

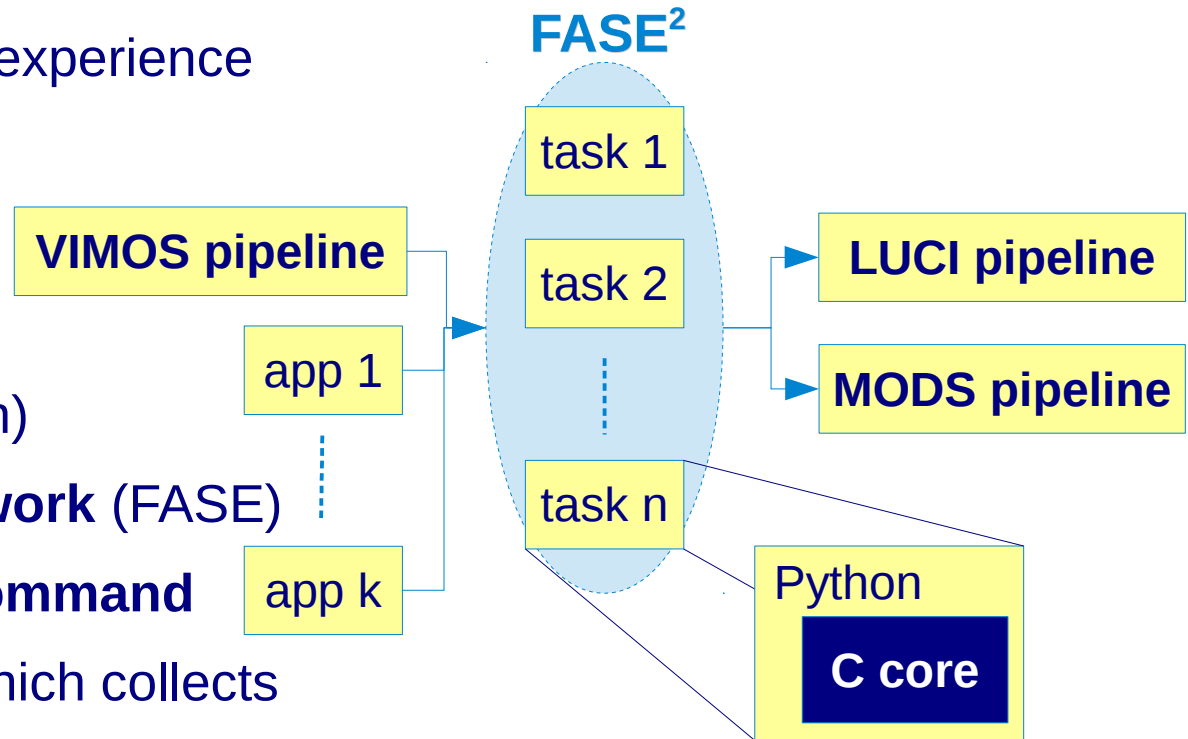
LBT Italy

Spectroscopic Reduction Center

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INAF-IASF Milano

Pipelines software design

- LUCI and MODS pipelines development
- Inherits from **VIMOS**¹ pipeline experience
- Adaptation to **specific cases**
(e.g. longslit mode)
- Plugged in **missing parts**
(e.g. infrared sky subtraction)
- Plugged into **common framework** (FASE)
- Recipes can be run both by **command line** and by the **GUI (VIPGI)** which collects and organize data



1. "The VVDS Data-Reduction Pipeline: Introducing VIPGI, the VIMOS Interactive Pipeline and Graphical Interface", Scodeggio et al 2005, PASP, 228, 1284

2. "A Future Astronomical Software Environment", P. Grosbøl et al in ADASS XXI, vol. 461, 619

Pipelines workflow

GENERIC CALIB

Darks &
Flat fields

Cold, hot,
non-linear
pixels

Darks/
Bias
prescan

Bad Pixel
Map

Master
Dark

TARGET CALIBRATIONS

Flat Field

Pixel2pixel
correction

Optical
distortion
correction

Spectra
location

Master
Flat

Arc
frames

Inverse
Dispersion
Solution

Master
Lamp

Telluric/
standard

Sensitivity
function

Telluric
correction

Flux
calibration
table

SCIENCE

Science
Exposure

Science
Exposures

bad pixels,
cosmic rays
and dark
correction

Optical
distortion
correction

Wavelength
calibration

2D extraction

Sky
subtraction

Flux
calibration

1D extraction

Data
products

Combine
exposures

1D extraction

Data unpacking and organizing

- **Trieste archive**¹ automatically send INAF data in Milan
- Data **unpacked**:
 - Mask info (LMS/MMS files)
 - Grism properties
 - **Mathematical models** used to describe the instrument configuration (**first guesses**)
- Data **automatically organized**:
 - collected according with PI, target and mask
 - Different nights/runs collected together
 - organized by data type and instrument mode

Observing night

The screenshot shows the Vipgi software interface with the following components:

- Top Bar:** Project, Parameters, Files tabs. Buttons for file operations and a lightbulb icon.
- Left Panel:** Reduction, Browsing, Plotting tabs. Buttons for image creation, adjustment, and reduction.
- Project List:** Vanzell...sj0717-ID523456-Flat, Vanzell...j0717-ID523456-G400L, Vanzell...j0717-ID523456-G670L.
- Main Table:**

FILENAME	FILETYPE	FILTER NAME	DICHNAME	EXPTIME	DATE OBS
ff_macsj0717_QTH1QTH6V_G670L_NS006.fits	FLAT	ND1.5	Dual	1.0	2014-01-31 01:30:02
ff_macsj0717_QTH1QTH6V_G670L_a001.fits	FLAT	ND1.5	Dual	1.0	2013-11-01 12:57:02
ff_macsj0717_VFLAT_G670L_NS007.fits	FLAT	Clear	Dual	1.0	2014-01-31 01:34:01
ff_macsj0717_VFLAT_G670L_a002.fits	FLAT	Clear	Dual	1.0	2013-11-01 13:01:01
lp_macsj0717_AR_G670L_NS010.fits	LAMP	ND1.5	Dual	1.0	2014-01-31 01:40:02
lp_macsj0717_AR_G670L_a005.fits	LAMP	ND1.5	Dual	1.0	2013-11-01 13:07:02
lp_macsj0717_HGNE_G670L_NS008.fits	LAMP	ND1.5	Dual	1.0	2014-01-31 01:36:02
lp_macsj0717_HGNE_G670L_a003.fits	LAMP	ND1.5	Dual	1.0	2013-11-01 13:03:02
lp_macsj0717_KRXE_G670L_NS009.fits	LAMP	ND1.5	Dual	1.0	2014-01-31 01:38:01
lp_macsj0717_KRXE_G670L_a004.fits	LAMP	ND1.5	Dual	1.0	2013-11-01 13:05:01
sc_macsj0717_None_G670L_a001.fits	SCIENCE	Clear	Dual	1200.0	2013-11-01 10:01:03
sc_macsj0717_None_G670L_a002.fits	SCIENCE	Clear	Dual	1200.0	2013-11-01 10:23:03
sc_macsj0717_None_G670L_a003.fits	SCIENCE	Clear	Dual	1200.0	2013-11-01 10:45:02
sc_macsj0717_None_G670L_a004.fits	SCIENCE	Clear	Dual	1200.0	2013-11-01 11:09:00
- Bottom Section:**

FILENAME	FILETYPE	GRISM	CHANNEL
ImMsFlat_Red_1.5_210113.fits	MASTER FLAT IMG	G670L	RED
msLamp_RedDual_LS5x60_050	MASTER LAMP	G670L	RED
msFlat_RedDual_LS5x60_0204	MASTER FLAT	G670L	RED
msFlat_RedDual_LS5x60_0504	MASTER FLAT	G670L	RED
bp_red_oct13.fits	FLAT	G670L	RED

