

**JCTVC-W0084:**

**HDR CE2: CE2.a-2, CE2.c, CE2.d, CE2.e-3**

**JCTVC-W0085:**

**HDR CE2 related: Further Improvement  
of W0084**



**INTERDIGITAL.**



# Overview

- Introduction
- Algorithm Description
- Results
- Related Contributions
- Conclusion

# Introduction

- HDR CE2: Core Experiment on 4:2:0 YCbCr NCL fixed point for HDR Video Coding
  - Aiming at improvements over the reference code base ETM
  - Software base: ETM\_RC\_r1 (software release on 1/21/16, results on 1/27/16)

## CE2 Time Line (w15795)

10/30/2015	Integration plan to be finalized and distributed over reflector
11/27/2015	Reference code base to be finalized and distributed among CE2 participants
11/27/2015	Refine test plan and tests description and distributed over reflector
01/12/2016	Description of the encoder
01/12/2016	Results for reference code base to be presented
02/01/2016	Software solutions for CE2 tests to be provided to CE2 participants
02/04/2016	CE2 test simulation results to be provided to CE2 participants
02/09/2016	CE2 test results and text description of the experiment to be reported
02/19/2016	CE2 test cross-check results to be reported

**W0084 : delivery of software, results, experiment report and crosscheck report fully complies CE2 timeline.**

# Introduction

- W0084: HDR CE2: CE2.a-2, CE2.c, CE2.d, CE2.e-3
  - **Joint optimization** of luma reshaper and encoder
  - **No changes** on chroma reshaper in ETM
  - **No changes** on ETM reshaper syntax
  - **Single test setting to provide one expected output**
- W0085: Further improvement of W0084
  - CE2.d improvement (luma deltaQP)
  - Delivered as non-CE due to timeline constraint

Planned sub-test
CE2.a-1 luma ATF with LCS (m37245)
CE2.a-2 reshaping (m37267)
CE2.a-3 adaptive transfer function (m37091)
CE2.b-1 Cross-channel modulation (m37088 and m37285)
CE2.b-2 SDR backward compatibility study (m37092)
CE2.c Chroma QP offset (m37179)
CE2.d DeltaQP adjustment for Luma
CE2.e-1 Enhancement of ETM
CE2.e-2 harmonization of luma and chroma reshaping (m37332)
CE2.e-3 automatic selection of ETM parameters

# W0084: Combined Improvement of Luma Reshaper and Encoder

- Improvement on Luma Reshaper
  - ***CE2.a-2: Luma reshaper improvement***
    - Reshaper update mechanism
    - Forward Luma reshaping model
  - ***CE2.e-3: automatic selection of ETM parameters for Luma reshaping***
    - Already integrated in ETM\_RC\_r1 release
- Joint Optimization of Reshaper and Encoder
  - ***CE2.c: Chroma quantization parameter adjustment***
  - ***CE 2.d: DeltaQP adjustment for Luma***
  - ***Deblocking filter parameter selection***

# Luma Reshaper Improvement: Reshaper Update Mechanism

- W0084: Fully automatic, one-pass, non look-ahead algorithm

	ETM_RC_r0(Dec.11 2015)	ETM_RC_r1(Jan.21 2016)	W0084 (Feb.1, 2016)
When to derive new metadata	POC info read from external cfg file	1 <sup>st</sup> frame, range change, every second (intra period)	1 <sup>st</sup> frame, range change, content characteristic change in every second (intra period)
When to update new metadata	update when a new metadata is derived	update when a new metadata is derived	update when a new metadata is derived and is not identical to the previous one

