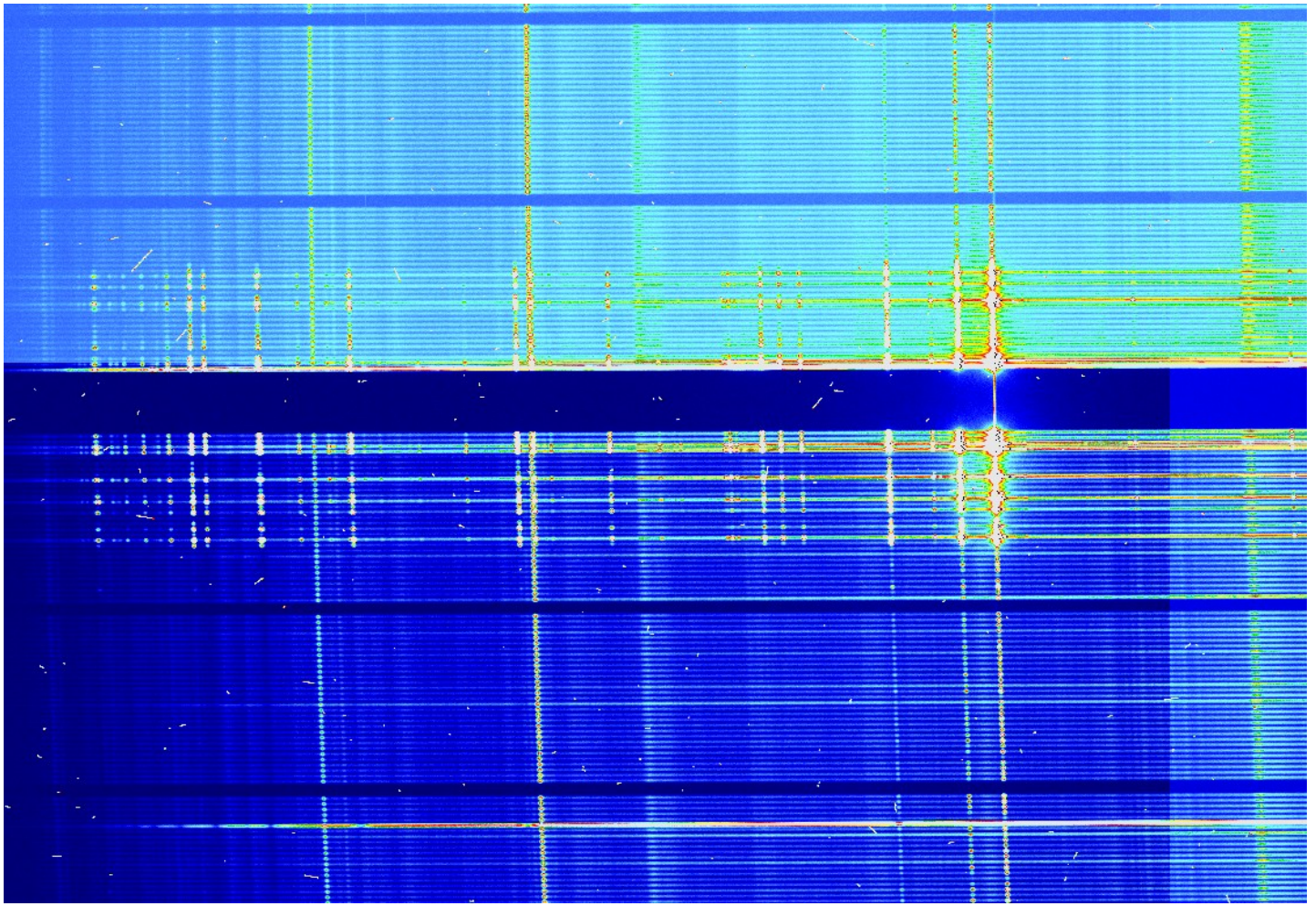
Integral-Field Spectroscopy data reduction made easy with p3d



Christer Sandin
Astrophysikalisches Institut Potsdam, Germany
IFUs in the era of JWST, 27.10.2010

AIP

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	
Magellan I		IMACS	8	3		3a
WHT	WYFFOS	INTEGRAL	2	4	IRAF	
Calar Alto 3.5 m	PMAS	LARR	1	5	P3D, P3D_ONLINE	5a
		PPAK	1	6	PPAK_ONLINE	
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] Scodeggio 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

