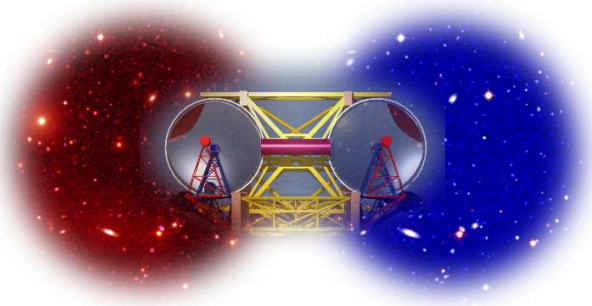

Large Binocular Camera

Large Binocular Camera

Active Optics LBC-Software Application

Reference Manual

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Active Optics LBC-Software Application, Reference Manual

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Active Optics LBC-Software Application

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1 - Overview of the Package

While the LBC-LBT control software performs the guiding with the tracking procedure, it is possible to perform active optics operations. The **low-order active optics** takes place to allow continuous correction of the telescope mirror shape.
Beside this typical behavior the module is also able to take images suitable for **high-order active optics** calculations; the operation consists in interactive pointing a bright star on two specific areas of the second technical chip that allows intra and extra focal images to be obtained.
The application is composed of a standalone windows executable which performs the following operations:
ao_reduction.exe -> reads an input ascii-file, makes a choice for low-orders active optics or high-orders active optics.

- if **low-order** is selected -> performs basic reduction of technical fits image; creates a source catalog; selects best stars from the catalog outside the special AO_box; makes thumbnails of these best stars and finally prints an output ascii-file.
- if **high-order** is selected -> performs basic reduction of technical fits image; creates a source catalog; selects best stars from catalog; extracts the brighter sources inside the special AO_bounding-box; makes thumbnails of the sources inside the bounding-box.

2 – Active Optics Description

2.1 - Prerequisites

To prevent windows and linux differences in absolute patterns this program must be placed in the "D:\" directory.
The active-optics program needs to work a standalone windows-executable of the Sextractor program (Bertin & Arnouts, 1996) with its own configuration files, the windows c-fitsIO.dll file , the input ascii-

file of configuration, the input ascii-files for the relative dimension among prescan/scan/overscan regions in the two chip files and the two fits image of the technical chip (fitsimage + pre/overscan and flatfieldimage + pre/overscan).

2.1 - Installation

To install the package simply go to the main "D:\" directory and unzip the archive *"ao_reduction.VERSION.zip"*, where VERSION is the current version of the package.
Take a look on the 'prerequisites' chapter for directory list in the D:\ path.
You should have these directories:

- D:\ao
- D:\flat
- D:\tmp
- D:\conf

2.2 - General AO_Reduction Steps

The active-optics reduction steps are the following:

- reading the input ascii-file "ao_reduction.in" (see app. A)
  ----------LOW-ORDERS----------
- reading the prescan/overscan size from the ascii-file "scan.dat"
- getting fits image dimension from fits keyword
- performing basic reduction step on fits image (see app. B)
- running sextractor on the image and saving the source catalog "image.cat" (see app. C).
- reading catalog, selecting the best stars (see app. C), outside the two bounding box defined by the coordinates (X0,Y0,X1,Y1) and sorting them in the flux value
- making thumbnail of bests stars found saving them in "d:\ao"
- saving output ascii-file "ao_reduction.out" (see app. A)

  ----------HIGH-ORDERS----------
- reading the prescan/overscan size from the ascii-file "scan.dat"
- getting fits image dimension from fits keyword
- performing basic reduction step on fits image (see app. B)

