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VLT PROGRAM

Paranal Observatory

Very Large Telescope

Detector Test and Analysis Procedures

Optical CCDs

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Chapter 1

CCD Test and Analysis Procedures

1.1 Scope of the Document

This document describes the requirements and specifications for the test procedures of optical CCDs. It defines high-level details for the performance of the tests and of the subsequent analysis of the data.

The document shall serve as input for the establishment of CCD test and analysis procedures for optical detectors of scientific instruments at the Very Large Telescope VLT.

The report is meant as guide for more detailed and instrument related requirements to be specified by the respective VLT instrument responsibles.

1.2 Abreviations and Acronyms

In the document the following abreviations and acronyms are used:

ADU	Analogue-to-Digital Unit
AUTREP	Automatic Reporting Database
CCD	Charge-Coupled Device
CTE	Charge Transfer Efficiency
ESO	European Southern Observatory
etc.	et cetera
FFT	Fast Fourier Transform
FITS	Flexible Image Transport Format
FWHM	Full Width At Half Maximum
i.e.	id est
IOT	Instrument Operations Team
IR	infra-red
nm	nanometer
OB	Observation Block
ODT	Optical Detector Team
rms	Root Mean Square
QC	Quality Control
TBD	to be defined
USG	User Support Group
UV	ultra-violet

VLT	Very Large Telescope
σ	Standard Deviation

Chapter 2

General Items

2.1 CCD Detectors to be Tested

The procedures are defined for charge-coupled devices CCDs that operate in the visible wavelength range (including near-UV and near-IR). The typical wavelength range covered by these CCDs is 300 - 1000 nm.

The described procedures apply equally to monolithic CCDs and to mosaic detector arrays.

2.2 CCD Configurations

The CCDs can be operated in different modes, i.e. with different read-out mode, windowing, and pixel binning. The CCD tests should refer to all CCD modes used during science operation of the instrument. In practice, only a subset of CCD modes may be tested. These modes are to be defined by the instrument scientist of the respective instrument.

2.3 Test Environment

The images and data needed for the described CCD tests are acquired with the operational instrument at the Paranal Observatory. If needed, special test equipment (like a Beta light) may be installed in the instrument for the execution of the CCD tests.

2.4 Illumination Environment

It is mandatory to perform the tests with the instrument in a dark enclosure.

Several of the CCD tests use flatfield exposures. A pre-requisite for these tests is a stable illumination level of the CCD during the test. Instrument calibration units may be used for the flatfield illumination provided that their stability is of the order of 1 percent. Otherwise Beta lights may be used for the tests or - at least - to verify the stability of the light source for the test duration.

2.5 Test Execution

The tests shall be performed - widely - automatically, i.e. with a minimum of human interaction. Dedicated observation blocks containing normal and/or special observing and/ot calibration templates are used.

The CCD tests are executed by the observatory operations staff, i.e. by members of the Paranal science operations group or by the engineers of the instrumentation group of the Paranal engineering department.

2.6 Analysis and Results

The analysis is done in two ways:

- numerical results obtained through pipeline scripts
- visual inspection of the images obtained/calculated the test

The analysis makes use of automatic reduction procedures that are integrated in the pipeline of the respective instrument as installed at the observatory.

The quantitative results of the CCD tests are determined through dedicated pipeline scripts. The execution of the scripts is triggered with the end of the respective observation templates. The reduction script can also be launched separately from the execution of the respective OB. The results are given in the form of tables and images that are stored at the pipeline machine.

The analysis and interpretation of the results of the CCD tests is the responsibility of Paranal observatory with support from ODT and QC ESO Garching.

2.7 Documentation of the Results

The test results are documented in a CCD test report. The report is machine readable.

The most important test parameters as defined by the instrument scientists are stored in the AUTREP database of the observatory.

Selected results that are most important for the performance of scientific observations are also made available to the users through a dedicated web page, separatly for each instrument.

This web page should also show trending plots of CCD parameter measured as well as example images and reference values for each CCD. Whenever possible, the web page information shall be produced by scripts and automatic routines from output obtained from AUTREP and/or the pipeline and reporting tools.

The web page should be updated automatically when the results become available.

The web page also documents the interventions (dis/mounting, warm-ups, decontamination, pumping, heating etc.) of the respective CCDs.

The CCD test report is distributed to:

- the observatory director
- the head of the science operations group

- the head of the engineering department
- the head of the instrumentation group within the engineering department
- the responsible instrument scientists
- the responsible instrument engineers
- the detector team ODT at ESO Garching
- the quality control team QC at ESO Garching
- the user support group USG at ESO Garching

2.8 Responsibilities

The following responsibilities are defined:

- definition of the CCD test parameters: instrument scientist ESO Paranal
- preparation, implementation and maintenance of the pipeline for the the CCD test analysis: data managment division ESO Garching
- preparation, implementation and maintenance of the CCD test procedure: instrument scientist ESO Paranal with the help of the respective IOT, the software group at Paranal and the DMD Garching. The IOT shall help to define and review the details of the CCD test procedure for the respective instrument. The Paranal software group is responsible for the definition, implementation and maintenance of instrument related software and of the observing templates. The DMD provides support for the installation and problem analysis/solution of the respective pipeline scripts for the CCD test analysis.
- execution of the CCD test: instrumentation group of the engineering department ESO Paranal
- analysis of the results: instrument scientist and instrumentation group of the engineering department ESO Paranal (with help of ODT Garching and QC Garching as needed)

Chapter 3

Individual CCD Test Procedures

The following sections describe individual CCD test procedures. For each test they give:

- the purpose of the test including an outline of the most important principles how to obtain the respective results
- the data acquisition procedure including CCD setups, name of observing block and template types to be used - if needed also new template types are specified
- the data reduction procedure including the individual steps of data computation and evaluation, the name of the recipe to be used for the pipeline processing (if applicable) as well as the table, image and graphic content for the results produced
- the minimum parameter set for the QC monitoring and the storage in the AUTREP database. Further monitoring/storage parameters can be specified by the instrument scientist as needed.

