VBI IPC Manual

Date: July 11, 2022

Version: VBI IPC Manual 20220512-1 (release)

Version History

Date	Tool Version	Manual Edition	Items changed
May 14, 2020	20200515-1	20200515-1	Draft
June 11, 2020	20200515-1	20200611-1	Updated Use Case 1&2 as well as formatting throughout the document.
April 25, 2022	20200515-1	20220325-1	Updated JDK installation process.
May 12, 2022	20200515-1	20220512-1	Updated JDK installation process to v18; changed download location info from DropBox to Bitbucket/git.
July 11, 2022	20200515-1	20220711-1	Added warning regarding Mac M1 chip java incompatibility and workaround options.

Table of Contents

List of Figures

INTRODUCTION

1.1 Overview

This manual describes the functionality and the use of the Instrument Performance Calculator (IPC) tool for the Visible Broadband Imager (VBI). This software enables testing of various use cases for acquiring scientific data with the VBI.

1.2 Scope

The VBI IPC software is a standalone tool, and therefore it may not reflect the current operational status of the instrument. Users should refer to the proposal call to understand what is available via the DKIST's current conditions at the time.

1.3 Audience

The document should prove useful to anyone looking to prepare a proposal to observe with the VBI or anyone requiring a further understanding of a particular part of the VBI IPC tool's functionality.

1.4 Features

The VBI IPC software provides the following functionality:

- Ability to create observing sequences for VBI Red and VBI Blue independently.
- Ability to synchronize VBI Red and VBI Blue with different options and visualize the timeline resulting in the execution of both sequences.
- Ability to compare cumulative data rate for a sequence with the allowable (peak) data rate defined for the instrument.
- Ability to save configurations and load previously created configurations.
- Ability to display individual wavelength ranges for each.

1.5 Glossary

DKIST	Daniel K. Inouye Solar Telescope
FOV	Field of View
GiB	Gibibyte
GUI	Graphical User Interface
IPC	Instrument Performance Calculator
JDK	Java Development Kit
JRE	Java Runtime Environment
MiB	Mebibyte
NSO	National Solar Observatory
ROI	Region of Interest
VBI	Visual Broadband Imager

1.6 Reference Documents

- NSO/DKIST VBI webpage: https://www.nso.edu/telescopes/dkist/instruments/vbi/

GENERAL INSTRUMENT DESCRIPTION

The Visible Broadband Imager (VBI) is a DKIST First Light Instrument capable of creating movies (from fast cadence images) of layers in the solar atmosphere.

The VBI0 consists of two channels, one operating within the spectral range between 390-550nm ("VBI blue"), and one operating within the spectral range between 550-860nm ("VBI red").

Figure 1 shows the two channels of VBI represented with the respective colors for the light paths Blue and Red.

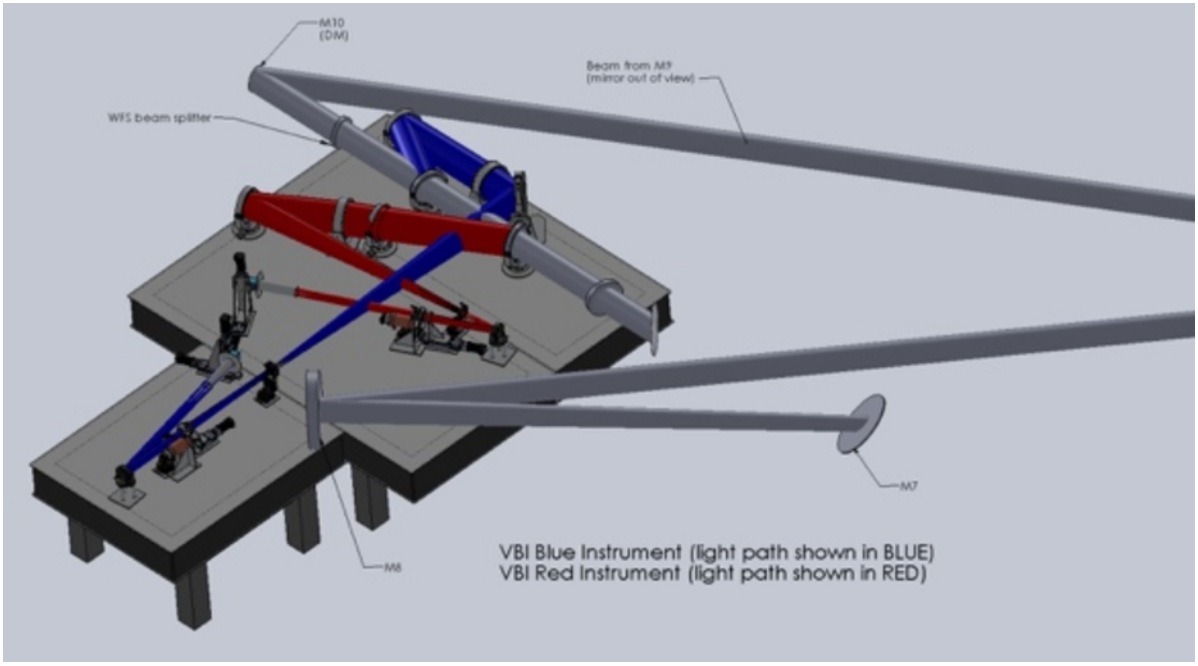

Figure 1: VBI Red and VBI Blue Channels

More information about the Instrument can be found in the following links:

https://www.nso.edu/instruments/

https://www.nso.edu/telescopes/dkist/instruments/vbi/

GETTING STARTED

3.1 Prerequisites to run the software

The VBI IPC tool was developed to run with Java. Described below is the process for downloading and installing the software needed to run this tool.

Warning: The VBI IPC & FIDO Tool do not run on the new Mac M1 architecture, as there is an incompatibility with Java. We ask that users use a different machine to run these DKIST tools, or a Linux VM, or under Parallels-Windows architectures. If you need assistance, please submit a ticket using the DKIST Help Desk.

3.1.1 Java OpenJDK

3.1.1.1 Windows Installation Process

Download Temurin for Windows (OpenJDK)

- The user can download an installer package Temurin from the following link: https://adoptium.net/temurin/releases
- Select the latest version and windows operating system (Figure 2). Click the .msi button to download.

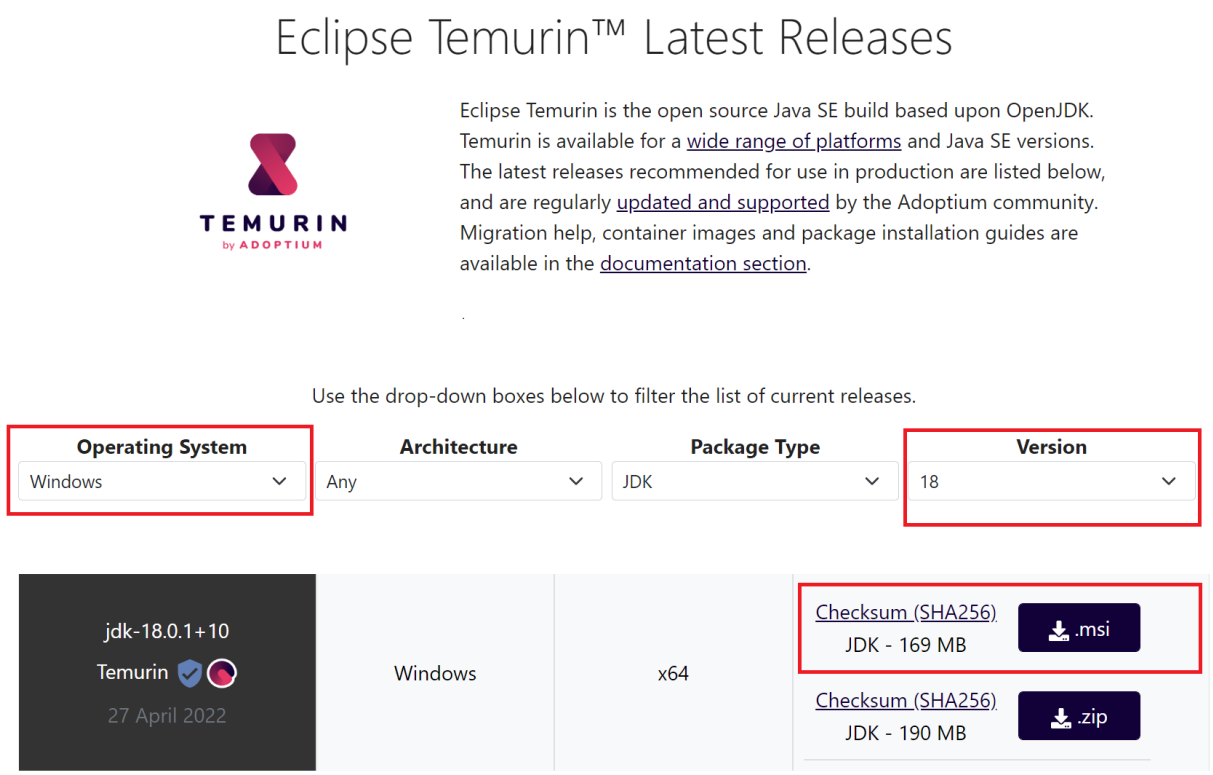

Figure 2: Download Tumerin (OpenJDK) selection

Start the installation procedure:

- After the installer file download, **open (or execute)** the file as it is described in (Figure 3).

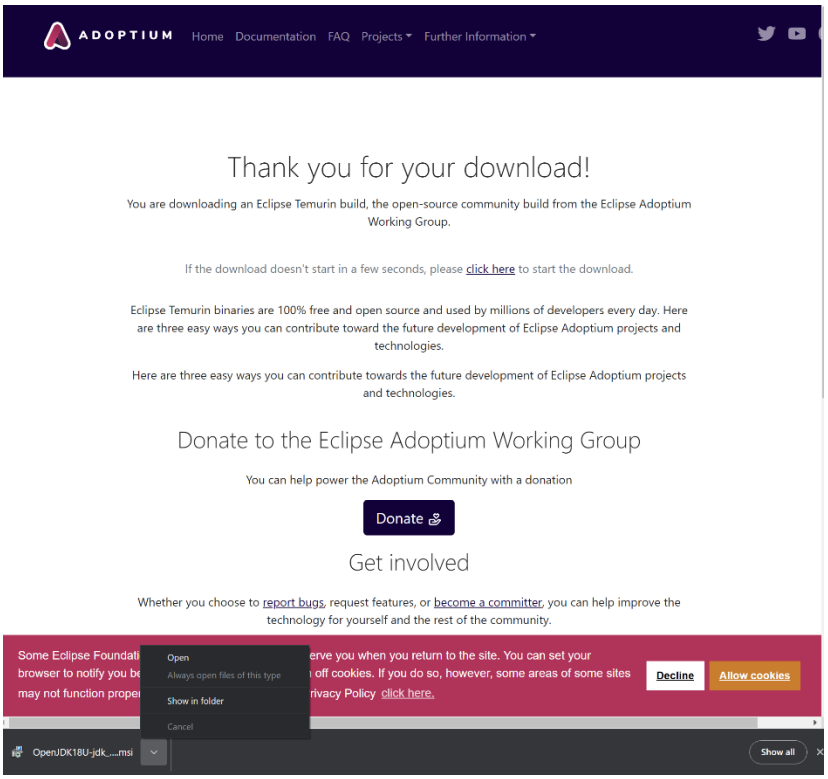

Figure 3: Execute the installation file.

- The process to install the software will start with the first window, click in **<Next>** button as is described in Figure 4.

