New Zealand's Warkworth Radio Astronomical Observatory

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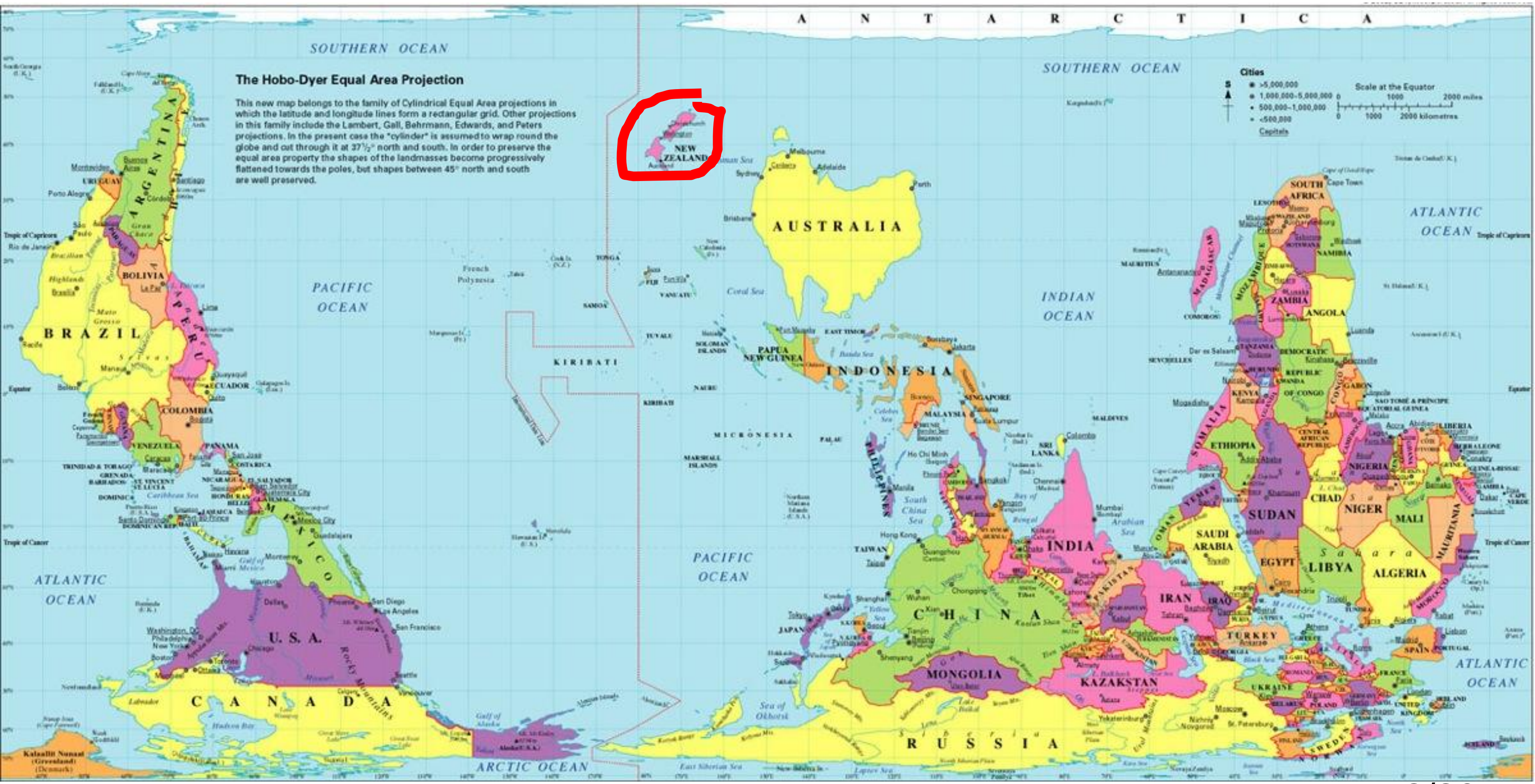
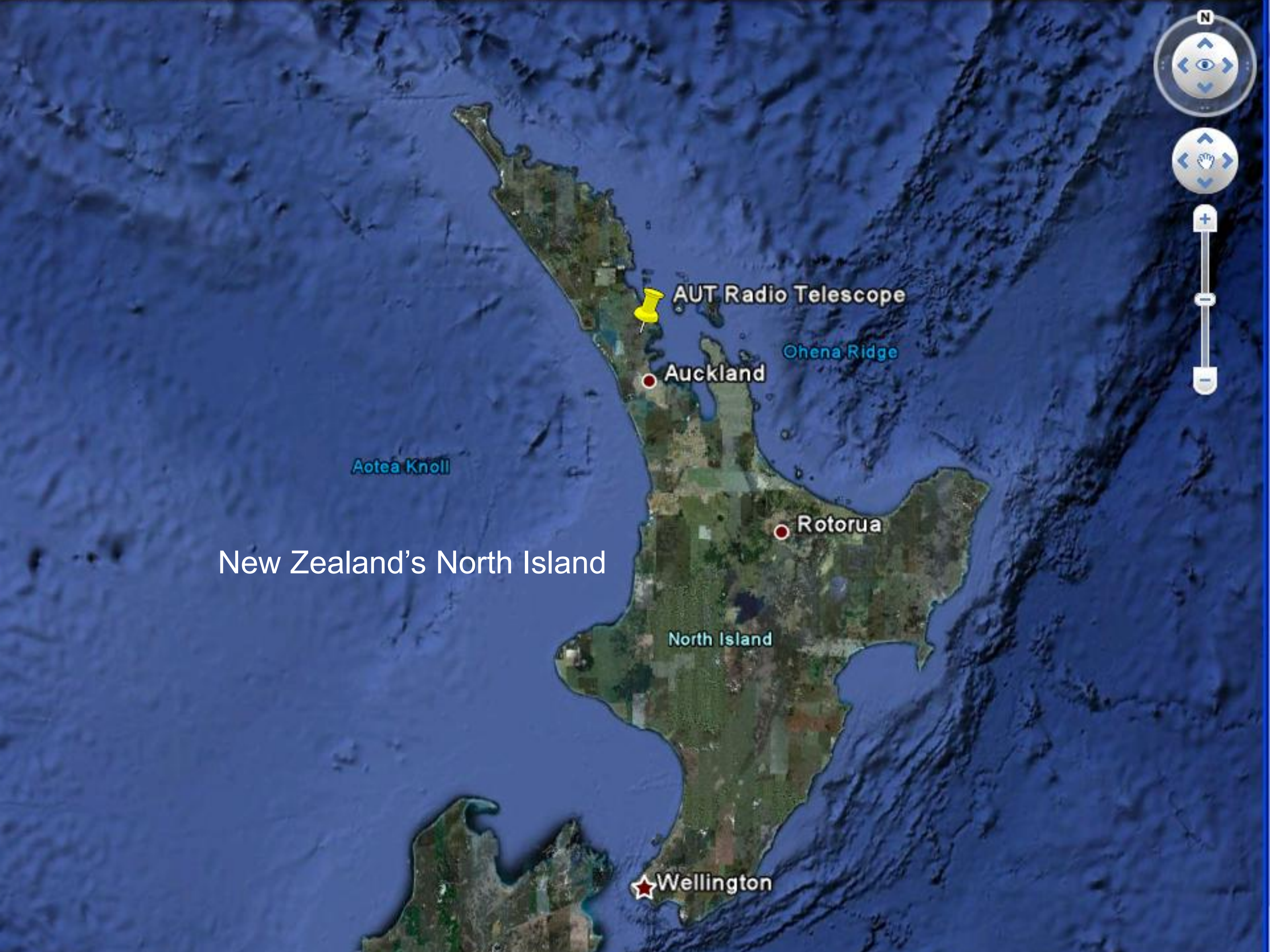
Institute for Radio Astronomy and Space Research, AUT University Auckland New Zealand

Warkworth Radio Astronomy Observatory


A N T A R C T I C A
SOUTHERN OCEAN
The Hobo-Dyer Equal Area Projection
This new map belongs to the family of Cylindrical Equal Area projections in which the latitude and longitude lines form a rectangular grid. Other projections in this family include the Lambert, Gall, Behrmann, Edwards, and Peters projections. In the present case the "cylinder" is assumed to wrap round the globe and cut through it at 37½° north and south. In order to preserve the equal area property the shapes of the landmasses become progressively flattened towards the poles, but shapes between 45° north and south are well preserved.
NEW ZEALAND
AUSTRALIA
PACIFIC OCEAN
INDIAN OCEAN
ATLANTIC OCEAN
ARCTIC OCEAN
INDONESIA
KIRIBATI
MICRONESIA
SOUTH AFRICA
ARGENTINA
BRAZIL
BOLIVIA
PERU
COLOMBIA
MEXICO
U. S. A.
CANADA
CHINA
INDIA
MONGOLIA
KAZAKSTAN
RUSSIA
IRAN
TURKEY
SAUDI ARABIA
EGYPT
SUDAN
LIBYA
ALGERIA
CHAD
NIGER
MALI
ETHIOPIA
ANGOLA
ZAMBIA
MADAGASCAR
Cities
Scale at the Equator

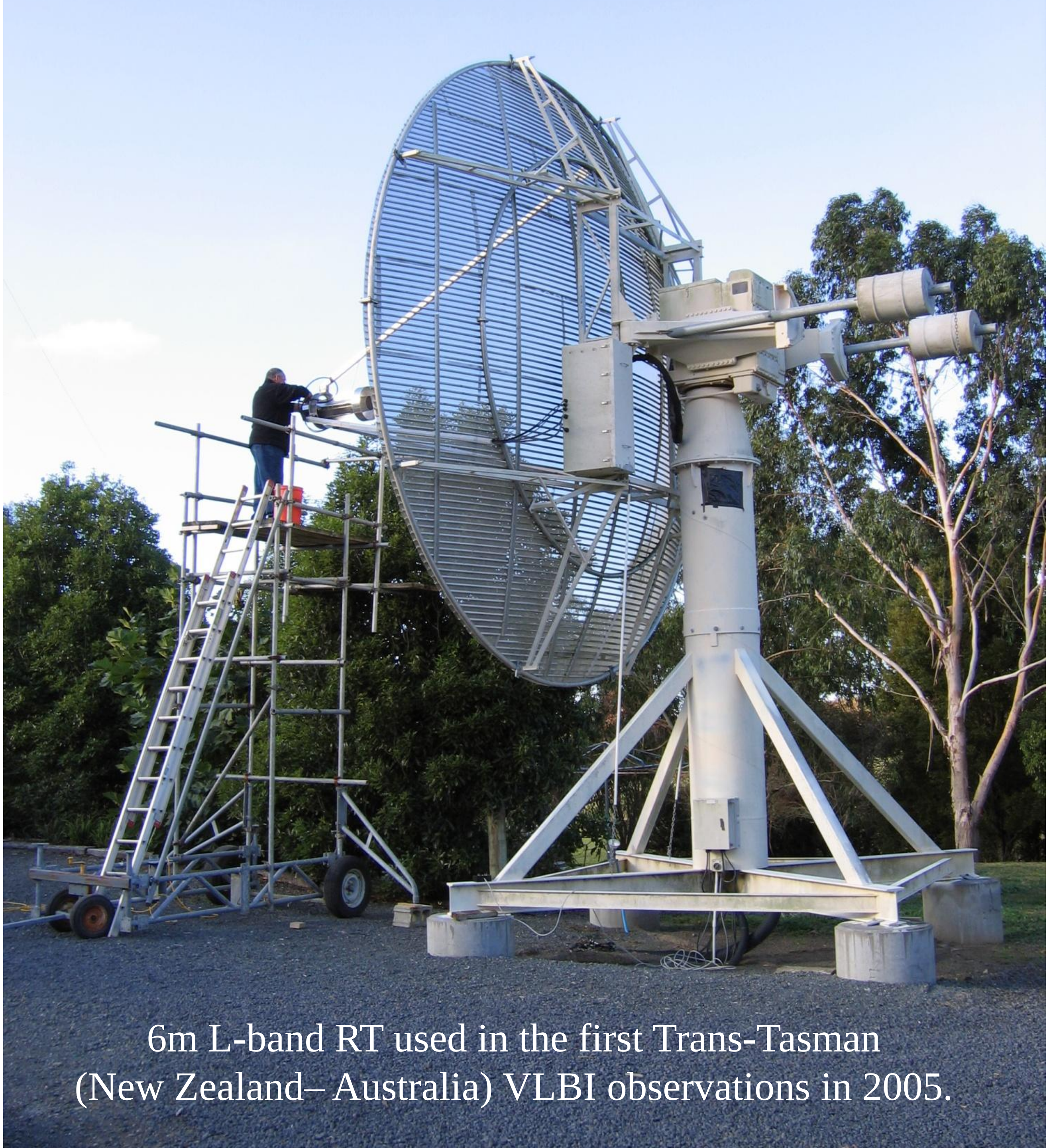


AUT Radio Telescope
Ohena Ridge
Auckland
Aotea Knoll
Rotorua
New Zealand’s North Island
North Island
Wellington
N

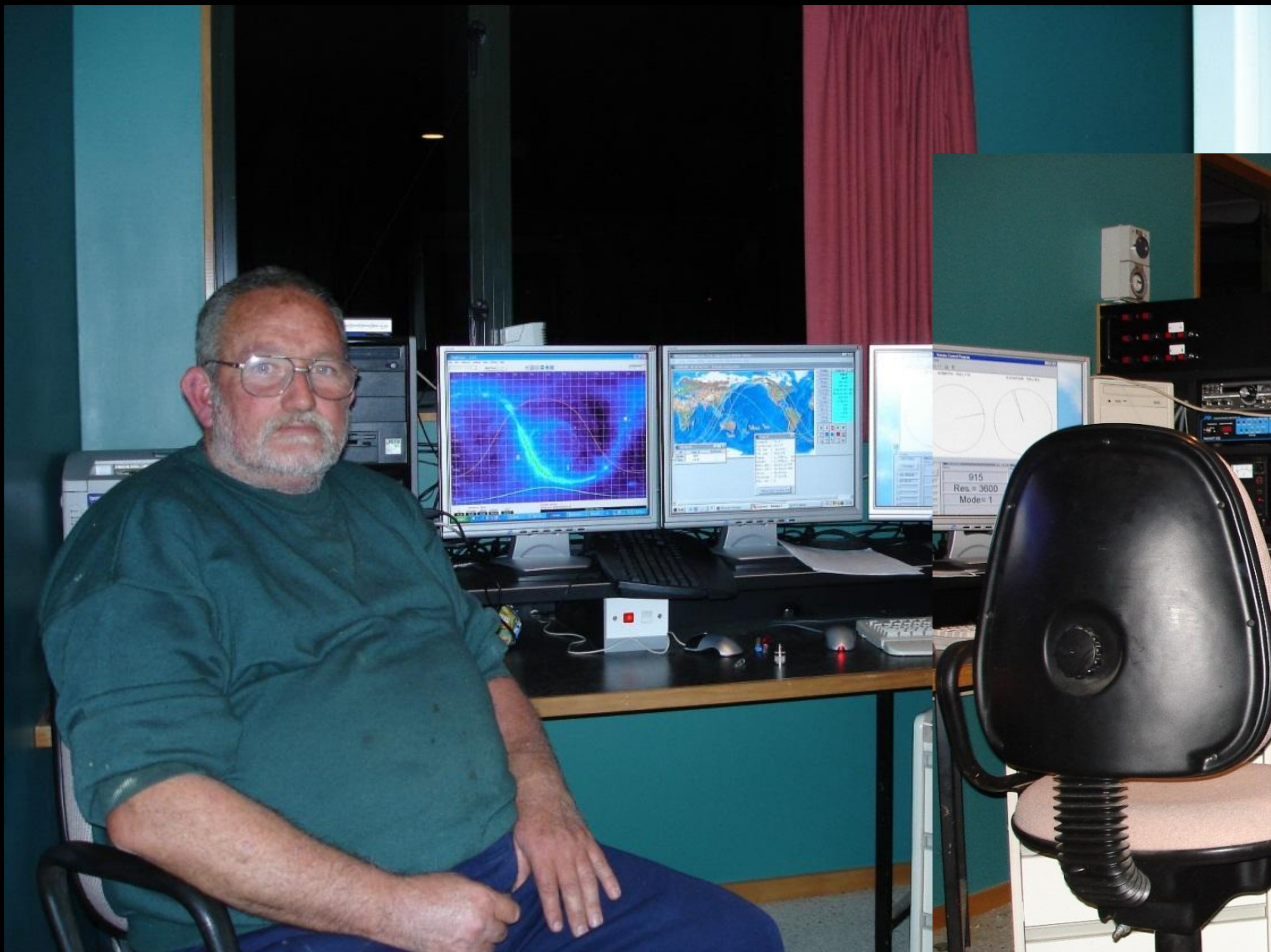

Thompson Rd

- Diameter: 12.1 m
- Manufacturer: Patriot/Cobham
- Shaped Cassegrain
- Slewing: 5 deg/s Az
  1 deg/s El
- Surface: 0.35 mm (rms)
- Receivers/feeds
  - S/X (dual circular pols)
  - L (1.1-1.8 GHz; prime focus)

- H-maser (Symmetricom MH2010)
- Mk5B+ , Mk5C
- DBBC 2 (4 IFs)
- 10 Gbps network connectivity



6m L-band RT used in the first Trans-Tasman
(New Zealand– Australia) VLBI observations in 2005.

