UHD World Association
世界超高清视频产业联盟

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HDR Vivid

Technical White Paper

(V2.0)

UHD World Association

November 30, 2022

About This Document

The Secretariat of the UHD World Association (UWA) oversaw efforts to formulate this document and is responsible for its interpretation.

This document was published on December 15, 2022.

This document is proposed and managed by the UWA.

This document is jointly drafted by: UHD World Association, China Media Group, China Electronics Standardization Institute, China Center for Information Industry Development, Huawei Technologies Co., Ltd., HiSilicon (Shanghai) Technologies Co., Ltd., Academy of Broadcasting Science of National Radio and Television Administration, Academy of Broadcasting Planning of National Radio and Television Administration, China Telecom Corporation Limited, Migu Culture Technology Co., Ltd. of China Mobile, Smart Home Operation Center of China Mobile, China United Network Communications Group Corporation Limited, The Fifth Electronics Research Institute of the Ministry of Industry and Information Technology, Shenzhen Tencent Computer System Co., Ltd., Beijing iQIYI Science & Technology Co., Ltd., Beijing Baidu Netcom Science & Technology Co., Ltd., Youku Information Technology (Beijing) Co., Ltd., Chengdu Sobey Digital Technology Co., Ltd., Hangzhou Arcvideo Technology Co., Ltd., FilmLight Ltd., Sharp Corporation, TCL Industries Holdings Co., Ltd., Konka Group Co., Ltd., Hisense Visual Technology Co., Ltd., Shenzhen Skyworth-RGB Electronics Co., Ltd., Qingdao Haier Multimedia Co., Ltd., Honor Device Co., Ltd., Guangdong Oppo Mobile Telecommunications Corp., Ltd., Beijing Xiaomi Electronics Co., Ltd., BOE Technology Group Co., Ltd., Sumavision Technologies Co., Ltd., Xin'aote Group, MediaTek Inc., Unilumin Group Co., Ltd., Leyard Optoelectronic Co., Ltd., Yutian Socam AV System Corp., Shanghai National Engineering Research Center of Digital Television Co., Ltd.,

Shanghai Media Group, Shanghai Media Tech Co., Ltd., and Shandong Radio and Television Station

The main authors are: Zhang Wengang, Li Yan, Ma Yue, Liu Bin, Ning Jinhui, Chen Renwei, Zhang Hongyu, Wang Xinge, Wen Xiaojun, Song Zixin, Yu Quanhe, Wang Yichuan, Wu Dongsheng, Yuan Le, Wen Dianjie, Luo Chuanfei, Guo Xiaoqiang, Zhou Yun, Li Lin, Shan Huaqi, Guo Peipei, Wang Qi, Li Kangjing, Xu Haibin, Chen Wei, Cheng Jian, Lin, Xie Chaoping, Chen Yong, Liu Yi, Zhang Yan, Xing Huaifei, You Li, Cha Li, Li Dalong, Sun Lei, Wang Chenliang, Luo Yonglin, Wang Zhihang, Pan Li, Zhang Feng, Yu Lei, Dun Shengbao, Zhou Cheng, Yang Ruihan, Zhang Manhua, Xu Yaoling, Chen Xun, Han Qiufeng, Wang Yedong, Wei Shengyu, Wang Yaming, Dai Lin, Bai Jianjun, Tang Xun, Liu Li, Wang Bin, Li Yanjun, Guo Bin, Guan Zhipeng, Yin Huiqing, Tan Shenglin

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1. Background

The popularization of network technologies (particularly 5G and fiber optic technologies) the evolution of device display capabilities are ushering in an era of true-to-life, immersive ultra-high-definition (UHD) audio and video experiences. High dynamic range (HDR) is a key technology of the UHD audio and video industry and outperforms standard dynamic range (SDR) in terms of color volume, dynamic range, and image details. HDR, in tandem with wide color gamut (WCG), makes videos more true-to-life, with improved brightness and colors. Compared to SDR, HDR delivers a 100-fold improvement in peak brightness and provides a minimum brightness of 0.0005 cd/m^2. HDR also promises greater detail in both bright and dark areas, along with a wider color space, thus enhancing video quality in terms of contrast, gray scale, and color. In an HDR video, details of bright and dark highlights across all colors are preserved to the greatest extent possible, resulting in far more vivid, lifelike, and impressive images.
Static metadata cannot ensure consistent and optimal display effects on different devices. This is causing static metadata to lose ground to dynamic metadata, a type of metadata that makes it possible to extract and transmit the key characteristics of every frame or scene in a video. Through a combination of dynamic metadata and their own display capabilities, display devices can perform tone mapping on the video source file for better scene adaptation.
Solutions that support dynamic metadata and HDR/SDR display adaptation and scene adaptation are primarily commercial solutions. The industry urgently requires new HDR technical standards that can address its three major challenges:

(1) Some technical solutions entail high patent fees, which is driving up costs across the industry value chain. The number of HDR-ready devices remains small, and the ecosystem is fragmented.
(2) Multiple HDR technical standards coexist, with low degrees of compatibility. These standards do not cover the entire adaptation, certification, and testing process of mainstream devices. Therefore, the display performance of devices varies significantly, and users are unable to enjoy a consistent visual experience.
(3) HDR content is still scant, and existing tools need to be optimized.

With HDR Vivid, it is possible to overcome these challenges. HDR Vivid is a set of HDR technical standards and solutions that provide dynamic metadata and HDR/SDR display adaptation. A number of organizations – led by the UHD World Association (UWA) – worked together to develop HDR Vivid in the spirit of openness, leadership, and friendliness. In 2020, the UWA released technical group standards. In 2022, the *GY/T 358—2022 Technical Requirements for Display Adaptation Metadata of High Dynamic Range Television Systems* was published as industry standards for China's broadcasting and television industry. Moving forward, HDR Vivid is in a position for large-scale adoption.

2. HDR Vivid Standards System

The HDR Vivid series standards cover technical specifications, application guides, and technical requirements and test methods for devices. These standards encompass every link of the industry value chain. Figure 1 shows the current HDR Vivid standards system.

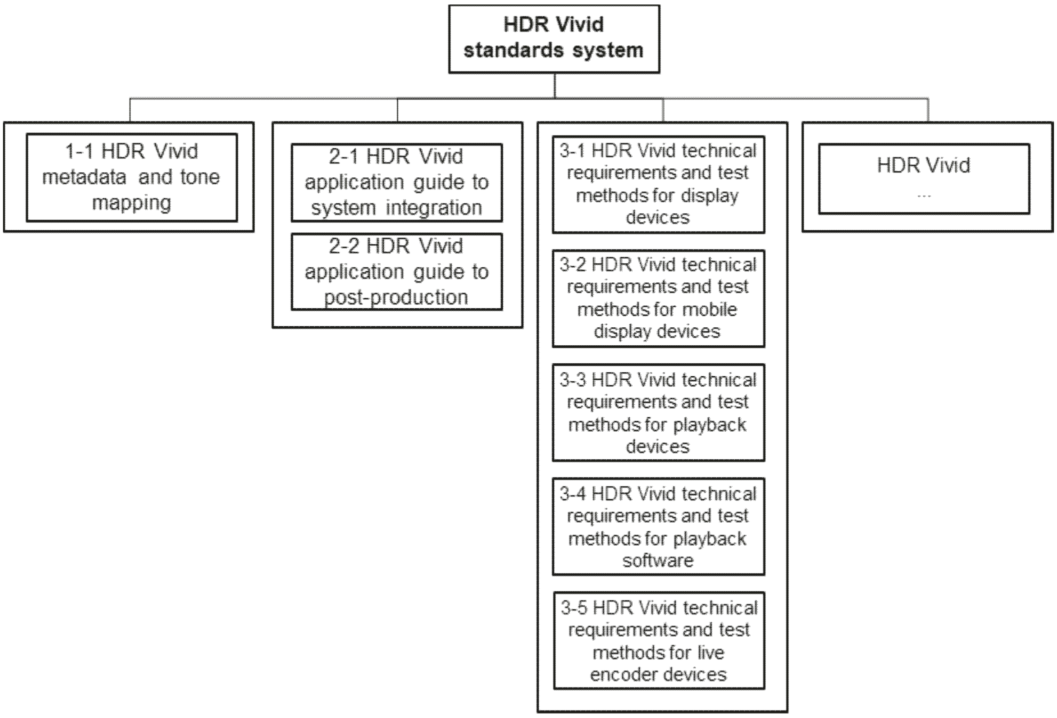


Figure 1 HDR Vivid Standards System

The following standards had been published by the end of October 2022:

(1) T/UWA 005.1-2022 High Dynamic Range Video Technology Part 1: Metadata and Tone Mapping

(2) T/UWA 005.2-1-2022 High Dynamic Range Video Technology Part 2-1: Application Guide to System Integration

(3) T/UWA 005.2-2-2022 High Dynamic Range Video Technology Part 2-2: Application Guide to Post-Production

(4) T/UWA 005.3-1-2022 High Dynamic Range Video Technology Part 3-1:

Technical Requirement and Test Method – Display Device

(5) T/UWA 005.3-2-2022 High Dynamic Range Video Technology Part 3-2: Technical Requirement and Test Method – Mobile Display Device

(6) T/UWA 005.3-3-2022 High Dynamic Range Video Technology Part 3-3: Technical Requirement and Test Method – Playback Device

(7) T/UWA 005.3-4-2022 High Dynamic Range Video Technology Part 3-4: Technical Requirement and Test Method – Playback Software

(8) T/UWA 005.3-5-2022 High Dynamic Range Video Technology Part 3-5: Technical Requirement and Test Method – Live Encoder Device

Table 1 specifies the types of standards planned for the future. For more information, visit the.

Table 1 Planned HDR Standards

Types of Planned HDR Vivid Standards					
1. Basic standards	2. General specifications	3. Technical standards and test methods	4. Evaluation criteria	5. Application guides	6. Other
Terms and definitions	Metadata and tone mapping	Metric definitions Technical requirements Testing verification methods	Subjective evaluation criteria Objective evaluation criteria	System integration Production process Tool guide	Technical white paper

3. HDR Vivid Technologies

3.1 Technical Principles

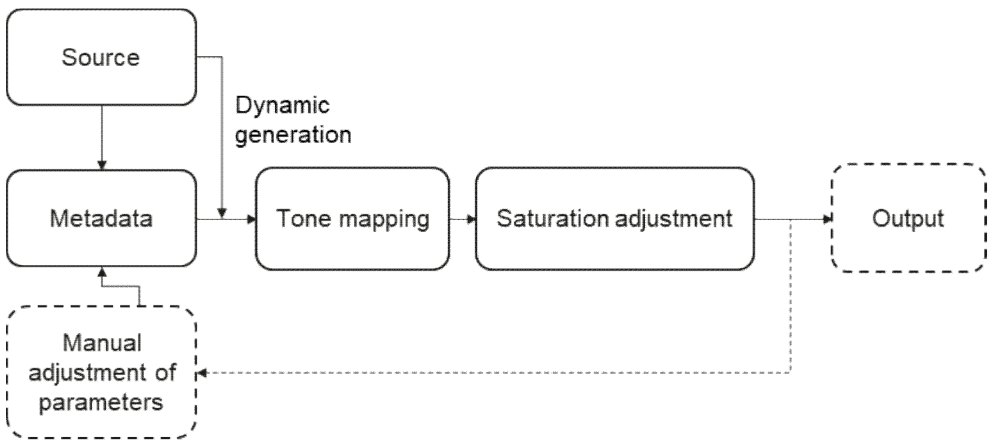


Figure 2 Technical Principles of HDR Vivid

The technical principles of HDR Vivid can be outlined as follows: (1) Analyze the video source file to generate dynamic metadata; (2) Conduct tone mapping and saturation adjustment based on dynamic metadata and devices' display capabilities; (3) Ensure consistent display effects across different devices.

HDR Vivid has three core technologies: dynamic metadata, tone mapping, and saturation adjustment.

(1) Dynamic metadata

Static metadata remains the same for the entire length of a video. Dynamic metadata changes on a scene-per-scene basis and can be used to represent the characteristic information of every frame or scene. Compared to static metadata, dynamic data is more robust and delivers better display effects. In terms of content production, dynamic metadata offers colorists more freedom to create personalized content by manually adjusting metadata in specific scenes.

(2) Tone mapping

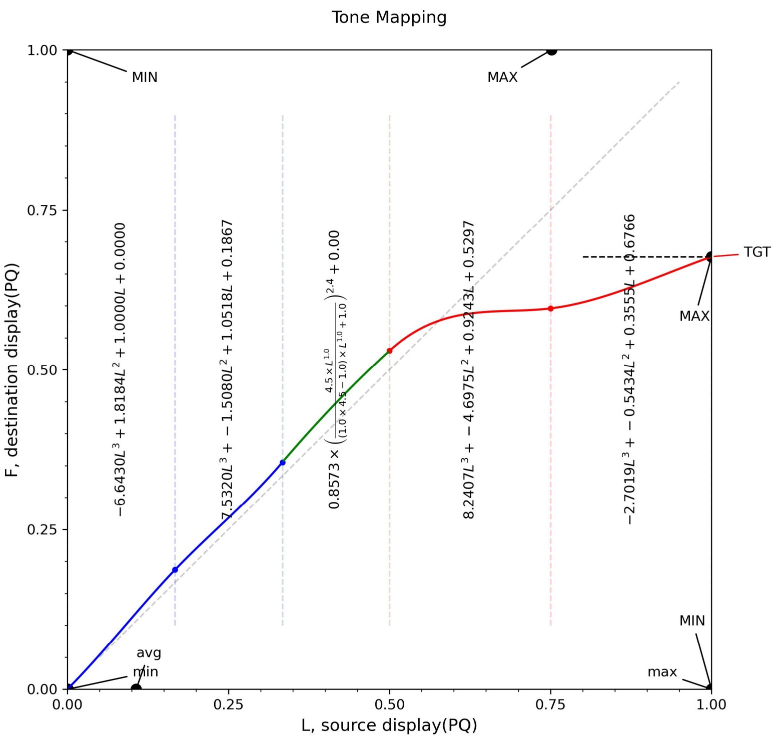


Figure 3 Metadata Mapping

Tone mapping relies on dynamic metadata and considers the analyses of scenes with

different characteristics as well as the maximum display capabilities of devices. The ability to generate different mapping curves through tone mapping (already defined within HDR Vivid standards) guarantees consistent display effects across different devices and reflects the creative intent of creators to the greatest extent possible.
Specifically, HDR Vivid offers two types of tone mapping curves: base curve and refined spline curve. The base curve is built on a human visual perception model and determines the overall style of tone mapping. The refined spline curve further optimizes the effects of tone mapping. The linear spline and the cubic spline for low-brightness areas can prevent the issue of excessive darkness. The cubic spline for high-brightness areas ensures that the maximum amount of detail is retained in bright areas.

(3) Saturation adjustment

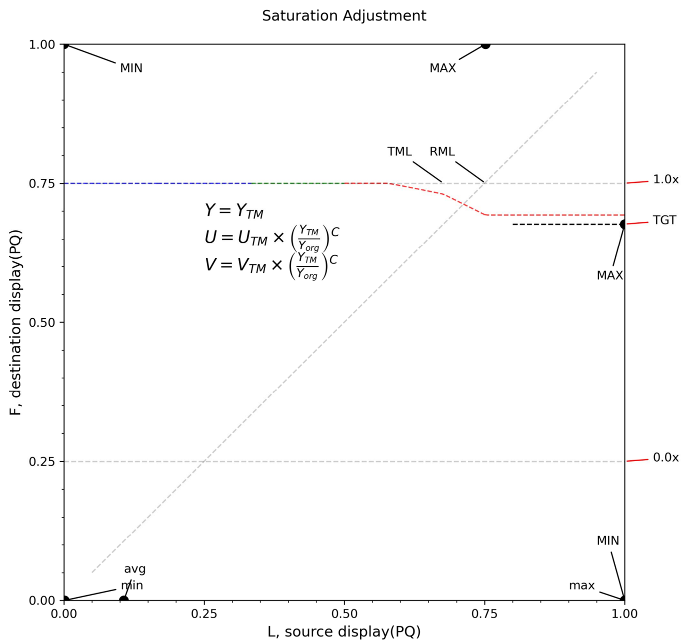


Figure 4 Saturation Adjustment

As brightness changes, so does saturation. Oversaturation is an issue that can seriously affect viewing experience. Fortunately, HDR Vivid can help prevent oversaturation. After tone mapping is completed, the next step is to conduct saturation adjustment, which means color correction. This ensures the video's color matches that of the source.

3.2 Key Technical Parameters

HDR Vivid is a globally-leading UHD video technology that has considerable advantages thanks to multiple technical parameters, such as bit depth, color gamut, luminosity curve, dynamic metadata, and metadata adjustment. Table 2 compares HDR Vivid with other video technologies.

Table 2 List of Standards and Their Parameters

	HDR Vivid	HDR10	SDR
Bit depth	10/12 bits	10 bits (default)	8 bits
Color gamut	BT.2020 or DCI-P3	BT.2020	BT.709
Luminosity curve	PQ and HLG	PQ	/
Dynamic metadata support	Yes	No	No
HDR/SDR compatibility	High	Medium	No
Openness	High	High	Low

3.3 Core Value

3.3.1 Technical Advantages

HDR Vivid has five key advantages:

(1) High compatibility

When a display device (e.g., smartphone, tablet, or TV) that doesn't support HDR Vivid receives an HDR Vivid signal, it can directly discard the metadata and display the content in HDR10 format.

(2) High consistency

By employing dynamic metadata, HDR Vivid can generate mapping curves of different brightness levels for different devices based on their display capabilities. Thanks to HDR Vivid, the display effects of the same image are basically consistent across different display devices. This consistency helps display the true creative intent of creators.

(3) High flexibility

In addition to supporting the automatic extraction of dynamic metadata, HDR Vivid allows colorists to create personalized content by manually adjusting metadata in a way that matches the creative intent of creators.

(4) Excellent adaptability across different application scenarios

HDR Vivid works across various application scenarios, such as online audio and video, program production and broadcasting, short videos, gaming, education, healthcare, etc. HDR Vivid supports both perceptual quantizer (PQ) and hybrid log gamma (HLG) formats.

(5) Great openness

HDR Vivid is an entirely open standard. All HDR Vivid resources, from code to implementation specifications, are accessible free of charge through designated channels.

3.3.2 Application Advantages

Aligning technical standards with real-world applications is the overarching principle of HDR Vivid. There are four main value propositions for HDR Vivid: high-quality HDR display definitions; optimal end-to-end standards; efficient content production and broadcasting tools; and industry-friendly applications. Facilitating the adoption of HDR Vivid technical standards throughout industries will generate tangible business value.

(1) High-quality HDR display definitions

The HDR Vivid technical standards provide open, comprehensive definitions for HDR Vivid, ensuring high quality at the source.

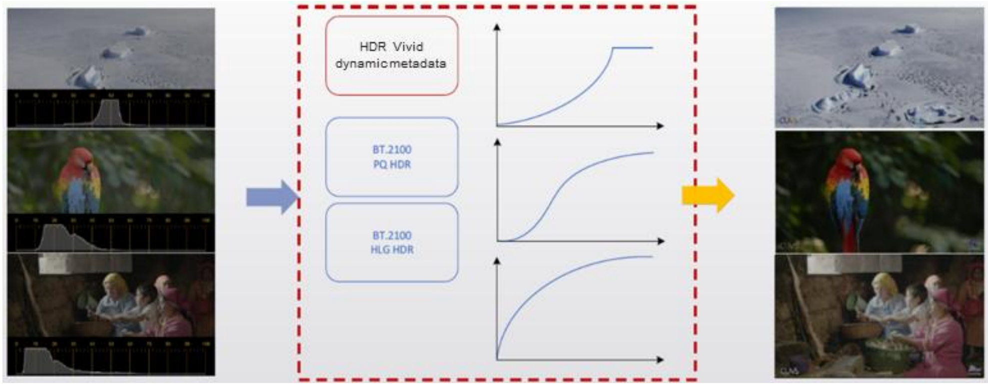


Figure 5 Metadata Definition

(2) Optimal end-to-end standards

The HDR Vivid standards system covers end-to-end technical specifications, application integration specifications, and certification and testing specifications, and will continue evolving to achieve rapid, sustainable development.

(3) Efficient content production and broadcasting tools

Efficient content production tools are available for HDR Vivid. At the production stage, the procedure of dynamic metadata generation is new, and there is no need to change the existing PQ (ST2084) and HLG HDR production processes. In addition, automatic dynamic metadata generation tools and manual adjustment tools (which help create personalized content that reflects creative intent) are in place, alongside graphic interfaces that are well-suited to colorists.

(4) Industry-friendly applications

HDR Vivid is an HDR standard led by China. It stands out for its openness and security, and is backed by favorable intellectual property policies.

4. End-to-End Solution

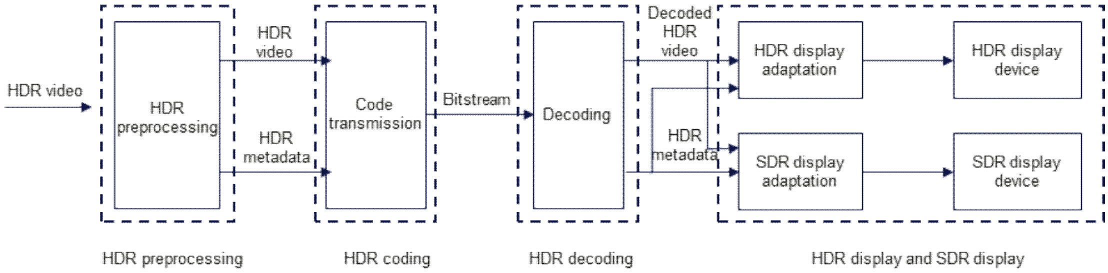


Figure 6 End-to-End Solution of HDR Vivid

HDR Vivid is an end-to-end solution that ensures optimal display effects by meeting the requirements of HDR preprocessing, coding, decoding, and display. The source file can be an HDR video in PQ or HLG format. The preprocessing module analyzes the HDR video and generates static metadata and dynamic metadata. The code transmission module encapsulates the HDR video and its metadata, and generates an HDR Vivid bitstream. The decoding module decodes the bitstream to obtain a decoded HDR video, along with its metadata. The HDR and SDR display modules perform display adaptation and processing on the HDR video, based on the video metadata and the parameters of the target display devices, and properly display the video on these display devices. Sections 4.1 and 4.2 will elaborate on content production and device-based processing solutions.

4.1 Content Production Solutions

4.1.1 Post-Production Solution

Post-production is necessary to create premium HDR Vivid content. So far, HDR Vivid technologies have been integrated into a variety of post-production tools. Professional content producers can work in familiar environments and create unique HDR Vivid videos by adjusting dynamic metadata to match their own artistic perceptions and expressions.

