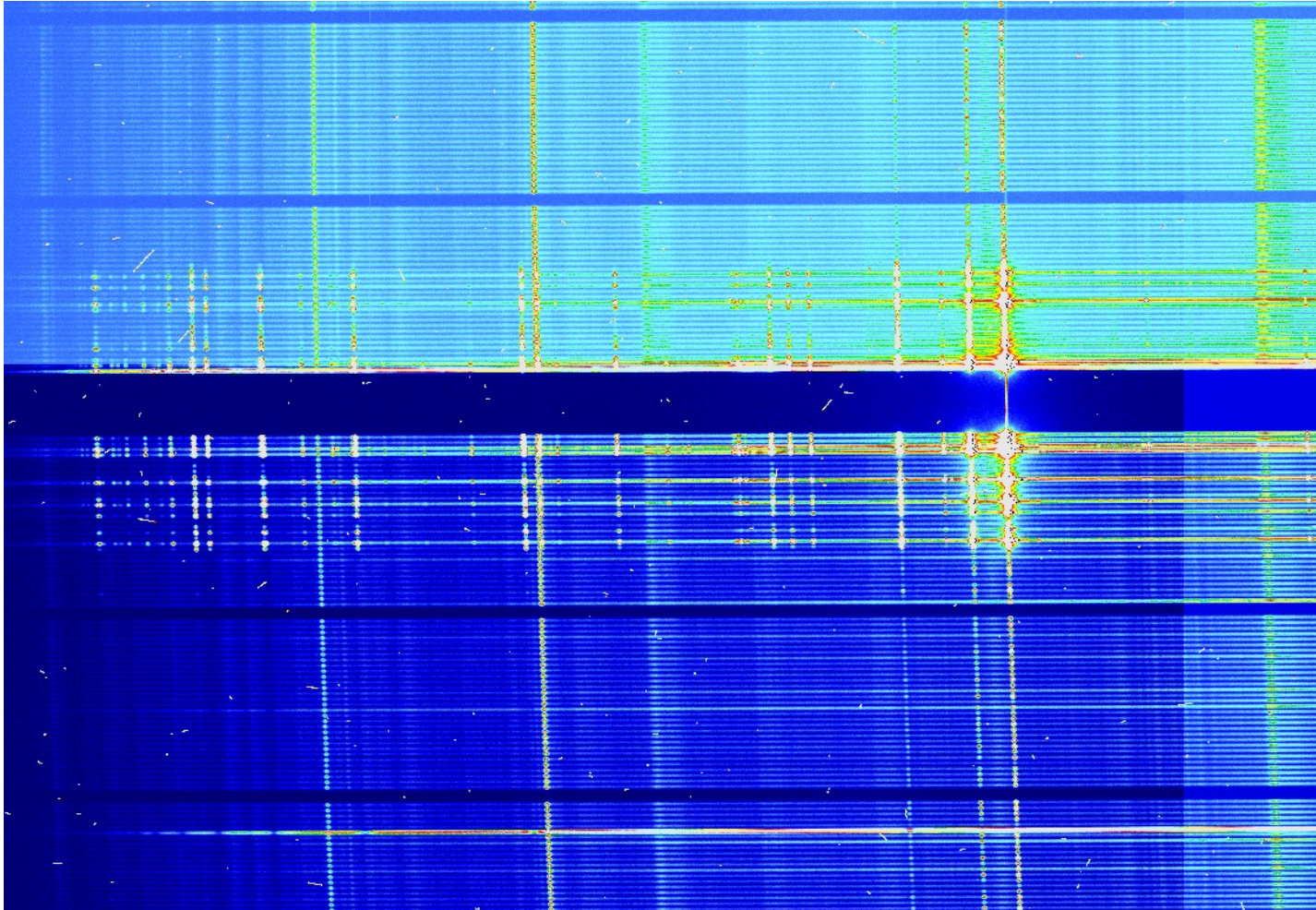


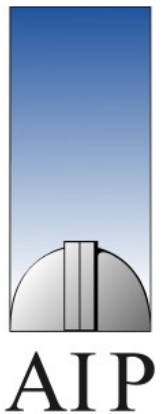
Integral-Field Spectroscopy data reduction made easy with p3d



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IFUs in the era of JWST, 27.10.2010



Several data-reduction tools already exist to reduce raw data of fiber-fed integral-field spectrographs

Table 1. A list of fiber-fed IFUs and their respective data-reduction pipelines.

Telescope	Spectrograph	IFU	n_d	Ref.	Reduction tool/Pipeline	Ref.
VLT/UT2	GIRAFFE	FLAMES-ARGUS	1	1	BLDRS	1a
					GIRAFFE PIPELINE	1b
Gemini North/South		GMOS-N, GMOS-S	3	2	 KUNGIFU	3a
Magellan I		IMACS	8	3		
WHT	WYFFOS	INTEGRAL	2	4	 IRAF	
Calar Alto 3.5 m	PMAS	LARR	1	5		
		PPAK	1	6	PPAK_ONLINE	5a
AAT	AAOMEGA	SPIRAL	2	7	2DFDR	7a
VLT/UT3	VIMOS	VIMOS-IFU	4	8	VIPGI	8a
					VIMOS PIPELINE	
McDonald 2.7 m	VIRUS-P	VIRUS-P	1	9	VACCINE	9a

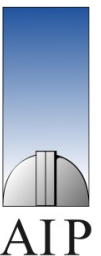
Notes. In Col. 4 we specify the number of detectors of the IFU. Column 5 specifies the main instrument reference paper, and Col. 7 gives the reference of each instrument-specific reduction tool/pipeline.

References. ¹ Avila et al. (2003); ^{1a} Blecha et al. (2000); ^{1b} Pasquini et al. (2000); ² Allington-Smith et al. (2002); ³ Schmoll et al. (2004); ^{3a} Bolton & Burles (2007); ⁴ Arribas et al. (1998); ⁵ Roth et al. (2005); ^{5a} Becker (2002); ⁶ Kelz et al. (2006); ⁷ Smith et al. (2004); ^{7a} Sharp et al. (2006); ⁸ LeFèvre et al. (2003); ^{8a} Scodreggio et al. (2005); ⁹ Hill et al. (2008); ^{9a} Adam et al., in prep.

