



Pursuing the Ideal Portrait Lens

RF85mm F1.2 L USM
Developer's Interview



The RF85mm F1.2 L USM development team



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A portrait lens boasting amazing high image quality thanks to the RF mount

The large-diameter, short back focus characteristics were utilized to achieve superb high image quality from f/1.2.

Q: What were some thoughts behind the RF85mm F1.2 L USM as you started this project?

Kawai (Product Planning): Our aim was to achieve a portrait lens with amazing optical performance, unstintingly incorporating Canon's optical technologies and utilizing the great level of freedom in design provided by the RF mount. The Canon portrait lenses currently on the market deliver an extremely high level of resolution, making it possible to capture sufficiently sharp images even when they are enlarged. However, even with such high performance lenses, when shooting from the widest aperture of f/1.4 or f/1.2 at a wedding, for instance, green and purple color fringing may stand out on pure white items such as the wedding dress and bouquet, and any shiny accessories. I sometimes shoot weddings, and I have always felt that color fringing on white clothing does not represent what people really want in a portrait on such a special day. So with this in mind, we decided to utilize the greater freedom in design allowed by the RF mount and make the most of Canon's advanced optical technologies cultivated over many years to achieve superb optical performance, and create a lens that captures subjects as beautiful as they look in person. We analyzed feedback from pro photographers during planning and development, aiming for a lens that pros on the front lines of photography can use for a long time without worrying about it becoming obsolete. Another area we were unwilling to compromise on was the pro specifications of toughness and durability as an L series lens so that professionals and enthusiasts can hold onto this lens and use it for a long time without worry.

Q: Why did you choose 85mm f/1.2 specs instead of 85mm f/1.4?

Kawai (Product Planning): The reason for this is that the combination of stunning sharpness in the focused areas and the extremely shallow depth of field of f/1.2 deliver unprecedented imaging expressions. The EF85mm f/1.4L IS USM, which went on sale in 2017, became very popular thanks

to its fast f/1.4 aperture and image stabilization mechanism (IS). However, even after the launch of the EF85mm F1.4L IS USM, the EF85mm f/1.2L II USM, which was available at the same time, has remained popular among users who desired to use f/1.2, and both models have had strong supporters. Although the RF50mm F1.2 L USM which went on sale earlier is a very sharp lens, the longer focal length of the RF85mm F1.2 L USM produces in stronger bokeh. Portraits that use the shallow depth of field of f/1.2 have unique beauty. Achieving amazing high image quality from the widest aperture setting on the RF85mm F1.2 L USM delivers a beautiful bokeh quality not found on other lenses, and amazing resolution to an extremely high degree, embodying a new type of imaging expression in portrait photography, which is why f/1.2 was chosen.

The Canon 85mm f/1.2 has over 40 years of history, and is a synonym for portrait lenses.

Q: Tell us about the historical 85mm f/1.2 lens and the technological challenges of that time.

Kawai (Product Planning): Canon's 85mm F1.2 lenses have a long history, and it has been over forty years since we have launched the first lens with the same specs. During all those years, the 85mm F1.2 spec has not changed, but the technology inside has evolved. The FD 85mm F1.2 S.S.C. Aspherical was the first Canon 85mm F1.2 lens and went on sale in 1976. At the time it was launched, it was the 85mm with the fastest aperture in the world at f/1.2 as an SLR lens. Mass production techniques of aspherical lenses had just been established around that time. This technically-challenging lens elements made possible the f/1.2 aperture. Later, lenses evolved with the New FD 85mm F1.2L, the EF85mm f/1.2L USM, along with mount changes and a switch to autofocus, with the current EF85mm f/1.2L II USM going on sale in 2006. Although it has been over ten years since it launched, the popularity due to its strong, beautiful bokeh thanks to the 85mm F1.2 spec remains popular, and is

counted as one of the go-to lenses among professional portrait and wedding photographer. The new RF85mm F1.2 L USM features stunning performance and the amazing 85mm F1.2 specs at the same time, that is ready to usher in a new age thanks to the large-diameter and short back focus of the RF mount in addition to advanced optical technology cultivated over the years.

FD85mm f/1.2 S.S.C. Aspherical

This was the first model in the 85mm F1.2 series, and pioneered what was to come for Canon. It had an aperture of f/1.2, which was the fastest in the world for an SLR 85mm lens at the time of its launch in 1976. It was packed with cutting-edge technologies, such as aspherical lenses and a floating system.



