

# ***basie* User Manual**

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## 1. Overview

*basie* is an application created to help the observers using the Italian radiotelescopes (Medicina, Noto and SRT) in single-dish mode. Its aim is to create the schedule files required by the ESCS/Nuraghe system.

### What it does:

- this tool reads and interprets a set of parameters provided by the user; it then **produces the schedule files** required by the ESCS/Nuraghe *ScheduleExecutor* in the proper format;
- it produces schedules for **continuum and spectroscopy** observations for the execution of OTF (On-The-Fly) **cross-scans** or **maps in OTF and raster mode**;

### What it does not do:

- **it is not a source visibility checker:** if a target is listed, *basie* will insert a scan for it in the schedule, not considering whether the target is going to be visible at execution time;
- **it is not an observation planner:** the scans in the schedule files will be executed in the same order as the sorted list of the targets;
- **it is not a format checker:** if users manually create or modify the schedule files for the ESCS system, they can **not** use this tool to check for format correctness or completeness (they could, however, use the *scheduleChecker* tool provided in ESCS/Nuraghe: follow the [ESCS/Nuraghe User Manuals](#)).

## 2. Getting and installing *basie*

The package is available for download here:

[github.com/discos/basie/](https://github.com/discos/basie/)

Installation instructions are provided inside the repository.

### 3. Running *basie*

Templates for the input files are provided. To get them,

```
> basie [-f] -t <destination_directory>
```

creates <destination\_directory> and copies *configuration.txt* and *targets.txt* user templates into the folder (see next chapter). If run with **-f** it will override eventually existing files.

To generate a schedule:

```
> basie [-f] -c <input_configfile_path> <destination_directory>
```

Generates the output schedule files into the destination directory, creating the folder if necessary. <input\_configfile\_path> is the path to a valid *Configuration file*. Path is relative to the working folder, unless an absolute path is specified. If run with **-f** it overrides eventually existing files.

**Example:** if the user edited the input files and renamed the *Configuration* one into *MyConfig.txt*, written inside the *Test/* subfolder, and wants to produce the output in the *Output/* folder, then the correct command is

```
> basie -c Test/MyConfig.txt Output
```

Help instructions can be retrieved by using

```
> basie --help
```

#### 3.1. Clarifications on the scan-subscan definition

Following the MBFITS definition, we call:

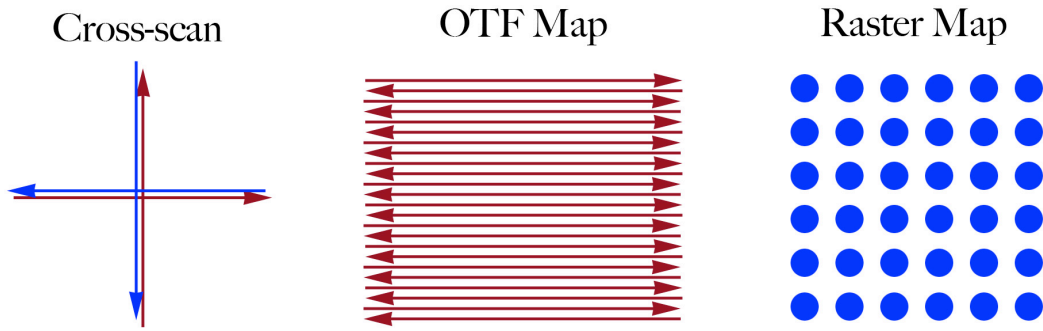
##### ***Scan***

it is the lowest level object normally used by an observer. *It is a sequence of one or more subscans that share a single goal:* for instance cross-scans and maps involve a pattern of subscans. Whether OTF maps mosaicing observations are considered a single scan or a series of scans is rather a matter of how the user would like to define it. In our implementation each map is considered a scan.

##### ***Subscan***

it is the minimal amount of data acquisition that can be commanded at the script language level. It is highly desirable that it is a simple enough element. For example, it is the single OTF “line” of a map or of a cross-scan.

The following plot visually represents what cross-scans, OTF maps and raster maps are.



In the case of cross-scan, a subscan is a single arrow (a line across the target), four arrows – i.e. two full crosses – constitute the schema which might be repeated as many times as needed within the scan.