- In the next window, read and accept the End-User License Agreement. Press **<Next>** button

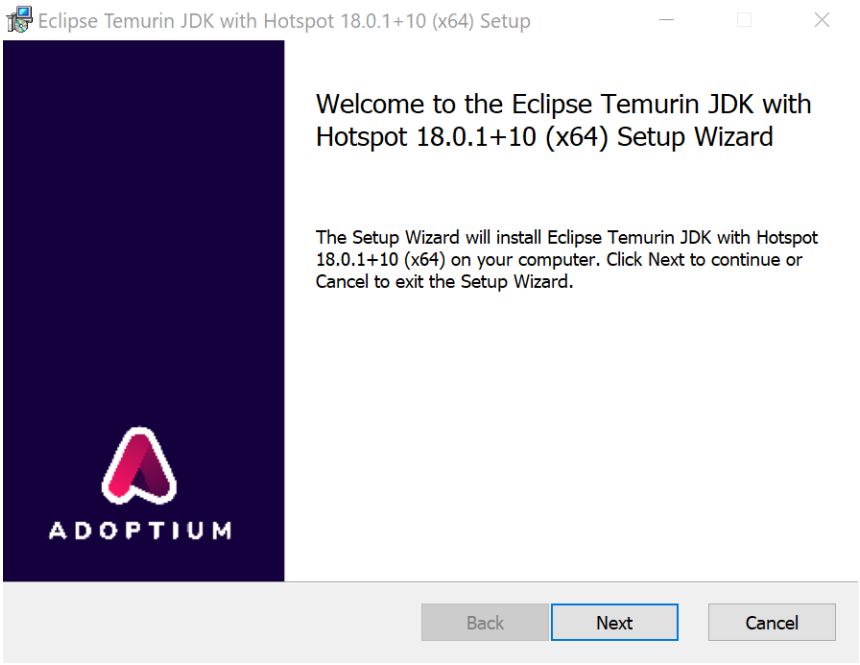

Figure 4: Window to start the installation process for Eclipse Temurin JDK

- In the next window, shown in Figure 5, the user must accept the custom setup by default. No changes are needed. Press the **<Next>** button.

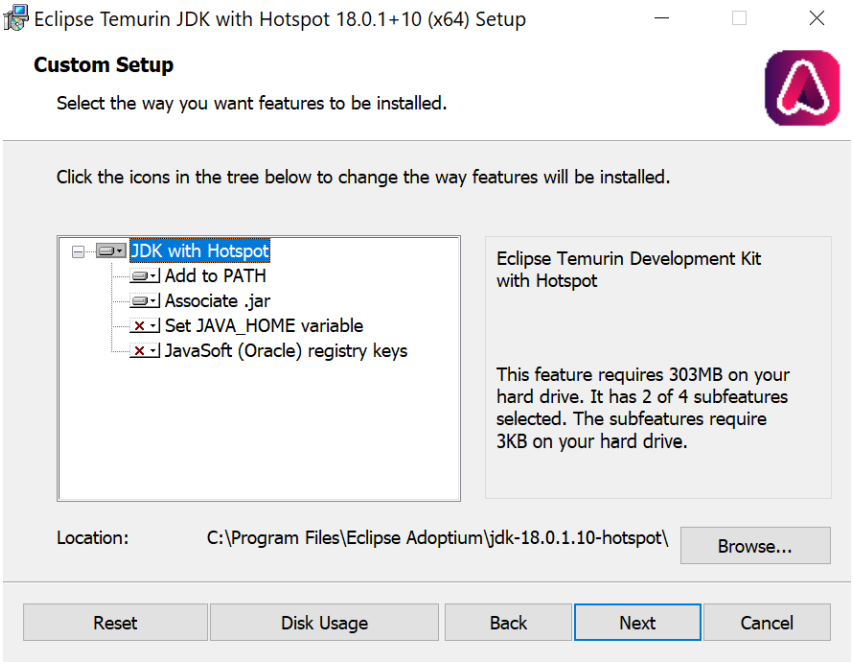

Figure 5: Window to select default features to install Eclipse Temurin JDK

- In the next window displayed in Figure 6, the user with administrator privileges must accept to start the installing process. The installation process will take ~20 seconds to be completed.

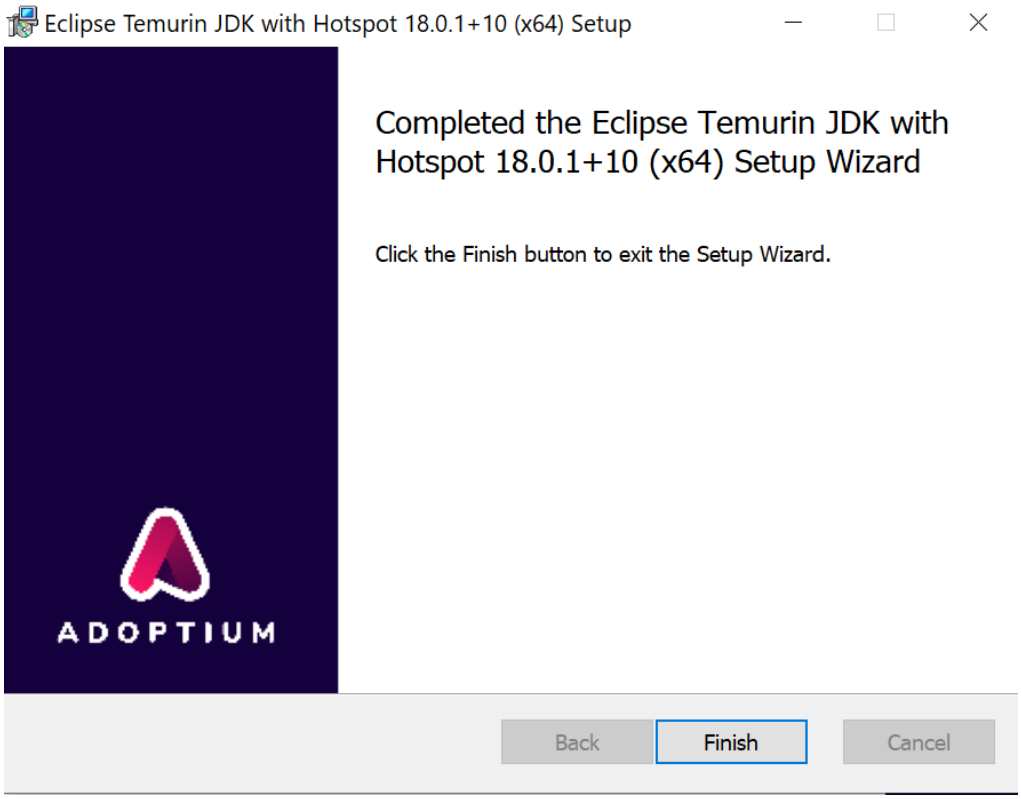

Figure 6: Window to begin the installation of files in the system.

- Once the installation is completed, press **<Finish>**.

3.1.1.2 Linux Installation Process

OpenJDK (Eclipse Adoptium) RPM and DEB packages are available for installing on your favorite Linux distribution.

Installation on Debian or Ubuntu

- Import the official Eclipse Adoptium GPG key by running the following command:

```
wget -O - https://packages.adoptium.net/artifactory/api/gpg/key/public | tee
/usr/share/keyrings/adoptium.asc
```

- Import the Eclipse Adoptium apt DEB repository by running the following command:

```
echo "deb [signed-by=/usr/share/keyrings/adoptium.asc]
https://packages.adoptium.net/artifactory/deb $(awk -F=
'/^VERSION_CODENAME/{print$2}' /etc/os-release) main" | sudo tee
/etc/apt/sources.list.d/adoptium.list
```

- If you get a command not found error, try running:

```
sudo apt-get install -y wget apt-transport-https
```

Then repeat the first command.

- Refresh your package list with

```
sudo apt-get update
```

- Then install your chosen Temurin version (OpenJDK)

```
sudo apt-get install temurin-18-jdk
```

Installation on Centos, RHEL, or Fedora

The following steps describe how to install an RPM package for Centos. To install an RPM for RHEL or Fedora update the baseurl value accordingly.

- Add the appropriate RPM repository to your /etc/yum.repos.d/adoptopenjdk.repo file, by running the following command:

```
cat <<EOF > /etc/yum.repos.d/adoptium.repo
[Adoptium]
name=Adoptium
baseurl=https://packages.adoptium.net/artifactory/rpm/centos/\$releaseever/\$
basearch
enabled=1
gpgcheck=1
```

```
gpgkey=https://packages.adoptium.net/artifactory/api/gpg/key/public
EOF
```

- Install OpenJDK

```
yum install temurin-18-jdk
```

Installation on openSUSE or SLES

The following steps describe how to install an RPM package on openSUSE v15.1. To install an RPM for SLES, or to install a different version of openSUSE, switch the baseurl value

- Add the appropriate RPM repository to your /etc/yum.repos.d/adoptopenjdk.repo file, by running the following command:

```
zypper ar -f
https://packages.adoptium.net/artifactory/rpm/opensuse/15.2/$(uname -m)
adoptium
```

- Install Temurin

```
zypper install temurin-18-jdk
```

3.1.1.3 macOS Installation Process

Warning: The VBI IPC & FIDO Tool do not run on the new Mac M1 architecture, as there is an incompatibility with Java. We ask that users use a different machine to run these DKIST tools, or a Linux VM, or under Parallels-Windows architectures. If you need assistance, please submit a ticket using the DKIST Help Desk.

Download Temurin for macOS (OpenJDK)

- The user can download an installer package Temurin from the following link: https://adoptium.net/temurin/
- Select the latest version and windows operating system <Other Platforms> button as is described in Figure 7.

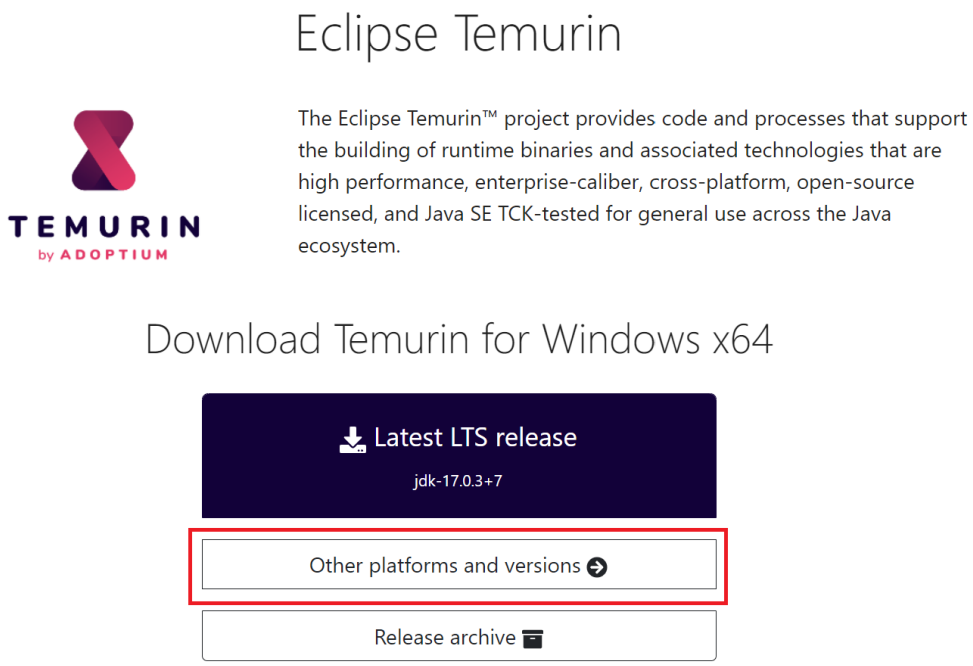

Figure 7: Download window with selection to search Temurin for macOS

Select the operating system "macOS" and proper architecture. In the example described in Figure 8 the selection is "x64" for macOS 64Bits. The user must select the *.pkg file for JDK (no JRE) to download the installation file.

