NUC Procedure

Contents

Preliminary notes:

This operating mode uses the CIRRUS software supplied with your camera. This software may have evolved since this version of the documentation was published, especially in terms of its appearance. It is your responsibility to adapt your reading to match your version of the software.

1. Specific Terminology

NUC: Non Uniformity Correction

IR: Infrared

Black Body: A temperature reference used here as an extended and homogenous source

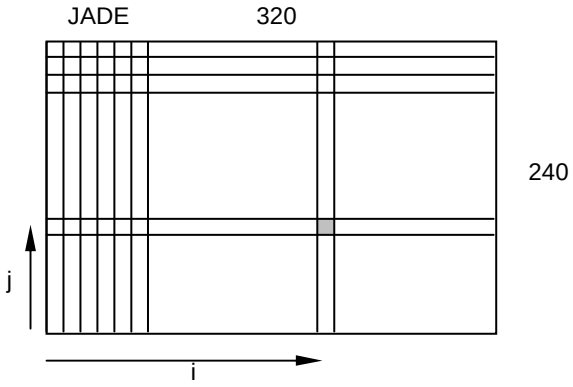
BPR: Bad Pixel Replacement

Flash memory: Non volatile memory built into the camera used to store the operating parameters. These parameters are automatically loaded on power up.

2. Why is Correction Required?

The first infrared cameras that appeared on the market were fitted with a single detector. A scanner, a mirror equipped mechanism, was used to scan the surface to be measured. The entire image provided by this single detector was implicitly coherent.

Your camera, on the contrary, is equipped with a matrix made up of a multitude of detectors[1] and not fitted with a scanner. This technology makes possible extremely high image capture rates and ensures higher reliability (with no mechanical elements in motion and detectors that are independent of each other). This does however come at the cost of disparate detector characteristics, something that affects the image quality.

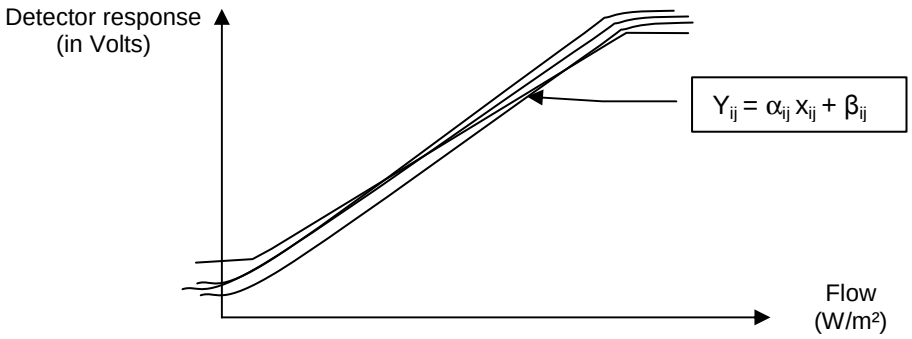


Non Uniformity Correction is provided to compensate for these disparities. NUC is therefore essential to provide a coherent image.

[1] Examples: JADE: a 320 x 240 (76,800 pixel) matrix - EMERALD: a 640 x 512 (327,680 pixel) matrix.

3. What is NUC?

Every detector (with coordinates ij) has its own gain (α_{ij}) and offset (β_{ij}) parameters.



Correction comprises bringing the curve for each detector into line with the average curve for the entire matrix.

We therefore seek to obtain: $\overline{X} = Y_{ij} = \alpha_{ij} X_{ij} + \beta_{ij}$

Where: $\overline{X}$ is the average of detector responses

(The response from each detector after correction equals the average of all of the detector responses).

Note:

NUC quality (curve superposition) is directly dependent on the resources applied.

NUC corrects image resolution, it does not affect your measurements.

4. Influences on NUC

NUC is dependent on two influences:

- The Integration Time, IT, and
- The Optical Path

The Integration Time is the time during which the detector remains open and collects the data flow (this time can be compared with the shutter opening time for a conventional camera).

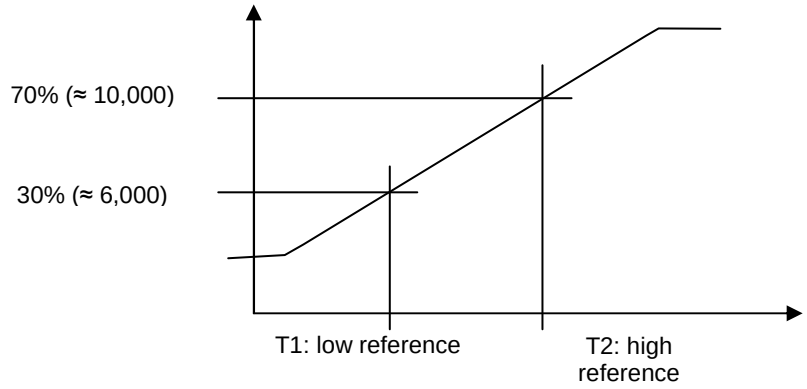
The Optical Path is formed by the lens and any other component like a window, a filter, etc.

The NUC will also introduce, for each Detector, α and β coefficients to produce a coherent image, taking the influences into account.

5. Correction Mode

5.1. "Two Point" Correction - Black Body Method

To create NUC, two reference points are needed. These references are taken at around 30% and 70% of the dynamic range.



The reference used is ideally a black body with extensive surface area. The latter will be placed a few centimeters from the lens (in an unfocused area).

5.2. "Single Point" Correction

A single temperature reference is needed to update the NUC.

5.3. "Two Point" Correction - Time Integration Method

In cases where two temperature references are not available (e.g. where you have extended black bodies at a maximum of 600°C, to perform an NUC ranging up to 1,500°C), the Time Integration method may provide an acceptable alternative. This comprises using the same temperature reference for two different Integration Times. This manipulation moves the detector's response curve opposite the reference, artificially positioning the reference points.

Warning

This method is an extrapolation method. NUC quality can be affected by this, especially in the extreme parts of the response curve. This approach should only be used when no solution is possible using the black body method.

6. When to Create a New NUC ("Two Point" Correction)?

A new NUC will need to be created every time one of the following values changes:

- Integration Time
- Optical path

7. When to Update the NUC ("Single Point" Correction)?

To break free of any drift that may occur due to the camera's environment, we recommend updating NUC every time the camera is set into service.

