Scheduling a VLBI Session

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Prerequisites & Goals

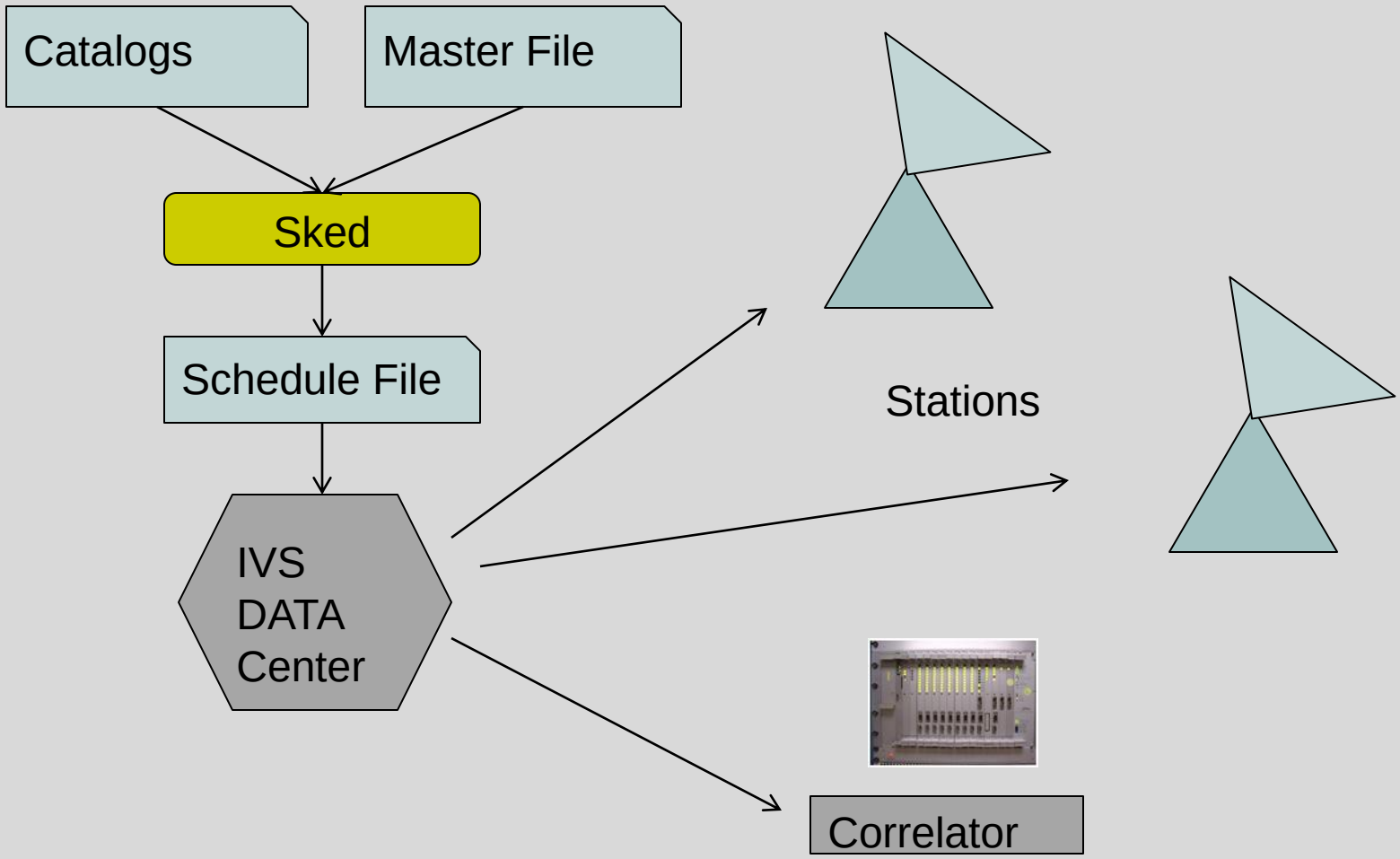
Prerequisite:

- General understanding of VLBI.

Goals:

- General understanding of scheduling.
- Some understanding of sked.
- Ability to produce simple schedules (R1, R4…)
- Ability to do some tweaking of schedules

Sked Data Flow



Terminology (1)

Site: A location with one or more VLBI antennas. GGAO is a VLBI site with two VLBI antennas.

Station: A given VLBI antenna together with all the electronics and recording equipment.

Source: Something that is observed by VLBI. Usually a quasar, but could be satellites or spacecraft.

Scan: A set of two or more VLBI antennas simultaneously observing the same source.

Observation: The result of cross-correlating the signal from two VLBI antennas in a scan.

Subnetting: When two sets of stations simultaneously participate in different scans.

Terminology (2)

Schedule File: A complete specification of a session. Includes information describing:

- Station positions
- Antenna parameters
- Electronics and recorders
- Source positions
- Source flux models
- Frequency mode
- A complete list of all scans in the session

Catalogs: A set of files used by scheduling programs that describe information used in scheduling. There is one catalog for each category of information: Antenna.cat, Source.cat, Flux.cat, ….

Terminology (3)

Sked: The program most often used to schedule geodetic VLBI sessions. Sked was developed by Nancy Vandenberg (NVI/GSFC) and is currently maintained John Gipson (NVI/GSFC)

Sched: A program used to schedule Astronomy VLBI sessions. Sched wes developed and is maintained by Craig Walker.

Vie_sched: An alternative program written in Matlab to schedule Geodetic VLBI sessions. Vie_sched was developed by Jing Sun at TU.

Master File: All of the sessions for a given year. It specifies start time, duration, stations and type of schedule: R1, R4, CRF, EURO,….

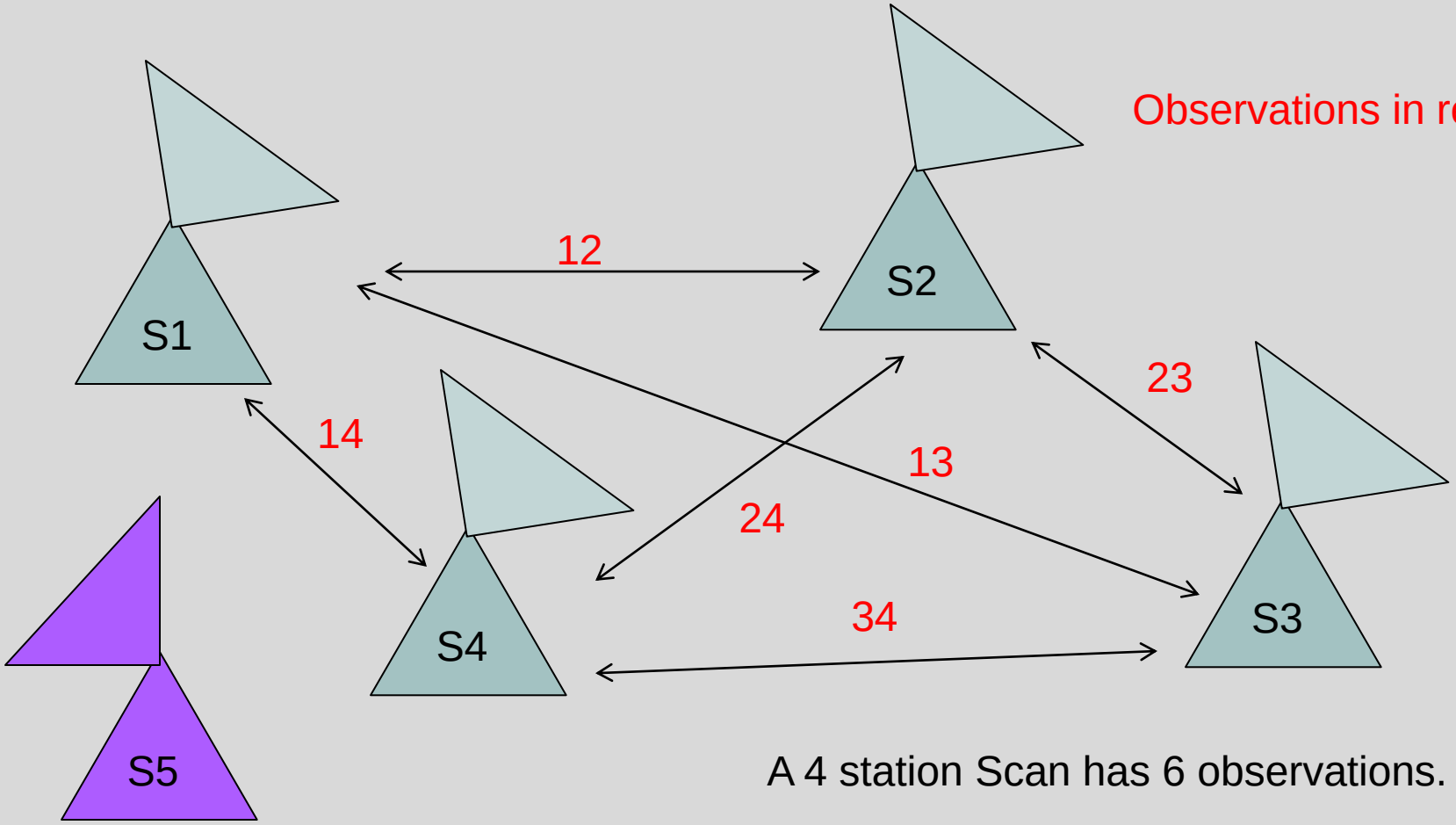
Terminology (3)

SKD format: Format for writing schedule format. Developed by Nancy Vandenberg.

VEX format: An alternative more modern format. Used at the correlators. Sked can write VEX files.

Scans & Observations

There are many observations in a single scan.



A 4 station Scan has 6 observations.

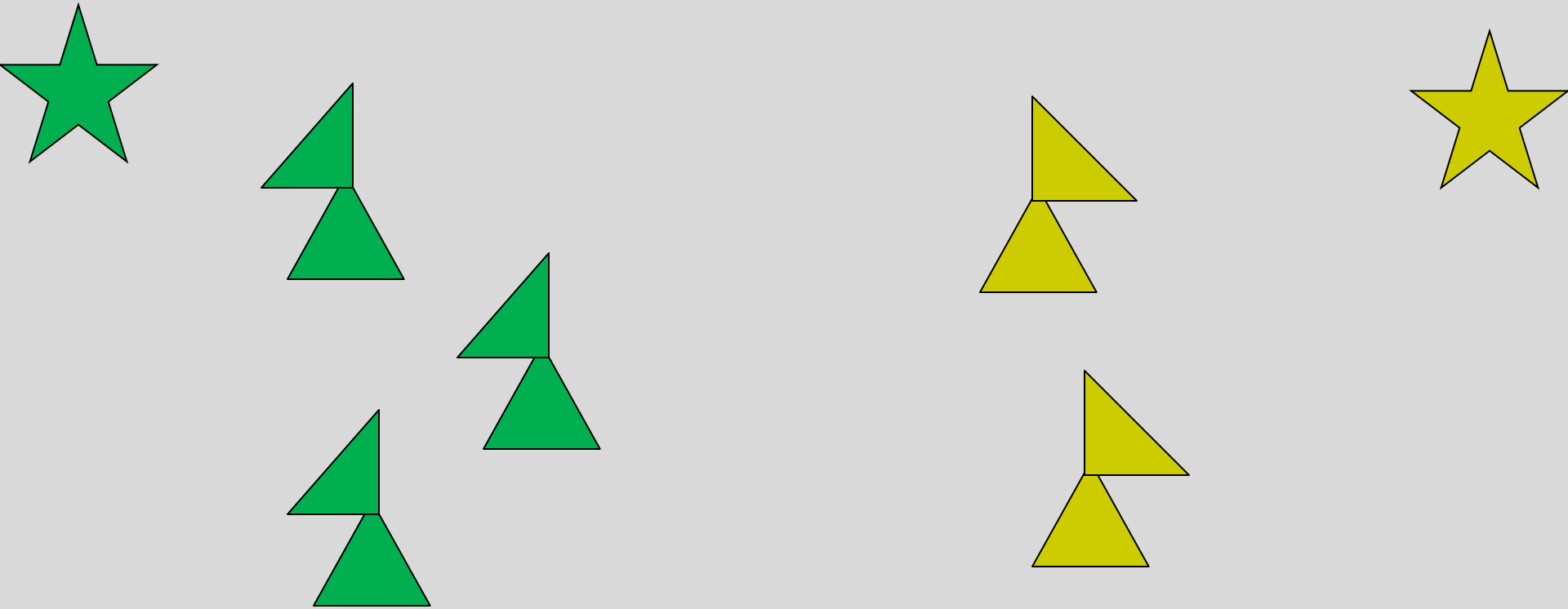
Scans and Observations

	1	2	3	4	5
1	11	12	13	14	15
2	21	22	23	24	25
3	31	32	33	34	35
4	41	42	43	44	45
5	51	52	53	54	55

Square has NxN elements.
We are interested in elements above the diagonal.
This is (NxN-N)/2=N*(N-1)/2

Subnetting

When two sets of antennas simultaneous participate in different scans.



