# Prototyping automation and dynamic observing with the AuScope array

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*University of Tasmania*
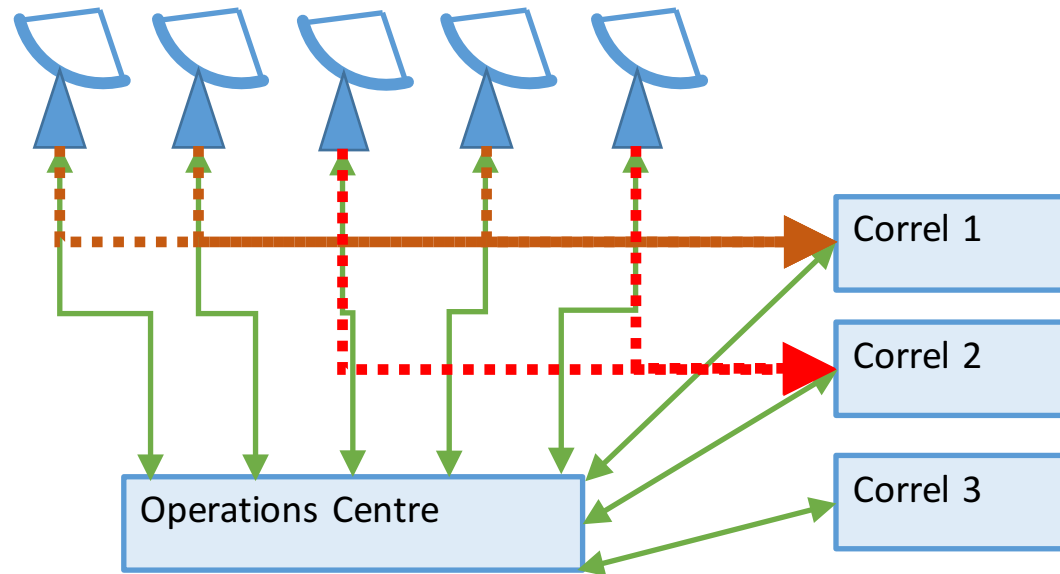
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*Technische Universität Wien*

# VGOS Operations

- Global array of ~20 stations
- Several correlators
- 24 hours a day, 7 days a week
- Initial products within 24h

# Ideal Solution?

- Multiple operations centres
- High level of automation

# Dynamic Observing

- Optimise available resources (telescopes and correlators)
- Adapt to changes
  - Antenna problems
  - Wind stows
  - Network interruptions
  - Etc
- Coordinate simultaneous observing programs:
  - Rapid UT1-UTC
  - EOP
  - Astrometry
  - Source imaging

**Observation Management Software**

Operations Centre: Shanghai

| Experiment: R320132 | | |
|---|---|---|
| Array 1 | Antennas: HtKkHbTaWw Correlator: Bonn | Source: 0537-441 Status: tracking |
| Array 2 | Antennas: HtYbAzWt Correlator: Curtin | Source: 0235+164 Status: acquiring |

| Experiment: U20132 | | |
|---|---|---|
| Array 1 | Antennas: OnTs Correlator: Tsukuba | Source: 0059+581 Status: tracking |

**Resources**

| Antennas | Correlators |
|---|---|
| Ke: available | Shanghai: available |
| Yg: available | Haystack: off line |
| Wf: available | Washington: available |
| Sh: available | |
| Ur: available | |
| Kb: off line | |
| Ny: available | |
| Sm: wind stow | |

# The Problem with Remote Control

- Some sites won't allow remote control due to safety and security concerns

# A Solution?

- The site always has full control over their participation. They can choose to observe or not, at any time, without prior notice.
    - This could cause havoc with the schedule, so…
    - If telescopes can join or leave at any time then the scheduling should be done in small pieces at a time.
- The site runs the observations locally, but:
    - Updates the schedule from the Operations Centre at regular, agreed intervals
    - Sends the Operations Centre regular status information needed for scheduling and correlation
    - Does the above automatically. However, station can choose to stop or start at any time.