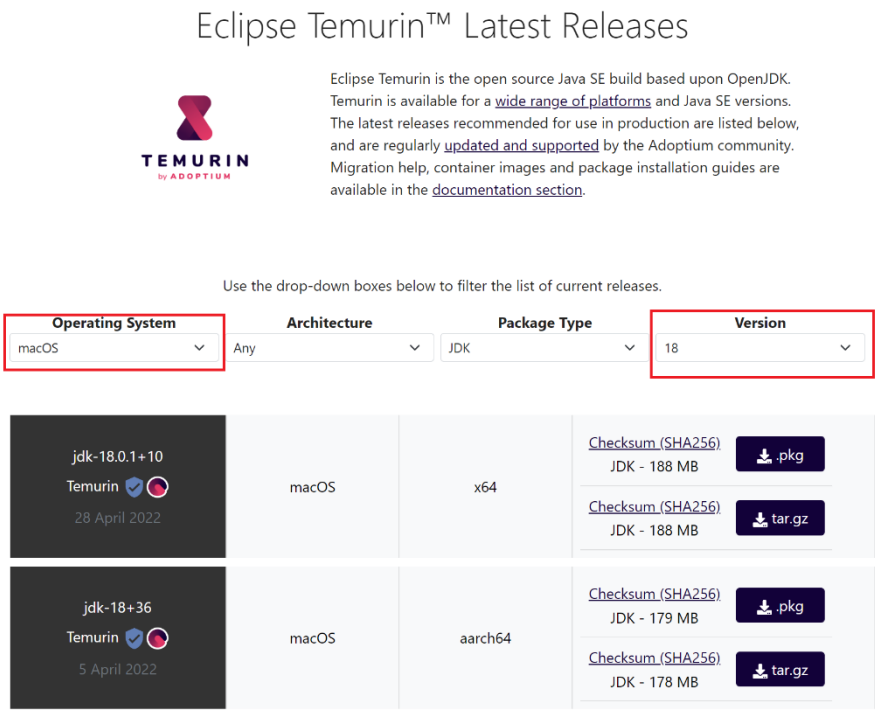

Figure 8:Download window with specific selection to download Temurin for macOS

Installation procedure (macOS)

- Once downloaded, **open** the file to start the installation process.
- The process to install the software will start with the first window as it is shown in Figure 9. The user must confirm the package to install and press <continue>

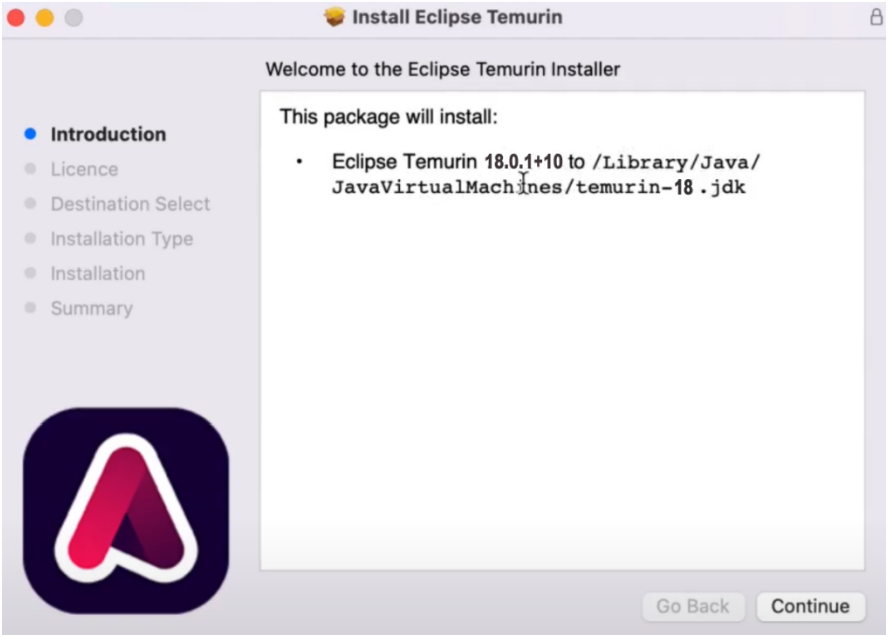

Figure 9: Confirmation window to install Temurin

- The next step in the process is to Read and Accept the End-User License Agreement. Press **<Continue>** button.
- To confirm the installation process, shown in Figure 10, press <Install>.

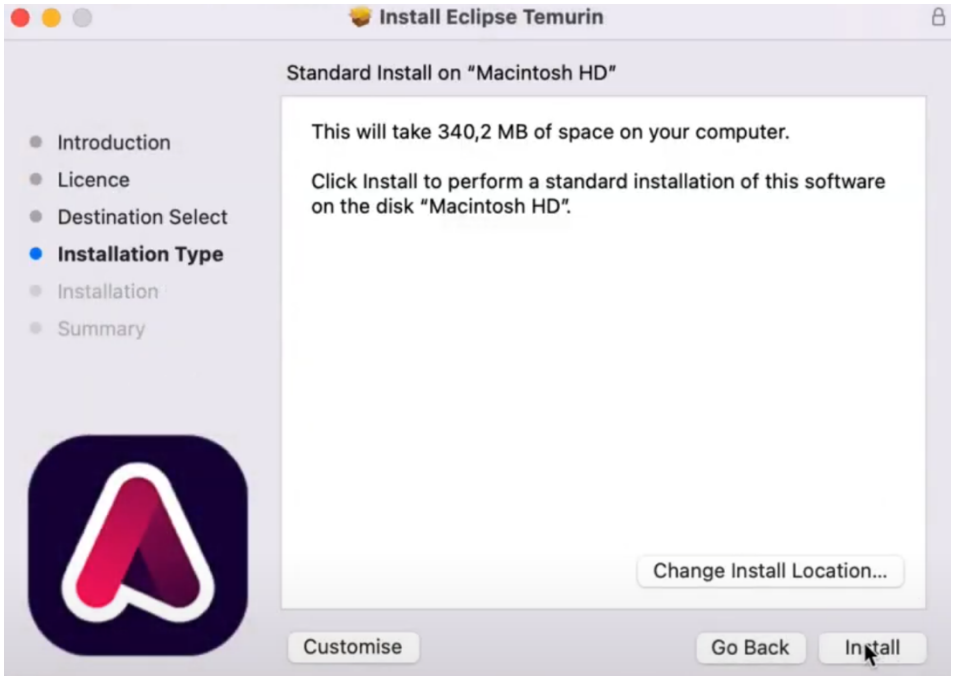

Figure 10: Confirmation window to install Temurin in macOS

- Wait until the installation process is completed successfully.

3.2 Download and Install VBI IPC Software.

- The VBI IPC software must be downloaded from the following NSO/DKIST webpage: https://www.nso.edu/telescopes/dkist/instruments/vbi/

In the right column of the page, there is a link to download the VBI IPC software (VBI IPC download) as is indicated in Figure 11. Click on the link and the user will connect with a Git repository on Bitbucket.

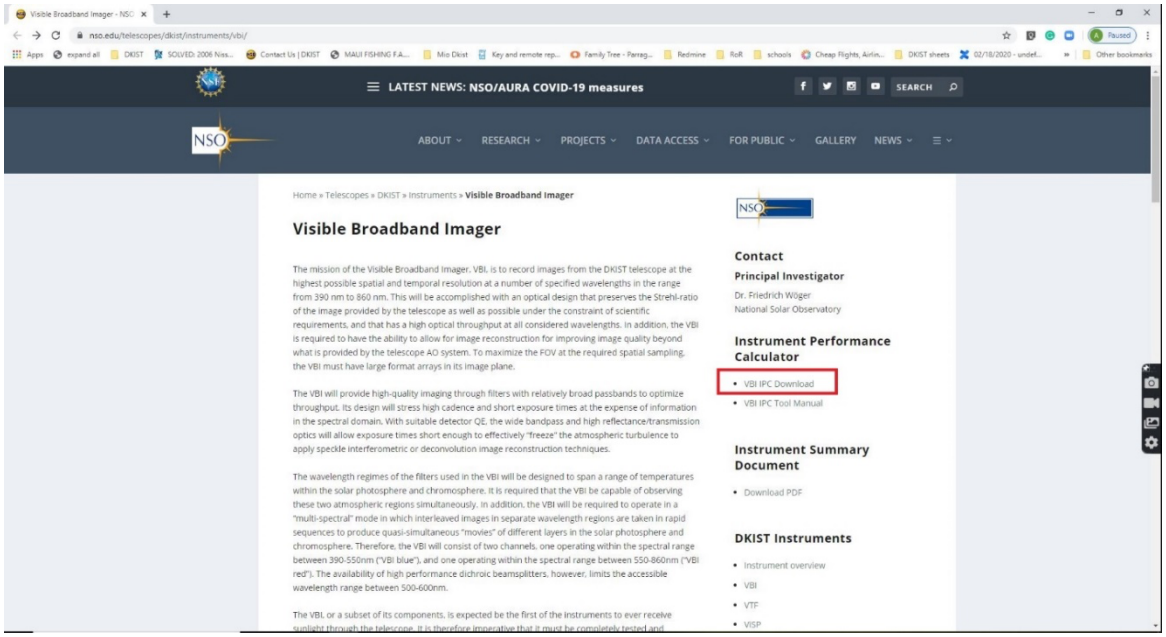

Figure 11: Link to the download Dropbox Page for VBI IPC Software.

- The browser will automatically start to download a compressed zip file from Bitbucket https://bitbucket.org/dkisthls/vbi_ipc/downloads/dkist.ipc.vbi.zip to your downloads area

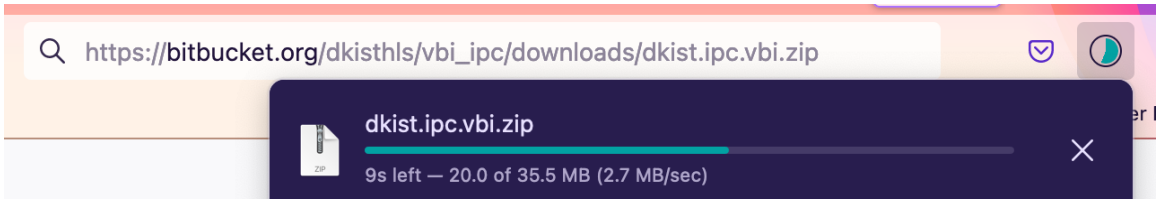

Figure 12: Download process for VBI IPC Software.

- Extract the files in the folder of your preference.
- **No installation is needed**.

3.3 Run the VBI IPC Software.

For all Operating Systems, the user will need to have privileges as an administrator to execute this software.

3.3.1 Windows

- The user can run the VBI IPC software by double-clicking in the file: ***/vbiipc/bin/vbiipc.bat***

3.3.2 Linux

- The user must run the VBI IPC software from the ***vbiipc*** directory using the following command:

```
./bin/vbiipc
```

3.3.3 macOS

- The user can run the VBI IPC software by double-clicking in the file: ***/vbiipc/bin/vbiipc***

SOFTWARE DESCRIPTION

4.1 VBI IPC Main Panel (GUI)

Once the user executes the *vbiipc* file, the VBI IPC software will open the Main Panel as it is shown in Figure 13.

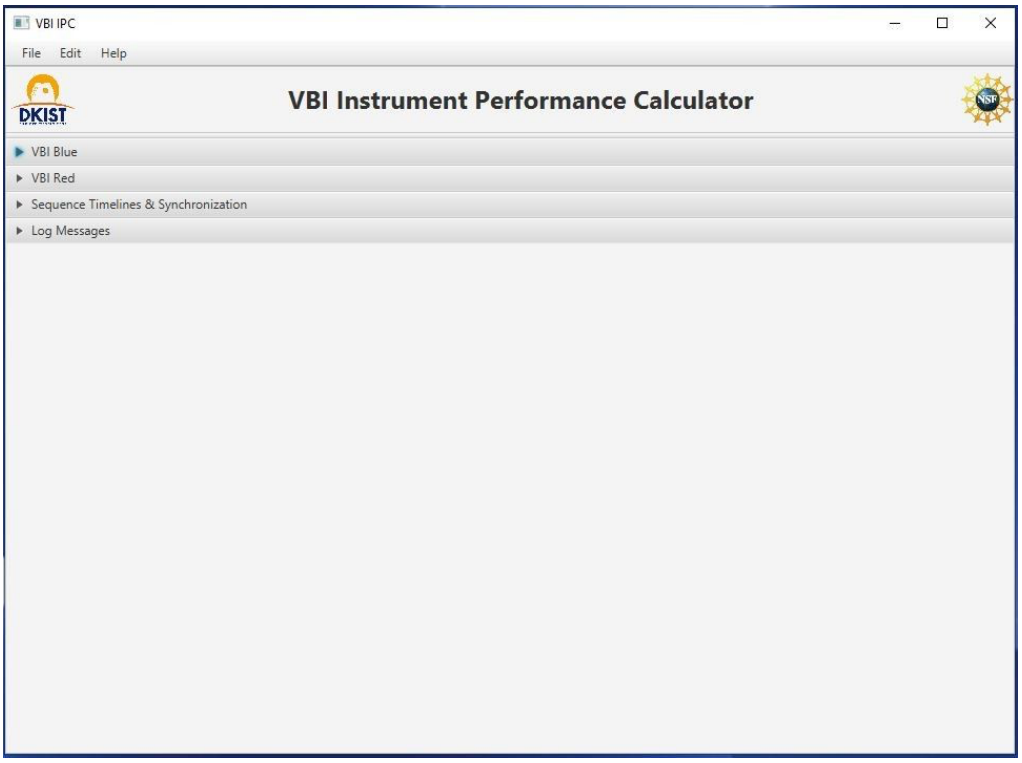

Figure 13: VBI IPC Main Panel (GUI)

4.2 Menu Options

The toolbar at the top of the GUI displays three dropdown menus: File, Edit, and Help.