SNR Calculations

Number of Bits

Source Strength

$$SNR = \frac{F}{\sqrt{SEFD_1 \times SEFD_2}} \frac{\sqrt{2 \times BW \times NumChannels \times Scanlength}}{1.75}$$

Antenna SEFDs

Correction Factor

Increasing SNR

To increase SNR you can:

- Increase F➔ Stronger sources
- Decrease SEFD ➔ Larger antennas or better electronics
- Increase Number of bits
  - Increase scan length
  - Increase BW
  - Two bit sampling
  - Increase number of samples

Ideal Source

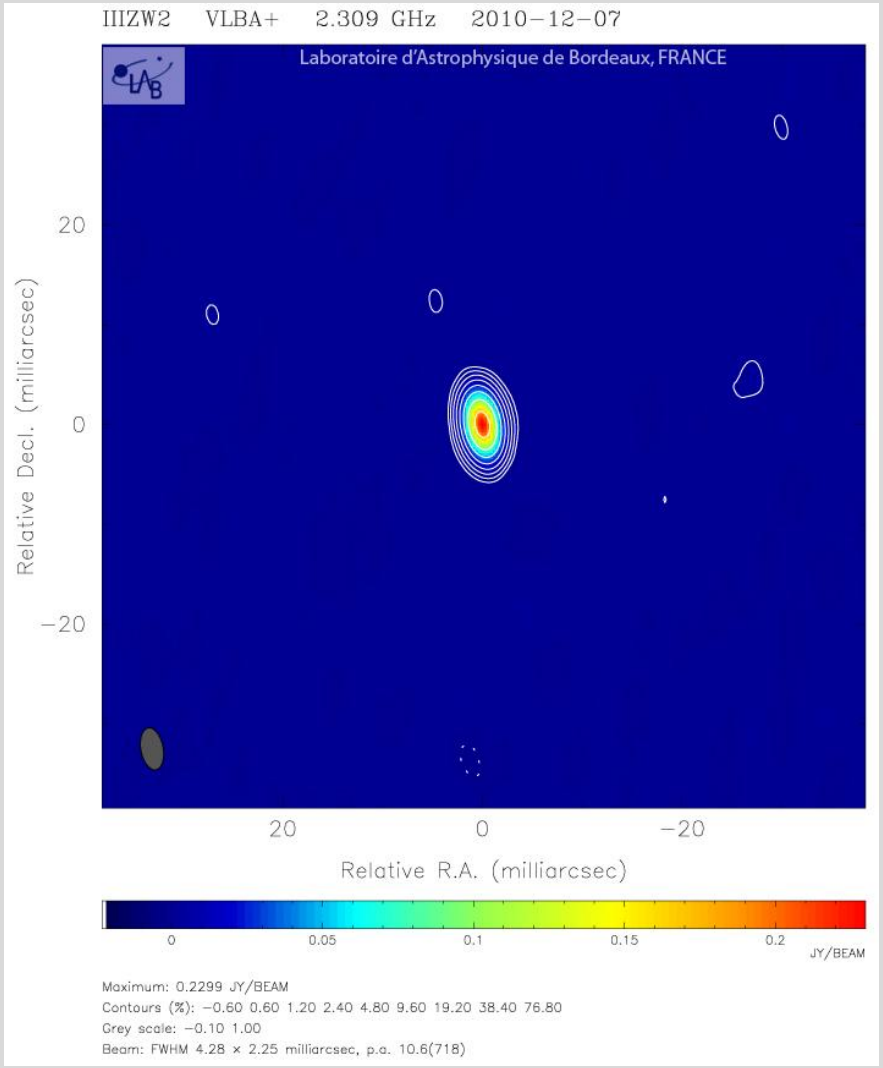
The ideal source is:

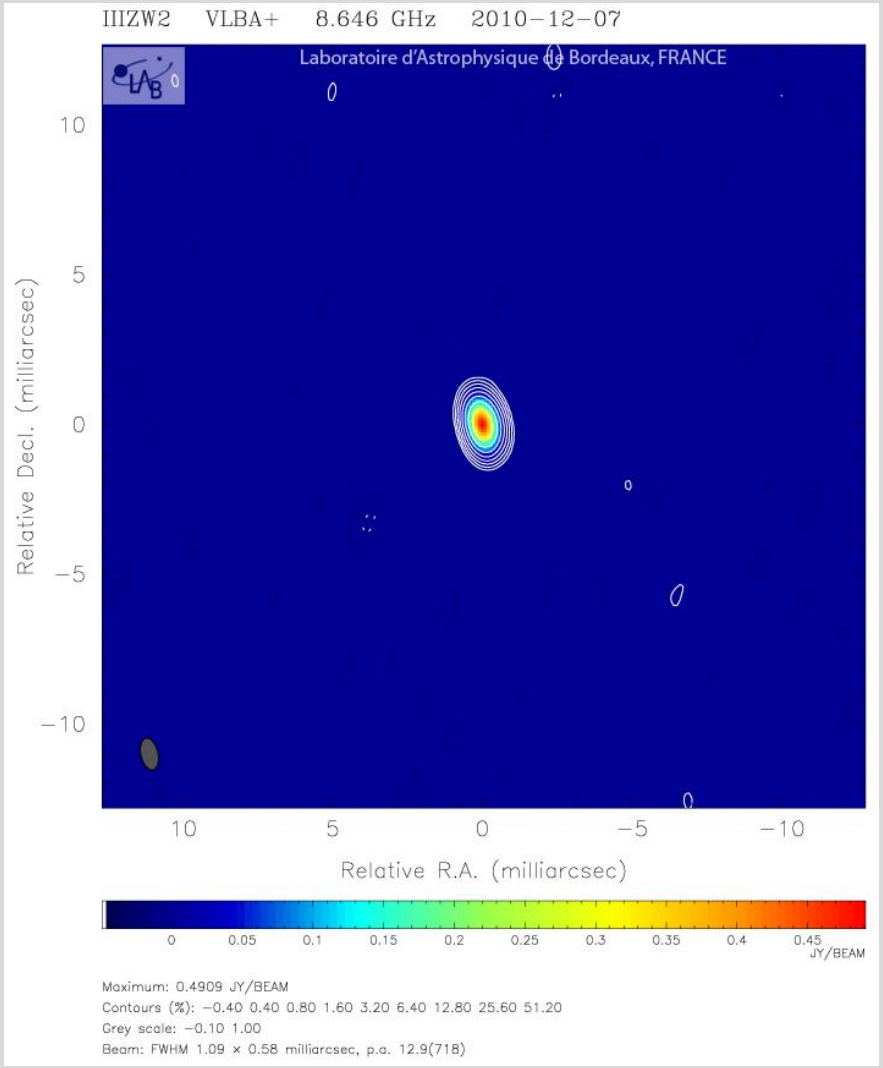
- Strong
  - Strong sources take less integration time. This means you can take more observations.
- Compact
  - Non-compact sources have lower flux on long baselines.
- No Source Structure
  - Source structure introduces ‘noise’.

Goddard periodically reviews the source list trying to find the best compromise between compact and strong.

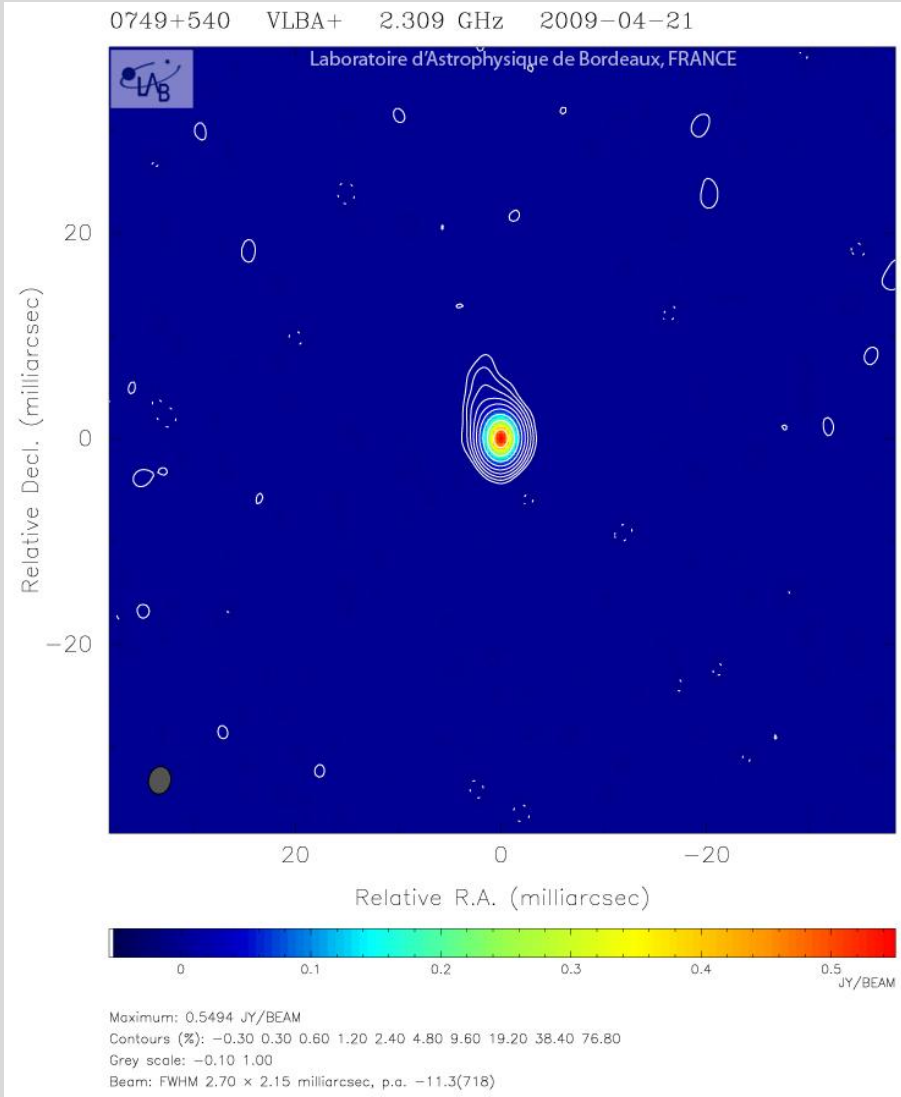
ftp://gemini.gsfc.nasa.gov/ftp/pub/sked/catalogs/source.cat.geodetic.good

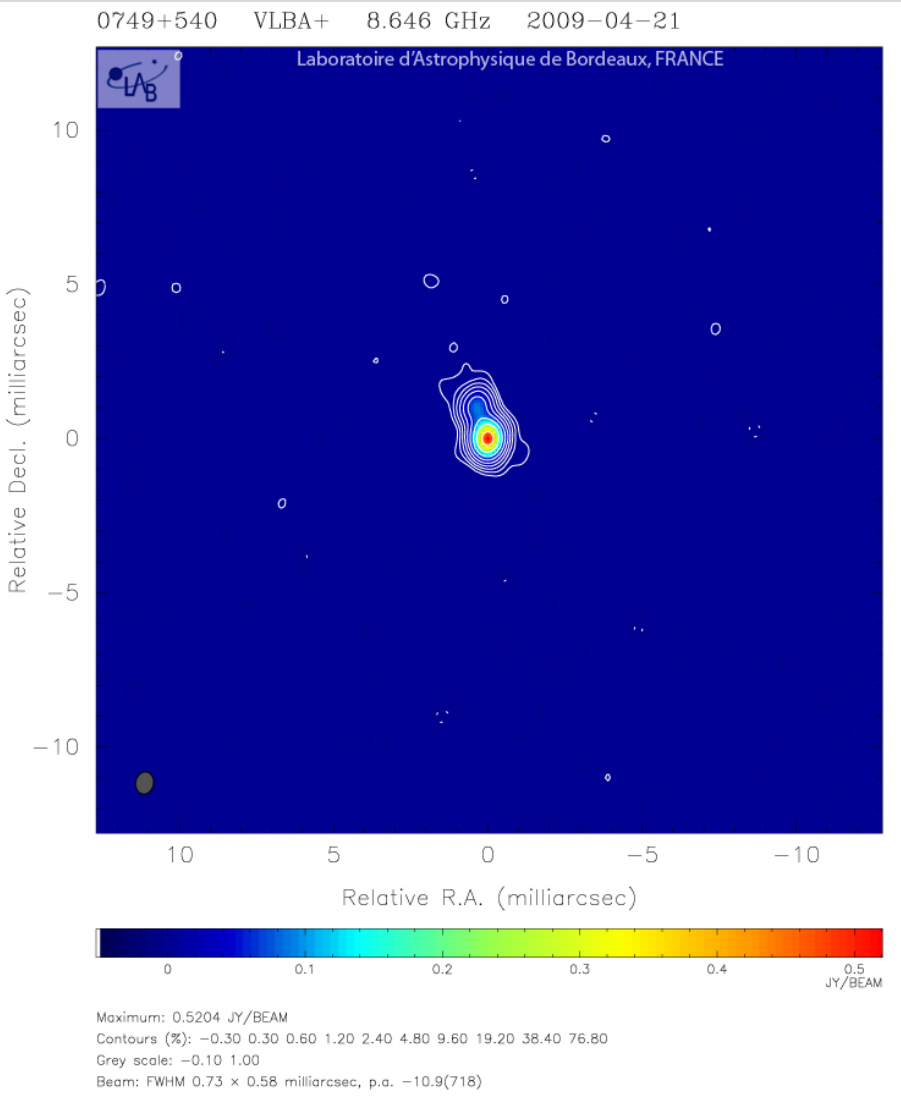
Good Source


IIIZW2 VLBA+ 2.309 GHz 2010−12−07
Laboratoire d'Astrophysique de Bordeaux, FRANCE
Relative Decl. (milliarcsec)
Relative R.A. (milliarcsec)
JY/BEAM
Maximum: 0.2299 JY/BEAM
Contours (%): −0.60 0.60 1.20 2.40 4.80 9.60 19.20 38.40 76.80
Grey scale: −0.10 1.00
Beam: FWHM 4.28 × 2.25 milliarcsec, p.a. 10.6(718)


IIIZW2 VLBA+ 8.646 GHz 2010−12−07
Laboratoire d'Astrophysique de Bordeaux, FRANCE
Relative Decl. (milliarcsec)
Relative R.A. (milliarcsec)
JY/BEAM
Maximum: 0.4909 JY/BEAM
Contours (%): −0.40 0.40 0.80 1.60 3.20 6.40 12.80 25.60 51.20
Grey scale: −0.10 1.00
Beam: FWHM 1.09 × 0.58 milliarcsec, p.a. 12.9(718)

