AuScope VLBI Operations Training

Jim Lovell
Updated 14 Dec 2015

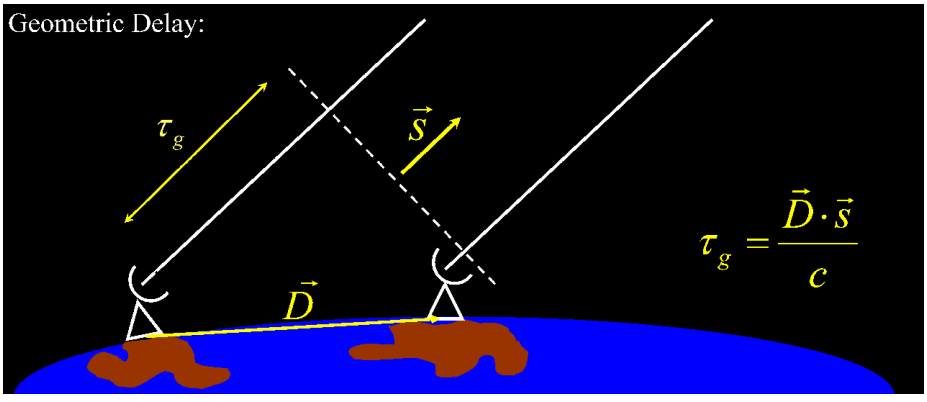
Program

9.30 – 10.30	Introduction
10.30 – 11.00	Coffee
11.00 – 12.30	Setup and observing procedure.

Background 1

- AuScope is a federally funded infrastructure project : "Structure and Evolution of the Australian Continent"
- Geospatial is a component of AuScope. Investment in:
  - three 12-meter radio telescopes and a software correlator
  - about 100 GPS receivers
  - upgrade of existing SLR facilities
  - an absolute gravimeter and three tidal gravimeters
  - improved computing facilities
- AuScope VLBI : auscope.phys.utas.edu.au

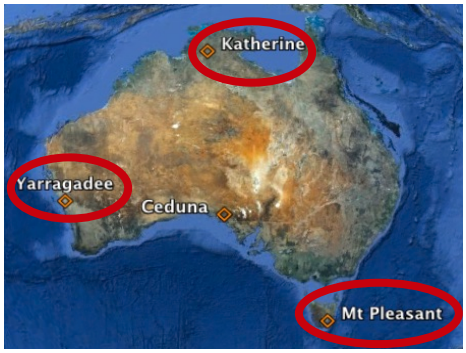
What is Geodesy?



- A Brief History of Geodesy (NASA GSFC)

Background 2: VLBI

- VLBI provides Earth Orientation Parameters (EOP) and ties the inertial Celestial Reference Frame (CRF) to the Terrestrial Reference Frame
- It's the only technique capable of this
- 3 observatories connect new GPS array to the CRF, help address lack of geodetic VLBI sites in the southern hemisphere.
- Built and operated by UTAS



AuScope VLBI and you

- 7 million dollars
- 4 years
- 3 observatories operated remotely
- 1 person in control..... you

Appointment policy for casuals

Appointment policy for AuScope VLBI Array Operators
26 Feb 2014

Priority is given to post-graduate students (Masters and PhD candidates) who intend to be at UTAS for at least six months from date of appointment. This provides an additional source of income for students and also gives them valuable training and experience in the use and operation of radio telescopes. The six month requirement exists given the significant amount of training and experience required for a new appointee to become fully competent. Appointments end when the post-graduate student's candidature finishes.

Others with previous experience in radio astronomy, VLBI operations or closely aligned fields (such as spacecraft tracking) will be considered if they have specially needed skills.

All new appointments are initially for a three month probationary period.

It is expected that all operators will make themselves available to support Australian Long Baseline Array (LBA) observations at Mt Pleasant, Ceduna, Katherine and Yarragadee on an unpaid basis.

Operator Observing shifts

- Experiments usually start ~4 - 5 AM but may be back-to back with other experiments.
- Shift changes at 09.00, 17.00, 23.00 local.
- Schedule prepared by IVS for a full calendar year. Roster done by students (currently Ellen).
- Non-casual staff take care of the day shifts
- You are in charge of the array and the first point of contact during the observations.
- You should be in the control room. It is also possible to run observations from Mt Pleasant if necessary.

Getting help

- The Operations Wiki is your friend
  auscope.phys.utas.edu.au/opswiki

  Feel free to add, update, edit & correct

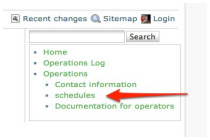
  You'll need an account.
- Nomenclature:
  - Hb = Hobart 12m
  - Ho = Hobart 26m
  - Ke = Katherine 12m
  - Yg = Yarragadee 12m

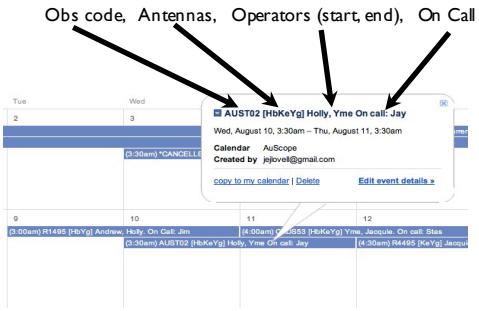
Stuff you should be familiar with

- Windows and Linux/UNIX environment
- Linux:
  - vi and emacs editors
  - Unix shell (ls, cd, cp, mv, ps, cat, less, grep, find, kill, df, sed, awk, ssh, sudo)

Schedules, Rosters

- Available from wiki
- Link to IVS Master schedule
- Google calendar with roster and on-call allocations. You should be able to edit it
- Please advise if you're going to be away, any times you can't observe. There's a calendar and a wiki page for this





On-call person

- For each experiment, someone is scheduled On Call, the first point of contact if there's a problem you can't solve yourself, or if there's anything you don't understand, doesn't look right etc.
- Currently Jim, Jamie, Warren
- Brett for maser-related issues
- Also someone at Ke, Yg to call on in emergencies. Ke and Yg people also do occasional maintenance, change disk modules etc

Operations Room

- You'll need a key & after-hours pass
- Main operations PC is ops2 (6-monitor PC)
- Ops4 for other observations, screen space (e.g. Ceduna, Mt Pleasant 26m, 14m) or if ops2 dies
- Also a Windows PC, PCs for status/public display on walls
- ops-serv2 in rack in 'kitchen' (username observer) for admin, serve shared directories etc.
- "Lounge" with PC (ops6) to echo alarms etc.
- Two phones:
  - x2407, "Admin" desk, next to Ops4. Cordless : take it with you.
  - x7528, "Operator" desk, next to Ops2

