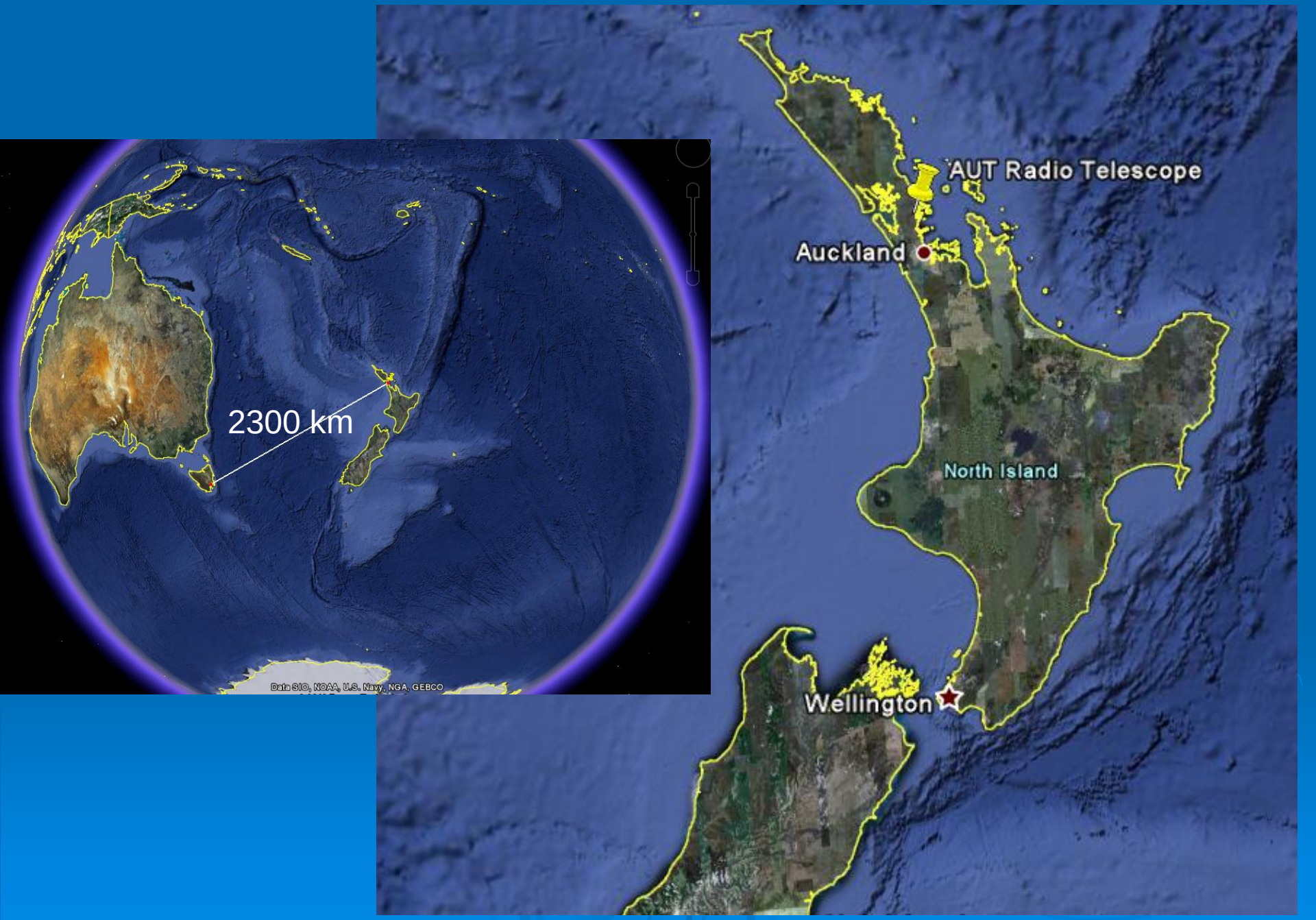
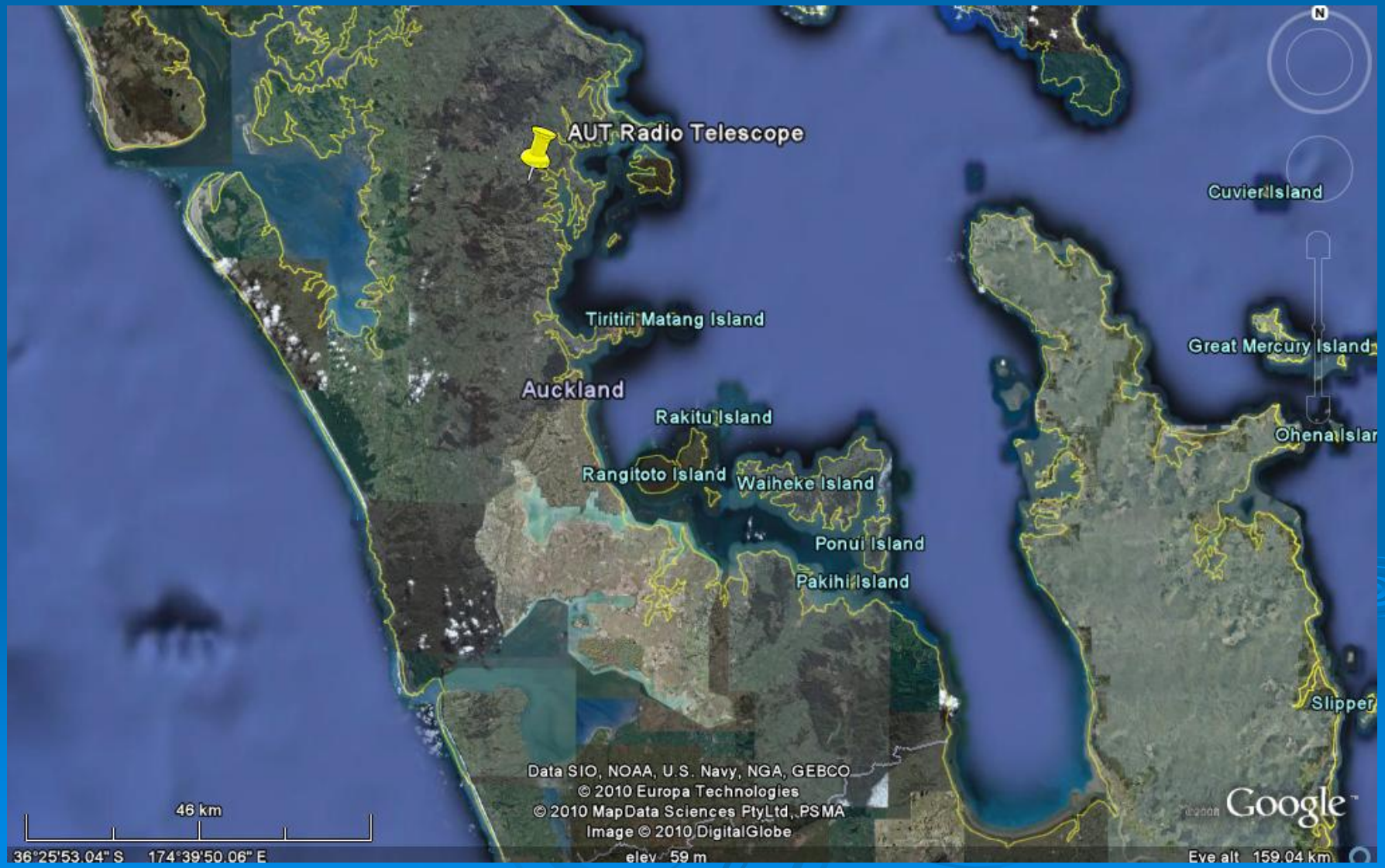
# The AUT 12 metre Telescope Characterisation and Calibration

Tim Natusch
Sergei Gulyaev


AUT Radio Telescope
Auckland
North Island
Wellington
2300 km
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

# Warkworth
# 60 km North of Auckland



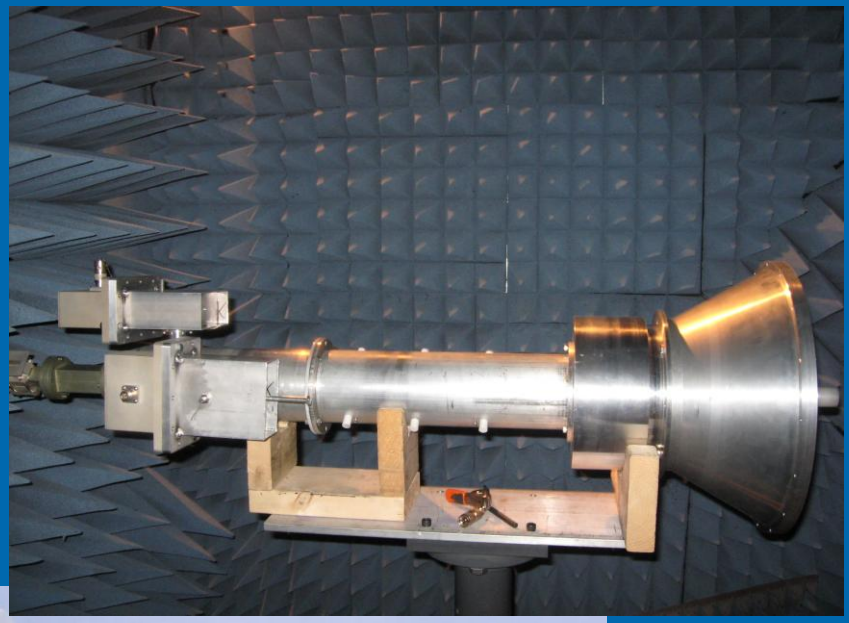
# Baselines to Australia

# Antenna

- Cobham / Patriot
- 12m Cassegrain
- Maximum Slew rates:
  - Azimuth = 5 deg $s^{-1}$
  - Elevation = 1 deg $s^{-1}$
- Currently equipped with dual polarisation dual frequency S/X feed