OK Source





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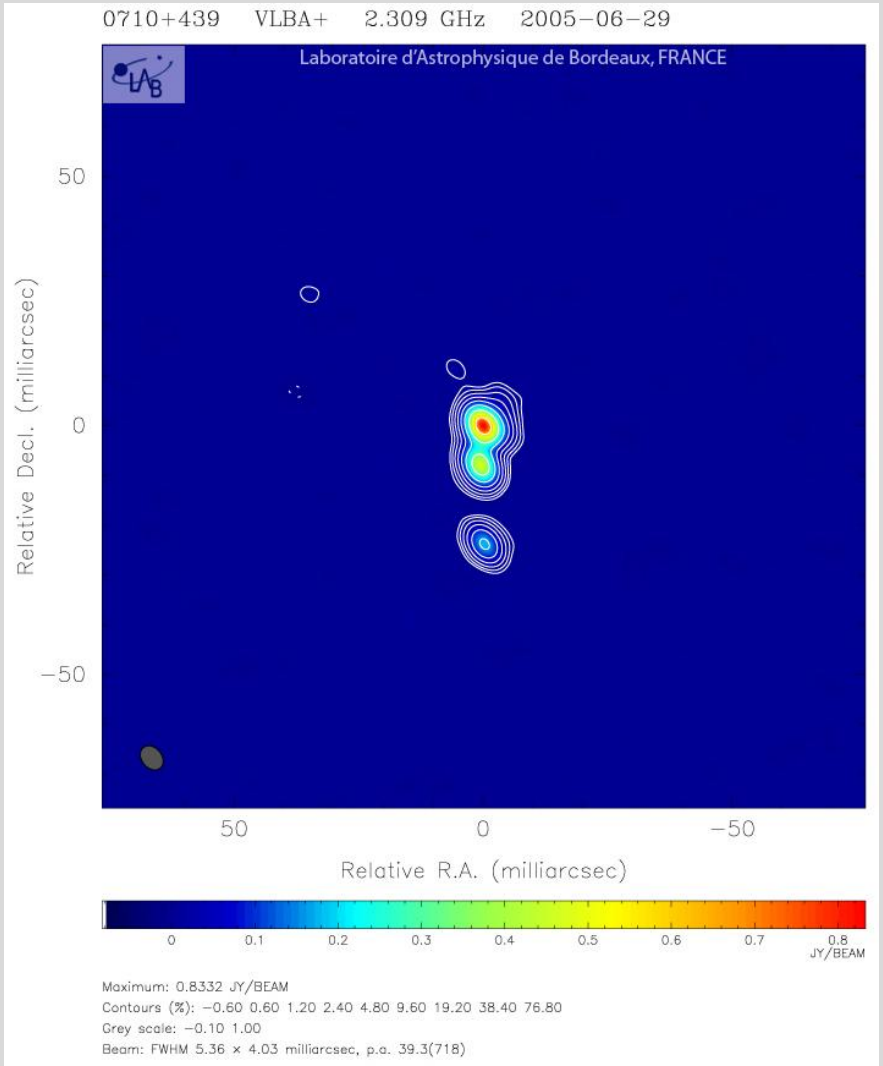
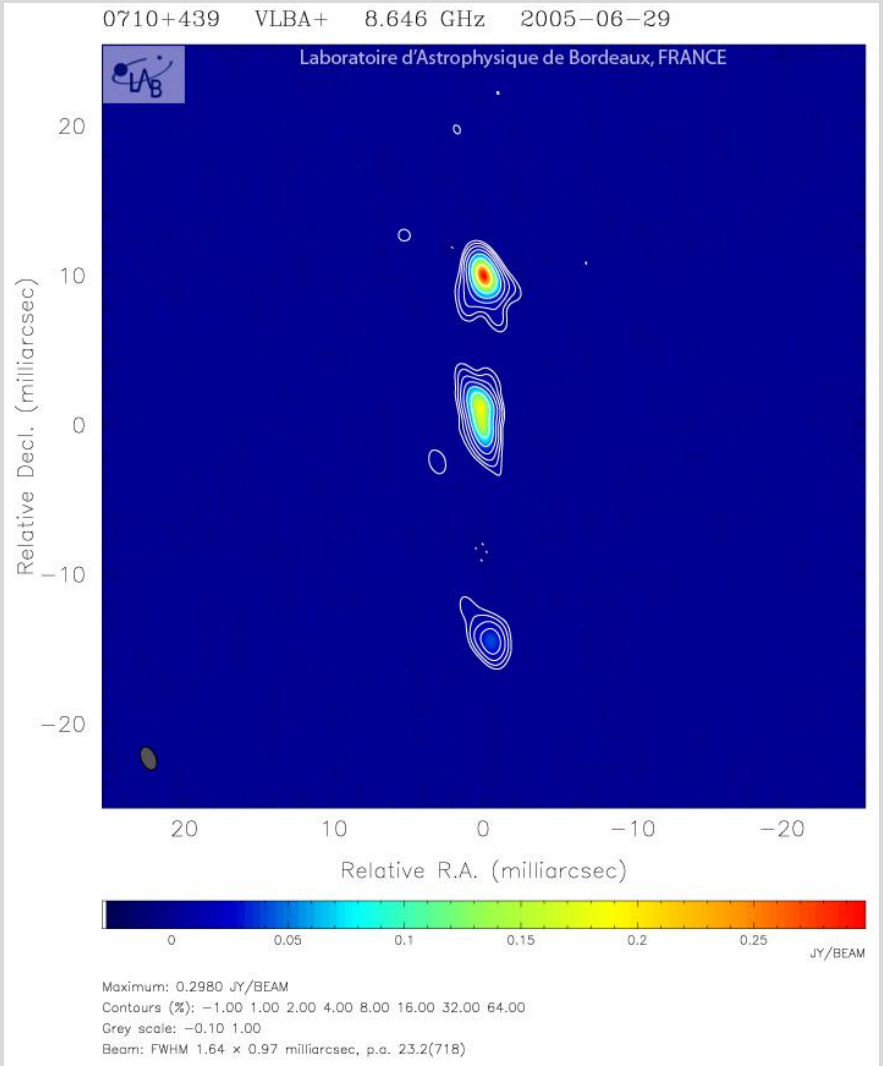
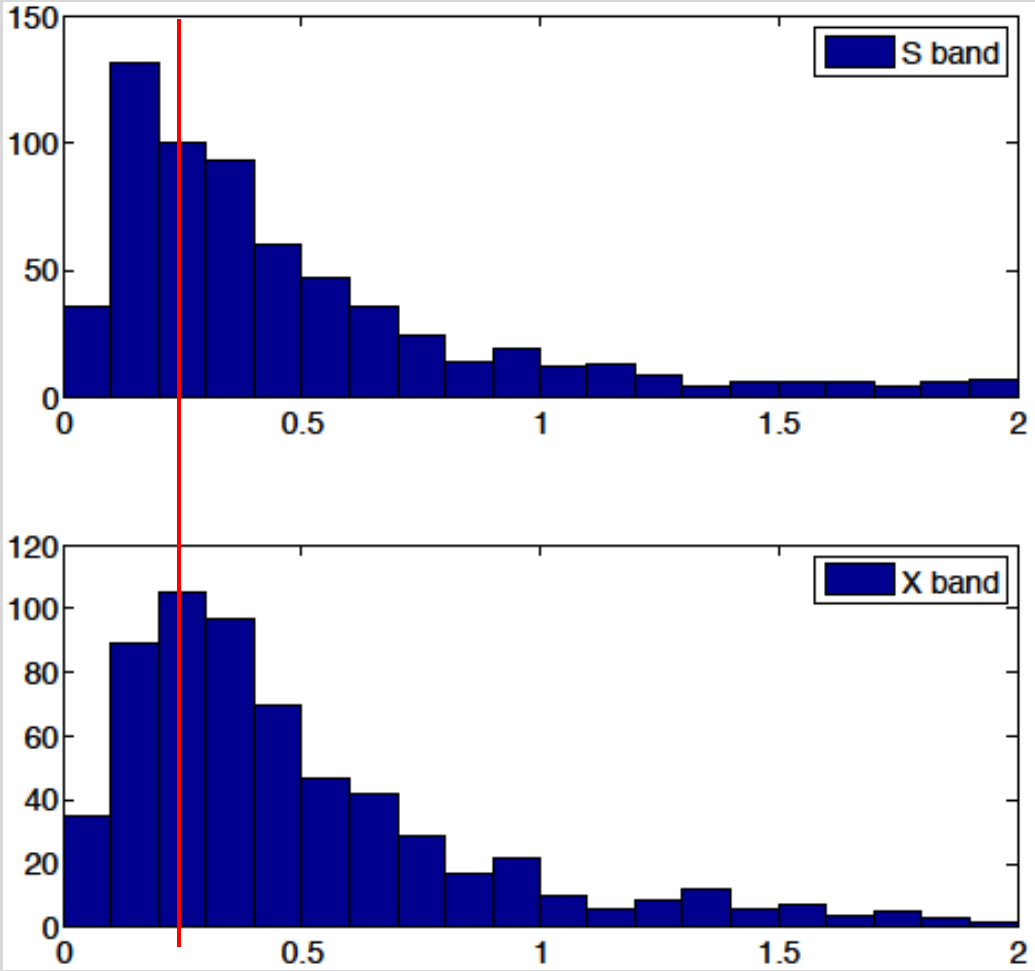
Scheduling VLBI Sessions

Bad Source With Structure





Source Fluxes



Fluxes above 0.25 are observable.

Scheduling a Scan

If you wanted to generate a schedule by completely by hand you would:

1. Determine what sources were visible now at which antennas.
2. Calculate time for antennas to slew to source.
3. Calculate source-flux on all baselines.
4. Calculate integration time based on SNR.
5. Pick scan to use.

Repeat for the next scan.

Most of this is just ‘plug-and-chug’ calculations—no thinking required.

The only item that requires thought is item 5.

This lead to the creation of scheduling programs to do the calculations for you.

Modern scheduling programs like sked and Vie_sched can even select the scans automatically.

What is a Good Schedule?

- Generally, the more observations the better.
- Like to have, at a minimum 10-12 scans/hour at each station.
- No gaps in schedule. We are unhappy if a station is not observing.
- Not too much idle time.
- Even sky distribution over periods ~ 1 hour or less.
- Some low elevation scans to help separate atmosphere and clocks. (*But too low will hurt because we introduce noise by mis-modeling the atmosphere.)*

What is Sked

Sked is a **command line based** scheduling program developed by Nancy Vandenberg and maintained by John Gipson

Sked prompt Command Arguments

```
? list start-171000
Source       Start       DURATIONS
name      yyddd-hhmmss    Ft   Hh   Kk   Ny   On   Tc   Ts   Wz
1954-388 12003-170000|      157                 157           |
3C371    12003-170000| 288       268  169  288        43  130|
1053+704 12003-170246|                                  43   43|
2215+150 12003-170606|       87        90   90             65|
1741-038 12003-170659| 106       287             287           |
0657+172 12003-170915|                 43   43        43   43|
0529+483 12003-171100|                 89   89             64|
End of listing.
?
```

What is Sked

Another example—listing SNR targets.

```
? SNR
Minimum SNR by baseline for multi-baseline scans
     X-band (margin   0)      S-band (margin   0)
     Ny  On  Sh  Tc  Wf  Wz          Ny  On  Sh  Tc  Wf  Wz
 On  25                          On  15
 Sh  25  25                      Sh  15  15
 Tc  20  20  20                  Tc  12  12  12
 Wf  25  25  25  20              Wf  15  15  15  12
 Wz  25  25  25  20  25          Wz  15  15  15  12  15
 Zc  25  25  25  20  25  25      Zc  15  15  15  12  15  15
?
```

Brief History of Sked

History	
1978	**Basic program created (Nancy Vandenberg)** **command line input** **manual selection of scans** **catalogs for sources, stations, equipment**
1981	Automatic calculation of antenna motion and tape handling
1988	**Automatic selection of observations (Autosked)** **Optimization by strict covariance.**
1992	Evaluation of schedules using SOLVE simulations Creation of pseudo-databases to evaluate formal errors.
1993	**Autosked merged into standard version.** **"Strange" schedules**
1995	**Beginning of rule based schedules.**
1996	Mark IV/VLBA recording mode support added Last time sked documentation updated.

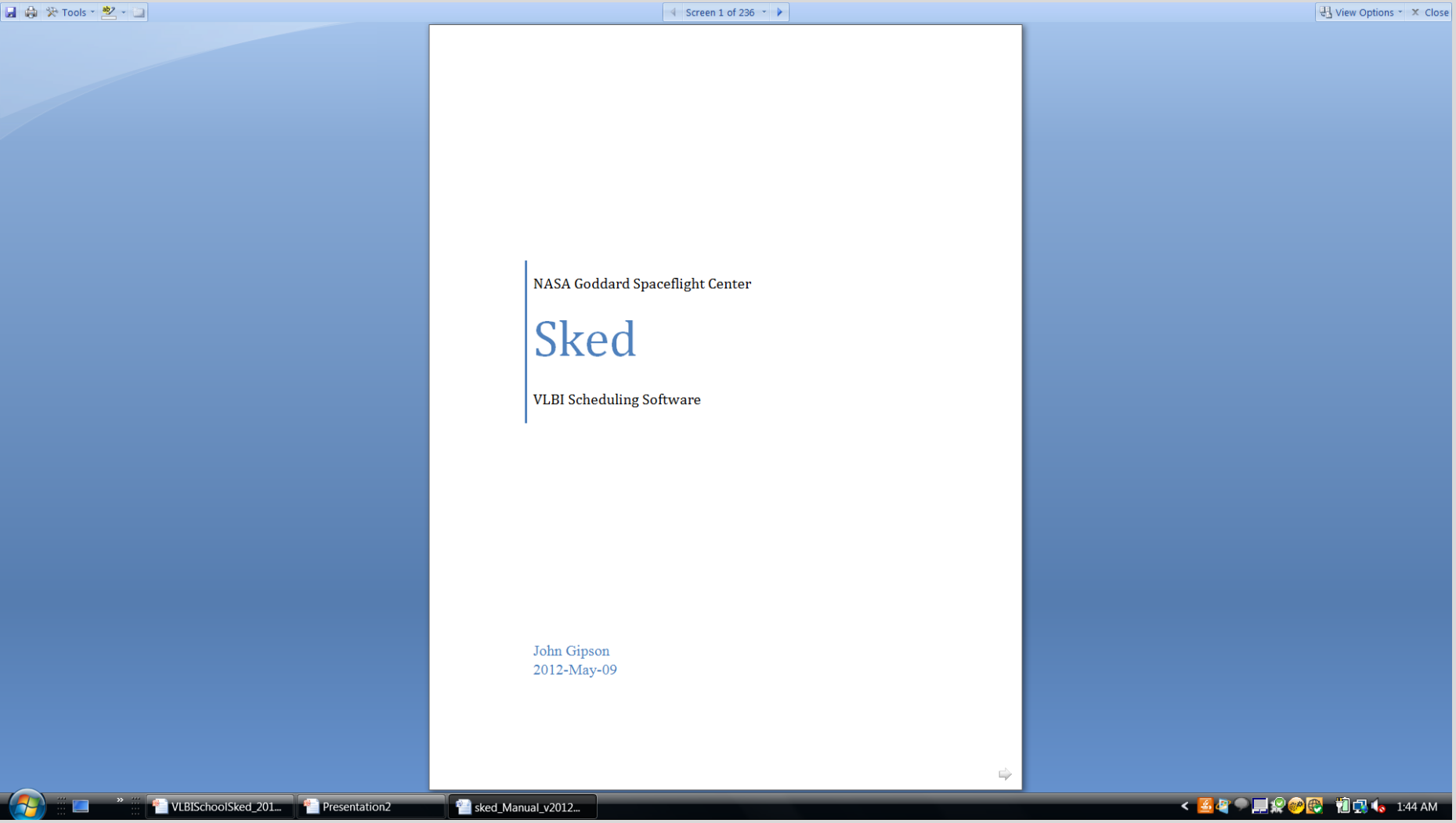
Brief History of Sked

History (Cont)	
1997	Numerous changes Support for VEX files Y2K fixes, new Java-based catalog interface S2 and K4 support
2002	**John Gipson takes over development/maintenance** Fill-in mode Best-N Source Selection
2004	**Linux port by Alexey Melnikov** Beginning of death of HP-sked Astrometric option: Specify min, max observing targets for set of sources.
2005	Full support of Disk-based recording: Mark5A, Mark5B, KK5
2006	Downtime: Ability to specify when an antenna is unavailable.
2009	Station limit raised from 32→64, and made parameter.

Brief History of Sked

History (Cont)	
2007	Resurrection of covariance optimization. Found and fixed various bugs in algorithms. Still not used routinely. By-product: sked can predict formal errors internally.
2008	Master command Read session setup from master file. Check session against master file.
2011	Introduction of MinAngle minor option. Limits closeness (in the sky) of the next source.
2012	Release of new Sked Manual. Update documentation *(only 16 years out of date!)* Prepare for VLBI2010 **Transitioning to native VEX format.**
Next	**What else do you want?**

Your Friend: Sked Manual



Sked Manual

Contains

- ***172 jam-packed pages full of thrills and chills***
- All of the sked commands with examples and screen shots.
- Algorithms used in sked
- Cookbook for making schedules

ftp::/gemini.gsfc.nasa.gov/pub/sked/

Sked Time Commands

Sked has several different ways of specifying the time. General format is:

YYDDDHHMMSS

DDD=Day of Year

Can insert ":" "-" or "/" for readability.

