TECHNISCHE UNIVERSITÄT WIEN
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# Vie_SCHED_V22

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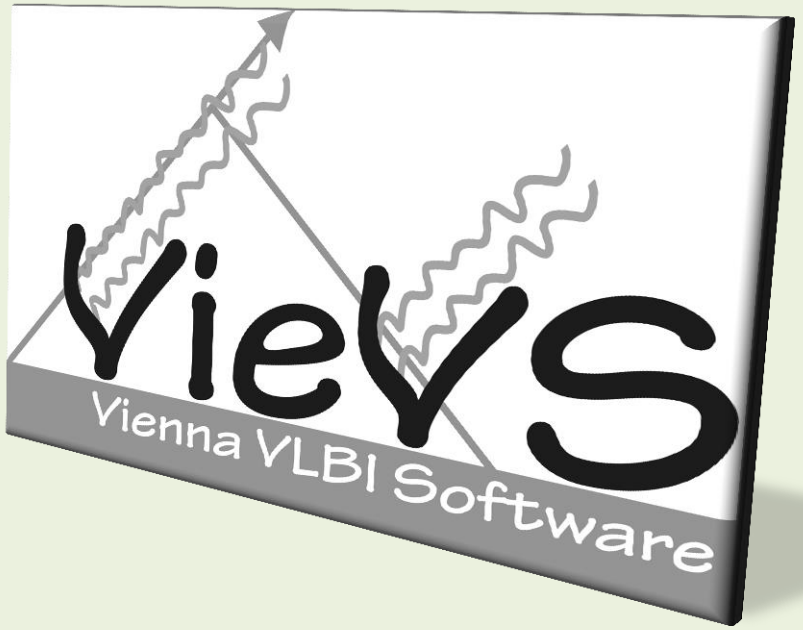
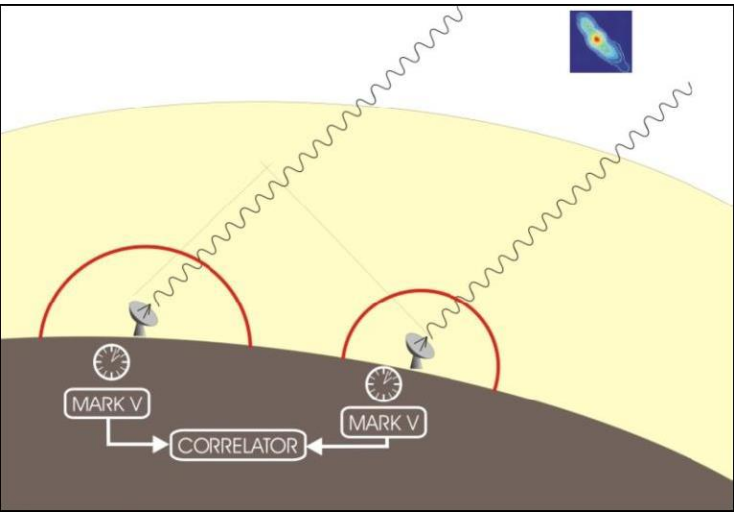



[1] Shanghai Astronomical Observatory

# Introduction (1)




**VLBI2010 goals:**

- 1 mm position and 0.1 mm/year velocity measurement accuracy on global baselines,
- continuous measurements (7d/week) of station positions and EOP,
- turnaround time to initial geodetic results of less than 24 hours.

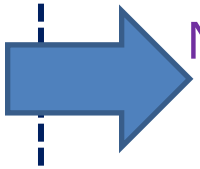
| Parameter | VLBI2010 system | Current VLBI system |
|---|---|---|
| antenna size | ~ 12 m dish, twin antennas | 5 – 100 m dish |
| slew speed | ≥ 360 deg/min | ~ 20 – 200 deg/min |
| sensitivity | SEFD ≤ 2500 | SEFD 200 – 15000 |
| frequency range | ~ 2 – 14 GHz | S/X band |
| recording rate | 8 – 16 Gbps | 128, 256 Mbps |
| data transfer | e-transfer, e_VLBI<br>disk shipping when required | usually disk shipping,<br>some e-transfer |

# Introduction (2)

VLBI2010 is on the horizon

New scheduling strategies are required

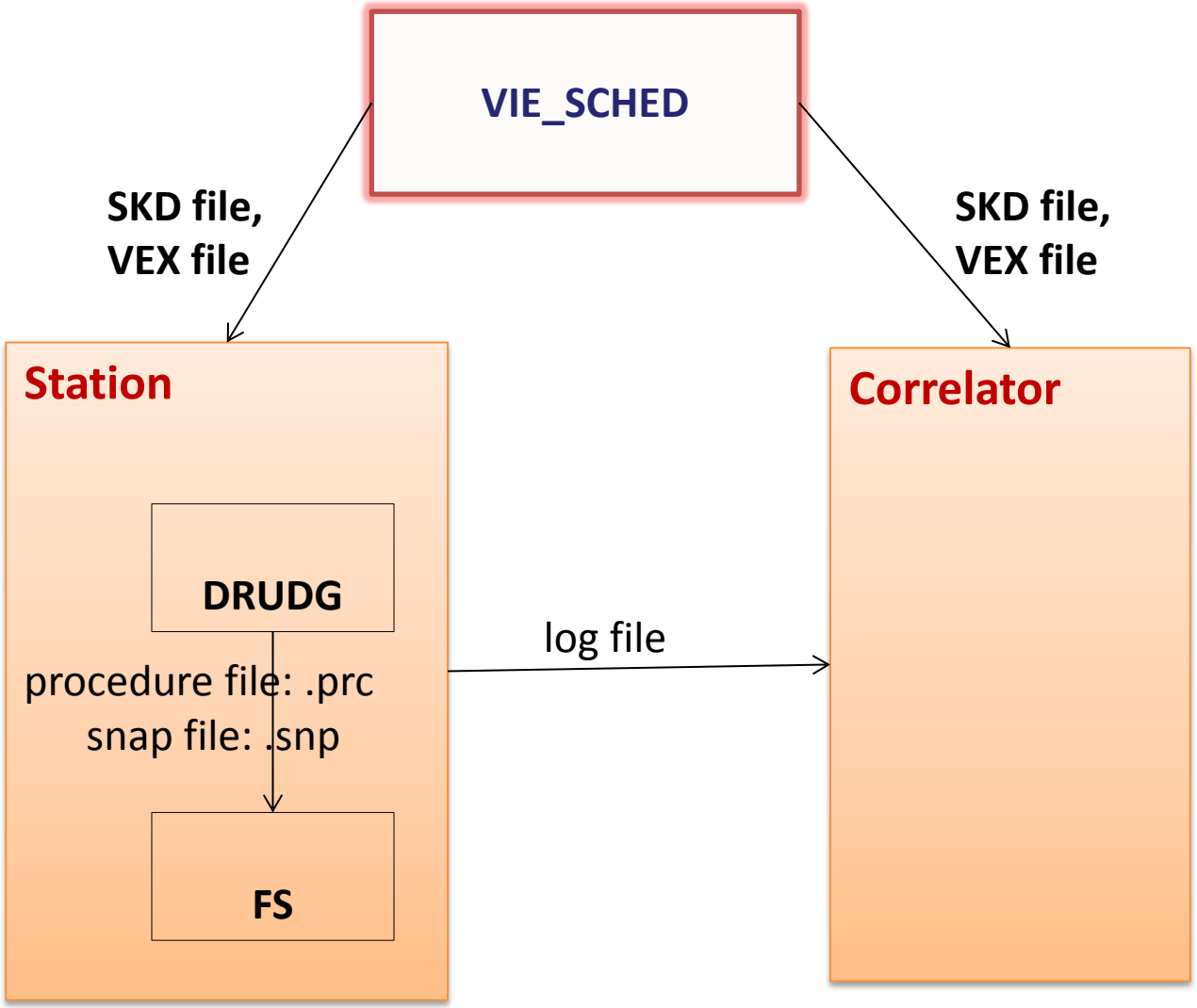
Only one scheduling package existed worldwide



Necessity for an indepedent new scheduling software !

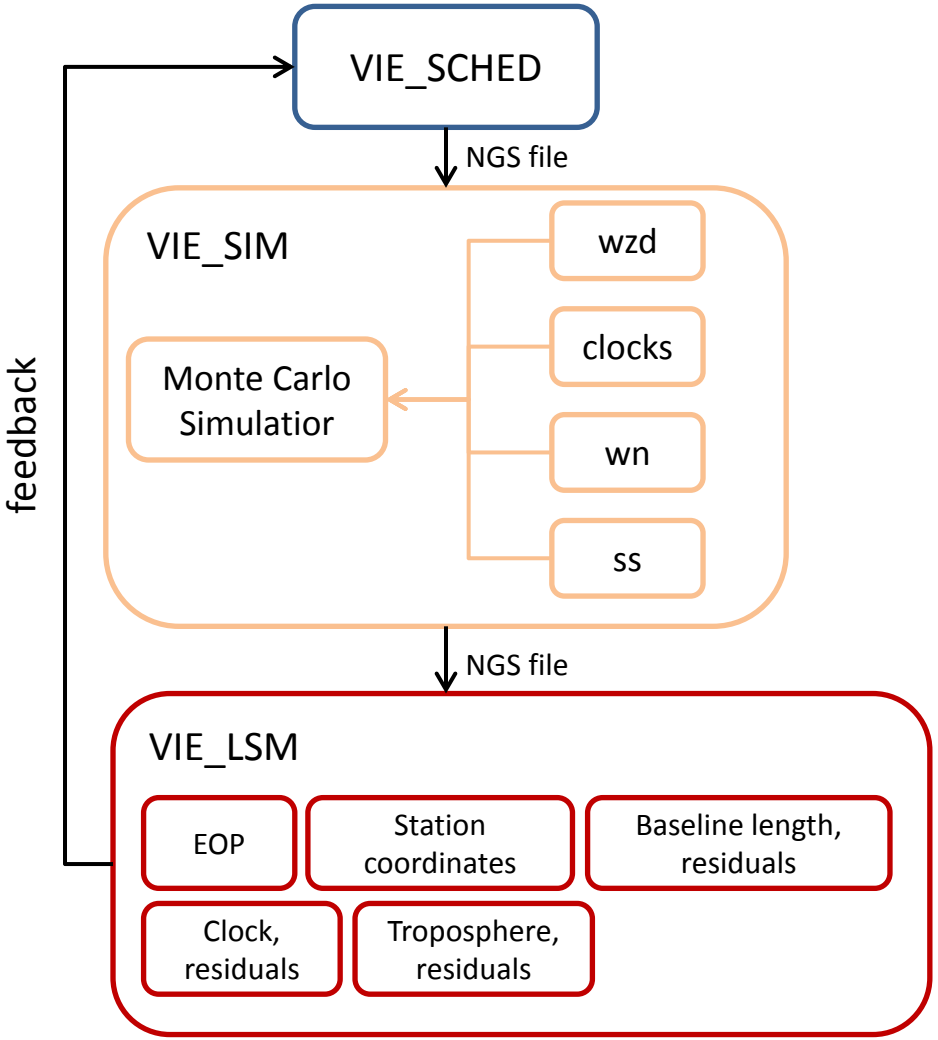
# Purpose of a scheduling program (1)

