EOS VIRTUAL REALITY SYSTEM WHITE PAPER

Version 1.0 (December 2021)

Abstract

Canon simplifies the setup, capture and workflow of 180° VR content creation

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Background

Stereoscopic Virtual Reality(VR) stills and videos have been around for some time in various formats, with the more modern take on VR devices appearing in the mid-1980's, such as those developed by VPL Research and its founder Jaron Lanier, but analogue film devices such as the View-Master have been around since 1939, offering a static, fixed field of view. Even earlier than this, stereoscopes were being conceived and developed as far back as the camera itself in the early 1800's. So, it is possible to understand that there has always been and is a real desire to see the world in a three-dimensional (stereoscopic) format, restricted in some ways by the technology available at the time. However, it is at about the time Facebook acquired Oculus VR (for about $2 billion) that technology has progressed and 'stereoscopic' virtual reality was really gaining interest, particularly among the gaming community, and by 2016 there were over 230 companies developing VR related products, including Amazon, Apple, Facebook, Google, HTC, Varjo, Microsoft and Sony, to name a few.

But with the lack of capable computing technology at an affordable price, the relatively low image quality from early Head Mounted Displays (HMD) / VR headsets and cameras, it struggled to gain traction in the wider market, remaining of interest to the gaming industry, theme parks and specialist industries / governments.

However, in the last few years technology has progressed significantly, giving rise to the increased availability and popularity of high-quality Head Mounted Displays from a growing number of manufacturers, plus access to high powered computers, that can better cope with the high resolution full 3D 360° VR files. So, with the likes of Facebook acquiring Oculus and now with Apple looking to get into the VR market too with its anticipated launch of Apple Glass in 2022 https://www.macrumors.com/roundup/apple-glasses/, then the market is set to expand further with increased demand for VR content at a high level of image quality.

In addition to technological improvements that make the ability to capture, process and view VR content more practical and appealing, the world is rapidly changing in how we all interact with each other. This is no more easily seen than by the unfortunate and tragic circumstances caused by COVID-19 and the global pandemic, which had an effect of accelerating change. Industries and individuals are now using technology more than ever to conduct work, view entertainment and interact with each other remotely, more regularly and over longer distances. This has opened up a whole future of possibilities and acceptance of 'new ways of working', with an interest in how virtual reality could become an increasing part of some of our lives, be it for work, education or entertainment adding value to how we interact with the world.

With the improvements in Head Mounted Displays driving a lot of the interest in greater realism and creating opportunities for more uses, then it is the creation of high-quality content that is now needed. However, VR cameras have been mostly polarised into either low-end, low-cost 'consumer' type products, or high-end multi-camera setups/rigs, with a few now dedicated more 'professional' all-in-one systems becoming available too — but all using multiple files and sensors.

Canon's EOS VR SYSTEM (which includes the RF 5.2MM F2.8L DUAL FISHEYE lens) aims to provide a better balance of price and performance while making the process of 180° VR content creation a lot simpler and more efficient, enabling greater opportunity to create more content and enabling more people to enter the VR content creation market.

What is Virtual Reality?

Virtual Reality is the creation of an environment that fills the viewers field of view and presented in such a way as to immerse the user within that environment and make them 'believe' they are somewhere else.

Environments can be filmed real life scenes, using specialist camera systems, or can be computer generated (or can even be a mixture of the two).

To experience virtual reality in its truest form, the user must wear a Head Mounted Display (HMD) / VR headset that projects a (3D) stereoscopic image onto the users eyes (using two images, one for each eye, showing the same scene but from slightly different angles), providing depth perception and filling their field of view, while ideally also incorporating spatial audio.

Virtual Reality vs Augmented Reality vs Mixed Reality

Cross or Extended Reality (XR)

Virtual Reality (VR)

Requiring the use of a Head Mounted Display (HMD) / VR headset, users are fully immersed in a Computer Generated (CG) or real-world environment, simulating the user's actual presence within that environment. Users are able to move their head to look around them, as if they are really there. Viewing a 3D/stereoscopic scene adds a true sense of realism with depth perception.

Augmented Reality (AR)

Users typically use a mobile phone or tablet that can be moved around while using the device's camera to view the real world on its 2D, flat screen in real time. Digital information and imagery is superimposed onto the screen. Computer vision and object recognition can enhance the relative size, position and representation of the digital overlay on the screen.

Mixed Reality (MR)

Mixed reality takes augmented reality a step further and incorporates VR characteristics, blending the physical and digital world together in an immersive mixed environment.

Wearing a head mounted display, users can still see the real world around them, but now digital objects can be placed relative to real objects within that world, and can typically be interacted with. With six degrees of movement users can even move around a digital object, while still seeing the boundaries and obstacles of the real world.

360° VR vs 180° VR

Ideally, requiring the use of a Head Mounted Display (HMD), and even though the viewers field of view is filled, only a portion of the scene is visible at any one time, requiring the user to move their head to view all the scene. Two popular formats of Virtual Reality are 360° VR, where the user can look in all directions and be totally surrounded by the environment and 180° VR, where only the forward facing (half sphere) part of the environment is visible.

*Note: **360° VR** and **180° VR** can be captured/displayed as either **monoscopic** or **stereoscopic** content, depending on the requirements of the content creator or distribution method.*

360° VR

Used when the viewer is made to feel like an entire scene, in any viewing direction, is visible. Various on-line 'street view' applications are an example of 360° VR.

Benefits of 360° VR:

- Fully immersive 360-degree environment where users can look in all directions including at what is behind them
- Possible to add a 3D look to the 360° viewing experience, but TWO cameras would be required for initial capture of each view (most on-line street view apps use a single camera, so there's no 3D effect)

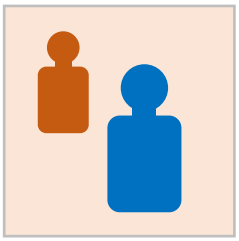
180° VR

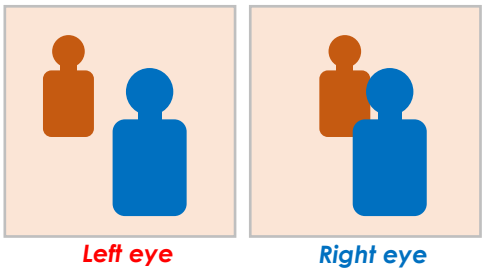
More useful when a content creator wants the viewer to be immersed in the environment, but also wants to focus the viewer's attention on the story / message they have to tell (i.e. documentary, natural history, training, travel, sports, concerts).

Benefit of 180° VR:

It is not always desirable to shoot 360° VR, so the option to only show what is happening in front of the user has its own benefits.

- Focus's the viewer's attention on the story being told in front of the camera
- It is a lot easier to shoot 180° VR — there is no need to worry about what is behind the camera (and therefore, no need to hide equipment or operators during the shoot)
- Typically, equivalent 180° VR systems are smaller than professional 360° VR rigs
- Easier to incorporate an immersive, 3D experience, with a single camera and Dual Fisheye, lens, such as the Canon RF5.2mm F2.8 L Dual Fisheye
- Smaller equivalent file sizes than 360° VR
- Simpler workflow with less editing / stitching





Monoscopic (2D)

Only a single image from one direction is captured and displayed. This image can be viewed on a standard flat screen, and if shot as a wide 'stitched' 360-degree image, it can simply be scrolled left/right or up/down on the screen to see the rest of the view.

As mentioned on the previous page, on-line sources like web-based 'street view' sites are an example of monoscopic, 2D capture.

This format of capture and display is very versatile, as it requires no specialist equipment to view the content, so anyone with a computer, mobile phone or tablet can easily view the image.

However, for a more immersive experience, a Head Mounted Display could be used to fill the viewers field of view, but the content will still be monoscopic with no depth perception.

Stereoscopic (3D)

Two images of the same scene are captured at the same time, but from slightly different angles (creating a parallax), requiring the use or two lenses, separated by a specific distance. For a more natural view, this 'baseline' distance usually approximates to an average interpupillary distance (the distance between the pupils) in a human. In the case of the RF5.2mm F2.8L DUAL FISHEYE lens the baseline distance is 60mm.

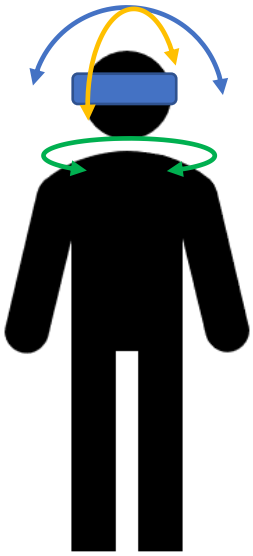
When viewing a stereoscopic VR image, a Head Mounted Display is required, where these two images from two slightly different angles can be seen and interpreted by the brain, calculating depth. Hence providing a true 3D and fully immersive experience, adding a greater sense of realism than a monoscopic image could.

3-degrees vs 6-degrees of freedom

More relevant to the headset capabilities and the viewing software. Degrees of freedom (DoF — not to be confused with depth of field) references how an object moves through three-dimensional space, of which there are a total of six degrees of freedom:

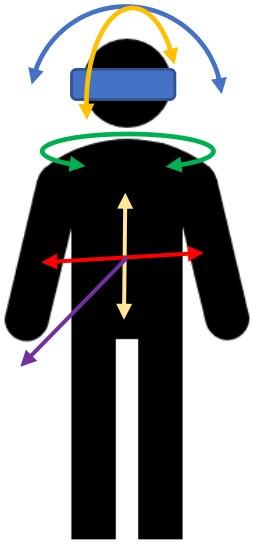
- Three degrees of freedom for rotation - pitch, yaw and roll
- Three degrees of freedom for translation - forwards/backwards, left/right and up/down

3-degrees of freedom



3-degrees of freedom (rotation) is more suited to being an observer within an immersive environment.

6-degrees of freedom



6-degrees of freedom (rotation and translation) is more suited to being an interactive participant within an immersive environment, as it allows the user to move within it. It is particularly associated with modern VR video games and training, often created with computer graphics.

Benefits of Virtual Reality

There are many benefits in the use of Virtual Reality in education, training, marketing, entertainment and industry. In particular, using VR can more effectively instil an '*emotional connection*' to the story or message you want to tell:

"I've learned that people will forget what you said, people will forget what you did, but people will never forget how you made them feel."

Maya Angelou (1928-2014) - *American poet, memoirist, and civil rights activist*

Virtual Reality also provides a more *realistic 'real-world'* view with depth perception to better understand relative positioning and textures of objects or situation, which can be particularly useful for training / education.