If the year and DOY are absent, assume current year and DOY time. The following are all equivalent.

- **09355170000**
- **09/355/17:00:00**
- **17:00:00**

Sked also recognizes several special times.

Special Sked Times	
., Now	Current time
^, Begin, Start	Beginning of experiment
*, End, Last	End of experiment or last scan scheduled, depending on context

Top Sked Commands

Command	Description
?	Sked help
List	List the schedule
Check	Check the schedule
Summ	Summarize schedule
Master	Check the schedule against the masterfile.
	Setup up the schedule using the masterfile.
SNR	Set, list SNR targets.
Station	Set, list stations
Source	Set, list sources
Freq	Set, list frequency modes
/ SRCNAME	Schedule a source manually
Auto	Automatic scheduling
Major	Set major options
Minor	Set minor options
Param	Set, list parameters
Down	Specify a station is unavailable
BestSource	Select the best sources for a given network.
Wr, wc	Write out a file.
Quit	Quit.

Listing, checking

Initial set up

Scheduling

Autosked parameters

Finishing up

Starting Sked

```
bootes: /home/jmg/schedules>> sked r1410

sked: Automatic/Interactive VLBI Scheduling Program
JMG/NRV/AEM HP/Linux SKED 2010Jan27
RDCTL02 - Reading system control file /usr/local/bin/skedf.ctl
RDCTL02 - Reading local control file skedf.ctl
Reading session: R1410
$OP
$SKED            659 scans
$SOURCES          60 sources
$FLUX
$STATIONS          7 stations
$CODES
```

Note VERSION

Local Configuration File

Global Configuration File

Configuration files specify location of catalogs

Starting Sked (Cont)

```
$HEAD
Re-reading CODES.      (1 frequency codes)
Re-reading HEAD.
Re-reading FLUX.
Re-reading $OP section
$PARAM
PRSET22 - Initializing schedule starting time to 2009-355-
   17:00:00
Source       Start       DURATIONS
name      yyddd-hhmmss    Ny   On   Sh   Tc   Wf   Wz   Zc
1611+343 09355-170000|   70 172      172 110   67     |
End of listing.
?
```

Getting Help in Sked

Typing ? at the sked prompt gives a summary listing of all sked commands.

```
? ?
 !              Shell to system                 /              Insert new scan
 ?              Info for <command>              ^              Previous line
 ABORT          Abandon all changes             ADD            Add station to scan
 ALLOCATION     Set, list tape allocation       ASTROMETRIC    Set desired #obs limits
 AUTOSKED       Auto generate schedule          BACK           Back up in the schedule
 BESTSOURCE     Find best sources               CATALOG        Start/get catalog info
 CHECK          Check schedule                  COMMENT        only used in scripts
 COVERAGE       Report coverage by station      CURRENT        List current scan
 DELETE         Delete scan(s)                  DOWNTIME       Set/list station Downtime
 EARLY          Set, list early start           EC             Create sked file & exit
 ELEVATION      Set, list el limits             ER             Write sked file & exit
 FLUX           Select or list flux             FREQUENCY      Set,list freq. modes
 HELP           List this screen                LIST           List scans
 MAJOR          List, select major opts         MAX            List max parameter values
 MASTER         Compare schedule, master        MEDIA          Set, list media types
 MINOR          List, select minor opts         MODIFY         Modify current scan
 MONITOR        Get sources to monitor          MOTION         Set, list tape motion
 MUTUALVIS      Display mutual vis.             NEXT           List next scan
 OPTIMIZATION   Set, list optimization          PARAMETERS     Set, list parameters
 PID            List Process ID #               PREVIOUS       List previous scan(s)
 PRINTL         Print file - landscape          PRINTP         Print file - portrait
 QUIT           Immediately w/o asking          REMOVE         Remove station
…..
```

About 80 sked commands in all.

Getting Help in Sked

For all commands if you type

"? cmd_name"

you will get more information about the syntax

Note: Can abbreviate sked command as long as abbreviation is unique. Hence "li" is the same as "list".

```
? ? li
 LIST [<range> [<source> [<subnet> [<ellim>]]]]
 <range> is ALL or <start>-<stop> or <start>#<number>
             <start>,<stop> are yydddhhmmss or ^(top),
.(current), *(end)  or first, last, begin, end,
```

Getting Help in Sked

For newer commands if you type

" Cmd ?" you will get more complete information.

```
? xlist ?
List, Clear, Toggle Extended listings
Usage: Xlist <option>
?          This screen
Clear      Clear all values
List       List values currently set
Off        Turn off extended listing
On         Turn on extended listing
--otions listed below--
AzEl       AzEl
Feet       Tape footage
HA         Hour Angle
Long       Long format for AzEl
Sky        Sky distribution info
SNR        SNR by baseline
Wrap       Include cable wrap
?
```

List Command

Note that "." = current time

```
? list .
Source       Start       DURATIONS
name      yyddd-hhmmss    Ny   On   Sh   Tc   Wf   Wz   Zc
1324+224 09355-173144|   46        43        46          |
End of listing.
? li beg-171000
Source       Start       DURATIONS
name      yyddd-hhmmss    Ny   On   Sh   Tc   Wf   Wz   Zc
1611+343 09355-170000|   70  172       172  110   67     |
1418+546 09355-170340|   57   99   78        99   48     |
1519-273 09355-170612|                117  117          |
0014+813 09355-170626|   43   43   43              43   43|
2141+175 09355-170915|   44   63             63   43     |
End of listing.
?
```

Summary command

summ _ _ _ li

```
? summ _ _ _ li
 SKED Summary from file ./r1566.skd for experiment R1566
     (all scans with at least one subnet station)
          4 chars/hour
  SOURCE | 0           3           6           9          12          15          18          21          | #SCANS #OBS #Obs/bl
 1738+499| x   x                   x  x             x    x        x           x x                          |     9    49   3.7
 1738+476| x x    x        x           x              x         x              x           x     x        |    10    59   3.2
 0202+319|        x x             x x   x               x x x   x             x               R  S         |    10    56   3.9
 1039+811|      x         x x               x                x                x                   x       |     7    57   3.8
 0059+581|x x x x x xx x xx x             x     x    x  x       x x x x x x xx x  x  x  x x x x xx  x x x |    35   291  24.1
 0104-408|                                                                                                |     0     0   0.0
 0201+113|  x      x                                                    xx    x   x     Rx  x       S x   x|    10    52   4.3
 0454-234|xx x x x x x x  xx x x    x                                          x  x x  x x x   x x x  x |    23   112  23.4
 0537-441|x x x xx  x x x xx x  xx x x                                                x xx x   x xx x  |    23    49  22.7
 0552+398|x   x x x x xx x x x x x x x  xx  x   x         x  x  x x x x xx x xx  x x x            x x x x |    36   329  26.4
 0556+238|R      S   x                                                 x                     x     x   x|     5    35   2.3
 0656+082|R           x S                                                      x            x       x   |     5     9   0.8
 OJ287   | x x   x x R  x  x S x x x  x x x   xx x x x                          x x x   x       x x      |    25   169  13.8
 1034-293|     x      x x   x      xx x x x  x  x x x x                                                |    14    36   8.2
 1057-797|x x x x  x x x x x x  x xx  xx  xx x x x x x x x                                x x xx  x  x x|    31    57  45.7
 1156+295| x x x x        x x  x    Rx  Sx x x x x x xx   x         x        x             x x x x x      |    24   151   9.8
 3C274   |         x             R   x   x x S   x x x                                              x     |     9    41   3.3
 1255-316|                                    x                                                           |     1     1   0.3
 1300+580|x  x x        x                            x          x  x  x xx  x  x x  x   x   x         x  |    17   122   8.1
 1334-127|    x   x  x   x x  x   x  x    x x x  x  x x  x  x x x  x x x                                |    21    71  12.3
 1424-418|                    x x x      x x  x  x x   x x x x  xx x  x x                                |    17    37  24.6
 1622-253|                         x  x  x  xx  x  x     x x x x x xx x x x x x x                      |    20    70  14.5
 1741-038|                   x   x  x x x  x    x  Rxx xSx x   x x x x  xx x xx xx x x x x xx           |    29   129  30.3
 3C371   |x xx  xx x   xx  x  x x x x x x x x     x   x           x       x x   x xx      xx x x  x x xx  |    33   283  21.3
 1923+210|                 x x  x    xx      x x  x    x   x xR x  x xS     x x xx x x x  x x x  x x x   |    27   133   8.8
 2052-474|                                         x  x                x  x  x  x x x xx x x x xx       |    15    17  13.8
 2209+236|    x     x x             x  x     x  x x     x                  R  x   Sx   x  x  xx  x      x |    17    81   5.5
 2255-282|                                                   x       x   x     x   xx x x      x         |     9    11   3.4
 2318+049|                                                                R           x S x              |     2    11   1.2
 2356+385|                                                                                 x             |     1     3   0.1
 0345+460|                                                                                                |     0     0   0.0
```

Summary command (cont)

summ _ _ _ li

```
2300-683|                                x  x  x    x   x        x  x                                    |     7     7   5.6
0308-611|                                         x x  x x x x x x     x       x  x x                    |    12    12   9.4
0332-403| x xx x x x x x x xx                                          x  xx x x  xx x x x x xx x|    25    87  46.6
0700-197|      x      x                                                      x         x    |     4     8   1.7
0743+277|        R     S                                                                    |     0     0   0.0
0925-203|                                                                                   |     0     0   0.0
1004-500|                                                                                   |     0     0   0.0
Total scans, obs:                                                                            703  3814

          4 chars/hour
 STATN  | 0           3           6           9          12          15          18          21          | #SCANS #OBS %OBS
FORTLEZA|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   232   534  14.0
HARTRAO |xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   195   476  12.5
MATERA  |xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   365  1277  33.5
NYALES20|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   403  1296  34.0
ONSALA60|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   372  1303  34.2
TIGOCONC|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   201   368   9.6
WESTFORD|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx|   343  1040  27.3
WETTZELL|xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx      xxxxxxxxxxxxxxxx|   401  1334  35.0
Average number of obs. per baseline per source(normalized by up-time) =   6.7
Min =    0.0  Max =  135.0 (Baseline Ma-Ny on 1741-038)   RMS =  12.1
Total time:       1440 minutes (  24.0 hours).
```

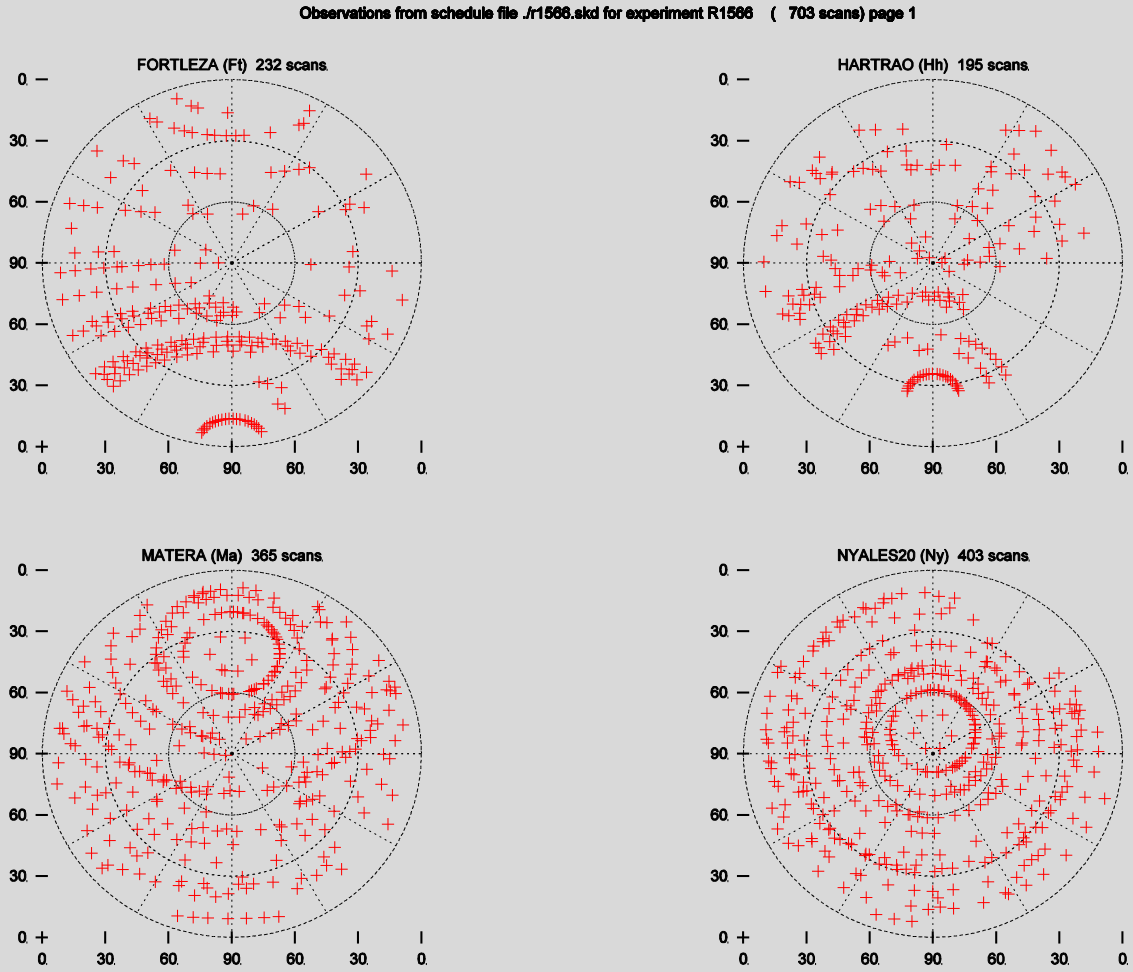
Summary command (cont)