# Luma Reshaper Improvement: Reshaper Update Mechanism

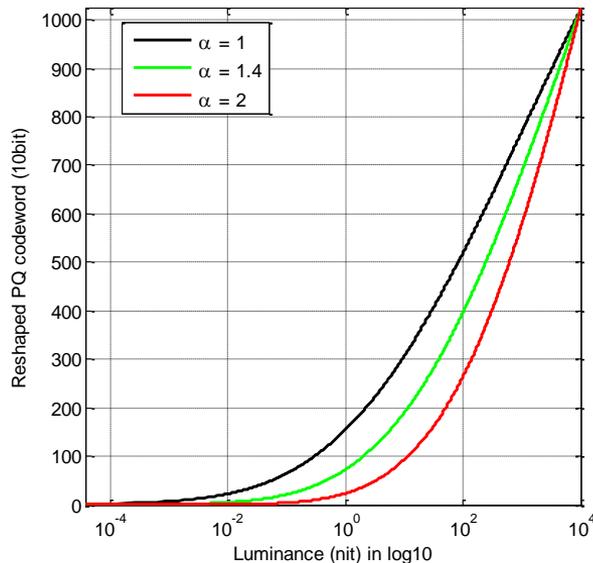
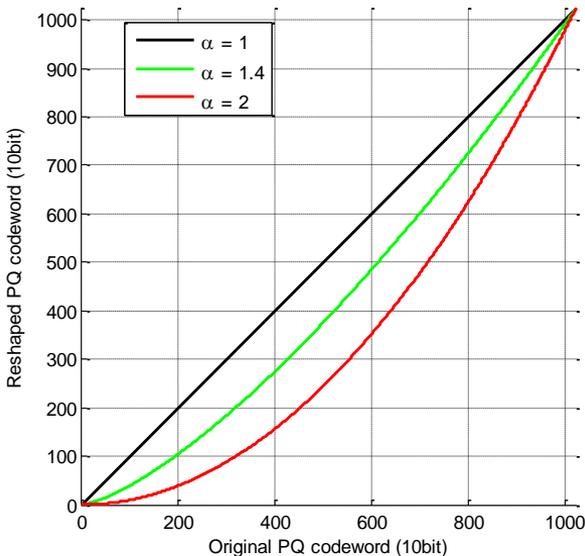
		Number Luma Reshaper Updates*			Reshaper bitrate (kbps)		Percentage of W0084 Reshaper bitrate over R4
		ETM_r0	ETM_r1	CE2_DI	ETM_r1	W0084	
class A	FireEaterClip4000r1	1	9	1	0.32	0.322	0.06%
	Market3Clip4000r2	1	9	1	0.645	0.369	0.03%
	SunRise	1	9	1	0.639	0.371	0.12%
class B	BikeSparklers cut 1	1	5	1	0.302	0.326	0.03%
	BikeSparklers cut 2	1	6	1	0.314	0.376	0.03%
	GarageExit	2	12	2	0.581	0.32	0.07%
class C	ShowGirl2Teaser	43	31	12	0.739	0.424	0.07%
class D	StEM_MagicHour cut 1	1	4	1	0.304	0.333	0.08%
	StEM_MagicHour cut 2	1	9	1	0.313	0.283	0.03%
	StEM_MagicHour cut 3	1	5	1	0.339	0.325	0.05%
	StEM_WarmNight cut 1	1	9	1	0.3	0.308	0.06%
	StEM_WarmNight cut 2	1	7	1	0.588	0.304	0.08%
class G	BalloonFestival	1	10	1	0.577	0.33	0.03%
class H	EBU_04_Hurdles	1	11	1	0.65	0.334	0.03%
	EBU_06_Start	1	11	1	0.642	0.363	0.07%
<b>Average</b>					<b>0.484</b>	<b>0.339</b>	<b>0.06%</b>

Overall sequence bitrate (kbps)			
R1	R2	R3	R4
2010	1229	807	524
7884	2695	1725	1268
1803	1026	557	319
5346	4057	2091	1194
5015	3845	2021	1157
2367	1402	747	460
3444	1681	1004	602
2062	1173	631	393
5515	3246	1679	1003
3641	2129	1111	683
3199	1524	884	520
1827	928	577	364
3820	2266	1569	1237
6540	3671	1858	1147
2675	1623	835	522

