# The Allen Telescope Array

SKA: Defining the Future

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Berkeley

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*Project Manager (Acting)*

# ATA: What is It?

- Massively parallel array of small dishes
  - ***350 elements*** each 6.1 m in diameter
  - total collecting area ***larger than 100 m dish***
  - 0.5 - 11 GHz ***simultaneously***
  - ***multiple*** beams
- Must be ***much*** cheaper than existing arrays
- Joint project of SETI Institute and UCB
- Funded by private donations

# ATA Performance

| | | | |
|---|---|---|---|
| Number of Elements | 350 | | |
| Element Diameter | 6.10 | m | |
| Total Geometric Area | 1.02E+04 | m^2 | |
| Aperture Efficiency | 63% | | |
| Effective Area | 6.44E+03 | m^2 | |
| | 2.33 | K/Jy | |
| System Temperature | 43 | K | |
| System Eqiv. Flux Density | 18 | Jy | |
| Ae/Tsys | 150 | m^2/K | |
| Effective Array Diameter | 687 | m | Natural Weighting |
| Frequency | 1 | 10 | GHz |
| Primary FoV | 3.5 | 0.4 | degree |
| Synthesized Beam Size | 108 | 11 | arc sec |
| Number of Beams | >4 | | |
| Continuum Sensitivity | | | |
| BW | 0.2 | GHz | Confusion |
| Flux Limit in 10 sec | 0.41 | mJy | 0.1 mJy at 1.4 GHz |
| Spectral Line | | | |
| Resolution | 10 | km/s | |
| Frequency | 1 | 10 | GHz |
| BW | 3.E+04 | 3.E+05 | Hz |
| Integration Time | 1000 | 1000 | sec |
| RMS brightness | 0.70 | 0.22 | K |

# ATA Science

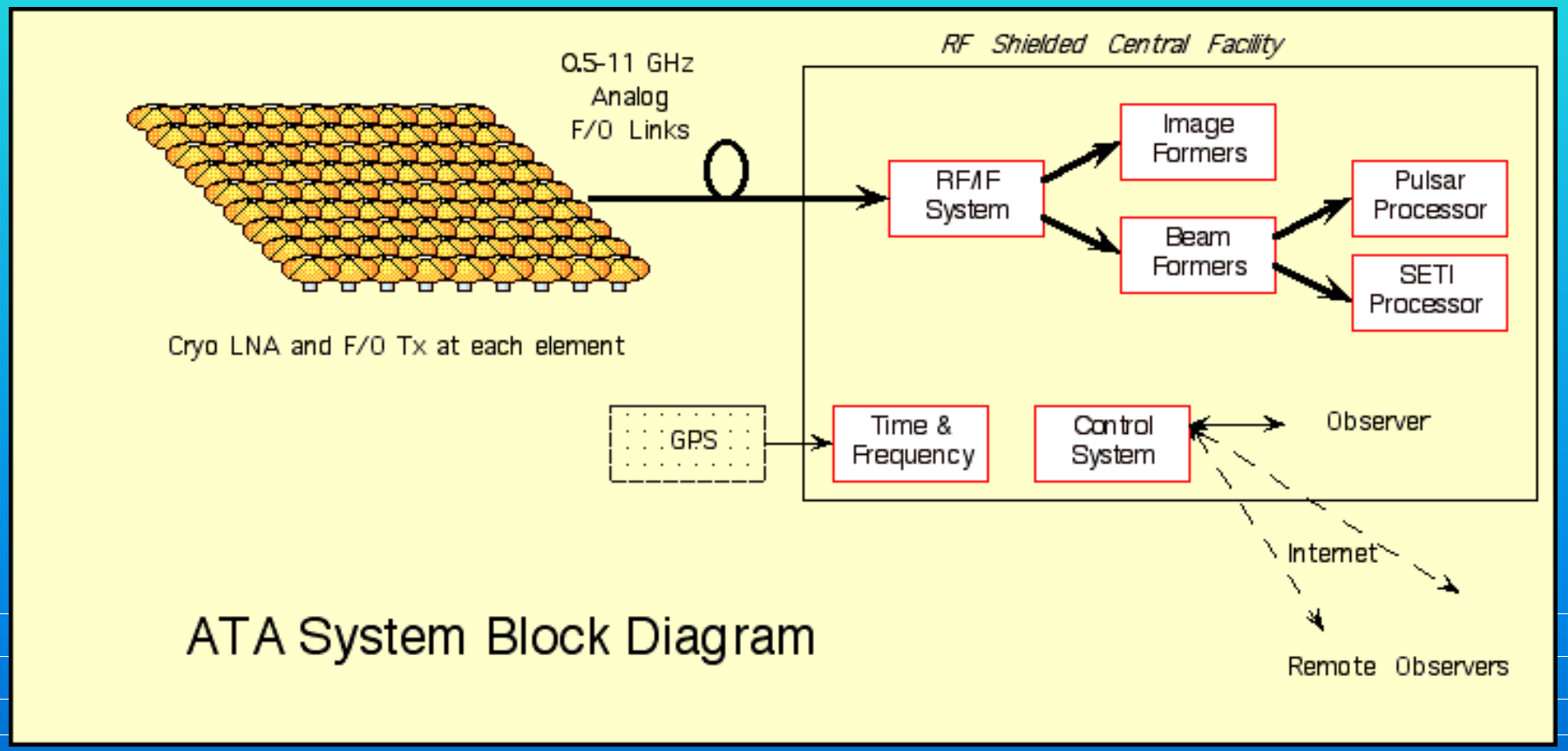
- SETI
  - 100,000 FGK stars
  - Galactic plane survey (2nd generation DSP)
- HI
  - All sky HI, z < 0.03, Milky Way at 100 σ
  - Large area to z ~ 0.1 or more
  - Zeeman
- Temporal Variables
  - Pulsar Timing Array
  - Pulsar survey followups
  - Extreme Scattering Events
  - Transients