Use of Operations Room

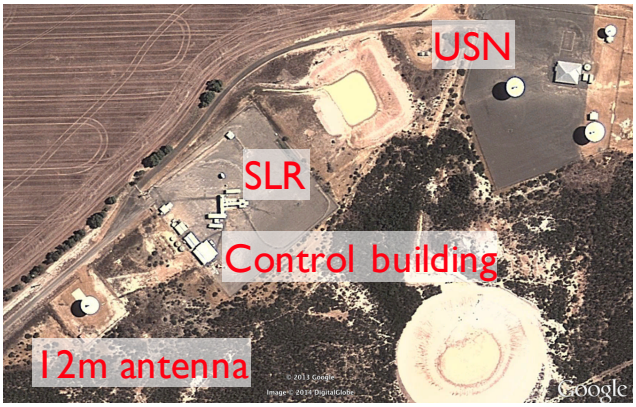
- Please keep kitchen area clean
  - Clean coffee machine after use
  - Replace coffee beans when gone
  - BYO
  - Water in tea room downstairs
- "Lounge"
  - If you use the sheets, take them home and wash them after your shift. Or bring a sleeping bag.

Sites: Hb

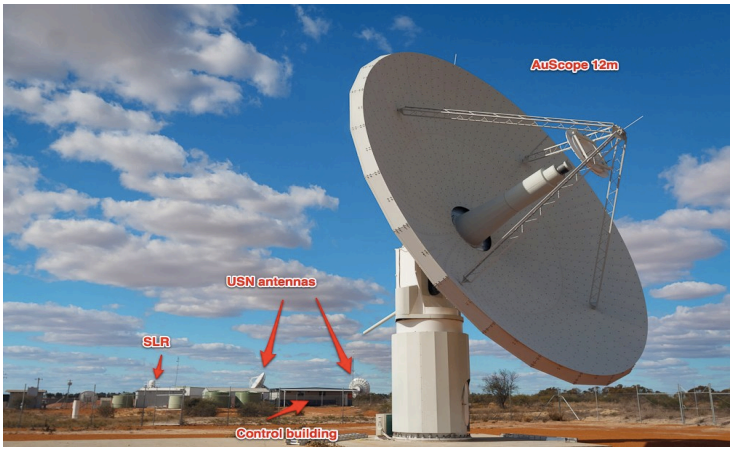
- Same location as Ho (Hobart 26m), 20 km from city
- 1 Gbps fiber

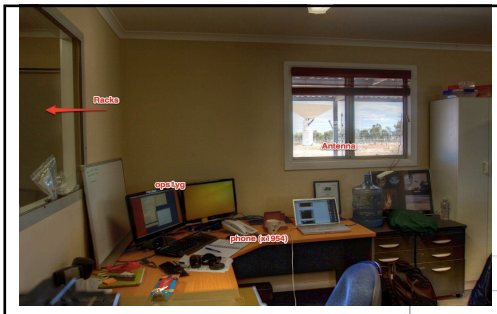
Sites: Yg

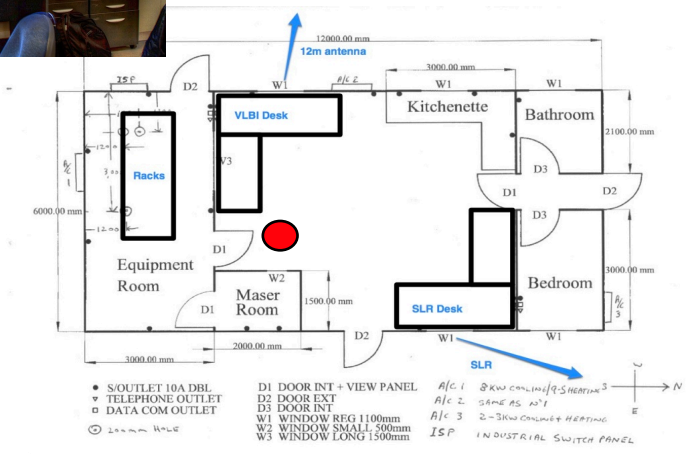
- Co-located with a Satellite Laser Ranging (SLR) facility, operated 24/7. SLR operator is our local contact
- Co-located with Universal Space Network (USN) and NASA tracking facilities



Sites: Yg

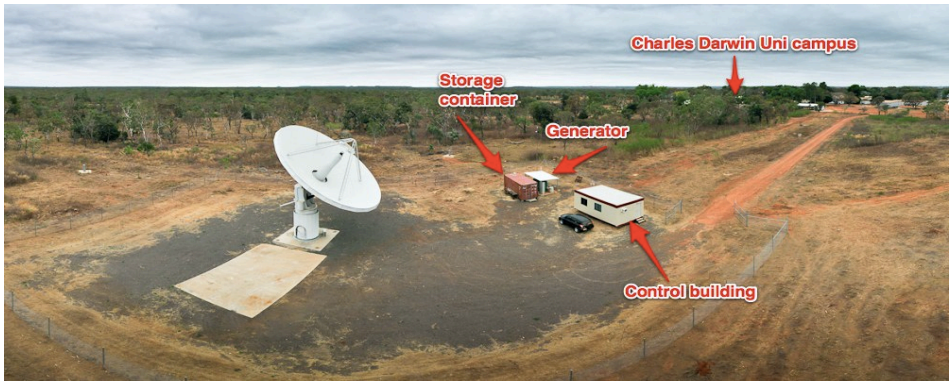

AuScope 12m
USN antennas
SLR
Control building


Racks
Antenna
ops-yg
phone (x954)

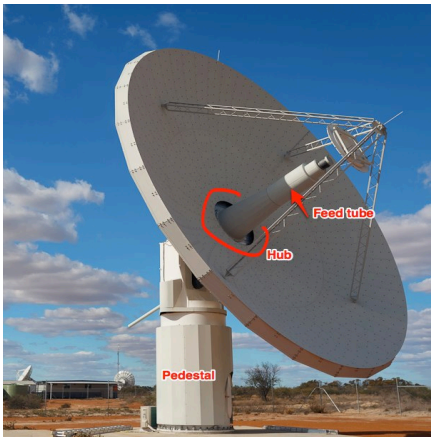

12000.00 mm
12m antenna
3000.00 mm
VLBI Desk
Kitchenette
Bathroom
2100.00 mm
Racks
6000.00 mm
Equipment Room
Maser Room
1500.00 mm
2000.00 mm
3000.00 mm
SLR Desk
Bedroom
SLR
S/OUTLET 10A DBL
TELEPHONE OUTLET
DATA COM OUTLET
D1 DOOR INT + VIEW PANEL
D2 DOOR EXT
D3 DOOR INT
W1 WINDOW REG 1100mm
W2 WINDOW SMALL 500mm
W3 WINDOW LONG 1500mm
A/C 1 8KW COOLING/9·5KW HEATING
A/C 2 SAME AS A/C 1
A/C 3 2·3KW COOLING & HEATING
ISP INDUSTRIAL SWITCH PANEL

