Interferometric Observations of the CMB from the South Pole with DASI

Clem Pryke

URSI Meeting

Bolder January 10 2001

DASI/CBI Collaboration

- CBI at CalTech / Chile
- Steve Padin / Tony Readhead
- Tim Pearson, Martin Shepherd, Brian Mason
- John Cartwright, J. Sievers, P. Udompraset
- W. Schaal
- S. Myers, M. Joy, L. Bronfman, J. May
- DASI UofC / South Pole (CARA)
- John Carlstrom / Mark Dragovan
- Bill Holzapfel, Erik Leitch, Clem Pryke
- Nils Halverson, John Kovac
- Ethan Schartman
- John Yamasaki / Gene Davidson

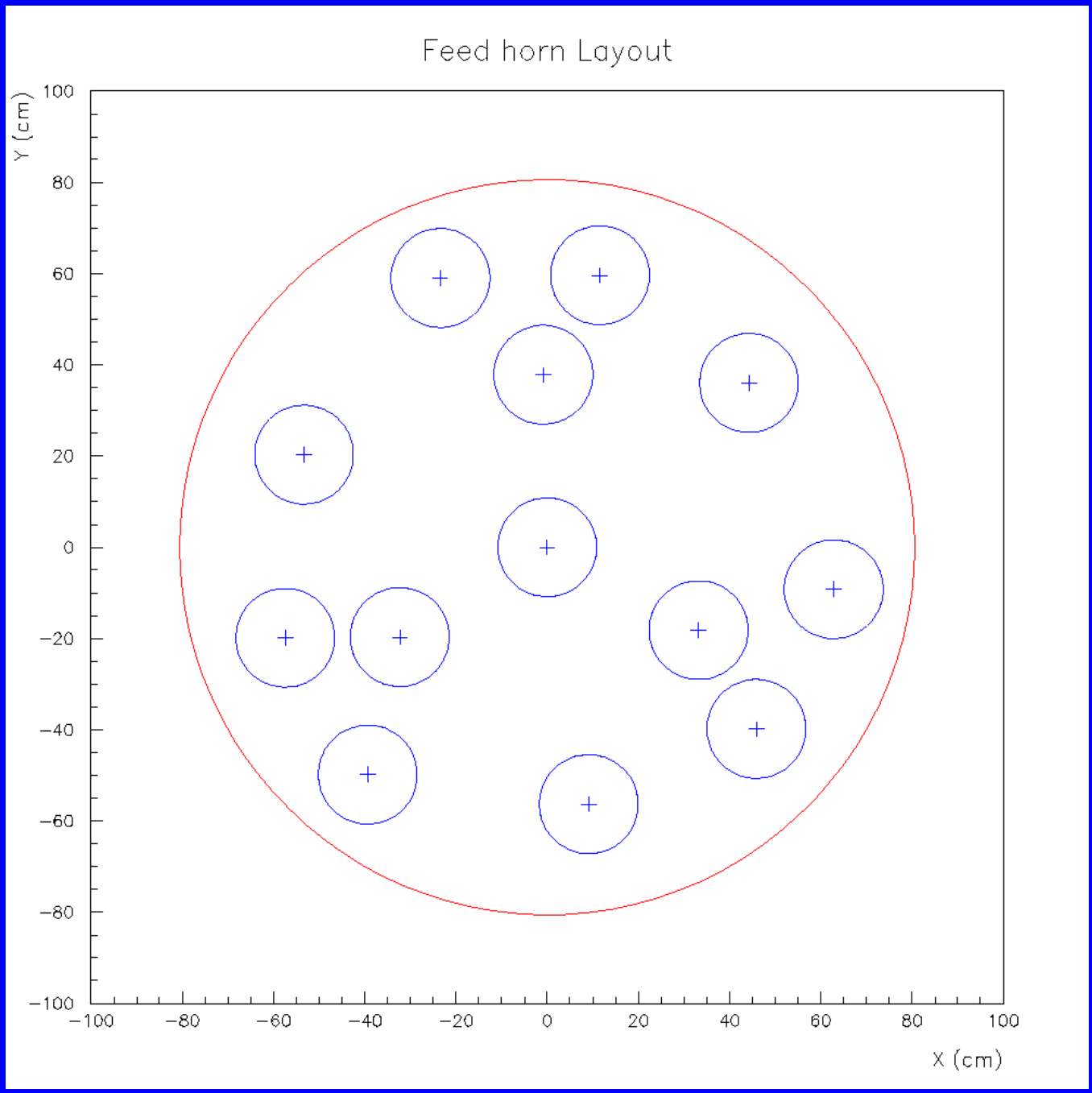
DASI at Sunset

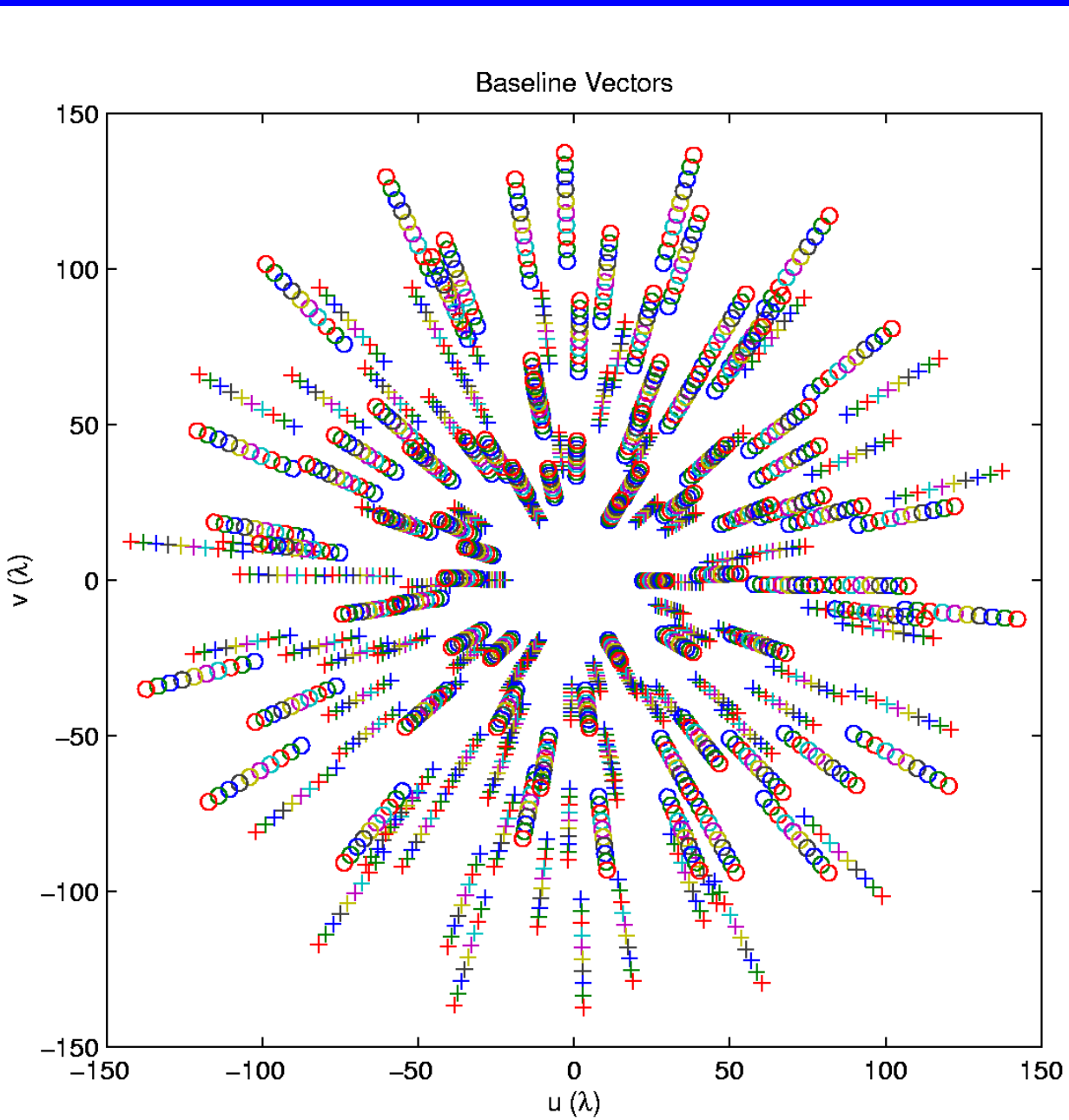
DASI System

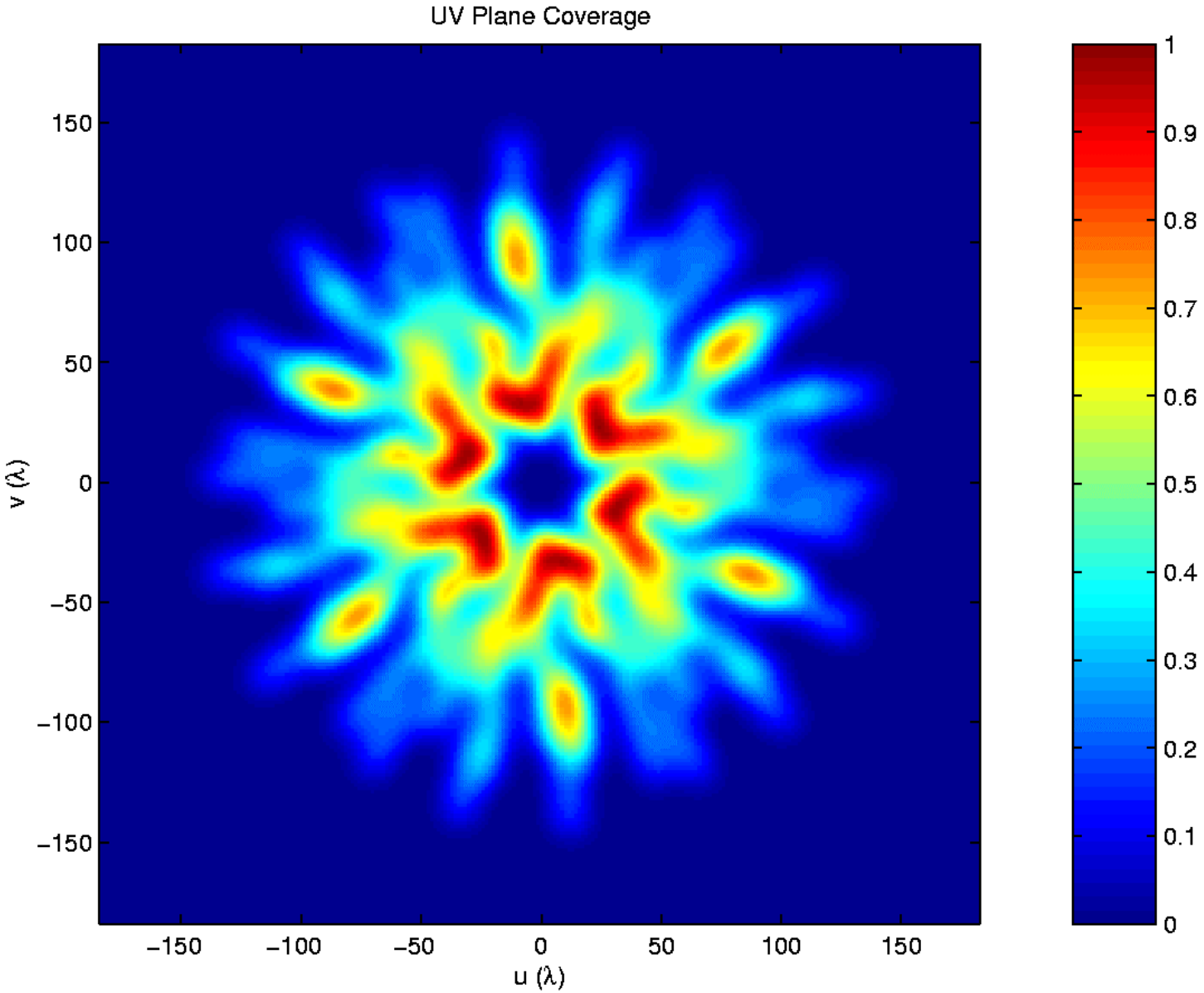
- Interferometer to measure power spectrum of the CMB anisotropy at $100<l<900$
- Co-planar array of thirteen 26-36 GHz receivers (NRAO design HEMTs)
- 20 cm lensed, corrugated, feedhorns with ultra low cross-talk.
- Correlator, receiver control electronics and online software replicated from CBI
- Located at South Pole – highly specialized mount design required