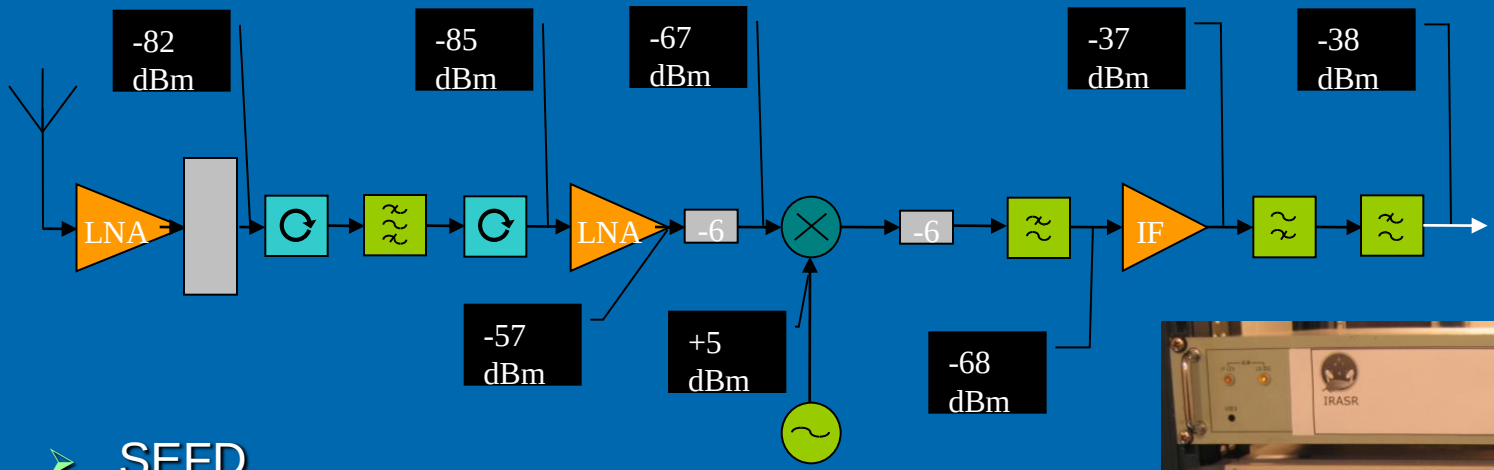
# Feed

- Coaxial S/X
  - S band 2.1 to 2.4 GHz
  - X band 8.1 to 9.1 GHz
  - RCP & LCP both bands
- ¼ wave plate polariser S Band
- Septum OMT polariser X Band

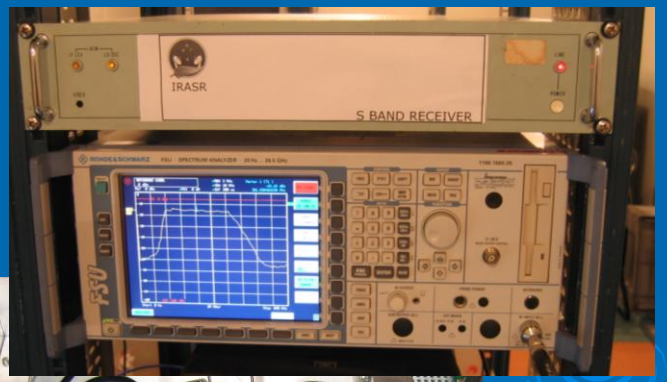


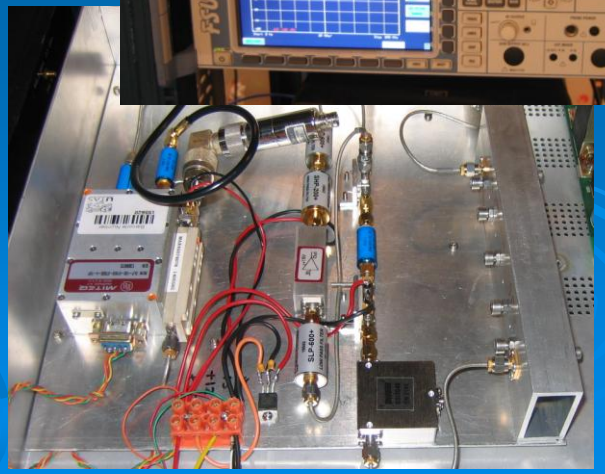
# Receivers

- Room temperature un-cooled design
- Superheterodyne receiver (powers in 1 MHz bandwidth)




- SEFD
  - ≈ 4000 Jy @ S Band
  - ≈ 5000 Jy @ X Band
  - Improvements expected; feed redesign



- Thanks to Peter McCulloch and UTAS for generous assistance with receiver development!

# Frequency Standard

- Hydrogen Maser

  Symmetricom MMH2010
  - 5, 10, 100 MHz outputs
  - Allan deviation

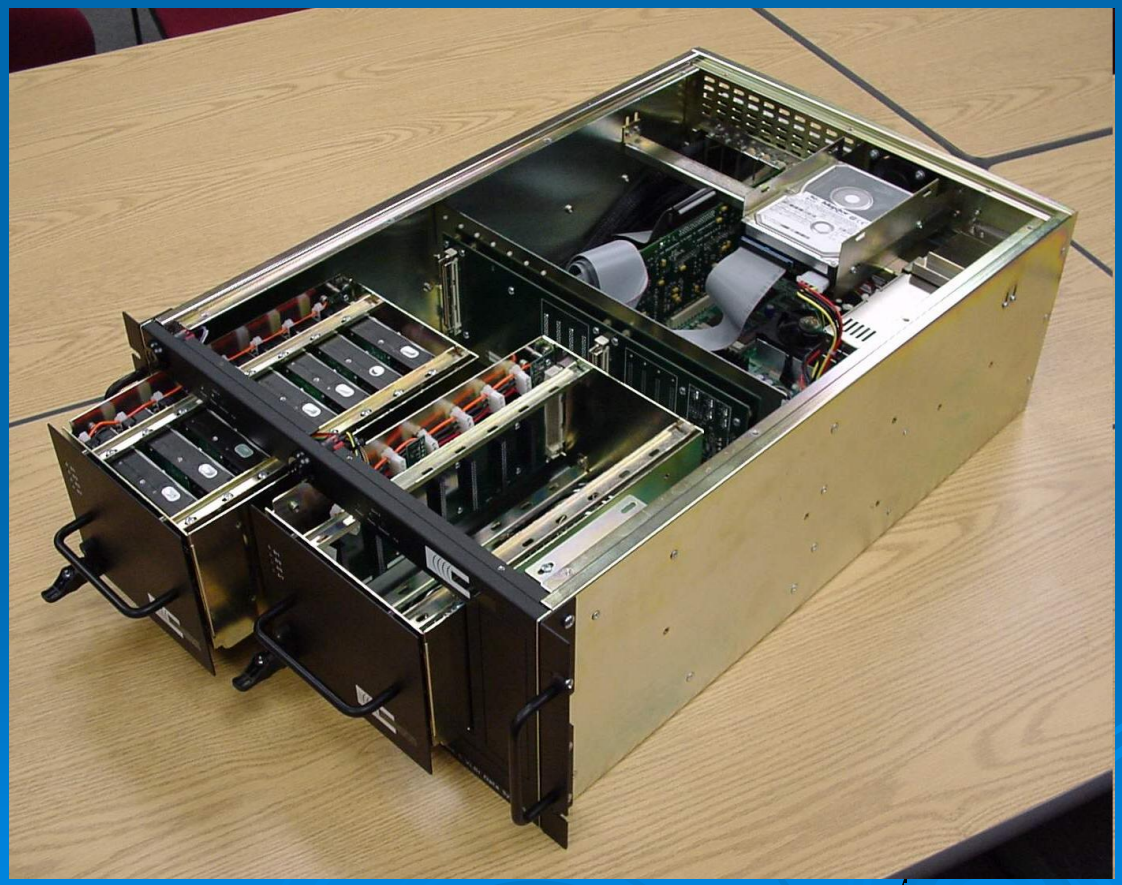
    1s 2.0E-13

    1000s 3.2E-15

    Floor 3.0E-15
  - Long term drift : <2.0E-16 per day
- Temperature stabilised room: currently system holds temperature to within 2 deg C swing, working on getting this down to <1 deg.