→ real VLBI experiment



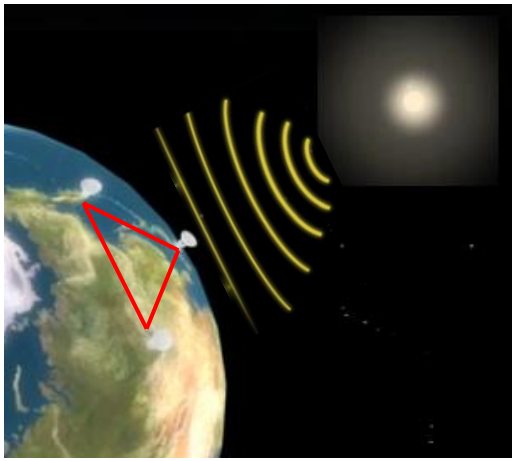
# Purpose of a scheduling program (2)

→ simulation research



# Algorithms and models for a scan

**Scan** – time period during which a network of stations observes the same source

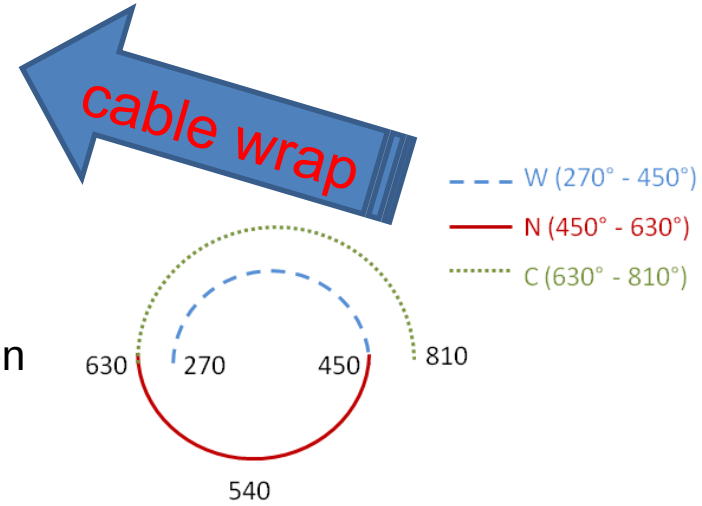


## Calculation of scan start time

- earliest possible start time for a new observation

$$T_{2s}(i) = T_{1e}(i) + Tslew(i) + SOURCE + TAPETM + IDLE + CALI$$

$T_{1e}$ – end time of previous observation
$T_{slew}$ – slew time required for the slew from the previous source to the new one
*SOURCE* – time for settling down
*TAPETM* – tape
*IDLE* – idling
*CALI* – calibration




- the maximum of start times of participating antennas is taken as the scan start time

$$T_{2s}(scan) = max(T_{2s}(1),\ T_{2s}(2),\ \ldots,\ T_{2s}(n))$$

for ambiquous position – shortest way from previous scan

# Algorithms and models for a scan

## Calculation of scan length

### antenna sensitivity

characterized by System Equivalent Flux Density (flux density corresponding to system temperature)

$$SEFD = \frac{2 \times k \times T_{sys}}{A_{eff} \times \eta \times 10^{-26}}$$

$k$ – Boltzmann's constant
$T_{sys}$ – system temperature
$A_{eff}$ – effective collecting area of the antenna
$\eta$ - processing factor

elevation dependence is applied

### scan length

$$scanlength = (\frac{1.75 \times SNR_{min}}{F_{obs}})^2 \times (\frac{SEFD_1 \times SEFD_2}{2 \times B \times N_{ch}}) + CORSYNCH$$

$F_{obs}$ – observed source strength
$B$ – bandwidth
$N_{ch}$ – number of channels

CORSYNCH – correlators extra time to synchronise up

# Algorithms and models for a scan

## Conditions of a valid scan

- important criterion: source has to be up at participating station during the observation

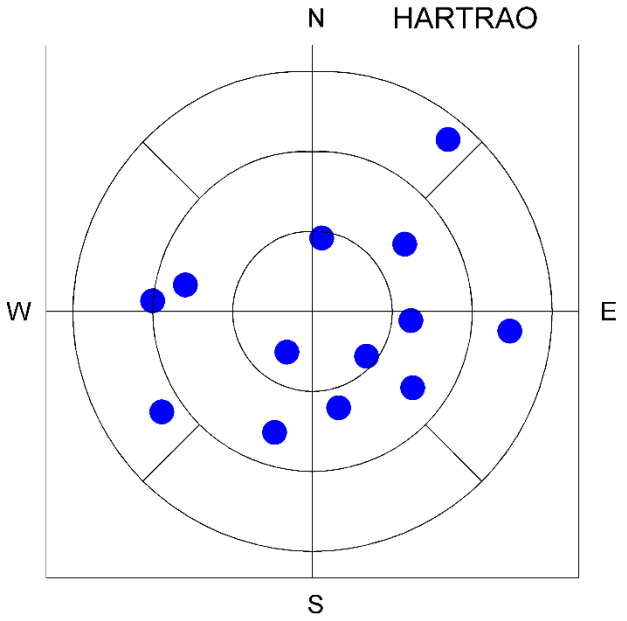
➢ Horizon mask (mask.cat) describes the surrounding mountains ...

## Vie_sched performs several checks to validate the scan

- at least 2 stations participate
- the source is visible at all stations (every 5 sec the position of the source is calculated)
- at stations with AZEL mount the cable wrap is checked
- enough time for slewing
- waiting time for the join scan does not exceed the user-specified maximum limit
- all baselines have to meet the user-specified SNR targets
- scan length is between the specified limits
- availability of the antenna is checked (downtime for maintenance or other observation program as intensive sessions ...)

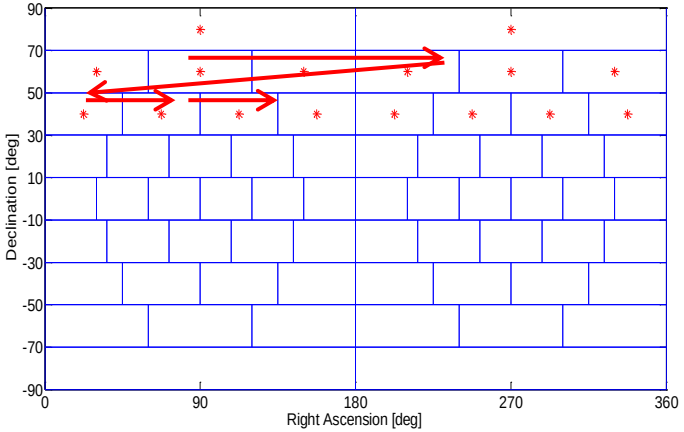
# Station-based scheduling strategy

- Classical approach to achieve uniform sky coverage at each station (needed for de-correlation of zwd, clocks and station height)
- Definition of a uniform sky coverage: The sky above the antenna is divided in three different elevation segments: low, middle, and high elevation observations.
- The middle segment is divided into four azimuthal segments and the low segments into eight parts.
- Radio sources from the same segment should not be observed within a certain time interval.
- Time window of sky coverage should correspond to the sapling interval of the estimated parameters



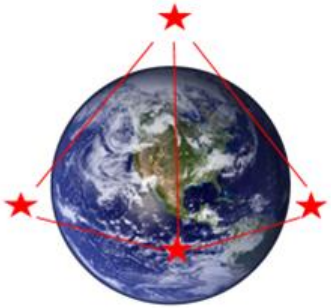
# Source-based scheduling strategy

- The source based strategy comes up with the more global station distribution and fast moving antennas
- The schedule program selects radio sources from the catalogue independently of the sky distribution at individual stations
- Different subnets are formed throughout the session in order to optimize geometry and number of observations




- **one** source scheduled each time

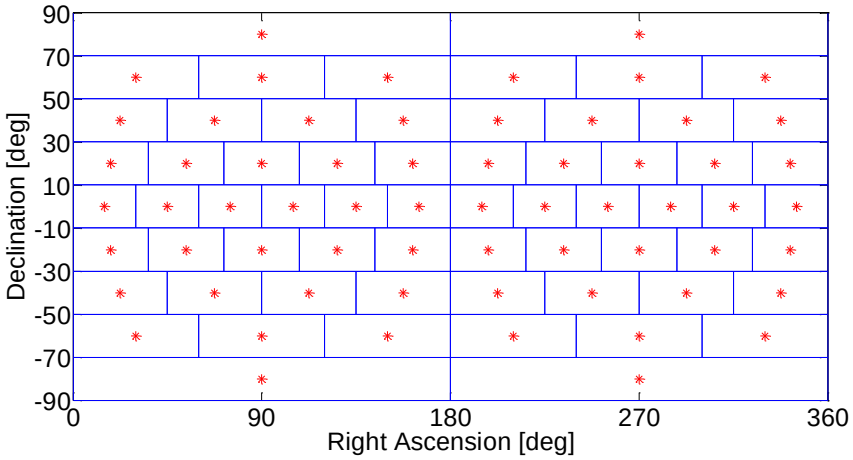
- **two** sources scheduled simult.