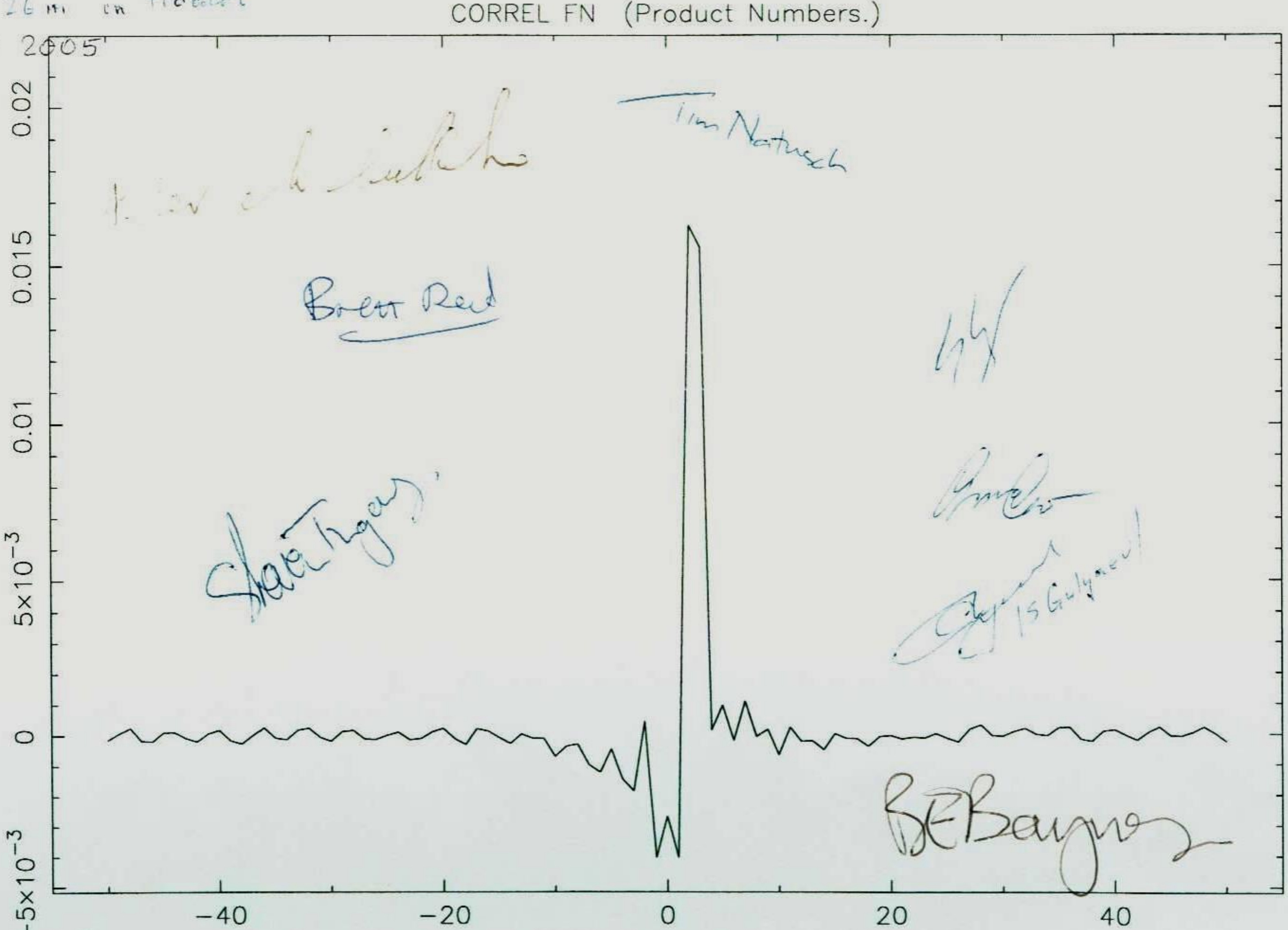



915
Res.= 3600
Mode= 1

FIRE EXTINGUISHER
CO2
CAUTION
BRUSHES

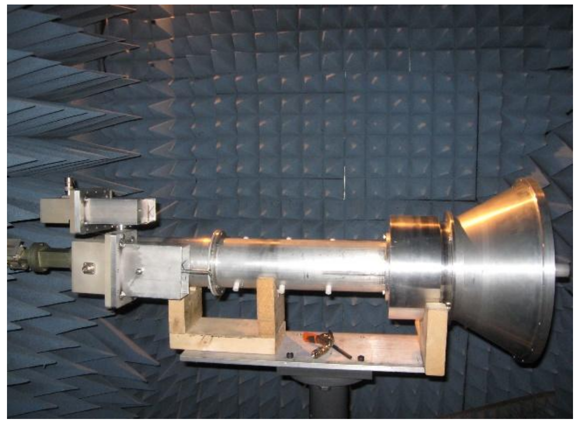

CTS

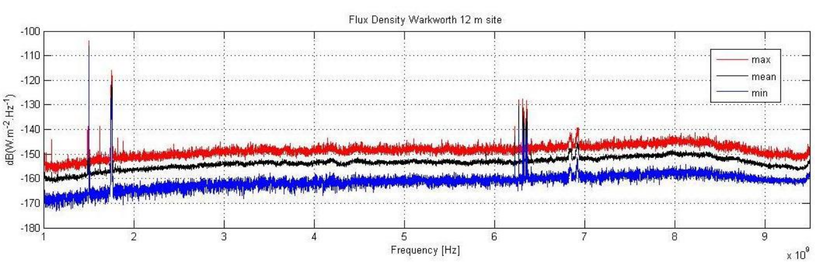
Taurus: First fringes
14m + 26m in Hobart
25 August 2005




HIREQUIP

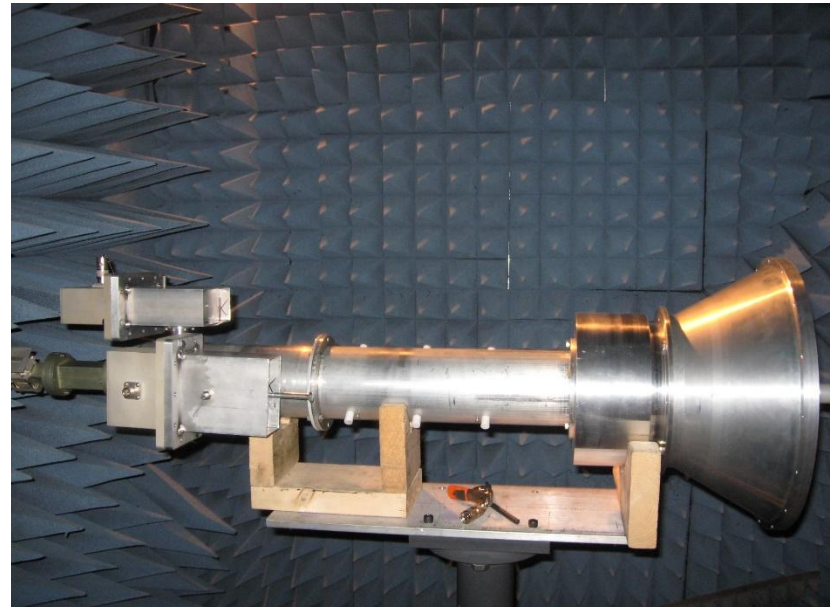
2008




Flux Density Warkworth 12 m site
max
mean
min
dB(W.m-2.Hz-1)
Frequency [Hz]
x 10^9

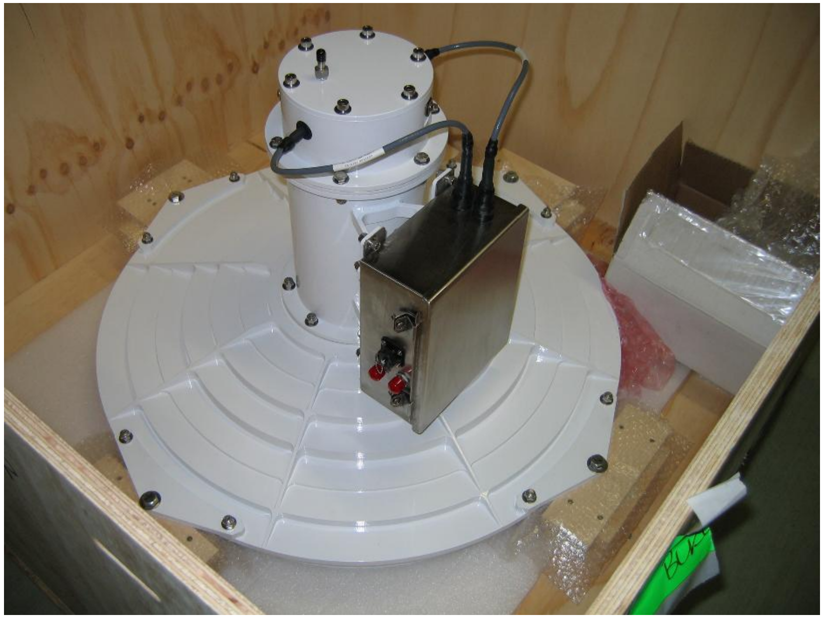
Feed

- 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



L Band Feed

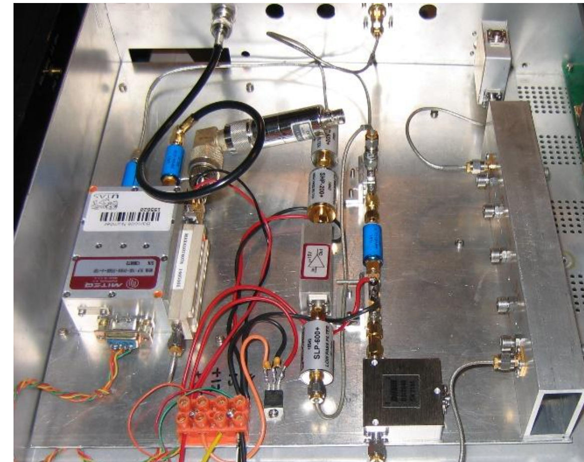
- Designed and manufactured by Intertronic Solutions Canada – Peter Shields / Bill Imbriale
- Prime focus – have to remove subreflector to use

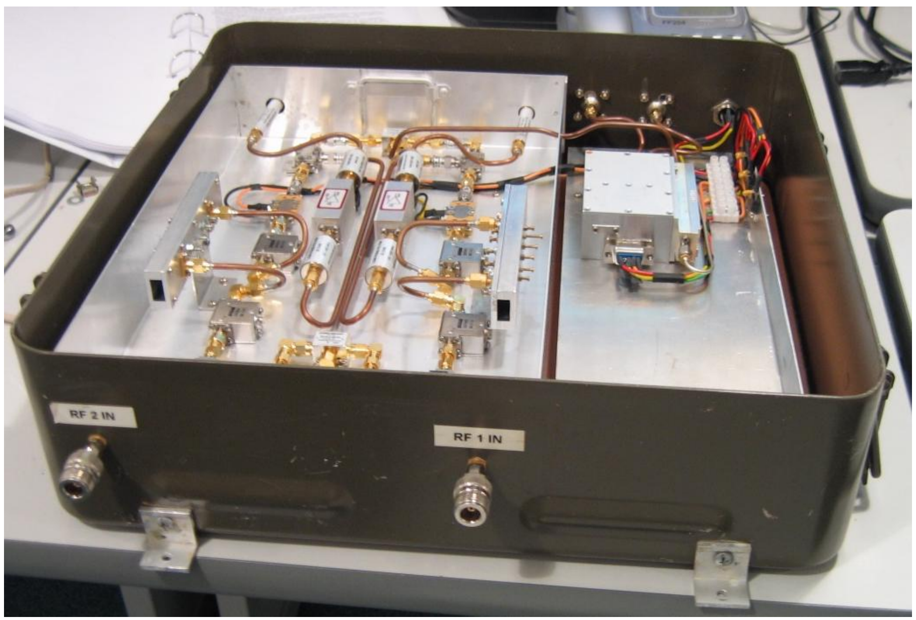


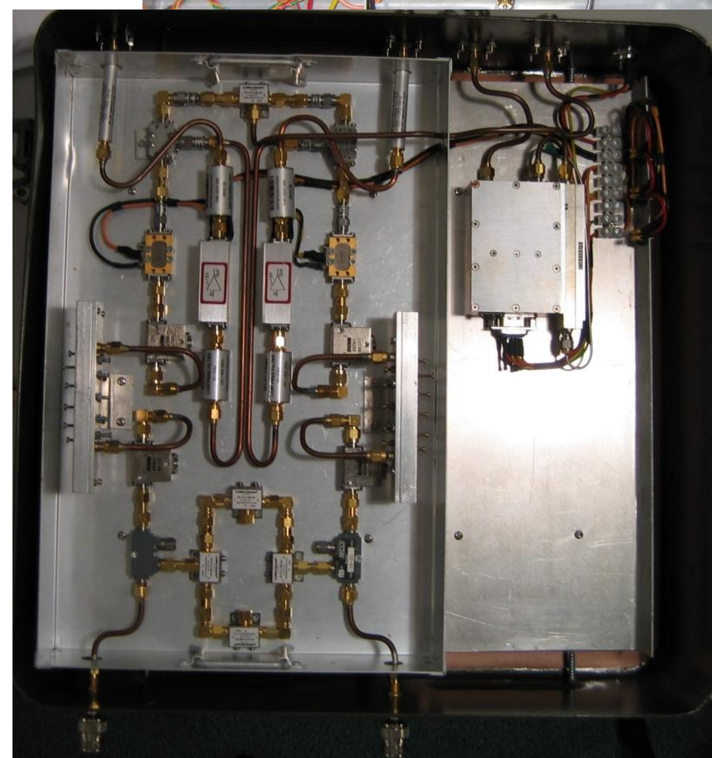
L Band Feed

Receivers

- Room temperature un-cooled design
- SEFD
  - ≈ 3500 Jy @ S Band
  - ≈ 3900 Jy @ X Band







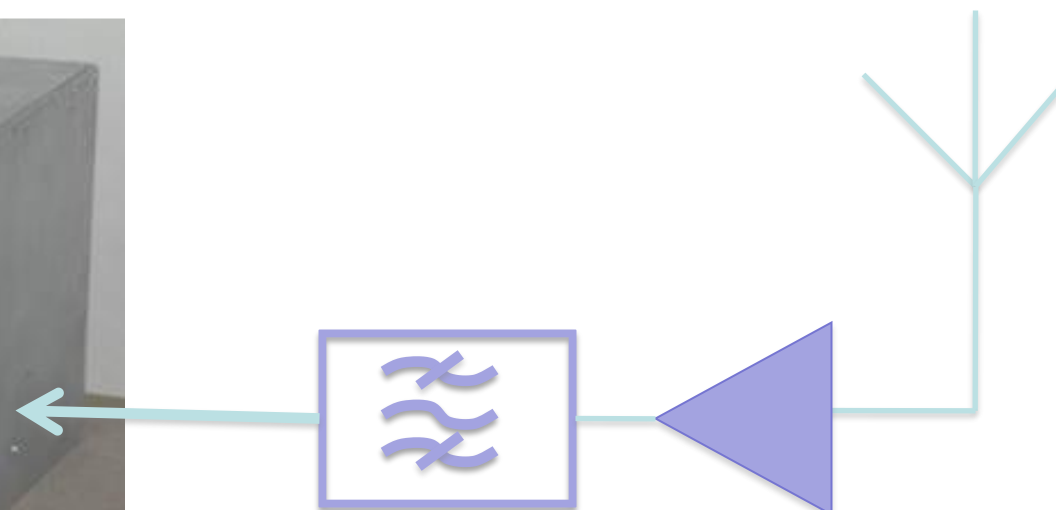
- Thanks to Peter McCulloch and UTAS for generous assistance with receiver development!