\* Updates in HDRTools Luma metadata output

# Luma Reshaper Improvement: Forward Luma Reshaping Model

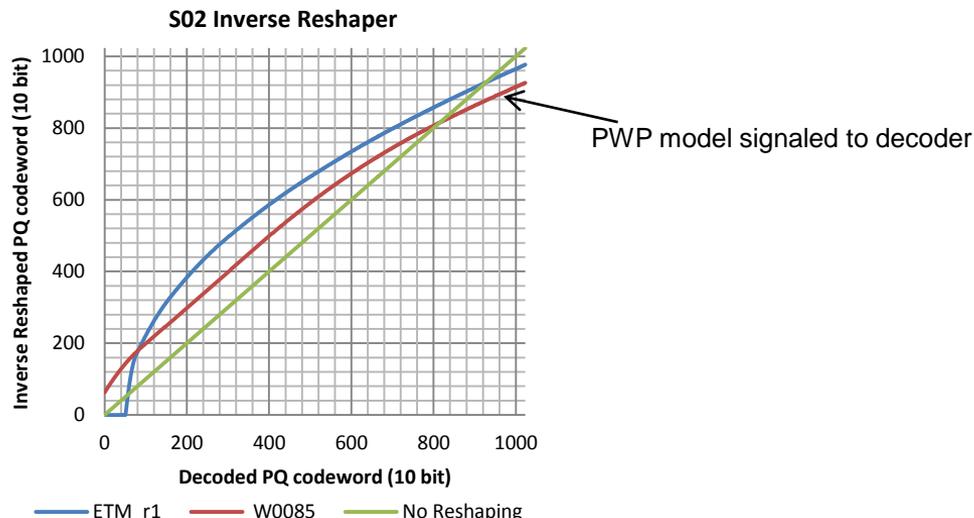
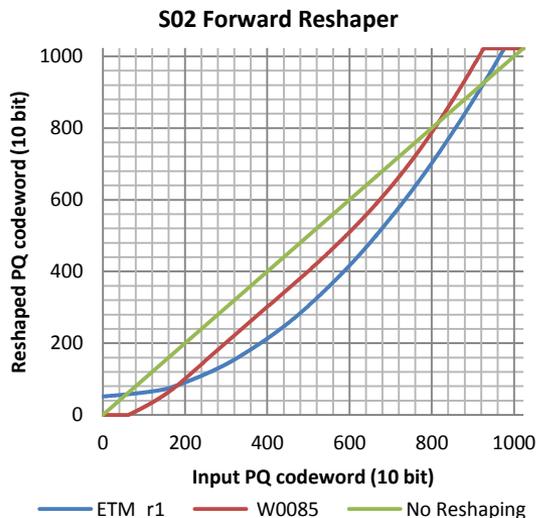
- Luma forward reshaping model in ETM:  $y = a * (x + b)^\alpha + c$ 
  - Codewords can be shifted between dark area and bright area by changing  $\alpha$ .
  - The reshaping curve (mapping between input codewords and output codewords) always has to be a power function.
    - One drawback: power function adjusts codewords globally in a relatively coarse manner.



alpha	#codeword (0.1-1nit)	#codeword (1-10nit)	#codeword (1000-4000nit)
1	90	213	153
1.4	51	207	199
2	19	172	253

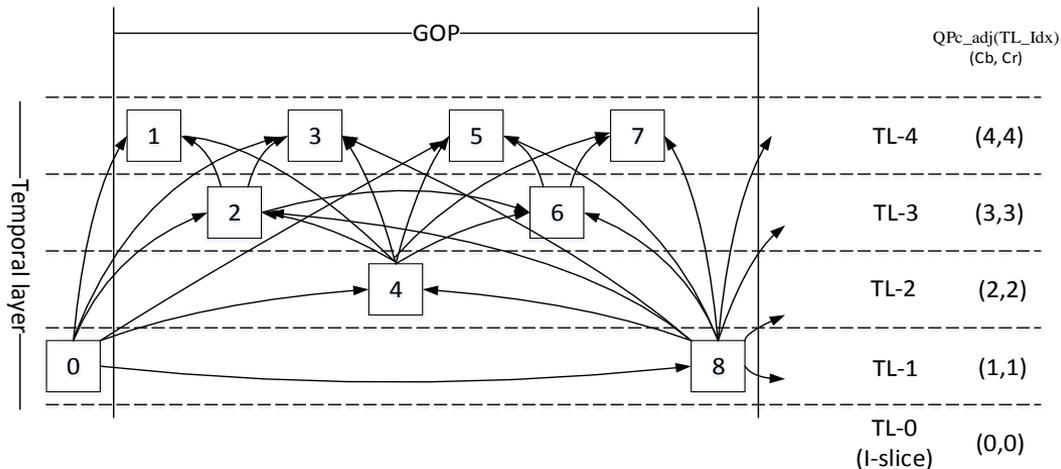
# Luma Reshaper Improvement: Forward Luma Reshaping Model

