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DENVER, CO  
OCTOBER 17-20





TAKING A CLOSER LOOK AT HDR

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# HDR for HD and Streaming

**Sean McCarthy, Ph.D.**

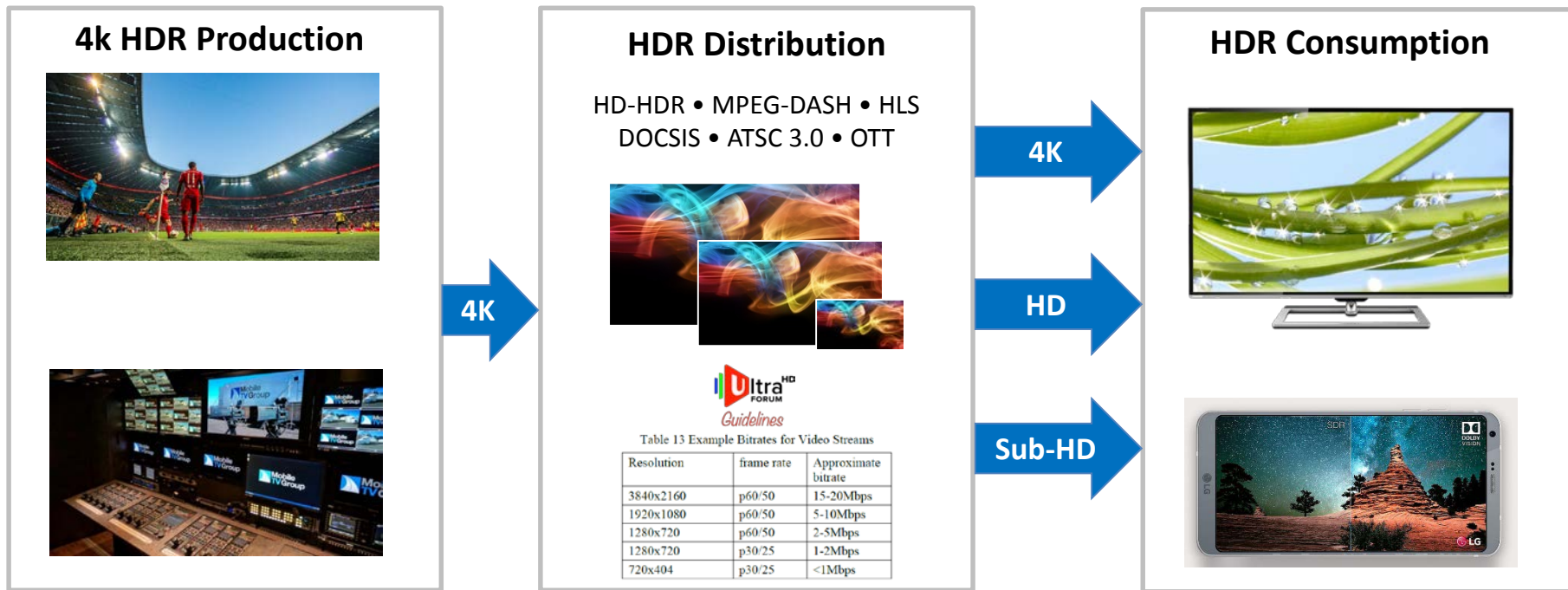
Independent

Sean McCarthy, Ph.D. Consulting



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OCTOBER 17-20

## HDR is Not Just for 4K Anymore



## HDR Quality & Consistency

How can we deliver consistently great multi-resolution HDR experiences across big and small displays?



