# 4:4:4

KAMERA/TECHNIK

4:4:4 Chroma-Subsampling behält volle Farbauflösung ohne Reduzierung der Chrominanzinformation. Jedes Pixel behält vollständige RGB- oder YCbCr-Farbinformation, erfordert maximale Bitrate und Speicher.

4:4:4 Chroma Subsampling (Full Color) 4:4:4 represents the highest chroma sampling ratio, retaining complete color information for every pixel. Each luminance (Y) sample is accompanied by complete chrominance (Cb and Cr) samples at the same resolution, providing lossless color representation essential for mastering and premium archival. Technical Foundation 4:4:4 maintains complete color fidelity: Sampling Pattern : Luminance (Y): Full resolution horizontal and vertical Chrominance (Cb): Full resolution, 1:1 with luminance Chrominance (Cr): Full resolution, 1:1 with luminance Result : No color subsampling; complete color per pixel Notation Explanation : First "4": Luminance sampling rate (baseline) Second "4": Chrominance Cb sampling (no reduction) Third "4": Chrominance Cr sampling (no reduction) Data Requirements 4:4:4 carries significant storage burden: RGB Color Space (if using RGB): 8-bit per channel: 24 bits per pixel 10-bit per channel: 30 bits per pixel 12-bit per channel: 36 bits per pixel YCbCr Color Space (if using YCbCr): 8-bit: 24 bits per pixel (same as RGB) 10-bit: 30 bits per pixel 12-bit: 36 bits per pixel Bitrate Examples (1080p/24fps): 8-bit 4:4:4: ~110 Mbps uncompressed 10-bit 4:4:4: ~137 Mbps uncompressed Requires compression for practical storage Applications Color Grading Mastering : Professional color-grading workflows Final master generation Preserves all creative grading information Premium deliverable creation Archival and Preservation : Museum/archive preservation masters Long-term color accuracy assurance Future-proofing color information Museum/gallery digital art archival Premium Delivery : High-end Blu-ray releases Premium streaming delivery Professional video formats Theatrical color masters Professional Video Systems : Non-linear editing masters Graphics and motion design work Color-grading platform native format Professional broadcast archival 4:4:4 in Compression 4:4:4 requires robust compression: Lossless Compression : Preserves all color information Codec examples: ProRes 4:4:4 XQ, DNxHD 444 Larger file sizes than 4:2:2 Ensures color accuracy preservation Lossy Compression : H.264/H.265 with 4:4:4 profile Reduced file size compared to uncompressed Visual quality loss may be imperceptible Smaller than 4:4:4 lossless but larger than 4:2:0 Hardware and Software Support Capture/Recording : Limited camera support for 4:4:4 (rare) Desktop capture systems support 4:4:4 Specialized hardware required Typically not used for on-set acquisition Editing and Grading : Professional NLE support (Avid, Premiere, Final Cut) Color-grading software native 4:4:4 support Standard in professional grading suites Increasing support in software tools Delivery : H.264/H.265 can support 4:4:4 Streaming platforms accept 4:4:4 masters Professional broadcast support Growing archival adoption 4:4:4 Workflows Mastering Pipeline Example : Source Material : Log video (typically 4:2:2 or 4:2:0) Linearization : Convert to linear light Color Grading : Work in 4:4:4 native color space Output Masters : Create both 4:4:4 and 4:2:0 versions Delivery : 4:4:4 premium, 4:2:0 standard delivery Comparison with Other Ratios Ratio Y Resolution Cb Resolution Cr Resolution Bitrate Use Case 4:4:4 Full Full Full High Mastering, Archive 4:2:2 Full Half Half Medium Professional Broadcast 4:2:0 Full Quarter Quarter Low Streaming, Consumer Perceptual Considerations Human Vision and 4:4:4 : Human eye less

sensitive to color detail than luminance 4:4:4 provides color fidelity beyond human perception 4:2:2 sufficient for most viewing conditions 4:4:4 essential for color-grading accuracy When 4:4:4 Matters : Professional color-grading work Fine color corrections requiring precision Premium deliverables justifying extra cost Archive preservation for future technologies Storage Considerations File Size Implications : 4:4:4 RGB: Largest file size 4:4:4 YCbCr: Same size as RGB per bitrate Compression essential for practical storage Archive cost significantly higher Compression Trade-offs : Lossless 4:4:4: Larger than lossy 4:2:2 Lossy 4:4:4: Smaller than lossless, larger than 4:2:0 Budget and quality requirements drive selection Archival standards increasingly favor 4:4:4 When to Use 4:4:4 Recommended : Creating premium distribution masters Color-grading professional work Archive preservation High-end post-production Not Necessary : On-set acquisition (4:2:2 or 4:2:0 sufficient) Streaming delivery (4:2:0 standard) Consumer broadcasts Preliminary grading Future Trends 4:4:4 adoption increasing for: Premium streaming content Archive preservation Professional mastering standards Future display technology compatibility However, remains primarily mastering format, not acquisition standard. Aktuelles ProRes 4444 nutzt 4:4:4 Chroma Subsampling und unterstützt zusätzlich einen Alpha-Kanal für Transparenzinformationen. Diese Kombination aus vollständiger Farbauflösung und Alpha-Unterstützung führt zu erheblich größeren Dateigrößen im Vergleich zu anderen ProRes-Varianten. Filmemacher sollten abwägen, ob die technischen Vorteile den Speicheraufwand rechtfertigen. Aktuelles In Foren wie r/cinematography wird häufig gefragt, wie 4:4:4 mit Bayer-Sensoren zusammenpasst, da diese pro Pixel nur einen Farbwert (Rot, Grün oder Blau) liefern und keine vollständigen RGB-Werte. Die Antwort liegt im Debayering-Prozess: Erst durch die Interpolation der Rohdaten im Kamera-Prozessor oder in der Postproduktion entstehen vollständige RGB-Werte pro Pixel, die anschließend in ein 4:4:4-Format wie ProRes 4444 geschrieben werden können. Native Bayer-Rohdaten (RAW) besitzen somit kein Chroma Subsampling im eigentlichen Sinne – der Begriff 4:4:4 bezieht sich erst auf das Ergebnis nach der Demosaicing-Verarbeitung.