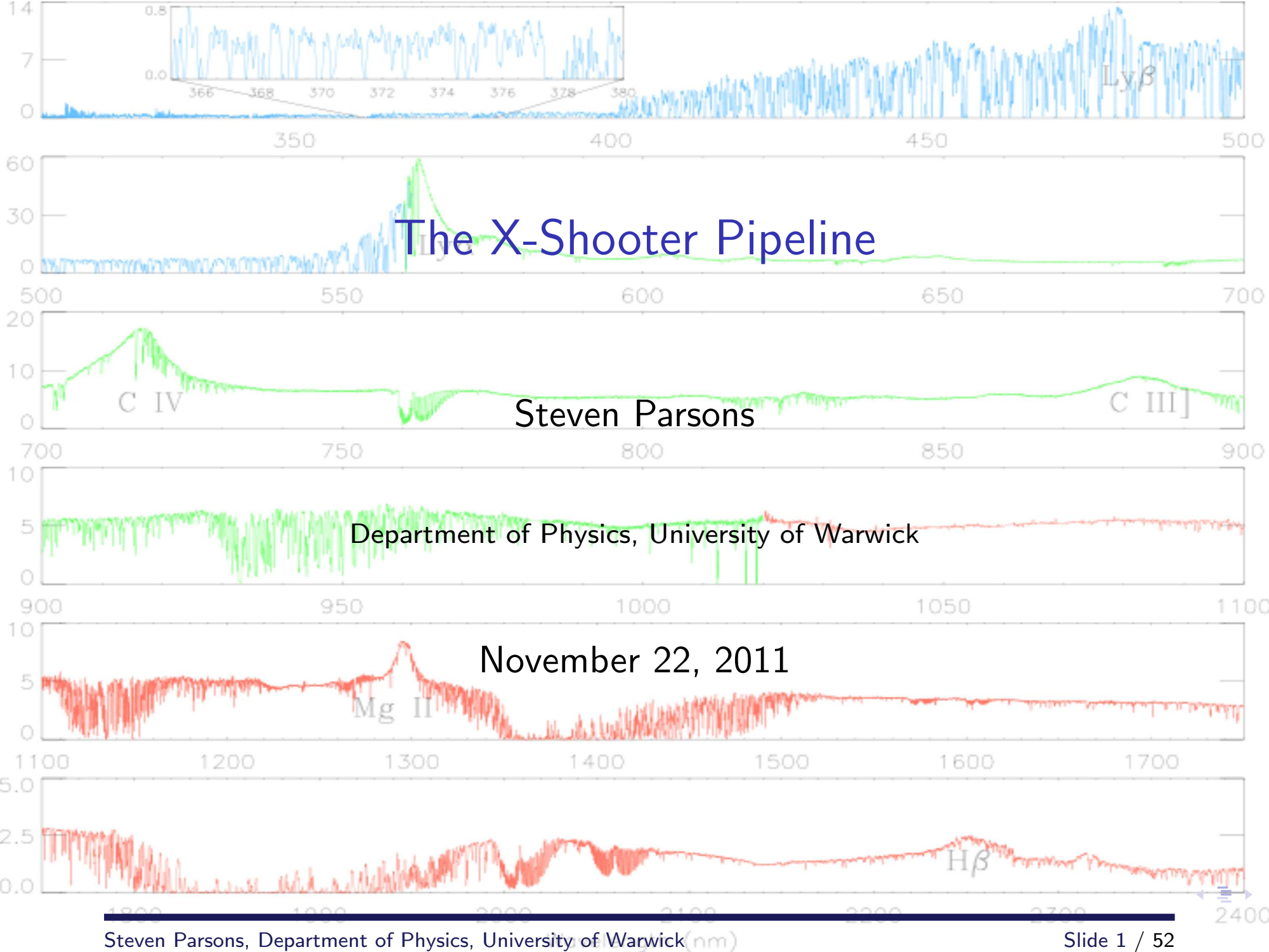

The X-Shooter Pipeline

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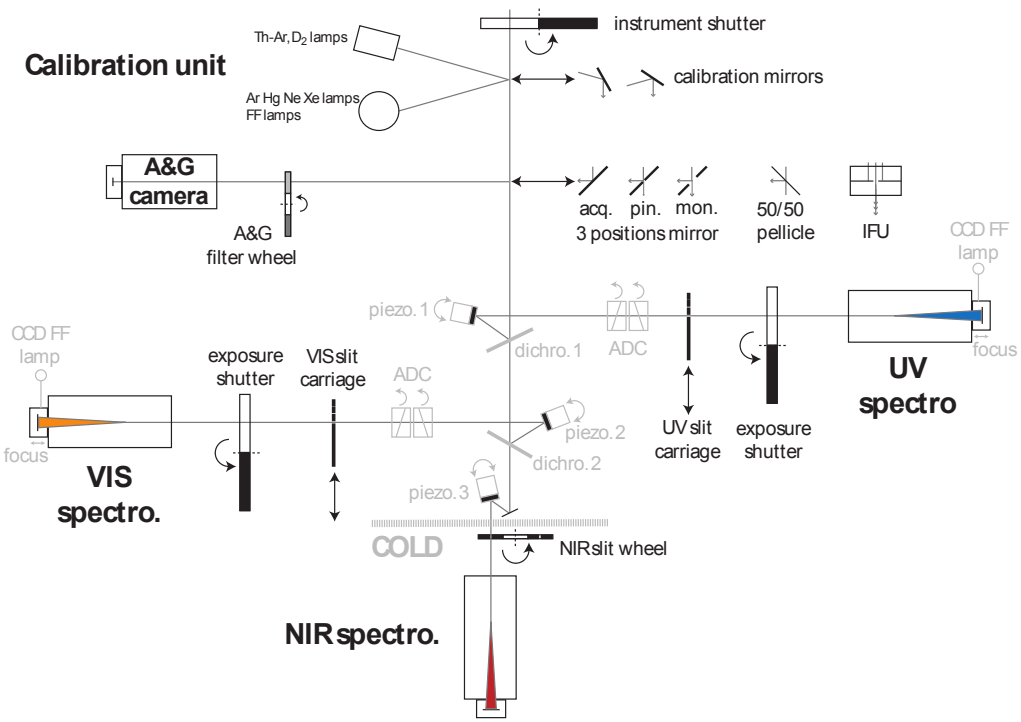
Outline

1. X-Shooter
2. The basics of ESO pipelines
3. Getting and sorting raw frames
4. Step-by-step guide to the X-Shooter pipeline
5. Some useful scripts

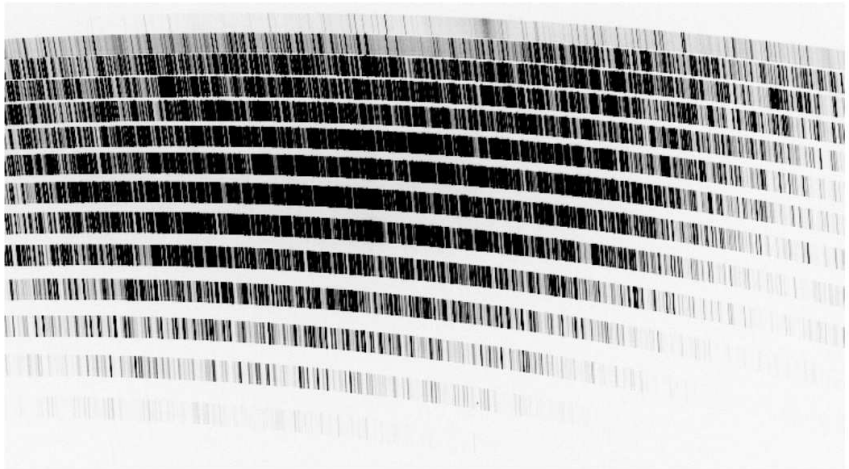
X-Shooter

- First of the "second generation" instruments at the VLT
- Mounted at the Cassegrain focus of UT2
- Intermediate resolution (R=4000-14000) echelle spectrograph
- Covers UV (300nm) to K band (2500nm) in a single exposure
- UVB arm: 300-550nm in 12 orders
- VIS arm: 550-1000nm in 14 orders
- NIR arm: 1000-2480nm in 16 orders
- UVB and VIS arm can be binned up to 2×2

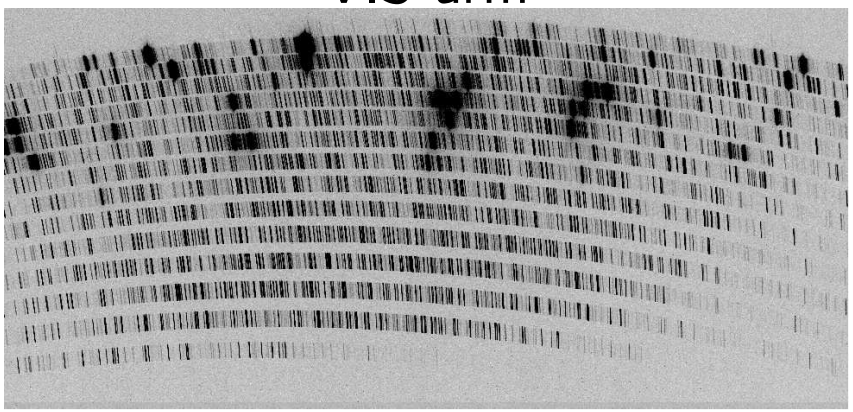


X-Shooter

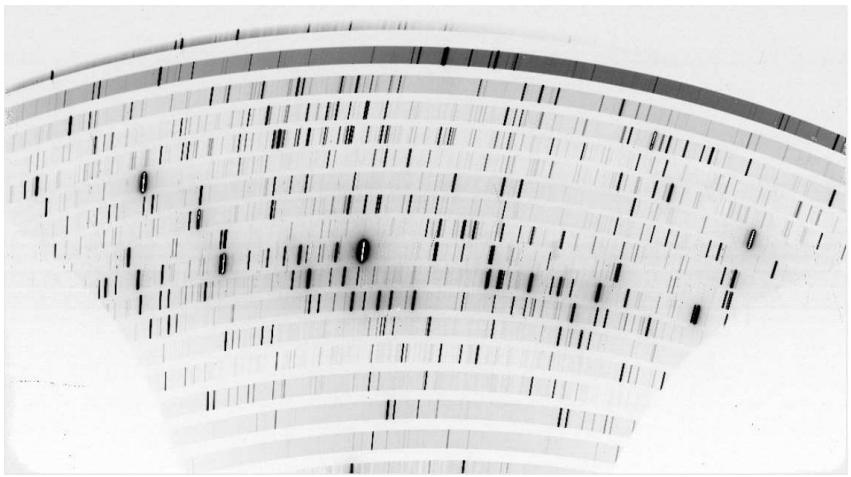
UVB arm



VIS arm



NIR arm



ESO pipelines

All ESO instrument pipelines are available at:

`http://www.eso.org/sci/software/pipelines/`

Pipelines include:

- CFITSIO
- Common Pipeline Libraries
- Gasgano
- Esorex
- Static calibration data

ESO pipelines

Frames (fits files) are classified based on fits header information e.g.

$$\left.\begin{array}{l}\text{HIERARCH ESO DPR TYPE} = \text{BIAS} \\ \text{HIERARCH ESO SEQ ARM} = \text{UVB}\end{array}\right\} \text{BIAS\_UVB}$$

$$\left.\begin{array}{l}\text{HIERARCH ESO DPR TYPE} = \text{LAMP, WAVE} \\ \text{HIERARCH ESO SEQ ARM} = \text{NIR} \\ \text{HIERARCH ESO DPR TECH} = \text{IMAGE} \\ \text{HIERARCH ESO INS OPTI5 NAME} = \text{Pin\_row}\end{array}\right\} \text{WAVE\_NIR\_OFF}$$

ESO pipelines

Each step in the data reduction is known as a recipe, e.g.