Sandin et al. 2010, A&A, 515, 35

+ MPFS/6m BTA/Russia

+ the general tools R3D of S. Sánchez, and IRAF



The purpose with p3d is to provide a general tool that works **with all** fiber-fed Integral-Field Spectrographs

Extended functionality

Easy to use

Easy installation and configuration

Mostly Automatic

Corrects for cross-talk

All operations are logged

Provides reduction and inspection tools

Released under GPL v3

Extendable

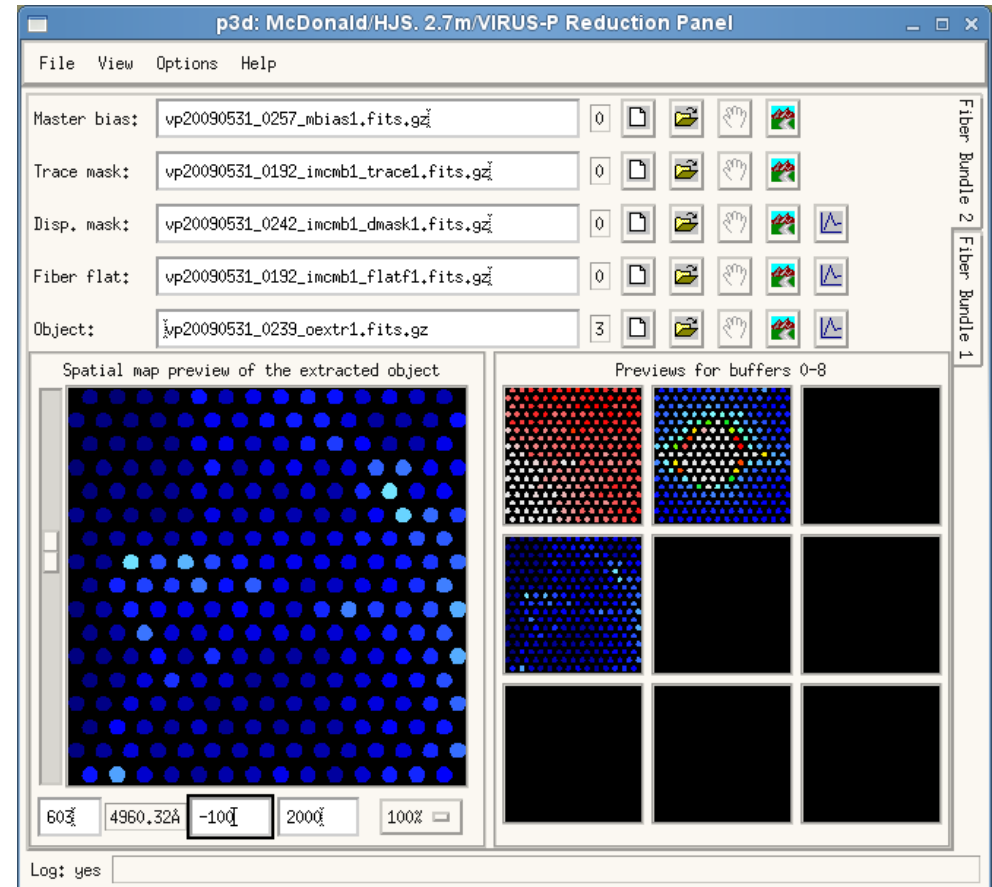
Based on IDL

Requires version 6.2, or higher

Works on all supported platforms:

Linux, Solaris, Mac, Windows

Can be used **without** an IDL license



Reference: Sandin C., Becker T., Roth M.M., Gerssen J., Monreal-Ibero A.,
Böhm P., Weilbacher P. 2010, A&A, 515, A35

Project web site: <http://p3d.sourceforge.net>

The purpose with p3d is to provide a general tool that works **with all** fiber-fed Integral-Field Spectrographs

Supported instruments (v. 1.1.1):

PMAS-PPAK/LARR – all setups

VIRUS-P – bundles 1 & 2, blue (and red)

SPIRAL – red and blue arms

Also available (in the repository):

VIMOS – HR and MR grisms

GMOS-S/N – the red and the blue slits

FLAMES/ARGUS – working on an easier wavelength calibration procedure

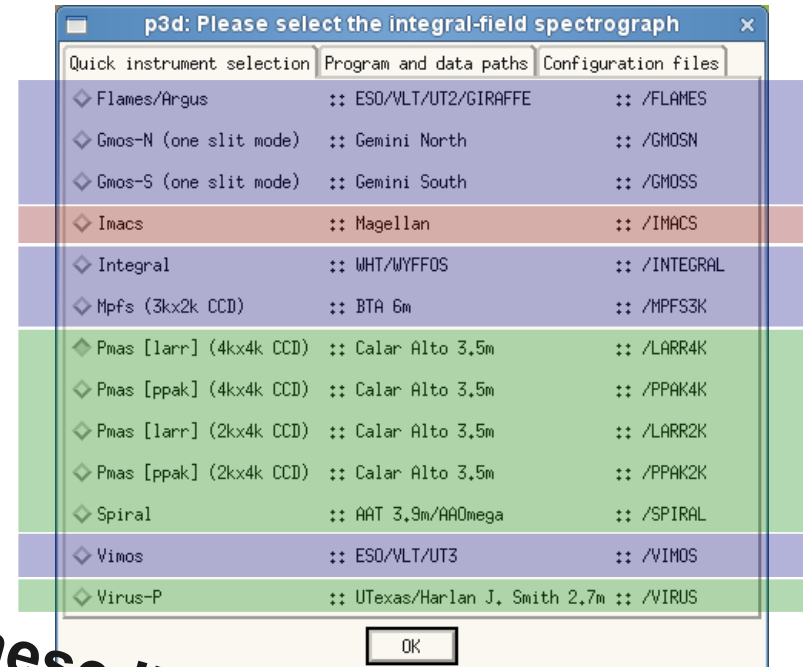
MPFS – for the newer 3kx2k CCD

INTEGRAL – the SB2 IFU and the old CCD are working, the remaining setups are implemented as time permits

Future possibilities:

IMACS – is complex to implement, infrastructure-wise

New instruments...