4.2.1 File Menu

Figure 14 shows the options under the File section.

Figure 14: VBI IPC Menu Options under the "File" section.

- **Open:** Open a previously saved file.
- **Save:** Save the current progress in the current file.
- **Save As:** Save the current progress as a different (or new) file.
- **Quit:** Quit the program.

4.2.2 Edit Menu

Figure 15 shows the options under the Edit section.

Figure 15: VBI IPC Menu Options under the "Edit" section.

- **Distance from Disk Center:** Adjust the anticipated linear distance from disk center 0 (disk center) ≤ input distance ≤ 1 (solar limb) The input value will be converted to the appropriate value for μ, the cosine of the viewing angle.
- **Expert Mode:** Toggle to allow the modifying of individual data sets that are non-standard. The use of this mode is subject to review and should be based on a very sound scientific justification.

NOTE: Switching to Expert Mode and back will lose your progress on generating the sequence. This is to ensure that no parameters were changed that could lead to invalid scientific data.

4.2.3 Help Menu

Figure 16 shows the options under the Help section.

Figure 16: VBI IPC Menu Options under the "Help" section.

- **Quick Help:** Opens a window with brief usage instructions
- **About:** Lists the authors who have created this program

4.3 Instrument Characteristics

VBI has two channels - red and blue - which act as two individual sibling instruments covering two different wavelength ranges.

Channel	Blue	Red
Reference Wavelength (nm)	430.5	656.3
Field of View (arcsec)	45	69
Spatial Sampling (arcsec/pixel)	0.011	0.017
Diffraction-Limited Resolution (arcsec)	0.022	0.034

4.3.1 Instrument Main Panel

Figure 17 shows the Main Instrument Panel with sections in different colors for the description below.

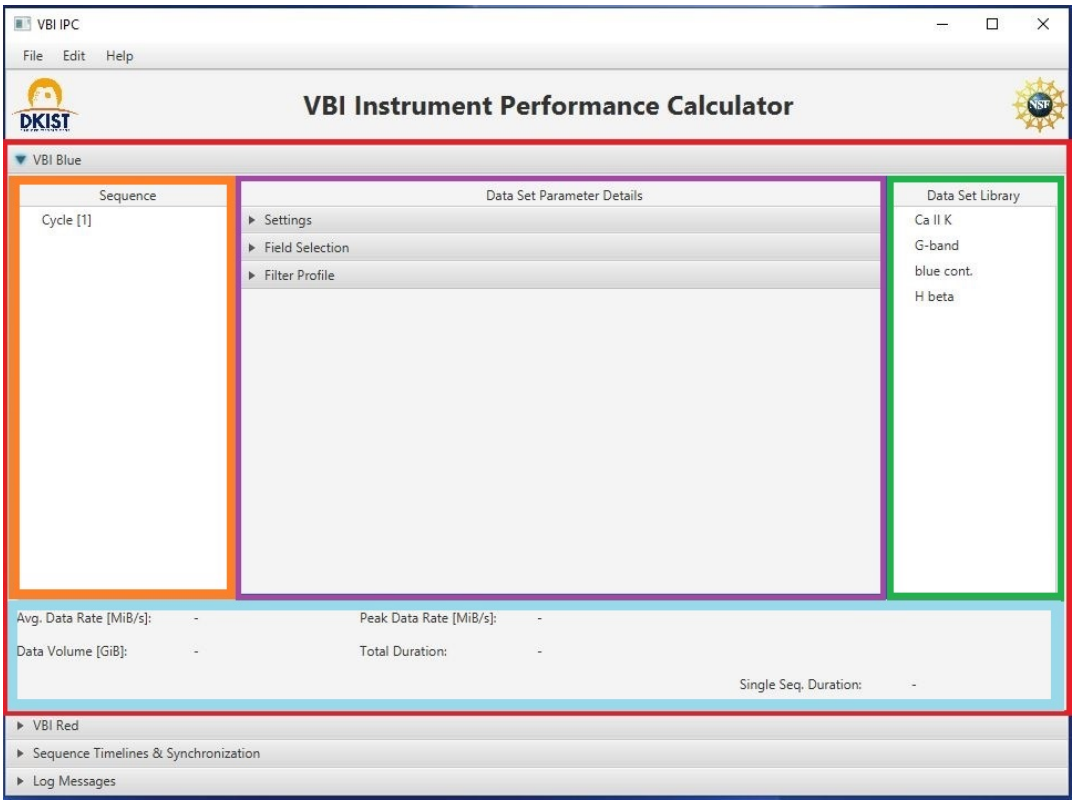

Figure 17: VBI IPC Instrument Panel Sections.

- **Pane (red):** This shows the area in which all details for one VBI Arm (Blue and Red) can be set. The user can click on "VBI Blue" or "VBI Red" to adjust the sequences for the respective arm.
- **Sequence Tree (orange):** This is the area where the sequence tree for one arm is built up.
- The user can drag and drop items from the **Data Set Library** to this area to populate the tree.
- Use a mouse 'right click' to open up a context menu to set cycle repeats (or double click the relevant "Cycle"), create new (sub-)cycles, or delete items.
- The sequence items can be rearranged via drag-and-drop in the tree.
- **Data Set Parameter Details (purple):** The sub-panes in this area (Settings, Field Selection, Filter Profile) allow the user to view and modify the parameters of the items in the Sequence tree.
- **Data Set Library (green):** In this area, there are pre-configured items that serve as 'good' starting points to generate a working sequence. These items cannot be modified.
- **Summary field (teal):** In this area, critical information is displayed that allows the user to verify cadence, duration, and data volume created by the sequence.

4.3.2 Instrument Sub-Panes

4.3.2.1 Settings Sub-Pane

The settings sub-pane, described in Figure 18, allows adjustment of most parameters that lead to data creation.

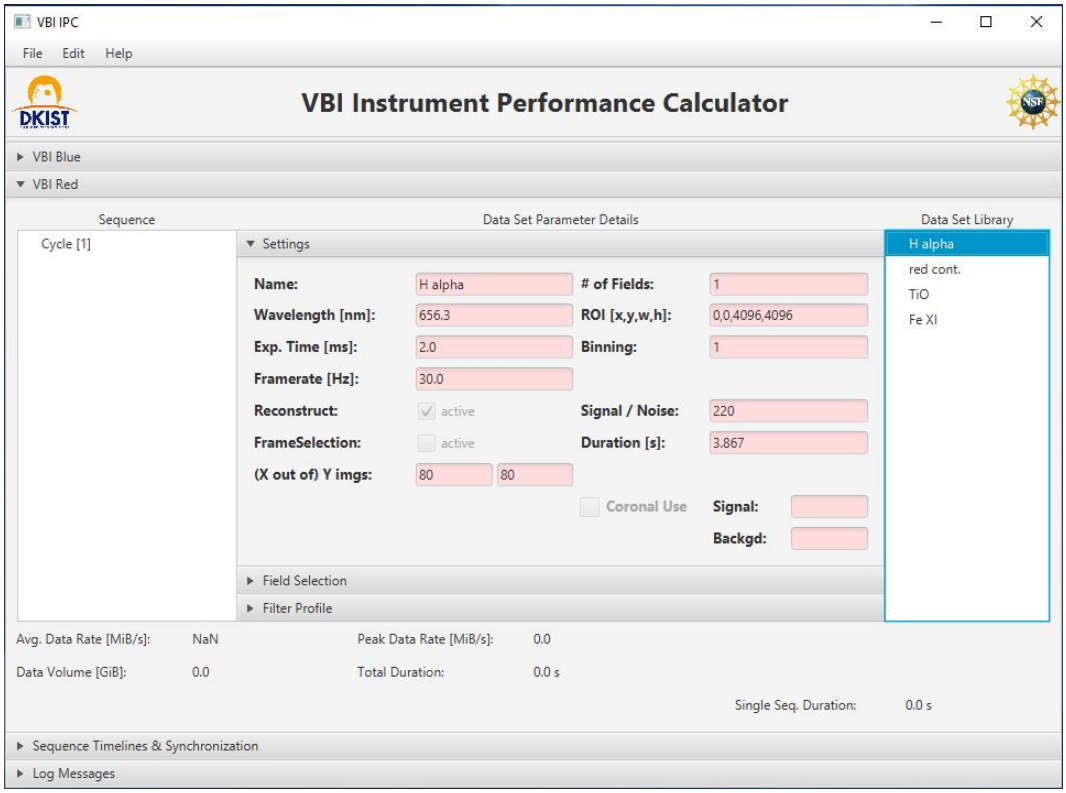

Figure 18: VBI IPC Instrument Settings Sub-Pane

Some of these parameters depend on each other, and these dependencies are verified when values are entered into the fields, in particular:

- **Exposure time [ms]:**
    - **Frame rate [Hz]:** The frame rate takes precedence over exposure time. If an exposure time entered is incompatible with the frame rate, the exposure time will be adjusted appropriately.
    - **Signal-to-Noise:** Each pixel has a limited full well capacity for photoelectrons. If the full well is exceeded, the pixel is over-exposed. The internal flux calculator of the VBI calculates- using the input exposure time - the number of photons to be expected per pixel, and adjusts the exposure time to be compatible with the full well capacity of the sensor.

- **Frame rate (expert mode only):**
    - **ROI [x,y,w,h] (Region of interest):** the ROI / frame rate settings must be compatible with the 960 MiB/s maximum bandwidth restriction
    - **Binning:** see a.

The Instrument Performance Calculator does not restrain the frame rate in combination with binning and ROI as long as the bandwidth restriction is satisfied. However, further restrictions might apply that will limit the frame rate in the future.

- **Reconstruct flag:**
    - **(X out of) Y Images** (number of images (X/Y)): Speckle image processing requires appropriate statistics to compute a robust reconstruction. This is provided by a sufficient number of independent exposures. At minimum 80 images are required to compute a reconstruction. This will be enforced when frame selection is chosen, as well.
    - **ROI [x,y,w,h] (Region of interest)**: Region of interest cannot be used when reconstruction is selected.
    - **Binning:** Binning cannot be used when reconstruction is selected.

Disabling the Reconstruct flag will require additional scientific justification.

- **Frame Selection flag:**
    - **Number of selected images (X):** the value has to be smaller or equal to the number of acquired images (Y).
    - **Reconstruct flag:** the number of selected images must be at minimum 80 if both frame selection and reconstruct is selected.
- **ROI [x,y,w,h] (Region of interest)** (expert mode only)**:**
    - Allowable values must be compatible with the 4096x4096 pixel sensor.
    - **Number of fields:** ROI is only available if a single field is selected, as otherwise, discontinuities in the field coverage are easily possible.
    - **Reconstruct flag:** ROI is not available when the Reconstruct flag is enabled.
- **Binning** (expert mode only)**:**
    - Allowable binning factors are integers between 1 and 4.
    - **Reconstruct flag:** Binning is not available when the Reconstruct flag is enabled.
- **Coronal Use** (expert mode only, Fe XI is the only coronal diagnostic at the moment):

- **Signal:** enter the expected peak signal strength in millionth relative to disk center intensity. For example, an expected peak signal of 40 erg/(cm^2 * s * sr) is equivalent to about 18 millionth of disk center intensity.

- **Backgd:** enter the expected background strength in millionth relative to disk center intensity. 'Excellent' conditions correspond to 0-50 millionth, 'good' conditions correspond to 50-100 millionth.

4.3.2.2 Fied Selection Pane

The sub-panes shown in Figure 19 for VBI Blue and Figure 20 for VBI Red are for the user to select what part of the actual field of view (2x2 arcmin) must be sampled in the sequence.

