

360 video

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Agenda

History - Examples from authors projects

Why?

Image projections

(Perspective - Fisheye - Cylindrical panorama - Cube maps - Equirectangular panorama)

Camera summary

(One - Two - More than two)

The fundamental problem (Parallax)

Solutions to the fundamental problem

(Mirrors - Optics - Optical flow)

Miscellaneous topics

(Conventions, problems, differences, tricks)

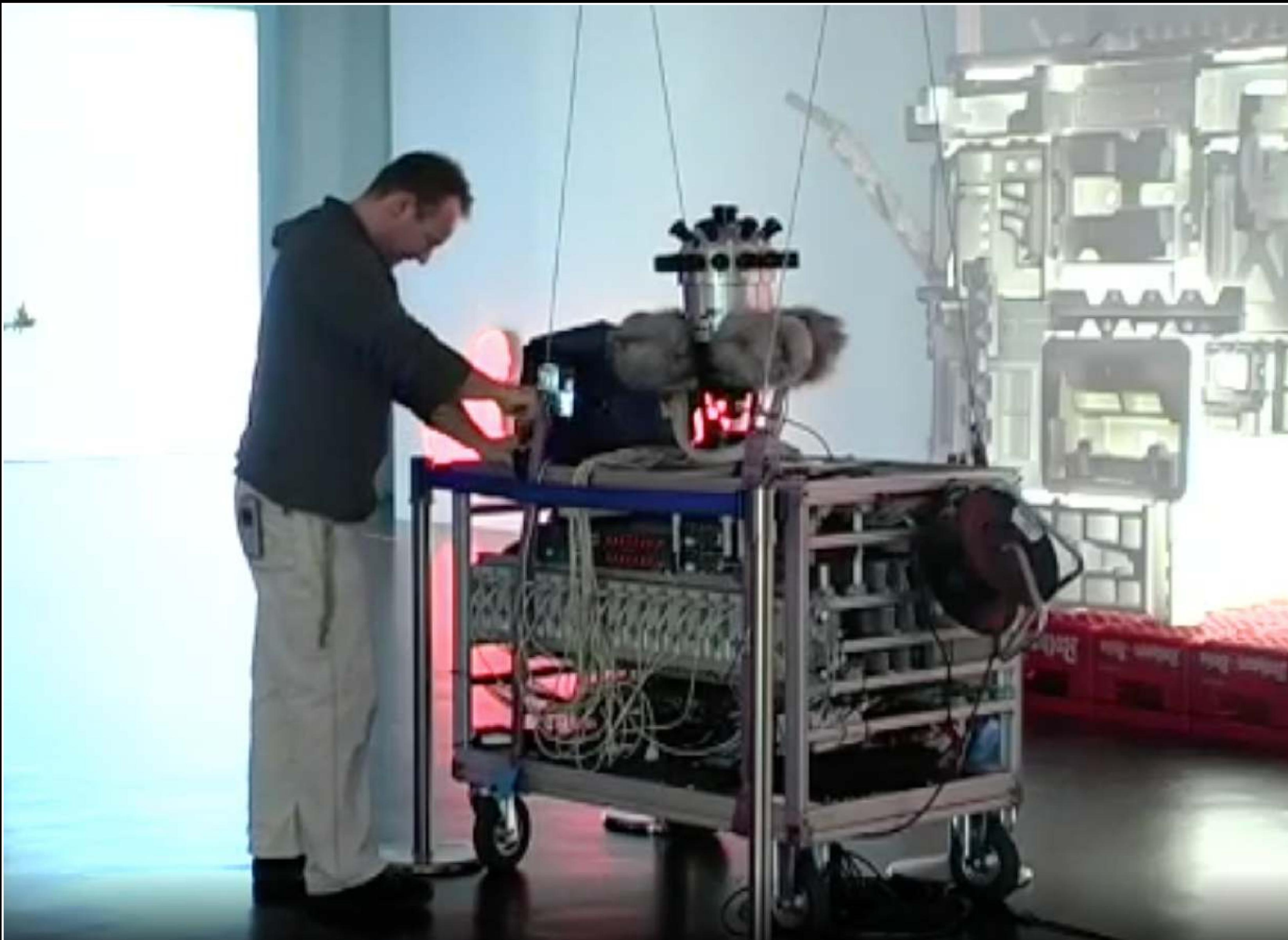
History



Jeffrey Shaw, ZKM



Sphercam





Examples - 2002

iCinema





Ladybug range of cameras: 2,3,5,5+



Fiming cultural events in Turkey

Examples - 2010



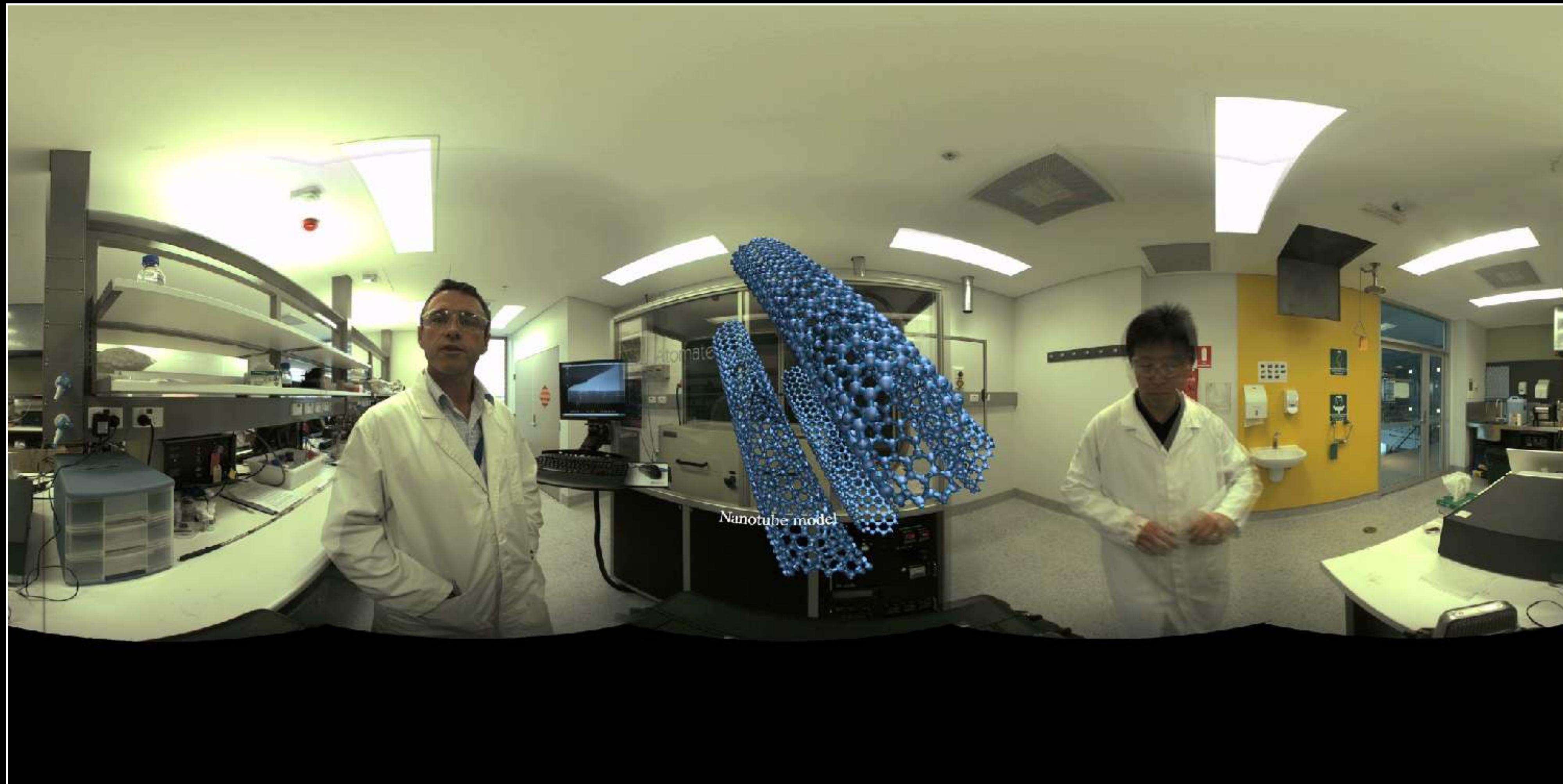
Hashibektashi, Turkiye



Whirling Dervish, Turkiye



Karratha iron ore ship loader



Nanotechnology, Wollongong



Sheep shearing, Barossa valley

Examples - 2015



Pig farming in Hong Kong



Obsidian camera

Examples - 2018



Sahet-Jetavana, India



Insta360Pro



Clothing Buddha, India



Micro and Nano Technology, EPFL, Switzerland



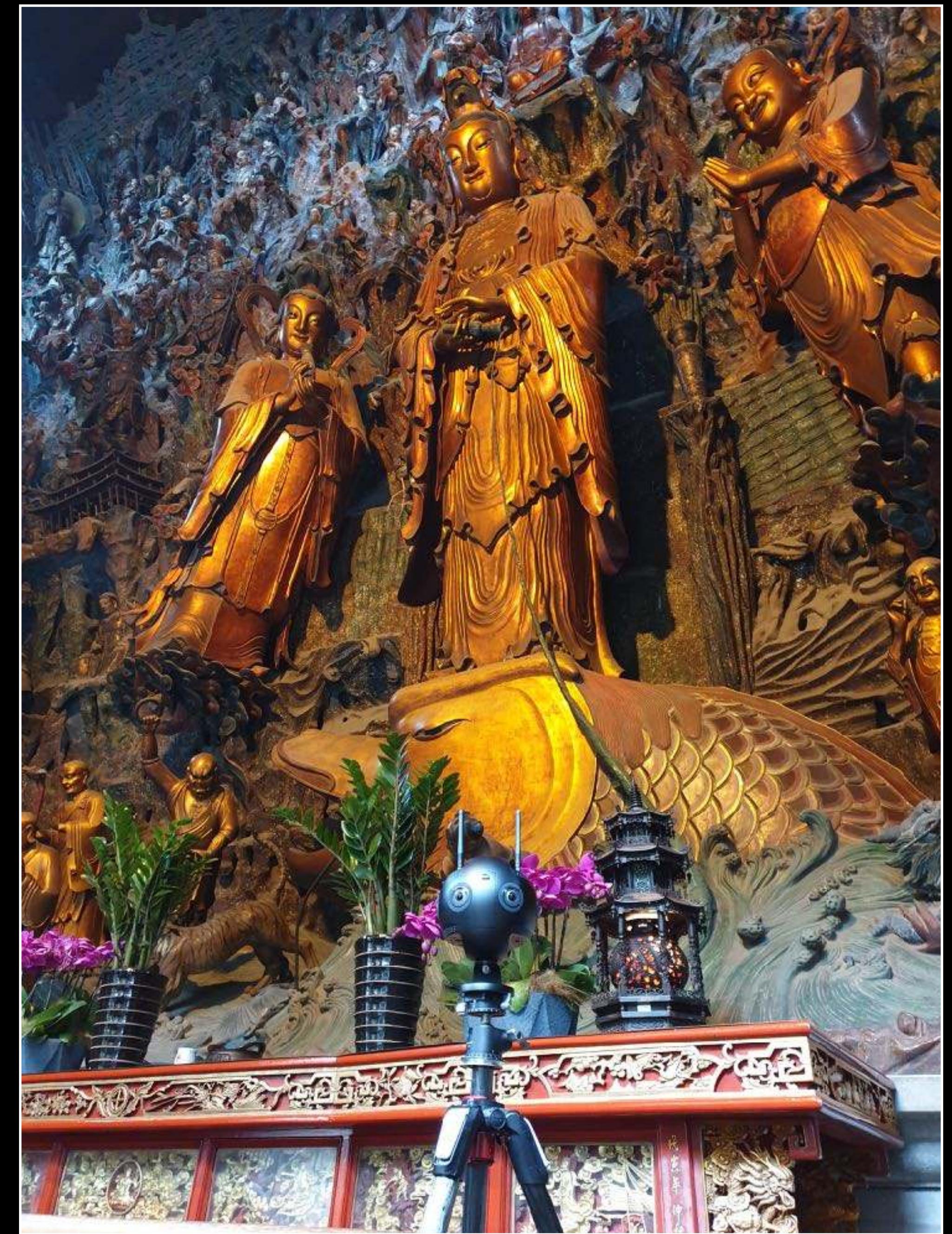
Insta360Pro

Examples - 2020

Insta360 Pro2



Titan





Shanghai temple, January 2020

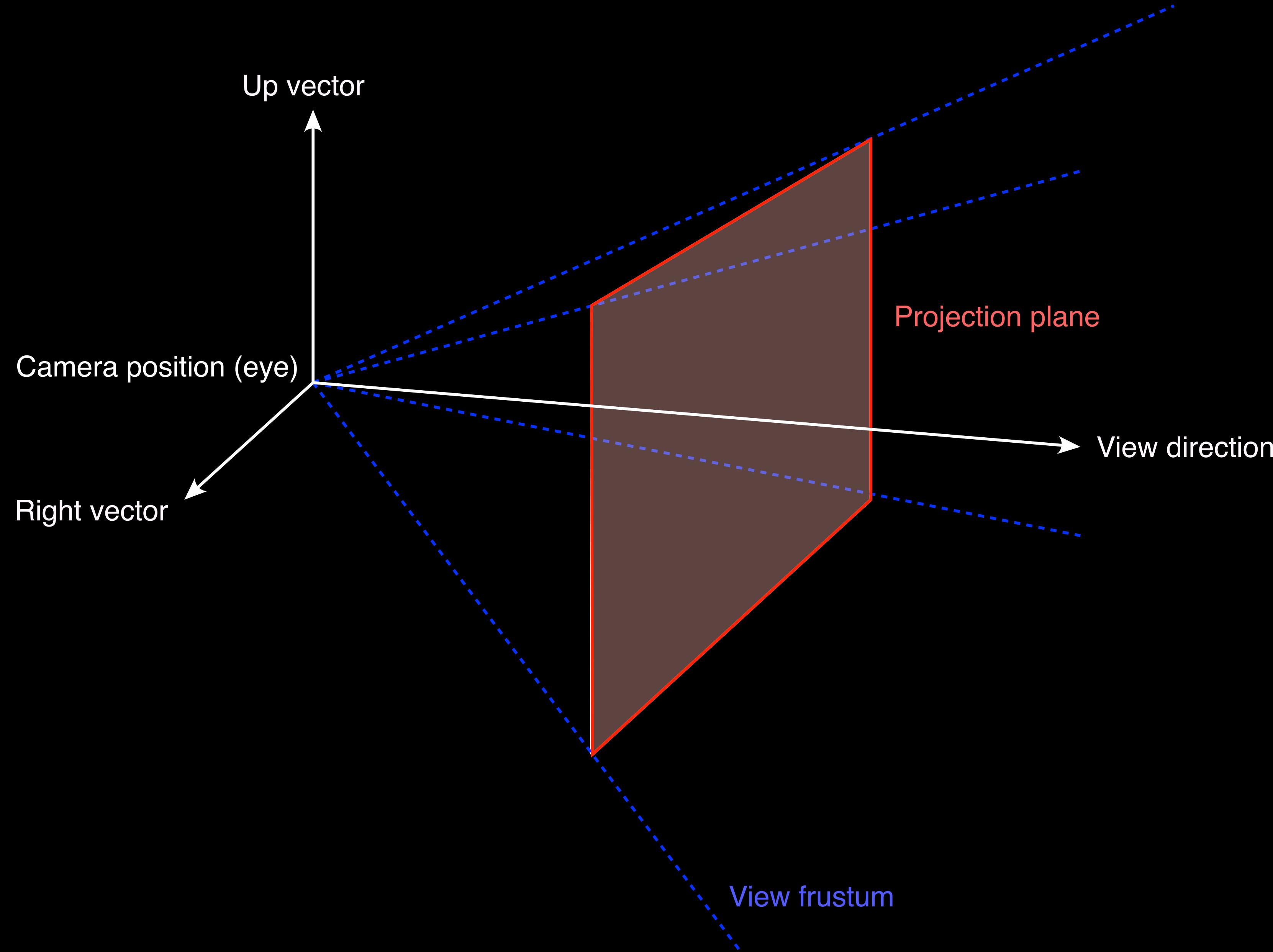


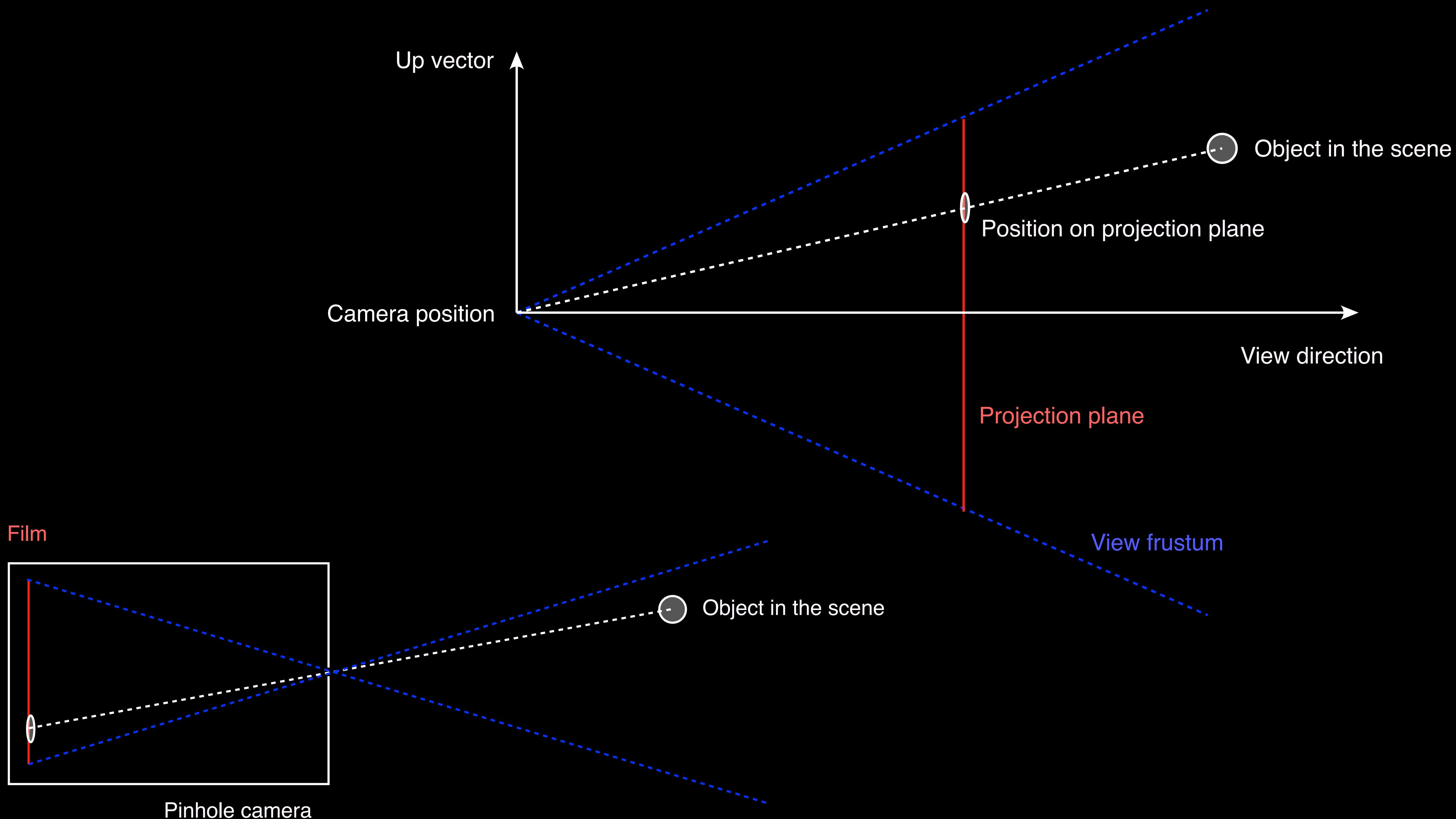
Chinese new year fireworks, Fo Guang Shan temple, Taiwan. January 2020

Why?

- Immersion.
- The sense of immersion here is the physical one, when our whole visual field of view is stimulated.
- The sense of “presence”, of “being there”.
- Head mounted displays are the most convincing examples.
- Not a new idea, the whole point of wide aspect movie theatres, omnimax dome theatres.
- Often referred to as “removing the frame”.

