

AHG7: On the need of luma delta QP for BT.2100 HLG content

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| Research & Development



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I Context and objectives

Context

- At the last meeting in Hobart:
 - F0094 proposed a new set of HDR sequences graded with the BT.2100 Hybrid Log-Gamma (HLG) characteristics
 - Proponents asked for inclusion of that material in the CfP's test set
 - During review in the BoG it was asked whether luma delta QP is also needed for HLG
- Luma delta QP:
 - Results from an extensive analysis presented in MPEG document m37439
 - Compensates for a code level redistribution when SDR content is mapped into PQ
 - Allows to use a BT.709-optimised codecs over PQ material
 - Is recommended in TRI (JCTVC-Y1017) for coding PQ material with HEVC
- The BoG recommended further study on luma delta QP for HLG and provision of additional coding rates for the material in F0094

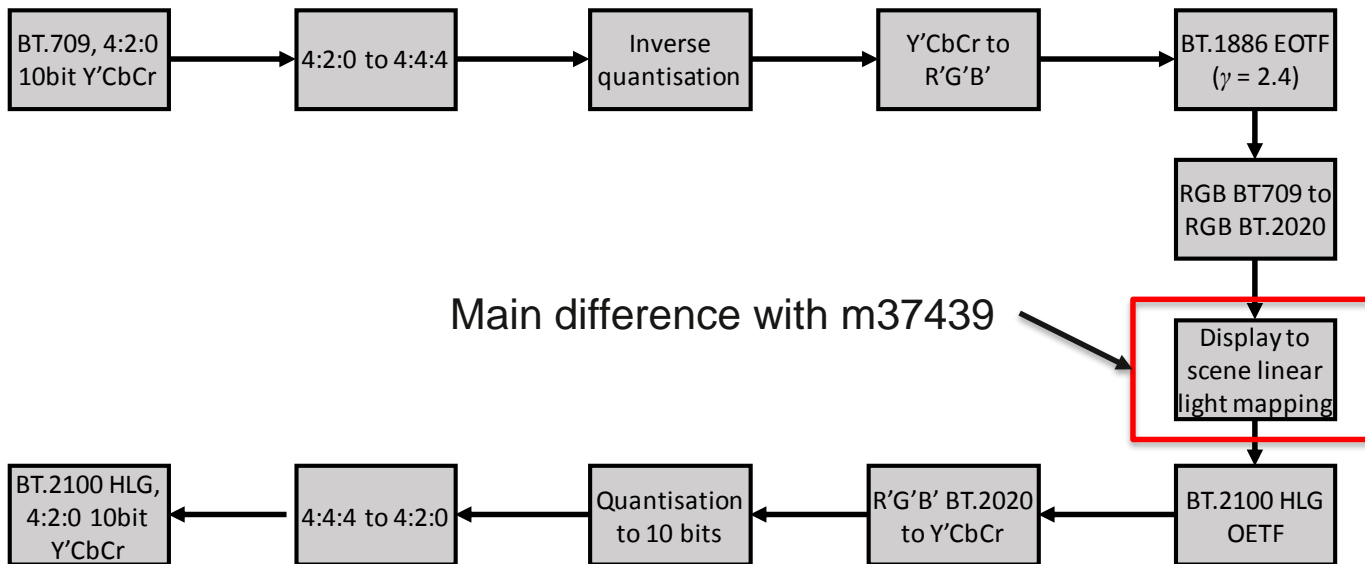
Objective

- Study of luma delta QP was also included as one of the mandates (4th) for AHG7
- Accordingly, the same methodology proposed in m37439 is followed to study the associated code level redistribution
- This contribution reports on the analysis made by BBC and NHK, particularly:
 - Remapping of SDR material into an HLG is considered and addressed
 - Results presented in terms of code levels distribution and coding performance
 - Conclusions are drawn accordingly on whether an ad-hoc QP adjustment is needed when HLG material is compressed with a BT.709-optimised codec