For OTF maps, the subscan is again the single arrow, and the scan coincides with the whole map obtained with lines along one axis only (e.g. along RA or Dec). For raster maps, which are based on discrete acquisitions, each point is a subscan, and the final map constitutes the scan.

### 3.2. General rules

The creation of the schedule files is based on parameters to be set in the two input files. Parameters in these files are written in the form “**keyword = value**”.

Some general rules apply to the reading procedures:

- keyword and value must be separated by a '=' character;
- the case of keywords is ignored;
- spaces, tabular and newline character at the beginning and at the end of lines are ignored;
- comment lines start with a '#' character (ignoring spaces and/or tabular);
- empty lines are ignored.

## 4. Input files: parameters lists

The user is required to create and/or edit two files before running *basie* (see dedicated chapters):

- 1) *Configuration file* – listing the basic information on the project and on the types of data acquisition required; it also lists the names of the other input file;
- 2) *Target file* – providing the list of targets to be observed;

Filenames can be freely chosen - any GNU/Linux valid filename is accepted.

Lines inside the files can be commented using the # character.

### 4.1. Accepted formats for coordinates.

Whenever celestial coordinates (Equatorial, Horizontal or Galactic) are specified, the allowed formats are:

- **decimal degrees**, using a ‘d’ suffix, for any coordinate → e.g. 30.00d
- **sexagesimal degrees**, with no suffix, for any coordinate → 30:00:00
- **hh:mm:ss**, with a ‘h’ suffix, for longitudes only → 02:00:00h (*not accepted for offsets*)

### 4.2. Accepted scan/target frames

Subscans can be executed moving the antenna along the axes of the most common coordinate frames: **Equatorial (J2000.0)**, **Horizontal** and **Galactic**. The same frames are accepted to specify the target coordinates.

The scan frame must coincide with the target frame. There is only an exception: Horizontal scans can be performed also on a celestial source whose J2000.0 Equatorial coordinates are provided.

### 4.3. Configuration file

This file contains the main parameters for the schedule creation, the reference to the other input file (the *Target file*), and all the scan definitions that are going to be used to produce the output schedule.

Here follows the list of parameters to be included in this main file.

#### **projectID**

Label for the project. It will contribute to the output schedule filename and header, and will consequently be written, during the observations, in the headers and names of the data files.

#### **observer**

Label for the observer name.

#### **scheduleLabel**

Label for the output schedule filenames.

#### **radiotelescope**

Code for the telescope: SRT, MED or NOTO

**receiver**

Code for the receiver.

For MED the available choices are: C, CL, X, K.

For SRT the available choices are: L, P, C, K, KM. *K* corresponds to the use of the central feed only (data streams from the other feeds will not be recorded), while *KM* means the whole multi-feed is employed.

**repetitions**

Number of repetitions generally valid for all scans. In case the scan is a cross, setting this keyword to 1 corresponds to a double cross (each axis of the chosen coordinate frame is run back and forth), while for maps it means the whole sequence of subscans will be repeated only once.

**tsys**

Rule for the execution of  $T_{\text{sys}}$  measurements generally valid for all scans.

Accepted values:

- negative value: do not measure any  $T_{\text{sys}}$
- zero: measure the  $T_{\text{sys}}$  just once for each scan, at the beginning of the scan
- positive integer: measure  $T_{\text{sys}}$  every “tsys” subscans

This choice applies to all the targets (i.e. all the scans), unless a different value is specified, for the individual targets, in the *Target file*.

The  $T_{\text{sys}}$  acquisition is performed in a “far” position from the current target. Depending on the subscan parameters, this off-source position is determined in order to minimise the antenna slewing time.

**restFrequency**

Value(s), in MHz, for the rest frequency to be observed. If the chosen backend allows it, different values can be specified, by means of a comma-separated list, for the various sections.

**targetsFile**

Name of the *Target file*, which must be in the same folder of the *Configuration file*.

After this general information, the file contains two sections, specifically devoted to the backend setup and to the scan definitions.

**4.3.1. Backend definitions**

This section is introduced by the mandatory line

**[backend]**

after which the various backend configurations follow, each introduced by a unique user-defined name written in double square brackets:

**[[bckconfname]]**

Each configuration is expressed by the following settings:

**type**

Choose from: TOTALPOWER, XARCOS, ROACH.

**integration** (TOTALPOWER only)

Integration time for each sample which gets recorded in the output file.

It is expressed in [ms].