Image projections





Perspective projection



60 degree FOV



100 degree FOV

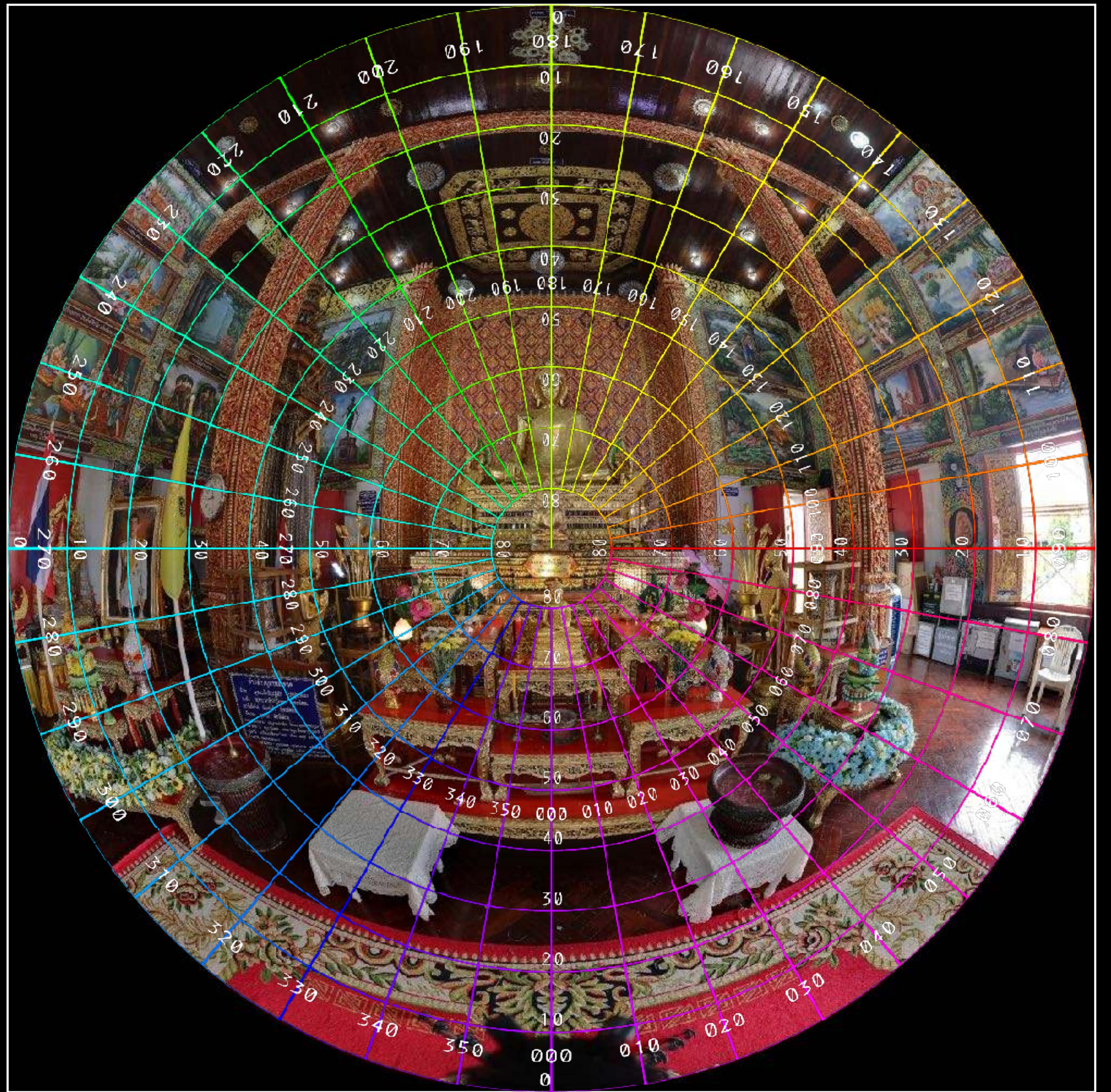


140 degree FOV

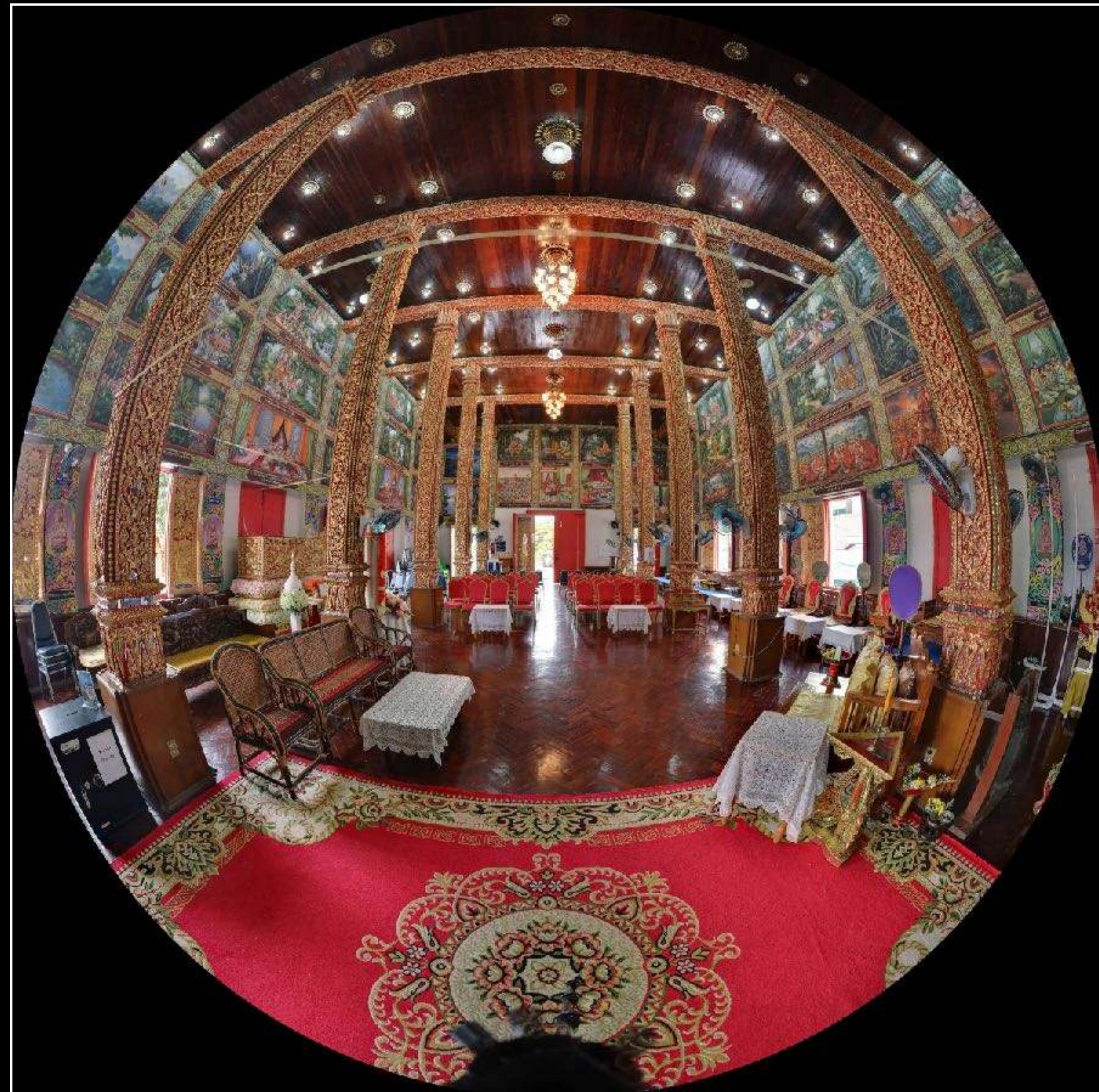
Fisheye projection



180 degree fisheye



180 degree fisheye

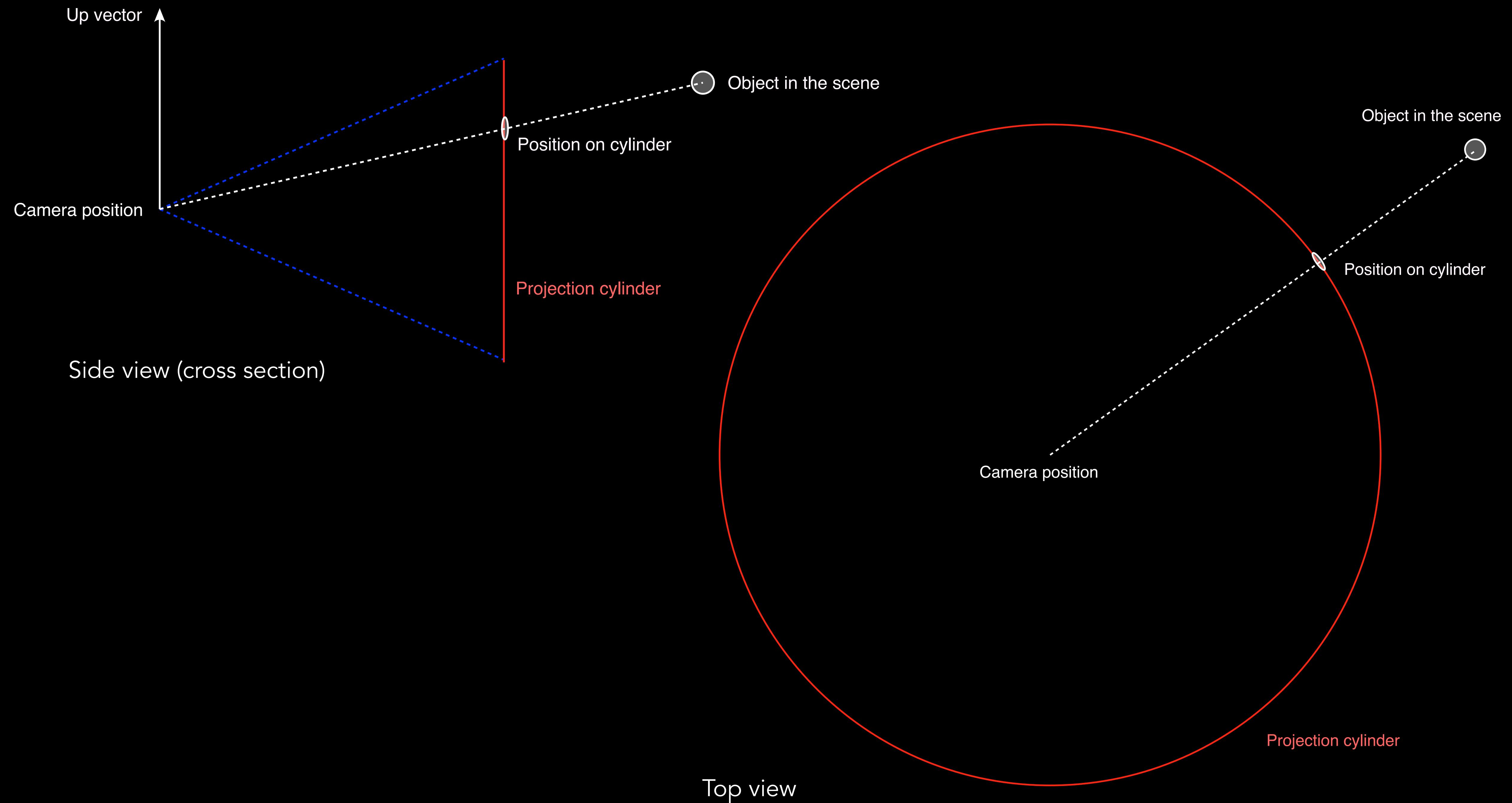


Cylindrical panorama

60 degrees vertical FOV



360 degrees



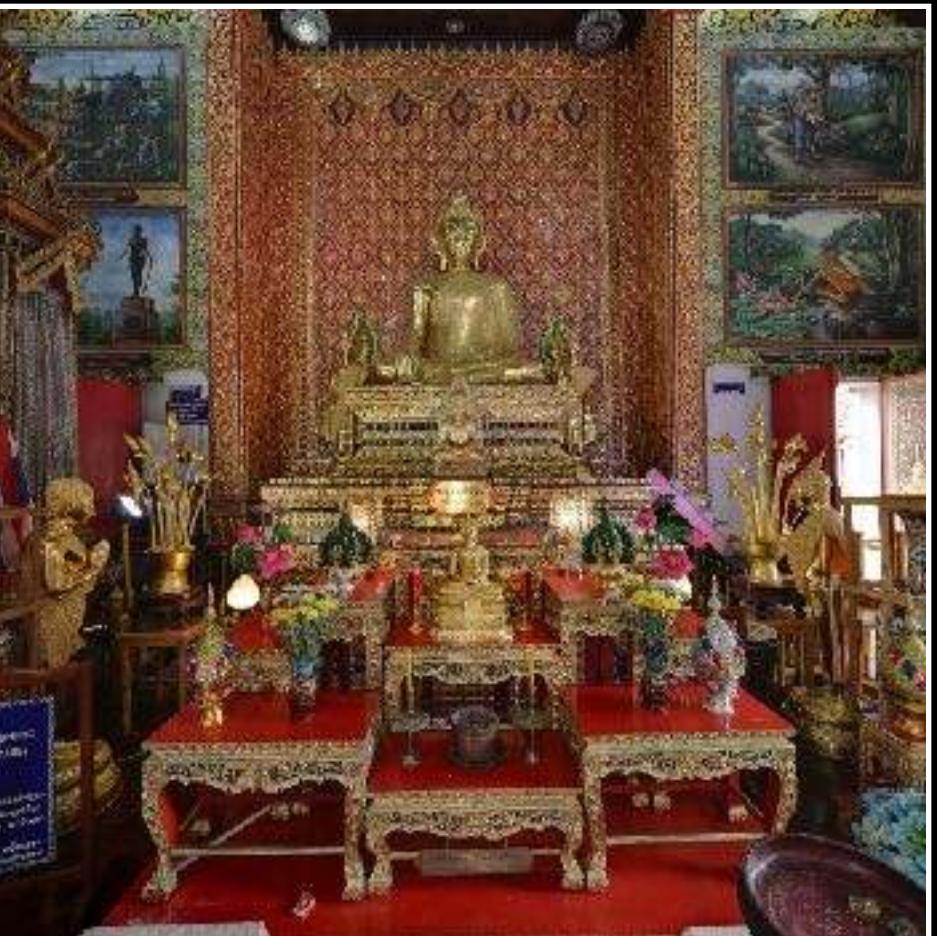
100 degrees vertical FOV



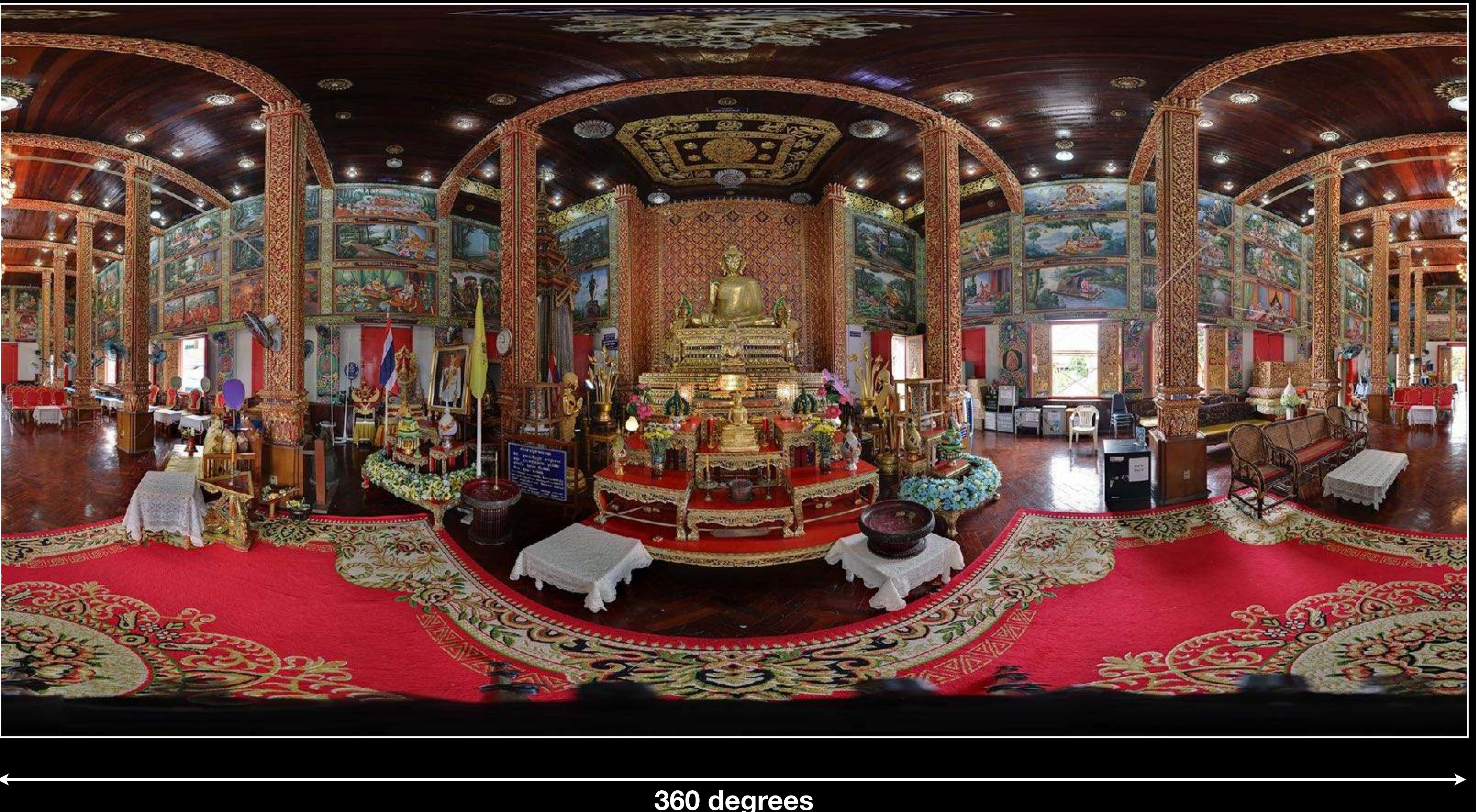


