

ASTROMAGIC

USER MANUAL

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What is ASTROMAGIC:

The software allows the user to extract highly accurate astrometric measurements of sources from FITS images. In particular, its capabilities extend to frames exposed with non-sidereal tracking, and to images on which the target detection is elongated or trailed.

In the PRO version, it is possible to perform measurements on a stacked image.

Hardware and Operating System requirements

The program works on PC in a Windows 10 or higher environment with a minimum of 2 GB of RAM.

Installation

The program does not require installation. Unzip the contents of the astromagic.zip file into any folder and launch the astromagic.exe executable. Warning: the folder must NOT be inside the C:\programs\ path.

AUTHORS

Gianpaolo Pizzetti

The Italian amateur astronomer (b. 1961) is active in the development of astronomical software. He is part of the observational staff at the Serafino Zani astronomical observatory, where he leads the technology and computer section.

Dott. David J. Tholen

is an American astronomer at the Institute for Astronomy of the University of Hawaii (IfA). He hold a 1984 PhD from the University of Arizona, and specializes in planetary and solar system astronomy. Its routines are used for the part of the program astrometrics


THANKS

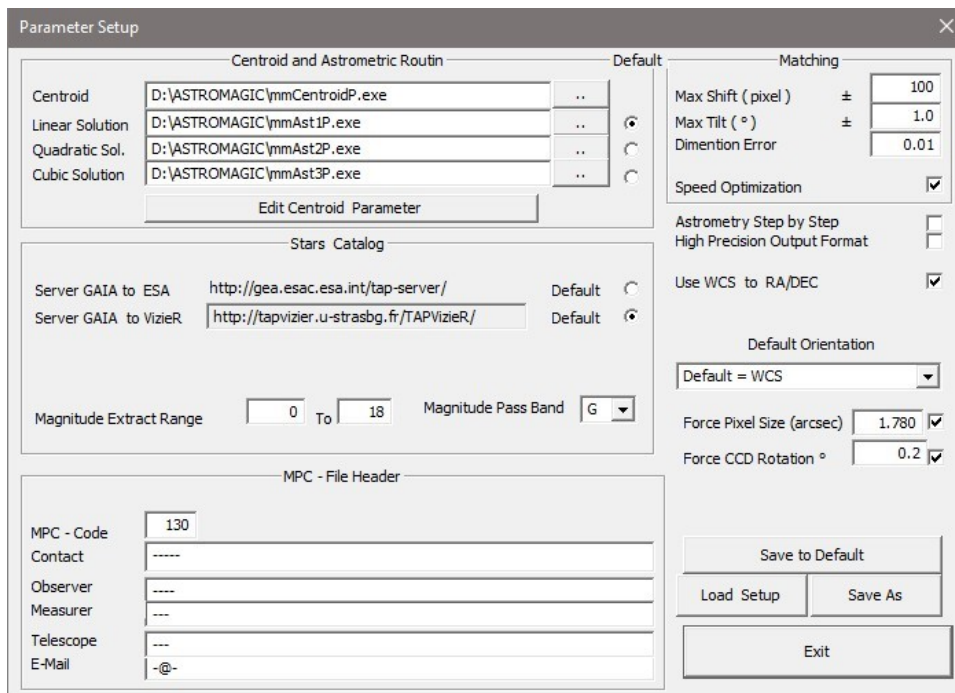
We thank **Dr. Marco Micheli** of NEO Coordination Centre ESA astrometry expert asteroid without which it would be possible to carry out this software.

Features of the current version include:

- Reads FITS (8, 16 and 32 bit integer files). The size of the images is only limited by the available memory.
- Automatic image calibration (Dark Frame and Flat Field correction).
- Blinking with automatic image alignment (2 or more images)
- Zoom for image inspection.
- Multi-Files automatic processing.
- Automatic Histogram Stretching.
- Automatic reference star identification.
- Use the GAIA-DR3 catalog
- Automatic matching even for images with non-sidereal tracking
- Stacking with astrometry even for images with non-sidereal motion (PRO version)

First Use

when you first start the program creates a file (astroimg.ini) containing the default parameters to be saved , modified and / or corrected with the proper function of the setup from the main menu bar 



IMPORTANT : Check the correct paths in " Centroid and Astrometric routin " which should indicate the 4 executables used for centroidatura and astrometry

Section Catalog:

It allows to select by default which server to use for access to the GAIA catalogs.

Matching parameters: are modified only in special cases and establish the range before attempting to perform here matching between image and star field taken from catalog

Max Shift: is the maximum shift value in pixels within which the matching perform

Max Tilt: It is the maximum angle of rotation of the image for the attempt to matching. Caution values greater than 2 degrees can generate an excess of " false positives "

Dimention Error : range for the scale factor used by the matching

Speed Ottimization : if the function is enabled the matching is attempted in several steps using rhyme a limited number of stars and gradually a larger number of reference stars , this usually allows to have shorter computation times

Astrometry Step by Step : If the function is activated , during centroidatura and astrometry of the program is interrupted to show each step and is expected to hold a key to continue to the next step . If not activated this function, the program runs without interruption astrometry

High Precision Output Format : (only authorized by the Minor Planet Center) the measurement is reported to one decimal more than in the standard

Default Orientation:

It is possible to indicate to the program that the images to be loaded are mirrored or upside down.

If this information is not indicated, the program assumes that the orientation is with the North upwards and the East facing left.

Force pixel size (arcsec)

you can force the pixel size expressed in arcsec. We recommend using this function when the pixel size information is not present in the file header

Force CCD Rotation

you can force the image rotation. We recommend using this function when the pixel size information is not present in the file header

MPC File Header

These fields must be completed to allow you to create a header file ready to send to the Minor Planet Center , the header is created as a file named header.mpc and used only the first time you create a file type .mpc

If the measures are added to a file .mpc existing header is not changed

Is very important to indicate the observatory code.

verify Image CCD pixel size:



Current Image Setting - (Date -Time - Sizes)

a

| | |
|------------------------------|-------------|
| Time | |
| Date : | 2015-04-21 |
| Time Start Exp. (UT) | 00:41:25.00 |
| Exposure (sec.) | 320.000 |
| Date/Time at Middle exposure | |
| 2015 04 21.03061343 | |

| | |
|-----------------|---|
| Sizes | |
| Arc Sec./ Pixel | 1.726 <input type="button" value="Modify ..."/> |
| Image Size | 765 x 510 pixels |
| Field Size (') | 22.0' x 14.7' |

verify the accuracy of the date and time of start exposure

CCD Pixel Size

| | |
|-------------------|---------------|
| Pixel Size (") | 1.726 |
| Pixel Size (µm) | 18.00 |
| Focal Length (mm) | 2151.42103 |
| CCD Field (') | 22.01 x 14.67 |

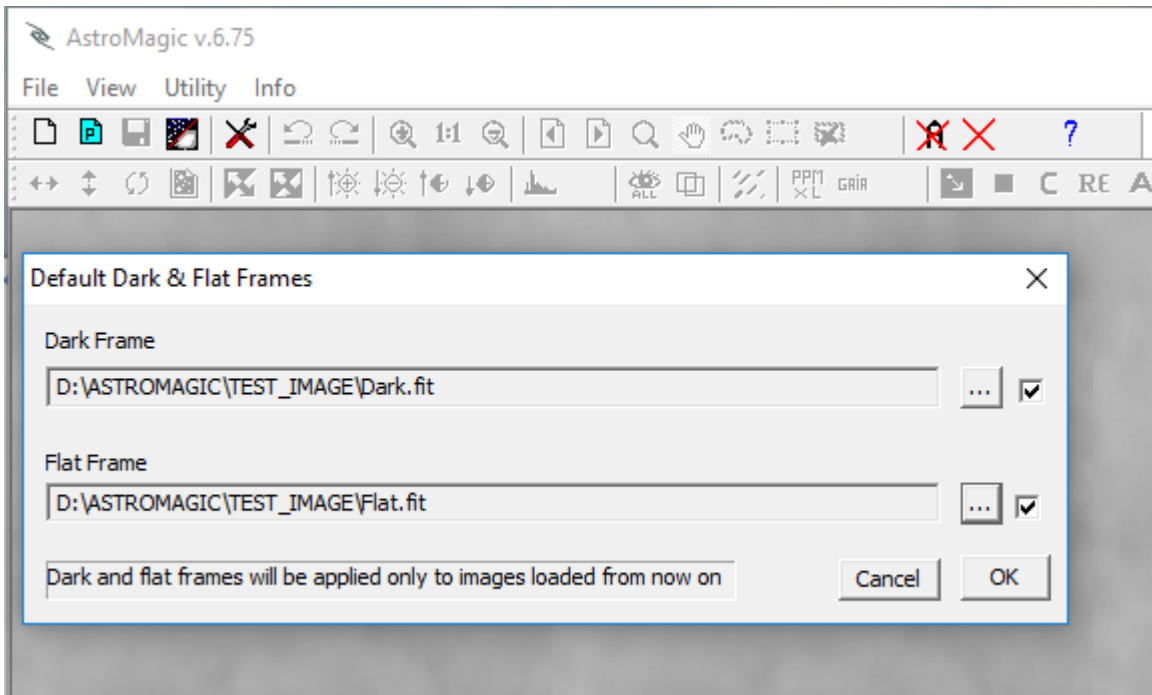
Image CCD pixel size :

Referred to the image currently in use : it is important that the size of the pixels in estresso arcseconds is as accurate as possible . You can act directly in the field ccdpixel size (") or if the fields Focal Length (mm) : equivalent focal length and Pixel Size (micon) if you do not have the first value .

ASTROMETRY EXAMPLE :

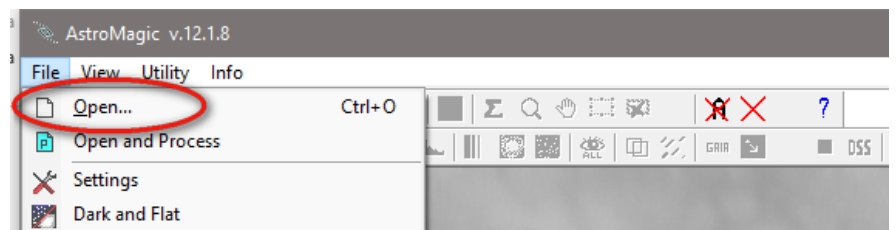
Step 1:

If the images need to be calibrated with Dark and Flat, from the appropriate function you need to indicate which Dark and Flat files you want to use and they will be applied to all the images loaded later.



ATTENTION the Dark and Flat are applied only on the video image while the file therefore remains unchanged
It is recommended to use already calibrated images because the astrometry is performed on the original images

OPEN FILE :