The RF mount brought the dreams of the ideal lens to life for the optical designers.

The ideal lens was made possible thanks to the large-diameter, short back focus of the RF mount.

Q: How much of a difference in design difficulty is there between f/1.4 and f/1.2?

Maetaki (Optical Design): Although one may think there isn't much difference between f/1.2 and f/1.4 when just looking at the numbers, there is nearly a half stop of difference in brightness, in other words, nearly 1.4 times more light is taken in, resulting in a whole new level in terms of design difficulty. The reason designing a large-diameter lens is so difficult is because light generally bends when passing through the lens. This phenomenon is called refraction. When light is refracted, it causes something called "aberrations", which are factors that reduce optical performance. Fast lenses with a low F number require a large-diameter lens elements to take in a lot of light, however, the larger the diameter, the more light beams are refracted when passing along the edge of the lens, which can result in more frequent aberrations. Therefore, in order to obtain the same image quality as a slower lens with a high F number, more

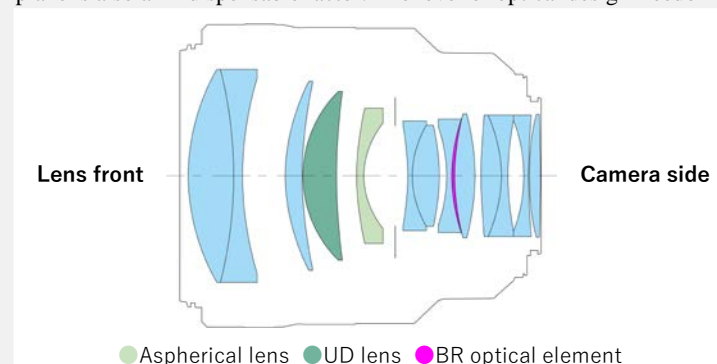
advanced aberration correction is necessary. A half stop difference may not seem like much, but when designing so-called large-aperture lenses such as f/1.2 and f/1.4, this half stop makes a huge difference in terms of design difficulty.

Q: Would it be difficult to create the same lens with an EF mount?

Maetaki (Optical Design): If we had aimed for the same f/1.2 specs and optical performance on an EF mount, we would have needed to increase the number of lens elements to suppress aberrations. Although not limited to this lens, space for a mirror box must be maintained at the rear of an EF lens, so the only space for additional lens elements would be in the front, making the front part of the lens significantly larger. Of course we can design it on paper, however, we believe it is impossible to keep it to a realistic size as a product. With the RF mount, on the other hand, lens elements can be placed close to the focusing plane of the camera with its short back focus. This makes advanced aberration correction possible. Also, the RF mount has the large 54 mm inner diameter, just like the EF mount. The ability to place large-diameter lens elements close to the focusing plane is also an indispensable factor. The level of optical design freedom

provided by the RF mount is thanks to the combination of the two elements of the short back focus and large-diameter mount, and neither one on its own would be insufficient. Not limited to this lens, and something that can be said about many other RF lenses, is that you can see how large the absolute rear lens element (close to the camera) is when looking at the cross-section illustration. It can be said that these specs, performance, and size were all achieved thanks to making the most of the level of optical design freedom provided by the RF mount.

Ichinose (Electrical Design): If the same optical performance as the RF85mm F1.2 L USM was to be achieved on an EF mount, the weight of the focus lens group could be increased due to additional lens elements at the front. Increased weight in the focusing lens group leads to a drop in focusing speed. Also, an increased number of lens elements resulting in a larger lens requires larger mechanical components to hold the lens elements, leading to a larger, heavier product. With these things in mind, even from the electronics and mechanics standpoint, the hurdles would be quite high with the EF mount when you take into consideration a balance of focusing speed, product size and weight.



Optical cross section

You can see that the large-diameter lens elements are almost touching the mount surface