# A test with the AuScope array

- Good for prototyping

- Proof-of-concept only

- Done in only a few weeks

- Little regard for network security, software robustness etc



Katherine

Yarragadee

Hobart
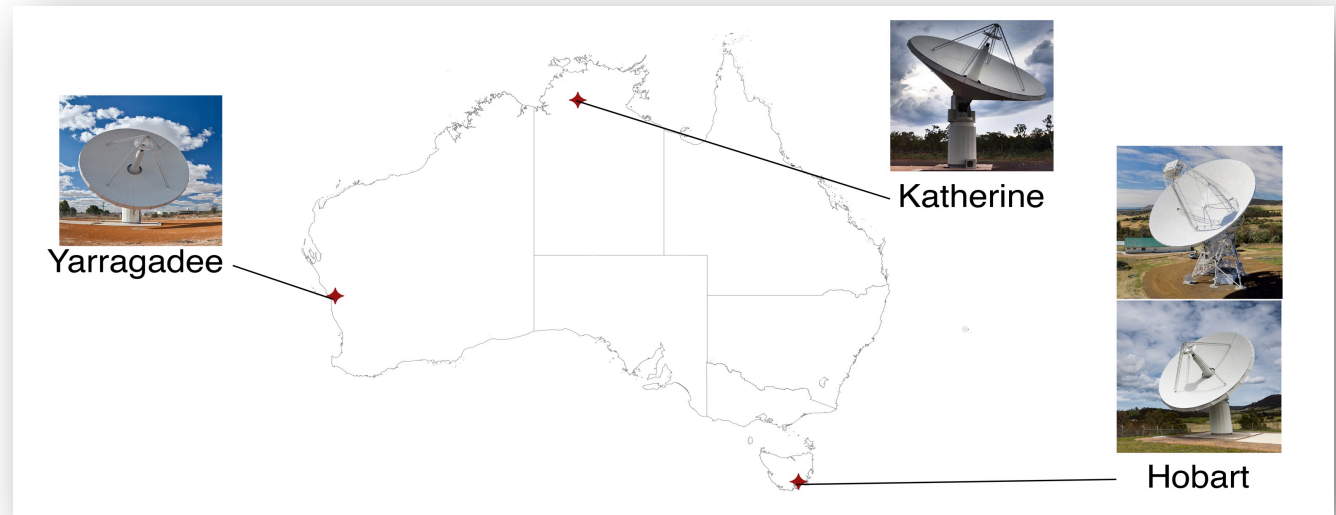
# A test implementation with AuScope

- Status info from each site:
  - Antenna available?
  - Current schedule
  - Coordinates
  - Recorder status
  - Weather

- *OC does not send any commands to the sites.* It just makes schedule files.
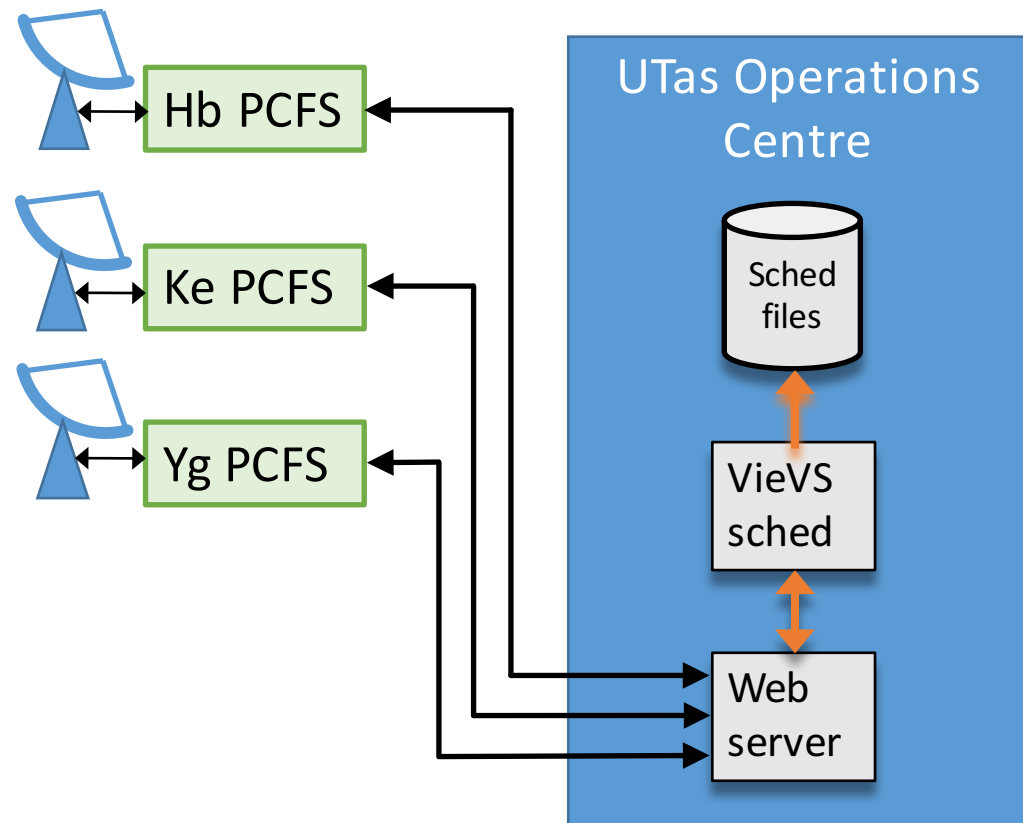
# Software at the stations

