Visual Imaging and the Electronic Age

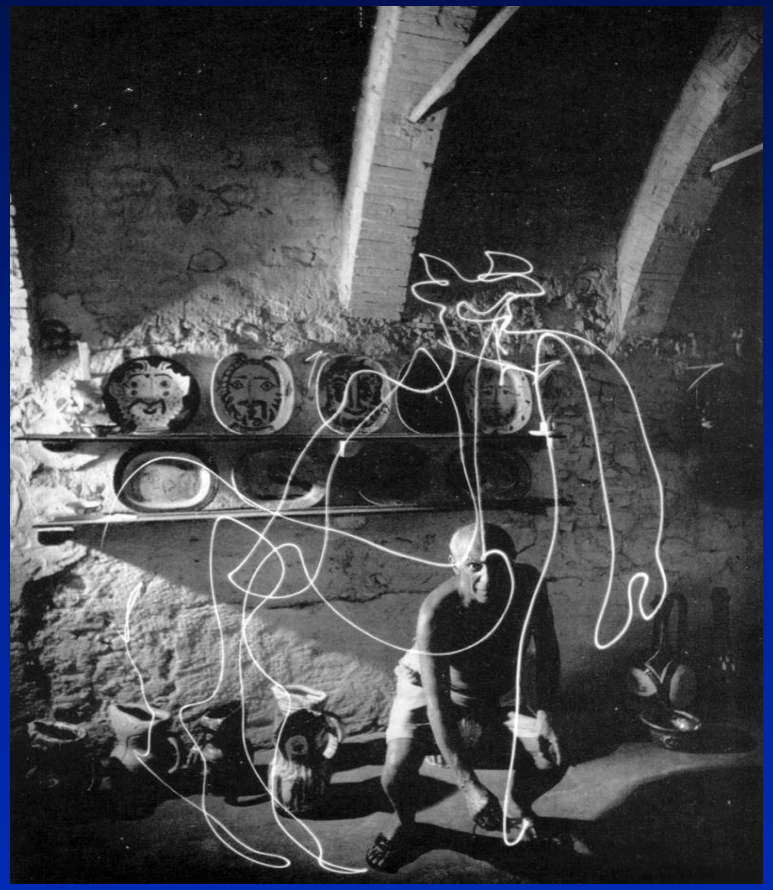
Display Technology

Lecture #12
October 13, 2020
Donald P. Greenberg

The persistence of vision

"And when a coal of fire is moved nimbly in the circumference of a circle makes the whole circumference appear like a circle of fire; is it not because the Motions excited in the bottom of the Eye by the Rays of Light are of a lasting nature..."

Newton, 1730



Picasso 1949

David Sarnoff, April 20, 1939

Television history was made on April 20, 1939, when David Sarnoff stood before a television camera and dedicated RCA's pavilion at the 1939 New York World's Fair. The dedication marked the first time a news event was ever covered by television. Sarnoff's speech, entitled "Birth of an Industry" predicted that television one day would become an important entertaining medium.

Felix the Cat Otto Messmer 1919

Limping To Living Color –RCA vs. CBS

Chronology of the last great television race, for color TV.

1946 - CBS demonstrates its mechanical color TV system using a color wheel that spins at high speed inside the set. It's incompatible with existing black-and-white TV's.

1949 - RCA begins work on a compatible, electronic color system.

1950 - CBS shows improved version of color-wheel system.
RCA calls color-wheel system "a horse and buggy."
RCA demonstrates its system: Bananas are blue.
F.C.C. chooses the CBS color-wheel system as the national standard.

Limping To Living Color –RCA vs. CBS

Cont'd: Chronology of the last great television race, for color TV.

1951 - RCA shows improved system and wins praise.

1953 - F.C.C. reverses itself and chooses RCA system as the new standard.

1954 - Manufacturers refuse to make color sets.
RCA puts first color TV on the market and begins airing color programs on NBC.

1956 - Time Magazine calls color TV a flop.

The Future of Television

"Television is a social novelty, a millionaire's toy, and there are not enough millionaires left in the U.S., not enough, anyway, on which to build an industry."

1939 New York Times


TIME
THE WEEKLY NEWSMAGAZINE
CBS'S FRANK STANTON
He wheeled in color TV.

Dec. 4, 1950

CBS Color Wheel

CBS Color Wheel Technology - 1951

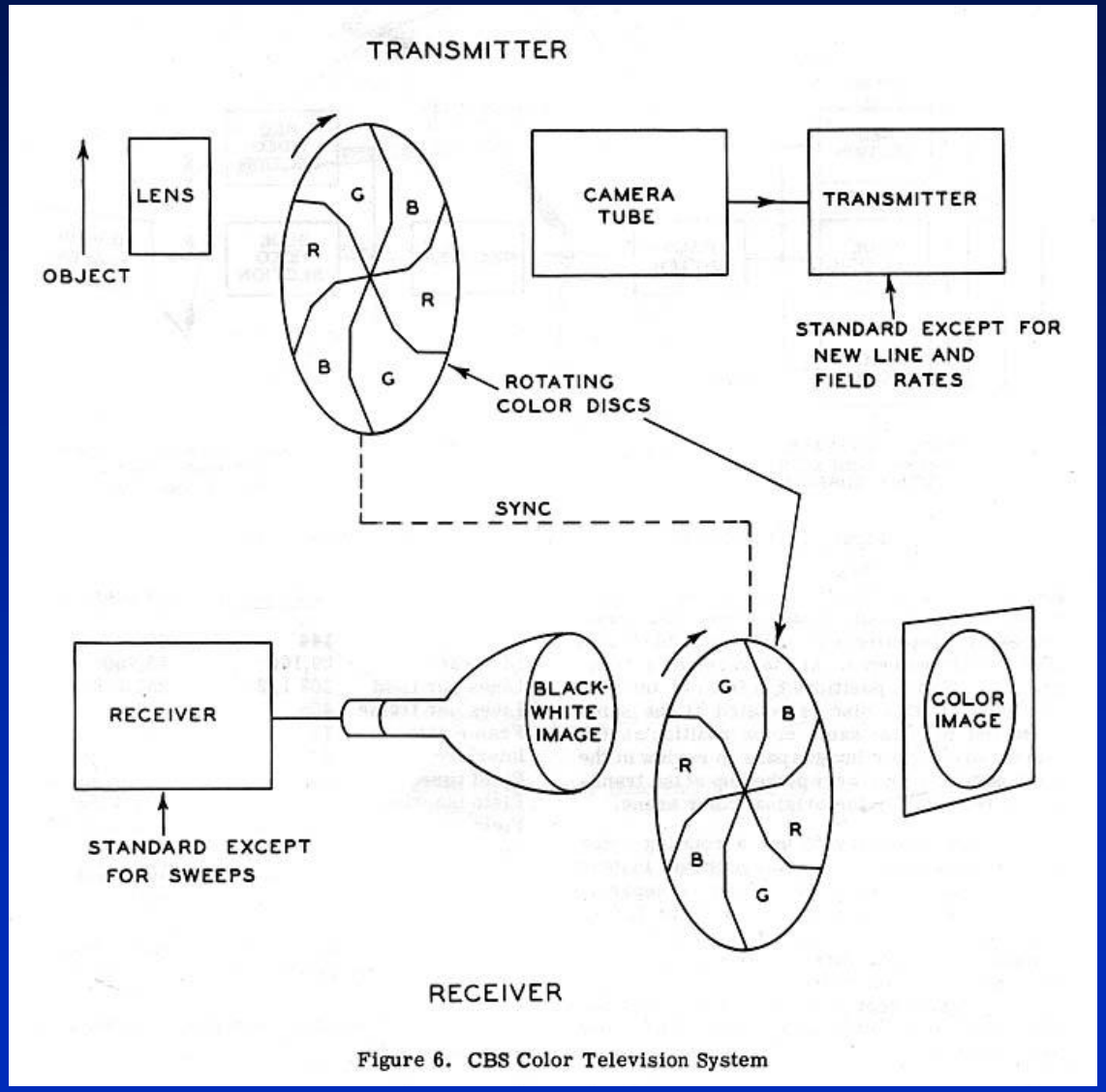
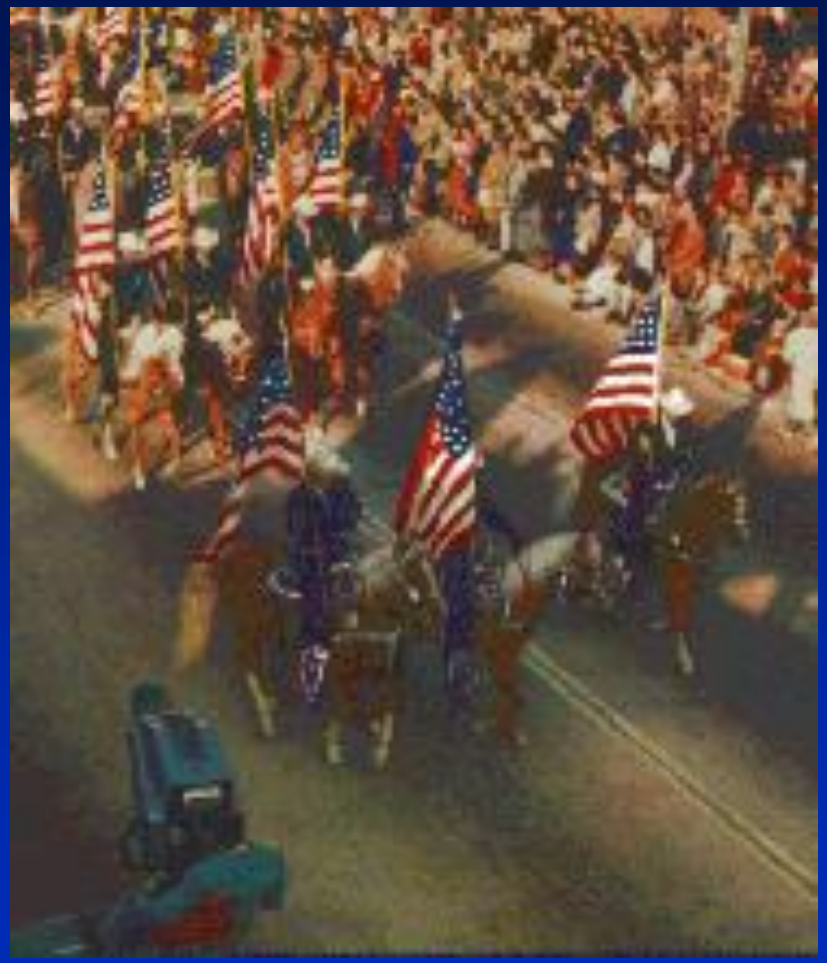


Figure 6. CBS Color Television System

“The Day a Black and White World, Changed into Living Color” January 1, 1954



A NBC/RCA Color Camera Pans the Opening Color Guard of the 1954 Pasadena Tournament of Roses parade.

