



Scheduling a VLBI Session

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Prerequisites & Goals

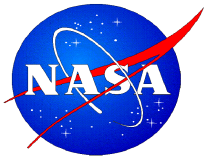


Prerequisite:

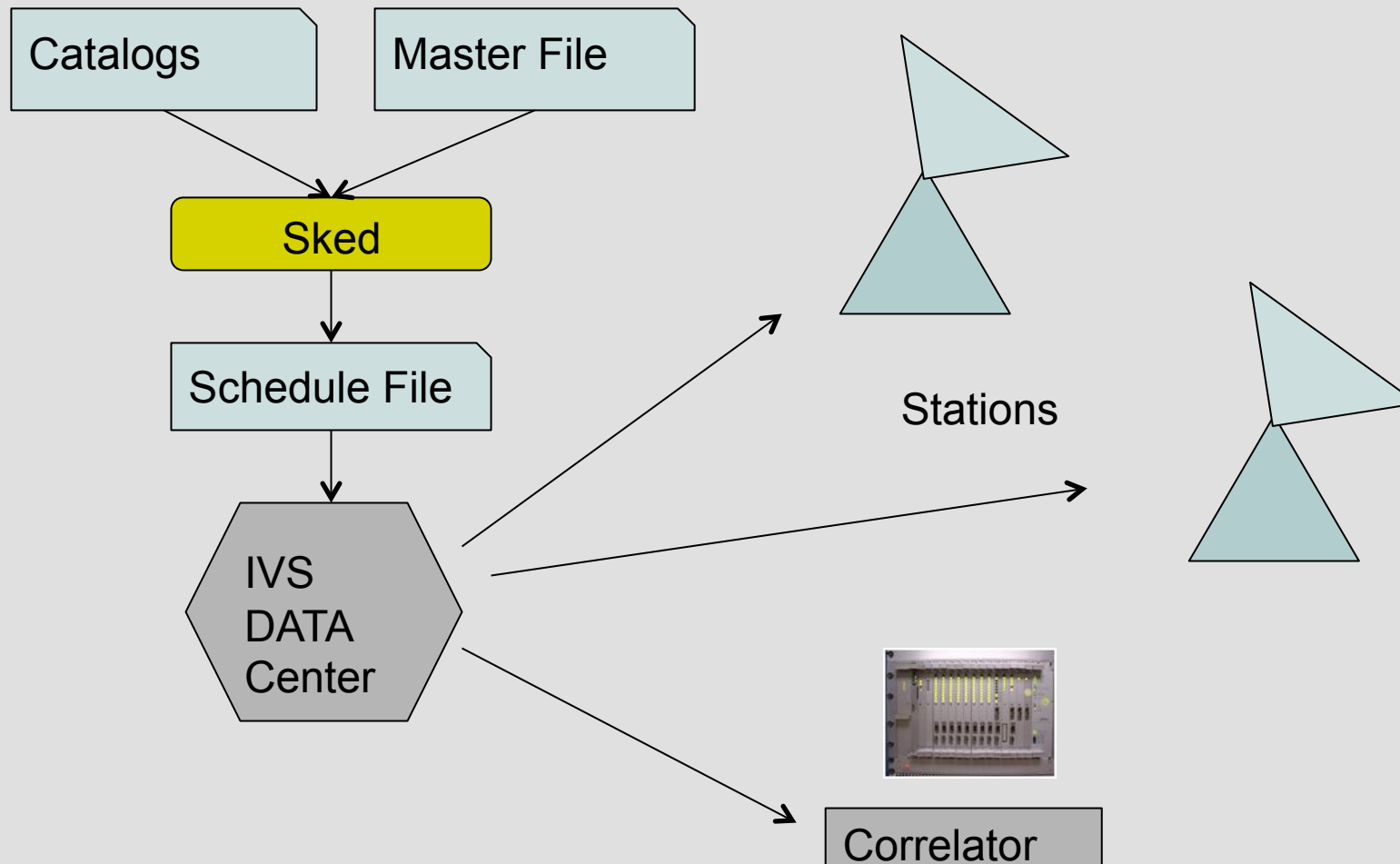
- General understanding of VLBI.

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 was 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.

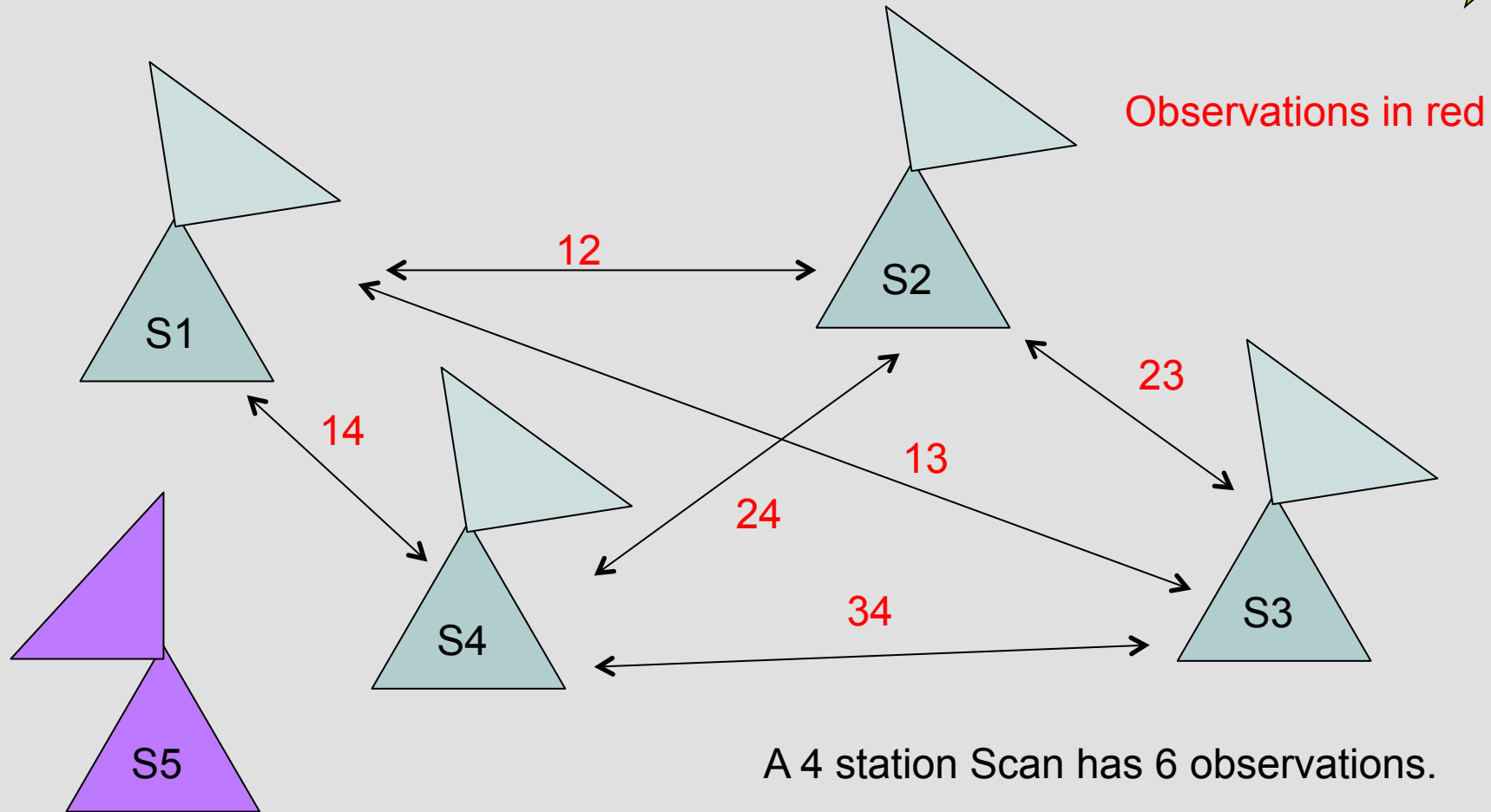
VEX format: An alternative more modern format. Used at the correlators. Sked can write VEX files.



Scans & Observations



There are many observations in a single scan. 





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 $N \times N$ elements.

We are interested in elements above the diagonal.

