

Study of the Carrier Signal in Multi-resolution Frame- Compatible (MFC)



Outline

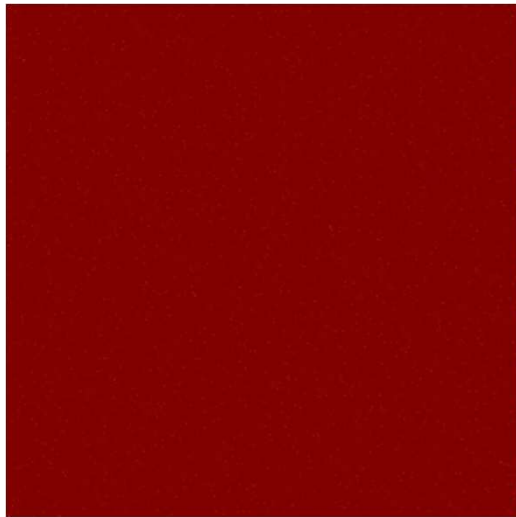
- MFC Design
- Study of Carrier Signal
 - F0 versus DC
 - In DC case, MVC versus Simulcast
- Conclusion

MFC Summary

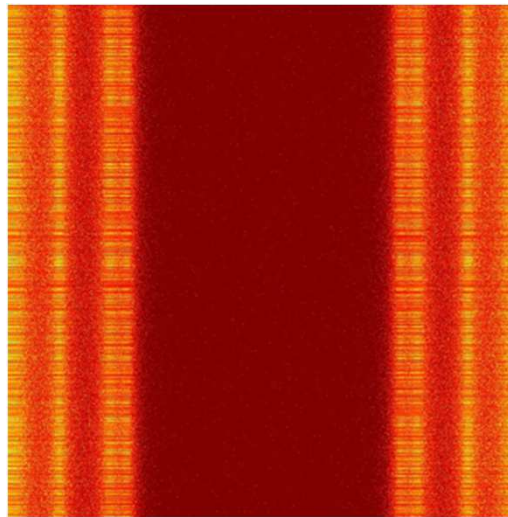
Overviews of multi-resolution frame compatible (MFC) stereo coding

- Reconstructs full resolution stereo 3D video while maintaining backwards compatibility with FC
- Achieves significant picture quality improvement over the FC anchors even with a low overhead (e.g., ~25% of FC bitrate)
- Built upon MVC Stereo High Profile of AVC
- Requires very simple syntax changes at high level
- Marginal increase of complexity c.f MVC decoding
- PDAM5 of MVC

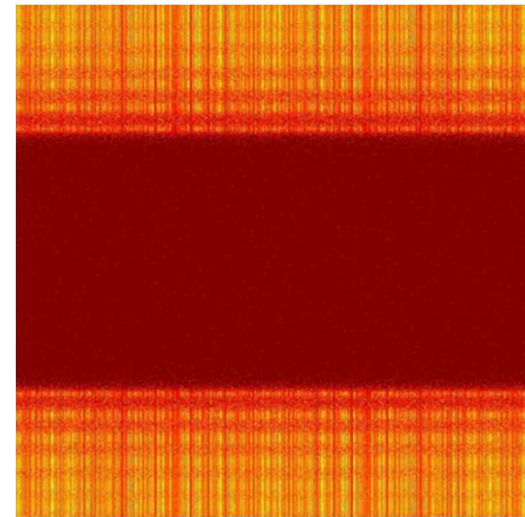
Spectrum Visualization: FC 3D-muxing in Frequency Domain



original frequency spectrum
(a “flat” spectrum)



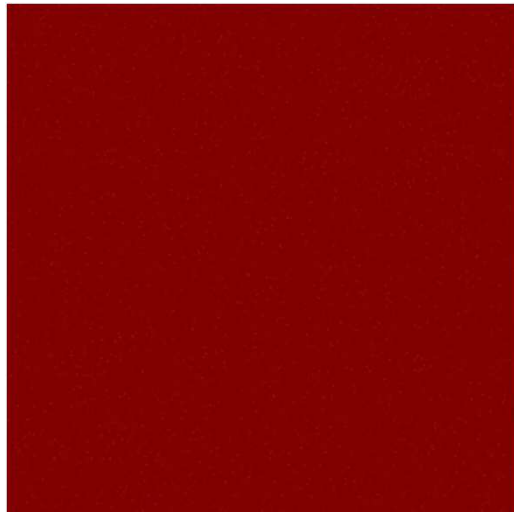
frequency spectrum after
demuxing from SbS-packing



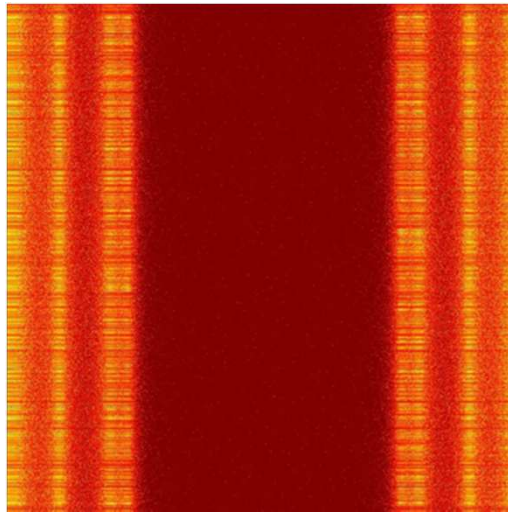
frequency spectrum after
demuxing from TaB-packing

