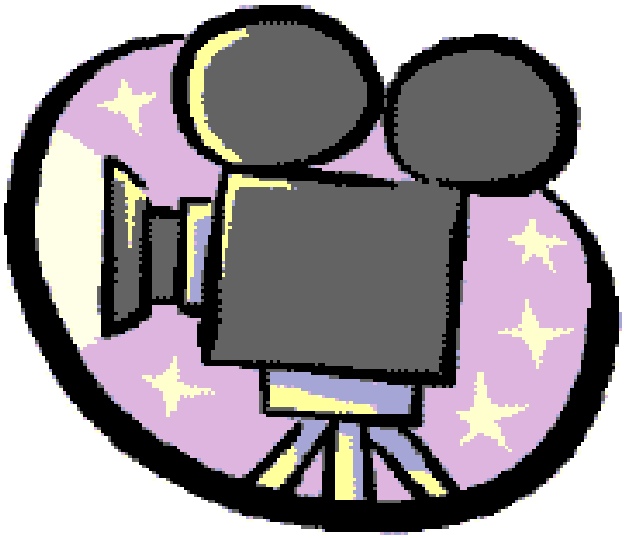
Analog and Digital Video Basics



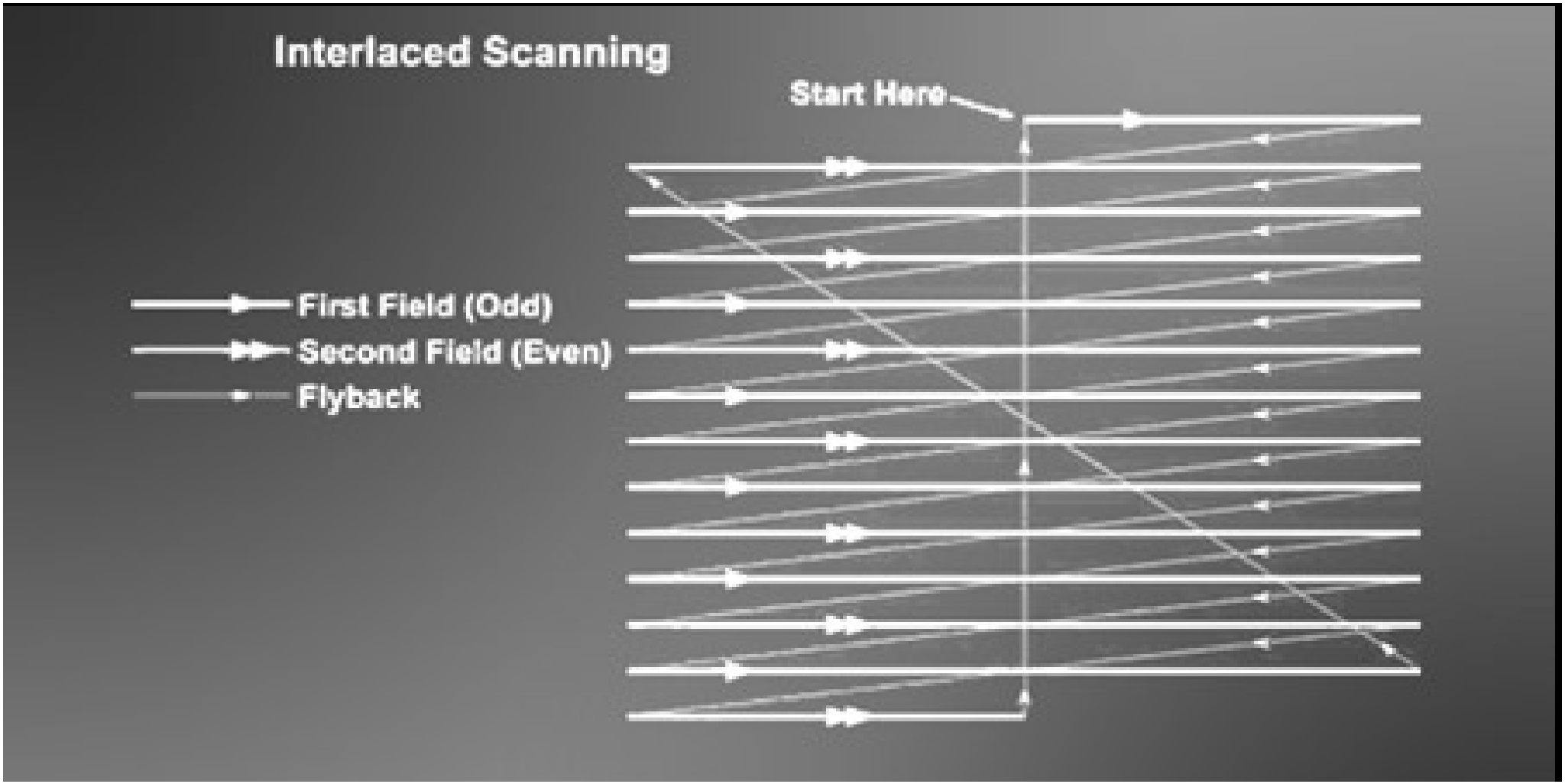
Nimrod Peleg

Update: May. 2009

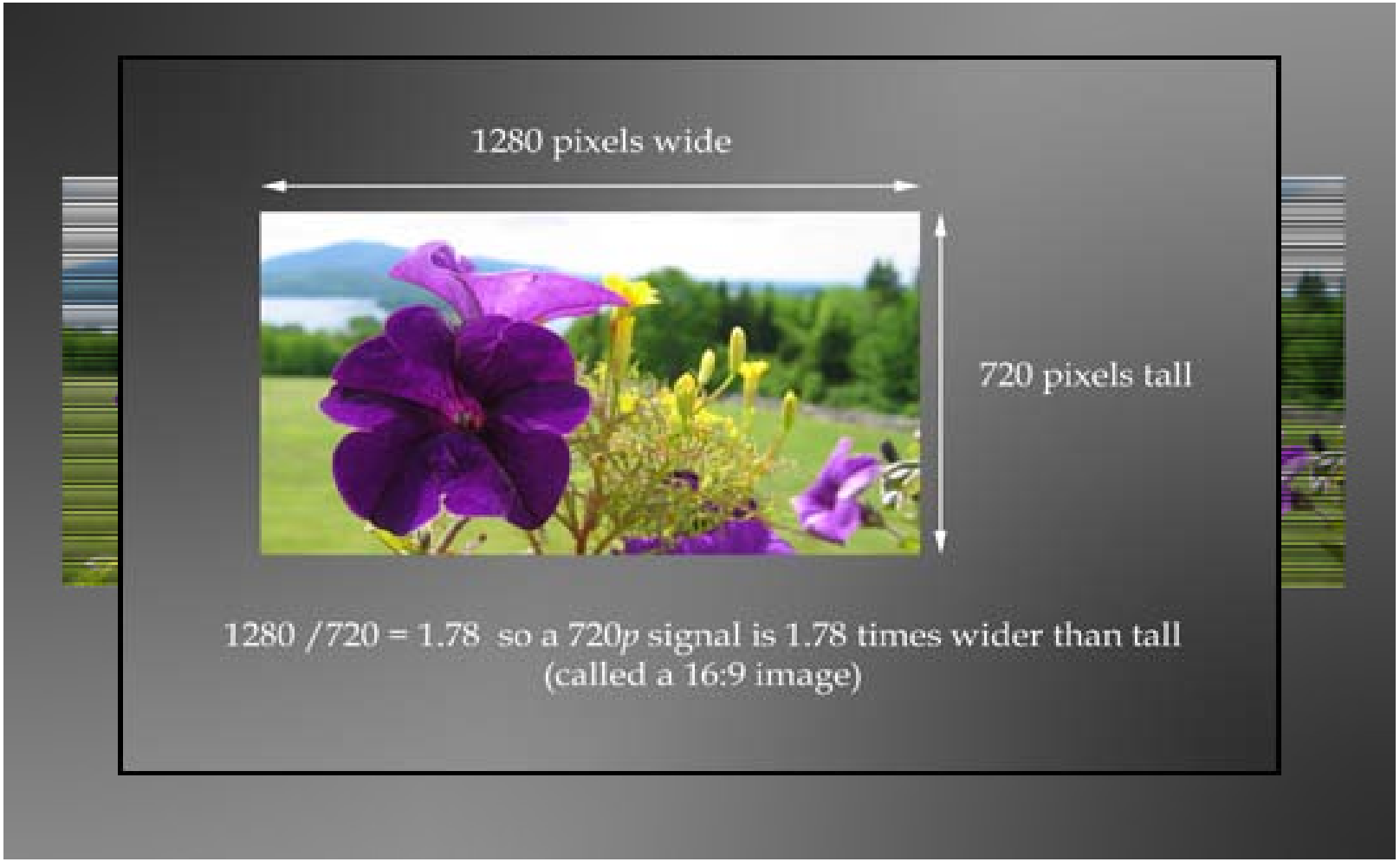
Video Compression: list of topics

- Analog and Digital Video Concepts
- Block-Based Motion Estimation
- Resolution Conversion
- H.261: A Standard for VideoConferencing
- MPEG-1: A Standard for CD-ROM Based App.
- MPEG-2 and HDTV: All Digital TV
- H.263: A Standard for VideoPhone
- MPEG-4: Content-Based Description

