Rockchip IQ Tools Guide ISP2x

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Over view of the prea mbl e

The purpose of this article is to introduce the use of RKISP2 Tuner and ISP debugging process. It mainly helps engineers who use RKISP2 Tuner for IQ debugging to get started quickly and provides reference.

Product Versions

Chip Name	kernel version	Tool Versions
RK356x		RKISP Tuner v2.0.0

Readership

This document (this guide) applies primarily to the following engineers:

ISP Debugging Engineer

Image Quality Debugging Engineer

revised record

version number	author	Modification Date	Modification Instructions
V2.0.0	Chen Yu	2021-06-22	Adaptation to v2.0.0
V2.0.1	Xu Suwanwan	2021-07-09	Adapted v2.0.1 version, added IQ file online import function
v2.0.2	Chen Yu	2021-07-10	Subsection 3.1.1 adds instructions for resetting camera application script-related operations

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catalogs

1 summarize

1.1 About **RKISP2.x Tuner**

RKISP2.x Tuner (hereinafter referred to as Tuner) provides a set of tools to facilitate users to debug ISP parameters, users can carry out calibration, debugging (Tuning) and other work on all ISP modules in Tuner. Users can use Tuner to provide a graphic tool.
(Capture Tool) to capture Raw images; complete the calibration of the base module in the Calibration Tool; connect the device in Tuner to debug the ISP parameters online.

1.2 Platform & Version Matching Rules

Chip Name	system platform	ISP version
RK356x	Linux/Android	RKISP21

The version matching rules of AIQ with Tuner and ISP Driver are as follows:

vA.B.C

where B is the hexadecimal representation, bit[0:3] identifies the version of the AIQ that matches the Tuner, and bit[4:7] identifies the version of the AIQ that matches the ISPDriver, for example:

ISP Driver: v1.0x3.0 matches AIQ: v1.0x30.0, does not match AIQ: v1.0x40.0

Tuner: v1.0x3.0 matches AIQ: v1.0x33.0, does not match AIQ: v1.0x30.0

Note that when the AIQ version number C is not 0, there is a possibility of version mismatch. For Tuner matching, it is recommended to prioritize the AIQ version with C version number 0.

1.3 debugging environment

Computer environment requirements:

The computer running Tuner must have a 64-bit Windows operating system with Windows 7 x64

version or above installed; the 64-bit version of MCR_R2016a (9.0.1) should be pre-installed

before running Tuner (only this version is supported), download address:

https://ww2.mathworks.cn/products/compiler/matlab-runtime

The use of the process should be avoided Tuner's path Tuning the path of the project in Chinese characters;

Equipment-side environmental requirements:

1. Has an Ethernet card and supports connecting to the LAN using wired and wireless;
2. If 1 is not met, you should be able to support the RNDIS service and use a USB analog NIC device to connect to the LAN;

1.4 Tool Installation and Configuration

RKISP2.x Tuner does not need to be installed, directly use the decompression tool to decompress to any directory can be used, but should be avoided to decompress to the path of the existence of Chinese characters.

In Section 3, it is mentioned that MCR_R2016a needs to be pre-installed before running Tuner, and the installation steps are as follows:

1. Open MCR_R2016a_x64.exe and wait for its self-extraction to complete;

Figure 1-4-1

2. Click Next, select Agree to Terms, Next, and click Install;

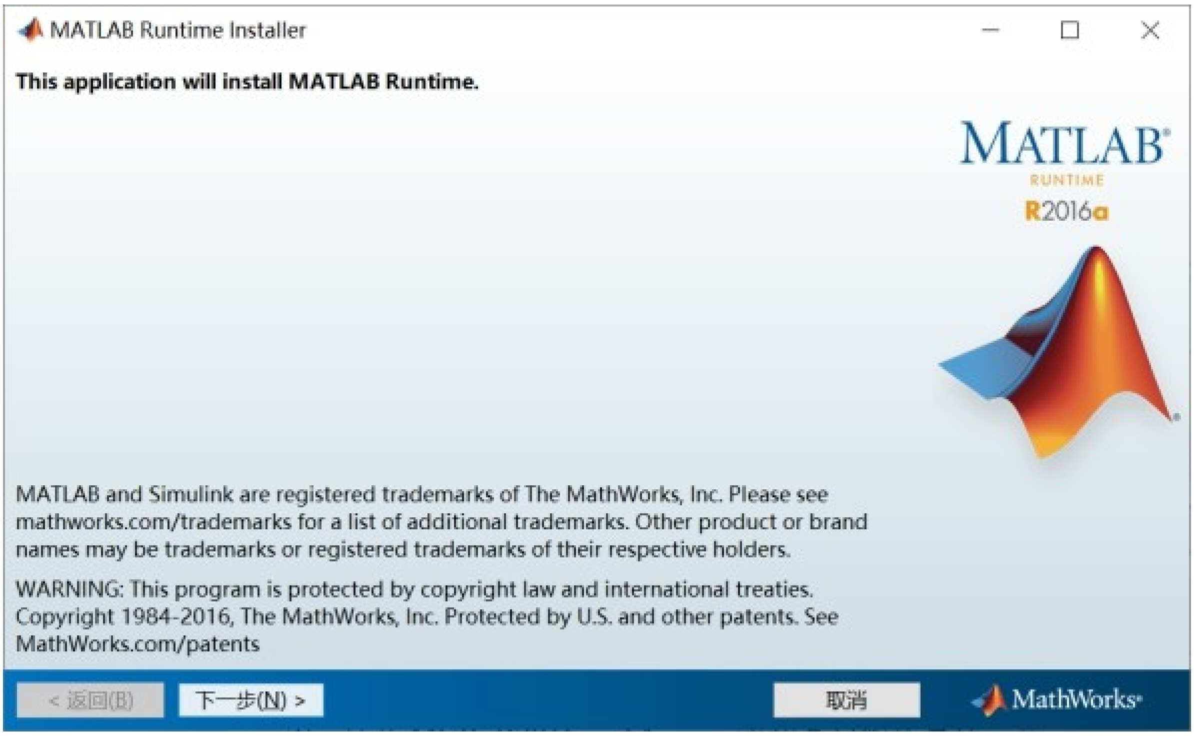


Figure 1-4-2

3. Wait for the installation to complete;

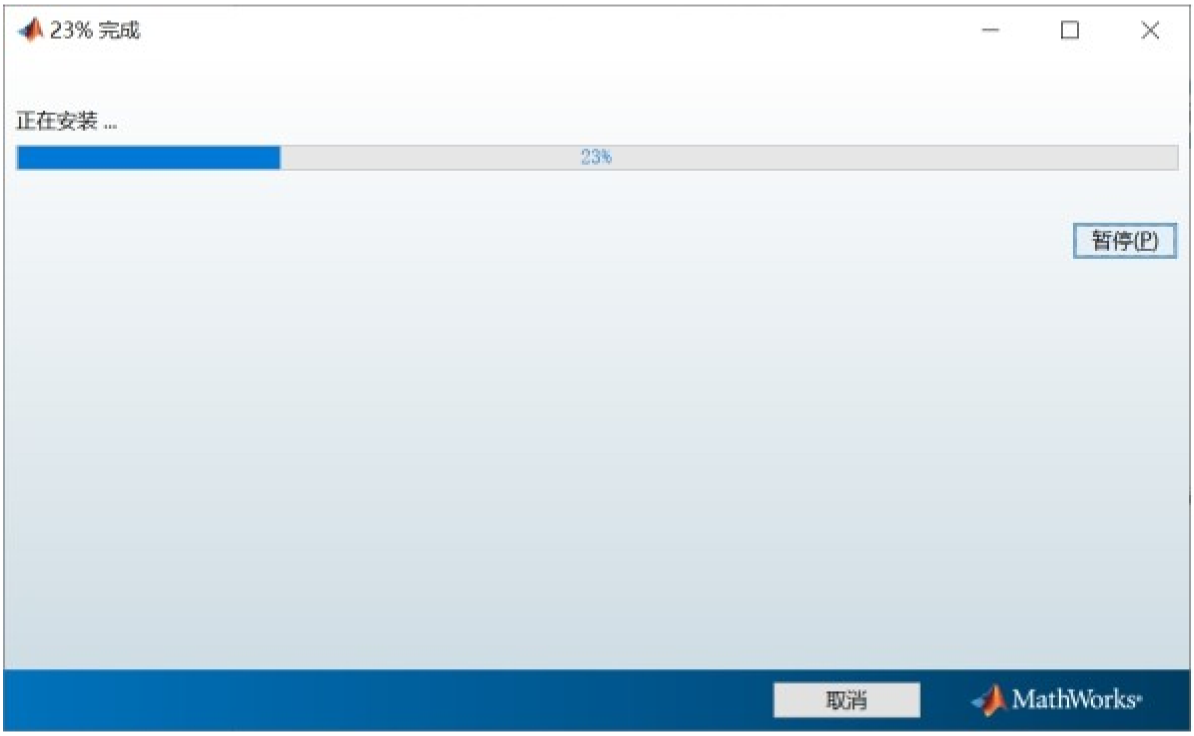


Figure 1-4-3

4. Installation complete;

Figure 1-4-4

2 Function Introduction

2.1 summarize

In the actual Tuning project, users should follow the process shown in the following figure to carry out Tuning work:

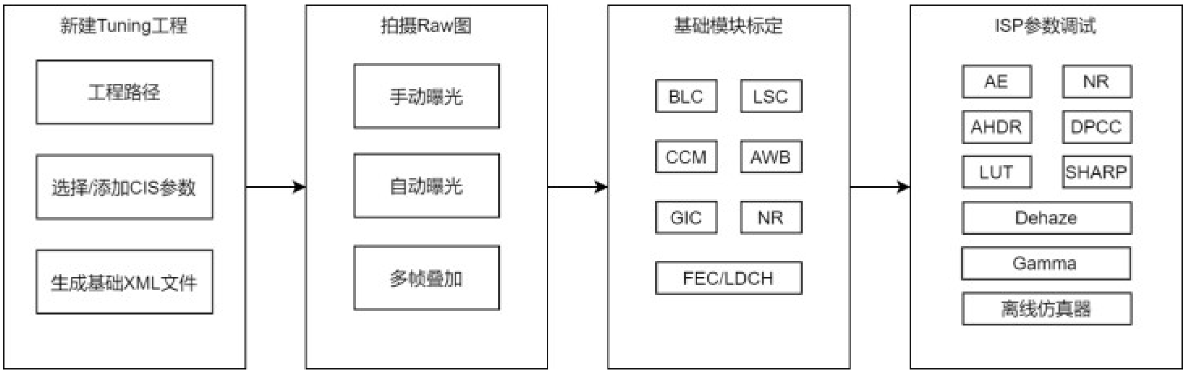


Figure 2-1-1

In the first step after the completion of the new project, the tool will generate an XML file under the project path, the file records all the adjustable parameters of the ISP open, whether it is the calibration parameters output in the subsequent calibration process, or the debugging process of the user debugging the results will be recorded in the XML file, and finally the user should be replaced by the XML file in the firmware or device in the corresponding location can be.

The Raw diagram is taken for the calibration of the base module, and also to capture the scenes with abnormal effects and troubleshoot the problems in the simulator. The base module calibration needs to follow a certain process, as shown below:

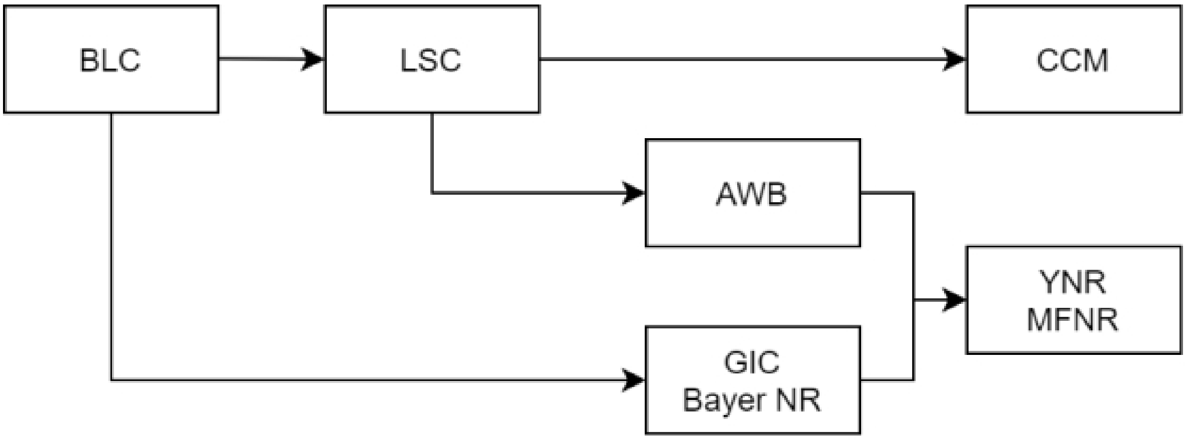


Figure 2-1-2

Since the calibration of some modules will depend on the calibration results of the previous modules, the user should complete the calibration in the order of the process. After completing the calibration calculations for a certain module, you should confirm that the parameters are correct so that incorrect results do not affect the later modules.

2.2 mapping tool

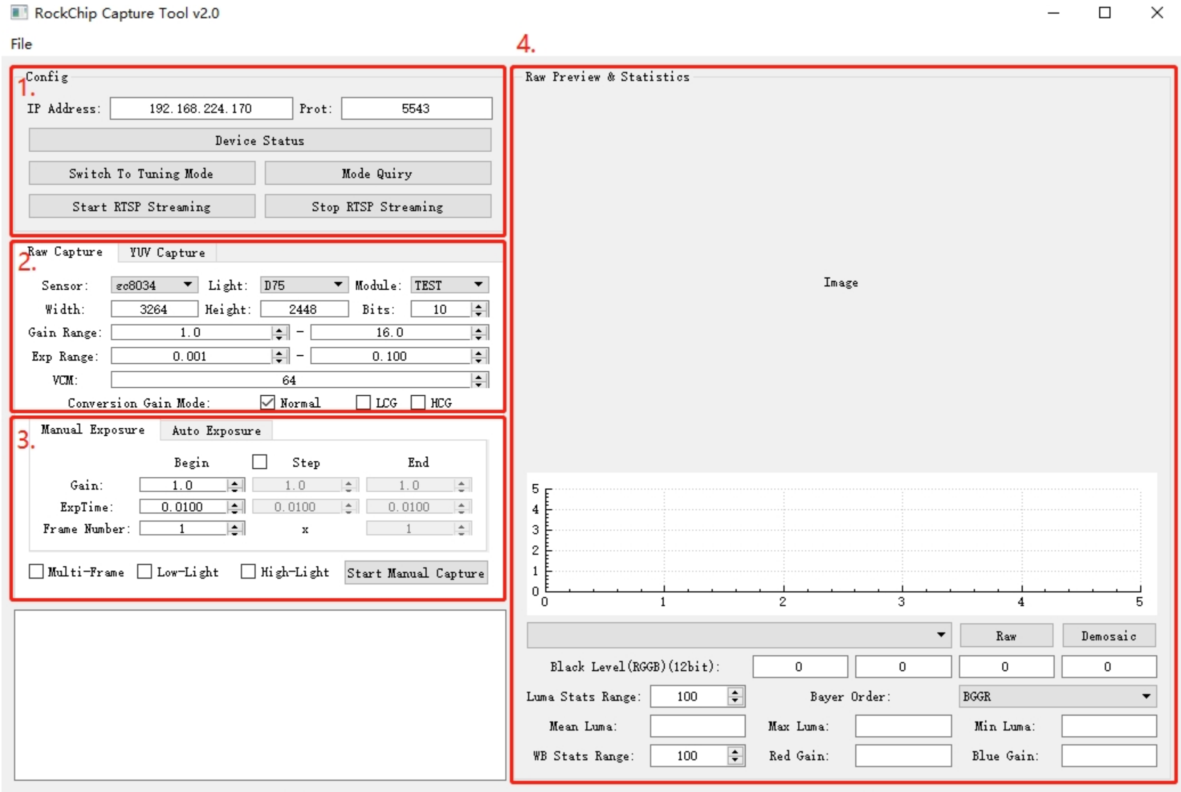


Figure 2-2-1

The main interface of RKISP Tuner Capture Tool is shown in Figure 2-2-1. The interface is mainly divided into the four sections marked in the figure:

1. Device-side connection configuration: Provides device network parameter configuration, Tuning/Calib mode switching function, and test connection function;
2. Camera Parameter Configuration: Provides sensor exposure parameters, module/light source name labeling, resolution and gain/exposure parameter ranges required for taking pictures;
3. Exposure Control: Supports both manual and automatic exposure, manual exposure allows the configuration of a step size for traversing multiple exposure combinations, and automatic exposure allows the user to set the target maximum brightness to pick the exposure parameters;
4. Raw chart preview and statistics function: Here the captured Raw chart will be displayed in the window as a grayscale chart with the corresponding histogram, brightness information and simple white balance gain;

2.3 Calibration tools

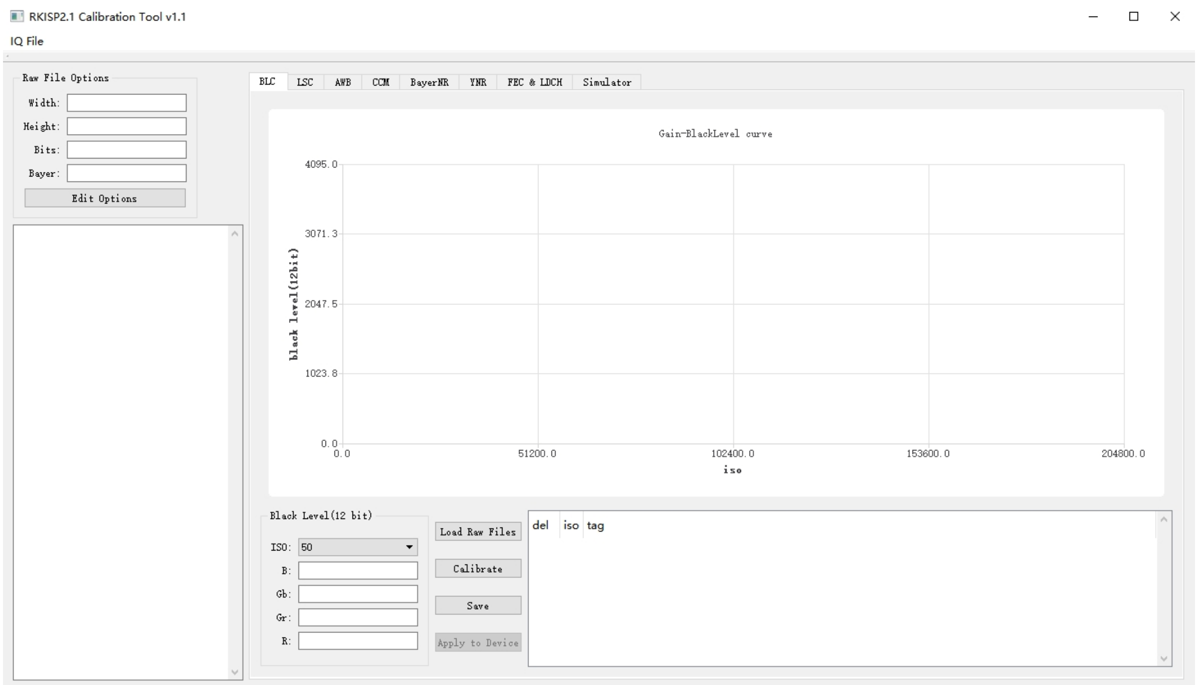


Figure 2-3-1

The main interface of RKISP Tuner Calibration Tool is shown in Figure 2-3-1, which mainly

includes the calibration functions of the following modules: BLC: Black Level Correction

LSC: Lens Shading Correction

CCM: Color Correction Matrix

AWB: Automatic White Balance Correction

GIC: Green Channel

Impact Correction Bayer

NR: Raw Domain Noise

Reduction YNR: Y

Channel Noise Reduction

MFNR: Multi Frame

Noise Reduction

FEC: Fisheye Correction

It is recommended that users import the corresponding raw diagram into the corresponding module to calculate the calibration parameters according to the calibration workflow.

3 Quick Start

3.1 Debugging environment preparation

In the ISP Tuning workflow, there is a lot of work that needs to be done on the device side, and here it is necessary to run a service application on the device side for passing data between the Tuner and the AIQ, which can also be used for Raw graph acquisition and other tasks. To do this, the service application and other dependent files need to be pushed into the device side and run before starting the Tuning work.

The following two subsections describe the preparations required for debugging Linux and Android platforms, respectively:

1. LAN connectivity
2. The operations that need to be performed to run `rkaiq_tool_server` (where the execution of commands and file transfers can be accomplished through: `TFTP`, serial port, `ADB` and other protocols or tools, the example operation uses `ADB`)

3.1.1 Android platform

For devices that can be connected using a wired network.

1. Connect the device to the router using the network cable
2. Use the `ifconfig` command to view the `IP` address of the device
3. `PC` is also connected to the same router (wired, wireless)
4. Check the `IP` address of `the PC` and use `ping` on the command line on the `PC` or device side to confirm that the network path is working.

For devices that cannot be connected using a wired network (tablets, etc.).

1. `PC` and `EVB` connected with `USB` cable (same port as `ADB`)
2. Turn on the power and enter the system
3. Open `Settings`
4. Go to `Network&internet`
5. Enter `Hotspot&tethering`
6. Turn on `USB tethering`
7. `adb shell` into the device side
8. Run `ifconfig usb0` to view the `IP` address
9. Use `ping` from the command line on the `PC` or device to confirm that the network path is working.