summ _ _ _ li

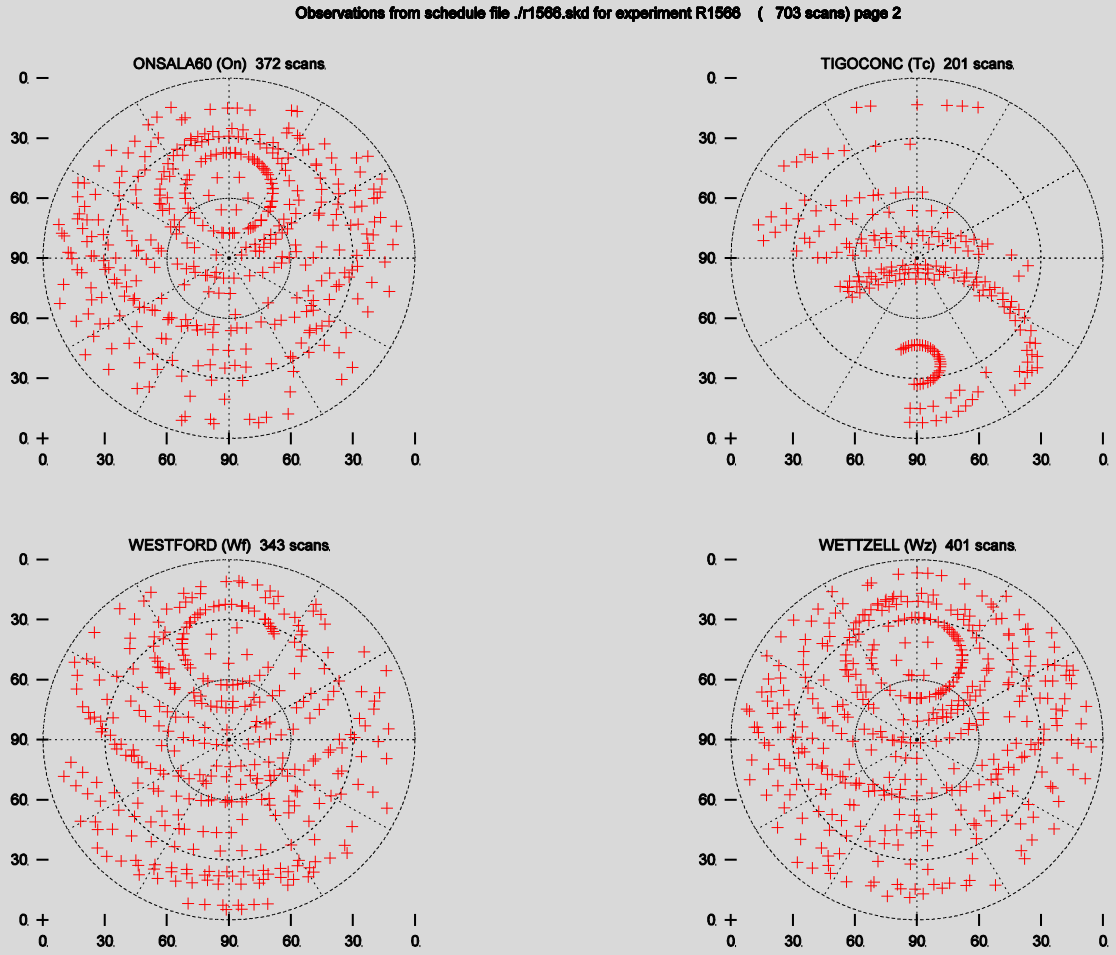
```
Key:      Ft=FORTLEZA   Hh=HARTRAO    Ma=MATERA     Ny=NYALES20   On=ONSALA60
           Tc=TIGO       Wf=WESTFORD   Wz=WETTZELL
                     Ft   Hh   Ma   Ny   On   Tc   Wf   Wz  Avg
 % obs. time:        39   30   51   44   55   48   52   32   44
 % cal. time:         3    2    4    5    4    2    4    5    4
 % slew time:        37   47   28   23   25    4   17   13   25
 % idle time:        21   20   16   27   15   45   26   49   28
 total # scans:     232  195  365  403  372  201  343  401  314
 # scans/hour :      10    8   15   17   16    8   14   17   13
 Avg scan (sec):   144  135  121   95  127  206  131   70  128
 # data tracks:      16   16   16   16   16   16   16   16
 # Mk5 tracks:       16   16   16   16   16   16   16   16
 Total GBytes:    1206  946 1586 1380 1704 1491 1620 1004 1367
 Total GB(M5):    1072  841 1410 1227 1514 1326 1440  893 1215
 # of tapes :       1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
 tape change times (hhmm):

Total number of tapes:   8.0  Total GBytes (M5) recorded:  9722.6
      # OF OBSERVATIONS BY BASELINE
   |  Ft   Hh   Ma   Ny   On   Tc   Wf   Wz  StnTotal
-------------------------------------------------------
Ft|       94   51   40   39  157  106   47     534
Hh|            86   44   60   87   32   73     476
Ma|                292  323   16  176  333    1277
Ny|                     333   12  243  332    1296
On|                           6  201  341    1303
Tc|                               82    8     368
Wf|                                   200    1040
Wz|                                          1334
 Number of  2-station scans:  188
 Number of  3-station scans:  170
 Number of  4-station scans:  149
 Number of  5-station scans:  158
 Number of  6-station scans:   26
 Number of  7-station scans:   12
 Number of  8-station scans:    0
```

Summary command (cont2)

```
Summ _ _ _ pol
```



Summary command (cont2)



Station Selection

```
? Stat Sel
```

Station	Rack	Recorder	Bnds	Station	Rack	Recorder	Bnds
AIRA	K4-1	K5	XS	ALGOPARK	VLBA4	Mark5A	XS
ALGOPARK	none	S2	XS	ARECIBO	unknown	unknown	XS
. . .							
KASHIM34	K4-1	K5	XS	KASHIM11	K4-2	K5	XS
KATH12M	VLBA4	Mark5A	XS	KAUAI	unknown	unknown	XS
KOKEE	**VLBA4**	**Mark5A**	**XS**	KOKEE	none	S2	XS
KP-VLBA	VLBA	Mark5A	XS	KOGANEI	K4-2	K5	XS
LA-VLBA	VLBA	Mark5A	XS	MADRID64	unknown	unknown	XS
MARCUS	unknown	unknown	XS	MATERA	Mark4	Mark5A	XS
MCMURDO	unknown	unknown	XS	**MEDICINA**	**Mark4**	**Mark5A**	**XS**
MEDICINA	Mark4	Mark5A	CC	METSAHOV	VLBA	Mark5A	XS
MIAMI20	unknown	unknown	XS	MIURA	K4-2	K4-2	XS
. . .							
WETTZELL	**Mark4**	**K5**	**XS**	YARRA12M	VLBA4	Mark5A	XS
YEBES40M	VLBA4	Mark5A	XS	ZELENCHK	VLBA4	Mark5A	XS
ZELENCHK	none	S2	XS				

```
Cursor key or ijkl    <E>nd     <F>irst    <N>ext     <P>rev     <R>efresh
```

Station List

```
? Stat li
```

```
STATION     AXIS  SLEW RATES   SLEW CONST  LIMIT STOPS
  1 K Kk KOKEE    AZEL 117.0 117.0     9    9    270.0    810.0      0.0     89.7
     Position     159.67 WEST         22.13 NORTH   Occupation code: 72983001
  2 A Ma MATERA   AZEL  90.0 100.0    20   20    277.0    803.0      4.0     88.0
     Position     -16.70 WEST         40.65 NORTH   Occupation code: 72435701
  3 B Ny NYALES20 AZEL 120.0 120.0     9    9    271.0    809.0      0.0     89.7
     Position     -11.87 WEST         78.93 NORTH   Occupation code: 73313301
     Horizon    0.  2.0  10.  4.0  60.  4.0  65.  2.0 120.  2.0 128.  5.0 150.  5.0
              152.  7.0 162.  9.0 176. 12.0 190.  5.0 226.  8.0 230.  6.0 250.  6.0
              256.  7.0 266. 12.0 270. 12.0 290.  4.0 310.  2.0 360.  2.0
  . . .
More sked output ...

#    ID  STATION    Band SEFD   Band SEFD  DAT name  ID  Rack     Recorder
 1 K Kk  KOKEE       X    900.   S    750.  KO-VLBA   102 VLBA4    Mark5A
 2 A Ma  MATERA      X   3500.   S   2000.  MATERA    119 Mark4    Mark5A
 3 B Ny  NYALES20    X    900.   S   1200.  RICHMOND  66  Mark4    Mark5A
 4 C Tc  TIGOCONC    X  20000.   S  15000.  TIGO      70  VLBA4    Mark5A
 5 D Ts  TSUKUB32    X    320.   S    360.  TSUKUB32  108 K4-2/M4  K5
 6 E Wf  WESTFORD    X   1500.   S   1400.  WESTFORD  07  Mark4    Mark5A
 7 F Wz  WETTZELL    X    750.   S   1115.  WETTZELL  33  Mark4    Mark5A
```

Source, Freq Commands

Work very similar to Station command.

Source Sel

Allows you to select sources.

Source Li

Lists the sources

Freq Sel

Allows you to select frequency modes

Freq Li

Lists the frequency modes.

DOWNTIME

Frequently stations are unavailable for part of a session. The most common reason is that the station drops out to **participate in an Intensive.**

In the past, schedulers had to “stop” and “start” the station manually.

1. Generate schedule to start of downtime.
2. Remove station from subnet.
3. Generate schedule until just after end of downtime.
4. Put station back in subnet.

The downtime setting makes this unnecessary.

The user **specifies which stations will be down, and for how long.**

Downtime Command

Down without any arguments lists the current downtime settings.

```
? down
Wz-Kk 2010-074-18:15:00 2010-074-19:45:00
?
```

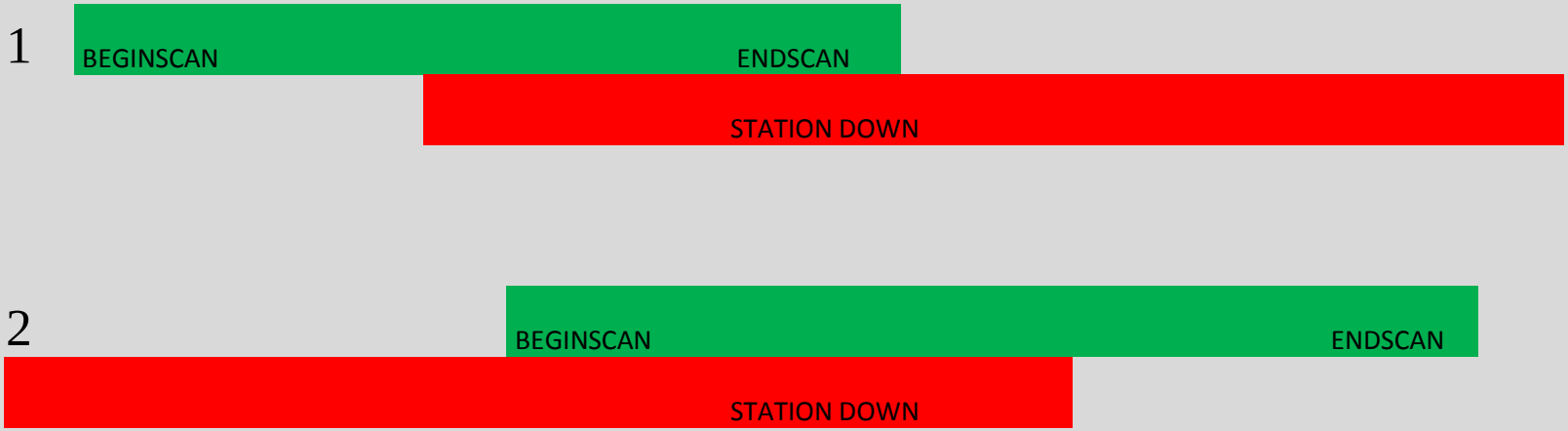
You can easily remove a station from the downtime listing.

```
? Down Wz off
? Down
Kk 2010-074-18:15:00 2010-074-19:45:00
?
```

To add a station to the downtime listing you must specify the station and stop and start times.

```
? down wz 200000 210000
? down
Kk 2010-074-18:15:00 2010-074-19:45:00
Wz 2010-074-20:00:00 2010-074-21:00:00
?
```

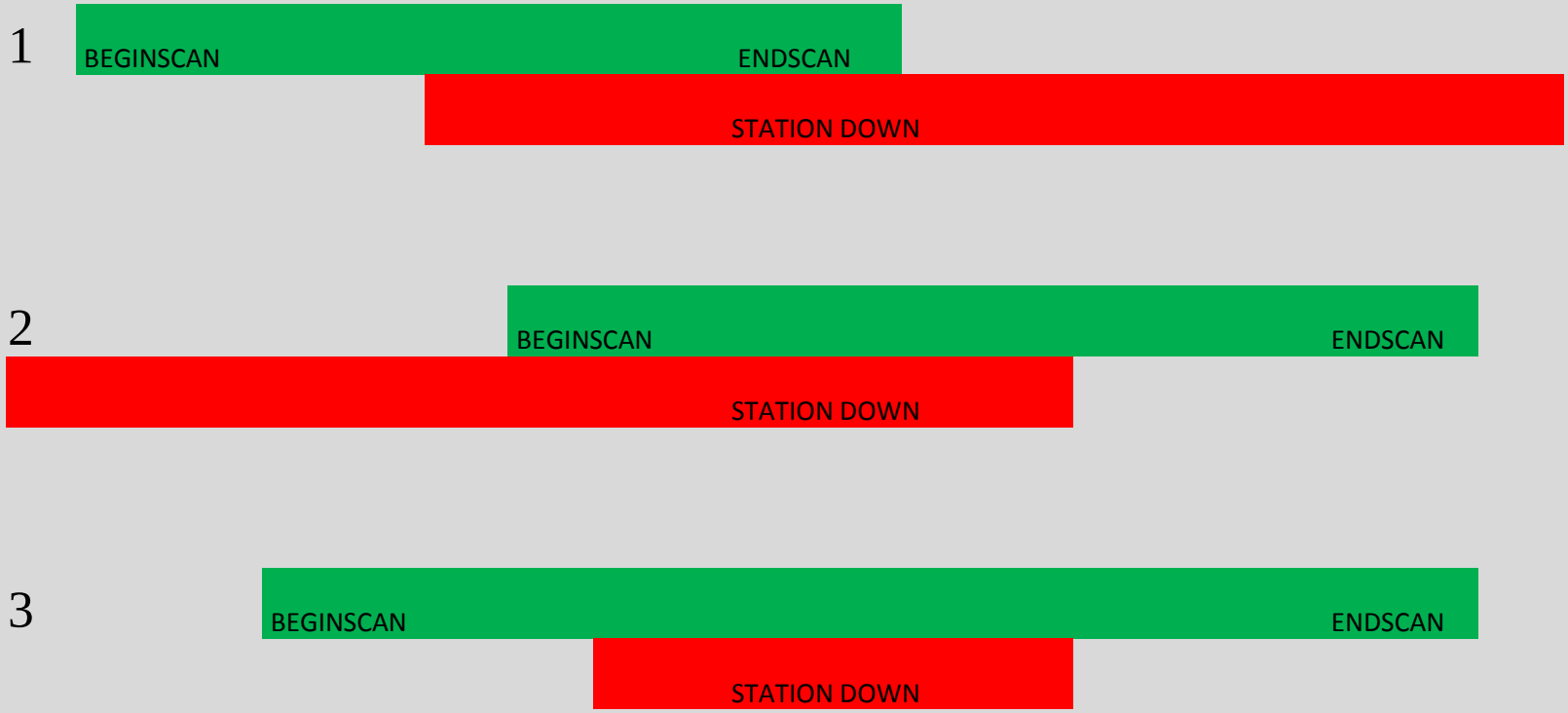
Downtime: How it works.