# Data Recorder

- Haystack MIT Mk 5 B+



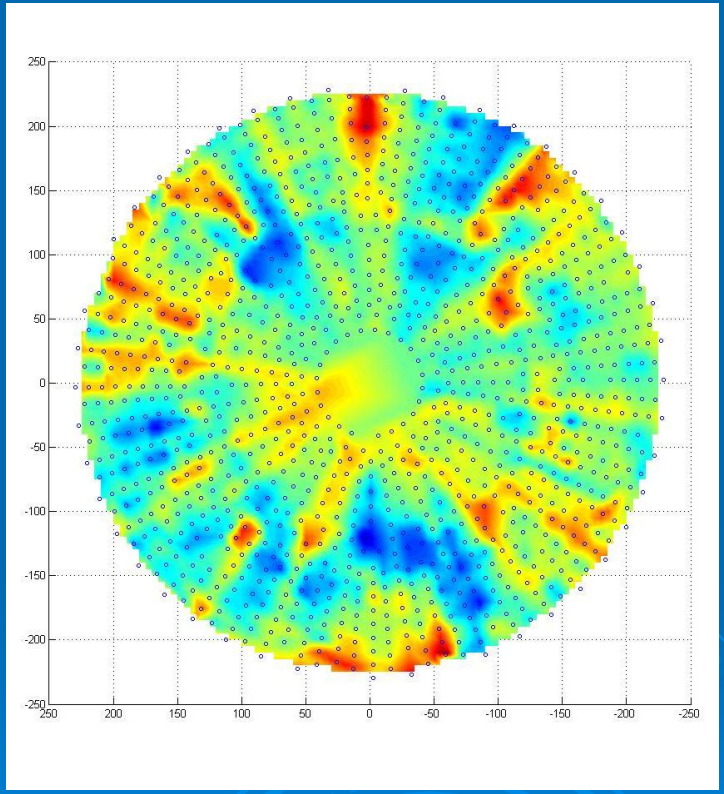
# Digitiser

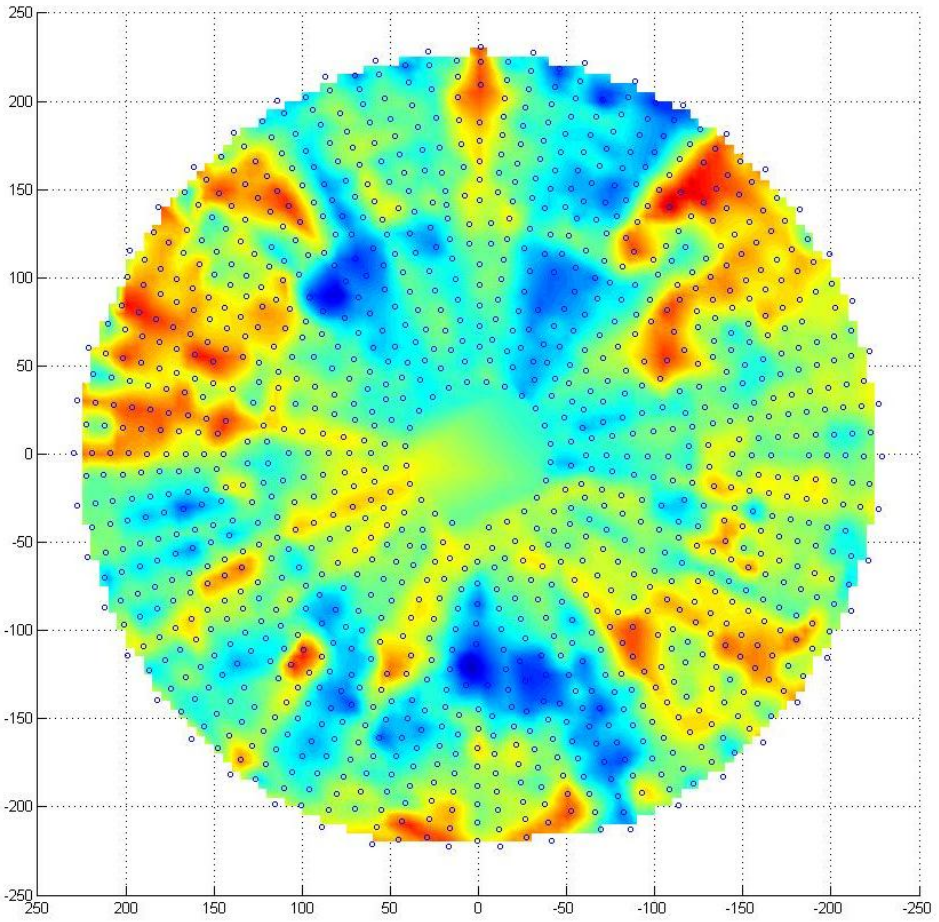
- DBBC (HAT Lab INAF/IRA)
- Ordered, delivery expected March 2010
- Geodetic configuration

  - 4 channel recording
  - 2 x 1 GHz @ X band
  - 2 x 500 MHz @ S band

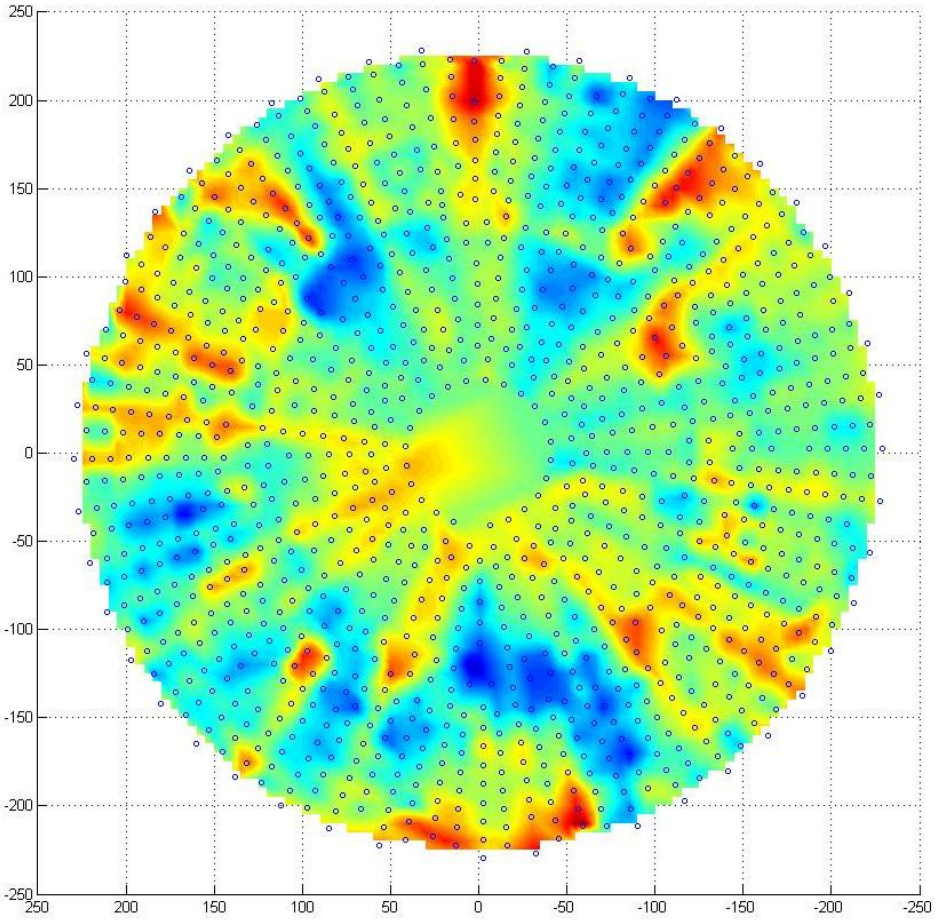
# Primary surface alignment

- Surface alignment conducted by extensive Photogrammetric testing; rms ≈ 0.35 mm
- Plan RF holography on surface in future to confirm the Photogrammetry results and further refine if possible

