EulerCAM User Manual

Version 0.9		
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Contents

1 Introduction

2 Instrument description

Overall description, CCD, filters, table with main characteristics (FOV,pixels size)
QE curve

Table 1: default

Parameter	Unit	Value
Detector type		E2V 231-84-1-E06
Detector size	[mm X mm]	61.4 X 61.7
Outputs		4
Readout mode		4-port/1-port
Readout speed	[Mpix/port]	1
Readout time	[s]	4.6/18.5
Pixels size	[μm]	15
Pixel scale	[arscec/pixel]	0.215
Image size	[pixel X pixel]	4096 X 4112
Field of view	[arcmin X arcmin]	15.68 X 15.73
Output #1 (LL)		
Gain	[electrons/ADU]	2.71
Readout noise	[electrons]	5
Output #2 (LR)		
Gain	[electrons/ADU]	2.67
Readout noise	[electrons]	5
Output #3 (UR)		
Gain	[electrons/ADU]	2.52
Readout noise	[electrons]	20
Output #4 (UL)		
Gain	[electrons/ADU]	2.69
Readout noise	[electrons]	22

2.1 Performances

Il me manque encore des valeurs ou certaines sont encore un peu flottantes TBD

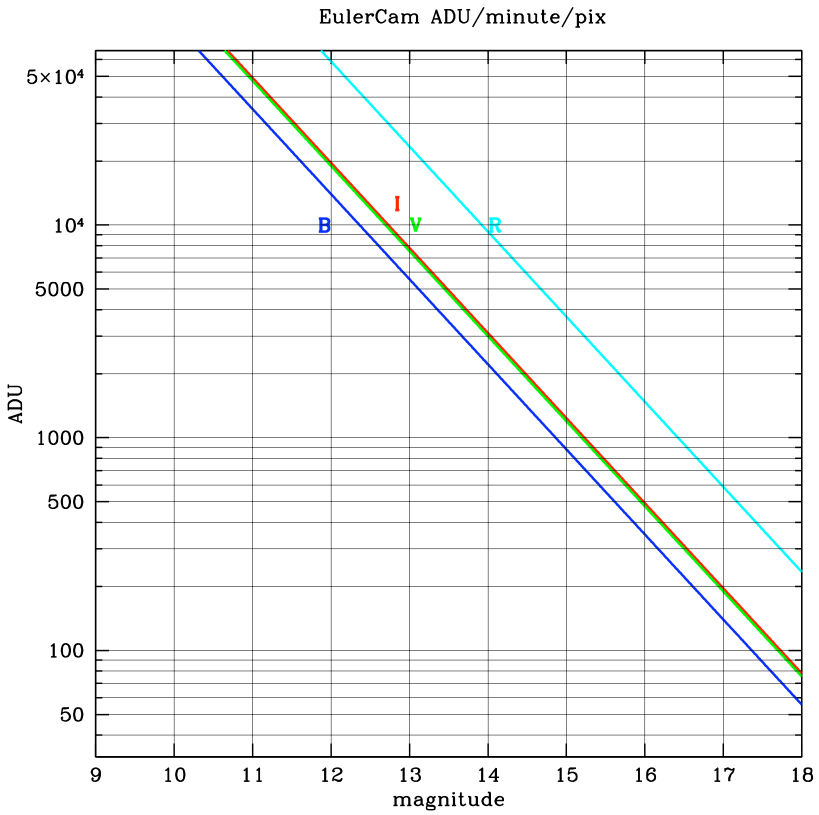

Figure 1: EulerCAM performance. The plots show the obtained peak flux for a one minute exposure as a function of the target magnitude for the 4 main broad band filters installed in the EulerCAM filter wheel. These curves are based on the ECAM calibrated Exposure Time Calculator.

3 Observing with EulerCAM

In this Section, we describe the observing and readout modes currently available with EulerCAM.

