Quick Reduce: Dark Energy Survey Camera mountain-top Quality Assessment tool and its master calibration pipeline

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Abstract. *To uncover the misteries of dark energy the Dark Energy Survey is covering 5,000 square degrees of the southern hemisphere with a 500 Mpixel camera. In order to timely assess the quality of data on mountain-top, a system was devised to process these huge frames, extract information and keep them in a database, providing a friendly interface for the observer to interact with. This work describes the challenges involved in the parallelization of field-of-views, their 62 chips, avoiding IO and memory trouble in the restricted computational mountain-top environment and at the same time delivering nearly science grade data to observers.*

1. Introduction

The accelaration of the universe is one of the greatest mysteries of our time. To better understand it, the Dark Energy Survey has begun to observe in the end of 2012 a large volume of the universe. In order to achieve that, one needs a large and sensitive camera like DECam (Flaugher et al. 2012), which comprises 500 Megapixels distributed in 62 science grade charge-coupled devices (CCD) that translates into roughly 1GB per exposure. Processing such massive image on real time requires large computational resources (and all their related infrastructure), which is not easily setup at mountain-top.

These large images are processed by Quick Reduce (QR), a quality assessment tool installed in the mountain-top, used to provide feedback to observers. CCD images are plagued by several effects that need to be removed and in order to do that one needs calibration images. The most basic effects are bias, an offset in the signal, and flat-field, a multiplicative variation in each pixel sensitivity. Other effects, like dark current, which is negligible in the case of DECam, or the crosstalk between amplifiers, are not taken into account in this process. Bias and flat-field images are exposed during the afternoon, saving night time, and totaling approximately 60 frames (10 bias + 50 flat-fields, with 10 in each of the 5 grizY bands). Processing each frame, one at a time, is already a challenge for QR, even taking advantage of the fact that CCD processing is an embarrassingly parallel problem. However, the production of high signal-to-noise master calibration frames needs one to process all 60 FoVs timely, with each CCD in parallel, and then combine the respective CCDs into a single master of each CCD that will be applied to the observed scientific frames, which can then be analyzed free of artifacts.

2. Material and Methods

The master calibration workflow demands memory and specially IO performance, since dozens of GB are handled by the pipeline, specially at the first stage of the pipeline where the parallelization happens at FoV level. In practice, this is dismissed to avoid the huge IO concurrency which ruins the benefit of the parallelization in the limited resources in mountain-top – this is not true in a shared file system operating in a cluster. However, on mountain-top, only the second stage, at CCD level, is worth parallelizing (using a XML workflow that allows for 1toN, 1to1, Nto1 data movement, keeping track of dependencies). Quick Reduce (QR) uses its high configurability (see Figure 1) to reduce images (remove bias and flat field with python codes), extract sources from them (using Sextractor (Bertin & Arnouts 1996)) and analyze their brightness and shape in order to assess the image quality of whichever number of CCDs and Field-of-View (FoV) configuration deemed necessary (Figure 2). This is all introduced to the user on a web-based system which runs a daemon that probes the telescope main storage for new data (Figure 3). When in automatic mode, this daemon transfers the new image and processes it, taking typically 100s for a set of 20 CCDs distributed across the FoV, which allows Quick Reduce to process almost every image exposed by DES on its standard survey mode 90s exposure time plus 20s readout. The source extraction configuration allows one to, among other things, setup the extraction threshold and different star/galaxy separation.