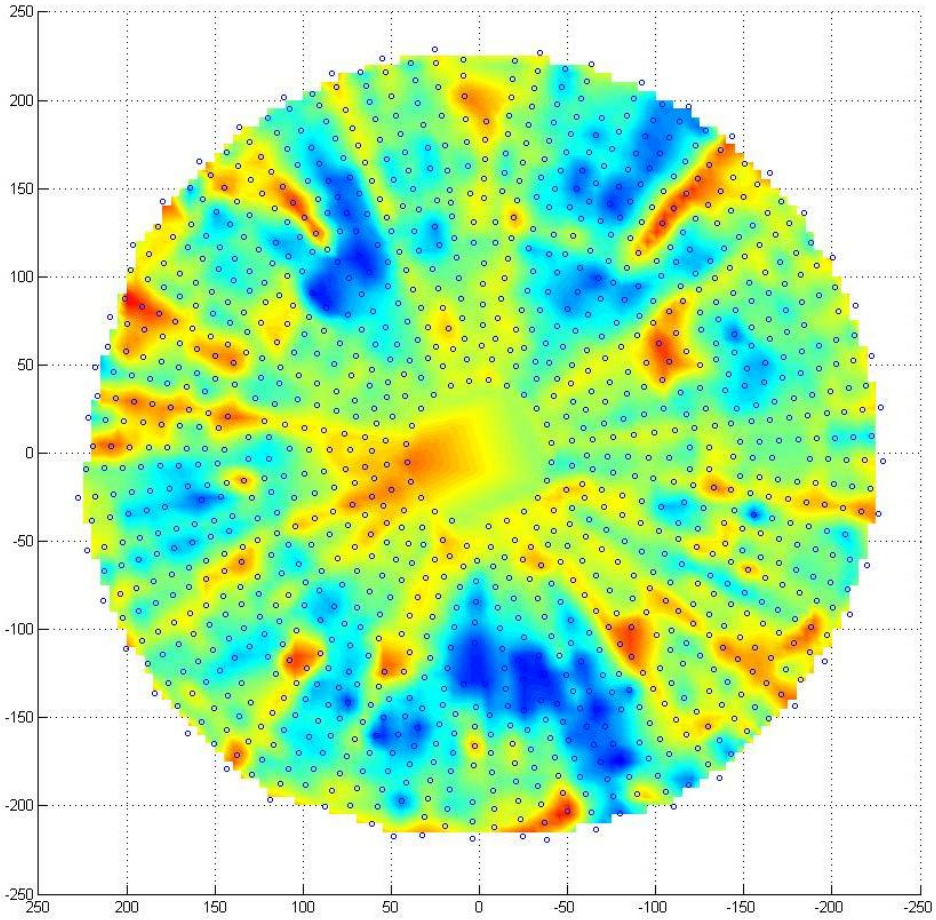




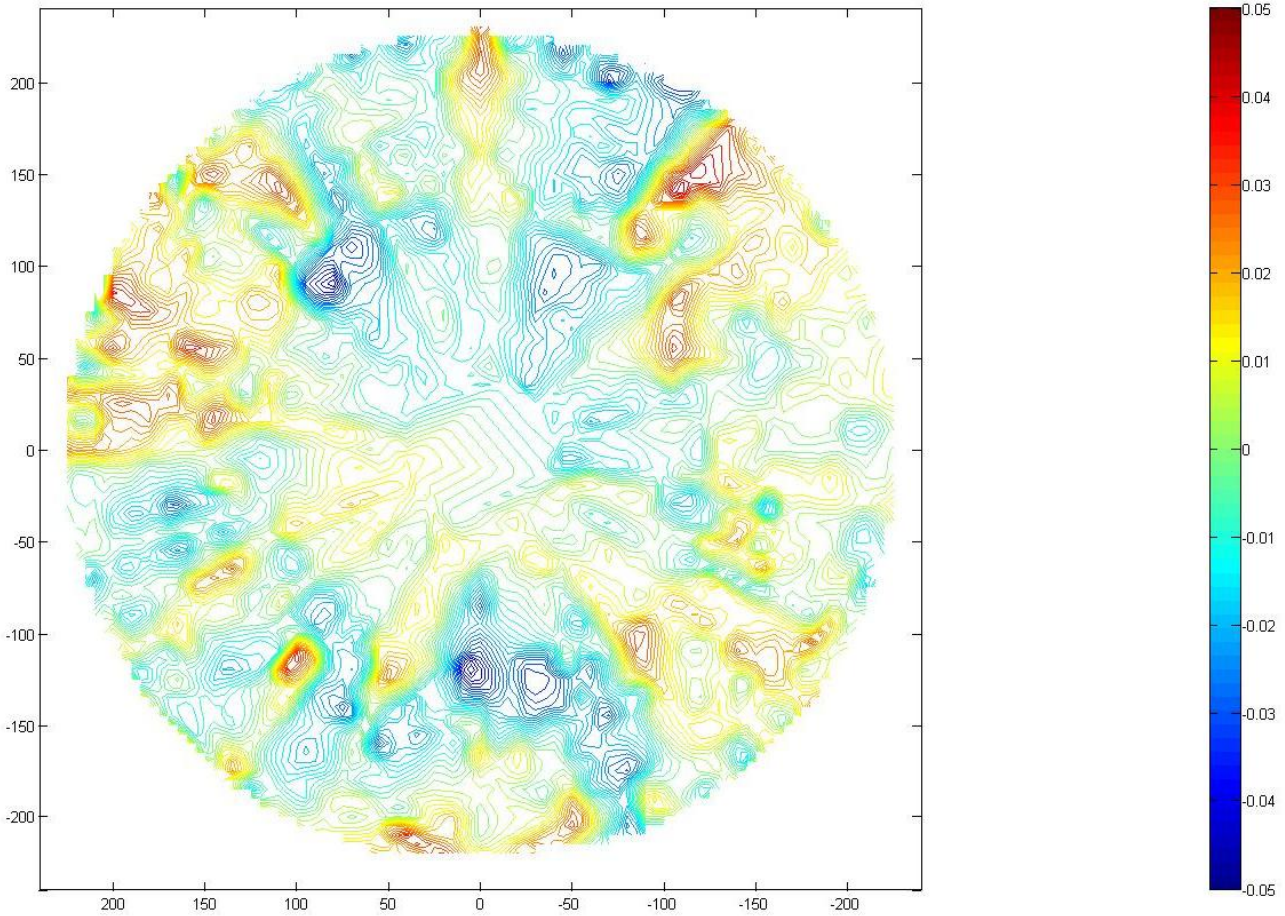

El = 10 deg rms = 0.0148”



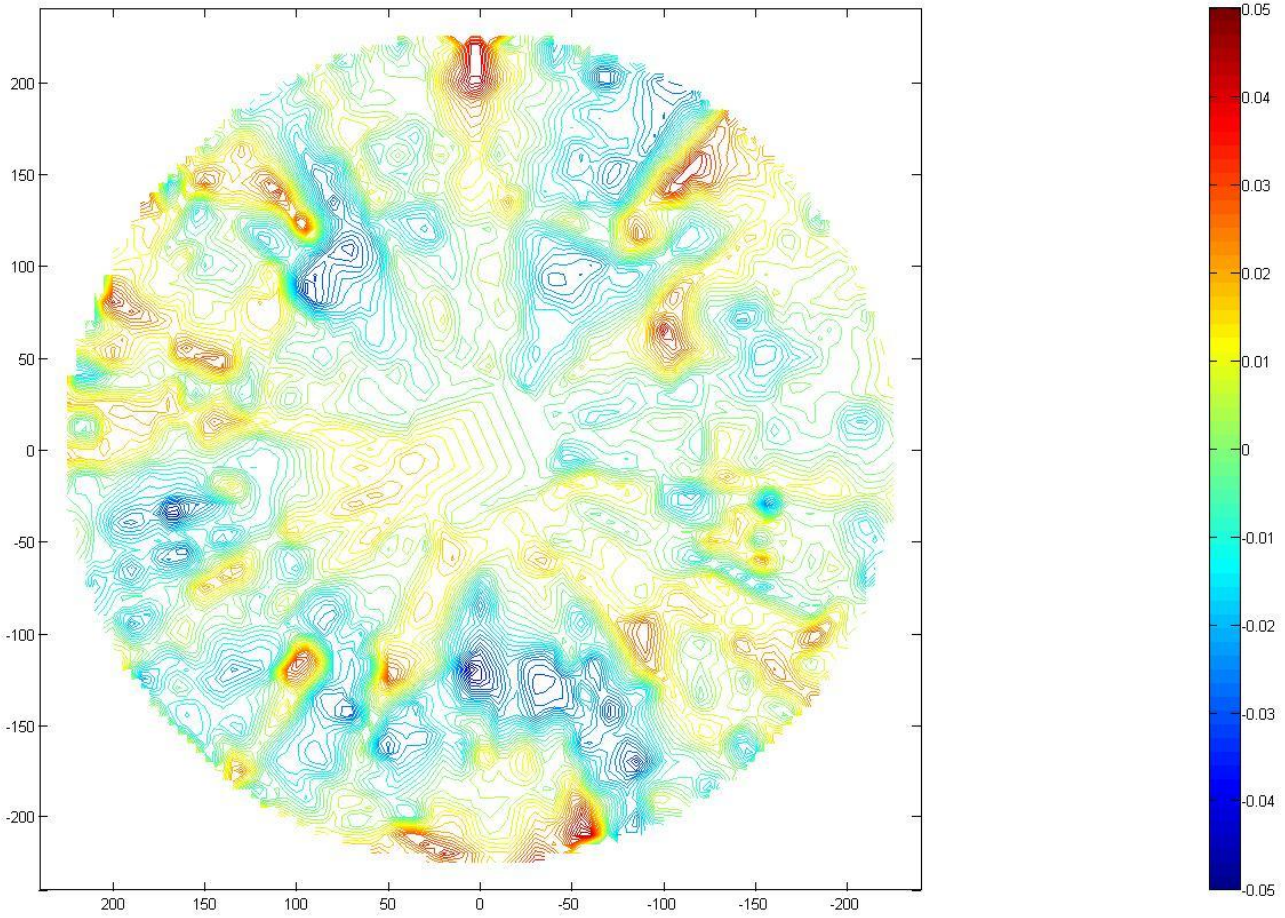

El = 50 deg rms = 0.0142”



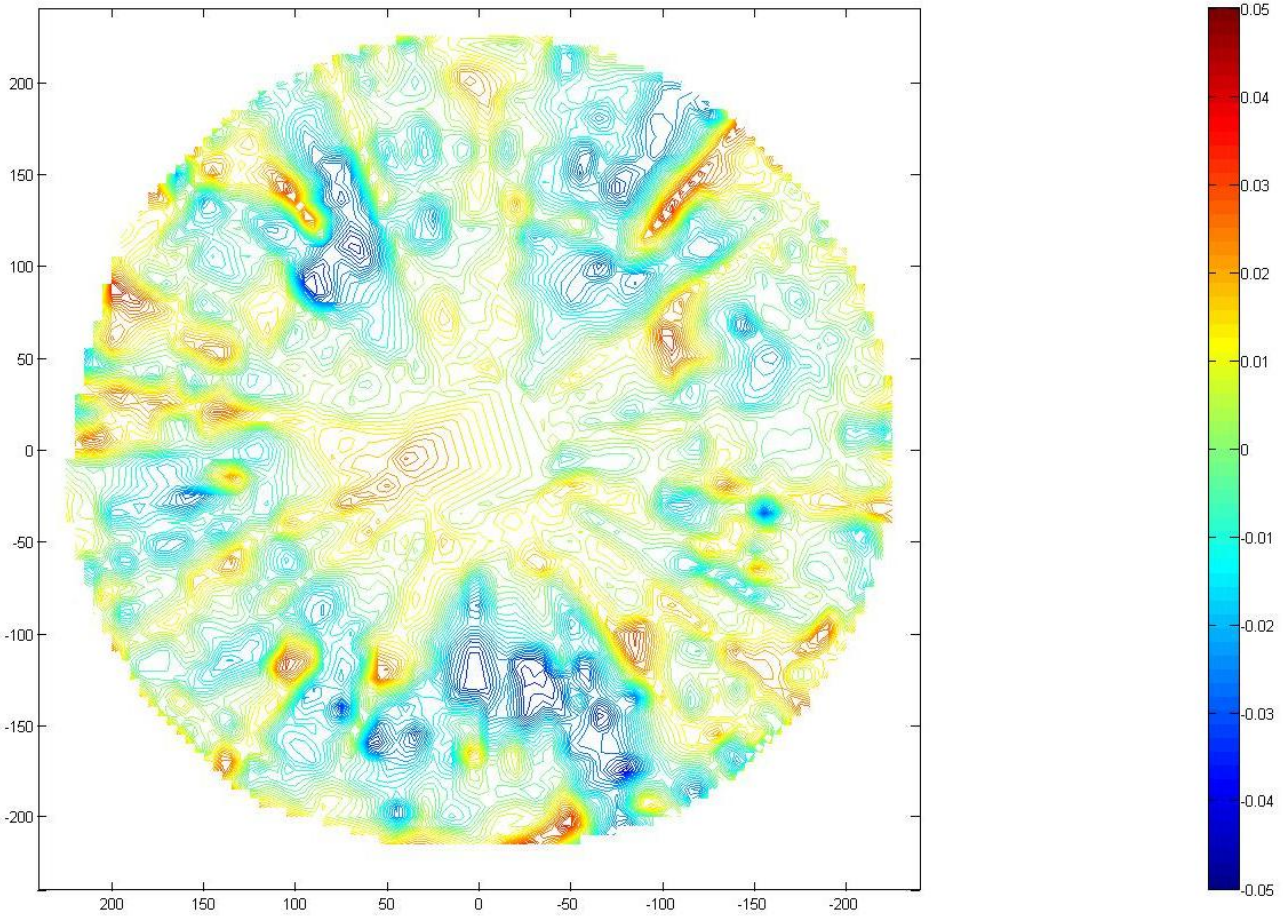

El = 88 deg rms = 0.0145”




El = 10 deg rms = 0.0148”