It has been argued that there are other benefits:

- It can help retention and recall of what has been shown / learnt
- It can put people in realistic environments that many be dangerous or unachievable before, but in a safe, low risk way
- Content can be viewed remotely
- It can be exciting, enjoyable and stimulating

Challenges of 'traditional' VR capture

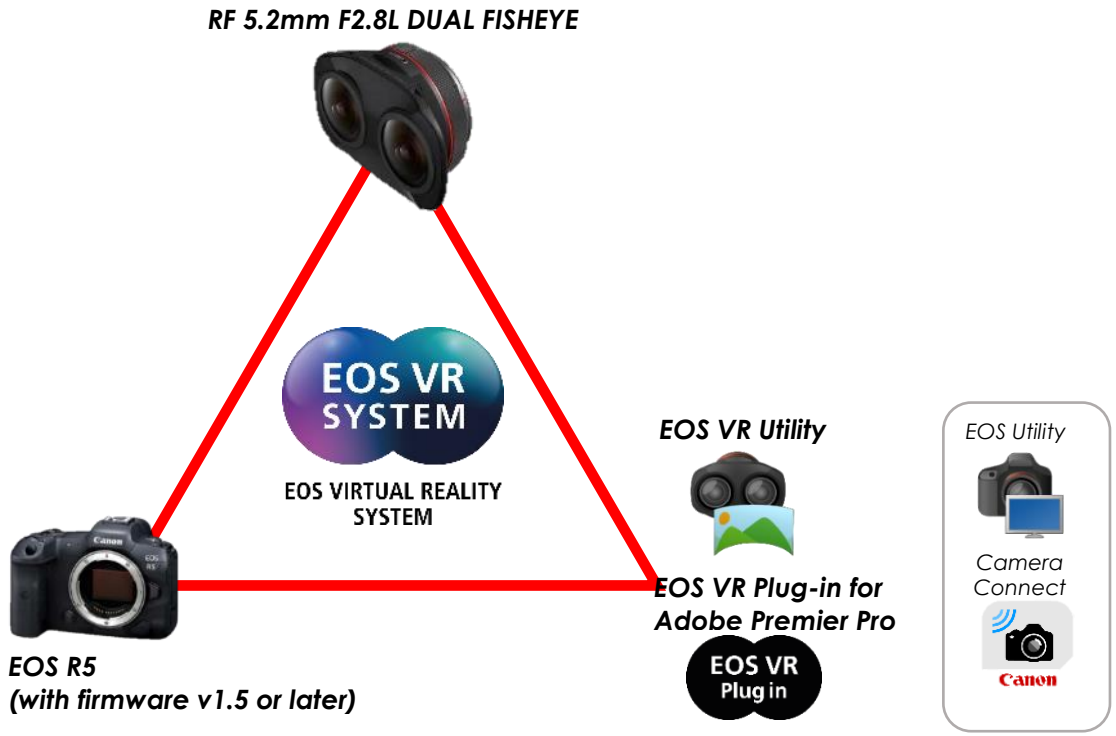
'Traditional' forms of VR capture can involve multiple cameras to setup and can mean there are multiple files to manage, process and stitch together:

- Need to have fully, precisely aligned cameras / images
- Need to have all the images fully synchronised
- Can take time to set-up the camera system, especially if there are rigs involved for multiple cameras.
- Difficulty in lighting 360° VR scenes without seeing the lights
- Higher frame rates are preferred for faster moving subjects and scenes with a lot of fast movement (e.g. 60fps or greater)
- Need high-quality ultra-wide lenses to reduce image stitching requirements.
    - Edge-to-edge performance is especially important if using a single fisheye lens for each 'eye', to aid an accurate conversion to an equirectangular projection
- The resolution needs to be high for a clearer, more immersive experience
- Images need to be level and stable to be comfortable to view
- Users need to be able to easily manage all the files for a quicker, more trouble-free post-production
- Equipment needs to be compact as rigs, etc can be cumbersome
- Converting the footage can be very time-consuming and needs expertise and/or software to stitch
- If using multiple cameras/lenes, stitch lines can sometimes be visible in the final output, especially if this is where the action happens to occur, providing a poorer, less realistic experience

Canon's aim with the EOS VR SYSTEM is to address many of these challenges and simplify the process from input to output.

Canon's EOS VR SYSTEM

Canon's innovative solution for 180° VR capture simplifies and streamlines the whole process from capture to output. It utilises the benefits of the RF mount system to enable the design of a compact dual fisheye lens that projects stereoscopic left and right eye images *onto a single Full Frame sensor*. This innovative design effectively eliminates issues of lens alignment and image synchronisation, capturing a dual side-by-side fisheye image directly onto a single file. Therefore, the process of converting and exporting to a final equirectangular projection is made simpler, more efficient and more robust.



Simplifying *stereoscopic 180° VR* capture of video and stills

Benefits of the EOS VR SYSTEM

Ease of setup
and operation

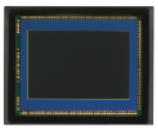
To prepare for shooting, simply attach RF 5.2mm F2.8L DUAL FISHEYE lens to a compatible EOS camera. Anyone can promptly start shooting VR content with minimal shooting gear.

Efficient workflow
in shooting and post-production

Single imaging sensor system dramatically reduces the burden of shooting and post-production that used to be difficult for a conventional VR system.

High-quality
assured by 8K + L-series lens combination

Full Frame 8K sensor with the EOS R5, plus high-performance L-series lens realises corner-to-corner high-quality images.

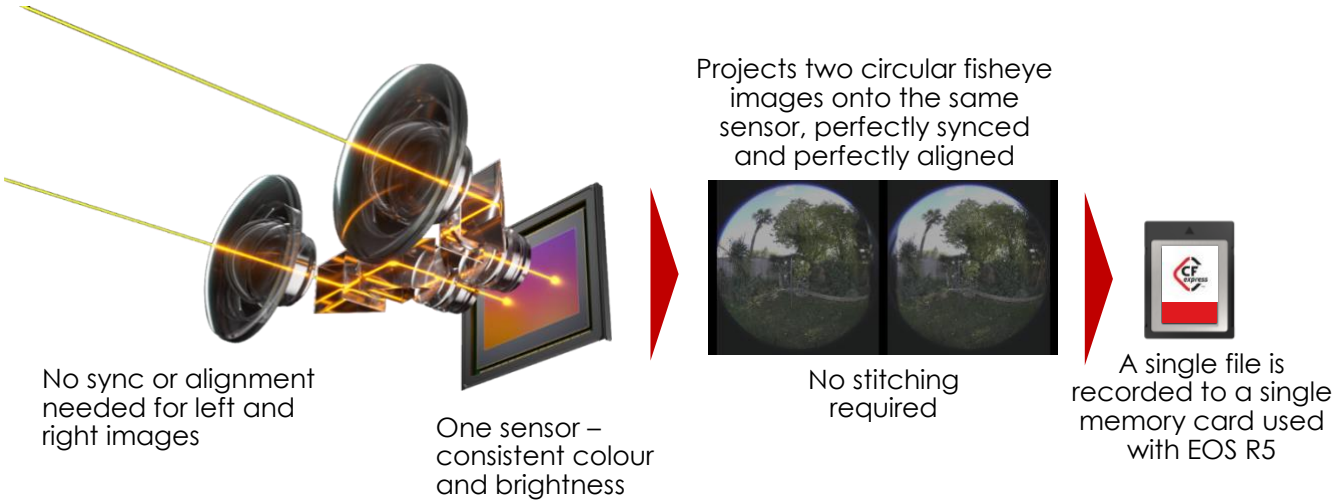


Ease of setup

Setup is as simple as attaching the RF 5.2mm F2.8L DUAL FISHEYE lens to the EOS R5 (with updated firmware — v1.5 or later) and setting the camera settings to the desired shooting parameters.

Efficient workflow — one sensor, one file

An efficient workflow is enabled by the recording of the (stereoscopic) dual circular fisheye image onto a single Full Frame sensor, which in turn means there is only a single file to handle within the system, making file management incredibly simple.



High Image Quality

Canon

High image quality is assured through the use of an L-series lens that utilises special glass and coatings to ensure edge to edge performance, while the Canon EOS R5's 8K sensor captures the detail needed for VR reproduction — into a sensor and camera that has proven itself to be capable of great low noise, high dynamic range capture.

Simplicity of image conversion to an Equirectangular Projection

What was once a complex process of alignment, synchronisation and stitching with multiple camera/file systems, is now made infinitely easier thanks to Canon's EOS VR Utility[1] software, which makes conversion of the stereoscopic footage and stills for editing and playback, a much more efficient process. You can even import and automatically convert Canon's VR footage direct into Adobe Premiere Pro[1], by using Canon's EOS VR Plug-in for Adobe Premier Pro.

EOS VR Utility

EOS VR Plug-in for Adobe Premier Pro

No stitching required!

[1] *EOS VR Utility and the EOS VR Plug-in for Adobe Premiere Pro are required to perform the equirectangular switch of recorded 180° VR images from a compatible Canon camera. A monthly or annual paid for subscription service may be required to access all the higher functions and export codecs.*

Compatible camera

EOS R5
(Requires the latest free firmware update for VR capture)

- Max. selectable resolution is 8K / 25fps (PAL) / 30fps (NTSC) ALL-I
- Selecting Log / Log 3 for 4:2:2 10-bit MP4 recording
- 8K recording times are the same as the EOS R5 with firmware 1.4 (20mins continuous recording at 23°C/73°F)*

** Depending on shooting conditions, shooting time may be shortened. Shooting time is regulated, on the basis of EOS R5's time limitation. A return to normal internal camera temperatures is required for additional, full recording time with the EOS R5.*

Note:

- 8K RAW is selectable in-camera, but EOS VR Utility and EOS VR Plug-in for Adobe Premier Pro do not support this format.
- No autofocus possible
- No image stabilization (optical or in-body) due to the complexities of using of two optical systems in the lens with one sensor.

When using the RF 5.2mm F2.8L DUAL FISHEYE lens, then certain functions are restricted / disabled, and the settings do not go back automatically even after taking the lens off.

- Therefore, save the camera settings to a memory card before attaching the RF 5.2mm F2.8L DUAL FISHEYE, so they can be restored once the RF 5.2mm F2.8L DUAL FISHEYE is removed.
- Evaluative metering and Face Detection with the Auto Lighting Optimizer are disabled.
- When shooting with UHD format, vignetting occurs at left and right ends of the circular image. DCI format recording is strongly recommended.

Disabled / restricted functions:

- Still photo cropping/ aspect ratio
- Dual Pixel RAW
- IS (image stabilizer) mode: Movie Digital
- Multi Shot Noise Reduction
- HDR PQ settings
- HDR Mode Auto Image Align
- Movie Recording Size: FHD
- Movie Cropping
- HDR movie recording
- Shooting information display: setting focus distance display
- Display performance: Power saving
- Change focus ring rotation direction
- Change RF lens MF focus ring sensitivity

RF 5.2mm F2.8L DUAL FISHEYE lens

World's first* lens for digital interchangeable lens cameras enabling 180° VR shooting with one camera to a single sensor

**As of October 5th 2021, among all lenses for full-frame digital interchangeable lens cameras (based on Canon research).*

L-series build and weather resistance*

Being an L-series lens, the RF 5.2mm F2.8L DUAL FISHEYE lens has a similar professional build and weather resistance* to other L-series lenses in the range. The below diagram highlights where weather resistant seals have been positioned and includes a seal on the lens mount.

** Cannot guarantee to prevent all dust and moisture from entering*

RF mount and lens design concept

Using the benefits of the RF mount, with its large rear diameter and short back focus, Canon has been able to design a sophisticated folding lens configuration that enables two 190° circular fisheye images to be projected onto a single Full Frame sensor, while maintaining image quality, suitable for professional usage and allowing the lens to carry the L-series red ring.

This compact design, utilising a single lens mount for compatible RF system cameras, ensures both lenses (and hence images) are perfectly aligned, unlike systems that require two cameras and two lenses on a rig. These previous style systems required specialist rigs and are often difficult and time consuming to align/set-up. With the RF 5.2mm F2.8L DUAL FISHEYE, you simply attach it to a single compatible camera in the normal way and once levelled on a tripod or gimbal you are ready to shoot (once the camera settings have been chosen). Being so compact and simple to setup, significant time, effort and expertise is saved.

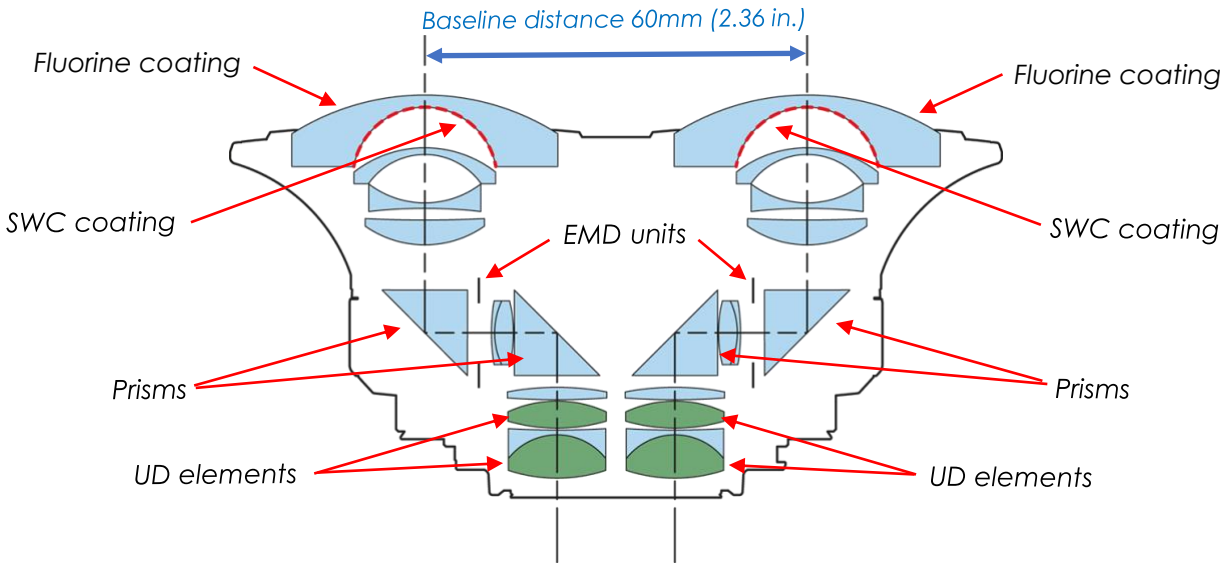
Since both the left and right images from the dual fisheye lenses are perfectly aligned and projected side-by-side onto one single sensor, then these images are also perfectly captured in sync, with no delay or difference between them, ensuring a good VR experience, especially for video.

