HCSS-16724: New Pointing Products Test:

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Introduction:

During the period following the change in STR temperature, the distortion parameters in the ACMS system remained unchanged. However, this lead to an incorrect effective focal length being used for the STR. In situations where the stars used for tracking are not evenly distributed across the STR CCD this lead to offsets in the pointing.

Later studies indicated there was a tilt (2D) to the distortion and even higher dimensional levels of distortion to the plane of the STR CCD. These have now been installed in the ACMS system on board the Herschel spacecraft and, together with the removal of some 73 suspect stars in the catalog used for identifying tracking stars, forms the basis of the current pointing system with an APE of approximately 1".

For the period OD320 to OD761 not even the 1D focal length correction was available on board the spacecraft. This produces the largest offsets for pointing in the system up to 7-8". Since the correction factor is known, it is possible to change the pointing information on the ground to adjust to what the STR was seeing at the time of all observations when this correction was not being applied.

New pointing products have been created for the time period OD320 to OD761 that can potentially bring all observations up to the level of pointing accuracy available when the correct focal length of the STR system is used. For the period up to OD1011 there are further, higher dimensional, corrections that can be applied. These will be the subject of future improvements.

This short report indicates the effect of using the updated pointing products in reprocessing data both interactively and using the standard pipelines, together with an evaluation of the pointing performance produced once applied to all observations in the time period.

Interactive Test Cases:

All PACS-P pointing calibration observations.

Pointing calibration observations have always used the PACS photometer. New pointing products were used with these observations. Results indicated that the APE was improved when measured using just these PACS observations. The improvement went from 2."3 to 1."6 (see Figure 1).

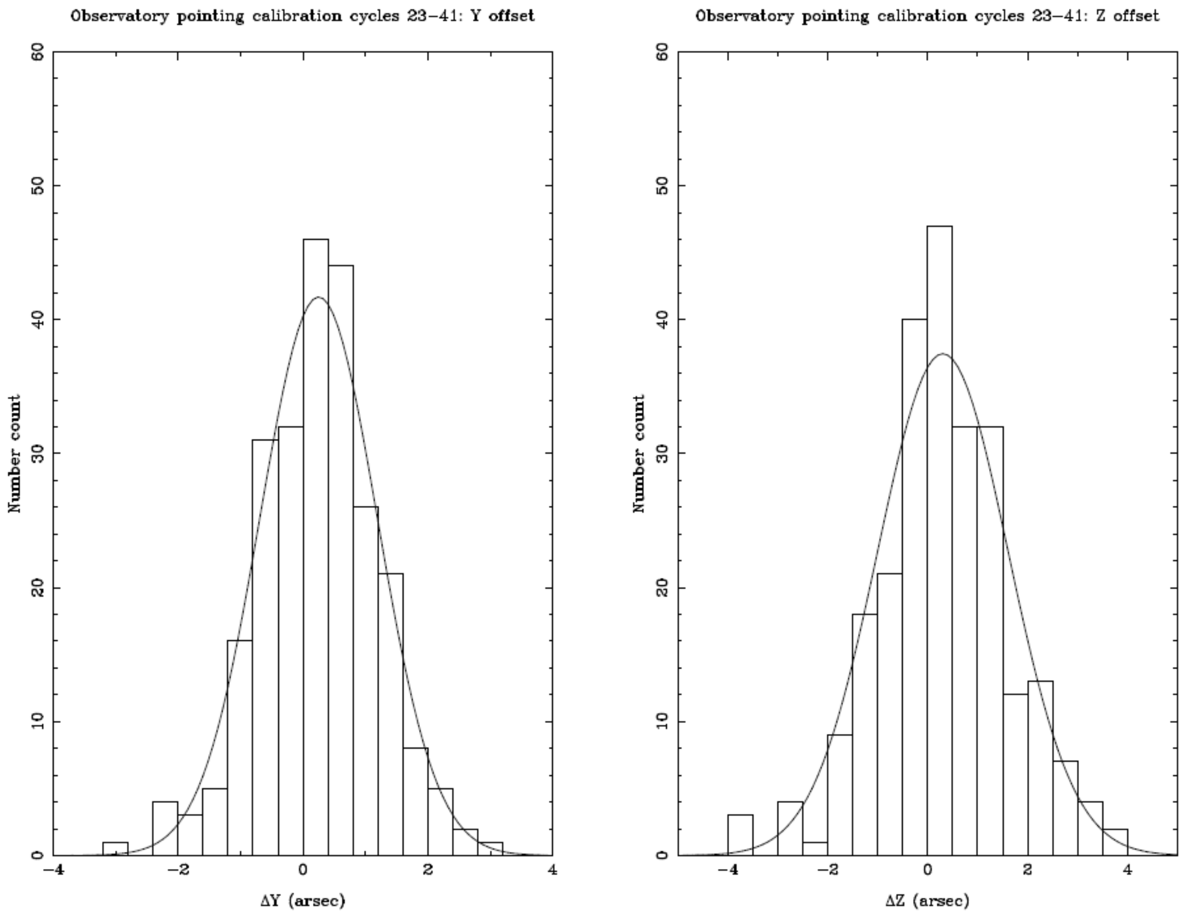

Figure 1: Pointing offsets for pointing calibration stars showing Gaussian distribution and overall APE improvement to 1.”6. This is similar to the results obtained directly after the STR focal length correction was applied on board the spacecraft on OD762.

PACS Checks:

Astrometry offsets for most of the PACS observations taken in the period OD320 to OD761 has been calculated. Figure 2 illustrates the distribution of the predicted shifts in bins of 0.5 arcsec, separated per PACS AOT mode (Spectroscopy/Photometry), and target type (fixed or moving).