- Motivation: ETM specification on luma reshaping (**up to 8 piece 2<sup>nd</sup> order piecewise polynomials**) can support more complex curve than a power function
- Idea: To construct a reshaping curve from codeword assignment point of view: resulting in a more flexible reshaping curve that can better fit content characteristics



# Joint Optimization of Reshaper and Encoder: Chroma Quantization Parameter Adjustment

- Idea: Improve CE1 chroma QP offset adjust algorithm by taking reshaping into consideration; and additional improvement on hierarchical adjustment
    - Chroma QP adjustment in HDR/WCG anchor:  $QPc\_offset = S2*(S1*QP + O)$
    - W0084/W0085:  $QPc\_offset = S2*(S1*QP + O) + QPc\_adj(TL\_Idx) - dQPc\_reshape$
- where:
- $dQPc\_reshape = Clip(-12, 6, 6*log2(slope(inv\_reshape(DCc))))$



# Joint Optimization of Reshaper and Encoder: DeltaQP Adjustment for Luma

- Idea: Improve CE1 Luma DeltaQP adjust algorithm by taking reshaping into consideration;

Anchor v3.2 (W0054)		W0084*		W0085
dQP	change points	dQP	change points*	Adaptive
-3	0	-3	0	
-2	301	-2	153	
-1	367	-1	307	
0	434	3	520	
1	501	2	616	
2	567	3	692	
3	634	2	737	
4	701	3	769	
5	767	2	846	
6	834	3	923	

\* W0084 change points are equivalent inverse reshaped average luma value in LCU; actual mapping table is adaptively changed based on different luma reshaper applied.

# Joint Optimization of Reshaper and Encoder: Deblocking Filter Parameter Selection

- Idea: Adaptively adjust two HEVC deblocking filter parameters,  $\beta$  and  $tc$ , to optimize picture quality:
  - Small QP -> High picture quality -> Weaker deblocking
  - Large QP -> Low picture quality -> Stronger deblocking
- The encoder select  $\beta$  and  $tc$  to minimize the distortion between deblocked picture and original picture. Denote  $BO$  and  $TO$  as  $\beta$  and  $tc$ , respectively.
  - $(\mathbf{BO}, \mathbf{TO})_{\text{opt}} = \mathit{arg}_{(BO, TO)} \mathit{minDistortion}(DB(\mathit{rec}, \mathbf{BO}, \mathbf{TO}), \mathit{org}_{YCbCr})$
- Also supported:
  - Early termination for parameter search
  - Hierarchical coding structure consideration to avoid temporal flicking

# Results

- Subjective evaluation on Pulsar and Sim2
  - W0084/W0085 texture improvement over anchor v3.2 is observed on many test clips.
    - Most visible on R3 and R4 rate points.
    - Onsite viewing demos to be arranged.
- Objective metrics
  - Current Luminance related metrics for study (tPSNR-Y, L100PSNR) have no strong correlation to the texture fidelity observed in subjective viewing.
  - Our experiment is not aiming at improving any of the metrics.

