

JVT-T080: Preliminary Results for an R-D optimized multi-loop SVC Encoder

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Introduction



Spatial scalable / CGS coding

- Layered approach
- In each layer: MCP, intra-prediction
- Additional inter-layer prediction mechanisms
- Current design allows single-loop decoding
- Encoder need to be operated in a multi-loop mode



JSVM encoder control

- Lagrangian bit-allocation techniques
- Bottom-up encoding process
- Encode base layer:
 - Coding parameters are optimized for the base layer
- Encode enhancement layer
 - Base layer coding parameters are given
 - Coding parameters are optimized for the enhancement layer

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JSVM encoder control

- Determination of base layer coding parameters

$$\mathbf{p}_0 = \arg \min_{\{\mathbf{p}_0\}} [D_0(\mathbf{p}_0) + \lambda_0 \cdot R_0(\mathbf{p}_0)]$$

- Determination of enhancement layer coding parameters

$$\mathbf{p}_i = \arg \min_{\{\mathbf{p}_i | \mathbf{p}_{i-1} \dots \mathbf{p}_0\}} [D_i(\mathbf{p}_i | \mathbf{p}_{i-1} \dots \mathbf{p}_0) + \lambda_i \cdot R_i(\mathbf{p}_i | \mathbf{p}_{i-1} \dots \mathbf{p}_0)]$$

- All enhancement layer decisions are conditioned on already determined base layer coding parameters
- Effective use of base layer rate for the enhancement layer coding is limited

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JSVM coding efficiency

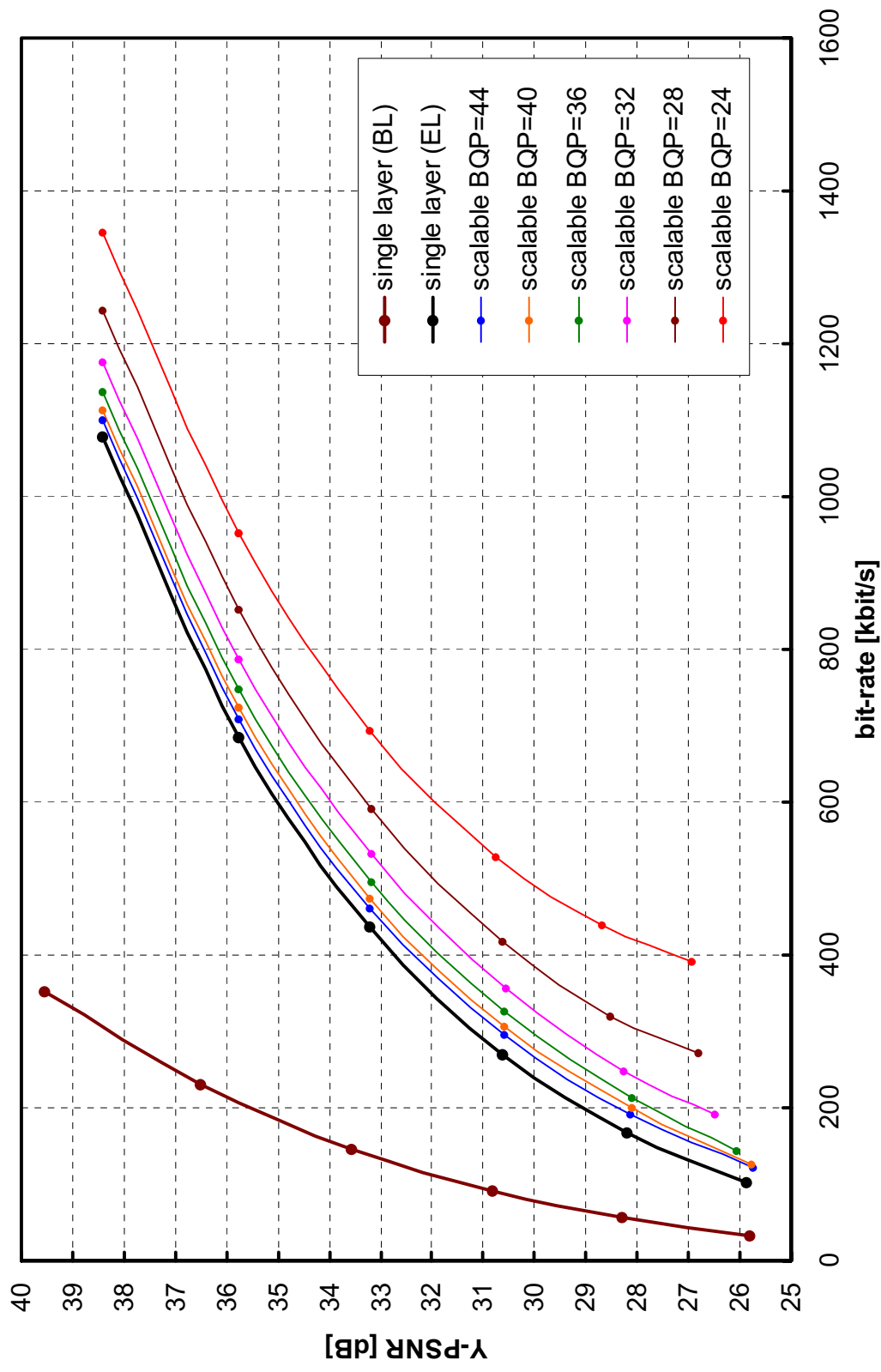


Simulations

- Spatial scalable coding: QCIF 15Hz – CIF 15Hz
- CABAC as entropy coding method
- Base layer QP: 40, 36, 32, 28, 24
- Enhancement layer QP: 40, 36, 32, 28, 24
- Tested all combinations of base and enhancement layer QP's
- Coding structures
 - Hierarchical B pictures with GOP 16
 - Simple IPPP... coding

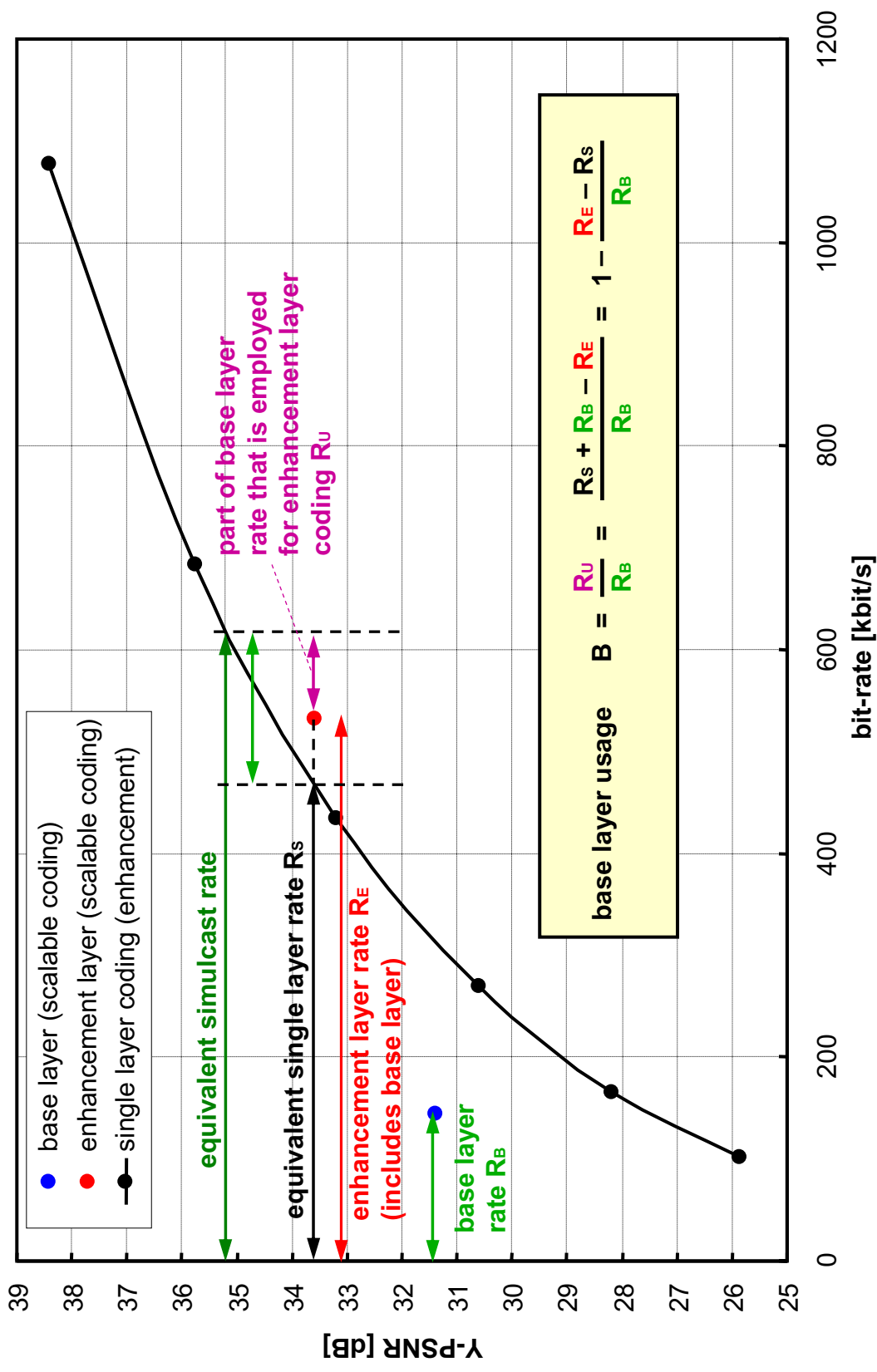
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Example: BUS – GOP 16