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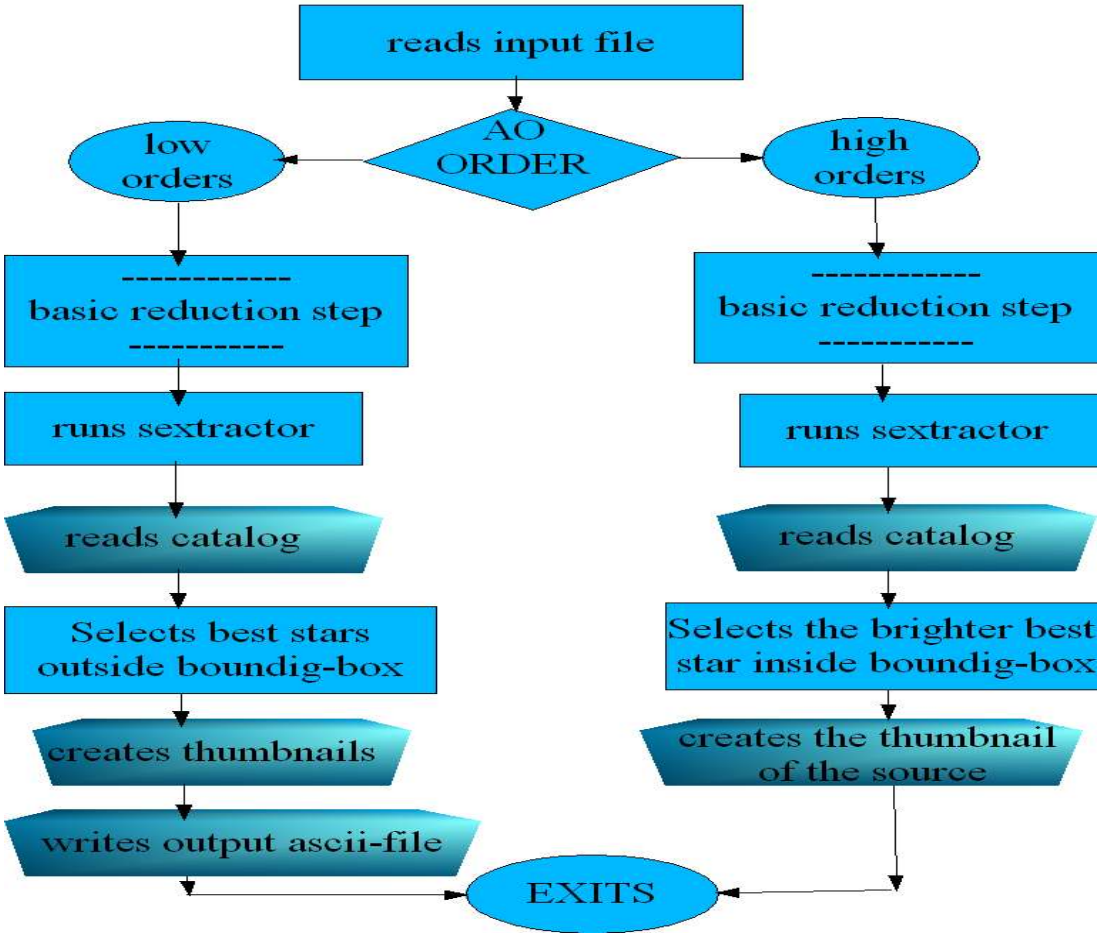
- running sextractor on the images and saving the source catalog "image.cat" (see app. C).
- reading catalog, selecting the best and brighter star (see app. C) inside the special AO_bounding-box defined by the coordinates (X0,Y0) and (X1,Y1).
- making thumbnail of the star and putting it in "d:\ao"

All these ao_reduction steps are summarized in the following picture. In the app. D is summarized a more detailed flow chart of the operation performed by the main program.