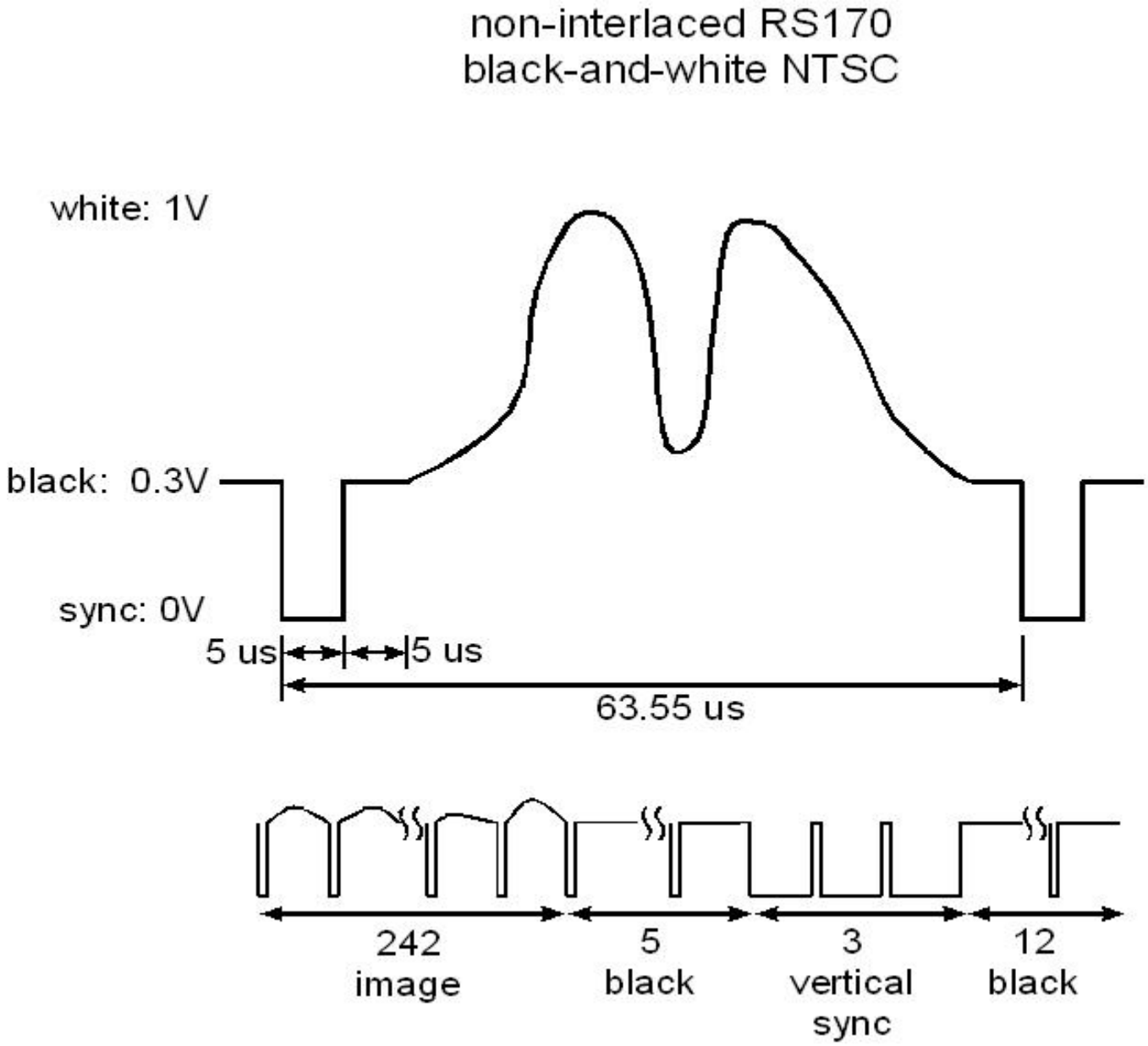
Analog Video Signal:
Raster Scan



Odd and Even Scan Lines



Analog Video Signal: Image line



Analog Video Standards

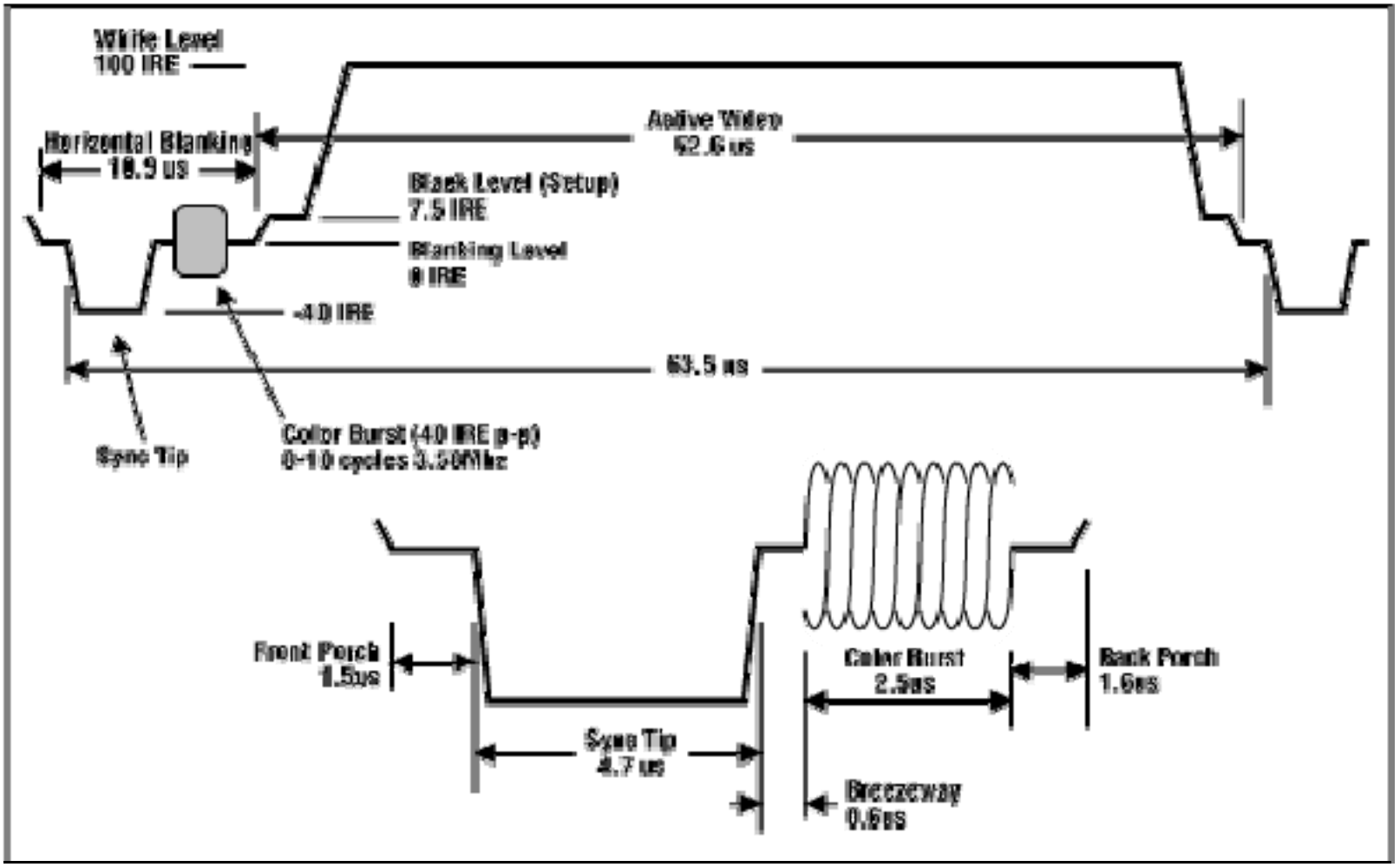
- All video standards are in 

- Almost any color can be reproduced by mixing the 3 additive primaries:

  R (red) , G (green) , B (blue)

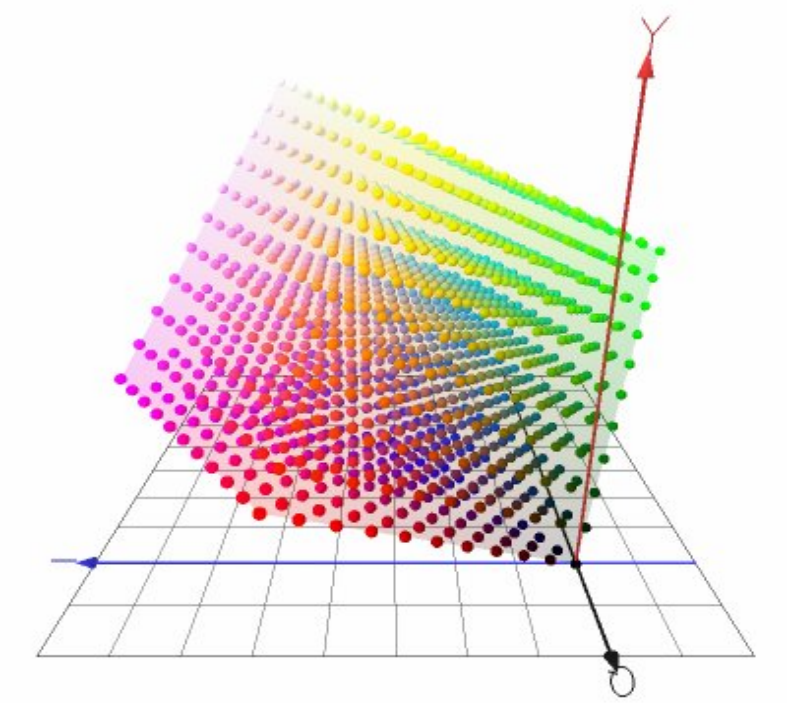
- 3 main different representations:
  - Composite
  - Component or S-Video (Y/C)

Composite Video



Component Analog Video

- Each primary is considered as a separate monochromatic video signal
- Basic presentation: R G B
- Other RGB based:
  - YIQ
  - YCrCb
  - YUV
  - HSI



To Color Spaces Demo

Composite Video Signal

Encoding the Chrominance over Luminance into one signal (saving bandwidth):

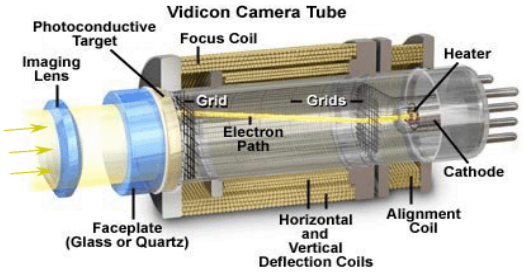
- NTSC (National TV System Committee)
  North America, Japan
- PAL (Phased Alternation Line)
  Europe (Including Israel)
- SECAM (Systeme Electronique Color Avec Memoire)
  France, Russia and more

