# Fulldome Content for DomeLab

# What do you need to know?

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# Brief introduction by presenters

# Projections

- Most familiar with rectangular frustum perspective projections.
- Cannot create 180 degree perspective projection.
- Most common projections for dome are: cube maps, spherical (equirectangular) and fisheye.
- These are not “distorted”, are legitimate methods of mapping a 3D scene to an image plane.

# Anatomy of cube maps

- Projection of the scene onto the surface of a cube. Each face a 90 degree FOV vertically and horizontally.
- Often shown with the cube folded out.

6 views capture the entire world

# Anatomy of a fisheye

Captures 1/2 the world


Directly left

Directly right

# Anatomy of a spherical projection

Captures the whole world

North pole

South pole

# Content types

- Computer generated
  - includes data visualisation

- Photographic
  - includes time lapse, multiple stitched fisheye and/or spherical images

- Filmed
  - includes multiple camera rigs, fisheye lenses

- Realtime, interactive
  - includes custom applications, game engines

# Computer generated

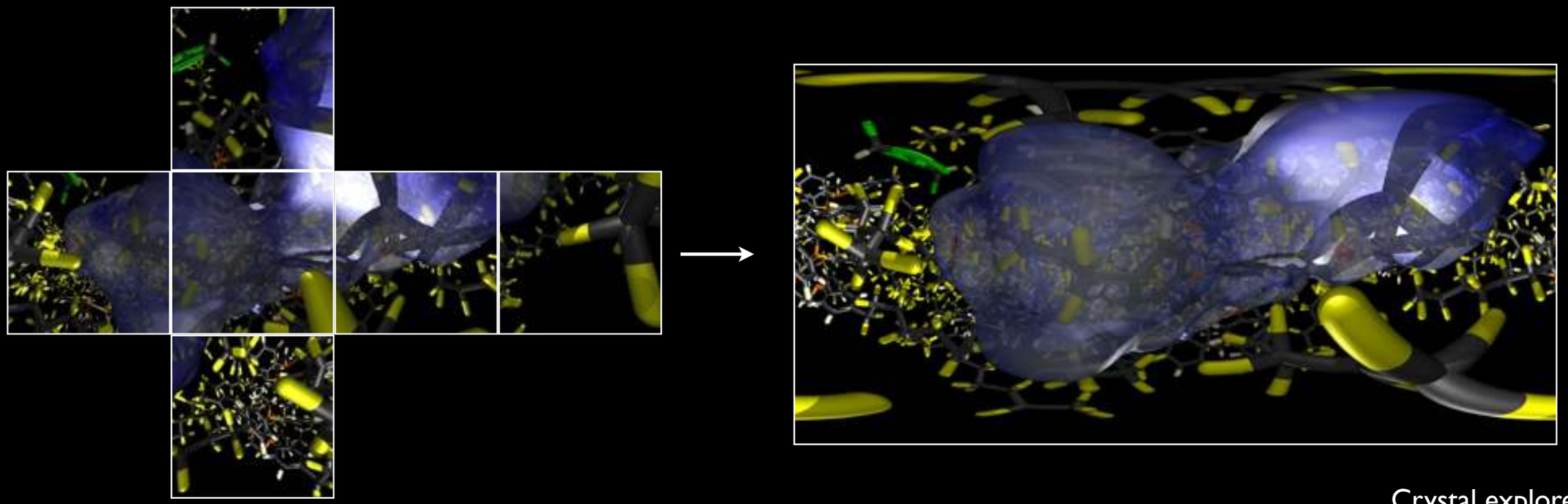
- Require a virtual camera that supports the desired projection type.
- Most rendering packages today have a fisheye lens type or a third party plugin.

# Cube maps to fisheye

- If fisheye virtual camera is not available then cube maps is the usual solution.
- Only requires perspective cameras.
- Can generate any fisheye view from 6 cube map shots.

# Cube maps to spherical

- Spherical maps can be more convenient in the compositing stage, wider support.
- Like cube maps allows fisheye direction to be chosen further down the pipeline.
- Also allows repurposing for different tilted domes.



Crystal explorer

# Fisheye photography

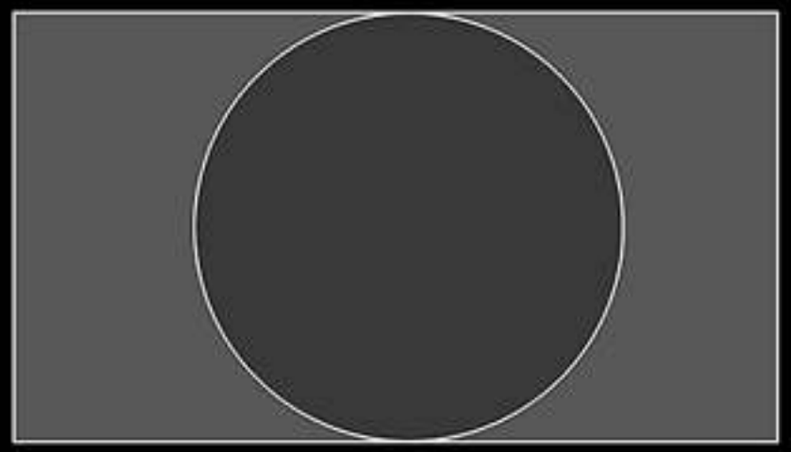
- Draw a distinction between wide angle fisheye and circular fisheye.
- Usually measured diagonally, for example: GoPro style cameras are typically 170 degrees diagonally.

