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DOCUMENT

HIFI Reference Position Spectra Data Products: Release notes

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1 INTRODUCTION

This release note describes the content of the Data Product archive compiling all HIFI reference position spectra (also called “OFF positions”) obtained in observations making use of an observing mode for which such data are relevant. These spectra are already generated by default in the pipeline processing, and are stored in products of the calibration context in a format corresponding to the ON-target level 2 products. The data products provided in this Highly-Processed Data Product (HPDP) archive, however, are slightly evolved versions of those spectra, aligned with the structure and processing assumptions applying to the ON-target level 2.5 products of the HIFI observation contexts.

2 DESCRIPTION OF THE HPDP

2.1 Scope and method for the product generation

Since HIPE 13, the HIFI pipeline generates by default stand-alone spectra of the reference position (also called “OFF position”) used in the differential measurements strategy applying to a large fraction of the HIFI observing modes. Exception to this rule are cases of observations taken with a referencing scheme explicitly skipping the observation of such reference position (so-called *NoRef* observing modes – see Chapter 3 of the HIFI Handbook for more details (<http://www.cosmos.esa.int/web/herschel/legacy-documentation-hifi>)).

These reference spectra are provided for each spectrometer (WBS or HRS), polarization (H or V) and sideband (USB or LSB) applicable to the observation. They are processed to a level equivalent to that of the level 2 of the ON-target spectra, and stored into the so-called “HIFI Timeline Products” (see Chapter 4 of the HIFI Data Reduction Guide (http://herschel.esac.esa.int/hcss-doc-15.0/load/hifi_um/html/hifi_uncertainty_table.html)).

Depending on the observing mode and type of target, these reference spectra are built following different assumptions:

- For Single Point and Spectral Scan observations taken in Double-Beam Switching mode, a single reference spectrum is provided per full backend combination. This assumption is true for either fixed targets or moving targets – in that latter case the spectrum is the average of the spectra acquired at the different tracked positions corresponding to the beam-switched reference positions
- For Mapping observations taken in Double-Beam Switching mode (called “DBS

Raster” mapping mode), there is one reference spectrum per ON-target position of the raster.

- For observing modes making use of the Load Chop or Frequency Switching referencing scheme, and asking for a separate OFF position, the reference position product correspond to the single difference spectra obtained on that position only, calibrated against the internal loads. This is applicable to Single Point, Mapping and Spectral Scan observing using this scheme.
 - For observations on fixed targets, there will be only one spectrum per full backend combination, irrespective of the AOT (single point, mapping or spectral scan)
 - For observations on moving targets, there will be only one spectrum per full backend combination **only** in the case of single point and spectral scan observations (it will be the average of all tracked OFF positions). For mapping observations (i.e. On-the-Fly – OTF), because the reference position may be visited several times, and will therefore correspond to different sky positions due to the tracking, different reference spectra will be provided
- For observing modes making use of the Position Switching, the data taken on the blank sky are compared to those of the cold internal load. As such this is a synthetic OFF position and it will suffer from additional baseline distortion.
 - For observations on fixed targets, there will be only one spectrum per full backend combination, irrespective of the AOT (single point or mapping)
 - For observations on moving targets, there will be only one spectrum per full backend combination **only** for single point mode observations. For mapping observations (OTF), different reference spectra will be provided at the different tracked OFF positions
- Reference spectra for Double-Beam Switching mode observations cannot distinguish the contribution from either of the two OFF positions applying to the nodding scheme. They are built from the difference of those two positions and therefore indicate essentially whether one of the two positions may contribute to a detectable level to some flux contamination. As such, strictly speaking, there is no unique sky position associated to this spectrum.
- In contrast with the above, reference spectra for observations in either frequency switching, load chop or position switching mode, a unique and well defined sky position applies

The top-level HIFI products, and usually most recommended ones to the archive user, are those from the level 2.5. They involve additional processing steps compared to those of the level 2, namely (see also Section 4.6 of the HIFI Data Reduction Guide):

