GTCMOS:
A semi-automatic pipeline for the reduction of GTC/OSIRIS MOS data

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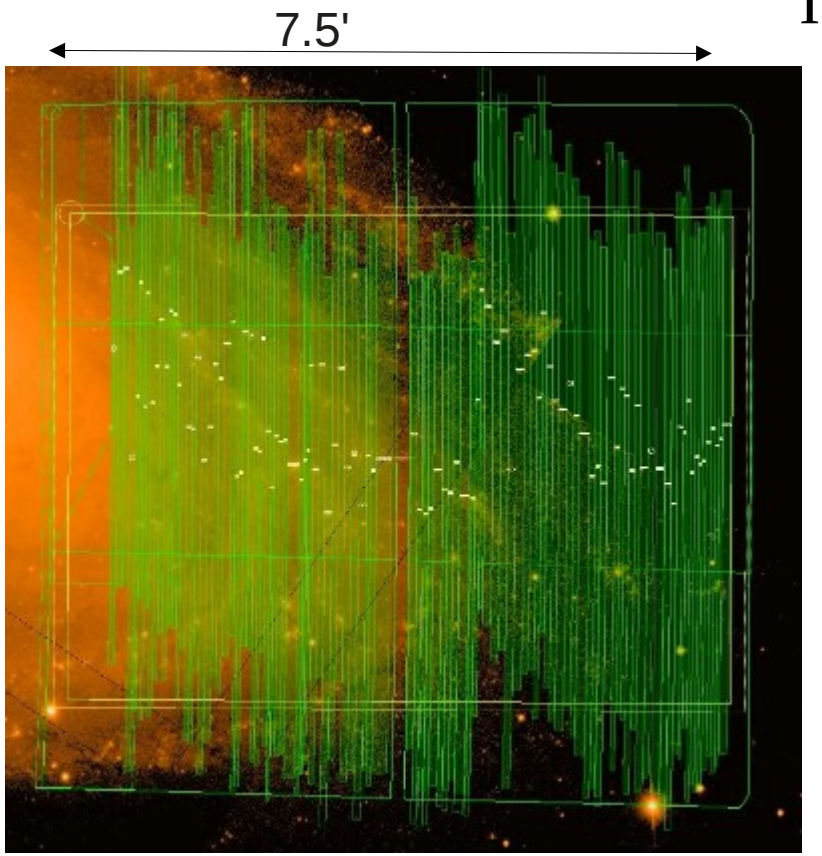
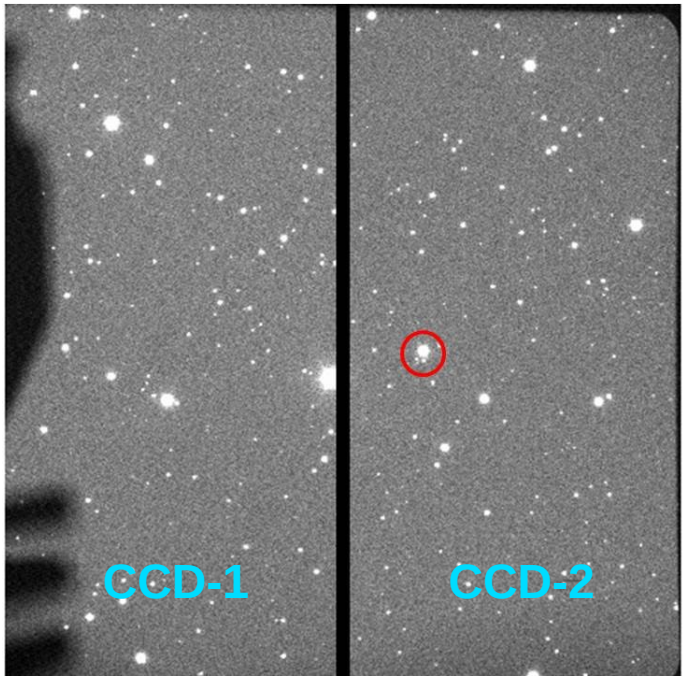


OSIRIS INSTRUMENT at the GTC

Optical
System for
Imaging and
low-Intermediate-
Resolution
Integrated
Spectroscopy

Wavelength range: 0.365 to 1.05 µm
Field of View: 7.8 x 7.8 arcmin
Detectors: 2 CCDs of 2048 x 4096 pixels with a 9.4” gap
Pixel size = 15 µm
image scale = 0.254”/pix

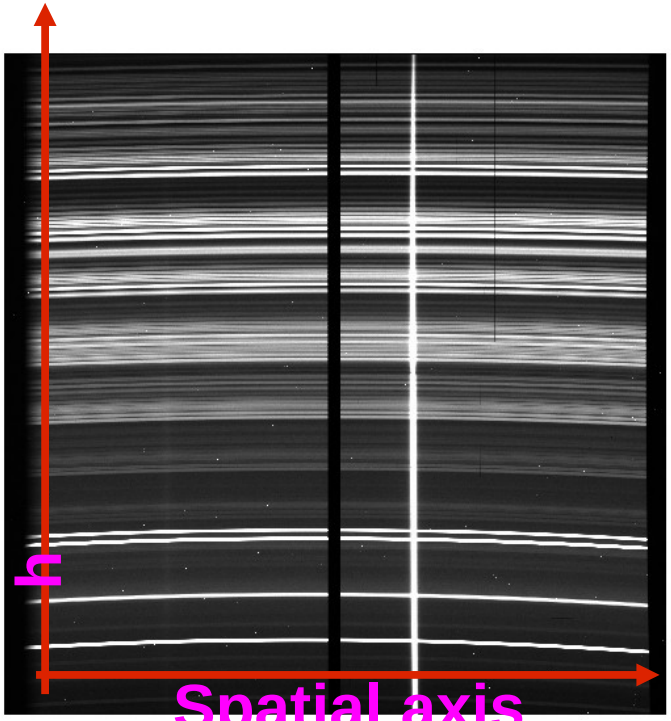


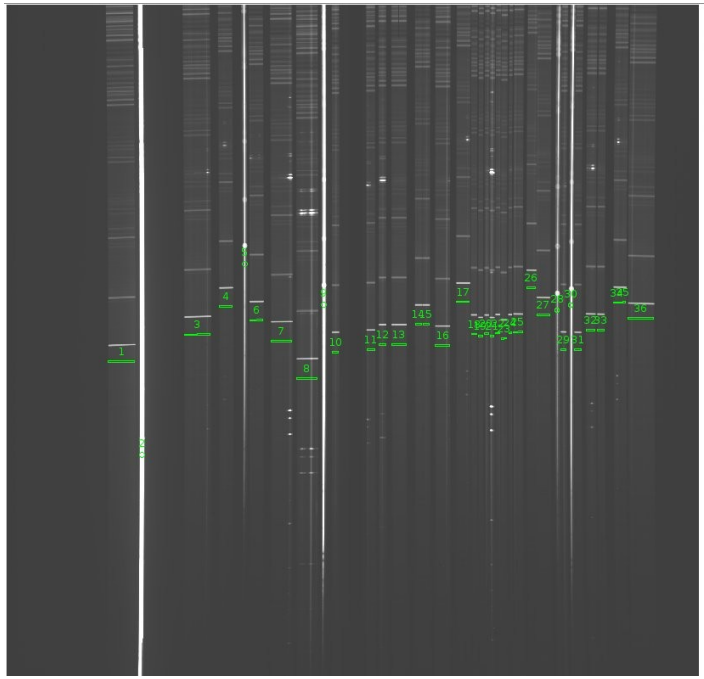
Imaging

- Broad Band
- Median Band (SHARDS filters)
- Tunable Filters
- Fast Photometry
- Frame Transfer Photometry