Analog Standards Comparison

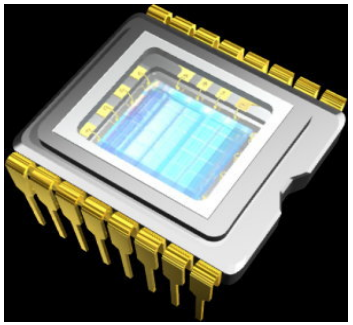
	NTSC	PAL/SECAM
Defined	1952	1960
Scan Lines/Field	525/262.5	625/312.5
Active horiz. lines	480	576
Subcarrier Freq.	3.58MHz	4.43MHz
Interlacing	2:1	2:1
Aspect ratio	4:3	4:3
Horiz. Resol.(pel/line)	720	720
Frames/Sec	29.97	25
Component Color	YUV	YCbCr

Analog Video Equipment

- Cameras
  - Vidicon, Film, CCD)



- Video Tapes (magnetic):
  - Betacam, VHS, SVHS, U-matic, 8mm ....



- Optical Video Disk

- Displays

All for all video standards !

First TV sets

1928 G.E. Scanning Disk Television Set (closed-open)

before 1935: "Mechanical Television Era". The display had a small motor with a spinning disc and a neon lamp, which worked together to give a blurry reddish-orange picture about half the size of a business card!

1939 - (GE-HM171) 5" tabletop, wood (mahogany), 3 channels, vision only - no sound !

From: http://www.tvhistory.tv/

Digital Video

- Developed with CD-ROM Technology

- Brings computers and communication together in a truly revolutionary matter:
  - Personal computer
  - VideoPhone, FAX, HDTV, Live video (with processing), Local image printer,

    Video Conferencing, ...

Digital Video Formats

- For a number of years: professional TV studios used D1 (component) and D2 (composite) digital formats.

- CCIR digitization (CCIR601) and interfacing (CCIR656) for digital video is base line for all formats, using component form known as 4:2:2 (Y, Cb, Cr).

CCIR Digitization

- For component video signals (studio source) with BW=6MHz, CCIR sampling rate is 13.5MHz, independent of scanning standard
- This rate represents 864 x Fh for 625 systems and 858 x Fh for 525 systems.
- Active lines per frame is 720 for both.
- For 8 bits/sample: 13.5M x 8 = 108M bit/sec.

Digital Video (CCIR 601)

- Coded Signals: Y, Cb, Cr
- Samples/line: 858 (NTSC) / 864 (PAL)
  - for color components: 429 / 432
- Active samples: 720
  - for color components: 360
- Quantizer: Uniform PCM , 8 bit/sample (Y,Cb,Cr)
- Gray levels Scale: 0 - 255
  - Y: 220 Q levels (black:16, gray-white:235)
  - Cb,Cr: 225 Q levels (zero: 128)

Digital Video Signal

- TrueColor: RGB , 24 bit (~16M colors)
- Resolution: lack of sufficient resolution causes pixellation (blockization).
- Synchronization: No need (“computer made”).
- Conversion: A/D & D/A after cameras and before display (still too expensive).
- **The bottleneck: BITRATE**

BitRates

- CD Quality digital audio:

44.1KHz * 16bps *2 (stereo) = ~1.4Mbps

- HDTV: about 1Gbps

One picture worth (almost) a 1000 words...

Digital Video Resolution (CCIR601, 4:2:2)

	525/60(NTSC)	625/50(PAL)	CIF
Active pel/line			
Lum (Y)	720	720	360
Chroma(U,V)	360	360	180
Active lines/pic			
Lum (Y)	480	576	288
Chroma(U,V)	480	576	144
Interlacing	2:1	2:1	1:1
Rate/Aspect Ratio	60/4:3	50/4:3	30/4:3

Network protocols and Bitrates

• Conventional telephone	0.3-56Kbps
• ISDN	64-144Kbps
• T-1	1.5Mbps
• Ethernet (Packet based)	10M/100M bps
• Broadband ISDN	100-200Mbps
• ATM (Cell based)	155Mbps …..
• Fast Ethernet	1Gbps ….

Proprietary Video Formats

• DVI, Indeo	Intel
• QuickTime	Apple
• CD-I	Philips
• PhotoCD	Eastman Kodak
• CDTV	Commodore
• And many more….	

Why Digital Video?

- Quality
- Error correction
- Interactivity
- Computer control (s/w)
- Real-time playback and all kinds of editing
- Integration of many multimedia platforms
- And more .....