- SbS preserves vertical frequencies
- TaB preserves horizontal frequencies

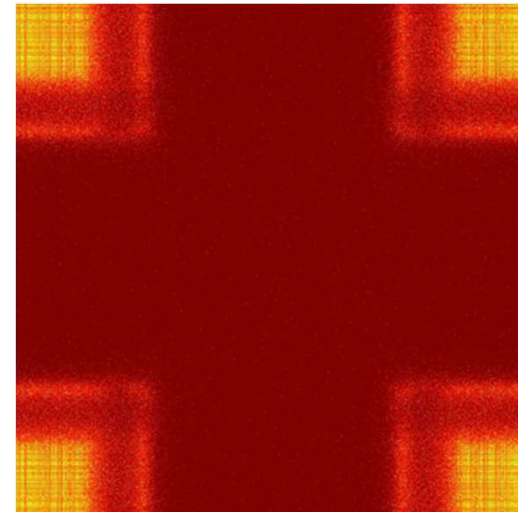
Spectrum Visualization: FC (SbS) vs. MFC in Frequency Domain



original frequency spectrum
(a "flat" spectrum)



frequency spectrum after
demuxing from SbS-packing



frequency spectrum after
MFC reconstruction

Design Choices

- Target: to bring back the missing high frequencies in the orthogonal direction of the FC base layer.
- Complexity constraint: minimum change to existing decoder/encoder implementations
- Two frameworks tested
 - Scalable solution
 - Simulcast solution
- Scalable solution:
 - Picture mode: prediction in pixel domain, most commonly used in scalable framework
 - Inter-layer prediction is used to explore redundancy existed in BL and EL
 - Diff mode: prediction in difference domain (residue)
 - Residue signal: EL picture - converted BL picture
 - SHVC explores the combination of two modes in some variation.
 - Our solution in PDAM5 is a tradeoff between the two modes.
- Simulcast solution
 - Pure diff mode only (i.e., EL input is a residue signal picture)

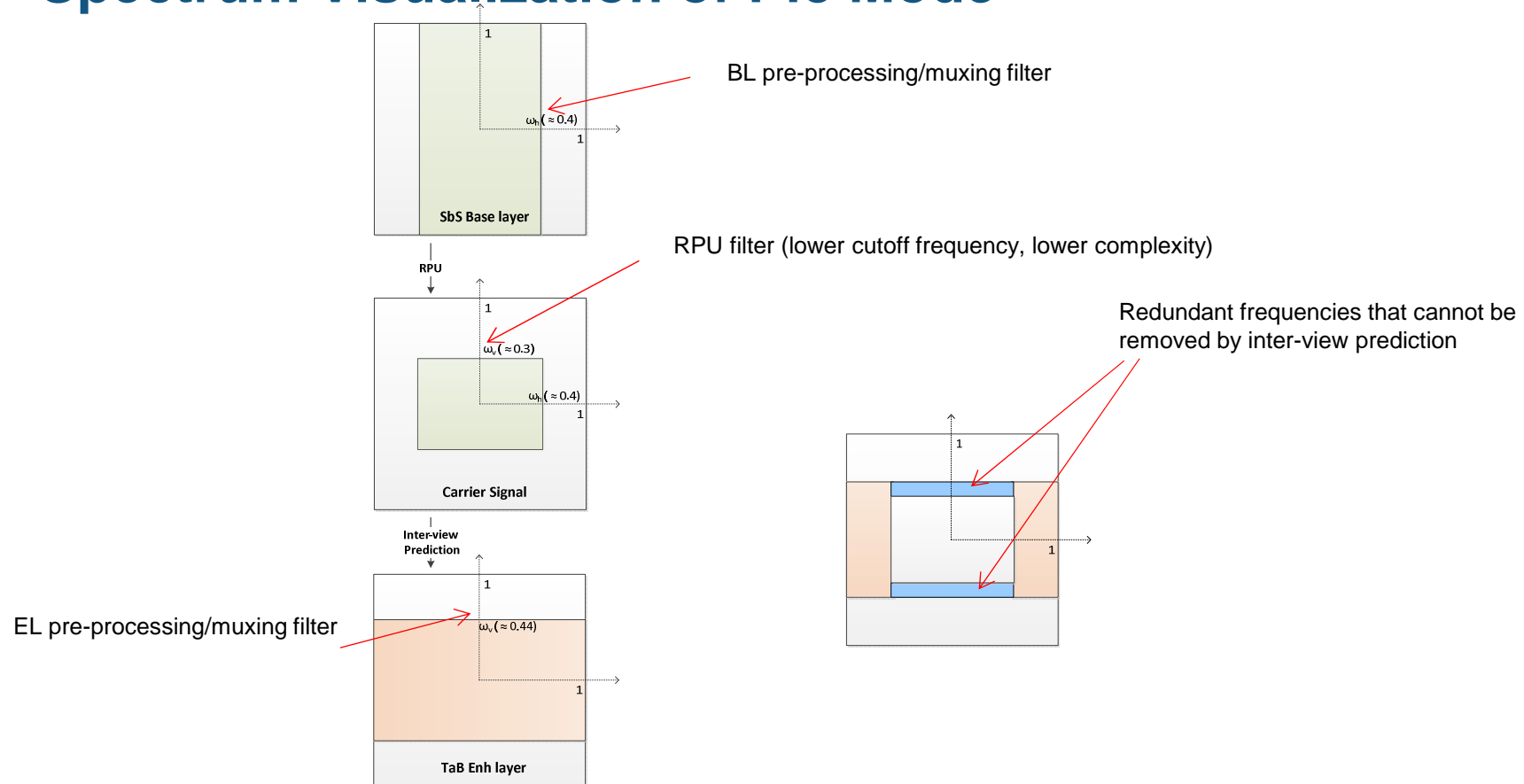
Scalable Solution (MVC based)

- Inter-layer reference processed by Reference Processing Unit (RPU) for better prediction
- Assuming BL is SbS FC format

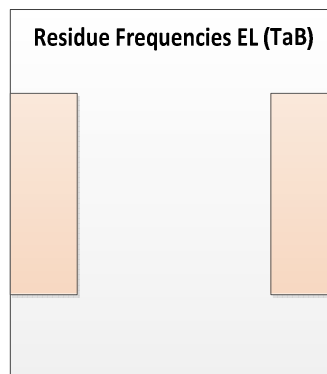
	EL input	Inter-view prediction reference	RPU	Full Resolution Reconstruction: only high frequency info needed
Pic Mode	TaB FC picture	RPU converts SbS BL to TaB as reference	1D downsampling filter + 1D upsampling filter	Needs to subtract low frequency signal
Diff Mode	TaB FC residue + 128	Uses flat gray picture as reference, i.e., to encode residue directly without prediction	Set pixel values to 128	Subtract 128

- Can we do better?