140 degrees vertical FOV

Cube maps

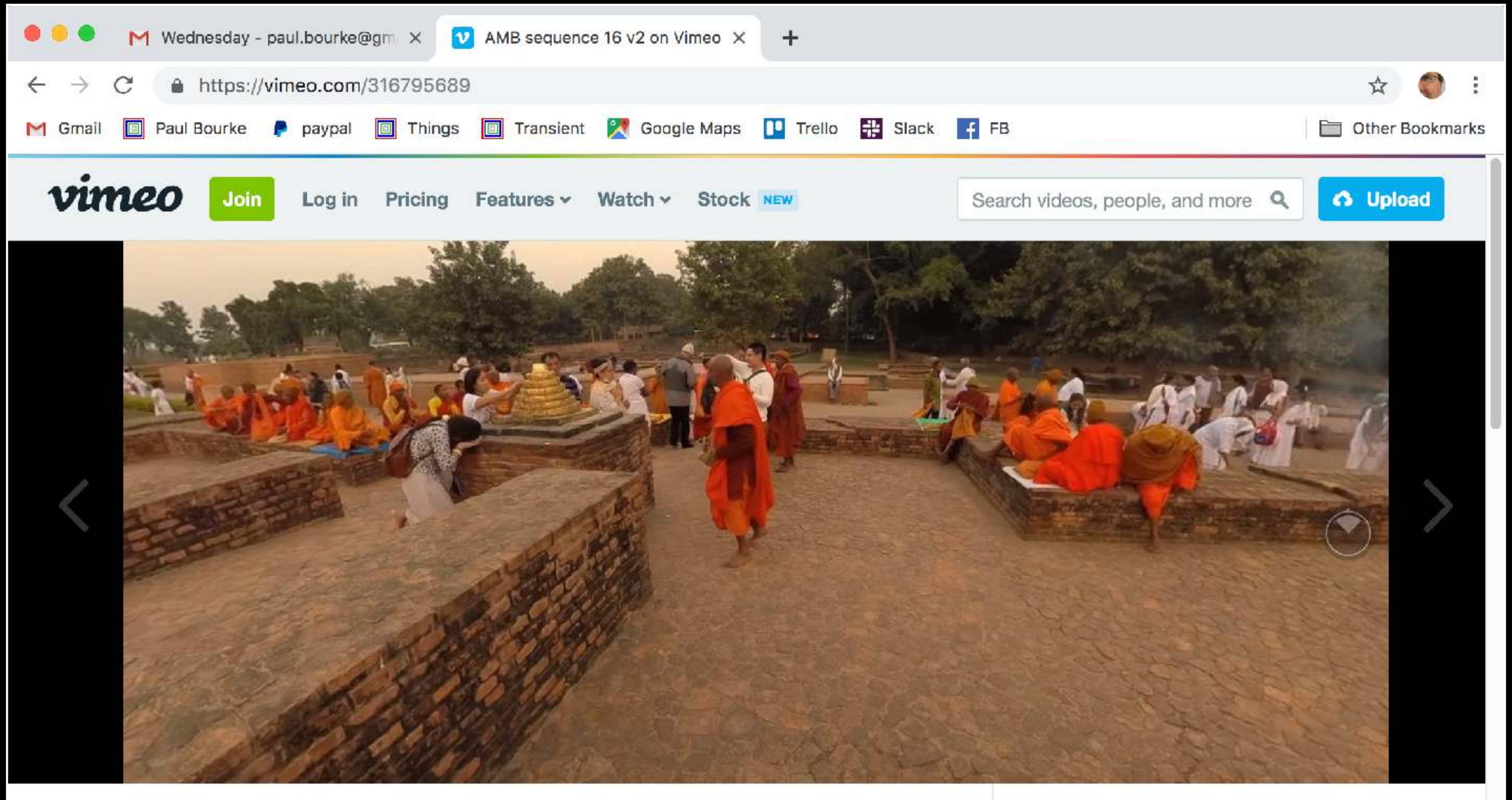


Equirectangular (sometimes simply “spherical”) projection



Viewing environments

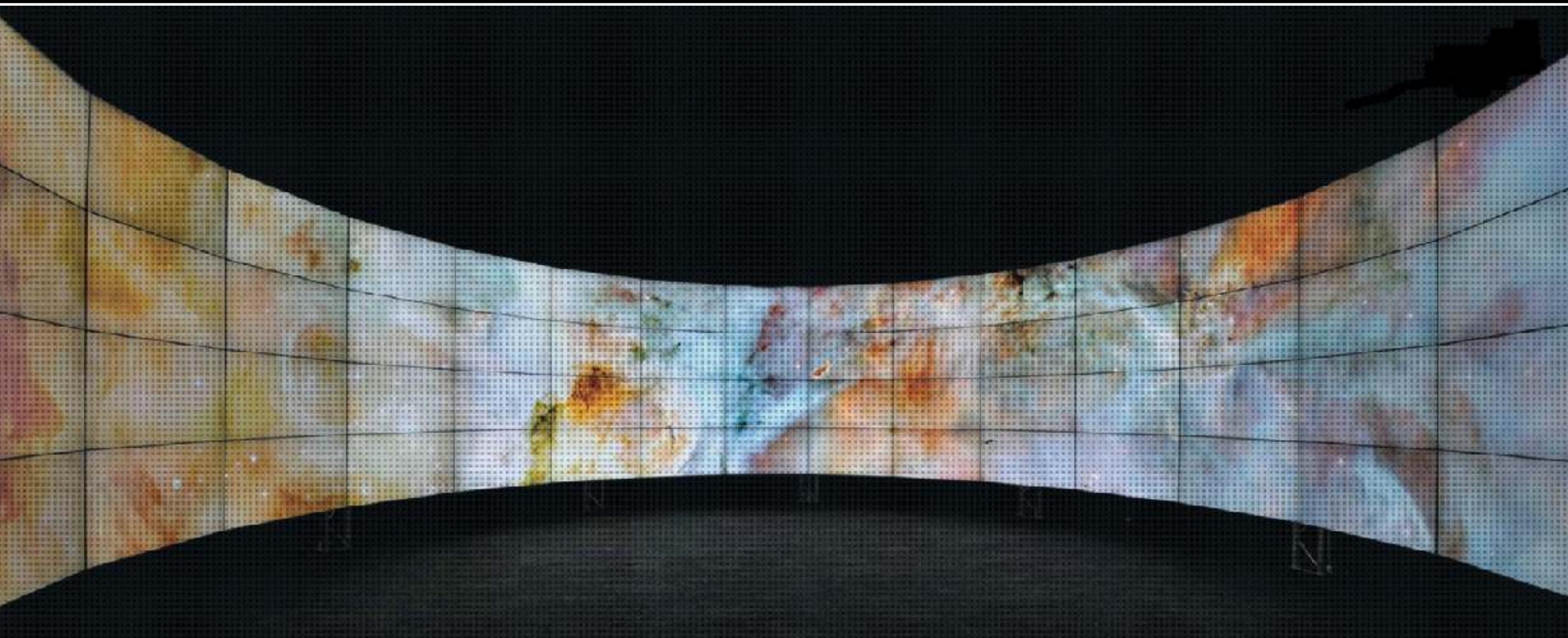
Perspective



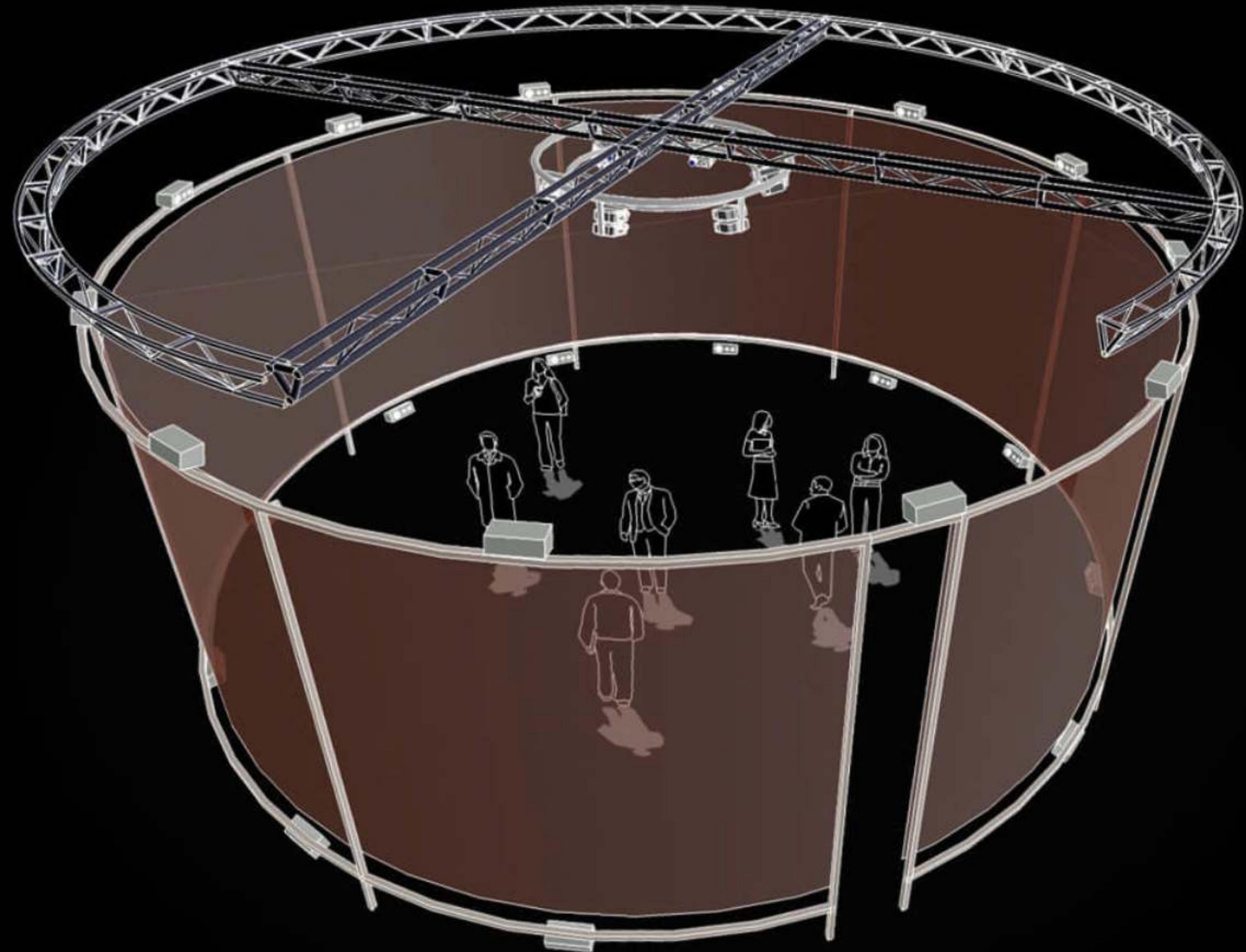
<https://vimeo.com/316795689>



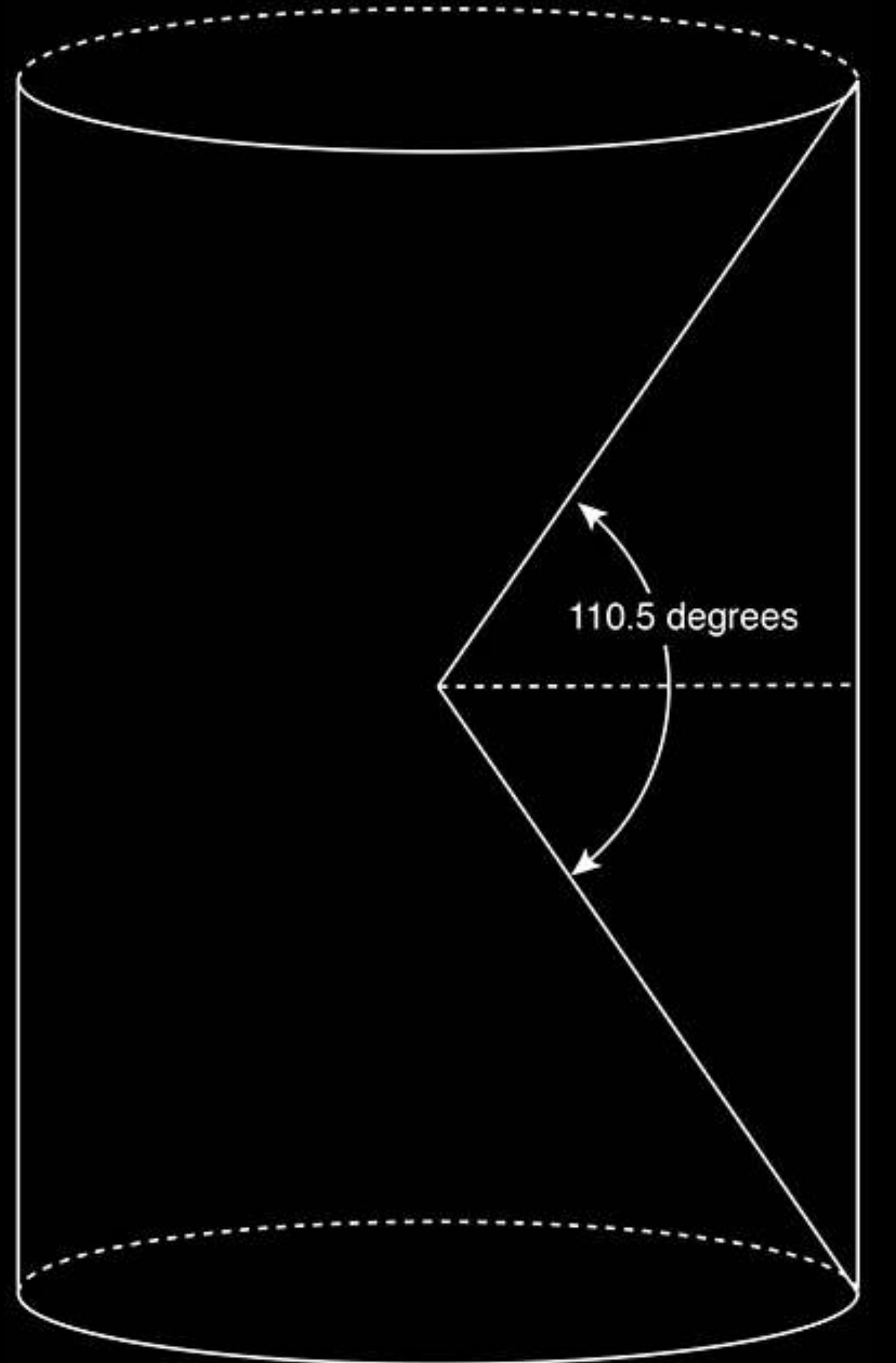




University of the Sunshine Coast







Fisheye







Broad camera classifications