- Single point mode level 2.5 products will be stitched, and folded in case of Frequency-Switching observations



- Mapping mode level 2.5 products are stitched cubes built from the re-gridded individual level 2 spectra
- Spectral Scan level 2.5 products are the result of the deconvolution of the individual level 2 spectra

In order to provide reference spectra products directly comparable to those of the ON-target level 2.5 products, we have therefore processed the reference spectra available from the pipeline processing in the Calibration context into level 2.5-equivalent products, meaning:

- Stitched spectra in cases where single reference spectra apply to a given observation (this is also true for mapping observations not taken in DBS raster map mode), and folded in case the referencing scheme is the Frequency Switching
- Stitched cubes in case of DBS raster maps
- Deconvolved reference spectra in case of Spectral Scan observations

In the latter case, it should be noted that additional effort was put in order to accurately mask all residual spurious features applying to the reference positions, and not already identified within the spur mask tables applied to the ON-target data (see also Section 5.3.2 of the HIFI Handbook, <http://www.cosmos.esa.int/web/herschel/legacy-documentation-hifi>). As such deconvolved reference spectra are free of spurious emission. Appendix A provides some scripting details about the exact post-processing steps corresponding to the above products.

It is a general rule that reference spectra offer worse baseline quality than those obtained for the ON-target data. This is intrinsically due to the fact that these are single differences of observation phases taken along different optical paths, leading to residual standing wave distortion (see also Section 5.3.1 of the HIFI Handbook). These artefacts are typically worst in the case of reference spectra for Position Switching observations (see Figure 2). These artefacts can be mitigated in the same fashion as for ON-target spectra – see Chapters 12 and 13 of the HIFI Data Reduction Guide.

The products distributed through the archive described here are based on the reference spectra generated with HIPE 14.1.

2.2 Content of the HPDP

2.2.1 Deliverable format and structure

The current delivery for this HPDP contemplates 9323 HIFI observations, out of which 7439 are Single Point observations, 1410 are Mapping observations, and 474 are Spectral Scan observations. These concern essentially all non-FAILED HIFI public observations taken in a mode offering a reference position, and belonging both to the Science and Calibration



programmes. The file content of this archive is as follows:

- The complete archive comes as a collection of gzipped tarballs associated to each ObsID, and called `<obsid>_OFF_Spectra.tar.gz`.
- Each tarball contains a collection of gzipped FITS files containing the individual reference spectra, as well as a postcard in PNG format. In the following, we call `<backend>` the combination of `<sp>-<pol>-<sb>`, where `<sp>` is either WBS or HRS, `<pol>` is either H or V, and `<sb>` is either USB or LSB.
 - `<obsid>_<backend>_OFF_Spectra.fits.gz` contain the reference spectrum for a given backend combination in case only one spectrum applies to a given observation.
 - `<obsid>_<backend>_SpectralMap_OFF_Spectra_Level2.fits.gz` contain the reference spectra applicable to cases where more than one reference spectrum exists for a given backend combination, and/or for observations taken in the DBS raster map mode. Unlike the above, they are embedded in the structure of an HIFI Timeline Product, which is the one applying to level 2 data of the HIFI products. Still, the spectrometer sub-bands will be stitched, like in data from the level 2.5.
 - `<obsid>_<backend>_Spectral_Map_OFF_Spectra_RegriddedCube.fits.gz` contain the reference spectra cubes in case of DBS raster map observations.
 - `<obsid>_WBS-<pol>_SpectralScan_OFF_Spectra_Deconvolved.fits.gz` contain the deconvolved reference spectra in case of Spectral Scan observations.
 - The postcard are named `<obsid>_Postcard_OFF_Spectra.png`
- The postcards are mimicking those provided e.g. as quick-look images in the HSA for the equivalent ON-target data. These are also called “Browse Products” in the Observation context, and a description of what they consist of can be found in Section 3.4 of the HIFI Data Reduction Guide (http://herschel.esac.esa.int/hcss-doc-15.0/load/hifi_um/html/hum_tour_browse.html). Examples are given in Figures 1 to 5 to illustrate the various kinds of postcards that can be found in the delivery.

