

# Canon

WHITE PAPER  
CINEMA EOS LENSES

## PERSONALITY OF THE CANON CINEMA EOS LENS: *DESIGN STRATEGIES*



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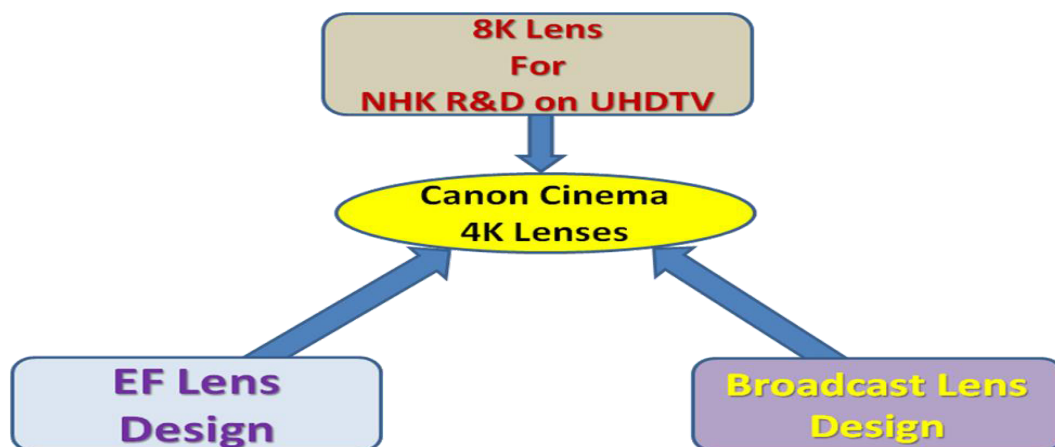
CINEMA EOS

# The Personality of the Canon Cinema Lenses

I read on a recent cinematographer's website a comment that the lens is the "brush" that paints an image on the "canvas" of the image sensor in the digital camera. This picturesque metaphor actually captures a reality not often understood. The cine lens is tasked with intercepting a significant amount of three-dimensional scene information in the form of optical wavefronts impinging on the lens faceplate and transforming these into a tiny two-dimensional optical representation that is then projected onto the camera image sensor. In that optical transformation a multiplicity of "footprints" are indelibly stamped on many attributes that collectively describe the image quality of that output optical image. The solid-state image sensor and its supporting electronics, in turn, are tasked with the optoelectronic transformation that creates the digital representation of that image. There is little that image sensor can do to make any improvement upon what the cine lens has delivered to it.

## Canon Cinema Lens

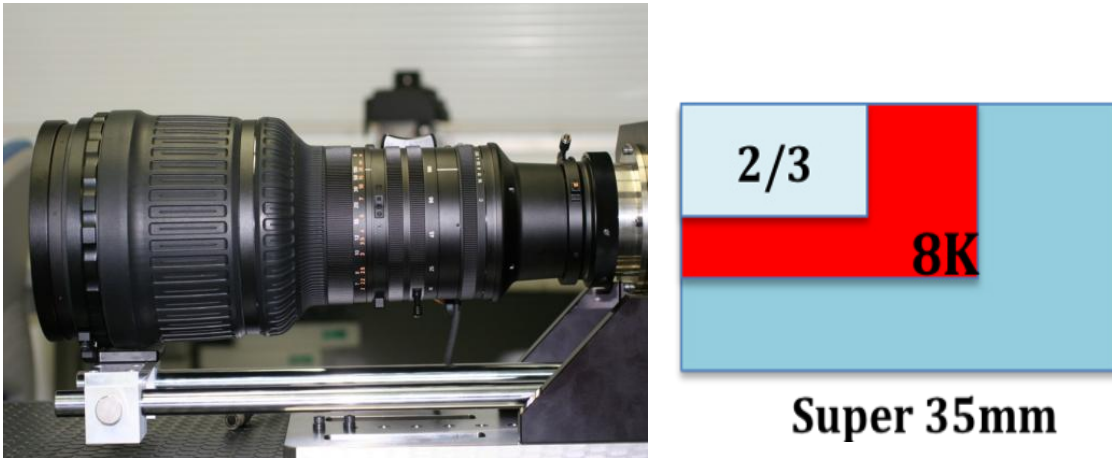
One often hears in the cinematography world various discussions about the "personality" of cine lenses that can endear a given optical manufacturer to the world's DP's and cinematographers. The intent of this series on the new Canon Cinema Lenses is to convey a little about the combination of deep optical technologies and creative expediciencies that were mobilized by our lens designers to bring to market a new series of lenses that would "paint" the best of cinematic imagery onto the many Super 35mm image sensors that are central to the world's contemporary digital cinema cameras. An attempt will be made to portray the "personality" sought in the design of these lenses – in a series of chapters. The optical technologies entailed were drawn from a number of major design groups that have formerly worked fairly separately on optical products that served quite different market sectors. Central to this is the substantial still imaging world of Canon DSLR cameras and their associated extensive EF lens family, and the broadcast lens group who, for more than fifty years, have developed generations of studio, field, and portable lenses for the broadcast and high-end production markets. Many of the current digital cine cameras originate 4K video – so this became central to the Canon design criteria.