Actions required to run rkaiq_tool_server (if the required service application and other dependent files are already present in the corresponding path on the device side, you can run rkaiq_tool_server directly).

```
1. Compile in SDK to get rkaiq_tool_server and rkaiq_3A_server
2. Firmware must be user-debug version
3. 将android.hardware.camera.provider@2.4-service.rc文件推入板端/vendor/etc/init/路径下
4. Go to the /vendor/etc/init/ path and execute the modify permissions command: chmod 644
android.hardware.camera.provider@2.4-service.rc
5. Push rkaiq_tool_server and rkaiq_3A_server into the /vendor/bin/ path on the board side
6. Go to the /vendor/bin/ path and execute the modify permissions command: chmod 755 rkaiq_tool_server
   (and the
rkaiq_3A_server)
7. Execute the flush cache command: sync
8. reboot
9. Execute the command: setenforce 0
10. Open the camera apk
11. Run rkaiq_tool_server
```

ADB Sample Operations.

```
# The following command runs
adb root in cmd on your PC
adb remount
adb pushandroid.hardware.camera.provider@2.4-service.rc /vendor/etc/init/ adb push
rkaiq_tool_server /vendor/bin/
adb shell

# The following commands are executed in an adb shell terminal
chmod 644 /vendor/etc/init/android.hardware.camera.provider@2.4-service.rc
chmod 755 /vendor/bin/rkaiq_tool_server sync
reboot

# After reboot, enter adb shell
again # Shut down SELinux
setenforce 0
# Run the camera apk manually first
# Then run tool_server
/vendor/bin/rkaiq_tool_server &
```

Below is a description of the parameters for rkaiq_tool_server:

```
-d: sensor selection, when there are multiple sensors in the device for debugging, you can use numbers
such as 0/1/2 to select which sensor to use, the order of the numbers is the same as the order of the v412
topology list, the default value is 0.

-m:   normal/HDR mode selection, 0/1/2 corresponds to normal/HDR2 frame/HDR3 frame respectively, default
value is normal

-i:   IQ file read path, if the path has been changed, should be synchronized to modify the path here

-w and -h:   rtsp preview resolution which is scaled to fit based on the ISP output size, defaults to 1920x1080
```

Example:

```
#If there are 2 sensors   in the device and need to switch to another sensor for debugging, run tool_server as
follows:
/vendor/bin/rkaiq_tool_server -d 1 &
```

Note: After pushing the initial IQ parameters generated by the New function into the device, you should use the following operation to reset the camera application and re-run the tool_server If there are abnormal problems such as crashes, seizures, online debugging failures, inability to preview, etc., please also try to reconnect to the tool by following the steps below

```
source /vendor/etc/camera/reset_camera.sh #
Run camera apk
/vendor/bin/rkaiq_tool_server &
```

3.1.2 Linux system platform

For devices that can be connected using a wired network.

```
1. Connect the device to the router using the network cable
2. Use the ifconfig command to view the IP address of the device
3. PC is also connected to the same router (wired, wireless)
4. Check the IP address of the PC and use ping on the command line on the PC or device side to confirm that the
   network path is working.
```

For devices that cannot be connected using a wired network.

```
1. Try to turn on the RNDIS service
2. Use the ifconfig command to view the IP address of the device
4. Use ping at the command line on the PC or device to confirm that the network path is working.
```

Actions required to run rkaiq_tool_server (if the required service application and other dependent files are already present in the corresponding path on the device side, you can run rkaiq_tool_server directly).

```
1. Compile in SDK to get rkaiq_tool_server and librkmedia.so
2. Push the librkmedia.so file into the /data/ path on the board side
3. Go to the /data/ path and execute the modify permissions command: chmod 777 librkmedia.so
4. Push the rkaiq_tool_server file into the /data/ path on the board side
5. Go to the /data/ path and execute the change permissions command: chmod 777 rkaiq_tool_server
6. Execute the flush cache command: sync
7. reboot
8. Running the Camera app
9. Run rkaiq_tool_server
```

ADB Sample Operations.

```
# The following command runs
adb root in cmd on your PC
adb remount
adb push librkmedia.so /data/
adb push rkaiq_tool_server /data/ adb
shell

# The following commands are executed in an adb shell terminal
chmod 777 /vendor/etc/init/android.hardware.camera.provider@2.4-service.rc
chmod 777 /data/rkaiq_tool_server
sync
reboot

# After rebooting, enter the adb
shell again # Run the camera
app first.
# Then run rkaiq_tool_server
```

```
/data/rkaiq_tool_server -d 0 -m 0 &
```

Below is a description of the parameters for rkaiq_tool_server:

```
-d: sensor selection, when there are multiple sensors in the device for debugging, you can use numbers such as 0/1/2 to select which sensor to use, the order of the numbers is the same as the order of the v412 topology list, the default value is 0.

-m:    normal/HDR mode selection, 0/1/2 corresponds to normal/HDR2 frame/HDR3 frame respectively, default value is normal.

-i:    IQ file read path, if the path has been changed, should be synchronized to modify the path here

-w and -h:    rtsp preview resolution which is scaled to fit based on the ISP output size, defaults to 1920x1080
```

3.2 Select platform & configure network address

1. Opening the RKISP2.x Tuner will display the initial configuration screen, as shown in Figure 3-2-1;

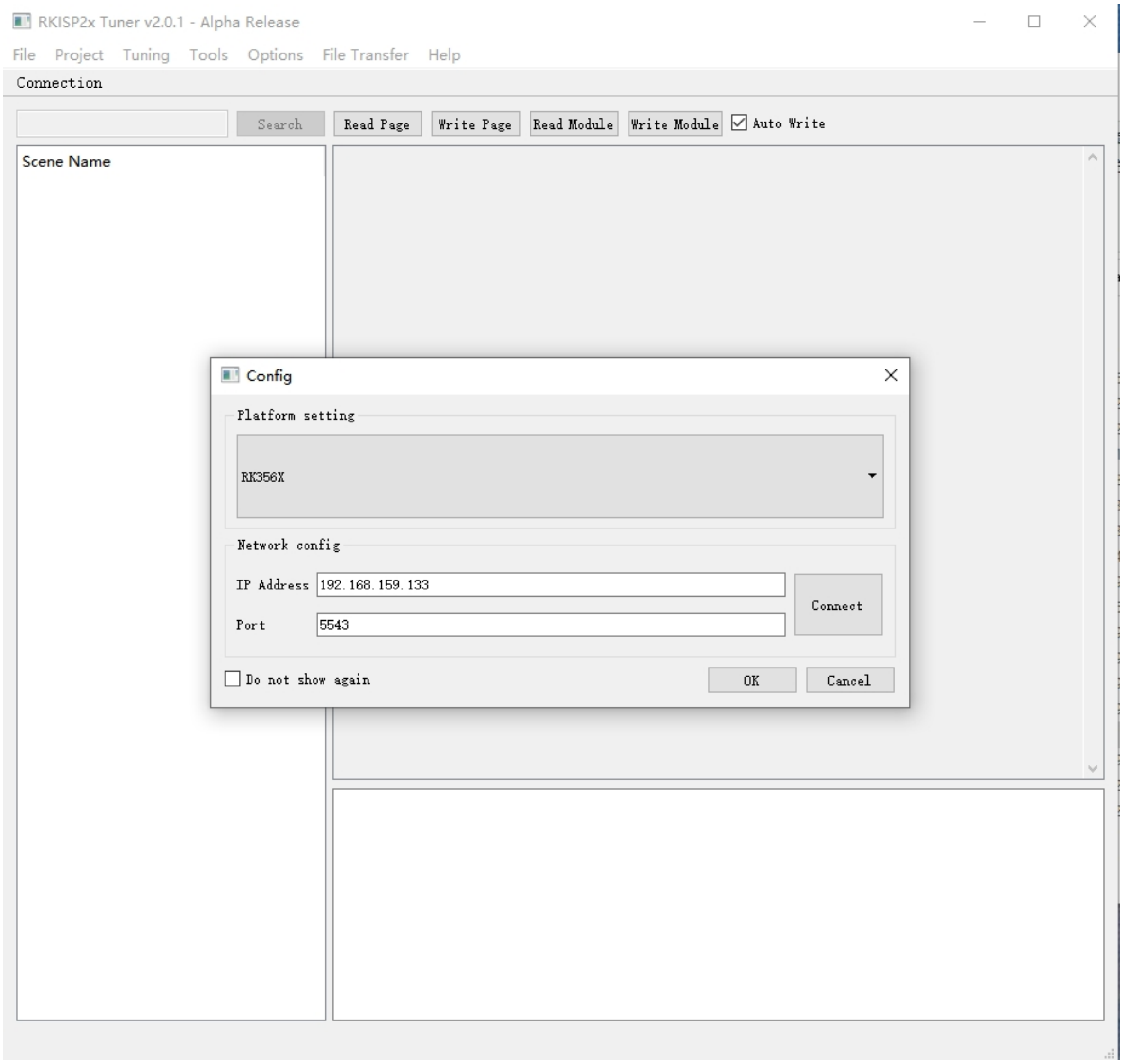


Figure 3-2-1

2. Select the appropriate platform, fill in the device IP address obtained in the previous subsection, the default port number 5543 (non-special needs, please do not modify), please ensure that rkaiq_tool_server has been running correctly, click Connect to connect to rkaiq_tool_server, connect successfully, if you need to use a third-party tool to preview, the specific operation of the refer to the 3.5 For more information, please refer to the third point of subsection 3.5.
3. Clicking the OK button will load the debugging interface for the corresponding platform, as shown in 3-2-2;

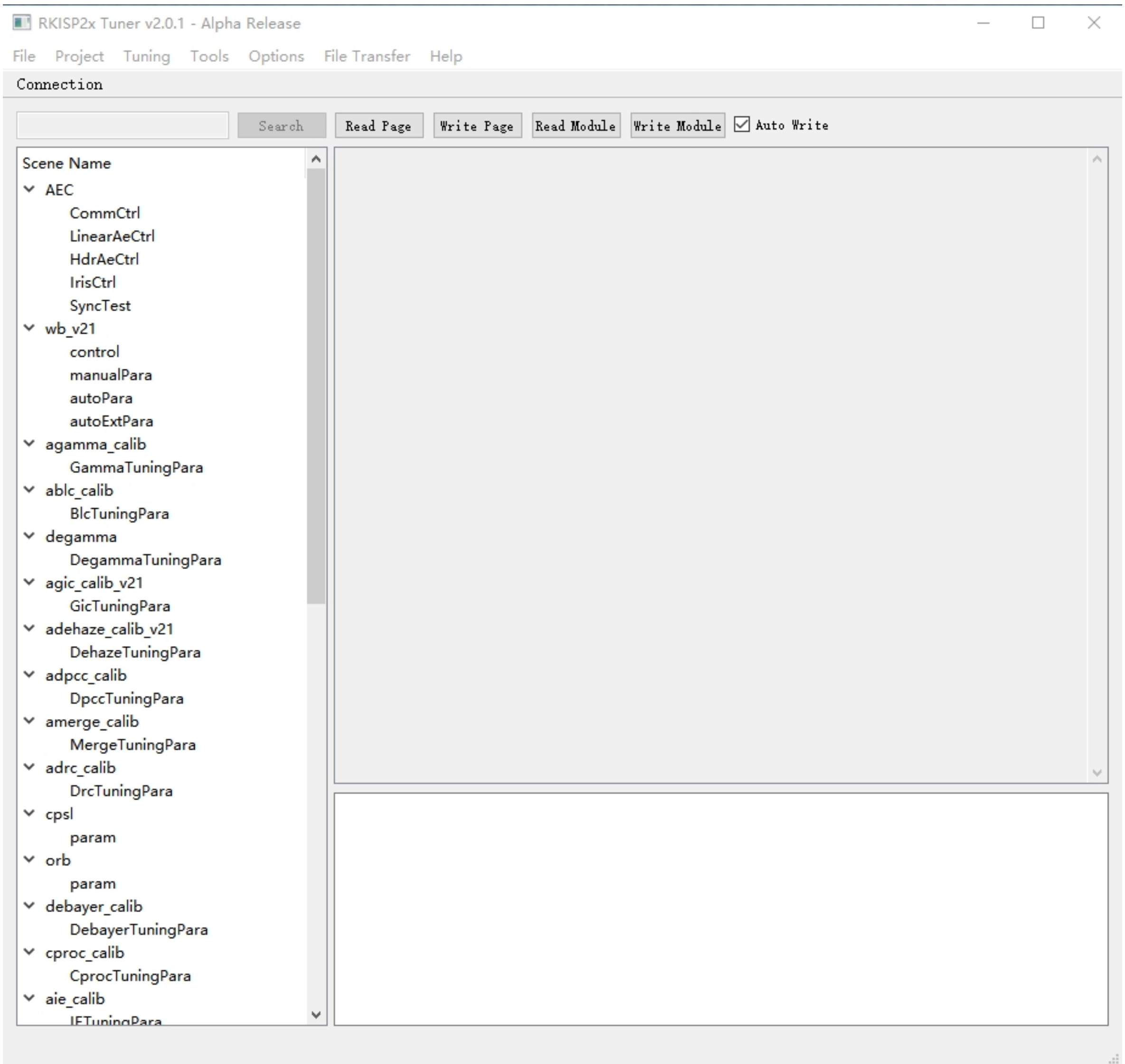


Figure 3-2-2

3.3 Load and save IQ parameter files

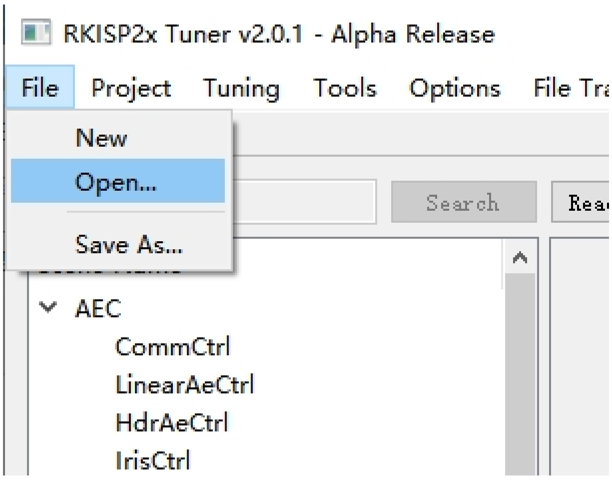


Figure 3-3-1

1. Click on the "File" - "Open..." button in the menu bar. button and select the IQ parameter file you want to load.

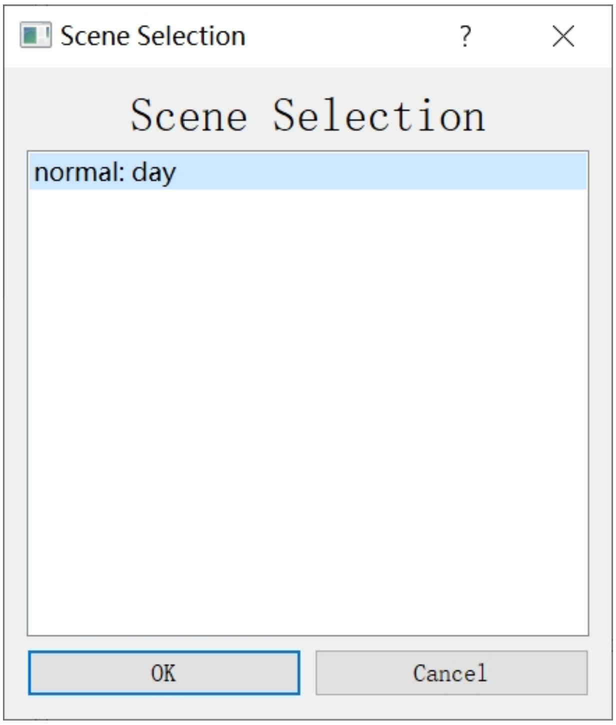


Figure 3-3-2

2. In the Scene Selection interface that pops up, it will display the name of each group of scenes within the IQ parameter file, select the scene you want to debug, click OK to load the parameters into the interface;

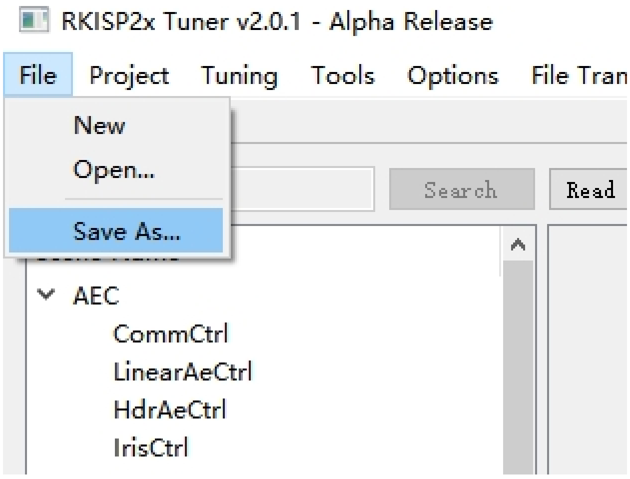


Figure 3-3-3

3. Click "File" - "Save As..." in the menu bar. in the menu bar "File" - "Save As...", you can save the modified IQ parameters to the specified path;

3.4 Importing or Modifying **Sensor Infomation** Parameters

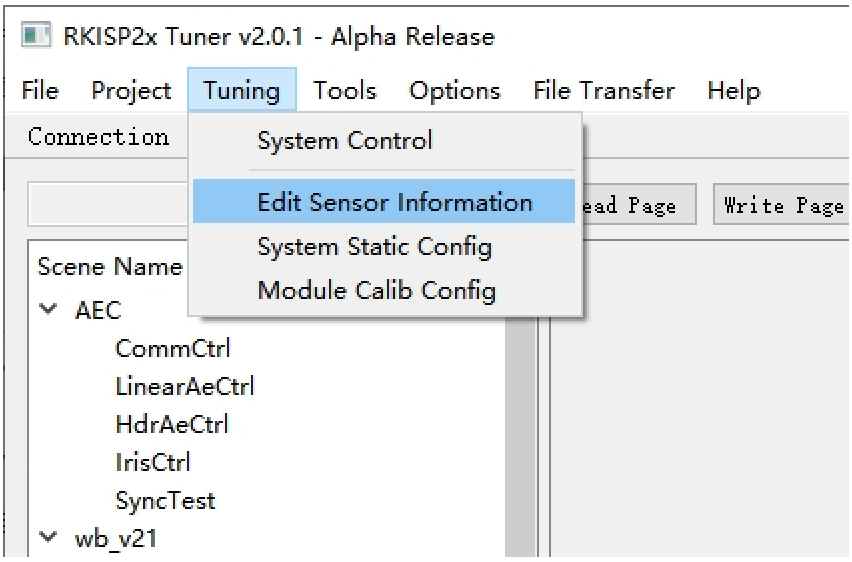


Figure 3-4-1

1. Refer to the steps in the previous subsection to load an IQ parameter file;
2. Click "Tuning" - "Edit Sensor Information" button on the menu bar to open the Sensor Info configuration interface;

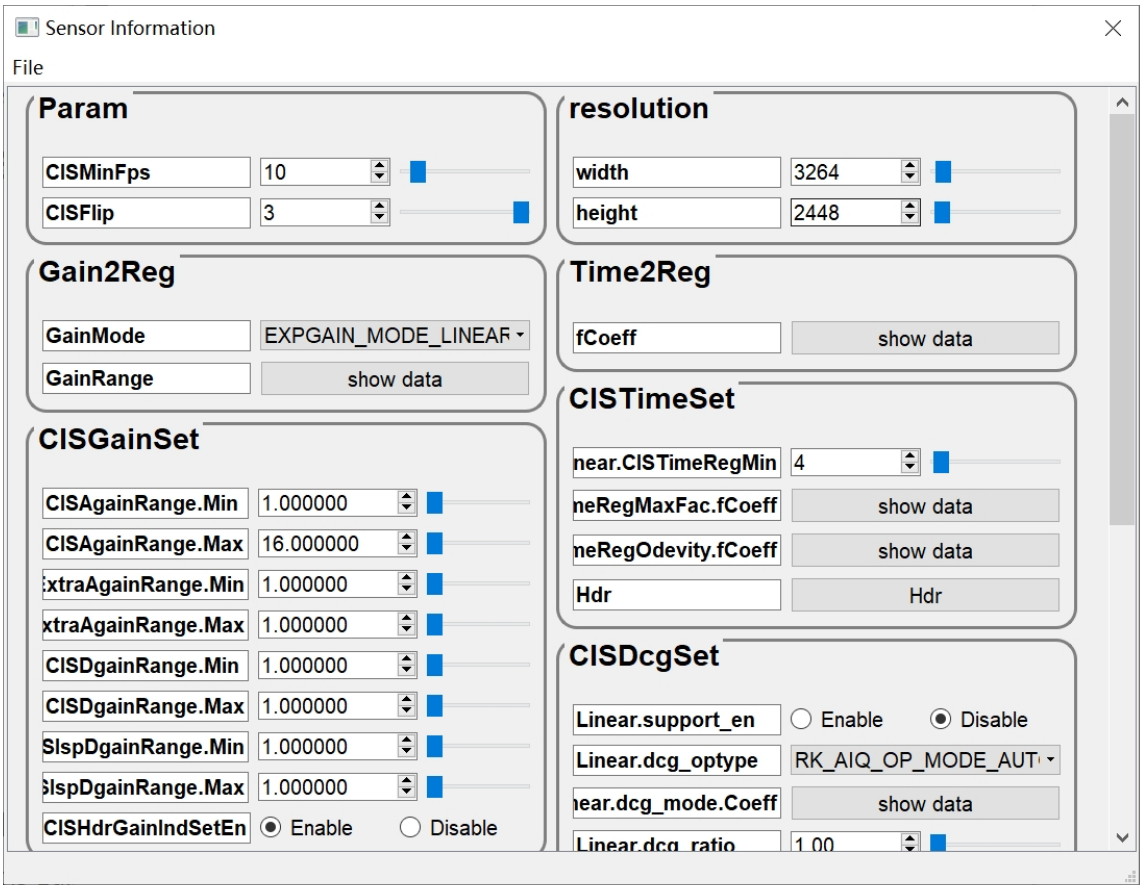


Figure 3-4-2

3. Click on the menu "File" - "Import From Sensor List" button to open the import interface.

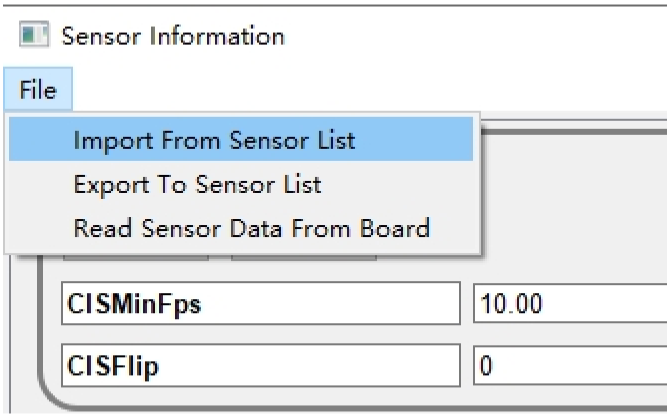


Figure 3-4-3

4. Select the Sensor configuration you want to import as follows

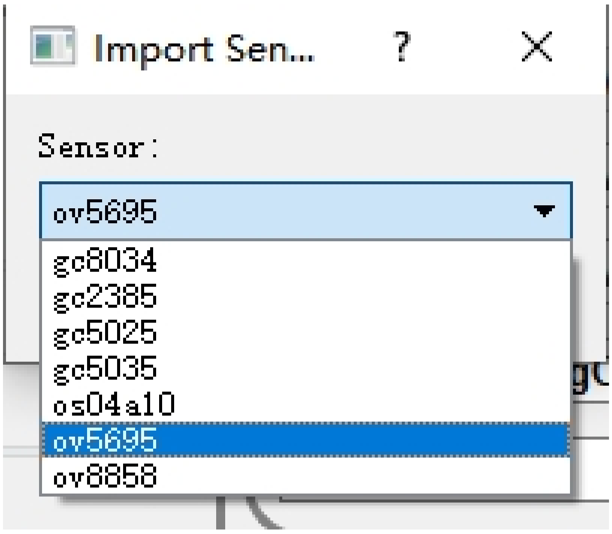


Figure 3-4-4

5. Click the "OK" button to import the configuration parameters;
6. Close the "Sensor Information" screen;
7. When the Sensor model for the current project cannot be found in the SensorList, the user can find the Sensor model in the Sensor Information dialog box.
   Refer to the Sensor manual in the interface to configure the appropriate parameters;
8. The following is the definition of each parameter, user should refer to the Datasheet of Sensor to fill in (this part is recommended to be completed by the driver debugger):

Parameter name	Parameter description
CISTimeRegUnEqualEn	sensor each frame exposure time row not equal limit switch; En=0: sensor each frame exposure time row can be equal; En=1: not allowed to be equal.
CISMinFps	Allow minimum frame rate for automatic frame-down mode
TimeRegMin	Sensor Exposure Time Row Allowable Minimum
DCGRatio	Conversion Gain Multiplier
BayerPattern	Bayer Array for Raw Output
FullResolution	Full-size resolution
TimeFactor	Sensor exposure time to line count formula
GainRange	Sensor Gain Register Conversion Equation
CISTimeRegSumFac	Sensor exposure time row sum limit
CISTimeRegOdevity	Sensor exposure time row parity
CISAgainRange	Sensor analog gain / LCG support range, the minimum value shall not be lower than 1; when the sensor supports dual conversion gain, this item indicates the LCG range supported by the sensor; if encountered when the digital gain is used to complement the accuracy, this item can indicate the total gain range of the sensor.
CISExtraAgainRange	Sensor analog gain (HCG) range, the minimum value shall not be lower than 1; when the sensor support dual conversion gain, this item indicates the HCG range supported by the sensor; Range range generally = CISAgainRange * dcg_ratio; when the sensor does not support dual When the sensor does not support dual conversion gain, the maximum and minimum values of this item can both be filled with 1.
CISDgainRange	Sensor supported digital gain range, the minimum value must not be lower than 1, if the digital gain is used to complement the accuracy, the maximum and minimum value of this item can be filled with 1.
CISIspDgainRange	ISP digital gain range, minimum value must not be less than 1

3.5 Capture **Raw** images with **Capture Tool**

1. Click "Tools" - "RK Capture Tool" button in the menu bar to open the capture tool;

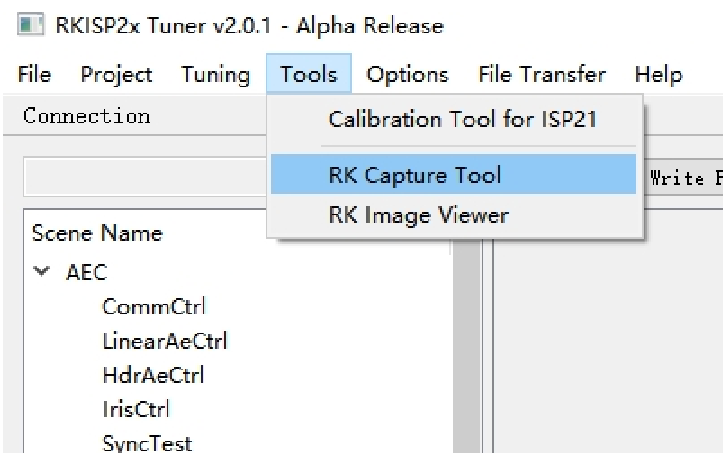


Figure 3-4-1

2. Confirm that the IP address of the device is filled in correctly, click the "Device Status" button, if Tuner

and rkaiq_tool_server are connected normally, it will display "Device is Ready".

