# MV-HEVC:
# HOW TO OPTIMIZE COMPRESSION OF IMMERSIVE 3D CONTENT

MHV 2024

Thomas Guionnet,
Khaled Jerbi,
**Thomas Burnichon,**
Mickael Raulet,
Ateme

ATEME
Captivate your audience

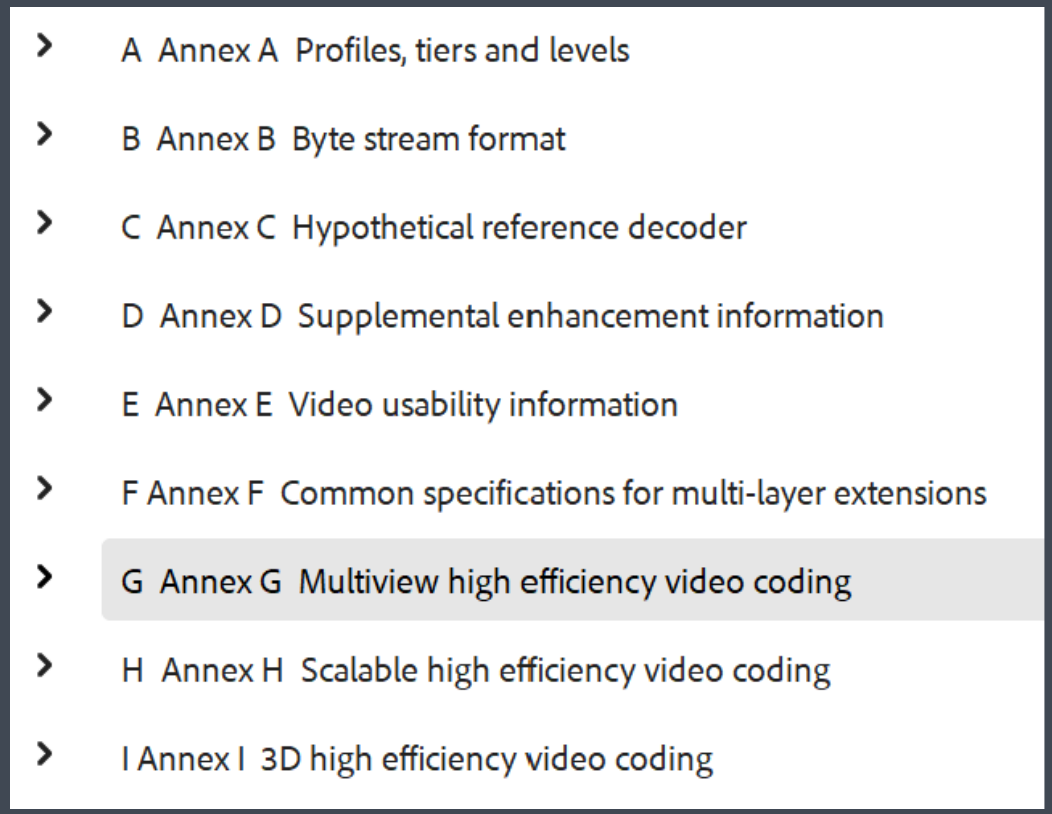
# A NEW ECOSYSTEM FOR 3D ENTERTAINMENT

- Apple announced support for 3D movies on the Apple Vision Pro at WWDC23 with Bob Iger, Disney's CEO
- Underlying codec is MV-HEVC
- Apple specs available for encoding, packaging, streaming and captioning
- ~**200** 3D titles available at launch on Feb 2nd, 2024 on Apple TV and Disney+

Apple Keynote, WWDC23

# WAIT, WHAT EVEN IS MV-HEVC?

- Extension of HEVC, standardized back in 2014!
- MV stands for **M**ulti**v**iew
- Released alongside SHVC
- Different from 3D-HEVC



