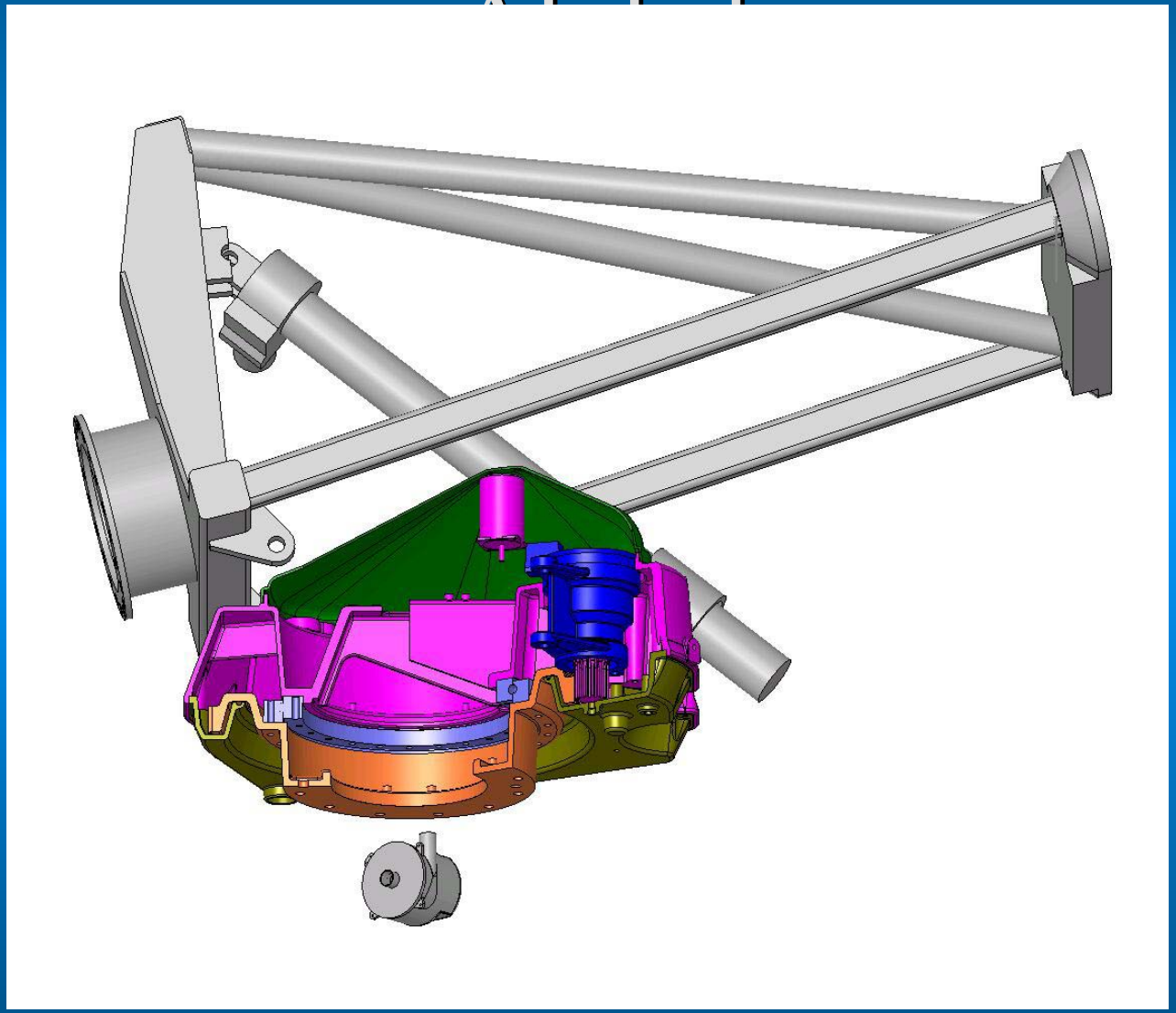
Allen Telescope Array



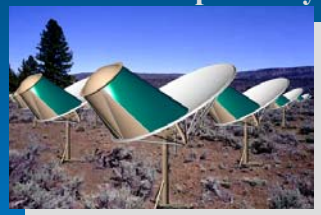


Allen Telescope Array

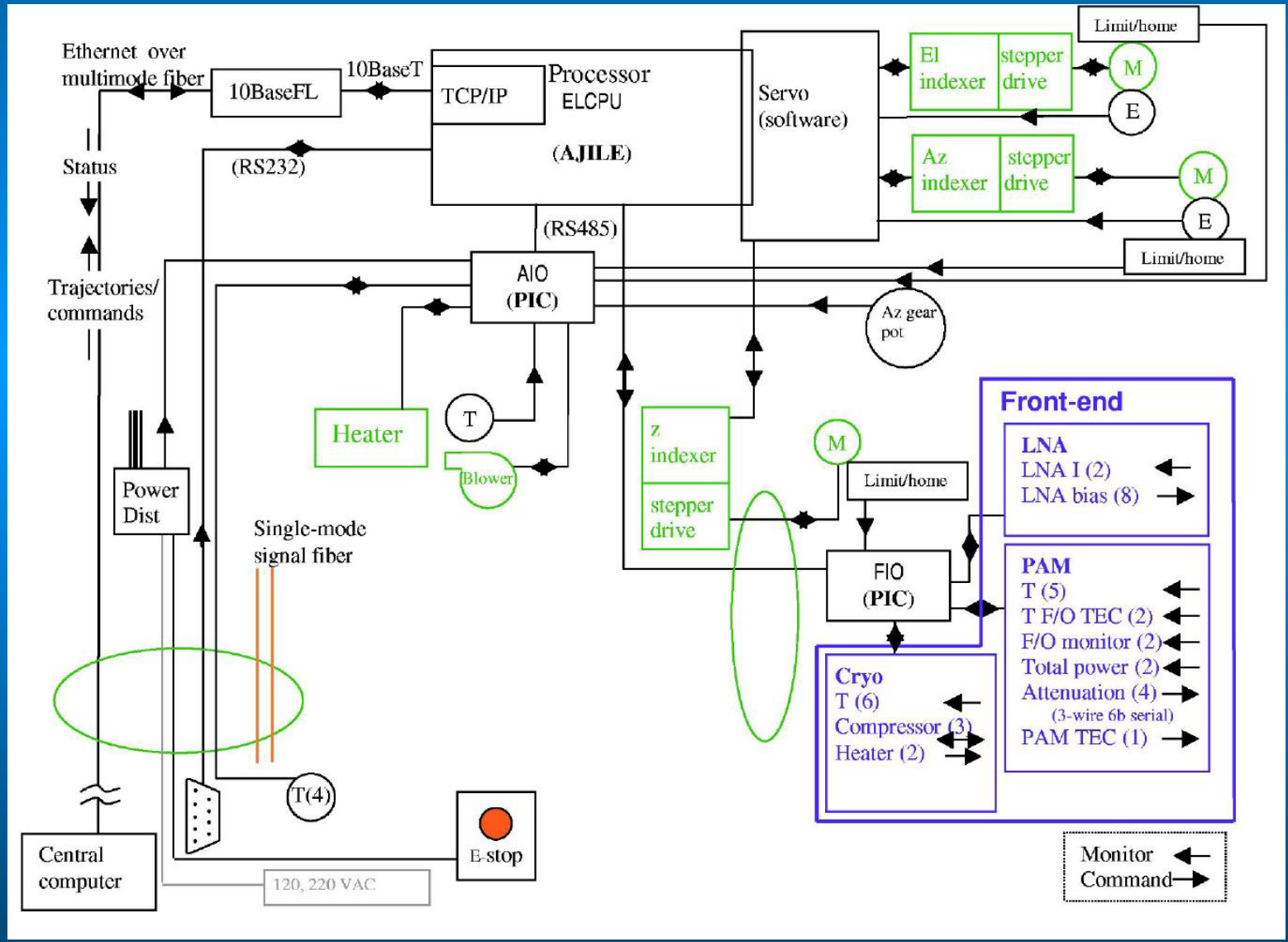




Allen Telescope Array



Antenna Control



Allen Telescope Array

Low Cost Antennas