These IFUs will be supported in the next release (v. 1.2 – Wolowizard)

See the poster on WR-Galaxies by Kehrig et al.

p3d is flexible, and allows the user great possibilities to customize her/his personal data-reduction tasks

Use an IDL license, or don't

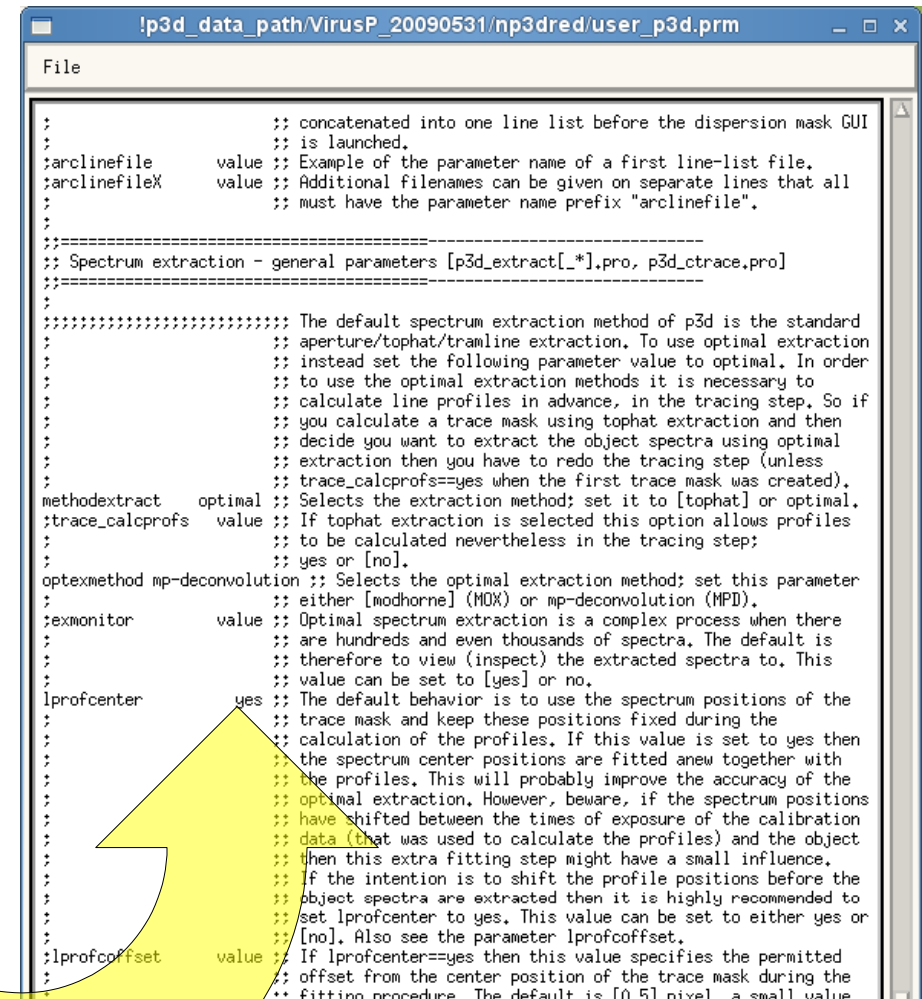
No IDL license is required when p3d is used through the IDL VM.

Use the GUI, or write scripts

The GUI allows fast reduction by pointing and clicking. Separate scripts could be more efficient if the amount of data is large.

Configure p3d to suit your needs

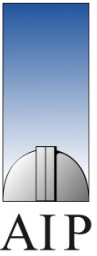
Edit the user parameter file to achieve a custom data-reduction procedure.



```
File
;
; concatenated into one line list before the dispersion mask GUI
; is launched.
;arclinefile value ;; Example of the parameter name of a first line-list file.
;arclinefileX value ;; Additional filenames can be given on separate lines that all
; must have the parameter name prefix "arclinefile".
;
;=====
;; Spectrum extraction - general parameters [p3d_extract[_*].pro, p3d_ctrace.pro]
;=====
;
;:::::::::::::::::::::::::::::::::::::::::: The default spectrum extraction method of p3d is the standard
;
; aperture/tophat/tranline extraction. To use optimal extraction
; instead set the following parameter value to optimal. In order
; to use the optimal extraction methods it is necessary to
; calculate line profiles in advance, in the tracing step. So if
; you calculate a trace mask using tophat extraction and then
; decide you want to extract the object spectra using optimal
; extraction then you have to redo the tracing step (unless
; trace_calcprofs==yes when the first trace mask was created).
methodextract optimal ;; Selects the extraction method; set it to [tophat] or optimal.
;trace_calcprofs value ;; If tophat extraction is selected this option allows profiles
; to be calculated nevertheless in the tracing step;
; yes or [no].
optexmethod mp-deconvolution ;; Selects the optimal extraction method; set this parameter
; either [modhorne] (MOX) or mp-deconvolution (MPD).
;exmonitor value ;; Optimal spectrum extraction is a complex process when there
; are hundreds and even thousands of spectra. The default is
; therefore to view (inspect) the extracted spectra to. This
; value can be set to [yes] or no.
lprofcenter yes ;; The default behavior is to use the spectrum positions of the
; trace mask and keep these positions fixed during the
; calculation of the profiles. If this value is set to yes then
; the spectrum center positions are fitted anew together with
; the profiles. This will probably improve the accuracy of the
; optimal extraction. However, beware, if the spectrum positions
; have shifted between the times of exposure of the calibration
; data (that was used to calculate the profiles) and the object
; then this extra fitting step might have a small influence.
; If the intention is to shift the profile positions before the
; object spectra are extracted then it is highly recommended to
; set lprofcenter to yes. This value can be set to either yes or
; [no]. Also see the parameter lprofcoffset.
lprofcoffset value ;; If lprofcenter==yes then this value specifies the permitted
; offset from the center position of the trace mask during the
; fitting procedure. The default is [0.5] pixel. A small value
```