Rx System performance

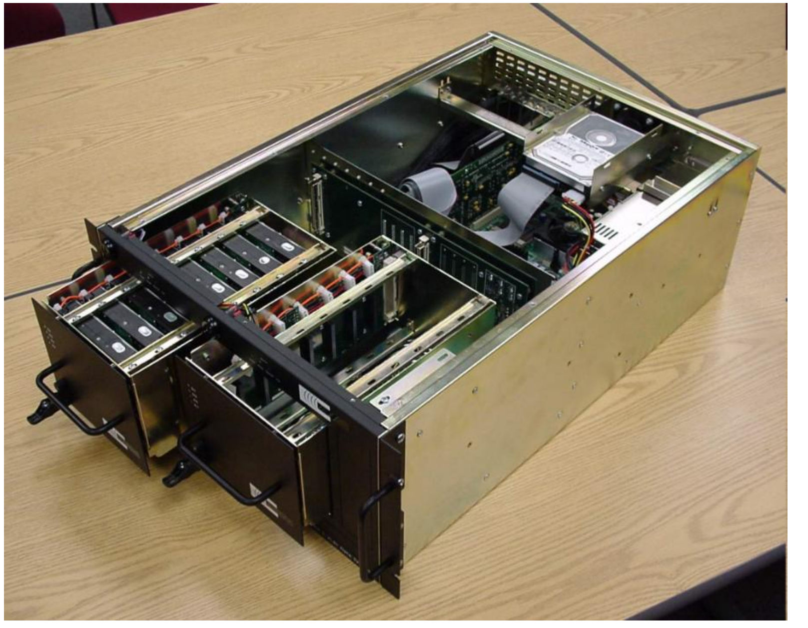
- System Equivalent Flux Density (SEFD) approx 3700 Jy
- Tsys approx 91 K
- Efficiency approx 0.65
- Pcal from Haystack

Digital Backend DBBC2

- 4 x 512 MHz IFs
- 512 Mbps output in default modes
- 2 Gbps possible
- FILA10



Digitiser + Recorders



- Data recorders:
  - Mk 5 B+ (2 Gbps to disk)
  - Mk 5 C   (4 Gbps to disk)
  - Network streaming possible
    - Have done 512 Mbps eVLBI with data transport to Perth

30 Metre

Specs:

Beam-waveguide cassegrain

Azimuth range:
+/- 270 deg from East

Elevation range:
0 to 90 degrees

Slewing rate:0.3 deg/s
(both El and Az)

Surface: 0.6 mm rms

Publications of the Astronomical Society of Australia (PASA), Vol. 32, e017, 14 pages (2015).

doi:10.1017/pasa.2015.13

Conversion of a New Zealand 30-Metre Telecommunicati
Antenna into a Radio Telescope

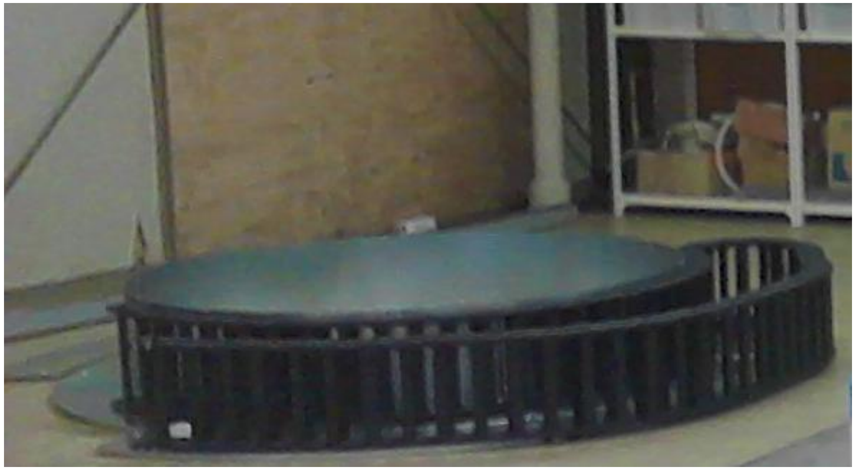
Lewis Woodburn[1], Tim Natusch[1], Stuart Weston[1,5], Peter Thomasson[1,2], Mark Godwin[3], Christophe Granet[4] and Sergei Gulyaev[1]

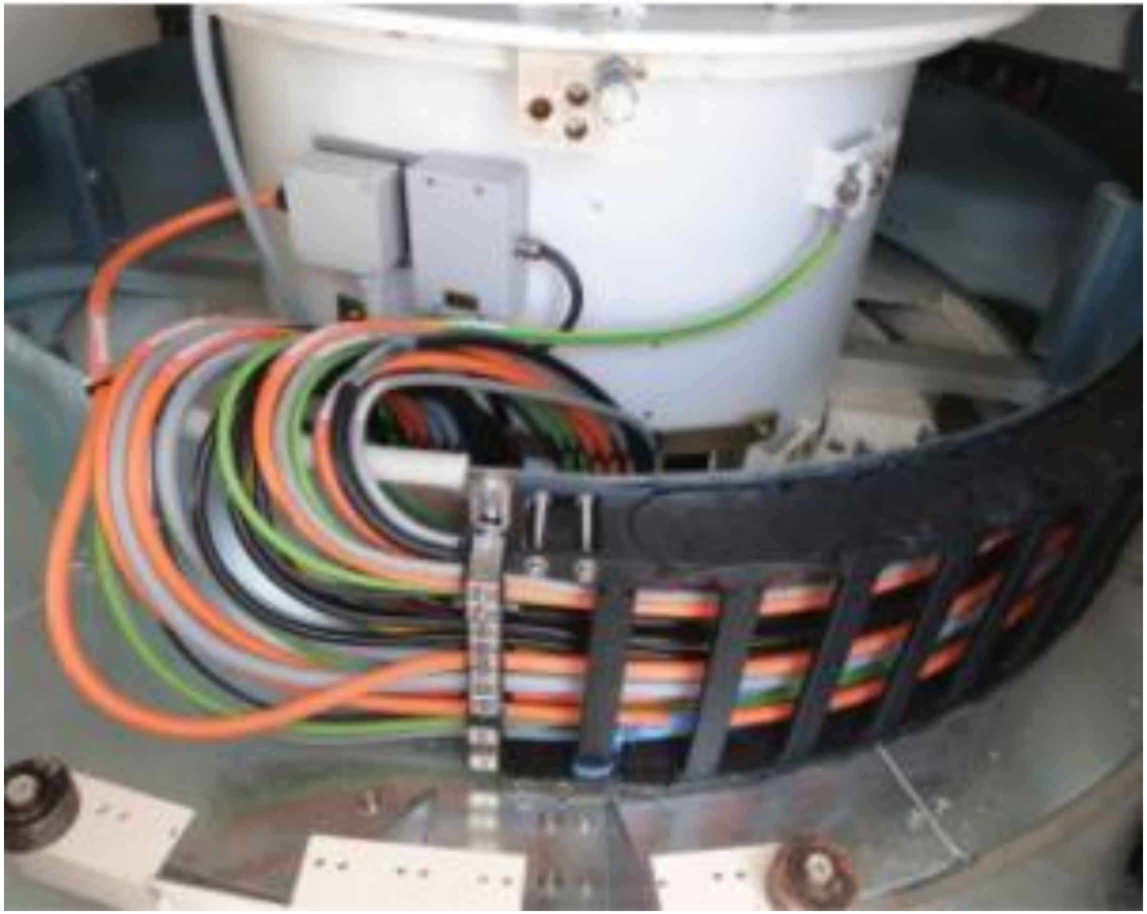
Table 1. Specifications of the Earth Station according to the manufacturer's (NEC) handbook.

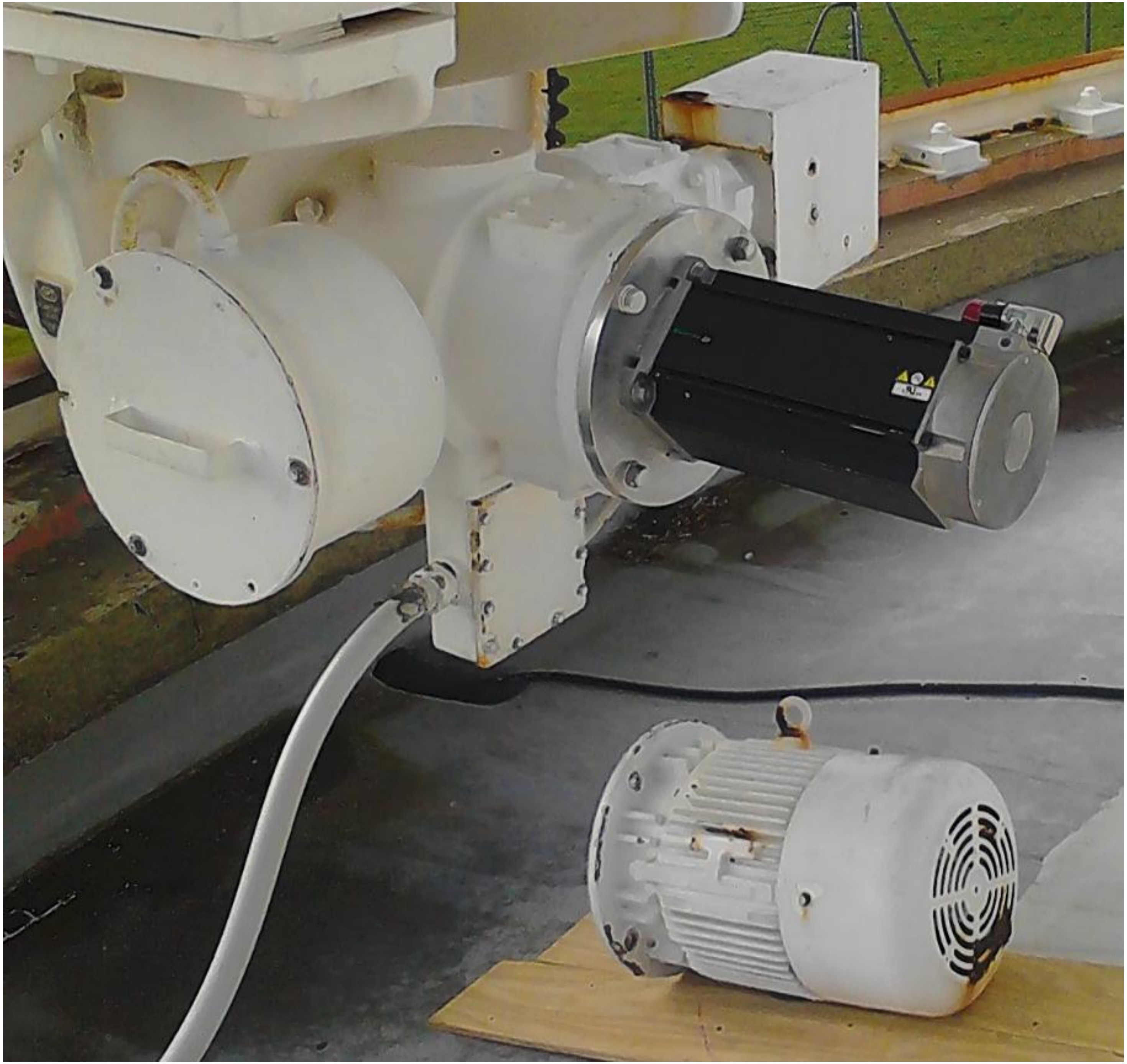
Description	Specification
System	Alt-azimuth, wheel-and-track, Cassegrain, beam-waveguide antenna
Drive system	Electric-servo, dual train for anti-backlash
Transmission frequency band	C-band
Reception frequency band	C-Band
Primary mirror diameter	30.48 m
Subreflector diameter	2.715 m
Azimuth maximum velocity in slew mode (open loop)	0.3 deg s^{-1} or 18.0 deg min^{-1}
Elevation maximum velocity in slew mode (open loop)	0.3 deg s^{-1} or 18.0 deg min^{-1}
Max acceleration/deceleration in both axes	0.2 deg s^{-1} s^{-1}
Max tracking velocity (closed loop)	0.03 deg s^{-1} or 1.8 deg min^{-1} (estimated as no data in the NEC documentation)
Azimuth working range (as defined by soft limits)	$-170°$ to $170°$
Elevation working range (as defined by soft limits)	$0°$ to $90°$
Surface accuracy (rms)	0.4 mm
Track diameter	16.97 m
Total weight on track	268 tons
Wind speed in tracking operation	up to 40 m s^{-1}
Survive wind speed in stow position	up to 70 m s^{-1}

Table 3. New parameters after control system replacement.

