



WHITE PAPER
CINEMA EOS C500

CHOICE OF WIDE COLOR GAMUTS IN CINEMA EOS C500 CAMERA



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CINEMA EOS



Choice of Wide Color Gamuts in Cinema EOS C500 Camera

Introduction

In September 2013 Canon issued a formal press release announcing a range of firmware upgrades for the Cinema EOS cameras. This paper will discuss one specific upgrade among this list – namely, a set of expanded color gamuts for the EOS C500 digital cine camera. A color gamut speaks to the range of colors in a specific print or display, or alternatively, what is originated in a specific camera. In the case of the latter color gamut is defined by a triangle that, in turn, is defined by the three RGB primaries that can be selectively set up in the camera.

Today, major media companies produce high-end programming intended for distribution on multiple platforms and in multiple digital formats. The higher the quality “overhead” of the program master – in terms of spatial resolution, temporal resolution, dynamic range, color gamut, bit depth – the better the flexibilities in formulating the many required distribution formats, especially over the long term. It was with this in mind that Canon now offers a choice in color gamut for the EOS C500 camera. This paper will explain the background to those choices.

Assessing Color

The study of color is complex. It is not the intention of this paper to attempt a tutorial on this topic. We will simply look at how color gamuts are defined and compared. Every color can be divided into a chromaticity and a brightness component. The chromaticity component describes the proportion of the different wavelengths that make up the particular color. Chromaticity is also what defines a color space or color gamut. Many studies over many years led to various methods of mapping all of the colors that the human visual system can perceive. The most common is the CIE 1931 xy chromaticity diagram [1].

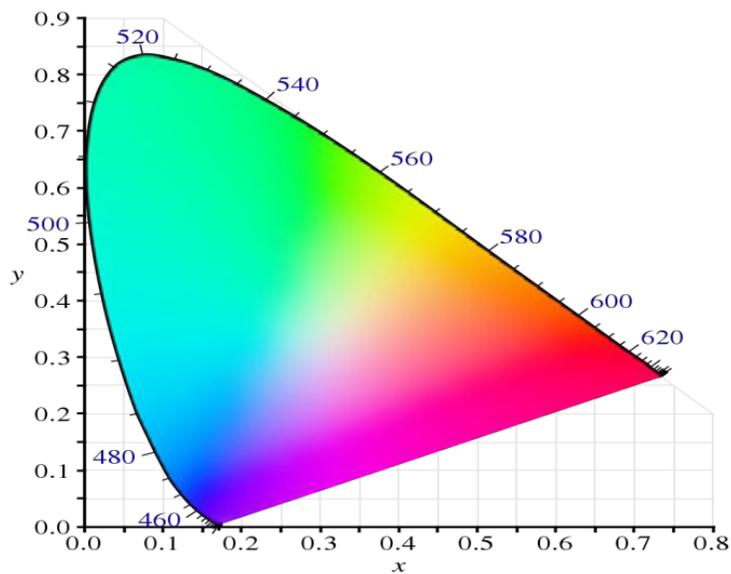


Figure 1 *Showing the long-established CIE Chromaticity Diagram used to explore color gamuts*

The unique visible wavelengths are distributed around the horseshoe shaped perimeter of this defined color space, and the outline itself represents the maximum saturation of a given spectral color.

The outline encompasses all of the color hues that are visible to us. Without going into the science of this diagram we are simply going to use it to COMPARE the four color gamuts of the EOS C500. This comparison will look at how each of the selectable camera color gamuts compare with three color gamuts important to today's world of program production:

1. Color gamut that encompasses most of the colors we encounter in the real world
2. Color gamut of motion picture film – recognized as greater than that of broadcast television
3. Color Gamut of the new UHDTV production standard – a blueprint for the future of television

Many studies have been conducted over the years to attempt to define the boundaries of the real-world colors that we see in everyday life. The most popular of these studies produced the well know Pointer's color gamut [2].