3.1 CCD Tests Performed

Sections 3.5 - 3.13 describe the CCD tests foreseen for the characterization of the optical CCDs. The tests determine:

- the CCD mean bias level and noise amplitude
- large scale trends in the CCD bias level
- the CCD bad/hot pixels
- the CCD cold pixels
- the CCD transfer curve
- the CCD conversion factor
- the CCD read-out noise
- the CCD linearity range
- the CCD dark current
- the CCD mean charge transfer efficiency
- the shutter pattern and shutter delay
- the CCD electronics bit biases

3.2 Master Calibration Files Produced

The tests described produce the following master images useful for further calibrations:

- the CCD master bias image
- the CCD large scale bias trend image
- the FFT image of the residual image between CCD master bias and large scale bias trend image
- the CCD bad/hot pixel map
- the CCD cold pixel map
- the shuttern pattern

3.3 CCD Tests Not Performed

The following tests of CCDs are not described here and also not included in the standard test procedure of optical CCDs:

- the CCD reminiscence
- the CCD particle event rate
- the CCD electrical cross talks
- the CCD electromagnetic compatibility

3.4 Test OB Optimization

TBD. Here a recipe should be given on how to optimize the execution of the tests in order not to repeat unnecessarily exposures that are already taken for another analysis item of the overall test. The description of the individual test procedures is however meant for stand-along tests.

3.5 Bias Level and Noise Analysis of the CCD

Purpose of this test is

- to determine the mean bias level of the CCD and its error for a particular CCD mode (i.e. read-out mode).
- to analyse the noise properties of the bias exposures

The data evaluation consists of two steps:

- visual inspection of the bias exposures
- pipeline reduction

3.5.1 Data Acquisition

Dataset: 9 bias exposures per each CCD and each CCD configuration (i.e. read-out mode) to be analysed, to be performed with dedicated OB

3.5.1.1 CCD Setup

image size:	full frame including overscan
binning:	all operational binning, others TBD by instrument scientist
gain:	all operational gain settings, other gain to be used are TBD instrument scientist
ports:	all operational port settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.5.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_BIAS
Template:	generic instrument template for bias exposures

3.5.2 Visual inspection

Tasks overview: the bias exposures shall be inspected visually one by one. The same inspection described below shall also be applied to the master bias frame calculated in section 3.5.3.3. It is important to choose the cut levels such that low level effects are not hidden. Inspection items are:

- excessive number of cosmic rays (>5 events could be radioactivity near detector)
- wavy patterns across the chip due to electronic interference
- burst noise in parts of the chip (for instance in certain rows)
- salt-and-pepper noise, i.e. neighbouring pairs of high and low pixels
- slopes across the chip, i.e. large scale trends of the bias level (also check for bias injection slopes at leading end of rows)

- hot regions, for instance brightening towards corners
- dark spots

Note: it may be feasible to replace some of the visual inspections by numerical analysis of the bias images. Details are TBD.

Name of reporting script: TBD

Output: the results are given in a check list. The following entries should be given in the check list:

1. image ID (archive name of image)
2. CCD chip ID
3. cosmic rays: $<$ or $>$ limit; comment field
4. wavy pattern: yes/no; regions of the chip; frequency; amplitude; comment field
5. burst noise: yes/no; regions of the chip; extension; amplitude; comment field
6. salt-and-pepper noise: yes/no; regions of the chip; comment field
7. slopes: yes/no; regions of the chip; direction; amplitude; comment field
8. hot regions: yes/no; regions of the chip; extension; amplitude; comment field
9. dark spots: yes/no; regions of the chip; extension; amplitude; comment field

3.5.3 Pipeline reduction

3.5.3.1 Mean bias level and standard deviation

Task description: for each exposure, read-out sector and chip determine

- the mean bias level and its standard deviation in predefined windows of the chip
- the mean values and standard deviation of the mean bias level over the set of bias exposures, separately for each readout sector and each chip
- find images, chips and sectors deviating
  (1) by more than average standard deviation of sector and chip from respective average mean bias level
  (2) by more than 1 ADU from respective average mean bias level

Name of pipeline script: TBD DMD

Output: the results reported in table format.

Table format: a table with the following content shall be produced:

1. Title: CCD bias level analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID

4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Result: list CCD sector, mean bias level and standard deviations for all bias exposures taken average over all windows per sector
8. Result: list images, chips and sectors deviating by more than standard deviation from respective average mean bias level, give also value of deviation
9. Result: list images, chips and sectors deviating by more than 1ADU from respective average mean bias level, give also value of deviation

3.5.3.2 Bias level noise distribution

Task description: for each bias image calculate frequency histogram of bias levels and determine the following properties per sector and chip

- the bias level for the peak in the histogram
- the full-width-at-half-maximum (FWHM) of the main peak in the histogram
- the root-mean-square (rms) of the best fit of a gaussian function to the histogram and the histogram of the deviations from the Gaussian fit

Name of pipeline script: TBD DMD

Output: the results reported in tabular and graphical format.