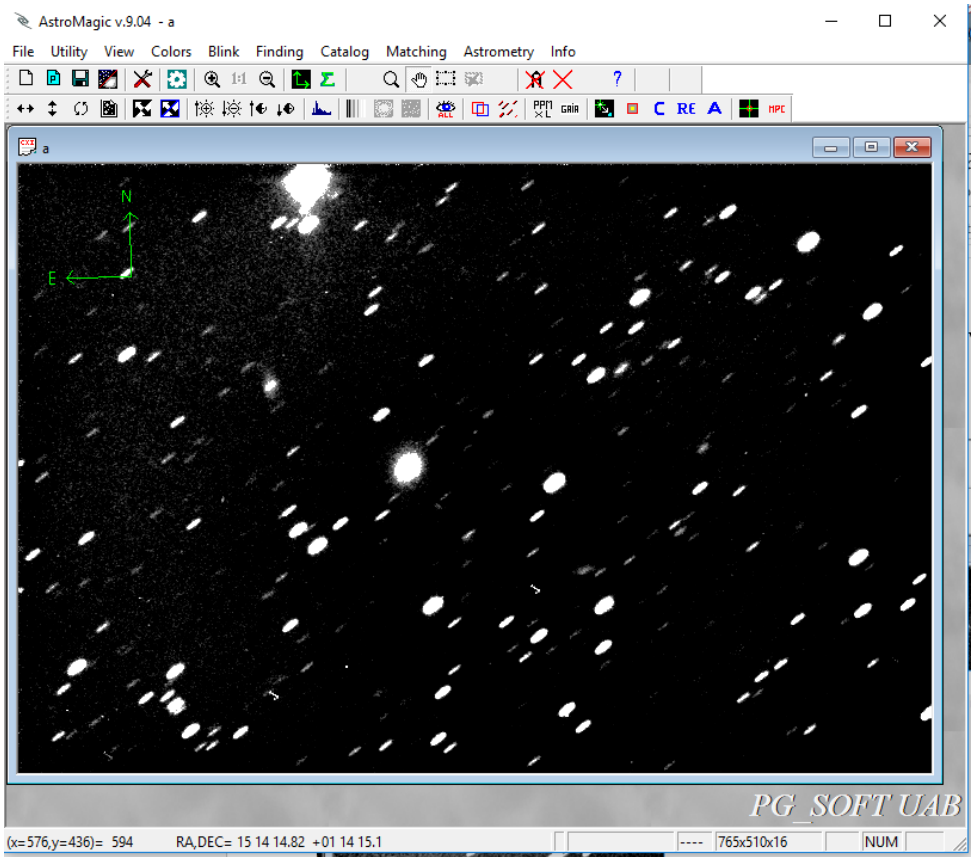


Select and open image

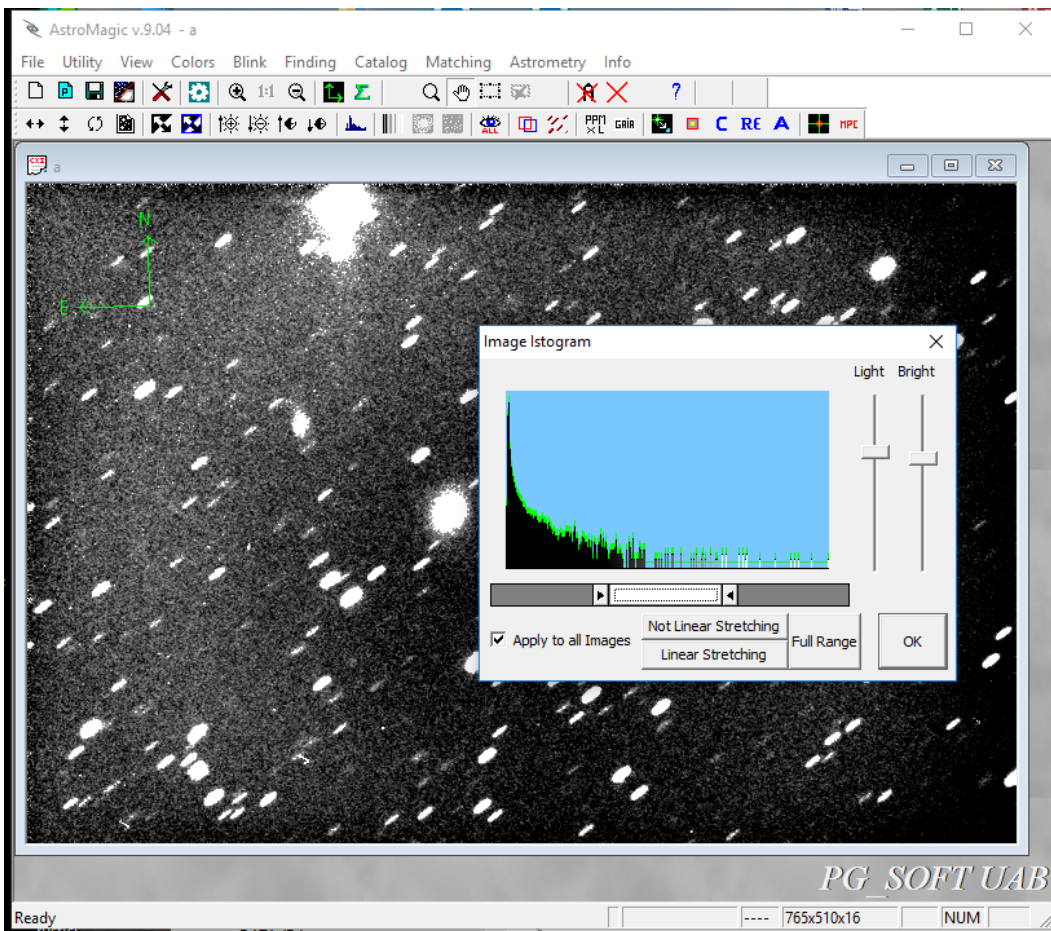
THE CORRECTED DARK AND FLAT IMAGES CAN BE SAVED WITH THE "Save All" FUNCTION

Which will save all the images adding to the name "_P" which indicates a preprocessed image.


The images thus saved can be used for astrometry while the originals should be kept separate for any future processing



after opening the image if the automatic stretching was not satisfactory you can act manually:
 runs a stretching machine that may be modified with the stretching function

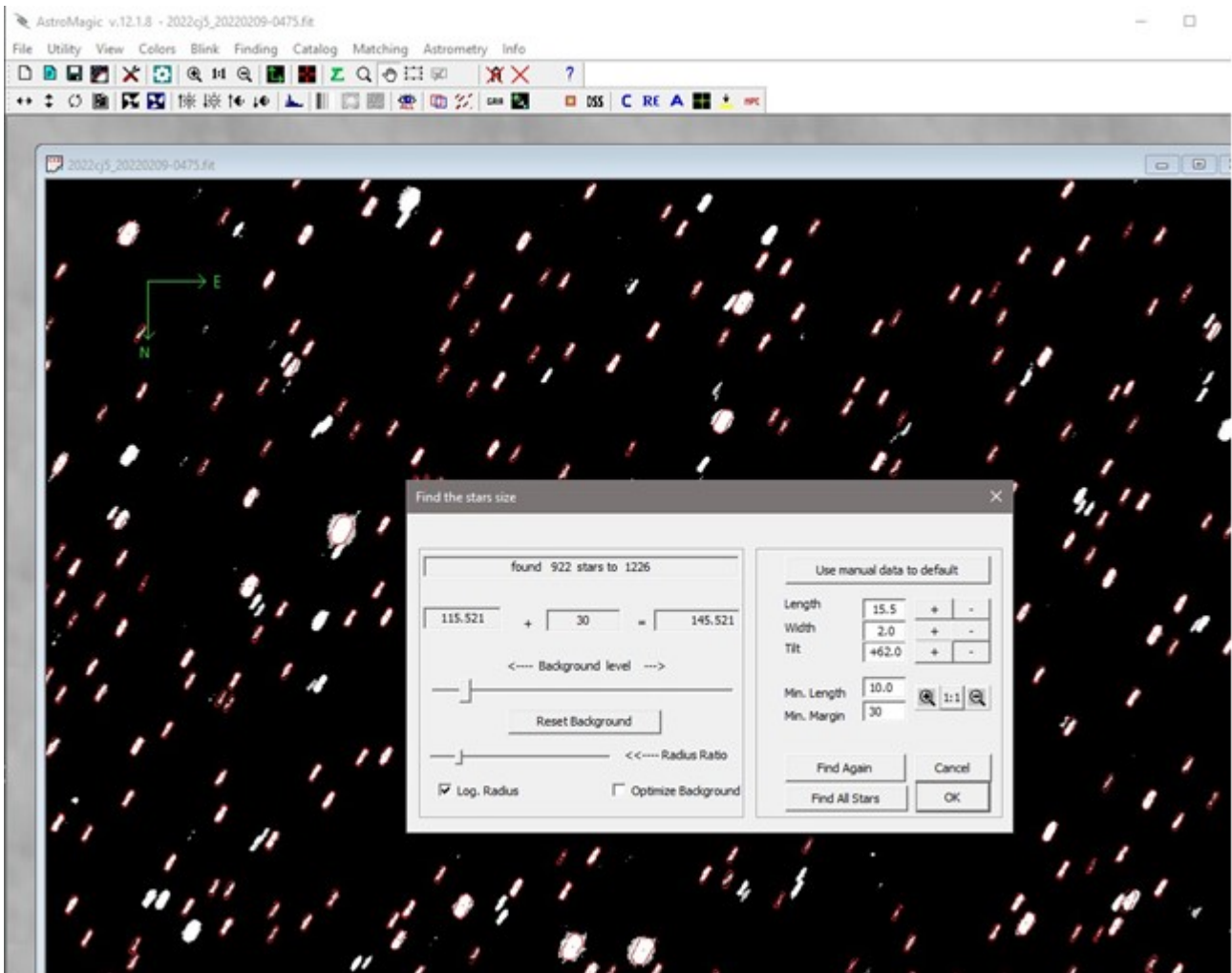


Step 2:

Stars Finding: 

The " Stars finding" useful search the stars in the image and calculates the length , width and inclination , these parameters will be used in the later stages of astrometry .

The program uses an average value of fondocielo that can be changed if they are not correctly find the reference stars , the values of length , width and angle found can be modified manually if you feel that may not match the automatically calculated If here 's the example fondocielo threshold is too low and must intervene manually raising it until trying again the key "new finding" will not get a better result



if the new development is properly detecting the stars press the OK button :

otherwise it is possible to act manually both on the background value (Slide Background level) and on the dimensions of the stars with the appropriate keys or by directly editing the values. The "Use manual to default" button temporarily locks the parameters so that the Finding function uses the same values for subsequent loaded images as well.

Step 3:

Reading stars catalog:

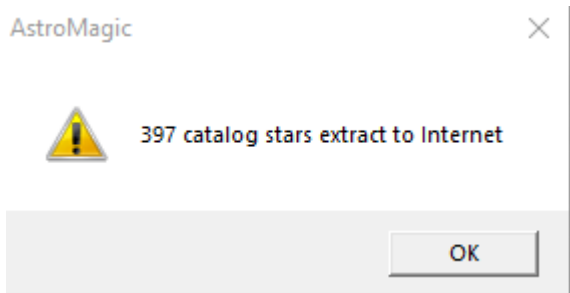
You can use either the stars catalog

With the appropriate function **GAIA**, you can download reference stars through a query directly from the GAIA site or from the alternative VizieR site. A file is created with the same name as the image and .GAIA extension in the same folder where the image is located. Once the file is created, it is no longer necessary to recreate it for future measurements. Verify that the plate center coordinates automatically taken from the FIT file are correct. If they are not present or you know the name of the object in the field, you can search for the coordinates through the Find Coordinate obj tool. Be careful of the limiting magnitude to avoid loading too many stars. The GAIA catalog is very accurate and often a few stars are enough for a good measurement. In the range field, a range in arcseconds is proposed that takes into account the size of the field framed, increased by an amount depending on how many maximum shift pixels have been set in the setup. It is also possible for very large images to define a box and download only the stars in the indicated rectangle.


| | | | | | |
|--|--------------|---|---|------------------------------|---------------------|
| RA Center | 07:48:57.629 | Date | 2022-02-10 | Date/Time at Middle exposure | |
| DEC Center | -05:32:15.13 | Time Start Exp. (UT) | 06:31:47.70 | | 2022 02 10.27211447 |
| <input type="button" value="Find Coordinate obj"/> | | Exposure (sec.) | 5.980 | | |
| Filter | | Range | | | |
| Min Magnitude | 0 | <input checked="" type="checkbox"/> Full Range x (') | 62.2 | | |
| Max Magnitude | 18 | <input checked="" type="checkbox"/> Full Range y (') | 62.2 | | |
| Mag. Passband G | | <input type="checkbox"/> Box Range x (') | 62.2 | | |
| | | <input type="checkbox"/> Box Range y (') | 62.2 | | |
| | | <input type="checkbox"/> Preview From Internet | <input type="button" value="Load Stars"/> | | |
| | | <input checked="" type="checkbox"/> Extract From Internet | <input type="button" value="Use Last"/> | | |
| <input type="text" value="Create D:\ASTROMAGIC\marco\2022cj5\2022cj5_20220209-0475.gaia"/> | | <input type="button" value="Exit"/> | | | |

If you do not have catalogs on disk check **Extract From Internet**

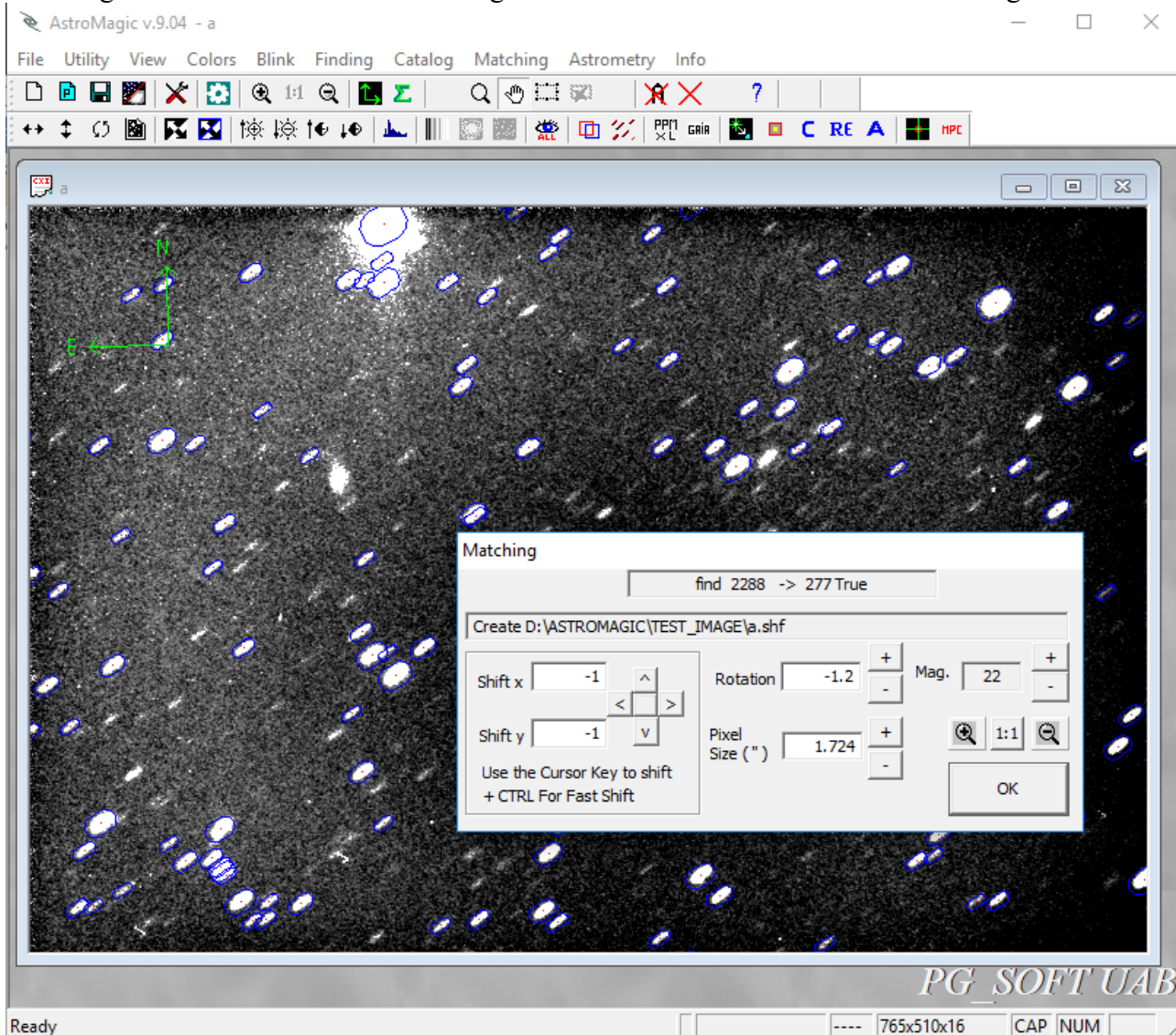
crushing ok to read a number of stars from the catalog:



Step 4:

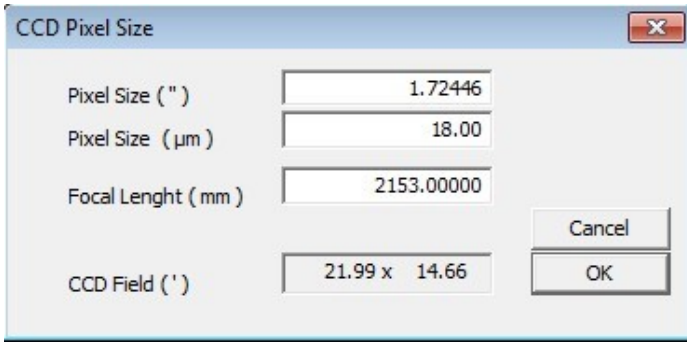
Matching 

matching is used to associate the star image to the reference extracted from the catalog



Also in this case you can intervene manually in case the automatic matching fails

The matching algorithm is very sensitive to possible errors in the definition of the parameters of the image especially for the pixel size, and rotation. If matching failed first is to verify the parameters (Menu - > Utilities - > CCD Pixel Size)



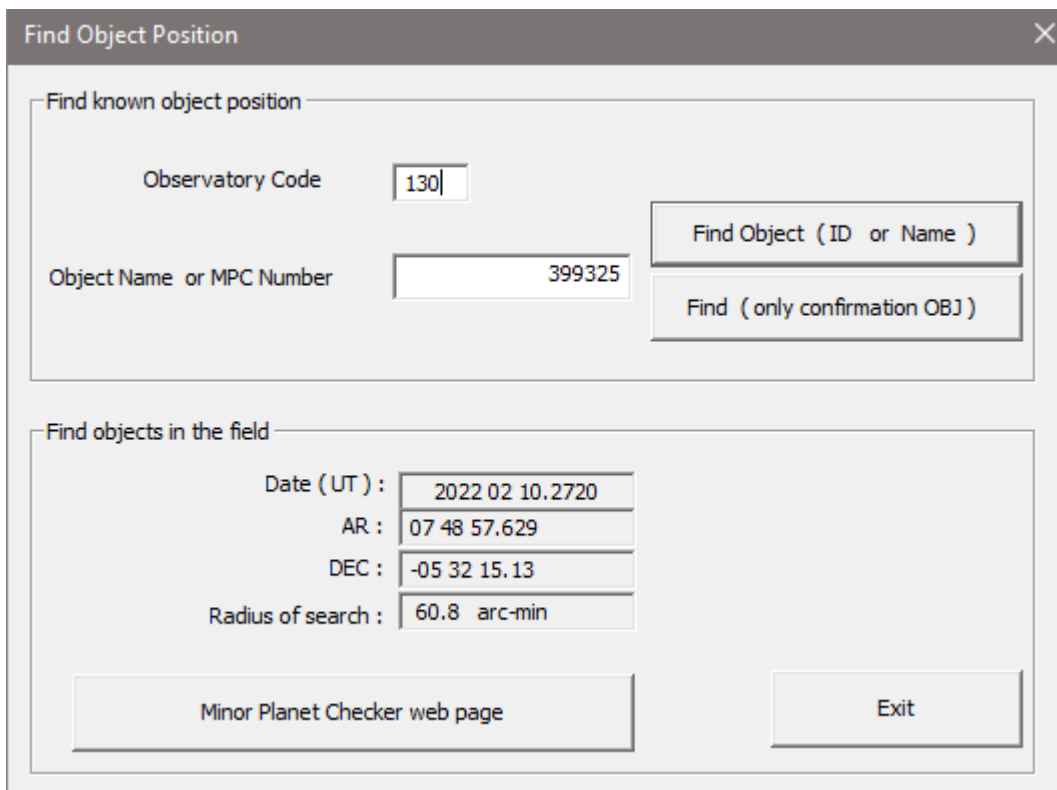
Another possible error in Matching

if the image is rotated by more than 2 degrees , matching can fail if the header of the FITS file is not present the Keyword " POSANGLE " that tells the program the value of this rotation.

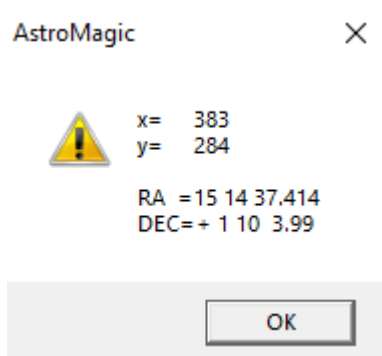
Step 5

Search object to be measured

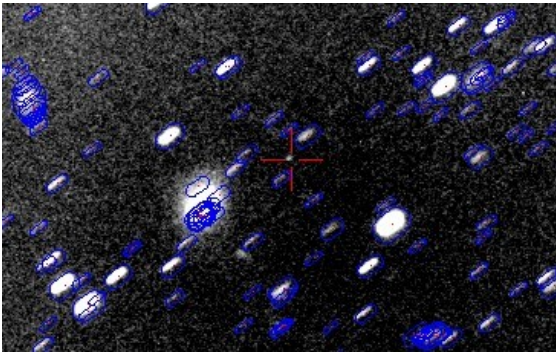
If the object to be measured is already cataloged you can use the function : "find known objec" :



in this example the object is a numbered 399325 and was observed by the observatory with code 130 , the " Find Object (ID or Name) " will return the following values ...



The object is shown on the picture with a red cross

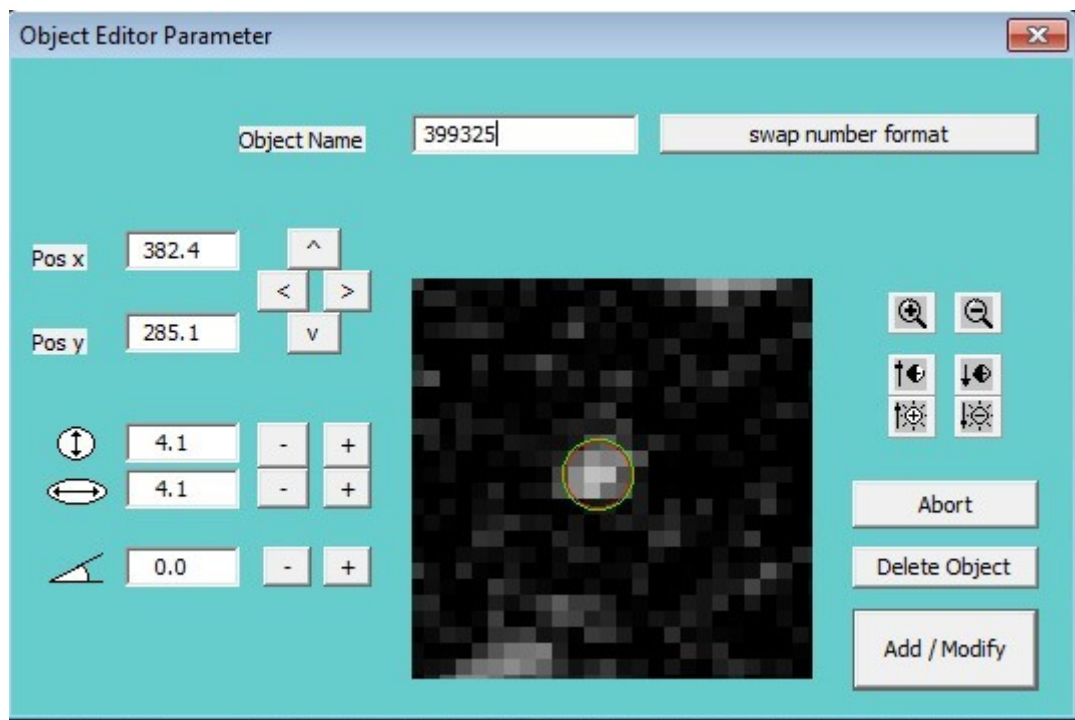


Step 6:

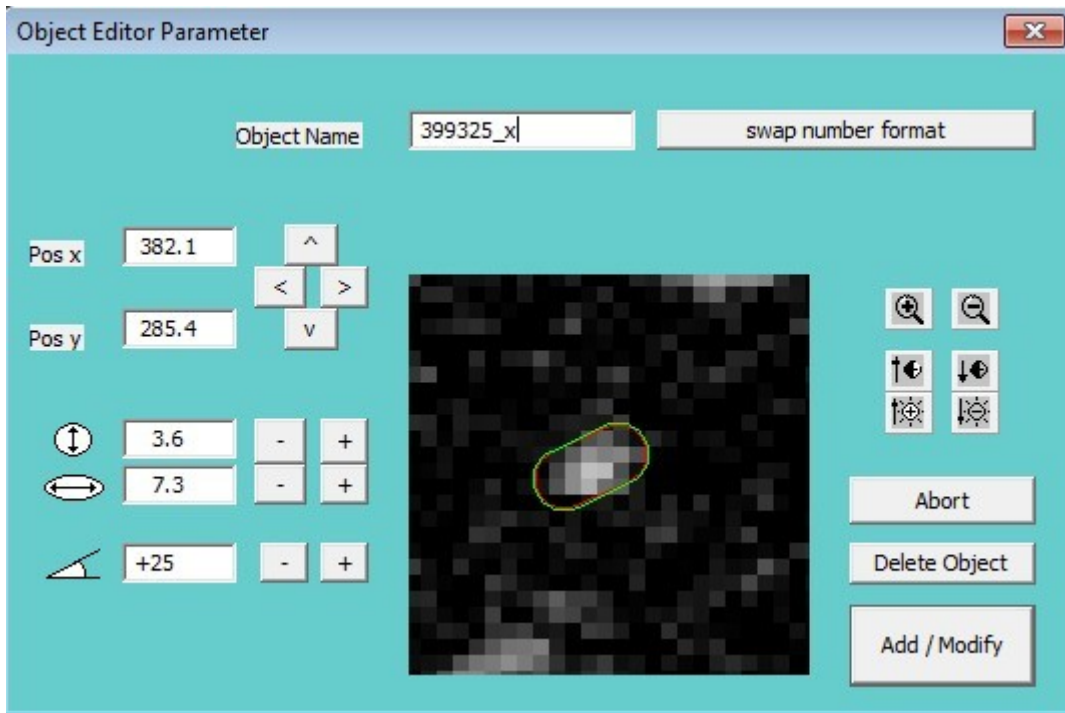
select the object to be measured.

After finding the object to be measured you must identify more precisely by clicking the right button .

A window will appear :

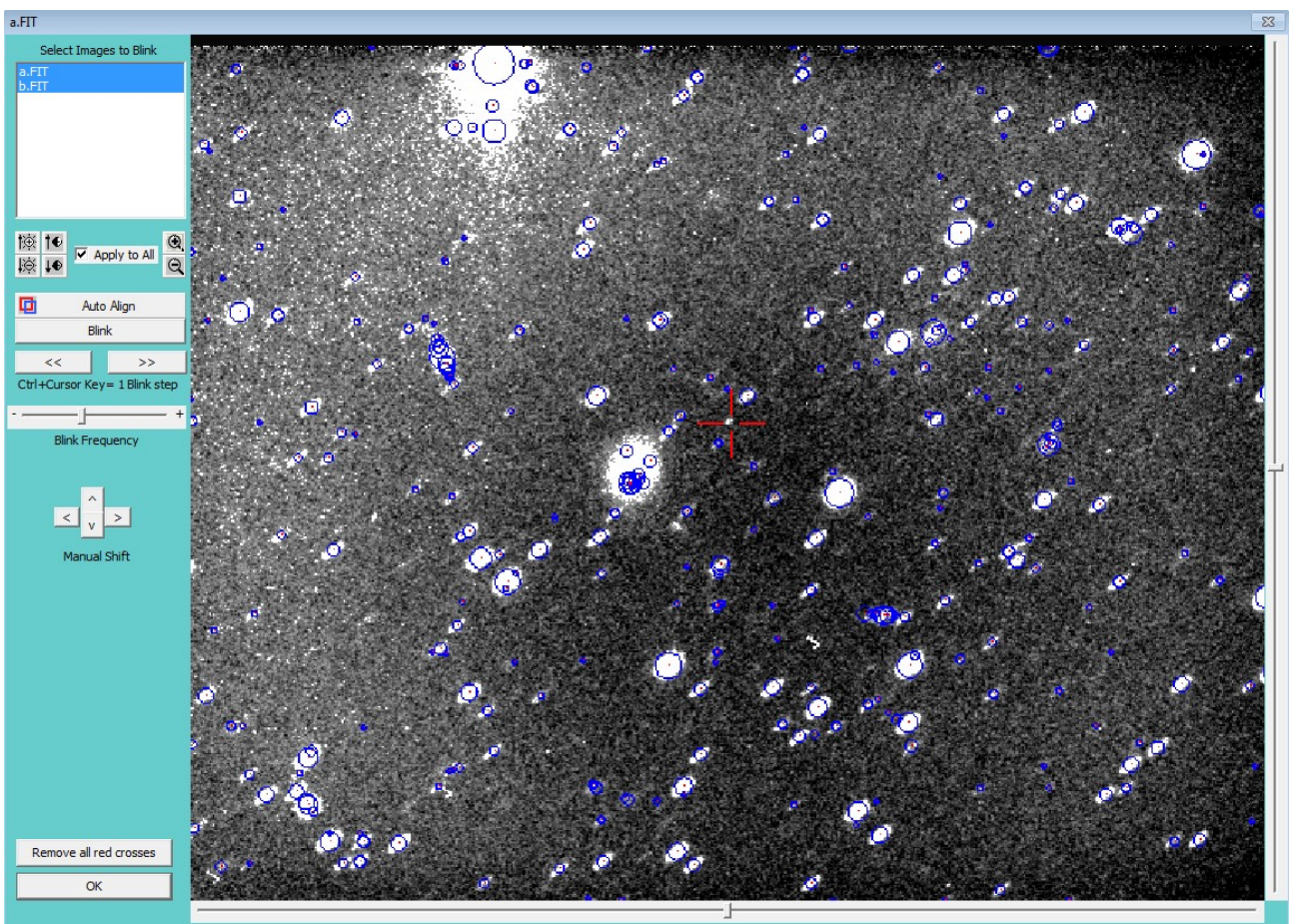


Here, you specify the approximate diameter of the object and possibly its form is not circular



(THIS LAST FUNCTION AND ' ENABLED ONLY VERSION " PRO ")

IF UNKNOWN OBJECT TO USE THE BLINK



Here you can select more than 2 images and you can perform self-centering that helps the research object . after finding the object can be marked with a red cross (click right mouse button) so you can then select the best function seen in the previous paragraph

Step 7

ASTROMETRY

This phase in fact consists of three steps which can be performed individually

R1 R2 A

In the first step (R1), the parameters for a correct calculation of the centroids of the reference stars and the asteroid are requested. The default values are usually valid for most images, but in some cases it is advisable to modify them if the stars have pixel sizes very different from the default range.