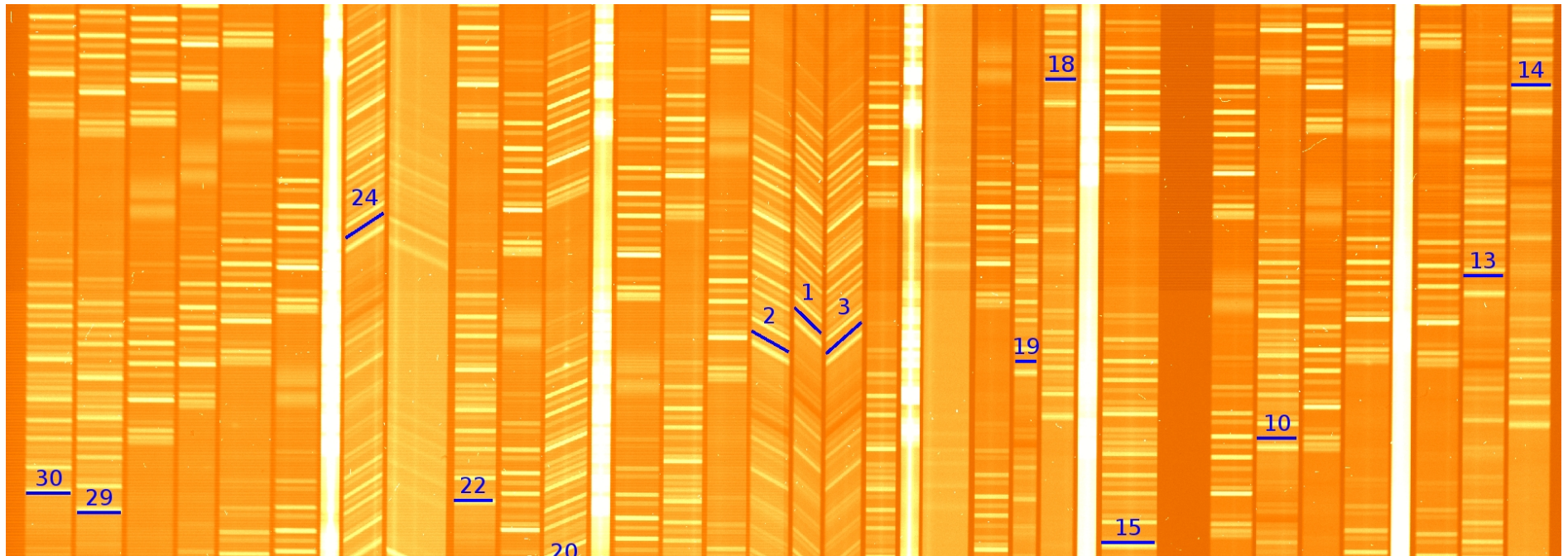
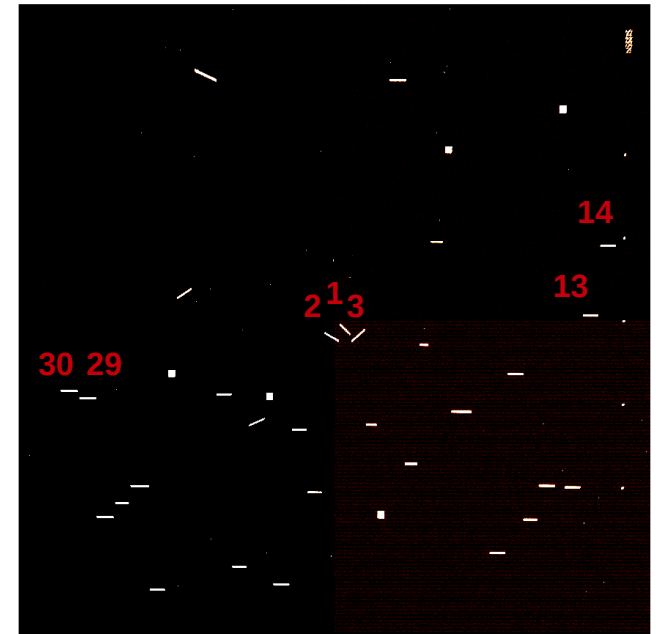
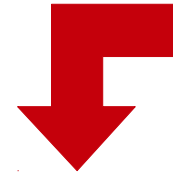
Data types

PI and target

Slits location

LMS/MMS information + mathematical model
are used to roughly **locate** slits

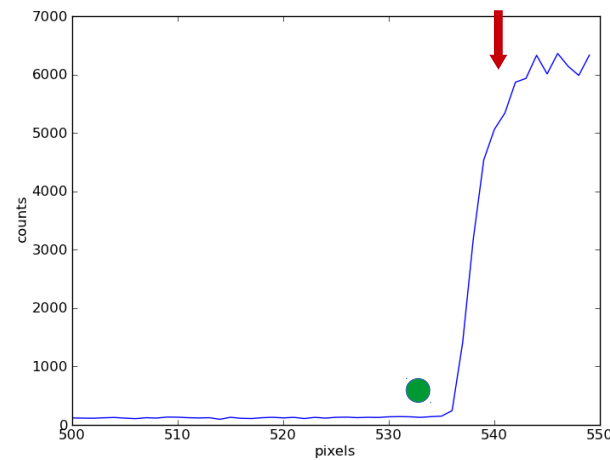
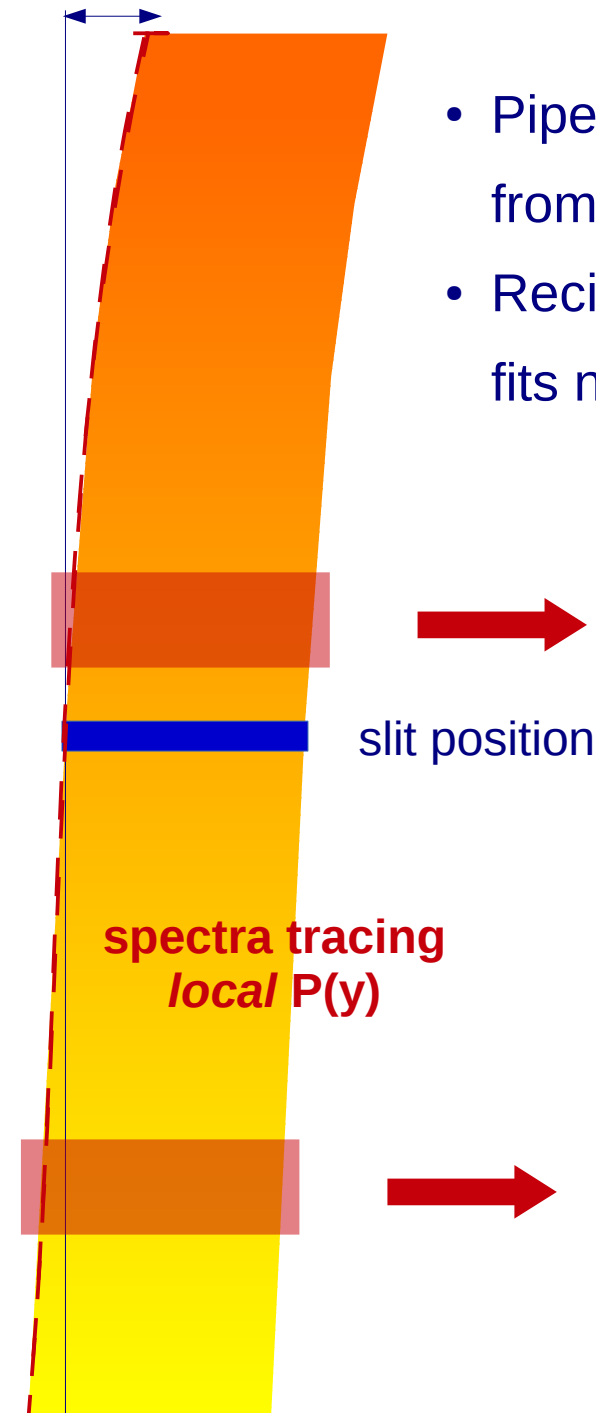
LMS/MMS
+
global $P(x,y)$



