INTEGRAL USERS MANUAL

Version 1.1 (January 1998)

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IAC-RGO-ING

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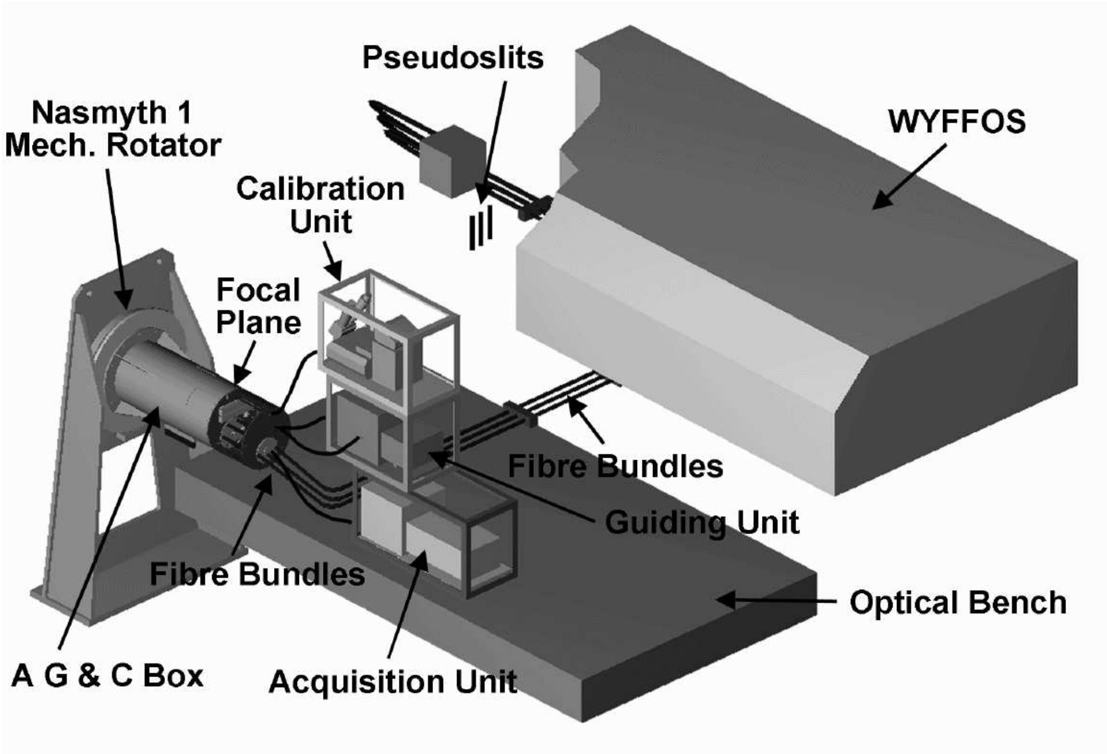


Figure 1: Outline of the INTEGRAL system

1 INTRODUCTION

The WYFFOS spectrograph was originally conceived to allow science exploitation of light carried by fibres from the AUTOFIB2 prime-focus robotic positioner. However, it quickly became apparent that other fibre fed instruments could take advantage of the spectrograph's optimized geometry. INTEGRAL extends the power of WYFFOS to an increasingly important observational technique – that of area (integral) spectroscopy of extended objects.

INTEGRAL is mounted at the GHRIL Nasmyth platform, where in addition to the fibre bundles themselves, new acquisition, guiding, and calibration units have been developed. Furthermore, new/experimental bundles can easily be installed once the focal plane and WYFFOS mechanical interfaces have been constructed. The acquisition, guiding, and calibration units of INTEGRAL can also be used with other fibre fed spectrographs (*i.e.*, IR spectrographs).

2 DESCRIPTION

2.1 General Description

INTEGRAL is mounted in the Nasmyth No. 1 platform (GHRIL) of the WHT. The general layout of the system is shown in Figure 1 and a more detailed description of the focal plane area is shown in Figure 2.

A cylindrical structure (Acquisition, Guiding, and Calibration box structure) is bolted to the Nasmyth mechanical rotator. As this structure rotates synchronously with the focal plane when the telescope tracks, the sky position angle is fixed during an observation.

The Swing Plate (SP) is located in the telescope focal plane area, and this is the connection point for the acquisition and scientific fibre bundles. By rotating the SP any installed bundle can be placed at the centre of the focal plane, while the other bundles are light blocked. Hence, only one bundle at any one time can feed the spectrograph.

For acquisition a coherent fibre bundle transmits the light from the focal plane (via the SP) to a standard TV camera.

Up to six scientific bundles can be simultaneously mounted in the SP, although in the standard configuration only three are used (called sb1, sb2, and sb3). These bundles are 5.5 m long, while their fibre core diameter (in sky units) is: 0.45 (sb1), 0.9 (sb2), and 2.7 (sb3) arcsec respectively. The bundles are simultaneously connected at the entrance (*pseudo-slit*) of the WYFFOS spectrograph. They can be interchanged very easily, with an overhead of a few seconds. Hence, depending on the prevailing seeing conditions the instrument can be easily optimized for the scientific program.

Guide stars may be acquired by moving an XY slide containing two coherent fibre bundles. This unit moves in an off-axis region and the bundles feed a TV based autoguider.

A liquid fiber is used to feed a calibration source (currently Copper-Argon, Copper-Neon, or Tungsten lamps) to the focal plane.

2.2 Acquisition System

A schematic representation of the acquisition unit is shown in Figure 3.

A coherent fibre bundle transports light from the focal plane (via the SP) to a standard

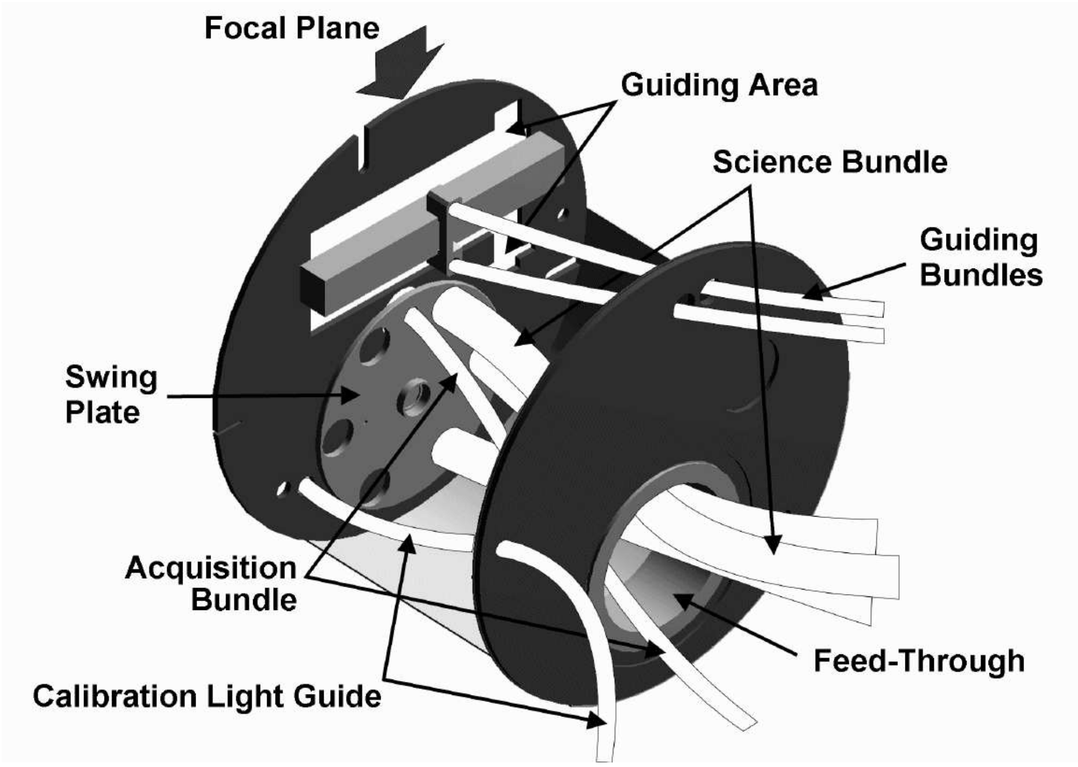


Figure 2: Focal plane area

TV camera. Figure 4 indicates where this bundle is connected into the SP. It has a field of view of 22.5×30.2 arcsec ^{2} in the telescope focal plane.

The acquisition system is equipped with a filter wheel which can accommodate up to six filters. The filters must be circular and 25 mm in diameter. In the standard configuration the following filters are provided: CLEAR, BG38, GG495, OG530, and RG630.

A lens (with magnification 1:1.5) forms the image of the bundle output over the chip of the TV camera.

The TV acquisition system consists of a Westinghouse ISEC TV camera connected to the TV camera controller, a VME camera microprocessing system, a display monitor, and the control terminal.

2.3 Guiding System

The general layout of the Guiding system is shown in Figure 5.

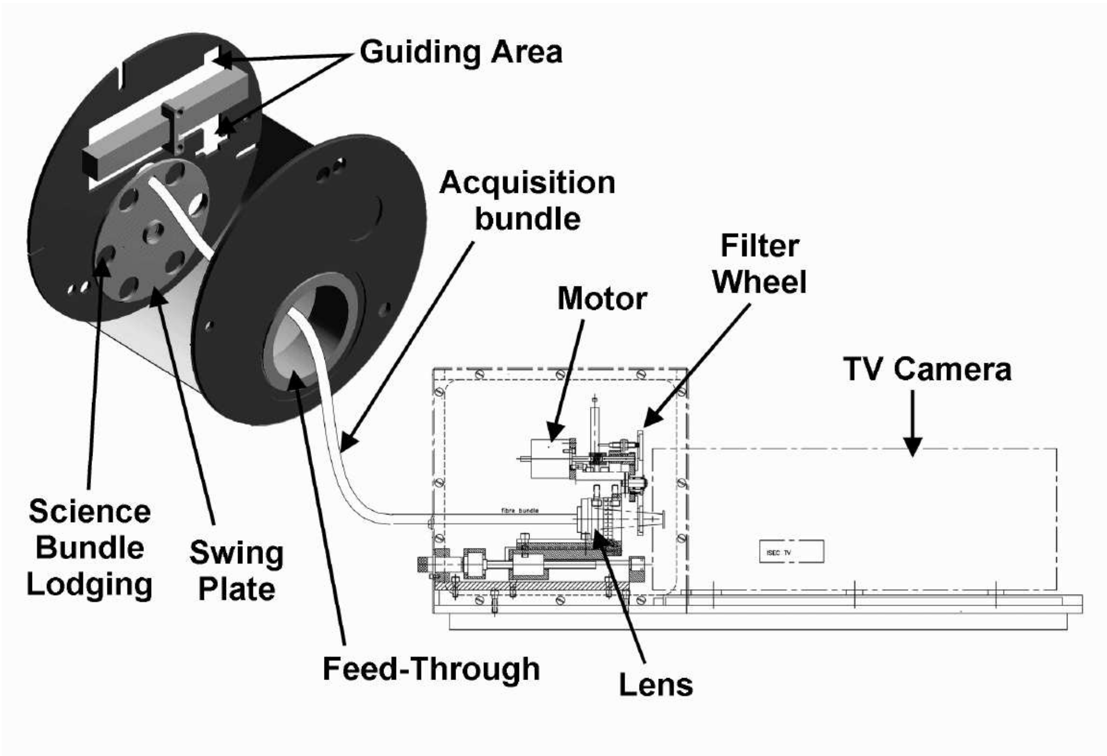
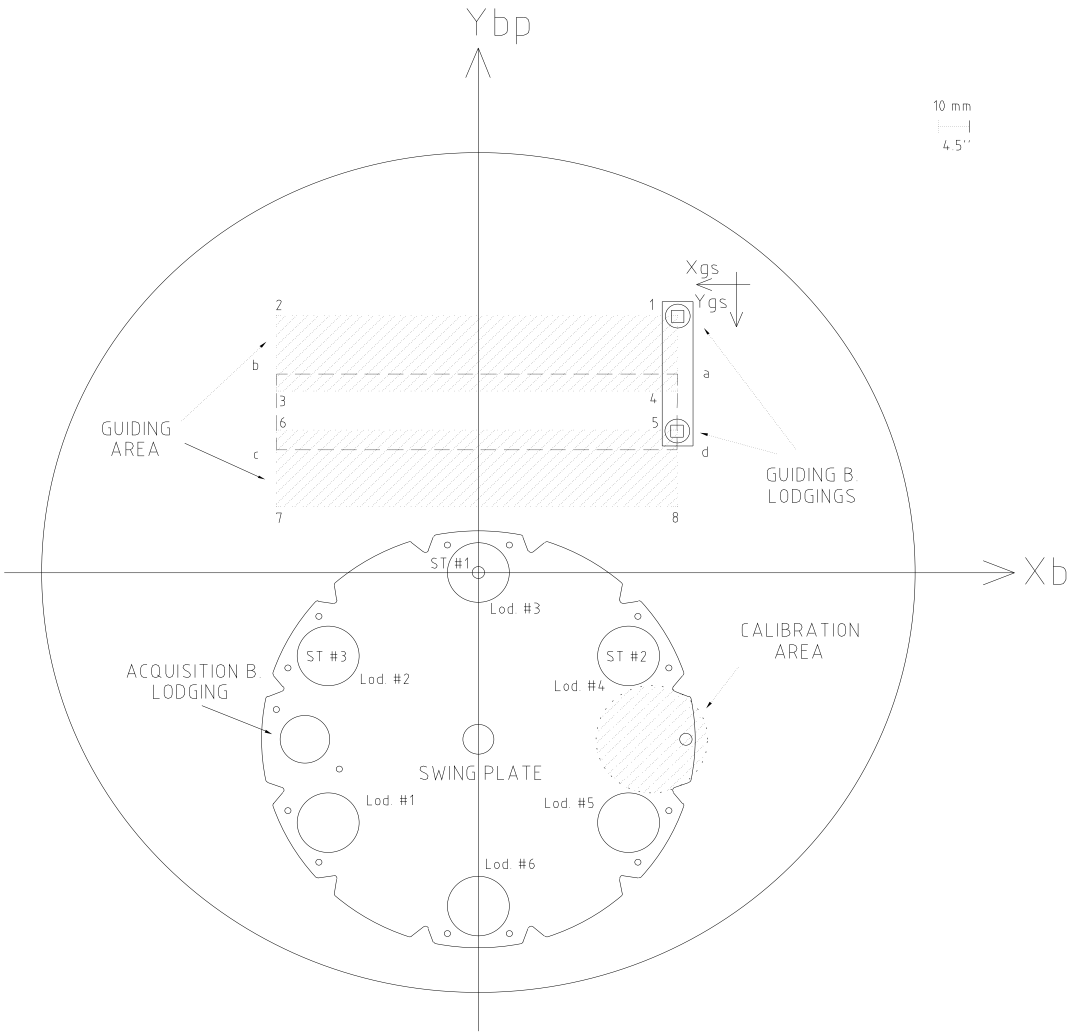


