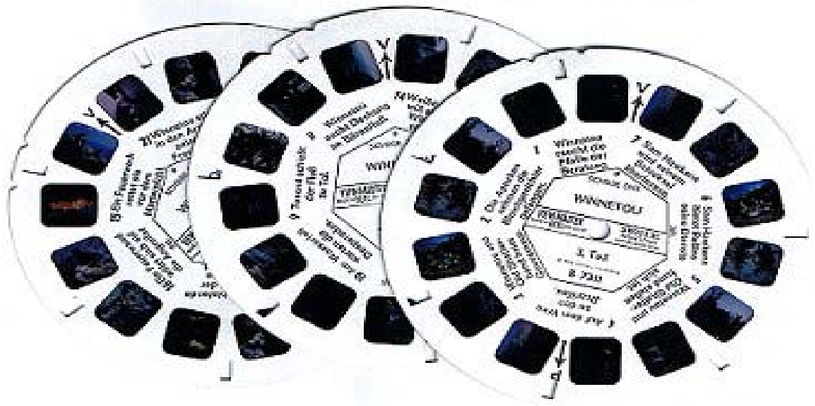
Simplicity vs. Flexibility

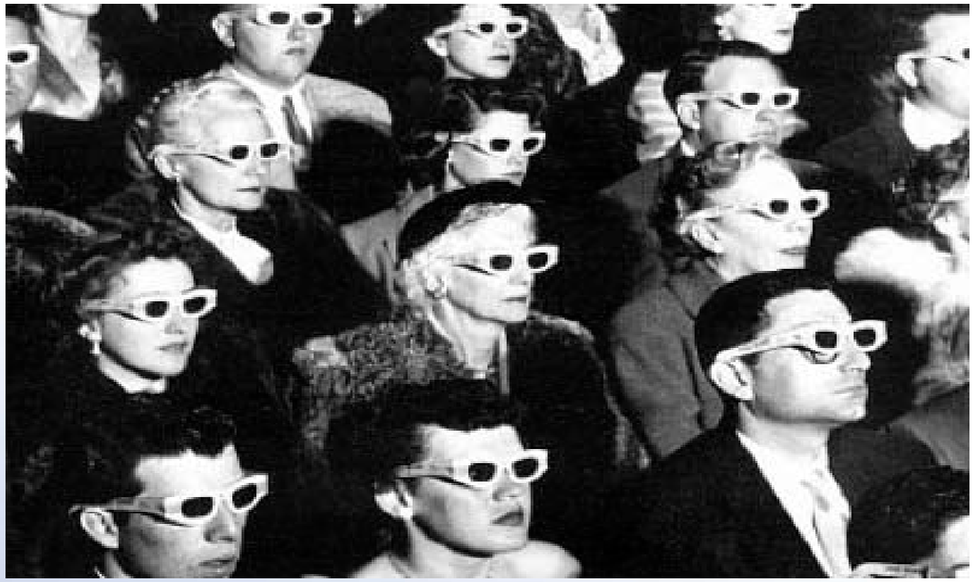
An integrated system approach to stereography

The old Business Of 3D



Technology

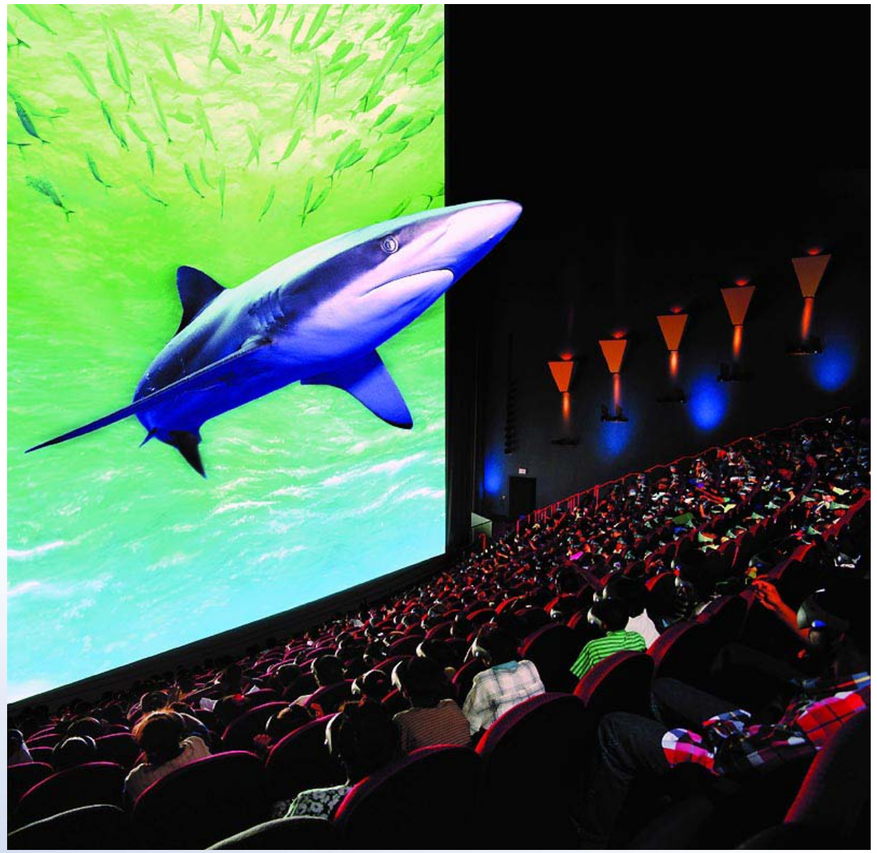
The old Business Of 3D



20s

50s

90s



So is this time different?

$2.7 Billion

Travel

Teleoperation

Simulation

Guidance

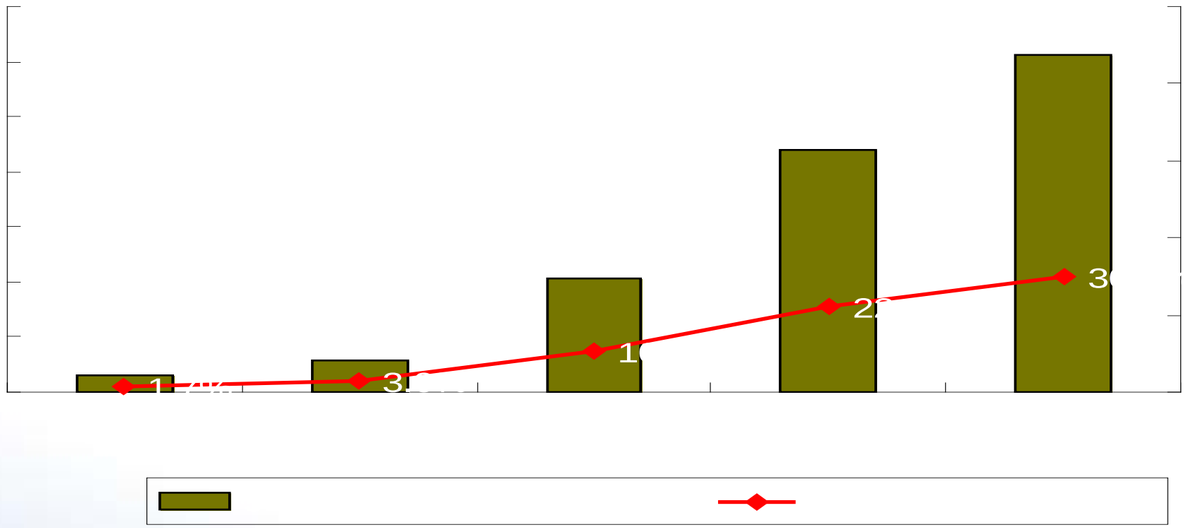
Exhibition

Medicine

Telepresence

Real Estate

Forecast: Explosive US & Global Growth

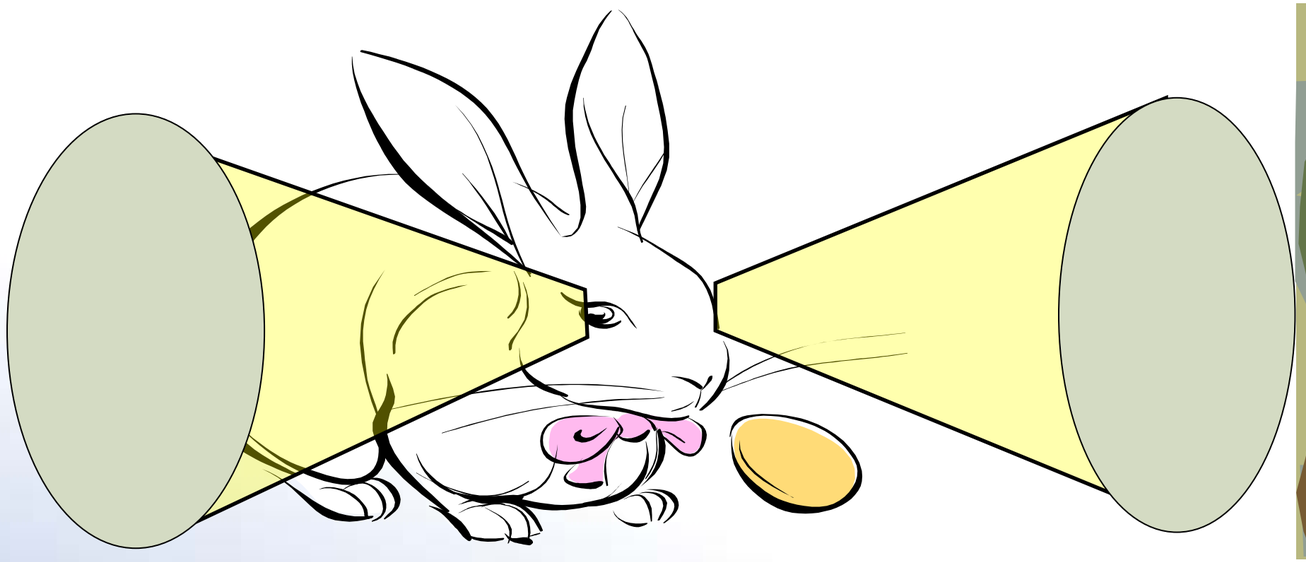


Source: CEA, Feb. 2010

DIRECTV 3D

Bringing it home

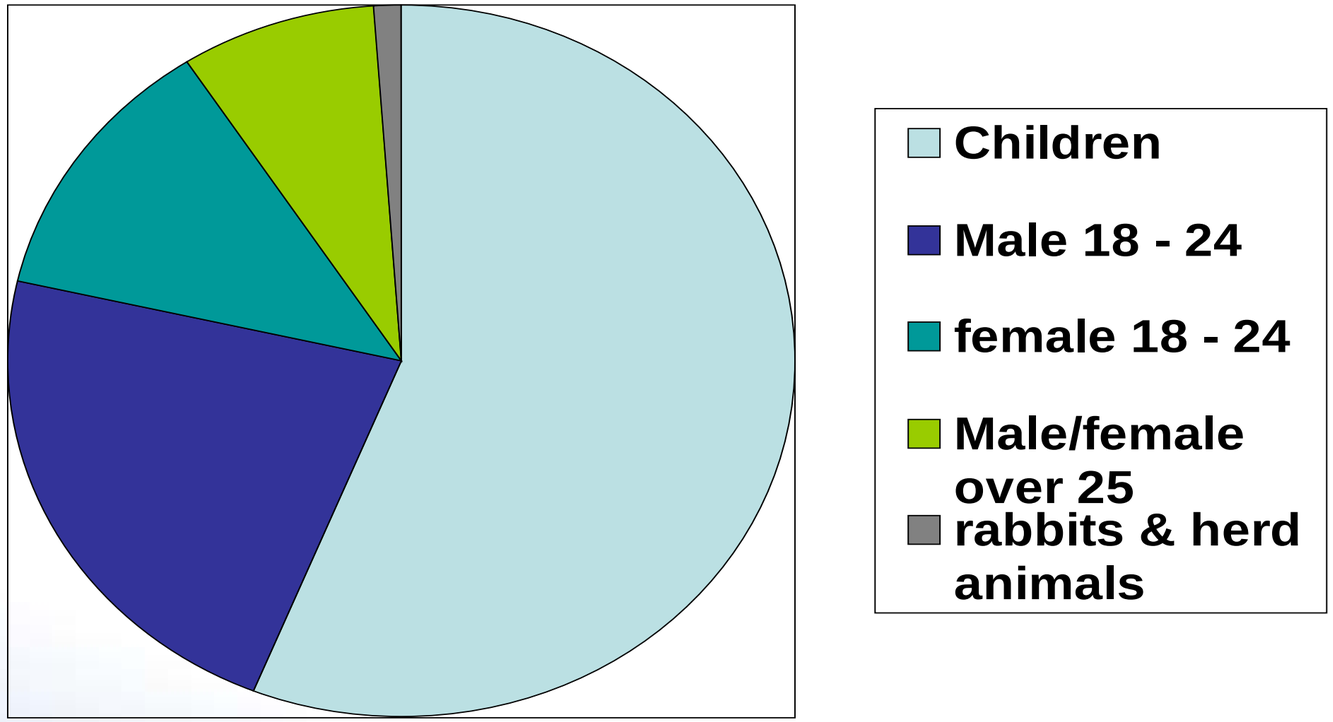
How do we see 3D?