displacement

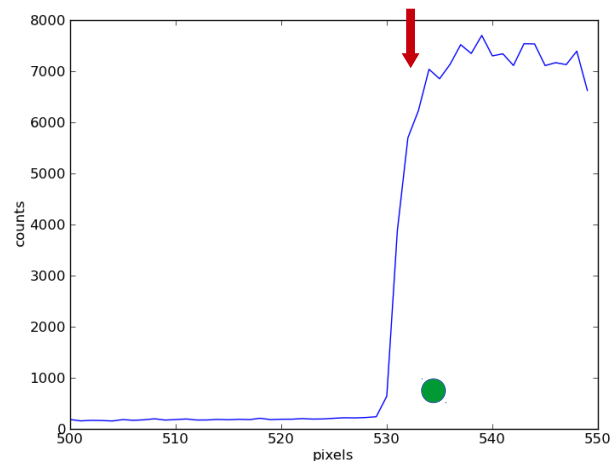
Spectra location

- Pipeline uses flats to trace spectra following the displacement from the **expected** position and the **real** position on frames
- Recipe **automatically finds flat edge** positions and fits new positions along dispersion direction



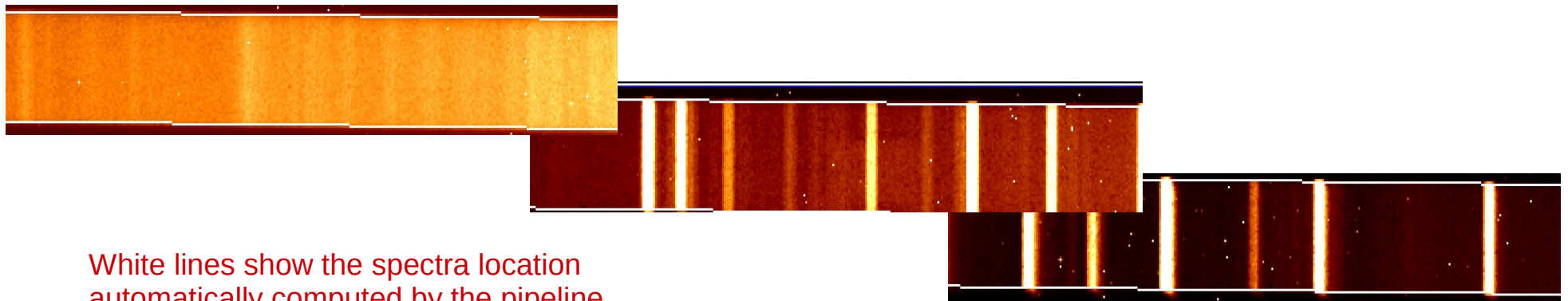
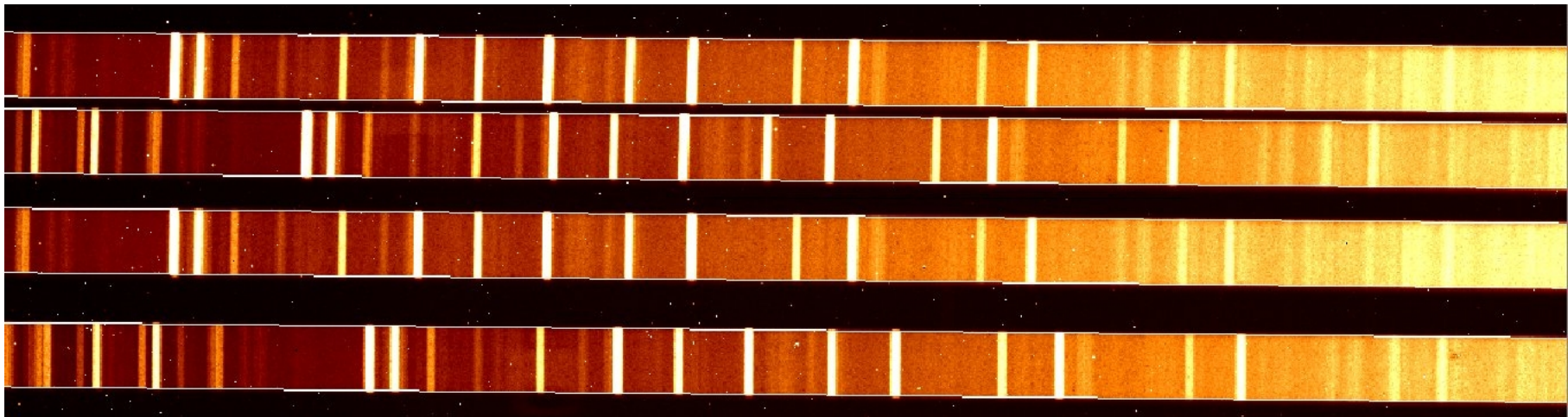
Expected spectra edge

Real edge on frame



Checks on Spectra location

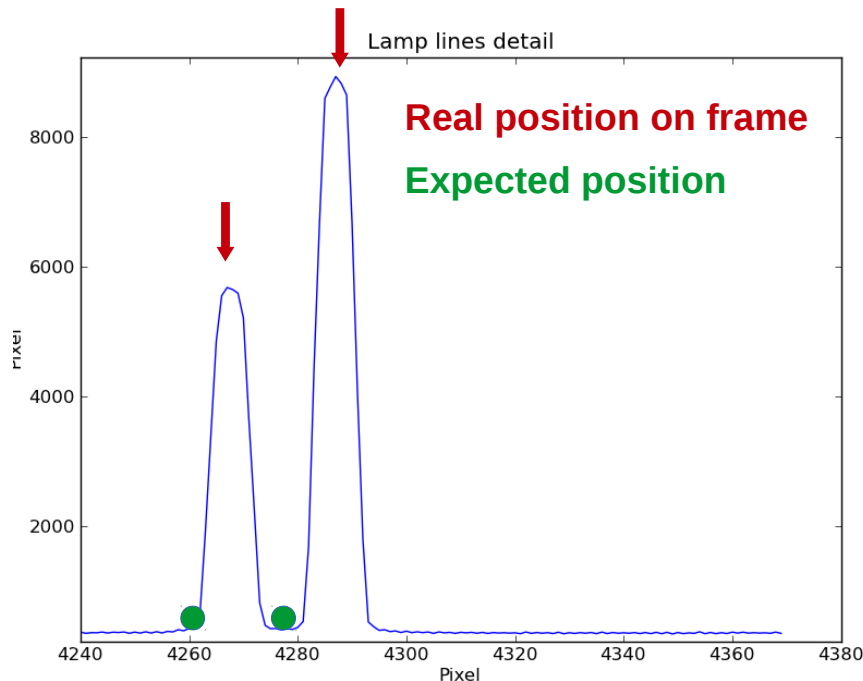
- **Quantitative check:** computes mean and maximum displacement between real and computed tracing solution
- **Visual check:** plots over frames computed solution



