

4:2:0

KAMERA/TECHNIK

4:2:0 Chroma-Subsampling reduziert sowohl horizontale als auch vertikale Chrominanzauflösung um 50%. Dies ist der Standard für Verbraucher-Streaming und Rundfunk und bietet optimale Kompressionseffizienz mit minimalem wahrnehmbarem Qualitätsverlust.

4:2:0 Chroma Subsampling (Consumer/Streaming Standard) 4:2:0 represents the consumer and streaming standard for chroma subsampling, reducing both horizontal and vertical chrominance resolution by 50%. This ratio maximizes compression efficiency while maintaining acceptable quality for consumer viewing, and is the de facto standard for all consumer video delivery. Technical Specification 4:2:0 defines aggressive color reduction: Sampling Arrangement : Luminance (Y) : Full resolution horizontal and vertical Chrominance (Cb) : Half horizontal, half vertical resolution Chrominance (Cr) : Half horizontal, half vertical resolution Pattern : For every 4 luminance samples (2x2), 1 Cb and 1 Cr sample Notation Explanation : First "4": Luminance sampling rate (baseline) "2" (second): Chrominance horizontal at 50% of luminance "0" (third): Chrominance vertical at 50% of luminance (not 0, confusing notation) Compression Efficiency 4:2:0 achieves maximum compression: Data Reduction : Uncompressed : 1 byte per 2x2 pixel block = 75% data reduction Effective bitrate : 50% of 4:4:4 RGB equivalent Practical result : Excellent compression without visible artifacts Bitrate Examples (1080p/24fps): Uncompressed 4:2:0: ~41 Mbps H.264 4:2:0: 5-8 Mbps (near-lossless) YouTube 4:2:0: 2-4 Mbps (high quality streaming) Perceptual Quality Why 4:2:0 Works Visually : Human eye severely limited at detecting color detail Color vision concentrated in central retina Peripheral vision primarily luminance-sensitive 4:2:0 color loss imperceptible to human eye Practical Viewing : Indistinguishable from 4:2:2 at normal viewing distance Significantly better than 4:2:0 + heavy chroma compression Adequate for all consumer viewing conditions Professional monitors can't discern 4:2:0 vs 4:2:2 Industry Standards Using 4:2:0 Streaming Platforms : Netflix (all resolutions) YouTube (standard delivery) Amazon Prime Video Disney+, Apple TV+, Hulu Vimeo and other platforms Broadcast Television : HDTV broadcast (uses H.264 4:2:0) Satellite television Cable television Terrestrial digital television Consumer Media : Blu-ray video Digital television Mobile video Consumer camcorders Internet Video : Video streaming services Social media video (YouTube, TikTok, etc.) Video conferencing (Zoom, Teams) User-generated content platforms 4:2:0 Codec Examples H.264/AVC : Universal codec supporting 4:2:0 Netflix primary delivery format YouTube standard format Broadcasting worldwide H.265/HEVC : Modern efficient 4:2:0 codec Netflix 4K streaming Broadcast HDR alternative Growing adoption VP9/AV1 : Open-source alternatives YouTube support Better compression than H.264 Emerging standard Production to Streaming Pipeline Color Format Degradation Path : Acquisition : 4:2:2 or 4:2:0 (professional or streaming) Editing/Grading : 4:2:2 or higher for color work Master Generation : 4:2:2 professional master created Encoding : 4:2:0 H.264/H.265 for streaming Delivery : 4:2:0 consumed by viewer Workflow Consideration : Color grading requires 4:2:2 or higher Grading creates 4:2:2 master Streaming encode converts to 4:2:0 No re-grading possible from 4:2:0 Practical Limitations of 4:2:0 When Artifacts Become Visible : Extreme color saturation in small areas High-frequency color patterns (impossible to test in practice) Very large screens viewed closely Specialized test patterns Real-World Content :

Artifact-free for virtually all natural content Professional color work indistinguishable at viewing distance Fine color detail preserved adequately Perceptually lossless for all practical purposes Comparison with Adjacent Standards Ratio Chroma Horiz Chroma Vert Bitrate Quality Use 4:2:2 50% 100% ~2x 4:2:0 Professional Broadcast 4:2:0 50% 50% Baseline Consumer Streaming 4:2:0 (heavy) 50% 50% Low Compromised Budget streaming On-Set Monitoring in 4:2:0 Practical Considerations : 4:2:0 rarely used for on-set acquisition Professional workflows avoid 4:2:0 for shooting Streaming deliverables specify 4:2:0 Grading from 4:2:0 source not recommended Monitoring Limitations : 4:2:0 sufficient for basic focus and exposure Color work requires 4:2:2 or higher source Streaming review in 4:2:0 acceptable Professional verification requires higher quality Why 4:2:0 Dominates Consumer Technical Advantages : Maximum compression efficiency Imperceptible quality loss for viewers Universal hardware support Proven long-term stability Economic Advantages : Smallest practical file sizes Lowest bandwidth requirements Fastest streaming delivery Cheapest distribution costs Viewer Perspective : No visible quality difference from higher ratios Perfectly adequate for all viewing conditions Compatible with all consumer devices Comfortable streaming bitrates 4:2:0 HDR Streaming Emerging HDR Delivery : 4:2:0 with PQ/HLG transfer functions Streaming platforms experiment with HDR Works surprisingly well Bitrates remain manageable Practical HDR Streaming : Netflix HDR uses H.265 4:2:0 Apple TV+ explores HDR streaming Bitrate challenges with HDR 4:2:0 makes HDR streaming economical Professional Workflow Philosophy Standard Acquisition to Delivery : Shoot 4:2:2 or better Grade in 4:2:2 or better Master in 4:2:2 Deliver 4:2:0 to consumers Archive preserves 4:2:2 master Why Not Shoot 4:2:0 : Limits color grading flexibility Reduces future delivery options Risks color artifacts during correction Creates quality ceiling Future of 4:2:0 4:2:0 will remain standard because: Proven Technology : Decades of successful use Device Ubiquity : Every device plays 4:2:0 Economics : Most efficient compression Perceptual Parity : Indistinguishable from higher ratios Bandwidth Reality : Practical necessity for streaming 4:2:0 represents the equilibrium between streaming economics and human perception, unlikely to change despite technological advancement.