A Standardized Color Gamut for HD Television Origination

The range of colors being originated is termed the color gamut of the particular camera. When Cinema EOS was introduced in Nov 2011, the associated cameras all had a color gamut meeting the international standard for HDTV – known as ITU Rec BT.709. By definition, this color gamut is television-centric. It is a quite subjectively pleasing color gamut and it is established worldwide. However, within the larger scope of contemporary program origination, the Rec BT.709 color gamut is considered limited. A sense of this limitation can be gleaned by seeing how Rec BT.709 straddles both Pointer's color gamut and that of motion picture film [3] – as illustrated in Figure 2.

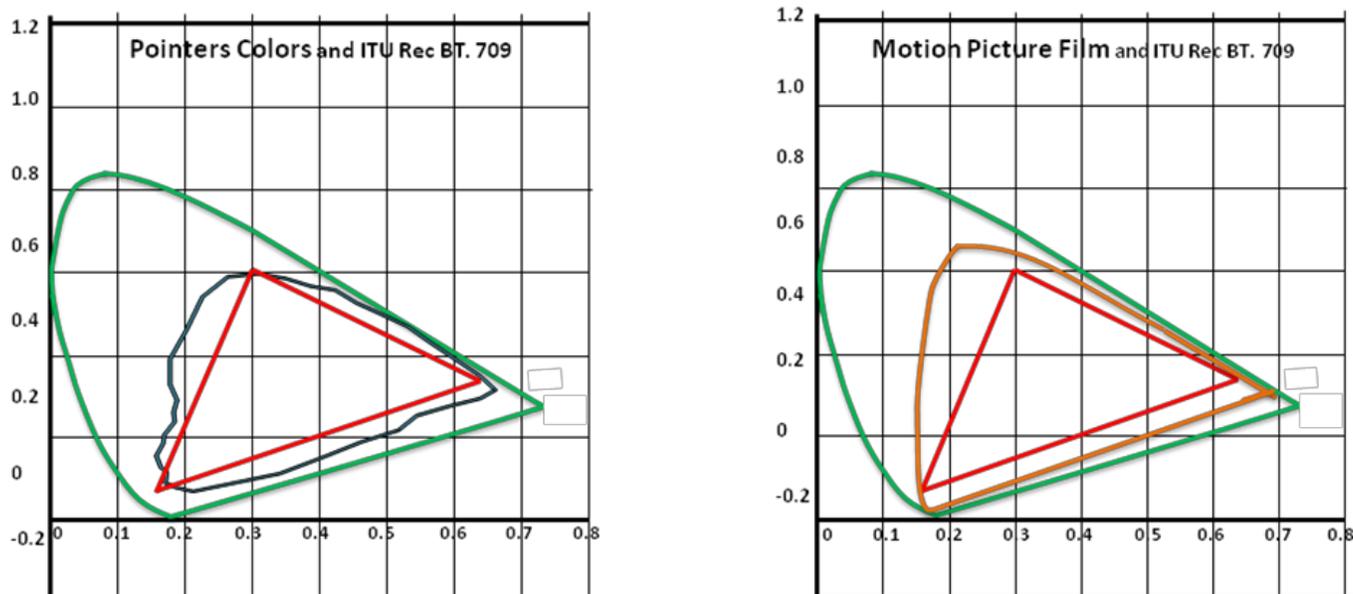


Figure 2 Using the CIE Chromaticity Diagram to show how a camera that conforms to the standardized HDTV color gamut (the red triangle) relates to both Pointers color gamut and also the color gamut of motion picture film

Canon's Approach to Wide Color Gamut

Canon designed the Cinema EOS family of lenses and cameras to address all forms of program genres. This includes the many different genres that make up today's television production, television commercial production, theatrical motion picture production, and a range of non-entertainment digital imaging applications.

In 2003 the Hollywood studios issued a specification for the emerging digital cinema system. This included a specified color gamut for digital cinema projectors – now known as DCI-P3. Later, this was formally standardized by SMPTE – as ST 431-2 [4]. While it is a wider color gamut than Rec BT.709 – it still not quite as wide as motion picture film itself, but it is close. The key goal here was to ensure a specification for the cinema that could be technically met by the different digital cinema projector technologies appearing in the marketplace.