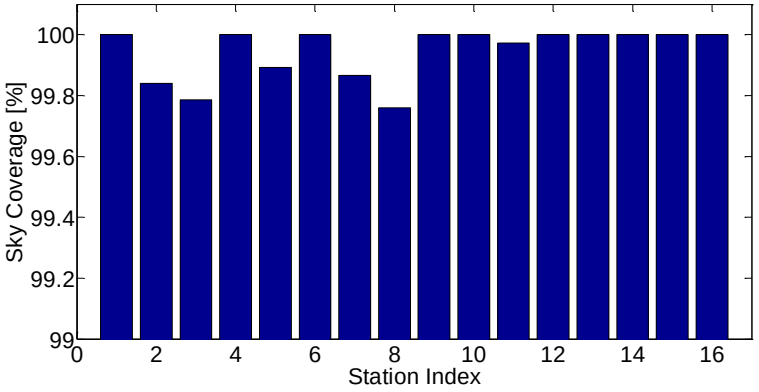
- **four** sources scheduled simult.

# Strategies for automatic scheduling

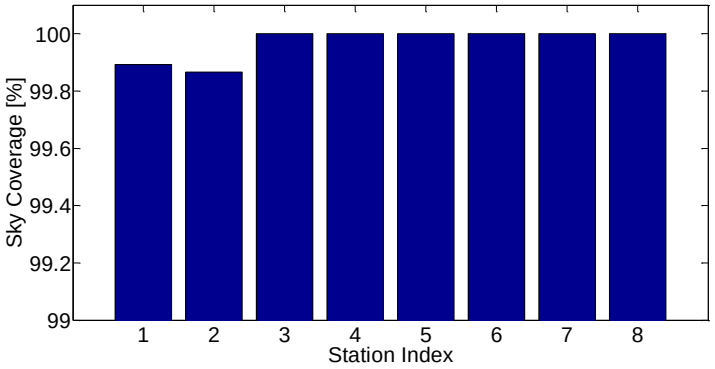
**Source-based strategy** ⟷ **Station-based strategy**




16-station test VLBI2010 network




8-station typical IVS R1 network



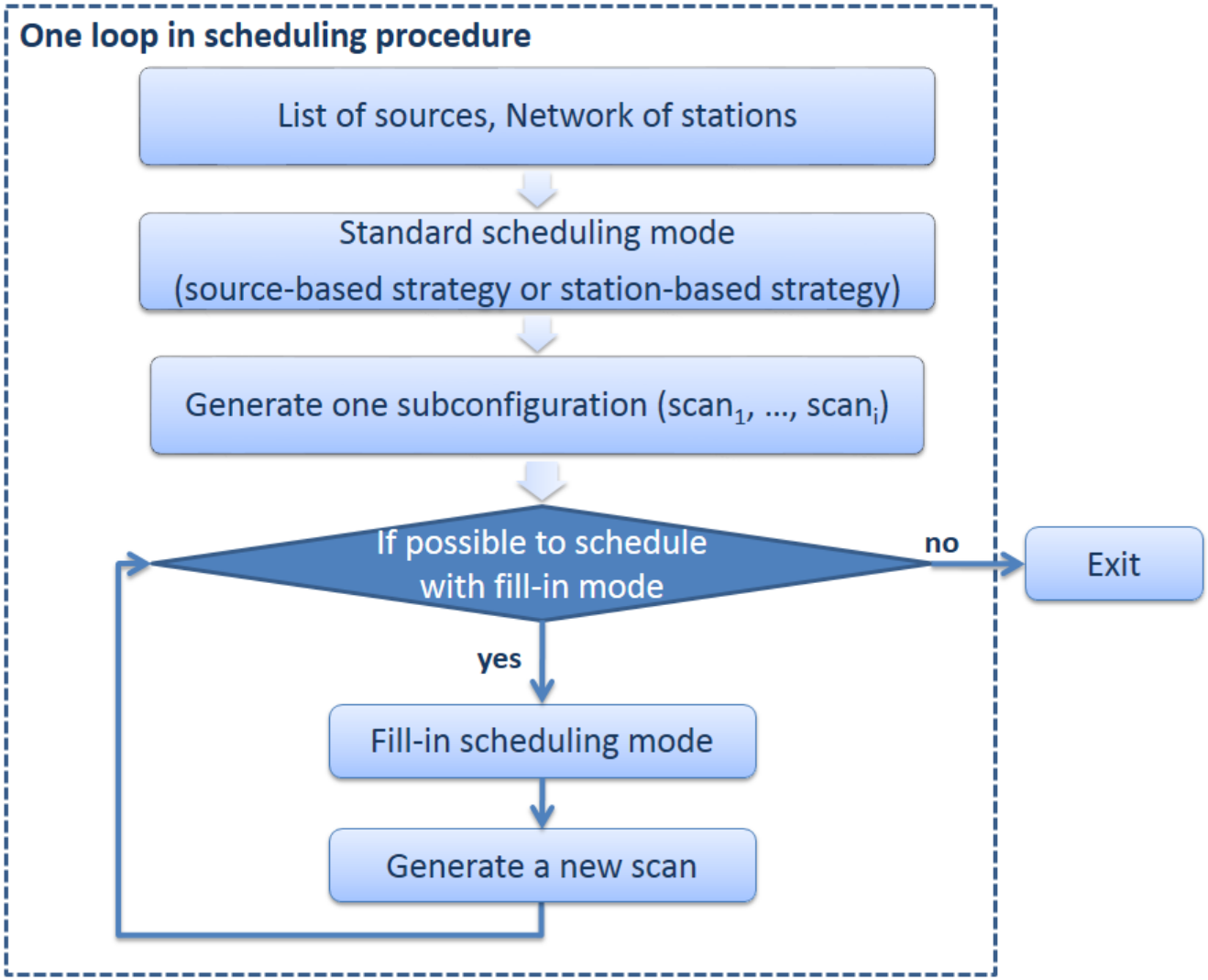

All **64 segments** on celestial sphere are scheduled.

At least **99.7%** sky coverage at stations is achieved.

# Fill-in mode

- Vie_SCHED schedules sub-configurations either with source-based or station-based strategy
- It can happen that there is still more than one station idling because of visibility or other restrictions
- Fill-in mode schedules for the idling stations another source (only one scan):
  - as many stations as possible
  - sky coverage criterion is applied if there are found two scans with the same number of idling stations
  - scan with the earliest start time is chosen
  - the fill-in scan should not end too much later than the scan from normal scheduling mode

# Fill-in mode

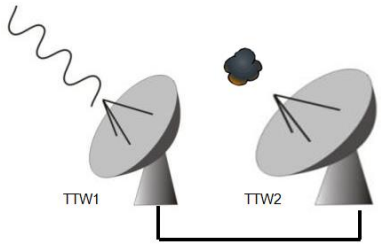

One loop in scheduling procedure
List of sources, Network of stations
Standard scheduling mode
(source-based strategy or station-based strategy)
Generate one subconfiguration (scan1, ..., scani)
If possible to schedule with fill-in mode
no
Exit
yes
Fill-in scheduling mode
Generate a new scan

# Twin telescopes at one site

**(1) Same troposphere above the twin telescopes;**

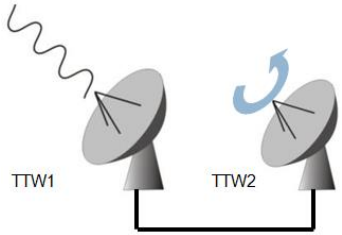
**(2) Same H-maser clock connecting them.**

## Mode1 : Maintenance



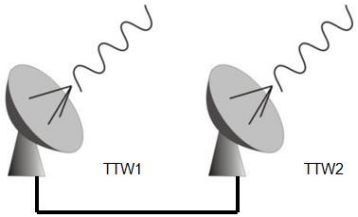

✓ full availability

## Mode3 : Continuous observations




✓ continuous observations, without any temporal gaps

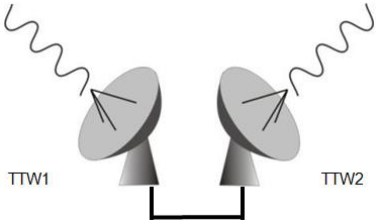
## Mode2 : Same source observations




✓ increase the sensitivity and decrease on-source time

✓ counteract the troposphere effect for calibration

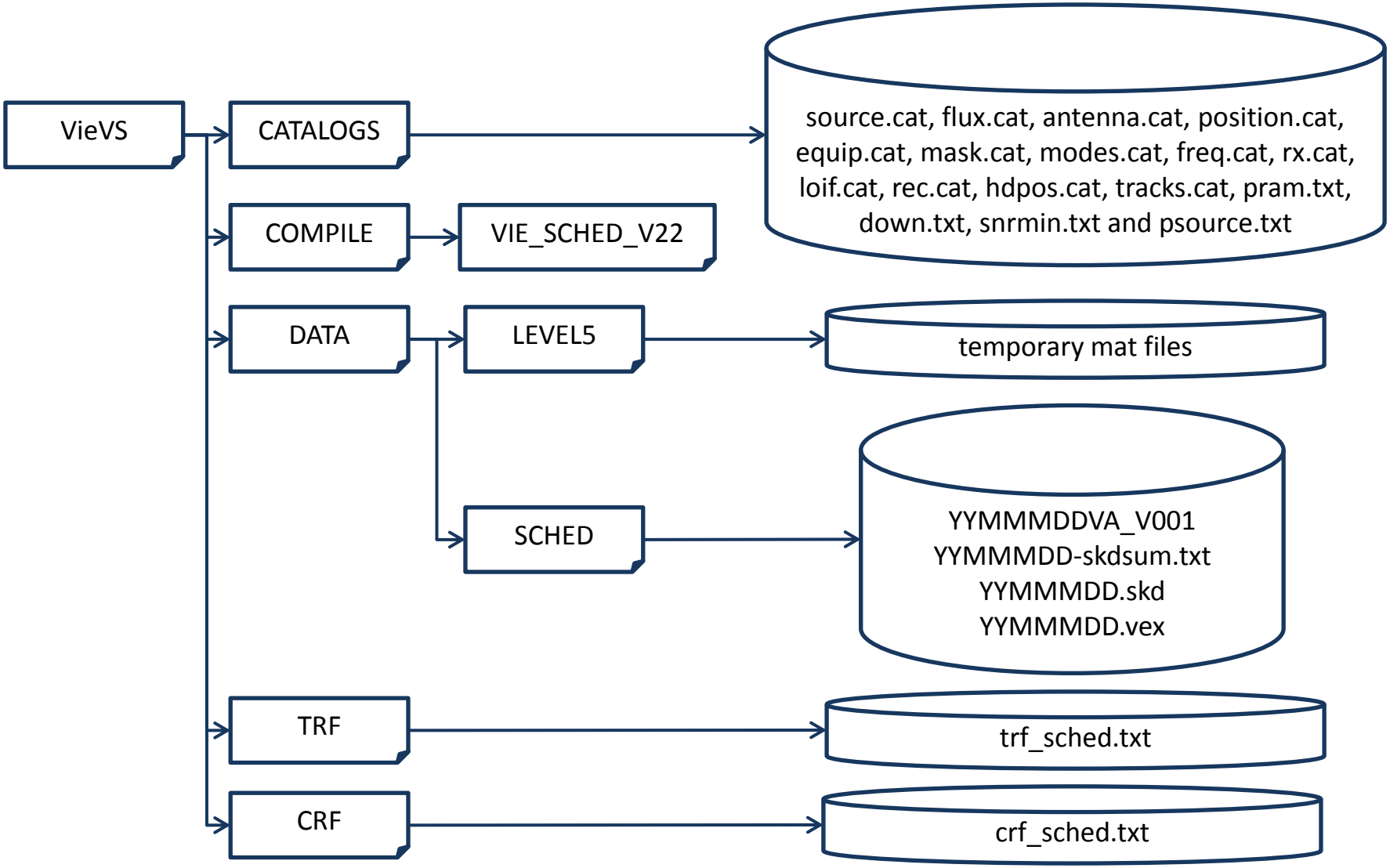
## Mode4 : Multidirectional observations