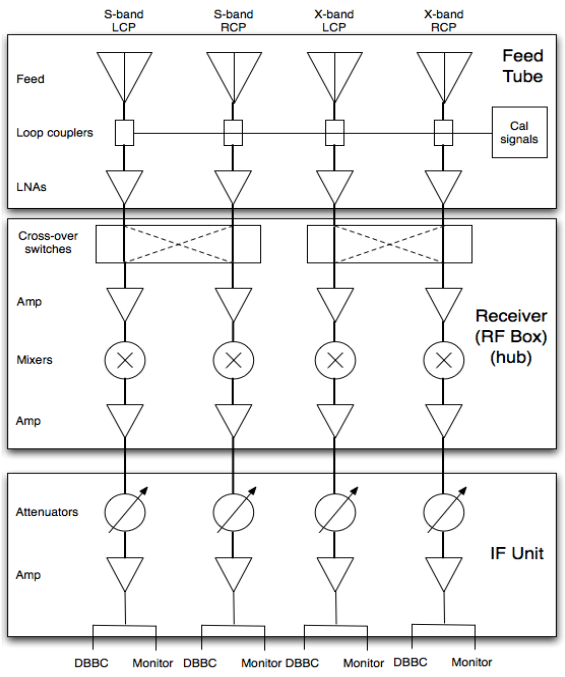
Sites: Ke

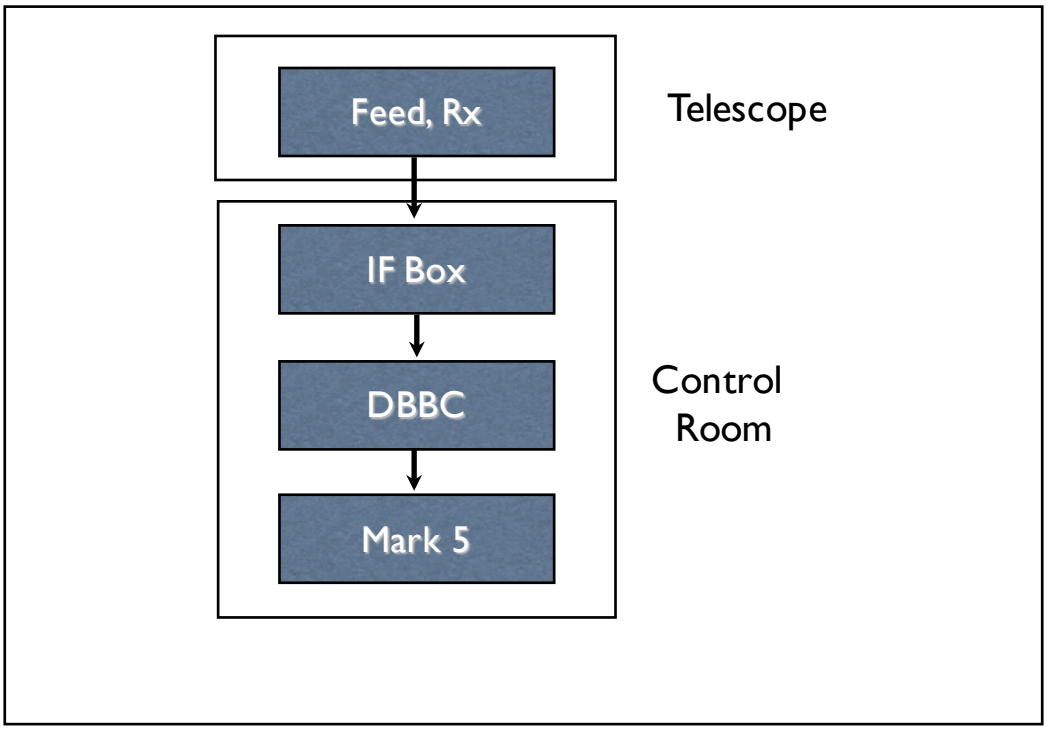
- Co-located with Charles Darwin Uni rural campus, 16km north of Katherine township
- Local contact is Martin Ephgrave