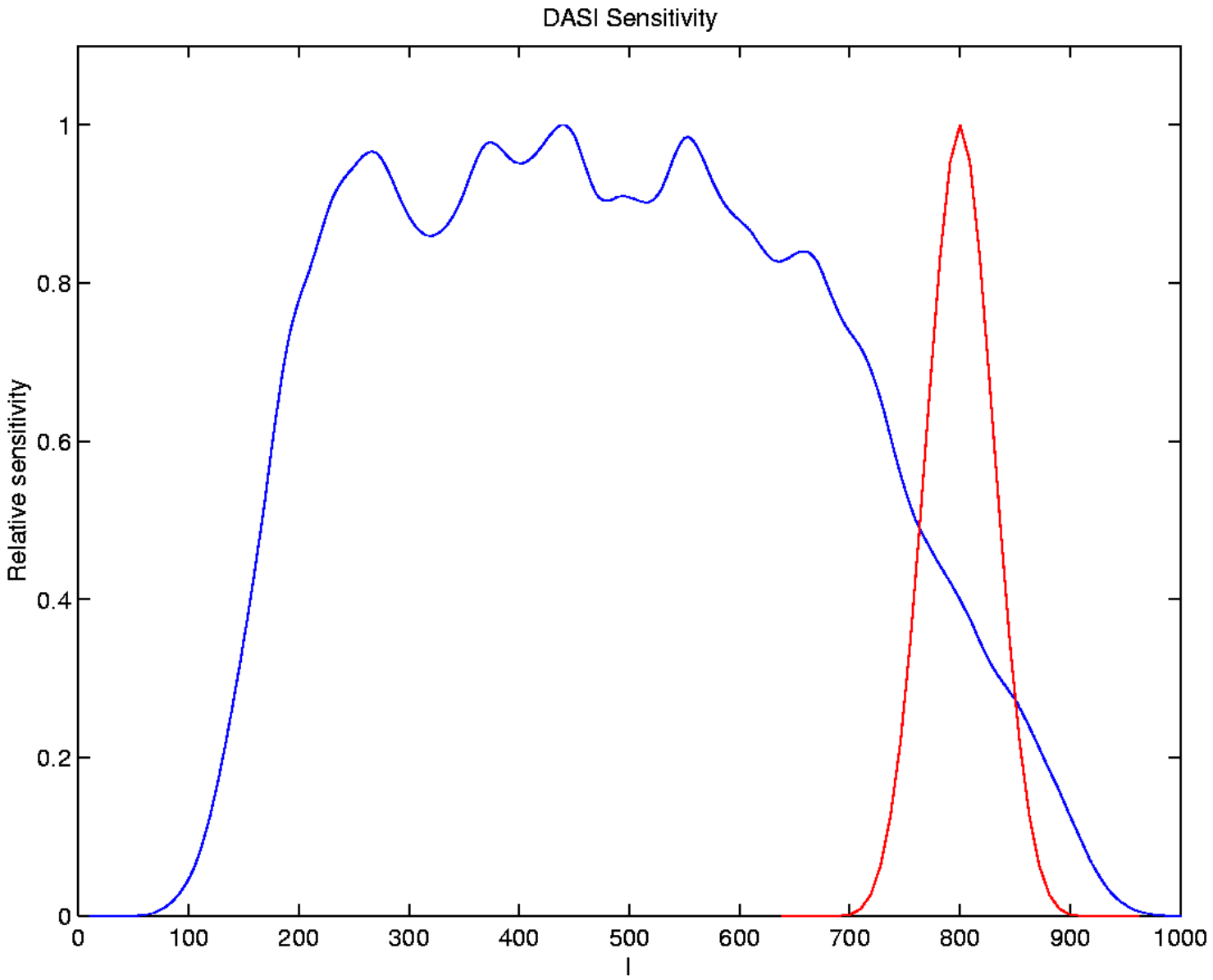
Why an Interferometer?

- Directly measures power spectrum of the sky.
- Intrinsically stable – only correlated signals are detected.
- Designer can control angular range covered.


Feed horn Layout
Y (cm)
X (cm)
100
80
60
40
20
0
−20
−40
−60
−80
−100
−100
−80
−60
−40
−20
0
20
40
60
80
100


Baseline Vectors
150
100
50
0
−50
−100
−150
v (λ)
−150
−100
−50
0
50
100
150
u (λ)

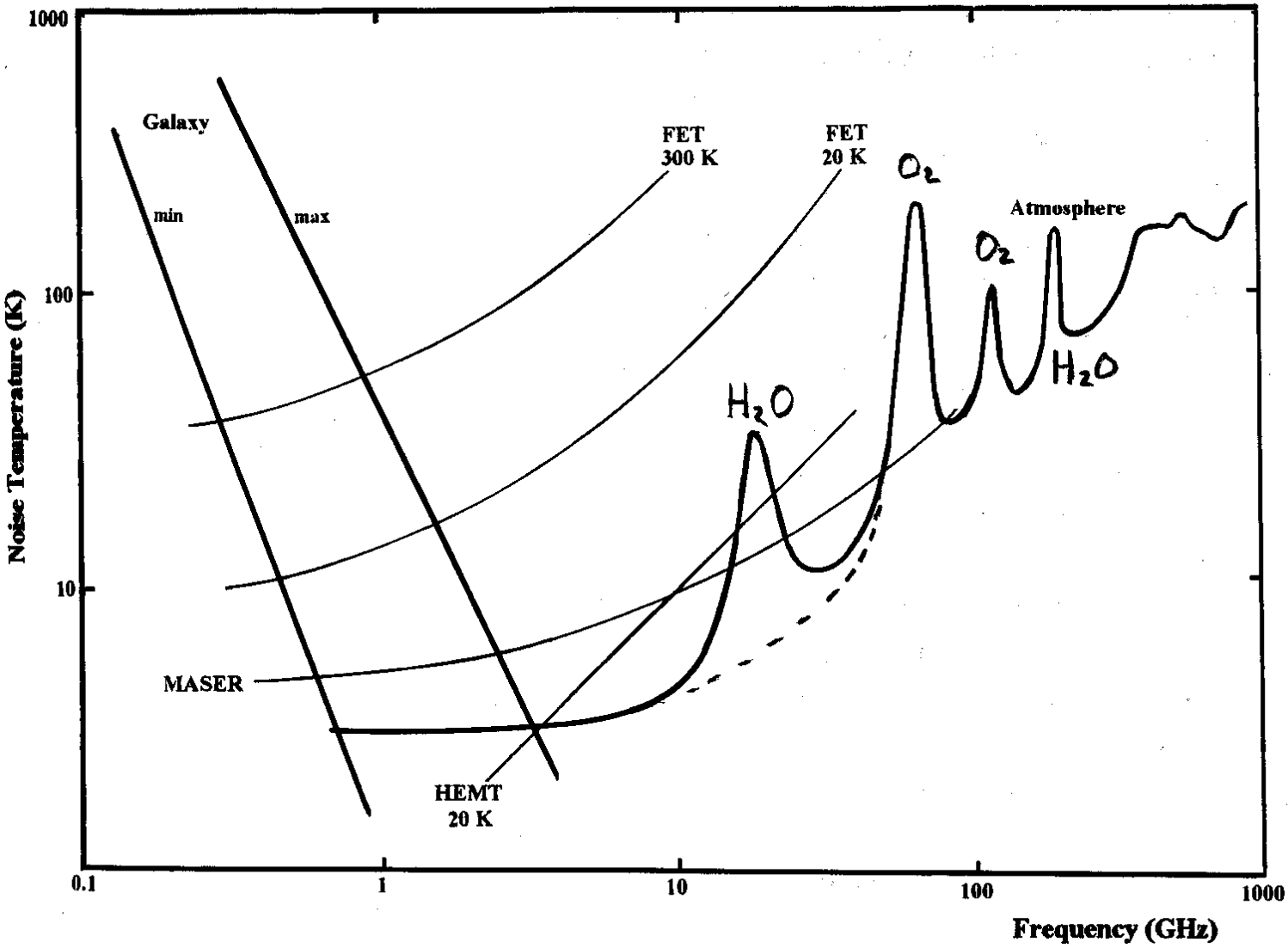

UV Plane Coverage
150
100
50
0
−50
−100
−150
v (λ)
−150
−100
−50
0
50
100
150
u (λ)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