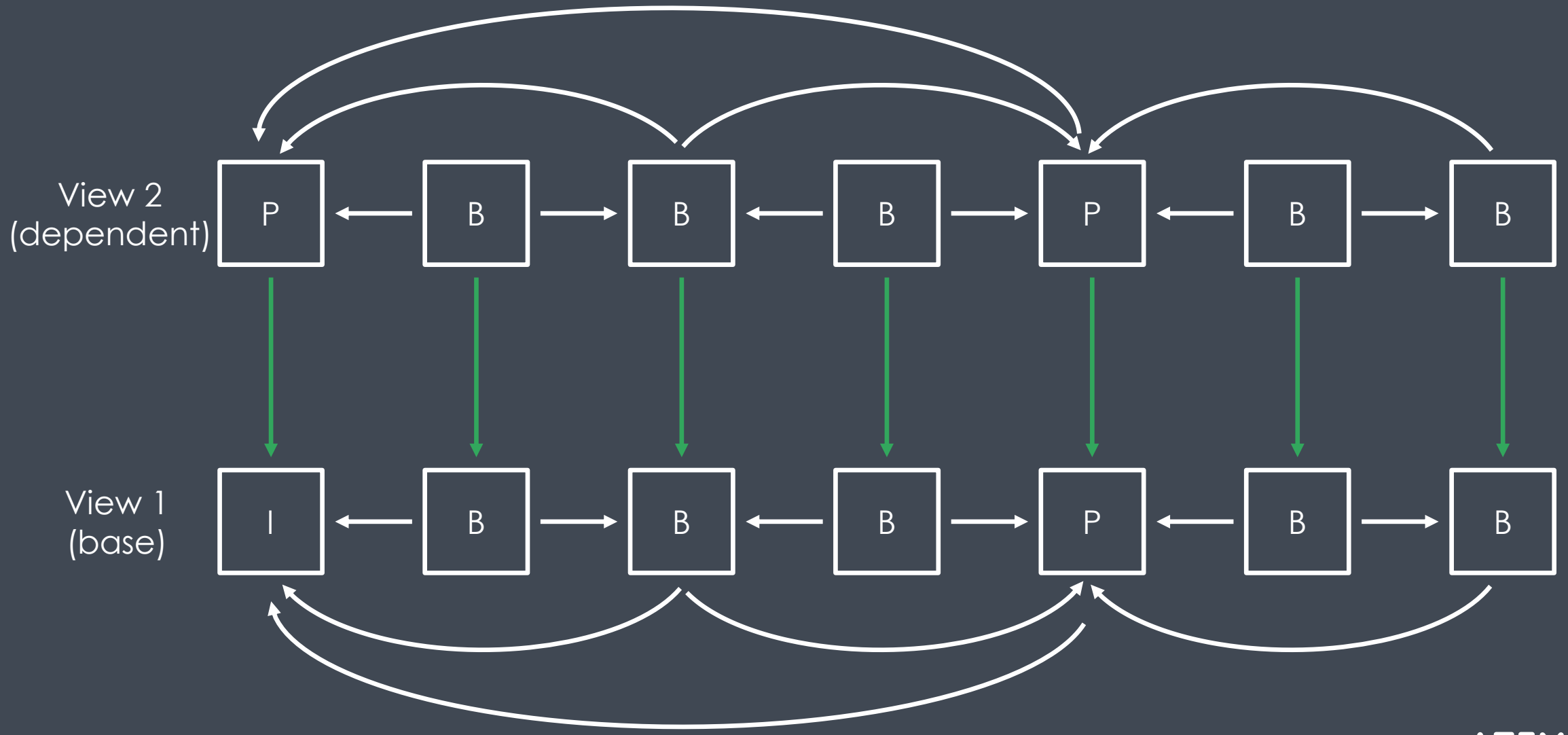

HEVC standard annexes, as of 2023



ATEME

# HOW DOES MV-HEVC WORK?

## Inter-layer prediction



# SOME MULTILAYER DETAILS

- Reference list management
  - Add the base layer decoded frame in list 0
- Backward Compatibility

> *"[...] decoders conforming to a profile specified in Annex A and not supporting the independent non-base layer decoding (INBLD) capability specified in Annex F shall ignore (i.e., remove from the bitstream and discard) all NAL units with values of* ***nuh_layer_id not equal to 0****."*

- 3D Reference Displays Information SEI message
  - Left and right eyes identification
  - Relationship between display width and viewing distance
- inter_view_mv_vert_constraint_flag
  - Limit vertical excursion of disparity vectors

# APPLE INTEROPERABILITY PROFILE

- Recommends using left view as base view with index 0
- Requires use of 3D Reference Displays Information SEI
- Includes Main 10 (!)