Another benefit of using a single sensor system on a single camera, is that both images exhibit the same colour response and exposure characteristics, as well as all the camera settings being exactly the same.

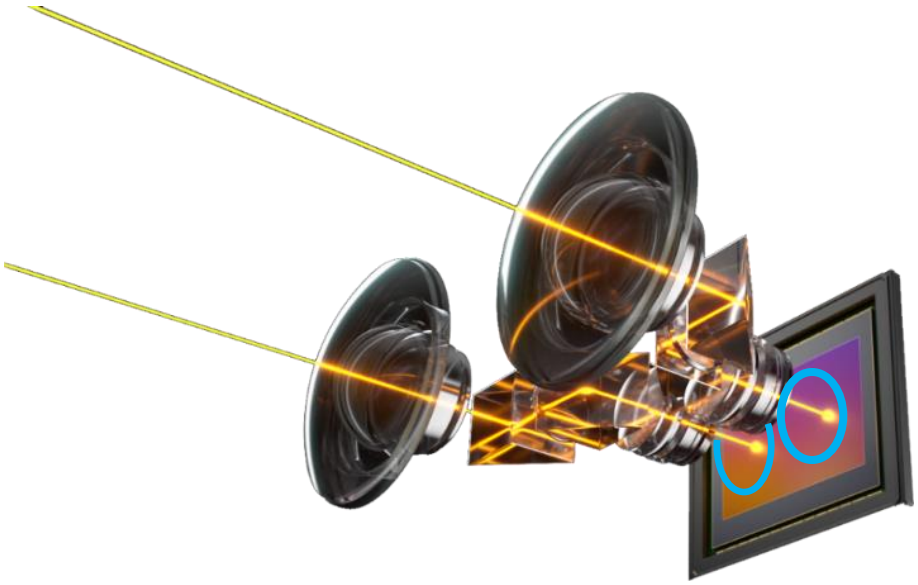
All the above ensures that both the left and right images are automatically synchronised in every way, enabling for a more efficient conversion to an equirectangular projection and less work is needed in post-production, enabling the content creator/editor to focus on the edit than trying to get the images to align, sync and match.

Advance optical design

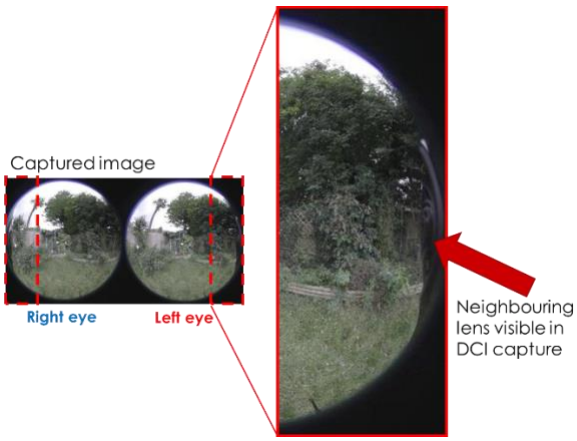
The construction features an optical prism system that folds the optical path to provide images with natural parallax, with a baseline length (similar to interpupillary distance) of 60 mm (2.36 inches) in a camera with a full-frame sensor. This enables the camera to use interchangeable lenses for simple and straightforward VR shooting while still retaining the camera's general-purpose capability with other RF lenses and adapted EF/EF-S lenses.



The use of advanced lens design techniques (including the use of prisms), technologies and materials (such as UD elements, SWC and Fluorine coatings, and strategically placed EMD diaphragm units) has enabled Canon to create this compact and lightweight stereoscopic VR lens, while maintaining image quality befitting the L-series range.

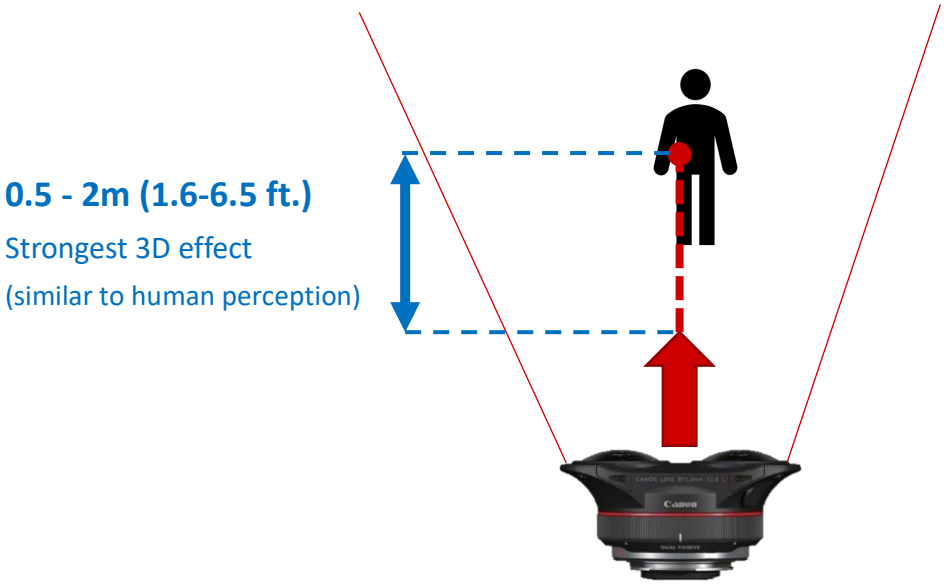


Lens is visible in DCI recording



Note: Slight visibility of the adjacent lens is normal on original, unprocessed video files, using DCI recording. Visibility of the neighbouring lens upon capture is reduced a little further when capturing in the UHD format.

Strongest 3D effect



High Image Quality

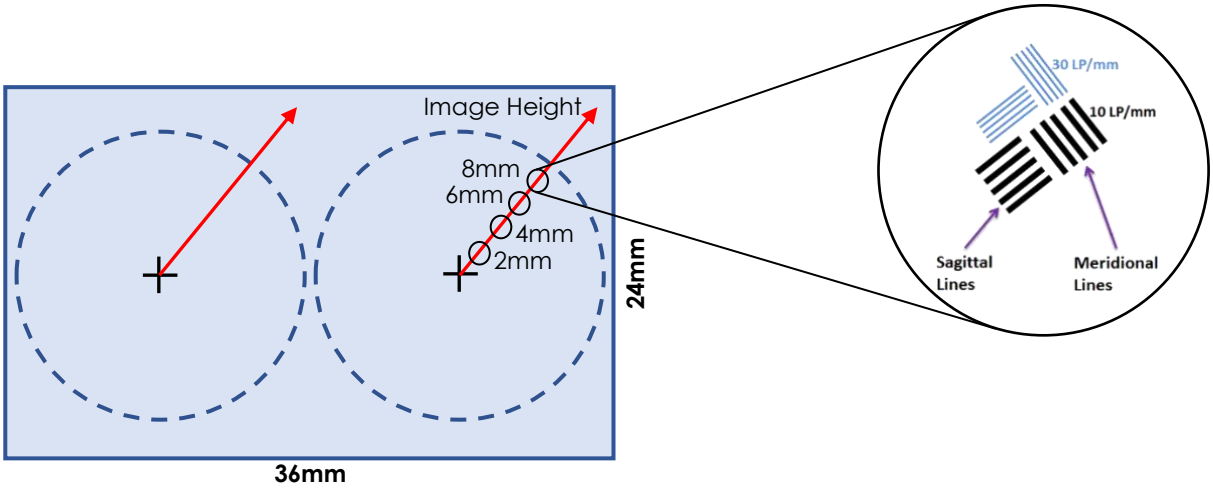
By combining a Full Frame 8K sensor and an L-series lens, superior edge-to-edge performance and high resolution can be achieved. This is of particular importance in achieving a high-quality conversion of the dual circular fisheye images to an equirectangular projection.

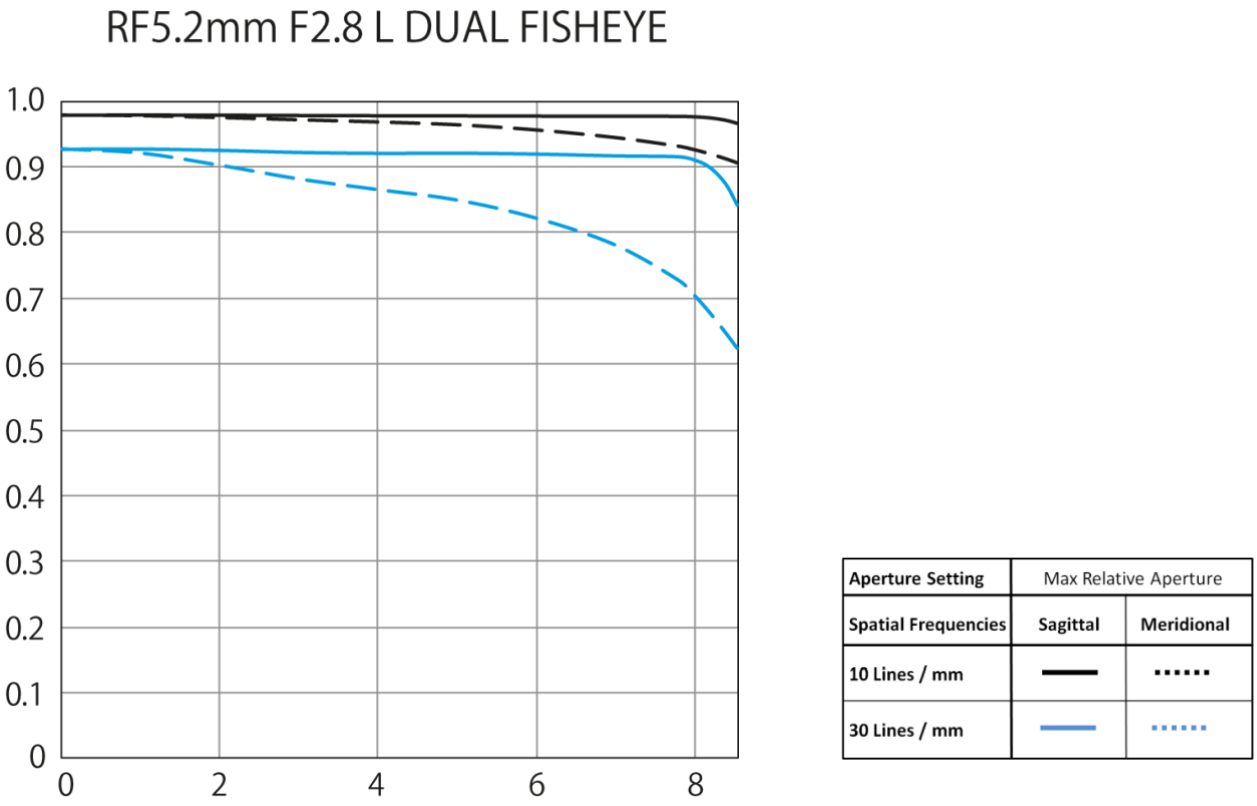
2 x UD elements per lens

Two strategically placed UD (Ultra-low Dispersion glass) elements help to reduce aberrations for sharper/clearer, high contrast images from edge-to-edge.

MTF Graph

The MTF curves in the graph below show the behaviour of this lens measured at four distances from the image centre. Two spatial frequencies are used — one, at the low 10 line pairs per millimetre (LP/mm) which is an important measure of the contrast of the lens, and the second is at a higher 30 LP/mm which indicates resolving power. Two separate measurements are made for each at right angles to each other. The term "image height" refers to how far toward the edge of the image a measurement is taken as shown in the diagram below.

