



# JCTVC-G245

## Use of chroma phase in LM mode

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# 2 proposals

- Proposal 1: LM mode generalization with chroma phase
- Proposal 2: simplification of luma interpolation filtering

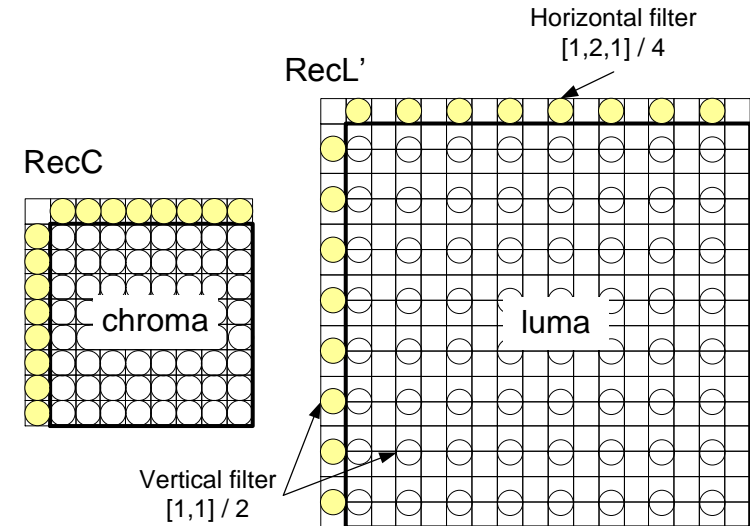
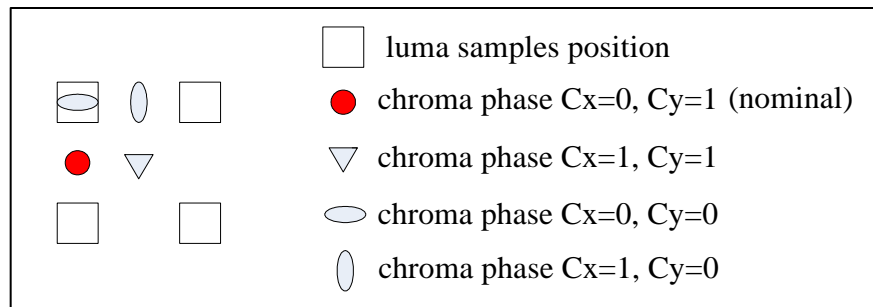
# Chroma phase in current HM design

- LM mode explicitly links chroma samples to luma samples

chroma samples position related to luma samples should be taken into account

## Definition for 4:2:0

- Cx,Cy indicate the chroma grid position / luma grid
- Nominal case: Cx=0,Cy=1



## In current HM design

- Syntax element **chroma\_format\_idc** indicating the chroma format (i.e. YUV4:2:0, ...)
- Left samples:  $\text{RecL}'[-1,y] = (\text{RecL}[-1,2y] + \text{RecL}[-1,2y+1]) \gg 1$
- Inner samples:  $\text{RecL}'[x,y] = (\text{RecL}[2x,2y] + \text{RecL}[2x,2y+1]) \gg 1$
- Top samples:  $\text{RecL}'[x,-1] = (\text{RecL}[2x-1,-1] + 2\text{RecL}[2x,-1] + \text{RecL}[2x+1,-1] + 2) \gg 2$

# Proposal 1: LM mode generalization with chroma phase

## ■ SPS syntax change: signal horizontal/vertical chroma phase

- Possibly insert other information
  - Such as those defined in AVC Video Usability Information, resolution ratio luma/chroma ...
  - SVC already signals that information for enhancement layers

## ■ New $\text{Rec}_L$ samples interpolation (linear/bilinear):

- Left samples:

$$\text{Rec}_L[-1,y] = ( \text{Rec}_L[-1,2y] + C_y \cdot \text{Rec}_L[-1,2y+1] ) \gg C_y$$

- Inner samples:

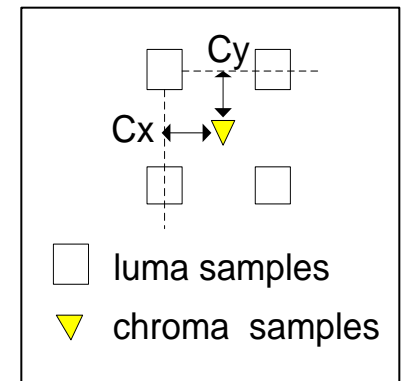
$$\text{Rec}_L[x,y] = ( \text{Rec}_L[2x,2y] + C_x \cdot \text{Rec}_L[2x+1,2y] + C_y \cdot \text{Rec}_L[2x,2y+1] + C_x \cdot C_y \cdot \text{Rec}_L[2x+1,2y+1] ) \gg (C_x + C_y)$$

- Top samples:

$$\begin{aligned} \text{Rec}_L[x,-1] = & ( ( \text{Rec}_L[2x-1,-1] + 2\text{Rec}_L[2x,-1] + \text{Rec}_L[2x+1,-1] + 2 ) \gg 2 + \\ & C_x \cdot ( \text{Rec}_L[2x,-1] + 2\text{Rec}_L[2x+1,-1] + \text{Rec}_L[2x+2,-1] + 2 ) \gg 2 ) \gg C_x \end{aligned}$$

- Note:  $C_x=0, C_y=0$  may cause important aliasing
  - Possibly apply prior low-pass filter to luma samples

seq_parameter_set_rbsp( ) {
profile_idc
reserved_zero_8bits
level_idc
seq_parameter_set_id
chroma_format_idc
if( chroma_format_idc == 3 ) {
chroma_phase_x
chroma_phase_y
}
...
rbsp_trailing_bits( )
}

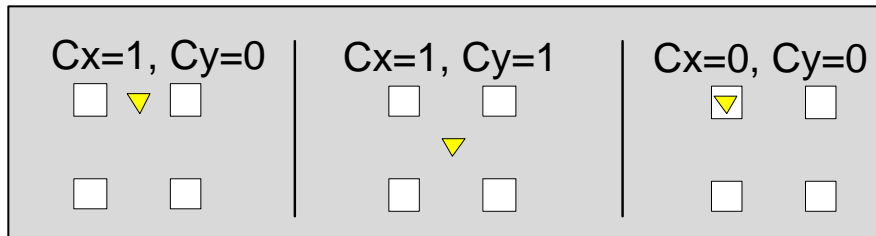


# Proposal 1: tool evaluation

## ■ Tested on 2 different sets of sequences

- Test set 1: classes A',B',C',D',E'
  - current HEVC set, with re-phased chroma samples (using 8-tap DCTIF filters for displaced chroma pictures)
- Test set 2: classes AP,BP,CP,EP,P
  - Class P: Four 4:4:4 1080p sequences, chroma downsampled with chroma samples re-phased
  - Class AP,BP,CP,EP: current HEVC set downsampled, with chroma samples re-phased

## ■ For each sequence, 3 versions generated and tested

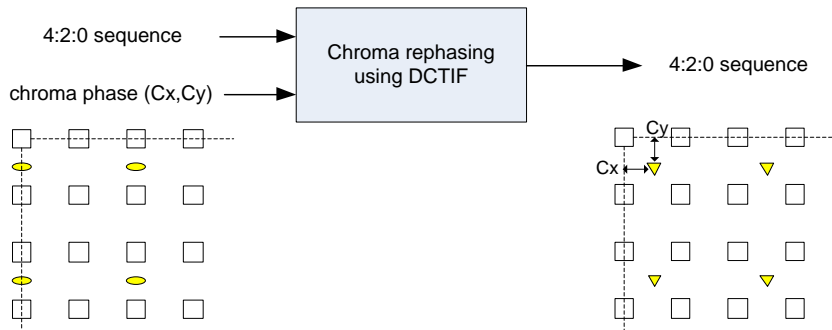


## ■ For each chroma phase (Cx,Cy), each sequence coded using

- HM4.0 (reference) vs modified HM with luma interp. using (Cx,Cy)

