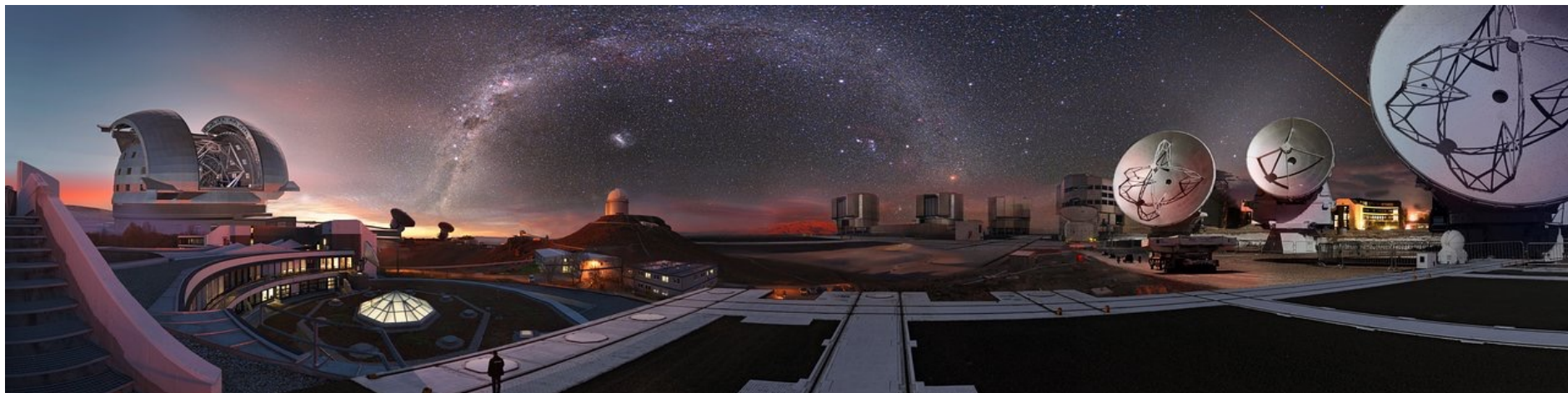


# ESO Science Data Products

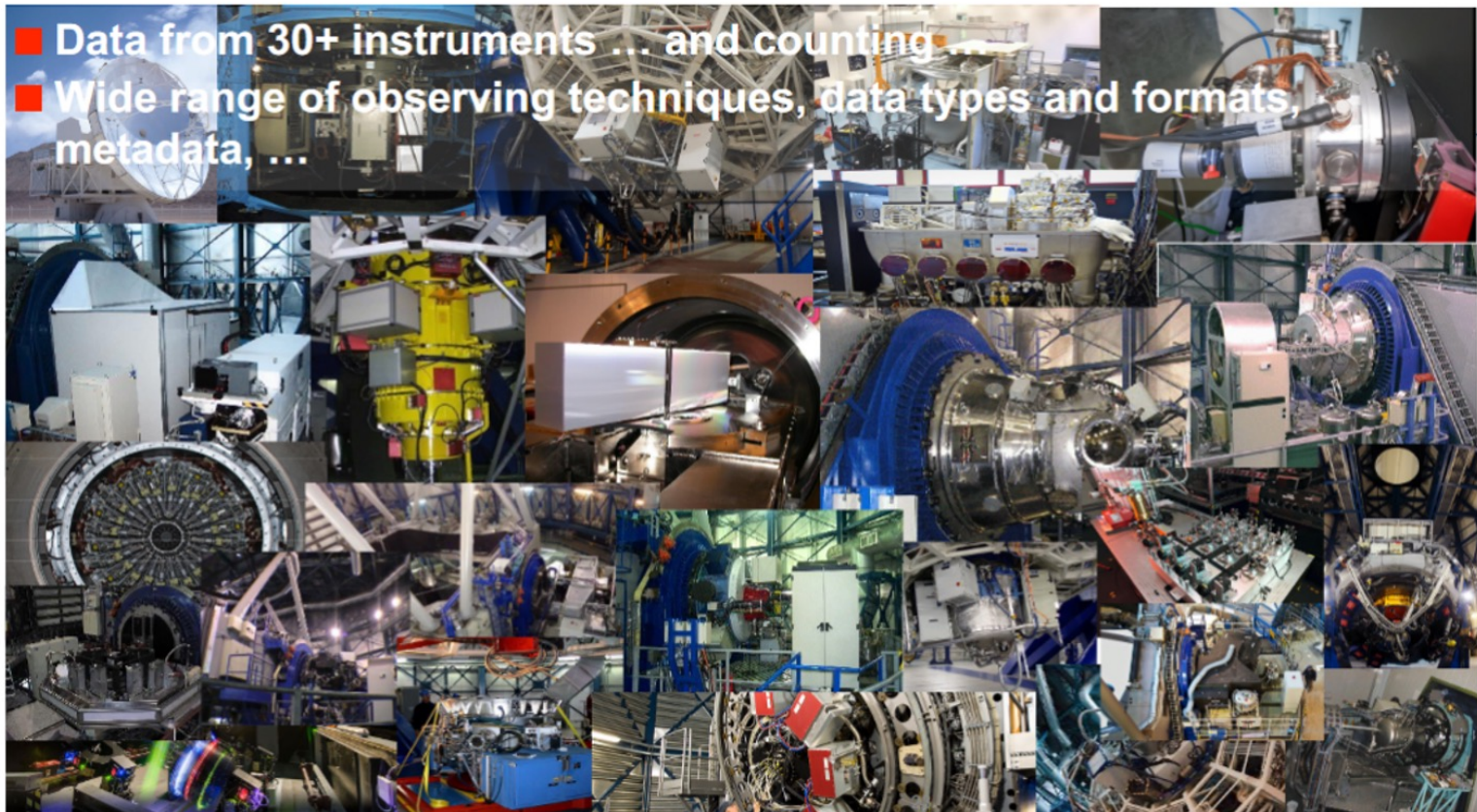
Danuta Dobrzycka (DMO-SDQ)

on behalf of the science, development and operation teams



# ESO Science Data Products

- In addition to the raw data from the ESO telescopes/instruments, ESO Archive also offers the science data products