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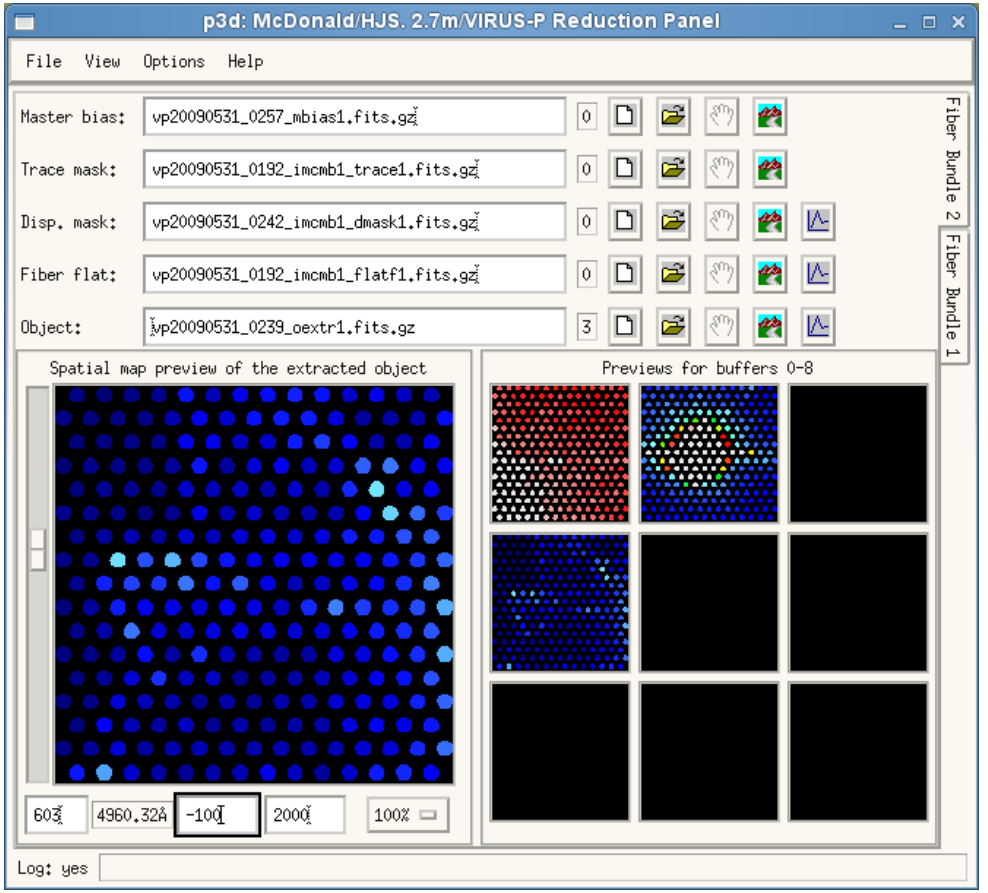
The purpose with p3d is to provide a general tool that works with all fiber-fed Integral-Field Spectrographs

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

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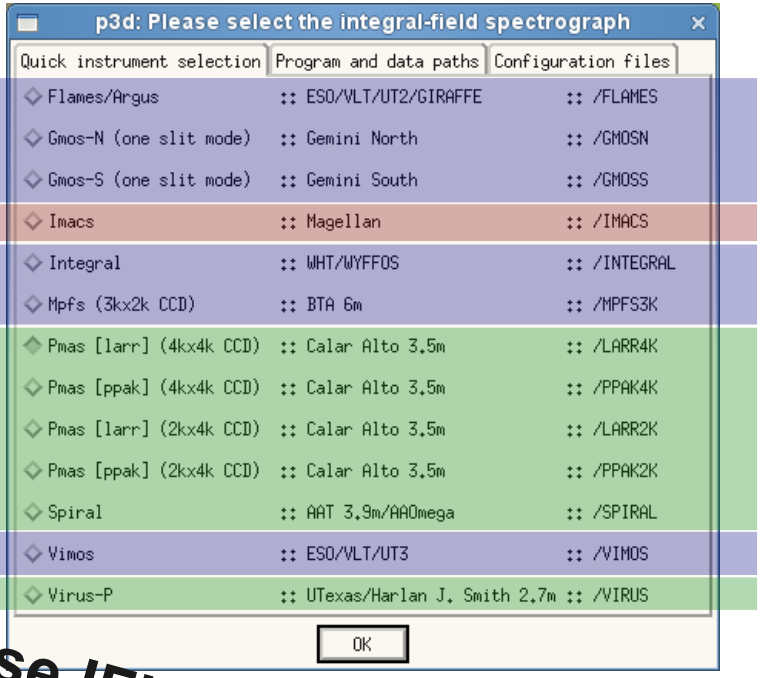
The purpose with p3d is to provide a general tool that works with all fiber-fed Integral-Field Spectropgraphs

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



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

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

Future possibilities:

IMACS – is complex to implement, infrastructure-wise
New instruments...