✓ more observations and better sky coverage

✓ strengthen the geometry

# The structure of VIE_SCHED within VieVS



# Input files (VieVS/CATALOGS)

- Catalog system files

| Type | File Name | Contents | Used for |
|---|---|---|---|
| Sources: | | | |
| | source.cat | source positions | simu + real |
| | flux.cat | source fluxes | simu + real |
| Stations: | | | |
| | antenna.cat | antenna information | simu + real |
| | position.cat | station x,y,z locations | simu + real |
| | equip.cat | equipment IDs | simu + real |
| | mask.cat | horizon and coordinate masks | simu + real |
| Observing modes: | | | |
| | modes.cat | observing modes | simu + real |
| | freq.cat | frequency sequences | real |
| | rx.cat | receiver setups | real |
| | loif.cat | station LO and IF setups | real |
| | rec.cat | recording modes | real |
| | hdpos.cat | head offsets | real |
| | tracks.cat | standard recorded tracks | real |

controlled and maintained at GSFC

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

(new) can be used directly (without manual changes) in VieVS.

# Input files (VieVS/CATALOGS)

- Local control files

(1) param.txt file

| Option | Description |
|---|---|
| PARA.WAVEL(1) | Wavelength of X band [meter] |
| PARA.WAVEL(2) | Wavelength of S band [meter] |
| PARA.RATE1A | Acceleration of AZ/HA axis [deg/s$^2$] |
| PARA.RATE2A | Acceleration of EL/DC axis [deg/s$^2$] |
| PARA.MARGEL1 | Marge for AZ/HA axis [deg] |
| PARA.MARGEL2 | Marge for EL/DC axis [deg] |
| PARA.MIN_SRCRP | The interval that the same source won't be observed twice [min] |
| PARA.SOURCE | Time for the antenna to settle down after slewing and before observation start time [sec] |
| PARA.TAPETM | Time for the tape after slewing and before observation start time [sec] |
| PARA.IDLE | Time allowed for idling after slewing and before observation start time [sec] |
| PARA.CALIBRATION | Time allowed for calibration after slewing and before observation start time [sec] |

# Input files (VieVS/CATALOGS)

Local control files

(1) param.txt file

| | |
|---|---|
| PARA.MAXSLEWTIME | Maximum time to allow an antenna to slew [sec] |
| PARA.MAX_WAIT | Maximum time to wait for the slow antenna [min] |
| PARA.CORSYNCH | Time to allow the correlator to synchronize tapes [sec] |
| PARA.MAX_SCAN | Maximum allowable scan time [sec] |
| PARA.MIN_SCAN | Minimum allowable scan time [sec] |
| PARA.FILLINMODE | If use fill-in mode (1/0) |
| PARA.FILLENDT | Maximum time for the end time of fill-in scan [min] |
| PARA.SCREEN | If print processing information on screen (1/0) |
| PARA.MIN_STANUM | Minimum subnet scheduled at one time |
| PARA.MIN_SRC2ANG | Minimum angle between two sources observed simultaneously [deg] |
| PARA.SKYDT | The interval for calculation of sky coverage [min] |
| PARA.EXPER | Experiment code |
| PARA.DESCRIPTION | Description of the experiment |
| PARA.SCANDURA | The default scan length [sec] |
| PARA.TRACKSMODE | The formatter mode |

# Input files (VieVS/CATALOGS)

Local control files

(1) param.txt file (new)

| | |
|---|---|
| PARA.UPSTA | different selection priority for station |
| PARA.DOWNSTA | different selection priority for station |
| PARA.SRCFRINGE | specify a source used for fringe check |
| PARA.FILLINMODE | four (0,1,2,12) options for the fill-in mode<br>0 no fill-in mode<br>1 fill-in mode 1<br>2 fill-in mode 2<br>12 fill-in mode 1 and 2 |
| PARA.MIN_STANUM | minimum subnet scheduled at one time (now available for both the station-based and source-based strategy) |

# Input files (VieVS/CATALOGS)

- Local control files

(1) param.txt file

(2) down.txt file

```
*
* down.txt - downtime information
*
* NOTE: Use this file for schedules to specify the downtime
*       that the station can't take part in observation.
*
* Name       start(YMDHMS)          end(YMDHMS)
 KOKEE      2012 08 28 18 15 00    2012 08 28 19 45 00
 WETTZELL   2012 08 28 18 15 00    2012 08 28 19 45 00
```

# Input files (VieVS/CATALOGS)

- Local control files

(1) param.txt file

(2) down.txt file

(3) snrmin.txt file

```
*
* snrmin.txt - minimum SNR information
*
* NOTE: Use this file for schedules to specify the minimum SNR
*       of each band at stations.
*
* Name        SNR_min(X)    SNR_min(S)
*
 TIGO         18            12
 TIGOCONC     18            12
```

# Input files (VieVS/CATALOGS)

## Local control files

(1) param.txt file

(2) down.txt file

(3) snrmin.txt file

(4) psource.txt file

```
*
* psource.txt - particular sources needed more observations
*
* NOTE: Use this file to specify a list of sources to be observed,
*       especially for astrometry.
*
*-----------------------------------------------------------------------------------------
*                                          ICRF      flux   structure
*         From       interval %year mo da    h        elon     sigma    3.6 cm       index      Nobs
*                      (min)                         (deg)     (uas)      (Jy)
*-----------------------------------------------------------------------------------------
* Session RD1206 12AUG28XA
*-----------------------------------------------------------------------------------------
 1030+074 20120829040000  20  %2012  8 29    0         2.3      92.2     0.299        2.64      1681
 1023+131 20120829040000  50  %2012  8 29    0         3.7     100.0     0.546        2.64      1167
 1015+057 20120828173000 180  %2012  8 29    0         4.9     134.5     0.285        2.75      1058
 1013+054 20120828173000 180  %2012  8 29    0         5.5      92.2     0.443        2.75      2674
 1022+194 20120828173000 180  %2012  8 29    0        10.0      78.1     0.670        2.64      3253
 1055+018 20120828173000 180  %2012  8 29    0        10.4      64.0     3.218        2.81      7749
 1111+149 20120828173000 180  %2012  8 29    0        12.1     122.1     0.423        2.53      1763
 1049+215 20120828173000 180  %2012  8 29    0        13.1      92.2     0.980        2.95      1599
 1012+232 20120828173000 180  %2012  8 29    0        14.2      84.9     0.859        2.75      2861
```