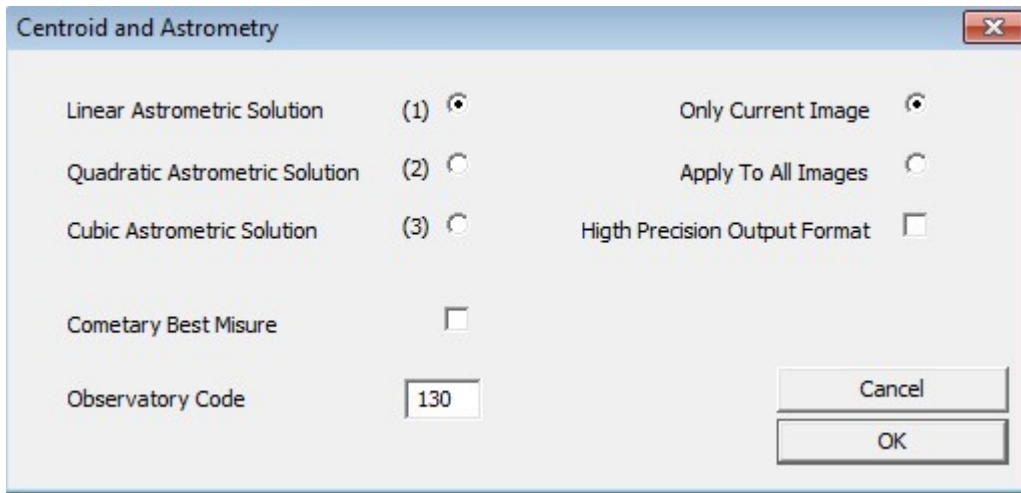
| Parameter | Value |
|--|---------|
| Verbose mode | .FALSE. |
| Sky annulus inner radius | 1.5 |
| Sky annulus outer radius | 3 |
| Default gain | 1.620 |
| Wraparound threshold | 0.0 |
| SNR threshold | 3.5 |
| Automatic rejection threshold on trail L, W, A | 10.0 |
| Minimum aperture size (tenths of a pixel) | 10 |
| Maximum aperture size (tenths of a pixel) | 80 |
| Aperture step size (tenths of a pixel) | 1 |

Buttons: Reset Standard Parameters, Abort, Save current parameters as Default, Save and Process

In the first two phases, the "centroiding" of each star is performed and stars with position problems or measurement difficulties are discarded. In the third phase, the actual calculation of the object's position is performed.

The three phases can also be performed in a single pass with the " centroid and Astrometry "





Here you can select one of three solutions astrometric (linear , quadratic or cubic) .

you can elaborate all images or only those in current use , as long as they have been previously prepared

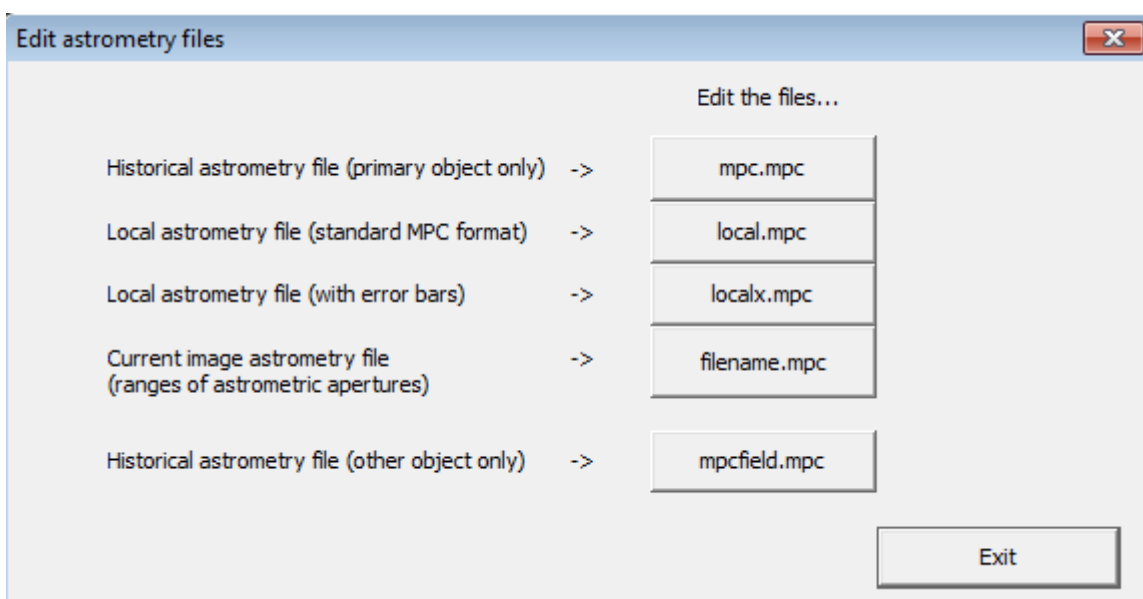
Only for authorized by the Minor Planet Center you can request a format of high precision output

For the measurement of comets can indicate a system of selection of best fit through the interpolation of all the measures rather than the selection of measurement with less error

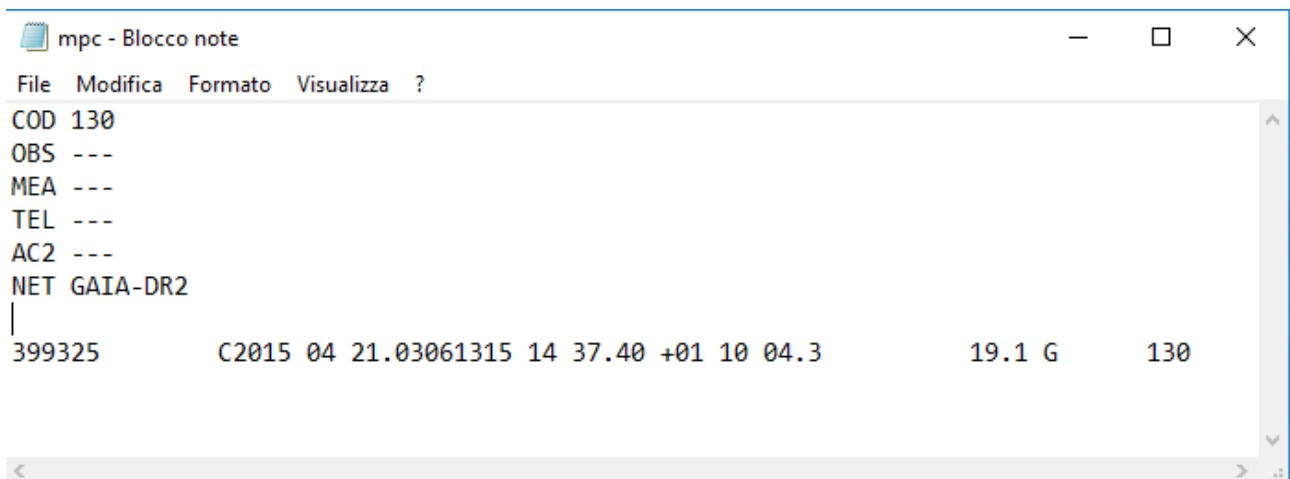
Confirming with OK will launch sequentially procedures centroid and astrometry, at this stage if the active mode " Astrometry step by step" in the setup must be confirmed with the ENTER key each step , if this mode is disabled , there are no interruptions .

The measure is ready to Be Sent to the Minor Planet Center

after astrometry can see the measures with the function of editing MPC



mpc.mpc file in the folder where the executable astromagic.exe contains all the measures carried out by when using the program



```
mpc - Blocco note
File Modifica Formato Visualizza ?
COD 130
OBS ---
MEA ---
TEL ---
AC2 ---
NET GAIA-DR2
399325 C2015 04 21.03061315 14 37.40 +01 10 04.3 19.1 G 130
```

local.mpc = files created in the folder where the file is the image contains all measurements made in that folder in the format compatible with the MPC

localx.mpc = files created in the folder where the file is the image contains all measurements made in that folder in the format that is extended with additional information astrometric

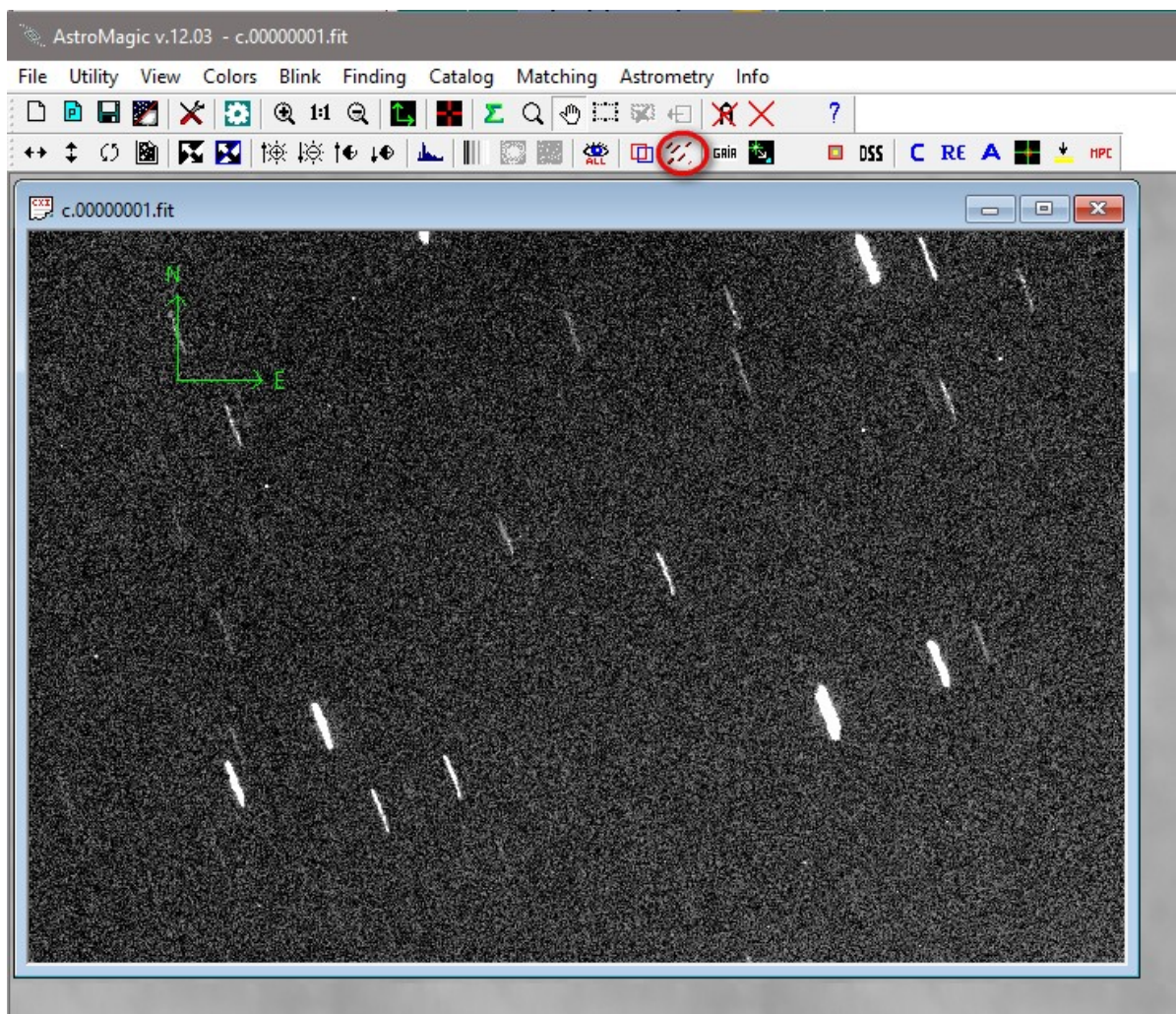
Filename.mpc= This file will have the same name of the currently in use contains the only full astrometry main object or all the tests carried out astrometry with variable radius which is then extracted the measure considered more precise .

Mpcfield.mpc = in this file are the measures of other miscellaneous items " secondary " measurement - (Not available yet)

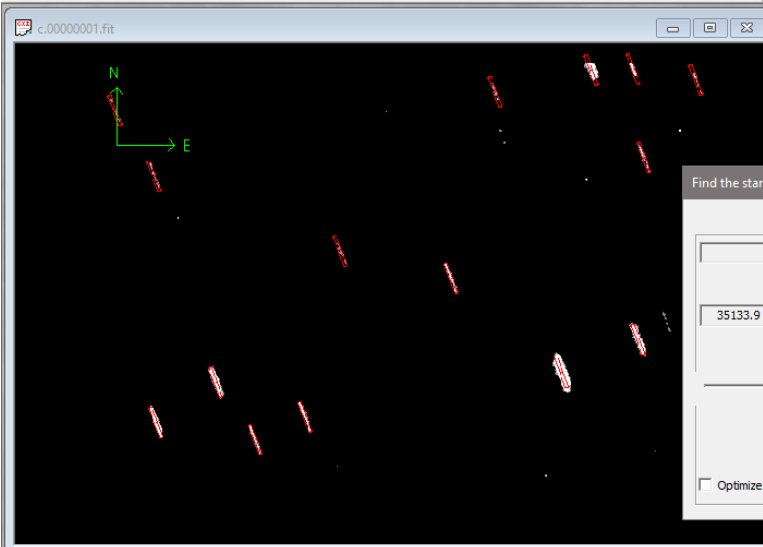
STACKING

For fast or weak objects, Astrometry can be performed using the Stacking technique. This involves aligning the images according to the motion of the asteroid and then making a measurement on the image obtained from the overlap of all the images. If the asteroid is too much, it may be necessary to move the telescope with a non-sidereal motion or set a tracking speed that allows you to keep the asteroid pointed, in this case the stars will appear to be streaked during each exposure, but the program still allows you to obtain a correct measurement even if you have to resort to the stacking technique. To obtain these results, you will first need to perform a complete astrometry for all the images without indicating the object to be measured, then you can perform stacking and astrometric measurement of the object. Here is an example of 5 images

1. Open the image, run the finding function.



- 2) Identify the stars with their length, width, and inclination.