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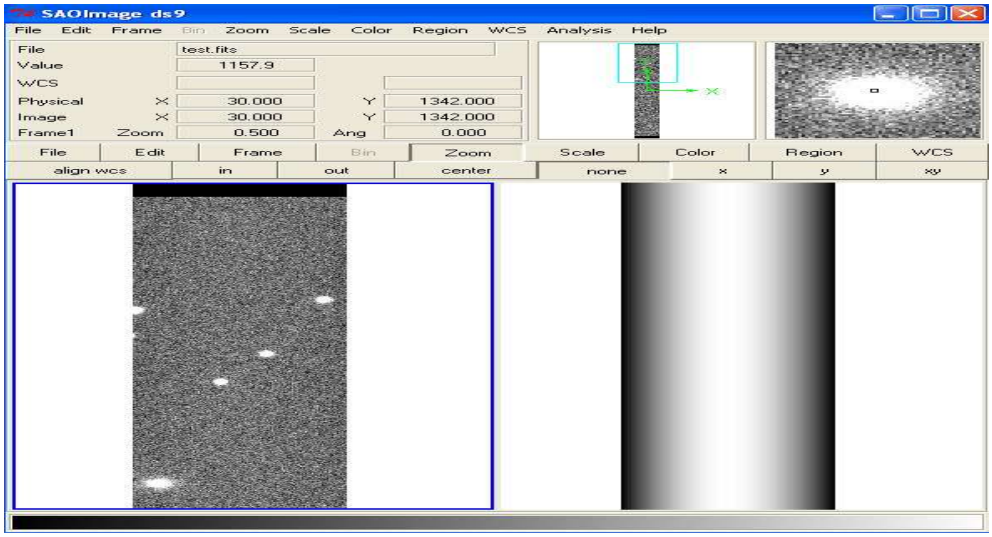
2.3 – Testing the Application

A wide test was performed on this program using one technical LBC–simulated chip to test the efficiency and stability of the application. The tech-chip fits image used was generated by the LBC-image simulator as a mixture of real objects from gsc2 catalog pointing the RA=16:34:00.00 and DEC=-17:22:00.00 coordinates plus the contribution of simulated stars and galaxies with faintLimit=18 (see pictures, object fits image and the corresponding flat-field).



The average simulation time for running is about *1.5 seconds* on a Athlon XP2000 with 512Mb of Ram.
Two type of tests were performed:

- active optics LOW ORDERS
- active optics HIGH-ORDERS

The first test for *Low-Orders active optics* was performed with the following input file:

```
-----
L
100.0
test.fits
flattest.fits
40,500
```

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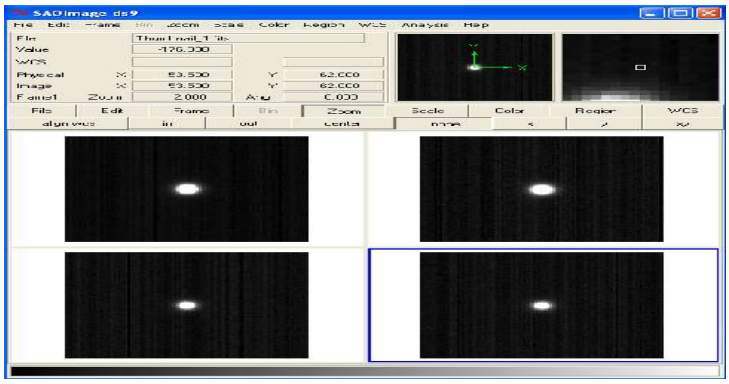
```
90,700
-----
```

The 1st line is the order of the active-optics (set al Low for this test), the 2nd line is the box size of the thumbnail, the 3rd line is the fits input file name, the 4th line is the input flatfield fits name, the 5th and 6th represents the coordinate of the bounding-box: the extraction of best stars must be performed outside the box delimited by X0,Y0 and X1,Y1 coordinates.

The result of this test is shown here:

```
-----
4
ao/Thumbnail_1.fits 196.0 236.6
ao/Thumbnail_2.fits 88.4 968.0
ao/Thumbnail_3.fits 160.7 1686.4
ao/Thumbnail_4.fits 106.4 1612.2
-----
```

Four good star sources were found outside the bounding-box defined by the (X0,Y0)=(40,500) and (X1,Y1)=(90,700) coordinates.
In the following picture the four thumbnails are shown.