More recently, the international standards body ITU issued their formal recommended production specification for Ultra High Definition Television (UHDTV). This included the 3840 (H) x 2160 (V) and the 7680 (H) x 4320 (V) digital sampling formats. It was approved in 2102 and is known as ITU Rec BT. 2020. It has a very wide color gamut – beyond that of motion picture film.

Our Canon color scientists had also been closely following the evolving UHDTV production standard, and once it was finalized [5], we were then ready to implement within the EOS C500 camera a remarkably innovative range of choices in color gamut that are intended to support all of the listed creative production requirements of today and tomorrow. A recent firmware update is all that is required here – and it facilitates a user selection of the following four camera color gamuts:

1. **ITU Rec BT. 709**

To support worldwide HDTV production according to this global colorimetric standard

2. **DCI-P3**

To support the production of theatrical motion picture production for those who seek colorimetry that matches the specification of today's digital cinema projectors

3. **DCI-P3 Plus**

To offer a wider color gamut than DCI-P3 – one that more closely matches contemporary motion picture film and supports creative postproduction grading that seeks a specific cinematic look

4. **Canon Cinema Gamut**

This is a very wide color gamut that fully encompasses that of the "4k/8k" UHDTV ITU Rec BT. 2020 and also encompasses the color gamut of all contemporary motion picture film stocks

An Important Standardized Color Gamut – the DCI-P3 for Digital Cinema

Figure 3 shows how the DCI-P3 color gamut overlays on the Pointer color gamut, the color gamut of motion picture film, and the very wide color gamut for UHDTV. It does a very reasonable coverage of Pointer and of film – but it clearly falls short of BT.2020.