Find the stars size

found 15 stars to 19

35133.9 + 7402 = 42535.9

<--- Background level --->

Optimize Background Reset Background

Use manual data to default

| | | | |
|--------|-------|---|---|
| Length | 33.6 | + | - |
| Width | 4.0 | + | - |
| Tilt | -70.0 | + | - |

Min. Length 10.0 1:1

Min. Margin 15

Find Again OK

Find All Stars Cancel



Reading GAIA Catalog

RA Center 11:40:47.007 Date 2022-04-05 Date/Time at Middle exposure

DEC Center +09:52:18.00 Time Start Exp. (UT) 19:57:40.02 2022 04 5.83182894

Find coordinate Exposure (sec.) 20.000

Filter

Min Magnitude 0 Mag. Passband G

Max Magnitude 19

Range

| | |
|--|------|
| <input type="checkbox"/> Full Range x (') | 35.7 |
| <input checked="" type="checkbox"/> Full Range y (') | 29.0 |
| <input type="checkbox"/> Box Range x (') | 35.7 |
| <input type="checkbox"/> Box Range y (') | 29.0 |

GAIA_DR2 Preview From Internet

GAIA_DR3 Extract From Internet

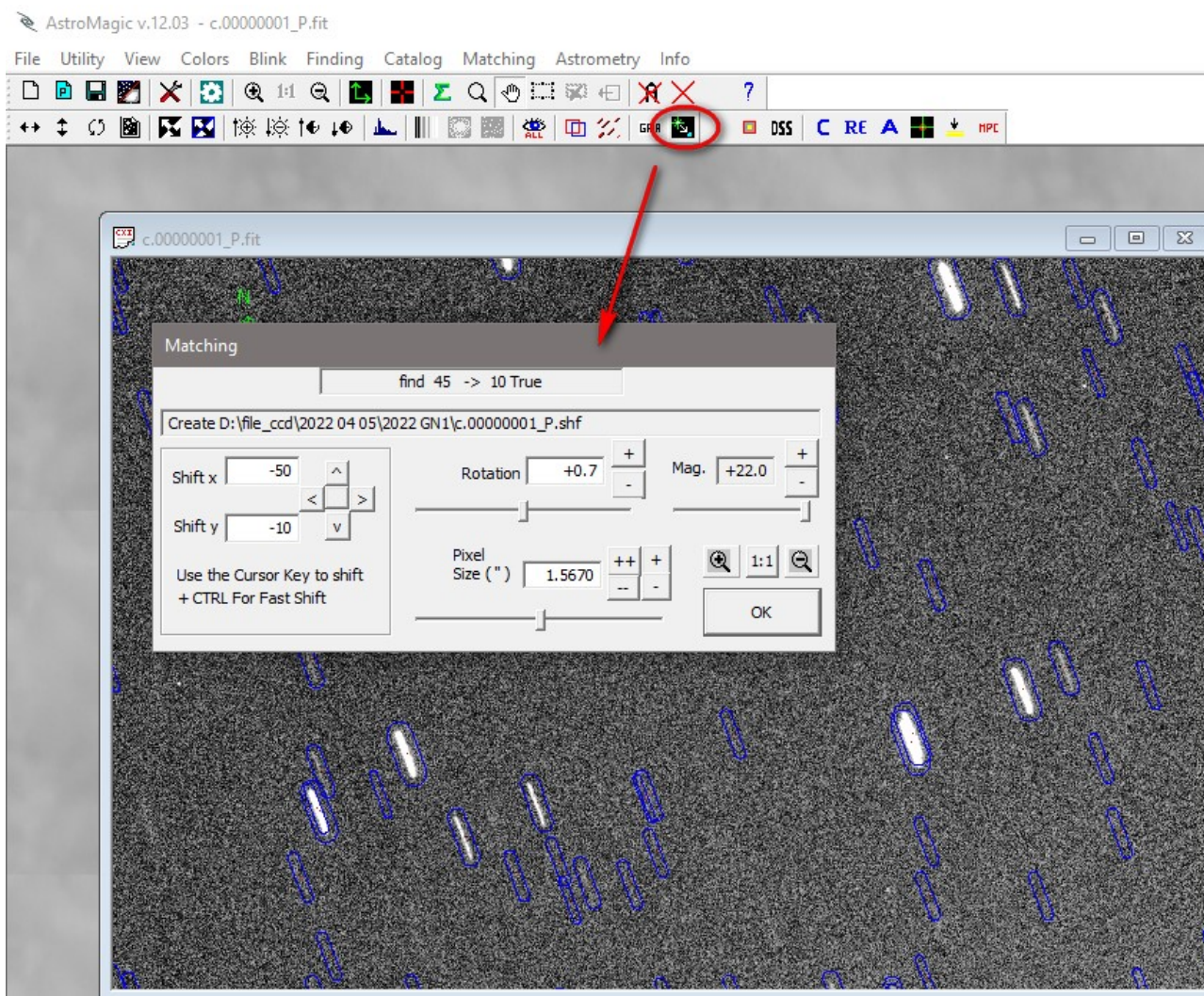
Load Stars Use Last Exit

AstroMagic

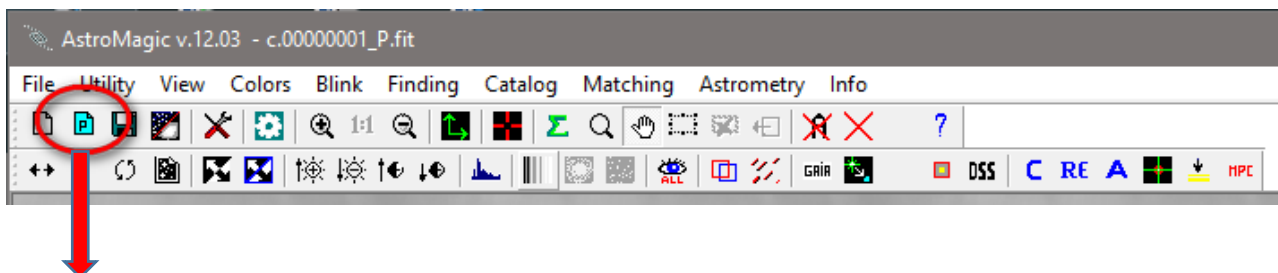
320 catalog stars extract to Internet

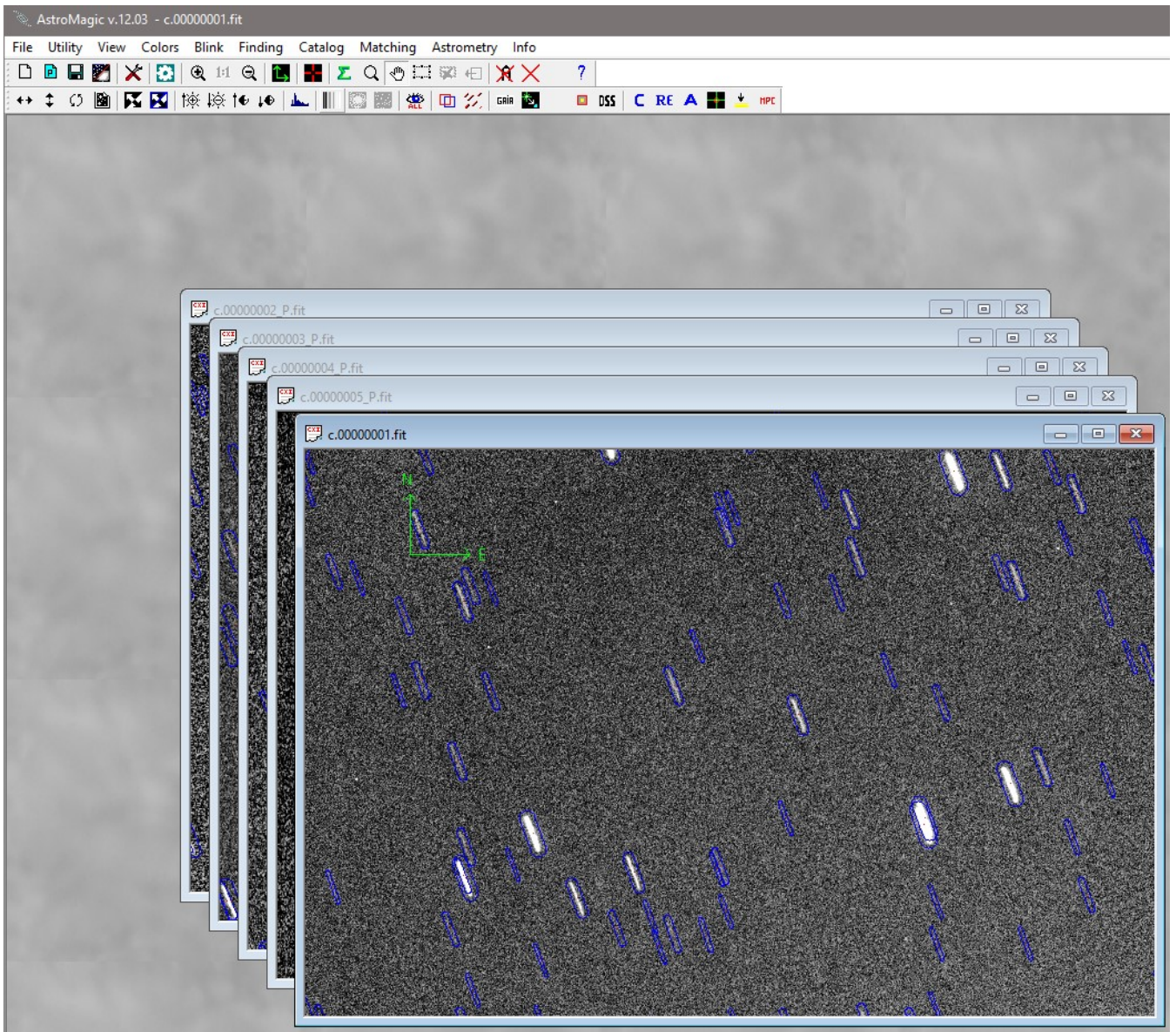
OK

With the Matching function, we have the overlay of catalog stars with reference stars.

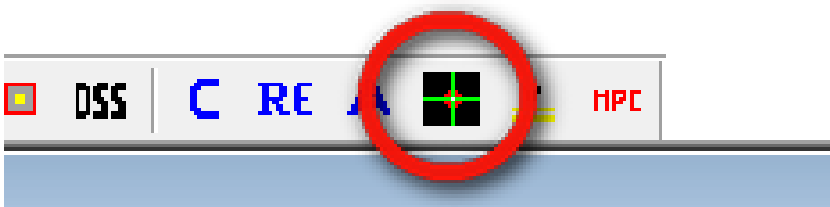


NOW YOU CAN PROCEED WITH THE SAME OPERATIONS ON THE REST OF THE IMAGES MANUALLY OR USING THE AUTOMATIC PROCESS FUNCTION THAT WITH A SINGLE CLICK PERFORMS ALL THE PREVIOUSLY INDICATED OPERATIONS.