3.1 Observing blocks & templates

A bit like what is done at the European Southern Observatory (ESO), EulerCAM makes use of two concepts for describing an observation: the **Observing Block (OB)** and the **observing template (TPL)**. An OB contains the full set of inputs required for observing a field: field cordinates, observing mode, and a list of observations. Every observation in the list is decribed in an observing template. The observing template contains all the inputs decribing the integration: exposure time, filter and offsets. Only these parameters can change between two different templates of the same OB. All the others (e.g. readout mode) remain the same for the entire OB. We will describe in Sect. 3.7 how observers can prepare catalogues of targets and OBs as well as all their required inputs.

3.2 Readout modes

The EulerCAM CCD can be readout in several ways but the readout speed is always set to the fast mode (1 Mpix s^{-1}). The readout mode is controlled by the user by setting two parameters: **readtype** and **ampname**. These parameters have can be specified in the observing catalogue or in the OB. Both have default values.

3.2.1 Readout type

The parameter is a remnant of the **ccdros** parameter in use with the C2 instrument. As mentionned before, the readout speed is fixed but there are still two different readout methods. In the first one call *simult*, one doesn't wait for the readout to be completed before to preset the telescope to its next position. In the second, called *delay* one, CCD readout and telescope preset are done in sequence. The goal of the *simult* mode is to prevent the moving telescope and dome to generate extra noise on the images. We are still checking if the telescope and dome actually generate noise. In case no significant difference in terms of noise is detected between the two mode, we will later suppress the *delay* mode and fix **readtype** to *simult*.

The default value for **readtype** is *simult*.

3.2.2 Amplifier name

The EulerCAM CCD possesses for readout ports. One can read the detector using the 4 ports (thus dividing the readout by 4) or read it using only one port (any of them in principle). Two different modes have finally been selected. These two modes can be selected using the **ampname** parameter. If **ampname** is set to *ALL*, the 4-port readout is used. If it is set to *LL*, then the full image is readout using only the Lower-Left amplifier. The lower-left amplifier produces images with a very clean cosmetics and a low readout noise.

The default value for **ampname** is *ALL*.

3.3 Observing modes

We describe here the two availlable observing modes, i.e. the two type of scientific images that can be used with EulerCAM. The parameter used for specifying the mode is called **type**. **type** can be set to *CAM_PRG* (Sect. 3.3.1) or *CAM_ABTR* (Sect. 3.3.2).

`The default value for` **type** `is` *CAM_PRG*`.`

3.3.1 PRG exposure

This is a simple science exposure without guiding. The user can apply telescope offsets between the various templates of an OB. These offsets can be set using the **dalpha**, **ddelta** and **phi** parameters. Rotation offsets are not offered yet so **phi** is always set to 0. The coordinates offsets are additive (the sign matters) and they are not cumulative (i.e. defined with respect to the OB coordinate). Their unit is the arcsec. The maximum offset value is 250 arcsec for both coordinates.

`The default values for` **dalpha**`,` **ddelta** `and` **phi** `in the` *CAM_PRG* `mode are 0,0 and 0 (fixed).`

The other parameters used in *CAM_PRG* template are: the filter (parameter = **filtre**), the exposure time in seconds (parameter = **texp**).

3.3.2 ABTR exposure

This is the ABsolute TRacking mode. EulerCAM is not equiped with a guiding device. The aim of the ABTR mode is to somehow replace such a device. With this mode, the target position on the detector is fixed and the telescope position is corrected so that the astrometric solution described with the image fits header WCS keywords is correct. The target is stable on the detector (down to some precision) and a given target of a given field will always land on the same pixel when the same field is reobserved (again, down to some precision that still needs to be characterized).

This works in the following way. The sequence starts. The telescope is sent to target but the preset precision is not perfect. The target coordinates are thus a bit off with respect to the absolute astrometric coordinate system. Once the first image is readout, targets are automatically detected using the *Sextractor* software. The list of detected targets is then sent to another software, *SCAMP*, that computes the true astrometric solution of the image. From this true solution and the solution assumed for the image (WCS keywords), the system computes the coordinate offsets that need to applied to the telescope to align them. The telescope position is then corrected.