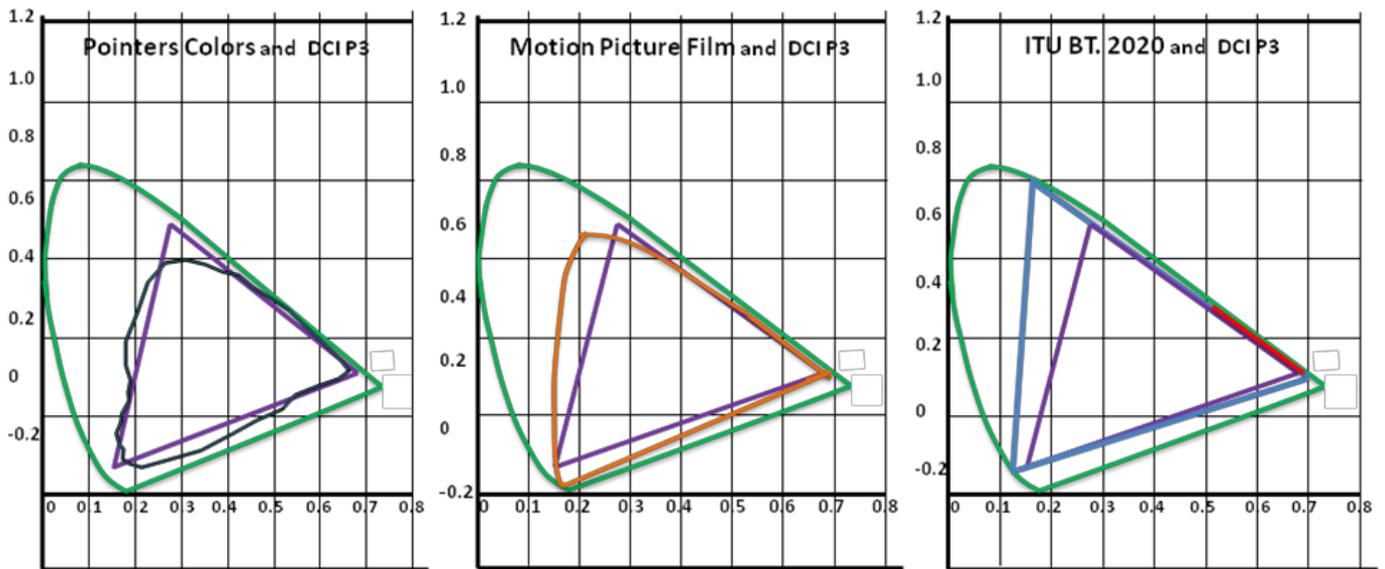


Figure 3 Showing how the Digital Cinema DCI-P3 color gamut (purple triangle) aligns with Pointer, motion picture film, and the new UHDTV color gamuts

Canon DCI-P3 “Plus” Color Gamut – for Theatrical Movie Origination

We have already discussed the first two on this list. Both of those, as mentioned, are international industry standards. The third color gamut is one designed by Canon – labeled DCI-P3 Plus – which suggests a step beyond the standardized DCI-P3. This wider color gamut is explicitly intended to:

- (a) Totally encompass the Pointer Real world colors
- (b) Almost totally encompass the color gamut of motion picture film

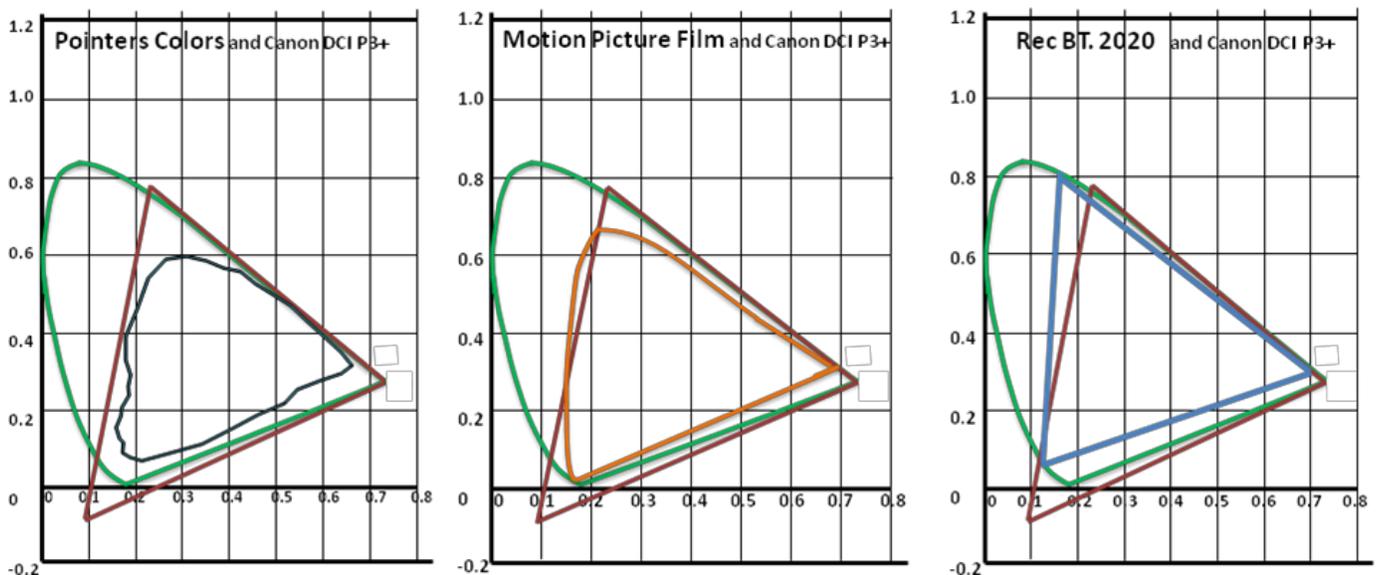


Figure 4 Showing the unique Canon DCI-P3+ color gamut (dark brown triangle) which does justice to both Pointers color gamut and that of motion picture film. Clearly, it does not match the color gamut of the new UHDTV production standard ITU BT.2020