Spectroscopy

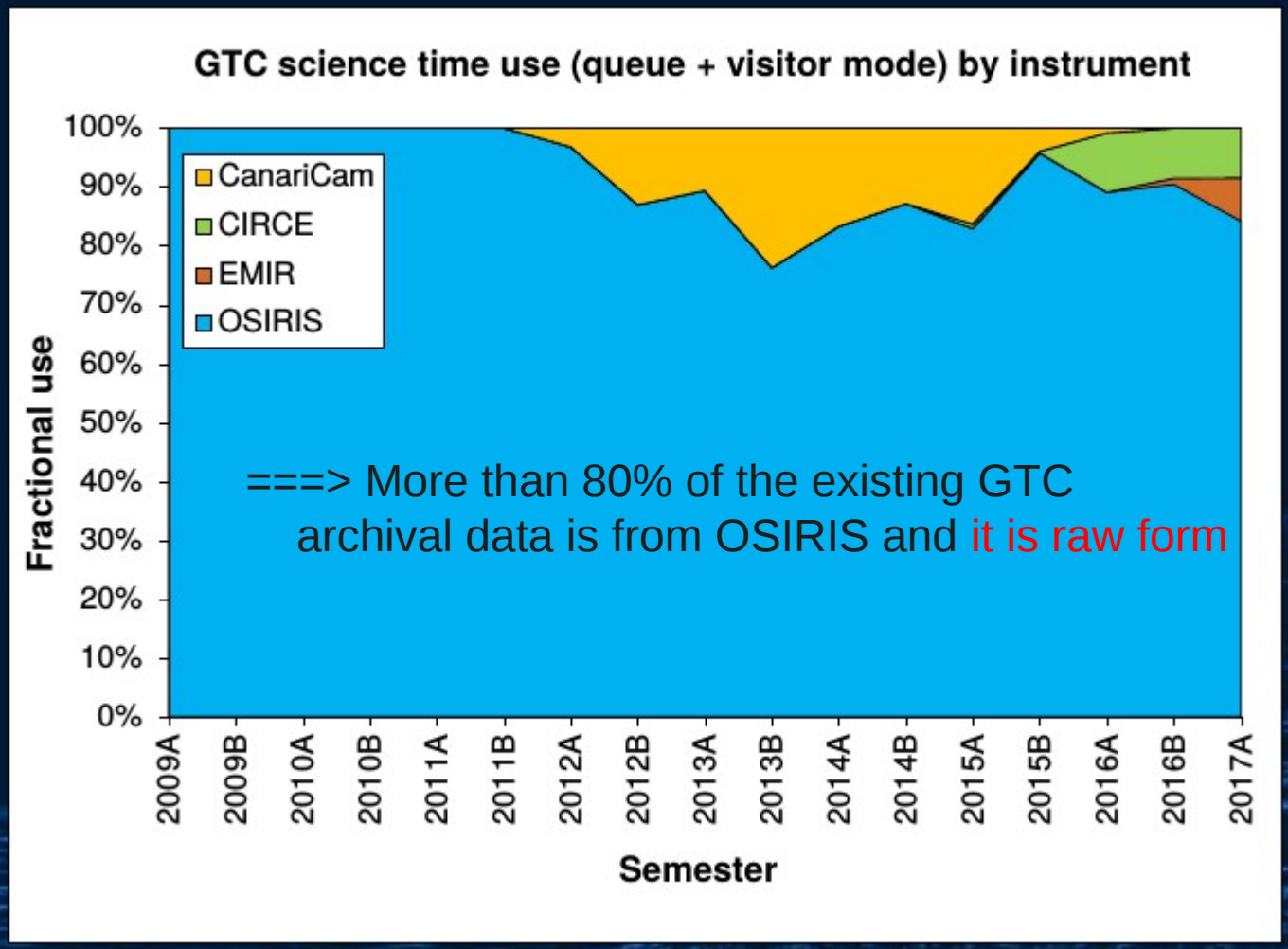
- LongSlit Spectroscopy
- Multi-Object Spectroscopy





OSIRIS INSTRUMENT at the GTC

Science time delivered per instrument



Scientific exploitation of these data by the international community requires easy-to-use pipeline

OSIRIS DATA reduction pipelines

OSIRIS Data Reduction Tools

Some useful data reduction tools can be retrieved here to process OSIRIS data:

- **OOPs (official pipeline)**, by A. Ederoclite (aederocl [at] cefca.es). It covers the complete set of OSIRIS observing modes. This can be retrieved here, where it's described its use and functionalities.
- **GTCMOS pipeline**, by D. Mayya (ydm [at] inaoep.mx). Produced for reducing longslit and MOS data.

Important note: A. Ederoclite and D. Mayya have kindly provided access to the reduction packages to the general OSIRIS user community. However, the kind of support they can provide is only in a best effort basis.