**Figure 1** *The new generation of cinema lenses drew from multiple optical design resources within Canon*

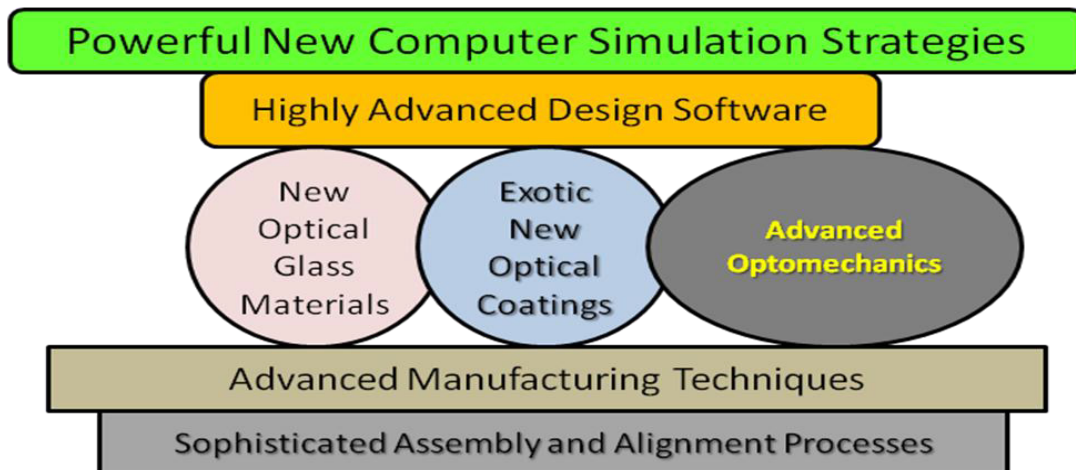
## A Central Technical Underpinning – the Legacy of Developments for 8K UHD TV

Some five years ago Canon was requested by the NHK Technical Research Labs to develop a zoom lens that met optical specifications for 8K (sixteen times the resolution of today's 1080-line HDTV) in support of their ongoing R&D work on UHD TV (termed Super HiVision in Japan).



**Figure 2** *The 8K 10:1 zoom lens developed by Canon in support of the UHD TV R&D project within the NHK Technical Research Laboratories. Note the relatively small image size that significantly challenged the optical design.*

This substantial design project required a return to the very fundamentals of what is presently feasible in optical technologies, and from this work was born a new optical platform that was to become central to Canon's more recent developments for the 4K Cinema zoom lenses. An optical platform is many things – that include the deployment of the very latest in computer simulation design techniques, the use of many of the latest glass materials, development of new optical coating materials and refinements in deposition technologies, and the mobilization of years of accumulated expertise in manufacturing, assembly and precision alignment.