It must be a positive integer number.

**samplingInterval** (TOTALPOWER only)

Sampling interval for the backend data acquisition.

It is expressed in [ms]. The fastest sampling (or “dump” time) is 1 ms. The above “integration” can coincide with the sampling interval, or be a longer time interval.

**bandwidth** (TOTALPOWER only)

Bandwidth filter selected for the section.

It is expressed in [MHz].

Accepted values are limited to a few possibilities Follow the examples given in the template configuration file.

Notice that these nominal values are usually different from the resulting actual bandwidth, as this depends on the frontend-backend coupling. See the ESCS/Nuraghe User Manuals for details.

**configuration** (for XARCOS and ROACH only)

Accepted values are specific to the backend. Follow the examples given in the template configuration file.

### 4.3.2. Scan definitions

This section is introduced by the mandatory line

**[scan]**

after which the various scan definitions are listed.

Depending on the scan type, the definitions have a different syntax, as described in the following sections.

#### Cross scans

*CROSSSCANNAME = CROSS FRAME LENGTH SPEED*

where

CROSSSCANNAME label/ID for this definition, it can be any string

CROSS mandatory string: ‘CROSS’

FRAME subscan frame, i.e. the coordinate frame along which the subscans will be performed. It can be ‘EQ’, ‘HOR’ or ‘GAL’

LENGTH actual subscan span, on sky [degrees]

SPEED actual subscan speed, on sky [degrees/min, equivalent to arcmin/s]

### **OTF maps**

*OTFMAPNAME = OTFMAP FRAME AXIS START LENGTH\_X LENGTH\_Y SPEED SCANS\_PER\_BEAM*

where

OTFMAPNAME	label/ID for this definition, it can be any string
OTFMAP	mandatory string: 'OTFMAP'
FRAME	subscan frame, i.e. the coordinate frame along which the subscans will be performed. It can be 'EQ', 'HOR' or 'GAL'
AXIS	frame axis along which the subscans will be performed. It can be 'LON' or 'LAT' for any frame, or more specifically 'RA', 'DEC', 'AZ', 'EL' according to the scan frame specified above. Assigning the value 'BOTH' to this keyword, two separate scans will be generated: one along longitude and one along latitude
START	code for the map starting point, visualizing the map as projected "on sky". Accepted values: 'TL' = Top Left corner, 'TR' = Top Right corner, 'BL' = Bottom Left corner, 'BR' = Bottom Right corner
LENGTH_X	actual map size in longitude, on sky [degrees]
LENGTH_Y	actual map size in latitude, on sky [degrees]
SPEED	actual subscan speed, on sky [degrees/min, equivalent to arcmin/s]
SCANS_PER_BEAM	interspacing between adjacent subscans [beam <sup>-1</sup> ]

### **Raster maps**

*RASTERMAPNAME = RASTERMAP FRAME AXIS START LENGTH\_X LENGTH\_Y DURATION  
POINTS\_PER\_BEAM*

where

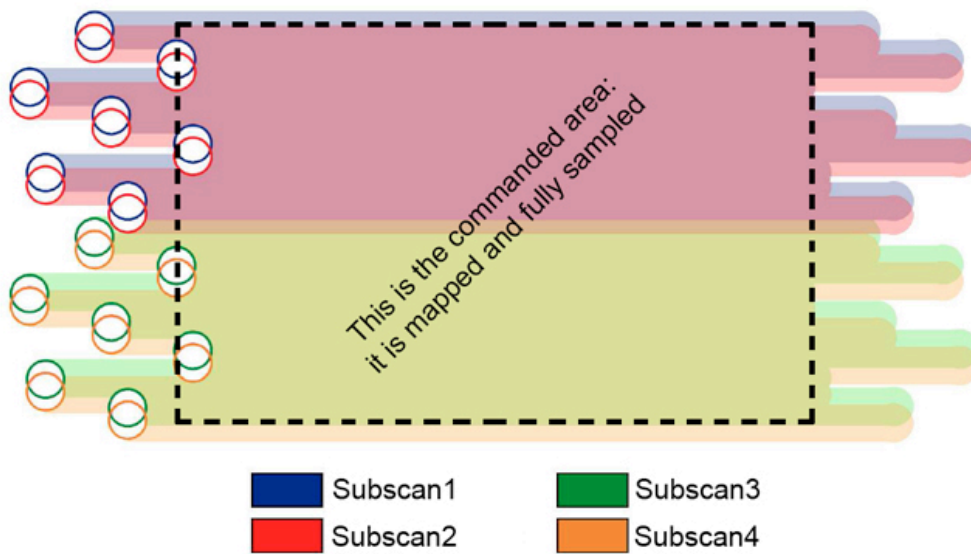
RASTERMAPNAME	label/ID for this definition, it can be any string
RASTERMAP	mandatory string: 'RASTERMAP'
FRAME	subscan frame, i.e. the coordinate frame along which the sequence of acquisitions will be performed. It can be 'EQ', 'HOR' or 'GAL'
AXIS	frame axis along which the subscans will be performed. It can be 'LON' or 'LAT' for any frame, or more specifically 'RA', 'DEC', 'AZ', 'EL' according to the scan frame specified above
START	code for the map starting point, visualizing the map as projected "on sky". Accepted values: 'TL' = Top Left, 'TR' = Top Right, 'BL' = Bottom Left, 'BR' = Bottom Right
LENGTH_X	actual map size in longitude, on sky [degrees]
LENGTH_Y	actual map size in latitude, on sky [degrees]
DURATION	duration of each subscan [s]
POINTS_PER_BEAM	interspacing between adjacent subscans [beam <sup>-1</sup> ]