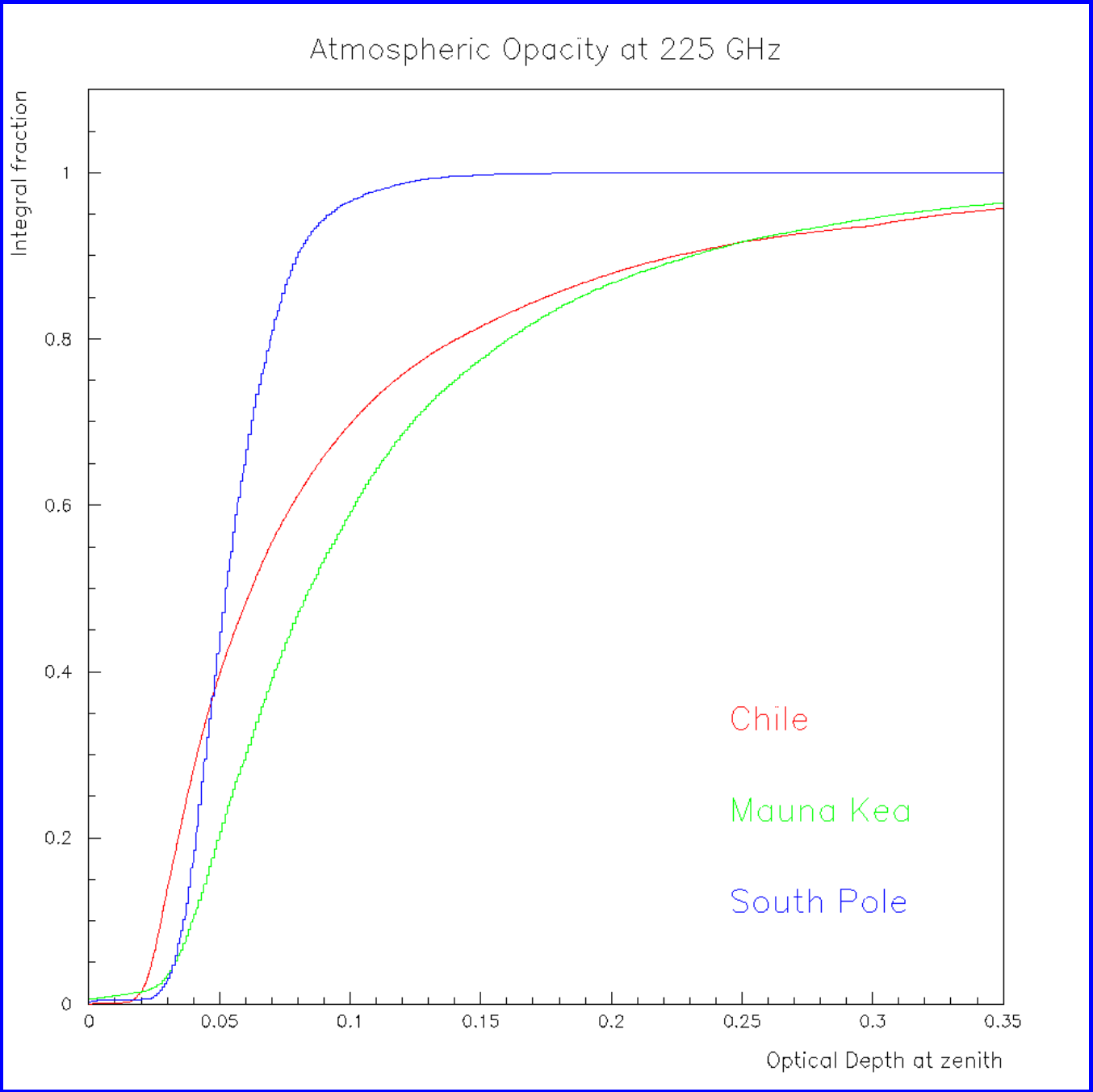

DASI Sensitivity
Relative sensitivity
0
0.2
0.4
0.6
0.8
1
0
100
200
300
400
500
600
700
800
900
1000
l

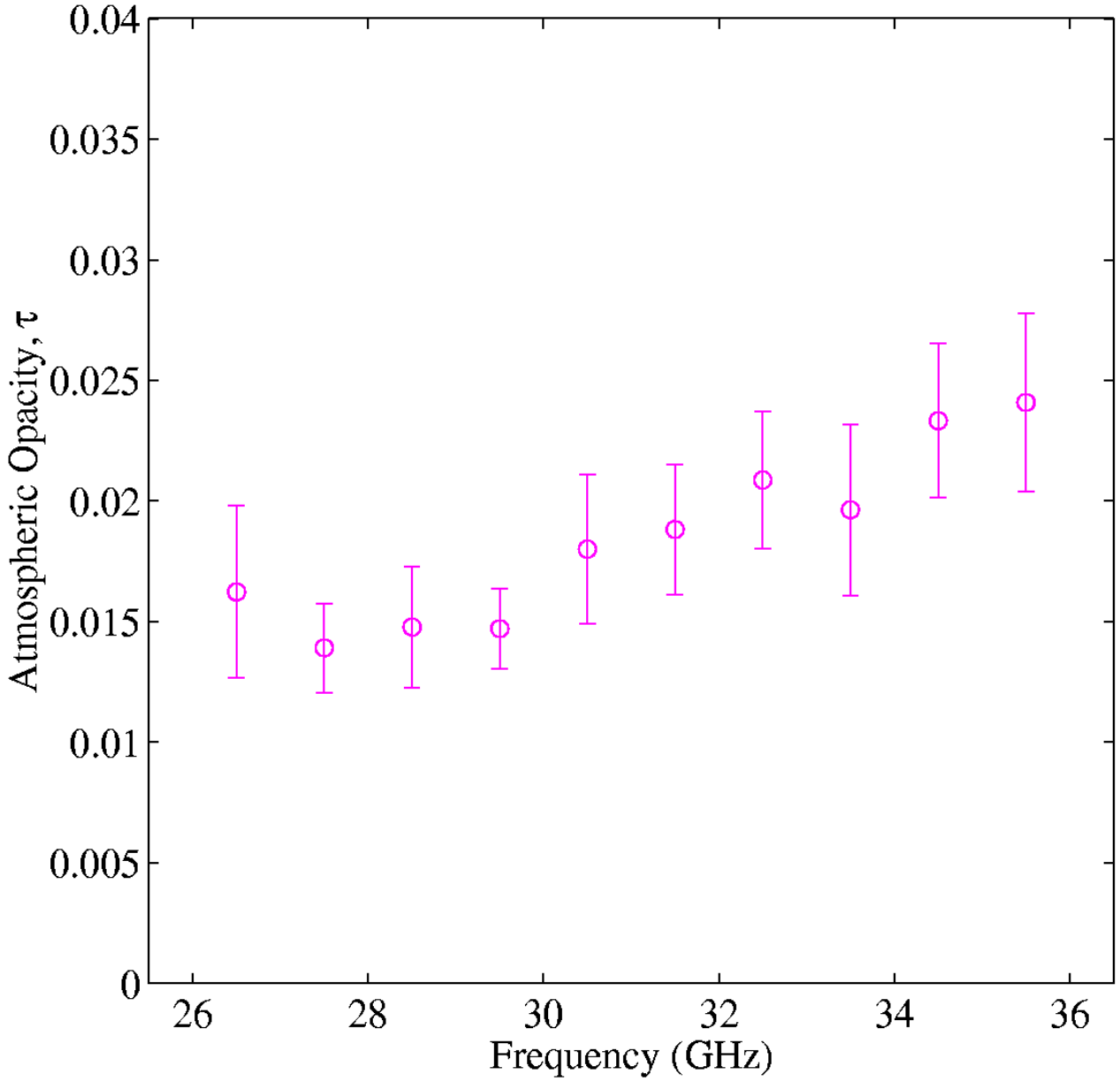
Why at the South Pole?

- Low atmospheric moisture
- Atmosphere highly stable
- No Sun for 6 months of the year
- Fields remain at constant elevation angle
- Existing infrastructure and logistics