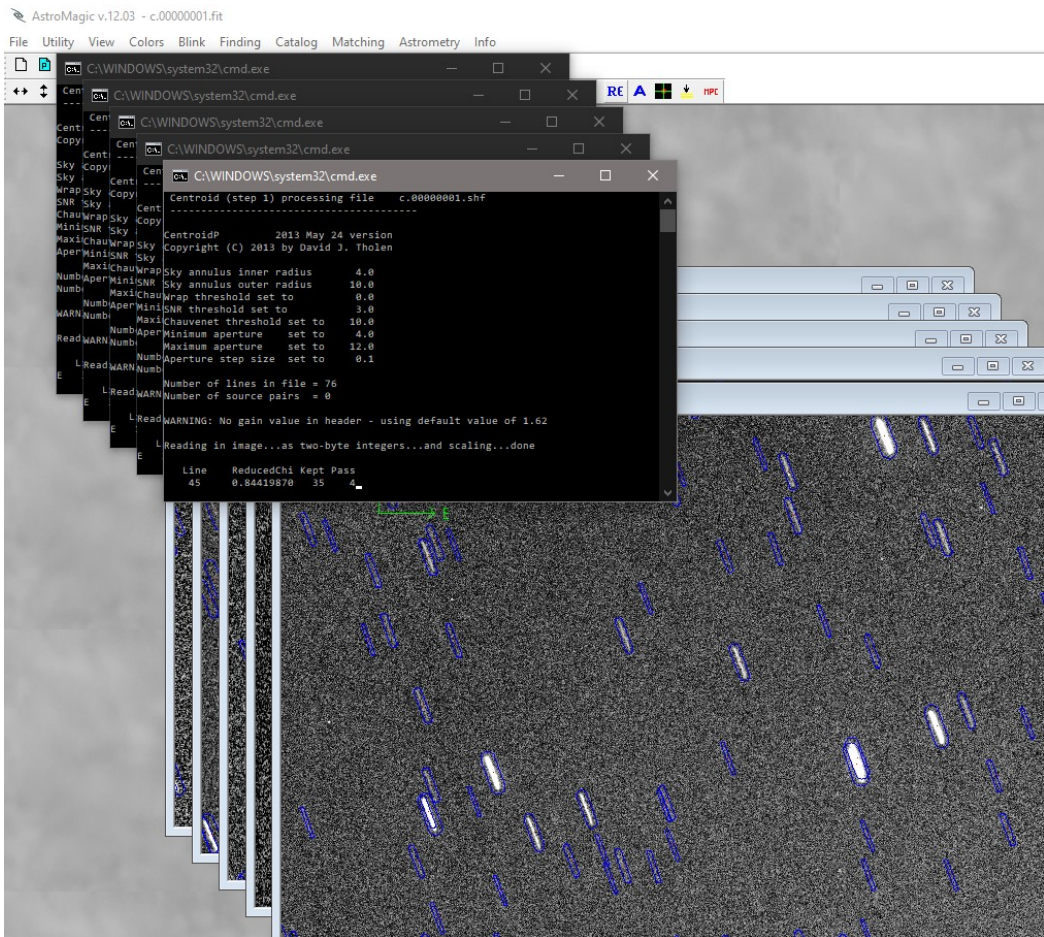




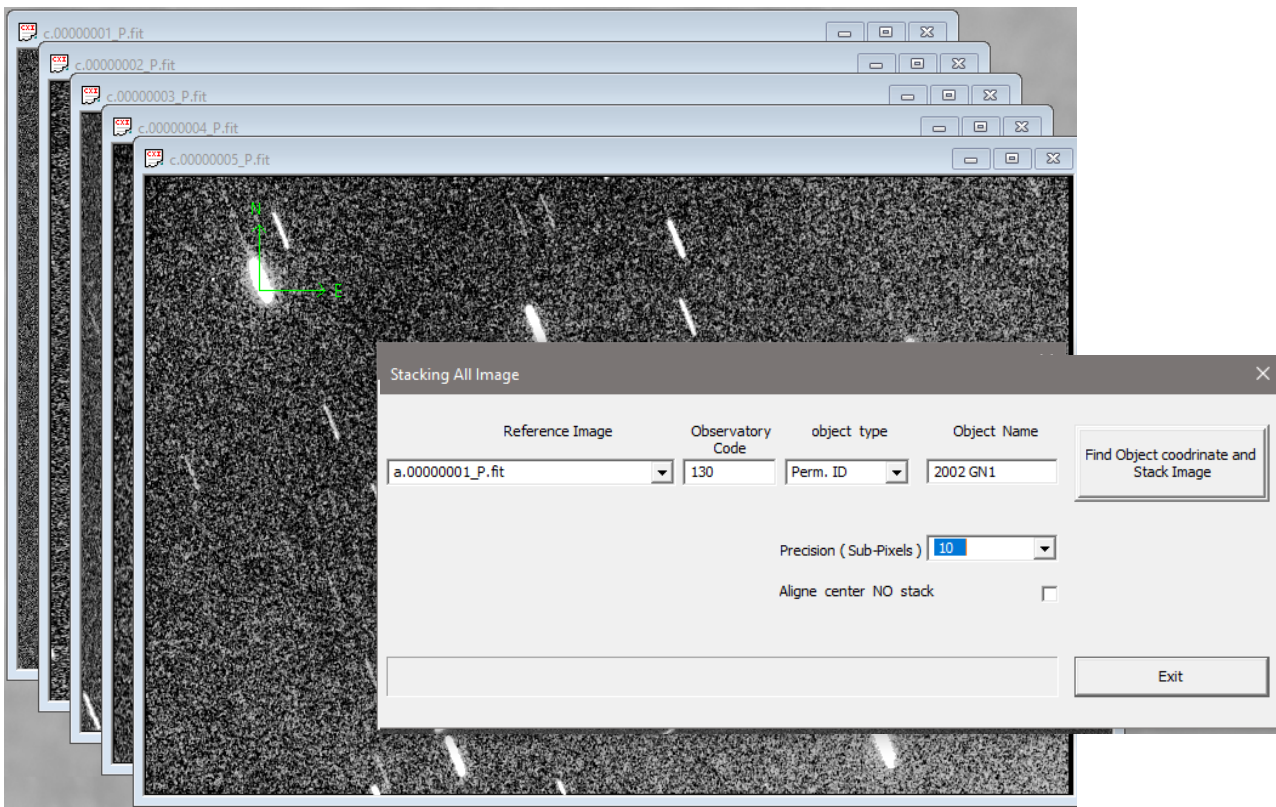
Proceed with the astrometry of images without the asteroid.



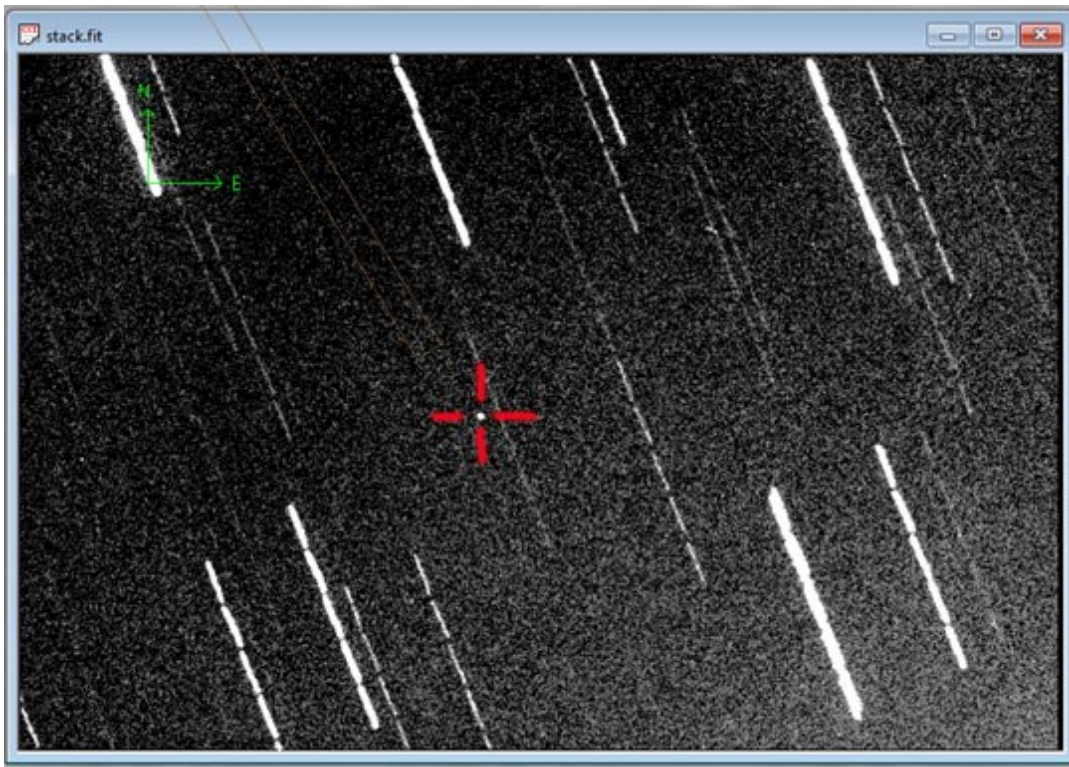
All images will be astrometrized



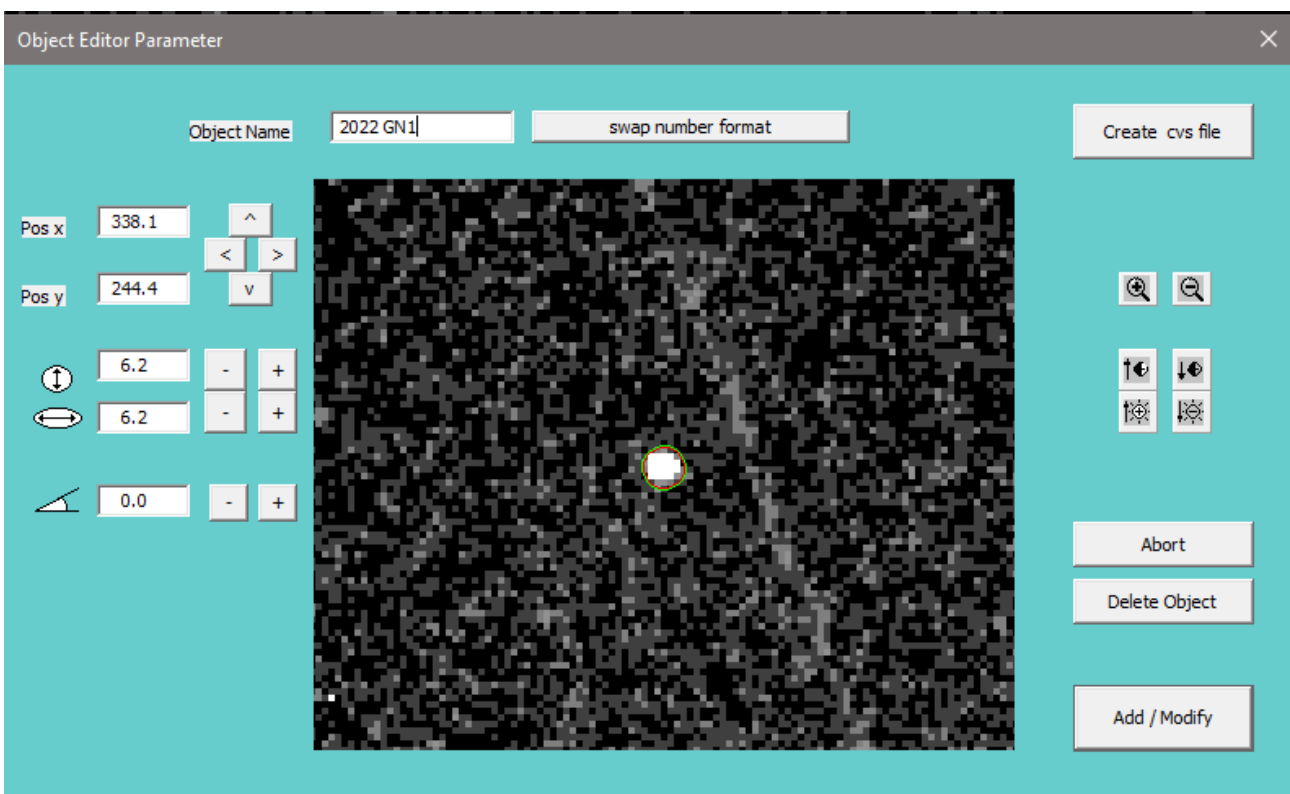
And finally, if everything went well, we proceed with the stacking: indicating the name of the asteroid, the positions of each image will be calculated, allowing us to align and stack.



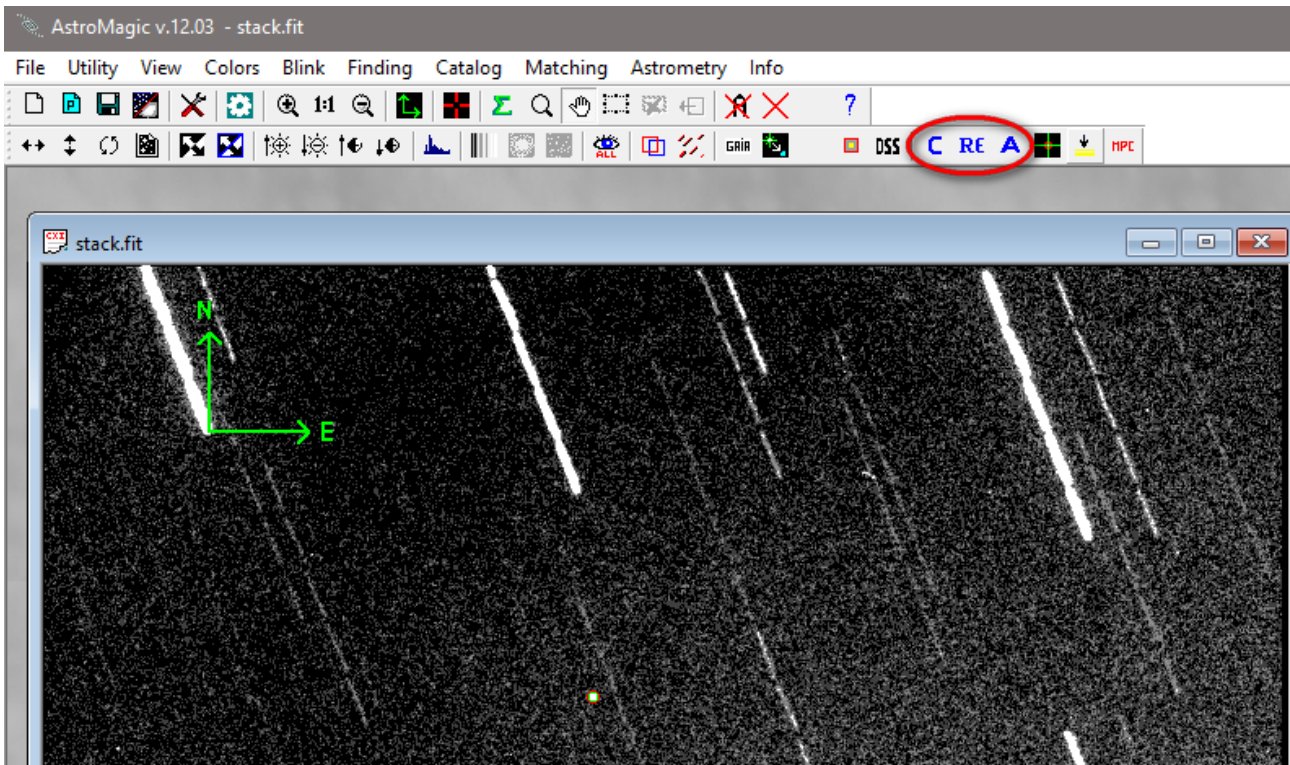
Finally, on the final image, you must then perform the astrometry of the object



