# The Speed Booster ™ – a New Type of Optical Attachement for Increasing the Speed of Photographic Lenses

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## 1) Introduction

Rev.01


We all know about teleconverters – the optical accessories that attach to the rear of an objective lens to increase its focal length. We also know about their drawbacks, such as slowing down the lens and generally degrading image quality. The loss of image quality is largely unavoidable – a teleconverter magnifies the image formed by the objective lens, and the aberrations are also magnified. Despite these drawbacks, teleconverters have been a photographer's staple for many decades because of their convenience and flexibility.

Ever since the introduction of DX and APS-C format DSLR's many have wondered why it isn't possible to build an "inverse" teleconverter that would reduce the focal length. After all, this sort of attachment, called a focal reducer, is widely available for telescopes. The short answer here is that the reflex mirror of DSLR's gets in the way, and makes the design of a true general purpose DSLR focal reducer essentially impossible.

Recent advances in electronic viewfinders have resulted in the spectacular rise of so-called mirrorless cameras. Since these cameras have no need for a reflex mirror, they typically have a very short lens flange to image plane distance compared with SLR cameras with a similar image size. Examples of mirrorless cameras include the Micro Four Thirds cameras manufactured by Olympus and Panasonic, the Sony NEX series cameras, the Fujifilm X series cameras and the Canon EOS M series cameras. The flange distance – the distance from the lens flange to the image plane - in all of these cameras is relatively small. In Micro Four Thirds cameras the flange distance is approximately 20mm, and in Sony NEX cameras the flange distance is approximately 18mm. By contrast, the flange distance in 35mm SLR cameras with a Nikon F mount is 46.5mm. The large difference between the flange distance of 35mm SLR cameras and mirrorless cameras allows for the design and implementation of a wide range of adapters to mount SLR lenses onto mirrorless cameras.

The Speed Booster is the first general-purpose focal reducer for increasing the speed and reducing the focal length of SLR lenses when mounted to mirrorless cameras. In the remainder of this paper we will cover the basic specifications, explain some of the seemingly impossible performance characteristics, give a brief historical perspective, and show some sample photos taken with a prototype Speed Booster.

## 2) Specifications

Magnification: 0.71x
Maximum input aperture: f/1.26
Maximum output aperture: f/0.90
Lens elements/groups: 4/4
Objective lens mounts: Canon-EF, Nikon-F (Leica-R, Contax C/Y, Contarex and Alpa planned)
Capabilities, Canon-EF version: Electronic iris control, AF and VR
Capabilities, Nikon-F version: Manual iris control of G type lenses
Camera mounts: Sony NEX, Micro Four Thirds, (Fuifilm X planned)
Length reduction (Sony NEX, version): 4.16mm
Length reduction (Micro Four Thirds version): 6.17mm
Dimensions Sony NEX version (diameter x length): 69mm x 27mm (with tripod mount removed)
Weight Sony NEX version: 194 grams
Tripod mount: Removable type with Arca Swiss compatibility

## 3) Design Basics

A focal reducer, schematically illustrated in Figure 1, is basically a positive lens that fits behind an objective lens, and its function is to reduce the focal length. However, the entrance pupil D remains fixed. Because of this, the f/#, given by f/# = (focal length) / D, is reduced. In other words, the speed of the lens is increased – for the same reason, why a teleconverter reduces the speed of the lens.

The amount of focal length reduction and speed increase can be calculated by the magnification of the focal reducer. So, if the focal reducer has a magnification of 0.7x, then the focal length of the new system is 0.7 times the original focal length of the objective. Similarly, the f/# of the new system is 0.7 times the original f/# of the objective.

Another unavoidable consequence of adding a focal reducer is that the new image is reduced in size compared to the original image formed by the objective. So, if the combined optical system must cover a certain size format, then the objective must cover a larger format. The change in image size can be calculated from the magnification of the focal reducer. For example, if a 0.7x focal reducer is added to an objective and the resulting system must cover a DX format sensor with a 28mm diagonal then the objective by itself must be capable of covering a 40mm diagonal format. Fortunately, all fullframe 35mm SLR lenses meet this requirement since they cover a 43.3mm diagonal format.

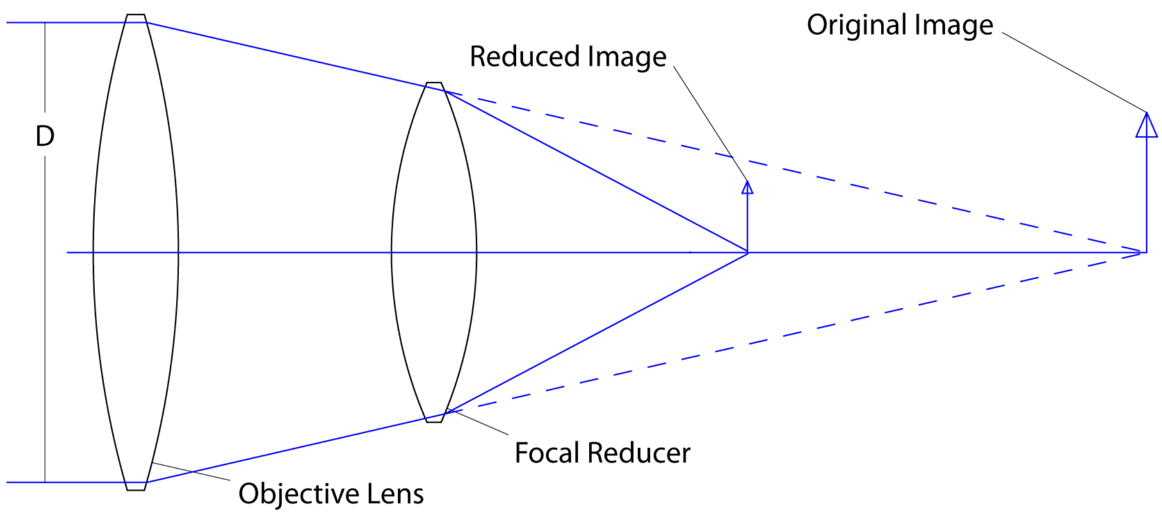



Figure 1: Basic function of a focal reducer.

Compatibility of Lens + SPEED BOOSTER

| | Canon EOS-M<br>Fujifilm X<br>Sony NEX | Micro 4/3 |
|---|---|---|
| FX Lens | yes | yes |
| DX Lens | no | yes * |

Figure 2: FX lenses can be widely used, but DX lenses can't be used on all sensor sizes
*) See note on page 14 for DX lenses with fixed lens hoods.

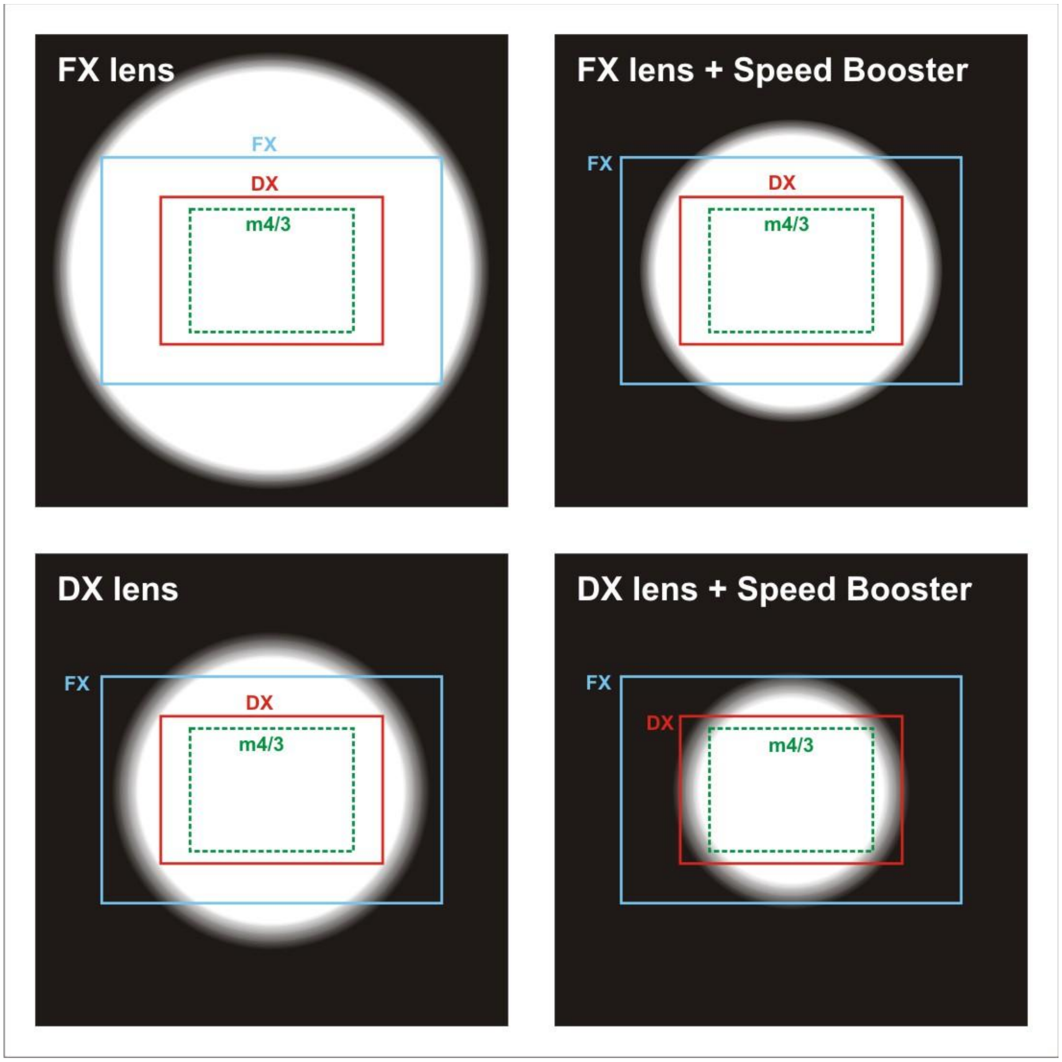



Figure 3: Illustration of how the reduced image circles fit to the different sensor sizes. Also see note on page 14.