Practically, the computations take some time (a few seconds, maybe 10 if the field is crowded). After the first is readout, we don't wait for the results before starting the next integration. Once the results are obtained sometimes during the second integration, the computed offsets are stored and applied just before the third integration. The system knows when a valid set of offsets is available. It applied them as soon as possible. It may happen in the case of a short-exposure time sequence on a crowded field (i.e. longer computing time) that the correction is postponned to the fourth or fifth image. Once a valid offset solution has been applied, it is deleted from the system in order to avoid to use it twice. The field stabilization takes some time depending on the exposure time and field richness.

The ABTR mode is still under developpment. Tests are still ongoing. In particular, we are trying to determine its limitations. Problems can be anticipated in the following cases: weakly populated fields and/or fields observed with very short exposure times (not enough faint stars appear). Also, we have noticed some problems when the exposure times are long (3 minutes or more). In this case, the time difference between the computation of the offsets and the moment they are actually sent to the telescope maybe an issue.

The behaviour of the ABTR can be followed up in the ABTR graphical interface (Image + caption to be added). It is useless to observe with this mode for too short sequences (say less than 10-20 images). The field will not have time to stabilize. Finally, the use of coordinate offsets is not possible in this mode:

`The default values for` **dalpha**`,` **ddelta** `and` **phi** `in the` *CAM_PRG* `mode are 0 (fixed),0 (fixed) and 0 (fixed).`

The other parameters used in *CAM_ABTR* template are: the filter (parameter = **filtre**), the exposure time in seconds (parameter = **texp**).

3.4 Éditeur de Poses

Most of the features of the ”éditeur de poses” (EDP) were already present with the C2 instrument (and CORALIE). EDP ca be used to build an OB online. At target field can be set (manually or via a catalogue). The observing sequence (i.e. the list of templates) can easily be manually built using the edition buttons (e.g. the **Dup** and **Copy** buttons). The EDP fields related to the templates can only be edited when a template is selected. The OB paramaters can only be edited when the OB is selected (i.e. the first line of the OB is selected). In order to open an OB to access the template parameters, one need to click on its blue square on the left.

3.4.1 Telescope focus and autofocus

The telescope focus sequence as well as the autofocus software have been largely improved during the commissionning run. Both are now robust and can be trusted. The autofocus should always be used. Before taking the first science exposure of the night, a focus sequence should be taken. The way to do it is the same as before. Open the `focus_for_camera.rdb` catalogue in the **Catalogs-Utils** EDP menu. Select an appropriate target (i.e. a target a low airmass), send it to the EDP list and run it. Normally, the focus target is detected automatically but sometimes, the system doesn’t find it. If this happens, the observer will have to click on it in the **AFF** window (Important: not