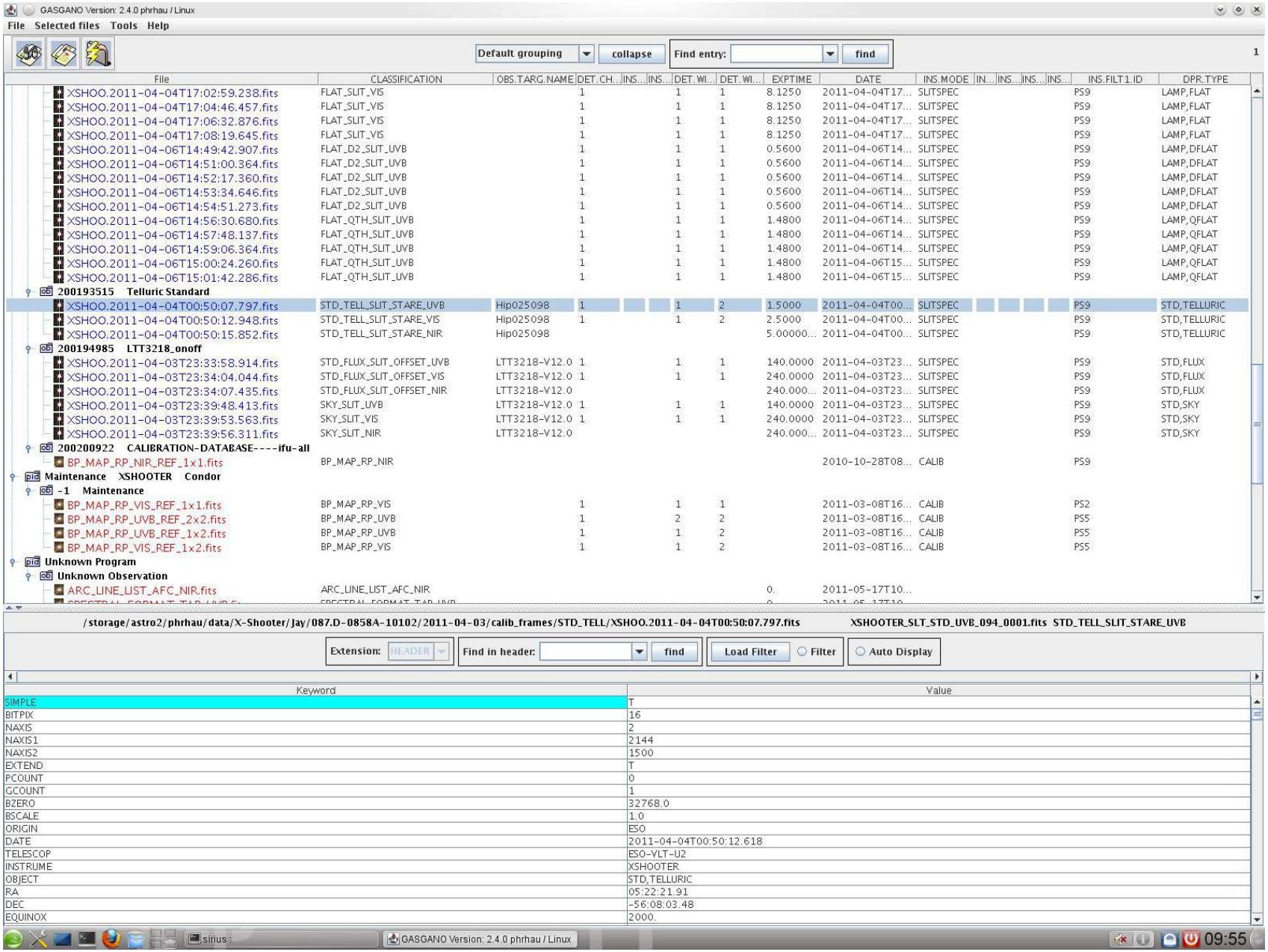
xsh_mbias = create a master bias frame

xsh_respon_slit_stare = compute response function using a standard star observation taken in stare mode

Each recipe requires a set of frames (sof) and a list of recipe parameters

Some frames are essential for the recipe and it will crash without them. Other frames are optional and the recipe will work without them but the results may be poor (e.g. all recipes will work without bad pixel maps but I highly recommend that you provide one)

Gasgano


GASGANO Version: 2.4.0 phrhau / Linux
File Selected files Tools Help
Default grouping
collapse
Find entry:
find
File
CLASSIFICATION
OBS.TARG.NAME
DET.CH...
INS...
INS...
DET.WI...
DET.WI...
EXPTIME
DATE
INS.MODE
IN...
INS...
INS...
INS...
INS.FILT1.ID
DPR.TYPE
XSHOO.2011-04-04T17:02:59.238.fits FLAT_SLIT_VIS 1 1 1 8.1250 2011-04-04T17... SLITSPEC PS9 LAMP,FLAT
XSHOO.2011-04-04T17:04:46.457.fits FLAT_SLIT_VIS 1 1 1 8.1250 2011-04-04T17... SLITSPEC PS9 LAMP,FLAT
XSHOO.2011-04-04T17:06:32.876.fits FLAT_SLIT_VIS 1 1 1 8.1250 2011-04-04T17... SLITSPEC PS9 LAMP,FLAT
XSHOO.2011-04-04T17:08:19.645.fits FLAT_SLIT_VIS 1 1 1 8.1250 2011-04-04T17... SLITSPEC PS9 LAMP,FLAT
XSHOO.2011-04-06T14:49:42.907.fits FLAT_D2_SLIT_UVB 1 1 1 0.5600 2011-04-06T14... SLITSPEC PS9 LAMP,DFLAT
XSHOO.2011-04-06T14:51:00.364.fits FLAT_D2_SLIT_UVB 1 1 1 0.5600 2011-04-06T14... SLITSPEC PS9 LAMP,DFLAT
XSHOO.2011-04-06T14:52:17.360.fits FLAT_D2_SLIT_UVB 1 1 1 0.5600 2011-04-06T14... SLITSPEC PS9 LAMP,DFLAT
XSHOO.2011-04-06T14:53:34.646.fits FLAT_D2_SLIT_UVB 1 1 1 0.5600 2011-04-06T14... SLITSPEC PS9 LAMP,DFLAT
XSHOO.2011-04-06T14:54:51.273.fits FLAT_D2_SLIT_UVB 1 1 1 0.5600 2011-04-06T14... SLITSPEC PS9 LAMP,DFLAT
XSHOO.2011-04-06T14:56:30.680.fits FLAT_QTH_SLIT_UVB 1 1 1 1.4800 2011-04-06T14... SLITSPEC PS9 LAMP,QFLAT
XSHOO.2011-04-06T14:57:48.137.fits FLAT_QTH_SLIT_UVB 1 1 1 1.4800 2011-04-06T14... SLITSPEC PS9 LAMP,QFLAT
XSHOO.2011-04-06T14:59:06.364.fits FLAT_QTH_SLIT_UVB 1 1 1 1.4800 2011-04-06T14... SLITSPEC PS9 LAMP,QFLAT
XSHOO.2011-04-06T15:00:24.260.fits FLAT_QTH_SLIT_UVB 1 1 1 1.4800 2011-04-06T15... SLITSPEC PS9 LAMP,QFLAT
XSHOO.2011-04-06T15:01:42.286.fits FLAT_QTH_SLIT_UVB 1 1 1 1.4800 2011-04-06T15... SLITSPEC PS9 LAMP,QFLAT
200193515 Telluric Standard
XSHOO.2011-04-04T00:50:07.797.fits STD_TELL_SLIT_STARE_UVB Hip025098 1 1 2 1.5000 2011-04-04T00... SLITSPEC PS9 STD,TELLURIC
XSHOO.2011-04-04T00:50:12.948.fits STD_TELL_SLIT_STARE_VIS Hip025098 1 1 2 2.5000 2011-04-04T00... SLITSPEC PS9 STD,TELLURIC
XSHOO.2011-04-04T00:50:15.852.fits STD_TELL_SLIT_STARE_NIR Hip025098 5.00000... 2011-04-04T00... SLITSPEC PS9 STD,TELLURIC
200194985 LTT3218_onoff
XSHOO.2011-04-03T23:33:58.914.fits STD_FLUX_SLIT_OFFSET_UVB LTT3218-V12.0 1 1 1 140.0000 2011-04-03T23... SLITSPEC PS9 STD,FLUX
XSHOO.2011-04-03T23:34:04.044.fits STD_FLUX_SLIT_OFFSET_VIS LTT3218-V12.0 1 1 1 240.0000 2011-04-03T23... SLITSPEC PS9 STD,FLUX
XSHOO.2011-04-03T23:34:07.435.fits STD_FLUX_SLIT_OFFSET_NIR LTT3218-V12.0 240.000... 2011-04-03T23... SLITSPEC PS9 STD,FLUX
XSHOO.2011-04-03T23:39:48.413.fits SKY_SLIT_UVB LTT3218-V12.0 1 1 1 140.0000 2011-04-03T23... SLITSPEC PS9 STD,SKY
XSHOO.2011-04-03T23:39:53.563.fits SKY_SLIT_VIS LTT3218-V12.0 1 1 1 240.0000 2011-04-03T23... SLITSPEC PS9 STD,SKY
XSHOO.2011-04-03T23:39:56.311.fits SKY_SLIT_NIR LTT3218-V12.0 240.000... 2011-04-03T23... SLITSPEC PS9 STD,SKY
200200922 CALIBRATION-DATABASE----ifu-all
BP_MAP_RP_NIR_REF_1x1.fits BP_MAP_RP_NIR 2010-10-28T08... CALIB PS9
Maintenance XSHOOTER Condor
-1 Maintenance
BP_MAP_RP_VIS_REF_1x1.fits BP_MAP_RP_VIS 1 1 1 2011-03-08T16... CALIB PS2
BP_MAP_RP_UVB_REF_2x2.fits BP_MAP_RP_UVB 1 2 2 2011-03-08T16... CALIB PS5
BP_MAP_RP_UVB_REF_1x2.fits BP_MAP_RP_UVB 1 1 2 2011-03-08T16... CALIB PS5
BP_MAP_RP_VIS_REF_1x2.fits BP_MAP_RP_VIS 1 1 2 2011-03-08T16... CALIB PS5
Unknown Program
Unknown Observation
ARC_LINE_LIST_AFC_NIR.fits ARC_LINE_LIST_AFC_NIR 0. 2011-05-17T10...
/storage/astro2/phrhau/data/X-Shooter/Jay/087.D-0858A-10102/2011-04-03/calib_frames/STD_TELL/XSHOO.2011-04-04T00:50:07.797.fits
XSHOOTER_SLT_STD_UVB_094_0001.fits STD_TELL_SLIT_STARE_UVB
Extension: HEADER
Find in header:
find
Load Filter
Filter
Auto Display
Keyword
Value
SIMPLE T
BITPIX 16
NAXIS 2
NAXIS1 2144
NAXIS2 1500
EXTEND T
PCOUNT 0
GCOUNT 1
BZERO 32768.0
BSCALE 1.0
ORIGIN ESO
DATE 2011-04-04T00:50:12.618
TELESCOP ESO-VLT-U2
INSTRUME XSHOOTER
OBJECT STD,TELLURIC
RA 05:22:21.91
DEC -56:08:03.48
EQUINOX 2000.
sirius :
GASGANO Version: 2.4.0 phrhau / Linux
09:55

Esorex

Command line version of Gasgano, useful for scripting the reduction.

>> esorex [general params] [recipe] [recipe params] frames.sof

Where:
general params = General esorex parameters, e.g.
--suppress-prefix
--output-dir
--help

recipe = name of the recipe e.g. xsh_mbias

recipe params = individual recipe parameters

frames.sof = a file listing all of the frames needed for the recipe along with their classifications

Esorex

Example of a frames.sof file:

../../calib_frames/STD_TELL/XSHOO.2011-08-25T09:41:01.296.fits	STD_TELL_SLIT_STARE_VIS
/home/astro/phrhau/software/calibrations/calib/xsh-1.3.7/cal/SPECTRAL_FORMAT_TAB_VIS.fits	SPECTRAL_FORMAT_TAB_VIS
/home/astro/phrhau/software/calibrations/calib/xsh-1.3.7/cal/xsh_paranal_extinct_vis.fits	ATMOS_EXT_VIS
/home/astro/phrhau/software/calibrations/calib/xsh-1.3.7/cal/xsh_high_abs_window_vis.fits	HIGH_ABS_WIN_VIS
XSH_MOD_CFG_OPT_2D_VIS.fits	XSH_MOD_CFG_OPT_2D_VIS
BINNED_BIAS_0000.fits	MASTER_BIAS_VIS
BINNED_FLAT_0001.fits	MASTER_FLAT_SLIT_VIS
BINNED_FLAT_0000.fits	ORDER_TAB_EDGES_SLIT_VIS
DISP_TAB_VIS.fits	DISP_TAB_VIS
RESPONSE_MERGE1D_SLIT_VIS.fits	MRESPONSE_MERGE1D_SLIT_VIS
BINNED_FLAT_0007.fits	MASTER_BP_MAP_VIS

Esorex

Individual recipe parameters can be set at the same time as calling the recipe e.g.

```
>> esorex --suppress-prefix xsh_2dmap --detectarclines-min-sn=8.0 --model-maxit=2000 frames.sof
```

Parameters can also be set using a .rc file. These are created by running the command

```
>> esorex --create-config recipe
```

Which creates the file recipe.rc in the current directory. Esorex will look for a .rc in the current directory and then in the directory $HOME/.esorex

The .rc file is just a list of parameters and their values. It also contains a short explanation for each parameter.

Set the value to -1 (if numeric) or auto (if string) to use the default value for that parameter.

Raw data

To run the X-Shooter pipeline on all three arms with the UVB and VIS arm binned you will need the following files:

LINEARITY_UVB ($\times$ 2)
LINEARITY_VIS ($\times$ 2)
LINEARITY_NIR_ON $\times$ 2)
LINEARITY_NIR_OFF ($\times$ 2)
LINEARITY_UVB (binned) ($\times$ 2)
LINEARITY_VIS (binned) ($\times$ 2)
BIAS_UVB ($\times$ 5)
BIAS_VIS ($\times$ 5)
BIAS_UVB (binned) ($\times$ 5)
BIAS_VIS (binned) ($\times$ 5)
DARK_NIR ($\times$ 3)
FMTCHK_UVB
FMTCHK_VIS
FMTCHK_NIR_ON
FMTCHK_NIR_OFF
ORDERDEF_D2_UVB
ORDERDEF_QTH_UVB
ORDERDEF_VIS
ORDERDEF_NIR_ON
ORDERDEF_NIR_OFF
WAVE_UVB
WAVE_VIS
WAVE_NOR_ON
WAVE_NIR_OFF
FLAT_QTH_SLIT_UVB ($\times$ 5)
FLAT_D2_SLIT_UVB ($\times$ 5)
FLAT_SLIT_VIS ($\times$ 5)
FLAT_SLIT_NIR_ON ($\times$ 5)
FLAT_SLIT_NIR_OFF ($\times$ 5)
FLAT_SLIT_VIS (binned) ($\times$ 5)
FLAT_QTH_SLIT_UVB (binned) ($\times$ 5)
FLAT_D2_SLIT_UVB (binned) ($\times$ 5)
AFC_ATT_UVB
AFC_ATT_VIS
AFC_ATT_NIR
ARC_SLIT_UVB
ARC_SLIT_VIS
ARC_SLIT_NIR_ON
ARC_SLIT_NIR_OFF
ARC_SLIT_UVB (binned)
ARC_SLIT_VIS (binned)
XSH_MOD_CFG_TAB_UVB
XSH_MOD_CFG_TAB_VIS
XSH_MOD_CFG_TAB_NIR
ARC_LINE_LIST_UVB
ARC_LINE_LIST_VIS
ARC_LINE_LIST_NIR
ARC_LINE_LIST_AFC_UVB
ARC_LINE_LIST_AFC_VIS
ARC_LINE_LIST_AFC_NIR
DRS_MDARK_NIR
SPECTRAL_FORMAT_TAB_UVB
SPECTRAL_FORMAT_TAB_VIS
SPECTRAL_FORMAT_TAB_NIR
BP_MAP_RP_UVB
BP_MAP_RP_VIS
BP_MAP_RP_NIR
BP_MAP_RP_UVB (binned)
BP_MAP_RP_VIS (binned)
FLUX_STD_CATALOG_UVB
FLUX_STD_CATALOG_VIS
FLUX_STD_CATALOG_NIR
ATMOS_EXT_UVB
ATMOS_EXT_VIS
ATMOS_EXT_NIR

Raw data

If you download a PI Pack you will get most of these files as well as a flux standard observation for each night and a telluric standard observation for each target, taken at a similar airmass to your observations.