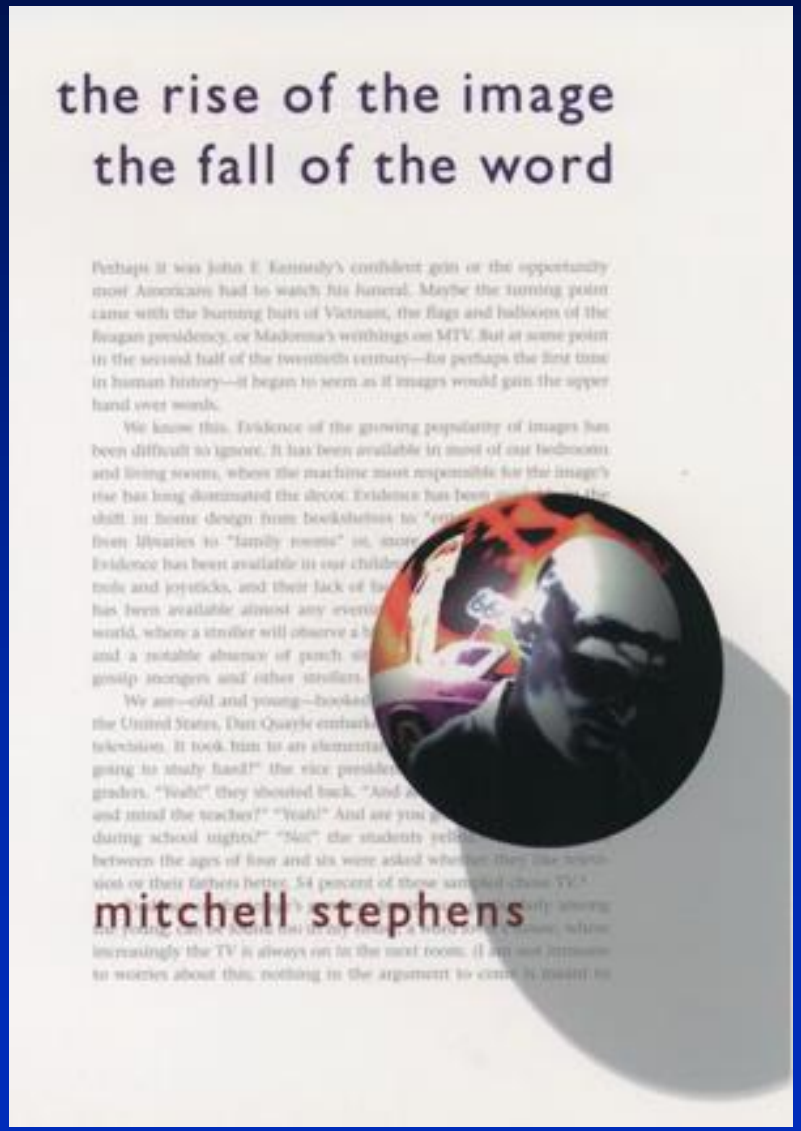
La Grande Jatte Seurat 1884

Georges Seurat, A Sunday on La Grande Jatte. 1884-1886

For Television to be Successful, the Following Was Necessary:

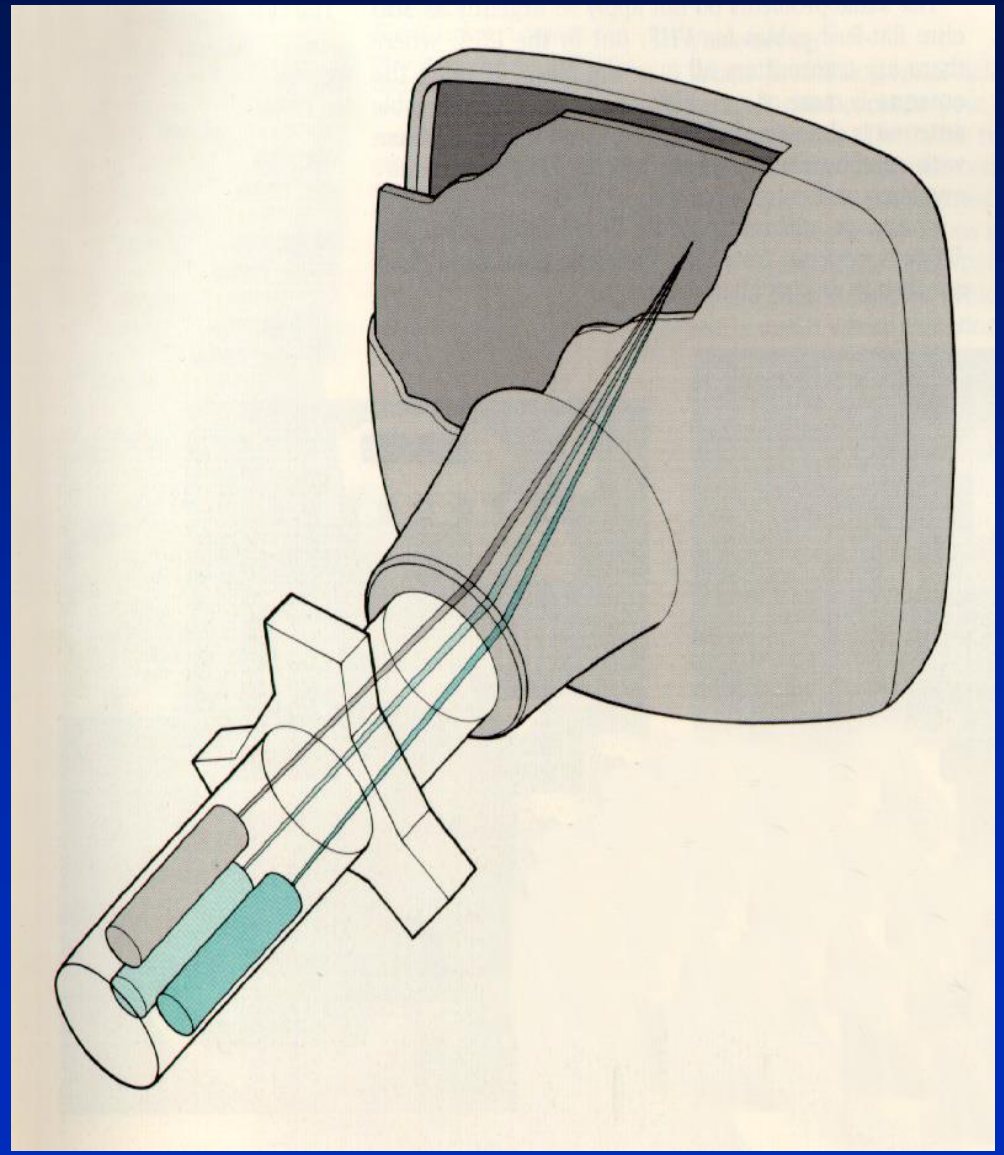
- Mass production to make cheap sets
- The show had to pay for itself, profit for telecasting & manufacturing
- Somebody to pay for building TV stations for both broadcasting and distribution (using airwaves in the 1940's & 1950's)

The Rise of the Image 1998

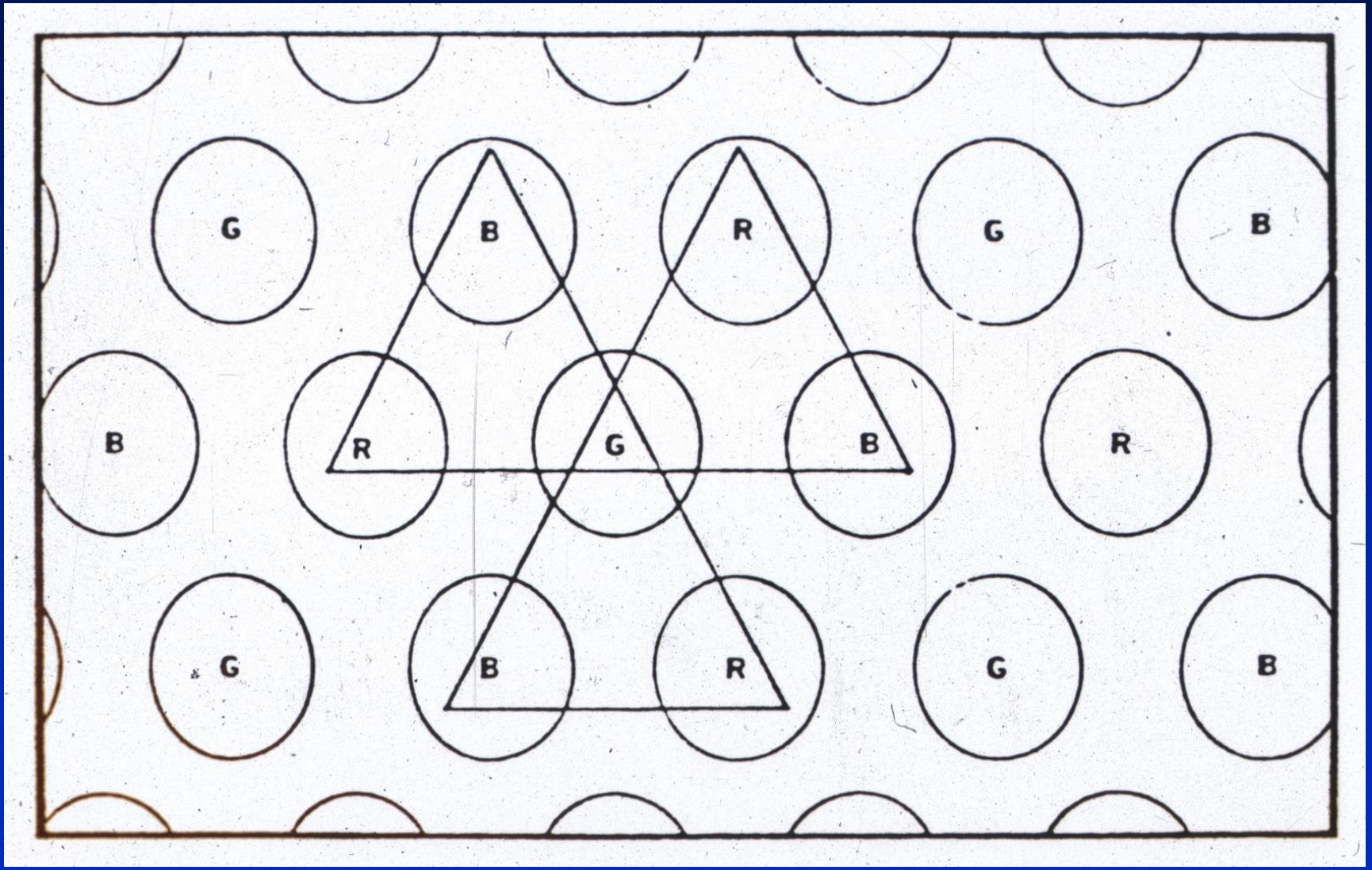


Old CRT Television

CRT Picture Tube



A Pixel Consists of Approximately 2 2/3 Triads



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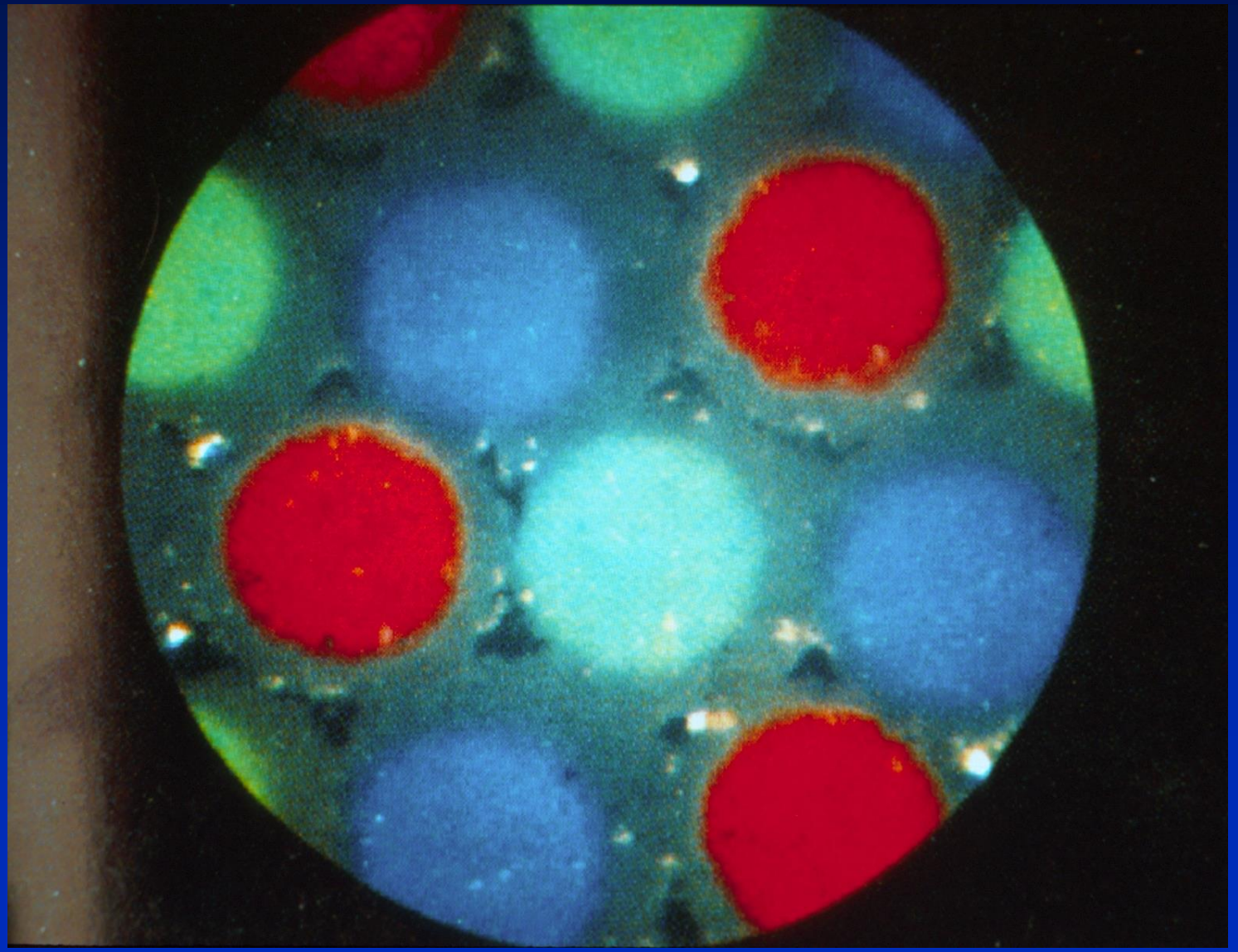


