P32TOOLS: REDUCTION OF ISOPHOT P32 OVERSAMPLED MAPS

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ABSTRACT

During the ISO mission, the ISOPHOT instrument has collected more than 1100 observations in oversampled mapping mode (AOT PHT32) in the wavelength range of 45 to 240 microns. The observations comprise mapping of small and large extended regions, but also faint point sources. PHT32 observations are affected by strong signal transients due to flux changes generated by the relatively fast chopper movement. A program described by Tuffs & Gabriel (2002), was developed to correct for these effects. It was integrated in the ISOPHOT Interactive Analysis (PIA) via a graphical user interface (GUI), so that most aspects of the processing can be addressed in a coherent and user friendly environment. The resulting package "P32Tools" was introduced to the user community at three hands-on workshops on PHT32 processing held in spring 2001. The hands-on experience from these workshops lead to further improvements. Here we present an overview of the functionalities of the final release of this new software.

Key words: ISO – data reduction

1. INTRODUCTION

Most of the P32 data cannot be satisfactorily reduced in a standard fashion because detector transients affect all readouts as a result of the relatively short durations of individual chopper steps. As described by Tuffs & Gabriel (2002), a dedicated algorithm has been developed for correction. The program uses all the readouts to estimate corrected signals by iteratively fitting a detector transient model. The model is fairly complex, involving a dozen tunable parameters per detector pixel. To "hide" much of this complexity from the user, while giving him the necessary control over the data reduction, a graphical user interface has been developed (Lu et al. 2002a). Both parts together form a software package called P32Tools, that is run as ad-don to the PHOT Interactive Analysis (PIA) (Gabriel et al. 1997).

There are 5 main steps to follow in using P32Tools: i) input of an Edited Raw Data (ERD) measurement into the P32Tools data buffer, ii) data structure initialization, iii) working with the **Main P32 Processing** window where maps can be examined and all-pixel transient model fits are initiated, iv) entering the **Inspect Single Pixel** window to examine more closely the time line of an individual detector pixel or fine-tune the transient model, and finally v) output the transient-removed data to PIA or construct a final map and save it to a FITS file. In the following, we highlight some of the most useful features at each of these steps. More information can be found in the on-line `help` facility of the interface and in the proceedings of the "ISOPHOT Workshop on P32 Oversampled Mapping" Feb/Mar 2001, Villafranca, Spain & Pasadena, USA, (ESA SP-482) eds. B. Schulz, N. Lu & S.B. Peschke. The final version 2.0 of P32Tools can be downloaded via the PIA homepage at:
`http://www.iso.vilspa.esa.es/manuals/PHT/pia/-pia.html`,
either separately or packaged together with PIA.

2. DATA INPUT

P32Tools expects the measurement to be already loaded into the ERD buffer of PIA. As a further preparation, the accompanying FCS measurements should already be processed to SCP level according to standard rules before starting the program. Otherwise default responsivities will be used for map making and display (see Gabriel et al. 1997 and Laureijs et al. 2001). P32Tools can be started either by a menu button if you are running PIA V10 or above, or by typing `pia_erd2map` at the IDL prompt within your PIA session. This pops up a **Measurement Selection** dialog.

3. INITIALIZATION

After the file selection, the `Data Initialization Options` window is presented. Along with some information about the measurement, it offers three options that, however, should be left in their default positions, unless for special investigations/debugging. Accepting these selections with the `OK` button starts the initialization of the internal data structures, including construction of natural grids and first-stage deglitching as described by Tuffs & Gabriel (2002).

4. THE MAIN P32 WINDOW

The initialization ends with the appearance of the **Main P32 Processing** window as shown in Fig. 1. Parameters identifying the measurement are displayed at the top. The **SHOW** section below allows to display contour maps of individual detector pixels (`Pixel Map`), the "natural grid" (`Grid`), the contents of FITS-header (`Header`), and compact status file (`Com.`

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`Status`), and a map (`Display Map`) according to the options specified in the **Map Display Options** window (Fig. 2). The window is accessed by a button of the same name. The options include if and how flux calibration should be done, if data between satellite slews should be included, which pixels should be combined and whether a flat fielding correction is required [1].