## 4) It's too Good to be True! – Part 1, Ultra-High Speed

Past attempts to come up with a general purpose focal reducer suitable for use with very high speed lenses have come up short. Usually, the problems involve insufficient correction for spherical aberration at large apertures, insufficient correction for other aberrations – especially field curvature, insufficient working distance (even mirrorless cameras need *some* working distance!) or all of the above.

The Speed Booster introduces essentially zero spherical aberration for an extraordinarily large output aperture of f/0.90. Note that in order to reach this output aperture it is necessary to attach the Speed Booster to an f/1.2 lens used wide open. All other aberrations, including field curvature, coma, astigmatism, distortion, and chromatic aberration are also well-corrected. Figure 4 shows longitudinal aberration plots of spherical aberration, astigmatism, field curvature, and distortion for the Sony NEX version of the Speed Booster when used with a perfect aberration-free objective lens. The left-most plot indicates that the Speed Booster has a very small amount of undercorrected spherical aberration at f/0.90, but this was done intentionally to improve the bokeh when the Speed Booster is used with ultra high speed f/1.2 objectives.

In fact, we could have designed the Speed Booster to work at apertures as large as f/0.70. However, in order to do this the lens element closest to the objective lens would have to be dramatically increased in size, which would have severely restricted the variety of compatible lenses. As it is, the Speed Booster is fully compatible with Canon EF or Nikon F mount SLR lens, and will not block the central ray bundle for lenses f/1.2 or slower.

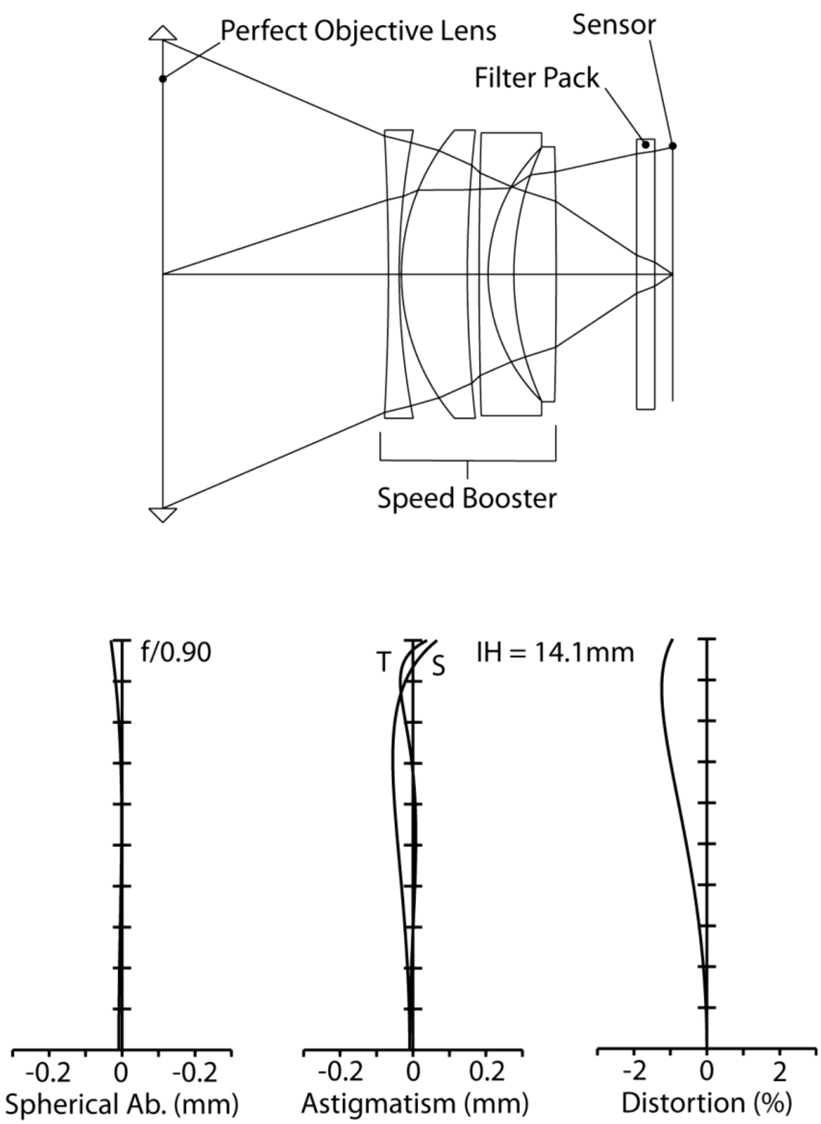



Figure 4: Longitudinal aberrations of the Sony NEX version of the Speed Booster at f/0.90 when using a perfect objective lens.

## 5) It's too Good to be True! – Part 2, Field of View is Increased

A big problem with DX, APS-C, and Four Thirds format sensors is that they crop the full format image produced by conventional 35mm full frame optics. Since the Speed Booster essentially compresses the image formed by the objective lens into a smaller size it helps to undo the cropping effect. The Speed Booster doesn't completely recover the corners of the original lens – it would have to have a magnification of 0.67x or 0.5x, respectively, to do that for DX or Four Thirds formats. However, it does provide a very useful and welcome field of view increase with its 0.71x magnification.

Figure 3 below shows how the Speed Booster increases the field of view (FOV) for a given image size. In this figure the red ray is the chief ray for the objective lens alone, and the blue ray is the chief ray for the objective lens with Speed Booster attached.

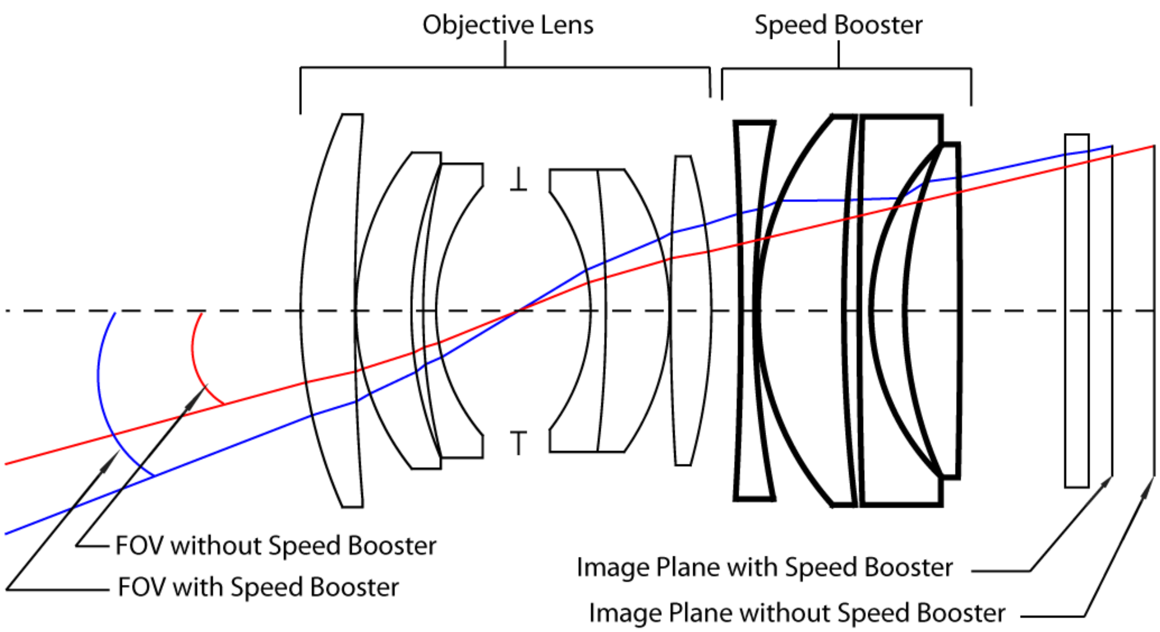



Figure 5: Speed Booster increases FOV for a given image size.

Although we feel that the most "magical" thing about the Speed Booster is its ability to speed up any lens by a full stop (hence the name!), its ability to increase the field of view of a lens used on a crop format sensor is also very interesting. For example, the widest lenses currently available for Micro Four Thirds format are the 7-14mm zooms offered by Olympus and Panasonic. However, by attaching a Speed Booster to a Sigma 8-16mm DX fomat lens you wind up with a 5.6-11.2mm zoom that covers Four Thirds! So, in addition to providing the fastest possible lens in many focal lengths, the Speed Booster can also provide the widest possible lens for certain formats.

## 6) It’s too Good to be True! – Part 3, MTF is Increased

There is a widespread belief that adding optical elements to an existing lens always reduces optical performance. This misconception is probably due to the fact that teleconverters do indeed reduce optical performance simply because they magnify the aberrations of the objective lens.

Fortunately, the opposite situation occurs with focal reducers. Here, the image formed by the objective lens is compressed by the reducer, so the aberrations are actually reduced. Of course, the focal reducer itself is not completely aberration-free, but in a well-executed design these aberrations can be kept small enough that the reducer can actually make a significant improvement in MTF compared to the objective lens used alone.