170 degree wide angle fisheye

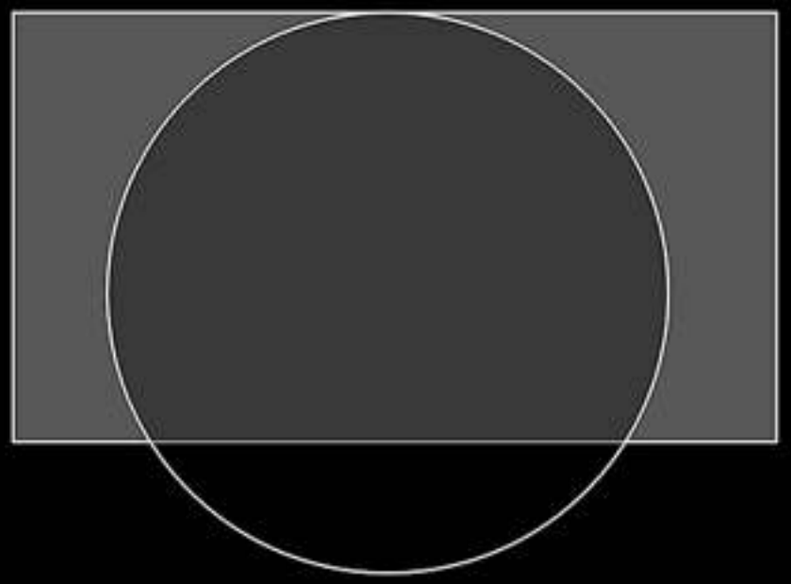
Circular fisheye

# Sensor sizes

- Need to consider the location and size of the fisheye circle on the camera sensor.
- Generally a match between sensor size (eg: full frame, APS-C, etc) and the lens.

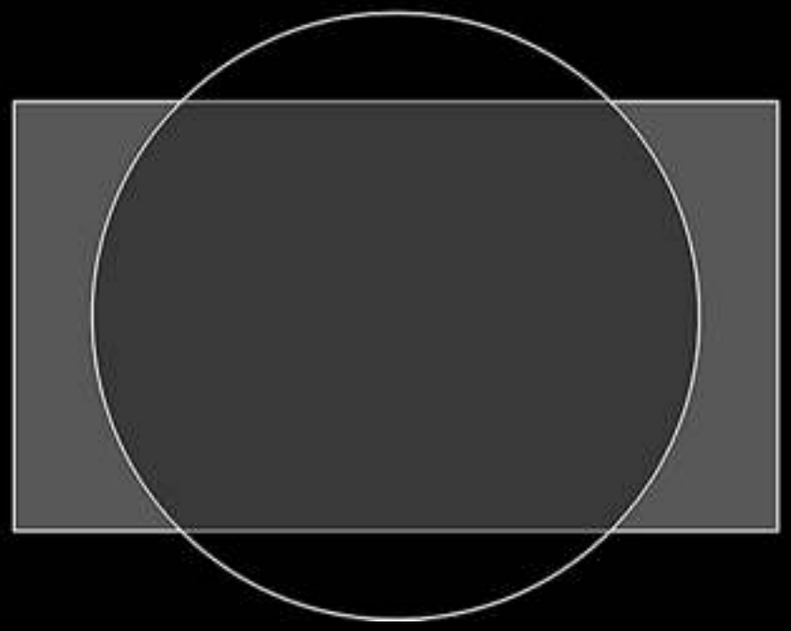


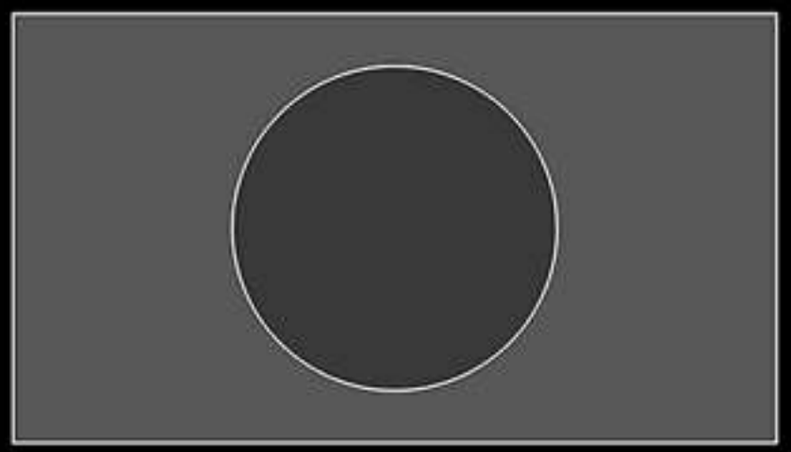
Optimal for general domes



Offset lens, rare

Optimal for iDome





Too small (Inefficient)