Table format: a table with the following content shall be produced:

1. Title: bias level noise histogram
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Result: chip sector, mean level, FWHM, rms of best fit, number of pixels inside/outside of FWHM around mean value

Graphical format: plots with the following content shall be produced:

1. Title: bias level noise histogram
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name

5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: chip sector, mean level, FWHM, rms of best fit, number of pixels inside/outside of FWHM around mean value
8. Subplot 1: histogram of bias level distribution
9. Subplot 1: graph of Gaussian fit to histogram
10. Subplot 2: histogram of the deviations from the Gaussian fit
11. Subplot 1+2: indicate mean value of bias level and FWHM

3.5.3.3 Master bias frame

Task description: determine the master bias frame by calculating for each pixel the median average value in the series of bias exposures available. This pixelwise median averaging must be done for each chip separately. For the master bias frame repeat calculation of section 3.5.3.2 i.e. calculate frequency histogram of bias levels in master frame for each chip and sector&region and determine

- the bias level for the peak in the histogram
- the full-width-at-half-maximum (FWHM) of the main peak in the histogram
- the root-mean-square (rms) of the best fit of a gaussian function to the histogram and the histogram of the deviations from the fit

Name of pipeline script: TBD DMD

Output: the results are reported in table format and as image.

Table format: the table format applies to the histogram analysis of the master bias frame and should follow the respective table format specifications as given in section 3.5.3.2.

Image format: the image format is given as bias image in FITS and postscript version.

FITS version: the master bias frame should be produced in the usual format as defined for bias exposures of the respective instrument.

Postscript version: the postscript file of the master bias image (one file per chip) should be produced with the following layout:

1. Title: CCD master bias frame
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: CCD chip ID
5. Title: CCD setting (gain, readout mode, binning, windowing)

followed by the postscript image of the master bias image.

3.5.3.4 Large scale trends in bias image

Task description: on the master bias frame (except overscan regions) perform a rms fit for large scale trends across the readout sector and chip using the following expressions:

$$x\ direction \quad A \times exp(B \times x) + C + D \times x + E \times x^2 + F \times x^3 \tag{3.1}$$

$$y\ direction \quad A \times exp(B \times y) + C + D \times y + E \times y^2 + F \times y^3 \tag{3.2}$$

The number of fit constants ABCDEF, separately for x and y direction, to be used should be defined by the instrument scientist. After the fit is optimized, the 2-dimensional result image of the fit and the 2-dimensional image of the residuals between master bias image and fit image is calculated.

Name of pipeline script: TBD DMD

Output: the results are reported in image format.

Image format: the image format is given as bias image in FITS and postscript version.

FITS version: two fits images are produced: the 2-dimensional result image of the fit and the 2-dimensional image of the residuals between master bias image and fit image.

Postscript version: postscript files (one file per chip) should be produced for both images with the following layout:

1. Title: CCD bias large scale trend frame
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: CCD chip ID
5. Title: CCD setting (gain, readout mode, binning, windowing)
6. Title: chip sector and fit parameters A, B, C, D, E, F in x and Y direction separately

followed by the postscript image of the the 2-dimensional image of the residuals between master bias image and fit image.

3.5.3.5 Fast Fourier transform analysis (FFT)

Task overview: calculate the FFT image of the residual image obtained via large scale trend analysis of bias exposures (see section 3.5.3.4). This image can be used for visual inspections of periodic and non-periodic noise patterns in the master bias image.

Note: in order to identify periodic and non-periodic patterns of individual images it is necessary to calculate FFT images from individual bias exposures first processed according to the procedure described in section 3.5.3.4. The result images should be suitable for the analysis of particular patterns of variable phase in time that may not appear in the master bias image of the series.

Name of pipeline script: TBD

Output: the result is the FFT image of the residual image in FITS format as described in section 3.5.3.4.

3.5.4 AUTREP/QC Parameters

For the results of the visual inspection no AUTREP/QC reporting is foreseen.

The pipeline analysis should provide the following AUTREP information:

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning, windowing)
6. chip sector, mean bias level and standard deviations for all bias exposures taken average over all windows per sector
7. chip sector, mean level, FWHM of histogram, rms of best fit, number of pixels inside/outside of FWHM around mean value all applicable for master bias frame
8. chip sector, parameters ABCDEF in x and y direction of large scale trend analysis of master bias frame
9. master bias frame
10. residual image of large scale trend analysis of master bias frame

3.6 CCD Bad Pixels

Purpose is to identify the CCD pixels with bad response (hot/bad pixels).

Bad/hot pixels are found in master bias frame as 5 sigma outliers (both directions) from the mean bias level in the respective sector of the chip.

3.6.1 Data Acquisition

Dataset: 9 bias exposures for each CCD and each CCD configuration (i.e. read-out mode) to be analysed, to be performed through dedicated OB

3.6.1.1 CCD Setup

image size:	full frame including overscan
binning:	1x1 (default), others TBD by instrument scientist
gain:	at least one gain setting, this and other gains to be used are TBD instrument scientist
ports:	single port (default), others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.6.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_BADPIX
Template:	generic instrument template for bias exposures

3.6.2 Pipeline Reduction

Task description: first, the master bias frame of the respective bias exposures is determined as well as the mean level and its standard deviation σ of master bias frame per sector and chip (see section 3.5).

For each chip and sector therein find all pixels that deviate in ADU level by more than 5σ from the mean ADU level of that chip and sector. For the pixels identified calculate the deviation factor defined as ratio of deviation from mean level divided by σ (in ADU)

Name of pipeline script: TBD DMD

Output: the results are reported in table format and as image as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD bad/hot pixel analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID

6. Title: CCD setting (gain, readout mode, binning, windowing)
7. Title: sector&region, average mean bias level, standard deviation
8. Result: then a list of all bad/hot pixels detected is given with x and y position on the chip as well deviation ratio

Image format: the image format is given as CCD bad pixels image in FITS and postscript version.