This is because the detector is subject to what is called the "Narcissus effect". A camera lens can never achieve 100% transmission. A small proportion of the radiation will always be reflected towards the detector. As the latter is perfectly aligned along the optical axis, it receives its own image superimposed on the object located in the field of view.

The radiation rate is directly linked to the difference in temperature between the detector (temperature regulated at 77K) and the lens (at ambient temperature). The result is a non negligible change in the response of detectors hit by reflected radiation. Every change in ambient temperature therefore requires readjusting NUC.

The impact is all the more important as the wavelength rises.

Influence value	"Two point" correction	"Single point" correction
Integration Time	X	
Filter	X	
External window	X	
Lens	X	
Power up		X
Frequency	No influence	
Windowing		X

8. Operating Mode

8.1. Creating a "Two Point" NUC - Black Body Method

Before starting any NUC creation or modification procedure, you will need to:

- define your measurement dynamic range (or your Integration Time),
- identify the optical filtering,
- define your two reference temperatures.

Method used for defining your reference temperatures

Your Integration Time is assigned the maximum temperature that you can observe. At this value level, your camera will send back a digital value close to 15,000.

We recommend that you set your lower and upper reference points to the 6,000 and 10,000 value marks, or around 30% and 70% of the camera's dynamic output range.

Tip

To illustrate the choice of reference points: You are looking to detect human presence in a room. Your measurement dynamic range is framed by ambient temperature and the temperature of the human body.

- Your lower reference point may be taken from an object present in the room for a "certain" length of time and that is not affected by an ancillary heat source.
- Your upper reference point can be taken from your hand.

If you are not equipped with black bodies, you will need to call on your imagination to find sources suited to the level required. For example:

- A clear sky (low temperature). Unfocus the lens.
- A pad of paper.
- The black side of a mouse pad.

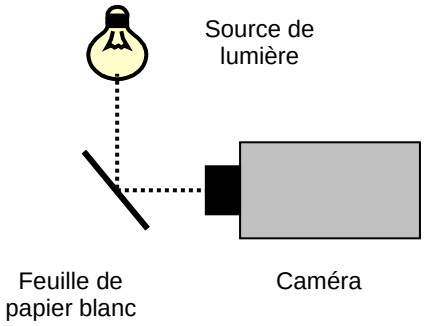
Avoid objects with low emissions levels (e.g. shiny metal objects).

Do not use the lens cover.

Specificities of a "Two point" NUC for a SWIR camera

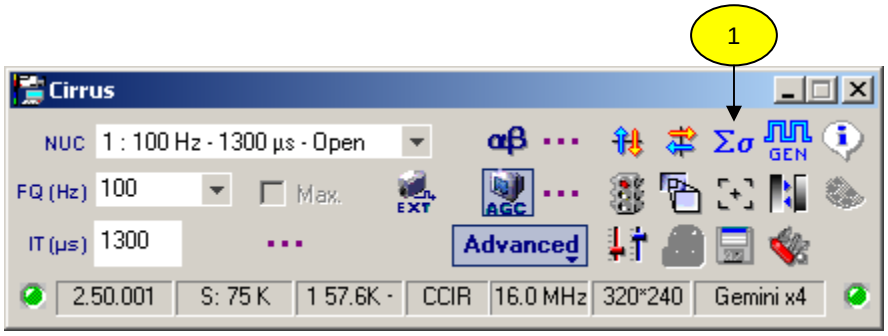
A SWIR camera operates in a temperature range where it is difficult to find extensive black bodies. We suggest that you proceed as follows:

- For the lower reference: completely close the iris (or cover the lens),
- For the upper reference: place a sheet of white paper in front of the lens, inclined at 45°towards a natural light source so as to refl ect back the (sun's) radiated light.

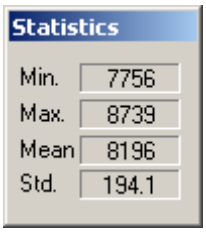


To determine the digital level returned by the camera

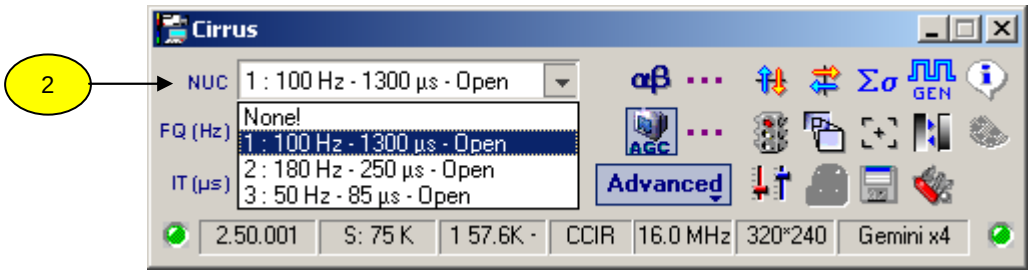
Start the CIRRUS software. From the main screen, click on "∑σ" (1).



The next window opens to show, for a given integration time and filter, the mean value returned by the camera.



The main screen presents the NUC currently applied to the camera (2).



(Here is the NUC for table 1, at 100 Hz, 1300 µs, no filter)

Notes:

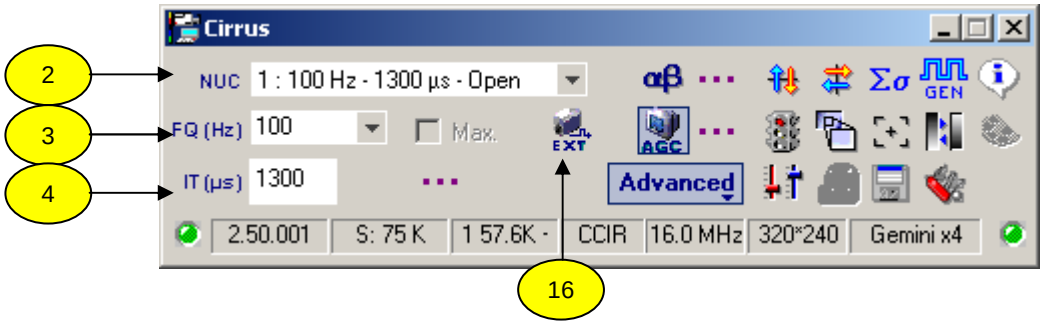
Depending on your camera, three to six different NUC values can be stored

"None!" indicates that no correction is applied.