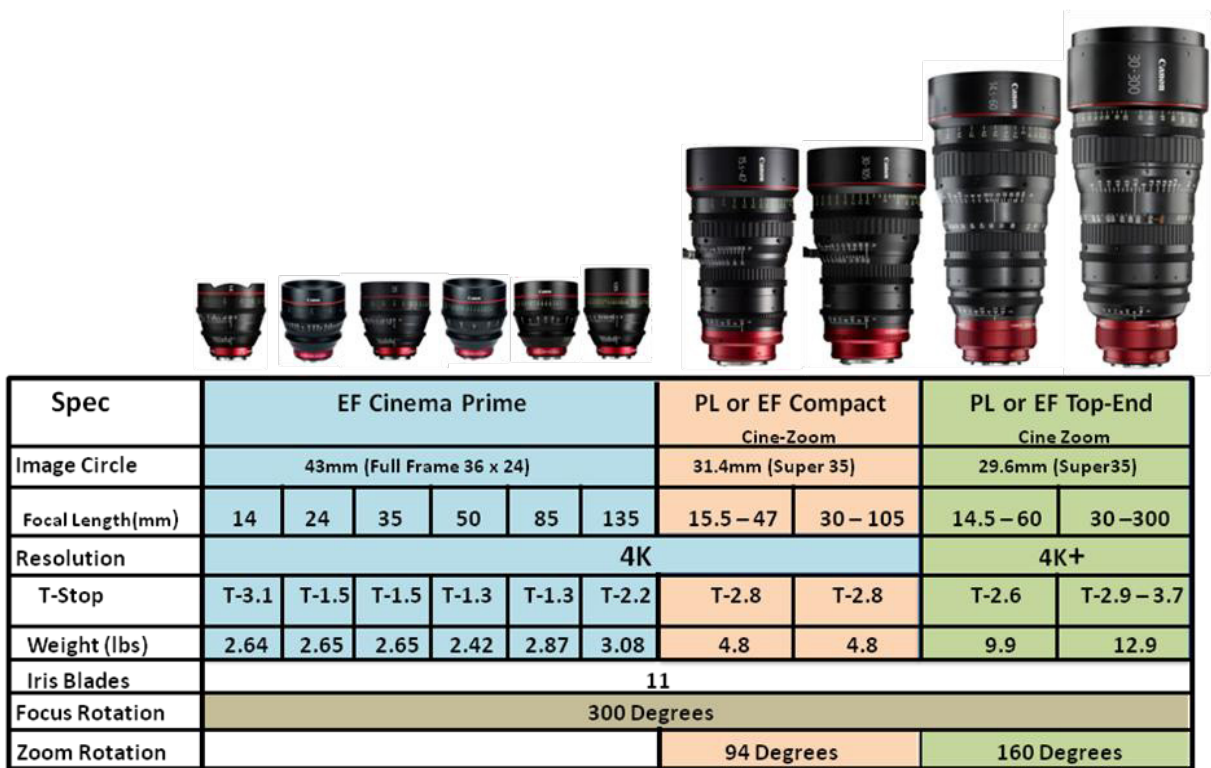


**Figure 3** *Depicting the many facets of what is termed an optical platform – all of which were central to the design of the cinema lenses*

## Personality of a Cine Lens – Mobilizing Resources and Experiences

Discourses on lens “personality” are probably best done at a bar because the conversation can sometimes become lengthy and, at times, convoluted. One certainly does regularly hear about the importance of optical artifacts and aberrations in imparting a certain desired look for some specific scenes. At the same time, one also hears of the enduring importance of sharpness, contrast, color reproduction and other core attributes of high quality imagery.

The major Canon Cinema Lens development project – that has so far produced four distinct cine zoom lenses and six prime lenses – drew upon that vast accumulated technical and creative knowledge within Canon. Ambitious 4K performance specifications were drawn up for these lenses. But, at the same time, there was extensive discussion about incorporating attributes that would aspire to address the cinematic look that was so passionately urged by many DP’s.



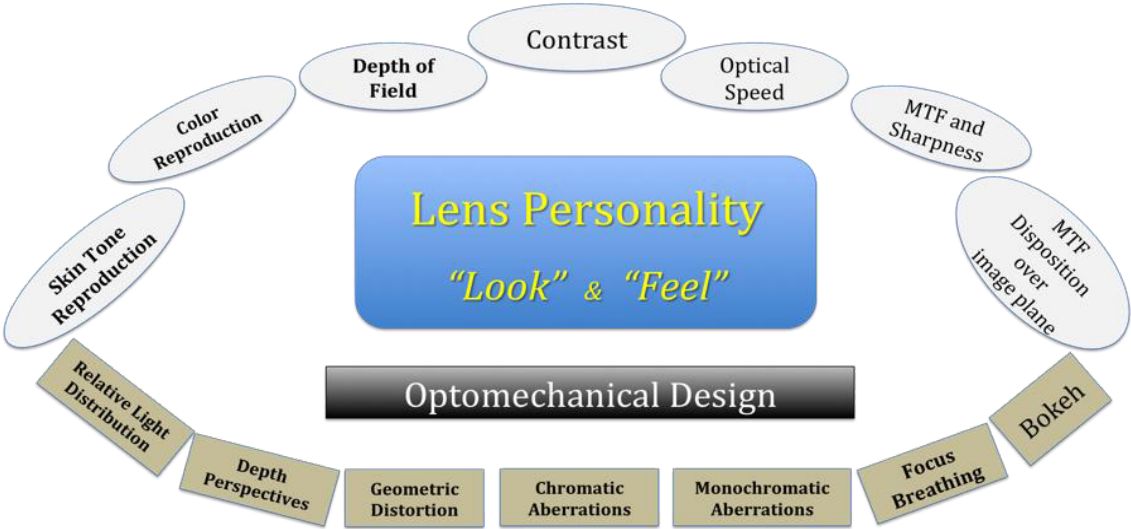
**Figure 4** *Showing the full present lineup of Canon’s Cinema Lenses and their salient operational specifications*