Example of a full frame fisheye on a 2/3 sensor

Example of a 2/3 fisheye on a full frame sensor

Ideal, 2/3 fisheye on a 2/3 sensor,
or full frame fisheye on full frame sensor

# Spherical images

- Can be captured with as few as 3 photographs

Beacon Island

# Higher resolution spherical images




Weld - Indigenous rock shelters

# Even higher resolution

- Large number of photographs, known as gigapixel.
- Normally use a motorised rig.

Wanmanna 220 photographs 80,000 pixels x 20,000 pixels

# Fulldome video

- The most challenging for high resolution.

- Options
  - SLR camera in video mode with fisheye lens
    for example Canon 5D with Canon 8-15mm fisheye.
  - Red camera, needs APS-C fisheye.


# My (Pauls) favourite shoot

# Spherical video

- The challenge is parallax errors arising from nodal points being separate.
- This is impossible to fix perfectly (can explain later if interested).

UNSW

Kolor

# Ladybug cameras

- Ladybug 3 and 5 the current models.
- Tradeoff between resolution and frame rate.

# Ladybug

- Captures 360 degrees in longitude.
- North pole to -50 degrees in latitude.

# Stereoscopic fisheye

- Fundamentally difficult
- Even more difficult for filmed material
- Three approaches for CG