*Not an exhaustive list!!*

# Timeline for ATA

- **1999-2001**
  - R&D phase
  - Rapid Prototyping Array
  - Site selection
  - Preliminary design reviews
- **2001-2002**
  - Design phase
  - Critical design reviews
  - Production Test Array
  - Plan construction phase
- **2003-2004**
  - Begin construction
  - First use of partial array
- **2005**
  - First hectare complete
  - Feed into SKA technology decision point

# ATA System Overview

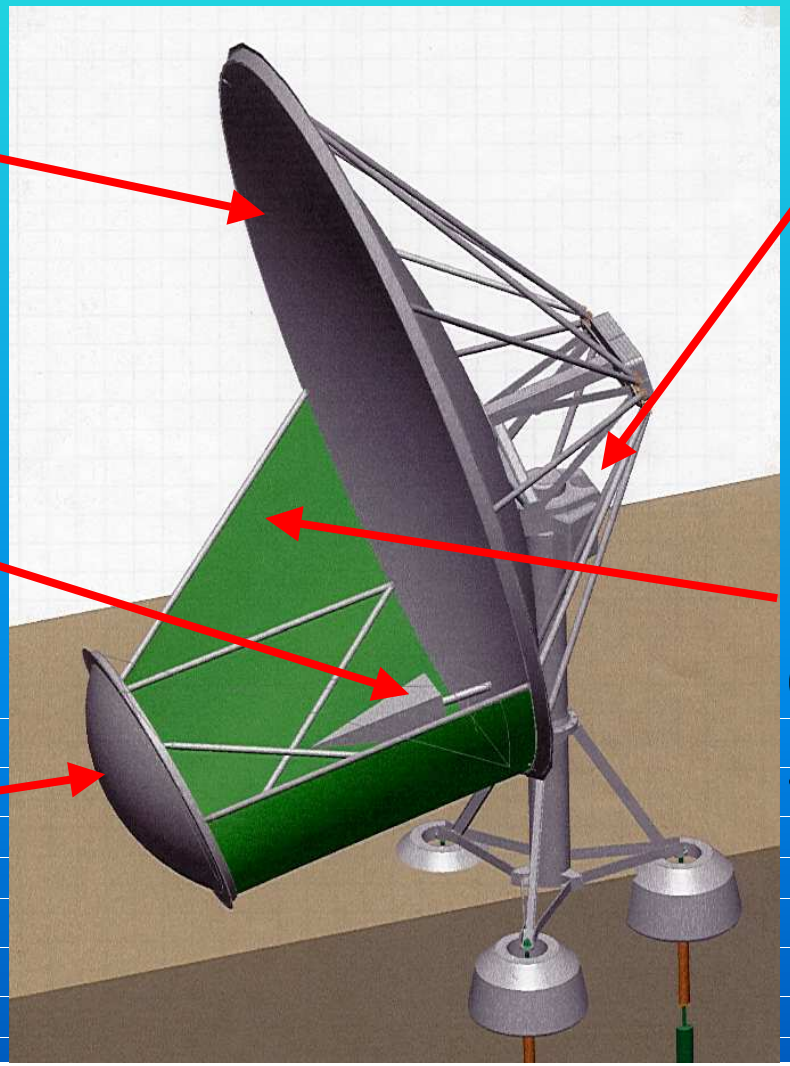