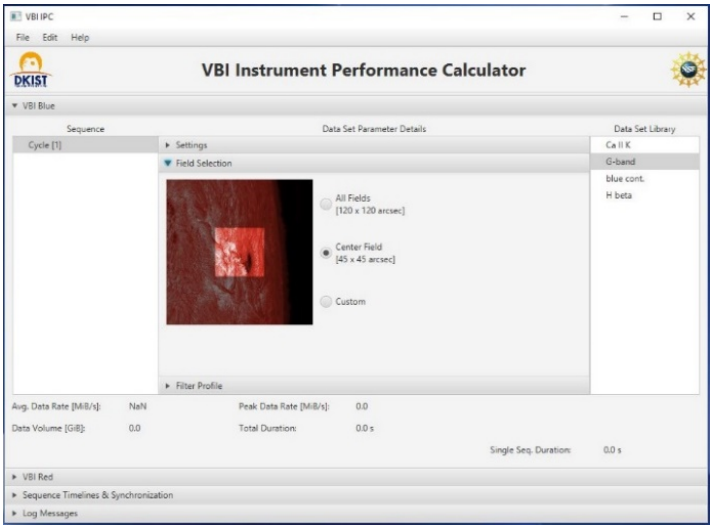

Figure 19: VBI IPC Field Selection pane for VBI Blue.

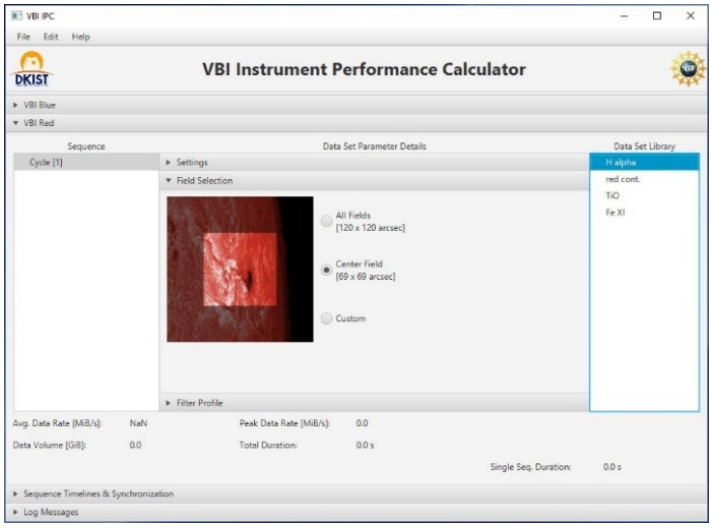

Figure 20: VBI IPC Field Selection pane for VBI Red.

In normal mode, the options are reduced to:

- **All Fields:** samples the full VBI FOV
- **Center Field:** sample only the center of the VBI FOV. For VBI Blue the center field is a FOV of 45x45 arcsec, while for VBI Red the center field is a FOV of 69x69 arcsec.
- **Custom** (expert mode option): a custom field coverage can be selected by clicking on the image.

A custom field sampling pattern has the potential to reduce the cadence of each field step; the details of which have not been implemented to be shown in the IPC yet.

4.3.2.3 Filter Profile Pane

The Filter Profile pane is for informational purposes only (no parameters can be changed).

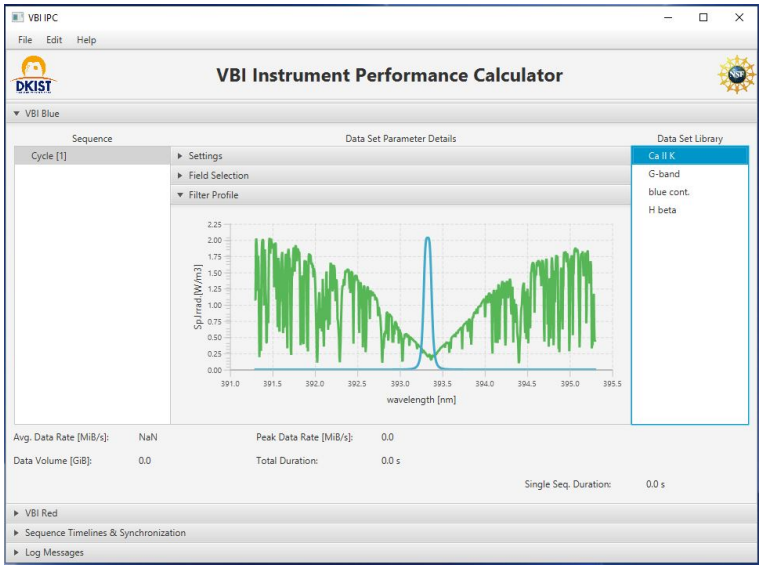

Figure 21: VBI IPC Filter Profile Pane

The user can select different filters in the Data Set Library Section to see the wavelength profile in the graph. An example is shown in Figure 21for Ca II K filter.

4.3.3 Sequence Timelines and Synchronization pane

The panel described in Figure 22 allows the user to set up synchronization parameters between VBI Blue and Red channels.

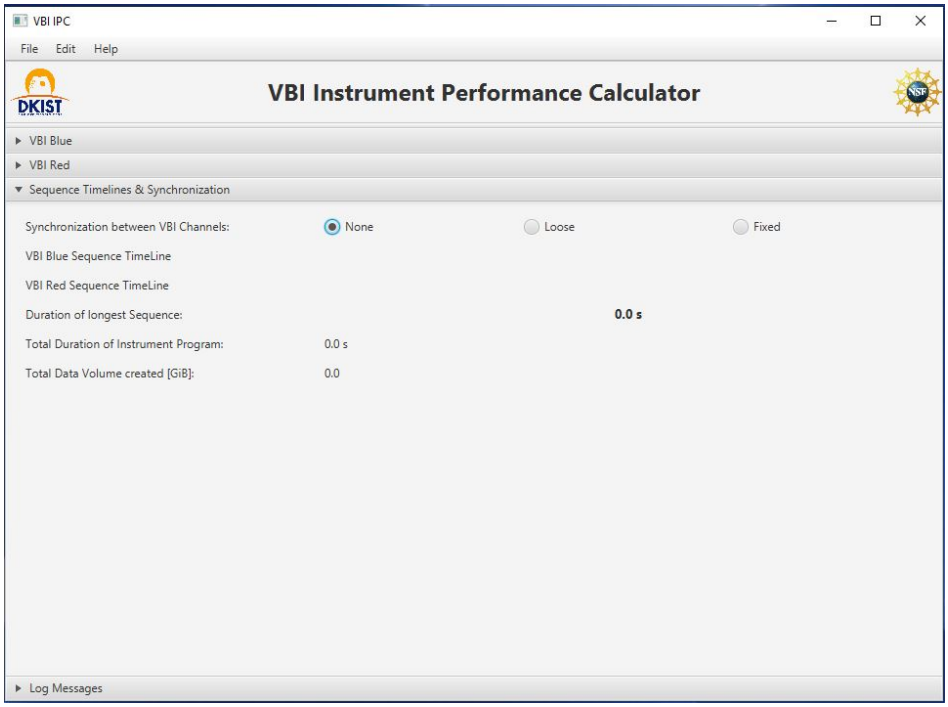

Figure 22: VBI IPC Synchronization and Sequence Timeline Pane

The options are:

- **None:** no synchronization; the data acquisition in both arms commences without coordination between the VBI Blue and Red channels.
- **Loose:** the start of each main cycle is synchronized between the VBI Blue and Red channels' sequence trees.
- **Fixed:** the start of each Data Set acquisition is synchronized between the VBI Blue and Red channels.

4.3.4 Log Messages pane

This pane allows reviewing any changes that the IPC made to the input. Figure 23 shows an example of some log messages after setting up a few simple parameters.

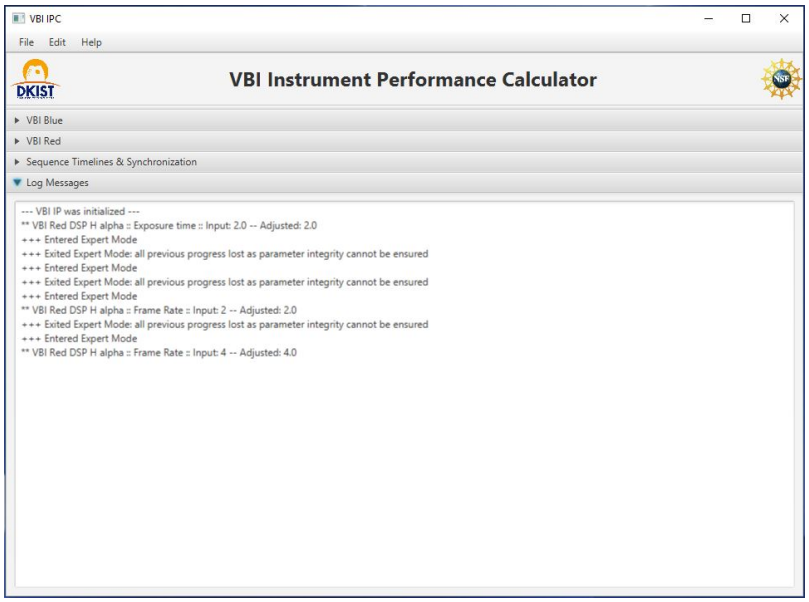

Figure 23: VBI IPC Log Messages pane

4.4 Outputs (results)

After the user creates the sequence with the required filters for each channel, some result information is available in the **summary section** for each channel and some global information in the **Sequence Timelines and Synchronization Pane**

4.4.1 Summary Information for VBI Blue & Red

With the list of filters included in the sequence, the **summary section** will be populated with the information needed to verify cadence, the total duration of the cycle, and data volume to be created by the sequence.

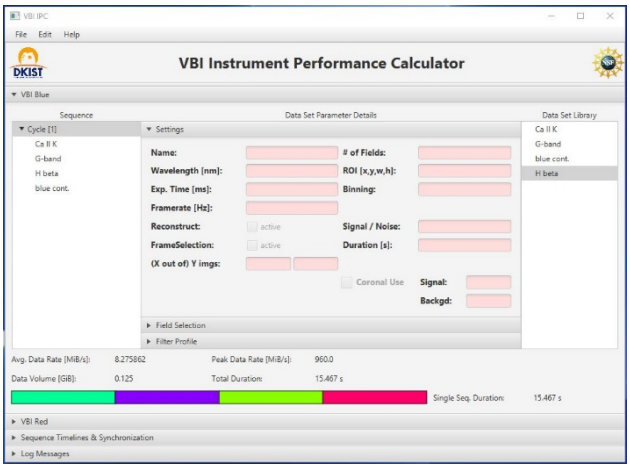

Figure 24: VBI IPC information for VBI Blue Sequence.

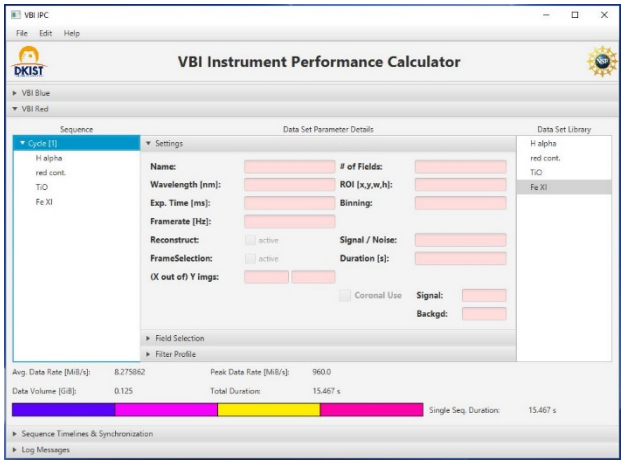

Figure 25: VBI IPC information for VBI Blue Sequence.

Figure 24 and Figure 25 show an example of VBI Blue and VBI Red respectively with one cycle and all of the filters in a sequence.

The information displayed here includes different variables:

- **Avg. Data Rate [MiB/s]:** The average data rate in MiB/s for all filters.
- **Peak Data Rate [MiB/s]:** The maxim data rate available in MiB/s for the exposures.
- **Data Volume [GiB]:** Total data generated after the execution of the cycle(s).
- **Total Duration [s]:** Total duration for the execution of the cycle(s). If the number of cycles is one, the total duration will be equal to the **Single Seq. Duration** time.
- **Single Seq. Duration [s]:** The duration for the execution of one cycle.

The horizontal bar with different colors represents the execution time for each filter in a sequence. The color definition for each filter/channel is shown in Figure 26 below.