Motion is a Series of static Images

Perceptual Constraints

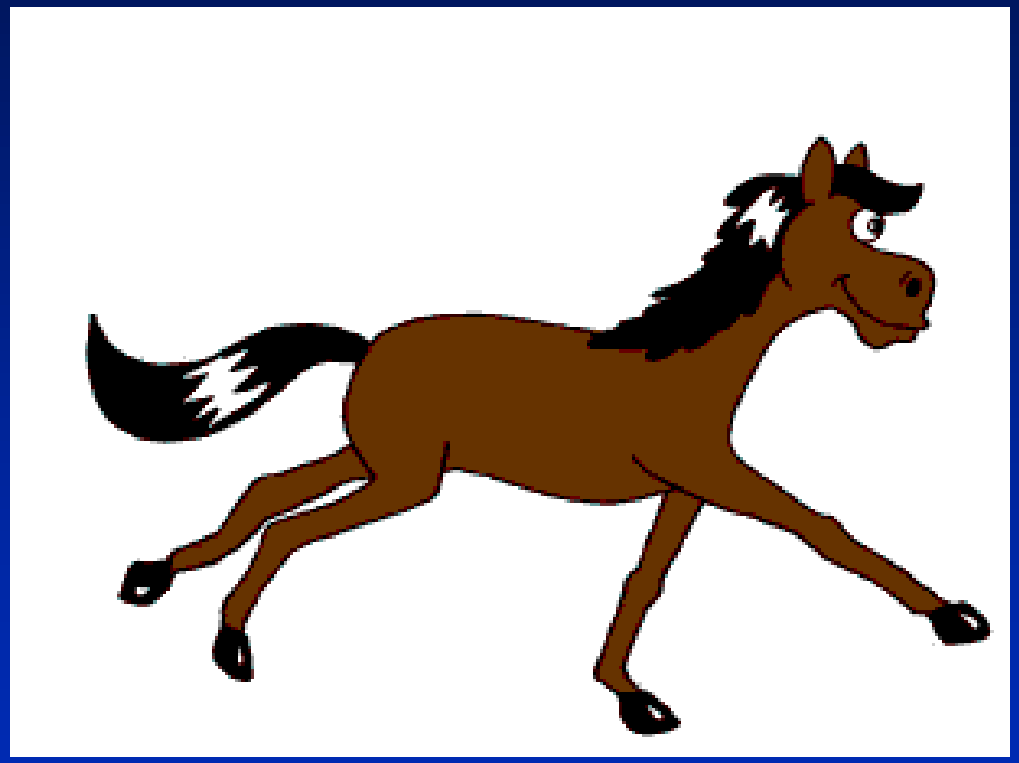
- Update rate
- Refresh rate

Update Rate

- The update rate is the number of changed images which are displayed per second.
- For the average human observer if changed images are shown at greater than 12 frames per second one can perceive motion .

Zoetrope William George Horner 1864

Update Demonstration



http://en.wikipedia.org/wiki/Persistence_of_vision

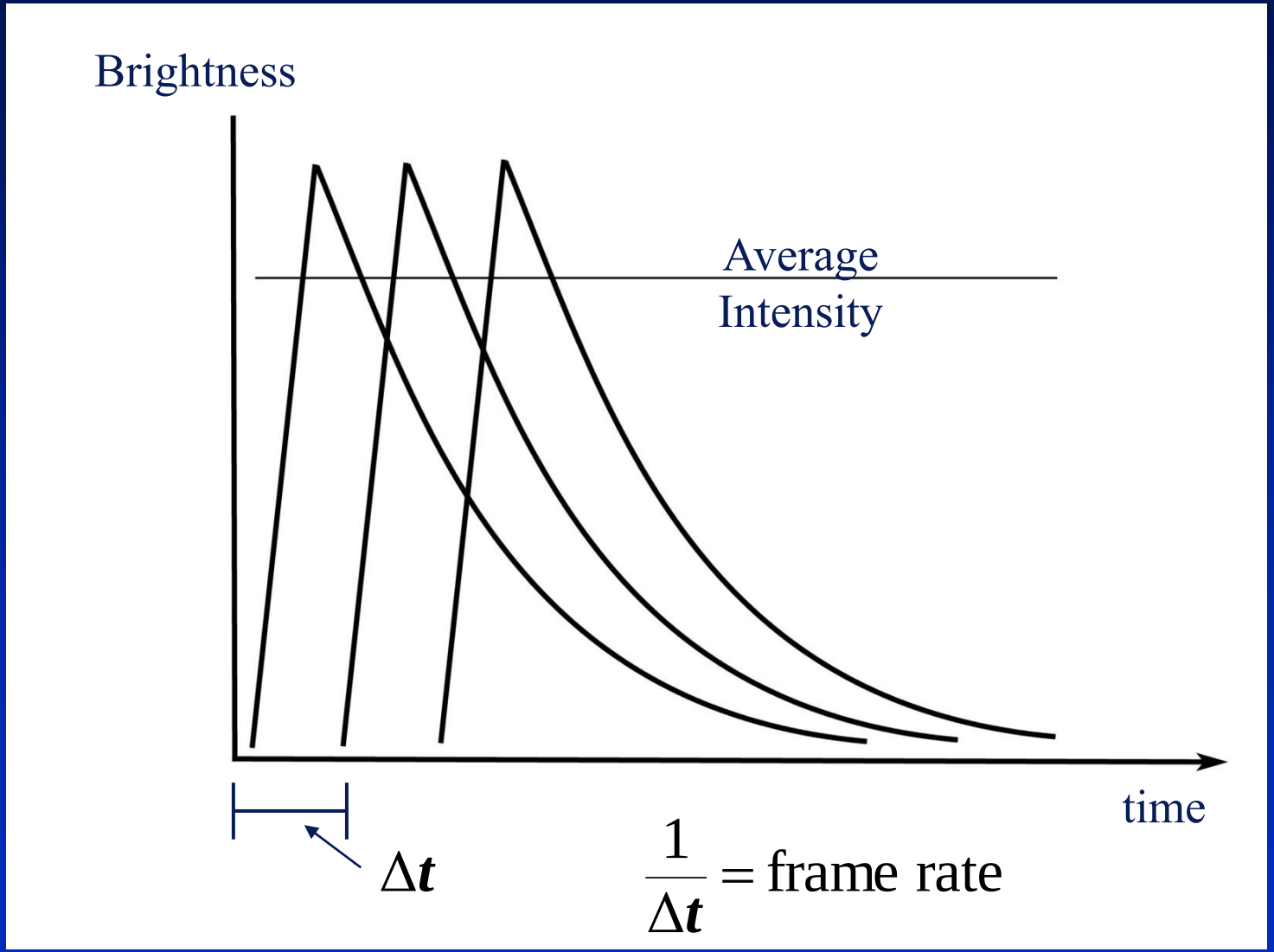
Perceptual Constraints

- Update rate
- Refresh rate

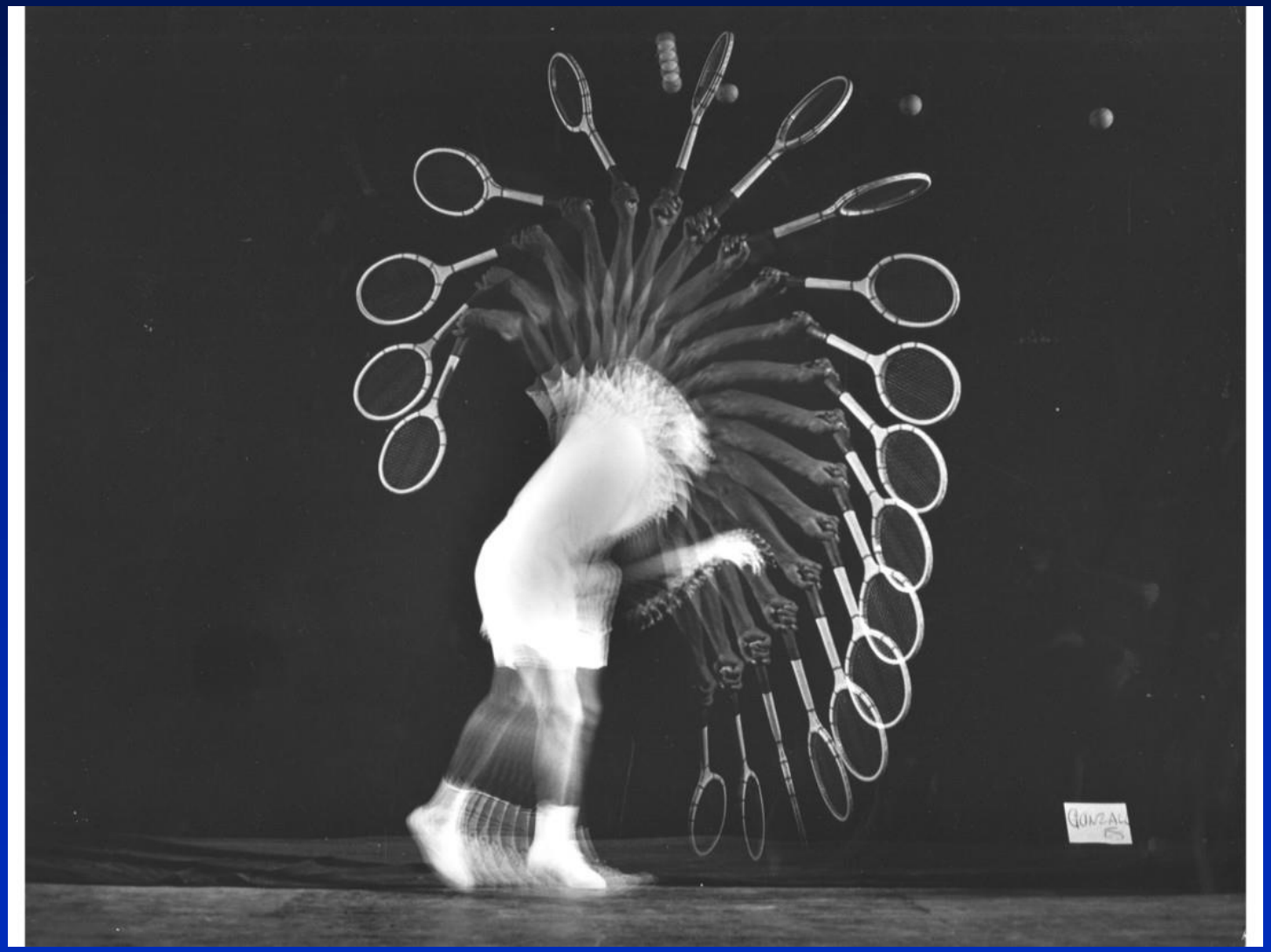
Refresh Rate Flicker Fusion Frequency

- The flicker fusion frequency of the average human observer is approximately 60 cycles per second.
- If the refresh rate is greater than this threshold, the observer sees a constant intensity.