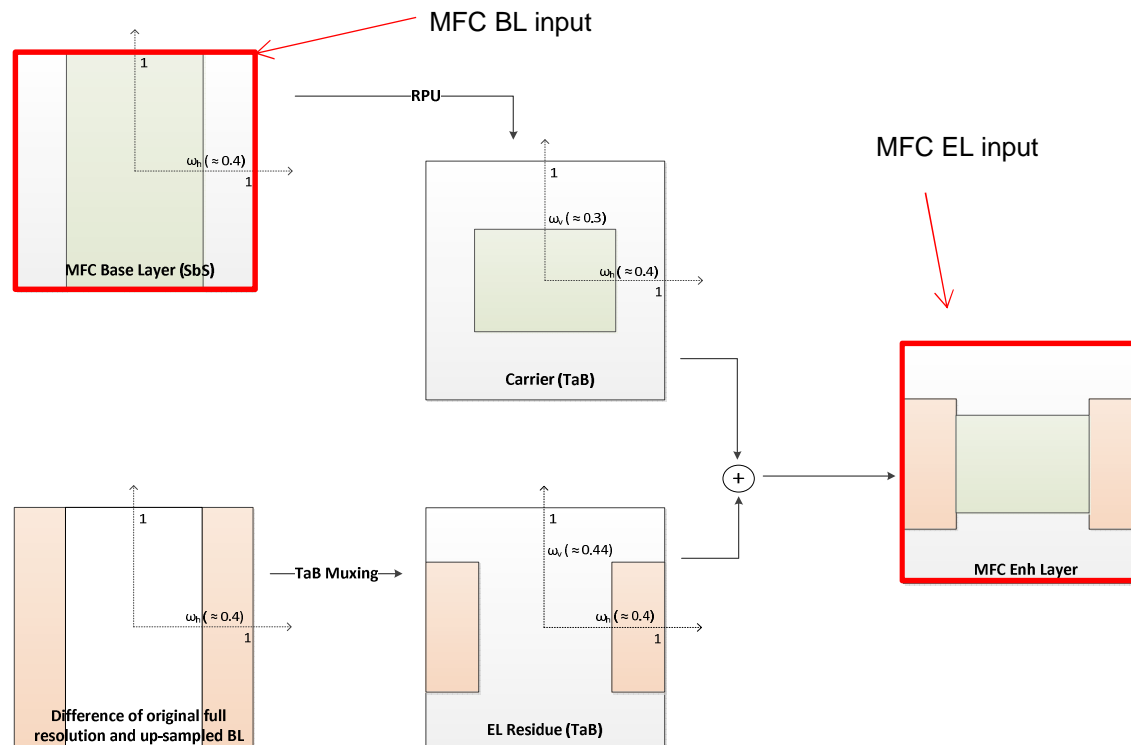
Spectrum Visualization of Pic Mode



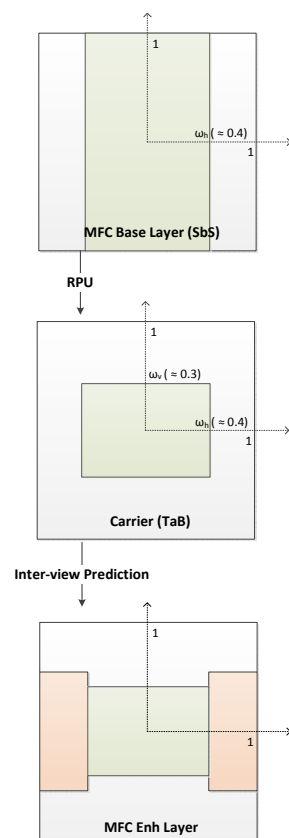
Visualization of Diff Mode



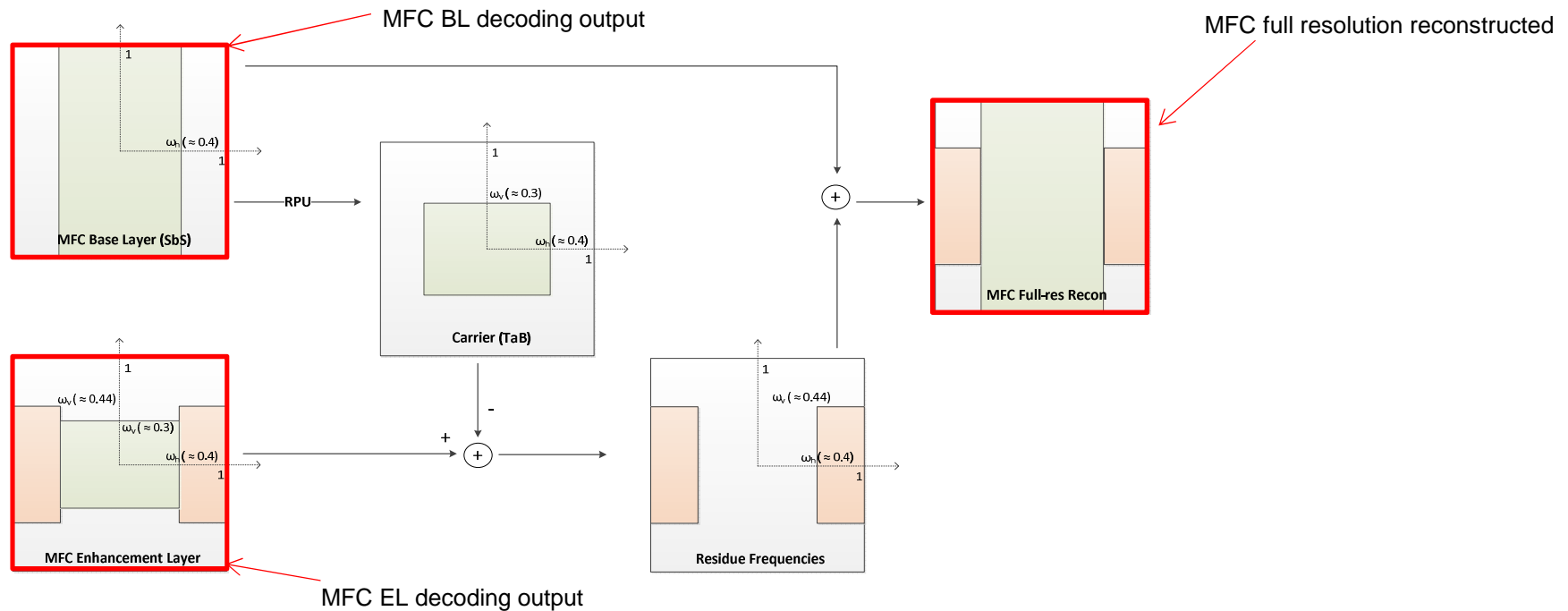
Visualization of MFC – Input Generation



Spectrum Visualization of MFC – Coding Loop



Spectrum Visualization of MFC – Reconstruction



MFC Solution

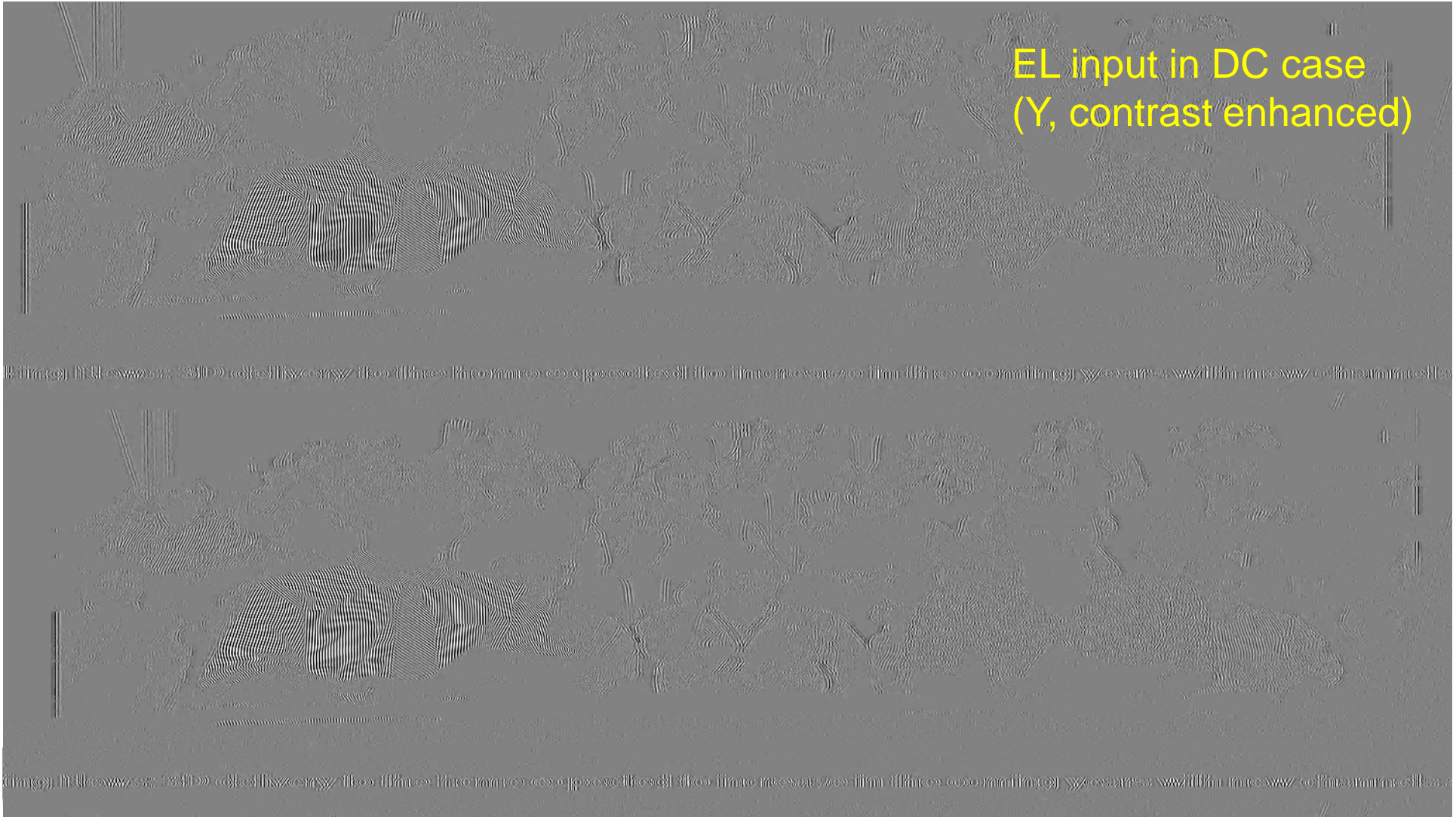
- Design Consideration
 - Improve coding efficiency with better prediction
- Form a new EL input signal
 - Residue + Carrier signal
 - Carrier signal is generated by RPU with a low pass filter
 - Extreme case: flat gray picture, where EL input is just the residue picture
 - At reconstruction, carrier signal is subtracted from the decoded EL picture
 - Non-normative, up to encoder implementation
- Low-frequency content brought by carrier signal exists in both EL input and RPU inter-view reference
 - Efficiently predicted by inter-view prediction
 - Low-frequency content in general is easy to encode by inter/intra prediction

MFC Solution in CfP (m26661)

