CCD Inspector, FWHM Monitor and CCDIS Plug-in

http://pk.darkhorizons.org

http://www.CCDWare.com

To purchase CCD Inspector: http://www.ccdware.com/buy

Check for product updates: http://www.ccdware.com/downloads/updates.cfm

Help and Support Forum: http://ccdware.infopop.cc/eve/forums

CCD Inspector

- *Dramatically Improve quality of your images: increase sharpness and resolution*
- Automatically sort many images at once by evaluating star sharpness and tracking quality
- Pick the best sub-frames for stacking, or for deciding which to keep
- Compare images by many objective criteria, plot the results for a better visual impact
- Measure and plot focus variations due to tilt or field curvature
- Determine how flat the image plane is. Compare performance of field flatteners and focal reducers
- Collimate your telescope in-focus with your CCD camera or DSLR!
- Evaluate optical system vignetting characteristics
- Estimate how well the current optical system will perform on a larger sensor before you buy that expensive new CCD or DSLR!
- Works with CCDSoft, MaxIm DL, and all other camera control software in real-time mode
- Focus and collimate your telescope using your favorite DSLR and DSLR control software!
- Create running charts to monitor seeing conditions, focus shift, tracking problems with your CCD or DSLR in real-time
- If you use CCDStack software, CCDInspector now ships with an amazing new plug-in, CCDIS.
  CCDIS completely automates CCDStack registration process, improves registration accuracy, and does so at blazing speeds

Astrophotograpers, CCD and digital camera users often take many shorter images to later process and stack to simulate one long exposure. To produce the highest quality image, it is important to eliminate from the stack sub-frames that are of lower quality than the rest. Sub-frames can be inferior due to changing focus, dew, tracking errors, flexure, mirror flop, wind, vibration, clouds, and many other things.

With CCDInspector, you'll be able to quickly select the best frames of the batch by measuring the quality of each of the images. The chosen images can be quickly moved or copied to a subfolder for stacking or further processing. CCDInspector works with your camera acquisition software to allow real-time evaluation of images to determine collimation, image tilt, focus, etc.

CCDInspector can also be used independently of any capturing or processing software with all SBIG, FITS, TIFF, or DSLR Raw formatted images on your computer. If your images are recorded with focal length information in the header, then multiple images, even acquired with different focal length and aperture, can be compared by computing the FWHM value in arcseconds.

Release History

Version 2.2.1

- Fix to a crash in Defocused Star Collimation Viewer when no star is found, or the star is dim

Version 2.2.0

- Added support for many more raw image file formats, including Canon 5D MkII, 50D, 500D, 1000D, Nikon D90, D700, D5000, etc.
- Added the menu option to select images that passed the limit alert test, and to invert image selection
- Improved the behavior of error messages in real-time displays, changed the look
- Improved Single Defocused Star Collimation to better detect real stars and to ignore other objects in the field of view
- Improved FWHM monitor single star detection when using a focus routine to deliver a much more stable, accurate display of FWHM values, even when the star is completely defocused
- Added transparency option and auto-fade option to FWHM monitor display to allow it to stay on top and not interfere with applications below
- Fixed a few small issues in background calculation in CCDIS plugin that should not have a major effect on functionality

Version 2.1.6

- Fix for FWHM Monitor crash due to some inadvertent changes introduced in v2.1.5
- Fix for a problem while entering license key under certain international settings/languages in both, CCDInspector and CCDIS/p

Version 2.1.5 2.1.5

- Added support for 8-bit image files (JPEG, BMP, GIF, PNG) to:
  - CCDInspector:
    - Can analyze 8-bit files for FWHM, Collimation, Curvature, Aspect ratio, etc.
    - Can use 8-bit files with the defocused-star collimation tool
    - Can use with Generic Camera driver
  - FWHM Monitor:
    - Can use 8-bit files with Generic Camera driver to analyze images from webcams or DSLRs
  - CCDIS and CCDIS/p CCDStack plug-ins:
    - Can register JPEG/BMP/GIF/PNG files to FITS, TIFF, or to each other
- Improved speed and overall performance of CCDIS plug-in
- Added support for sensors with non-square pixels in Default Image Properties dialog
- Fixed a crash caused by tooltips in the Analysis Charts tool

Version 2.1.0

- Added Single Star Collimation method and viewer
- Fixed an issue with Flat Analysis tool when processing Bayer-matrix images
- Added support for upgrading from CCDIS/p plugin

Version 2.0.6

- Fixed CCDIS S/N calculation routine to ignore wildly out-of-range pixels that can be generated by CCDStack calibration routines.
  This should improve success rate of finding registration solutions to, especially, narrow-band calibrated images.

Version 2.0.5

- Fixed CCDIS crash on 64-bit systems when processing images with mostly transparent (rejected) pixels at the edge of the image
- Changed File Open dialog to be resizable
- Fixed CCDInspector "hanging" problem when encountering certain rare combinations of FITS keywords

Version 2.0.4

- Improved CCDIS behavior when running in low-memory conditions, i.e., when handling a large stack on a 32-bit Windows
  - CCDIS will scale-down its own memory requirements when memory conditions are tight
  - Better error messages reported when out-of-memory conditions occur
- Fixed CCDInspector RAW DSLR image date handler: it used to apply Daylight Savings time correction twice

Version 2.0.3

- Improved CCDIS registration algorithm to:
  - Better handle saturated stars and very bright areas of the image, such as dense nebula or galactic core
  - Better handle 8-bit images, such as JPEGs
  - Find registration solution more consistently among similar images
  - Produce better accuracy by using more stars in a solution
  - Optimized for even more speed!
- Improved CCDInspector screen painting behavior while measuring images to reduce the appearance of 'hanging'
- Fixed a problem with certain TIFF and RAW images that would result in huge curvature, FWHM, and tilt numbers due to the use of invalid image scale
- Fixed a problem with real-time FWHM monitor update (affected only certain registered users)
- Added real-time simple image viewer to Real Time menu

Version 2.0.2

Internal test release of new CCDIS functionality. Not an official release.

Version 2.0.1

- Fixed Next/Previous menu items when using Image Viewer with Flat Analysis and Aspect Ratio maps
- Fixed a bug that would cause a crash with some images containing stars very close or overlapping image frame
- Added default sensor pixel size setting to use for images without this information in the header

Version 2.0.0

- Major new release, many new features, bug fixes, and enhancements.

Version 1.3.4

- Fixed bugs in the Auto-update mechanism that resulted in failures to update with some DSL and cable modems
- Made changes to allow for an easier upgrade to the upcoming CCDInspector 2

Version 1.3.2

- Addresses variability in measurement results due to the use of DirectX3D. DirectX3D sets floating point calculation accuracy to ***low*** for better performance, but this results in less precision in all calculations by CCDInspector. This has been fixed.

Version 1.3.1

- Fixed curvature display on the 3-D plot
- Added automatic software update with periodic checks

Version 1.3.0

- Full support of Windows Vista
- Converted to .NET 2.0
- Rewrite of the FWHM measurement algorithm to improve accuracy for undersampled images
- Added Ignore button to warning messages
- Added support for drag-and-drop of image lists to and from CCDStack
- Added support for single-shot Bayer matrix CCD sensors
- Added support for setting a custom saturation value
- Fix for curvature % display: was incorrectly adjusted by image scale when displayed in arcseconds
- Fix for X and Y tilt values in the Charts dialog (only Y was shown)
- Fixed OK button placement in warning messages

Version 1.2.0

- Fixed star selection algorithm that sometimes caused noise to be treated as stars
- Added three Noise Threshold settings to improve star selection with noisy sensors (e.g., CMOS). The default, Low setting should work well for most cooled CCD sensors.
- Added "Measure selected images only" feature: if one or more images are selected in the list, only these will be measured when Measure button is pressed. If none are selected, only new images in the list that have not been measured yet will be measured.

- Added Exposure, Bin Mode, and Temperature columns to the main image display and charts
- Files that are loaded via AutoOpen option that are not in a recognizable format will now be quietly skipped and not measured: no error message will be displayed

Version 1.1.10

- Fixed TIFF file processing in FWHM Monitor
- Improved filtered RGB image processing when most of the information is contained in one of the three channels
- Added image date/time display for images that don't contain this information in the header (file creation date/time is now shown)
- Fixed the Measure All function bug that on occasion would still process some images that have already been measured

Version 1.1.9

- Added support for ImagesPlus color FITS format (16-bit)
- Measure All now measures only images that haven't been measured yet
- Added AutoOpen feature to automatically measure any new image saved into specified folder

Version 1.1.7

- Fixed: various errors and failures to measure with certain size images
- Fixed: chart tilt X/Y were shown as the same value, and only in arcseconds
- Improved star extraction algorithm: more stars are detected resulting in more accurate measurement
- Improved algorithm for measuring undersampled stars: gives accurate result down to approximately 1.5 pixel FWHM

Version 1.1.3

- Fixed failure to measure a large image or an image with a large number of stars
- Collimation Viewer display no longer shows recommended correction to avoid setup confusion
- Fixed the Curvature display in the main CCDInspector window column: the value originally displayed was incorrectly adjusted by the image scale, and resulted in a number different from the one on the Curvature Map display

Version 1.1.1

- Added user adjustable Top of Chip display to the Collimation Viewer to accommodate all camera positions on the back of the telescope
- Changed Collimation Viewer display to select only two of the three knobs for collimation to reduce risk of loosening the secondary
- Fixed the problem with reading TIFF files that was introduced with the addition of the RAW file support

Version 1.1.0

- Intuitive Collimation Viewer added for fast and precise real-time collimation
- Generic support for all image capture software, including AstroArt, MaxDSLR, etc., capable of writing FITS, TIFF, SBIG, or most native DSLR Raw file formats:
  - For real-time curvature display and collimation, and
  - For FWHM Monitor for focusing, focus monitoring, and running charts
- Native support for over 100 DSLR RAW file formats - no conversion is needed into any other format
- Support for color (RGB) FITS files in 16- and 8- bit formats as created by MaxIm DL
- Added FITS header viewer
- Air Mass index added to the calculated values
- Stars Used is now displayed in the 2-D map viewer
- Fixed a bug that caused problems copying and displaying large images
- Star extraction algorithm tuned to find and use many more stars
- Significantly improved collimation error computation improves stability and accuracy
- Image list now shows Collimation and Tilt values in arcseconds or pixels, based on user selection
- Support for OBJCTALT keyword for images captured in MaxIm DL
- MaxIm DL image selection was improved for use with FWHM monitor: clicking on an image now activates it
- Added Moving Average and Real-Time numeric display options to FWHM monitor to display the values from the current running chart
- Added the list of most-recently loaded images to the file menu

Version 1.0.0

Initial public release

2.0 New Features in CCDInspector 2

1. **Limit Alerts:** Set limits on image parameters, such as FWHM, aspect ratio, background, etc. All images exceeding the limits will be flagged in red on the display for easy identification.

2. **Automatic dark frame scaling**: you no longer have to pick another dark frame just to change the exposure, or take auto-darks. All you'll need is a single master dark frame (and a bias)

3. **New camera extrapolation tool**: allows curvature, star aspect ratio, and vignetting to be projected to a different size chip. Easily find out if you'll need a field flattener with that larger sensor, or whether you'll need a larger secondary due to severe vignetting, or if the new camera will produce acceptable images with your current optics.

4. **Improved image Tilt indicator** that shows the direction and the absolute magnitude of the tilt.

5. **New Aspect Ratio Map tool**. Similar to curvature map, aspect ratio map shows how stars shapes vary across the field of view, for example due to coma or to optical tilt.

6. New Flat Frame Analysis tool to help measure degree of vignetting from a star field image or a flat frame.

7. New Single Star Collimation tool to allow collimation on a single defocused star (v 2.1.0)

8 **CCDIS** plug-in is included with CCDInspector 2.0. This plug-in works in conjunction with CCDStack to provide a much faster and extremely accurate image registration using CCDInspector advanced star detection algorithm. This works seamlessly with CCDStack 1.3.2 and later, and registers images completely automatically. CCDIS handles rotation, differences in scale, image flip, and linear shift with ease. For all the CCDStack users, you'll love it, I guarantee it! And it's fast!

9. Over 100 new RAW DSLR image formats added, including some of the more popular:

Canon 40D, 1D II and III, 400D/XTi, 450D/XSi, DNG
Nikon D3, D300, D40, D60
Fuji E900, S100FS, S5200/S5600, S5Pro, S6000, S9100/S9600

Click here for the full list of supported RAW formats

10. Support for displaying and sorting all FITS header keywords in the CCDInspector image list.

11. Support for command-line arguments so that CCDInspector can now be launched via script.

12. Improvements in noise rejection algorithm allow images with fewer stars to produce stable measurements of curvature and collimation.

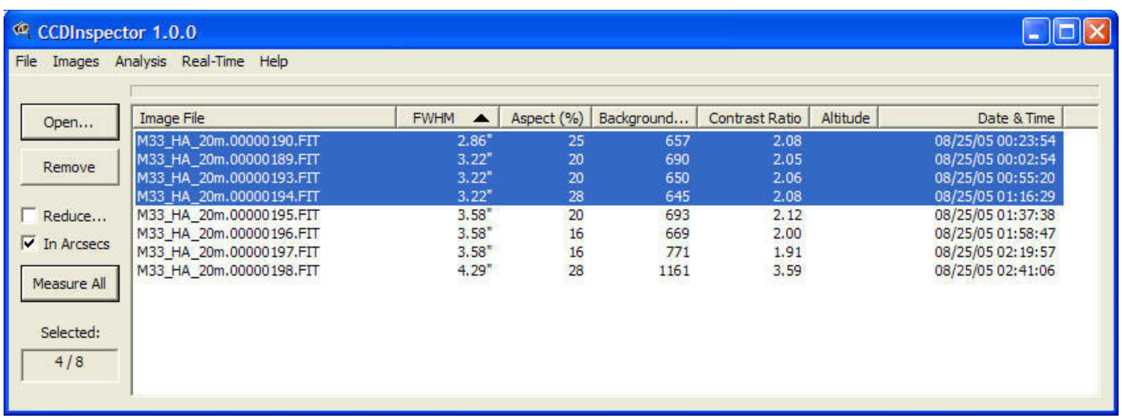
13. Most other features and bug fixes requested by the users.

Using CCDInspector

Start CCDInspector by double-clicking on the CCDInspector Panel icon on the desktop:

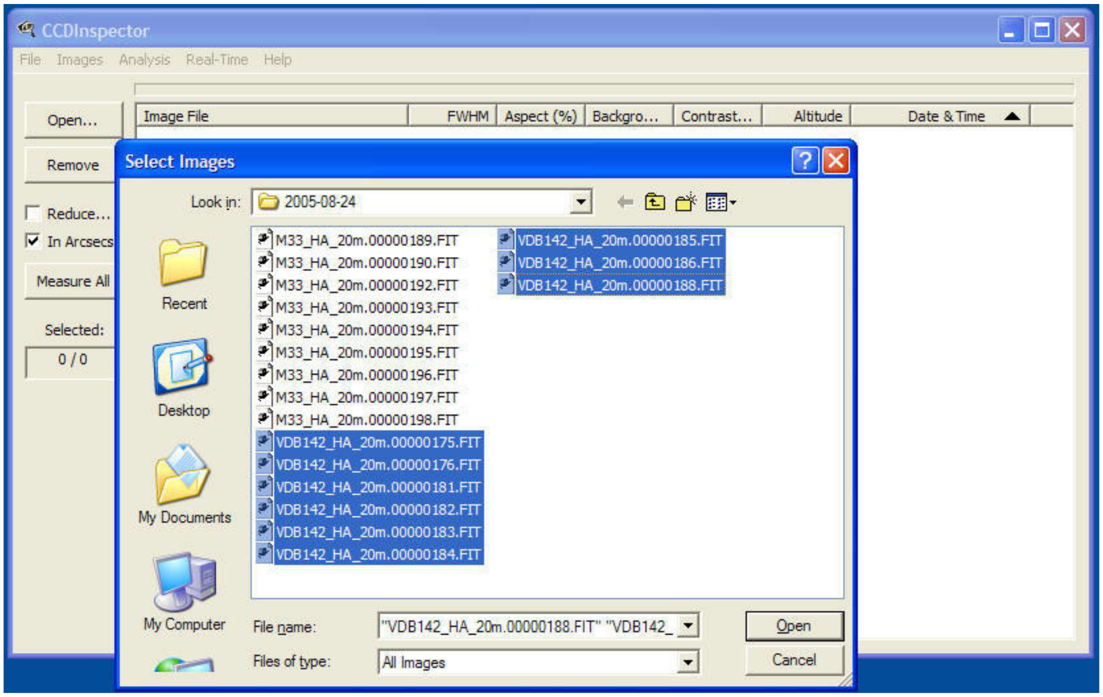
CCDInspector

CCDInspector window will come up. The window is resizable, so you can expand it or collapse it to see more or less of the image data:



The display is designed to be as simple to use as possible. Here's a typical session with CCDInspector:

1. Click on the ***Open...*** button. A windows explorer will come up giving you the ability to select one or more images you'd like to measure:

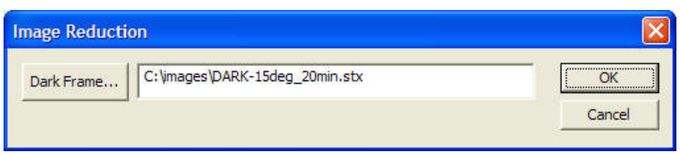


Note that only files with Extensions of FIT, FTS, FITS, .S*, and .TIF* will be listed, as these are all the supported image types

2. Select any number of the images from the ***Select Images*** window, and click Open. You'll see the images you picked added to the list of images in the CCDInspector window:

3. If there are more images you'd like to sort through, simply click on the ***Open...*** button again, and select more images. The images list can be assembled from any number of folders.

4. To measure raw, unprocessed images more accurately, you may chose to subtract a dark frame from each. This is particularly recommended with very faint or long exposure raw images. To chose the dark frame reduction, click on the ***Reduce*** check box. You'll see the following window displayed:



Click on the ***Dark Frame*** button to browse for the appropriate dark frame file. Note that if you are measuring multiple exposures that of different exposure length, a single dark frame will not work on all of them. In this case, it is better to not use image reduction.

Also, if the images you are measuring have already been dark-subtracted in another software package, uncheck the ***Reduce*** check box, as a second dark-subtraction will be counter-productive.

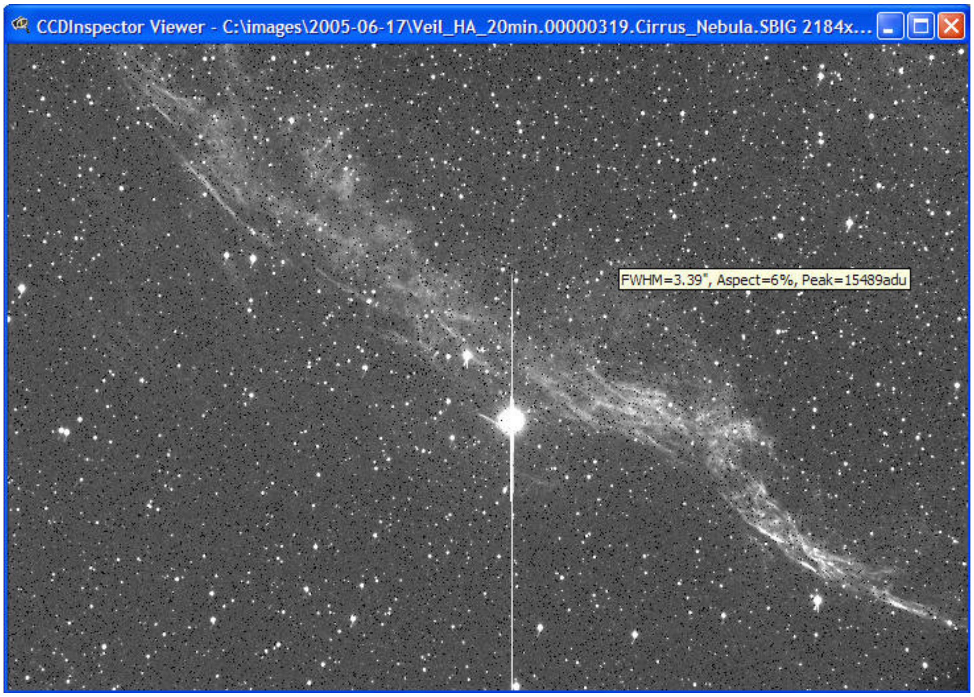
5. Once you pick all the images, click on ***Measure All*** button and CCDInspector will go through the list of newly added images and measure each in turn. When done, you'll see the results of the measurement next to each image name.

Any images that do not contain enough stars (or are too noisy to measure) will be listed with "N/A" in the FWHM and Aspect ratio columns. All other images will have a number assigned to them representing their average FWHM and Aspect Ratio. If the images contain focal length information in their header, you can click the ***In Arcseconds*** check box on, and the FWHM values will be shown in arcseconds, otherwise FWHM will be given in pixels.

6. Once measured, you can sort the images by any of the columns in the CCDInspector window, including FWHM and Aspect ratio, by simply clicking on the label in the appropriate column. An up or down arrow will indicate what column is being sorted, and the direction of the sort (up means increasing values from top to bottom, down means decreasing).

Note: there are many values that CCDInspector collects and measures for each image. You can chose to display all of them, or only the ones of interest to you by going to the File/Settings/Display Columns menu, and then picking the columns you'd like to see.

7. At this point it is easy to see what images are better (for example, the ones with lower FWHM values, lower Aspect Ratio, and highest Contrast Ratio). You can select a number of images to preview them before deciding to use them or not to use them. Simply highlight multiple images you want to see, and click on the ***Open Selected*** button. The chosen images will come up in a number of Image Viewer windows floating above CCDInspector.



You can scroll around the image, and zoom in or zoom out by clicking anywhere in the image and picking the zoom level. As a shortcut, you can simply double-click on any of the image names in the CCDInspector window to open it in the Image Viewer.

It is very easy to see the FWHM and Aspect Ratio values for any of the stars in the image: simply move the mouse pointer to point to the desired star, and a tool-tip window will pop-up with the measured statistics for this star. If there's no star or the star cannot be properly measured (for example if it's too dim or oversaturated, or bloomed), the tool-tip will display "N/A". Note that Image Viewer does not filter out hot pixels, as is done in the overall image Measurement step. This may result in some hot pixels displaying an FWHM and Aspect value -- you should be able to tell where the real stars are. Hot pixels are ignored when determining the overall image statistics.

8. When you decide on the set of images you'd like to use for stacking, you can select them in the CCDInspector window, and then click on ***Move To Folder*** or ***Copy to Folder*** from the ***Images*** menu.

Move To Folder will physically move the images from their original folder to the folder of your choice. ***Copy To Folder*** will create a copy of all the chosen images, keeping the originals intact.

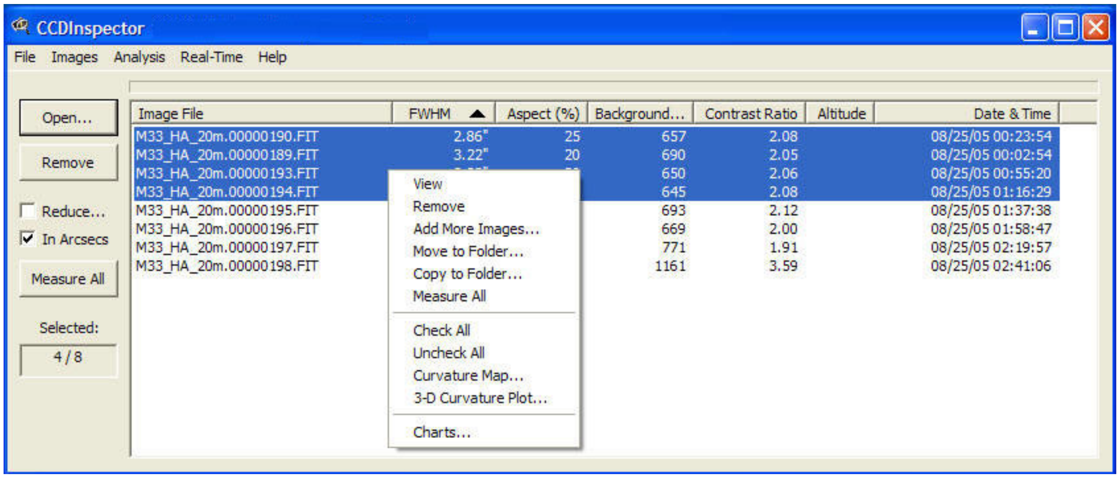
9. You can also drag-and-drop files between CCDInspector and Windows Explorer or other applications. Files can be added by dragging them into CCDInspector. Once measured and sorted, files can be moved or copied to the folder open in Windows Explorer by selecting and dragging them from CCDInspector to the Explorer or other application window. Note that if you use just the mouse button to drag images, they will be moved (equivalent to ***Move Selected***). If you'd like to copy the files, leaving original images in the original folder, hold down the ***Ctrl*** key on the keyboard as you star the drag. This is the same way drag-and-drop works in Windows Explorer to move files between folders.