# Science Data Products

## Main requirements for the data products

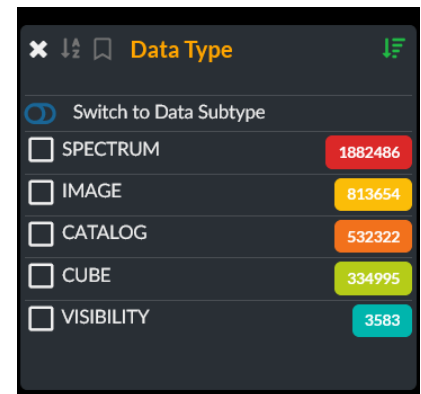
- Instrumental signatures removed
- They must be calibrated in physical units
- Error information must be present
- Photon provenances recorded

## There are two main types:

- External Data Products (EDPs) - processed by PIs, consortia
- Internal Data Products (IDPs) - data from selected instruments processed in-house
  - UVES, GIRAFFE, HAWKI, XSHOOTER, FORS2-SPECTROSCOPY, MUSE, KMOS, ESPRESSO, VIMOS - supervised processing
  - HARPS, FEROS - unsupervised processing

# Data Types

- Images (monolithic and multi-detector arrays)
- Source lists extracted from images
- Flux maps (APEX)
- 1D spectra
- IFU cubes
- Visibilities (PIONIER)
- Catalogues (physical quantities)
- .... + coming new ones like e.g. time-series, polarimetric data



Data Type	Count
<input type="checkbox"/> SPECTRUM	1882486
<input type="checkbox"/> IMAGE	813654
<input type="checkbox"/> CATALOG	532322
<input type="checkbox"/> CUBE	334995
<input type="checkbox"/> VISIBILITY	3583

# Internal Data Products

- IDPs processed in-house, mostly by the SDQ group
- Data of selected instruments with pipelines declared “science (or Phase 3)” ready
- Best master calibrations are used, previously processed and certified for quality
- Automated, uniform processing with most universal set of recipe parameters
- Come with extensive release description documents  
[https://www.eso.org/sci/observing/phase3/data\\_streams.html](https://www.eso.org/sci/observing/phase3/data_streams.html)
- Available in the Archive ~ 1-3 months after original data acquired



# Internal Data Products

## ■ IDP's processing supervised and monitored

dfos = Data Flow Operations System, the common tool set for DFO

monitors	VLT instruments														VLT I				ICCF		survey cameras				
calib completeness	CAL	[retired]	[retired]	FORS2	KMOS	GIRAFFE	UVES	XSHOOTER	[retired]	SPHERE	[retired]	VISIR	HAWKI	[retired]	[retired]	MUSE	[retired]	GRAVITY	[retired]	PIONIER	MATISSE	ESPRESSO	OCAM	VIRCAM	
daily workflow	DFO	[retired]	[retired]	FORS2	KMOS	GIRAFFE	UVES	XSHOOTER	[retired]	SPHERE	[retired]	VISIR	HAWKI	[retired]	[retired]	MUSE	[retired]	GRAVITY	[retired]	PIONIER	MATISSE	ESPRESSO	OCAM	VIRCAM	
condor processing	MUC	muc01			muc02			muc03			muc04			muc09		muc05		muc12		muc11		muc06		muc07	
history	histo	CRIRES	FORS1	FORS2	KMOS	GIRAFFE	UVES	XSHOOTER	ISAAC	SPHERE	VIMOS	VISIR	HAWKI	NACO	SINFONI	MUSE	AMBER	GRAVITY	MIDI	PIONIER	MATISSE	ESPRESSO	OCAM	VIRCAM	
For instruments with a pre-imaging process there is the processing monitor maintained by <i>processPrelmg</i> . Find the process documentation <a href="#">here</a> .																									
	pre-imaging			FORS2																					
IDP processing:																									
IDPs	overview			phoenix (muc08): KMOS_R	phoenix (muc08): GIRAF_STACK	phoenix (muc08): UVES_STACK	phoenix (muc08): XSHOOT_R2					phoenix (muc08): HAWKI_R					phoenix (muc10, muc11): MUSE_R   MUSE_DEEP								

### PHOENIX history monitor (instrument: KMOS, release: KMOS\_R)

last update: 2020-10-16T15:08:01 UT by kmos\_ph@muc08

This is the status page for the KMOS\_R IDP project.

It is based on SCIENCE ABs in \$DFO\_LOG\_DIR directories. For any date with ABs, the monitor displays:

- an overview of file and AB statistics,
- colour coding for nights with SCIENCE data, SM/VM flags,
- the product ingestion status for SCIENCE products,
- links to nightlogs, data reports and ingestion logs,
- links to the AB monitor.