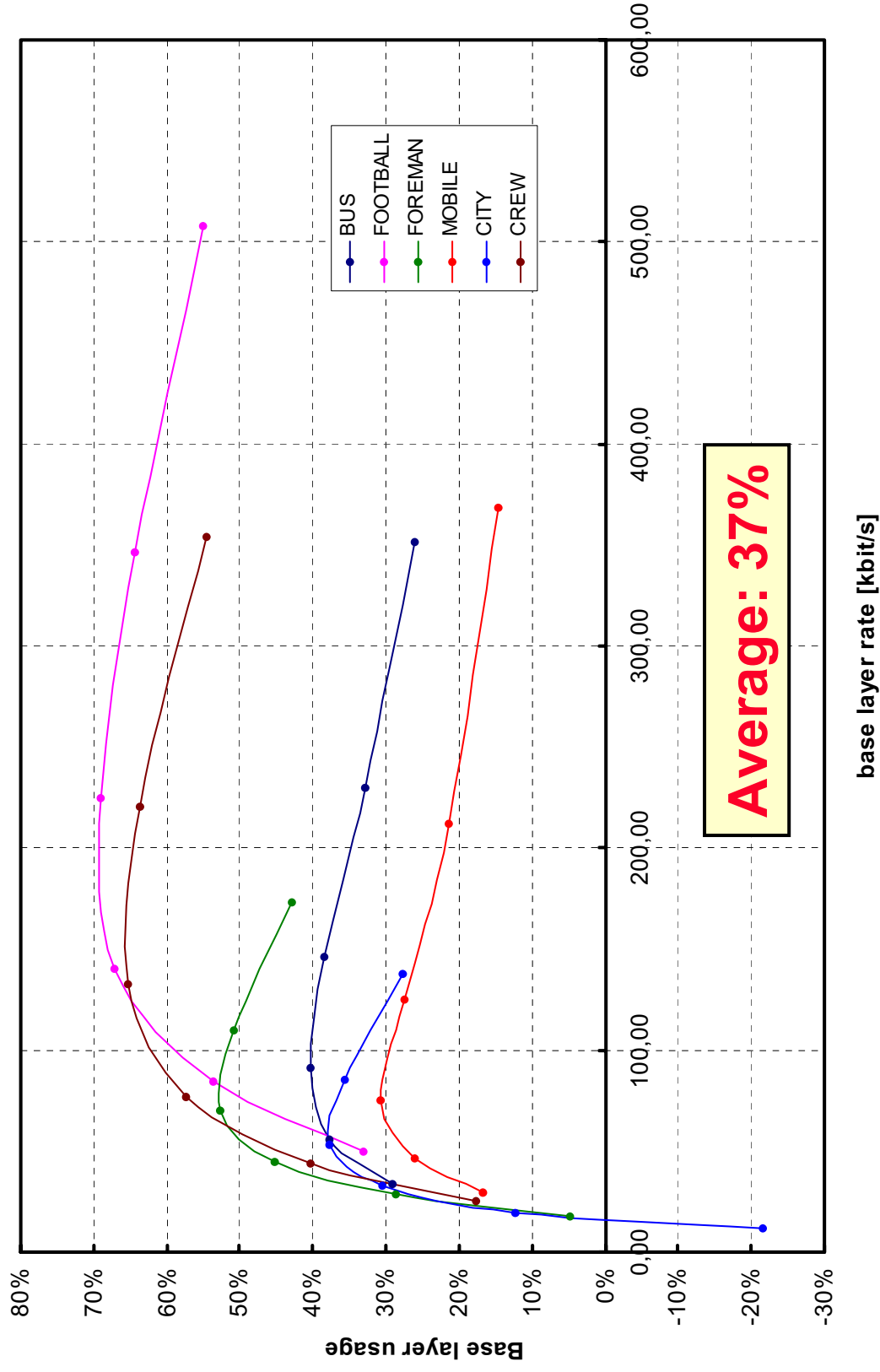
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How to measure coding efficiency ???



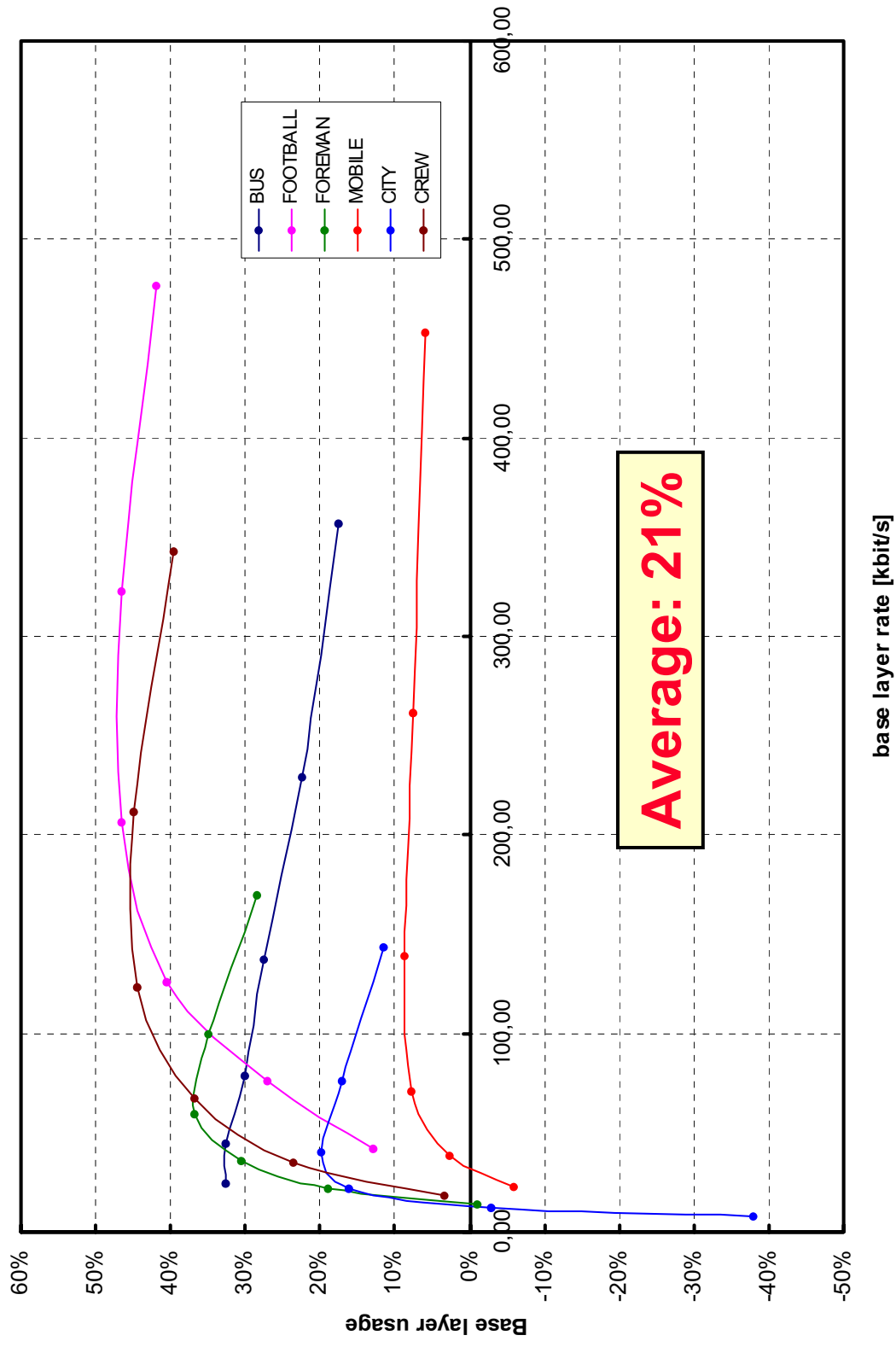
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Base layer usage for GOP 16



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Base layer usage for IPPP



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Disadvantages of the JSVM

- Coding efficiency losses in comparison to single-layer coding are unequally distributed between base and enhancement layer
 - Base layer coding efficiency is virtually identical to single-layer coding
 - Enhancement layer show significant loss in coding efficiency compared to single-layer coding
 - Unsuitable for applications that focus on enhancement layer coding efficiency, but can tolerate coding efficiency losses for the base layer
 - E.g. when scalability is used for improving error robustness
- Efficiency of scalable coding
 - Measured as the relative usage of the base layer rate for enhancement layer coding
 - Not sufficient for a wide usage of spatial scalable coding, especially for IPPP coding
- Both disadvantages can be partly attributed to the encoder control

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Joint multi-loop encoder control



Basic idea

- Jointly optimize base and enhancement layer coding parameters
- Consider enhancement layer during base layer encoding
- Prevent usage of base layer coding parameters that are disadvantageous for enhancement layer coding
- Modified Lagrangian approach for base layer encoding

$$\mathbf{p}_0 = \arg \min_{\{\mathbf{p}_0, \mathbf{p}_1 | \mathbf{p}_0\}} [(1-w) \cdot (D_0(\mathbf{p}_0) + \lambda_0 \cdot R_0(\mathbf{p}_0)) + w \cdot (D_1(\mathbf{p}_1 | \mathbf{p}_0) + \lambda_1 \cdot R_1(\mathbf{p}_1 | \mathbf{p}_0))]$$