The broadcast lens design group of Canon has serviced the world’s broadcasters, production studios, and mobile production facilities for many decades. This long experience speaks to a global dialog that never ceases as the huge number of practitioners who use these lenses constantly offer critiques, suggestions and pleas that unceasingly propel our developments. From very high-end studios to major sporting events to multiple genres of television programming – the associated design refinements never cease. Our optical engineers have a vast experience in all of the nuances of subjective “looks” desired by disparate creative entities within the larger motion imaging industry.

Separately, the EF lens design groups have seen some ninety million of the more than sixty different EF lens types that they designed over the past twenty five years spread into the hands of some of the most demanding and creative artisans in the global still imaging world. This too, has spawned a continuing vigorous exchange that constantly drives new optical innovations. In turn, the extensive EF design group has accumulated a tremendous pool of imaging expertise.

Nor should it be forgotten that Canon long ago developed and manufactured 35mm cine lenses for motion picture film – that won an Emmy back in the 1970s. That was flanked by an even longer history in producing lenses for 16mm and Super16mm motion picture film cameras.

Canon’s optical design teams spent a considerable time using powerful computer aided simulation tools to explore the possibilities in reconciling very high 4K specifications with a variety of novel design strategies that would collectively contribute to a unique *Canon Personality* in the new cine zoom lenses. That extensive exploration examined all aspects of lens image quality parameters and image aberrations and distortions in a prolonged search for an aggregate performance that would speak to the urgings of those with whom we had consulted.



**Figure 4**                      *The “personality” of a given lens is bound up in the accumulated imaging attributes of that optical system that is further tempered by the residual aberrations and artifacts*

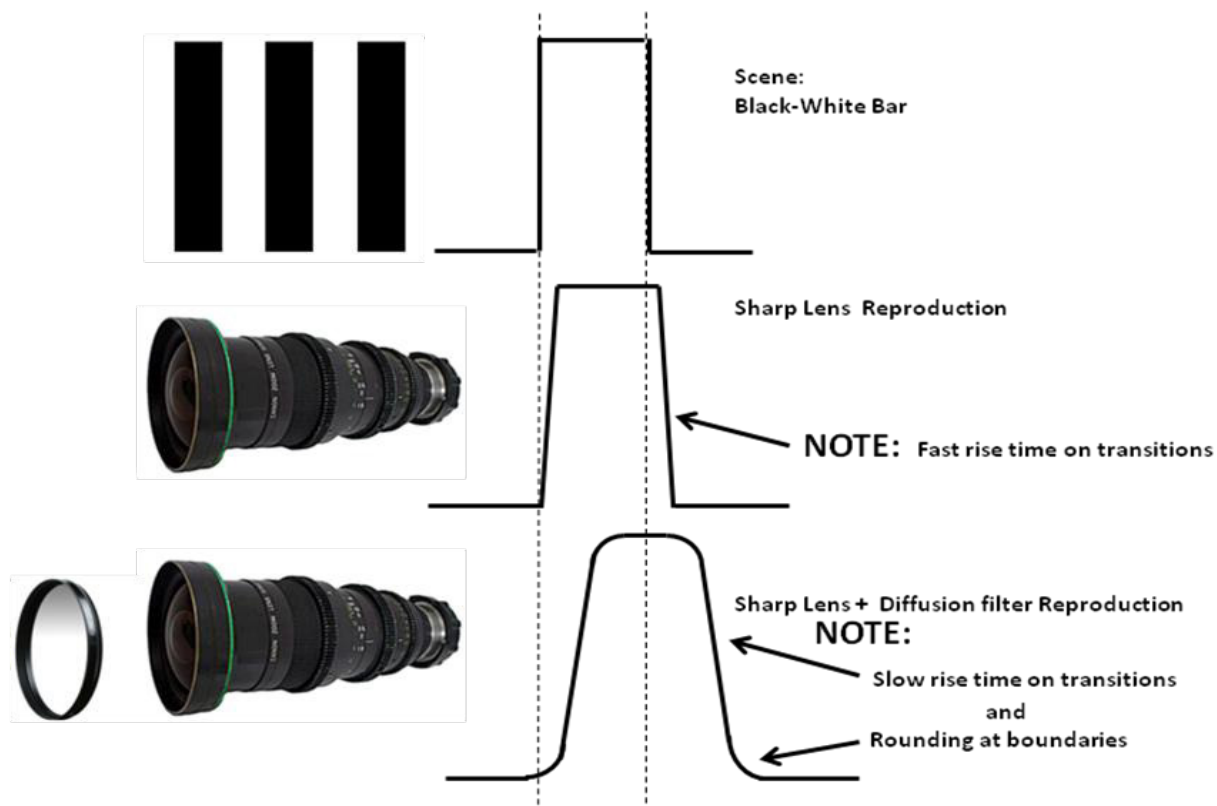
**Cinema Zoom Lens Personality – One Specific Design Strategy**