Figure 6 below shows MTF at 20 lp/mm as a function of image height for the 50mm f/1.2 AIS Nikkor lens under various conditions. The red curves show sagittal and tangential values for the objective lens used by itself wide-open at f/1.2. In this case, the radius of the image circle is 21.63mm (43.27mm diameter). The green curve shows the resulting MTF when the Micro Four Thirds version of the Speed Booster is added to the lens. Again, the lens is evaluated wide open, but this time the aperture is f/0.90, with a focal length of 35mm. Amazingly, the objective lens plus Speed Booster has significantly better MTF over most of the Micro Four Thirds image circle radius of 10.8mm, even though the combined 35mm lens is evaluated at f/0.90 and the original lens is evaluated at f/1.2.

The Speed Booster for the Sony NEX is optimized for a larger format size than the Micro Four Thirds version, and as a result the performance in the outer part of the field is reduced slightly. The blue curve in Figure 6 shows the MTF resulting from combining the NEX Speed Booster with the 50/1.2 AIS Nikkor. Performance near the axis is very similar to the Micro Four Thirds version, and is significantly better than the objective lens used alone. Off-axis, the performance isn’t quite as good, but of course it covers a much larger area. Note that the off-axis position at 14mm for the blue curve originates from the 20mm position of the original 50/1.2 lens. Keeping this in mind, it is clear that most of the off-axis performance drop at the corner of the NEX format is due to the 50/1.2 objective. In all cases a patent design corresponding to the 50/1.2 AIS Nikkor lens (U.S. Patent 4,621,909, Example #3 of 3) was used for evaluation purposes.

This MTF behavior turns out to be typical of most lenses when used with the Speed Booster, namely: 1) both the Sony NEX and Micro Four Thirds versions give a dramatic MTF enhancement near the center of the image; 2) the Micro Four Thirds version is better than the original lens used by itself over nearly all of the Micro Four Thirds format; 3) in the outer parts of the field the Sony NEX version has slightly reduced contrast relative to the Micro Four Thirds version where their image circles overlap; and 4) the Sony NEX version in the extreme corner of the NEX format has similar MTF to the original lens in its original image corner.

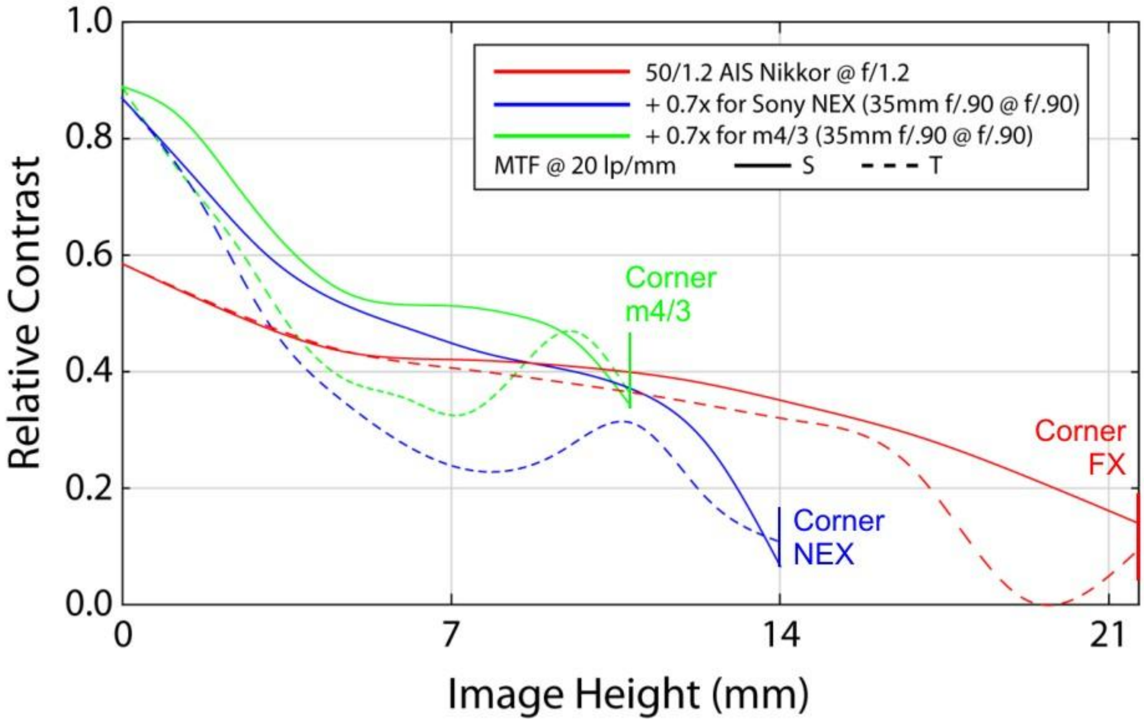



Figure 6: MTF at 20 lp/mm vs Image Height for the 50mm f/1.2 AIS Nikkor with and without 0.7x Speed Booster.

Figures 7 and 8 show the same MTF analysis given in Figure 6, but this time with the 28mm f/1.4 AF Nikkor and 85mm f1.4 AIS Nikkor, respectively, to illustrate that the Speed Booster is truly a general purpose device capable of being used with a wide variety of lenses. In this case, the 28/1.4 (U.S. Patent 5,315,441, example #1 of 2) and 85/1.4 (U.S. Patent 4,396,256, example #3 of 4) are transformed into 20mm f/1.0 and 60mm f/1.0 hyperspeed lenses, respectively. As before, all MTF evaluations are done at full aperture – f/1.4 for the original lenses and f/1.0 for the converted lenses.

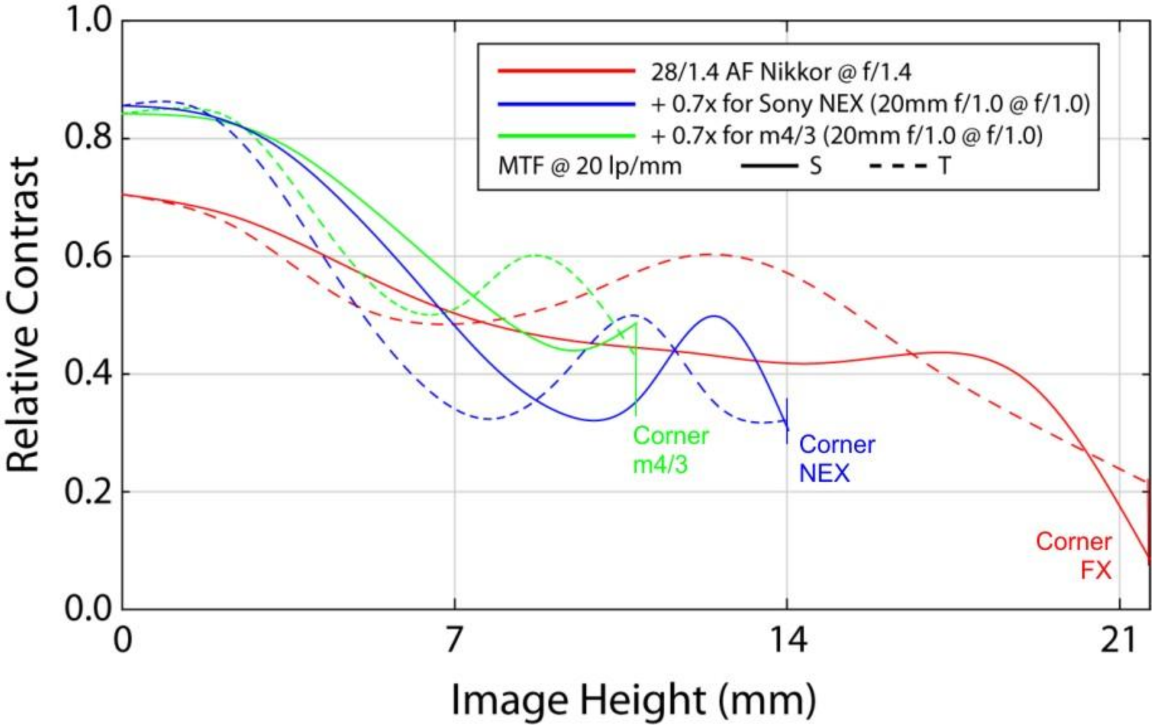



Figure 7: MTF at 20 lp/mm vs Image Height for the 28mm f/1.4 AF Nikkor with and without 0.7x Speed Booster.

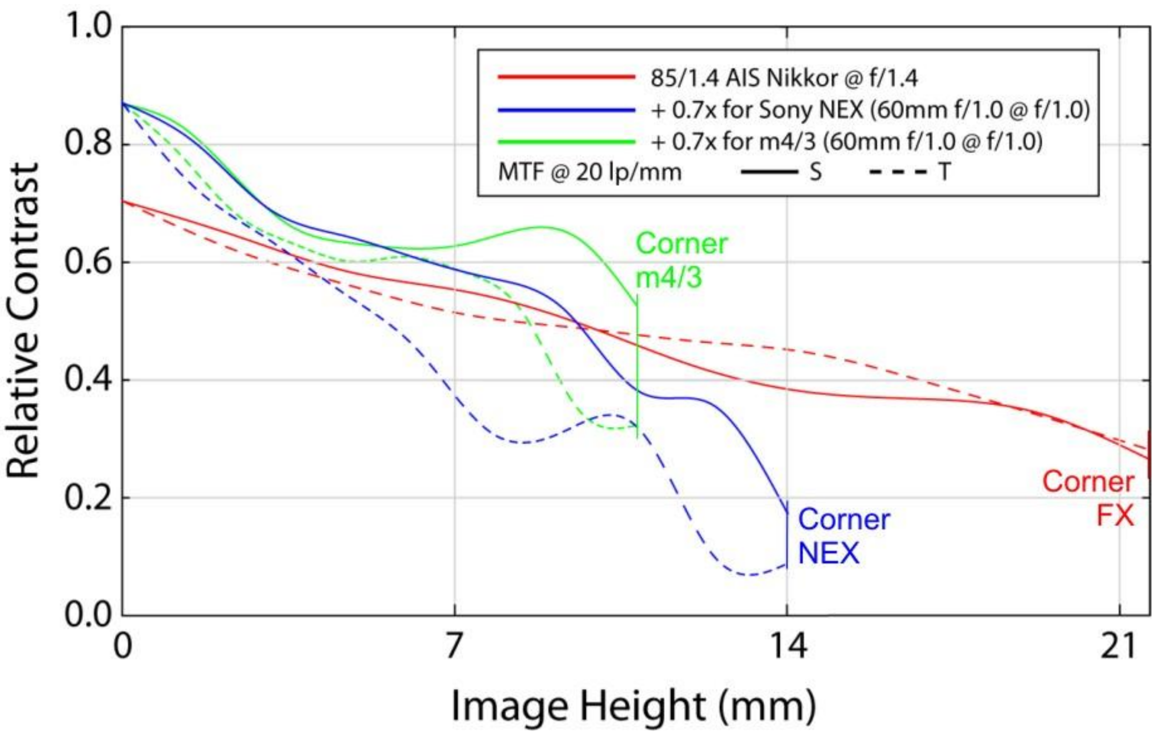



Figure 8: MTF at 20 lp/mm vs Image Height for the 85mm f/1.4 AIS Nikkor with and without 0.7x Speed Booster.