- "Big red button" – sends yes/no flag to Operations Centre

- Dynamic scheduling program – every minute:
  - Sends status data to OC
  - Checks with OC for new addition to the schedule. If there is one, appends it to the current one

# Software at UTAS OC

- VieVS scheduling software (Octave).
  - Modified vie_sched
  - Every 15 min:
    - schedules the next 15 min based on available antennas.
    - New 15 min of SKD file made available for download.
    - Web page updated with information needed by stations to decide if they need it, where to get it.
  - At 0 UT every day, produces a VEX file of the past 24h for correlation



```
KATH12M      38slew-->    0idle-->   20obs
HOBART12     31slew-->    8idle-->   20obs
YARRA12M     34slew-->    5idle-->   20obs
scan 4  0208-512  2016 03 07 02 05   48.0000000000 3
HOBART12     21slew-->    0idle-->   42obs
KATH12M      18slew-->    4idle-->   42obs
YARRA12M     17slew-->    4idle-->   37obs
scan 5  1622-253  2016 03 07 02 07   26.0000000000 3
HOBART12     40slew-->    0idle-->   57obs
KATH12M      26slew-->   15idle-->   57obs
YARRA12M     29slew-->   16idle-->   43obs
scan 6  2145+067  2016 03 07 02 09   38.0000000000 3
HOBART12     59slew-->    0idle-->   20obs
KATH12M      56slew-->    4idle-->   20obs
YARRA12M     52slew-->   21idle-->   20obs
scan 7  0332-403  2016 03 07 02 11    2.0000000000 3
HOBART12     32slew-->   16idle-->   39obs
KATH12M      48slew-->    0idle-->   48obs
YARRA12M     36slew-->   12idle-->   48obs
scan 8  2232-488  2016 03 07 02 12   51.0000000000 3
HOBART12     38slew-->   16idle-->   64obs
KATH12M      37slew-->    8idle-->   71obs
YARRA12M     45slew-->    0idle-->   71obs
scan 9  1954-388  2016 03 07 02 14   40.0000000000 3
HOBART12     26slew-->    4idle-->   29obs
KATH12M      16slew-->    7idle-->   29obs
YARRA12M     22slew-->    0idle-->   26obs
----------------------vie_sched output----------------------
3. write output file in NGS format: ds20160670201
4. write output file in SKD-sum format: ../DATA/SCHED/ds2016067/16MAR06-skdsum.t
xt
5. write output file in SKD format: ds20160670201.skd

ARA, t_att);
```

| Station | Availability | Timestamp |
|---|---|---|
| HOBART12 | 1 | 2016-03-06 23:07:37 |
| KATH12M | 1 | 2016-03-06 22:57:46 |
| YARRA12M | 1 | 2016-03-06 22:40:39 |