The AB monitor links to the processing logs, QC plots and scoring files.

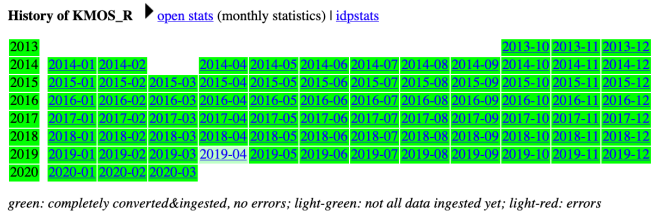
This overview page has the month boxes coded dark green if all products for that month have been ingested yet, and light red in case of ingestion errors.

For the total number of IDPs (or of master calibrations if this is an MCALIB project) click 'open stats'.

Other IDP streams: [UVES | XSHOOTER | GIRAFFE | MUSE&MUSE\\_DEEP | KMOS](#) .

Find the release description on the phase-3 archive page.

For research on QC parameters use [QC1 table kmos\\_science\\_idp](#).



### PHOENIX history monitor (instrument: UVES, release: UVES\_STACK)

last update: 2021-02-05T05:41:11 UT by scirootmuc08

This is the status page for the UVES\_STACK IDP project.

It is based on SCIENCE ABs in \$DFO\_LOG\_DIR directories. For any date with ABs, the monitor displays:

- an overview of file and AB statistics,
- colour coding for nights with SCIENCE data, SM/VM flags,
- the product ingestion status for SCIENCE products,
- links to nightlogs, data reports and ingestion logs,
- links to the AB monitor.

The AB monitor links to the processing logs, QC plots and scoring files.

This overview page has the month boxes coded dark green if all products for that month have been ingested (without error), light green if prod ingested yet, and light red in case of ingestion errors.

For the total number of IDPs (or of master calibrations if this is an MCALIB project) click 'open stats'.

This is UVES\_STACK, the **version 2** of the UVES IDPs. It contains stacks or single exposures at the OB level.

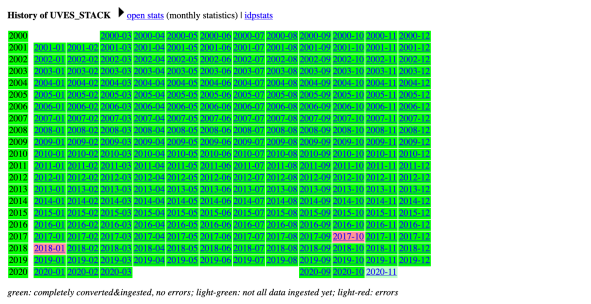
The earlier version 1 did not contain stacks. For reference, find the earlier version here:

- UVESR\_2 (2007-04-01 until 2019-04-30), and
- UVES\_R3 (2000->2007-03-31).

Both the UVESR\_2 and the UVES\_R3 streams are not operational anymore. The UVES\_R3 stream was reprocessing of the R2 stream until 2019.

Other IDP streams: [GIRAFFE | XSHOOTER | MUSE&MUSE\\_DEEP | KMOS | HAWKI](#).

Find the release description on the phase-3 page. For research on QC parameters use [QC1 table uvex\\_science\\_public](#).



### PHOENIX history monitor (instrument: XSHOOTER, release: XSHOOT\_R2)

last update: 2021-01-27T12:19:16 UT by xshooter\_ph@muc08

This is the status page for the XSHOOT\_R2 IDP project.

It is based on SCIENCE ABs in \$DFO\_LOG\_DIR directories. For any date with ABs, the monitor displays:

- an overview of file and AB statistics,
- colour coding for nights with SCIENCE data, SM/VM flags,
- the product ingestion status for SCIENCE products,
- links to nightlogs, data reports and ingestion logs,
- links to the AB monitor.

The AB monitor links to the processing logs, QC plots and scoring files.

This overview page has the month boxes coded dark green if all products for that month have been ingested ingested yet, and light red in case of ingestion errors.

For the total number of IDPs (or of master calibrations if this is an MCALIB project) click 'open stats'.

Find the release description for the XSHOOTER releases [here](#).

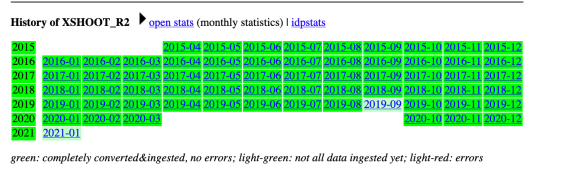
The IDP stream is divided into

- science IDPs: XSHOOT\_R (before 2015-04-01, master response curves) and XSHOOT\_R2 (after 2015-04-01 - telluric std stars processed as IDPs: XSHOOT\_TELL (until 2017-09); included in XSHOOT\_R2 afterward