2 Overall workflow

Processing chain for HLG graded material

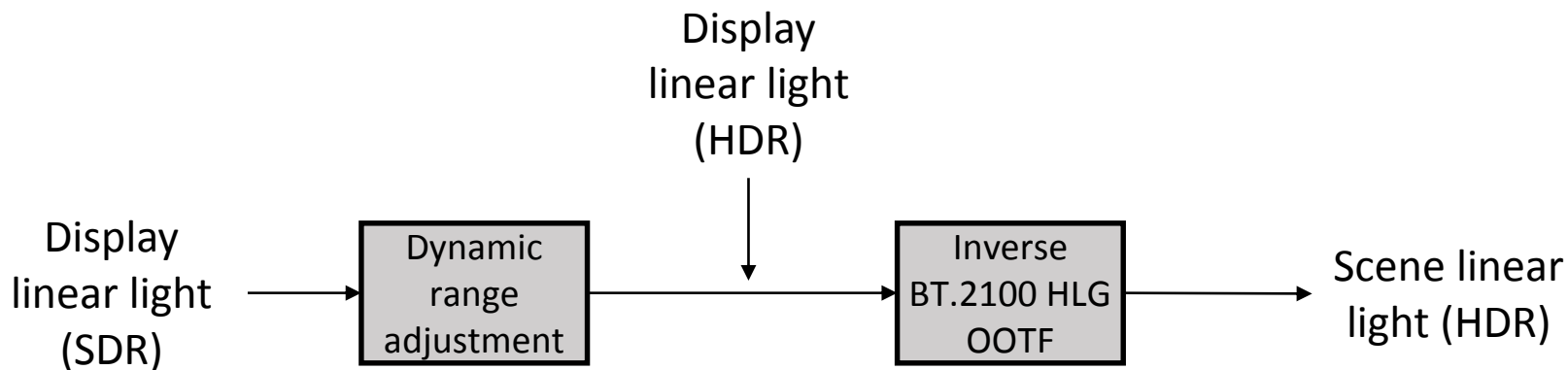
- M37439 studied how code levels redistribute when BT.709 content is put in a PQ container
- The same approach is followed here, adapted for HLG



3 Remapping to an HLG container

Remapping to an HLG container: Preliminary remarks

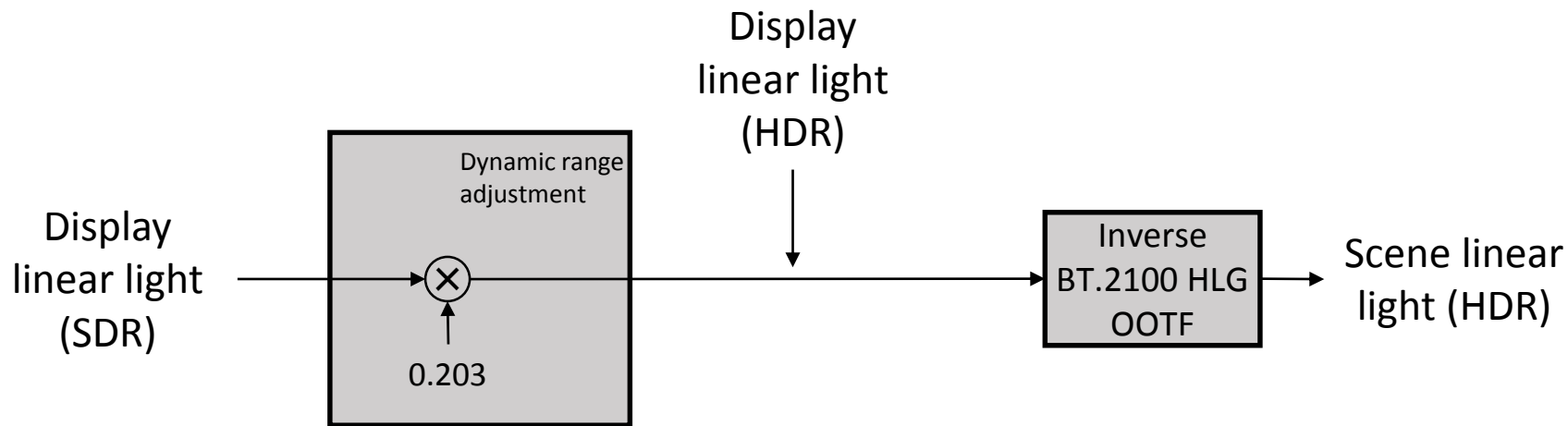
- HLG OETF applied after BT.1886 means that 100% SDR \leftrightarrow 100% HLG (very bright images)
- The Digital Production Partnership (DPP) recommends 100% SDR \leftrightarrow 75% HLG
- After scaling, resulting linear display light is converted to linear scene light