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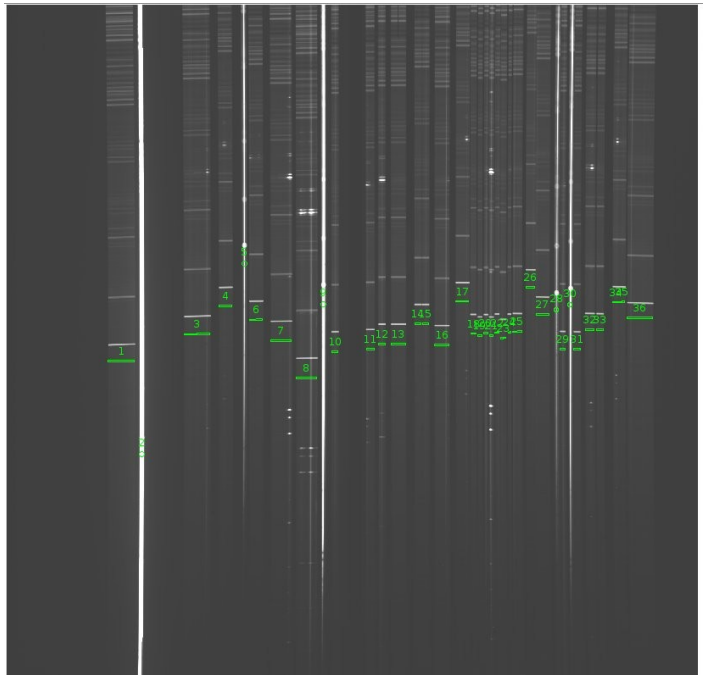
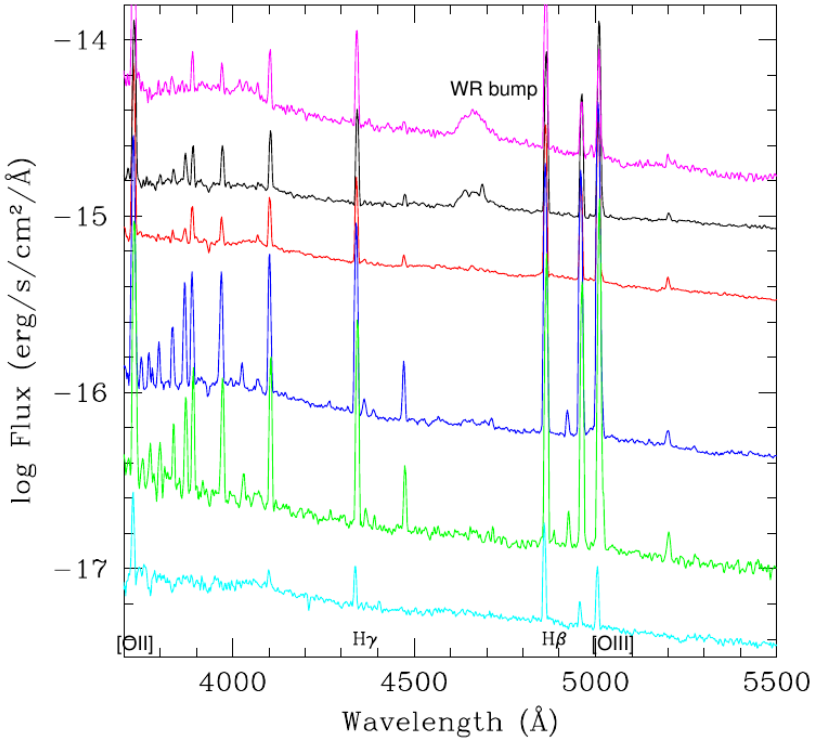
Aim of the GTCMOS pipeline:

To produce science quality spectra from RAW data with minimum user interaction.

Spectroscopic data reduction steps

Obtain wavelength and flux-calibrated spectrum of individual objects





Basic reduction:
(Image)

- Bias and flat-field corrections
- Mosaic the 2 CCDs into one image
- Removal of cosmic ray events

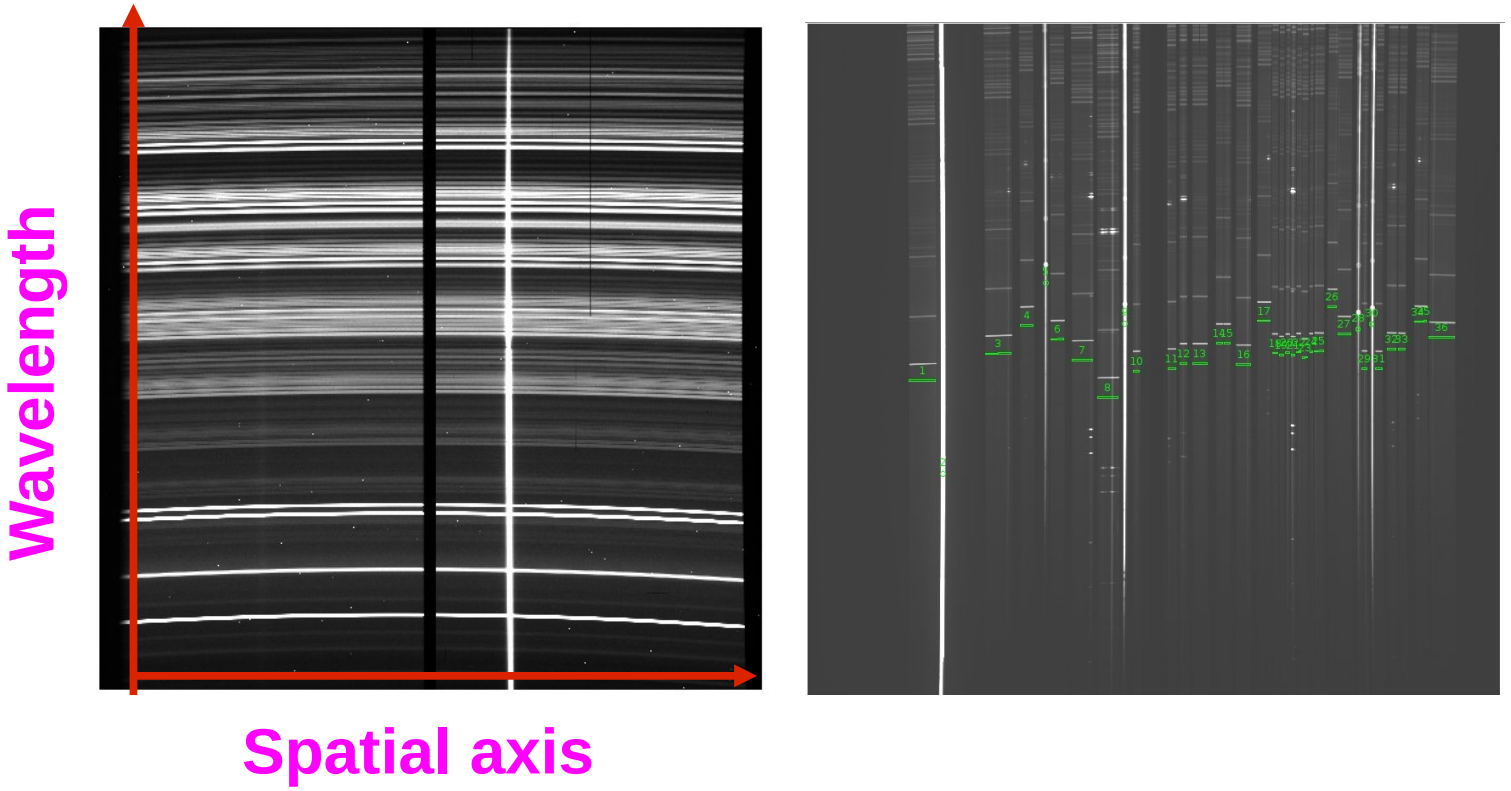
Spectroscopic reduction

- Wavelength calibrate using arc lamps
- Flux calibrate using standard stars
- Subtract sky using sky spectra
- Extract the 2-D spectral image to get 1-D spectrum

Longslit vs MOS data reduction

LongSlit Spectroscopy - **Wavelength independent (almost) of spatial axis**

Multi-Object Spectroscopy - **Wavelength depends on the position of the slitlet along the dispersion axis**



===> Need to find wavelength solution for each slitlet
….. can be boring and time-consuming

GTCMOS – a pipeline to reduce GTC/OSIRIS data

http://www.inaoep.mx/~ydm/gtcmos/gtcmos.html

www.inaoep.mx/~ydm/gtcmos/gtcmos.html

User's guide for reduction of OSIRIS/MOS spectral data using ***GTCMOS*** pipeline

Divakara Mayya (*ydm@inaoep.mx*)

GTC

Pipeline Overview and Cookbook with examples (version 1.1)

Download GTCMOS pipeline | Read changes in the New version 1.4 04-AUG-2016

IRAF Installation instructions
GTCMOS Installation instructions

Please cite V.M.A. Gomez-Gonzalez, Y.D.Mayya & D. Rosa-Gonzalez (2016) MNRAS, 460, 1555 (also available at astroph) in any work published using data that were reduced with the GTCMOS pipeline.