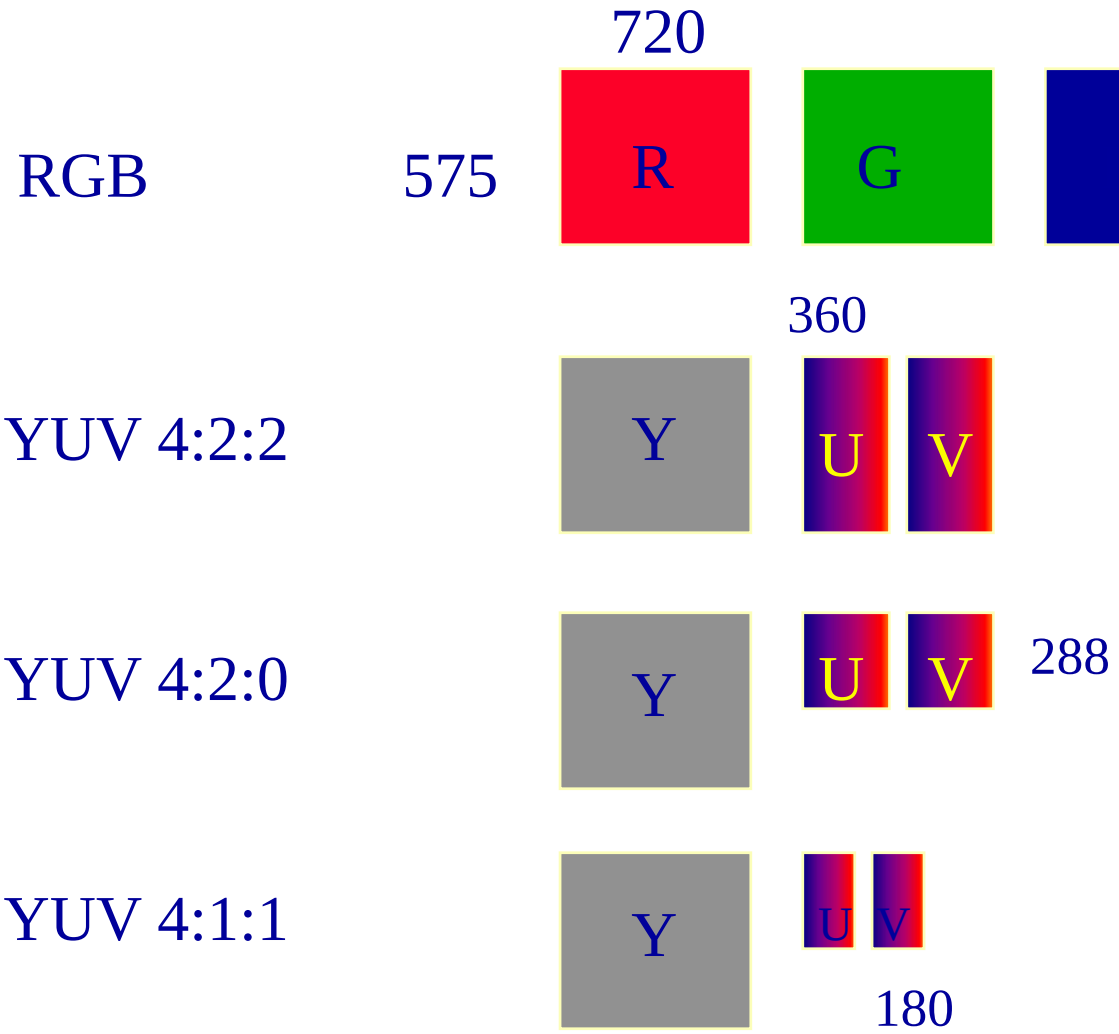
A Summary of Video Formats

- CCIR Size (D1) Progressive Pictures:
  - NTSC - 720x480 (29.97 Pictures/Sec)
  - PAL - 720x576 (25 Pictures/Sec)
- CCIR Size (D1) Interlaced Pictures:
  - NTSC - 720x(240x2) (29.97 Pictures/Sec)
  - PAL - 720x(288x2) (25 Pictures/Sec)
- HD1 (Half D1) Progressive Pictures:
  - NTSC – 352x480 (29.97 Pictures/Sec)
  - PAL – 352x576 (25 Pictures/Sec)
- HD1 (Half D1) Interlaced Pictures:
  - NTSC – 352x(240x2) (29.97 Pictures/Sec)
  - PAL – 352x(288x2) (25 Pictures/Sec)

Video Formats (Cont'd)

- SIF (Source Input Format) :
  - NTSC – 352x240 (29.97 Pictures/Sec)
  - PAL – 352x288 (25 Pictures/Sec)
- QSIF :
  - NTSC – 176x112 (29.97 Pictures/Sec)
  - PAL – 176x144 (25 Pictures/Sec)
- CIF (Common Intermediate Format) :
  - 352x288 (30 Pictures/Sec)
- QCIF Size Pictures:
  - 176x144 (30 Pictures/Sec)