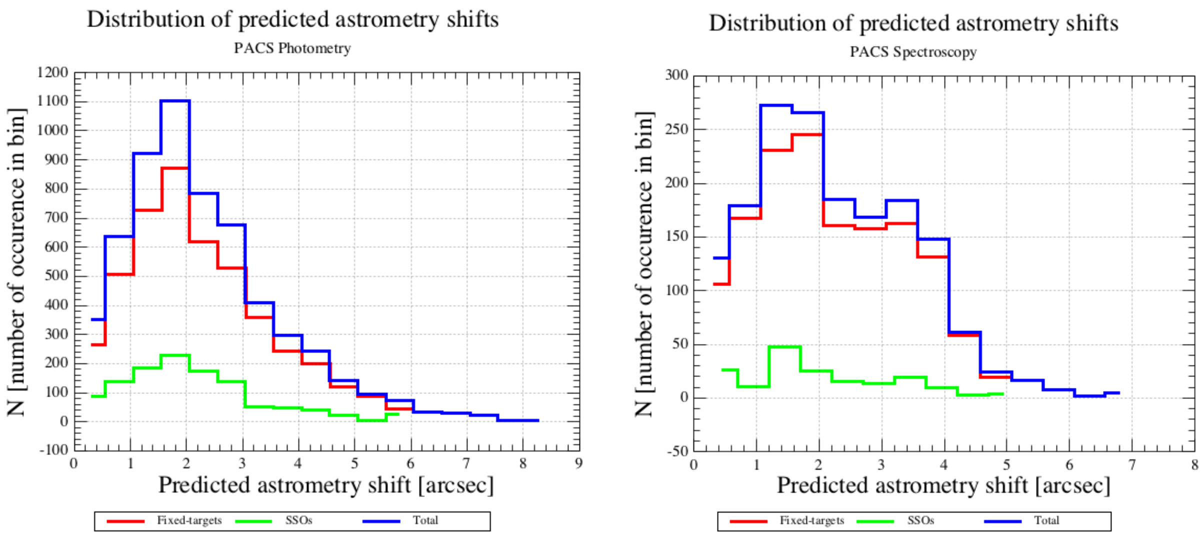

Figure 2: Histograms of predicted astrometry shifts for PACS obsids

Figure 3 illustrates how the amplitude of these shifts are distributed on the sky. Although the amplitude is fairly independent of the epoch of the observation (i.e. the position angle) the shift direction may vary with time, this is not shown on the figure.

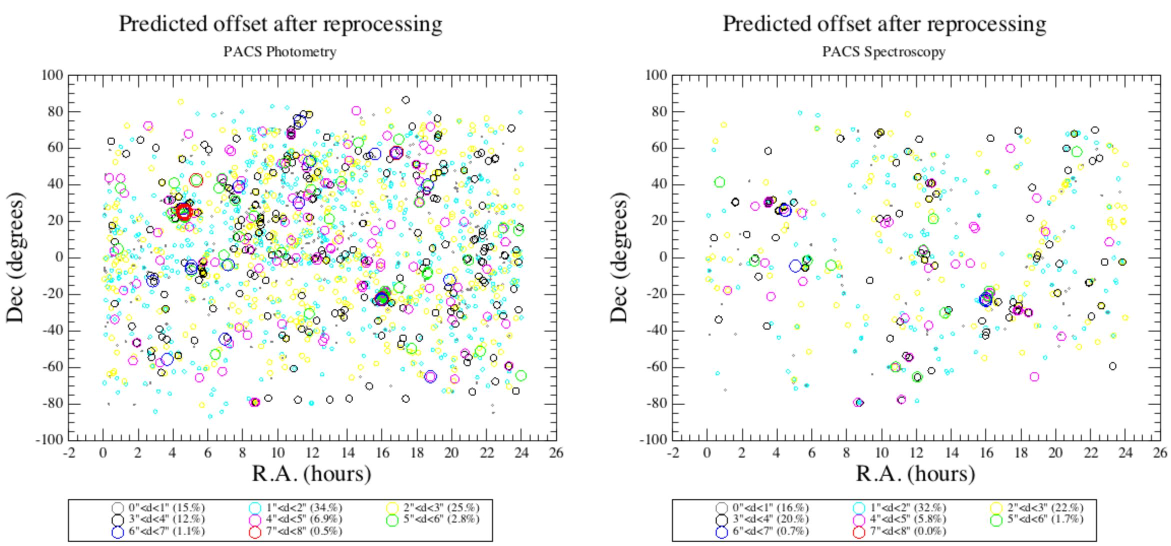

Figure 3: Sky distribution of the predicted astrometry shifts in bins of 1 arcsec

The calculated astrometry offsets have been validated on a number of selected photometer maps applying point-source centroiding (see earlier in this report). Further checks have been carried out to ensure the predicted offsets can be reproduced after the pipeline reprocessing of the observations.

The computed expected shifts have been cross-checked with reprocessed PACS data, where the [new-old] astrometry is calculated from the observation context meta data provided for the target position. This process has been done for 72 spectrometer observations available in the HSAINT environment and reduced with SPG 9.0.2959 (old PP) and SPG 9.0.3048 (new PP). The distribution of predicted vs. pipeline processed astrometry shifts is compared below for a subset of 19 mapping observations in spectroscopy mode (see Figure 4). One can conclude the pipeline E2E reprocessing is reproducing extremely well the predicted values, down to ~0.003 arcsec accuracy with few outliers at ~<0.06 arcsec amplitude.