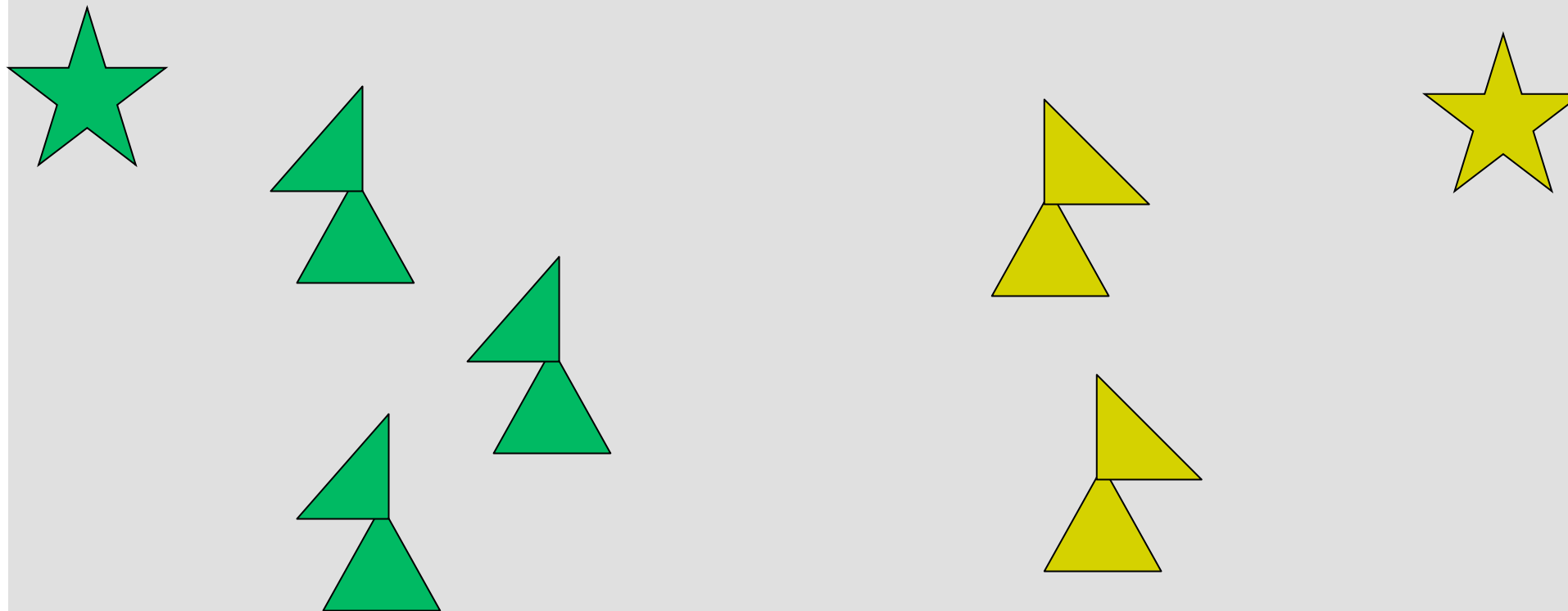
This is $(N \times N - N) / 2 = N * (N - 1) / 2$



Subnetting



When two sets of antennas simultaneous participate in different scans.





SNR Calculations



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

Source Strength

Number of Bits

Antenna SEFDs

Correction Factor



Increasing SNR



To increase SNR you can:

- Increase $F \rightarrow$ Stronger sources
- Decrease SEFD \rightarrow 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:

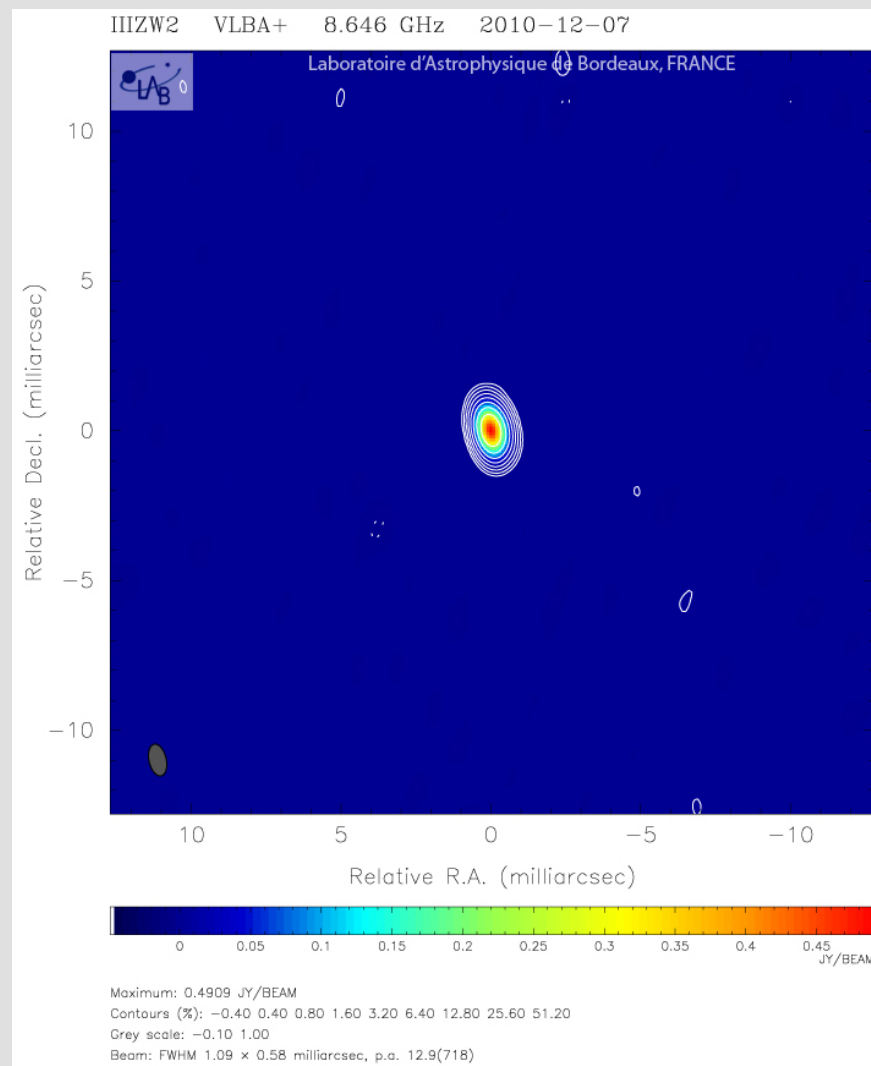
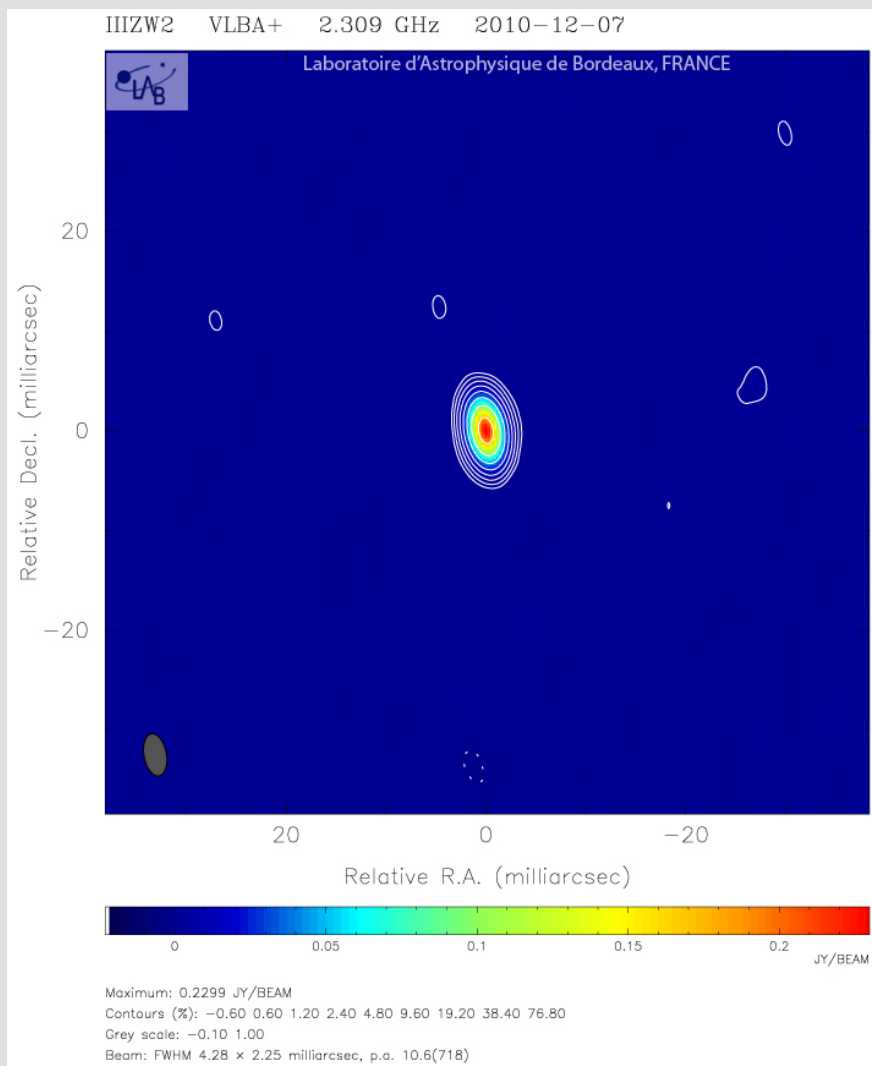
- Strong
 - Strong sources take less integration time. This means you can take more observations.
- Compact
 - Non-compact sources have lower flux on long baselines.
- No Source Structure
 - Source structure introduces 'noise'.