4.1.2 Livestreaming Solution

At present, HDR Vivid can support content generation on livestreaming devices.

Specifically, the livestreaming coder conducts real-time analyses of the original HDR bitstream (in PQ or HLG format), extracts dynamic metadata, encapsulates the metadata based on HDR Vivid encapsulation standards, and creates an HDR Vivid bitstream that is distributed and transmitted subsequently.

4.1.3 Cloud Transcoding Solution

Cloud-based intelligent processing is about utilizing the cloud's computing power to perform transcoding and automatically generate HDR Vivid videos. Cloud capabilities are available to perform the parsing and transparent transmission of HDR Vivid metadata. The process of cloud transcoding includes parsing the input file format, decoding, processing, coding, and generating the output file format.

There are three major methods for performing end-to-end automated HDR video production on the cloud:

(1) Conduct transparent transmission of HDR Vivid metadata immediately after it is modified. Specifically, it's necessary to parse the metadata in a text format (XML or JSON), modify the data, and embed it within the media stream in accordance with preset standards. The transparent transmission of metadata makes it possible to directly write the metadata of the original video into the transcoded video, thus staying true to the creative intent of creators.

(2) Conduct transparent transmission of a non-HDR Vivid video after conversion. Specifically, if the original video is an HDR video without HDR Vivid metadata, then metadata can be automatically generated in accordance with standards and embedded into the video stream.

(3) If the original video is an SDR video, it can be converted into an HDR video with the help of inverse tone mapping or AI. After conversion, the image quality of the video can

be reconstructed, and metadata can be automatically generated and written into the video.

4.2 Device-Based Processing Solutions

After a playback device receives an HDR Vivid bitstream, the device decodes the video to analyze the dynamic metadata, uses the data for HDR rendering, and ultimately displays high-quality images. An HDR Vivid bitstream can either be premium content produced through post-production, or a real-time bitstream of live content. Typically, there are two decoding methods, namely hardware-based decoding and software-based decoding. These will be explained in detail in 4.2.1 and 4.2.2. Figure 7 shows the basic decoding and playback process.

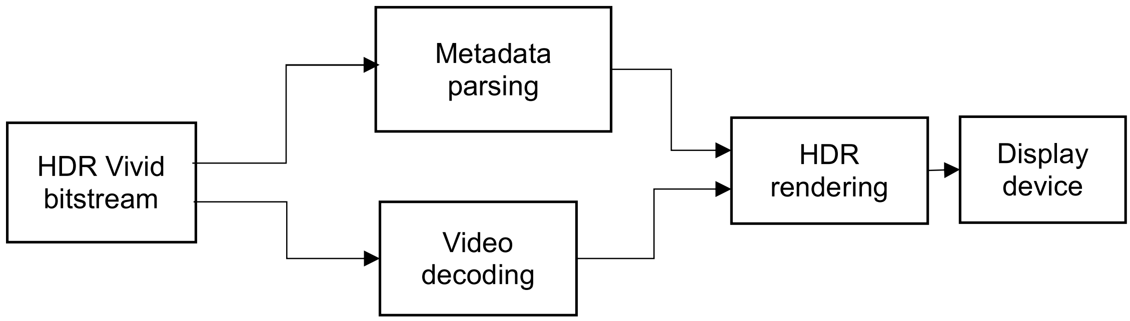


Figure 7 Device-Based Processing Process

4.2.1 Hardware-Based Decoding and Playback

Hardware-based decoding and playback: a process in which a display device employs its own hardware decoding capabilities to parse the dynamic metadata of an HDR Vivid bitstream, performs dynamic mapping and color correction based on the metadata, and properly displays the content.

A growing array of devices, including TVs, smartphones, and tablets, can support hardware-based decoding and playback of HDR Vivid videos.

If a display device lacks hardware decoding capabilities, the user can still watch HDR Vivid videos through apps or players that support software-based decoding and playback.

In cases where neither hardware-based decoding and playback nor software-based decoding and playback is available, the display device discards the metadata and plays the video in the original bitstream format (HDR10 or HLG). This perfectly demonstrates the excellent backward compatibility of HDR Vivid.

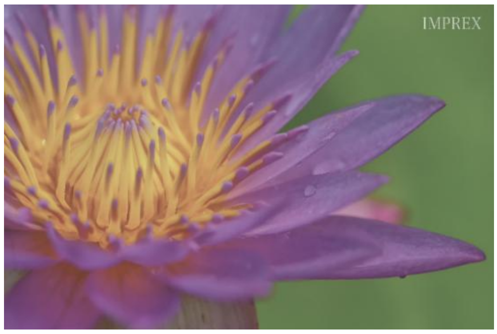
4.2.2 Software-Based Decoding and Playback

Software-based decoding and playback: a process in which a piece of software employs its decoding capabilities to parse the dynamic metadata of an HDR Vivid bitstream, performs dynamic mapping and color correction on the display device, and ensures proper display on the device. Such software can include both apps on smartphones, tablets, and smart TVs, and video players on personal computers (PCs).
This approach of software-based decoding and playback can work even if the display device doesn't support hardware-based decoding and playback. This approach is conducive to the popularity of HDR Vivid content, as well as the development of an HDR Vivid industry value chain. Software-based decoding and playback brilliantly complements hardware-based decoding and playback.

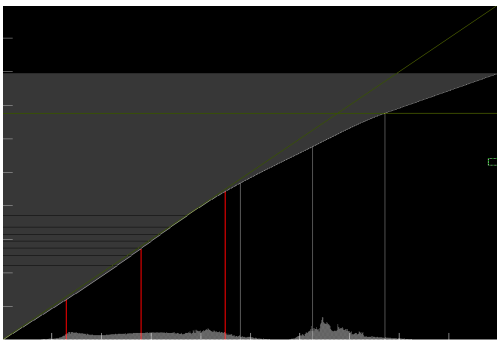
4.3 Examples of Images in HDR Vivid Videos

HDR Vivid supports tone mapping based on dynamic metadata by generating mapping curves in a way that considers the characteristics of different scenes and the maximum display capabilities of different devices. This mapping approach helps reflect the creative intent of creators. Figure 8 provides examples of different mapping curves that were generated for a mountain scene and a flower scene.

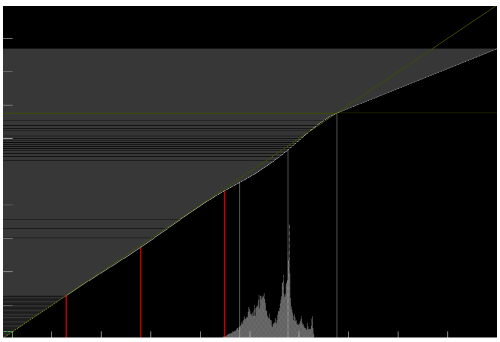
(1) Mountain



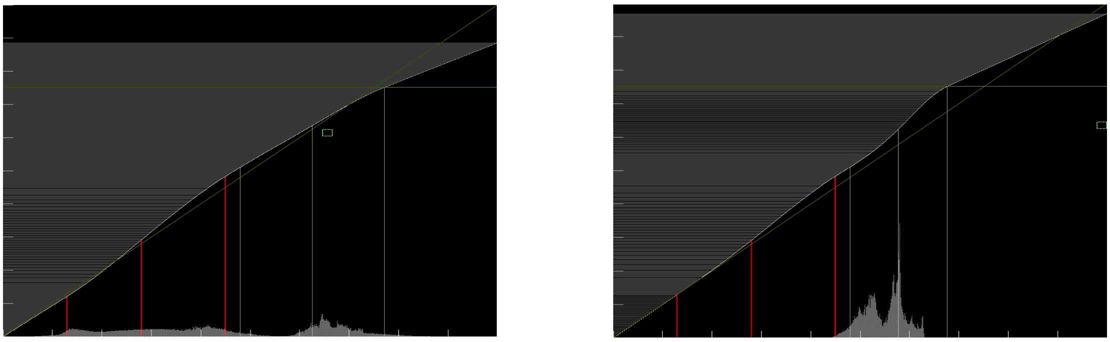
(2) Flower



(1a) 500 nits



(2a) 500 nits



(1b) 1000 nits

(2b) 1000 nits

Figure 8 Brightness Comparison

Traditional tone mapping approaches often lead to a loss of details in brighter areas – a phenomenon known as overexposure. HDR Vivid uses dynamic metadata to resolve this issue. By analyzing scenes, HDR Vivid creates a proper mapping curve to retain details in brighter areas. In addition, HDR Vivid considers the devices' display capabilities to ensure that the original scenes can be visually reproduced as faithfully as possible.

Figure 9 Retaining Details in Bright Areas (HDR Vivid Image on the Right)

A loss of details in dark areas can happen if too much priority is given to bright areas and some parts of the mapping curve are lowered too much (similar to an S curve). HDR Vivid uses a Phoenix segmented mapping curve, which preserves details in darker areas by avoiding compressing luminance in these areas (achieved with linear mapping).

Figure 10 Retaining Details in Dark Areas (HDR Vivid Image on the Right)

Color hue shift and distortion often happen when brightness changes. After brightness mapping is completed based on mapping curves, HDR Vivid performs hue correction and compensation to make sure the hue closely matches that of the source.

Figure 11 Color Correction (HDR Vivid Image on the Right)

5. HDR Vivid Progress and Development Recommendations

5.1 Current Progress

Over the two years since its release, HDR Vivid has seen breakthroughs across all links of its value chain, from content supply, production tools, and service platforms to coding, transmission, chips, and display devices.

On January 30, 2022, China's National Radio and Television Administration released an industry standard entitled *Technical Requirements for Display Adaptation Metadata of High Dynamic Range Television Systems* (GY/T 358-2022). Key technologies of this standard have been deployed in all links of the value chain for UHD videos, including content production, coding, receiving, decoding, and display. HDR Vivid was first applied in broadcasting activities related to the Beijing 2022 Winter Olympics and Paralympic Winter Games.

China Media Group (CMG) started building a public service platform for 8K video production and broadcasting in early 2021, and has used this platform on a trial basis. On January 24, 2022, CMG officially launched the CCTV-8K channel to provide 8K content for the Beijing 2022 Winter Olympics. That same day, CMG kicked off its Thousands of Screens in Hundreds of Cities Program, through which large 8K displays would be installed at public venues to broadcast 8K content. HDR Vivid is a key technology of both the CCTV-8K channel and the Thousands of Screens in Hundreds of Cities Program.

iQIYI, Tencent Video, Youku, and other online video service providers have already incorporated HDR technology into their products. In September 2021, iQIYI announced that HDR Vivid had been used for its entire HDR catalog. In August 2022, iQIYI held an online screening on the sidelines of the Beijing International Film Festival, showcasing high-quality video content with HDR Vivid.

With the support of industry partners, Migu – the digital content subsidiary of China Mobile – demonstrated the use of HDR Vivid during its broadcast program for the UEFA European Championship in 2020. In early 2022, Migu adopted HDR Vivid for the live broadcasting of all events at the Beijing 2022 Winter Olympics and Paralympic Winter Games. In August 2022, Migu launched a documentary entitled "One Cup, A Thousand Stories" in HDR Vivid format, immersing audiences in the tea cultures of both the East and the West.

By the end of October 2022, Chinese telecom carriers had acquired more than 370 million Internet protocol television (IPTV) subscribers. Supported by HDR Vivid, 4K and 8K smart set top boxes (STBs) offer audiences a UHD video experience. According to China's IPTV business plans and centralized procurement requirements for telecom carriers, HDR Vivid is essential for the 4K smart STBs of China Telecom and the Magic Box STBs of China Mobile.

HDR Vivid also supports large screens as part of China's Thousands of Screens in Hundreds of Cities Program. Many display vendors have played an active role in the standardization work of the UWA. Large outdoor screens powered by HDR Vivid can offer ultra-high definition, ultra-high luminance, ultra-high contrast, a high refresh rate, a wide angle of view, and broadcast-level UHD display.

In November 2022, China Mobile – in collaboration with the UWA – put HDR Vivid and Audio Vivid into commercial use for the livestreaming of the FIFA World Cup Qatar 2022, providing audiences with lifelike and immersive audio and video experiences. This marked the first time that HDR Vivid and Audio Vivid – China's proprietary UHD audio and video standards – had been used to livestream the World Cup. This also signaled the beginning of large-scale commercialization of these UHD audio and video standards in the mobile device sector.

Industry partners are actively applying innovative technology to short videos, livestreaming, virtual reality (VR), extended reality (XR), gaming, WeChat videos, manufacturing, agriculture, and healthcare. Further exploration and implementation of HDR Vivid is already taking place across a wide range of business scenarios.

5.2 Development Recommendations

Future plans for HDR Vivid technical standards are currently being developed and will cover areas such as content production, broadcasting, certification, operations, coding, decoding, display, user experience, and review. All industry players are encouraged to work closely together to grow the industry through the following initiatives:

1. Building an open ecosystem

Bring together top industry players from around the world to build the standards system and the broader ecosystem. Drive efforts to promote the technical standards in the radio and television, new media, and entertainment sectors. Create an end-to-end industry value chain and promote close cooperation both upstream and downstream to facilitate standards adoption at scale.

2. Demonstrating technical standards in real-world projects to drive their adoption and popularity

Apply related technical standards during major sports events and activities to drive their adoption and popularity. Promote their application in the entertainment and manufacturing sectors to create premium case studies. Focus on leveraging technical standards during key events (e.g., sports and entertainment) to achieve early adoption. Produce case studies to facilitate deep cooperation between upstream and downstream industry players and generate awareness among audiences.

3. Encouraging businesses to accelerate application and R&D

Over the next two to three years, double down on deploying applications for individuals, homes, vehicles, cinemas, and industries; motivate the content production sector; accelerate content production and distribution on distribution platforms; redouble efforts to build the industry value chain; drive industry evolution; and create a solid foundation for the future UHD audio and video industry in terms of both technology and talent.

Appendixes

Appendix 1: Terminology

- Metadata:

  A set of data that describes key information or features needed in video or image processing

- Static metadata:

  The metadata that stays unchanged in videos

- Dynamic metadata:

  The metadata that changes with videos or images

- PQ HDR video:

  The video transmitted in PQ format specified in GY/T 315-2018

- HLG HDR video:

  The video transmitted in HLG format specified in GY/T 315-2018

Appendix 2: Sobey's Post-Production Solution

In video content production, the process of turning raw footage into a finished video is called post production. HDR coloring is an important step in this process. The currently available Sobey Editmax is a UHD non-linear editing (NLE) system that offers a complete HDR Vivid post-production solution, covering numerous operations such as workflow processing, coding, decoding, and footage editing. This section describes the end-to-end post-production process with Sobey Editmax.

Sobey Editmax has adopted the UWA's HDR Vivid standard based on the PQ curve in the E2E production process. The HDR Vivid standard enables display of rich colors and layers, enhances the contrast between bright and dark areas, and makes images more vivid, detailed, and true-to-life. In addition, Editmax supports the adjustment of metadata parameters based on HDR Vivid. It can adjust details such as the contrast and saturation of the dark, middle, and bright tones of images, and write the adjusted parameters into the metadata to adapt to the different luminance levels of devices of different display capabilities.

1. Production environment setup

Figure 12 Production Environment Example

A production environment primarily consists of a workstation, color grading system, color grading panel, monitor, and other display devices. The following table lists recommended models of production environment hardware and software:

Table 3 Configuration Parameters

Software or Hardware Type	**Recommended Model**	**Notes and Requirements**
Workstation	Sobey Editmax 11.5 NLE or Apple Mac Pro or HP Z8 G4	Depends on the software used For detailed system configuration and installation procedures of Sobey Editmax, see sections 6.2.5 and 6.2.6.
Color grading system	Sobey Editmax: Supports HDR Vivid metadata and master production DaVinci Resolve 18: Supports HDR Vivid production Baselight 5.3: Supports HDR Vivid production (New)	The color grading system needs to support PQ and HLG HDR workflows.
Color grading panel	Tangent Element grading panels or higher-spec versions	—
HDR monitor	Monitor model: Apple/XDR/Canon/DPV-2420; DPV-3020; DPV-2410/Sony/BVM-X300; BVM-HX310/Konvision KUM-3120QD/EIZO/CG3146/Postium/OBM-N310-NB/TVlogic/LUM-310X/Dolby-4220/pulsar	Support for ST2084/HLG/OETF Peak brightness of at least 1,000 nits Luminance contrast ratio of 200,000:1 HDR monitor (after rigorous calibration) with a grayscale/Delta E 2000 of < 2 Coverage of the entire DCI-P3 color gamut and at least 90% Rec.2020 color space An 18% gray darkroom environment and a DCI-P3-light-based monitor (regular calibration needed) with a Color Rendering Index (CRI) of at least 90%
SDR target monitor	—	Coverage of the standard Rec. 709 color space Average Delta E-2000 of < 1 Luminance contrast ratio of at least 1,000:1 Brightness of 100 nits ± 5 Support for a legal range of signals
Reference display devices (mobile phones, tablets, TVs, etc.)	For HDR Vivid-certified models, see the lists on the UWA official website.	HDR Vivid-certified

2. Workflow processing

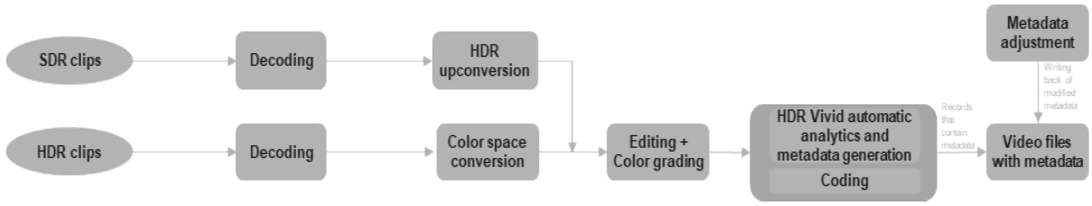


Figure 13 Workflow

SDR and HDR video clips are processed at Sobey's post-production workstation. This includes video editing, color grading, and vocal mixing. Video files with HDR Vivid metadata can then be automatically analyzed and generated in Editmax 11.5. When the output is complete, users can switch to the director mode to fine-tune details such as the brightness, contrast, and saturation of HDR Vivid video files. The adjusted parameters are written back into the metadata of the video clips and displayed on the monitoring screen in real time. Finally, completed video files with HDR Vivid metadata are generated.

3. Coding and decoding

XAVC MXF and H.265 MP4 formats are supported. HDR Vivid metadata is stored in video files.

4. Steps

(1) Create a PQ timeline

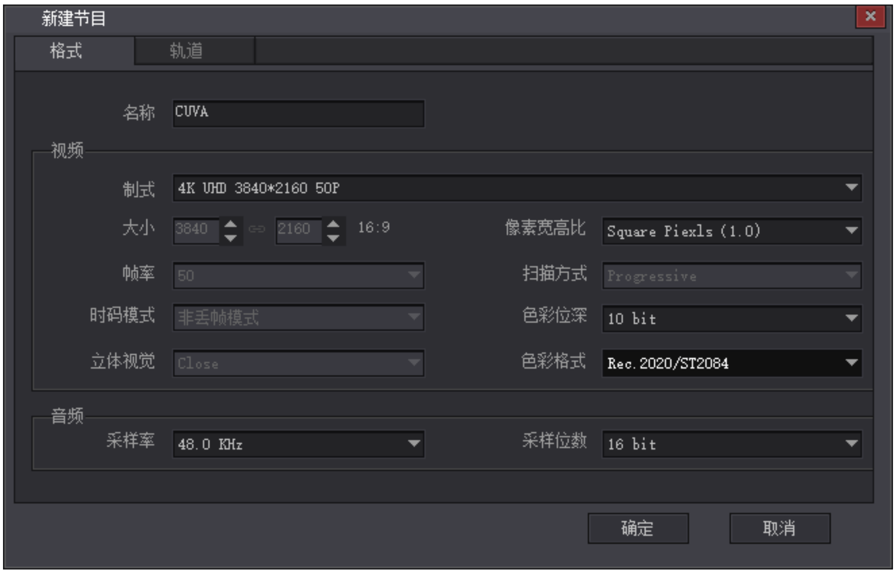


Figure 14 Example of PQ Operations

(2) Edit and color-code clips in the timeline

For details, see the *Sobey_Editmax11_v11.5.0_ UHD Non-linear Editing System User Manual.*

(3) Generate video clips with metadata

Parameters for generating 4K clips:

Figure 15 Clip Parameter Configuration

Parameters for generating HD clips:

Figure 16 Export Parameter Configuration

(4) Adjust dynamic metadata

After video clips are generated in the timeline, users can right-click **Dynamic Metadata Adjustment** to enter the metadata adjustment interface. Here, they can adjust details such as the contrast and saturation of the dark, middle, and bright tones, and write the adjusted parameters back into the metadata of the clip file in real time.

Figure 17 Adjustment Configuration

5. System configurations

Table 4 System Configurations

Editmax 11.5 NLE HP Z8 G4	CPU	Intel Xeon/6226R/2.9 GHz (16 cores) x 2
	Memory	8 GB/DDR4-2933/ECC memory x 24 (192 GB in total)
	System disk	480 GB/SATA/Enterprise/SSD x 1
	Data disk	Built-in data disk: 2 TB/7200/rpm/SATA hard drive x 1 Optional: 4 TB/7200/rpm/SATA hard drive disk Optional: 6 TB/7200/rpm/SATA hard drive disk Optional: 8 TB/7200/rpm/SATA hard drive disk Number of disks: 1–3
	Graphics card	NVIDIA GeForce/RTX/2080Ti/11 GB high-end graphics card
	Monitor	2560 x 1440 27-inch widescreen LCDs x 2 (dual monitors)
	Sound monitoring	Stereo headphones or speakers If 5.1 or 7.1 surround sound monitoring is required, choose one of the following devices: 1. 5.1/7.1 surround sound headphones with USB audio engines 2. Audio adapters that support 5.1/7.1 surround sound and the corresponding number of speaker units (1) Audio adapter for 7.1 surround sound: RME Fireface-802 (2) Audio adapter for stereo sound: Focusrite 18i8 (with mic pre-amplifier)
	OS	Windows 10 Pro for Workstations 64-bit
	I/O card	(1) Sobey MG6000E/4K UHD/HD/SD compatible broadcast-grade digital I/O card (3G-SDI x 4) (2) Blackmagic DeckLink 4K Extreme 12G (12G-SDI) (3) Blackmagic DeckLink 8K Pro (12G-SDI x 4)
	Power supply	1,125 Watts
	Software	Editmax 11 5.0

6. Installation steps

➢ Install the software running environment

a) Run the installation package [Sobey_Software Running Environment_3.2.2017.0925.exe].

b) Click **Next** on the subsequent wizard pages until the installation is complete.

c) Restart the computer.