- Enhancement layer encoding is not modified
- Weighting factor w
 - $w = 0$: Current JSVM encoder control
 - $w = 1$: Single-loop encoder control (base layer is not controlled)
 - $0 < w < 1$: Partly consider enhancement layer during base layer encoding

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First simulation results

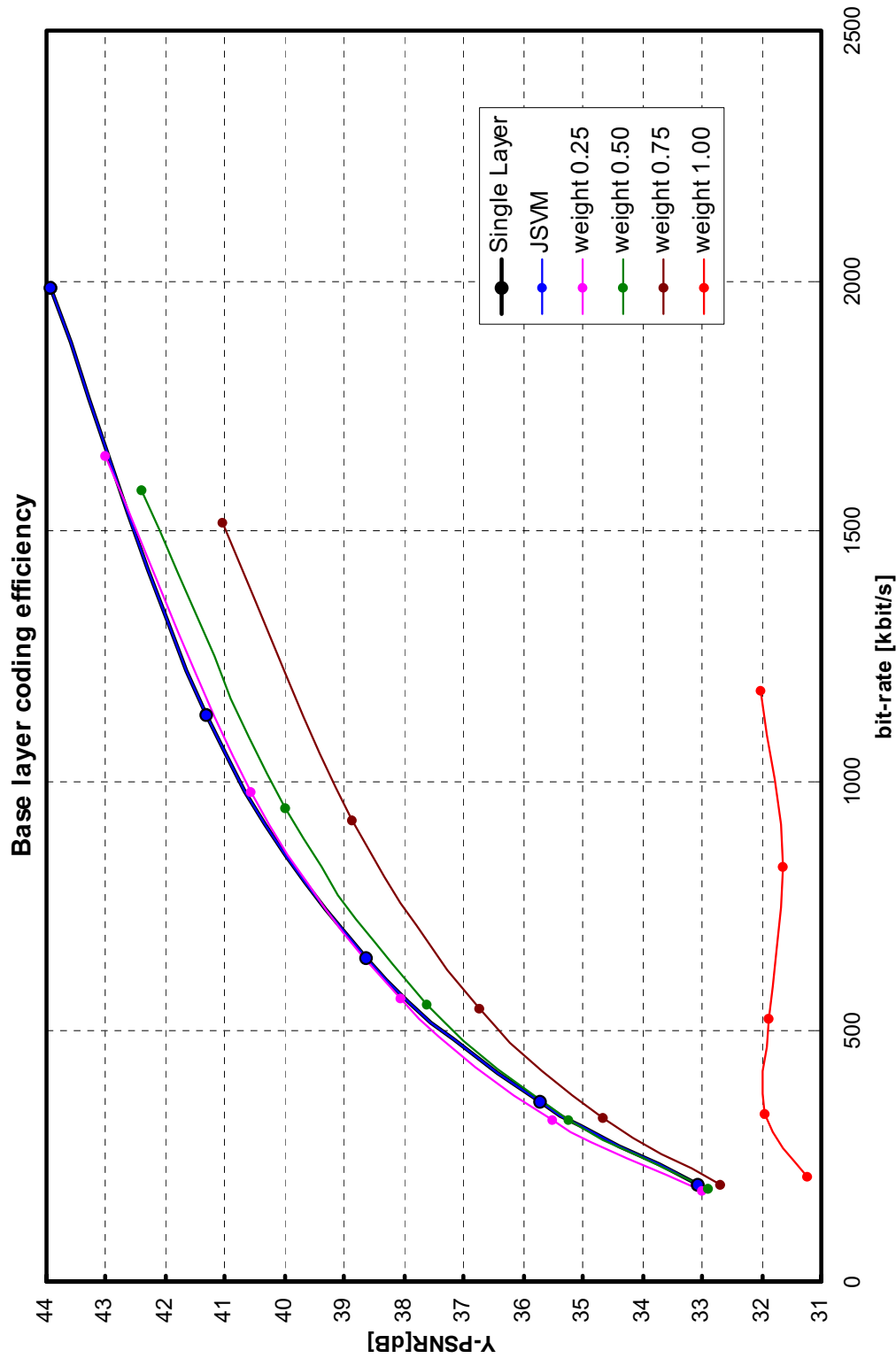


Spatial scalable coding

- Only IPPP coding structure
- 30 frames of each sequence
- QP(EL) = 40, 36, 32, 28, 24
- QP(BL) = QP(EL) – 3
- CABAC as entropy coding method
- $w = \{0, 0.25, 0.5, 0.75, 1\}$

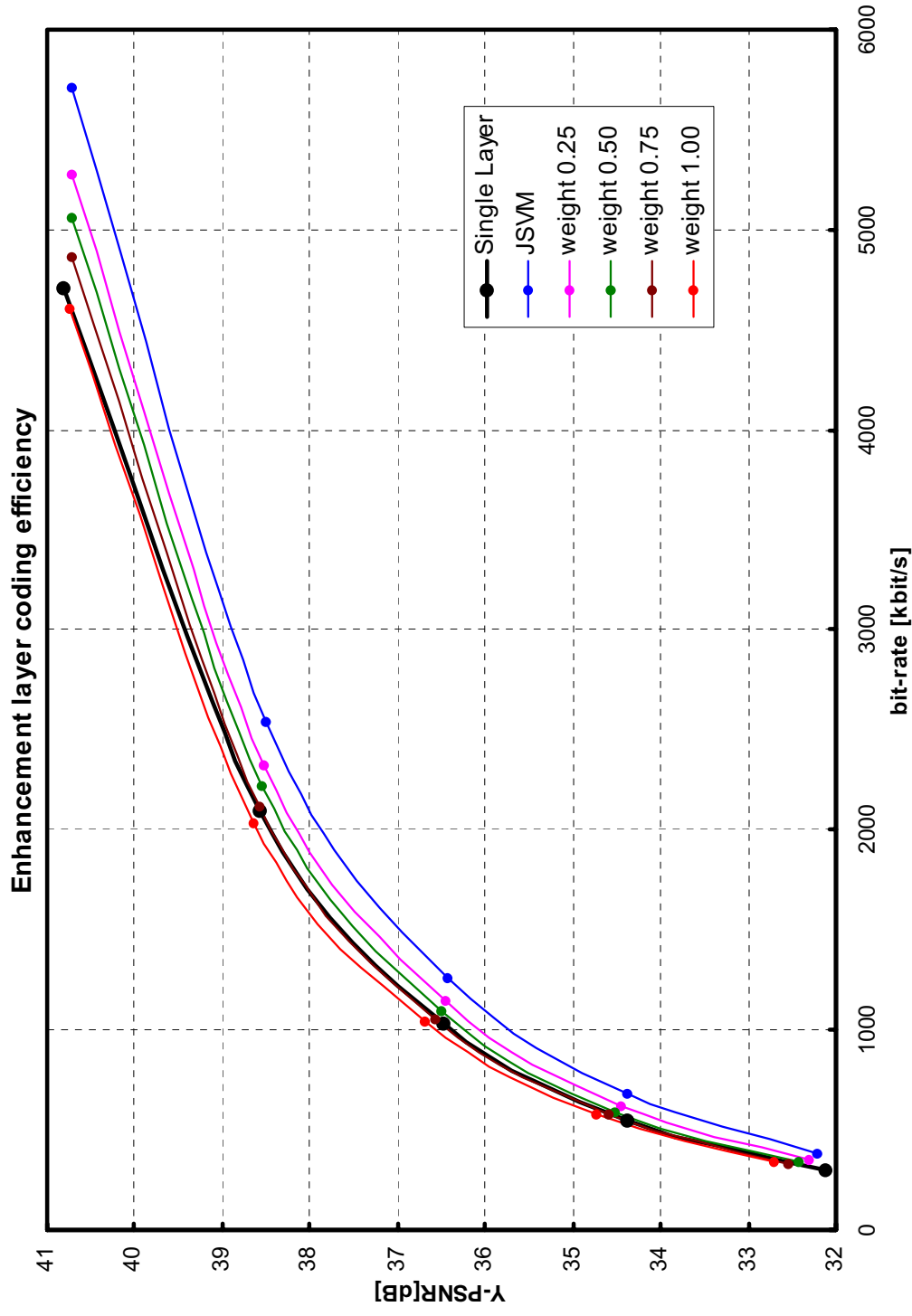
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Example: Crew CIF30 -> 4CIF 30