## NOTE on MULTI-FEED mapping

When OTF or raster maps are coupled to the “KM” receiver choice, *basie* produces optimized maps. This means that:

- The schedule includes the configuration of the derotator in “BSC” mode (best space coverage);
- The schedule contains properly spaced subscans, conceived to allow for the desired area to be fully sampled, according to how many scans-per-beam are required, exploiting all the beams provided by the multi-feed. The figure below offers an example for a 2 scan/beam setup. Additional “fringes” outside the desired area are inevitably produced, for geometrical reasons.



### ON-OFF acquisitions

*ONOFFNAME* = ONOFF *DURATION* *OFF\_FRAME* *LON\_OFF* *LAT\_OFF* [*duty cycle*]

where

*ONOFFNAME*      label/ID for this definition, it can be any string  
 ONOFF            mandatory string: ‘ONOFF’  
 DURATION       duration of each subscan [s]  
 OFF\_FRAME      frame for the off-source slewing, i.e. the coordinate frame along which the antenna will go off-source. It can be ‘EQ’, ‘HOR’ or ‘GAL’  
 LON\_OFF        offset along the longitude axis of the above-specified frame [degrees]  
 LAT\_OFF        offset along the latitude axis of the above-specified frame [degrees]  
 [*duty\_cycle*]    sequence specifying the duty cycle. It exploits the labels:  
                   ‘on’ – on-source, with calibration mark switched off  
                   ‘off’ – off-source, with calibration mark switched off  
                   ‘on\_cal’ – on-source, with calibration mark switched on  
                   ‘off\_cal’ – off-source, with calibration mark switched on  
                   Order and amounts are free (see the following examples):  
                   [2on,2off,2off\_cal]  
                   [3off,3off\_cal,4on]

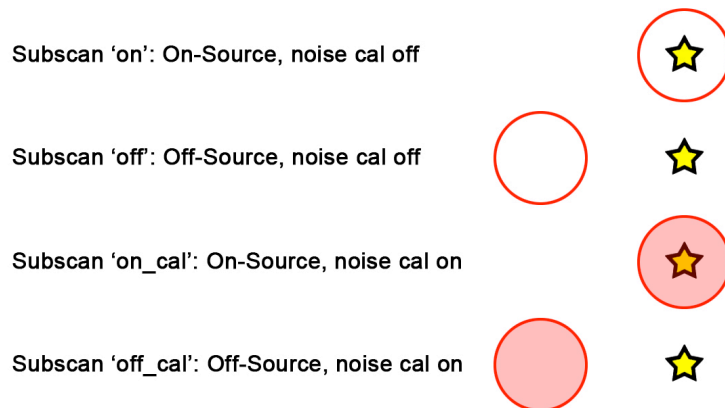
**NODDING acquisitions**  
(for multi-feed receivers only!)

