

Offaxis frustums: What are they and what are they good for?

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Alternative title:

Rendering content for immersive environments

<http://astronomy.swin.edu.au/~pbourke/HET409/>

Contents

Camera model for computer based rendering.

Introducing offaxis frustum.

Stereoscopic projection (eg: IMAX3D).

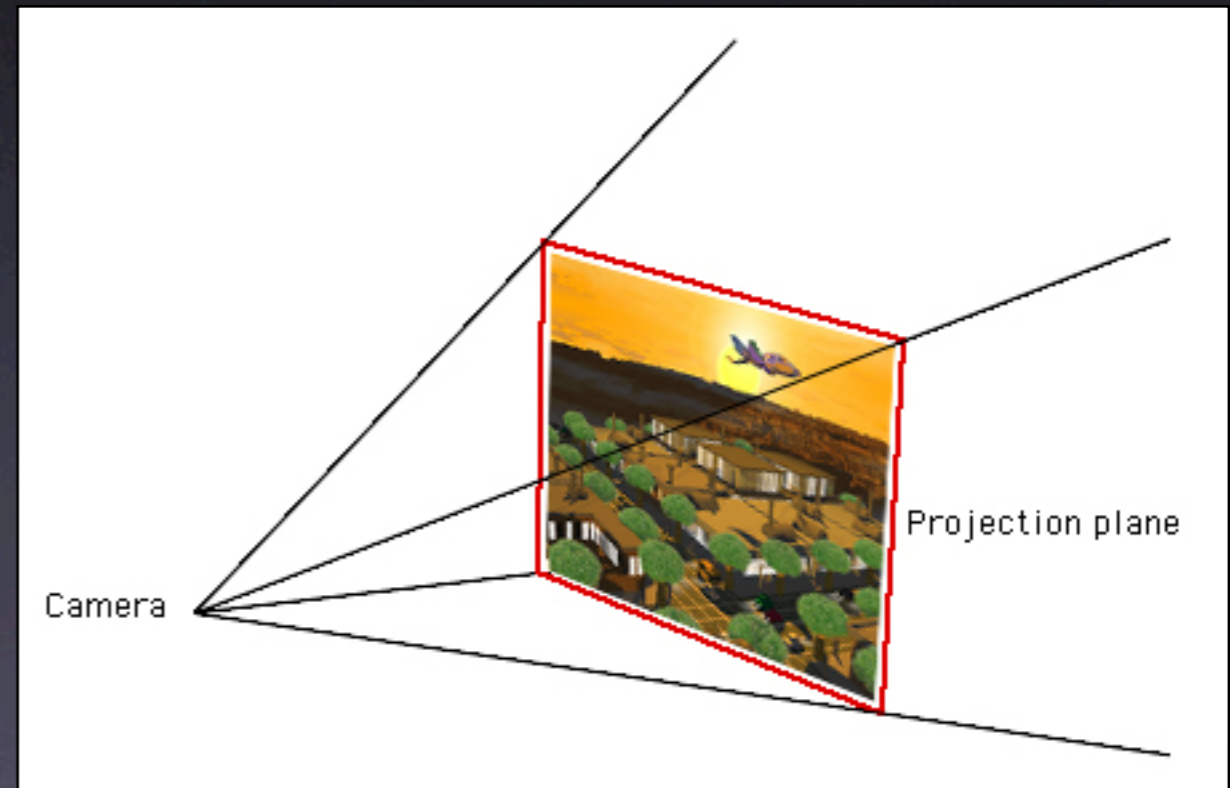
Multiple wall, tiled displays.

Curved and dome projection (eg: Planetarium).

Visit to the Swinburne stereo-capable theatre, AS406

Definition: Frustum

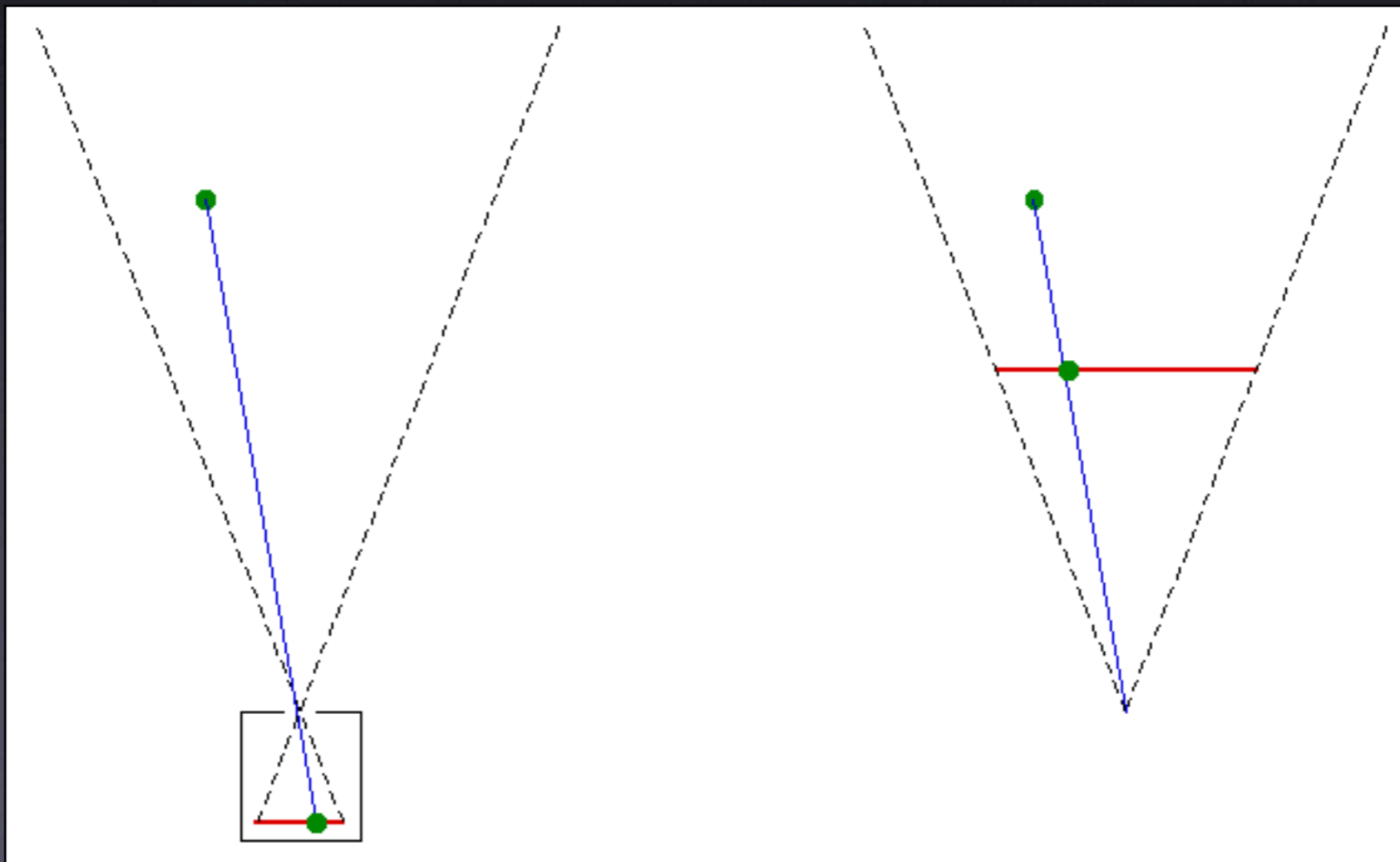
- Pyramid formed by lines from the camera to the corners of the picture plane.
- Contains the set of objects that can be “seen” by the camera.
- Ignoring lens effects.



Pinhole (perspective) camera model

- Projection plane (behind or in front).
- Frustum is symmetric, vertically and horizontally.
- Straight line between the object and camera determines its position on the projection plane.

Top view of frustum



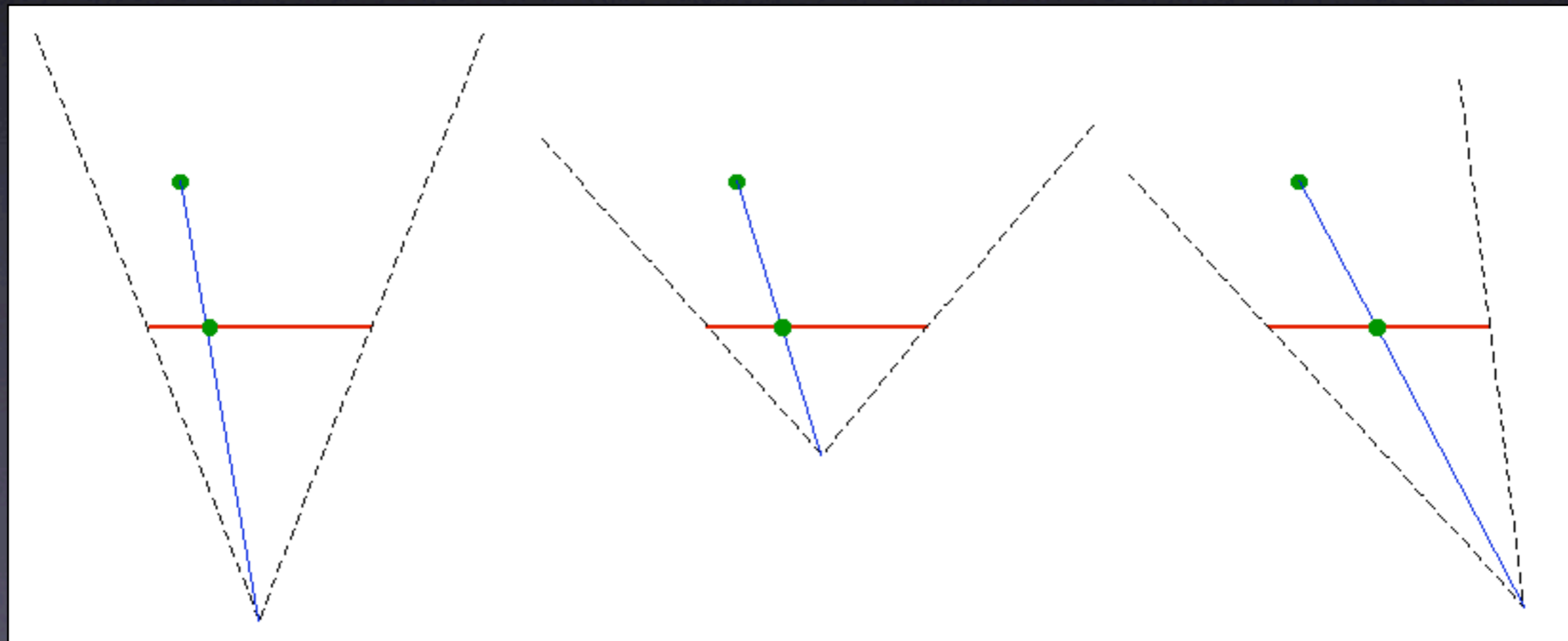
Pinhole camera

Computer equivalent

What's the problem?