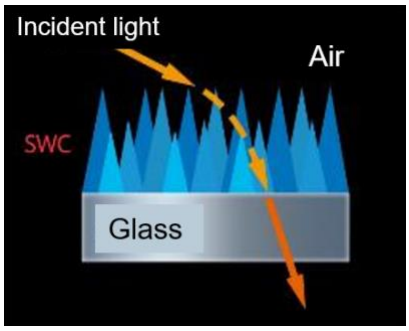




This graph shows the excellent edge-to-edge performance characteristics of the RF 5.2mm F2.8L DUAL FISHEYE lens in relation to contrast and resolution, with only the behaviour of the 30 Lines/mm Meridional curve falling slightly as it approaches the extremity.

Subwavelength Structure Coating (SWC)

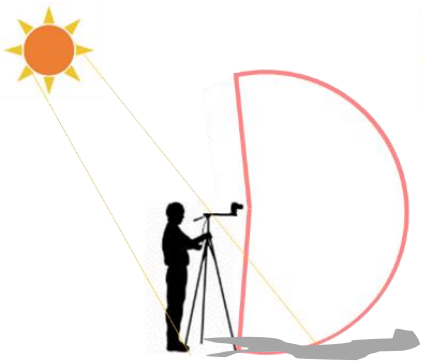
Developed by Canon, this remarkable anti-reflection technology controls light striking at strong angles, greatly reducing risk of flare, ghosting, and internal reflections. SWC coating — especially valuable on ultra wide-angle lenses — achieves this by adding innumerable nanometer-sized wedge-shaped structures smaller than the wavelength of visible light (380 to 780 nm*) on a critical internal surface of the lens.



Better results with backlighting

For precisely this reason, back-lit shots with the sun just outside the frame, or even shooting into the sun, are at far less risk of flare and stray reflections. The RF 5.2mm F2.8L DUAL FISHEYE lens with its Subwavelength Structure Coating (SWC) displays exceptional antireflection performance, for effective ghost and flare reduction. This allows you to actively shoot in the morning and evening, capturing attractive images of oblique ambient lighting.

The sun from behind causes shadows in the frame.



The sun pointing into the lens causes issues of flare and ghosting in conventional lenses

Direct front light

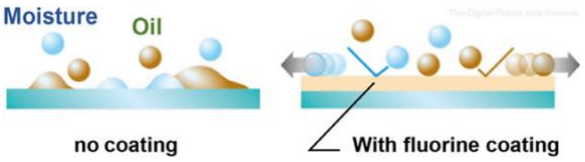
When the sun descends, the photographer's shadow is revealed.

Backlight

Shooting into the sun, when the sun descends lower, ghosting now occurs with conventional lenses.

Fluorine coating — easy maintenance

Since the focal length is so short, a foreign object like dust on the front lens can be visible in finished imagery. The Fluorine coating on the front two elements of the lens makes it easier to clean and repel dirt.



Exposure control

*For illustration purposes only

Dual Electro-magnetic diaphragms (EMDs)

Two EMD (aperture) units, one for each lens, are precisely synchronized and finely controlled to maintain a consistent exposure onto the sensor for each image — helping to reduce post-production grading and expertise required to match the left and right image output.

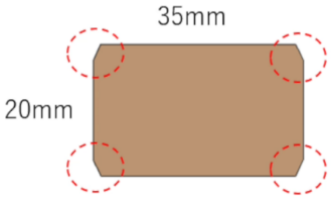
Electronically controlled diaphragm:

Electro-magnetic Diaphragm (EMD), showing wide-open and stopped-down aperture — coordinated but separate aperture units for each lens in the Dual Fisheye design.

Rear mounted gelatin filter holder

Particularly useful for video capture — helping to maintain smooth images by suppressing the 'fluttering' or choppy feeling of videos caused by high shutter speeds.

Use a single third-party gelatin filter, designed for use with camera lenses, and cut it to size:



Carefully slide the gelatin filter into the holder, covering the two rear elements

f/2.8 — Great low light performance

With an aperture range of f/2.8 to f/16, the RF 5.2mm F2.8L DUAL FISHEYE has great low light performance. Along with Canon's high-performance CMOS sensor and DIGIC X processor, images demonstrate a high noise reduction capability for clear, clean images in low light.

Automatic Exposure

Automatic exposure through the lens is calculated in the same way as usual, however, it should be noted that the automatic metering range is limited to within the image circle of the left lens (the right hand image as seen on the back of the camera).

Also, if shooting stills, then because this is an ultra-wide lens, there may be large discrepancies in the exposure value for auto exposure in close range flash

photography. Therefore, it is recommended to use a light meter and set the exposure manually.

Manual focusing only

The RF 5.2mm F2.8L DUAL FISHEYE lens has no USM motors and is manual focus only with a closest focusing distance of 0.2m (7.9 in.).

The lens focus ring and focusing system are mechanically linked, allowing for a short movement of the focusing ring between two hard stops, indicated by two white dots on the lens body.

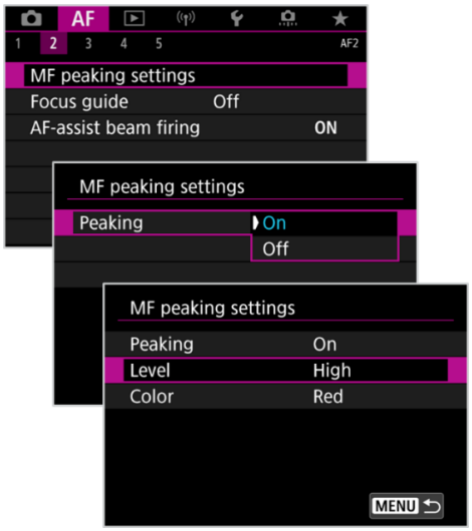
Limits of the manual focusing ring

- Because this lens does not have a depth of field scale, the image should be focused while viewing the live view image.
- The focusing ring rotation direction cannot be changed (mechanical manual focus system).
- The sensitivity for MF on this lens cannot be changed.
- Touching the focusing ring during shooting could shift the focusing position.

Focus Peaking

A manual focus peaking feature is provided by the EOS R5, highlighting outline of in-focus subjects in colour during manual focusing, making it easier for the videographer to focus. Users can also change the outline detection sensitivity (level) and outline colour as required.

With EOS R5, this function is effective even when the image is magnified*.
**Note: When shooting at high ISO sensitivity, noise may occur and may be erroneously detected, resulting in decreased peaking accuracy.*



In-focus subjects are highlighted by coloured outlines

Peaking also works when magnified

Dual Pixel Focus Guide

Even though the system does not support Canon's Dual Pixel CMOS AF capability, it can still use the technology to provide the Dual Pixel Focus Guide on screen graphics

to aid the user attain focus with this feature. The Dual Pixel Focus Guide will appear by default in the centre of the frame in right hand image on the camera's LCD (left side lens, viewed from shooting position behind the camera). This can then be moved to the centre of the left-hand image on the LCD (right hand lens) if required, but cannot be moved off centre from either side.

Lens focus difference adjustment

A left-right focus differences in this lens can be adjusted by turning the left-right focus difference adjustment screw/dial and can be found on the right lens only. When first mounting this lens on the camera, or when using the lens after a long period of transportation, a check of the left-right focus should be made. If the left and right focuses differ, then the focus should be adjusted, using the left-right focus difference adjustment dial.

Left-right focus difference adjustment dial

The procedure for checking and adjusting the left and right focus positions is as follows:

1. Set the camera to f/2.8 and use the magnify button **<🔍>** to enlarge the image on the left lens (right hand image on the camera's LCD screen) and turn the focusing ring to set the focus.

- The default on the EOS R5, is to show the enlargement frame in the centre of the left lens image. Manually adjust focus for the left lens first. The enlargement frame can also be displayed in any position in the left or right lens image by touching the camera's LCD.
- While the enlarged image is displayed, the display can be switched between the left and right lens enlarged images by pressing the **<INFO>** button on the camera.

Magnify button

Press the INFO button when magnified to swap between left and right images to easily check for focus differences

Dual Pixel Focus Guide – arrows and frame turn green when in focus

Magnifying frame

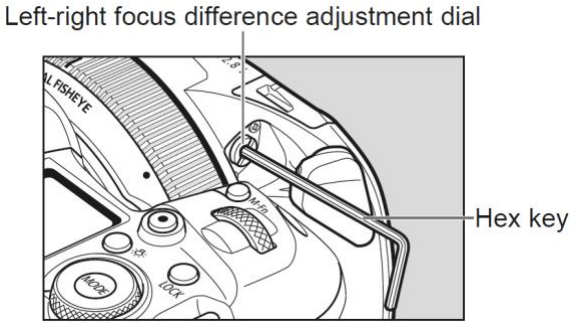
2. Press the **<INFO>** button on the camera to switch to the enlarged image from the right lens.

- If the enlarged image is in focus (obtained by focusing with the left lens, viewed on right side of the camera's LCD screen) after switching to the enlarged image from the *right lens*, no adjustment is needed. If the image is out of focus, then the focus will need to be adjusted.

3. Remove the cap on the left-right focus difference adjustment dial (right lens).

4. Use the bundled 1.5mm hex (Allen) key to turn the left-right focus difference adjustment dial and adjust the focus. Standard, commercially available 1.5mm hex (Allen) wrenches/keys can also be used for this adjustment.

- Turning the left-right focus difference adjustment dial roughly ±90° moves the right lens by the maximum amount.
- Turning the left-right focus difference adjustment dial more than ±90° reduces the amount of right lens movement, and turning the dial ±180° returns the right lens to its starting point (zero movement).



- If the enlarged image for the right lens is in focus, adjustment is complete.

Basic shooting guidelines

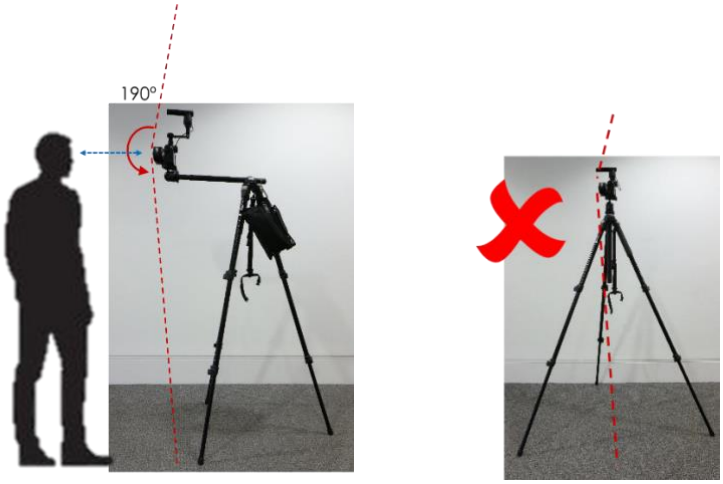
The below information aims to add to the information and advice already provided.

Clean the lenses

Since the focal length is short, foreign objects like dust on the front/back lens can be captured, a blower should be used to remove dust and dirt before shooting to reduce the risk of seeing dust or ghosting.

Level and stable?

- The camera/lens should be level at all times — use a tripod (and use the camera's electronic level display) or gimbal.
    - Note: the camera should be mounted/held at about typical adult head height for shooting, to capture a more realistic and comfortable point of view, as if the viewer was standing in that same position themselves.



- Due to the extreme wide angle of view, care should be taken to avoid getting the operators body, tripod legs, gimbal, microphone, cables etc in the shot. The screen should be checked carefully for anything that is not wanted in the frame, and the camera and accessories should be mounted in such a way as to avoid these.
- Care should be taken to avoid camera shake when shooting. A VR movie shot when riding in a moving vehicle or while walking could cause a sense of fatigue or discomfort.
- Movies should not be shot that involve extreme movement. Doing so may cause the user to experience motion-sickness when viewing the VR movie, especially using headsets.

Focusing:

- The minimum focusing distance for this lens is 0.2m (7.9 in.). If the subject is too close, then it will not be possible to view the image correctly and could make the viewer feel uncomfortable.
- This is a Manual Focus only lens:
    - The Dual Pixel Focus Guide can be enabled to help focus, but it is advised to use Focus Peaking in magnified view for greater accuracy / fine tuning.

