X-shooter pipeline reductions

In 7 (x3) easy steps

Overview

- Cascade
- X-shooter headers, tools
- Example Run chain(VIS)
- Differences VIS/UVB/NIR chains
- Examples Outputs
  - Observing strategy : To nod or not to nod?
- Extra processes beyond the pipeline
  - 1D extraction (will soon work?)
  - telluric correction
  - flux calibration (will soon work)

Why learn to use the pipeline

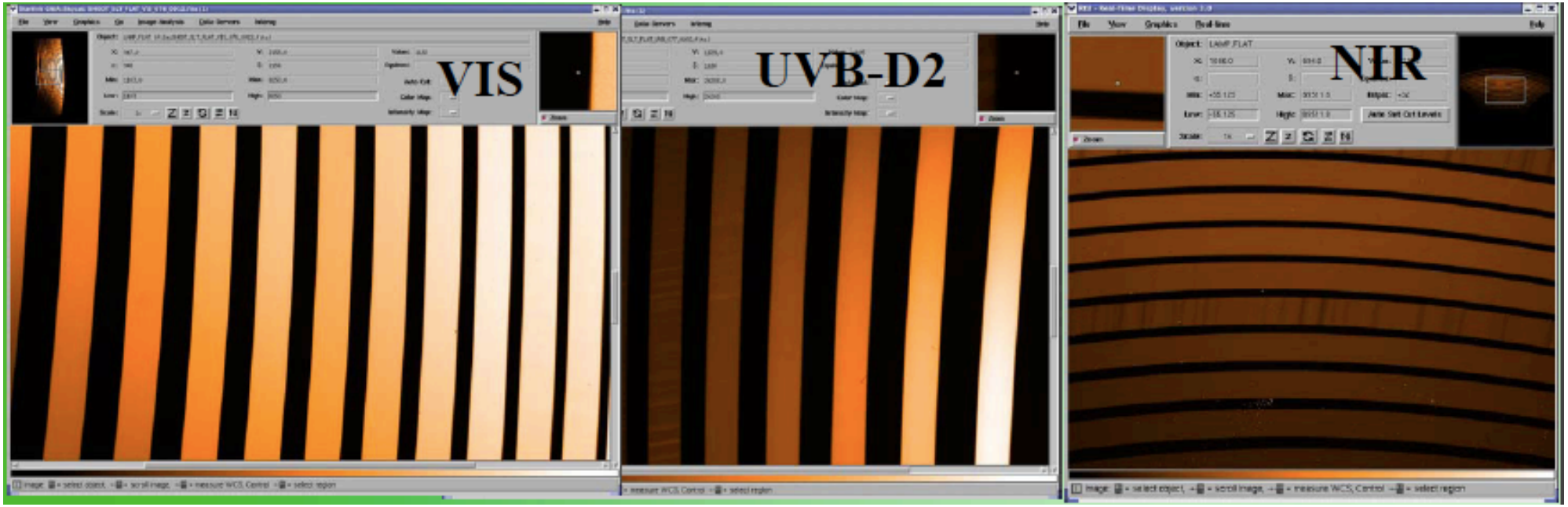
- Data package delivered in reduced form after programme completion

The data is not piped for:

- Science verification data
- PI data right from the archive
- Archive data

Most importantly: you know your own science!!!

Look at your data



Reduction cascade (7 steps)

- Make theoretical prediction tables
- Prepare calibration data
  - Create master BIAS (NIR: DARK)
  - Predict order position
  - Trace center of order
  - Create master flat
  - Determine wavelength solution
- Reduce science data

Useful header keywords

- Arm
  "HIERARCH ESO SEQ ARM"
- Slit (independent widths) / IFU
  "HIERARCH ESO INS OPTI3,4,5 NAME"
- Read out mode (UVB and VIS) (fixed for NIR)
  "HIERARCH ESO DET READ CLOCK"
  - 100khz,1x1
  - 100,1x2
  - 100,2x2
  - 400,1x1

Use the correct BIAS, FLAT in your reduction!
(don't flatfield your slit data with IFU flats)
E.g. check the output fits files category:
"HIERARCH ESO PRO CATG"