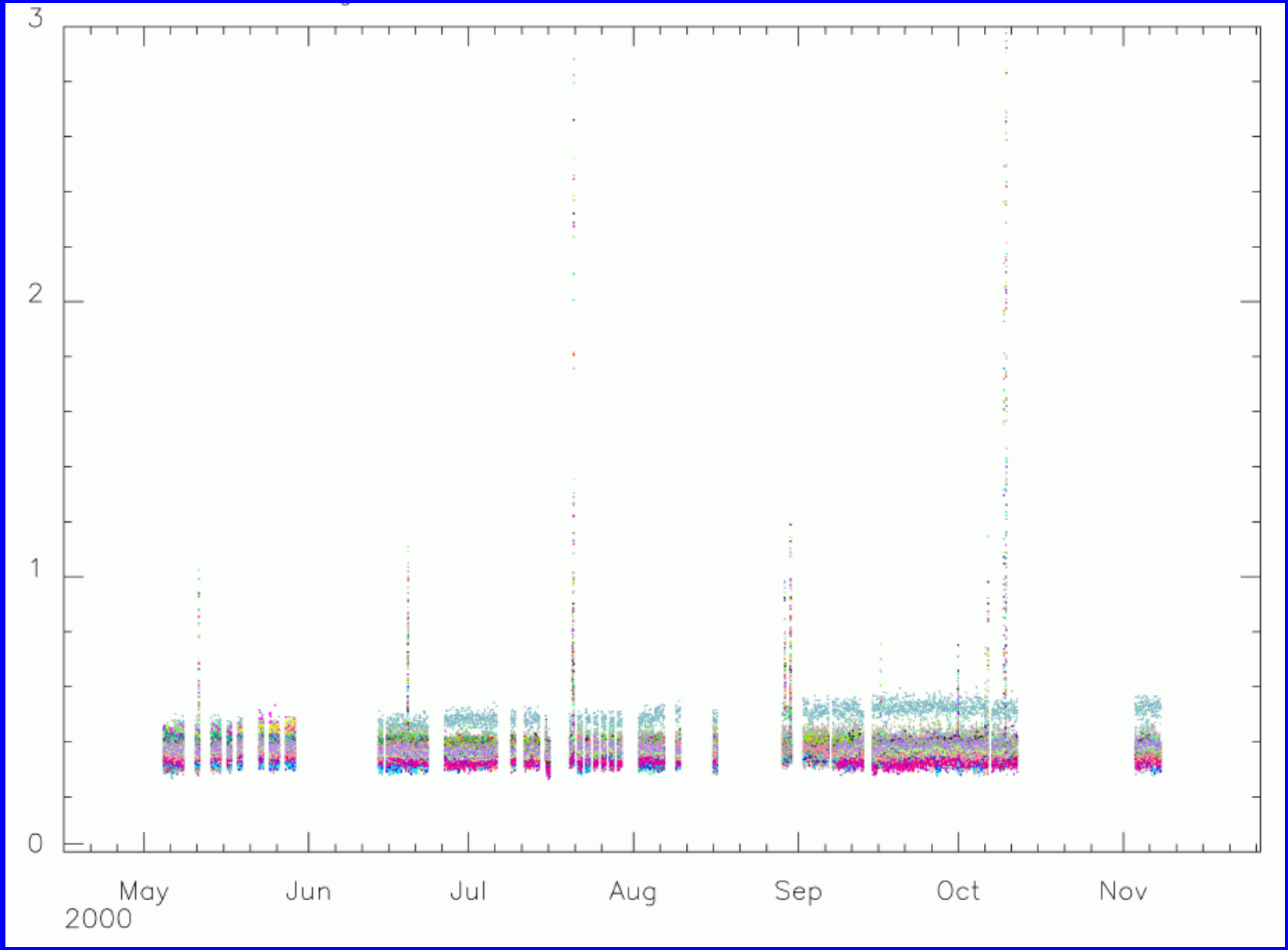
Atmospheric Emission



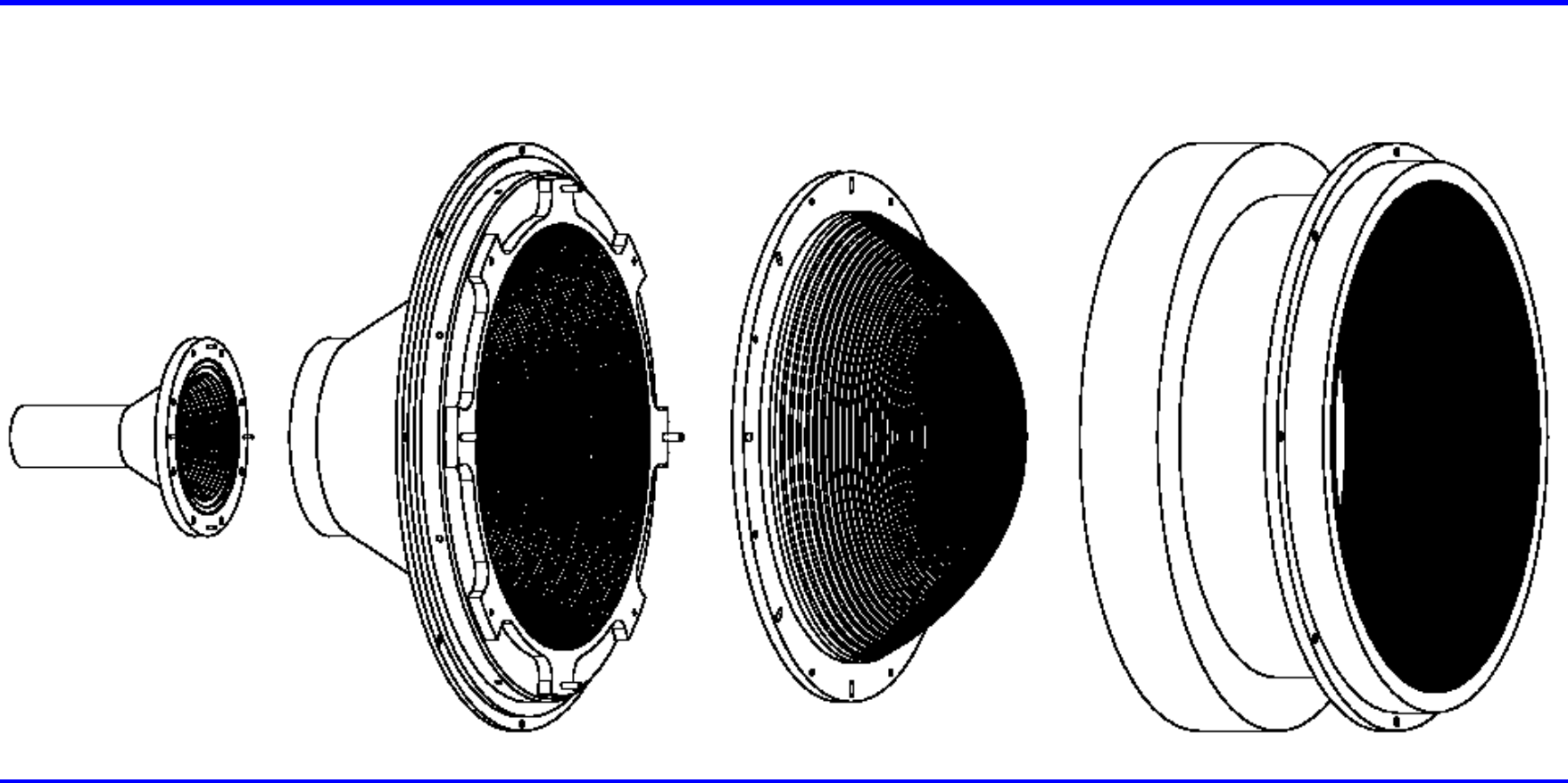

Atmospheric Opacity at 225 GHz
Integral fraction
0
0.2
0.4
0.6
0.8
1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Optical Depth at zenith
Chile
Mauna Kea
South Pole


0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Atmospheric Opacity, τ
26
28
30
32
34
36
Frequency (GHz)

