# IRAM Memo 2015-1

# Extended support of sky spherical coordinates in **CLASS**

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**Abstract**

Up to now, **CLASS** only supported natively the radio projection of the sky spherical coordinates. The main limitation of the radio projection is the absence of support of a projection angle. This could imply some approximation in the handling of On-The-Fly data with rotated scanning directions. **CLASS** now supports all the projections already supported in the **GILDAS** kernel, i.e., none (unprojected spherical coordinates), gnomonic, orthographic, azimuthal, stereographic, lambert, aitoff, radio, and sfl. This required the introduction of the `MODIFY PROJECTION` command, the modification of the `MODIFY POSITION` command, and the modification of the position header section in the **CLASS** Data Format. This memo describes all this in details.

Keywords: coordinates, (re)projection, **CLASS** Data Format
Related documents: **CLASS** documentation, **CLASSIC** Data Container

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# 1 Goal

The goal of the present **CLASS** (data format and library) improvements is to provide a (much) less restrictive list of supported projections. This revision relies on the **GREG** projection engines which support:

- more projection systems, namely: none (unprojected spherical coordinates), gnomonic, orthographic, azimuthal, stereographic, lambert, aitoff, radio, and sfl.
- non-zero projection angles (when allowed by the projection system). Before this revision, this support was not possible in **CLASS** since there was no provision of such angle in the **CLASS** Data Format.

With these improvements, a direct application is for example the native support of the rotated (i.e. scanning is not performed along azimuth or elevation) On-The-Fly mapping when observing at the telescope, using the azimuthal projection with a non-zero angle.

# 2 The new Position section in the CLASS Data Format

In order to achieve the goal described in section 1, the section Position in the **CLASS** files is redesigned as described in table 1. This section is delivered in the version 2 of the observations[1]. The modifications are:

- the projection angle has been added,
- the coordinate system is duplicated from the index[2] into the Position section,
- the *descriptive system* has been removed; it had no known application up to the present day,
- the items have been reordered for clarity.

Table 1: New Position section in observations version 2 (since 26-mar-2015 in the **GILDAS** development branch). The elements are ordered this way, contiguously in the file. The section length is now 14 words (1 word is 4 bytes).

| Fortran type | Parameter | Position | Description |
|---|---|---|---|
| C*12 | SOURC | 1-3 | Source name |
| I*4 | SYSTEM | 4 | Code for coordinate system |
| R*4 | EQUINOX | 5 | Equinox of coordinates |
| I*4 | PROJ | 6 | Code for projection system |
| R*8 | LAM | 7-8 | Lambda of projection center |
| R*8 | BET | 9-10 | Beta of projection center |
| R*8 | PROJANG | 11-12 | Projection angle |
| R*4 | LAMOF | 13 | Offset in Lambda |
| R*4 | BETOF | 14 | Offset in Beta |

As a reminder and for comparison, the description of the old Position section is available in the Appendix A.

[1] See the **CLASSIC** Data Container memo about versioning of the observations.

[2] Note that the General section is not affected ON THE DISK. See section 3.1 for the effects on the General section IN MEMORY.

# 3 Support in CLASS

## 3.1 Fillers and variables

The standard **CLASS** fillers reflect the changes in the Position section. At the Fortran level, the `type(observation)` is modified as follows:

- `obs%head%pos%projang` (angle in radians) is added,
- `obs%head%pos%system` replaces `obs%head%gen%typec`. Its value remains the special **GILDAS** code for coordinate systems. Note that `obs%head%gen%typec` was a convenient duplicate in memory of the corresponding index element, so this affects only the General section in memory, not on disk.
- `obs%head%pos%sl0p`, `obs%head%pos%sb0p` and `obs%head%pos%sk0p` are removed.

At the end-user level, the following **SIC** variables are affected:

- `R%HEAD%POS%PROJANG` is added,
- `R%HEAD%POS%SYSTEM` replaces `R%HEAD%GEN%TYPEC` and `TYPEC` which are removed,
- `R%HEAD%POS%SL0P`, `R%HEAD%POS%SB0P` and `R%HEAD%POS%SK0P` are removed,

Finally, for Python-based fillers, the attributes are changed in the same way:

- `obs.head.pos.projang` is added,
- `obs.head.pos.system` replaces `obs.head.gen.typec`,
- `obs.head.pos.sl0p`, `obs.head.pos.sb0p` and `obs.head.pos.sk0p` are removed.

## 3.2 Commands

The **CLASS** commands dealing with the position of the spectrum are not affected by the renaming of the coordinate system, nor by the reordering of the variables. On the other hand, several commands are added or improved to fully benefit the new projection kinds and possible non-zero angle.

- `MODIFY PROJECTION` is added. It allows to modify the current R spectrum projection, including setting a new projection and a non-zero angle. It uses the **GREG** reprojection engines from any projection to another.
- `MODIFY POSITION` is now a shortcut for `MODIFY PROJECTION`, in the particular case when the projection system and angle are left unchanged. Thanks to this, it supports now any kind of projection.
- `CONSISTENCY` now checks in details the projection of all observations in index, i.e. the projection systems, centers, and angles.
- `TABLE` benefits the `CONSISTENCY` improvements, in both `NEW` or `OLD` modes. In the latter case, `TABLE` verifies that the appended spectra have a projection consistent with the old ones. The projection description of the spectra (including their angle) is saved in the table header.
- `XY_MAP` benefits the `TABLE` improvements, including the possible non-zero projection angle in the table header.

# A Old Position section

Table 2: Old Position section in observations version 1 (before 26-mar-2015 in **GILDAS** development branch). The elements are ordered this way, contiguously in the file. The section length is 17 words.

| Fortran type | Parameter | Position | Description |
|---|---|---|---|
| C*12 | SOURC | 1-3 | Source name |
| R*4 | EQUINOX | 4 | Equinox of coordinates |
| R*8 | LAM | 5-6 | Lambda of projection center |
| R*8 | BET | 7-8 | Beta of projection center |
| R*4 | LAMOF | 9 | Offset in Lambda |
| R*4 | BETOF | 10 | Offset in Beta |
| I*4 | PROJ | 11 | Code for projection system |
| R*8 | SL0P | 12-13 | Lambda of descriptive system |
| R*8 | SB0P | 14-15 | Beta of descriptive system |
| R*8 | SK0P | 16-17 | Angle of descriptive system |