Getting the right data

Input files: BIAS, ORDER DEFINITION, FORMAT CHECK, FLAT, WAVE (pin hole), ARC

Example : getting a VIS FLAT with a given slit width

- gethead “hierarch eso det read clock” “hierarch eso seq arm” *fits | grep VIS | grep FLAT
- dfits *fits | fitsort object det.read.clock seq.arm ins.opti4.name | grep VIS | grep FLAT
- Alternative: Gasgano GUI with preferences (not supported yet)

other useful tools

- Output FITS tables – view with:
  - Topcat
  - fv

Other files needed from beginning:

- ThAr line list, physical model, BadPix_map.fits

Esorex chain (VIS)

or pages 32-50 in the pipeline manual

> esorex xsh_mbias –parameters ListOfFileNames.sof

Getting help for available parameters

Examples:

> esorex --man xsh_mbias

> esorex --help xsh_scired_slit_nod

Physical model/poly mode?

- **Physical model mode**
  - **XSH_MOD_CFG_TAB**
  - **Expected to be more accurate (XSH is non linear)**
  - **Some functionality to be provided (flux cons, IFU, response)**
  - **Slower**
  - **The one run by QC-Garching (as it gives insights on the instrument)**
- **Poly mode**
  - **Use a valid XSH_MOD_CFG_TAG and xsh_util_physmod to get THEO_TAB_SING_ARM/THEO_TAB_MULT_ARM**
  - **All functionalities are provided (IFU to be validated)**
  - **Faster**
  - **More accurate single frame sky subtraction (NIR)**
  - **Possibly less accurate/robust on predict/2dmap**

Step 1

- Configuration (xsh_util_physmod)

  Creates theoretical tables from input model data.

Physical mode or polynomial mode

Run example, > topcat theo_tab_sing.fits

Step 2

Master Bias (xsh_mbias)

you need a few different read-out modes :

100,1x1; 100,1x2; 400,1x1

Input

type	filename	TAG	n	bin	RO
raw	SHOOT.biasN	BIAS_VIS	5	any	100k/400k
ref	BADPIXEL_MAP_VIS	BADPIXEL_MAP_VIS	?	match	match

Output

ID	PRO.CATG	type	Note
0	MASTER_BIAS_VIS	cdb	Master bias via median stacking
1	CPIX_MAP_VIS	qc	Cold pixel map
2	HPIX_MAP_VIS	qc	Hot pixel map
3	BADPIXEL_MAP_VIS	cdb	Updated bad pixel map

No

Step 3

- Guess order position and wave table (xsh_predict)
  - positions of a given line list are determined
- Only 400, 1x1 !

input

type	filename	TAG	n	bin	RO
raw	SHOOT_SLT_FCK_VIS	FMTCHK_VIS	1	1x1	400k
ref	SPECTRAL_FORMAT_TAB_VIS	SPECTRAL_FORMAT_TAB_VIS	1	-	-
ref	ARC_LINE_LIST_VIS	ARC_LINE_LIST_VIS	1	-	-
cdb	THEO_TAB_SING_VIS	THEO_TAB_SING_VIS	1	-	-
cdb	MASTER_BIAS_VIS	MASTER_BIAS_VIS	?	match	match
ref	BADPIXEL_MAP_VIS	BADPIXEL_MAP_VIS	?	match	match

Show format check frame, topcat order_tab_guess.fits

Step4

- Trace orders (xsh_orderpos)
  - Detects the orders and computes a polynomial description
  - Only 400,1x1
  - Show input pinhole trace file,

Step 5

- Make master flat (xsh_mflat)

  Use correct slit width data

Show masterflat.fits

(note telluric lines to the very red end, stronger in the NIR arm)

Step 6

- Wavelength calibration (xsh_2dmap)
  - Only 400, 1x1
  - Show wave_map.fits

Step 7

- Reduce science data (xsh_scired_slit_stare)

  Many parameter options: (Important!)