# Proposal 1: test conditions

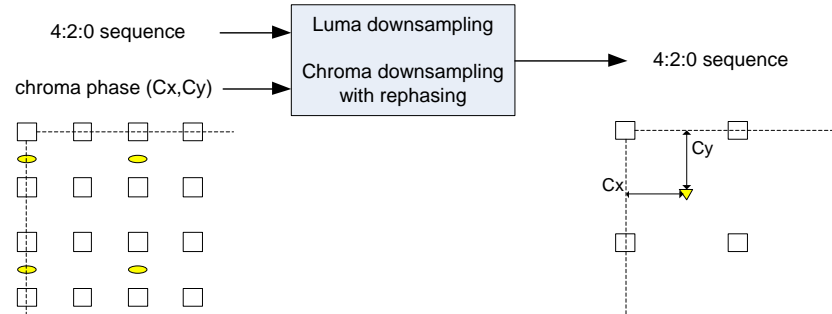
SET 1



## ■ Re-phasing commonly HEVC 4:2:0 sequences

- using 8-tap DCTIF filters

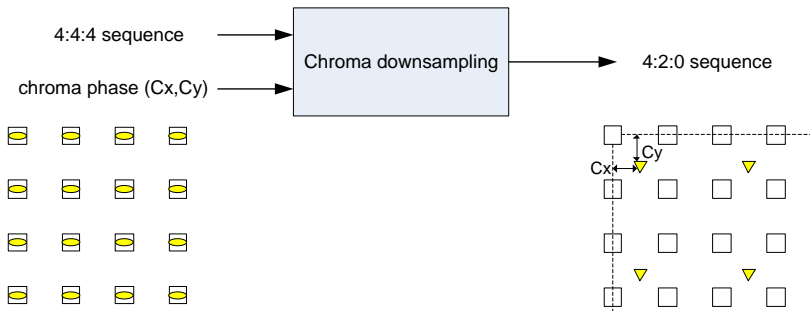
→ classes A', B', C', D', E'



## ■ Downsampling & re-phasing HEVC 4:2:0 sequences

- Downsampling ratio  $\frac{1}{2}$

→ classes AP, BP, CP, EP



## ■ Downsampling & re-phasing chroma of 4:4:4 1080p sequences

- Downsampling ratio  $\frac{1}{2}$

→ class P

SET 2

# Proposal 1: Results – ref: HM4.0+LM bug fix

Cx=1, Cy=0



Set1	All Intra HE			All Intra LC			Set2	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V		Y	U	V	Y	U	V
A'	-0.2%	-5.1%	-2.1%	-0.2%	-4.9%	-2.2%	AP	-0.1%	-1.4%	-0.2%	0.0%	-1.3%	-0.3%
B'	0.0%	-1.3%	0.3%	0.0%	-1.1%	0.3%	BP	-0.1%	-1.9%	0.2%	-0.1%	-1.8%	0.2%
C'	-0.3%	-1.9%	-2.1%	-0.3%	-1.7%	-1.8%	CP	-0.3%	-2.5%	-2.5%	-0.3%	-2.1%	-2.1%
D'	-0.2%	-1.0%	-1.2%	-0.2%	-1.0%	-1.2%	EP	0.0%	0.0%	-0.5%	0.0%	0.3%	-0.1%
E'	0.0%	-0.2%	-0.2%	0.0%	-0.2%	-0.1%	P	-0.1%	-1.9%	-5.6%	-0.1%	-1.8%	-5.4%
All	-0.1%	-1.9%	-1.0%	-0.1%	-1.8%	-1.0%	All	-0.1%	-1.6%	-1.7%	-0.1%	-1.5%	-1.5%
	-0.1%	-1.9%	-1.0%	-0.1%	-1.7%	-1.0%		-0.1%	-1.6%	-1.7%	-0.1%	-1.4%	-1.5%