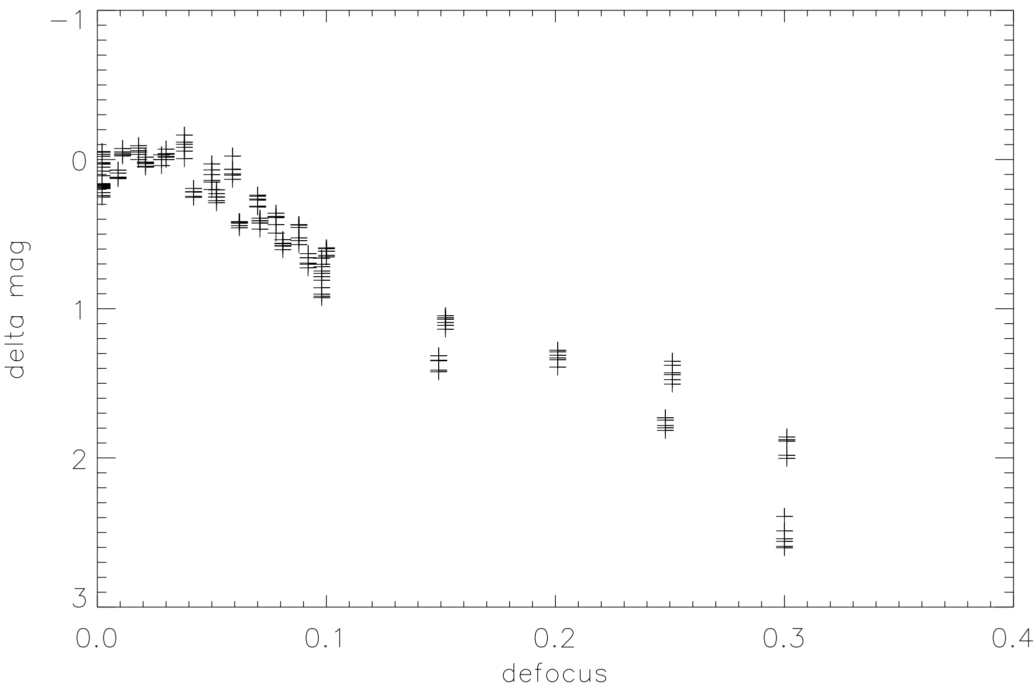

Figure 2: Effect of telescope defocus on the target apparent magnitude.

in the Real Time Display window, RTD, see Sect. 3.6). The sequence should then run smoothly. The observer should check that a minimum of the target image size was reached inside of the sequence. In case the best image quality is obtained in the first or in the last image of the sequence, then the sequence should be repeated.

3.5 The Exposure Time Calculator

An imaging Exposure Time Calculator has recently been installed in the system. It has two main operation modes. First, one can compute the exposure time of a given template. The template needs to selected. Then, a click on the **Compute** button will set the correct exposure time (**Je dois demander a Monika pour quel peak-flux ou quel S/N il est calcule**). The seconde mode is a graphical approach. Again, a template has to be selected. Then, a click on the **Extra** button will open a menu where the following option can be selected: ”EulerCAM: snr and peak ADU versus exposure time plot”. This will open a graphical window contaning the two indicated plots for the selected template.

The peak flux and S/N computation take the following imputs into account:

- the target magnitude **mv**. Note that it is assumed the indicated magnitude is the band of the filter used
- the template filter **filtre**
- the target airmass as computed by the EDP.
- the Lunar phase (for the background computation)
- the seeing. It uses the DIMM seeing value when available. Otherwise, a seeing of 1.5 arcsec is assumed.
- CCD readout noise (**Pas certain de quelle valeur est utilisee. Demander a Monika).**

The ETC doesn't take the telescope defocus into account. The effect of the telescope defocus on the target apparent magnitude is illustrated in Fig. 3.5. The target magnitude should be corrected accordingly when defocusing the telescope. The S/N ratio is the one obtained over the target point-spread function (assuming a gaussian profile).

3.6 The Real Time Display

All the images produced by EulerCAM are now automatically displayed in an ESO Real Time Display. The RTD tool has many features but we just summarize some of them:

- Image cuts: they can be adjused automatically with the **autocut** button or manually.
- Checking the peak flux with the **Pick Object** tool. Open it from the **View** menu and click on your target.
- Checking the flux with the **Cuts** tool. Open it from the **View** menu and draw a line crossing the target with the mouse. The line can be repositioned after relescting it. This way, one can scan the target flux.
- Using the **Pixel Table** tool for checking the saturation or measuring the readout noise (on BIAS images). Open it from the **View** tool, Select a 9x9 table. Click on the **Statistics** button and point the region you want to examine.