Figure 3: Acquisition system. The focussing mechanism is at bottom-left of the main unit



	X	Y	
1	63.987	85.803	Center of the Guiding Bundle #1
2	-65.436	85.220	
3	-65.450	59.867	
4	63.984	60.466	
5	64.193	47.298	Center of the Guiding Bundle #2
6	-65.230	46.714	
7	-65.237	21.363	
8	64.186	21.960	
a	64.090	66.550	Center of the support
b	-65.333	65.967	
c	-65.343	40.615	
d	64.193	47.298	

Figure 4: View of relevant regions/components at the telescope focal plane area. On the Swing Plate all possible bundle mount points are marked along with those currently used (the standard positions for bundles 1, 2, and 3 – code 3, 4, and 2 respectively). The acquisition bundle location is also shown. The rectangular shaded areas illustrate the available region for guiding, which can be scanned by the two coherent bundles. Numbers in the table indicate the coordinates of the extremes of this region. The circular shaded area represents the region which can be illuminated by the calibration lamp. This orientation corresponds to a view *from* the GHRIL table at Sky Position Angle (SPA) = 0 degrees. Therefore, North is Top.

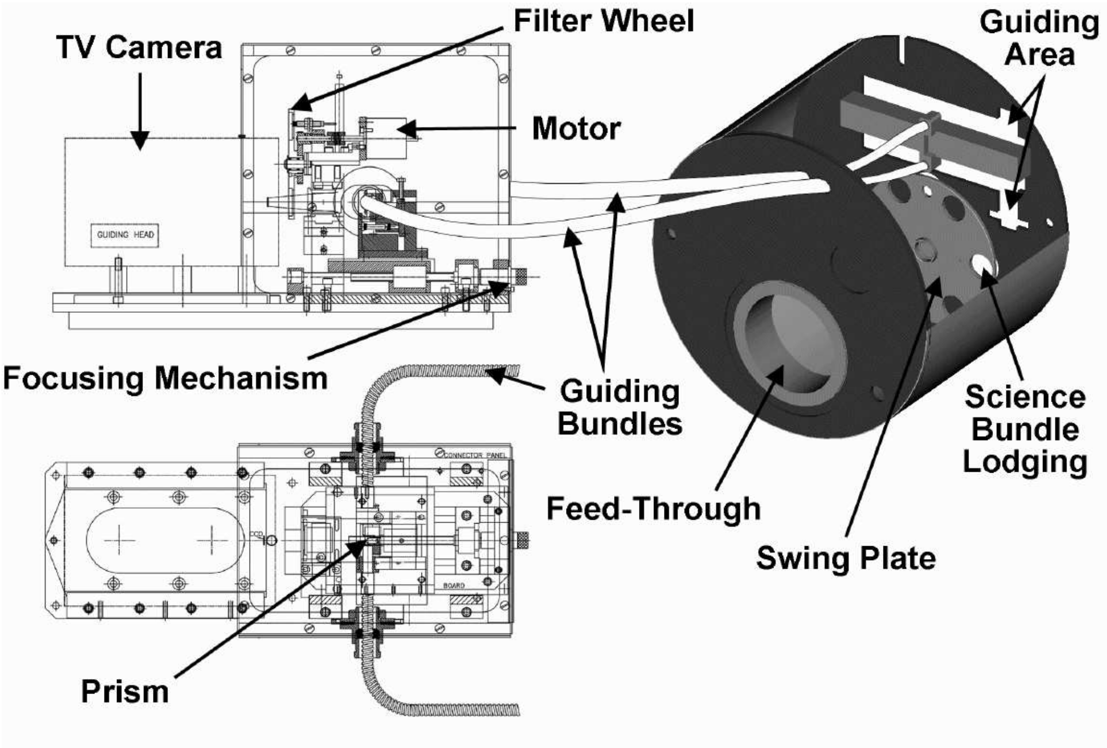


Figure 5: Guiding system

A remotely driven XY slide simultaneously moves two coherent optical fibre bundles over the focal plane (see also Figure 4). An area of $30'^2$ ($2 \times 15'^2$) is available for guiding purposes. Each bundle has a field of view of 18×18 arcsec ^{2} on the focal plane.

The Guiding unit is equipped with a filter wheel housing up to six filters. The filters must be circular and 25 mm in diameter. In the standard configuration the following filters are installed: CLEAR, BG38, GG495, OG530, and RG630.

The two guiding bundles are focussed onto a standard CCD autoguider head with thermoelectric cooler, through a prism and a lens (magnification 1:1).

2.4 Calibration Unit

Figure 6 shows the general layout of the Calibration system.

The unit is equipped with a white and two arc lamps. The standard arc lamps are CuAr and CuNe and manufactured by S.& J. Juniper, with references 4114QA and 4114QN, respectively. They can be switch on simultaneously. The white lamp is a quartz-halogen

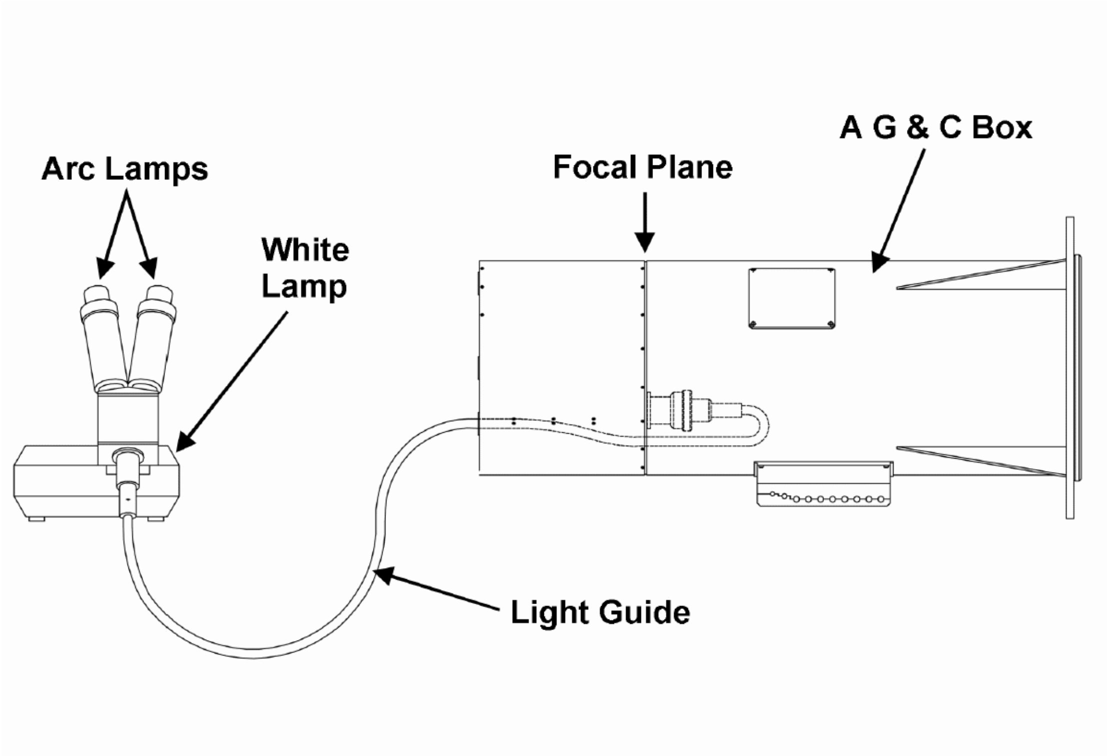


Figure 6: The Calibration system

tungsten lamp supplied by Dolan-Jenner of the type DDL.

A liquid lightguide is used to illuminate a region of the focal plane, accessible to the scientific bundles by rotating the SP (see also Figure 4).

A set of coloured filters are available within WYFFOS to suppress strong arc lines.

A more detailed description may be found in INT-IAC-DDD-004.

2.5 Observing Bundles

The SP has six focal stations for science bundles (see Figure 4). However, only three bundles are mounted in the standard configuration. The different SP positions are described in Table 1.

These bundles were manufactured by the IAC, using Ceramoptec fibres. The bundles sb1 and sb2 use 'ultradry special' hydrogen treated fibres. Bundle sb3 uses Optram 'UV' fibres. Each is 5.5 m long. Their spectral response can be found in figures 7 and 8.

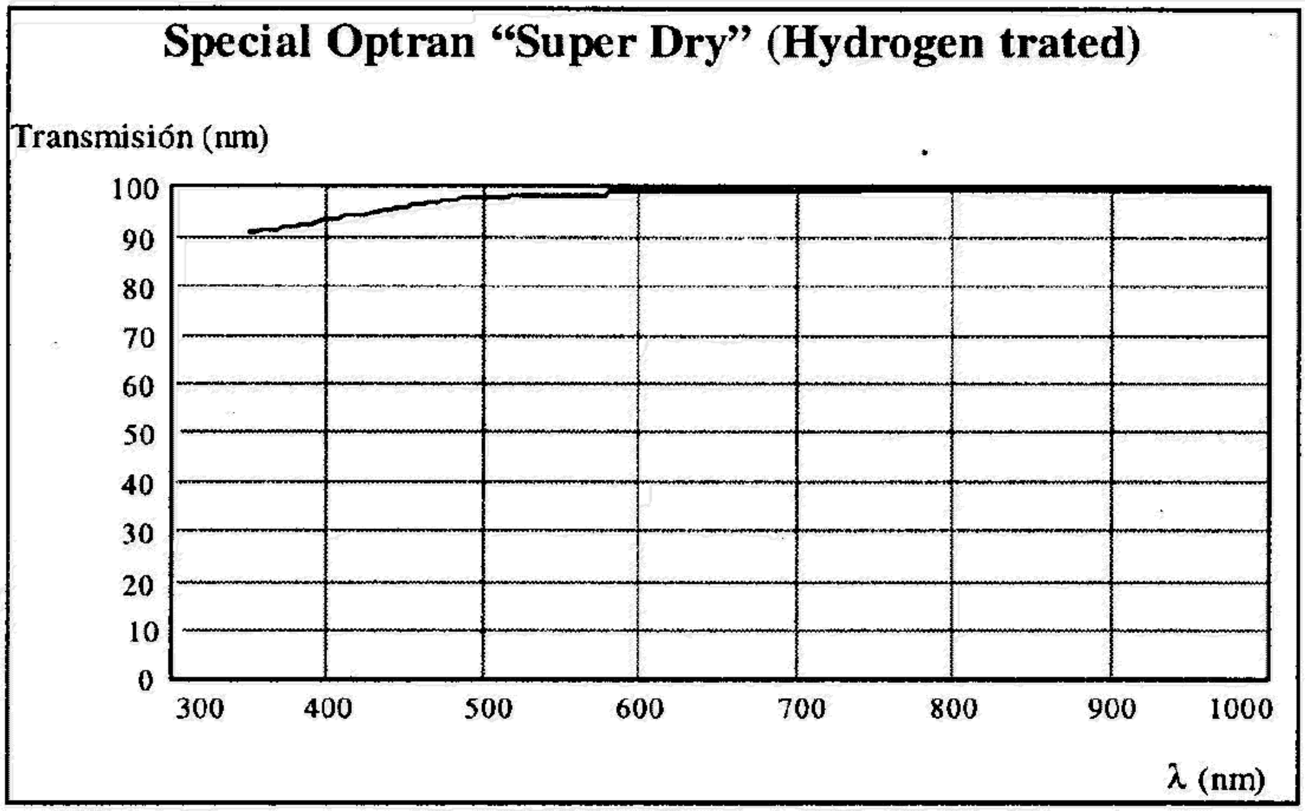


Figure 7: Transmission of the fibers (5.5m) used for sb1 and sb2, according to the fiber manufacturer

