A Fully GTC-compliant Pipeline for the Direct Imaging Mode of EMIR

S. Pascual, J. Gallego, and N. Cardiel

Abstract EMIR is a near-infrared wide-field camera and multi-object spectrograph being built for the 10.4m Spanish telescope (*Gran Telescopio Canarias*, GTC) at La Palma Observatory. The Data Factory Pipeline will be optimized for handling and reducing near-infrared data acquired with EMIR. Both reduced data and associated error frames will be delivered to the end-users as a final product. The DFP is being designed and built by the EMIR *Universidad Complutense de Madrid* group.

1 Introduction

Gran Telescopio Canarias (hereafter GTC) is a 10.4m telescope located at the Roque de los Muchachos Astronomical Observatory at La Palma, Spain. A unique near-infrared wide-field camera and multi-slit spectrograph it's being built for GTC: EMIR. EMIR is a state-of-the-art instrument with which multi-object spectroscopic observations will be possible for up to 45 simultaneous targets with a resolution about 4000 and a spectral coverage from 0.9 to 2.5 microns. The field of view (FOV) is 6 3 in spectroscopic mode. EMIR also has imaging capabilities in the J, H and K near-IR bands. In this case, the FOV is 6 6, with a spatial sampling around 0.175 "/pixel. The main scientific driver of EMIR is the extension of the study of distant galaxies up to the z = 2 - 3 redshift regime, where the rest-frame visible spectrum features are shifted to the K-band. EMIR will also allow the analysis of other kind of objects (see, for a more detailed description Balcells et al., 2000). EMIR is being developed by a consortium of Spanish and French institutions.

Due to the nature and complexity of EMIR, it will produce a great amount of data that will need to be analyzed. The EMIR Data Factory Pipeline (hereafter DFP), which is being developed by the EMIR Universidad Complutense de Madrid group, is intended to reduce the data acquired with EMIR as a part of the GTC Control Sys-

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tem. It will use a set of robust and fail-safe software tools and algorithms specialized in near-IR data.

2 Overview of the EMIR DFP

The DFP has set of advanced reduction algorithms and the Quality Check rules to be followed. It is fully integrated into the GTC Data Factory, which constitutes a common framework in which EMIR and other instruments can be used. T he EMIR DFP can be accessed through Inspector, developed in Java. The EMIR DFP contributes to GTC Data Processing Kit (DPK) with new procedures and improvements in key steps of the IR reduction that are useful for the common use.

For each of the EMIR observing modes (imaging and multi-object spectroscopy), there are associated Reduction Recipes and calibration and science frames. Once an observation is completed, the GTC DFP Server will need to interact with the GTC Operation Repository, where the existing calibration frames and the results are stored. The DFP Server will run the appropriated Reduction Recipe from the set providede by the EMIR DFP. In the end the DFP will provide the users with a final reduction set of observations in physical units and its associated error frames. The EMIR DFP is being coded under an object-oriented architecture (C++), following GTC programming and software standards.

2.1 Current issues

- Handling $\sim$100 images simultaneously is needed in IR processing, but can't be done with the current DPK memory model. We have created a new class FILEFRAME that reduces the usage of main memory by accessing the hard drive. The new class has been submitted to GTC to be evaluated and eventually included in DPK.
- We have implemented two new FRAME combination filters with integer offsets and several combination methods. The combination methods are abstracted as C++ concepts, in order to create a combination filter as generic as possible.
- We actively submit bug reports and fixes to GCS bugzilla.

3 Direct imaging prototype

In Figure 1 we show images from a test run of the prototype with real IR K' data from Omega 2000 at 3.5m telescope (Calar Alto, Almera, Spain).