Canon Cinema Gamut

This is a color gamut specifically developed by Canon to empower the C500 cine camera to meet all of the color origination requirements for contemporary program production – including:

1. HDTV
2. Improved digital emulation of motion picture film stock color gamuts – at 2K and 4K levels
3. New wide color gamut of ITU BT.2020 for 4K UHD TV

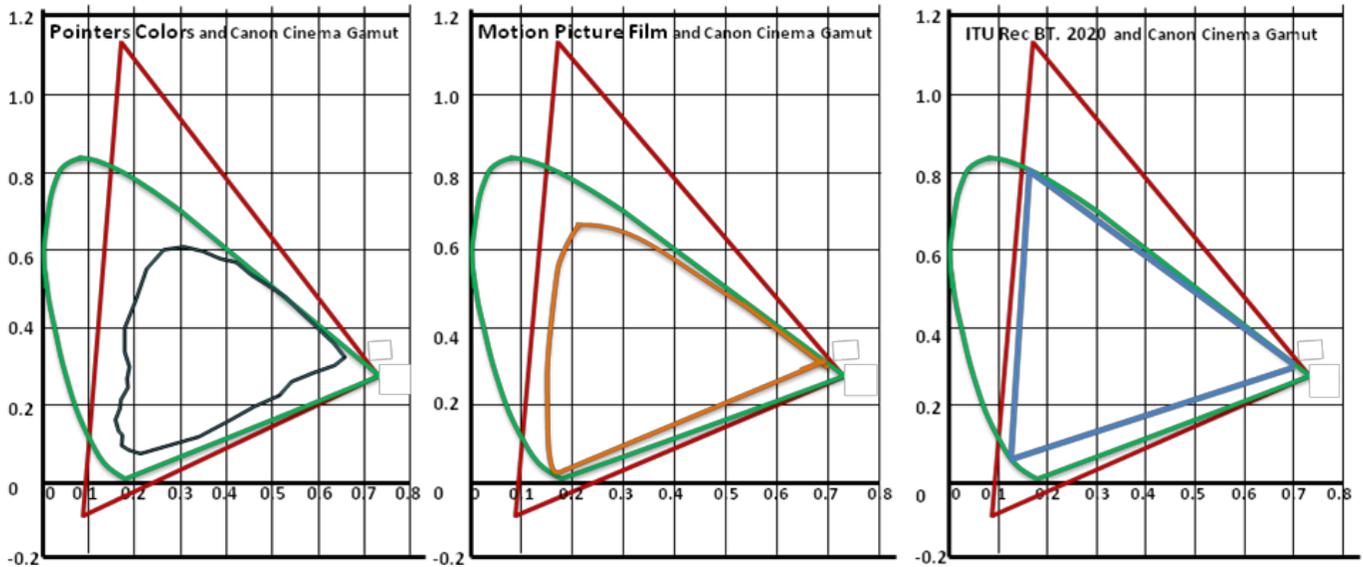


Figure 5 Showing the very wide gamut of the Canon Cinema Gamut (red triangle) and how it can encompass all of contemporary motion picture film color gamuts as well as the new UHD TV color gamut specified by ITU Rec BT.2020