"Open" indicates that there is no filter.

Follow the steps described below with care:

Step 1- Select the NUC to replace using the popup list (2).



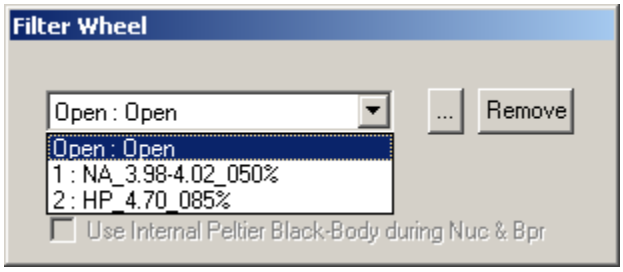
Step 2- Specify your frequency (3). This parameter does not affect the main work area, but must still be noted.

Note

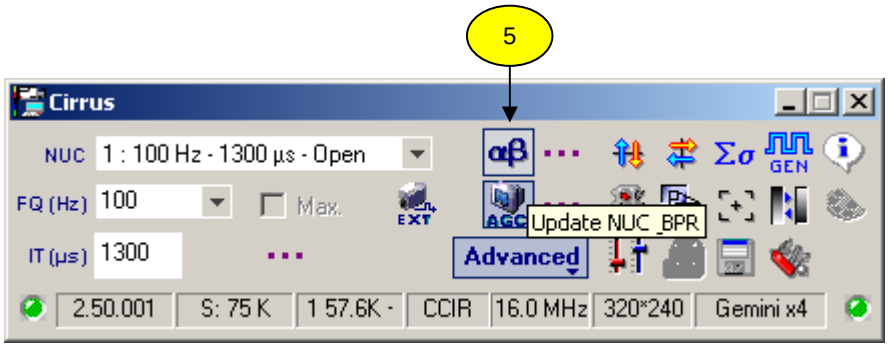
When using an external camera synchronization, you will need to enter a frequency that is close to the external synchronization frequency. To do this, click on the "Ext" button (16) so as to enter the value. Click on "Ext" once again to continue the procedure.

Step 3- Specify your Integration Time (4) and confirm it using "Enter" on the keyboard.

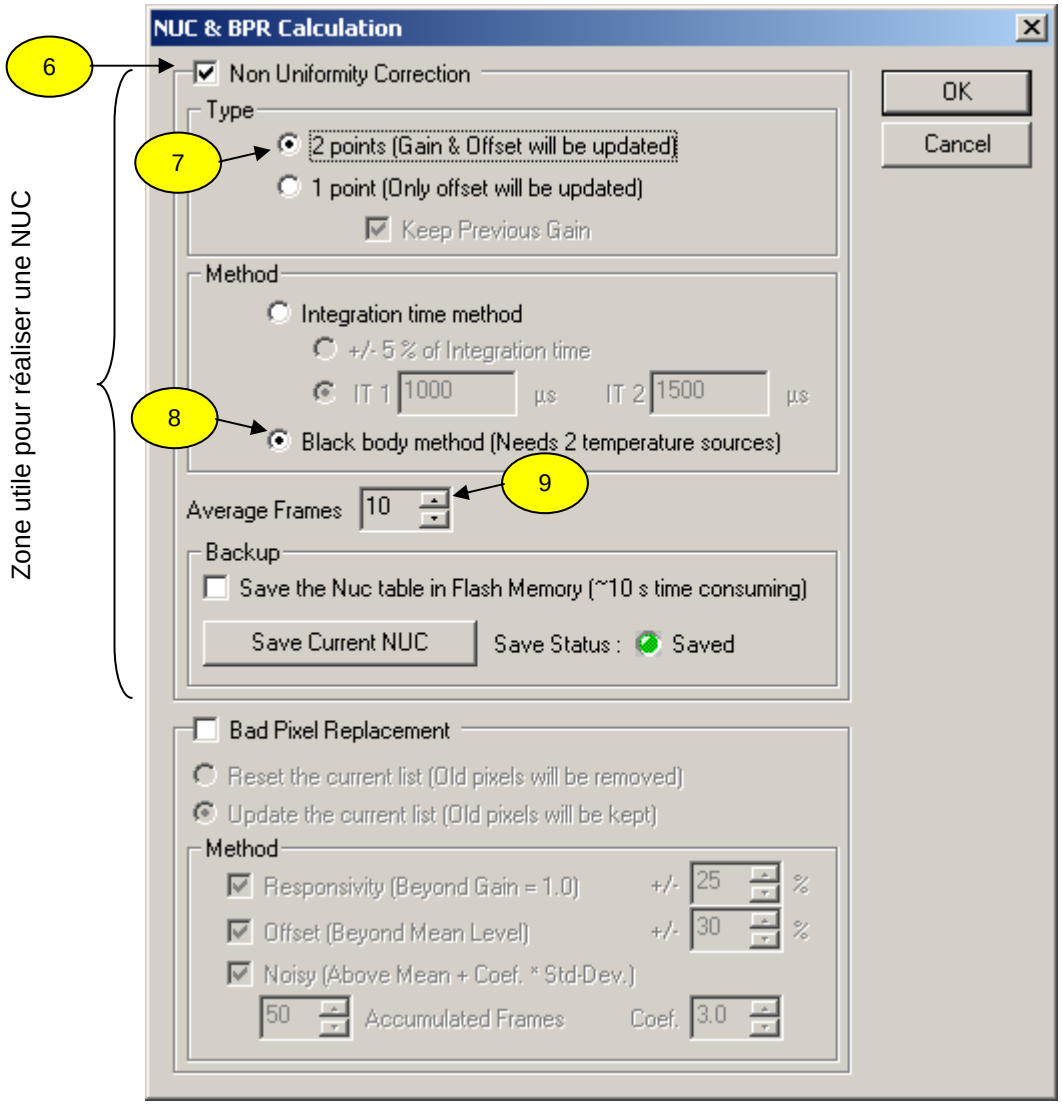
Step 4- If you use a filter, specify it from "Filter Wheel" window.