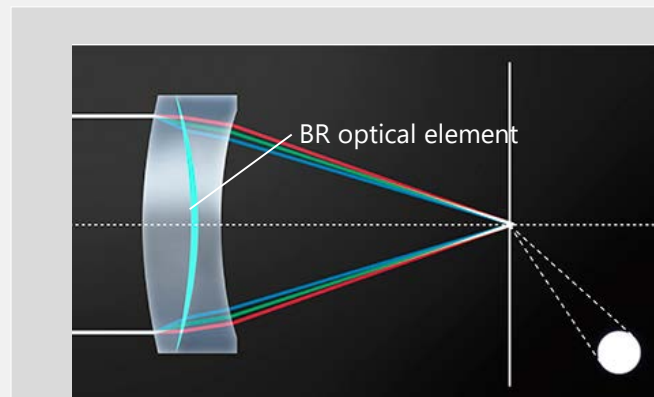


RF mount with a large mount diameter, short back focus

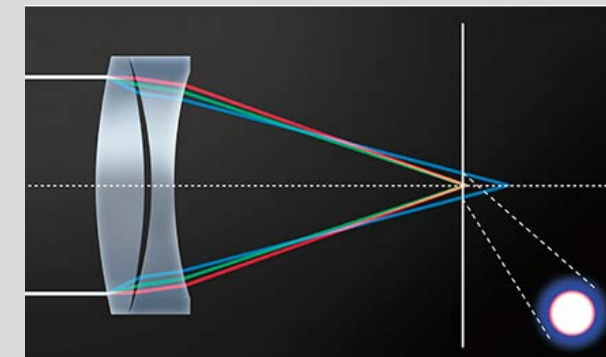
A large mount with a 54mm inner diameter, and short back focus was employed to enable lens element placement near the focusing plane and to achieve a greater level of optical design freedom. This enables optical designs of stunningly sharp lenses with fast apertures, high operational specifications, compactness and/or lightweight.

**Reducing aberrations as close to zero as possible from the widest aperture setting.
BR optics* reached fruition due to unchanging design concepts passed down over many years.**

* BR optics stands for Blue Spectrum Refractive Optics



Blue light is significantly refracted using the BR optical element, and concave and convex lenses are combined to virtually focus light on a single point across the entire wavelength of the visible light spectrum.



Simply combining concave and convex lenses made of conventional materials is insufficient for correcting the blue light wavelength (short wavelength spectrum), resulting in a shifted light collection position and color fringing.

Q: Are there any differences from conventional design concepts?

Maetaki (Optical Design): The lens optics design concept at Canon remains the same as it always has. Points represented as points, lines as lines, and squares as squares. Basically, this means reducing aberrations to zero. At Canon we have the saying “You can’t get rid of too many aberrations”. However, to what extent this can be achieved that depends on the technological level of the time. The EF85mm f/1.2L II USM and RF85mm F1.2 L USM did not have different design concepts, rather differences in technology that could be used at the time. For example, such technology could be BR optical elements, design knowhow, new glass materials, etc.

Q: What did you do to minimize chromatic aberration?

Ishibashi (BR/DS Design): The most significant point in reducing chromatic aberration for the RF85mm F1.2 L USM is the BR optical element. This is the second lens to use a BR optical element after the

EF35mm f/1.4L II USM. In addition to BR optical elements, Canon possesses various optical materials such as fluorite, DO lenses and UD lenses, which correct various types of chromatic aberration, and we carefully select which materials to use depending on the optical system of each lens. Compared with other optical materials, the BR optical element significantly refracts blue colors (short wavelength spectrum). It has extraordinary dispersion properties compared to conventional optical materials, offering sufficient chromatic aberration effects even on extremely thin lens shapes, making it possible to achieve our goal of amazingly high performance. If we didn’t have the BR optical element, we would have needed to increase the number of lens elements in the design, which would have been impossible at this size.

The high image quality is not due to the BR optical element alone, but also a combination of new glass materials resulting from many years of research.

Maetaki (Optical Design): We chose to use various new glass materials that have been developed over ten years in addition to the BR optical element. In parallel with the development of the BR optical element, we focused on studying the extraordinary dispersion of general glass materials from an early stage, working together with glass manufacturers to develop new glass materials, resulting in design technology that proactively incorporates these. This technology grew from seeds that we sewed over five to ten years. Although we did not give these new glass materials any special names, we have focused on various innovations in glass materials in addition to the BR optical element, and a combination of these materials has helped us finally achieve such high optical performance in this lens.

It is our mission as developers to provide the best “raw materials” to users.



Although it is difficult to create an aberration-free image from an image with aberrations, the opposite is comparatively easy.

Q: Some photographers like the EF85mm f/1.2L II USM for its slightly soft depiction of the focused areas, or something they refer to as the lens’ “character”. What is your take on such lens qualities?