# Input files (VieVS/CATALOGS)

- Local control files

(1) param.txt file

(2) down.txt file

(3) snrmin.txt file

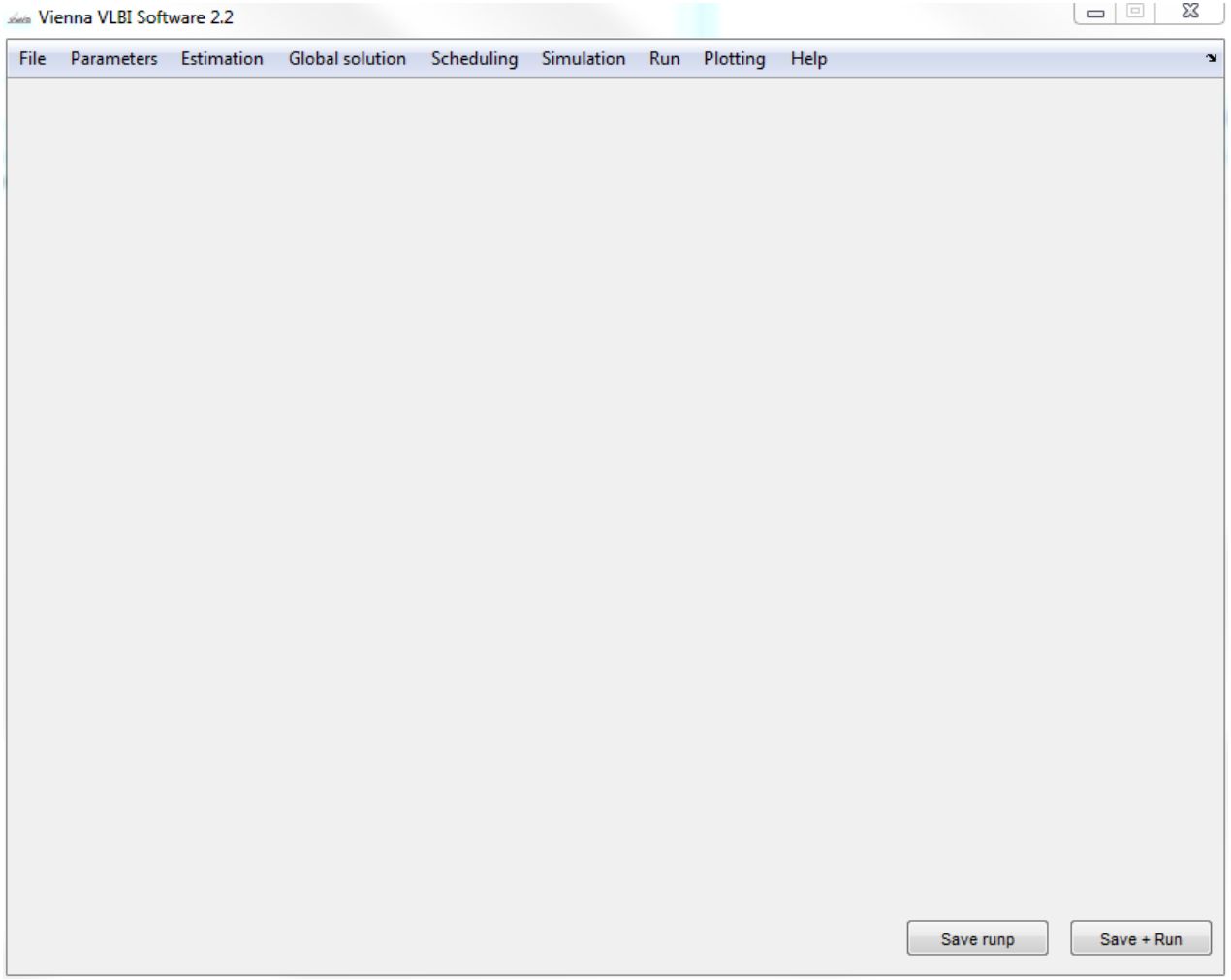
(4) psource.txt file

(5) tagalong.txt (new)

```
*
* tagalong.txt
*
* NOTE: Use this file to specify the station for tag-along mode
*       in Vie_Sched.
*
* StaName
*
 HARTRAO
```