FITS version: for the whole CCD chip mosaic produce a fits image of the size of the bias frames used for this test with the following flux levels

- 0 for all pixels below 5 σ deviation from the mean flux level in the master bias frame
- 1 for all pixels below 5 σ deviation from the mean flux level in the master bias frame

The fits header of the image shall be as defined for a bias image. However, it should contain the fits header keywords as defined for the bad/hot pixel mask image.

Postscript version: the postscript file of the image (one file per chip) should be produced with the following layout:

1. Title: CCD bad/hot pixel analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: CCD chip ID
5. Title: CCD setting (gain, readout mode, binning, windowing)

followed by the postscript image of the bad/hot pixel image.

3.6.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning, windowing)
6. x and y pixel coordinates and deviation ratio of bad/hot pixels

3.7 CCD Cold Pixels

Purpose is to identify the CCD pixels with reduced response.

Cold pixels are found in master screen flatfield frames as outliers with more than 5 σ (σ = standard deviation) below the mean exposure level in the respective sector of the chip.

3.7.1 Data Acquisition

Dataset: 5 screen flatfield exposures for each CCD and each CCD configuration (i.e. read-out mode) to be analysed, use of suitable filter (without artifacts) is recommended, to be performed through dedicated OB

3.7.1.1 CCD Setup

image size:	full frame including overscan
binning:	1x1 (default), others TBD by instrument scientist
gain:	at least one gain setting, this and other gains to be used are TBD instrument scientist
ports:	single port (default), others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.7.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_COLDPIX
Template:	generic instrument template for screen flatfield exposures

3.7.2 Pipeline reduction

Task description: first, the master flatfield frame for the respective series of screen flatfield exposures is determined as well as mean level and standard deviation σ of master screen flatfield frame per sector and chip (for details of producing a master flatfield see normal pipeline procedures).

For each chip and sector therein find all pixels that deviate - to the negative side - in ADU level by more than 5σ from the mean ADU level of that chip and sector. For the pixels identified calculate the deviation factor defined as ratio of deviation from mean level divided by σ (in ADU).

Name of pipeline script: TBD DMD

Output: the results are reported in table format and as image as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD cold pixel analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name

5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning, windowing)
7. Title: sector&region, average mean bias level, standard deviation
8. Result: then a list of all bad/hot pixels detected should be given with x and y position on the chip as well as deviation ratio

Image format: the image format is given as CCD cold pixels image in FITS and postscript version.

FITS version: for the whole CCD chip mosaic produce a fits image of the size of the master flatfield frame used for this test with the following flux levels

- 0 for all pixels below 5σ deviation from the mean flux level in the master bias frame
- 1 for all pixels below 5σ deviation from the mean flux level in the master bias frame

The fits header of the image shall be as defined for a bias image. However, it should contain the fits header keywords as defined for the cold pixel mask image.

Postscript version: the postscript file of the image (one file per chip) should be produced with the following layout:

1. Title: CCD cold pixel analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning, windowing)

followed by the postscript image of the bad/hot pixel image.

3.7.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning, windowing)
6. x and y pixel coordinates and deviation ratio of cold pixels

3.8 Transfer curve, CCD conversion factor and readout noise

Purpose is

- to determine the CCD conversion factor (inverse CCD gain factor)
- to determine the readout noise of the CCD

The transfer curve allows to measure the CCD conversion factor and the CCD read-out noise through the relationship:

$$\sigma_A^2 = 1/g_0 \times I_{ADU} + 1/({g_0}^2 \times {\sigma_{ron}}^2) \tag{3.3}$$

with

σ_A = the standard deviation of the signal in ADU
g_0 = CCD gain (inverse conversion factor in electrons/ADU)
I_{ADU} = the illumination level in ADU
σ_{ron} = readout noise of the CCD in ADU

σ_A^2 and I_A can be determined through a series of screen flatfield exposures of different exposure level. The equation defines a linear relationship between σ_A^2 and I_A with the CCD conversion factor (inverse gain) as slope parameter and $1/(g^2 \times \sigma_r on^2)$ as y axis intercept.

The CCD transfer curve can be determined from a set of screen flatfield exposures of different exposure level.

Eq. 3.3 assumes strict linearity of the CCD response which may only be fullfilled over a certain range of exposure levels (TBD instrument scientist). The non-linearity of the CCD is assessed through a procedure described in section 3.9. Consequently, the gain factor g_0 obtained in the test described in this section is only the zero-order approximation.

3.8.1 Data acquisition

Dataset: take two exposure series of screen flatfield exposures, each series consisting of pairs of exposures with identical integration time. The first series should have increasing exposure times, the second one decreasing exposure times. The exposure times should chosen such as to cover the linearity range of the CCDs from close to bias level to start of non-linearity or just below saturation. The exposure times of the increasing and decreasings series should be interleaved to allow for checks of the stability of the illumination level (if required).

Example:

- series with increasing exposure times: 0.5 1.0 2.0 4.0 8.0 15. 30.
- series with decreasing exposure times: 50. 25. 12. 6. 3. 1.5 0.75 0.25

with the actual exposure series executed to be:

0.5 – 0.5 – 50. – 50. – 1.0 – 1.0 – 25. – 25. – 2.0 – 2.0 – 12. – 12. etc.

The actual exposure times to be used depend on the CCDs to be measured and their bias level and linearity range as well as on the illumination level provided by the calibration unit. For the characterization of the bias level see section 3.5, for the linearity range see section 3.9 .

The data acquisition is to be performed through a dedicated OB using suitable templates for the screen flatfield exposure series.

It is assumed that suitable master bias frames for the respective CCD settings are available (see section 3.5).