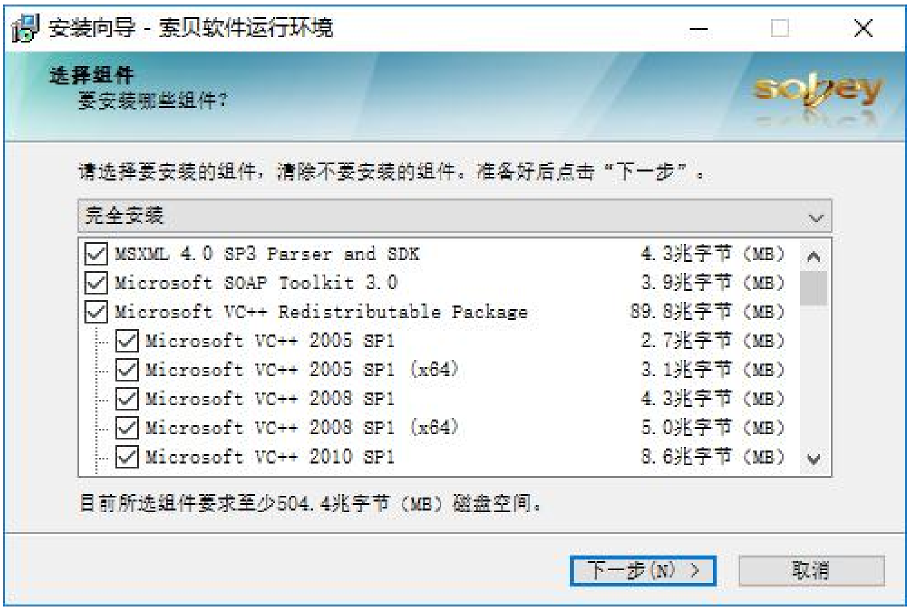


Figure 18 Installation Environment

➢ Install Editmax 11.5

Run the installation package [Sobey_Editmax11_v11.5_Setup (64bit) .exe].

a) Click **Next** on the welcome page.

b) Select **Accept** on the **Licensing Terms** page and click **Next**.

c) Select the installation path. Use the default path C:\Sobey\Editmax.

d) Select **Yes** and click **Next** in the pop-up dialog box:

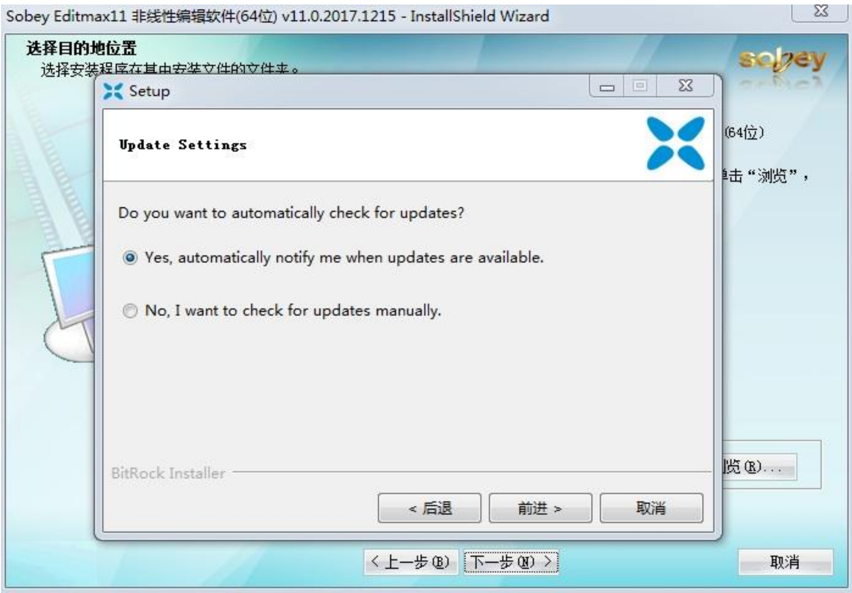


Figure 19 Installation Settings

e) Select all the three media types and click **Next**.

Figure 20 Setting Parameters

f) Click **Next** until the installation is complete.

- **Install the Vernox database**

Install the server

a) Run the installation package [Vernox database_Server_v1.1_Setup.exe].

b) Select an installation path and click **Install**. Allow the installation to finish.

c) After the installation is complete, find and double-click C: \Sobey\Vernox\Bin\VernoxConfiguration.exe, and click **Start**. If the database is successfully started, the Vernox database service status is displayed as **Running**.

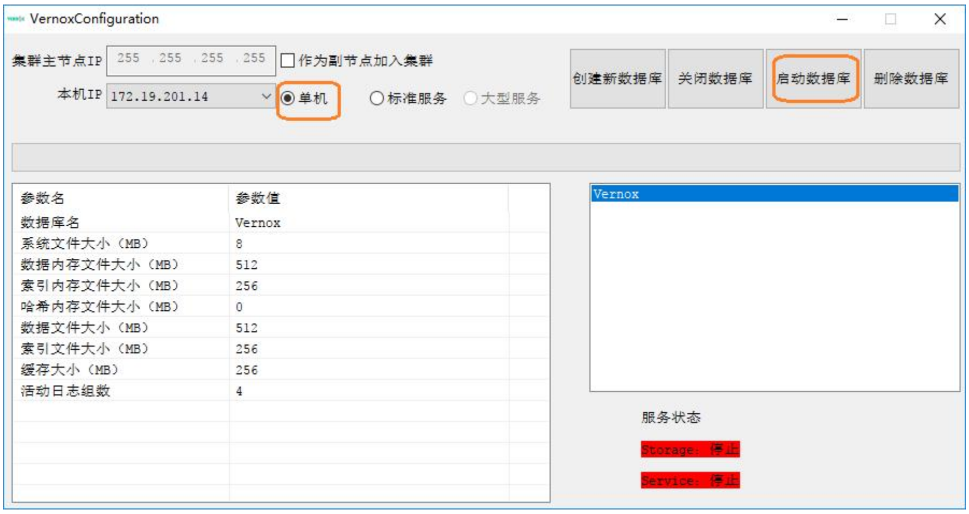


Figure 21 Database Startup Settings

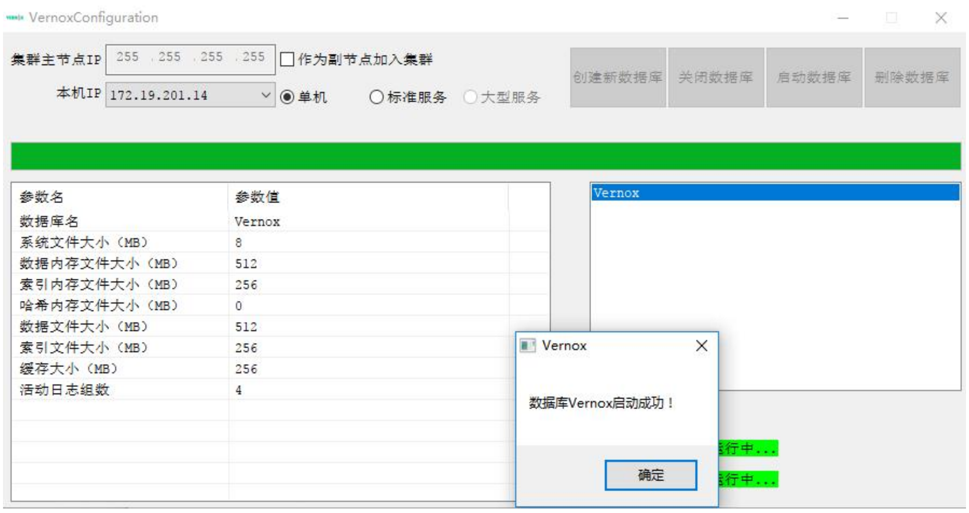


Figure 22 Database Startup Settings

- Ensure that the operating system has a readable and writable X: drive which is the default path configured for delivery.
- For offline usage, install the server only. For online usage, install the client and access the server's C: \Sobey\EX\MaterialList\bin\ETLocalDBSettingU.exe to set the department and user.

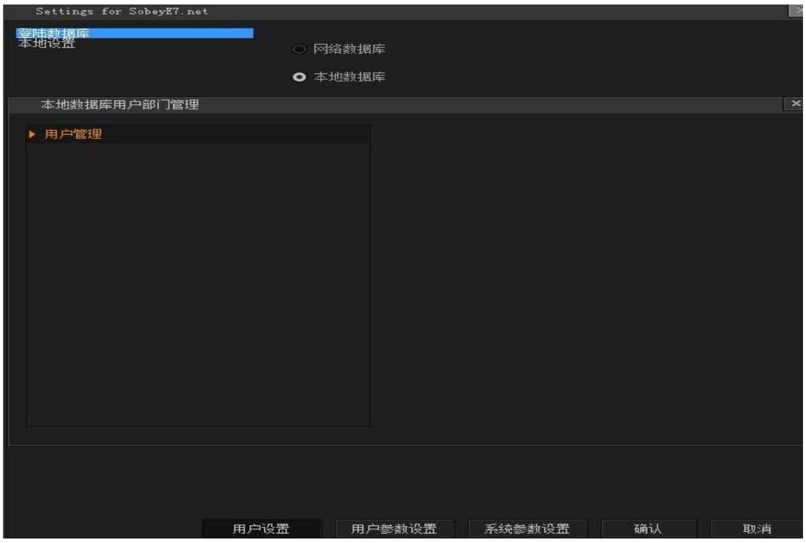


Figure 23 Login Settings

➢ Modify the configuration file and enable HDR

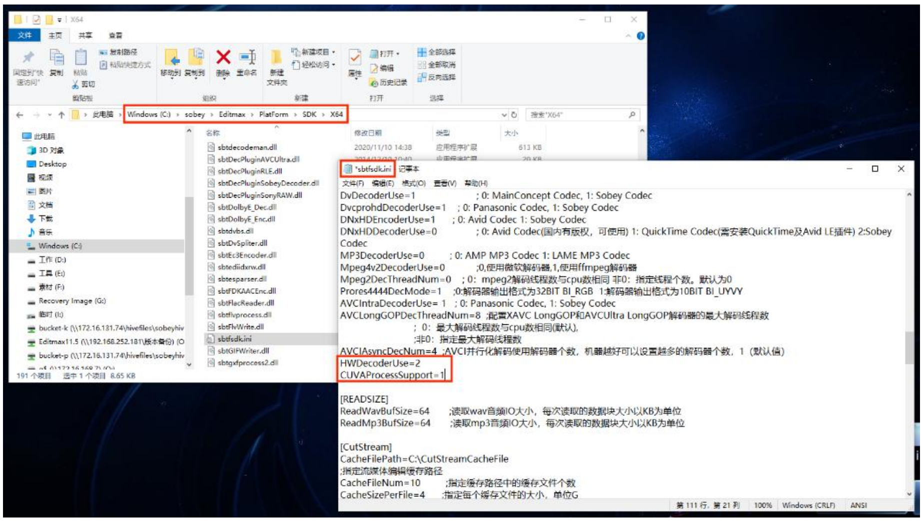


Figure 24 Script Settings

➢ **Update the NVIDIA graphics card driver of the NLE workstation**

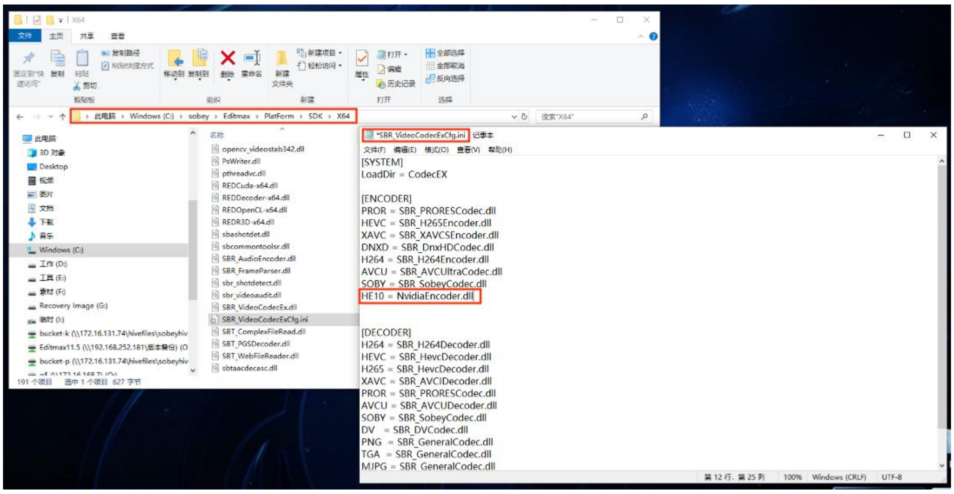


Figure 25 Script Graphics Card Settings

Appendix 3: Baselight's HDR Vivid Solution

Baselight, developed by FilmLight, is an industry-leading color grading system for movies, TV series, and commercials. It supports high-performance 4K and 8K HDR/HFR real-time color grading. The system provides top colorists with the strongest support and helps them achieve more efficient creative production. Baselight integrates the Truelight color management system to give users end-to-end color management technology that covers video recording, editing, visual effect production, and color grading. Baselight has gained widespread use among renowned film and TV production companies around the world.

In April 2022, FilmLight announced that its latest Baselight 5.3 would support HDR Vivid video production, marking a new stage in the partnership between FilmLight and the UHD World Association. HDR Vivid now supports a wide array of functions, and the current Baselight color grading system fulfills the color grading and master production requirements of HDR Vivid videos.

Users can use the following guidelines to create HDR Vivid videos in Baselight:

1. Video export and connection

In this example, the workstation Baselight ONE is connected to two monitors via the video output ports. Sony BVM-HX310 is the HDR master monitor and Sony PVM-A250 is the SDR HD monitor. To display HDR and SDR content on the monitors in real time, set the video output of Baselight to stereo mode so that the two channels of videos can be exported in different color spaces.

2. Standard HDR program production

Users first need to use the standard Rec. 2100: PQ / Rec. 2020 / 1000 nits as the monitor color space, and then perform different grading operations to complete basic color grading for HDR videos, as shown in the figure below:

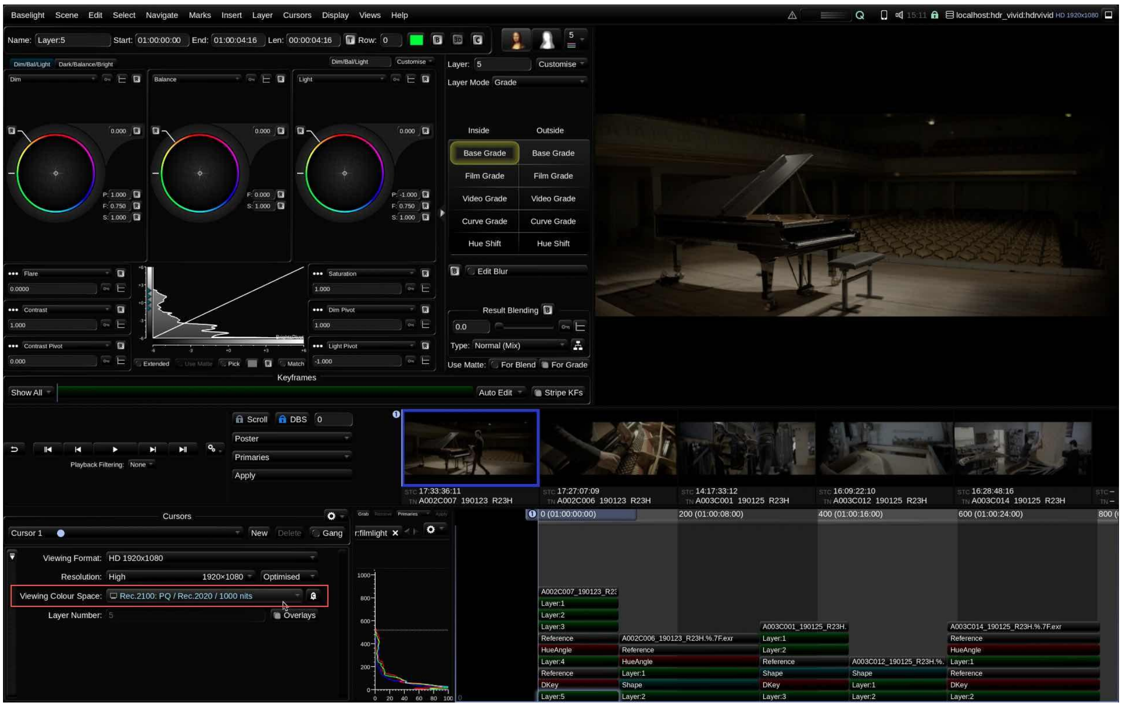


Figure 26 Selecting the Correct Parameter under "Viewing Colour Space"

3. Enabling the HDR Vivid function

When coloring is approved by the creator on the standard HDR monitor, the colorist can begin making an HDR Vivid video using the following steps: Open the **Views** menu -> Open **Scene Settings** -> Click **Format & Colour** -> Click **Advanced** -> Click **Enable HDR Vivid** -> Select an appropriate value for **Mastering Display Brightness**. In the figure below, 1,000 nits is chosen to match the brightness of the current HDR monitor:

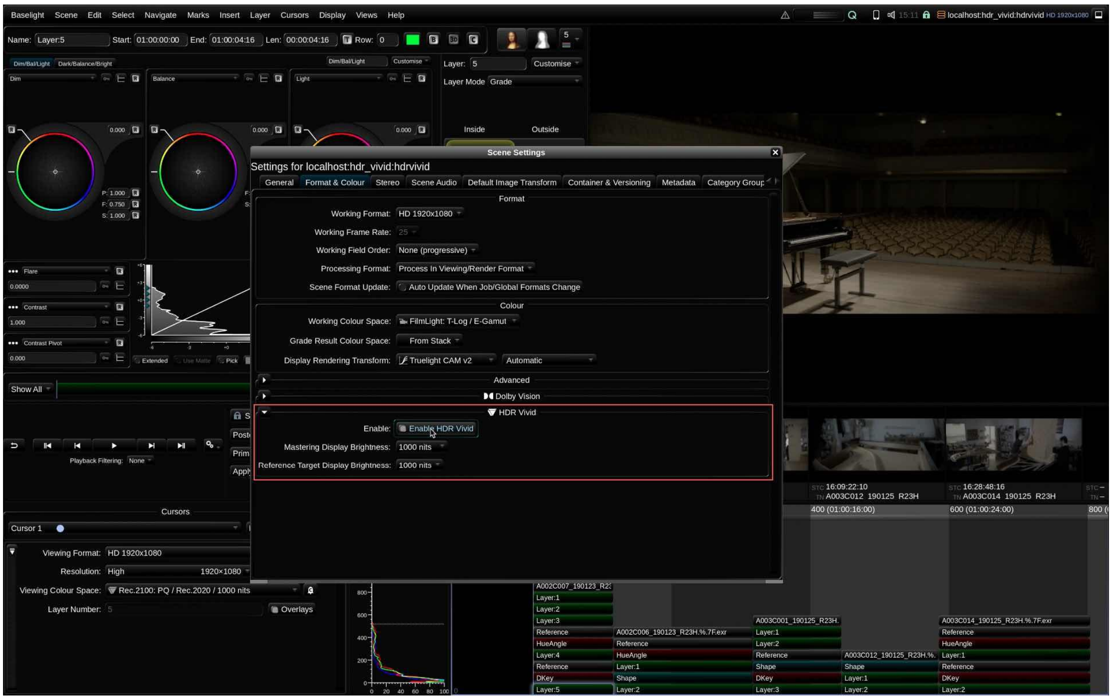


Figure 27 Enabling HDR Vivid

Once HDR Vivid is enabled, the **Viewing Colour Space** on Baselight will automatically switch to the corresponding color space with an HDR Vivid mark, indicating that Baselight has entered the HDR Vivid algorithm-based production controls.