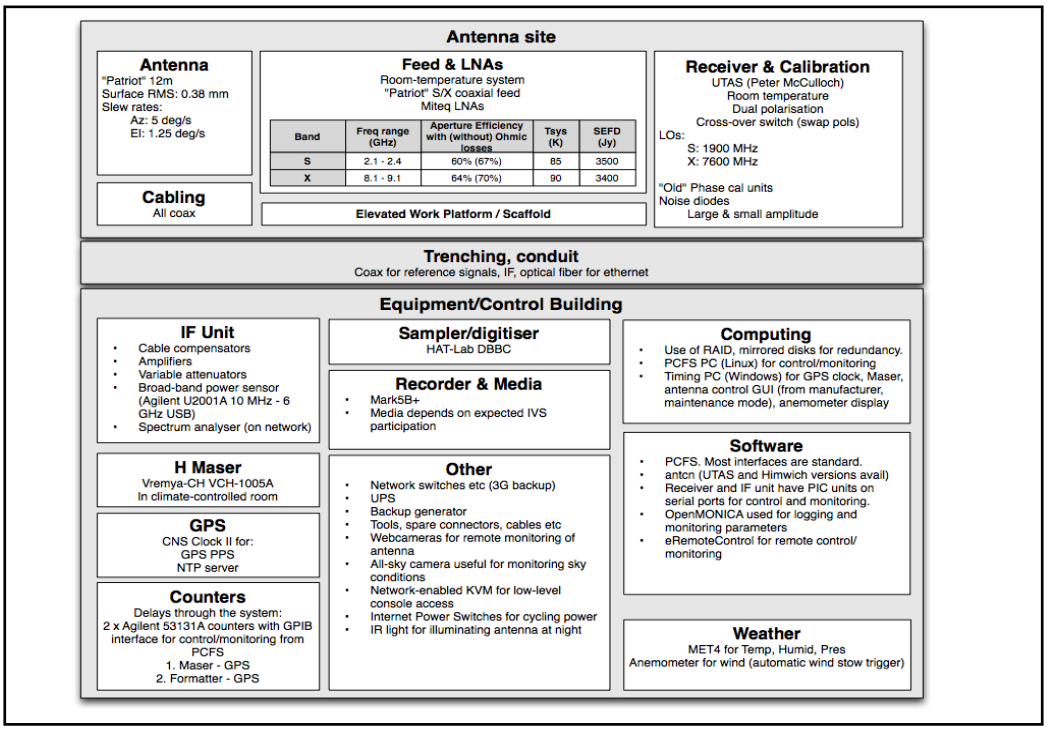


Signal Path and equipment






Feed, Rx
IF Box
DBBC
Mark 5
Telescope
Control Room

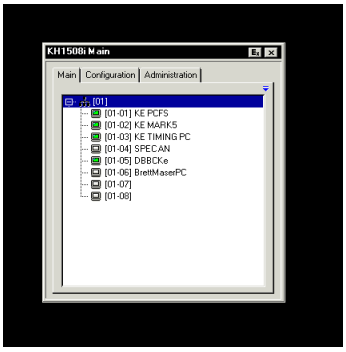

Antenna site
Antenna
"Patriot" 12m
Surface RMS: 0.38 mm
Slew rates:
Az: 5 deg/s
El: 1.25 deg/s
Cabling
All coax
Feed & LNAs
Room-temperature system
"Patriot" S/X coaxial feed
Miteq LNAs
Band | Freq range (GHz) | Aperture Efficiency with (without) Ohmic losses | Tsys (K) | SEFD (Jy)
S | 2.1 - 2.4 | 60% (67%) | 85 | 3500
X | 8.1 - 9.1 | 64% (70%) | 90 | 3400
Elevated Work Platform / Scaffold
Receiver & Calibration
UTAS (Peter McCulloch)
Room temperature
Dual polarisation
Cross-over switch (swap pols)
LOs:
S: 1900 MHz
X: 7600 MHz
"Old" Phase cal units
Noise diodes
Large & small amplitude
Trenching, conduit
Coax for reference signals, IF, optical fiber for ethernet
Equipment/Control Building
IF Unit
Cable compensators
Amplifiers
Variable attenuators
Broad-band power sensor (Agilent U2001A 10 MHz - 6 GHz USB)
Spectrum analyser (on network)
H Maser
Vremya-CH VCH-1005A
In climate-controlled room
GPS
CNS Clock II for:
GPS PPS
NTP server
Counters
Delays through the system:
2 x Agilent 53131A counters with GPIB interface for control/monitoring from PCFS
1. Maser - GPS
2. Formatter - GPS
Sampler/digitiser
HAT-Lab DBBC
Recorder & Media
Mark5B+
Media depends on expected IVS participation
Other
Network switches etc (3G backup)
UPS
Backup generator
Tools, spare connectors, cables etc
Webcameras for remote monitoring of antenna
All-sky camera useful for monitoring sky conditions
Network-enabled KVM for low-level console access
Internet Power Switches for cycling power
IR light for illuminating antenna at night
Computing
Use of RAID, mirrored disks for redundancy.
PCFS PC (Linux) for control/monitoring
Timing PC (Windows) for GPS clock, Maser, antenna control GUI (from manufacturer, maintenance mode), anemometer display
Software
PCFS. Most interfaces are standard.
antcn (UTAS and Himwich versions avail)
Receiver and IF unit have PIC units on serial ports for control and monitoring.
OpenMONICA used for logging and monitoring parameters
eRemoteControl for remote control/ monitoring
Weather
MET4 for Temp, Humid, Pres
Anemometer for wind (automatic wind stow trigger)

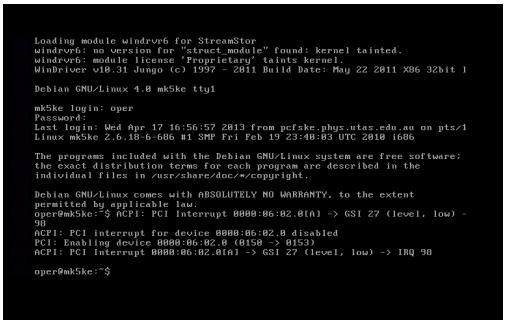
Network

- Hb: good fiber (AARNET) connection
- Yg:
  - microwave link to nearby town
  - backup 3G connection
- Ke:
  - ~1 Mbps fiber
  - 3G backup

Networked KVM

Console-level (keyboard, mouse) access over the network.