Last changed: 08-AUG-2016

```
vocl> gtcmos

     +------------------- GTCMOS IRAF Package -------------------+
     |             Version 1.4, Aug 04, 2016                     |
     |            Tested with IRAF v2.16 on Fedora               |
     |    Developed by Divakara Mayya at INAOE, Puebla, Mexico   |
     |                                                           |
     |    Type  help  before using it for the first time         |
     |                                                           |
     | User's guide is available at                              |
     |   file:///iraf/iraf/extern/gtcmos/html/mos_reduction.html |
     |                                                           |
     |Please contact ydm@inaoep.mx if you have questions/comments|
     +-----------------------------------------------------------+

      omcombine     omfindstd     omidentify    omreidentify  omslice       omstart       omunlearn
      omextract     omflat        omreduce      omskysub      omslits       omstd

gtcmos>
```

Brief illustration of the pipeline

OSIRIS Data types and file structure

tar ztvf GTC5-15BMEX.OB0005.tar.gz

GTC5-15BMEX/OB0005/
GTC5-15BMEX/OB0005/GTC5-15BMEX_0005_qc.txt
GTC5-15BMEX/OB0005/object/
GTC5-15BMEX/OB0005/object/0000852936-20160206-OSIRIS-OsirisMOS.fits
GTC5-15BMEX/OB0005/object/0000852937-20160206-OSIRIS-OsirisMOS.fits
GTC5-15BMEX/OB0005/object/0000852938-20160206-OSIRIS-OsirisMOS.fits
GTC5-15BMEX/OB0005/object/0000852939-20160206-OSIRIS-OsirisMOS.fits
GTC5-15BMEX/OB0005/object/0000852940-20160206-OSIRIS-OsirisMOS.fits
GTC5-15BMEX/OB0005/flat/
GTC5-15BMEX/OB0005/flat/0000853001-20160206-OSIRIS-OsirisSpectralFlat.fits
GTC5-15BMEX/OB0005/flat/0000853002-20160206-OSIRIS-OsirisSpectralFlat.fits
GTC5-15BMEX/OB0005/flat/0000853003-20160206-OSIRIS-OsirisSpectralFlat.fits
GTC5-15BMEX/OB0005/flat/0000853004-20160206-OSIRIS-OsirisSpectralFlat.fits
GTC5-15BMEX/OB0005/flat/0000853005-20160206-OSIRIS-OsirisSpectralFlat.fits
GTC5-15BMEX/OB0005/bias/
GTC5-15BMEX/OB0005/bias/0000853021-20160206-OSIRIS-OsirisBias.fits
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GTC5-15BMEX/OB0005/bias/0000853035-20160206-OSIRIS-OsirisBias.fits
GTC5-15BMEX/OB0005/arc/
GTC5-15BMEX/OB0005/arc/0000852998-20160206-OSIRIS-OsirisCalibrationLamp.fits
GTC5-15BMEX/OB0005/arc/0000852999-20160206-OSIRIS-OsirisCalibrationLamp.fits
GTC5-15BMEX/OB0005/arc/0000853000-20160206-OSIRIS-OsirisCalibrationLamp.fits
GTC5-15BMEX/OB0005/stds/
GTC5-15BMEX/OB0005/stds/0000852913-20160206-OSIRIS-OsirisLongSlitSpectroscopy.fits
GTC5-15BMEX/OB0005/stds/0000852914-20160206-OSIRIS-OsirisLongSlitSpectroscopy.fits
GTC5-15BMEX/OB0005/stds/0000852919-20160206-OSIRIS-OsirisLongSlitSpectroscopy.fits

OBJECT Files

Flat Files

Bias Files

Arc lamp Files

Standard star Files

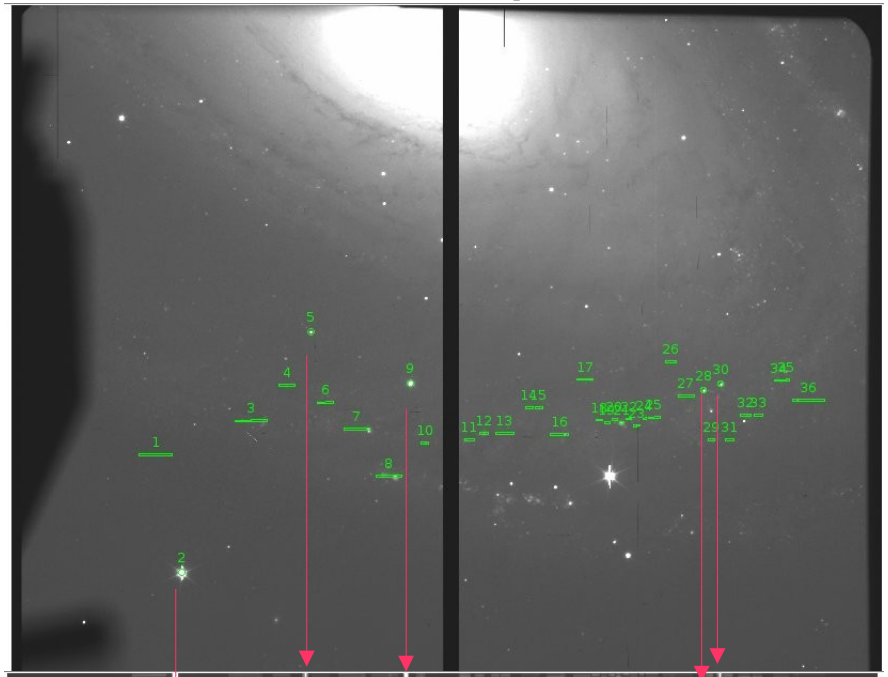
Works directly on the directory structure of GTC data

```
gtcmos> omstart ../MOS/GTC4-14AMEX/OB0001/object
Analyzing the following files
OBSDATE  SEM OB    OBTYPE ###   NX       NY     GRISM  FILTER1  FILTER2 FILTER3 EXPTIME CCDSUM  SLITW   OBJECT
20140403 14A OB001 OBJECT 265 1049      2051    OPEN    OPEN    Sloan_r OPEN    10.     "2 2"   0.      M81-MO
20140403 14A OB001 OBJECT 266 1049      2051    OPEN    OPEN    Sloan_r OPEN    60.     "2 2"   0.      M81-MO
20140403 14A OB001 OBJECT 267 1049      2051    R1000B  OPEN    OPEN    OPEN    1308.   "2 2"   0.      M81-MO
20140403 14A OB001 OBJECT 268 1049      2051    R1000B  OPEN    OPEN    OPEN    1308.   "2 2"   0.      M81-MO
20140403 14A OB001 OBJECT 269 1049      2051    R1000B  OPEN    OPEN    OPEN    1308.   "2 2"   0.      M81-MO
gtcmos>
```