3.7 Preparing catalogues and Observing blocks

There are two main ways of preparing EulerCAM observations offline: target catalogues and observing blocks preparation. A catalogue is a list of targets together with required observing inputs: coordinates, observing modes, readout modes, etc. An observing block is a ready-to-run observing sequence on a given field. It contains the same inputs as a catalogue plus the informations related to the observations to be carried out. In other words, this is a catalogue entry plus a list of templates. Note that one can build a catalogue of OBs by simply adding in the catalogue file the fields related to the templates (Sect. 3.7.2).

3.7.1 Catalogues

An EulerCAM catalogue is an `ascii` file in *rdb* format: TAB-separated fields with a 2-line TAB-separated header. The format of the file header is the following. The first line contains the field names. The second line contains dashes: the same number of dashes as the number of characters of the various field names. For example, if the first line of the *rdb* file is:

alphacat **TAB** type**TAB** mv

then its second line would be:

8-d **TAB** 4-d **TAB** 2-d

where 8-d means 8 dashes (i.e. ———), 4-d means 4 dashes (i.e. —-), and 2-d 2 dashes (i.e. –). In order to be accessed by the system via the *Catalogs* button of the EDP, a catalogue needs to be installed. In the `/gls/catalogues/` directory, create a sub-directory whose name should start with ECAM (e.g. ECAMlenses, ECAMtransits, ECAMclusters,...). The catalogue file should then copied in this sub-directory. The catalogue file name is not important but it should be explicit (e.g. ECAMlenses.rdb, ECAMtransits.rdb, ECAMclusters, ...).

We list in table 2 the EulerCAM catalogue parameters (i.e. the *rdb* fields of the catalogue file).

3.7.2 Observing templates

We describe in this Sect. the parameters used for describing an EulerCAM observing template. Every EulerCAM integration is described by 5 inputs: the filter to be used, the exposure time and offsets (for CAM_PRG only). The parameters used for these inputs are described in Table 3.

The observing sequence (i.e. the list of observing templates) of an OB is decribed using the **sequence** parameter. The format of this parameter is long chain of integration parameters separated by ”/”:

Table 2: List of parameters for an EulerCAM catalogue.

Parameter	Description
alphacat	Field right ascension (format: hh:mm:ss.ii)
deltacat	Field declination (format: +/-dd:mm:ss.i)
equicat	Equinoxe (format: yyyy.0)
code	Field/target code (format: free, describes the targetted field or the main target in the field. If empty, it will become hhmmss(N/S)ddmmss)
mualph	Alpha proper motion (format: float, unit: ”/yr) Generally irrelevant for ECAM
mudelt	Delta proper motion (format: float, unit: ”/yr) Generally irrelevant for ECAM
mv	Target magnitude (format: float, unit: mag) Used by the Exposure Time Calculator (ETC).
type	Observing mode (format: CAM_PRG or CAM_ABTR) Default value=*CAM_PRG*
readtype	Readout mode (format: simult or delay) Default value=*simult*
ampname	Amplifier name (format: ALL or LL) Default value=*ALL*
defoc	Telescope defocus (format: can be any of 0.0, 0.05, 0.1, 0.15 or 0.2, unit: mm) Default value=*0.0*

Table 3: List of parameters for an EulerCAM integration.

Parameter	Description
filtre	(format can be any of: UG,B1,B2,GG,V1,BG,VG,ZG,IC,ZG,OO,NO). A filter can be set in a catalogue but the one(s) defined in the sequence field will be used (see below). Filtre is used by the ETC: it assumes that the indicated target magnitude mv is in the band of filtre.
texp	Exposure time in seconds (format: float).
dalpha	Alpha offset (format: float, unit: arcsec). Must be < 250 arcsec. A positive dalpha offsets the telescope to the East (hence your favorite target to the West). The offsets are absolute ones: defined with respect to the OB coordinates alphacat and deltacat. They are not cumulative.
ddelta	Delta offset (format: float, unit: arcsec). Must be < 250 arcsec. A positive ddelta offsets the telescope to the North (hence your favorite target to the South). The offsets are absolute ones: defined with respect to the OB coordinates alphacat and deltacat. They are not cumulative.
phi	Rotation offset (format: float, unit: degree). Not offered yet. Will be set to 0 for the moment.

filtre1/texp1/dalpha1/ddelta1/phi1/filtre2/texp2/dalpha2/ddelta2/phi2/filtre3/ etc.