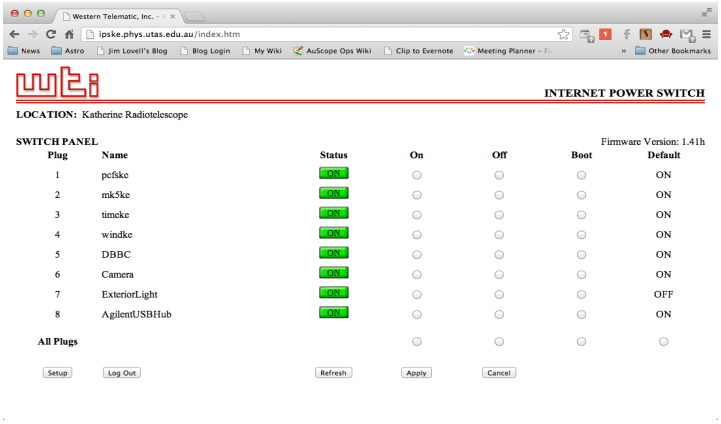




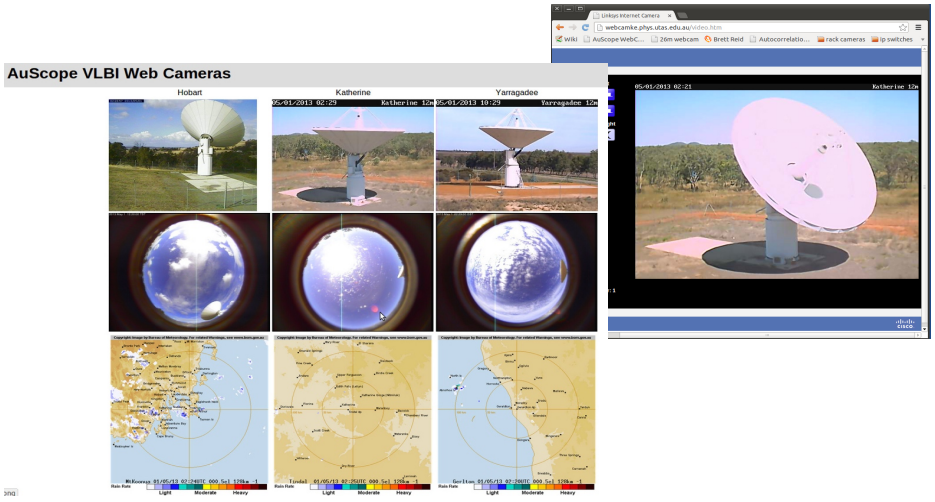
UPS

- Uninterruptible Power Supplies
- Diesel generator

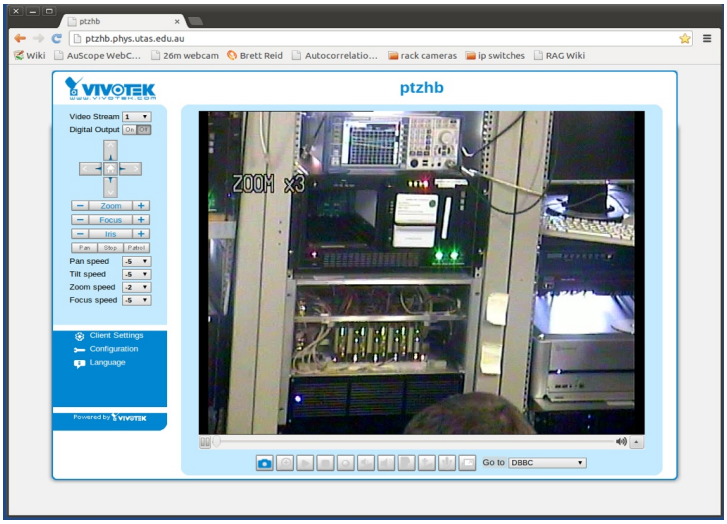
Internet Power Switch



Cameras



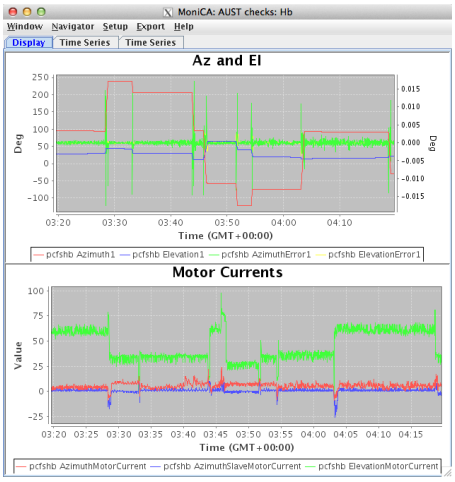
- Webcam web page plus (internal network) live view
- Linux compatibility a good idea



- PTZ (Pan, Tilt, Zoom) camera in control room

Monitor Points

- Most of the analogue interfaces are provided by PICAXE-based devices which are interfaced to Monica via simple TCP servers.



Important parts and what they do

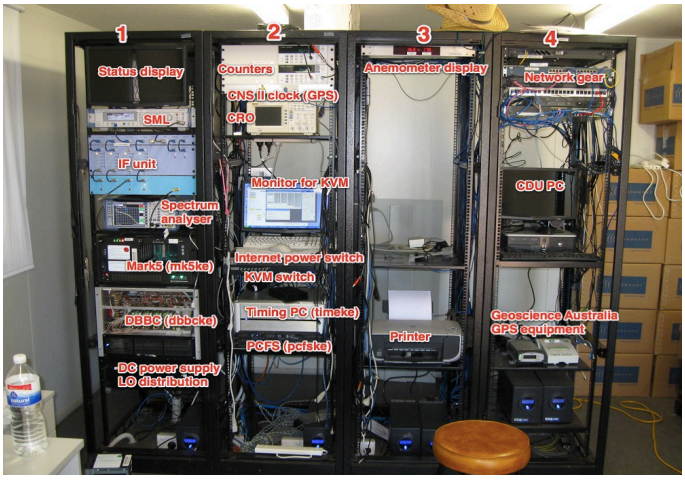
- Hydrogen Maser. Ultra-precise time and frequency standard
- GPS clock. Provides UT and comparison with maser PPS (pulse per second)
- RF (Radio Frequency) Unit or Receiver. Down-converts signal from sky frequencies to IF.
- IF (Intermediate Frequency) Unit. Signal conditioning, filtering, monitoring, splitting
- DBBC. Digital Base-Band Converter. Analog to Digital stage. Splits signal into 16 x 8 (or 4 or 16) MHz sub-bands and digitises for recording. Also used for measuring Tsys (System Temperature).
- Mark5B+ recorder. Records data from DBBC

Racks

- Numbered the same at Ke, Yg with same equipment in each
- Hb numbered and arranged differently

Yg racks

Ke racks

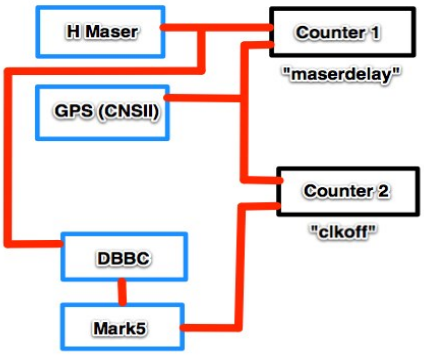


Hb racks

Timing

- "maserdelay" measures difference between maser and GPS 1PPS. Used by correlator to find initial solution. A good quick monitor of Maser stability.
- "clkoff" measures delay through signal path. A good diagnostic of DBBC and Mark5 stability.
- Difference between the two should be constant and ~ 0.300 us
- Log monitor calculates the difference and rings an alarm if it detects a problem. Usually the DBBC needs attention.
- The program *fmset* is used to synch the Mark5 to the 1PPS from the DBBC. This should only be needed once during setup unless there's a timing problem (DBBC failure, clock jump). Avoid re-synching after a start unless the delay is unstable or gets too big (few us).
- Note, in PCFS, "formatter" = "Mark5".