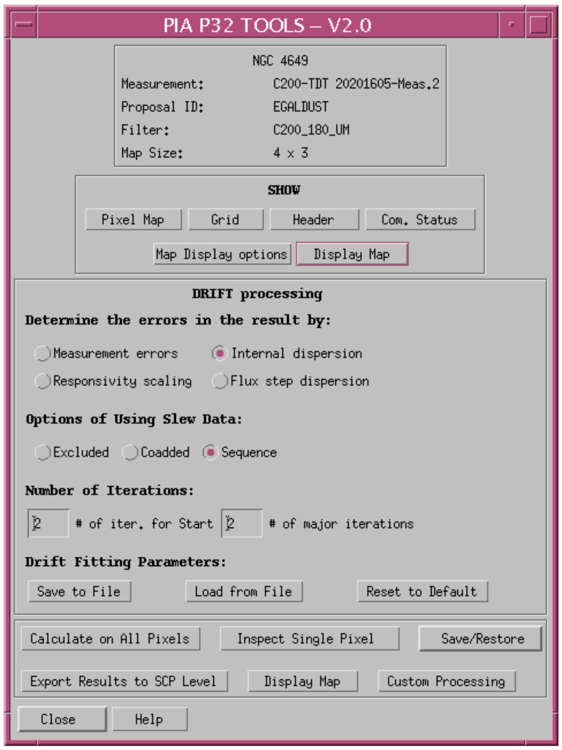

Figure 1. An illustration of the **Main P32 Processing** *window.*

In the following section of the **Main P32 Processing** window, a few basic parameters for the transient modeling algorithm are set. These determine i) how the uncertainties are calculated that are used for the model fit, ii) how and whether the data during slews between raster points are used and iii) the number of iterations allowed for the determination of the start conditions and generally for the model fit. The three buttons at the bottom of this section enable the management of entire sets of model parameters, i.e. to `Save to File`, `Load from File`, or `Reset to Default` the 12 parameters that exist for each detector pixel. Working on the parameters of individual detector pixels requires to enter the **Inspect Single Pixel** dialog (see Sect. 5) via the corresponding button in the section below.

Here a couple of further action buttons are grouped together:

[1] Note that these options affect the display only. The underlying data buffer, which may be exported to PIA, is kept in units of V/s without having the signal linearization correction applied.

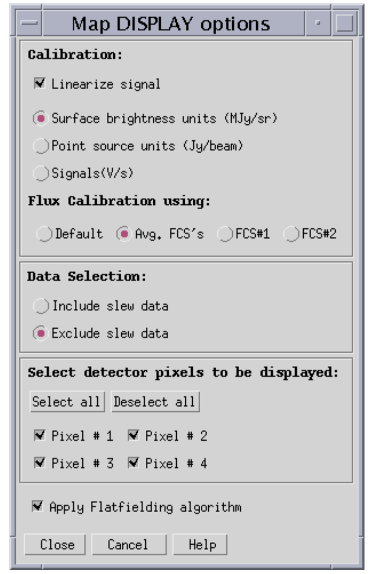

Figure 2. An illustration of the **Map Display Option** *window.*

The button `Calculate on All Pixels` fits the transient model with its current parameter settings to the data of each detector pixel. This procedure is typically one of the first activities after loading the data.

After the measurement has been inspected and has been worked on via the neighboring **Inspect Single Pixel** button, one may want to choose to break the fitting process into certain ranges of data in a preprogrammed way. This is done via the `Custom Processing` dialog and is useful to circumvent a limitation of the model, which results in excessive memory effects after strong changes from high to low flux. This condition typically arises with strong point sources at the centre.

With `Save/Restore` the entire data buffer can be stored on disk or loaded back into memory. This feature is particularly useful for processing data in separate parts, for instance pixel by pixel. Then backup copies of the different reduction stages can be made in case of a software problem along the way. It is also useful for exploring several flavors of processing using a common starting point. It should be noted that for technical reasons, saving data does not save as much time as could be assumed. Once having closed the **Main P32 Processing** window, the original measurement must be loaded and initialized again, before the saved version can be restored.

The `Display Map` button leads to the same map as described in Sect. 4. Instead of deriving the map in this way, the data can be exported back to the SCP buffer of PIA (see Sect. 6), using `Export Results to PIA/SCP`.