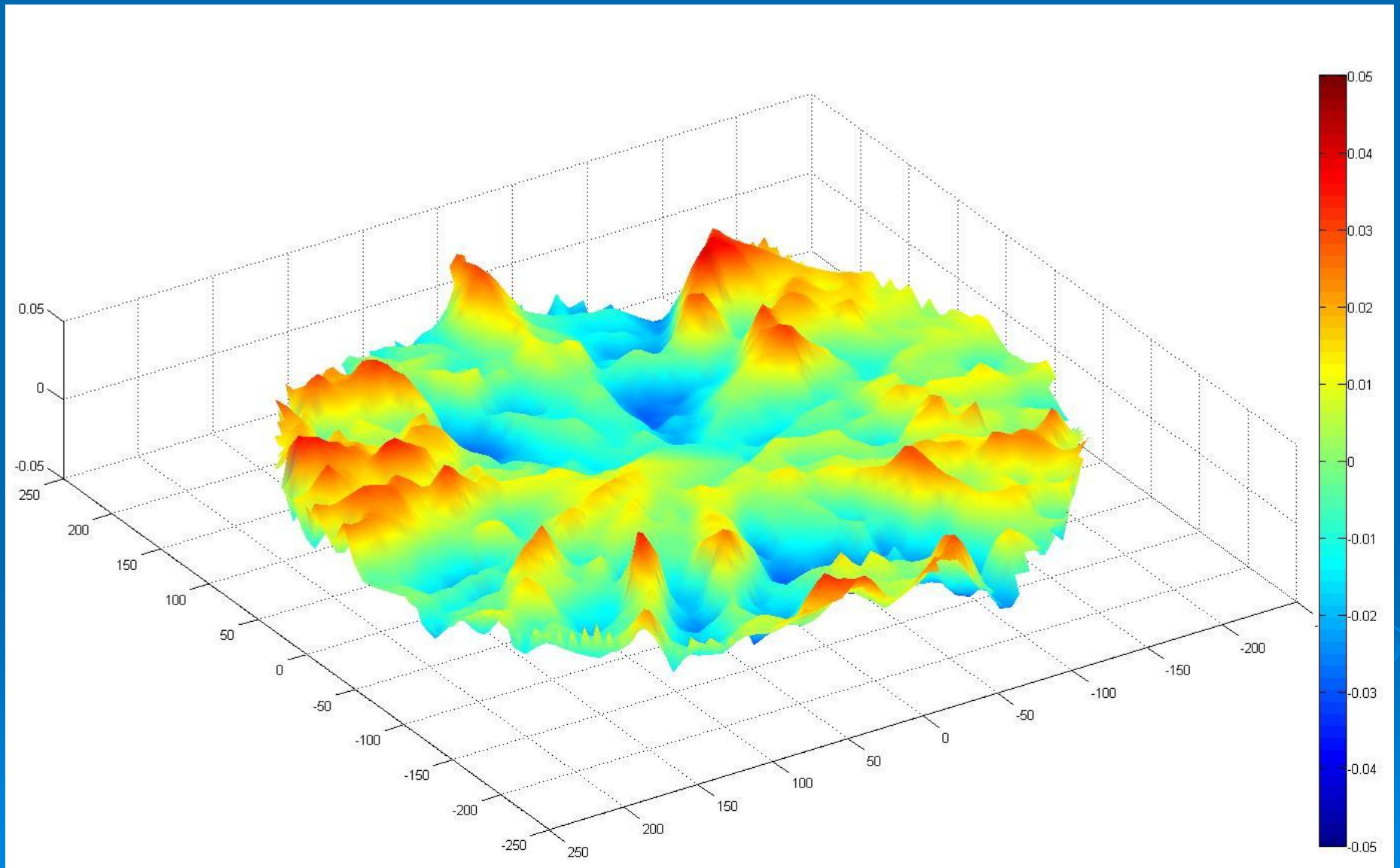



El = 50 deg rms = 0.0142”



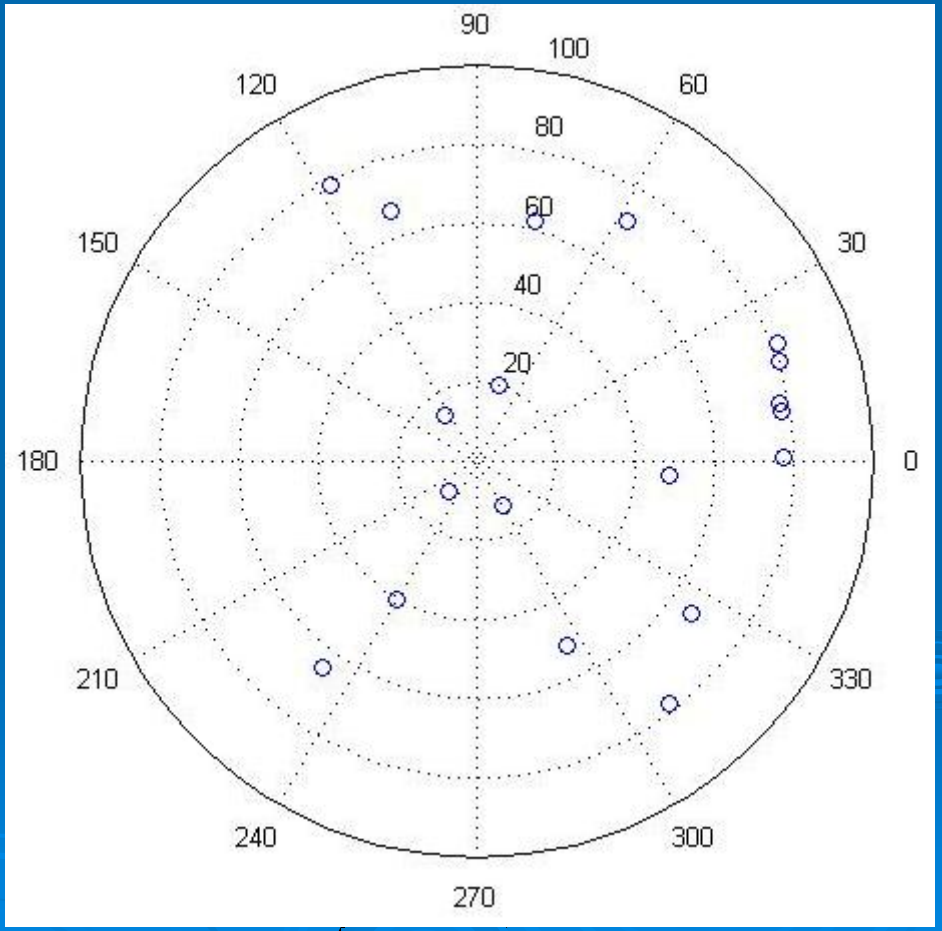

El = 88 deg rms = 0.0145”

# 10 Deg Elevation, surface deviations in mm



# Pointing models and calibration

- Work in progress
- S band observations



# Nine term pointing model built into control system

```
dXEl = p1 + p2*cos(E) + p3*sin(E) + p4*sin(E).*cos(A) +  p5*sin(E).*sin(A)

dEl = -p4*sin(A) + p5*cos(A) + p7 + p8*cos(E)+ p9*cot(E)
```

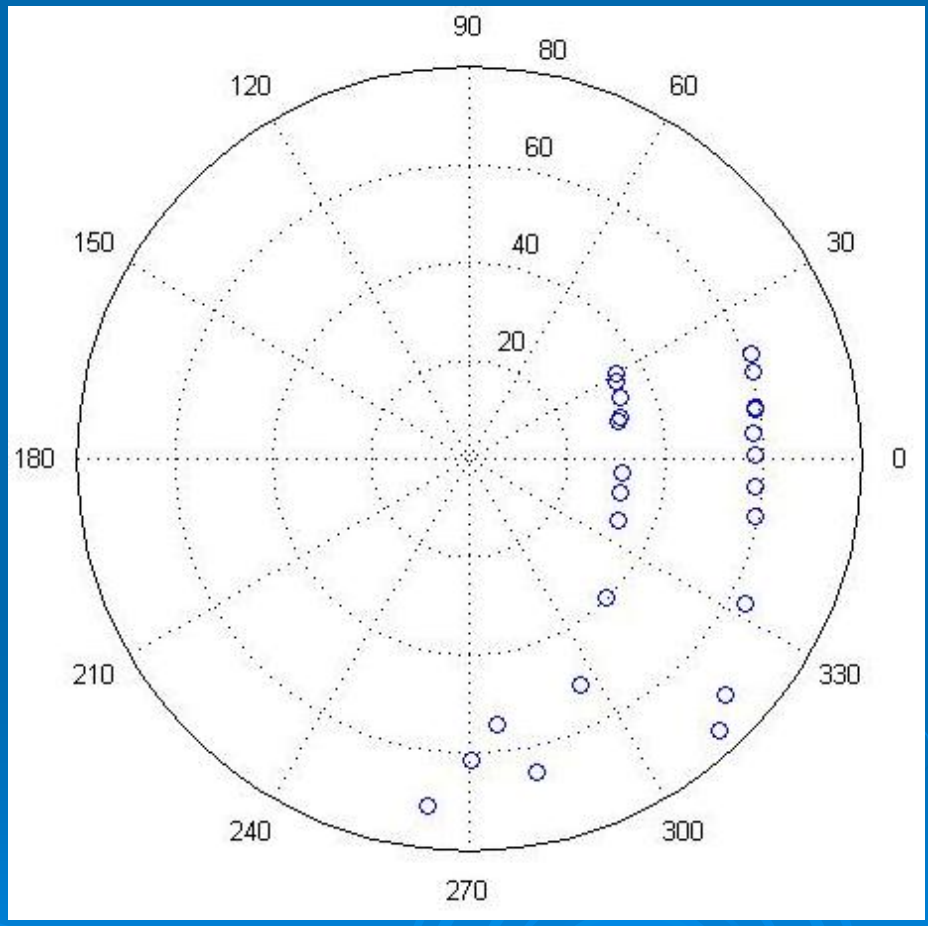
- Least squares fit of model and X band data to 25 measurements

| | | |
|---|---|---|
| p1 | 0.1218 | |
| p2 | -0.4861 | Az encoder offset |
| p3 | -0.0576 | |
| p4 | 0.1266 | |
| p5 | -0.0254 | |
| p7 | 0.5119 | Elevation encoder offset |
| p8 | 0.0586 | |
| p9 | - | |