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

Use an IDL license, or don't

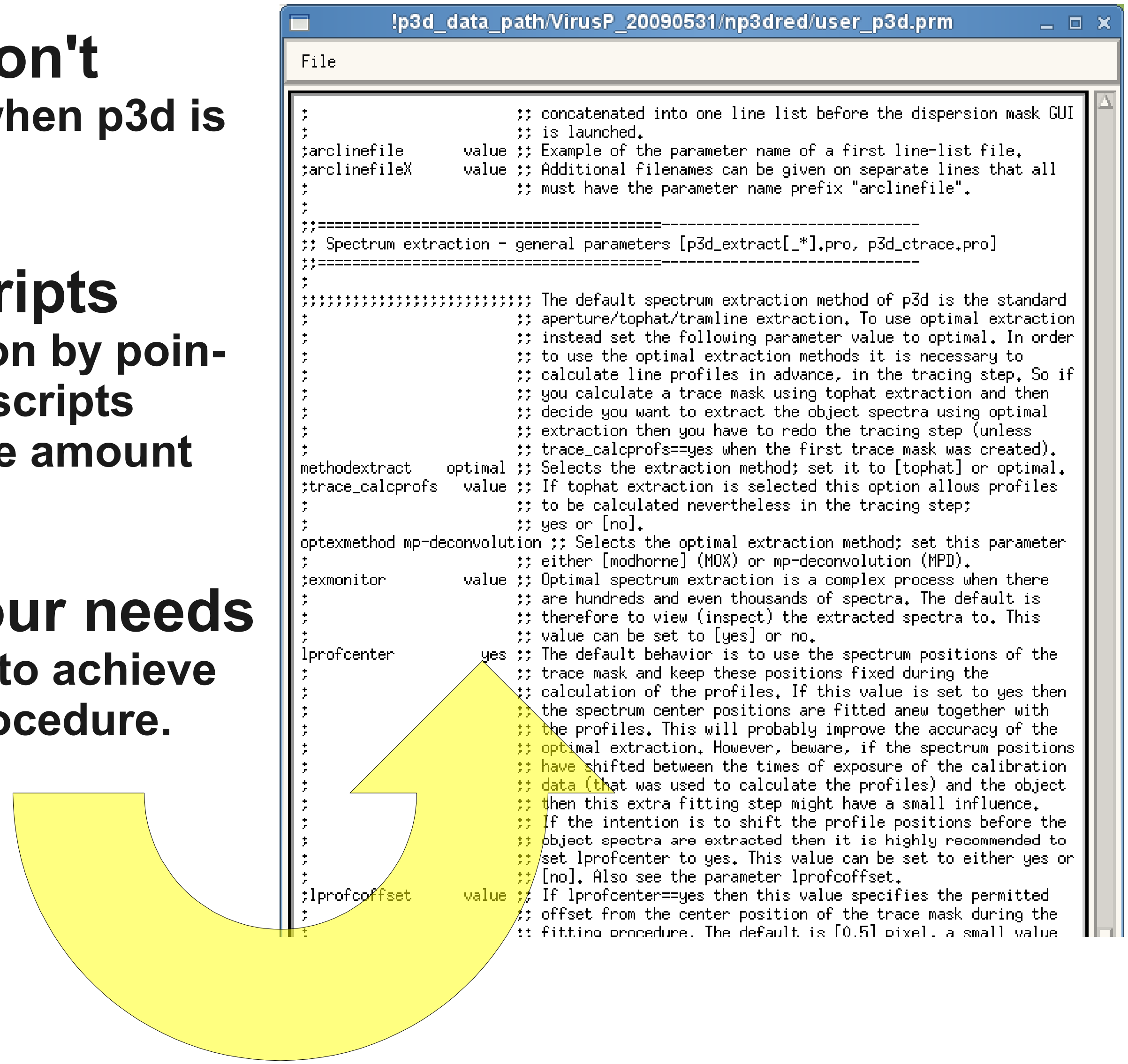
No IDL license is required when p3d is used through the IDL VM.

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.