Raw visibility noise data

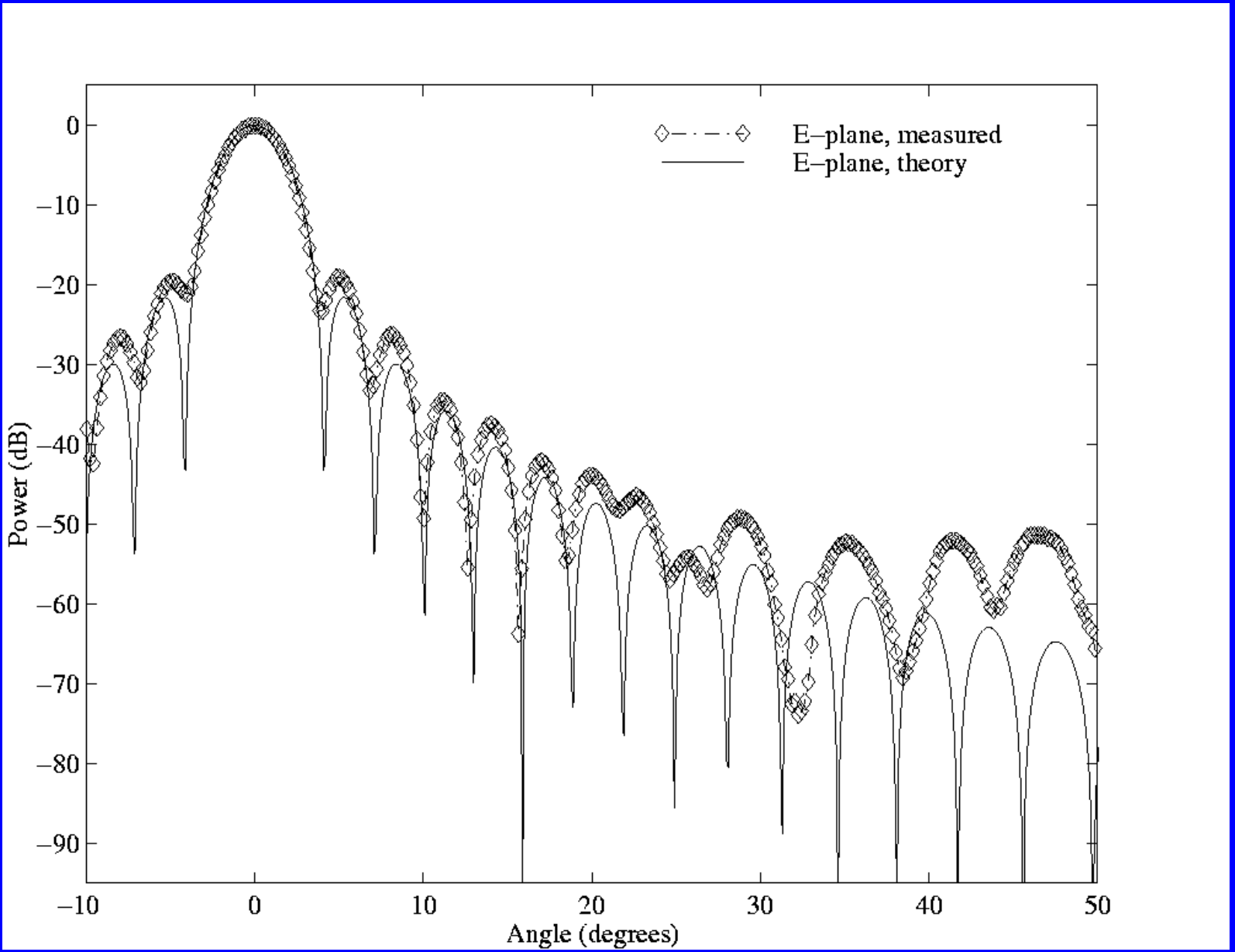


Feedhorns

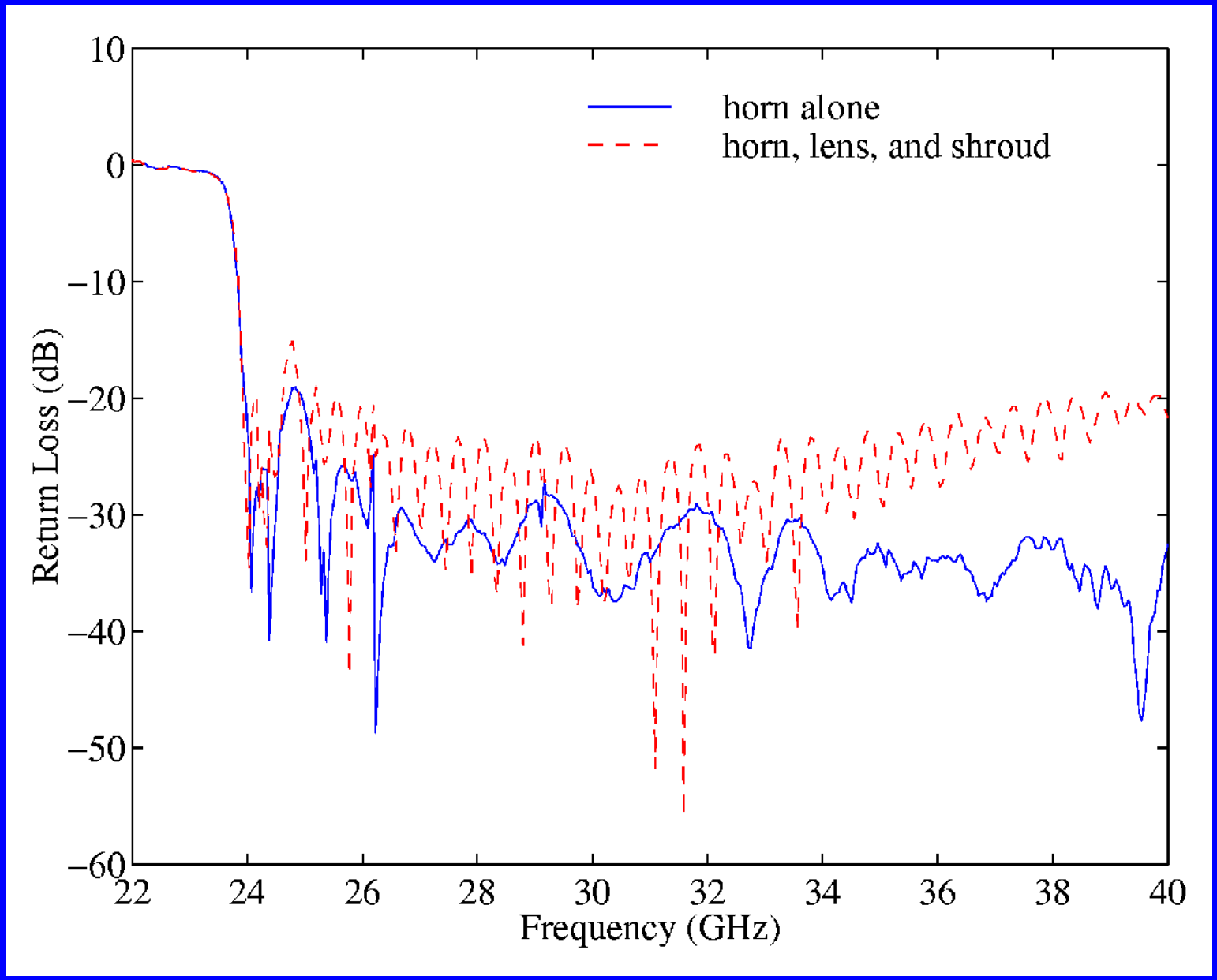


- 20 cm lensed corrugated horns
- Unobstructed apertures – low sidelobes
- Aperture efficiency 84%
- Crosstalk better than -100dB
- 3.4 deg FWHM beam at 30 GHz