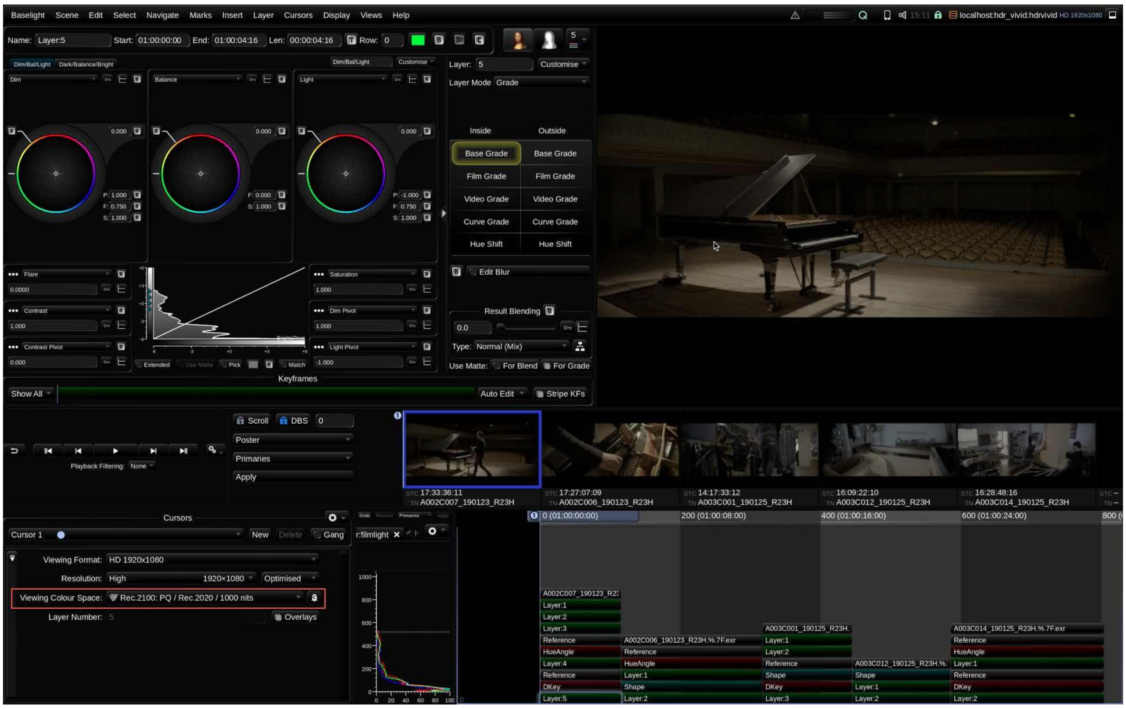


Figure 28 Switching to the Color Space with an HDR Vivid Mark

4. Adding HDR Vivid effect layers

Once HDR Vivid is enabled and the **Mastering Display Brightness** is set, select the bottom layer (i.e., the final grading result layer) of all color grading stacks through the **Select** menu, and add HDR Vivid effects by clicking HDR Vivid in the **Insert** menu. Once completed, each grading stack will have a separate HDR Vivid effect layer, as shown in the figure below:

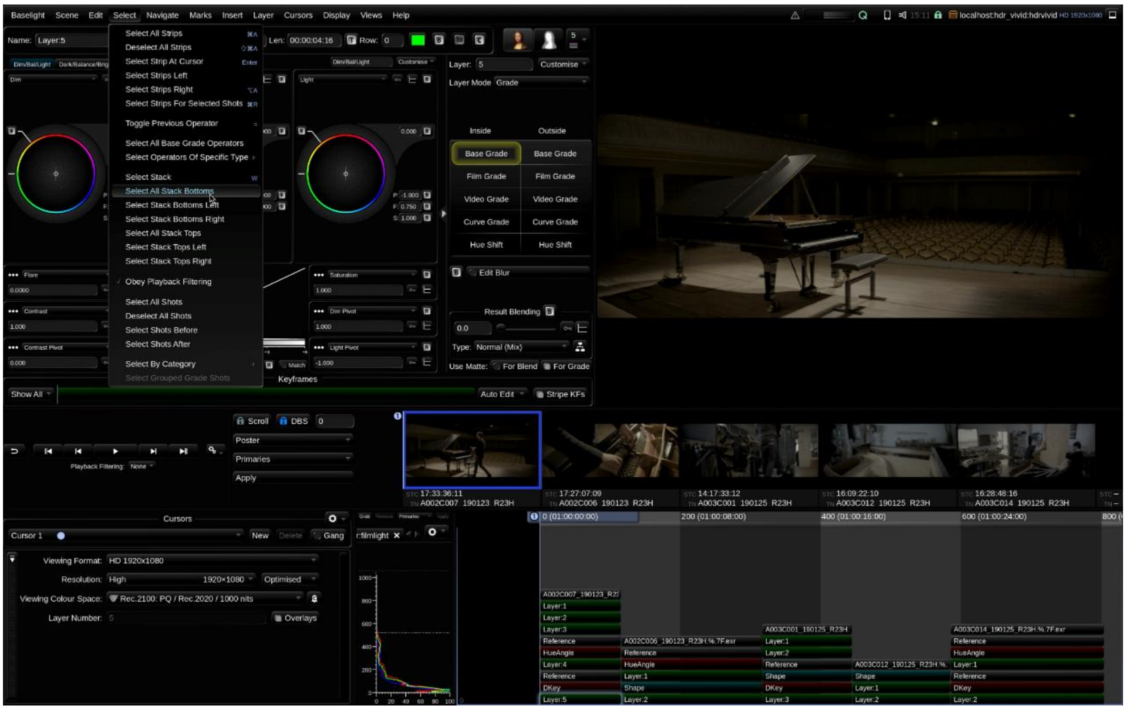


Figure 29 Selecting the Bottom Layer of the Color Grading Stack

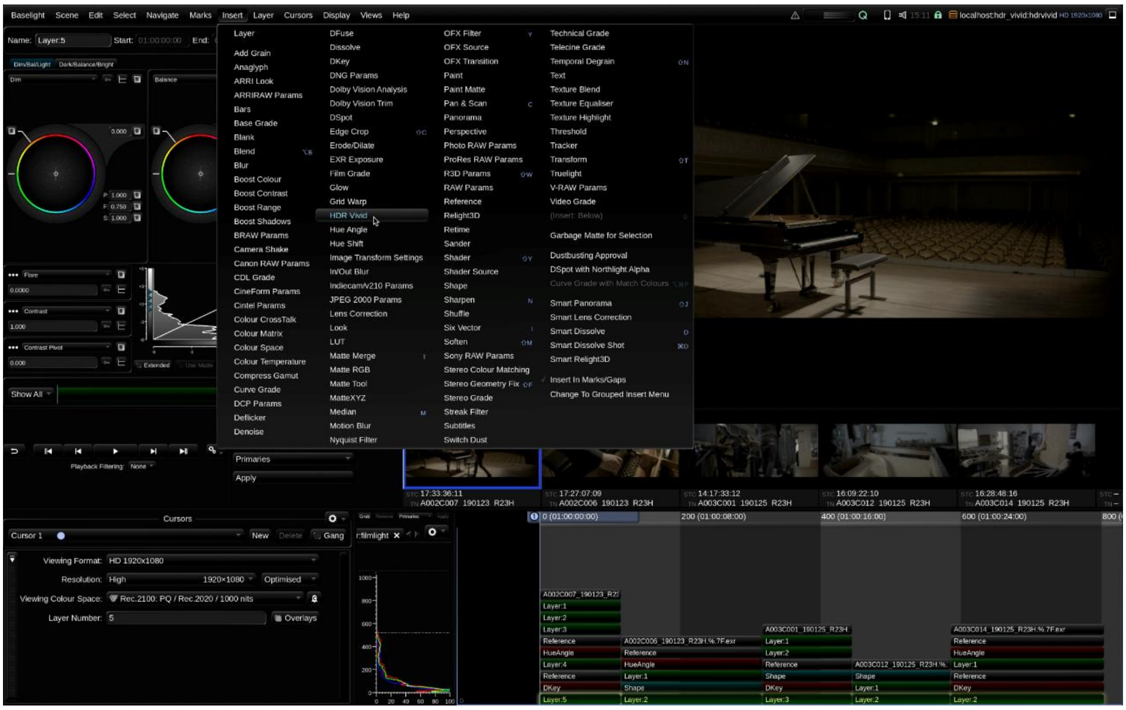


Figure 30 Adding the HDR Vivid Effect Layer

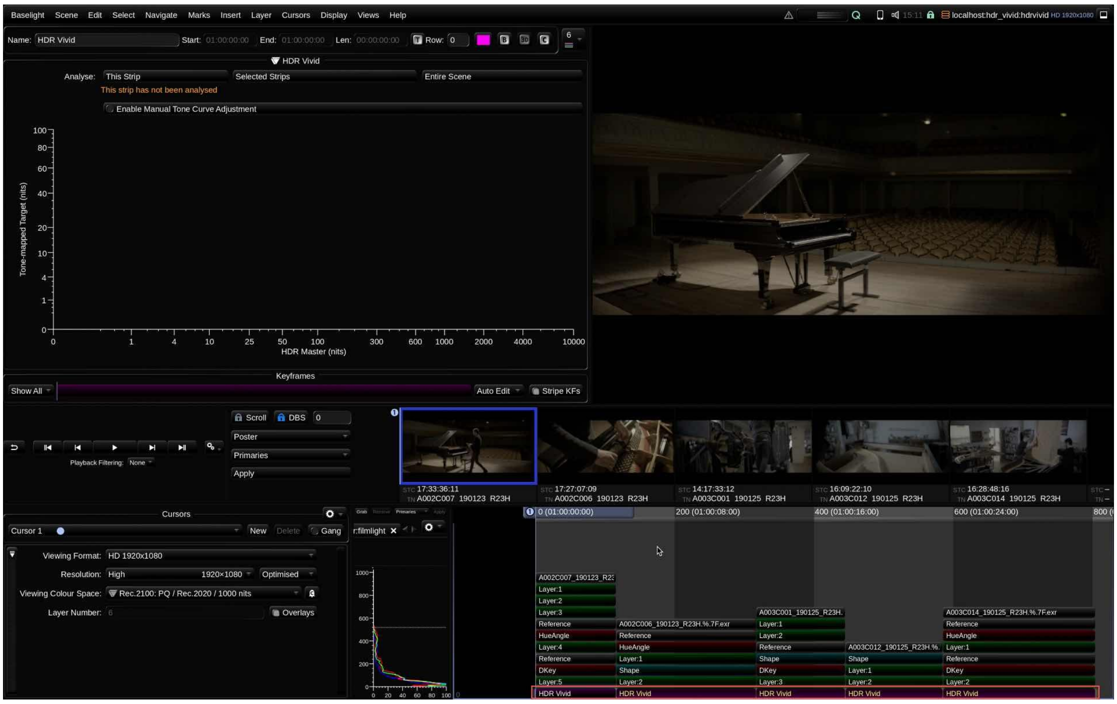


Figure 31 Addition of HDR Effect Layer Completed

5. Automatic analysis and curve mapping

After adding an HDR Vivid effect layer under each color grading stack, HDR Vivid algorithms can be used to automatically analyze a single shot, multiple selected shots, or the entire timeline. Once the analysis is complete, the system will generate and display a curve chart, as shown in the figure below:

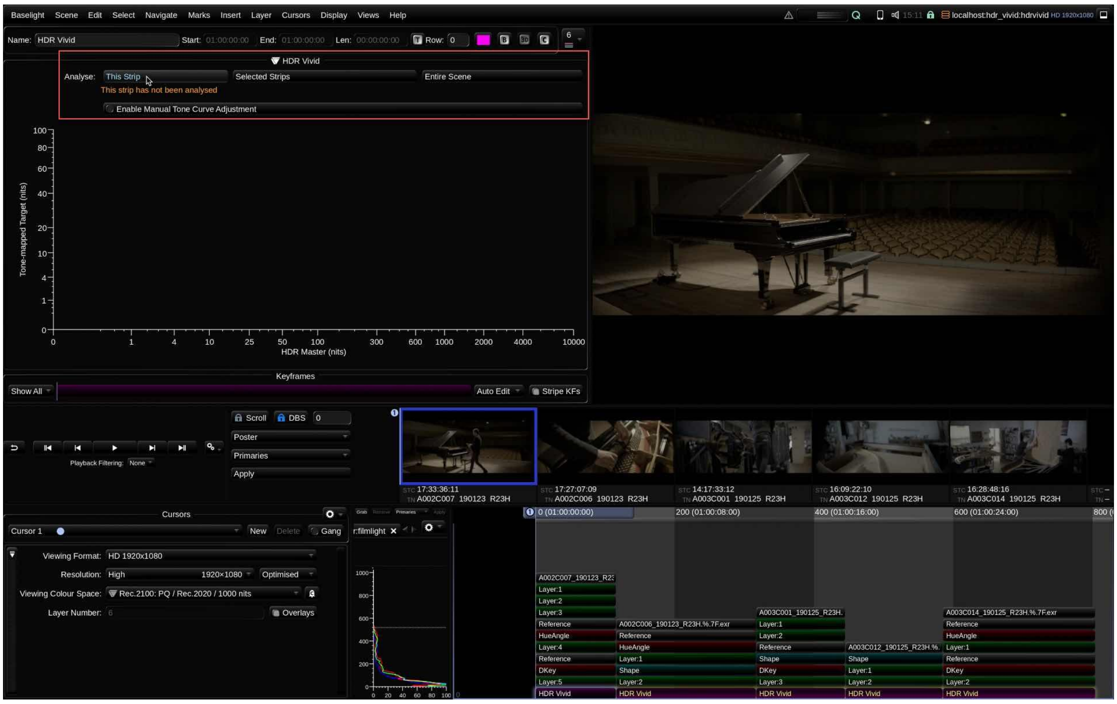


Figure 32 Automatic Analysis

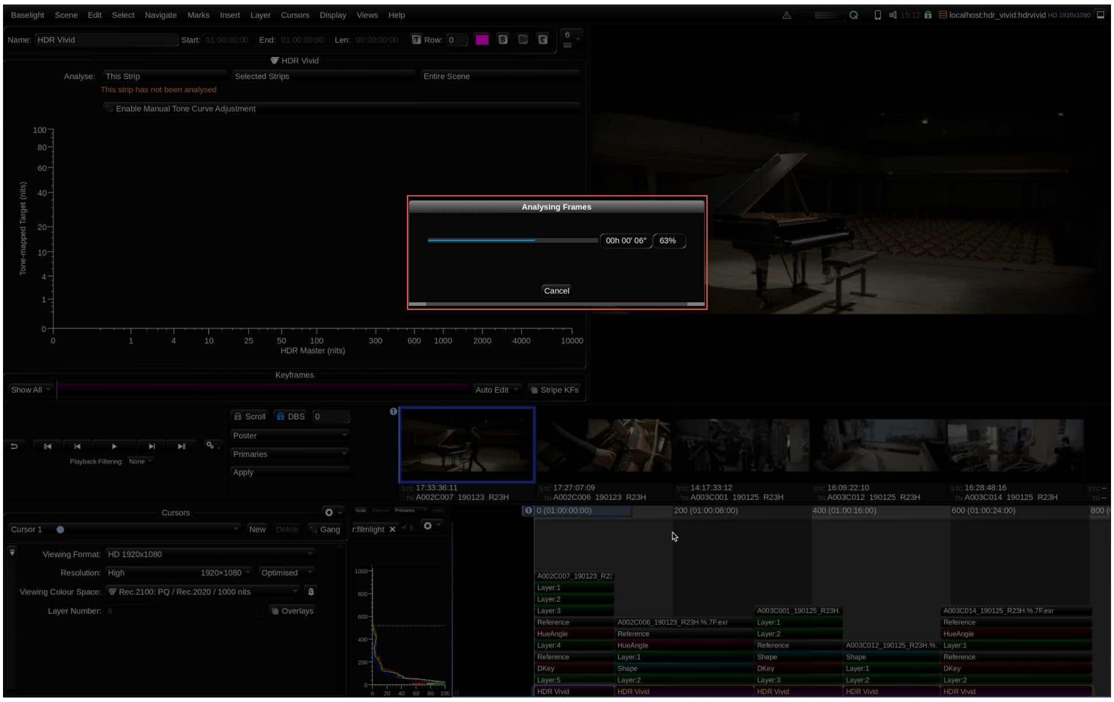


Figure 33 Automatic Analysis Underway

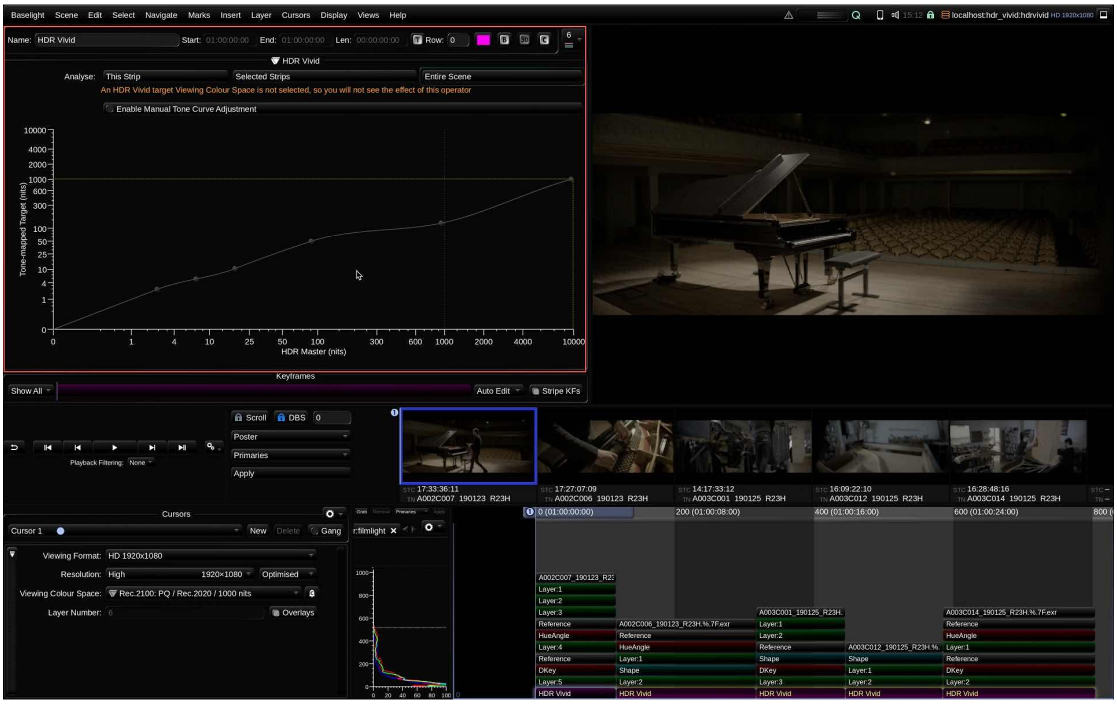


Figure 34 Automatic Analysis Completed

6. Monitoring and manual fine-tuning

Once automatic analysis is complete, the user can select a different monitoring color space (with an HDR Vivid mark) based on the connected monitor, i.e., HDR Vivid Target Displays. Because a standard HD monitor is connected, Rec. 1886: 2.4 Gamma/Rec. 709/100 nits is selected in this example as the color space for downward mapping, as shown in the figure below. In the meantime, the SDR images generated by the system based on an analysis and calculation will be displayed on the connected standard HD monitor. In addition, a curve chart will be displayed in the upper left corner. Users can select **Enable Manual Tone Curve Adjustment** to manually adjust the calculation results based on the SDR images mapped to the standard HD monitor. They can adjust details such as middle and dark tone details, highlights, and overall saturation through multiple HDR Vivid options. The adjustment results will be displayed on the standard HD monitor in real time, as shown in the figure below.

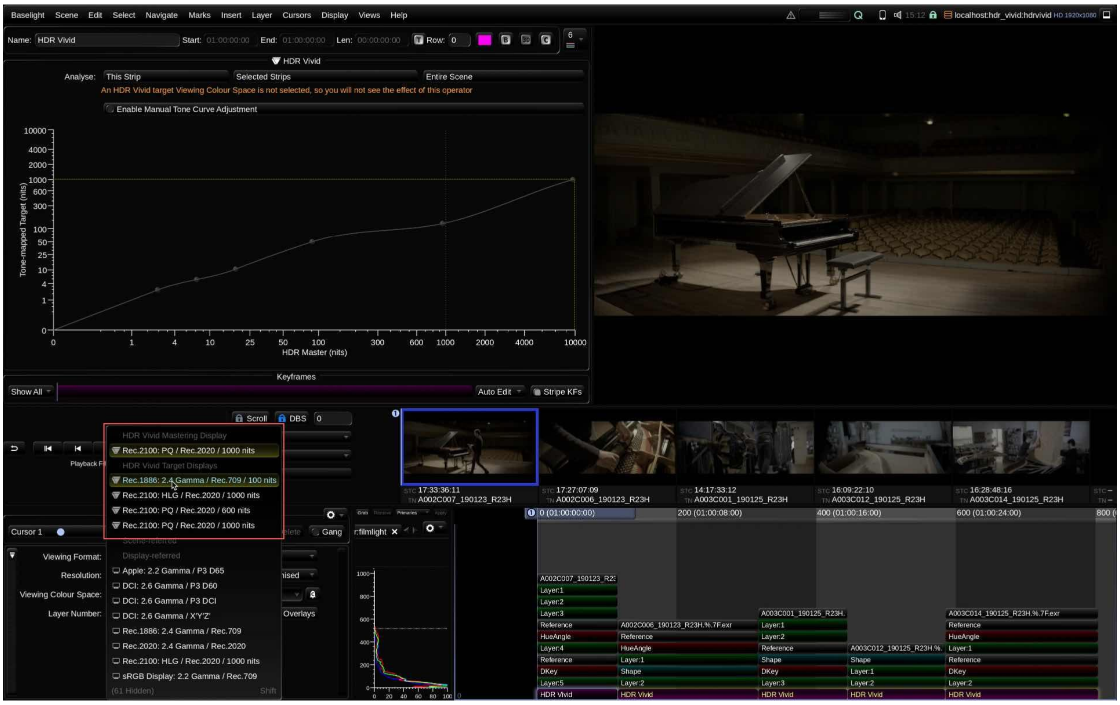


Figure 35 Selecting Different Color Spaces Mapped

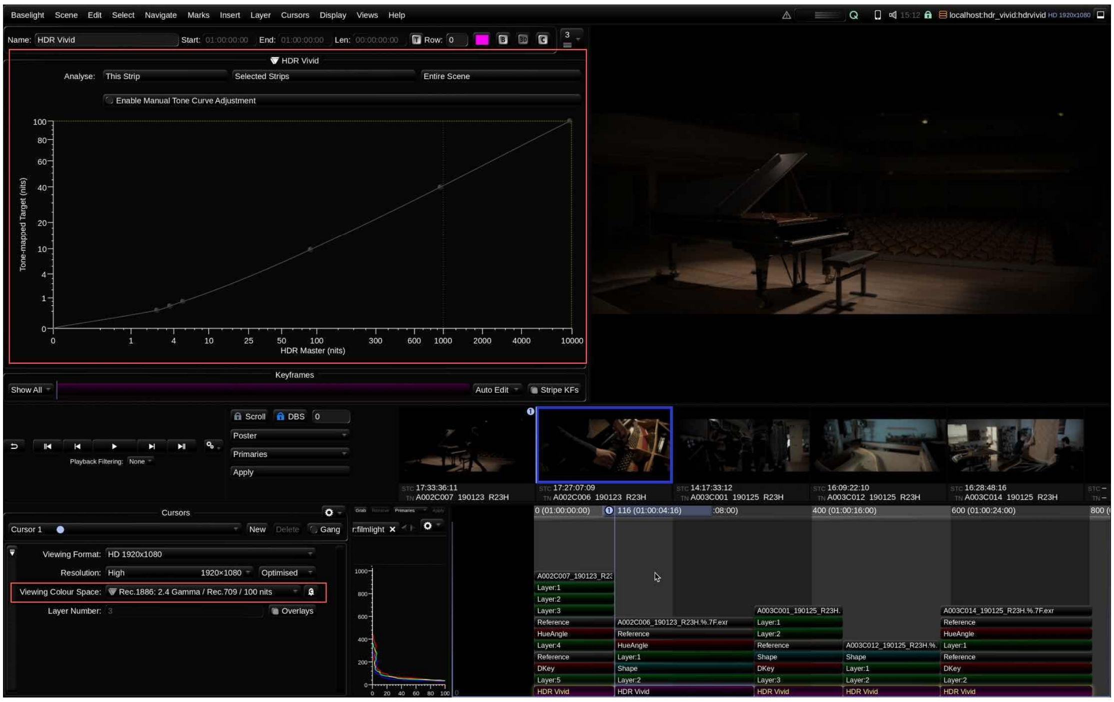


Figure 36 Selecting Rec. 1886: 2.4 Gamma/Rec. 709/100 nits with an HDR Vivid Mark