3.8.1.1 CCD Setup

image size:	full frame including overscan
binning:	all operational binnings, others TBD by instrument scientist
gain:	all operational gain setting, others TBD by instrument scientist
ports:	all operational port settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.8.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_GAIN
Template:	generic instrument template for screen flatfield exposures generic instrument template for bias exposures (to produce master bias if not available otherwise)

3.8.2 Pipeline reduction

Task description: in preparation of the analysis phase the following data processing is needed:

- obtain the master bias according to section 3.5 and applicable for the CCD setup used and the time of the evaluation of the CCD transfer curve
- subtract master bias from each exposure of the series of screen flatfields

Thereafter, for each CCD and each readout sector:

- subtract the two exposures of the pairs of equal integration time in a series from each other
- compute the variance in the difference image and divide result by 2 (result 1)
- compute mean signal of pair of exposure of equal integration time in a series (result 2)
- compute linear fit of result 1 versus result 2
- derive slope ($= 1/\mathrm{g}_0$) and y axis intercept ($= 1/{g_0}^2 \times {\sigma_{ron}}^2$) plus error and quality of the fit
- compute g_0 and σ_{ron} plus errors
- determine mean value of g_0 and σ_{ron} plus errors for all windows measured per CCD sector

Notes: (1) Suitable regions for the various CCDs and readout sectors need to be defined by the instrument scientist in beforehand. Such regions should be free of non-linear effects (like hot and cold pixels, traps, bad rows/columns, fixed pattern noise).

(2) For the calculation of the CCD transfer curve it is also important keep the exposure levels used within the linearity range of the CCD (see section 3.9).

Name of pipeline script: TBD DMD

Output: the results are reported in tabular and graphical format as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD gain and read-out noise analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: date and name of the master bias used
8. Result: list CCD sector, mean conversion factor plus error, mean readout noise plus error per sector
9. Result: list for each window per CCD sector the conversion factor and readout noise plus errors
10. Result: list for each window per CCD sector the quality parameter of the fit and the range of exposure level used for the fit
11. Result: thereafter for each chip and readout sector list exposure pair, result 1, result 2, the residual of result 1 compared to the fit

Graphical format: for each CCD and read-out sector (port) a plot with the following layout should be produced:

1. Title: CCD gain and read-out noise analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: date and name of the master bias used
8. Title: list CCD sector, mean gain factor plus error, mean readout noise plus error per sector
9. Title: list for each window used in the subsequent plot the mean gain factor, the mean readout noise plus errors and the quality of the fit
10. Plot: for each window of read-out sector plot result 1 versus result 2 and fit line (in same plot for up to 5 read-out windows)

The transfer curve, below saturation, should be a straight line.

3.8.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning)
6. CCD sector, mean gain and mean readout noise per sector plus errors and fit quality
7. CCD windows per sector plus mean gain and readout noise per window plus errors and fit quality

3.9 Linearity of the CCD response and shutter delay

Purpose of the test is

- to measure the linearity of the CCD response over the range of non-saturation
- to determine the average shutter delay

Linearity: deviations from linearity in the CCD response appear in two ways: a systematic non-linearity g_1 of the gain factor g_0 and a statistical variation g_s of the CCD response over the range of non-saturation.

The determination of the gain factor described in section 3.8 assumes "zero non-linearity" of the CCD conversion factor g_0. As a first-order approximation the effective CCD conversion factor g may depend the actual exposure level, both systematically (g_1) and in a statistical (g_s) way.

Shutter delay: the shutter delay s is the correction by which the reported shutter-open time T deviates from the actual shutter-open time t. The reported shutter-open time T is the time written in the fits header of the image as reported by the instrument, the actual shutter-open time t is the one actually seen by the pixels of the CCD. The actual shutter-open time t may vary over the field of view of the CCD chip. This variation is determined through the procedure described in section 3.12. However, as a good first-order approximation a constant average shutter delay s across the field of view can be assumed.

$$t = T + s \tag{3.4}$$

Test principle: like for the determination of the CCD conversion factor the determination of the deviations from linearity (g_1 and g_s) and of the shutter delay (s) are obtained by a statistical analysis of an exposure series with different exposure level. The most important pre-requisite for the success of such a test series is constant illumination level over time, i.e. the light source and illumination level of the CCD should not vary during the duration of the test. Usually this requires special stabilized light sources or so called Beta lights, devices that use radioactive fluorescence in the illumination source.

g_1 and s: a fit of the count level I measured in the exposure series, using a second order polynomial in the actual exposure time t,

$$I = a_2 \times t^2 + a_1 \times t + a_0 \tag{3.5}$$

yields the fit parameters a_2, a_1 and a_0 and from that - using also zero-order approximation of the CCD gain g_0 (see section 3.8) - the non-linear conversion factor g_1

$$g_1 = g_0^2/(a_1^2/a_2 - 4 \times a_0) \tag{3.6}$$

and the first approximation of the average shutter delay as one of the zero points of the quadratic function for I

$$I = 0 \qquad for\ t\ =\ s \tag{3.7}$$

In order to avoid artifacts introduced by inaccurate bias level subtraction of the exposure series used, one should check that the following inequality is fulfilled:

$$b << g_0 \times F \times s = I_0(s) \tag{3.8}$$

with b as the estimated uncertainty of the bias level subtracted from the images of the exposure series, F as the number of signal electrons per second and $I_0(s)$ as the estimated count rate using the zero-order gain factor g_0 (see section 3.8) and the shutter delay s as exposure time.

g_s: g_s can be estimated by an analysis of the so called fractional count rate C_f. In first-order approximation C_f is given by:

$$C_f = 1 + g_1 \times F \times (T + s)/g_0 \tag{3.9}$$

C_f is approximately equivalent to the ratio of the count rate of the actual exposure time corrected for the shutter delay to the mean count rate of the whole exposure series. The deviations dev of the C_f data obtained from the exposure series versus the best fit curve of C_f determines the statistical non-linearity variations g_s. Usually, the maximum deviation is considered to be representative for the statistical non-linearity factor g_s.