Maetaki (Optical Design): Generally, there is no such thing as getting rid of too many aberrations. However, there are limits on size, cost, and available technology, so it is not always possible to completely eliminate aberrations. We of course understand that each lens has its own character. A small amount of aberration remains in actual optical design, which is taken into consideration when balancing bokeh quality, resolution, etc. Actually, this process is quite difficult on a large-aperture f/1.2 lens, and it is accomplished by fine control over all light that reaches the focal plane.

Also, while digital correction has become easier recently, we believe that the original image quality should ideally have zero aberrations. An opposite viewpoint of high image quality is for example, that there are some people who enjoy the character of a lens for its residual spherical aberrations. Even in such cases, although it is difficult to create an aberration-free image from an image with aberrations, the opposite is comparatively easy using image processing technology. In other words, by providing the best possible “raw materials” to work with as image quality, people can use them as-is, or arrange them as they like. As designers, we want to give users that option.

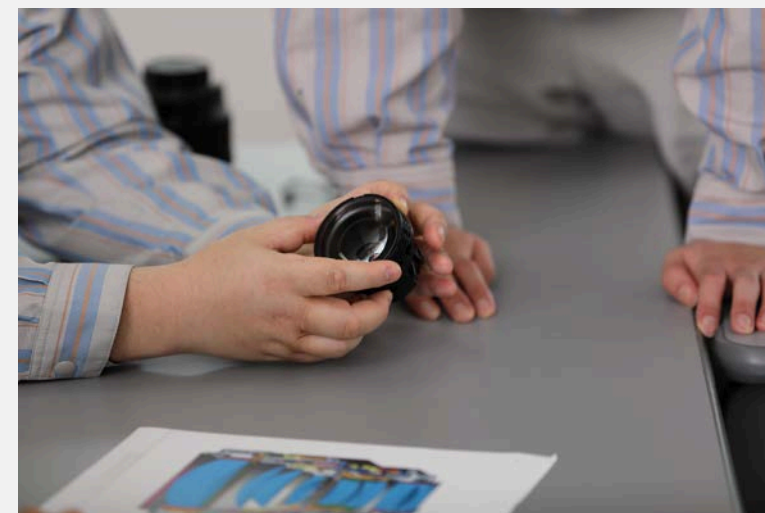
Ishibashi (BR/BS Design): Chromatic aberration, in particular, is the mortal enemy of large-aperture lenses, and because it prevents the photographer from showing the subject’s true form, it is not very good to have this in residual aberrations. We strive to provide a lens that have as little chromatic aberration as possible by incorporating such technologies as BR optics and carefully selecting optical materials so that users can obtain shots that are as close as possible to what they have in mind.

Q: How is the ground aspherical lens effective at correcting spherical aberrations?

Maetaki (Optical Design): The ground aspherical lens in the RF85mm F1.2 L USM is helpful in correcting spherical aberrations. Compared with glass molded aspherical lenses, ground aspherical lenses offer more choices in glass materials. For this lens, we were thoroughly focused on correcting chromatic aberration. We wanted to use a glass material that is advantageous in correcting chromatic aberration on this aspherical lens, so we decided to use the grinding aspherical technique for the 5th element of this lens rather than glass-molding. On this lens, the aspherical lens is placed near the aperture, where the space is tight. However, because this location affects various aberrations in the optical design, we went back and forth with the mechanical designers to adjust space in 0.1 mm increments numerous times. Ground aspherical lenses with superb aberration

correction effects were absolutely essential in order to satisfy requirements in both mechanical and optical design, and to achieve an f/1.2 large-aperture lens.

In addition to the usual multilayer coating, ASC (Air Sphere Coating) is used to suppress ghosting and flare. Although the RF mount with a short back focus provided a greater level of freedom over optical design, the short back focus makes it difficult to release harmful light rays outside the screen, meaning that we had to pay extra attention to the design regarding ghosting and flare. In this regard, we used ASC on the lens surface near the focusing plane on the RF85mm F1.2 L USM. We use optical design tools developed in-house at Canon, and one of the tools is a specialized simulation tool for precision simulations to control single beams of light for checking ghosting and flare. The simulation technology and ASC helps suppress ghosting and flare to roughly the same level as the existing model.



There is no “correct” bokeh quality, which is why Canon will provide two options.



Q: What kind of approach did you take to improve bokeh quality?

