

360 video

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Agenda

Examples from authors projects

Image projections

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

Camera summary

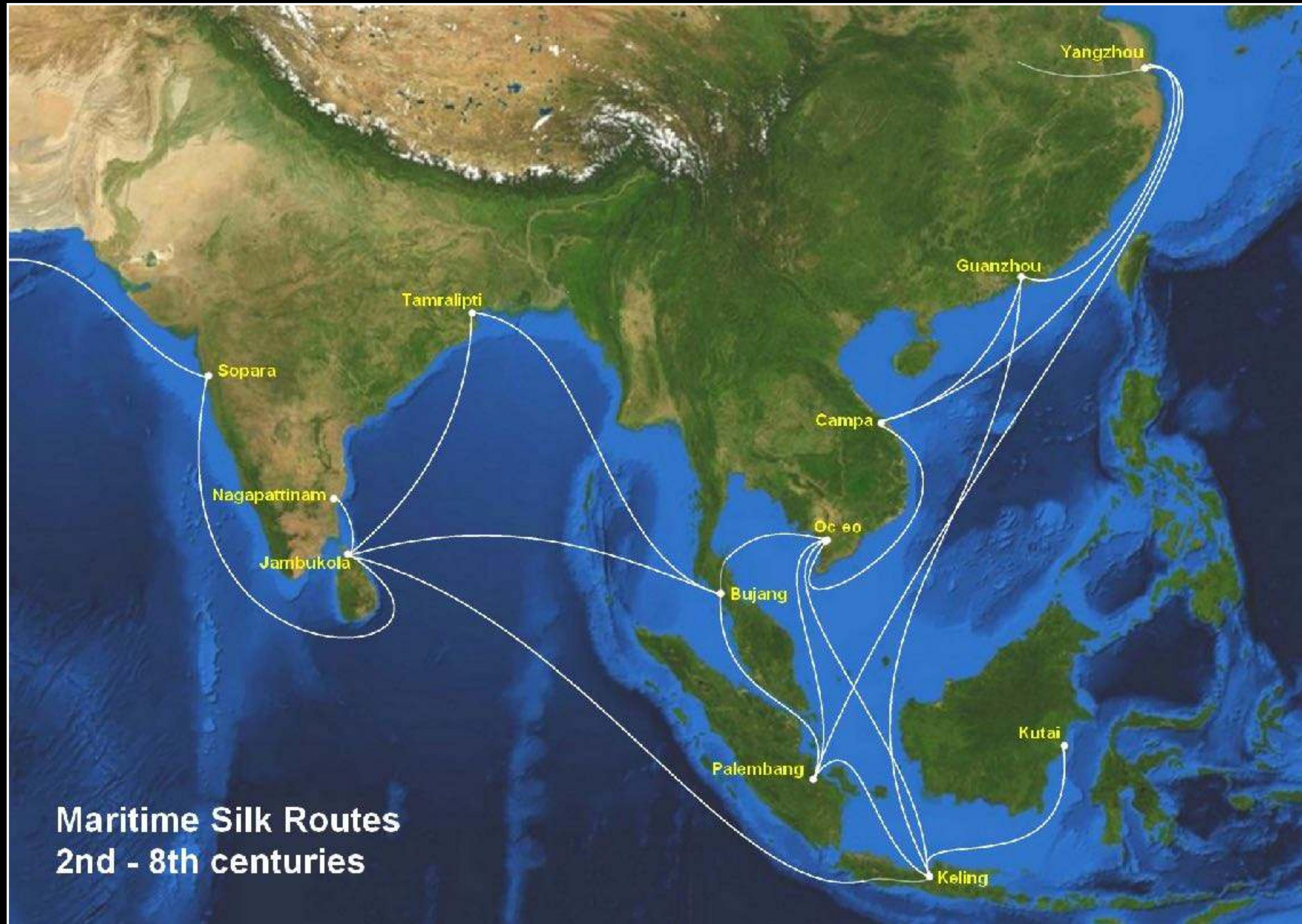
(One - Two - More than two)

The fundamental problem
(Parallax)

Solutions to the fundamental problem
(Mirrors - Optics - Optical flow)

Miscellaneous topics

Current project
The Altas of Maritime Buddhism





RoundShot



Gigapixel





Gigapixel





3D reconstruction



360 video



Repurpose: HMD



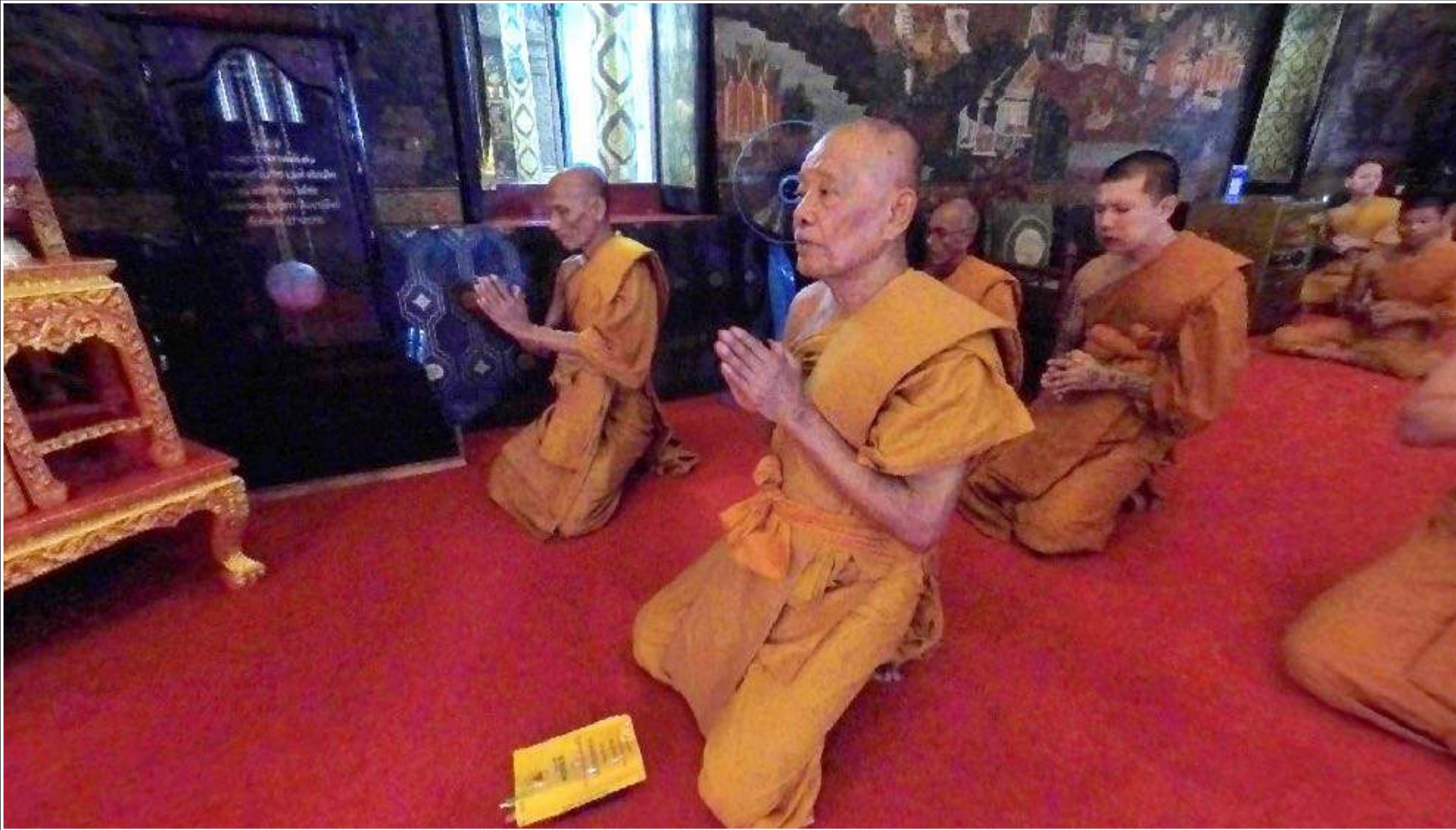
Repurpose: Cylindrical



Repurpose: Fisheye (domes)