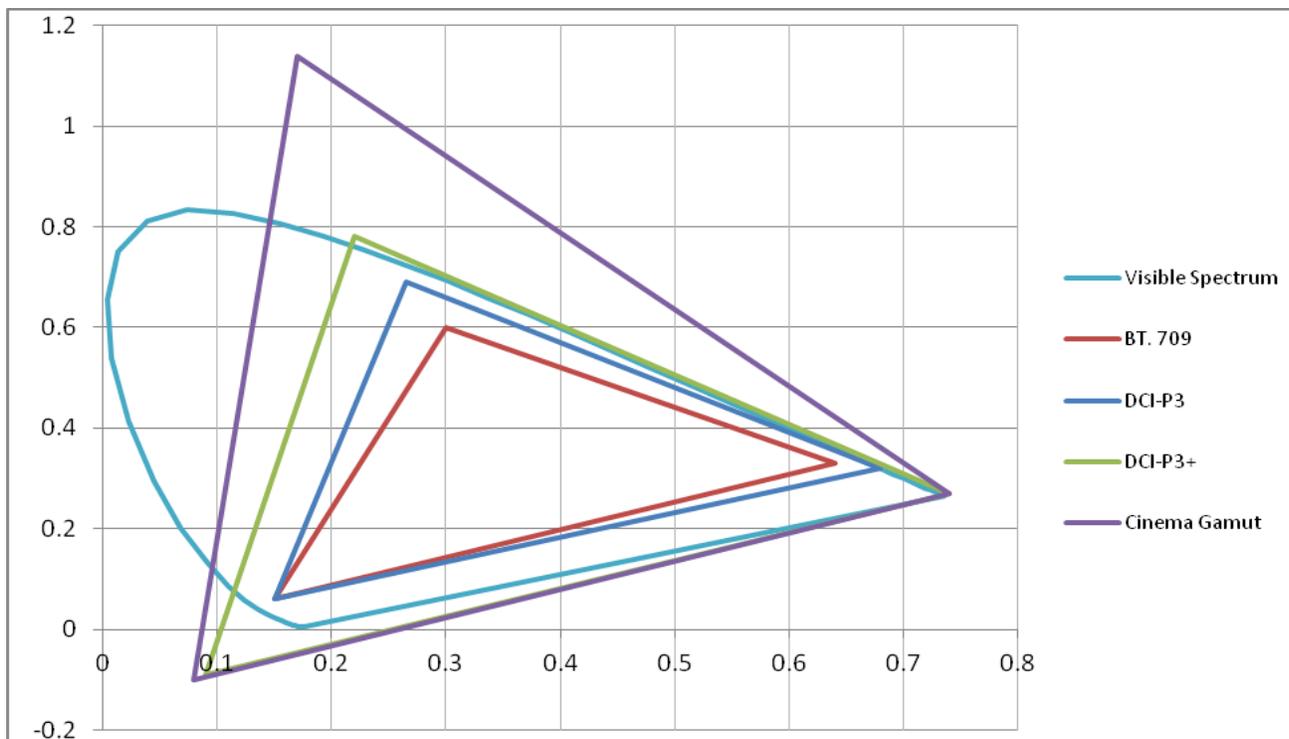
Summary

As the industry continues today to produce both HDTV programming and an increasing amount of theatrical motion pictures in digital 2K, the steady advance of digital 4K offers further promise of enhanced viewing experiences – both in the cinema and in the home. But, in addition to resolution considerations, there is also a heightening industry interest in improving other critical dimensions of image quality with higher picture capture rates, increased dynamic range – and, wider color gamuts. In combination, these attributes can significantly elevate the overall viewing experience.

It was in this context that Canon deemed it important to offer new creative choices in color gamut. A specific EOS C500 camera may be shooting a television drama in HD – where the ITU Rec BT.709 color gamut is chosen. This production may be followed by a theatrical motion picture being shot in 2K or 4K.

And, on such a production, a selection of the DCI-P3 Plus, or the Canon Cinema Gamut in the EOS C500 camera will offer far greater latitude in final color grading – allowing the production team to achieve one of a number of choices in a cinematic “film” look.

There might also be a time where a broadcaster, wishing to enhance the archival value of a new HDTV production, may elect to originate this in 4K on the C500 according to the UHDTV ITU Rec BT.2020 – then release today in downconverted HDTV (a superior HDTV image quality because of the super-sampling of the original), while also protecting the UHDTV master for some future release date within a total 4K environment. Here again, the Canon Cinema Gamut would be ideal.



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- [5] Recommendation ITU-R BT.2020 (08/2012) "Parameter values for ultra-high definition television systems for production and international programme exchange" BT Series Broadcast