1 PPS distribution



Computers

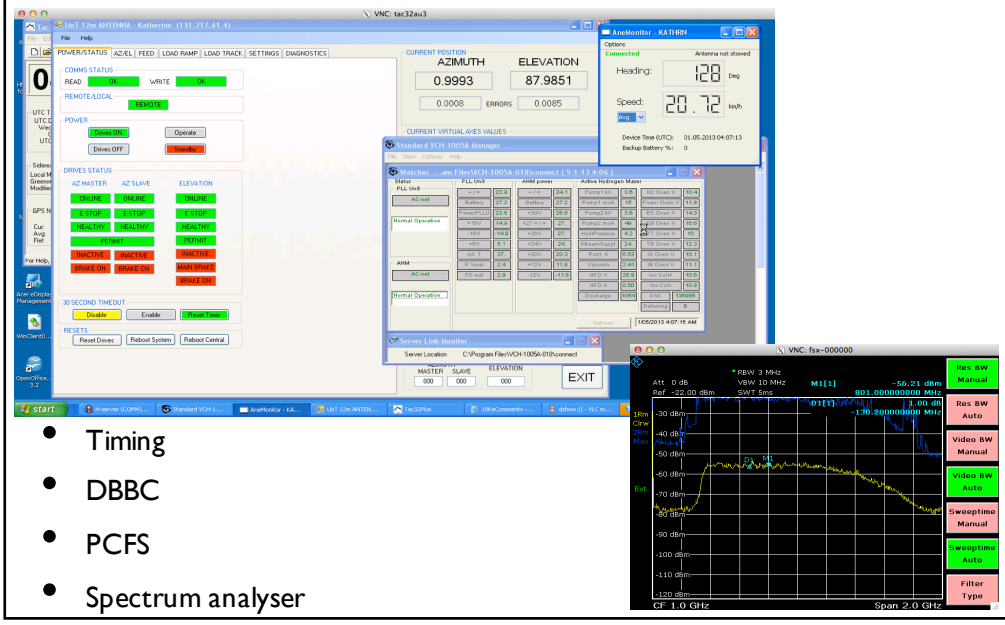
Type	Function	Computer Name			Access with...
		Hobart	Katherine	Yarragadee	
PC Field System	Linux PC that runs Field System software to control the antenna, DBBC and Mark5	pcfshb	pcfske	pcfsyg	ssh, VNC (display 1)
Mark5 recorder	A Linux PC inside the Mark5 recorder which runs dimino, a program the PCFS communicates with to control data recording	mk5hb	mk5ke	mk5yg	ssh
Timing PC	Windows PC that monitors the H maser, the CNS-II GPS clock, shows the wind speed and direction, and runs HMI: a GUI for controlling and monitoring the antenna	timehb	timeke	timeyg	VNC display 0
DBBC	A Windows PC in the DBBC which runs a server (and optionally a client) program to allow control and monitoring of the DBBC	dbbchb	dbbcke	dbbcyg	VNC display 0

- User account is "observer" on all PCs except pcfs and mk5 where it's "oper" and DBBC where user = dbbc, password =
- Password is the same everywhere except the DBBC :
- Root password is:
- Other accounts:
  - Telescope webcam: webcamXX : observer : standard
  - Control room cameras: ptzXX : admin : standard
  - Internet Power Switches : ipsXX : admin : root password
  - KVM switches (java client) : kvmXX : administrator : standard
- Proxy. Use your UTAS account or user=jamies1, password=

Software

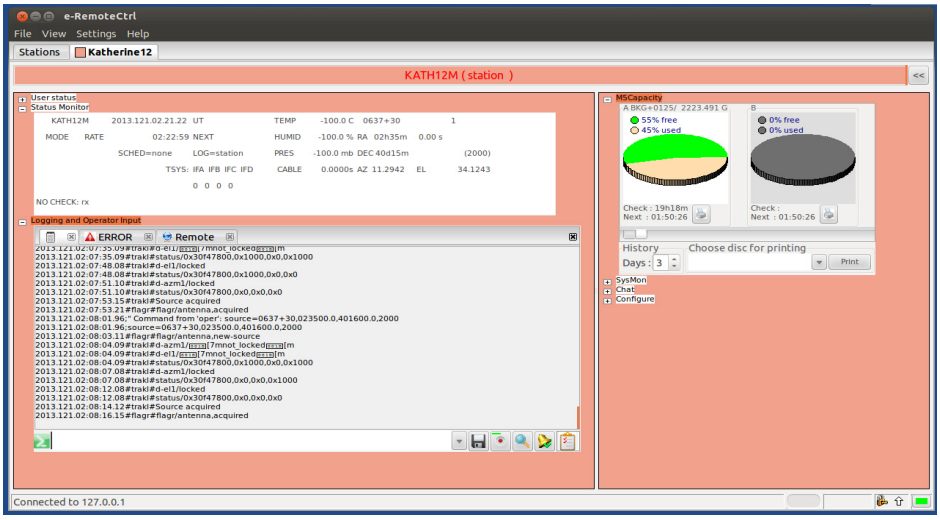
- Central repository of software on a server in Operations Room.
- We use Git for software distribution, version control

VNC



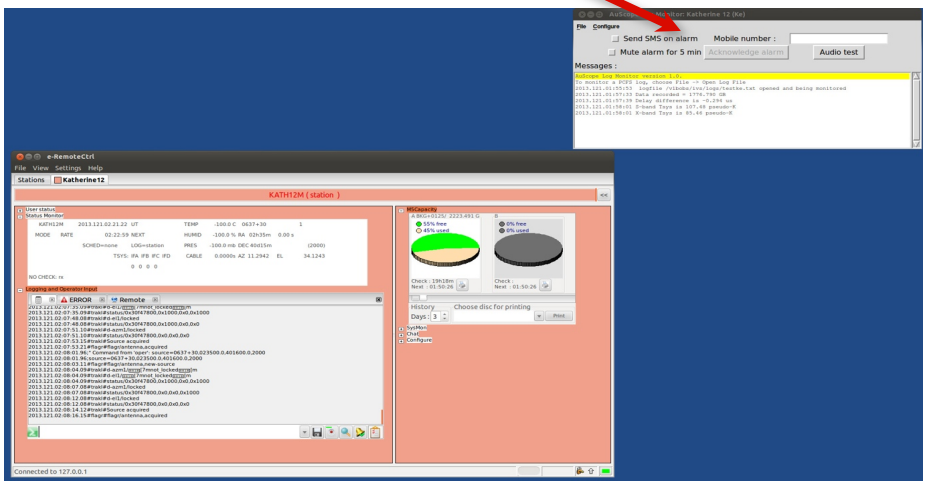
- Timing
- DBBC
- PCFS
- Spectrum analyser