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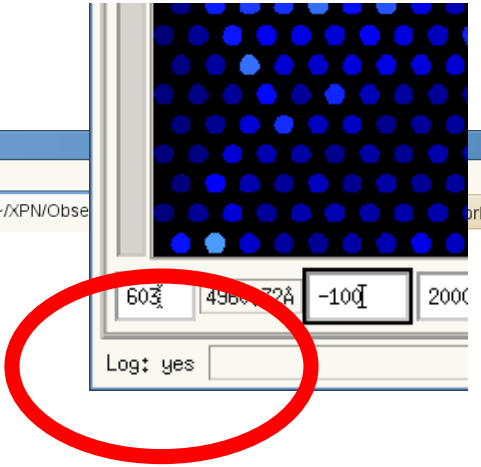
Information about all steps of the data reduction is saved to a plain text log file.




```
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 | ork1/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_imcmb_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 coefficents are stored for each spectrum in an image, λ(px) [Å].

Fiber-flat field

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

Extract object spectra

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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.

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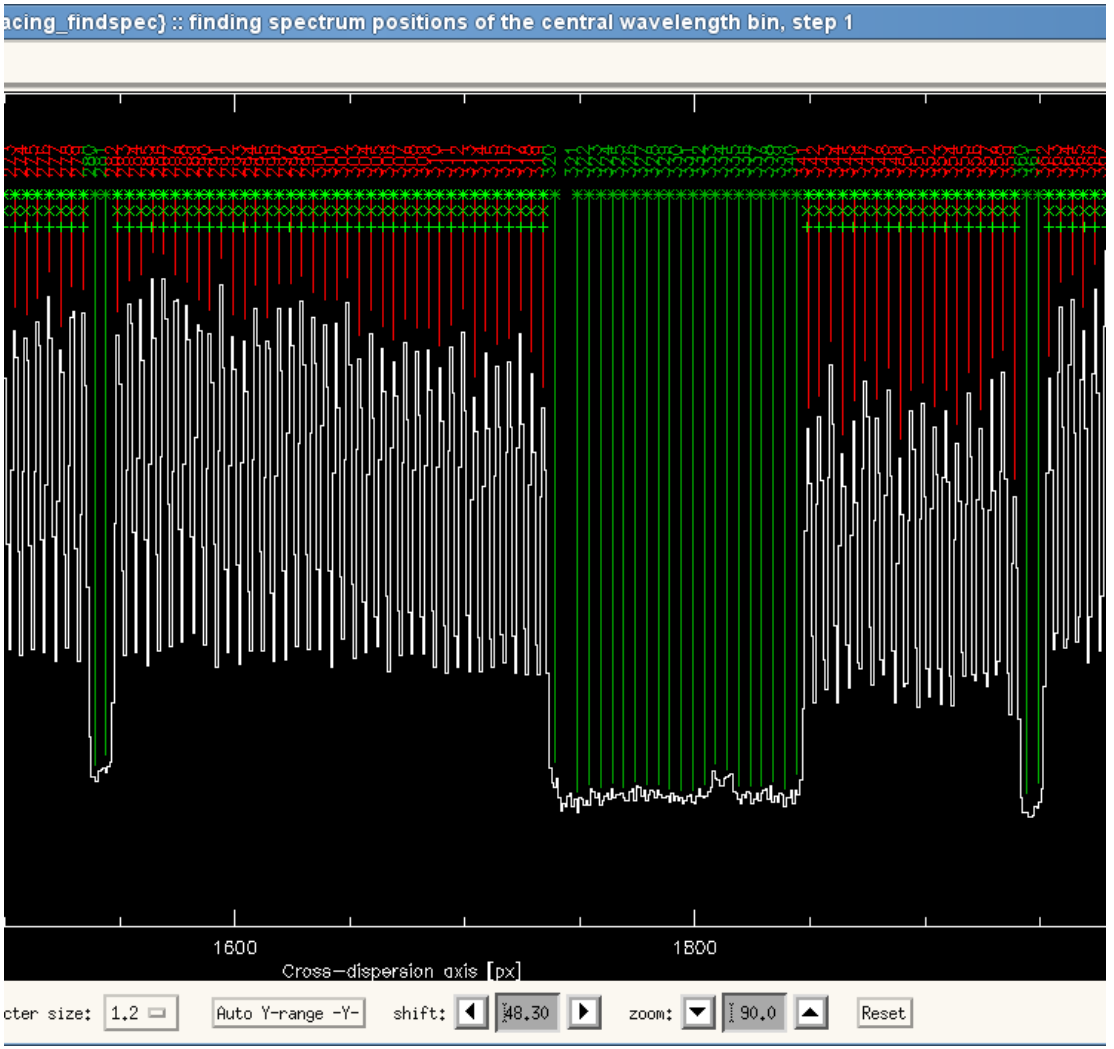
The spectrum tracing is a fully automatic procedure in p3d, the same number of spectra are always found

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.