0.0173

dAfit_error = 0.0328

dEfit_error = 0.0344




- Have not combined S + X measurements due to S band beam squint

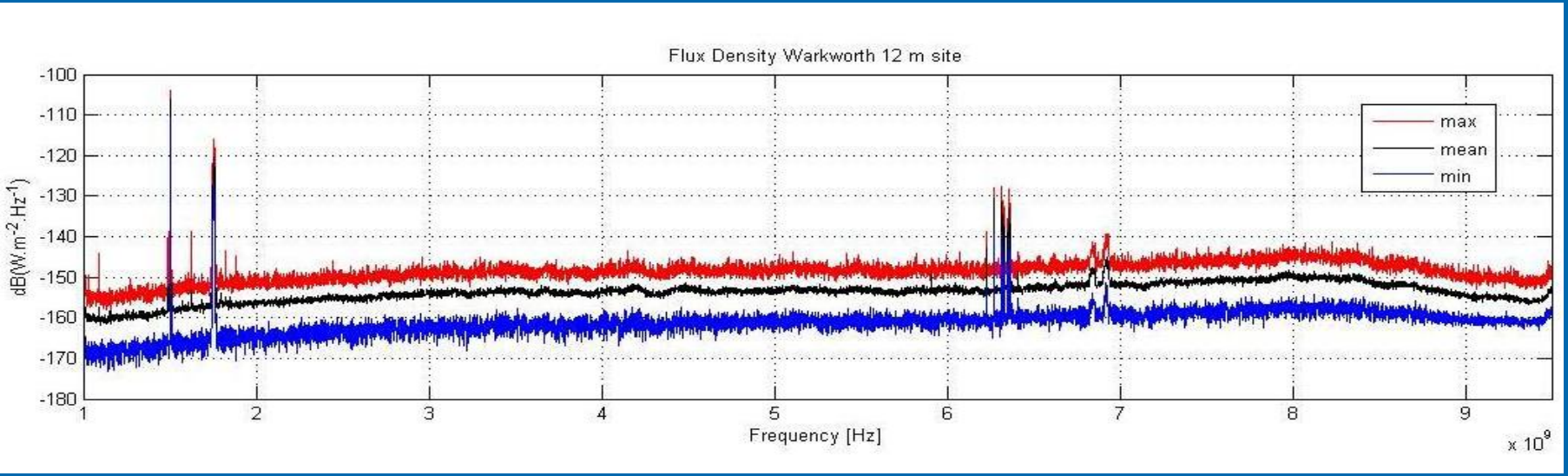
# S Band squint

- Detected offset of S band beams relative to X band
- Elevation offsets dominate
- S band RCP ≈ -0.15 deg.

  LCP ≈ +0.07 deg.
- No detectable offset $X_{RCP}$ to $X_{LCP}$

# RFI situation

- Initial RFI measurements (thank you to staff of ATNF for assistance)




- 1 problem identified in S band subsequent to antenna construction
  - 2.11 GHz; Vodafone NZ inter cell site data link #@$!!!
  - Notch filter to suppress
- X Band clean

