

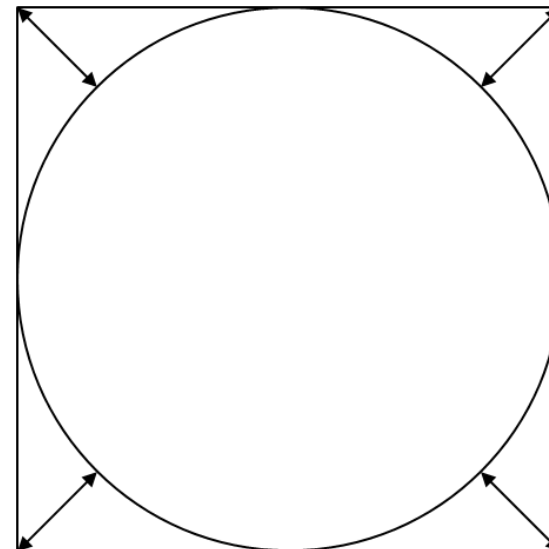
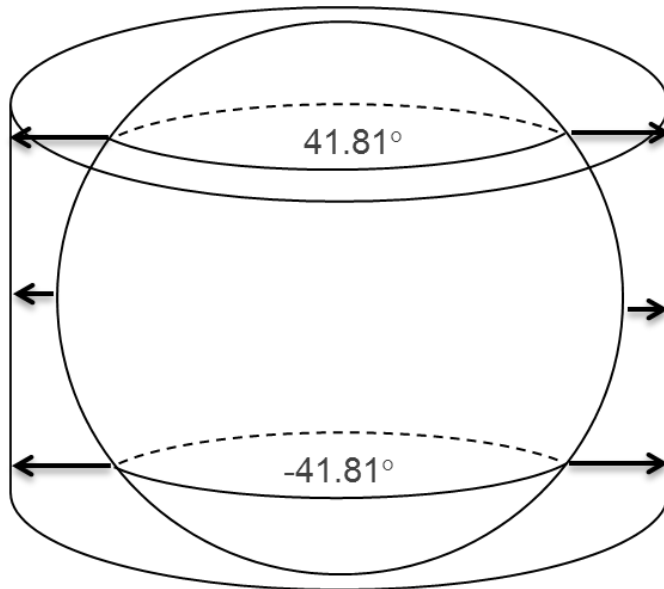
# AHG8: ECP with padding for 360-degree video (JVET-G0074)

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# Introduction

The equatorial cylindrical projection (ECP) is proposed for efficient compression of 360-degree video:

- Projecting equatorial region of the sphere using the Lambert cylindrical equal-area projection
  - Latitude interval of the equatorial region is  $\pm \sin^{-1}(2/3) \approx \pm 41.81^\circ$ , which is chosen such that the equatorial region is 2/3 of the total sphere area, hence, one pole area is 1/6 of the sphere area
- Projecting the poles of the sphere onto square faces in the video frame to avoid inactive pixels



# Coded Frame

ERP

0			
2	3	4	5
1			

ECP

2	3	4
1	5	0

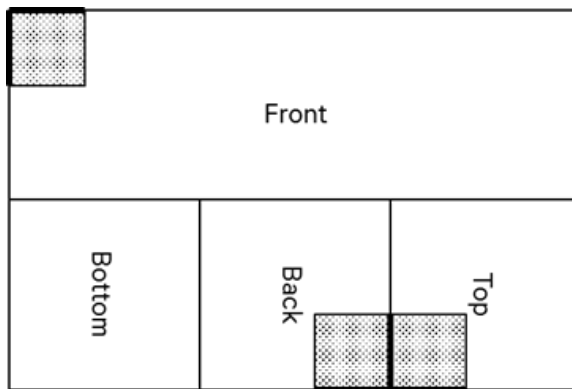
- ECP coded frame similar to 3x2 CMP
- ECP coded frame has 2/3 equatorial samples, 1/3 pole samples