    1. Parallel cameras and head tracking

    2. Omnidirectional cylindrical, precludes the north pole region

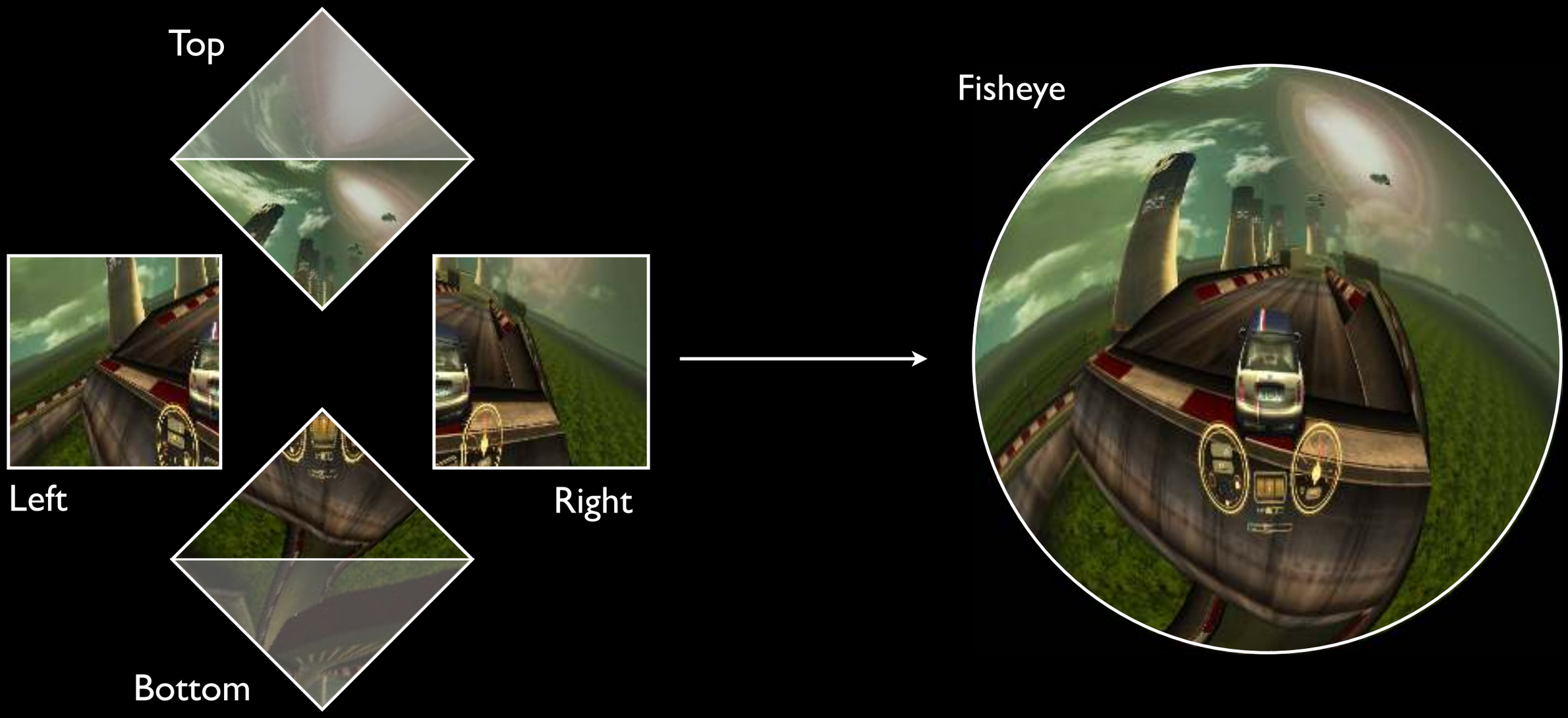
    3. Blended parallax

- Can discuss further if there is interest.

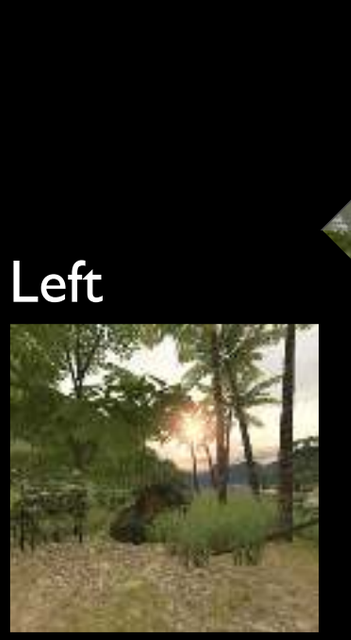
# Realtime

- Realtime APIs don’t support fisheye directly.
- Two approaches
  - multi-pass rendered cube maps
  - vertex shader
- Each has relative merits, most implementations choose cube maps.
- Unity3D and Blender have proven fisheye generation.

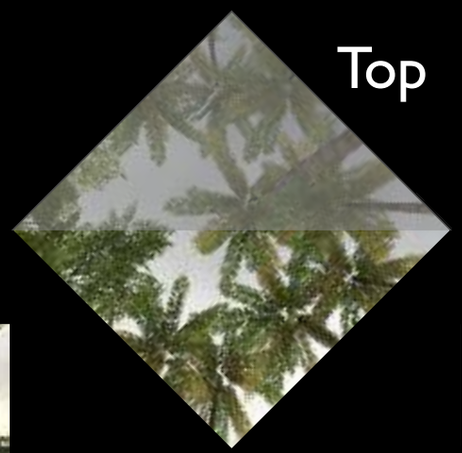
# Blender example



# Unity example



Left



Top

Right

Bottom

Fisheye

# Vertex shaders

- Other approach is single pass (followed by warping) using vertex shader.

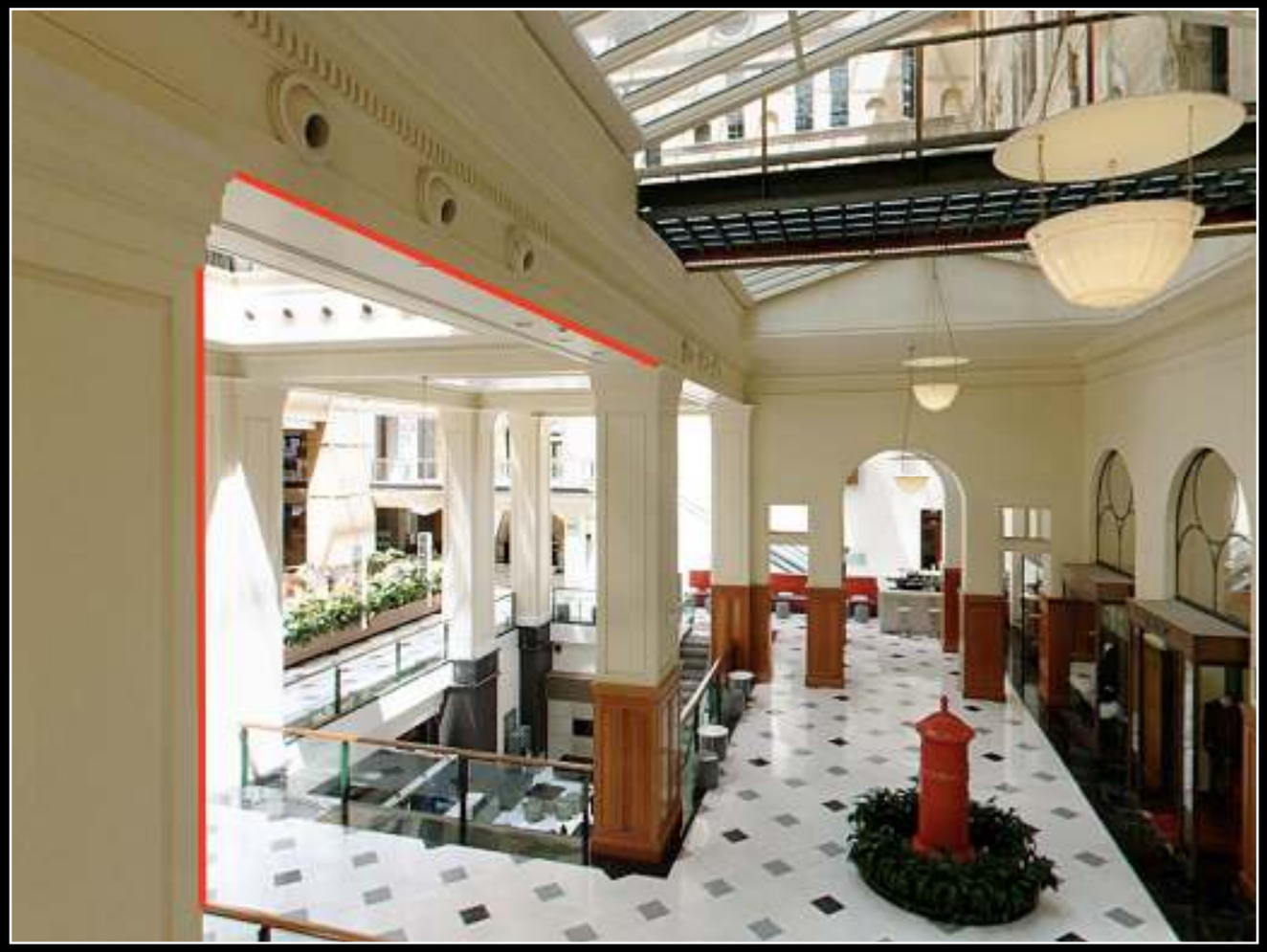
- A cunning trick: modify the position of each vertex such that the result when viewer with an orthographic camera is a fisheye image.