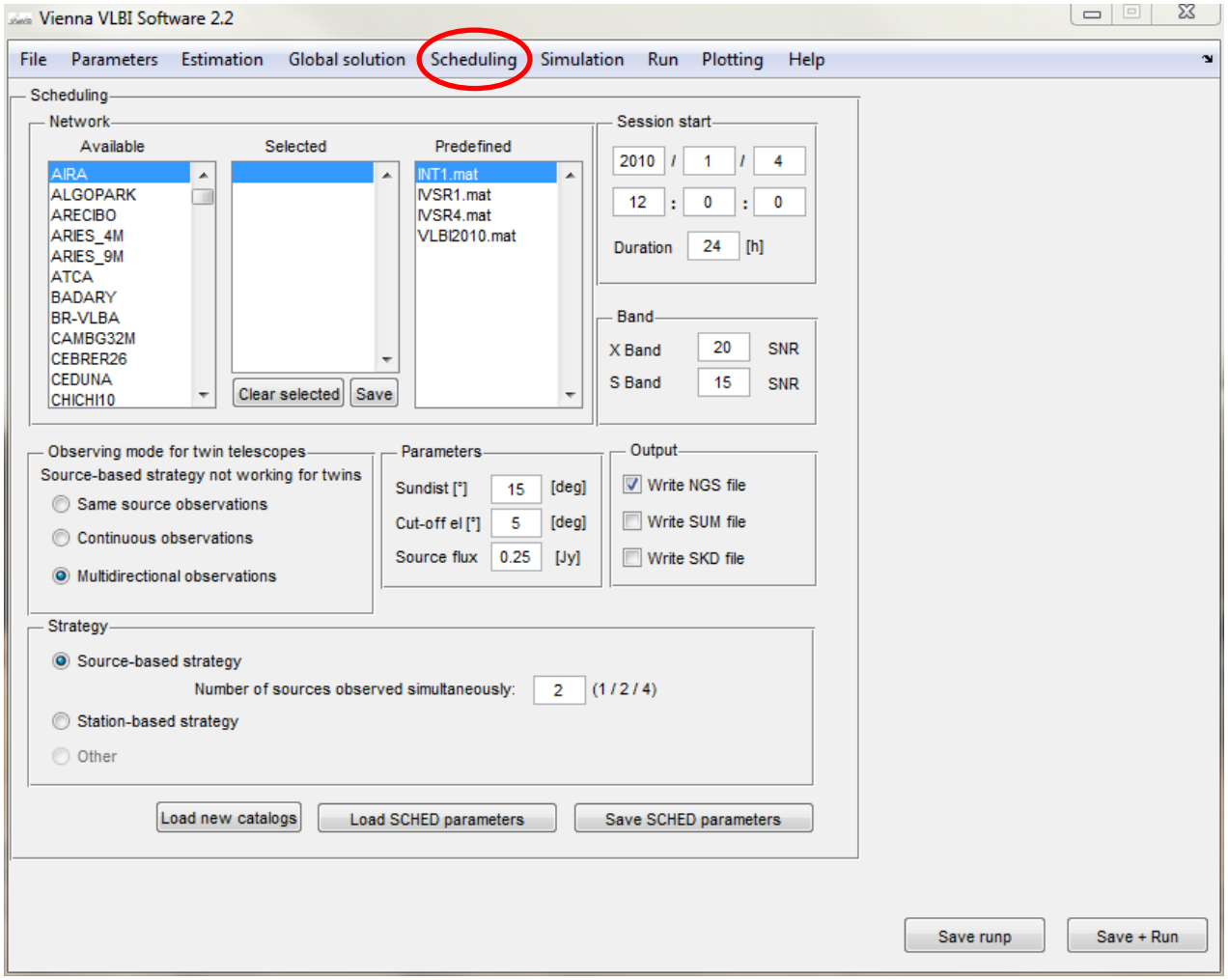
# How to run VIE_SCHED

- start VieVS as usual



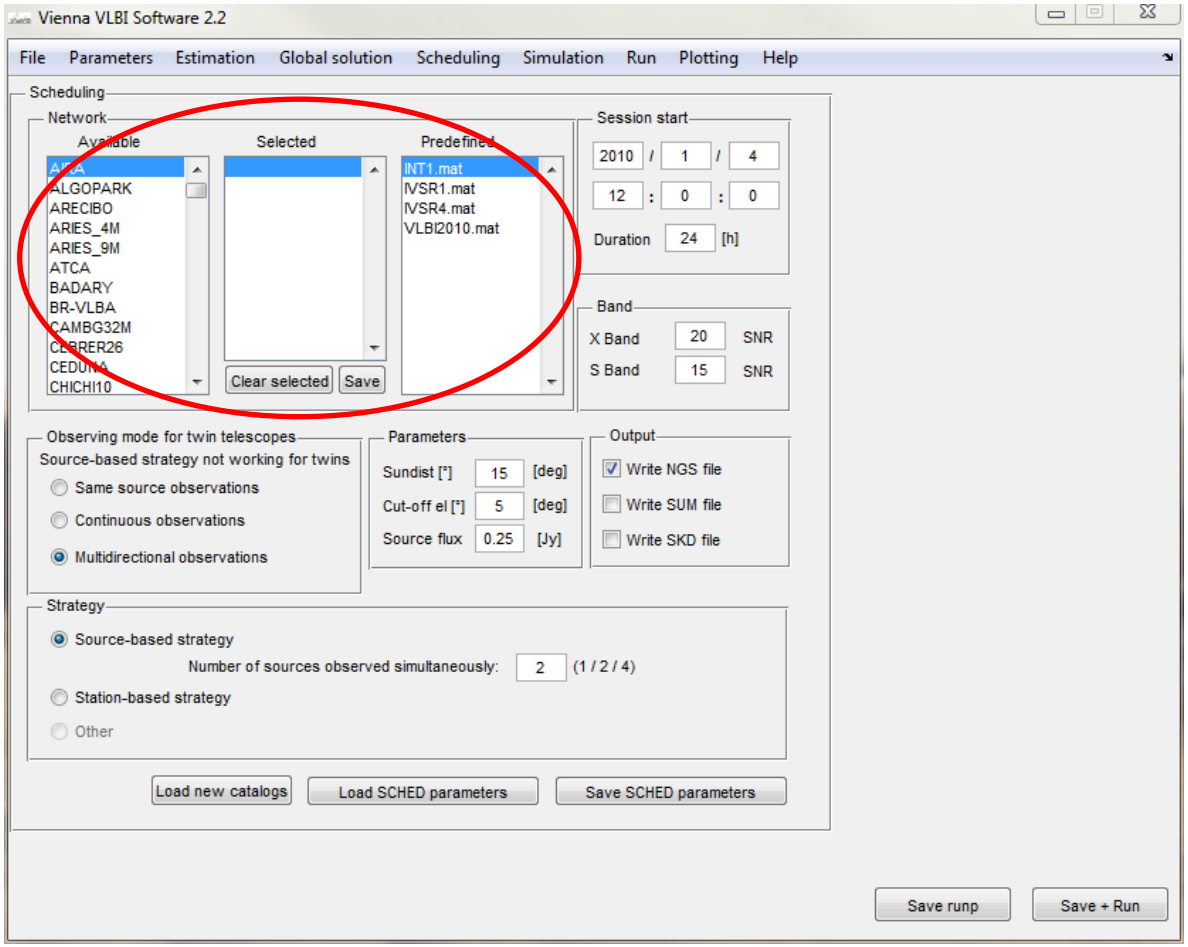
# How to run VIE_SCHED

## Scheduling GUI



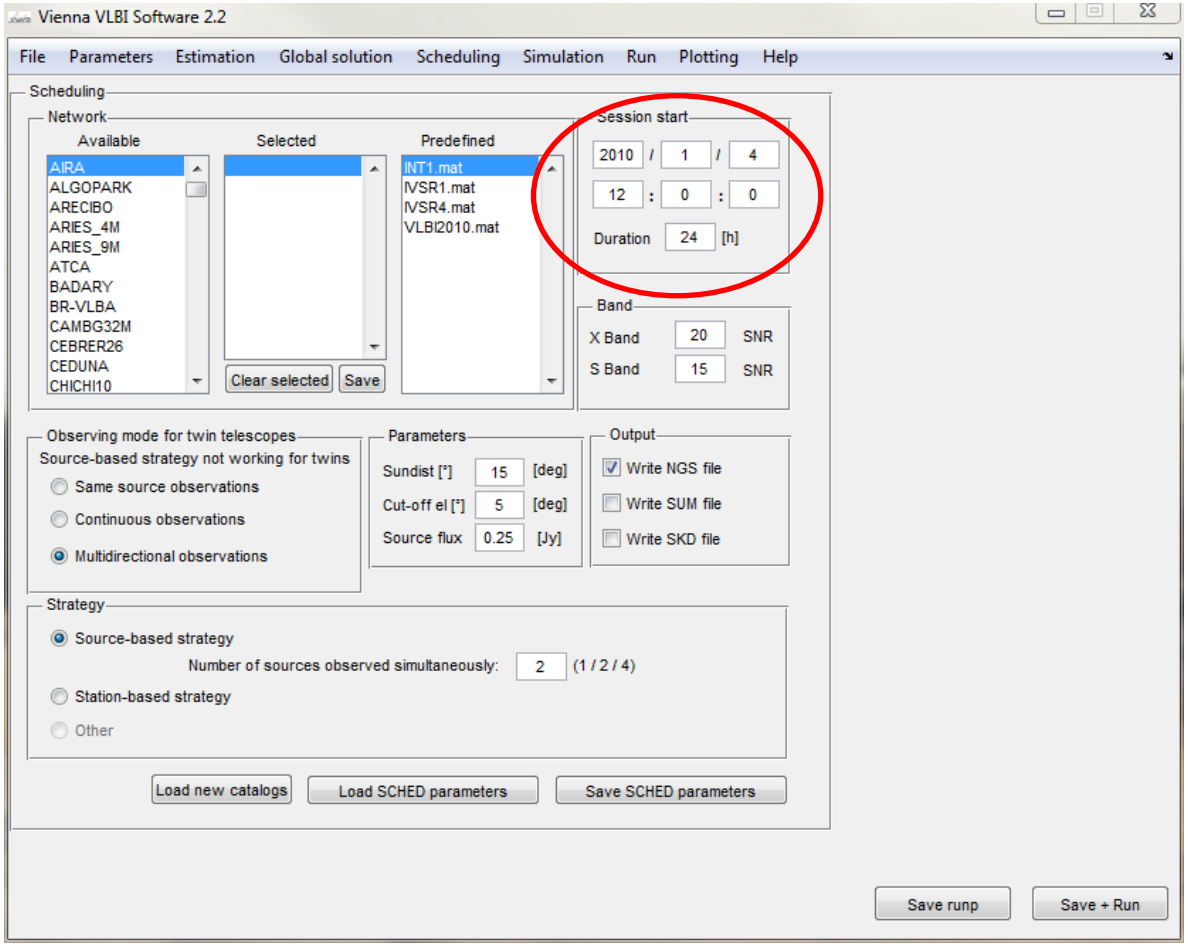
# How to run VIE_SCHED

Select the stations or use a predefined network. This is usually done according to the master file.



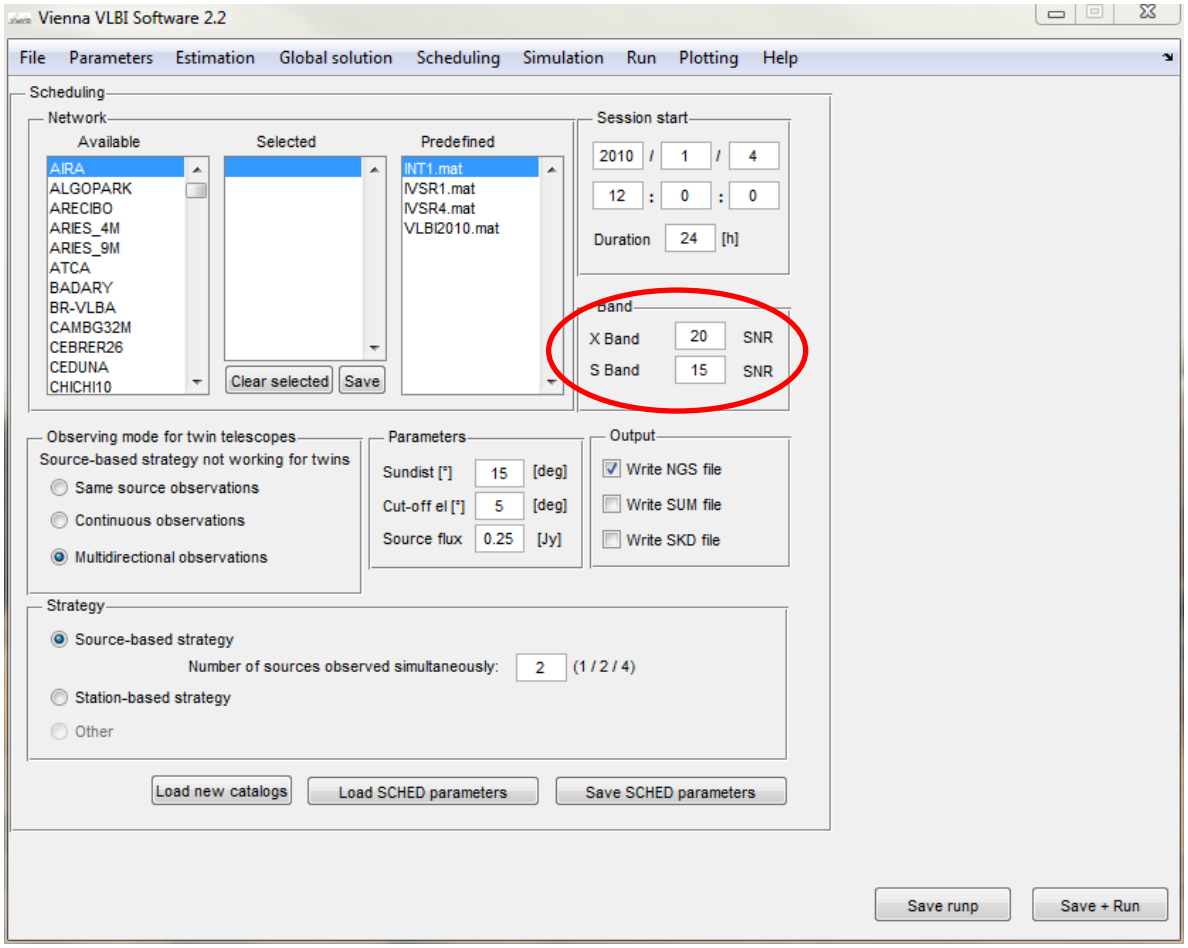
# How to run VIE_SCHED

Change the start times of the session and its duration. The start and end times are also contained in master file.



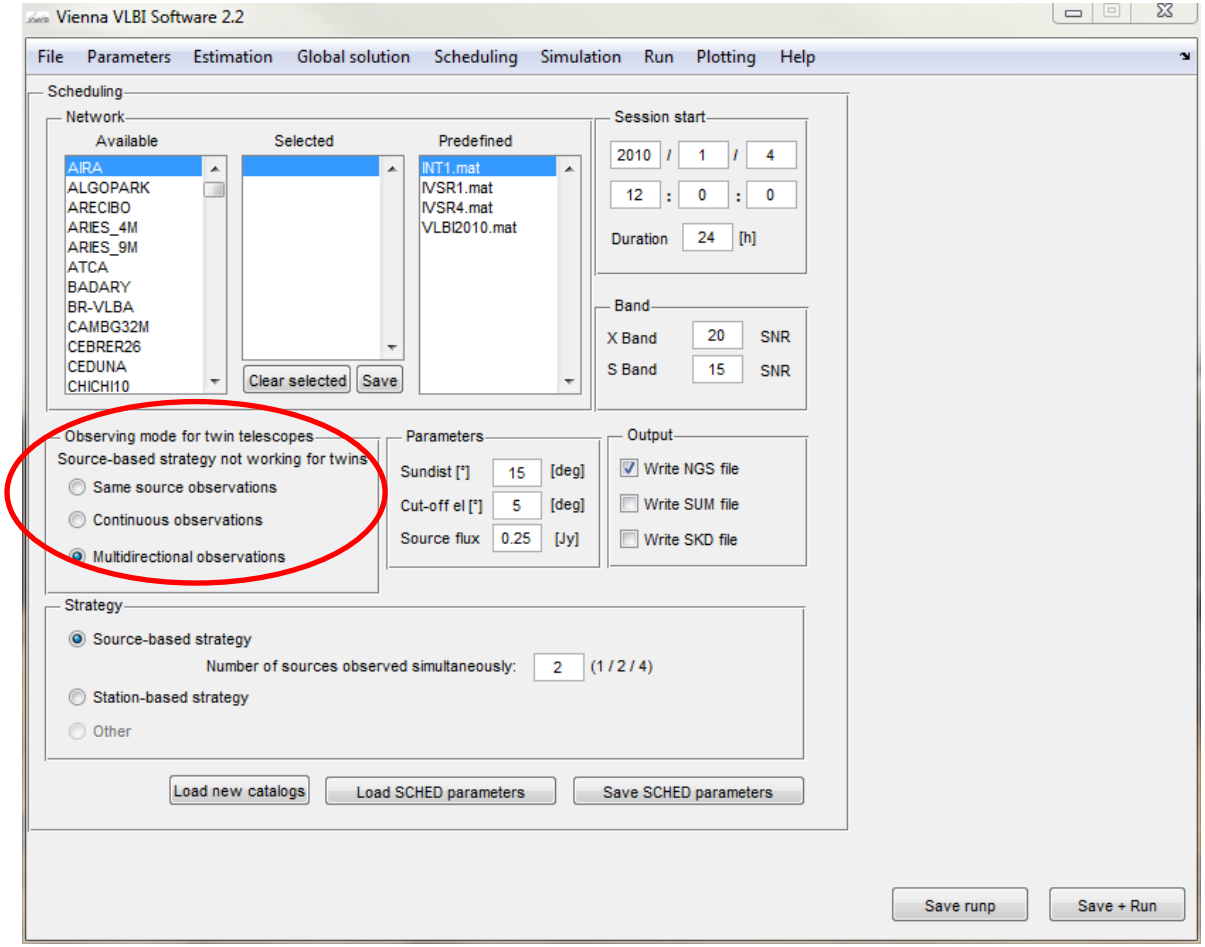
# How to run VIE_SCHED

Set the SNR targets.