Remapping to an HLG container: Details

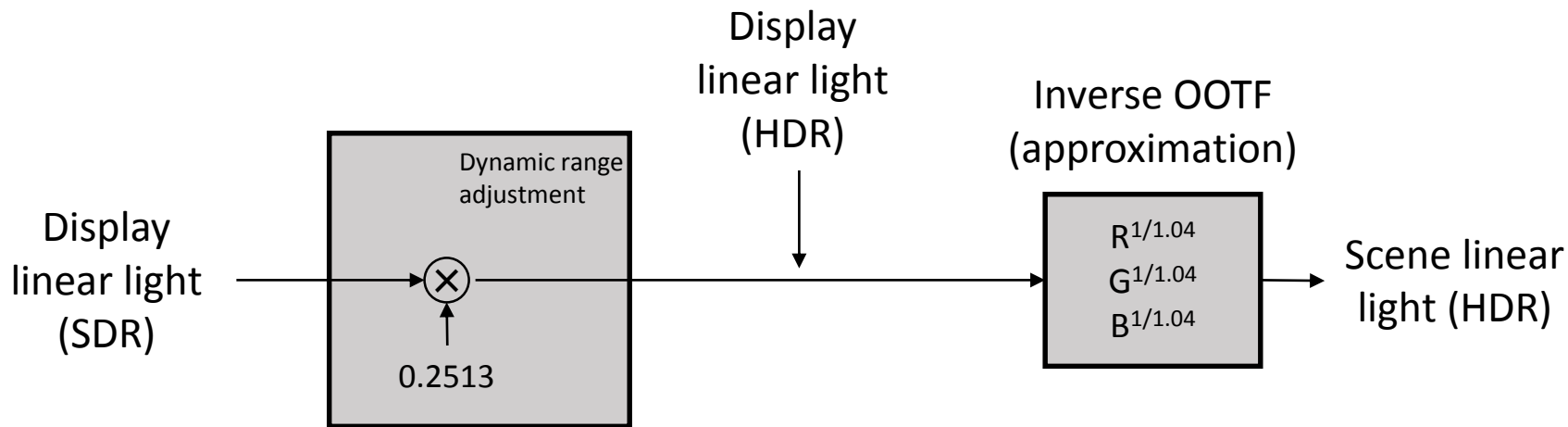
- Assuming a peak luminance of 1000 nits, the system gamma for the HLG OOTF is 1.2
- The scaling factor for dynamic range adjustment is given by:

$$M = \frac{EOTF_{HLG}(0.75)}{EOTF_{BT.709}(1.0)} = \frac{OOTF_{HLG}(OOTF_{HLG}^{-1}(0.75))}{OOTF_{BT.709}(OOTF_{BT.709}^{-1}(1.0))} = \frac{0.265^\gamma}{1.0^{2.4}} \xrightarrow{\gamma=1.2} 0.203$$



Remapping to an HLG container: Simplified scheme

- Mapping to 75% HLG can also be done assuming a peak luminance of 392 nits
- Resulting gamma is 1.03 (close to unity), avoiding to invert the gamma on luma
- In the experiments a system gamma of 1.04 was used instead



4 Results analysis

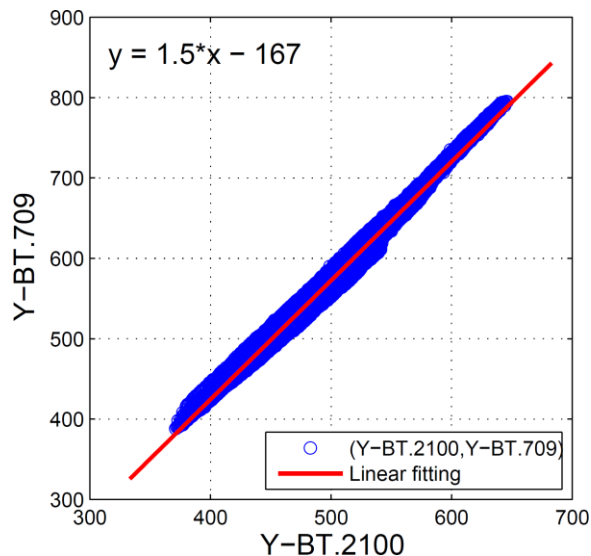
Results analysis: Test material and experimental conditions