# Offset Gregorian Antenna

6.1 m x 7.0 m Primary

Log-periodic Feed

2.4 m Secondary

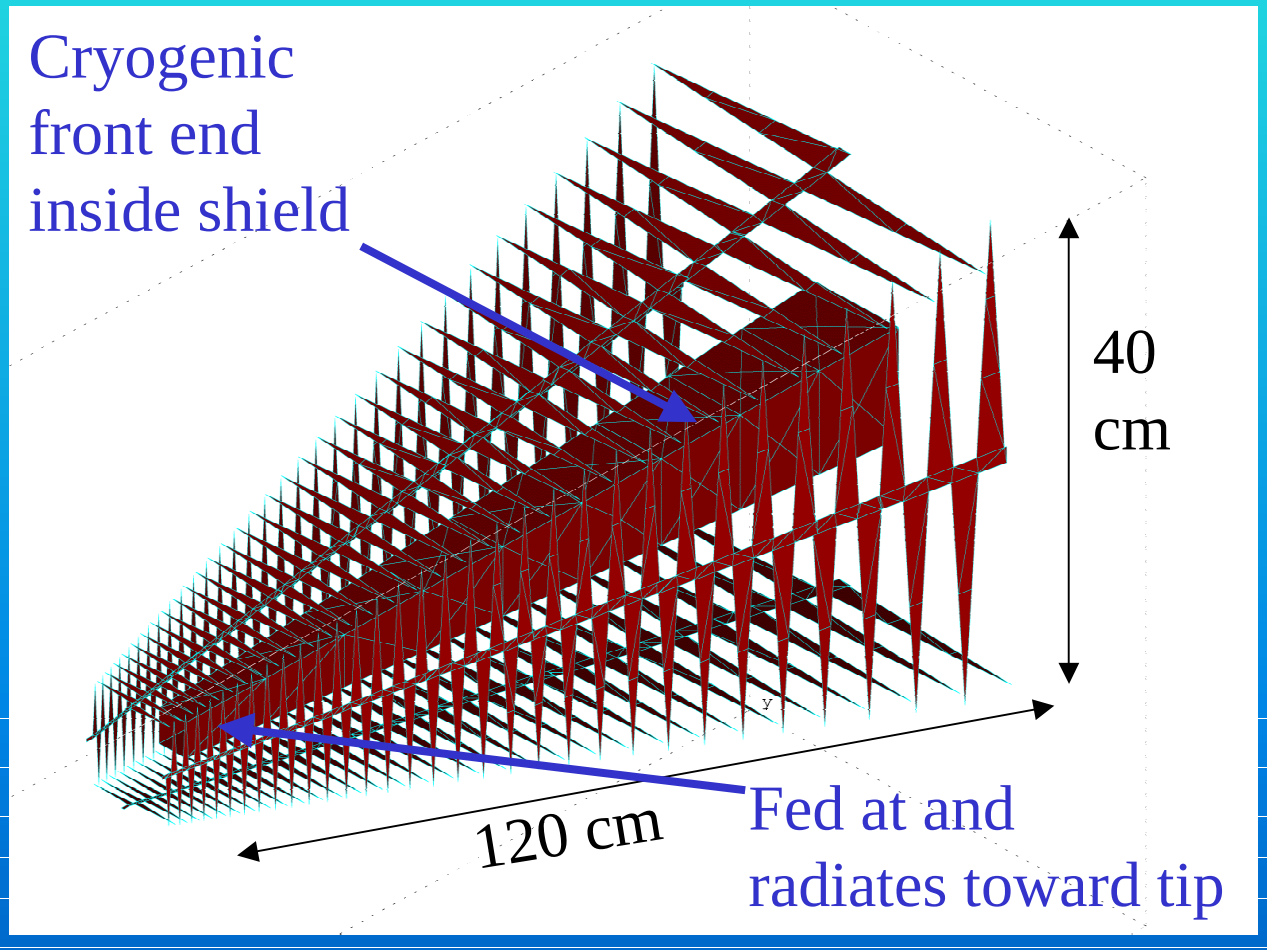


Az-El Drive

Shroud
(feed can't see
ground or array)

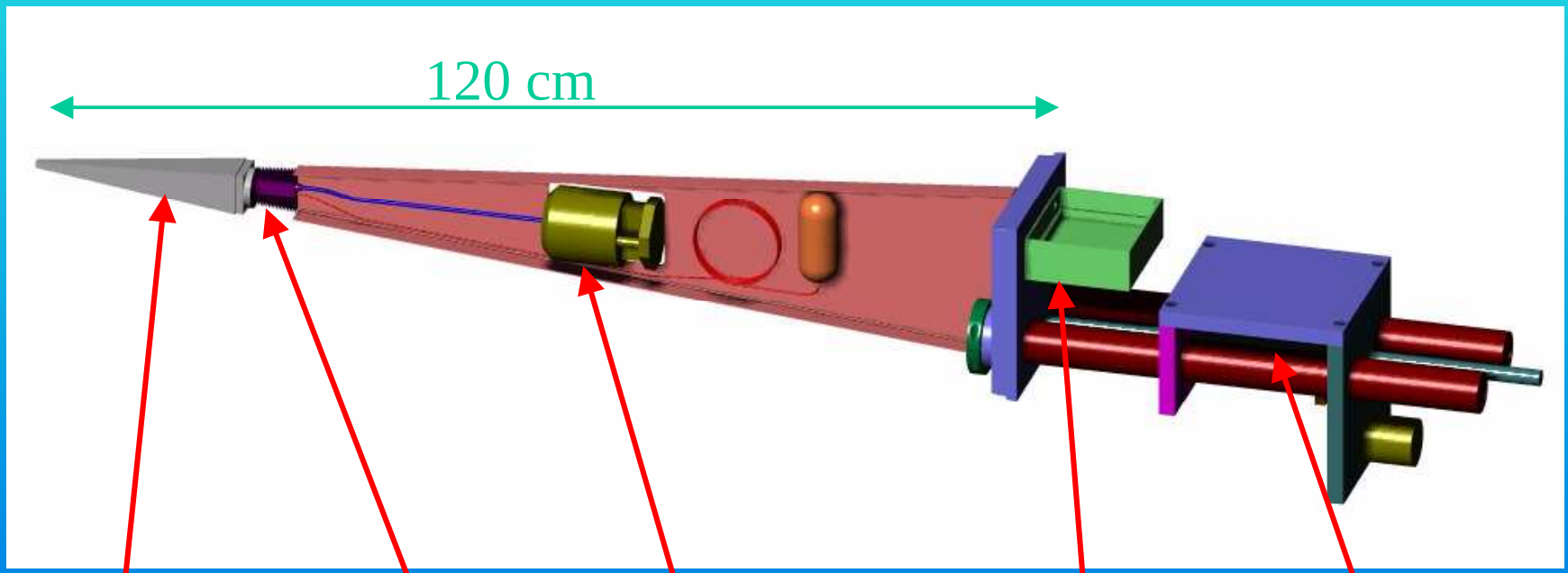
# 0.5-11 GHz Log Periodic Feed

Dual polarization



Talk 2.9: Progress at JPL Concerning Antenna and Wideband Receiver Design
Talk 2.1: Fiber-Optic Technology for Antenna Remoting
Poster 30: The Allen Telescope Array Signal Path