A

particularly innovative, and indeed quite elegant, design strategy incorporated into the cine zoom lenses was founded on an expressed desire by numerous DP’s to have a lens that exhibited a desired high sharpness that was tempered by a subtle softness. In one sense, this might seem contradictory. DP’s and cinematographers regularly employ diffusion filters when certain scenes require a requisite degree of softening. But, there are times when the desired balance between sharpness in a region of the scene and a sought-for softness in a face within that scene cannot be struck.

Or perhaps there is a desire to slightly soften a facial reproduction while maintaining high sharpness in the hair surrounding that face. In interviews with DP's such issue became a topic of some considerable discussion, particularly when we spoke about our aspirations for the high sharpness of these new 4K lenses.

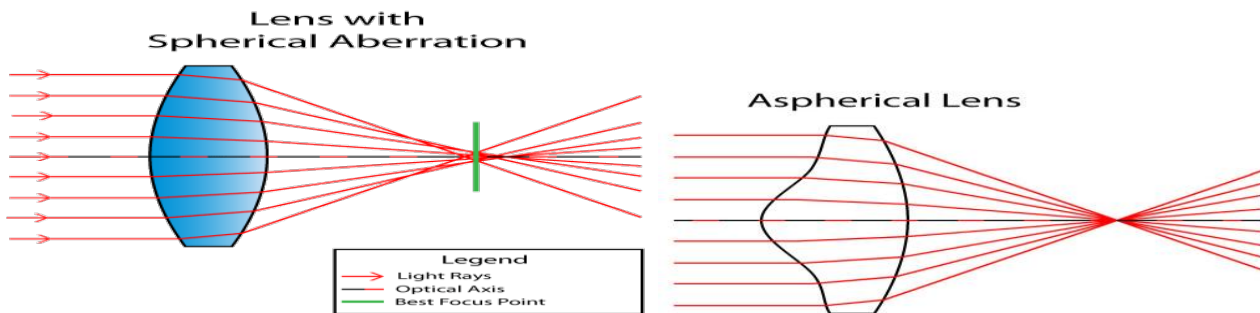
To understand the novel approach taken by the Canon optical designers to seek this particular aspect of a cine lens personality the simple illustration of Figure 5 should help set the stage. This shows a simple scene comprising a high and sharp brightness transition – between black bars and adjacent white bars. When this is imaged by a lens having high sharpness, there is an inevitable small degree of filtering that will slightly slope that vertical transition on the lens optical output. That may still be too sharp for a certain desired “look” – so now resort is made to an optical diffusion filter in front of the lens. That will produce the optical output suggested at the bottom of the image. The filter has done a number of things here – first, it has increased the slope of the transition, has rounded all corners, and has skewed (or delayed) the transitions as shown. These effects have been exaggerated in the drawing to convey the concept.