Refresh Rate Phosphor Decay



Strobe Photography Edgerton



Pancho Gonzales

Strobe Photography Edgerton

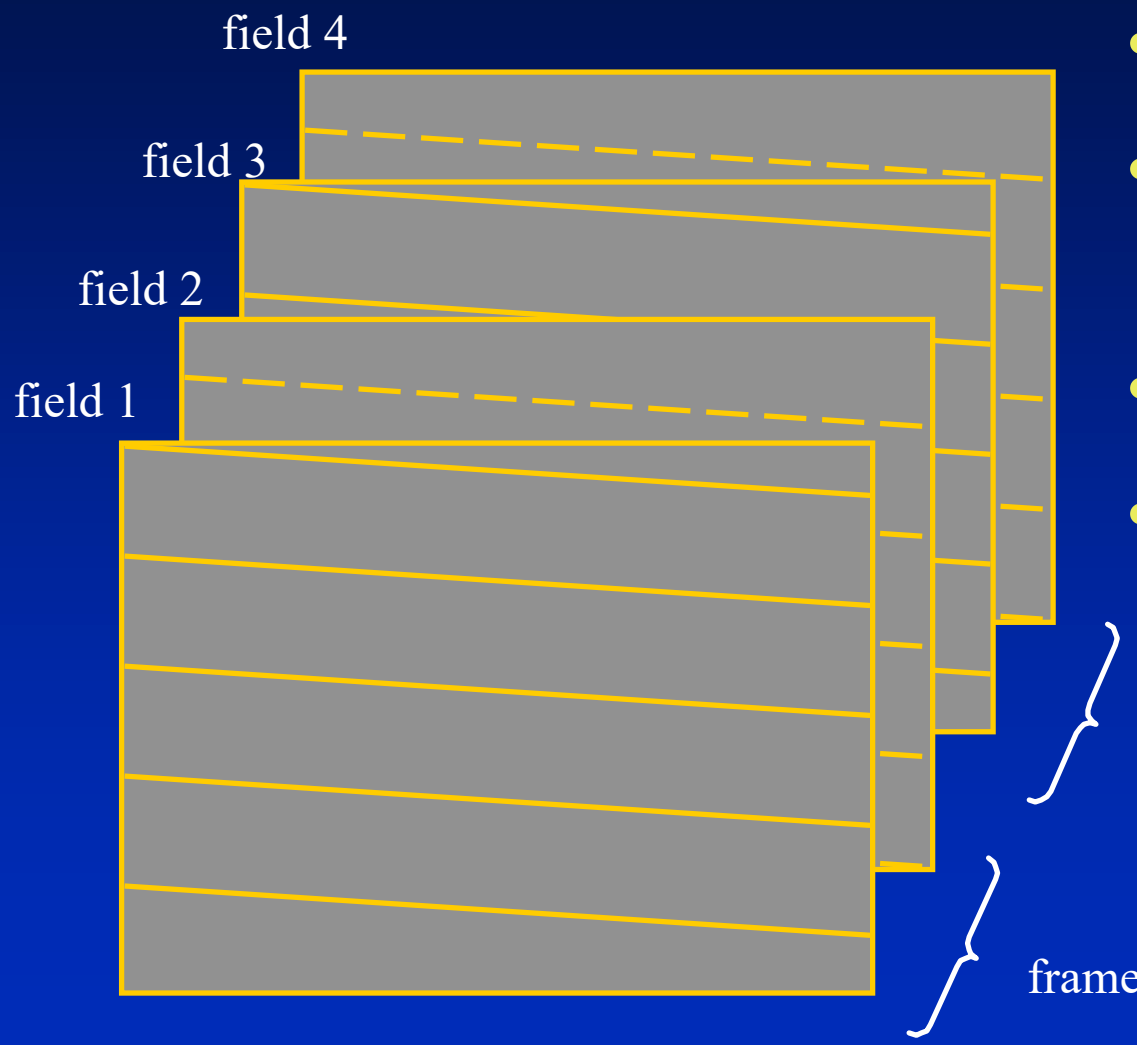
3D Printed Zoetrope

Pixar

Pixar Zoetrope Video

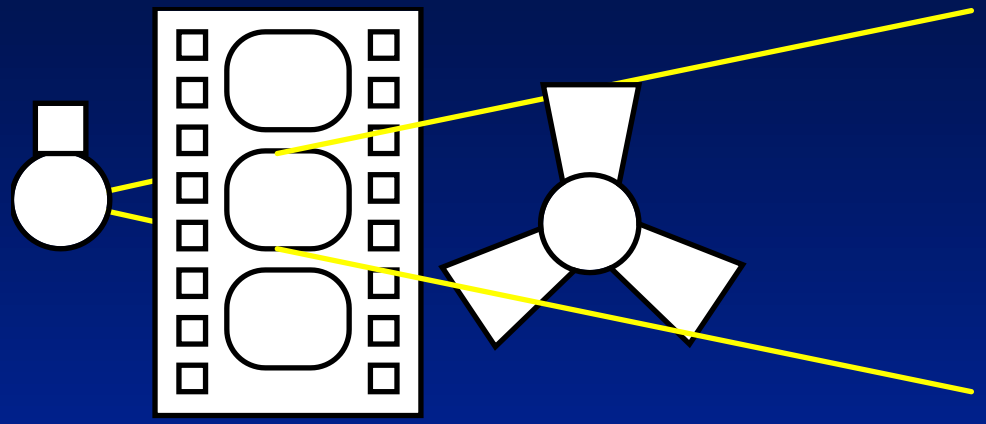
Temporal Properties of NTSC

REFRESH

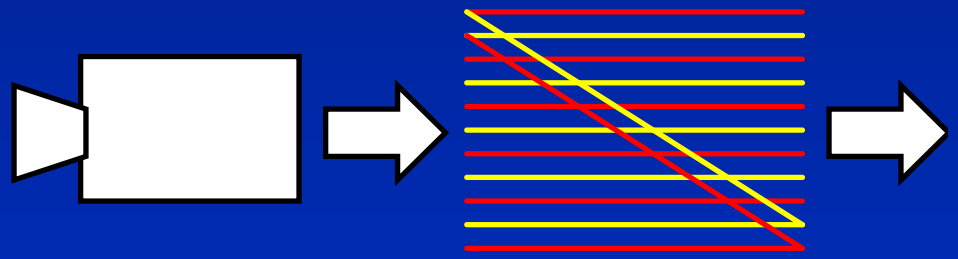


- low refresh rate -> flicker
- high refresh rate -> too much bandwidth
- solution: interlacing
- provides 60 Hz refresh rate with only 30 Hz update rate

Update Rate vs. Refresh Rate



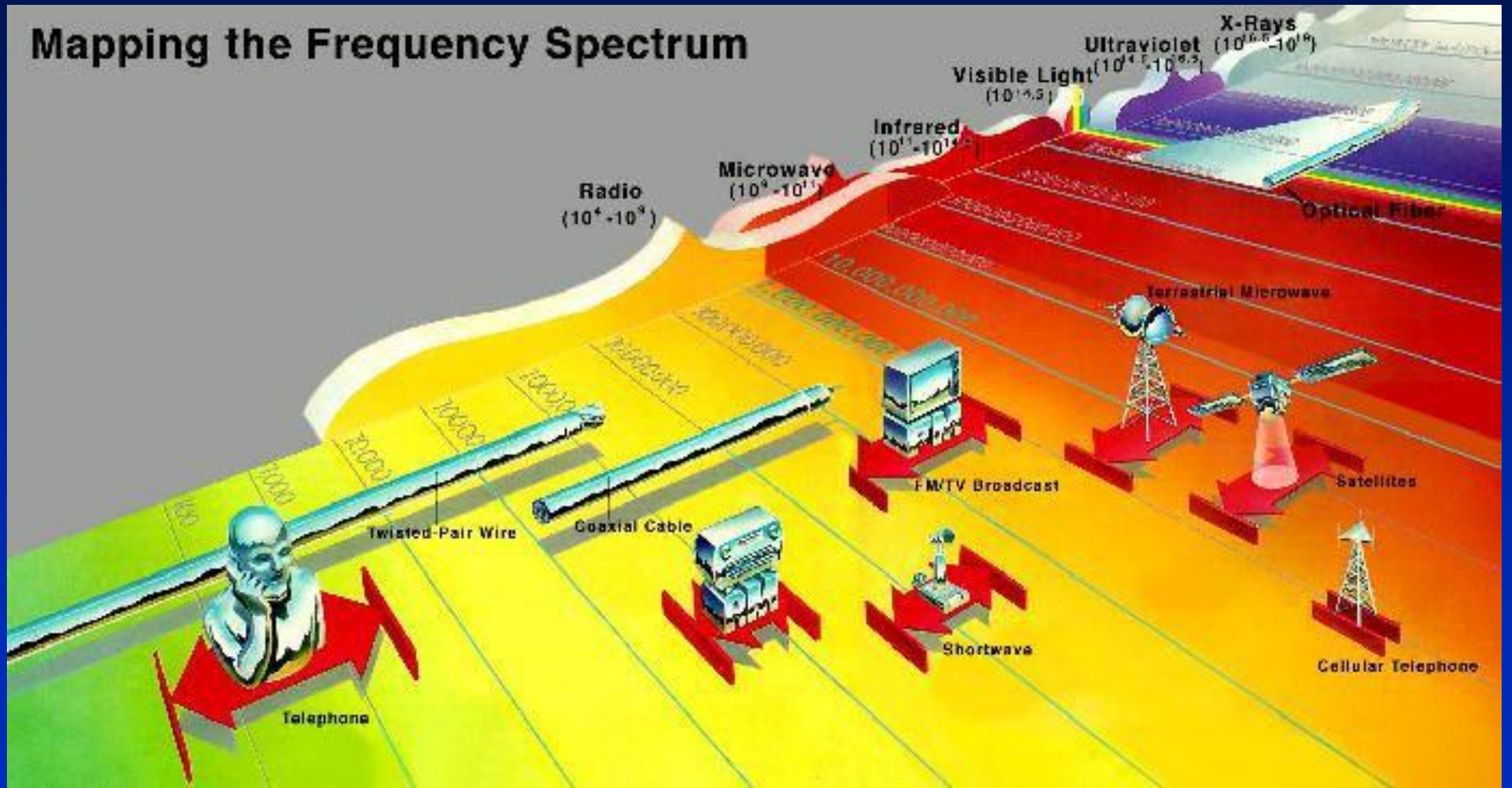
Film: 24fps update rate, 3 blade shutter, 72Hz refresh rate