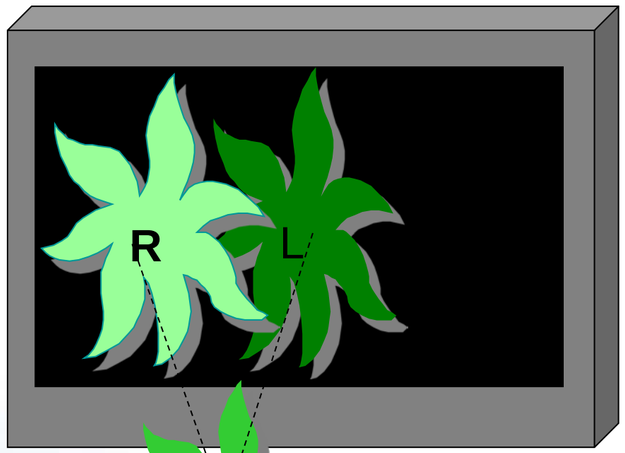
Prey

Predator

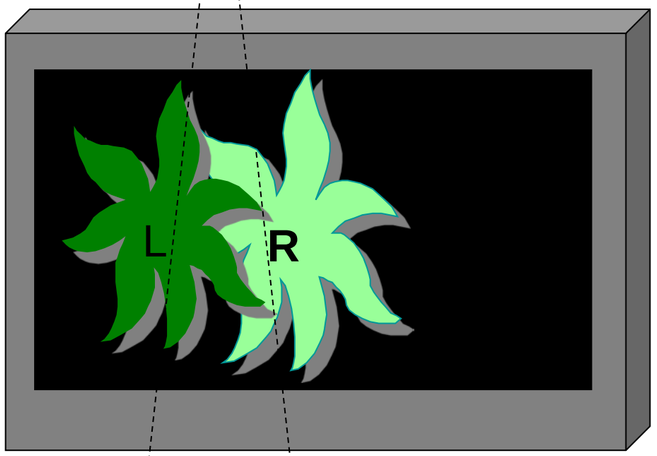
3D Viewership By Category



A flat screen must separate views

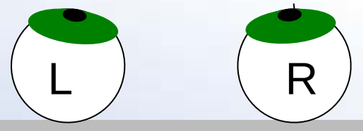


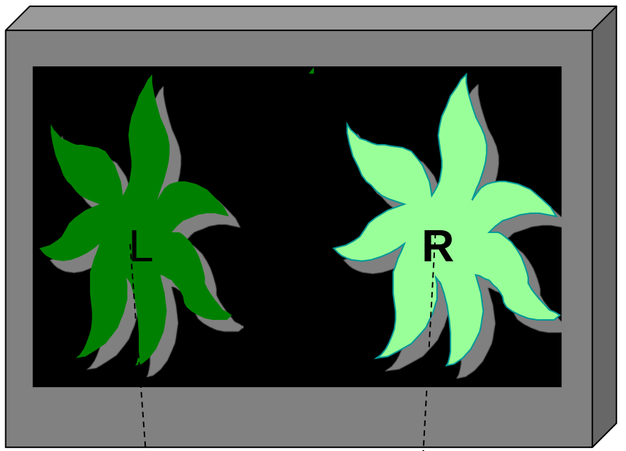
Negative parallax
brings object closer



Positive parallax

puts objects behind the screen





???

Absolute parallax violation

Anaglyph

Replace the right eye red channel with the left eye red channel

- **Advantage**

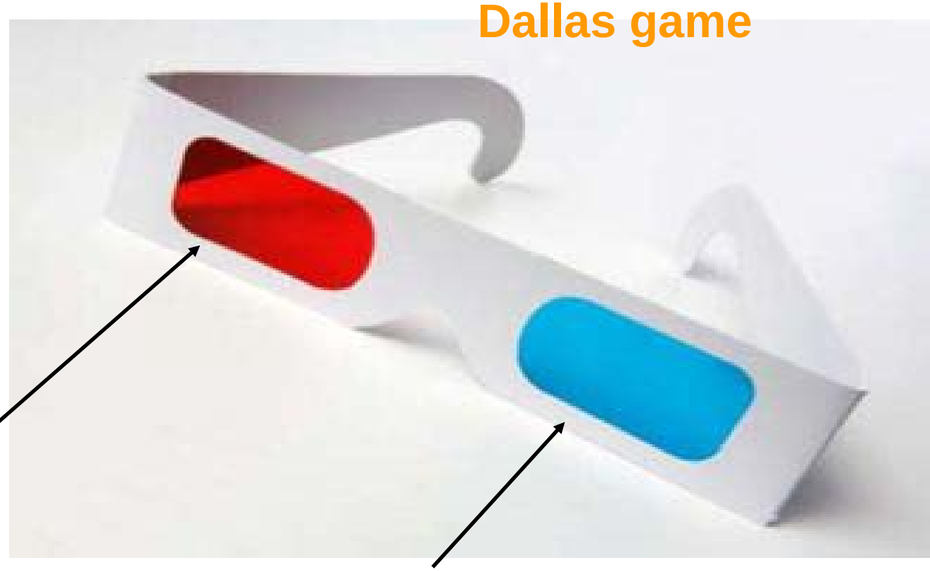
  Works with existing displays

- **Disadvantage**

  Color is incomplete

Examples

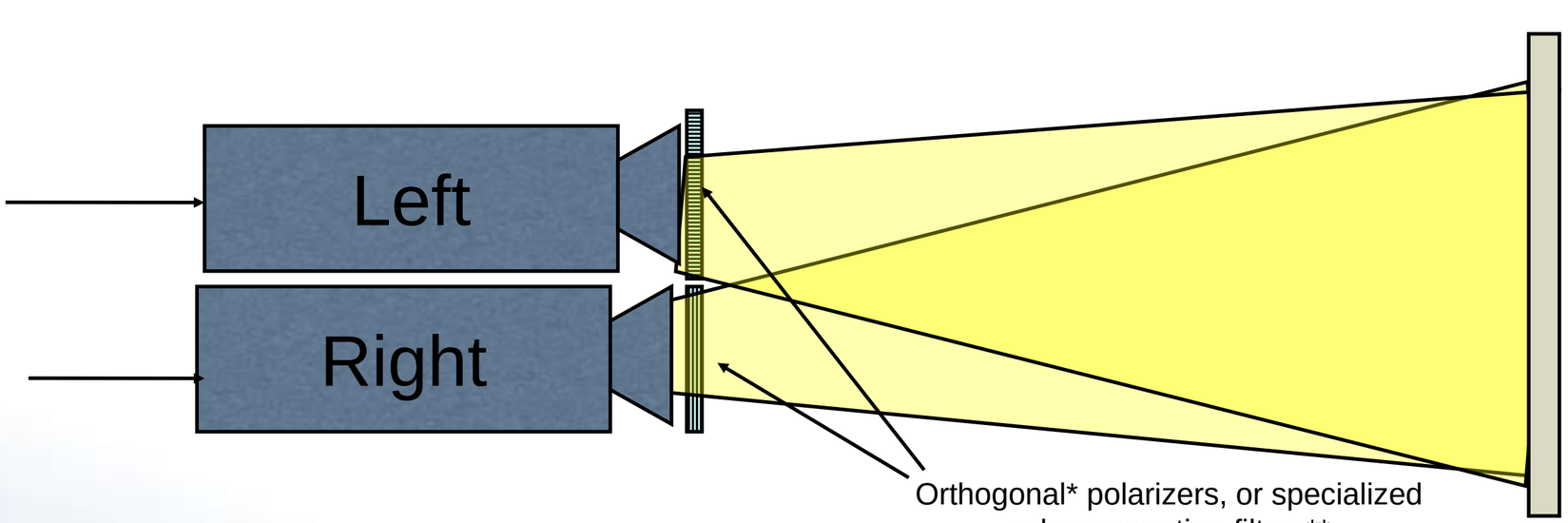
Super Bowl Ad
“Chuck” Episode
Dallas game



Filtered right eye can’t see red so only sees right channel

Left eye can’t see right signal as it has no red

Passive Glasses: projector



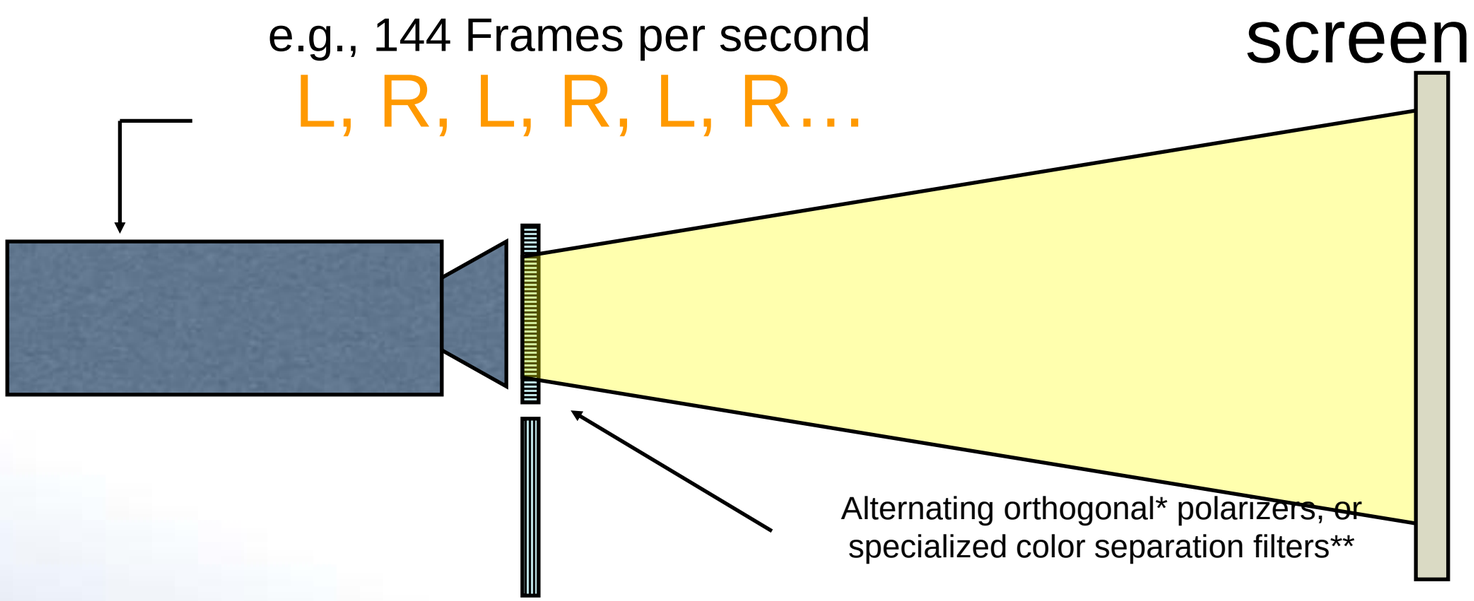
Left and right eye filters
match the projectors

- Two independent left and right projectors
- Orthogonal polarization blacks left picture from right eye and right from left
- Projectors must have twice the illumination