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>



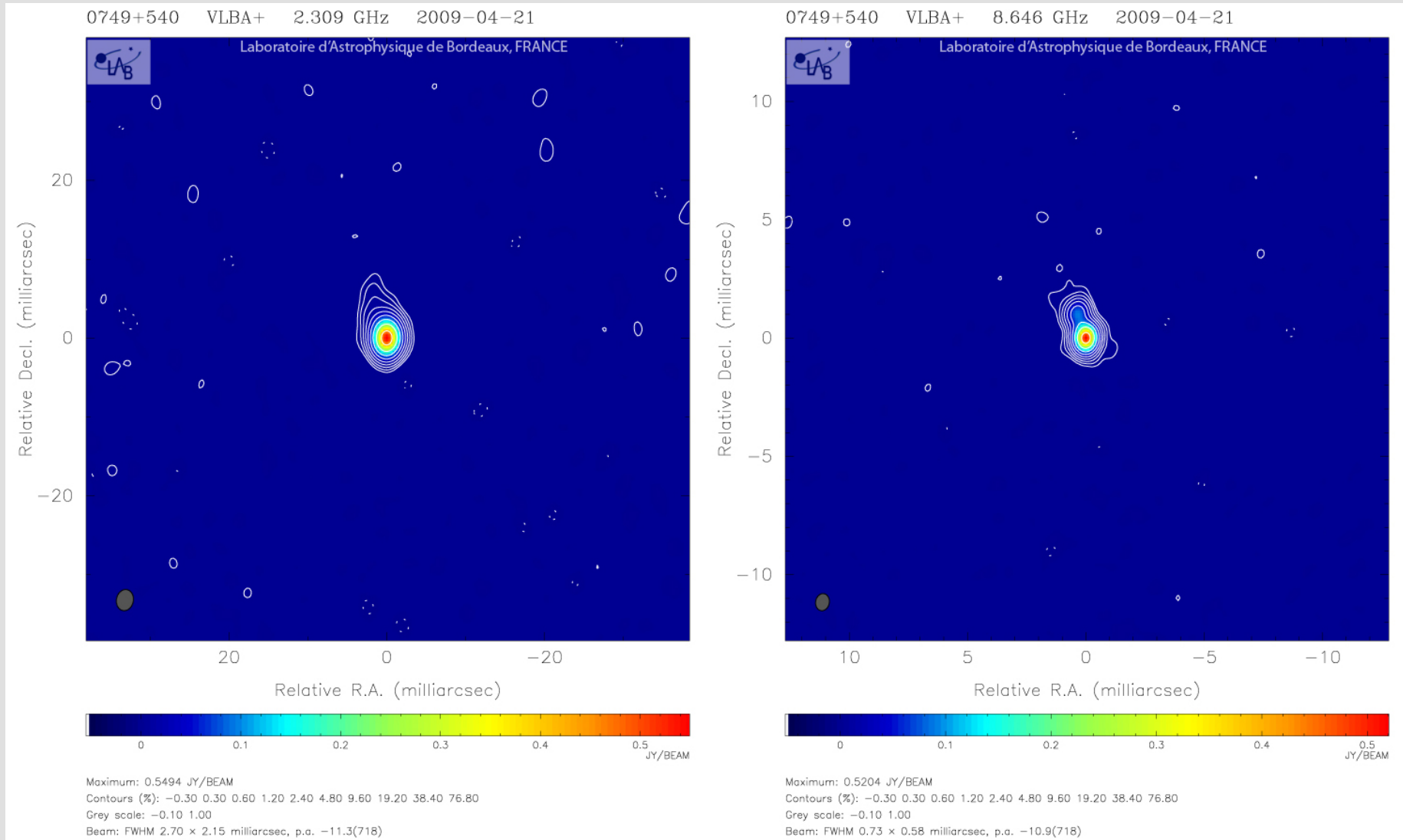
Good Source



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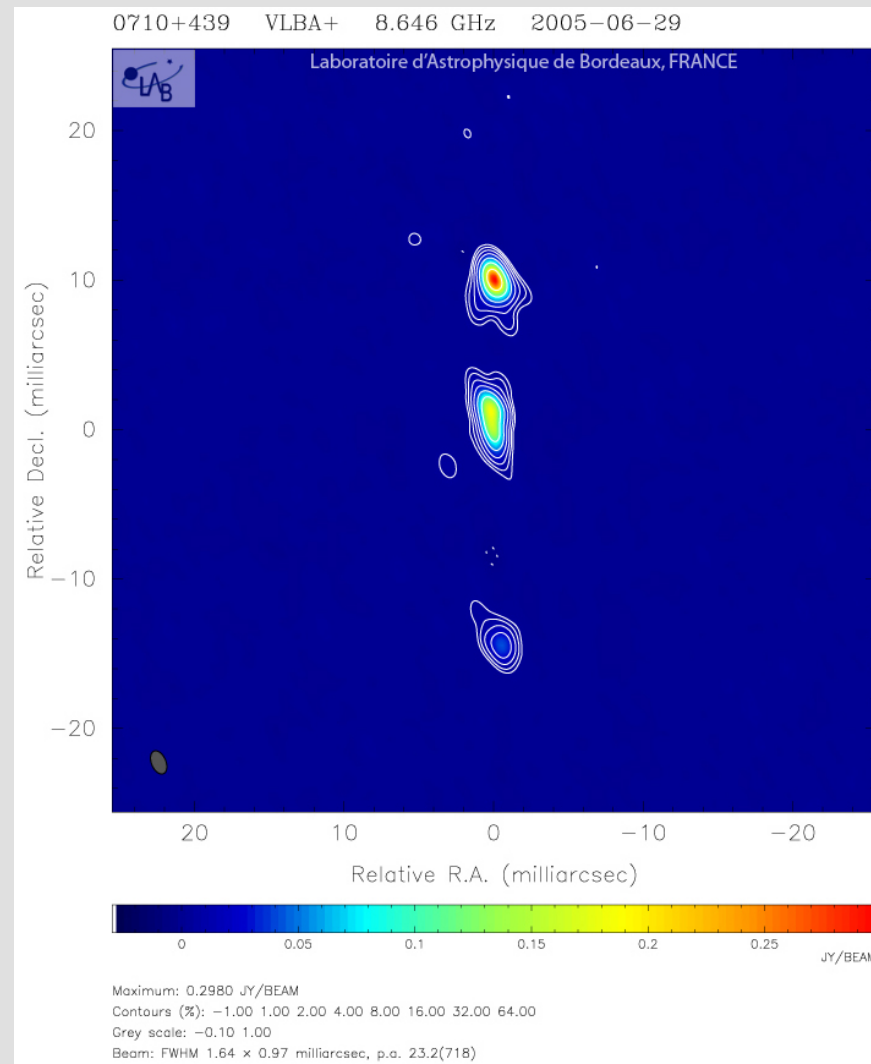
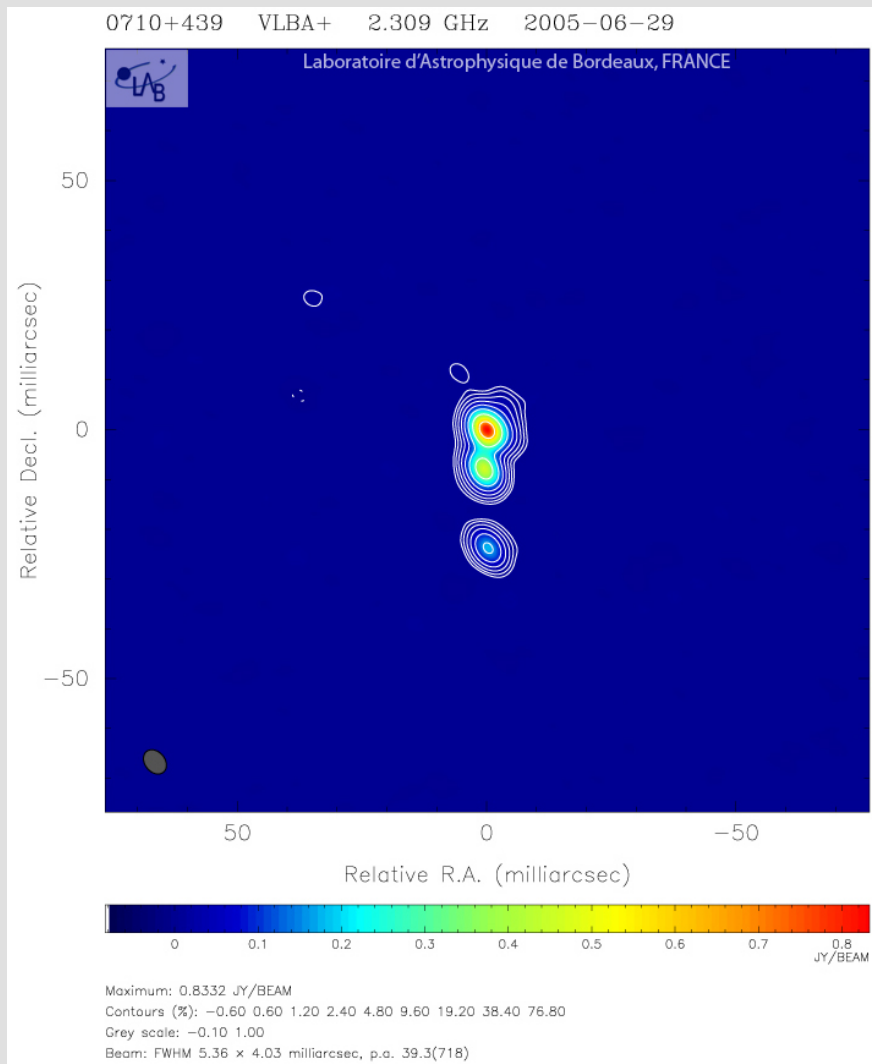
OK Source