Calibration_PM_7-Aot2_P_LChop_7b_CII_G345.7+0.0 (1342190778)

Observing Mode = Load Chop Ref
 Reference Spectra = true
 Spectrometer = HRS-H HRS-V WBS-H WBS-V
 Source = CII_G345.7+0.0
 Requested RA = 17h 6m 19.10s
 Requested Dec = -40° 49' 57.72"

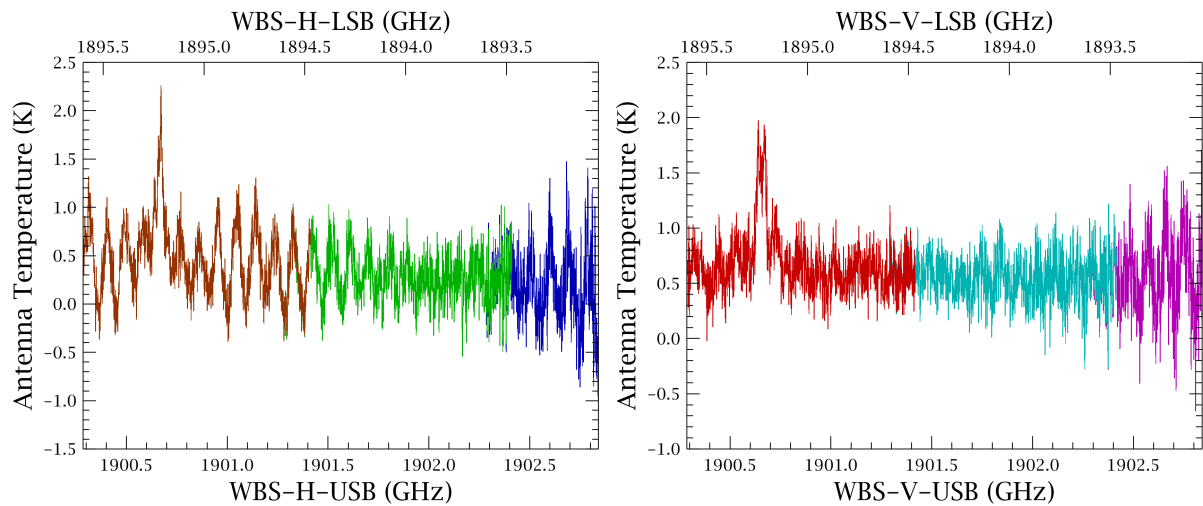


Figure 1: Illustration of a postcard in case a single reference spectrum applies for each backend combination. Note the strong contamination at the frequency of the [CII] line.

CO 6-5 (1342252113)

Observing Mode = Position Switch
 Reference Spectra = true
 Spectrometer = HRS-H HRS-V WBS-H WBS-V
 Source = Cha-MMS1
 Requested RA = 11h 6m 31.70s
 Requested Dec = -77° 23' 32.00"