- Simple in concept but involves geometry tessellation which can be expensive.

- A straight line in a standard perspective projection only requires knowledge of the two end points.
  A straight line is not “straight” in a fisheye projection.

- The solution is to tessellate all the 3D geometry being drawn. The optimal algorithm to do this is not at all trivial, inefficient tessellation results in a high geometry load on the graphics card.

# Vertex shader



# How is fulldome different?

- Filming is hard at high resolution.
- A 4K camera sensor only gives a 2K fisheye circle.
- Multiple camera rigs are challenging.
- Need to carefully consider fisheye image and sensor size relationship.

# How is fulldome different?

- Large canvas.
- Temptation is to pan or move objects in the fisheye image without realising the distances they are moving on the dome.

# How is fulldome different?

- Best suited for environments where one is “inside”.
- Consequences to the degree of 3D modelling required.
- Cannot simply model what is in front of a traditional narrow field of view camera.

# How is fulldome different

- There is only one position in the dome where the view is perfect.
- Generally the centre but it need not be (called offset fisheye).
- Only at this one spot are straight lines straight.

# How is fulldome different

- No such thing as zooming, cannot change the camera angle (FOV).
- To see something in more detail one needs to move towards it.
- Anything offscreen MUST be behind the camera (eg Director, lighting, boom microphones) or be on-screen.

# How is fulldome different

- A range of unique considerations
  - keeping it interesting around the dome
  - deciding on point or points of attention
  - being aware of washout from ultra bright regions
  - care not to induce vertigo e.g.: sudden start/stops
  - size and extent of text
  - creating content that works across installations
  - consideration of dome tilt

# Standards

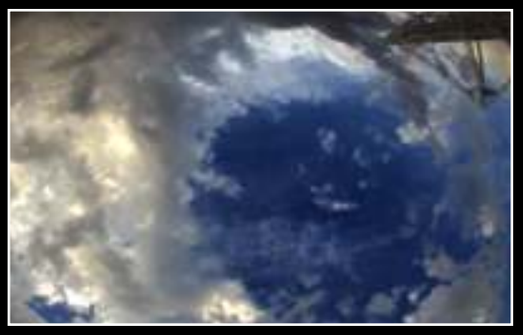
- 30fps (not NTSC 29.97)
- “Front” is at the bottom of the fisheye.
- Semi standard to place frame numbers and logos around the unused portion of the frame.
- A mixture of frame sizes, sites need to deal with all frame sizes.
- A mixture of audio specifications, 5.1 most common.
- No single file format. JPEG, TGA, PNG most common.

# Domelab standards

- 30fps (60fps in the future?)
- 5.1 audio
- 4K (maximum)
- PNG format for frames
- We use Mac &/or Linux Workflow. Windows also common but interoperability issues.