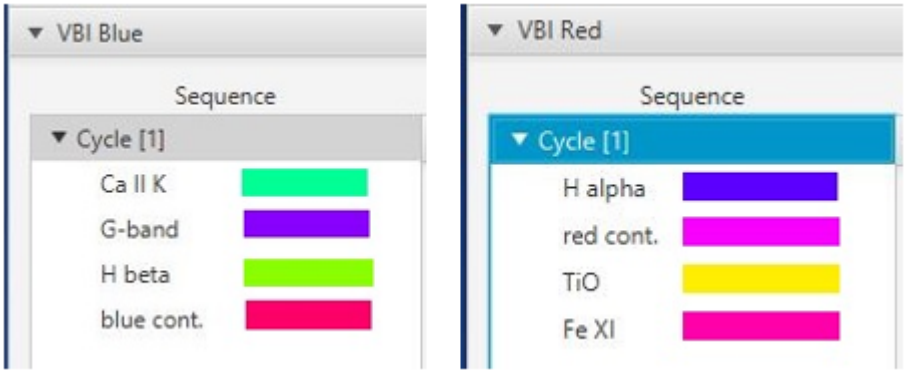

Figure 26: VBI IPC Color codes for Filters in the summary section.

4.4.2 Combined Timeline and Synchronization.

With the sequence configuration ready for both channels (VBI Blue & Red) the user must complete the process defining the synchronization mode for the combined execution as is shown in Figure 27.

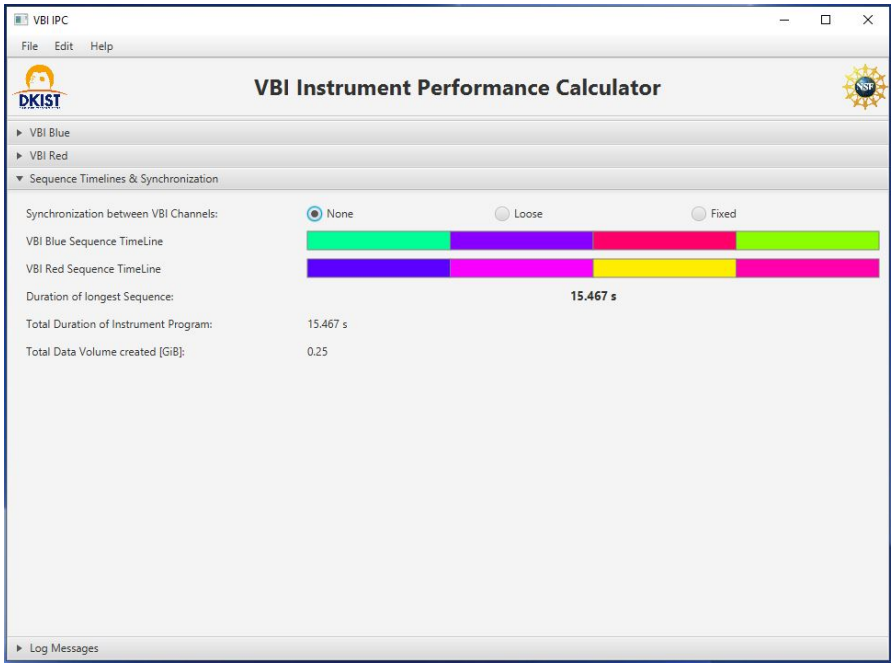

Figure 27: VBI IPC Channels Synchronization options and combined timeline

The information displayed here includes different variables:

- **Duration of Longest Sequence [s]:** Time needed to execute the longest sequence. This could be the sequence created for VBI Blue or VBI Red.
- **Total Duration of Instrument Program [s]:** Total time needed to execute all sequences. This parameter will change with the Synchronization mode defined by the user.
- **Total Data Volume created [GiB]:** Total of data generated after the execution of all sequences considering VBI Blue & VBI Red. This parameter will not change with the Synchronization mode defined by the user.

USE CASES

5.1 Use Case 1:

This use case utilizes VBI Blue to observe the photosphere and some aspects of the chromosphere. The sequence includes the following configuration parameters:

VBI BLUE		
Cycles	20	
Filters	Exposure time [ms]	Field Selection [arcsec]
G-Band	0.3	120x120
Blue continuum	0.2	120x120
H beta	3.0	120x120

The following Figure 28, Figure 29, and Figure 30 will show the configuration parameter for the Filters G-band, Blue Continuum, and H Beta respectively.

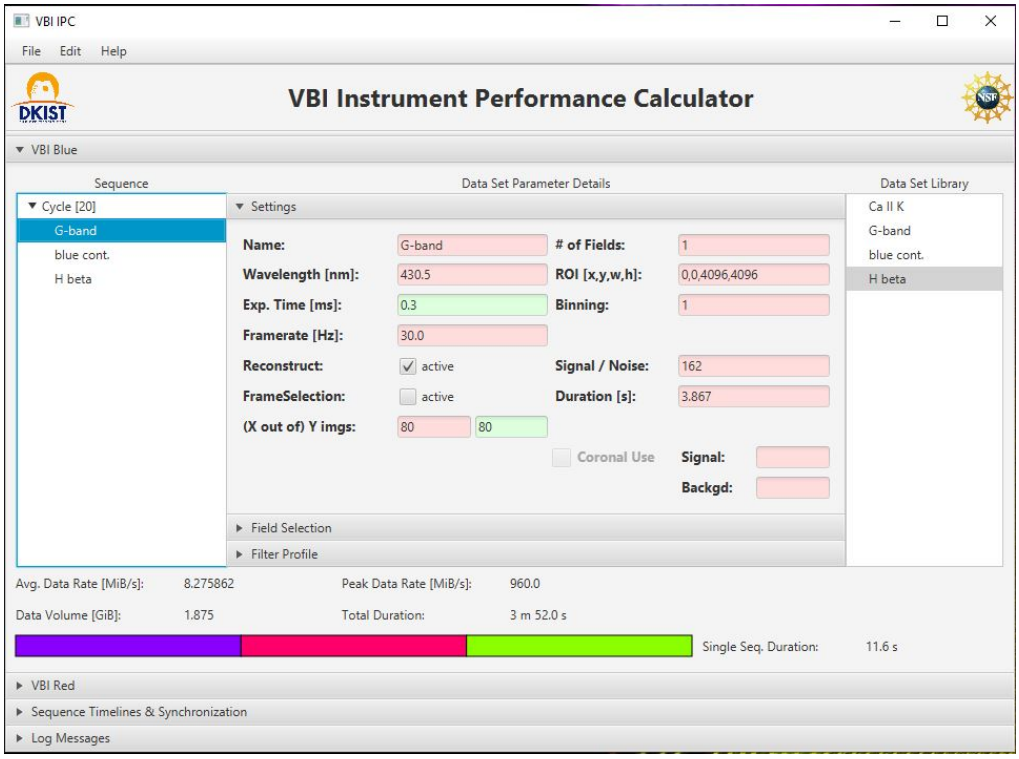

Figure 28: Use Case 1: G-Band parameters setup

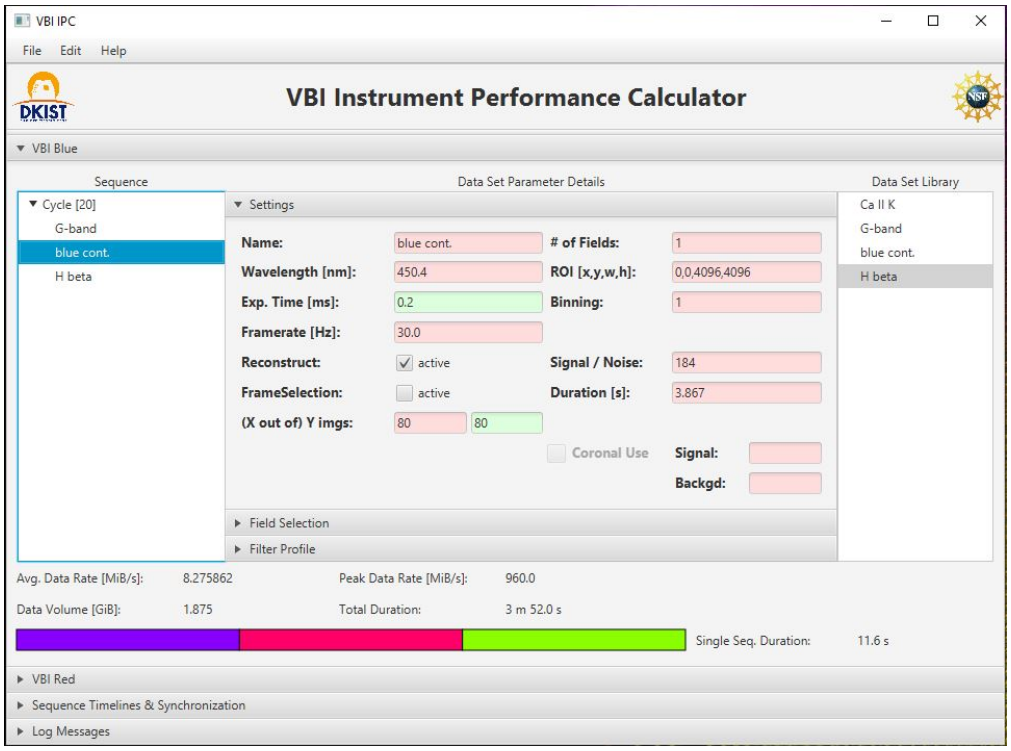

Figure 29: Use Case 1: Blue Continuum parameters setup

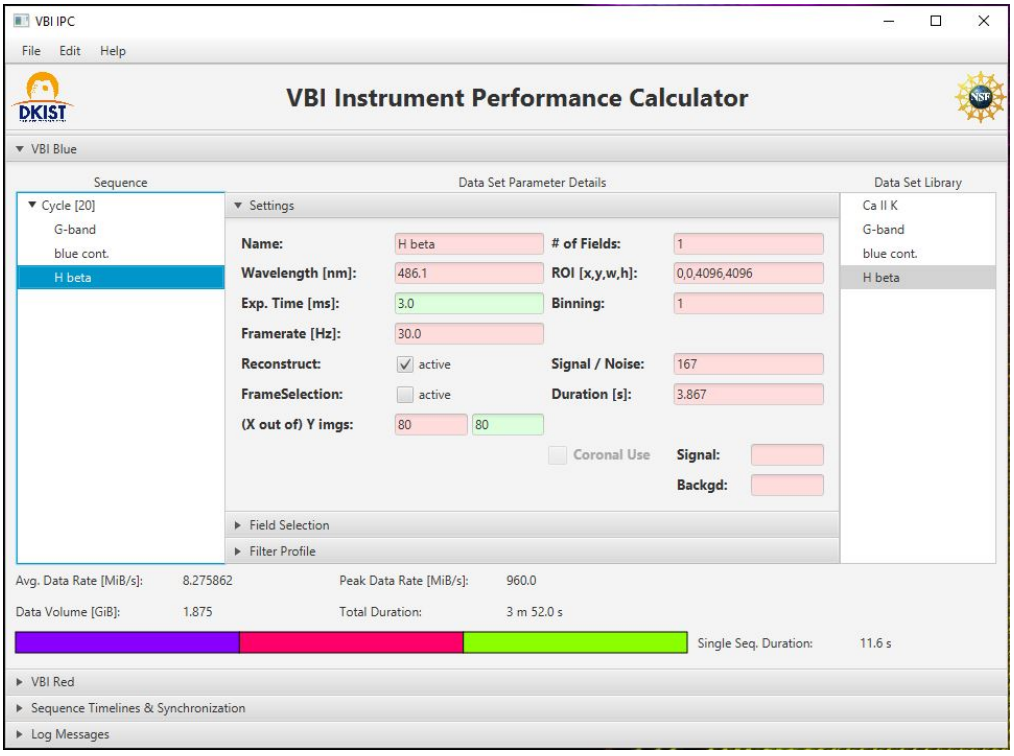

Figure 30: Use Case 1: H Beta parameters setup

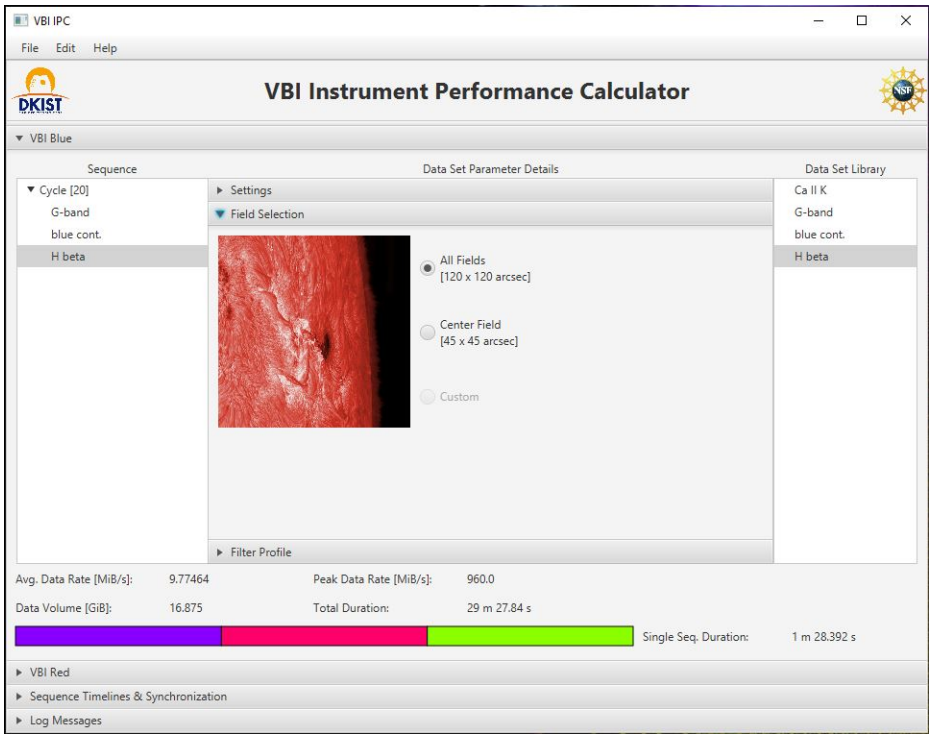

Figure 31: Use Case 1: Field Selection

In Figure 31 above is shown how to define the field selection to "All Fields" (120x120 arcsec) in this example. The field size must be selected for each filter in the sequence.