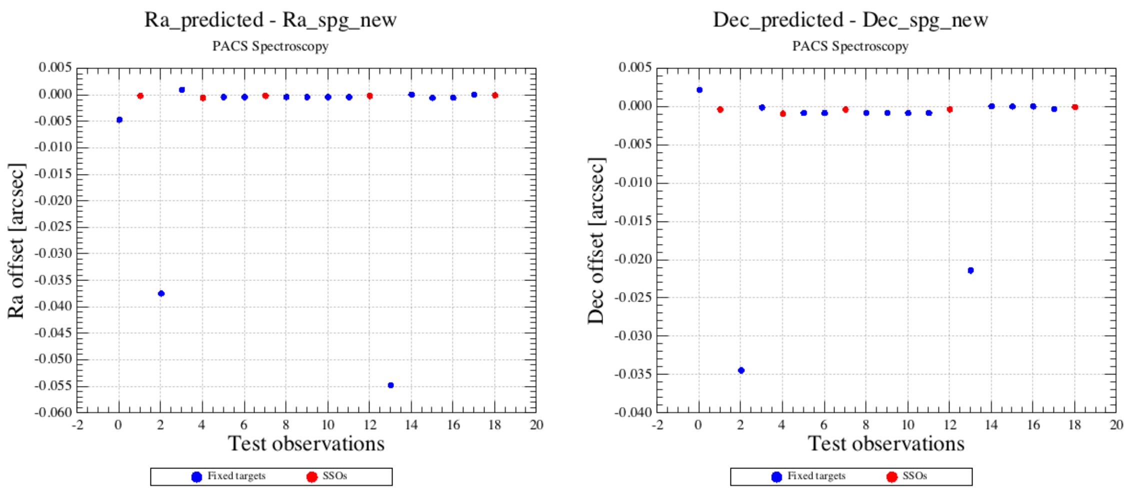

Figure 4: Predicted pipeline-processed Ra/Dec values for 19 spectrometer observations

Astrometry has been taken also from the science data instead of the observation context meta data. The figures below show the amplitude of Ra/Dec offsets per observing blocks for the all the 72 test observations in HSAINT (see Figure 5). A block may indicate raster position or wavelength slice. It is noticeable, the scatter of block-to-block astrometry correction is somewhat different for certain observations but the variation is within ~0.015 arcseconds.

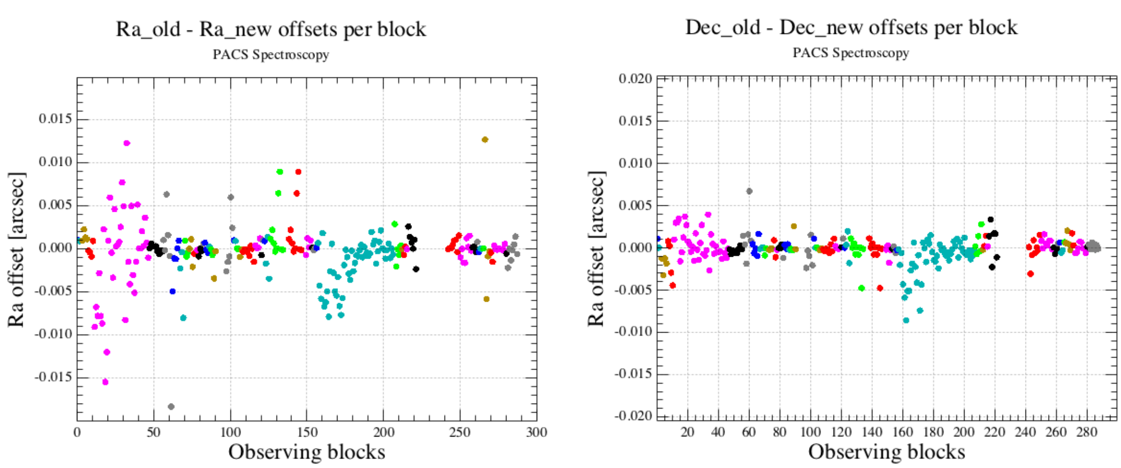

Figure 5: Old-New Ra/Dec offsets for PACS spectrometer observing blocks. Colours indicate 72 spectrometer test observations.

A typical footprint of a pointed spectrometer observation before/after correction is shown in Figure 6.

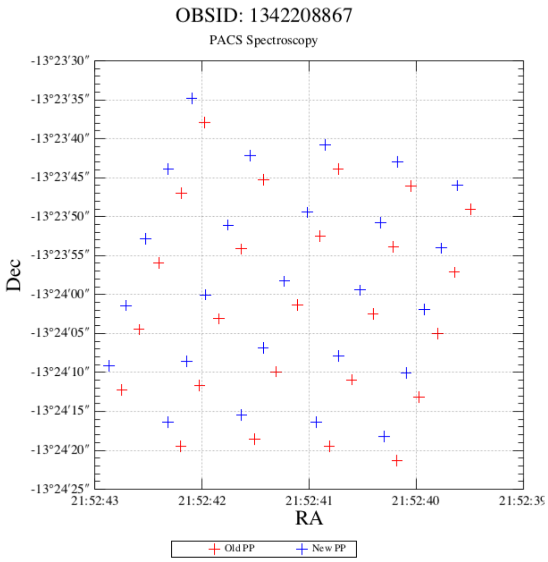

Figure 6: Changed PACS-S footprint on the sky with new pointing product.

Specific PACS-P and SPIRE-P Observations.

It was noted through a variety of Helpdesk tickets that certain areas of the sky appeared to be affected by poorer than expected pointing. A particular area of concern Is in Taurus. Particular observations of point sources in this area have been considered. A total of 10 PACS and SPIRE observations of objects with significant predicted shifts have been checked individually.

An example is shown in Figure 7 for the star (UZ Tau) in OD684, on the left the current HSA level 2 blue channel (70 microns) maps and in the right processed with the new pointing product. The absolute astrometry offset is reduced from 7.5 arcsec to 1 arcsec.

Figure 7: UZ Tau before and after application of the new pointing products. The SIMBAD position is indicated by a green circle with the original pointing on the left and update pointing shown on the right.

The star Gamma Dra has been the most frequently observed star for flux monitoring purposes. It shows a small offset from the nominal catalogued position for most of the mission. In Figure 8 it is shown that this quite small offset has been due to STR distortion.