**Figure 5** *Showing the optical performance of a high resolution lens and then the effect of adding a diffusion filter*

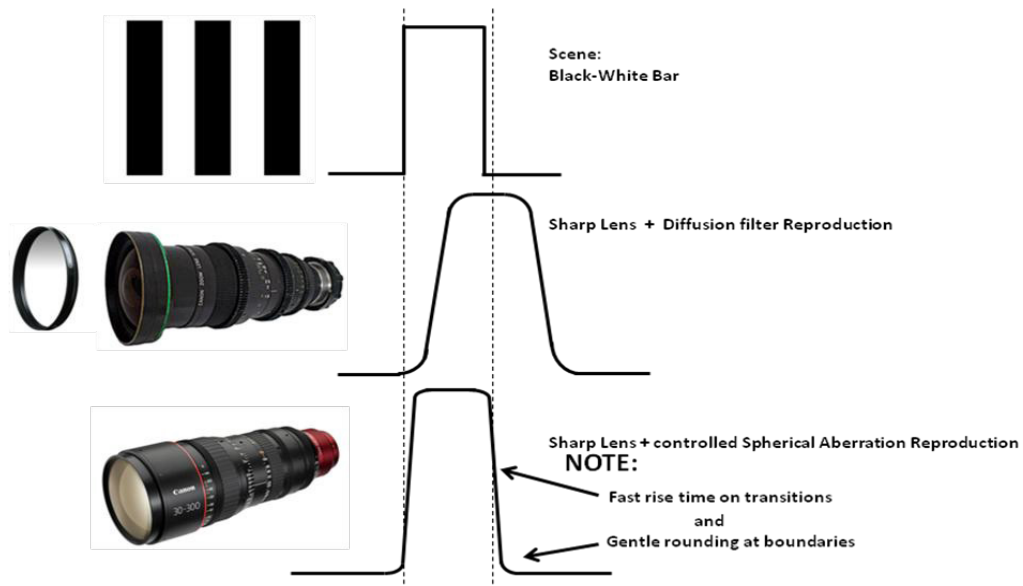
The combination of these effects has not achieved the desired result. What is actually sought is a preservation of the fast edge transitions provided by the sharp 4K lens, but a far more modest rounding of all corners that will introduce the subtle degree of softening that is sought. It is not possible for an optical diffusion filter to do this.

Using powerful computer simulation Canon optical designers explored the possibilities that might support the fast transitions associated with a full 4K optical resolution specification while also introducing a modest degree of rounding of those corners. They ultimately came upon a powerful and reproducible method to do so. They mobilized one of the monochromatic aberrations – which traditionally all optical designers struggle mightily to minimize in a lens design. There are four classic monochromatic aberrations that are fundamental to all lens elements – they are astigmatism, curvature of field, comatic, and spherical aberration. Over the past century and more the art of optical design has progressively developed ingenious ways to counteract these aberrations by playing one lens elements against another (or groups of elements against each other in terms of shapes and different glass materials. In more recent years the innovation of aspherical lens design has produced powerful new ways to minimize this distortion – as outlined in Figure 6.



**Figure 6** *A simplistic rendition of the nature of spherical aberration in a lens element and also one of the lens innovations used to combat this*

By a tightly controlled design, a small and precise amount of spherical aberration is introduced into these 4K lenses that has precisely the softening effect shown in Figure 7



**Figure 7** *Showing the subtle softening of the Canon Cinema lens in contrast to the effect of a diffusion filter on a typical cine lens*

This is illustrated with an actual test conducted on one of the new cine zoom lenses. Following verification of the 4K optical resolution and the high MTF achieved by these lenses, the test was extended to subsequently explore how the lens dealt with sharp contrast transitions on real world scenes. Figure 7 shows the results of these tests. The print does not do justice to the subtlety of the effect – but on a studio reference monitor the effect is startling and was acclaimed by the DP, Alfonso Parra, who conducted the test [1].



**Figure 6**                      *Showing a subtle softening on the boundaries of the sharp contrast transition between the candle flames and the very dark room interior*

## **Personality of the Canon Cinema Lenses – a Summary**

We have described one novel approach to imbuing the new Cine lenses with an imaging attribute that, while described in different ways by different cinematographers, did pose a challenge that excited our optical designers. We feel that something important has been achieved here. While it is still relatively early days for these new cine lenses, the experiences to date are most heartening.

In the next in this series on these cine zoom lenses we will explore the extraordinary measures taken to have these lenses perform as credible *Variable Prime* lenses.

## **References:**

[1]     [http://alfonsoparra.com/en/press/cat/research/234/Canon-CN-E-14-5-60mm-T2\\_6-](http://alfonsoparra.com/en/press/cat/research/234/Canon-CN-E-14-5-60mm-T2_6-)