## 7) It's too Good to be True! – Part 4, Physical Length is Reduced

This part really does sound too good to be true, but rest assured that it really is true: when you attach the Speed Booster to an objective lens, the physical length of the combination as measured from the front lens surface to the image plane is actually shorter than that of the objective lens alone. The Micro Four Thirds version shortens the system by 6.2mm (~1/4"), and the Sony NEX version by slightly less at 4.2mm (~1/6"). Although these amounts may not seem large, it can result in a very noticeable improvement in compactness when "pancake" style objectives are used. For example, when the Speed Booster is combined with the compact recent version of the 50mm f/1.8 AIS Nikkor, the resulting 35mm f/1.2 is actually more compact than any 35/1.2 lens on the market, and it handles quite well on a tiny Sony NEX camera body.

Figure 9 shows a marginal ray trace through an objective lens and the Speed Booster illustrating the shortening effect. Two things are going on here: first, the Speed Booster is occupying otherwise empty space behind the objective, so its not adding to the overall system length; and second, the increased steepness of the marginal rays means that the focal plane is shifted toward the objective.

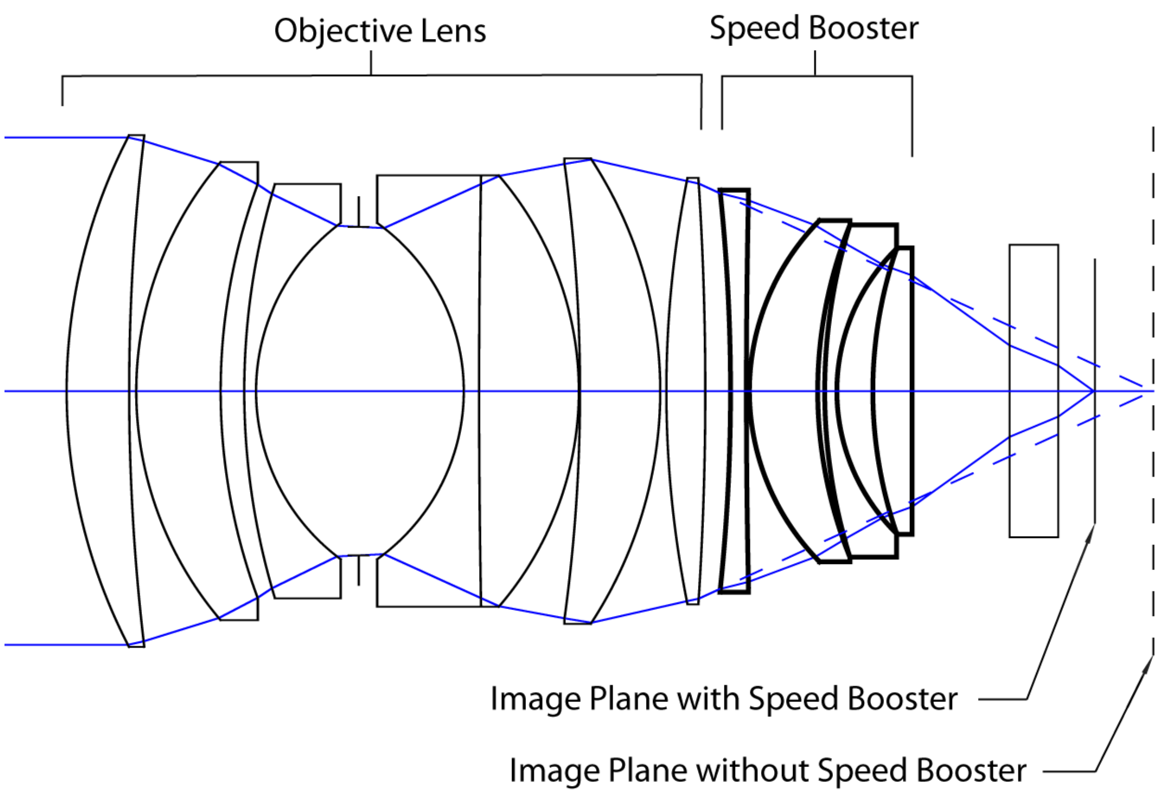



Figure 9: The Speed Booster actually reduces the overall lens length.


Example 1
Attach an inexpensive 50mm f/1.8 pancake lens with a plain mechanical adapter, and you get a rather boring
**50mm f/1.8**

Example 2
By using the SPEED BOOSTER instead, you now get a slightly more compact combination and a more exciting
**35mm f/1.2**

Example 3
To get something almost as fast as Example 2 without the SPEED BOOSTER, you can mount the big, heavy and expensive
**35mm f/1.4**

Example 4
However, with the SPEED BOOSTER this big lens is worth its bulk, because you now have a slightly more compact and really exciting
**24mm f/1.0**

Figure 10: Comparison of Speed Booster vs. plain mechanical adapter (here for m4/3)

## 8)  It's too Good to be True! – Part 5, Telecentricity is Improved

Another nice benefit of the Speed Booster is that it moves the exit pupil further from the image plane for any objective lens.  In other words, it actually improves the telecentricity of the lens system.  This helps to improve corner illumination and reduce sensor artifacts such as color variations caused by pixel crosstalk.

Figure 11 illustrates how telecentricity is improved by the Speed Booster.  To find the exit pupil location you need to extend a chief ray (i.e., the ray that passes through the center of the aperture stop and the corner of the image) back through the lens until it crosses the optical axis.  The amount by which the exit pupil location is increased by the Speed Booster changes depending on the degree of telecentricity of the objective lens, but the general trend is the same for all existing SLR objective lenses.

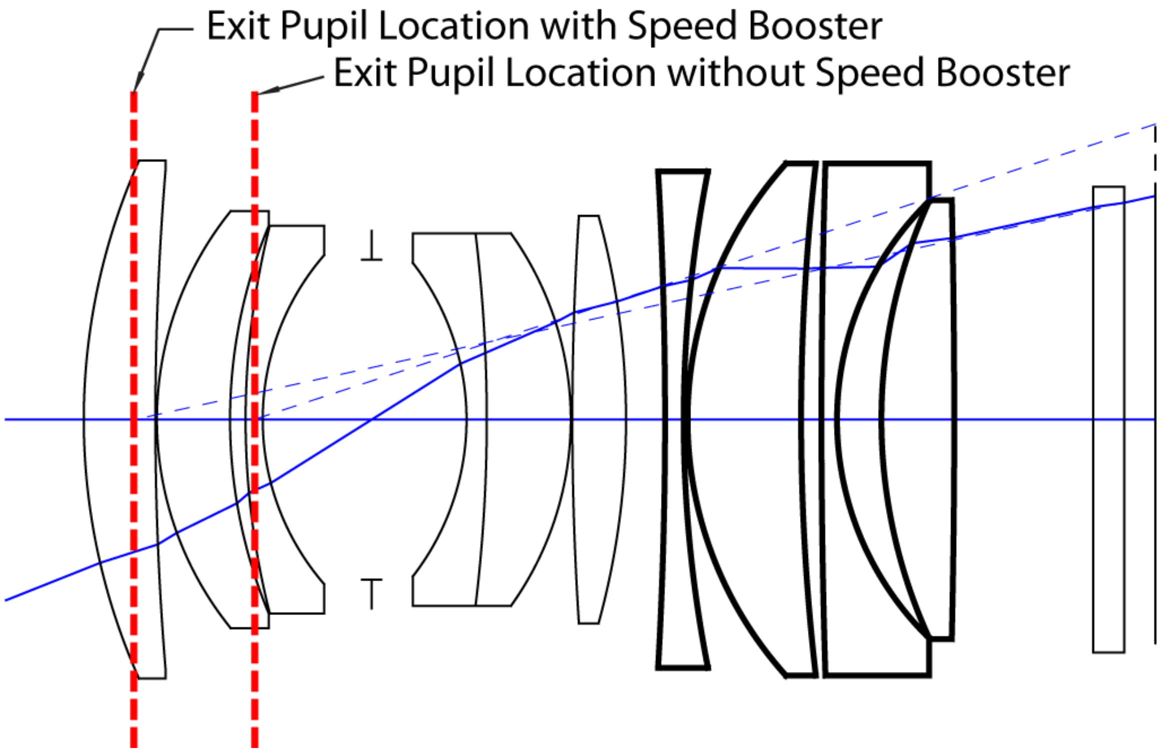



Figure 11:  The Speed Booster improves telecentricity.