A scan is rejected because the station is down if:

1. **The end of the scan is in downtime**.
2. **The beginning of the scan is in downtim**

Downtime: How it works.



A scan is rejected because the station is down if:

1. **The end of the scan is in downtime**.
2. **The beginning of the scan is in downtime**
3. **There is downtime in the middle of a scan**

Master Command: Motivation

Before 2008, users would set up a schedule by doing the following:

1. Start with a similar schedule: `cp r1412.skd r1413.skd`
2. For the new schedule, determine the following from the masterfile:
   A. Start time;
   B. Stop time;
   C. Stations;
3. Modify the new schedule accordingly.
4. Change the $EXPER parameter in the schedule.
5. Make the schedule.

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   A. Start time;
   B. Stop time;
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3. Modify the new schedule accordingly.
4. Change the $EXPER parameter in the schedule.
5. Make the schedule.

There were several schedules with wrong stations or incorrect stop and start times.

Master Command

The Master command checks the schedule against the masterfile.

It uses the $EXPER parameter in the *sked* file as a key.
There are two modes:

1. **Master check**: Compares *sked* file against master, and reports discrepancies.
2. **Master get:** Reads the master file to determine a) start and stop time; b) stations; c) Correlator; d) Scheduler. Puts this in the schedule file.

This makes generating a schedule much **easier, and reduces the chance of error.**

Some schedulers have complained that this makes sked *too* easy!

Master Check

```
? master check
 Finding session R1410
 Checking /shared/gemini/ftp/pub/master/master10.txt
 Checking /shared/gemini/ftp/pub/master/master10-int.txt
 Checking /shared/gemini/ftp/pub/master/master09.txt
master_cmd: schedule and master file agree!
?
```

Master Check

```
?  master get
 Finding session R1411
 Checking /shared/gemini/ftp/pub/master/master10.txt
 Checking /shared/gemini/ftp/pub/master/master10-int.txt
 Checking /shared/gemini/ftp/pub/master/master09.txt
master_cmd: Initializing experiment.
START: 2009/362-17:00
END:   2009/363-17:00
Stations:
    Station  Rack     Recorder Bnd
  1 MATERA   Mark4    Mark5A   XS
  2 NYALES20 Mark4    Mark5A   XS
  3 SESHAN25 VLBA4    Mark5A   XS
  4 TIGO     VLBA4    Mark5A   XS
  5 WESTFORD Mark4    Mark5A   XS
  6 WETTZELL Mark4    Mark5A   XS
  7 ZELENCHK VLBA4    Mark5A   XS
Writing out station select file for SKED.
/shared/gemini/ftp/pub/sked/catalogs/equip.cat: MATERA NYALES20 SESHAN25 TIGO
WESTFORD WETTZELL ZELENCHK
MAKE_MODE_LIST: Found mode 256-16(R1)        GEOSX       8.0   16.0  32-16-2-1
```

Master Get (cont)

Note warning message

```
MAKE_MODE_LIST: Found mode 256-16(R1)        GEOSX       8.0   16.0  32-16-2-1
Opt est parameters initialized to off.
Following stations are new:
Name      EL  Early   Tape
NYALES20  5.0   10 START&STOP
SESHAN25  5.0   10 START&STOP
ZELENCHK  5.0   10 START&STOP
Some baselines have 0 SNR! Please set.
HINT:  SNR Subnet Band Value
 Minimum SNR by baseline for multi-baseline scans
     X-band (margin   5)     S-band (margin   3)
     Ma  Ny  Sh  Tc  Wf  Wz          Ma  Ny  Sh  Tc  Wf  Wz
 Ny   0                          Ny   0
 Sh   0   0                      Sh   0   0
 Tc  15   0   0                  Tc  12   0   0
 Wf  20   0   0  15              Wf  15   0   0  12
 Wz  20   0   0  15  20          Wz  15   0   0  12  15
 Zc   0   0   0   0   0   0      Zc   0   0   0   0   0   0
?
```

Types of Scheduling

Two modes of scheduling:

1. **Manual mode.** User specifies everything about a scan.
2. **Automatic mode.** Sked determines best scan based on heuristic rules. These rules are a distillation of what works.

These modes can be intermixed. Sked can run in auto-mode for a while, then scheduler can insert scans by hand, and return to auto-mode.

Manual Scheduling

User specifies everything about the scan. General form:

`/ src_name [start time] [sub Subnet] [dur duration]`

src_name is required. The terms in brackets are optional. If they are omitted, sked will try to schedule a scan with the maximum number of stations which meets the SNR targets, as soon as possible after the current time.
If it detects problems (doesn't meet SNR targets, a station is unavailable, etc.,) sked will notify the user and ask if they want to proceed.

Example:

```
/ 3c84 start 17:30:00 sub NyWzWt
```

A typical R1 has about 900 scans→900 commands if scheduling manually.

Automatic Mode

In automatic mode, the user instructs sked to schedule a network until some endtime.

`? Auto` *`subnet endtime`*

Example:

`Auto KkWfNyMa 19:30:00`

Generate scans with Kokee, Westford, NyAlesund, Matera until 19:30:00.

Example:

`Auto _ End`

Generate scans with full subnet from the current time to end of the session.
A single command in automatic mode instead of 900 in manual mode.

If *`endtime`* is not specified, sked will schedule a single scan:

`Auto _`

Automatic Mode

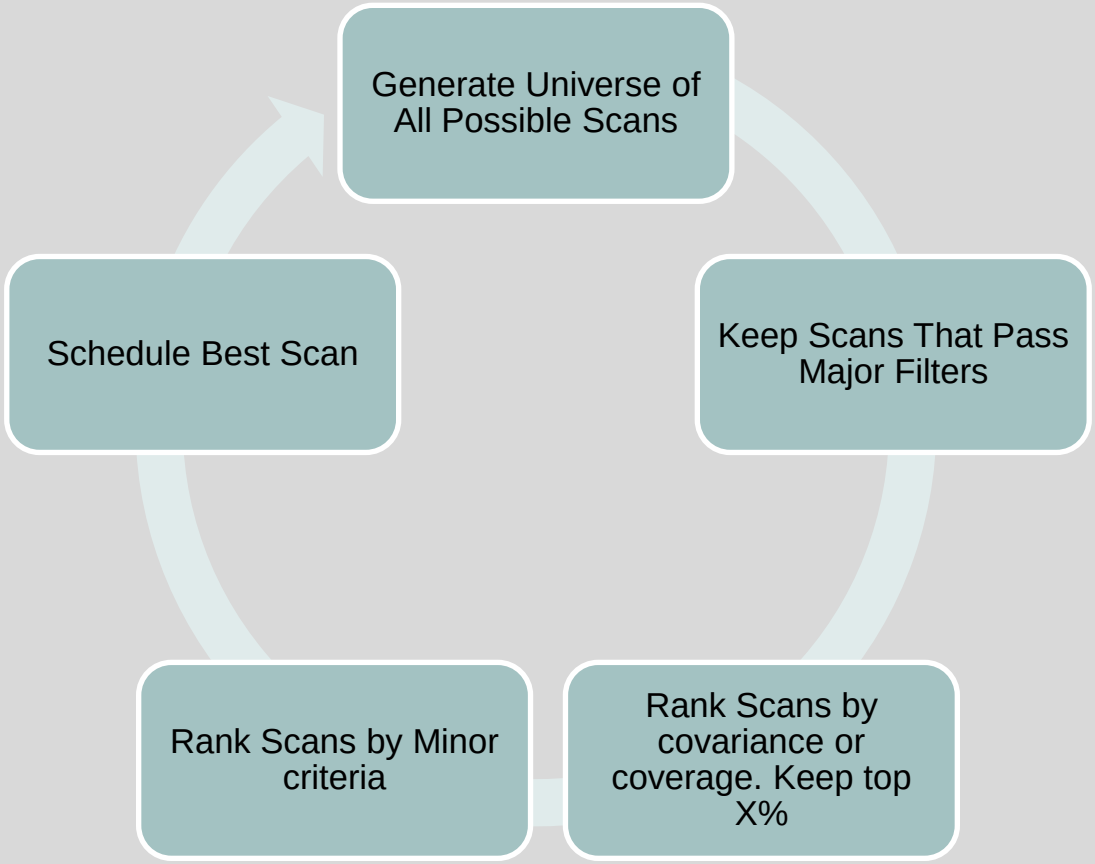
In automatic mode, user specifies general parameters for scheduling the session. *Sked* generates and schedules the scans.

Two kinds of parameters (or options):

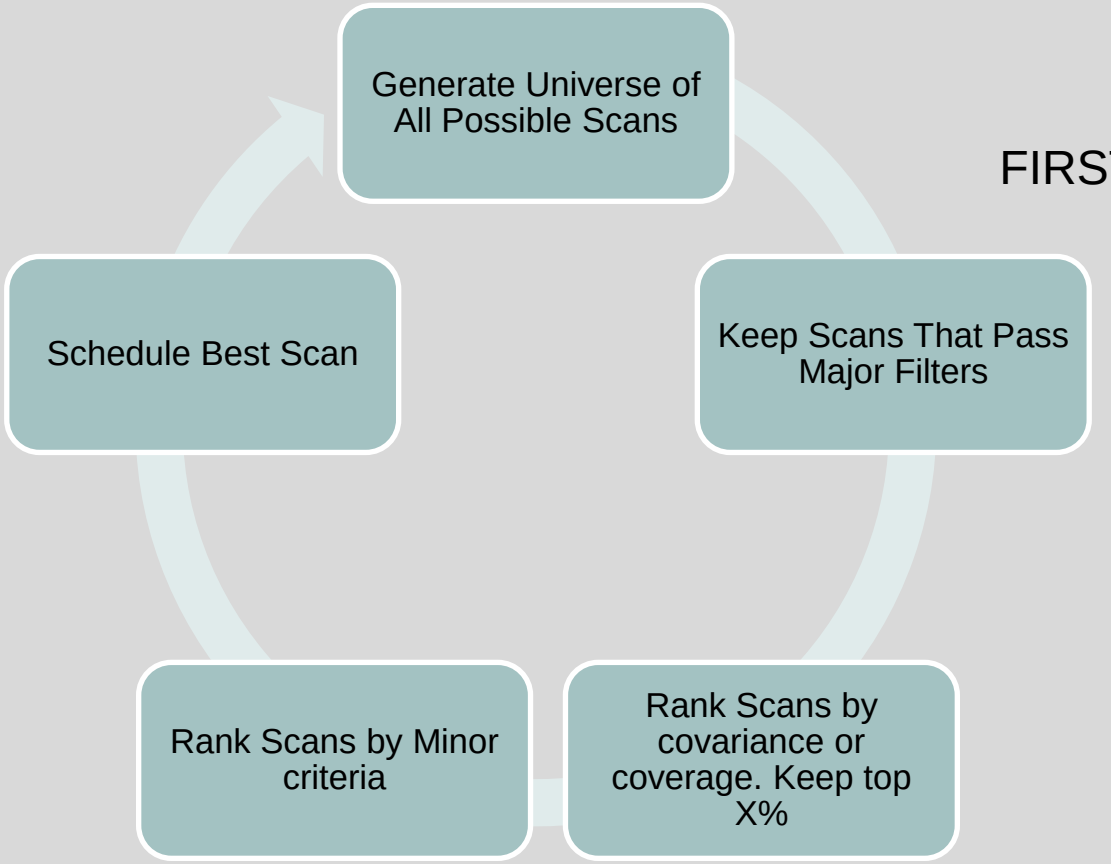
1. **Major options** determine what scans are considered for inclusion.
2. **Minor options** determine the *ranking* of the resultant scans. The highest ranked scan is selected.