*e.g., For RealD ”Orthogonal” means circular/circular @ different angles

**Dolby 3D uses Wavelength multiplex visualization

Passive Glasses: single projector



Left and right eye filters match the projectors

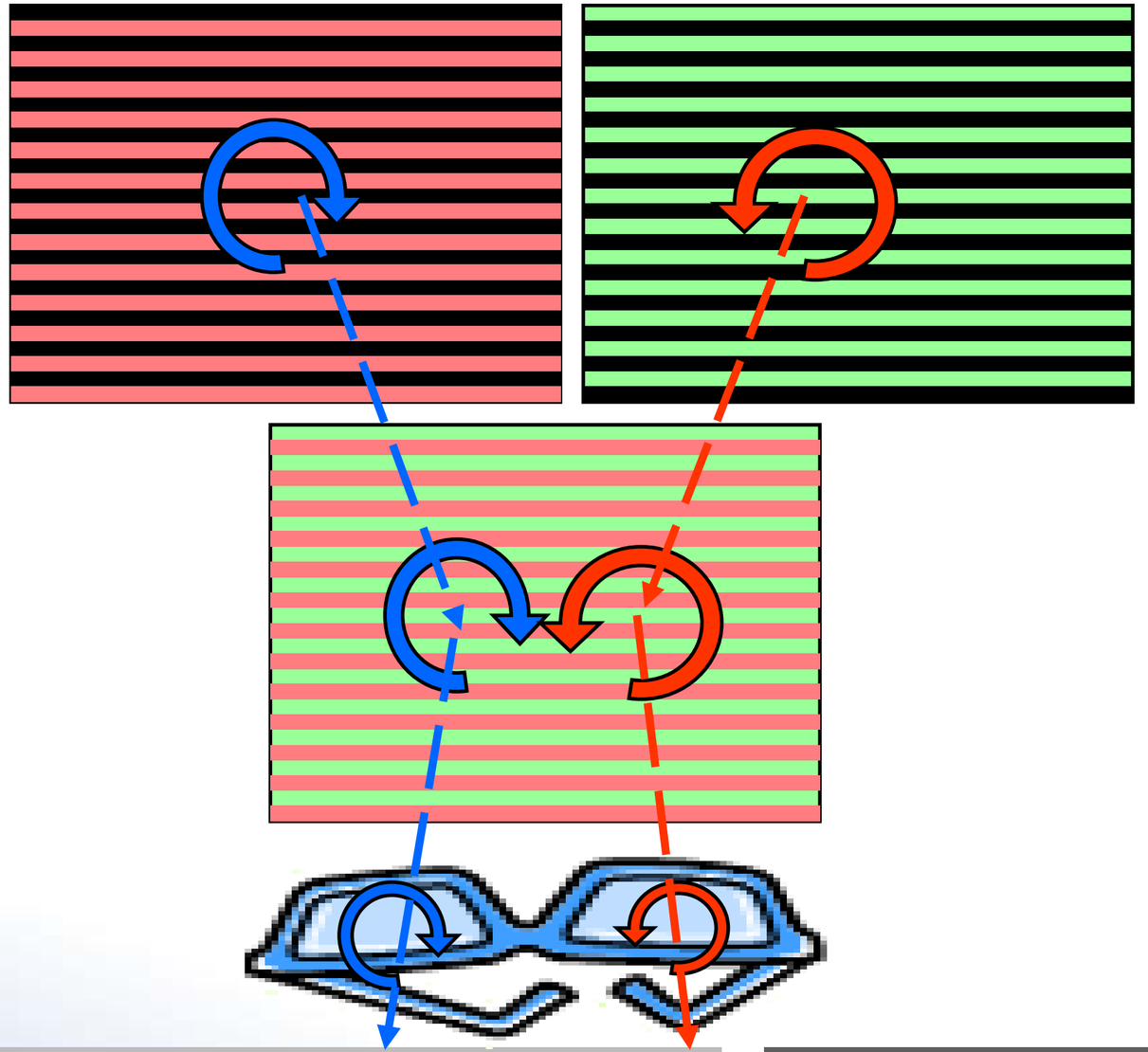
- Left and right frames alternate from projector (more than twice per frame)
- Switched polarizer is synched with the projector
- Same passive glasses can be used as two projector system

*e.g., For RealD ”Orthogonal” means circular/circular @ different angles

**Dolby 3D uses Wavelength multiplex visualization

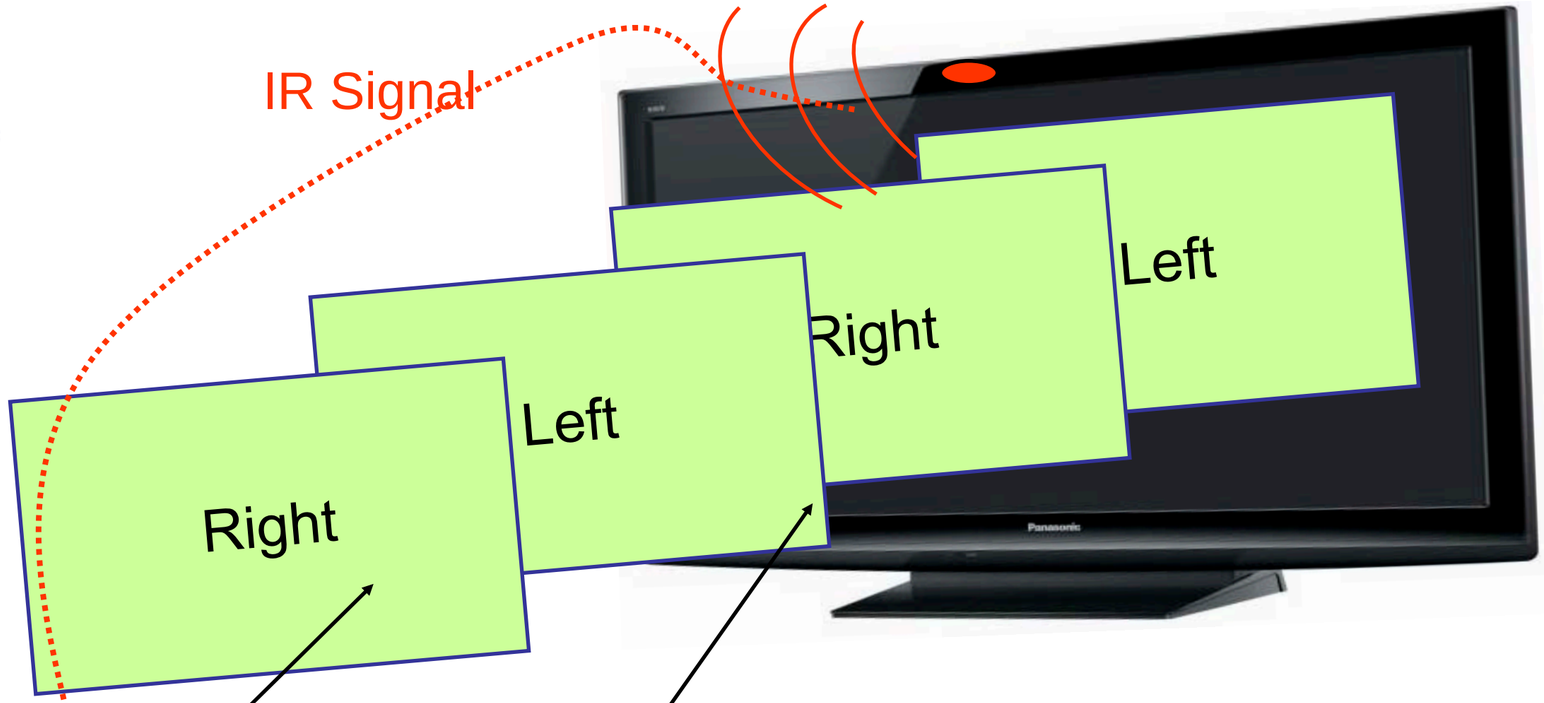
Passive Glasses: Flat Panel (Micropolarized)

- **Left and right image appear on the display simultaneously**
- Micropolarizing film on the display polarizes left image in same direction on alternating lines, and right image is polarized the other direction on the opposite lines
- Passive polarizing glasses block left image from right eye and right image from left eye
- 3D Image is ½ **resolution of the display**

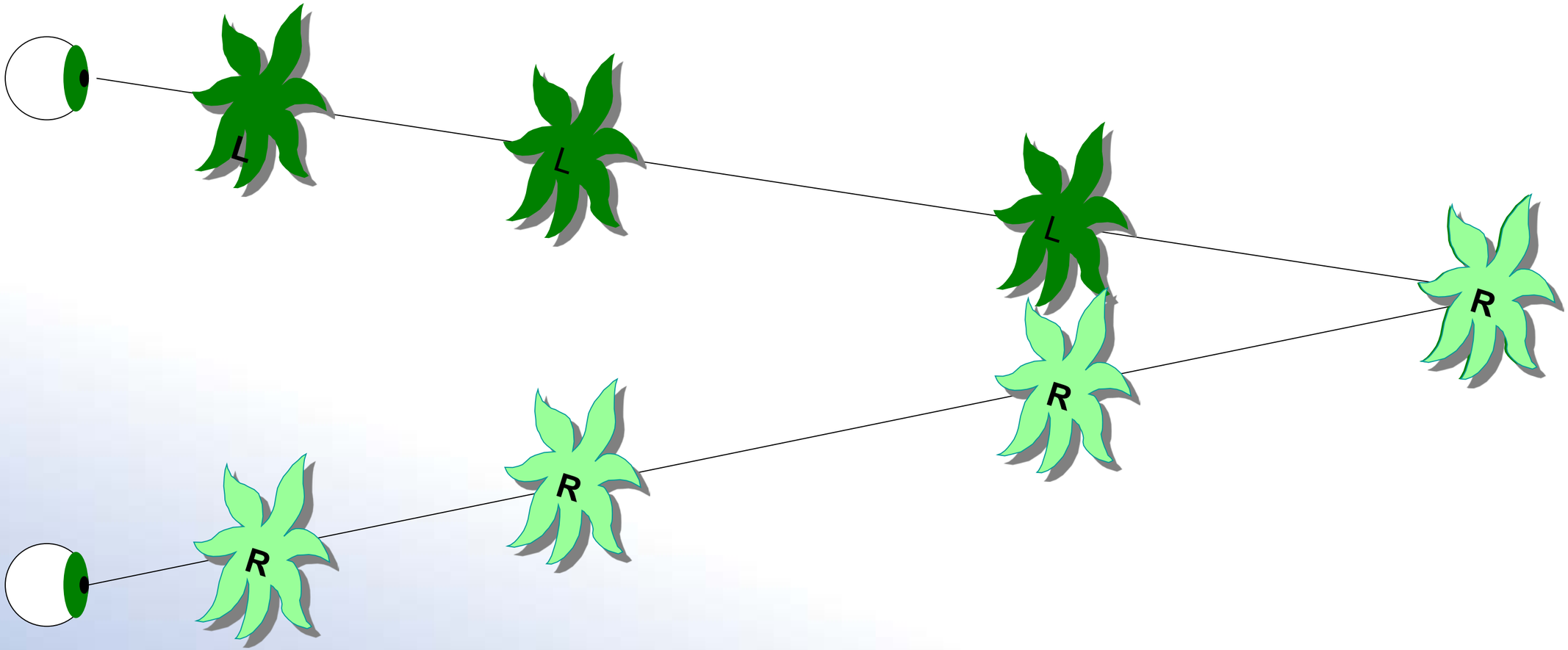


Active Shutter Glasses

- Left right frames alternate on 120 fps Panel
- IR emitter sends sync signal from the display
- Active glasses block left and right eye with LCD shutter as right and left images are displayed
- 3D Image is **Full HD Resolution**
- Full HD = 1080i for each eye, 720p 60 for each eye or 1080 24p for each eye.
- Display is capable of 1080 60p but there is no content