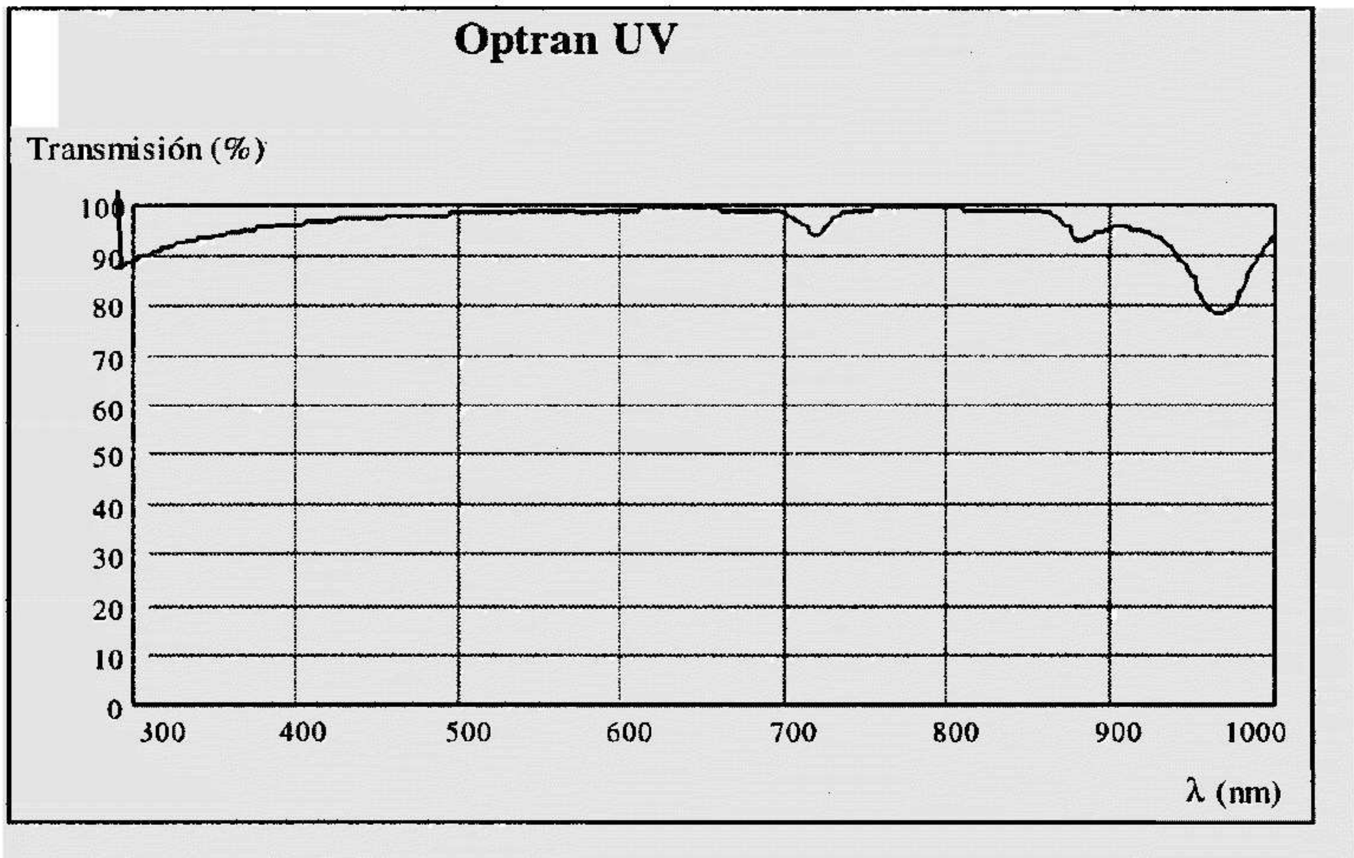


Figure 8: Transmission of the fibers (5.5m) used for sb3, according to the fiber manufacturer

Table 1: Swing Plate/Bundles Codes

code	bundle	Calibration/Observation	SP position
01	void	OBS	5
02	void	CAL	6
03	sb2	OBS	4
04	void	CAL	5
05	sb1	OBS	3
06	sb2	CAL	4
07	sb3	OBS	2
08	sb1	CAL	3
09	void	OBS	1
10	sb3	CAL	2
11	void	OBS	6
12	void	CAL	1
13	ACQ	OBS	

At the focal plane the fibres are arranged in two groups, one forming a rectangle, and the other a ring which is intended for collecting background light (for small-sized objects). Table 2 and Figure 9 show the main characteristics of each bundle.

For each bundle the fibre correspondence between the focal plane and slit position is given in Appendix 1.

3 PERFORMANCE

3.1 Throughput

Figure 10 gives a first estimation of the performance of the whole system (atmosphere + telescope + INTEGRAL + WYFFOS). This is based on data taken for the flux calibrator PG1708+602 (Massey et al., ApJ, 328, 315) under average observing conditions. These results were derived using the R1200B grating in ~1.5 arcsec seeing. Repeated observations lead to a realistic uncertainty of about ±0.5 mag. The background was removed by subtracting a sky exposure of equal observing time. No significant differences were found between the different bundles.

Table 2: Characteristics of INTEGRAL fibre bundles

Bundle	1	2	3	4	5	6
sb1	0.45	0.7	205 (175+30)	7.80×6.40	variable	90
sb2	0.90	1.4	219 (189+30)	16.0×12.3	4.6	90
sb3	2.70	4.0	135 (115+20)	33.6×29.4	7.4	90

1 – fibre core diameter (arcsec)
2 – fibre image size on the detector (to be convolved with a 1.4-2.6 pixel PSF)
3 – total number of fibres (rectangle + ring)
4 – spatial coverage of the central rectangle (arcsec × arcsec)
5 – distance between adjacent fibre/spectra at the CCD (in pixels)
6 – diameter of the outer ring (arcsec)

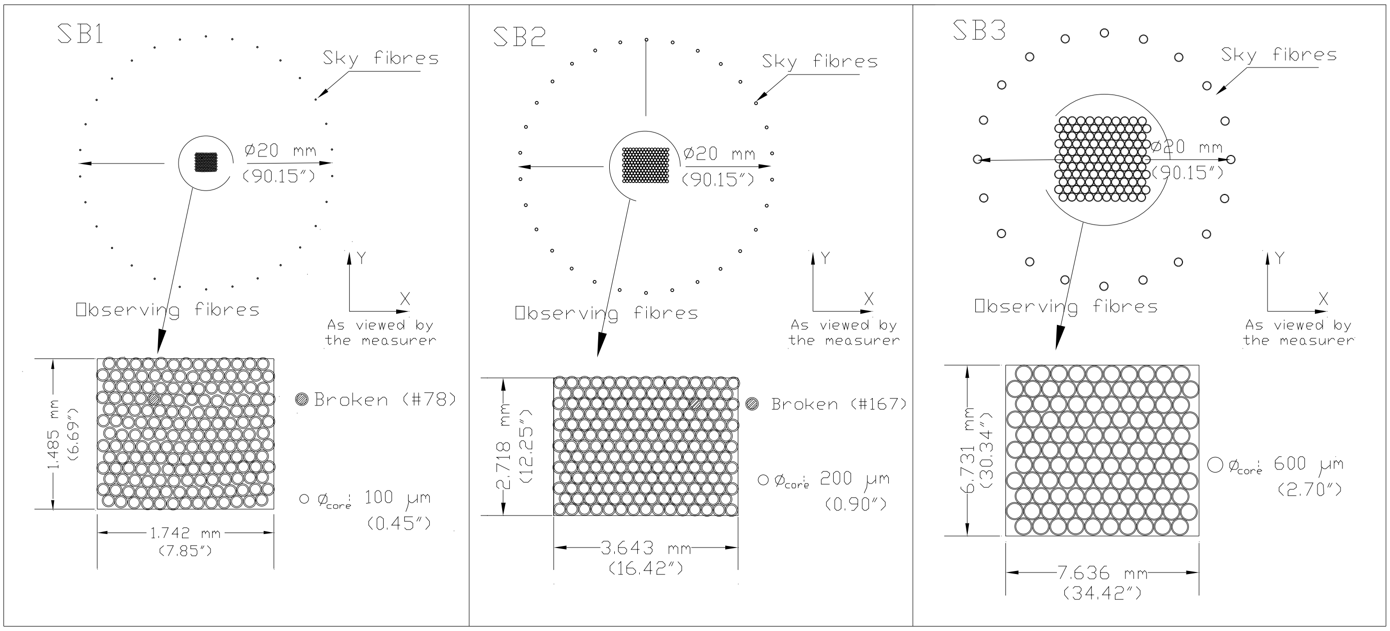


Figure 9: Configuration of the fibres of the standard bundles, at the focal plane end.

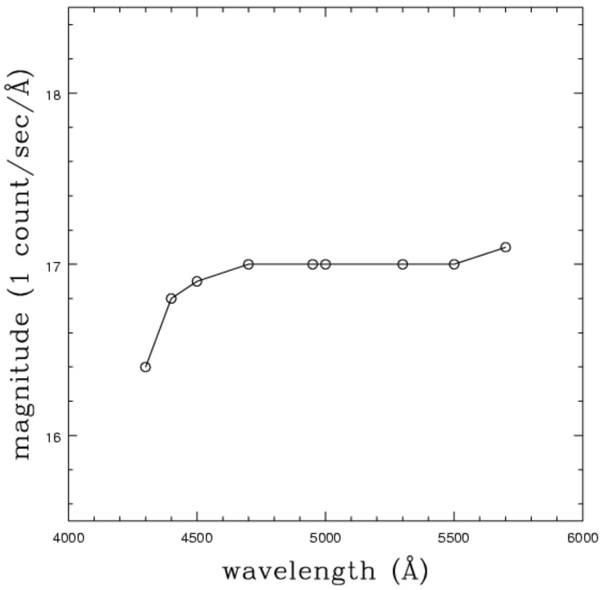


Figure 10: AB magnitude for obtaining 1 count/sec/Å, with INTEGRAL

3.2 Spectral Resolutions

For any particular grating the spectral resolution depends on the fibre bundle as a consequence of the different fibre sizes. Table 3 lists the mean spectral resolution and linear dispersions for different gratings and bundle (reflexion mode). Note that due to the variation of the WYFFOS focus over the CCD (which affects the FWHM) the spectral resolution *also* changes over the CCD.

Table 3: Spectral Characteristics*

	2400 g/mm	1200 g/mm	600 g/mm	316	300
Resolution (sb1) (Å)		2.7	5.8	10.8	11.
Resolution (sb2) (Å)		3.1	6.7	12.5	13.2
Resolution (sb3) (Å)		6.2	13.5	25.	26.5
Linear dispersion (Å/px)		1.4	3.07	5.7	6.
Spectral Coverage (Å)		1445	3140	5837	6144

*Derived from calibration data with a mean PSF of 1.8 pixels, and λ_c=6000Å

3.3 Stability

i) Arc and Flat-Field Calibrations
In principle we expect the system to be stable over sustained periods, and indeed test data obtained during the commissioning runs show this to be *generally* the case. However, very occasionally relatively large variations have been seen that defies explanation. While this problem remains under-investigation, 'over-calibration' would seem a wise procedure to adhere to (especially as the overheads in obtaining calibration data are small).

ii) Swing Plate Mechanism
The SP mechanism is stable at the level of our uncertainties when determining centroids (*i.e.*, less than 0.2 arcsec / 40 microns).

4 SET UP PROCEDURES

4.1 Mechanical Installation

Details on the mechanical installation of INTEGRAL can be found in the document INT-IAC-PRC-003.

4.2 Electronic Installation

Details on the electronic installation of INTEGRAL can be found in the document INT-IAC-DDD-009.

4.3 Software Installation

Details on the software installation of INTEGRAL can be found in the document INT-IAC-STD-001.

4.4 Focusing the Slit Assembly

A detailed procedure for aligning the slit unit can be found in document INT-IAC-PRC004. As the INTEGRAL slit unit is similar to that of AUTOFIB2, the slit focus procedure is identical for both instruments.

Note, the WYFFOS optical design results in some field curvature. Hence it is not possible to obtain a similar focus for all parts of the chip, therefore a compromise value for the focus must be reached. Figure 11 shows an example of the de-focusing on the CCD and its effect on the measured FWHM.

When the INTEGRAL slit assembly is in proper alignment within WYFFOS all science bundles have the same focus. Further details may be found in INT-IAC-TRP-009.