Automatic Scheduling

START

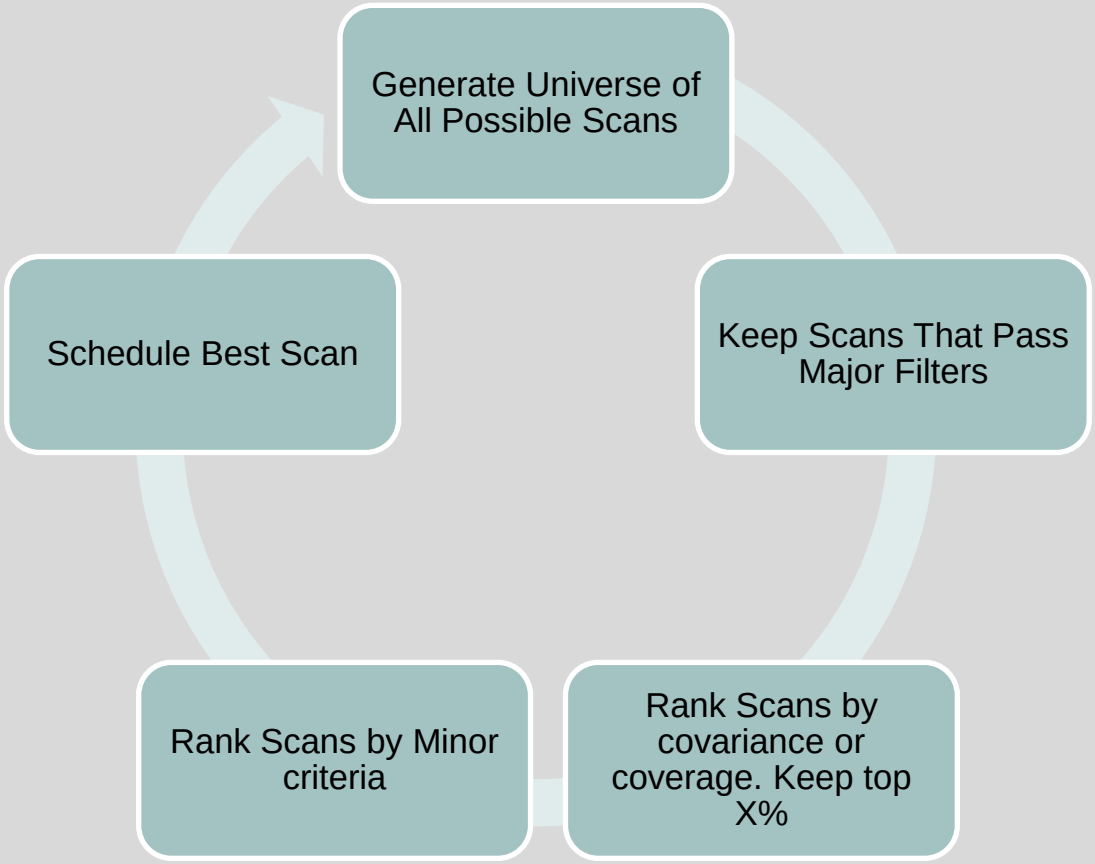


Automatic Scheduling



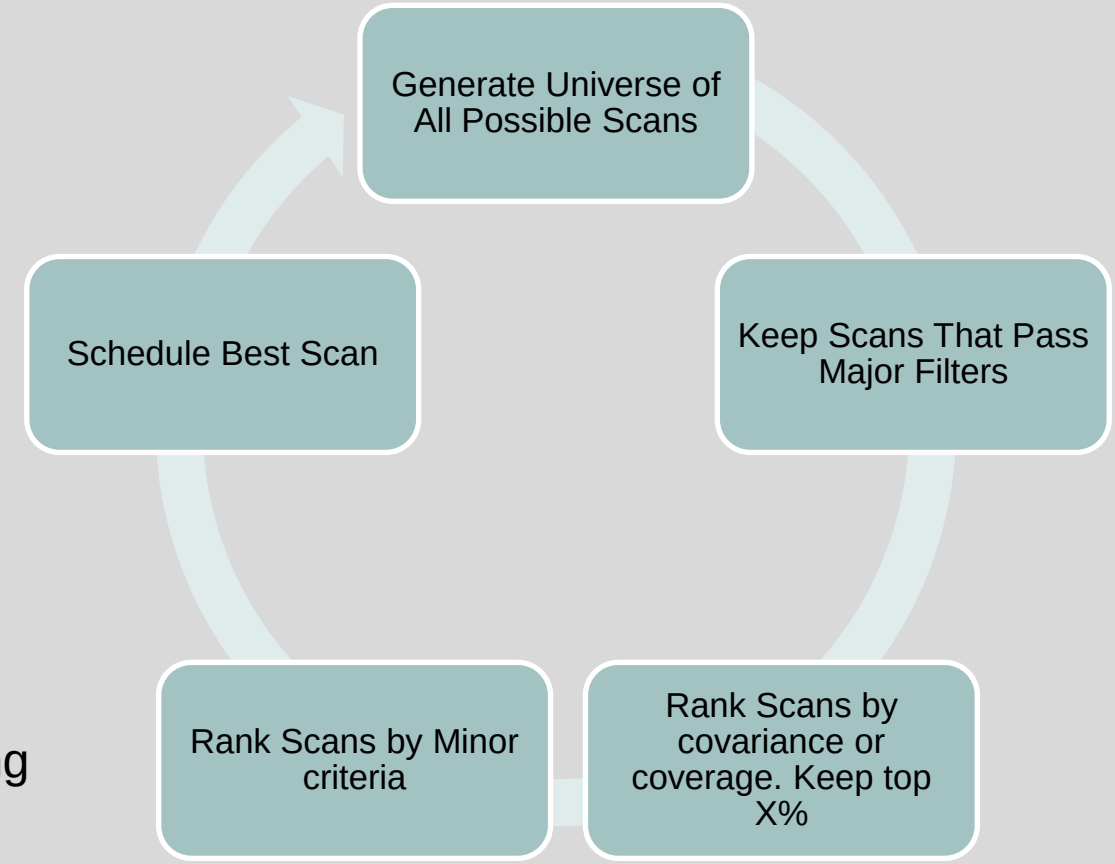
FIRST CUT

Automatic Scheduling



SECOND CUT

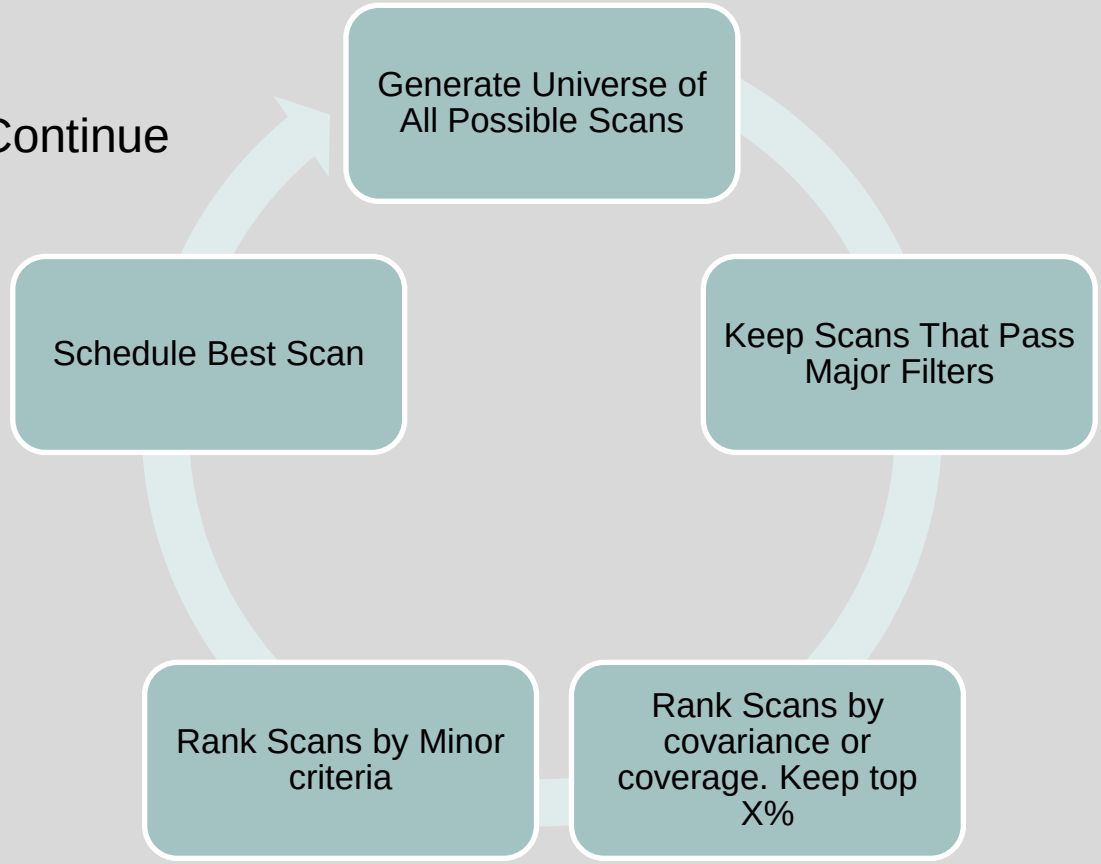
Automatic Scheduling



Scoring

Automatic Scheduling

START



More time? Continue

Major Options

Option	Description
Subnet	Current subnet. Only stations in this subnet are scheduled.
SkyCov	Do initial ranking by sky coverage (Yes) or covariance (No).
AllBlGood	Do all baselines in a scan need to meet the target SNR to schedule?
MinAngle	Minimum angular distance between successive observations.
MinBetween	Minimum time (minutes) between observations of the same source.
MinSunDist	Minimum angular distance of a source with respect to the sun. If the distance is less than this, the source will not be considered for scans.
MaxSlewTime	Maximum time to allow an antenna to slew. If the slew time at a station is longer than this, the source is not considered visible at that station.
TimeWindow	Window of time (hours) to consider in computing sky coverage or covariance.
MinSubNet	Only schedule scans if the subnet is at least this size.
NumSubNet	Maximum number of subnets to try to schedule at one time.

Major Options

Option	Description
Best	Scans are ranked by Sky coverage or covariance, and the top *Best%* of the scans kept for further consideration.
FillIn	Turn on fill in mode.
FillMinSub	Minimum size of fill-in subnet.
FillMinTime	Minimum time a station must be idle to be considered for fill-in mode.
FillBest	This is the same as “Best”, but for the fill-in scans. If we are in fill-in mode, the top *FillBest% scans are kept for further consideration.*
Add_ps	Noise to add (in an RSS sense) to the normal observations. This may affect the ranking of scans by covariance. It also affects the formal errors calculated in the the `solve` interface.
SNRWts	If yes, weight the observations by SNR. If not, consider all observations the same. This only affects the `solve` interface.

Major Options (cont)

The general format for setting a major option is:

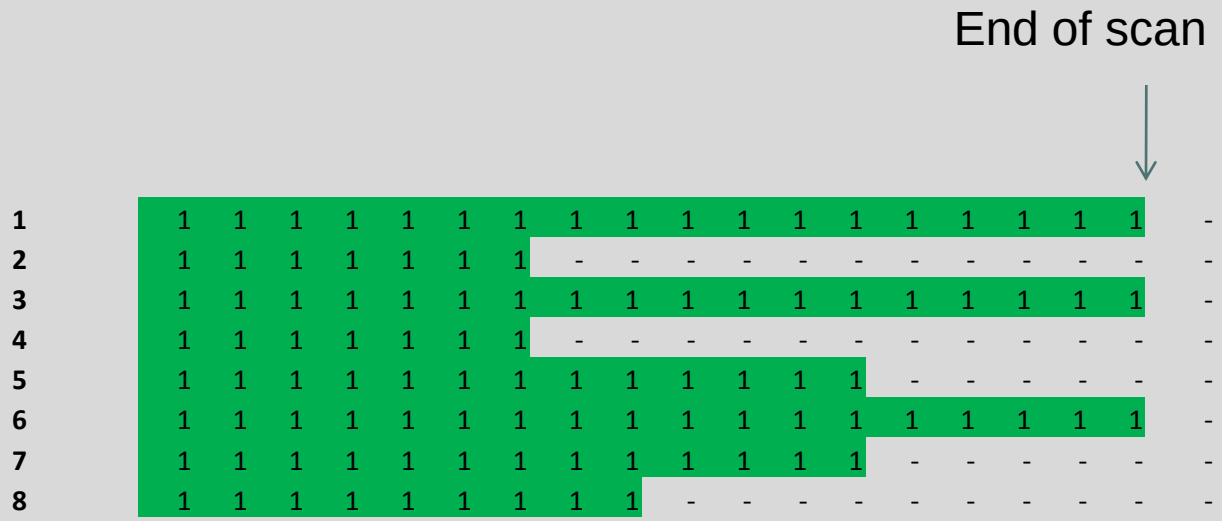
```
Major Option Value(s)
```

Example:

```
Major MinAngle 30
```

Sets the minimum angle between observations to 30 degrees.

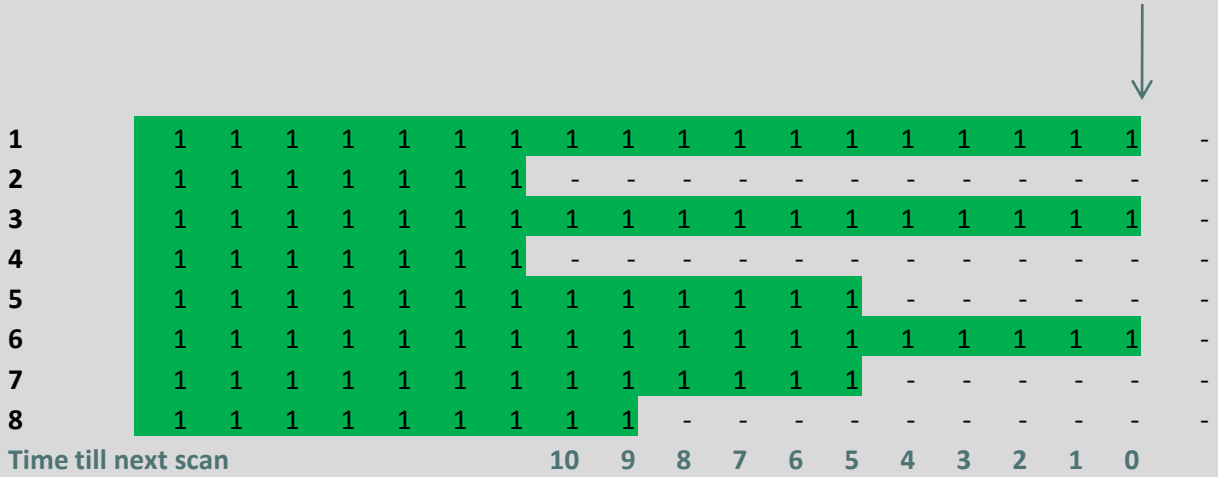
Major Option: Fill In Mode



By default, *sked* tries to schedule full net-work scans.
The next scan would start as soon after the end of the scan as possible.
This can leave a lot of time when stations are not observing.
“Fill In Mode” attempts to decrease idle time by filling in the gaps.

Fill In Mode

When to start fill-in scan?



Strategy: Find possible starting times, and calculate how much idle time we could eliminate.

Idle Stations	# Stations	Time Left	Maximum Fill Time
2,4	2	10	20
2,4,8	**3**	**8**	**24**
2,4,5,7,8	5	4	20

2nd option maximizes possible fill time

Fill In Mode

Allowable spillover

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-		
2	1	1	1	1	1	1	1	-	-	2	2	2	2	2	2	2	2	-	-		
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-		
4	1	1	1	1	1	1	1	-	-	2	2	2	2	2	2	2	-	-	-		
5	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3		
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-		
7	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3		
8	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-		

Repeat until all the idle time is filled.

Fill In mode results in:

1. More observations
2. Fewer large network scans
3. More smaller network scans
4. More scans per station

Fill In Mode

Allowable spillover

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
2	1	1	1	1	1	1	1	-	-	2	2	2	2	2	2	2	2	-	-
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
4	1	1	1	1	1	1	1	-	-	2	2	2	2	2	2	2	-	-	-
5	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
7	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3
8	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	-	-

Repeat until all the idle time is filled.