| Station | Schedule | Log | Halted? | Scan Name | Next command |
|---|---|---|---|---|---|
| HOBART12 | ds001hb | ds001hb | no | 067-0152 | 01:51:56 |
| KATH12M | ds001ke | ds001ke | no | 067-0152 | 01:51:56 |
| YARRA12M | ds001yg | ds001yg | no | 067-0152 | 01:52:03 |

| Station | Source | Az | El | RA | Dec | Epoch | Wrap |
|---|---|---|---|---|---|---|---|
| HOBART12 | 0106+013 | 46.5820 | 34.6098 | 01:09:27.6 | +01:39:59 | 2016.2s | neutral |
| KATH12M | 0106+013 | 77.0841 | 36.0274 | 01:09:27.6 | +01:39:59 | 2016.2s | neutral |
| YARRA12M | 0106+013 | 77.8234 | 17.5864 | 01:09:27.6 | +01:39:59 | 2016.2s | neutral |

| Station | Active Bank | VSN in use | VSN A | VSN B | Recording time A | Recording time B | Usage A (GB) | Usage B (GB) | Usage A (%) | Usage B (%) | Check time A | Check time B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOBART12 | hob+1006/16000/1024 | a | hob+1006 | usn+0221 | 30h12m | | 13916.343 | | 87.0 | | 1:50:57 | 1:50:57 |
| KATH12M | hay-0062/4000/1024 | a | hay-0062 | | 7h51m | | 3617.591 | | 90.4 | | 1:50:57 | 1:50:57 |
| YARRA12M | hob+0107/16000/1024 | a | hob+0107 | | 34h05m | | 15707.043 | | 98.2 | | 1:50:55 | 1:50:55 |

| Station | Temp | RH | Pres |
|---|---|---|---|
| HOBART12 | 20.9 | 85.60 | 1014.1 |
| KATH12M | $$$$$ | $$$$$$ | -100.0 |
| YARRA12M | 30.9 | 28.50 | 984.7 |

# Dynamic Scheduling Status

```
Stations Schedule_file      Time_stamp
KeYg ds20160642245.skd 2016.064.2245
KeYg ds20160642300.skd 2016.064.2300
KeYg ds20160642315.skd 2016.064.2315
KeYg ds20160642331.skd 2016.064.2331
KeYg ds20160642345.skd 2016.064.2345
KeYg ds20160662230.skd 2016.066.2230
KeYg ds20160662245.skd 2016.066.2245
HbKeYg ds20160662315.skd 2016.066.2315
HbKeYg ds20160662330.skd 2016.066.2330
HbKeYg ds20160662346.skd 2016.066.2346
HbKeYg ds20160670014.skd 2016.067.0014
HbKeYg ds20160670030.skd 2016.067.0030
HbKeYg ds20160670045.skd 2016.067.0045
HbKeYg ds20160670100.skd 2016.067.0100
HbKeYg ds20160670115.skd 2016.067.0115
HbKeYg ds20160670131.skd 2016.067.0131
HbKeYg ds20160670145.skd 2016.067.0145
HbKeYg ds20160670201.skd 2016.067.0201
```

## Dynamic Scheduling Big Red Button

◆ Enable    ◇ Disable    Apply

```
Dynamic Scheduling Big Red Button version 0.0.
2016.063.23:18:51 Opened log file /usr2/log/ds_allow_ke_2016_063_231851.log on pcfske
2016.063.23:18:54 Antenna will be included in Dynamic Scheduling
2016.066.22:57:46 Antenna will be included in Dynamic Scheduling
```

Link To Old Desktop

### Terminal (KATH12M)

```
            KATH12M
1622-253      (2016.2)
R.A.      16:26:46.3
Dec.     -25:29:38
CW

            Offsets
AzEl   0.0000   0.0000
RaDc   0.0000   0.0000
----------------------
2016-067 01:54:19.05
L.A.S.T. 21:43:48.7
Eq. of Equinox -0.1
---          ----
         Az        El
Sky  247.0687  15.6526
Cmd  246.7552  16.1934
Act  246.7555  16.1935
Err    0.0003   0.0001
Tracking
Cor   -0.3135   0.4632
Ref             0.0776
----------------------
Currents        Status
  0    0    0M        0
  2                   0
 35                  080
              30f47800
```

