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Document version tracking

Deliverable	Date	Pages	Description of changes	Comments
D2.1	30/09/2014		V0 of the package	
D2.2	17/10/2015		V1 of the package - code bug fixing, described in section 8	
D2.3	30/09/2016		V2 of the package	Fixing of bugs, adaption to run on small maps, inclusion into the WP3 workflow

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1. Introduction

This document is the description and user manual of the VIALACTEA Compact Sources extraction package. The package is the deliverable 2.3 (D2.3) of the Work Package WP3 of the VIALACTEA project.

The delivery package of D2.3 is constituted by:

- The Compact Sources extraction package code (set of IDL files)
- The package user manual (this document)

2. Applicable & Reference documents.

Doc. Ref.	Title	Ref.	Issue	Date
AD1	VIALACTEA Description of Work	ARES(2013)2743335		24/07/2013
RD1	Source extraction and photometry for the far-infrared and sub-millimeter continuum in the presence of complex backgrounds	A&A Vol.530, p. 133		2011
RD2	Hi-GAL Compact Sources Catalog	VL-IAPS-DI-2014-004	0	30/09/2014

3. Acronyms and Abbreviations

4. Overview of the document

This document is intended to be used for all foreseen Compact sources extraction package deliveries. Therefore in addition to section 5 dedicated to the package description, and section 6, containing the package user manual, three sections dedicated to the description of delivery specific notes have been added to the overall document contents.

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5. Compact Sources extraction package general description

In comparison to ground-based submillimeter continuum surveys, the data obtained by the Hi-GAL project with the *Herschel* cameras do not suffer from the varying atmosphere, allowing therefore to recover the rich and highly structured large-scale emission from Galactic cirrus and extended clouds. Such variable and complex background severely hinder the use of traditional methods to detect compact sources based on the thresholding of the intensity image widely used in the case of large scale millimeter and radio surveys from ground-based facilities, like the Bolocam GPS (Rosolowsky et al., 2010, ApJS 188, 123), CORNISH (Purcell et al., 2013, ApJS 205, 1) or ATLASGAL (Contreras et al., 2013, A&A 549, A45), where diffuse emission is filtered out either by the atmospheric variations or the instrumental transfer function. We deemed therefore necessary to develop a specialized approach to work in the severe background conditions typical of Hi-GAL maps.

5.1. Package characteristics

5.1.1. Basic principles

In a previous work Molinari et al. (2011, A&A 530, 133, RD1) introduced a new approach to detect sources and extract their fluxes tailored to the case of the complex and structured background present in IR/sub-mm observations. With respect to other popular algorithms, this photometry code, CuTE_x standing for Curvature Thresholding Extractor, adopts a different design philosophy, looking for the pixels in the map with the highest curvature. In short, CuTE_x algorithm highlights those regions computing the second derivative of the map. All the “clumps” of pixels above a defined threshold are analyzed and the ones larger than a certain area are kept as candidate detections. The pixels of the large “clumps” are further analyzed to determine if there are more than one statistically significant local maximum of curvature, as expected in the case of very close sources. For each detected peak in the derivatives map, an estimate for the guess size of the source is determined by fitting an ellipse to the positions of the minima of the second derivative in each of the 8 directions. The output fluxes and sizes are determined by fitting elliptical Gaussian functions plus a flat surface for the background. In case sources are detected closer than a given reciprocal distance (see Sect. 6.3.2 below), they are simultaneously fitted as a group, where the peaks relative positions are kept fixed in the fit.

5.1.2. Upgrades in the present release

The code has considerably evolved with respect to its original prototype in RD1), undergoing not only upgrades but also detailed characterization in some of its aspects.

- **General package-wide bug-fixing and improvements in code robustness.**
- **Improved code flexibility.** A number of detection and source fitting options to adapt to particular conditions in the input map are now configurable in the command line using keywords (see §§6.3.2 and 6.3.3).
- **Improvement estimate of detection threshold.** The detection is carried out in the 2nd derivatives map by thresholding on the curvature value. The threshold is by default expressed as a number of standard deviations of the curvature in the map; to adapt to the local background conditions, the curvature

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r.m.s. is computed locally in small portions (size is configurable using input keywords) rather than on the whole map. In this way the selected threshold is relative to the local conditions, so that a single value can be effectively used from the Galactic center to the outer Galaxy.