For example, if one wants to take one 60-sec exposure with the VG filter and a 2-min exposure with the BG filters with offsets (i.e. in the CAM_PRG case), then the sequence field should contain the following chain:

VG/60/0/0/0/BG/120/-10/25/0

Again, offsets are not offered in the CAM_ABTR mode. Offsets will always be ignored in this case.

4 Calibrations

4.1 Bias

The bias correction can be done using the overscan regions. Nevertheless, it is requested to take at least a series of 5 biases everyday. Insert a *CAM_BIAS* using the EDP **Insert** button. Select the observing template and click 4 times on the **DUP** button. By default, this will produce biases in the *ALL* mode (i.e. 4-ports). Do not forget to take biases with *LL* mode if you use it for your science (click on **ampname** and set it to *LL*.

4.2 Dark

Please take a least one series of 3 900-second darks once during your run. Insert a *CAM_DARK* using the EDP **Insert** button. Select the observing template and click twice on the **DUP** button. By default, this will produce dark frames in the *ALL* mode (i.e. 4-ports). Do not forget to take biases with *LL* mode if you use it for your science (click on **ampname** and set it to *LL*.

4.3 Flat-field

This is the most important calibration. Skyflats have to be taken on daily basis in all the filters and modes used during the night. Flats are taken as before. Open the `flat.rdb` from the **Catalogs-Utils** EDP menu. Select the flat region corresponding to the current month and the for the correct twilight (matin=morning twilight, soir=evening twilight). Set the **flatlist** in the EDP. The system will take 3 flats per filter indicated in the list (you don't need to write the filter name 3 times). Filter names are separated by commas "," in the list. Remember to start with blue filters in the evening twilight and with the red filters in the morning. For the broad band filters, the correct filter order is the following for the evening:

flatlist=UG,BG,VG,ZG,RG,IC

In the morning, the list is simply reversed:

flatlist=IC,RG,ZG,VG,BG,UG

The full 6-filter sequence can taken with the 4-port mode (i.e. *ALL* in the evening twilight. It cannot be completely executed in the morning. Do not forget to take flats in *LL* if you sue it for your science. Note that the **ampname** parameter is an OB parameter. I thus cannot be changed in the middle of the OB. If the modes,*LL* and *ALL* are used, at least two different OBs need to be inserted.

The way to acquire the flats was significantly improved during the EulerCAM commissioning run. We now use the known sky brigthness properties for setting the exposure time. For a given filter, a flux control loop is executed. We take a series of short exposures and measure their fluxes in order to determine when the sky brigthness is in acceptable range. When this is the case, the first flat is taken with the exposure time obtained from the control loop but the exposure time of the next two are set from using the known relations for the brigthness evolution. We then move to the next filter starting again with a control loop.

Skyflats should only be taken in clear conditions, i.e. no visible cloud above an elevation of 20 degrees. In the morning, it is sometimes difficult to determine if the conditions are good enough. In case of doubt, take the flats anyway and check the conditions later when the sky is brigther. If you realize later that there were some clouds, please take not of this information and report it to the people involved in the observations (make sure they don't use these bad flats.

On devrait faire outil qui permet de flagger les mauvais flats.