HINT: *Sometimes, you may want to move several files at once. If this is the case, hold down CTRL when you click on the file names. Each name will stay highlighted as you select the next file. If all the files you wish to move are listed sequentially in a group, you can click on the first file, hold down the Shift key and click on the last file. To move the selected documents, hold down the mouse button and drag to the desired destination. To copy, hold down the Ctrl key as you start to drag.* **If you are having problems selecting multiple, please see FAQ item #1 below for a work-around.**

10. Once images are measured, it is easy to create a full report of the image names and their corresponding FWHM and Aspect Ratio values by clicking on the ***File/Copy Report To Clipboard*** menu. The resulting report will be placed on the Windows Clipboard, and can be pasted into a text document, spreadsheet, e-mail, etc. Here is an example of the report after being pasted into Microsoft Word:

File Path	FWHM	Aspect Ratio
C:\images\2005-08-24\VDB142_HA_20m.00000188.FIT	N/A	N/A%
C:\images\2005-08-24\VDB142_HA_20m.00000185.FIT	2.86 "	16%
C:\images\2005-08-24\VDB142_HA_20m.00000184.FIT	2.93 "	13%
C:\images\2005-08-24\VDB142_HA_20m.00000186.FIT	3.01 "	15%
C:\images\2005-08-24\VDB142_HA_20m.00000181.FIT	3.08 "	11%
C:\images\2005-08-24\VDB142_HA_20m.00000182.FIT	3.08 "	17%
C:\images\2005-08-24\VDB142_HA_20m.00000183.FIT	3.08 "	13%
C:\images\2005-08-24\VDB142_HA_20m.00000175.FIT	4.94 "	18%
C:\images\2005-08-24\VDB142_HA_20m.00000176.FIT	5.80 "	17%

11. As a shortcut, you can do most of the operations listed above by simply clicking the right mouse button on the image list:



View will open all the selected images in Image Viewer
Remove will remove all the selected images from CCDInspector list
Add More Images... will allow to select more images for measurement
Move To Folder... will allow you to pick a folder to move the selected images to
Copy To Folder... will allow you to pick a folder to move the selected images to
Measure All will measure all the images in the list
Check All will select all items in the list
Uncheck All will unselect all items in the list
Curvature Map... will determine field curvature from selected images and display the map
3-D Curvature Plot... will use selected images to display the curvature in three dimensions
Charts... will allow you to see any of the measured values for all the images plotted against time, or any other image value

Installing CCD Inspector

To install CCD Inspector,

1. Ensure that all the pre-requisites are installed (see details here)

2. Download the installation file

3. Extract the files from the zip archive into a temporary folder

4. Double-click on the Setup.exe file to start the installation.

5. Follow prompts to select folders CCD Inspector. In most cases, accepting the default values will be sufficient.

6. On completing the install, double-click the CCD Inspector Panel icon on your desktop.

7. If you are going to use CCDIS plug-in with CCDStack on a 64-bit operating system (XP-64, Vista-64, Windows 2003 x64), double-click on the CCDIS64.msi file to install the 64-bit components for CCDStack plugin.

How does it work?

CCD Inspector employs a proprietary algorithm for star filtering and extraction. For each image, it will extract up to a few thousand stars from the entire image, ignoring hot pixels and other non-stellar structures. As part of the analysis, CCD Inspector will throw out stars that are bloomed or saturated, and any stars with too low a signal-to-noise ratio that may yield an inaccurate measurement. It will then pick the median FWHM value, and the median Aspect Ratio value of all the stars remaining in the list. These will be the values displayed next to the image name.

By its nature, the FWHM and Aspect Ratio displayed represent an "average" value for the image. There will be some stars with higher and some with lower FWHM in the image. The same applies to aspect ratio value. The values chosen are meant to quantify the image for a meaningful comparison between similar images, such as multiple sub-frames of the same field of view.

For images that contain some field curvature at the edges, the resulting measurement will not be skewed by such curvature, as long as the majority of the stars are not on the periphery of the image.

What's in CCD Inspector?

CCDInspector is a collection of tools to help you get the best quality images from whatever optics and mount you currently use.

The two major tools are **CCDInspector** itself and a real-time **FWHM Monitor** utility. Both tools are integrated, but can be used independently of each other.

2.0 New with version 2.0 of CCDInspector is the **CCDIS** plug-in to CCDStack.

The basic functions of each tool are as follows:

CCDInspector

1. Measure and compare any number of saved images
2. Chose the best images by any measured criteria, move, copy, or drag selected images to other folders or applications
3. Plot values for all the images against any other value for a direct comparison
4. Preview any of the images, and determine FWHM and Aspect ratio of any star in the image by pointing to it
5. Analyze 2-D and 3-D curvature plots, determine image plane tilt, distance from perfect collimation, etc.
6. Monitor 2-D or 3-D curvature plots of images captured by the camera in real-time
7. Collimate your optics in real-time, in-focus, and with your CCD camera attached to the telescope

FWHM Monitor

1. Focus your telescope by monitoring FWHM, HFD, Peak Value, or a number of other variable in real-time
2. Measure FWHM value for images as they are downloaded from the camera
3. Monitor focus over time by measuring FWHM of the autoguider star image
4. Monitor guiding or tracking accuracy by measuring star centroid wander
5. Monitor seeing conditions by measuring FWHM variations of a star in the focus window
6. Plot, on real time running chart, all the variables, such as FWHM, HFD, Peak Value, Aspect Ratio, Star Profile, Centroid wander.
7. Select real-time or a moving average (or both) for the display, and choose how many points to keep on the running chart

2.0 **CCDIS Plug-In**

1. CCDIS is an advanced image registration plug-in that works in conjunction with CCDWare CCDStack software
2. If both, CCDStack 1.3.2 or later and CCDInspector 2.0 are installed together, you'll notice a new CCDIS tab in the Registration dialog of CCDStack
3. CCDIS performs a completely automatic registration of any number of images
4. Images can be rotated, flipped, binned, or at different focal length: CCDIS can handle them all ***automatically***. No manual star selection is needed.
5. CCDIS is optimized for speed and is extremely accurate, usually resulting in registration accuracy much better than 1/10 of a pixel.
6. CCDIS is made possible by the advanced image extraction and recognition algorithms that power the rest of the CCDInspector software.

Software Requirements

Operating systems currently supported are: Windows Vista, Windows XP, Windows 2000, Windows 98.

Microsoft Direct X version 8.0 or later is necessary for 3-D graphics support. Follow the link for DirectX End-User Runtimes Web Installer:

http://msdn.microsoft.com/en-us/directx/aa937788.aspx

Visual Basic 6.0 run-time environment is necessary to support real-time monitors when using CCDSoft:

http://www.microsoft.com/downloads/details.aspx?familyid=7b9ba261-7a9c-43e7-9117-f673077ffb3c&displaylang=en

Microsoft .NET Framework environment 2.0:

Microsoft .NET Framework runtime

Upgrading to CCDInspector 2

CCDInspector 2 is designed as a replacement for CCDInspector version 1. No new features are planned for version 1. All future enhancements and new features will be released as part of version 2.

In order to ease the migration to the new version and to allow existing users to compare and contrast features, CCDInspector 2 is installed separately from the previous versions. This means that CCDInspector 1 and 2 can co-exist on the same computer and can even run side-by-side.

Registered users of CCDInspector 1 can upgrade to CCDInspector 2 at a greatly reduced cost, while new users are asked to purchase a full license. Both types of users can evaluate CCDInspector 2 for the standard trial period of 30 days. The trial period starts as soon as CCDInspector 2 is installed and launched for the first time.

CCDInspector 2 trial period is also independent of CCDInspector 1, so even if you have already evaluated version 1 for 30 days, you go ahead and test out the new features in version 2 for an additional 30 days.

When upgrading from version 1 to version 2 with a purchased upgrade license, CCDInspector version 1 must also be installed and registered on the same computer. Only then will CCDInspector 2 prompt for the upgrade license.

Alternatively, if you don't have CCDInspector 1 installed and registered, but did receive a license key for it, you can still enter the upgrade license key in CCDInspector 2, but you'll need to do so through a menu in the main window. The menu is under **Help->Upgrade from v1.0**. When clicked, you will be prompted to enter your version 1 registration information first. When done, another window will pop-up for requesting an upgrade license key for version 2. Once that's entered, version 2.0 will be fully registered and unlocked for your use. Please make sure that you have both, version 1 and version 2 registration keys and e-mail addresses before proceeding down this path.

Upgrading to CCDInspector 2 from CCDIS/p Plug-In for CCDStack

Owners of CCDIS/p plug-in can upgrade at a discount to CCDInspector 2. Both license keys, CCDIS/p and CCDInspector2 upgrade from CCDIS/p are required to perform the upgrade.

1. If you already have CCDIS/p plug-in installed and registered on your computer, simply start CCDInspector 2, and enter your upgrade key when prompted

2. If you don't have CCDIS/p plug-in installed but have previously purchased a license, then follow these instructions:

- Locate CCDIS/p and the upgrade license keys
- Start CCDInspector 2
- Go to **Help->Upgrade License from CCDIS/p...** menu
- You'll be first prompted to enter your CCDIS/p license key, enter it now
- When done, you'll be prompted to enter your CCDInspector2 upgrade key: enter it now
- Start using CCDInspector2

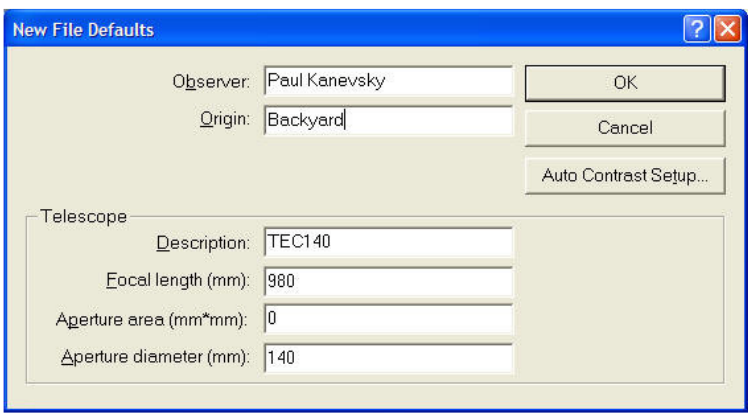
3. Note: CCDInspector 2 installation includes CCDIS plug-in for CCDStack, so once you register your CCDInspector 2, you can safely remove the original CCDIS/p installation from your hard drive

Setting Image Scale

CCDInspector derives the information about image scale from the image header. The software used to acquire the image needs to be set to record this information in the header, or it will not be available to CCDInspector.

Setting up CCDSoft to record the focal length information in the image header:

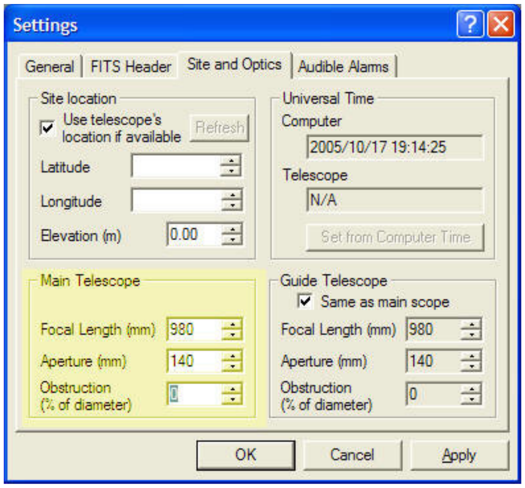
In order to display information in arcseconds, you will also need to ensure that CCDSoft knows the focal length of your imaging setup. For use with CCDInspector, this should be expressed in units of mm. This can be entered in CCDSoft in the Camera Setup screen by pressing the File Defaults button:



Please make sure that the focal length is set in mm, and not inches, otherwise the arcseconds calculation will be incorrect.

Setting up MaxIm DL to record the focal length information in the image header:

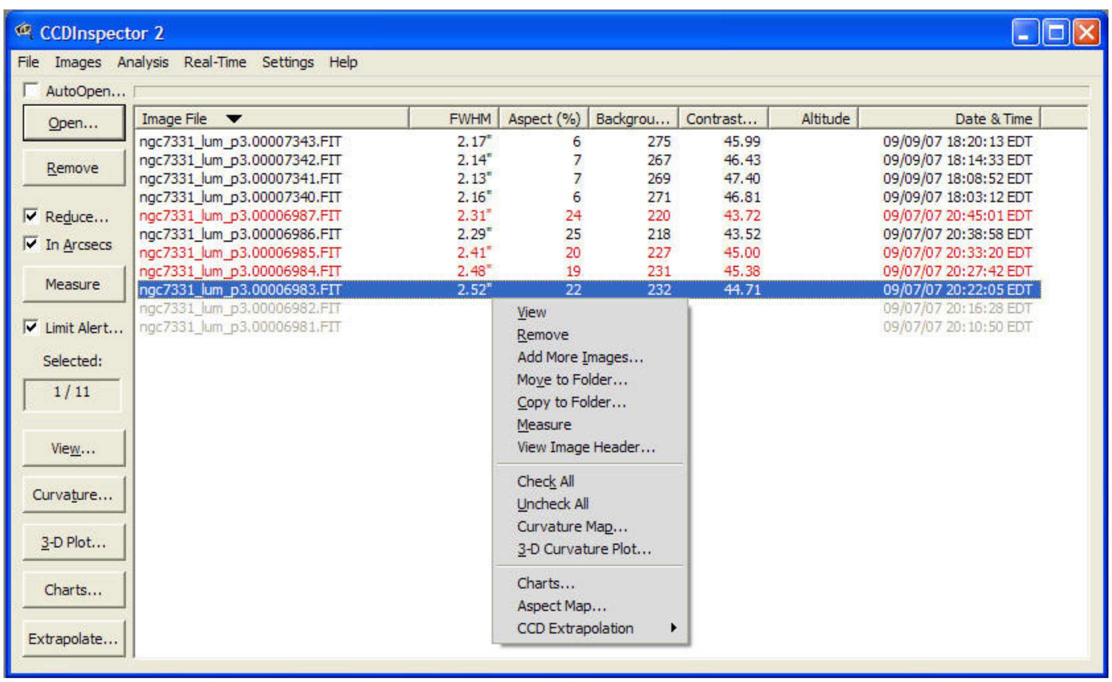
Click on **File/Settings** menu, and select **Site and Optics** tab, and enter the focal length and aperture parameters:



Note: If you select display in Arcseconds, but the focal length or pixel size parameters are not available from the image, CCDInspector will display measurements in pixels by default.

CCD Inspector Display Elements

CCD Inspector main window provides the view of the sorted list of images, the mechanism for their selection, and a choice of operation:. Features that are new in CCDInspector 2.0 are marked with the 2.0 symbol.



Across the top of the list are column headers (Image File, FWHM, Aspect (%), etc.). Shown are the default columns. The actual display can be tailored to show any values calculated by CCD Inspector, as well as any standard or custom values stored in an image FITS header 2.0.

Clicking on the header of a column defines the sort order for all the images. An up arrow in the header indicates images are ordered in the increasing value order, and a down arrow means the order is decreasing.

To select more than one image: *hold down CTRL when you click on the file names. Each name will stay highlighted as you select the next file. If all the files you wish to move are listed sequentially in a group, you can click on the first file, hold down the Shift key and click on the last file. To move the selected documents, hold down the mouse button and drag to the desired destination. To copy, hold down the Ctrl key as you start to drag.*

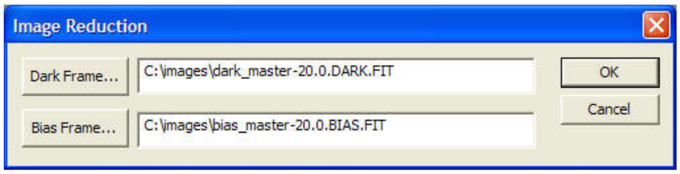
You can also drag-and-drop files between CCD Inspector and Windows Explorer, CCDStack, or other programs accepting file dragging and dropping. Files can be opened by dragging them into CCD Inspector and releasing (dropping) them on top of the list. Once measured and sorted, files can be moved or copied to the folder open in Windows Explorer by selecting and dragging them from the list to the explorer window. Note that if you use the mouse button to drag images, they will be moved. If you'd like to copy the files, leaving original images in the original folder, hold down the ***Ctrl*** key on the keyboard as you star the drag. This is the standard way in which drag-and-drop works in Windows Explorer to move files between folders.

2.0 Images are shown color-coded. Images shown in gray have not been measured yet. Unmeasured images will still show all values that don't require calculations.

When the Limit Alert feature is turned on, images that are within the specified limits will be displayed in black, while images outside the defined limits will be shown in red.

Right click on any of the images or anywhere inside the list area will display the pop-up shortcuts menu shown above. The options in the menu are equivalent shortcuts to the various menu commands at the top.

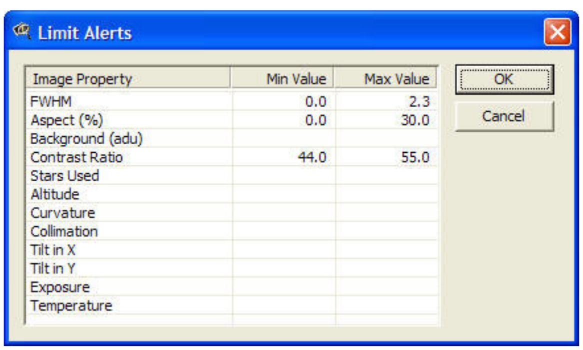
AutoOpen checkbox provides a way to to continually monitor a folder of images. When a new image is detected, it will be automatically added to the list and measured
Open button provides a shortcut to add new images to the list. It is equivalent to File/Open menu command
Remove button is a shortcut to Images/Remove menu. It removes selected images from the list.
Reduce invokes the dark frame subtraction dialog that defines an image file containing the dark frame to be subtracted from all images. If you don't want to subtract a dark frame, uncheck the box next to **Reduce**...



2.0 CCDInspector provides automatic scaling of dark frames to match the length of the light exposure. For best results, specify a master bias frame in addition to a good master dark. Once specified, all images with varying exposure length can be automatically and optimally reduced. For best results use light and dark frames acquired at the same (or nearly the same) temperature. Although CCDInspector will do its best to reduce an image with temperature-mismatched images, the results will not be as accurate.

In Arcsecs tells CCD Inspector that whenever possible the display should be in arcseconds instead of pixels. If image scale is not available from the image, CCD Inspector will use the default image scale defined through Settings/Default Image Scale dialog. If that's also not set, the values will be displayed in pixels.
Measure All will measure and display all the appropriate statistics for all the images in the list. You can interrupt the measurement process by pressing and holding the Esc key until it stops. This option is available when no images are highlighted in the list.
Measure will measure only the selected images in the list. The selected images will be measured whether or not they have already been measured previously.

2.0 **Limit Alert** feature allows you to set bounds on a number of different image attributes. All images that measure outside the specified bounds will be highlighted in red color in the main CCDInspector display. Limit alerts are only active when the Limit Alert check box is checked.



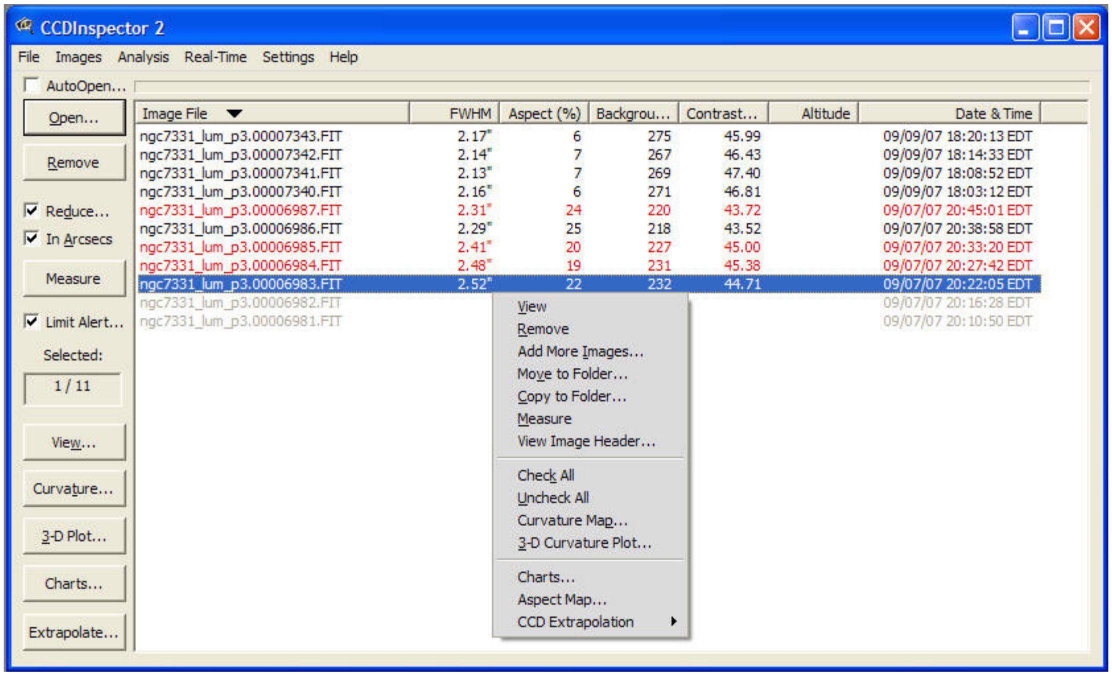
Selected: the box below this label shows how many images are currently selected, and out of how many total images in the list.
View : shortcut to Images/View menu command: open selected images in the image viewer
Curvature shortcut to Analysis/Curvature Map menu command. Displays 2-D Curvature Map for all selected images
3-D Plot shortcut to Analysis/3-D Plot menu command
Charts shortcut to Analysis/Charts menu command
2.0 **Extrapolate** this feature estimates the performance of the optical system to another camera/sensor size from just a single measured image

2.0 Limit Alert Settings

Limit Alert feature sets bounds on a number of different image attributes. All images that are measured to be outside the specified bounds will be highlighted in red color in the main CCDInspector display. This allows quick identification of images that are out of focus, with trailed stars, or too bright a background. Once identified, these images can be removed from the list, or further examined to determine whether they are acceptable.

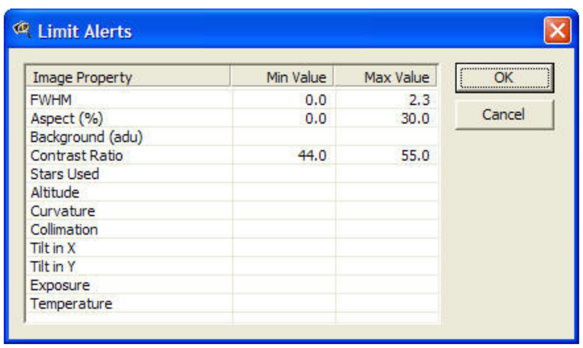
Limit alerts are only active when the Limit Alert check box is checked.

Images are shown color-coded in the main CCDInspector display:



- Images shown in gray (gray) have not been measured yet.
- When the Limit Alert feature is turned on, images that are within the specified limits will be displayed in **black**,
- Images outside the defined limits will be shown in **red**.