Repurpose: Perspective









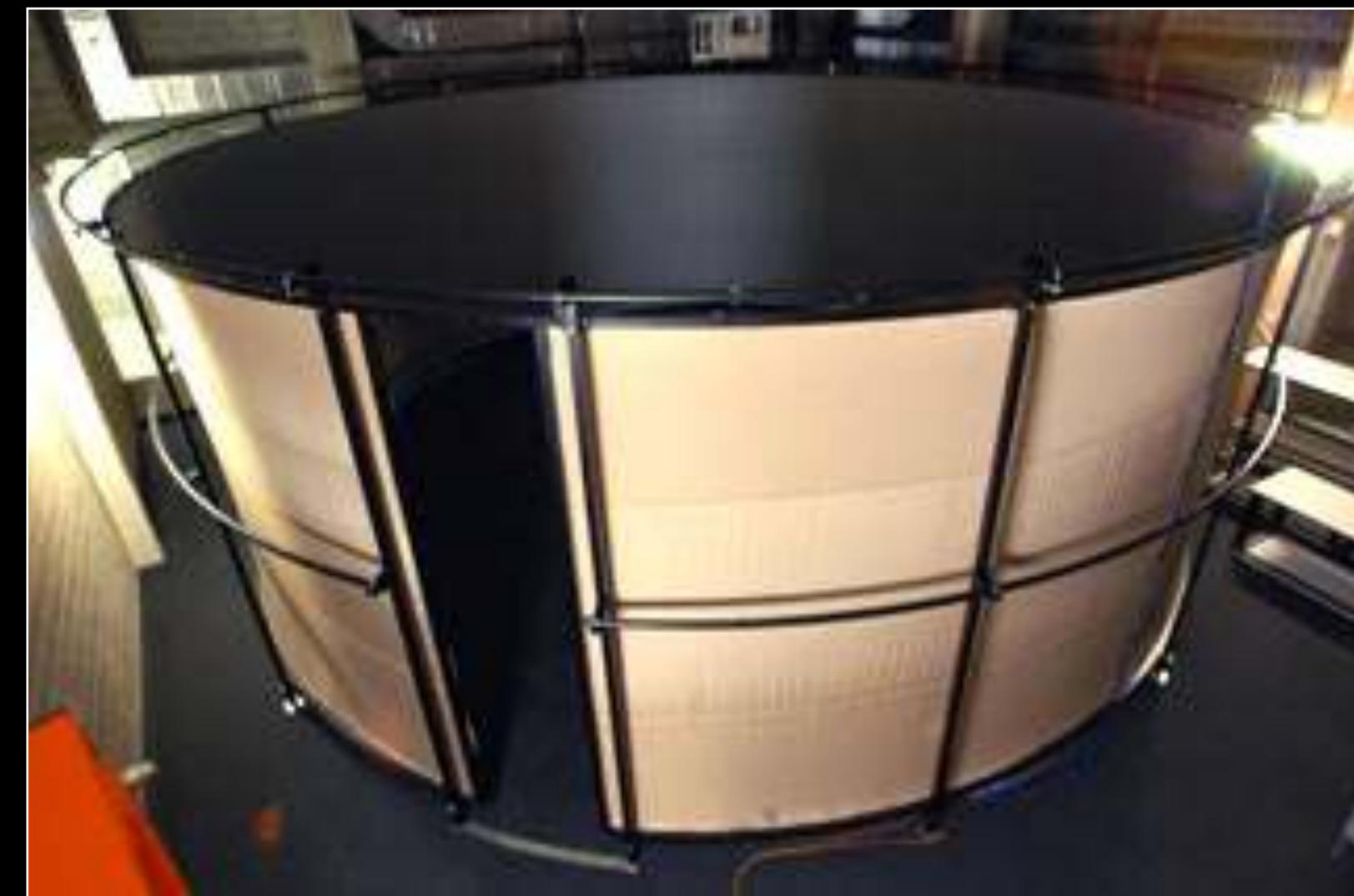
Insta360Pro2

- 6 Cameras in a horizontal line
- Each camera 190 degrees in order to capture the north pole and lots of overlap for optical flow work (see later).
- 30fps at 8K resolution.
- Controlled by App over wifi network.
- Surpassed now by the “Titan”, same company.



