

# **Digital Color Coding**

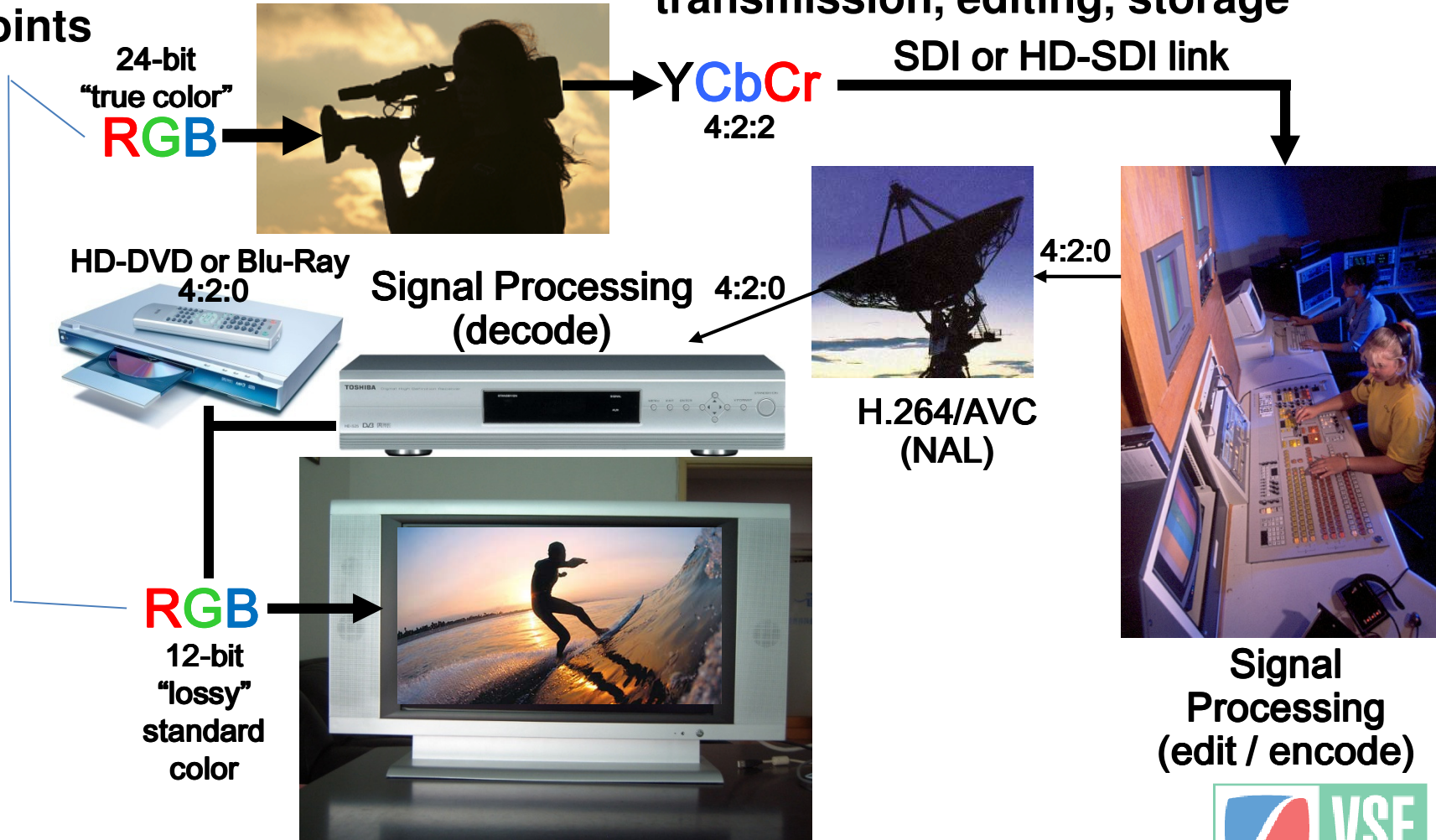
## **Using the YUV model to reduce pixel depth**