- Three bids
  - Orbitron
  - Vertex/RSI
  - Andersen Manufacturing ✓

Allen Telescope Array

Andersen Mfg

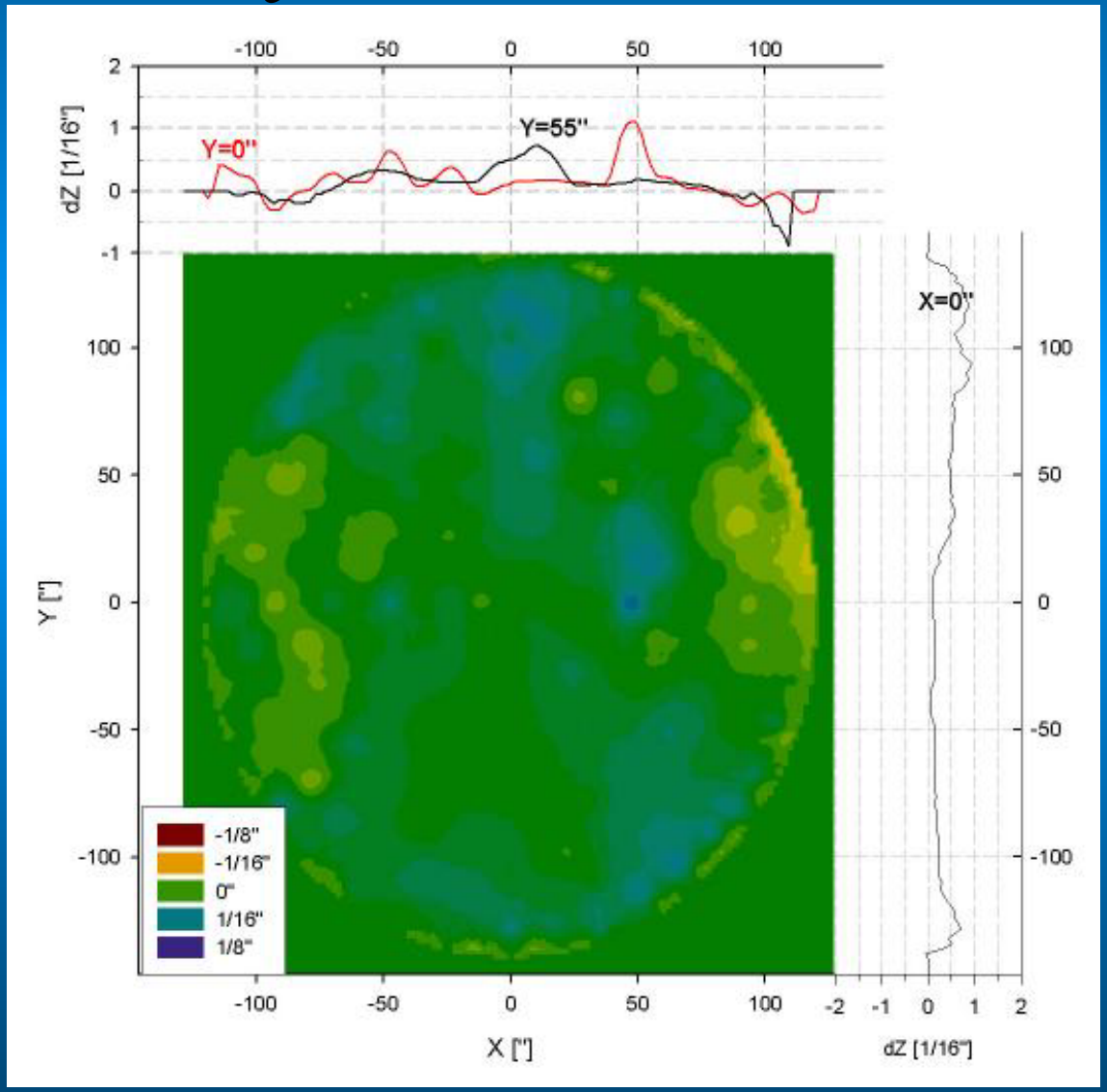
Allen Telescope Array

Primary Surface

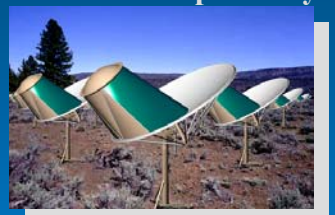
#7

0.027" RMS