Result is an offaxis frustum.

- The camera is not always centered on the projection plane.
- The frustum, and therefore what can be seen, changes depending on the camera position.
- Window model for virtual environments.



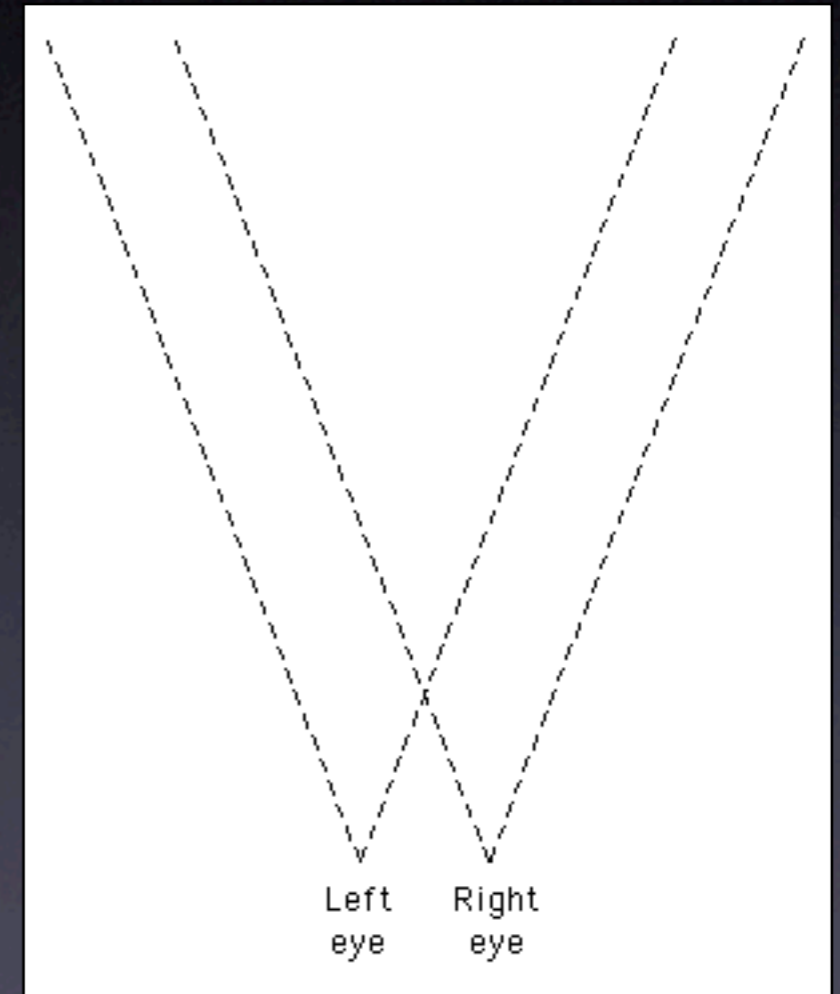
Symmetric

Closer to "window"
Symmetric

At an angle to "window"
Asymmetric

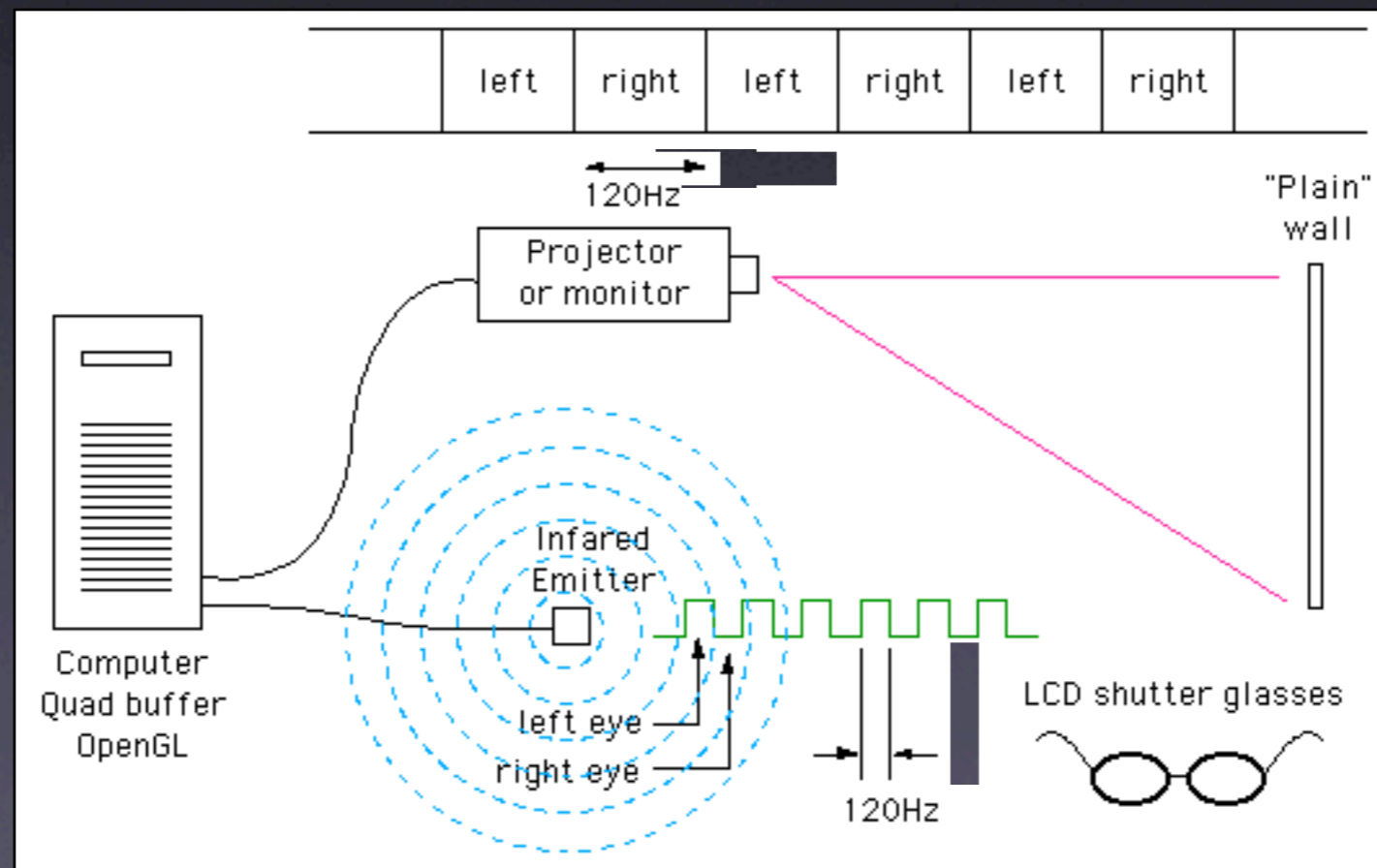
Stereographics

- Human visual system has 2 eyes.
- Horizontal separation delivers two different views of the world to our visual cortex for processing.
- These two views allow our visual system to construct the stronger sense of depth we perceive in the real world compared to photos, paintings, computer renderings.
- For computer generated stereographics we need to render two images, one from each eye position. These are then presented independently to each of our eyes. [More on this when we visit the Swinburne stereocapable theatre].