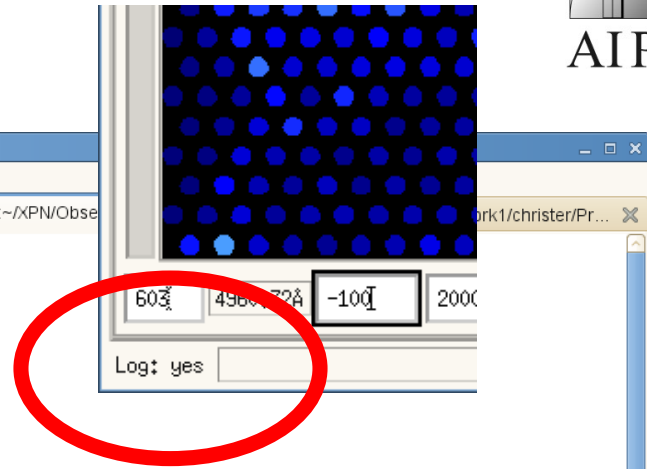


Information about all steps of the data reduction is saved to a plain text log file.



```
christer@halo:~/XPN/Observations/VLT/077.D-0652A.1/p3dred
File Edit View Terminal Tabs Help
christer@halo:~/Projects/p3d
christer@halo:~/work1/christer/LargeScal...
christer@halo:~/work1/christer/LargeScal...
christer@halo:~/XPN/Obse...
christer@halo:~/work1/christer/Pr...

p3d_cdmask: =====
p3d_cdmask: ===== Creating a dispersion mask image
p3d_cdmask: ===== Wed Oct 13 11:26:14 2010
p3d_cdmask: =====
p3d_misc_read_params: Read          daxis="      2" (->integer).
p3d_misc_read_params: Read          keywordsfile="flames_keywords.dat" [default].
p3d_misc_read_params: Read          gratingsfile_dm="flames_gratings.dat" [default].
p3d_misc_read_params: Read          deadfibersfile="argus_dead_fibers.dat" [default].
p3d_misc_read_params: Read          postable="argus_positions.dat" .
p3d_misc_read_params: Read          lampsfile_dm="flames_lamps.dat" [default].
p3d_misc_read_params: Read          daxis="      2" (->integer).
p3d_misc_read_params: Read          keywordsfile="flames_keywords.dat" [default].
p3d_misc_read_params: Read          daxis="      2" (->integer).
p3d_misc_detsec: Using DETSEC=[1:2147,1:4096] [instrument default], xbin,ybin=1,1.
p3d_wavecal_set_linelist: Concatenating the contents of the following files to create one linelist:
p3d_wavecal_set_linelist: 1/1 "!p3d_path/data/tables/linelists/flames_h504.8.dat"
p3d_misc_getinformation: Read the following keywords from the instrument-specific header keywords file:
p3d_misc_getinformation: KW(GAIN)="HIERARCH ESO DET OUT1 GAIN" [ADU/e],
p3d_misc_getinformation: KW(RDNOISE)="HIERARCH ESO DET OUT1 RON" [e].
p3d_misc_getinformation: Read the following values:
p3d_misc_getinformation: dbias= 1.069e+00 [ADU].
p3d_misc_getinformation: gain= 2.273e+00 [e-/ADU] {masterbias header},
p3d_misc_getinformation: rdnoise= 1.852e+00 [ADU] {masterbias header}.
p3d_misc_getinformation: Read the following values:
p3d_misc_getinformation: gain= 4.400e-01 [e-/ADU] {data header},
p3d_misc_getinformation: rdnoise= 9.568e+00 [ADU] {data header}.
p3d_extract_prepare_extraction: Loading and trimming object data [2148,4096] "/work1/christer/XPN/Observations/VLT/077.D-0652A.1/2006-08-12/GIRAF.2006-08-12T12:19:35.520.fits".
p3d_extract_prepare_extraction: Loading and trimming the trace mask [319,4096] "/work1/christer/XPN/Observations/VLT/077.D-0652A.1/p3dred/GIRAF.2006-08-12T12:05:06_1mcmb_trace.fits.gz".
p3d_extract_prepare_extraction: Loading and trimming master bias [2148,4096] "/work1/christer/XPN/Observations/VLT/077.D-0652A.1/p3dred/GIRAF.2006-08-12T12:24:20_mbias.fits.gz".
p3d_misc_read_params: Read          daxis="      2" (->integer).
p3d_misc_detsec: Using DETSEC=[1:2147,1:4096] [instrument default], xbin,ybin=1,1.
p3d_misc_read_params: Read          spnum="     319" (->integer).
p3d_misc_read_params: Read          profwidth_ex="    2.0" (->float ) [default].
p3d_extract: Extraction method is: tophat
p3d_extract: Extracting spectra in the object data [no beam switching].
p3d_extract_tophat: Used the following extraction parameters:
p3d_extract_tophat: profwidth=    2.000 :: spectrum extraction half width.
p3d_extract_tophat: match=0.
p3d_extract: Data is not flat fielded.
p3d_misc_read_params: Read          linewidth_dm="    4" (->integer) [default].
p3d_misc_read_params: Read          refdist_dm="    1" (->integer) [default].
p3d_misc_read_params: Read          nrows_dm="    0" (->integer) [default].
p3d_misc_read_params: Read          residualcut_dm="    3.0" (->float ) [default].
p3d_misc_read_params: Read          polynomialorder_dm="    4" (->integer) [default].
p3d_misc_read_params: Read          fwhm_tr="    3.0" (->float ) [default].
p3d_misc_read_params: Read          centermethod_dm=" Gaussian" [default].
p3d_misc_read_postable: shape, nvertices, scale, xisw2e, xfac, yfac :: 0, 15,  1.00, 0,  1,  1
dred.log lines 3942-3988/4470 91%
```



p3d takes care of the time-consuming repetitive tasks in your data-reduction work

Master bias

Several bias images are combined to create a low-noise master bias.

Trace mask

All spectrum positions (λ) are found and stored in an image.

Dispersion mask

The fitted polynomial coefficients are stored for each spectrum in an image, $\lambda(px)$ [\AA].

Fiber-flat field

A well illuminated continuum-lamp image is used to normalize spectra for optical variations.

Extract object spectra

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Extract object spectra

Future features?

Flux calibration

Removing cosmic ray hits in single images

Correcting for differential atmospheric refraction

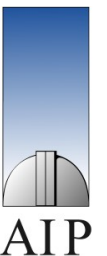
Combining dithered/mosaiced data

Fitting emission/absorption lines to measure fluxes and velocities

Reducing the many reduction steps to one single interpolation.

...

See, for example, the poster of R. Houghton.



The **spectrum tracing** is a fully automatic procedure in p3d, the same number of spectra are always found