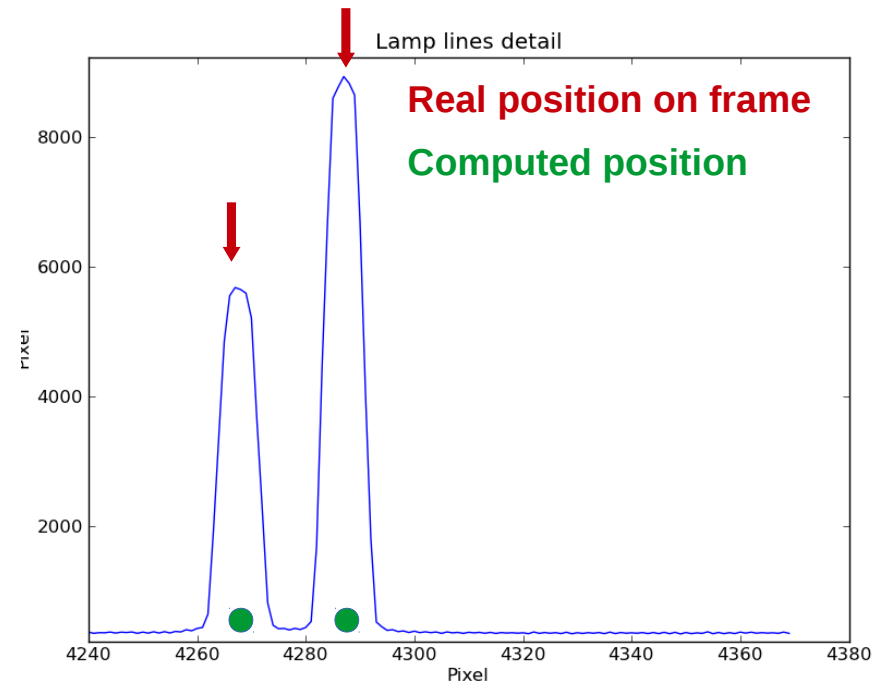
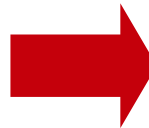
White lines show the spectra location
automatically computed by the pipeline

2D Wavelength calibration

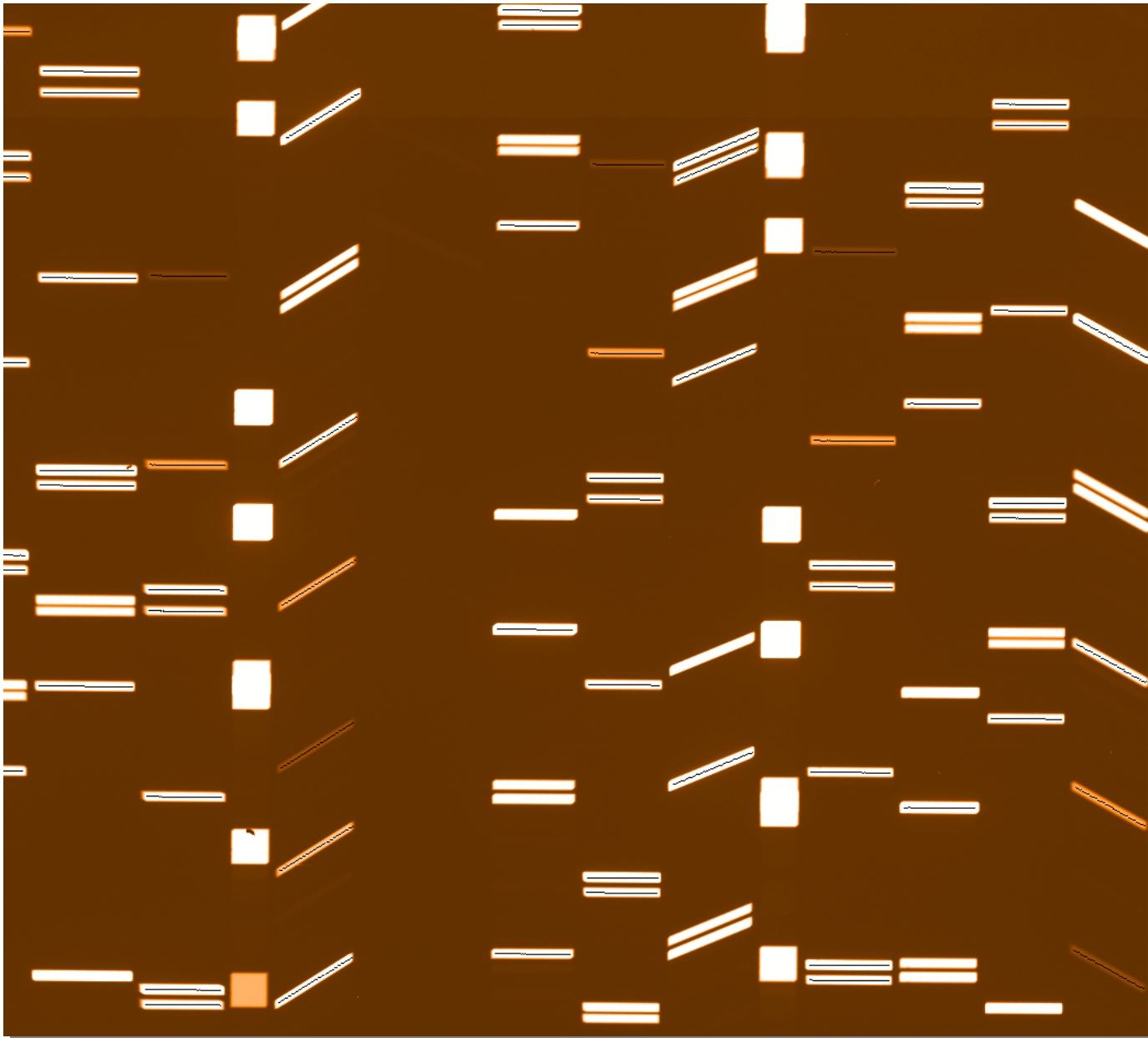
- First guesses model (global matrices) gives an **expected position**
- Pipeline **searches real lines** around expected positions (tabulated in a line catalog)
- Wavelength solution recomputed (local polynomial slit by slit)
- **Iteration** until a stable solution is obtained