Video: 30fps update rate, 2:1 interlacing, 60 Hz refresh rate

- interlacing: matches flicker limits of vision, minimizes bandwidth

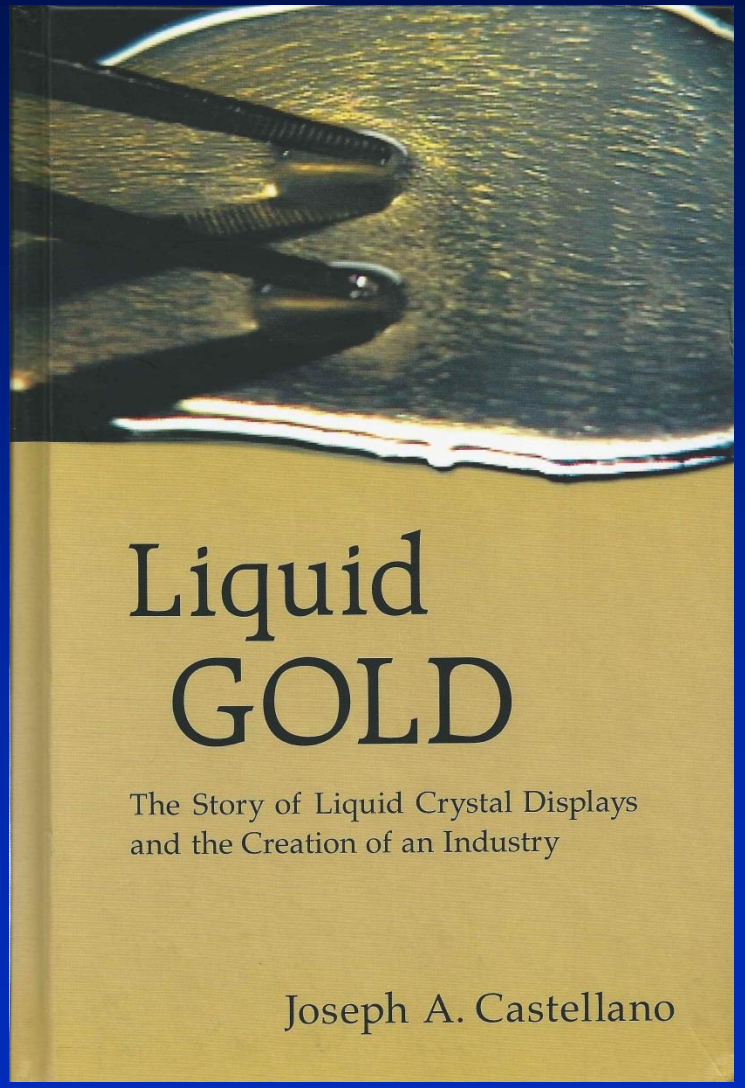
Mapping the Frequency Spectrum



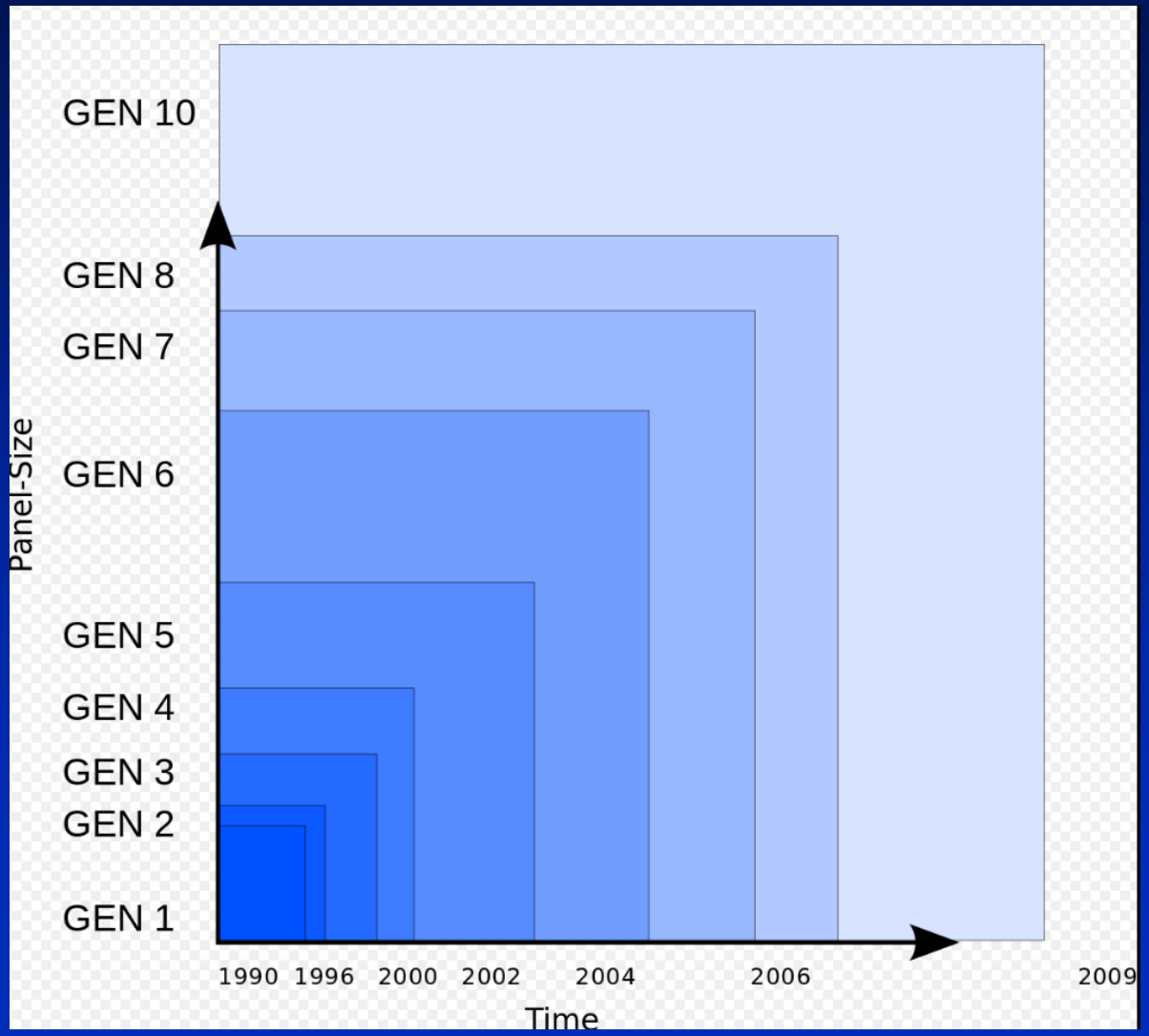
E & S Frame Buffer 1975

$80,000

Liquid Crystal Color Displays



LCD Panel Size 1990-2020+



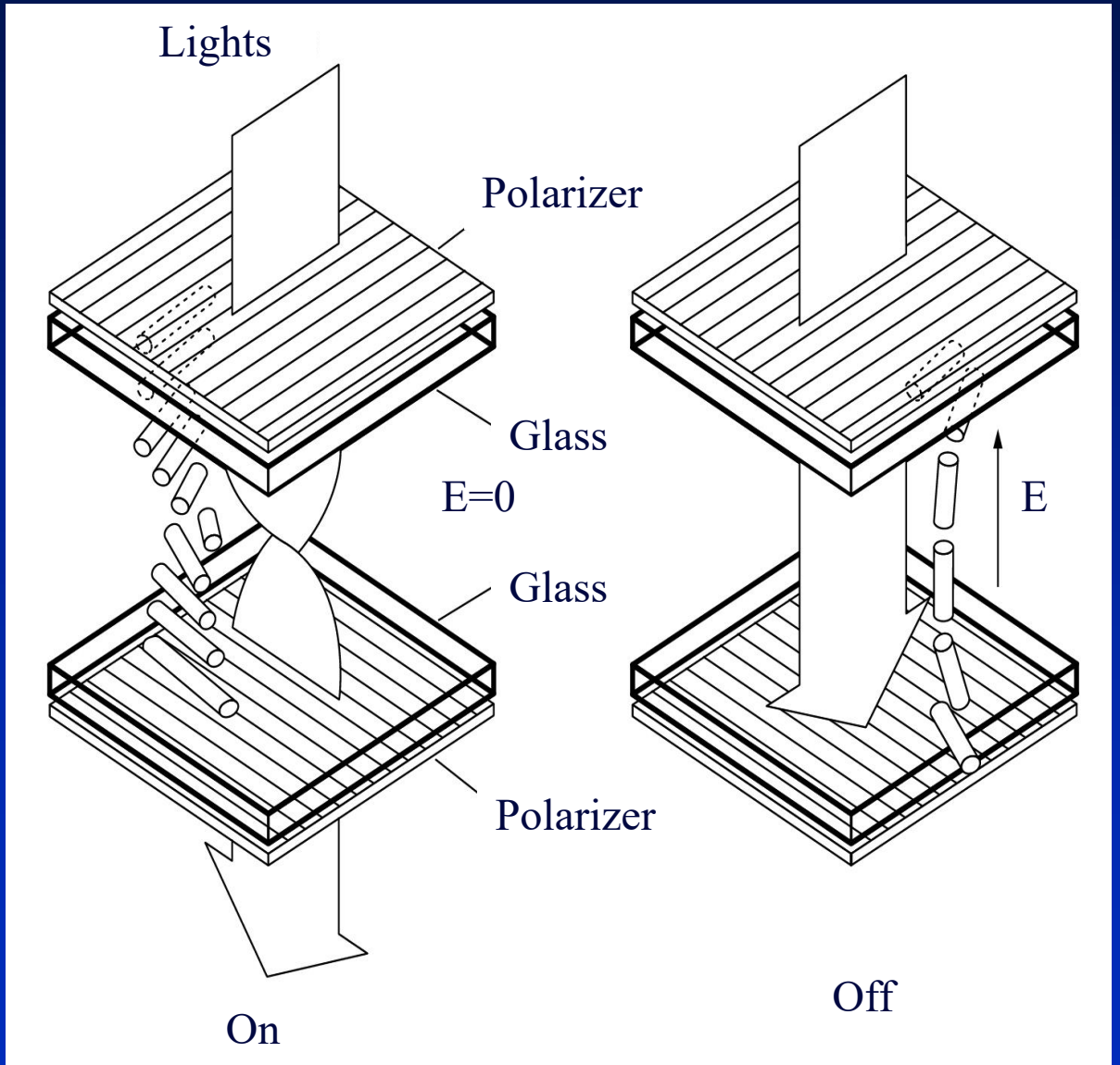
LCD Advantages & Disadvantages

- Can have high resolution. (Corning & Samsung)
- Requires very flat glass panels which are now being produced relatively cheaply.

Important Properties of Liquid Crystals

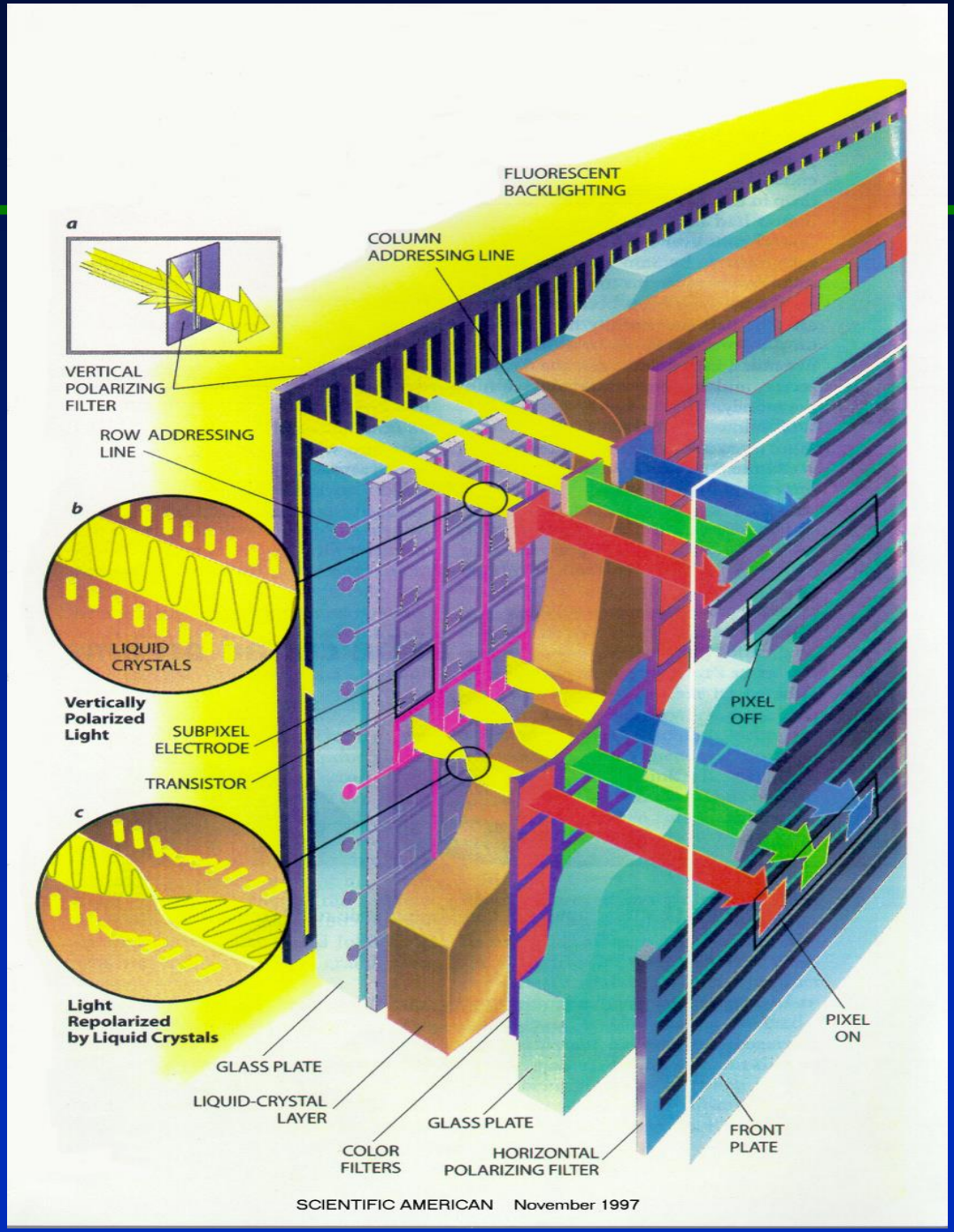
- Crystals are transparent
- Can alter the orientation of polarized light passing through them
- Polarization properties can be changed by applying electrical field
- Switching can be done fast