    - Note the magnified window can be moved around the frame by using the camera's joystick or by touching the LCD screen.
- Set the camera to f/2.8 and check the focus difference between the left and right lens to ensure both lenses are correctly synchronised for focus — see the Lens Focus Difference Adjustment section on age 21 of this document for more details.

Exposure:

Please see the previous section on auto exposure control, noting:

- Set the cameras aperture to balance the light gathering and depth of field requirements, along with the use of gelatin ND filters in bright conditions.
- The AE (automatic exposure) metering range is limited to within the image circle in the **left lens**.
- In general, Manual exposure mode is recommended for consistent results, although all Automatic exposure modes will function.

Monitoring the output:

There is no way to monitor the VR output from the EOS R5 with a head mounted display during recording. However, it is possible to use either EOS Utility or Canon's Camera Connect applications to view a live side-by-side preview (dual fisheye images, on-screen) remotely of the scene to be captured. In these applications it is possible to independently perform a left-right eye switch and view a live preview of the equirectangular projection, to more easily view/frame the scene.

Audio

By default, the audio captured is from the EOS R5's built-in microphones, but this will not provide the best audio experience, since it will not be as immersive or as high a quality as an external microphone.

A simple stereo upgrade to the audio, will be to use Canon's stereo microphones DM-E1 (set to 120°) or the DM-E100. Using the 120° pickup will help increase the stereo audio effect, but will not 'move' the sound's source location with the user's head movement when wearing a head mounted display. Also, an adapter, plate or rig will be needed to place the microphone further back from the lens, so that it is not picked up by the super wide 190° field of view!

Ambisonic microphones

For the capture of true spatial audio, ideal for VR productions, then a specialist Ambisonic microphone is required to achieve this immersive audio experience.

Typically, an Ambisonic microphone will have four capsules in a tetrahedral array to record 360° audio on four channels and requires a compatible audio recorder. Recording the audio in such a way allows for a fully head-tracked audio experience when combined with the video footage in the correct way in post-production. However, this requires time and expertise to ensure the audio and video tracks are correctly synchronised, with the correct metadata and the direction of the

microphone is correctly mapped. To repeat, it is not possible to record Ambisonic audio directly into current Canon EOS cameras, even when using a dedicated, third-party Ambisonic microphone.

Supported File Types — EOS VR Utility

		Format	Frame Rate	Whether the app supports the format	
Movie	8K	MP4 (Canon Log OFF)	up to 30fps	Yes	In case frames are dropped with ALL-I, etc., depending on the PC environment, it is necessary to convert the footage to 4K with a conversion application and then check the footage.
		MP4 (Canon Log 1, 3)			
		RAW movie		No	
	8K/4K	Time-lapse movie		Yes	Supported video format is UHD.
	4K	MP4 (Canon Log OFF)	up to 60fps High-frame rate (120fps, No sound)	Yes	
		MP4 (Canon Log 1, 3)			
Still		JPEG	—	Yes	Played back by HMD such as Oculus via PC.
		RAW/CRAW	—	No	
		HEIF	—		

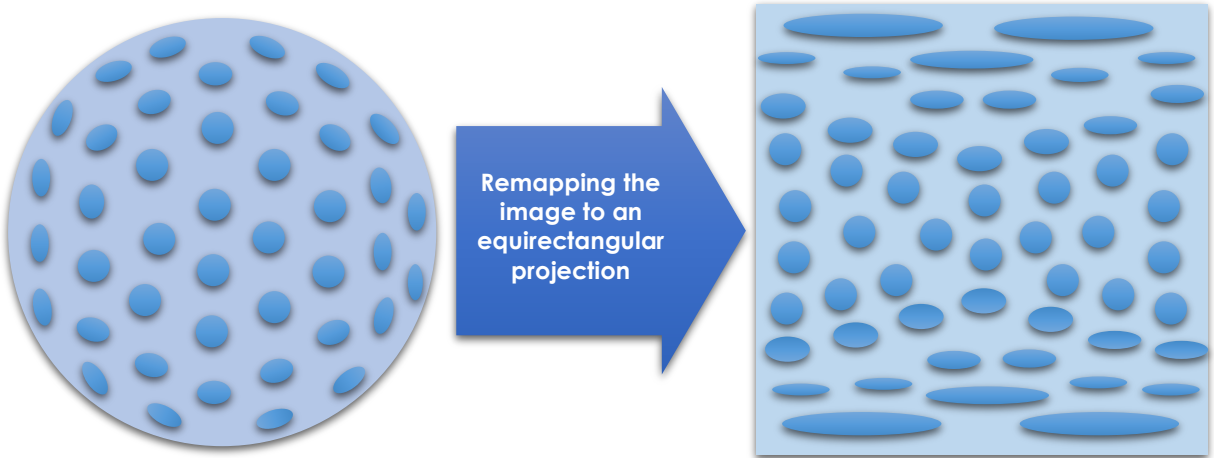
**RAW movie recording is possible with the EOS R5, but is not supported by the EOS VR Utility or EOS VR Plug-in for Adobe Premier Pro for Equirectangular Projection.*
**VR metadata is embedded in the file.*

Equirectangular projection

Probably the most popular format for VR imagery is the Adobe standard, that uses equirectangular projection, which is a 'flattened' square / rectangular representation of the originally captured 180° (or 360°) circular fisheye image. This is the standard Canon supports.

Converting a circular fisheye image captured by the RF 5.2mm F2.8L DUAL FISHEYE lens and remapping that image into an equirectangular projection, is a similar process to that used in the cartography industry* where they take a spherical image of the world and remap it onto a flat rectangle.

**Cartographers would need to take the full 360° sphere of the world and remap to a 2:1 aspect ratio equirectangular projection, whereas the RF 5.2mm F2.8L DUAL FISHEYE lens captures a 180° equivalent image for a 1:1 aspect ratio output per lens.*



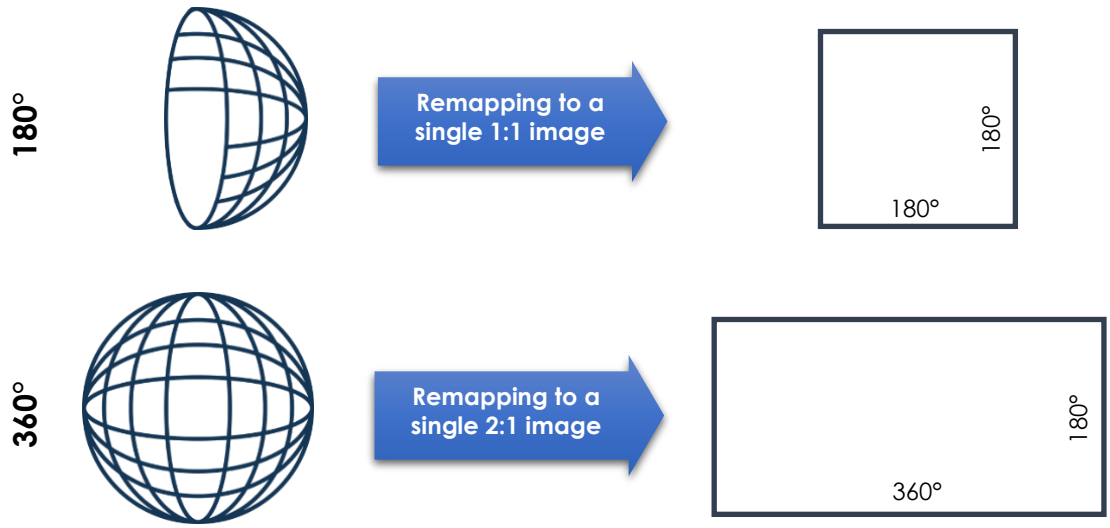
Circular fisheye
(180° image)

Equirectangular projection
(180° x 180°)

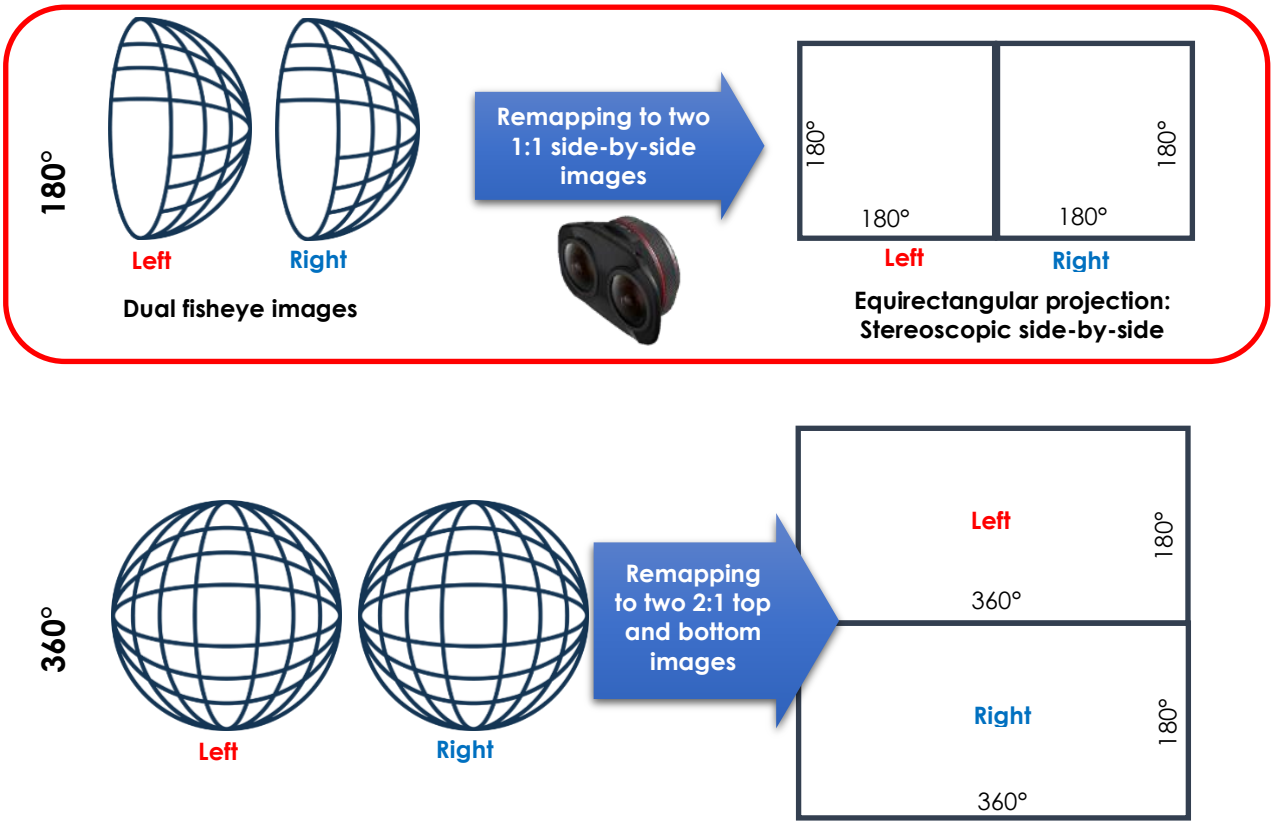
We can see that by remapping the circular fisheye image into an equirectangular projection, that the outer most pixels are 'stretched' more relative to the other pixels in the image, filling the corners of the frame.

Therefore, lens edge-to-edge performance and image resolution have a significant effect on image quality, particularly in the corners/periphery and the feeling of realism / reality when viewed on a Head Mounted Display. Canon's lens design, UD-glass elements and manufacturing expertise aims to maximise this edge-to-edge performance on capture, to help improve the image quality during conversion to an equirectangular projection.