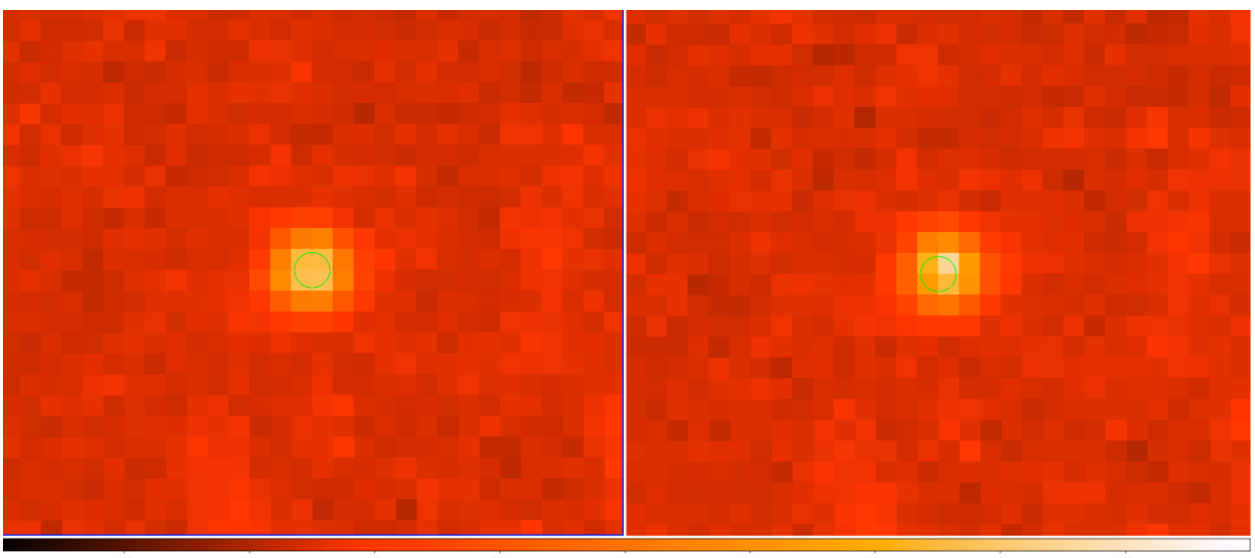

Figure 8: Gamma Dra as seen with SPIRE-P with the new pointing product applied (left) and with the original pointing product (right).

SPIRE FTS Checks:

Checks were made with respect to all FTS measurements made in the time period associated with the pointing product updates. Figure 12 shows the sizes of the offsets associated with SPIRE FTS measurements.

The largest predicted offset is 5.”5 for obsid 1342213373 (a low resolution mapping observation on OD625). The effect is seen in reprocessed data as an update to the “ra” and “dec” meta data.

For SOF1 (pointlike) observations, two observations checked particularly.

Obsid 1342219551 (High Resolution): predicted 5.1

ΔDec=0.3”, ΔRA=-5.1” (old - new)

Obsid 1342219572 (Low Resolution): predicted 5.3

ΔDec=1.0”, ΔRA=-5.2” (old - new)

For mapping observations (e.g. SOF2) the WCS coordinate system will be shifted in the spectral cubes created.

Obsid 1342213373 (Low resolution, mapping): predicted 5.”5 offset. WCS offset check

ΔDec=-1.8”, ΔRA=-5.2” (old - new)

These results are precisely in line with expectations. The SPIRE-S products are updated as predicted.

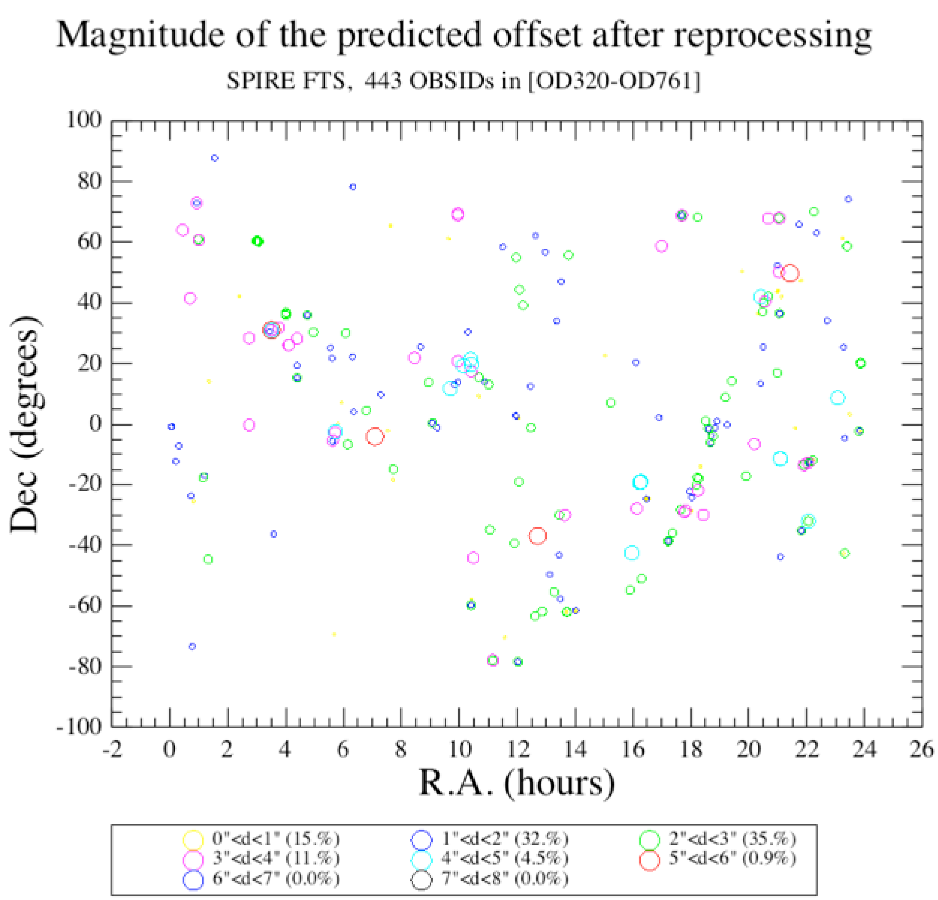

Figure 9: The offsets for SPIRE-FTS for the more than 400 obsids in the time period OD320 to OD761.