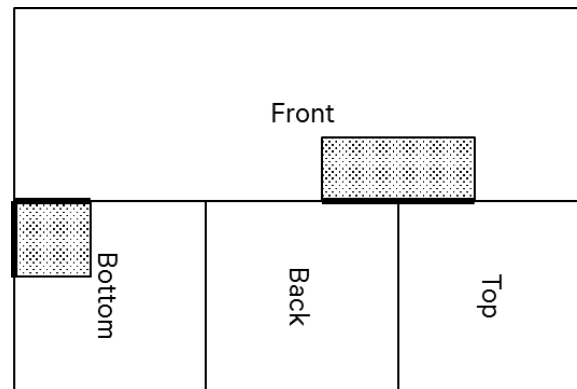
‘PoleVault’

# ECP Seam Artifact Reduction

- Front region is continuous
- Discontinuous boundaries between back and front/top regions in JVET-F0026 are mitigated
- Viewport seams influenced by motion intensity, in-loop filtering
- Examples of viewports:

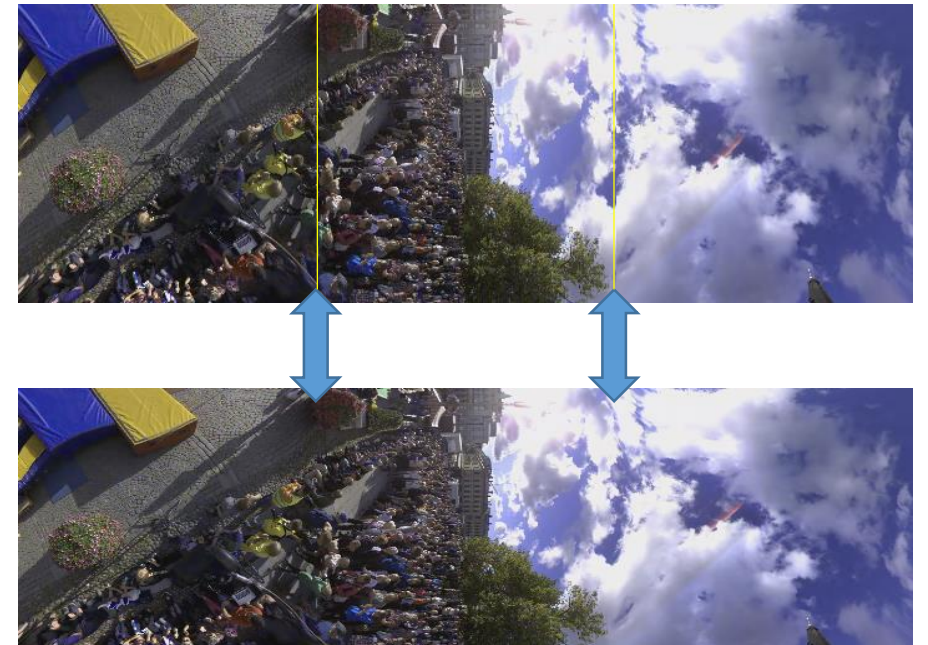


Viewport1 (-180°, 35°)