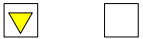
Cx=1, Cy=1



Set1	All Intra HE			All Intra LC			Set2	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V		Y	U	V	Y	U	V
A'	-0.1%	-2.1%	-1.0%	-0.1%	-2.0%	-1.0%	AP	-0.1%	-2.2%	-0.6%	-0.1%	-2.0%	-0.5%
B'	0.0%	-0.6%	0.3%	0.0%	-0.7%	0.2%	BP	-0.1%	-1.1%	-0.1%	-0.1%	-1.3%	-0.1%
C'	-0.3%	-1.9%	-1.7%	-0.3%	-1.8%	-1.7%	CP	-0.3%	-2.2%	-2.0%	-0.3%	-2.1%	-2.0%
D'	-0.2%	-1.2%	-1.3%	-0.2%	-1.3%	-1.4%	EP	0.0%	0.3%	-0.6%	0.0%	0.2%	-0.4%
E'	0.0%	0.2%	-0.1%	0.0%	0.2%	0.0%	P	-0.1%	-1.2%	-3.9%	-0.1%	-1.2%	-3.9%
All	-0.1%	-1.2%	-0.7%	-0.1%	-1.2%	-0.8%	All	-0.1%	-1.3%	-1.4%	-0.1%	-1.4%	-1.4%
	-0.1%	-1.1%	-0.7%	-0.1%	-1.1%	-0.7%		-0.1%	-1.3%	-1.4%	-0.1%	-1.3%	-1.4%

Cross-check:  
G488 (INRIA)

Cx=0, Cy=0



Set1	All Intra HE			All Intra LC			Set2	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V		Y	U	V	Y	U	V
A'	-0.1%	-3.9%	-1.4%	-0.1%	-3.7%	-1.6%	AP	0.1%	0.0%	0.2%	0.1%	0.1%	0.1%
B'	0.0%	-0.6%	0.2%	0.0%	-0.4%	0.2%	BP	0.0%	-0.8%	0.2%	0.0%	-0.6%	0.3%
C'	0.0%	-0.5%	-0.7%	0.0%	-0.4%	-0.5%	CP	0.0%	-0.8%	-0.9%	0.0%	-0.4%	-0.4%
D'	0.1%	0.1%	-0.1%	0.0%	0.2%	0.1%	EP	0.0%	-0.1%	0.0%	0.0%	0.1%	0.4%
E'	0.0%	-0.3%	-0.1%	0.0%	-0.3%	-0.1%	P	0.0%	-1.0%	-3.0%	0.0%	-0.8%	-2.6%
All	0.0%	-1.1%	-0.4%	0.0%	-0.9%	-0.4%	All	0.0%	-0.6%	-0.7%	0.0%	-0.4%	-0.4%
	0.0%	-1.0%	-0.4%	0.0%	-0.9%	-0.4%		0.0%	-0.6%	-0.6%	0.0%	-0.3%	-0.5%

**Canon** Higher gain for high-res classes (A': 2560x1600 and P: 1080p)

# Proposal 2: LM mode simplification

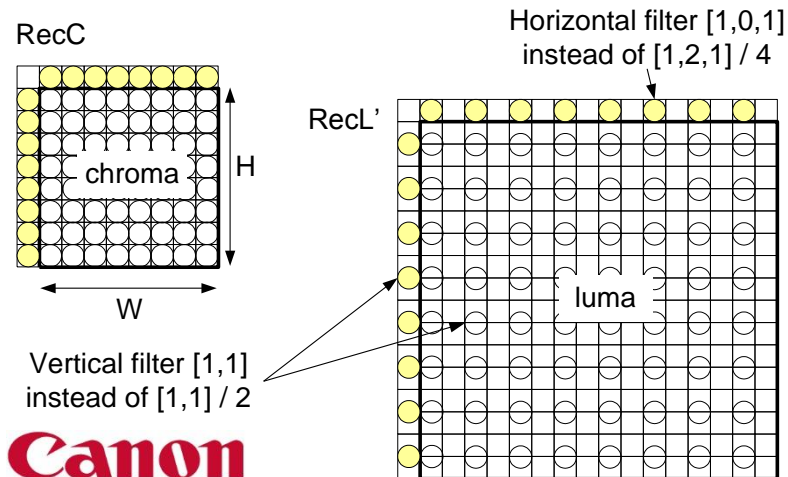
## ■ Applies to nominal chroma phase case