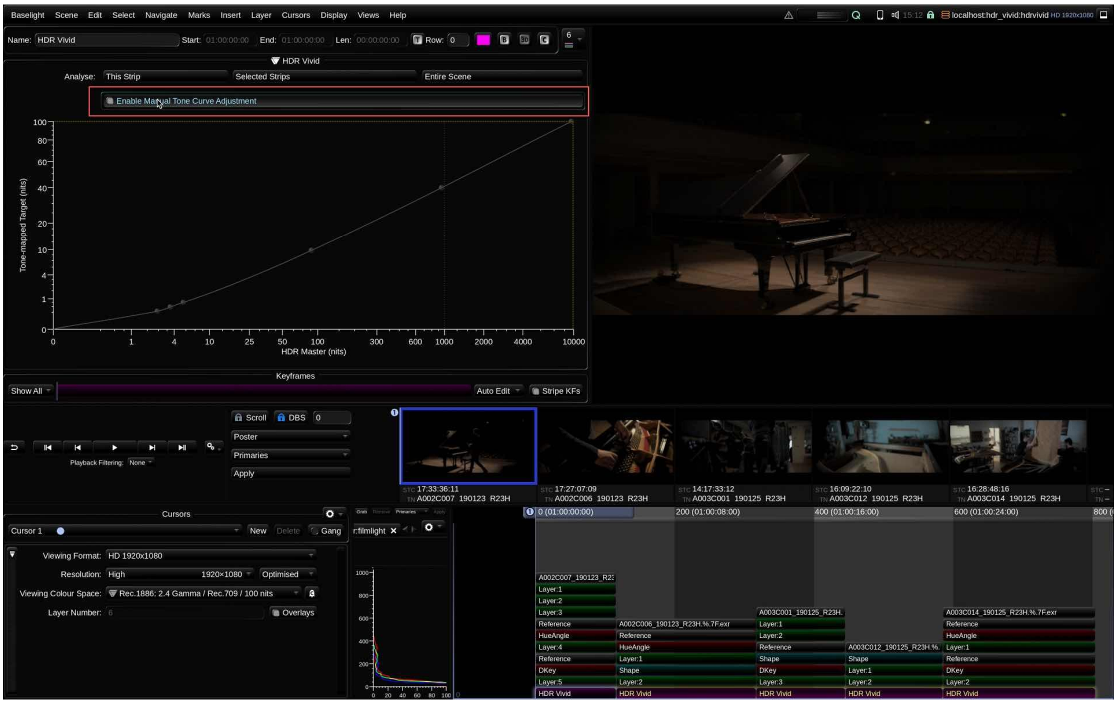


Figure 37 Enabling Manual Fine-tuning

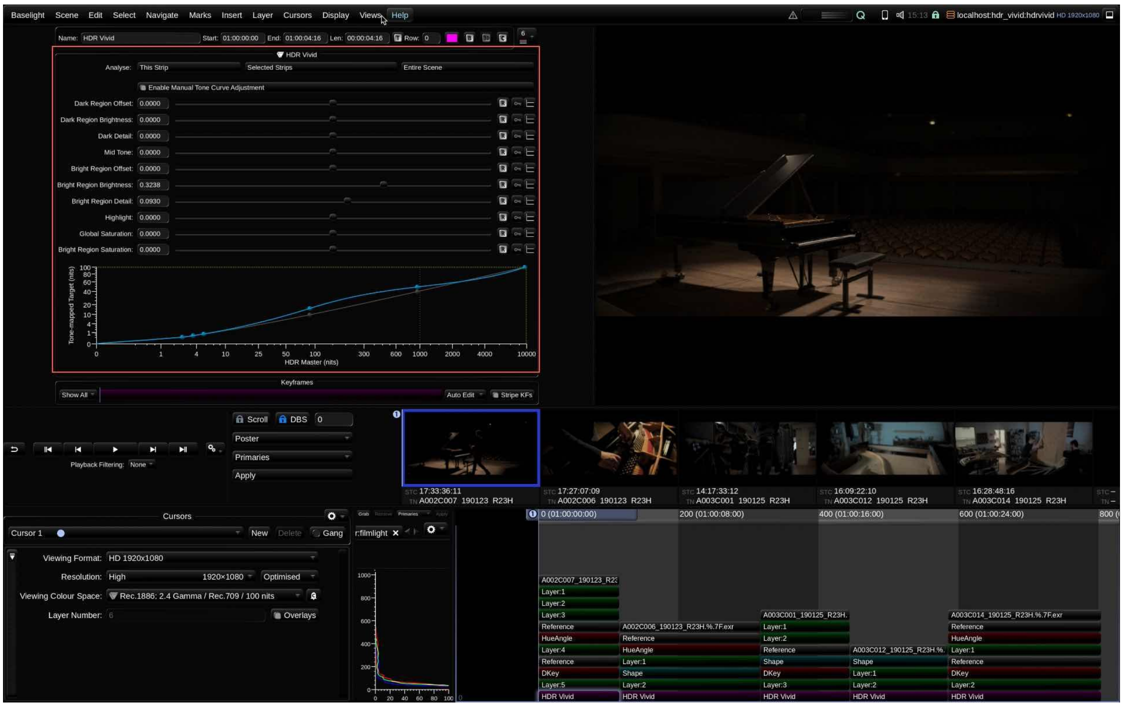


Figure 38 Manual Fine-tuning

7. Exporting media files containing metadata

Once the manual HDR Vivid fine-tuning is complete for all shots, users can choose to export specific media files containing metadata. In this case, users need to open the rendering page. In this example, specify the file type as **Quicktime Movie** and select HEVC 10bit hardware encoder with an HDR Vivid mark, as shown in the figure below. Then select Rec.2100: PQ/Rec. 2020/1000 nits under **Render Colour Space** and enable **Embed HDR Vivid Metadata** to record the metadata in the rendering media files, as shown in the figure below. After the settings are complete, submit the final rendering task to export the HDR Vivid master, as shown in the figure below.

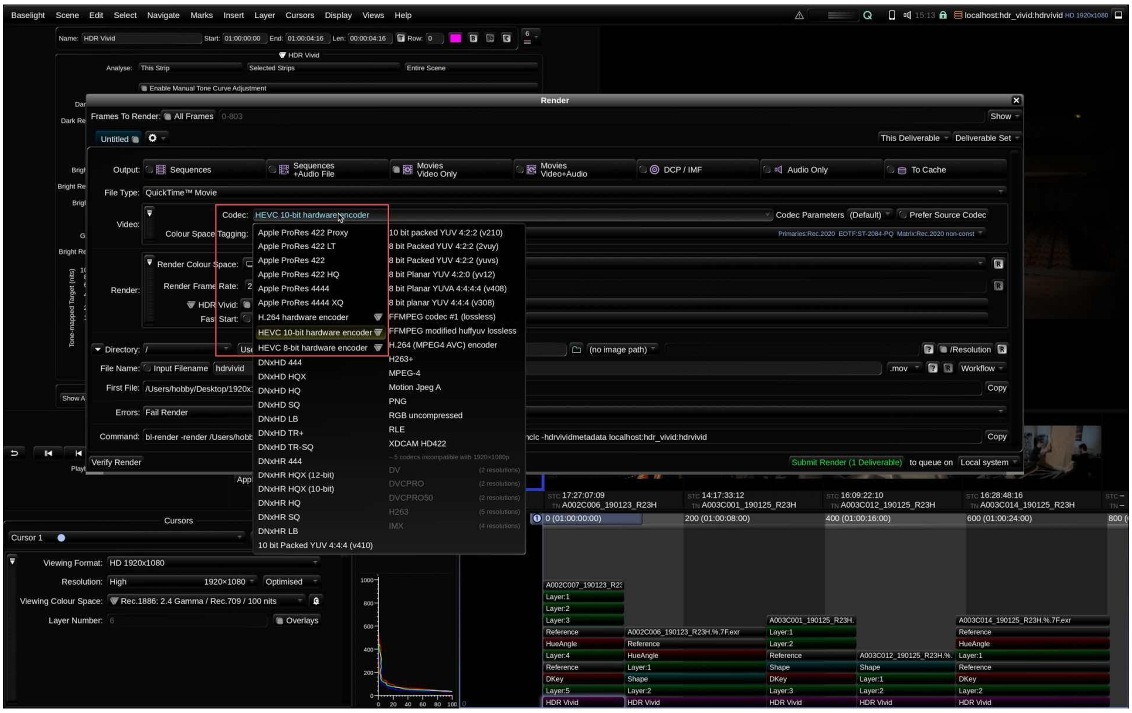


Figure 39 Selecting the Coding Format

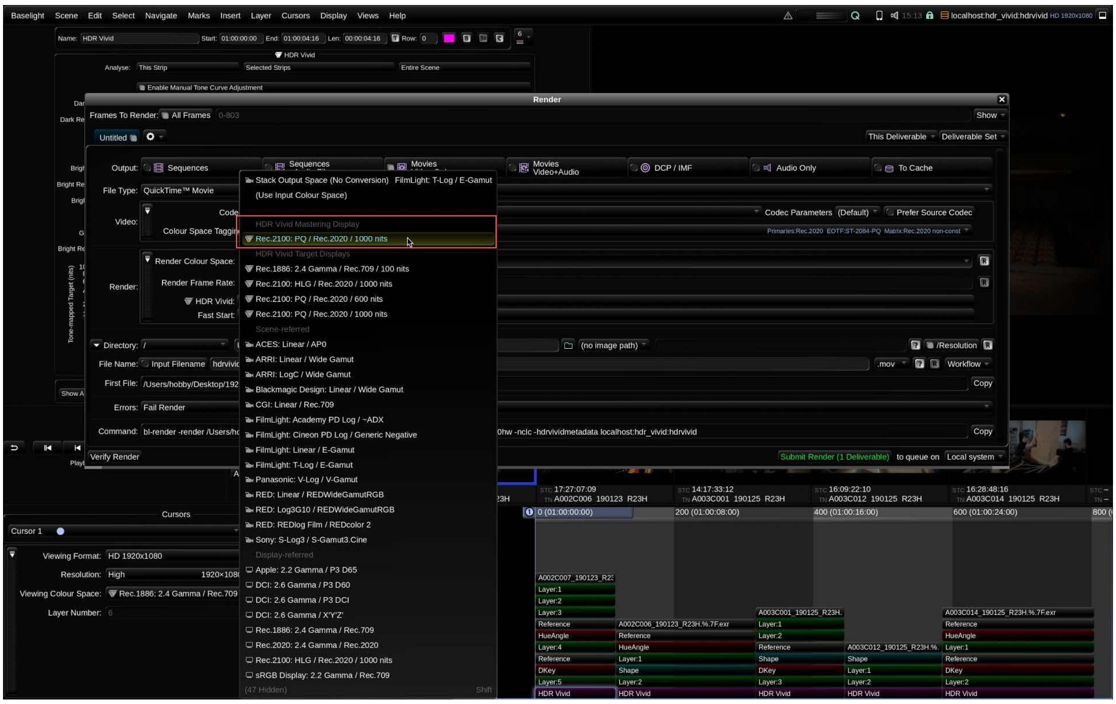


Figure 40 Rendering Color Space Options

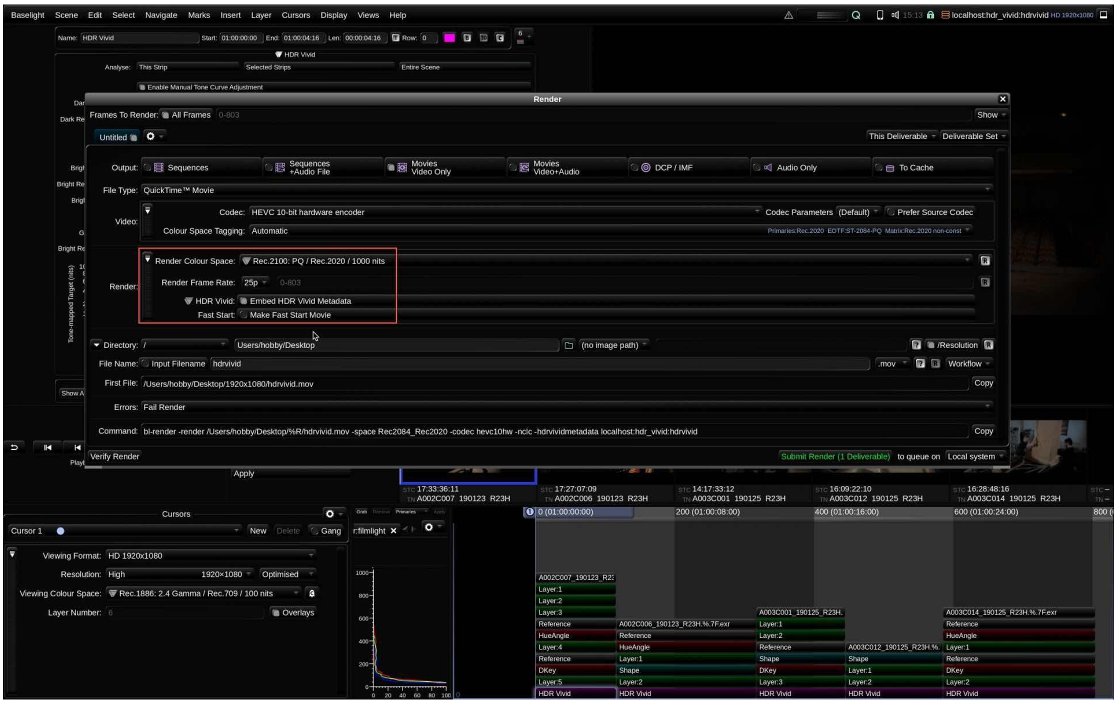


Figure 41 Selecting a Master Color Space and Embedding Metadata

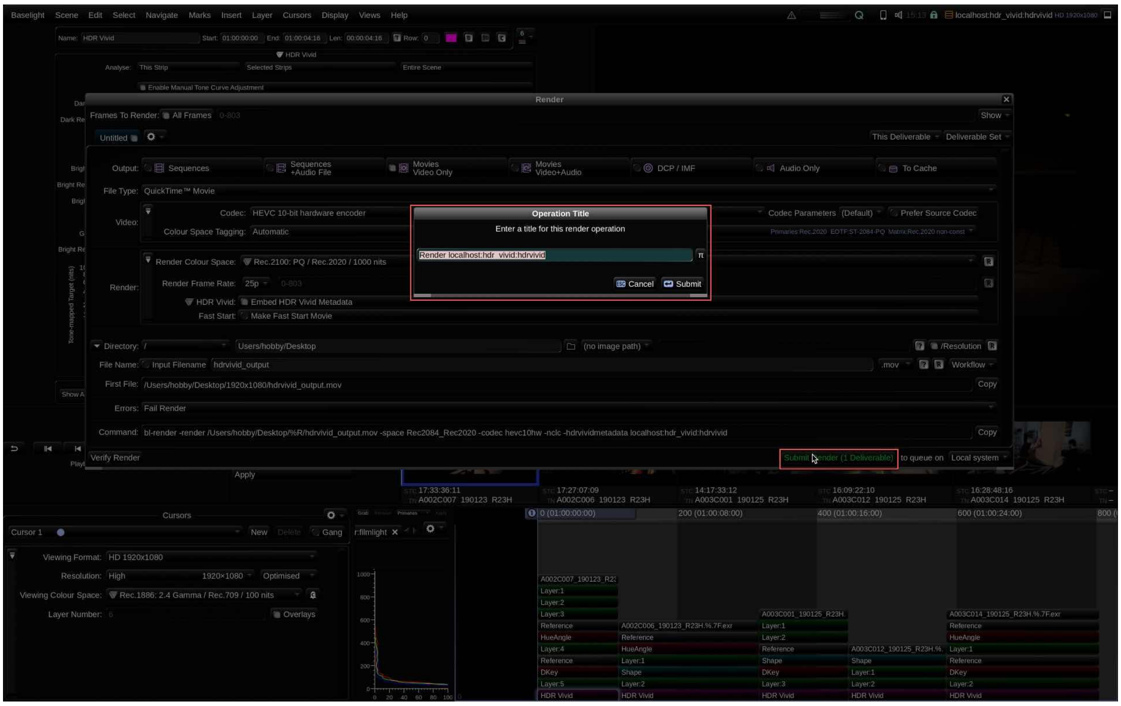


Figure 42 Render Submission

This is a brief guide to HDR Vivid. For more information about Baselight updates, please see the relevant update information.

Appendix 4: Arcvideo's Online Multi-Screen Coding and Transcoding Solution

The livestreaming system that supports HDR Vivid uses the x86 server architecture. The operating system and corresponding software versions are pre-installed before delivery. To connect a device to the livestreaming system, a GE or 10GE Ethernet interface can be used to connect with the switch. After the IP address is configured, the system's operation interface can be accessed through a browser.

1. Input source configuration

Users can create HDR livestreaming tasks for input sources in different formats in the livestreaming system. A livestreaming task can be created in four steps: Basic Settings, Input Source, Coding Parameter Settings, and Output Configuration. Input sources SDI, IP, and 2110 are supported. The following figures show the system operations.

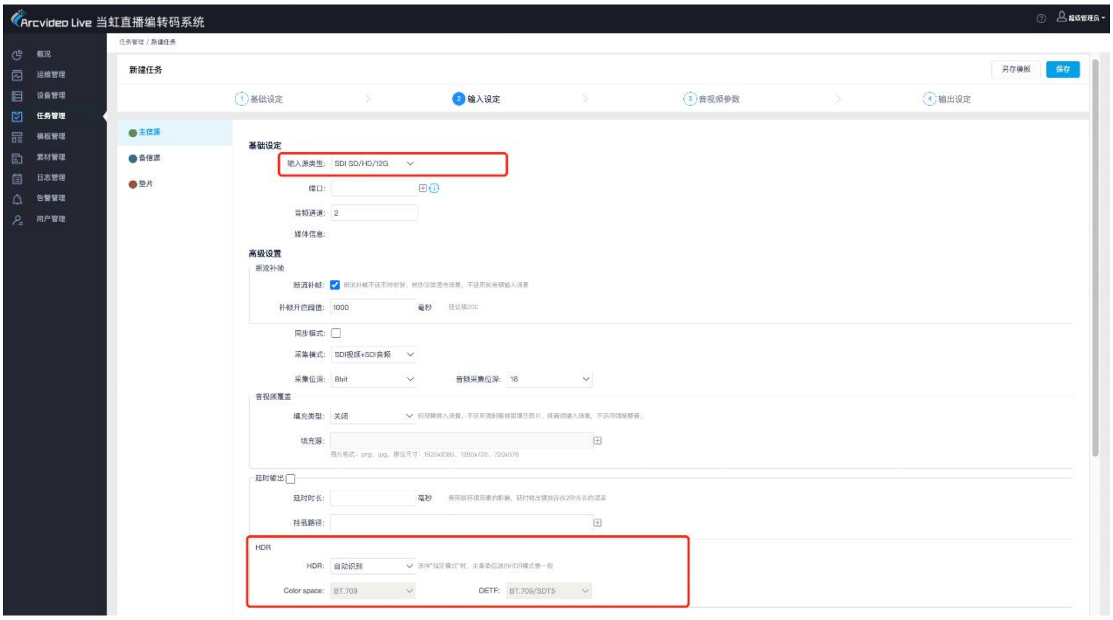


Figure 43 SDI Input

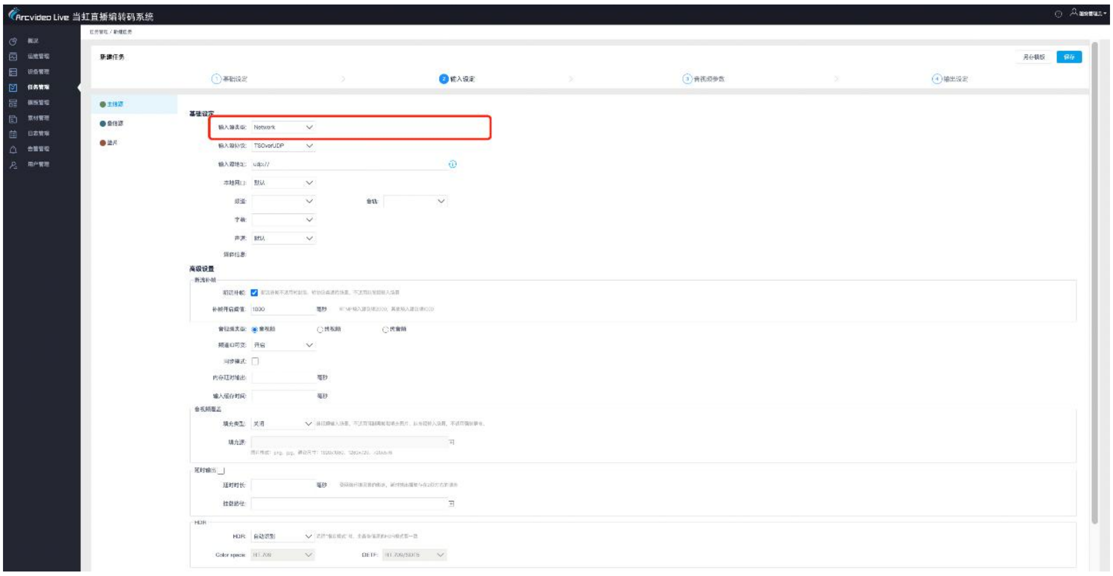


Figure 44 IP Input

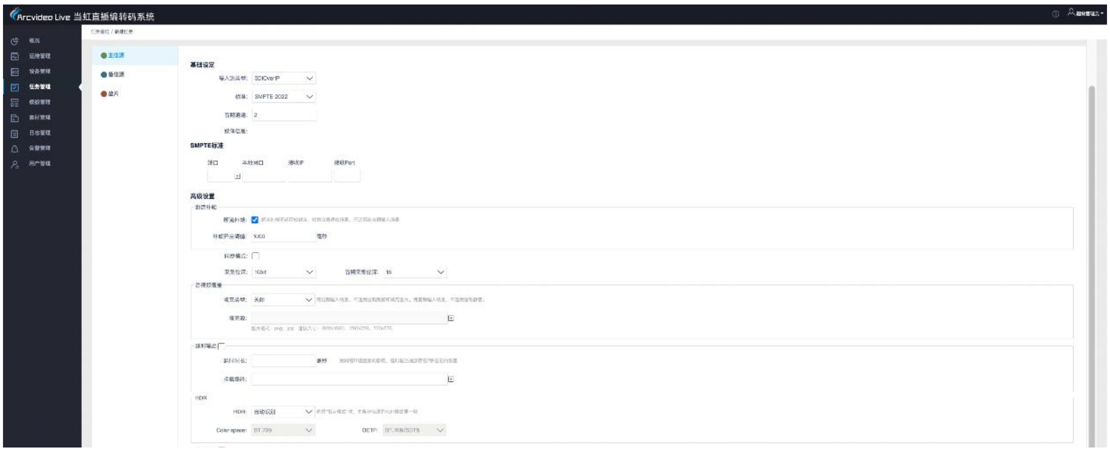


Figure 45 2110 Input

2. Coding parameter and HDR Vivid configuration

After the input source is configured, uses can configure coding parameters and HDR Vivid. The livestreaming system supports multiple types of coding parameters.