*NODDINGNAME* = NODDING *FEED\_A FEED\_B DURATION* [*duty cycle*]

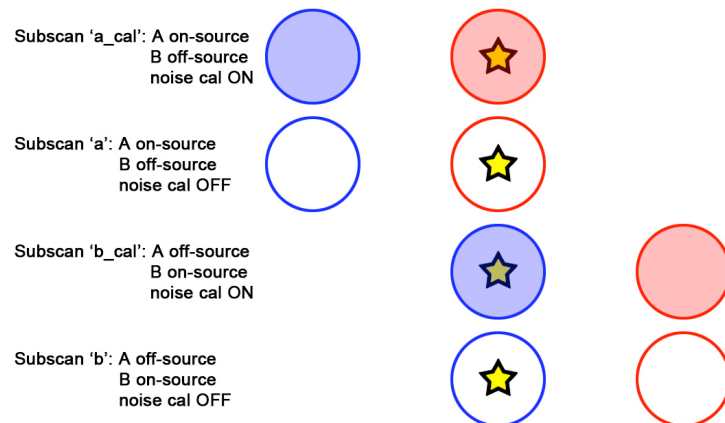
where

**NODDINGNAME** label/ID for this definition, it can be any string  
**NODDING** mandatory string: 'NODDING'  
**FEED\_A** number of the first feed to be employed  
**FEED\_B** number of the second feed to be employed  
**DURATION** duration of each subscan [s]  
**[duty\_cycle]** sequence specifying the duty cycle. It exploits the labels:  
 'a' – subscan with the FEED\_A pointing to the source  
 'a\_cal' – as 'a', but with the calibration mark switched on  
 'b' – subscan with the FEED\_B pointing to the source  
 'b\_cal' – as 'b', but with the calibration mark switched on  
 Order and amounts are free (see the following examples):  
 [2a,2b,2b\_cal]  
 [3b,1a,1a\_cal]

### ON-OFF



### 2-beam NODDING



## 4.4. Target file

This file provides the **sorted list of targets** used to define the sequence of scans within the schedule. Each line contains one target and corresponds to the creation of one scan in the schedule.

The first six values are mandatory, then some optional ones can follow.

We stress again that the order of the targets in this file determines the order of the scans in the schedule. If one target is to be observed N times, producing N separate scans, then it must appear N times in the list. Here is the syntax for each target:

LABEL SCANTYPE BACKEND TARGET\_FRAME LONGITUDE LATITUDE  
[tsys, repetitions, offset\_lon, offset\_lat, offset\_frame, rvel, vref, vdef]

where

LABEL	label for target. It will end up in the data files
SCANTYPE	name of the scan definition, it must be among the ones listed in the <i>Configuration file</i>
BACKEND	name of the backend definition, it must be among the ones listed in the <i>Configuration file</i>
TARGET_FRAME	frame of the target coordinates specified in the next two positions. It can be 'EQ', 'HOR' or 'GAL'
LONGITUDE	target longitude [degrees or - for RA only – hours (using the 'h' suffix!)]
LATITUDE	target latitude [degrees]

**tsys** [optional]

Choice for the  $T_{\text{sys}}$  measurements, to be applied only to this target.

If present, this value overrides the general setup specified in the *Configuration file*, so that the user can change this preference for each target.

The value must be in the format “tsys=<number>”, <number> must be an integer number.

Accepted values:

- negative value: do not measure any  $T_{\text{sys}}$
- zero: measure the  $T_{\text{sys}}$  just once for each scan, at the beginning of the scan
- positive integer: measure  $T_{\text{sys}}$  every “tsys” subscans

**repetitions** [optional]

Choice for the number of repetitions of the whole set of subscans inside the scan. If present, this value overrides the general setup specified in the *Configuration file*, so that the user can change this preference for each target.

**offset\_lon** [optional]

Offset longitude to be applied to all the subscans for the current target [degrees].

It is considered as “sky offset” (actual offset on sky).

Default value, if not specified, is 0.0d.

**offset\_lat** [optional]

Offset latitude to be applied to all the subscans for the current target [degrees].

It is considered as “sky offset” (actual offset on sky).

Default value, if not specified, is 0.0d.

**offset\_frame** [optional]

Coordinate frame associated to the specified offsets. For OTF acquisitions it must coincide with the scan frame, the one specified in the scan definition appearing in the *Configuration file*, and this is the default if the keyword is absent.

For raster acquisitions, any frame can be specified: 'EQ', 'HOR', 'GAL'.