Single camera + wide angle fisheye lens

Dual camera rigs

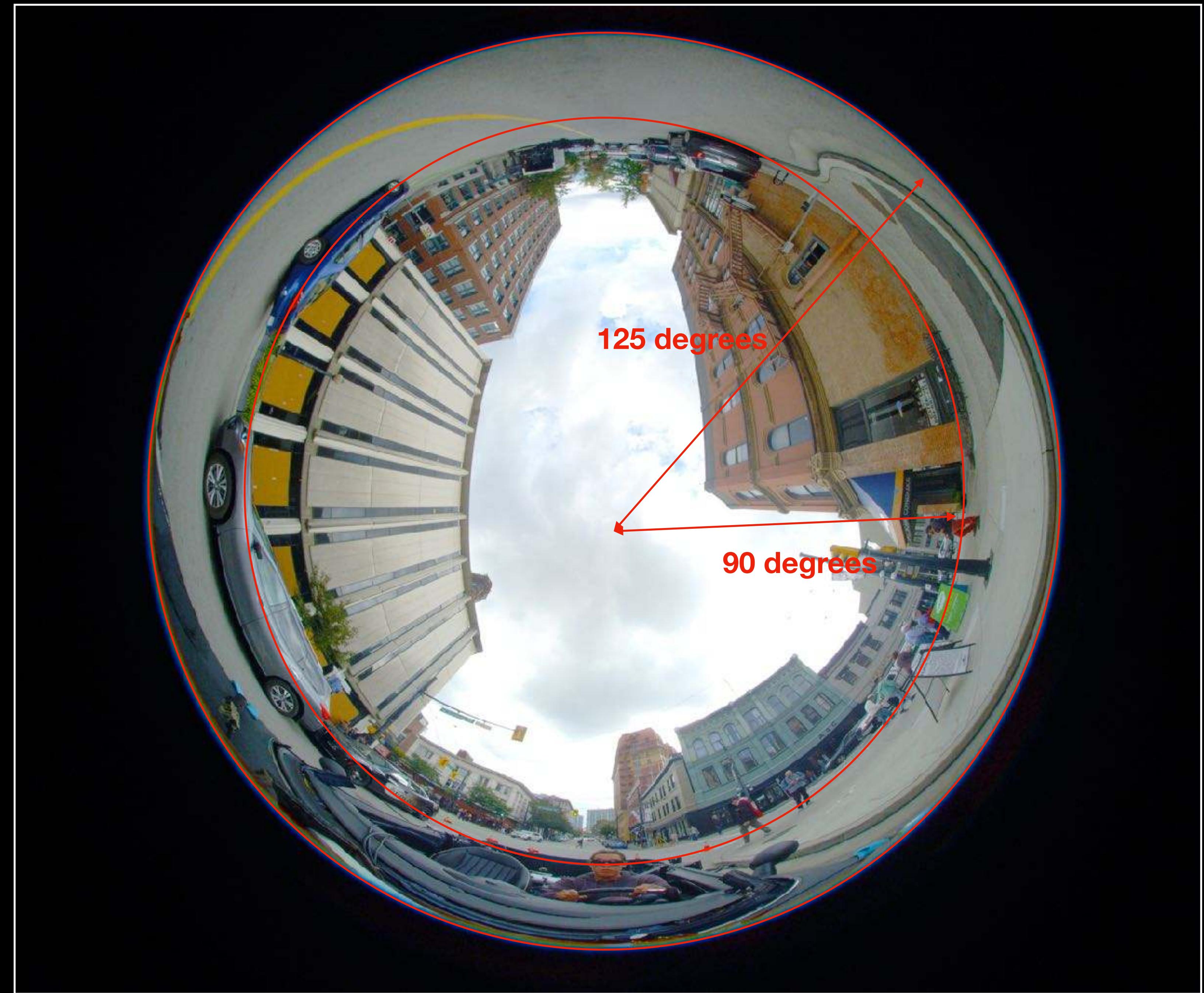
Greater than 2 camera rigs, typically 5 or more

Single camera + fisheye lens



Entaniya 250 degree fisheye







Single camera merits

Advantages:

Simple - Small - No blending - No parallax errors

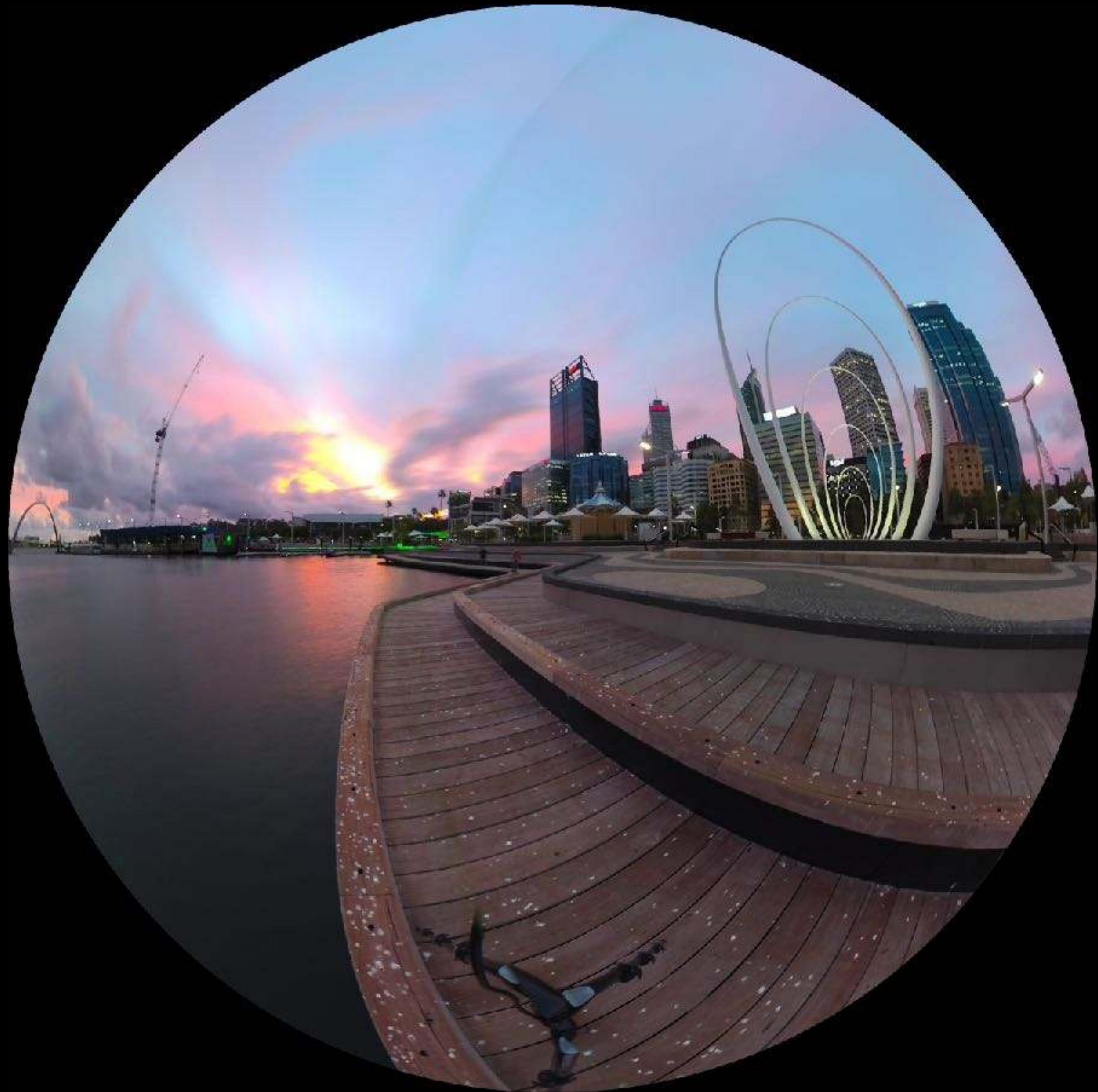
Disadvantages:

Doesn't capture whole 360x180 field of view

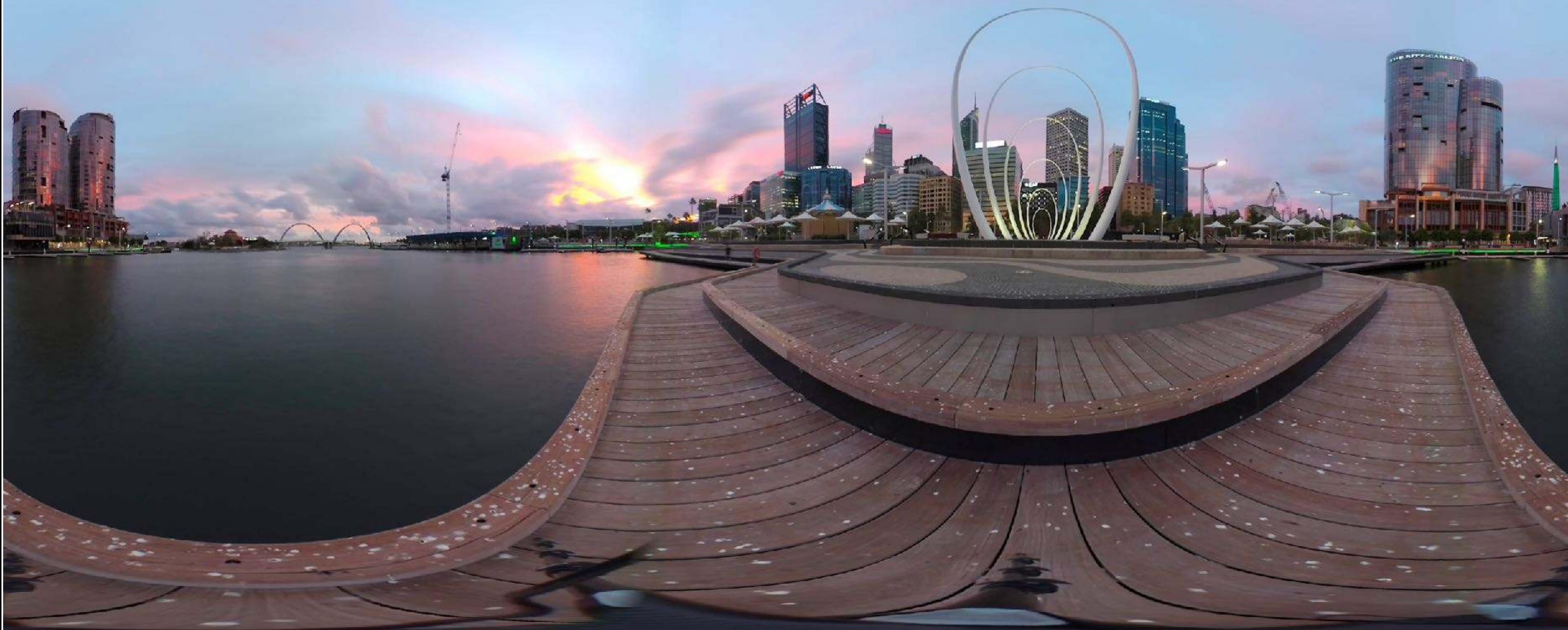
Doesn't scale!