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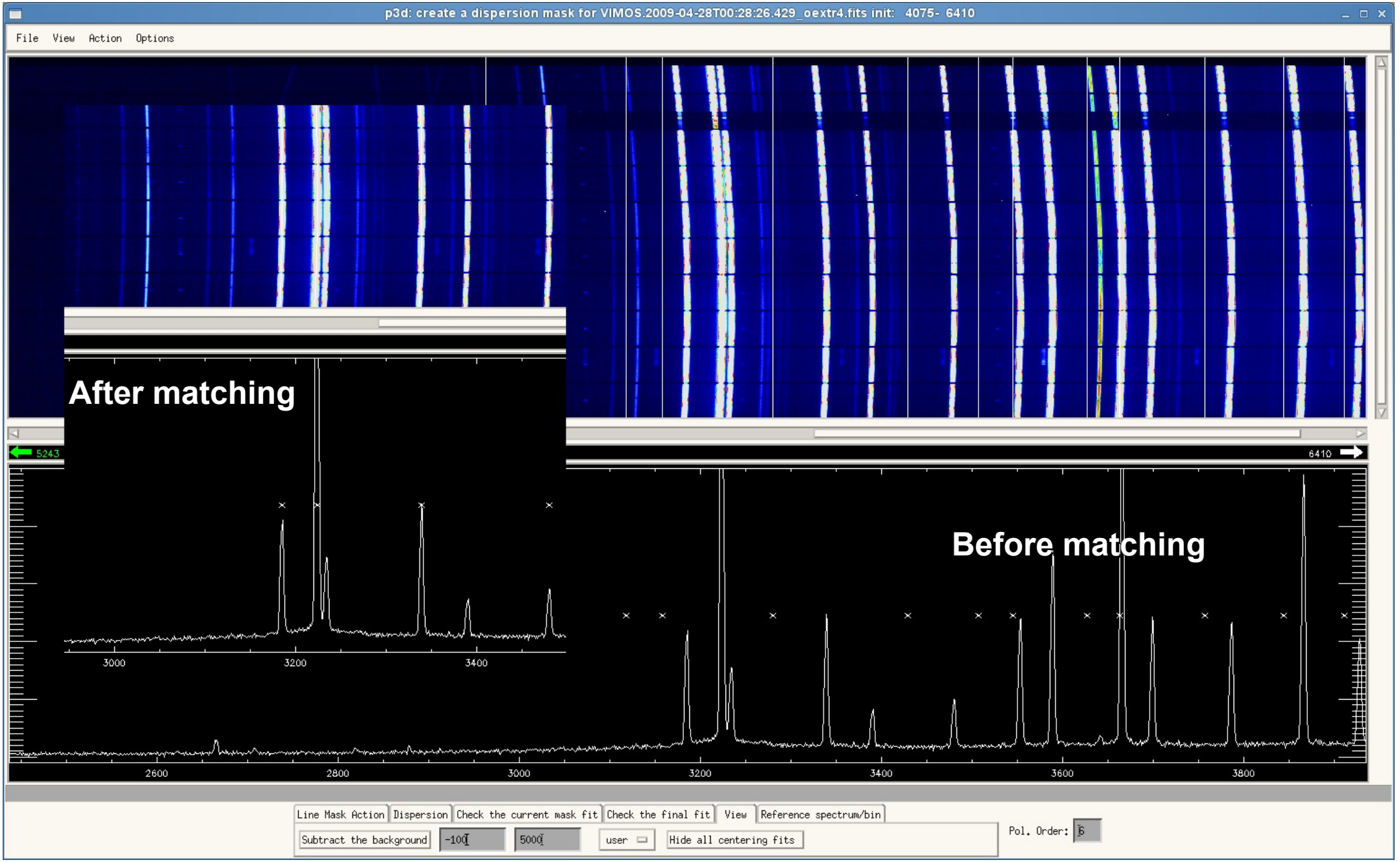
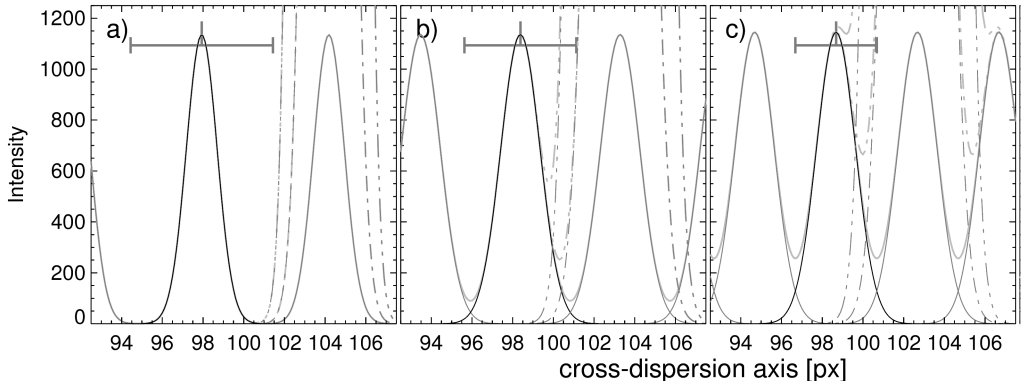
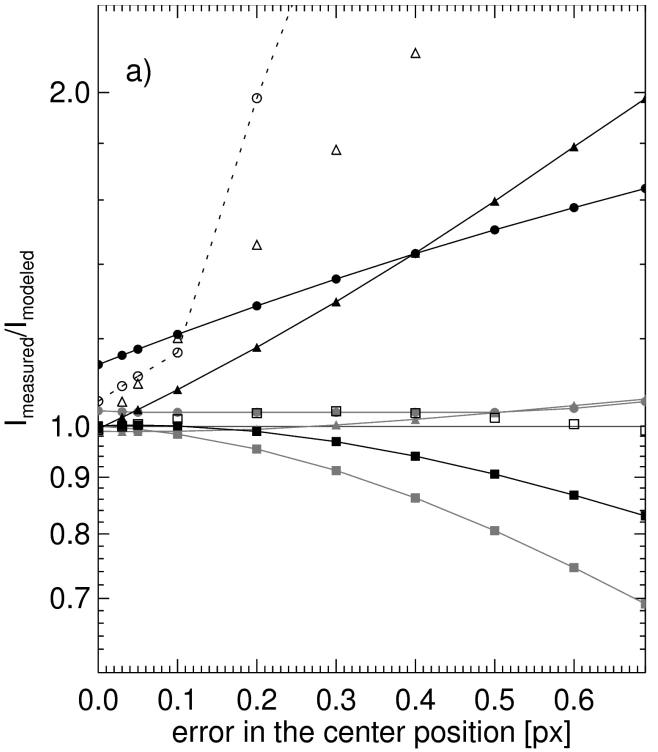
When creating a dispersion mask, entries in a line list are matched with extracted arc spectra

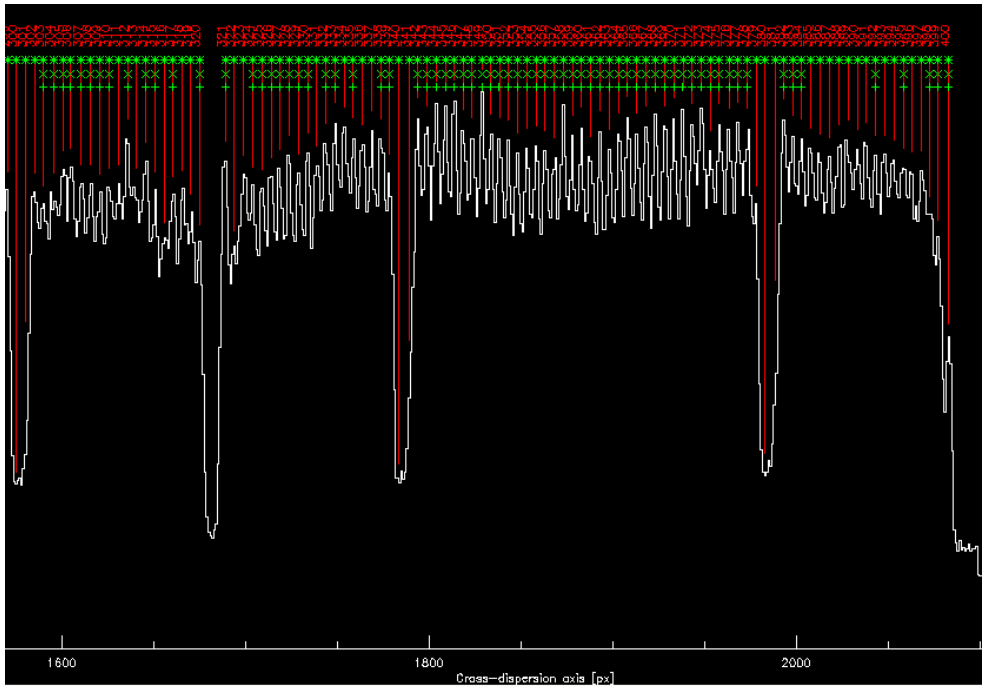


The spectrum extraction should be treated carefully – otherwise the intensity error can be very large