Personal history

iCinema





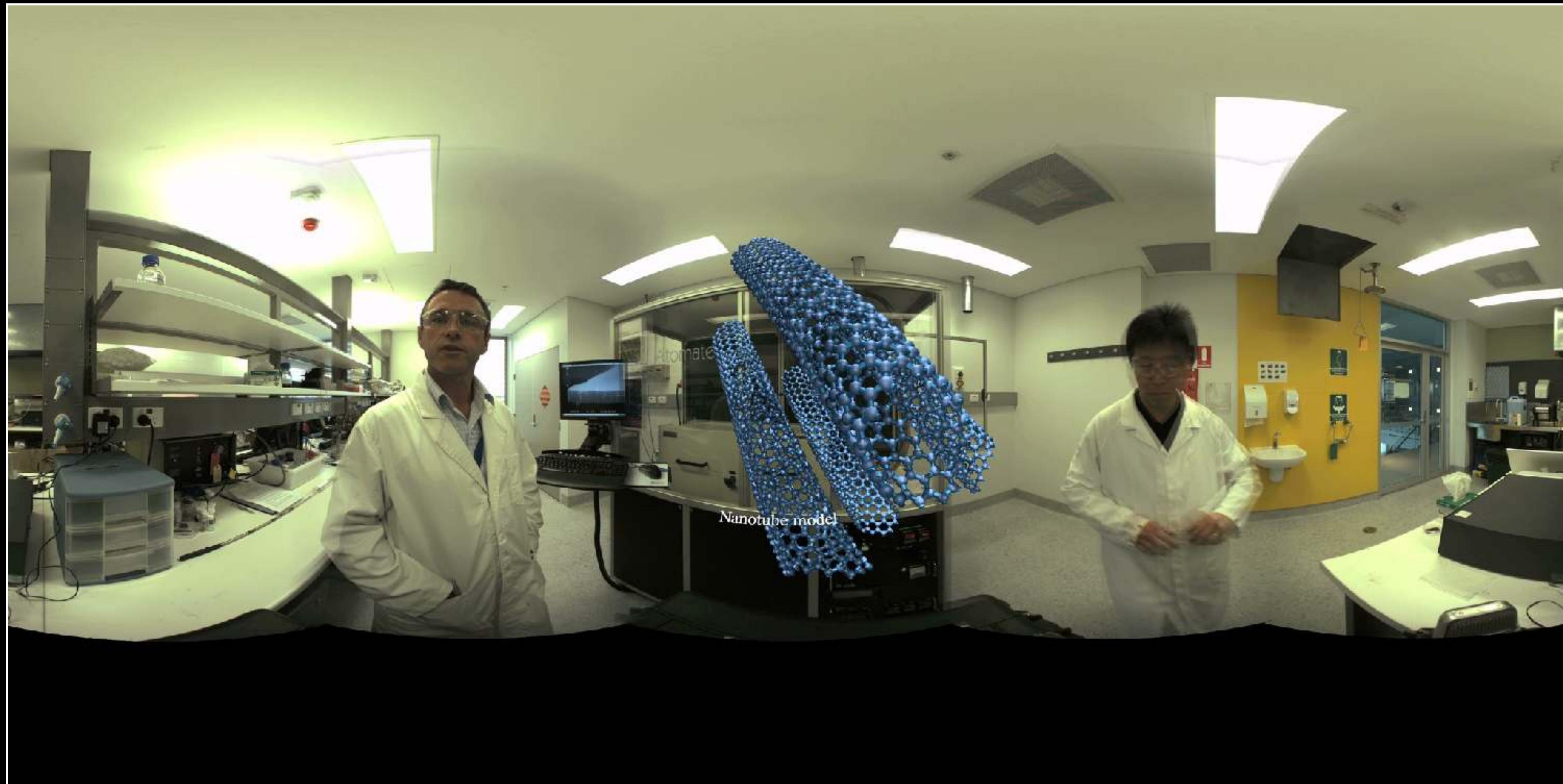
Whirling Dervish, Turkiye



Karratha iron ore ship loader



Mah Meri, Malaysia



Nanotechnology, Wollongong



Sheep shearing, Barossa valley



Pig farming in Hong Kong



Sahet-Jetavana, India

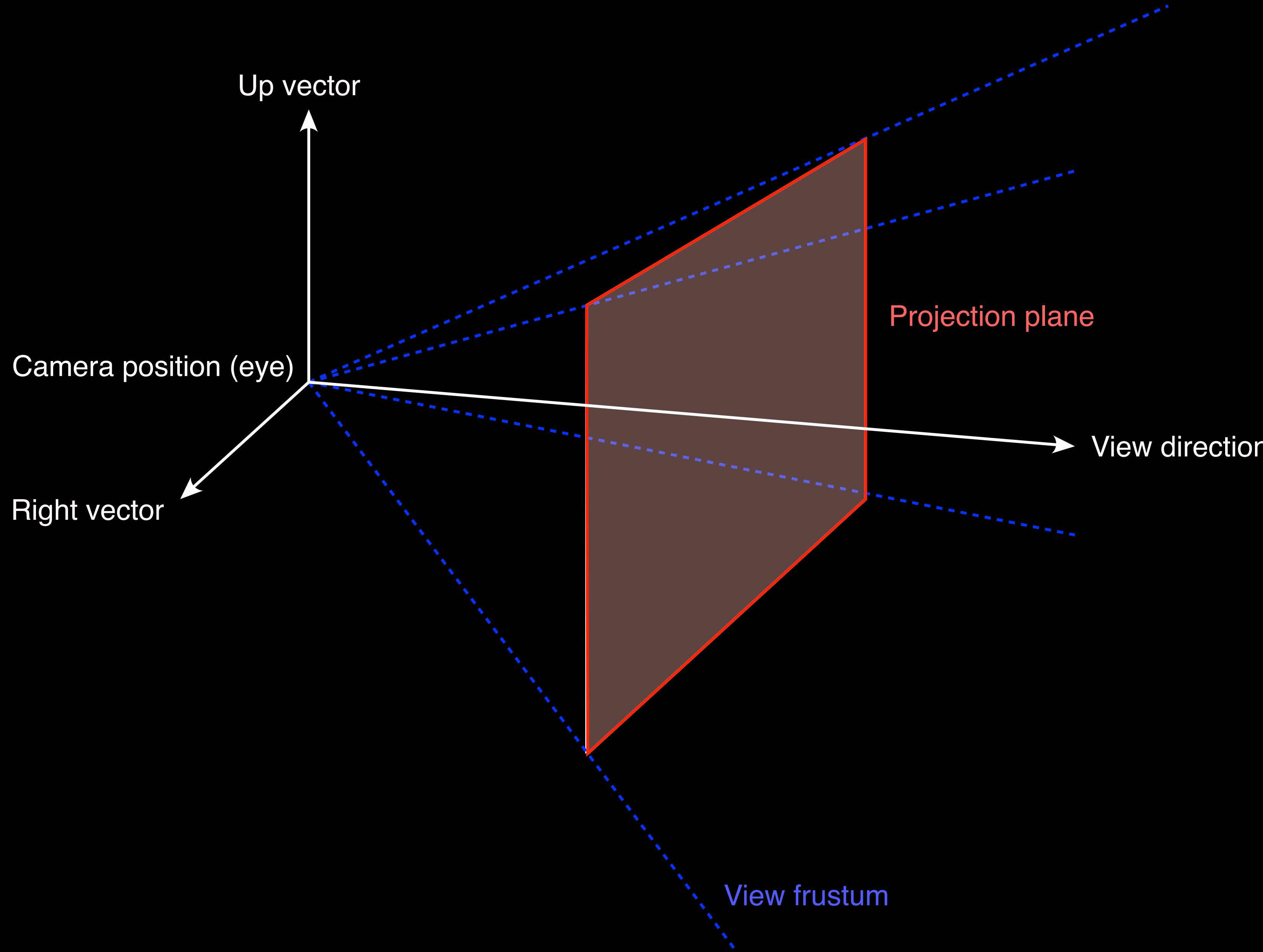


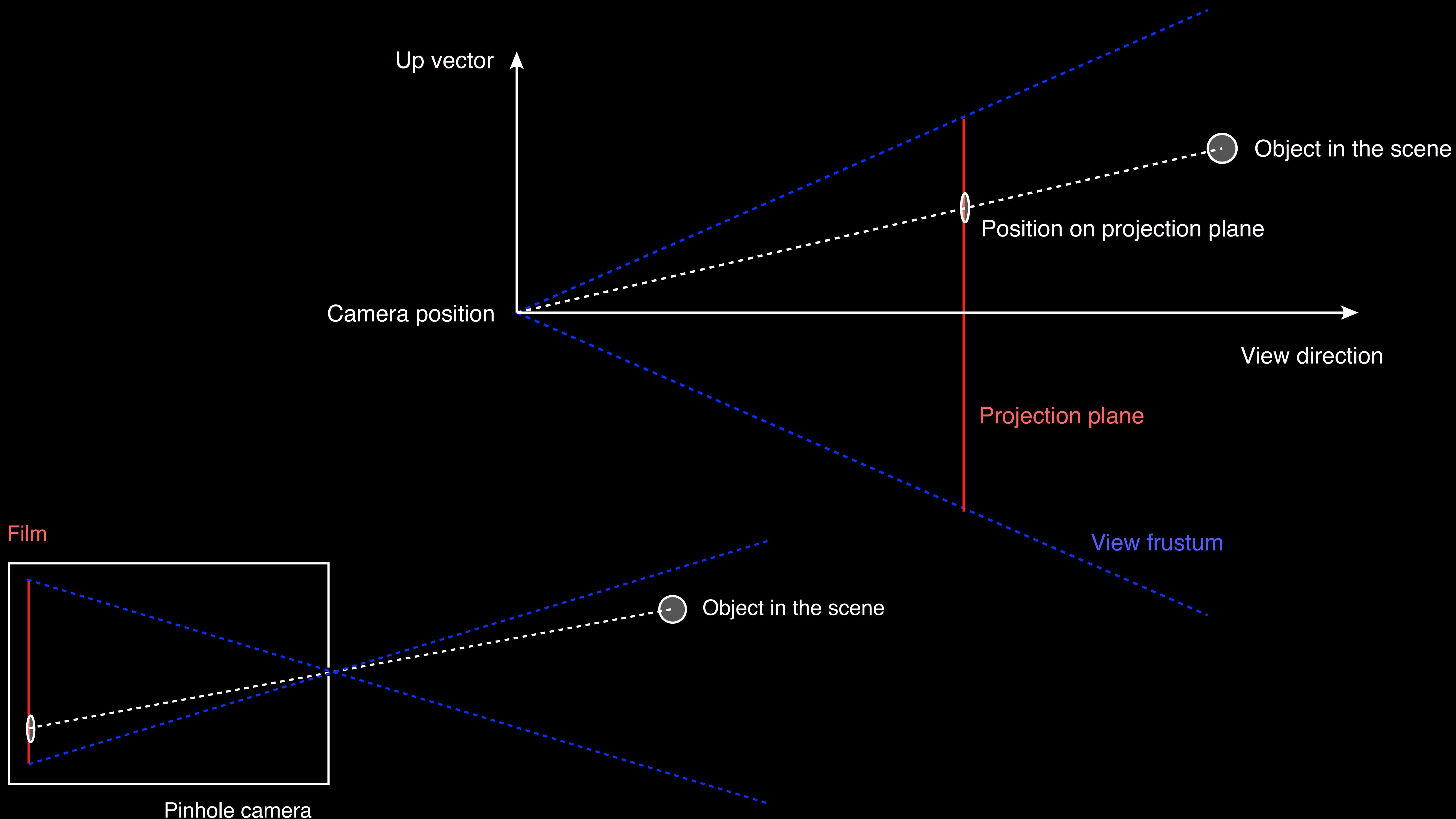