## HDR Quality & Consistency



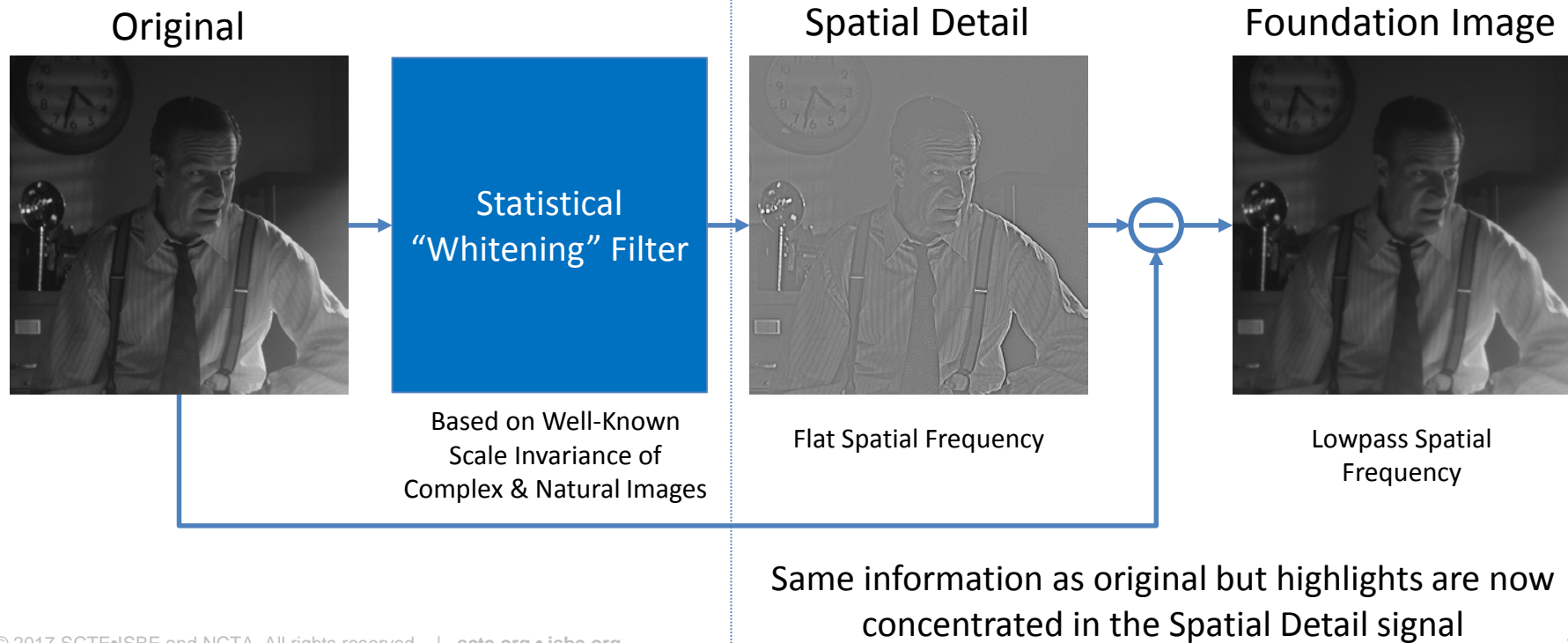
Find the Best  
Combinations of  
Bitrate and  
Resolution



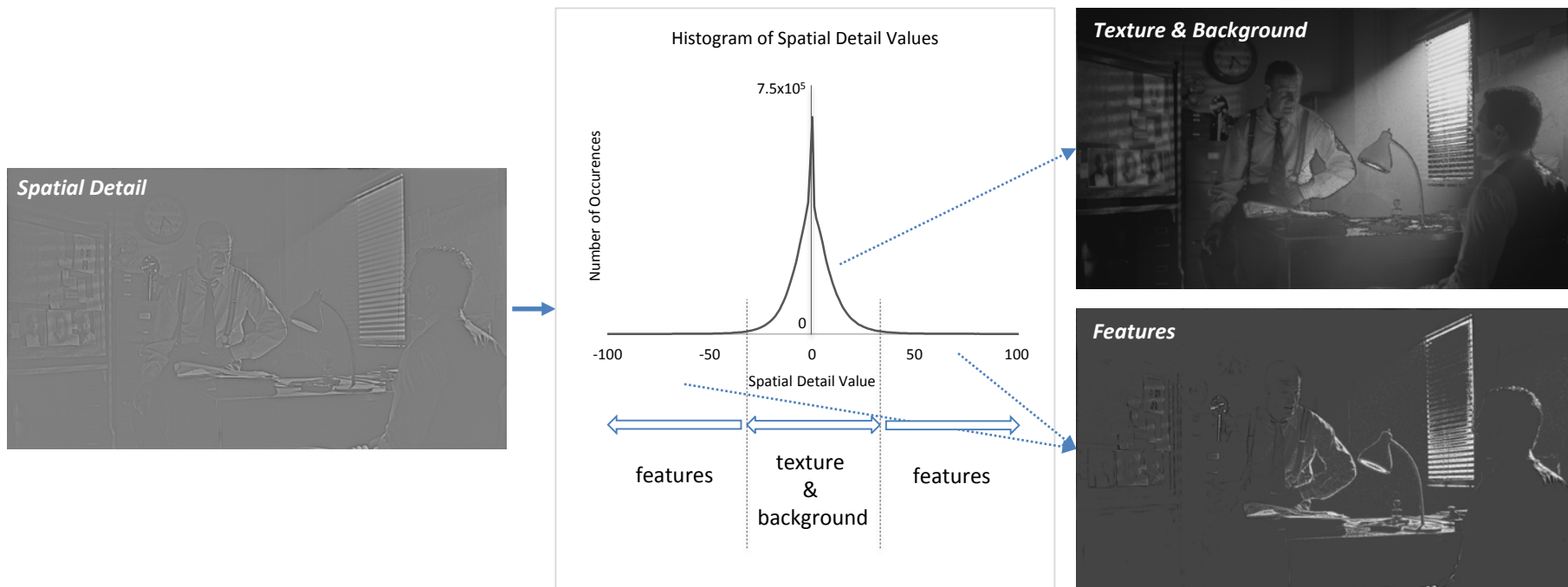
## Method to Pick the Best Bitrate-Resolution Combinations