- **Improved input data for individual source fitting.** The subimage that is provided to the fitting engine was modified to mask pixels belonging to close-by detected sources within the subimage
- **Improved fit convergence.** The Gaussian fitting is carried out for each source by considering a fitting window centered on each source and with a width of 3 times the instrumental PSF to make sure to include sufficient space surrounding the source for a reliable estimate of the background. This has the drawback that the pixels used to constrain the background are numerically predominant with respect to the pixels characterizing the source; to counterbalance this effect, the pixels located within a distance equal to the initial guesstimated source size from the source position are given a higher weight in the fit, as specified by the user (§6.3.2). This feature greatly improved the fit convergence.
- **Improved estimate of the background.** The estimate of the source background can now be estimated also using a 2nd-degree surface, instead of a flat plane. This better adapts to the highly variable background conditions, even at high spatial frequencies that, that are typically found on Herschel maps in the Galactic Plane as well as in star-forming regions in general.
- **Improved group-sources fitting.** The fitting of very close detected sources (threshold distance is configurable with input keywords, §6.3.3) was carried out by simultaneously fitting N Gaussians to the sources group. The improvement consists in the fact that an N-sources group is fitted N times, each time keeping as a valid source parameters only those of the i^{th} source, each time recentering the source fitting window on the position of the i^{th} source. This overcomes the problems that the accuracy of the fit greatly decreases for sources at the borders of the fitting subimage.

5.1.3. Transfer function of the noise properties

Through the use of simulated images, Molinari et al. (2011, A&A 530, 133) showed the potential of the algorithm in detecting sources in the harsh conditions of variable background typical of the Galactic Plane. Despite the great performances of CuTE_x on the simulations, particular care has to be applied when it is applied to the real observations. In particular, we report here the characterization of the derivative operator used in the detection process. A different way to understand how CuTE_x works is to consider the second derivative operator as a high spatial frequency band pass filter that dampens the intensity of background emission more than the one from the compact sources. To show its behaviour as function of the scale, we processed multiple Gaussians with increasing FWHM through the detection module and measured the ratio between the second derivatives image and the original one at the peak position. The result is shown in Figure 1 that reports the ratio between the power spectrum from the average of the 4 power spectra (in the four derivation directions) and the power spectra of the intensity image for SPIRE 250 μ m. Different colors refer to different lines of sight in the Galactic Plane.



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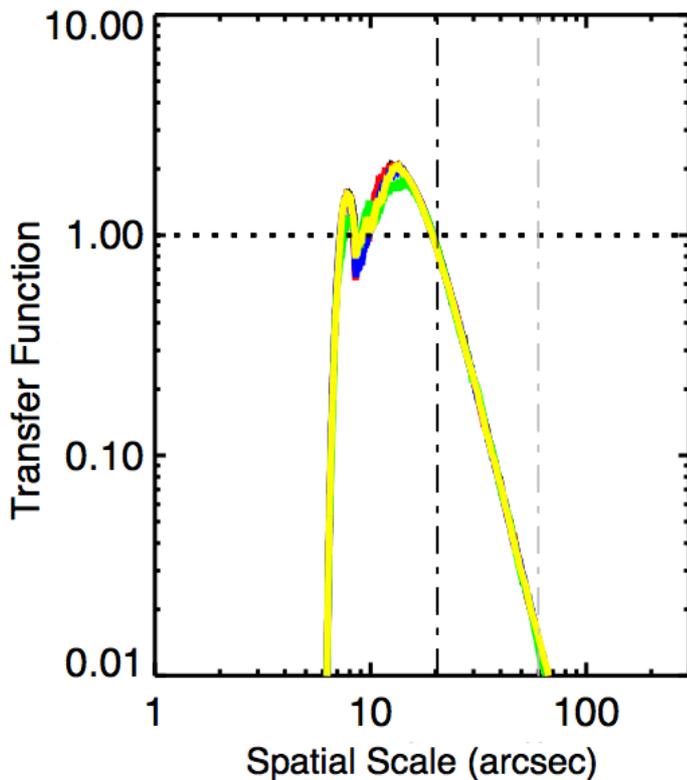