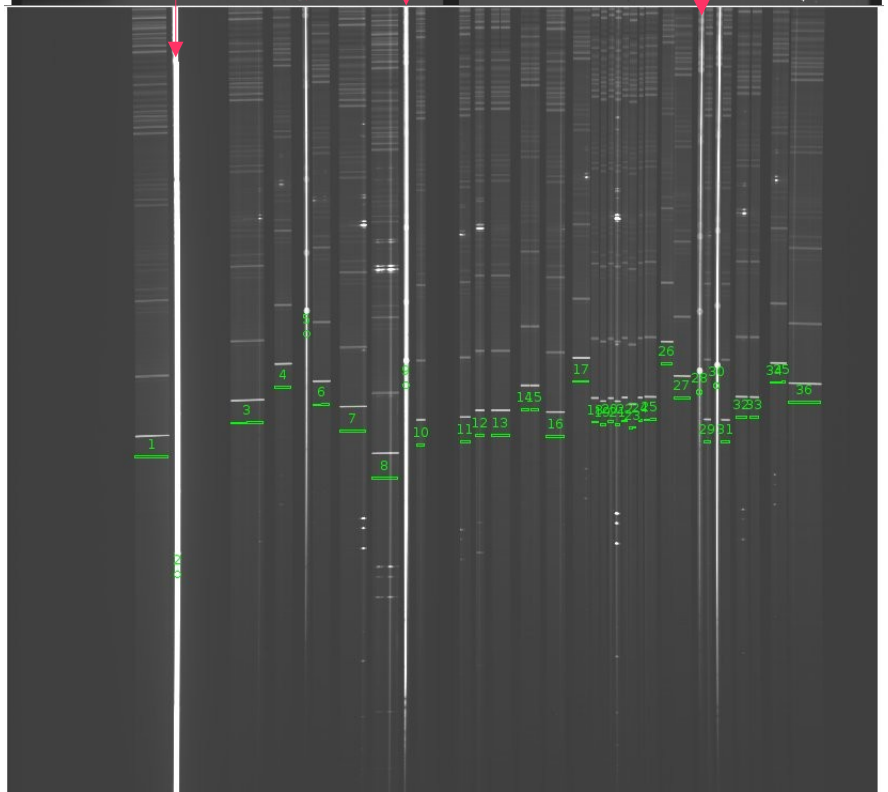
```
gtcmos> lpar omidentify
       filarc = "gtc10aob005_arcs" Comparison arc file [arcfile]
      coordli = "DEFAULT"       Line id coordinate list
      (cursor = "gtcinputs$identify_spline3_2.cursor") Cursor file for identify
     (display = no)             Display graph showing each identification?
     (lastlis = "gtcinputs$R1000B_HgAr_Ne_Xe.dat") Line id coordinate list
        (mode = "ql")
gtcmos>
```

```
OMREDUCE (Feb15)                gtcmos                OMREDUCE (Feb15)



NAME
    omreduce  --  This  task  applies  the  dispersion  correction  and
    converts MOS spectra to longslit-like spectrum


USAGE
    omreduce filnam filarc


PARAMETERS

    filnam
        Name  of  the  file  to  be  wavelength  calibrated.  The output
        filename is formed using filnam as  the  root  ([filnam]_wl  for
        tilt_slit=no, or [filnam]_wl_tlt if tilt_slit=yes).
```

OSIRIS/MOS observations: illustrations



Aquisition image showing the positions of slitlets



Spectral image showing spectra of
Astrometric reference stars (arrows)
and Science objects

Registration of spectra of ALL reference stars confirms that the desired astrometric accuracy had been reached in the real observations.

Illustration 1: Bias-subtracted, 2-CCDs mosaic, 3-images combined, cosmic-ray cleaned, Slitlets identified image

