Req 5.6.3

Title:

Photometric Calibration - Zeropoint key bands - doit

Objective:

Determine the zeropoint of the overall detector chain, separately for each CCD chip, in all four keybands (no composite filter) and the true atmospheric extinction at midnight by measuring standard stars in the 4 key passbands in one of the eight equatorial fields and the polar field. Do this every night whatever the science programme on the telescope may be. Optionally, add one observation of another equatorial standard field with higher airmass to obtain a redundant, classical, measurement of the atmospheric extinction.

The keybands plus the two-lens corrector form the standard for this requirement, the use of the ADC is considered as User mode (see **req.**564).

The zeropoint corresponding to the DQE of each of the 32 CCD chips will be determined on an individual chip basis $g_{DQE}(0, N, X)$. Thus the composite filter can not be used for this. However, additional data will be acquired with the composite filter for redundancy. In case the relative gain variations of individual CCD chips appear small and well characterized by the overall flatfield (which is not really expected) then the **req.** might be fulfilled with only the composite filter, substantially releaving the data rate and workload.

The combination of the data of **req. 562** $Monitoring$ taken at the middle of the night with the present zeropoint data will be used to solve separately for the effect of the extinction and DQE at the middle of the night. A standard extinction curve will be used as a reference, for error analysis, and to support the derivation of the solutions in the pipeline processing.

As **primary standards** the Landolt equatorial fields will be used, possibly extended with preparatory programme results (Section 7 of CP). For each of the 8 equatorial fields a solution for **secondary standard** stars will be made for a larger, one degree, field of view. The acquisition of catalogues of secondary standards is discussed in **req.**569. These secondary standards data will be used for the nightly determination of the zeropoint.

During commissioning the reproducibility of the zeropoint determination should be verified for the different observing modes **Mode– jitter** N=5 and **Mode–dither** N=5. This also serves as an end-to-end-test.

In the case that composite filter data is used for the analysis, the transformation between composite and monolithic key band filters should be taken into acount (see **req. 565** *Filter band passes*).

Fulfilling or fulfilled by:

selfstanding, but uses data of **req.**562 at the middle of the night.

When performed/frequency:

Once in the middle of each night. The linking of external (primary) to internal (secondary) standards will be done once during commissioning, and the first year of operation for each standard field; after that to be determined by experience.

It is to be determined by experience (stability of the system) whether the nightly zeropoint measurements can be relaxed as follows: in case the keyfilters are not used for science observations in a particular night, it is sufficient to only take an exposure with the composite filter.

During commissioning the **Mode– dither** N= and **Mode– jitter** N= have to be verified.

Sources, observations, instrument configurations:

Strategy– freq Mode– Stare N=1 **OmegaCAM** equatorial fields; exposures in u', g', r' and i' and composite. Two lens corrector.

Inputs:

In pipeline data reduction, the **req.**563 reductions of a given night should preceed the **req. 562** *Monitoring* reductions.

The inputs for deriving the photometry result tables are:
Fully calibrated image of equatorial standard field
CalFile– 569 *Secondary Standard Catalog*

The inputs for deriving the zeropoints for the night are:
List of photometry result tables
CalFile– 562 *Extinction night report*
CalFile– 564E *Standard extinction curve*

Outputs:

The output from deriving a photometry result table is the same as for **req.** 562.

The outputs from deriving the zeropoints for the night are:
CalFile– 563 *Zeropoint + extinction - keybands* (always) used by **seq.– 636.**

Required accuracy, constraints:

1% on the photometric scale

Estimated time needed:

Observation: 12 min. each night Reduction: 3 min/CCD/filter.

Detailed estimate of required integration time:

The secondary standard stars in the standard fields have a limiting magnitude g'~ 20. The internal accuracy of the present task is set on the 2% level in order to achieve an overall end-to-end accuracy of better than 5% on the photometric scale. Given an airmass of 1.3 and an S/N=50, we expect an integration time of:

u' band 110 sec but S/N =45 for F0V
g' band 60 sec
r' band 75 sec
i' band 115 sec

As there will be many much brighter stars (than the g'=20 limiting mag for which this calculation is made) in the field of view, leading to much better S/N these integration times will be sufficient for the goals, also at other moonphases (actually checked with ETC). The u' band observations are on the limit and should be carefully checked during Commissioning. Thus a total sequence would last including readout of 42 sec:
preset (100), u'(110 + 42), g'(60 + 42) , r'(75 + 42), i' (115 + 42) = 628 sec
In addition, a composite filter image should be taken (100 sec) which in the long run might replace the u', g', r', i' sequence with monolithic filters.

Priority:

essential

TSF:

Strategy– freq
Mode– Stare N=1
(**TSF– OCAM_img_obs_stare,** N=1, filter=key band)
= **TSF– OCAM_img_obs_zpkey**

Recipe:

For deriving a photometry result table:

```
PhotCal_Extract_Resulttable -i science_frame -s standard_catalog
                            [-t transformation_table]
```

```
  science_frame         : input frame that has been de-biased, flat-
fielded
                          and astrometrically calibrated. An il-
lumination
                          correction (if needed) should also have
been
                          applied.
  standard_catalog      : standard star catalog.
  transformation_table : transformation table containing color-
terms.
```

For deriving the zeropoints for the night:

```
  PhotCal_Extract_Zeropoint -e <photometry_result_tables>
                             -m monitoring_report
                             -c extinction_curve
```

```
  photometry_result_tables : list of photometry result tables as
derived
                              from a list of fully reduced images
of a
                              standard field.
  monitoring_report        : extinction night report.
  extinction_curve         : a standard extinction curve.
```