Polarization of Liquid Crystal



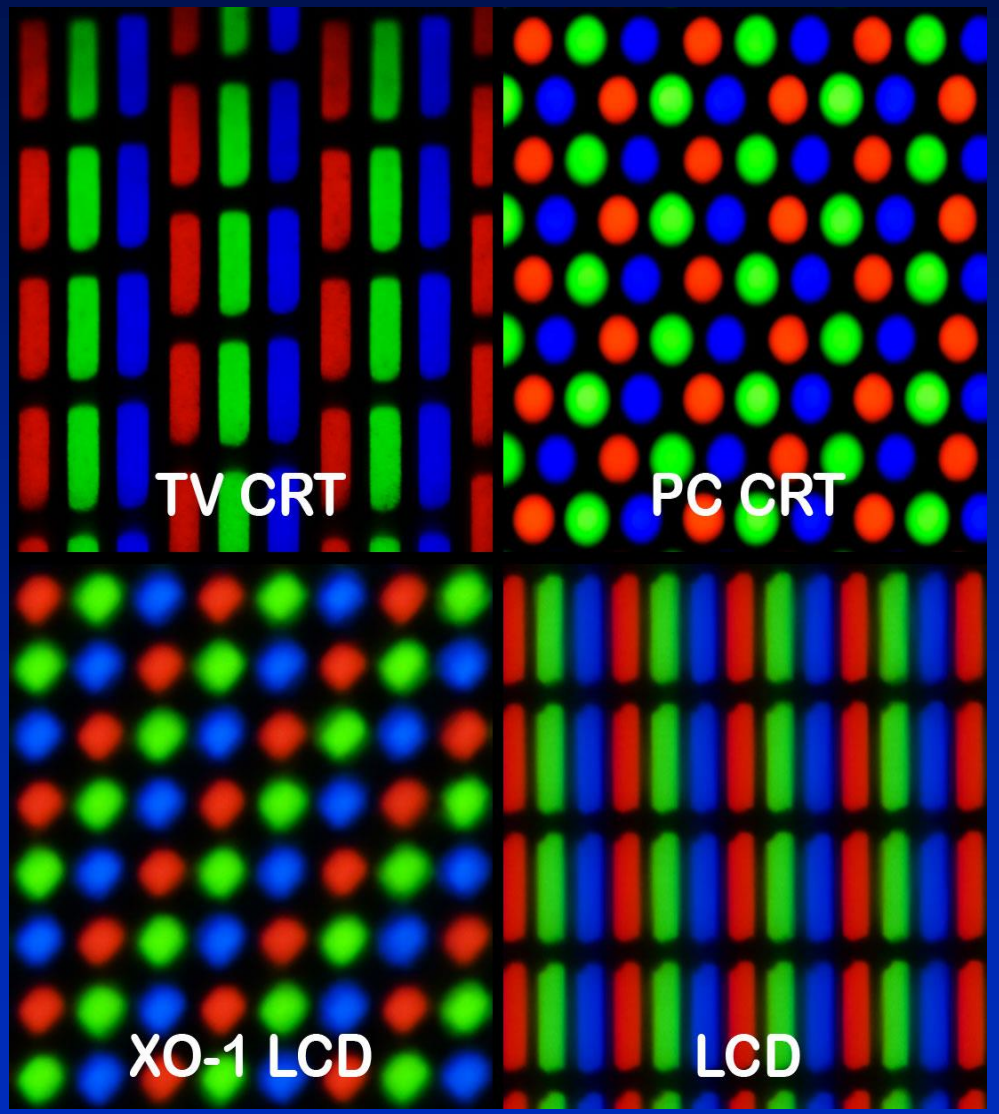
Scientific American, November 1997

Liquid Crystal Color Display



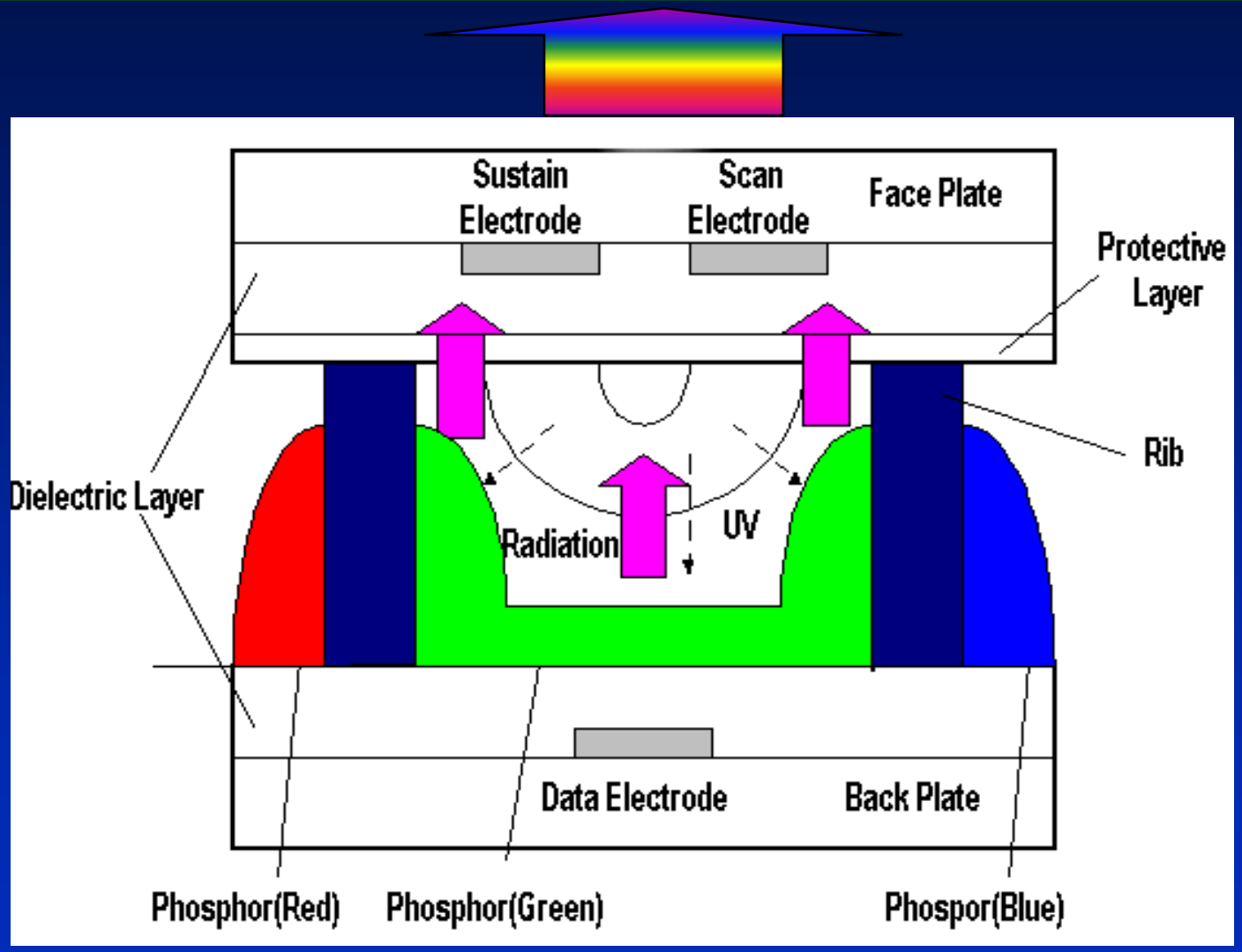
Scientific American, November 1997

Different Pixel Configurations



Plasma Displays

Plasma Display Technology



Plasmaco 60” Diagonal HDTV Plasma Display Panel

Information Display , December 2000

Plasma Display: Advantages & Disadvantages

- The advantage is that they can have high brightness (at the expense of watts). Thus can be used in brightly lit areas.

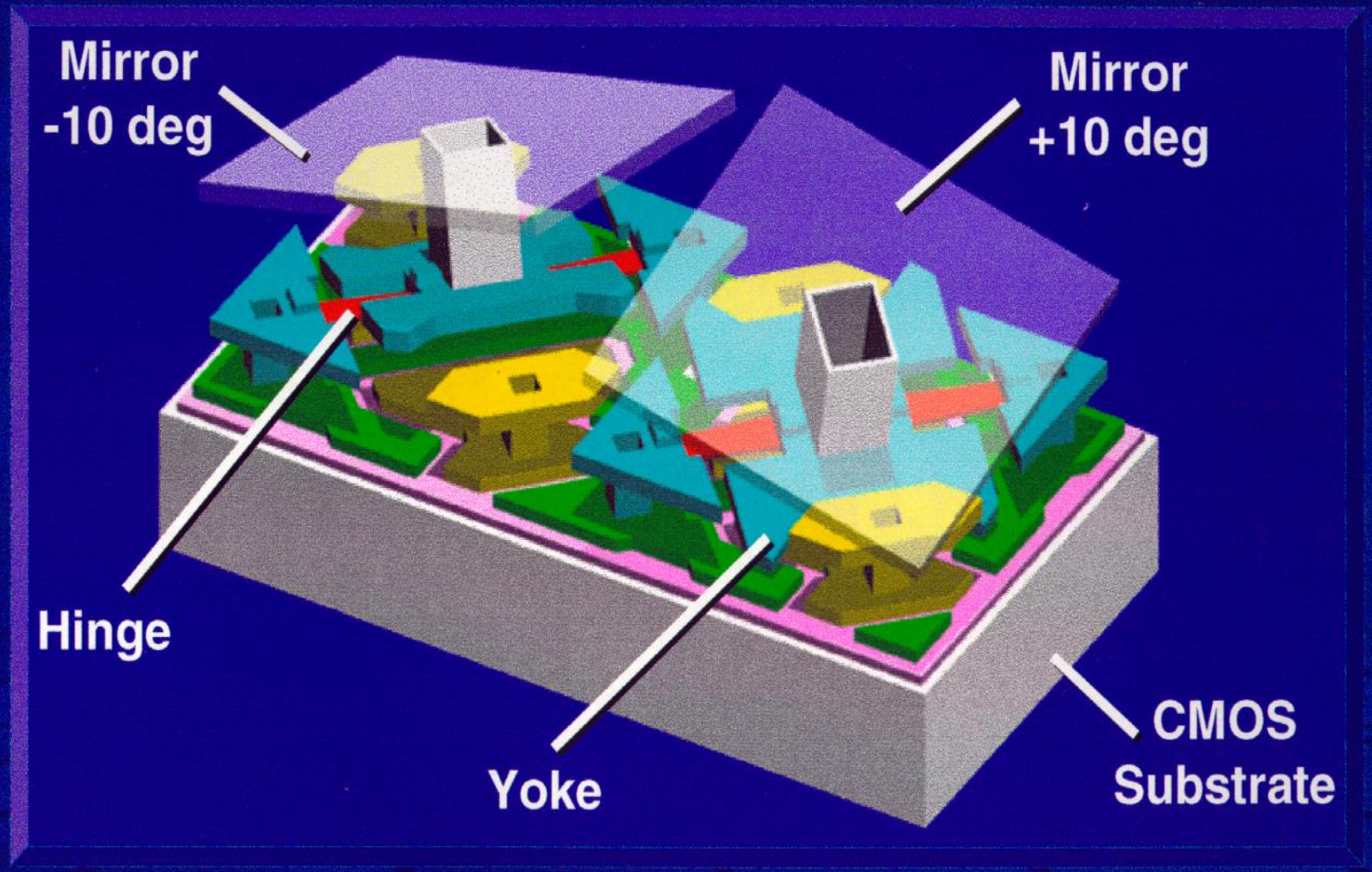
- The difficulty with plasma displays is that the cell size (pixel) is large relative to a liquid crystal. Thus for a given resolution, the screens must be large.