Parallax increases as objects move closer



Inter-axial spacing defines stereo infinity

Smallest perceptible change

Parallel Optics

∞

Range of perceptible parallax

Convergence Plane

∞

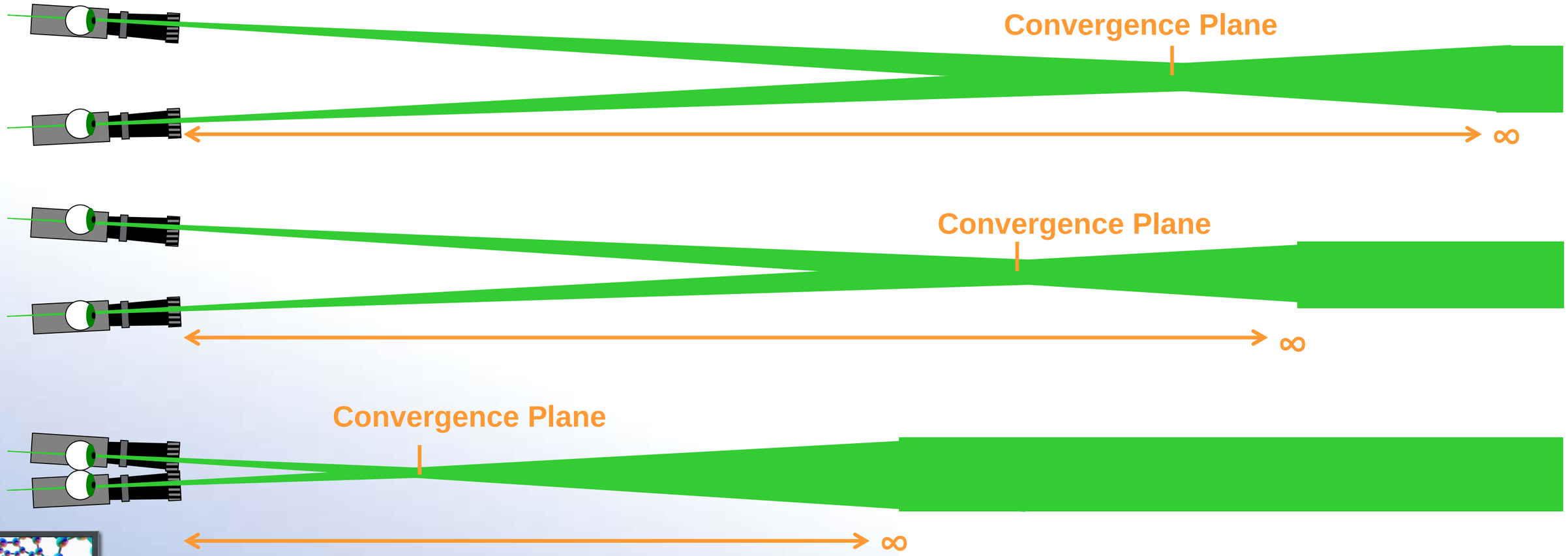
Convergence Plane

∞

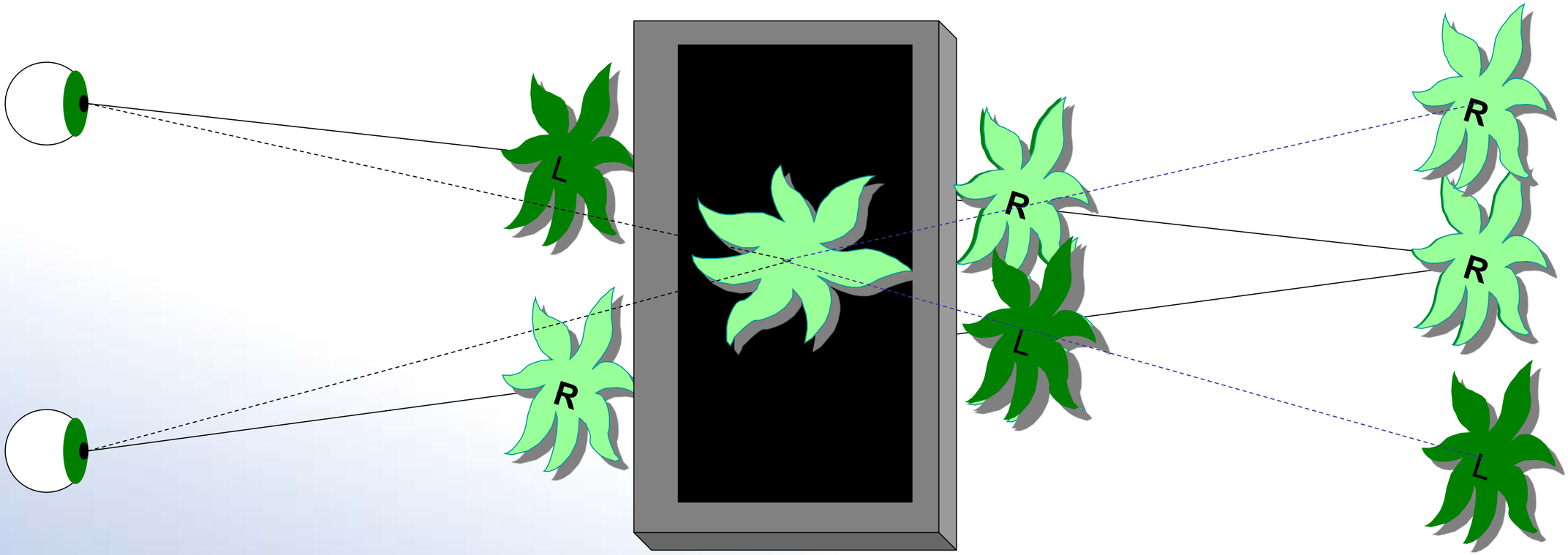
Convergence Plane

Inter-axial spacing defines stereo infinity &*impacts convergence plane*

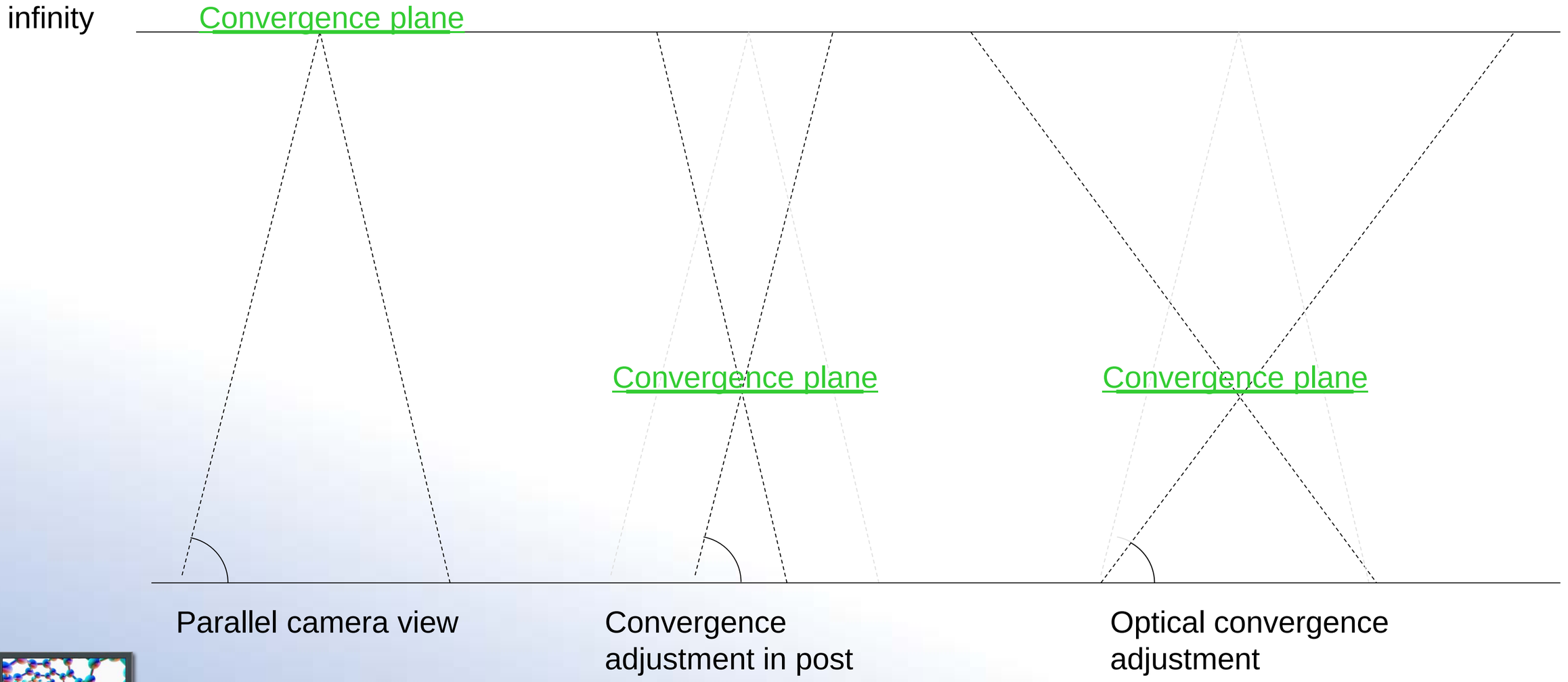
Converged Optics



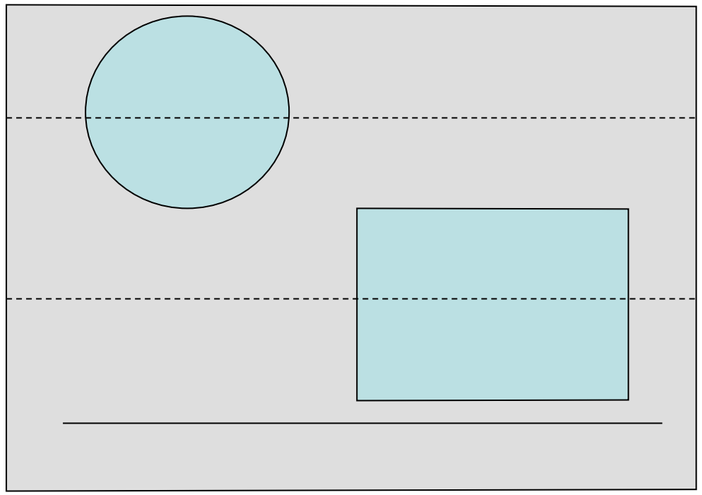
Convergence must be adjusted for viewing