Monoscopic conversion to equirectangular projection:



Stereoscopic conversion to equirectangular projection:



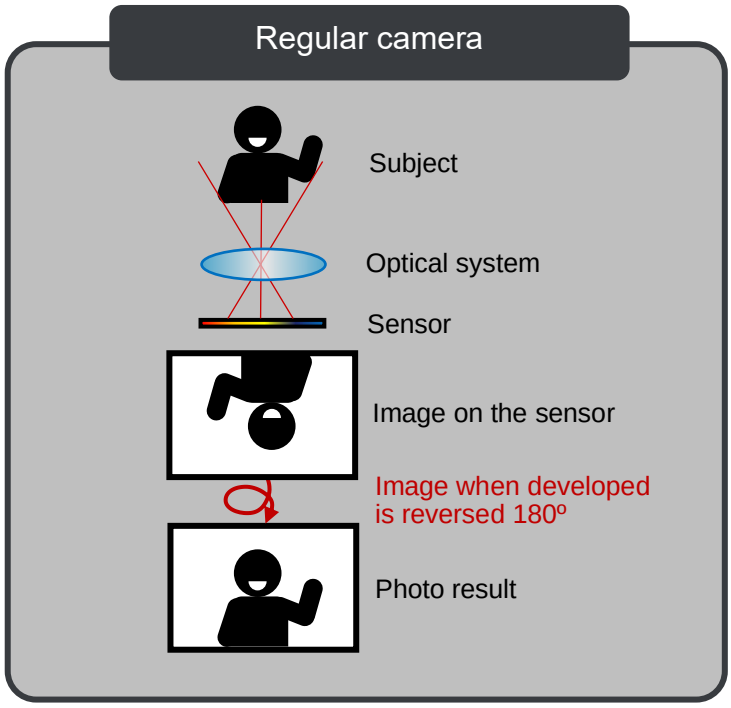
VR Imaging process with the RF 5.2mm F2.8L DUAL FISHEYE lens

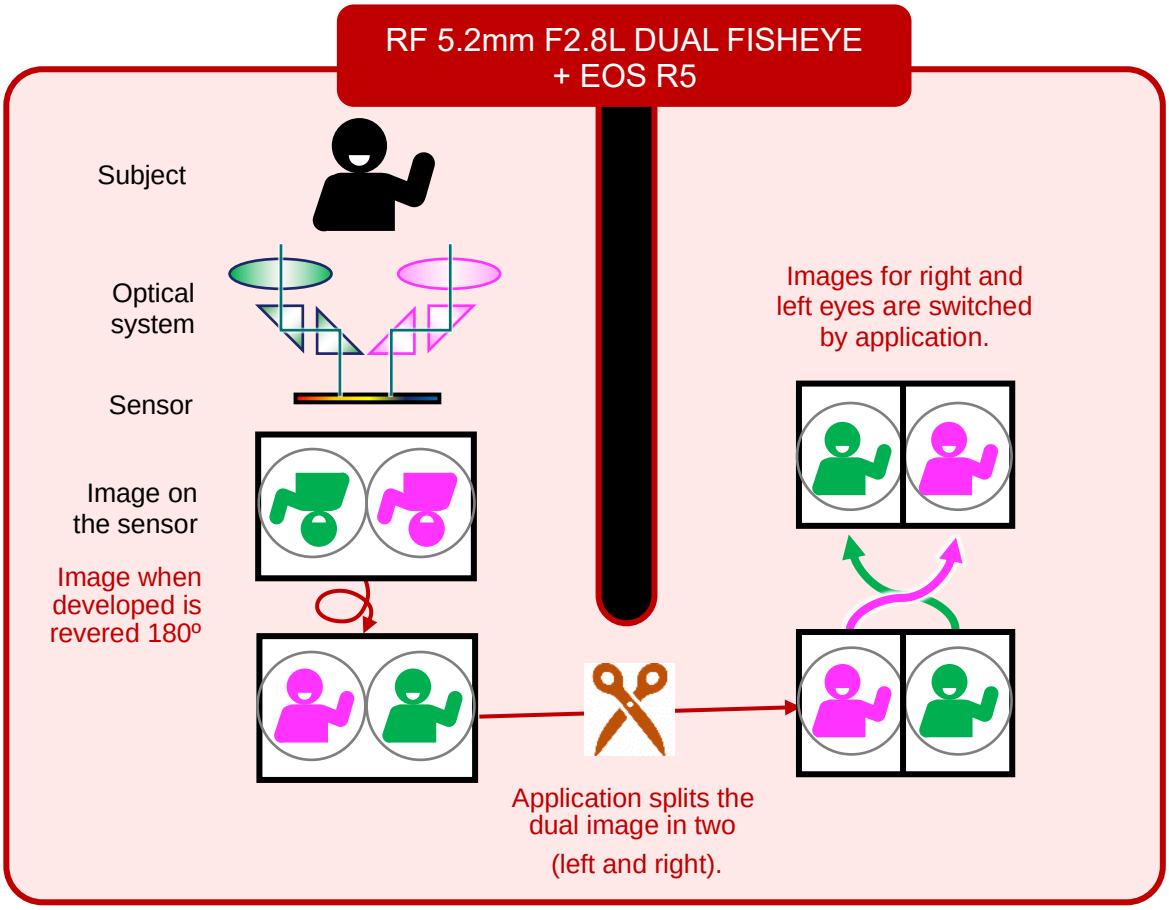
With a 'regular' camera/lens, the image is recorded upside down.

The same is true for the RF 5.2mm F2.8L DUAL FISHEYE lens, but records a dual, side-by-side image. However, when rotated 180° the correct way up, then the left-right orientation of the images is now incorrect.

This can be seen on the rear LCD of the camera.

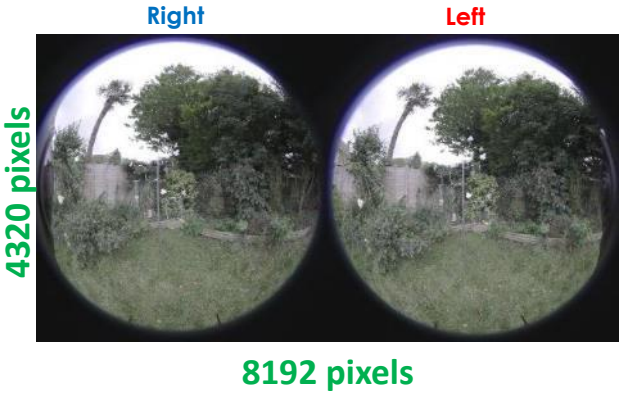
Therefore, when using Canon software and as part of the conversion to an equirectangular projection, an additional step is required to split the image in two and reposition the left and right image into the correct orientation.





DCI (or UHD) 8K file captured by the EOS R5

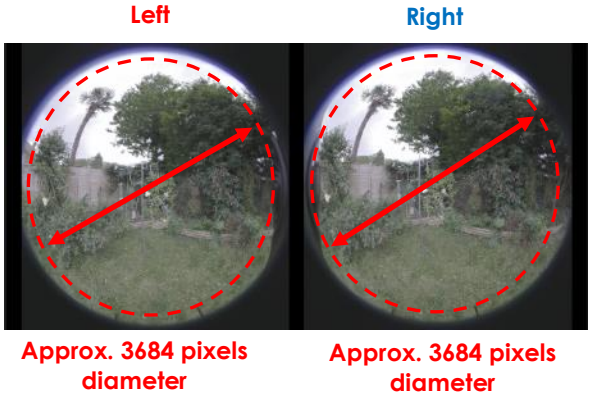
Capture



The stereoscopic fisheye images are captured by one sensor onto a single file. Right and left lens images are initially captured in reverse order, as viewed on the camera's LCD screen.

EOS VR Utility — pre-conversion

Process



Left and right eye image are automatically swapped to the correct position/order.

The 'Equirectangular projection' check box can be selected to review the converted circular fisheye image.

The EOS VR Utility, effectively, slightly crops the image circle per eye and on the EOS R5, uses an approx. pixel diameter of approx. 3684 pixels per eye in the conversion process to an equirectangular projection.

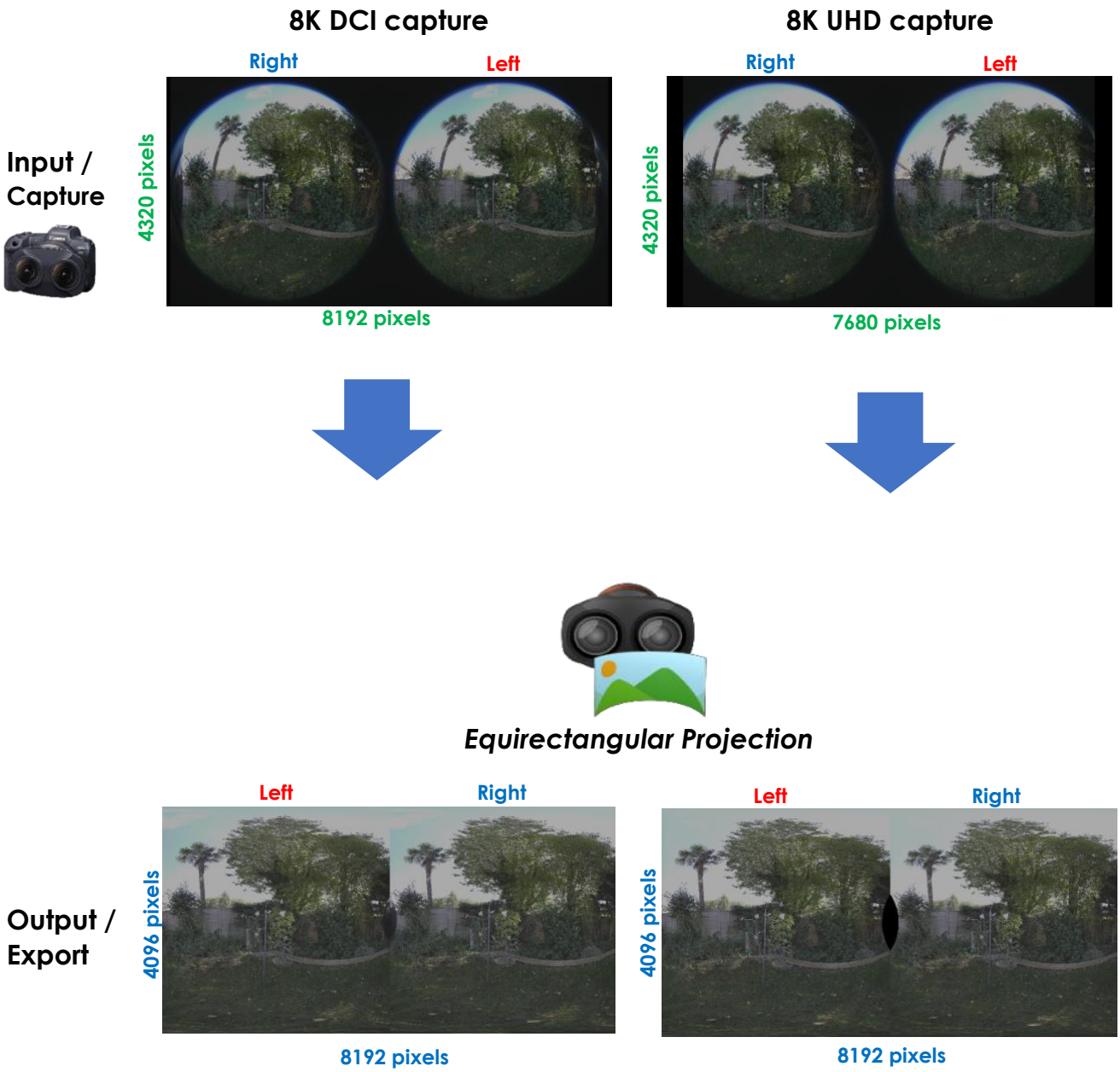
Equirectangular projection — Export

Output:
View / Edit

The final image is ready for export to the desired resolution (an 8K size output is recommended for best image quality) and into a side-by-side stereoscopic (2:1 aspect ratio) VR format. A choice of professional codecs is provided.

This file can then be transferred and viewed in a compatible head mounted display, or imported into a compatible NLE system, such as Adobe Premier Pro, for further editing, grading and integration into a production timeline.

8k DCI vs 8K UHD capture and conversion views



Note: Any possible lens manufacturing errors, mount errors and environmental changes that may affect deviations in the image position are effectively reduced and corrected by algorithms in the Canon software.

Software

Canon have introduced two new dedicated VR applications/plug-ins and have updated the existing EOS Utility and Camera Connect applications:

Required

EOS VR Utility

EOS VR Plug-in for Adobe Premier Pro

These are **required applications** to convert the captured circular fisheye images to an **equirectangular projection** — videos greater than 2 minutes require a paid for subscription to be able to save.

