

## JCTVC-N0224 SEI MESSAGE: POST FILTERS TO ENHANCE THE CHROMA PLANES

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14<sup>th</sup> JCT-VC meeting, July 2013



invention | collaboration | contribution

# Introduction

- This contribution proposes an SEI message for HEVC
  - Carrying post filter coefficients used to enhance the quality of the reconstructed chroma planes.
- Methodology: enhance the chroma planes using the corresponding information from the luma plane.
  - Filters derived on the encoder side have high-pass characteristics.
  - Filters are applied to the surrounding luma pixels, in order to extract high-frequency components.
  - Output of the filtering is added to the chroma pixel to be enhanced, in order to restore the edges.
- Achieve significant chroma quality improvement in Class A, Class B, and screen content sequences (up to 1.5 dB).
- Has been proposed to SHVC for inter-layer prediction in previous meetings

# Overview of Chroma Enhancement Filtering

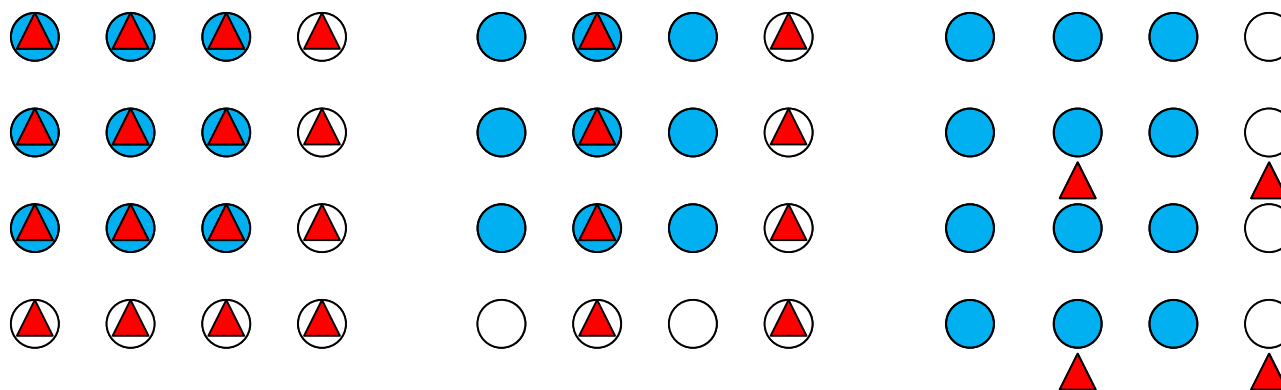
- Each chroma pixel is added by an offset

$$Cb_{enh}(x,y) = Cb(x,y) + o(x,y)$$

- Offset is the output of applying a high-pass filter  $f_{Cb}$  to the surrounding  $W \times H$  luma pixels ( $W$  and  $H$  are signaled in bitstream)

$$o(x,y) = \sum_{j=-H/2}^{H/2} \sum_{i=-W/2}^{W/2} f_{Cb}(i,j) Y(s_x x - i, s_y y - j)$$

$(s_x, s_y)$  equal to (1, 1), (2, 1), and (2, 2) for 4:4:4, 4:2:2, and 4:2:0, respectively.



4:4:4

4:2:2

4:2:0

○ Luma sample

▲ Chroma sample

# Filter Training and Signaling

- Filter derivation on the encoder side
    - Use Least Minimum MSE (LMMSE) estimator to minimize the MSE between the reconstructed and original chroma planes
  - Quantization:
    - 16-level uniform quantizer
    - Quantization stepsize:  $Q_{Cb}/2^{N_{Cb}}$
- $$h_{Cb,opt}(i, j) = f_{Cb}(i, j) \times \frac{Q_{Cb}}{2^{N_{Cb}}}$$
- Signaling
    - $W$  and  $H$ : coded using ue(v)
    - Flag indicating On/Off for certain chroma plane: 1-bit
    - $(W - 1)$  filter coefficients: 4 bits each, the rest one is derived based on zero-sum constraint
    - $Q_{Cb}$ : 11 bits (10 bits for magnitude and 1 bit for sign)
    - $N_{Cb}$ : 5 bits