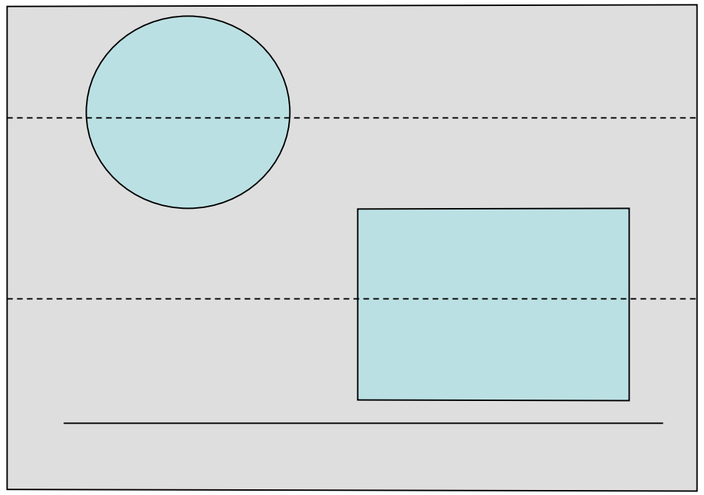


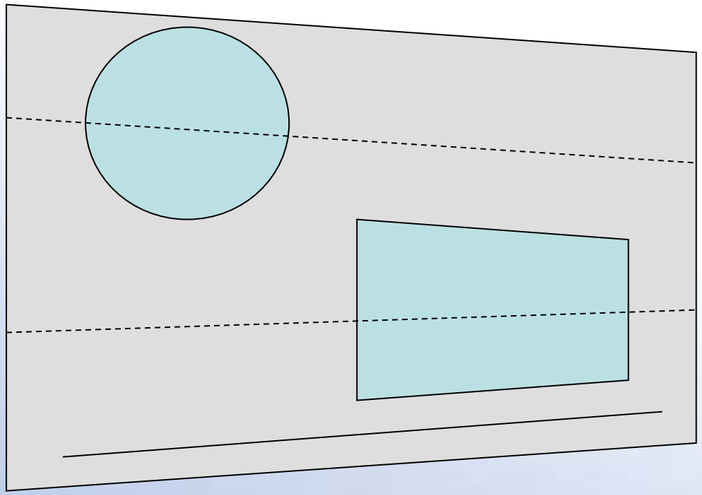
Either electronically or optically

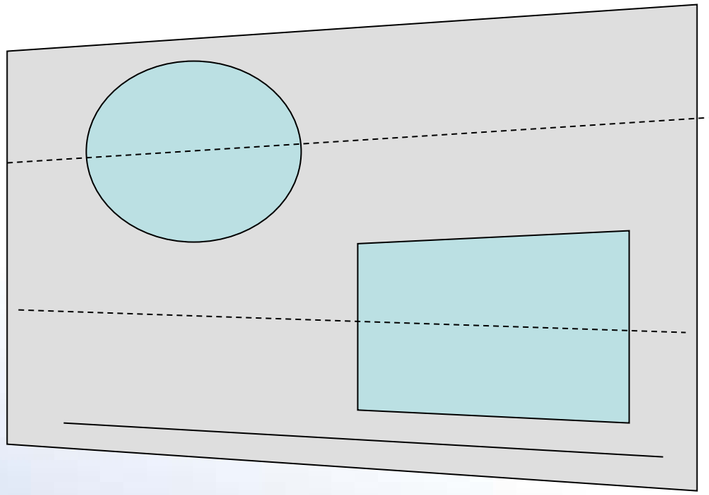


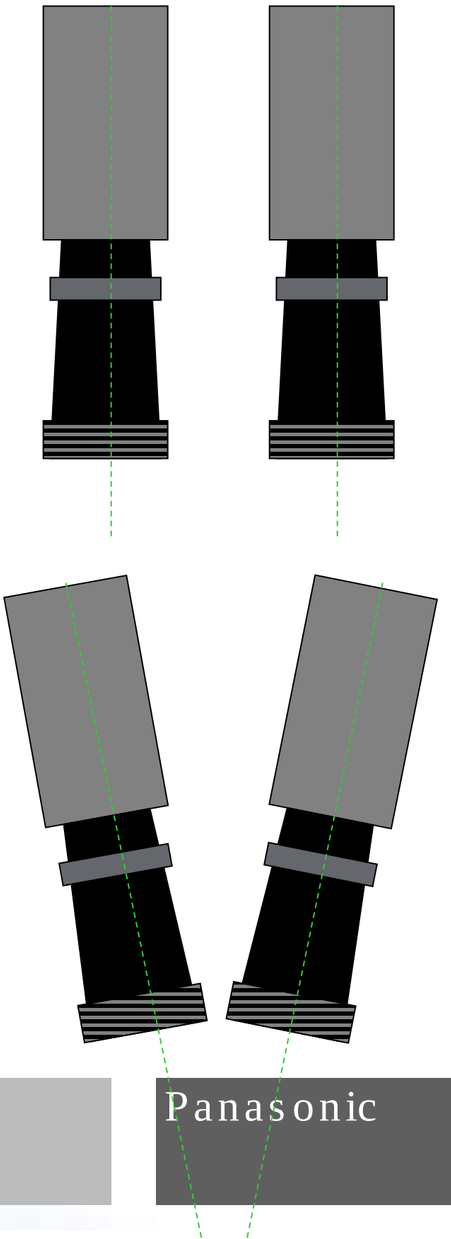
Verging Cameras can cause keystone



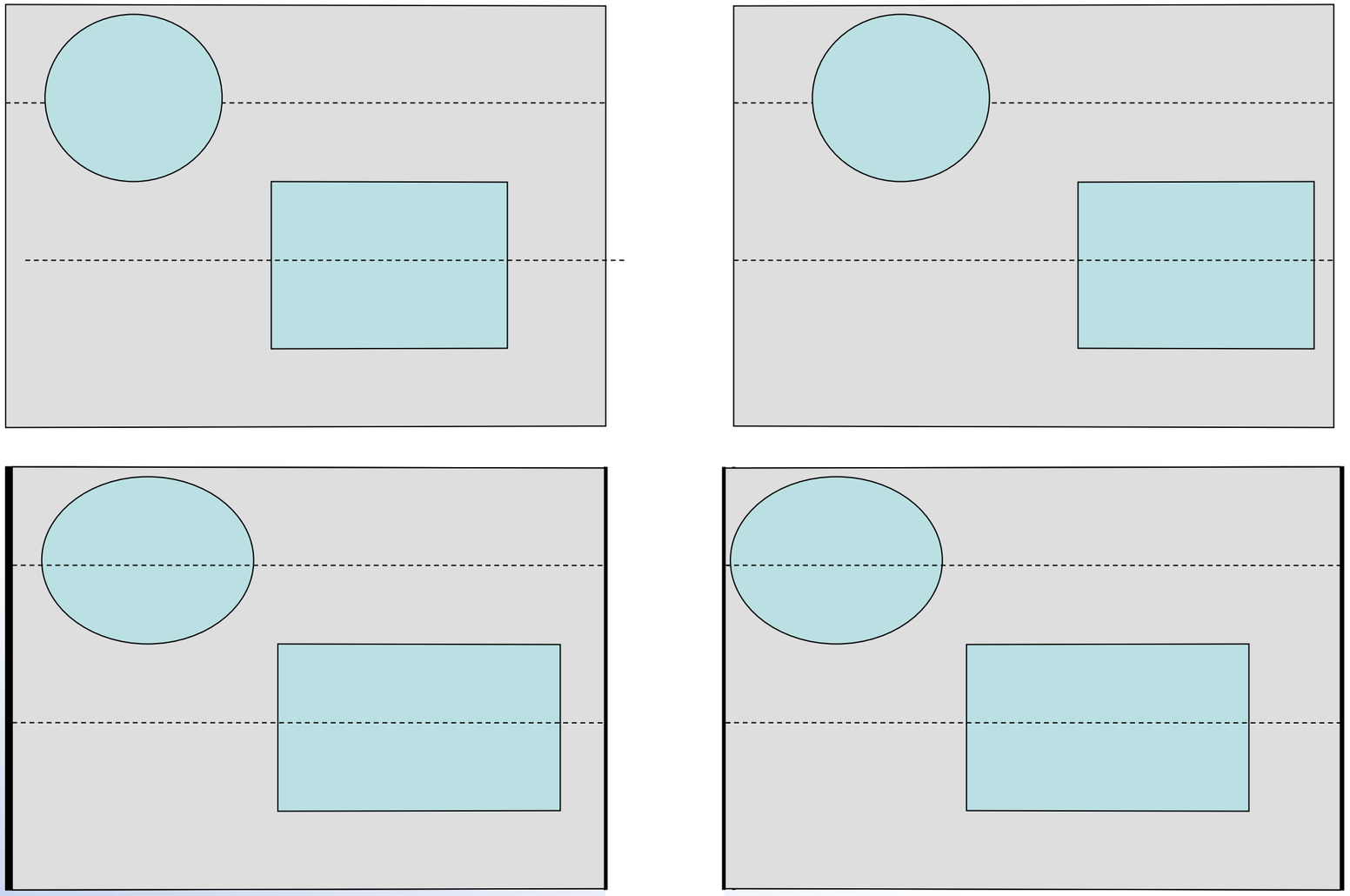






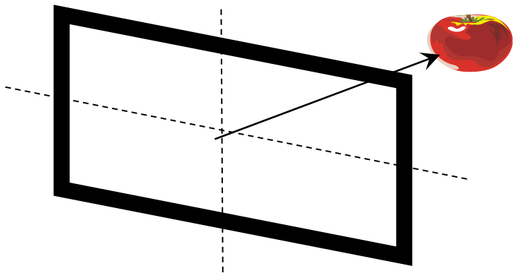


Electronic adjustment has other issues

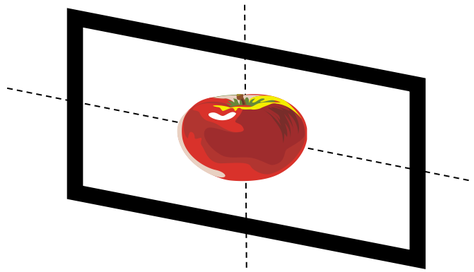


Importance of in camera convergence adjustment

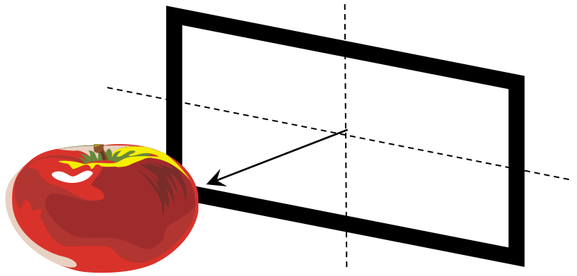
Convergence can direct viewers attention