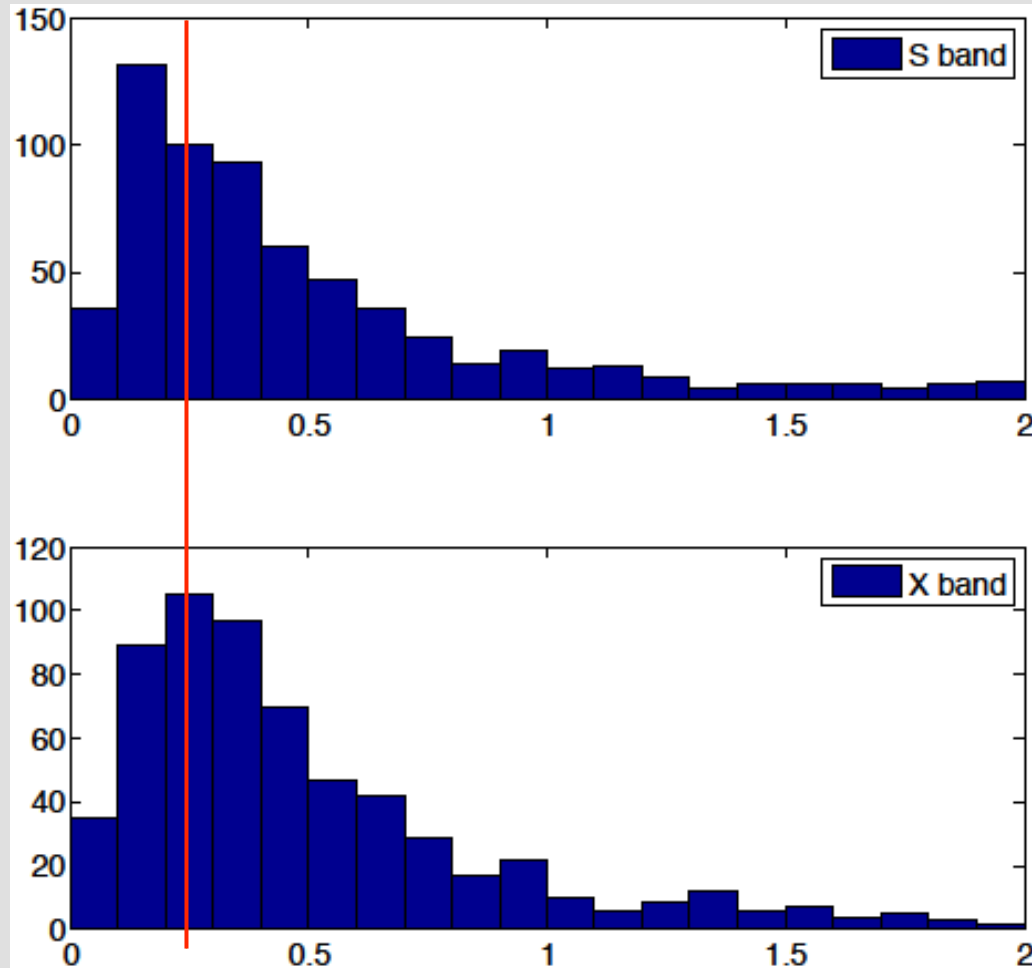
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Bad Source With Structure



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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)



What is Sked?



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

? Command <arguments>

Example:

? 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

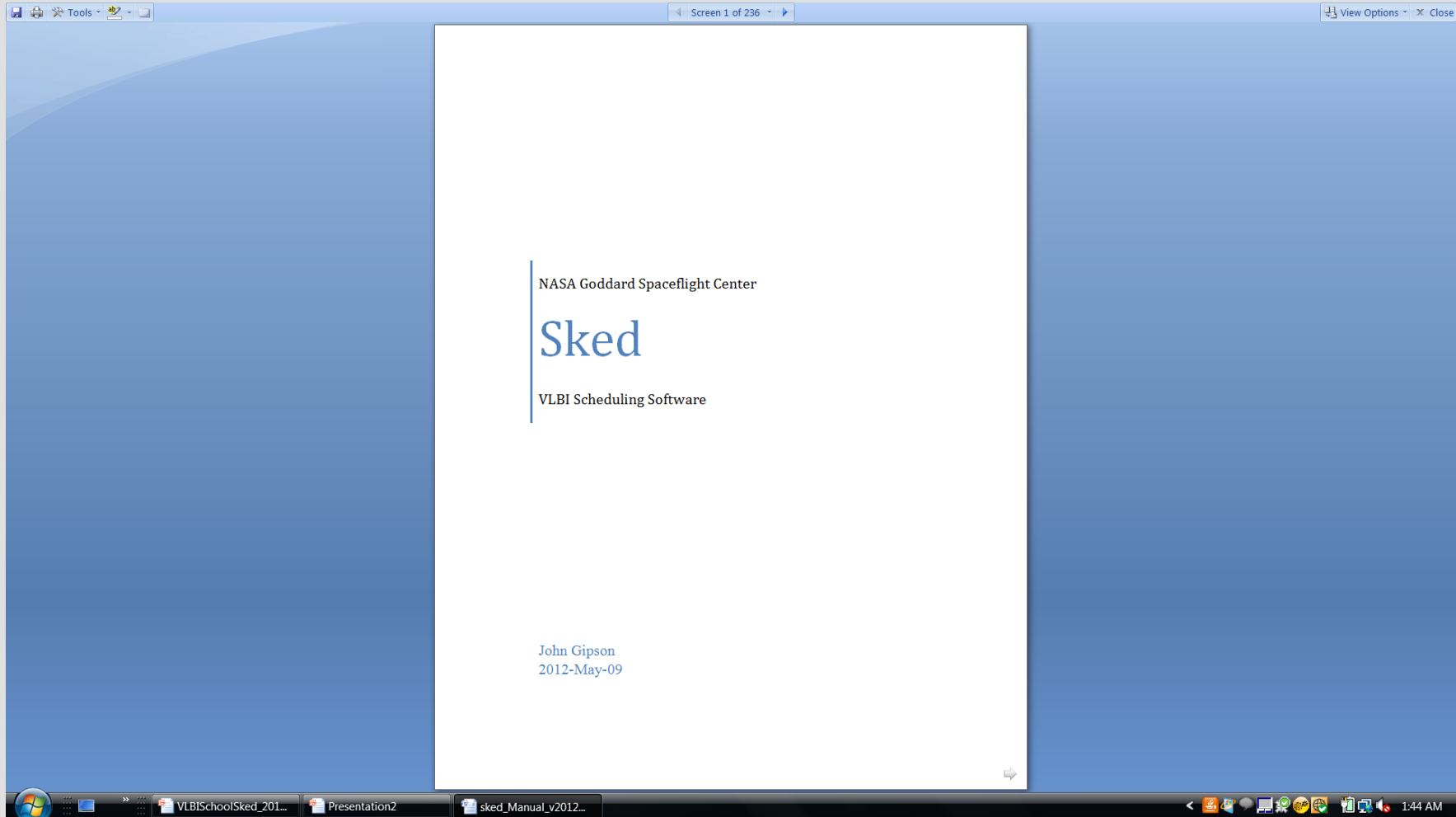


History (Cont)