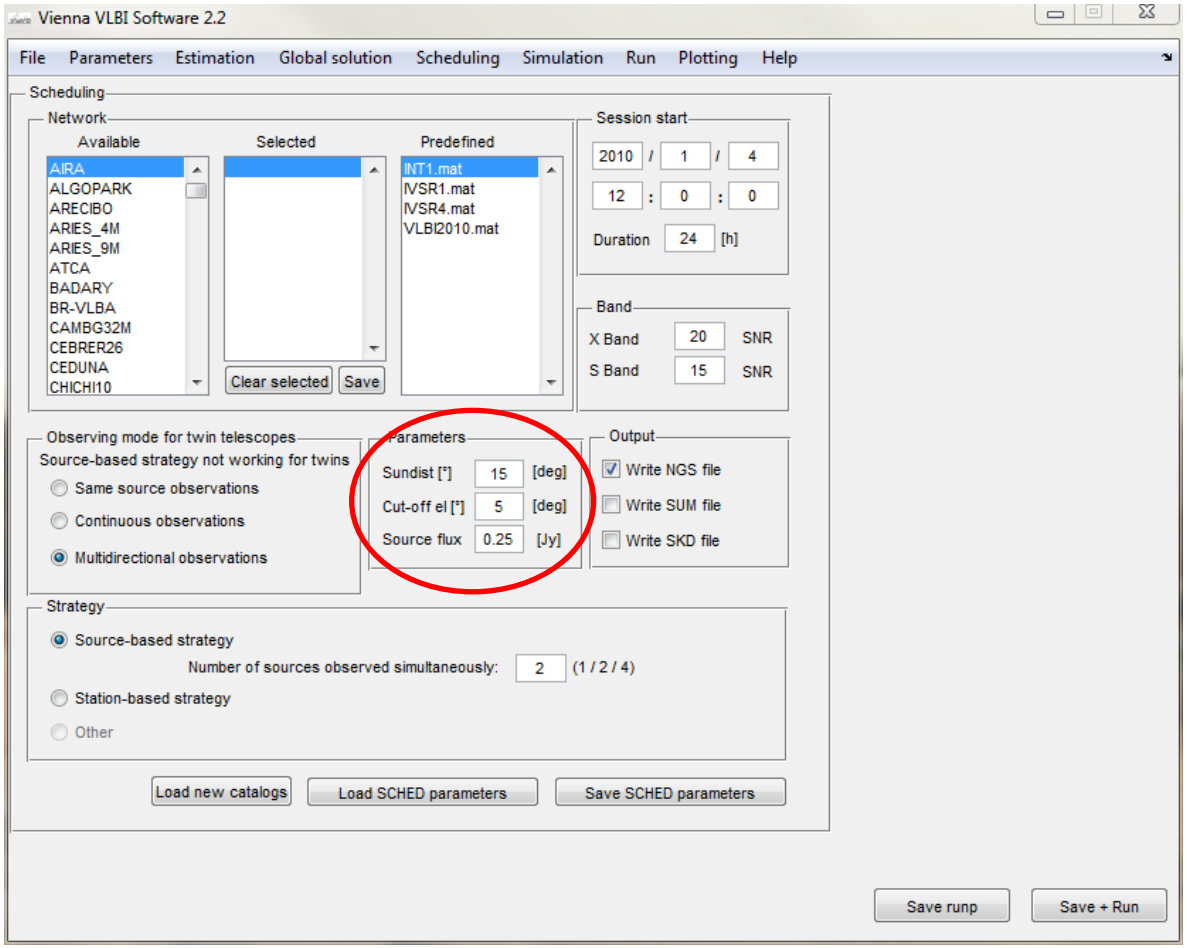
# How to run VIE_SCHED

Specify the observing mode for twin telescopes if there are twin telescopes in the network.



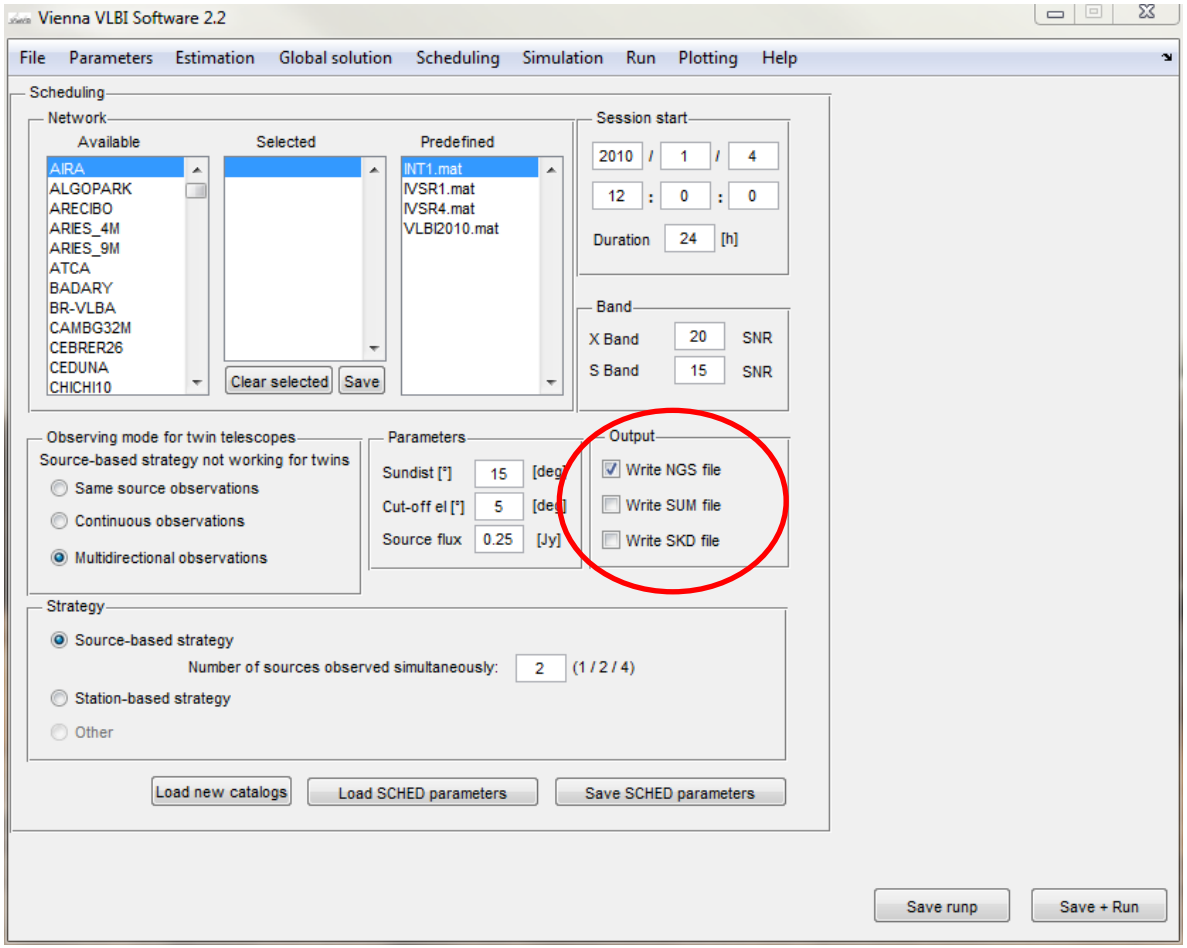
# How to run VIE_SCHED

- Give the parameters for scheduling.



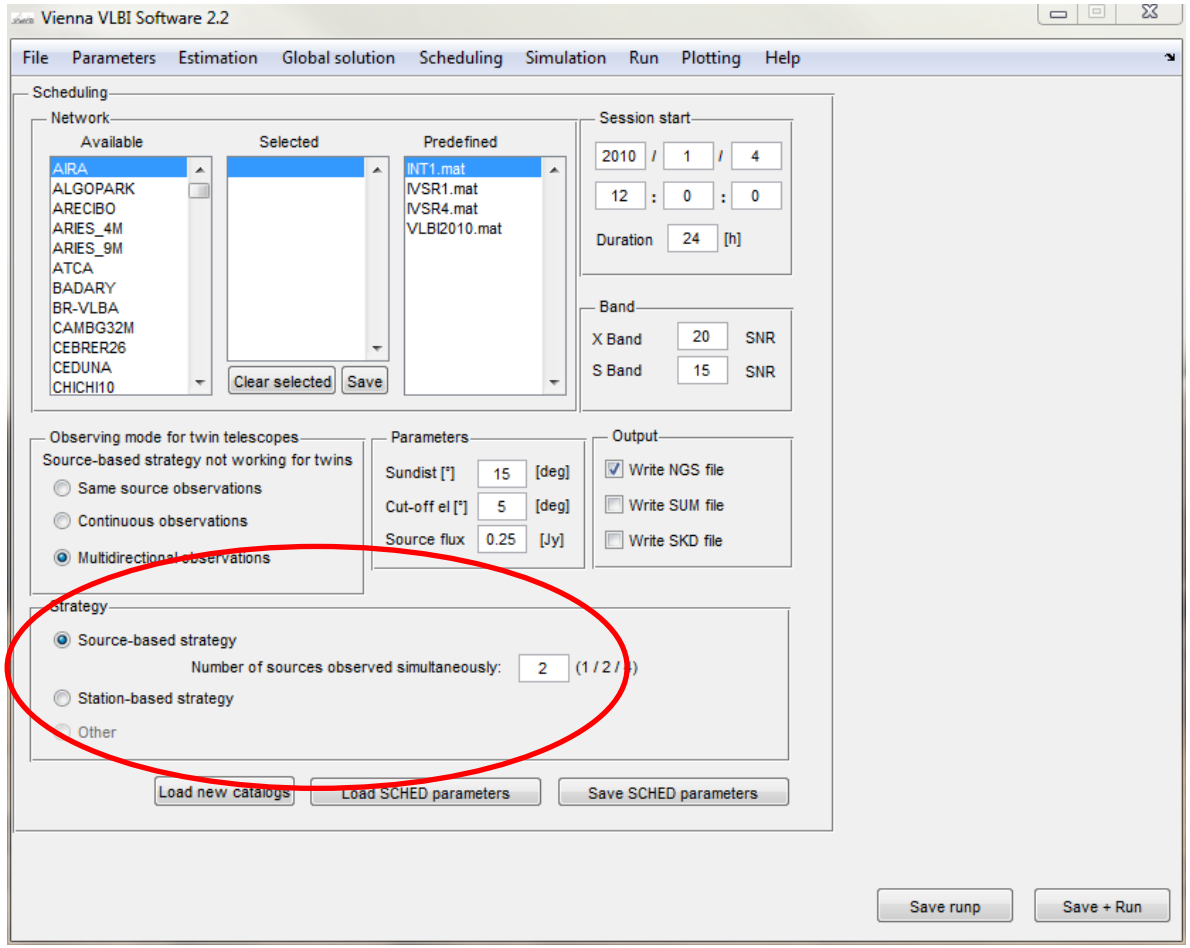
# How to run VIE_SCHED

- Specify the type of output files (NGS file, SUM file, or SKD/VEX file).