- JCT-VC sequences (Class A-E) with 10 bit upscaling by simple bit shifting
- Coding of this material according to the JCT-VC CTC (L1100):
 - Main10 profile
 - Random Access
 - Low Delay
- Distribution of code levels is analysed by scatter plots inspection (luma and chroma)
- Least square regression is applied to quantify the code level variation

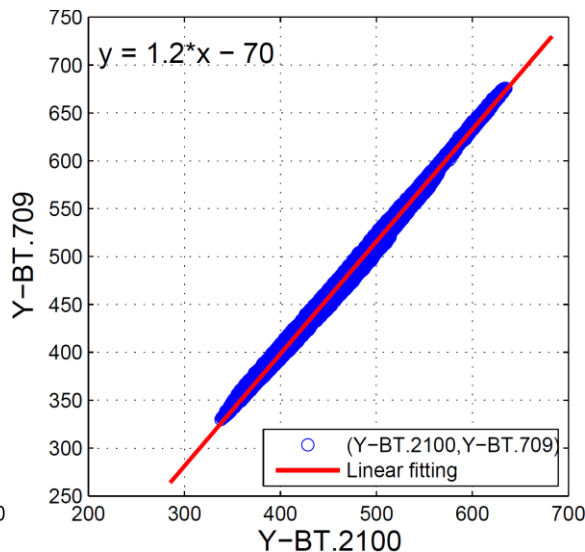
Results analysis: Code levels distribution for luma and BQSquare

- Scatter plots for luma codewords are reported for both remapping schemes

Full conversion



Simplified conversion

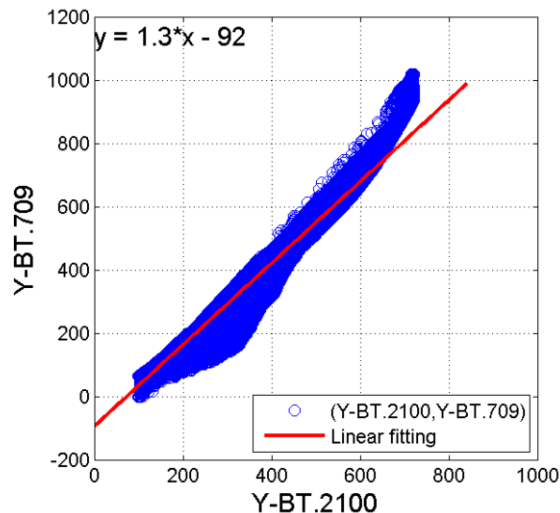


- Content spans same range of levels
- Linear relationship exists
- $QP_{709} - QP_{2100}$ independent on luma level

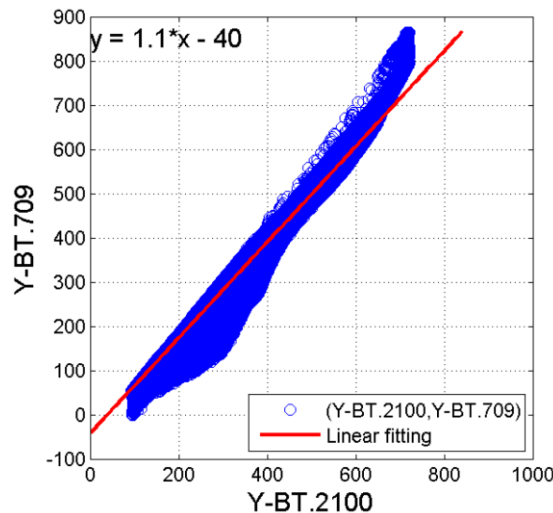
Results analysis: Code levels distribution for luma and all content