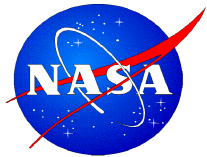
2007	Resurrection of covariance optimization. Found and fixed various bugs in algorithms. Still not used routinely. By-product: sked can predict formal errors internally.
2008	Master command Read session setup from master file. Check session against master file.
2011	Introduction of MinAngle minor option.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



Your Friend: Sked Manual



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Scheduling VLBI Sessions



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
```

Note VERSION

```
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
```



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 abbreviat 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



? list . ← Note that "." = current time

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	10	59	3.2
0202+319		x x	x x	x	x x x	x		R S	10	56	3.9
1039+811		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 xx x 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 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	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	x xx xx xx	x 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					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			21	71	12.3
1424-418			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 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 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 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	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

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

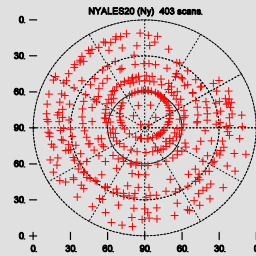
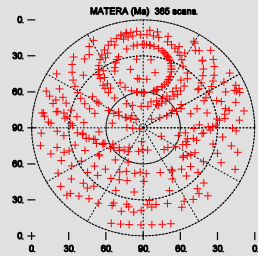
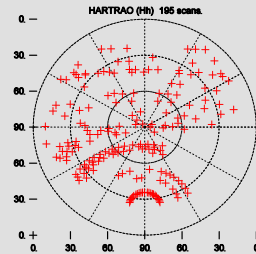
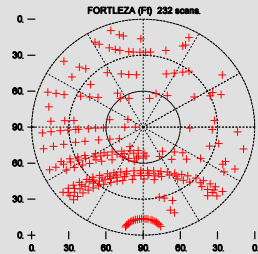


Summary command (cont2)



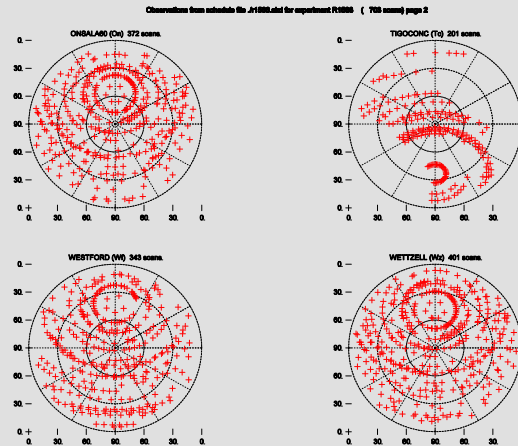
Summ _ _ _ pol

Observations from schedule file ./1000.tbl for experiment R1000 (705 scans) page 1





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.

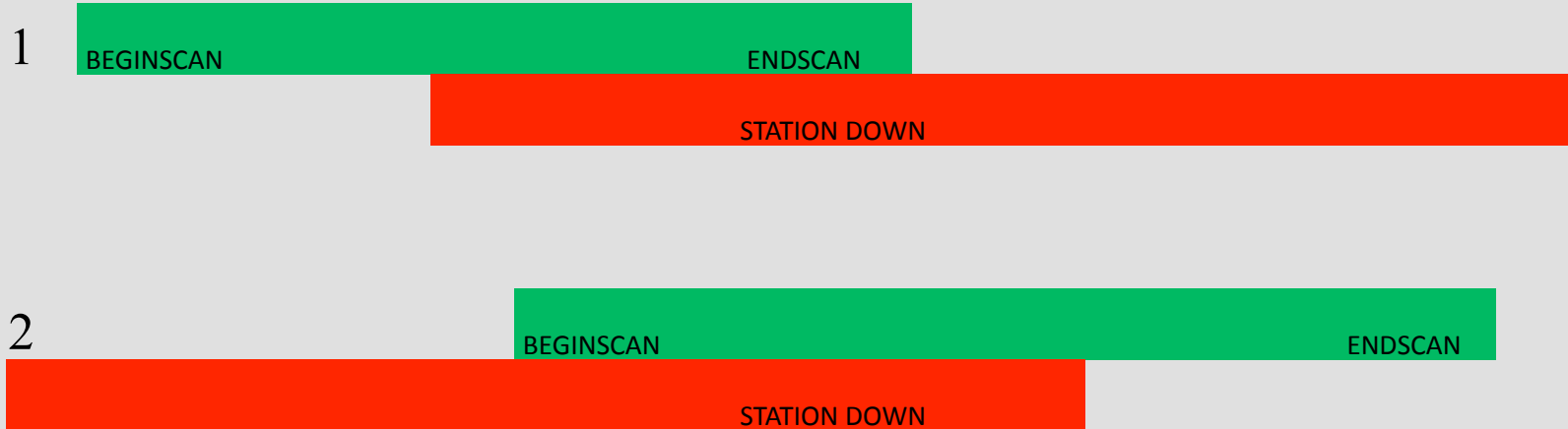
```
? Down Wz off
? Down
Kk 2010-074-18:15:00 2010-074-19:45:00
?
```

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
?
```



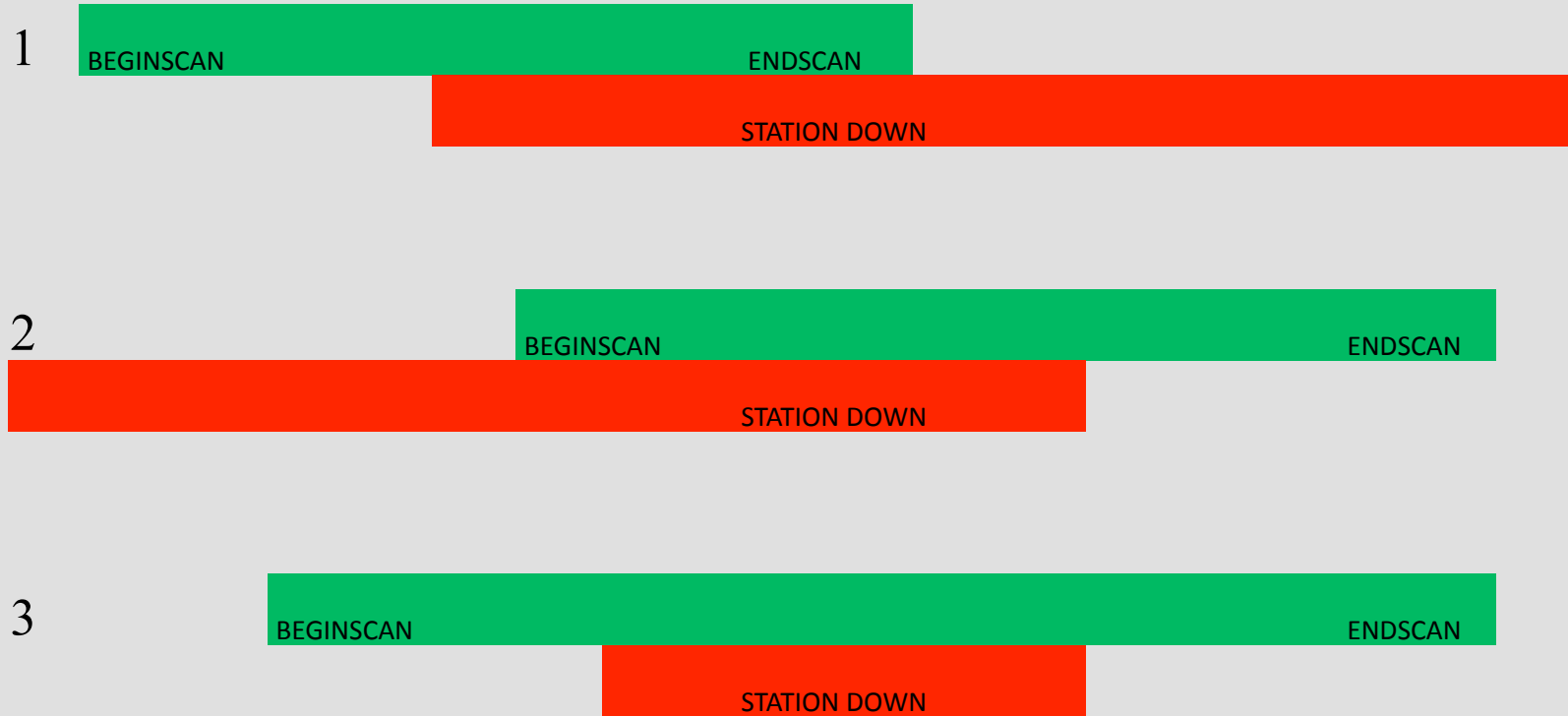
Downtime: How it works.