For the Sequence and Time Synchronization pane, the option to select is "**None"** since we are only observing with the Blue Channel as it is shown in Figure 32.

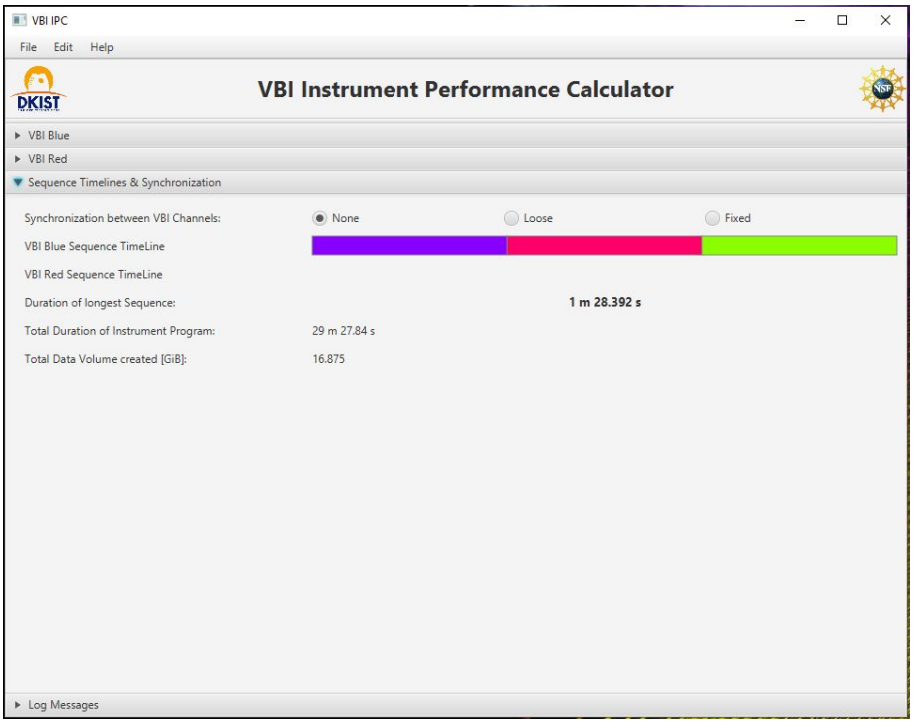

Figure 32: Use case 1: Synchronization and Times

The output displays both, the duration for each sequence equals to 1 minute and 28 seconds, and the total run time according to the number of cycles (20) is equivalent to 29 Minutes and 27.8 seconds.

5.2 Use Case 2:

This use case utilizes VBI Blue and VBI Red with different wavelengths and synchronization options. The sequence for channel Blue includes the following configuration parameters:

VBI BLUE		
Cycles	10	
Filters	Exposure time [ms]	Field Selection [arcsec]
Ca II K	30	120x120
H beta	3	120x120

The following Figure 33 and Figure 34 show the configuration parameter for the Filters Ca II, and H Beta respectively.

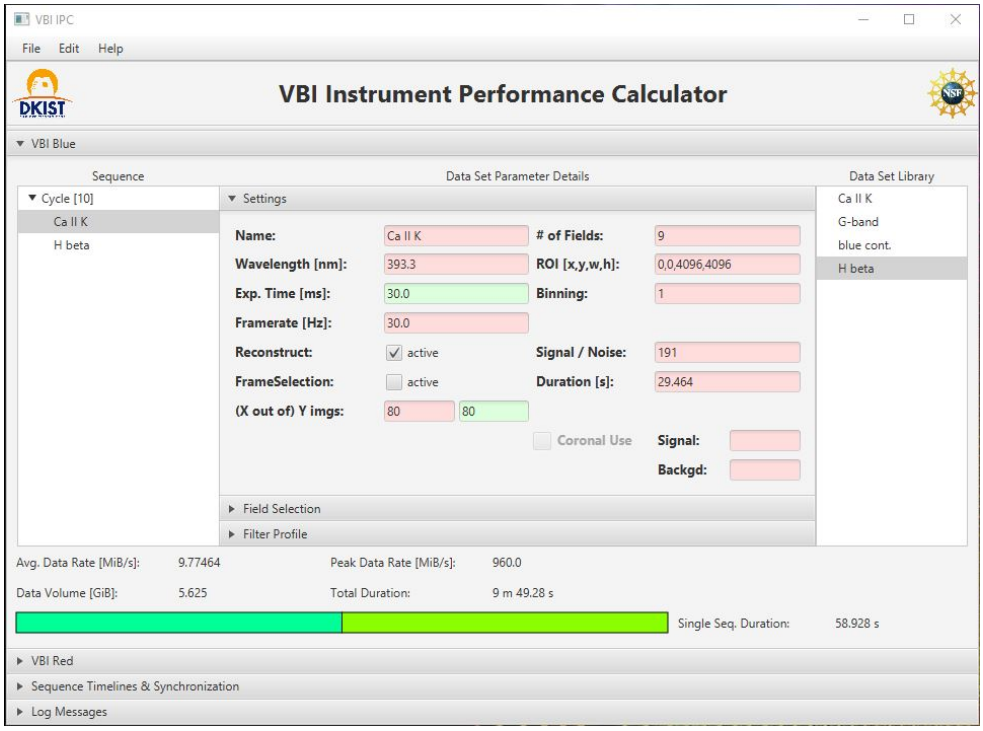

Figure 33: Use Case 2: VBI Blue Ca II K parameters setup.

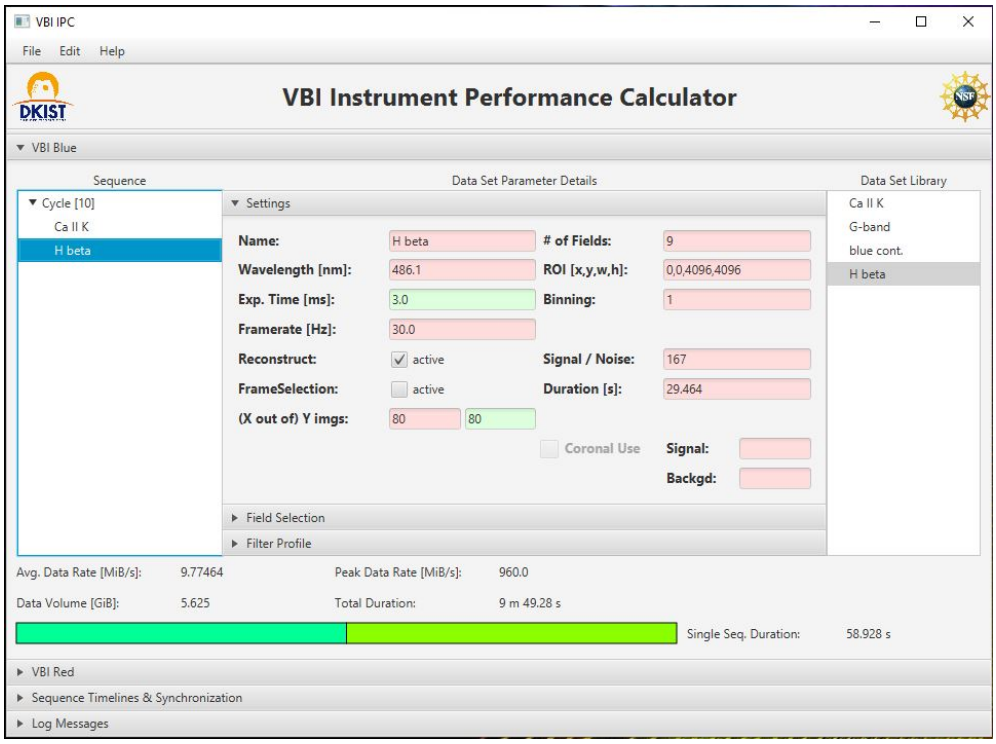

Figure 34: Use Case 2: VBI Blue H beta parameters setup.

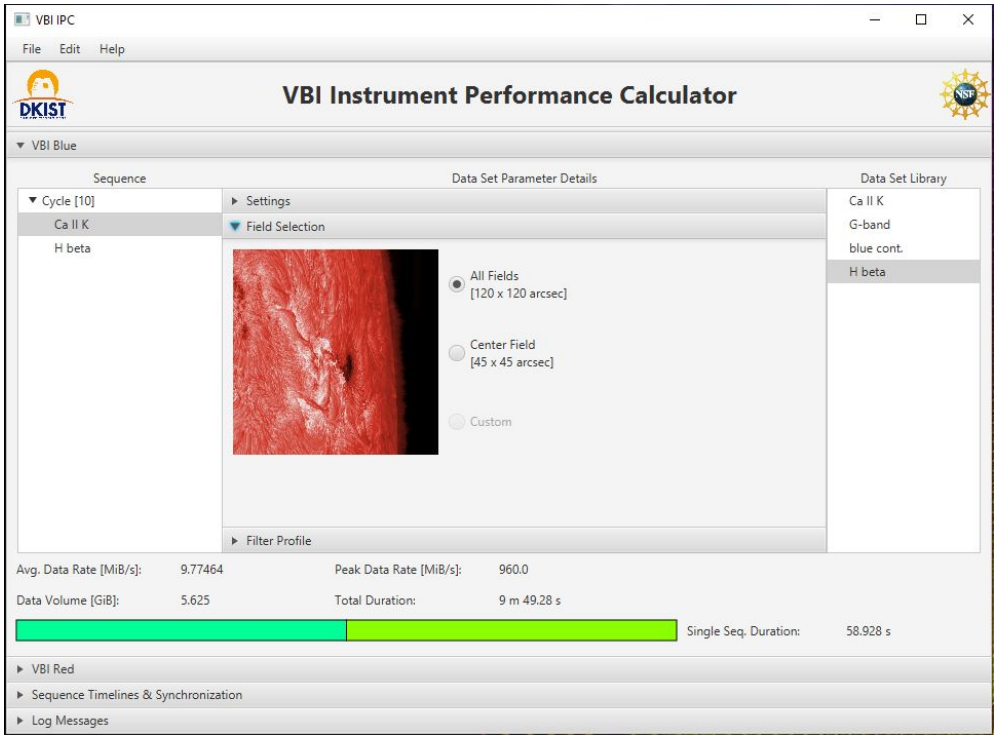

Figure 35: Use Case 2: VBI Blue Field selection.

In Figure 35 above is shown how to define the field selection to “All Fields” (120x120 arcsec). The field size must be selected for each filter in the sequence.