- Represent HDR video as the sum of 2 components
  - Spatial Detail – localized contrast variations
  - Foundation Image – broader smoother contrast variations
- Spatial Detail captures most of the HDR distortion introduced in encoding
- Measure the statistical correlation between encoded and original Spatial Detail signals for many bitrate-resolution combinations
- Find the bitrate-resolution pairs that maximize correlation (minimizes HDR distortion)
- Methodology is intrinsically independent of HDR transfer characteristics (PQ, HLG, etc.)

## Spatial Detail and Foundation Image

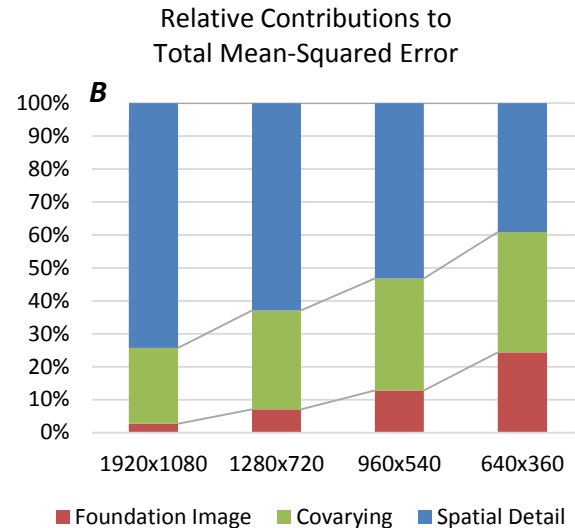
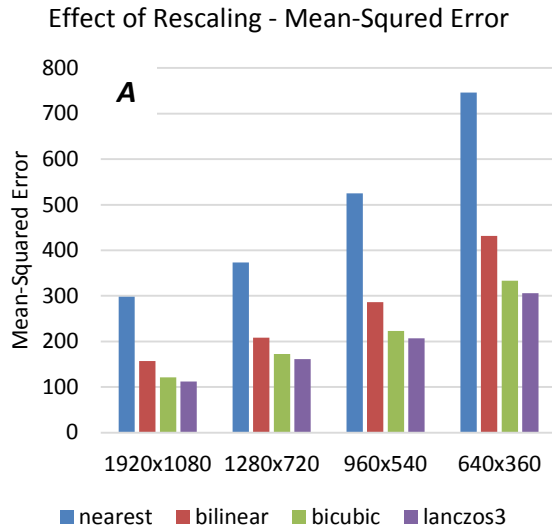