Step 5- Click on "αβ" - "Update NUC BPR" (5).



Then the window presented on the next page will open:



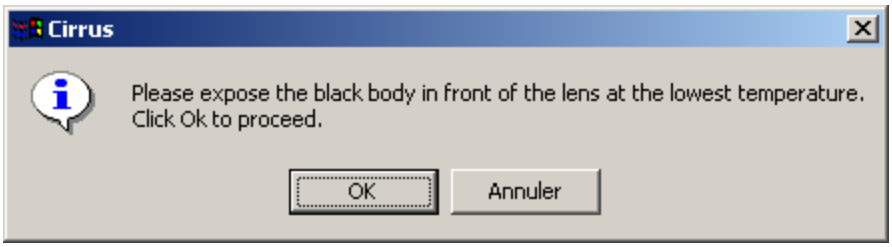
- Tick the "Non Uniformity Correction" box (6)
- Choose the "2 points" type (7)
- Choose the "Black body method" (8)
- Choose the number of images for each point (9). The result retained for each point is the average of the measurements made on these images.

Note:

Setting ten as the number is a good compromise between reducing noise and the time required to product the measurement.

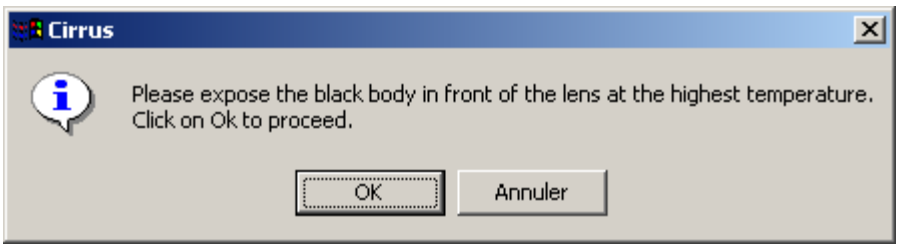
- Do not tick the "Save the Nuc table in Flash Memory" box. It is preferable to await complete confirmation of the new NUC before saving it.
- Do not tick the "Bad Pixel Replacement" box.
- Click on "OK".

This window prompts you to place your low temperature reference (the black body) in front of the lens.



Place your low temperature reference in the measurement position (close to the lens, in an unfocused area), then click on "OK".

At the end of the measurement process, a new window prompts you to place your temperature reference source (black body) in front of the lens.

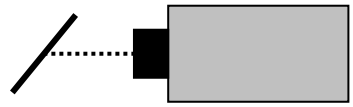


Place your high temperature reference in the measurement position (close to the lens, in an unfocused area) then click on "OK".

At the end of the measurement process, the main CIRRUS screen reappears. You will see that the NUC name has been updated in line with the parameters chosen at the start of the process.

Tip

If you use an object that is not a black body as the reference, then place it a few centimeters from the lens (in an unfocused area) but without touching the lens and making sure to apply it at an angle. This ensures that you will avoid detector reflection onto your reference (Narcissus effect).



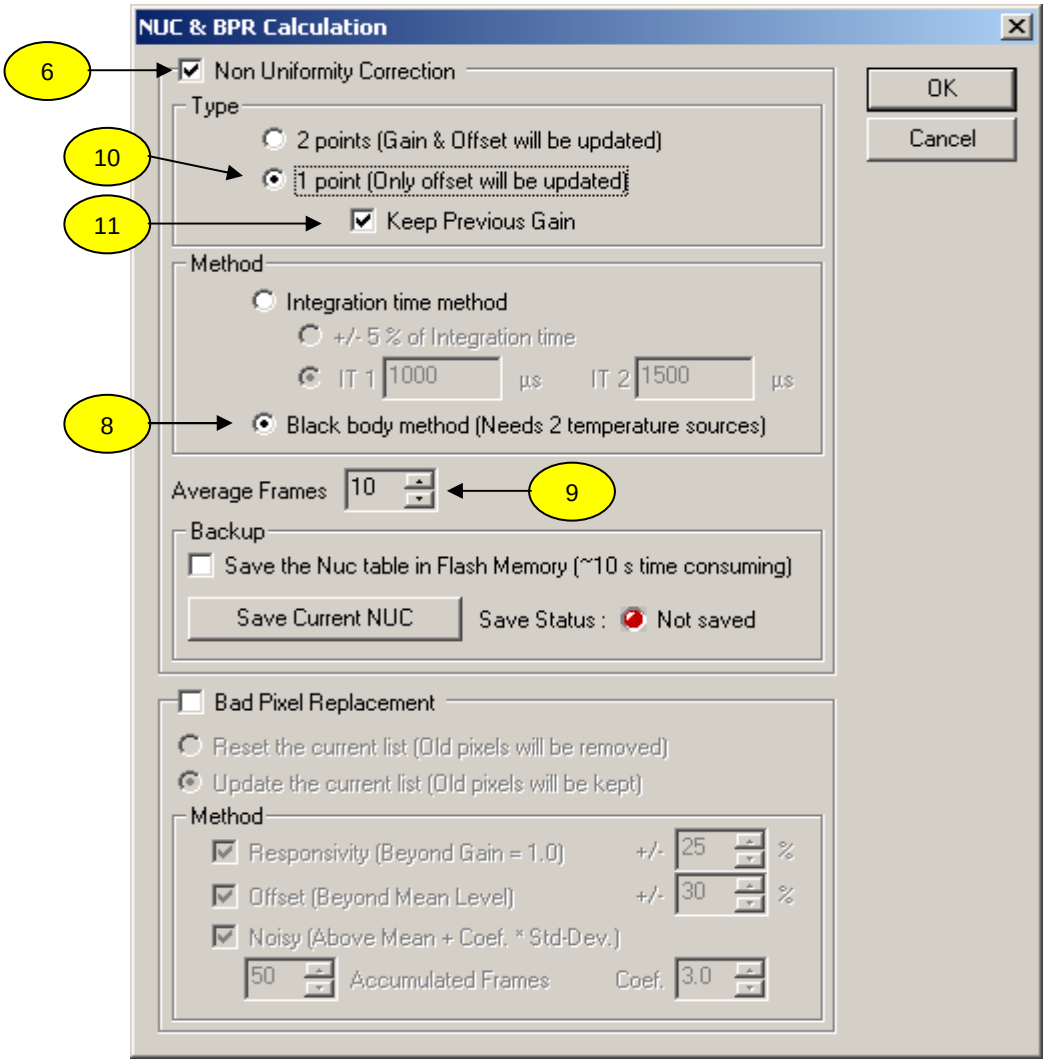
8.2. Updating a "Single Point" NUC

Step 1- Select the NUC to update.