Recipe
computation



Wavelength calibration checks



The check tool overplots
computed line positions
(black lines) on lamp frame

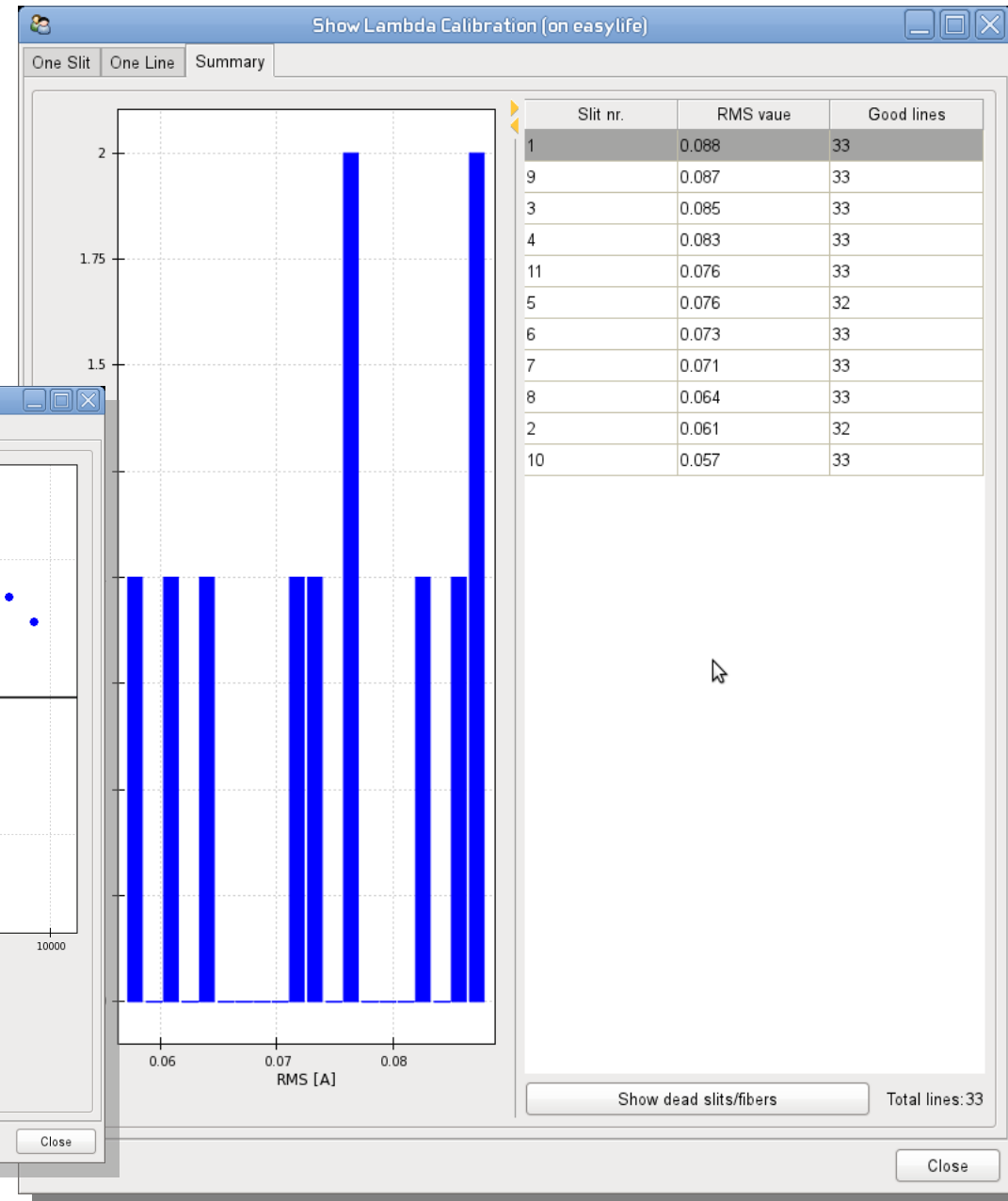
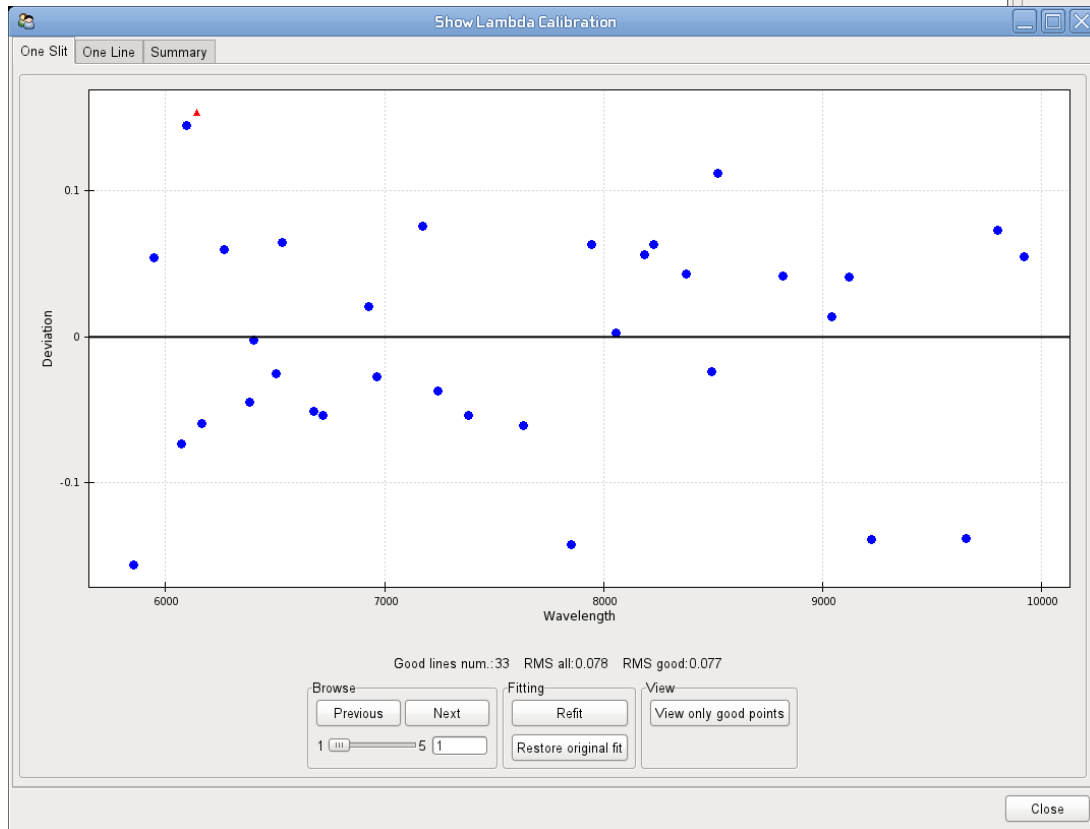
Quantitative check

Mean accuracy values:

- MODS red $\sim 0.83\text{\AA}$
- MODS blue $\sim 0.69\text{\AA}$
- LUCI 200HK (HK) $\sim 0.57\text{\AA}$
- LUCI 200HK (zJ) $\sim 0.29\text{\AA}$
- LUCI 210zJHK (K) $\sim 0.26\text{\AA}$
- LUCI 210zJHK (H) $\sim 0.15\text{\AA}$

Wavelength calibration check and refine

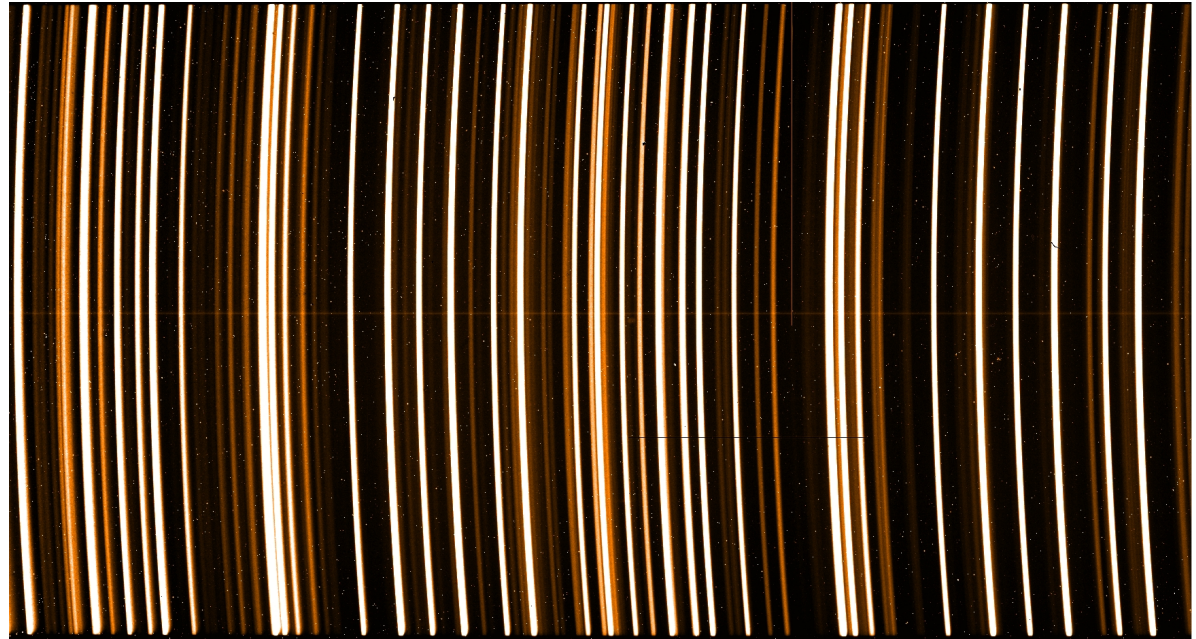
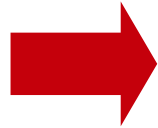
- **select lines** used in wavelength solution computation
- **check** lambda calibration in each slit