HIFI Checks:

An extensive set of tests on most of the HIFI observations taken in the period OD320 to OD761 has been done. The initial checks compared the computed expected shifts with the metadata information checks of source position information within reprocessed HIFI data.

Figure 10 illustrates the distribution of the predicted shifts in bins of 0.5 arcsec, separated per HIFI AOT type, and target type (fixed or moving).

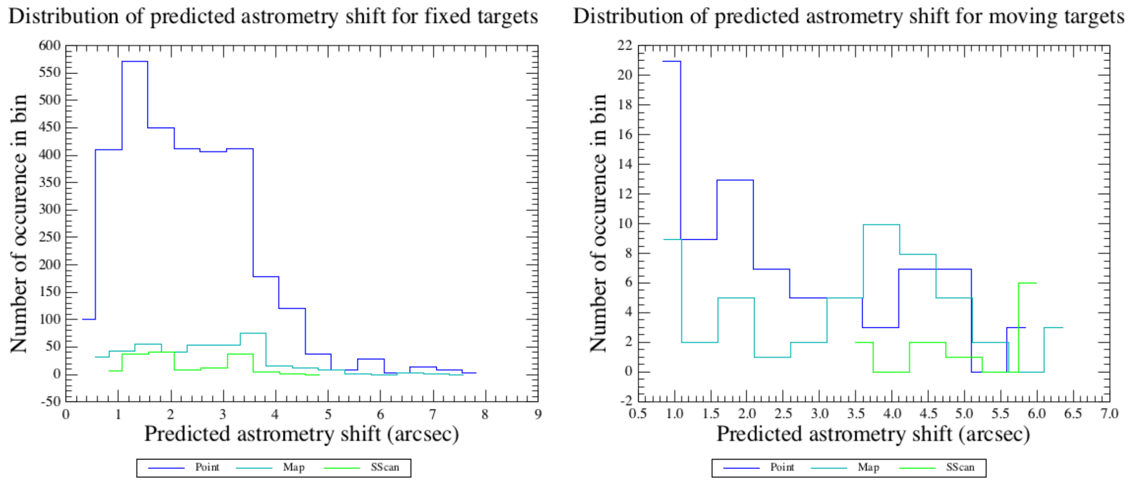

Figure 10: Histograms of predicted astrometry shifts for more than 4000 HIFI obsids

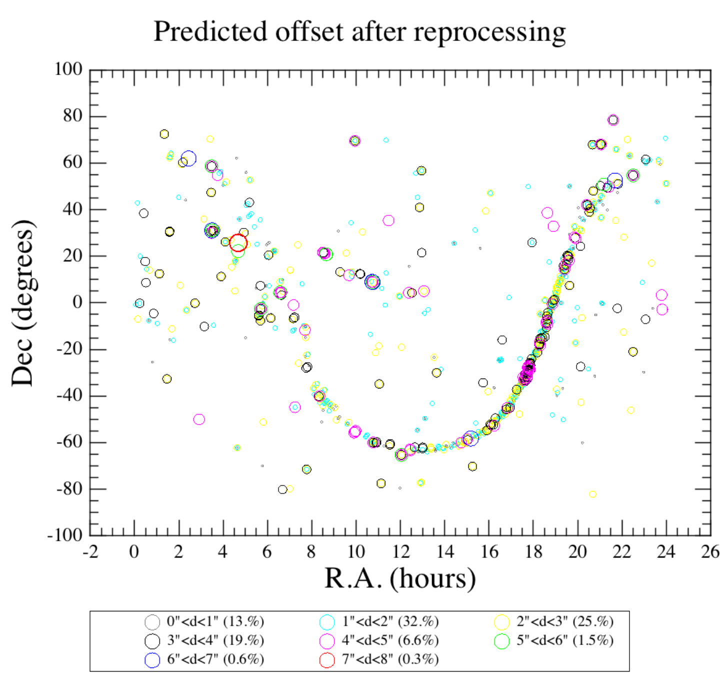

Figure 11: Sky distribution of the predicted astrometry shifts in bins of 1 arcsec

As can be seen, astrometry shifts of up to 8 arcsec are expected from the improved pointing products. Figure 11 illustrates how these shifts are distributed on the sky. It shows that the largest shift is experienced in the Taurus area, already known to be affected by the effect one aims at correcting here.

The bulk reprocessing was performed from the level0 products as of the last bulk reprocessing exercise using HCSS 8.2.1. The following syntax was used in order to apply the new astrometry to the level 0 products, and the HIFI pipeline was then run up to level 2.5 with standard parameters.

The same kind of statistics as above can be performed based on the effectively measured shift. Note that this shift applies to the average of all ON-target positions observed over the obsid. The overall distribution is confirmed in Figure 12.

