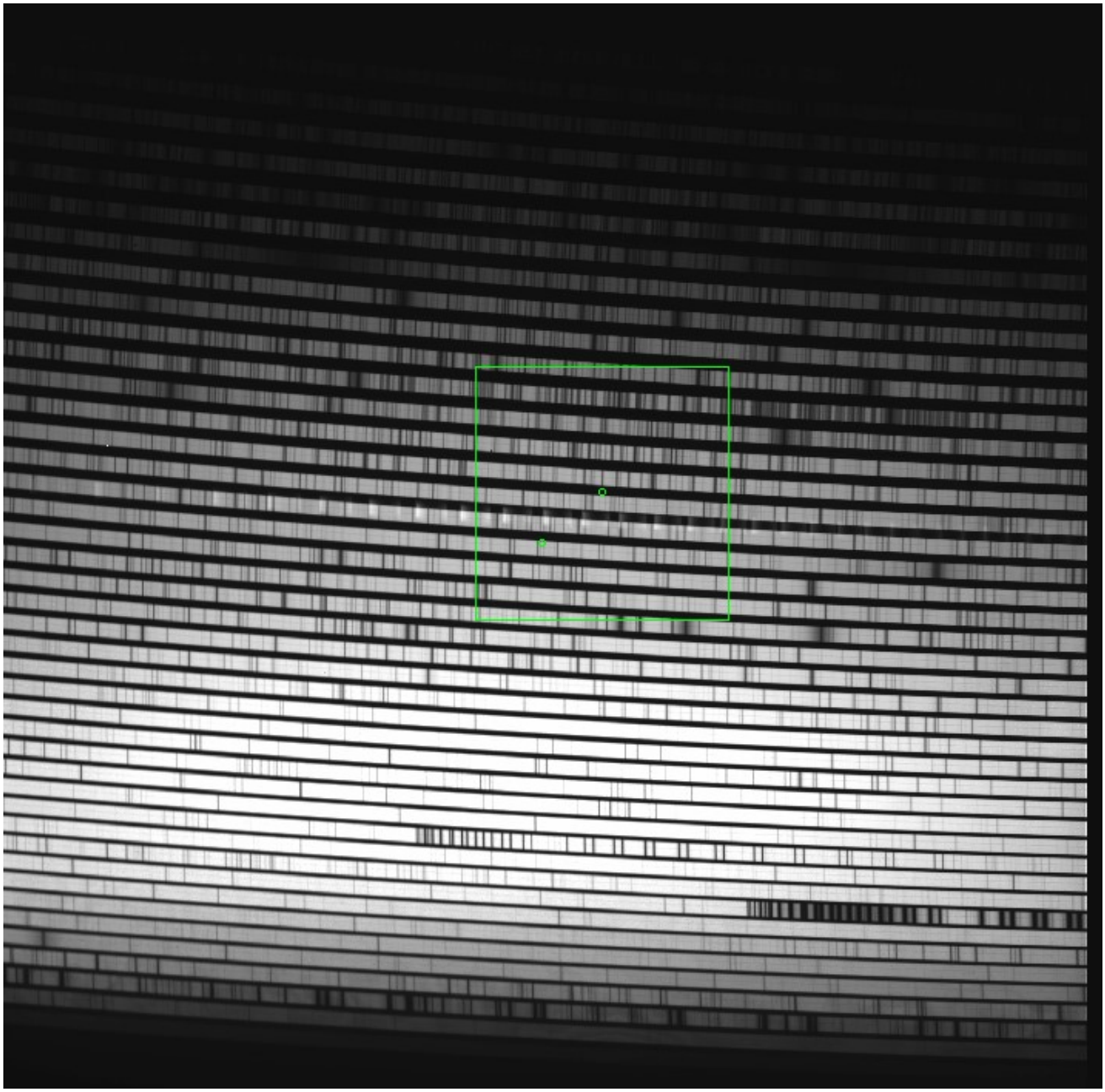
Finding TS21-E1 disperser configurations



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1 Introduction

1.1 Background

This document assumes the reader is familiar with the terminology and concepts underlying TS2, as discussed in the document *Orientation to TS2 and its spectra*. The procedure is quite simple, but takes quite a few words to describe.