Fill In mode results in:

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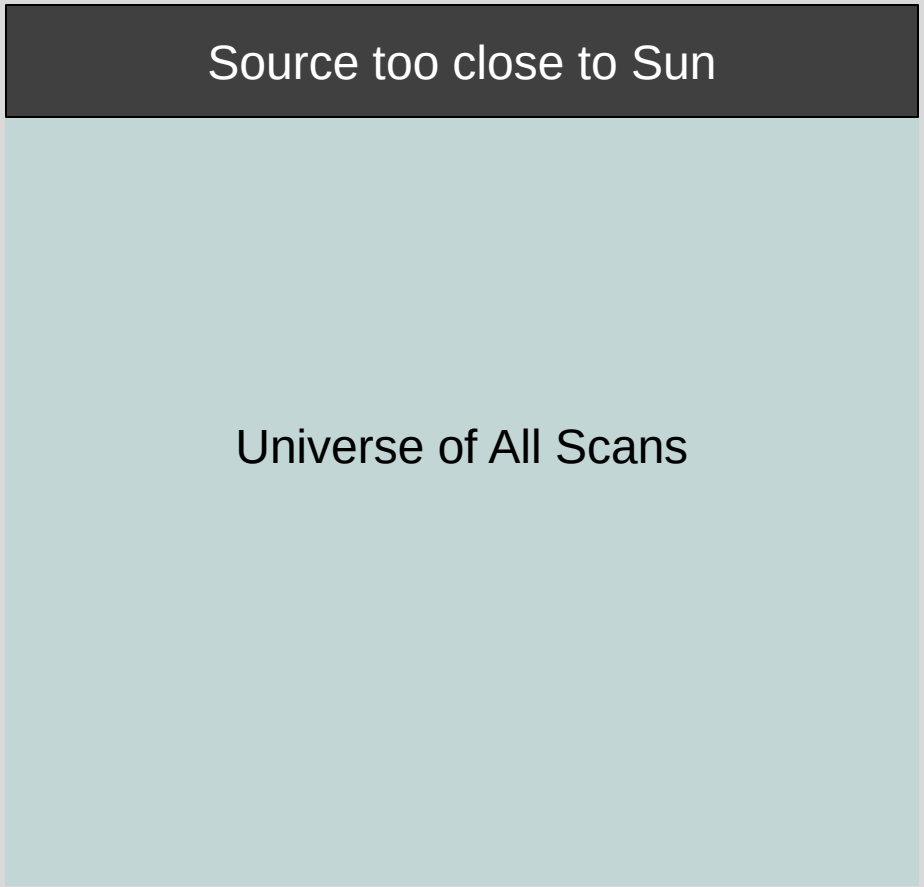
3. More smaller network scans

How Major Works

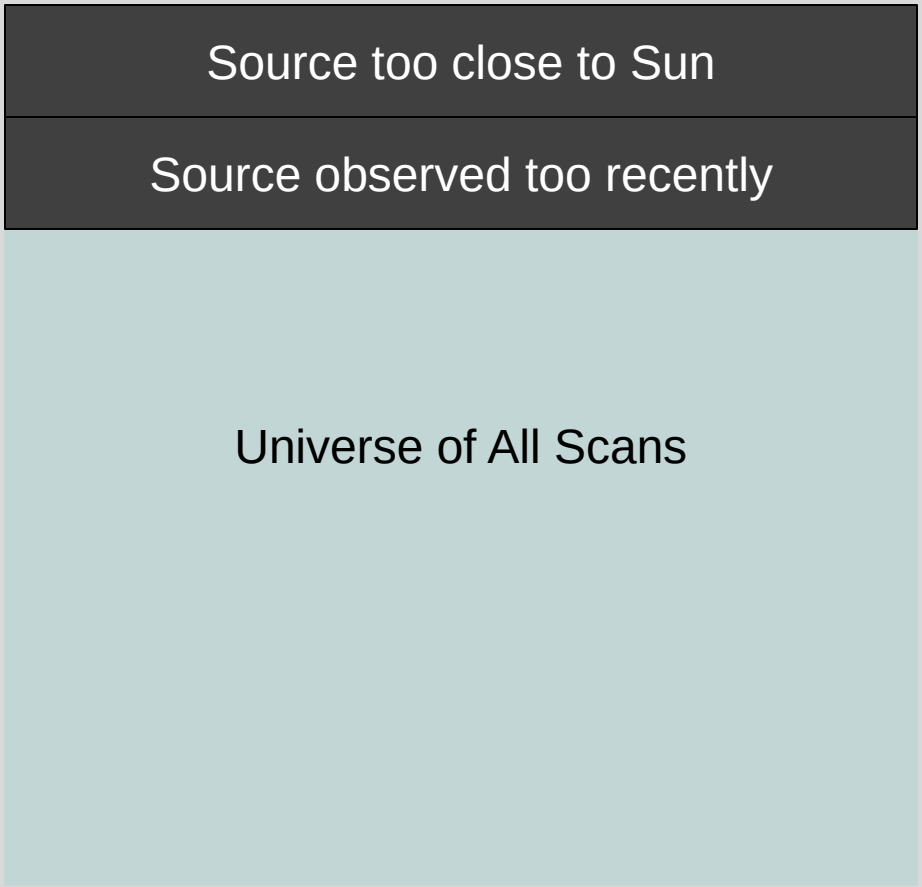
Universe of All Scans

How Major Works



Start by eliminating sources.

How Major Works



Continue to eliminate sources

Questions & Commen

Source too close to Sun

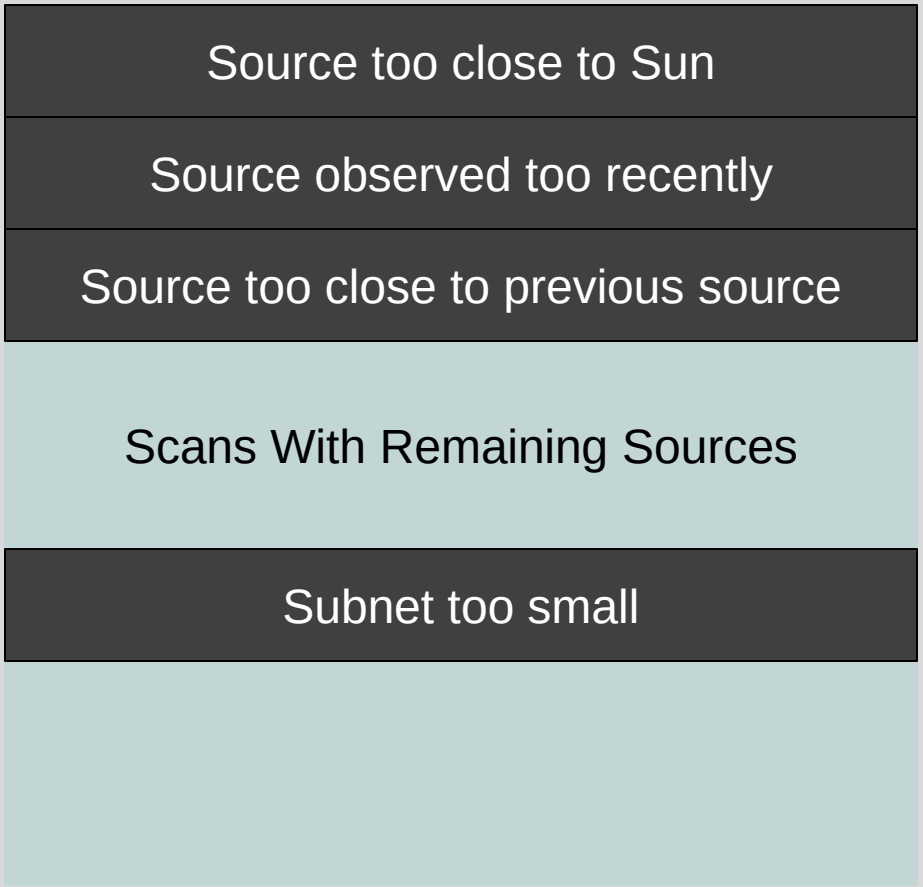
Source observed too recently

Source too close to previous source

Scans With Remaining Sources

Arrive at set of sources to consider.
Now generate Scans with these sources.

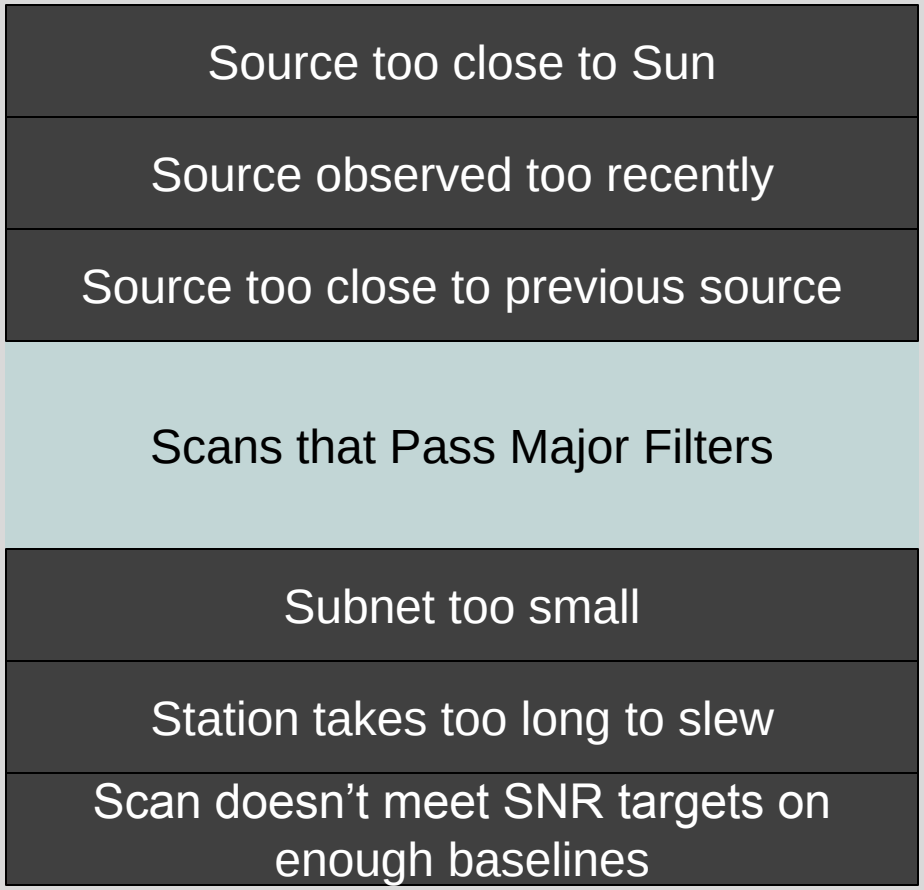
Questions & Commen



Use Major filters and SNR targets to eliminate scans.

Start throwing scans away.

Questions & Commen



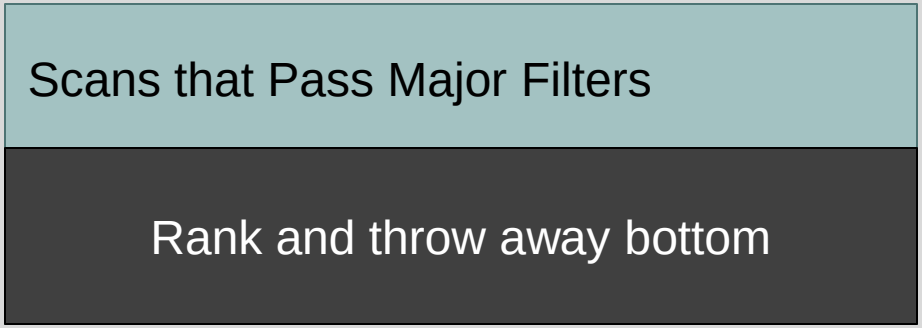
Use Major filters and SNR targets to eliminate scans.

Left with a much smaller universe.

Major Options

Scans that Pass Major Filters

Major Options



1. Rank sources by **sky-coverage** or by **covariance**.
2. Keep top X% (usually 25-50%) and throw away rest

How to rank and what percentage to keep are controlled by the Major Options **SkyCov** and **Best**

Minor Options

Option	Description
Astro	Prefer scans with astrometric sources.
BegScan	Prefer scans which start earlier.
EndScan	Prefer scans which end earlier.
LowDec	Prefer scans with low declination sources.
NumLoEl	Prefer scans which involve sources which are low at one or more sites.
NumRiseSet	Prefer scans involving sources which are setting at one or more sites.
NumObs	Prefer scans with more observations.
SkyCov	Prefer scans with better sky coverage.
SrcEvn	Try to even up the distribution of observations by source.
SrcWt	Prefer scans involving certain sources.
StatEvn	Try to even up the distribution of observations by stations.
StatIdle	Prefer scans which minimize station idle time.
StatWt	Prefer scans involving particular stations.
TimeVar	Prefer scans where all stations end close to the same time.

Scoring with Minor Options

1. A minor option can be either ON or OFF.
2. The “ON” options are assigned weights by the scheduler.
3. For each minor option that is on, *sked* calculates a score.
4. The final score for each scan is the weighted sum.

$$Total\ Scan\ Score = \sum_{options} Wt_j Score_j$$

The “best scan” is the scan with the highest total score.

This is the scan that is scheduled.

Minor Options (Cont)

All of the minor options are things that are generally considered ‘good’, or are desirable in some circumstances.

You can turn the minor options on or off, and vary the weight of the different options to emphasize different characteristics.

The command to do so is very similar to the Major Options:

```
Minor Option [ON|OFF]  Weight Aux
```

9 Step R1 Schedule

```
jmg/scedules>cp r1412.skd r1413.skd
```
Start with a similar schedule

```
jmg/schedules>sked r1413.skd
```
Open it in sked.

… sked displays info about schedule

```
? param exper r1413
```
Change the experiment key

```
? master get
```
Initialize the session using the masterfile

… sked displays information about the new session.

… sked prompts you if it finds potential problems.

```
? best 60
```
Select the best sources for this session

… sked finds the best sources, and reports problems.

```
? Down kk-wz 18:00-20:00
```
Set downtime because of intensives.

```
? Auto _ end
```
Generate schedule until end of the session

…sked generates scans and schedules them, displaying the progress on the screen.

```
? Wr
```
Write out the schedule

```
? Quit
```

What a Sked File Looks like

A Sked file is an ASCII File comprised of several sections.

```
$EXPER G12104
$PARAM
DESCRIPTION GGAO DEMONSTRATION
SKED_VERSION 2011Dec02
SKED_CREATE_DATE 2012/05/01 15:24:48
SCHEDULER  GSFC   CORRELATOR BONN START 2012129050000 END   2012130050000
CALIBRATION     0 CORSYNCH         3 DURATION      196
EARLY           0 IDLE             0 LOOKAHEAD      20
MAXSCAN       200 MINSCAN         15 MINIMUM         0
….
$OP
XP F YP F DUT F PSI F EPS F
Z AOFF F ARAT F COFF F CRT1 F CRT2 F X F Y F Z F
E AOFF F ARAT F COFF F CRT1 F CRT2 F X F Y F Z F
  1 F    2 F    3 F    4 F    5 F    6 F    7 F    8 F
….
$SKED
…
$MAJOR
```

Parts of Sked File

Parts of a Sked File	
$EXPER G12104	Session name
$PARAM	Session parameters: Start & Stop time, SNR targets, …
$OP	Used in Covariance
$DOWNTIME	Indicates when stations are unavailable.
$MAJOR $MINOR	Determines how sked chooses scans.
$ASTROMETRIC $SRCWT	List of sources to preferentially observe
$STATWT	List of stations to preferentially observe.
$SOURCES	Sources and positions
$FLUX	Source flux models
$STATIONS	List of stations, positions, antennas, equipment, horizon mask
$CODES	Frequency setup
$HEAD	Related to tape recording. Now obsolete.
$SKED	Scans

Demonstration of Using Sked

In this section I demonstrate how to use sked by generating some simple schedules.

Questions & Comments

?

Special Cases

Q: What happens if a sked stops before finishing the schedule?

A: This frequently happens if there are no legal scans left. Try scheduling a few scans and then restarting, or relaxing some of the constraints (MinAngle, MinBetween, Best)

Q: My schedule has very observations on station XYZ. What can I do.

A: This frequently happens with smaller stations. Try using the Minor Option StatWt together with the StatWt command to weight scans with this station more heavily.