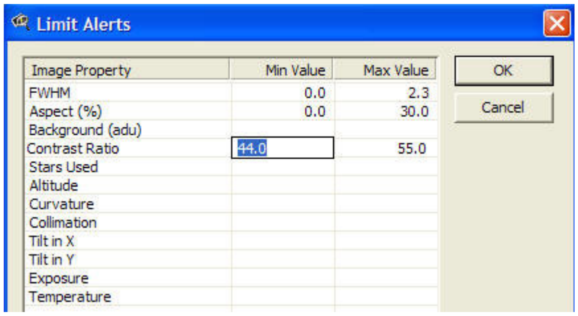
To activate Limit Alerts, click on the Limit Alert... check box on the main CCDInspector display. The following dialog will pop-up:



You can now enter the desired limits on any of these parameters:

- FWHM
- Aspect Ratio
- Background brightness
- Contrast Ratio
- Stars used (found)
- Altitude where the image was acquired
- Curvature
- Collimation
- Tilt in X
- Tilt in Y
- Exposure length
- Temperature of the CCD

To change the limit, click on the Min Value or Max Value box next to the desired Image Property. The value will become editable:



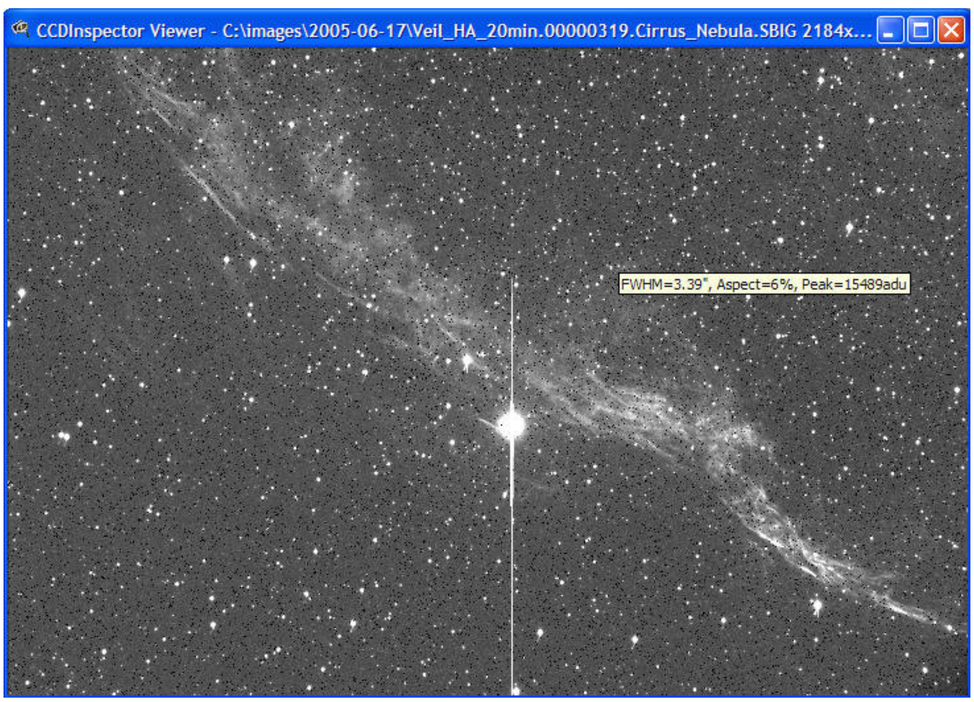
You can now type in the desired limit. Click on the Max Value cell if you want to change the Max Value for that property. To clear the property, either enter a blank for the value, or click on the Image Property name to highlight the whole row, and then press the Delete key.

Note that all the properties that contain Min and/or Max values will be evaluated for each image. If ***any one*** of these properties exceed the specified bounds, the image will be highlighted in red.

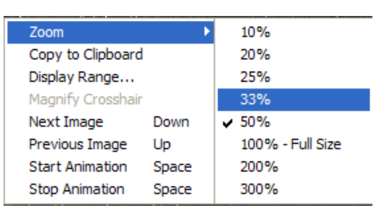
Using Image Viewer

Image Viewer (available from Images/View menu) provides a quick preview of the image. This can be useful to confirm the measurements or to verify that the image.

When an image is displayed in the Viewer, moving the mouse over any of the stars in the image will display the measurements associated with that star in a pop-up window above the mouse cursor. Information displayed will contain the FWHM value, Aspect Ratio, and peak ADU value. N/A will be displayed for any stars that CCD Inspector fails to measure (either because they are too large, distorted, too dim, not a stellar object, or multiple stars too close to each other to distinguish). Note that Image Viewer does not filter out hot pixels, as is done during image measurement. This may result in some hot pixels displaying an FWHM and Aspect value -- you should be able to tell where the real stars are. Hot pixels are ignored when determining the overall image statistics.



You can scroll around the image, and zoom in or zoom out by clicking anywhere in the image and picking the zoom level. The following options are available by clicking the right mouse button anywhere in the viewer window:



- Use Zoom level to select the magnification level for the image display

- Use Copy to Clipboard to place a copy of the image onto the Windows Clipboard. It can then be pasted into a document or into any image editing software.
- Display Range can be used to adjust the brightness levels for the image display, so as to show off more of the stars, or the object in the image
- Use Next Image to display the next image in the list (in the order that they appear in the main CCD Inspector window)
- Use Previous image to go back one image in the list
- Start Animation will start an automatic display of all the images in sequence, in the order they appear in the main window
- Stop Animation will stop the automatic display at the currently displayed image

Image Selection for Better Curvature Mapping

Ideally, the following criteria should be applied to the multiple image selection to produce an accurate curvature map:

1. All images must be of the same size
2. Images should be acquired during the same session with the same optical configuration, preferably with little or no focus variations between the frames. The images do not have to be of the same area of the sky, but should be close-by to avoid the effects of mirror-flop and flexure on focus.
3. Use CCDInspector to measure images, and pick only ones that are very close to each other in FWHM and Aspect Ratio.
4. Use images with a good sprinkling of unsaturated stars throughout the image frame. For example, a globular cluster would **not** be a good image, as all the bright and bloated stars will be concentrated at the center of the glob.
5. Use CCDInspector dark frame reduction, or images that are already reduced by dark frame subtraction.
6. Use 3 or more consecutive images for building a more accurate curvature map. This increases signal-to-noise of the measurement and produces a more accurate representation of the field curvature.
7. Use good sampling: if FWHM values are well below 2 pixels, the FWHM measurement will not be performed accurately, and the resulting curvature map may appear distorted due to uncertainty in determining the correct stellar profile. One way to deal with undersampled, short focal length configurations is to defocus the telescope slightly before taking a test image. This will result in greater FWHM values that can then be more accurately measured by CCDInspector.

If you'd like to measure a single image, it should contain an evenly spread-out star field of unsaturated stars, and should be dark-frame subtracted for best results.

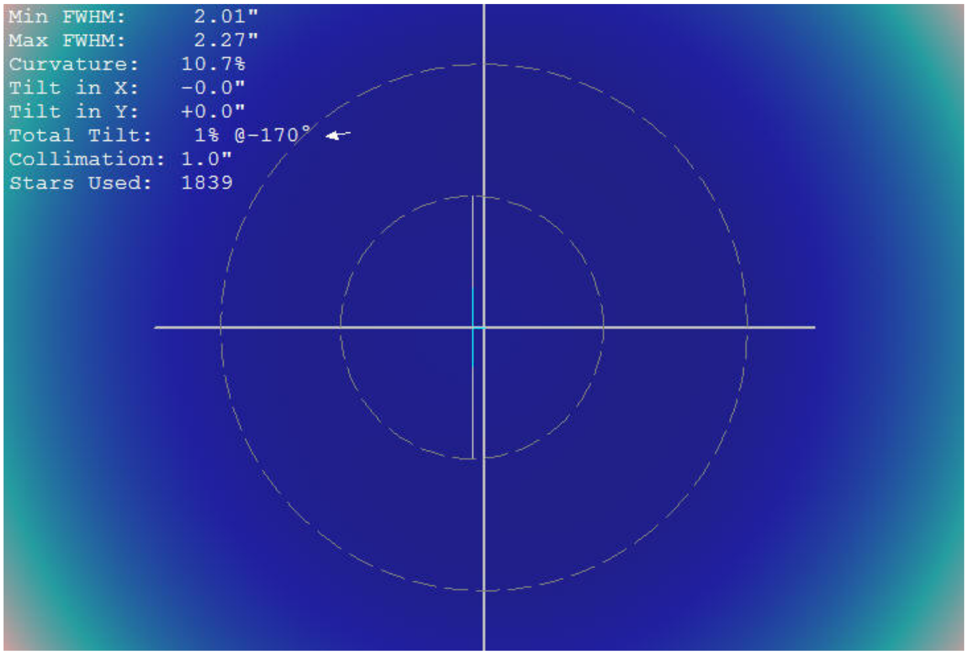
Using Curvature Map Viewer

Curvature Map Viewer (available from Analysis/Curvature Map menu) provides a topographic map of the image surface. Different colors are assigned to various levels of focus: the darkest colors are best focus, the brightest colors -- the worst focus.

CCDInspector extracts thousands of stars from each image and computes their FWHM. Then, a polynomial function is fitted to the distribution of FWHM values. This is then plotted using varying colors, as follows:

Black: lowest FWHM
Blue: slightly defocused
Green: more defocused
Red: highest defocus

Moving the mouse over any portion of the curvature map will display FWHM measurement associated with the stars in this area in a pop-up window above the mouse cursor.



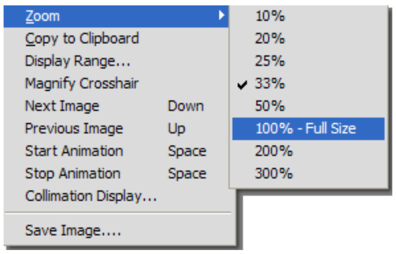
The top left corner contains a number of valuable statistics derived from the measured image:

- Min FWHM: lowest FWHM value in the curvature map

- Max FWHM: maximum FWHM value
- Curvature: percent defocus between lowest and highest defocus points on the map
- Tilt in X, Y: defocus from left to right, and from top to bottom of the image, expressed in arcseconds or pixels
- Total Tilt: is the absolute amount of measured tilt in the image, expressed in %, and its direction shown in degrees, as well as with a pointing arrow
- Collimation: the distance between physical and optical centers in the image, shown in arcseconds or pixels. Assuming a small optical tilt, this is how far the optics are from perfect collimation.

The two sets of crosshair in the middle of the image mark the physical (large circle) and optical (small circle) centers of the image. In a perfectly collimated telescope, these will coincide. As much as a few arcseconds mis-collimation can affect image quality.

You can zoom in or zoom out by clicking anywhere in the image and picking the zoom level. The following options are also available by clicking the right mouse button anywhere in the viewer window:



- Use Zoom level to select the magnification level for the image display
- Use Copy to Clipboard to place a copy of the map onto the Windows Clipboard. It can then be pasted into a document or into any image editing software.
- Display Range can be used to adjust the color assignment from lowest to highest FWHM values (the values in the range are always in pixels).
- Use Next Image to compute and display the map for next image in the list (in the order that they appear in the main CCD Inspector window)
- Use Previous image to go back one image in the list
- Start Animation will start an automatic display of maps of all the images in sequence, in the order they appear in the main window
- Stop Animation will stop the automatic display at the currently displayed image
- Collimation Display will show the collimation viewer with computed collimation error from the current map
- Save Image will allow this image to be saved as a FITS file.

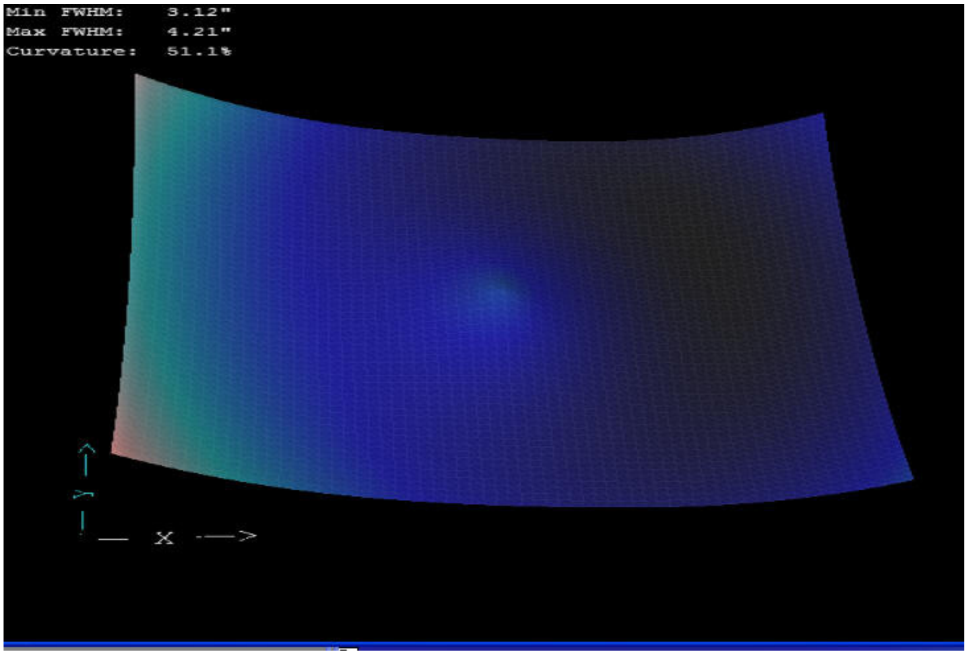
Using 3-D Curvature Plot Viewer

Just like the Curvature Map, the 3-D Curvature Plot provides a map of the image surface. The plot is shown in 3-Dimensions, with different colors assigned to various levels of focus: the darkest colors are best focus, the brightest colors -- the worst focus.

CCDInspector extracts thousands of stars from each image and computes their FWHM. Then, a polynomial function is fitted to the distribution of FWHM values. This is then plotted on a 3-D surface, with varying colors, as follows:

Black: lowest FWHM
Blue: slightly defocused
Green: more defocused
Red: highest defocus

Moving the mouse over any portion of the 3-D plot will display FWHM measurement associated with the stars in this area in a pop-up window above the mouse cursor.



You can rotate, tilt and zoom in and out using the mouse in the 3-D view. To do this, click down on the left button anywhere in the 3-D view and:

- Move mouse up and down to tilt back and forward
- Move mouse left and right to rotate the image

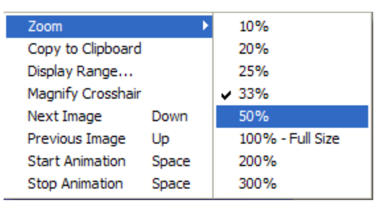
Use the mouse track-wheel to zoom in and out, or hold down the Ctrl key on the keyboard and move the mouse up or down to zoom in or out.

The top left corner contains a number of valuable statistics derived from the measured image:

- Min FWHM: lowest FWHM value in the curvature map
- Max FWHM: maximum FWHM value
- Curvature: percent defocus between lowest and highest defocus points on the map

The two axis are labeled X and Y near the bottom right corner of the image. X is the horizontal axis of the image.

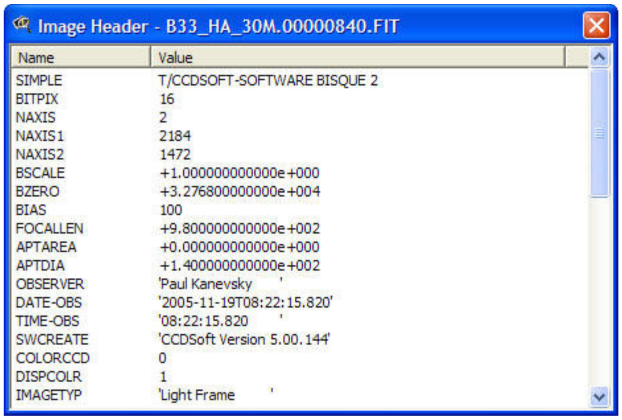
You can zoom in or zoom out by clicking anywhere in the image and picking the zoom level. The following options are also available by clicking the right mouse button anywhere in the viewer window:



- Use Zoom level to select the magnification level for the image display
- Use Copy to Clipboard to place a copy of the map onto the Windows Clipboard. It can then be pasted into a document or into any image editing software.
- Display Range can be used to adjust the color assignment from lowest to highest FWHM values (the values in the range are always in pixels).
- Use Next Image to compute and display the map for next image in the list (in the order that they appear in the main CCD Inspector window)
- Use Previous image to go back one image in the list
- Start Animation will start an automatic display of maps of all the images in sequence, in the order they appear in the main window
- Stop Animation will stop the automatic display at the currently displayed image

FITS Header Viewer

FITS Header Viewer is useful for verifying that the right image scale, focal length, camera settings, altitude, etc. are in the image header. To display the viewer, select a single image from the list of all images, and click on the **Images/View Image Header...** menu. This option is also available from the pop-up menu when right-clicking on any of the images in the list.



If any of the values are incorrect, you can use CCDSoft or MaxIm DL among other tools to correct them.

Precise Collimation

Unlike collimation procedures of the past, CCD Inspector provides a revolutionary new way to collimate a compound-optics telescope.

Collimation makes a huge difference in the quality of image and resolution that can be achieved. With CCDInspector, a collimation error of 10 arcseconds can produce as much as 1 arcseconds increase in FWHM of a star. This means that a good 3.0 arcsecond FWHM image can become a 2.0 arcsecond image with proper collimation!

By measuring the exact displacement of the optical center from the physical center of the imaging configuration, CCDInspector is capable of detecting the smallest collimation errors with your CCD still attached to the telescope, and with telescope well focused! This is the best possible way to collimate, since:

- The optical train is not disturbed by removing an eyepiece and replacing the camera after collimation
- Focus position will need only minor adjustments to get to best focus after collimation is completed
- What's more, the collimation can occur right on, or very near-by to the field you will be imaging. This may be the best way to collimate a telescopes with significant mirror flop
- Since collimation is done on hundreds of stars, there's no need to re-center anything after adjusting collimation: just take the next image, and keep adjusting.

With CCDInspector version 2.1.0, we introduce another breakthrough innovation: Single Defocused Star Collimation method. This method will help you achieve the same spectacular results as with the original collimation routine, but using only one bright star centered in the field of view.

Differences between Multi-Star and Single Defocused Star collimation methods

- Multi-star method can be used in perfect focus. This is beneficial when the focuser mechanism can introduce changes in the collimation of the system, or if you want to do a quick collimation check without losing focus
- Single-star method can be used with a single bright star. There's always a bright star somewhere in the sky, but sometimes, there is not a rich star cluster, such as is required by the multi-star method
- Multi-star method doesn't require re-centering after making collimation adjustments, Single-star method does
- Single-star method is not as sensitive to tracking errors because a bright defocused star can be used with 1 second or less exposure. Multi-star method can require much longer exposures that are subject to tracking errors

Which method should I use?

That depends on what's most convenient at the time. Decide based the differences listed above. Either method will help you achieve excellent collimation.

[NOTE: CCDInspector also provides a simplified Collimation Viewer display that is even easier to use for real-time collimation]

To facilitate achieving perfect collimation, CCD Inspector provides two sets of crosshair on the screen: the larger one marking the physical center of the chip, and the smaller one marking the current optical center of collimation. By making collimation adjustments to move the small crosshair to the physical center of the chip, the best collimation is achieved. To help, CCD Inspector also provides a numeric reading at the top left of the Curvature Map Viewer window that shows the distance between the two crosshair in arcseconds or pixels (based on the choice made in the main CCD Inspector window).

The procedure to adjust collimation is fairly simple:

1. Find a reasonably crowded star field of reasonably evenly-spread stars, with no extremely bright stars in the field of view. Just point somewhere near the Milky Way and you'll likely see many hundreds of stars in one shot.

2. Start CCD Inspector, and open the Real-Time Curvature Map window from ***Real-Time/Curvature Map...*** menu.

3. Start taking exposures using the camera's main chip. The following are some guidelines, actual settings will be different for each individual setup:

- 30 to 60 seconds exposure should be sufficient for best S/N and for collecting enough stars to measure field curvature. A longer exposure may be necessary with really long focal length telescopes, or if a well-populated star field is not available. The goal is to see at least 100 or more reasonably bright, but not saturated or bloomed, stars in the shot. More stars are better. A large concentrated star collection anywhere in the image will distort the measurement (such as a globular cluster, for example).
- Bin the chip 1x1 for best results with shorter focal length systems. FWHM of an average star in the field should be around 2 pixels or more. If it's less, the FWHM measurement will not be as precise, resulting in a less sensitive curvature computation. If the seeing is exceptionally good or the image is really undersampled, it would be desirable to defocus the image a bit to achieve the minimum of 2 pixels FWHM.
- If your image scale is 0.6 arcsecs/pix
- CCD Inspector will detect conditions when there aren't enough stars in the field of view, or they are not evenly spread out, and will display a message indicating this may not result in an accurate measurement. If you receive this message, it's usually best to stop, and adjust the parameters to get more stars in the field of view (increase exposure, or move the telescope).

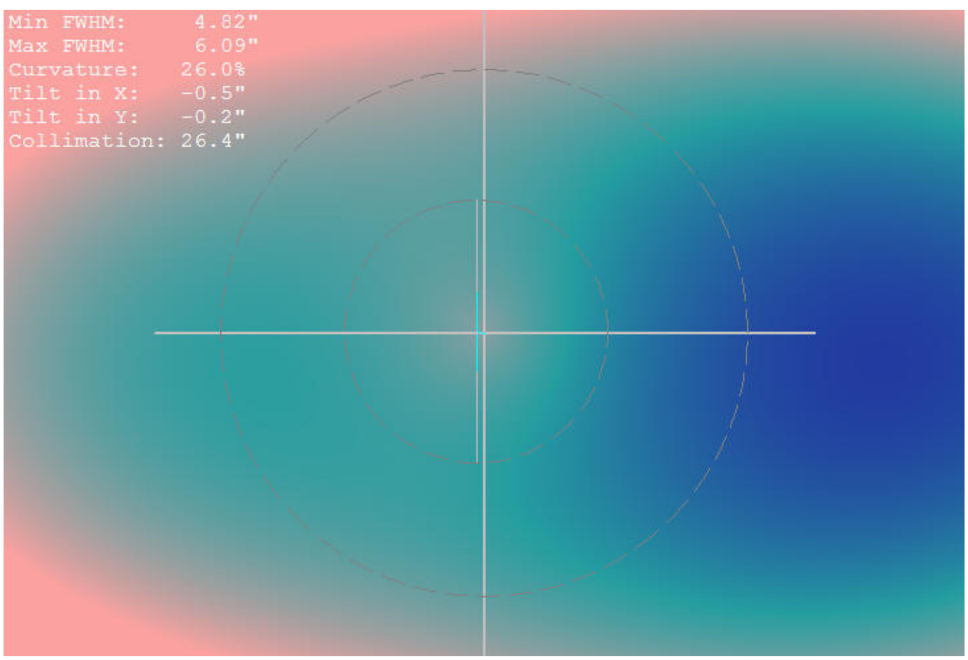
4. After each exposure, check the curvature map to see how much, and in what direction to adjust collimation. Just like in standard collimation techniques, the closer you get to perfect, the smaller the adjustments needed.

5. Make an adjustment, take the next image, and repeat with step 4. Keep doing this until the crosshair at the center overlap, and the error is indicated as only a few arcseconds. At this point, you're in excellent collimation!