5. INSPECT INDIVIDUAL PIXELS

5.1. THE INSPECT SIGNALS PER PIXEL

The **Inspect Signals per Pixel** window shown in Fig. 3 provides a facility to visualize the results of a fit more closely,

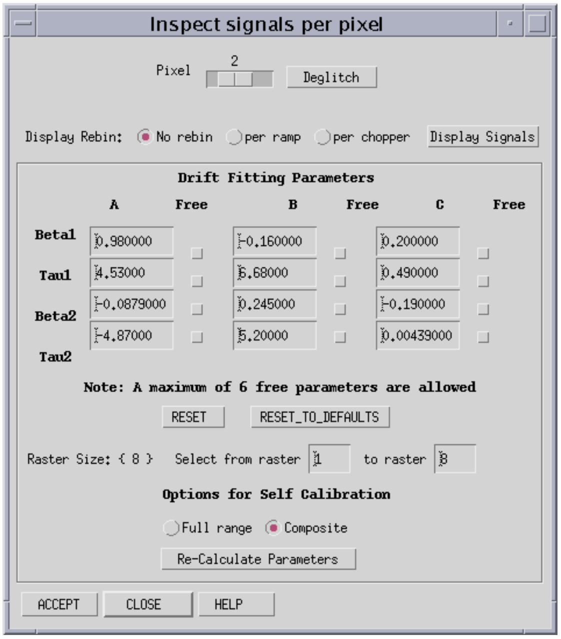

Figure 3. An illustration of the **Inspect Signals per Pixel** *window.*

working on one pixel at a time. It allows for further data cleaning (e.g., deglitching, see Sect. 5.3) and manual or automatic tweaking of detector parameters (see Schulz et al. 2002 for examples on self calibration).

Selection of a pixel is facilitated by a sliding bar near the top of the window. The **Deglitch** button on the right leads to a corresponding dialog, which is covered in Sect. 5.3. This is typically one of the first activities after starting to work on individual pixels.

The data sequence (or time line) of the selected pixel can be displayed by clicking the `Display Signal` button. The data sequence can also be displayed after being rebinned per integration ramp (`per ramp`) or per chopper step (`per chopper`). Some rebinning is useful if the data are noisy or the number of data points slows down the display. Note that rebinning is done using only valid data points.

The transient model parameters for the selected detector pixel are displayed as a matrix of 4 rows by 3 columns. These parameters are defined in Tuffs & Gabriel (2002). Each parameter is associated with a `free` flag. If none is set, the `Re-calculate Parameters` button at the bottom of the window just fits the transient model to the detector signal. If at least one free flag is checked, the so-called self calibration mode is entered. Here the selected parameters together with the modeled signal are varied to give the best fit to the detector data. If parameter fitting does not converge, the two buttons below the parameter matrix provide a shortcut to reset the parameters to the values presently in the main P32 window (`Reset`) or to their default values (`Reset to Defaults`). Note that the buttons act only on the detector pixel currently selected.

A working data range is specified by indicating the start and end points within the raster in two fields further down (`Select from raster / to raster`) This range determines which data are displayed or acted upon by the deglitcher and the fitting process.The total number of available raster points is shown on the left between curly brackets.

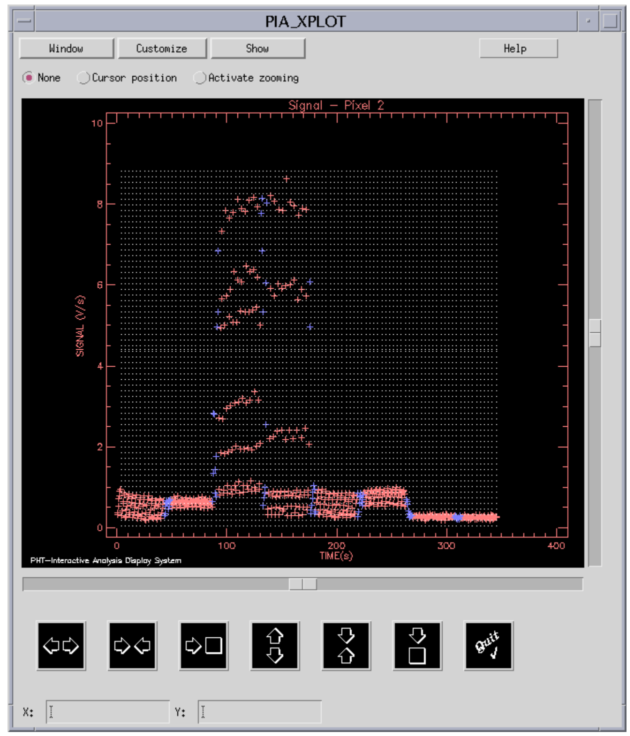

Figure 4. Display of a pixel data sequence with the option of rebinning per chopper step.