The combination of spectrograph focus and detector known as TS21-TK3 covers about 1/18th of the spectral region covered by TS23-TK3. When working at TS21 this small spectral coverage makes it difficult to find spectral features and position them on the detector. The task can be facilitated using TS23 spectra, taken with the same echelle grating, as described in this document. Most of the task can be done before the observing run which is likely to make the observing run easier.

The cover page shows a TS23-E1-TK3 spectrum from the solar port. The green square shows the relative size of the TS21-E1-TK3 field of view. Note the two green circles on the image. The left circle is the position of the center of this TS23 image, and the right circle is the position of the center of the TS21 field (and the box) relative to TS23. There is a small offset (see section x.x), and the offset may not be highly repeatable for reasons currently under investigation.

1.2 Library of TS23-E1 spectra

On the HJST computer Atlas, in the directory given below, there are the two sets of FITS images specified in the following table

Directory: /home/hjst/example_files/TS23-E1-TK3

File name	Source	Echelle	Prism	Slit	Comment
TS23-E1-ThAr-1blue	ThAr	1,590,000	137,452	9	25,000 blue of blaze
TS23-E1-ThAr-2blue	ThAr	1,600,000	137,452	9	15,000 blue of blaze
TS23-E1-ThAr-3blue	ThAr	1,610,000	137,452	9	5,000 blue of blaze
TS23-E1-ThAr-4blaze	ThAr	1,615,000	137,452	9	On blaze
TS23-E1-ThAr-5red	ThAr	1,620,000	137,452	9	5,000 red of blaze
TS23-E1-ThAr-6red	ThAr	1,630,000	137,452	9	15,000 red of blaze
TS23-E1-ThAr-7red	ThAr	1,640,000	137,452	9	25,000 red of blaze
TS23-E1-SP-1blue	Solar Port	1,590,000	137,452	9	25,000 blue of blaze
TS23-E1-SP-2blue	Solar Port	1,600,000	137,452	9	15,000 blue of blaze
TS23-E1-SP-3blue	Solar Port	1,610,000	137,452	9	5,000 blue of blaze
TS23-E1-SP-4blaze	Solar Port	1,615,000	137,452	9	On blaze
TS23-E1-SP-5red	Solar Port	1,620,000	137,452	9	5,000 red of blaze
TS23-E1-SP-6red	Solar Port	1,630,000	137,452	9	15,000 red of blaze
TS23-E1-SP-7red	Solar Port	1,640,000	137,452	9	25,000 red of blaze

These images of the ThAr comparison lamp, and of the Solar Port can be used to determine TS21-E1 disperser configurations. Each set covers a range of echelle rotations that in one image or another show the full blue-to-red extent of the wideest (reddest) echelle orders.

In the same directory is the following DS9 region file that is used in the process, and can be seen on the title page overlayed on the TS23-E1-SP-4blaze image.

Region file: TS23-TS21-E1-relative_centers.reg

1.3 Useful numbers

1.3.1 TS21 to TS23 magnification ratio

The camera focal length of TS23 is 775 mm, and the camera focal length of TS21 is 3316 mm. That means the magnification ratio of TS21-to-TS23 is 3316/775 = **4.279.** It follows that TS23 covers 4.279^2 = 18.3 times the area of TS21.

1.3.2 Echelle motion factors

These factors give the required rotation of the echelle, measured in the echelle position units used by the GUI, for a 1 pixel motion of the image on the CCD. References below to *left* and *right* refer to the image displayed in ds9.

For a CCD column binning of 1:
TS23 echelle factor = 26 position units per pixel of motion ; lines move left
TS21 echelle factor = 6.077 position units per pixel of motion ; line move right

1.3.3 Prism motion factors

These factors give the required rotation of the prisms, measured in the prism encoder units used by the GUI, for a 1 pixel motion of the image on the detector. References below to *left* and *right* refer to the image displayed in ds9.