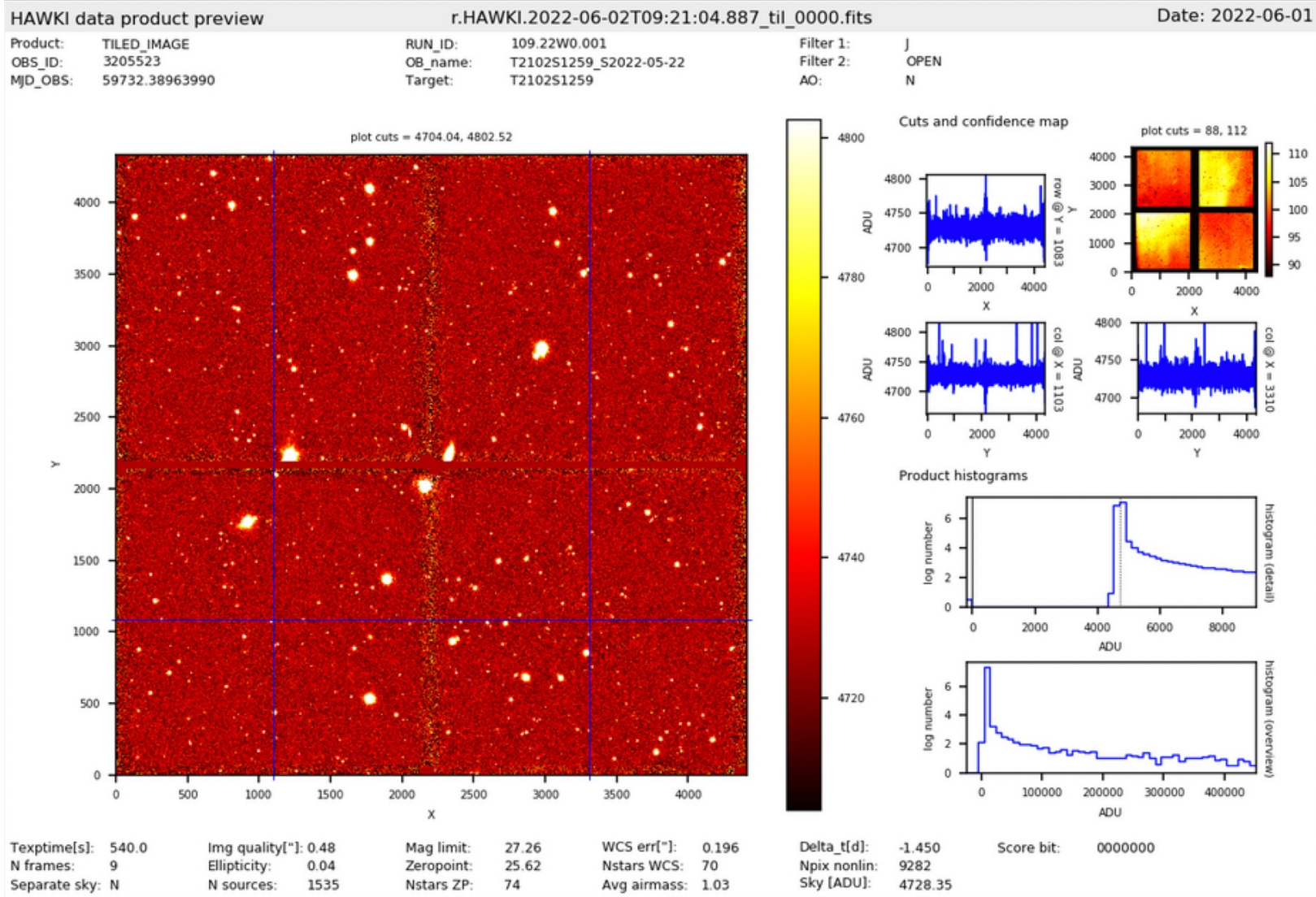
History monitors for XSHOOTER: [XSHOOT\\_R](#) (until 2015-03) | [XSHOOT\\_R2](#) (after 2015-03) | [XSHOOT\\_TELLuric spectra sorted by target: \[here\]\(#\)](#)

Other IDPs: [UVES | GIRAFFE | MUSE&MUSE\\_DEEP | KMOS | HAWKI](#)

Find the release description on the phase-3 archive page. For research on QC parameters use [QC1 table xsho](#)