Figure 1:

intensity image is an approximation of the transfer function of the derivative operator used by CuTEx. Figure 1 shows such ratio as function of the spatial scales for the different Hi-GAL bands. The black and grey dot-dashed line indicates the scales corresponding respectively to the 1 and 3.3 times the PSF for each band. These results confirm that CuTEx behaves as predicted by the simulations, but also point out a drawback of the method. At spatial scales smaller than the PSF the effect of the filtering results in an amplification. This has the consequence that any pixel-to-pixel noise present in the maps is amplified in the second derivative maps. In order to quantify such amplification, we conducted a series of Montecarlo simulations adopting Gaussian noise and found that in the second derivative image the noise follows a Gaussian distribution in the same way as in the intensity images, but with a standard deviation 1.13 times the initial one. In other words we have a linear correlation between the noise in the intensity maps and in the second derivatives maps, as we have between the intensity map and its second derivative; we are therefore confident that source extraction on the second derivatives images can be carried out using thresholding as we would normally do for packages that work on intensity maps.

5.2. Package structure

The filamentary detection package consists in a set of IDL scripts, optimized for IDL ver 7.1. The current delivered package refers to the stable version 0.997 that include all the tools to perform the detection and flux extraction of the compact sources from Hi-GAL maps. The delivered tar file is organised in a number of directories where routines are broadly grouped according to their function.

The two main scripts are `detection.pro` (located in the directory `Detection`) to detect the sources and `extract_photo.pro` (located in the directory `Extraction`) to extract the fluxes.

It is easily seen in the figure that a point source with FWHM of 3 pixels is damped in the derivative image to about 40% of its original value, and decreasing to about 10% for scales as large as 7.5 pixels. For all the scales larger than 6 pixels, the attenuation in the derivative map declines with increasing spatial scale following a power-law with an exponent -2. For the detection of a source the important point is that the attenuation caused by the 2nd-derivative increases going toward larger spatial scales: for example, a point source that in terms of intensity is 10 times fainter than a surrounding background with a typical scales of about 15 pixels, will appear ≈ 1.7 brighter than the background emission in the derivative map.

To characterize the CuTEx behaviour on real maps we selected 5 individual maps among the Hi-GAL map set, and computed their power spectra. We then computed, for each map, the power spectrum of second derivative image for each direction and averaged them together. The ratio between the power spectrum of the 2nd-derivatives map with the one of the

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5.3. Package inputs

The package is optimized to run on images in FITS format readable by the IDL routine 'readfits.pro' included in the standard 'astrolib' library. It works on single frame/layer FITS, like the maps produced by the Hi-GAL project, on which the pixels with a not defined number ('NaN') have been replaced by the same, constant, value (preferably 0).

An input ascii file defining the region of the map where to extract the sources is required for a complete successful run. The format file has to follow the one of the region files the application SAOImage ds9 (available at <http://ds9.si.edu/site/Home.html>). The ds9 application is a wide spread software adopted in the astronomical community for imaging and data visualization and it allows easily to write the necessary region file. For a precise description of the format of the region file see the section 6.2.

Both the map FITS file and the region file has to be present in the directory where the package is actually launched.

5.4. Package outputs

Package outputs consist of a number of intermediate product, plus a final source catalogue.

5.4.1. Intermediate products and ancillary outputs

The products of the procedure `detection.pro` are of 4 types:

1. Data files containing the list of source candidates and their size estimate
2. Derivative maps
 - a. 'der1x'+*mapfile* and 'der1y'+*mapfile* - First Derivative Maps (along x,y)
 - b. 'der2x'+*mapfile*, 'der2y'+*mapfile*,
 - c. 'der2x45'+*mapfile*, 'der2y45'+*mapfile* - Second Derivative Maps along x, y and the two crossed-diagonal directions
 - d. 'allder2'+*mapfile*) - Mean of the four second derivative maps.
3. Binary masks
 - a. 'mask'+*threshold+filename* - Mask of all pixels above the (curv.) threshold
 - b. 'mask'+*threshold+filename*+' removed.fits' - Mask of pixel groups above the (curv.) threshold and satisfying the number of closest neighbours
4. Region files in ds9 format
 - a. 'sources wcs'+*threshold+filename* - Region file in WCS of the source candidate centers and size
 - b. 'sources image'+*threshold+filename* - Same as above but in image cords
 - c. 'sources der2ellipses'+*threshold+filename* - Region file containing the points used to estimate source sizes (8 points defining an ellipse).