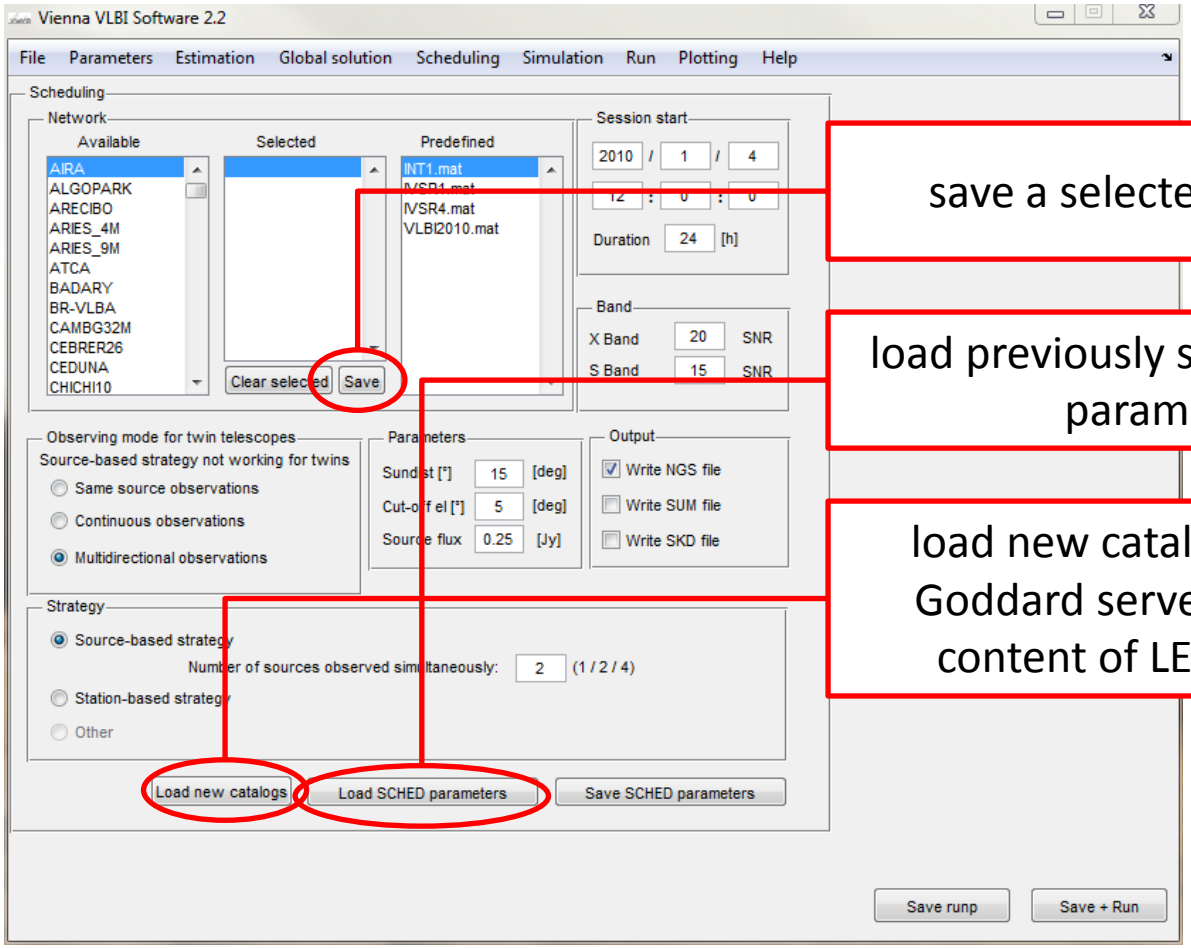
# How to run VIE_SCHED

Specify the strategy used for scheduling.



# How to run VIE_SCHED

## New options in the scheduling GUI



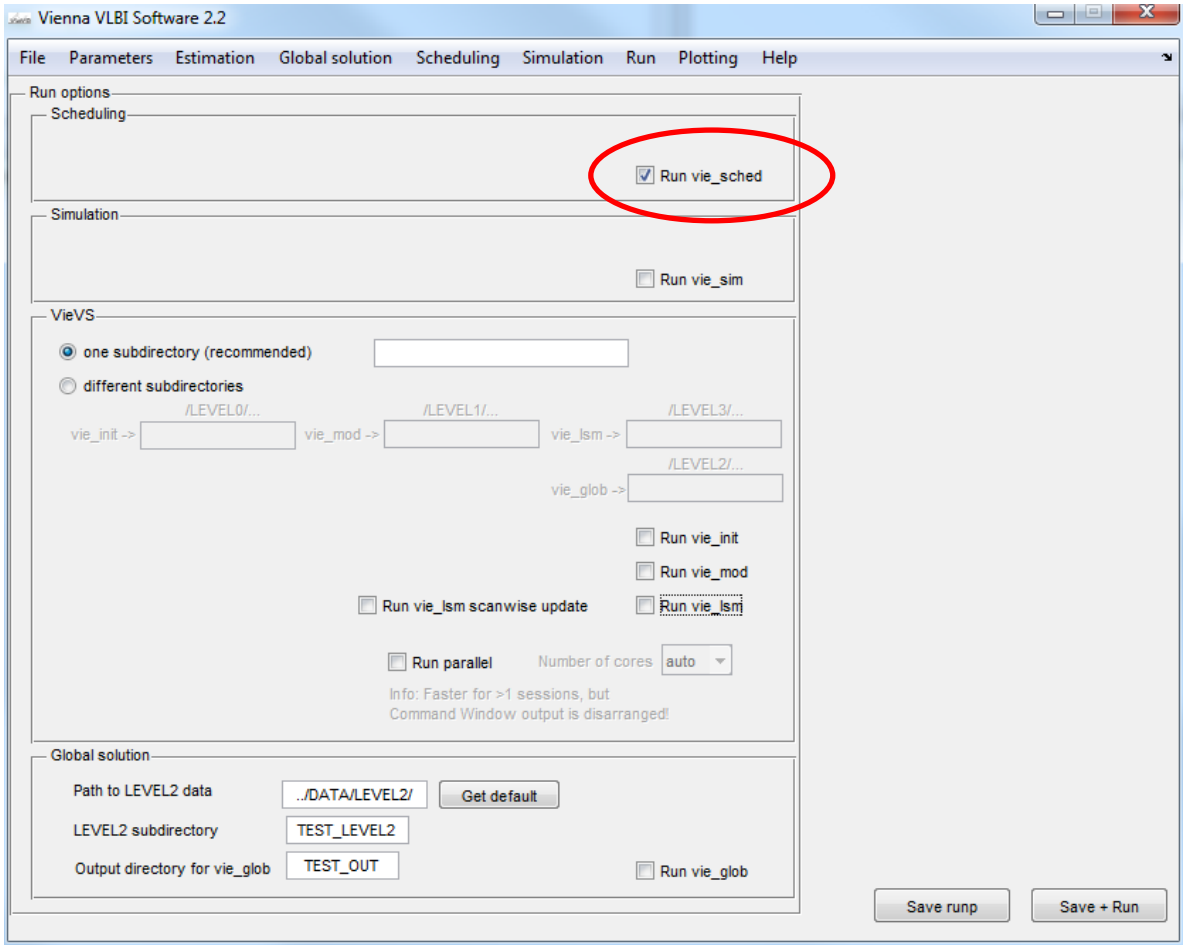

save a selected stationlist

load previously saved schedling parameters

load new catalogs from the Goddard server and delete content of LEVEL5 folder

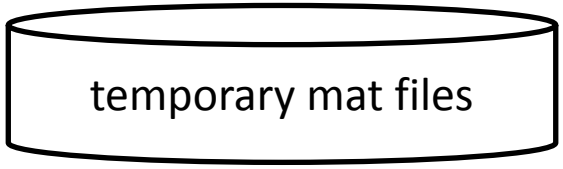
# How to run VIE_SCHED

## Run options for VIE_SCHED

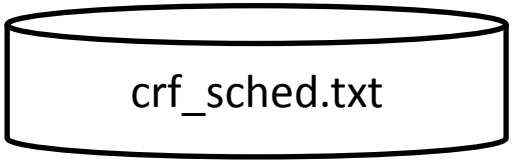


# Output files

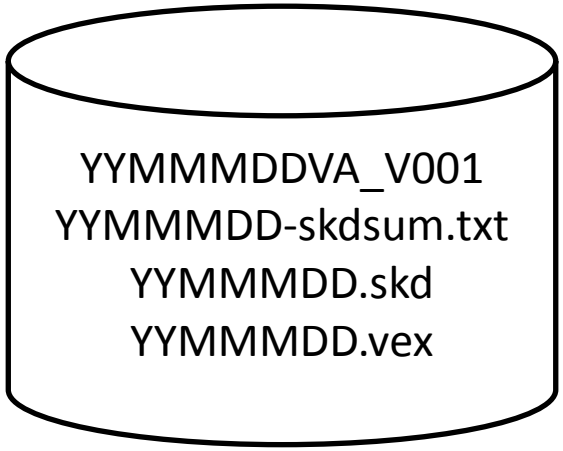
/VieVS/DATA/LEVEL5/



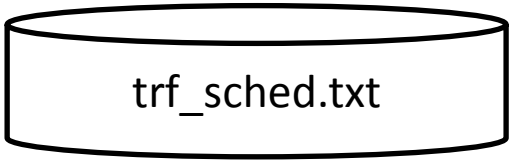

/VieVS/CRF/




/VieVS/DATA/SCHED/




/VieVS/TRF/



Thank you for your attention!

problems? questions?
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