*For 3x3 filter, 104 bits per SEI message payload; for 3x4 filter, 122 bits; for 5x5 filter, 236 bits*

# Process of Chroma Enhancement

- Performed out of the coding loop
- Filter the surrounding  $W \times H$  luma pixels to get the scaled offset  $z(x,y)$

$$z(x, y) = \sum_{j=-H/2}^{H/2} \sum_{i=-W/2}^{W/2} f_{Cb}(i, j) Y(s_x x - i, s_y y - j)$$

- Normalize and round  $z(x,y)$  to  $o(x,y)$

$$o(x,y) = \text{Sign}(z(x,y) \gg Q_{Cb}) \left( (\text{Abs}(z(x,y) \gg Q_{Cb}) + (1 \ll (N_{Cb}-1))) \gg N_{Cb} \right)$$

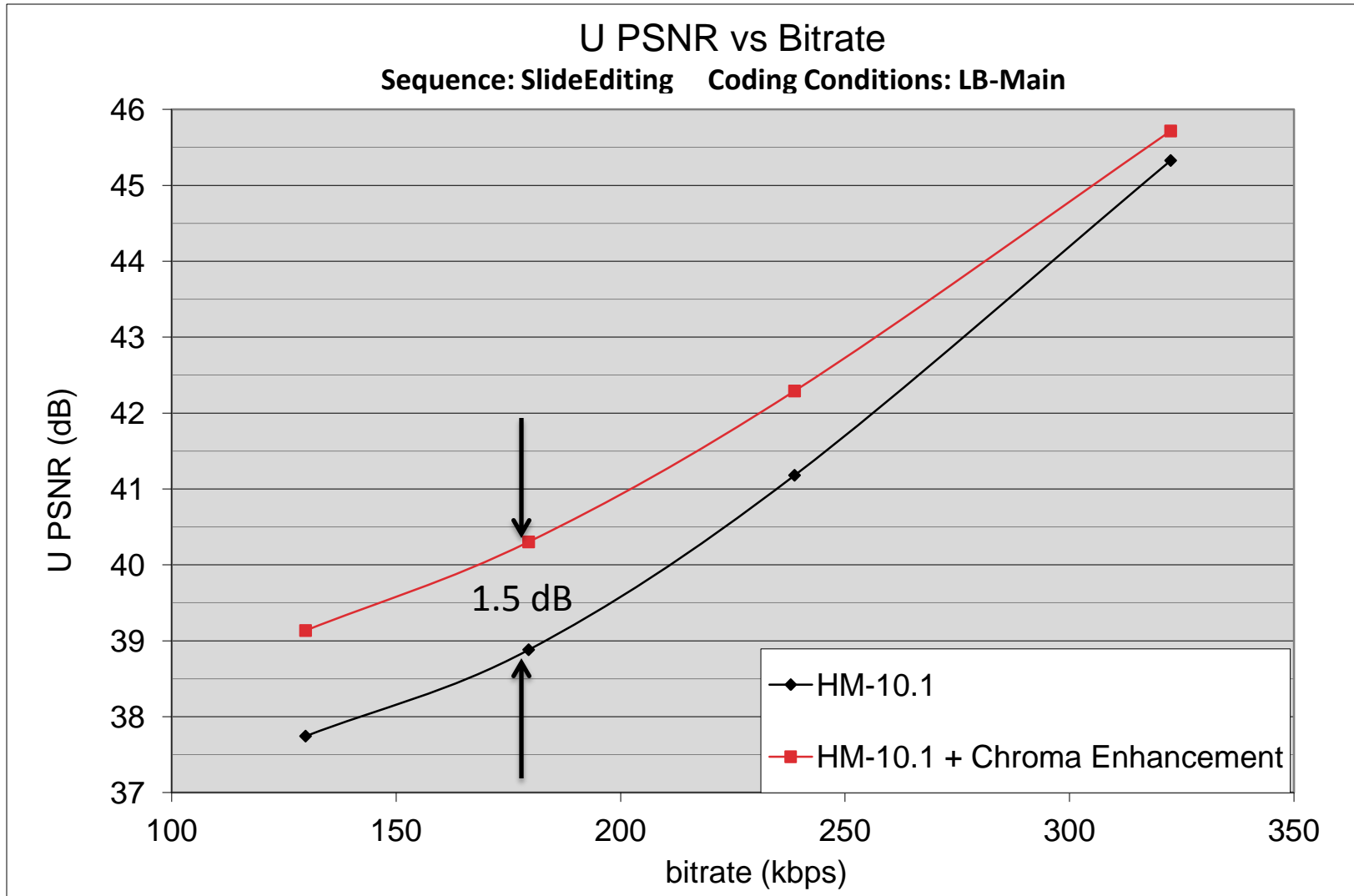
- Add offset  $o(x,y)$

$$Cb_{enh}(x,y) = Cb(x,y) + o(x,y)$$

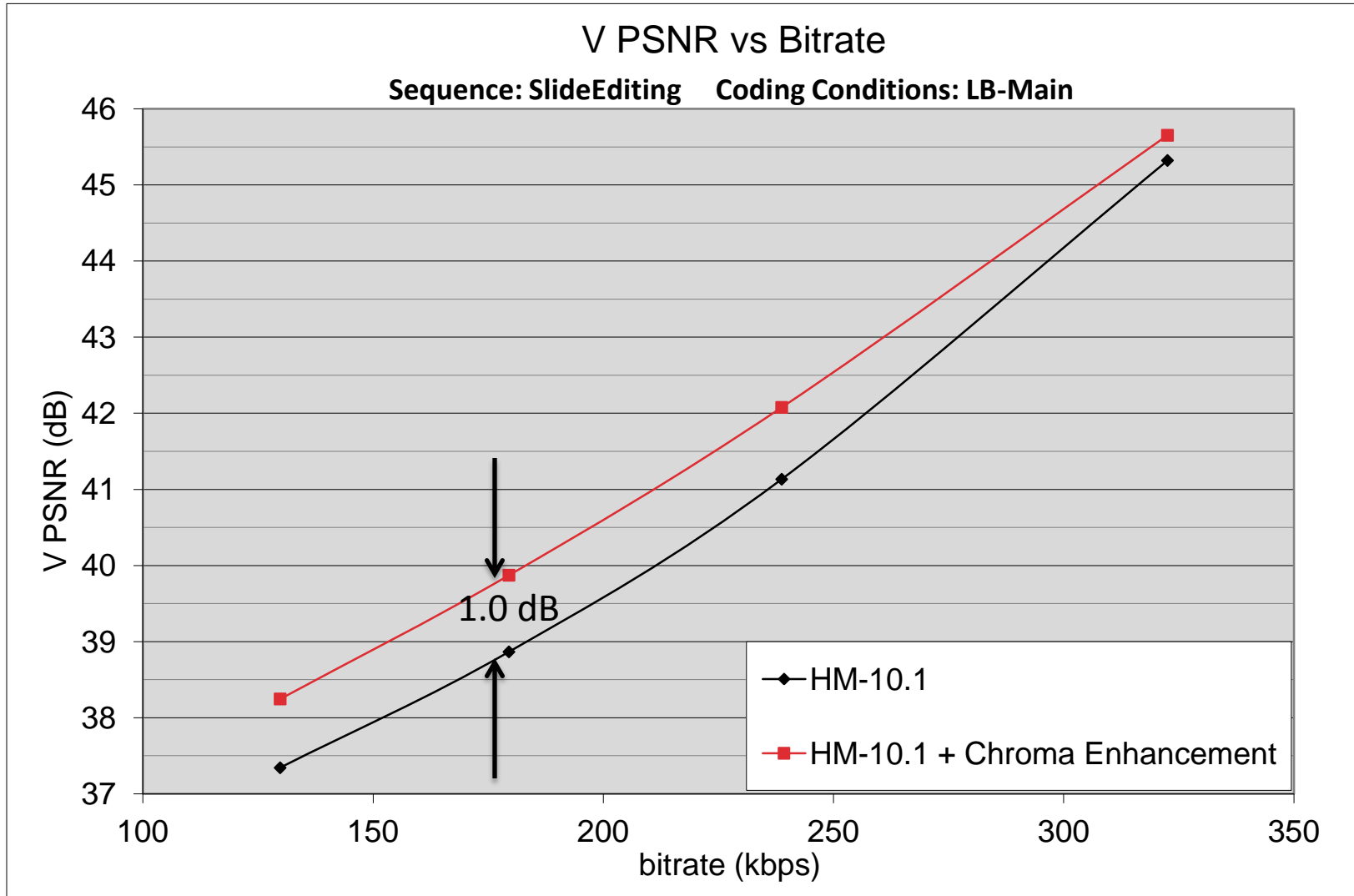
# Payload of the Proposed SEI message

chroma_enhancement_filter (payloadSize ) {	<b>Descriptor</b>
<b>chroma_enhancement_filter_enabled_flag</b>	u(1)
if (chroma_enhancement_filter_enabled_flag) {	
<b>num_coeff_hori_minus1</b>	ue( )
<b>num_coeff_verti_minus1</b>	ue( )
<b>cb_enhancement_flag</b>	u(1)
if (cb_enhancement_flag) {	
for ( i=0; i<((num_coeff_hori_minus1+1)×(num_coeff_verti_minus1+1)-1 ); i++ )	
<b>cb_filter_coeff_plus8 [i]</b>	u(4)
<b>cb_scaling_factor_abs_minus1</b>	u(10)
<b>cb_scaling_factor_sign</b>	u(1)
<b>cb_bit_shifting</b>	u(5)
}	
<b>cr_enhancement_flag</b>	u(1)
if ( cr_enhancement_flag ) {	
for ( i=0; i<((num_coeff_hori_minus1+1)×(num_coeff_verti_minus1+1)-1 ); i++ )	
<b>cr_filter_coeff_plus8 [i]</b>	u(4)
<b>cr_scaling_factor_abs_minus1</b>	u(10)
<b>cr_scaling_factor_sign</b>	u(1)
<b>cr_bit_shifting</b>	u(5)
}	
}	
}	