## Spatial Detail as Guide to Features, Textures & Background

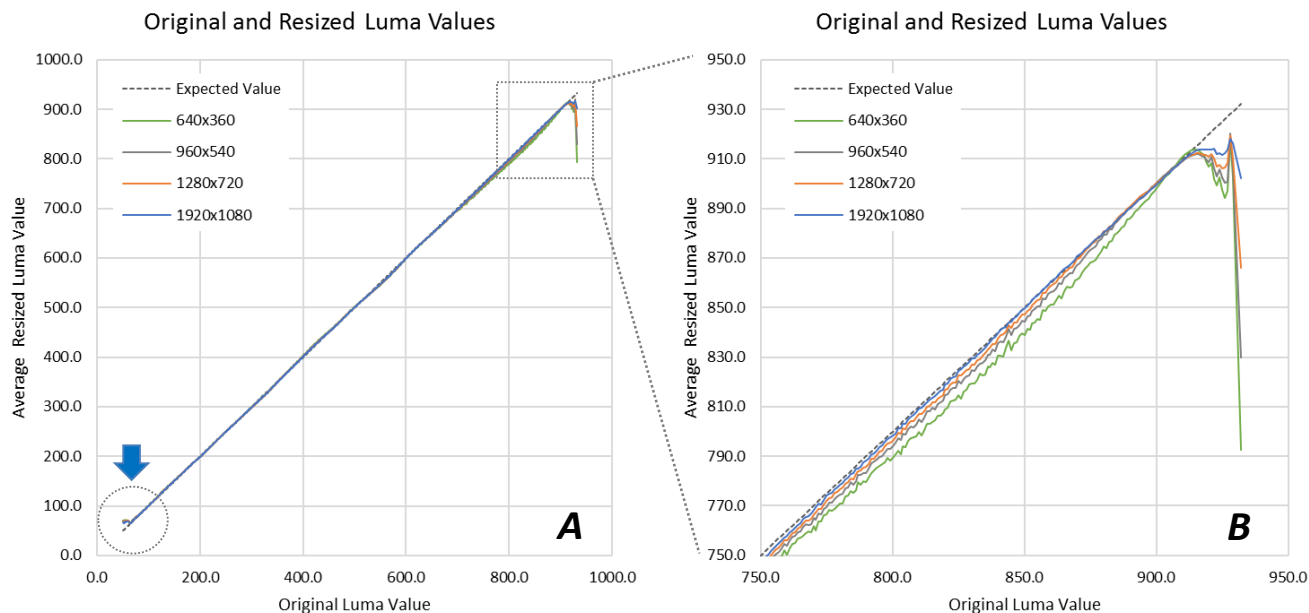




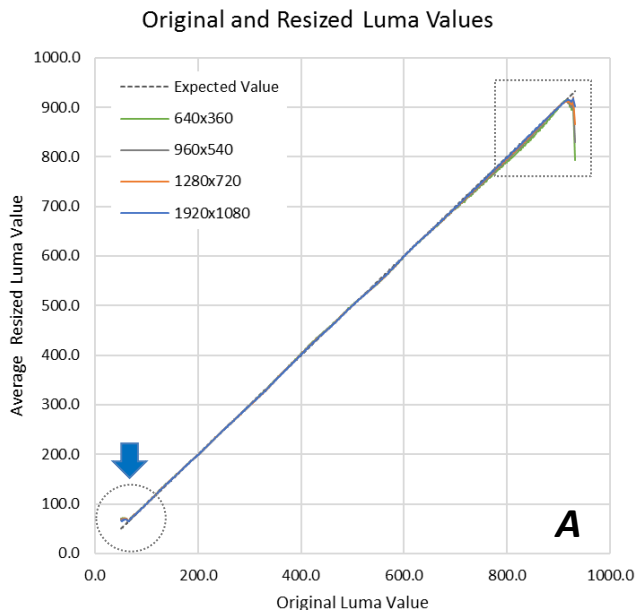
## Spatial Detail Contributes Most to Distortion



## Rescaling Affects Extremes of Luma



## Rescaling Affects Extremes of Luma



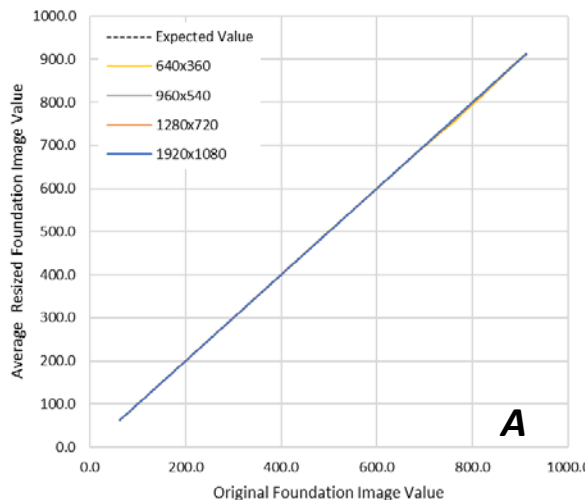
Very bright and dark distortions appear to be a result of spatial averaging during resizing.