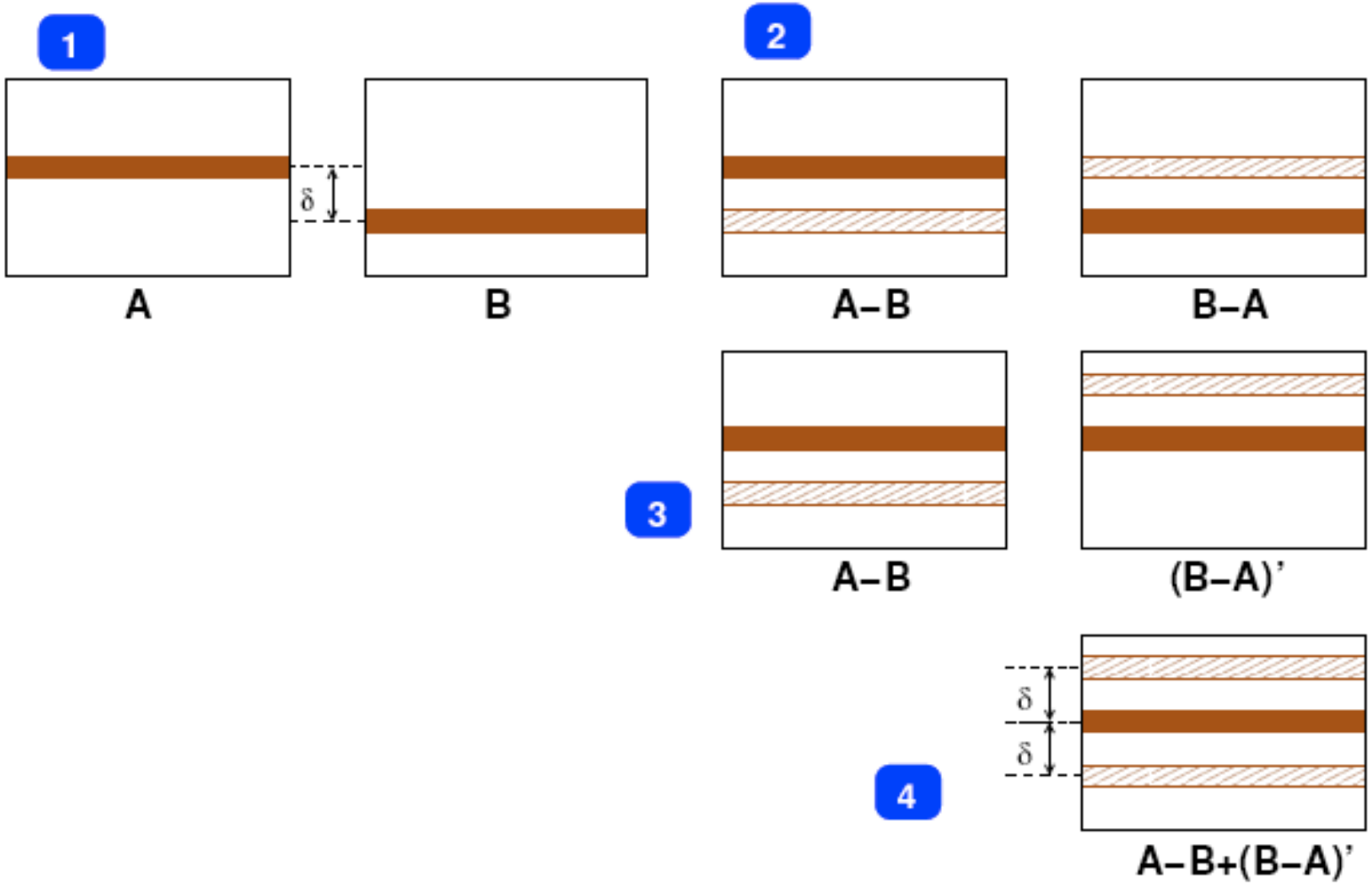
  – Cosmic rejection
  – Sky subtraction, method, region
  – Spectral resolution, spatial resolution (bin)
  – Merging orders

Differences VIS/UVB/NIR

- UVB: no flux in the very blue:
  - 2 lamps are needed: D2 and QTH:
    - Necessary for FLAT, ORDERPOS
    - Be aware of bad data in the archive!

- NIR: Bad pixel mask essential (xsh_lingain: BP_MAP.fits)
- NIR: On – Off lamp fits files
- NIR: no bias, but dark – choose the same DIT
    - Dark frame is not important for nodded (A-B) data
- NIR: xsh_scired_slit_nod or xsh_scired_slit_stare

NIR nod on slit - output



More differences

- IFU : create masterflat with (xsh_mflat_ifu)
- IFU : need a better wave map (xsh_wavecal)