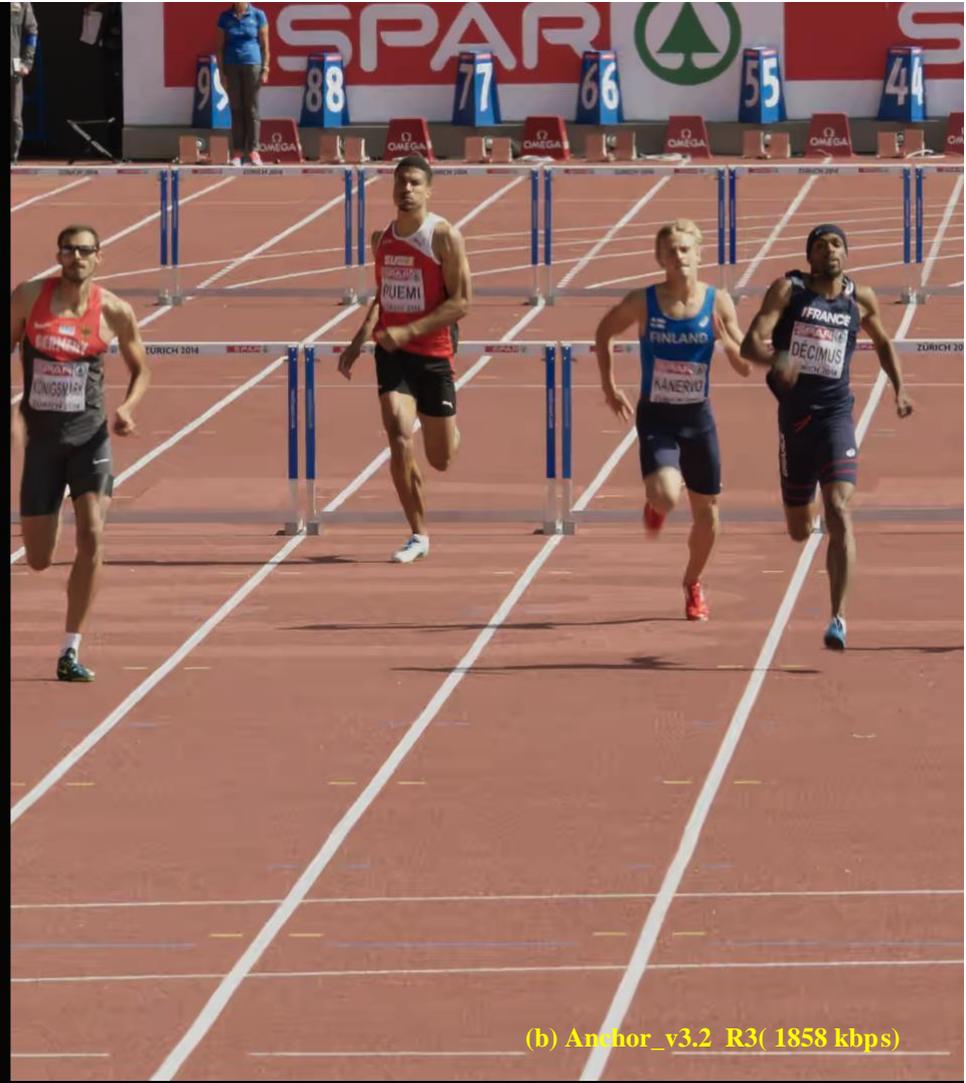
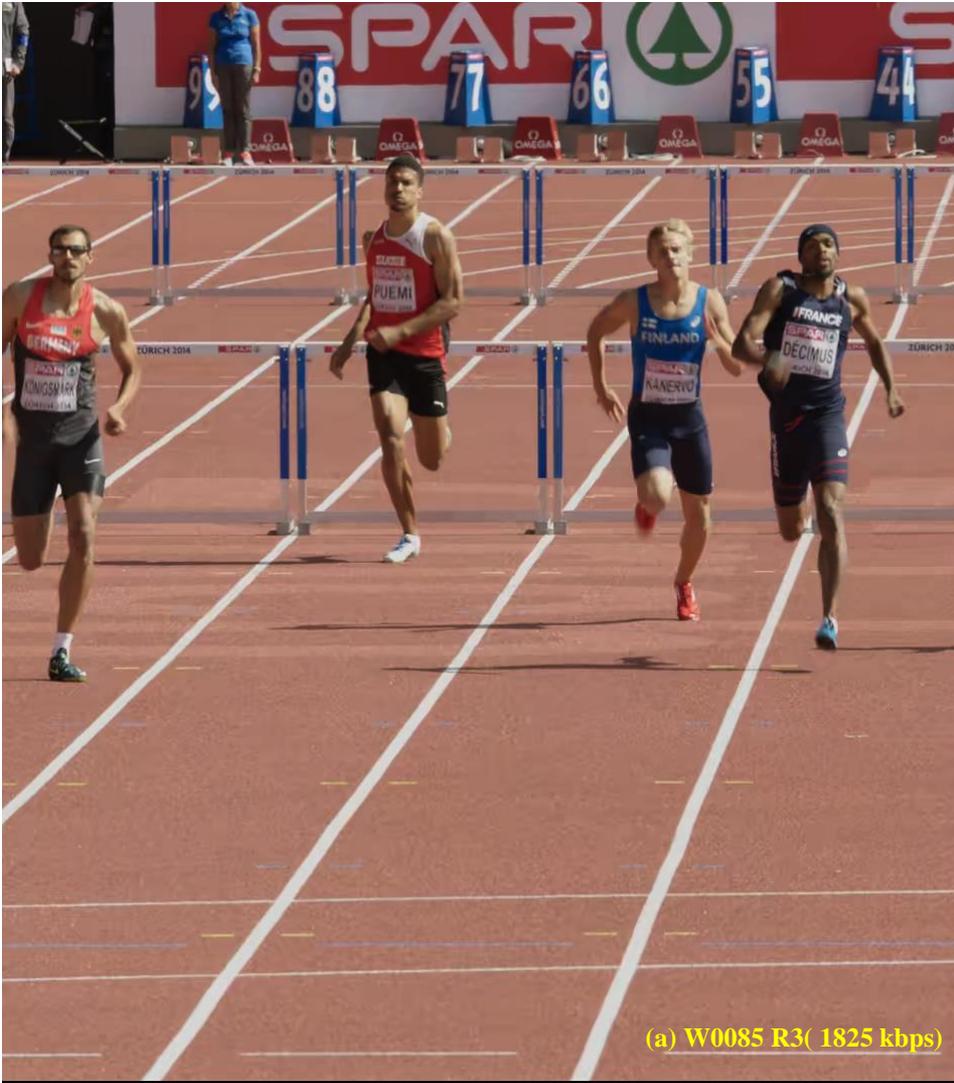