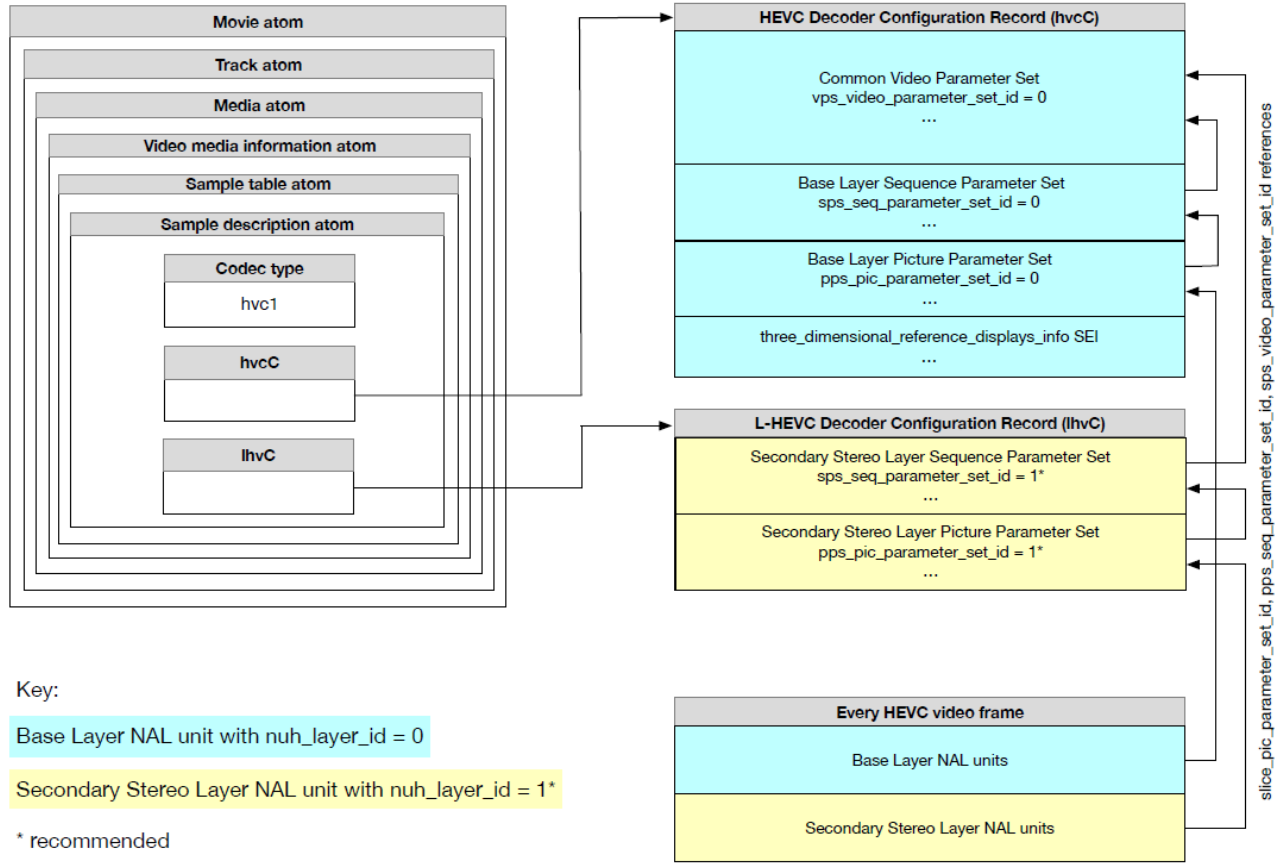



Figure 1. HEVC and L-HEVC Decoder Configuration Records, Parameter Sets and Video Frames

Apple HEVC Stereo Video Interoperability Profile, as of June 2023

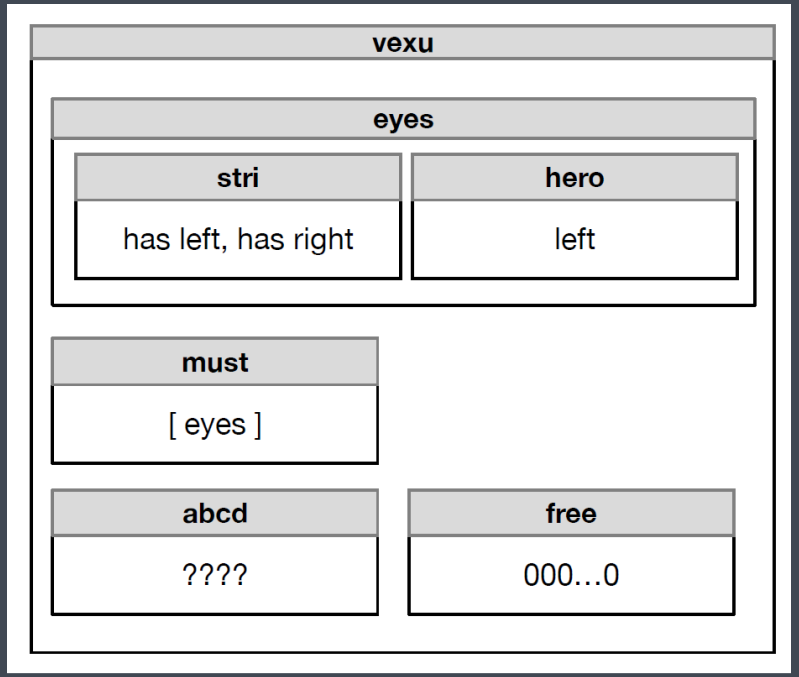


ATEME

# TRANSPORT AND STREAMING

- New ‘vexu’ box for ISOBMFF identification

- HLS v12 draft 14 introduced REQ-VIDEO-LAYOUT, require by the Apple Authoring Specification