Clothing Buddha, India



Micro and Nano Technology, EPFL, Switzerland

Image projections - Perspective









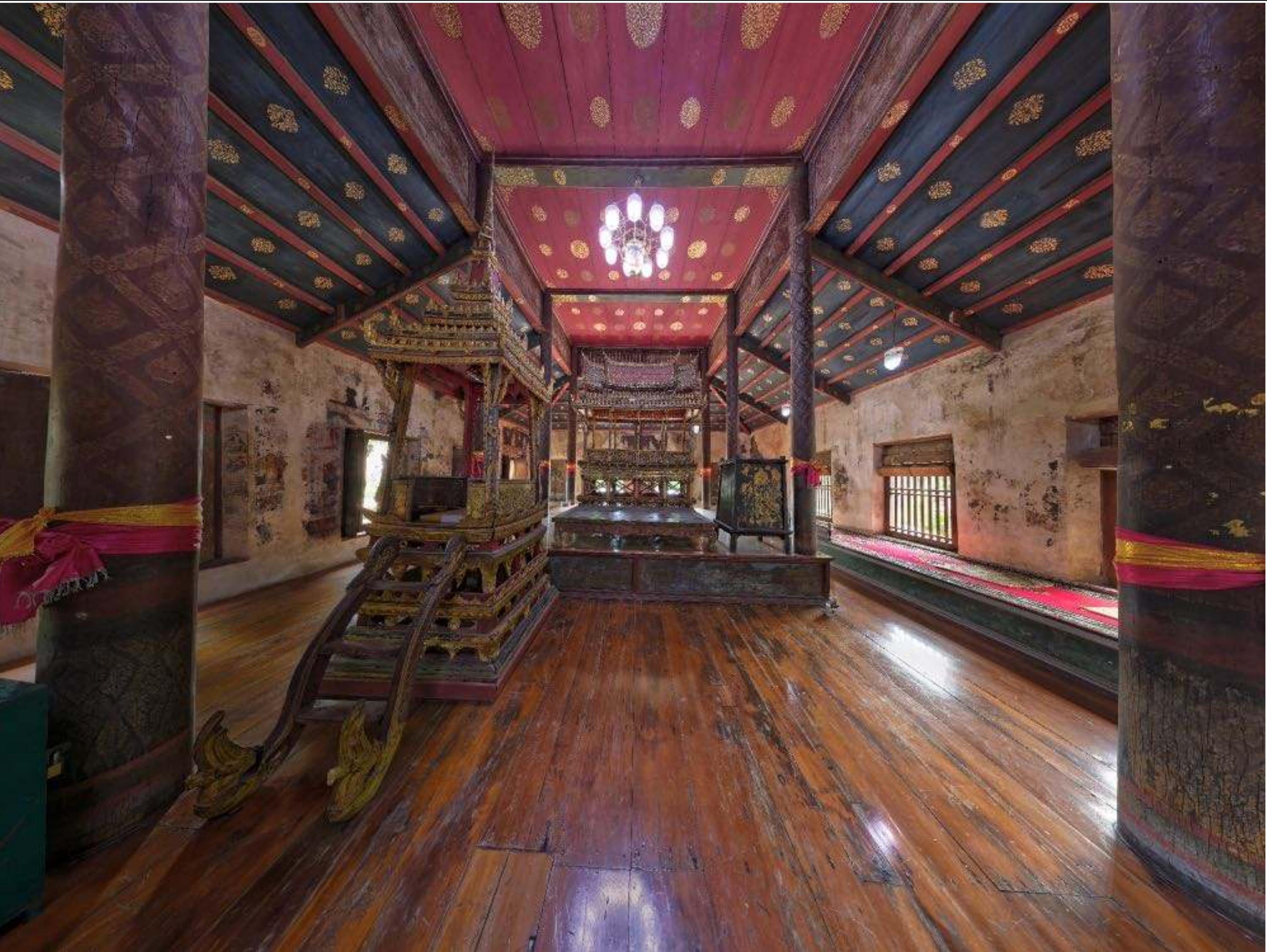
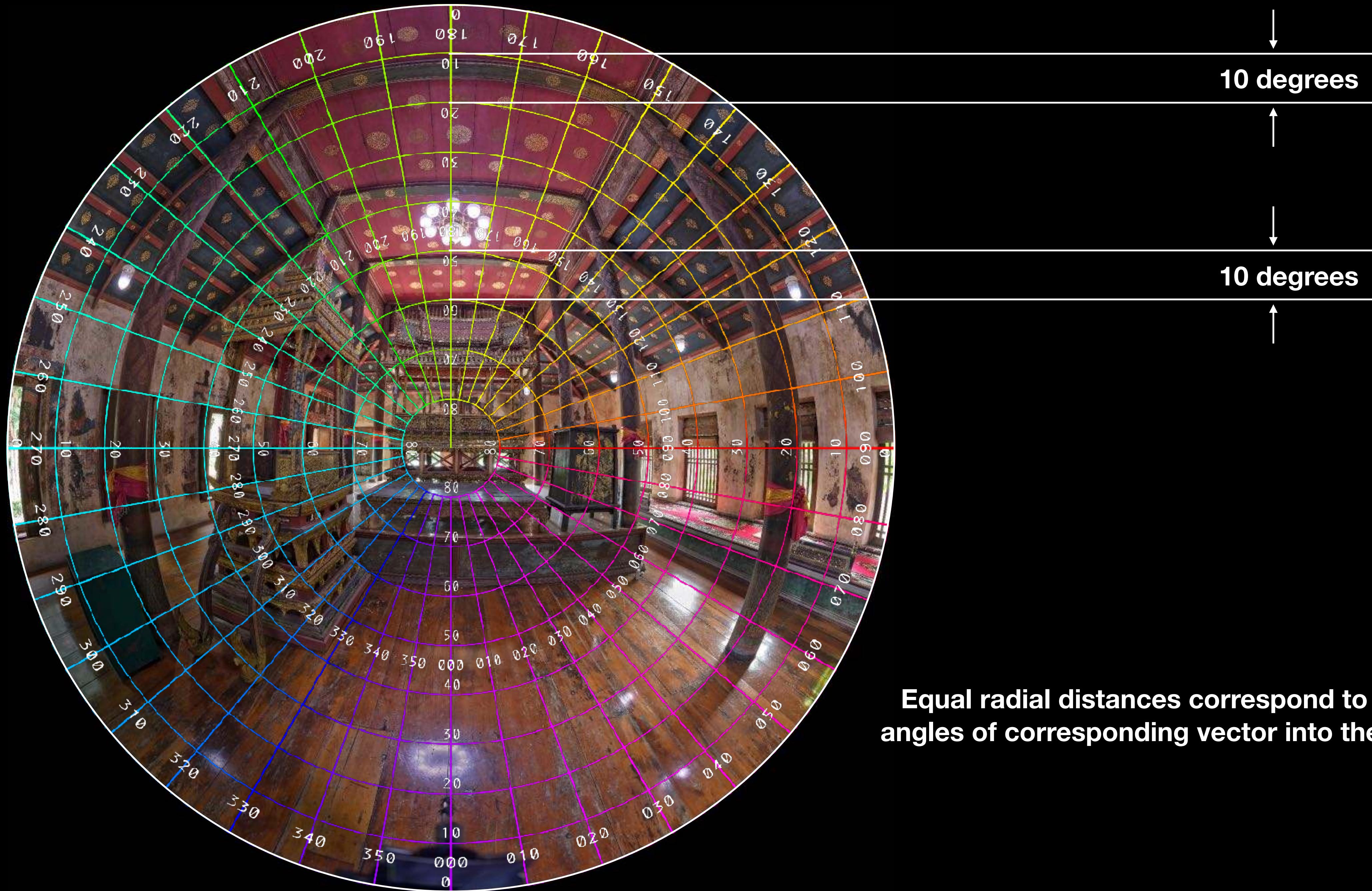


Image projections - Fisheye





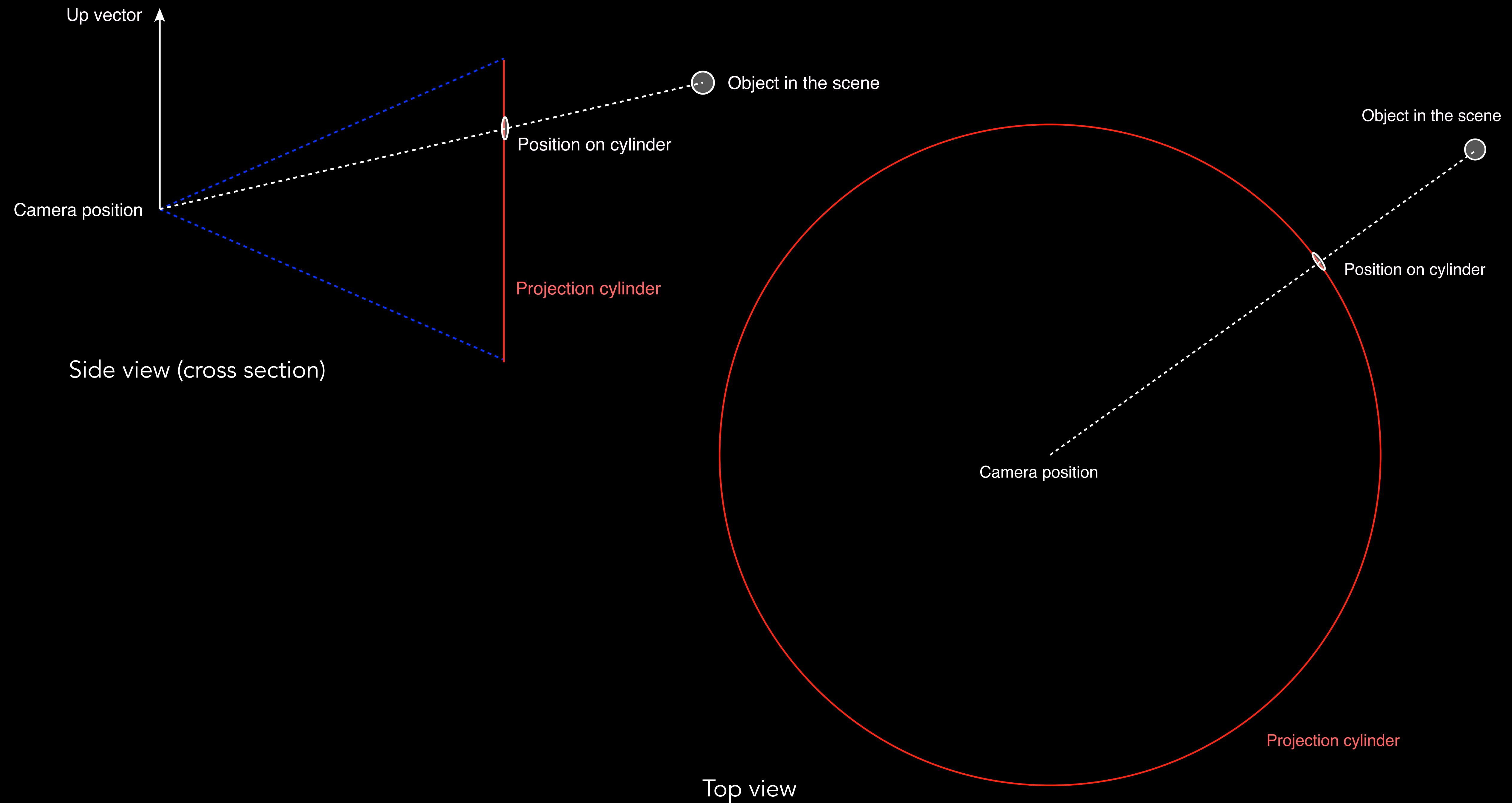
**Equal radial distances correspond to equal
angles of corresponding vector into the scene**