3.9.1 Data acquisition

Dataset: as for the determination of the CCD transfer curve and conversion/gain factor (see section 3.8) take two exposure series of screen flatfield exposures, each series consisting of pairs of exposures with identical integration time. The first series should have increasing exposure times, the second one decreasing exposure times. The exposure times should be chosen such as to cover the exposure level range of the CCDs from close to bias level to just below saturation. The exposure times of the increasing and decreasings series should be interleaved.

Example:

- series with increasing exposure times: 0.5 1.0 2.0 4.0 8.0 15. 30.
- series with decreasing exposure times: 50. 25. 12. 6. 3. 1.5 0.75 0.25

with the actual exposure series executed to be:

0.5 – 0.5 – 50. – 50. – 1.0 – 1.0 – 25. – 25. – 2.0 – 2.0 – 12. – 12. etc.

The actual exposure times to be used depend on the CCDs to be measured and their bias and saturation level as well as on the illumination level provided by the calibration unit. For the characterization of the bias level see item 1, the saturation limit should be found in the CCD system specifications (physical saturation limit of the chip or saturation limit set by the analogue-to-digital converter in the read-out registers of the chip, whatever is smaller).

The data acquisition is to be performed through a dedicated OB using suitable templates for the screen flatfield exposure series.

It is assumed that suitable master biases for the respective CCD settings (see section 3.5).

3.9.1.1 CCD Setup

image size:	full frame including overscan
binning:	all operational binnings, others TBD by instrument scientist
gain:	all operational gain setting, others TBD by instrument scientist
ports:	all operational settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.9.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_LINEARITY
Template:	generic instrument template for screen flatfield exposures generic instrument template for bias exposures (to produce master bias if not available otherwise)

3.9.2 Pipeline reduction

Preparation: the following data processing is needed in preparation of the analysis phase:

- obtain the master bias according to item 1 and valid for the CCD setup used and the time of the evaluation of the CCD transfer curve
- subtract master bias from each exposure of the series of screen flatfields

3.9.2.1 First-Order non-linearity of CCD conversion factor and Shutter Delay

Analysis: for each CCD and each readout sector define a set of windows and separately for each window

- compute mean signal I of pair of exposure of equal integration time per exposure series
- compute quadratic fit to I using equation (3.2) to obtain fit parameters a_0, a_1 and a_2
- calculate g_1 using equation (3.3) and s solving equation (3.4)

Then, for each CCD sector

- calculate the mean values of g_1 and s as well as their standard deviations

Notes: Suitable regions for the various CCDs and readout sectors need to be defined by the instrument scientist in beforehand. Such regions should be free of non-linear effects (like hot and cold pixels, traps, bad rows/columns, fixed pattern noise).

Name of pipeline script: TBD DMD

Output: the results are reported in tabular and graphical format as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD systematic non-linearity and shutter delay analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: date and name of the master bias used
8. Title: mean conversion factor g_0 applied
9. Result: list CCD sector, mean first-order gain factor g_1 plus error, mean shutter delay plus error per sector

10. Result: list for each window per CCD sector the first-order gain factor g_1 and the shutter delay s plus errors
11. Result: thereafter for each chip and readout sector list exposure pair, mean signal I and comparison exposure level computer from fit plus deviation between both

Graphical format: for each CCD and read-out sector (port) a plot with the following layout should be produced:

1. Title: CCD systematic non-linearity and shutter delay analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: date and name of the master bias used
8. Title: mean conversion factor g_0 applied
9. Title: list CCD sector, mean first-order gain factor g_1 plus error, mean shutter delay plus error per sector
10. Title: list for each window used in the subsequent plot the mean first-order gain factor g_1 and the shutter delay s plus errors
11. Plot: for each window of read-out sector plot mean signal I and fit line versus time T (in same plot for up to 5 read-out windows)
12. Plot: the exposure level range used for the fit

3.9.2.2 Statistical Non-Linearity of the CCD

Analysis: for each CCD and each readout sector

- compute mean signal I of each pair of exposure of equal integration time in the series
- compute mean count rate R(T) of each exposure pair in the series by dividing I through reported exposure time T
- calculate mean value of R(T) over the whole exposure series
- calculate fractional count rate $C_f(T)$ by dividing R(T) of each exposure pair of the series by the mean value of R(T)
- determine best fit to $C_f(T)$ using equation (3.6)
- determine deviations dev of $C_f(T)$ data from best fit for the exposure times used,
- determine the mean absolute and maximum values of deviations dev over the readout sectors of the CCD and the standard deviations (mean value only); the maximum of the absolute values of dev is called the statistical non-linearity g_s

- compute also the mean value and maximum of g_s for the whole CCD

Notes: (1) Suitable regions for the various CCDs and readout sectors need to be defined by the instrument scientist in beforehand. Such regions should be free of non-linear effects (like hot and cold pixels, traps, bad rows/columns, fixed pattern noise).

(2) Light sources that are not constant will introduce additional scattering in the data and results. As a simple check for constant illumination level the calculations mentioned above could be repeated for the two exposure series, if performed during the tests, i.e. separatedly for the series of increasing exposure times and for the series of decreasing exposure times. Non-constant illumination level should be identified by systematic offsets between the two series, in particular in plots of R(T) versus I(T).