**rvel** [optional]

Target radial velocity (km/s) or redshift, according to the velocity reference frame.

If rvel is present, vref and vdef must also be used.

**vref** [optional]

Velocity reference frame. Choose from "BARY", "LSRK", "LSRD", "GALCEN", "TOPCEN".

If vref is present, rvel and vdef must also be used.

**vdef** [optional]

Velocity definition. Choose from "OP", "RD", "Z". If vdef is present, rvel and vref must also be used. NOTICE: when vdef=Z

## 5. Output files

The tool creates **four files**, fully described in the [ESCS/Nuraghe User Manuals](#), to be given in input to the ESCS/Nuraghe system when the observation is carried out.

It is a duty of the users to copy/move these output files to the directory as required by ESCS/Nuraghe.

The output files share a common basename: it is the **scheduleLabel** specified in the *Configuration file*.

Here follows the list of the five output files that constitute the schedule:

- **backend configuration** setup: scheduleLabel.bck
- set of **procedures** to be applied during the schedule execution: scheduleLabel.cfg
- sequence of **scan-level definitions** and **subscan references** for each target: scheduleLabel.lis
- set of **subscan-level definitions** for each target: scheduleLabel.scd

A more accurate description of these files can be found in the [ESCS/Nuraghe User Manuals](#). However, users ideally should never edit the schedule files, so their structures might remain totally transparent to them. We advise only expert users to attempt direct modifications to the schedules.

## 6. Examples

### 6.1. Configuration file

```
#####
projectID = ProjectName
observer = YourName
scheduleLabel = TestSched
# SRT, MED or NOTO
radiotelescope = SRT
# for Medicina receivers can be:
# C, CL, X, K
# for SRT receivers can be:
# P, L, C, K, KM
receiver = K
# default repetitions value for each scan
repetitions = 1
# default tsys value for each scan
tsys = 0
#optional restFrequency in MHz, can be a list
#restFrequency = 22345.18,22410.10
#restFrequency = 22000

# File name of the target specs in this same directory
targetsFile = targets.txt

[backends]
# Here we configure which backend we are using in this schedule.
[[TP]]
    type = TOTALPOWER
    # integration period in ms
    integration = 10
    # sampling interval in ms
    samplingInterval = 10.0
    # bandwidth in MHz, possible values are:
    # 300, 730, 1250, 2000
    bandwidth = 300

[[TP20_730]]
    type = TOTALPOWER
    # integration period in ms
    integration = 20
    # sampling interval in ms
    samplingInterval = 20.0
    # bandwidth in MHz, possible values are:
    # 300, 730, 1250, 2000
    bandwidth = 730

[[XK77]]
    type = XARCOS
    # one of XK77 XK03 XK06 XK00 XC00
    configuration = XK77

[[XC00]]
    type=XARCOS
    configuration = XC00
```

```

[[ROACHRK00]]
  type = ROACH
  # one of RK00 RK77 RC00 RL00 RP00
  configuration = RK00

[scantypes]

#CROSSSCANNAME = CROSS FRAME LENGTH SPEED
EqCross1_3 = CROSS EQ 1.0d 3.0
EqCross1_5 = CROSS EQ 1.0d 5.0
HorCross1_3 = CROSS HOR 1.0d 3.0

#OTFMAPNAME = OTFMAP FRAME AXIS START LENGTH_X LENGTH_Y SPEED SCANS_PER_BEAM
ELMAP1x1TL = OTFMAP HOR EL TL 1.0d 1.0d 5.0 3
AZMAP1x1TR = OTFMAP HOR AZ TR 1.0d 1.0d 5.0 3
RAMAP1x1BL = OTFMAP EQ RA BL 1.0d 1.0d 5.0 3
DECMAP1x1BR = OTFMAP EQ DEC BR 1.0d 1.0d 5.0 3
GLONMAP2x2TL = OTFMAP GAL LON TL 2.0d 2.0d 10.0 3
GLATMAP2x2TL = OTFMAP GAL LAT TL 2.0d 2.0d 10.0 3
EQMap1x1 = OTFMAP EQ BOTH TL 1.0d 1.0d 5.0 3

#RASTERMAPNAME = RASTERMAP FRAME AXIS START LENGTH_X LENGTH_Y DURATION
#POINTS_PER_BEAM
HorRasterTL = RASTERMAP HOR LON TL 1.0d 1.0d 10.0 3
HorRasterTR = RASTERMAP HOR LAT TR 1.0d 1.0d 5.0 3

#ONOFFNAME = ONOFF DURATION OFF_FRAME LON_OFF LAT_OFF [Non,Noff,Non_cal,Noff_cal]
OnOff = ONOFF 4.0 EQ 1.0d 1.0d [4on,4off,2off_cal]
AlwaysOn = ONOFF 10.0 EQ 0.0d 0.0d [4on,4on_cal]

#NODDINGNAME = NODDING FEED_A FEED_B DURATION [Na,Nb,Na_cal,Nb_cal]
Nodding06 = NODDING 0 6 10.0 [2a,2a_cal,2b,2b_cal]