# Front End Inside Feed




Dewar with InP MMIC LNA inside

Pulse Tube Cooler

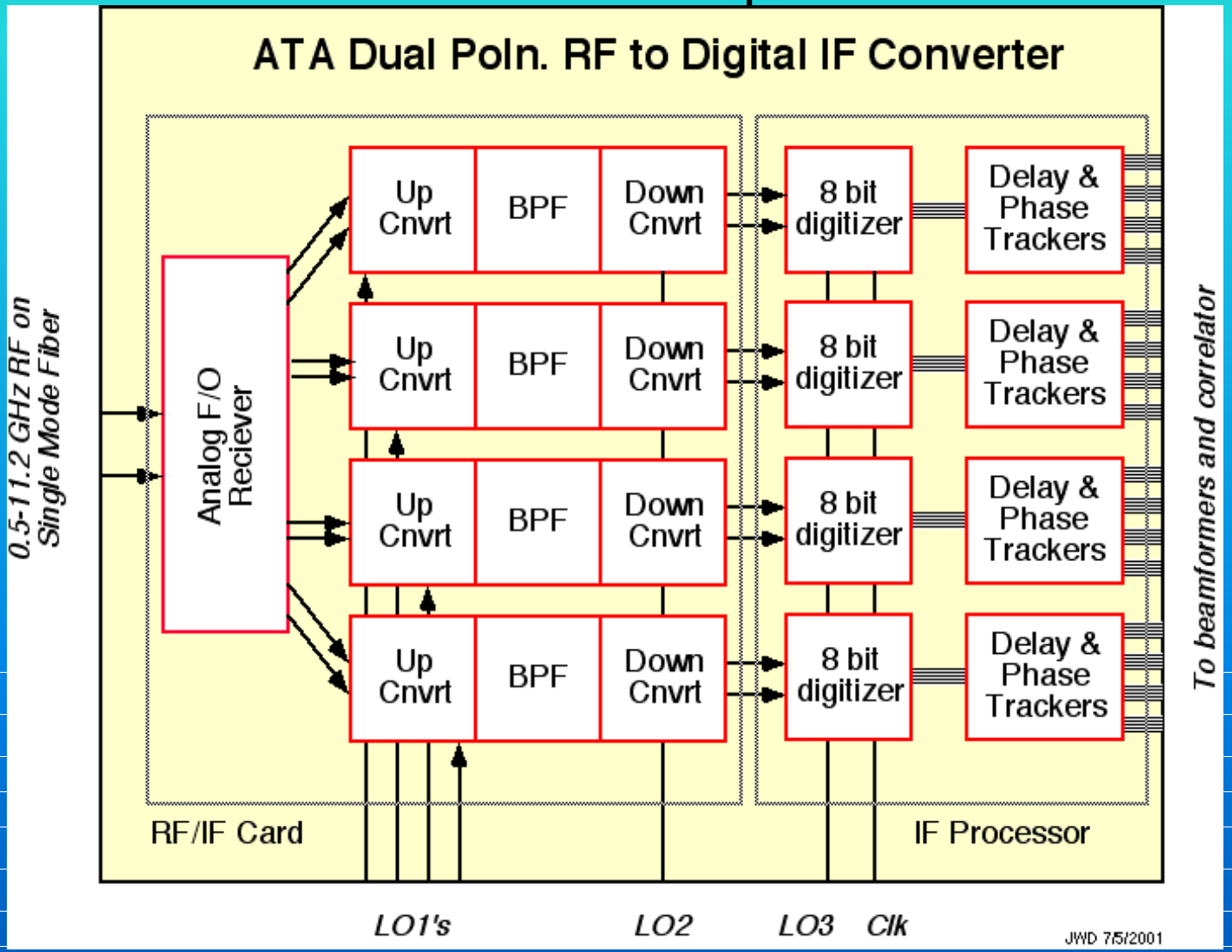
Clearance Seal Compressor

Post Amp and F/O Xmitter

Focus Drive

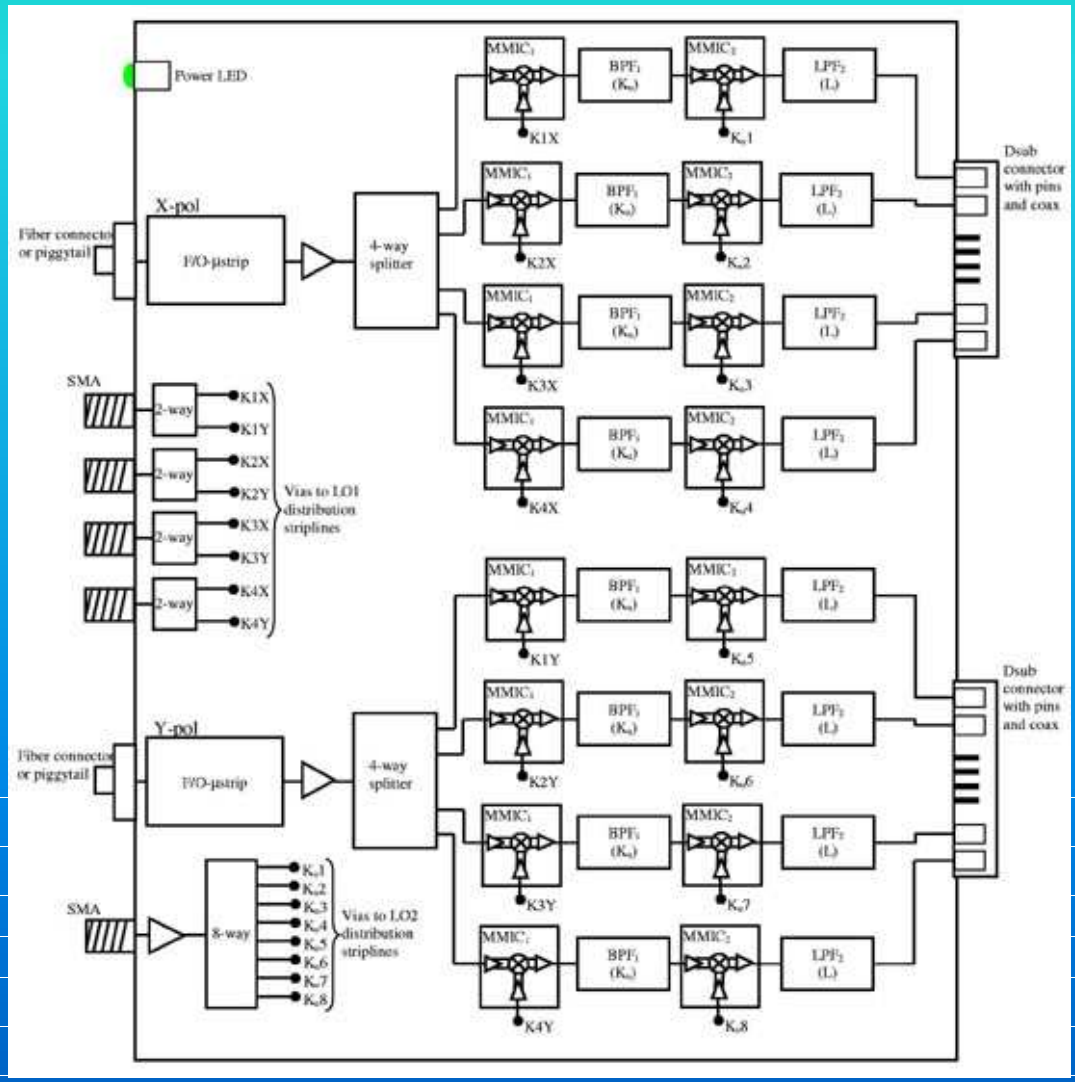
# Poster 30: The Allen Telescope Array Signal Path
# Talk 6.6: Active antennas and the use of MMIC's

*Post PDR* | *Pre PDR*



Poster 30: The Allen Telescope Array Signal Path
Talk 6.6: Active antennas and the use of MMIC's

# RF/IF Card




*Preliminary Layout*

# IF Processing

| Tradeoffs to be made | Likely to achieve | |
|---|---|---|
| # RF tunings (LO1's) | 4 | *Total of 16 dual polarization beams* |
| # Beams (dual poln.) per RF tuning | 4 | |
| BW per beam | 100 MHz | |
| Constraints on beam locations | primary beam? | |
| Image and alias rejection | 30-40 dB | |

**Only 5 K$ per antenna**

# Correlator

- Image entire primary field of view
- Large number of antennas is a challenge
- Achievable BW will be set by funding
- F/X design looks best for large N
- Potential for using industry terabit switching