# IDP – Preview plots



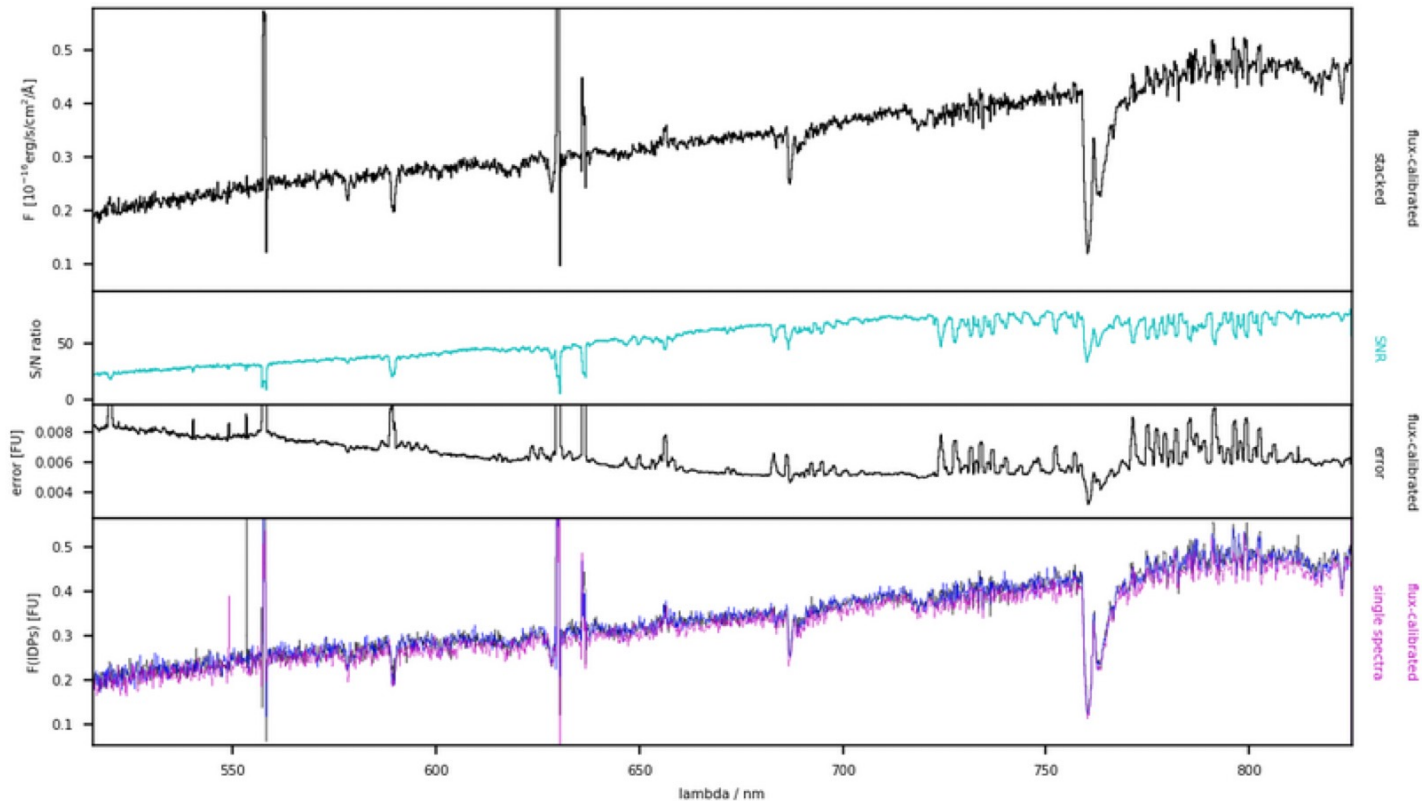
# IDP – Preview plots

## FORS2 data product preview

2022-05-02T00:05:33.440

Date: 2022-05-01

Product:	ESOTK_SPECTRUM_IDP_FORMAT	RUN_ID:	109.238K.001	INS MODE:	LSS	IQ:	0.89 arcsec
OBS_ID:	3251145	TotalExptime/s:	2429.9	Binning:	2x2	airmass:	1.19
TPL_ID:	FORS2_iss_obs_off_fast	DET_EXP_NUM:	U1_9	GRI+FILT:	600RI+GG435	slitwidth:	1.31 arcsec
MJD_OBS:	59701.00385926	Field:	NV55 J080405-362909mComb:	3	RA,DEC:	08:04:05.4 -36:29:18	



S/N: 56  
 lambda bin [nm]: 0.1660  
 resolving power: 762.16

lambda\_min [nm]: 515.40  
 lambda\_max [nm]: 825.16  
 score bits: 000

flux unit = FU:  $10^{-16}$  erg/s/cm<sup>2</sup>/Å



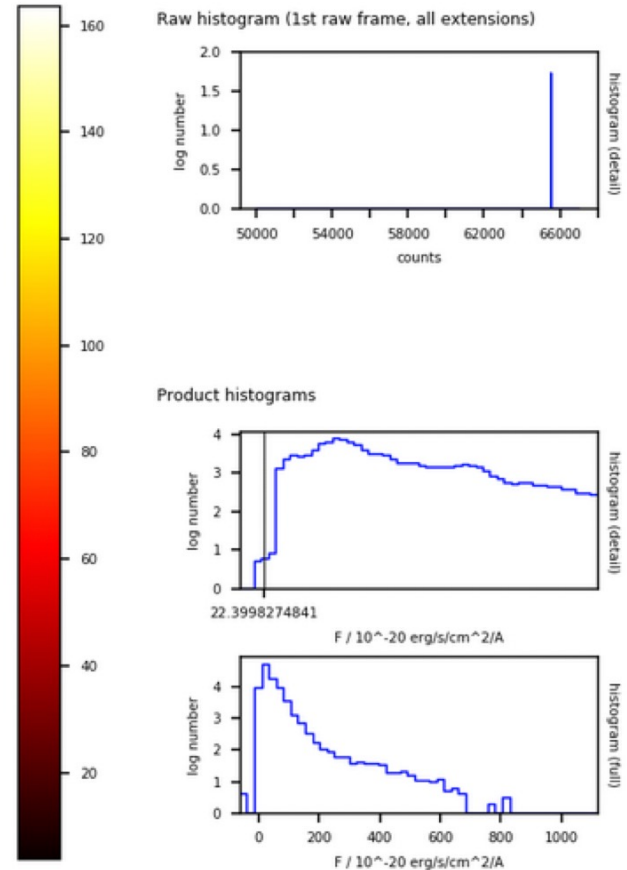
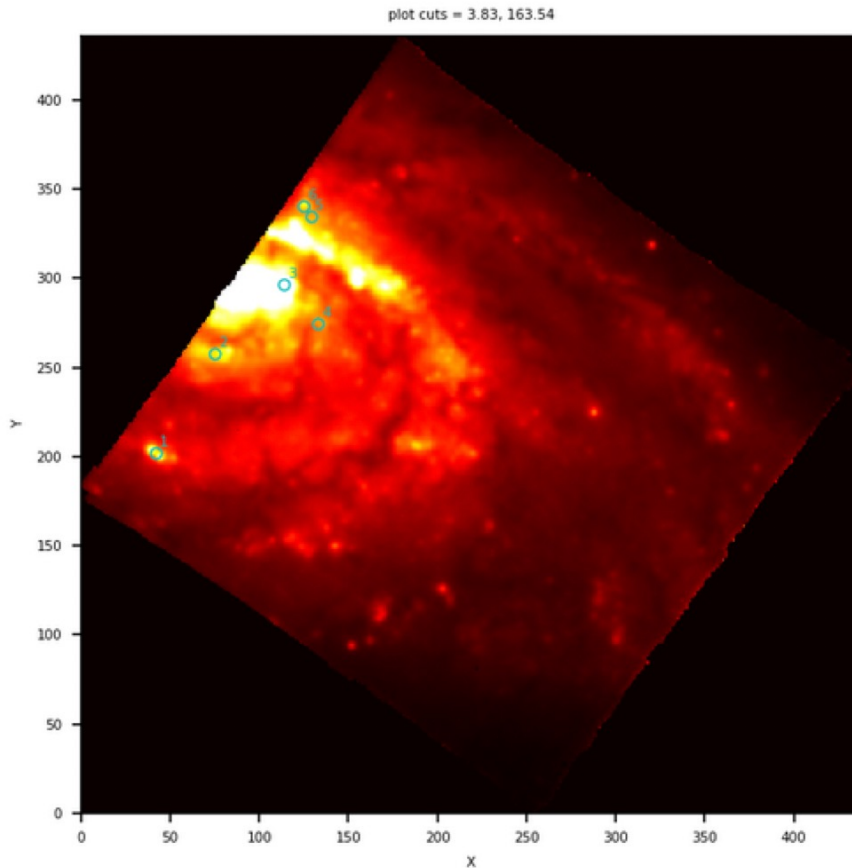
# IDP – Preview plots