For a CCD row binning of 1:
TS23 prism factor = 51 position units per pixel of motion ; lines move up
TS21 prism factor = 11.919 position units per pixel of motion ; lines move down

For a CCD row binning of 2:
TS21 prism factor = 23.839 position units per pixel of motion ; lines move down

1.4 TS21 and TS23 relative image centers

The center of a TS23 image is by definition at the center of the TK3 array at pixel (1024,1024). On a TS23 image the center of a TS21 image is slightly off center due to a spectrograph misalignment (see the title page image). At the time of writing the cause and correction of the misalignment is under investigation. The offset may vary slightly each time the spectrograph is reconfigured from TS23 to TS21. The offset might be different between the two echelle gratings E1 and E2. The center of the TS21-E1 field of view is at pixel (1136,1120), that is, 112 pixels right and 96 pixels up from center on a TS23-E1 image. See the title page and section 1.1.

2 Determining a disperser configuration

Here is an overview of the procedure in words, followed by a worked example.

This first section can be done away from the telescope:

1. Find the spectral feature or spectral region of interest on one of the images tabulated in section 1.2. In particular, choose the image in the set of 7 where the region of interest is closest to the central column.
2. Assuming the image selected above is displayed in ds9, load the region file referenced at the end of section 1.2. In loading a region file, make sure that in the ds9 *Edit* menu that *Regions* is selected. Also, during the loading of the region file look for the popup window that might be at some random location on the computer monitors. Complete the region loading with that popup.
3. The square region (the box) is the size of the TS21 field of view. Select the box (click inside it), and drag the box to position it on the spectral region of interest. Once the box is in approximately the right position, double click on the inside the box to open the popup window for the box. Fine positioning of the box can be done by entering the center coordinates

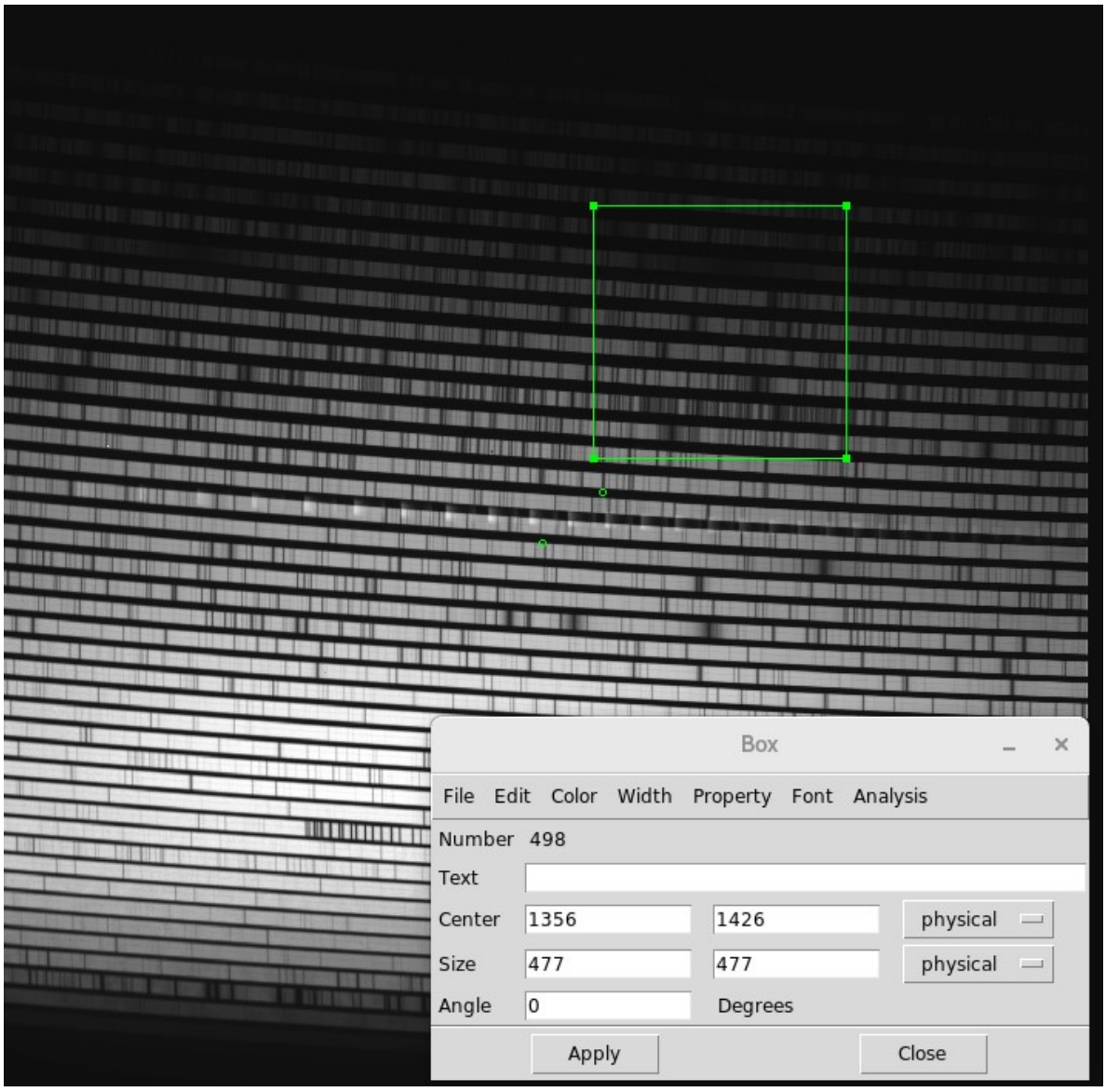
for the box as numbers (to the nearest pixel) and clicking *Apply*. It can be helpful to screenshot the image once the positioning is finished.
4. When the box position has been fine tuned, read the center position of the Box from the popup window (to the nearest pixel)
5. Determine how much the Box was moved (delta-columns and delta-rows) from its original position given in section 1.4 as (column,row)=(1136,1120)
6. Covert the image deltas to echelle and prism deltas using the *echelle and prism factors* given in sections 1.3.2 and 1.3.3, respectively
7. Apply the echelle and prism deltas to the prism and echelle values given in section 1.2 table for the image selected in step 1 above