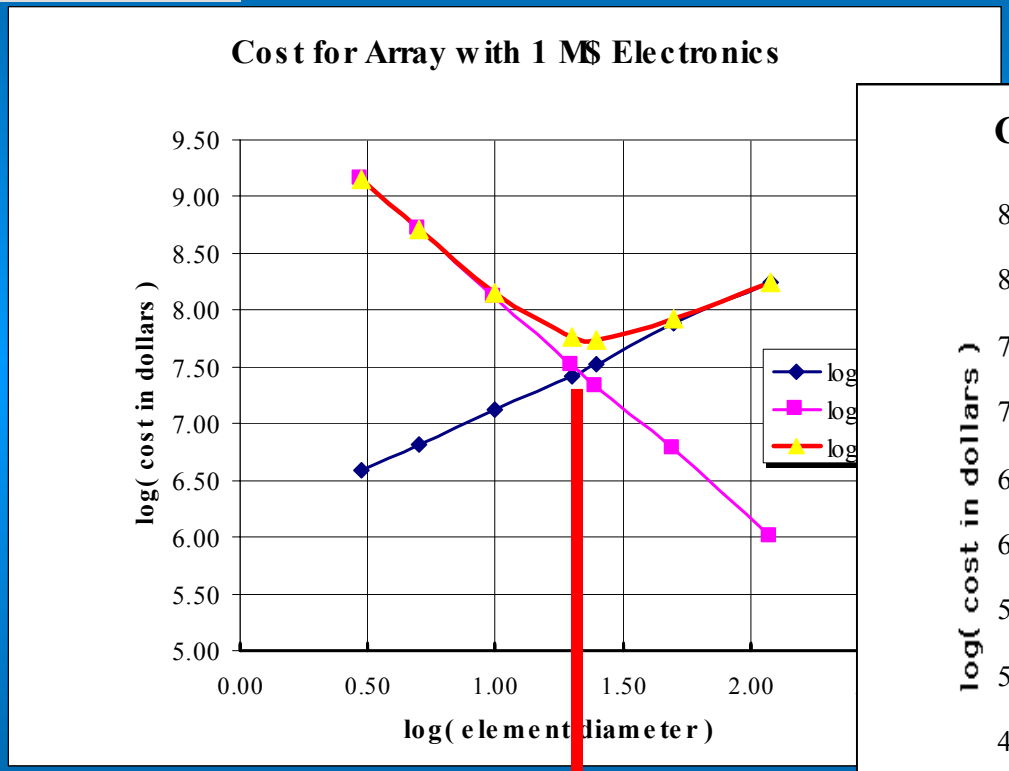
Additional money from JPL to improve

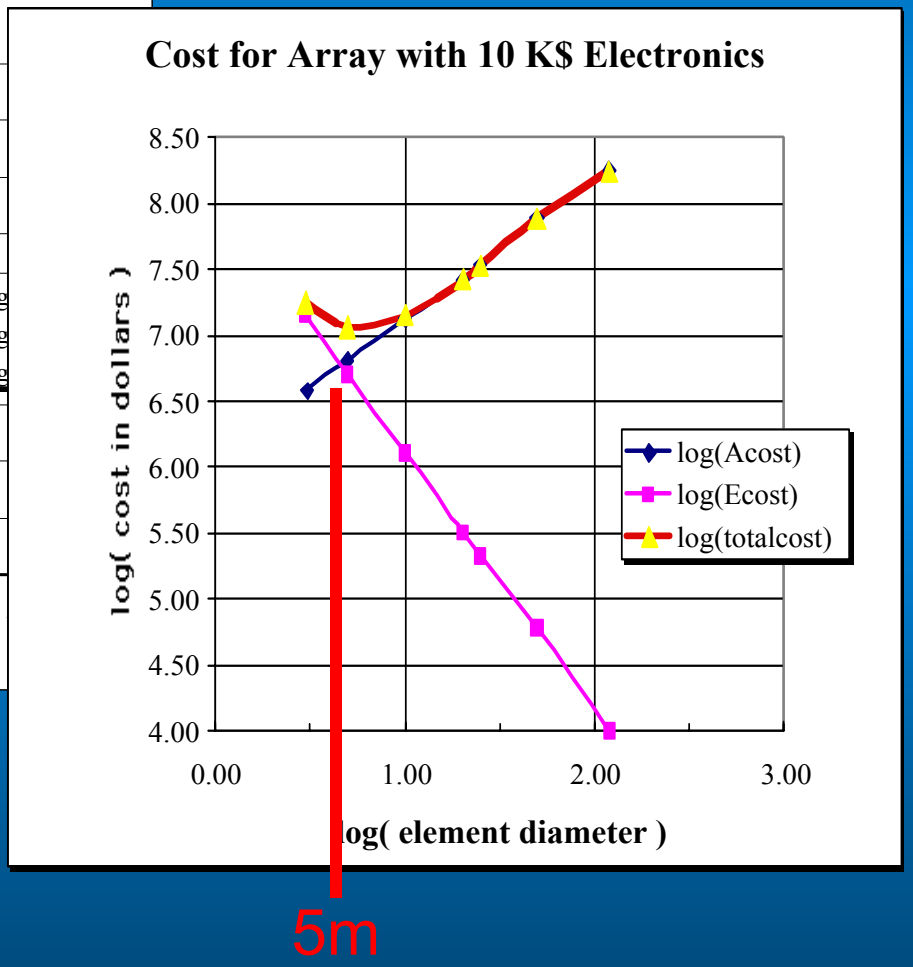


Allen Telescope Array

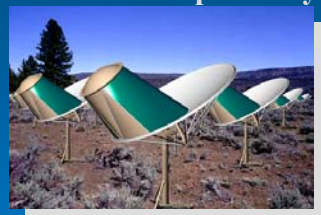


Electronics and Power-law Sets Size

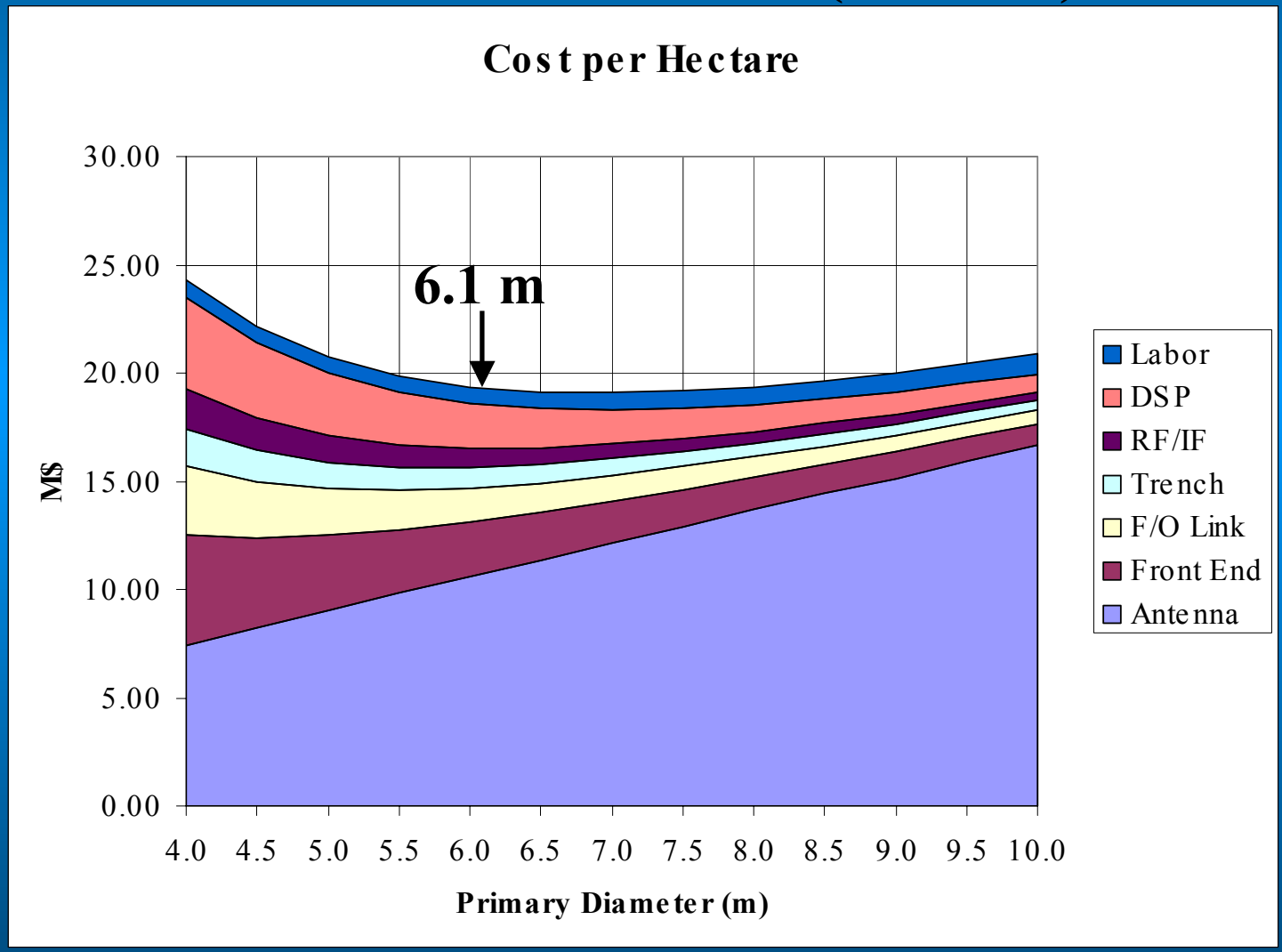