Small features having bright & dark values tend to average with other regions nearer the midtones.

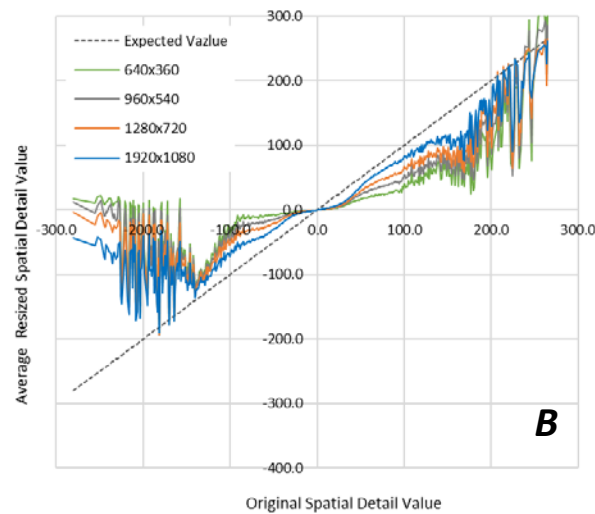
Indicates an opportunity to design a better HDR-sensitive resizing algorithm!

## Spatial Detail Captures Almost All Distortion

Original and Resized Foundation Image  
Luma Values



Original and Resized Spatial Detail Values



## Spatial Detail Correlation for Bitrate-Resolution Pairs

### Test content for bitrate-resolution tests

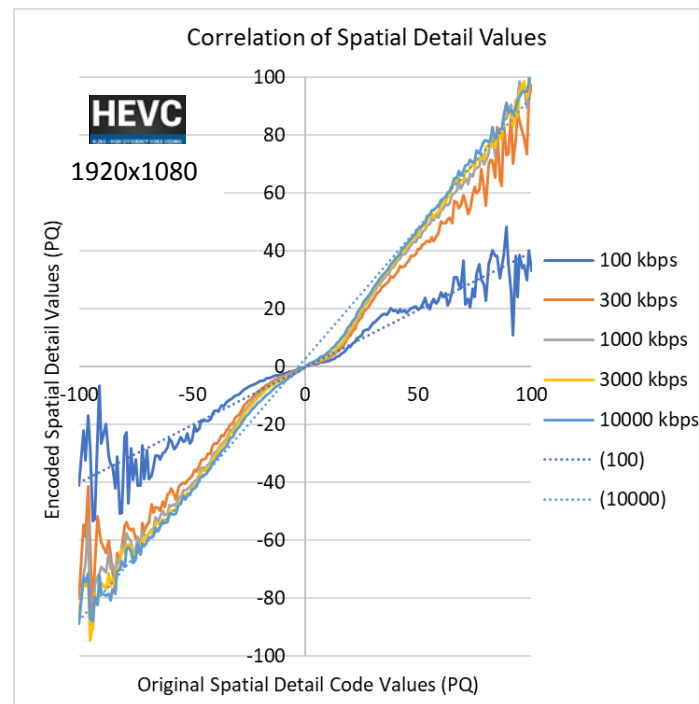


Cinematic Wide Gamut HDR-Video  
for the Evaluation of Tone Mapping  
Operators and HDR-Displays

1920x1080p24 color graded for Rec.2020  
primaries & 0.005-4000cd/m<sup>2</sup> luminance