Finally, for EulerCAM, the correct sky brightness range is obtained when the Sun is between elevations of -5 and -7 degrees. **C'est bien ca Didier?**

4.4 Linearity

TBD

4.5 Gain

TBD

5 ECAM versus C2

listing the differences between ECAM & C2 (tbd)

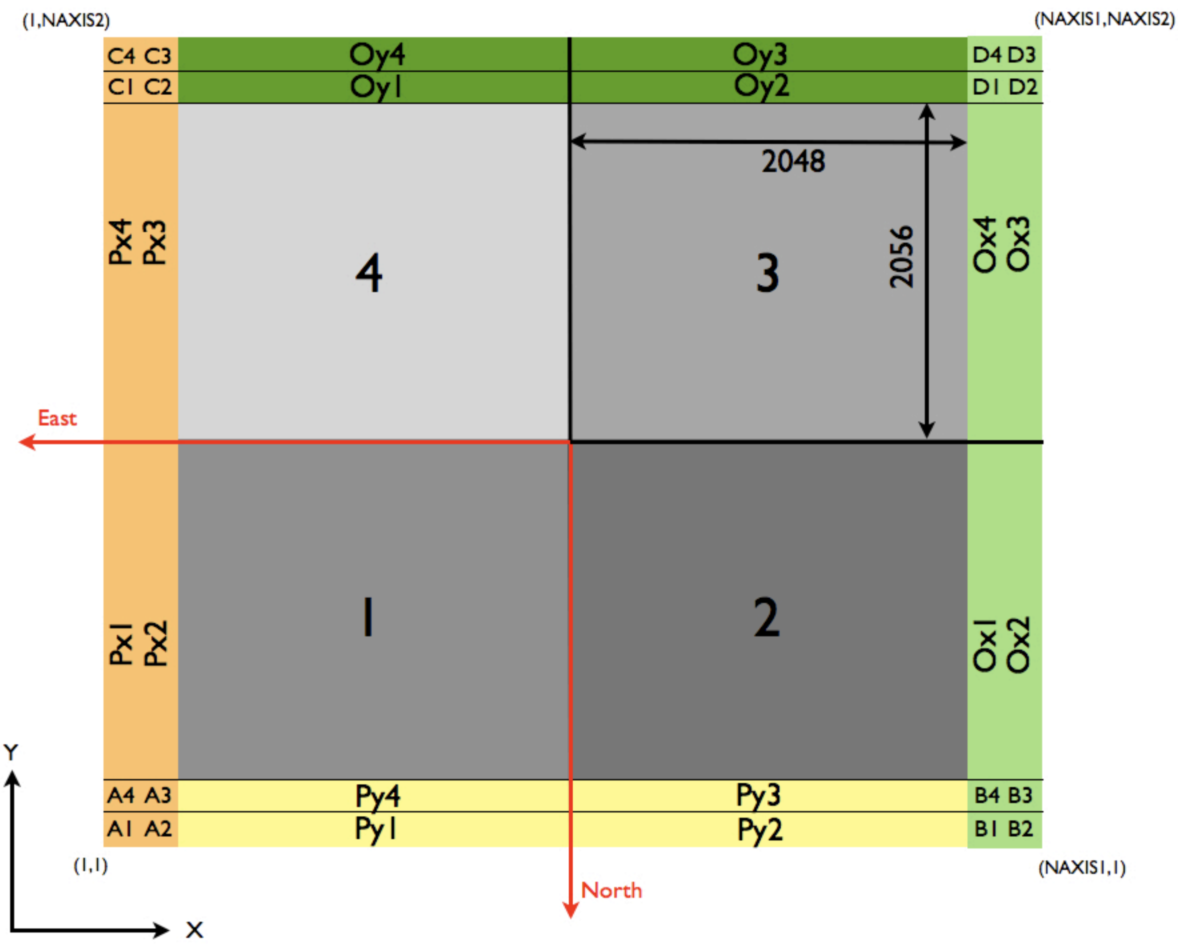

Figure 3: EulerCAM image layout for the4-port readout mode.

6 Appendix

6.1 EulerCAM image layout

6.1.1 4-port readout

6.1.2 1-port readout

6.2 Filters transmissions

Voir avec Grenon et/ou Bürki pour les filtres Genève. Pour RG et ZG, les courbes doivent être sur les pages ESO. Pour le IC???