Some additional hints to help with collimation:

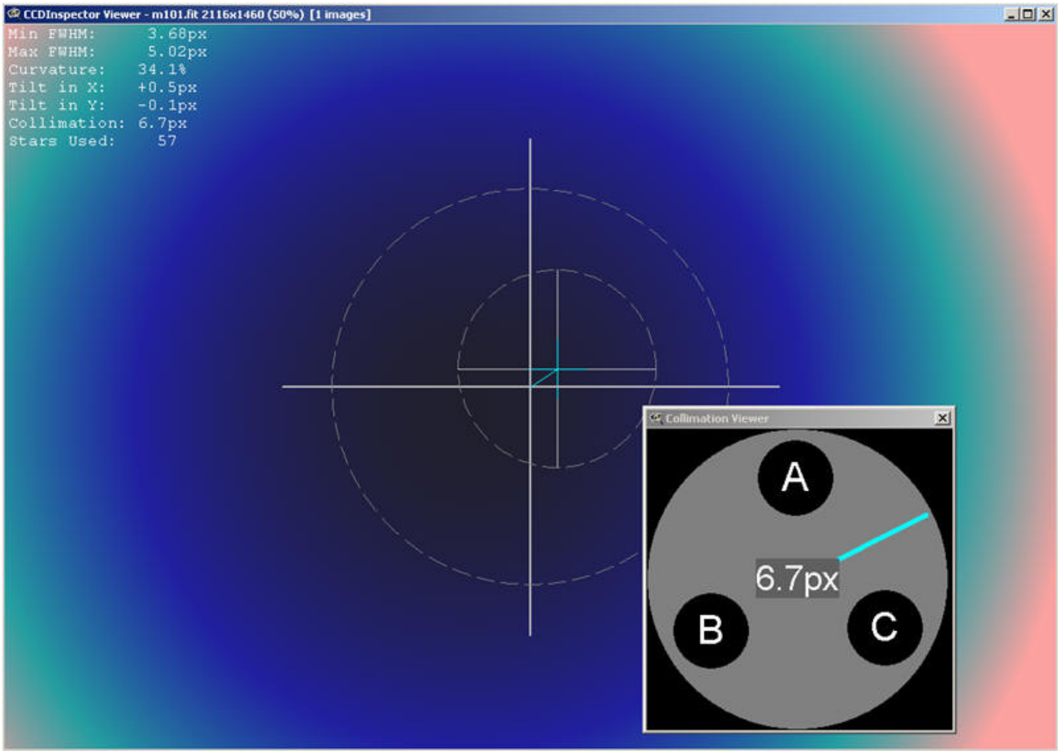
- To help see the direction and distance of the collimation error, right click on the field curvature map. From the pop-up menu , select ***Magnify Crosshair***

  You can also zoom-in further from the pop-up menu to see the error magnified. You may need to scroll the image to the center to see the crosshair, if the zoomed-in image does not fit completely on the screen.
- Remove as much tilt from the camera as possible to achieve best collimation. Use screw-in connectors exclusively, and if your focuser has collimation adjustments, use them to square the camera to the optical train. You can use the CCD Inspector Tilt measurements in the real-time curvature map view to help with doing this.
- Make sure the telescope is cooled down and equalized with ambient air: if not, you will see strange artifacts in the curvature maps that are due to air currents as the OTA cools, such as this:



Collimation Viewer

Collimation Viewer is a real-time display that provides an intuitive guide to the corrections necessary to achieve perfect collimation. This tool uses the same calculation as the Curvature Map display, but shows the result in a form more suitable to real-time collimation:



Collimation Viewer can be started in two different ways:

- To do real-time collimation, click on the ***Real-Time/Collimation Viewer*** menu from the main window in CCDInspector. Then start taking exposures using your camera, and it will automatically show collimation from the most recently acquired image.
- To see collimation display for an image, first display the curvature map for it: ***Analysis/Curvature Map*** menu. Then, right click on the map image, and select ***Collimation Display***... The Collimation Viewer will show the error and recommended correction for the image that was used to create the original curvature map.

Collimation viewer shows the three-screw, tip-tilt collimation arrangement that is commonly used on SCT's, RC's, Newtonians, and other styles of telescopes.

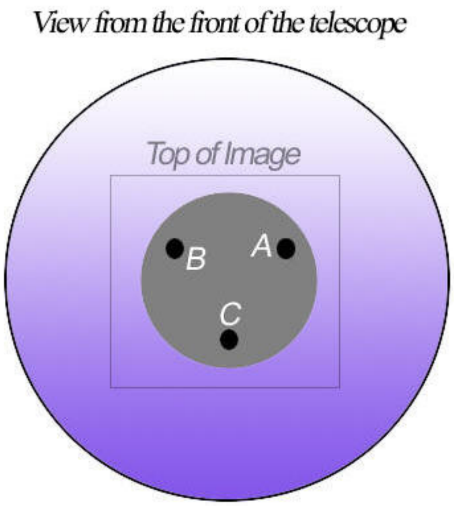
Here are the necessary configuration steps to start using the Collimation Viewer:

1. First, note that the top of the collimation viewer must always correspond to the top of the OTA
2. When looking at an SCT from the front, the three knobs, labeled A,B, and C need to be aligned to the top of the Collimation Viewer in the same way the physical knobs are aligned to the top of the OTA. To align the display knobs, click the left mouse button on one of them, and drag to rotate to the desired position. Note that the labels A, B, and C are not important, and are used just to make it easier to identify which button is being selected. Whether A, B, or C is aligned with the top side in the above image does not matter, as long as one of the knobs is located in this position.

Important: In order not to loosen the secondary mirror completely, avoid repeatedly turning any one knob in the counter-clock-wise direction.

To collimate an SCT, start by looking at it from the front of the telescope towards the back. In the middle of the corrector, you'll find a the secondary mirror with three collimation screws or knobs.

The image below shows a schematic view of the front of the secondary mirror with collimation screws represented by circles A, B, and C (note that the actual labels are not important. They are there to make it easier to identify a knob on the telescope. If convenient, you can even add a sticker next to each of the knobs to label them with the corresponding letter. This will make it easier to identify which knob to turn when the telescope is rotated or when you are facing it from an difficult angle):



The top of the image will coincide with the top of the OTA and the top of the secondary mirror. To match the knobs to their position on the SCT , click and drag any of the A/B/C collimation knobs in the Collimation Viewer to rotate them to align with the top of image.

The same type of alignment procedure applies to an RC, MCT, or a Newtonian, although Newtonian may require a little experimentation to determine which knob corresponds to the top of the image, since the camera is positioned at a 90 degree angle to the primary. For the RC or Newtonian, simply imagine the Collimation Viewer knob display to show the back of the primary, with the three knobs controlling the tip-tilt of the primary mirror.

Once properly aligned, the Collimation Viewer will show the collimation error direction and magnitude automatically, as soon as a new image is downloaded from the camera using your configured image acquisition software. To make a correction, try turning each knob in turn to see which one reduces the collimation error number displayed in the middle.

The display shows:

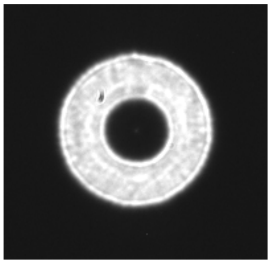
- The magnitude of the collimation error in the center of the display
- The direction of the collimation error shown by a line from the center of the viewer display. The line only shows the direction of the error, not the error magnitude.
- Number of stars detected in the image (shown in the title of the Collimation Viewer window). The same recommendations apply to the Collimation Viewer as do for the Curvature Map Viewer: 50 stars is a minimum, 100+ stars is recommended for a more accurate collimation computation, and proper star sampling is required.

Note that the Collimation Viewer window can be sized to be better visible from a distance: simply click and drag on the bottom-right corner of the window to increase or decrease the display size. Collimation viewer can be displayed at the same time with the real-time Curvature Map display for a different view of the collimation error.

Single (Defocused) Star Collimation Method

Defocused star collimation method is new in CCDInspector 2.1.0. The main differences between the previously available collimation method in CCDInspector and the Single Star Collimation (SSC) are:

- Only one, centered bright star is needed for SSC
- The star must be sufficiently out of focus, so as to fill out a circle of at least 40-100 pixels radius
- The star must be positioned close to the image center
- The star must be be exposed well enough to get a good signal-to-noise ratio



This method should look familiar to anyone who has done visual collimation through an eyepiece. The main advantage of using CCDInspector is that unlike the conventional methods, you can keep your camera attached to the telescope, your hands and eyes next to the collimation screws and get a continuous and precise numerical read-out of collimation error and direction.

Quick Start

The following describes all the steps necessary to start collimating. With practice, this process can take as little as few minutes, even when the scope is far out of collimation.

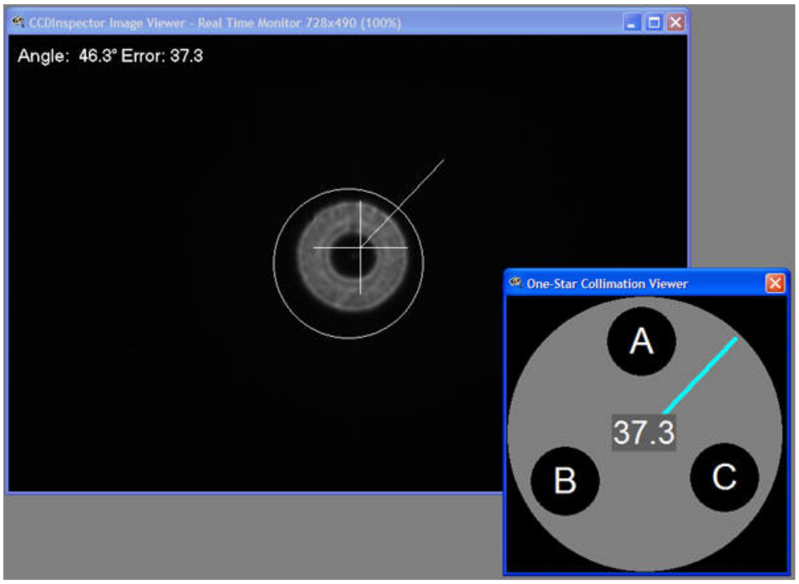
1. Point your telescope at a bright star, well above the horizon. A magnitude -2 or higher is recommended, but larger aperture telescopes may use dimmer stars. A dim star can still be used, but may require a longer exposure.

2. Start taking continuous images of the star using a focus routine of your image acquisition software:

   - Make sure the image acquisition software is properly selected in ***Settings->Camera Control Software*** menu of CCDInspector
   - you can bin the chip 2x2 or even 3x3. Binning increases S/N ratio, and increases download/processing speed, so it's definitely recommended
   - use automatic dark subtraction, if this option is available in the acquisition software
   - for bright enough stars, an exposure of one second can be plenty, especially with a binned chip

3. Start the collimation viewer from ***Real-Time->Collimation->Defocused Star Collimation Viewer*** menu in CCDInspector

4. Start the image viewer from ***Real-Time->Image Viewer*** menu



5. Position the image viewer window and the collimation viewer side-by-side, so you can see both at the same time

6. Defocus the star so that it occupies about the size of the circle near the center in the image viewer. Exact size is not very important, but it should be greater than about 20 pixels radius, and not so defocused so as to become too dim. CCDInspector can handle stars the size of about 90% of the whole chip, and as small as 20 pixels radius. If the star is too dim, or too small, CCDInspector will display a brief error message indicating the problem.

7. Center the star as best as you can using your telescope's movement controls. If it's not exactly at the center, no big deal. But, if it is really far away, the error size and the direction will no longer be accurate.
   - The circle at the center of the image viewer is positioned exactly in the middle.
   - The cross marks the center of the defocused star.
   - Ideally, the cross should be positioned near the center of the circle (in the image above, its away from the center, to the top right)

8. Take a few images and watch the Collimation Viewer update. Each time the window is updated, it will flash red for a few seconds, the number in the center will change, and the direction arrow will be adjusted

9. Your goal is to turn a collimation knob so that the image of the star moves ***in the direction that the collimation arrow is pointing***. The star movement doesn't have to be exactly in this direction, but should be close. You can determine which knob to turn by trial and error.

10. After you turn the correct knob, you will see the image of the star shift in the direction the arrow is pointing. In order to read the updated collimation values, first, re-center the star using your telescope controls

11. Wait a few seconds after making the adjustment for the telescope vibrations to die down, and then watch the result shown in the Collimation Viewer. The error number should decrease

12. As the number gets smaller, the amount of knob adjustment needed also gets smaller. With error value less than about 5, a very light touch to the knob in the right direction is all that may be needed.

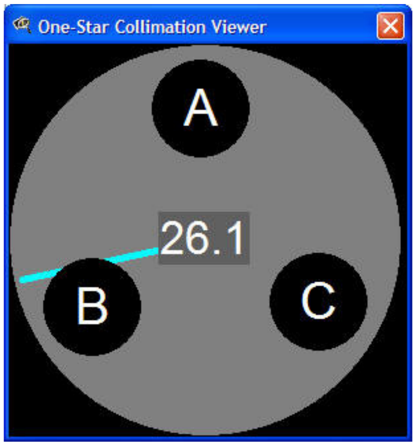
13. Note: If the direction arrow keeps pointing in different directions all by itself, your optics are already collimated to the best possible level under the current seeing conditions: it's not advisable to proceed any further

14. Repeat steps 8-14 until the value in the middle is as low as possible, and while the direction arrow does not jump around to completely different directions

15. Under good seeing conditions, it should be possible to reduce the error to near zero.

Collimation Viewer

The same Collimation Viewer that is used for the multi-star collimation method in CCDInspector is also used for One Star Collimation method. The viewer is a real-time display that provides an intuitive guide to the corrections necessary to achieve perfect collimation. This tool uses innovative image processing and image recognition algorithms, and shows the result in a form suitable to real-time collimation:



Collimation Viewer can be started by clicking on the ***Real-Time->Collimation->Defocused Star Collimation Viewer*** menu in CCDInspector.

Collimation viewer shows the three-screw, tip-tilt collimation arrangement that is commonly used on SCT's, RC's, Newtonians, and other styles of telescopes. This display is for mnemonic purposes, to help you keep track of which knob does what.

Important: In order not to loosen the secondary mirror completely, avoid repeatedly turning any one knob in the counter-clock-wise direction. Turning a knob counter-clockwise is equivalent to turning the other two knobs clock-wise.

The Viewer display shows:

- The magnitude of the collimation error in the center of the display. This number is unit-less, and doesn't change with image scale or the amount the star is defocused
- The direction of the collimation error is shown by a line from the center of the viewer display. The line only shows the direction of the error, not the error magnitude

Your goal is to get the error number as low as possible. On a night of good seeing, this value can be lowered to nearly zero.

Note that the Collimation Viewer window can be sized to be better visible from a distance: simply click and drag on the bottom-right corner of the window to increase or decrease the display size.

Image Viewer

While the Collimation Viewer is displayed, the Image Viewer display will overlay the image of the star with some additional graphics:

The Angle and Error display at the top show the collimation error numerically: the error value is the same value as shown at the center of the collimation viewer, while the angle is the angle in degrees of the error direction (negative degrees indicate clock-wise direction, while positive indicate counter-clock-wise).

The cross indicates the center of the star image, while the line circle indicates the center of the CCD chip. As you make adjustments to collimation, re-center the star by moving the cross closer to the center of the circle. The extra line coming out from the center of the circle is the collimation direction arrow. It points in the same direction as the arrow in the collimation viewer.

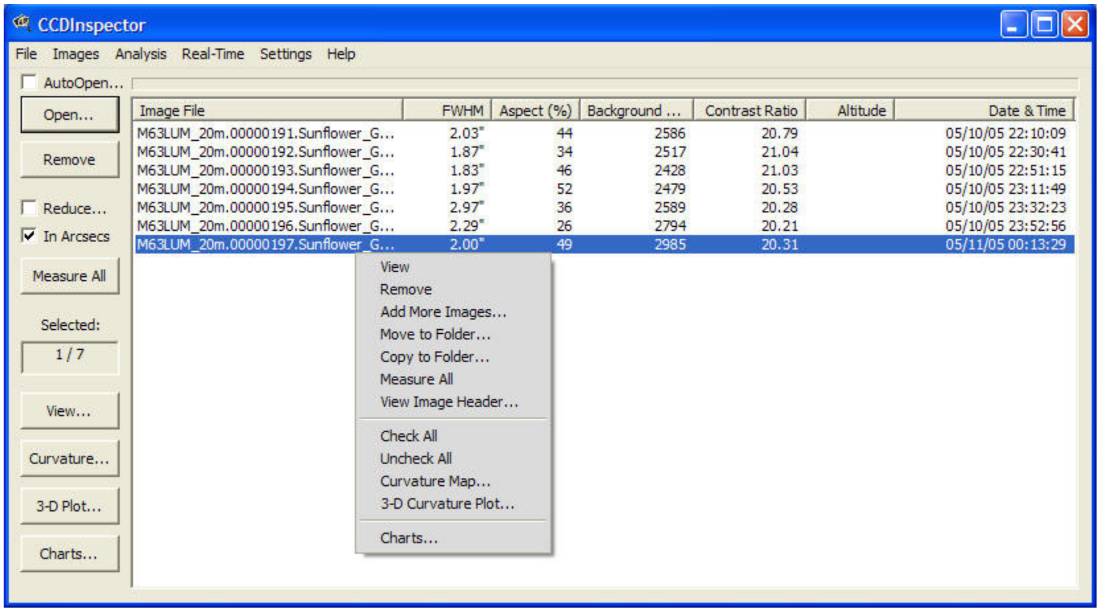
Helpful Hints

- Make sure to re-center the star if it moves more than about 20 pixels away from the camera center. The accuracy of the measurement will be affected in some optical designs (for example, SCT) if the star is far away from the center
- You can use a sub-frame mode, but leave a background border of about 20-50 pixels all around the defocused star. Make sure that the subframe you use is centered on the chip, otherwise the collimation accuracy will be affected
- A very bright star may require shorter exposure and/or no binning. If the exposure is too long, there could be bright blooming and diffraction spikes around the star that can affect accuracy. To see if this is the case, decrease the display range of the image to make the star very bright on the display. If you see solid rays emanating from the top and the bottom (sometimes left and right) of the star, then the exposure is too long
- Don't make the exposure time too short, either. Less than 0.5 seconds is not recommended, as that will often be affected by seeing changes in the atmosphere. Best results will be achieved with an exposure from 0.5 to about 2 seconds.
- Pay particular attention to the collimation error direction arrow: if it keeps jumping by more than 30-40 degrees between consecutive measurements, then you have reached the limit of what can be done in the current seeing conditions, regardless of the value of the actual error. Under good seeing conditions, I have been able to lower the collimation error to less than 1. Under poor seeing conditions, the error direction started getting jumpy at around 5.

Using Charts

Charts feature is a powerful analytical tool that allows direct comparison of various measured values from multiple images. Any of the numeric values can be used in a chart, whether computed or derived from the image.

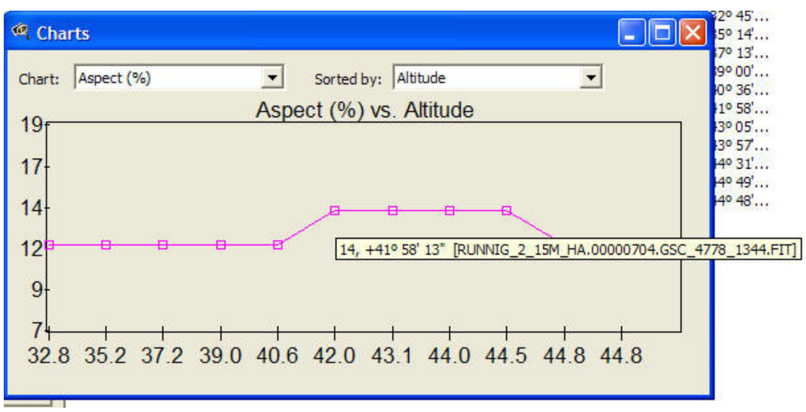
To invoke charts, the images in the list must be measured, and CCD Inspector will prompt if this not already done. All images in the list are plotted on the chart. Charts feature can be invoked through the Analysis/Charts menu or by clicking on the Charts button on the lower left panel of the main window.



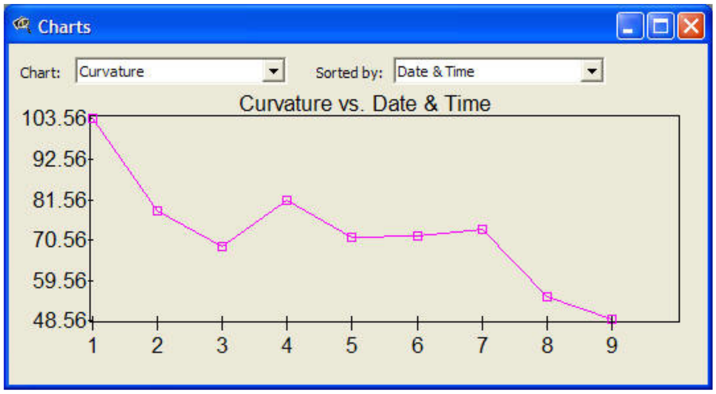
Charts default to displaying FWHM values over time. In this way, one can see the change in focus or tracking over a number of images. Any of the numeric values can be selected for the horizontal axis, and any for the vertical. In this way, it's easy to find a correlation between different variables in your system. Each point on the chart represents a single image and is marked by a small rectanle. If you move the mouse over the rectangle, a popup window will show both, the values for X and Y axis for that image, and the image file name.

Here are some examples:

- Aspect Ratio plotted against Altitude can give an indication of how the mount tracks depending on position in the sky:



- Collimation plotted against altitude or time can give an indication of mirror flop in the system
- X or Y tilt over time can be an indicator of focuser sag, flexure, or mirror flop
- Background brightness over time can indicate the time of the night when the sky is darkest
- Changing curvature over time also implies changing collimation due to flexure or mirror flop:



Using Generic Camera Control Software

CCDInspector works directly with CCDSoft and MaxIm DL to acquire and process images in real-time. Starting with version 1.1 it can also be used with all other software acquisition packages, as long as they are able to automatically save captured images into a specific folder in FITS, SBIG, TIFF, or DSLR RAW formats.

To use the Generic camera support:

- Select **Settings/Camera Control Software/Generic...** menu command. You will be prompted to chose the destination folder where the acquisition software will write out captured images. Pick an existing empty folder or create a new one.

- Select **Real Time/Curvature Map...** or **Real Time/3D Curvature Plot** menu to bring up the real-time viewer. You'll be asked if you want to delete the images from the specified folder after measuring. Select Yes if you are not going to need the images: CCDInspector will delete them automatically. Select No if you want to keep the images after they have been measured by CCDInspector. CCDInspector will only inspect new files written to the folder, so you can keep older images in the same folder.

- Now, start the acquisition software, connect to the camera, point the telescope into a star-rich portion of the sky not far from zenith, and set it to automatically save all the exposures to the same folder selected for CCDInspector Generic analysis.

- Next, start taking 10-30 second exposures. After each exposure is downloaded from the camera and saved into the chosen folder, CCDInspector will pick it up, load and measure it, and display the corresponding curvature map.

If you chose Yes to delete the images, the image will be removed from this folder after the map is generated, otherwise, all images captured by the camera will remain in this folder.

Do not use too short of an exposure. A short exposure is not very good for curvature analysis, and CCDInspector may not have enough time to process the first image before the second one is downloaded. As a result, some images may be skipped. 10-30 seconds exposure should be long enough, but may depend on the speed of your computer.

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2.0 Sensor Extrapolation Tool

The Sensor Extrapolation Tool can be invoked from the Analysis menu. The basic function of the tool is to provide an estimate of how well an optical system will perform with a different size sensor by analyzing images taken with your existing camera. The tool contains a long list of different cameras and sensor chips, so the appropriate camera can be quickly selected from the list. For example, if the current camera has a KAF-3200 chip, and the user is considering upgrading to a larger, KAF-16803 chip, some reasonable questions may be:

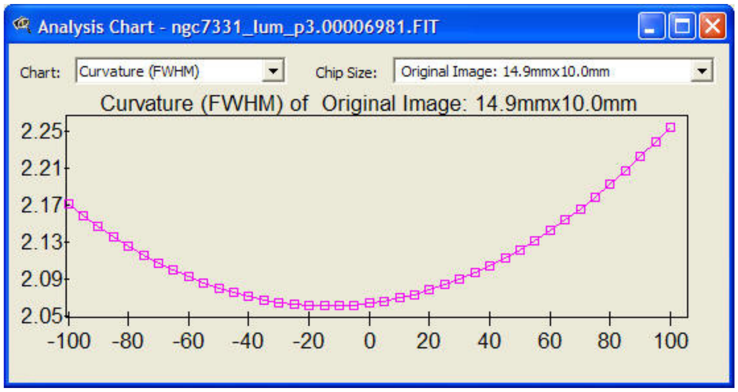
1. How flat will the field be at the edges of the image? Will the stars be too defocused in the corners? Will I need a field flattener?
2. How much coma will there be in the corners? How elongated will the stars appear with the new chip?
3. How much light fall-off (vignetting) will there be with the larger chip? Will the edges and the corners be sufficiently illuminated?