J. Froehlich, et al. "HdM-HDR-2014 Project,"  
<http://www.hdm-stuttgart.de/~froehlichj/hdm-hdr-2014>

30 bitrate-resolution  
combinations for each  
test sequence

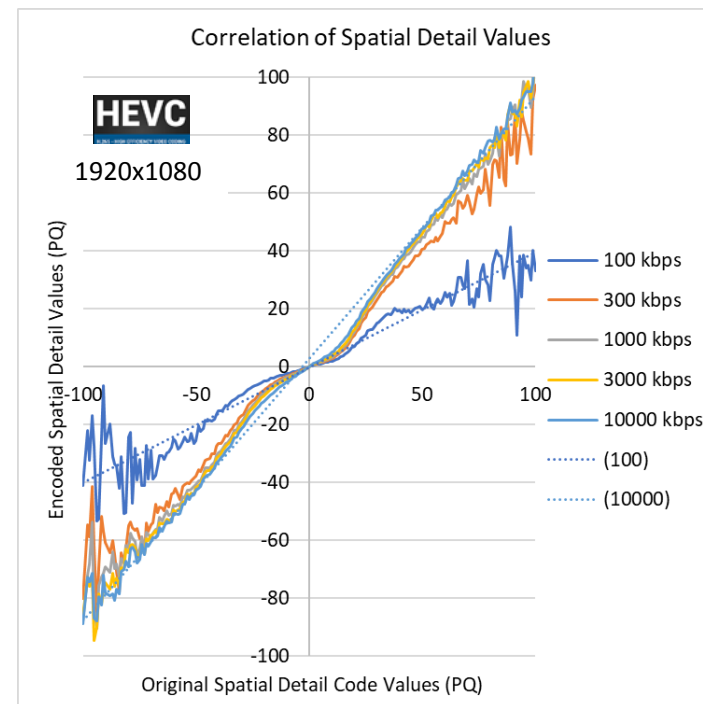


## Spatial Detail Correlation and HEVC Compression

Note decrease of slope and increase in variability with decreasing bitrate

Decrease in slope indicate loss of localized contrast

Increase in variability indicates increased distortion and decreased correlation

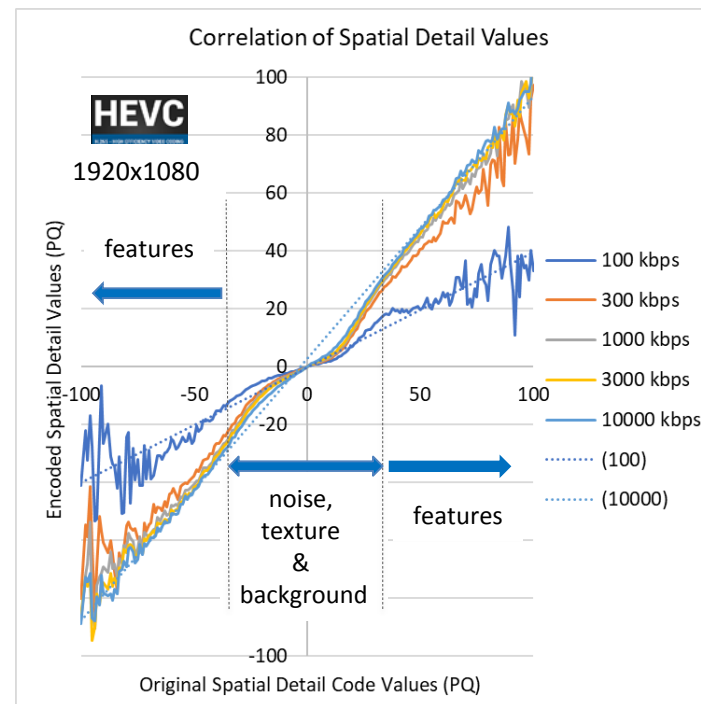


# Spatial Detail Correlation and HEVC Compression

Plots like these can be used as an engineering tool.

They indicate the relative distortion in noise, textures, and features.