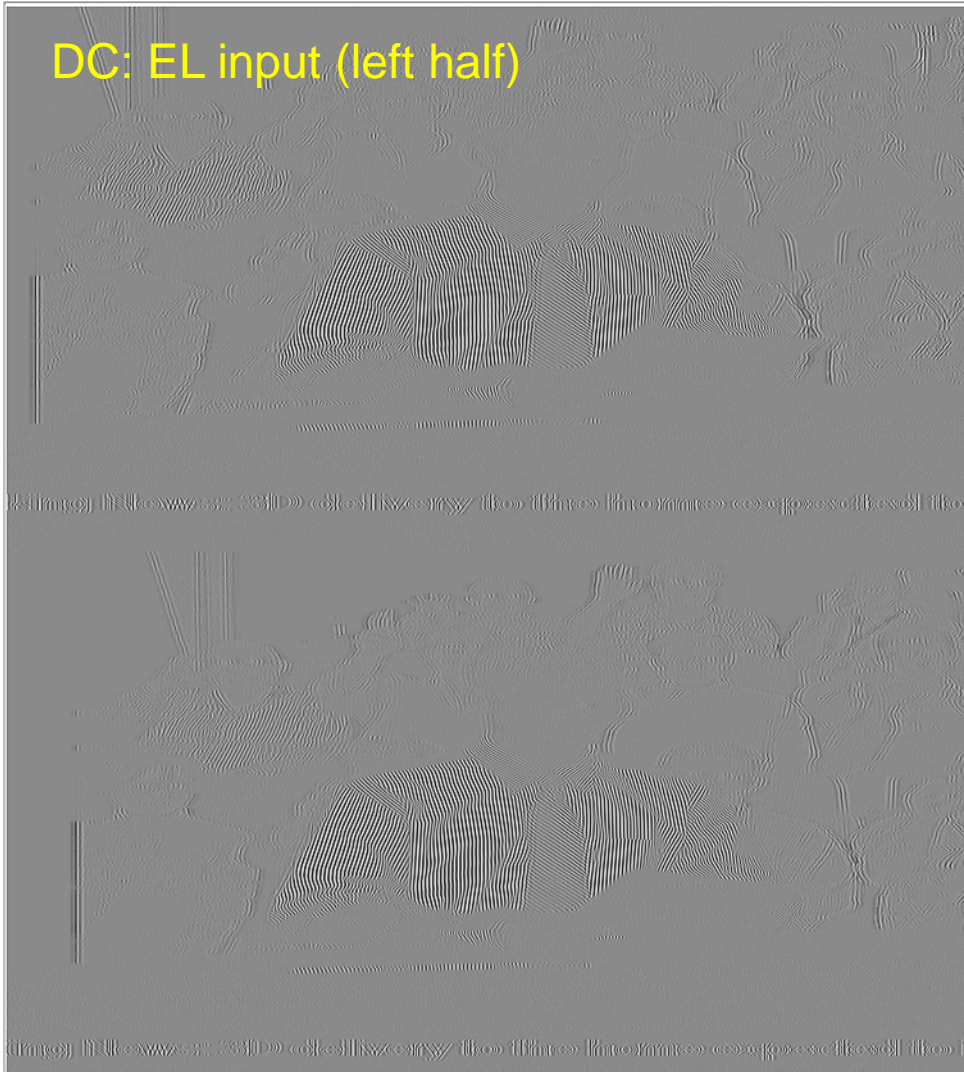
- Naming convention for the two carrier signal cases:

	Carrier signal	CfP Performance	MFC Spec
F0	Format converted through 1D downsampling filter (5 tap) + 1D upsampling filter (6 tap)	Higher efficiency with acceptable complexity	Yes. Adopted after AHG discussion at the 102nd MPEG
DC	Flat gray picture where pel values set to 128	Lower complexity with sacrificed coding efficiency	No. Removed after AHG discussion at the 102nd MPEG meeting

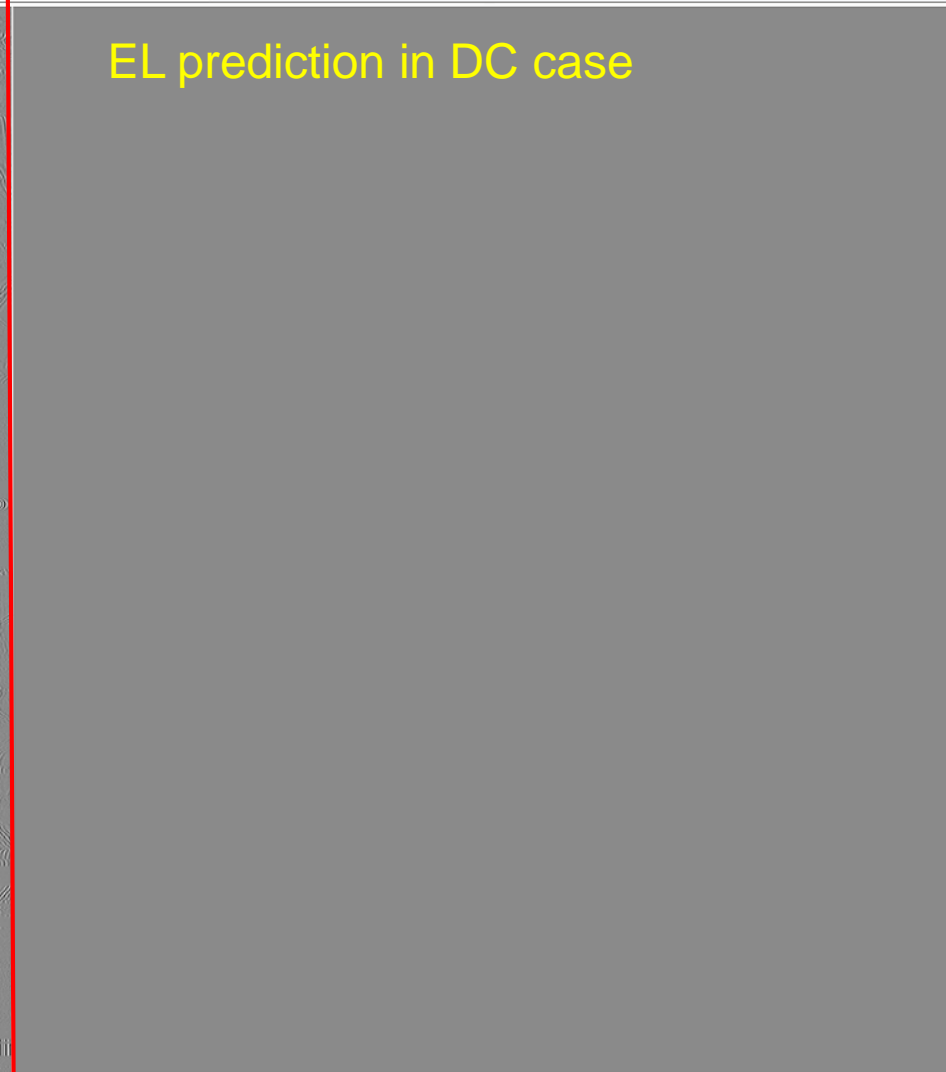
EL input in DC case
(Y, contrast enhanced)