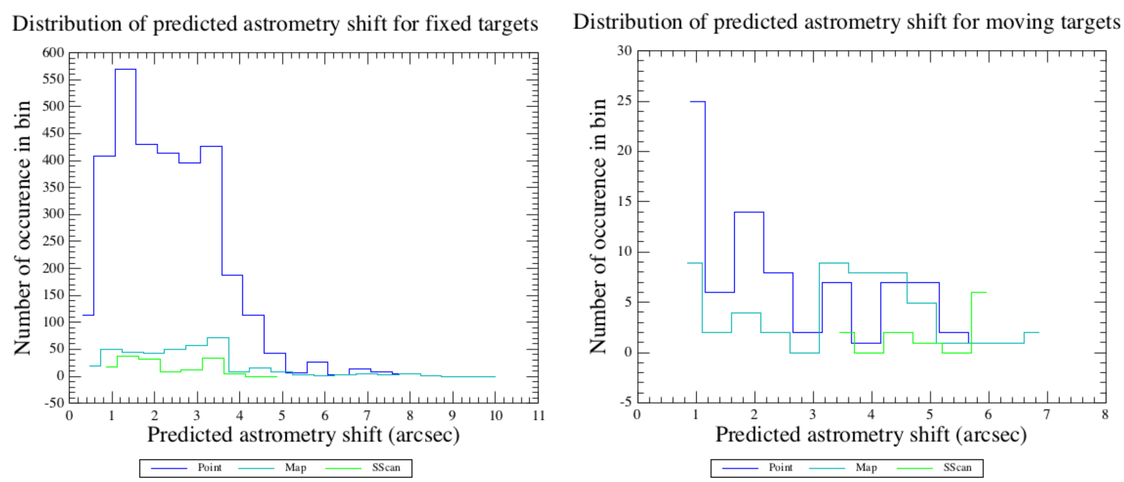

Figure 12: Histograms of pipeline-computed astrometry shifts for HIFI obsids

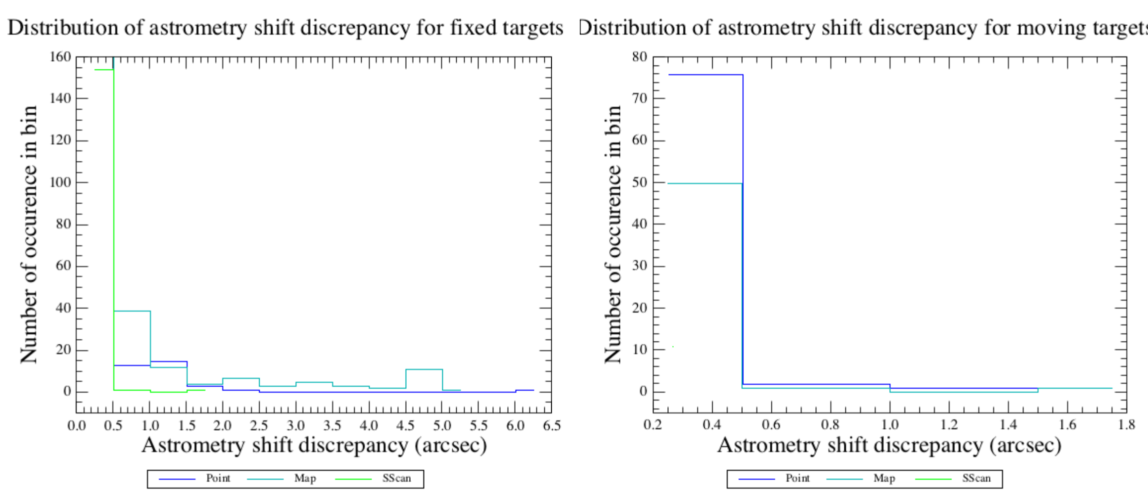

Figure 13: Histograms of the discrepancy between the respective predicted and pipeline-computed astrometry shifts for HIFI obsids

One can directly compare the predicted shifts by MSP to those reported by the pipeline, and form the difference as shown in Figure 13.

The agreement is very good. There are some outliers, mostly in maps, due to a non-optimum call to the doPointing task. Revised plots will be generated with the output of the corrected bulk reprocessing. **As that stage, the conclusion is that the HIFI pipeline is making a totally consistent use of the new pointing products, so that the E2E validation is considered successful**.

The following examples illustrate the way the reconstructed pointing positions will change after the reprocessing.

The generated plots display the following:

- In blue filled circles, the positions of the individual frames with the old pointing products, as of 8.2.1 bulk reprocessing
- In red filled circles, the position of the individual frames with the new pointing products, reprocessed with 9.0
- As a black filled circle, the R.A./Dec nominal, i.e. the intended position
- In open circle, joined by a solid line, the initial (i.e. Ra/Dec nominal) and predicted new position according to MSP's computation

DBS point observation:

This case is considered to illustrate the obsid (1342203230) for which the discrepancy between MSP's prediction and the pipeline-computed shift is the largest (~2.3 arcsec). In Figure 14 the left plot shows that both ON-target and OFF-target positions experience the same shift in this region of the sky.

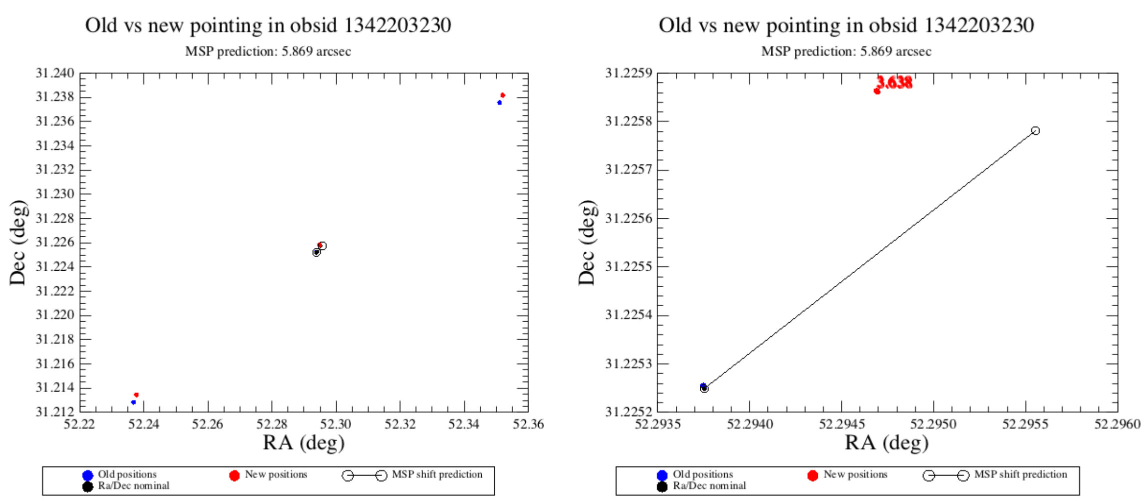

Figure 14: Old and new positions for level 0 science frames (left) and level1 ON-target science frames (right)

DBS raster map:

A similar check is shown in a DBS raster map (obsid 1342205482). The match between the predicted and computed astrometry shift of the overall map is excellent (0.07 arcsec – see Figure 15).