### Terminal

File  Edit  View  Terminal  Tabs  Help

```
Antenna is available for use
-------------------------------------------------
Checking for an addition to the schedule...
No new schedule addition is currently available.
Now waiting for 1 minute before checking again...
xxxxxx

-------------------------------------------------
Checking antenna availability...
Antenna is available for use
-------------------------------------------------
Checking for an addition to the schedule...
No new schedule addition is currently available.
Now waiting for 1 minute before checking again...
xxxxxx

-------------------------------------------------
Checking antenna availability...
Antenna is available for use
-------------------------------------------------
Checking for an addition to the schedule...
No new schedule addition is currently available.
Now waiting for 1 minute before checking again...
xxx
```

### Terminal

File  Edit  View  Terminal  Tabs  Help

```
01:53:27/bbc07/1312.990000,b,16, 1,agc, 25, 25,    0,  0,15479,15600
01:53:27/bbc08/1332.990000,b,16, 1,agc, 29, 25,    0,  0,16004,15851
01:53:27/bbc09/ 325.990000,c,16, 1,agc, 38, 36,    0,  0,15896,16289
01:53:27/bbc10/ 345.990000,c,16, 1,agc, 35, 37,    0,  0,16029,15863
01:53:27/bbc11/ 365.990000,c,16, 1,agc, 36, 35,    0,  0,15625,15928
01:53:27/bbc12/ 395.990000,c,16, 1,agc, 42, 38,    0,  0,15995,16420
01:53:27/bbc13/ 445.990000,d,16, 1,agc, 55, 56,    0,  0,16397,16072
01:53:27/bbc14/ 465.990000,d,16, 1,agc, 65, 56,    0,  0,16180,16204
01:53:28/fmout-gps/+1.13244E-005
01:53:29/maser2gps/+1.16390E-005
01:53:29/dbbc/pps_delay/61945
01:53:29/dbbc/pps_delay/9
01:53:29/dbbc/pps_delay/7
01:53:29/dbbc/pps_delay/5
01:53:29/mk5b_mode/ext,0xffffffff,1,(32.000),2
01:53:29#wx#/WX/33.6, 993.7, 54.48
01:53:30/mk5/!dot? 0 : 2016y067d01h53m30.0775s : syncerr_eq_0 : FHG_on : 2016y
7d01h53m30.0763s : 0.001167s ;
01:53:30/mk5/!bank_set? 0 : A : HAY-0062/4000/1024 : - : ;
01:53:30#setcl#time/46207529,0,2016,067,01,53,30.08,0.000,0.000,0
01:53:30#setcl#model/old,1456853562,-579,0,-5.355,1.031,computer,0,unknown,0,0
01:53:32: !2016.067.01:54:20
01:53:48;cont
```

### Operator Input

```
>wth
>list
>wth
>list
>
```

### Terminal

Edit  View  Terminal  Tabs  Help

```
2M          2016.067.01:54:19  UT        TEMP  $$$$$C 1622-253   TRACKING
RATE             01:54:20  NEXT       HUMID $$$$$$% RA  16h22m44.1s
            SCHED=ds001ke  LOG=ds001ke   PRES -100.0mb DEC-25d20m    (1950
            TSYS: IFA IFB IFC IFD    CABLE  0.000000s AZ   247.1  EL   15.7
                  0   0   0   0
```

Taskbar: Terminal | Operator In... | Terminal | Terminal | [Terminal] | [oper@mk5... | Terminal | D Dynamic Scheduling Big Red Button

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Dynamic Scheduling Status | AJAX Example | Index of /DS

| Station | Availability | Timestamp |
|---|---|---|
| HOBART12 | 1 | 2016-03-06 23:07:37 |
| KATH12M | 0 | 2016-03-07 01:54:23 |
| YARRA12M | 1 | 2016-03-06 22:40:39 |

| Station | Schedule | Log | Halted? | Scan Name | Next command |
|---|---|---|---|---|---|
| HOBART12 | ds001hb | ds001hb | no | 067-0158 | 01:58:03 |
| KATH12M | ds001ke | ds001ke | no | 067-0158 | 01:58:03 |
| YARRA12M | ds001yg | ds001yg | no | 067-0157 | 01:57:00 |