(1) When the coding format is set to H265 and the bit depth is set to 10 bits, HDR Vivid is configured as follows:

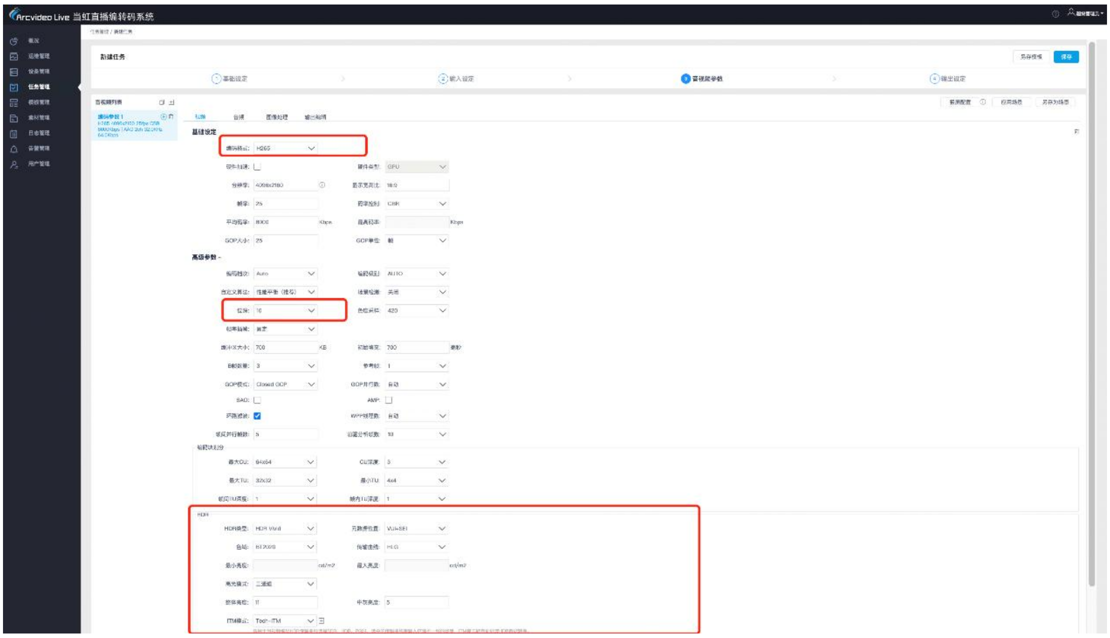


Figure 46 H265 and HDR Vivid Configurations

(2) When the coding format is set to AVS2 and the bit depth is set to 10 bits, HDR Vivid is configured as follows:

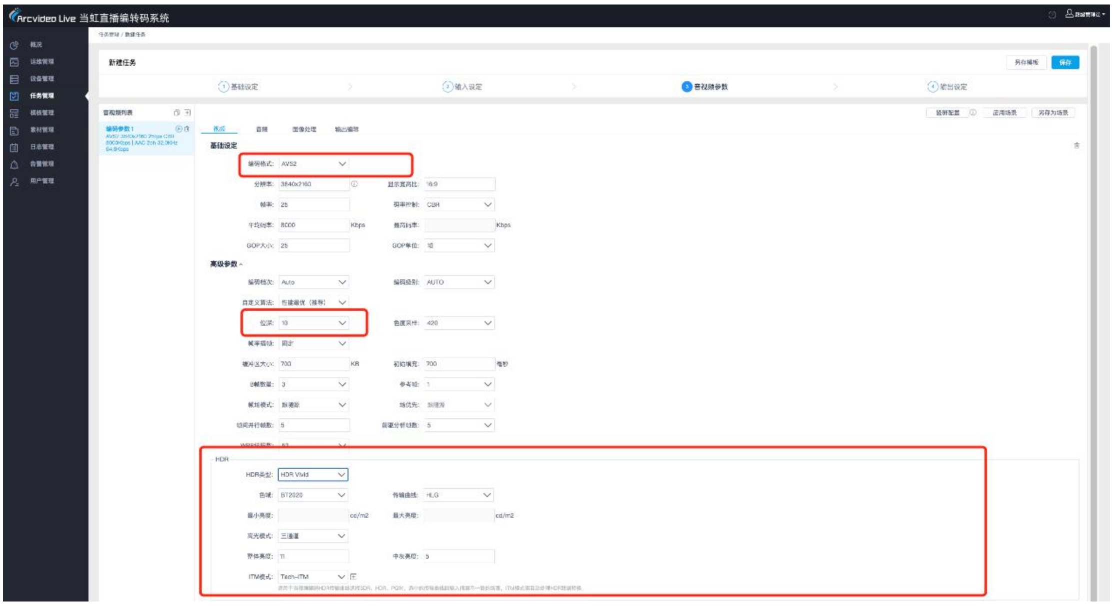


Figure 47 AVS2 and HDR Vivid Configurations

(3) When the coding format is set to AVS3 and the bit depth is set to 10 bits, HDR Vivid is configured as follows:

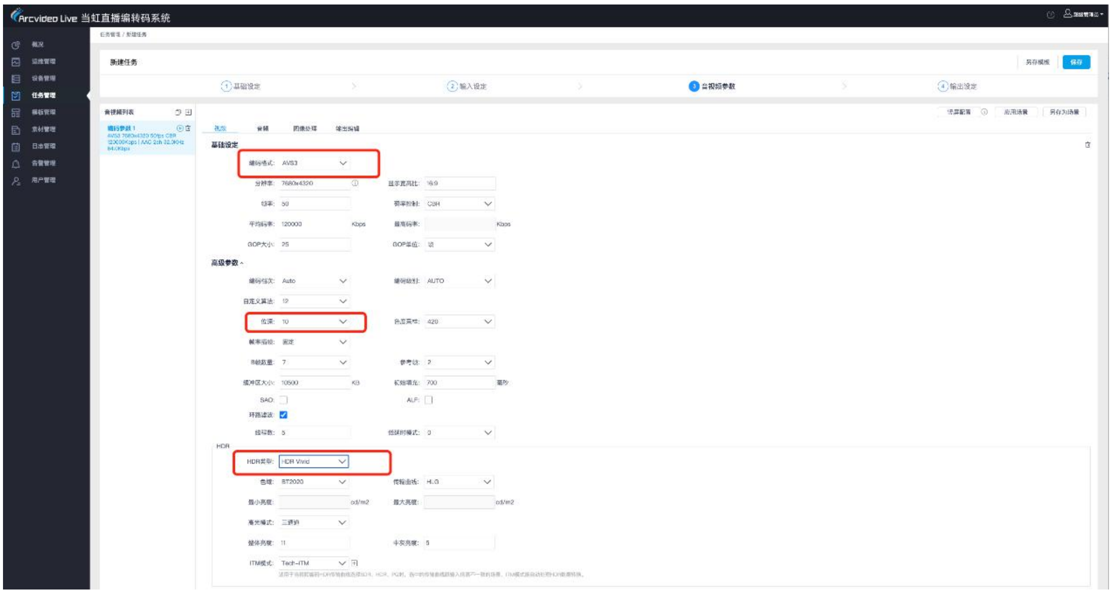


Figure 48 AVS3 and HDR Vivid Configurations

The figures above show the HDR Vivid configurations for different coding formats. The HDR livestreaming system also supports SDR-to-HDR Vivid conversion and HLG-to-HDR Vivid conversion. When the input source is SDR, it can be up converted to HDR Vivid, as shown in the following figures:

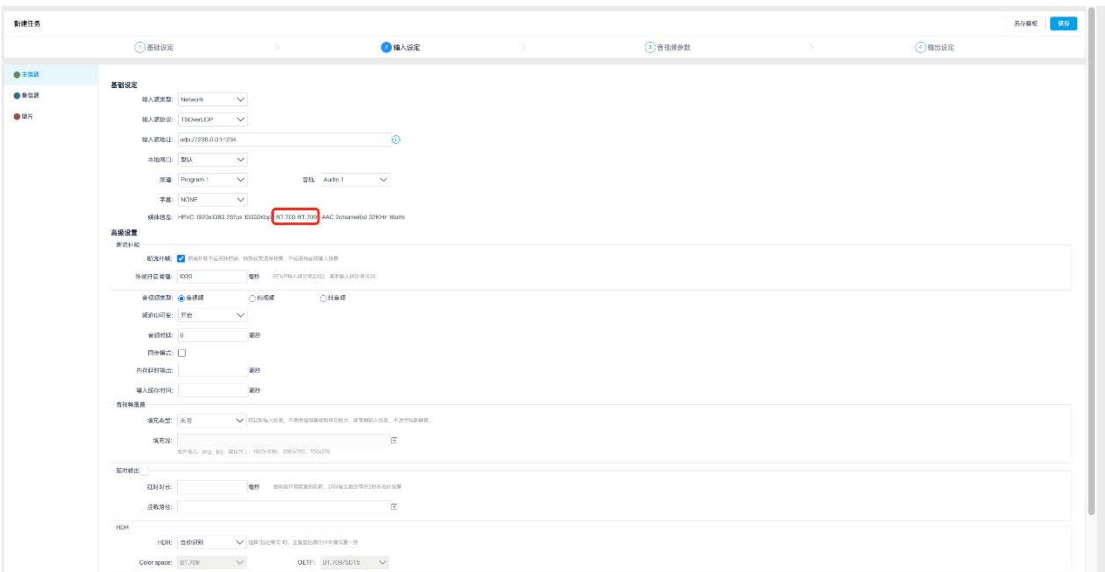


Figure 49 SDR Input Source

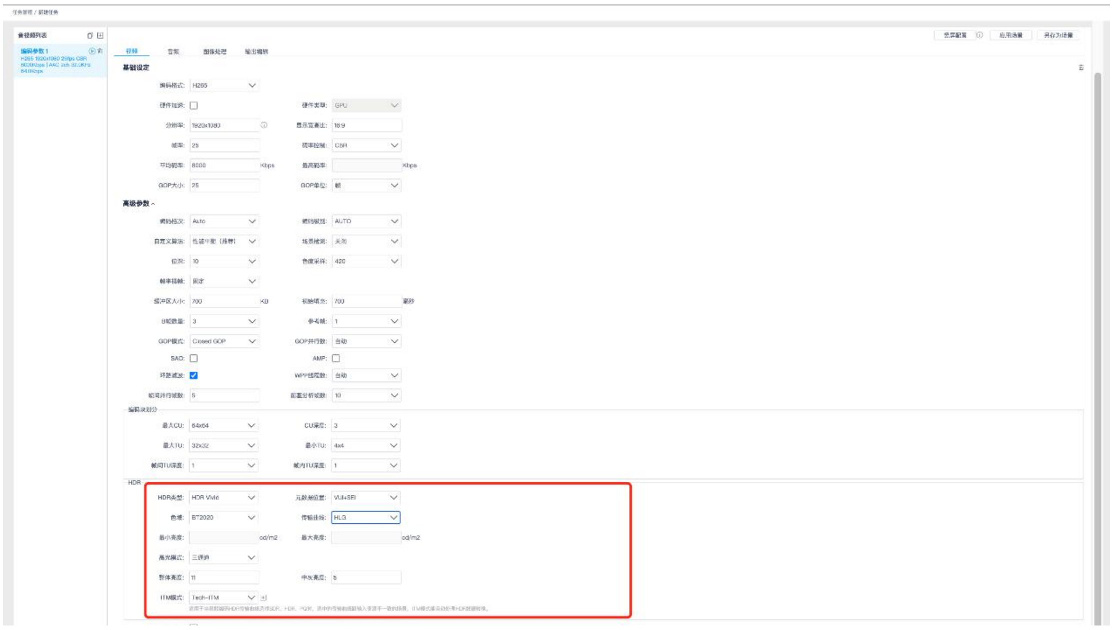


Figure 50 HDR Vivid Coding Configuration

When the input source is HLG, it can be converted to HDR Vivid:

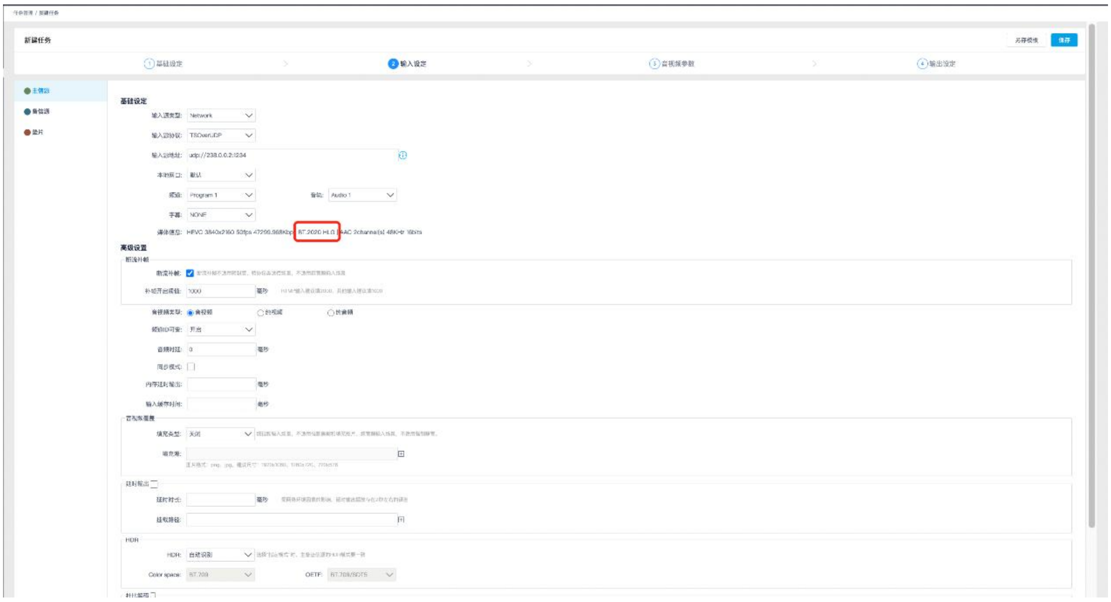


Figure 51 HLG Input Source

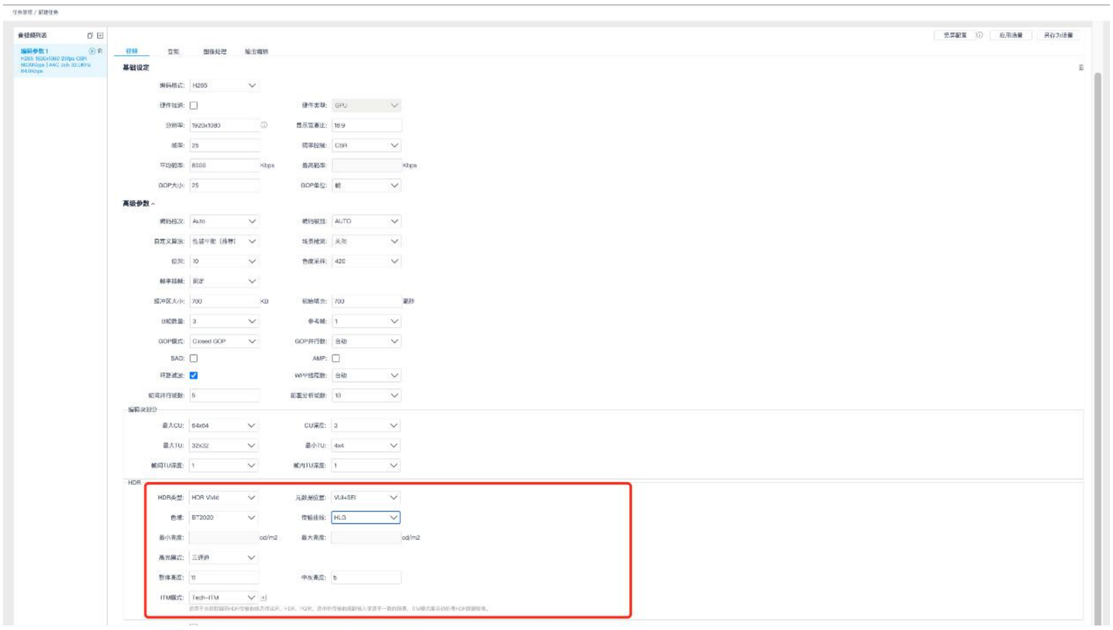


Figure 52 HDR Vivid Coding Configuration

When configuring HDR Vivid coding, the transfer curve can be set to PQ or HLG as needed:

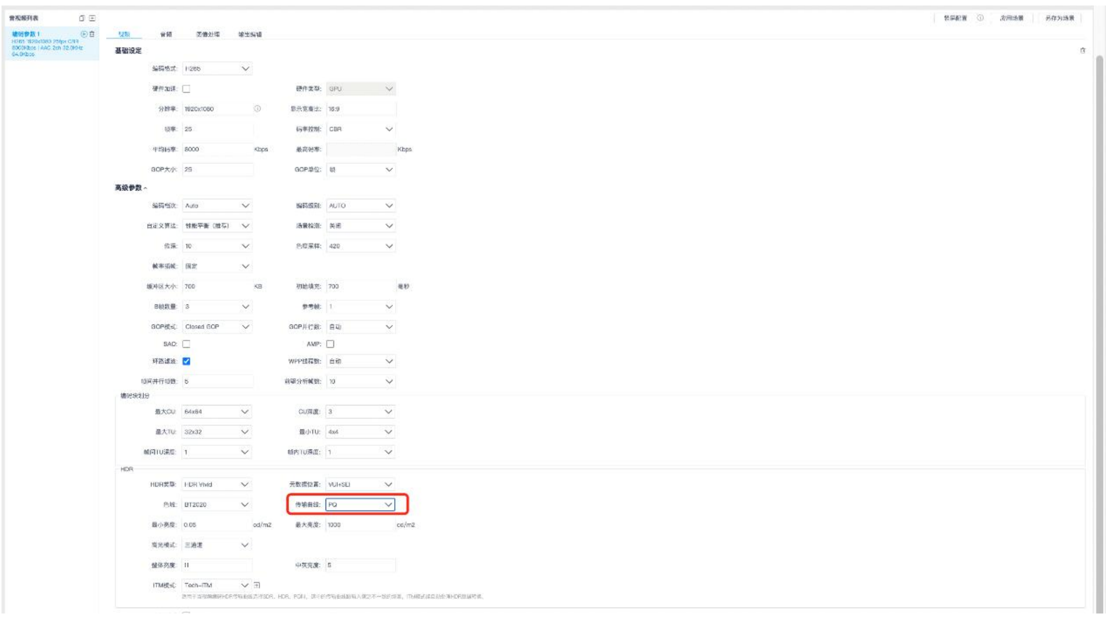


Figure 53 HDR Vivid Configuration with the Transfer Curve Set to PQ

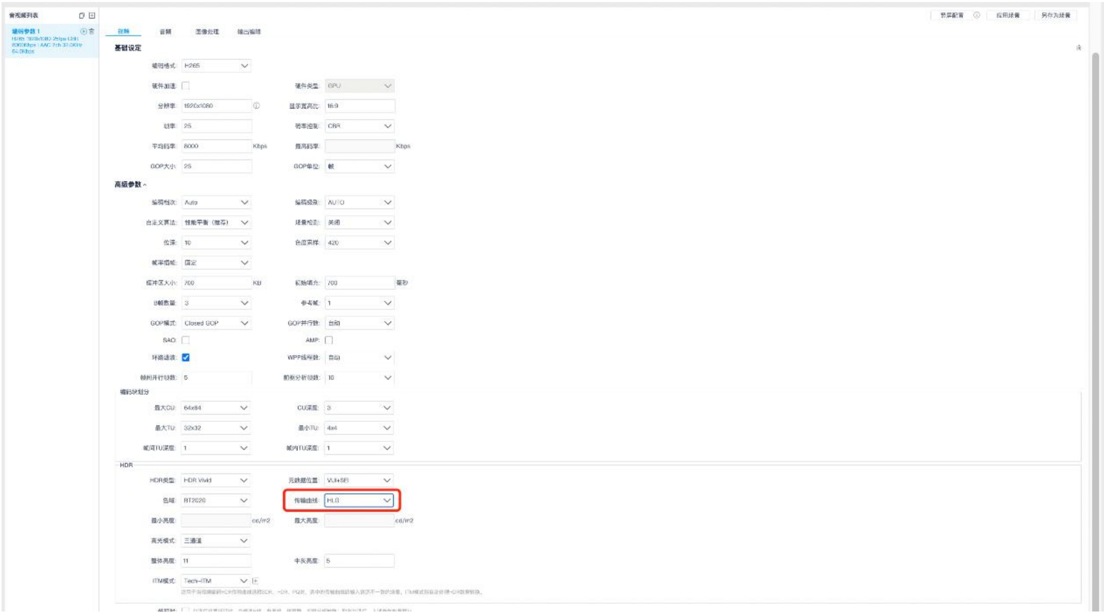


Figure 54 HDR Vivid Configuration with the Transfer Curve Set to HLG

3. Output configuration

After the input, coding, and HDR Vivid configurations are complete, users need to configure the output protocol for the livestreaming task. Four protocols are supported: UDP, SRT, HLS, and RTMP. The specific configurations are as follows:

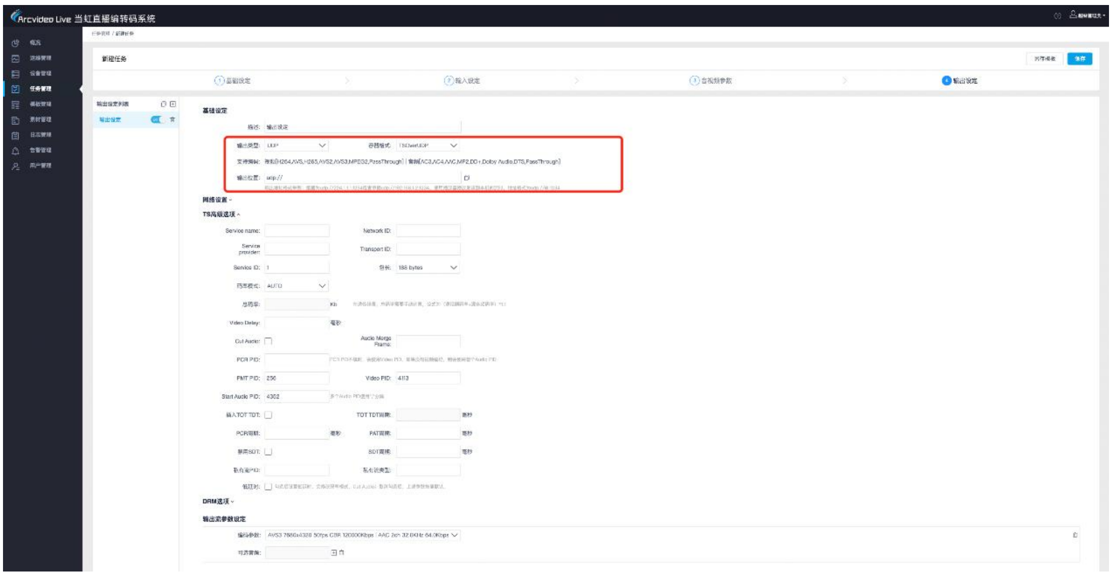


Figure 55 UDP Output Configuration

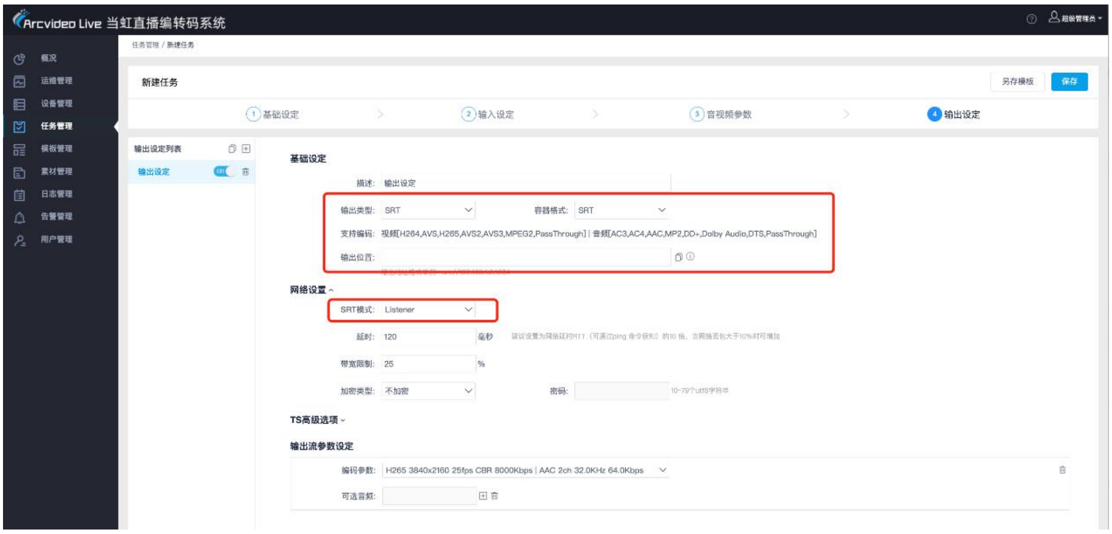


Figure 56 SRT Output Configuration

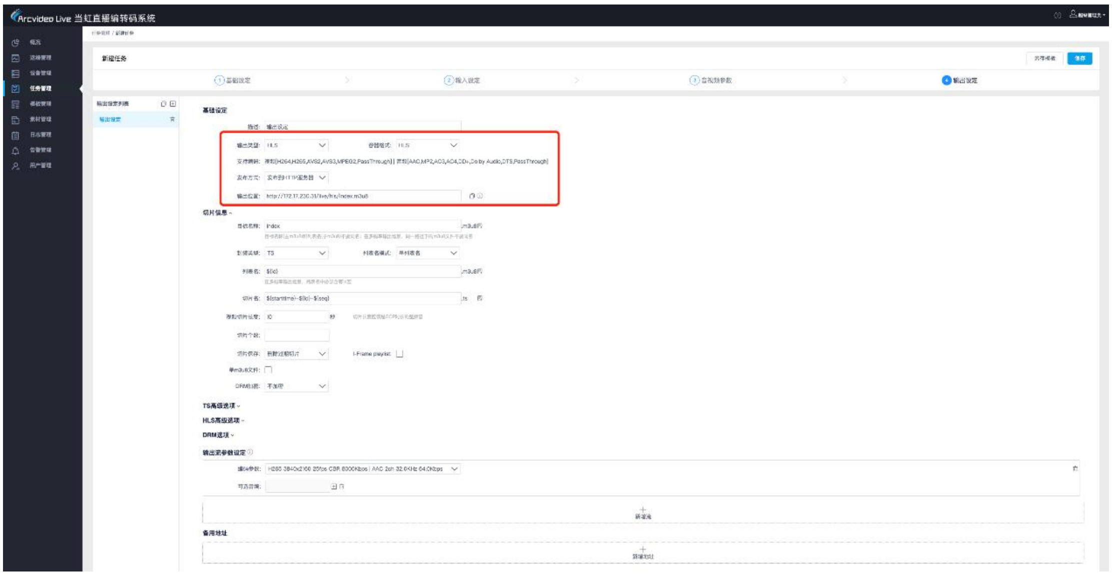


Figure 57 HLS Output Configuration

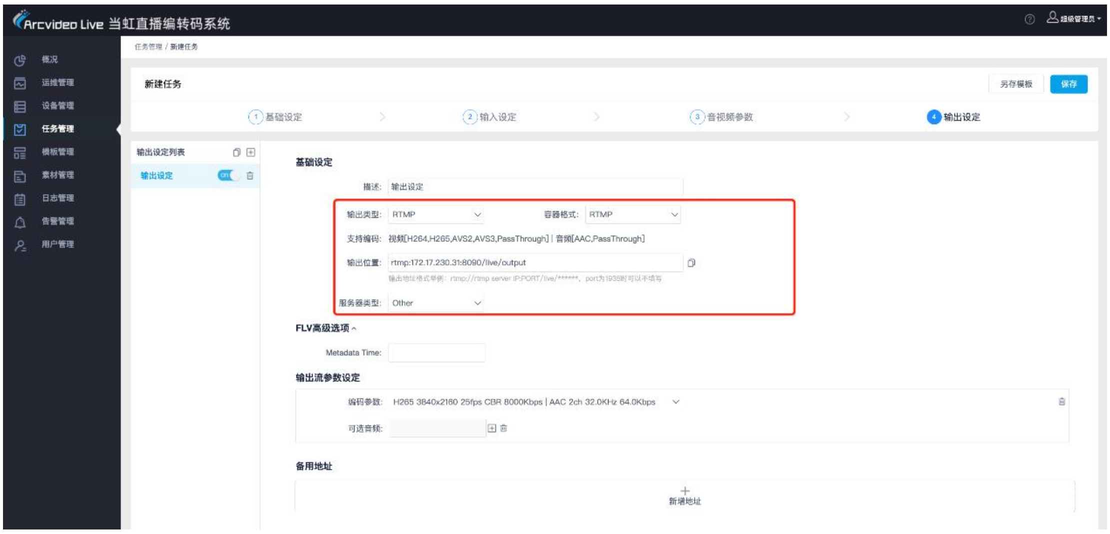


Figure 58 RTMP Output Configuration

After the livestreaming task is configured and saved, users can return to the **Task Management** page and click **Start** to start the task. After the task is successfully executed, live content can be viewed on a player that supports HDR Vivid.

Figure 59 Starting a Livestreaming Task

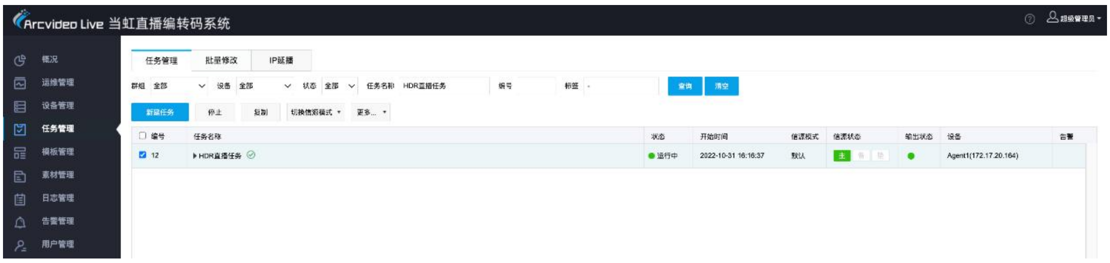


Figure 60 Livestreaming Task in Progress

This is a brief guide to HDR Vivid livestreaming tasks. For more information about Arcvideo updates, please see the relevant update information.

Appendix 5: Sumavision's UHD Real-Time Codec Solution

Sumavision's 10k118 and 10k218 real-time codec platforms are broadcast-level codec products and support up to 8K video coding and decoding. Sumavision's unique prediction algorithms give them advantages in both service stability and program quality. In addition, the codec products can be continuously updated using the algorithms developed by Sumavision's professional R&D team.

The 10k118 and 10k218 real-time codec platforms use the x86 architecture. Their software systems fully support HDR Vivid video coding and decoding.

1. Configuration requirements

Table 5 Configuration Parameters

Type	Recommended Model	Configuration Description
Real-time coding platform	Real-time coding platform 10k118 (1) 1U rack server (2) Sumavision's UHD coding software system	1U rack server — hardware configurations: CPU: Intel 6258R * 2 Memory: 192 GB Hard disk: 512 GB SSD * 2
Real-time decoding platform	Real-time decoding platform 10k218 (1) 1U rack server (2) Sumavision's UHD decoding software system	1U rack server — hardware configurations: CPU: Intel 8163 * 1 Memory: 96 GB Hard disk: 512 GB SSD * 2

2. Livestreaming protocols

The 10k118 and 10k218 real-time codec platforms support multiple transmission protocols, such as TS-UDP, TS-HTTP, SRT, HLS, RTP, and RTMP.

3. Codec formats

The 10k118 and 10k218 real-time codec platforms support various video formats, such as H.265, H.264, AVS2, and AVS3.

4. HDR Vivid program configuration

(1) Function parameter settings

On the **Function Parameters** tab, users can configure the task type, input source, etc.

Figure 61 Function Parameters

(2) Video parameter settings

On the **Video Parameters** tab, users can configure video coding and related preprocessing parameters for a task. Video parameters include basic parameters and coding parameters. Basic parameters are ones that may be frequently modified during the regular use of HDR Vivid codec platforms. Coding parameters are encoder parameters for specific coding formats. In general, default values for coding parameters are used and they change in sync with coding format changes.

Figure 62 Video Parameters

(3) HDR Vivid parameter settings

On the **HDR Parameters** tab, users can configure the video color gamut and HDR type. The **HDR_Vivid Dynamic Metadata** can be set to **On** or **Off** to enable or disable the advanced function of HDR Vivid dynamic metadata generation.

Figure 63 HDR Vivid Parameters

(4) Audio parameter settings

On the **Audio Parameters** tab, users can configure audio coding and related preprocessing parameters for a task. Audio parameters include basic parameters, dedicated parameters, and stereo channel configurations. Basic parameters are public parameters for audio coding. Dedicated parameters are exclusive parameters for specific coding formats and change in sync with coding format changes. Stereo channel configurations change in sync with audio channel mode changes.

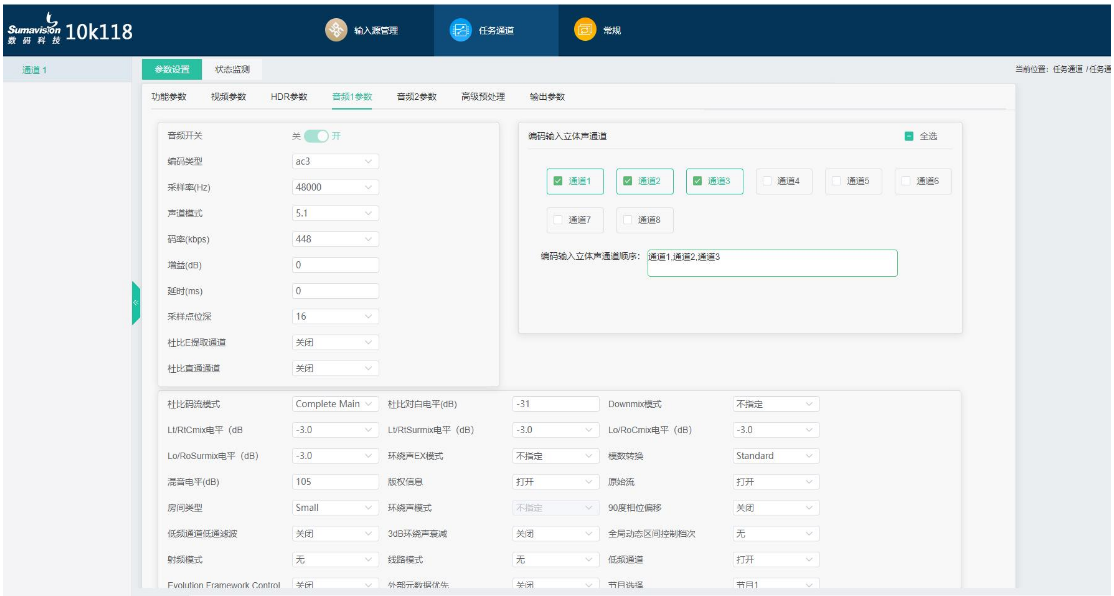


Figure 64 Audio Parameters

(5) HDR Vivid function and SDR/PQ/HLG conversion function

The HDR Vivid function and SDR/PQ/HLG conversion function are exclusively available when the protocol is 2110-22 and the source input is JXS.

The HDR Vivid function can be found by choosing **Task Channel** > **Parameter Settings** > **HDR Parameters**. To enable this function, the **HDR_Vivid Dynamic Metadata** should be set to **On**. When this function is enabled, HDR Vivid dynamic metadata will be generated and transmitted along with the video stream.

The SDR/PQ/HLG conversion is a default function when the protocol is 2110-22 and the source input is JXS. When the value of the **HDR Type** field on the **Preset Video Parameters** tab on the **ST2110** tab of the **Input Source Management** page is inconsistent with the value of the **HDR Type** field on the **HDR Parameters** tab on the **Parameter Settings** tab of the **Task Channel** page, the SDR/PQ/HLG conversion function will be directly used for image processing and conversion. When **PQ** is selected for the **HDR Type** field on the **Preset Video Parameters** tab on the **ST2110** tab of the **Input Source** page, the configuration and use of the maximum and minimum luminance will be activated for the ST2110 input source.

(6) Output parameter settings

On the **Output Parameters** tab, users can configure TS encapsulation parameters and transmission network parameters for outputs. Output parameters include basic parameters, TS multiplexing parameters, UDP parameters, TS parameters, PID settings, and transmission interval settings.

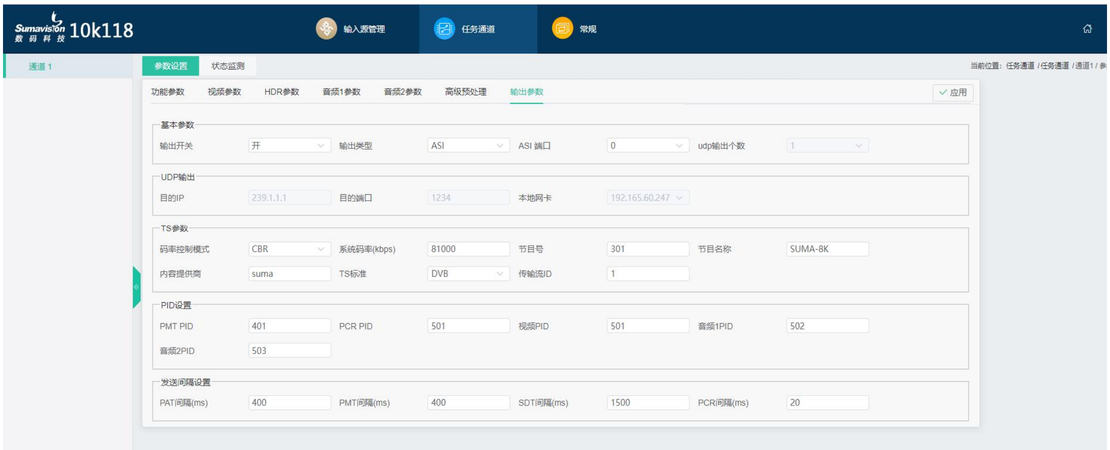


Figure 65 Output Parameters

Appendix 6: Tencent Video's End-to-End HDR Vivid Solution

Tencent Video has played an active role in HDR Vivid standard development and implemented an HDR Vivid solution. It has built an initial complete system that encompasses content production, cloud transcoding, and device playback. Tencent Video enables both manual and automated content post-production, from which users can choose based on their business needs. Manual post-production is preferred for high-quality content, helping ensure the best possible quality of HDR Vivid images. For other types of content, automated post-production can be used to fully leverage the strengths of batch production and improve the conversion efficiency of HDR Vivid content.

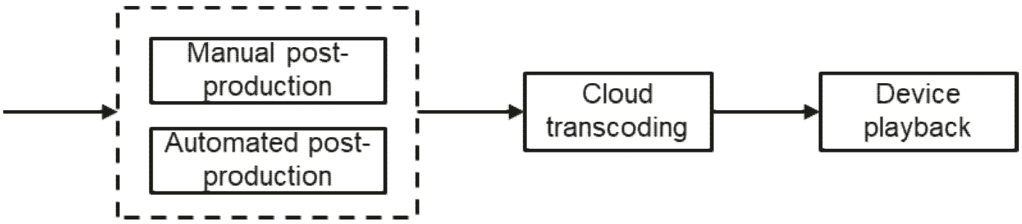


Figure 66 How Tencent Video's HDR Vivid Solution Works

1. Manual post-production

Tencent Video's HDR Vivid manual post-production includes remastering HDR content to HDR Vivid content, and remastering SDR content to HDR Vivid content. The process of remastering SDR content to HDR Vivid content is as follows:

(1) Production environment setup

The color grading system uses an integrated software and hardware workstation with Baselight ONE software (Version 5.3) built in. The HDR monitor is EIZO CG3146, and the SDR monitor is EIZO CG319X.

(2) Material preparation

Tencent Video has formulated the *Tencent Video Specifications for Video Source Files*, which specifies the technical parameters of video source files to ensure the high image quality of video source files and facilitate subsequent HDR Vivid remastering and transcoding.

Currently, many master files fail to meet all the technical parameter requirements set out in the *Tencent Video Media Asset Specifications for Video Source Files*. Most video source files are in a YCbCr 4:2:2 or 10-bit limited range (64–960) format. Signals between 4 and 64 (known as super blacks) and between 960 and 1019 (known as super whites) often contain information which is essential for HDR content production. Therefore, limited-range materials containing super-black and super-white data are always preferred.

In addition, images should be separated from subtitles. Specifically, images should be remastered into HDR before subtitles are synthesized. In this way, subtitle brightness will not make viewers feel uncomfortable and will not impact metadata analysis.

(3) Manual remastering

Taking all factors into careful consideration, we decided to use Rec2020 PQ 1000nit as the specification for master production. If an SDR master is of poor quality, its images will be repaired before being remastered to reduce color banding and noise.

Many tools offer automated HDR up-conversion, which can make the content on an HDR device look similar to SDR content. In order to create better results, Tencent's colorists would manually color each shot. During the up-conversion, SDR content of 50 to 100 nits is released to a wider range, and the gamma is converted to PQ. The effects of automated mapping can sometimes be inaccurate. In this case, brighter or darker scenes need to be manually repaired to balance contrasts and boost highlights. The backgrounds and skin tones in some scenes may also need to be manually fine-tuned to enhance gradation.

During the remastering process, the creative intent of creators should be preserved. In other words, the HDR content remastered from SDR content should look similar to the SDR content to which the HDR content is remapped through HDR Vivid.

(4) Metadata analysis and tone mapping

HDR Vivid metadata can be analyzed after HDR content is color graded. If an image contains a mask, the mask should be removed to avoid potential impacts on metadata analysis.

In Baselight 5.3, metadata is analyzed frame by frame. Even if the video is not cut into different shots, the entire video can be analyzed. However, in production, it is recommended to cut the video by shot to facilitate metadata adjustment for different mapping objects by scene.

The current production process makes it difficult to adjust mapping objects of different luminance levels separately, and the master file to be outputted can contain only one piece of HDR metadata. Therefore, we chose to adjust the metadata for only one of the HDR mapping effects. Given the fact that consumer devices vary in their ability to display dark areas, mapping adjustment for dark areas should be done with greater caution. After the mapping effects are adjusted, they should be packaged in the master file for output. Metadata tone mapping will change as the production process updates or iterates.

(5) Master output and upload

After HDR Vivid content is produced, a high-quality master file containing metadata should be outputted in accordance with coding requirements. The metadata should be verified before being uploaded to the back-end file format system and starting transcoding.

2. Automated post-production

Tencent Video's automated production system supports the automated production of HDR Vivid videos using its self-developed SDR2HDR algorithm and metadata generation algorithm. The automated production system automatically detects the input format type, adjusts the production process according to the input format type, and ultimately outputs a high-quality HDR Vivid video.

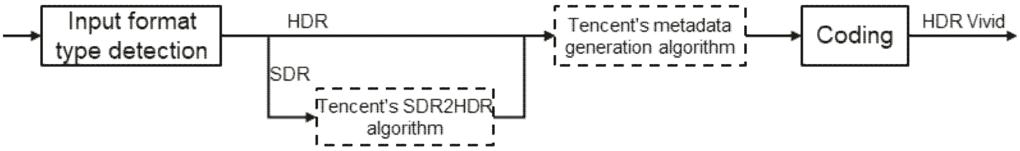


Figure 67 How Tencent Video's Automated Post-Production for HDR Vivid Works

(1) Automated HDR remastering

For HDR10 or HLG input, the system decodes the images, uses Tencent's self-developed algorithms to analyze the images and generate HDR Vivid metadata, codes the metadata into a binary stream using the syntax defined in *High Dynamic Range Video Technology Part 1: Metadata and Tone Mapping*, and ultimately embeds the metadata into the HDR video stream using the method defined in *High Dynamic Range Video Technology Part 2-1: Application Guide to System Integration*. This method enables batch conversion of HDR10 or HLG videos into HDR Vivid videos. With this method, devices that support HDR Vivid are better able to preserve the creative intent of creators. This method is also backward compatible with devices that support HDR10 or HLG.

(2) Automated SDR remastering

For SDR input, the system first uses Tencent Video's self-developed SDR2HDR algorithm to up-convert the video content into HDR content, reconstructs the image quality, and generates static metadata. The system then leverages the automated HDR remastering process to generate HDR Vivid dynamic metadata and ultimately output an HDR Vivid video. This method automates the batch conversion of a large amount of existing SDR content into HDR Vivid content. This is key to expanding the HDR Vivid video catalog and delivering better visual experiences.

(3) Cloud transcoding

Tencent Video's cloud transcoding system has complete HDR Vivid transcoding capabilities. The transcoding system not only performs conventional transcoding on video source files, but conducts transparent transmission of HDR Vivid metadata. Specifically, the cloud transcoding system intelligently detects the video source file by using the HDR Vivid metadata embedding method specified in *High Dynamic Range Video Technology Part 2-1: Application Guide to System Integration*. If detection shows that the video source file contains the HDR Vivid metadata ID code specified in the standard, the system will truncate the contained HDR Vivid metadata from the bitstream, and rewrite the metadata into the transcoded video stream without making any changes. This transparent transmission approach for metadata helps ensure that metadata is not distorted in the transcoding process, thereby preserving the creative intent of creators as much as possible.

There is a close relationship between automated content production and cloud transcoding. The two can be combined in a real-world production environment to improve overall production efficiency.