## 9)  It's too Good to be True! – Part 6,  Filter Effect is Cured

A dirty little secret in digital photography is that the filter pack (low-pass filter + infrared filter + sensor cover glass) found in virtually all digital cameras can contribute significant aberration to the image when a lens designed for film is used.  This problem is particularly troublesome for very fast lenses.  The Speed Booster corrects this defect, and automatically corrects for filter pack aberrations regardless of the objective lens used.

## 10) Comparison to Front Mounted Wide Converters

Front-mounted wide converters, sometimes called afocal wide converters, have been used for many decades and are still in wide use today. They are especially popular for use with small format video cameras and consumer digicams. Even the ultra high-end anamorphic lenses used in cinematography are a special type of front mounted wide converter that uses cylindrical lens elements.

The problem with front mounted wide converters is that they generally have low image quality unless they are optimized to work with one particular objective lens, or a narrow range of objective lenses. Distortion and lateral color are particularly difficult to correct. Focusing can cause difficulty because the front converter can interfere with the floating element optical correction found in high quality objectives. Better quality front converters are also quite large, especially if they must work with wide angle objectives.

But perhaps the biggest disappointment with front mounted wide converters is that they offer no increase in lens speed. By comparison, a well-designed rear mounted focal reducer is very compact (heck, it actually *decreases* the size of the system!), can work with virtually any objective lens, can actually increase the MTF, and most importantly will increase the lens speed.

## 11) Comparison to Relay Type Wide Converters

In the early days of digital photography, relay type wide converters were occasionally used to help overcome the large crop factor of early digital sensors. Unfortunately, these optical relays were very bulky, they couldn't be used at large apertures, and they were expensive. Nowadays these are best used as museum display items.

## 12) Comparison to Teleconverters

Focal reducers and teleconverters are really part of the same general family of rear optical attachments. However, because teleconverters have a magnification greater than unity they increase focal length, decrease lens speed, and magnify aberrations. They are almost always used to increase the reach of telephoto lenses, and are not commonly paired with shorter focal length objectives. By contrast, we expect that the Speed Booster focal reducer will most commonly be paired with normal and short focal length objectives to increase lens speed and increase the field of view.

## 13) Some Intriguing Combinations

Untold millions of SLR lenses in hundreds of different designs have been manufactured in the last 50 years, so all sorts of interesting Speed Booster pairings are possible. Some of the more interesting possibilities are:

***Fastest Lenses Available:*** There are only a handful of production lenses that are f/1 or faster, and even the fastest are only f/0.95. However, the Speed Booster can be combined with an f/1.2 SLR lens to yield a true f/0.90 combination with excellent performance.

***Compact High Speed Lenses:*** 35mm f/1.2 lenses are available and can be used with mirrorless cameras via various mount adapters. However, these lenses are bulky and expensive. By contrast, the Speed Booster can be combined with a tiny inexpensive 50mm f/1.8 lens to produce a very compact and high performance 35mm f/1.2.

***Ultra-Wide Lenses:*** As mentioned in Section 6 above, the Speed Booster can be combined with ultra-wide lenses such as the 8-16mm Sigma zoom lens to produce a record-breaking 5.6 – 11.2mm ultra-wide zoom for Micro Four Thirds (but see note below).

***Fast/Wide Tilt-Shift Lenses:*** Canon and Nikon have recently made major upgrades to their fullframe tilt shift lens offerings. The Speed Booster allows these phenomenal lenses to be used on mirrorless cameras without losing their field of view. For example, a Canon 17mm f/4 TSE now becomes a 12mm f/2.8 ultra-wide tilt shift for either the Sony NEX or Micro Four Thirds platforms. What's more, the full range of adjustment in the tilt shift objective can be used even after the Speed Booster is attached.

***Note for using DX lenses with the Speed Booster:*** The micro-4/3 version of the Speed Booster can be used with almost all Nikon DX lenses, with the exception of lenses with fixed lens hoods, such as the Nikon AF 10.5mm f/2.8 fisheye and the Sigma 8-16mm zoom.

Fig. 12: Extreme test by shooting with the 10.5mm fisheye + Speed Booster into a white bowl, with the focus set to infinity, aperture wide-open (effectively f/2.0) and the aspect ratio of the Panasonic Lumix GH1 set to 4:3.
This is the worst case.
With close focus, smaller apertures and aspect ratio 3:2 the shadow of the fixed lens hood gradually disappears. With the Speed Booster the nominal image circle of the DX lens (Ø28.8mm) is reduced to Ø20.5mm, which is around 5% smaller than the image circle of m4/3. All DX lenses still have plenty of reserve to fill the entire m4/3 frame, but unfortunately the fixed lens hoods become visible. After cropping away the dark shadows, the remaining image matches the original FOV.

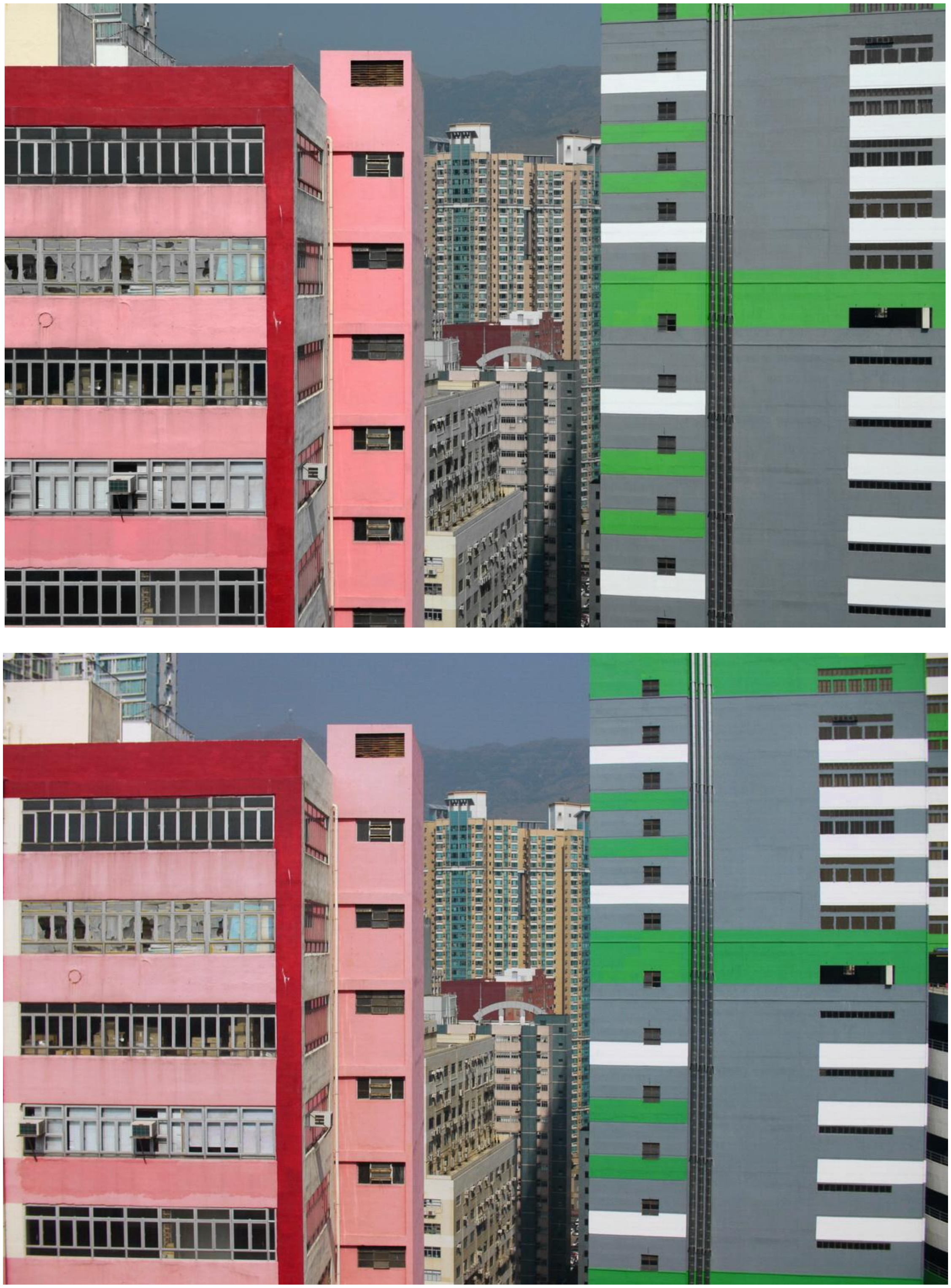


Figure 13: The picture on top shows the FOV of a Nikon AF-S 35mm f/1.8 DX lens when used on a Nikon DX body.
Below is the same lens + Speed Booster (now a 24.5mm f/1.2 system) on a m4/3 camera. The FOV is noticeably wider. Both pictures were taken stopped-down (the light was too bright for f/1.2).

## 14) History

Focal reducers and their close relative – the aplanatic meniscus lens – have actually been around for a very long time, although a true general purpose reducer suitable for photographic cameras and high speed lenses simply hasn't existed until now.

Lens designers have been using aplanatic meniscus lenses as a focal reducer for more than a century. This type of lens is placed in the converging beam formed by an objective lens, as shown in Figure 14, and is specially shaped so that the first surface obeys Abbe's sine condition and the second surface is normal to the marginal ray. When these two conditions are met, the lens reduces the focal length of the objective by a factor of n, where n is the refractive index of the material comprising the meniscus lens. In addition, the meniscus lens has the special and useful property that it introduces no spherical aberration or coma. For narrow-field systems the meniscus aplanatic lens is therefore a very effective focal reducer with a magnfication of 1/n.