Step 2- Click on "αβ" - "Update NUC BPR" (5).

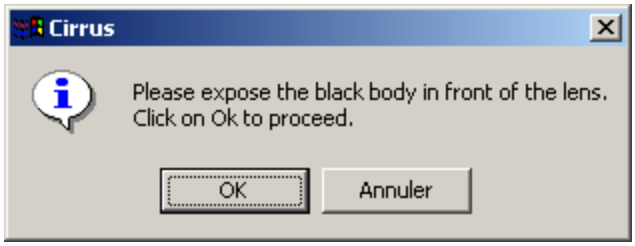
Step 3- From the NUC window:

- Tick the NUC box (6).
- Tick the "1 point" line (10).
- Leave the "Keep Previous Gain" box ticked (the correction only applies to the offset parameter β) (11).
- Choose the "Black body method" (8).
- Choose the number of images for each point (9).
- Do not tick the "Save the Nuc table in Flash Memory" box.



- Click on "OK".

When prompted, place your reference source in front of the lens and click on "OK".



Note

This reference must simply be within a range. Wherever possible use a reference that is close to the target value of the actual measurement to be taken.

8.3. Creating a "Two Point" NUC - Time Integration Method

Before creating or changing a NUC, you will need to:

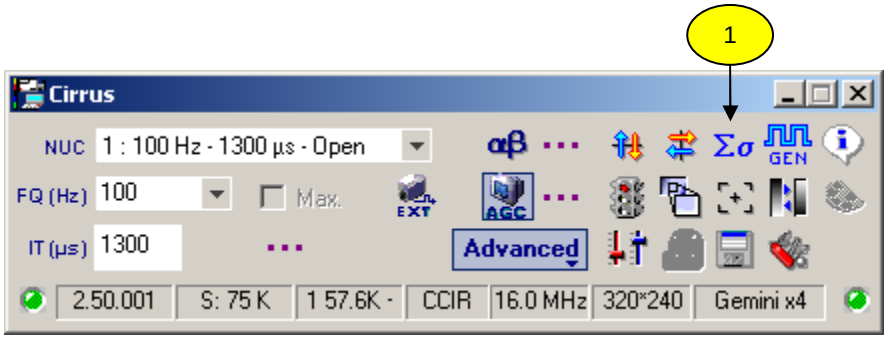
- define your Integration Time,
- identify the optical filtering,
- define your two Integration Times according to the temperature reference available.

Method used for defining your reference Integration Times

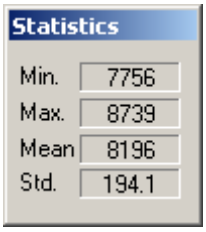
We recommend that you set your low and high ITs to the 6,000 and 10,000 digital value marks, or around 30% and 70% of the camera's dynamic output range.

To determine the digital level returned by the camera

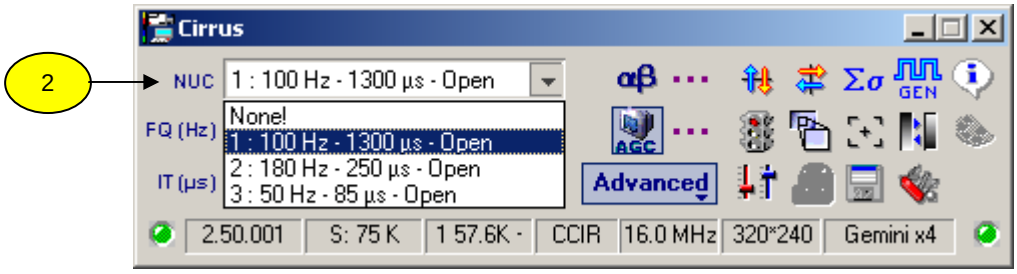
Start the CIRRUS software. From the main screen, click on "∑σ" (1).



The next window opens to show, for a given integration time and filter, the mean value returned by the camera.

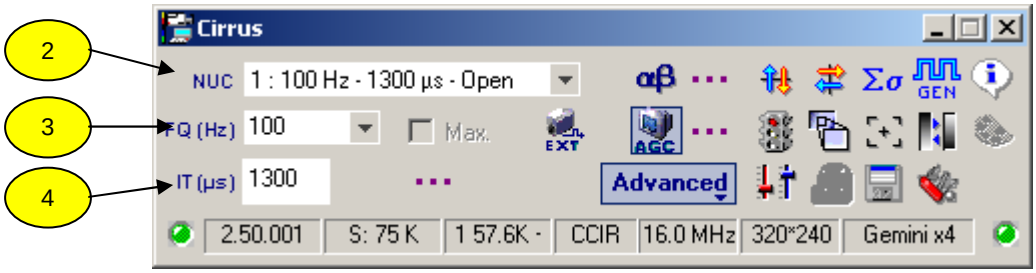


The main screen presents the NUC currently applied to the camera (2).



(here is the NUC for table 1, at 100 Hz, 1300 µs, no filter)

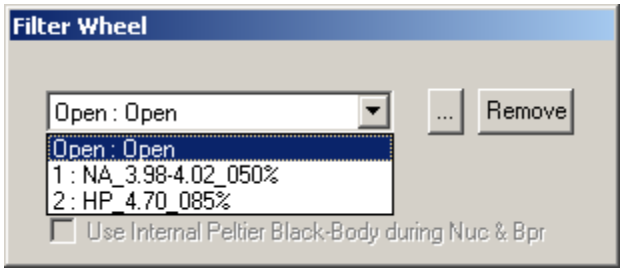
Select the NUC to replace using the popup list (2).