Image Projections - Cylindrical panorama

360 degrees





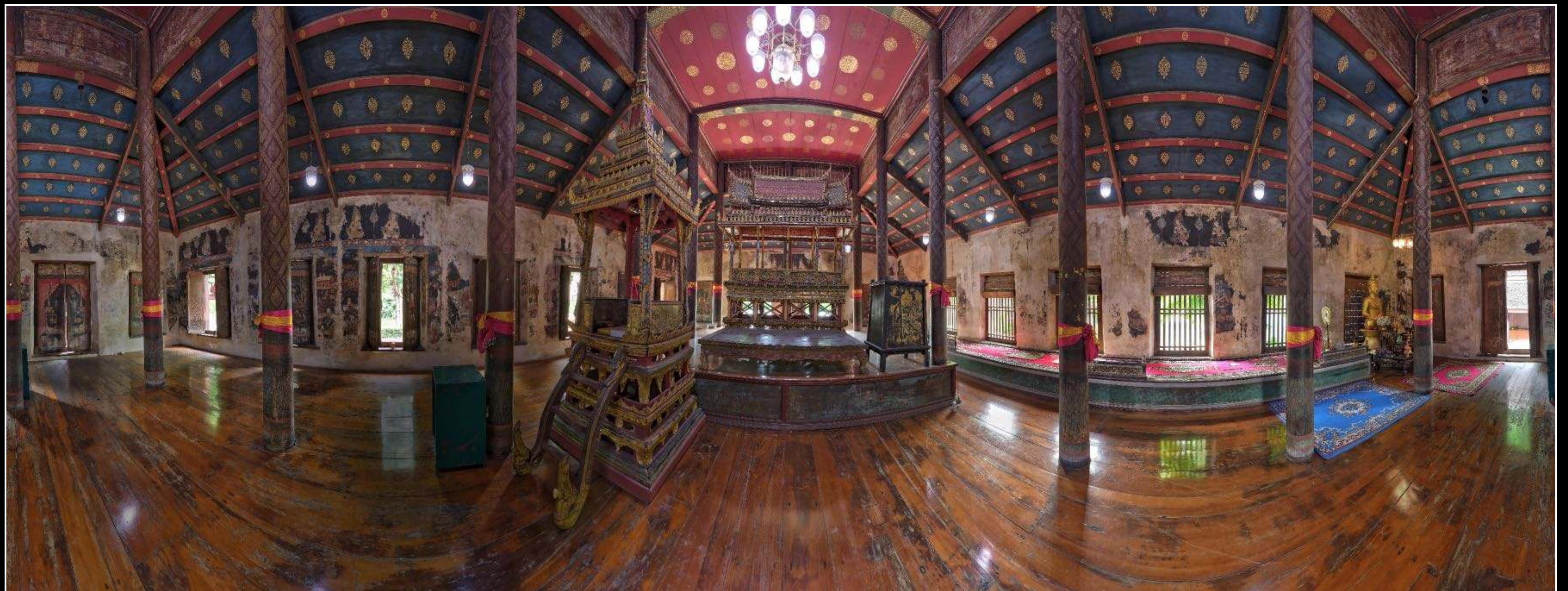




Image projections - Cubemaps

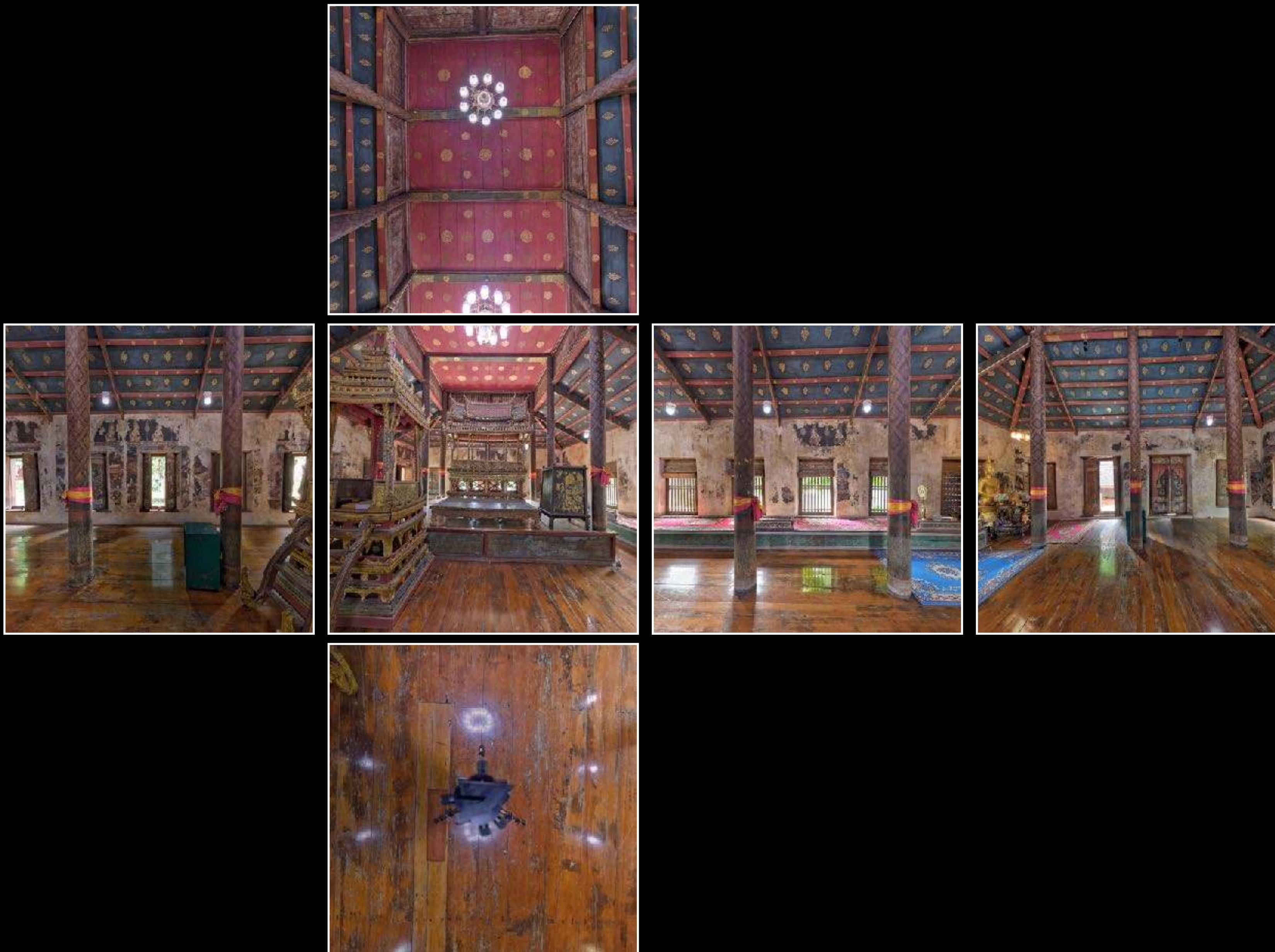
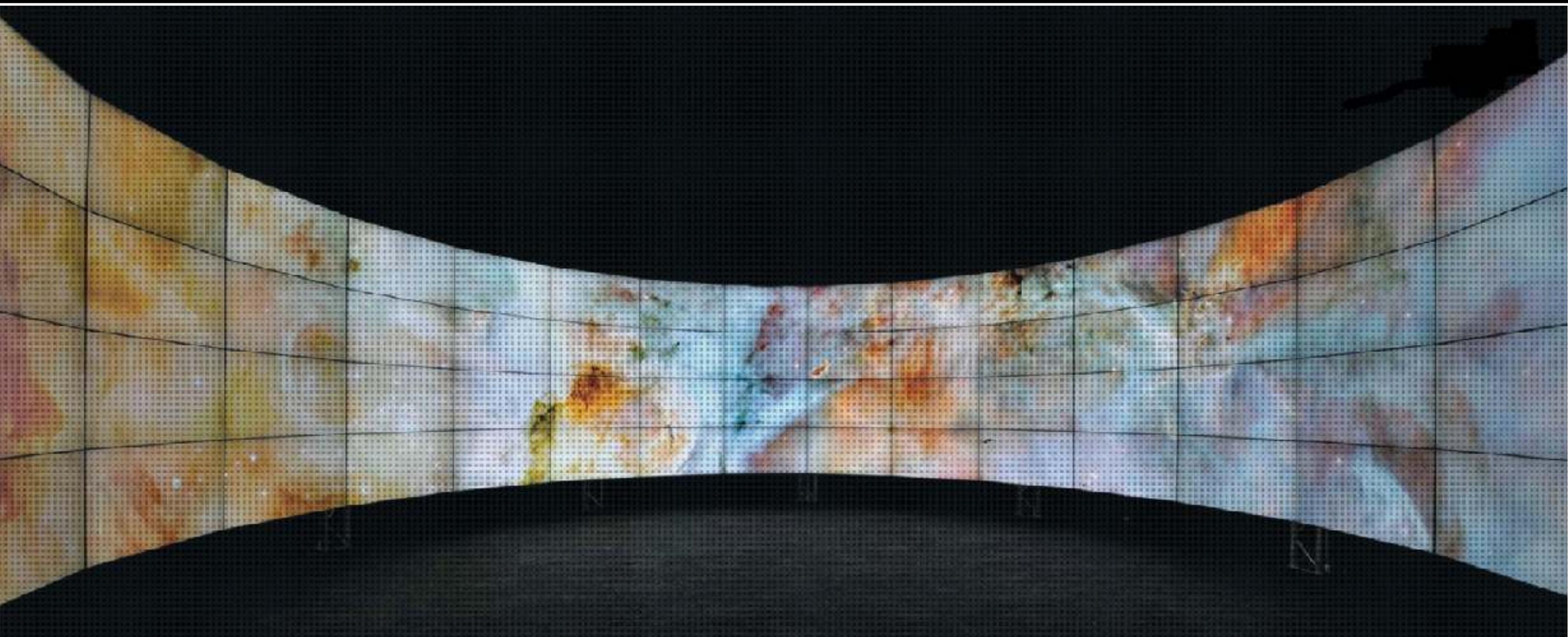