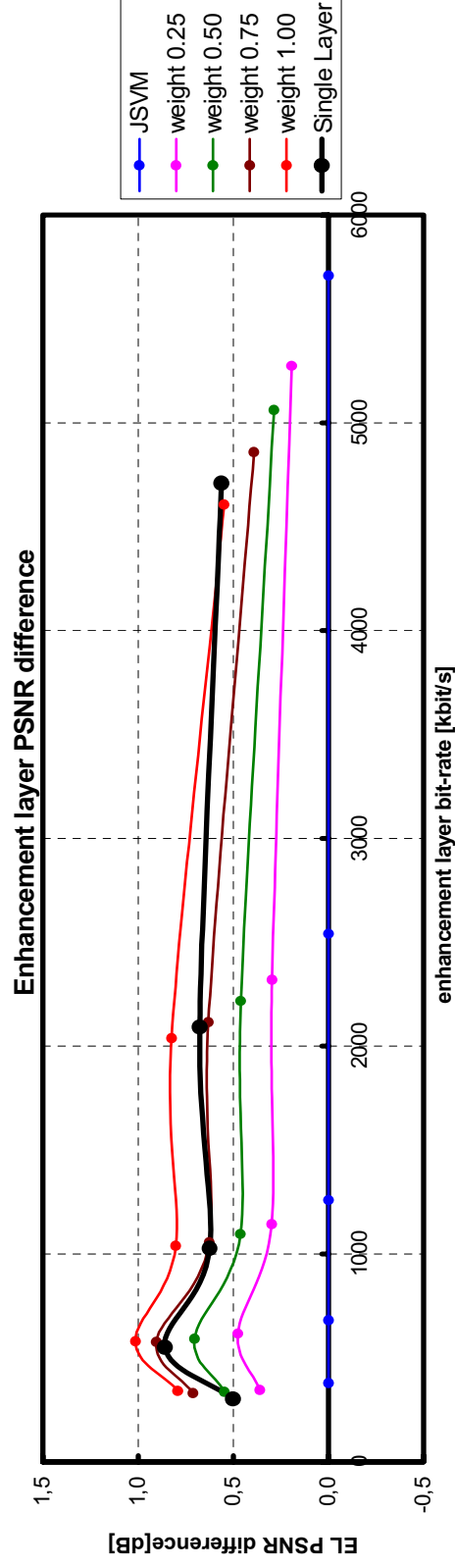
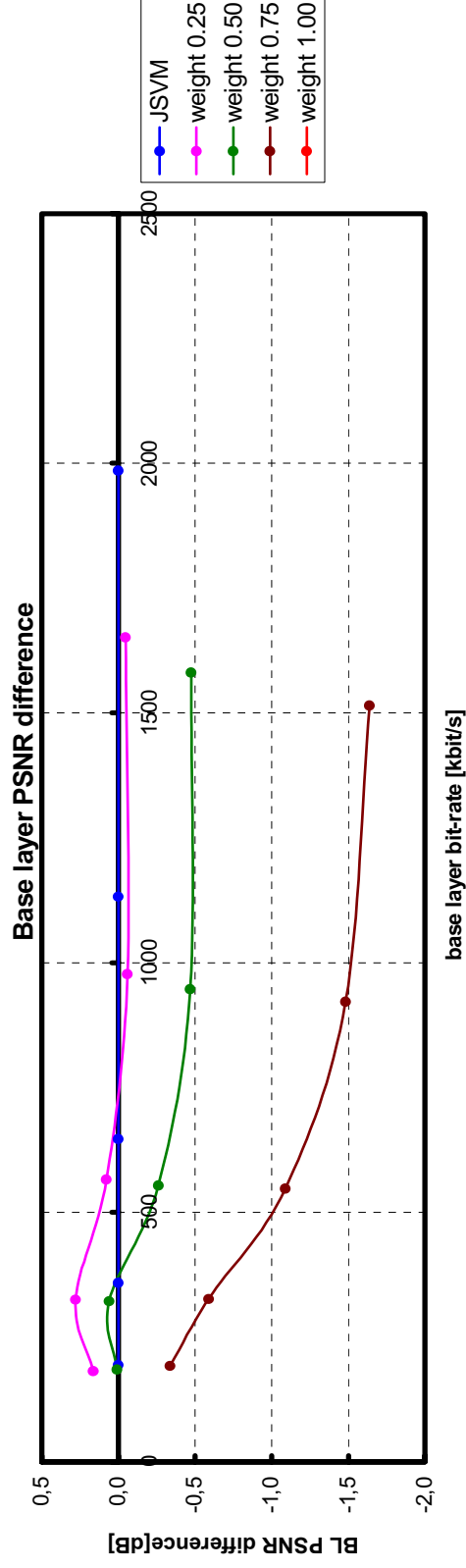
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Example: Crew CIF30 -> 4CIF 30