Normally, to answer all of these questions one would have to borrow, steal, or buy the new camera and try it out on the existing equipment. CCDInspector makes this process much easier (and cheaper!) Simply acquire one or more images of a well-populated star field, just like the ones used for Curvature Map, Collimation, and any other analysis tools in CCDInspector. If you have some old frames, these will work just as well.

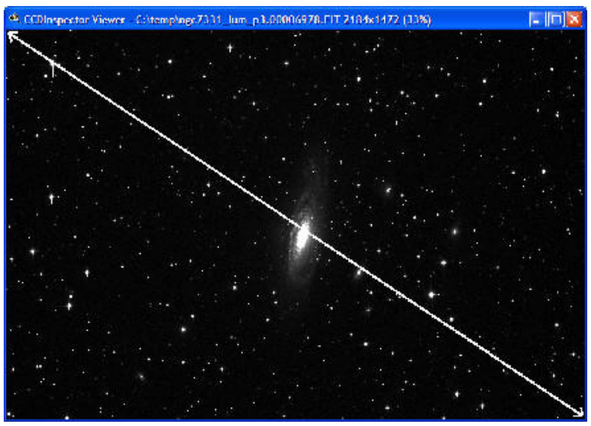
Load the images into CCDInspector, select one or more of them, and then click on the Analyze/Sensor Extrapolation menu (also available from the Extrapolate... button on the main screen). Pick the desired measure you'd like to extrapolate:

- FWHM (curvature)
- Aspect Ratio
- Vignetting

CCDInspector will display a chart of the measure you selected:

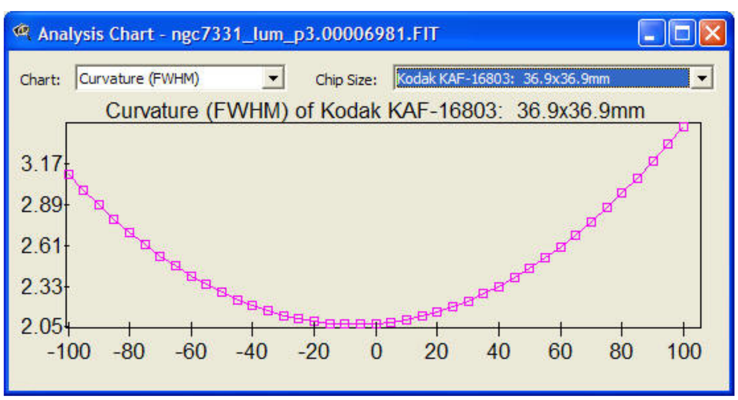


Initial chart will represent the measurement of the existing system and chip size. The current chip is displayed next to the Chip Size label, at top left. Note that the sensor, KAF-3200 has chip size of 14.9mm x 10mm. The image below represents a measurement taken along a line from the top left to the bottom right of the sensor. The vertical axis represents the measure (FWHM value above), while the horizontal axis represents percent distance from the center of the chip. 0% is at the chip center, while -100% is at the top left corner, and +100% at the bottom right:



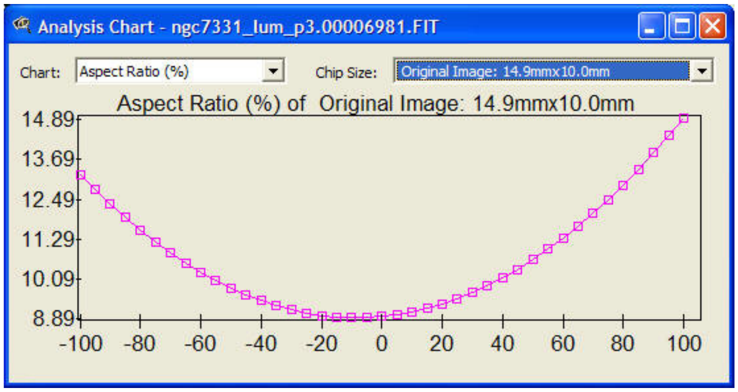
Note that from the chart above, one can see that there's a slight tilt to the image that makes the stars at the bottom right (100% mark) bigger than the stars at the top left (-100%). Overall, star sizes are about 8-10% larger at the corners than they are at the center. Pretty good performance.

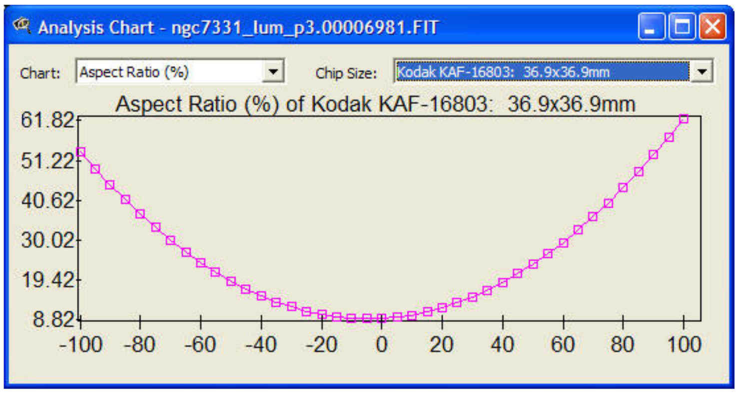
Now, let's see what the same optical system will do with the larger, KAF-16803 sensor. Click on the down arrow next to Chip Size, and pick either the camera brand you are considering, or the name of the sensor:



Analysis chart will now display FWHM values as estimated by CCDInspector for the new sensor size. Note that the new sensor is significantly larger, 36.9 x 36.9mm, and is square instead of rectangular. From the chart above, it is easy to see that the stars in the corners will be quite a bit larger, about 3.3 arcseconds FWHM on the average. This represents a 60% increase in star size at the corners -- much more obvious than the 8% measured with the smaller chip. Looks like a field flattener would be a good idea for this size chip!

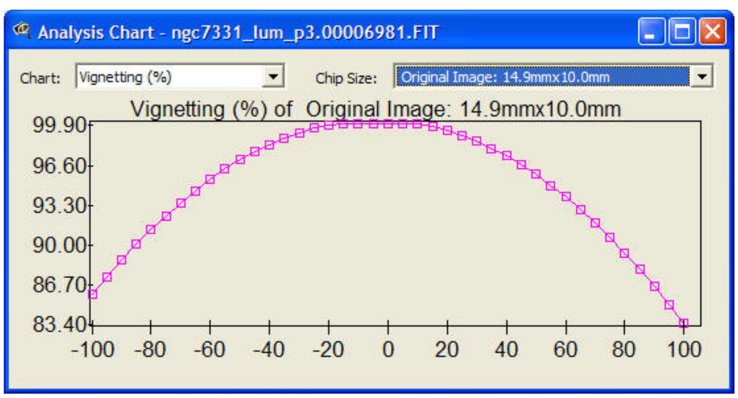
CCDInspector can also estimating star aspect ratio as it would appear on the new chip. Simply change Chart: type to Aspect Ratio (%), and the chart on the left will be displayed for the original sensor:



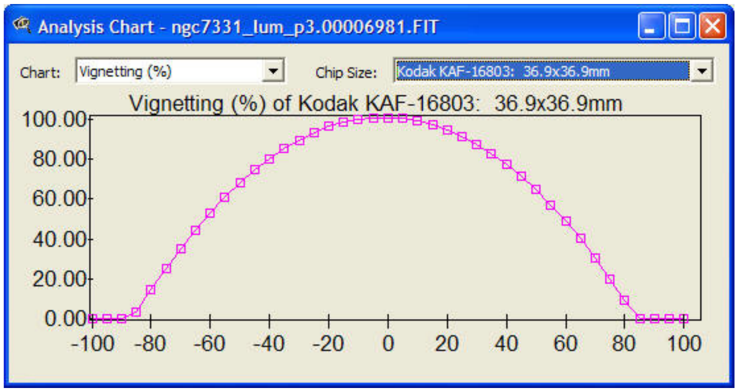


Note that aspect ratio increases towards the edges, probably due to coma and other aberrations present in the system. For the KAF-3200 sensor, the increase is fairly negligible, and aspect ratio is under 15% for stars all the way in the corners. Now, let's see what the aspect ratio system performance would be with the larger chip. The chart at the right shows that the estimated aspect ratios will be nearly 55% in the corners! This will be fairly noticeable and so, a coma corrector is very likely needed when upgrading to the larger sensor.

Similarly, one can analyze the amount of light fall-off in the corners of the image. Select Vignetting (%) from the Chart: drop-down list. For the original image, the chart will be shown in % of light available along the same diagonal line as before:



From the chart above, it's easy to see that light fall-off is about 15% in the corners of the current sensor. Although that's reasonably large, this amount of vignetting is easily handled by a good flat frame application. Now, let's see what the light fall-off will be for the larger chip:



Wow! The larger chip will have 0% illumination in the corners! That's a serious problem that will need to be addressed! If 30% is about the maximum acceptable level of vignetting , then only about 1/2 of this larger chip will be sufficiently illuminated, judging from the above chart.

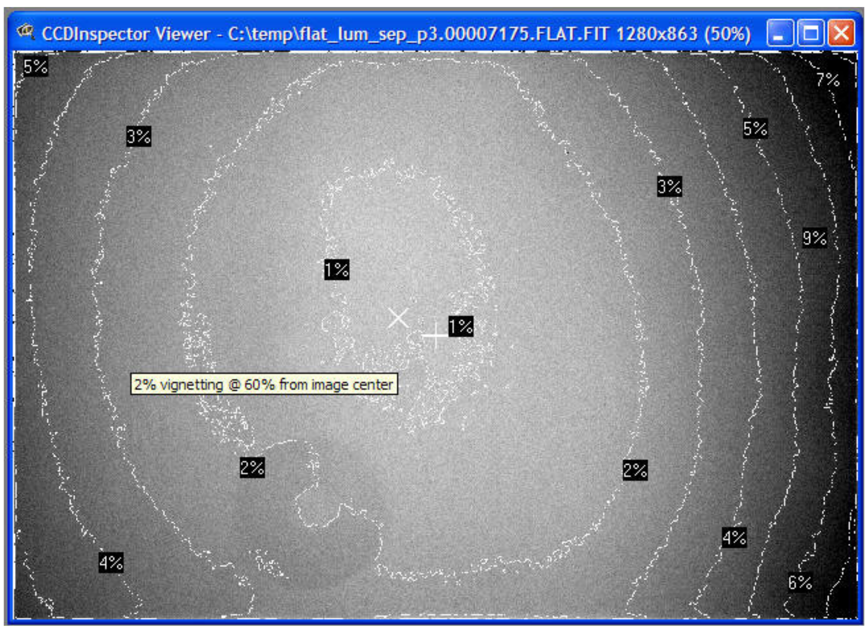
2.0 Using Flat Frame Analysis Tool

Flat frame analysis tool provides an easy quantitative way to determine the degree of illumination throughout an image frame.

This tool can analyze images containing a star-field, similar to the kind that would be used for collimation using CCDInspector, or a true flat frame image.

For best results, don't use images containing any extended objects (nebulae, galaxies, dense globular clusters).

To analyze an image, select it in the main window and click on the Analysis/Flat Frame Analysis menu. If your image contains stars, the result will look something like this:

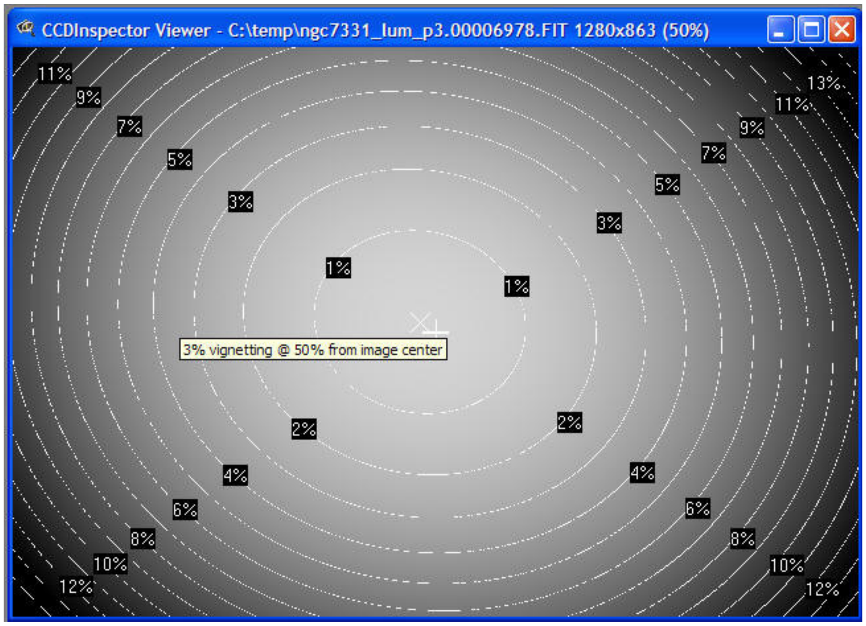


The jagged lines indicate the percent of light fall-off from the center. For example, line labeled 2% encloses the area of the image where light fall-off is less than 2%.

From the image above, it's clear that the light fall-off for this system is about 5%-7% all the way in the corners of the sensor. As you move the mouse across the flat field analysis image, a small pop-up will display the amount of light fall-off under the cursor, and will also show how far away the cursor is from the center of the image. In the image above, the mouse pointer is at 60% away from center, and shows that at that location, the vignetting is only at 2%.

In addition to seeing the percent light fall-off, the display above also shows how far the optical illumination center is from the physical center of the chip. The center of the chip is marked by the + symbol, while the optical illumination center by X.

An image of a star field can also be analyzed for vignetting. Proceed as before, by selecting the image and then clicking on Analyze/Flat Frame Analysis menu. The resulting image may look something like this:

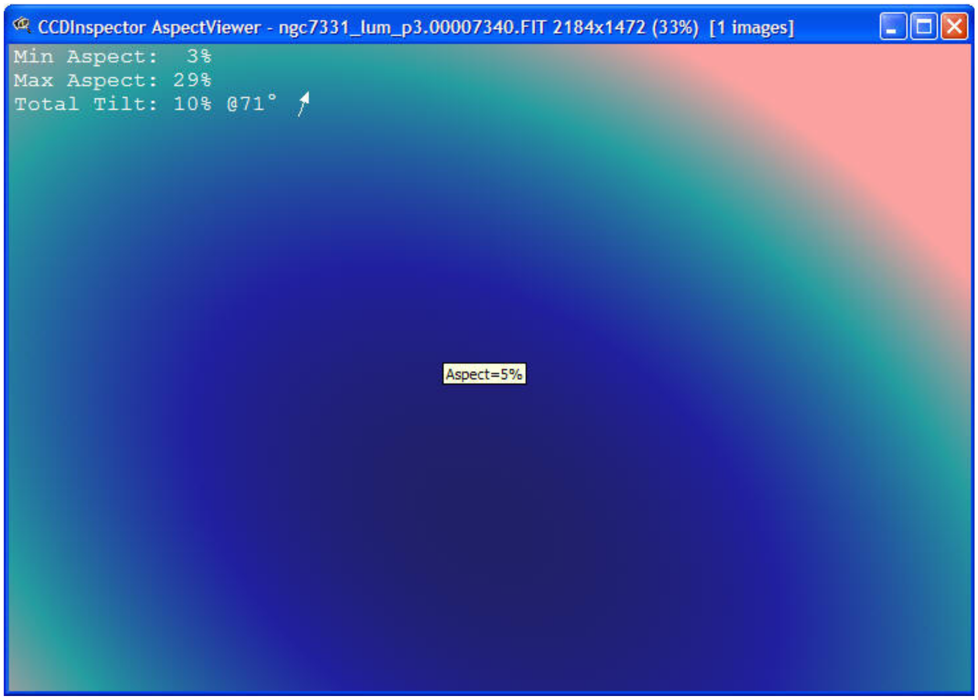


The same type of information is available in this display as in the one described above, although the image itself represents a mathematical approximation of the flat field, computed by evaluating image background at various points in the image.

2.0 Aspect Ratio Map

Aspect Ratio Map is a new tool that helps visualize stars elongation throughout the image. Stars can be elongated for various reasons, including collimation errors, image plane tilt, and coma.

Aspect Map is a ***heat-map***, similar to the Curvature Map. But, instead of assigning different colors to star FWHM values across the field, Aspect Map assigns different colors to aspect ratios of the stars across the field. Blue, darker colors indicate low aspect ratio values, while brighter, redder colors indicate higher aspect ratios.



In addition to a ***heat-map*** display, Aspect Ratio Map provides a minimum and maximum aspect ratios for the image. Total Tilt value is an indication of asymmetry in the distribution of elongated stars. The total tilt shows the amount of asymmetry, in percent, and the direction in which the aspect ratios increase the most.

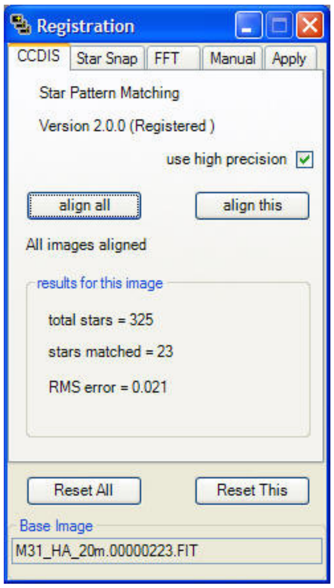
2.0 CCDIS Plug-in for CCDStack

A new and exciting development in CCDInspector 2 is the inclusion of an advanced, automated image registration module that works seamlessly with CCDStack. This module, CCDIS will only work if both, CCDStack and CCDInspector are installed on the same computer.

Image registration is the process of adjusting an image stack so that all the images are properly aligned to a base image. This can involve scaling the images to the same dimensions, shifting them vertically and horizontally, and de-rotating them so as to allow them to be stacked.

Without CCDIS registration process can be tedious, and the resulting registration may not be as accurate. Inaccuracies in registration can lead to blurring and loss of resolution in the stacked image -- something to be avoided at all costs! CCDIS uses an extremely accurate and sophisticated algorithm to find unique star patterns between all the images, ***automatically***! CCDIS then applies the appropriate scaling factor, de-rotation, and linear offset to align the images in the best possible way. CCDIS will also flip the image if the horizontal or vertical axis are reversed. Generally, CCDIS alignment accuracy will be better than 1/10 of a pixel. In many cases it is better than 1/30 of a pixel!

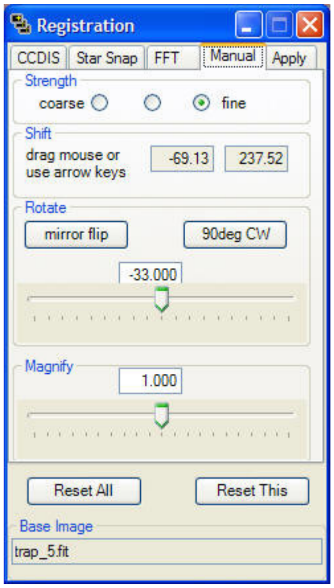
CCDIS plug-in is included and automatically enabled during the installation of CCDInspector 2. If you already have CCDStack or decide to install it later, CCDIS will quickly become your primary choice of registration methods:



When installed, CCDIS tab will be the first tab of available registration methods in the CCDStack Registration dialog. There are no complicated settings: just click **align all** or **align this** buttons to perform the fully automatic registration. When done, the results of the registration will be shown in the lower half of the dialog. **Results for this image** section shows the registration statistics for the currently selected image. Above example indicates that a total of 325 stars were chosen for the registration process, and from these, a 23-star unique pattern was identified that matched with the base image (base image is shown on the bottom of the dialog). The RMS error shown is the average error across all 325 stars, after the registration process completes. This is expressed in pixels. The above result is very good, showing that the error is almost 1/50 of a pixel!

The only option in the CCDIS Registration dialog is to **use high precision**. This option makes CCDIS do more work by extracting more stars from the image, and by looking for the star pattern for a bit longer. The results are usually somewhat improved compared to the low-precision registration. High precision mode can take a bit more time, but can work better especially for images that do not have a large overlap, such as when doing mosaics. If CCDIS is unable to find a matching star pattern in the low-precision mode, it will automatically switch to the high-precision mode and try again. In most cases, it is safe to leave **use high precision** option unchecked.

Once registration completes, you can see the actual transformation settings CCDIS found for each of the images by opening the Manual tab:



As you select different images in the image manager, the values in the Manual tab will change to show the CCDIS-determined registration parameters. In the example above, the selected image was shifted over by -69.13 pixels horizontally, 237.52 pixels vertically, and was rotated by 33 degrees. The image scale was found to be the same, so the scaling factor (Magnify) was set to 1.000.

NOTE: after performing registration and looking at the color display in CCDStack, the stars may appear to be slightly out of alignment, especially at high magnification. This is because the display cannot adjust images by a fraction of a pixel, and is not an indication of CCDIS error. Once you apply the registration to the images, the position errors will disappear (except when using the Nearest Neighbor interpolation method, the stars also cannot be adjusted by less than a whole pixel).

CCDIS uses a highly optimized, efficient algorithm to perform pattern matching. It will use multi-core, or multi-processor computers to perform its functions even faster than on a single CPU.

DSLR RAW File Support

CCDInspector supports native RAW digital camera formats created by the cameras shown below.

The RAW format capability is based on the source code provided by David Coffin, and only some have been tested by us. David's software is very well written, and we are confident that all of the formats listed below will work. Should you find a format that's listed but not working, please let us know.