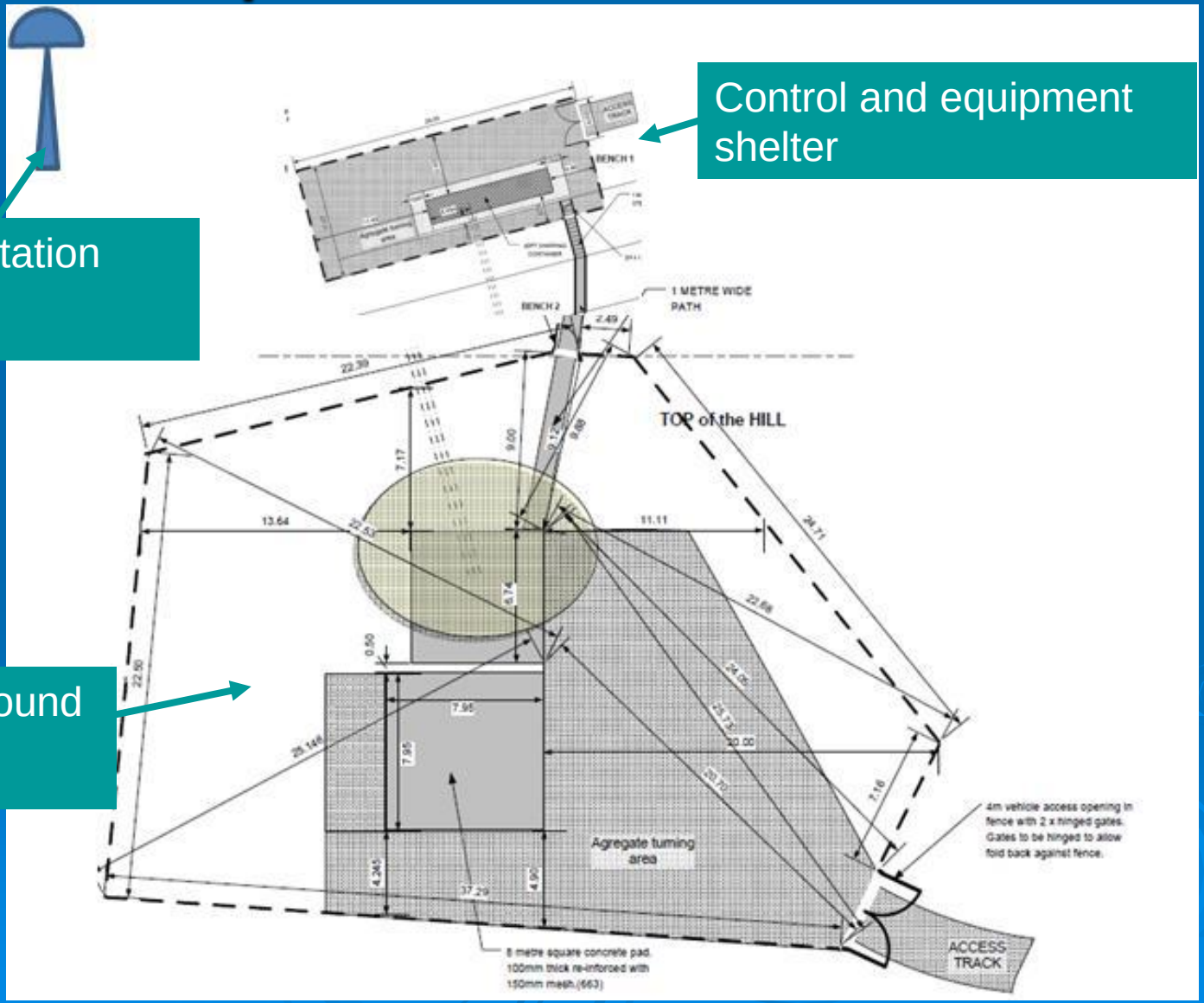
# Site plans and detail

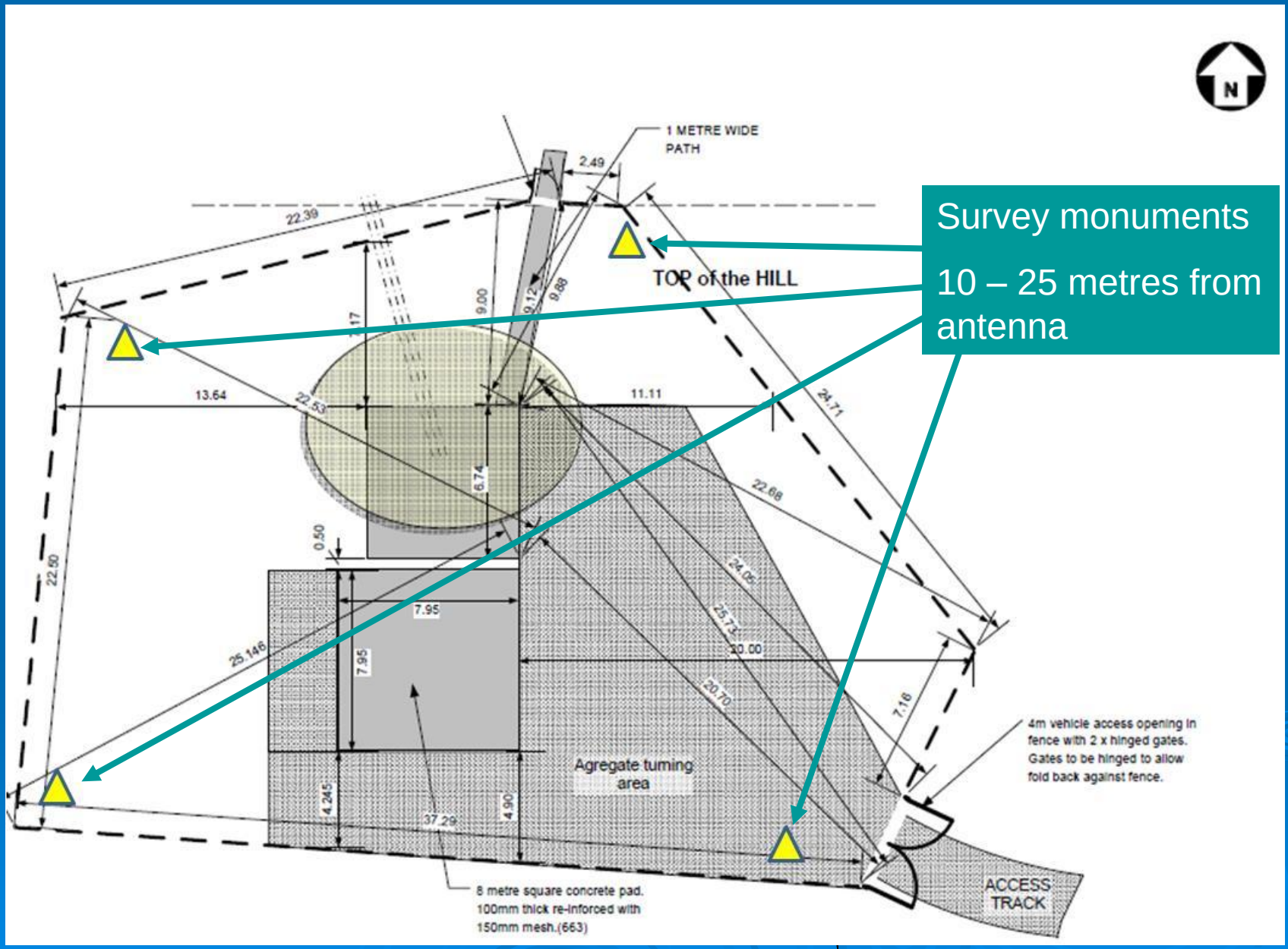
Co sited GPS station

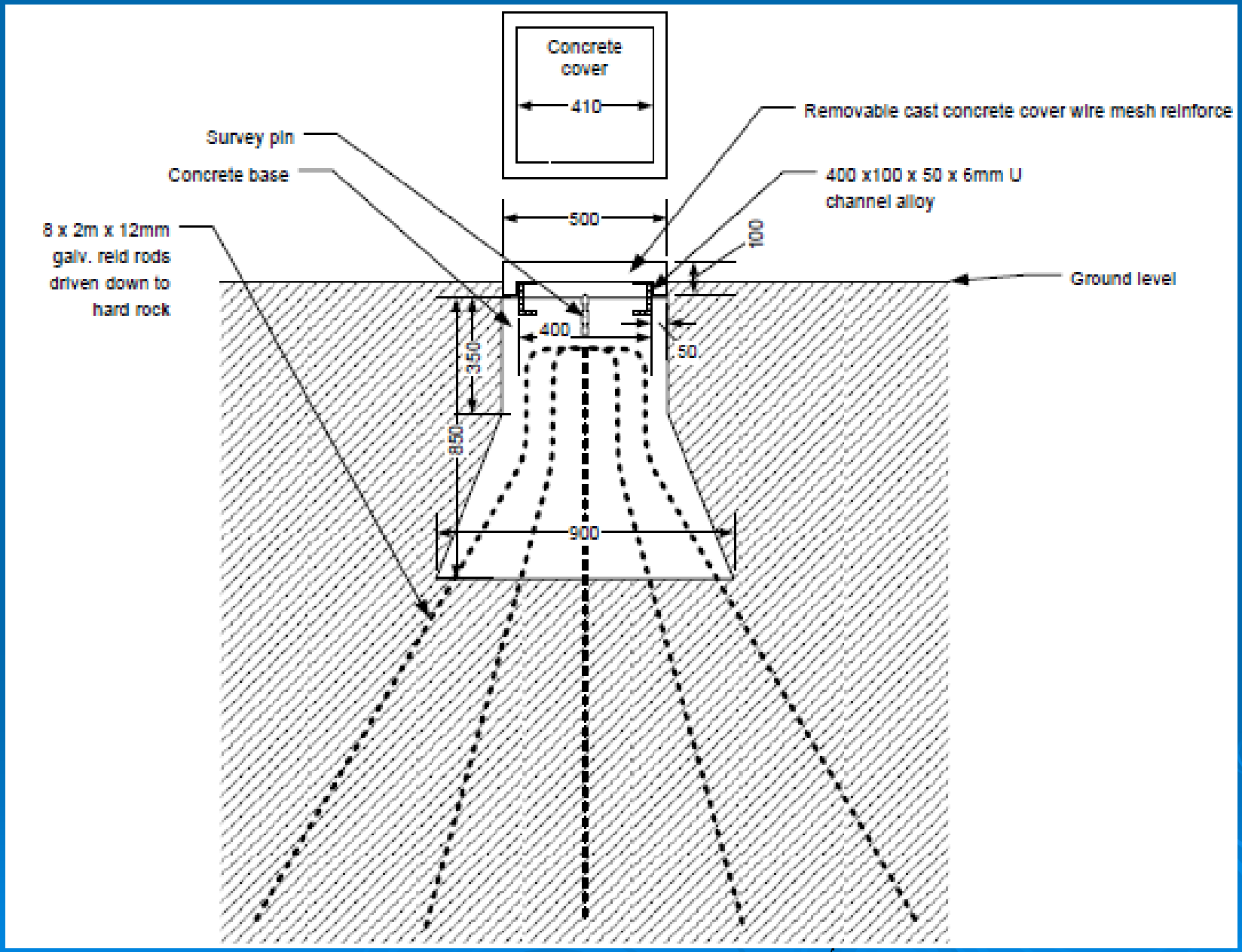
GNS / LINZ

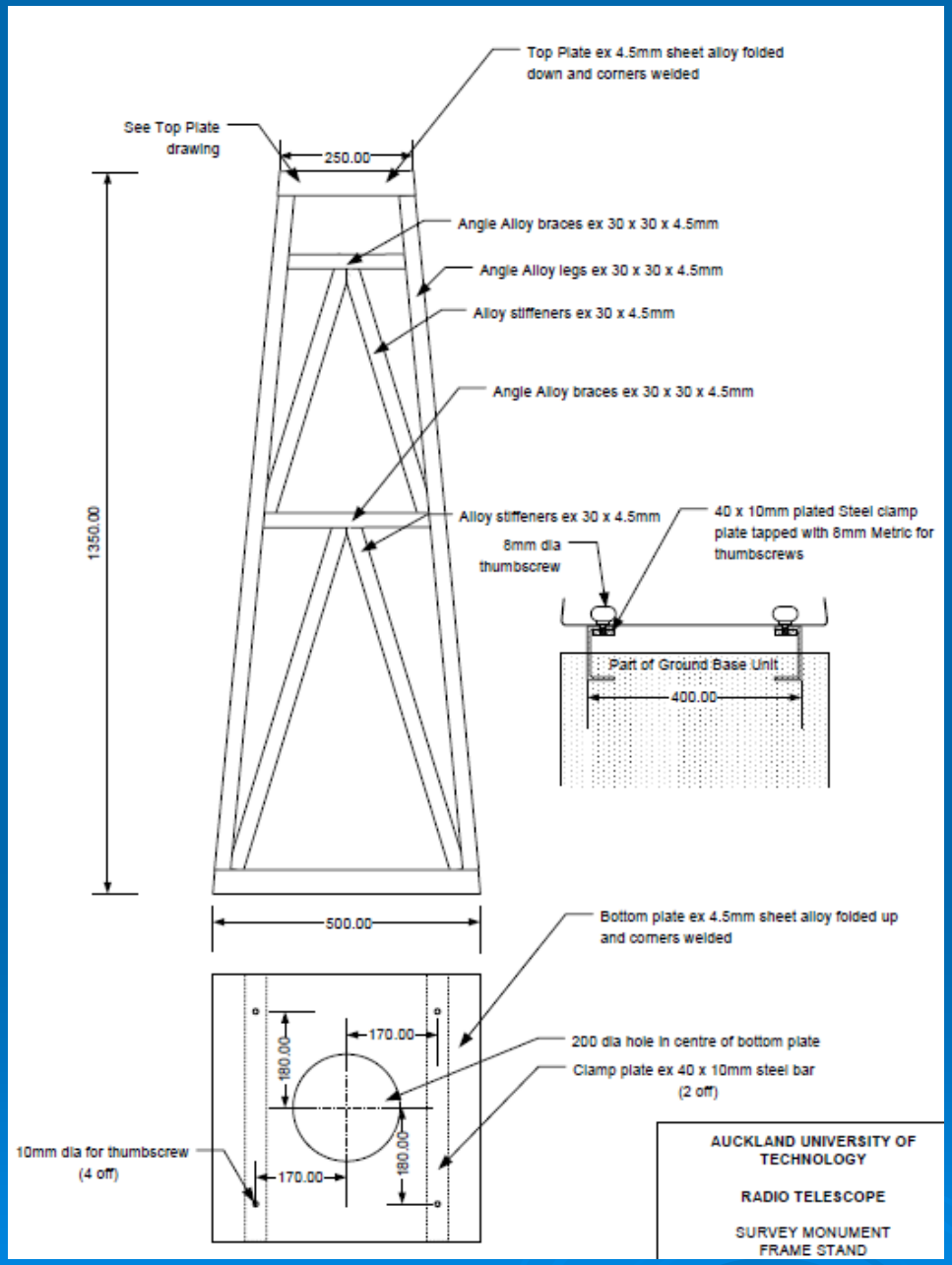
Control and equipment shelter

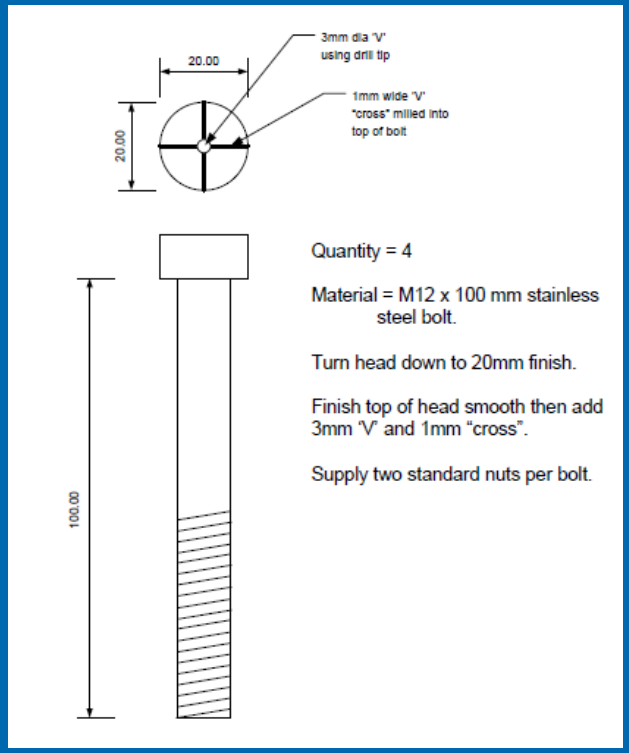
Antenna compound




Survey monuments
10 – 25 metres from antenna
1 METRE WIDE PATH
2.49
22.39
TOP of the HILL
9.00
9.12
9.88
3.17
13.64
22.53
11.11
24.71
6.74
22.68
0.50
22.50
24.05
25.73
20.00
7.95
7.95
25.146
20.70
7.16
4m vehicle access opening in fence with 2 x hinged gates. Gates to be hinged to allow fold back against fence.
Agregate turning area
4.245
37.29
4.90
8 metre square concrete pad. 100mm thick re-inforced with 150mm mesh.(663)
ACCESS TRACK