Spectra extraction and lambda calibration

Spectra are **resampled** and extracted
(here LUCI longslit spectrum)

Raw frame



Extracted spectra
lambda calibrated



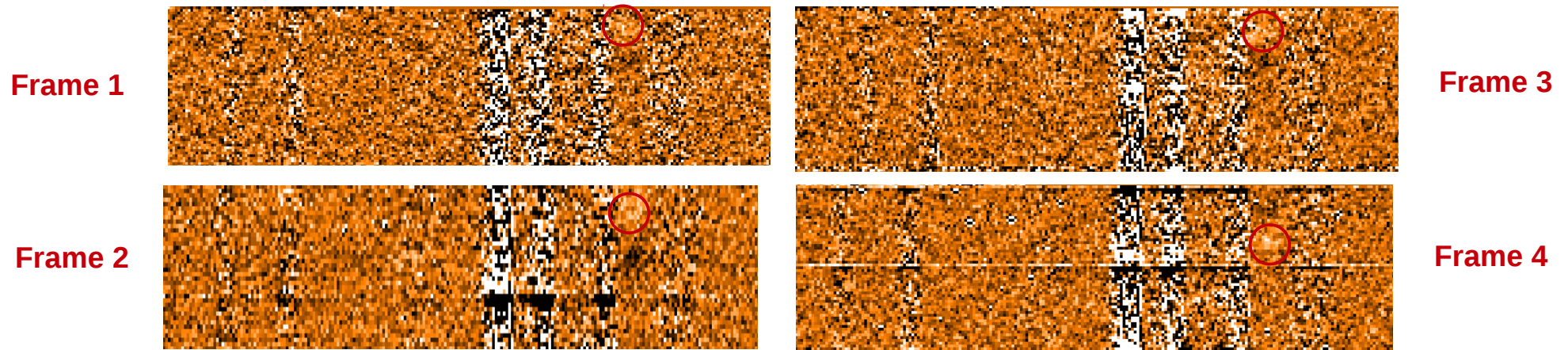
Lambda calibrated



Background subtraction and slits combination

Background is removed in each exposure

- **MODS**: local estimation of the background slit by slit
- **LUCI**: Removed OH emission lines based on Davies algorithm¹

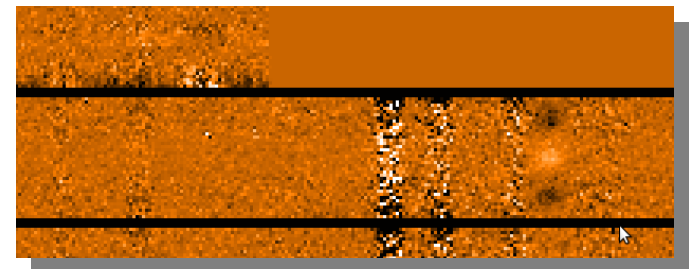


Frames are stacked, taking into account of **frame offsets**.

Offsets are computed using:

- **bright objects** on frame
- **header info** (if available)

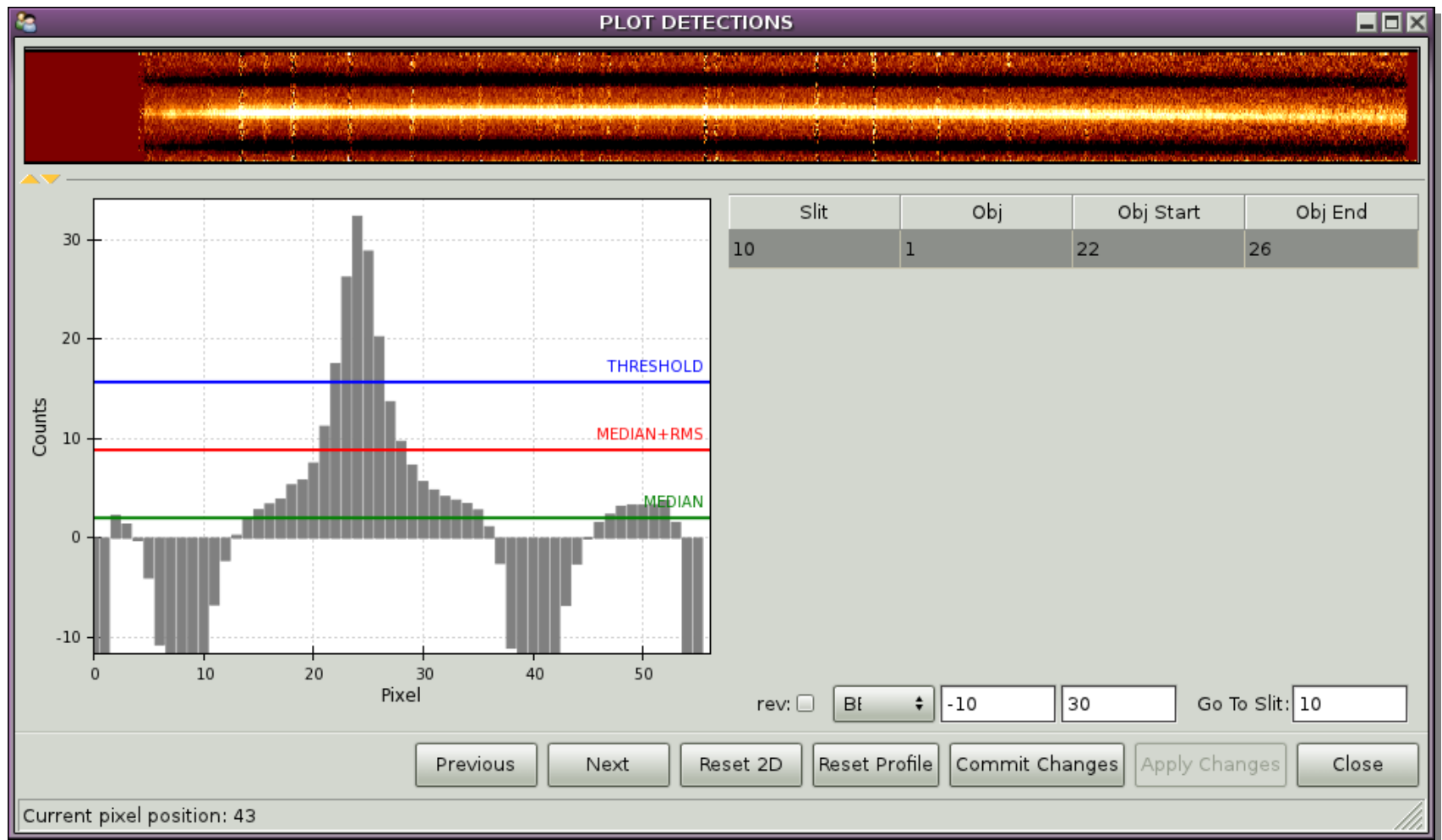
Combined frame



1. Porting (C code) of Davies R. and Cresci, G. algorithm implementation Davies 2007: MNRAS, 375, 1099

Automatic spectra extraction

- Create a **spectrum profile**: collapse 2D spectrum along spatial direction
- Detect objects using sigma clipping
- Perform optimal Horne extraction¹ to obtain 1D spectrum