MUSE data product preview

r.MUSE.2022-01-07T03:31:36.769\_tpl\_0000.fits

Date: 2022-01-06

product:	DATA_CUBE_COMBINED	setup:	WFM-NOAO-E
OBS_ID:	3094343	RUN_ID:	108.2221.001
MJD_OBS:	59586.14695334	OB_name:	WFM-IC1954_Pri02
DPR_TYPE:	OBJECT	target:	IC1954



Texptime[s]:	2120	N_sources:	6	lambda_start[nm]:	459.98	resolving power:	2988
airmass:	1.290	ABMAG_limit:	20.78	lambda_end[nm]:	934.98	delta_t[d]:	0.252
seeing:	1.03	mean FWHM:	0.851				

N_input:	4	score_bit:	0000000000
histo mode:	22.40		
histo -1.7dex:	3.83		

# IDP – Release Descriptions

The ESO IDPs come with detailed description documents:

[https://www.eso.org/sci/observing/phase3/data\\_streams.html](https://www.eso.org/sci/observing/phase3/data_streams.html)

## ESO Phase 3 Data Release Description

Data Collection	FORS2-SPEC
Data Provider	ESO, Science Data Quality Group
Document Date	04 January 2023
Document Version	1.0.1
Document Author	Danuta Dobrzycka, Sabine Möhler, Wolfgang Hummel, Burkhard Wolf

### Abstract

This is the release of reduced spectra from the FORSS2<sup>1</sup> - the visual and near-UV FOCal Reducer and low dispersion Spectrograph 2 for the Very Large Telescope (VLT) of the European Southern Observatory (ESO). Data of the three spectroscopic modes of FORSS2 are included in this release: long-slit spectroscopy (LSS) using a mask with 6.8' long slits of different widths, and multi-object spectroscopy with movable slit blades (MOS, slit length about 20") or with masks (MXU, arbitrary slit length). The spectra are taken using a wide variety of gratings with different wavelength ranges and dispersions. They include a set of normal gratings, which cover the full operational wavelength range of FORSS2 with essentially three different dispersions (230 Å/mm, 110 Å/mm, and 45 to 50 Å/mm) and medium resolution, high throughput holographic gratings, which are based on volume-phased holographic gratings cemented between two glass prisms. The response of the holographic gratings depends on the position on the CCD along the dispersion axis. This requires specific steps during the flux calibration, which are handled correctly by the pipeline. The gratings can be combined with filters for order separation or more specialized settings.

### Known features and issues

#### 1. Issues: Misalignment

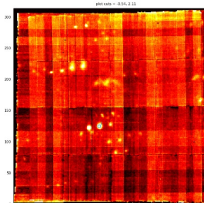


Figure 9. Combined datacube with duplicated sources.