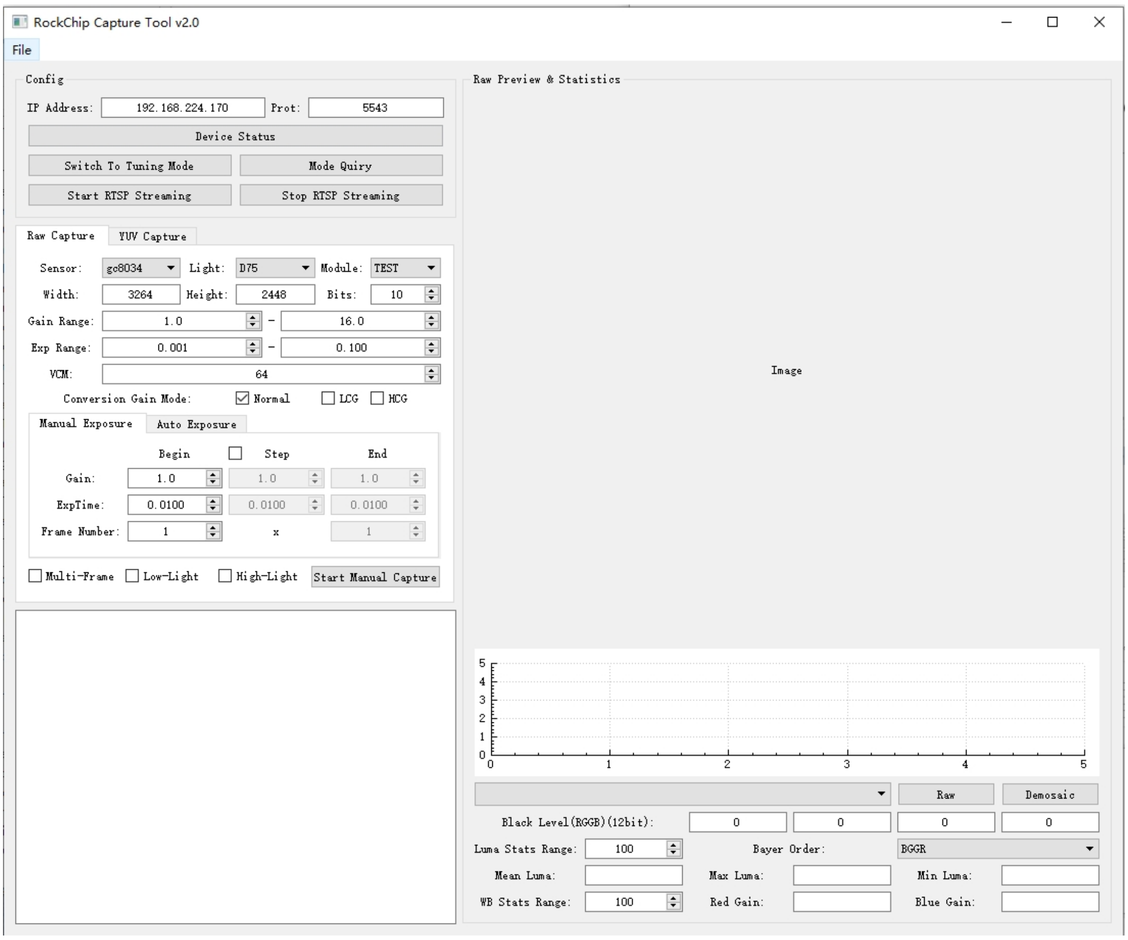


Figure 3-4-2

3. After clicking Start RTSP Streaming, you can use the third-party playback tool to open rtsp://192.168.224.170:1234/v (specific IP to the actual debugging equipment shall prevail) to view the preview screen, at this time, the camera application on the device will be disconnected, such as the need to continue to use the camera, you need to first click Stop RTSP If you want to continue to use the camera, you need to click Stop RTSP Streaming, and then click Switch To Tuning Mode before you can open the camera application;
4. The user should select the Sensor in the Sensor drop-down box that needs to be Tuned for the project;

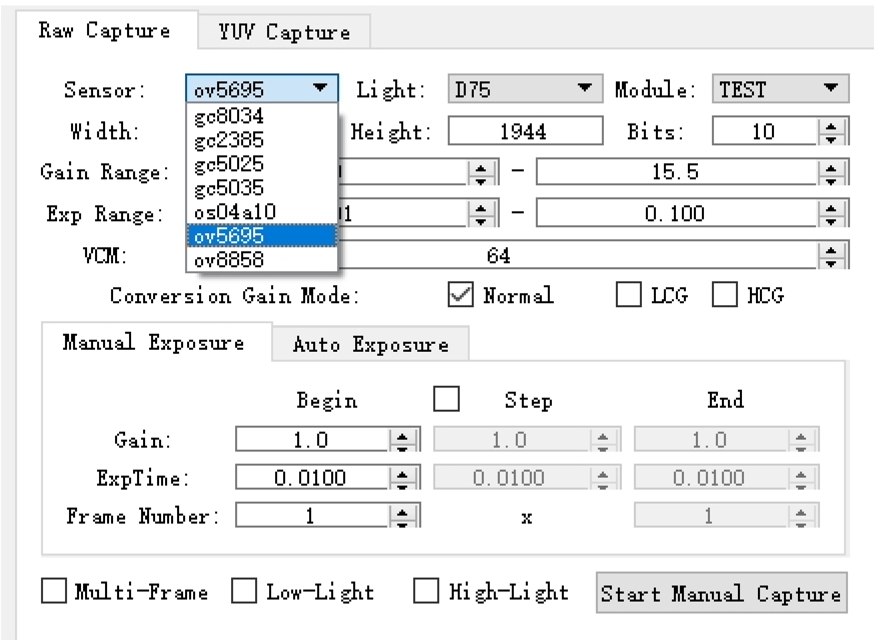


Figure 3-4-3

3. Select the correct resolution, light source, and module name for easy differentiation for subsequent use;
4. Configure parameters such as gain, exposure time, and number of shots;
5. Tap Start Manual Capture button, at this time the camera application on the device will be

disconnected, if you need to continue to use the camera, you need to tap Switch To Tuning Mode before you can open the camera application;

6. The captured raw image is displayed in the Raw Preview & Statistics screen on the right;
7. Below shows the histogram information corresponding to that raw map, maximum/minimum/mean brightness, global white balance gain, etc;
8. Raw images are stored by default in . /raw_capture/module_name/;

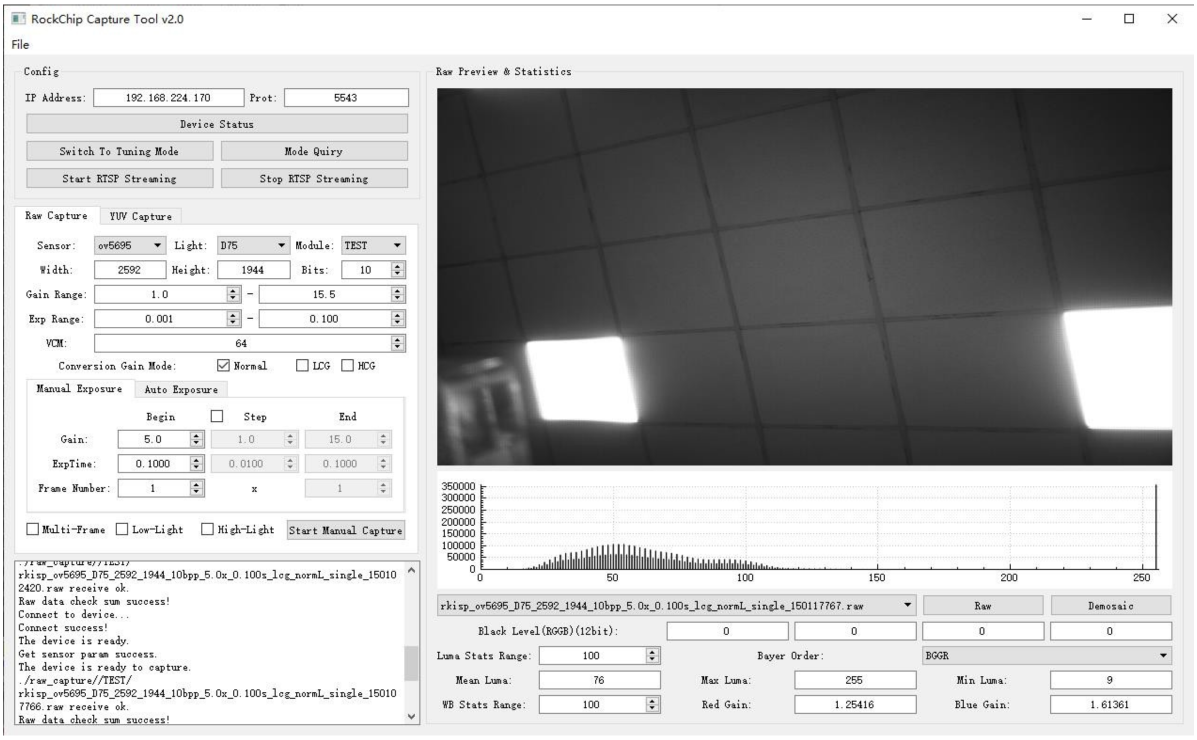


Figure 3-4-4 Shooting Gain=5x ExpTime=0.1s single frame Raw plot

4 Calibration process description

The calibration of the modules can be divided into three main parts:

Shooting calibration maps: Shooting raw maps of calibration boards or scenes with appropriate exposures according to the needs of each module;

Calculate the calibration parameters: import the raw diagram, calculate the calibration parameters, individual modules can fine-tune some parameters as needed; confirm the effect and save the parameters: according to the standards of each module, judge whether the calibration parameters are correct;

4.1 Shooting RAW

Just refer to the procedure in subsection 3.5.

4.2 BLC Calibration

4.2.1 Basic Principles of BLC Calibration

The presence of dark current in the Sensor circuit results in a certain output voltage in the pixel unit even when there is no light shining on the pixel unit, resulting in the digital signal output from the A/D not being 0. The dark current is mainly affected by the gain and the temperature, and therefore needs to be calibrated separately at different ISOs. Since BLC is an offset, all other modules need to deduct this offset when calibrating, otherwise the correct calibration parameters cannot be obtained.

4.2.2 BLC Calibration Raw Chart Shooting Requirements

1. Black out the lens when shooting to make sure no light is getting in;
2. Shooting requires traversing Gain=1x, 2x, 4x, 8x, 16x.... ...Max (Max=32 if the driver supports a maximum

Gain up to 40x);

3. The exposure time does not affect the BLC calibration and can be harmonized to 10ms;

4.2.3 BLC Calibration Raw Chart Shooting Method

1. Open the RK Capture Tool, refer to the instructions in subsections 3.1 and 3.2, connect the device, select UNKNOW (no light) for the light source name, and select BLC for the module name;
2. Place the device or module in a light-free environment and cover the lens tightly with a black cloth, lens cap, etc;
3. Configure Gain=1.0 ExpTime=0.010 Frame Number=1 in the Manual Exposure page;
4. Click Start Manual Capture to take a Raw image;
5. The captured raw image will be displayed on the right side, make sure the raw image is basically normal and take the next one;
6. Adjust the Gain value, Gain = 2, and repeat steps c, d, and e until the traversal is complete;

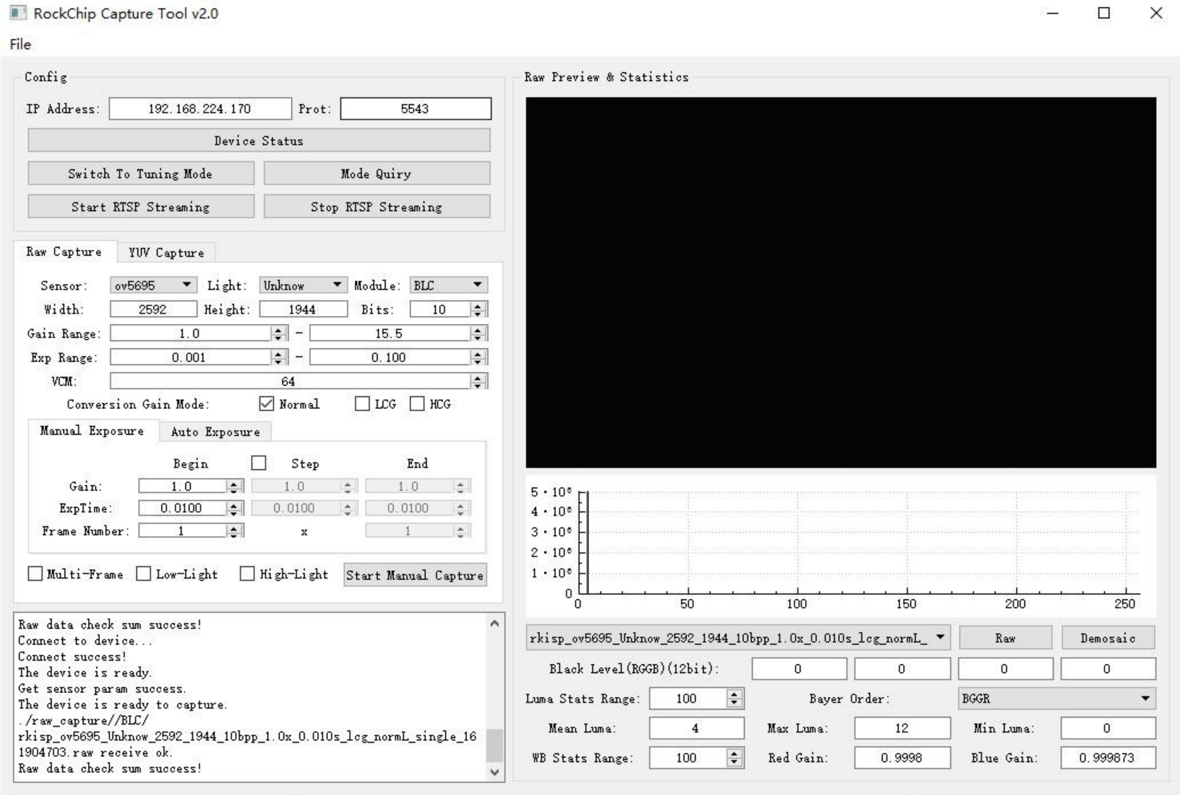


Figure 4-2-3-1

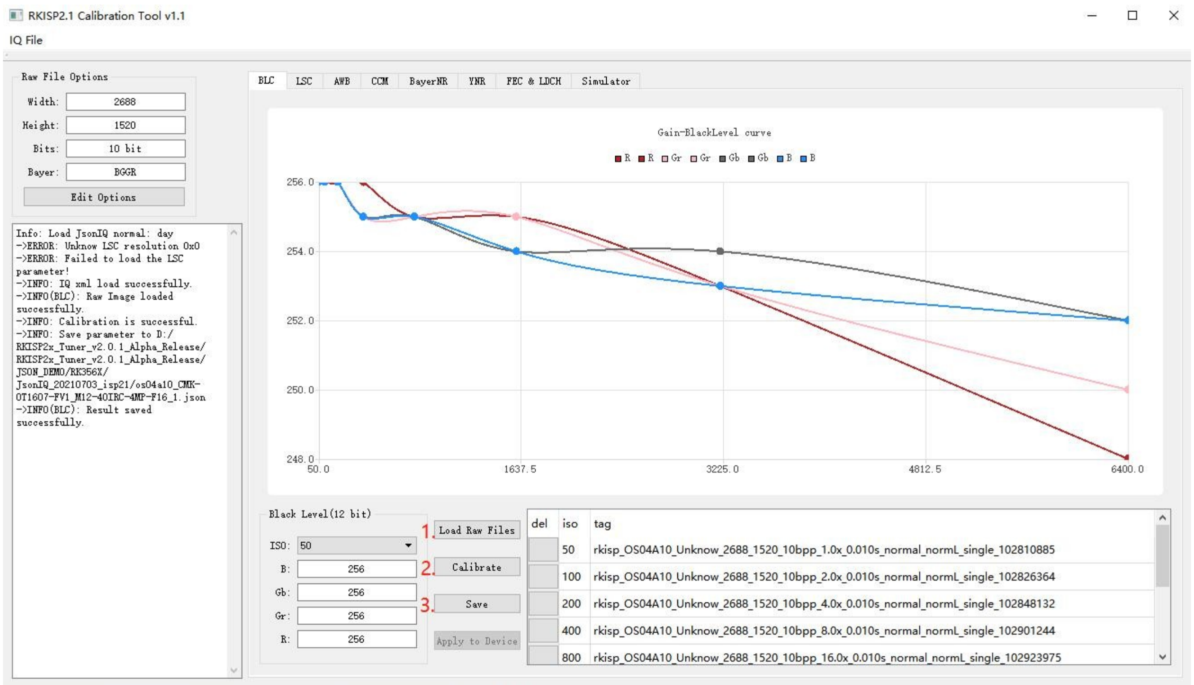


Figure 4-2-4-1 BLC

Calibration Results

Calibration method:

1. Open Calibration Tool, click Edit Options button on the upper left corner of the interface to open the configuration interface, enter the size, bit width and bayer order of the raw image;
2. Select the BLC tab and click the Load Raw Files button at the bottom to select the folder where the Raw image is stored;
3. Imported Raw images are displayed in the list on the right;
4. Click the Calibrate button to start the calibration calculation;
5. The curve of the dark current value of each channel obtained from the calibration as a function of ISO is displayed in the upper axis;
6. Click Save to save the parameters;

Caveats:

1. If the unit itself has indicators such as power lights, status, etc., you should be aware of any light leakage;
2. An incorrect BLC value will affect the calibration results of all subsequent modules, be sure to ensure that this BLC result is correct before proceeding with the calibration of subsequent modules;

4.3 LSC Calibration

4.3.1 LSC Calibration Basics

Lens Shading is generally known as the dark corner or vignetting effect, and can be subdivided into Luma Shading (brightness uniformity) and Color Shading (color uniformity).

Luma Shading is caused by the optical properties of the lens. For the entire lens, think of it as a convex lens. Since the light gathering capacity of the center of the convex lens is much larger than that of its edges, the intensity of light in the center of the Sensor is greater than that around it. This phenomenon is also called edge light attenuation. For a camera without aberrations, the illuminance attenuation around the image follows

$$cos^4\theta$$

The decay law of the

The cause of color shading is a bit more complicated. Different types of IR-cut filters have different transmittance rates, and when the angle of incidence θ changes, the transmittance rates of different bands also change, so the phenomenon of color inconsistency between the center and the surroundings occurs. On the other hand, the mismatch between the CRA (angle of incidence of the main light) of the Micro Lens and the CRA of the lens can also lead to the phenomenon of color shading.

4.3.2 LSC Calibration Raw Chart Shooting Requirements

1. Cover the lens with a hair glass or light-equalizing film (or use equipment such as a DNP light box or integrating sphere) when shooting;
2. Shooting in a light box with standard light sources requires shooting 7 light sources: HZ, A, CWF, TL84, D50, D65, D75;
3. To prevent the AC light source from generating Flicker, it is recommended to configure the exposure time using an integer multiple of 10ms;
4. The maximum brightness of the Raw plot is around 200 (8bit) and the minimum brightness should be significantly greater than the black level value calibrated in the previous section;
5. We recommend the use of a light equalizer as shown below;

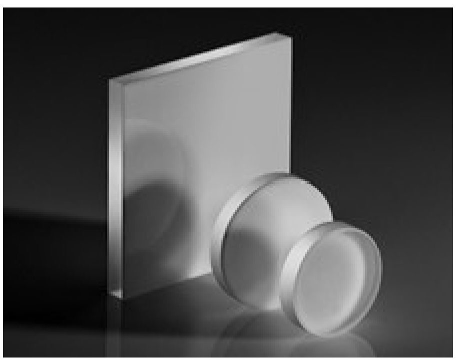


Figure 4-3-2-1 Opal Diffuser

4.3.3 LSC Calibration Raw Chart Shooting Method

1. Open the RK Capture Tool and refer to the instructions in subsections 3.1 and 3.2 to connect the device, select LSC for the module name;
2. Place the module in the light box, switch to HZ light, and hold the light equalizer close to the lens;
3. Choose HZ for the light source name, check Search Exposure By Max Luma (8bit) in Auto Exposure page, check Anti- Flicker (50hz), and configure the maximum brightness of the target on the right side to be 200±10%, Frame Number = 1;
4. Click Start Auto Capture to take a Raw image, during which the tool automatically picks the appropriate exposure until the preset maximum brightness is met;
5. Switch the light source to A light, modify the light source name to A, and repeat step 4 until all light sources are captured;

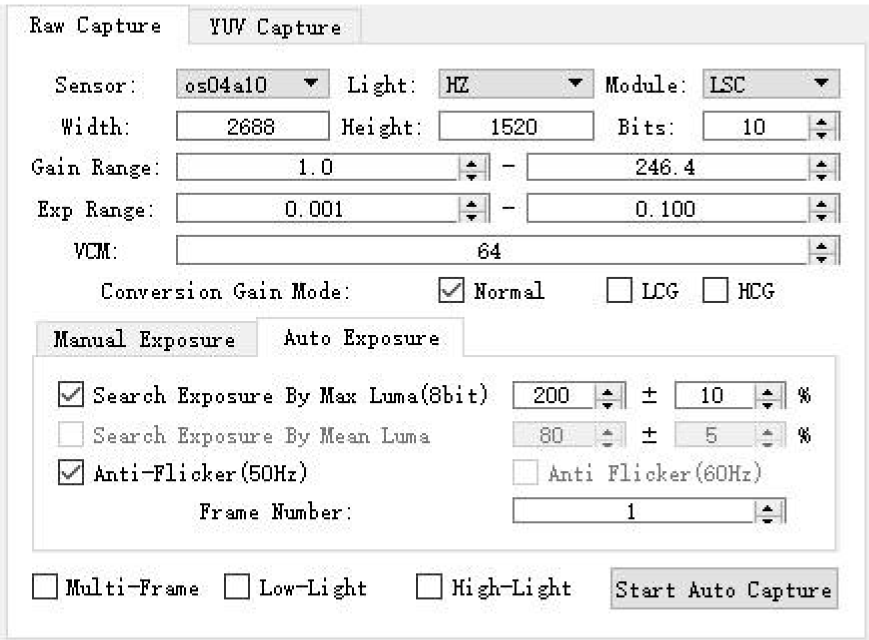


Figure 4-3-3-1

4.3.4 LSC Calibration Procedure

1. Open Calibration Tool, click the Edit Options button on the upper left corner of the interface to open the configuration interface, and enter the dimensions, bit width, and bayer order of the Raw plot;
2. Select the LSC tab and click the Load Raw Files button at the bottom to import all the raw drawings;
3. The imported Raw image is displayed in the window above, toggle the drop-down list to view the image for different light sources;
4. Modify Light Fall off to 100%;
5. Click the Calibrate button to start the calibration calculation;
6. After the calibration is completed, you can view the Raw image of each light source in the RESULT page after applying the calibration parameters;
7. Click Save to save the parameters;
8. Modify Light Fall off to 70% and repeat steps 5~7;