DC: EL input (left half)



EL prediction in DC case



EL input in F0 case
(Y, contrast enhanced)

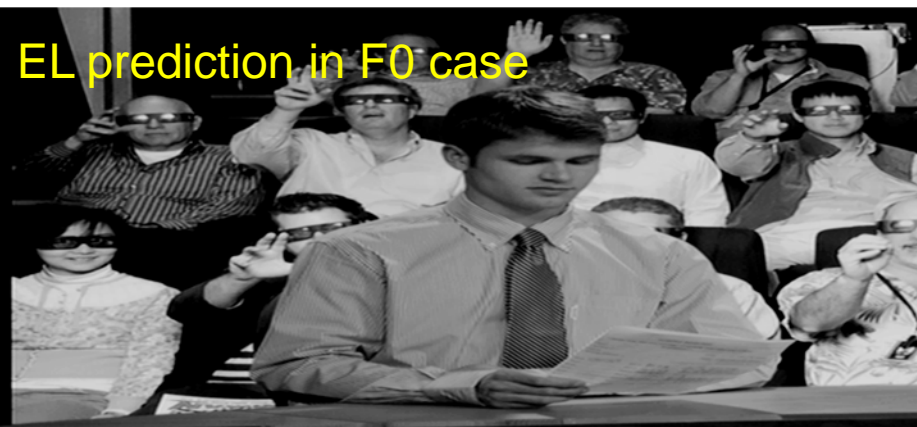
ing News: 3D delivery to the home expected to increase in the coming years with new channels

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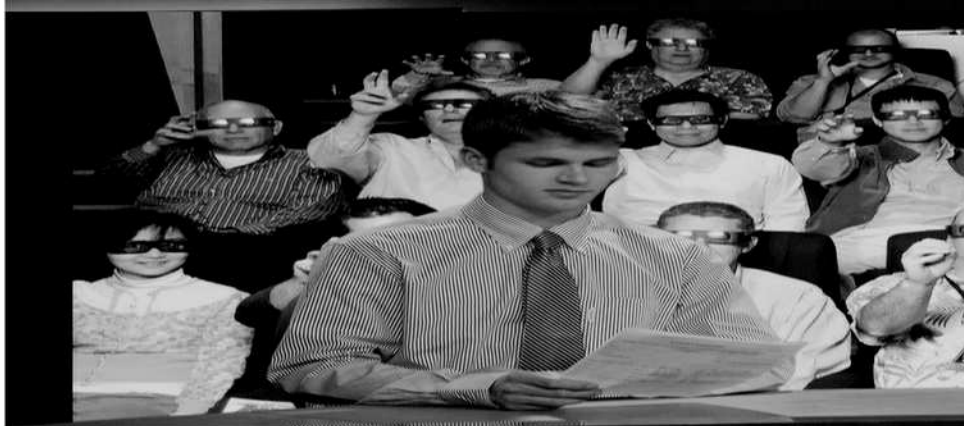
F0: EL input (left half)



EL prediction in F0 case



ing News: 3D delivery to the home expected to

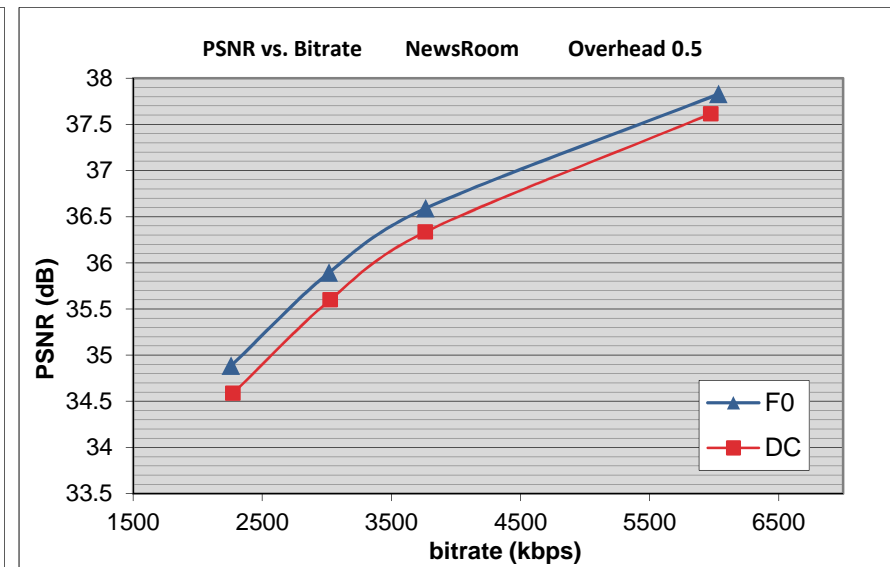
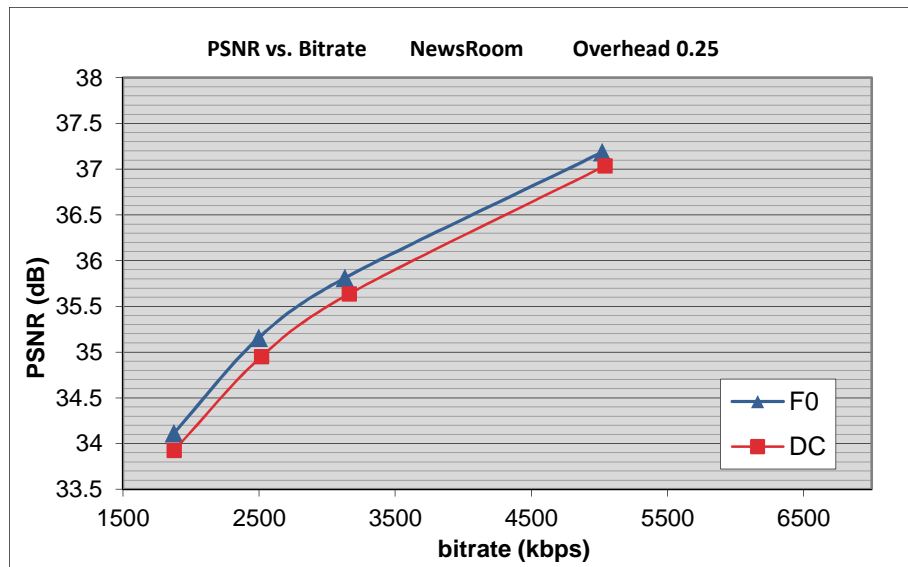