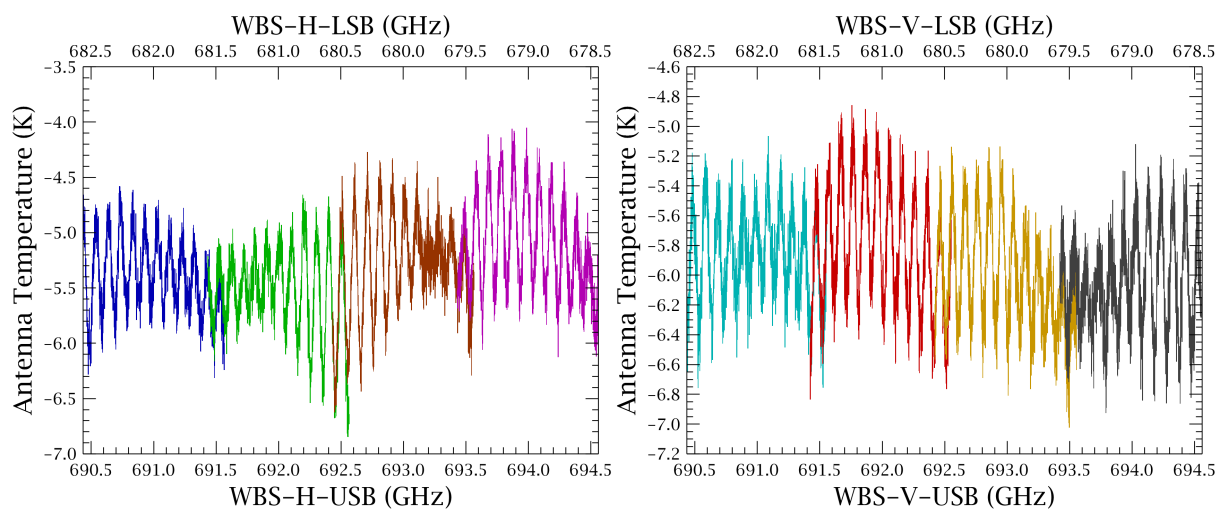


Figure 2: Same as Fig. 1 for a Position Switching observation

Aot2_M_OTF_7b_Cplus_Mars (1342199673)

Observing Mode = OTF - Position Switch
 Reference Spectra = true
 Spectrometer = HRS-H HRS-V WBS-H WBS-V
 Source = Mars
 Requested RA = 10h 43m 58.23s
 Requested Dec = 9° 1' 57.70"

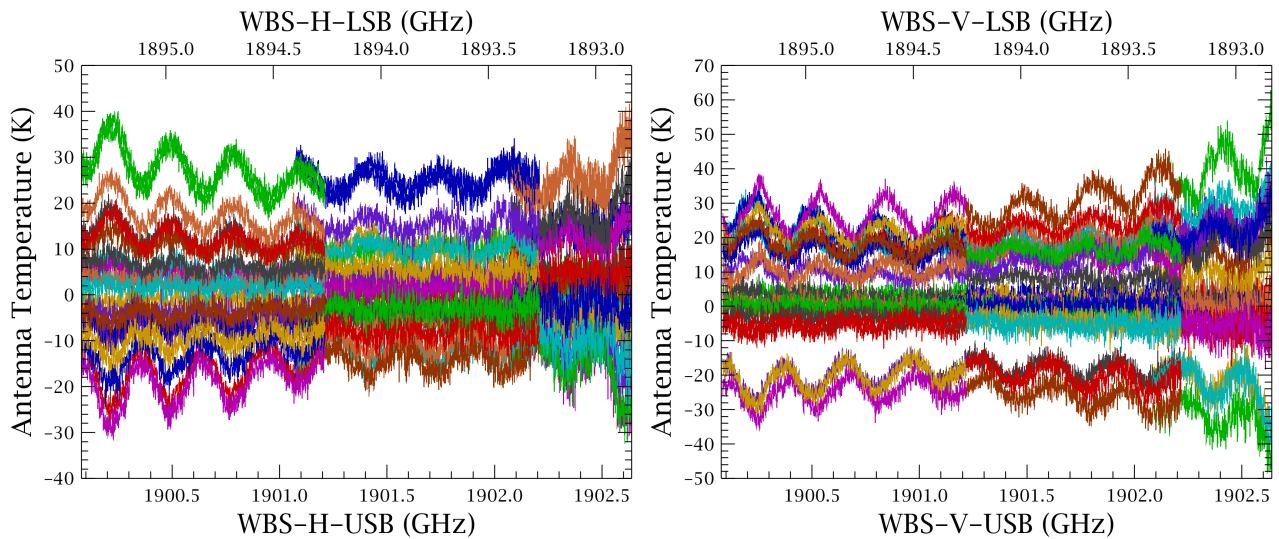


Figure 3: Illustration of a postcard for reference spectra applicable to a mapping observation towards a moving target (here Mars). The different spectra correspond to the various sky positions of the reference spectra acquired during the tracking. Note the enhanced standing wave baseline ripples.