Then, during instrument configuration when using TS21

1. the prism and echelle values determined in step 7 can be applied to the dispersers using *tsgui* to get to approximately the required spectral region
2. Take TS21 images and refine the position. Use the TS21 *Echelle and prism factors* given in sections 1.32. and 1.3.3 to move the image around

Example

The Ca K line is wanted plus spectral lines to its red. Image TS23-E1-SP-5red is selected, the TS21 region Box is positioned suitably on the image, and the center of the box is determined to be (1356,1427) per the image below



Per section 1.4, the center of the actual TS21 field of view is at (column,row)=(1136,1120) on the TS23 image, so on TS23 the image must be moved left (negative) by (1136-1356)=220 pixels, and down (negative) by (1120-1426)=306 pixels.

Using the appropriate *factors* in sections 1.3.2 and 1.3.3, the echelle position value must be increased by (220*26)=5720 units (positive is a move left), and the prism position value must be decreased by (306*51)=15,606 units (positive is a move up).

The reference image being used has an echelle value of 1,620,000 (see the table), which must be changed to (1,620,000+5,720)=1,625,720, and the prism value is 137,452, which must be changed to (137,452–15,606)=121,846

Setting the echelle and prism positions to the values determined above should put the spectral region of interest on the detector for TS21-E1-TK3. This will need some adjustment when at the telescope. Following is a hypothetical example.

The TK3 CCD is binned 1x2 = column-binning x row-binning. An image is taken and it is determine that the image should be moved on the CCD 200 pixels to the right (in the normal ds9 display) and 50 pixels up. The echelle and prism factors in sections 1.3.3 and 1.3.4 are applied to determine the echelle position must be increased by (200x6.077)=1,215 echelle position units, and the prism position must be decreased by (50*23.839)=1,192 prism position units. The next positioning try (iteration) would be with the echelle at (1,625,720+1,215)=1,626,935 and the prisms at (121,846-1,192)=120,654. It may take more than one iteration to fine tune the position.