ISO Base Media File Format and Apple HEVC Stereo Video, as of June 2023

```
#EXTM3U
#-- Copyright © 2023 Apple Inc. All rights reserved.
#EXT-X-VERSION:12
#EXT-X-INDEPENDENT-SEGMENTS
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="atmos-48-448",NAME="English",LANGUAGE="en-US",AUTOSELECT=YES,DEFAULT=YES,CHANNELS="16/JOC",URI="ec3-atmos-48khz-448kbps-en_audio/prog_index.m3u8"
#EXT-X-MEDIA:TYPE=AUDIO,GROUP-ID="ac3-48-384",NAME="English",LANGUAGE="en-US",AUTOSELECT=YES,DEFAULT=YES,CHANNELS="6",URI="ac3-5.1-48khz-384kbps-en_audio/prog_index.m3u8"
#EXT-X-STREAM-INF:AVERAGE-BANDWIDTH=726521,BANDWIDTH=910558,VIDEO-RANGE=PQ,CODECS="dvh1.20.01,ac-3",RESOLUTION=640x360,FRAME-RATE=24.000,CLOSED-CAPTIONS=NONE,AUDIO="ac3-48-384",REQ-VIDEO-LAYOUT="CH-STEREO"
DoVi_P20_00270_t360p/prog_index.m3u8
```

Apple Streaming Examples, as of 2023



ATEME

# HDR: DOLBY VISION PROFILE 20

- Dolby introduced a new Dolby Vision Profile for Stereoscopic Video: the Profile 20

- 10-bits processing required (!)
- Non backward compatible
- Full range (same as Profile 5)
- Explicit IPT-PQ-c2 signaling
- Top Left Chroma Location instead of Center Left

*Table 1: Dolby Vision bitstream profiles*

| Dolby Vision bitstream profile ID | Representative Dolby Vision bitstream profile string | BL/EL codec | BL:EL | BL signal cross-compatibility ID (CCID for Pro Tools and content creation) | Metadata carriage mechanism | Metadata compression supported |
|---|---|---|---|---|---|---|
| 20 | dvh1.20 | 10-bit MV-HEVC (for 3D) or HEVC (for 2D) | N/A | 0 | Unspecified NALu | None |

*Table 2: Cross-compatibility ID to VUI mapping*

| BL signal cross-compatibility ID | Cross-compatibility ID label | Type of cross-compatibility | VUI |
|---|---|---|---|
| 0 | Dolby Vision proprietary 10-bit | None | • For base layer of profile 5, if taking option to include VUI: 1,2,2,2,0[a]<br>• Optional VUI for base layer of profile 5: 1,9,16[b],15,0<br>• For base layer of profile 20: 1, 9, 16[b], 15[c], 2[a] |