Dual camera rigs





220 degree fisheye



Dual camera merits

Advantages:

Small - Single blend line - Higher resolution than single camera

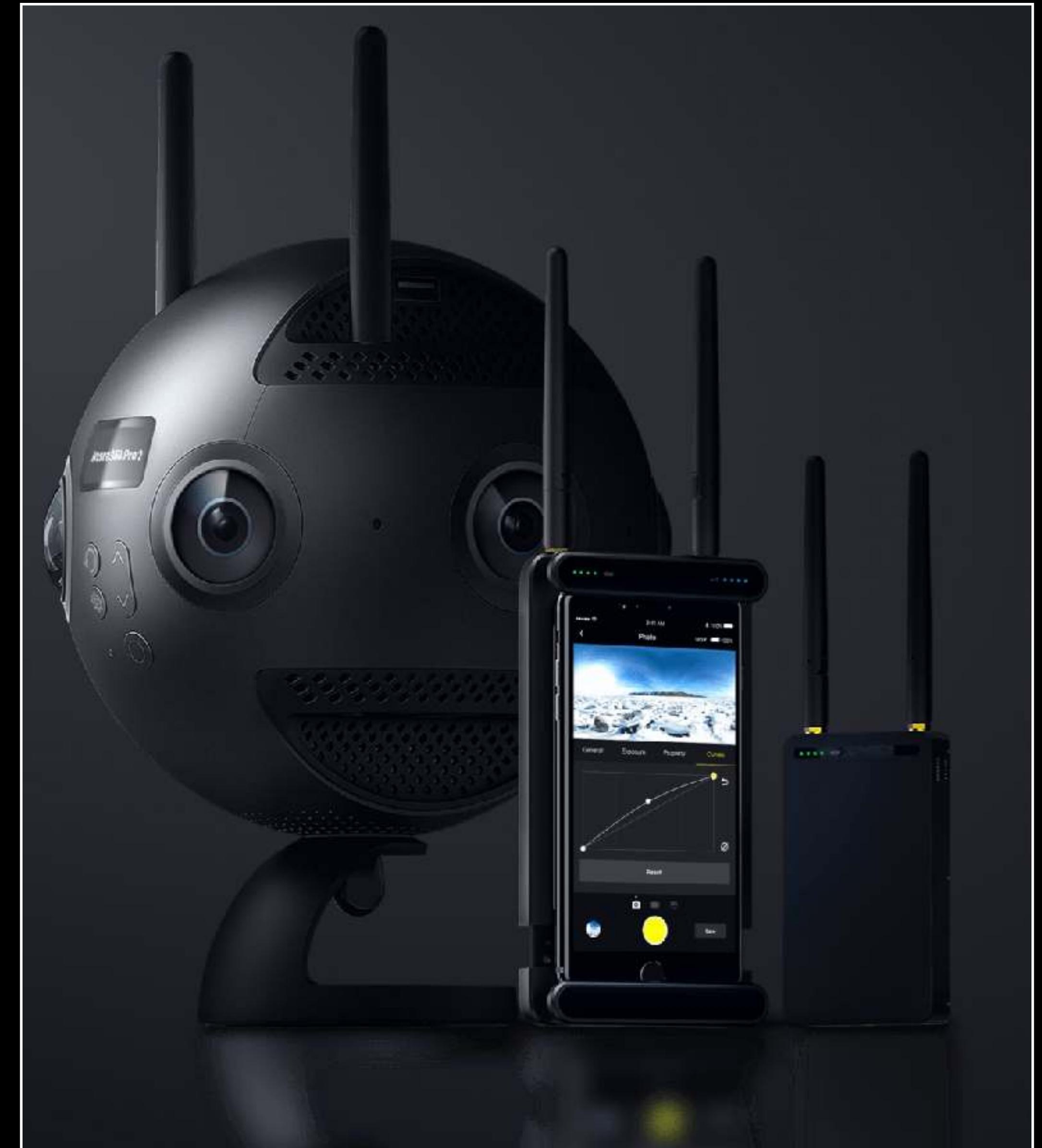
Disadvantages:

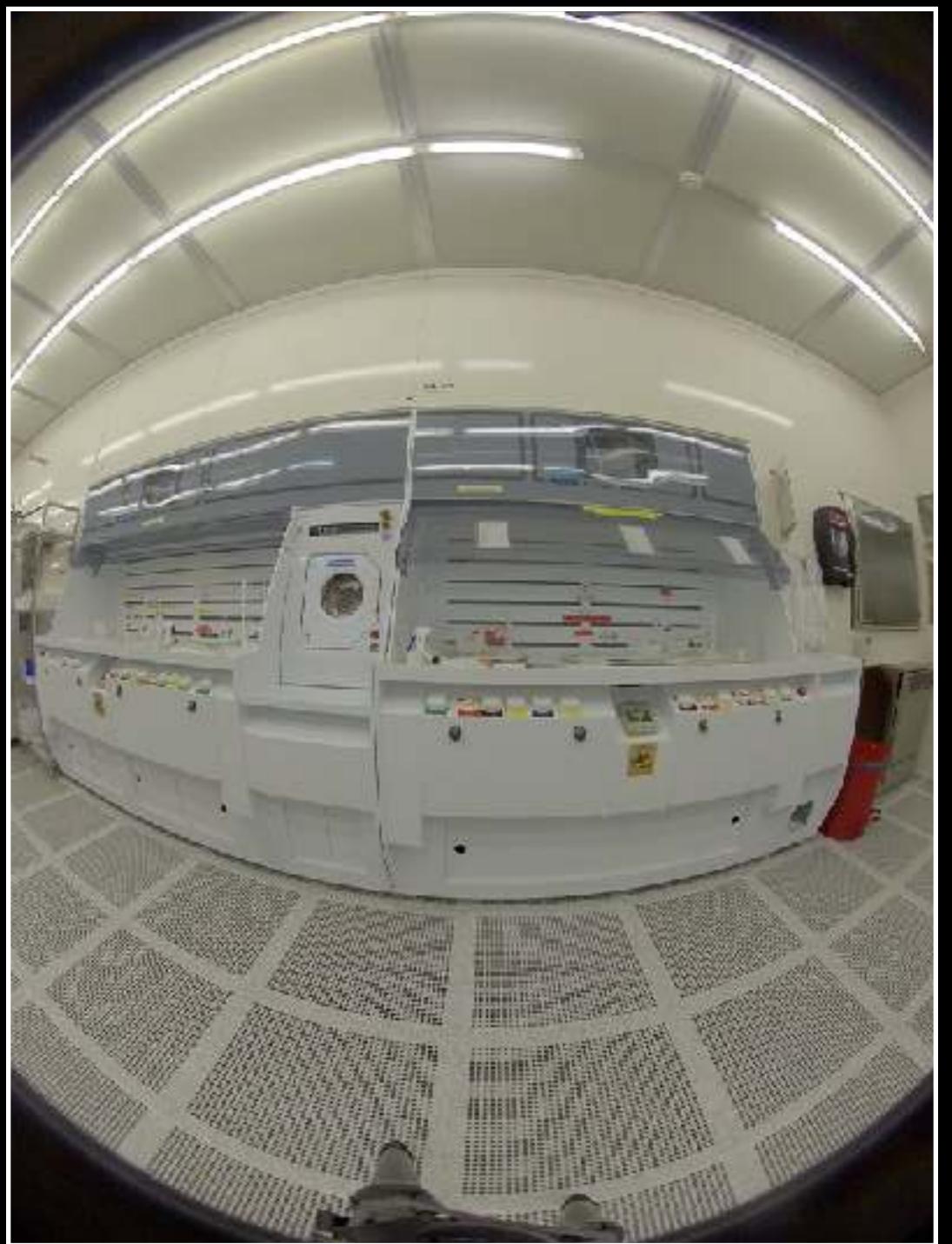
Doesn't scale!

Cannot support stereoscopic 3D

Multiple cameras (>2)

- Insta360Pro2
- 6 Camera/lenses
- One microSD card per camera
- Maximum resolution 7680 x 3840 @ 30fps
- Long range live feed and control
- Built in stabilisation







Multiple camera merits

Advantages:

Scales to higher resolution

Supports stereoscopic 3D

Disadvantages:

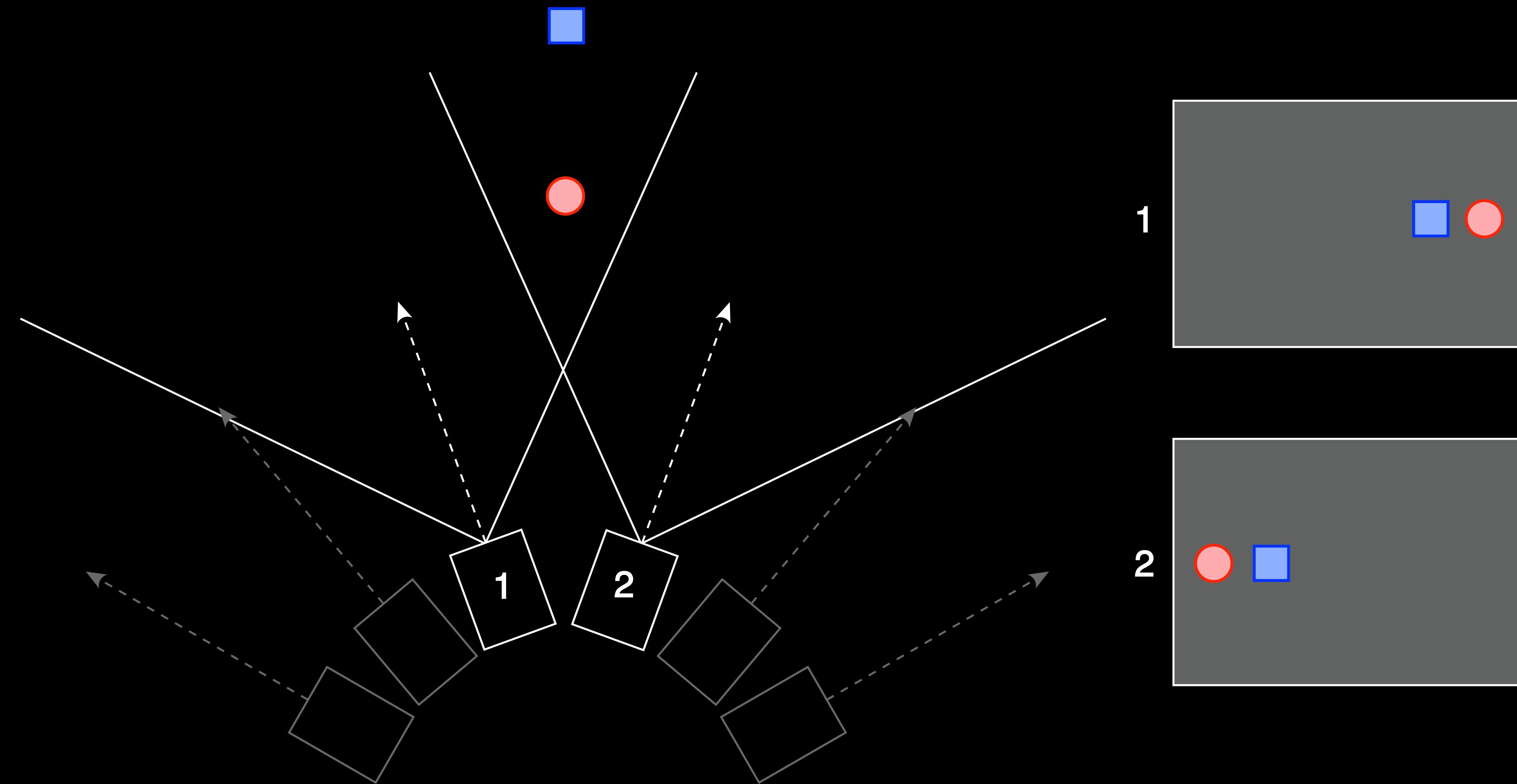
Larger units, More expensive

More complex data management and stitching

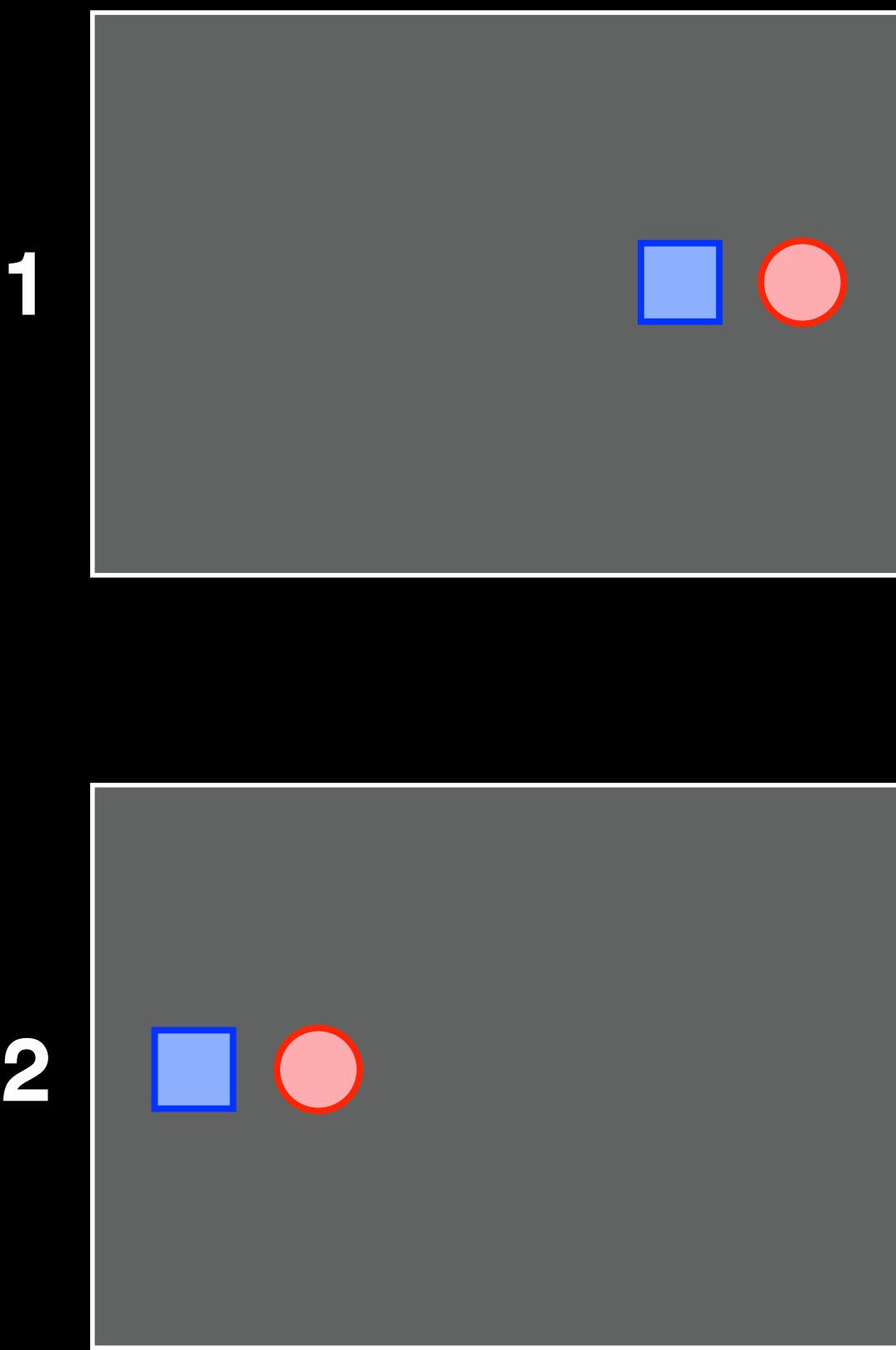
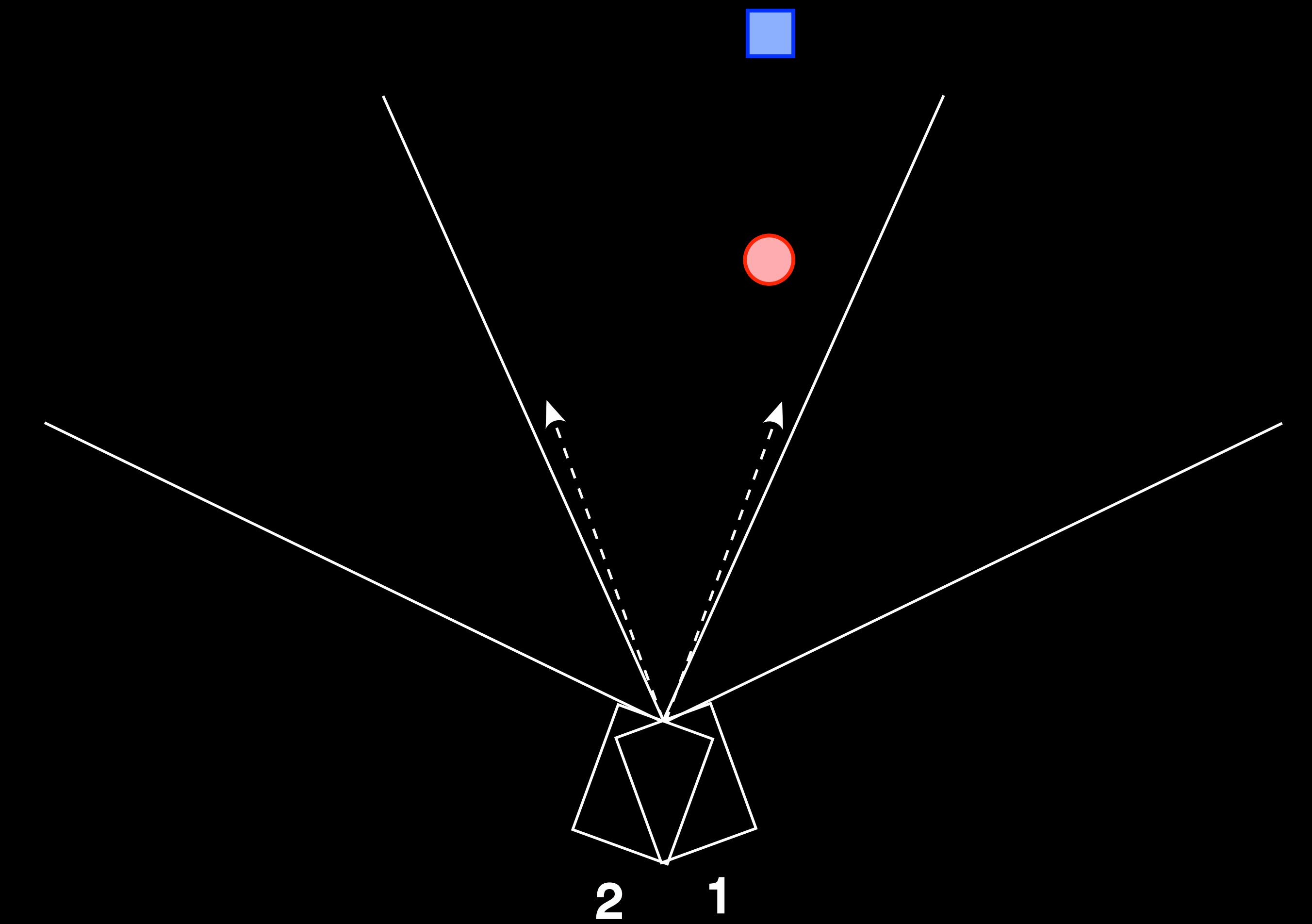
Summary