e-RemoteCtrl

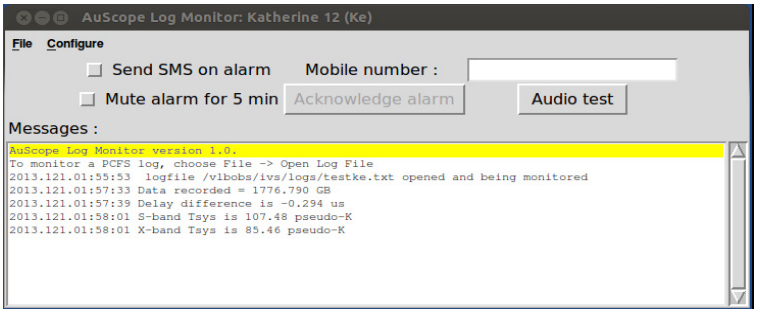


eRemoteControl and log monitoring

Monitors log, rings warnings, alarms, can send text messages, based on error

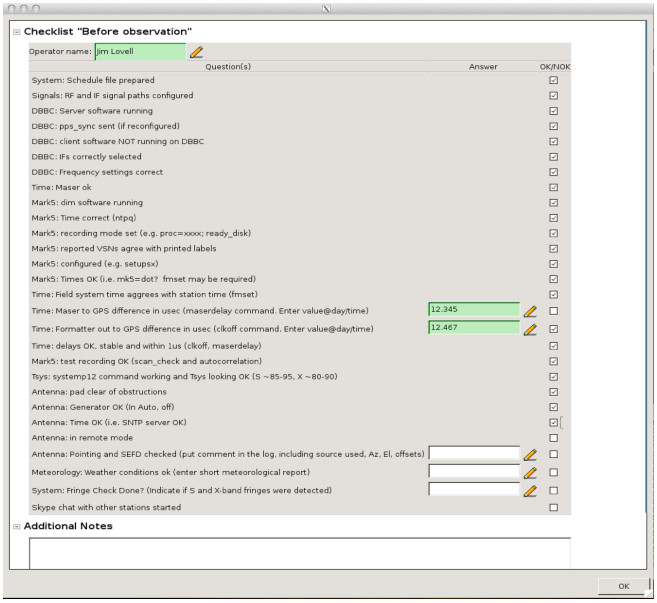


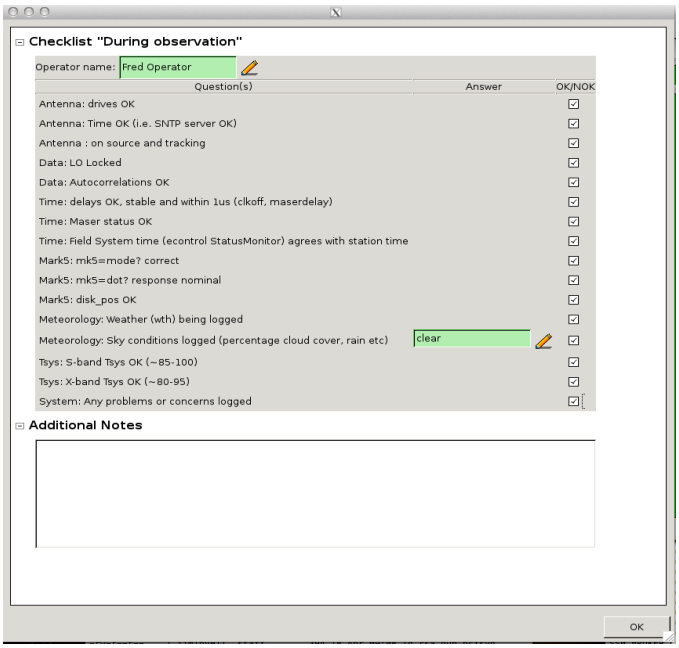
Log monitor

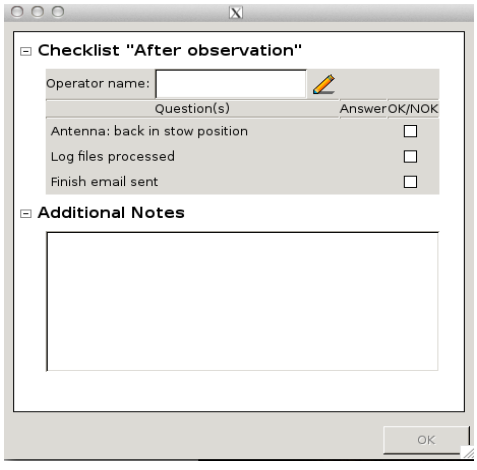


Checklists

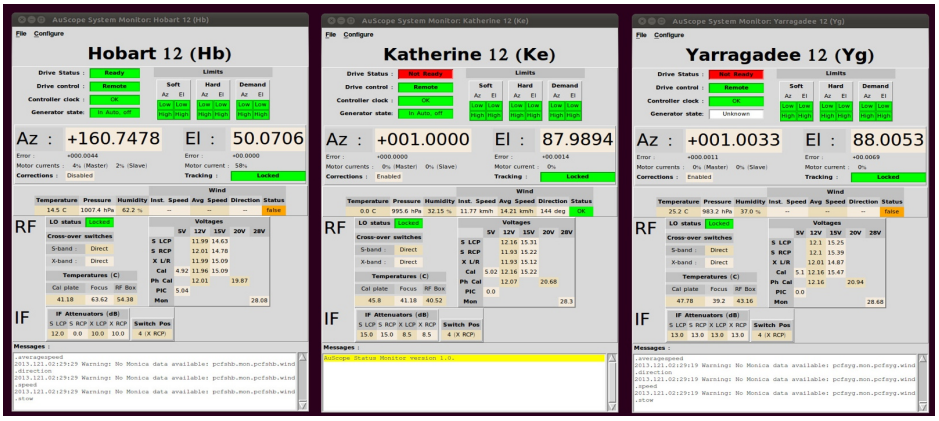
- Part of e-RemoteCtrl
- One per station, configurable



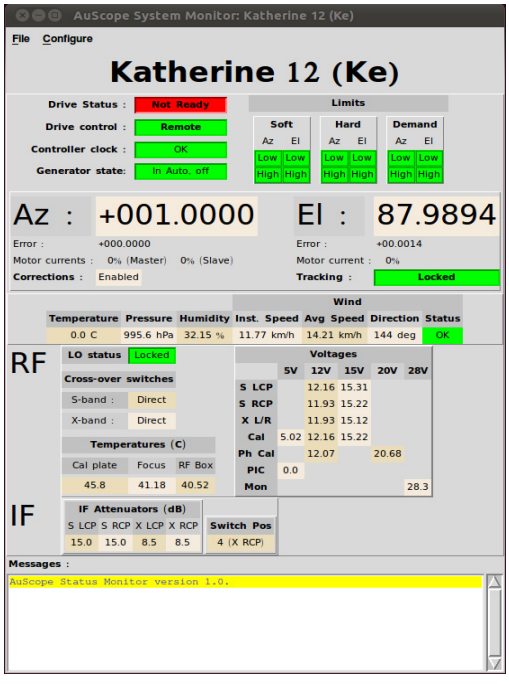

Checklist "During observation"
Operator name: Fred Operator
Question(s)
Answer
OK/NOK
Antenna: drives OK
Antenna: Time OK (i.e. SNTP server OK)
Antenna : on source and tracking
Data: LO Locked
Data: Autocorrelations OK
Time: delays OK, stable and within 1us (clkoff, maserdelay)
Time: Maser status OK
Time: Field System time (econtrol StatusMonitor) agrees with station time
Mark5: mk5=mode? correct
Mark5: mk5=dot? response nominal
Mark5: disk_pos OK
Meteorology: Weather (wth) being logged
Meteorology: Sky conditions logged (percentage cloud cover, rain etc)
clear
Tsys: S-band Tsys OK (~85-100)
Tsys: X-band Tsys OK (~80-95)
System: Any problems or concerns logged
Additional Notes
OK