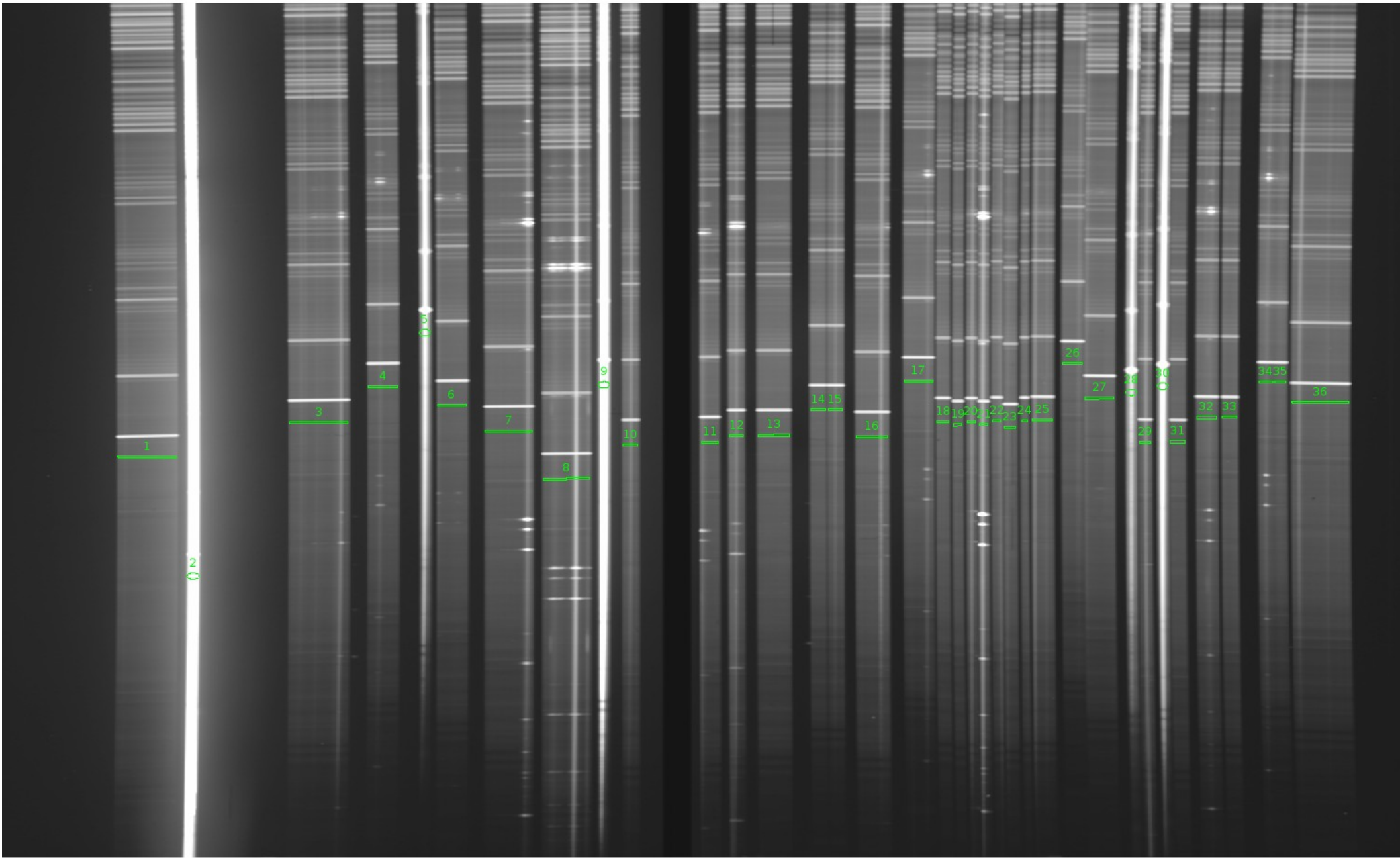


Illustration 2: ….. wavelength-corrected, flux-calibrated

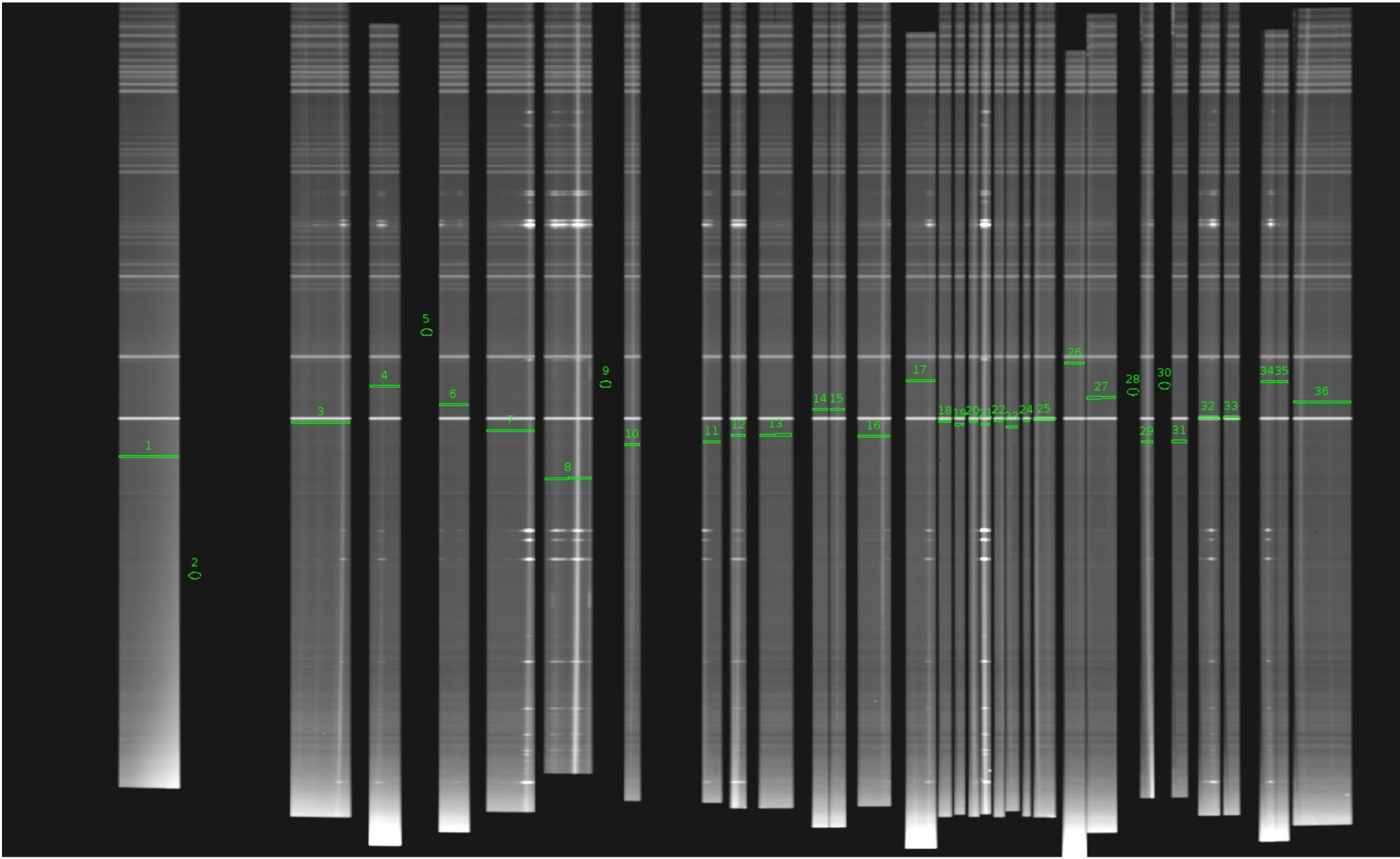


Illustration 3: ….. wavelength-corrected, flux-corrected, sky-subtracted

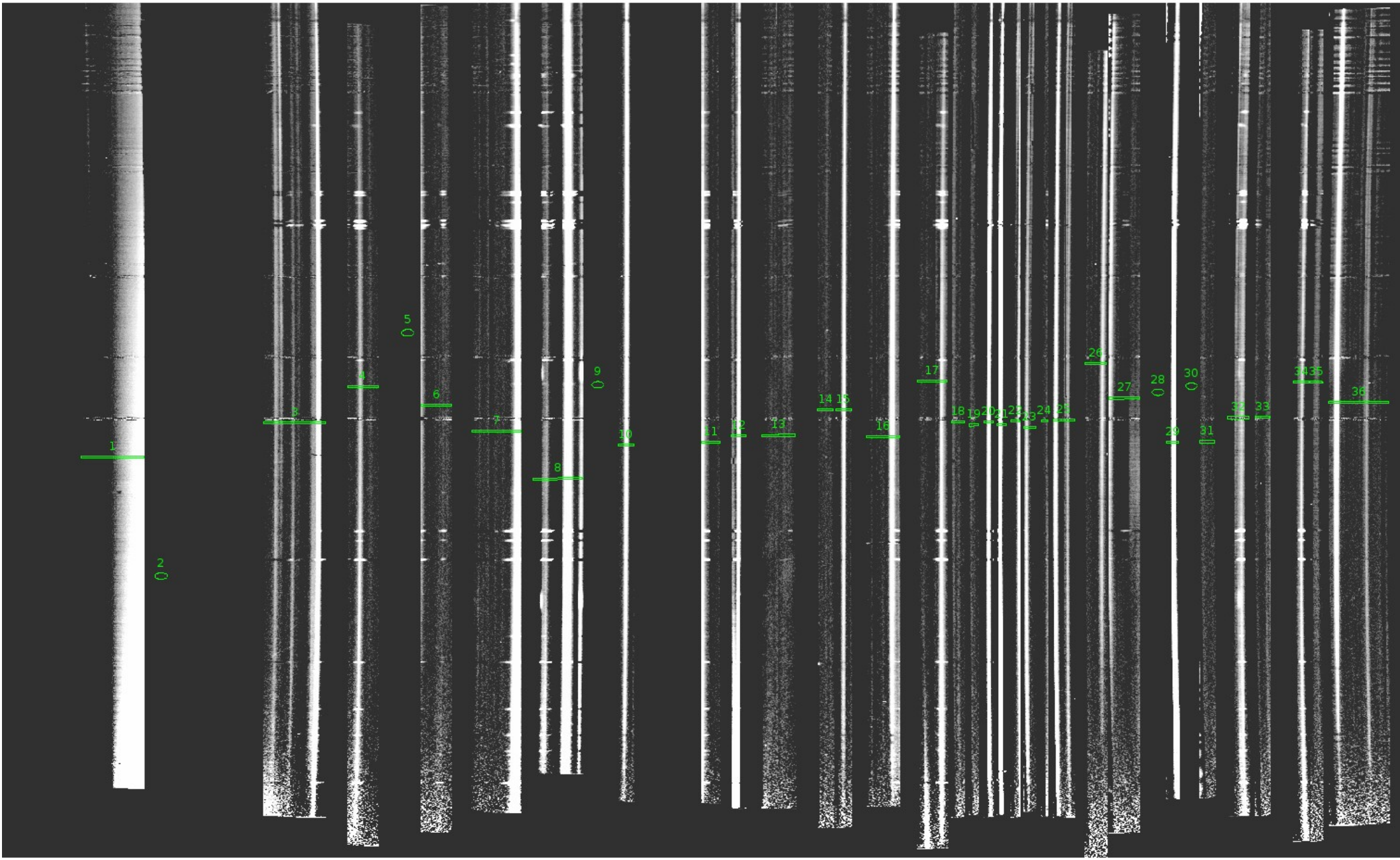