Projection Displays

Digital Micromirror Devices (DMD)

- Pioneered by Texas Instruments. The research on these micromechanical (MEMs) devices started in 1977.
- The first digital light valve projection systems (DLPs) had mirrors measuring 17 microns per side. At 1280 x 1028 resolution (HDTV) this resulted in a rather large chip in 1996.

DMD Structure

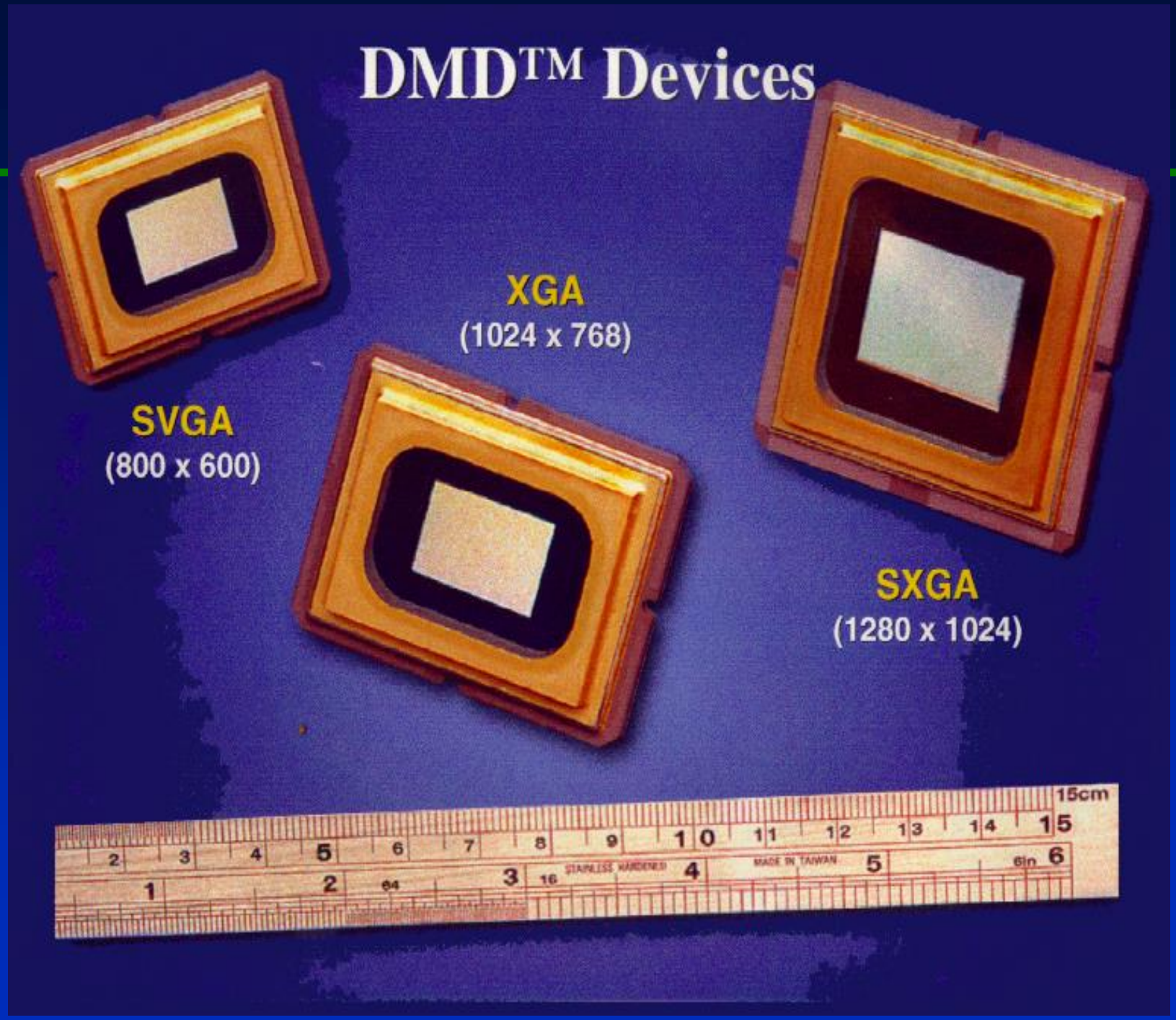


Digital Micromirror Device (DMD™)

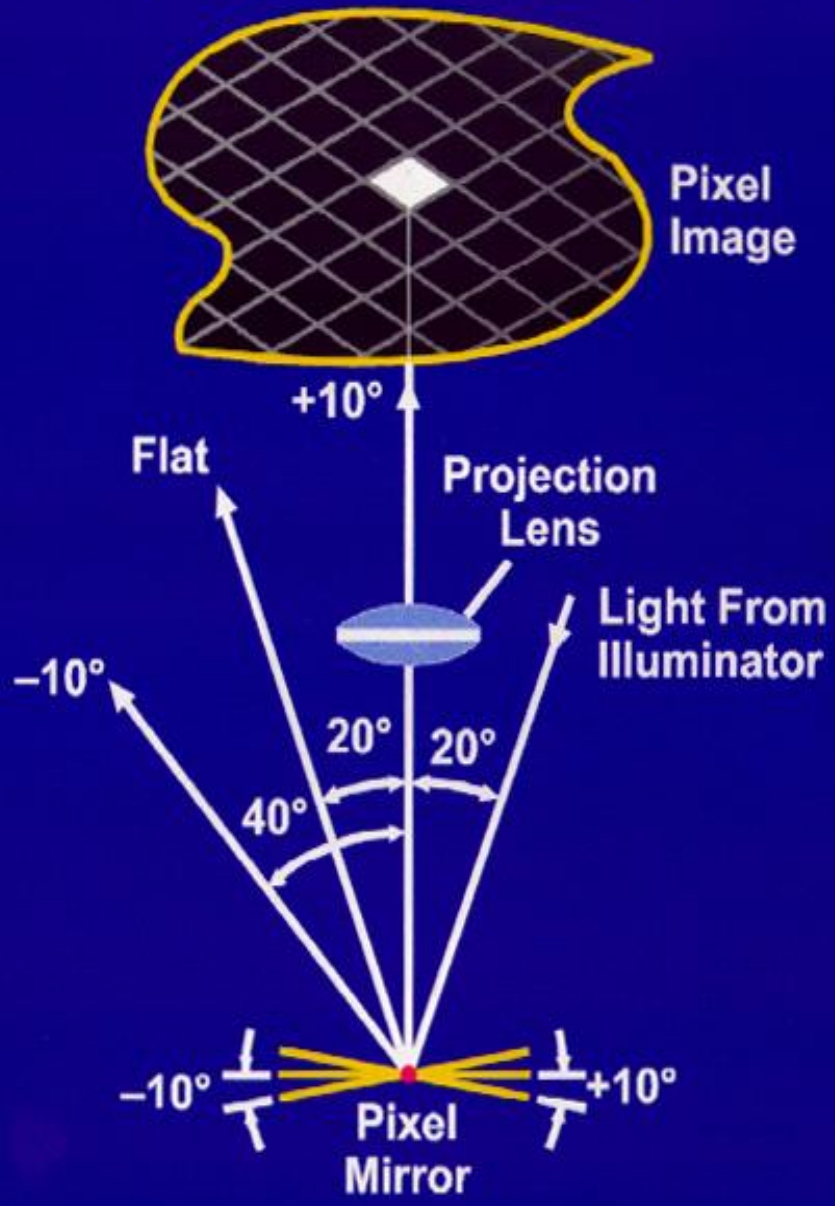
A True Microelectromechanical System

DLP™

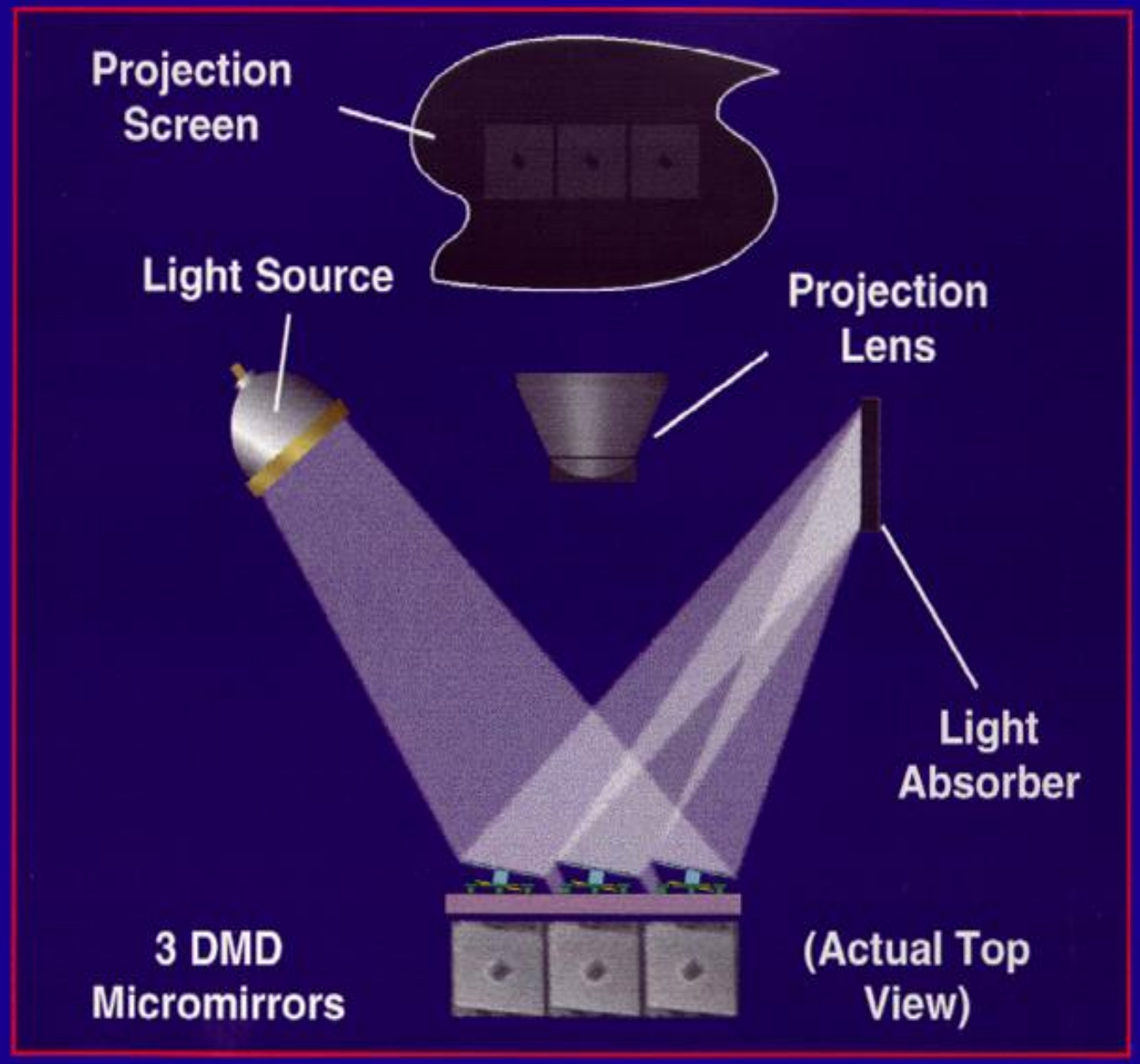
A TEXAS INSTRUMENTS TECHNO


DMD™ Devices
SVGA
(800 x 600)
XGA
(1024 x 768)
SXGA
(1280 x 1024)
15cm
STAINLESS HARDENED
MADE IN TAIWAN
6in