A `Full Range` self calibration fits the transient model to all signals in the sequence of raster points. This can be very time consuming. A considerable shortening of processing time is achieved by limiting the data range to one raster point only and averaging all signals measured at the same chopper position. In this mode, the model is fitted to the few remaining data points, which are interpreted as the average reaction of the detector signal to the sequence of fluxes seen during each chopper sweep. This self calibration mode is selected via the `Composite` button. For both options, the `Re-calculate Parameters` button triggers the fitting process.

Finally, the `Accept` button closes the **Inspect Single Pixel** dialog and updates the signal and parameter buffers of the **Main P32 Processing** window. No matter how many pixels have been worked on, upon accepting, the buffers of all pixels are updated. The `Close` button leaves the **Inspect Single Pixel** window without updating the parameters in the **Main P32 Processing** window. However, the dialog can only be closed after turning off any free flags.

5.2. Signal Display

Fig. 4 shows how the display of a single pixel signal appears. Data points taken at a raster position are shown in red and those taken during telescope slews in blue. Without rebinning, any de-selected data points would show as yellow dots. Evenly-spaced dotted vertical lines in the plot mark the beginning of a chopper sweep. For convenience the same display facility is used, as in PIA, allowing to easily zoom for closer inspection (see PIA Users Manual).

5.3. Deglitching

Fig. 5 shows the dialog appearing upon pressing the `Deglitch` button in the **Inspect Single Pixel** window. The appearance is similar to the standard signal display. Valid signals are shown as red squares, while de-selected data show as yellow crosses. Dotted vertical lines indicate the beginning of a chopper sweep and valid slew data points are marked in blue. On the top-right corner of the window are a number of quick navigation and scaling buttons. There are also several display options for the data points. The **Manual Deglitching** buttons allow to de-select and re-select data points using the mouse pointer. This is useful after running the automatic deglitcher described below, to weed out any “stubborn”glitches that were not caught.

The fields along the bottom row of the window contain parameter values for the automatic deglitcher, that are described in detail by Peschke & Tuffs (2002). The `Deglitch` button runs the algorithm, which leads to an update of the display. It is important to note that any further run of the algorithm starts again with the initial dataset that is present when the dialog is started and also discards any manual de-selections. Only leaving the dialog via `EXIT` commits the changes to the main buffer. Leaving via `Quit` discards them.

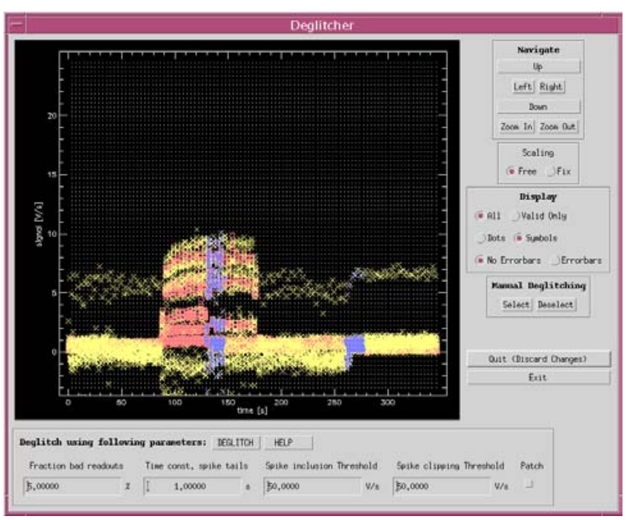

Figure 5. An illustration of the **deglitching window** *where a manual deglitcher and an auto deglitcher are available.*

6. Saving Results and Data Output

Once a satisfactory model fit has been found for all pixels, a map can be generated directly by P32Tools via the `Display Map` button. The process uses the options set in the **Map Display Options** dialog (see Sect. 4). To make use of the larger number of options to produce maps in PIA and further processing possibilities (e.g. the IMAP tool at SPD level, Lu et al. 2002b), the deglitched and transient-corrected data can be exported to the SCP buffer of PIA using the `Export Results to PIA/SCP` button.

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