Based on a three-step matching procedure

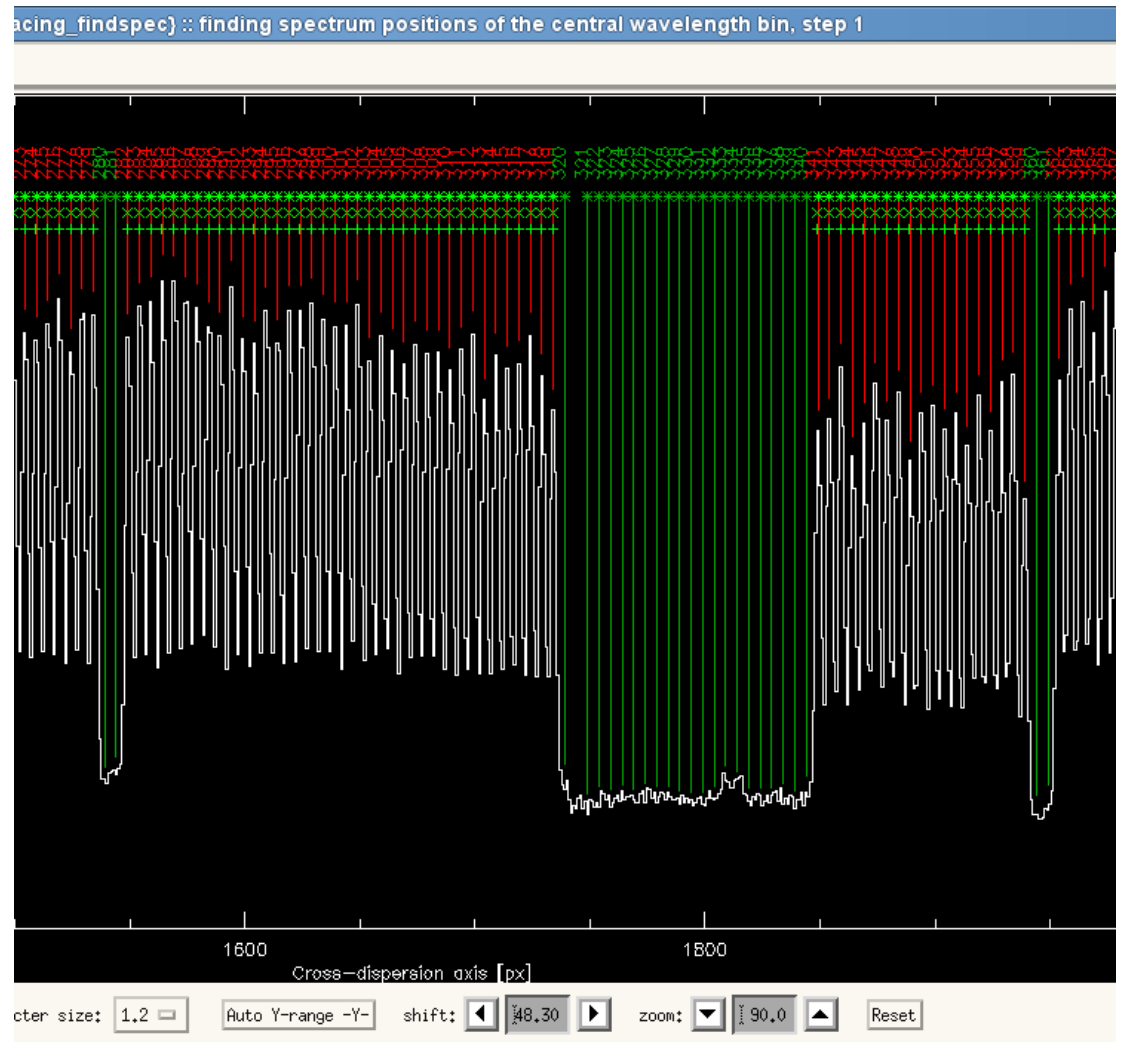
Assumes either a constant or a variable separation between spectra

Dead and unused fibers are ignored, but still included

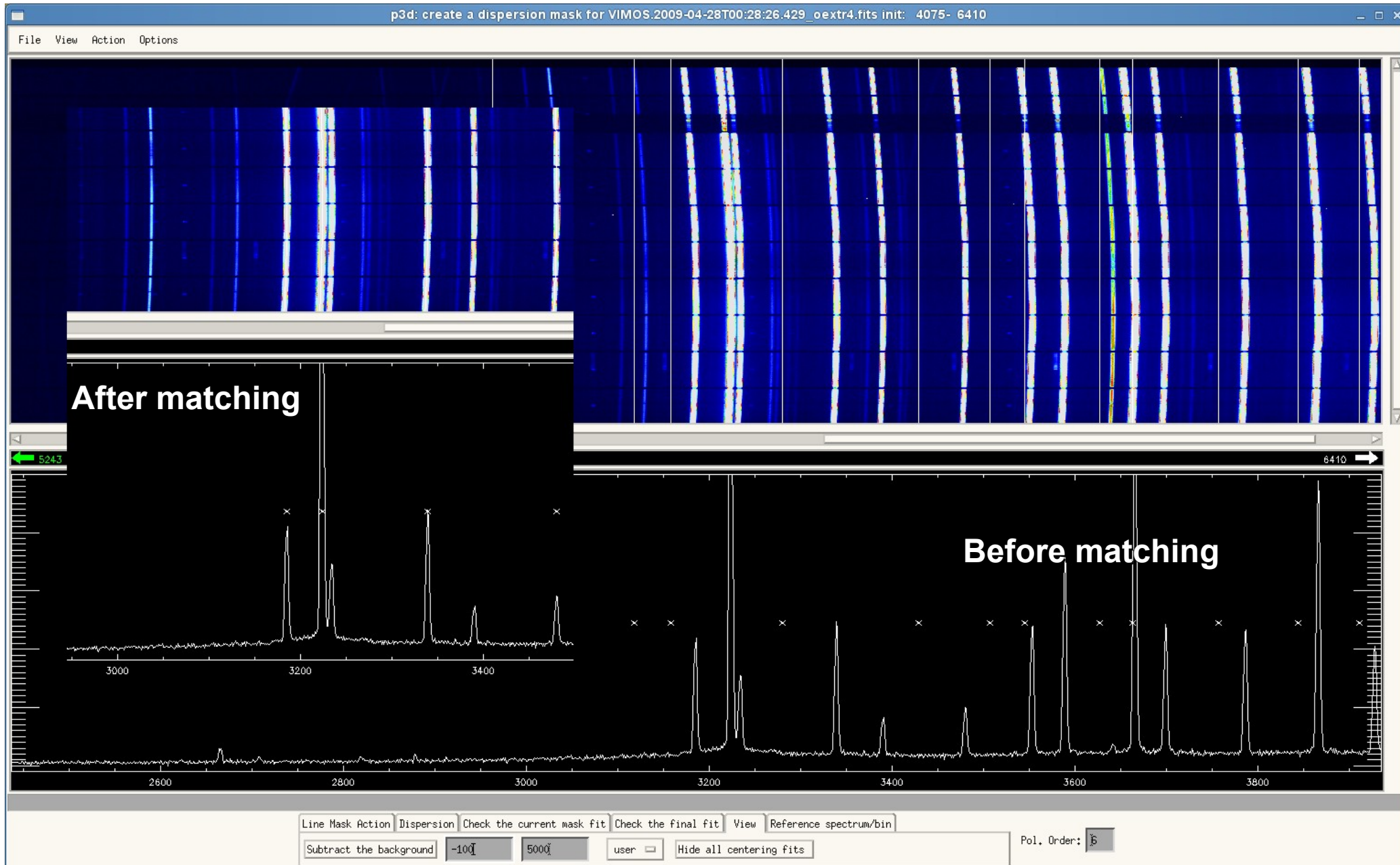
Fits cross-dispersion line profiles – of any kind