Description	Specification
Azimuth maximum (tracking and slewing) velocity	0.37 deg s^{-1} or 22.2 deg min^{-1}
Elevation maximum (tracking and slewing) velocity	0.36 deg s^{-1} or 21.6 deg min^{-1}
Azimuth acceleration/deceleration	0.2 deg s^{-1} s^{-1}
Elevation acceleration/deceleration	0.25 deg s^{-1} s^{-1}
Azimuth working range (as defined by soft limits)	−179.0 to 354.0 deg
Elevation working range (as defined by soft limits)	6.0 to 90.1 deg







30 M optics + geometry

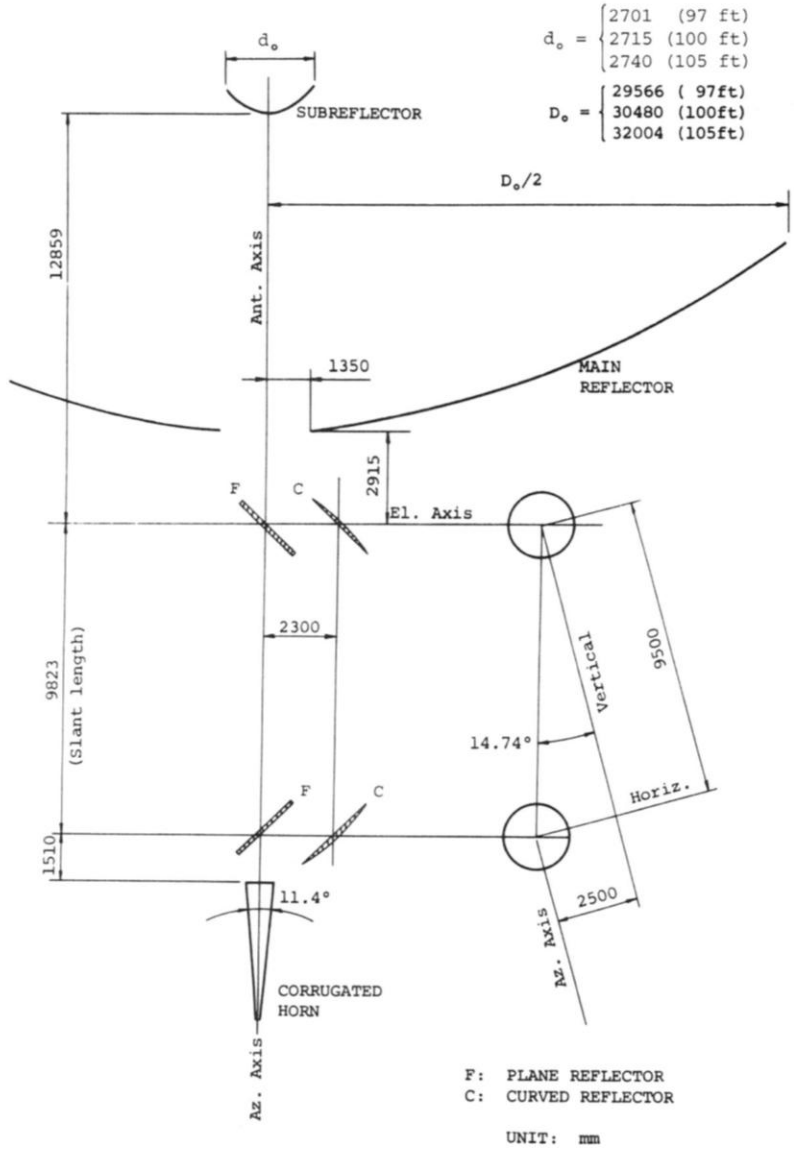


Figure 3-1. Cassegrain Antenna Geometry

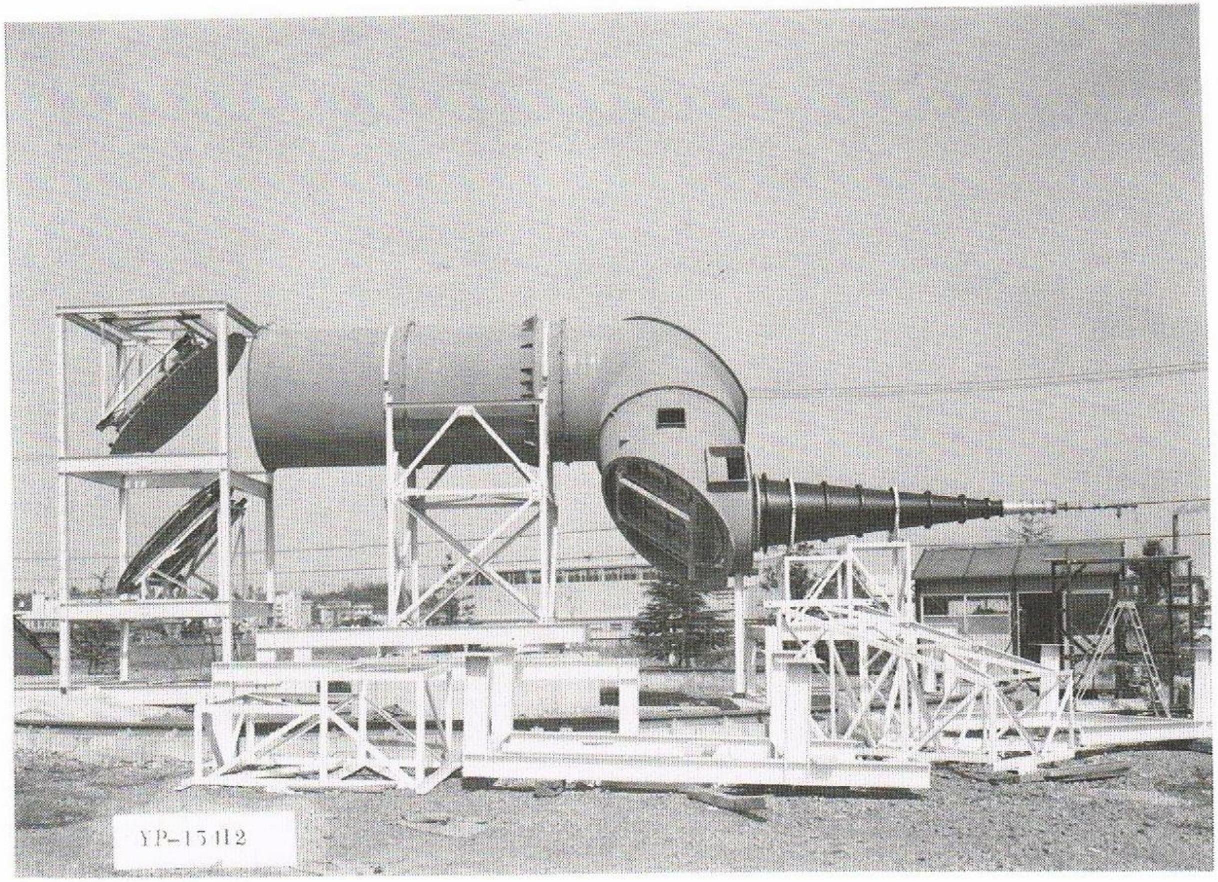


Figure 1-1. Four-Reflector Primary Feed (YP-15412)

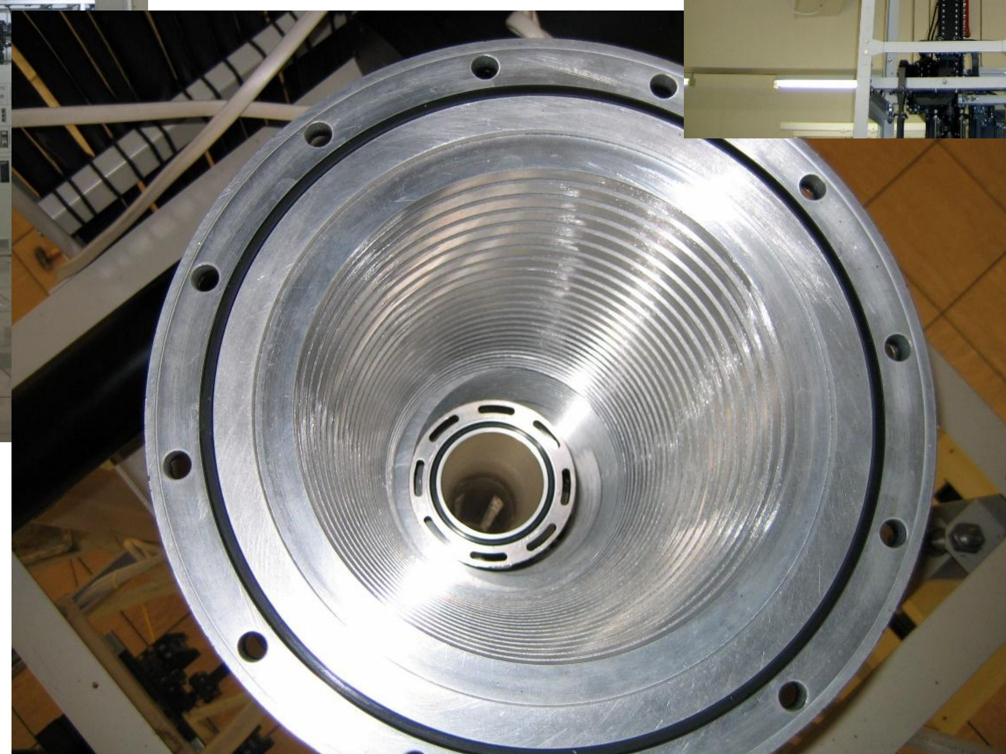


Figure 11. The *C*-band receiver with the new feedhorn transition unit man-
ufactured by BAE Systems Australia. (Image courtesy of Stuart Weston.)

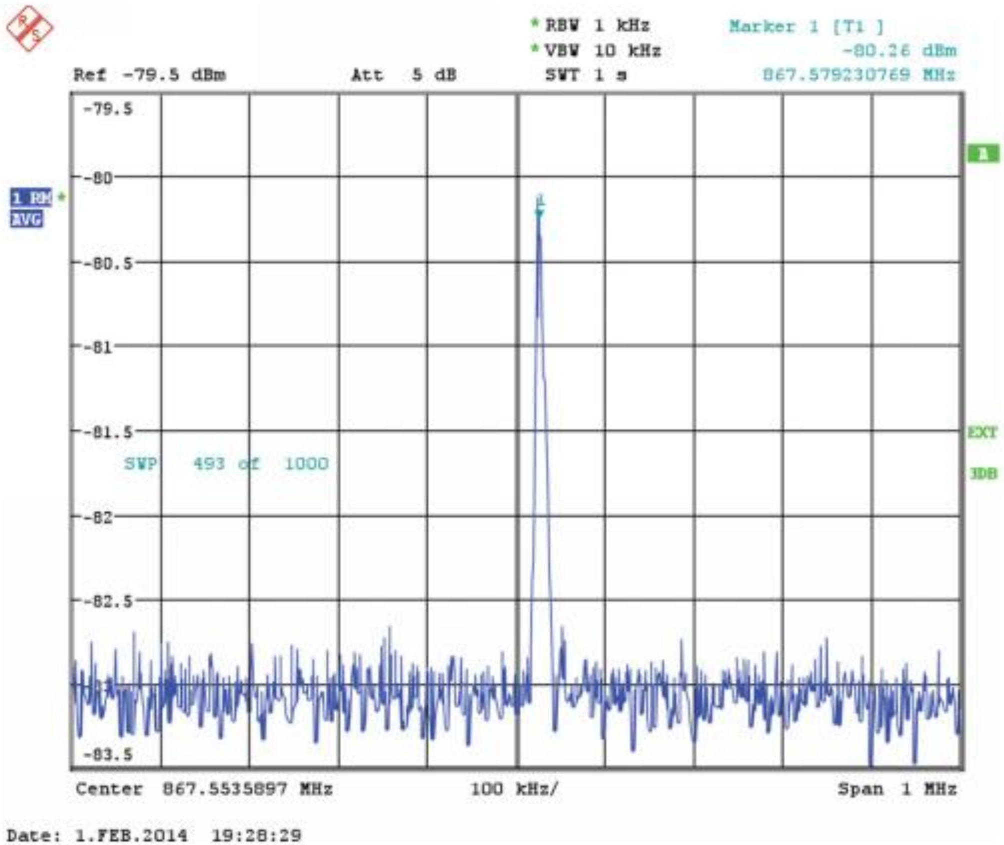
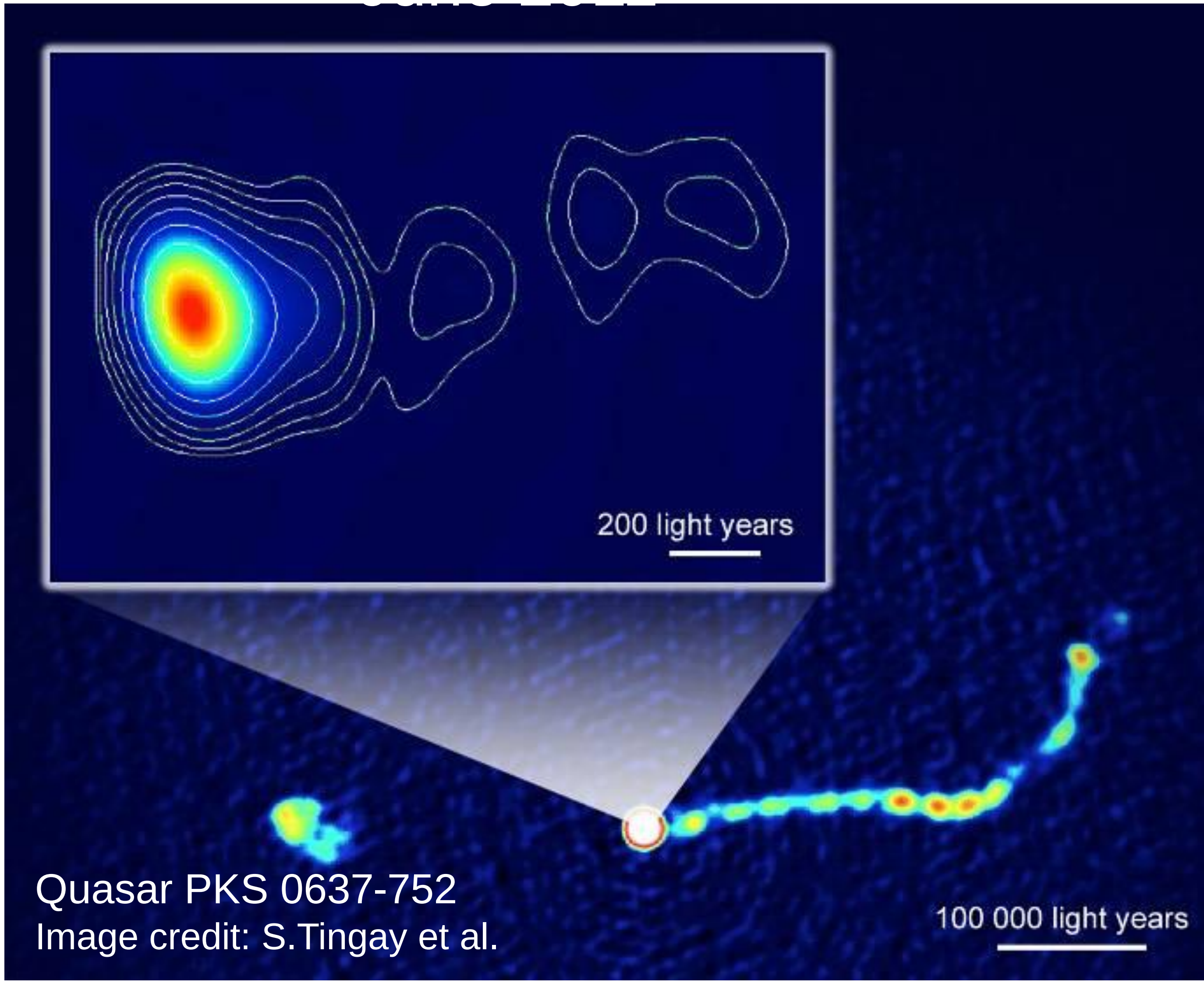


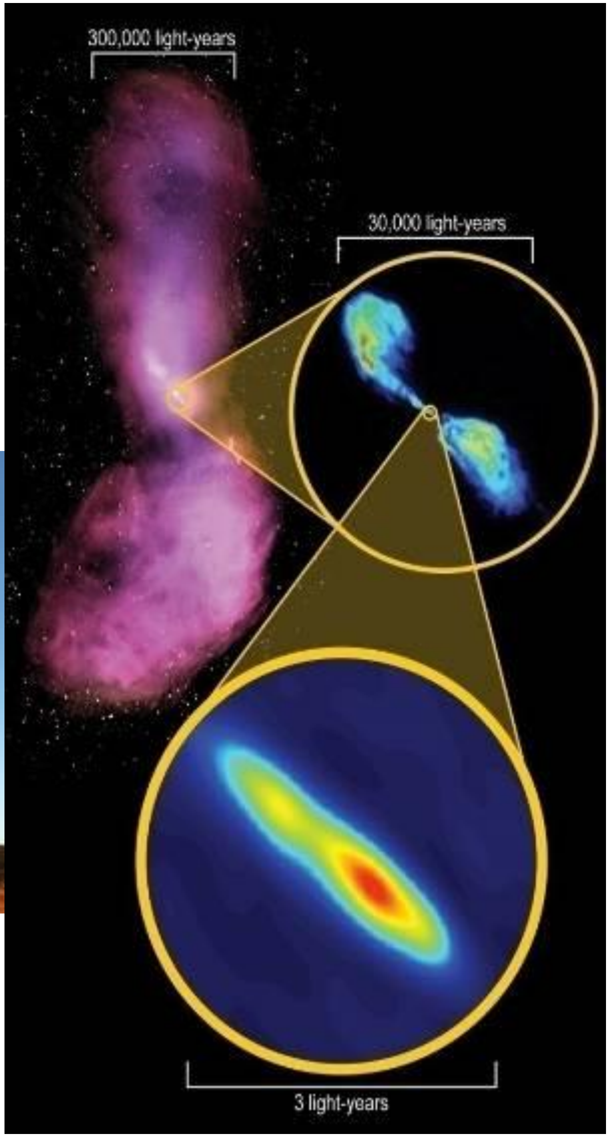
Figure 15. The 'First Light': the spectrum of the galactic Methanol Maser source G188.95+0.89 near 6.7 GHz.