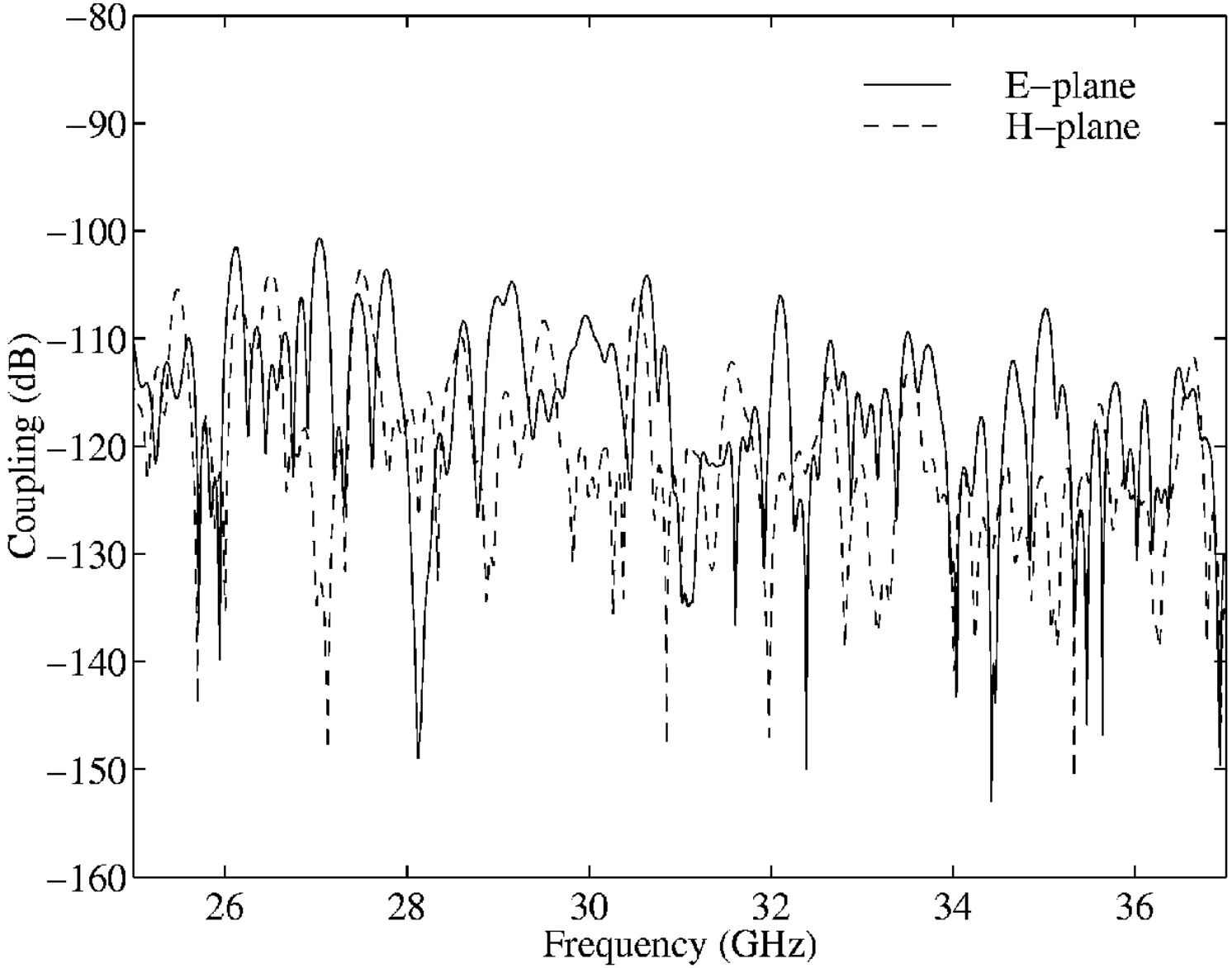
Horn Angular Response



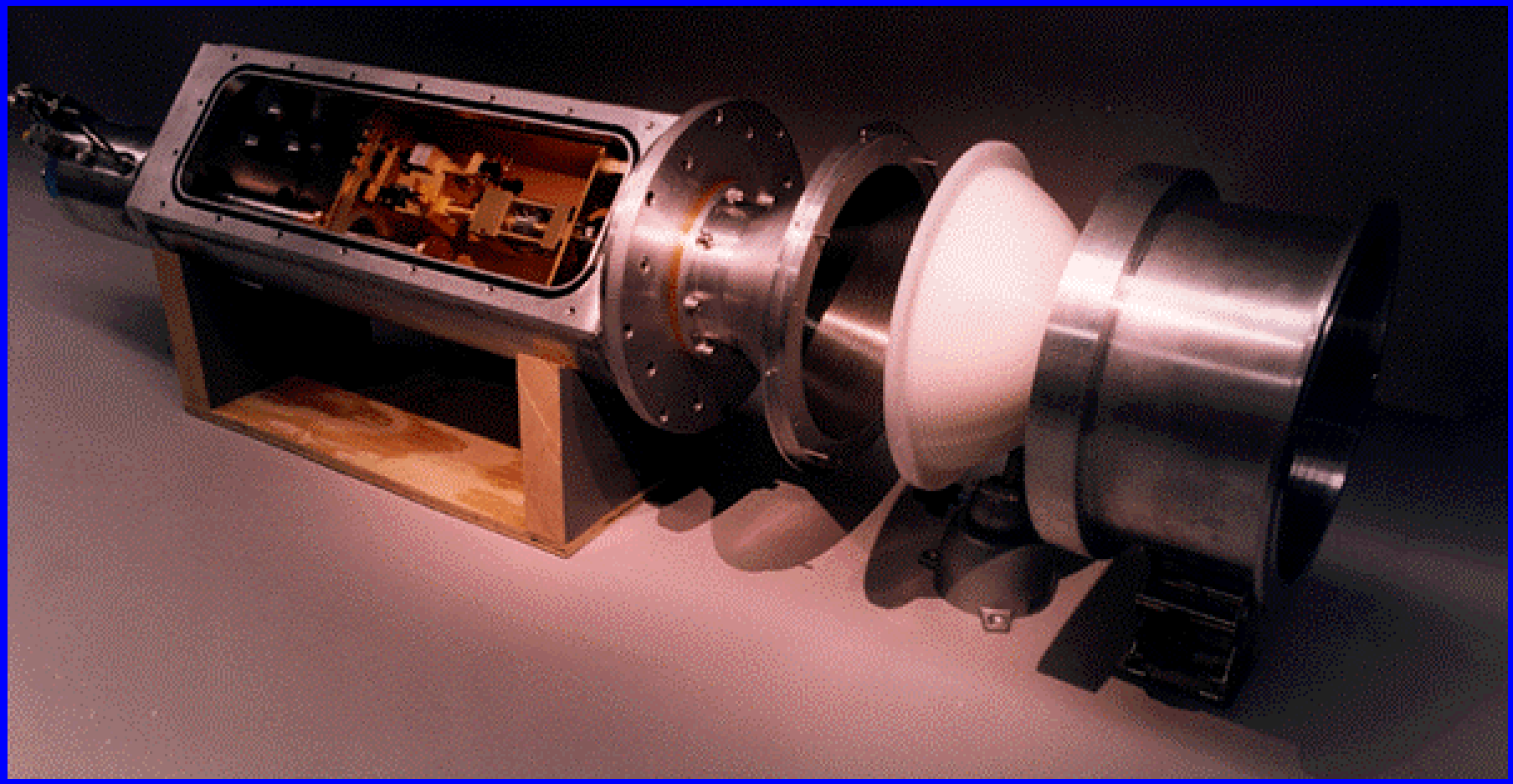
Horn Return Loss



Horn Crosstalk



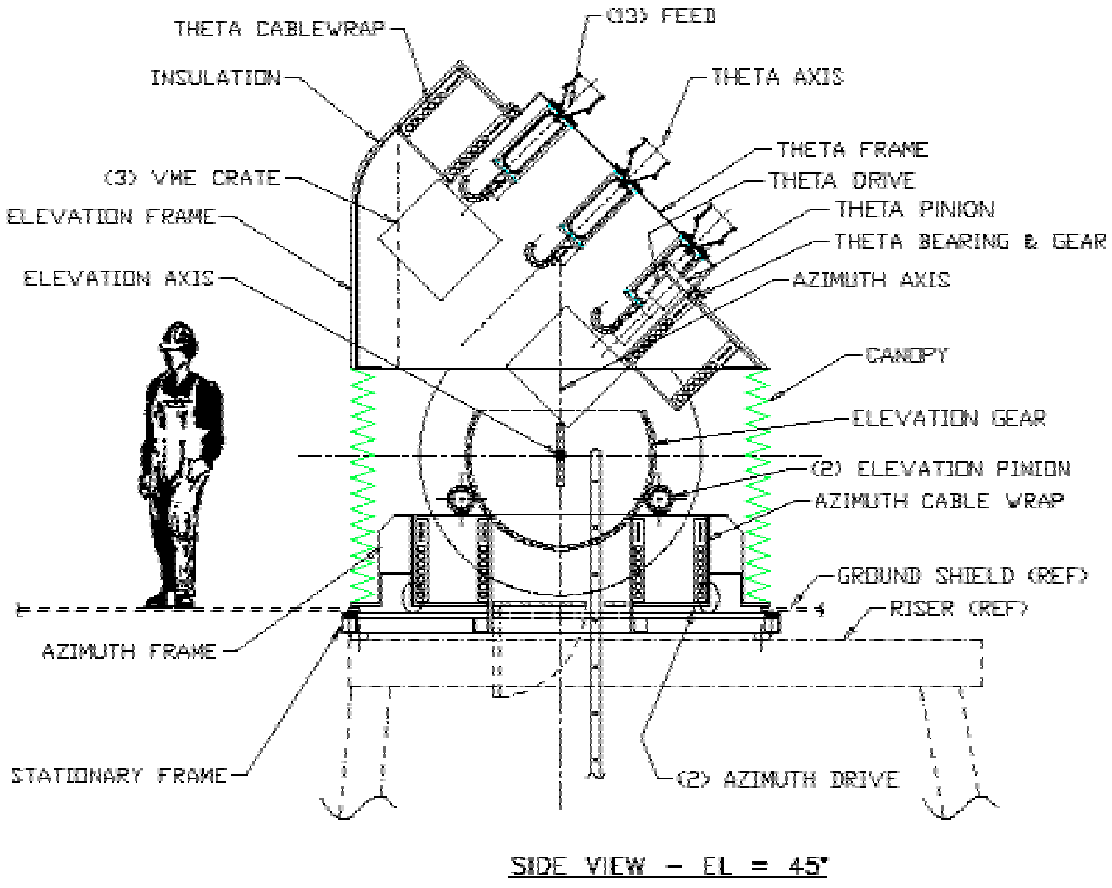
Complete receivers



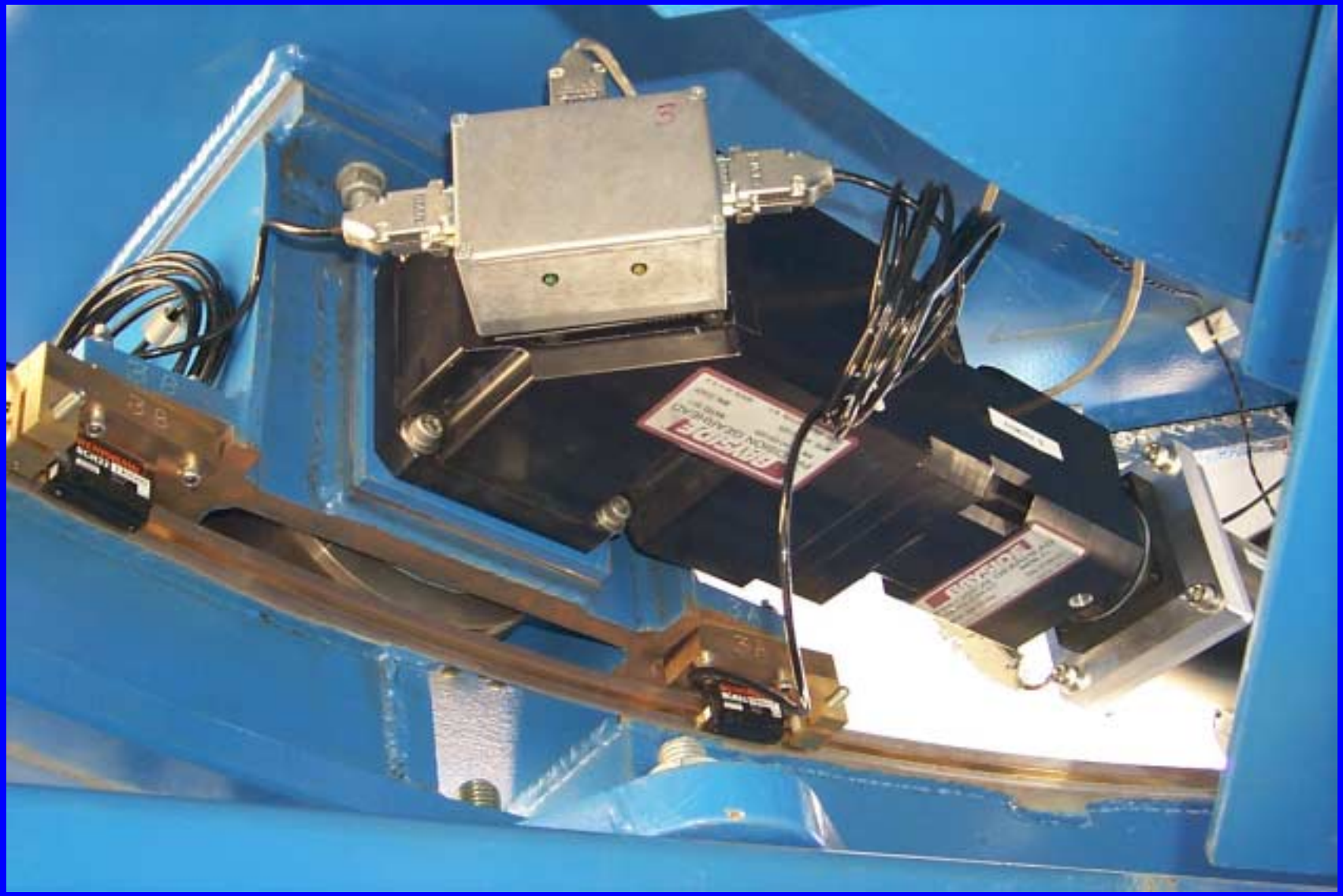
DASI Mount

- Designed in conjunction with Vertex Inc.
- 3 axis platform (az, el, line-of-sight)
- Az and los axis use incremental tape encoders and have 400 deg travel.
- Use readhead pairs and gap switching. (4 Pairs on az to reduce eccentrity and ellipticity errors.
- Fully enclosed design; Polar temperature –30/–80 C Summer/Winter.
- Telescope access from warm room in tower below, which also houses helium compressors, drive amplifiers etc.

Mount Cross Section



Readhead pair



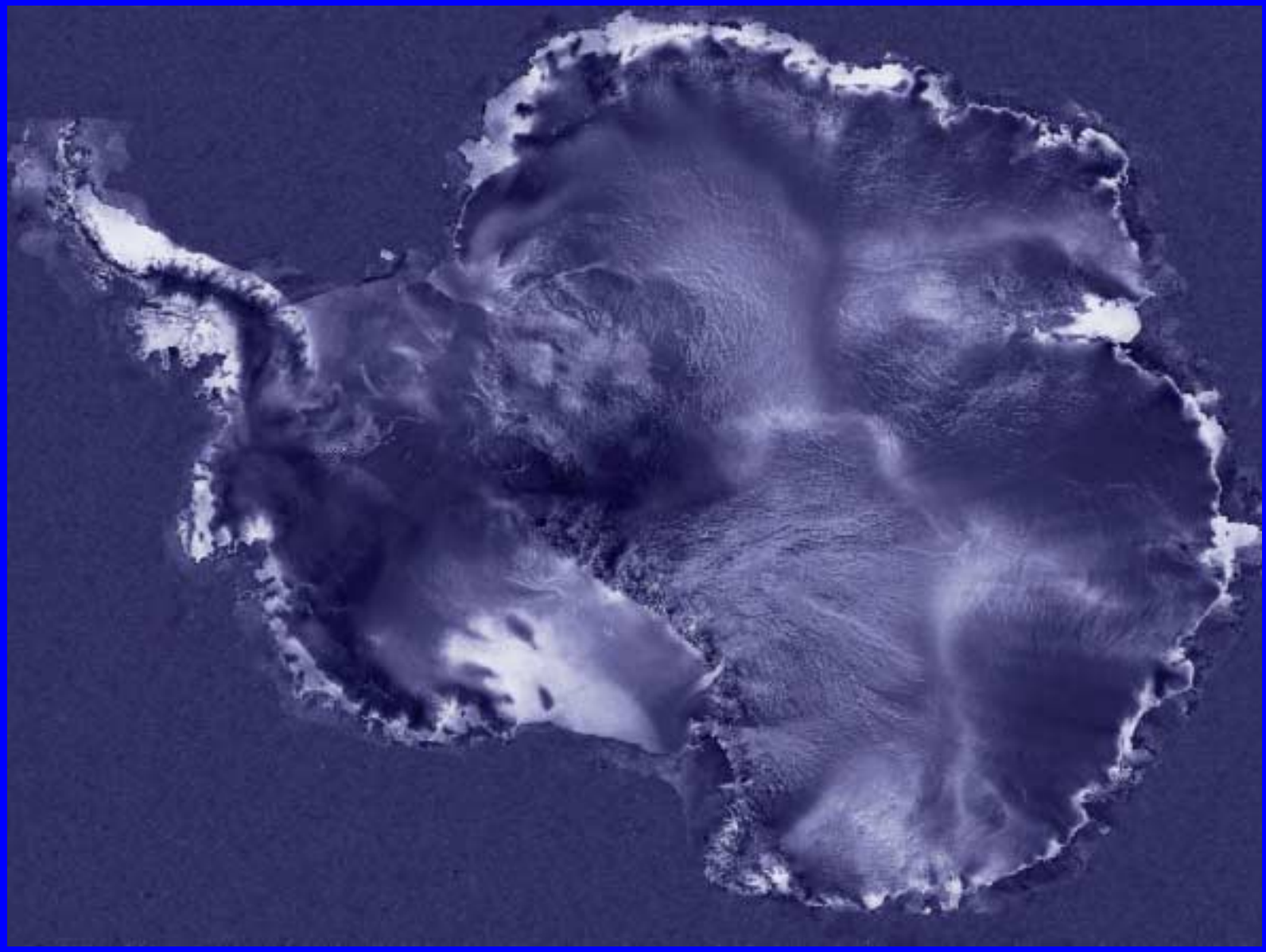
DASI Deployment

- Mount completed April 99 by Vertex Inc.
- Initial assembly and integration in EFI high bay.
- Moved out to parking lot July 99
- Disassembled for shipping August 99
- Arrived in Antarctica October 99
- Arrived at South Pole November 99
- Fully operational by station closing February 00
- Data taken from sunset to sunrise