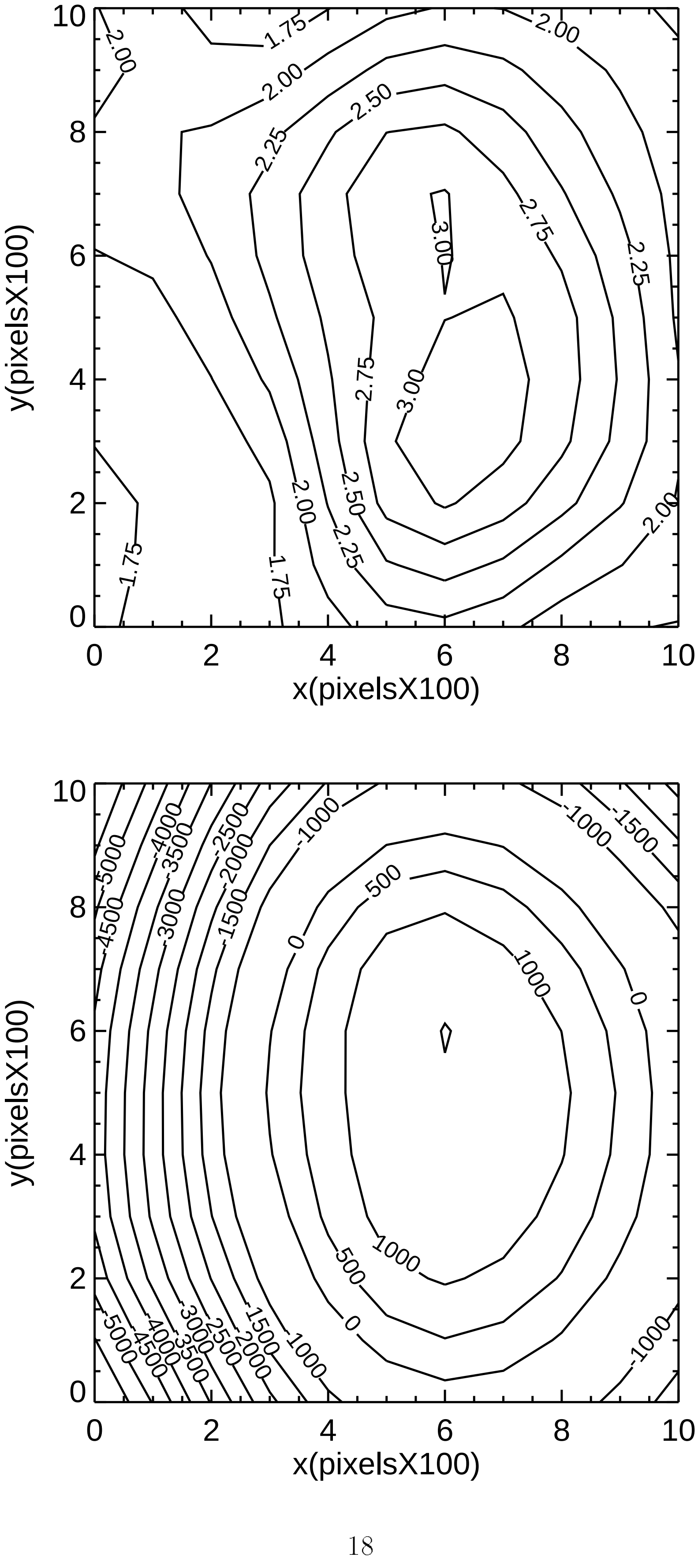


Figure 11: Top: FWHM (in pixels) of arc lines over the CCD at the best focus position. Bottom: Best focus value (encoder units) over the CCD. These were obtained with the bundle sb2 (200 micron fibres) and the R1200B grating.

4.5 Focusing and Orientation of the Acquisition Bundle

The end of the acquisition bundle in front of the TV camera should be focussed, using the manual mechanism (see Figure 3). In principle there are two procedures, both requiring the interaction of two people: one at the GHRIL (moving the focus mechanism), and the other in the control room watching the TV screen.

i) With the bundle connected to the to the SP, the inside of AG&C box is illuminated (*e.g.*, with a torch, a faint dome light, etc). By inspecting the edges of the image bundle on the TV screen, the best focus can be determined. If the focus remains unsatisfactory the following procedure must be used (as a last resort).

ii) The bundle is dismounted from the SP (see INT-IAC-PRC001), and connected to a dedicated focusing system. This system allows a test image (*e.g.*, a number) to be seen through the bundle.

Currently, a painted mark is used to fix the bundle orientation. However, we anticipate that before the instrument reaches common user status the bundles will be doweled in the correct positions.

In order to aid night-time acquisition the outline of the bundle should be marked on the TV screen.

4.6 Focusing and Orientation of the Guiding Bundle

The end of the guiding bundle in front of the TV camera can be focussed using the manual mechanism (see Figure 5). The same procedures as those described for focusing the acquisition bundle should be adhered to here. If procedure i) is used, the sharpest image of the space between the two bundles indicates the best focus position.

As is the case with the acquisition bundle the correct orientation is currently indicated by a painted mark, but again, we anticipate that the bundle will be shortly doweled into position.

In the standard configuration the inner (outer) field is to the right (left) of the TV screen.

4.7 Observing System

Log out of lpss3 and lpvs1. Log-on to the main system terminal lpvs1 as observer.

We will see a banner asking which system computer to use- type LPVF at the command prompt.

Log-in to LPVF as observer.

When asked if you want to start the observing system reply NO.

At the VMS command prompt type-

@v9-0b1_system

This sets the default observing system to V9-OB1_system.com and starts it up.

When asked if you want to start the observing system reply YES.

At the VMS command prompt, type-

ICL

Answer the observer name and the PATT reference questions. Then when asked if you want to use the current setup respond NO, then select option 11 (WYFFOS using INTEGRAL).

Answer YES to the question about loading the system.

Then at the ICL prompt (hh:mm:ss>) type-

load fixfits
fixfits

Then go to the Sparc Real time Display (lpss3) and login as observer. Everything starts up automatically.

As this instrument reaches common user status we anticipate that it will be fully brought into the normal start up procedures common to all WHT instrumentation. Hence, the above startup procedure will reduce to logging onto the system computer (lpvf/g) under username 'observer', starting ICL, and then selecting the instrument combination required for that nights observing.

4.8 Autoguider

The INTEGRAL autoguider application must be run from the software version 4.5 DEV9. Currently this is loaded from a floptical disk. To configure the autoguider for INTEGRAL, do the following:

1) ensure that the floptical disk marked V4.5 DEV9 is in the insite drive in the autoguider VME cabinet (if not, it should be in the green ring-binder which resides in the same cabinet).

2) power-cycle the autoguider VME and interrupt the startup after several seconds by entering CTRL_C at the autoguider terminal.

3) enter the following commands at the autoguider terminal
EMPTY
INSITE
RELOAD

4) wait for the system to load from the floptical disk, and select INTEGRAL when prompted during the startup.

In order to configure the autoguider for other focal stations (CASS or UES), which use the default software on hard disk, power-cycle the autoguider VME and select the appropriate focal station when prompted during startup.

Note that the INTEGRAL autoguider application uses the PRIME serial port. CASS and UES use their normal allocated ports.

4.9 TCS

Before observing with INTEGRAL, be sure to issue the following commands (along with the usual ZEROSET's, CAL LAST's and so on) when setting up the TCS:

USER> GHRIL ROT
USER> INSTRUMENT OWN
USER> AGSELECT GHRIL

Note that having done a calibrate on the rotator centre, a nominal aperture (aperture zero) can be defined in order to place the telescope reference position at the center of the acquisition field. GSS will take account of such an aperture if you enter APERTURE <x> <y> at the GSS prompt before searching for guide stars.

4.10 Rotator Limits

The GHRIL rotator has hardware switches limiting its motion to slightly less than one revolution. The TCS software limits are set about 1 degree inside the hardware limits, constraining the rotator mount position angle to a range of 3 to 358 degrees. The safety of INTEGRAL should not be entrusted to these mechanisms – the rotation of the instrument should be checked visually several times during each night, after which an assessments of the reliability of the limits can be made.

4.11 Rotator Zero Set

Owing to the fact that the absolute encoder 'wraps' at a certain point, it is very important to zeroset the incremental encoder against the absolute at a known physical position. That position is mount PA 180, and it is the 'park' position for INTEGRAL. When the rotator is at this position the '180' label marked on the rotator in indelible ink is at the 12 'O' Clock position when viewed from the GHRIL bench. Before observing with INTEGRAL it is important to ensure that the rotator is in this position (to within twenty degrees or so is adequate). The local controls can be used to move it if necessary. The incremental encoder can then be zeroset against the absolute in the usual way. It must not be zeroset without a visual check that the rotator is in the required position.

4.12 The Guide Star Server – GSS

The GSS with configurations for WHT INTEGRALINNER and WHT INTEGRALOUTER is selected when you log on to the GSS account and select WHT.

4.13 Control in Engineering Mode

To start the WYFFOS mimic, log in to lpss3 (from a xterm), as user WYFFOS (username: wyffos; password: wht_wyffos) and type start_eng

To start the INTEGRAL mimic log in to orion.roque (from a xterm) as user integral (username: integral; password: wht_integral) and type

start_eng

The low level *Software Users Manual* has the reference INT-IAC-MNL-001

4.14 Data Analysis Software Installation

For the installation of the different scientific software tasks and source programs see *http://www.iac.es/project/integral/index.html*.

5 OBSERVING PROCEDURES

5.1 Acquisition and Telescope Focusing

Locate the acquisition bundle at the center of the field using the SP mechanism (ISPFC ACQ OBS). The field of view of this bundle is 22.5×30.2 arcsec ^{2}.

At SPA=0 degrees, the orientation on the TV screen is such that North is up and East is left (when H down, and V up on the TV switches at the control room).

By moving the rotator, the acquisition (and observing) bundle can be aligned at the desired angle.

Limiting magnitude of the acquisition TV without integration is V$\sim$15.

The following filters are currently installed in the acquisition system: CLEAR, BG38, GG495, OG530, and RG630.

5.2 Focusing the Telescope

INTEGRAL is focused by visually inspecting the image of a faint star on the acquisition TV system. A typical telescope focus encoder value is 97.7.

5.3 Adjustment of the Rotator Axis and Orientation

Determine the X and Y coordinates of a star on the TV acquisition screen. Change the Sky Position Angle (SPA) by 180 degrees. The star describes a semi-circle reaching a final location on the TV (*i.e.*, [Xf,Yf]). The center of this circle [(X+Xf)/2,(Y+Yf)/2] should be the rotator center. Repeating this process will lead to a more accurate determination of the rotator centre.

To minimize tracking uncertainties, select a star near the pole.

After the rotator centre has been determined a CALIBRATE should be done at this point.

5.4 Guiding

In order to check that the guiding bundles are properly mounted the following check can be done:

i) Locate the slide unit at (65237, 0.). For that use the commands IXS and IYS.
ii) Align a star at the rotator centre
iii) Applying an off-set of 212 (386) arcsec (Telescope to the South) the star should appears at the centre of inner (outer) guiding bundle.

With the handset in the XY mode, at SPA=0 degrees, the up button will cause an object to move down the TV screen while the handset left button will cause an object to move left on the TV screen.

Use the WHT INTEGRALINNER and WHT INTEGRALOUTER configurations of the GSS for finding guide stars within the inner and outer fields (see Figure 3).

The ICL commands IXSlideAbs and IYSlideAbs are used to moved the XY slide to the GSS indicated position .

5.5 Feeding the Science Bundles

To locate the scientific bundles at the center field, move the SP using (ISPFC [sb1,sb2,sb3] [obs]).

There are small off-sets between the rotator center and the positions of the central fibres.

If high spatial consistency is required individual apertures can be defined for each bundle. If it proves necessary to re-determine the offsets for any particular bundle(s) software is available for quick image reconstruction (see Section 5.8). In this case, to save time, make sure the autoguider is setup and the chip readout speed is set to turbo.

5.6 Calibrating

The bundles are located at the calibration position using the SP mechanism (ISPFC [sb1,sb2,sb3] [cal] [1,2,white]).

CuAr, CuNe and a tungsten lamps are housed in the calibration unit. The two arc lamps can be switched on simultaneously. Typical exposure times with the R1200B/R gratings are a few seconds.

Arc maps obtained with INTEGRAL are shown in INT-IAC-TRP011.

5.7 Controlling INTEGRAL: A Glossary of Commands

Details of the commands available from ICL are given below, Commands may be issued in any mixture of upper and lower case. Most commands offer help and prompt if no parameters are specified.

IAF Move AU filter wheel to new position
IGF Move GU filter wheel to new position
IXA Set autoguider slide X axis to absolute position
IYA Set autoguider slide Y axis to absolute position
IXR Move autoguider slide X axis by relative position
IYR Move autoguider slide Y axis by relative position
ISA Move autoguider X/Y slides to absolute position
ISR Move autoguider X/Y slides by relative position
ILA Turn on/off any of the calibration lamps
IDA Move mechanism to datum point
IUP Update position of a mechanism
IST Stop a mechanism
ISP Move Swing plate to a new position
IG General purpose command covering all the above options

<u>IAF</u>

Move the acquisition filter wheel to a new position. This command can also set a default position for the filter wheel. The default position can then be set by just typing IAF <CR>.

Command long-form: IAFW

ICL Command Format:

IAF posn   Move AU filter wheel to <posn>
IAF SetDefault posn   Set default position to <posn>
IAF   Move filter wheel, prompt for <posn>

<u>IGF</u>
Move the guider filter wheel to a new position. This command can also set a default position for the filter wheel. The default position can then be set by just typing IGF<CR>.

Command long-form: IGFW

ICL Command Format:

IGF posn   Move GU filter wheel to <posn>
IGF SetDefault posn   Set default position to <posn>
IGF   Move filter wheel, prompt for <posn>

<u>ILA</u>
Turn on or off any of the INTEGRAL calibration lamps. A prompt will be issued for the lamp name and for the state if none is supplied on the command line.

Current lamp options are: CuNe, CuAr and White

Command long-form: ILamps

ICL Command Format:

ILA <lamp> <On|Off> Turn calibration lamp <lamp> ON or OFF

<u>IXA</u>
Move the autoguider X slide to a new position. The new position is an absolute position in microns. A prompt will be issued if no parameter is supplied.

Command long-form: IXSlideAbs

ICL Command Format:

IXA position   Move autoguider X slide to <position>

IYA

Move the autoguider Y slide to a new absolute position. The position is specified in microns. A prompt will be issued if no parameter is given.