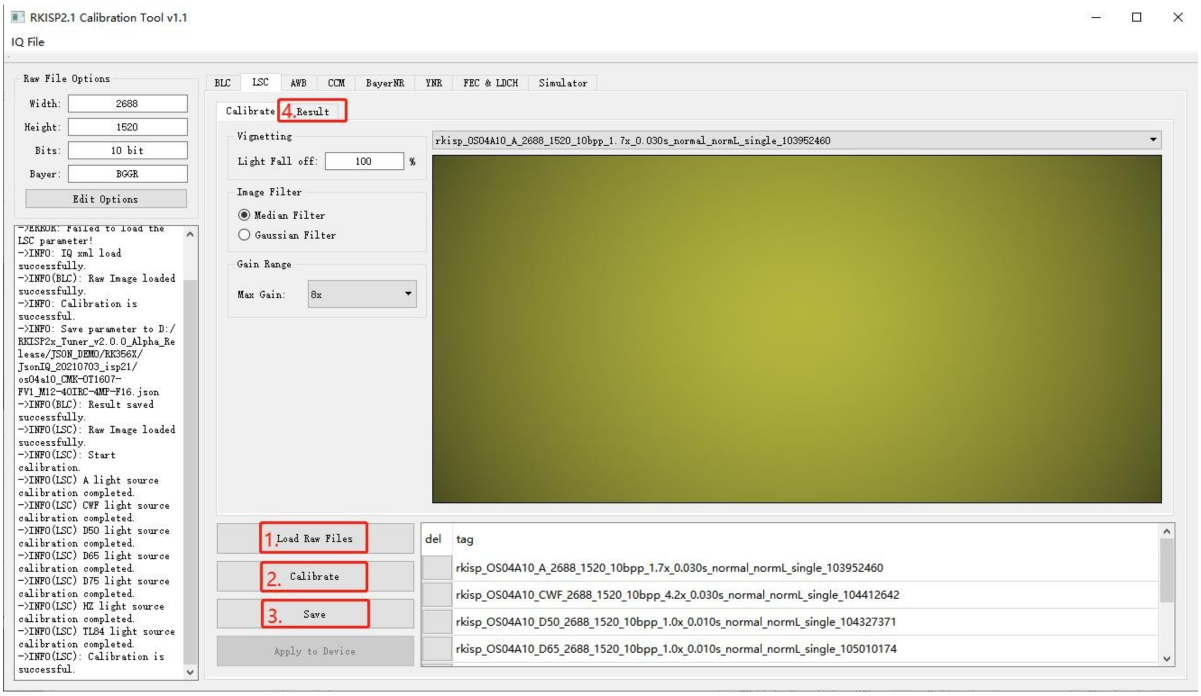


Figure 4-3-3-2

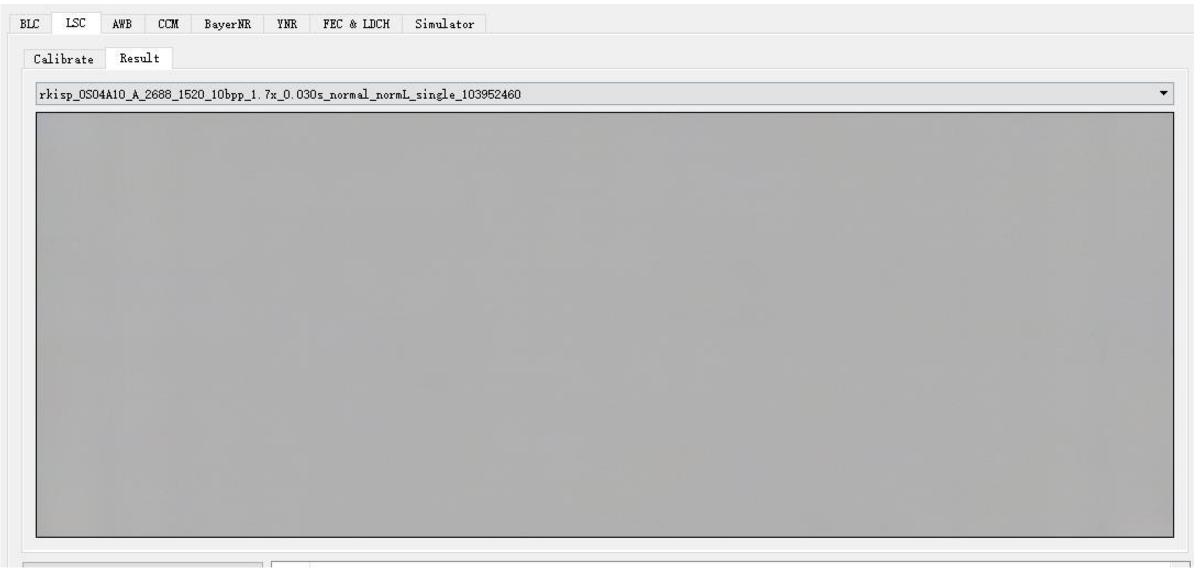


Figure 4-3-3-3

Caveats:

1. When shooting, there is a possibility that the ambient light is too bright or too dark, and you can't search for the right exposure parameters, so depending on the situation, you can refer to the solutions listed below:

   Adjust the

   brightness of

   the light source;

   use a scrim;

   adjust the lens

   orientation;

   Modify the range of Gain Range or Exp Range on

   the interface; adjust the maximum brightness or

   threshold for auto exposure;

   Switch to manual exposure (the minimum criterion for picking is a minimum brightness significantly greater than the black level value calibrated in the previous section);

4.4. AWB Calibration

4.4.1 AWB calibration content

The main purpose is to calibrate the white point conditions of Raw in XY, UV and YUV, the parameters of the simple color algorithm and the white balance gain under standard light sources.

4.4.2 AWB Calibration Raw Chart Shooting Steps and Requirements

The environment to be prepared for Raw map acquisition is as follows:

1. Equipment: x-rite 24 color card, light box (contains D75, D65, D50, TL84, CWF, A, HZ)
2. Adjust the exposure parameters so that the maximum value of the brightest white block in the color is [150-240], the brighter the better in this range (if you want to share the raw image with the CCM later, the image should be darker).
3. Color cards take up more than 1/9th of the screen

Raw diagram shooting method:

1. Open the RK Capture Tool, refer to subsection 3.1 and 3.2 for instructions, connect the device, and select CCM_AWB for the module name;
2. Place the equipment and the color card in the light box, adjust the position of the equipment and the color card, so that the color card is in the center of the screen, as far as possible to shoot larger, try not to move the equipment after adjustment;
3. Turn on the light box and switch the light source to HZ light;
4. Choose HZ for the light source name, check Search Exposure By Max Luma(8bit) in Auto Exposure page, check Anti-Flicker(50hz), the maximum brightness of the target on the right side is configured to be 200±10%, Frame Number = 1; (if under 1x Gain, 10ms integer times) (If you can't capture the raw image at 1x Gain, you can remove the Anti-Flicker(50hz) √)

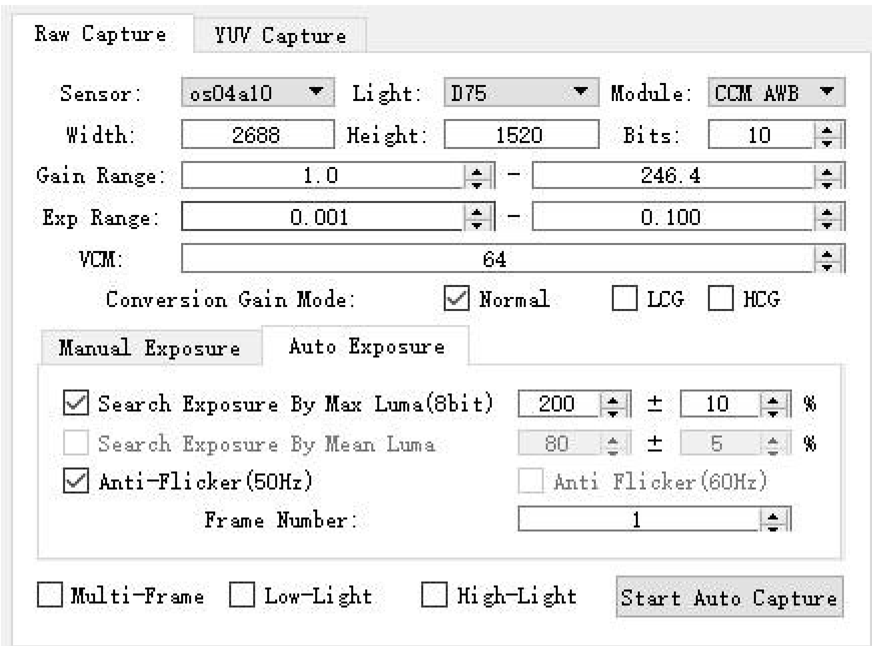


Figure 4-4-2-1

1. Click Start Auto Capture to take a Raw image, during which the tool automatically picks the appropriate exposure until the preset maximum brightness is met;
2. Switch the light source to light A, modify the light source name to A, and repeat step d until all light sources have been photographed;

Take x-rite 24 color card under A,CWF,D50,D65,D75,HZ,TL84 light source in turn, the schematic diagram after solving the mosaic is as follows:

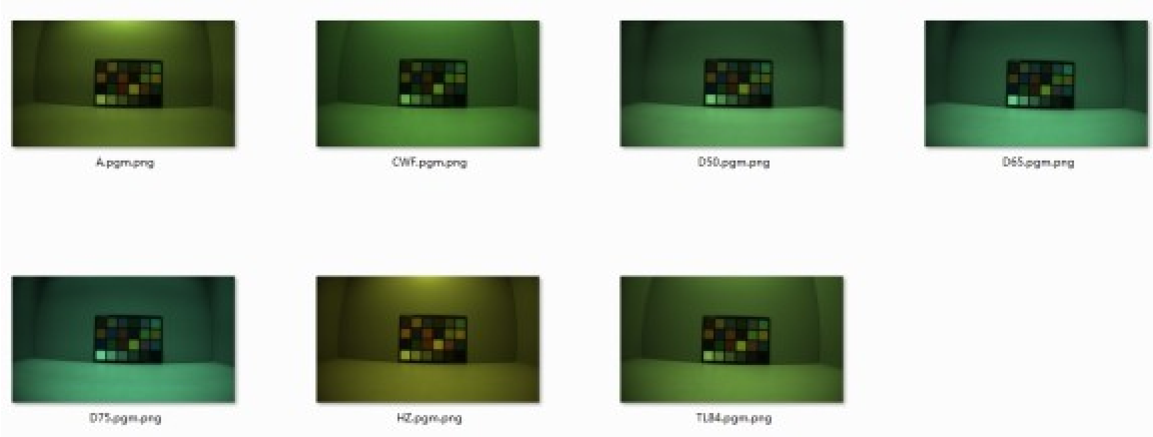


Figure 4-4-2-2

4.4.3 Description of the interface of the AWB calibration tool

1. The calibration is mainly to adjust the white point boundary in the UV and XY domains, and the TH value in the YUV domain.

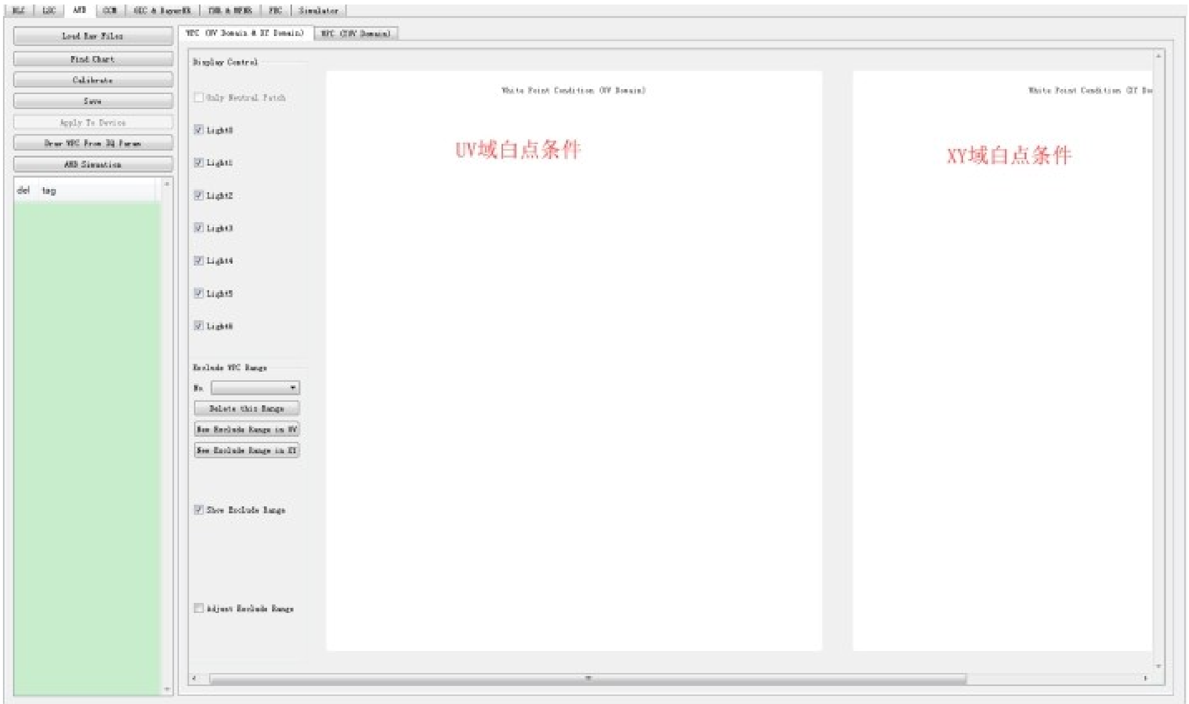


Figure 4-4-3-1

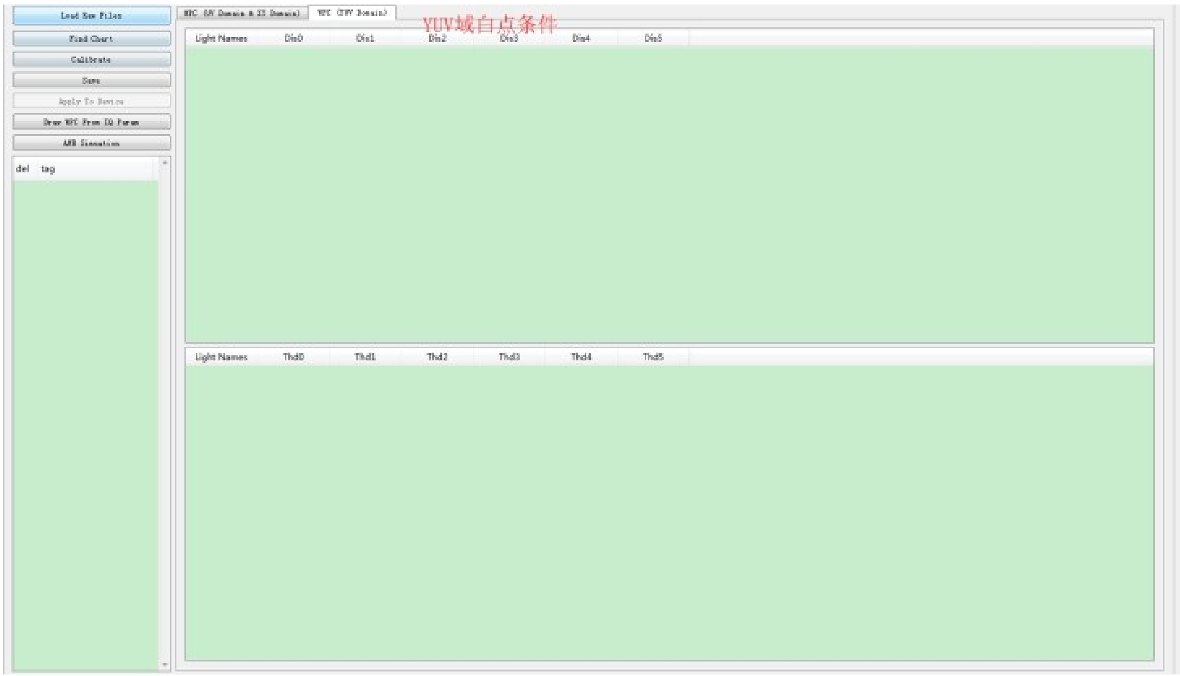


Figure 4-4-3-2

2. UV, XY field adjustment white point interval operation instructions
   a) Drag the corners of the white dot condition with the mouse in the coordinate system to adjust the position and the size of the white dot interval.
   b) Mouse dragging a blank area in the coordinate system allows you to drag the entire white point interval
   c) Use the scroll wheel to zoom in and out
3. The display of information about each light source can be selected by the checkbox in front of LightX in the Display Control panel.
4. The Exclude WPC Range panel can be used to add non-white point intervals and white point intervals for additional light sources.
5. AWB Simulaton is used for white point detection on raw maps and counting white point gain.

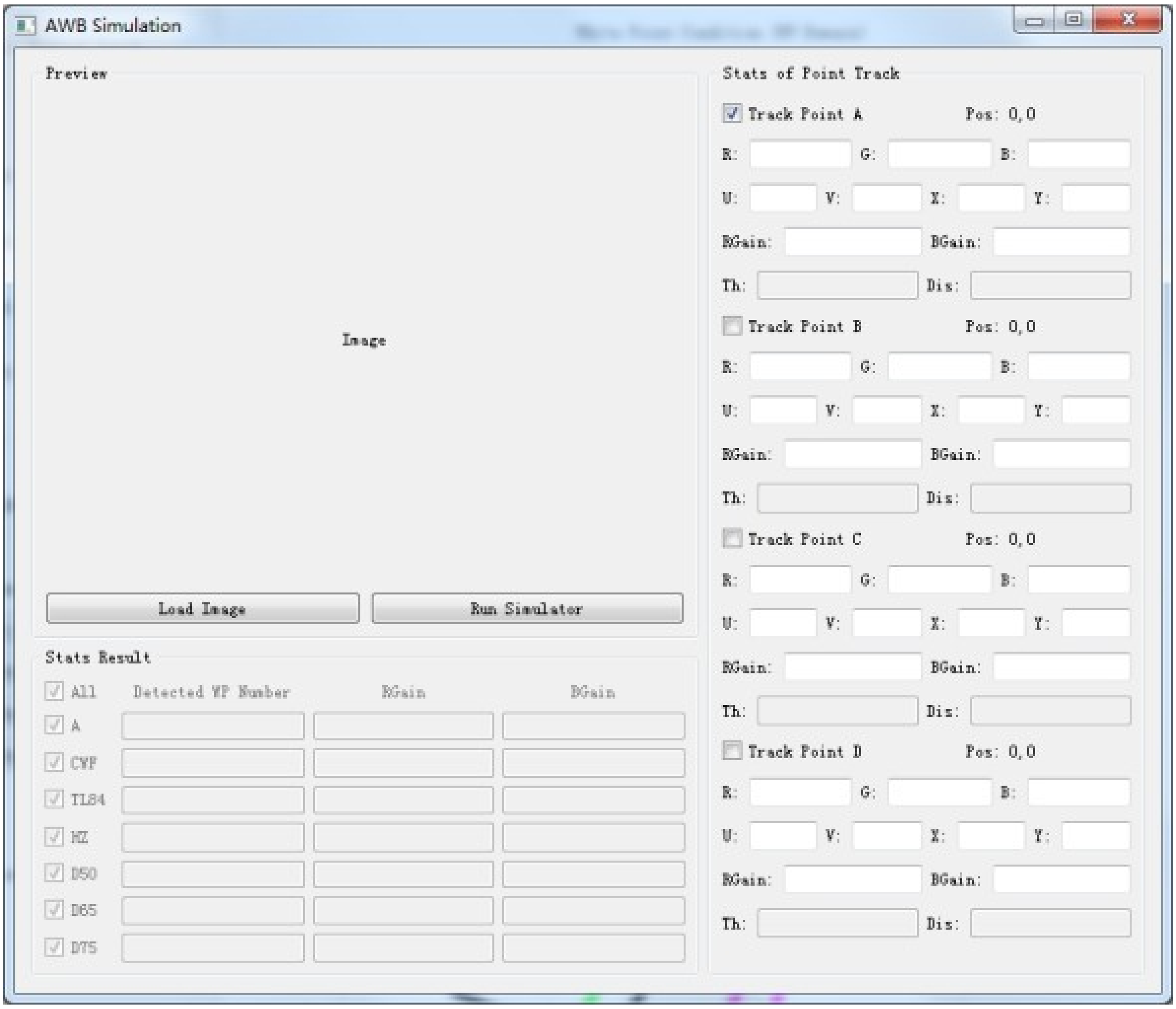

AWB Simulation
Preview
Image
Load Image
Run Simulator
Stats Result
All
Detected WP Number
RGain
BGain
A
CWF
TL84
HZ
D50
D65
D75
Stats of Point Track
Track Point A
Pos: 0,0
R:
G:
B:
U:
V:
X:
Y:
RGain:
BGain:
Th:
Dis:
Track Point B
Track Point C
Track Point D

Figure 4-4-3-3

a) `LoadImage` After importing `the Raw` image, as shown below, the white point information will be printed. The white point of different light sources is shown in different colors. The white point number of the center, large and small boxes, `RGain` cumulative and `BGain` cumulative and will be displayed in the `Detected WP Number`, `RGain` and `BGain` text boxes.

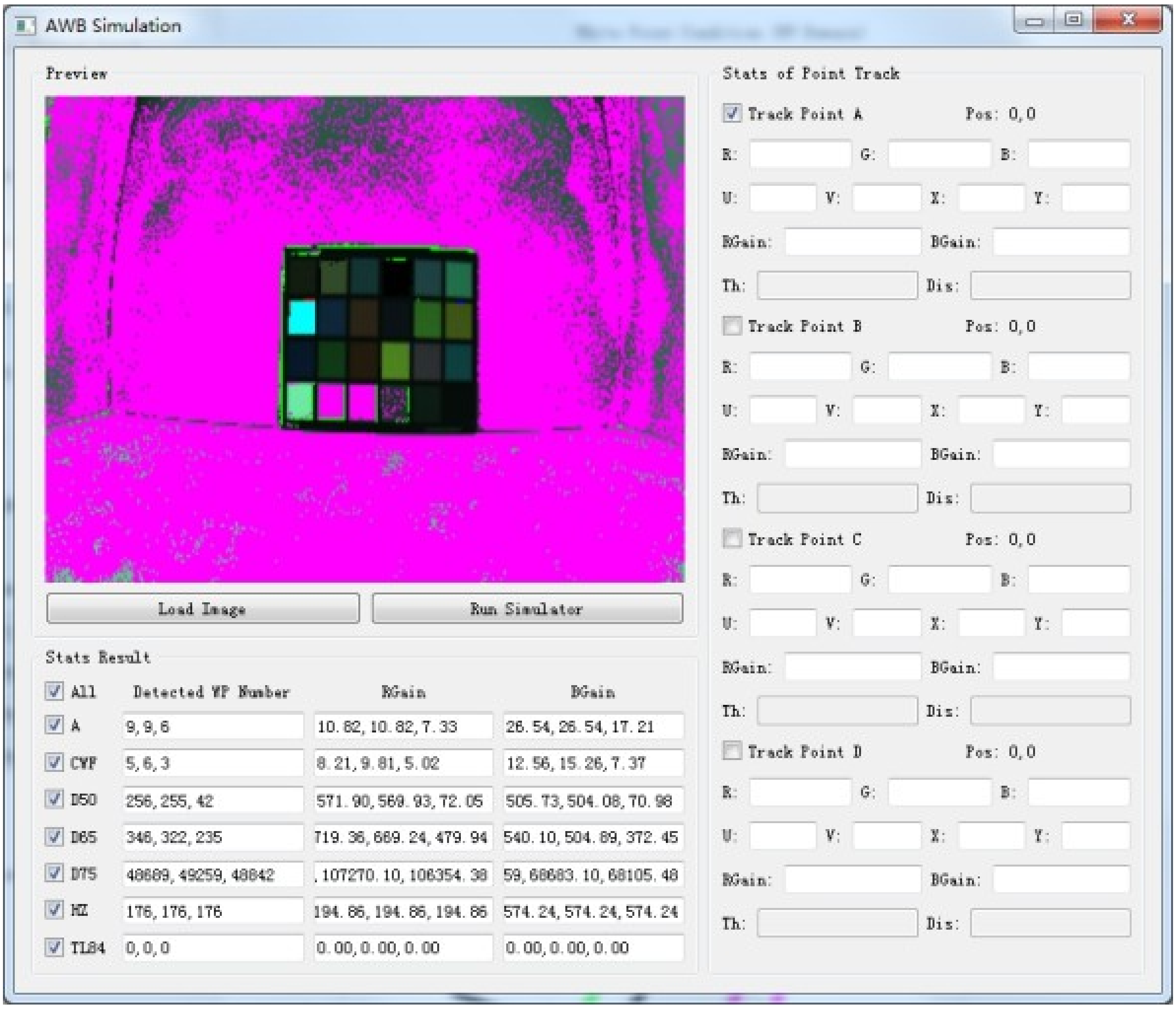


Figure 4-4-3-4

b) Click anywhere in the image, it will be mapped to the `UV` domain white point condition interface and `XY` domain condition interface, marked with a black square dot, so that it is easy to check whether the point falls within the white point interval, and the `R G B U V X Y RGain BGain Dis Th of` the point will be displayed in the `Stats of Point Track` panel of the interface.