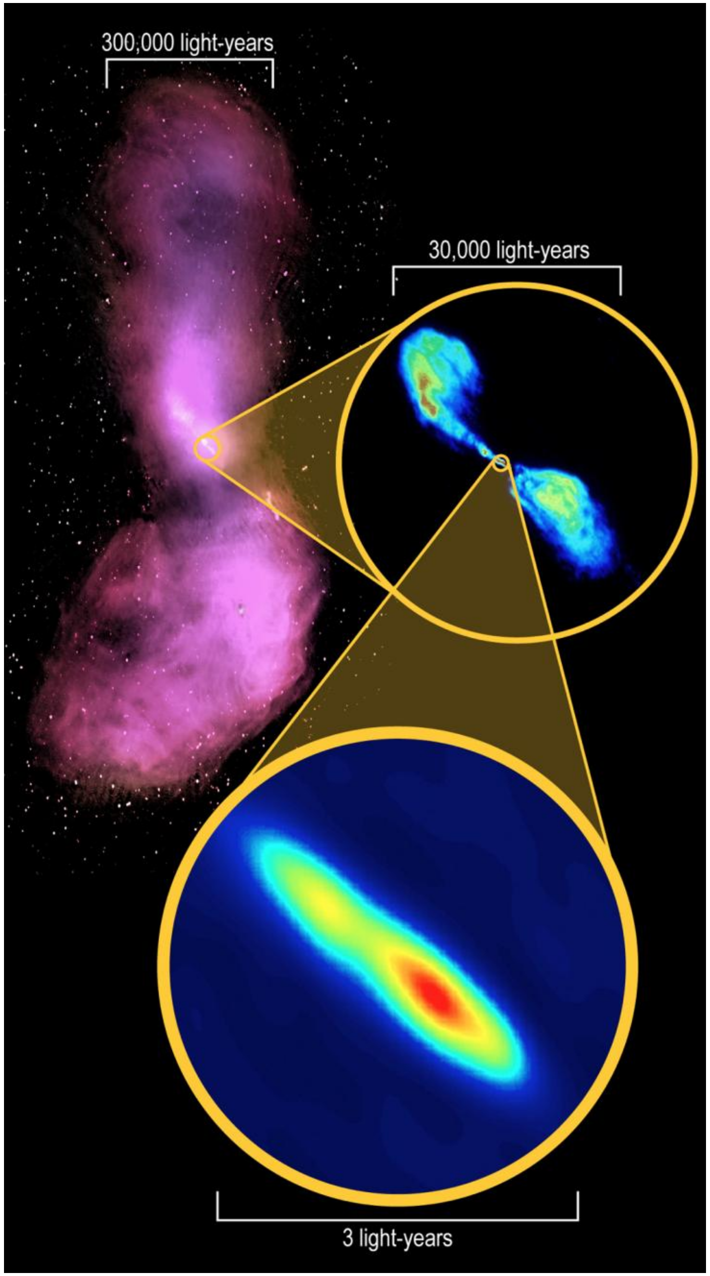
Control system based on “Commercial Of The Shelf”

(COTS) industrial control technology
Emerson Control Techniques



Quasar PKS 0637-752
Image credit: S.Tingay et al.

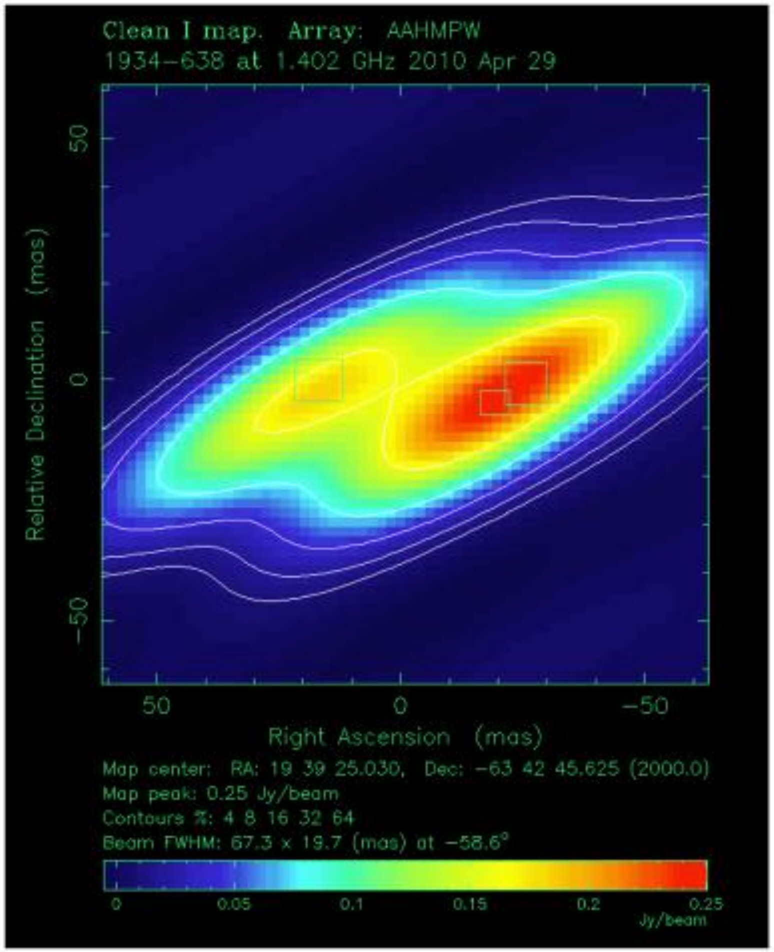

300,000 light-years
30,000 light-years
3 light-years



Zooming in to the heart of galaxy Centaurus A 14 million light-years away. Image Credits: Whole galaxy: I. Feain, T. Cornwell & R. Ekers (CSIRO/ATNF); ATCA northern middle lobe pointing courtesy R. Morganti (ASTRON); Parkes data courtesy N. Junkes (MPIfR). Inner radio lobes: NRAO / AUI / NSF. Core: S. Tingay (ICRAR) / ICRAR, CSIRO and AUT

ASKAP & NZ VLBI of 1934-638

Normal LBA at 1.4 GHz



LBA with NZ and ASKAP

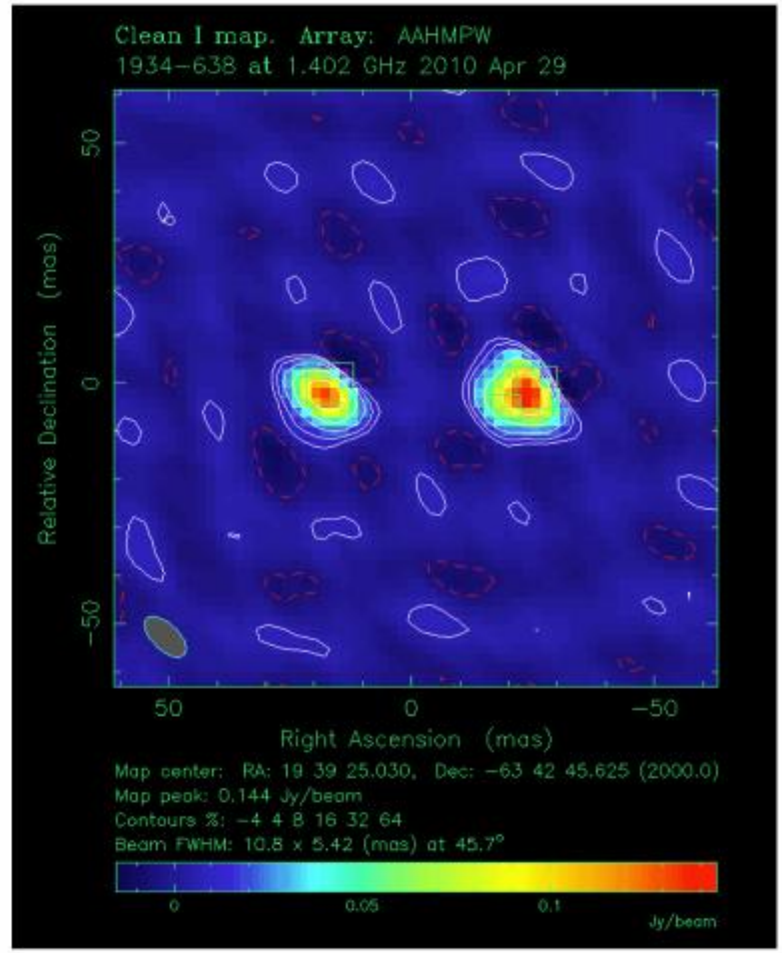
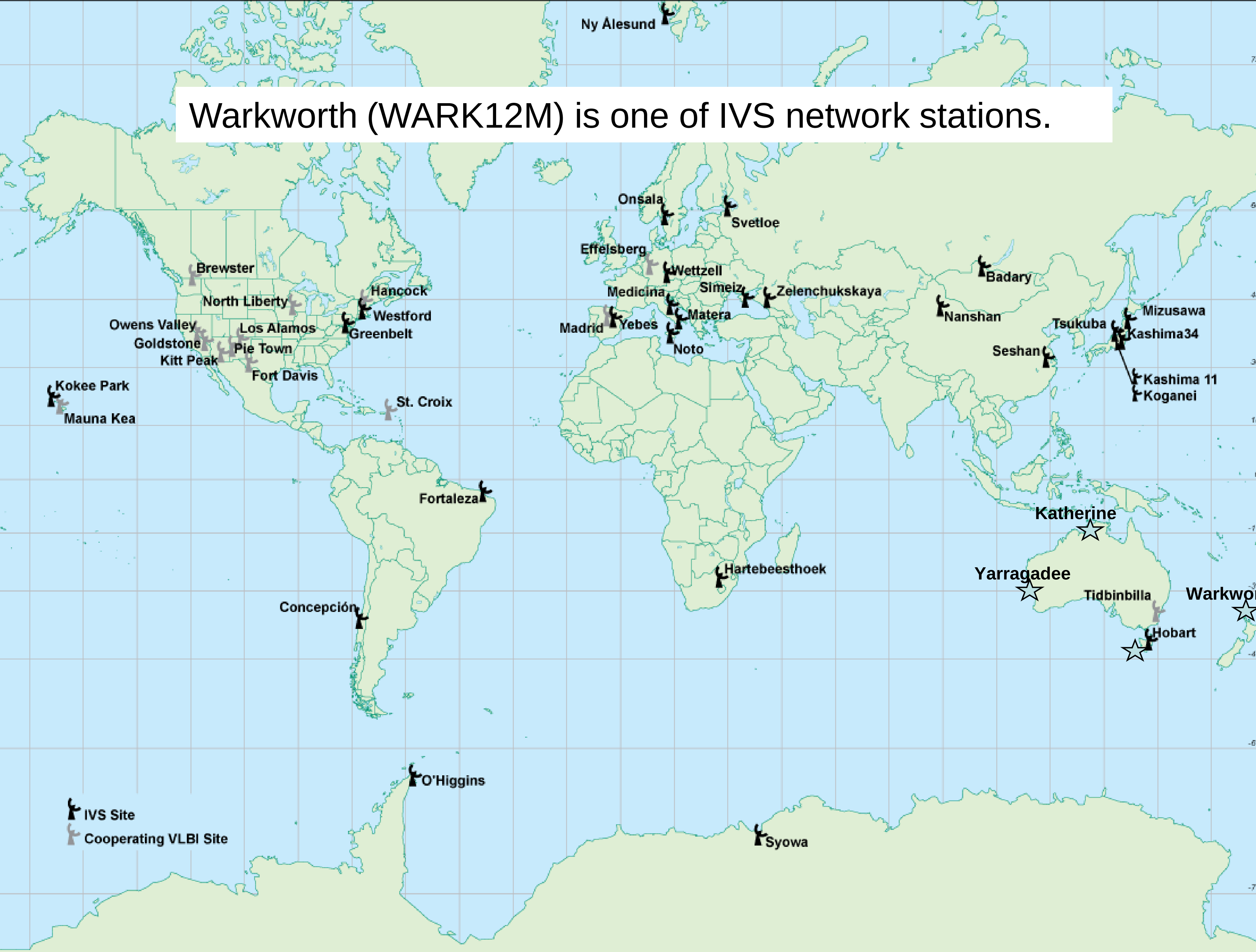


Image credit: Steven Tingay
(see also Tzioumis et al. AJ, 140, 2010)

Warkworth (WARK12M) is one of IVS network stations.



Warkworth (WARK12M) is one of IVS network stations. And the only station in NZ that has more than one geodetic techniques

positioNZ

PositioNZ is LINZ's Global Positioning System Active Control Network. Through this site you c download GPS 30 second RINEX files from the active control stations which you can use with r GPS station data to determine precise positions in terms of New Zealand Geodetic Datum 200 ....

PositioNZ-RT – real-time data streams

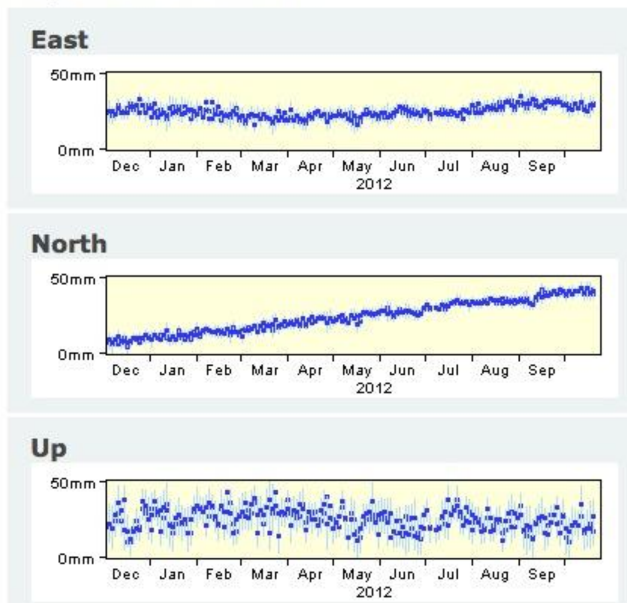
Find out how to access real-time data from PositioNZ stations. more...