| Station | Source | Az | El | RA | Dec | Epoch | Wrap |
|---|---|---|---|---|---|---|---|
| HOBART12 | 1741-038 | 276.7990 | 12.8949 | 17:44:49.7 | -03:50:25 | 2016.2s | neutral |
| KATH12M | 1741-038 | 273.7262 | 29.3863 | 17:44:49.7 | -03:50:25 | 2016.2s | neutral |
| YARRA12M | 2145+067 | 27.5797 | 50.2323 | 21:48:52.5 | +07:02:07 | 2016.2s | neutral |

| Station | Active Bank | VSN in use | VSN A | VSN B | Recording time A | Recording time B | Usage A (GB) | Usage B (GB) | Usage A (%) | Usage B (%) | Check time A | Check time B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOBART12 | hob+1006/16000/1024 | a | hob+1006 | usn+0221 | 30h09m | | 13899.291 | | 86.9 | | 1:57:26 | 1:57:26 |
| KATH12M | hay-0062/4000/1024 | a | hay-0062 | | 7h49m | | 3603.616 | | 90.1 | | 1:57:26 | 1:57:26 |
| YARRA12M | hob+0107/16000/1024 | a | hob+0107 | | 34h03m | | 15693.325 | | 98.1 | | 1:55:59 | 1:55:59 |

| Station | Temp | RH | Pres |
|---|---|---|---|
| HOBART12 | 21.1 | 85.30 | 1014.0 |
| KATH12M | $$$$$ | $$$$$$ | -100.0 |
| YARRA12M | 30.4 | 29.00 | 984.7 |

```
  KATH12M      38slew-->    0idle-->   20obs
  HOBART12     31slew-->    8idle-->   20obs
  YARRA12M     34slew-->    5idle-->   20obs
scan  4   0208-512   2016 03 07 02 05   48.0000000000  3
  HOBART12     21slew-->    0idle-->   42obs
  KATH12M      18slew-->    4idle-->   42obs
  YARRA12M     17slew-->    4idle-->   37obs
scan  5   1622-253   2016 03 07 02 07   26.0000000000  3
  HOBART12     40slew-->    0idle-->   57obs
  KATH12M      26slew-->   15idle-->   57obs
  YARRA12M     29slew-->   16idle-->   43obs
scan  6   2145+067   2016 03 07 02 09   38.0000000000  3
  HOBART12     59slew-->    0idle-->   20obs
  KATH12M      56slew-->    4idle-->   20obs
  YARRA12M     52slew-->   21idle-->   20obs
scan  7   0332-403   2016 03 07 02 11    2.0000000000  3
  HOBART12     32slew-->   16idle-->   39obs
  KATH12M      48slew-->    0idle-->   48obs
  YARRA12M     36slew-->   12idle-->   48obs
scan  8   2232-488   2016 03 07 02 12   51.0000000000  3
  HOBART12     38slew-->   16idle-->   64obs
  KATH12M      37slew-->    8idle-->   71obs
  YARRA12M     45slew-->    0idle-->   71obs
scan  9   1954-388   2016 03 07 02 14   40.0000000000  3
  HOBART12     26slew-->    4idle-->   29obs
  KATH12M      16slew-->    7idle-->   29obs
  YARRA12M     22slew-->    0idle-->   26obs
------------------------vie_sched output----------------------
3. write output file in NGS format: ds20160670201
4. write output file in SKD-sum format: ../DATA/SCHED/ds2016067/16MAR06-skdsum.t
xt
5. write output file in SKD format: ds20160670201.skd
```