Needed functionality:

catalog - source extraction (Sextractor)
catalog - associate (LDAC prephotom)
catalog - select stars (LDAC filter)

CA:

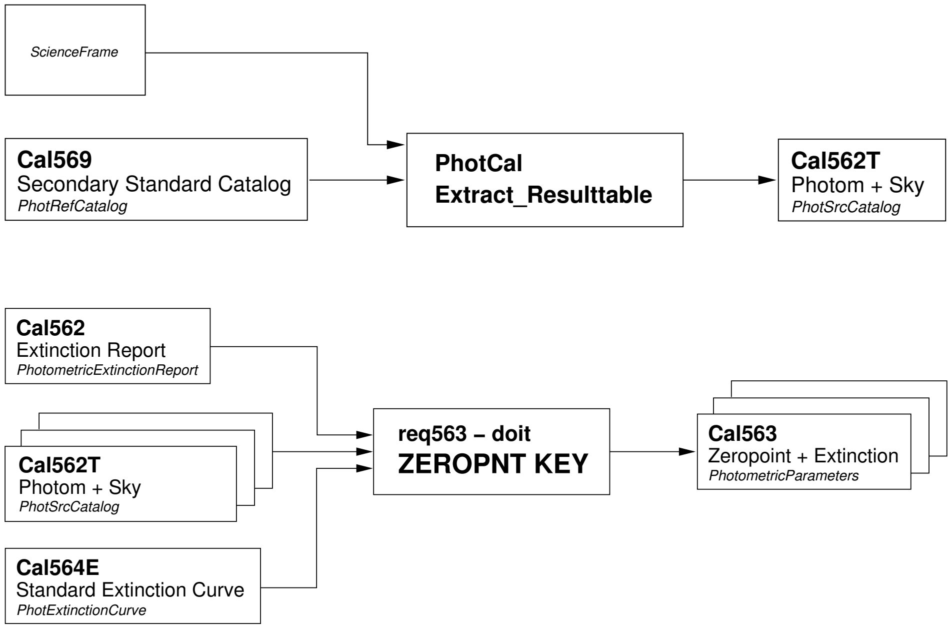

Fig 5.6.3 Dataflow and object class names for req563

The processing in the photometric part of the pipeline must be done for every **key band** separately and has two phases: 1) derive a photometry result table for every input chip, 2) use the photometry result tables in deriving the zeropoints for the night. The photometry result tables are derived in the same way as described in steps 1-8 of the relevant section of the **CA** from **req.** 562; these have to be derived first before the zeropoints for the night. The zeropoints for the night are derived from these photometric result tables as described in the steps 1-5 below. These steps are repeated for every separate input photometry result table.

1. Retrieve from the input extinction report (**CalFile– 562**) the atmospheric extinction for the middle of the night (see **req.** 562).
2. Multiply the retrieved extinction with the airmass contained in the input photometry result table.
3. Subtract the resultant value for the extinction from every raw zeropoint contained in the input photometry result table.
4. Derive the zeropoint from the resultant raw zeropoints by deriving the weighted average.
5. Store the derived zeropoint and the input extinction per unit airmass, together with the name of the chip for which the zeropoint was derived and the

name of the key band.

CAP:

```
Constant:
  DETECT_THRESH  : Sextractor processing parameter (float). Value:
10.0.

/* Step 1 : make photometry result tables

(1)      create_empty_list_for_photometry_result_tables
(2)      for every frame in the list of science frames:
(2.1)      derive_source_catalog_from_frame:
             Sextractor.sextractor(frame_name)
(2.2)      remove_saturated_stars_from_the_catalog:
             LDAC.filter(catalog_name, filter_criterium_1)
(2.3)      associate_source_catalog_with_standard_star_catalog:
             LDAC.prephotom(catalog_name, refcat)
(2.4)      remove_not_associated_sources_from_catalog:
             LDAC.filter(catalog_name, filter_criterium_2)
(2.5)      create_empty_list_for_raw_zeropoints
(2.6)      for every source in the source catalog:
             mag = take_magnitude_of_source_from_standard_catalog
(2.6.1)        if composite_filter_data:
                 apply_transformation_to_mag
             instmag = take_measured_magnitude_of_source
             raw_zeropoint = mag - instmag
             raw_zeropoint_err = sqrt(mag_err**2 + instmag_err**2)
             add_raw_zeropoint_and_error_to_list
(2.7)      save_the_photometry_result_table
(2.8)      add_photometry_result_table_to_list

/* Step 2 : make extinction

cwl = central_wavelength_of_key_band
extinction  = value_from_extinction_curve_at_cwl
extinction += shift_from_input_report_at_middle_of_the_night

/* Step 3 : make zeropoints
```

```
(1)   for every table in list of photometry_result_tables:
(1.1)   ext = extinction * airmass_from_table
(1.2)   ext_err = extinction_error * airmass_from_table
(1.3)   create_empty_list_for_zeropoints
(1.4)   for every raw_zeropoint in table:
          zeropoint = raw_zeropoint + ext
          zeropoint_err = sqrt(raw_zeropoint_err**2 + ext_err**2)
          add_zeropoint_and_error_to_list
(1.5)   get_weighted_mean_and_error_of_zeropoint
(1.6)   save_zeropoint_and_extinction
```