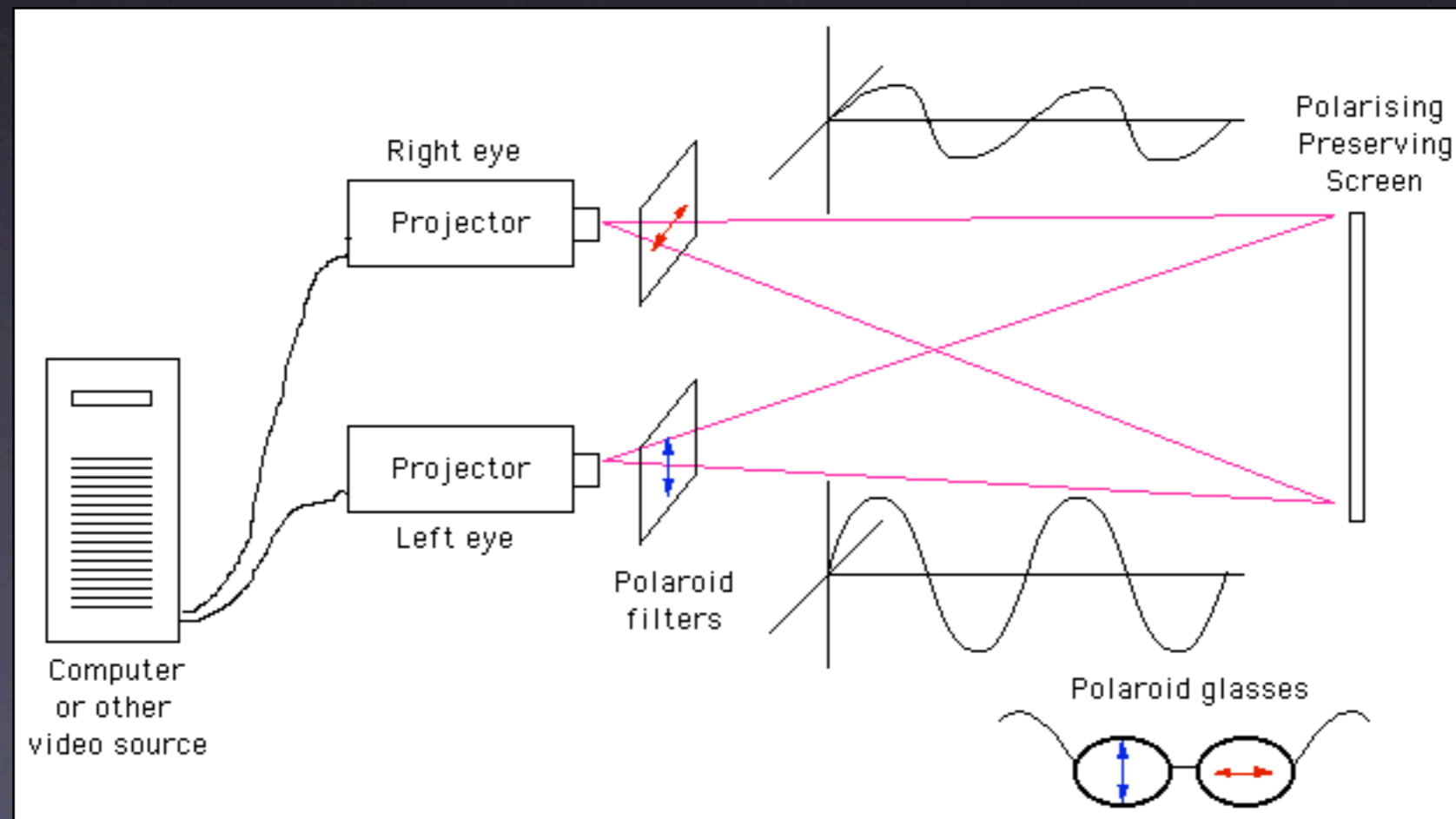
Active stereoscopic projection

- Glasses with active components (Electronics, batteries...).
- Single projector or monitor, fast phosphor required for a good result.
- 120Hz to minimise flicker.
- Wired or infrared synchronisation between the glasses and video card.



Passive stereoscopic projection

- Cheap polaroid glasses = suitable for public installations.
- Two projectors.
- Special (polaroid preserving) projection surface.



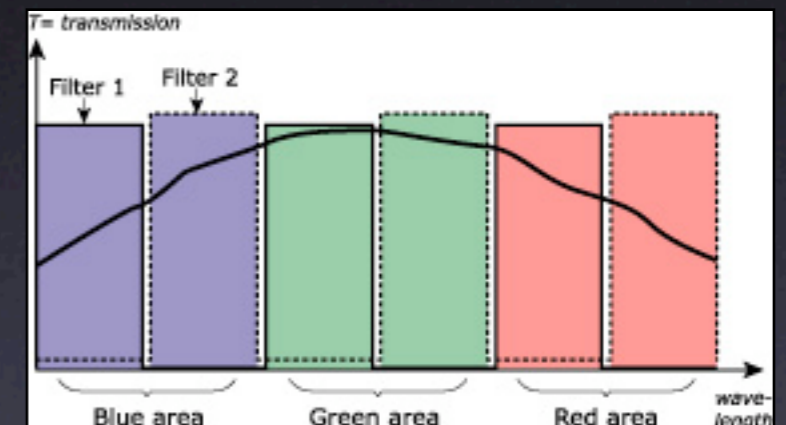
Other technologies

Not discussed

- red/blue, doesn't give full colour images.
- techniques that require viewing "tricks".

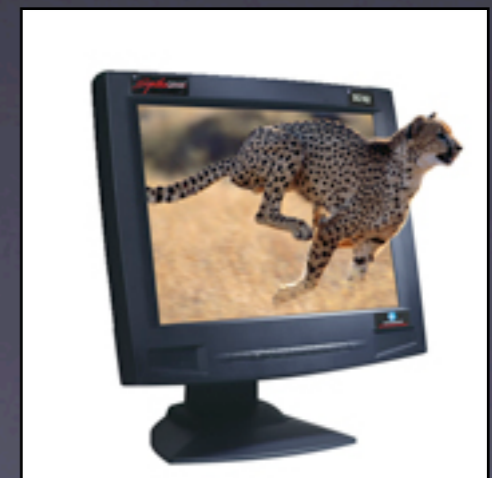
Infitec

- encodes red, green, blue channels.
- special optical glasses.
- advantage over passive are low ghosting levels.



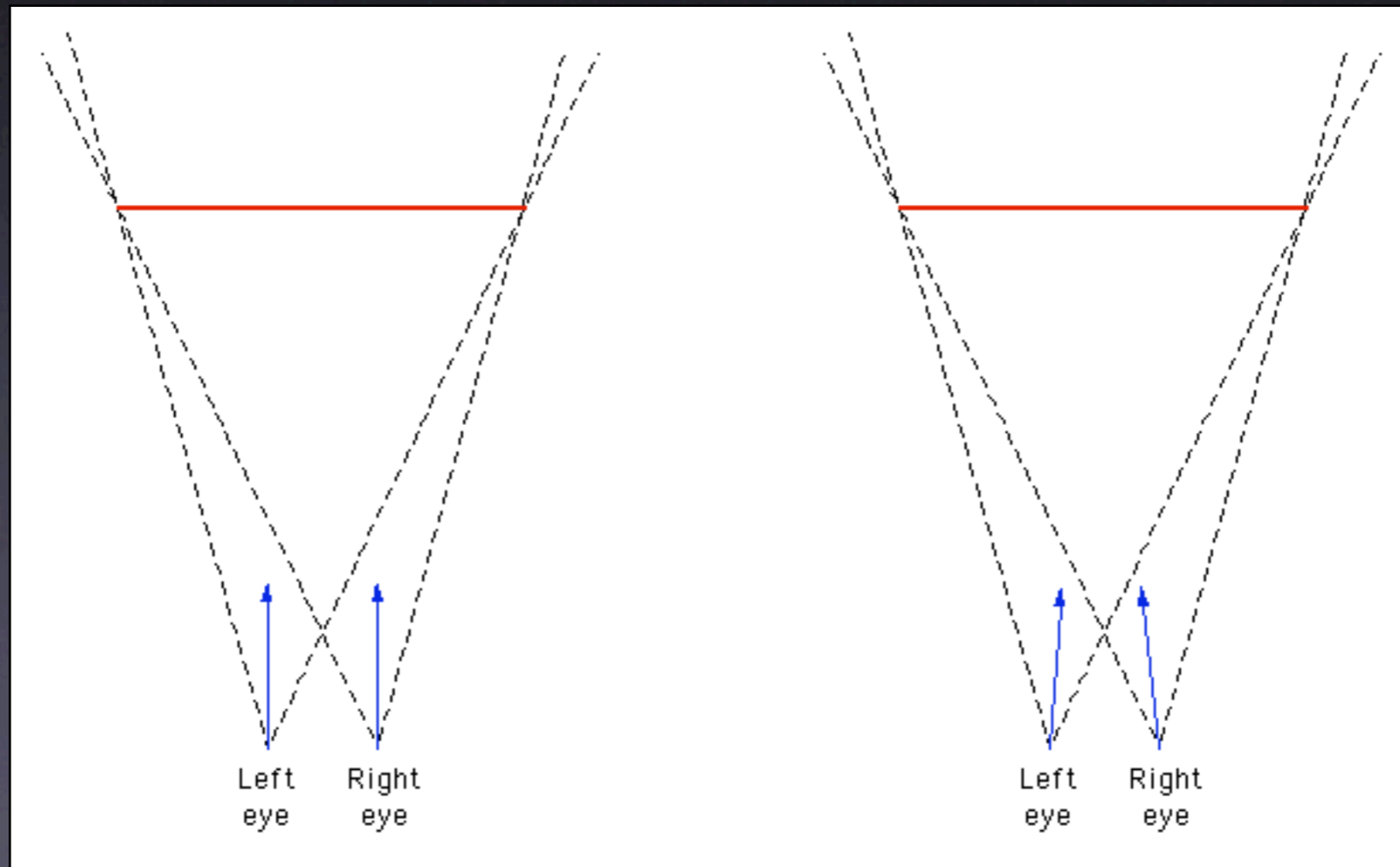
Autostereoscopic = no glasses

- still quite low resolution.
- only suitable for monitor displays, not large audiences.



Offaxis frustums required for stereographics

- Offaxis frustum method has parallel cameras.
- Unfortunately many rendering packages don't support offaxis frustums.
- Option is "toe-in" - not strictly correct although it "mostly" works.