Text only version

PositioNZ stations | Velocity Model | Download data

Details | Timeseries | Availability | Photo

Daily solutions for WARK



WARK is one of three NZ IGS stations, and the only one that operates all available GNSS systems

GPS coordinates and Telescope survey

- Determination of VLBI reference point

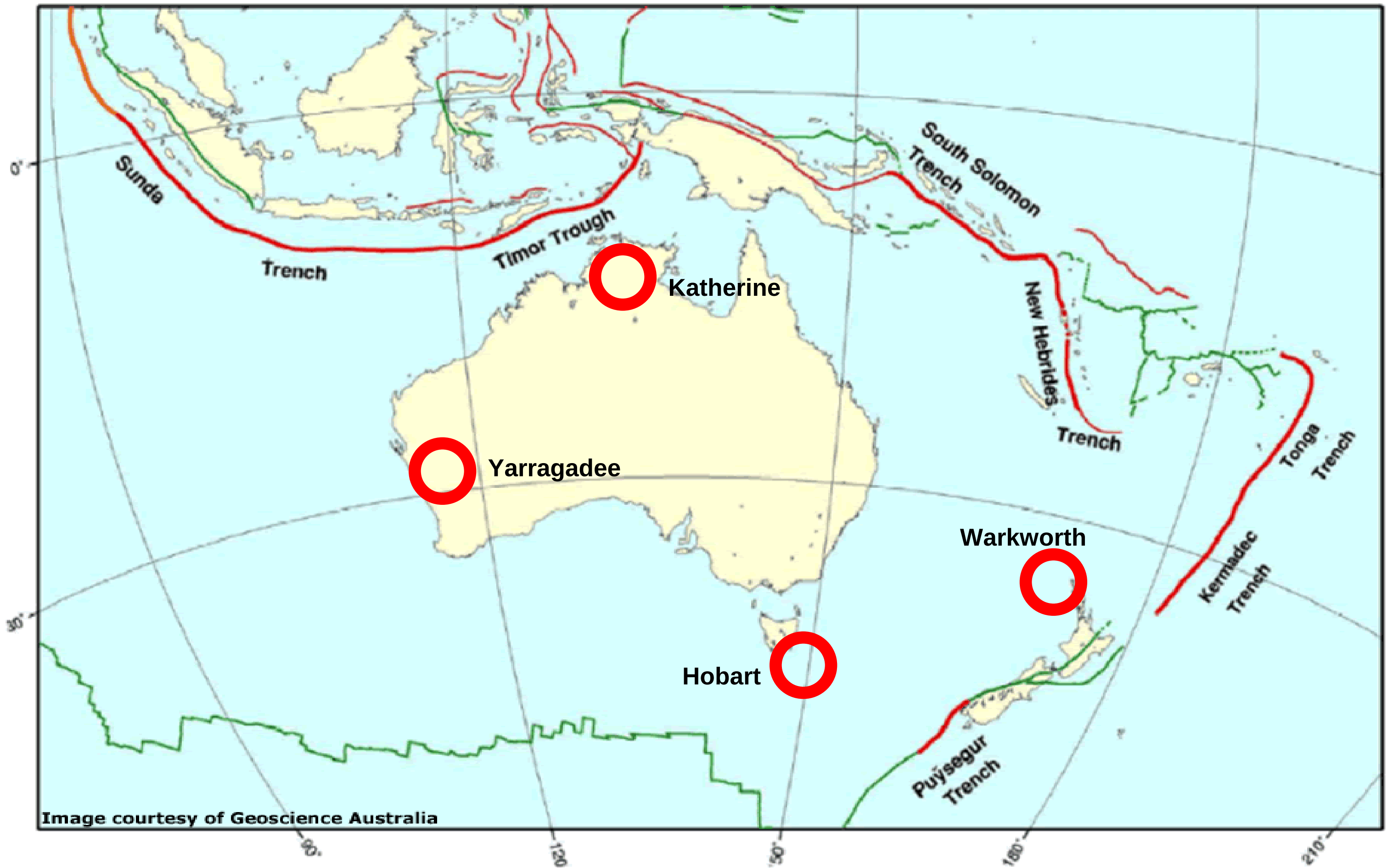
- PositioNZ: WARK
- RTK GPS

X =	−5115324.5	+/−	0.1	m
Y =	477843.3	+/−	0.1	m
Z =	−3767193.0	+/−	0.1	m

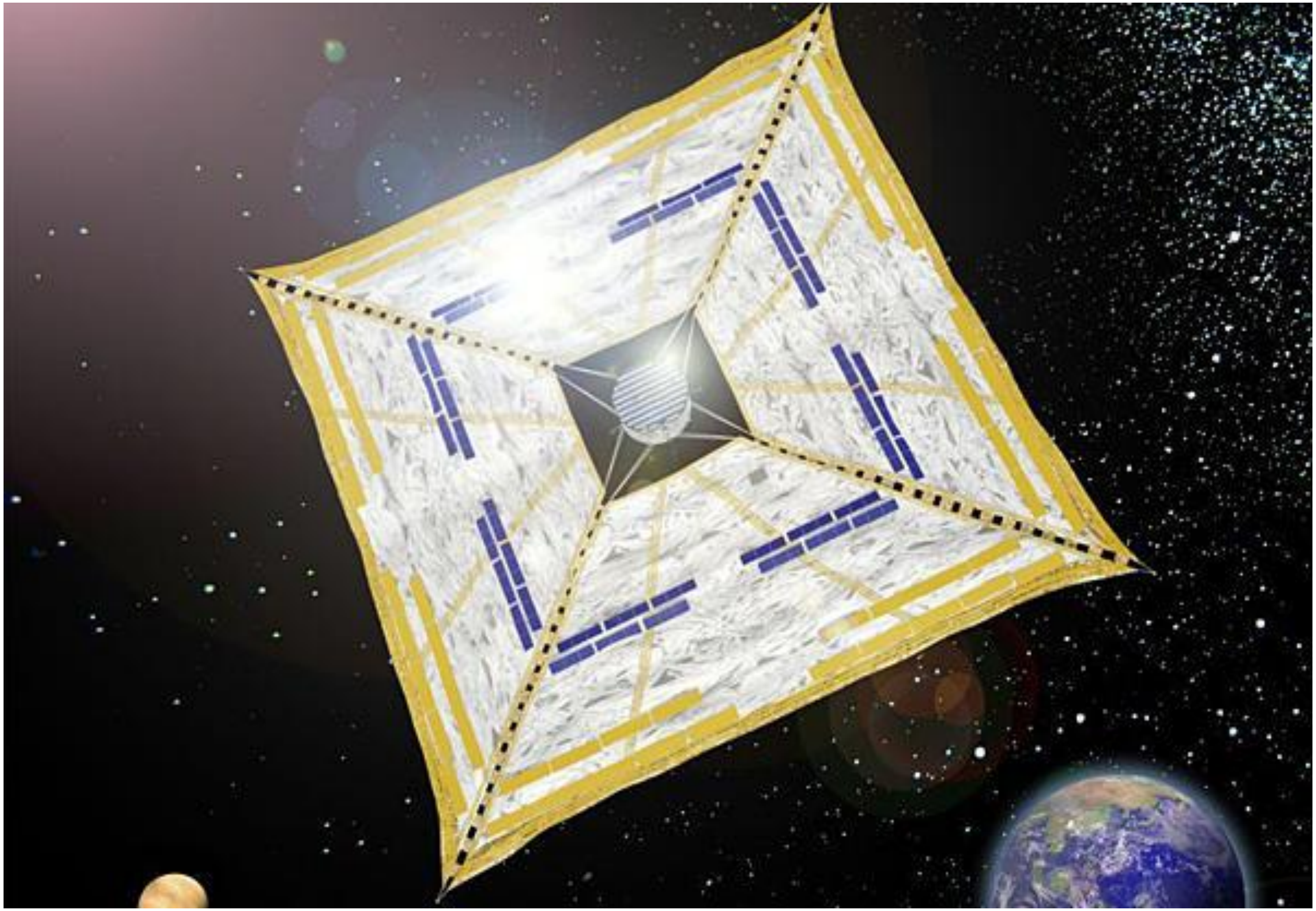
- Local tie survey Dec 2012
- Recent survey - Jan 2015

AuScope

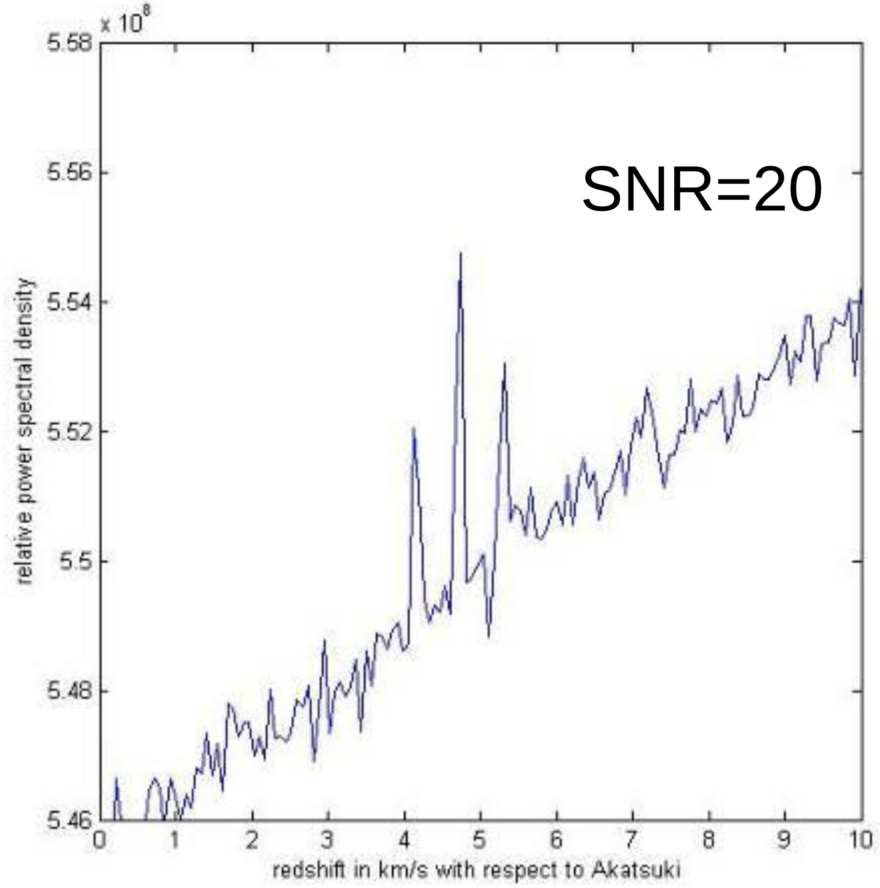
Study of Australian Tectonic Plate deformation



JAXA: IKAROS and Akatsuki



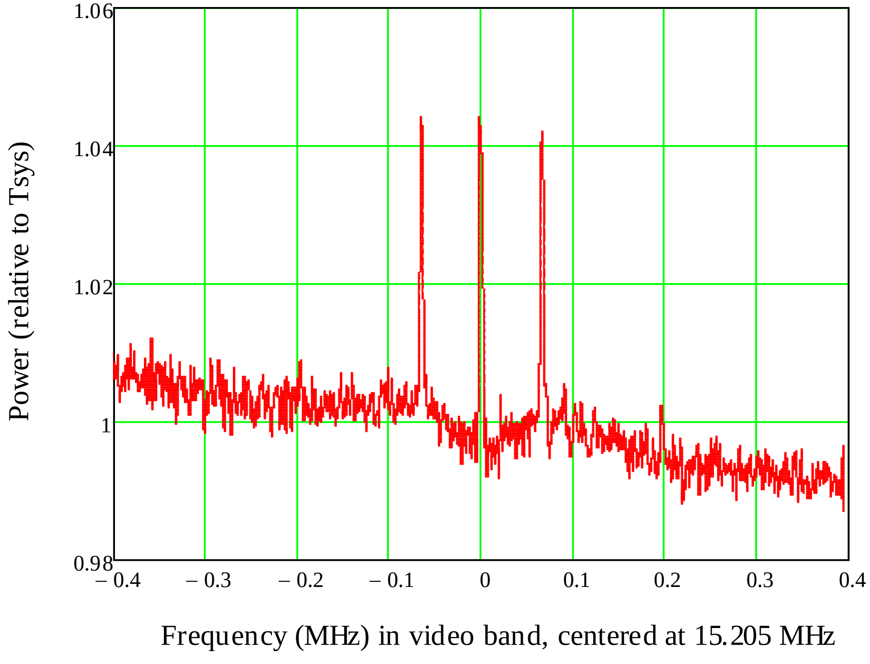
Akatsuki over NZ, August 2010

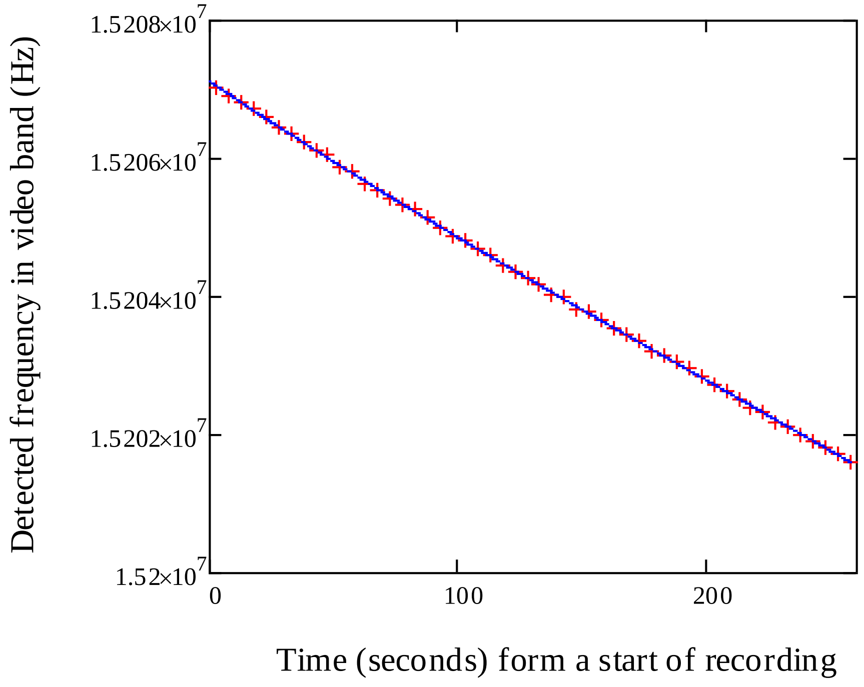


Resolution 1000 Hz, integration 500s

Mars Express over NZ

September 2010





Credit: Guifre Molera

YEAR: 1977
MISSION: VIKING 1 ORBITER
TARGET: MARS / PHOBOS

GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L09202, 4 PP., 2010

Precise mass determination and the nature of Phobos

by T. P. Andert et al.