Checklist "After observation"
Operator name:
Question(s)
Answer
OK/NOK
Antenna: back in stow position
Log files processed
Finish email sent
Additional Notes
OK

System Monitor

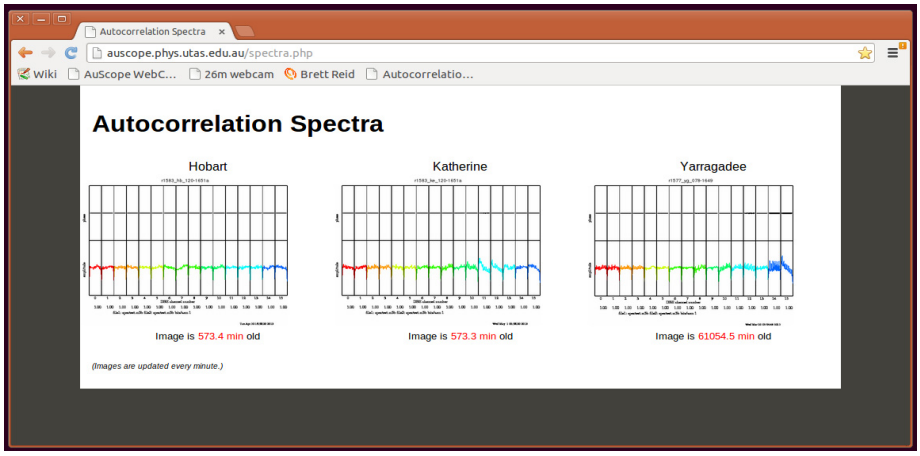


- One-page summary based on MONICA data



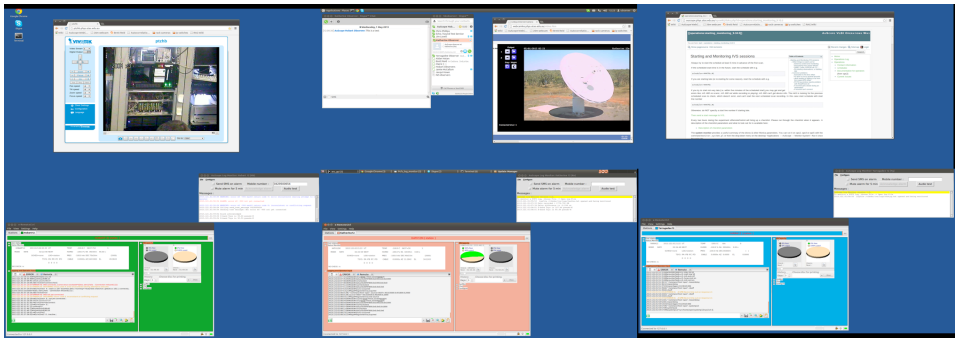
This system monitor uses data from the Monica server

Autocorrelation plots

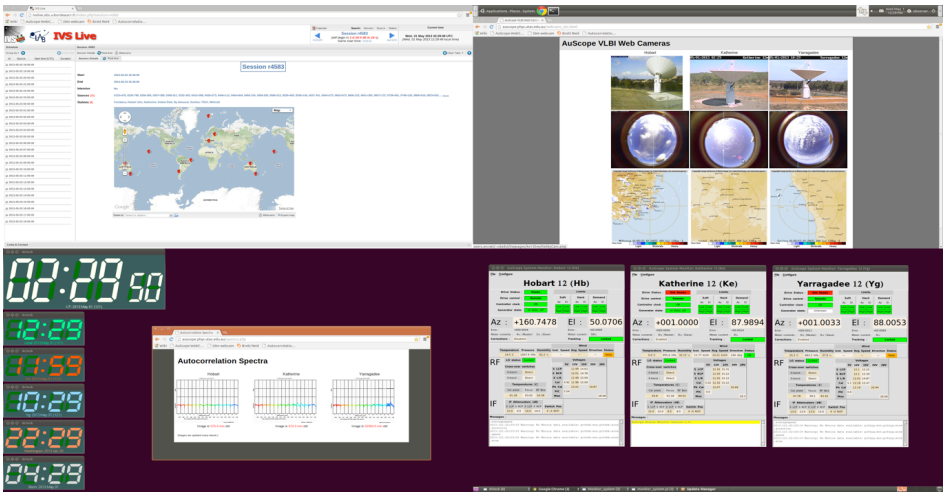


- 1 sec of data autocorrelation after every scan, sent to web server. Good DBBC diagnostic. Can also extract bit statistics

Operator's desktop



Monitor screens



Sequence of events

1. Before an observation
    1. Retrieve and prepare schedule files
    2. Configure and check hardware, run a fringe check
    3. Start the observation
2. During the observation
    1. Regular checks, at least every 2 h
    2. Respond to warnings, alarms
3. After the observation
    1. Prepare and send log files
    2. Ship/e-transfer data (sometimes)
    3. If another observation is to follow, go to 1.1

Setup procedure

- Schedule and Procedure Files
  - script slogit.auscope.sh on ops-serv2 to grab .skd file, drudg
  - edit .prc file to check DBBC settings
- Check all local software is running (including FS, Dimino, DBBC server) via VNC
- Start system monitor
- Start e-RemoteCtrl
- Start log monitor
- Step through pre-observation checklist in e-RemoteCtrl:
  - RF/IF Signal path
  - DBBC setup
  - Maser check
  - Mark5B setup
  - Clock checks (maser-GPS fmout-GPS)
  - Test recording
  - Tsys/SEFD check
  - Antenna check
  - Weather check
  - Fringe check
- Start observations

You should be able to

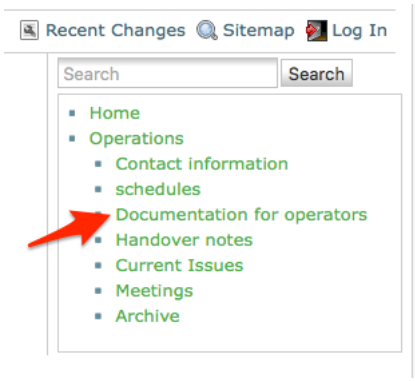
- Start up an observation from scratch
- Run through the checklist
- Know how to fix common problems
- Finish off, process logs
- Not fear the wiki

Before observing solo

- Observatory visit
- At least one setup
- At least one shift with an experienced observer

Example setup procedure

Step-by-step guide on the wiki



In 3 months time, you should be able to answer questions that demonstrate you understand the system. Questions like…

- What does the DBBC do?
- What does fmset do? When should you run it?
- Describe what the Field System does and how eRemoteControl interacts with it
- What is a fringe check and why is it useful?
- What is System Temperature? What is SEFD?
- What do the two counters measure and why do we monitor their output?