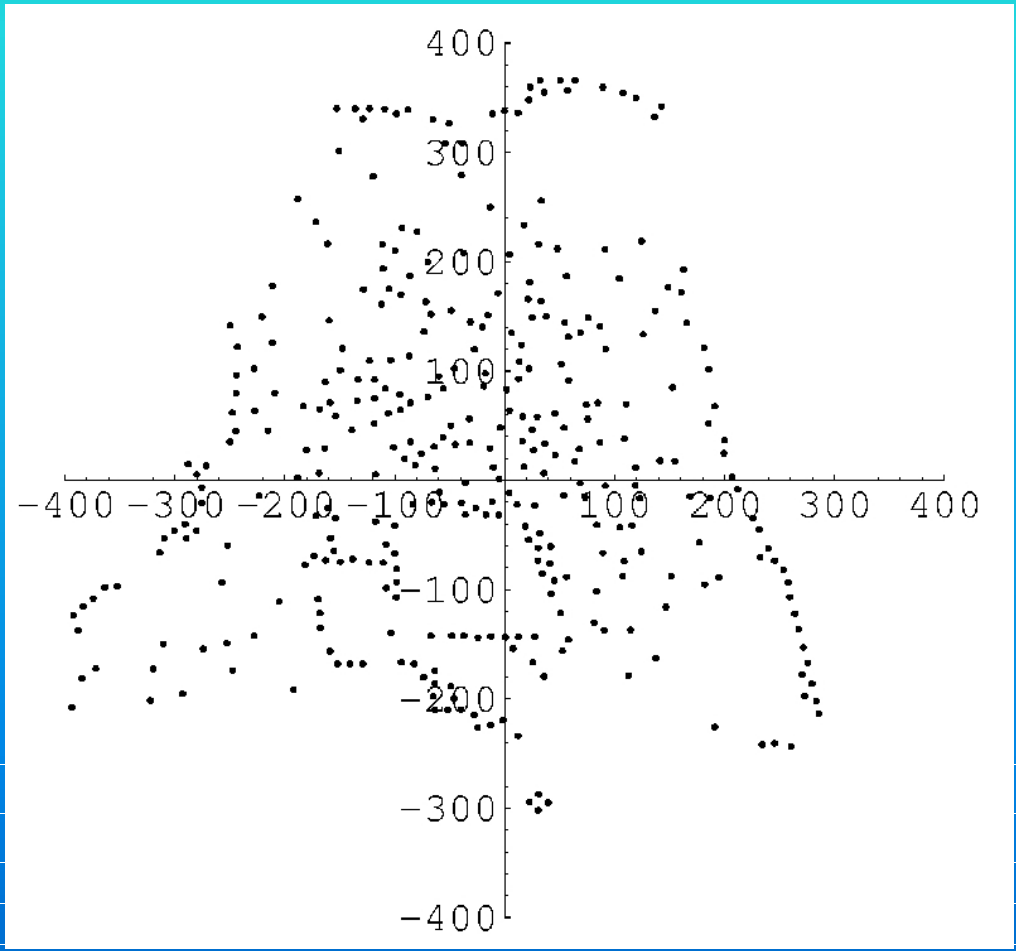
Talk 6.1: SETI and Its Detectors at the SKA
Talk 7.7: RFI Observations at the Rapid Prototyping Array

# Beamformers ⇨ Backends

- Multiple beams speed up SETI searches
  - More than 1 star per field of view
  - Run in anticoincidence to identify RFI
  - Enables **simultaneous SETI and radio astronomy**
- Pulsar research will be a major use
- RA spectrometer in addition to correlator?
- Active RFI suppression