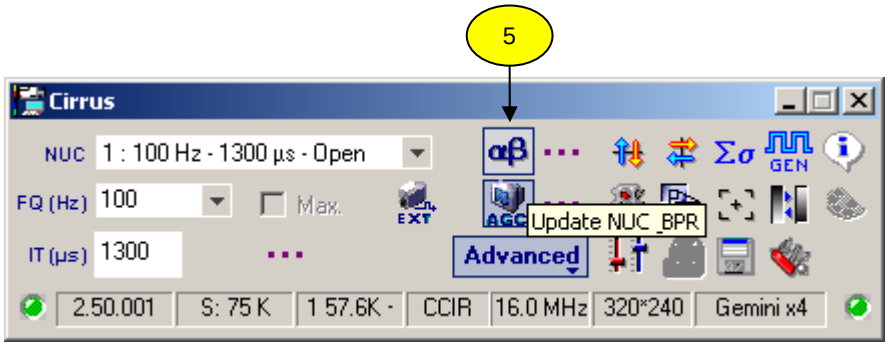
Specify your frequency (3). This parameter does not affect the main work area, but must still be noted.

Specify your Integration Time (4) and confirm it by pressing "Enter" on the keyboard.

If you use a filter, specify which one from the "Filter Wheel" window.

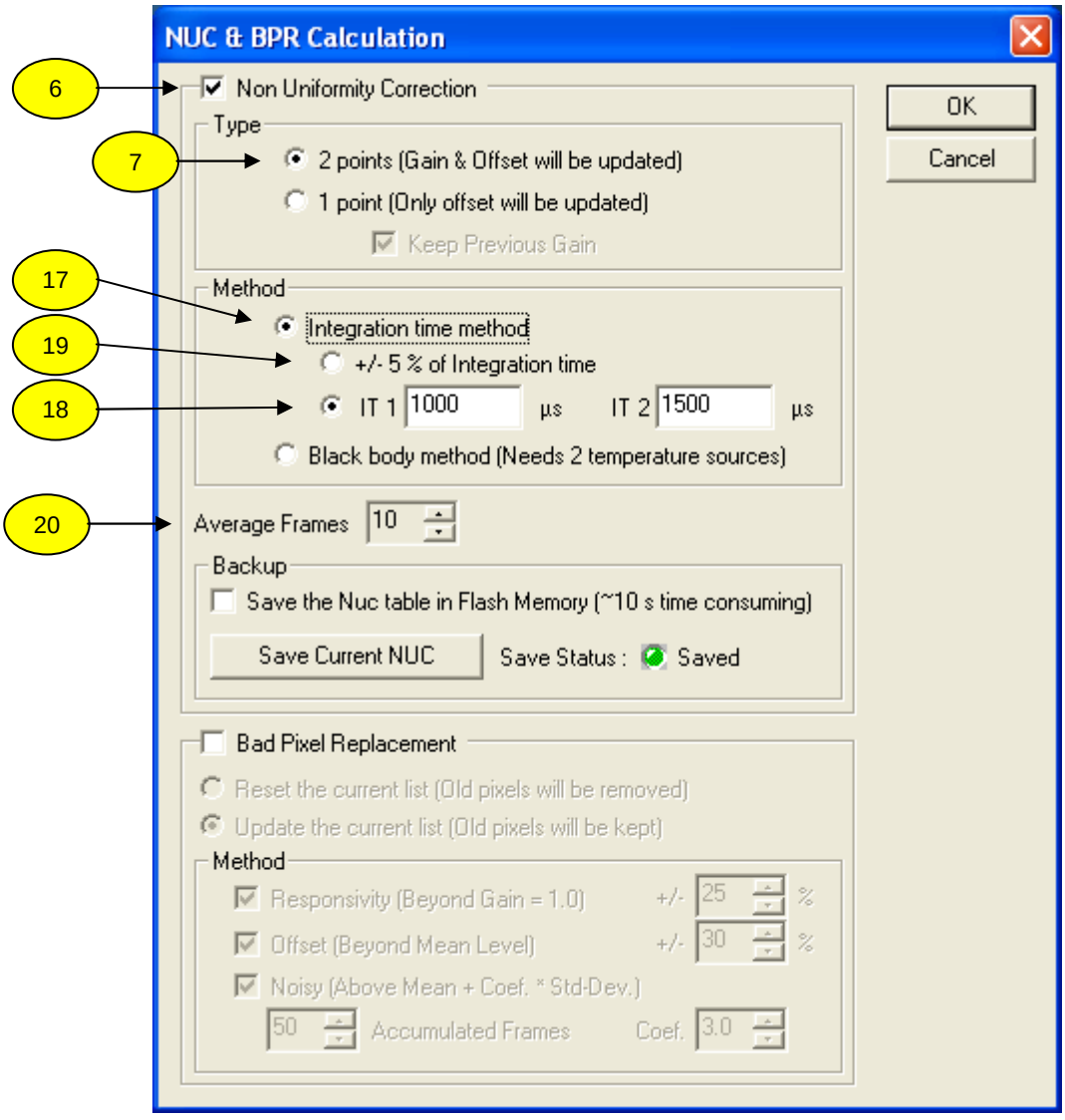


Click on "αβ" - "Update NUC BPR" (5).



Then the window presented on the next page will open:

- Tick the "Non Uniformity Correction" box (6)
- Choose the "2 points" type (7)
- Choose the "Integration time method" (17)
- Choose the IT option (18) and enter the two integration times that will be used for the measurement.
- Choose the number of images that the measurement average will apply to (20).

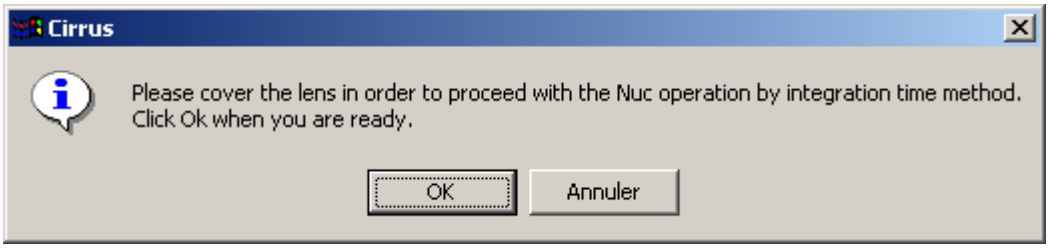


Note:

The figure 10 is a good compromise between noise reduction and the time required to perform the measurement.