In a similar way that was described for VBI Blue, the setup for VBI Red must be made according to the following parameters:

VBI RED		
Cycles	10	
Filters	Exposure time [ms]	Field Selection [arcsec]
H alpha	2	120x120
Fe XI	0.15	120x120

The following Figure 36 and Figure 37 show the configuration parameter for the Filters H alpha, and Fe XI respectively.

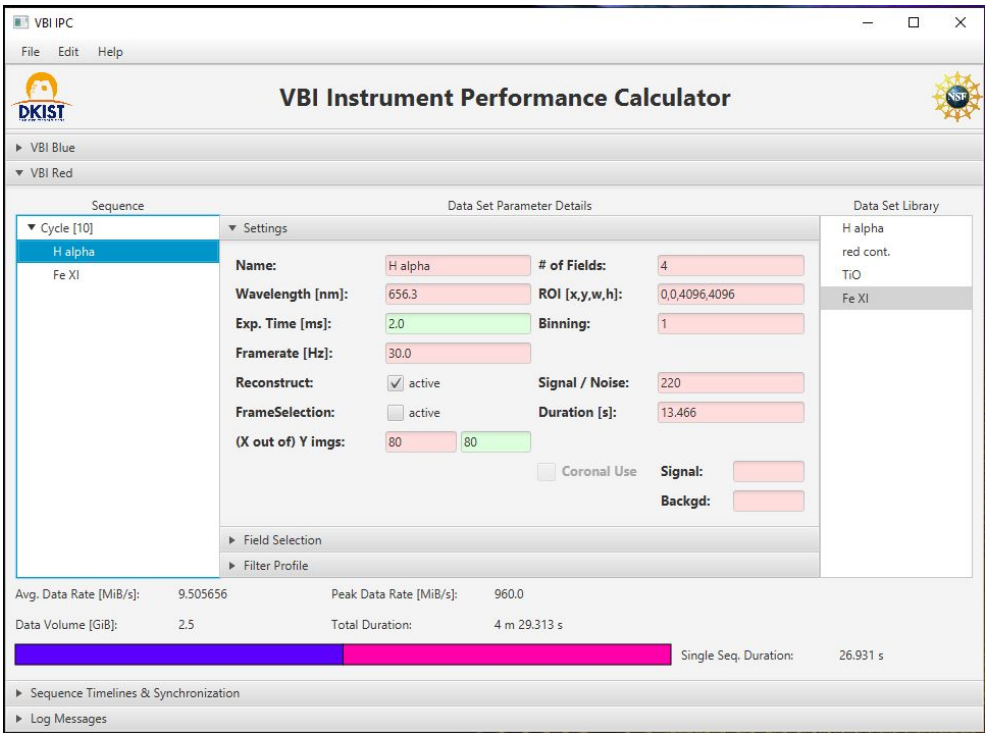

Figure 36: Use Case 2: VBI Red H alpha parameters setup.

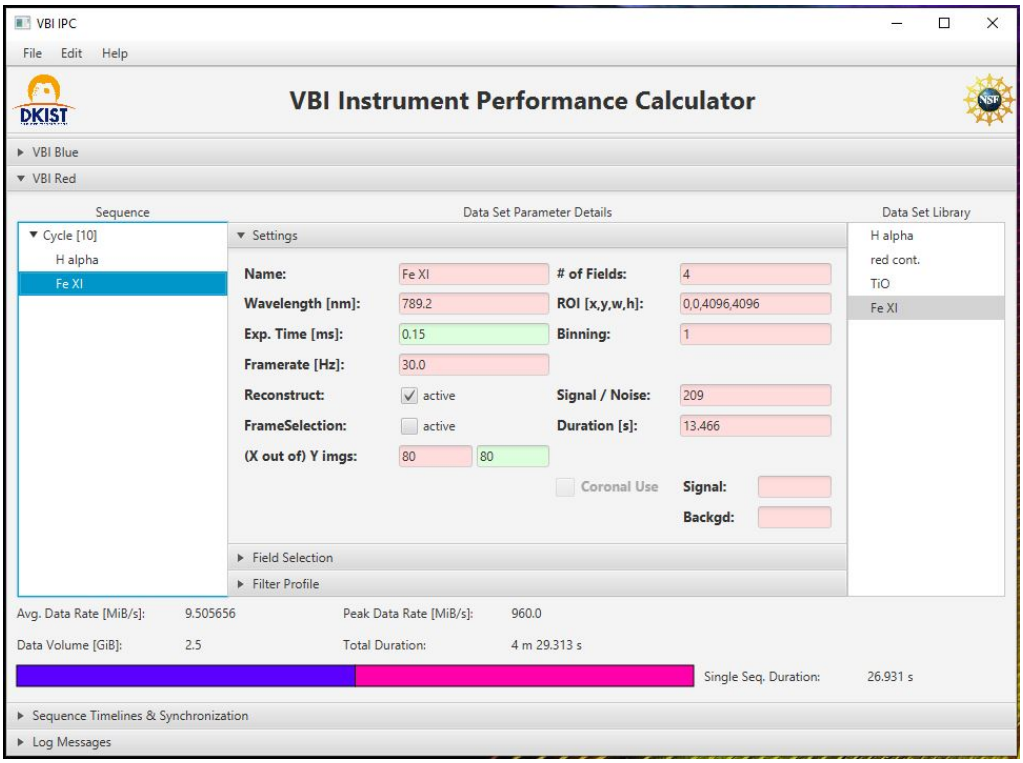

Figure 37: Use Case 2: VBI Red Fe XI parameters setup.

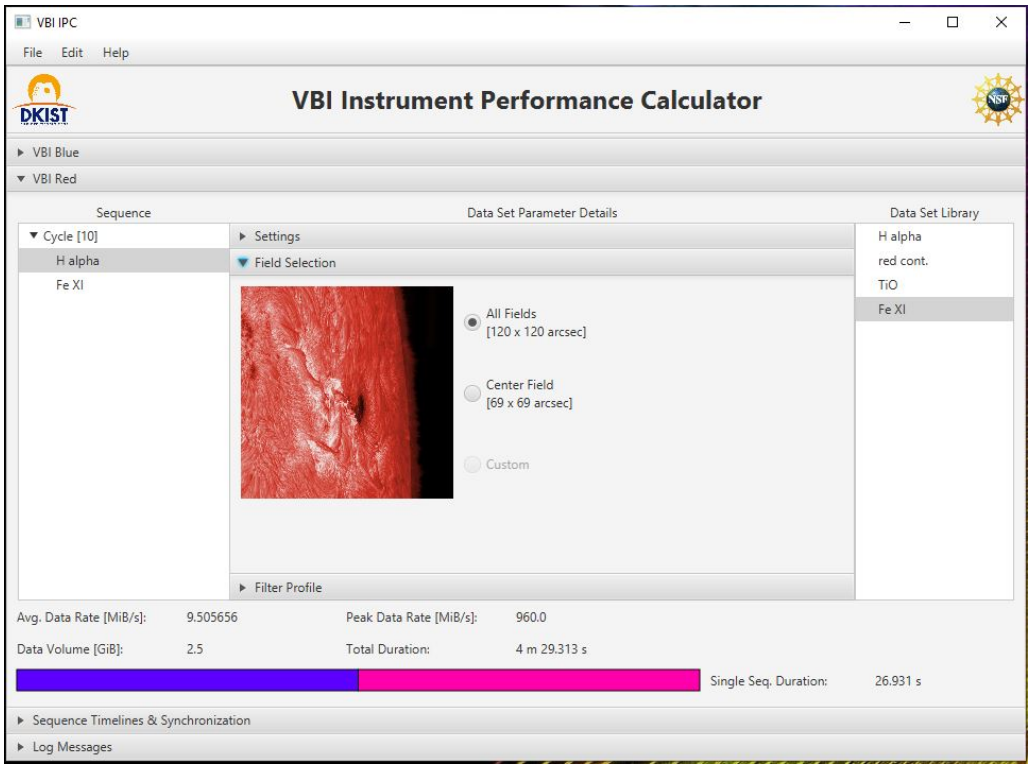

Figure 38: Use Case 2: VBI Red Field selection

In Figure 38 above is shown how to define the field selection to “All Fields” (120x120 arcsec). The field size must be selected for each filter in the sequence, in this case for H alpha and Fe XI filters.

Having both VBI Blue and Red active opens up the possibility for different synchronization options. VBI Blue is the longer of the two sequences and sets the pace.

Figure 39 shows the results for a Fixed synchronization between VBI Blue and VBI Red which means that the start of each Data Set acquisition is synchronized.

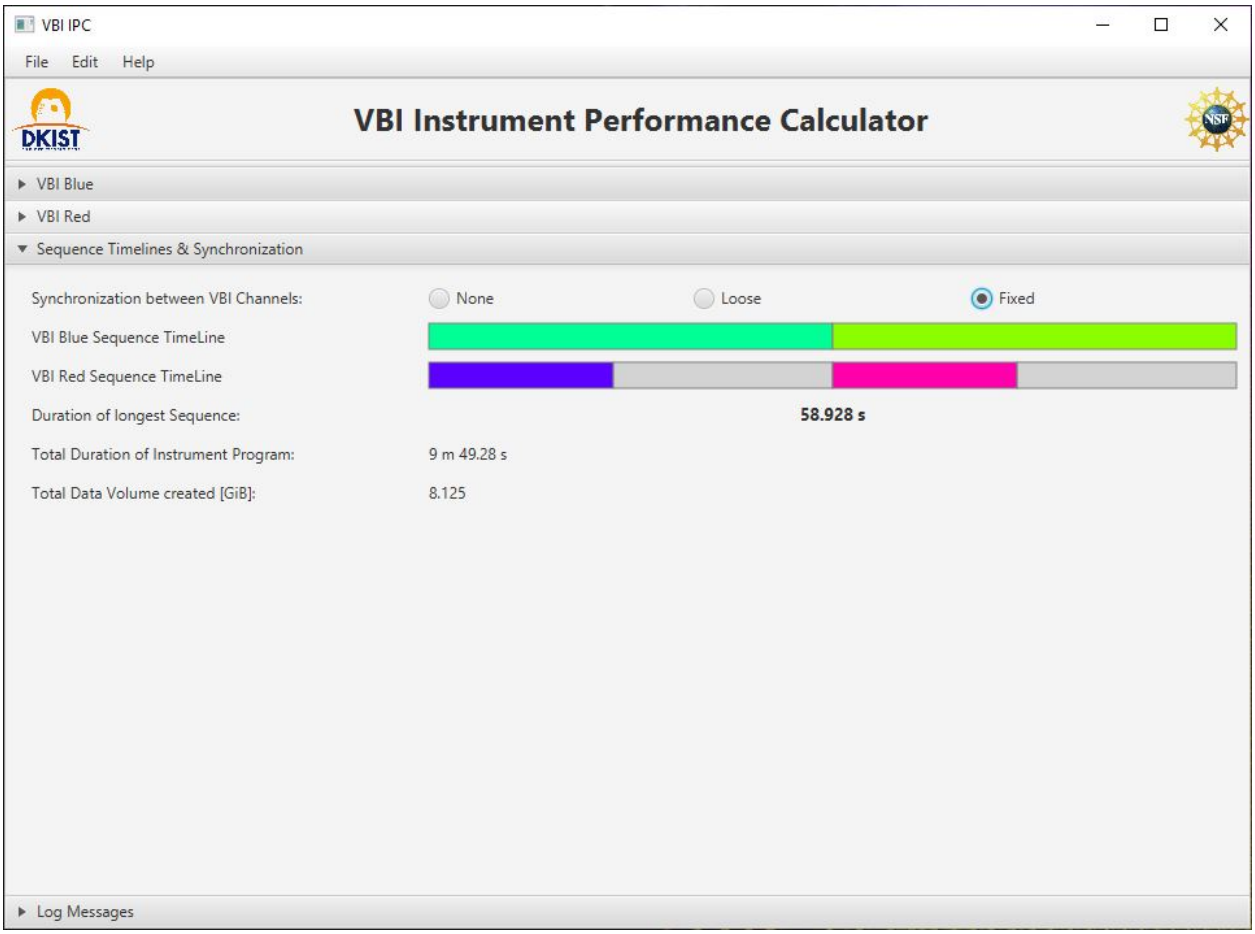

Figure 39: Use Case 2: VBI Synchronization Fixed

CONTACT DETAILS

Did not find what you're looking for? File a DKIST Help Desk ticket with your question **here.**

- How to set up a Help Desk account.
- Responses typically take 2-3 working days.

.