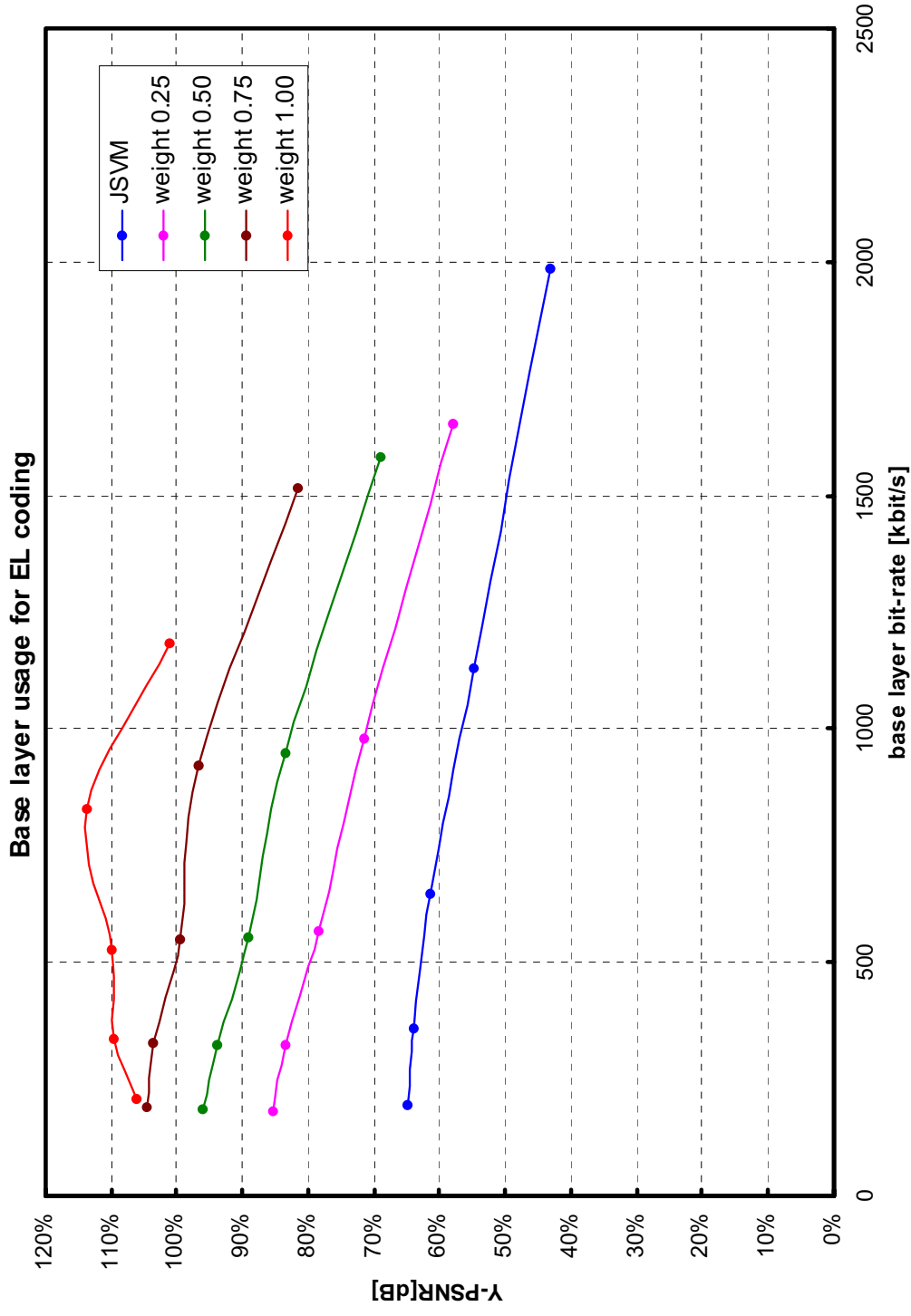


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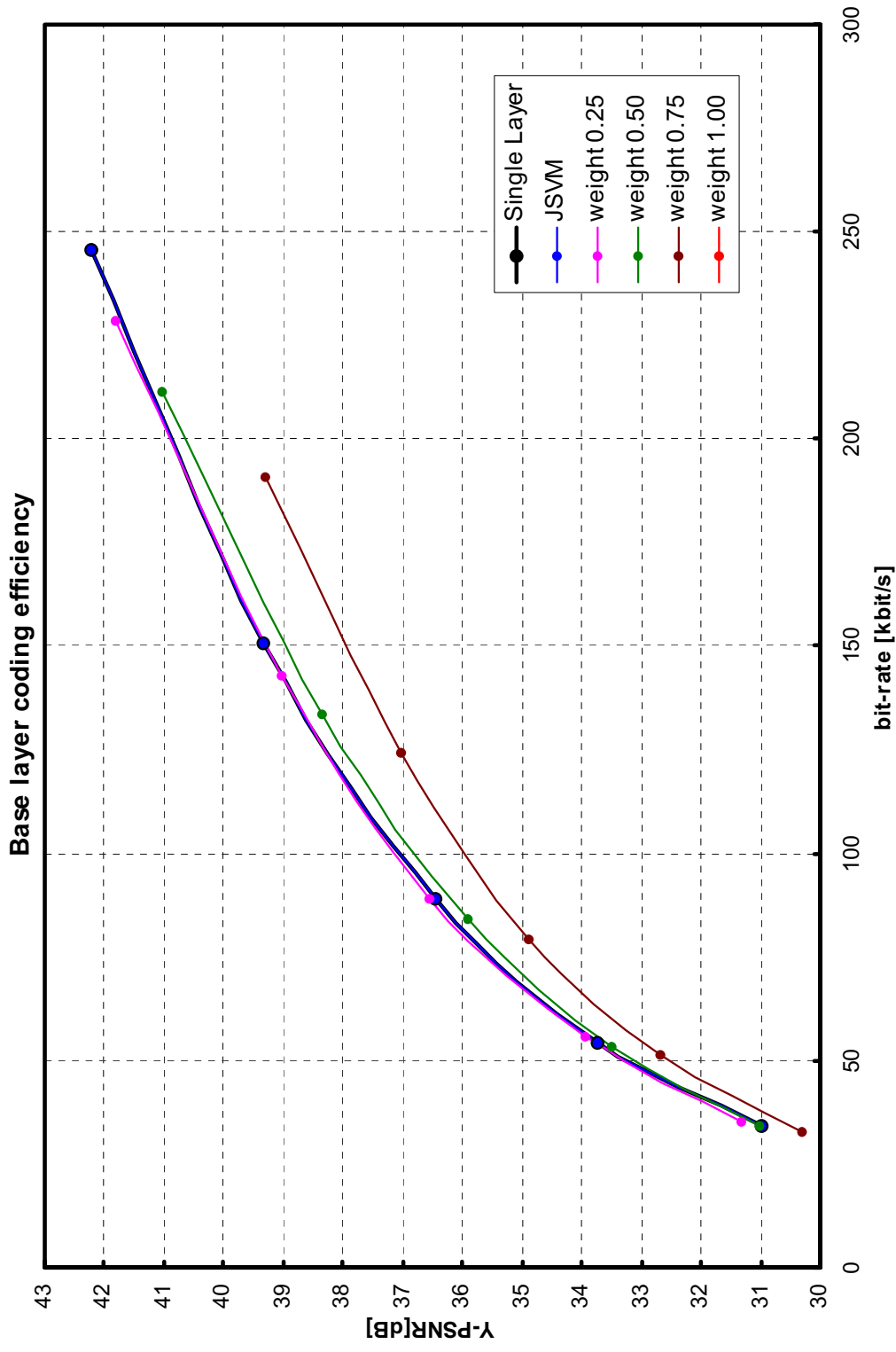
Example: Crew CIF30 -> 4CIF 30



Example: Crew CIF30 -> 4CIF 30

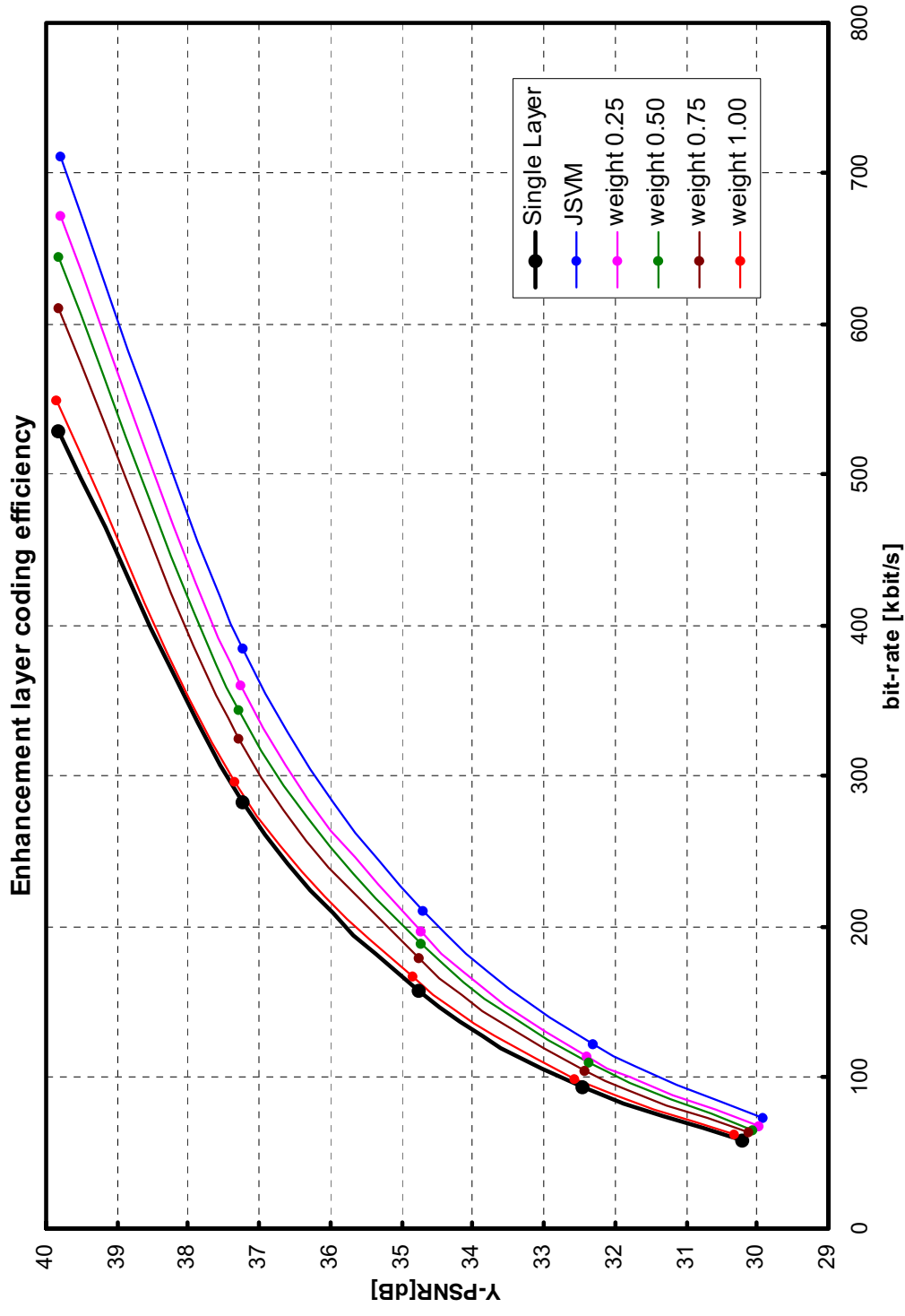


Example: Foreman QCIF15 -> CIF 15



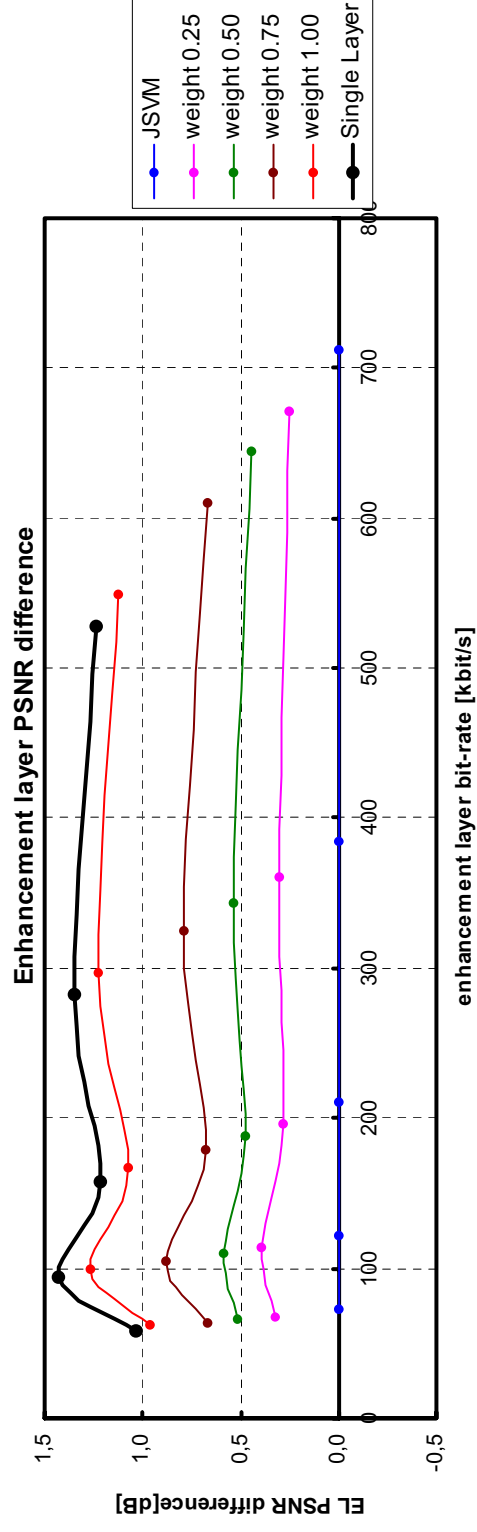
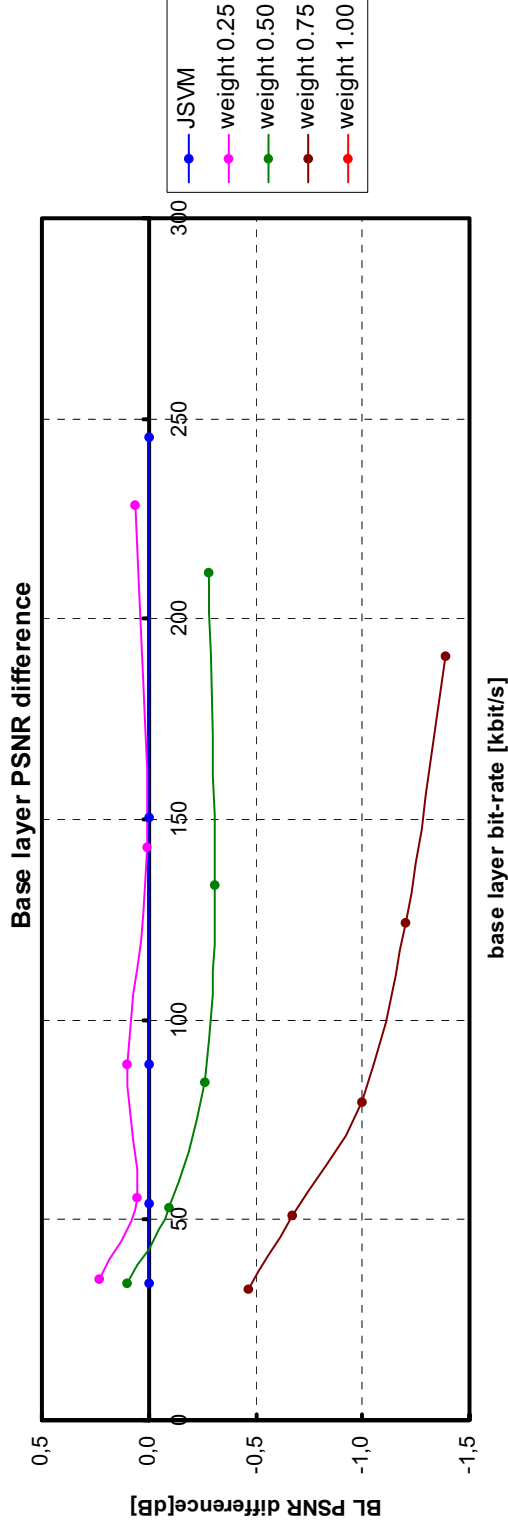
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Example: Foreman QCIF15 -> CIF 15