	Single camera	Dual camera	More than 2 cameras
Resolution	Rarely > 4K	5K -> 8K	8K or more
Stitching	None	Single strip	Multiple
Lens quality	Good	Generally poorer	Good
Size/weight/Price	Medium	Small	High
Full equirectangular	No	Usually	Usually
Stereoscopic 3D	No	No	Possible

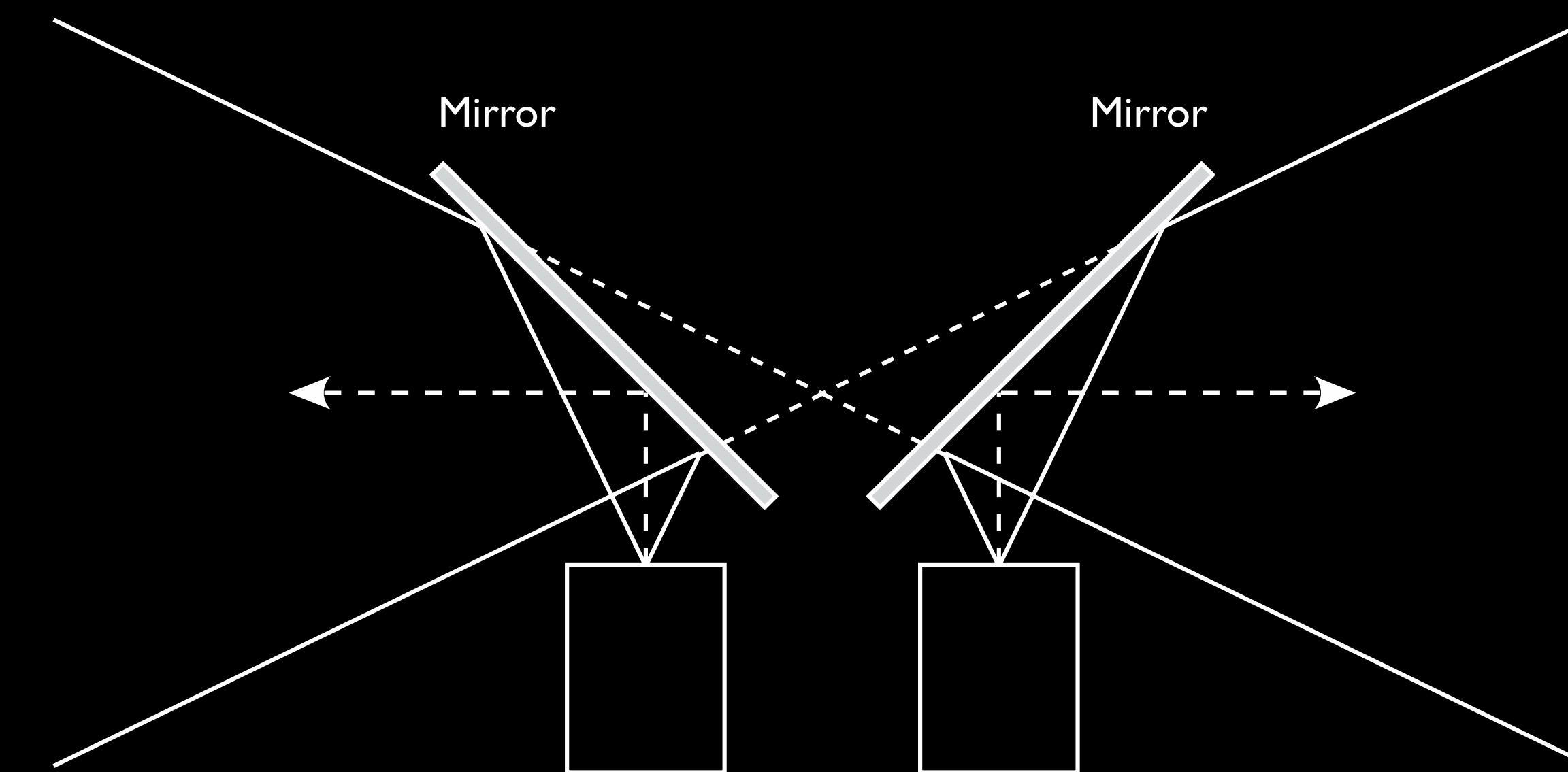
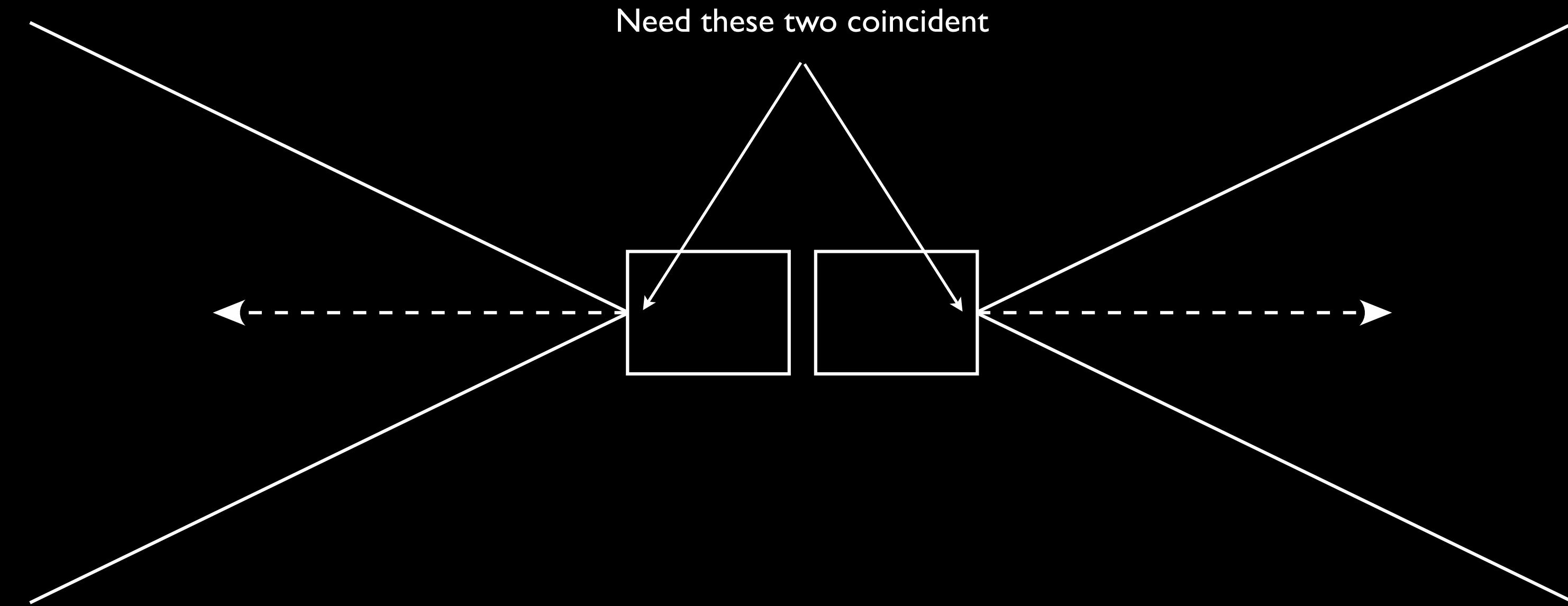
The fundamental problem