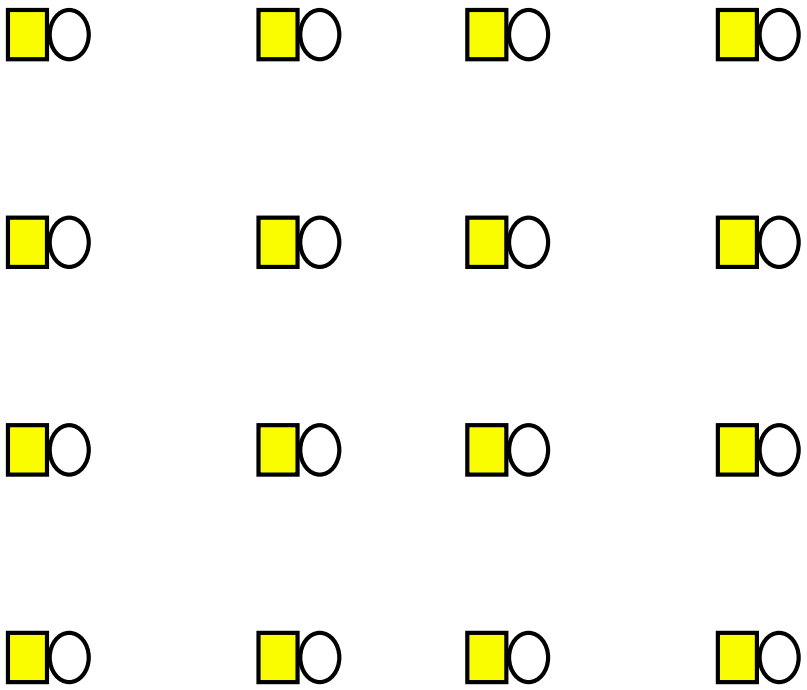
Video Chroma SubSampling



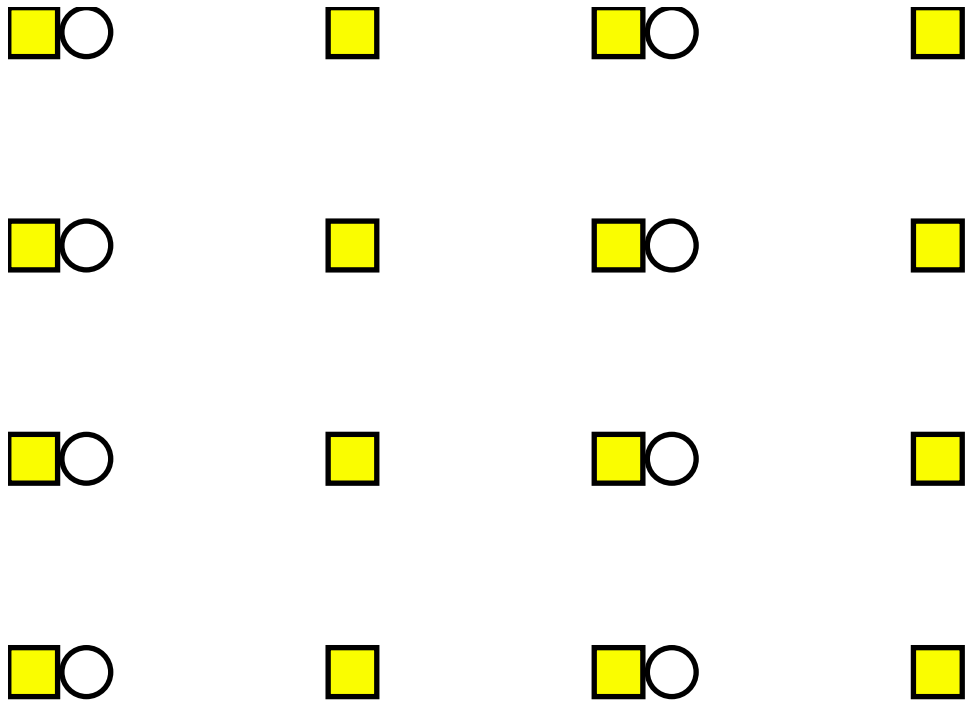
The basic line sampling rate of 3.375MHz is common to both PAL and NTSC TV systems