Adobe Digital Negative (DNG)
AgfaPhoto DC-833m
Apple QuickTake 100
Apple QuickTake 150
Apple QuickTake 200
AVT F-080C
AVT F-145C
AVT F-201C
AVT F-510C
AVT F-810C
Canon PowerShot 600
Canon PowerShot A5
Canon PowerShot A5 Zoom
Canon PowerShot A50
Canon PowerShot A460
Canon PowerShot A530
Canon PowerShot A570
Canon PowerShot A590
Canon PowerShot A610
Canon PowerShot A620
Canon PowerShot A630
Canon PowerShot A640
Canon PowerShot A650
Canon PowerShot A710 IS
Canon PowerShot A720 IS
Canon PowerShot Pro70
Canon PowerShot Pro90 IS
Canon PowerShot Pro1
Canon PowerShot G1
Canon PowerShot G2
Canon PowerShot G3
Hasselblad V96C
Imacon Ixpress 16-megapixel
Imacon Ixpress 22-megapixel
Imacon Ixpress 39-megapixel
ISG 2020x1520
Kodak DC20
Kodak DC25
Kodak DC40
Kodak DC50
Kodak DC120
Kodak DCS200
Kodak DCS315C
Kodak DCS330C
Kodak DCS420
Kodak DCS460
Kodak DCS460A
Kodak DCS520C
Kodak DCS560C
Kodak DCS620C
Kodak DCS620X
Kodak DCS660C
Kodak DCS660M
Kodak DCS720X
Kodak DCS760C
Kodak DCS760M
Kodak EOSDCS1
Kodak EOSDCS3B
Kodak NC2000F
Kodak ProBack
Kodak PB645C
Kodak PB645H
Nikon E4500
Nikon E5000
Nikon E5400
Nikon E5700
Nikon E8400
Nikon E8700
Nikon E8800
Nikon Coolpix P6000
Nikon Coolpix S6
Nokia N95
Olympus C3030Z
Olympus C5050Z
Olympus C5060WZ
Olympus C7070WZ
Olympus C70Z,C7000Z
Olympus C740UZ
Olympus C770UZ
Olympus C8080WZ
Olympus X200,D560Z,C350Z
Olympus E-1
Olympus E-3
Olympus E-10
Olympus E-20
Olympus E-30
Olympus E-300
Olympus E-330
Olympus E-400
Olympus E-410
Olympus E-420
Olympus E-500

Canon PowerShot G5
Canon PowerShot G6
Canon PowerShot G7
Canon PowerShot G9
Canon PowerShot G10
Canon PowerShot S2 IS
Canon PowerShot S3 IS
Canon PowerShot S5 IS
Canon PowerShot SD300
Canon PowerShot S30
Canon PowerShot S40
Canon PowerShot S45
Canon PowerShot S50
Canon PowerShot S60
Canon PowerShot S70
Canon PowerShot SX1 IS
Canon PowerShot SX110 IS
Canon EOS D30
Canon EOS D60
Canon EOS 5D
Canon EOS 5D Mark II
Canon EOS 10D
Canon EOS 20D
Canon EOS 30D
Canon EOS 40D
Canon EOS 50D
Canon EOS 300D / Digital Rebel / Kiss Digital
Canon EOS 350D / Digital Rebel XT / Kiss Digital N
Canon EOS 400D / Digital Rebel XTi / Kiss Digital X
Canon EOS 450D / Digital Rebel XSi / Kiss Digital X2
Canon EOS 500D / Digital Rebel T1i / Kiss Digital X3
Canon EOS 1000D / Digital Rebel XS / Kiss Digital F
Canon EOS D2000C
Canon EOS-1D
Canon EOS-1DS
Canon EOS-1D Mark II
Canon EOS-1D Mark III
Canon EOS-1D Mark II N
Canon EOS-1Ds Mark II
Canon EOS-1Ds Mark III
Casio QV-2000UX
Casio QV-3000EX
Casio QV-3500EX
Casio QV-4000
Casio QV-5700
Casio QV-R41
Casio QV-R51
Casio QV-R61
Casio EX-S20
Casio EX-S100
Casio EX-Z4
Casio EX-Z50
Casio EX-Z55
Casio EX-Z60
Casio EX-Z75
Casio Exlim Pro 505
Casio Exlim Pro 600
Casio Exlim Pro 700
Contax N Digital
Creative PC-CAM 600
Epson R-D1
Foculus 531C
Fuji FinePix E550
Fuji FinePix E900
Fuji FinePix F700
Fuji FinePix F710
Fuji FinePix F800
Fuji FinePix F810
Fuji FinePix S2Pro
Fuji FinePix S3Pro
Fuji FinePix S5Pro
Fuji FinePix S20Pro
Kodak PB645M
Kodak DCS Pro 14n
Kodak DCS Pro 14nx
Kodak DCS Pro SLR/c
Kodak DCS Pro SLR/n
Kodak C330
Kodak C603
Kodak P850
Kodak P880
Kodak Z980
Kodak Z1015
Kodak KAI-0340
Konica KD-400Z
Konica KD-510Z
Leaf AFi 7
Leaf Aptus 17
Leaf Aptus 22
Leaf Aptus 54S
Leaf Aptus 65
Leaf Aptus 75
Leaf Aptus 75S
Leaf Cantare
Leaf CatchLight
Leaf CMost
Leaf DCB2
Leaf Valeo 6
Leaf Valeo 11
Leaf Valeo 17
Leaf Valeo 22
Leaf Volare
Leica Digilux 2
Leica Digilux 3
Leica D-LUX2
Leica D-LUX3
Leica D-LUX4
Leica V-LUX1
Logitech Fotoman Pixtura
Mamiya ZD
Micron 2010
Minolta RD175
Minolta DiMAGE 5
Minolta DiMAGE 7
Minolta DiMAGE 7i
Minolta DiMAGE 7Hi
Minolta DiMAGE A1
Minolta DiMAGE A2
Minolta DiMAGE A200
Minolta DiMAGE G400
Minolta DiMAGE G500
Minolta DiMAGE G530
Minolta DiMAGE G600
Minolta DiMAGE Z2
Minolta Alpha/Dynax/Maxxum 5D
Minolta Alpha/Dynax/Maxxum 7D
Motorola PIXL
Nikon D1
Nikon D1H
Nikon D1X
Nikon D2H
Nikon D2Hs
Nikon D2X
Nikon D2Xs
Nikon D3
Nikon D3X
Nikon D40
Nikon D40X
Nikon D50
Nikon D60
Nikon D70
Nikon D70s
Nikon D80
Nikon D90
Nikon D100
Nikon D200
Nikon D300
Olympus E-510
Olympus E-520
Olympus E-620
Olympus SP310
Olympus SP320
Olympus SP350
Olympus SP500UZ
Olympus SP510UZ
Olympus SP550UZ
Olympus SP560UZ
Olympus SP570UZ
Panasonic DMC-FZ8
Panasonic DMC-FZ18
Panasonic DMC-FZ28
Panasonic DMC-FZ30
Panasonic DMC-FZ50
Panasonic DMC-FX150
Panasonic DMC-G1
Panasonic DMC-GH1
Panasonic DMC-L1
Panasonic DMC-L10
Panasonic DMC-LC1
Panasonic DMC-LX1
Panasonic DMC-LX2
Panasonic DMC-LX3
Pentax *ist D
Pentax *ist DL
Pentax *ist DL2
Pentax *ist DS
Pentax *ist DS2
Pentax K10D
Pentax K20D
Pentax K100D
Pentax K100D Super
Pentax K200D
Pentax K2000/K-m
Pentax K-7
Pentax Optio S
Pentax Optio S4
Pentax Optio 33WR
Pentax Optio 750Z
Phase One LightPhase
Phase One H 10
Phase One H 20
Phase One H 25
Phase One P 20
Phase One P 25
Phase One P 30
Phase One P 45
Phase One P 45+
Pixelink A782
Polaroid x530
Rollei d530flex
RoverShot 3320af
Samsung GX-1S
Samsung GX-10
Samsung S85
Samsung S850
Sarnoff 4096x5440
Sigma SD9
Sigma SD10
Sigma SD14
Sinar 3072x2048
Sinar 4080x4080
Sinar 4080x5440
Sinar STI format
SMaL Ultra-Pocket 3
SMaL Ultra-Pocket 4
SMaL Ultra-Pocket 5
Sony DSC-F828
Sony DSC-R1
Sony DSC-V3
Sony DSLR-A100
Sony DSLR-A200
Sony DSLR-A300
Sony DSLR-A330
Sony DSLR-A350

Fuji FinePix S100FS
Fuji FinePix S5000
Fuji FinePix S5100/S5500
Fuji FinePix S5200/S5600
Fuji FinePix S6000fd
Fuji FinePix S7000
Fuji FinePix S9000/S9500
Fuji FinePix S9100/S9600
Fuji IS-1
Hasselblad CFV
Hasselblad H3D
Nikon D700
Nikon D5000
Nikon E700
Nikon E800
Nikon E880
Nikon E900
Nikon E950
Nikon E990
Nikon E995
Nikon E2100
Nikon E2500
Nikon E3200
Nikon E3700
Nikon E4300
Sony DSLR-A700
Sony DSLR-A900
Sony XCD-SX910CR
STV680 VGA

Definitions

A point source of light, such a star illuminates a number of pixels surrounding the center of the star. The center pixel is usually the brightest, with the intensity of the pixels falling off rather rapidly the further away one looks from the center pixel. The faster the light falls, the better the quality and sharpness of the star. The slower it falls, the more pixels the star occupies, the more bloated it is, and therefore less focused. To come up with a standardized way to measure star quality, independent of the brightness and magnitude of the star, the FWHM measure is used. FWHM stands for Full-Width at Half-Maximum and is simply the width (or the diameter) of the circle surrounding the star where the intensity has fallen off by 50% from the peak value (half-maximum).

FWHM can be measured in pixels, or in arcseconds. Pixels is the default in CCDInspector if the focal length and the pixel size of the camera cannot be determined. If these are known and specified in CCDSoft, CCDInspector can be used to automatically convert pixels to arcseconds. The value in pixels is dependent on both, focal length and pixel size, and so cannot be used to directly compare two images from different cameras, or from different telescopes. On the other hand, measurement in arcseconds is independent from telescope focal length or the camera pixel size, and can be used for direct comparison between different instruments.

Lower FWHM values are better -- means the star brightness falls off faster. There are many factors that limit just how low an FWHM value one can get. Some of these are:

1. Focus: telescope must be well focused to produced lowest possible FWHM.
2..Collimation: poor collimation will lead to more bloated stars with higher FWHM
3. Seeing conditions: atmosphere is one of the major limiting factors even for professional astronomers. On a good day, an average amateur with excellent optics and collimation can hope for FWHM of 2"-2.5". On rare occasions or at really great locations, the seeing can dip to as low as 1.6" but not much below. More often than not, you're likely to see FWHM in the 3" to 4" range. Anything much above 4" is usually a signal to go inside and watch some TV -- the seeing is really poor.
4. Tracking and guiding: FWHM of a star in a long exposure can be much greater than FWHM of the same star in a really short exposure. This happens because the air masses keep moving causing seeing fluctuations during long exposures, and guiders and mounts usually have small errors that add up over a long period to smear the star a bit more.

Aspect Ratio: Aspect ratio represents how much out-of-round the star image is. It is the ratio of the longest axis to the shortest axis of the star profile, expressed in percent. A number below 20-30% represents a pretty round star. A number of 0% represents perfectly round star, but you will most likely not see this in real images due to noise and measurement uncertainty.

Image Header Keywords Used by CCDInspector

Keyword	Used In	Used For
FOCALLEN	CCDInspector, FWHM Monitor	Image scale determination
XPIXSZ YPIXSZ	CCDInspector, FWHM Monitor	Image scale determination
PEDESTAL	CCDInspector, FWHM Monitor	To remove fixed pedestal from the image
EGAIN E-GAIN E_GAIN	CCDInspector, FWHM Monitor	For reporting purposes
DATE-OBS	CCDInspector	Date and time of the exposure
CENTALT OBJCTALT	CCDInspector	Altitude of the exposure
CCD-TEMP TEMPERAT TEMPERATURE	CCDInspector	Temperature of the sensor
EXPTIME EXPOSURE	CCDInspector	Image exposure length
XBINNING CCDXBIN	CCDInspector	Image binning mode

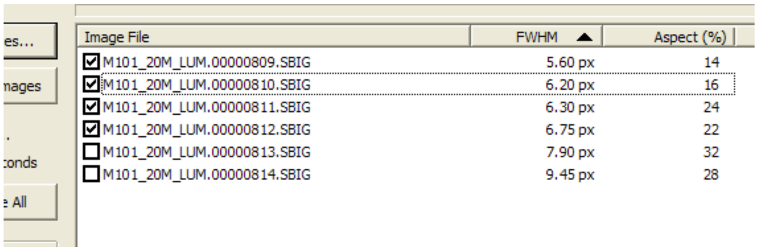
FAQ

Frequently Asked Question (FAQ):

1. Question: My non-US keyboard does not allow me to select multiple items in the CCDInspector image list. What should I do?

Answer: This is a known issue with some international configurations of Windows. To work around this, go to the CCDInspector File/Settings menu and click on
the ***Use Checkboxes*** option near the bottom of the menu.

You should now see checkboxes appear next to all items in the image list. To select multiple images simply place a check mark next to each by clicking on the corresponding check box:



The rest of the CCDInspector functionality will remain the same.

2. Question: Some of the images are reporting FWHM values that are too low, or Aspect Ratio values that are too high. What's wrong?

Answer: Images with a lot of noise may fool the noise rejection filter in CCDInspector and force it to measure some hot pixels as stars. To reduce the chance of this happening, measure images that have already been reduced with a d ark-frame subtraction, or let CCDInspector subtract a dark frame as described in step Quick Start topic..

3. Question: I select "In Arcseconds" option, but the FWHM is still shown in pixels. What's wrong?

Answer: Images are normally saved with headers containing information about pixel size and focal length of the telescope. If the image you are measuring does not contain this information, CCDInspector will be unable to determine the conversion factor from pixels to arcseconds, and will default to display in pixels. Check your image acquisition software to make sure that the focal length is properly specified for all new images.

4. Question: "CCDInspector looks very much like another product I saw recently"

Answer: Yes! CCDInspector is the next generation of two products released earlier this year: StarSieve and CFWHM. Both products are fully contained in CCDInspector, but CCDInspector is a major step forward in functionality, providing three-dimensional curvature plots, comparison charts, background and contrast measurement, support for MaxIm DL, configurable columns, real-time collimation, and much, much more!

File Menu

Open	Select images for analysis and charting. Use the Files Type drop-down to select the type of images you are looking for. SBIG, FITS, and TIFF format files are supported by CCDInspector. Multiple images can be selected at once. If you'd like to pick images from multiple folders, select images from first folder first and click Open. Then, click on Open... menu again, change directory, and pick more files to add.
AutoOpen	Select a folder of images to be measured and monitored in real-time. CCDInspector will load and measure all existing images in the folder. What's more, it will continually monitor the folder for any new images. As soon as new image(s) are added to the folder, these will automatically be added to the list and measured as well. This allows one to monitor all downloads from a camera, and have them automatically measured as soon as they are saved by the image capture software. The images can be in any of the formats supported by CCDI, including RAW. To stop the automatic monitoring, click on AutoOpen again to uncheck it. To pick a different folder, uncheck AutoOpen first, then check it again. When prompted, pick the new folder.
Copy Report to Clipboard	Measures the images, if they are not measured, and copies the result into a tabulated format onto Windows Clipboard. This report can then be pasted into a document, spreadsheet, or a text file.
Exit	Quit CCD Inspector

Images Menu

View	Displays one or more selected images in their own Viewer windows.
View Stars	Displays one or more selected images, placing circles around all the stars that were picked for FWHM measurement and curvature analysis. These may not be all the stars in the image, as CCD Inspector rejects stars based on multiple criteria: saturation, aspect ratio distortion, S/N, etc.
View Image Header	Displays a viewer with the list of all the keywords and values from the image header.

Remove	Remove selected images from CCD Inspector window. The actual image files are not affected by this operation.
Move to Folder	Allows selected images to be moved to another folder. Image files will be physically moved from one folder to the one specified.
Copy to Folder	Allows selected images to be copied to another folder. Image files will remain in the original folder, and their copies will be created in the one specified.
Check All	Select all image files
Uncheck All	Unselect all image files
Check All Items Within Limits	Select all images that are within the specified limit settings under Limit Alerts (images displayed in black). This option only works if Limit Alert checkbox is checked on the main CCD Inspector window. After the image are selected, they can be operated on by any of the commands above, such as Remove, Move, Copy, etc.
Invert Checked Items	Unselect all selected images, and select all unselected images in the list (invert selection)

Analysis Menu

Measure All	CCD Inspector attempts to measure every image in the list. FWHM, Aspect ratio, and many other values are computed. If any of the following columns are selected in the display, additional computation will be performed to determine image curvature: • Collimation • Curvature • Tilt in X • Tilt in Y If none of these columns are selected, the curvature computation will not be performed, resulting in faster measurement of all images.
Curvature Map	Compute and display curvature map for the selected images. If more than one image is selected, all will be used in the curvature computation, resulting in an average curvature map. In order to get best results, the images must be of similar FWHM and similar exposure length, and of the same (or very near-by) portion of the sky. For a proper curvature map, the image(s) must contain sufficient number of well-exposed, but not saturated stars to measure. The stars should be reasonably evenly spread out through the field of view. For best results, avoid any really bright objects in the field of view, such as galaxies, bright nebulae, or globular clusters.
3-D Plot	Show the same information as presented in the Curvature Map, but in a 3 dimensional display. The 3-D Viewer shows the curvature in perspective, and provides controls to rotate, tilt, and zoom in and out. Using the mouse, click down on the left button and: • Move mouse up and down to tilt back and forward • Move mouse left and right to rotate image Use the mouse track-wheel to zoom in and out, or hold down the Ctrl key on the keyboard and move mouse up or down to zoom in or out.
Aspect Map 2.0	Aspect Map is a ***heat-map***, similar to the Curvature Map. But, instead of assigning different colors to star FWHM values across the field, Aspect Map assigns different colors to aspect ratios of the stars across the field. Blue, dark colors indicate low Aspect Map values, while brighter, redder colors indicate higher aspect ratios. Aspect ratio of a star is an indication of how elongated the star is. Therefore, Aspect Map can easily show coma (aspect ratio increases outwards from the center).
Charts	Provides an analytical too to measure image quality based on a large number of measured values. Charts window uses all images in the list as data points to plot. You have full control over the X and Y axis of the chart. The following variables can be selected for either axis: • FWHM • Aspect Ratio • Air Mass Index • Background Brightness • Image Scale • Focal Length • Pixel Size • Camera Gain • Contrast to Noise Ratio

	• Total stars used in analysis • Altitude of the image • Date and time of the image • Curvature amount • Collimation error • Tilt in X • Tilt in Y Chart window can be resized to see more details. Each point plotted on the chart has a small rectangle surround it. If a mouse is positioned over the rectangle, a tool tip will display with both, the X and Y values for the data point, and the image file name associated with it. More than one chart viewer can be displayed at the same time, if desired..
Sensor Extrapolation 2.0	Sensor Extrapolation option estimates curvature, vignetting, and star aspect ratios as they would appear on a different size sensor. The estimation is done by analyzing an image using a known sensor size, and then projecting the result to a different sensor. You can quickly estimate whether the curvature will be too much on that larger DSLR chip, or if the light fall-off will be too extreme before before spending the money. The choices are: • FWHM • Aspect Ratio • Vignetting
Flat Frame Analysis 2.0	Flat Frame Analysis creates a contour display with lines delineating percentage changes in light fall off. This allows for a quick determination of how much vignetting is present in the system, and how much is present at different distances from the image center. Optical Illumination center is also marked to demonstrate an offset, if any, that may exist between the chip center, and the illumination center.

Real-Time Menu

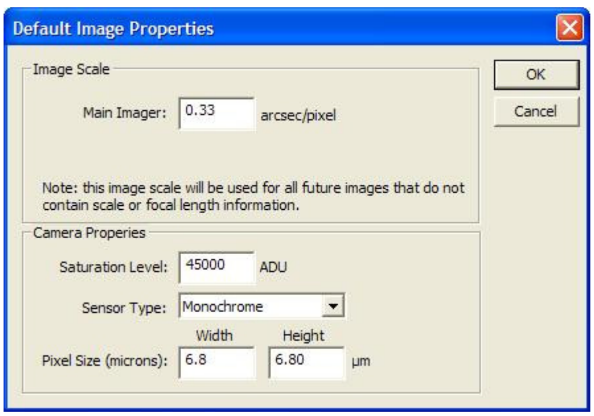
Curvature Map	Creates a real-time viewer window to measure and display the curvature of every image as it is acquired from the camera. To start real-time measurement, follow these steps: • Choose the correct camera acquisition software for you setup under the Settings menu (CCDSoft or MaxIm DL) • If the camera control software is not already started, start it as usual • Start acquiring images using the main imager chip. As each image is downloaded from the camera, CCD Inspector will automatically measure it and display the curvature map based on its content. With the cross-hair showing the difference between the optical center and physical center of the image, Real-Time Curvature Map makes it easy and precise to collimate a telescope, without an eyepiece. If the star field being imaged does not contain enough stars, CCD Inspector will display a warning message that the curvature map may not be accurate.
3-D Curvature Map	Creates a real-time viewer window to measure and display 3-D plot of the curvature of every image as it is acquired from the camera. Follow the same steps to start the acquisition process as in the Curvature Map description above.

Collimation	• Multi-Star Collimation Viewer
	  ◦ Displays the Collimation Viewer window for real-time collimation. Follow the same directions to start collimating as in the section on Curvature Map above.
	
	• Defocused Star Collimation Viewer
	  ◦ Displays the Single Star Collimation Viewer window for real-time collimation.

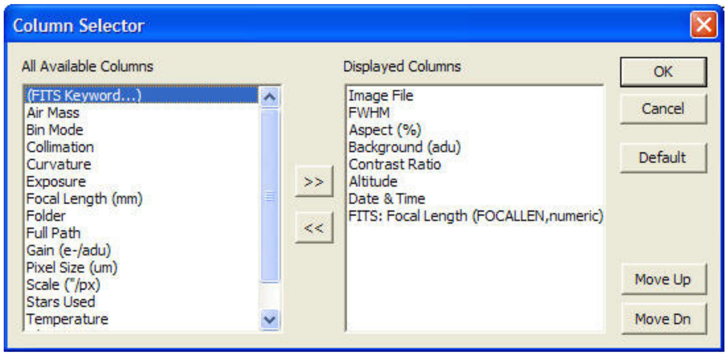
Image Viewer	Displays Image Viewer. Updates to show the latest image captured by the camera. Dark subtraction and Debayering (if configured in Default Image Properies) will be automatically applied.
Images to Average	Select how many real-time images will be used to create each curvature or 3-D map. CCDInspector will wait for this number of images to be captured before computing and displaying the curvature map. If 1 is selected, then no averaging will be done. Averaging process allows a more accurate assessment of curvature and collimation to be made by including stars from multiple exposures. Stars do not have to be aligned between frames: some shift is even desirable between frames, as it will yield more information about the curvature of the entire image.

FWHM Inspector	Displays the FWHM Monitor tool. This tool can also be invoked directly from the Desktop icon, or from the CCD Inspector Start menu. FWHM Monitor provides real-time measurement of the following: • Image FWHM • Image Aspect ratio • Half-Flux Diameter (HFD) • Peak Value • Star Centroid Error • FWHM error due to seeing fluctuations In addition, a number of real-time running charts are provided for display of all of these values in real-time or as a moving average.

Settings

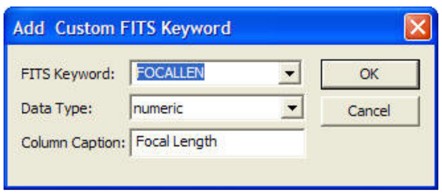
Default Image Properties	Set the default image scale, saturation level and monochrome/color options for all images where it cannot be determined.  • The image scale will be used in all cases where the arcseconds units are used for display, and the image header does not contain either the focal length or pixel size keywords. • Saturation level sets the cut-off level, in ADU, beyond which a star will be considered saturated. Saturated stars have distorted shapes, and their FWHM and star profiles cannot be accurately determined. For most raw images from 16-bit CCD sensors, the default value of 45000 is a reasonable cut-off level and should not need to be changed. • Sensor Type defaults to Monochrome. If you are using a single-shot color sensor with a Bayer matrix, select Bayer Matrix instead. This will help CCDInspector to remove the effects of the Bayer filter matrix to more accurately compute star profiles. • Pixel Size can be specified, for example, for DSLR or webcam sensors, where this information is not available from the FITS header. Non-square pixel size can be specified by entering different width and height.
	Chose the columns displayed in the main window of CCD Inspector. Once selected, any of the displayed columns can be used to sort the image list in ascending or descending order of values for that column. The available choices are shown below.

Display Columns



To select columns for display, highlight one or more column names in the list on the left (All Available Columns) and click the **>>** button. To unselect a column, highlight it in the list on the right, and click << button. To rearrange the order of columns, highlight a column in the Displayed Columns list, and use **Move Up** or **Move Dn** buttons to reposition it. To restore the columns to default CCD Inspector settings, click the **Default** button.

- 2.0 **(FITS Keyword...)** allows the selection of any values available in the FITS image header for display and sorting. When selected, the following dialog will be displayed:



Chose the desired keyword from the drop-down, or type a custom keyword in, select Data type (text or numeric) and the caption to use for the column display. If present, the value of this keyword will be automatically displayed in CCDInspector main display for each image.