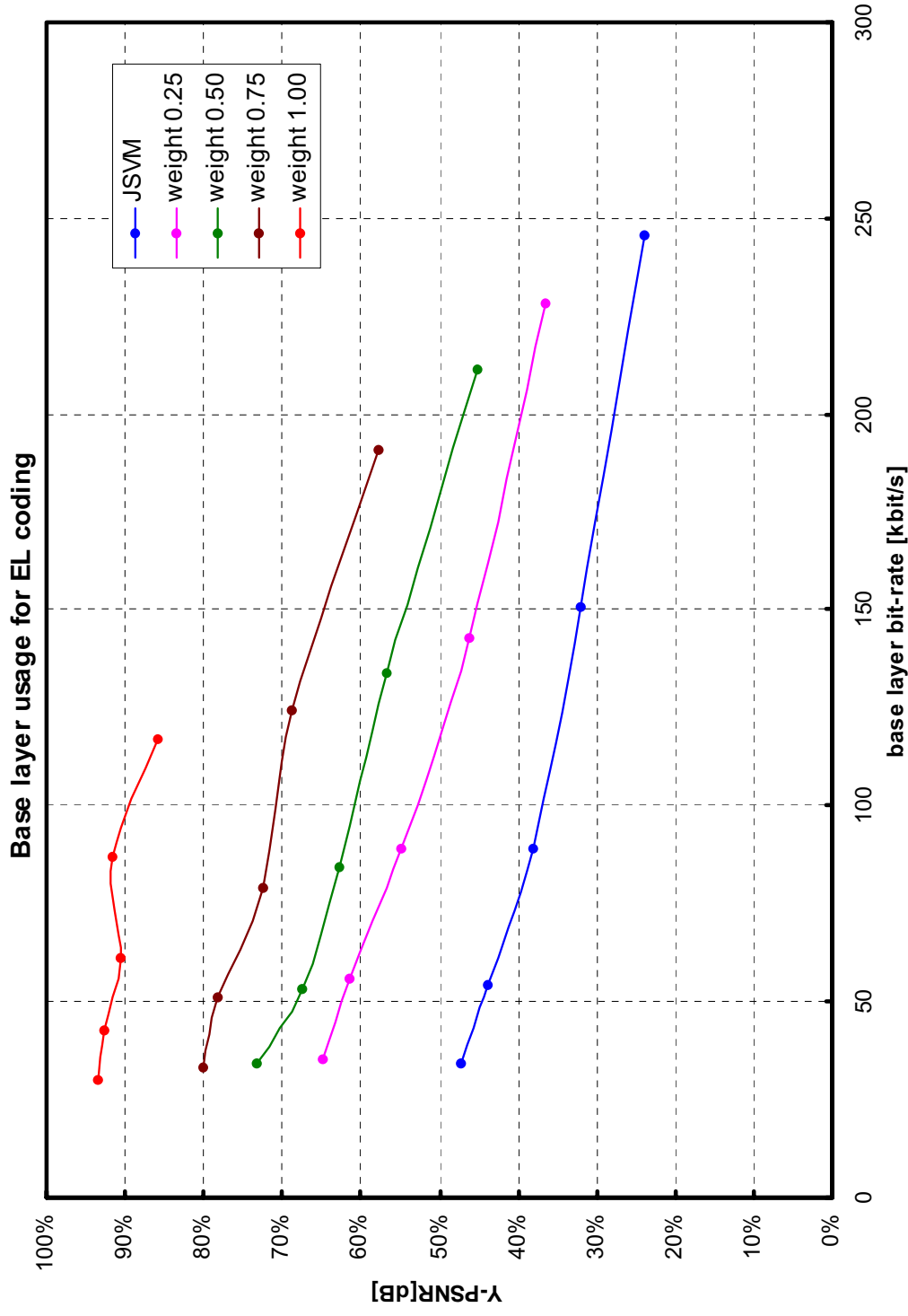


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Example: Foreman QCIF15 -> CIF 15



Example: Foreman QCIF15 -> CIF 15



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Summary of results

- Increase of weighting factor w leads to
 - Improvement of enhancement layer coding efficiency
 - Decrease in base layer coding efficiency
 - Increase of relative base layer usage (efficiency of scalable coding)
- Weighting factor of 1 results in
 - Enhancement layer coding efficiency close the single-layer coding
 - Useless base layer: Only represents a data partition for the EL

	Average PSNR difference for the base layer	Average PSNR difference for the enhancement Layer	Average base layer usage	Average increase in base layer usage B compared to JSVM
JSVM	0,00 dB	0,00 dB	31,37 %	0,00 %
$w = 0.25$	-0,01 dB	0,29 dB	43,01 %	11,64 %
$w = 0.50$	-0,30 dB	0,48 dB	51,78 %	20,42 %
$w = 0.75$	-1,09 dB	0,70 dB	63,00 %	31,63 %
$w = 1.00$	-8,41 dB	1,14 dB	85,91 %	54,54 %

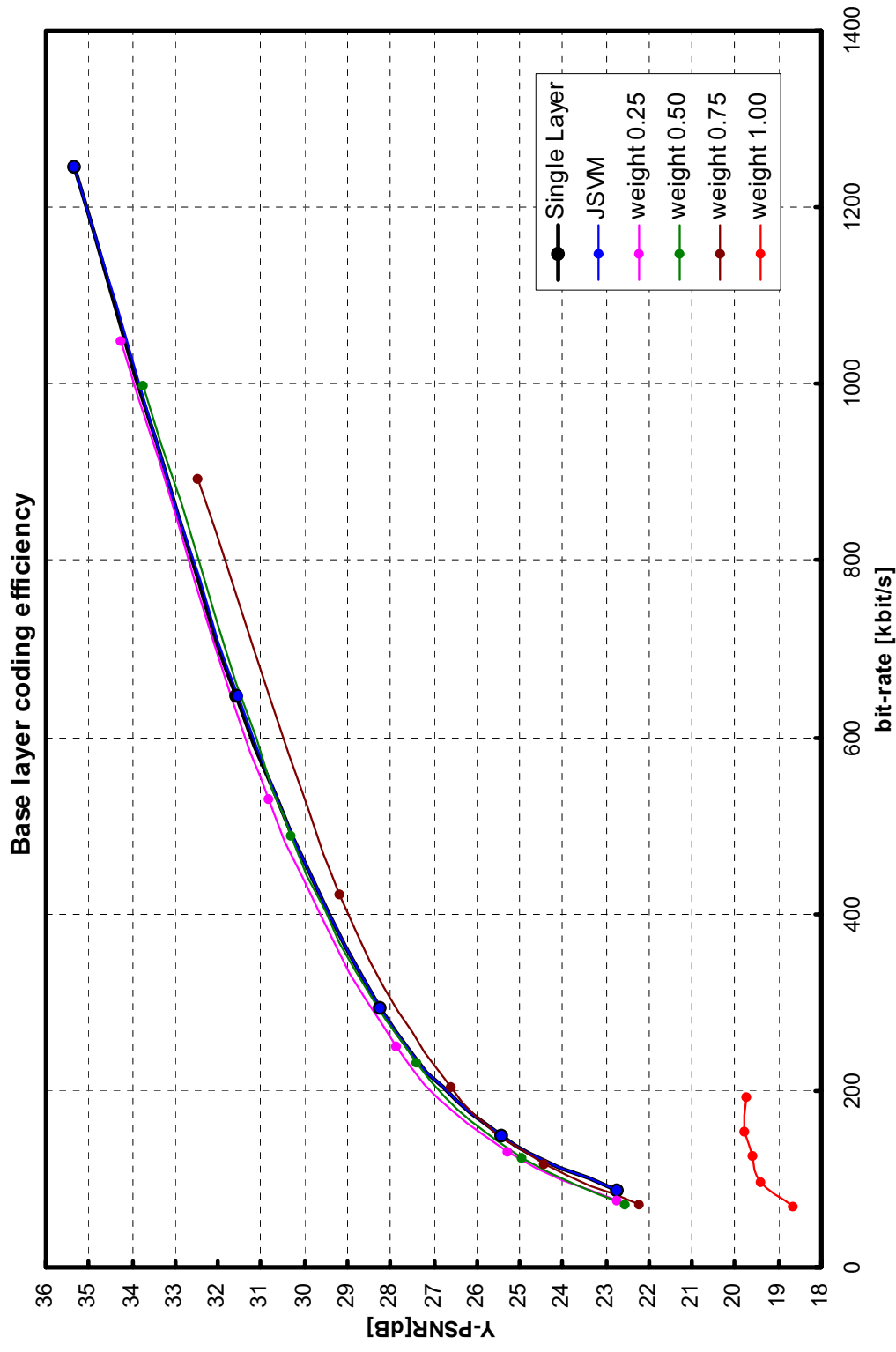
First simulation results

§ Coarse-grain SNR scalable coding

- Only IPPP coding structure
- 30 frames of each sequence
- QP(EL) = 40, 36, 32, 28, 24
- QP(BL) = QP(EL) – 4
- CABAC as entropy coding method
- $w = \{0, 0.25, 0.5, 0.75, 1\}$