Aot3_M_DBS_3x3.7b_CII_S140 (1342205481)

Observing Mode = DBS Raster fastChop
 Reference Spectra = true
 Spectrometer = 183-H 183-V WBS-H1 WBS-V1
 Source = S 140 (IRS 1)
 Requested RA = 22h 19m 18.21s
 Requested Dec = 63° 18' 46.90"

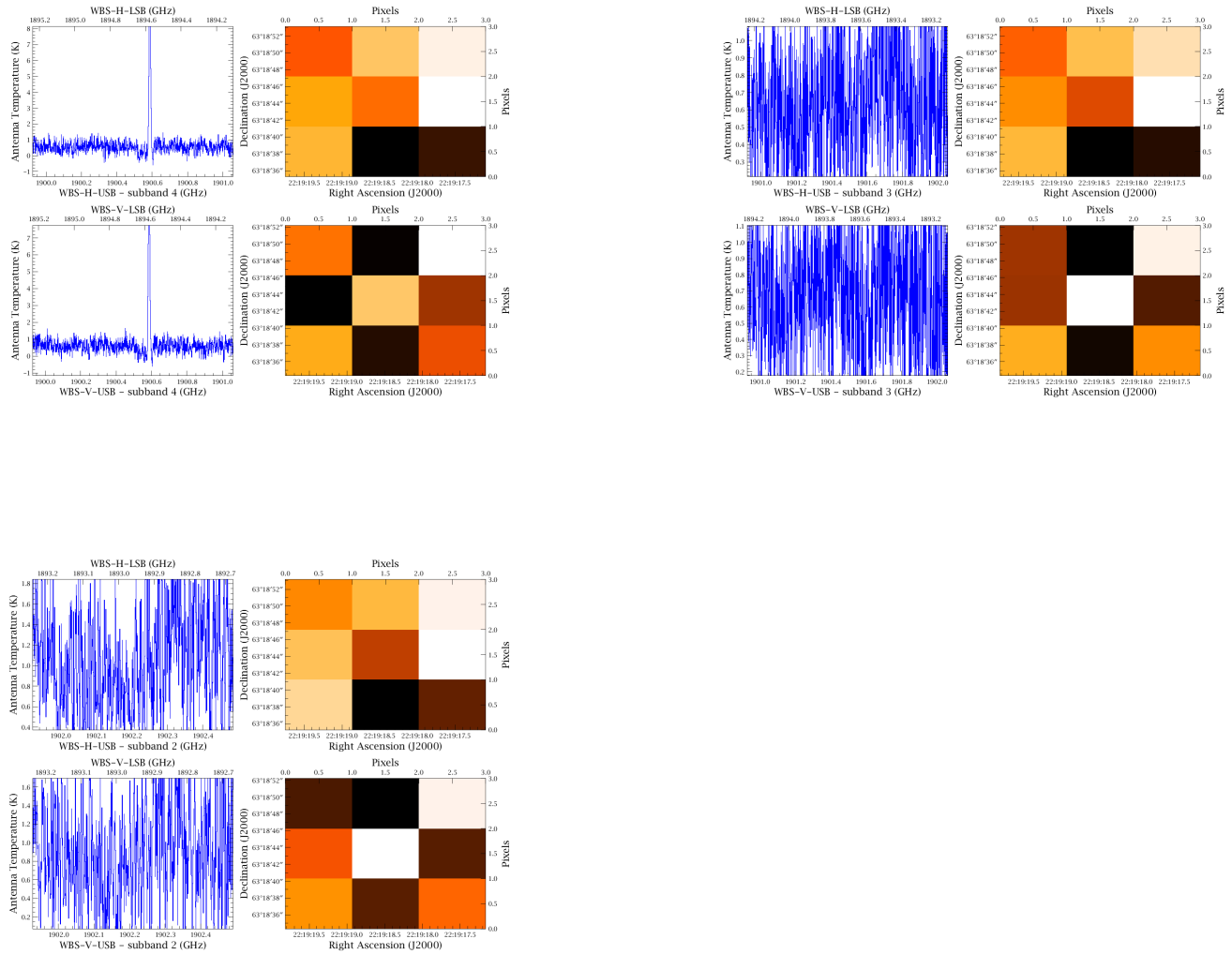


Figure 4: Illustration of a postcard for reference spectra applicable to a DBS raster mapping observation in band 7b. Note the C+ line contamination in WBS sub-band 4 (upper left).