5.4.2. Compact source catalogue

The most important output of `extract_photo.pro` is an ascii file in 'IPAC Table' format that contains all the parameters for the extracted fluxes. The reader should refer to VIALACTEA deliverable D2.4, i.e. the Compact sources catalogue and its explanatory supplement, for a full description of the output catalog structure and properties (RD2). The script also produces ds9 region files '.reg' files for each type of detected

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sources, single, group of 2, 3, or more sources. These are very convenient products to be shown on top of original maps to evaluate the performance of the detection and extraction.

6. Compact Sources extraction package user manual

6.1. System needs

The package requires IDL ver 7.0 or a newer version to run. Unzip the package in a directory accessible to your IDL path for a successful run. The package can also be run in IDL's OpenSource equivalent called GDL, (GNU Data Language) that is available at <http://sourceforge.net/projects/gundata1anguage>.

The IDL Astronomy User's Library, 'astrolib', not included in the delivered file but available at <http://idlastro.gsfc.nasa.gov/> is needed for a successful run of the complete package.

The astronomical imaging and data visualization application SAOImage ds9 is suggested to produce in a short time the input region file with the correct format required for a safe run of the package.

6.2. Configuration files

There is one configuration file that needs to be run in order to load into the IDL/GDL runtime environment all the routines of the package. The command to be given at the IDL/GDL prompt is "@phot_pack_99.lis". The file phot_pack_99.lis is found in the CuTEx_99.7 main directory.

6.3. How to run

6.3.1. Preliminary region selection

The first thing to do is to create a map with sharply defined edges, to avoid large detection of false positives due to the nature of the derivative-based algorithm (high sensitivity to pixel-to-pixel variations). In case of source extraction from Herschel maps, which is the main use we make of this code in VIALACTEA, the region selection should be done so that one defines a region common to both PACS and SPIRE maps.

1. Open the map(s) with ds9
2. Define a polygon region (it is often enough with a square, i.e. 4 vertices). In ds9 select Region-Shape-Polygon and click on the image to get a square. Click on the square and move the vertices to shape the region included in the field of view of both PACS and SPIRE. (use Control c - Control v to transfer the region from one window to the other).
3. Save the region file: Region-Save regions... as e.g. photo_region_l323.reg

6.3.2. Source Detection

The package used here is called detection and is based on curvature analysis. Run it like this:

```
outvar = detection(mdir, mfile, thr, outd, out_var, keywords)
```

where:

- outvar = Output variable containing the total number of sources detected.

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- mdir = String containing the directory of the map
- mfile = String containing the filename of the map (mask map)
- thr = Float number of σ defining the detection threshold. Observe! The detection threshold is defined by thr times the standard deviation of the mean derivative map, which is the mean of derivative maps in four directions.
- outd = The output directory for the results of the routines.
- out_var = IDL string variable with the candidate list filename.
- keywords: see Table 1

A standard run on the map 'spire250_I59_igls.fits' in the directory './maps/' adopting a threshold level of 2 and putting the results in the directory './PSW/' is given by:

```
out = detection('./maps/', 'spire I59_igls.fits', 2.0, './PSW/', det250)
```

The IDL variable det250 will contain the filename of the list of detected sources. All products will land in the directory ./PSW/.

The following points aim to clarify the essence of detection.pro in order to give a better general view of its functions.

- Users are warned of the fact that the code assumes that the input map is Nyquist sampled, i.e. there are at least 3 pixels covering the instrumental PSF. If that is not the case, and the input map is over- or undersampled, the sampling has to be specified through the keyword PSFPIX.
- The estimate of the size of the sources (FWHM of the Gaussian used to fit them) is a two step process: measure of distance from peak and ellipse fitting. To measure the distances from the peak detection.pro analyses the value of the second derivative along 8 different directions searching for the first minimum. The group of 8 points around the peak is then fit with an ellipse (after flagging "misleading" points) and the size of that ellipse is the first guess. This first guess is then easily referred to the FWHM of the Gaussian that will be fit to the candidate source. Observe! detection.pro is designed to "see" compact sources, so as a hard coded rule, all sources with first guess sizes larger than 3 PSF are not fit with an ellipse. In case of oversampling of the instrumental PSF the user should even change the distance from the peak (in pixels) to be searched for the derivative minimum: use the keyword RANGE.
- The most important parameter of detection.pro is thr, the threshold in multiples of the standard deviation r.m.s. of the second derivative of the input image. As a default, detection.pro uses 1.0. It is advisable to try different values and check the results at every time (by e.g. overplotting region files on input maps) as every map has different morphological properties of its emission making it virtually impossible to set a general threshold value.
- Adopting the r.m.s. value estimated on the entire second derivative map to set the threshold level (thr) might not always be a good choice. Crowded bright regions can bias the r.m.s. by increasing it and the final result is that one misses faint sources on faint backgrounds. It is therefore possible to adopt a local thresholding, where the r.m.s. is calculated on sub-maps of 61x61 pixels (the Median Absolute Deviation, MAD, is calculated). Note that to decrease the computational burden the local MAD is calculated on sub-maps of 61x61 pixels and the value is adopted on the inner 31x31 pixel sub-map.