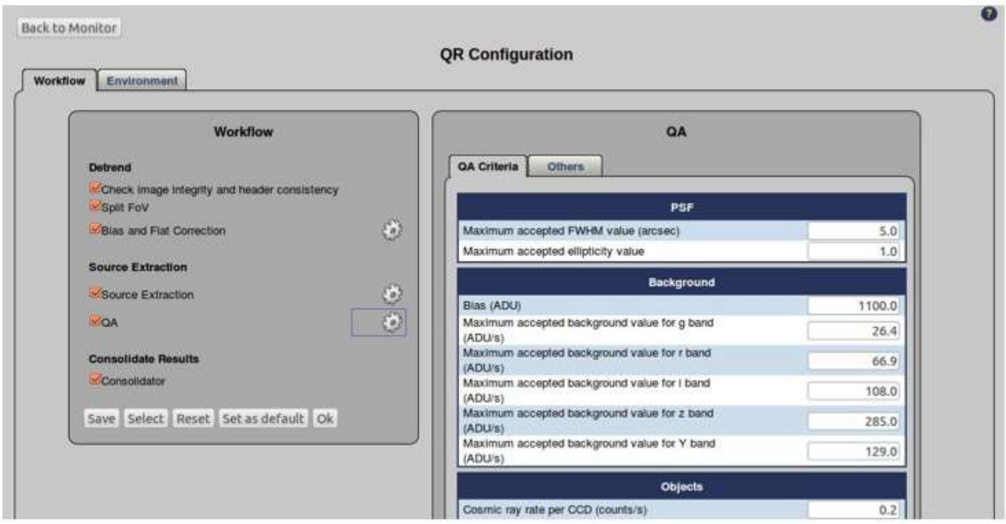

Figure 1: Quick Reduce configuration screen

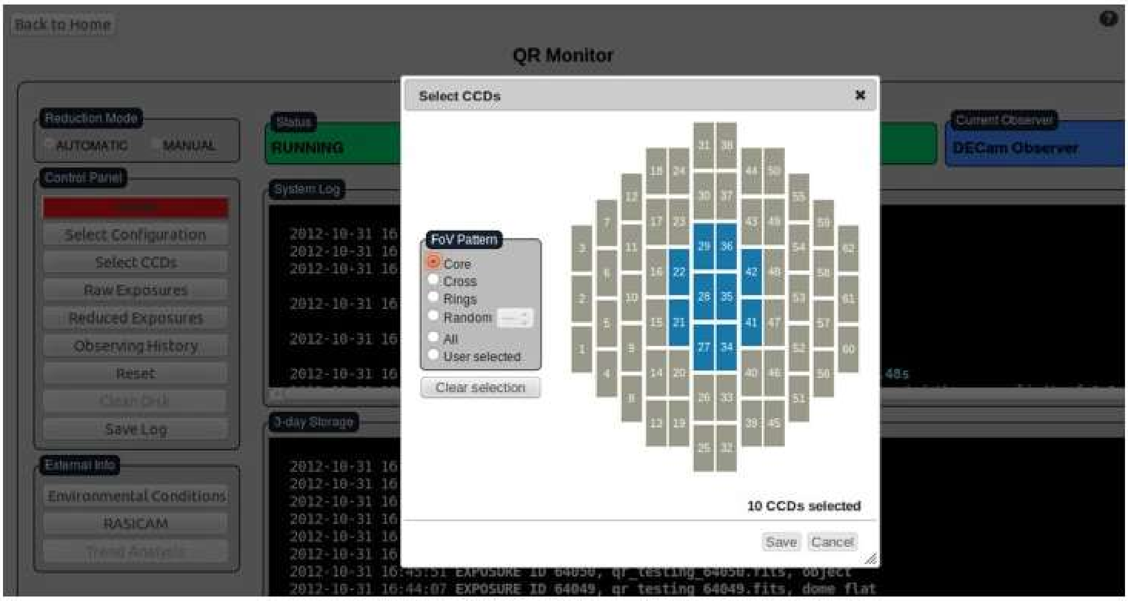

Figure 2: Selection of patterns for the CCDs to be reduced. The user can choose among several pre-defined patterns, a random selection of a user-specified number of CCDs, all or select CCDs by hand.