Plots like these can help developers optimize algorithm and help compressionists optimize encoder settings



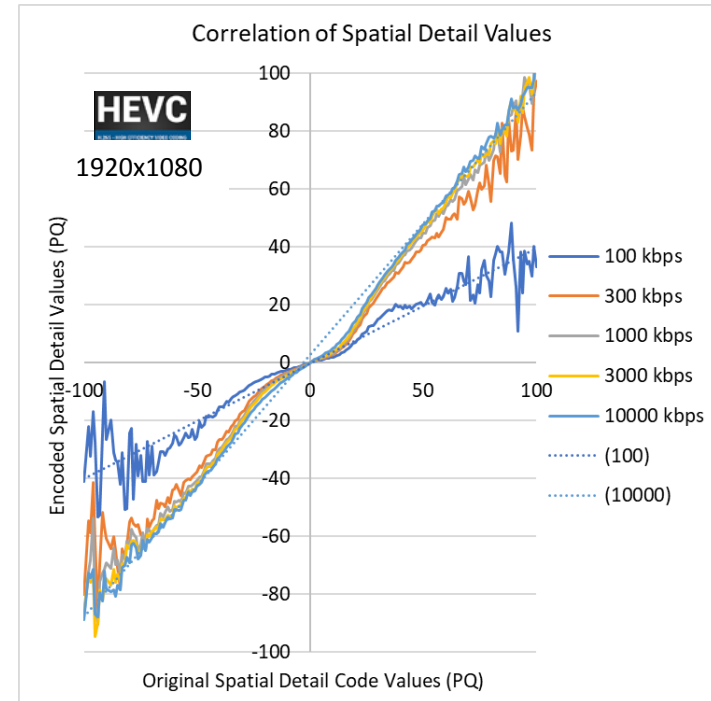
## Spatial Detail Correlation and HEVC Compression

Coefficient of Determination

$$R^2$$

quantifies correlation

Increase in variability indicates  
increased distortion and decreased  
correlation





## Spatial Detail Correlation and Best Bitrate-Resolution Pairs

$R^2$

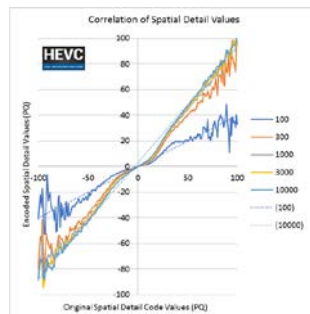
### Average Spatial Detail Correlation

Resolution	Bitrate (kbps)				
	100	300	1000	3000	10000
1920x1080	0.900	0.933	0.946	0.966	0.983
1440x1080	0.893	0.939	0.949	0.968	0.982
1280x720	0.919	0.942	0.955	0.965	0.976
960x540	0.903	0.934	0.946	0.955	0.962
720x540	0.892	0.924	0.935	0.943	0.950
640x360	0.869	0.897	0.902	0.909	0.914

These results are for the **average over all test content**.  
 But some content could benefit from lower or higher resolution encoding



Find the Best Combinations of Bitrate and Resolution



## Content-Aware “Per-Title” Best Bitrate-Resolution Pairs

Tables like these can be used to customize encoder setting to optimize per-title encoding ladders.



Resolution	bistro					carousel_fireworks				
	100	300	1000	3000	10000	100	300	1000	3000	10000
1920x1080	0.958	0.987	0.995	0.997	0.999	0.841	0.848	0.878	0.942	0.985
1440x1080	0.956	0.990	0.995	0.997	0.998	0.848	0.879	0.898	0.956	0.989
1280x720	0.979	0.990	0.993	0.995	0.996	0.841	0.901	0.932	0.966	0.986
960x540	0.963	0.985	0.987	0.988	0.988	0.860	0.906	0.927	0.948	0.968
720x540	0.966	0.983	0.988	0.988	0.989	0.866	0.916	0.931	0.946	0.960
640x360	0.950	0.966	0.967	0.967	0.968	0.869	0.912	0.920	0.927	0.929

## Discussion

### 4k HDR Production



### Take-Home Message

Spatial Detail Correlation Analysis Provides:

A Method to Choose Bitrates for HD-HDR

A Method to Optimize HDR Encoding Ladders

Resolution	bistro					carousel_fireworks				
	100	300	1000	3000	10000	100	300	1000	3000	10000
1920x1080	0.958	0.987	0.995	0.997	0.999	0.841	0.848	0.878	0.942	0.985
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1280x720	0.979	0.990	0.993	0.995	0.996	0.841	0.901	0.932	0.966	0.986
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720x540	0.966	0.983	0.988	0.988	0.989	0.866	0.916	0.931	0.946	0.960
640x360	0.950	0.966	0.967	0.967	0.968	0.869	0.912	0.920	0.927	0.929

### HDR Consumption



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**THANK YOU!**

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