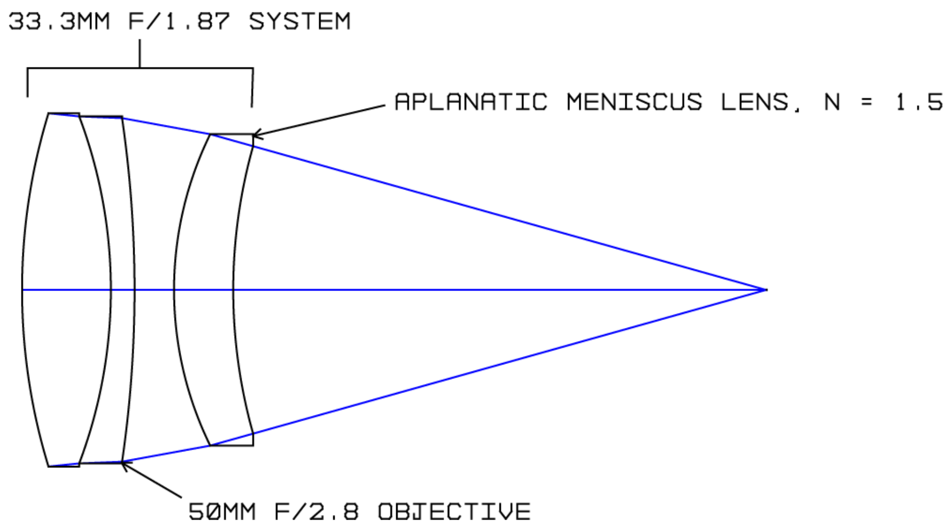
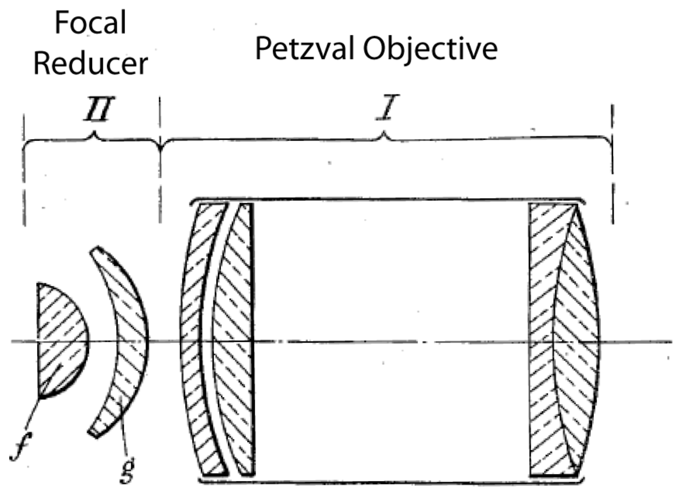



Figure 14: Aplanatic meniscus lens functioning as a focal reducer

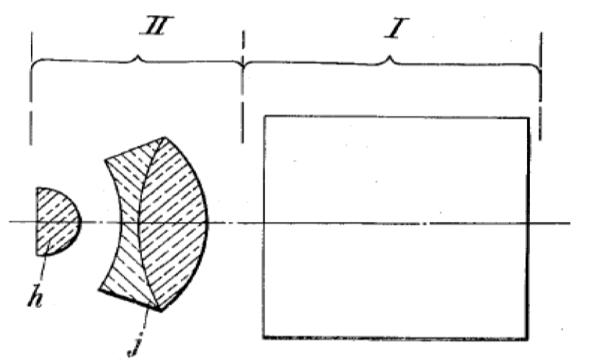
Ultra-high power oil immersion microscope objectives first developed in the late 19$^{th}$ century use two aplanatic elements – essentially two focal reducers in series – to produce an extremely high numerical aperture very close to the theoretical limit. In this case the back surface of the second element is actually flat since it is in contact with a conjugate plane. In early microscope objectives the remainder of the system was generally a modified Petzval objective, as illustrated in Figure 15. Modification was necessary to correct the chromatic aberration introduced by the pair of aplanatic elements.




From U.S. Patent 1,910,115 (Luboshez, 1928)

Figure 15: Early focal reducer design by Luboshez, similar to an oil-immersion microscope objective.

An early focal reducer design by Luboshez is shown in Figure 14. This design replaces one of the aplanatic elements with a cemented doublet to correct chromatic aberration, and is thus a generaly purpose focal reducer that can be used with any well-corrected objective. A more advanced design of this type from Herzberger is shown in Figure 16. Unfortnately, all of these designs suffer from a large amount of undercorrected field curvature, and thus they are not suited for use with photographic objectives.




From U.S. Patent 1,910,115 (Luboshez, 1928)

Figure 16: Early focal reducer design with chromatic aberration correction

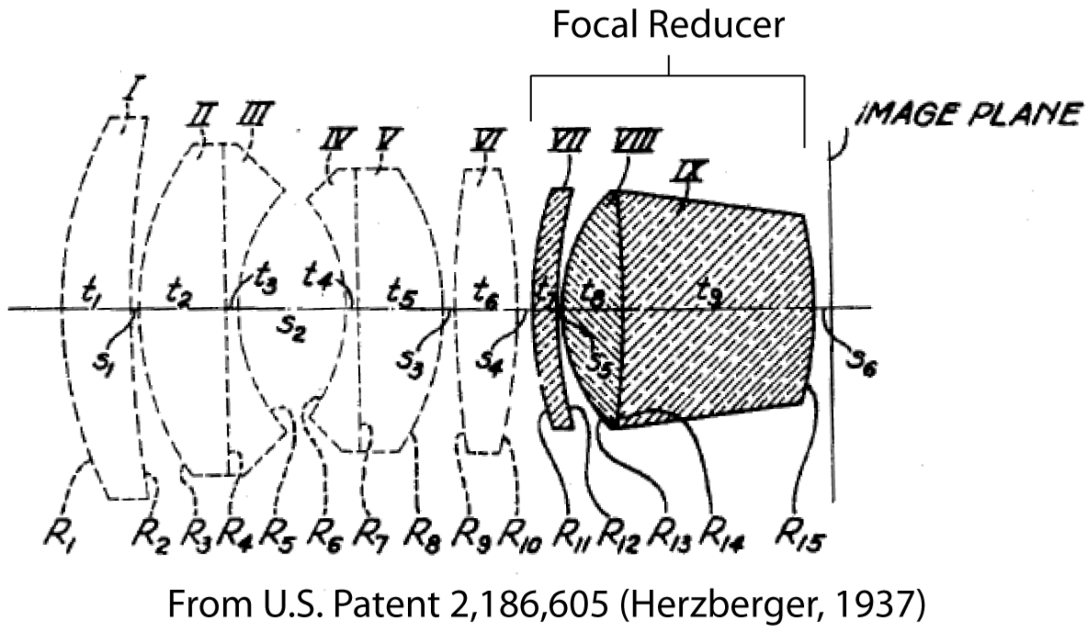



Figure 17: Early focal reducer design by Herzberger.

In the 1960's, Zeiss developed a 50mm f/0.70 lens for NASA. This lens later became very famous when it was adapted by Stanley Kubrick to film candle-lit scenes in the movie "Barry Lyndon." This lens is designed with an integrated focal reducer as shown in Figure 18. Becase the rear converging group and primary lens are both optimized to function together the converging group itself cannot function as a general purpose focal reducer. However, the success of this design does illustrate the usefulness of the focal reducer concept.

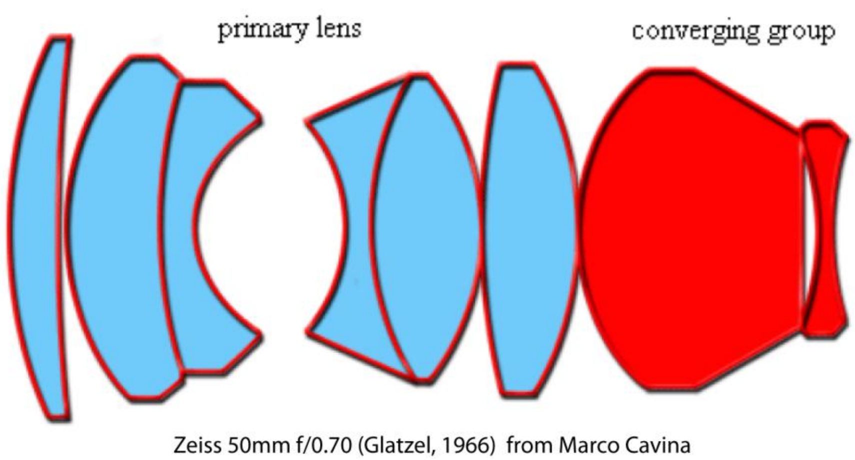



Figure 18: Zeiss 50mm f/0.70 (Kubrick's "Barry Lyndon" lens) with integrated focal reducer.

Since the 1960's there have been several attempts to produce general purpose focal reducers, but these had significant shortcomings. Of course, focal reducers for astronomical telescopes work very well and have been widely available for a long time, but these are not adequate for general purpose use since they are designed for slow, narrow field objectives with plenty of rear working space. Focal reducers designed to work well on-axis at a large aperture tended to have very poor off-axis performance, similar to the early Luboshez and Herzberger designs. Several companies developed focal reducers for use with compact film cameras in the 1980's and 1990's, but in every case these were suitable only for very small apertures. Kodak made an interesting attempt to design a focal reducer that maintained the working distance required in SLR cameras, but the system was very complex and was completely unsuitable for large apertures.

A little over a year ago it dawned on us that mirrorless cameras might offer a unique opportunity to develop a true general purpose photographic focal reducer with full correction of all aberrations at a very large aperture. Much to our surprise, after a couple of months of frantic design and patent filing effort we had a pair of designs that were promising enough to proceed to the prototype phase. Actual testing of those prototypes fulfilled all of our expectations. The following pages show some early "real world" test shots.