- Do not tick the "Save the Nuc table in Flash Memory" box. It is preferable to await complete confirmation of the new NUC before saving it.
- Do not tick the "Bad Pixel Replacement" box.
- Click on "OK".

When the window shown below appears, ensure that your camera is aimed at the temperature reference and click on "OK".



At the end of the measurement process, the main CIRRUS screen reappears. You will see that the NUC name has been updated in line with the parameters chosen at the start of the process.

8.4. Saving a NUC

8.4.1. Saving to Flash Memory

There are two possible methods for saving a new NUC:

When creating or changing the NUC, tick the "Save the Nuc table in Flash Memory" box. The new NUC will then be saved automatically at the end of the process.

After confirming the new NUC or the changed NUC. From the NUC screen, click on the "Save current NUC" button.

WARNING!

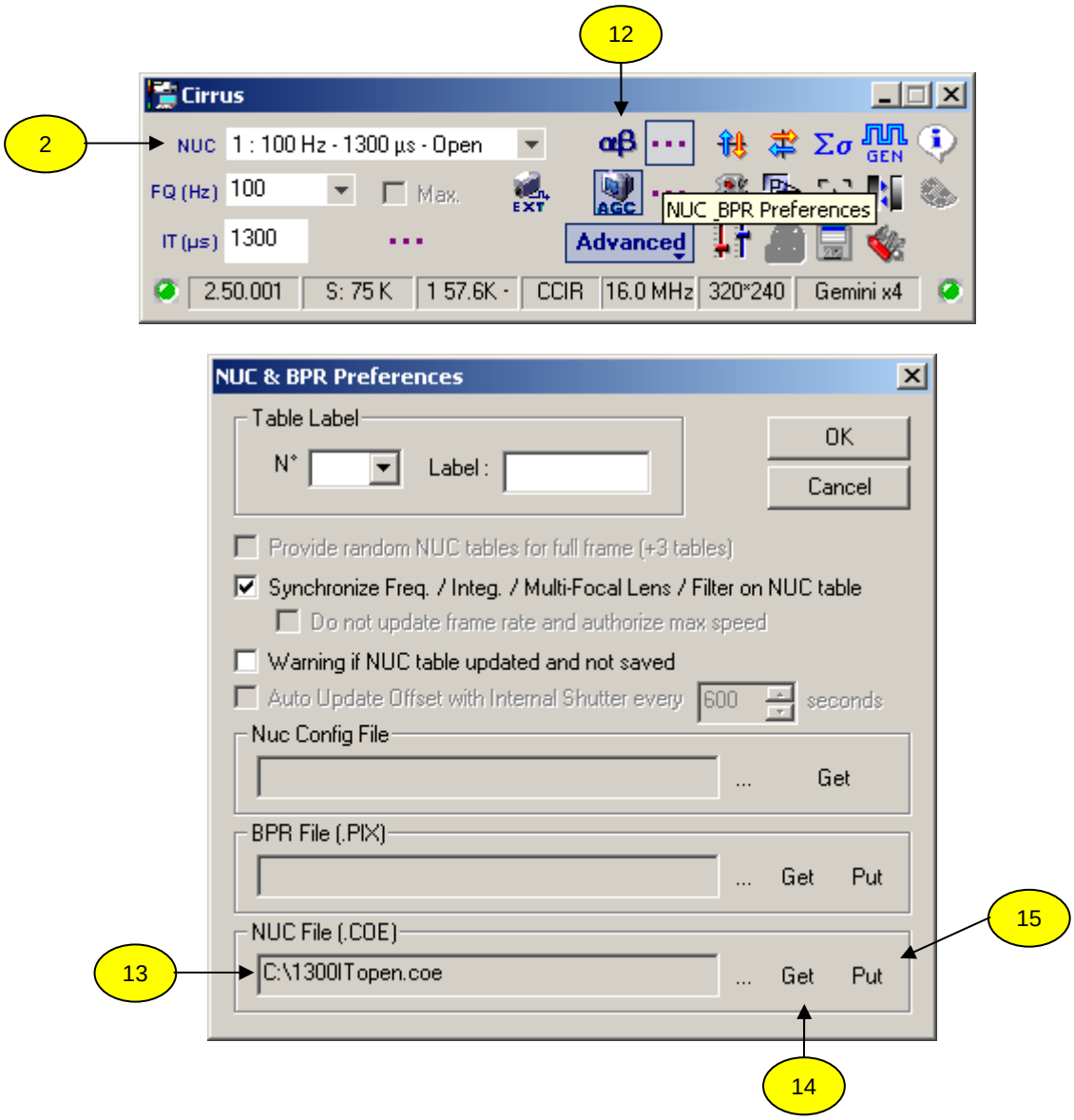
In both cases the table selected at the start of the process will be permanently erased.

Tip

It is preferable to save the NUC after final confirmation.

8.4.2. Saving an NUC from the Camera to the PC

From the CIRRUS main screen, select the table to be saved (2), then click on the NUC_BPR Preferences button (12).



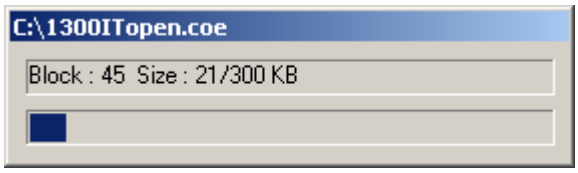
The following screen appears:

Note:

The "Synchronize Freq. / Integ. / Multi-Focal Lens / Filter on NUC table" box is ticked by default. This option ensures, when selecting an NUC that influential settings suited to this NUC are set (Integration Time, frequency, filter).

In the "NUC File" box, enter an access path and a save file name (with a .coe extension) as referenced in the Appendix (13), then click on "Get" (14) to transfer the NUC from the camera to the PC.

A progress bar shows the transfer status.



Notes

The original NUC files are supplied by FLIR SYSTEMS on the CD that comes with your camera.