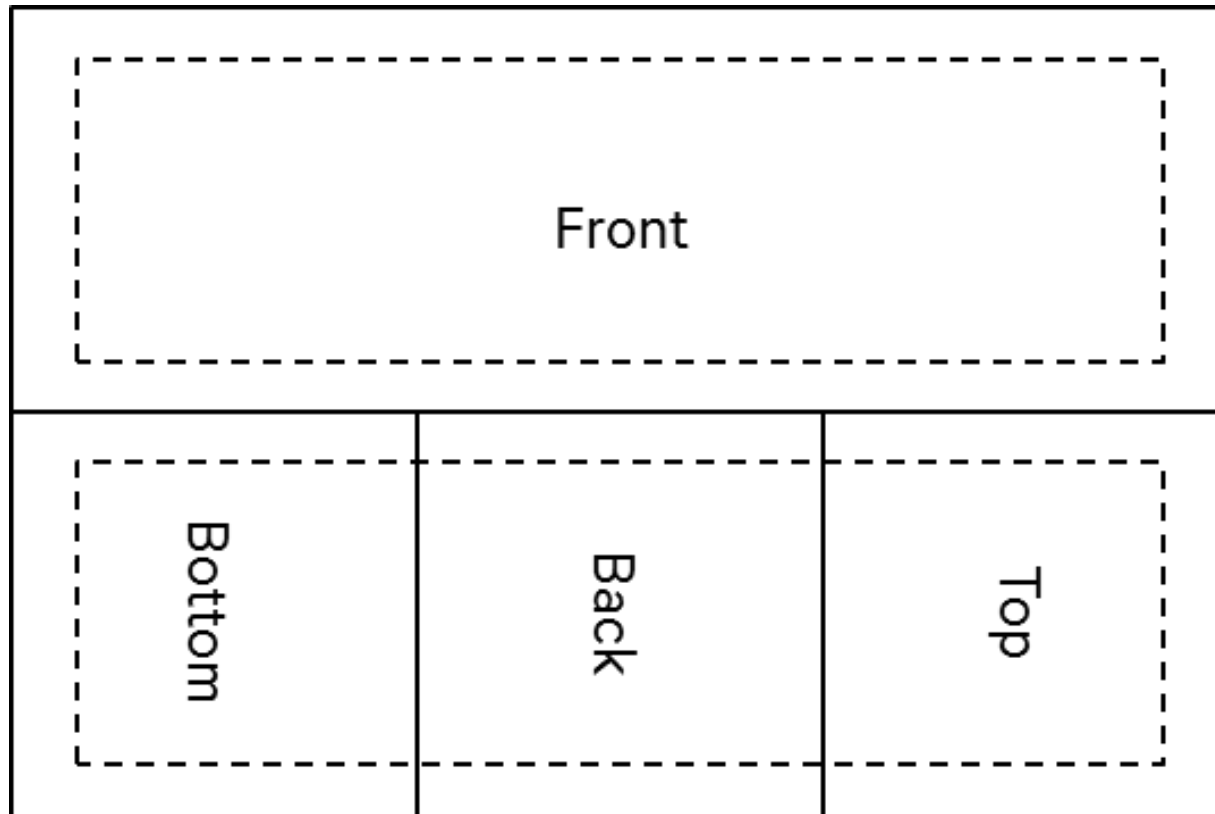
Viewport2 (0°, -35°)

Continuous transition between back and top/bottom regions:



# ECP Seam Artifact Reduction (2)

- Padding is proposed around top and bottom picture halves
- Geometry padding
- Padding width is 4 samples



# Viewport Examples

- Viewport 1



Not padded



Padded



# Viewport Examples

- Viewport 2



Not padded



Padded

# Results

BD-rates (RA) for ECP comparison with ERP following CTC for 360-degree video (JVET-F1030)

Not padded:

ECP vs. ERP	Y	U	V
<i>End-to-end</i>			
SPSNR-NN	-11.3%	-6.2%	-6.7%
SPSNR-I	-11.2%	-6.5%	-7.0%
CPP-PSNR	-11.2%	-6.5%	-7.0%
WS-PSNR	-11.3%	-6.3%	-6.8%
<i>Cross Format</i>			
SPSNR-NN	-11.3%	-6.3%	-6.8%
SPSNR-I	-11.1%	-6.5%	-7.0%
CPP-PSNR	-11.0%	-6.9%	-7.5%
<i>Dyn. Viewports</i>			
Viewport0	-22.1%	-12.1%	-12.4%
Viewport1	-16.0%	-5.9%	-6.5%

Padded:

ECP vs. ERP	Y	U	V
<i>End-to-end</i>			
SPSNR-NN	-11.2%	-6.5%	-7.1%
SPSNR-I	-11.0%	-6.6%	-7.3%
CPP-PSNR	-11.0%	-6.6%	-7.3%
WS-PSNR	-11.2%	-6.5%	-7.2%
<i>Cross Format</i>			
SPSNR-NN	-11.2%	-6.6%	-7.2%
SPSNR-I	-10.8%	-6.5%	-7.2%
CPP-PSNR	-10.8%	-7.0%	-7.8%
<i>Dyn. Viewports</i>			
Viewport0	-21.4%	-11.9%	-12.6%
Viewport1	-14.9%	-6.1%	-6.6%