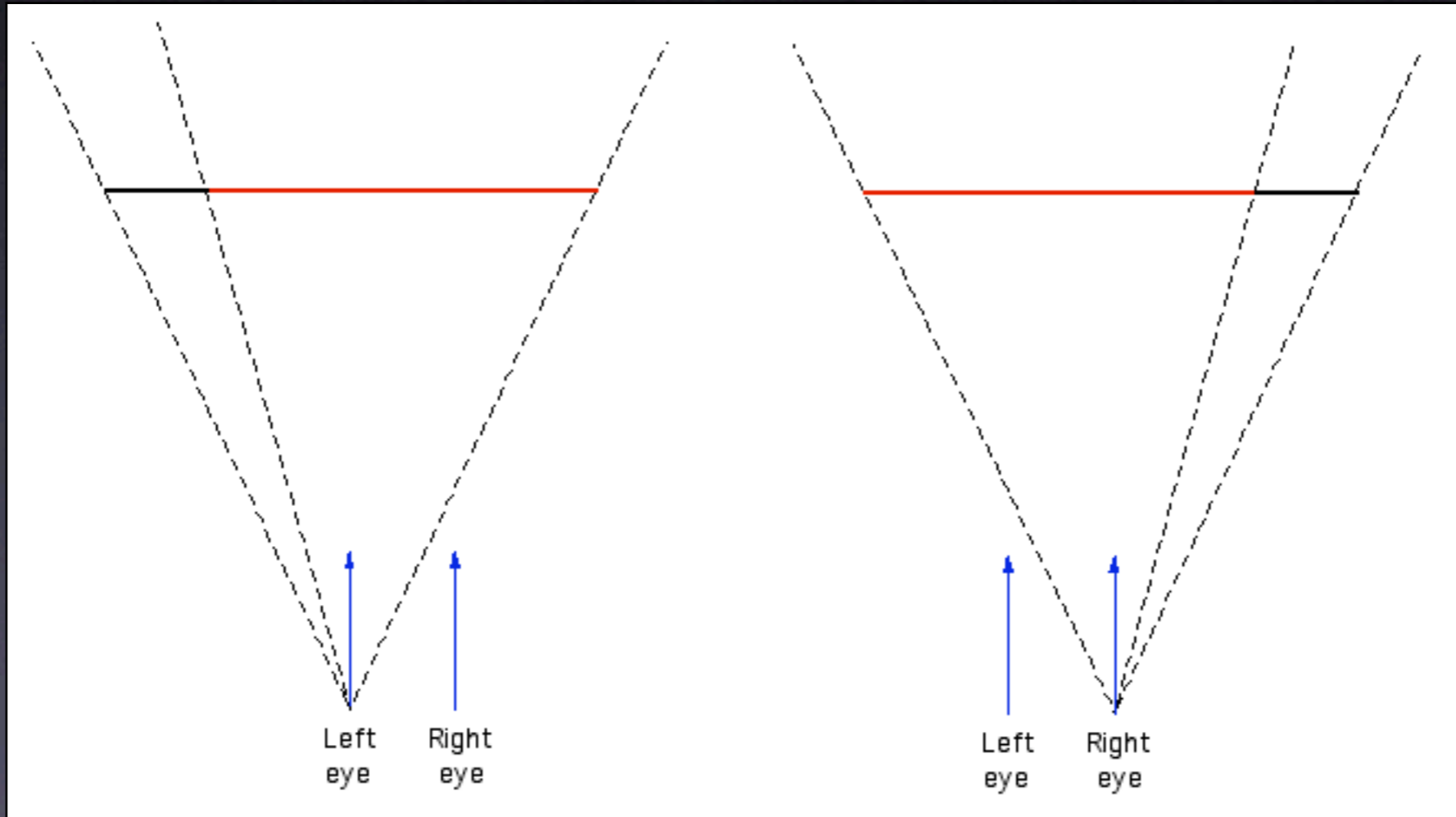


Parallel cameras

Toe-in cameras

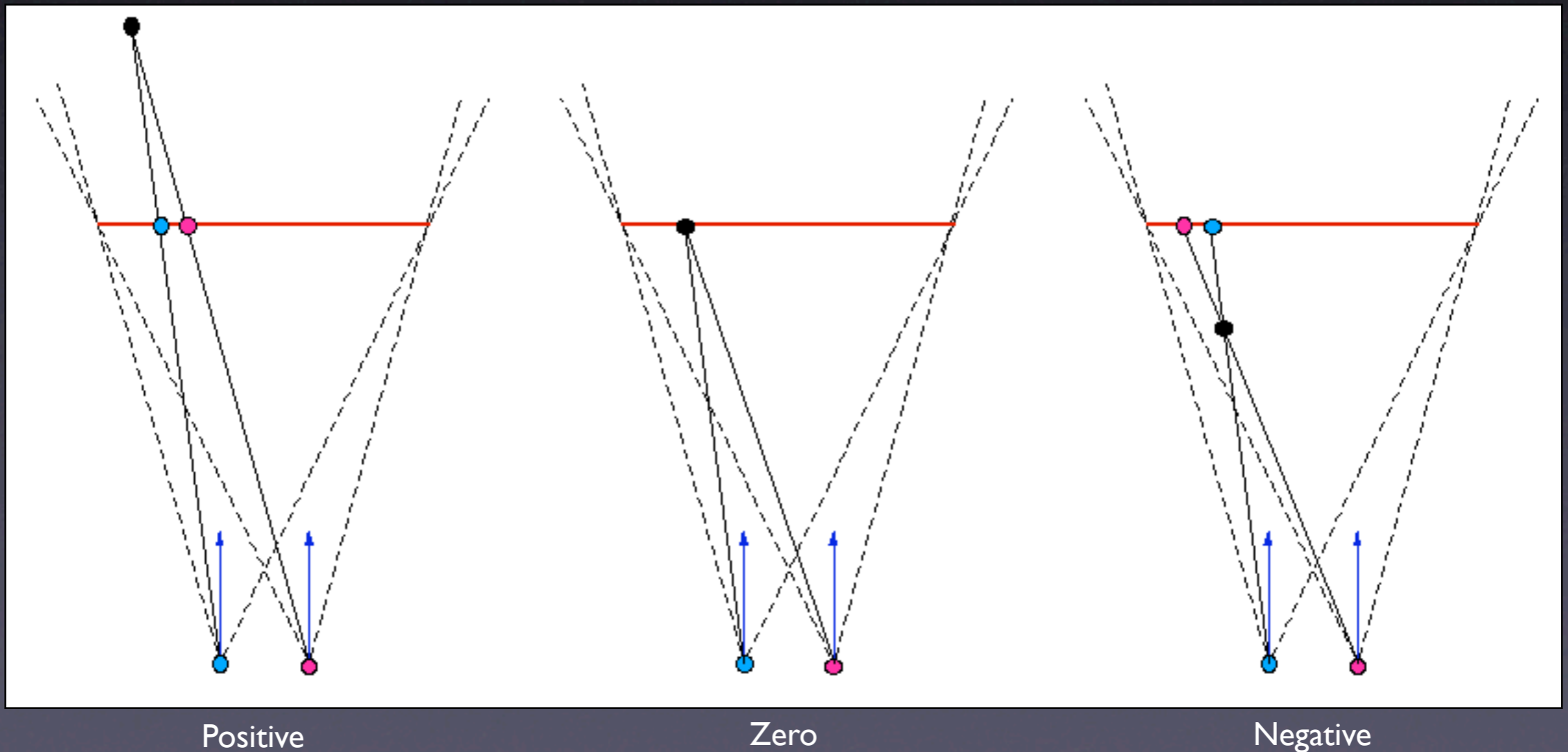
Creating stereo pairs without explicit software support.

- Render wider symmetric frustum and trim.
- Typically less than 10% overhead (wasted rendering).



Parallax and perceived depth

- Positive parallax (objects behind the screen)
- 0 parallax (objects appear at the screen)
- Negative parallax (objects appear in front of the screen)