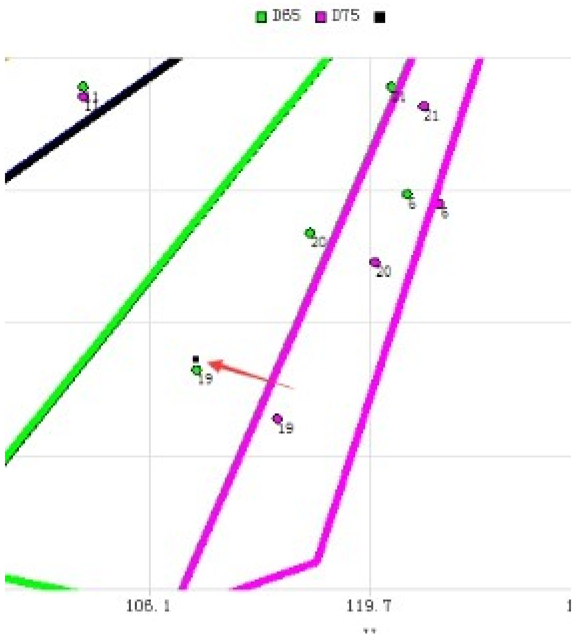


Figure 4-4-3-5

4.4.4 AWB Calibration Procedure

1. Open Calibration Tool, click the Edit Options button on the upper left corner of the interface to open the configuration interface, and enter the dimensions, bit width, and bayer order of the Raw plot;
2. AWB calibration to be completed for BLC and LSC
3. Click Load Raw Files to import the raw maps under A, CWF, D50, D65, D75, HZ, TL84 (recommended to calibrate the raw maps of these seven light sources).
4. Click Find Chart to identify the color swatches

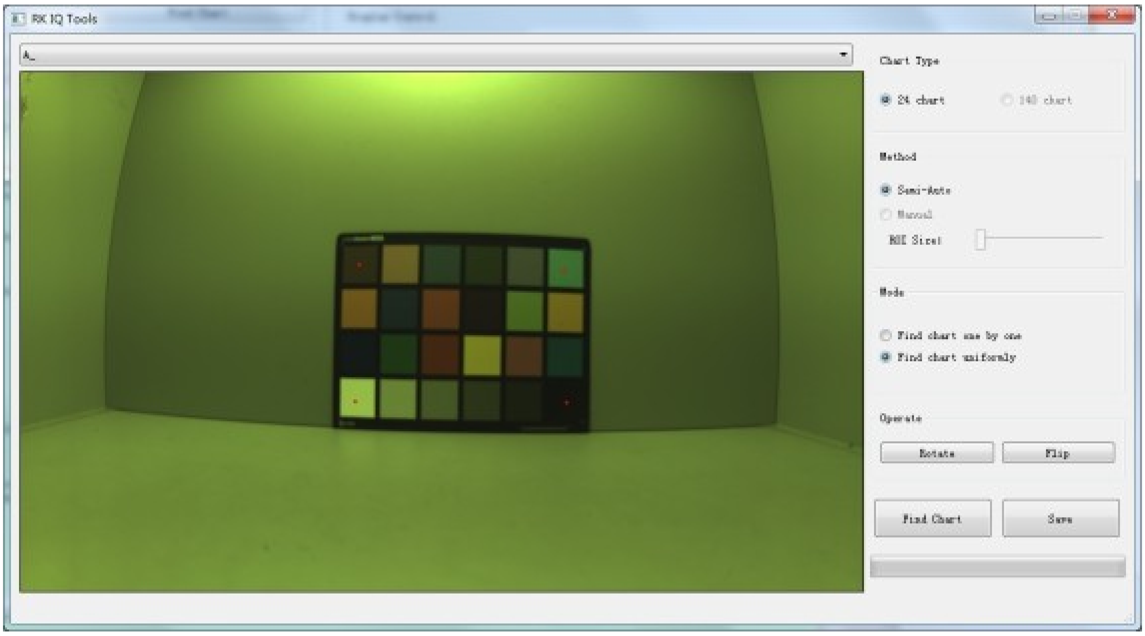


Figure 4-4-4-1

a) Click on block `1`, block `6`, block `19`, block `20`, in that order.
b) Clicking `FindChart` will batch identify the color swatches of all light sources as follows (showing the white point detection result of the last light source)

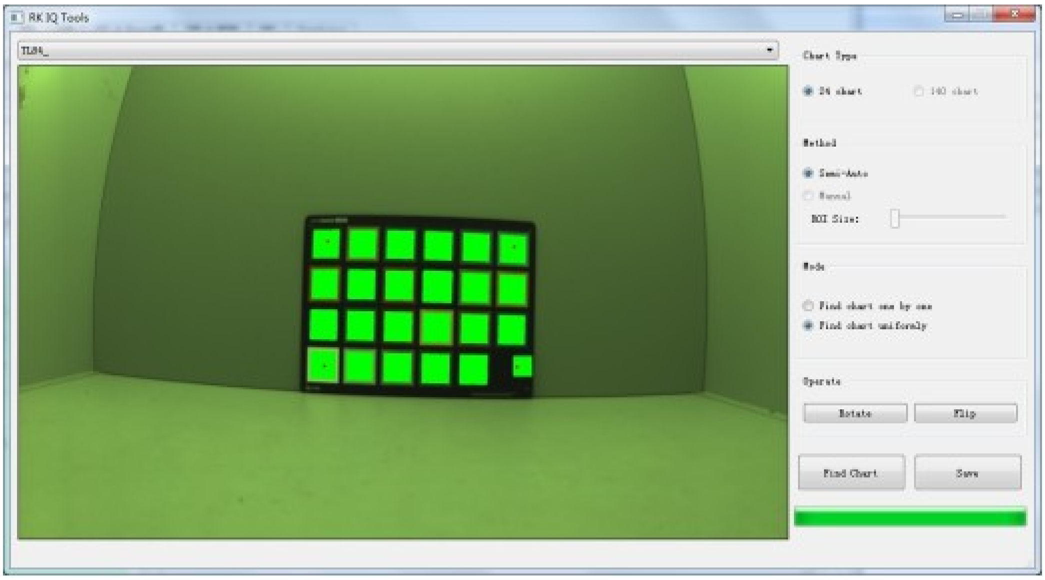


Figure 4-4-4-2

c) from the drop-down menu inside the selection of other light sources, to confirm the correctness of the identification of color blocks, found that only the last piece of `TL84` identification a little to the right, this time only need to re-test can be solid `Mode` inside the selection of `Find chart one by one` Repeat step 12, until the color of the `TL84` color card color block identification is correct, as follows

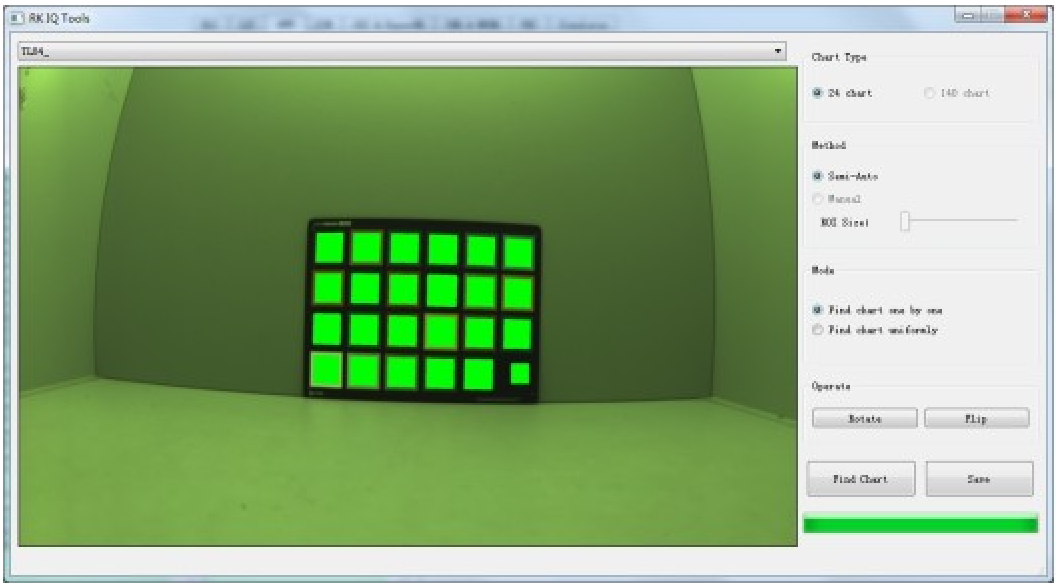


Figure 4-4-4-3

d) Click `Save` to complete the identification

5. Click Calibrate to start the calibration calculation, the module takes a long time, about 30s; to get the following initial white point conditions and other parameters; UV domain, XY domain coordinate system of different colors of the dots on behalf of each light source photographed in the color card color block in the UV, XY color space location; quadrilateral box on behalf of the different light sources of the white point conditions;

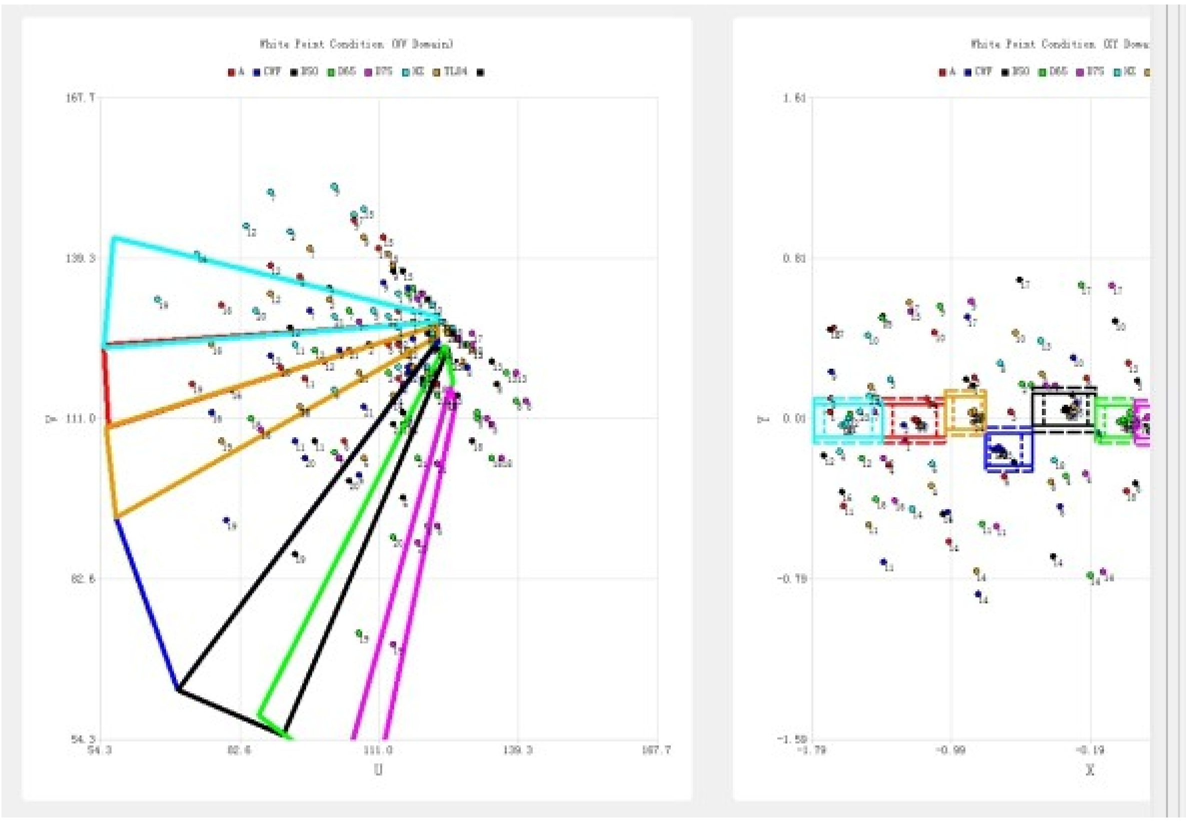


Figure 4-4-4-4

WPC (UV Domain & XY Domain) | WPC (YUV Domain)

	Light Names	Dis0	Dis1	Dis2	Dis3	Dis4	Dis5
1	A	44	108	236	364	620	876
2	CWF	39	103	231	359	615	871
3	D50	30	94	158	414	542	798
4	D65	18	82	210	338	594	850
5	D75	7	71	199	327	583	839
6	HZ	50	114	242	370	626	882
7	TL84	38	102	166	294	550	806

	Light Names	Thd0	Thd1	Thd2	Thd3	Thd4	Thd5
1	A	11	14	17	20	23	26
2	CWF	11	14	17	20	23	26
3	D50	11	14	17	20	30	40
4	D65	11	14	17	20	23	26
5	D75	11	14	17	20	23	26
6	HZ	11	14	17	20	23	26
7	TL84	11	14	17	20	23	26

Figure 4-4-4-5

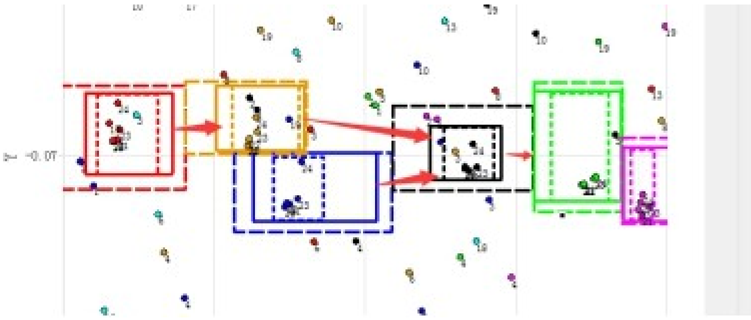
6. Click AWB Simulaton and import the raw plots under import A, CWF, D50, D65, D75, HZ, TL84 in order to check the accuracy of white point detection.
7. Modify the frame of UV field or XY field or TH of YUV to make the white point detection of color cards under each light source more accurate.
8. Click Save
9. Repeat steps 5 to 7 until the white point detection for each light source is reasonable.

Caveats:

Adjust the border as much as possible so that the white dots (dots labeled as blocks 19, 20, 21, and 22) are inside the box and the non-white dots are outside the box (generally not possible to do)

The intervals enclosed by the center frame or large frame of all light sources must

be tightly contiguous (the three line styles indicate three sizes of frames)Error



Demonstration (the intervals of the large frame are tightly contiguous, but there is

a spacing between the center frames, as shown by the arrows below):

Correct demonstration:

a and hz sources can be compact in the Y direction of the XY domain and relaxed in the

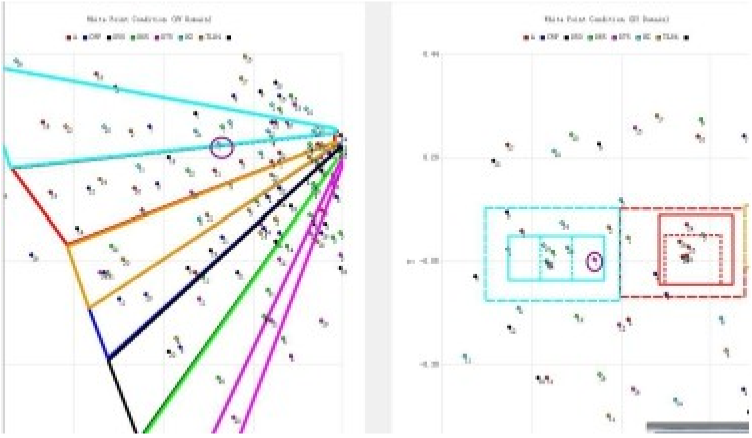
Y direction of the d50 d65 XY domain All sources must be tightly contiguous in the zones

enclosed by the UV domains

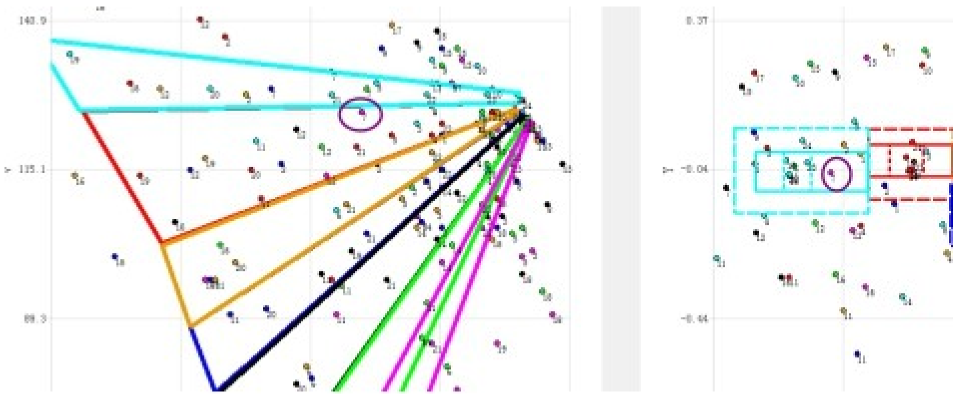
Boundaries of different light sources can overlap, but not both in XY and UV space at the same time.

Divide UV space with reference to XY space to exclude non-white spots

If the 7th block of the circled D75 light source falls within the hz range, it will be recognized as a white point



After realignment, block 7 of the D75 light source is not in the same light source in xy and uv space and will not be recognized as a white point



When a non-white point falls in the XY and UV white point intervals, it can also be excluded by turning down TH, or increasing the non-white point interval.

When the white point falls in the white point interval of XY and UV, but is still not a white point, it may be excluded because it exceeds the luminance range, or it falls in the non-white point interval or it does not fall in the white point interval of the YUV domain because it is smaller than the TH

4.4.5 Example of AWB calibration results

Final white point condition:

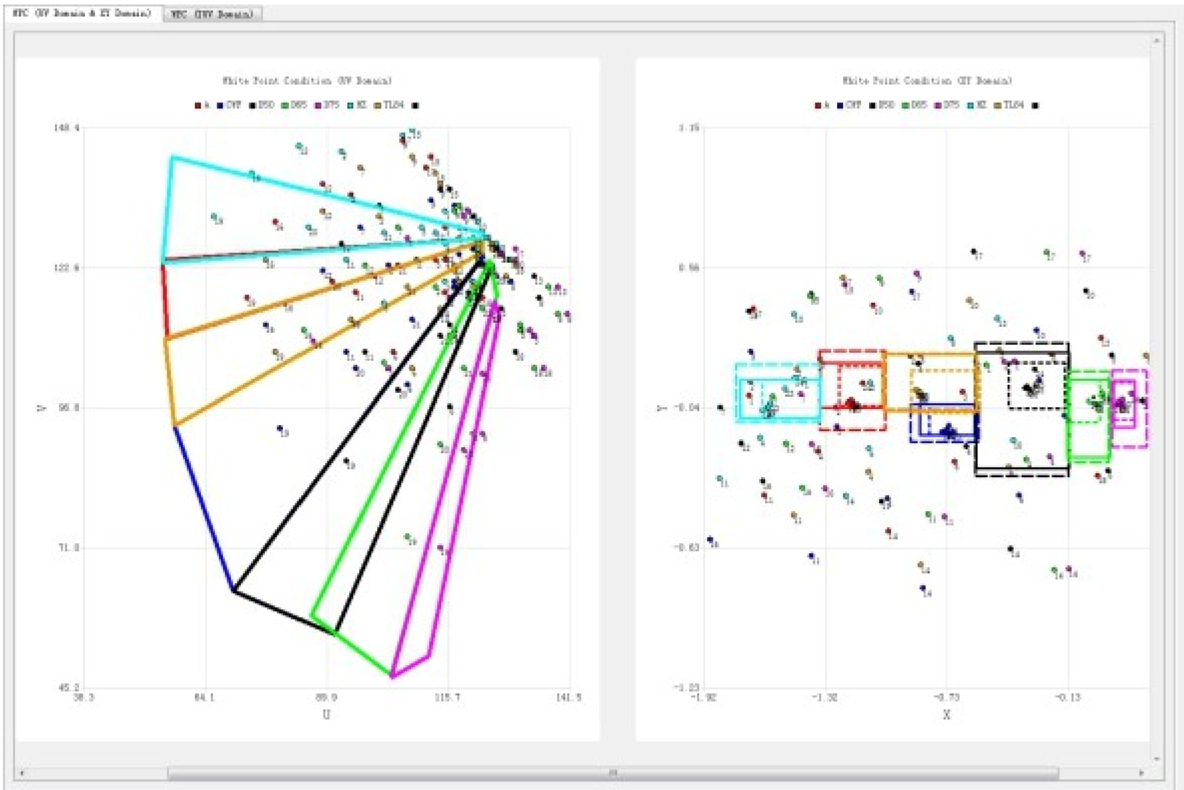


Figure 4-4-5-1

The white point test results for each light source are:

Figure 4-4-5-1 A

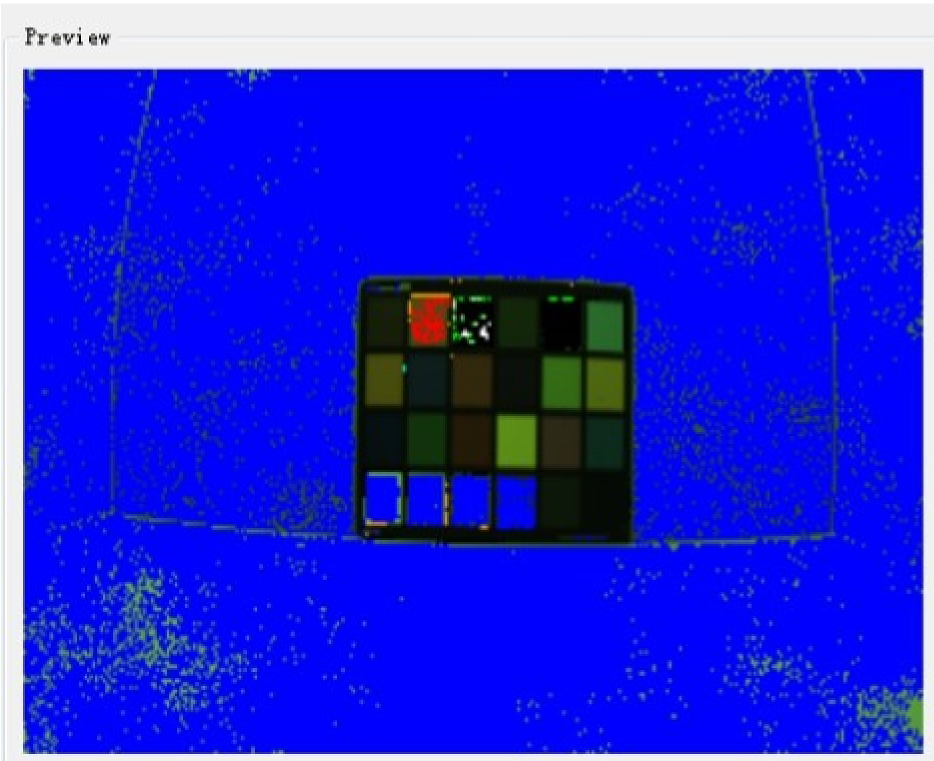


Figure 4-4-5-2 CWF

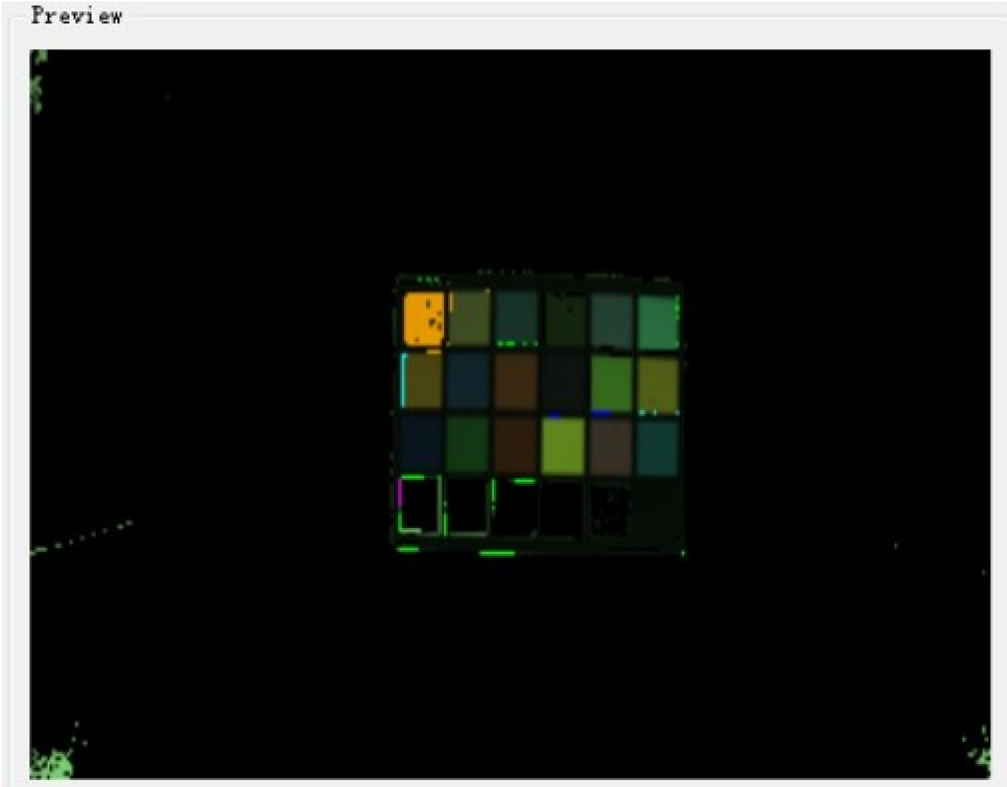


Figure 4-4-5-3 D50

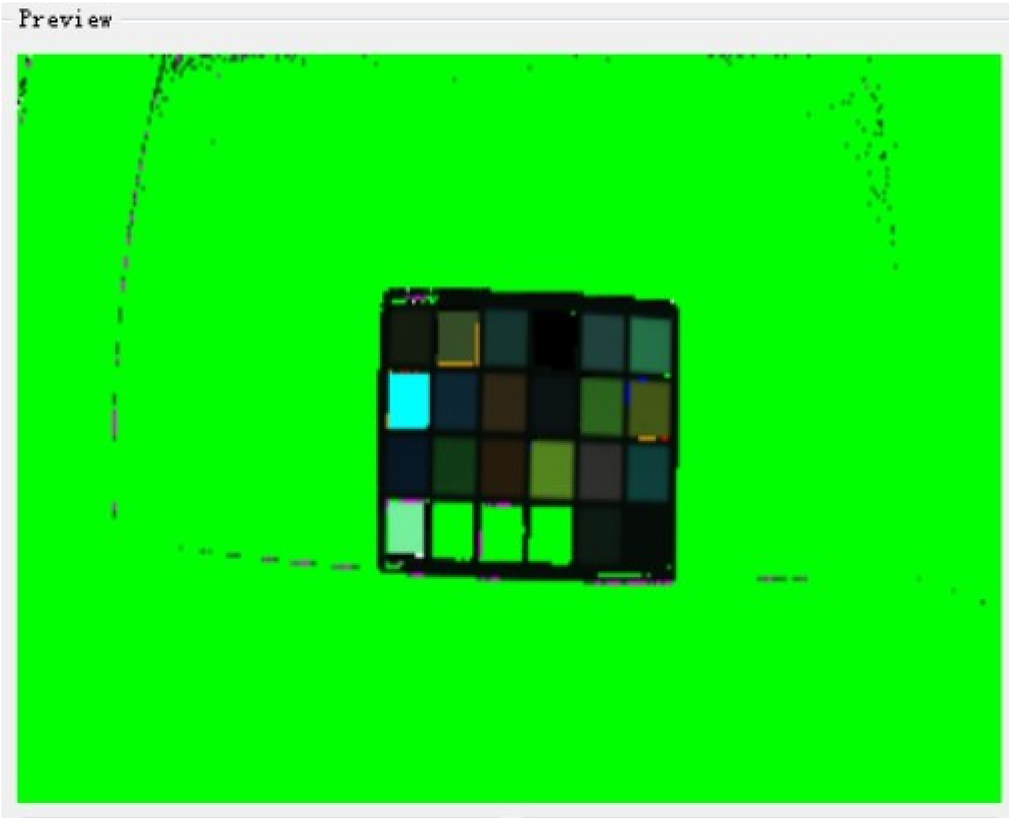


Figure 4-4-5-4 D65.

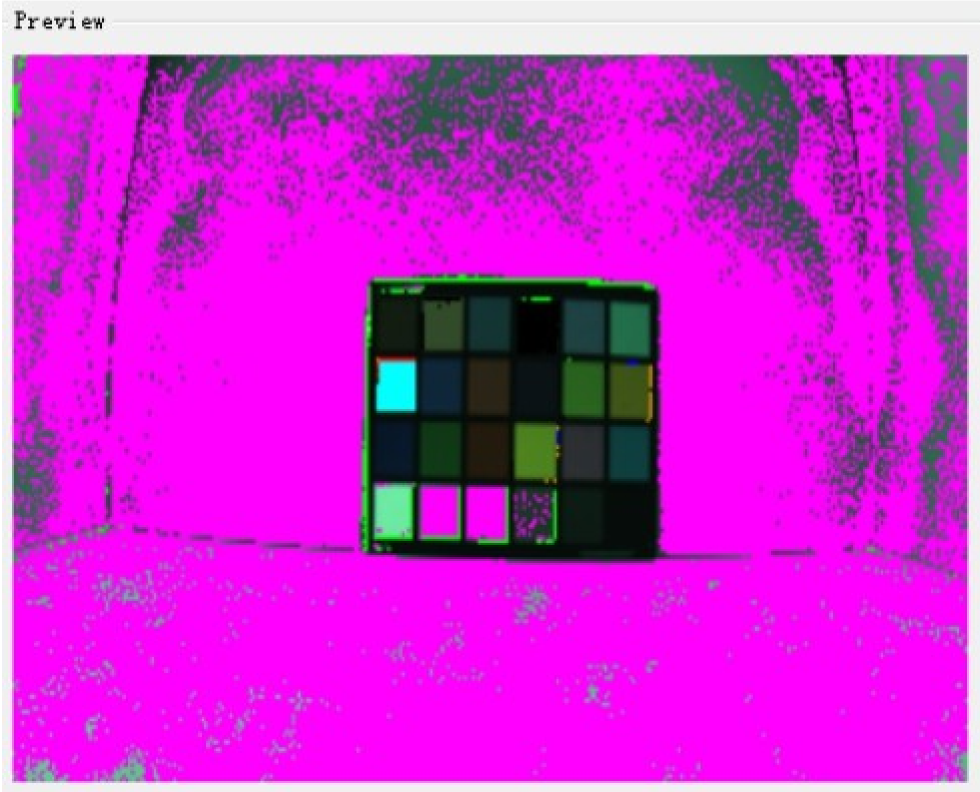


Figure 4-4-5-5 D75.

Figure 4-4-5-6 HZ

Figure 4-4-5-7 TL84.

4.5 CCM calibration

4.5.1 CCM Module Raw Image Capture Requirements

Refer to section 4.4 AWB module, in general CCM and AWB use the same set of Raw maps together, for the cases that need to be retaken due to the influence of the Gamma module, please refer to subsection 4.5.2, point 10;

4.5.2 CCM Calibration Procedure

1. Open Calibration Tool, select the CCM tab, and click the Load Raw Files button at the bottom to import all the Raw files. The imported Raw files will be displayed in the list below;

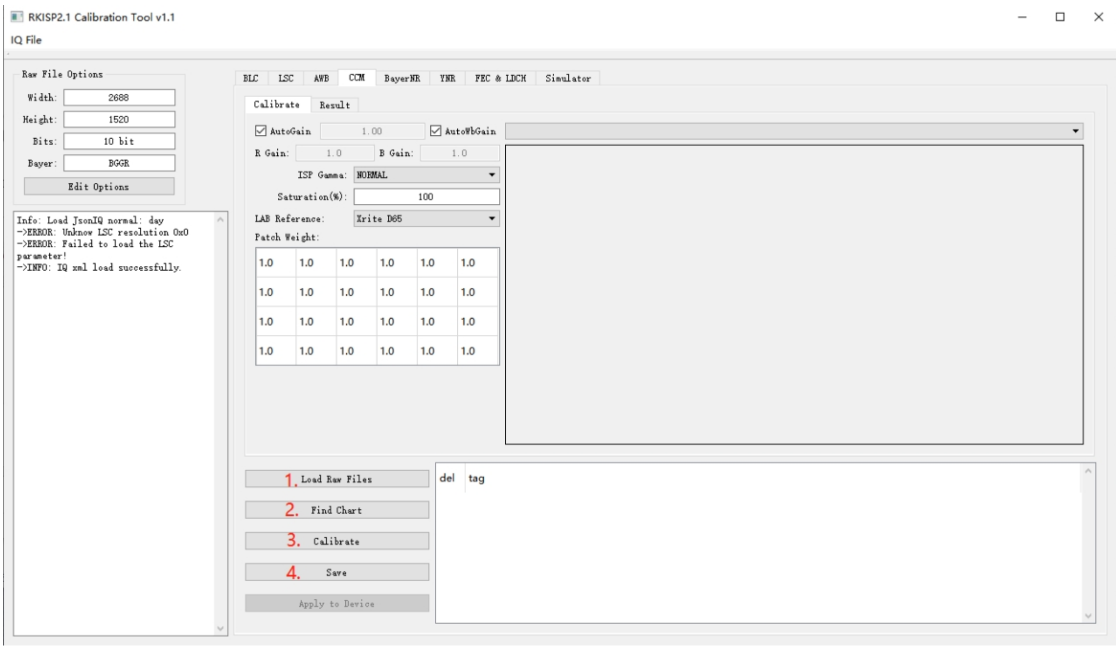


Figure 4-5-2-1

2. Click Find Chart to open the color block search interface;

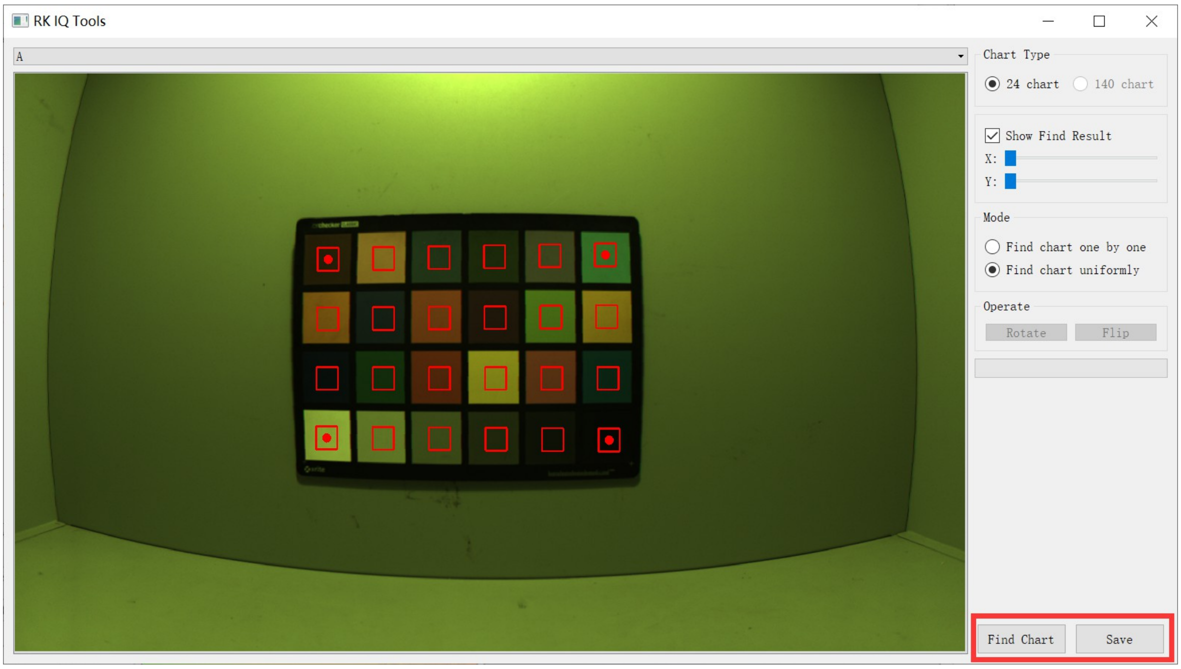


Figure 4-5-2-2

4. Adjust the sampling area by dragging the center dots of the red boxes in the upper left, upper right, lower left, and lower right, trying to ensure that the sampling area is in the center of each color block;
5. Click Find Chart to start counting the color block values and the statistic area will be marked green;
6. The user should check each light source in the drop-down list to check that the statistic areas are all correct;

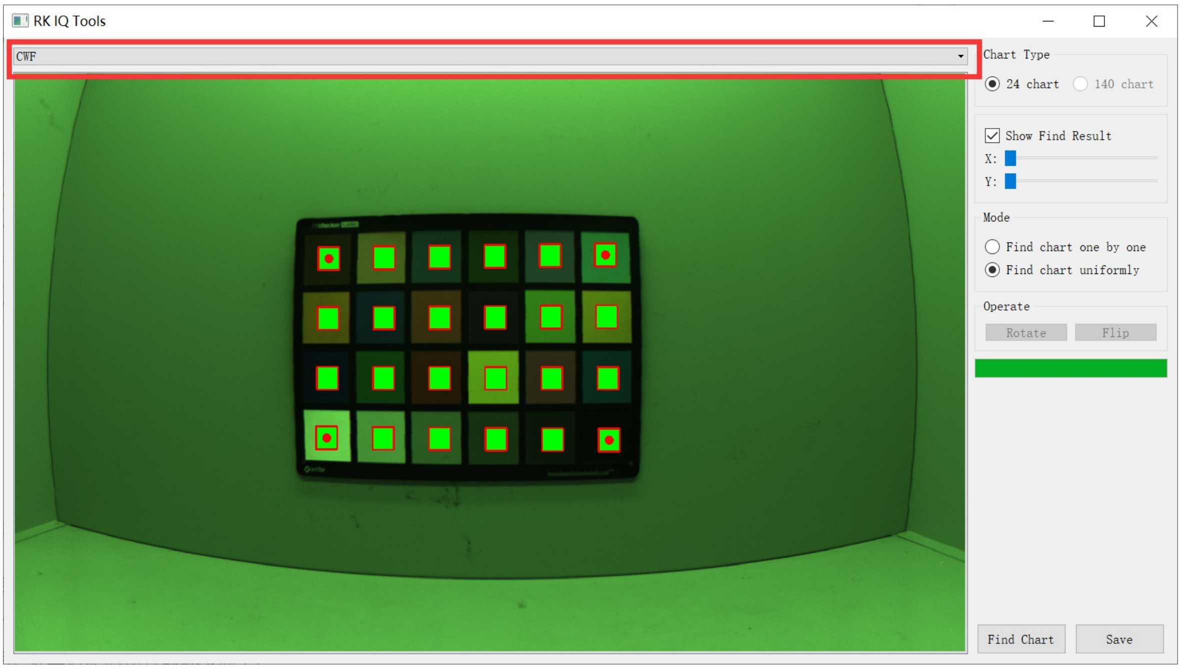


Figure 4-5-2-3

6. Click the Save button to save and exit when the search is complete;
7. Set Saturation to 100%, as shown in Figure 4-5-2-4;

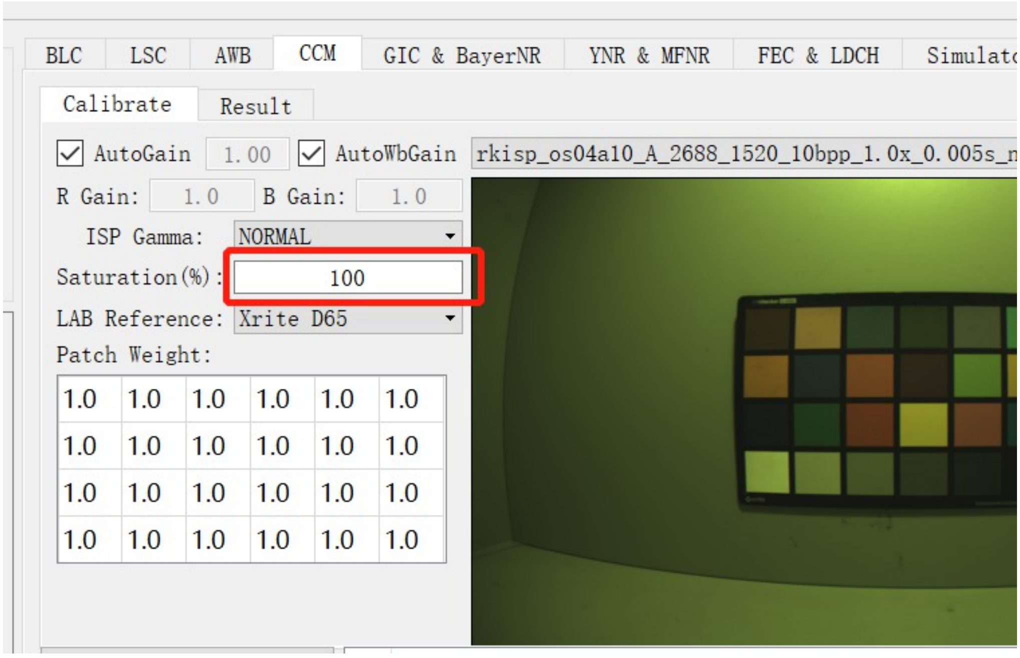


Figure 4-5-2-4

8. Click the Calibrate button to start the calibration calculation, this module takes a long time, about 20s;
9. After the calibration is complete, the calculation results are displayed in the RESULTS page;
10. Click the Save button to save the results;
11. Modify the saturation to 74% and repeat steps 8 to 10;

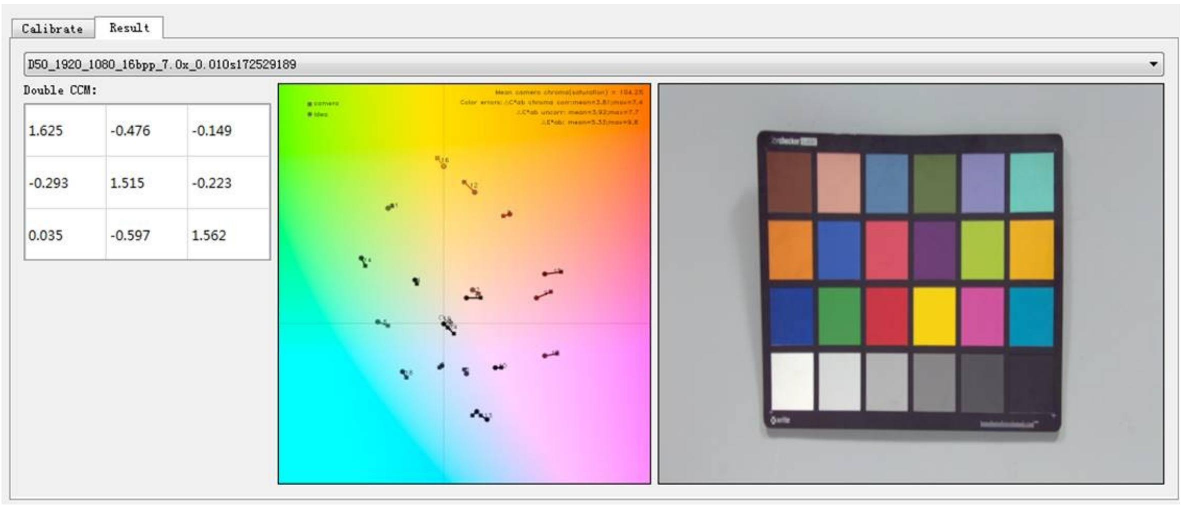


Figure 4-5-2-5

10. If ΔE exceeds the expected situation, it may be caused by the Raw map brightness is too high, you can right-click on the color card image on the right side in Figure 4-5-2-2, click Save Current to save the image and check whether each color block is overexposed or saturated in a certain channel (due to the Gamma curve that will be introduced during CCM calibration, it may lead to saturation of the calibrated color block);
    1. If there is indeed a problem with overbrightness or oversaturation, the color chart for that light source should be retaken, the exposure lowered, and a new calibration performed;
    2. If the brightness of the color blocks are more normal, the possible causes of the problem are: abnormal BLC parameters, abnormal LSC parameters, lens light leakage (infrared light), etc.; and
11. Please refer to Rockchip_Color_Optimization_Guide for specific debugging methods;

4.6 NR calibration

NR Module Raw Chart Shooting Requirements:

Shooting in a light box with a standard light source, a DC light

source with adjustable brightness is recommended; a gray scale

gradient card must be used, as in Figure 4-6-1;

Exposure requires traversing Gain=1x,2x,4x,8x,16x.... ...Max (Max=32 if the driver supports a maximum Gain up to 40x);

Under each Gain, you need to shoot four Raw images, which are Highlight-Stacked Frame, Highlight-Single Frame, Lowlight-Stacked Frame, and Lowlight-Single Frame; Highlight and Lowlight can be differentiated by adjusting the exposure time or ambient light brightness, while Stacked Frame and Single Frame are done automatically by the tool;

Low-light shooting requirements: brightest pixel brightness in the 120~140 range;

Requirements for highlight shots: at least one overexposed block within the 3x3 block centered on the brightest block in Figure 4-6-1; no overexposed blocks are permitted beyond that 3x3 block;

The value of the brightest pixel can be determined by the histogram or the Max Luma obtained from the statistics below, Max Luma=255 means that at least one point in the plot reaches the saturation value;

The HDR Sensor with DCG mode requires two sets of Raw images, LCG and HCG, to be taken separately;

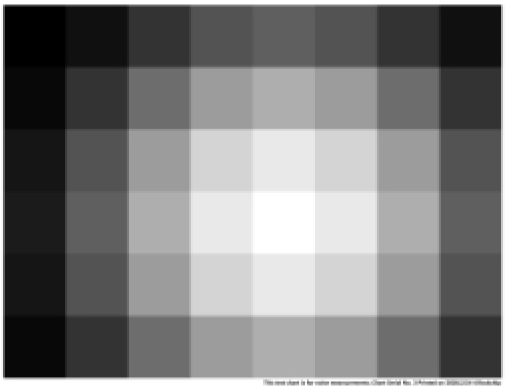


Figure 4-6-1

4.6.1 How to take a Raw image

1. Open the RK Capture Tool and refer to the instructions in subsections 3.1 and 3.2 to connect the device;
2. Place the device or module inside the light box and attach the gradient card to the back panel of the light box;
3. Adjust the position of the device so that the gradient card moves to the center of the frame and is shot as close as possible to be as large as possible;
4. Open the light box and switch the light source to TL84 or CWF;
5. Modify the name of the light source in the interface to TL84 or CWF and the module name to NR_Normal;
6. Assuming the sensor in the example supports Gain=1-24, you need to shoot 1x 2x 4x 8x 16x;
7. Shoot low light:

The light box brightness is adjusted to approximately `800lux`;

Change the value of `Gain Range` in the interface to `1.0 - 1.0`, `Exp Range` is not modified; check `Multi-Frame` and `Low-Light`;

Select the `Auto Exposure` page, check `Search Exposure By Max Luma`, and set the value to `165±10%`.