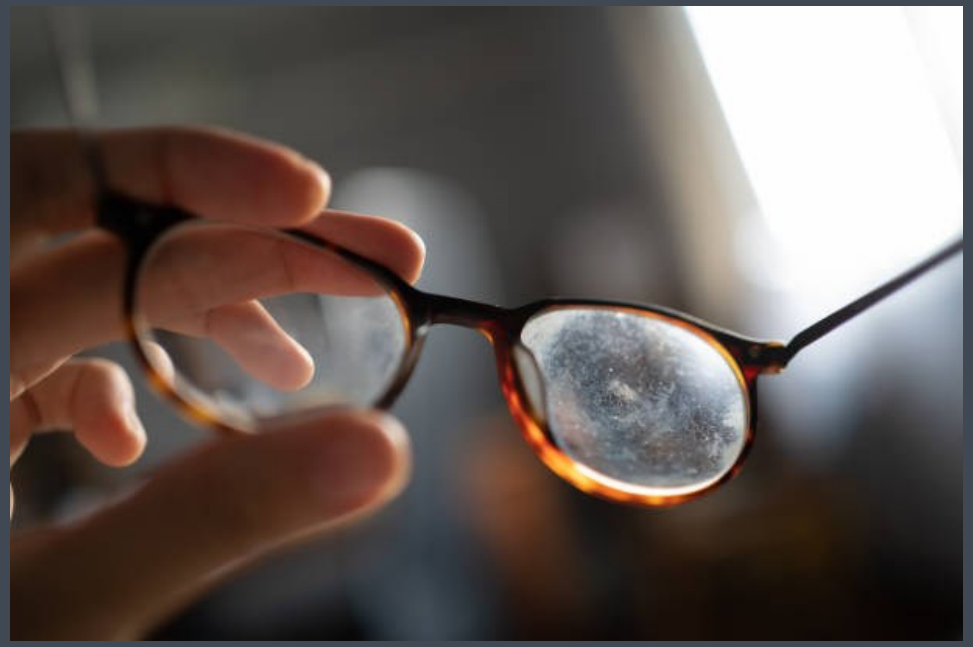
Dolby Vision Profiles, as of 2023



ATEME

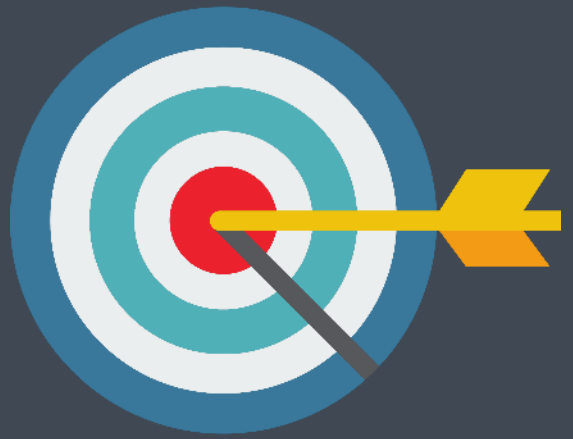
# MV-HEVC RATE CONTROL CONSIDERATIONS

- Consistent video quality between eyes needed for user comfort
- Constant bitrate allocation is not enough, as no fix ratio between eyes can be used because of content dependencies
- Require an accurate quality model!



# MV-HEVC PERFORMANCE IN PRACTICE

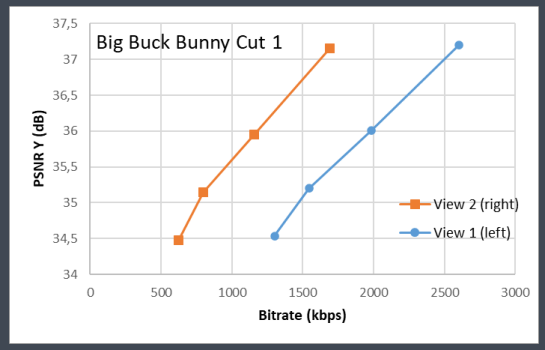
- Perf calculated on the second eye
- Five examples reported here from Big Buck Bunny 3D clips in 1080p30
- Up to over **50%** Bjøntegaard Delta Rate savings
- Ranging from -23% to -51%
- Highest gain on difficult motion, precisely when it's most needed!
- Apple guidelines are at 30% savings in average

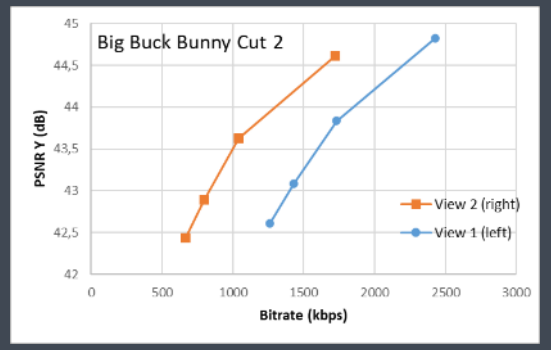


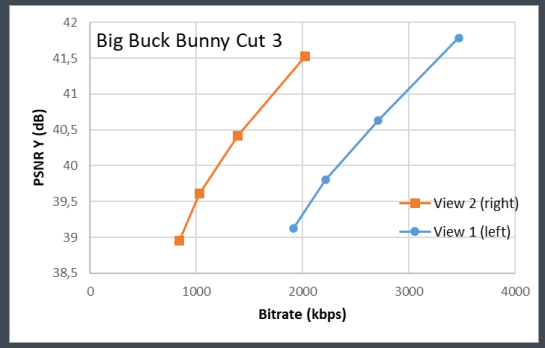
# OBJECTIVE TEST

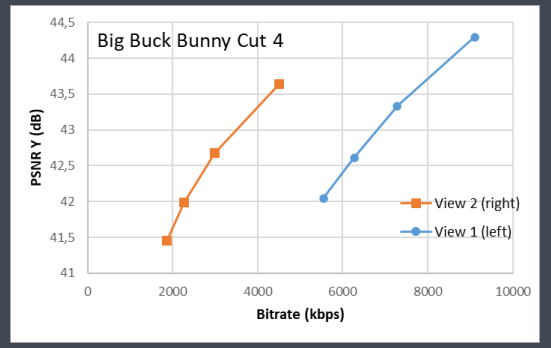
## Big Buck Bunny

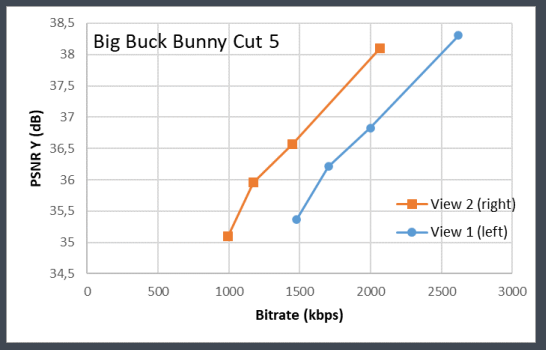
- Comparing the second view to the first view
  - Without MV-HEVC, both views have the same performance
- 23 to 51% Bitrate gain
  - Corresponding to 12~25 % on the total bitstream