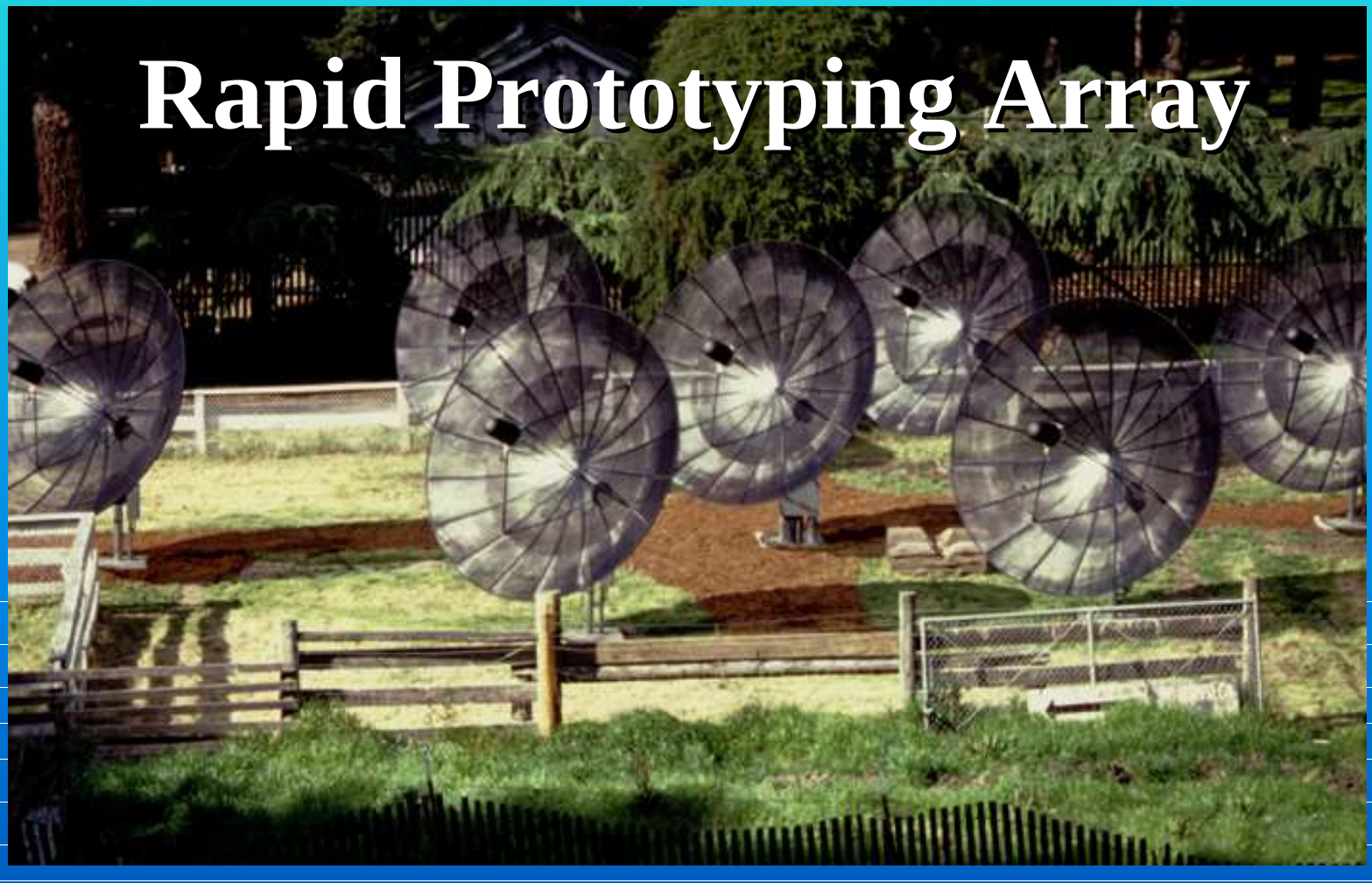
# Hat Creek Observatory

# Configuration for ATA

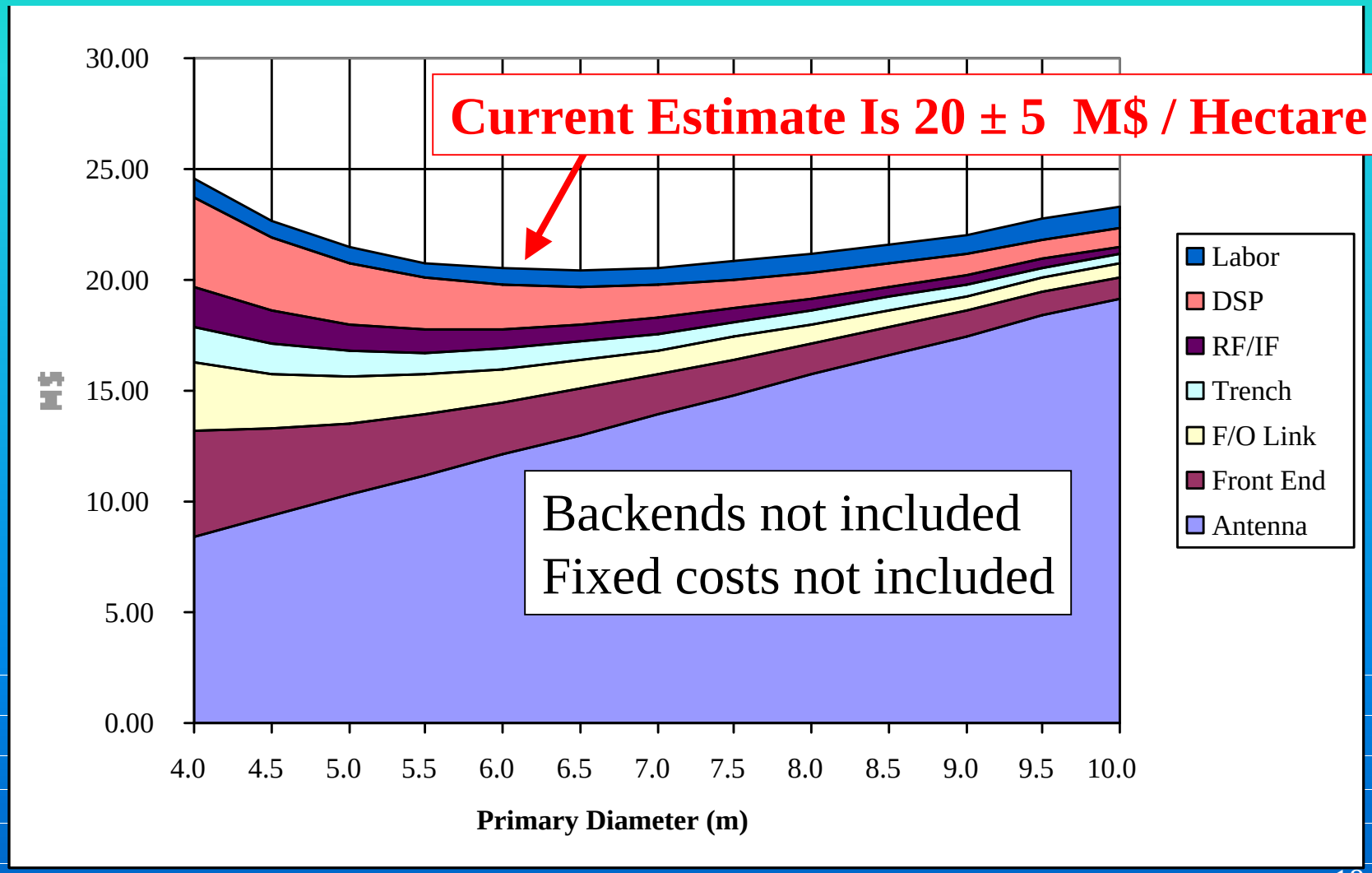



- Nearly circular beam
- 76 arcsec at 1.4 GHz
- Near-in sidelobes peak at 1%
- Far-out sidelobe ~ 1/N