Remember to make a note of the influence values used in the saved NUC. The best way to do this is to choose a filename that explicitly records these values.
For example: f100_IT1300_open.coe where:

- f100: Frequency: 100 Hz
- IT1300: Integration Time: 1300 µs
- open: No filter

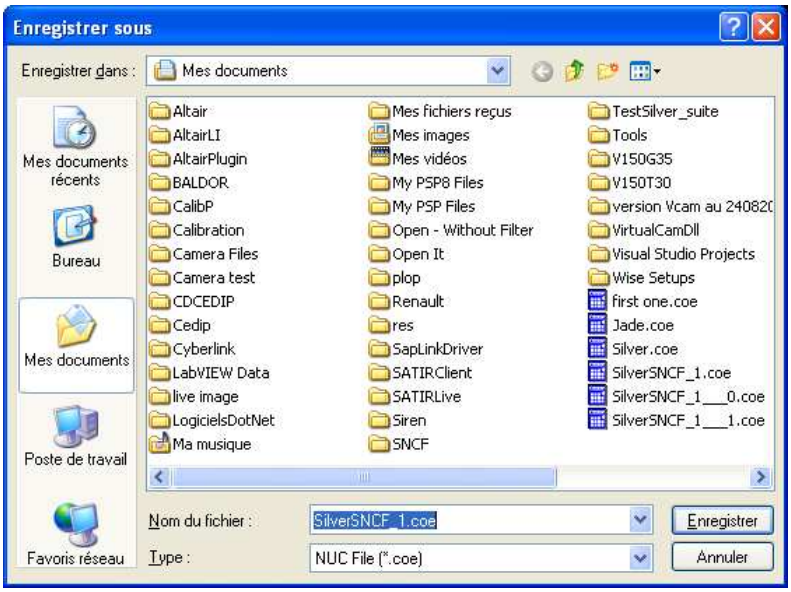
8.5. Restoring an NUC Saved in a PC or on CD to the Camera

From the CIRRUS main screen:

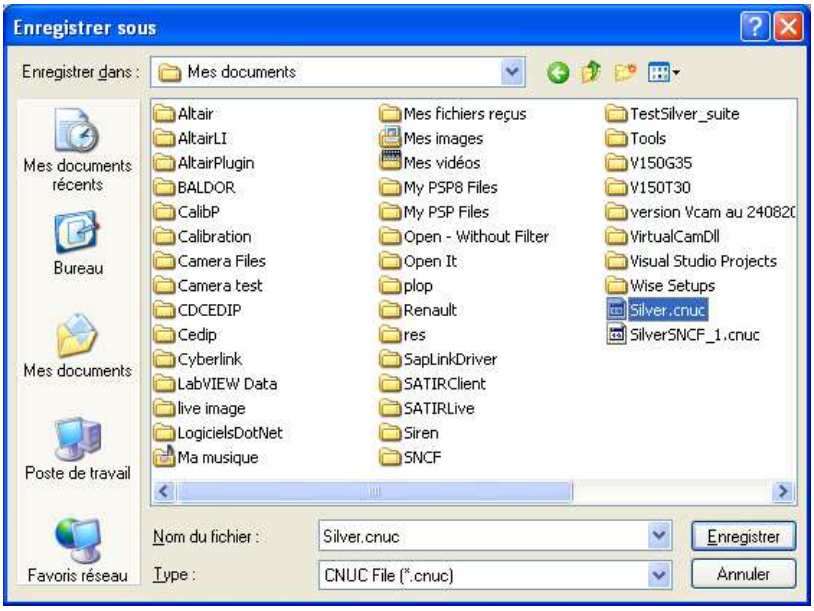
- Select the table containing the NUC to be replaced (2)
- Confirm the integration time (select IT field and press Enter) (4)
- Confirm the frequency (select Frequency field and press Enter) (3)
- When necessary, choose the filter (from the "Filter Wheel" window)
- Click on the "NUC BPR preferences" button (12)

From the "NUC BPR preferences" window:

- Enter the file access path (13)

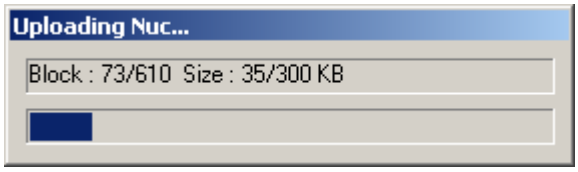


– Select extension .coe for a classic NUC and .cnuc for a compensated one.



– Click on "Put" (15)

A progress bar shows transfer status.



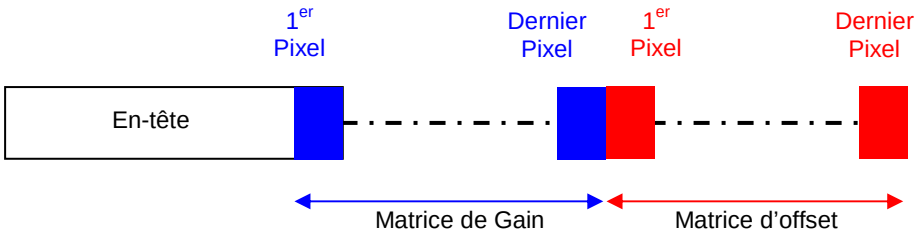
When uploading is finished, close the window.

Then you will need to update your NUC using "1 point" correction to take the new parameters into account.

At the end of the process, the table name is automatically updated. The NUC is then saved to the current table. If you wish to apply it, don't forget to save it to the camera's Flash memory (refer to the section on "Saving to Flash Memory").

Appendix

NUC (*.coe) file structure



Header format

Data type	Designation and size	Description	Offset (byte)
char	Signature[5]	"**COE**" character string	**0**
char	Version[5]	Version number	**5**
char	EndOfFile	Reserved for PTR	**10**
char	Reserve[241]	Reserved	**11**
int	NombreColonne	Number of pixels per line	**252**
int	NombreLigne	Number of lines per image	**254**
long	**Size**	Number of pixels in the table	**256**
float	Alpha[**Size**]	Gain matrix (**Nbr. of pixels**)	**260**
float	Beta[**Size**]	Offset matrix (**Nbr. of pixels**)	**260+4*Size**

Warning

For compatibility reasons with previous file formats, when the **NombreColonne** and **NombreLigne** fields are at 0, their value must be interpreted as 128.