Turn off `Anti-Flicker (50hz)`;

set `Frame Number=32`;

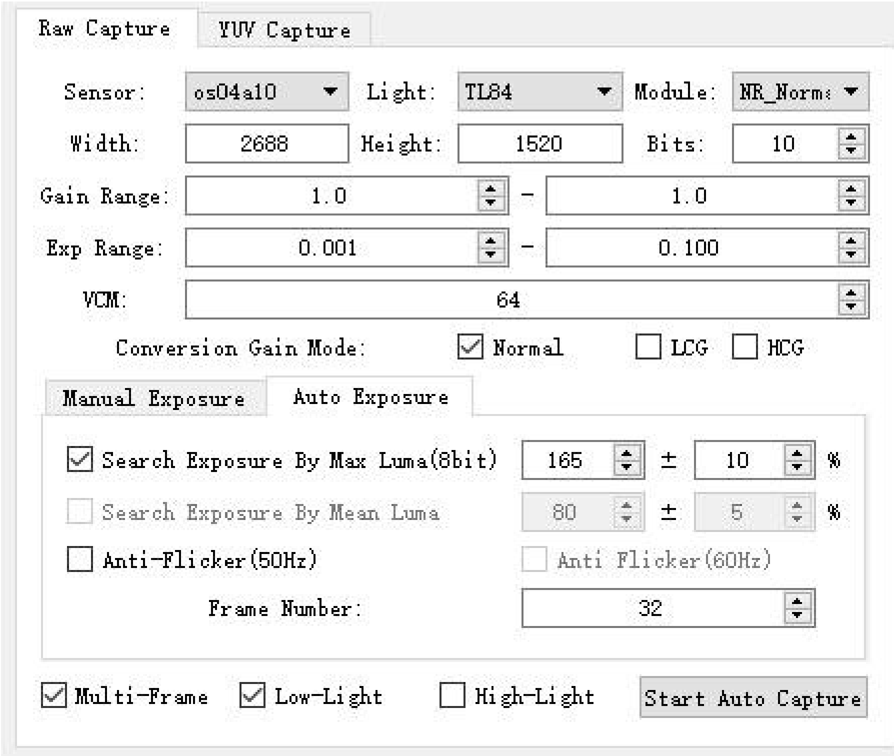


Figure 4-6-1-2

8. Click the Start　Auto　Capture button to start shooting, and the tool will automatically pick the right exposure value so that the Raw image meets the set value;
9. One Raw image each with Multiple and Single suffixes;

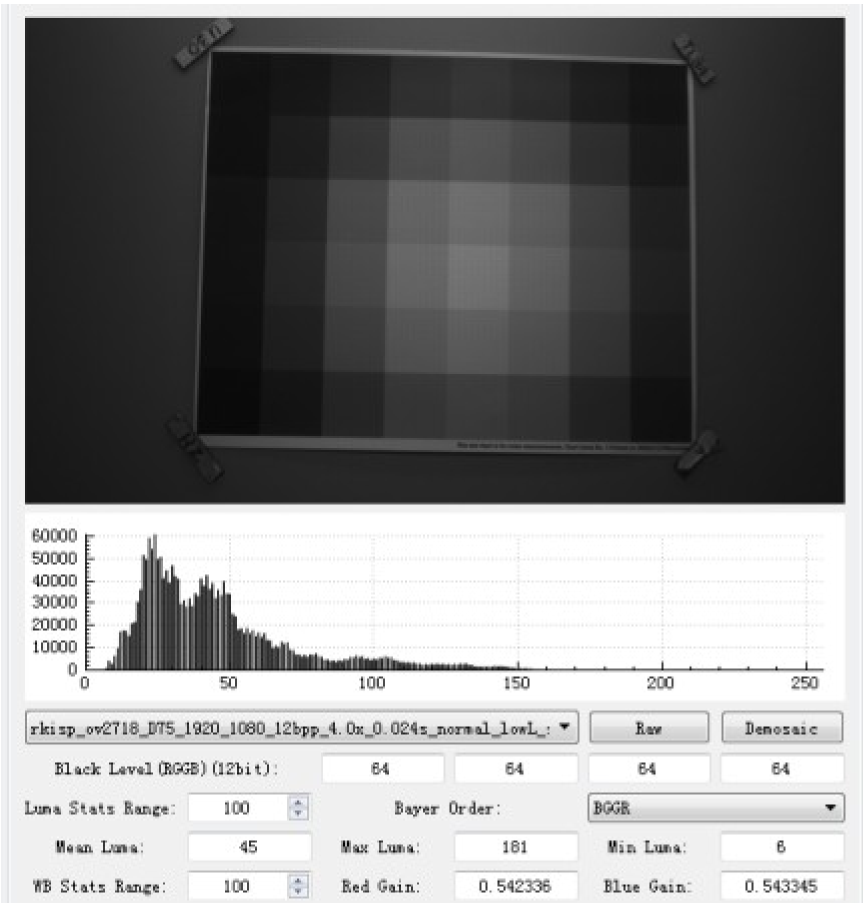


Figure 4-6-1-3

10. Shoot the highlights:

The light box brightness is adjusted to approximately 800lux;
Change the value of Gain Range in the interface to 1.0 - 1.0, Exp Range is not modified; check Multi-Frame and High-Light;

Select the Auto Exposure page, check Search Exposure By Max Luma, and set the value to 255±1%.

Turn off Anti-Flicker (50hz);

set Frame Number=32;

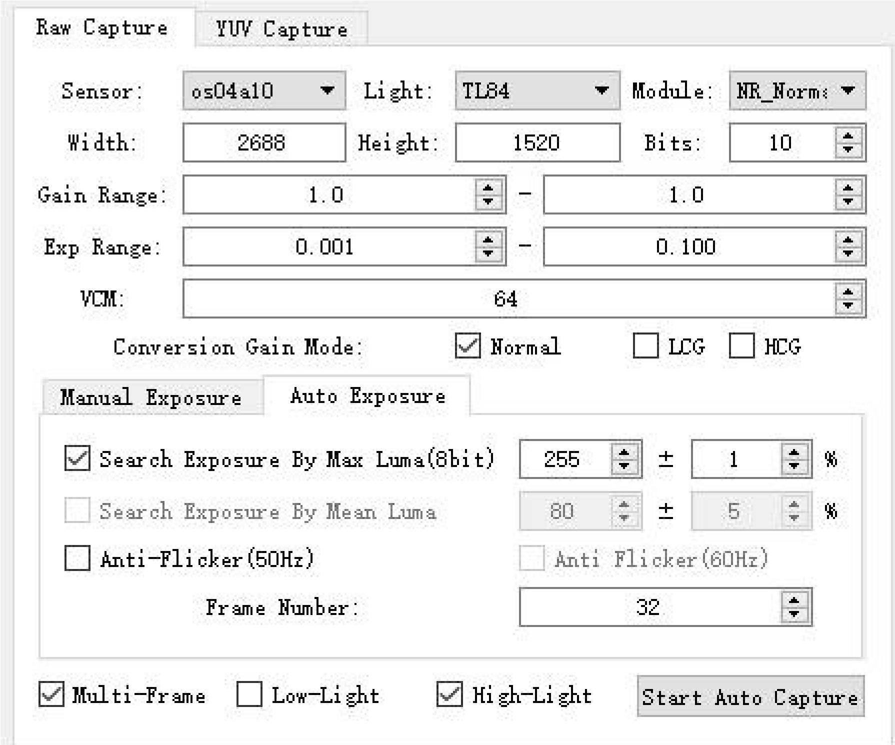


Figure 4-6-4

Click the `Start Auto Capture` button to start capturing, the tool will automatically select the appropriate exposure value, so that `the Raw` image meets the set value; the capture is completed to get a `Raw` image with `Multiple` and `Single` suffixes;

Since highlights do not allow too many overexposed blocks to appear, the user needs to check if there are overexposed blocks in the `3x3` centered only on the brightest block in the diagram;

If you need to reduce the brightness, you can switch to the `Manual Exposure` page, fine-tune it according to the results of the automatic exposure, and retake the shot;

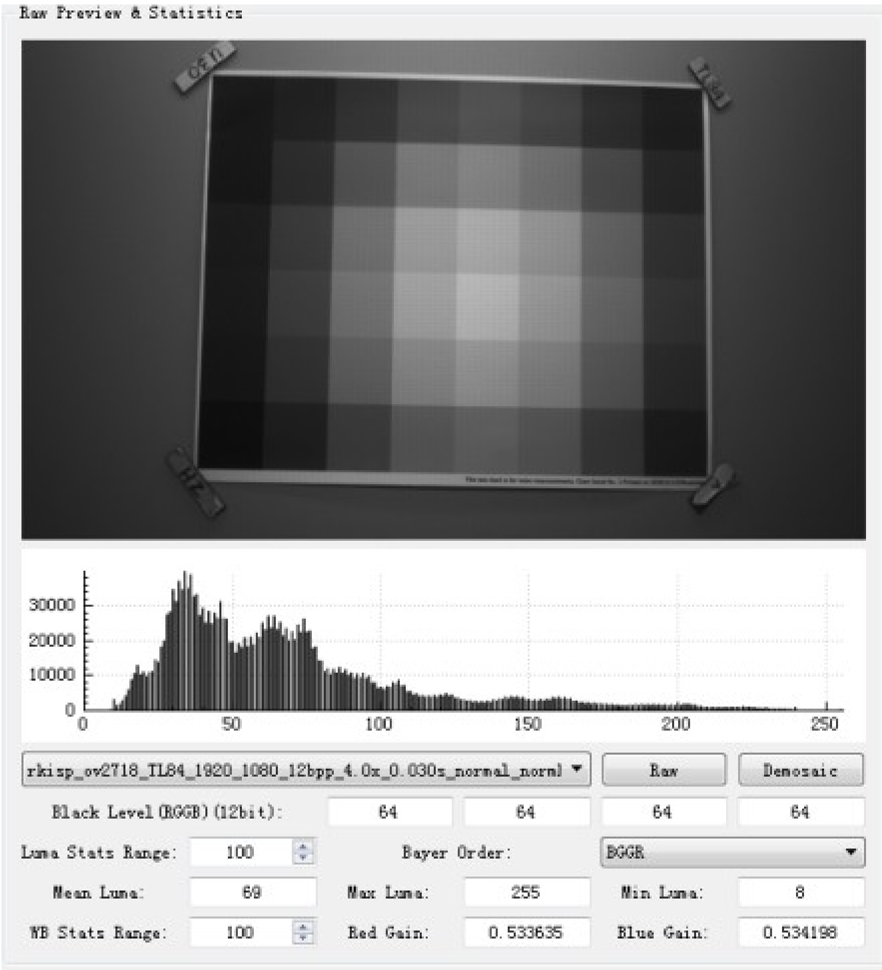


Figure 4-6-1-5

11. Modify the Gain Range value to 2x and repeat steps g and h until all Gain shots are complete;
12. As Gain will continue to increase, there may be automatic exposure can not pick the appropriate exposure value, as shown in Figure 4-6-6, the print information indicates that the tool uses a combination of Gain = 4x ExpTime = 0.03s (the combination of the current setting range of the maximum value), the shooting of the Raw map obtained the maximum brightness of 166.375, can not reach the target value of 255. At this time should increase the brightness of the light box and then retry;

```
./try_exp/try_single_175616523.raw receive ok.
Raw data check sum success!
curGain = 4 curTime=0.03
maxValue = 166.375 targetValue=255
tolerance = 0
Nearest exposure is: gain=9999 exp=0
Unsupported target exp or gain.
```

Figure 4-6-1-6

4.6.2 NR Calibration Procedure

The GIC & BayerNR and YNR & MFNR modules share the same set of Raw diagrams:

1. Open Calibration Tool, click the Edit Options button on the upper left corner of the interface to open the configuration interface, and enter the dimensions, bit width, and bayer order of the Raw plot;
2. Select the GIC & Bayer NR page and click the Load Raw Files button at the top to import all the Raw maps, the imported Raw maps will be displayed in the list below;
3. Click the Calibration button to calculate the calibration parameters;
4. Click the Save button to save the parameters;
5. Select the YNR&MFNR tab and click the Load Raw Files button at the top to import all the Raw maps, the imported Raw maps will be displayed in the list below;
6. Click the Calculate YUV button and the Raw map will be processed through the emulator as a YUV map;
7. Click the Calibration button to calculate the calibration parameters;

8. The noise profile obtained after the calibration is completed will be displayed in the right window;
9. Click the Save button to save the parameters;

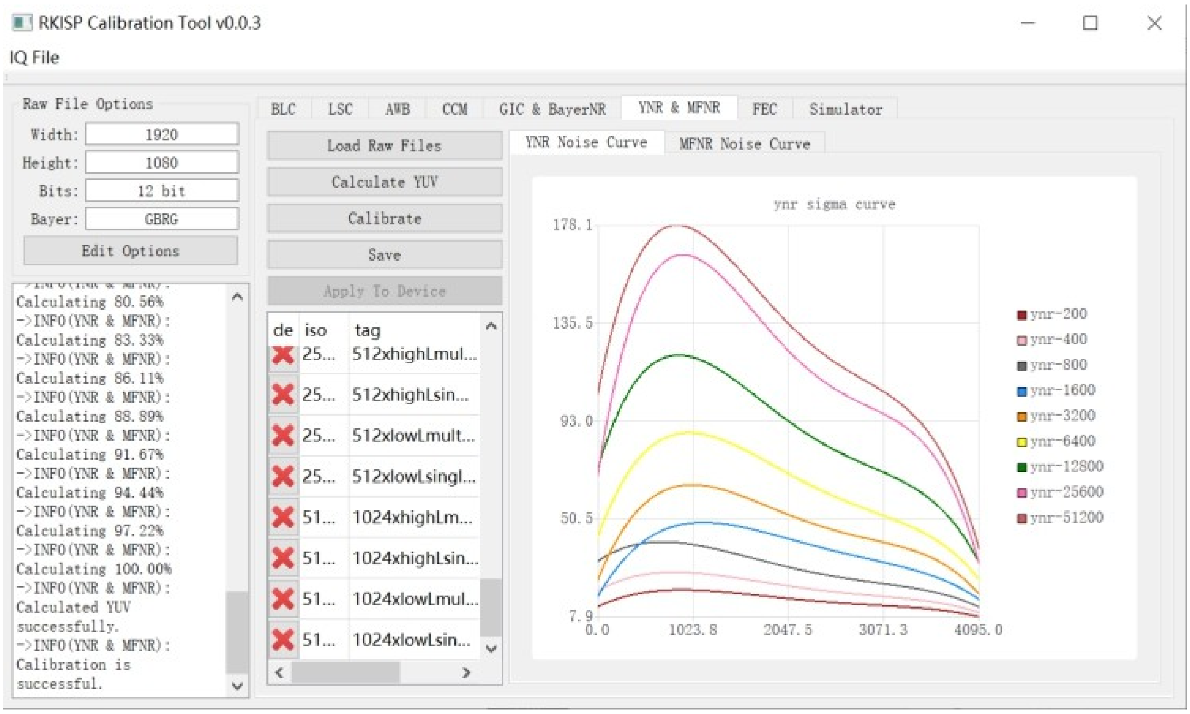


Figure 4-6-2-1

Caveats:

If `Auto Exposure` consistently fails to pick the right exposure parameters, it is recommended that you use `Manual Exposure` to adjust the exposure, using the histogram and statistical values of the captured `Raw` image to determine if the brightness is appropriate;
If the calibrated curve is far from the shape shown in Figure `4-6-7`, it indicates that the high or low light brightness is incorrect, which can be determined by the location of the curve abnormality:
Wrong shape on the left side means
inappropriate low light brightness;
wrong shape on the right side means
inappropriate high light brightness;
Please make sure to choose the correct light source when shooting `Raw` images, otherwise the result of `Calculate YUV` may be incorrect. If the minimum brightness of the adjustable light source of the light box can no longer satisfy the shooting, it is recommended to use a color-neutral filter such as a scrim to assist the shooting;

4.7 FEC/LDCH

4.7.1 FEC/LDCH Calibration Chart Shooting Requirements

Shoot checkerboard grid, checkerboard grid size support variable, calibration map only support jpg, bmp, png format; allow two ways to shoot:

1. Four calibration charts with checkerboard grids occupying four positions, upper left, upper right, lower left and lower right, in the calibration charts, with no specific order required;

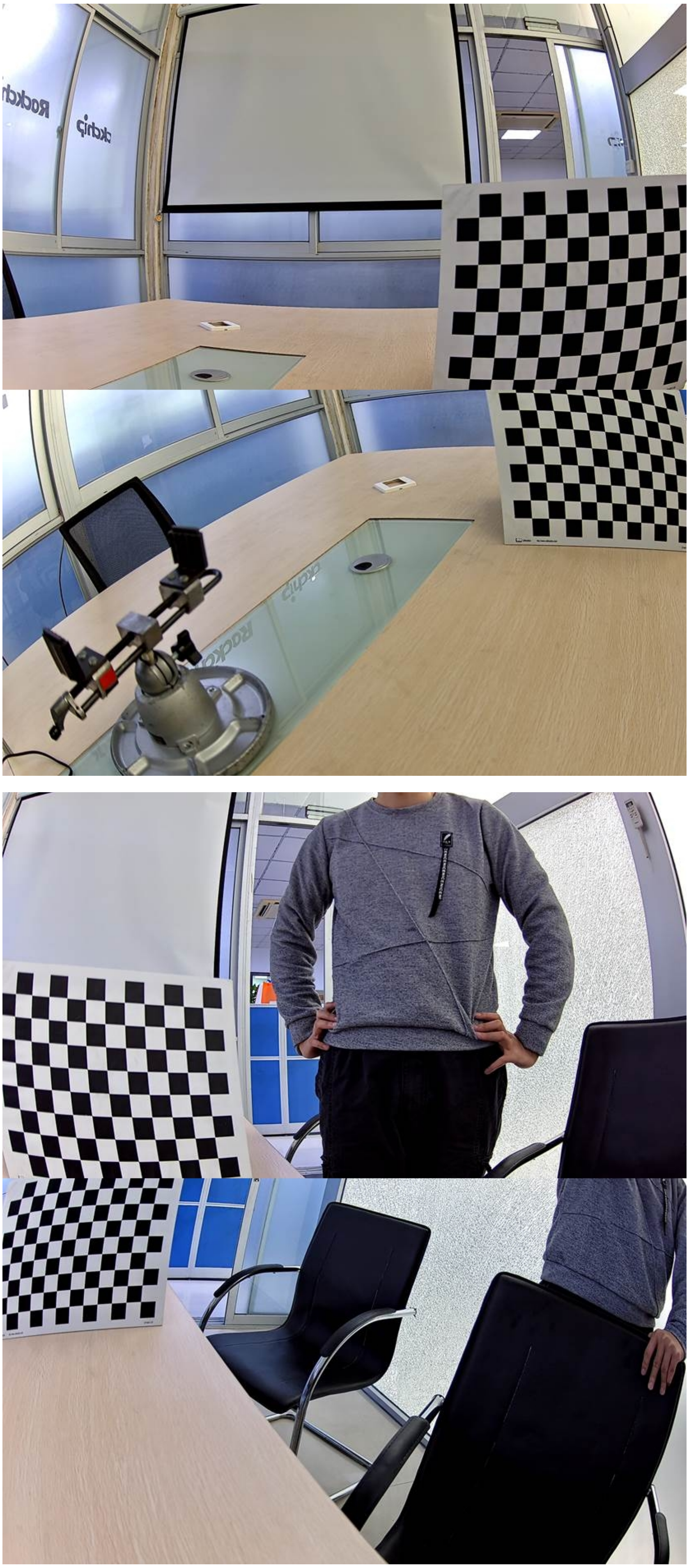


Figure 4-7-1-1

2. A calibrated map with checkerboard grids covering the four corners of the upper left, upper right, lower left and lower right;

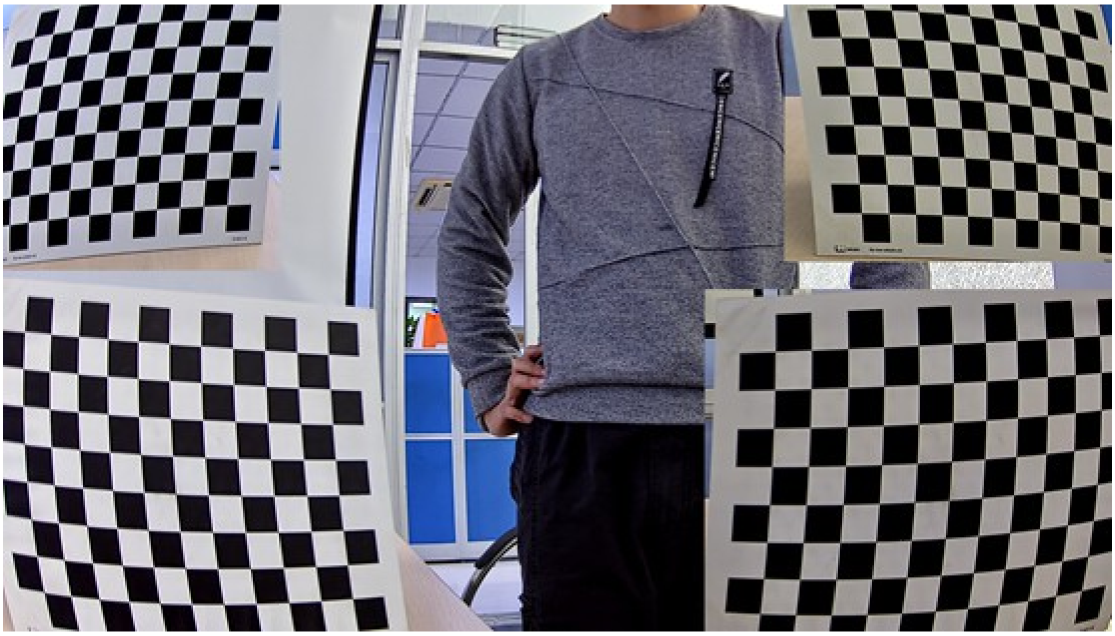


Figure 4-7-1-2

4.7.2 FEC/LDCH Calibration Procedure

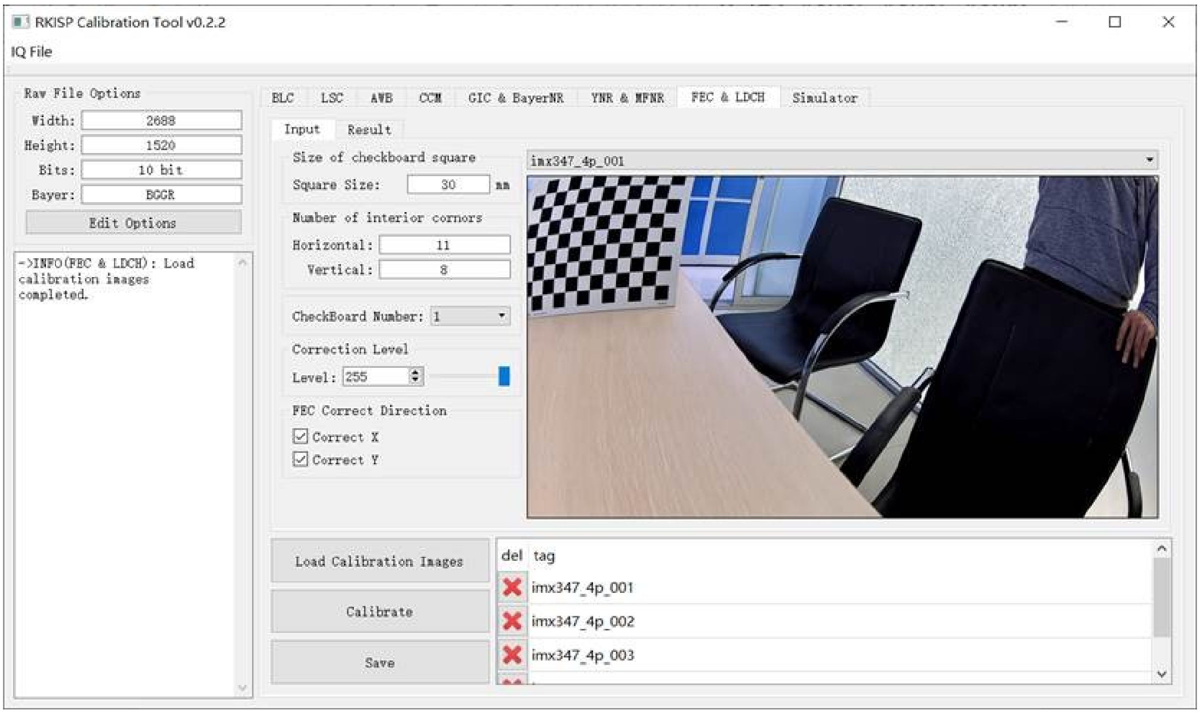


Figure 4-7-2-1

1. Configure the resolution in the Raw Options property. the Bit and Bayer Pattern can be ignored.
2. Import the folder where the calibration map is located. Supports jpg, bmp, png image reading.
3. Adjust the calibration configuration parameters.
   a) Confirm the actual size of the checkerboard grid squares and the number of corner points in the horizontal and vertical directions.
   b) Select the number of board grid sheets included in the calibration diagram.
   c) Confirm the correction level and the direction of correction of the FEC.
4. Click the "Calibrate" button to calibrate.
5. Click the "Save" button to save the

calibration result. Note

1. The outermost circle of the checkerboard grid is not involved in the calculation. However, the black and white blocks in the outermost circle may not be fully obscured by the preview when the calibration chart is taken.
2. The number of corner points in the horizontal and vertical directions is obtained by adding one to the number of black and white blocks in each direction after excluding the black and white blocks in the outermost circle of the board grid.
3. The FEC is calibrated in both directions by default. When calibrating, you can select the direction to be calibrated according to the actual situation.
4. The folder for storing calibration maps should preferably be named with sensor name+ lens name/focal length+ resolution, and the tool will generate a folder for storing calibration files based on this naming.