(a) W0085 R4( 1233 kbps)



(b) Anchor\_v3.2 R4( 1237 kbps)





(a) W0085 R3( 2077 kbps)



(b) Anchor\_v3.2 R3( 2091 kbps)



# EBU04 Rate 3

Source



Anchor v3.2



W0084



W0085



# BalloonFestival Rate 4

Source

Anchor v3.2

W0084

W0085



# Market Rate 4

Source

Anchor v3.2

W0084

W0085



# Sunrise Rate 3

Source

Anchor v3.2

W0084

W0085



# WarmNight Rate3

Source

Anchor v3.2

W0084

W0085



# Objective Metrics: W0084 vs. Anchor v3.2

		X	Y	Z	XYZ	tOSNR-XYZ	DE100	MD100	PSNRL100
class A	FireEaterClip4000r1	1.9%	7.1%	-6.8%	1.0%	0.0%	-6.3%	-17.7%	3.4%
	Market3Clip4000r2	3.4%	3.6%	1.6%	2.8%	-1.0%	12.8%	-80.3%	-10.8%
	SunRise	4.7%	6.6%	3.1%	4.7%	4.9%	34.4%	-40.4%	0.4%
class B	BikeSparklers cut 1	-5.5%	-6.3%	-2.9%	-4.7%	-9.6%	-7.9%	-27.2%	-0.6%
	BikeSparklers cut 2	-3.1%	-3.7%	-1.4%	-2.6%	-7.4%	-2.9%	-45.3%	0.0%
	GarageExit	7.0%	6.4%	11.1%	8.3%	5.6%	11.7%	0.3%	3.3%
class C	ShowGirl2Teaser	10.7%	12.8%	11.9%	11.7%	16.1%	-4.9%	-2.8%	-0.3%
class D	StEM_MagicHour cut 1	-2.9%	0.0%	1.0%	-0.1%	-1.2%	-10.2%	0.6%	-0.9%
	StEM_MagicHour cut 2	-0.9%	0.8%	2.3%	1.2%	0.7%	-7.6%	-5.0%	0.2%
	StEM_MagicHour cut 3	-0.5%	1.1%	3.6%	2.1%	1.9%	-5.5%	23.2%	0.0%
	StEM_WarmNight cut 1	8.7%	10.5%	1.4%	6.3%	4.1%	-11.9%	1.3%	-4.2%
	StEM_WarmNight cut 2	2.1%	4.4%	-4.6%	-0.2%	2.9%	-12.8%	-29.3%	-2.0%
class G	BalloonFestival	14.9%	19.4%	9.1%	13.7%	9.2%	19.0%	-21.9%	-5.1%
class H	EBU_04_Hurdles	2.9%	-1.4%	1.4%	0.9%	-2.6%	28.5%	64.9%	-11.0%
	EBU_06_Start	13.6%	10.1%	6.9%	9.9%	6.2%	50.3%	-17.0%	-5.7%
	<b>Overall</b>	3.8%	4.8%	2.5%	3.7%	2.0%	5.8%	-13.1%	-2.2%