Name of pipeline script: TBD DMD

Output: the results are reported in tabular and graphical format as follows:

Output: the results are reported in tabular and graphical format as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD statistical non-linearity analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: date and name of the master bias used
8. Title: mean conversion factor g_0 applied
9. Result: list mean and maximum absolute value of g_s plus error for whole chip
10. Result: list CCD sector, mean and maximum absolute value of g_s plus error
11. Result: list for each window per CCD sector the mean and maximum absolute value of g_s plus errors
12. Result: thereafter for each chip and readout sector list exposure pair, mean signal I, C_f(T) and deviation dev between C_f(T) and best fit

Graphical format: for each CCD and read-out sector (port) a plot with the following layout should be produced:

1. Title: CCD statistical non-linearity analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID

6. Title: CCD setting (gain, readout mode, binning)

7. Title: date and name of the master bias used

8. Title: mean conversion factor g_0 applied

9. Title: mean and maximum absolute value of g_s plus error for whole chip

10. Title: list CCD sector, mean and maximum value of g_s plus error per sector

11. Title: list for each window used in the subsequent plot the mean and maximum absolute values of g_s plus errors

12. Subplot 1: for each window of read-out sector plot $C_f(T)$ versus $R(T)$ and fit line (in same plot for up to 5 read-out windows)

13. Subplot 2: for each window of read-out sector plot dev versus $R(T)$ (in same plot for up to 5 read-out windows)

14. Subplot 1+2: the exposure level range used for the fit

3.9.3 AUTREP/QC Parameters

1. date, start/end time for OB execution

2. OB name and ID

3. pipeline recipe name

4. CCD chip ID

5. CCD setting (gain, readout mode, binning)

6. CCD sector plus mean first-order gain factor g_1 plus error, mean shutter delay plus error, mean and maximum absolute value of g_s plus error determined for sector

7. CCD windows per sector mean first-order gain factor g_1 plus error, mean shutter delay plus error, mean and maximum absolute value of g_s plus error determined for window

3.10 CCD Dark Current

Purpose is to measure the electronic dark current of the CCD.

3.10.1 Data Acquisition

Dataset: a series of (at least) 3 half hour integrations with the exposure shutter (and all other shutters in the light path) closed. The integrations should happen in a dark environment around the instrument (dark dome).

3.10.1.1 CCD Setup

image size:	full frame including overscan
binning:	1x1 (default), others TBD by instrument scientist
gain:	all operational gain setting, others TBD by instrument scientist
ports:	all operational settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.10.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_DARK
Template:	generic instrument template for dark exposures generic instrument template for bias exposures (to produce master bias if not available otherwise)

3.10.2 Pipeline reduction

Task description: first, the following data processing is needed in preparation of the analysis phase:

- obtain the master bias according to section 3.5 and valid for the CCD setup used and the time of the evaluation of the CCD dark current
- subtract master bias from each exposure of the series of dark exposures

Then, for each CCD chip and readout sector

- determine median of bias subtracted dark exposures (median dark image)
- divide median dark image by exposure time and multiply by CCD conversion factor (dark current image)
- measure dark current (in electrons per second) and its standard deviation in selected regions of the dark current image
- for each CCD chip determine the mean dark current values of the readout sectors used for the respective CCD setting as well as the standard and maximum deviation of the mean value of the dark current.

Note: the regions for the dark current measurements should be free of CCD artifacts. They should be defined by the instrument scientist.

Name of pipeline script: TBD DMD

Output: the results are reported in tabular format as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD chip ID
2. Title: CCD readout setting
3. Title: date of the OB execution
4. Title: date and name of the master bias used
5. Title: dates and names of the dark current exposures
6. Title: OB name
7. Title: pipeline recipe name
8. Result: for each chip the regions of the dark current measurements together with the dark current value, its standard and maximum deviation
9. Result: for each chip the mean value of the dark current plus standard and maximum deviation

3.10.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning, windowing)
6. mean dark current and its standard and maximum deviation

3.11 Charge transfer efficiency

Purpose is to measure the average charge transfer efficiency CTE of the CCD chip for colmns and rows. CTE is only defined for the direction in which the pixel charges are transfered during readout (column or row).

The CTE is obtained through

$$CTE = 1 - I_{n+1}/(n \times I_n) \tag{3.10}$$

with

I_n = the counts above bias level in the last pixel of the imaging region of the row/column
$\mathrm{I}_n + 1$ = the counts above bias level in the first pixel in the overscan region
n = number of pixel transfers along the row/column which the nth pixel made before arriving at the output amplifier (i.e. including prescan region).

For readout direction along rows the intensity I should be obtained by collapsing the columns of the chip and vice versa.

3.11.1 Data acquisition

Dataset: obtain a well exposed (but unsaturated) screen flatfield exposure together with a series to create a master bias (see section 3.5). Single port unbinned read-out is recommented.

3.11.1.1 CCD Setup

image size:	full frame including overscan
binning:	1x1 (default), others TBD by instrument scientist
gain:	all operational gain setting, others TBD by instrument scientist
ports:	all operational settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.11.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_CHARGETRANSFER
Template:	generic instrument template for screen flatfield exposures
	generic instrument template for bias exposures (to produce master bias if not available otherwise)

3.11.2 Pipeline reduction

Preparation: the following data processing is needed in preparation of the analysis phase:

- obtain the master bias according to item 1 and valid for the CCD setup used and the time of the evaluation of the CCD dark current

Task description: for each CCD and each readout sector:

- subtract master bias from screen flatfield exposure

- collapse result frame to calculate the mean row/column of the image leaving out pixels from the overscan region
- apply equation above to calculate CTE for row/columns of the CCD plus error
- average CTE over available pixels of imaging section

Name of pipeline script: TBD DMD

Output: the results are reported in tabular format.