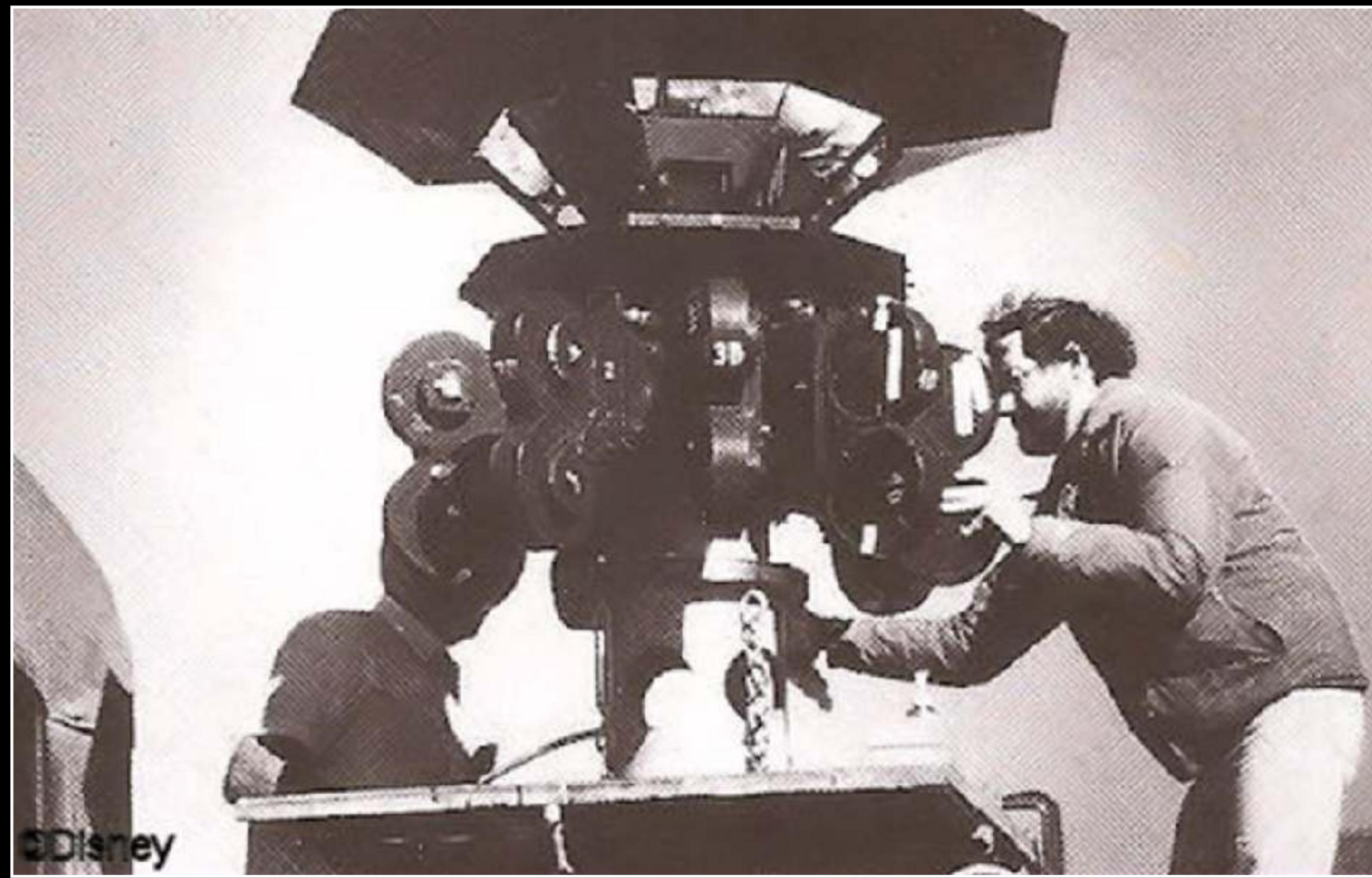




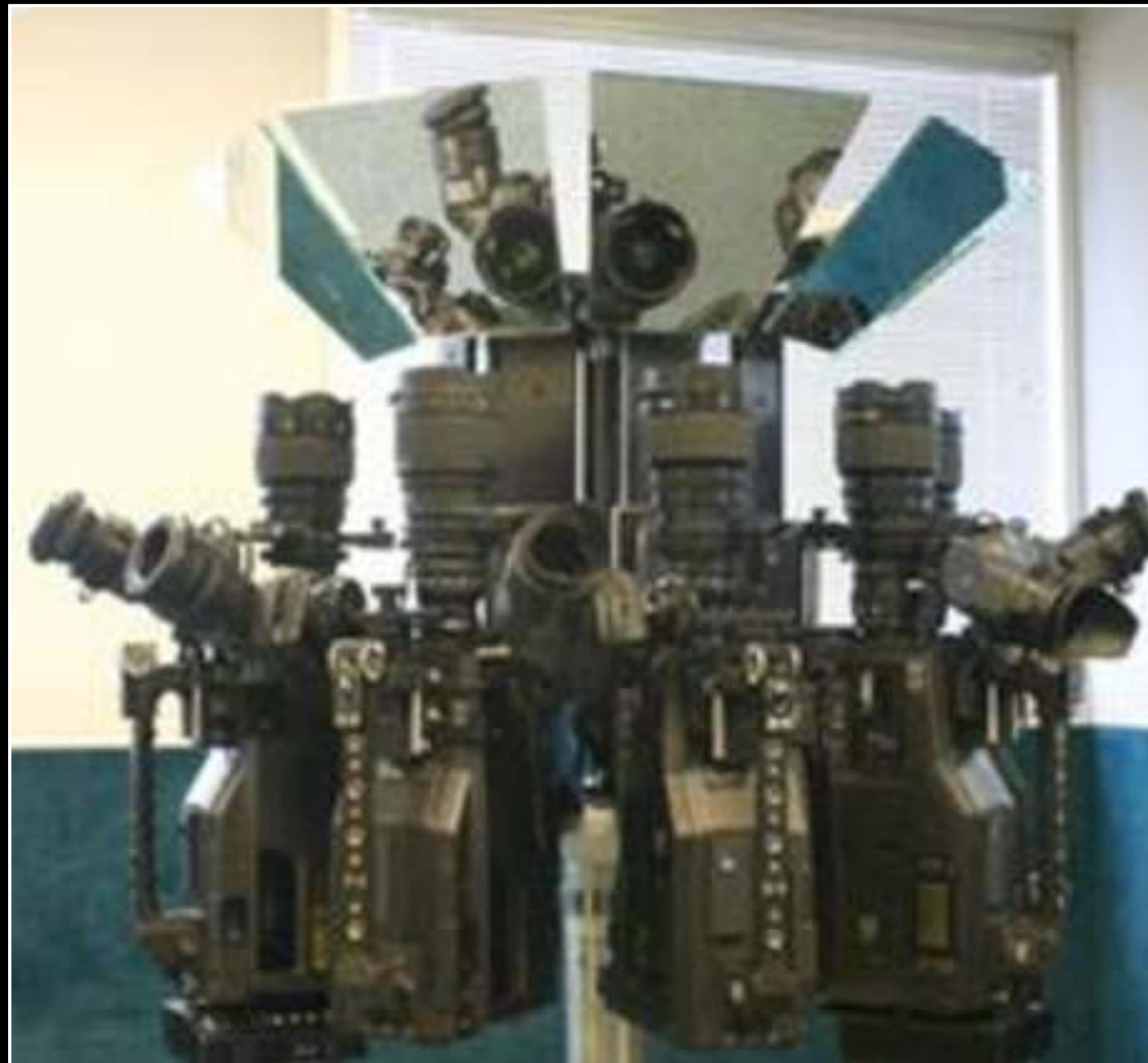


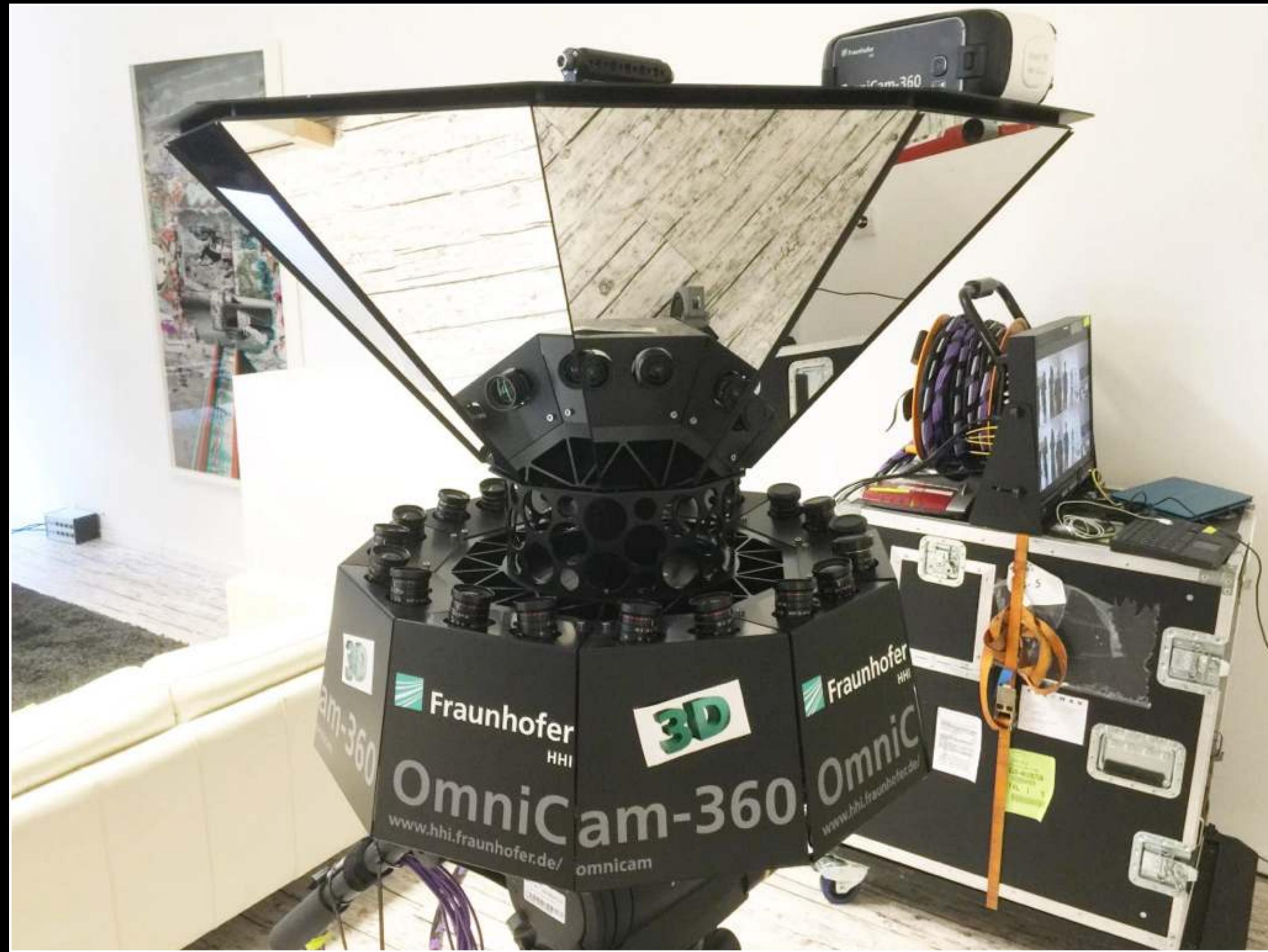
Solutions - Mirrors





Circlorama camera #2 (Disney)





(12) **United States Patent**
Masuda et al.

(54) **IMAGING SYSTEM AND IMAGING OPTICAL SYSTEM**

(75) Inventors: **Kensuke Masuda**, Kawasaki (JP);
Noriyuki Terao, Sendai (JP); **Yoshiaki Irino**, Kawasaki (JP); **Tomonori Tanaka**, Yokohama (JP); **Nozomi Imae**, Yokohama (JP); **Toru Harada**, Yokohama (JP); **Hirokazu Takenaka**, Kawasaki (JP); **Hideaki Yamamoto**, Yokohama (JP); **Satoshi Sawaguchi**, Yokohama (JP); **Hiroyuki Satoh**, Kawasaki (JP)

(73) Assignee: **RICOH COMPANY, LTD.**, Tokyo (JP)

(10) **Patent No.:** US 9,201,222 B2

(45) **Date of Patent:** Dec. 1, 2015

USPC 348/36, 335; 359/725
See application file for complete search history.

(56)

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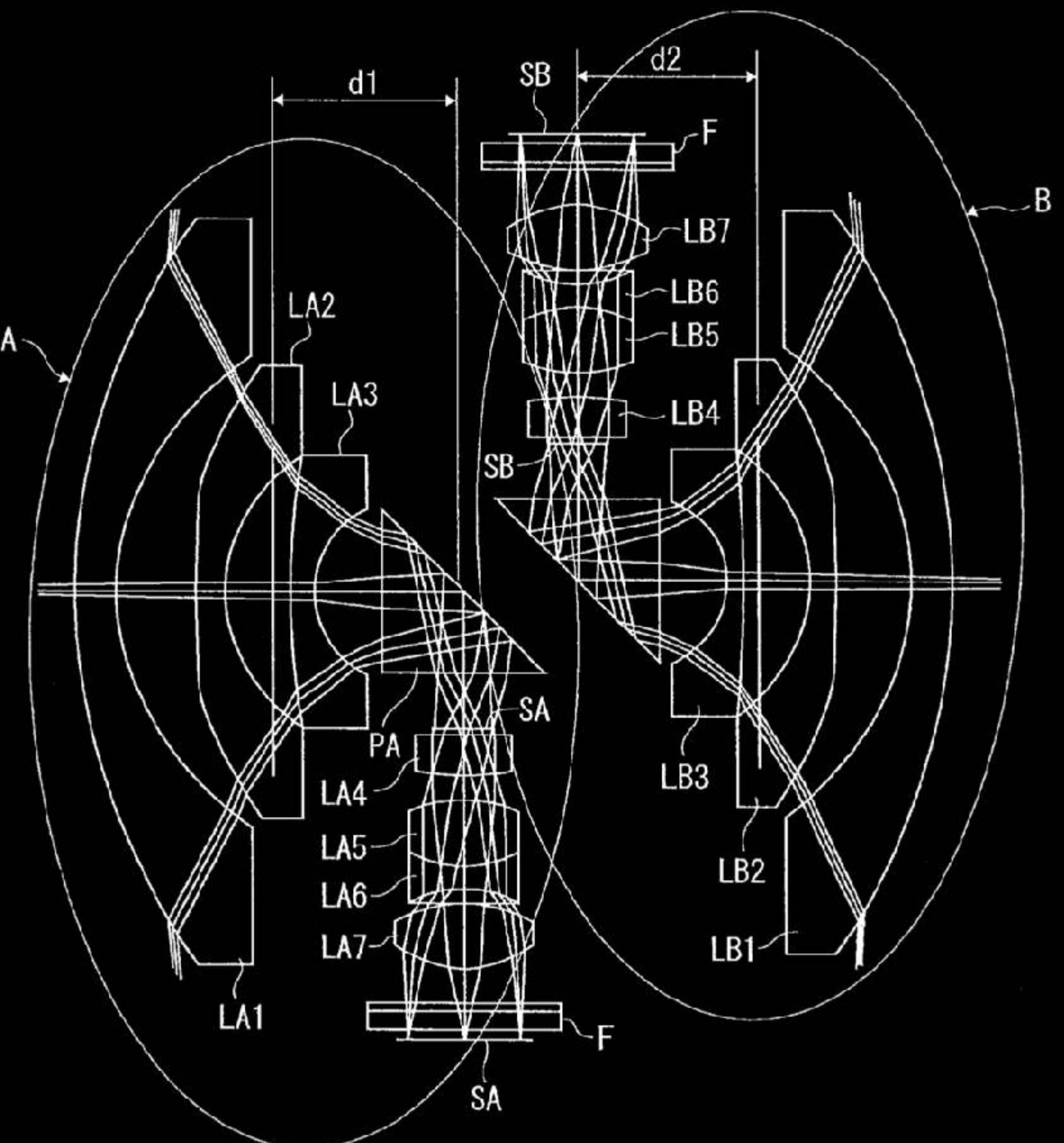
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7,154,551 B2 * 12/2006 Kuriyama et al. 348/335
(Continued)

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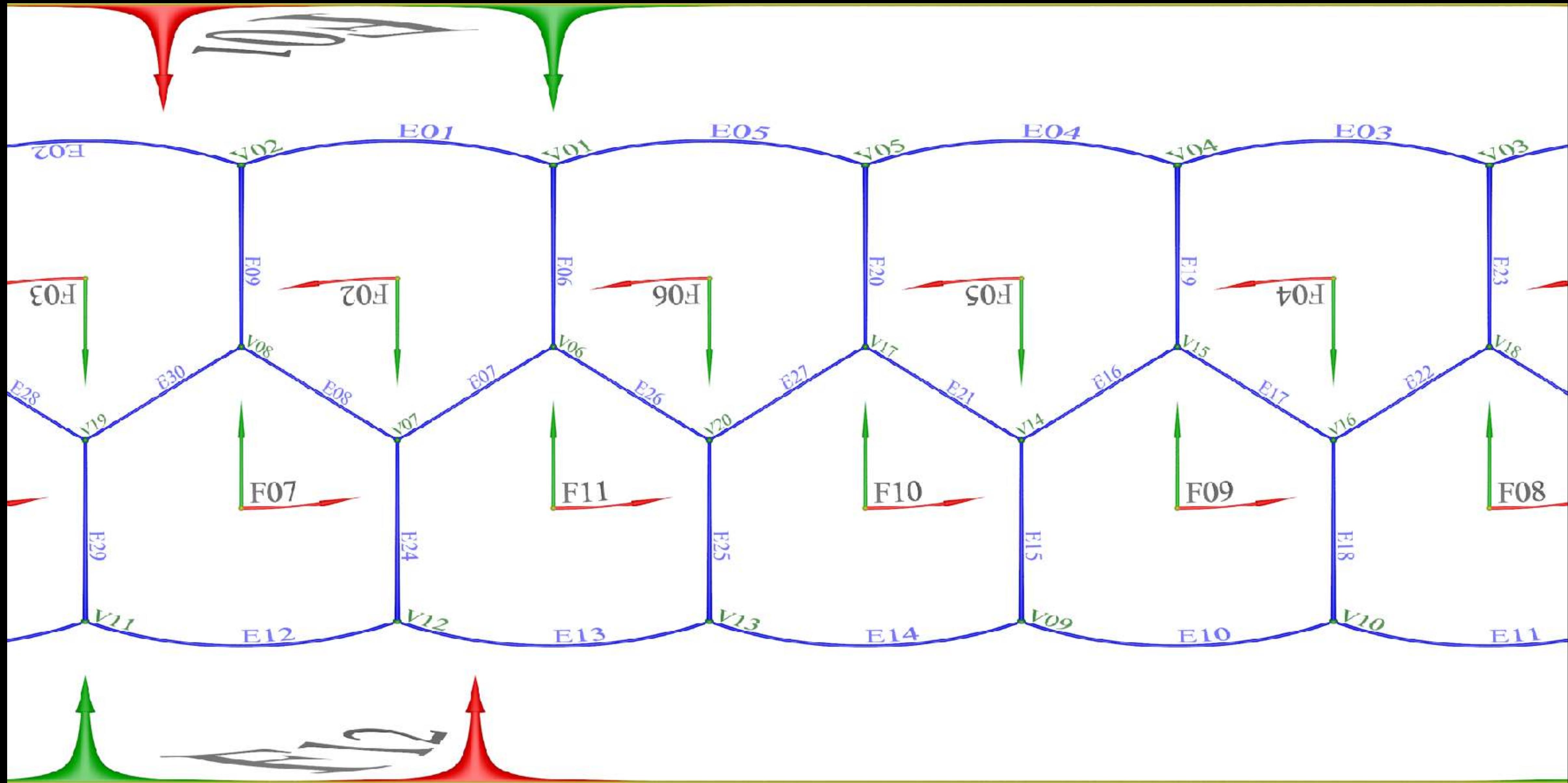
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FIG. 1