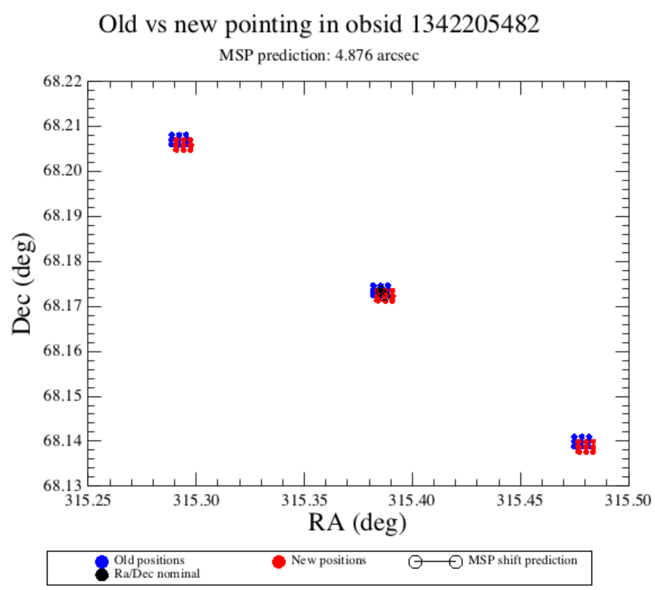

Figure 15: Old and new positions for science frames at level0 in a DBS raster

OTF maps:

Figure 16 to Figure 18 show a gallery of various types of HIFI OTF maps (single strip line, odd/even number of legs, tilted scan lines with respect to the Eq. frame, etc). In all such examples, the predicted shift matches very well the computed one on average, which indicates that the astrometry shift applies similarly to all points in the map. This is not however always the case (see next section).

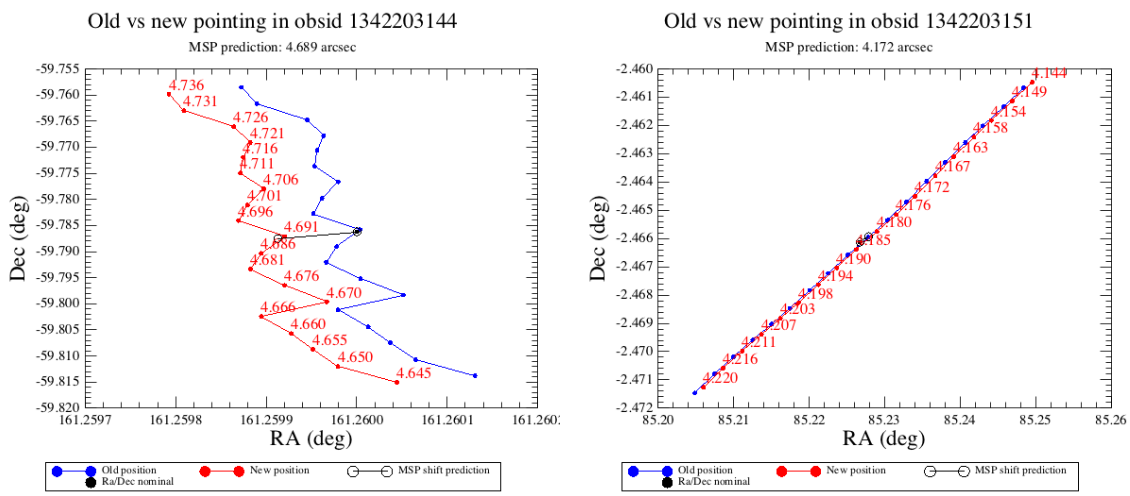

Figure 16: Old and new positions for level2 science frames in an OTF stripe maps

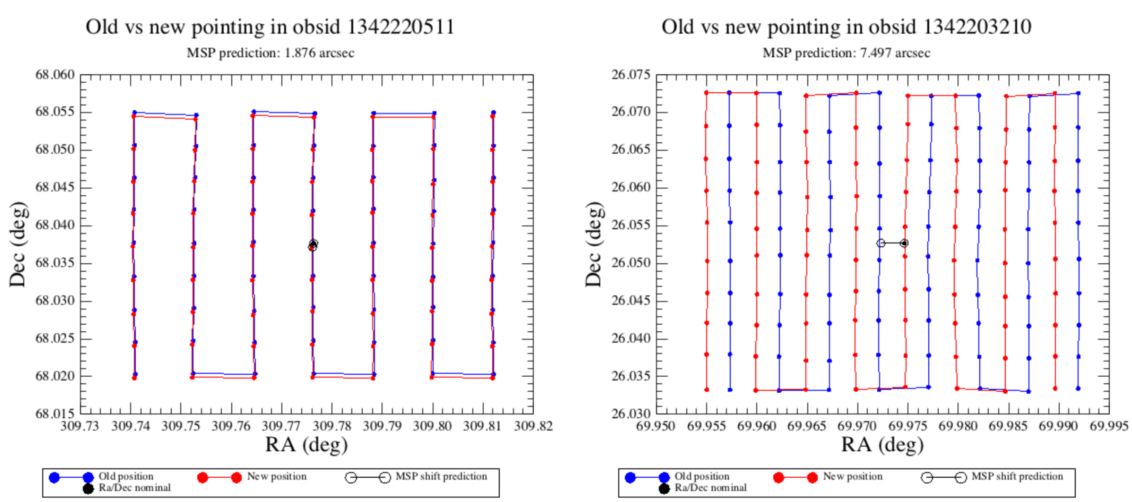

Figure 17: Old and new positions for level2 science frames in a 2-D OTF maps. Note the large offset for the right obsid (Taurus area)