Command long-form: IYSlideAbs

ICL Command Format:

IYA position   Move autoguider Y slide to <position>

IXR

Move the autoguider X slide by a relative amount specified in microns. A prompt will be issued if no parameter is specified. The offset is relative to the current position.

Command long-form: IXSlideRel

ICL Command Format:

IXR delta   Move autoguider X slide by <delta>

IYR

Move the autoguider Y slide by a relative amount specified in microns. A prompt will be issued if no parameter is specified. The offset is relative to the current position.

Command long-form: IYSlideRel

ICL Command Format:

IYR delta   Move autoguider Y slide by <delta>

ISA

Move both axes of the autoguider slide to a new absolute position. Both axes will move simultaneously and the command will complete when both have reached their final positions. Positions are specified in microns.

Command long-form: IAGAbs

ICL Command Format:

ISA X Y   Move autoguider slide to (X,Y)

<u>ISR</u>
Move both axes of the autoguider slide by a specified amount relative to the current position. Both axes will move simultaneously and the command will complete when both moves have finished. The deltas are specified in microns.

Command long-form: IAGRel

ICL Command Format:

ISR dX dY   Move autoguider slide by (dX,dY)

<u>IDA</u>
Move a selected mechanism to its datum point. The mechanism should be specified by name or abbreviation, and will be prompted for if not supplied.

Command long-form: IMechDatum

ICL Command Format:

IDA <mech>   Move <mech> to its datum point.

<u>IUP</u>
Updates the mechanism's position by instructing the micro to report the current position.

Command long-form: IMechUpdate

ICL Command Format:

IUP <mech>   Update position of <mech>

<u>IST</u>
Stops the specified mechanism if it is currently moving. Any outstanding ADAM command on the mechanism must be CANCEL'led first.

Command long-form: IMechStop

ICL Command Format:

IST <mech>   Stop <mech>

<u>ISP</u>

Move the swing plate to select a new fibre bundle. The command also selects whether the bundle is used at its observing or calibration position. Prompts will be offered if parameters are not specified.

Command long-form: ISPFC

ICL Command Format:

ISP bundle position Select <bundle> at <position> where <position> = CALIBRATION!OBSERVING

IG(General-purpose-command)
General purpose command to control all aspects of INTEGRAL operation. If parameters are not specified, then appropriate prompts and help are supplied.

ICL Command Format:

IG act mech p1 p2 Perform action <act> on mechanism <mech> parameters <p1> and <p2> may be supplied if required.

5.8 Raw and Quick Data Analysis

This section briefly describes procedures for a quick and crude analysis of INTEGRAL data. This is done in the IRAF environment (of which a basic knowledge is assumed).

Most of the different steps for the data reduction and analysis can be performed using standard IRAF tasks, though some particular operations require some non-standard programs. These programs have been collected into a separate package called *integral* (see *http://www.iac.es/project/integral/index.html* for availability and installation instructions).

For loading the relevant (standard and non-standard) tasks type the following sequence:
cl (to start the IRAF environment)
integral (to load non-standard and standard IRAF tasks required)
int_status (to generate the files required for the 2D reconstruction)

By typing *help integral opt=sys*, a general description of the INTEGRAL package is printed on the display. To obtain a paper copy of this help type *help integral opt=sys | lprint*.

Listing INTEGRAL tasks.
When the INTEGRAL package is loaded, all *non-standard tasks* are showed on the display. By typing *help* a list of these specific tasks and a brief description of each is printed on display. The non-standard INTEGRAL tasks are the following.

Task	Function
int_hart	Hartmann test for a list of couples of images
int_fwhm	Center, peak, sigma and FWHM of a list of 2D images for a lines array
int_stat	Statistics data for a list of images
ms2ascii	Convert a multispec format 2D image to ASCII format spectra
readfxcor	Export to a file the values of radial velocities, pixel shifts, or widths obtained using fxcor
int_map	2D reconstruction from a ASCII file with fibre number, x, y, parameter to be mapped, and fiber status columns
int_rec	2D reconstruction from a non-reduced 2D image
int_spd1f	Spatial shift between two images for a fibre
int_spdXf	Spatial shift between two images for a fibre list
int_nspec	Extract a calibrated spectrum of a selected fibre
int_xyfib	Show on display xcenter (middle line in the dispersion axis) and ycenter (spatial coordinate) of the 'apfile' parameters for a selected fiber
int_daref	Shifts along a.r. and dec. produced by differential atmospheric refraction

Help on integral tasks
Help is available for each task (*e.g.*, *help int_spdXf*)

Some examples of the quick data examination
For a raw analysis of the images standard INTEGRAL tasks, like *imexamine* or *implot* can be used. With *imexamine* the user can generate profiles along the dispersion or spatial axes (type *j* and *k* respectively), contours (type *e*) etc. More complex operations (e.g. extraction of a fiber aperture, wavelength calibration, building up a map) require the knowledge of the standard tasks of IRAF devoted to fiber-data analysis (see, for instance, table in next section). The INTEGRAL software offers some specific tasks which can be used to obtain an extracted spectrum or a 2D reconstruction of a filter image.

2D reconstruction of a filter image

To perform a 2D reconstruction use the task *int_rec*. In the example below, an object image ("M32center") was taken with the sb2 bundle. Using *int_rec* an intensity map ("M32_300_500") between pixels 300 and 500 in the dispersion axis was obtained.

The first step of the *int_rec* task is the positional defining, tracing, and extraction of the apertures in the "referenceflat", unless this operation has been already done. The name of the file with the parameters corresponding to the definition, tracing and extraction is saved in the database as apnamep1_p2, where 'name' refers to the flat field image ("referenceflat" in the example), 'p1' is the value of the first pixel (parameter pix1) along the dispersion axis, and 'p2' is the value of the second pixel (parameter pix2). If this file is already in existance, the operations will not be repeated.

The definition (width and center), tracing and extraction of the apertures in "referenceflat" is done interactively. Within *int_rec*, this is achieved using the standard IRAF task *apall*. On execution, the profile of the apertures along the middle line in the dispersion axis are displayed. All apertures will appear identified and ordered, however, it is possible that a cosmic ray event has been falsely identified instead of a true aperture. In this case, this aperture should be deleted (typing *d*) and the true aperture marked (typing *m*). The rest of the apertures will then need to be selected (typing *a*), and ordered (typing *o*). Help is available on these commands by typing *?*. The widths of the apertures will not have to changed.

After defining of the aperture positions, they are spectrally traced. In principle, the user can do this operation interactively (for each fibre!). Various operations are possible *e.g.* changing the order of the fitting polynomial *etc.* *apall* then displays the indivually extracted spectra (which may or may not be viewed).

The second step is the definition, tracing and extraction of the apertures in the object image, (in this case, "M32center"). If the previous operations have been carried out on the flat field image (with the same instrument configuration), then it is safe to assume that the same extraction parameters will apply (database file apnamep1_p2). This can then be used as a reference for tracing and extraction in other images taken during the same night because INTEGRAL/WYFFOS should be very stable. Obviously, if p1 and/or p2 are changed, a new definition, tracing and extraction paramter file is required.

The third step is the reconstruction of the image, according to a interpolation (NAG routines e01saf and e01sbf).

Note that an estimation of the BIAS is required for *int_rec*.

PACKAGE=integral	
TASK=int_rec	
object = "M32center"	Object image
flat = "referenceflat"	Flat image
pix1 = 300	First pixel in the dispersion axis
pix2 = 500	Second pixel in the dispersion axis
bundle = 2	SB1(1), SB2(2), SB3(3)
bias = 1000	BIAS
outimage = "M32_300_500"	Outimage
(mode = "q")	

Extraction of a particular spectrum

This is done with the task *int_nspec*. In the example below, the spectrum #25 of "M32center" will be stored in the file "M32_25".

The first step of the *int_nspec* task is the definition, tracing, and extraction of the "referenceflat" (see the last section).

Secondly, the apertures are defined, traced and extracted for the object image (see the last section).

After that, a calibrated (or non-calibrated) spectrum of the selected fiber is showed on display. The calibration is done acoording to the parameters of the image header.

Note that an estimation of the BIAS is required.

PACKAGE= integral	
TASK=int_nspec	
image = "M32center"	Object image
reference = "referenceflat"	Flat image
fibre_n = 25	Number of fibre
bundle = 2	SB1(1), SB2(2), SB3(3)
bias = 1000	BIAS
spectrum = "M32_25"	Output image of the spectrum_n
calibra = yes	Calibrate the spectrum (yes/no)?
(mode = "q")	

5.9 Data Reduction Guide

Steps for INTEGRAL Data Reduction

The following steps are recomended to successfully reduce data obtained with INTEGRAL:

Step	Function	Package	Task
1	The BIAS Subtraction	*ccdred*	*ccdproc*
2	Aperture Definition and Trace	*specred*	*apall*
3	Scattered Light Correction	*specred*	*apscatter*
4	Extraction	*specred*	*apall*
5	Flat Spectra and Thoughtput Correction	*specred*	*msresp1d*
6	Arc Line Identification and Dispersion Correction	*specred*	*identify*, *reidentify* *refspectra*, *dispcor*
7	Sky Subtraction	*specred*	*skysub*
8	2D reconstruction	*integral*	*int_map*

A detailed guide for the INTEGRAL data reduction can be found in INT-IAC-MNL-004.

6 Appendix: Positions and Coordinates of Fibres, and Orientations of the Scientific Observing Bundles

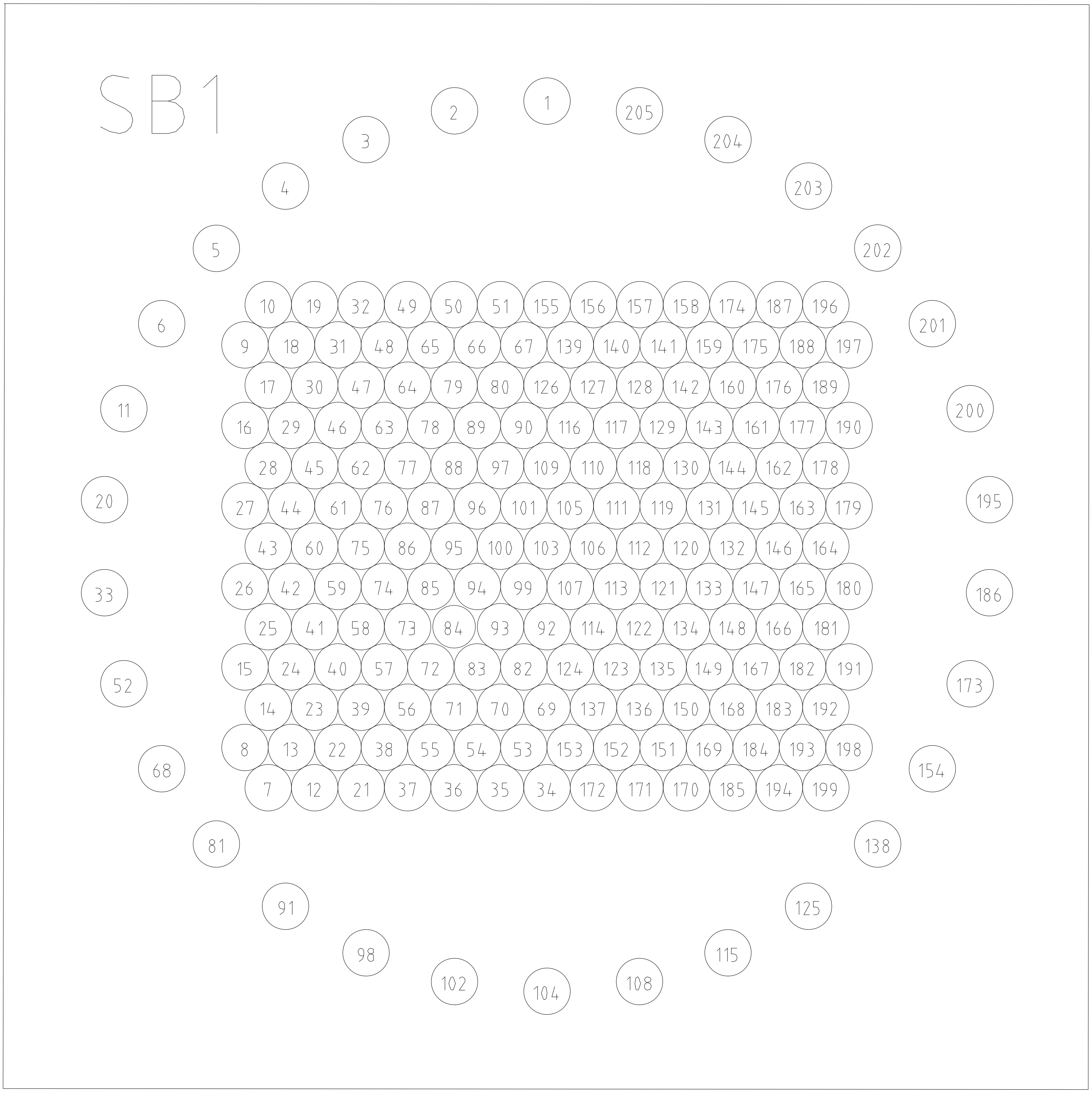


Figure 12: Fibre numeration at the focal plane for sb1. For SPA=0 degrees, North is top, East is left. For SPA=90 degrees, East is top, North is right. Y increases to top and X increases to right

Table 4: Fibre identification: bundle sb1. Values of -Δalpha and Δdelta, correspond to SPA=0.