However, usually there are some files missing and you will have to get them yourself using the ESO archive:

`http://archive.eso.org/eso/eso_archive_main.html`

Usually the missing files are unbinned biases and flats (if you used a binned setting) or darks with the right DIT.

Alternatively, you can use the (new) X-Shooter archive. I recommend using this since you can search for specific binning, arms etc. This can be found here:

`http://archive.eso.org/wdb/wdb/eso/xshooter/form`

The reduction cascade

All fits files must be unpacked. Both Gasgano and Esorex will crash if supplied a .tar, .gz or .Z file

All NIR calibration frames are taken in ON/OFF pairs. You will need both.

Flux standard observations (taken in service mode) are taken with 1×1 binning. Therefore, if you want to reduce these you will need unbinned flats and biases.

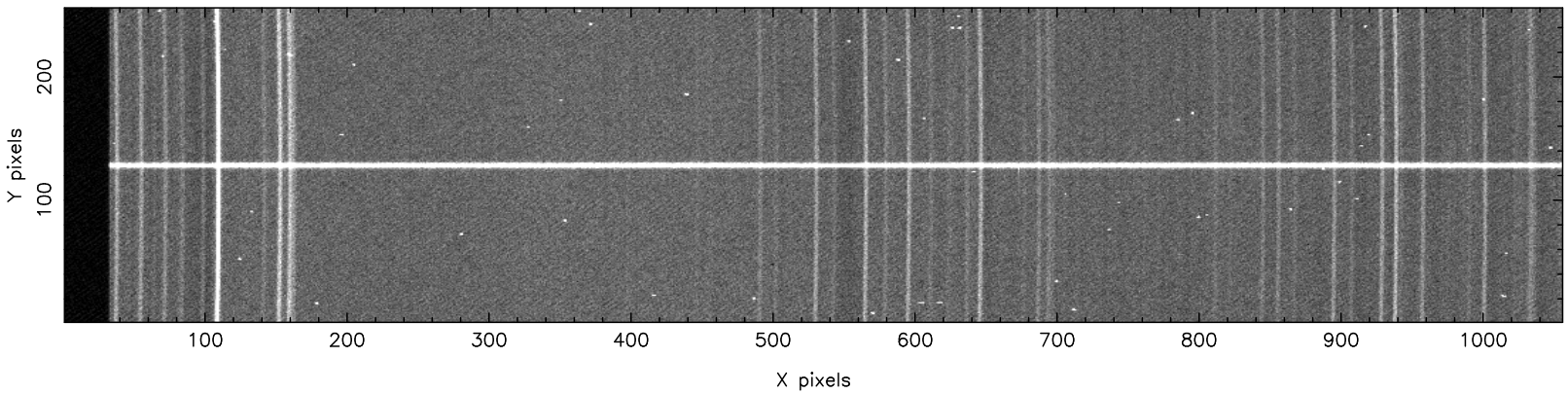
Non-linear pixels are present mainly in the NIR arm, while in the UVB and VIS arm their contribution is negligible .

There are two data reduction modes:

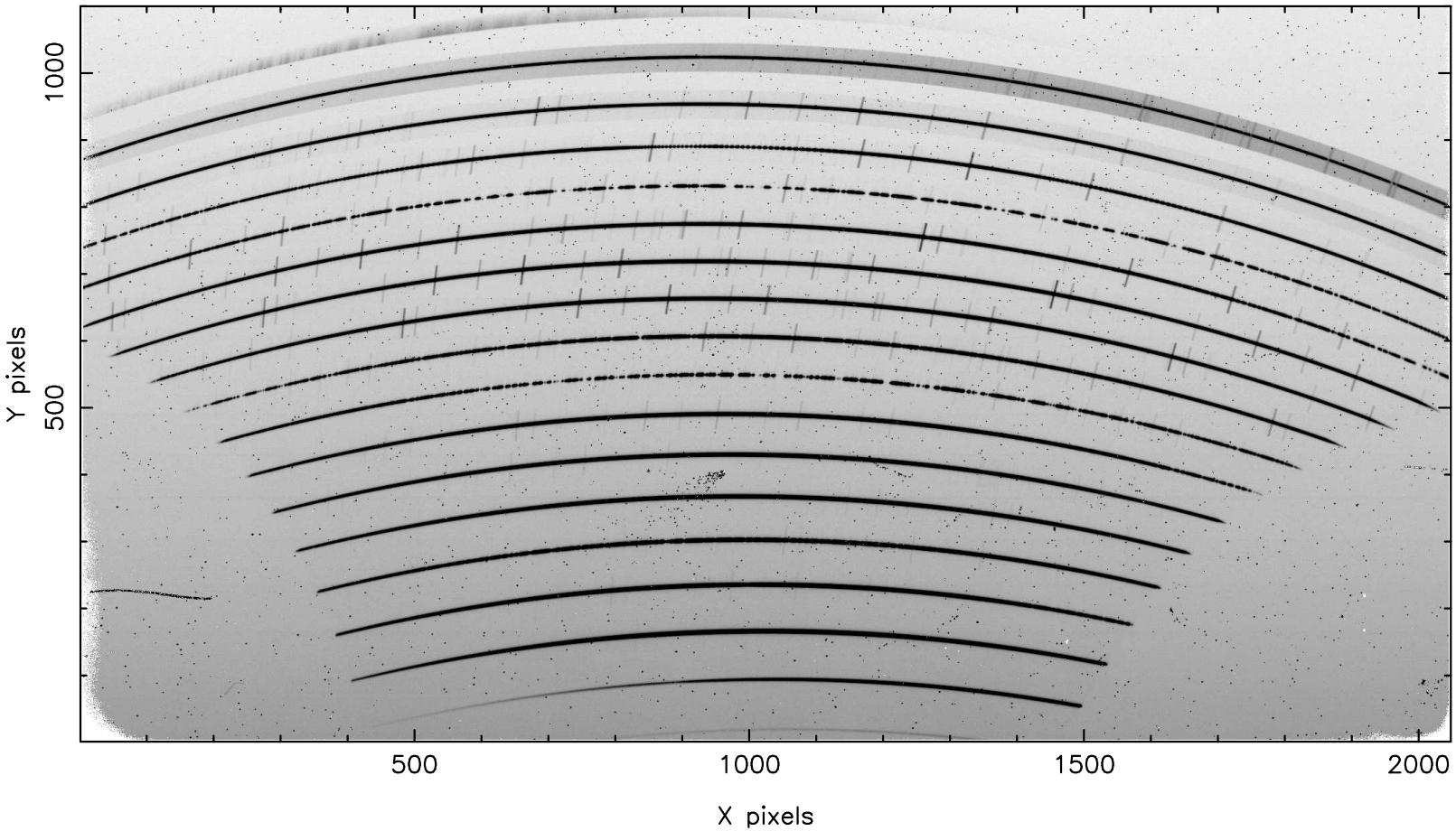
poly: solutions are obtained via polynomial fits to the data starting from a reference table.

physical: solutions are obtained by optimising the instrument physical model parameters contained in a table (XSH_MOD_CFG_TAB_ARM) to the data

The reduction cascade



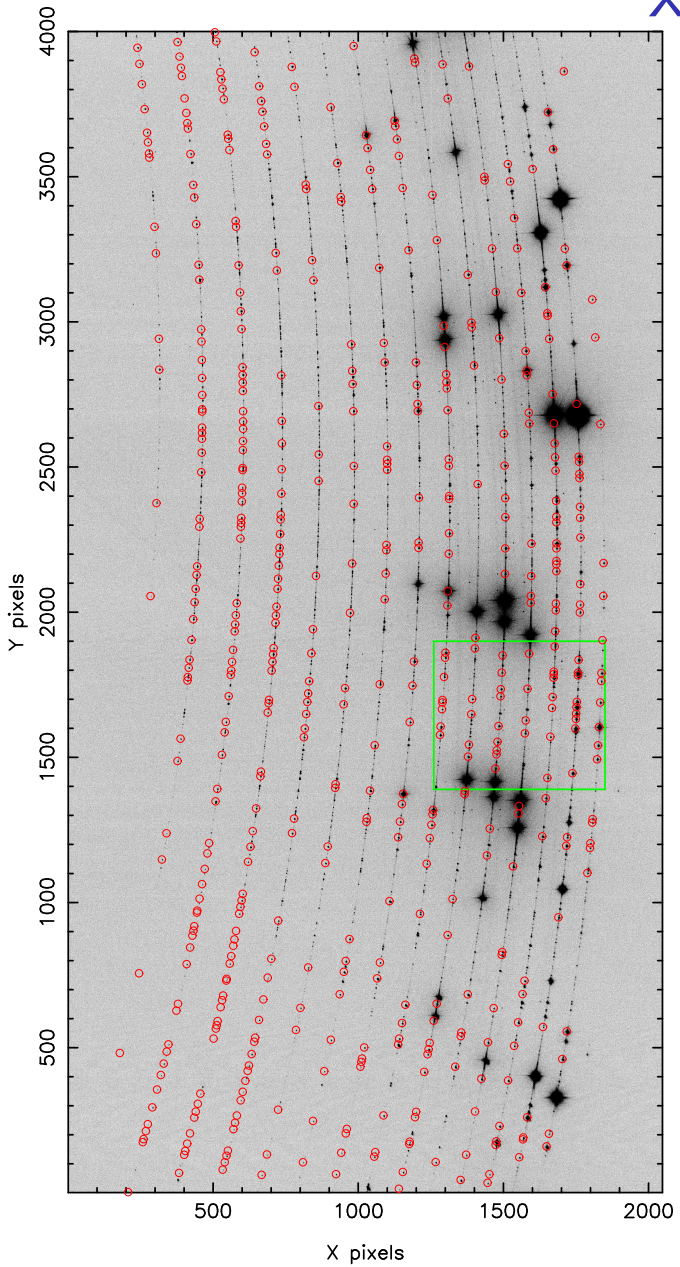
The reduction cascade

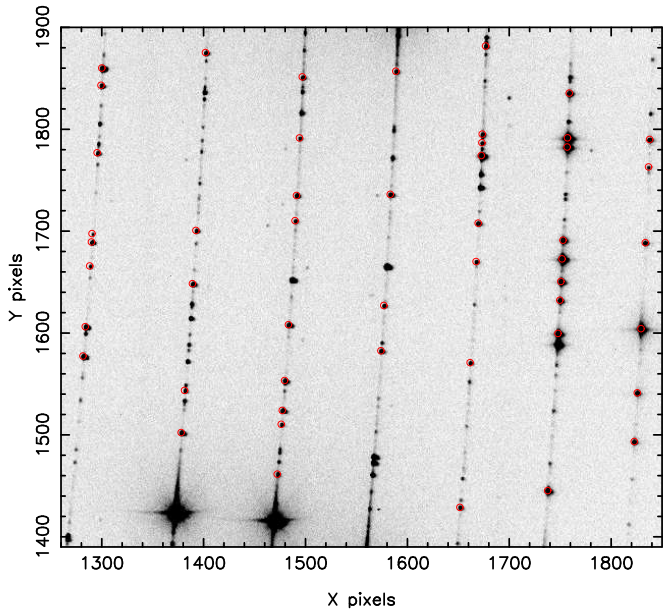


The reduction cascade

1. Generate general configuration frames using **xsh_util_physmod**
2. Generate unbinned bad pixel maps using **xsh_lingain**
3. Generate binned bad pixel maps using **xsh_lingain**
4. Create unbinned master bias frames for the UVB and VIS arms using **xsh_mbias**
5. Create binned master bias frames for the UVB and VIS arms using **xsh_mbias**
6. Create a master dark frame for the NIR arm using **xsh_mdark**
7. Determine the instrument spectral format using **xsh_predict**
8. Trace the echelle orders using **xsh_orderpos**
9. Make unbinned master flat frames using **xsh_mflat**
10. Make binned master flat frames using **xsh_mflat**
11. Determine the 2D transformation needed to rectify the X-shooter spectral format and wavelength calibrate the spectra using **xsh_2dmap**
12. Correct for the instrumental flexures using **xsh_flexcomp**
13. Determine the instrumental response using **xsh_respon_stare**
14. Extract, sky subtract, remove cosmic rays, merge and wavelength calibrate the science data using a **xsh_scired_slit** recipe

xsh_util_physmod





Generates theoretical maps for use with poly mode reduction

Input files:

XSH_MOD_CFG_ARM

ARC_LINE_LIST_ARM

For the XSH_MOD_CFG_ARM frame use either:

xs_arm_def_com4.fits for data taken before 1st October 2009

xs_arm_def_aug10.fits for data taken after 1st October 2009

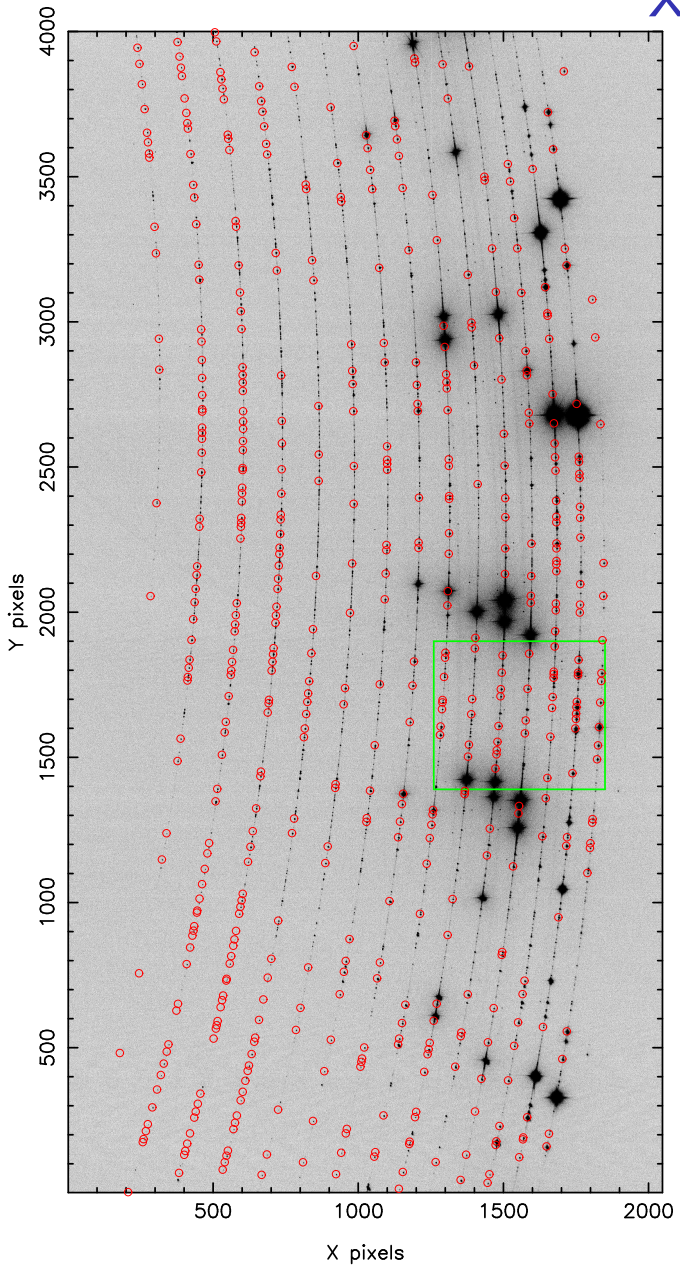
For the ARC_LINE_LIST_ARM use:

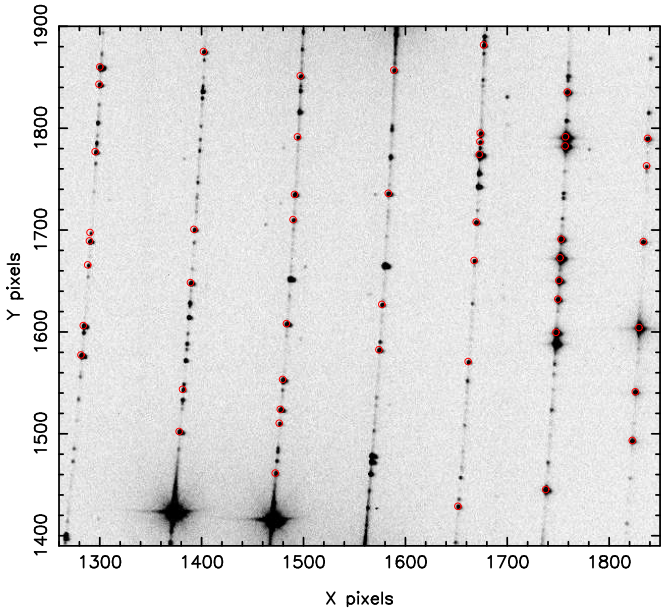
ThAr_uvb_custom.fits

ThAr_vis_custom.fits

penray_nir_custom_air_ext_paul.fits

xsh_util_physmod





Output files:

- THEO_TAB_MULT_ARM
- THEO_TAB_IFU_ARM
- THEO_TAB_SING_ARM
- SPECTRAL_FORMAT_TAB_ARM
- WAVE_MAP_ARM
- SLIT_MAP_ARM

The THEO_TAB_MULT_ARM and THEO_TAB_SING_ARM are used as a starting point for the poly mode reduction.

These are fits tables, the columns "detector_X" and "detector_Y" show the predicted positions for the lines. SING for the FMTCHK frames and MULT for the WAVE frames

Do not use the SPECTRAL_FORMAT_TAB_ARM in subsequent recipes, use the one provided with the pipeline.

xsh_lingain

Identifies non-linear pixels. Makes no difference to the results in the UVB and VIS arm.

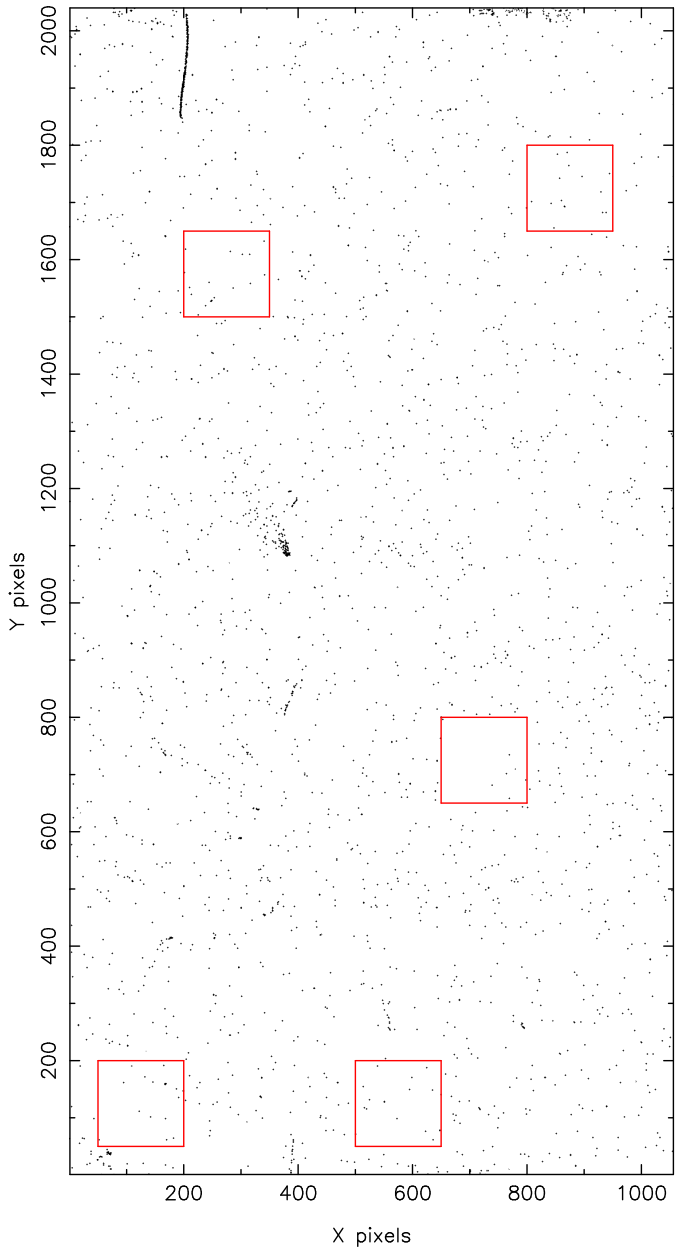
Input files:

- UVB and VIS arm:
  - LINEARITY_ARM (even number ≥ 8)
  - BP_MAP_RP_ARM
- NIR arm:
  - LINEARITY_NIR_ON (even number ≥ 8)
  - LINEARITY_NIR_OFF (same as LINEARITY_NIR_ON)
  - BP_MAP_RP_NIR

LINEARITY frames were not taken regularly before 1st January 2010, and they are not part of the standard package i.e. they are not provided with the PI pack. Need to run this for all the various binning used.

Use BP_MAP_RP_ARM_REF_NxN.fits for the BP_MAP_RP_ARM frame, supplied with the pipeline.

xsh_lingain



Important parameters (for the NIR arm):

--llx1,2,3,4,5 = 50,500,650,200,800

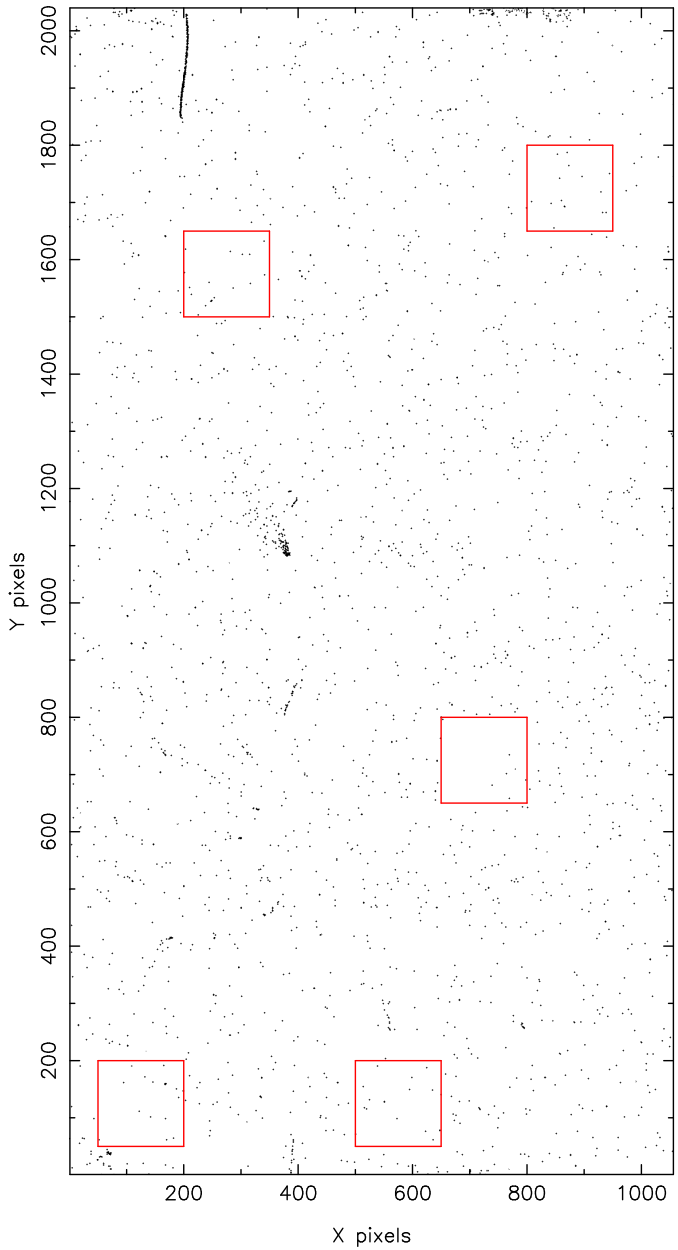
--lly1,2,3,4,5 = 50,50,650,1500,1650

--urx1,2,3,4,5 = 200,650,800,350,950

--ury1,2,3,4,5 = 200,200,800,1650,1800

May need to slightly adjust these. Need a decent number of pixels but not too many bad pixels. Also need to cover as much of the chip as possible.

xsh_lingain



Output files:

- DET_LIN_INFO_ARM
- GAIN_INFO_TABLE
- MASTER_BP_MAP_ARM

Can skip this recipe by using the BP_MAP_RP frame as the MASTER_BP_MAP frame for the next recipe.

xsh_mbias

Creates a master bias frame for the UVB and VIS arms.

Input files:

- BIAS_ARM ($\times$5)
- MASTER_BP_MAP_ARM

Output files:

- MASTER_BIAS_ARM
- MASTER_BP_MAP_ARM

Simple recipe, standard parameters work fine. New MASTER_BP_MAP overwrites the old one. Can use the BP_MAP_RP_ARM_REF_NxN.fits file and label it as a MASTER_BP_MAP_ARM file in the .sof file if you havent run xsh_lingain

xsh_mdark

Creates a master dark frame for the NIR arm.