DASI Leaves Chicago High Bay

Testing outside at U of C

Antarctica from Space



Arrival in Antarctica

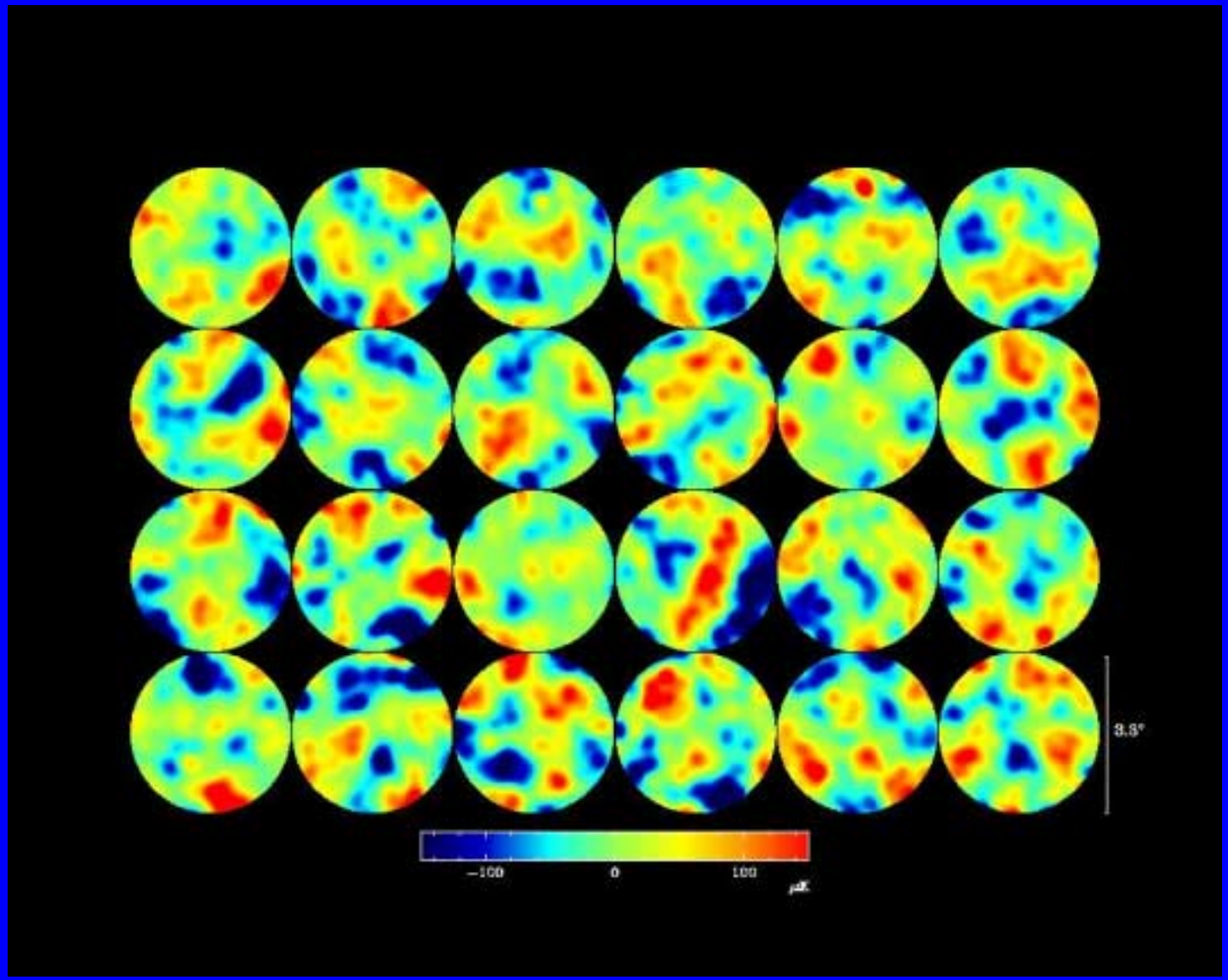
Arrival at South Pole

Re-assembly

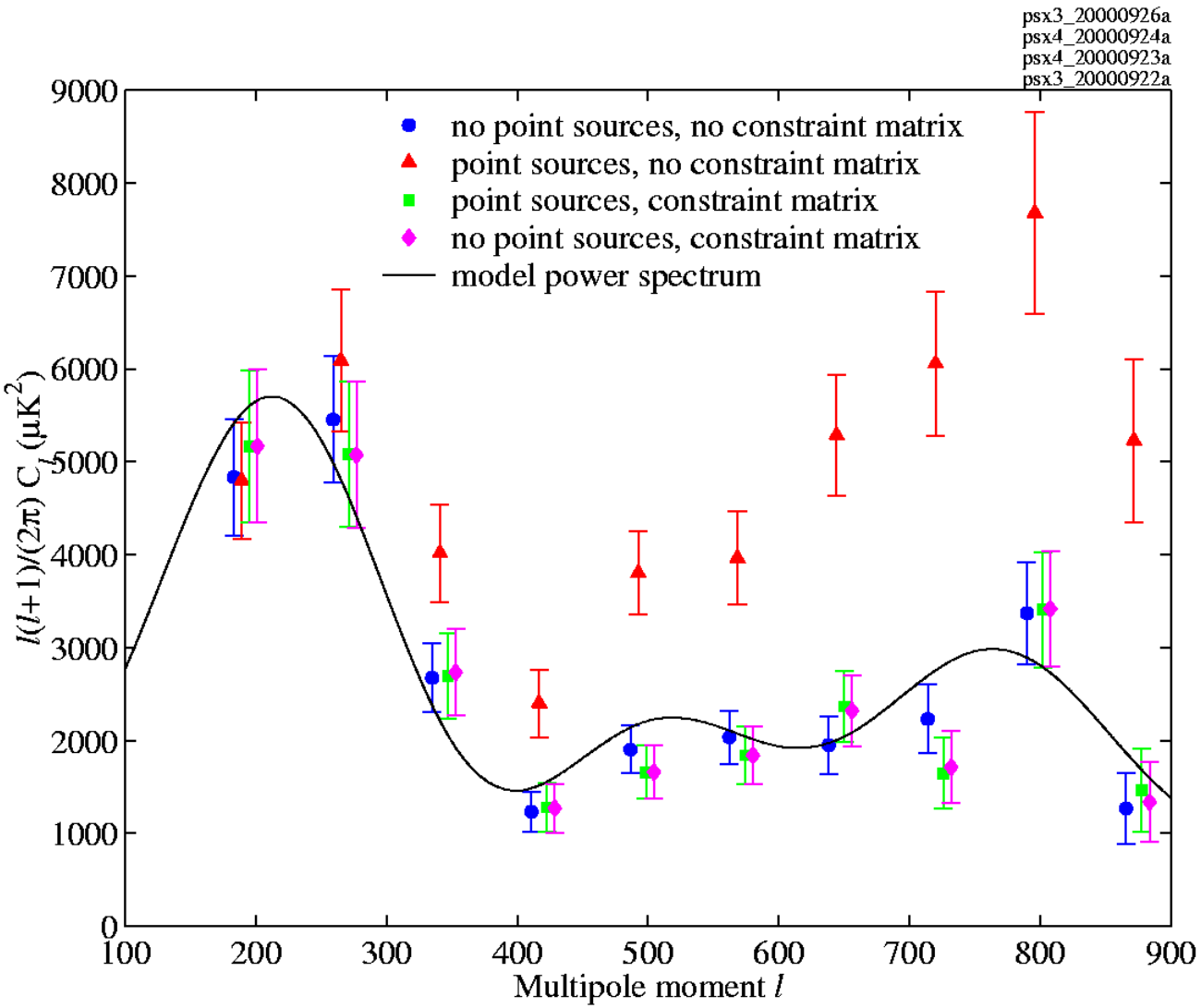
Lifting to Tower

Cover for Working

CMB Images



Simulations!