- Scatter plots for luma codewords are reported for both remapping schemes

Full conversion



Simplified conversion



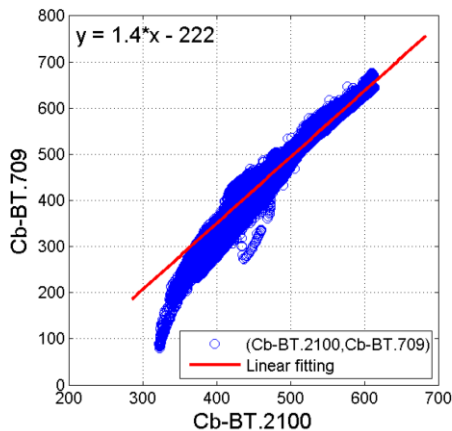
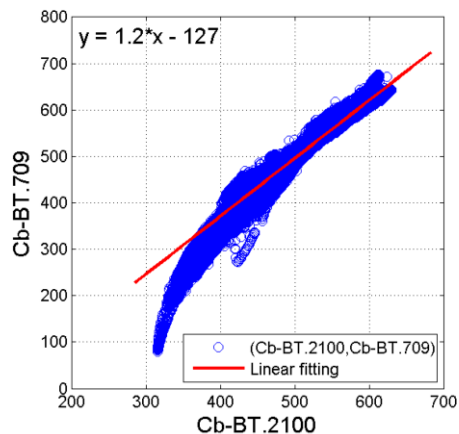
- Content spans same range of levels
- Linear relationship exists
- $QP_{709} - QP_{2100}$ independent on luma level

Results analysis: Code levels distribution for Cb and Cr and all content

Cb

Full conversion

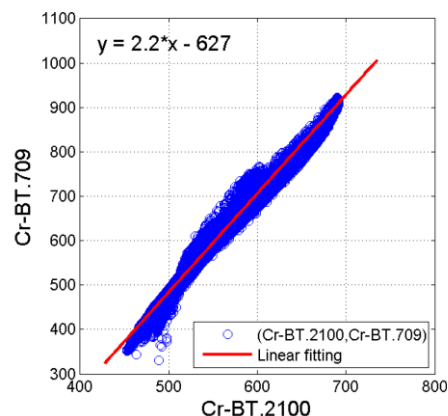
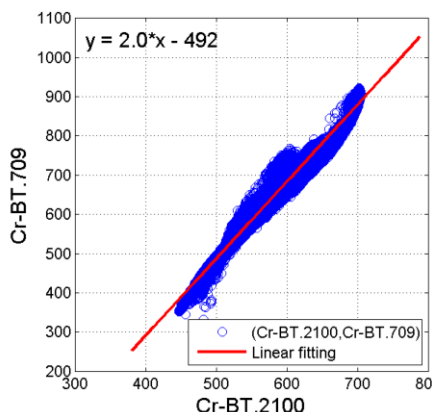
Simplified conversion