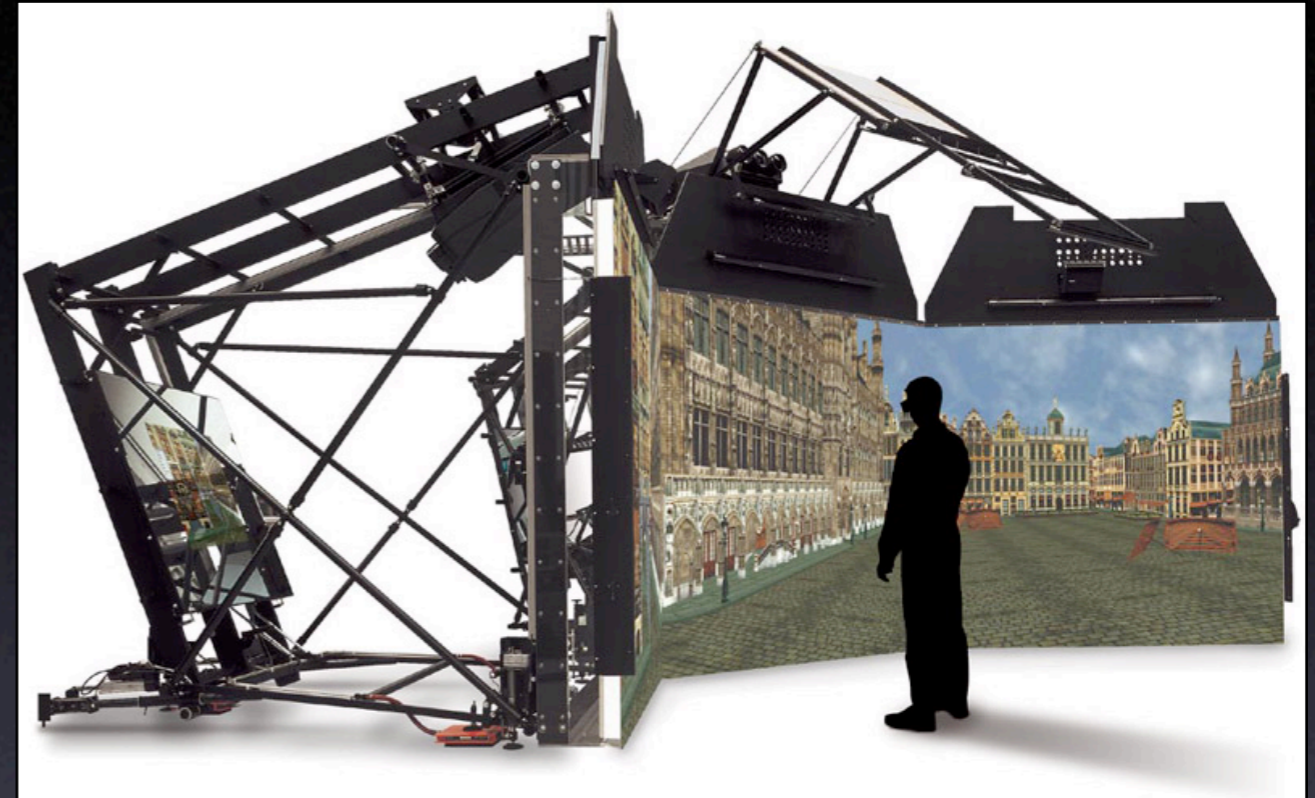


Quality and eye strain

- Main determinant of stereoscopic quality is the degree of ghosting, leakage between eyes.
- Positive parallax easier on the visual system than negative parallax.
- Consistent depth cues, perspective depth, lighting, motion cues.
- Accommodation is still in conflict, muscle tension is setting the focal length to the screen distance instead of the objects distance.
- A perfectly correct stereoscopic image can only be achieved for a single person. Keep the group/audience near the “sweet spot”.
- Flicker rate for active stereoscopic projection.
- Resolution for autostereoscopic displays.

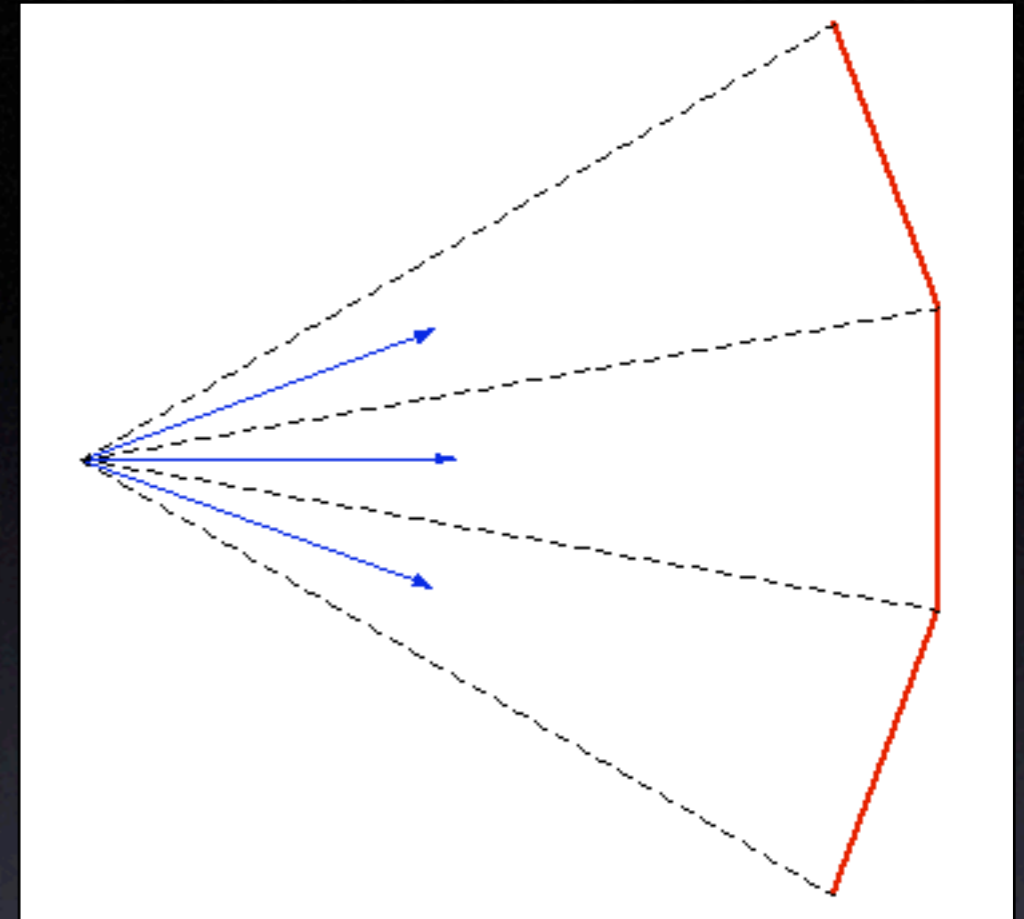
Offaxis frustums and tiled displays

- Goal: Peripheral vision, considered necessary for strong sense of “being there” [Immersion].

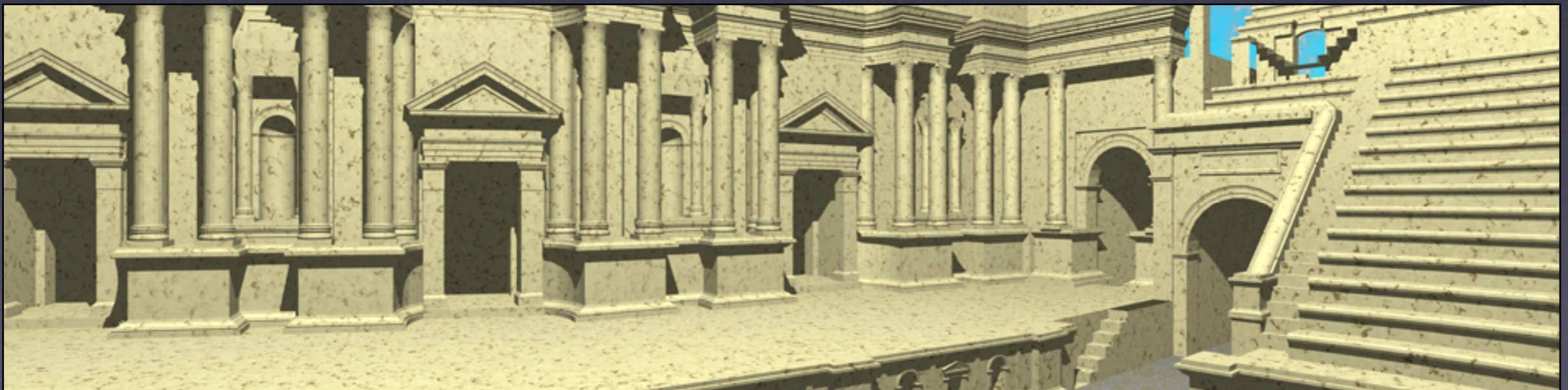
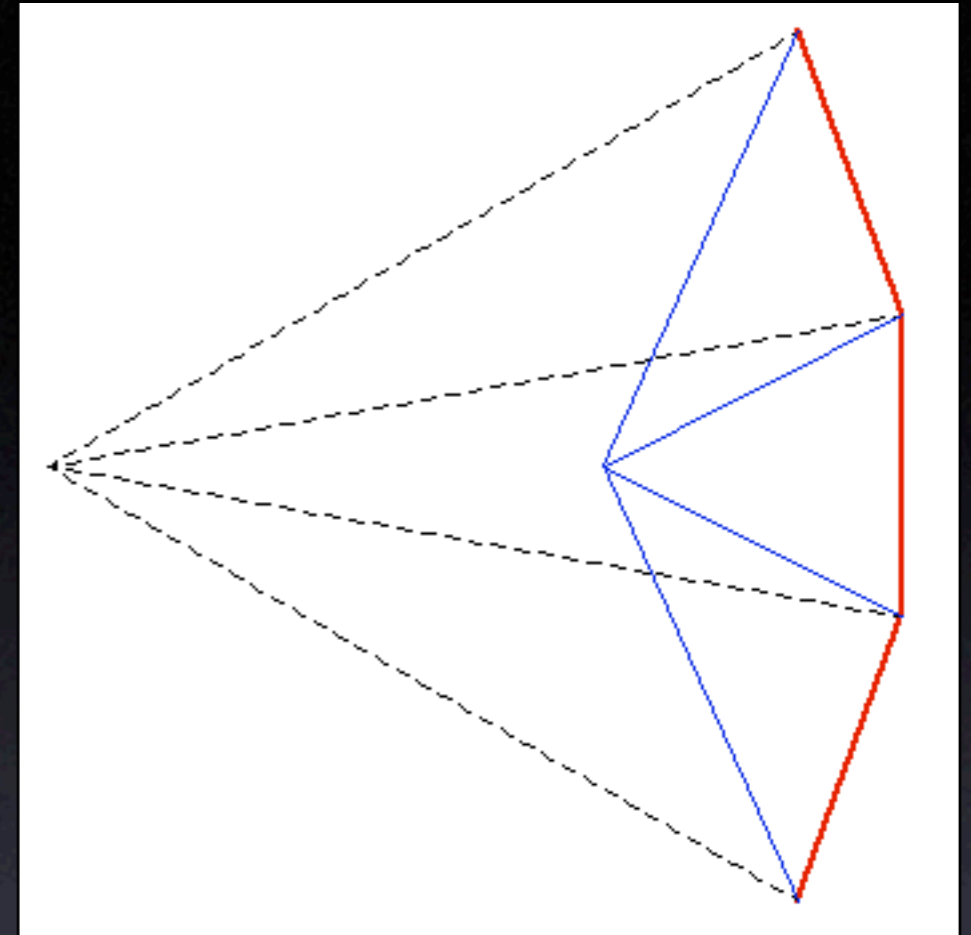