# The Big Picture

RGB at end points

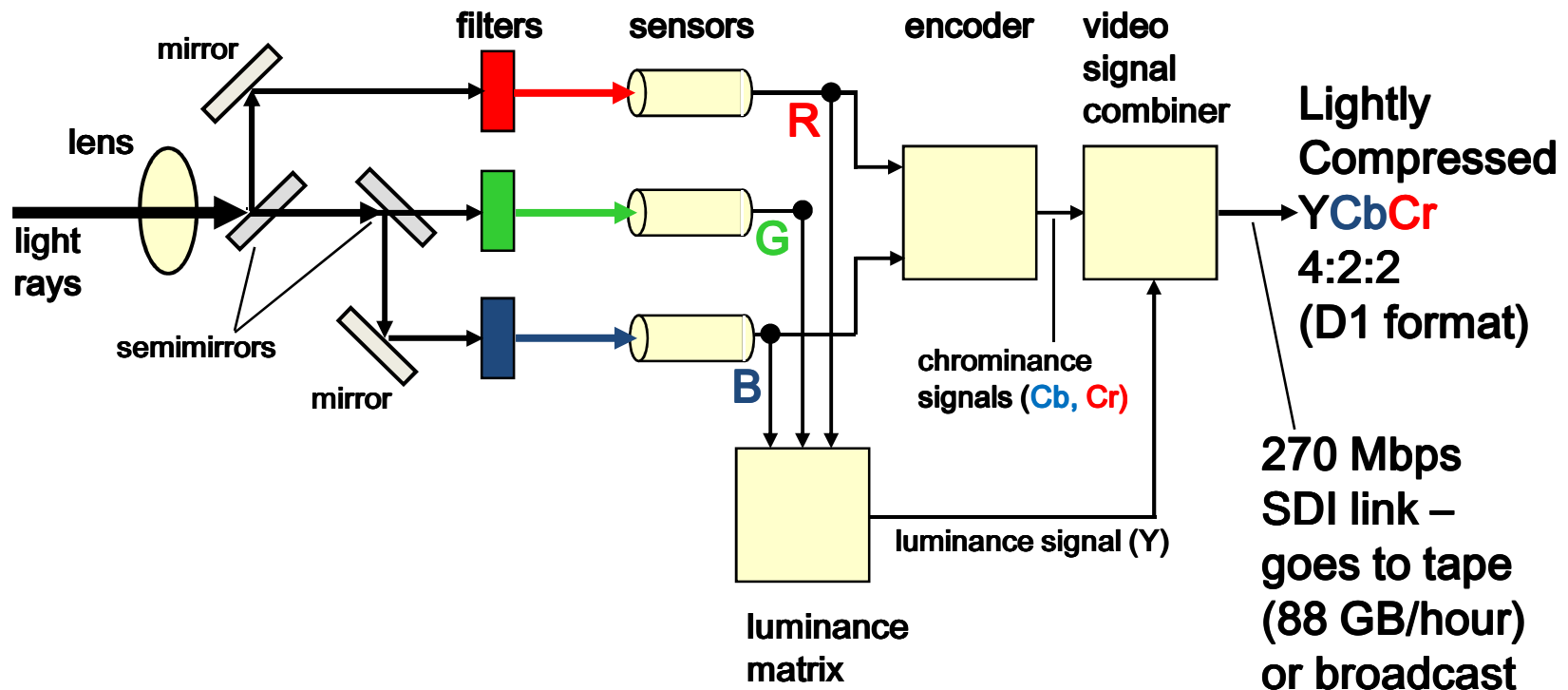
YUV in between for transmission, editing, storage



# Digital TV Camera

RGB input

YUV output



# YUV Color Model

- **Used worldwide by color TV broadcasts**
  - Lots of variations: YCbCr, YPbPr, YDbDr, YIQ
- **Breaks RGB representation into 4 parts**
  - 1 luminance (grayscale) component (Y)
  - 3 chrominance (color) components (**Cr**, **Cg**, **Cb**)
    - Sum to a constant, so only need Cr, Cb (calculate Cg)
    - Calculate YCbCr from RGB and RGB from YCbCr

| RGB to YCbCr                   | YCbCr to RGB                |
|--------------------------------|-----------------------------|
| $Y = 0.299R + 0.587G + 0.114B$ | $R = Y + 1.402Cr$           |
| $Cb = 0.564(B - Y)$            | $B = Y + 1.772Cb$           |
| $Cr = 0.713(R - Y)$            | $G = Y - 0.344Cb - 0.714Cr$ |