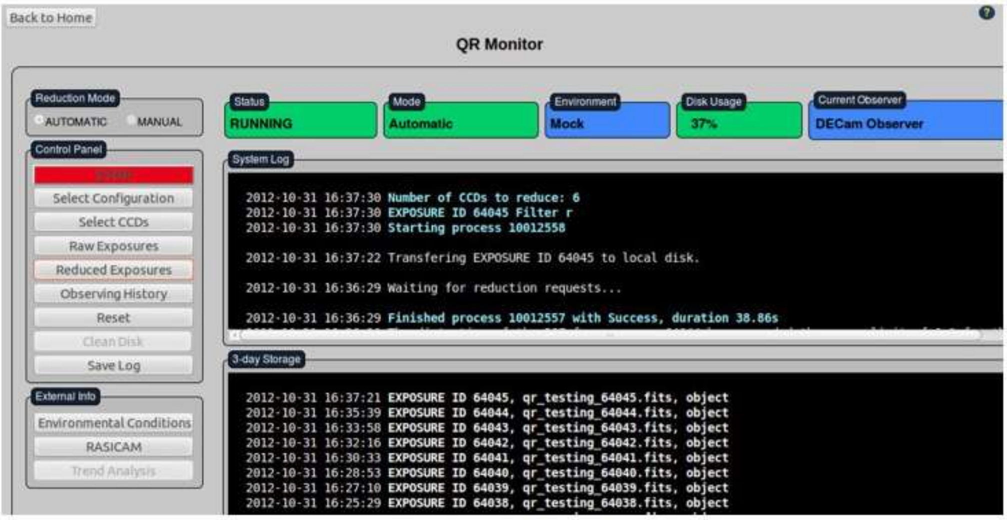

Figure 3: Quick Reduce monitor screen

3. Results

Here we report on the mountain-top DECam master calibration pipeline, which also performs quality control over the input and output frames allowing observers to have their data reduced. For that matter, stars, as point sources, are the main subject of QR on its analysis of brightness and shapes. Several tests are available, on both CCD and FoV level, allowing the observer to have a global view of the data quality, as well as investigate particular CCDs. All this information is ingested into a local database and feeds the Observation History tool (Figure 4), where the observer can keep track of the quantities throughout the night, being alerted for sudden changes in the system behavior and accessing the details of troubled runs. The processed data is also accessible by download, if further investigations are needed. To assist with that, and since the mountain-top servers have restricted access, a mirror site called QR Data Server was installed in LIneA data center, where the DES collaboration can access QR results, the Observing History plus a Trend Analysis tool, which allows the scientist to plot several quantities against each other looking for trends and comparing them.

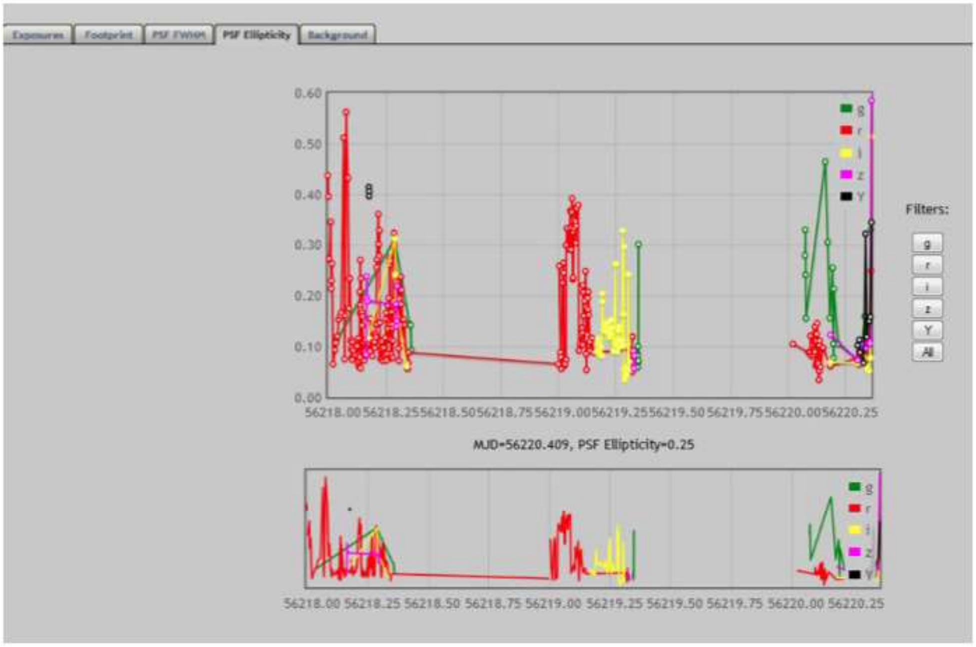

Figure 4: Evolution of the measured median ellipticity of the stars in all reduced CCDs as a function of the MJD

4. Conclusions and Perspectives

QR has been operating since November 2012 with a high level of availability and has processed 77% of the ~30.000 exposures, including community time. Daily monitoring of QR (e.g. daemon status and disk space) is reported via email to the team in Brazil, which supports the operation. and received extensive feedback from observers, allowing the improvement of QR during its 150 nights on the sky and making an indispensable tool in the mountain for observers tracking the data quality. Improvement in hardware and software in the mountain-top are envisioned in order to produce better and faster results.

5. References

Bertin, E.; Arnouts, S. (1996) “SExtractor: Software for source extraction.”, Astronomy and Astrophysics Supplement, v.117, p.393-404

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