3. Device playback

The Tencent Video player supports both hardware rendering and software rendering policies. The player can automatically identify HDR Vivid videos and choose a rendering policy based on the hardware capabilities of the playback device to achieve the best possible visual display effects.

Tencent Video offers an HDR Vivid software rendering solution that supports metadata parsing, curve parameter calculation, and tone mapping on different platforms. These platforms include iOS, Android, and system platforms for PCs and TVs. The software rendering process is illustrated as follows:

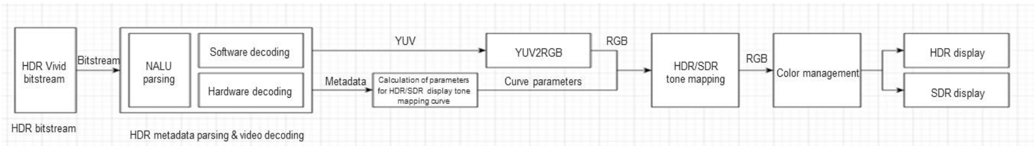


Figure 68 How HDR Vivid Is Played on a Tencent Video Device

(1) Metadata parsing and video decoding

According to the technical standards set out in *High Dynamic Range Video Technology Part 1: Metadata and Tone Mapping*, a playback device parses static and dynamic metadata in a bitstream and uses a software or hardware decoder to decode the video data. After each frame of the video is decoded, the dynamic and static metadata parsed from each of the frames is carried as side data and transferred to the downstream rendering module of the player.

(2) Display tone mapping

The rendering module identifies the HDR type of each video frame according to the frame's side data, so as to create a different render for each frame. When rendering HDR Vivid video frames, Tencent Video obtains information about the display device's maximum luminance, minimum luminance, and color gamut, determines whether the device has an HDR or SDR screen, and decides to perform HDR or SDR display tone mapping.

After determining the display tone mapping type (HDR or SDR), Tencent Video calculates the curve parameters based on the dynamic metadata carried in video frames and the screen's maximum and minimum luminance levels, in accordance with the technical standards set out in *High Dynamic Range Video Technology Part 1: Metadata and Tone Mapping* (Sections 9.2, 9.3, 10.2, and 10.3). The curve parameters are then entered in the Shader for tone mapping and color conversion.

In the Shader, the decoded video frame data is converted from YUV into RGB. After this, color conversion and correction is performed as per the technical standards set out in *High Dynamic Range Video Technology Part 1: Metadata and Tone Mapping* (Sections 9.4, 9.5, 9.6, 10.4, 11.1, and 11.2).

In the end, the RGB data with colors converted and corrected is displayed on the screen after going through the color management procedures of the device.

Appendix 7: Baidu AI Cloud's Intelligent UHD Services Provide an End-to-End HDR Vivid Solution

To help customers create comprehensive, high-quality HDR Vivid visual experiences, Baidu AI Cloud's intelligent UHD services provide an end-to-end HDR Vivid solution for video production, processing, coding, transmission, decoding, and display.

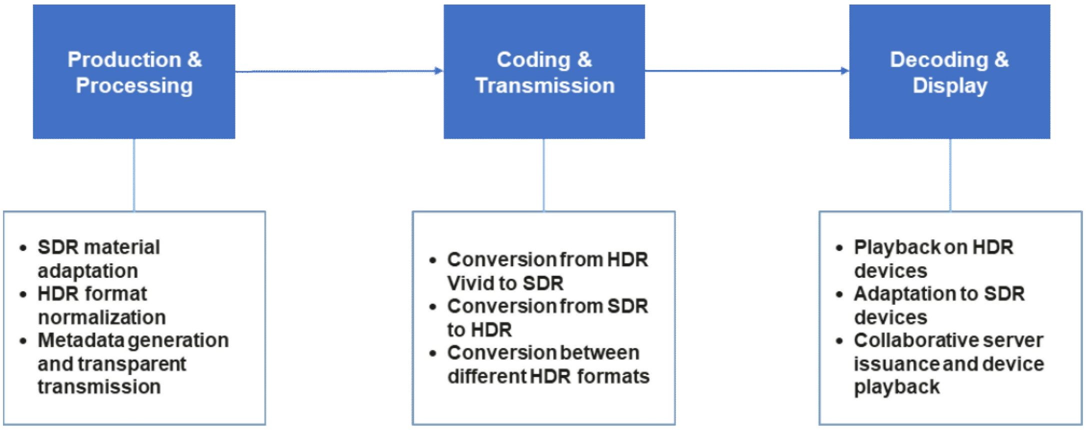


Figure 69 Baidu's HDR Vivid Processing Flow

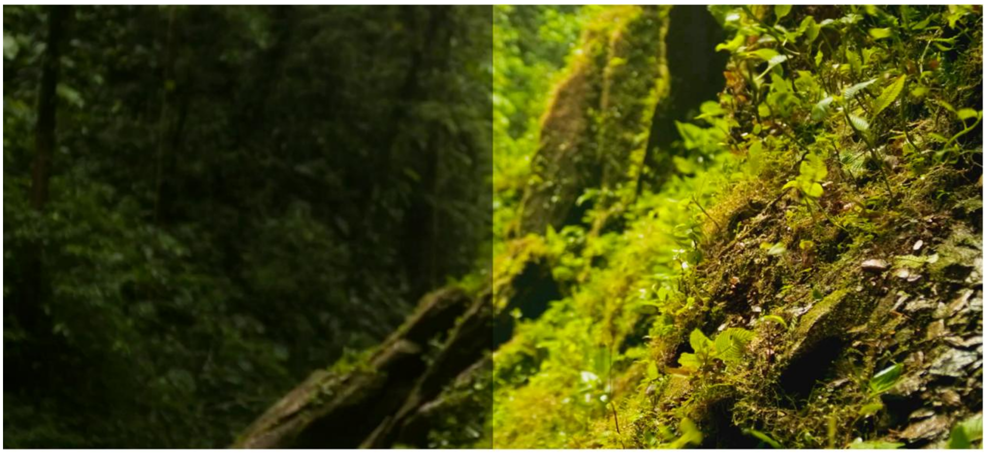
1. Production and processing

HDR Vivid content is produced mainly using Baselight. Baidu AI Cloud's fast editing tool is able to synthesize HDR Vivid clips. In this step, the various formats of input videos pose a challenge, and the key to overcoming this challenge is finding a way to normalize format standards and output high-quality HDR effects. Our cloud-based fast editing tool mainly normalizes formats in the pre-processing stage, after which two types of files will be output. A low-bitrate file will be used for real-time preview on the web browser to ensure smooth display, and an HD HDR video file will become the input for final synthesis. Here, the transcoding capability is used to upconvert all SDR videos into HDR Vivid videos and normalize HDR videos in different formats (such as HLG, HDR10, and Dolby) into HDR Vivid videos. Standardizing the input for synthesis ensures that the display effects appear as expected. In the rendering and synthesis phase, rendering engines such as OpenGL and Vulkan are used to ensure that the PQ curve information is completely reserved and output, while the BT.2020 color gamut and 10-bit depth are supported.

2. Coding and transmission

Videos must be transcoded several times during the process from production to final release, in order to provide better user experiences. To cope with diverse application scenarios, we provide a variety of processing capabilities.

- **Conversion from SDR to HDR**



(SDR) (HDR)

Figure 70 Baidu's HDR Vivid Processing Effects

Baidu AI Cloud's intelligent UHD services leverage the capabilities of AI models to remaster SDR content into HDR content by improving the luminance and color space, and adapt to devices' HDR display capabilities while preserving the creator's intent. This includes converting BT.709 content to BT.2020 content and 8 bits to 10 or 12 bits, while enhancing the details in dark area and restoring the details in overexposed areas. Algorithms for noise control are also optimized to prevent bad cases such as color gradients and artifacts. As shown in Figure 70, compared to the original SDR video on the left, the HDR video processed by intelligent UHD services is brighter, shows more details, and has more striking colors. Intelligent UHD services also provide intelligent super resolution, intelligent frame insertion, intelligent restoration, intelligent enhancement, and intelligent coding technologies to significantly improve video definition and user experiences. These, alongside panoramic sound effects, can create immersive visual and audio experiences.

- **Conversion between different formats**

Different HDR formats are used in different scenarios. HLG is widely used for broadcasting and television, and HDR10 is more often used for online content. Therefore, conversion between different formats must be supported to adapt to different playback devices and service scenarios. To better apply and promote HDR Vivid standards, Baidu AI Cloud now supports the conversion of different HDR formats, such as Dolby Vision, HDR10, and HLG, into HDR Vivid. To that end, metadata must be correctly parsed, defined, and written to ensure that the display effects are consistent across different devices. In addition, we have made many optimizations at the codec level, so that the BD265 encoder can better support the transparent transmission of metadata, including the parsing, retention, and writing of video usability information (VUI) and supplemental enhancement information (SEI), ensuring that no information is lost and no errors occur during coding.

The intelligent UHD appliance's parameter configuration page is shown below.

Click **Create Transcoding Template** to go to the **Create Transcoding Template** page, and enter parameters to create a transcoding template.

The descriptions of some parameters are as follows:

- The default H.265 encoder is Baidu's BD265 encoder, which is 2 to 4 times faster and reduces the bit rate by more than 30% compared with the X265 encoder.

- Currently, HDR formats including HDR Vivid, HLG, and HDR10/PQ are supported. If HDR is enabled, the coding standard must be H.265, and the coding profile must be Main10.

- When an SDR video is input, if HDR is enabled but the intelligent UHD-SDRtoHDR operators are not enabled, the traditional algorithm will be used to upconvert the video into HDR. If the operators are enabled, the AI model will be used to process the video.

Figure 71 Baidu's HDR Vivid Processing Parameter Settings

- There are three types of intelligent UHD operators: old video restoration, color adjustment, and picture quality improvement operators. Some operators are capable of adjusting the color intensity. To enable intelligent color enhancement, AI models are used to intelligently adjust the luminance, contrast, and color saturation of images to improve their overall quality. This function cannot be used together with the saturation adjustment, contrast adjustment, or luminance adjustment functions.

- If the intelligent HDR operators are enabled, when an SDR video is input, the AI model will automatically convert it into the specified HDR format, including HDR Vivid.

Figure 72 Baidu's HDR Vivid Coding Parameter Settings

3. Decoding and display

If decoding and rendering are all conducted using HDR formats on hardware that does not support HDR display, overexposure-resulted distortion may occur. Therefore, the display effects of different HDR videos will vary significantly due to technical differences. To deal with the diversity of display devices, we provide two solutions. First, both the HDR and SDR versions of a video are transferred to the server, and the more suitable version that is supported by the display device will be issued. Second, the video is adapted on the player of playback devices. For devices that do not support HDR, HDR videos are converted into SDR videos in real time through tone mapping. Meanwhile, the SDR videos are optimized through algorithms in terms of luminance, color gamut, and color depth, in order to make the display effects as close as possible to those of HDR videos. The SDK of Baidu AI Cloud's mobile player already supports optimized playback for HDR effects, as shown below:

(True HDR display) (Direct playback on SDR devices) (Baidu-optimized, downgraded playback on SDR devices)

Figure 73 Baidu's HDR Vivid Device Optimization Results

Appendix 8: Migu's End-to-End HDR Vivid Livestreaming Solution

China Mobile Migu has actively participated in HDR Vivid standardization and actively promoted its commercialization. This has led the company to gain rich experience in HDR Vivid livestreaming. Migu's HDR Vivid livestreaming technology is becoming increasingly mature. The technology was first applied during UEFA Euro 2020, first commercially adopted during the Beijing 2022 Winter Olympics, and commercially used at scale during the FIFA World Cup Qatar 2022, receiving wide recognition from users. Migu has developed the end-to-end HDR Vivid livestreaming solution based on its experience in livestreaming multiple sports events. The solution profoundly optimizes key aspects of HDR Vivid livestreaming, such as livestream source inspection, source preprocessing, source coding, decoding upon reception, and display on devices, thus enabling a superior and immersive livestreaming experience for end users.

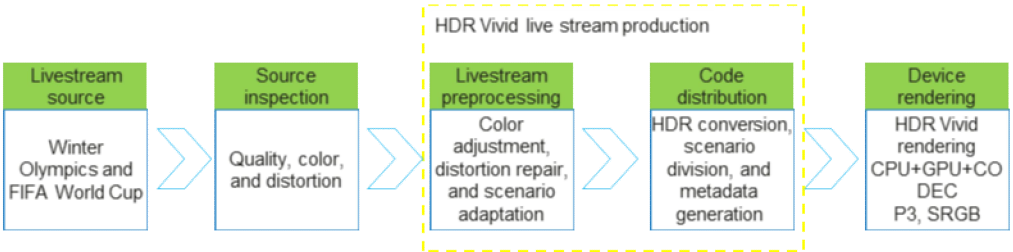


Figure 74 End-to-end Live Streaming Solution

1. Livestream Source Inspection

Source inspection is used to replace manual operations and automatically and efficiently analyze whether source quality meets preset standards and whether any quality issues exist like color cast, oversaturation, low definition, and insufficient dynamic range.

Migu supports multi-dimensional source quality inspection, including both comprehensive and indicator-specific quality inspections. Comprehensive quality inspection focuses on overall image quality, while indicator-specific inspections focus on color richness and dynamic range indicators like luminance, chrominance, and contrast, as well as common coding distortion indicators like blur, blocking, and noise.

Through source inspection, signal sources are preliminarily assessed to ensure they meet preset standards and provide normal colors and clear pictures. Source inspection paves the way for subsequent HDR Vivid production, transcoding, rendering, and display, thus ensuring optimal display effects.

2. HDR Vivid Livestream Production

(1) Preprocessing livestream sources

Based on the inspected color information (like luminance and contrast) and distortion information (like blur and noise), livestream sources are processed to enhance their quality. The sources are trained based on videos of the UEFA European Championship and the top five European football leagues, with different templates used for different scenarios, such as studios, strong contrast between light and shade, and insufficient sunlight, in order to create a better and more immersive experience.

(2) Live HDR content transcoding for automated HDR Vivid production

For input videos in HLG format, accounting for the fact that human eyes vary in their sensitivity to luminance, the 3D lookup table (LUT) for HLG-to-PQ conversion is divided into multiple LUTs with different precisions and lengths. This enables efficient and visually lossless HLG-to-PQ conversion for dynamic metadata extraction. Optimized HLG-to-PQ conversion significantly improves both the efficiency and effects of HDR Vivid production, in turn significantly benefiting the large number of existing HLG videos.

(3) Live SDR content transcoding for automated HDR Vivid production

Migu's SDR-to-HDR 3D LUT algorithm is used to upconvert SDR content into HDR content, with dynamic metadata being automatically generated and HDR Vivid video being the final output. This method can be used to upgrade the large amount of existing SDR content to HDR Vivid content, thus expanding the HDR Vivid video catalog and improving viewing experience.

(4) Efficient generation of HDR Vivid metadata

Migu HDR Vivid performs temporal filtering on dynamic metadata involved in the same scenario to reduce flicker caused by overall luminance jumps. Migu uses the scene luminance statistics feature, and references the texture and contours to more accurately and quickly determine scene switches and improve temporal filtering performance.

In terms of bright- and dark-area protection, Migu's HDR Vivid metadata generation technology expands the luminance range of bright areas based on the characteristics of human-eye perception while avoiding random noises in bright areas. When dealing with dark areas, the technology adjusts the slope of the primary spline curve based on the richness of details in order to generate a content-adaptive primary spline curve, thereby protecting the rich details found within dark areas.

Migu's HDR Vivid metadata generation technology significantly improves the bright-dark contrast of HDR Vivid videos by optimizing scene switching and bright and dark areas. This creates a better sense of depth and prevents flickers.

3. Playback and Rendering on HDR Vivid Devices

Playback of Migu HDR Vivid video requires decoding, metadata parsing, and software-based post-processing. Furthermore, key device parameters must be identified so that the most effective playback solutions can be created for various mobile devices across different platforms. The decoding and display process is as follows:

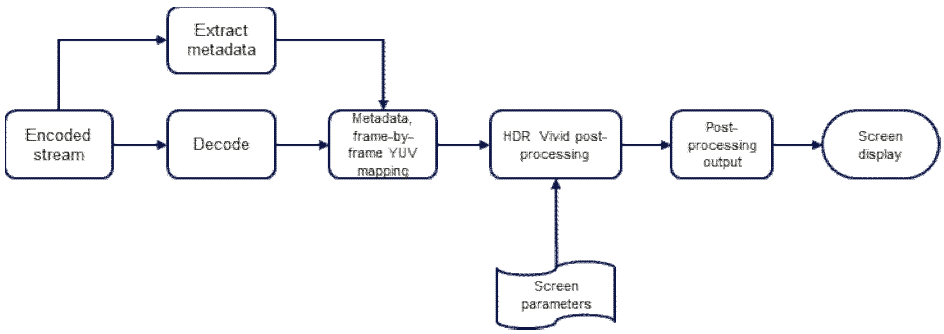


Figure 75 HDR Vivid Decoding and Display Process

Playback experience optimization technology dynamically schedules the HDR Vivid post-processing and rendering module based on the identified color gamut and luminance of displays. This creates an experience that offers the highest-possible color fidelity for different devices. Devices must adopt the in-depth hybrid rendering optimization architecture, in which GPU, screen, and decoder parameters determine device rendering strategies (such as P3 and SRGB). CPUs extract the HDR Vivid dynamic metadata and optimize decoder compatibility; video decoder hardware is used for decoding; and GPUs handle HDR Vivid rendering information. During rendering, the cubic spline curve is fine-tuned, pixel by pixel, based on the related parameters in strict accordance with the HDR Vivid standards. This brings high-fidelity HDR Vivid display effects to a wider range of devices.

Appendix 9: Certification Methods for HDR Vivid Devices

The HDR Vivid standard is designed to be advanced, open, shared, and secure, and boost the development of the UHD audio and video industries. Certification is key to the development of the industry ecosystem. The certification system for HDR Vivid is authoritative, standardized, scientific, and open. In addition, the system strictly standardizes the display effects of regular and portable display devices, and provides the highest-quality, UHD technical support for certified companies. This will drive the device industry towards higher-standard display technologies.

(1) Why certification is important

- The UWA is a symbol of advanced audio and video technology, meaning all UWA-certified products are equipped with high-quality audio and video technology.
- The certification process is fast and simple.

(2) What to expect after being certified

- The right to use the certificate and certification mark (HDR Vivid)
- Inclusion in the UWA's public certification directory
- Prioritized participation in joint marketing activities organized by the UWA for certified companies
- Long-term and effective high-quality HDR Vivid technical support
- Participation in professional technical training for technicians and engineers organized by the UWA

(3) Certification method

The certification method for display devices or systems that support HDR Vivid is type test[1] and post-certification supervision. The basic certification process is shown in the flow chart below, with the blue blocks representing the basic certification nodes specified in the *HDR Vivid Certification Rules*. For further details about the certification method, refer to the *HDR Vivid Certification Rules*.

[1] Type test: A test method that verifies that a product meets all the technical specifications

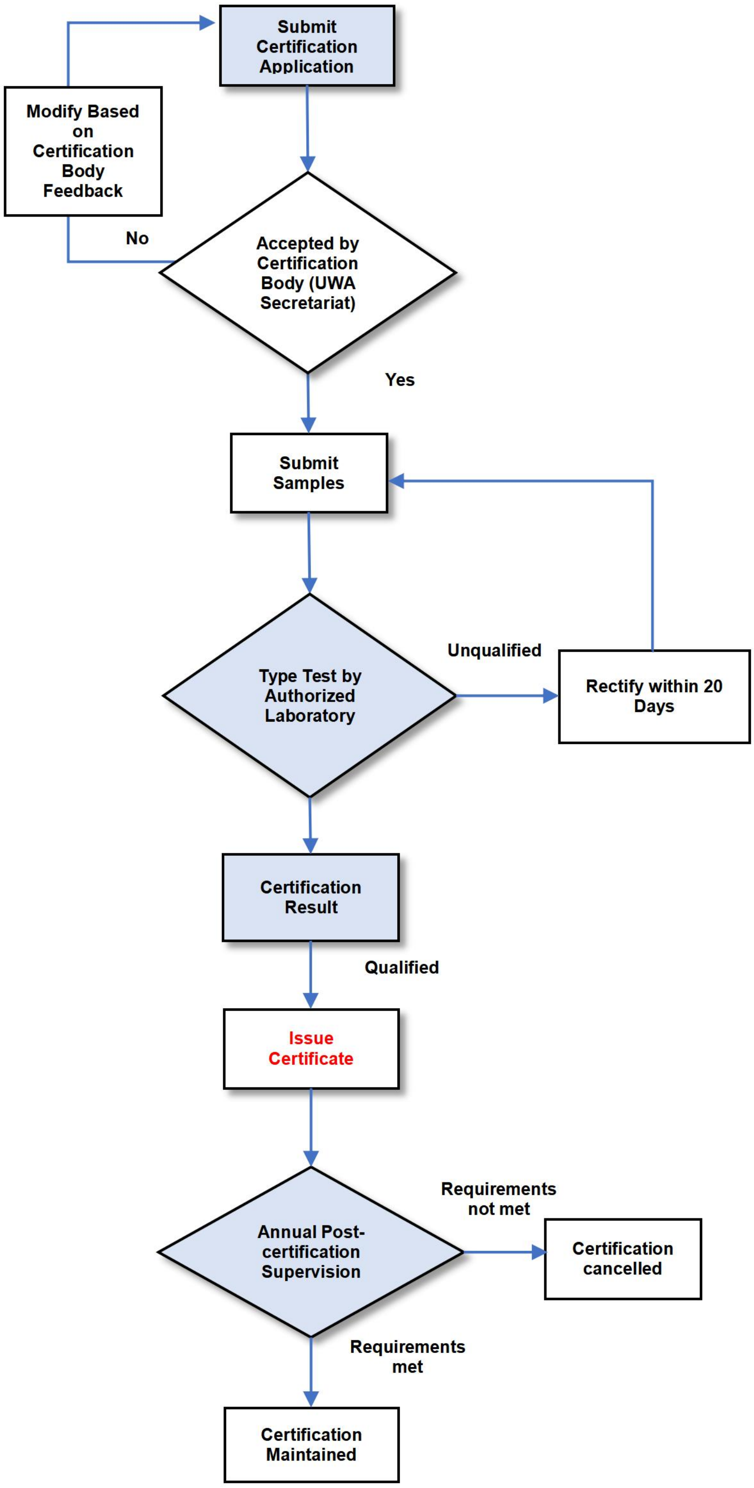


Figure 76 Certification Process

The certification process is subject to updates in accordance with the UWA regulations. For further details, refer to the UWA website.

UHD World Association
世界超高清视频产业联盟

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UWA联盟邮箱： support@theuwa.com
UWA联盟官网： www.theuwa.com