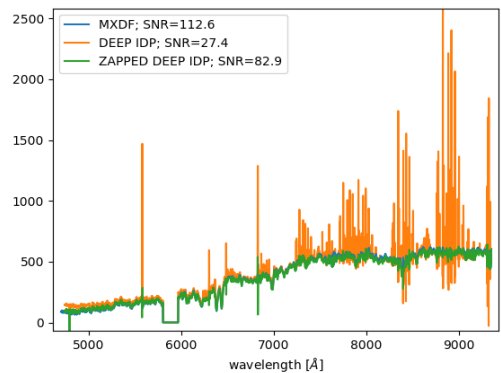
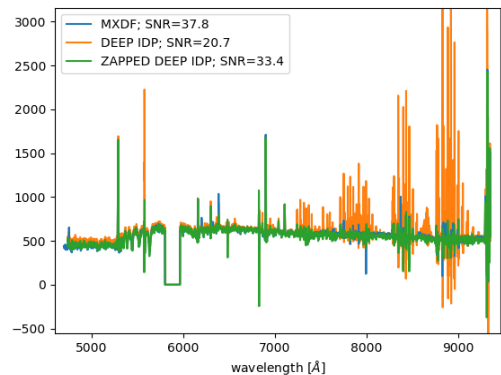
The alignment procedure (recipe `muse_exp_align`) aims at detecting cases of “telescope wobble”. This effect can happen with the instrument derotator, causing small unintended shifts between subsequent exposures that are not registered in the header. This effect is rare. The recipe attempts to detect a possible misalignment numerically, by extracting sources and matching them. The underlying assumptions are: the sources should be clearly detectable and should be the same in all exposures. They are a bit risky however.

ESO Instrument	Release Content	Access
UVES - Ultraviolet and Visual Echelle Spectrograph	1-dimensional wavelength-calibrated spectra of point-like objects	
XSHOOTER - multi wavelength (300-2500nm) medium resolution spectrograph	1-dimensional wavelength-calibrated spectra	
HARPS - High Accuracy Radial velocity Planet Searcher	1-dimensional wavelength-calibrated spectra	
FLAMES/GIRAFFE, MEDUSA mode, medium-high (R=5600-46000) resolution spectrograph	1-dimensional wavelength-calibrated spectra	
MUSE - Multi Unit Spectroscopic Explorer, Wide Field Mode	IFU data cubes	
MUSE-DEEP - Deep 3D cubes obtained with the Multi-Unit Spectroscopic Explorer	IFU data cubes	
HAWKI - High Acuity Wide field K-band Imager (0.85-2.5 μm)	Images and associated source lists	
FEROS - Fibre-fed Extended Range Optical Spectrograph	1-dimensional wavelength-calibrated spectra	
PIONIER - Precision Integrated-Optics Near-infrared Imaging ExpeRiment	squared visibility amplitudes and closure phases	
VIMOS - Visible wide field imager and multi-object spectrograph (360 to 1000 nm)	Images and associated source lists	
KMOS - K-band Multi Object Spectrograph	IFU data cubes	
ESPRESSO - Echelle Spectrograph for Rocky Exoplanets and Stable Spectroscopic Observations	1-dimensional wavelength-calibrated spectra	
FORS2-SPEC - Visual and near-UV FOCal Reducer and low dispersion Spectrograph	1-dimensional wavelength-calibrated spectra	
SPHERE - Spectro-Polarimetric High-contrast Exoplanet REsearch	high-resolution imaging (IRDIS)	

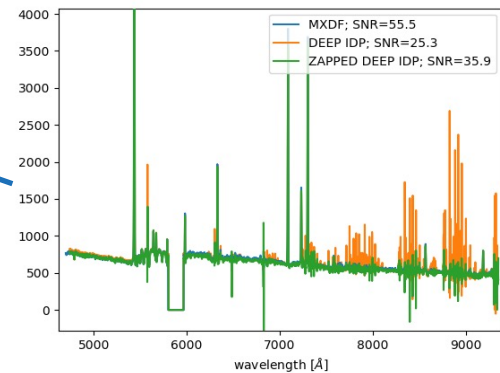
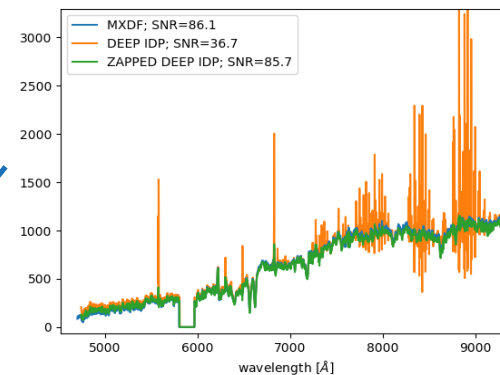
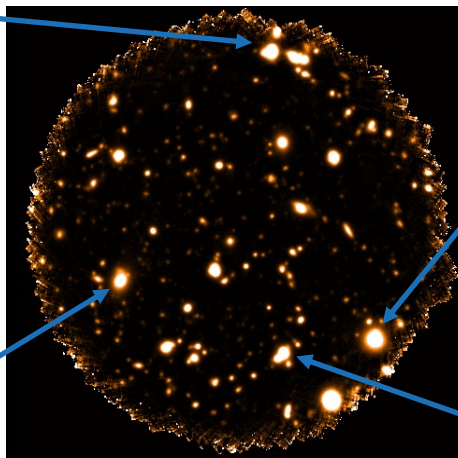
The following page contains an overview of [Phase 3 Data Releases](#), including ESO public survey programmes.

# MUSE IDP: comparing data quality

- MUSE eXtreme Deep Field (MXDF): deepest spectroscopic exposure ever



141 hours, 373 exposures  
<https://www.eso.org/sci/publications/announcements/sciann17569.html>



The in-house reduction compares well with the one from GTO and the differences are understood



# Access to the Science Data Products

[archive.eso.org](https://archive.eso.org) → Science Portal

The screenshot shows the Science Portal interface. On the left, there are several control panels for 'Data Type', 'Spectral Range', 'Filter/Band', and 'Spectral Resolution'. The main area displays a star field with a grid overlay. Below the star field is a table of observations with columns for 'Address', 'Site Name', 'Spectral Range', 'Spect. Res.', 'Date', 'Obs. Date', 'Collection', 'Status', 'Flag', 'Filter', 'PI', 'Program ID', 'ObsID', 'Data Price', and 'Pub. Date'. The table contains multiple rows of observation data.