Thanks to InterDigital (JVET-G0133) for cross-check



# Results (2)

Conversion-only results:

Not padded:

ECP conversion (without padding)	Face W	Face H	WS-PSNR (End to End)		
			Y	U	V
Trolley	1184	1184	45.03	57.96	57.87
GasLamp	1184	1184	50.13	58.76	57.58
Skateboarding_in_lot	1184	1184	49.99	61.49	61.12
Chairlift	1184	1184	50.16	59.47	59.53
KiteFlite	1184	1184	45.97	57.66	57.66
Harbor	1184	1184	48.90	59.13	58.07
PoleVault	960	960	50.70	51.66	53.50
AerialCity	960	960	47.90	55.89	55.19
DrivingInCity	960	960	52.45	59.56	59.05
DrivingInCountry	960	960	49.01	60.64	60.63
Overall			49.03	58.22	58.02

Padded:

ECP conversion (padding)	Face W	Face H	WS-PSNR (End to End)		
			Y	U	V
Trolley	1184	1184	44.95	57.94	57.84
GasLamp	1184	1184	50.05	58.74	57.56
Skateboarding_in_lot	1184	1184	49.91	61.46	61.08
Chairlift	1184	1184	50.08	59.43	59.50
KiteFlite	1184	1184	45.89	57.63	57.63
Harbor	1184	1184	48.83	59.10	58.04
PoleVault	960	960	49.36	49.96	51.77
AerialCity	960	960	47.02	54.86	54.16
DrivingInCity	960	960	51.17	58.60	58.10
DrivingInCountry	960	960	47.72	59.41	59.40
Overall			48.50	57.71	57.51

Thanks to InterDigital (JVET-G0133) for cross-check

# Results

Comparison with other projections:

Projection	SPSNR-NN (End to End)			SPSNR-I (End to End)			CPP-PSNR (End to End)			WS-PSNR (End to End)		
	Y	U	V	Y	U	V	Y	U	V	Y	U	V
OHP1 vs ERP	-2.1%	1.6%	0.5%	-2.1%	1.4%	0.3%	-2.1%	1.4%	0.3%	-2.2%	1.5%	0.4%
CMP vs ERP	-3.6%	-2.4%	-2.4%	-3.5%	-2.6%	-2.6%	-3.5%	-2.6%	-2.6%	-3.5%	-2.5%	-2.5%
ISP1 vs ERP	-5.1%	-0.3%	-1.2%	-5.0%	-0.4%	-1.3%	-5.1%	-0.5%	-1.4%	-5.2%	-0.4%	-1.3%
SSP vs ERP	-9.6%	-3.0%	-3.6%	-9.3%	-3.2%	-3.7%	-9.3%	-3.3%	-3.9%	-9.7%	-2.9%	-3.5%
RSP vs ERP	-9.8%	-5.0%	-5.1%	-9.6%	-5.1%	-5.3%	-9.7%	-5.2%	-5.4%	-9.9%	-5.1%	-5.2%
ACP vs ERP	-11.1%	-6.2%	-6.3%	-11.0%	-6.3%	-6.4%	-11.0%	-6.3%	-6.5%	-11.0%	-6.1%	-6.3%
<b>G0074 vs ERP</b>	<b>-11.3%</b>	<b>-6.2%</b>	<b>-6.7%</b>	<b>-11.2%</b>	<b>-6.5%</b>	<b>-7.0%</b>	<b>-11.2%</b>	<b>-6.5%</b>	<b>-7.0%</b>	<b>-11.3%</b>	<b>-6.3%</b>	<b>-6.8%</b>

# Conclusion

- Padded ECP was proposed
- Coding gain without padding is 11.3% (e2e WS-PSNR) compared with ERP for RA conditions; coding gain with padding (4 samples width) is 11.2% (e2e WS-PSNR)
- Requested to include padded ECP into the next version of 360Lib for further exploration of 360-degree video coding