## 15) Sample Photos


Figure 19: Carl Zeiss 50mm/1.4 in Yashica/Contax mount on a Fujifilm X-E1 camera. The left image is with a simple mechanical adapter, the right image with the Speed Booster. Same distance, but different exposure time because of the increased speed. Left image is 50mm f/1.4 and 1/30s, the right image is 35mm f/1.0 and 1/60s. Obviously, the magnification is different.

The pictures of the vodka bottle were not taken by ourselves, but by photo enthusiasts, who were given some pre-production Speed Boosters for field testing. The pictures are a good example for the shallow depth of field and for the change in the field of view, but the more striking difference between the two images is the much sharper look of the one with Speed Booster.

To investigate this issue deeper we conducted similar tests in the test lab with 2 different Nikon lenses (50mm f1.4 AIS and 50mm f/1.2 AIS) and also with both types of Speed Boosters (the models for NEX and for micro-4/3).

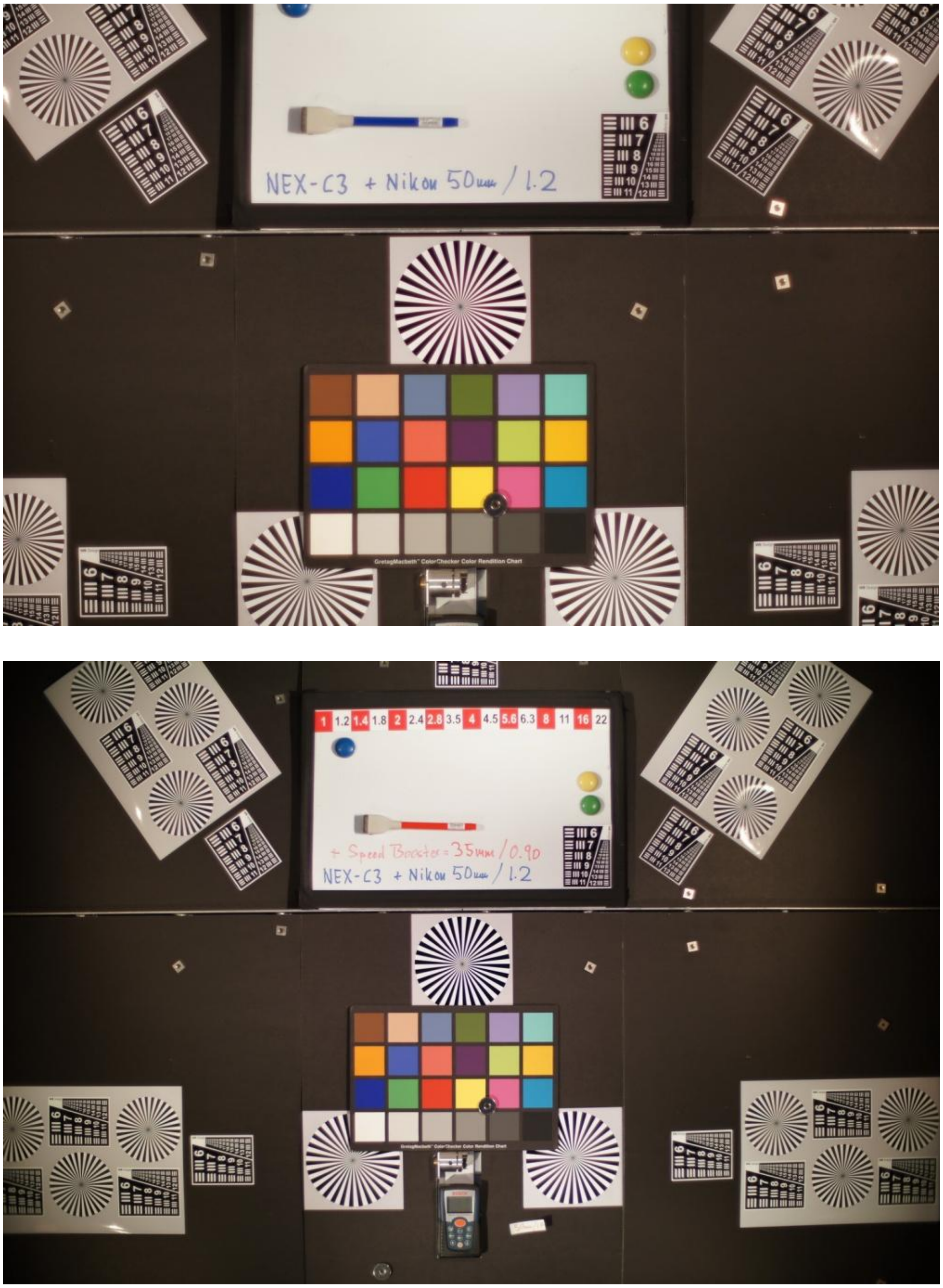



Fig. 20: On top is the test shot from the lens with a plain adapter, below with the Speed Booster. The distance remained the same, therefore the magnifications are different. The shutter speed was adjusted achieve equal exposure

Here are the center crops for better comparison:

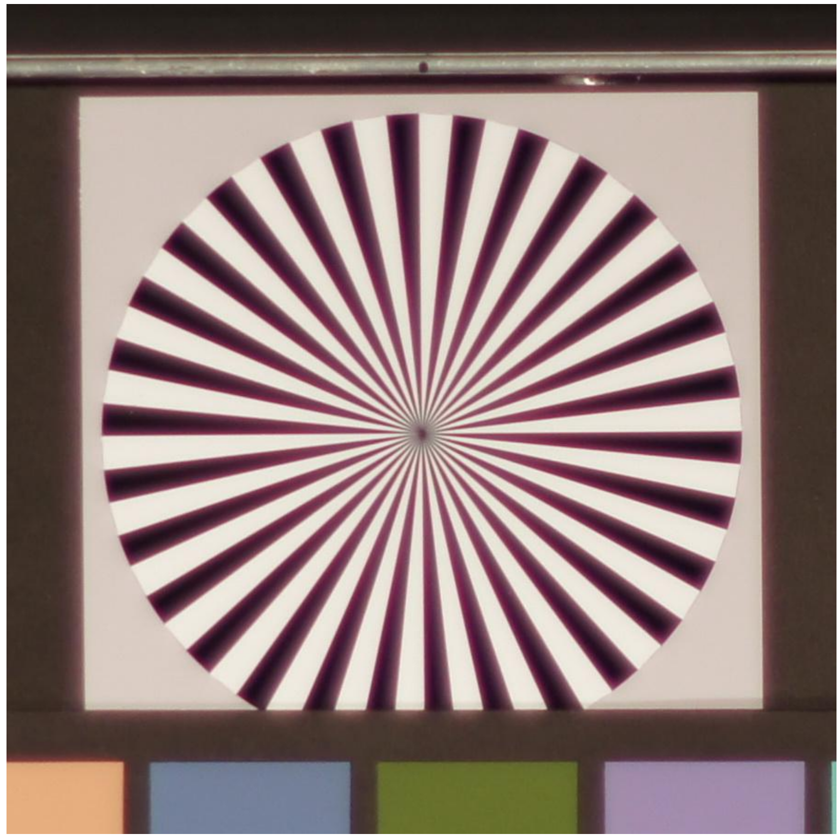


Fig. 21: On top is the bare lens with a plain adapter (50mm f/1.2), below with the Speed Booster to make it a much cleaner and more contrasty 35mm f/0.90 system. The same results were found for the Nikon 50mm f/1.4 AIS lens and for the Speed Booster for micro-4/3.

We made another interesting observation: When shooting with the Sony NEX-C3 it is very convenient to focus with the really nice focus peaking feature. For working on the mostly black and white resolution test wall we prefer to set the peaking color to red.
The Nikkor 50mm f/1.2 AIS is a great lens, but like all super-fast lenses it is getting a slightly soft at maximum aperture.
With the focus assist on the NEX-C3 set to 15x magnification, it is very easy to find the best focus. However, the contrast is too low to trigger any red focus peaking (although at 7.5x magnification it still works). Now, as soon as the Speed Booster is attached, the contrast increases enough to trigger some focus peaking.