Example: 3 wall display

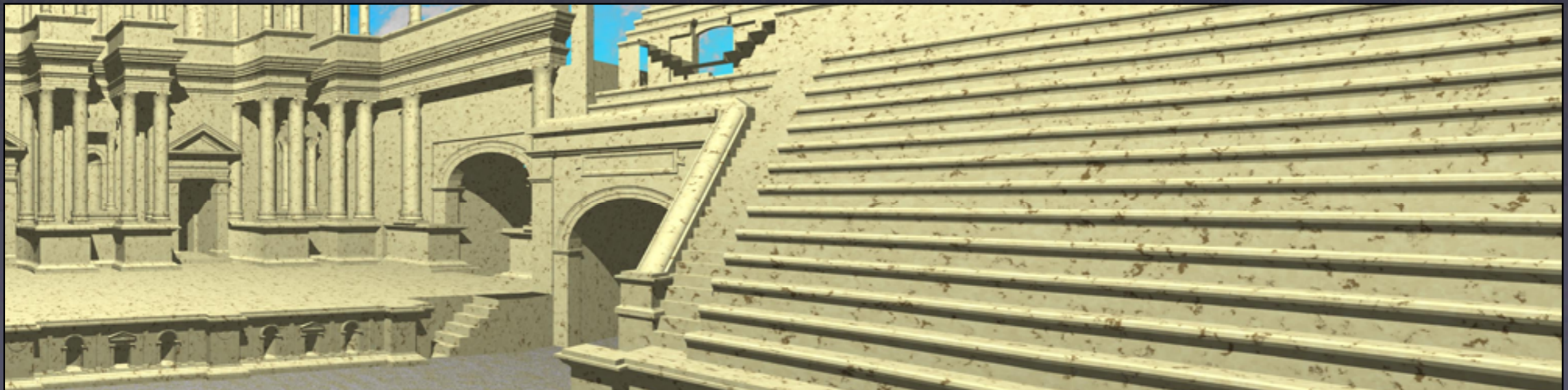
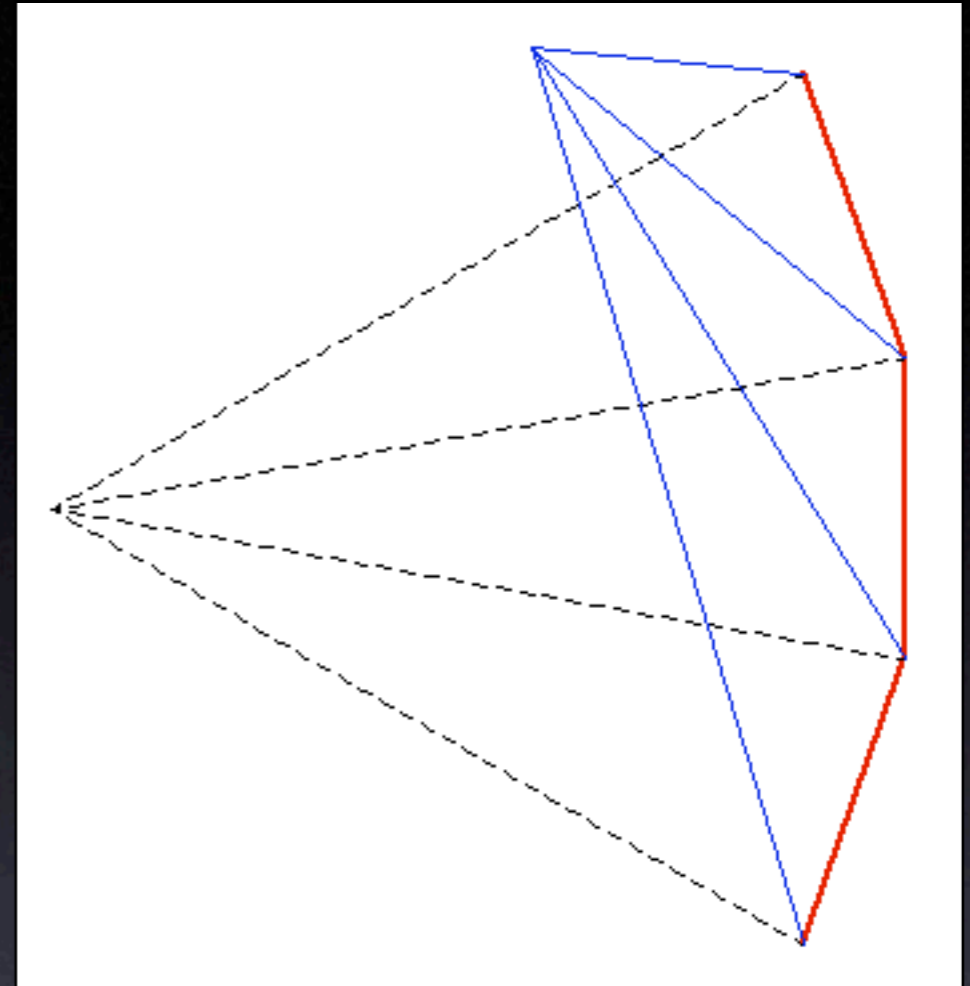
- Three symmetric frustums.
- Undistorted view only possible from one position.
- Sweet spot for audiences.



- Head tracking used in immersive environments
- One symmetric, two offaxis frustums

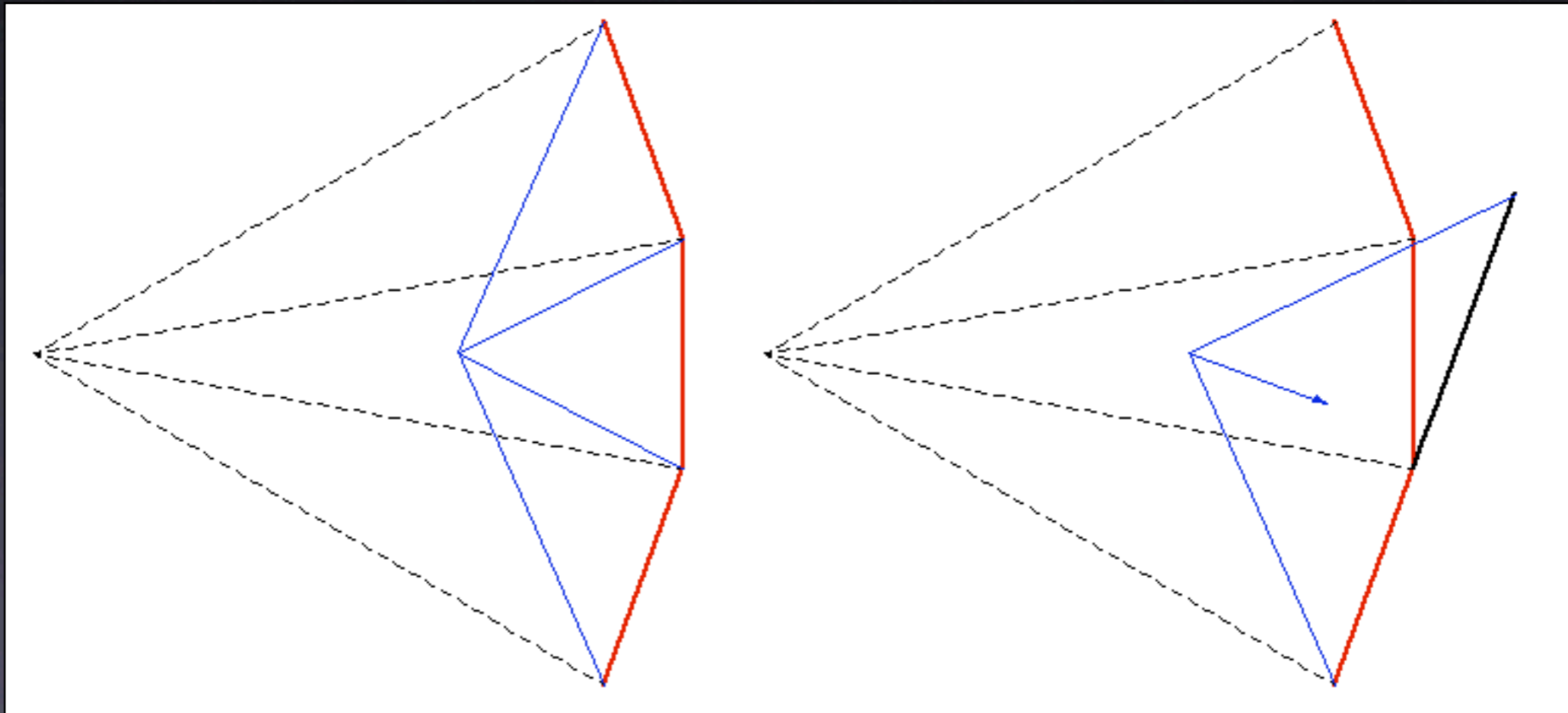


- Three asymmetric frustums



Creating asymmetric frustums without explicit support.

- Rather inefficient unless the column range can be restricted.