# Fisheye to dome

- Fulldome Masters (4k fisheye images) as PNG sequences.
- Slicing using Windows dFormCutter
- Slices to 8 image streams 2560x1600 (WQXGA)
- Encode using ffmpeg (Win, OS X, Linux) to MPEG2 (using specially defined settings)
- ffmpeg -threads auto -r 30 -i "/Volumes/Drobodome/Ocean_cut/0/%07d.png" -f vob -vcodec mpeg2video -b:v 50000k -minrate 50000k -maxrate 50000k -g 1 -bf 2 -an -trellis 2 "/Volumes/DomeLab_1_1/Ocean_50k_g1/Display_0.m2v"
- 8 videos (mpeg 2) eg. 10 mins = 10GB



# Compute

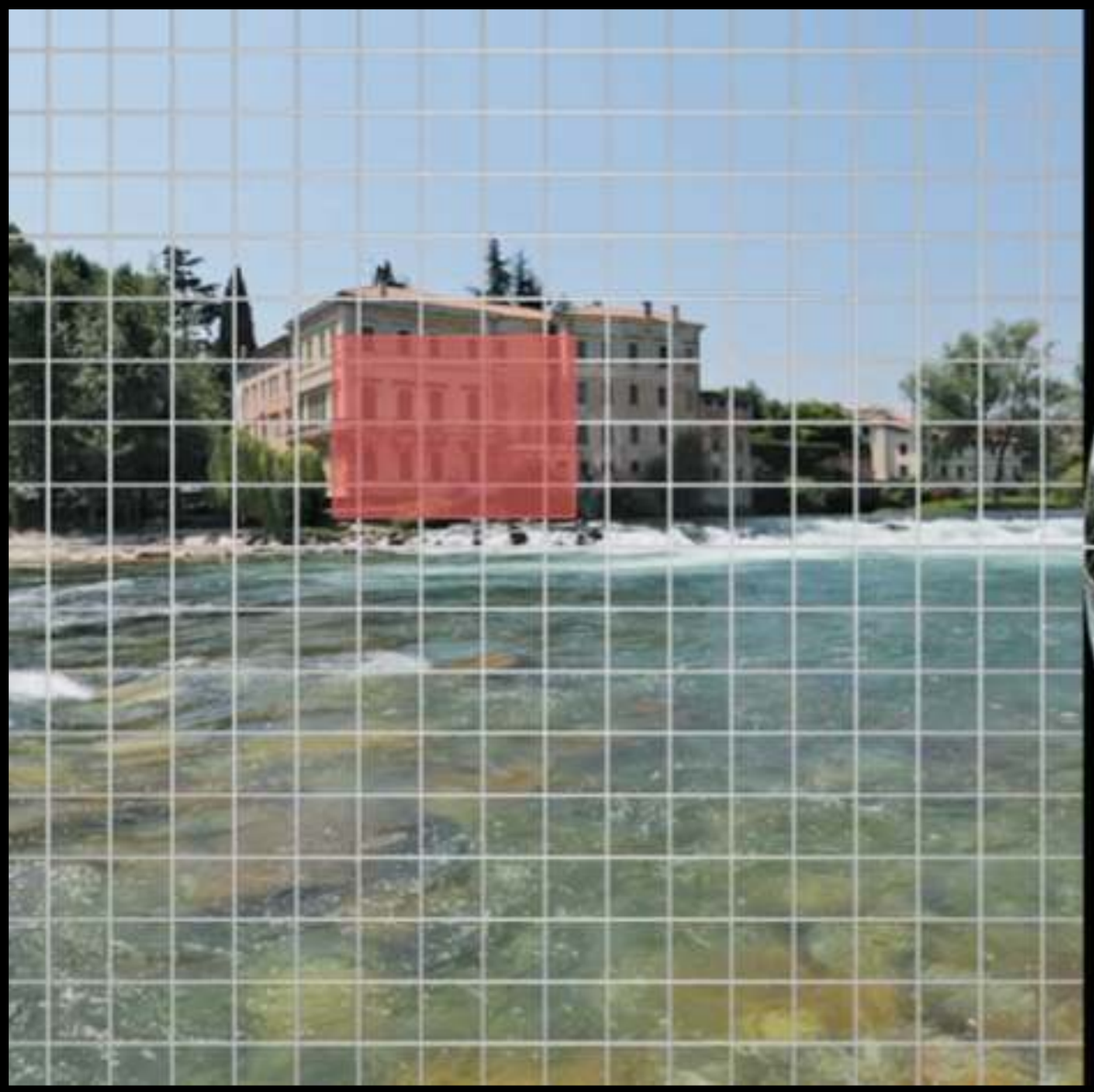
- You need a render farm, that is, a cluster of networked computers with terabytes of storage.
- High speed data storage and transfer.