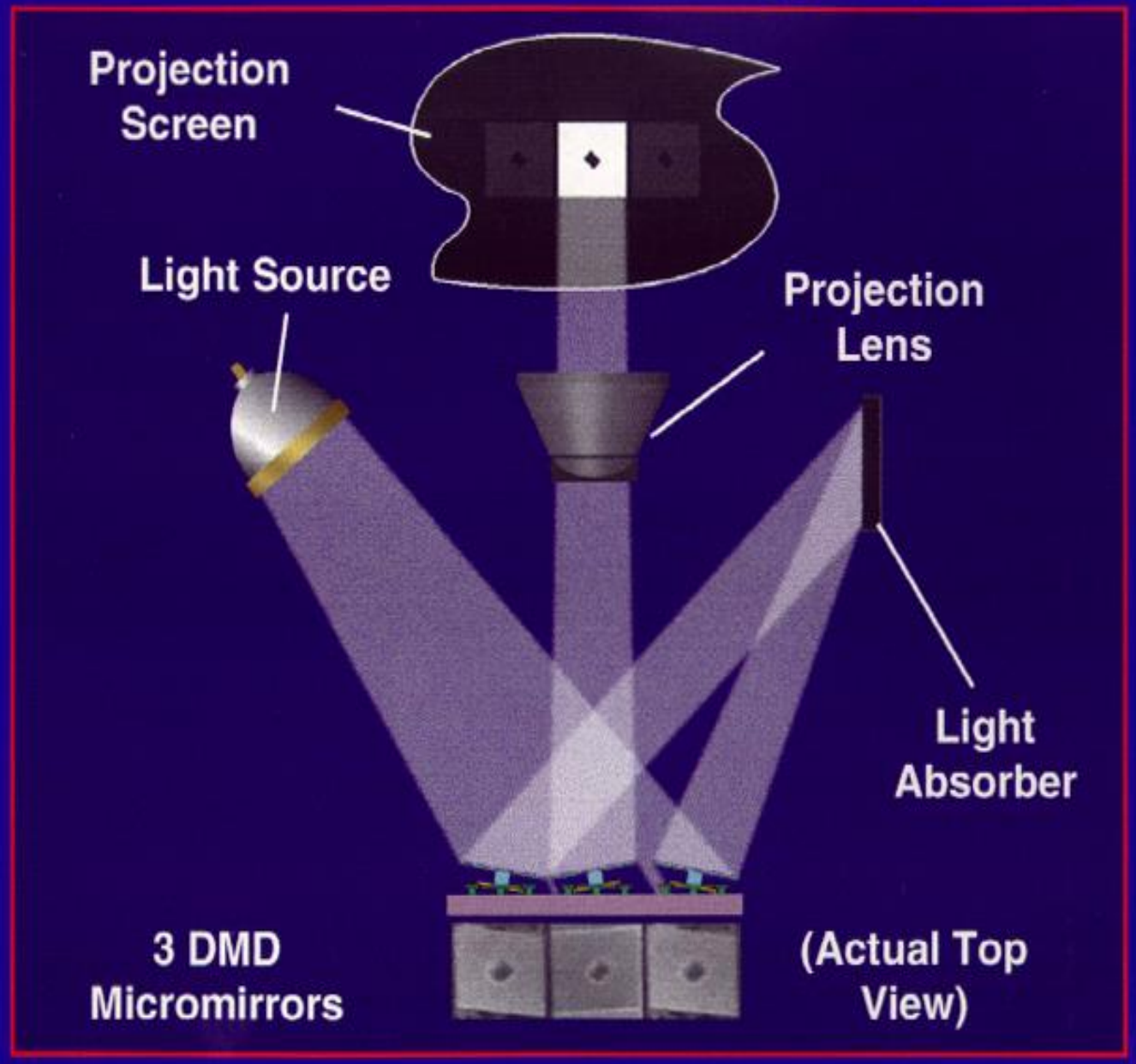
DMD™ Optical Switching Principle



DMD™ Switching Example (All Off)

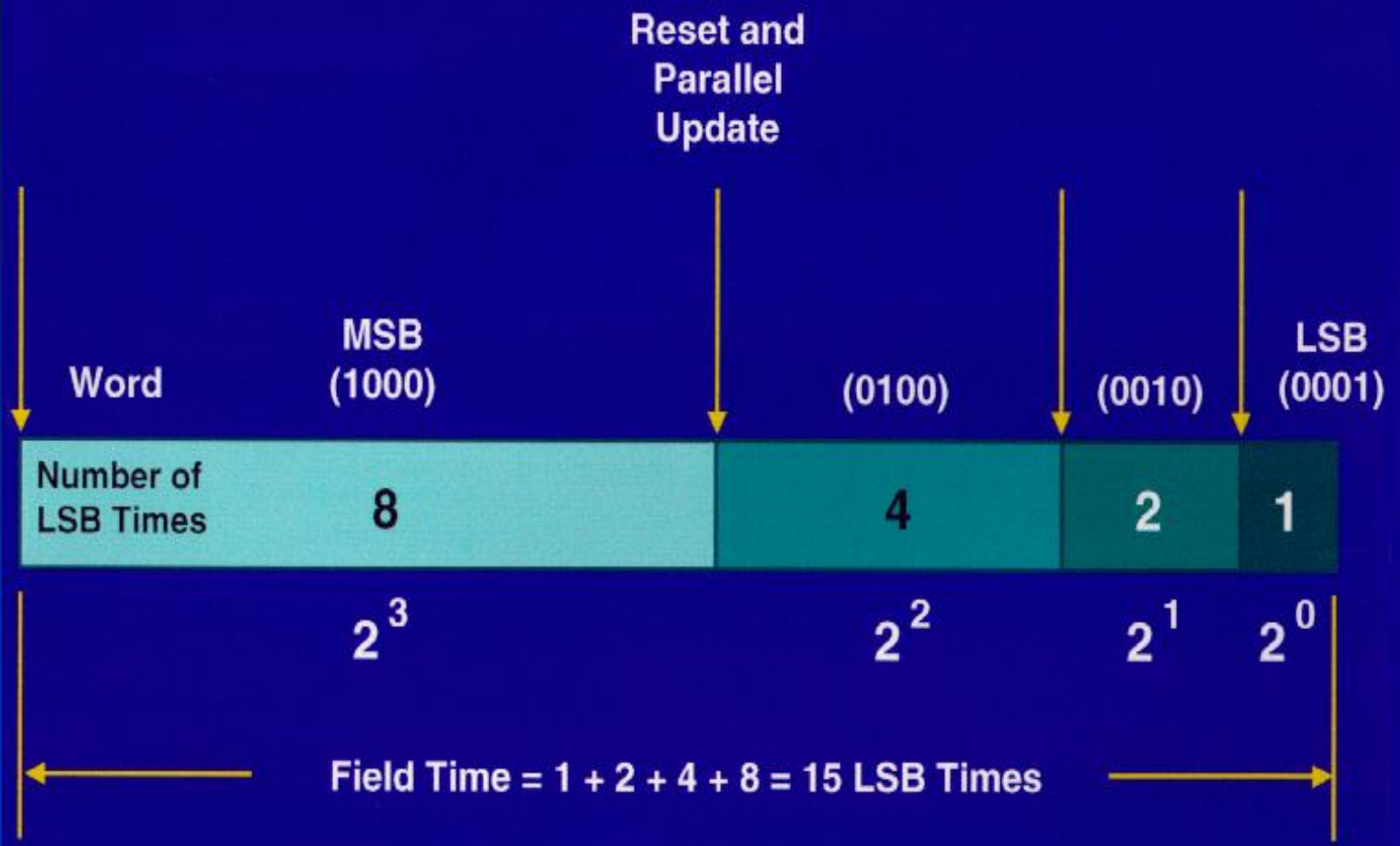


DMD™ Switching Example (1 On)



DMD™ Grayscale Projection

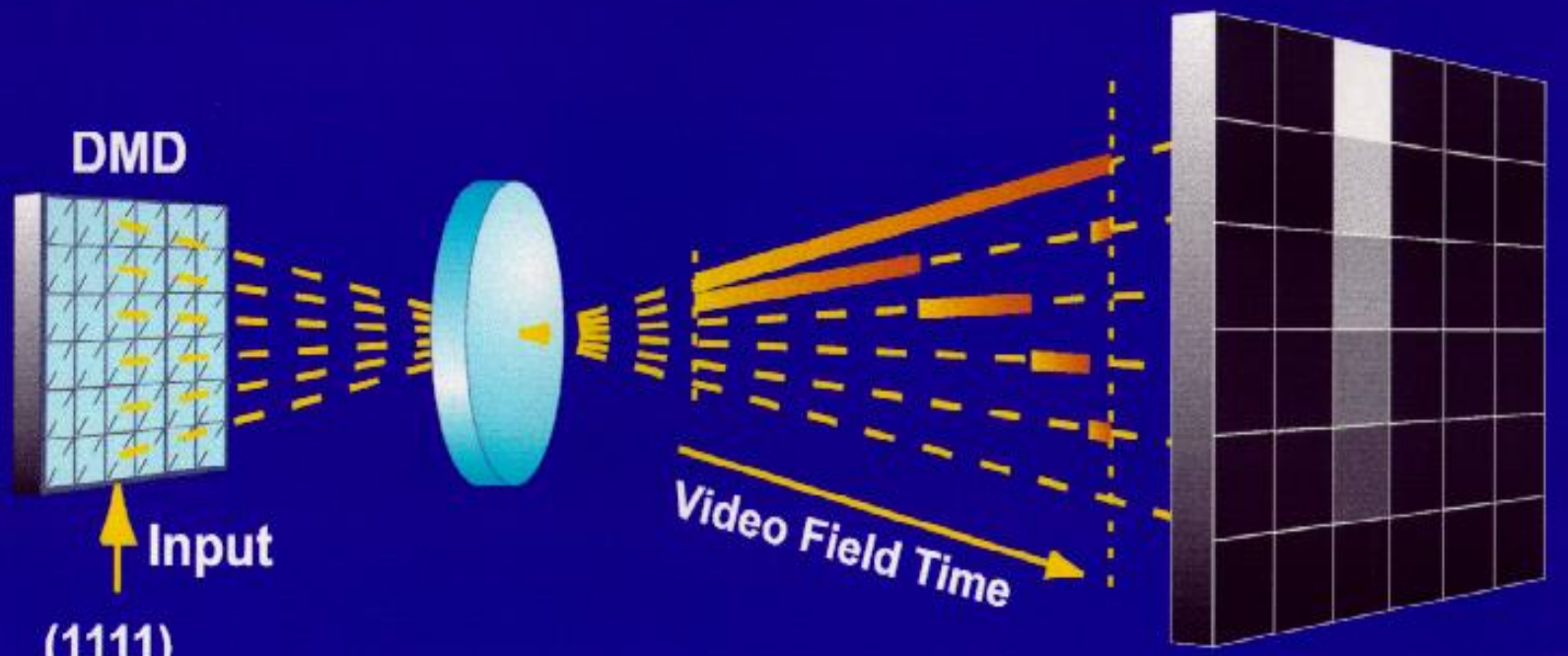
Pulsewidth Modulation



(4-Bit, 16 Gray-Level Example)

How Grayscale is Created

DMD™ Binary Pulsewidth Modulation



(1111)
(1001)
(0100)
(0010)
(0001)
(0000)

(Sensations of Gray Shade By Viewer's Eye)

4-Bit, 16 Gray-Level Example

Example: Lenna Original

1000

0100 (diff)

1100

1110

1111

11111111

End