# YUV Advantages

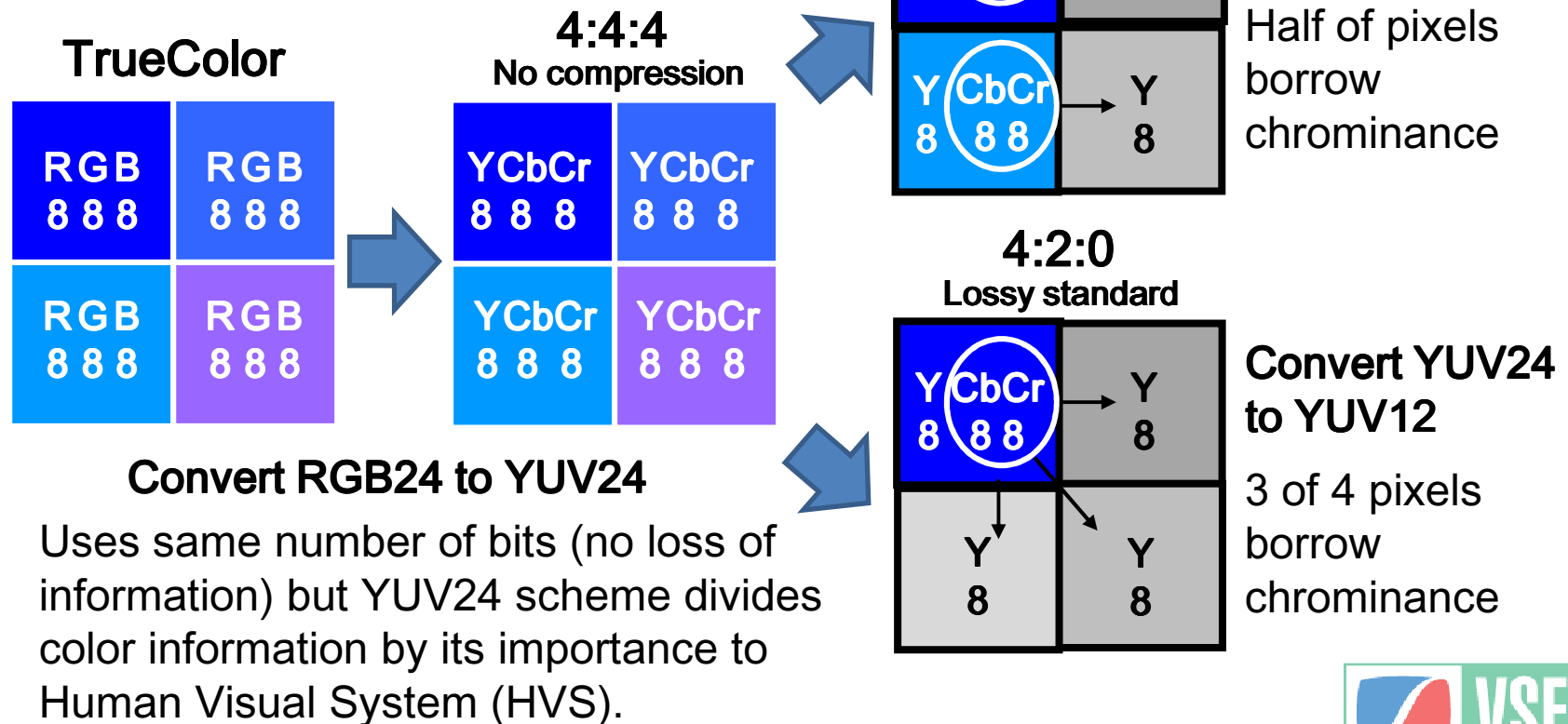
- **Color signals compatible with black & white**
  - Just use Y (256 shade grayscale, ignore Cb, Cr)
- **Allows pixel depth compression**
  - For HVS, luminance (Y) more important than chrominance (Cr, Cb)
  - Don't need full Cb, Cr information for good color fidelity as long as keep Y value for each pixel