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
1	-8	10000	-0,04	45,07	RING
2	-2060	9748	-9,29	43,94	RING
3	-4059	9118	-18,3	41,1	RING
4	-5858	8086	-26,4	36,45	RING
5	-7427	6662	-33,48	30,03	RING
6	-8640	4979	-38,94	22,44	RING
7	-760	-617	-3,43	-2,78	
8	-812	-508	-3,66	-2,29	
9	-817	624	-3,68	2,81	
10	-752	737	-3,39	3,32	
11	-9510	3056	-42,86	13,77	RING
12	-637	-628	-2,87	-2,83	
13	-689	-515	-3,11	-2,32	
14	-745	-403	-3,36	-1,82	
15	-812	-295	-3,66	-1,33	
16	-818	402	-3,69	1,81	
17	-752	512	-3,39	2,31	
18	-687	617	-3,1	2,78	
19	-622	735	-2,8	3,31	
20	-9935	1020	-44,78	4,6	RING
21	-506	-637	-2,28	-2,87	
22	-562	-531	-2,53	-2,39	
23	-621	-408	-2,8	-1,84	
24	-686	-297	-3,09	-1,34	
25	-749	-190	-3,38	-0,86	
26	-810	-75	-3,65	-0,34	
27	-810	172	-3,65	0,78	
28	-751	287	-3,38	1,29	
29	-696	397	-3,14	1,79	
30	-626	508	-2,82	2,29	
31	-561	624	-2,53	2,81	
32	-489	731	-2,2	3,29	
33	-9941	-1070	-44,81	-4,82	RING
34	2	-640	0,01	-2,88	
35	-122	-648	-0,55	-2,92	
36	-251	-647	-1,13	-2,92	
37	-373	-646	-1,68	-2,91	
38	-436	-536	-1,97	-2,42	
39	-497	-417	-2,24	-1,88	
40	-559	-296	-2,52	-1,33	
41	-621	-197	-2,8	-0,89	
42	-688	-77	-3,1	-0,35	
43	-746	48	-3,36	0,22	
44	-685	172	-3,09	0,78	
45	-623	276	-2,81	1,24	
46	-569	392	-2,56	1,77	
47	-499	502	-2,25	2,26	
48	-429	611	-1,93	2,75	
49	-367	732	-1,65	3,3	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
46	-569	392	-2,56	1,77	
47	-499	502	-2,25	2,26	
48	-429	611	-1,93	2,75	
49	-367	732	-1,65	3,3	
50	-240	736	-1,08	3,32	
51	-115	723	-0,52	3,26	
52	-9527	-3108	-42,94	-14,01	RING
53	-57	-536	-0,26	-2,42	
54	-189	-530	-0,85	-2,39	
55	-309	-537	-1,39	-2,42	
56	-372	-428	-1,68	-1,93	
57	-433	-308	-1,95	-1,39	
58	-490	-190	-2,21	-0,86	
59	-558	-85	-2,52	-0,38	
60	-626	28	-2,82	0,13	
61	-563	154	-2,54	0,69	
62	-500	277	-2,25	1,25	
63	-442	391	-1,99	1,76	
64	-370	501	-1,67	2,26	
65	-299	616	-1,35	2,78	
66	-178	611	-0,8	2,75	
67	-53	610	-0,24	2,75	
68	-8644	-5020	-38,96	-22,63	RING
69	21	-418	0,09	-1,88	
70	-	-	-	-	
71	-249	-418	-1,12	-1,88	
72	-309	-307	-1,39	-1,38	
73	-368	-196	-1,66	-0,88	
74	-429	-85	-1,93	-0,38	
75	-495	30	-2,23	0,14	
76	-437	155	-1,97	0,7	
77	-375	271	-1,69	1,22	
78	-313	384	-1,41	1,73	
79	-245	490	-1,1	2,21	
80	-119	492	-0,54	2,22	
81	-7424	-6720	-33,46	-30,29	RING
82	-46	-314	-0,21	-1,42	
83	-170	-309	-0,77	-1,39	
84	-244	-194	-1,1	-0,87	
85	-306	-86	-1,38	-0,39	
86	-368	42	-1,66	0,19	
87	-308	153	-1,39	0,69	
88	-253	270	-1,14	1,22	
89	-185	380	-0,83	1,71	
90	-62	372	-0,28	1,68	
91	-5864	-8106	-26,43	-36,54	RING
92	7	-207	0,03	-0,93	
93	-123	-206	-0,55	-0,93	
94	-184	-88	-0,83	-0,4	
95	-247	37	-1,11	0,17	
96	-186	150	-0,84	0,68	
97	-132	259	-0,59	1,17	
98	-4053	-9156	-18,27	-41,27	RING
99	-60	-96	-0,27	-0,43	
100	-122	24	-0,55	0,11	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
101	-62	140	-0,28	0,63	
102	-2073	-9794	-9,34	-44,14	RING
103	1	25	0	0,11	
104	14	-9992	0,06	-45,04	RING
105	65	141	0,29	0,64	
106	126	28	0,57	0,13	
107	67	-88	0,3	-0,4	
108	2091	-9774	9,42	-44,05	RING
109	-5	257	-0,02	1,16	
110	128	252	0,58	1,14	
111	192	138	0,87	0,62	
112	251	30	1,13	0,14	
113	194	-85	0,87	-0,38	
114	131	-197	0,59	-0,89	
115	4087	-9124	18,42	-41,12	RING
116	64	383	0,29	1,73	
117	187	373	0,84	1,68	
118	254	256	1,14	1,15	
119	320	144	1,44	0,65	
120	376	31	1,69	0,14	
121	316	-85	1,42	-0,38	
122	255	-194	1,15	-0,87	
123	200	-299	0,9	-1,35	
124	77	-306	0,35	-1,38	
125	5898	-8082	26,58	-36,43	RING
126	13	492	0,06	2,22	
127	132	484	0,59	2,18	
128	258	496	1,16	2,24	
129	313	365	1,41	1,65	
130	377	253	1,7	1,14	
131	442	145	1,99	0,65	
132	503	35	2,27	0,16	
133	440	-79	1,98	-0,36	
134	383	-191	1,73	-0,86	
135	325	-300	1,46	-1,35	
136	268	-412	1,21	-1,86	
137	148	-417	0,67	-1,88	
138	7442	-6679	33,54	-30,1	RING
139	74	603	0,33	2,72	
140	200	608	0,9	2,74	
141	324	614	1,46	2,77	
142	384	497	1,73	2,24	
143	443	381	2	1,72	
144	506	267	2,28	1,2	
145	569	156	2,56	0,7	
146	630	35	2,84	0,16	
147	564	-75	2,54	-0,34	
148	508	-188	2,29	-0,85	
149	449	-293	2,02	-1,32	
150	394	-407	1,78	-1,83	
151	317	-528	1,43	-2,38	
152	194	-536	0,87	-2,42	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
153	70	-533	0,32	-2,4	
154	8673	-4990	39,09	-22,49	RING
155	7	733	0,03	3,3	
156	132	724	0,59	3,26	
157	257	725	1,16	3,27	
158	384	733	1,73	3,3	
159	449	614	2,02	2,77	
160	515	499	2,32	2,25	
161	572	374	2,58	1,69	
162	636	268	2,87	1,21	
163	694	154	3,13	0,69	
164	768	48	3,46	0,22	
165	693	-71	3,12	-0,32	
166	635	-183	2,86	-0,82	
167	572	-284	2,58	-1,28	
168	516	-399	2,33	-1,8	
169	444	-522	2	-2,35	
170	383	-637	1,73	-2,87	
171	257	-638	1,16	-2,88	
172	125	-642	0,56	-2,89	
173	9526	-3079	42,94	-13,88	RING
174	513	731	2,31	3,29	
175	573	613	2,58	2,76	
176	645	498	2,91	2,24	
177	697	378	3,14	1,7	
178	763	273	3,44	1,23	
179	820	163	3,7	0,73	
180	816	-66	3,68	-0,3	
181	758	-179	3,42	-0,81	
182	695	-284	3,13	-1,28	
183	639	-390	2,88	-1,76	
184	565	-514	2,55	-2,32	
185	506	-626	2,28	-2,82	
186	9974	-1040	44,96	-4,69	RING
187	637	733	2,87	3,3	
188	696	624	3,14	2,81	
189	768	492	3,46	2,22	
190	824	383	3,71	1,73	
191	820	-276	3,7	-1,24	
192	759	-387	3,42	-1,74	
193	691	-506	3,11	-2,28	
194	634	-625	2,86	-2,82	
195	9952	1060	44,86	4,78	RING
196	765	732	3,45	3,3	
197	819	611	3,69	2,75	
198	815	-506	3,67	-2,28	
199	753	-610	3,39	-2,75	
200	9506	3091	42,85	13,93	RING
201	8666	5006	39,06	22,56	RING
202	7420	6706	33,44	30,23	RING
203	5882	8100	26,51	36,51	RING
204	4060	9148	18,3	41,23	RING
205	2079	9777	9,37	44,07	RING

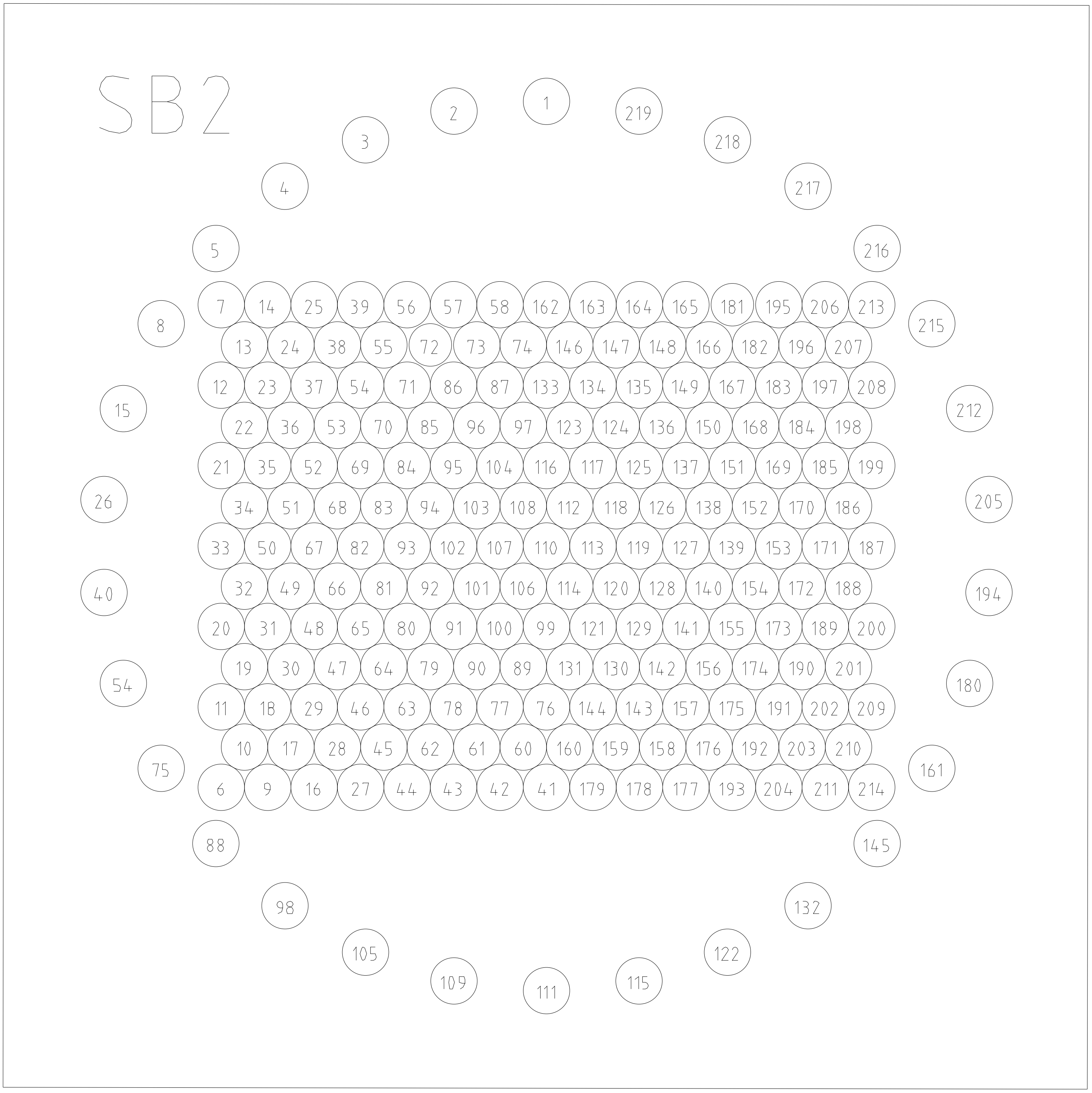


Figure 13: Fibre identification: bundle sb2. For SPA=0 degrees, North is top, East is left. For SPA=90 degrees, East is top, North is right. Y increases to top and X increases to right

Table 5: Fibre identification: bundle sb2. Values of -Δalpha and Δdelta correspond to SPA=0.