Illustration 4: astrometric precision

Pointing is good to 0.1-0.2 arcsec even when using RADEC instead of XY coordinates in the pre-image

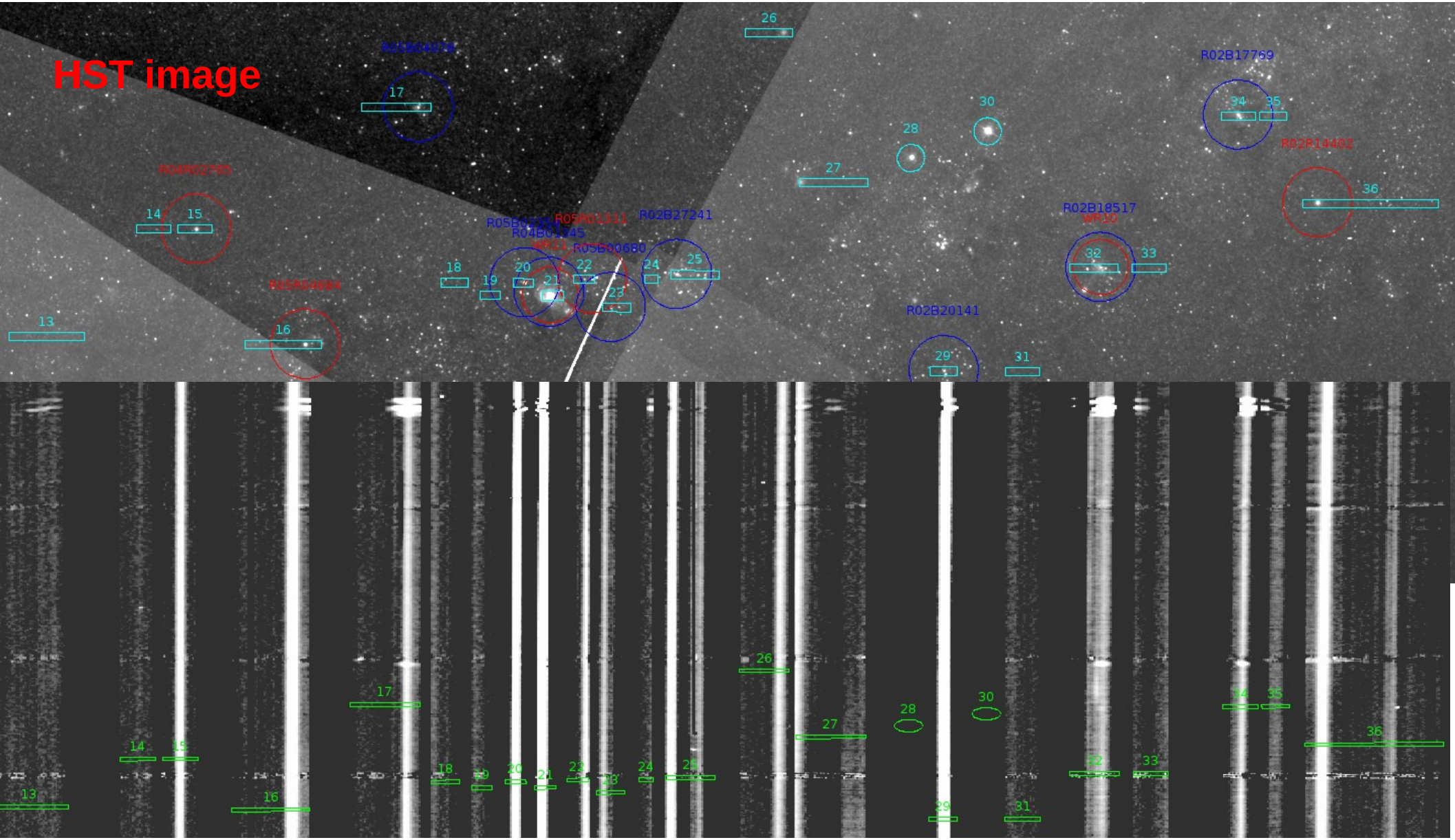
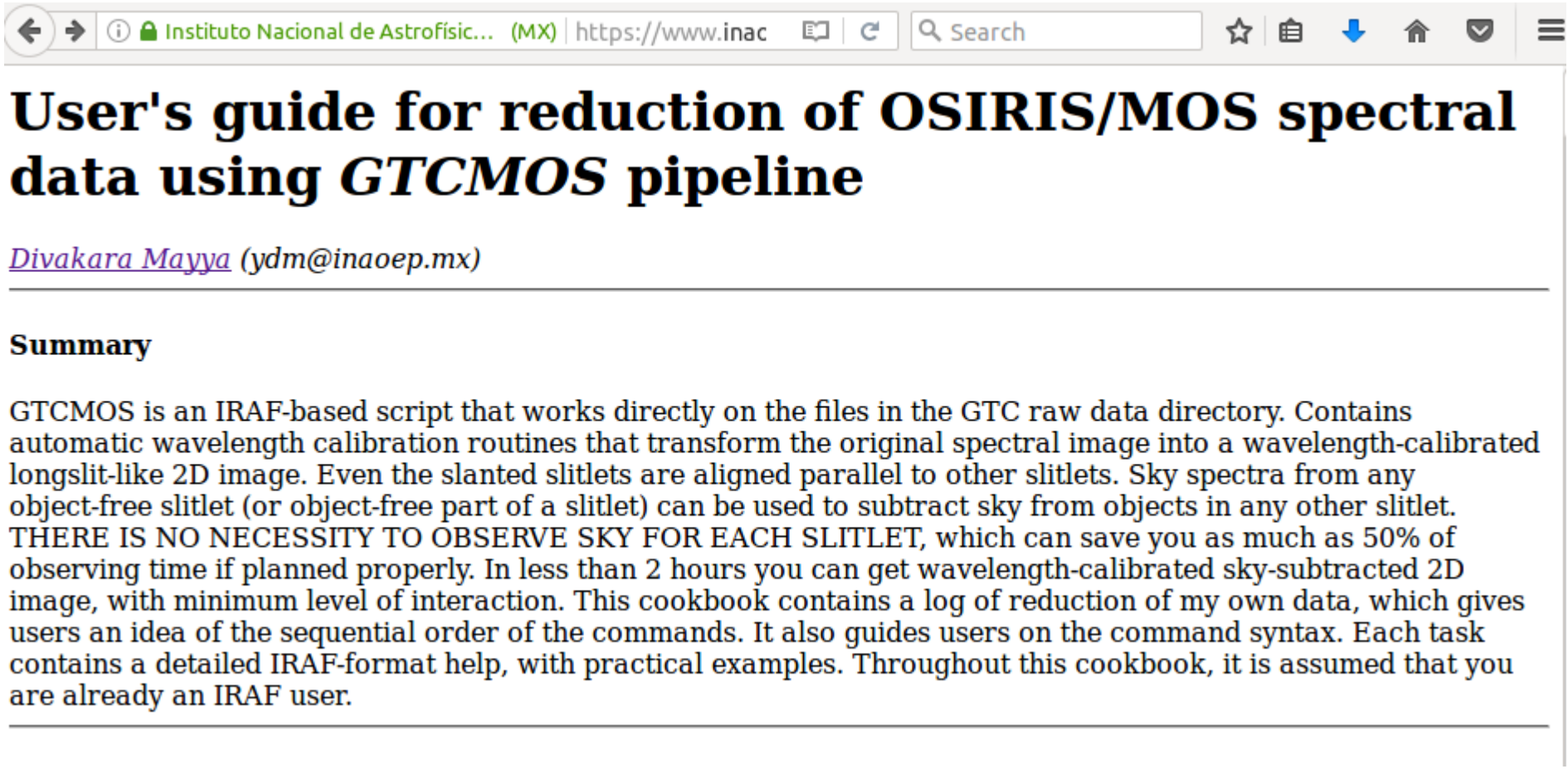