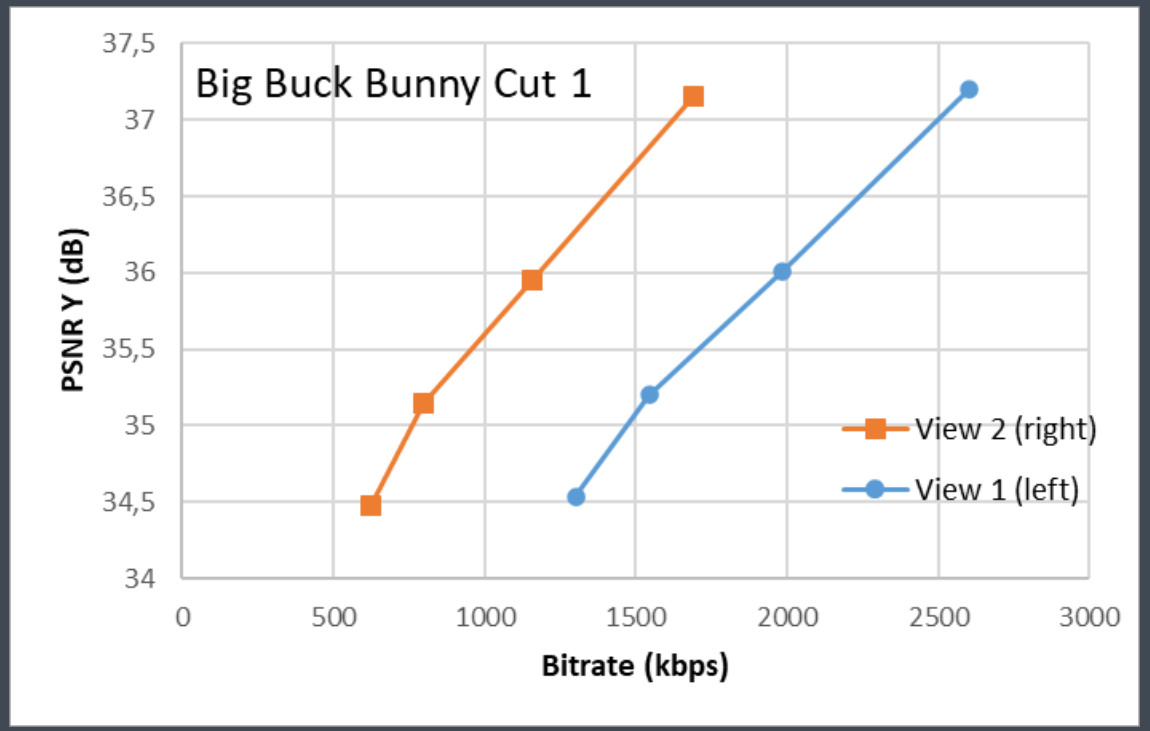



# EXAMPLE CUT 1

## -42% BD-DR

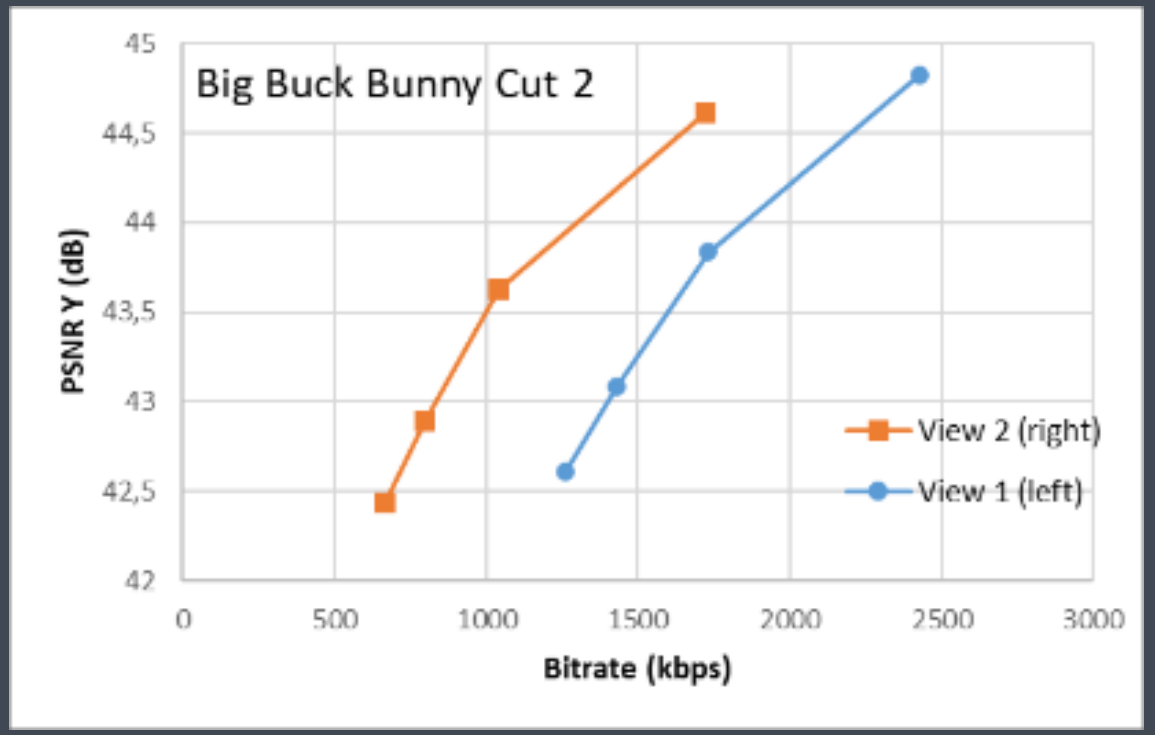





ATEME

# EXAMPLE CUT 2

## -35% BD-DR

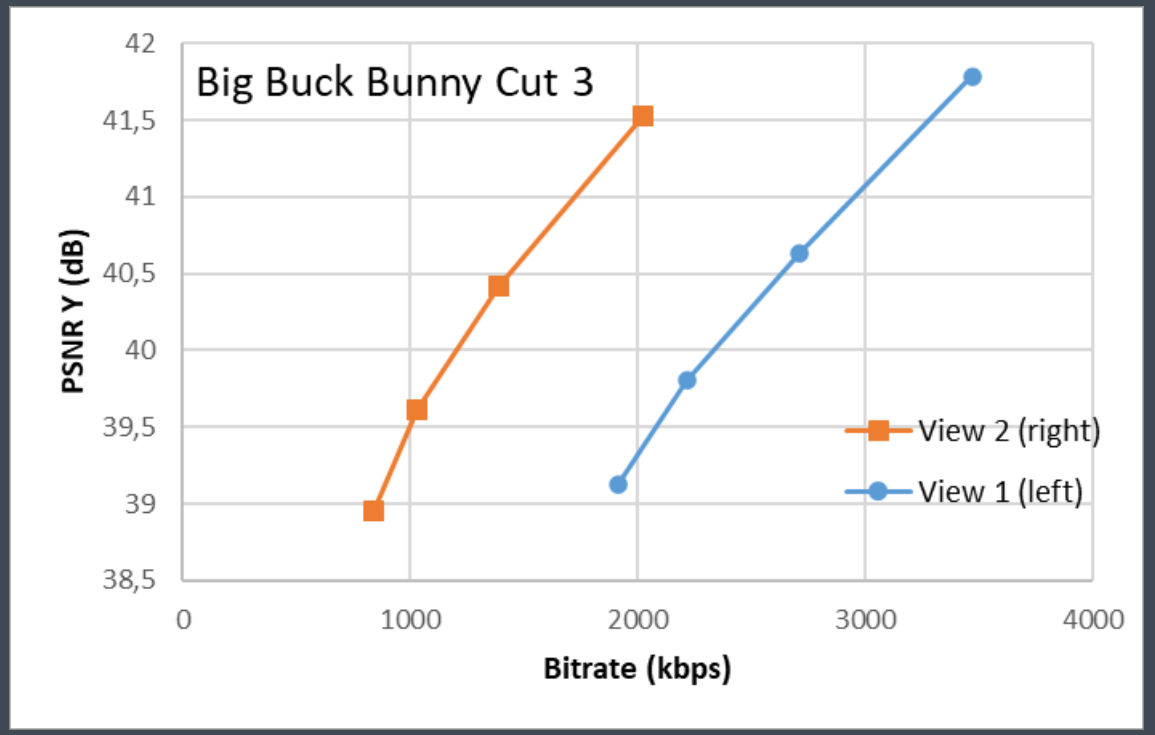





ATEME