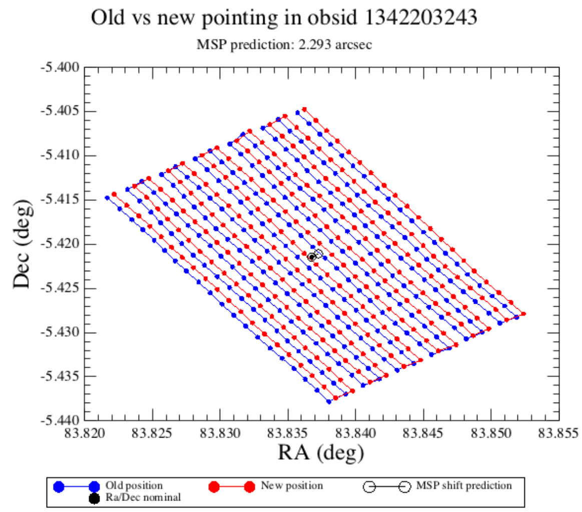

Figure 18: Old and new positions for level2 science frames in the Orion Bar case highlighted for its problematic zig-zag effect in structure (HIFI-4252)

Inhomogeneous position shift over the map:

There exist cases where the improved pointing will imply some discontinuous shift over a portion of the map. Some such cases are illustrated Figure 19. In such cases, it is expected that the shift predicted at the very centre of the map by MSP can differ from that obtained from the average of all shifts, leading to some of the outliers in Figure 13.

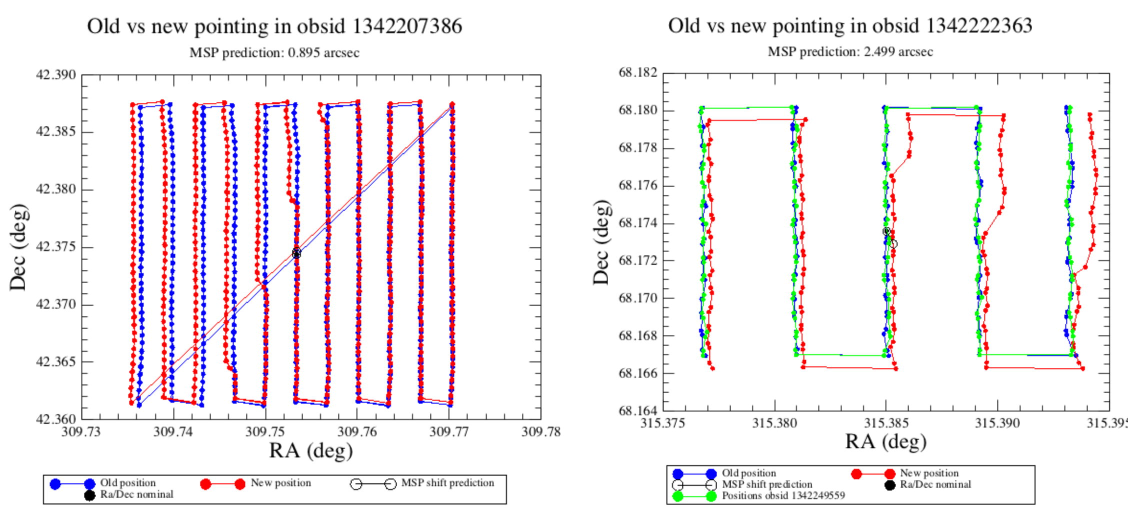

Figure 19: Illustration of discontinuous position shift over an OTF map

Figure 19 also shows the shift that was predicted over an area covering the map in the left of Figure 19, demonstrating again that the effect computed by the pipeline is perfectly in line with the updated pointing product in this field.

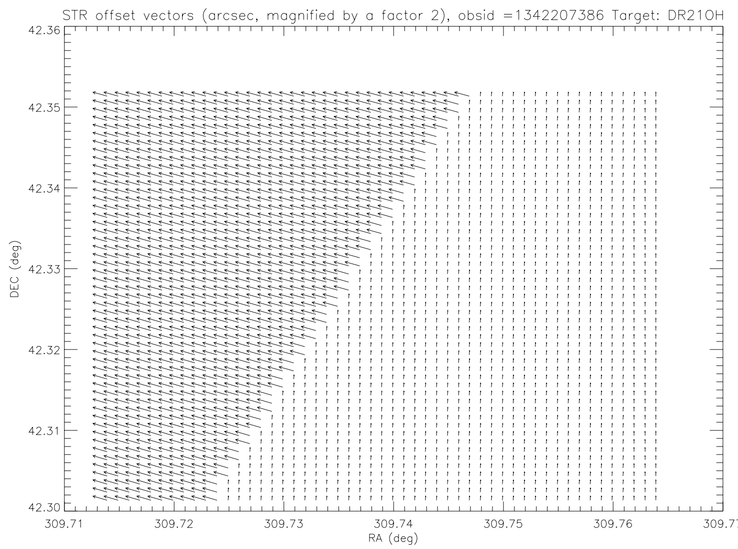

Figure 20: Position shift expected for the field applying to obsid 1342207386 (left plot of Fig. 10). The vectors indicate the direction of the expected position shift (note that the R.A./Dec positions refer to the ACA frame, so they differ slightly from those of the aperture in use for obsid 1342207386)

SPG Testing:

Pointing products have been checked against all observing modes in the SPG. Results are identical to interactive processing and there have been no failures with any of the observing modes.

Results from interactive and SPG testing are indistinguishable – as should be expected since the interactive reprocessing simply uses the pipeline processing from the command line with the additional line of code for inserting the new pointing product.

Conclusion:

Instructions for using the new pointing products interactively are contained on the Twiki at http://herschel.esac.esa.int/twiki/bin/view/Public/HowToUseImprovedPointingProducts

The intention is that these products can also be used in standard processing in the bulk reprocessing exercise associated with HCSS 9.1.

Testing has illustrated that interactive or standard pipeline processing can use the new pointing products equally well and there are no indications of problems using any of the observing modes on board Herschel. It is therefore requested that the updated pointing products be placed in the archive as the latest version of pointing products for the ODs 320 to 761.