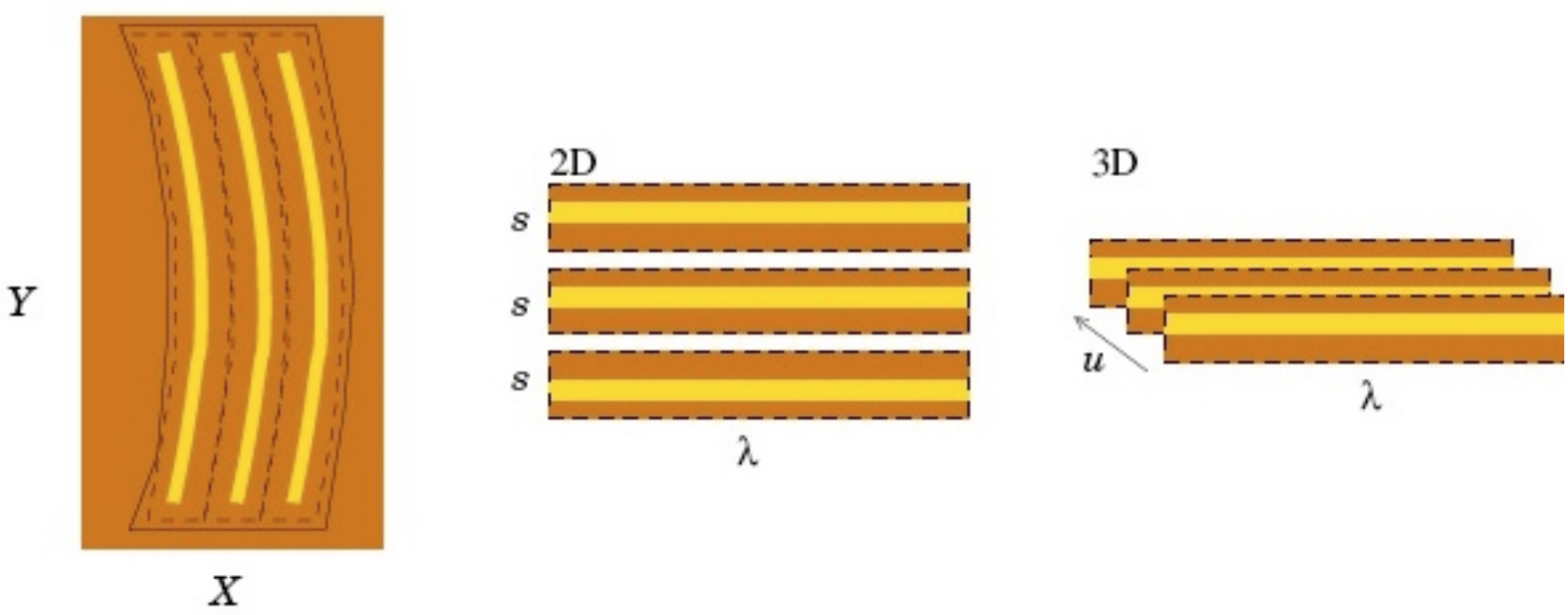
  = Step 6.5

  Input file with 100,1x1 works too
- IFU : reconstruct the cube (xsh_geom_ifu)

  = step 6.7

How to deal with IFU data now:

- Reduce as slit (xsh_scired_slit_stare --sky-subtract=FALSE)
- Cut the product up yourself + make your own cube



Beyond the pipeline (1)

- Extraction of 1D spectra (optimal extraction?)

- Telluric correction – hot star O3-O8V
  - Close in time (2 hours) and in airmass (< 0.2)
  - Observation with the same slit width!

  Procedure:
  - use .sof file from your science data (same calibration files needed)
  - Extract 1D spectrum
  - Normalise in regions outside strong telluric bands + outside the J-H-K gaps
  - Divide science data with this

Beyond the pipeline (2)

- Flux calibration (e.g. IRAF)
  - Pick a specphot star from the same date
  - 5” slit width
  - Reduce with the same calibration files (including the e.g. 1” masterflat, or see §10.13.1 in manual)
  - Extract the 1D spectrum
  - Compare with table data (only a few stars available now) -> sensitivity function
  - Divide your data with this

Procedures to be checked

- Xsh_response_stare (flux calibration)

  Technically this should work, but it has to be verified by real astronomers (critical users)

Some example reductions

- GRB spectrum, nod on slit
- Haro B,C galaxy, stare mode !?
- CV : timing sequence, stare mode (NIR)
- Cassowary 5 lensed galaxy, obj - sky

The end (or your beginning)

You will have a basic understanding of the pipeline, and be able to understand and follow the steps in the manual

If not, and if you find real errors : inform the pipeline people at ESO.