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!

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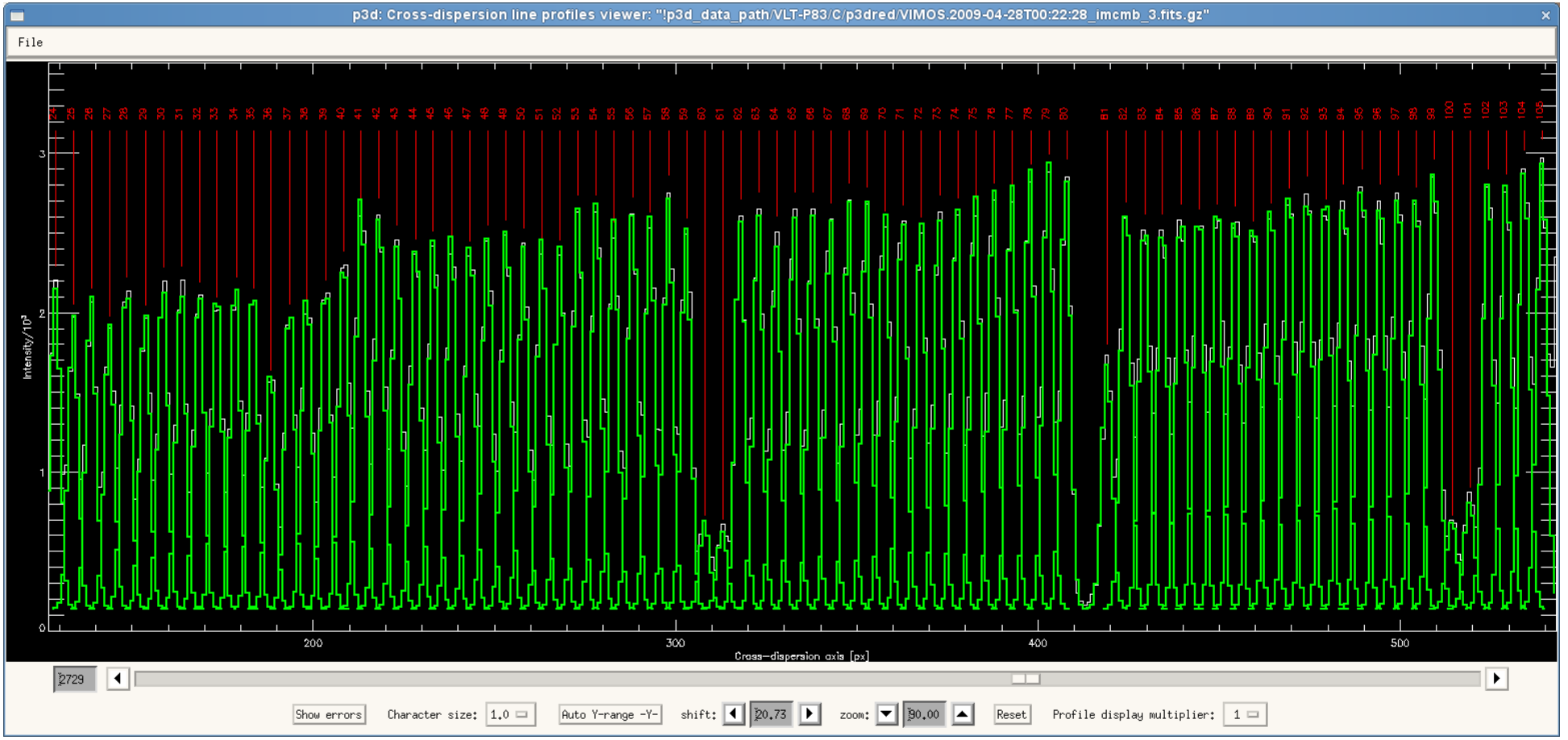

It is a good idea to check if the extraction went well

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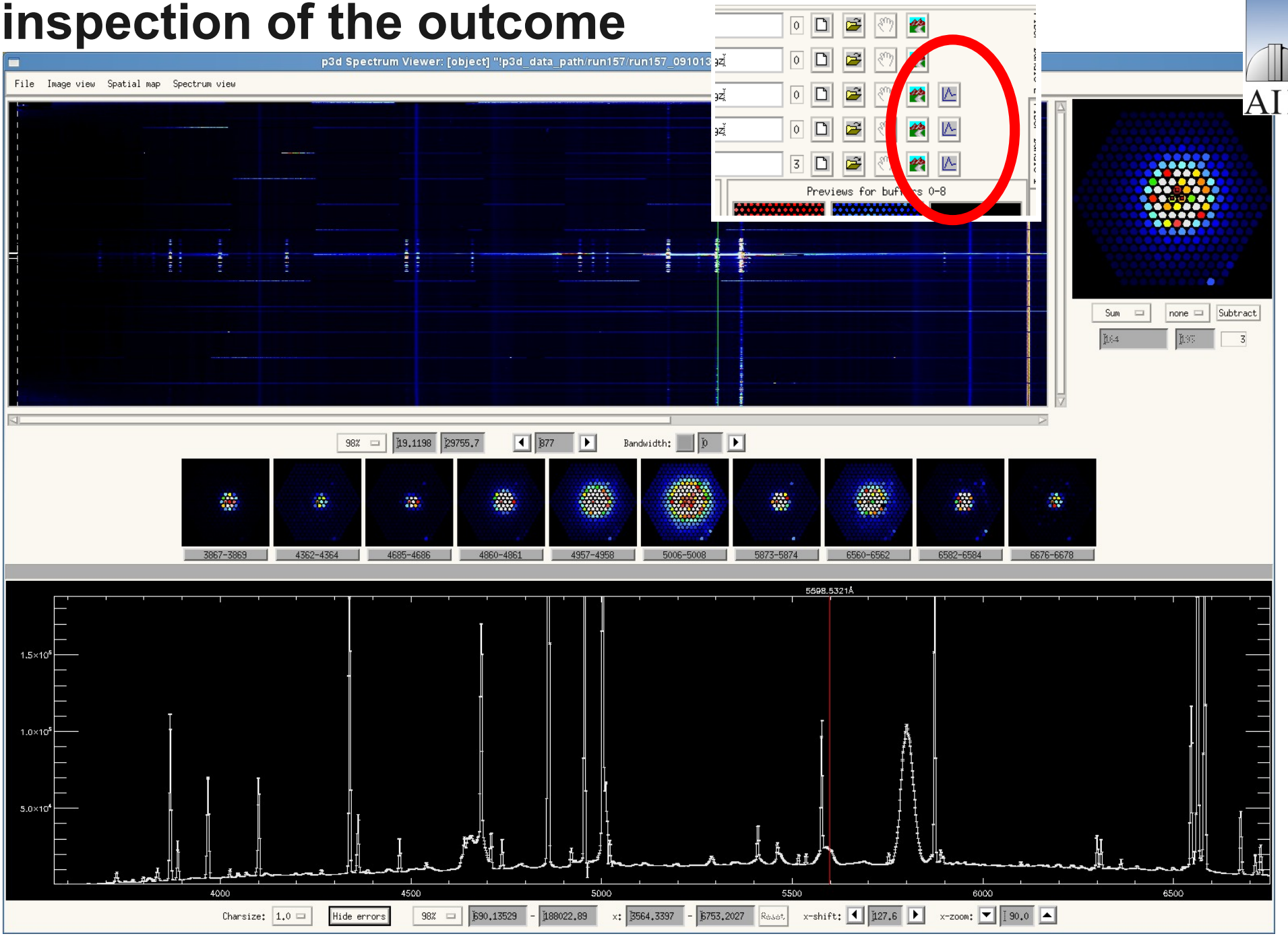
The built-in spectrum viewer of p3d allows a direct inspection of the outcome



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

Instructions