```

#####

**Note:** you can list as many scan definitions as you want. Only the ones invoked in the *Target file* will be actually employed.

## 6.2. Target file

```

#####
# Comment lines to exclude them from the schedule computation
#
# Mandatory params:
# LABEL SCANTYPE BACKEND TARGET_FRAME LONGITUDE LATITUDE
# where:
# SCANTYPE is defined in configuration file
# BACKEND is defined in configuration file
# TARGET_FRAME = [EQ, GAL, HOR]
#
# Optional params:
# [tsys, repetitions, offset_lon, offset_lat, offset_frame, vref, vdef, rvel]
# where:
# vref = [BARY, LSRK, LSRD, GALCEN, TOPCEN]
# vdef = [OP, RD, Z]

Alpha EqCross1_3 TP EQ 12:00:00h +45:00:00
Alpha EqCross1_3 TP EQ 180:00:00 +45:00:00
Alpha EqCross1_3 TP EQ 180.0d +45.0d
Beta HorCross1_3 TP HOR 124.5d 38.2d

```

```

Gamma  EqCross1_5  TP EQ 13:45:12.3h +34:56:43.0  tsys=2  repetitions=4
Gamma  EqCross1_5  TP EQ 13:45:12.3h +34:56:43.0  offset_lon=-0.5d
Delta  RAMAP1x1BL  TP EQ 12:00:00h +45:00:00
Delta  DECMAP1x1BR  TP EQ 12:00:00h +45:00:00
Delta  EQMap1x1     TP EQ 12:00:00h +45:00:00
Epsilon GLONMAP2x2TL TP GAL 275.0d -12.0d  tsys=10
Epsilon GLATMAP2x2TL TP GAL 275.0d -12.0d  tsys=10
#Zeta  HorRasterTL  TP EQ 12:00:00h +45:00:00  offset_lon=0.1d offset_frame=EQ
Zeta   OnOff TP EQ 12:00:00h +45:00:00
Zeta   OnOff XK77 EQ 12:00:00h +45:00:00
#Zeta  Nodding06 XC00 EQ 12:00:00h +45:00:00  rvel=2.5  vref=GALCEN  vdef=Z

#####

```

**Note:** remember that each uncommented line will generate a scan inside the output schedule. Pay attention to the correct use of coordinate formatting. The optional keywords can be specified in any order.

### 6.3. Notes on $T_{\text{sys}}$

The  $T_{\text{sys}}$  measurements are inserted before the execution of the selected subscan. If the scan is composed by 10 subscans and the **tsys** keyword is set to 3, the measurements will take place before the subscans number 1, 4, 7 and 10.

The measurement actually takes place as a post-scan operation within a virtual SIDEREAL subscan (i.e. performing a pointing in the same frame selected for the scan), whose duration is zero. This way no data is recorded, but the  $T_{\text{sys}}$  value is employed inside ESCS/Nuraghe in order to compute the counts-to-K conversion.

Tsys measurements are always performed far from the intended target, yet minimizing the slewing. In case of maps, the chosen position is identified as the nearest one outside the whole mapped area.

If the FITS output is selected, this conversion factor is used to calibrate data, and the resulting stream is saved in a dedicated table (ANTENNA TEMP), while raw counts data is written in the previous table. See the [ESCS/Nuraghe User Manual](#) for details.

**WARNING:** the conversion factor remains valid until a new  $T_{\text{sys}}$  is taken.

Avoiding to update the  $T_{\text{sys}}$  for too long, or after a frequency/receiver change, will lead to the use of an obsolete or totally wrong conversion factor.