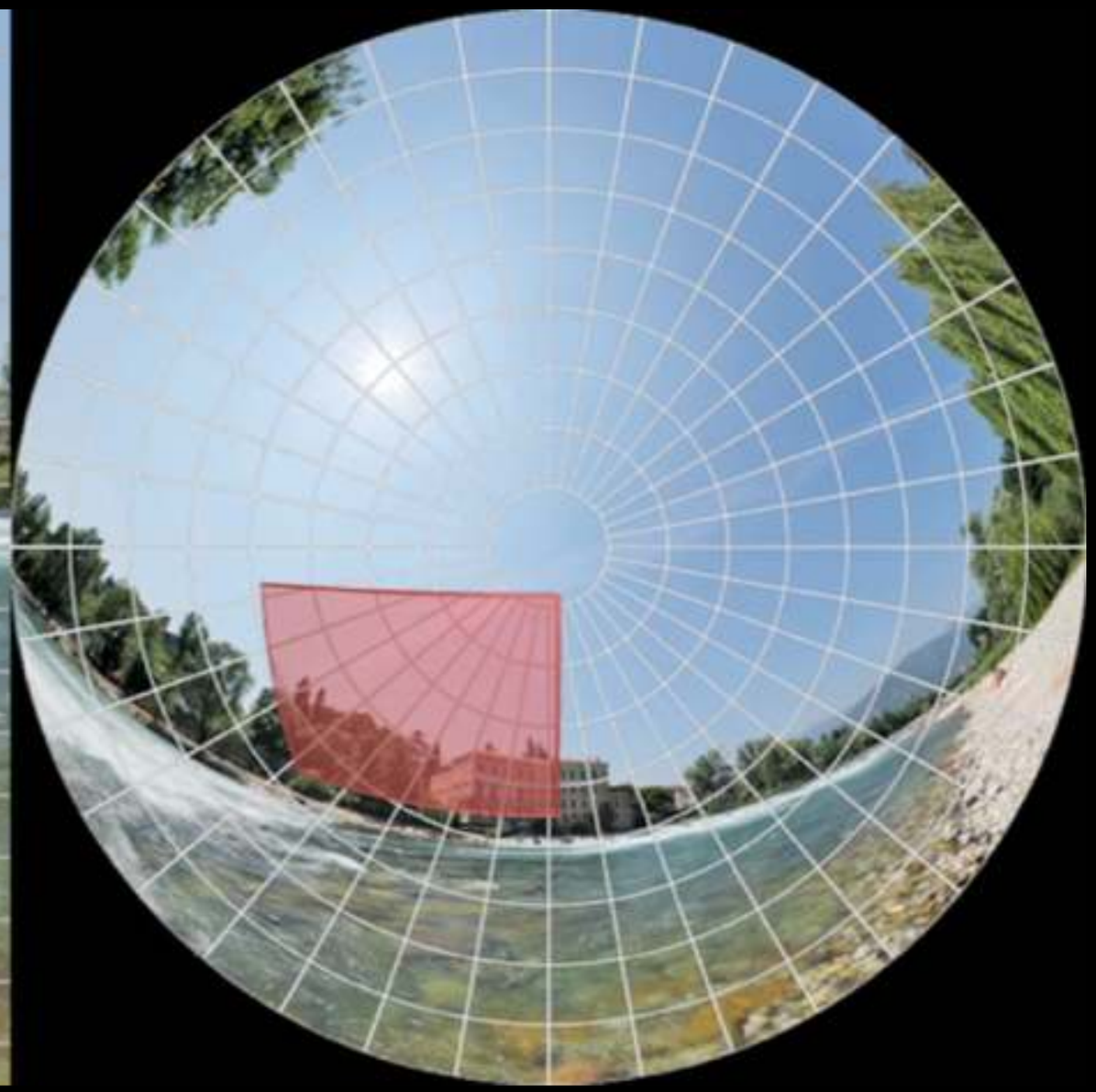
# Audio production

- Watchout 5.1 standard
- 44.1Khz 16bit (testing 48KHz, 24bit)
- L R C LFE Ls Rs
- Adequately resourced audio production suite

# Compositing

- Compositing packages typically operate in cartesian coordinates.





# Straight lines are not straight in fisheye

Dragon Gardens, Hong Kong

# Colour saturation

- Common to create higher saturated images to compensate for inter-reflections/cross-bounce.

Vibrance adjustment

# Compositing

- 4k x 4k now supported in AFX, FCPX, Nuke etc.
- http://software.multimeios.pt/fulldome/
- Work also in Photoshop & Lightroom & Darkroom (eg. HDR)
- Requires experience to work in ‘hemispherical’ space
- Fulldome plugins available - but good support isn’t
- Incorporating spherical, text, cube maps and so on.

# 3D Modelling & Animation

- Plugins for Cinema 4D, Maya, 3DS Max, Arnold Renderer

- http://www.andrewhazelden.com/blog/free-downloads/
- http://software.multimeios.pt/wfcam4d/

# Recommendations

- Content creators, if not already versed in fulldome, need to spend time in a dome. Creating and viewing test material.
- Don’t rely on non-dome means of previewing content in the early days.

# Recommendations

- Don’t cheat by not working with a true 180 degree fisheye.

- Occurs most often with filmed material.