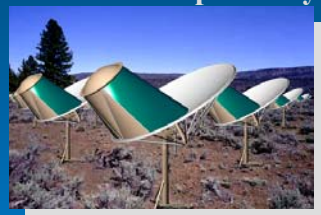
Allen Telescope Array



Current Model (JWD)



Allen Telescope Array

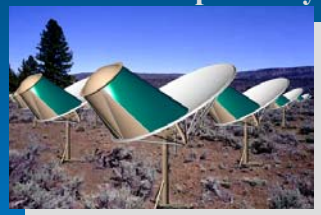


Timeline for ATA

2002

- CDR
- Build Production Test Array (PTA)
  - Foundations next week
  - Pedestals in mid-July
  - Antennas by October (room temperature feed)
  - Cryogenic feed by December
- Operational tests begin
- Develop tools/infrastructure

Allen Telescope Array



Timeline for ATA

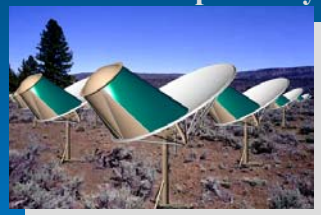
2003-2004

- Begin construction
- First use of partial array

2005

- Array complete - extensions begin
- Feed into SKA technology decision point

Allen Telescope Array



Thanks

- ATA Intranet site
  - Send me an e-mail at ddeboer@seti.org
- www.seti.org
- astro.berkeley.edu/ral