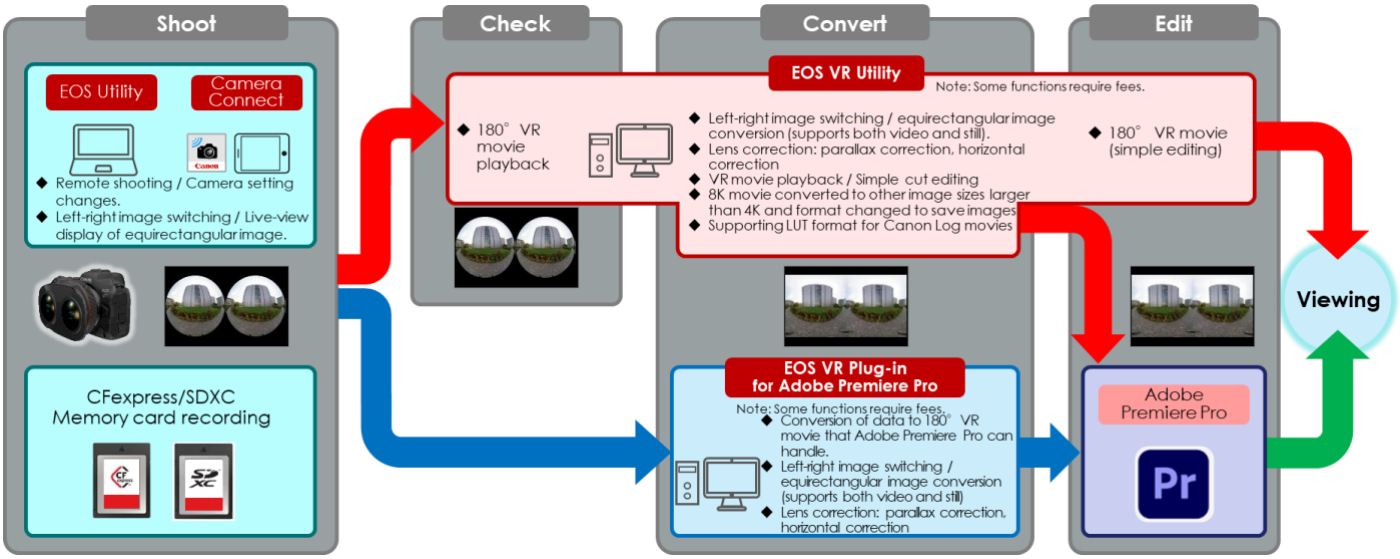
Optional

EOS Utility

Camera Connect

Remotely control the camera settings, view a live preview and shoot.

Post-Production Workflow



Supported VR standard: *Adobe's 180° VR standard (an industry standard, editable in Adobe Premier Pro with an upload format for YouTube)*

External recorders: *Footage recorded to an external device via the HDMI terminal are not supported by EOS VR Utility or the EOS VR Plug-in.*

Recommended computer specifications, or better:

The following specifications or higher are recommended for smoother operation at the higher image quality levels being processed (e.g. MP4 — 8K ALL-I files at 30fps) – the more CPU cores the better.

Windows 10 (64-bit) Pro or Home	Apple Mac (MacOS 10.15.11)
2x Intel Xeon CPU E5 -2687 W v3 3.1 GHz CPUs At least 32 GB RAM	Intel Xeon W 2.5 GHz 14 core CPU At least 32GB RAM *(No native support for Apple Silicon, as of October 2021)*

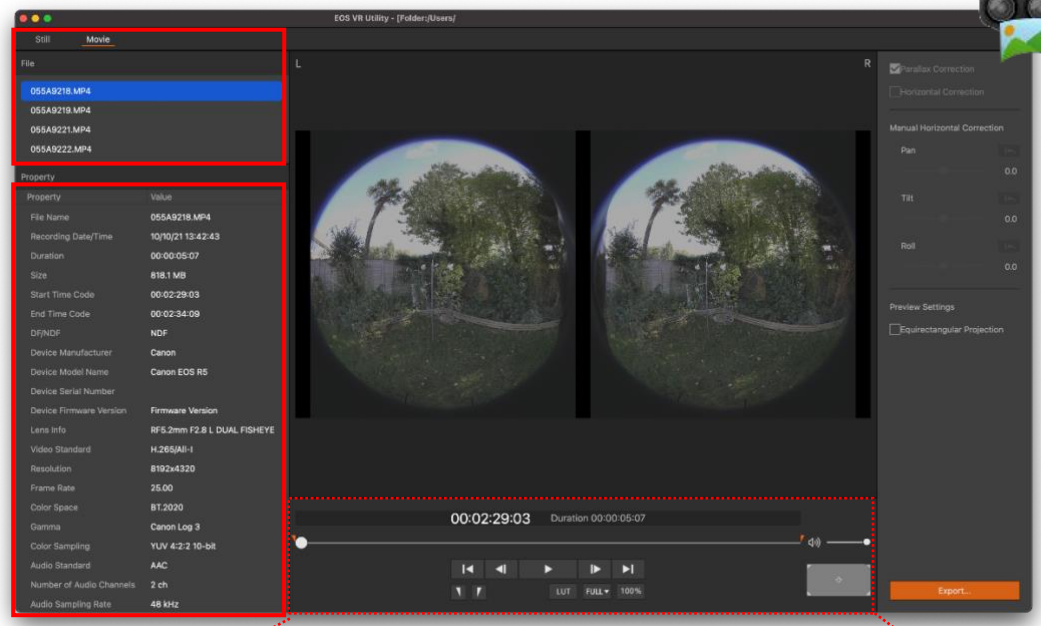
EOS VR Utility

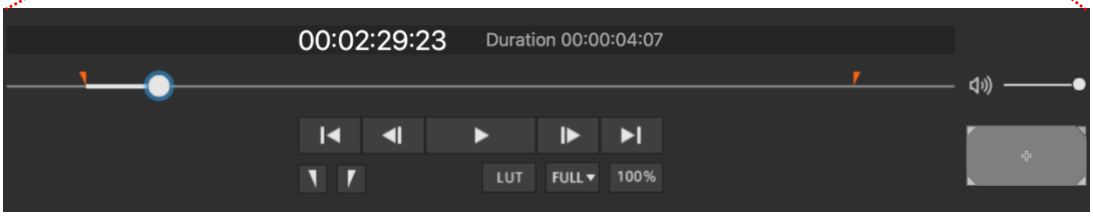
Once installed, opening EOS VR Utility will show a window similar to below (Mac screen shown). An automatic left and right eye switch is performed to place the left and right eye image in the correct position (since the original captured image is recorded as right eye and left eye, in that order).

Preview image below shows the circular fisheye view:

File window: Select "Still" or "Movie", then select the file to view.

Property window: Displays the file properties and metadata





Edit options:

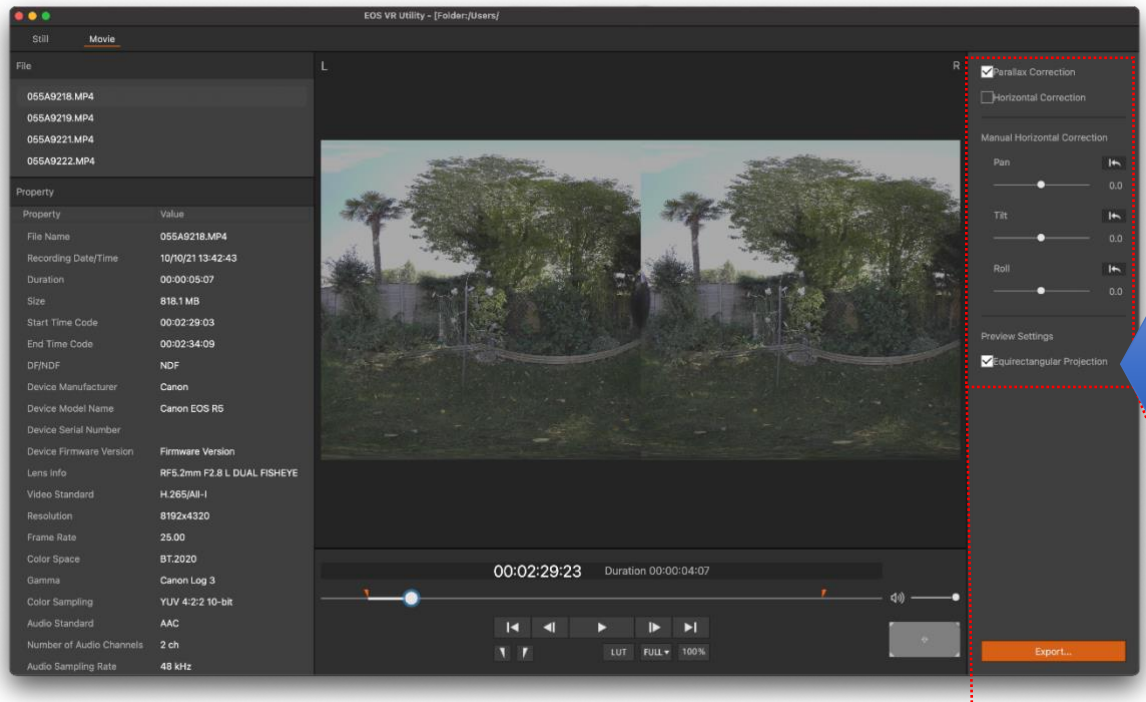
- Replay the video
- Mark in and out points for video export
- View at 100%, and scroll around the image for inspection
- Select FULL, ½ or ¼ resolution for processing
- Apply at **LUT** in preview (LUT applied is BT.7069 Wide-DR) — only available if recorded with Canon Log / Log 3

Canon Log 3 — flat image, ideal for grading

LUT

LUT applied — BT.709 Wide-DR

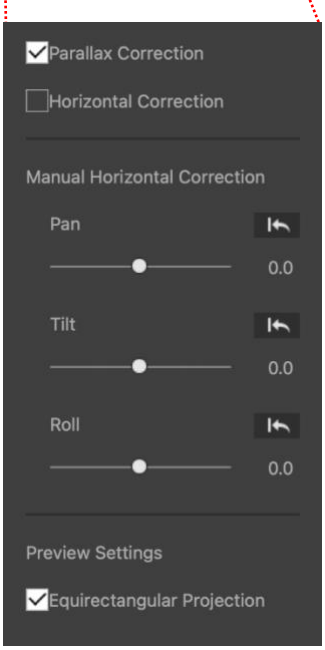
*Preview image below now shows the '**equirectangular projection**' view:*



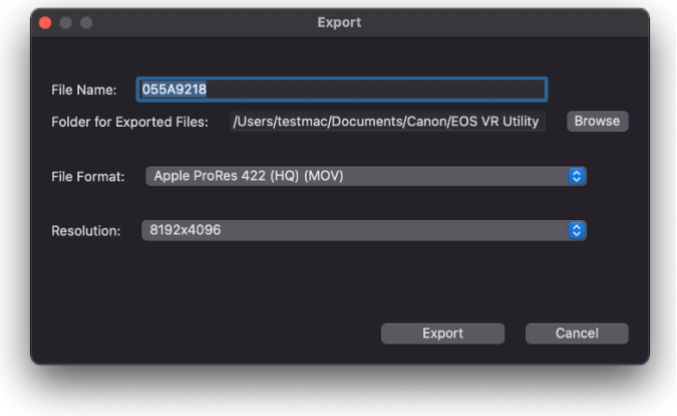
Correction options:

- Parallax Correction
- Horizontal Correction
- Manual Horizontal Correction
    - Pan (+/- 5 degrees)
    - Tilt (+/- 5 degrees)
    - Roll (+/- 5degrees)

- **Equirectangular Projection** (preview)
  Select this to see a preview of the final output file upon '**Export…**'



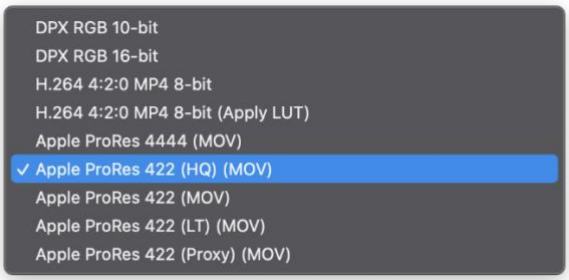
Export:



Selecting the 'Export…' button in the main window, opens the export window.