Ishibashi (BR/DS Design): Any remaining chromatic aberration results in particularly noticeable color fringing in the defocused area (where the image is out of focus). Because I believe many large-aperture lens users utilize such lenses for the sake of great bokeh when shooting, we're very particular about the quality not only in the focused areas, but also defocused areas in product design. Purple fringing (purple coloring on the contours of a subject) and color fringing in defocused areas are phenomena resulting from light on the blue side of the spectrum shifting from the condensing point of other wavelengths. This is reduced by incorporating the BR optical element and other innovations to focus the visible light wavelengths close to a single point.

Maetaki (Optical Design): We talked earlier about the high-precision simulation tools developed at Canon for ghosting and flare, but we also

have simulation tools developed in-house for bokeh quality. These are used for careful checking and adjustment at the design stage. Simulation technology grows by leaps and bounds on a daily basis, currently making it possible to evaluate images during the design phase as if they were photos taken on the actual lens.

Kawai (Product Planning): In terms of bokeh, another key point is that the minimum focusing distance is closer than the EF85mm F1.2L II USM. The strong bokeh created by f/1.2 can be used to create new types of imaging expressions such as close-ups of areas decorated with jewels, etc.

Q: How is the vignetting and bokeh shape in the peripherals compared to the conventional model?

Maetaki (Optical Design): Balancing the the degree of vignetting and the bokeh shape in the peripherals is tough with a large f/1.2 lens. It is possible to correct for lack of peripheral brightness or vignetting to some extent using digital correction, but as we try to ensure the bokeh shape stays round at the edge of the frame at such a large aperture, the lens size needs to be considerably larger. Considering a balance between size and performance, we made sure that the vignetting and the bokeh shape is not inferior to that of the EF85mm f/1.2L II USM. However, unlike SLRs, because there is no mirror box on the camera, I believe to a certain extent, users can see the improvements to the bokeh shape being cut out in the peripherals, as there is no mirror box to block the light rays, which is one of the causes of this phenomenon.

Development of the “DS” (Defocus Smoothing) version, delivering smoother bokeh.

Q: What kind of features does the DS model in development have?

Ishibashi (BR/DS Design): The strong bokeh produced by the large aperture of the RF85mm F1.2 L USM is one feature of the lens, however, lenses with significant chromatic aberration suppression tend to have slightly clear bokeh contours. Depending on your preferences, when the leaves of a tree overlap in the background, for example, in the defocused area, some users are not fond of the overlapping bokeh edges. In this regard, we wanted to create a unique lens that delivers smoother bokeh quality, motivating us to start the development of the RF85mm F1.2 L USM DS with DS (Defocus Smoothing) coating. Although the specifications are basically the same as the RF85mm F1.2 L USM, the DS coating lets users enjoy a softer bokeh quality. It is currently under development with plans to begin sales in 2019, so keep an eye out for it in the future.

DS Coating (in development)

DS (Defocus Smoothing) coating is Canon's proprietary vapor deposited coating technology currently in development. A lens element with this coating has high transmittance in the center, which becomes lower toward the edges, resulting in a smoothening effect for bokeh. It is easily modified to fit lens shapes, and two models are currently in development in parallel.

Canon's USM* with the most powerful torque has been employed along with increased maximum motor torque.

Q: What's the reason this lens is larger than the EF85mm F1.2L II USM?

Murakami (Mechanical Design): Although it is bigger and heavier than the EF85mm f/1.2L II USM for SLR cameras, we put priority on high image quality, designing for a balance of the practical weight and size.

Maetaki (Optical Design): In terms of optical design, the total length is measured from the focal plane. If you compare the EF and RF mounts, the lens mount is closer to the camera on the RF mount than is the case with the EF mount. This, in nature, makes the RF version longer in the total length to compensate the difference in flange focal distance. An easier way to see this is comparing the size of the RF85mm F1.2 L USM by itself and the EF85mm F1.2L II USM with the Mount Adapter EF-EOS R attached. The difference is now smaller, and this is the difference you see when you mount the two lenses on the same EOS R camera. Another reason is the difference in the focusing type. The EF85mm F1.2L II USM employs a focus system that extends the front elements as you focus closer to the camera. The RF85mm F1.2 L USM, on the other hand, does not extend for focusing. In fact, if you attach the EF85mm F1.2L II USM to the Mount Adapter EF-EOS R and focus to the closest point (thus extending the lens),

and compare the size with the RF85mm F1.2 L USM, the RF version is slightly shorter. On top of that, the optical performance is significantly higher on the RF85mm F1.2 L USM.