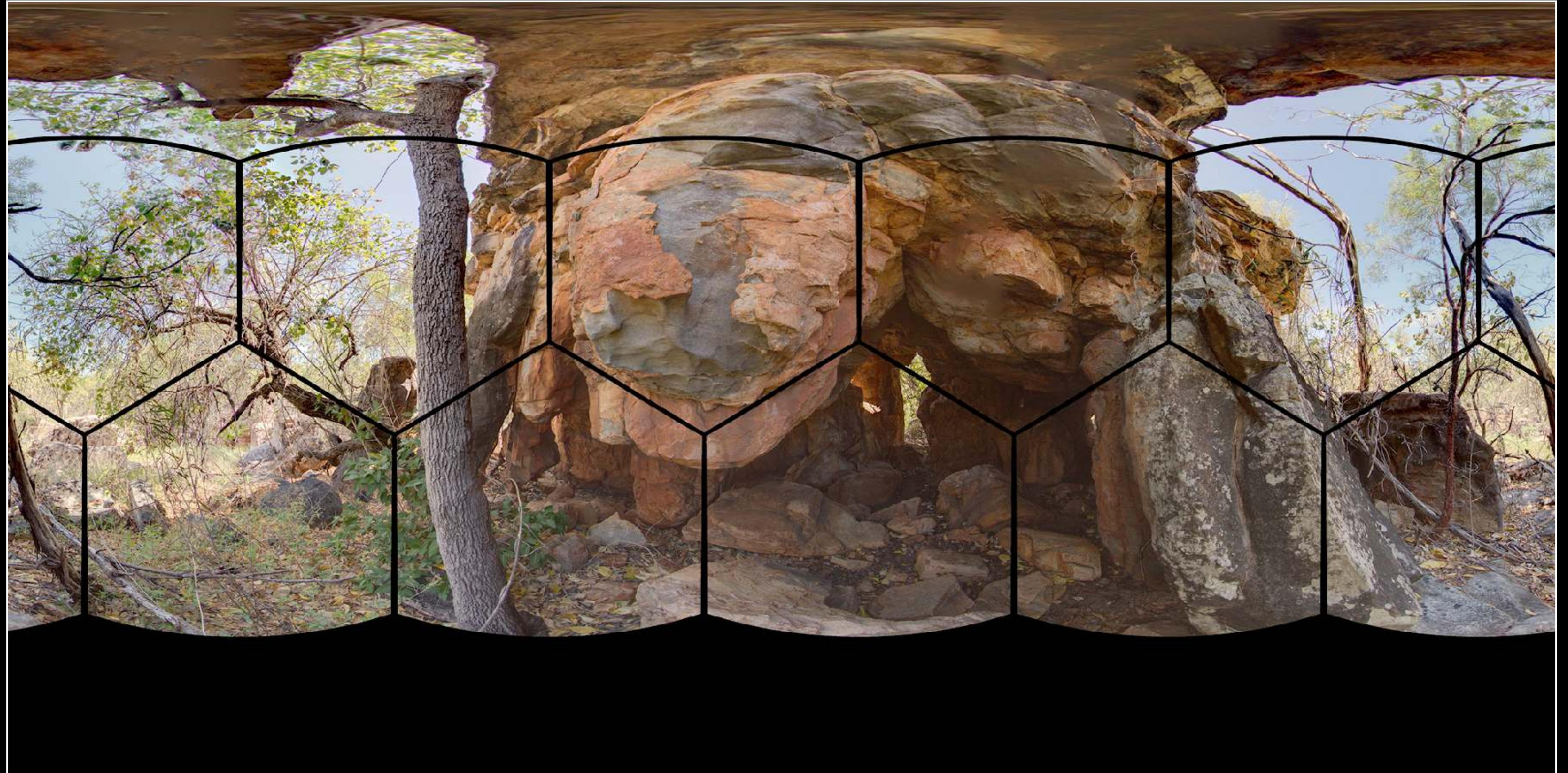


Solutions - Custom Optics









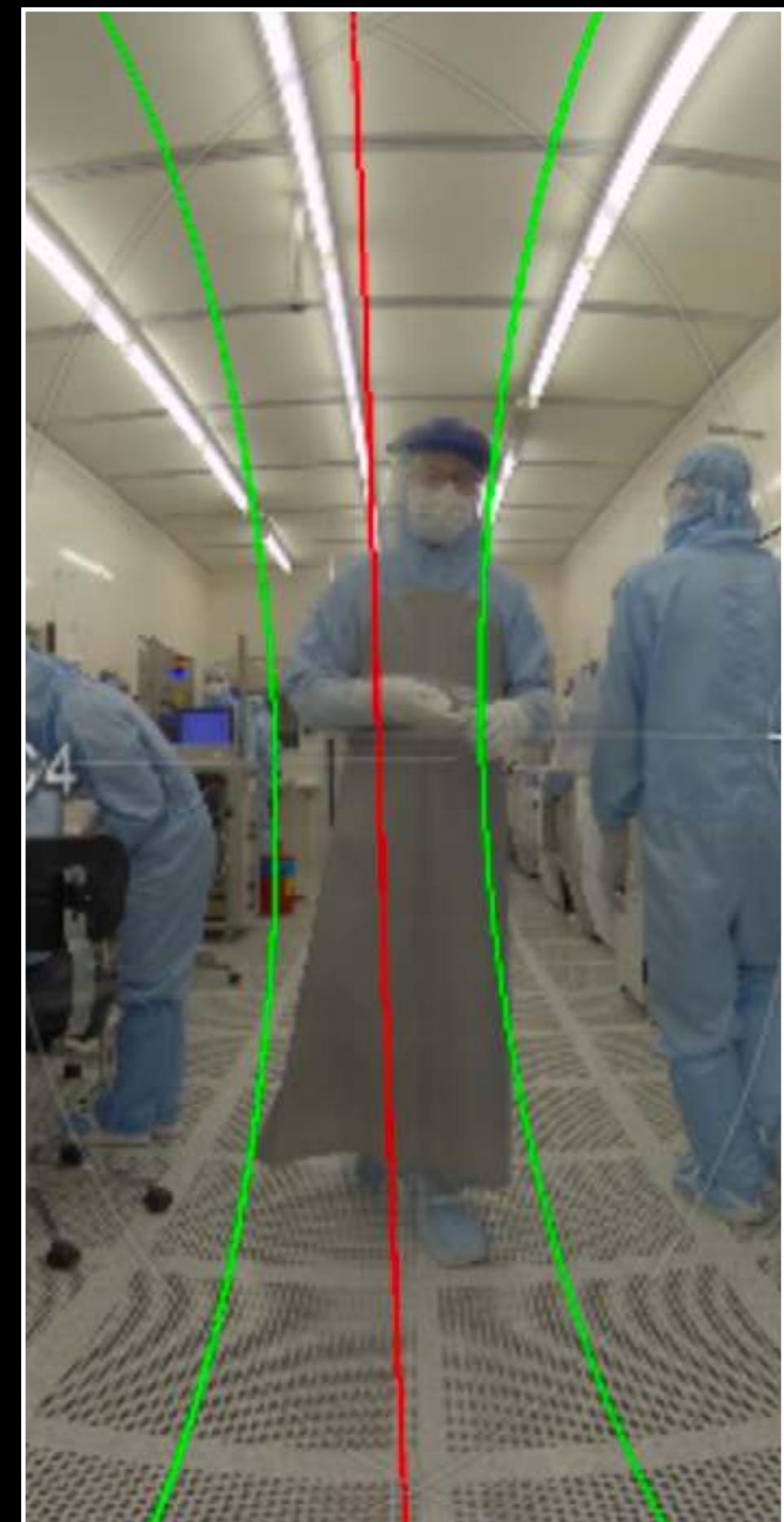
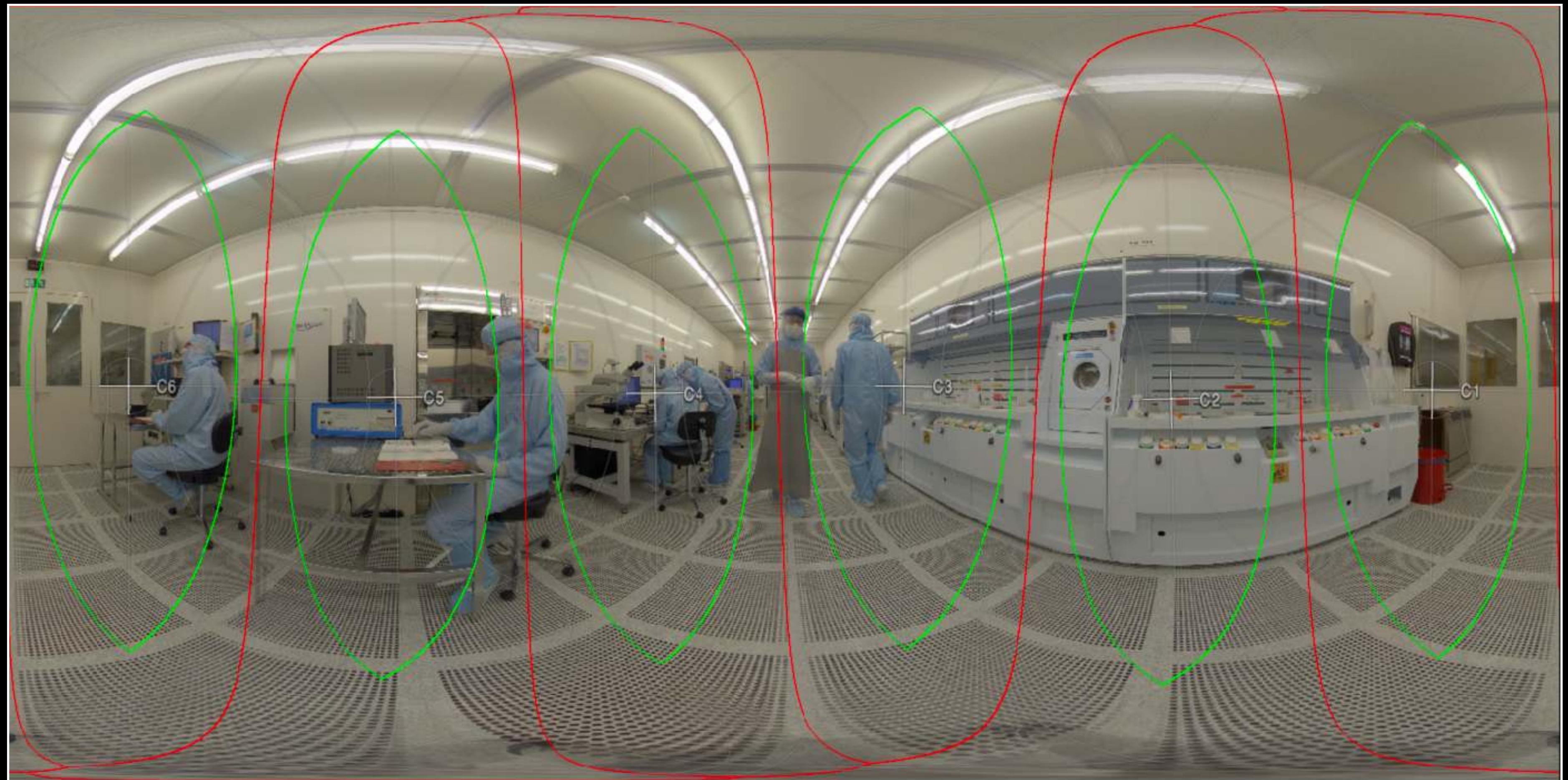


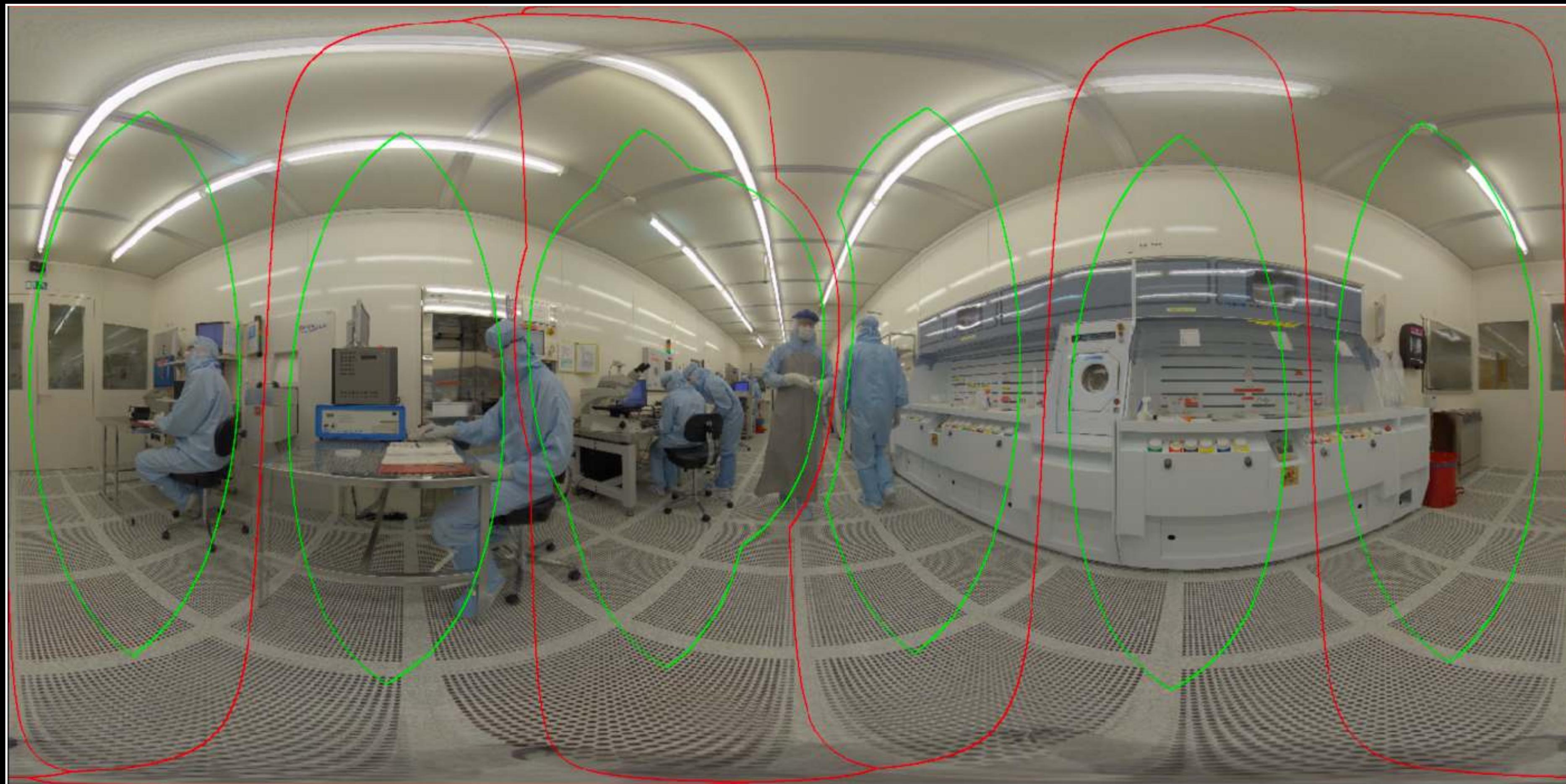
Solutions - Optical Flow

- Tracks image content between frames and performs local warping to maintain continuity.
- Pretty much the standard solution today in all multiple camera rigs and associated software.
- To facilitate this most cameras have a lot of overlap between lens views.
- Perhaps one of the software leaders is MistakaVR.
- NOTE: It is not perfect, the parallax issue cannot always be corrected/hidden.

Mistika VR - epfl[epfl.vrenv] - 3840x1920 30.00 fp







Miscellaneous topics - Resolution

- Currently equirectangular projections are the norm, resolution measured as horizontal pixels.
- Aspect always 2:1, 360 degrees horizontally, 180 degrees vertically.
- Most dual camera rigs are now around 5.7K pixels across, some are now 8K.
- Most of the multiple camera (>2) rigs are 8K.
Including 8K in stereoscopic 3D.
- A few multiple camera rigs are now 12K, or greater.
- Most cameras to date have been just 8 bit, a few now and on the horizon are 10 or 12 bit.
- But like normal cameras it eventually becomes more about optical quality, dynamic range and camera reliability rather than purely resolution.

Miscellaneous topics - Audio

- No such thing as a boom mic on set!
- If one is recording 360 vision then 360 audio is also expected.
- Generally in-camera audio is terrible.
- Also issue of fan noise (cameras run hot) or limited recording time when fans turned off.
- Most common scenario is an ambisonic recording from the position of the camera (eventual viewer).







Miscellaneous topics - Lighting

- Similarly, no space for lighting?
- Sometimes space under the tripod or in the visual dead zone above or below the camera.



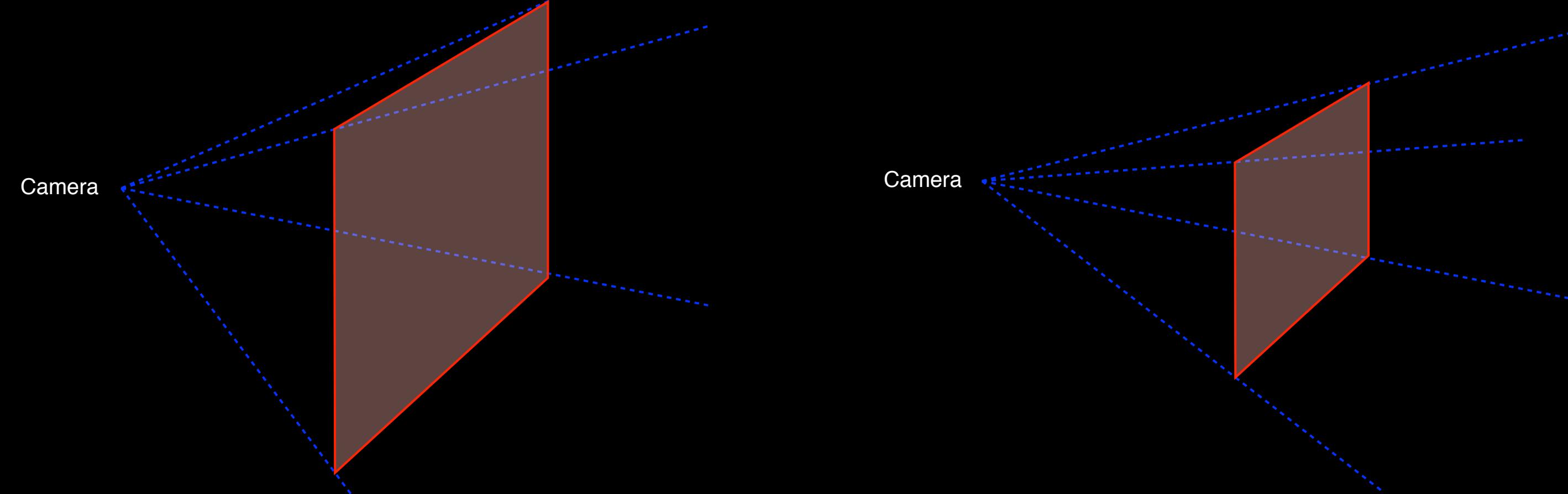






Miscellaneous topics - Zooming

- There is no such thing as a zoom.
Zoom is achieved in perspective projection by changing the field of view.



- To magnify something or to see more detail the camera needs to move closer towards it.
- Actually it is the notion of zoom in traditional film that is the strange case, our eyes cannot zoom in real life. So when one creates displays that are closer to the way we see the real world, we lose some of the artificial devices ... like zooming.

Miscellaneous topics - Wrapping

- Equirectangular images wrap horizontally so pixels to the right of the right edge are actually on the left edge.
- Need to be careful with imaging effects that affect neighbouring pixels. For example, colour changes generally don't, but operations like sharpening do.
- Compositing also needs to occur across the wrapping zone.
- Note also the expansion at the poles. Editing software needs to be equirectangular aware.



Miscellaneous topics - Nonlinear space





Miscellaneous topics - Stereoscopic 3D (VR)

- Stereoscopic filming is a whole topic in itself and should start with a good understanding of stereoscopic theory for flat screens first.
- Obviously head mounted (VR) displays are geared to support this.
- Well understood for computer generated content (still not always done well!).
- Hugely problematic for video recording despite lots of camera rigs (including the Insta360Pro-2) supporting it.
- Quality is generally not of a high standard and is only accepted due to novelty and low user expectations.

Miscellaneous topics - It's a new medium

- 8 years ago we had stereoscopic 3D movie peak, it failed to become ubiquitous, why?
 - Productions made stereoscopic because it was possible. Didn't add to the storytelling.
 - Not exploit the opportunities, simply used their monoscopic techniques.
 - Not fully understanding the limitations, LOTS of really bad technical choices.
 - There are other reasons related to human vision ... topic for another day.
- We now have another new storytelling tool in 360 video. But I see some of the same things.
 - Shooting as if it were directional.
Hear questions like "*how to ensure someone is looking at the action?*"
 - Just because it is possible, doesn't mean there are advantages in recording in 360.
- Lots of challenges.
 - Lack of large enough user base of 3D headsets.
 - Lack of a large collection of good content.
 - Many recordings were made when camera hardware was more primitive.
 - Lack of large scale social environments, 360 theatres.

End - Questions?