The reduction steps are roughly the following:

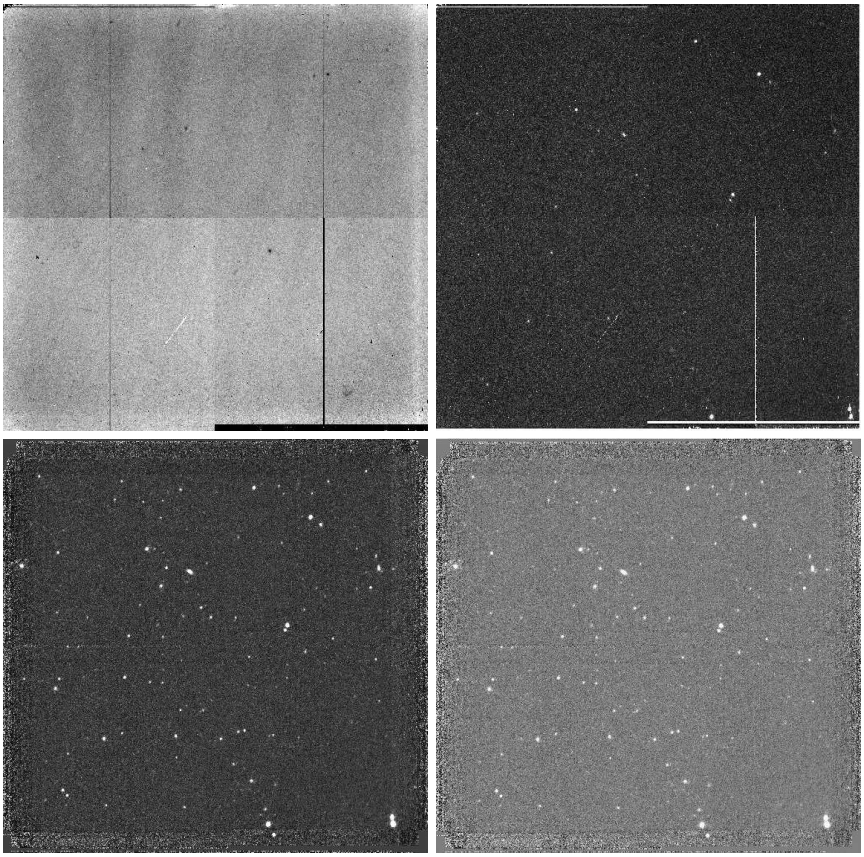

Fig. 1 From top to bottom and left to right, a raw frame, frame corrected from dark and flat field. The two images on the bottom are obtained combining the complete set of frames. On the bottom left, the image is the result of the first iteration of the process. On the right, the final image obtained after four iterations, using with a full object mask to remove the contribution of the objects to the sky background.

- The raw science images are corrected from dark and flat-field. The corrected science images then enter a iterative process
- Science images are combined to obtain a sky flat-field. A object mask is used to avoid including data from the objects in the sky flat-field. Initially this mask is empty
- Images are corrected from the computed sky flat-field.
- The sky background in each image is computed and subtracted.
- The frames are combined and an object mask is produced.
- The object mask is used to refine the sky flat-field obtained in the first step

The pipeline goes through these steps until convergence (several different criteria are used) is achieved. Usually four iterations are needed. Improvements in different steps are planned to be included before the final pipeline is finished.

4 Linux version

Although a linux version of the DPK is not officially supported, we have an agreement with GTC office to create a version of DPK than runs in linux for our development work. DPK code is basically ISO/ANSI C++, so the code developed in Solaris with GCC 2.93 compiles flawlessly in Linux with GCC 4.1/4.3 The build system has been migrated to autotools. This means that each module of the DPK can be built and installed using simply:

```
$ ./configure
$ make
$ make install
```

Linux DPK depends currently in 3 external libraries: cfitsio, wcstools and ACE+TAO

- cfitsio provides basic FITS support
- wcstools is used for astrometry tasks.
- ACE+TAO provides IDL/CORBA and hardware-independent system calls

We are trying to reduce the dependencies on CORBA, so that a version of DPK can be run with a smaller set of dependencies.

We would like to build a standalone version of the DPK that could be deployed in Unix-like systems (Linux, Mac OS, etc) and used without the need of the complete set of DPK and GCS dependencies. This is an ongoing effort and not supported (for the moment) by the GTC office.

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