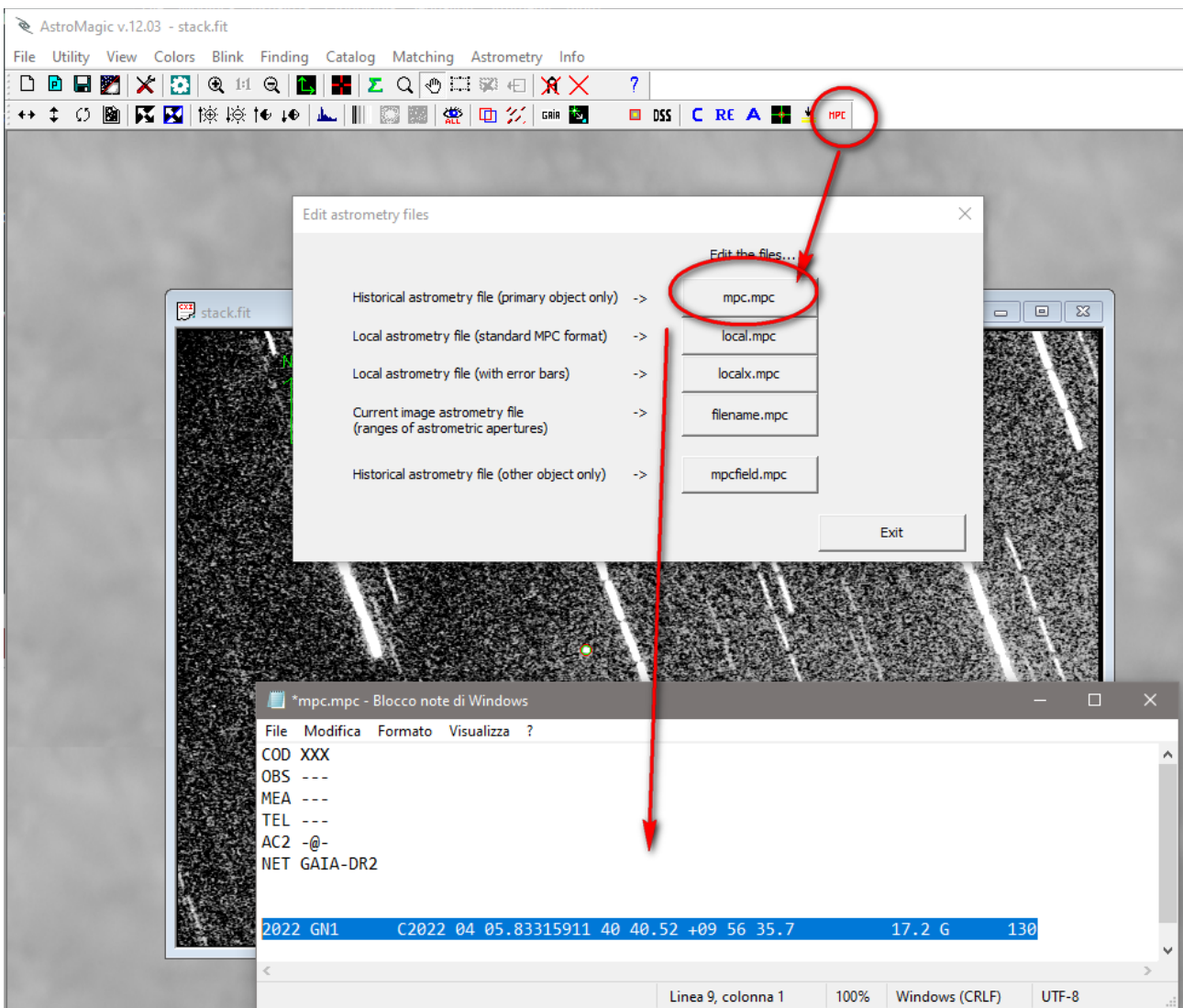
You can then go to the mask by clicking the right mouse button and indicate the object.



Finally, the three astrometry phases (centroiding, recentroiding, astrometry) are performed.



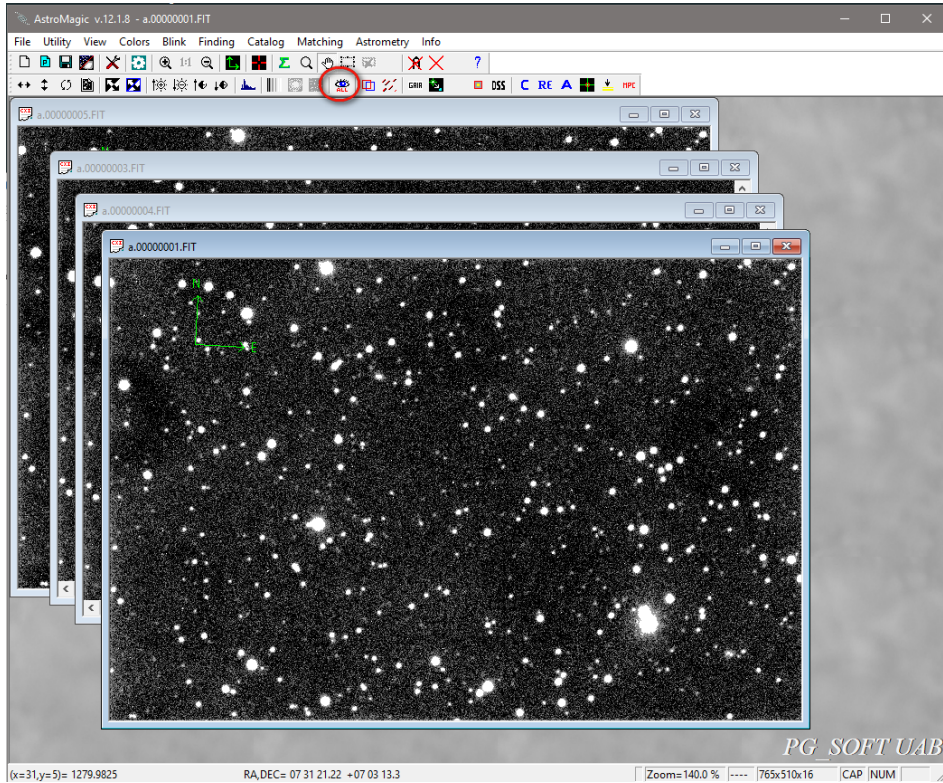
At the end of the three steps, we will have the final astrometry of the object.



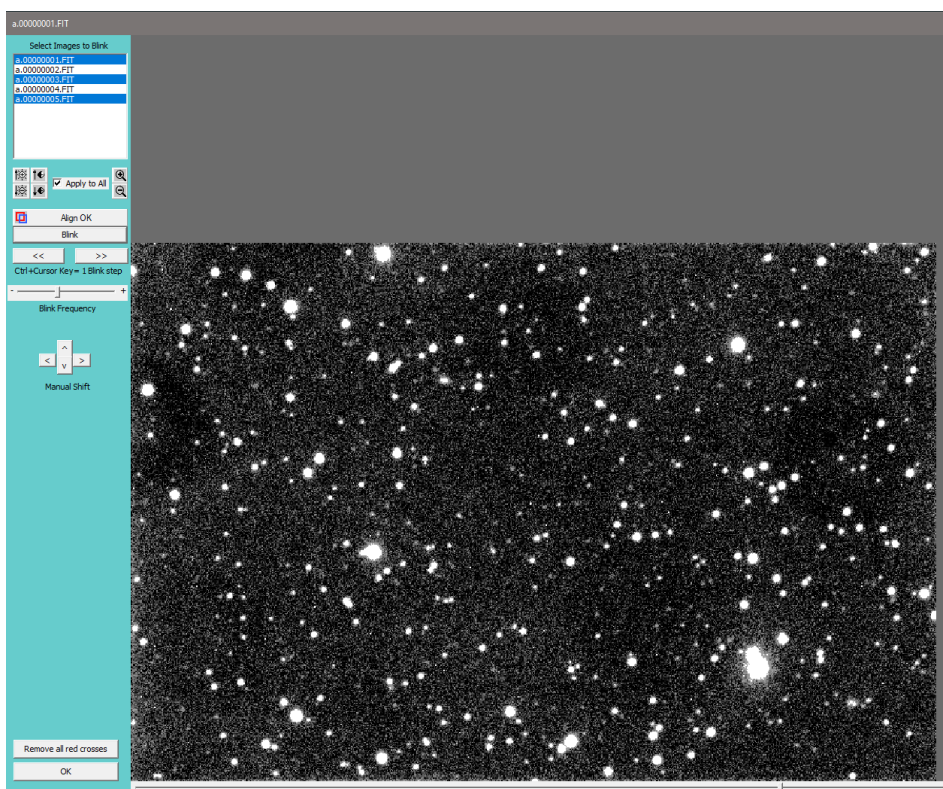
ALTRE FUNZIONI

BLINK

Load images and use Blink function:



select images, align and run Blink function



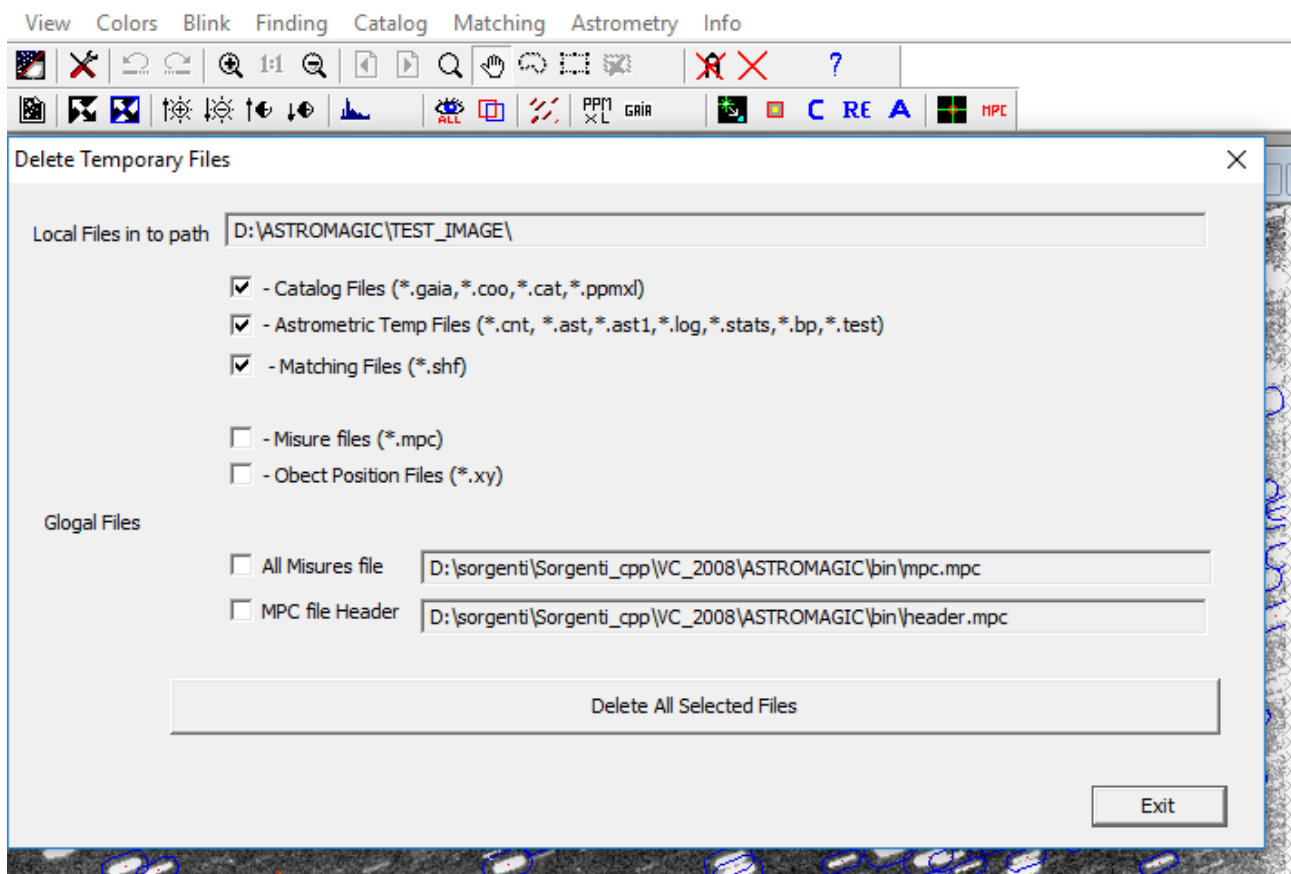
Delete temporary files

Nella cartella dove si trovano le immagini si creano diversi file che possono essere eliminati dopo aver eseguito l'astrometria.

Per facilitare tale operazione si può usare l'apposita funzione



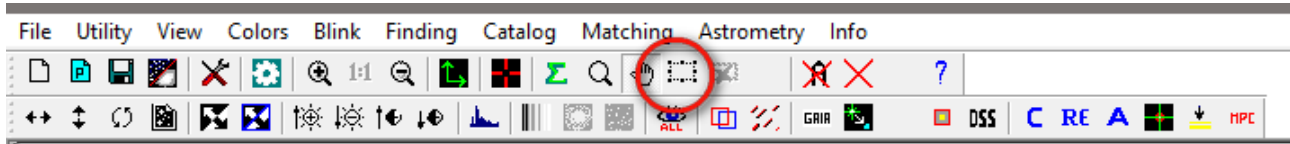
Dalla maschera proposta a video si possono selezionare i tipi di file che si vogliono eliminare...