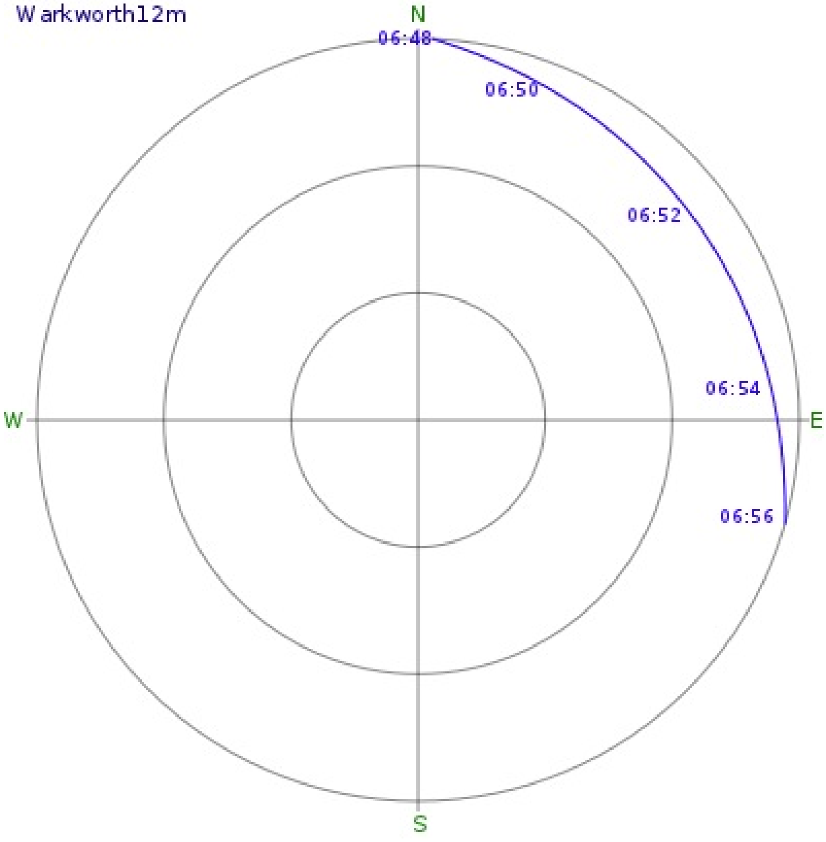
We report independent results from two subgroups of the **Mars Express** Radio Science (MaRS) team who independently analyzed **Mars Express** (MEX) radio tracking data for the purpose of determining consistently the gravitational attraction of the moon Phobos on the MEX spacecraft, and hence the mass of Phobos. New values for the gravitational parameter (GM = $0.7127 \pm 0.0021 \times 10^{-3}$ km^3/s^2) and density of Phobos (1876 ± 20 kg/m^3) provide meaningful new constraints on the corresponding range of the body's porosity ($30\% \pm 5\%$), provide a basis for improved interpretation of the internal structure. We conclude that the interior of Phobos likely contains large voids. When applied to various hypotheses bearing on the origin of Phobos, these results are inconsistent with the proposition that Phobos is a captured asteroid.

SpaceX Tracking

Ground tracking station

- Used SpaceX supplied TLE and files to generate ground track for Dragon passes
- Received downlink at 2.2 GHz
  - Flight and operational telemetry
  - Video (as seen on NASA TV)

- Track all passes visible from Warkworth
- Cover Launch, docking with ISS, opening of Dragon capsule
- Re-entry of Dragon
- SNR typically > 40 dB

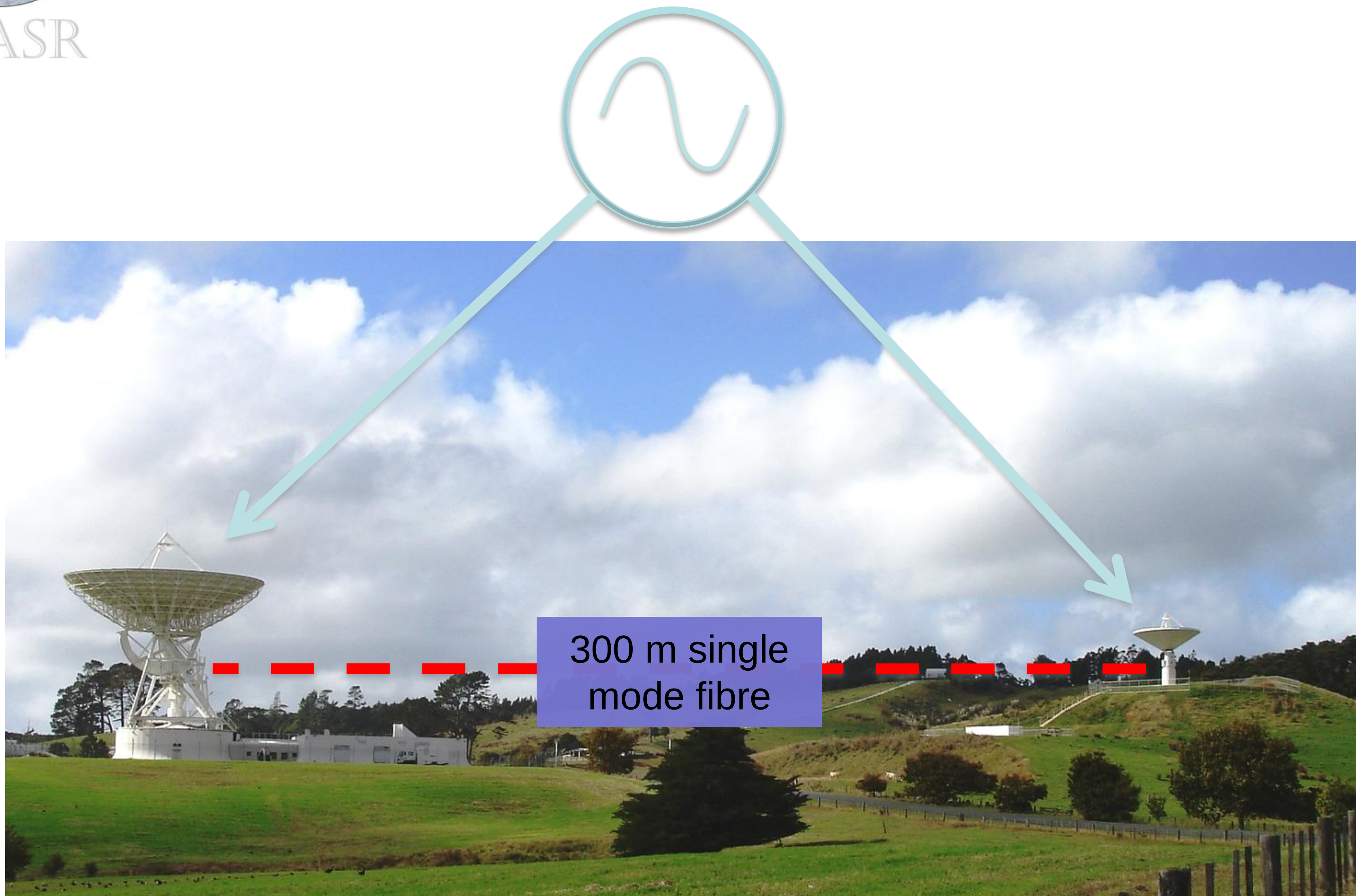



05/31/2012
15:37:46:11

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: <+-0.5 deg.

Frequency Standard distribution



Symmetricom Universal Time and Frequency Distributor

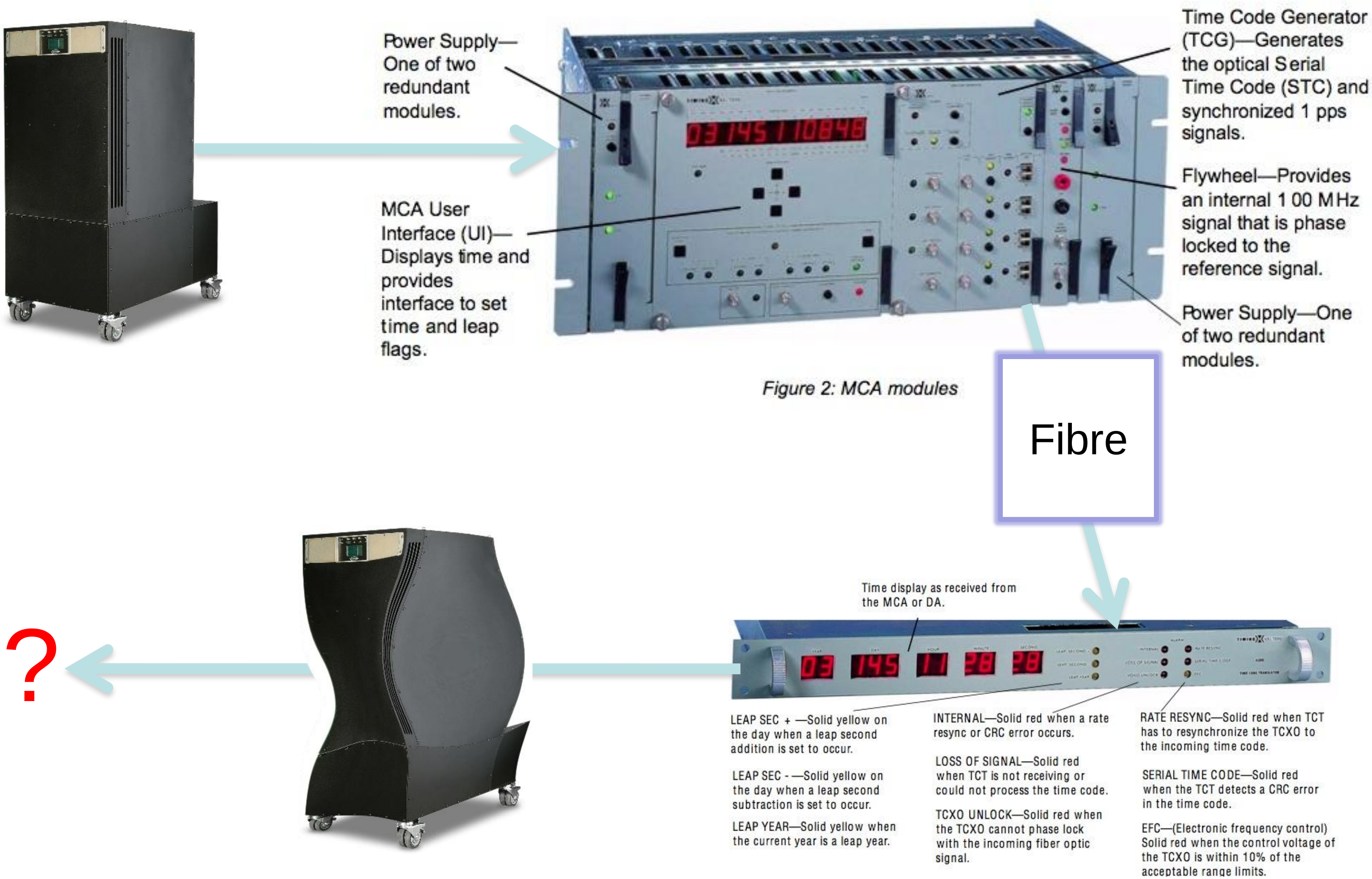
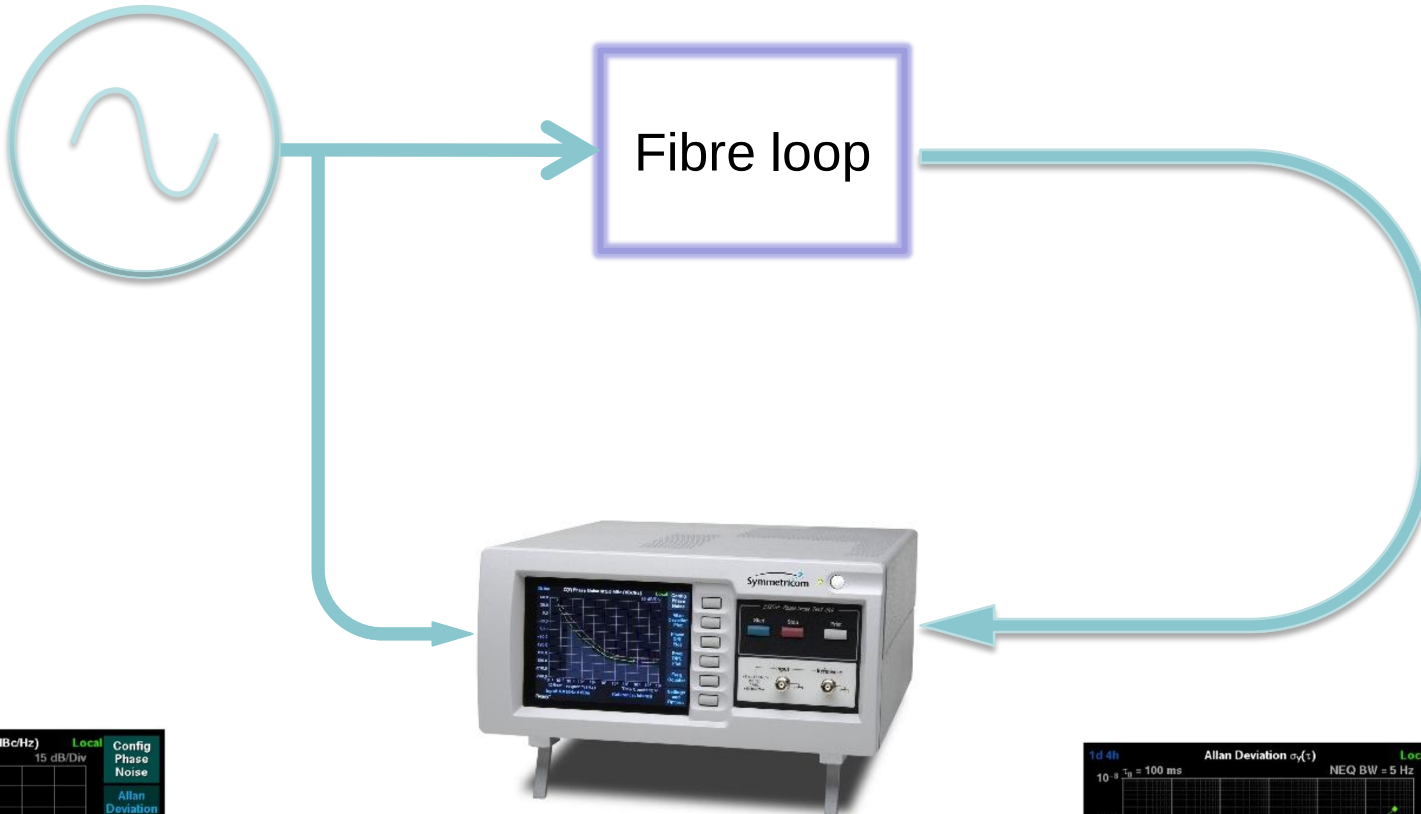
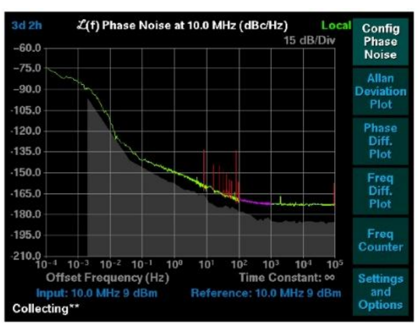