Calibration_mo_13-Aot2_S_FastDBSNoC_1b_563-585_R3_etaCar (1342181171)

Observing Mode = DBS fastChop
Reference Spectra = true
Spectrometer = HRS-H HRS-V WBS-H WBS-V
Source = eta Car
Requested RA = 10h 45m 3.590s
Requested Dec = -59° 41' 4.300"

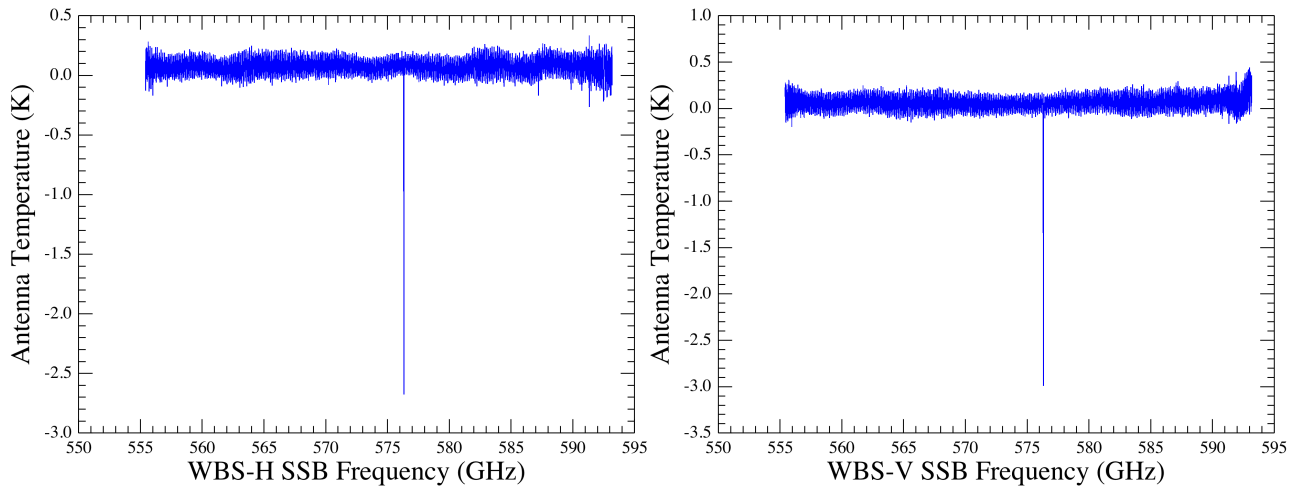


Figure 5: Illustration of a postcard for a Spectral Scan observation, showing the deconvolved spectra for the respective reference spectra. Note the strong contamination at a frequency close to that of the CO (5-4) line.

The individual tarball size will depend mostly on the type of observations. Single reference spectra observations will imply compressed archives of ~0.2 to 2 Mb, depending on which spectrometer and/or polarisations are present or not. Spectral Scan observations will offer archives of sizes between 1 Mb and 10 Mb for the largest number of tunings. Finally, DBS raster map reference spectral cubes will be stored in archives of size between 2.5 and 227 Mb for the largest. The total (compressed) size of the HPDP is 22 Gb.

2.2.2 HIFI reference position spectra data product queries in the HSA

The HIFI reference position Data Products can be retrieved through the HSA like any other HPDP, namely either as a full download, or following the results of a filtered query. Alternatively, they can also be fetched in the Herschel Science Centre portal – see <http://www.cosmos.esa.int/web/herschel/highly-processed-data-products>.