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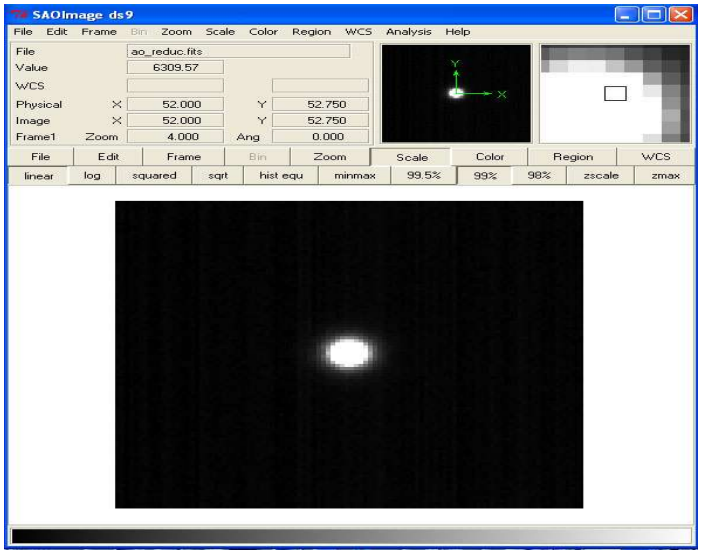
To tests the application for *High-Order active optics* the following input file was used:

```
-----
H
100.0
test.fits
flattest.fits
40,500
90,700
ao_reduc.fits
-----
```

The 1st line is the order of the active-optics (set al Low for this test), the 2nd line is the box size of the thumbnail, the 3rd line is the fits input file name, the 4th line is the input flatfield fits name, the 5th and 6th represents the coordinate of the bounding-box, the 7th line is the filename of the output high-order fits thumbnail.
In this case no output file is produced and in the "d:\ao" the brightest best star is created inside the bounding-box defined by the (X0,Y0)=(40,500) and (X1,Y1)=(90,700) coordinates. In the following picture the extracted high order thumbnail is shown.



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App. A: Input and Output Files

The input scan file ("scan.dat") for fits-image configuration looks like this:

```
-------------
57    2048   57
-------------
```

Where the line is composed of three quantities (integer numbers) which represent the size of prescan; scan and overscan region of the images. These are very important configuration files because the correct setting of these values lead to a correct basic reduction step: the mean BIAS value is calculated for each fits-image row by the median pixels value of the prescan and overscan regions.

The input ascii-file ("ao_reduction.in") for configuration is similar to this:

```
-------------
L/H
100.0
test.fits
flattest.fits
550,200
580,280
ao_reduc.fits
-------------
```

Where the 1st line is the boulean selection for (L)ow-orders or (H)igh-orders active-optics, the 2nd line is the box-size of the thumbnail files, the 3rd line is the filename of the input fits image, the 4th line is the flatfield filename of the input fits image, the 5th line is the first coordinate of the bounding-box, the 6th line is the second coordinate of the bounding-box, the 7th line is the name of the output fits-file for the central star only for High-orders active optics.
All the configuration files are located in the `"D:\conf\"` path.
If the Low-order is selected the program extracts the best stars outside the bounding-box defined in 5th and 6th lines; else if High-order is selected the program extracts the only the best brighter star inside

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the bounding-box defined in 5th and 6th lines. In the High-order case no output file is needed in the configuration input file.

The output ascii-file (ie: "ao_reduction.out") is similar to this:

```
-------------
4
d:\ao\Thumbnail_1.fits 1235.8 64.0
d:\ao\Thumbnail_2.fits 1038.8 244.0
d:\ao\Thumbnail_3.fits 637.8 163.0
d:\ao\Thumbnail_4.fits 200.8 86.0
------------
```

Where the 1st line is the number of best sources found outside the two bounding-box (the output file is created only for low-order active optics), from the 2nd line to the tail of the file there are the list of the thumbnail file names with absolute path and the center of the sources (X and Y coordinates).

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App. B: Basic reduction Steps

The general reduction steps performed by this program are the following:

- taking a look in the "D:\tmp\" directory for filename presence.
- calculating the media of prescan and overscan of each fits-image and setting it as the medianBIAS of the image.
- calculating for each pixel of the image the two quantities:
  outimage = (fitsimage-medianBIAS)/flatimage
  saturation = (65536.0-medianBIAS)/flatimage
- saving output reduced fits file int the "D:\tmp\" directory.

All the flatfield filenames are located in the "D:\flat\" directory.

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App. C: Best stars selection algorithm

The general algorithm for best stars selection performed by this program consists in reading the Sextractor generated catalog and parsing it for flux, classstar and flag keywords:

if (flag==0 && classstar>0.9 && flux>10.0) => bestStar

After this generic check, all the best source vectors are sorted in their flux.
Another selection for bounding-box is performed and it depends on the value of the boolean flag for Low-orders or High-orders active optics: if low-orders the selection is for stars outside the bounding box else if high-order the selection is for the brighter source in the bounding-box.
If no good star is found the program prints an error message and exits.