- 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 downtime.



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.



Master Command: Motivation



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 - B. Stop time;
 - C. Stations;
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



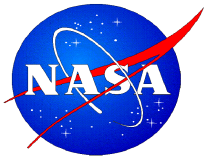
```
? master check
Finding session R1410
Checking /shared/gemini/ftp/pub/master/master10.txt
Checking /shared/gemini/ftp/pub/master/master10-int.txt
Checking /shared/gemini/ftp/pub/master/master09.txt
master_cmd: schedule and master file agree!
?
```



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
Sh      0  0
Tc     15  0  0
Wf     20  0  0  15
Wz     20  0  0  15  20
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



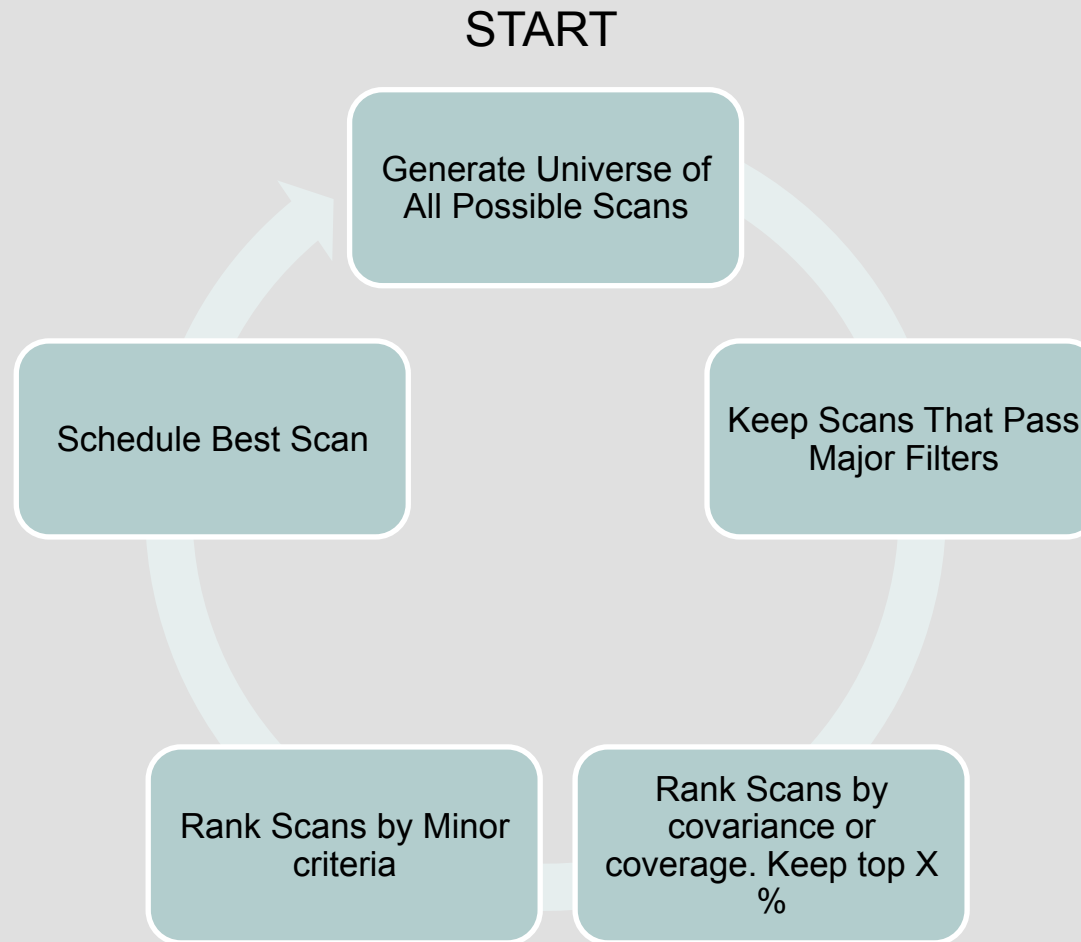
In automatic mode, user specifies general parameters for scheduling the session. *Sked* generates and schedules the scans.

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.