Table: a table with the following content shall be produced:

1. Title: CCD charge transfer efficiency analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning)
7. Title: date and name of the master bias used
8. Result: per readout sector list mean CTE, standard and maximum deviation from mean CTE value

3.11.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning)
6. CCD sector plus mean mean CTE, standard and maximum deviation from mean CTE value

3.12 Shutter pattern

Purpose is to determine the shutter pattern that is indicative for a non-linear performance of the shutter during opening and closing and that may result in a non-uniform exposure level across the chip.

The shutter pattern is obtained from two image of equal exposure level (equal reported exposure time), one image being exposed with one opening/closing of the shutter, the other one being exposed with a larger number of opening/closing of the shutter without reading out the CCD. The important aspect is to obtain the same exposure level for both images for the maximum number of opening and closing operations of the shutter. This is usually achieve by making the total shutter open time of the second exposure equal to the exposure time of the first image and using a short (shortest possible) shutter open time for the individual open/close cycles. Exposure saturation should be avoided.

The shutter delay s_i for a CCD pixel is calculated by

$$s_i = (t_1 \times I_{2,i} - t_2 \times I_{1,i})/(n \times I_{1,n} - I_{2,i}) \tag{3.11}$$

with

s_i = total shutter delay at a pixel i
t_1 and t_2 = reported exposure time of image 1 (single opening/closing of shutter) and image 2 (multiple opening/closing of shutter), respectively
I_1, i and I_2, i = counts in pixel i for image 1 and image 2, respectively
n = number of shutter opening and closing operations of image 2

3.12.1 Data acquisition

Dataset: obtain two images of equal reported shutter open time, one images exposed with a single opening and closing of the shutter, the other one with multiple openings and closings of the shutter until the same total opening time as for the first one is reached.

3.12.1.1 CCD Setup

image size:	full frame including overscan
binning:	1x1 (default), others TBD by instrument scientist
gain:	one gain setting, others TBD by instrument scientist
ports:	all operational settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.12.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_SHUTTERPATTERN
Template:	new template INSTRUMENT_GEN_CCD_SHUTTERPATTERN (see below)

The new template INSTRUMENT_GEN_CCD_SHUTTERPATTERN should

- put the instrument and telescope in calibration position

- setup the instrument configuration
- switch on/off the calibration unit (flatfield lamps only)
- take first exposure with single opening of the shutter
- take second exposure with multiple openings of the shutter, but equal total reported exposure time as first exposure
- exposure time and number of shutter openings should be user defined through template keyword

3.12.2 Pipeline reduction

Task description: for each pixel and CCD chip

- calculate the total shutter delay according to the formula above
- divide the resulting image s_i by the number of opening and closing operations of the multiple exposure image
- calculate average shutter delay time from the result image plus standard and maximum deviations from mean value

Name of pipeline script: TBD DMD

Output: the results are reported in table format and as image.

Table format: a table with the following content shall be produced:

1. Title: CCD shutter delay pattern analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning, windowing)
7. Result: average shutter delay for whole image plus standard and maximum deviation from mean value

Image format: the image format is given as shutter delay pattern image in FITS and postscript version.

FITS version: the calculated shutter delay pattern image (see above)

Postscript version: the postscript file of the image (one file per chip) should be produced with the following layout:

1. Title: CCD shutter delay pattern analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID

4. Title: CCD chip ID
5. Title: CCD setting (gain, readout mode, binning, windowing)
6. Title: average shutter delay for whole image plus standard and maximum deviation from mean value

followed by the postscript image of the shutter delay pattern.

3.12.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning, windowing)
6. average shutter delay for whole image plus standard and maximum deviation from mean value
7. fits image of the shutter delay pattern

3.13 Bit Biases

Analogue-to-digital converters (ADC) occasionally show imperfect performance and a bit can become completely stuck. In result, a well performing ADC should produce a "white" distribution of 0 and 1 bits for a well-exposed and unsaturated image.

3.13.1 Data Acquisition

Dataset: a well exposed unsaturated screen flatfield image.

3.13.1.1 CCD Setup

image size:	full frame including overscan
binning:	1x1 (default), others TBD by instrument scientist
gain:	one gain setting (default, TBD instrument scientist), others TBD by instrument scientist
ports:	all operational settings, others TBD by instrument scientist
chips:	all chips in dewar, other selection TBD instrument scientist

3.13.1.2 Observing Block and Templates

OB name:	INSTRUMENT_GEN_CCD_BITBIAS
Template:	generic instrument template for screen flatfield exposures

3.13.2 Pipeline reduction

Task description: for CCD chip and for each bit of the digital dynamic range used, count the number of occurences of 1's and 0's in the image. Calculate the relative occurence of 1's and 0's.

Name of pipeline script: TBD DMD

Output: the results are reported in tabular and graphical format as follows:

Table format: a table with the following content shall be produced:

1. Title: CCD bit bias analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning, windowing)
7. Result: for each CCD chip and each bit of the digital dynamic range list the counts of 1's and 0's plus the relative percentage of their occurence

Image plot: the image format is given as postscript version with the following layout:

1. Title: CCD cold pixel analysis
2. Title: date, start/end time for OB execution
3. Title: OB name and ID
4. Title: pipeline recipe name
5. Title: CCD chip ID
6. Title: CCD setting (gain, readout mode, binning, windowing)
7. for each CCD chip plot the occurence statistics of 1's and 0's over the bit number

3.13.3 AUTREP/QC Parameters

1. date, start/end time for OB execution
2. OB name and ID
3. pipeline recipe name
4. CCD chip ID
5. CCD setting (gain, readout mode, binning, windowing)
6. for each bit number the occurence statistics of 1's and 0's