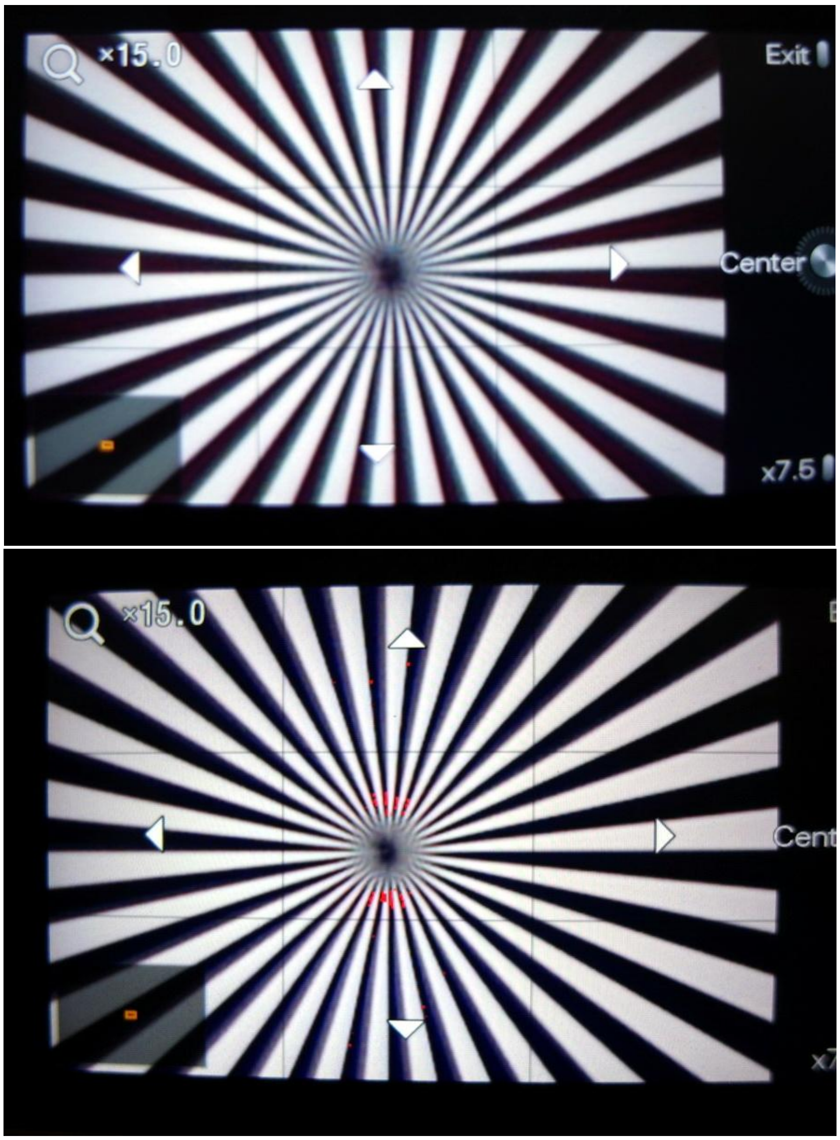



Fig. 22: On top is a view of the Sony LCD set to 15x focus assist with best focus for the bare Nikon 50mm f/1.2 AIS objective wide-open.
Below is the same lens with the Speed Booster - now an f/0.90 system. It looks visibly sharper, and the camera also responds with focus peaking highlights in red color.

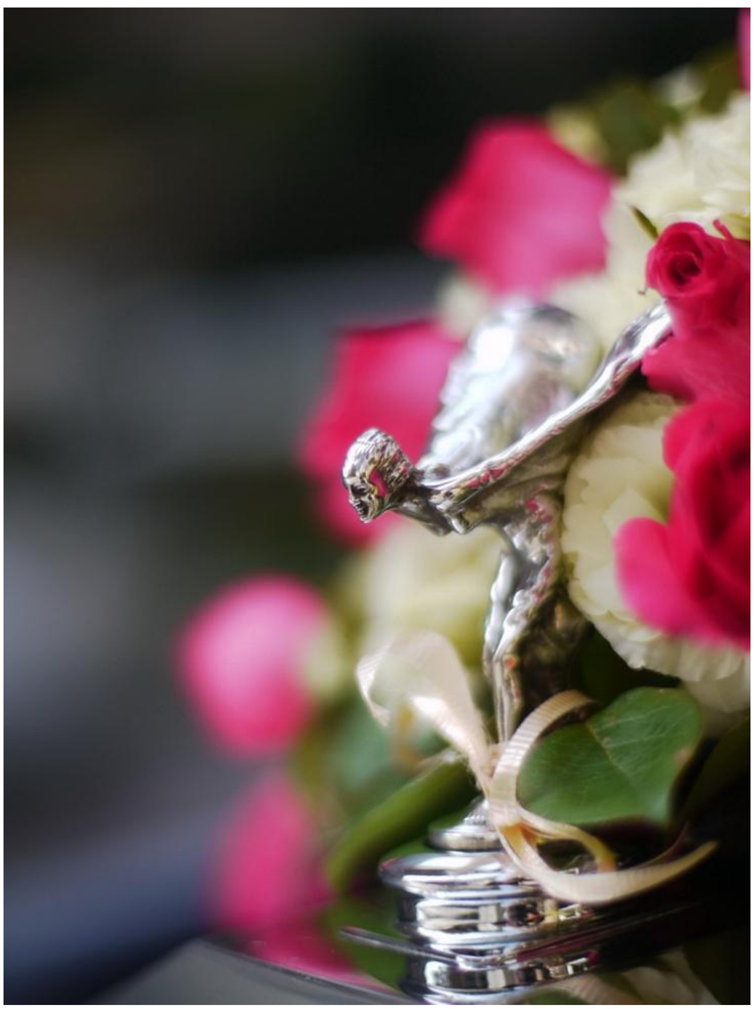


Figure 23: Above, Nikon 58mm f/1.2 Noct Nikkor objective plus a prototype 0.7x Speed Booster (41mm f/0.90 system) shot wide-open at f/0.90 on Sony NEX-5 camera, illustrating ultra-shallow depth of field.

Figure 24: Rolls Royce Emily shot with a Nikon 50mm f/1.2 AIS plus prototype 0.7x Speed Booster (35mm f/0.90 system), wide-open on a Panasonic Lumix GH1 camera.

Figure 25: Nikon 55mm f/2.8 macro AIS objective plus a prototype 0.7x Speed Booster (38.5mm f/2.0 system) shot wide-open at f/2.0 on a Sony NEX C3 camera.

Figure 26: Crop of Figure 19 shows good sharpness and contrast at f/2.0.

Fig. 27: Nikon 50mm f/1.2 with Speed Booster = 35mm f/0.90 shot wide-open.

Fig. 28: Nikon 50mm f/1.2 with Speed Booster = 35mm f/0.90 shot wide-open.

Fig. 29: Nikon 50mm f/1.2 with Speed Booster = 35mm f/0.90 shot wide-open.

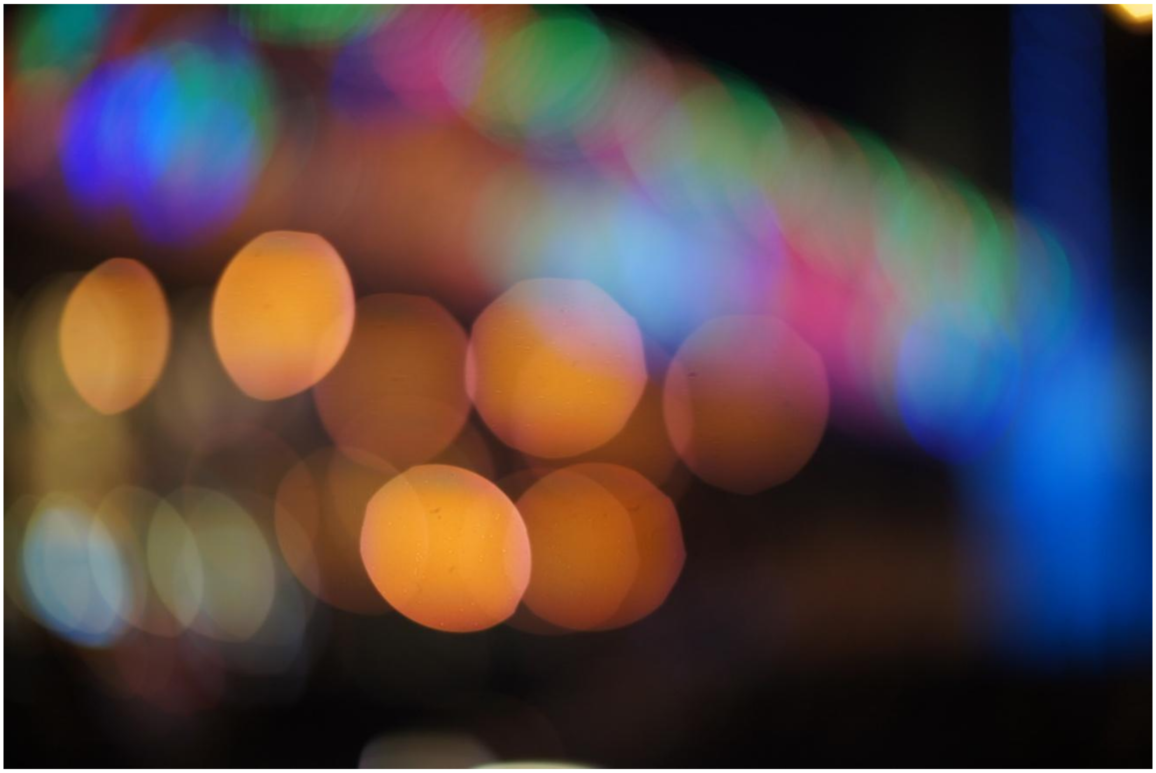


Fig. 30: Nikon 50mm f/1.2 with Speed Booster = 35mm f/0.90 shot wide-open. This image shows the size of the out-of-focus distant lights, when the lens is focused to 0.5m


Fig. 31: Nikon 50mm f/1.2 with Speed Booster = 35mm f/0.90 shot wide-open.

Wow!

Brian Caldwell

Wilfried Bittner

## 16) The Authors

**Brian Caldwell** is a lens designer and optical engineer with more than 25 years experience, and has 500+ design projects and 100+ manufactured products to his credit. Brian founded Caldwell Photographic in 2001 to do independent consulting, and to develop and manufacture optical products.

**Wilfried Bittner** is a mechanical engineer specializing in opto-mechanics, and has more than 35 years experience in the optical and photographic industries, both in Germany and Hong Kong. Wilfried founded WB Design in 2006 to do specialized mechanical design and product development work

Brian and Wilfried have worked together since 2000 on numerous product development projects ranging from inexpensive consumer cameras to high end cinematography and aerospace systems. Among these products is the 60mm UV-VIS-IR photographic lens currently licensed for manufacture by Coastal Optical Systems. One of their most recent collaborations is the design of twelve different high speed prime lenses with nearly diffraction-limited performance for Panavision’s new 70mm digital cinematography camera.