# Objective Metrics: W0085 vs. Anchor v3.2

		X	Y	Z	XYZ	tOSNR-XYZ	DE100	MD100	PSNRL100
class A	FireEaterClip4000r1	-3.8%	2.2%	-14.4%	-4.8%	-6.5%	-13.0%	-21.8%	3.6%
	Market3Clip4000r2	6.5%	6.7%	4.3%	5.7%	0.2%	11.5%	-79.5%	-11.2%
	SunRise	-2.2%	-1.3%	-5.8%	-3.4%	4.6%	55.9%	-58.5%	11.4%
class B	BikeSparklers cut 1	-5.5%	-6.3%	-2.9%	-4.7%	-9.6%	-7.9%	-27.2%	-0.6%
	BikeSparklers cut 2	-3.1%	-3.7%	-1.4%	-2.6%	-7.4%	-2.9%	-45.3%	0.0%
	GarageExit	9.2%	9.1%	11.4%	10.0%	5.6%	5.2%	-3.4%	3.7%
class C	ShowGirl2Teaser	13.9%	16.3%	13.4%	14.6%	18.4%	-3.8%	-20.4%	3.6%
class D	StEM_MagicHour cut 1	-3.3%	0.0%	-2.6%	-1.9%	-2.9%	-15.0%	-4.9%	0.8%
	StEM_MagicHour cut 2	-0.9%	1.3%	-0.3%	0.1%	-0.9%	-12.3%	-6.1%	1.9%
	StEM_MagicHour cut 3	-1.4%	0.9%	-0.4%	-0.2%	-1.2%	-10.7%	20.0%	1.9%
	StEM_WarmNight cut 1	23.0%	25.6%	5.5%	16.6%	11.5%	-18.7%	-1.2%	-2.0%
	StEM_WarmNight cut 2	6.5%	9.5%	-8.8%	0.5%	4.0%	-20.2%	-42.4%	0.8%
class G	BalloonFestival	18.8%	23.4%	13.3%	17.7%	11.0%	19.6%	-19.7%	-4.5%
class H	EBU_04_Hurdles	2.0%	-2.8%	0.6%	-0.1%	-4.2%	28.0%	64.6%	-13.3%
	EBU_06_Start	13.7%	9.9%	9.2%	10.8%	6.5%	57.3%	21.0%	-7.3%
	<b>Overall</b>	4.9%	6.0%	1.4%	3.9%	1.9%	4.9%	-15.0%	-0.7%

# Related Contributions in This Meeting

- We thank crosscheckers for the kind help.
  - Crosschecker for W0084
    - Technicolor: JCTVC-W0112
    - Qualcomm: JCTVC-W0128
    - Ericsson:
  - Crosschecker for W0085
    - ETRI: JCTVC-W0120
    - Intel: JCTVC-W0130

# Related Contributions in This Meeting

- JCTVC-W0032: Encoder optimization for HDR/WCG coding (InterDigital)
  - Chroma QP offset, deblocking filter adjustment
- JCTVC-W0038: HEVC encoder optimization (InterDigital)
  - Chroma QP offset, deblocking filter adjustment
- JCTVC-W0097:HDR CE2: CE2.c-Chroma QP offset study report (QCOM)
  - Test2: A combination of W0084 luma reshaper + W0097 chroma reshaper + W0084 encoder optimization

# Conclusions

- Additional HDR compression efficiency over the Anchor could be expected with joint optimization of Luma reshaping and encoding.
  - Encoder Optimization technologies used in Anchor can be applied on reshaped signal with proper adjustment.
- Software of W0084 is available on MPEG FTP.
- Software of W0085 is available in JCTVC-W0085 package.