Wide Shot

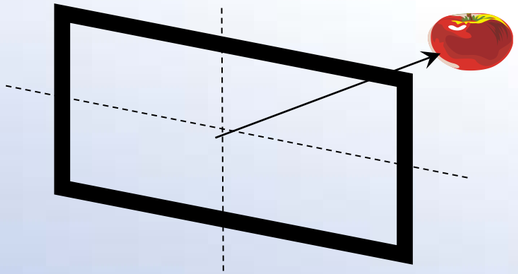


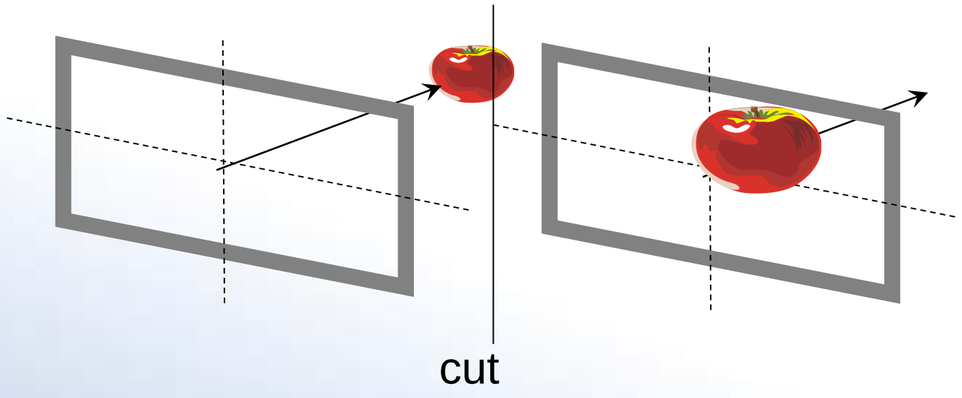
Medium Shot



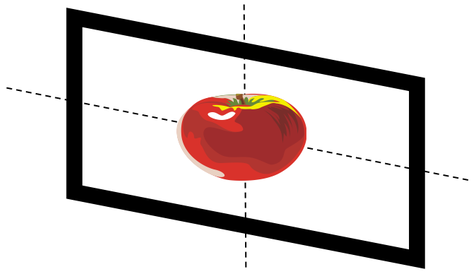
Close Up

But vergence changes cannot be abrupt



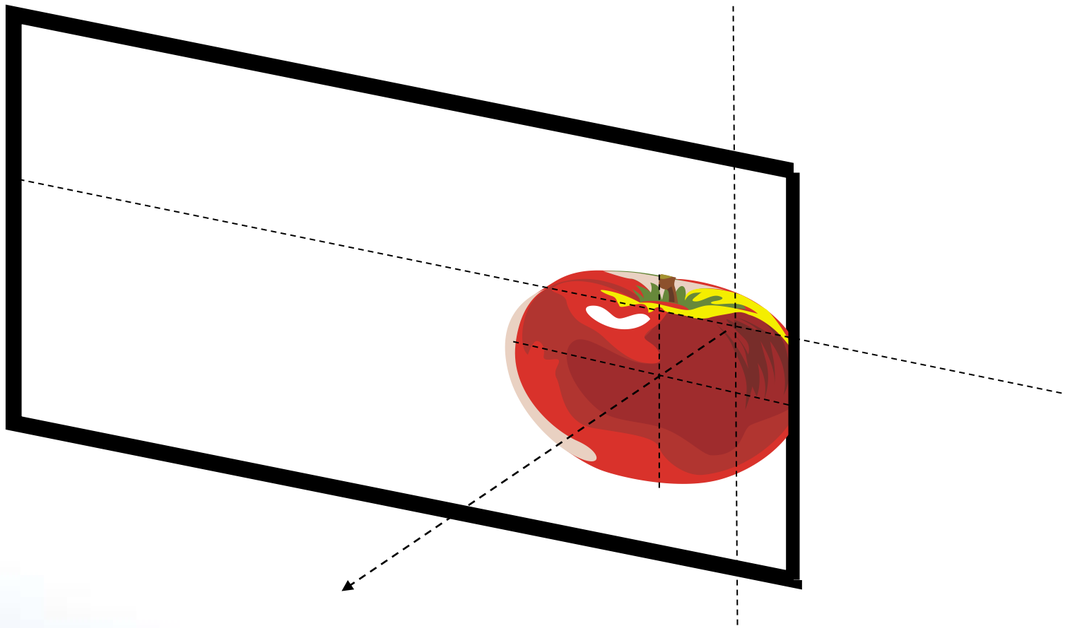


cut

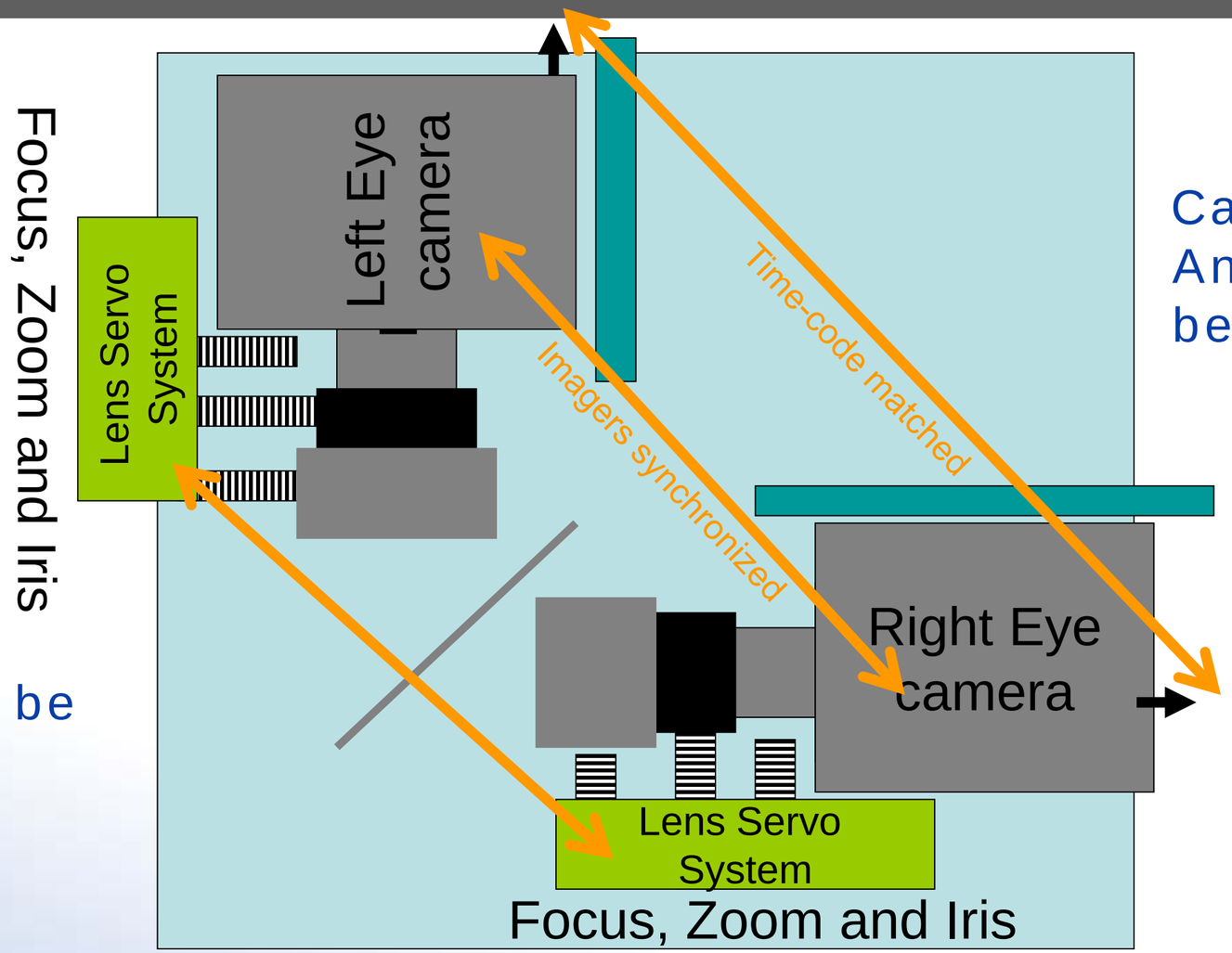


Importance of in camera convergence adjustment

Adjusting Convergence can eliminate a window violation



Modern Rig Locks 2 Cameras

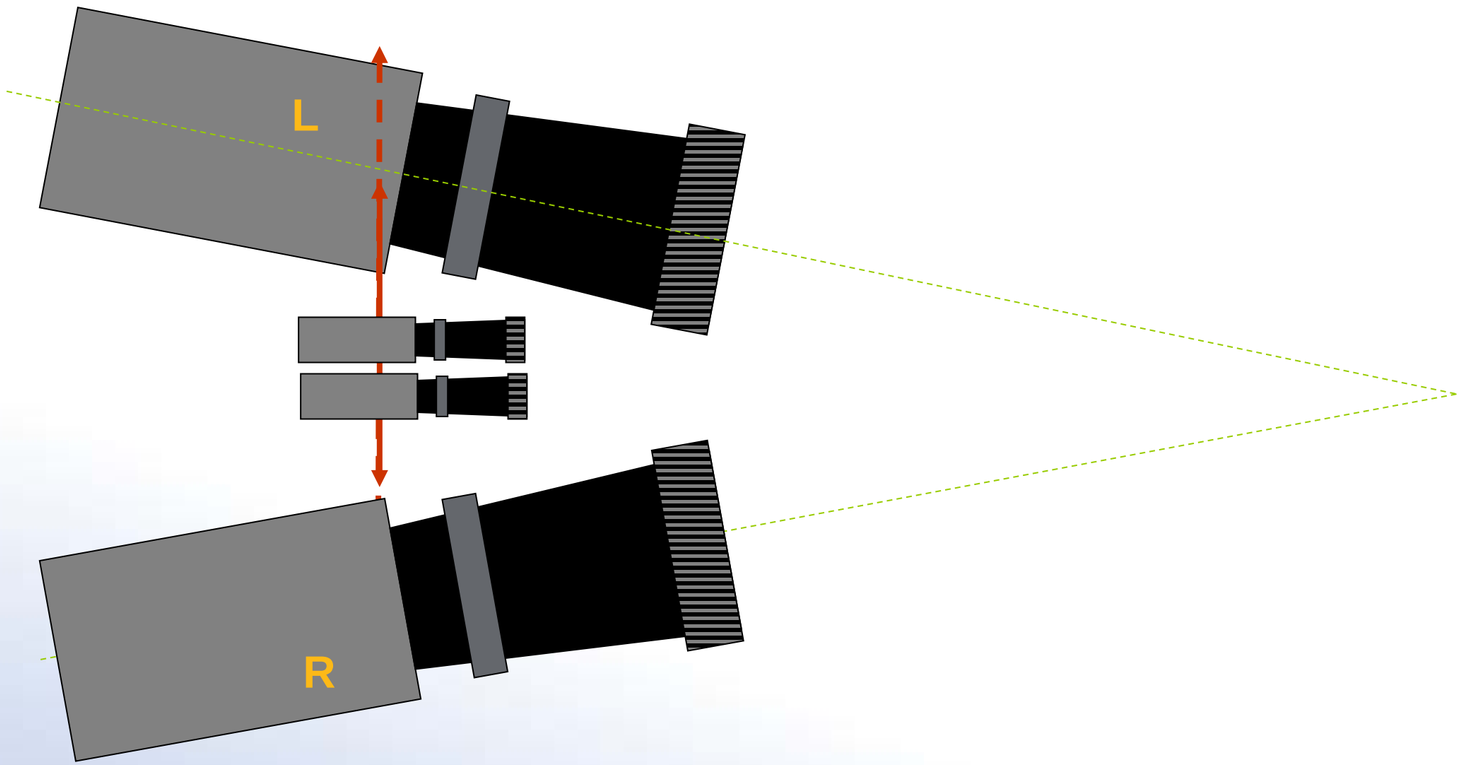


Camera convergence And Inter-axial should be adjustable

Lens servos must be Linked

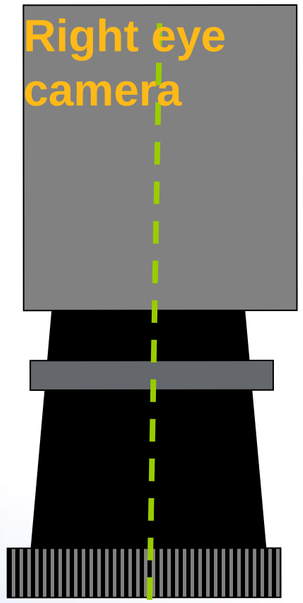
Top View

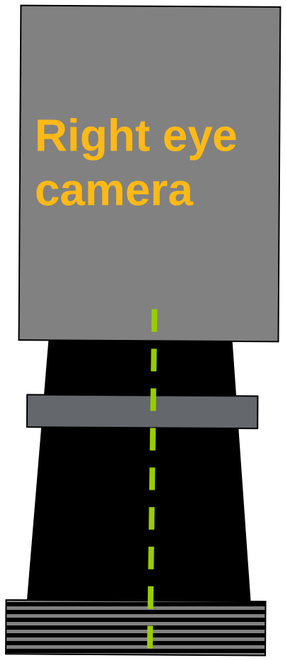
Side by side rig

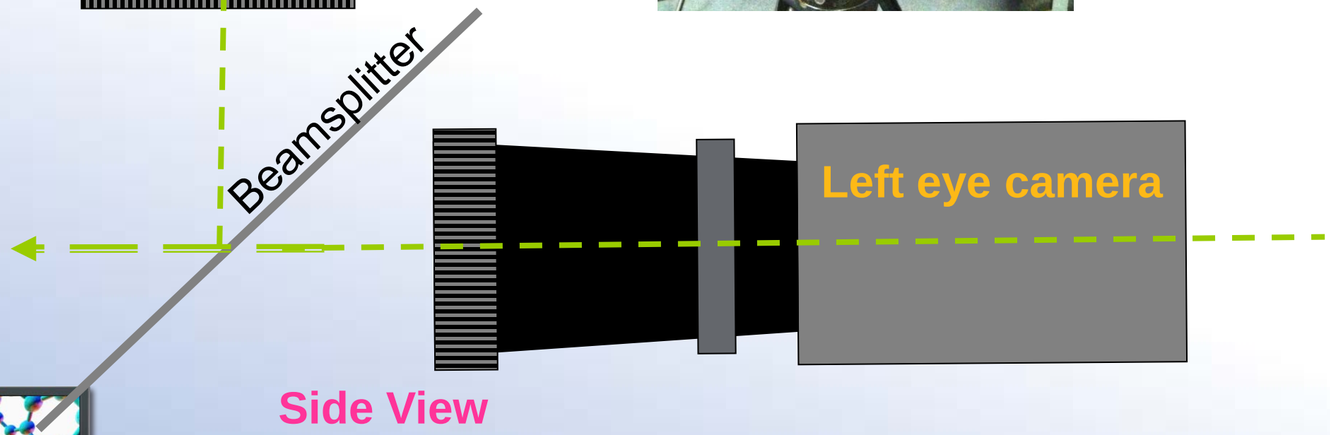


- Minimum inter-axial > 0
- Tight close up is a problem
- Minimum inter-axial depends on camera/lens size
- Wider Inter-axial is possible
- Good for shooting distant objects