Illustration 5: Cookbook

https://www.inaoep.mx/~ydm/gtcmos/mos_reduction.html



html cookbook with

practical examples and clickable illustrative figures

Salient features of the pipeline

-IRAF-based scripts, user friendly, IRAF-like help

-Works directly on the raw-data directory (GTC?-MEX?/OB0001/object)

- no need to type long filenames.....

-Generates automatically logical/unique output names

-Combines the 2 CCD images into one using astrometric solution

-Automatic line-identification and wavelength calibration

-Converts MOS spectral image into longslit-like 2D image

-Aligns slanted slitlets

-Not necessary to observe sky for each slitlet

===> can observe more targets, if available

-Standard star Wavelength and Flux-calibration in one command

(no longslit arc provided, uses standard solution)

-Generic sky subtraction and extraction tasks included

-Reduction of longslit spectra and OSIRIS images is trivial

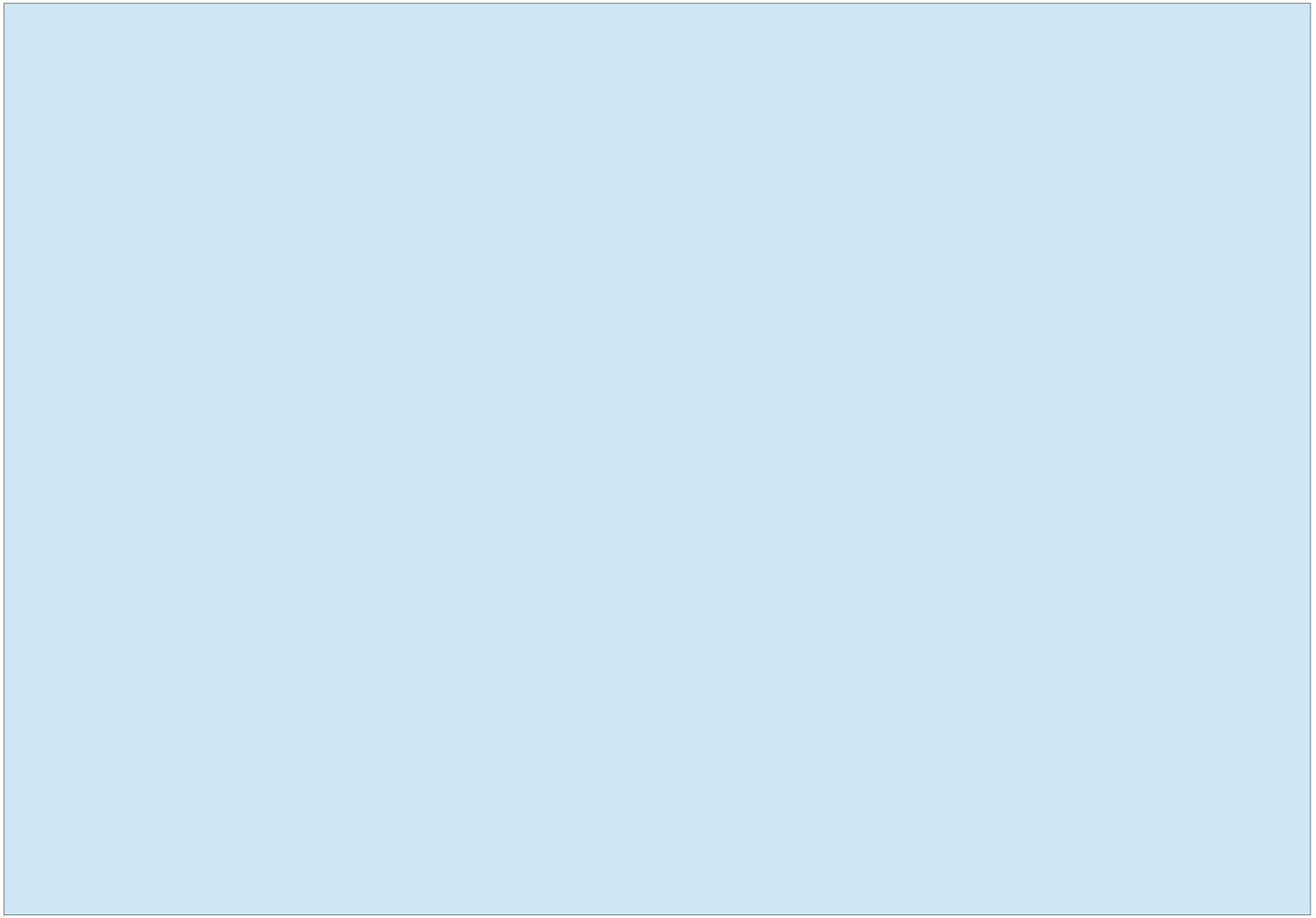
-Compatible with pre-MOS longslit/imaging data as well

-Can be easily used to reduce OSIRIS raw-data from GTC data archive

GTCMOS – Usage statistics

72 users and counting …..

from Mexico, Spain, China, Canada, Hong Kong, India, France, Germany, US, Bulgaria, ...



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