- **Air Mass** index: specifies the amount of air the shot was made through, as compared to the amount of air when shooting starlight at zenith. At zenith, the value for Air Mass is 1.0, and at Altitude 0 it is 40. Greater value of Air Mass index indicates greater atmospheric distortion due to scatter, refraction, and seeing effects.
- **Altitude:** this is the Alt coordinate of where the image was acquired, in degrees. This value is derived from the image header
- **Bin Mode:** binning mode of the detector that was used for this image
- **Aspect Ratio (%):** the aspect ratio of an average star in the image. Aspect ratio number is a good indication of how far out of round the stars are, possibly due to tracking errors or other distortions
- **Background (adu)**: Background brightness, in adu units. This represents an average background of the image. This can be a good indication of how bright the sky was during the exposure
- **Collimation**: error in collimation, expressed in arcseconds or pixels. Distance between optical and physical centers at the image plane.
- **Contrast Ratio**: actually, Contrast-to-Noise ratio. This is a good indicator of signal quality in the images being compared. For example, amount of signal can be directly compared between images acquired through different color filters. The higher the CNR, the more signal, and less noise and the darker the background in the image.
- **Curvature**: expressed in %: the amount of defocus between center and edge of the image, normalized to a value that is independent of the actual FWHM values in the image. A good indication of how defocused the stars are at the edge of the field compared to the center due to coma, spherical aberration, etc.
- **Date & Time**: date and time of the exposure, as reported in the header of the image. This value is converted to the local timezone configured on the computer.
- **Exposure**: exposure length, in seconds

	• **Focal Length (mm)**: focal length of the instrument used to acquire the image. This is derived from the image header. • **Folder**: folder where the image file resides • **Full Path**: full path to the image, including the file name • **FWHM:** expressed in arcseconds or pixels. Average FWHM value derived from the image. • **Gain (e-/adu)**: gain of the camera. Derived from image header. • **Image File**: name of the image file, without the folder • **Pixel Size (um)**: pixel size of the camera, in microns. Derived from image header. • **Scale ("/pix)**: image scale in arcseconds per pixel. Derived from image header focal length and pixel size parameters, or, if not present, from the default image scale setting for CCD Inspector. • **Stars Used**: number of stars CCD Inspector used in measuring FWHM, Aspect Ratio, Curvature, etc. This is not the actual number of stars in the image, as CCD Inspector can reject stars as unsuitable for measurement due to saturation, low signal-to-noise ratio, or other distortions. • **Temperature**: sensor temperature used for this image • **Tilt in X**: the amount of defocus, in arcseconds or pixels, from left to right side of the image. • **Tilt in Y**: the amount of defocus, in arcseconds or pixels, from top to bottom of the image.
Camera Control Software	Chose the camera acquisition software that CCD Inspector will use with all the Real-Time monitors. The supported software packages are: • CCDSoft from Software Bisque • MaxIm DL from Diffraction Limited • Generic image acquisition software If you are not going to use real-time features of CCD Inspector, use the default setting of CCDSoft. Generic support provides real-time support for any camera and acquisition software that allows FITS, SBIG, or TIFF formatted images to be automatically written to a specified folder on the hard disk. As soon as an image is captured, and saved to the selected folder, CCDInspector will automatically retrieve and analyze this image. You'll have a choice of selecting whether the measured image is kept in the folder, or deleted after measurement.
Use Checkboxes	Changes the main CCD Inspector window list to display check boxes next to each of the images. To select images for any operation will then require placing a check mark next to the desired image(s). This is necessary in some international versions of Windows, where the list control used in CCD Inspector does not allow multiple selection.
Collimation Screw Direction	Sets the direction that the collimation screws move the mirror surface. Used by Collimation Viewer. The options are: • Clock-Wise = Pull (Default) • Clock-Wise = Push The default setting is appropriate for most commercial SCT's, RC's and Newtonian telescopes when collimating the primary or the secondary mirrors. Changing this selection reverses the recommended direction to turn the collimation screw in the Collimation Viewer.
Noise Threshold	Sets the noise threshold to use when selecting stars for measurement. The options are: • Low (default) • Medium • High This setting allows for better star selection in some noisy sensors, such as CMOS-based, uncooled detectors. To allow better discrimination between noise and stars for such sensors, set the Noise Threshold to Medium. If noise is still selected as stars, increase the threshold to High. For most CCD-based cooled sensors, the setting should be left at the default Low.

Help Menu

CCD Inspector Help	Displays this help file
Check for Updates	Set up automatic check for new software updates, or check for new updates right now. When a new update is available, CCDInspector will inform you of this fact, and allow you to download and install the new version. Note that if CCDInspector is already running, it will be closed before installation will begin: • **Now!** -- check if new updates are available right now. If they are, you'll be prompted to see if you want to download and install them • **Never** -- disable automatic checks for new software releases • **Every Time** -- automatically check for new software releases every time CCDInspector is started • **Once a Day** -- automatically check for new software releases only the first time each day that CCDInspector is started • **Every 5 Days** -- automatically check for new software releases every five days • **Every 10 Days** -- automatically check for new software releases every ten days • **Every 30 Days** -- automatically check for new software releases every thirty days
About CCD Inspector	Display the About box, with software version number and copyright notice.

FWHM Monitor for CCD Inspector

Measure and Plot In Real-Time Any Star, Any Sub-Frame, Any Image:

FWHM, HFD, ASPECT RATIO, FLUX, CENTROID, PEAK VALUE and MORE!

FWHM Monitor is designed to work seamlessly with CCDSoft and MaxIm DL to provide these functions, along with a number of other useful tools to estimate seeing, image quality, and tracking, and guiding performance.

FWHM Monitor can help perform the following functions:

1. Real-time focusing using Full-Width-at-Half-Maximum (FWHM), Peak Value, Half-Flux Diameter (HFD), and other display statistics
2. Seeing conditions estimation by measuring FWHM or HFD of a star
3. Focus quality monitoring during a long exposure by measuring the quality of the star image on the autoguider chip
4. Fast and easy way to evaluate the quality of a long exposure containing multiple stars and extended objects
5. Measure FWHM or a number of other statistics of a specific star in the image by selecting it in CCDSoft
6. An easy and objective way to sort a number of exposures by sharpness.

There are many other uses. For example, the eccentricity measurement allows one to evaluate the coma distortion of a star near the edge of the chip compared to the one in the center. The star profile plot allows one to see at a glance whether the star is saturated, or has reached the non-linear region of the CCD chip, or has been distorted in some way by poor guiding or poorly adjusted optics.

FWHM Monitor contains some very sophisticated algorithms to provide the most accurate measurement possible, while ignoring spurious data, noise, and artifacts.

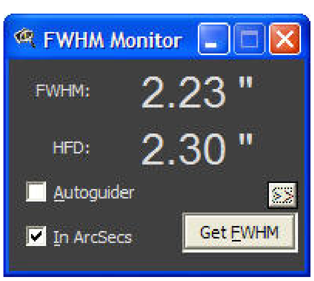
Using FWHM Monitor

FWHM Monitor application can be started or closed as needed. You don't have to shut down and restart CCDSoft or MaxIm DL -- FWHM Monitor will automatically connect to the running instance of the configured application. The panel position, size and selected options are remembered between sessions. If two instances of the Panel are started, only one will receive real-time updates from the camera.

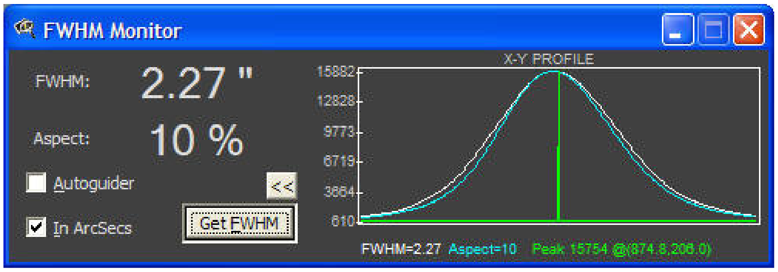
Double-click on the FWHM Monitor icon on the desktop to launch:

FWHM Monitor

The panel will float on top of your image acquisition software. If you will be focusing and standing far away from the monitor, simply drag the bottom right corner of the panel window to increase its size. The text size will increase in proportion to the size of the window. If desired, the panel can be stretched to occupy the size of the full screen.



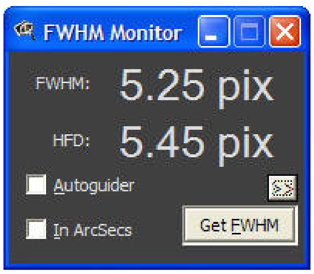
The display panel is designed to be as simple to use as possible, and as easy to see in the dark and from a distance. If you would like to see the profile plot of the star or a running real-time chart, click the expand button ">>" at the right :



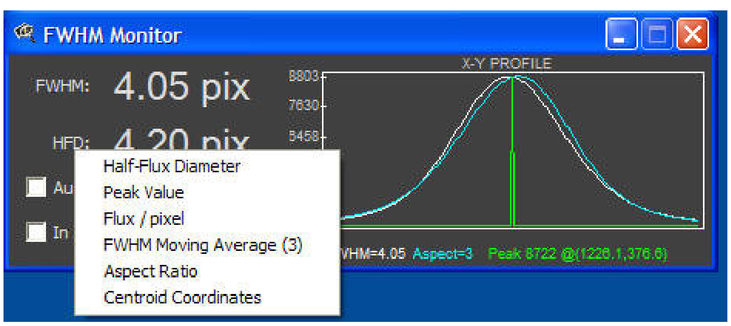
There are some additional statistics shown below the profile plot: FWHM value, Aspect ratio, Peak value, and centroid coordinates. Aspect ratio indicates how far out-of-round the star image is. For example, a star that's elongated due to tracking error, or coma, will exhibit much higher aspect ratio. The ratio is expressed in %. A 9% out of round means that the longer axis of the star is 1.09 times longer than the short axis. Usually a value below 30% or so is nearly invisible, but the elongation becomes more obvious as the ratio increases.

The vertical line in the middle of the plot points to the location of the centroid. The coordinates of the center of the star, expressed in CCD pixels, are shown in parenthesis at the right as (x,y).

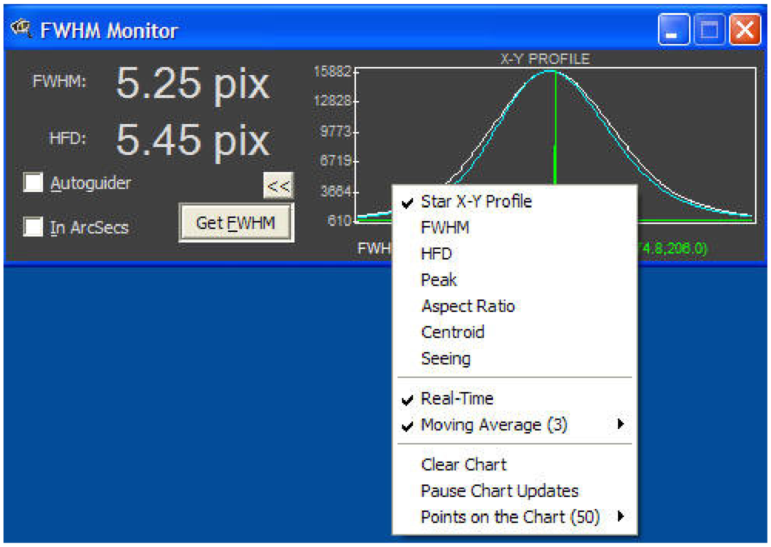
You have a choice of display unit in FWHM Monitor: the values can be displayed in arcseconds or pixels. Simply place a check mark next to In Arcsecs option if you'd like to see the display in arcseconds, and uncheck it to see it in pixels:



Click on the label next to the second number (the one showing Avg(3) in the above photo) to see additional choices of values that can be displayed in addition to FWHM:



Once the chart window is opened with the ">>" button, clicking anywhere on the chart will display a menu with a number of different options. These allow the selection of what values to display, whether to average them or not, and how many values to keep on a running chart:



Setting Image Scale

CCDInspector derives the information about image scale from the image header. The software used to acquire the image needs to be set to record this information in the header, or it will not be available to CCDInspector.

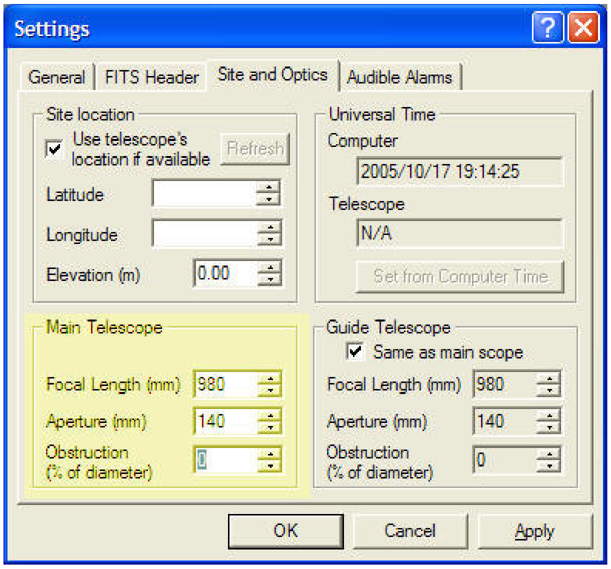
Setting up CCDSoft to record the focal length information in the image header:

In order to display information in arcseconds, you will also need to ensure that CCDSoft knows the focal length of your imaging setup. For use with CCDInspector, this should be expressed in units of mm. This can be entered in CCDSoft in the Camera Setup screen by pressing the File Defaults button:

Please make sure that the focal length is set in mm, and not inches, otherwise the arcseconds calculation will be incorrect.

Setting up MaxIm DL to record the focal length information in the image header:

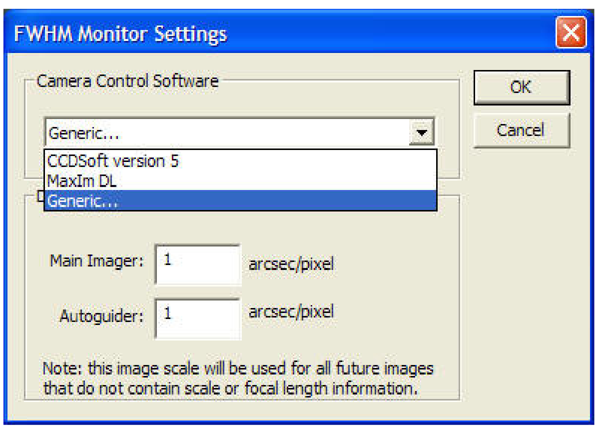
Click on **File/Settings** menu, and select **Site and Optics** tab, and enter the focal length and aperture parameters:



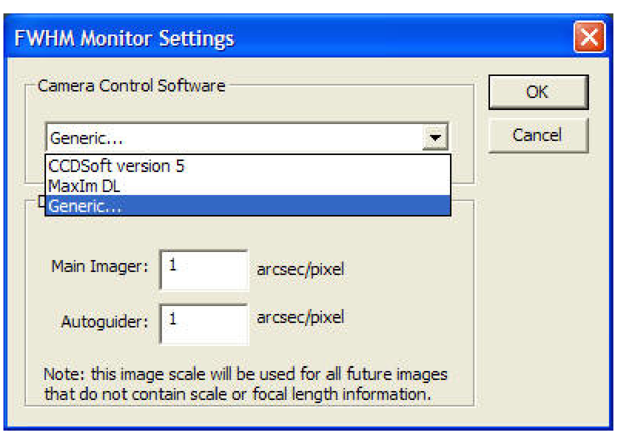
Note: If you select display in Arcseconds, but the focal length or pixel size parameters are not available from the image, CCDInspector will display measurements in pixels by default.

Selecting Camera Control Software

FWHM Monitor works with CCDSoft version 5 and MaxIm DL versions 3, and 4. To set the acquisition software you use, click on the control menu at the top left of the FWHM monitor window:



Click on FWHM Monitor Settings..., and pick the desired control software from the drop-down list::



Generic Capture Software

CCDInspector works directly with CCDSoft and MaxIm DL to acquire and process images in real-time. It can also be used with all other software acquisition packages, as long as they are able to automatically save captured images into a specific folder in FITS, SBIG, or TIFF formats.

To use Generic camera support, select **Generic...** Camera Control Software from the drop-down list.. You will be prompted to chose the destination folder where the acquisition software will write out captured images. Pick an existing empty folder or create a new one. Next, you will be prompted whether images are to be automatically deleted after being processed. If you chose Yes to delete the images, the image will be removed from the selected folder after its measurements are displayed by FWHM Montior, otherwise, all images captured by the camera will remain in this folder.

Now, set up your acquisition software to automatically write out FITS, TIFF, or SBIG format files into the same folder you selected in FWHM Monitor. The images can be full-frame, or sub-frame for faster focusing purposes.

Sub-second exposure may result in not enough time for FWHM Montior to process the image before the next image is downloaded. As a result, some images may be skipped. A few seconds seconds exposure should be long enough, but may depend on the speed of your computer. If you find that the images are being written faster than they are being processed by FWHM Monitor, simply increase the exposure time, or add a small delay between the exposures in your capture software.

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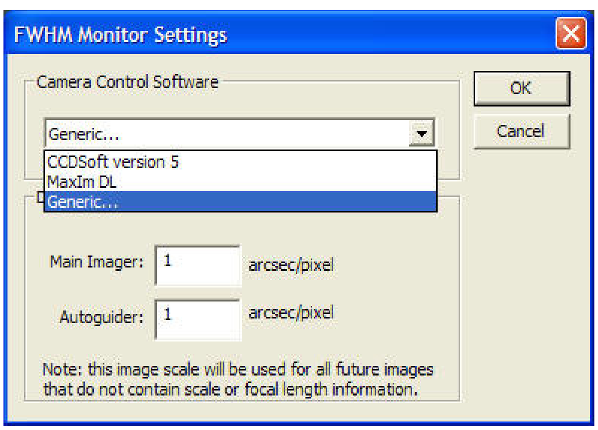
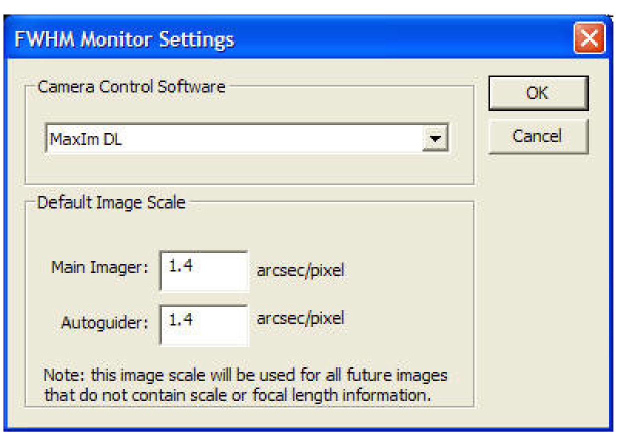
Selecting Default Image Scale

To set the default image scale to be used by FWHM monitor if the scale is not provded by the camera acquisition software, click on the FWHM control menu at the top left of the window:



Click on FWHM Monitor Settings..., and enter the actual image scale for main imager and/or autoguider for your configuration:



Display Settings

FWHM Monitor has an automatic display mode that will measure the star immediately from an image captured by the camera. You can choose to monitor images captured by either the main camera chip, or by the autoguider chip. To monitor the autoguider chip, place a check mark next to the Autoguider option. To monitor the main imager, uncheck this option.

FWHM Monitor will automatically refresh its display and recalculate the values when a new image is captured. If you'd like to measure a star from a specific image after it's already been captured (or loaded from disk), simply make this image active in the camera control software, and click on the Get FWHM button. This will measure the currently active image in CCDSoft or MaxIm DL.

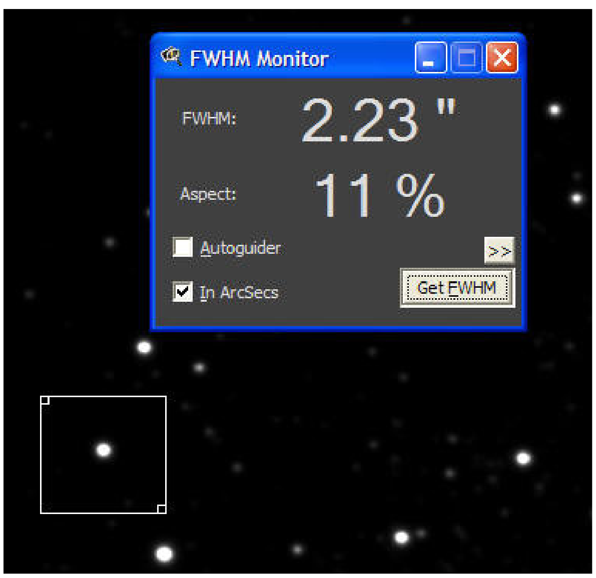
If the image contains only one star, then FWHM Monitor will display its measurements. This works great for the autoguider window, or in rapid focus mode with the sub-frame set to display one star. FWHM Monitor is smart, and will make every attempt to ignore hot pixels, noise, airplane tracks, and other artifacts that are not stellar in nature.

In case of an image that is too noisy, or contains no valid star data, FWHM Monitor may display N/A or Not Available. This can also happen if the star is very unfocused or extremely saturated, causing the FWHM value to exceed 30 pixels.

When an image contains many stars, and possibly other objects, such as nebulae, galaxies, etc., FWHM Monitor will pick a single star to measure, based on a number of attributes. It will first isolate up to 1000 stars from the image.   From these stars, it will discard stars that are saturated, or very close to the background. It will then sort the remaining stars by their FWHM value and will pick the median (middle) star from the list. This star will be most representative of the quality of the image. In this way, FWHM Monitor allows a very easy and automatic measurement of the quality of any image. You can judge the guiding performance of your mount, the changing seeing or focus conditions, and also sort your exposures based on sharpness.

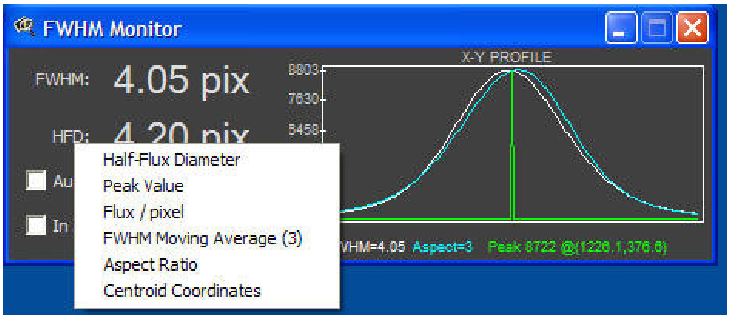
In addition, you can select an area of the image, or even a single star that you'd like to measure using CCDSoft's or MaxIm DL's rectangular selection tool: 

Once selected (the selected area can include one or many stars, or even extended objects), press Get FWHM button on the display panel, and the best representative star from the selected rectangle will be measured and displayed.

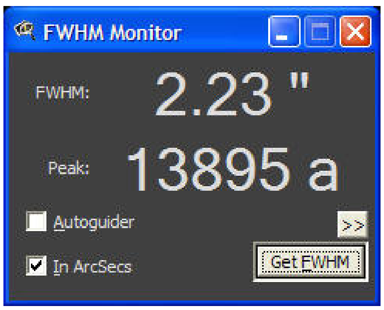


Note that you can load a saved image at any time after it's been captured, and measure its quality using FWHM Monitor by clicking on the Get FWHM button.

The FWHM Monitor display panel shows two values: FWHM and HFD by default. The top value will always show FWHM, but you have a choice of what metric to display in the bottom value. Click your mouse directly on the label next to the lower number display that contains the word HFD. You will see a pop-up menu with the following choices:



Click on the value you'd like to see displayed below the FWHM. See the [Definition] section for explanation of what each one of these values measure. For example, here is a display with peak value option selected:



Note that the Peak Value display in FWHM Monitor is not exactly the same as the image maximum value: the peak value is the maximum value of the selected star, not the whole image.

Chart Settings

FWHM Monitor provides a number of chart displays that can be useful in both, monitoring focus and image quality in real-time, and in measuring an existing image. To view the chart, expand FWHM Monitor by clicking on the >> button. The Chart display will appear, showing the default selected chart.