Input files:

- DARK_NIR ($\times 3$)
- DRS_MDARK_NIR
- MASTER_BP_MAP_NIR

Output files:

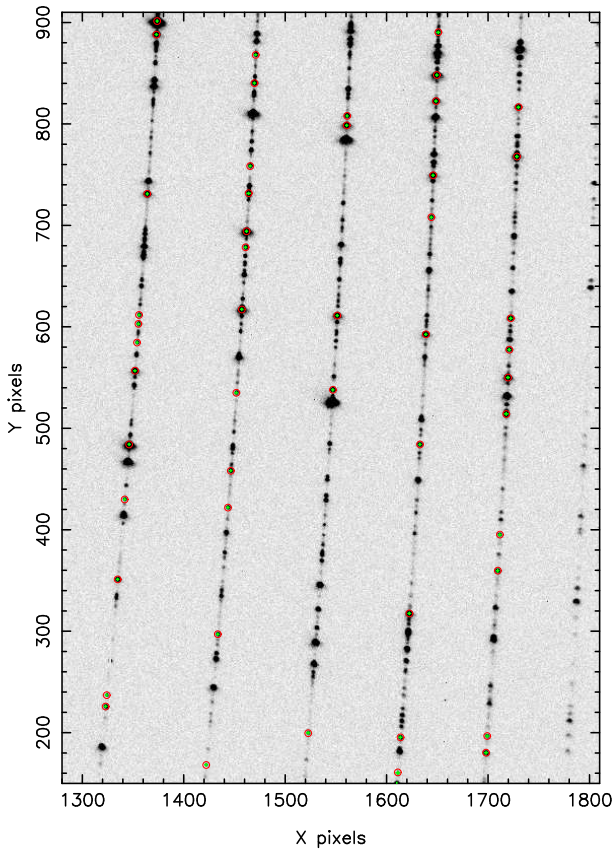
- MASTER_DARK_NIR
- MASTER_BP_MAP_NIR

Simple recipe, standard parameters work fine. The pipeline does not check the exposure times on the dark frames so make sure that they are all the same or all the pixels will be flagged as bad!

xsh_predict

>>> The most important recipe in the whole pipeline <<<

Generates a first guess at the instrument spectral format i.e. the position of the orders and the wavelength solution



Input files:

POLY mode:

FMTCHK_ARM (ON/OFF for NIR)
SPECTRAL FORMAT_TAB_ARM
ARC_LINE_LIST_ARM
THEO_TAB_SING_ARM
MASTER_BIAS_ARM (DARK for NIR)
MASTER_BP_MAP_ARM

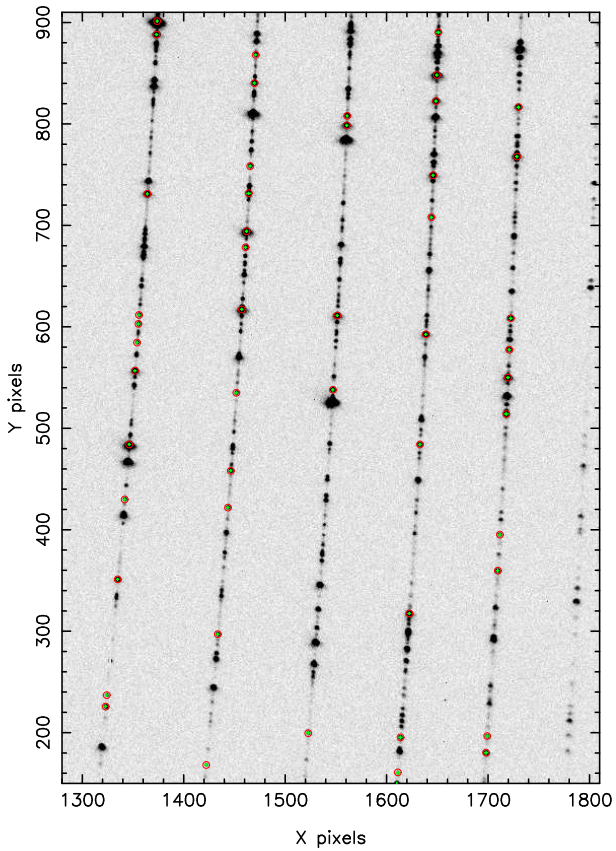
PHYSICAL mode:

FMTCHK_ARM (ON/OFF for NIR)
SPECTRAL FORMAT_TAB_ARM
ARC_LINE_LIST_ARM
XSH_MOD_CFG_TAB_ARM
MASTER_BIAS_ARM (DARK for NIR)
MASTER_BP_MAP_ARM

xsh_predict

>>> The most important recipe in the whole pipeline <<<

Generates a first guess at the instrument spectral format i.e. the position of the orders and the wavelength solution

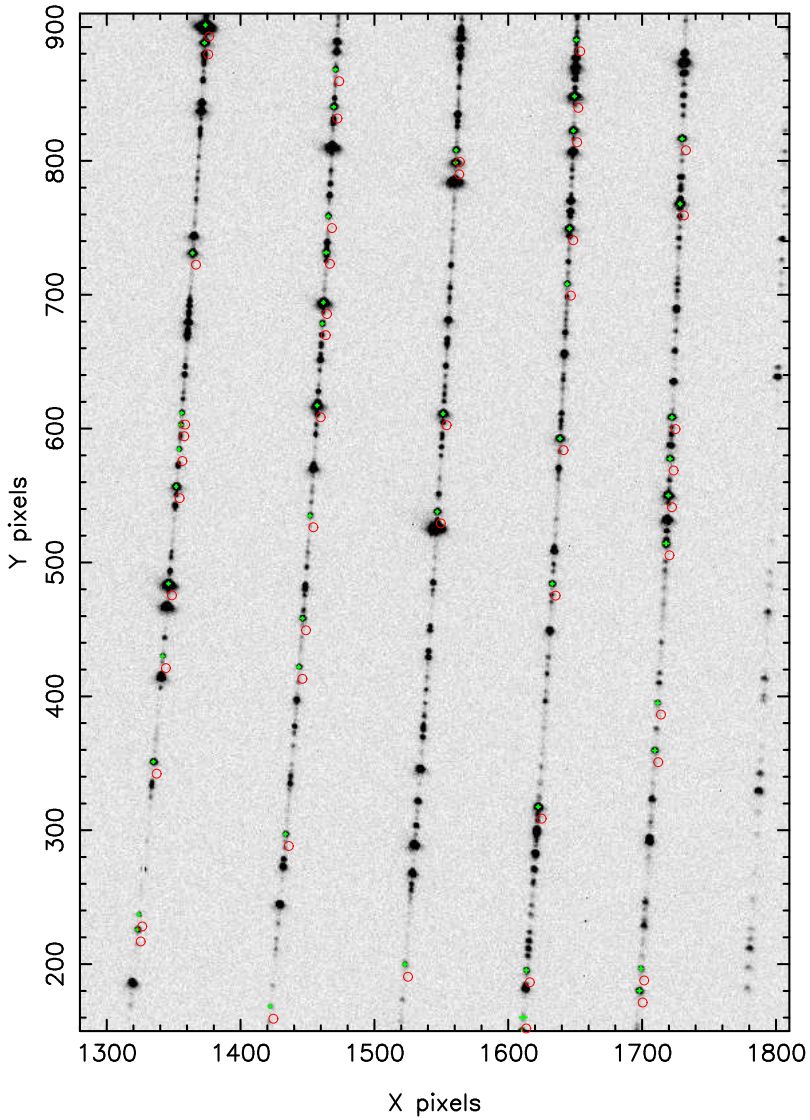


Important parameters:

- --detectarclines-fit-window-half-size = 8
- --detectarclines-search-window-half-size = 7
- --detectarclines-wavesol-deg-lambda = 5 (POLY mode)
- --detectarclines-wavesol-deg-order = 5 (POLY mode)
- --detectarclines-min-sn = 4.0
- --model-maxit = 5000 (PHYSICAL mode)

A good number of lines to detect is 300 (UVB), 430 (VIS) and 210 (NIR). The mean X and Y residuals should be less than 0.2 (UVB and VIS) or 0.4 (NIR).

xsh_predict



--detectarclines-wavesol-deg-lambda = 13 (POLY mode)
--detectarclines-wavesol-deg-order = 13 (POLY mode)
--detectarclines-min-sn = 20.0

xsh_predict

Output files:

POLY mode:

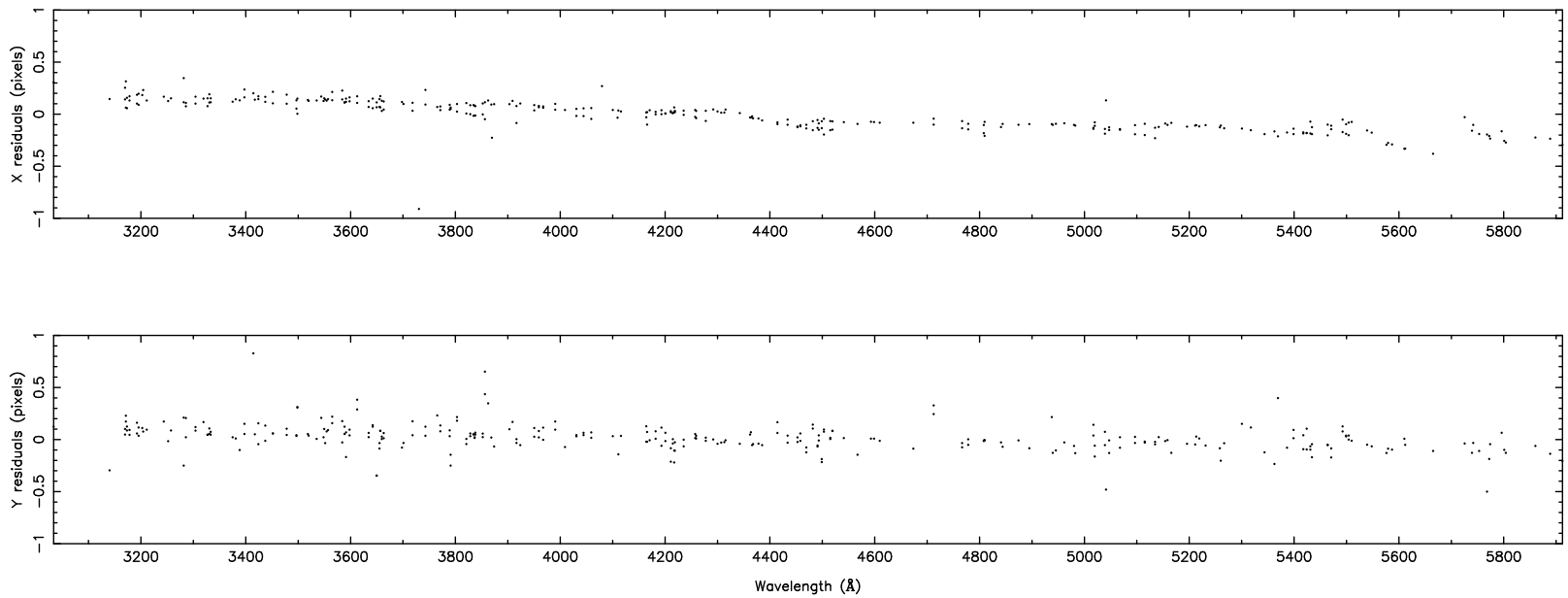
ARC_LINE_LIST_PREDICT_ARM	- cleaned line catalog
WAVE_TAB_GUESS_ARM	- guess wave table
ORDER_TAB_GUESS_ARM	- guess order table
FMTCHK_RESID_TAB_LINES_ARM	- residual line table
FMTCHK_ON_ARM	- bias-subtracted format-check frame

PHYSICAL mode:

ARC_LINE_LIST_PREDICT_ARM	
ORDER_TAB_GUESS_ARM	
FMTCHK_RESID_TAB_LINES_ARM	
FMTCHK_ON_ARM	
XSH_MOD_CFG_OPT_FMT_ARM	- optimised model configuration table

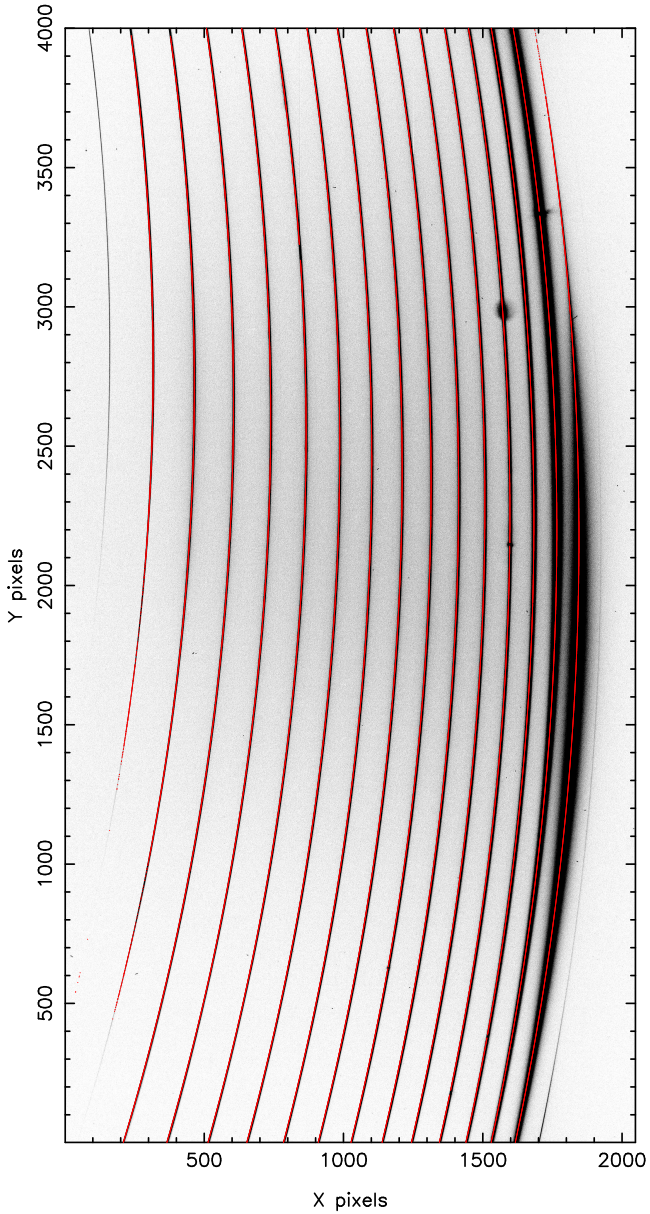
xsh_predict

FMTCHK_RESID_TAB_LINES_ARM:
Plots of "Wavelength" vs. "ResidXmodel" and "ResidYmodel"