- Many of the perceptual effects one observes in a dome (eg: depth) arise from the correct mapping into a 180 degree fisheye.

# Recommendations

- Don’t under estimate the modelling and rendering time required for CG content.
- Unlike a traditional small FOV render the models need to be more complete and some rendering efficiencies don’t occur with a 180 degree fisheye.

# Recommendations

- Don’t underestimate post production.
- Dealing with 4K frames is outside the intended use of many packages.
- Be smart with proxies and previews.

# Recommendations

- Don’t underestimate the image storage requirements.
- Think carefully about where the best place is to store frames at different stages of the pipeline.
- Avoid any lossy compression codecs.

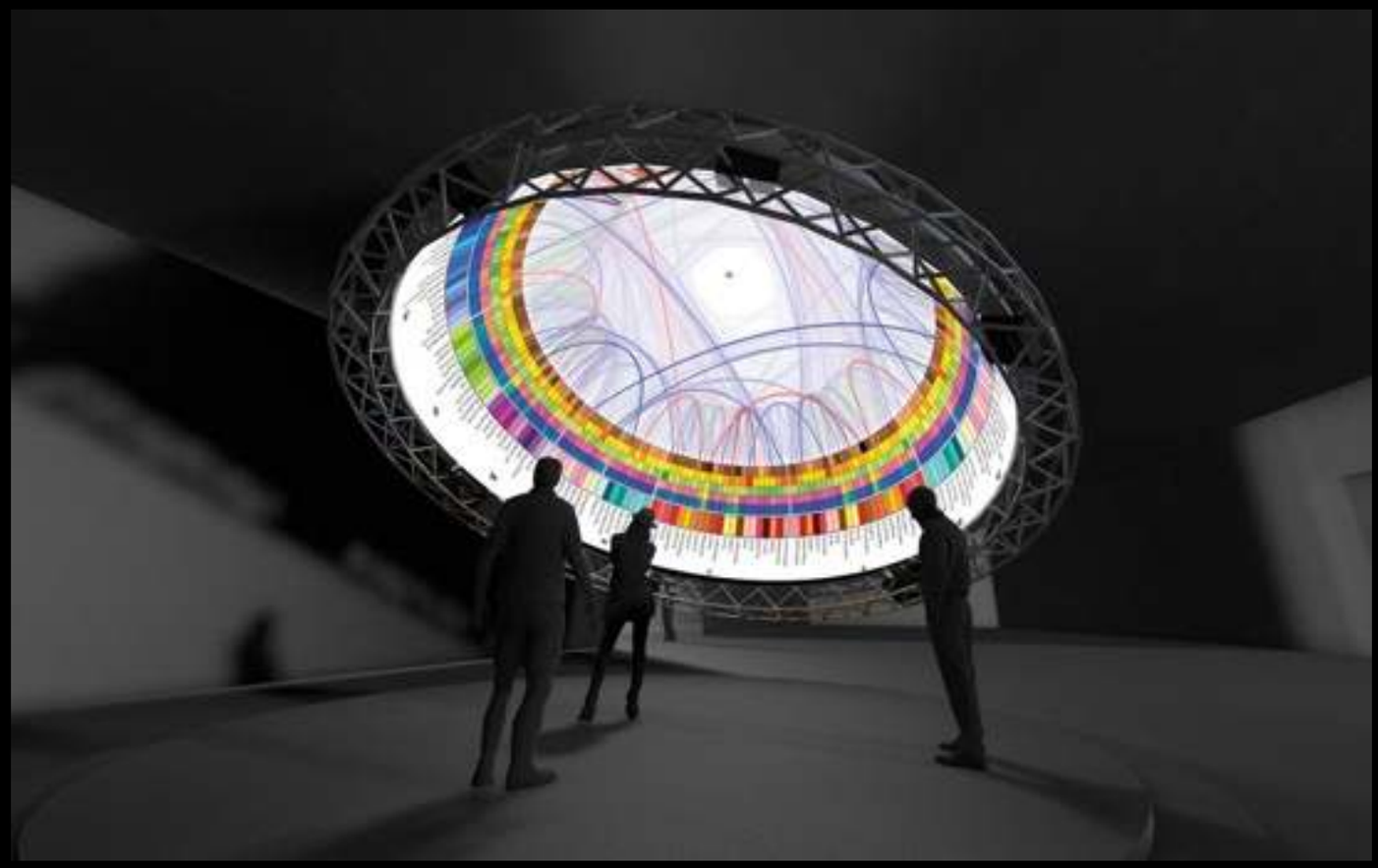
# Recommendation

- Think carefully about why you are using fulldome?
- Ensure you are going to leverage the media rather than use it as a curved flat screen.

Presentation &
Analysis Systems

DomeLab, Sydney
(iGLAMS, UNSW -
Sarah Kenderdine,
Paul Bourke, Peter
Morse)

Immersive
Screens vs Shared
Spaces



# Questions and discussion