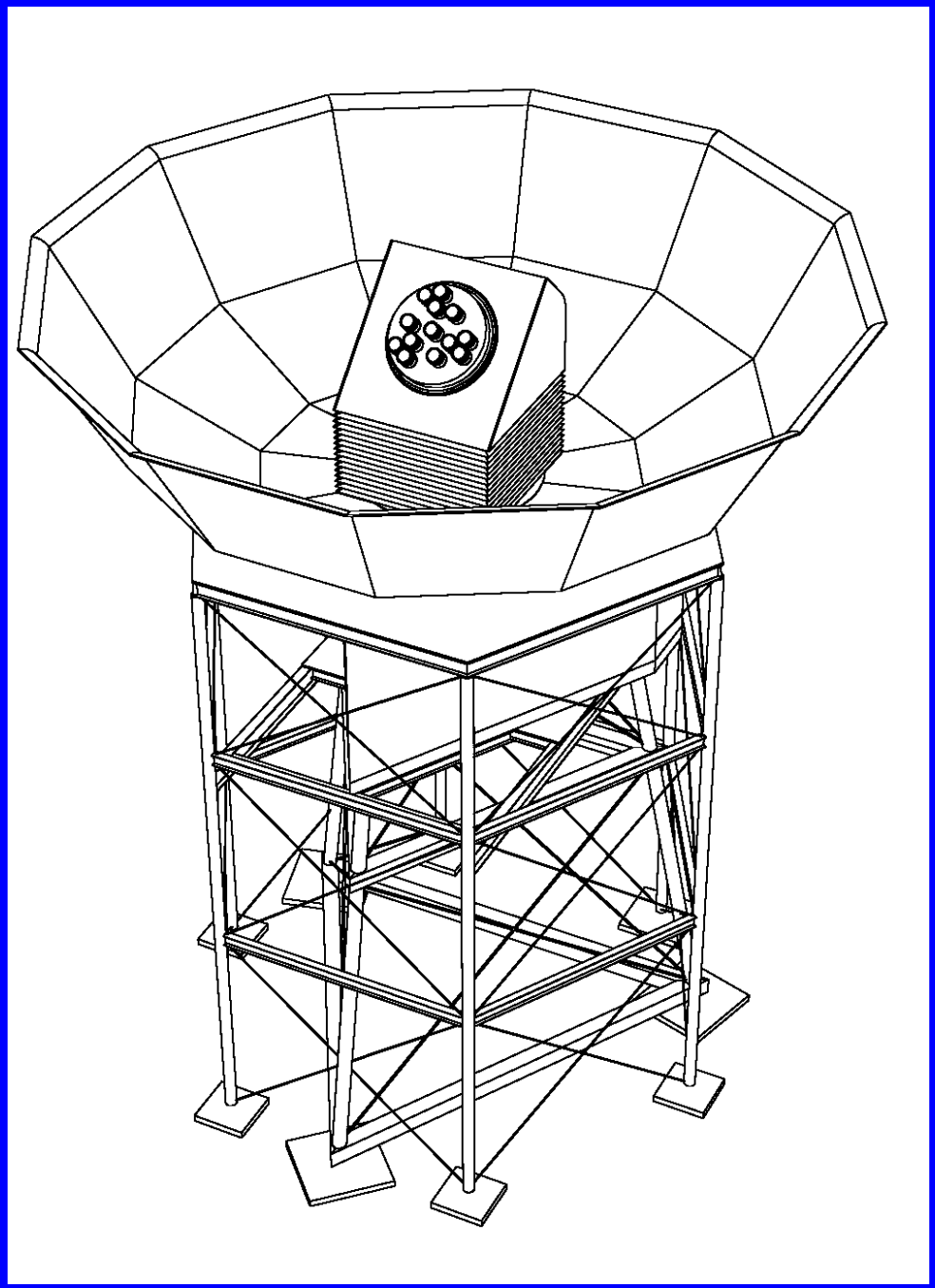


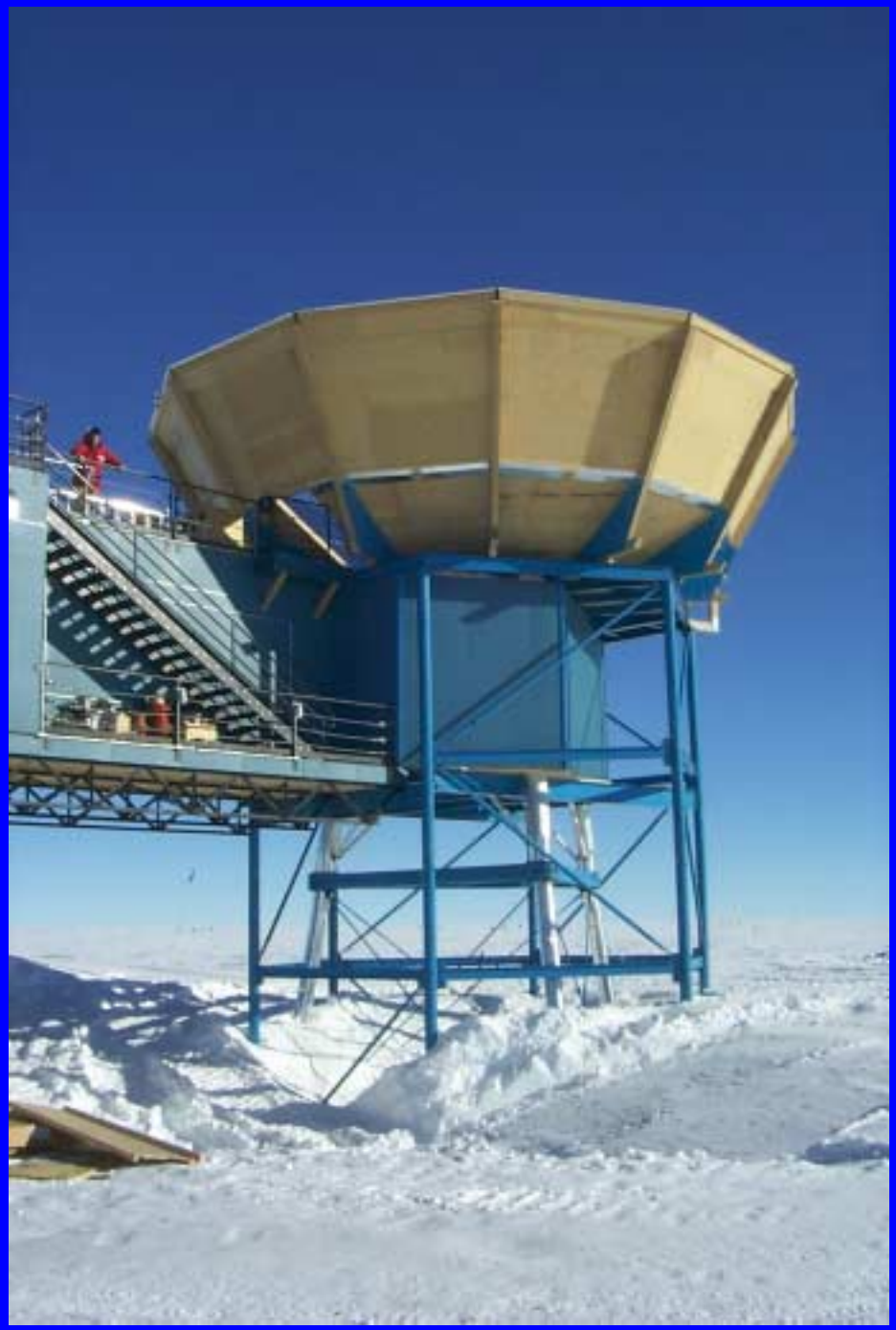
2000-2001 Season

- Ground Shield Installed
- Receivers being upgraded with achromatic polarizers

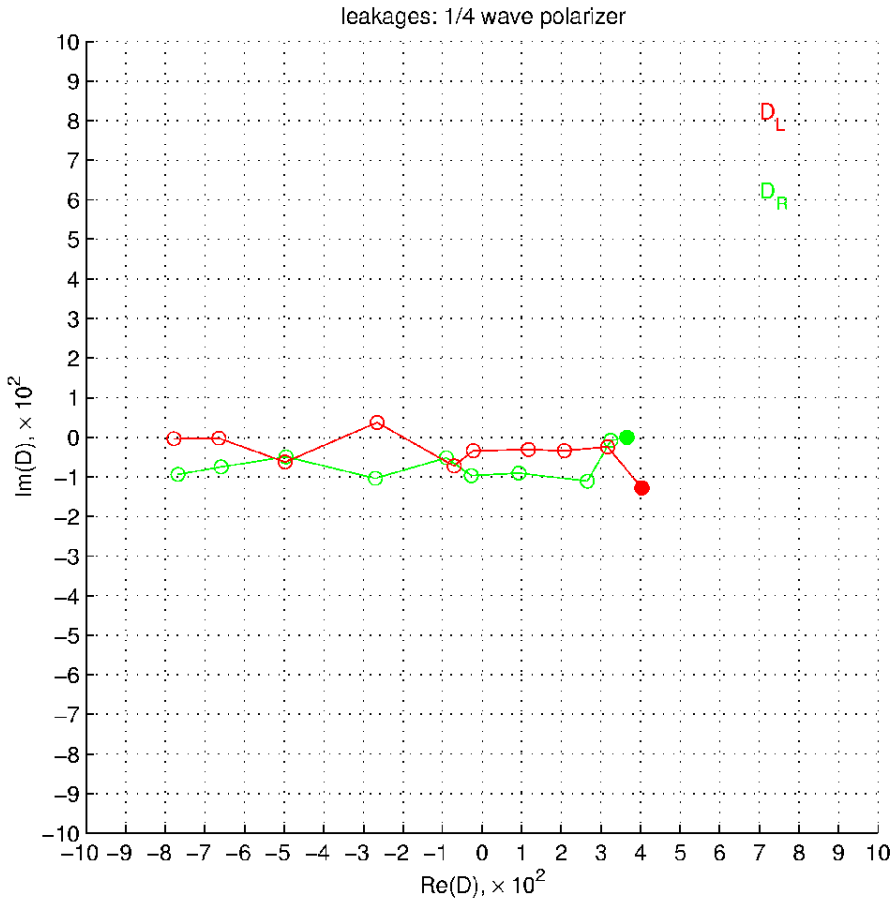
2001-2002 Season

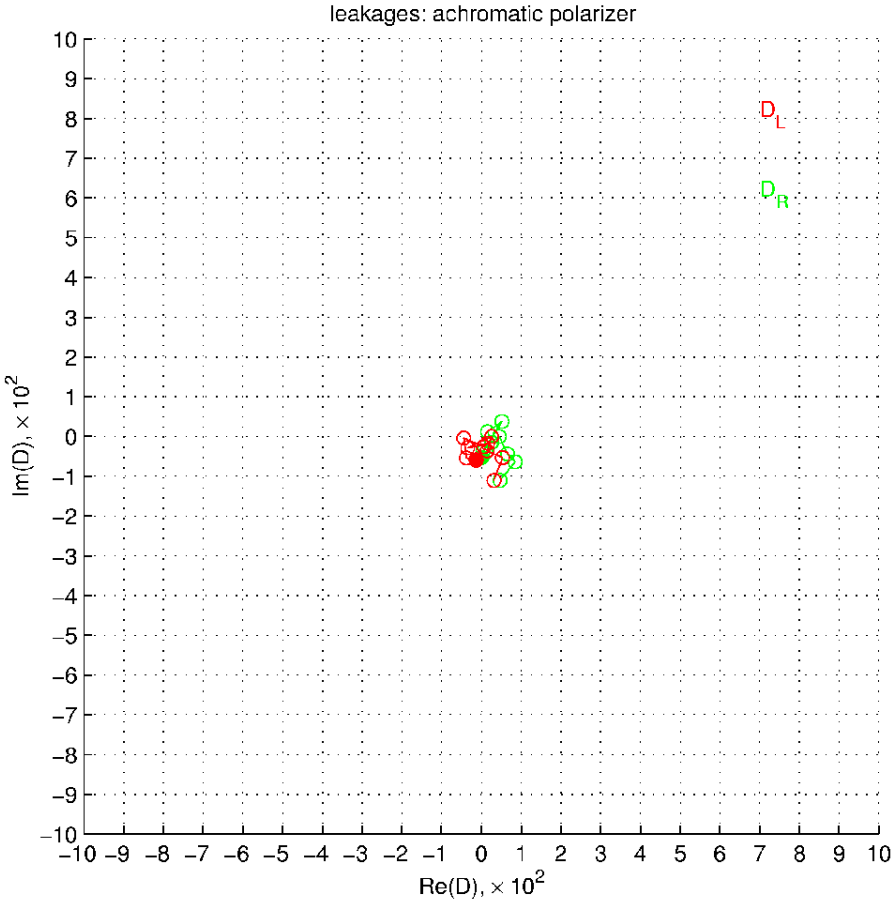
- 100 GHz Receivers (proposed)





Achromatic Polarizer





Conclusion

- DASI has run excellently in it's first season – careful engineering paid off.
- 1000 (good) hours of CMB field integration have been collected.
- Initial power spectrum will be released soon
- 2000-2001 season will focus on polarization at 26-36 GHz
- 2001-2002 will move to 100 GHz