5 Online debugging interface and function introduction

5.1 Debugging interface function introduction

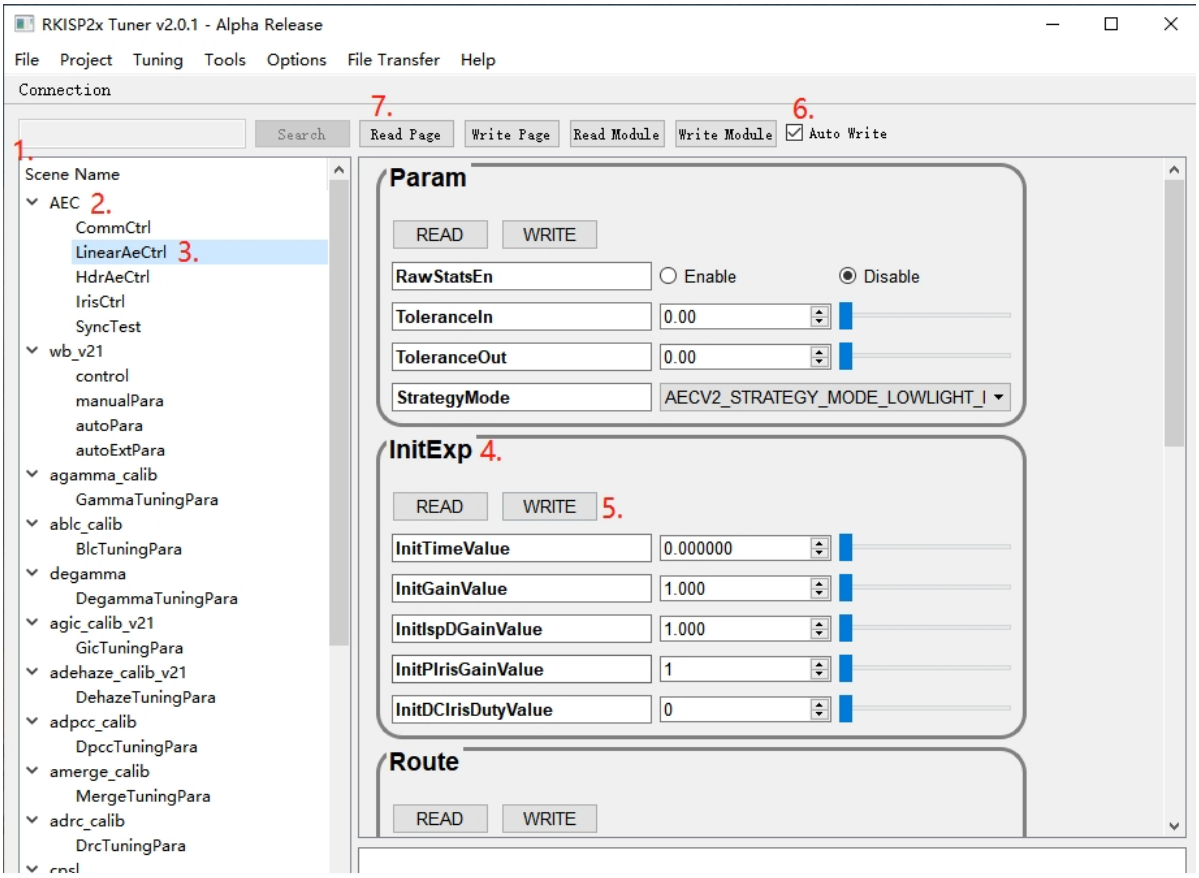


Figure 5-1-1 RKISP Tuner v2 Main Interface

As shown in Figure 5-1-1, this interface is a typical use state: the interface after loading the debugging interface is completed and the IQ parameters are imported. The following will briefly introduce the UI meanings and functions of the labeled numbers in the figure:

1. Tree structure of the module: `"normal: day"` shown at the top is the name of the scene that you choose to load when loading the `IQ` parameter, where `"normal"` `is` the name of the main scene and `day` is the name of the sub-scene.
2. `ISP` modules: a scene can contain multiple modules, a module can contain multiple debug pages
3. Debug pages: a module node can contain multiple debug pages, and a debug page can contain multiple debug units.
4. Debugging unit: for example, the unit is named `InitExp` and contains `five` numeric member parameters
5. Debugging unit read/write button: Provide online read/write function for all parameters in the whole unit
6. Auto-write function: when it is checked, if the tool has established a connection with `rkaiq_tool_server`, every parameter modification will be sent to the device automatically and the setting will take effect.
7. Page/module read/write buttons: Provide online read/write functions for the entire debug page or module

5.2 Platform & Network Configuration Features

The Platform & Network Settings screen opens when you first start the tool or click the "Project" - "Network and Platform Settings" button in the menu bar, as shown in the following figure.

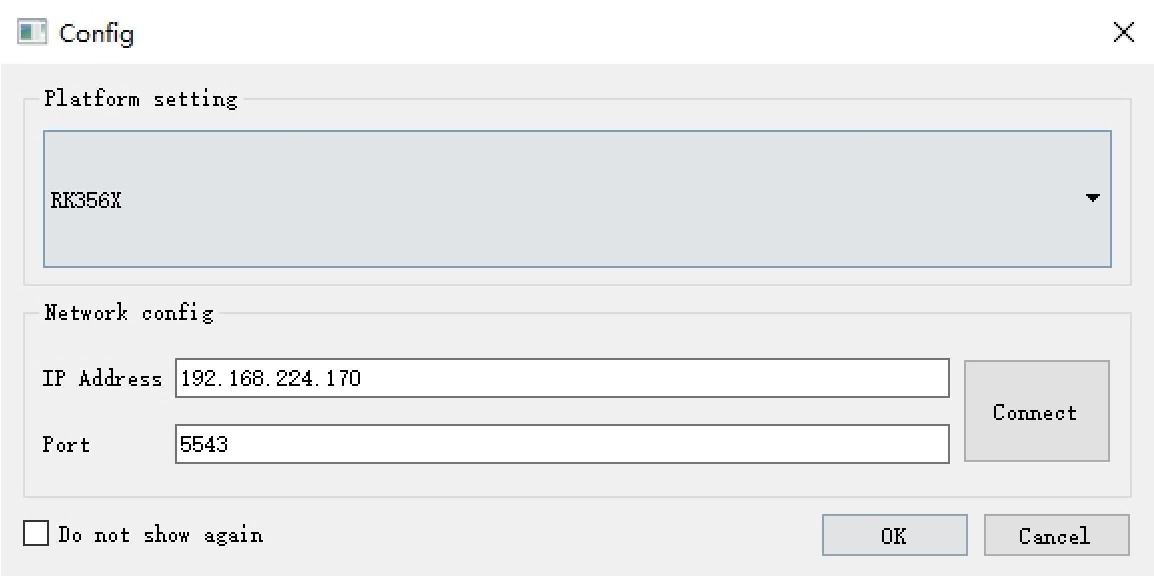


Figure 5-2-1

Platform Setting

Selecting the corresponding chip platform will load different debugging interface configuration files, and the correspondence between different platforms and configuration files is recorded in the

in config/config.ini

Network Config

Configure the network address of the debugging device, the port number is 5543 by default, do not change it for non-special needs.

Click on the "Connect" button, the tool will try to establish a connection to the rkaiq_tool_server in the debug device, make sure that

rkaiq_tool_server has been run correctly

5.3 Register and Algorithm Parameter Adjustment

Each debugging unit contains registers or algorithm parameters, which are divided into the following categories according to the form and range of the respective parameters, using different controls:

Numeric: An integer or floating point value with a range of values;

Modify the value of the text box directly; Use the small up and down arrows on the right side of the text box to adjust the value; use the slider on the right side to adjust the value;

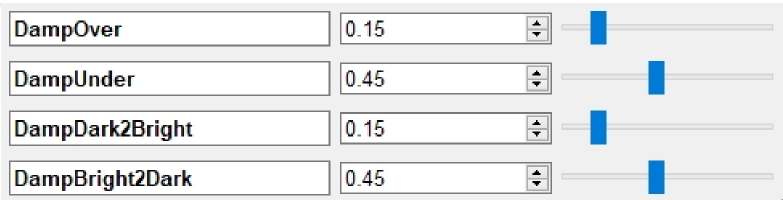


Figure 5-3-1

Boolean: Parameters that take values of 0 or 1, mainly various function switches, etc;

```
Take 1 for Enable and 0 for Disable;
```

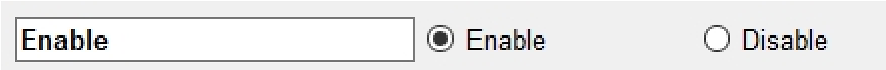


Figure 5-3-2

List: take one of the preset options, mainly the various function modes, ISO, Day/Night and LCG/HCG gear selections.

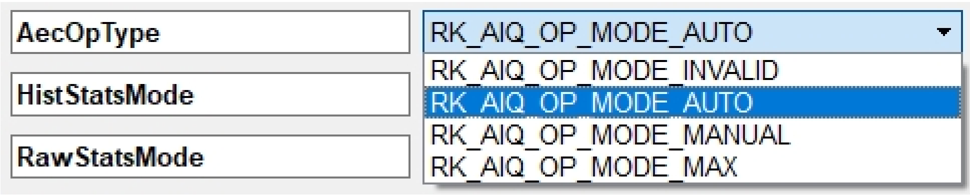
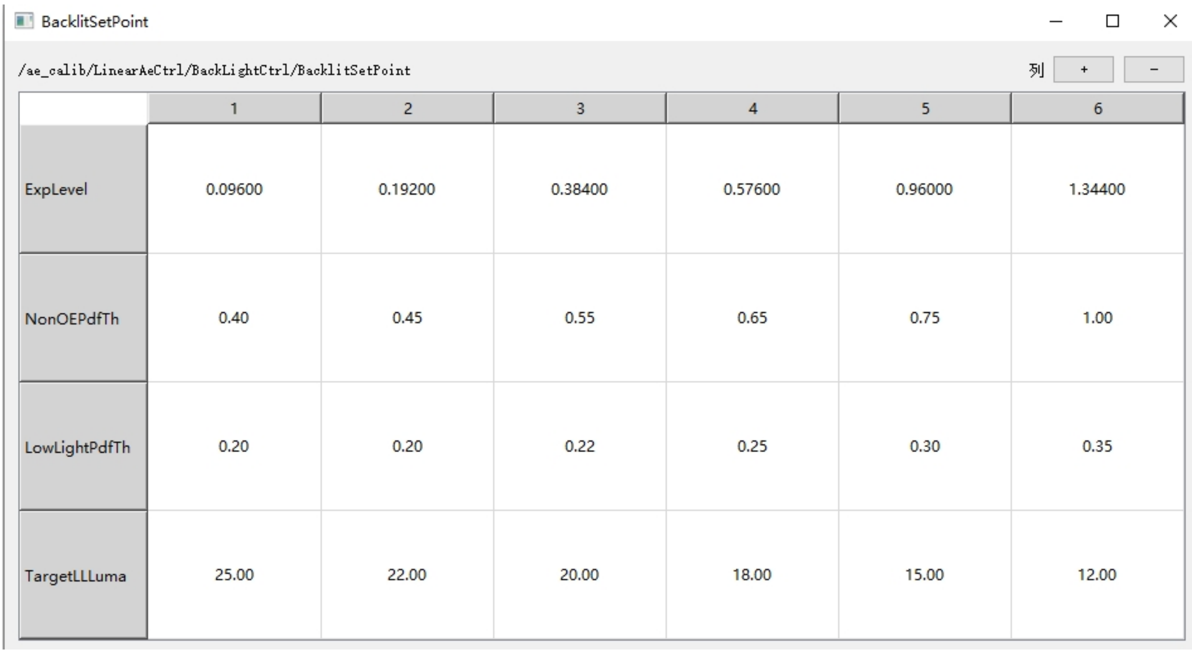


Figure 5-3-3

Table: Matrix parameter of NxM, matrix elements may be integer or floating point, expanded by clicking show data or Enter Array Table button on the interface;


BacklitSetPoint

/ae_calib/LinearAeCtrl/BackLightCtrl/BacklitSetPoint

列 + −

	1	2	3	4	5	6
ExpLevel	0.09600	0.19200	0.38400	0.57600	0.96000	1.34400
NonOEPdfTh	0.40	0.45	0.55	0.65	0.75	1.00
LowLightPdfTh	0.20	0.20	0.22	0.25	0.30	0.35
TargetLLLuma	25.00	22.00	20.00	18.00	15.00	12.00

Figure 5-3-4

5.4 IQ file online import function

Click "File Transfer" - "Send File To Device" in the menu bar, select the IQ file you want to transfer, and input the path where you want to store the IQ file on the device side, as shown in Figure 5-4-1, click Send, and then you can find the file under the corresponding path after successful transfer.

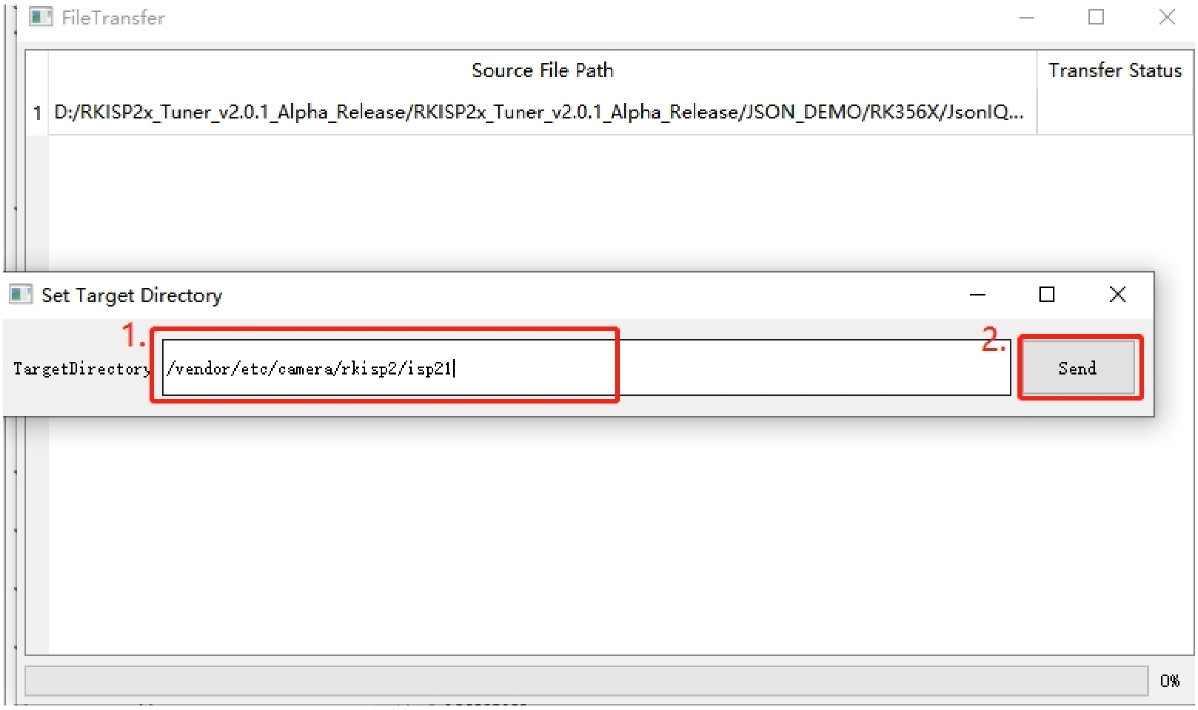


Figure 5-4-1 Select Transmission Path Screen

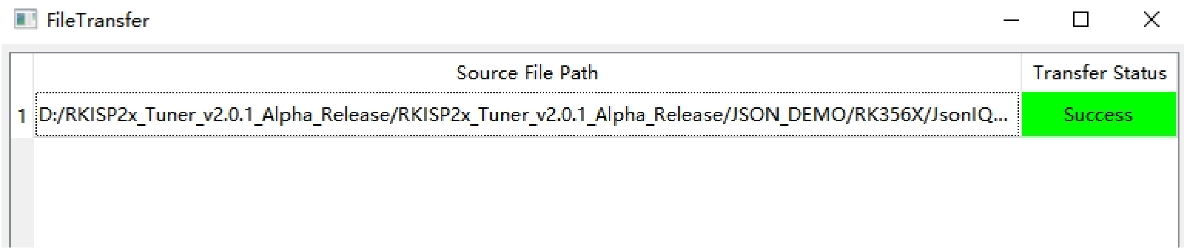


Figure 5-4-2 Transmission Success Screen

5.5 Gamma

5.5.1 Gamma Visual Debugging

Click Enter Curve in Figure 5-5-1-1 to open the Gamma visual debugging interface, as shown in Figure 5-5-1-2

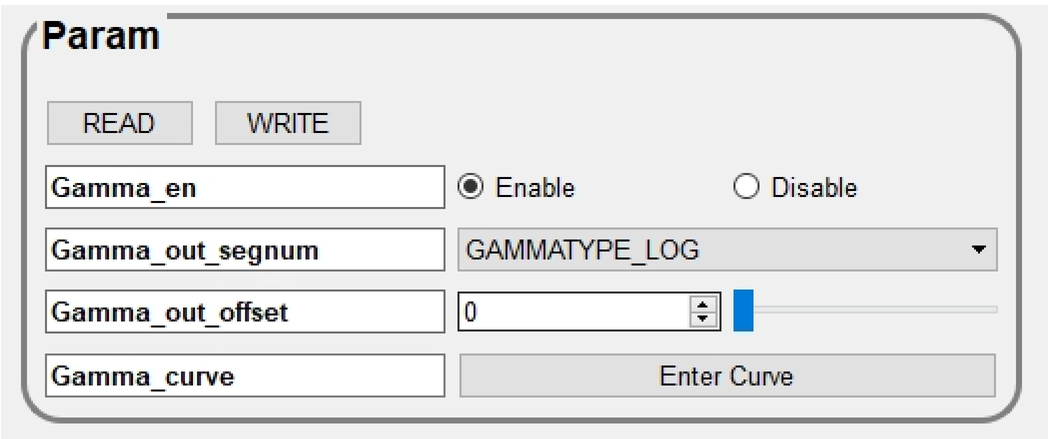


Figure 5-5-1-1 Gamma Interface

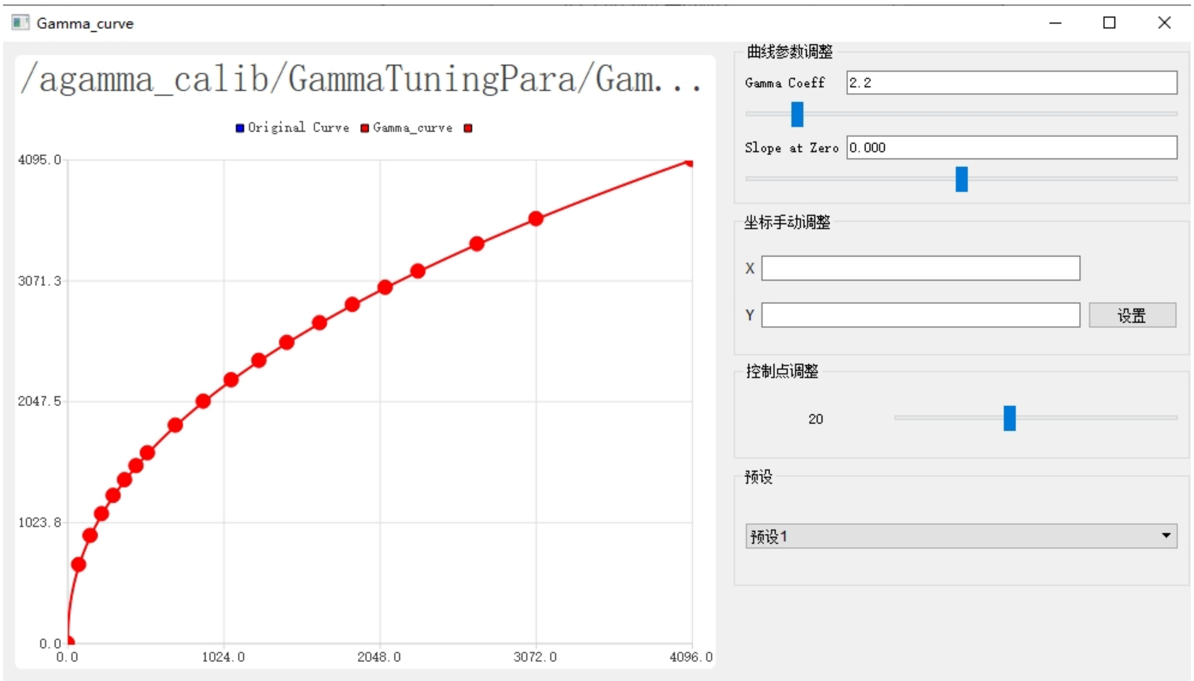


Figure 5-5-1-2 Gamma Visualization Debugging Interface

5.5.2 Gamma curve basic debugging method

There are two curves on the interface, the blue one is the original curve and the red one is the adjustable curve, when the pointer moves to the dot on the red curve, it will be displayed as **up and down arrows**, at this time, you can drag the dot up and down, and the red curve will be changed with the position of the dot, as shown Figure 5-5-2-1.

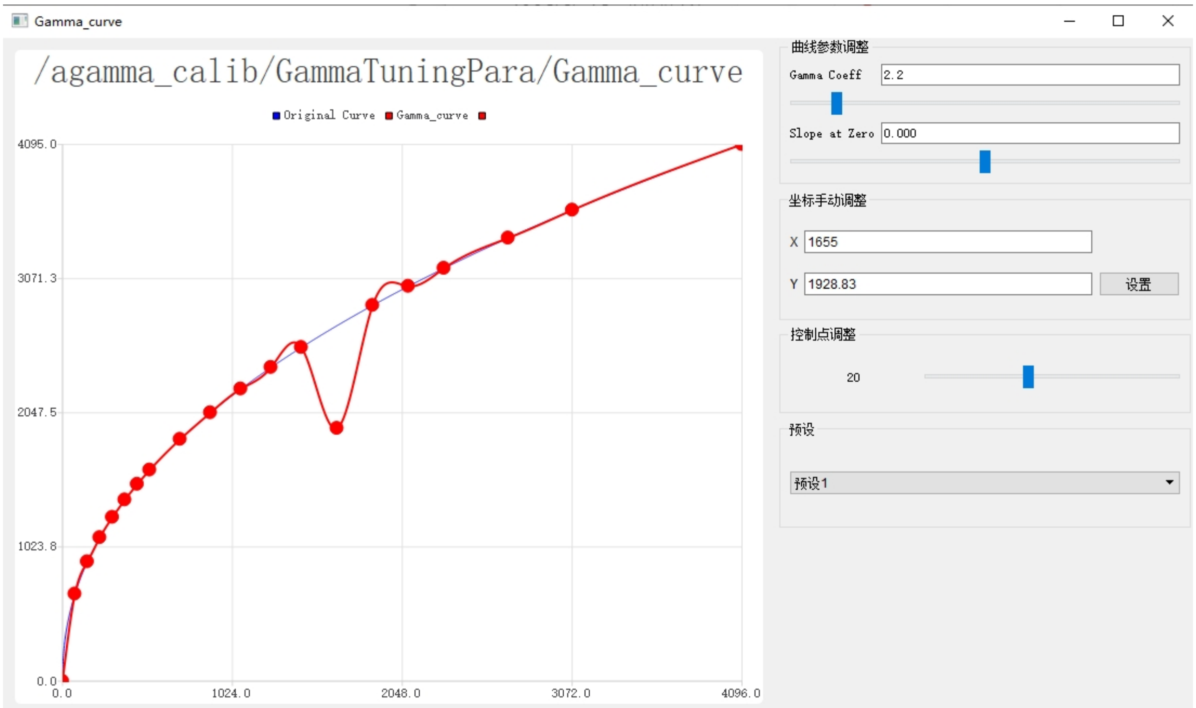


Figure 5-5-2-1 Curve after dragging dot