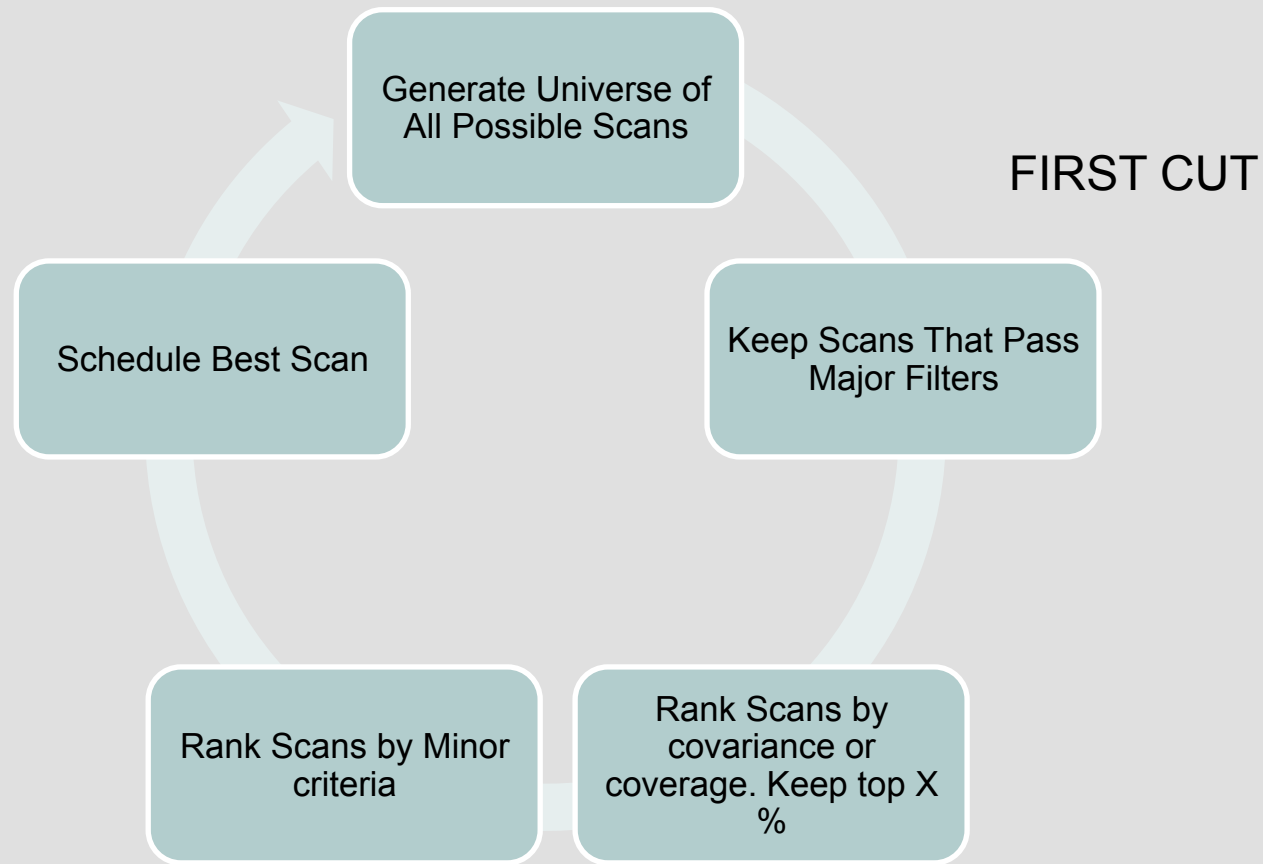


Automatic Scheduling



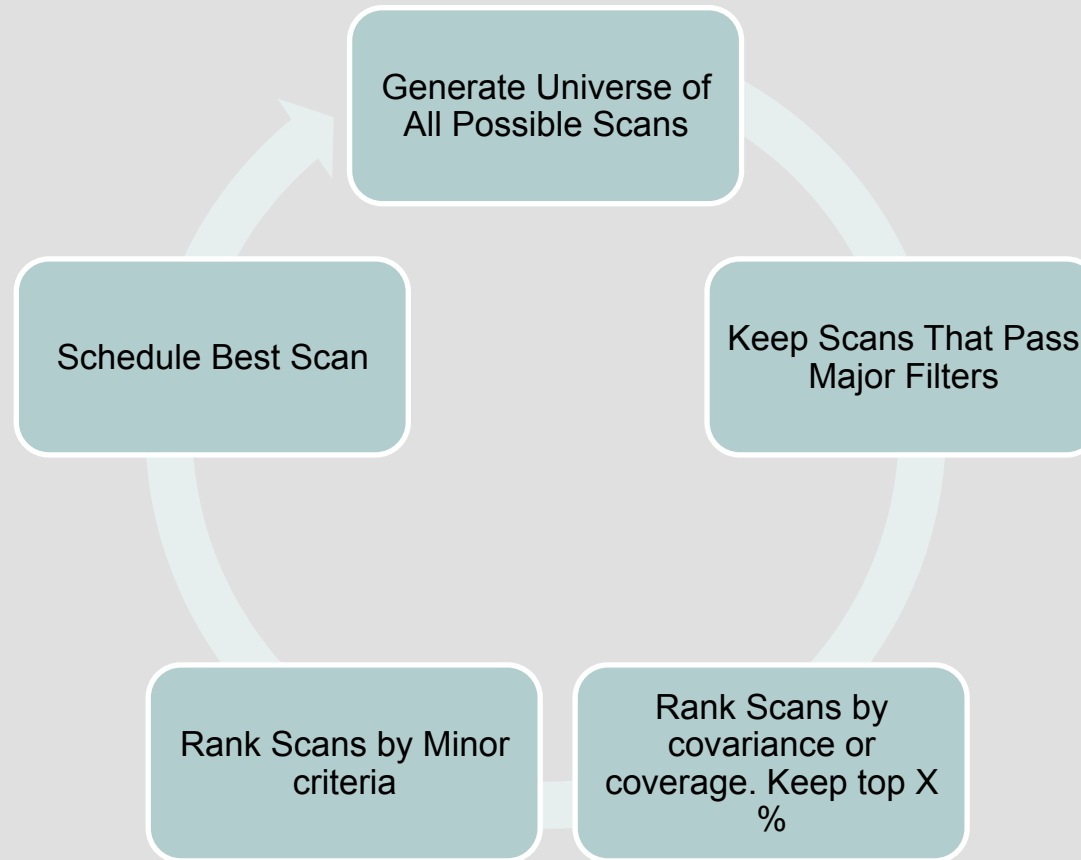


Automatic Scheduling





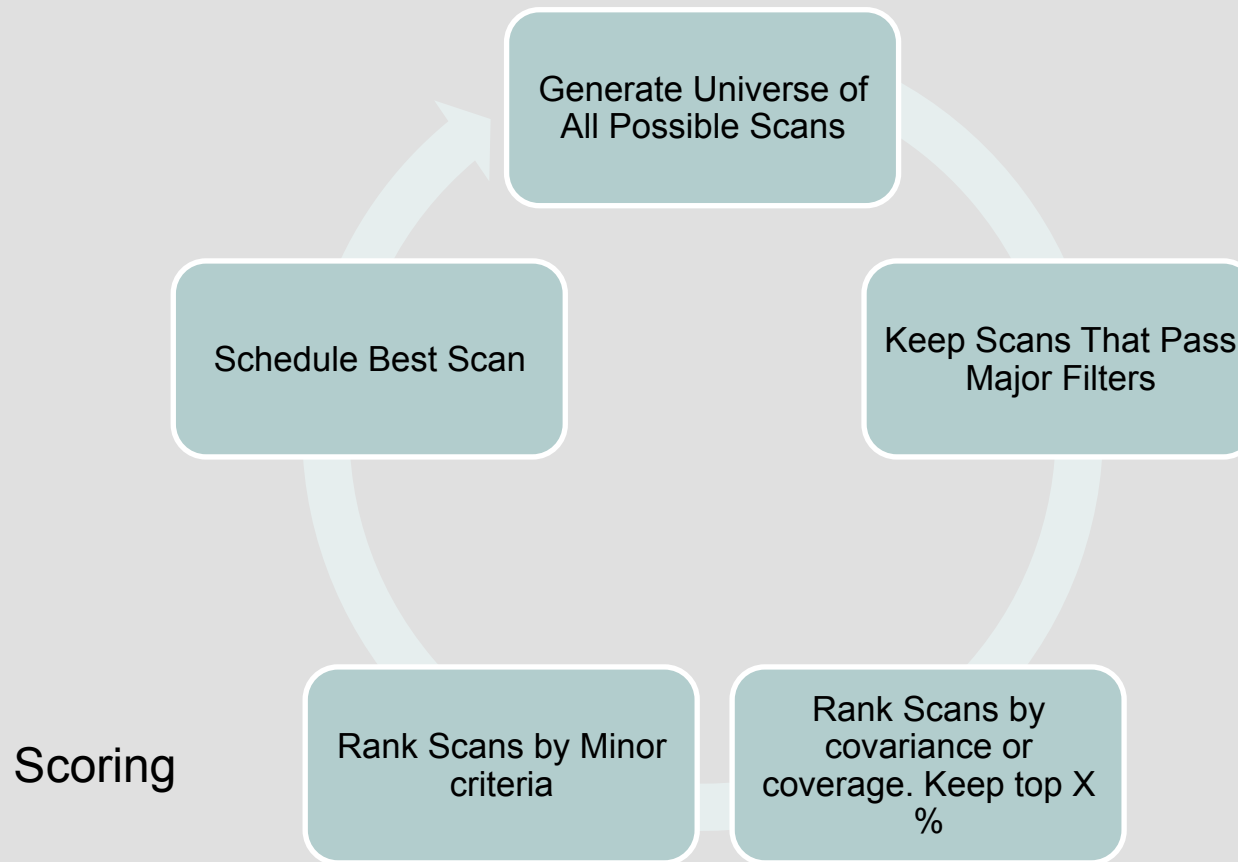
Automatic Scheduling



SECOND CUT

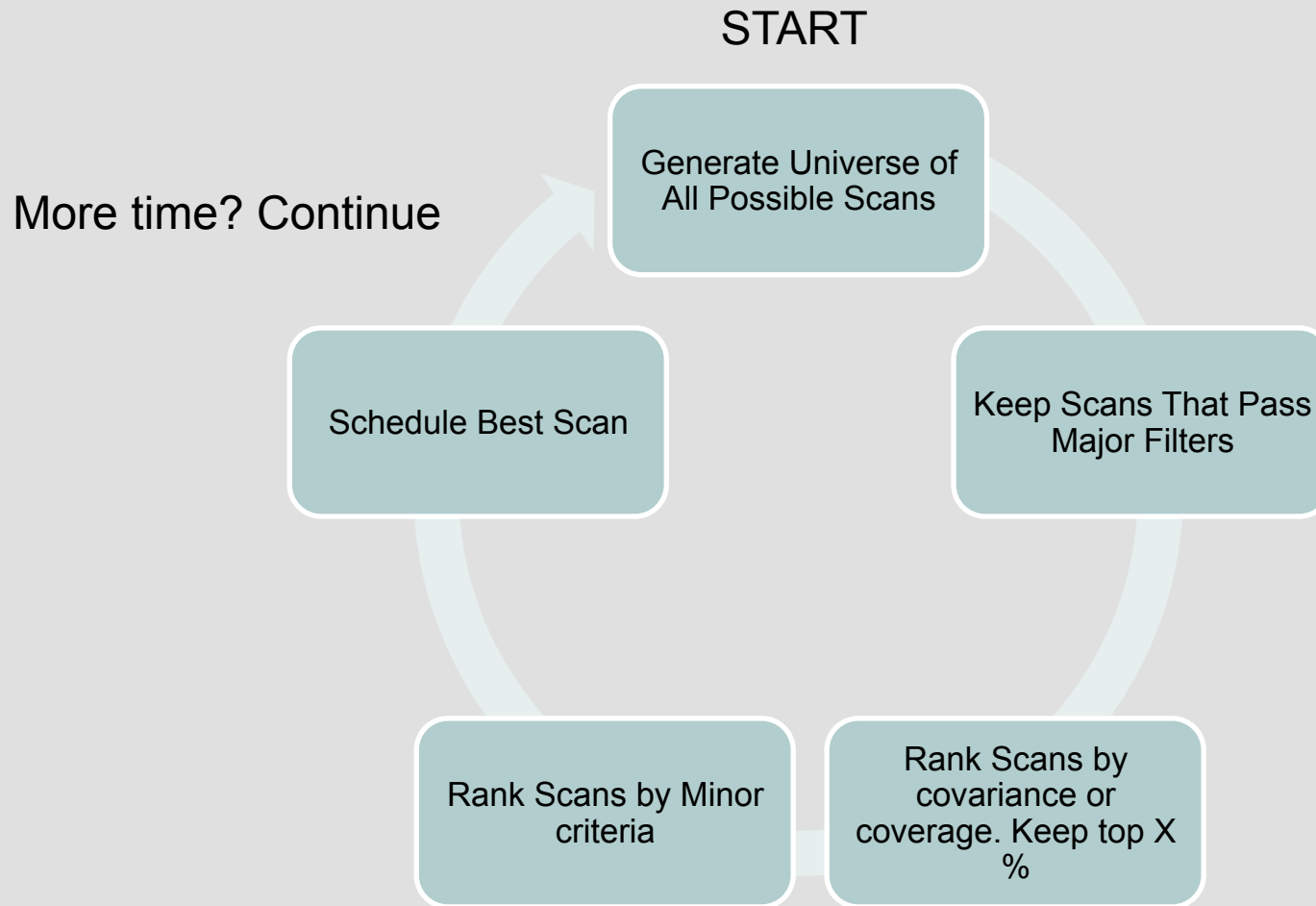


Automatic Scheduling





Automatic Scheduling





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 <i>Best%</i> 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 <i>FillBest% scans are kept for further consideration.</i>
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 <i>solve</i> interface.
SNRWts	If yes, weight the observations by SNR. If not, consider all observations the same. This only affects the <i>solve</i> interface.



Major Options (cont)



The general format for setting a major option is:

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

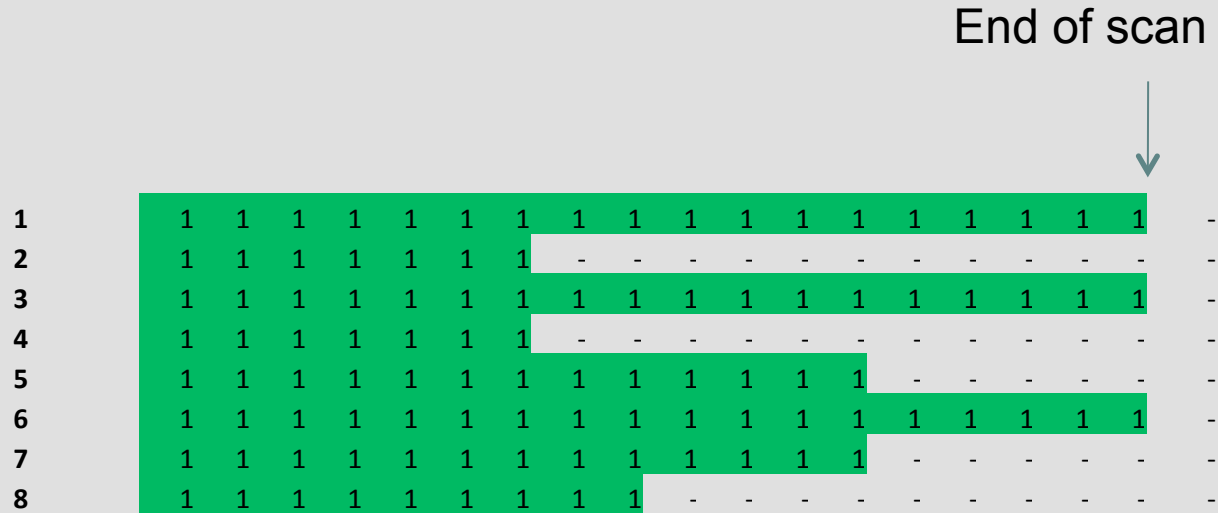
Example:

```
Major MinAngle 30
```

Sets the minimum angle between observations to 30 degrees.



Major Option: Fill In Mode



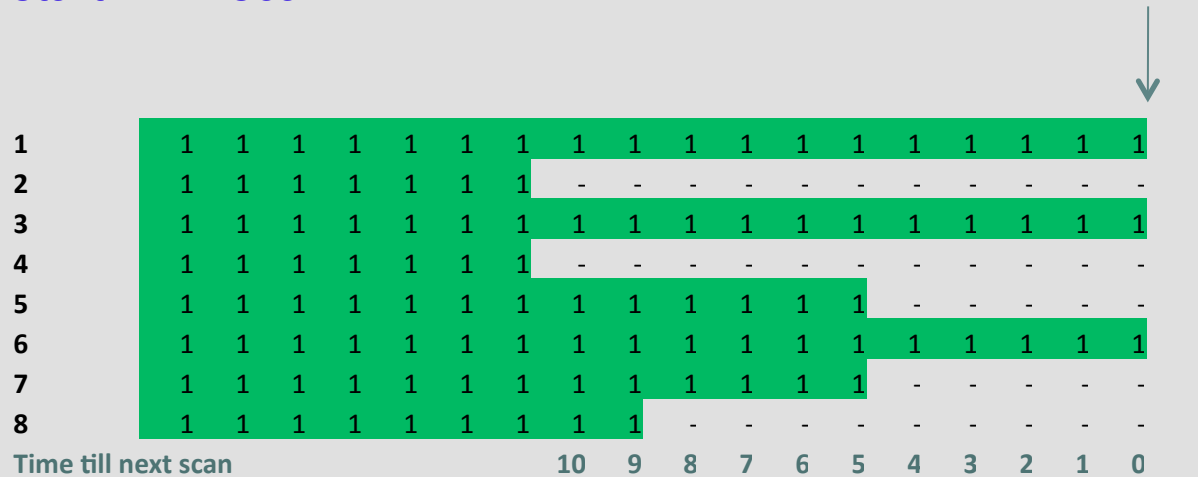
By default, *sked* tries to schedule full net-work scans.
 The next scan would start as soon after the end of the scan as possible.
 This can leave a lot of time when stations are not observing.
 “Fill In Mode” attempts to decrease idle time by filling in the gaps.



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



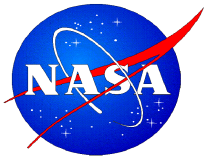
Allowable spillover

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	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	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	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



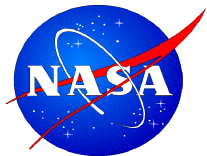
Allowable spillover

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	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	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	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



How Major Works



Universe of All Scans



How Major Works



Source too close to Sun

Start by eliminating sources.

Universe of All Scans



How Major Works



Source too close to Sun

Source observed too recently

Continue to eliminate sources

Universe of All Scans



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



Source too close to Sun

Source observed too recently

Source too close to previous source

Use Major filters and SNR targets to eliminate scans.

Scans With Remaining Sources

Subnet too small

Start throwing scans away.



Questions & Commen



Source too close to Sun

Source observed too recently

Source too close to previous source

Use Major filters and SNR targets to eliminate scans.

Scans that Pass Major Filters

Subnet too small

Station takes too long to slew

Scan doesn't meet SNR targets on enough baselines

Left with a much smaller universe.



Major Options



Scans that Pass Major Filters



Major Options



Scans that Pass Major Filters

Rank and throw away bottom

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.

$$\text{Total Scan Score} = \sum_{\text{options}} Wt_j \text{Score}_j$$

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/schedules>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 comprised of several parts. Each part starts with \$

```

$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	Determines how sked chooses scans.
\$MINOR	
\$ASTROMETRIC	List of sources to preferentially observe
\$SRCWT	
\$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



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.