ing News: 3D delivery to the home expected to

Simulation Results

- Simulations have been conducted on the CfP sequences and broadcaster provided sequences.
- F0 provides substantial bitrate reduction when content carries a lot of high frequencies.
- Official MPEG subjective evaluation: improvement of visual quality by MFC is more appreciated in content carrying more high frequencies.
 - Viewers could easily distinguish the missing high frequencies brought back by MFC
 - Otherwise, it suggests an encoding to be optimized to spend more bits in the base layer.
 - Out of the scope of the problem that MFC is to solve.

RD Comparison



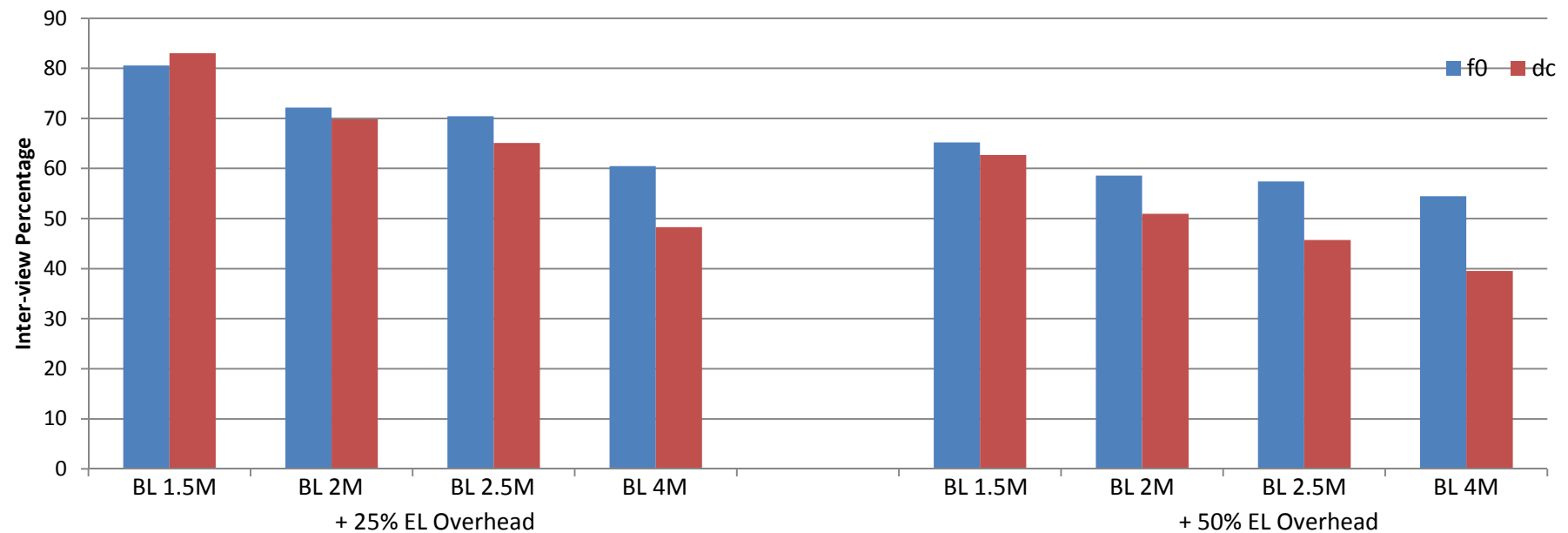
F0 shows more than 6% and 8% BD rate gain over DC for 25% and 50% overhead.

Observations from Statistical Analysis

- For content containing a lot of high frequencies, compare F0 and DC encoding at a same bitrate
 - Using F0 results in smaller residue energy and much fewer number of coded bits for transform coefficients
 - Better prediction reduces residue energy
 - Using F0 yields higher percentage of inter-view prediction than using DC
 - Better takes advantage of MVC framework

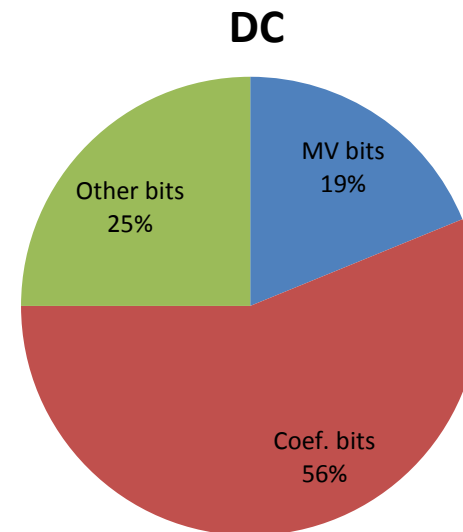
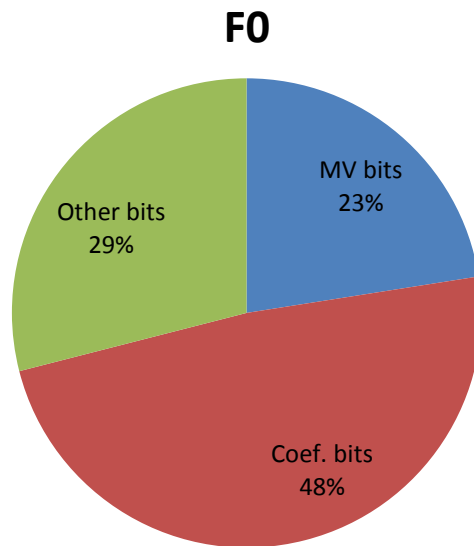
Inter-view Prediction Percentage