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
1	33	9985	0,149	45,005	RING
2	-2036	9775	-9,177	44,059	RING
3	-4019	9133	-18,115	41,165	RING
4	-5852	8086	-26,377	36,446	RING
5	-7393	6686	-33,322	30,136	RING
6	-1734	-1190	-7,816	-5,364	
7	-1737	1313	-7,829	5,918	
8	-8638	4998	-38,934	22,527	RING
9	-1493	-1188	-6,729	-5,355	
10	-1621	-980	-7,306	-4,417	
11	-1745	-774	-7,865	-3,489	
12	-1755	899	-7,91	4,052	
13	-1615	1098	-7,279	4,949	
14	-1495	1312	-6,738	5,914	
15	-9493	3092	-42,788	13,937	RING
16	-1245	-1186	-5,612	-5,346	
17	-1379	-986	-6,216	-4,444	
18	-1499	-777	-6,756	-3,502	
19	-1616	-566	-7,284	-2,551	
20	-1745	-361	-7,865	-1,627	
21	-1741	480	-7,847	2,163	
22	-1612	689	-7,266	3,106	
23	-1486	898	-6,698	4,048	
24	-1370	1101	-6,175	4,963	
25	-1243	1313	-5,603	5,918	
26	-9942	1048	-44,811	4,724	RING
27	-1006	-1190	-4,534	-5,364	
28	-1137	-985	-5,125	-4,44	
29	-1253	-777	-5,648	-3,502	
30	-1377	-574	-6,207	-2,587	
31	-1500	-357	-6,761	-1,609	
32	-1626	-149	-7,329	-0,672	
33	-1747	62	-7,874	0,279	
34	-1611	277	-7,261	1,249	
35	-1490	481	-6,716	2,168	
36	-1366	688	-6,157	3,101	
37	-1245	900	-5,612	4,057	
38	-1119	1099	-5,044	4,954	
39	-997	1311	-4,494	5,909	
40	-9924	-1034	-44,73	-4,661	RING
41	-33	-1193	-0,149	-5,377	
42	-278	-1194	-1,253	-5,382	
43	-521	-1190	-2,348	-5,364	
44	-761	-1190	-3,43	-5,364	
45	-890	-986	-4,011	-4,444	
46	-1011	-779	-4,557	-3,511	
47	-1133	-569	-5,107	-2,565	
48	-1259	-364	-5,675	-1,641	
49	-1384	-150	-6,238	-0,676	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
50	-1505	56	-6,783	0,252	
51	-1368	275	-6,166	1,24	
52	-1245	478	-5,612	2,154	
53	-1122	689	-5,057	3,106	
54	-998	899	-4,498	4,052	
55	-877	1100	-3,953	4,958	
56	-758	1312	-3,417	5,914	
57	-515	1312	-2,321	5,914	
58	-271	1311	-1,221	5,909	
59	-9504	-3088	-42,837	-13,918	RING
60	-157	-984	-0,708	-4,435	
61	-404	-987	-1,821	-4,449	
62	-648	-985	-2,921	-4,44	
63	-768	-779	-3,462	-3,511	
64	-894	-573	-4,03	-2,583	
65	-1016	-359	-4,579	-1,618	
66	-1139	-153	-5,134	-0,69	
67	-1262	60	-5,688	0,27	
68	-1125	275	-5,071	1,24	
69	-1003	483	-4,521	2,177	
70	-879	691	-3,962	3,115	
71	-758	896	-3,417	4,039	
72	-632	1098	-2,849	4,949	
73	-390	1100	-1,758	4,958	
74	-145	1100	-0,654	4,958	
75	-8661	-5007	-39,038	-22,568	RING
76	-35	-775	-0,158	-3,493	
77	-278	-778	-1,253	-3,507	
78	-522	-772	-2,353	-3,48	
79	-650	-568	-2,93	-2,56	
80	-773	-363	-3,484	-1,636	
81	-898	-153	-4,048	-0,69	
82	-1014	57	-4,57	0,257	
83	-880	272	-3,966	1,226	
84	-759	478	-3,421	2,154	
85	-637	687	-2,871	3,097	
86	-512	897	-2,308	4,043	
87	-272	894	-1,226	4,03	
88	-7421	-6686	-33,449	-30,136	RING
89	-159	-566	-0,717	-2,551	
90	-402	-568	-1,812	-2,56	
91	-531	-364	-2,393	-1,641	
92	-653	-153	-2,943	-0,69	
93	-775	58	-3,493	0,261	
94	-640	272	-2,885	1,226	
95	-514	479	-2,317	2,159	
96	-392	683	-1,767	3,078	
97	-147	689	-0,663	3,106	
98	-5879	-8101	-26,498	-36,514	RING
99	-36	-362	-0,162	-1,632	

slit position	X(microns)	Y(microns)	-Δalpha(”)	Δdelta(”)	Ring (?)
100	-280	-361	-1,262	-1,627	
101	-407	-155	-1,834	-0,699	
102	-524	54	-2,362	0,243	
103	-390	269	-1,758	1,212	
104	-271	480	-1,221	2,163	
105	-4065	-9151	-18,322	-41,246	RING
106	-159	-155	-0,717	-0,699	
107	-284	57	-1,28	0,257	
108	-149	272	-0,672	1,226	
109	-2085	-9794	-9,398	-44,144	RING
110	-39	55	-0,176	0,248	
111	-3	-10026	-0,014	-45,19	RING
112	97	272	0,437	1,226	
113	207	53	0,933	0,239	
114	85	-155	0,383	-0,699	
115	2069	-9809	9,326	-44,212	RING
116	-28	477	-0,126	2,15	
117	215	483	0,969	2,177	
118	336	267	1,514	1,203	
119	446	53	2,01	0,239	
120	327	-153	1,474	-0,69	
121	204	-366	0,919	-1,65	
122	4066	-9161	18,327	-41,291	RING
123	96	687	0,433	3,097	
124	336	685	1,514	3,087	
125	462	477	2,082	2,15	
126	581	263	2,619	1,185	
127	692	52	3,119	0,234	
128	572	-155	2,578	-0,699	
129	447	-363	2,015	-1,636	
130	325	-571	1,465	-2,574	
131	88	-568	0,397	-2,56	
132	5883	-8126	26,516	-36,626	RING
133	-27	896	-0,122	4,039	
134	214	896	0,965	4,039	
135	461	894	2,078	4,03	
136	584	681	2,632	3,069	
137	706	474	3,182	2,136	
138	826	266	3,723	1,199	
139	930	51	4,192	0,23	
140	809	-160	3,646	-0,721	
141	685	-364	3,087	-1,641	
142	567	-571	2,556	-2,574	
143	448	-780	2,019	-3,516	
144	205	-778	0,924	-3,507	
145	7437	-6722	33,521	-30,298	RING
146	96	1100	0,433	4,958	
147	342	1096	1,541	4,94	
148	586	1100	2,641	4,958	
149	707	893	3,187	4,025	
150	823	683	3,709	3,078	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
137	706	474	3,182	2,136	
138	826	266	3,723	1,199	
139	930	51	4,192	0,23	
140	809	-160	3,646	-0,721	
141	685	-364	3,087	-1,641	
142	567	-571	2,556	-2,574	
143	448	-780	2,019	-3,516	
144	205	-778	0,924	-3,507	
145	7437	-6722	33,521	-30,298	RING
146	96	1100	0,433	4,958	
147	342	1096	1,541	4,94	
148	586	1100	2,641	4,958	
149	707	893	3,187	4,025	
150	823	683	3,709	3,078	
151	945	475	4,259	2,141	
152	1068	265	4,814	1,194	
153	1176	50	5,301	0,225	
154	1056	-158	4,76	-0,712	
155	929	-364	4,187	-1,641	
156	812	-572	3,66	-2,578	
157	689	-782	3,106	-3,525	
158	568	-989	2,56	-4,458	
159	329	-987	1,483	-4,449	
160	81	-982	0,365	-4,426	
161	8673	-5036	39,092	-22,699	RING
162	-27	1311	-0,122	5,909	
163	221	1313	0,996	5,918	
164	459	1309	2,069	5,9	
165	707	1313	3,187	5,918	
166	827	1099	3,728	4,954	
167	945	893	4,259	4,025	
168	1071	680	4,827	3,065	
169	1189	471	5,359	2,123	
170	1312	266	5,914	1,199	
171	1421	49	6,405	0,221	
172	1299	-159	5,855	-0,717	
173	1179	-364	5,314	-1,641	
174	1053	-572	4,746	-2,578	
175	936	-782	4,219	-3,525	
176	812	-989	3,66	-4,458	
177	692	-1198	3,119	-5,4	
178	451	-1192	2,033	-5,373	
179	211	-1192	0,951	-5,373	
180	9534	-3132	42,972	-14,117	RING
181	947	1310	4,268	5,905	
182	1070	1095	4,823	4,935	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
183	1191	894	5,368	4,03	
184	1311	681	5,909	3,069	
185	1433	468	6,459	2,109	
186	1552	259	6,995	1,167	
187	1661	46	7,487	0,207	
188	1542	-159	6,95	-0,717	
189	1421	-371	6,405	-1,672	
190	1298	-576	5,85	-2,596	
191	1175	-780	5,296	-3,516	
192	1055	-992	4,755	-4,471	
193	935	-1197	4,214	-5,395	
194	9958	-1075	44,884	-4,845	RING
195	1188	1309	5,355	5,9	
196	1318	1097	5,941	4,944	
197	1432	888	6,454	4,002	
198	1561	680	7,036	3,065	
199	1683	468	7,586	2,109	
200	1667	-370	7,514	-1,668	
201	1544	-579	6,959	-2,61	
202	1420	-786	6,4	-3,543	
203	1295	-991	5,837	-4,467	
204	1175	-1204	5,296	-5,427	
205	9959	1003	44,888	4,521	RING
206	1449	1303	6,531	5,873	
207	1565	1088	7,054	4,904	
208	1688	884	7,608	3,984	
209	1668	-786	7,518	-3,543	
210	1543	-992	6,955	-4,471	
211	1413	-1205	6,369	-5,431	
212	9527	3054	42,941	13,765	RING
213	1696	1299	7,644	5,855	
214	1658	-1206	7,473	-5,436	
215	8688	4965	39,159	22,379	RING
216	7454	6657	33,597	30,005	RING
217	5905	8068	26,616	36,365	RING
218	4086	9110	18,417	41,061	RING
219	2102	9771	9,474	44,041	RING

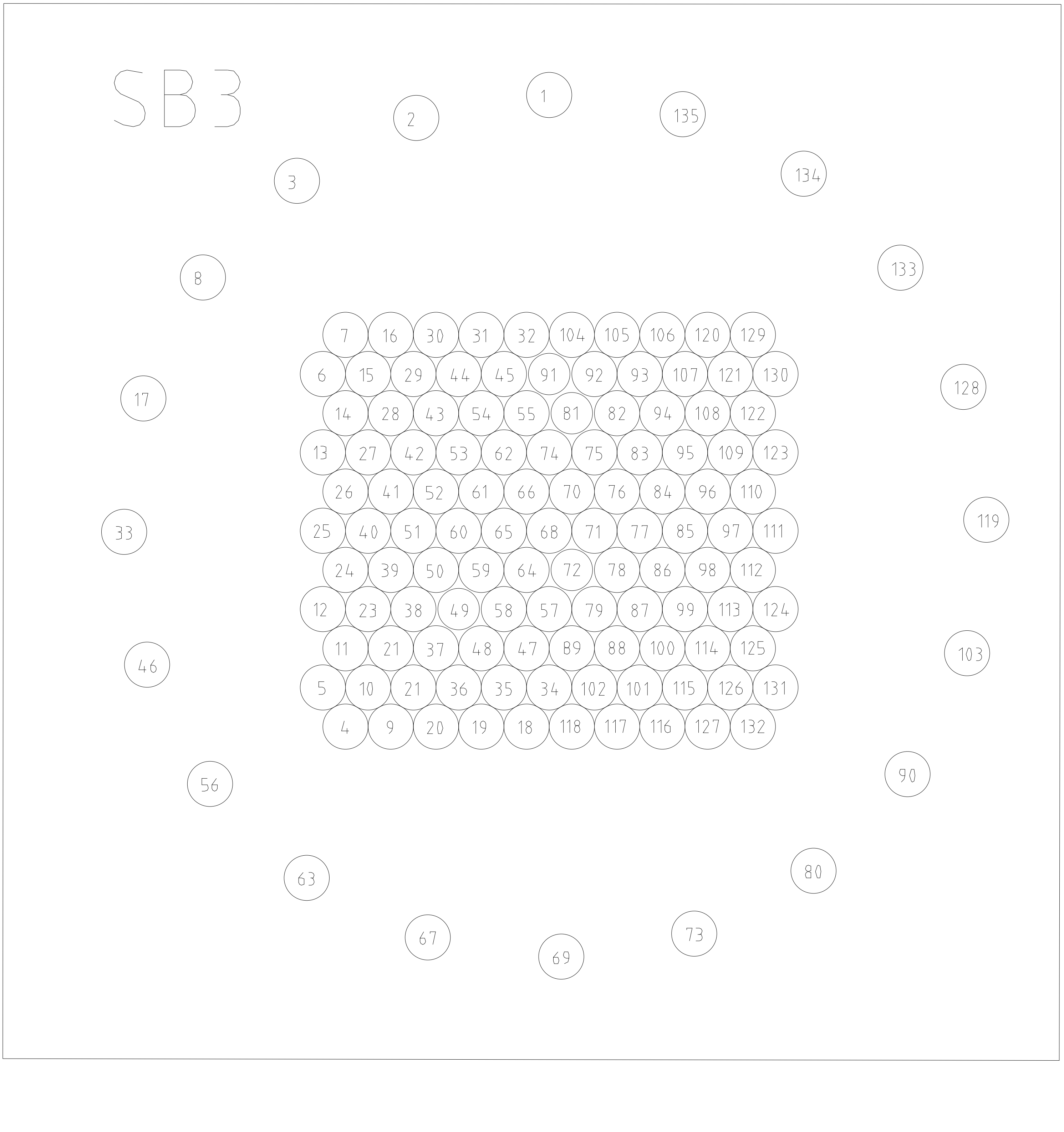


Figure 14: Spatial distribution of the fibres at the focal plane for sb3. For SPA=0 degrees, North is top, East is left. For SPA=90 degrees, East is top, North is right. Y increases to top and X increases to right

Table 6: Fibre identification: bundle sb3. Values for -Δalpha and Δdelta correspomnd to SPA=0.