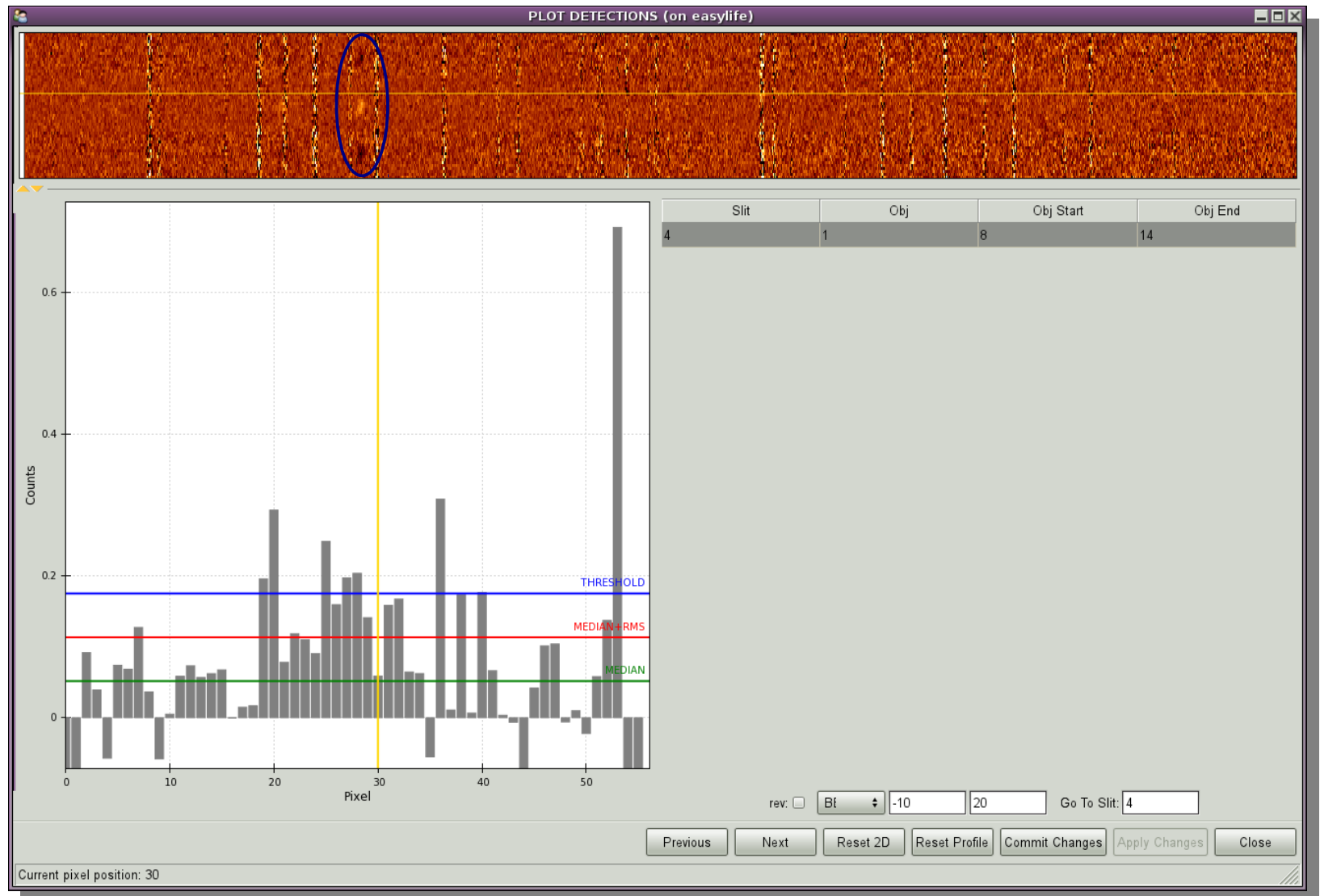
Collapsing

Spectra profile

¹ "An optimal extraction algorithm for CCD spectroscopy", Horne, K. 1986, 1986PASP...98..609H