# YUV Compression Strategy

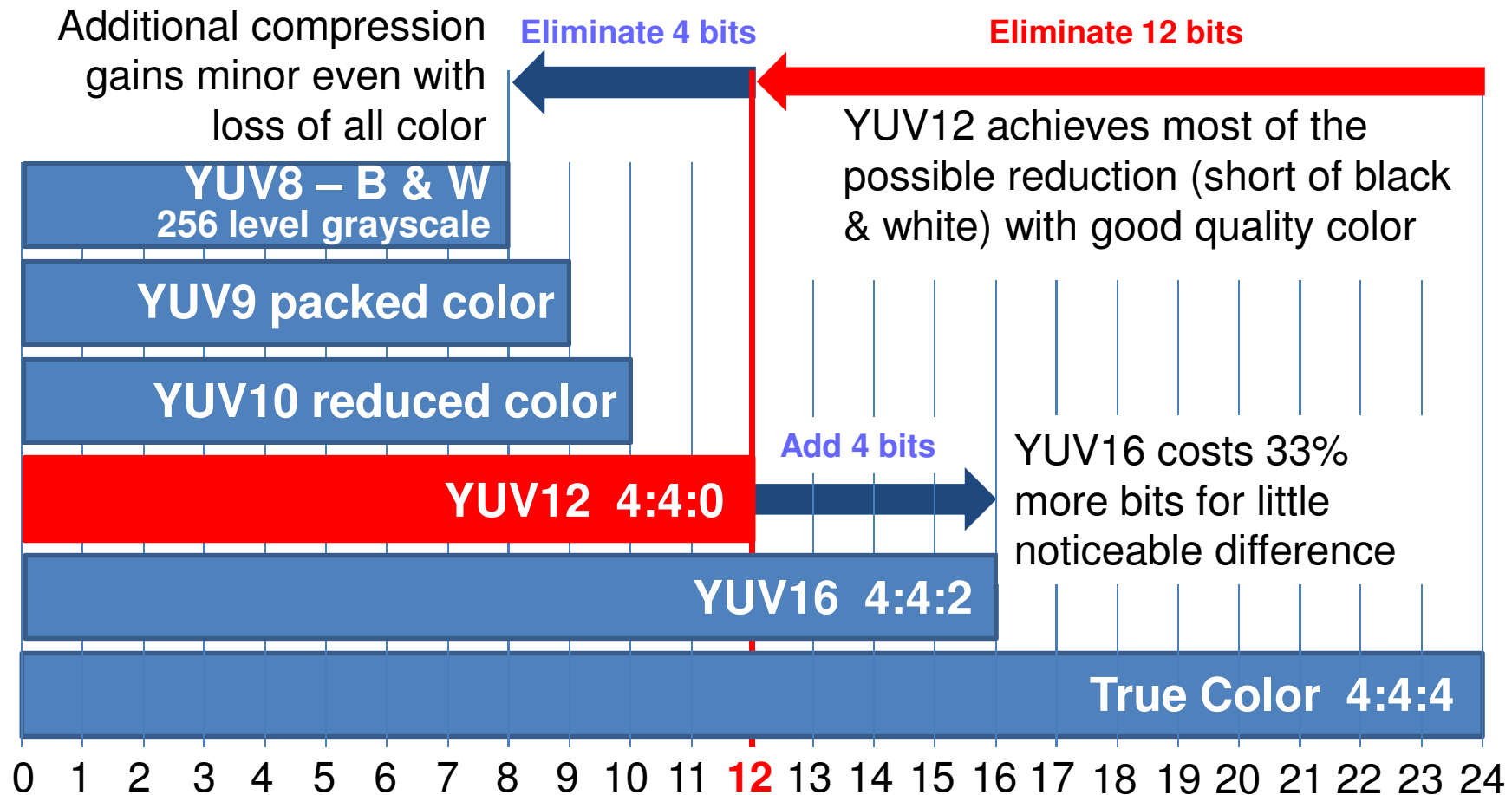
- Each pixel keeps its Y value, but some borrow **Cr**, **Cb** from a neighboring pixel
  - Number of pixels that borrow determine amount of compression (no borrowing = YUV24 or 4:4:4)
    - YUV16: 1 of 2 pixels borrow = lossy high quality 4:4:2
      - $24 + (1 \times 8) = 32 / 2 = 16\text{bpp}$
      - Used for source, editing
    - YUV12: 3 of 4 pixels borrow = lossy standard 4:2:0
      - $24 + (3 \times 8) = 48 / 4 = 12\text{bpp}$
      - Distribution format used in broadcasts, by DVDs, etc.
    - YUV10: 7 of 8 pixels borrow = noticeable color loss
      - $24 + (7 \times 8) = 80 / 8 = 10\text{bpp}$
    - YUV9: 15 of 16 pixels borrow = “packed color”
      - $24 + (15 \times 8) = 144 / 16 = 9\text{bpp}$
    - YUV8: black & white (luminance only)

# YUV Compression Schemes

Adjacent pixels are usually similar in color. In YUV compression, every pixel keeps its own luminance value, but some borrow chrominance from an adjacent pixel.



# YUV Compression Levels



**“Lossy” YUV compression: eliminate half the bits but keep good color quality**