## ■ In current HM design

- Left samples:  $\text{Rec}_L[-1,y] = (\text{Rec}_L[-1,2y] + \text{Rec}_L[-1,2y+1]) \gg 1$
- Inner samples:  $\text{Rec}_L[x,y] = (\text{Rec}_L[2x,2y] + \text{Rec}_L[2x,2y+1]) \gg 1$
- Top samples:  $\text{Rec}_L[x,-1] = (\text{Rec}_L[2x-1,-1] + 2\text{Rec}_L[2x,-1] + \text{Rec}_L[2x+1,-1] + 2) \gg 2$

## ■ Proposal

- Left samples:  $\text{Rec}_L[-1,y] = \text{Rec}_L[-1,2y] + \text{Rec}_L[-1,2y+1]$
- Inner samples:  $\text{Rec}_L[x,y] = \text{Rec}_L[2x,2y] + \text{Rec}_L[2x,2y+1]$
- Top samples:  $\text{Rec}_L[x,-1] = \text{Rec}_L[2x-1,-1] + \text{Rec}_L[2x+1,-1]$



	Upper line	Left column	Inner	total
HEVC	3W additions W left shifts W right shifts	H additions H right shifts	W*H additions W*H right shifts	2W+H+W*H additions W left shifts W+H+W*H right shifts
proposed	W additions	H additions	W*H additions	W+H+W*H additions - -
saved	2W additions W left shifts W right shifts	H right shifts	W*H right shifts	2W additions W left shifts W+H+W*H right shifts



# Proposal 2: Results – ref: HM4.0 LM bug fix

	All Intra HE			All Intra LC		
	Y	U	V	Y	U	V
Class A	0.0%	-0.1%	-0.2%	0.0%	-0.2%	-0.3%
Class B	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Class C	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%
Class D	0.0%	0.2%	0.1%	0.0%	0.1%	0.1%
Class E	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
<b>Overall</b>	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	101%			100%		
Dec Time[%]	100%			100%		

	Random Access HE			Random Access LC		
	Y	U	V	Y	U	V
Class A	0.0%	-0.2%	-0.2%	0.1%	-0.4%	-0.1%
Class B	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%
Class C	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Class D	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%
Class E						
<b>Overall</b>	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.1%
	0.0%	0.0%	-0.1%	0.0%	-0.1%	0.0%
Enc Time[%]	101%			100%		
Dec Time[%]	100%			100%		

	Low delay B HE			Low delay B LC		
	Y	U	V	Y	U	V
Class A						
Class B	0.0%	-0.3%	-0.2%	0.0%	0.1%	0.2%
Class C	0.0%	0.2%	-0.2%	0.0%	0.1%	-0.1%
Class D	-0.1%	-0.3%	0.7%	0.0%	0.0%	0.0%
Class E	-0.1%	0.8%	0.5%	0.1%	1.1%	0.0%
<b>Overall</b>	0.0%	0.0%	0.2%	0.0%	0.3%	0.0%
	0.0%	0.1%	0.1%	0.0%	0.2%	0.0%
Enc Time[%]	100%			101%		
Dec Time[%]	100%			100%		

- Almost no impact on coding efficiency
- Similar performance when combined with luma samples subsampling for 16x16 PUs (TI proposal G129)
- Cross-check G756 (Huawei)

# Conclusions

## ■ 2 proposals related to LM mode :

- Proposal 1: taking into account chroma format information in LM mode
  - Insert chroma format information signaling in SPS
  - Adapt Luma samples interpolation based on these chroma format information
  - Current proposal handles any chroma-phased 4:2:0 content
  - Can be generalized to other formats (4:2:2, Bayer sampling)
  - Chroma Gain observed in all tested cases, up to 5.6% on high res classes
- Proposal 2: Simplification of Luma samples interpolation
  - No significant impact on performance
  - Significant reduction of the number of operations
    - $2N$  additions +  $N$  left shifts +  $(2N+N^2)$  right shifts ( $N$  chroma block width/height)