Concrete cover
410
Removable cast concrete cover wire mesh reinforce
Survey pin
Concrete base
400 x100 x 50 x 6mm U channel alloy
8 x 2m x 12mm galv. reld rods driven down to hard rock
500
100
Ground level
400
50
350
850
900


Top Plate ex 4.5mm sheet alloy folded down and corners welded
See Top Plate drawing
250.00
Angle Alloy braces ex 30 x 30 x 4.5mm
Angle Alloy legs ex 30 x 30 x 4.5mm
Alloy stiffeners ex 30 x 4.5mm
Angle Alloy braces ex 30 x 30 x 4.5mm
1350.00
Alloy stiffeners ex 30 x 4.5mm
8mm dia thumbscrew
40 x 10mm plated Steel clamp plate tapped with 8mm Metric for thumbscrews
Part of Ground Base Unit
400.00
500.00
Bottom plate ex 4.5mm sheet alloy folded up and corners welded
170.00
180.00
200 dia hole in centre of bottom plate
Clamp plate ex 40 x 10mm steel bar (2 off)
10mm dia for thumbscrew (4 off)
170.00
180.00
AUCKLAND UNIVERSITY OF TECHNOLOGY
RADIO TELESCOPE
SURVEY MONUMENT FRAME STAND

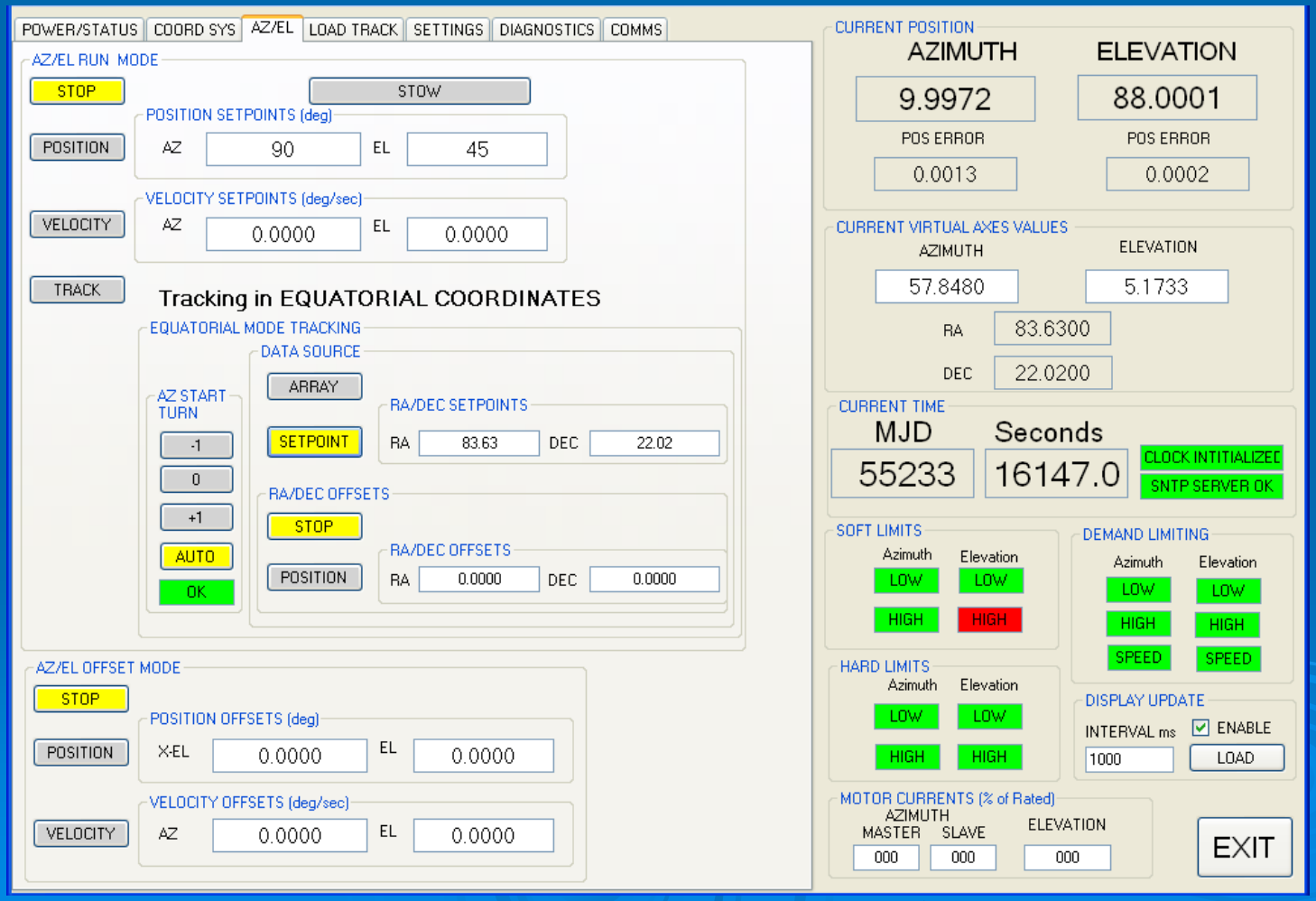

20.00
3mm dia 'V' using drill tip
20.00
1mm wide 'V' "cross" milled into top of bolt
100.00
Quantity = 4
Material = M12 x 100 mm stainless steel bolt.
Turn head down to 20mm finish.
Finish top of head smooth then add 3mm 'V' and 1mm "cross".
Supply two standard nuts per bolt.

# Network connectivity

- Expect 1 Gbps connectivity to KAREN March 2010
- KAREN = Kiwi Academic Research Network
  - 10 Gbps backbone
  - 155 Mbps connection to Australia
  - 625 Mbps connection to Seattle

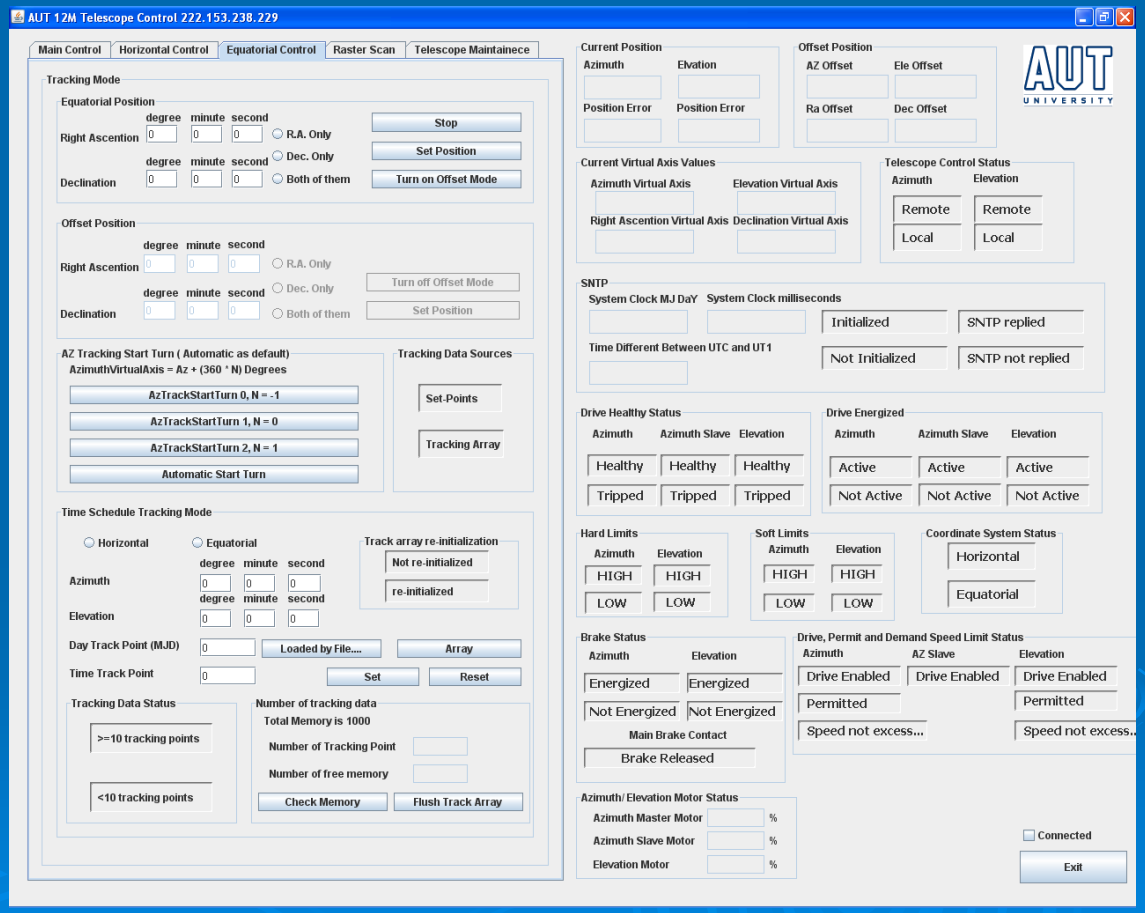
# Control System interface

- Manufacturer supplied simple HMI program



# Development of AUT Software interface

- Java + Modbus-TCP
- All basic control functions implemented
- Adding features to interact with data recording, system calibration and logging systems
- Probably won't use this, want to use AUSCOPE interface for compatability



# Acknowledgements


- UTAS for assistance with Receiver design
- ATNF for help with RFI investigations
- Steven Tingay for supporting development of VLBI capability in NZ