## Dynamic Scheduling Status

```
Stations Schedule_file        Time_stamp
KeYg ds20160642245.skd 2016.064.2245
KeYg ds20160642300.skd 2016.064.2300
KeYg ds20160642315.skd 2016.064.2315
KeYg ds20160642331.skd 2016.064.2331
KeYg ds20160642345.skd 2016.064.2345
KeYg ds20160662230.skd 2016.066.2230
KeYg ds20160662245.skd 2016.066.2245
HbKeYg ds20160662315.skd 2016.066.2315
HbKeYg ds20160662330.skd 2016.066.2330
HbKeYg ds20160662346.skd 2016.066.2346
HbKeYg ds20160670014.skd 2016.067.0014
HbKeYg ds20160670030.skd 2016.067.0030
HbKeYg ds20160670045.skd 2016.067.0045
HbKeYg ds20160670100.skd 2016.067.0100
HbKeYg ds20160670115.skd 2016.067.0115
HbKeYg ds20160670131.skd 2016.067.0131
HbKeYg ds20160670145.skd 2016.067.0145
HbKeYg ds20160670201.skd 2016.067.0201
HbYg ds20160670215.skd 2016.067.0215
```
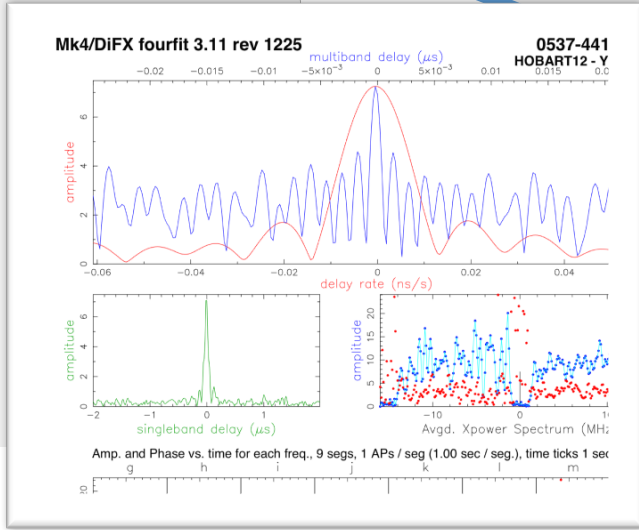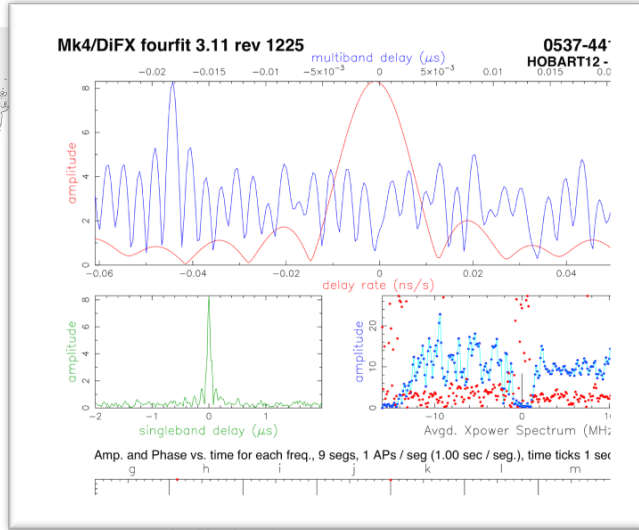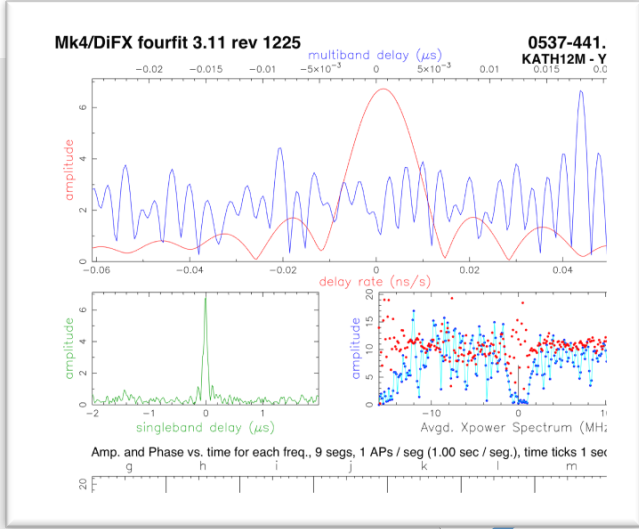
# Does it work?

- Yes

# Next steps

- 24 h observation. Compare with results from traditional scheduling
- Add correlation support
- Add fringe checking
- Add other feedback to vie_sched (e.g. SEFD, Tsys)
- More telescopes?
- Coordination with other groups, testing of other techniques