Image Projections - Equirectangular

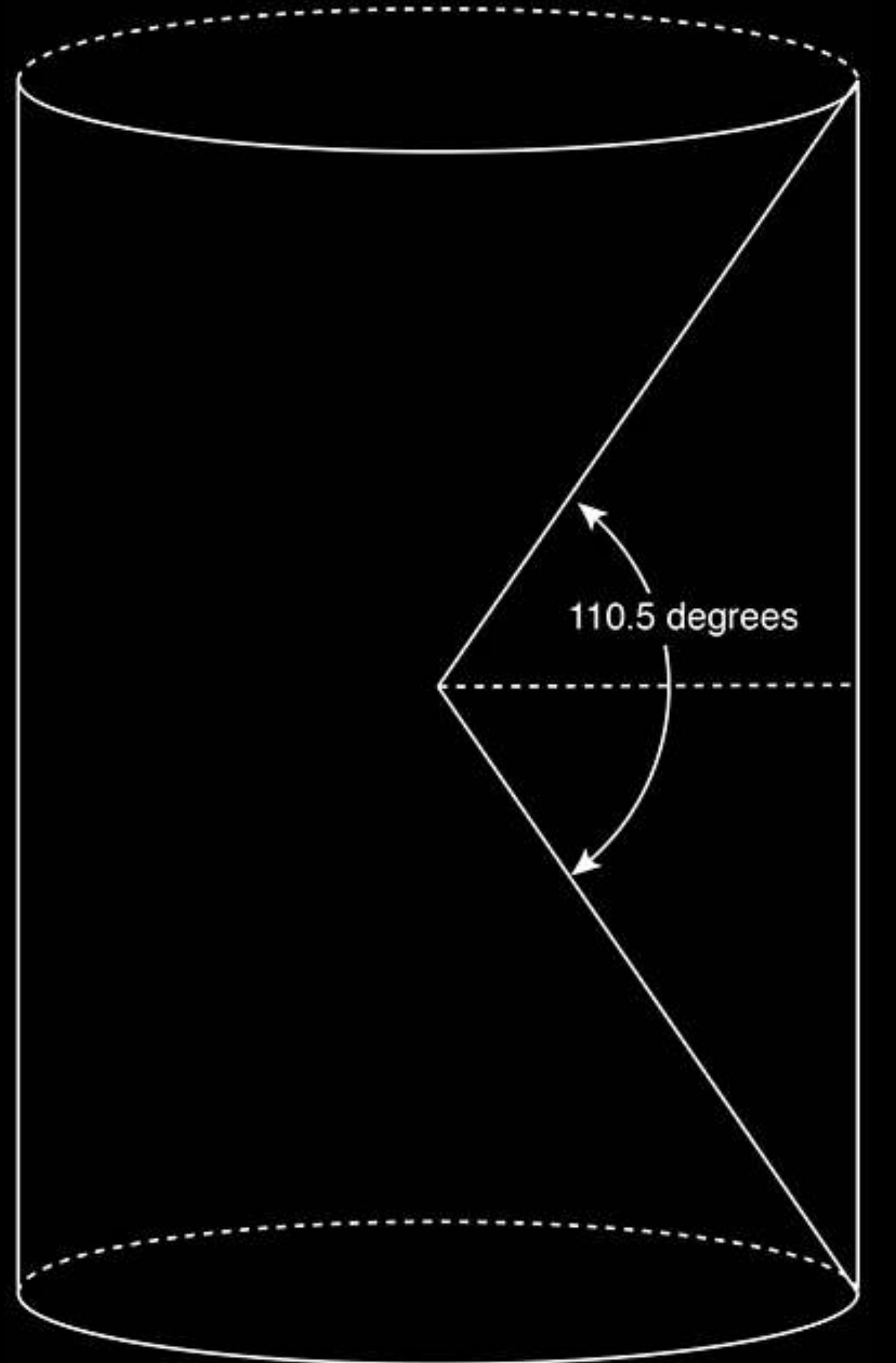


Display environments



University of the Sunshine Coast





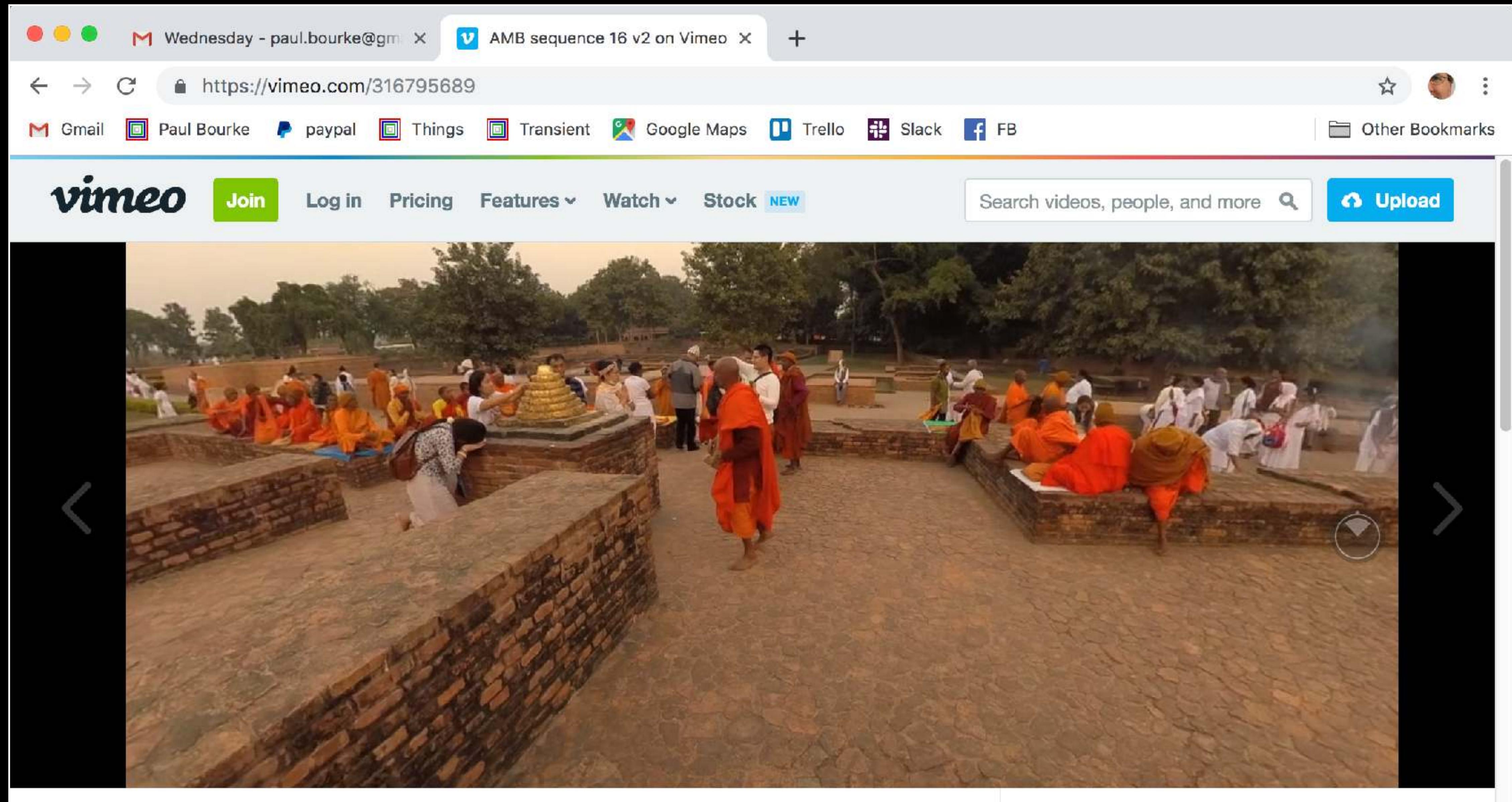
Domes





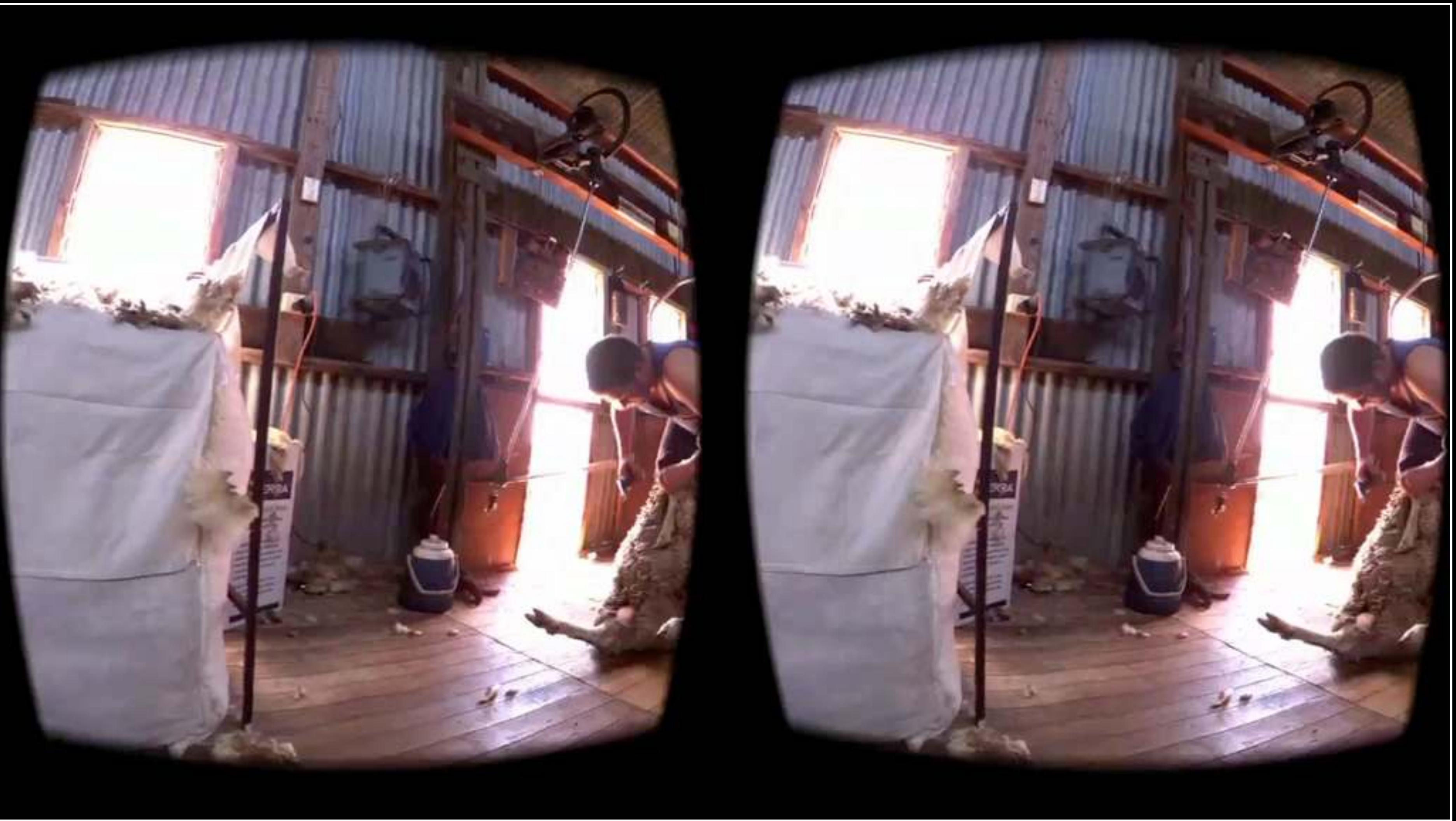