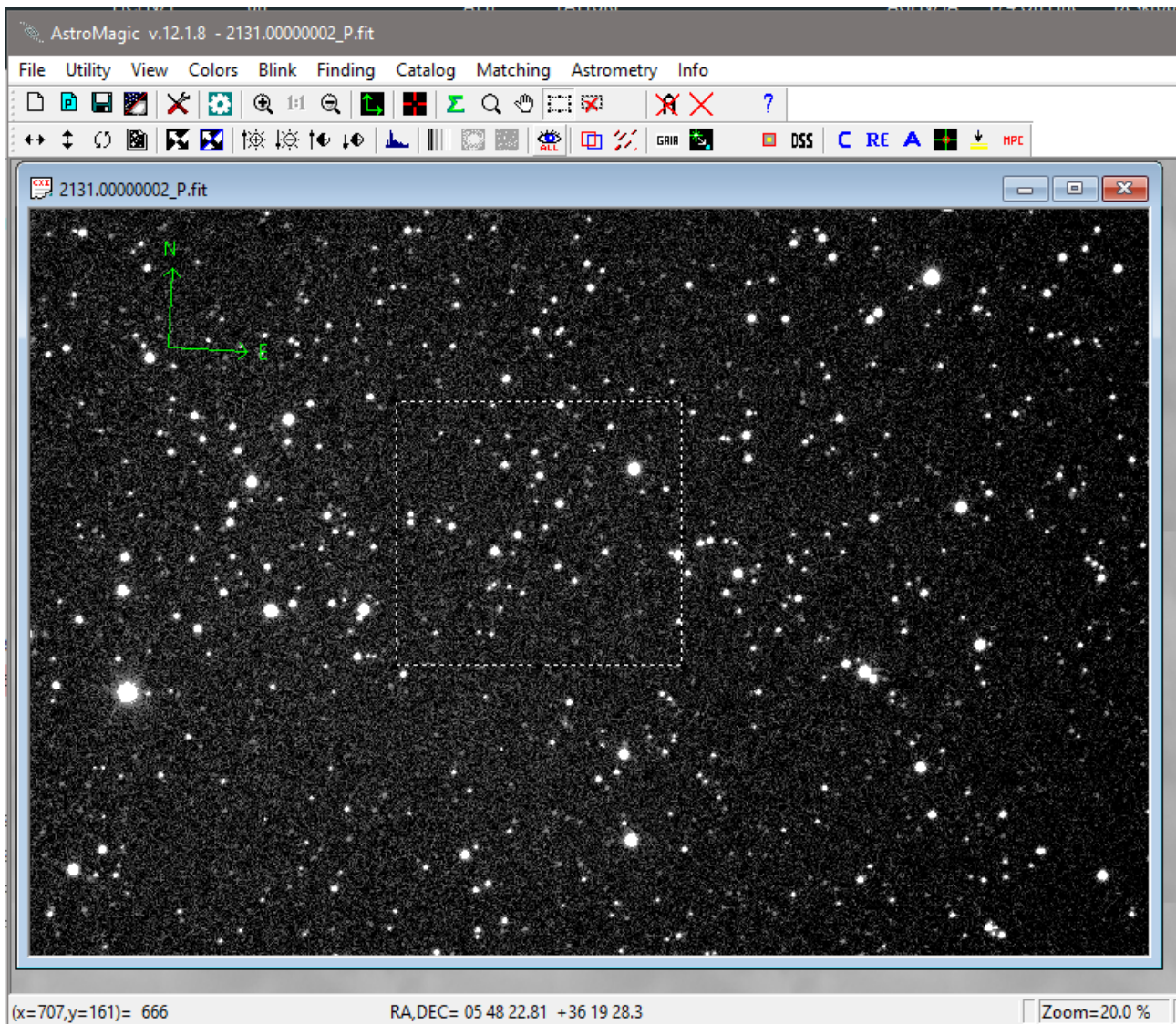
Use astrometry area

In case of very large images it is possible to define a portion of the image to limit the number of catalog stars to be downloaded and used for astrometry.

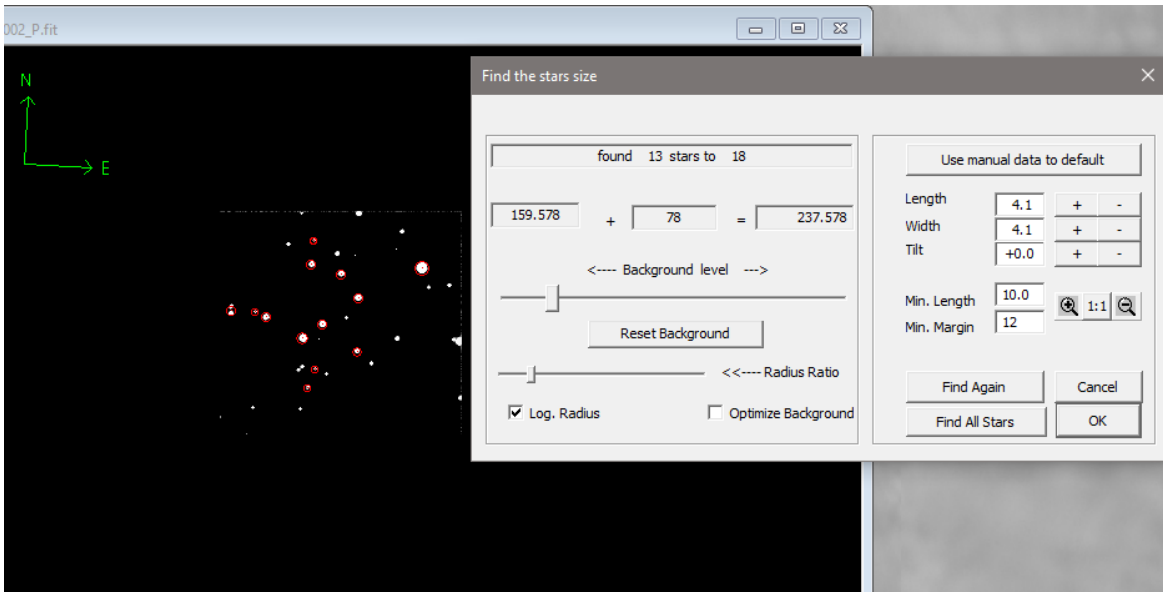
By activating the “selection area”



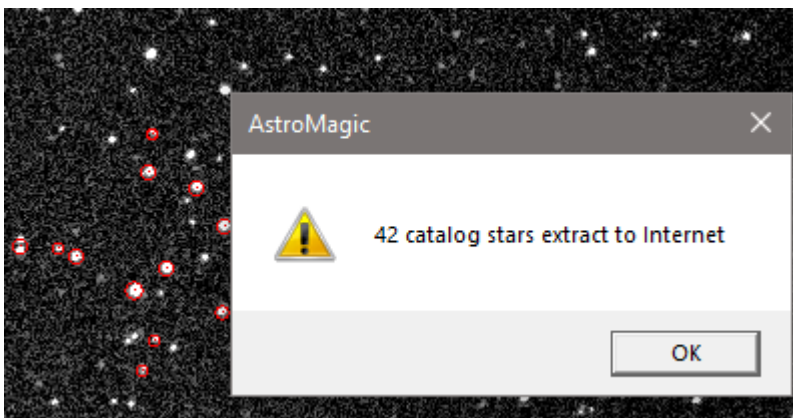
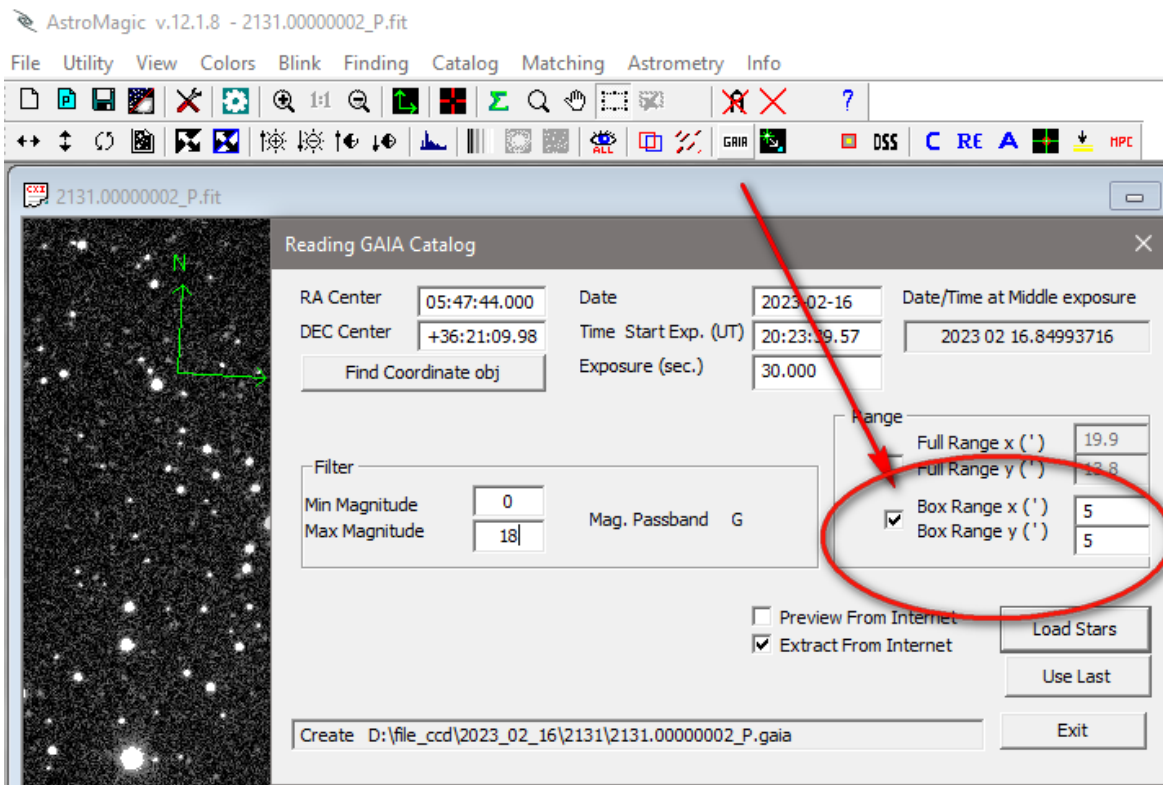
It indicates an area within which to work



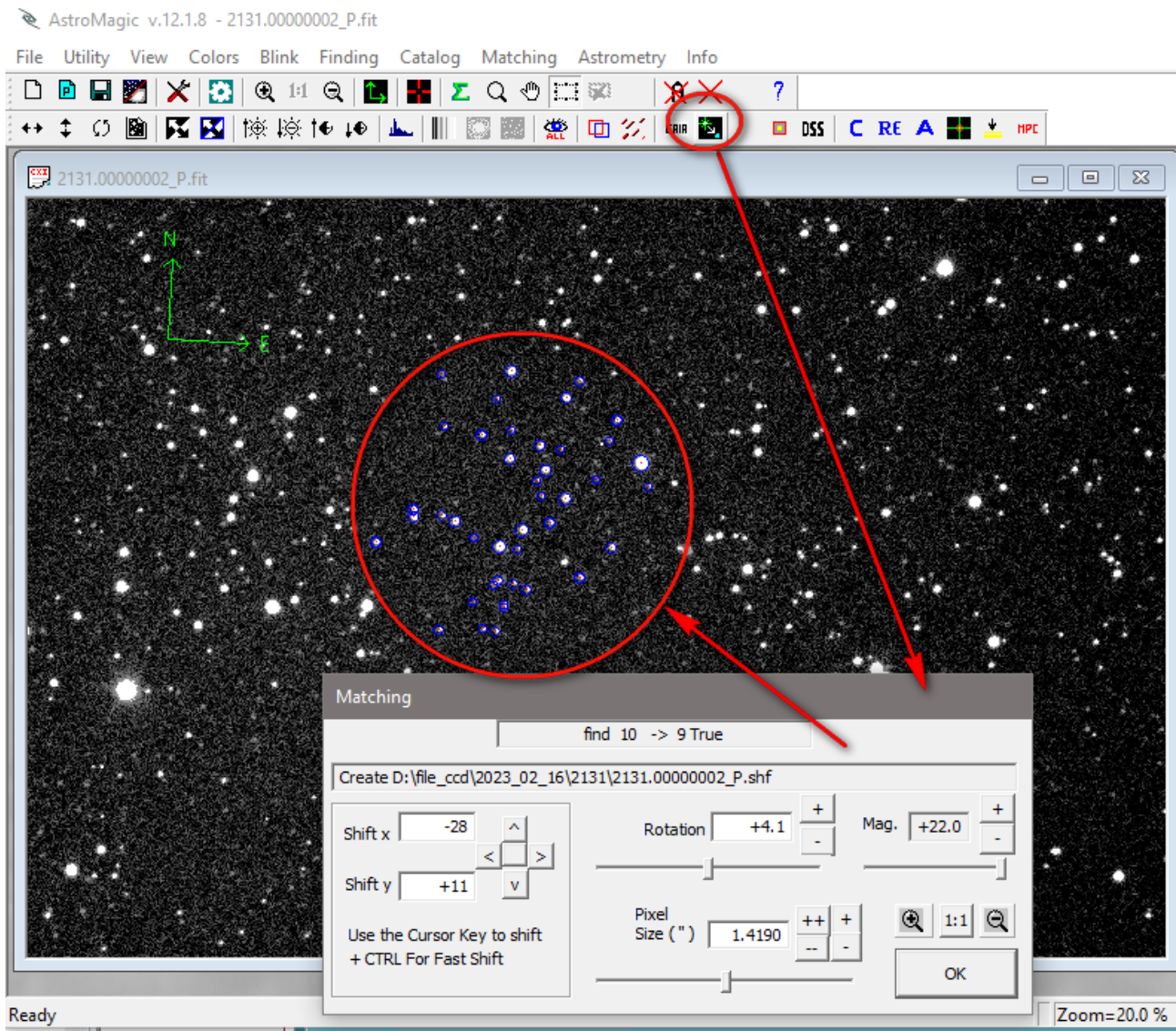
The search for the stars on the image will be done only in the delimited area



When loading the catalog stars, it will indicate to use only the area and not the whole image



The matching then takes place using only the stars of the selected area



now we proceed then we proceed with astrometry.