Offaxis frustums and curved (dome) displays

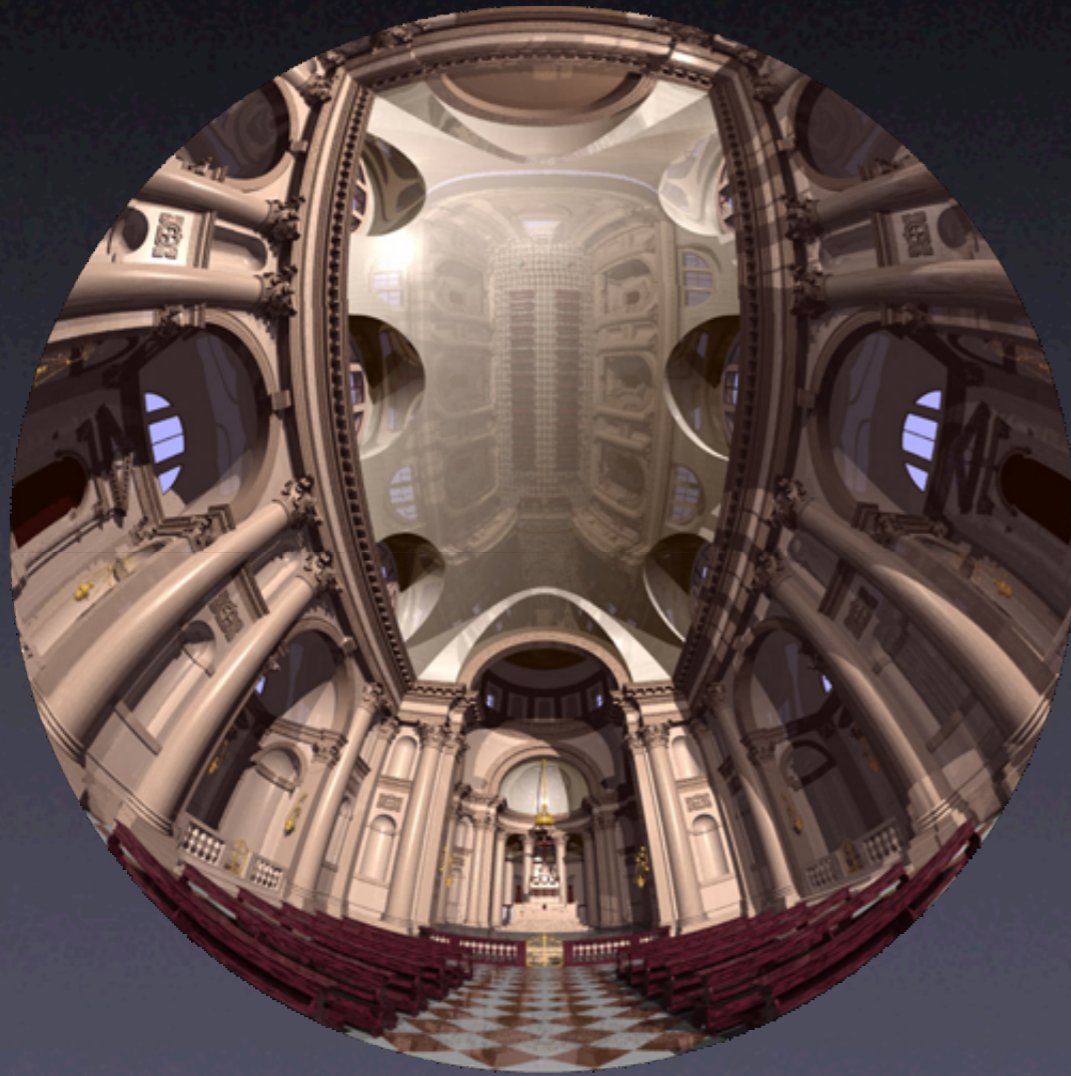


- Peripheral vision

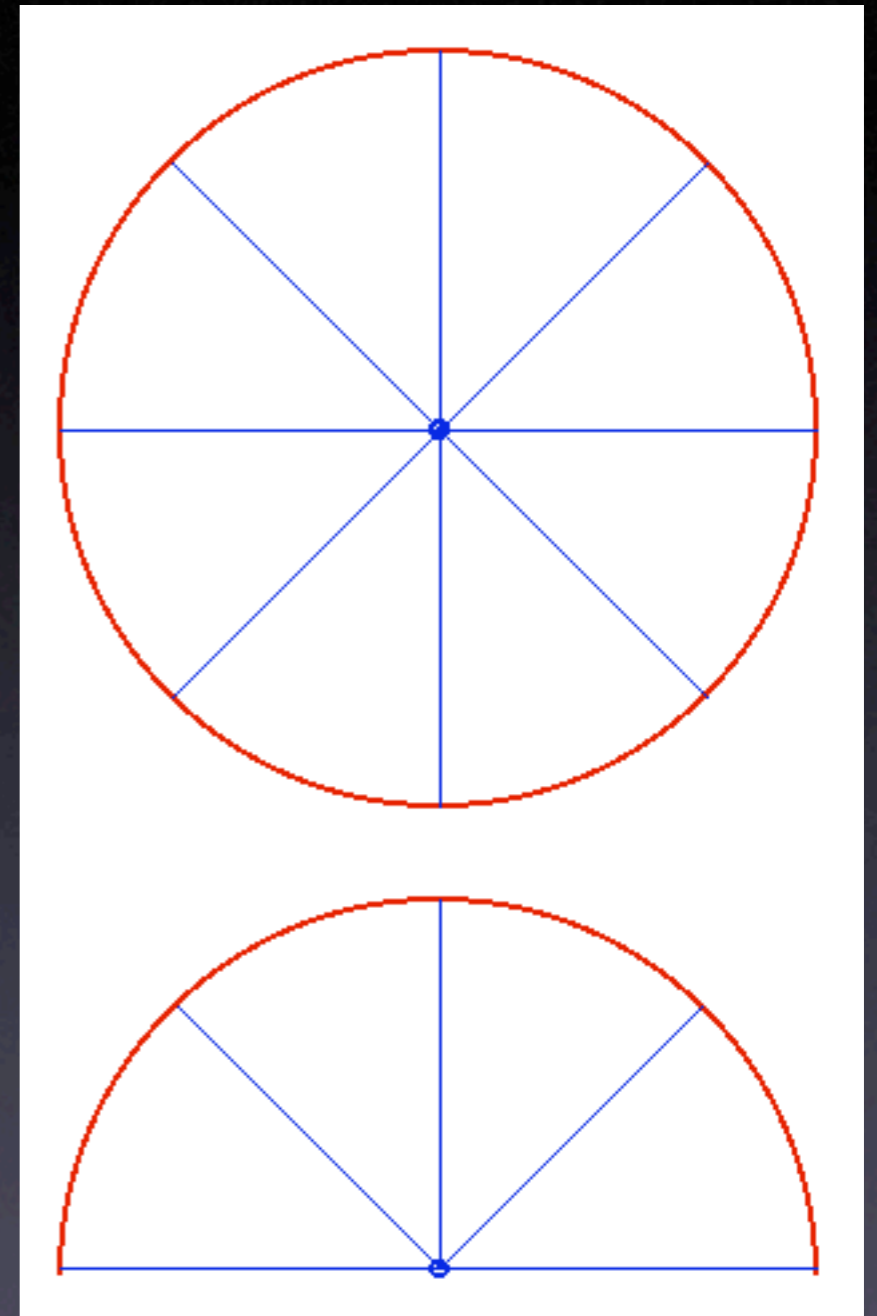


Fisheye projections

Observer in the center of the dome



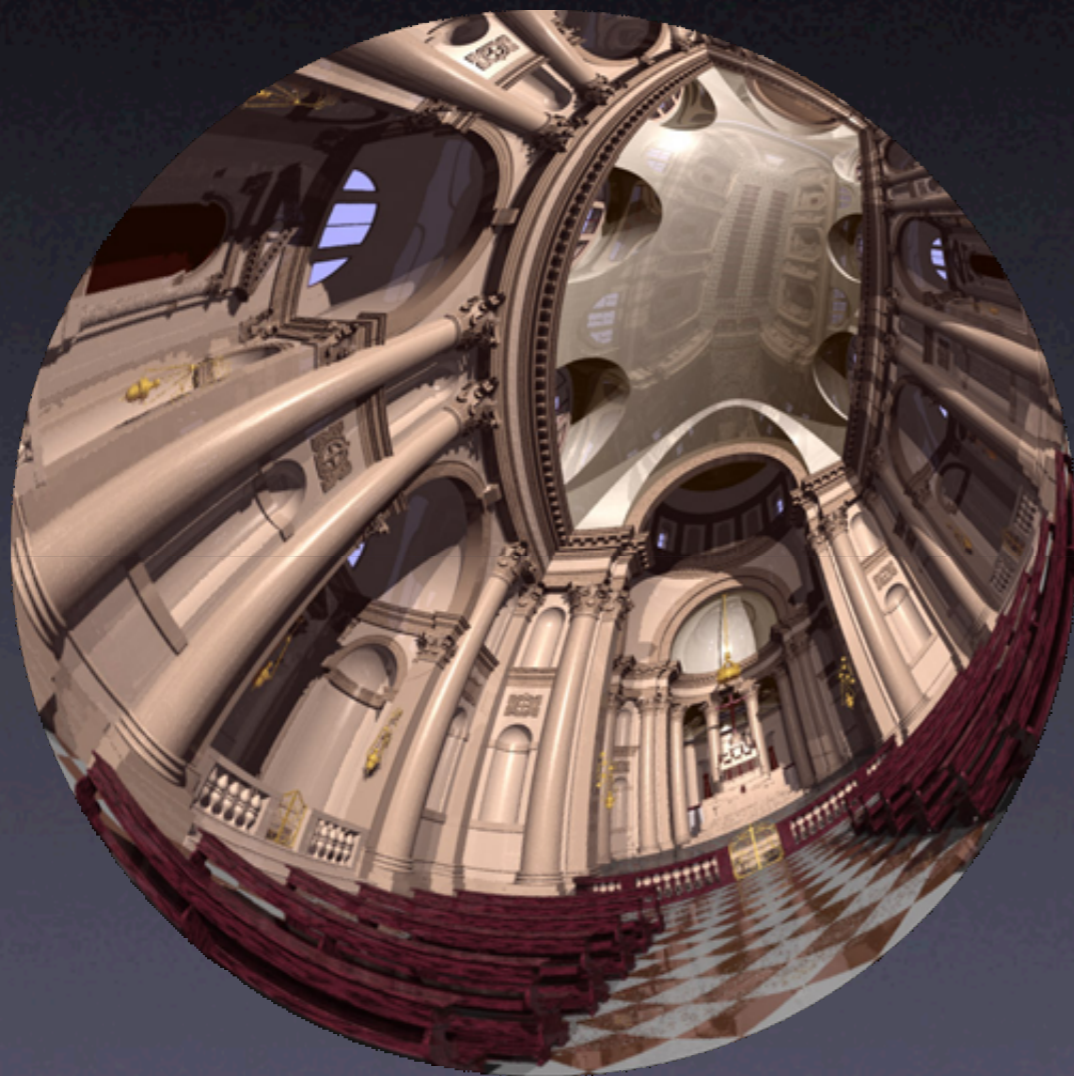
Plan



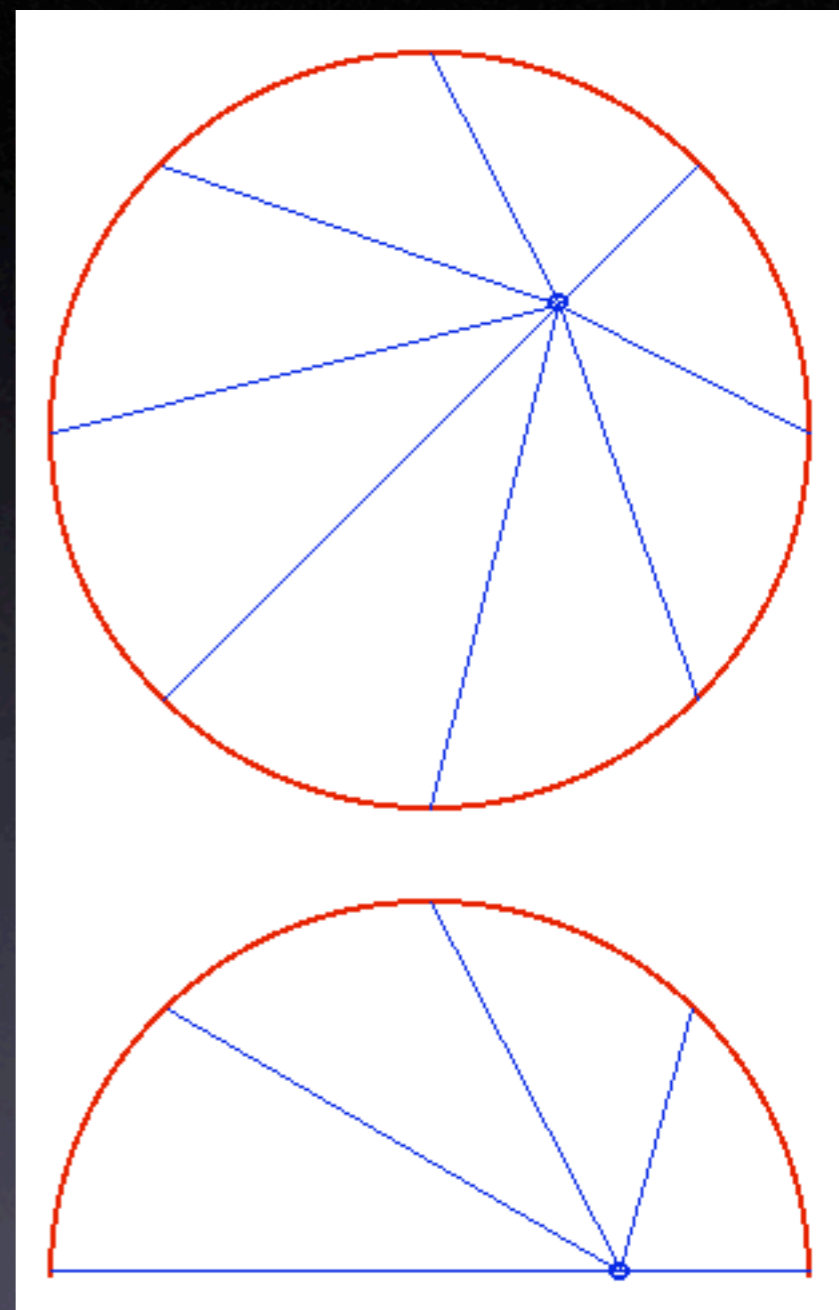
Elevation

Offaxis fisheye projections

Observer along the diagonal



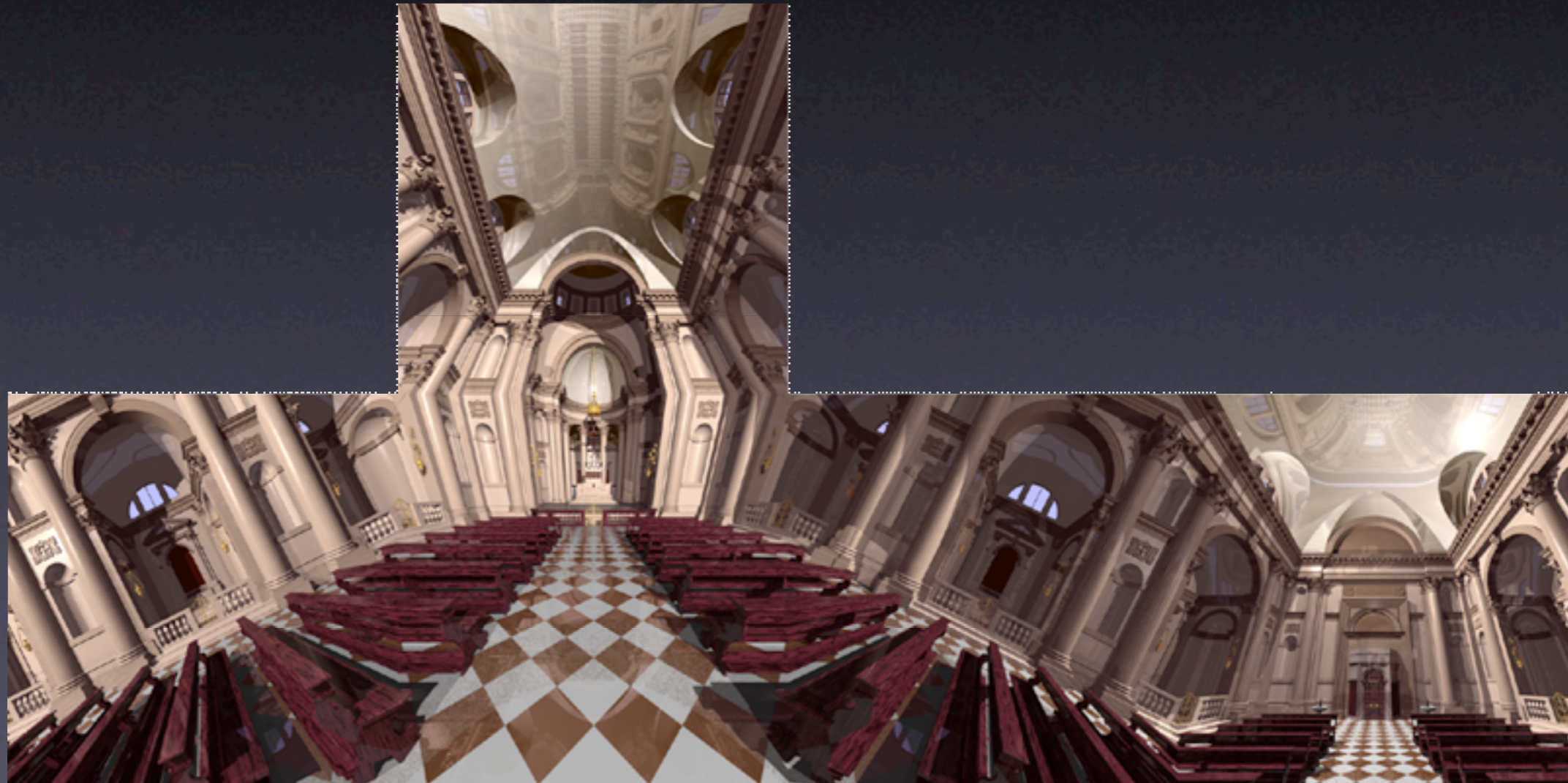
Plan



Elevation

Creating fisheye images without explicit software support.

- Render 5 or 6 views for a cubic environment.
- Creating any projection is now just a matter of image processing!



5 views

The end

Questions ?

Places to visit

- VROOM (Melbourne Museum) - Virtual ROOM
- Melbourne Planetarium (Science Museum)
- ICUBED (RMIT) public visits (<http://www.iii.rmit.edu.au/vrc/booking/>)
- Swinburne stereoscopic theatre (Now)