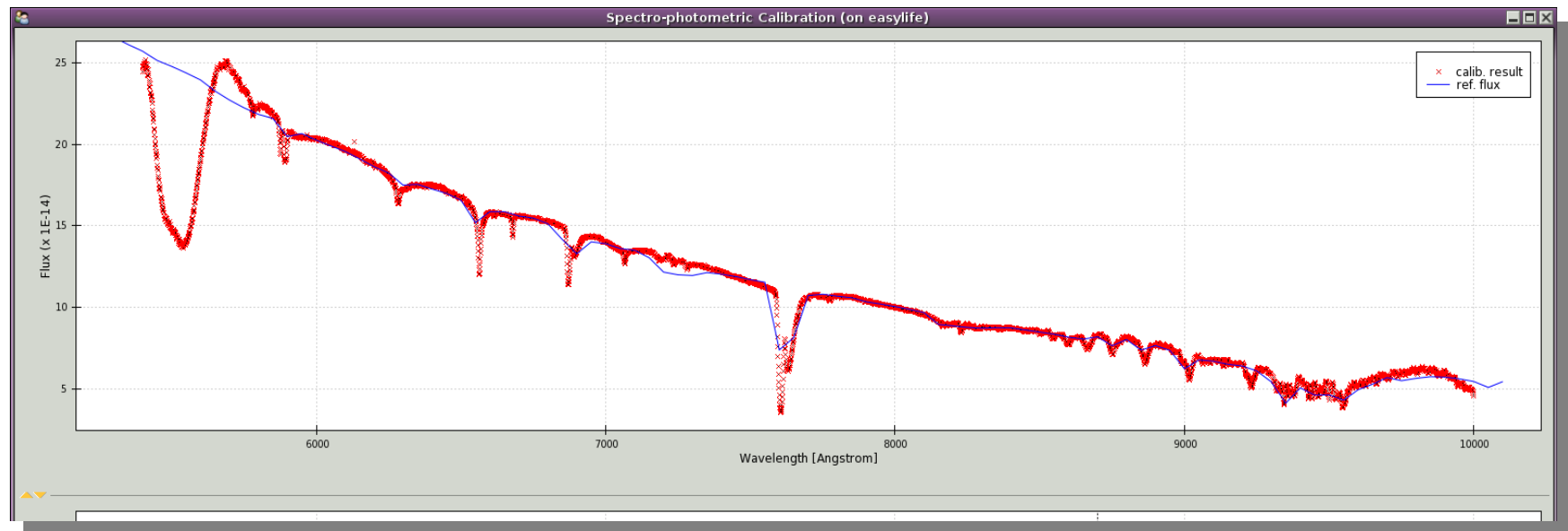
Manual spectra extraction

- Examine 2D spectra
- Looking for features
- Extract 1D spectra

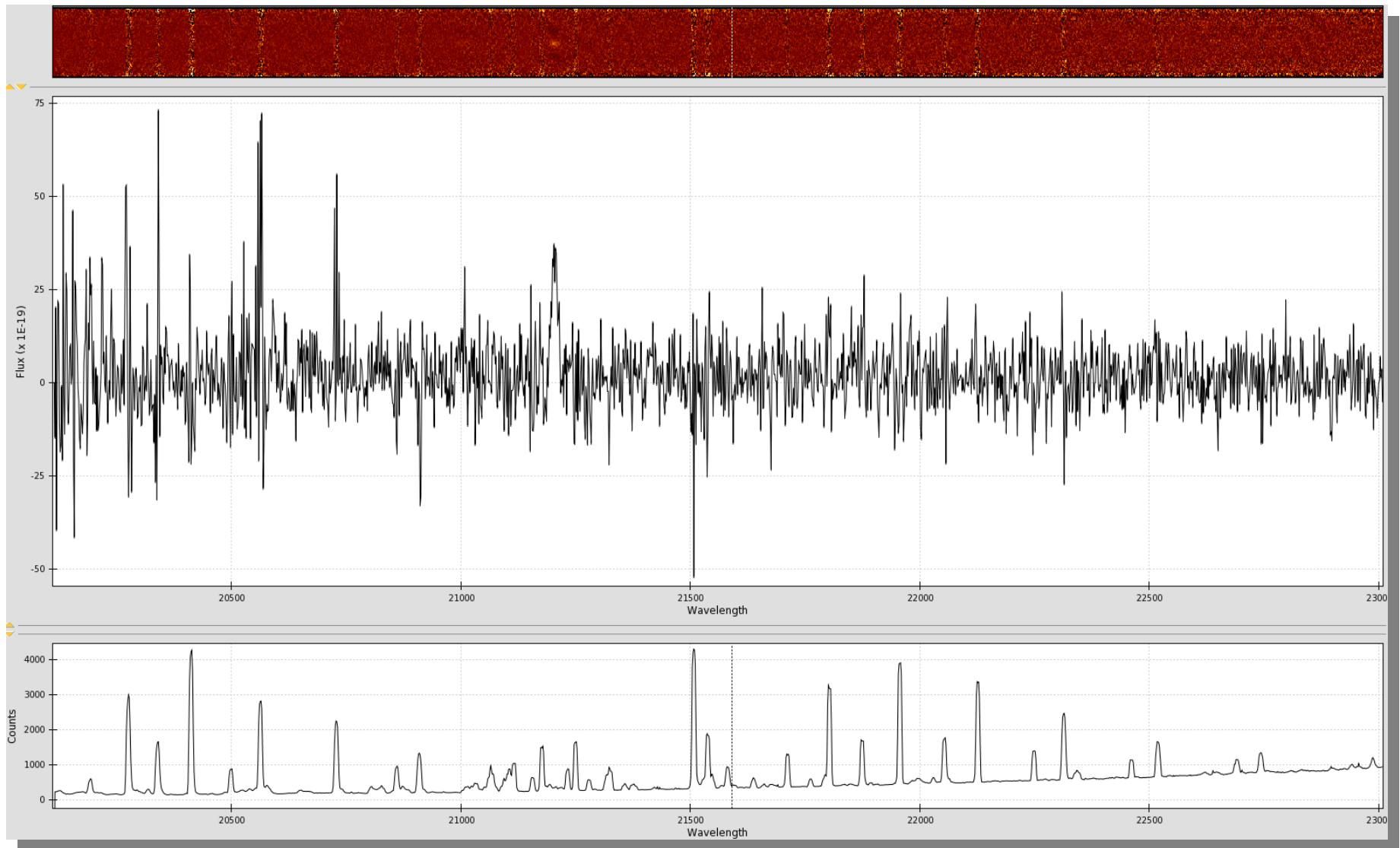


Spectra flux calibration

- Observed calibration star reduced by the pipeline
- Star spectrum is used to obtain a sensitivity function
- **MODS:**
 - reduced spectra is compared with **spectrophotometric standard**
- **LUCI:**
 - Stellar type, luminosity class and magnitude are retrieved (**Hipparcos catalog**)
 - **Pickles template** is rescaled
 - Reduced spectra is compared with the rescaled template



Distributed data products



- **2D spectra** lambda calibrated
- Sky spectra lambda calibrated
- **1D spectra**, lambda and flux calibrated
- Others upon request

Data distribution

- Reduced data are uploaded on the **LSC¹** database in Rome
- System sends a mail to the PI
- PI can retrieve data

Proposal n. 19
P.I.: M.T. Botticella

Run	Target	RA	DEC	Instrument	Bulk Action on RUN
19.A	COSMOS	00:00	02:15	LBC-BIN	→RE-DO →UNLINK

[Upload archive for the RUNS in this Proposal:](#)

Bulk Action on PROPOSAL:

alter EXEC_STATUS of ALL Proposal's OBs →RE-DO →UNLINK

Delete ALL Proposal's OBs →UNLINK

Proposal n. 20
P.I.: E. Vanzella

Run	Target	RA	DEC	Instrument	Bulk Action on RUN
20.A	fnacs0717	07:17	07:46	MODSL-MOS	→RE-DO →UNLINK
20.B	fnacs0647	06:47	07:15	MODSL-MOS	→RE-DO →UNLINK
20.C	fn1532	05:32	00:22	MODSL-MOS	→RE-DO →UNLINK
20.D	fnacs0744	07:44	09:28	MODSL-MOS	→RE-DO →UNLINK
20.E	fnacs1149	01:48	22:25	MODSL-MOS	→RE-DO →UNLINK

[Upload archive for the RUNS in this Proposal:](#)

Bulk Action on PROPOSAL:

alter EXEC_STATUS of ALL Proposal's OBs →RE-DO →UNLINK

Delete ALL Proposal's OBs →UNLINK

Run	Target	RA	DEC	Instrument	Bulk Action on RUN
3660	C2_L5_081 (MODS_SPEC)				done
3662	C3_L5_obs (MODS_SPEC)				to do
3571	COSMOS_r1_obs (LBC_OB)				to do
3572	COSMOS_r2_obs (LBC_OB)				to do
3573	COSMOS_r3_obs (LBC_OB)				to do
3574	COSMOS_r4_obs (LBC_OB)				to do
3575	COSMOS_r5_obs (LBC_OB)				to do
3576	COSMOS_r6_obs (LBC_OB)				to do
3577	COSMOS_r7_obs (LBC_OB)				to do
3578	COSMOS_r8_obs (LBC_OB)				to do
3386	mod.macsj0717_m01_1_obs (MODS_SPEC)				done
3387	mod.macsj0717_m01_2_obs (MODS_SPEC)				done
3388	mod.macsj0717_m01_3_obs (MODS_SPEC)				done
3389	mod.macsj0717_m01_4_obs (MODS_SPEC)				done
3390	mod.macsj0717_m01_5_obs (MODS_SPEC)				done
3391	mod.macsj0717_m01_6_obs (MODS_SPEC)				done
3392	mod.macsj0647_m01_1_obs (MODS_SPEC)				done
3393	mod.macsj0647_m01_2_obs (MODS_SPEC)				done
3394	mod.macsj0647_m01_3_obs (MODS_SPEC)				done
3395	mod.macsj0647_m01_4_obs (MODS_SPEC)				done
3396	mod.macsj0647_m01_5_obs (MODS_SPEC)				done

LSC Data Centre Image Repository

Database: **Reduced Fields** Target: Seeing(<=): Back (<=):

Channel: **ALL** Type: **ALL** Tot.ExpoTime: Proprietary: **All Data**

Filter: **ALL** ObsDate: n.Exposures: ☐ has tri

Cone Search:

RA [deg]: DEC [deg]: Radius [arcmin]:

Here are requested images:

#ID#	Target	Database	Type (*)	Description	FileP
27	CL2244	Reduced Fields	MOSAIC	Gravitational Arch	/data/DBLBC
28	CL2244	Reduced Fields	MOSAIC	Gravitational Arch	/data/DBLBC
29	CL2244	Reduced Fields	MOSAIC	Gravitational Arch	/data/DBLBC
30	CL2244	Reduced Fields	MOSAIC	Gravitational Arch	/data/DBLBC
31	CL2244	Reduced Fields	MOSAIC	Gravitational Arch	/data/DBLBC
32	CL2244	Reduced Fields	MOSAIC	Gravitational Arch	/data/DBLBC

Conclusions

- Pipelines provide good quality results which are being used by Italian community
- Data reduction is “**mostly automatic**”, with human intervention required for:
 - Quality checks
 - Calibrations
- Automatization could be **further improved** adding:
 - Integration of the quality checks in the reduction workflow
 - Handling of the various instrument configurations

Thanks