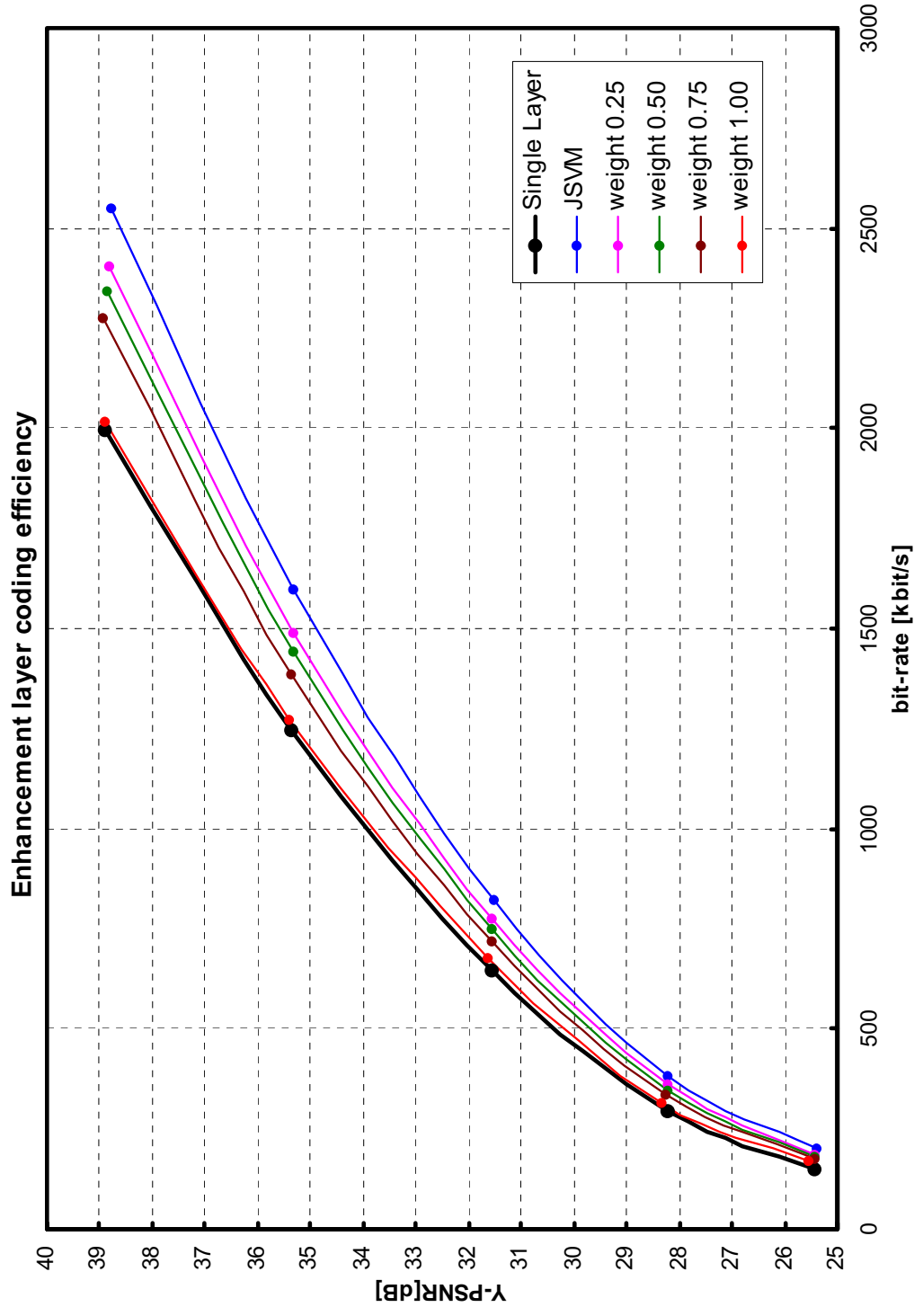
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Example: Mobile CIF 15Hz



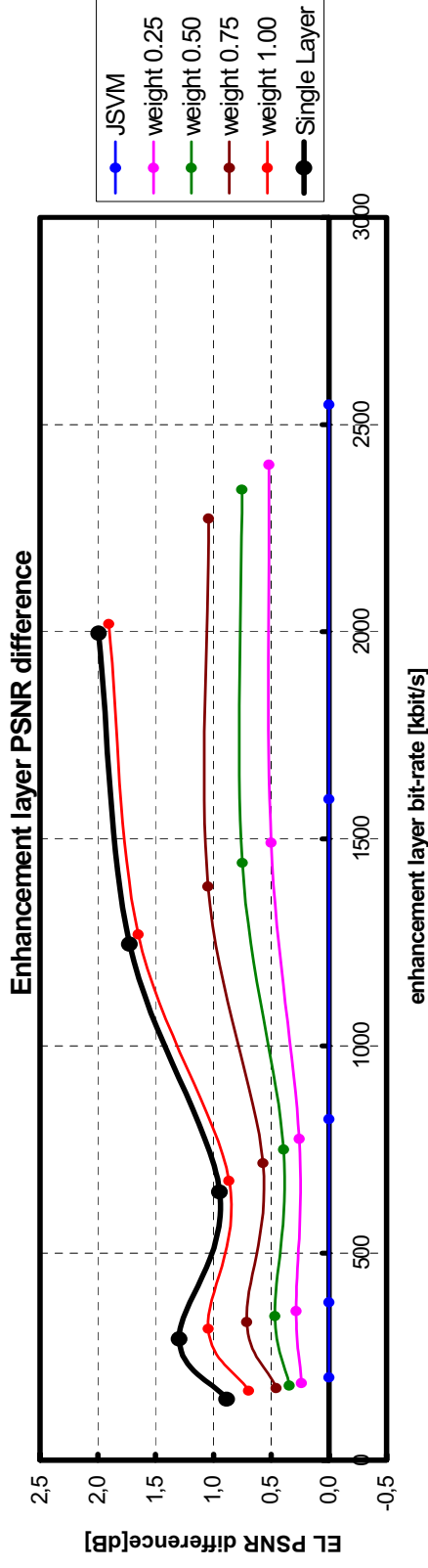
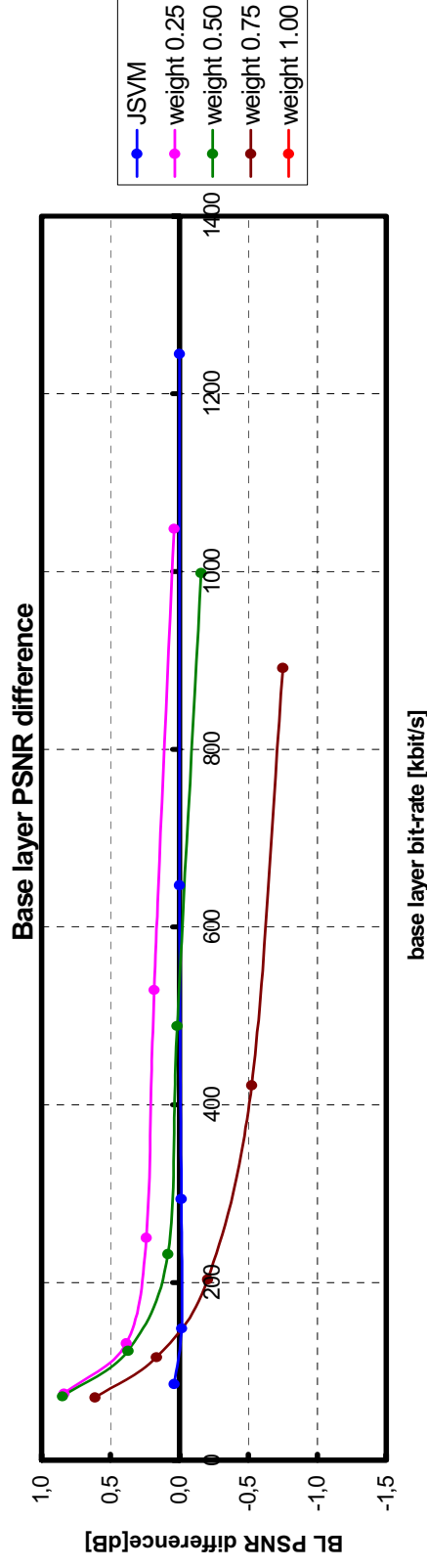
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Example: Mobile CIF 15Hz