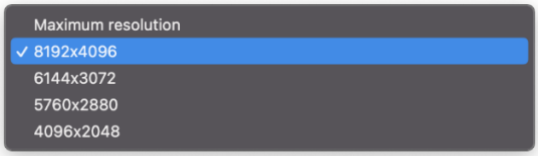
Here, you can select the:

- Destination folder
- Desired codec / file type
- Output resolution



Certain codecs will be limited, depending on the shot parameters.

*Note: For **'still' images**, it is only possible to export as a JPEG file, up to a maximum of 8192x4096, with a quality setting of between 1 and 10.*



It is not possible to export to a higher resolution than the captured resolution i.e. if recorded in 4K then it is not possible to output in 8K

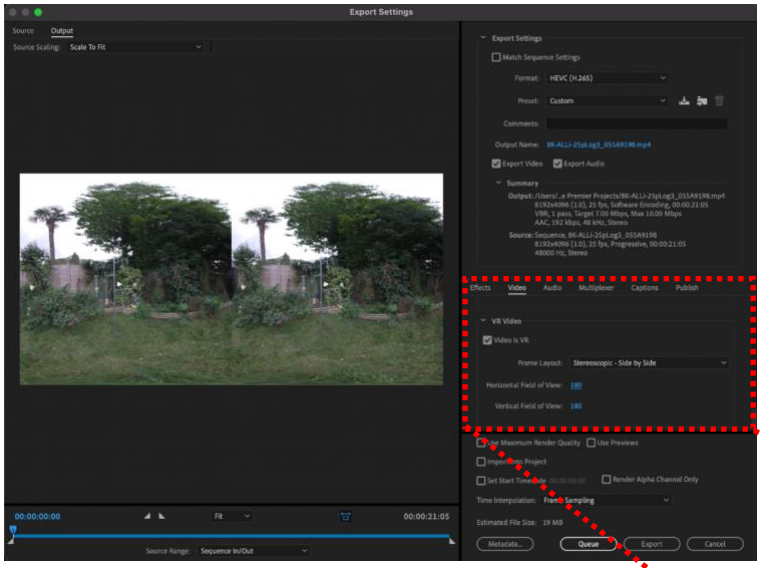
EOS VR Utility benefits:

- No stitching of multiple images
- No synchronisation issues
- Only fine tune the horizontal correction, IF required
- Simple **one step conversion** to an **Equirectangular Projection and export**

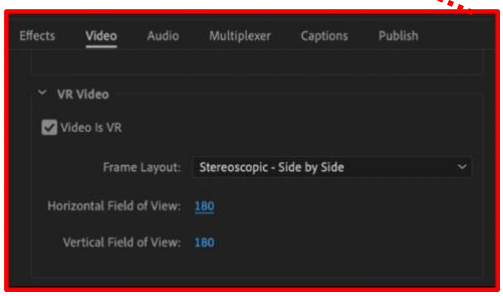
EOS VR Plug-in for Adobe Premier Pro*

Installing Canon's EOS VR Plug-in for Adobe Premier Pro streamlines the conversion and workflow process further, when wanting to use an NLE application for post-production editing and grading. Use Adobe Premier Pro v.14.5 or later.

Installing the application enables the user to simply open Adobe Premier Pro and 'Import' the camera's VR files directly, without needing to use EOS VR Utility. The files are automatically switched for correct left and right eye orientation and converted to an 'Equirectangular Projection' upon import and placed in Adobe's media window. These files are then ready for inserting into the user's timeline where they can be cut and graded etc as required for final production output. If ambisonic audio has been recorded at time of capture, then this can now be added and synced with the camera footage for an even greater immersive experience when viewed on a head mounted display.



When exporting from Adobe Premier Pro for VR, select "Video is VR" in the Export window and ensure the Frame Layout is set to "Stereoscopic - Side by Side", with the Horizontal and Vertical Filed of view, both set at "180".

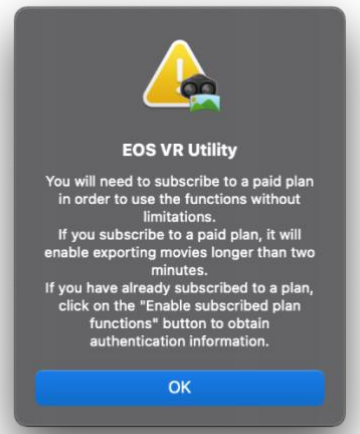


** A separate paid Adobe Creative Cloud subscription is required for access to Adobe Premiere Pro and other Adobe brand software. This is independent of paid subscription required for full access to Canon EOS VR Utility software, and EOS VR Plug-in for Adobe Premiere Pro.*

Subscription service

A paid for subscription service is needed to convert for export or import videos file that are longer than two minutes to an Equirectangular Projection.

Once **EOS VR Utility** and **EOS VR Plug-in for Adobe Premier Pro** have been installed, and upon opening EOS VR Utility or importing to Adobe Premier Pro, a message will be shown informing the user of paid for subscription service that is required to enable the conversion of video files of longer than two minutes.



Note, still images and video files shorter than two minutes will not need use of the subscription service to operate EOS VR Utility or use the plug-in. In this case, users can simply reject the subsequent question to sign up or manage a subscription and continue to use the applications.

If this service is required, a low monthly fee or (reduced) annual fee will be charged to the user. Users simply need to follow the prompts and messages which appear in the application and they will be taken to the Canon subscription portal and subsequent payment facility.

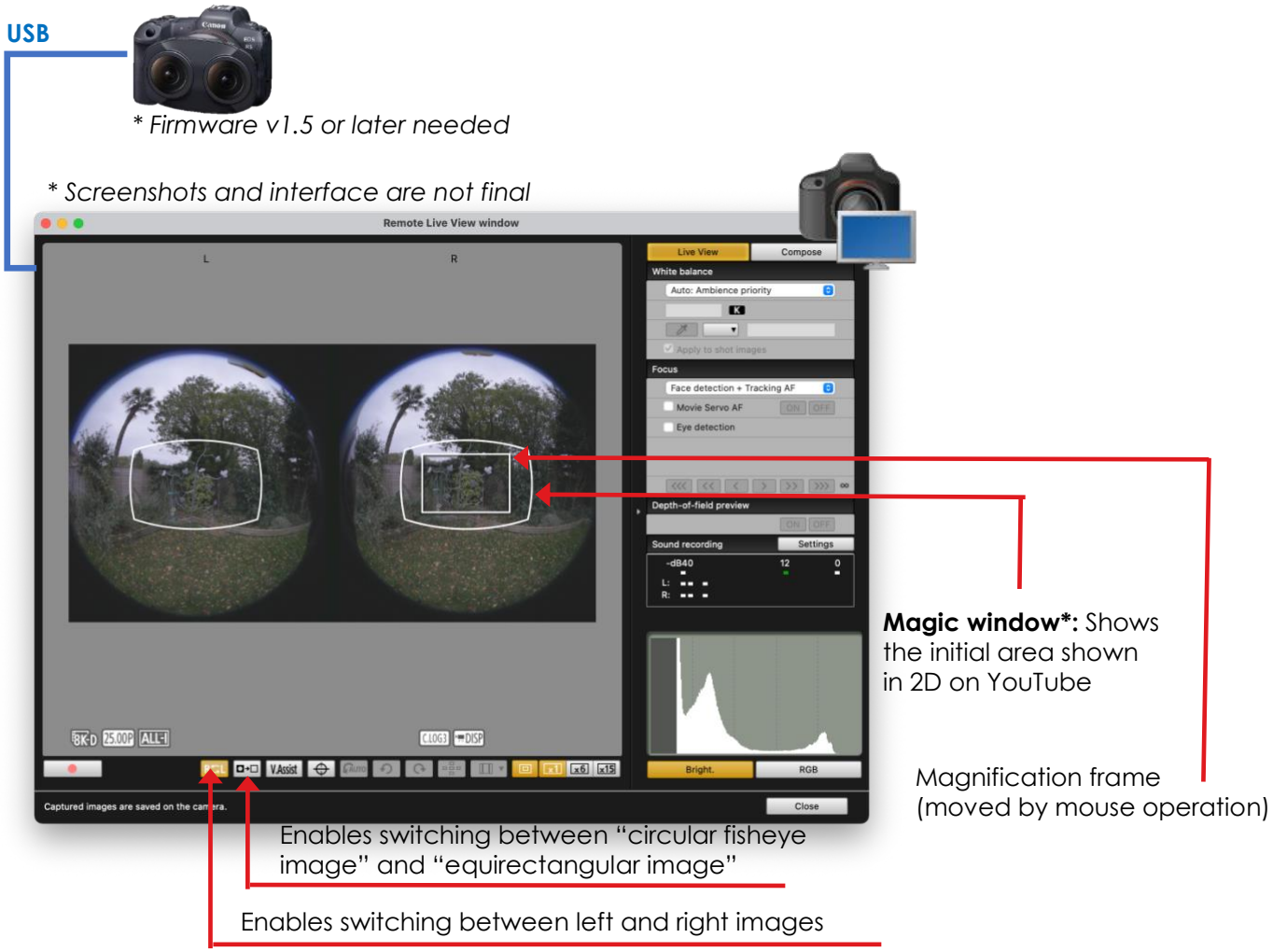
- A Canon ID will need to be used or created
- A subscription plan will be required for each application used
- Subscription plans and users can be managed from the Canon subscription portal
- Monthly service plans can be cancelled for the next month
- VAT receipts will be available
- This is separate from any requirements for paid subscriptions to Adobe's Creative Cloud, or other third-party software services

Remote capture

EOS Utility (Win/Mac)

EOS Utility (not to be confused with the EOS VR Utility software) supports remote shooting from a computer and automatically detects when the RF 5.2mm F2.8L DUAL FISHEYE lens is attached to the camera, enabling additional functions for VR capture.

- Switch left and right eye images to the correct orientation
- Display the live preview in either circular fisheye format or as an equirectangular projection, enabling easier visualisation for setup
- Magnified view (but not in equirectangular projection preview)
- Enables the level tool



Magic window: *The magic window size is 2045 pixels horizontally and 1391 pixels vertically with a horizontal angle of view of 100 deg and vertical angle is 68 deg.*

Camera Connect App (iOS / iPad OS / Android)

Camera Connect enables WiFi connection to smartphones and tablets for convenient remote shooting outdoors, automatically detecting when the RF 5.2mm F2.8L DUAL FISHEYE lens is attached to the camera, enabling additional functions for VR capture.

- Switch left and right eye images to the correct orientation
- Display the live preview in either circular fisheye format or as a side-by-side equirectangular projection, enabling easier visualisation for setup
- Magnified view (but not in equirectangular projection preview)
- Change camera settings

APPENDIX

Specifications – RF 5.2mm F2.8L DUAL FISHEYE

Optical Features/Specifications		
	Image size	Full Frame
	35mm film equivalent focal length (mm)	-
	Angle of view (horzntl, vertl, diagnl)	190°, 190°, 190°
	Lens construction (elements/groups)	12/10
	Special optics	2 x UD
	Special features	Dual Fisheye with Baseline length of 60mm
	No. of diaphragm blades	7
	Minimum aperture	16
	Closest focussing distance (m)	0.2
	Maximum magnification (x)	0.03
	Control Ring	No
	Image stabilizer OIS[1]	-
	Image stabilizer IBIS x OIS[1]	-
	AF actuator	-
	Coatings	Super Spectra, SWC
	Fluorine	Front
Physical Specifications		
	Dust/moisture resistance[2]	Yes, rubber ring on lens mount
	Exterior coating	-
	Filter diameter (mm)	Rear-mounted gelatin filter (35x20mm)
	Max. diameter x length (mm)	(121.1 x 83.6) x 53.5
	Weight (g)	350
Accessories		
	Lens cap	Lens Cap 5.2 (centre pinch type)
	Lens hood	-
	Lens case/pouch	LS1014
	Rear cap	Lens Dust Cap RF
	Extender Compatibility	Not Compatible
	Other Accessories	Hexagon wrench

[1] *Tested under CIPA standards*
[2] *Lenses with dust/moisture resistance are fitted with a rubber ring on the lens mount which may cause slight abrasion of the camera mount. This in no way effects either the lens or camera performance.*