To configure properly sextractor under windows an executable binary file of sextractor batch program for win32 systems is needed. It must be placed in the same directory of the executable tracking programs. The configuration files for Sextractor (placed in the "D:\conf\" directory) must be standard Sextractor files and the parameter (default.param) file must contain the following keyword in the same order:

-NUMBER
-X_IMAGE
-Y_IMAGE
-FWHM_IMAGE
-FLUX_BEST
-CLASS_STAR
-FLAGS

The “defaultAO.sex” file name must be similar to the following:

```
---
# Default configuration file for SExtractor V1.2b14 - > 2.0
# EB 23/07/98
# (*) indicates parameters which can be omitted from this config file.

#------------------------------- Catalog ------------------------------------

CATALOG_NAME   image.cat      # name of the output catalog
CATALOG_TYPE   ASCII          # "NONE","ASCII_HEAD","ASCII","FITS_1.0"
                              # or "FITS_LDAC"
```

```
PARAMETERS_NAME       conf/default.param    # name of the file containing catalog contents

#------------------------------- Extraction ----------------------------------

DETECT_TYPE    CCD            # "CCD" or "PHOTO" (*)
FLAG_IMAGE     flag.fits      # filename for an input FLAG-image
DETECT_MINAREA 5              # minimum number of pixels above threshold
DETECT_THRESH  10.0           # <sigmas> or <threshold>,<ZP> in mag.arcsec-2
ANALYSIS_THRESH 10.0          # <sigmas> or <threshold>,<ZP> in mag.arcsec-2

FILTER         Y              # apply filter for detection ("Y" or "N")?
FILTER_NAME    conf/default.conv     # name of the file containing the filter

DEBLEND_NTHRESH       32             # Number of deblending sub-thresholds
DEBLEND_MINCONT       0.005          # Minimum contrast parameter for deblending

CLEAN          Y              # Clean spurious detections? (Y or N)?
CLEAN_PARAM    1.0            # Cleaning efficiency

MASK_TYPE      CORRECT               # type of detection MASKing: can be one of
                              # "NONE", "BLANK" or "CORRECT"

#------------------------------- Photometry ----------------------------------

PHOT_APERTURES 5              # MAG_APER aperture diameter(s) in pixels
PHOT_AUTOPARAMS       2.5, 3.5       # MAG_AUTO parameters: <Kron_fact>,<min_radius>

SATUR_LEVEL    50000.0               # level (in ADUs) at which arises saturation

MAG_ZEROPOINT  0.0            # magnitude zero-point
MAG_GAMMA      4.0            # gamma of emulsion (for photographic scans)
GAIN           2.09           # detector gain in e-/ADU.
PIXEL_SCALE    0.23           # size of pixel in arcsec (0=use FITS WCS info).

#------------------------ Star/Galaxy Separation ----------------------------

SEEING_FWHM    1.2            # stellar FWHM in arcsec
STARNNW_NAME   conf/default.nnw      # Neural-Network_Weight table filename

#------------------------------- Background ----------------------------------

BACK_SIZE      64             # Background mesh: <size> or <width>,<height>
BACK_FILTERSIZE       3              # Background filter: <size> or <width>,<height>

BACKPHOTO_TYPE GLOBAL         # can be "GLOBAL" or "LOCAL" (*)
BACKPHOTO_THICK       24             # thickness of the background LOCAL annulus (*)

#------------------------------- Check Image ---------------------------------

CHECKIMAGE_TYPE       NONE           # can be one of "NONE", "BACKGROUND",
                              # "MINIBACKGROUND", "-BACKGROUND", "OBJECTS",
                              # "-OBJECTS", "SEGMENTATION", "APERTURES",
                              # or "FILTERED" (*)
CHECKIMAGE_NAME       check.fits     # Filename for the check-image (*)
```

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```
#--------------------- Memory (change with caution!) ------------------------