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
1	21	9987	0,095	45,014	RING
2	-3075	9525	-13,860	42,932	RING
3	-5883	8101	-26,516	36,514	RING
4	-3237	-2990	-14,590	-13,477	
5	-3584	-2382	-16,154	-10,736	
6	-3568	2444	-16,082	11,016	
7	-3218	3042	-14,504	13,711	
8	-8090	5881	-36,464	26,507	RING
9	-2549	-2977	-11,489	-13,418	
10	-2895	-2388	-13,049	-10,763	
11	-3227	-1791	-14,545	-8,073	
12	-3577	-1184	-16,123	-5,337	
13	-3557	1233	-16,032	5,557	
14	-3217	1851	-14,500	8,343	
15	-2874	2443	-12,954	11,011	
16	-2518	3042	-11,349	13,711	
17	-9527	3096	-42,941	13,955	RING
18	-489	-2994	-2,204	-13,495	
19	-1176	-2979	-5,301	-13,427	
20	-1861	-2995	-8,388	-13,499	
21	-2203	-2384	-9,930	-10,745	
22	-2537	-1793	-11,435	-8,082	
23	-2890	-1170	-13,026	-5,274	
24	-3214	-559	-14,486	-2,520	
25	-3561	38	-16,050	0,171	
26	-3205	628	-14,446	2,831	
27	-2867	1247	-12,922	5,621	
28	-2538	1853	-11,439	8,352	
29	-2183	2440	-9,839	10,998	
30	-1829	3042	-8,244	13,711	
31	-1127	3041	-5,080	13,707	
32	-436	3023	-1,965	13,626	
33	-10001	6	-45,077	0,027	RING
34	-139	-2385	-0,627	-10,750	
35	-830	-2386	-3,741	-10,754	
36	-1517	-2388	-6,838	-10,763	
37	-1852	-1796	-8,347	-8,095	
38	-2198	-1170	-9,907	-5,274	
39	-2523	-570	-11,372	-2,569	
40	-2876	30	-12,963	0,135	
41	-2525	616	-11,381	2,776	
42	-2179	1217	-9,821	5,485	
43	-1854	1836	-8,357	8,275	
44	-1497	2432	-6,747	10,962	
45	-796	2431	-3,588	10,957	

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
46	-9511	-3052	-42,869	-13,756	RING
47	-475	-1794	-2,141	-8,086	
48	-1164	-1796	-5,246	-8,095	
49	-1509	-1162	-6,801	-5,237	
50	-1844	-572	-8,311	-2,578	
51	-2178	24	-9,817	0,108	
52	-1831	622	-8,253	2,804	
53	-1490	1237	-6,716	5,576	
54	-1142	1831	-5,147	8,253	
55	-450	1827	-2,028	8,235	
56	-8113	-5861	-36,568	-26,417	RING
57	-133	-1177	-0,599	-5,305	
58	-819	-1179	-3,691	-5,314	
59	-1138	-577	-5,129	-2,601	
60	-1487	12	-6,702	0,054	
61	-1146	617	-5,165	2,781	
62	-799	1227	-3,601	5,530	
63	-5878	-8097	-26,494	-36,495	RING
64	-455	-582	-2,051	-2,623	
65	-804	25	-3,624	0,113	
66	-432	603	-1,947	2,718	
67	-3095	-9524	-13,950	-42,927	RING
68	-98	9	-0,442	0,041	
69	-14	-10031	-0,063	-45,213	RING
70	250	613	1,127	2,763	
71	582	12	2,623	0,054	
72	225	-598	1,014	-2,695	
73	3076	-9541	13,864	-43,004	RING
74	-99	1203	-0,446	5,422	
75	588	1228	2,650	5,535	
76	946	598	4,264	2,695	
77	1268	-1	5,715	-0,005	
78	915	-598	4,124	-2,695	
79	552	-1197	2,488	-5,395	
80	5869	-8124	26,453	-36,617	RING
81	236	1824	1,064	8,221	
82	937	1820	4,223	8,203	
83	1276	1198	5,751	5,400	
84	1626	608	7,329	2,740	
85	1954	-8	8,807	-0,036	
86	1595	-607	7,189	-2,736	
87	1245	-1198	5,612	-5,400	
88	898	-1800	4,048	-8,113	
89	215	-1793	0,969	-8,082	
90	8091	-5912	36,468	-26,647	RING

slit position	X(microns)	Y(microns)	-Δalpha(")	Δdelta(")	Ring (?)
91	-107	2421	-0,482	10,912	
92	597	2420	2,691	10,908	
93	1294	2423	5,832	10,921	
94	1625	1817	7,324	8,190	
95	1965	1214	8,857	5,472	
96	2314	588	10,430	2,650	
97	2641	-12	11,904	-0,054	
98	2283	-601	10,290	-2,709	
99	1929	-1203	8,695	-5,422	
100	1591	-1795	7,171	-8,091	
101	1233	-2394	5,557	-10,790	
102	549	-2391	2,475	-10,777	
103	9520	-3098	42,909	-13,964	RING
104	252	3034	1,136	13,675	
105	940	3018	4,237	13,603	
106	1626	3030	7,329	13,657	
107	1983	2420	8,938	10,908	
108	2303	1811	10,380	8,163	
109	2651	1197	11,949	5,395	
110	3004	589	13,540	2,655	
111	3323	-29	14,978	-0,131	
112	2979	-606	13,427	-2,731	
113	2624	-1200	11,827	-5,409	
114	2275	-1802	10,254	-8,122	
115	1927	-2399	8,686	-10,813	
116	1568	-2998	7,067	-13,513	
117	884	-2996	3,984	-13,504	
118	199	-2994	0,897	-13,495	
119	10014	-16	45,136	-0,072	RING
120	2314	3020	10,430	13,612	
121	2670	2416	12,034	10,890	
122	2988	1806	13,468	8,140	
123	3339	1198	15,050	5,400	
124	3314	-1203	14,937	-5,422	
125	2965	-1804	13,364	-8,131	
126	2610	-2404	11,764	-10,836	
127	2259	-2996	10,182	-13,504	
128	9559	3023	43,085	13,626	RING
129	3007	3018	13,553	13,603	
130	3367	2423	15,176	10,921	
131	3295	-2416	14,852	-10,890	
132	2946	-3004	13,278	-13,540	
133	8126	5815	36,626	26,210	RING
134	5899	8064	26,588	36,347	RING
135	3112	9497	14,027	42,806	RING

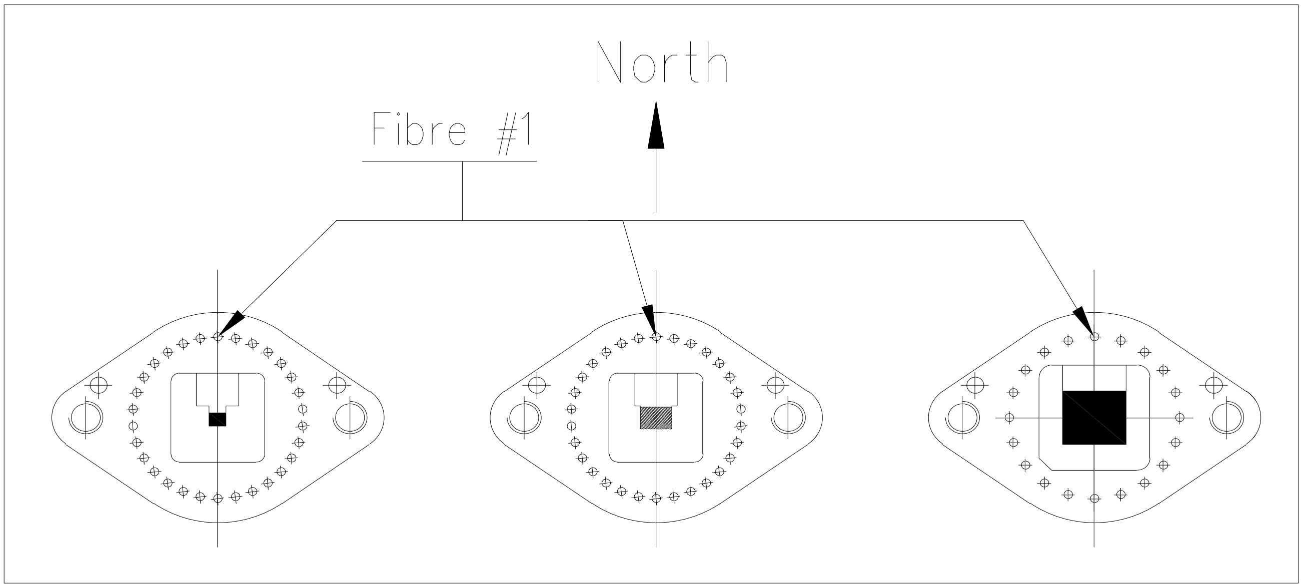


Figure 15: Orientation of the fibres bundles at the telescope focal plane. For SPA=0 degrees, North is top and East is left.

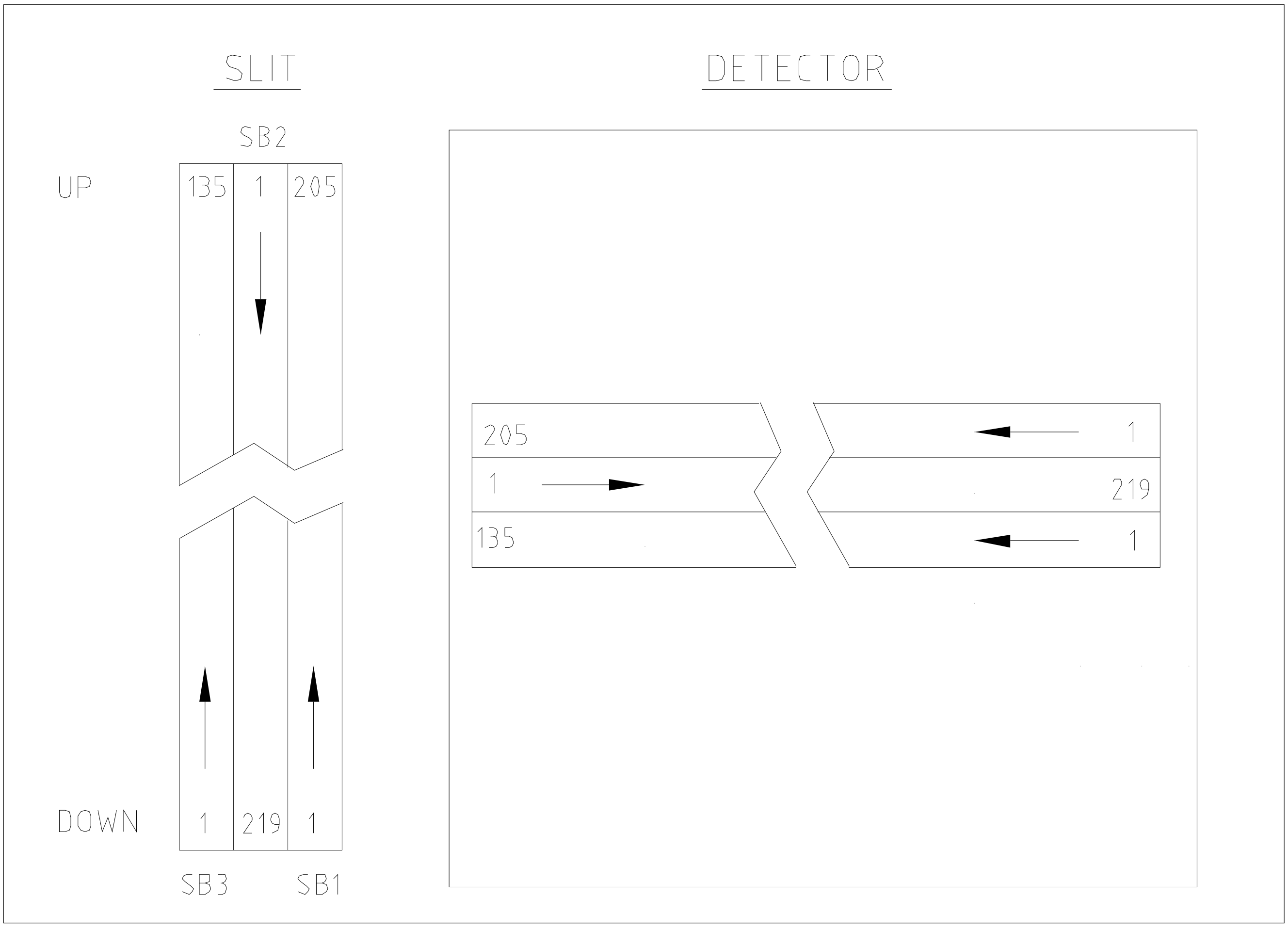


Figure 16: Orientation of the fibres bundles at the spectrograph slit and detector levels.