Cr

Full conversion

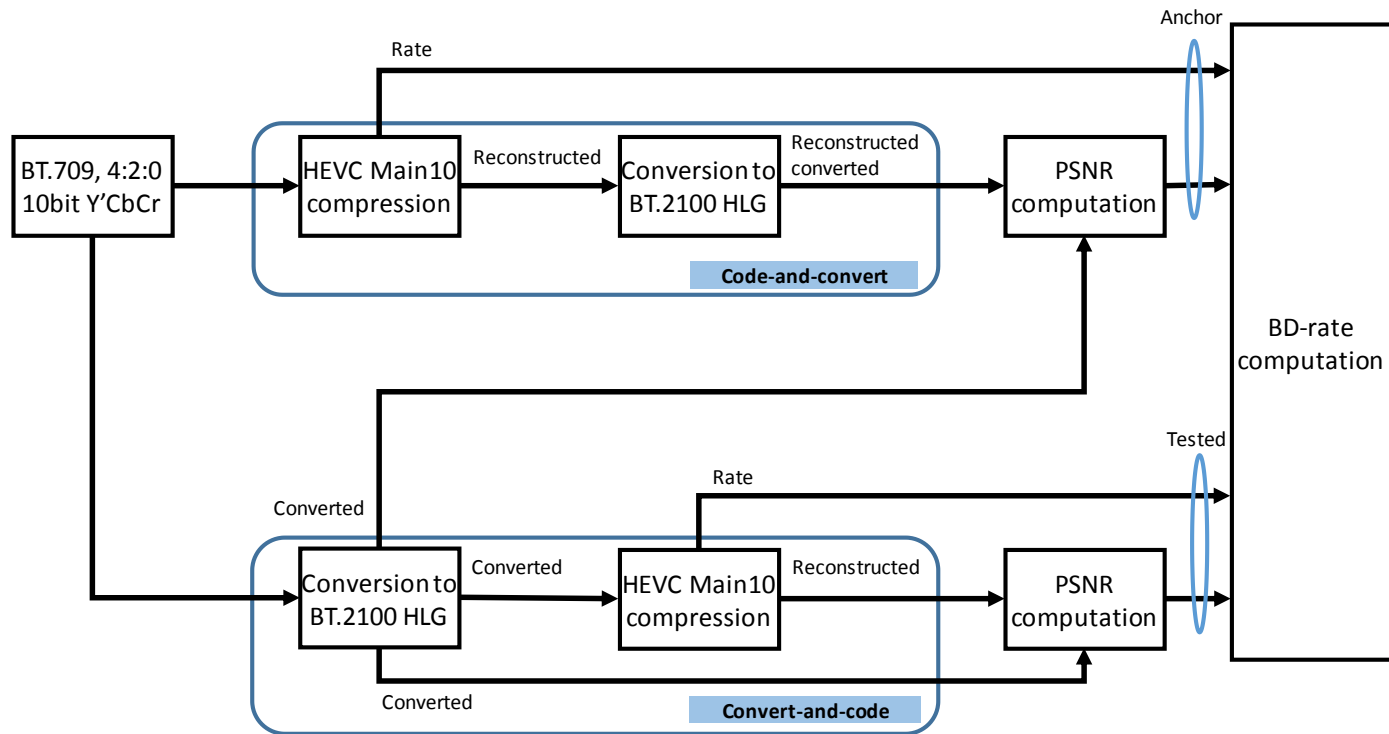
Simplified conversion



- Differently from m37439 the relationship is not piecewise linear (i.e. not luma dependent)
- The slope of the linear model is not close to unity which would suggest a static QP offset is needed
- Results suggest a QP offset of -3 and -7 for Cb and Cr, respectively

Results analysis: Coding performance measurement

- BD-rates are computed as follows:



Results analysis: Coding performance results

	Random Access Main10			Low delay B Main10		
	Y	U	V	Y	U	V
Class A	3.6%	11.5%	33.2%	3.4%	15.2%	28.9%
Class B	3.4%	10.2%	-6.6%	2.8%	11.0%	-4.5%
Class C	2.4%	21.1%	7.7%	2.3%	21.2%	8.7%
Class D	5.7%	14.5%	7.3%	4.9%	14.4%	9.6%
Class E	5.9%	2.5%	3.7%	7.2%	7.8%	15.4%
Overall	4.1%	12.3%	8.6%	3.8%	12.6%	6.0%

- BD-rate losses due to joint effects or conversion process and use of QP offset
- Losses on the chroma components inline with the findings of m37439
- Losses not noticeable during visual inspection of the coded material

5 Conclusions and recommendations

What we've learned

- Remapping SDR material to an HLG container to study how code levels are distributed:
 - Linear relationship between luma and chroma codewords over a large set of test material
 - For luma slopes of linear models close to unity
 - Hence a code level perturbation in the BT.709 space translates in the same amount in the HLG one
 - Chroma components have slopes different from unity, so a static QP offset might be used
- Recommendation:
 - No particular ad-hoc luma delta QP seems to be needed for HLG graded material
 - Chroma can be addressed with static/adaptive offsets or some ad-hoc RDO technique
- **Very important caveat:**
 - Is not suggested that HLG would not benefit from luminance adaptive quantisation
 - Is only suggested that no particular bitrate redistribution between the highlights and lowlights should be expected and addressed