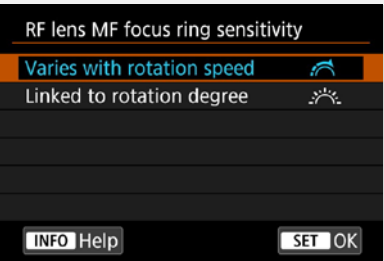
The area we discussed most with members of the mechanical design team during development was the placement and rear lens near the aperture and the weight of the focusing lens group. From an optical design standpoint, we wanted to avoid aberrations caused by the position of the focus, so we requested that the aperture move together with the focusing lens group, which the mechanical design team accommodated.

Ichinose (Electrical Design): The RF85mm F1.2 L USM uses the same ring-type USM as on the super telephoto lenses, which has the most powerful torque at Canon. By modifying the control method, maximum motor torque was also raised, which works to move this heavy focusing unit with high precision.

Murakami (Mechanical Design): Although the AF drive speed from close-up to infinity is approximately the same as conventional models, including a focusing range distance selector switch reduces the focusing time during normal shooting, such as portraiture, for more comfortable usage.

The electronic focusing ring has just the right torque sensation to deliver the perfect character during operation.

Kawai (Product Planning): The EF85mm f/1.2L II USM and RF85mm F1.2 L USM both have the electronic focusing ring. The torque is light on the EF85mm f/1.2L II USM, resulting in easy operations, but we discovered from feedback that it also can move unintentionally for some users. We adjusted the torque on the electronic ring for the RF85mm F1.2 L USM for improved controls during manual focusing. This adjustment improves operability for focusing operations when recording videos, as well as manual focusing with the focusing guide and focus peaking for still images. When paired with the EOS R or EOS RP there are two focus modes: one which is linked to rotation degree and one which varies with rotation speed. The mode linked to rotation degree in particular allows finer control over the focus. Although it is an electronic ring, we paid close attention to the right amount of torque feel to give the focus ring a certain character.



When paired with the EOS R or EOS RP, users can select from two manual focus ring sensitivity options: "Varies with rotation speed" and "Linked to rotation degree". (Left: EOS R camera menu)

Manufacturing that is as close to design values as possible, with minimal sample variation.

We recommend that you try assigning exposure compensation on the control ring during portrait shooting.

Q: What improvements did you make in usability?

Murakami (Mechanical Design): We added a control ring, which is unique to RF lenses. Just as on the other RF lenses, the aperture, shutter speed and other functions can be assigned to the control ring. The control ring was positioned toward the front as on previous RF lenses in consideration of balance during handheld shooting, and considering ease of operation.

Kawai (Product Planning): We recommend that users try assigning exposure compensation to the control ring during portrait shooting. For

example, when shooting portraits outdoors and the lighting conditions suddenly change, you can use your left hand to operate the control ring and adjust exposure compensation while simultaneously focusing on using the shutter button with your right hand. This provides flexible adaptation to changes in the environment where pros have no room to fail, and even a 0.1 second difference can change everything.

Also, the very front and rear of the lens surfaces are coated with fluorine, making maintenance easier than on the EF85mm f/1.2L II USM. Oil and moisture are easily repelled, and oil can be easily wiped off with a dry cloth without using solvents.

Q: Is there anything you would like to say about its reliability?

Murakami (Mechanical Design): As the latest L series lens, it is built for

excellent reliability and durability, assuming use in pro shooting environments. In addition to ensuring reliability including shock resistance at an early stage in development using the latest simulation technologies, we have also conducted extremely demanding reliability tests on the actual lens itself.

Maetaki (Optical Design): It doesn't matter how good the design performance is if there is inconsistent performance and too much sample variation during production that results in significant performance degradation, or if the performance deteriorates after an extended time of use. The factory staff are dedicated to producing a stable supply of extremely high-quality, high-performance products that are as close to the design values as possible, so photographers can use the lens with confidence.



Be sure to try shooting from the widest aperture setting.

Kawai (Product Planning): When planning this lens, many performance tests were carried out repeatedly on a prototype. When shooting at the widest aperture setting using Eye Detection AF in portrait photography, photographers unthinkingly let out cries of excitement when seeing how sharp photos were. The RF85mm F1.2 L USM thoroughly suppresses chromatic aberration and delivers photos with high resolution and high contrast in focused areas. We believe the particular appeal of this lens is in its widest aperture setting. We hope that users who have always stopped down a bit during shooting will enjoy the photos that can be captured when shooting at f/1.2..