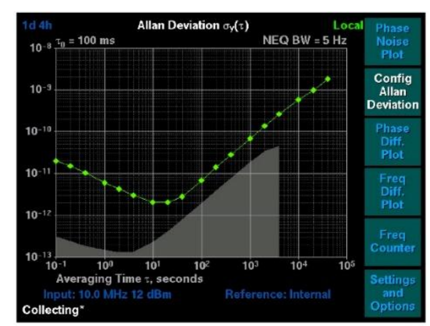
Figure 2: MCA modules

Maser reference distribution testing / performance test

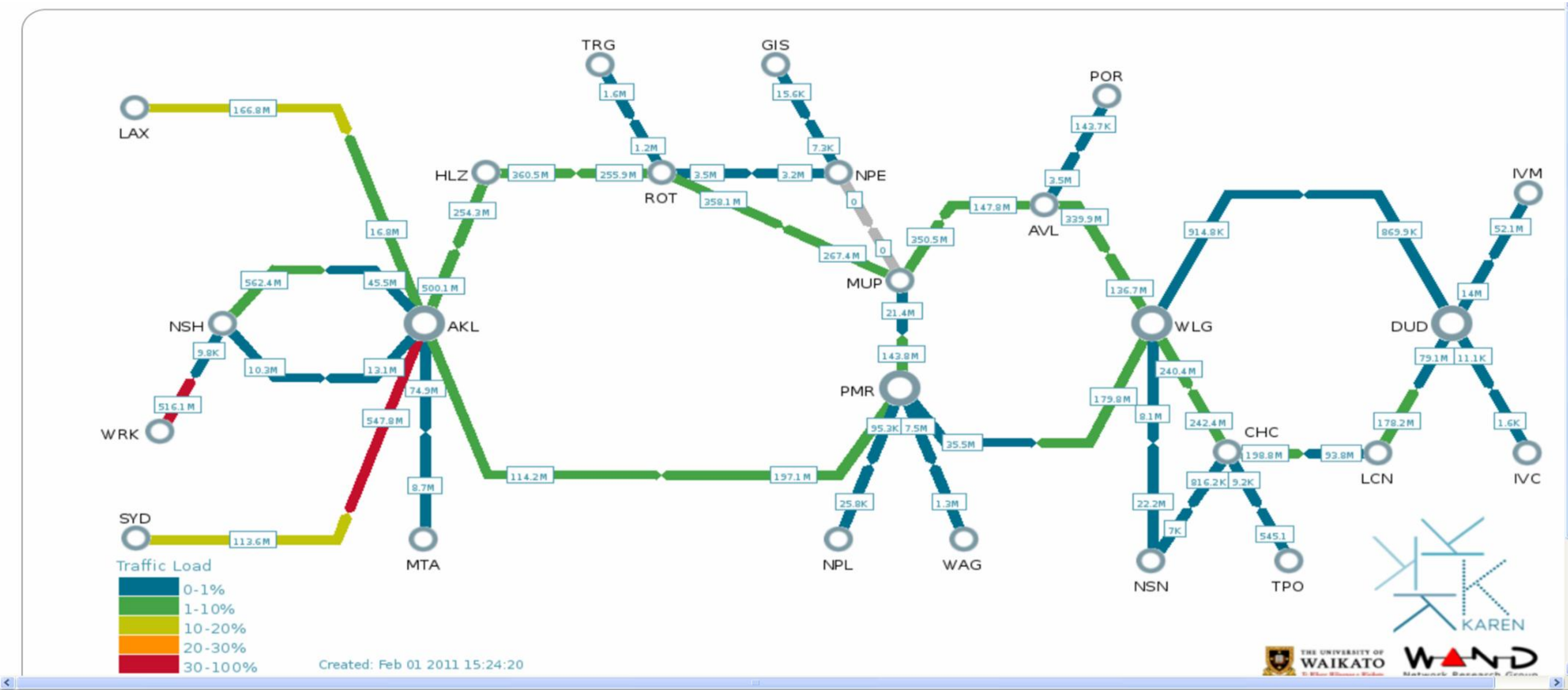




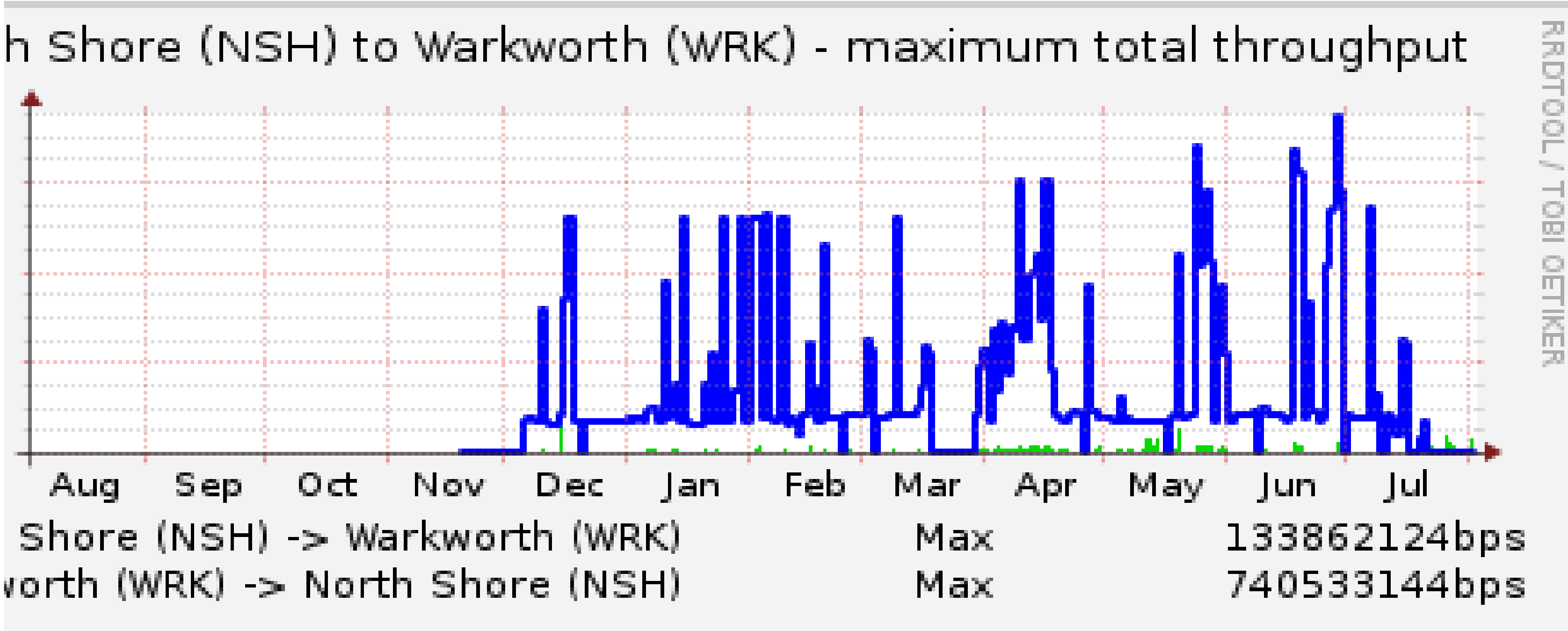
Symmetricom 5115A Phase Noise tester



REANNZ – Research and Education Network



- 10 Gbps backbone linking Universities and Crown research Institutes
- 40 Gbps International connectivity to Australia and US as of Oct 2015



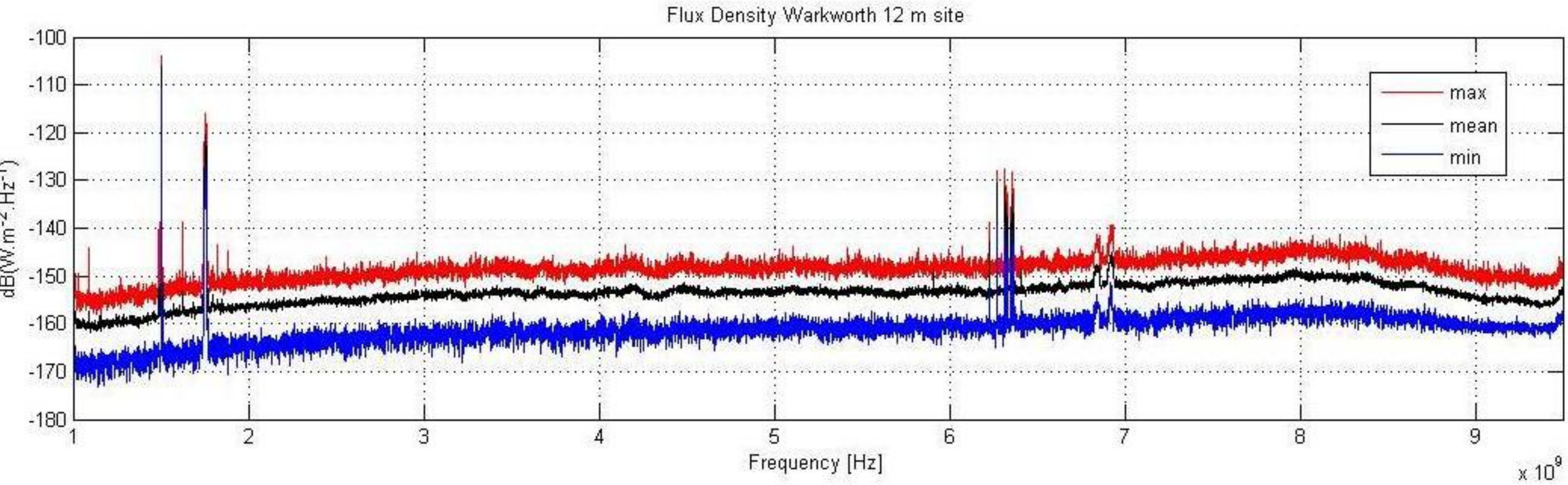
eVLBI, e-transfer via REANNZ has been demonstrated on several occasions.

Maximum data rates of 6.4 Gb/s where achieved from Warkworth for real-time e-transfer.

REANNZ connectivity: timeline

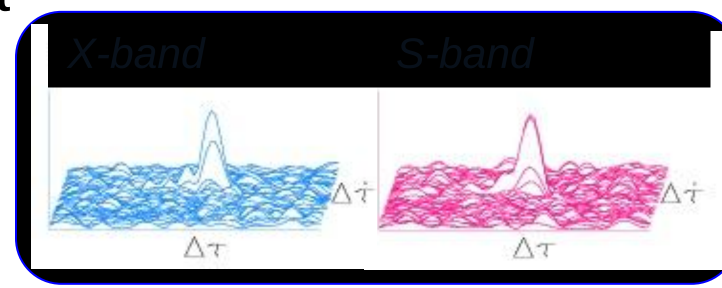
- **2012: 10 Gbps**
- **2014: 40 Gbps**
- **2017: 80 Gbps**
- **2022: 160 Gbps**

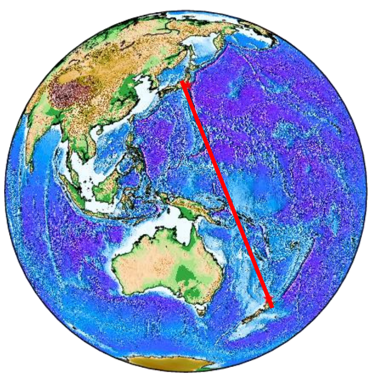
Noise floor measurements



Collaboration with Japan

- Establishment of the geodetic experiment environment
  - Ultra-rapid EOP measurement
  - Experimental Phase_cal thanks to NICT Kashima





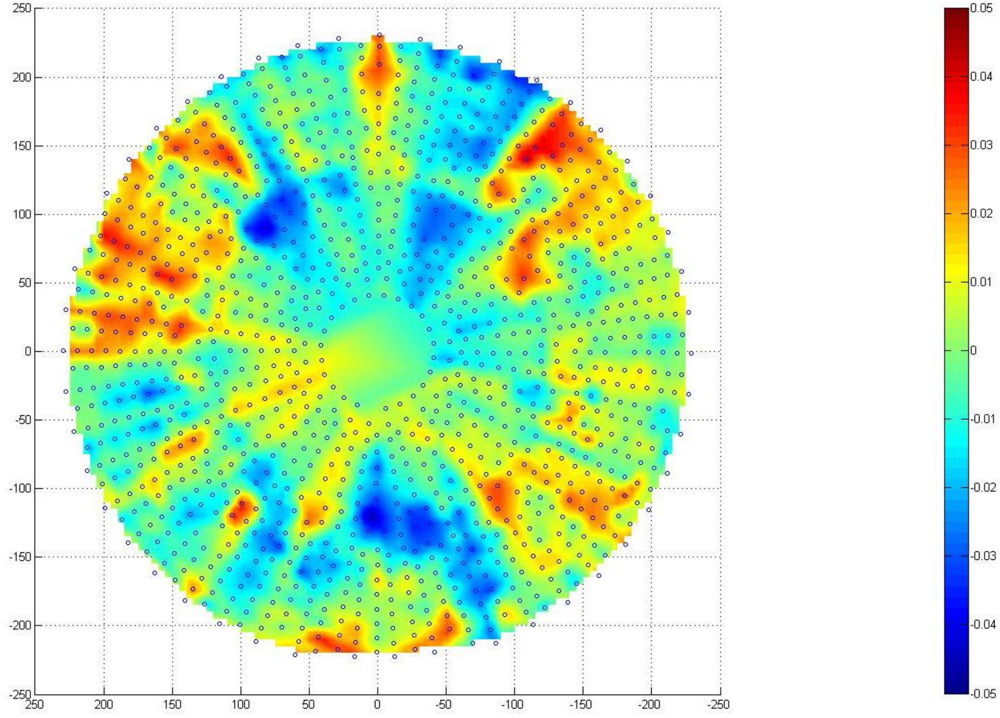
Correlation processing
Bandwidth synthesizing
Data analysis

Baseline length
Ww-Ts 8,105 km
Ww-K1 8,075 km

Ww-K1 (2012/4/17)
8,075.003546 km

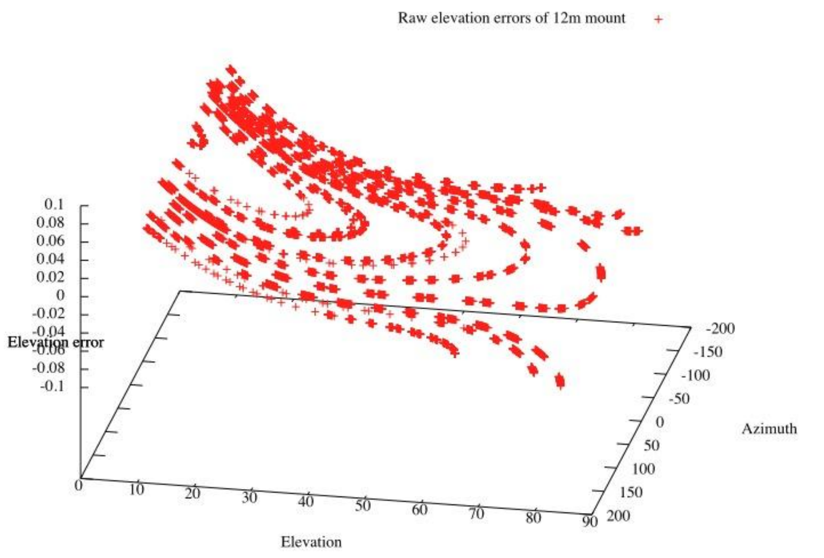
Primary surface alignment

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



Integration of DBBC with Field System

- DBBC digitised channel power measurements fed back to Field System pointing model



- DBBC channel/IF configuration integration with Field System completed
- Thanks to Ed Himwich

Astronomy Major


The Cosmic Noise Expedition