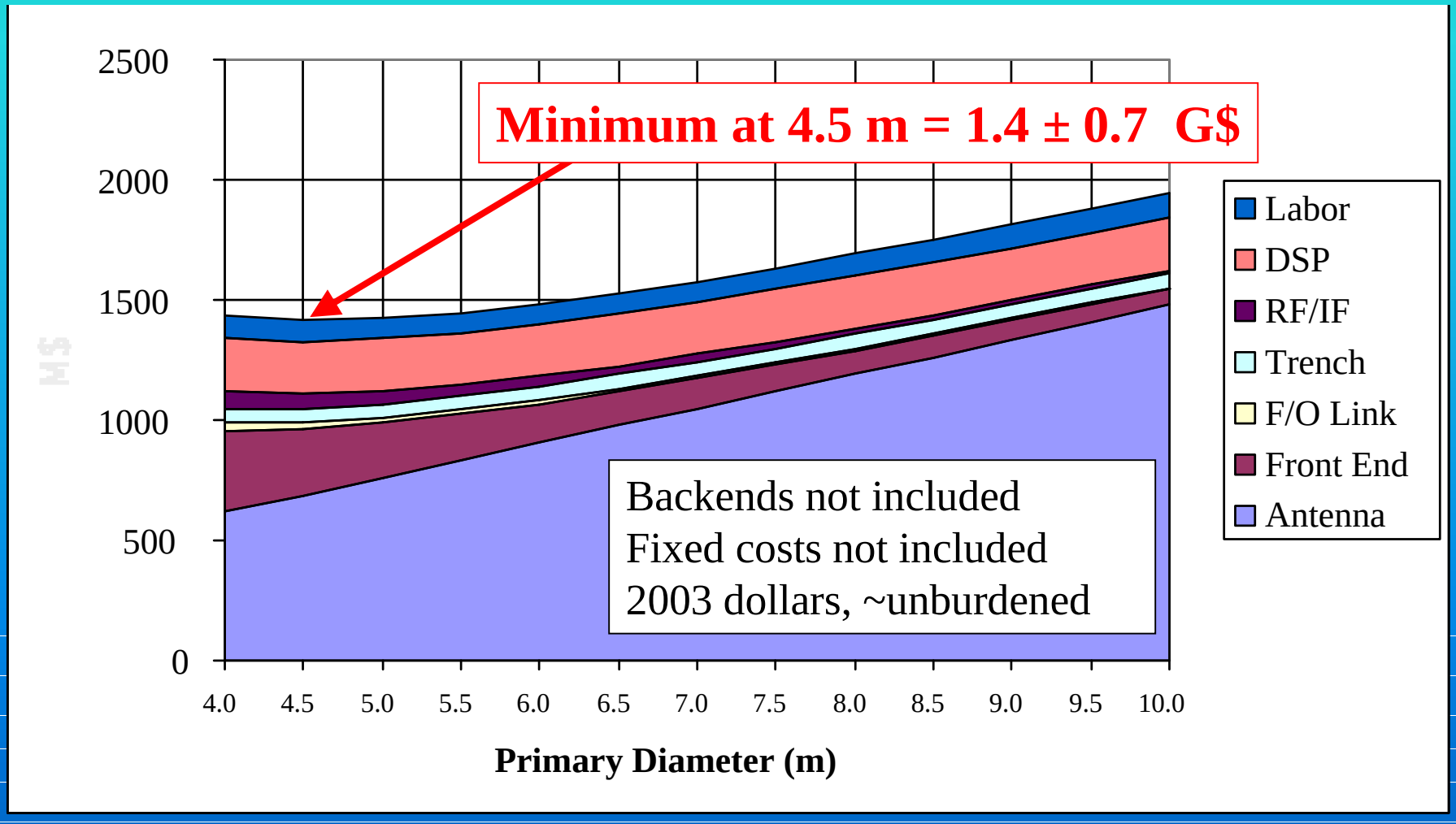
Poster 27: The Rapid Prototyping Array
Talk 7.7: RFI Observations at the Rapid Prototyping Array
Poster 28: Prototyping a Distributed, Scalable Control System at the RPA
Poster 29: RFI Observations at the Rapid Prototyping Array



# PDR Estimate of ATA "Scaling" Costs



# ATA scaled to SKA in 2015




$A_{eff}/T_{sys} = 2 \times 10^4\ m^2/K$

73,000 elements

# A Very Rough SKA Budget

| Item | M$ | Comment |
|---|---|---|
| Antennas | 689 | assumes cost proportional to D^2.7 |
| Front Ends | 271 | assume factor of two for microwave components |
| FO Links | 30 | assume -20% per year |
| Station Trenching and Fiber | 56 | assume 300 m station |
| RF/IF | 66 | assume factor of two for microwave components |
| DSP | 170 | assumes 10% of total cost |
| Correlator | 50 | guess |
| Labor | 237 | explicit labor + 5 years of I&T at 30 M$/year |
| Buildings | 50 | wild guess |
| Intrastation trenching | 30 | assumes 300 km runs, 120 stations |
| Design cost | 50 | guess |
| Project cost | 1,699 | 2003 dollars, ~unburdened |
| Uncertainty | 50% | |
| Low | 1,100 | |
| High | 2,500 | |