xsh_orderpos

Traces the order centres

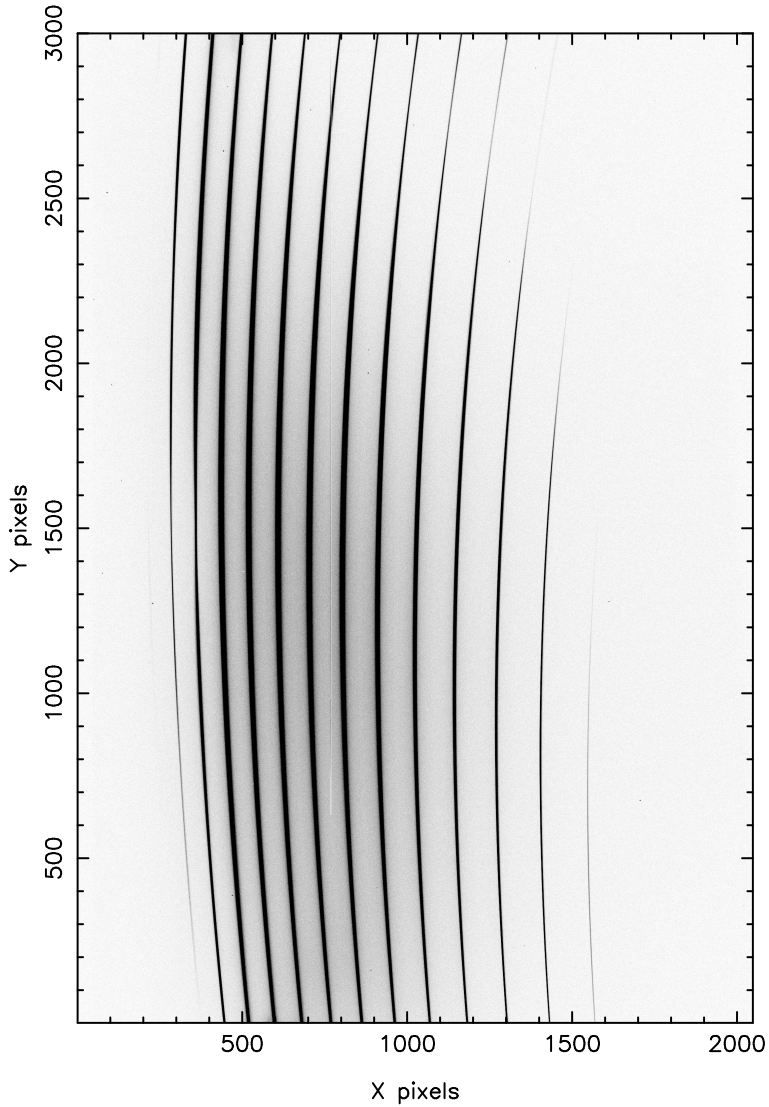


Input files:

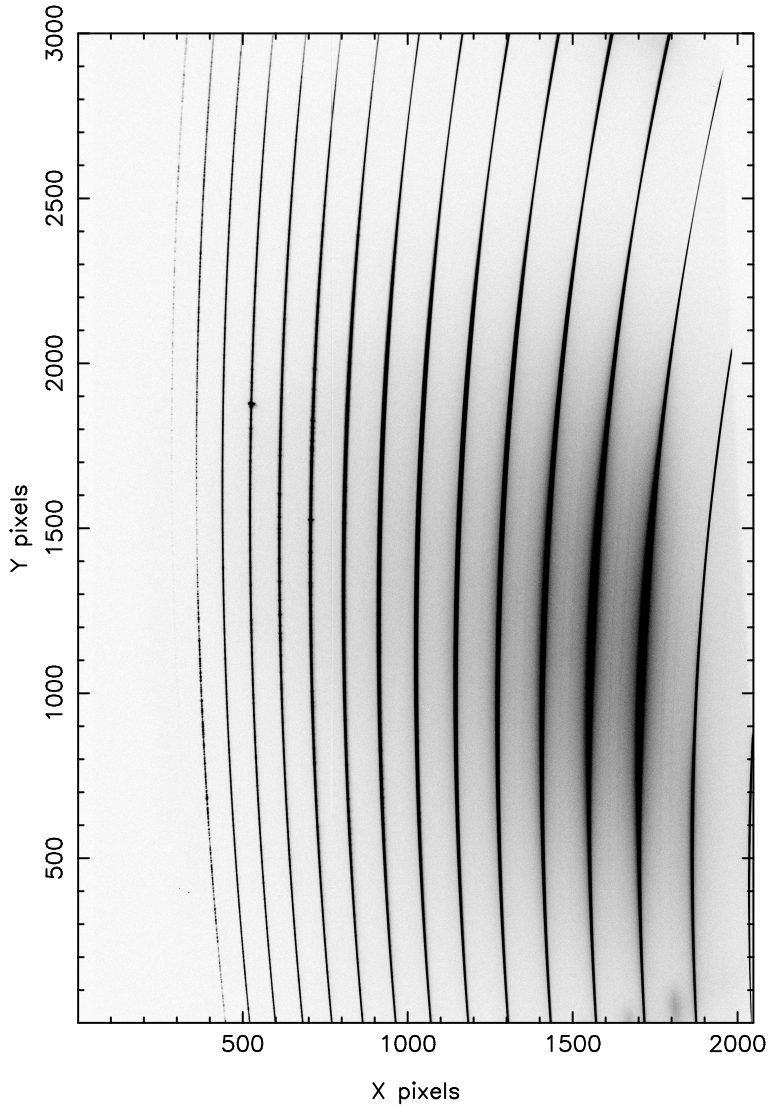
- UVB arm:
  - ORDERDEF_D2_UVB
  - ORDERDEF_QTH_UVB
  - SPECTRAL_FORMAT_TAB_UVB
  - ORDER_TAB_GUESS_UVB
  - MASTER_BIAS_UVB
  - MASTER_BP_MAP_UVB
- VIS arm:
  - ORDERDEF_VIS
  - SPECTRAL_FORMAT_TAB_VIS
  - ORDER_TAB_GUESS_VIS
  - MASTER_BIAS_VIS
  - MASTER_BP_MAP_VIS
- NIR arm:
  - ORDERDEF_NIR_ON
  - ORDERDEF_NIR_OFF
  - SPECTRAL_FORMAT_TAB_NIR
  - ORDER_TAB_GUESS_NIR
  - MASTER_DARK_NIR
  - MASTER_BP_MAP_NIR

xsh_orderpos

D2



QTH



xsh_orderpos

Important Parameters:

--detectcontinuum-search-window-half-size = 8
--detectcontinuum-running-window-half-size = 6
--detectcontinuum-fit-window-half-size = 6

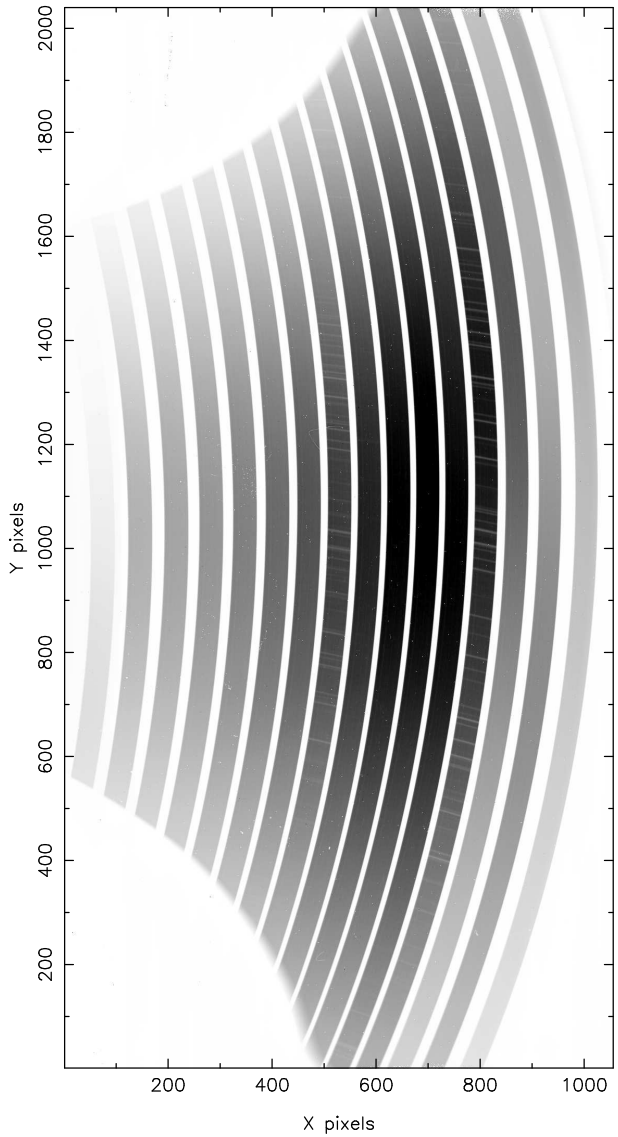
Output files:

ORDER_TAB_CENTR_ARM	- Table tracing order centres
ORDERPOS_RESID_TAB_ARM	- Order tracing residuals table
ORDERDEF_ON_ARM	- Bias subtracted order frame

From ORDERPOS_RESID_TAB_ARM plot "X" vs. "Y" to see the order tracing. Expected number of orders is 12 (UVB), 14 (VIS) and 16 (NIR).

xsh_mflat

Creates a master flat field frame

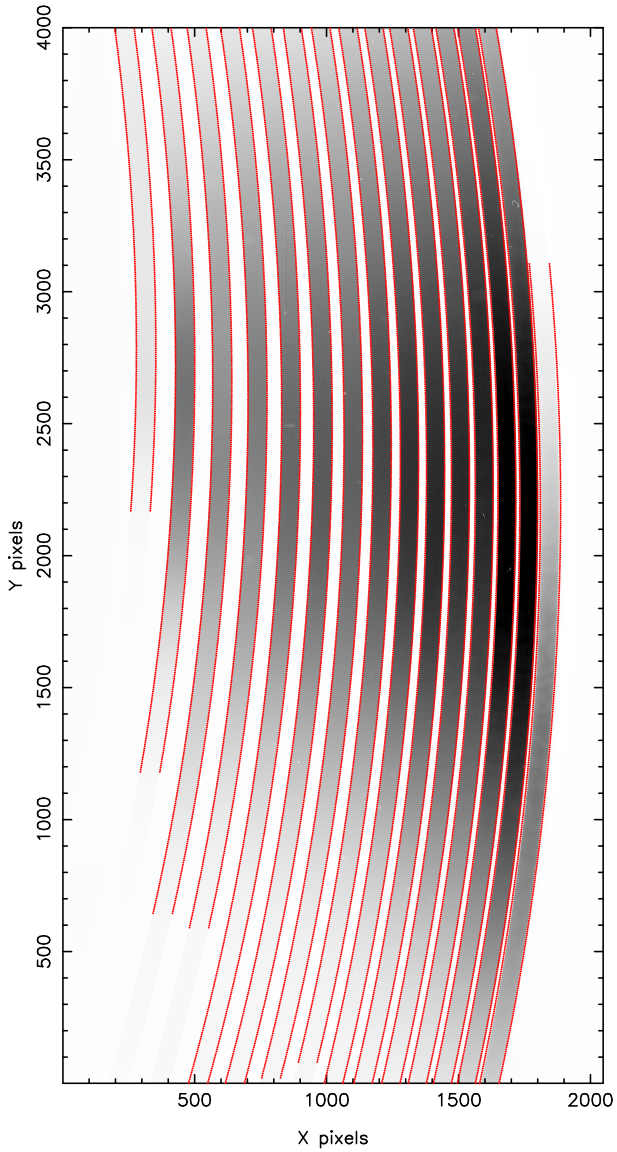


Input files:

- UVB arm:
  - FLAT_D2_SLIT_UVB
  - FLAT_QTH_SLIT_UVB
  - SPECTRAL_FORMAT_TAB_UVB
  - ORDER_TAB_CENTR_UVB
  - MASTER_BIAS_UVB
  - MASTER_BP_MAP_UVB
- VIS arm:
  - FLAT_SLIT_VIS
  - SPECTRAL_FORMAT_TAB_VIS
  - ORDER_TAB_CENTR_VIS
  - MASTER_BIAS_VIS
  - MASTER_BP_MAP_VIS
- NIR arm:
  - FLAT_SLIT_NIR_ON
  - FLAT_SLIT_NIR_OFF
  - SPECTRAL_FORMAT_TAB_NIR
  - ORDER_TAB_CENTR_NIR
  - MASTER_DARK_NIR
  - MASTER_BP_MAP_NIR

xsh_mflat

Creates a master flat field frame



Important parameters:

--background-method = median
--detectorder-min-sn = 35 (UVB, VIS) 25 (NIR)

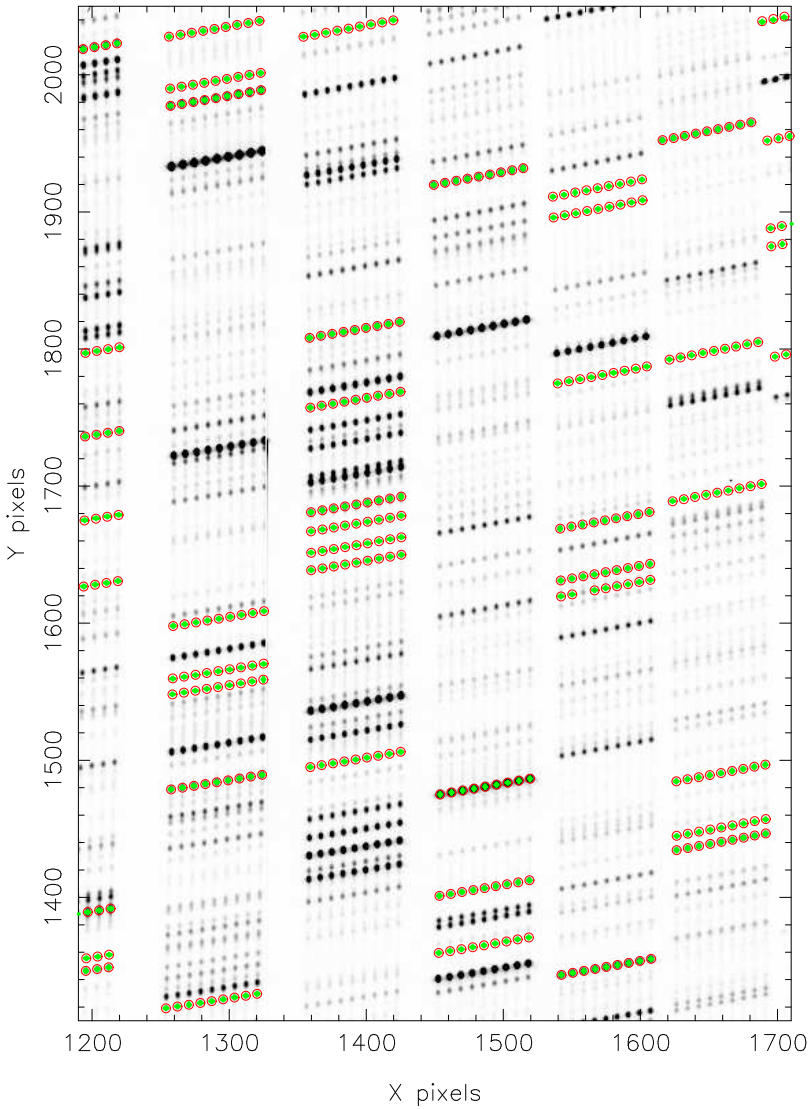
Output files:

ORDER_TAB_EDGES_SLIT_ARM
MASTER_FLAT_SLIT_ARM
MFLAT_BACK_SLIT_ARM
MASTER_BP_MAP_ARM

From ORDER_TAB_EDGES_SLIT_ARM plot "EDG_LO_X" and "EDG_UP_X" vs. "CENTER_Y" to see the detected order edges.

xsh_2dmap

Creates a wavelength and spatial resampling solution



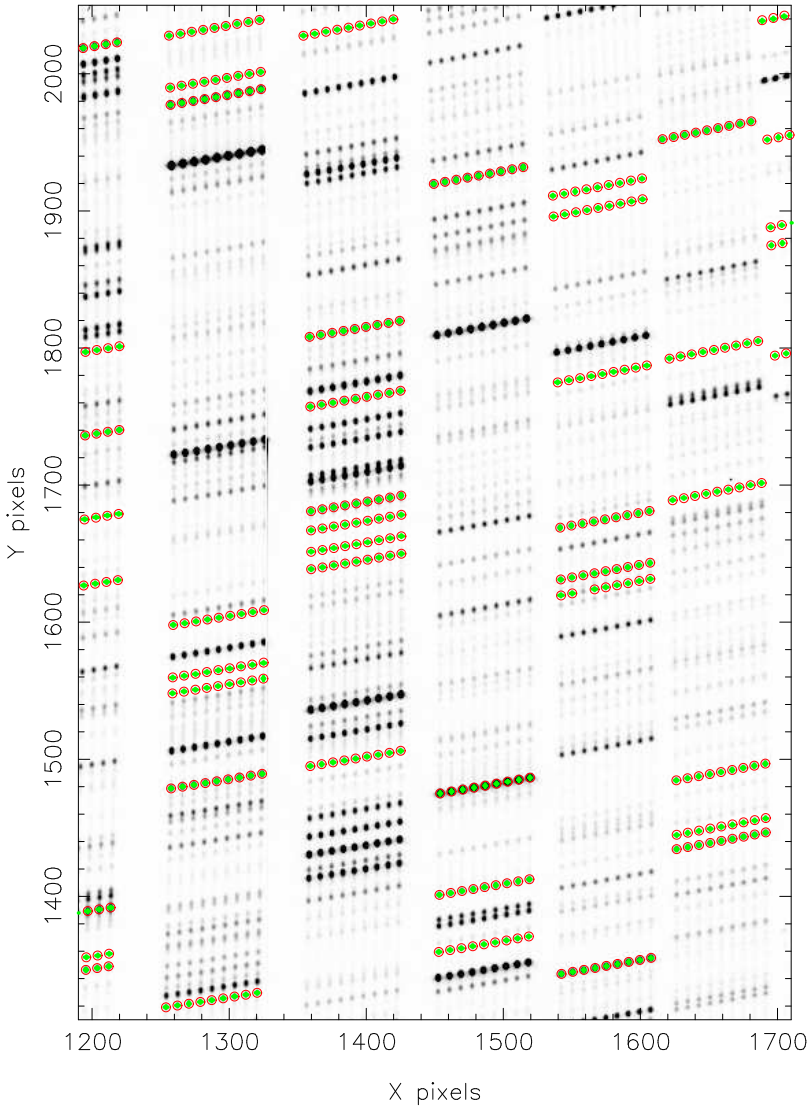
Input files:

POLY mode:
- WAVE_ARM (ON/OFF for NIR)
- SPECTRAL_FORMAT_TAB_ARM
- ARC_LINE_LIST_ARM
- WAVE_TAB_GUESS_ARM
- MASTER_BIAS_ARM (DARK for NIR)
- ORDER_TAB_EDGES_SLIT_ARM
- THEO_TAB_MULT_ARM
- MASTER_BP_MAP_ARM

PHYSICAL mode:
- WAVE_ARM (ON/OFF for NIR)
- SPECTRAL_FORMAT_TAB_ARM
- ARC_LINE_LIST_ARM
- ORDER_TAB_EDGES_SLIT_ARM
- MASTER_BIAS_ARM (DARK for NIR)
- XSH_MOD_CFG_OPT_FMT_ARM
- MASTER_BP_MAP_ARM

xsh_2dmap

Creates a wavelength and spatial resampling solution



Important parameters:

- --detectarclines-fit-window-half-size = 6
- --detectarclines-search-window-half-size = 4
- --detectarclines-wavesol-deg-lambda = 5 (POLY mode)
- --detectarclines-wavesol-deg-order = 5 (POLY mode)
- --detectarclines-ordertab-deg-y = 5
- --detectarclines-min-sn = 5.0
- --detectarclines-find-lines-center = gaussian
- --dispersol-deg-x = 5
- --dispersol-deg-y = 5
- --model-maxit = 2500 (PHYSICAL mode)

A good number of lines to detect is 2440 (UVB), 3550 (VIS) and 1400 (NIR). The mean X and Y residuals should be less than 0.1 for all arms.

xsh_2dmap

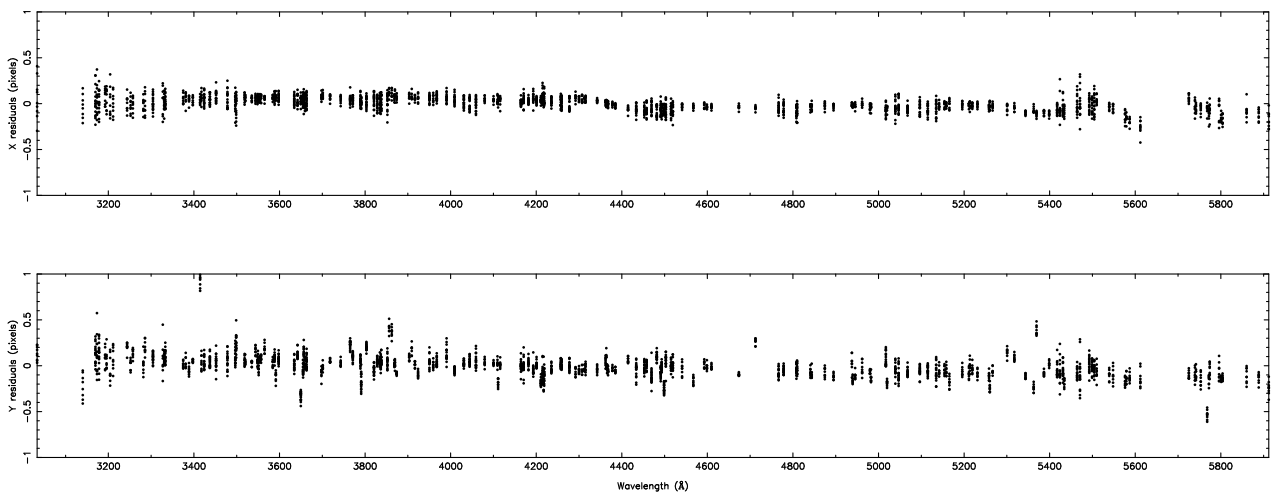
Output files:

POLY mode:

ARC_LINE_LIST_2DMAP_ARM
WAVE_TAB_2D_ARM
WAVE_RESID_TAB_LINES_ARM
WAVE_MAP_ARM
SLIT_MAP_ARM
DISP_TAB_ARM
WAVE_ON_ARM

PHYSICAL mode:

ARC_LINE_LIST_2DMAP_ARM
WAVE_RESID_TAB_LINES_ARM
WAVE_MAP_ARM
SLIT_MAP_ARM
DISP_TAB_ARM
WAVE_ON_ARM
XSH_MOD_CFG_OPT_2D_ARM



xsh_flexcomp

Updates the wavelength solution based on the instrumental flexures

Input files:

POLY mode:

AFC_ATT_ARM
SPECTRAL_FORMAT_TAB_ARM
ARC_LINE_LIST_AFC_ARM
MASTER_BIAS_ARM (DARK for NIR)
ORDER_TAB_EDGES_SLIT_ARM
WAVE_TAB_2D_ARM

PHYSICAL mode:

AFC_ATT_ARM
SPECTRAL_FORMAT_TAB_ARM
ARC_LINE_LIST_AFC_ARM
MASTER_BIAS_ARM (DARK for NIR)
ORDER_TAB_EDGES_SLIT_ARM
XSH_MOD_CFG_OPT_2D_ARM

Important parameters are the same as xsh_2dmap

xsh_flexcomp

Output files:

POLY mode:	PHYSICAL mode:
WAVE_TAB_AFC_ARM	XSH_MOD_CFG_OPT_AFC_ARM
ORDER_TAB_AFC_SLIT_ARM	ORDER_TAB_AFC_SLIT_ARM
DISP_TAB_AFC_ARM	DISP_TAB_AFC_ARM
AFC_ATT_RESID_TAB_LINES_ARM	AFC_ATT_RESID_TAB_LINES_ARM

xsh_respon_slit_*

Computes the instrumental response and the telescope + instrument + detector efficiency

* = "stare", "nod" or "offset", depending upon the observing mode. Before June 2011 this was usually "offset". Since June 2011 flux standards are usually observed in "nod" mode.

currently this recipe will only work with 7 standard stars (although others are observed!):

- GD 71 - DA
- Feige 110 - sdOB
- GD 153 - DA
- LTT 3218 - DA
- LTT 7987 - DA
- BD+17 4708 - F8 (binary!)
- EG 274 - DA

Flux standards are always observed with a 5" slit for all arms and 1×1 binning unless a "special calibration" was requested.

You can add your own standards to the xsh_star_catalog_arm.fits files but they must cover the wavelength range 0.3-2.5 microns and be in units of erg $\mathrm{cm}^{-2}\,\mathrm{s}^{-1}\,\text{Å}^{-1}$.

xsh_respon_slit_*

Input files:

POLY mode:	PHYSICAL mode:
STD_FLUX_SLIT_*_ARM	STD_FLUX_SLIT_*_ARM
SPECTRAL_FORMAT_TAB_ARM	SPECTRAL_FORMAT_TAB_ARM
MASTER_BIAS_ARM (DARK for NIR)	MASTER_BIAS_ARM (DARK for NIR)
MASTER_FLAT_SLIT_ARM	MASTER_FLAT_SLIT_ARM
ORDER_TAB_EDGES_SLIT_ARM	ORDER_TAB_EDGES_SLIT_ARM
WAVE_TAB_2D_ARM	XSH_MOD_CFG_OPT_2D_ARM
DISP_TAB_ARM	DISP_TAB_ARM
MASTER_BP_MAP_ARM	MASTER_BP_MAP_ARM
FLUX_STD_CATALOG_ARM	FLUX_STD_CATALOG_ARM
ATMOS_EXT_ARM	ATMOS_EXT_ARM
HIGH_ABS_WIN_ARM	HIGH_ABS_WIN_ARM

If you have run the xsh_flexcomp recipe then use the AFC frames instead

xsh_respon_slit_*

Important parameters:

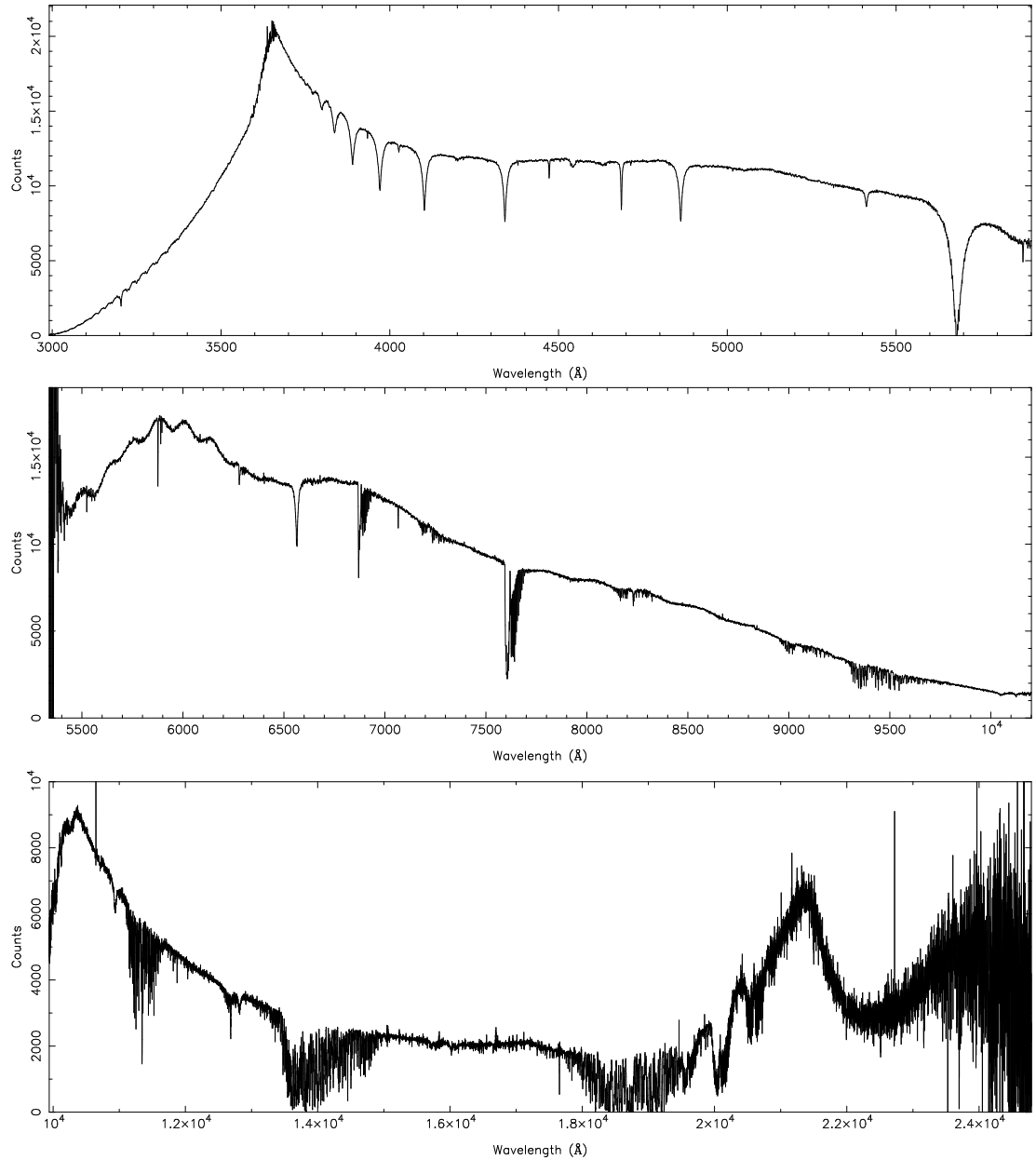
- --rectify-bin-lambda = 0.1
- --rectify-bin-slit = 0.21
- --localize-method = GAUSSIAN, MAXIMUM or MANUAL
- --localize-chunk-nb = 10
- --localize-thresh = 0.1 (MAXIMUM)
- --localize-slit-position = 0.0 (MANUAL)
- --localize-slit-hheight = 2.0 (MANUAL)
- --do-optextract = TRUE

xsh_respon_slit_*

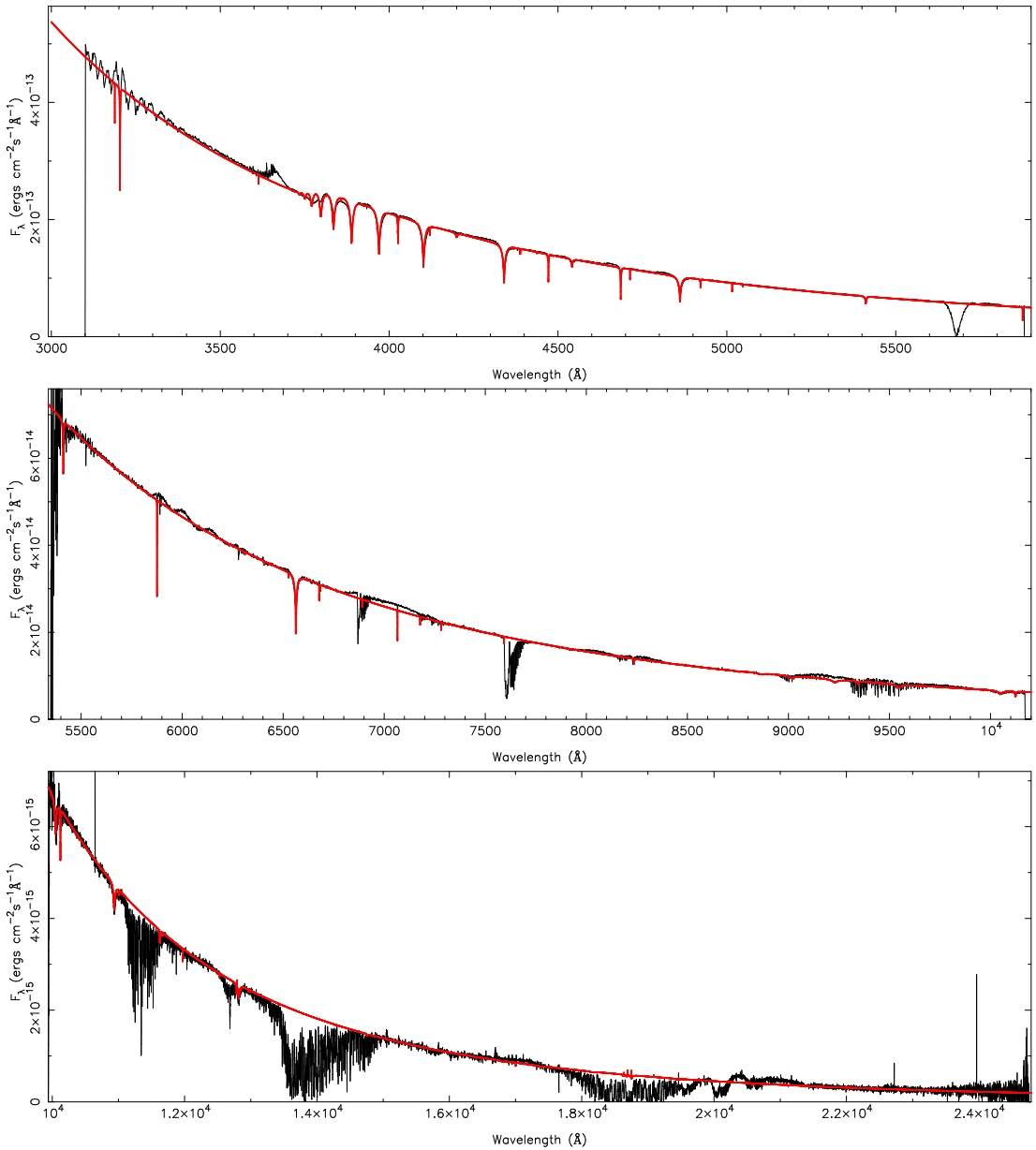
Output files:

MRESPONSE_MERGE1D_SLIT_ARM	- merged response function
MRESPONSE_ORDER1D_SLIT_ARM	- order-by-order response function
FLUX_SLIT_ORDER2D_ARM	- order-by-order 2D flux standard spectrum
FLUX_SLIT_ORDER1D_ARM	- order-by-order 1D flux standard spectrum
FLUX_SLIT_MERGE2D_ARM	- merged 2D flux standard spectrum
FLUX_SLIT_MERGE1D_ARM	- merged 1D flux standard spectrum
FLUX_SLIT_FLUX_ORDER2D_ARM	- order-by-order flux calibrated 2D flux standard spectrum
FLUX_SLIT_FLUX_ORDER1D_ARM	- order-by-order flux calibrated 1D flux standard spectrum
FLUX_SLIT_FLUX_MERGE2D_ARM	- merged flux calibrated 2D flux standard spectrum
FLUX_SLIT_FLUX_MERGE1D_ARM	- merged flux calibrated 1D flux standard spectrum
EFFICIENCY_SLIT_ARM	- telescope + instrument + detector efficiency

xsh_respon_slit_*



xsh_respon_slit_*



xsh_scired_slit_*

Reduce a science spectrum

Input files:

POLY mode	PHYSICAL mode
OBJECT_SLIT_*_ARM	OBJECT_SLIT_*_ARM
SPECTRAL_FORMAT_TAB_ARM	SPECTRAL_FORMAT_TAB_ARM
HIGH_ABS_WIN_ARM	HIGH_ABS_WIN_ARM
SKY_LINE_LIST_ARM	SKY_LINE_LIST_ARM
MASTER_BIAS_ARM (DARK for NIR)	MASTER_BIAS_ARM (DARK for NIR)
MASTER_FLAT_SLIT_ARM	MASTER_FLAT_SLIT_ARM
ORDER_TAB_EDGES_SLIT_ARM	ORDER_TAB_EDGES_SLIT_ARM
DISP_TAB_ARM	DISP_TAB_ARM
WAVE_TAB_2D_ARM	XSH_MOD_CFG_OPT_2D_ARM
MRESPONSE_MERGE1D_SLIT_ARM	MRESPONSE_MERGE1D_SLIT_ARM
ATMOS_EXT_ARM	ATMOS_EXT_ARM
MASTER_BP_MAP_ARM	MASTER_BP_MAP_ARM

If you have run the xsh_flexcomp recipe then use the AFC frames instead

xsh_scired_slit_*

Important parameters:

--rectify-bin-lambda:
    UVB: 0.015 (0.8" slit) – 0.020 (1.0" slit)
    VIS: 0.015 (0.8" slit) – 0.020 (1.0" slit)
    NIR: 0.060
--rectify-bin-slit = 0.16 (UVB and VIS), 0.21 (NIR)
--localize-use-skymask = FALSE (TRUE for NIR)
--localize-method = GAUSSIAN, MAXIMUM or MANUAL
--localize-chunk-nb = 50
--localize-thresh = 0.1 (MAXIMUM)
--localize-slit-position = 0.0 (MANUAL)
--localize-slit-hheight = 2.0 (MANUAL)
--do-optextract = TRUE

Values of --rectify-bin-lambda and --rectify-bin-slit need to be doubled in the binned case for the UVB and VIS arms

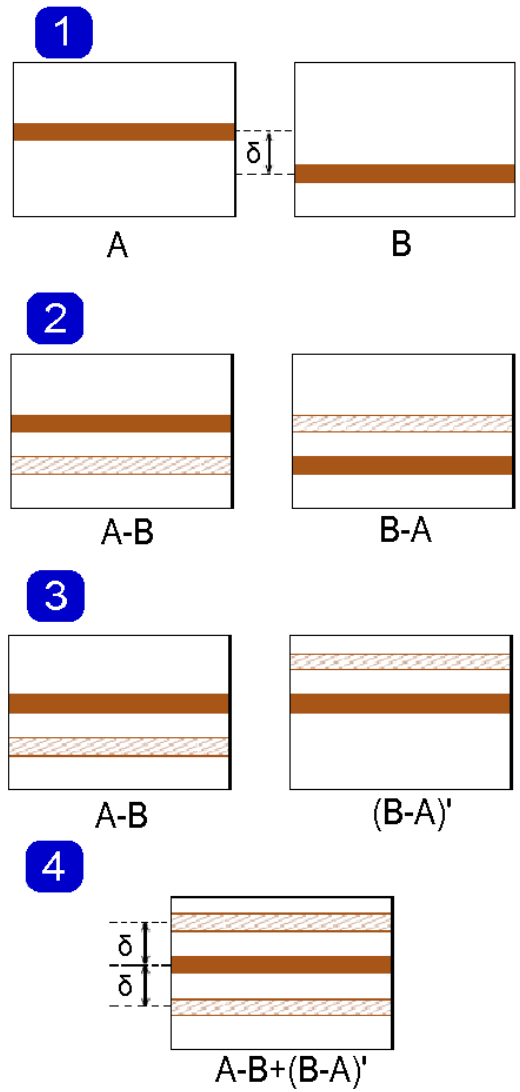
xsh_scired_slit_*

Output files:

SCI_SLIT_ORDER2D_ARM	- order-by-order 2D science spectrum
SCI_SLIT_ORDER1D_ARM	- order-by-order 1D science spectrum
SCI_SLIT_MERGE2D_ARM	- merged 2D science spectrum
SCI_SLIT_MERGE1D_ARM	- merged 1D science spectrum
SCI_SLIT_FLUX_ORDER2D_ARM	- order-by-order flux calibrated 2D science spectrum
SCI_SLIT_FLUX_ORDER1D_ARM	- order-by-order flux calibrated 1D science spectrum
SCI_SLIT_FLUX_MERGE2D_ARM	- merged flux calibrated 2D science spectrum
SCI_SLIT_FLUX_MERGE1D_ARM	- merged flux calibrated 1D science spectrum

xsh_scired_slit_*

Nodding:



Useful scripts

Due to the large number of files created it is a good idea to run the entire reduction cascade as a script. I have created several scripts that you may find useful. To use these you will need to add my python modules to your PYTHONPATH:

/home/astro/phrhau/software/Python/sgp

You will also need to add Tom's python paths:

/home/astro/phsaap/software/lib64/python2.5/site-packages
/home/astro/phsaap/software/lib64/python/site-packages

Then add the following to your .cshrc:

alias xshooter "source /home/astro/phrhau/software/xshooter/xshooter.tcsh"

Then typing "xshooter" into a terminal will give you a list of scripts.

Useful scripts

These scripts include:

- xsh_check_predict – checks the fitted positions of identified lines made with xsh_predict
- xsh_check_orderpos – traces the positions of the orders as determined by xsh_orderpos
- xsh_check_mflat – traces the positions of the order edges found by xsh_mflat
- xsh_check_2dmap – checks the fitted positions of identified lines made with xsh_2dmap
- xsh_check_response – plots the flux calibrated standard star against the library spectrum
- xsh_ftype – returns the type of X-Shooter frame for a file or list of files
- xsh_prepare_files – will unpack and sort a PI pack .tar file so that it is ready to reduce. Only works if the pack contains a single OB
- xsh_reduce – run the X-Shooter reduction pipeline. Runs everything up to xsh_scired_slit.

xsh_reduce

Usage: xsh_reduce -p reduce.red

Using the -p option will pause the reduction after certain recipes and allow you to analyse the results.

reduce.red is a file which lists all of the main recipe parameters (as well as some general parameters). An example of which can be found here:

/home/astro/phrhau/software/reduce.red

You also need to give it a list of all raw calibration frames (except those provided by the pipeline).