# Cb R-D Curve of SlideEditing (LD-B Main)

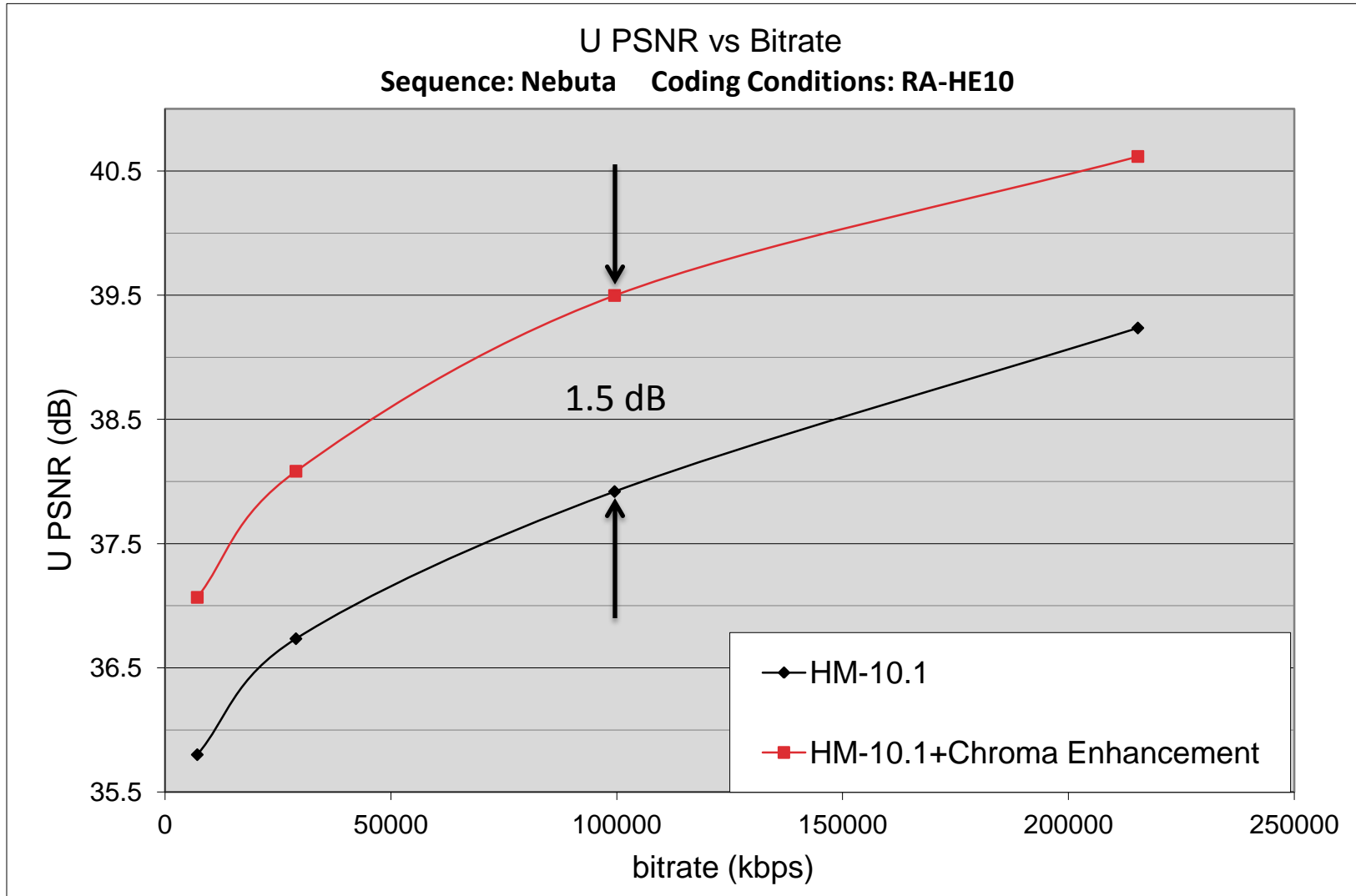


# Cr R-D Curve of SlideEditing (LD-B Main)

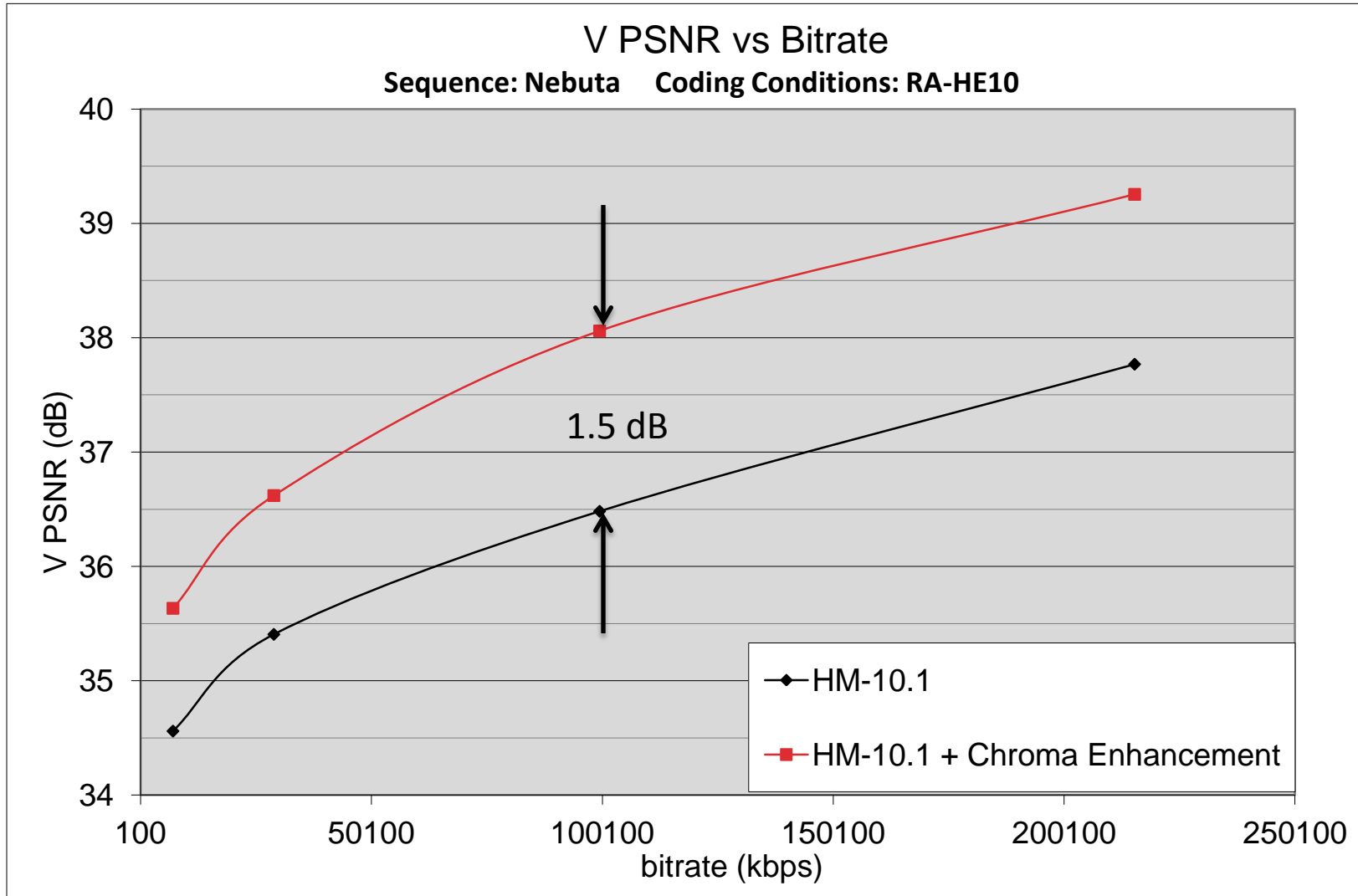




# Cb R-D Curve of Nebuta (RA Main10)



# Cr R-D Curve of Nebuta (RA Main10)



# Example of Restored Edges in Chroma Plane

- Cr plane of the 1<sup>st</sup> frame of Kimono (RA, QP=32)

Original Image



Original Cr plane



Rec. Cr plane w/ enh.

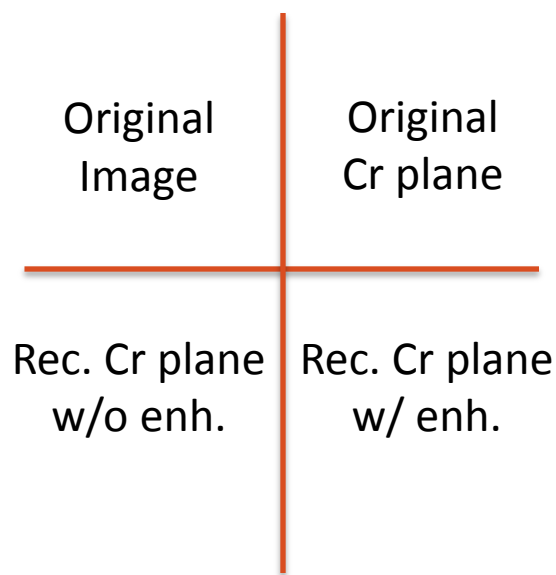


Rec. Cr plane w/o enh.



# Example of Restored Edges in Chroma Plane

- Cr plane of the 1<sup>st</sup> frame of ParkScene (RA, QP=32)



# Conclusion

- This contribution proposes an SEI message for HEVC
  - Carrying post filter coefficients used to enhance the quality of the reconstructed chroma planes.
- Achieve significant chroma quality improvement (up to 1.5 dB) for various test sequences, including Class A, Class B, and screen content sequences
- Marginal payload size (104 bits with 3x3 filter, 236 bits with 5x5 filter)
- We suggest adopting this SEI message into HEVC.