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- Source detection is a multistep procedure: a) selection of pixels in which the second derivative is above the threshold in the four derivative directions; b) identification of candidtaes through the definition of groups of pixels (default is four continguous pixels above threshold). The latter step is necessary to discard isolated pixels. These may pass the threshold filter because the second derivative is very sensitive to pixel-to-pixel variations. If the first run seems to identify too many (contamination by spurious objects) or too few sources (missing of evident objects) the keyword to change to obtain better results is NPIXMASK, set as default to 4. Larger values then 4 will result in fewer sources.

Table 1: Keywords description for detection.pro

Name	Description	Default
NPIXMASK	Key parameter for the detection of sources. It indicates the minimum number of closest-neighbouring pixels having curvature above the threshold to define a source candidate	4
PSFPIX	defines the number of pixels that samples the instrumental PSF. If it is not specified the code assumes a sampling of 3 pixels per PSF. For Hi-GAL maps taken at a scan speed of $60''s^{-1}$ the PSF sampling is 2.7, 2.7, 2.98, 3.125 and 3.11 pixels per PSF, for 70, 160, 250, 350, 500 μm data, respectively. Observe that if you are reducing data taken at $20'' s^{-1}$, PSFPIX for 160 μm data is 2.4 (no blue data were taken at that scan speed). It is safe to assume 3 for all the bands except at 70 μm .	3
/allow_single	Equivalent to NPIXMASK=1, overrides NPIXMASK	off
smoothing	width (in pixels) of boxcar smoothing window, to be applied before detection sources	off
/no_overwrite	If switched on uses existing derivative images	off
/all_neighbours	Considers as nearest neighbouring pixels as belonging to a candidate source even the diagonal ones. Increases the running time if switched on	off
/derivate	If switched on performs 3-point Lagrange derivative instead of 5-points	off
/abscurv	If on, then the detection threshold thr will have to in absolute curvature value, and not, as default, in multiples of the rms-curvature	off
range	Distance in pixels from curvature peak to search for first minima in curvature, when estimating the size of the candidate sources	8
/local_thresh	If on detection takes into account the local "rms" when deciding whether a pixel is part of a source/group or not. Observe! This keyword produces maps of the median deviation form the median i a box of 61x61 pixels, applied to a box of 31x31, starting from the derivative maps. These maps are then "degraded" by a factor 15. The keyword uses available median maps if available.	off
/super_resolution	For clusters of sources. Checks curvature statistics to define how many sources there are on derivative maps in single directions instead of using the mean derivative	off
thresh	When a cluster of above-threshold pixels is found, each candidate curvature pixels has to be higher than its surrounding pixels by $thresh * \sigma_{curv}$, where σ_{curv} is computed as the r.m.s. of curvature only within the given cluster of pixels. In case the /super_resolution keyword is set, then the above condition is relaxed in the sense that the candidate maximum has to be a local	0.5

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	maximum in at least two directions only.	
fact_mask	Factor controlling the size in pixels of the pixel mask that is generated for each detected source. The mask size will be $\text{fact_mask} * \text{FWHM}_{\text{source}}$ as determined from the initial source size guess.	2
/checkhits	If the keyword is set, then the hits map must be available and the detection is carried out only for portions of the map where the hits are at least 60% of the maximum hits value.	off
/quiet	If set, only a minimal set of output messages are printed on the screen	off