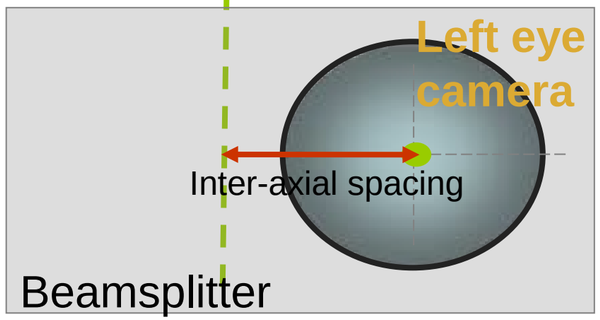
Beam-splitter rig





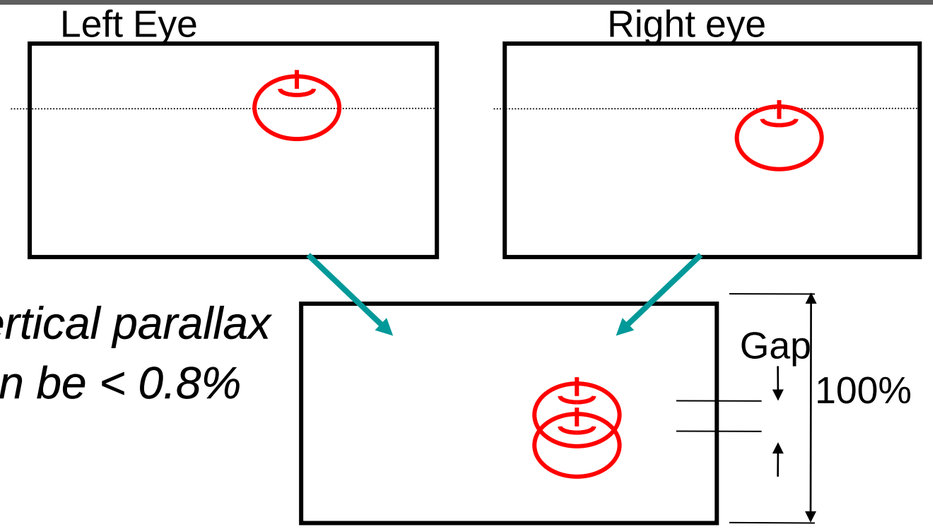


Side View

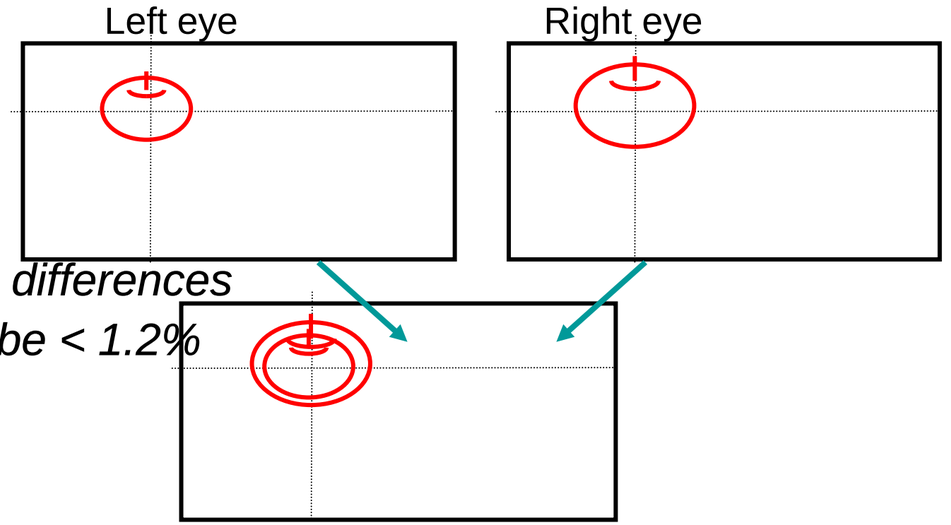


Front View

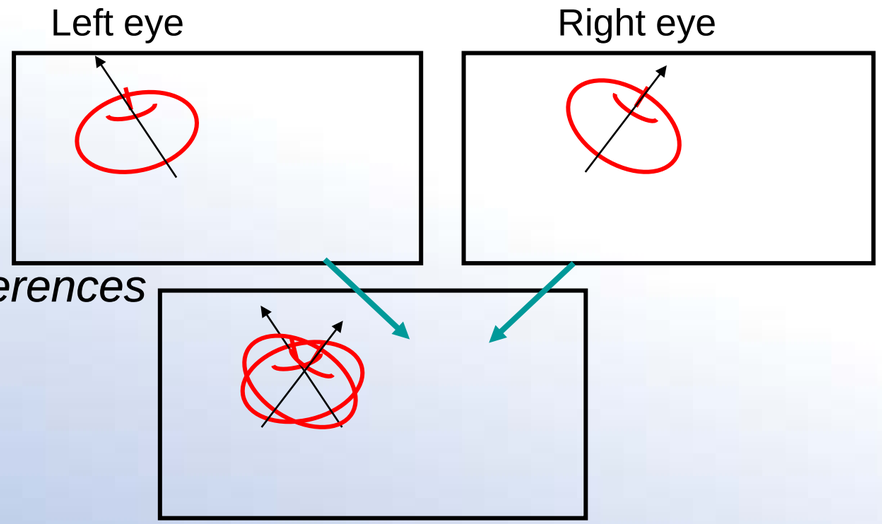
Limited parallax errors are tolerable to the viewer over time



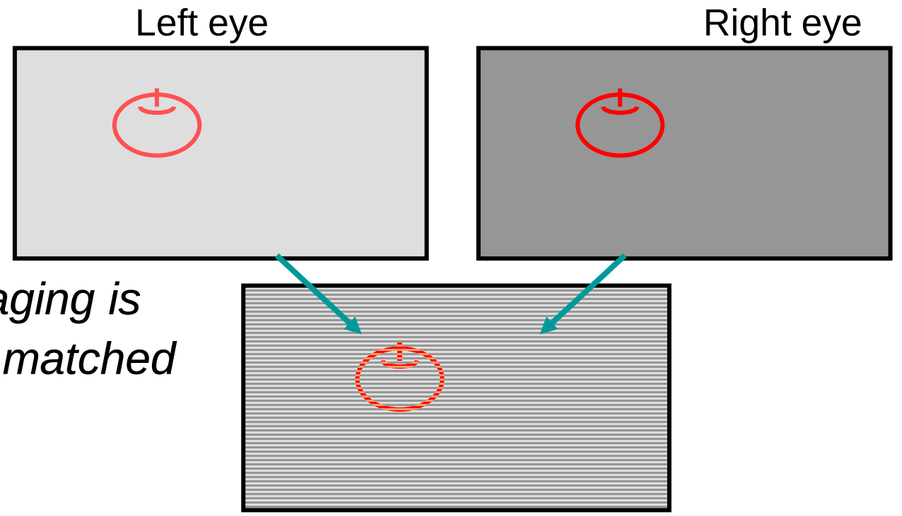
Vertical parallax can be < 0.8%



Size differences can be < 1.2%

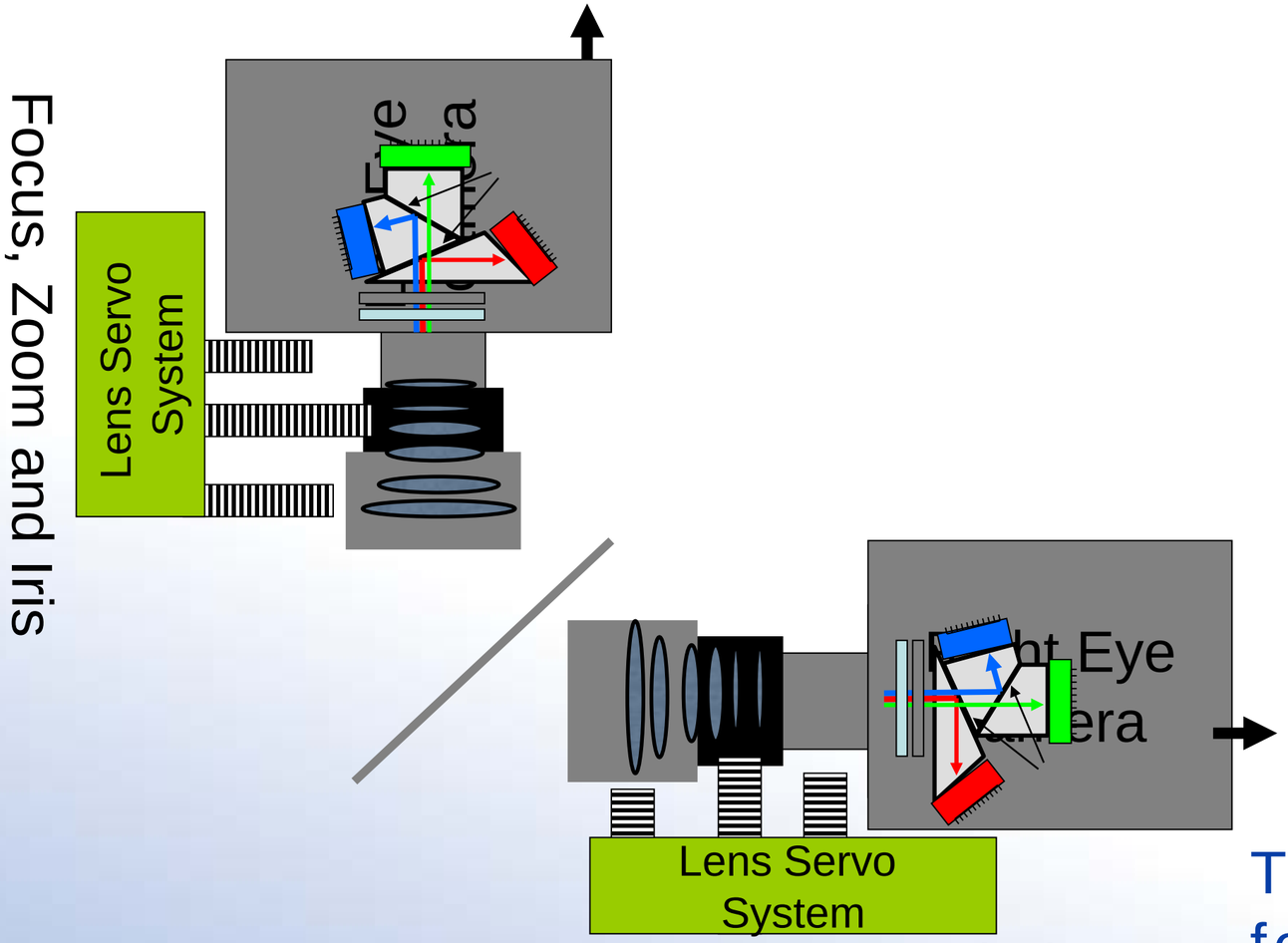


Rotational differences can be < 0.8°



Electronic imaging is automatically matched

Camera & Lenses in 1 Package: Advantages?



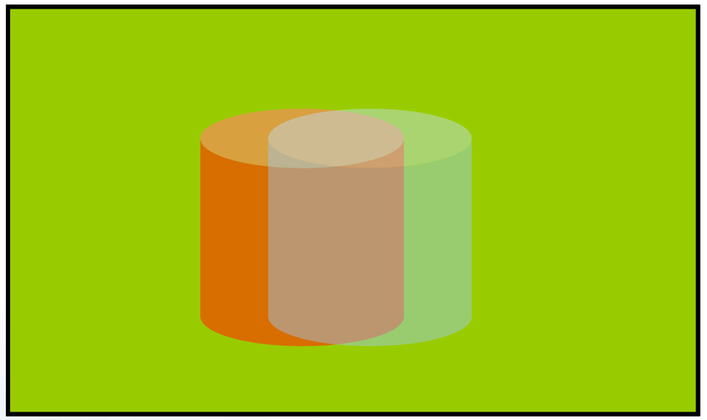
Tracking in camera reduces the need for post parallax error correction

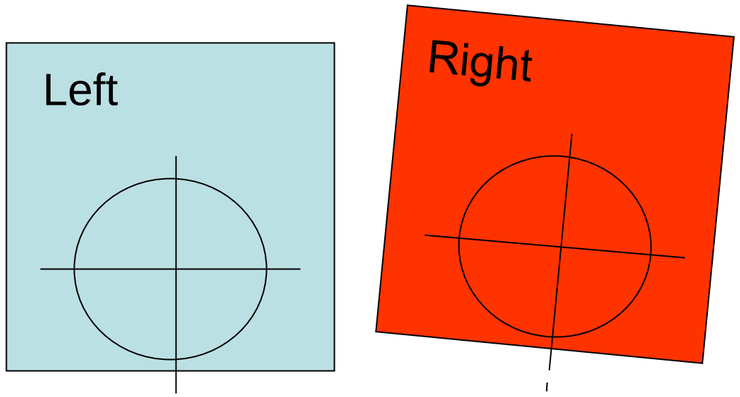
Simplified Operation

We can Eliminate need for External Parallax Corrections by Internal correction

- Track optics and Imagers as part of manufacturing
- Electronically correct for optical flaws
- Control optics through internal servos

Correcting Externally requires real-time allignment adjustments (at the pixel level!!)





- Completely fixing in post requires image warping
- To correct parallax errors you can move the camera
- This needs to be changed for each lens position

We Can Constrain Optics for Safe 3D

- Fix Inter-axial
- Limit focal lengths
- Limit convergence angles

We Can Constrain Optics for Safe 3D

1/4” **3Chip** imagers

Allows for 60mm inter-axial side by side config

Fixed 60mm inter-axial

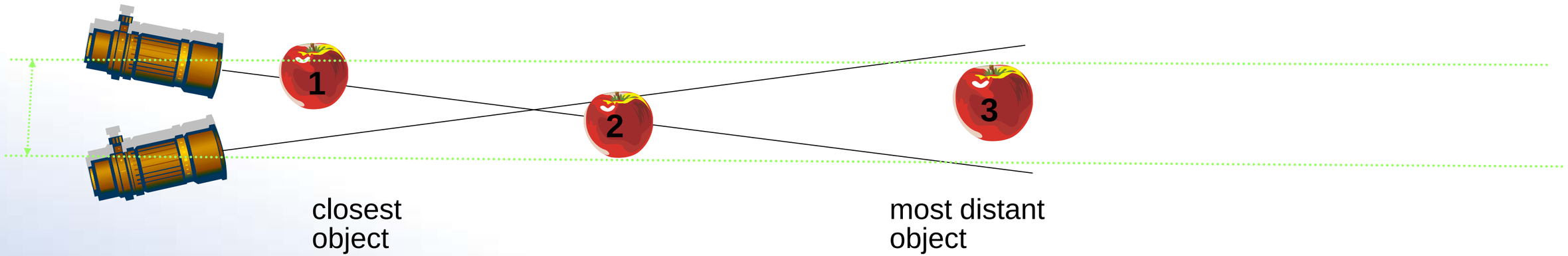
Allow easy calculations for safe 3D

Widest focal length close to “Normal”

Combined with optical convergence technique means NO KEYSTONE

Limited zoom range

Encourages froper camera placement for 60mm inter-axial



But how do we compose the shot?

Displays should provide 3D help

Display Choices:

Left Image

Toggle right image

L/R Mix

Display Shows:

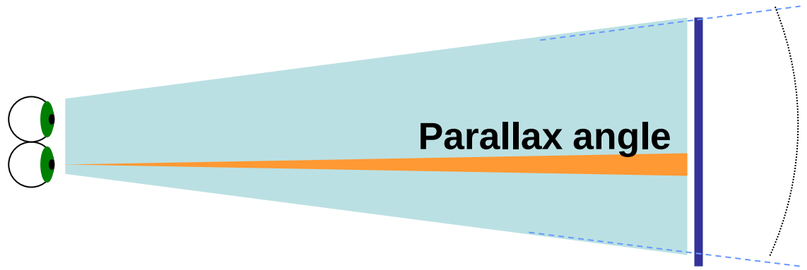
Convergence plane distance

Range of safe 3D

For Safe live viewable 3D...