■ Newsroom



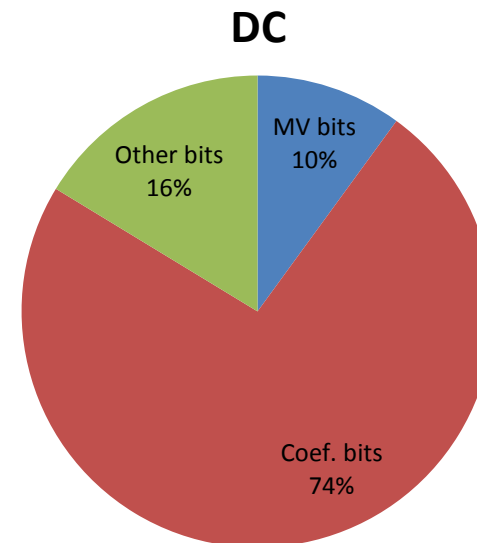
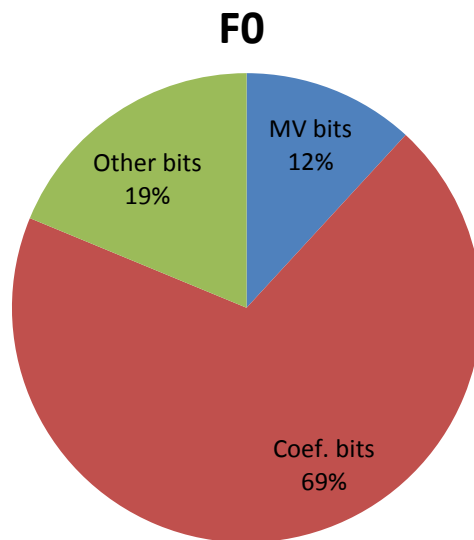
Bit Usage Statistics (lowest total bitrate)

- Newsroom 1.5M + 25% EL

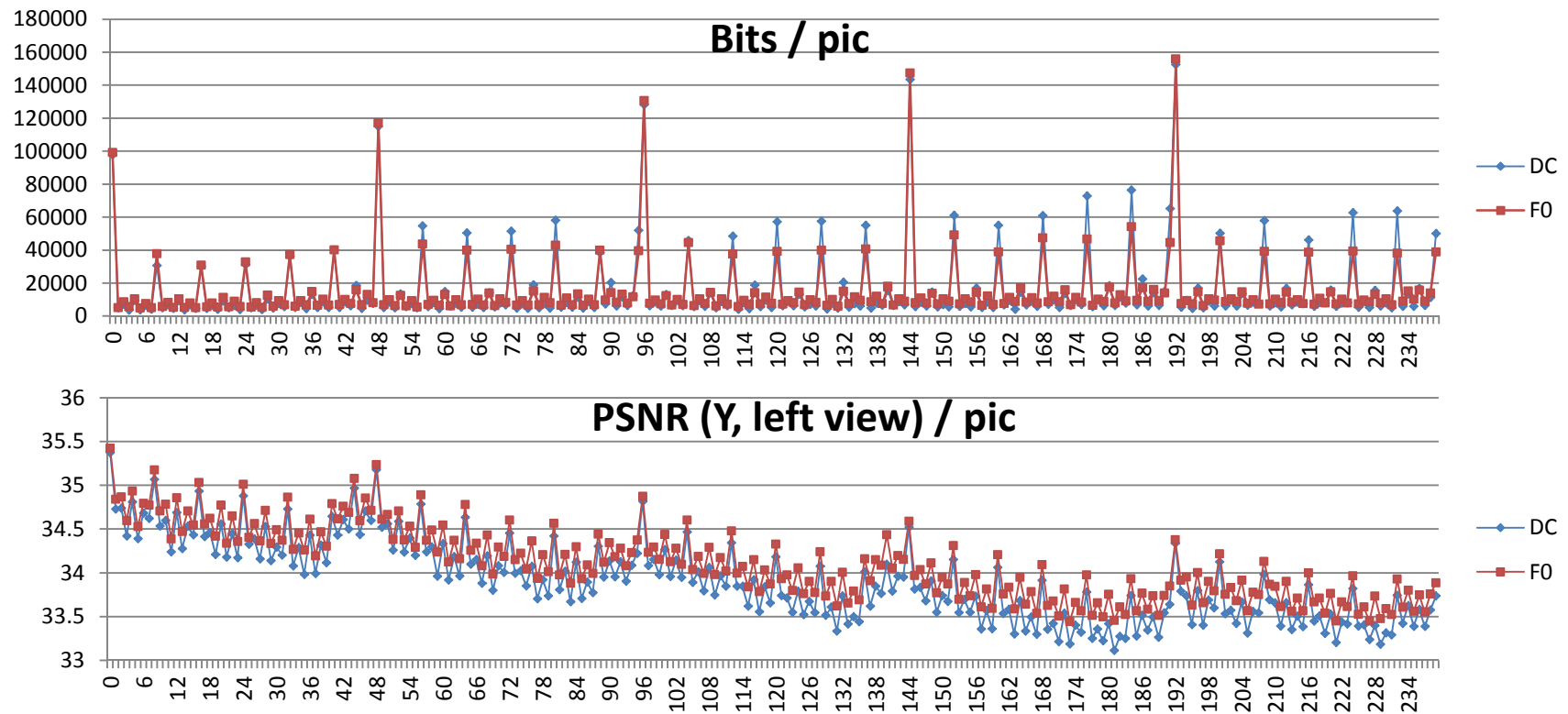


Bit Usage Statistics (highest total bitrate)

- Newsroom 4M + 50% EL



Newsroom 1.5Mbps 25% EL overhead



Scalable vs. Simulcast

- Even in DC case, MVC offers a mode to code residual signal directly without prediction.
 - Provide additional gain when inter/intra prediction on residual signal is not as efficient.
 - More efficient than Intra DC mode.
 - Added complexity is low by simply forcing inter-view prediction motion vectors to be zero (or using MV predictor).
 - Almost no performance change.

Conclusion

- MFC solution in the current spec provides noticeable gain in coding efficiency when MFC produces visible picture quality improvement over frame-compatible based layer.
- It is beneficial to use the low-frequency carrier signal in the MFC framework.

Acknowledgement

- We would like to thank Alexis Tourapis, Gary J. Sullivan and Jizheng Xu for inspirational discussion.