YCbCr 4:x:y Chroma Formats

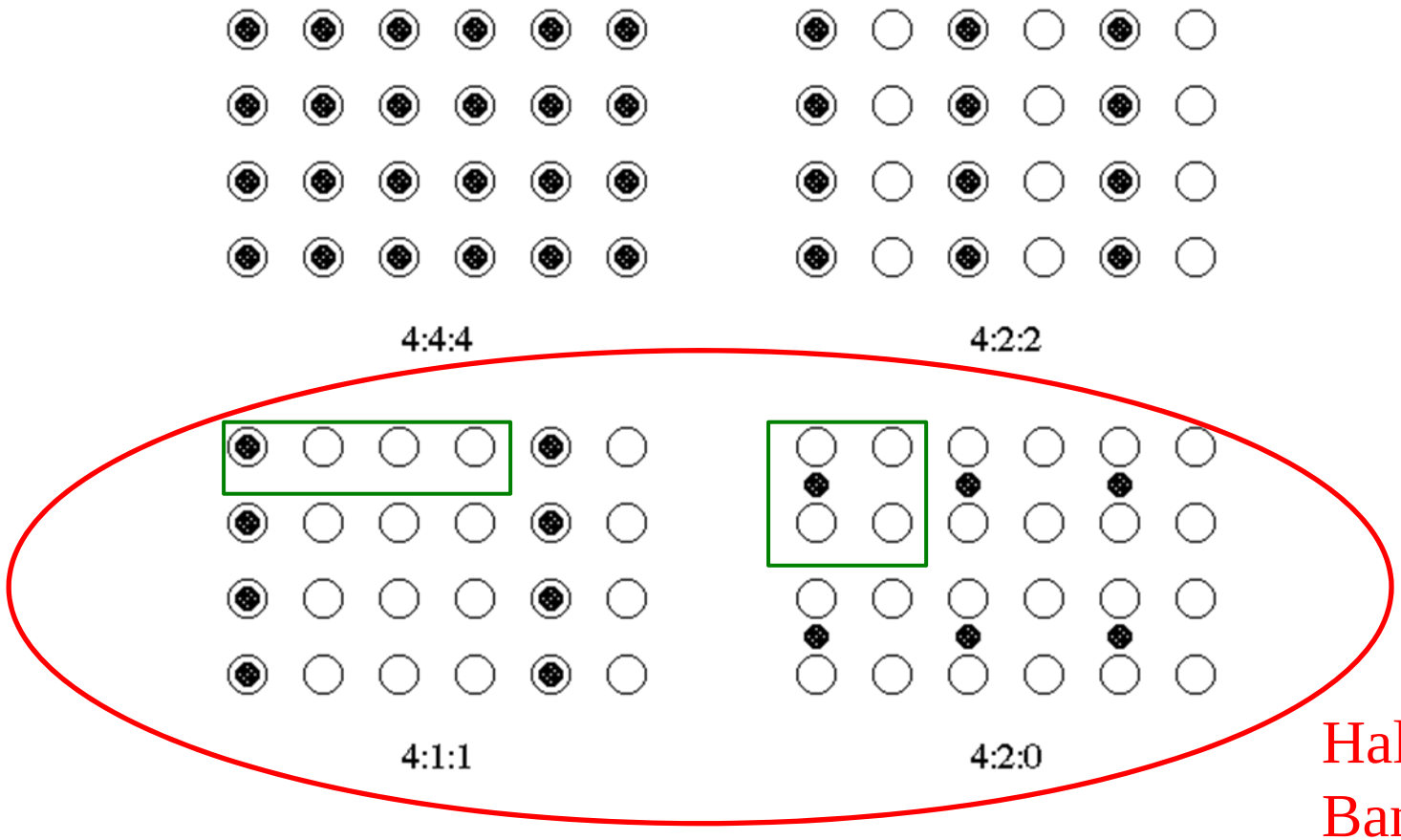
YCbCr
4:4:4



YCbCr 4:2:2

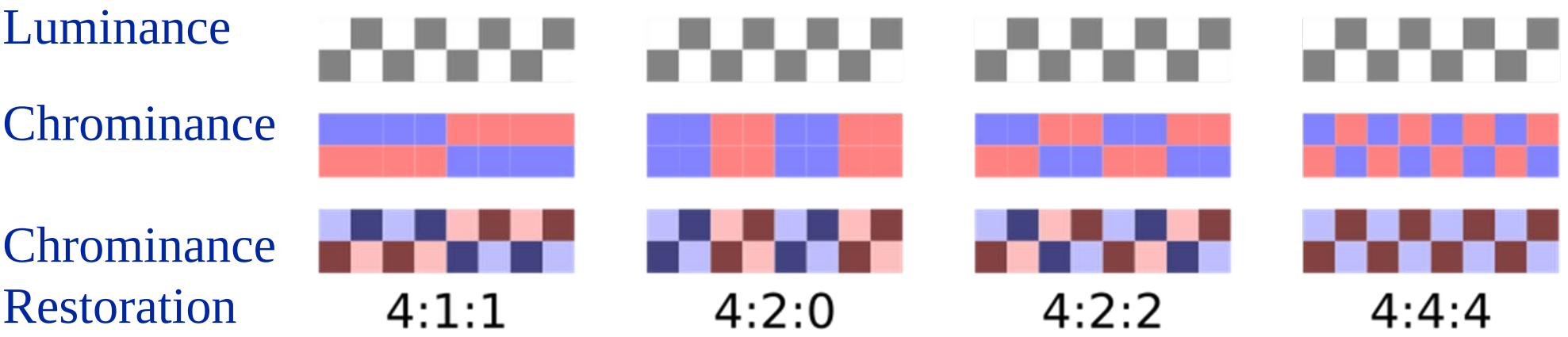


Color Decimation: 4:1:1 etc.



Half color Bandwidth ! !

Color Decimation Effect



[Taken from: Wikipedia, “Chroma subsampling”]

Color decimation Artifacts: Moving text example

Original, single field. The moving text has some motion blur applied to it.

Original still image.

4:2:0 **progressive** sampling (single field) applied to moving interlaced material. the chroma leads and trails the moving text.

4:2:0 **progressive** sampling applied to a Still image. Both fields are shown.

4:2:0 **interlaced** sampling (single field) applied to moving interlaced material.

4:2:0 **interlaced** sampling applied to a still image. Both fields are shown.

Why ?

In the 4:2:0 interlaced scheme, vertical resolution of the chroma is roughly halved since the chroma samples effectively describe an area 2 samples wide by 4 samples tall instead of 2X2.

- As well, the spatial displacement between both fields can result in the appearance of block-like chroma artifacts.

Hebrew Literature: analog video

- טלוויזיה בשחור-לבן ובצבע ,מט"ח - 1982
- אוניברסיטה פתוחה