For groups of spectra

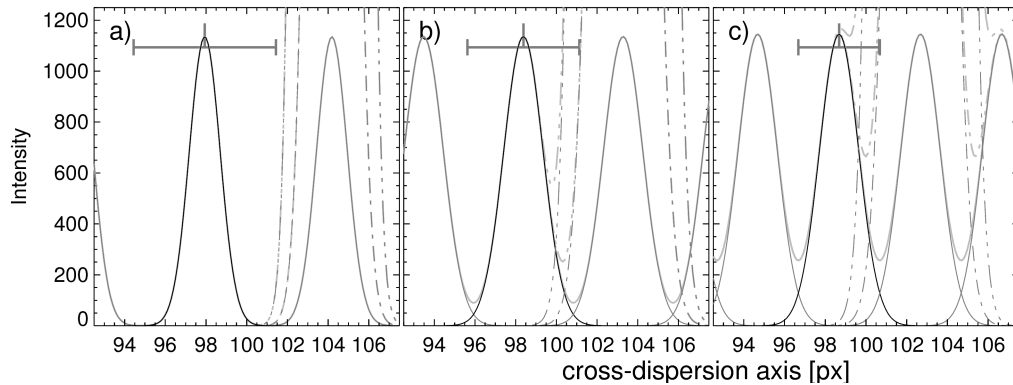
To perform optimal spectrum extraction, to allow correcting for cross talk.



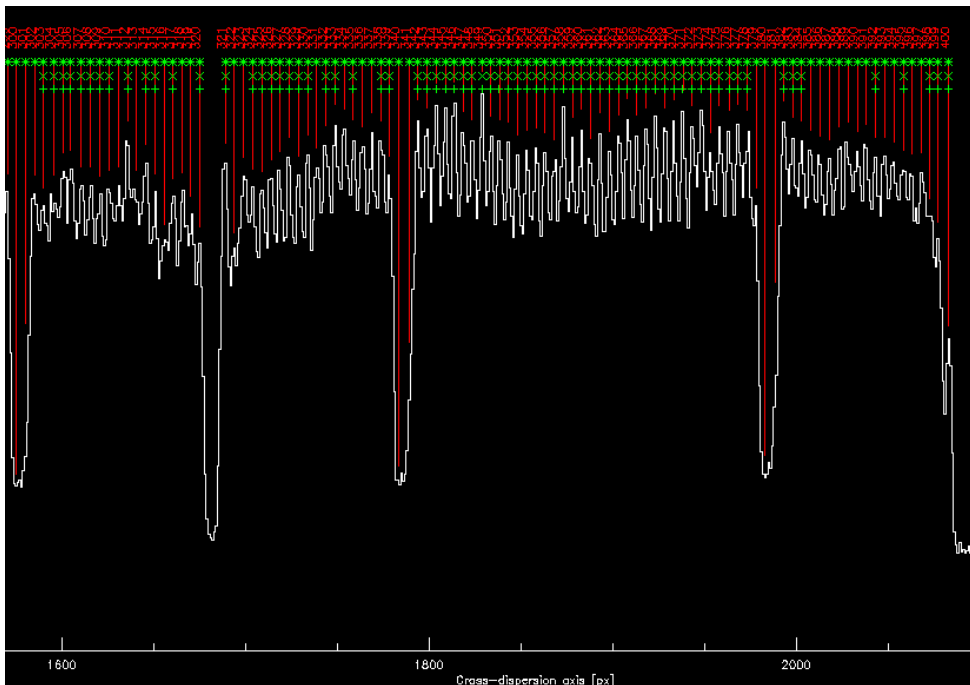
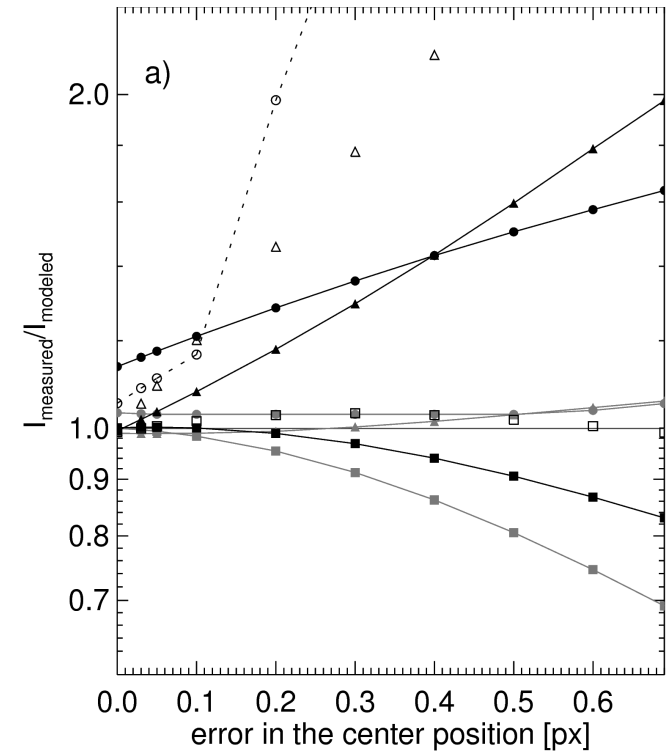
When creating a **dispersion mask**, entries in a line list are matched with extracted arc spectra



The **spectrum extraction** should be treated carefully – otherwise the intensity error can be very large