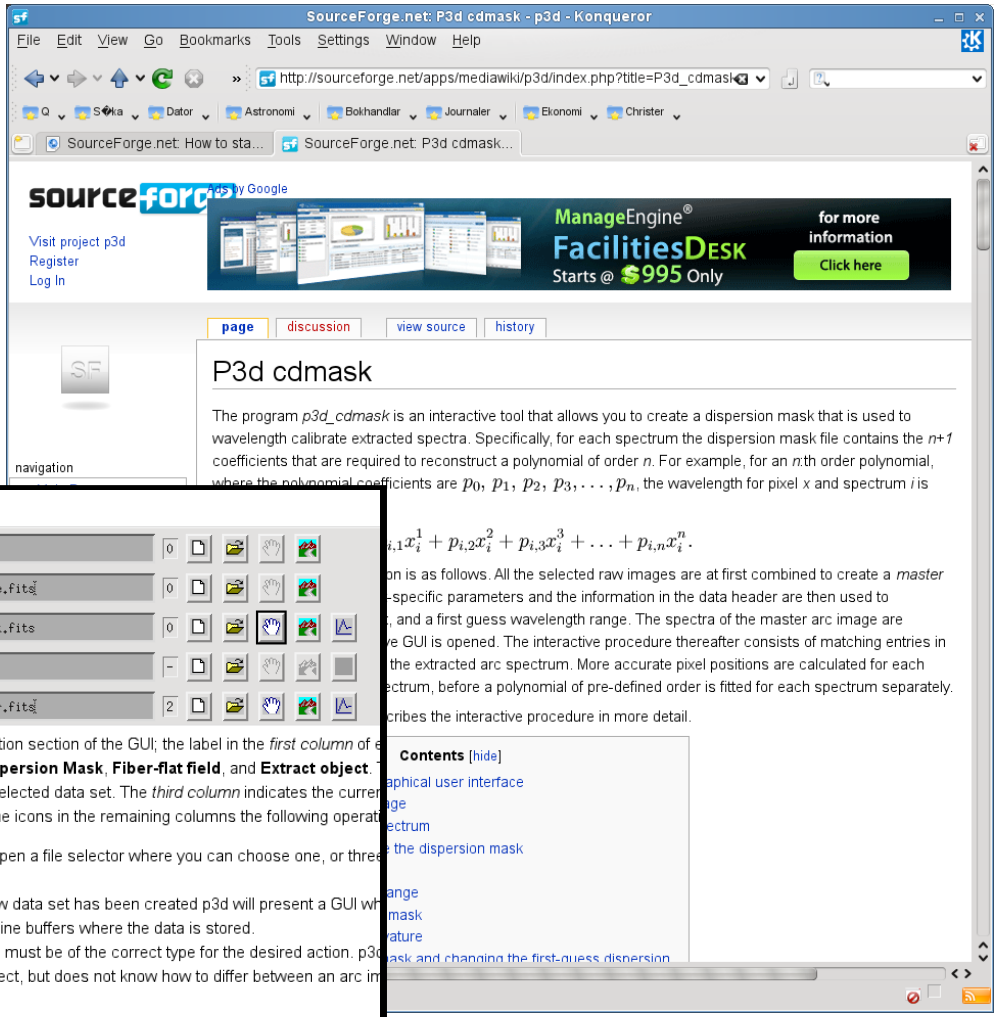
The purpose is to describe the data-reduction process for the separate steps

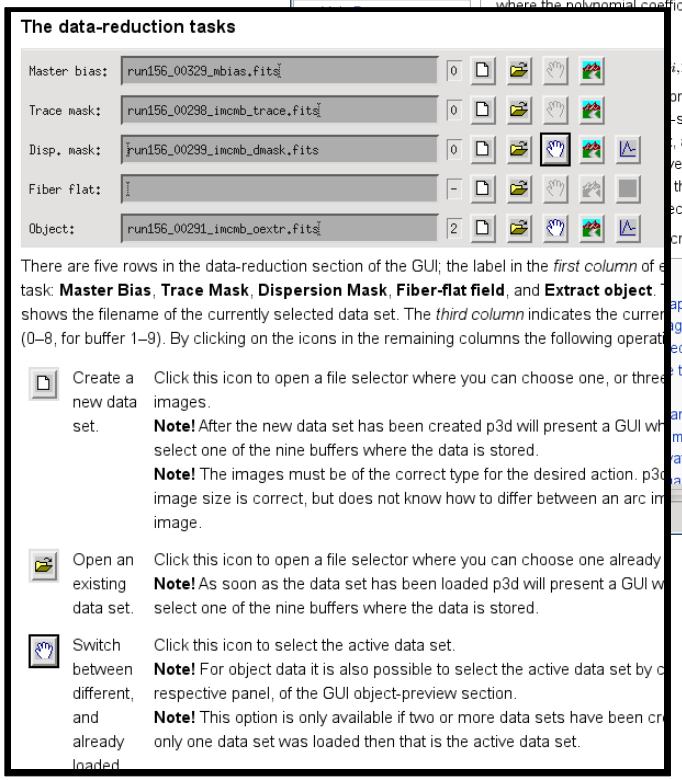
Tutorials

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





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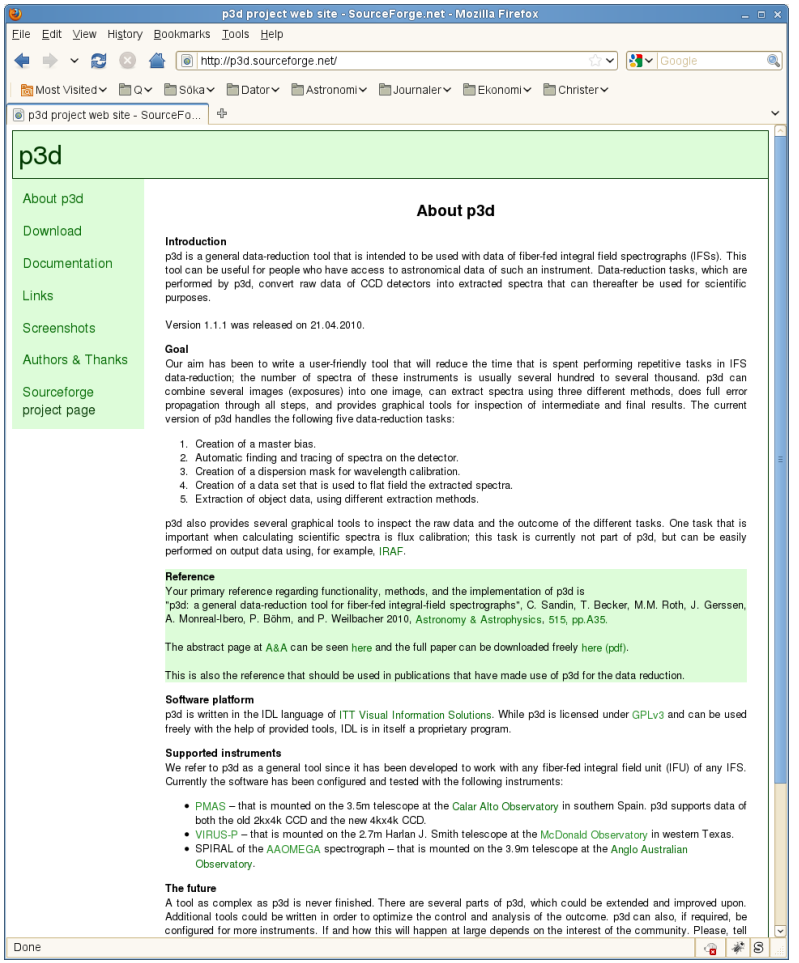
cf.: http://p3d.sourceforge.net

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

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