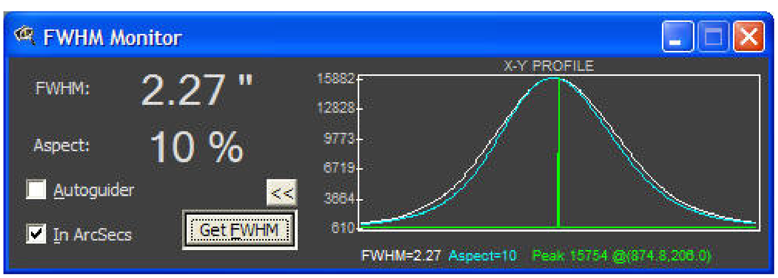
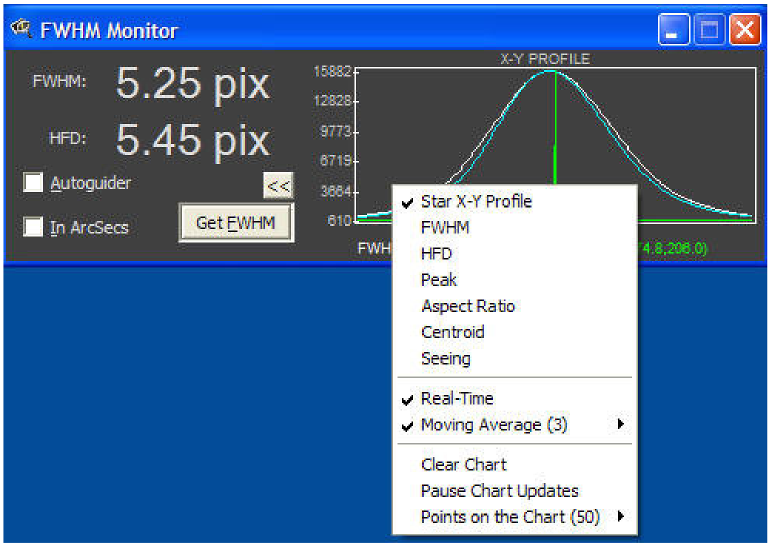


Chart settings can be changed by clicking the left mouse button anywhere on top of the chart area:



The following chart options are available:

1. Star X-Y Profile chart (default) shows currently measured star's profile in horizontal and vertical directions. Note that Moving Average setting is not applicable to this chart type.

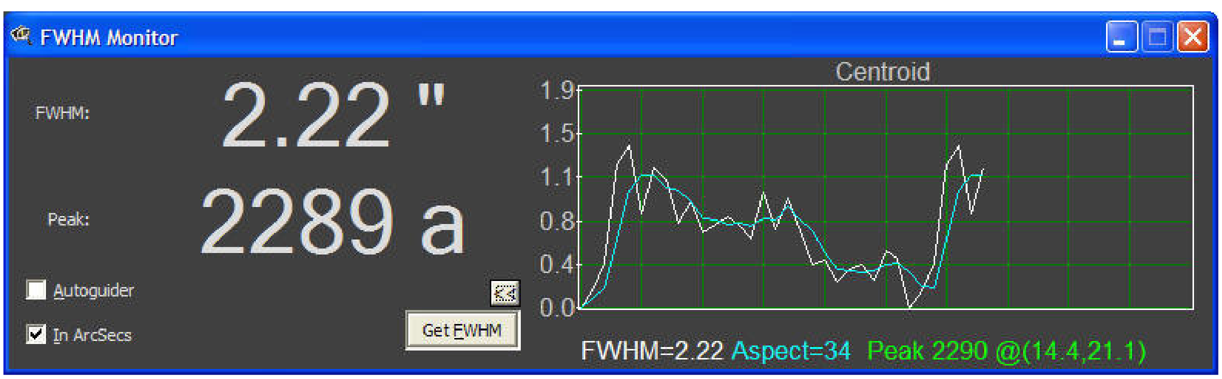
2. FWHM - a real-time running display showing a number of latest FWHM value measurements in pixels or arcseconds. Real-time, or Moving Average or both can be displayed at the same time.

3. HFD - a real-time running display of a number of latest HFD measurements. Shown in pixels or arcseconds.

4. Peak - running display of a number of latest peak values of a star. Shown in ADU.

5. Aspect Ratio - a running display of a number of latest aspect ratio measurements, in %.

6. Centroid - a running display of the distance, in pixels or arcseconds, from the initial star position centroid. Can be used to evaluate seeing, and tracking problems.



7. Seeing - is an RMS value of the FWHM variation. If taking really short exposures, this approximates the blurring effect of seeing, and can be used to judge how good or bad the current atmospheric conditions are. Note that this does not measure the centroid wander resulting from bad seeing, and so will usually underestimate the true FWHM value of seeing.

All charts except for the X-Y Profile can be used to display Real-time measurement, a Moving Average, or both by placing a checkmark next to the appropriate menu selections.

For moving average selection, you have a choice of 2 points, 3, 4, 5, 6, 7, 8, 9, 10, or 20 points moving average.

The chart can also be set to display more or less points, as desired. To pick the number of points to keep on the chart, select ***Points on the Chart*** menu, and pick the desired number (50,100,200,500, or 1000).

To restart the chart, and to reset the chart scale choose Clear Chart option. This will erase all historical data and will start measurements from scratch.

If you'd like to pause the automatic chart refresh, click on the Pause Chart Updates option. The chart will not be updated until the check next to the Pause Chart Updates option is removed.

FWHM Monitor will always show units next to the value. The following abbreviations are used:

"	(double quotation mark) stands for arcseconds
pix	stands for pixels
a	stands for ADU or analog to digital units
a/p	stands for ADU/pixel and is used for the average flux display
%	is used for the aspect ratio display

DSLR RAW File Support

CCDInspector supports native RAW digital camera formats created by the cameras shown below.

The RAW format capability is based on the source code provided by David Coffin, and only some have been tested by us. David's software is very well written, and we are confident that all of the formats listed below will work. Should you find a format that's listed but not working, please let us know.

Adobe Digital Negative (DNG)
AgfaPhoto DC-833m
Apple QuickTake 100
Apple QuickTake 150
Apple QuickTake 200
AVT F-080C
AVT F-145C
AVT F-201C
AVT F-510C
AVT F-810C
Canon PowerShot 600
Canon PowerShot A5
Canon PowerShot A5 Zoom
Canon PowerShot A50
Canon PowerShot A460
Canon PowerShot A530
Canon PowerShot A570
Canon PowerShot A590
Canon PowerShot A610
Canon PowerShot A620
Canon PowerShot A630
Canon PowerShot A640
Canon PowerShot A650
Canon PowerShot A710 IS
Canon PowerShot A720 IS
Canon PowerShot Pro70
Canon PowerShot Pro90 IS
Canon PowerShot Pro1
Canon PowerShot G1
Canon PowerShot G2
Canon PowerShot G3
Canon PowerShot G5
Canon PowerShot G6
Canon PowerShot G7
Canon PowerShot G9
Canon PowerShot G10
Canon PowerShot S2 IS
Canon PowerShot S3 IS
Canon PowerShot S5 IS
Canon PowerShot SD300
Canon PowerShot S30
Canon PowerShot S40
Canon PowerShot S45
Hasselblad V96C
Imacon Ixpress 16-megapixel
Imacon Ixpress 22-megapixel
Imacon Ixpress 39-megapixel
ISG 2020x1520
Kodak DC20
Kodak DC25
Kodak DC40
Kodak DC50
Kodak DC120
Kodak DCS200
Kodak DCS315C
Kodak DCS330C
Kodak DCS420
Kodak DCS460
Kodak DCS460A
Kodak DCS520C
Kodak DCS560C
Kodak DCS620C
Kodak DCS620X
Kodak DCS660C
Kodak DCS660M
Kodak DCS720X
Kodak DCS760C
Kodak DCS760M
Kodak EOSDCS1
Kodak EOSDCS3B
Kodak NC2000F
Kodak ProBack
Kodak PB645C
Kodak PB645H
Kodak PB645M
Kodak DCS Pro 14n
Kodak DCS Pro 14nx
Kodak DCS Pro SLR/c
Kodak DCS Pro SLR/n
Kodak C330
Kodak C603
Kodak P850
Kodak P880
Kodak Z980
Kodak Z1015
Kodak KAI-0340
Nikon E4500
Nikon E5000
Nikon E5400
Nikon E5700
Nikon E8400
Nikon E8700
Nikon E8800
Nikon Coolpix P6000
Nikon Coolpix S6
Nokia N95
Olympus C3030Z
Olympus C5050Z
Olympus C5060WZ
Olympus C7070WZ
Olympus C70Z,C7000Z
Olympus C740UZ
Olympus C770UZ
Olympus C8080WZ
Olympus X200,D560Z,C350Z
Olympus E-1
Olympus E-3
Olympus E-10
Olympus E-20
Olympus E-30
Olympus E-300
Olympus E-330
Olympus E-400
Olympus E-410
Olympus E-420
Olympus E-500
Olympus E-510
Olympus E-520
Olympus E-620
Olympus SP310
Olympus SP320
Olympus SP350
Olympus SP500UZ
Olympus SP510UZ
Olympus SP550UZ
Olympus SP560UZ
Olympus SP570UZ
Panasonic DMC-FZ8

Canon PowerShot S50
Canon PowerShot S60
Canon PowerShot S70
Canon PowerShot SX1 IS
Canon PowerShot SX110 IS
Canon EOS D30
Canon EOS D60
Canon EOS 5D
Canon EOS 5D Mark II
Canon EOS 10D
Canon EOS 20D
Canon EOS 30D
Canon EOS 40D
Canon EOS 50D
Canon EOS 300D / Digital Rebel / Kiss Digital
Canon EOS 350D / Digital Rebel XT / Kiss Digital N
Canon EOS 400D / Digital Rebel XTi / Kiss Digital X
Canon EOS 450D / Digital Rebel XSi / Kiss Digital X2
Canon EOS 500D / Digital Rebel T1i / Kiss Digital X3
Canon EOS 1000D / Digital Rebel XS / Kiss Digital F
Canon EOS D2000C
Canon EOS-1D
Canon EOS-1DS
Canon EOS-1D Mark II
Canon EOS-1D Mark III
Canon EOS-1D Mark II N
Canon EOS-1Ds Mark II
Canon EOS-1Ds Mark III
Casio QV-2000UX
Casio QV-3000EX
Casio QV-3500EX
Casio QV-4000
Casio QV-5700
Casio QV-R41
Casio QV-R51
Casio QV-R61
Casio EX-S20
Casio EX-S100
Casio EX-Z4
Casio EX-Z50
Casio EX-Z55
Casio EX-Z60
Casio EX-Z75
Casio Exlim Pro 505
Casio Exlim Pro 600
Casio Exlim Pro 700
Contax N Digital
Creative PC-CAM 600
Epson R-D1
Foculus 531C
Fuji FinePix E550
Fuji FinePix E900
Fuji FinePix F700
Fuji FinePix F710
Fuji FinePix F800
Fuji FinePix F810
Fuji FinePix S2Pro
Fuji FinePix S3Pro
Fuji FinePix S5Pro
Fuji FinePix S20Pro
Fuji FinePix S100FS
Konica KD-400Z
Konica KD-510Z
Leaf AFi 7
Leaf Aptus 17
Leaf Aptus 22
Leaf Aptus 54S
Leaf Aptus 65
Leaf Aptus 75
Leaf Aptus 75S
Leaf Cantare
Leaf CatchLight
Leaf CMost
Leaf DCB2
Leaf Valeo 6
Leaf Valeo 11
Leaf Valeo 17
Leaf Valeo 22
Leaf Volare
Leica Digilux 2
Leica Digilux 3
Leica D-LUX2
Leica D-LUX3
Leica D-LUX4
Leica V-LUX1
Logitech Fotoman Pixtura
Mamiya ZD
Micron 2010
Minolta RD175
Minolta DiMAGE 5
Minolta DiMAGE 7
Minolta DiMAGE 7i
Minolta DiMAGE 7Hi
Minolta DiMAGE A1
Minolta DiMAGE A2
Minolta DiMAGE A200
Minolta DiMAGE G400
Minolta DiMAGE G500
Minolta DiMAGE G530
Minolta DiMAGE G600
Minolta DiMAGE Z2
Minolta Alpha/Dynax/Maxxum 5D
Minolta Alpha/Dynax/Maxxum 7D
Motorola PIXL
Nikon D1
Nikon D1H
Nikon D1X
Nikon D2H
Nikon D2Hs
Nikon D2X
Nikon D2Xs
Nikon D3
Nikon D3X
Nikon D40
Nikon D40X
Nikon D50
Nikon D60
Nikon D70
Nikon D70s
Nikon D80
Nikon D90
Nikon D100
Nikon D200
Nikon D300
Nikon D700
Panasonic DMC-FZ18
Panasonic DMC-FZ28
Panasonic DMC-FZ30
Panasonic DMC-FZ50
Panasonic DMC-FX150
Panasonic DMC-G1
Panasonic DMC-GH1
Panasonic DMC-L1
Panasonic DMC-L10
Panasonic DMC-LC1
Panasonic DMC-LX1
Panasonic DMC-LX2
Panasonic DMC-LX3
Pentax *ist D
Pentax *ist DL
Pentax *ist DL2
Pentax *ist DS
Pentax *ist DS2
Pentax K10D
Pentax K20D
Pentax K100D
Pentax K100D Super
Pentax K200D
Pentax K2000/K-m
Pentax K-7
Pentax Optio S
Pentax Optio S4
Pentax Optio 33WR
Pentax Optio 750Z
Phase One LightPhase
Phase One H 10
Phase One H 20
Phase One H 25
Phase One P 20
Phase One P 25
Phase One P 30
Phase One P 45
Phase One P 45+
Pixelink A782
Polaroid x530
Rollei d530flex
RoverShot 3320af
Samsung GX-1S
Samsung GX-10
Samsung S85
Samsung S850
Sarnoff 4096x5440
Sigma SD9
Sigma SD10
Sigma SD14
Sinar 3072x2048
Sinar 4080x4080
Sinar 4080x5440
Sinar STI format
SMaL Ultra-Pocket 3
SMaL Ultra-Pocket 4
SMaL Ultra-Pocket 5
Sony DSC-F828
Sony DSC-R1
Sony DSC-V3
Sony DSLR-A100
Sony DSLR-A200
Sony DSLR-A300
Sony DSLR-A330
Sony DSLR-A350
Sony DSLR-A700

Fuji FinePix S5000
Fuji FinePix S5100/S5500
Fuji FinePix S5200/S5600
Fuji FinePix S6000fd
Fuji FinePix S7000
Fuji FinePix S9000/S9500
Fuji FinePix S9100/S9600
Fuji IS-1
Hasselblad CFV
Hasselblad H3D
Nikon D5000
Nikon E700
Nikon E800
Nikon E880
Nikon E900
Nikon E950
Nikon E990
Nikon E995
Nikon E2100
Nikon E2500
Nikon E3200
Nikon E3700
Nikon E4300
Sony DSLR-A900
Sony XCD-SX910CR
STV680 VGA

FWHM Monitor FAQ

Here are some common questions and answers:

1. "I selected display In Arcseconds option, but the display still shows values in pixels?"

Solution: Make sure you set the focal length in CCDSoft Camera File Defaults dialog or MaxIm DL Main Telescope Optical Settings dialog.

2. "The FWHM or HFD display in arcseconds appears to be incorrect?"

Solution: Make sure to set the <u>correct</u> focal length (see #2 above) . If you are trying to measure an existing image, then you may need to edit image header in CCDSoft or MaxIm DL, and verify that the FOCALLEN keyword is set to the correct focal length in mm. To display image header information, select View\File Information... menu and click on the Edit Header tab in CCDSoft, or View\Fits Header Window in MaxIm DL.

3. "It takes too long to display FWHM for a new image"

Solution: This may happen when trying to measure a large image with a lot of stars, or a lot of hot pixels. You can either use the camera control software to select a small portion of the image with some representative stars to measure, use a sub-frame to reduce image size, and/or use auto-dark frame subtraction to reduce noise.

4. "The display does not update when a new image is downloaded from the camera"

Solution #1: Check that the "Autoguider" option is set appropriately. If it's checked, and the camera is exposing images using the main imager, no updates will be calculated since FWHM Monitor is waiting for an image from the autoguider.

Solution #2: If using CCDSoft, verify that the plugin is properly installed and enabled in CCDSoft. From the Camera Setup screen, press Events Plug Ins button. If you don't see the "CCD Monitor Relay" event plug in, then it wasn't installed properly. Try uninstalling FWHM Monitor from the Windows control panel Add/Remove software screen. Then, re-install FWHM Monitor, making sure to provide the correct path to the CCDSoft folder.

5. I did a plate solve to get the exact image scale, but I don't know my effective focal length. What do I do?

FWHM Monitor will use image scale as computed by a plate solution, if available. Focal length doesn't need to be set in this case. But, if you want to compute the focal length from a "solved" image scale, here is the formula you can use:

$$\text{FocalLength} = \text{pixelsize} * 206.2648 / \text{imagescale}$$

where *FocalLength* is the effective focal length expressed in millimeters, *pixelsize* is the size of the CCD pixel in microns, and *imagescale* is the image scale as computed by the astrometric solution, in arcseconds/pixel.

7. What are the upper and lower limits on star size and image scale?

FWHM Monitor uses advanced interpolation and curve fitting techniques to measure star FWHM, even for very tiny stars. There is a limit, though, to how small a star image can be before it becomes impossible to measure. For FWHM Monitor that limit is 1.3 pixels FWHM. In other words, if the star size is at or below 1.3 pixels, FWHM Monitor will be unable to measure it. This is because the star spans a radius of less than two pixels, and therefore, there is just not enough information in the image to properly measure its size.

At the other extreme, if FWHM value of an object exceeds 30 pixels, FWHM Monitor will give up on trying to measure it. This is an arbitrary choice, made mostly to help FWHM Monitor not get bogged down in trying to measure large objects that are not stellar in nature (such as the core of a galaxy, for example, or an extremely bloated and saturated star).

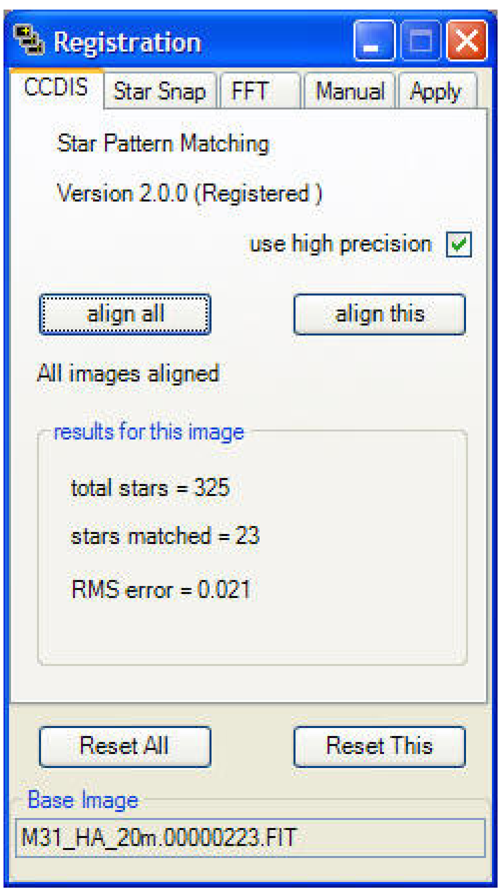
CCDIS Plug-in for CCDStack

A new and exciting development in CCDInspector 2 is the inclusion of an advanced, automated image registration module that works seamlessly with CCDStack. This module, CCDIS will only work if both, CCDStack and CCDInspector are installed on the same computer.

Image registration is the process of adjusting an image stack so that all the images are properly aligned to a base image. This can involve scaling the images to the same dimensions, shifting them vertically and horizontally, and de-rotating them so as to allow them to be stacked.

Without CCDIS registration process can be tedious, and the resulting registration may not be as accurate. Inaccuracies in registration can lead to blurring and loss of resolution in the stacked image -- something to be avoided at all costs! CCDIS uses an extremely accurate and sophisticated algorithm to find unique star patterns between all the images, ***automatically***! CCDIS then applies the appropriate scaling factor, de-rotation, and linear offset to align the images in the best possible way. CCDIS will also flip the image if the horizontal or vertical axis are reversed. Generally, CCDIS alignment accuracy will be better than 1/10 of a pixel. In many cases it is better than 1/30 of a pixel!

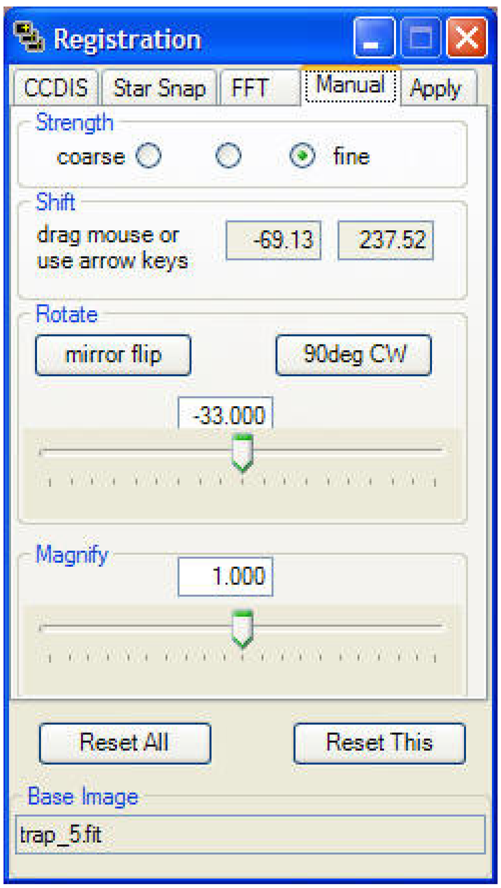
CCDIS plug-in is included and automatically enabled during the installation of CCDInspector 2. If you already have CCDStack or decide to install it later, CCDIS will quickly become your primary choice of registration methods:



When installed, CCDIS tab will be the first tab of available registration methods in the CCDStack Registration dialog. There are no complicated settings: just click **align all** or **align this** buttons to perform the fully automatic registration. When done, the results of the registration will be shown in the lower half of the dialog. **Results for this image** section shows the registration statistics for the currently selected image. Above example indicates that a total of 325 stars were chosen for the registration process, and from these, a 23-star unique pattern was identified that matched with the base image (base image is shown on the bottom of the dialog). The RMS error shown is the average error across all 325 stars, after the registration process completes. This is expressed in pixels. The above result is very good, showing that the error is almost 1/50 of a pixel!

The only option in the CCDIS Registration dialog is to **use high precision**. This option makes CCDIS do more work by extracting more stars from the image, and by looking for the star pattern for a bit longer. The results are usually somewhat improved compared to the low-precision registration. High precision mode can take a bit more time, but can work better especially for images that do not have a large overlap, such as when doing mosaics. If CCDIS is unable to find a matching star pattern in the low-precision mode, it will automatically switch to the high-precision mode and try again. In most cases, it is safe to leave **use high precision** option unchecked.

Once registration completes, you can see the actual transformation settings CCDIS found for each of the images by opening the Manual tab:



As you select different images in the image manager, the values in the Manual tab will change to show the CCDIS-determined registration parameters. In the example above, the selected image was shifted over by -69.13 pixels horizontally, 237.52 pixels vertically, and was rotated by 33 degrees. The image scale was found to be the same, so the scaling factor (Magnify) was set to 1.000.

NOTE: after performing registration and looking at the color display in CCDStack, the stars may appear to be slightly out of alignment, especially at high magnification. This is because the display cannot adjust images by a fraction of a pixel, and is not an indication of CCDIS error. Once you apply the registration to the images, the position errors will disappear (except when using the Nearest Neighbor interpolation method, the stars also cannot be adjusted by less than a whole pixel).

CCDIS uses a highly optimized, efficient algorithm to perform pattern matching. It will use multi-core, or multi-processor computers to perform its functions even faster than on a single CPU.

Installing CCDIS Plug-in on a 64-bit Windows

CCDIS plug-in requires an additional installation when used with CCDStack running on a 64-bit version of Windows:

- Windows XP-64
- Windows Vista-64
- Windows 2003 x64

To complete the installation on a 64-bit Windows, please double-click on the CCDIS64.msi file included in your CCDInspector package.