- Camera eliminates parallax errors internally
- Convergence control allows adjustable convergence plane
- Display guides user when setting convergence
- **Display helps user compose scene for good 3D**

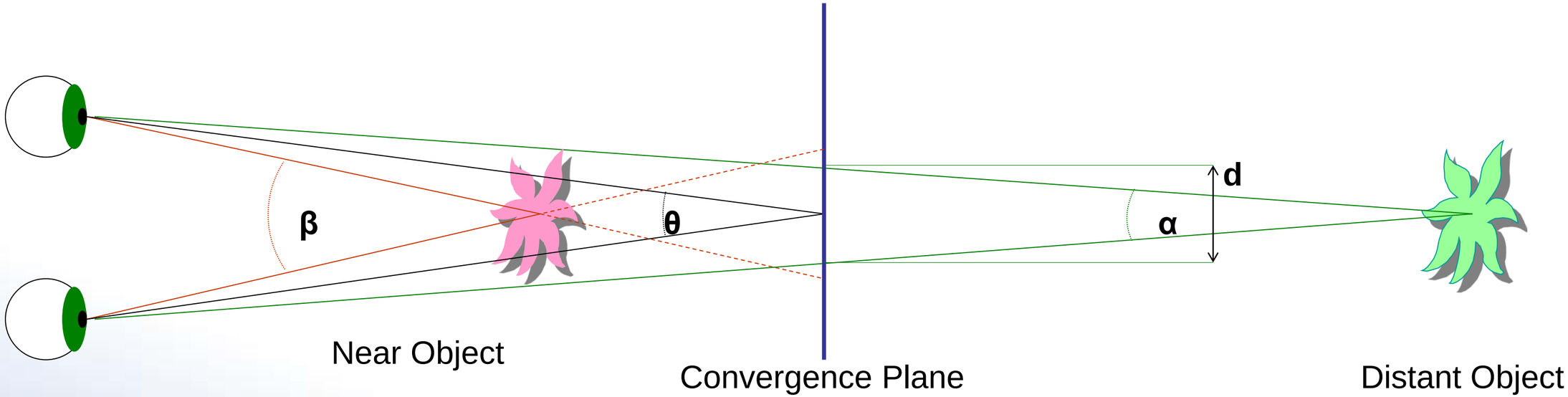
Determine Disparity Ratio



1° is **2.94%** of the typical 34° viewing angle of an HDTV at 3X screen height viewing distance

2° is **5.88%** of that 34° viewing angle

Calculate object distance from parallax angles



- The difference between vergence to the screen and vergence to object portrayed in 3D is the parallax angle.
- Parallax angle = Θ - α, or β - Θ
- Parallax angle < 1° for prolonged viewing but up to 2° merge-able

Derive Scene Object Distances from Disparity Ratios (via Convergence angles)

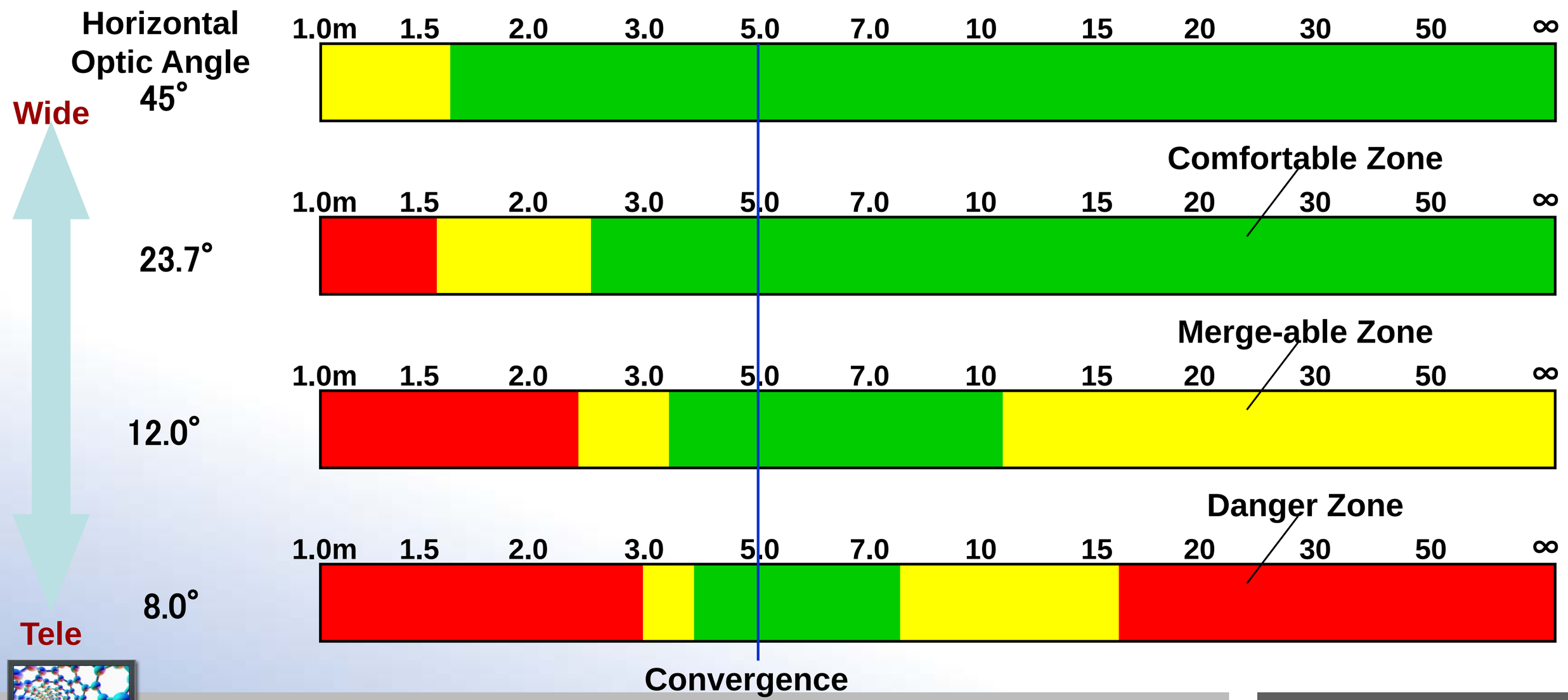
$$\frac{I \times (C - Dn)\times 100}{Dn \times 2C \tan(\omega/2)} \quad \text{or} \quad \frac{I \times (Df - C)\times 100}{Df \times 2C \tan(\omega/2)}$$

I = Inter-axial

C = Convergence plane distance

ω = Viewing angle (determined by imager size and focal length)

Safe Z range for 3D Shooting

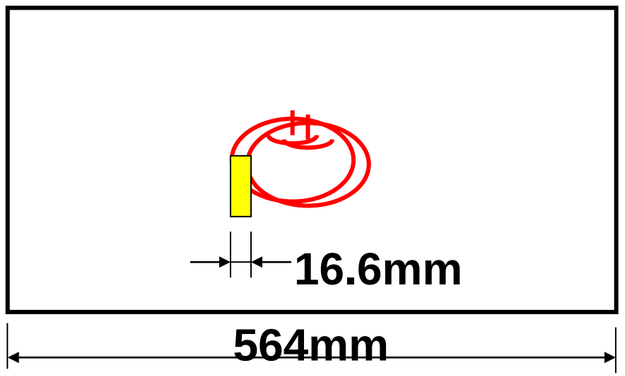


For larger screens, Absolute Parallax becomes dominant factor (primary concern for features)

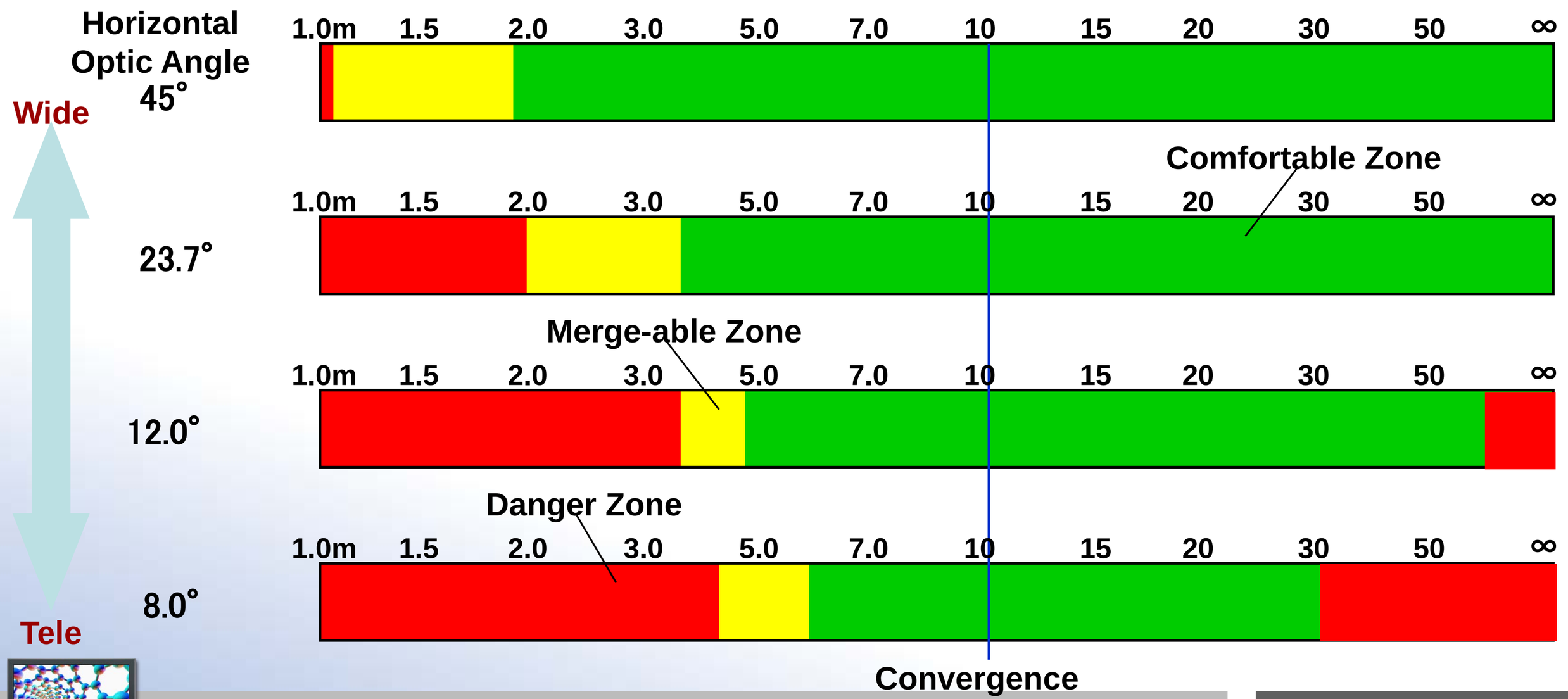
Point 1: Foreground Object Parallax ⇒ H Ratio≦2.94%

Point 2: Background Object Parallax ⇒ H Ratio≦2.94%

Point 3: When the supposed screen size is bigger than 77 inches, the parallax horizontal ratio of the background object will be smaller than 2.94%.
77”⇒2.94%, 103”⇒2.2%, 152”⇒1.5%, 200”⇒1.1%



For larger >77” absolute parallax is factor



One Person Operation & Viewable output

May not maintain cinema shooting shot vocabulary but…

- Reduces 3D shooting user errors
- Eliminates rig generated parallax errors
- Significantly reduces “3D Finishing” so grading and finishing can proceed as in 2D shooting
- Allows for reasonable “test shooting” in pre-production

SDI

AVC INTRA

AVCHD

(L) (R)

Finish

SDI x2

DCP

Edit- PC

Adobe CS5
Apple FCP
Avid MC5
+ CineForm Neo 3D +

AJA KONA3

SDI x2

3DL2550

Edit- Mac

Adobe CS5
Apple FCP
Avid MC5
+ CineForm Neo HD +

AJA KONA

Encode to AVC INTRA

L,R

DDR

Side/Side

SDI
Side/Side

DVI-D
Line/line

3DL2550

Apple FCP + DashWood S3D Toolbox

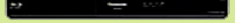
Automatic merging of left and right files

Full HD

Sonic, CineVision、
Panasonic Hollywood Lab

3D TV

3D-BD



HDMI 1.4

BD Authoring

Frame Compatible

Adobe Encore
Sonic Toast

Adobe Encore
COREL, Sonic Roxio

Side/Side
HDMI 1.3

BD

Thank You