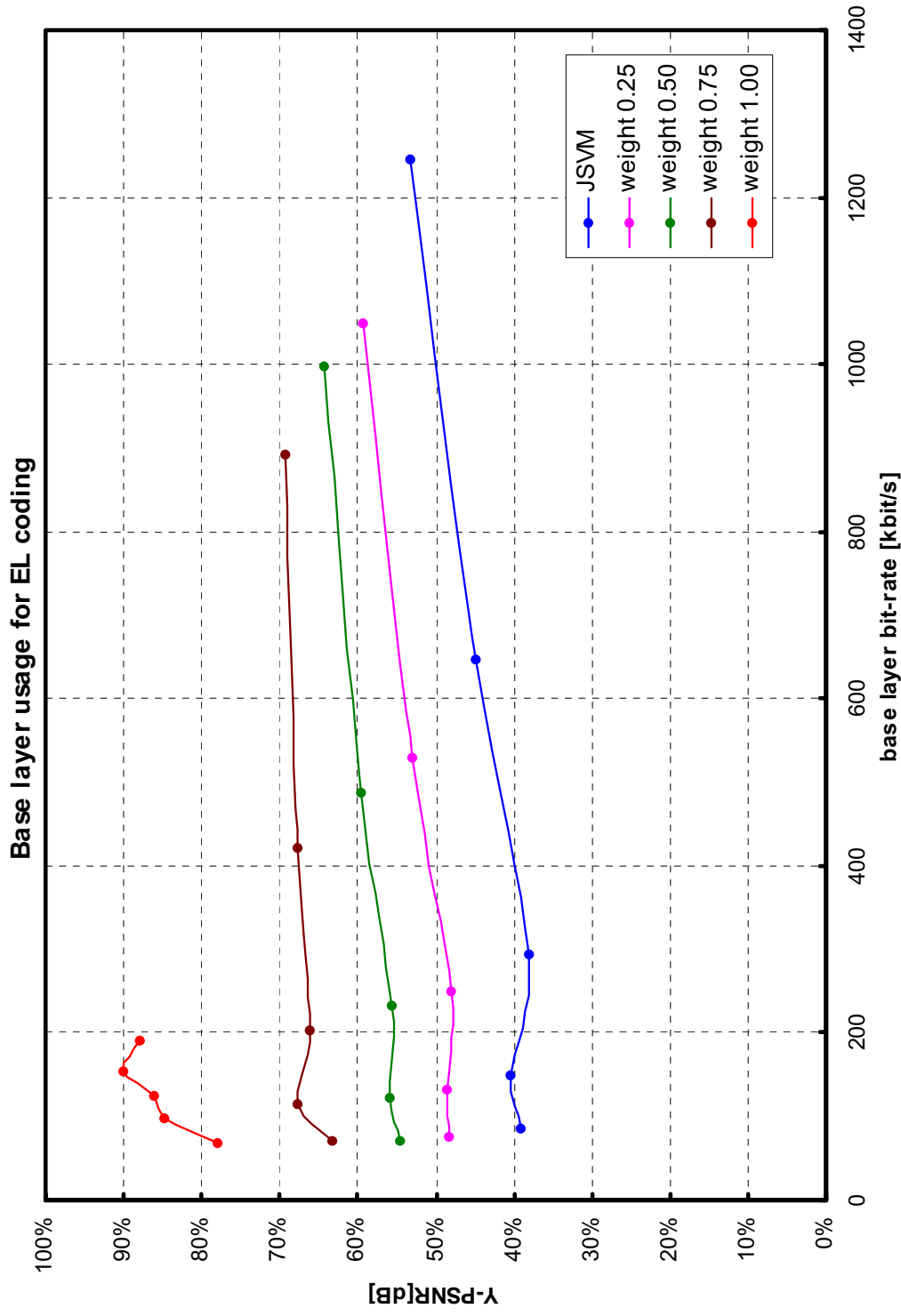


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Example: Mobile CIF 15Hz

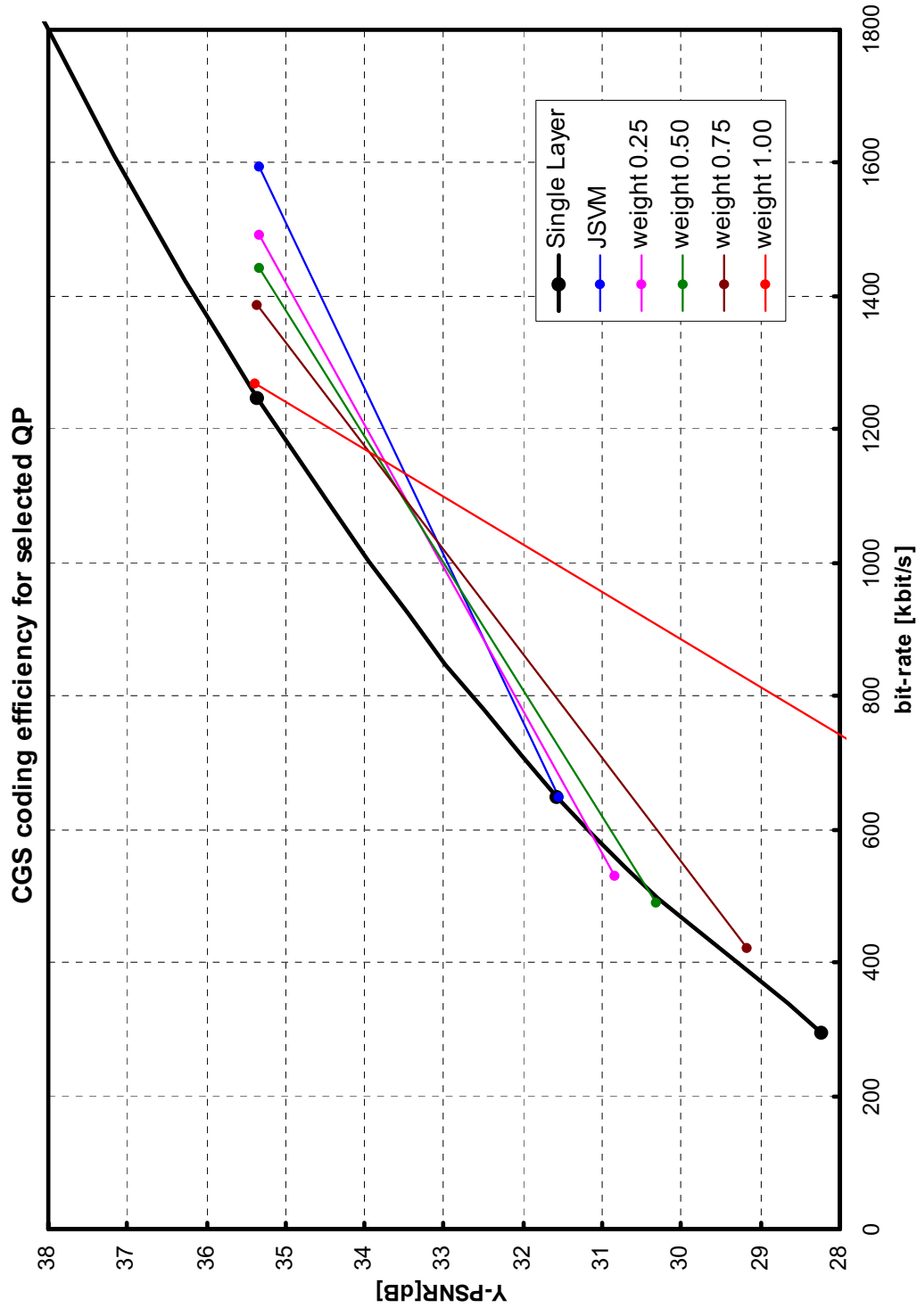


Example: Mobile CIF 15Hz



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Example: Mobile CIF 15Hz



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Summary of results

- Similar behaviour as for spatial scalable coding
 - Base and enhancement layer coding efficiency can be traded off
 - Efficiency of scalable coding (base layer rate usage) can be increased
- Difference to spatial scalable coding
 - Less coding efficiency loss in base layer for similar improvement of the scalable coding efficiency
 - With a pure enhancement layer control ($w = 1$) it is not possible to achieve a coding efficiency that is superior to that of single-layer coding

	Average PSNR difference for the base layer	Average PSNR difference for the enhancement Layer	Average base layer usage	Average increase in base layer usage B compared to JSVM
JSVM	-0,11	0,00	41,33%	0,00%
$w = 0.25$	0,01	0,30	50,70%	9,37%
$w = 0.50$	-0,10	0,49	58,10%	16,77%
$w = 0.75$	-0,48	0,71	67,71%	26,37%
$w = 1.00$	-5,45	1,10	81,52%	40,19%

Conclusion



Presented multi-loop encoder control

- Simulation results for IPPP coding
 - Spatial scalability
 - Coarse-grain SNR scalability
- Trade off base and enhancement layer coding efficiency
- Increases the efficiency of scalable coding, measured by the relative base layer usage for enhancement layer coding, on the cost of base layer coding efficiency



Future research

- Improve details of the multi-loop encoder control
- Application to hierarchical B pictures