# EXAMPLE CUT 3

## -47% BD-DR

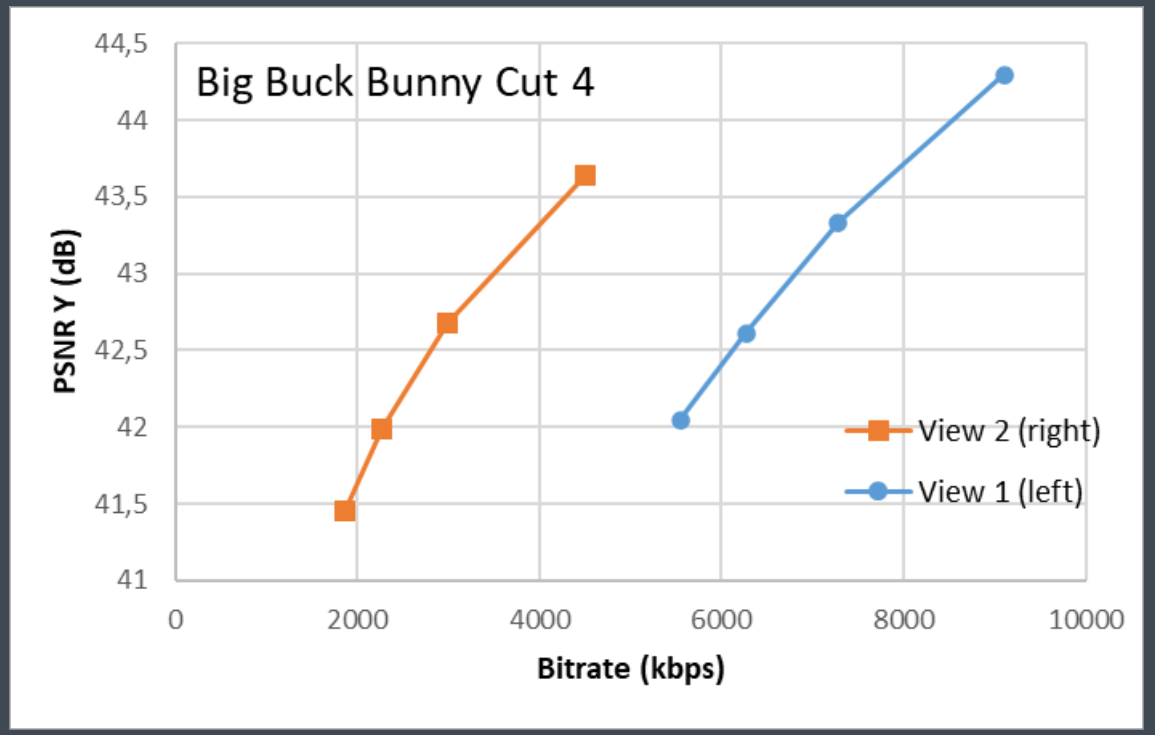





ATEME

# EXAMPLE CUT 4

## -52% BD-DR

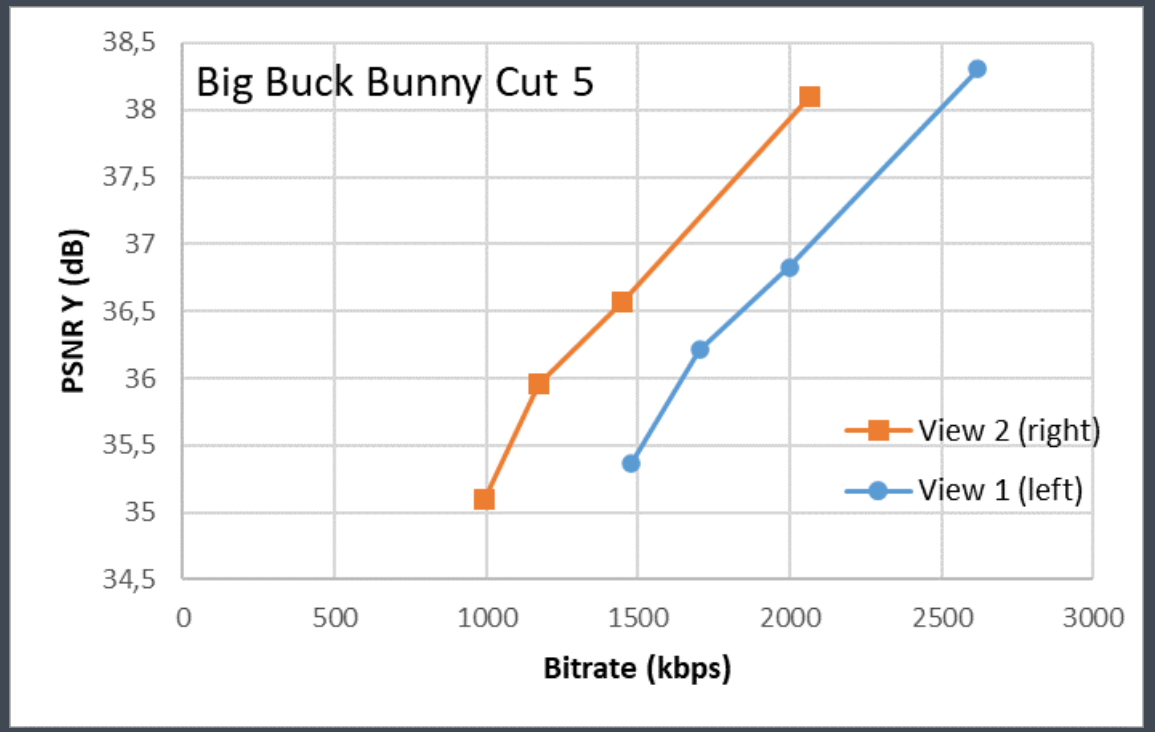





ATEME

# EXAMPLE CUT 5

## -23% BD-DR






ATEME

# WHAT'S NEXT?

- Continuous improvement on compression efficiency and perceptual quality
- Further collaboration with Dolby on Dolby Vision Profile 20
- Subtitles placement, immersive audio
- MV-HEVC Live!

ATEME

Captivate your audience

# THANK YOU.