The screenshot shows a grid of 18 plots for observation ID 3735864. The plots are arranged in a 3x6 grid. The top row includes: 'Observatory', 'Site Type', 'Spectral Range', 'Filter/Band', 'Spectral Resolution', and 'Signal-to-Noise Ratio'. The middle row includes: 'Date of Observation', 'Field of View', 'Sky Resolution', 'Filter Date', 'Data Collection', and 'Total Exposure Time'. The bottom row includes: 'Number of Data', 'Proposed Investigator', 'Program ID', 'Filter', 'Data Provider', and 'Publication Date'. Each plot shows a distribution of values for that parameter.

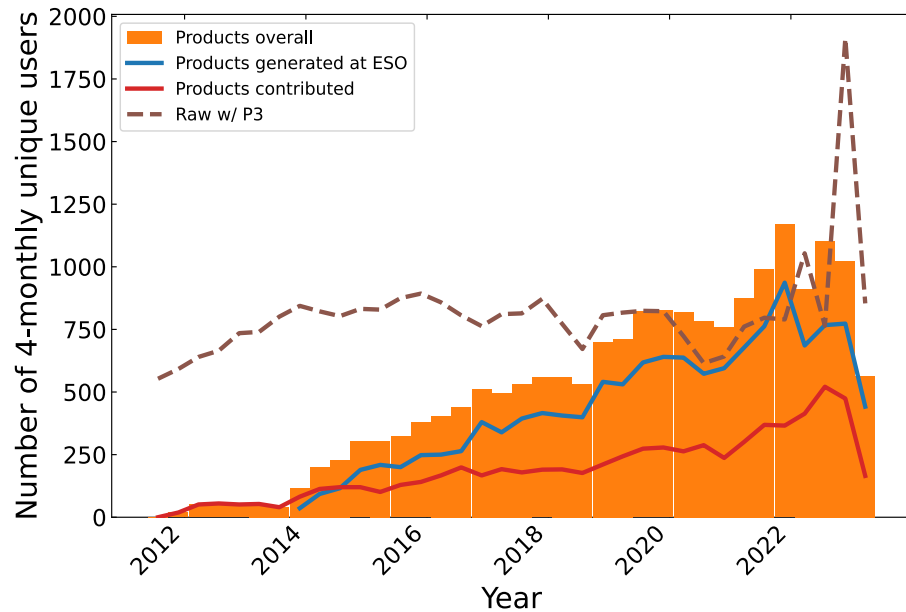
The screenshot shows a zoomed-in view of a star field. A blue circle highlights a specific region of interest. The stars are shown as bright points of light against a dark background.

The screenshot shows a detailed view of an observation. On the left, there is a 'Details' panel with fields for 'Object', 'RA', 'Dec', 'Spectral Resolution', 'Filter', 'Program ID', 'ObsID', 'Data Price', 'Pub. Date', 'Date of Observation', 'Field of View', 'Effective Exposure Time', and 'Number of Observations'. On the right, there is a 'Spectral Resolution' plot showing the sum of 412 objects observed at 02:29:52.73 - 01:34:17.2. The plot shows a sharp peak in the spectral resolution.

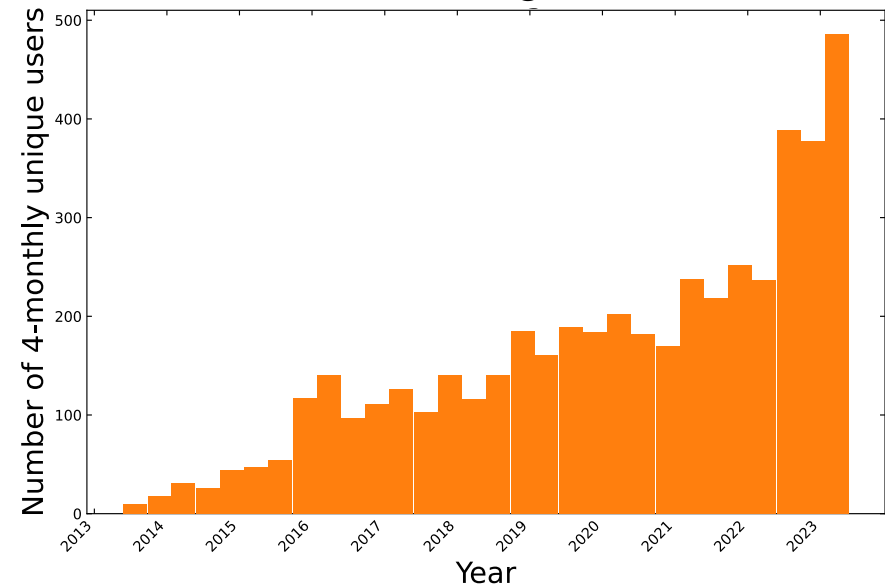


# Download statistics

## Archive Science Portal



## Catalogues



- Strong increase of the demand of all types of the science data products
- Sustained strong use of raw data



# Thank you!



60  
years

FEET ON THE GROUND

EYES ON THE SKY