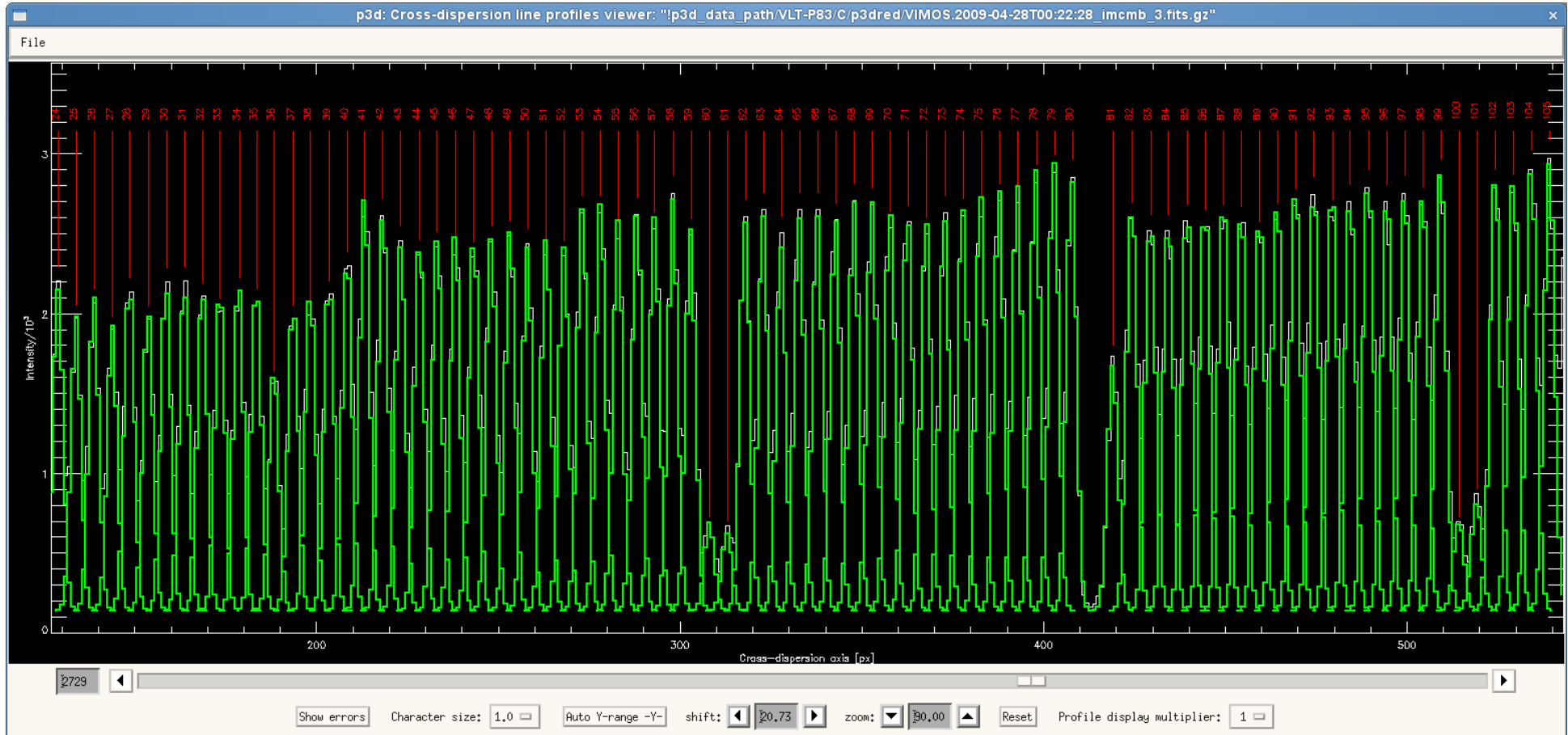


Sandin et al. 2010, A&A, 515, 35
also see: Sharp & Birchall 2010, PASA, 27, 91



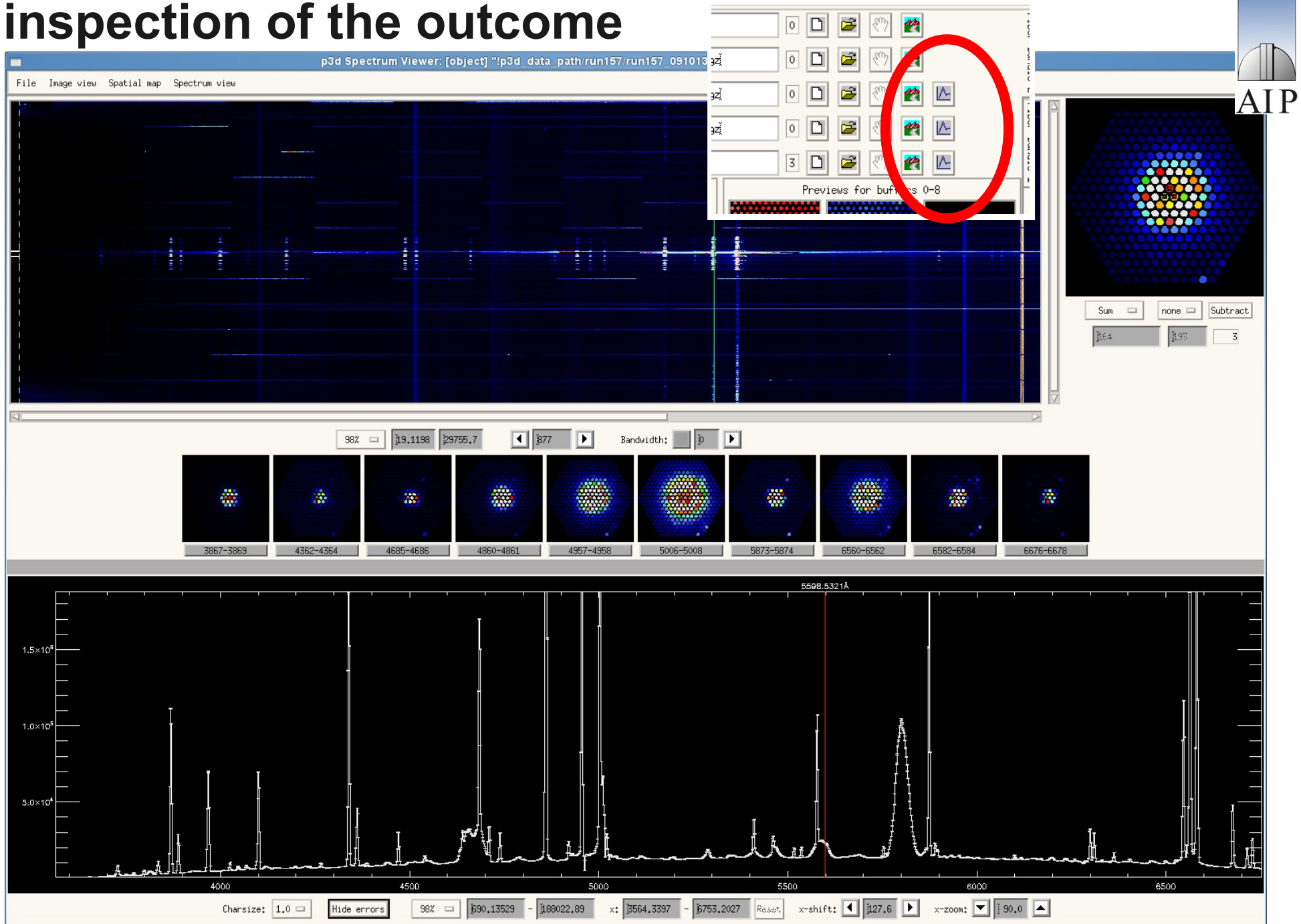
Spectra of VIMOS/Q3 are often very densely packed!