6.3.3. Extraction of Fluxes

Run the procedure `extract_photo.pro` to obtain a catalogue containing all information about the detected sources from the previous detection step: peak position, peak flux, integrated flux and angular size. The command to be run is:

`extract_photo, 'indir', 'map_mask', 'outdir', output_var, keywords`

where

- indir, outdir: directory of the files to be read and to write the products in
- map_mask: input file, that is the cut map obtained earlier
- output_var is the same variable used for detection. (no quotes!)
- keywords: see Table 2

The final products of this step are the catalogue of all sources including their photometry and their related errors, e.g. `igls_I059_PSW_cnr_reg_mask_photall.dat` and `igls_I059_PSW_cnr_reg_mask_photall_err.dat`. Together with these files `.reg` files are produced for each type of detected sources, single, group of 2, 3, or more sources. These are very convenient products to be shown on top of original maps to evaluate the performance of the detection and extraction.

Observe! A first order check of the quality of the output can be done by inspecting of the final catalogue: the last column lists a flag qualifying the convergence: 1, 6/7 are ok; 5 indicate maximum iterations reached; 0,2,3 indicate possibly wrong results.

Observe! Beware of the fact that you always should check your final result by plotting the output region file(s) on top of the images you run the extraction on. The visual inspection is the best and quickest first order verification of the reliability of the output. Be prepared to redo the entire extraction with a different threshold, different pixel matching radius etc.

The following points aim to clarify the essence of `extract_photo.pro` in order to give a better general view of its functions.

- The `extract_photo.pro` routine uses the Markwardt MPFIT package (Markward et al. 2009, ASP Conf. Ser., 411, 251) to fit elliptical Gaussians to the identified candidate sources. Fitting always starts from the first guessestimated with `detection.pro`.
- As for `detection.pro`, you need to tell the program with how many pixels the instrumental PSF is sampled in the image. Do so through the keyword `PSFPIX`.

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- extract_photo.pro extracts photometry information for the list of sources identified by detection.pro and stored in one of the last files written by that procedure. The name of this file is stored in detection.sav, use the IDL procedure restore to recover the variable containing the name of that file. If you run bulk processing, this is taken care of.
- This task fits elliptical Gaussians to single sources or groups of sources on top of a background (that can be a plane or a second order polynomial, see below). Sources in groups are fit simultaneously. The difficulty here is to determine which sources belong to which group and how big the group is. The code uses a nearest-neighbour/ friend-of-friends algorithm to do this. A critical parameter in this matter is the maximum allowed size for groups. This is set through the keyword DMAX_FACTOR (in multiples of the PSF, default is 2.0). Observe! If the group contains more than the maximum number of sources the program is able to simultaneously fit the user has to change the value of that keyword. For the moment there is no way to a priori estimate and fix the size of the groups.
- Beside the general fitting of groups as they are identified, another approach has been implemented to enhance the quality of the results. The idea is to extract peak flux, size and position for a certain candidate by simultaneously fitting its closest neighbours in the group (i.e. not all the members of the group). In a group of candidates not all sources of that group will be fit in one go, but the program will cycle through all sources in the group fitting simultaneously only a subgroup of closest neighbours. This is performed if the keyword CLOSEST_NEIGH is set. The first switches the algorithm on, the second sets the distance (in pixels) to define "closest neighbours". Because sources are fit by Gaussians on top of an estimate of the background, extract_photo.pro in closest neighbour mode needs to define the size of the subimage to fit the member of the group. For Hi-GAL data this has been fixed to be a square of $N \times (2 \times \text{PSF}(\text{in pixels}) + 1)$ pixels. Keyword DMAX_FACTOR sets the value of N, default is 2.0.
- When fitting elliptical Gaussians from first guesses extract_photo.pro has to be given limits in which to find the best fit for the source size. This interval is set by the keyword PSFLIM, defaults are [0.7,1.3], i.e. 30% variation from the first guess. This has been fixed after a number of tests using the MPFIT fitting package
- Check your final results for "quantisation" on the limits in PSFLIM. Tuning this keyword might not be easy to control, so take care when doing so. In some cases better results are obtained if the fit is left completely free. Also, it is to notice that size estimates from detection.pro can be affected by several pathologies. Flags in the candidate source list are given to dubious ellipse fitting: -1 if one of the axes is smaller than the PSF; 0 for sources where the axes were larger than 3 PSF (see complementary info on detection.pro) or the ellipse fitting failed. In those cases, an "arbitrary" size is given as first guess: $\text{FWHM } x = \text{PSF}(\text{in pixels})$ and $\text{FWHM } y = 1.1 \times \text{PSF}(\text{in pixels})$.
- For simultaneous elliptical Gaussian fitting on small groups for which the subimage is "small", the background can be approximated as a plane, and this is the default. In Hi-GAL images we have noticed that sometimes groups are large and the planar approximation for the background is too coarse. Switching on the keyword BACKGFIT imposes that the background is fit with a second order polynomial:

$$F_{\text{back}} = A \cdot x(\text{pix})^2 + B \cdot y(\text{pix})^2 + C \cdot x(\text{pix}) \cdot y(\text{pix}) + D \cdot x(\text{pix}) + E \cdot y(\text{pix}) + F$$

Table 2: Keywords description for extract_photo.pro

Name	Description	Default
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smoothing	width (in pixels) of boxcar smoothing window, to be applied before detection sources	off
/noforcefit	For candidate sources that have been flagged during the detection step, Gauss-fitting is left without constraints in size and position	off
/weight	Weight to be assigned during the source fitting process to pixels assigned to the source mask. Pixels outside the source mask and hence belonging to the background are assigned weight=1	300
/correl	If switched on assumes that peak flux and width of the fitted sources are correlated when calculating errors	off
psflim	Defines the variability range of the estimated source size during the fitting process. It is an array of two numbers, in fraction (i.e. [0.7,1.3] means $\pm 30\%$)	[0.7,1.3]
/adaptive_window	When switched on, adapts the size of the subimage around source groups to the value of dmax_factor in multiples of source size	off
dmax_factor	Dimension of the fitting subimage in multiples of the PSF (when /adapt_window is off) or of the source size (when /adaptive_window is on)	2xPSF
/adaptive_group	Adapts grouping radius in the same way of /adaptive_window	off
max_dist_fac	Grouping radius in multiples of PSF (when /adaptive_group is off) or multiples of source size	2xPSF
/closest_neigh	When switched on uses only closest neighbours to fit sources in groups. If switched off, the fit uses all sources in the group	off
dthr	If /closest_neigh keyword is set, then dthr is the distance in pixels between two detected candidate sources to be considered as a group to be fitted simultaneously.	0
/backgfit	If switched on uses a second order polynomial surface to fit background (default is a plane)	off
/posback	Forces the fitted background to be positive (i.e. > 0)	off
/centering	When extracting groups members centers the fitting subimage to the baricentre of the group of sources that is being fitted. By default is that subimage centered on the source actually being fitted	off
psfpix	Sampling of the PSF in pixels. This keyword is used especially for non-Herschel data. As default, i.e. when extracting sources from Hi-GAL data, the task calculates the PSF sampling from the information contained in the map's header	computed from the map
photfile	Explicit name of the output catalog file	
margin	avoid fitting sources whose peak is less than margin pixels from the border of the image	0
/quiet	If set, only a minimal set of output messages are printed on the screen	off

7. Compact Sources extraction package V0 delivery notes

This is the first version of the deliverable, so that there are no explicit notes to be added.

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8. Compact Sources extraction package V1 delivery notes

The package version 1 does not introduce major changes in the main routines and procedures released with previous version:

- the problem reported by the package users about the incompatibility between the initial (guess) estimate of the source dimensions and the proposed maximum parameters variability range has been fixed;
- minor code bugs have been fixed;
- code procedures have been cleaned-up from un-necessary comments.

9. Compact Sources extraction package V2 delivery notes

The package version 2 does not introduce major changes to the main routines released previously. The preliminar masking to have a sharp edge in the map is not necessary anymore, however the results along map borders are less reliable do to the edge effects. Such edge effect allows a worse estimate of the derivative that is the main tool adopted by CuTEx to identify sources. Nevertheless in the majority of cases the algorithm has been revealed to be stable and consistent, in such a way that it has been adopted in the overall pipeline for distance estimation adopted in WP3. Minor bugs in the code have been fixed, in particular to allow the run on very small maps, minimizing the edge effect (that anyway cannot be totally removed). This version of CuTEx photometric packaged is designed ver 1.0.