MEMORY_OBJSTACK       2000           # number of objects in stack
MEMORY_PIXSTACK       100000         # number of pixels in stack
MEMORY_BUFSIZE 1024           # number of lines in buffer

#---------------------------- Miscellaneous ---------------------------------

VERBOSE_TYPE   NORMAL         # can be "QUIET", "NORMAL" or "FULL" (*)

#------------------------------ New Stuff -----------------------------------
- - -
```

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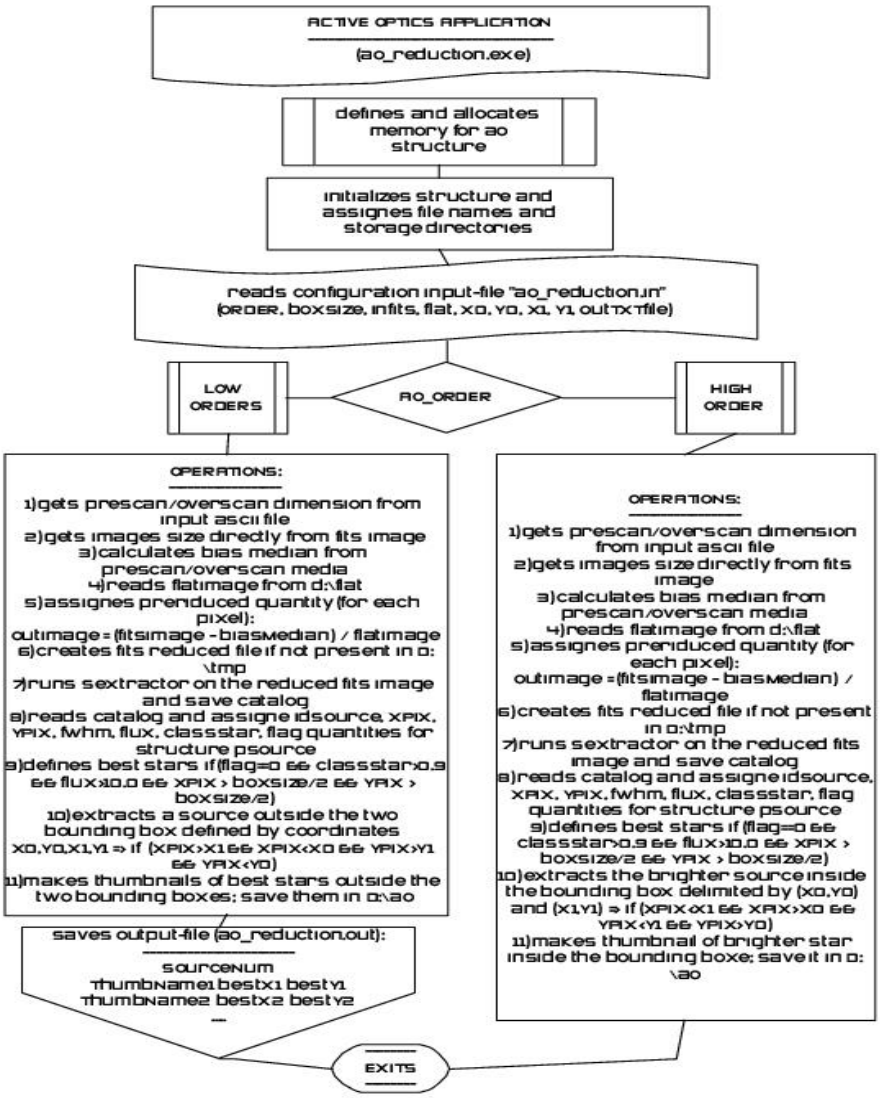
App. D: Detailed Application operations

In the following picture all the operations performed by the program are described.



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3 - Conclusions

The ao_reduction program passed preliminary tests on August 2004 and are going to be integrated in the LBC Blue Channel Camera Control System on the LBT telescope.

The official-software repository-URL is:
http://lbc.mporzio.astro.it/activeoptics_version.zip

Last version:
http://antu.mporzio.astro.it/activeoptics_sett2004.zip

REFERENCES

1. A. Di Paola et al., LBT Double Prime Focus Camera Control Software.

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