The **spectrum extraction** should be treated carefully – otherwise the intensity error can be very large



It is a good idea to check if the extraction went well

The built-in **spectrum viewer** of p3d allows a direct inspection of the outcome



Documentation is being prepared as a WIKI page – there will only be **one** version of each description

Instructions

The purpose is to describe the data-reduction process for the separate steps

Tutorials

How to reduce data of the different instruments; including example data sets

Routines

are already documented – but this text is perhaps less useful for normal users

SourceForge.net: P3d cdmask - p3d - Konqueror

http://sourceforge.net/apps/mediawiki/p3d/index.php?title=P3d_cdmask

sourceforge by Google

Visit project p3d
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page discussion view source history

P3d cdmask

The program `p3d_cdmask` is an interactive tool that allows you to create a dispersion mask that is used to wavelength calibrate extracted spectra. Specifically, for each spectrum the dispersion mask file contains the $n+1$ coefficients that are required to reconstruct a polynomial of order n . For example, for an n th order polynomial, where the polynomial coefficients are $p_0, p_1, p_2, p_3, \dots, p_n$, the wavelength for pixel x and spectrum i is

$$\lambda_{i,x} = p_0 + p_1 x_i + p_2 x_i^2 + p_3 x_i^3 + \dots + p_n x_i^n.$$

on is as follows. All the selected raw images are at first combined to create a *master* arc image. The *master* arc image is then used to determine the dispersion mask parameters and the information in the data header are then used to determine the wavelength range. The spectra of the master arc image are extracted and the interactive GUI is opened. The interactive procedure thereafter consists of matching entries in the extracted arc spectrum. More accurate pixel positions are calculated for each spectrum, before a polynomial of pre-defined order is fitted for each spectrum separately. The interactive procedure is described in more detail.

Contents [hide]

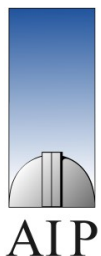
- Graphical user interface
- Image
- Image spectrum
- Image the dispersion mask
- Image range
- Image mask
- Image attribute
- Image mask and changing the first-guess dispersion

The data-reduction tasks

Master bias:	run156_00229_nbias.fits	0	[icon]	[icon]	[icon]	[icon]
Trace mask:	run156_00298_incnb_trace.fits	0	[icon]	[icon]	[icon]	[icon]
Disp. mask:	run156_00299_incnb_dmasks.fits	0	[icon]	[icon]	[icon]	[icon]
Fiber flat:	1	-	[icon]	[icon]	[icon]	[icon]
Object:	run156_00291_incnb_oextr.fits	2	[icon]	[icon]	[icon]	[icon]

There are five rows in the data-reduction section of the GUI; the label in the *first column* of each row is the task: **Master Bias**, **Trace Mask**, **Dispersion Mask**, **Fiber-flat field**, and **Extract object**. The *second column* shows the filename of the currently selected data set. The *third column* indicates the current buffer number (0–8, for buffer 1–9). By clicking on the icons in the remaining columns the following operations are available:

- Create a new data set.** Click this icon to open a file selector where you can choose one, or three, new data sets. **Note!** After the new data set has been created p3d will present a GUI where you can select one of the nine buffers where the data is stored. **Note!** The images must be of the correct type for the desired action. p3d will check if the image size is correct, but does not know how to differ between an arc image and a spectrum image.
- Open an existing data set.** Click this icon to open a file selector where you can choose one already existing data set. **Note!** As soon as the data set has been loaded p3d will present a GUI where you can select one of the nine buffers where the data is stored.
- Switch between different data sets.** Click this icon to select the active data set. **Note!** For object data it is also possible to select the active data set by clicking on the respective panel, of the GUI object-preview section. **Note!** This option is only available if two or more data sets have been created. If only one data set was loaded then that is the active data set.



cf.: <http://p3d.sourceforge.net>

p3d is a general tool that is designed to help you reduce data of fiber-fed integral field spectrographs

Free, works on:

Linux, Solaris, Mac, Windows

The code and the documentation are all available at:

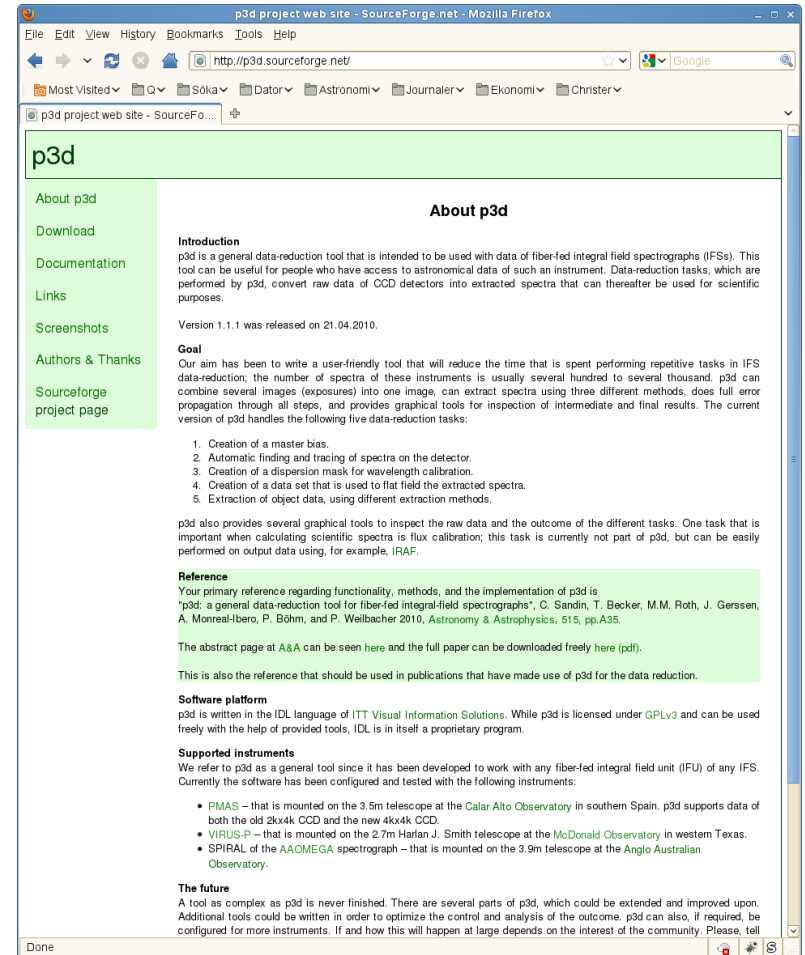
<http://p3d.sourceforge.net>

Support is available (by me)

p3d is extendable

extent and rate of new implementations depend on the (number of) requests from of the community

Contributors: **Thomas Becker**, Martin M. Roth, Joris Gerssen, Ana Monreal-Ibero, Petra Böhm, Peter Weilbacher – and many more



AIP