Perspective



Head mounted displays





Camera summary



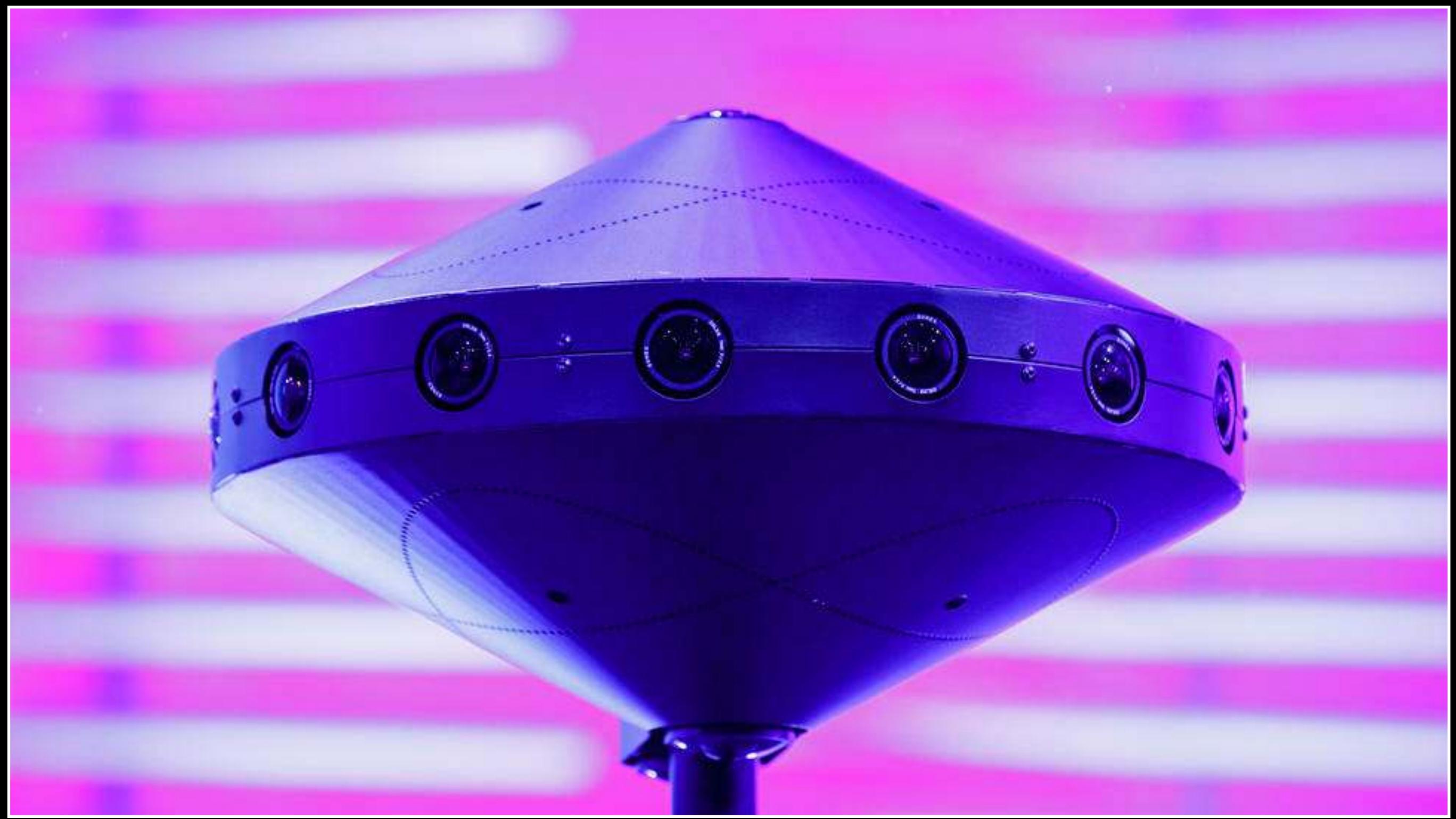














Ladybug-3

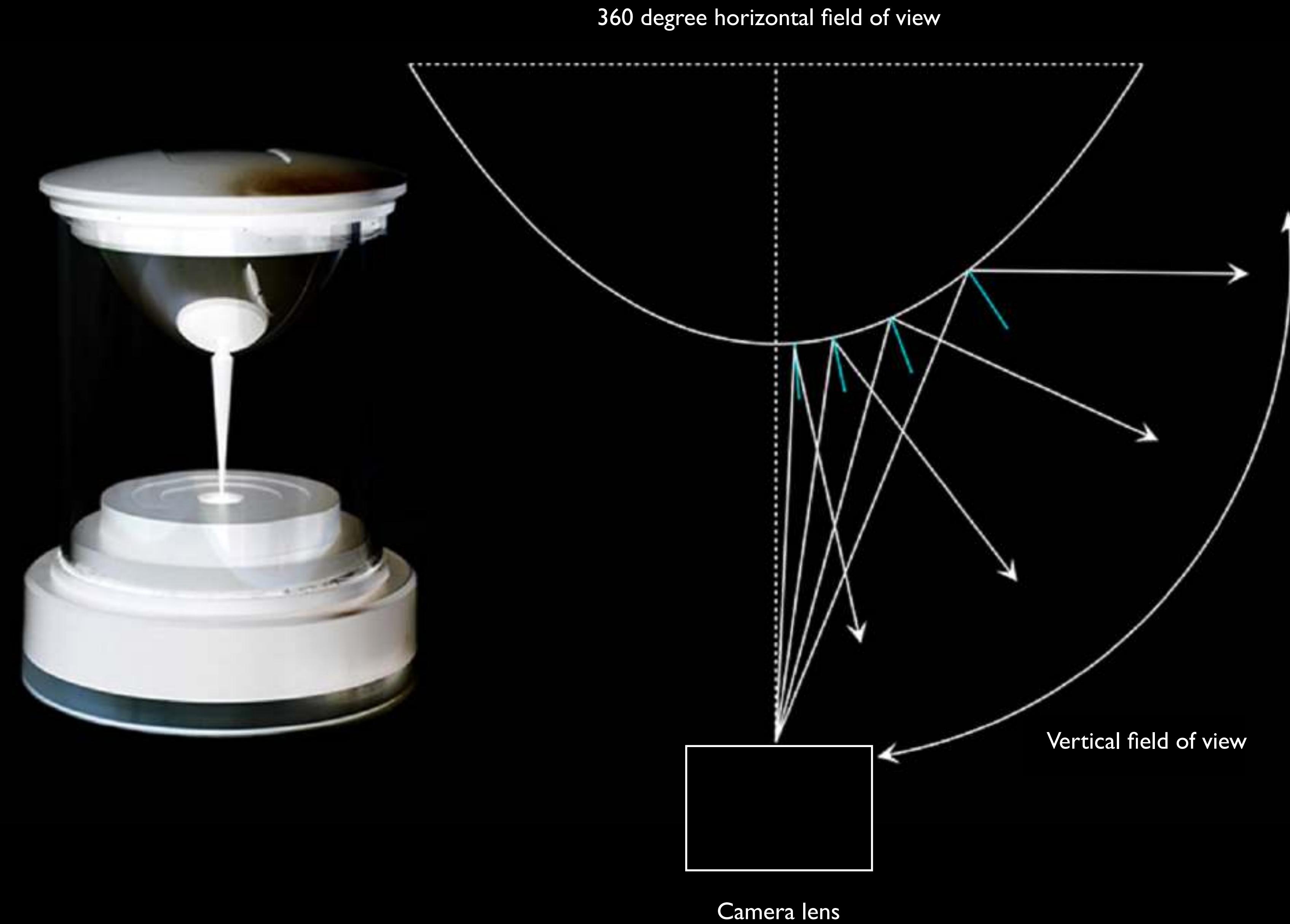


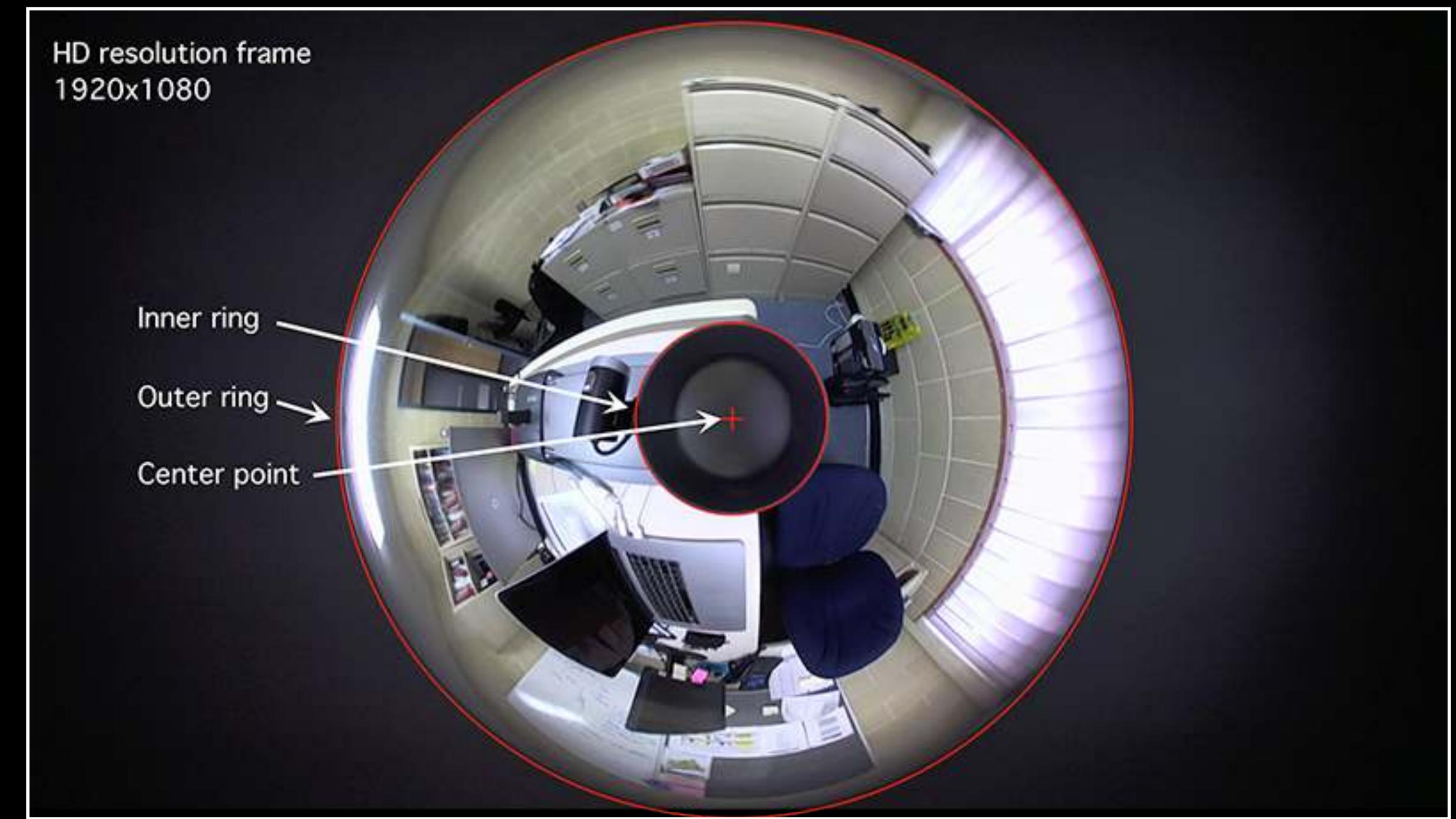
Insta360Pro-2



Garmin Virb

Single camera







Entaniya 250 degree fisheye







Single camera merits

Advantages:

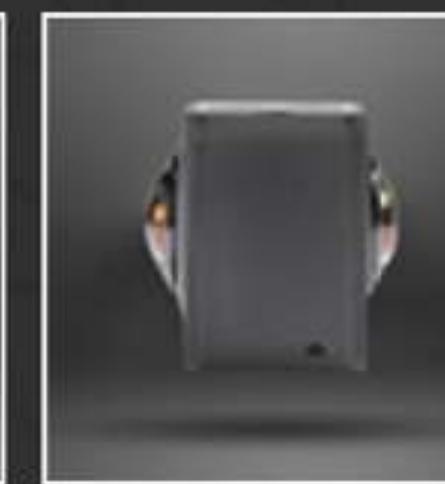
Simple - Small - No blending - No parallax errors

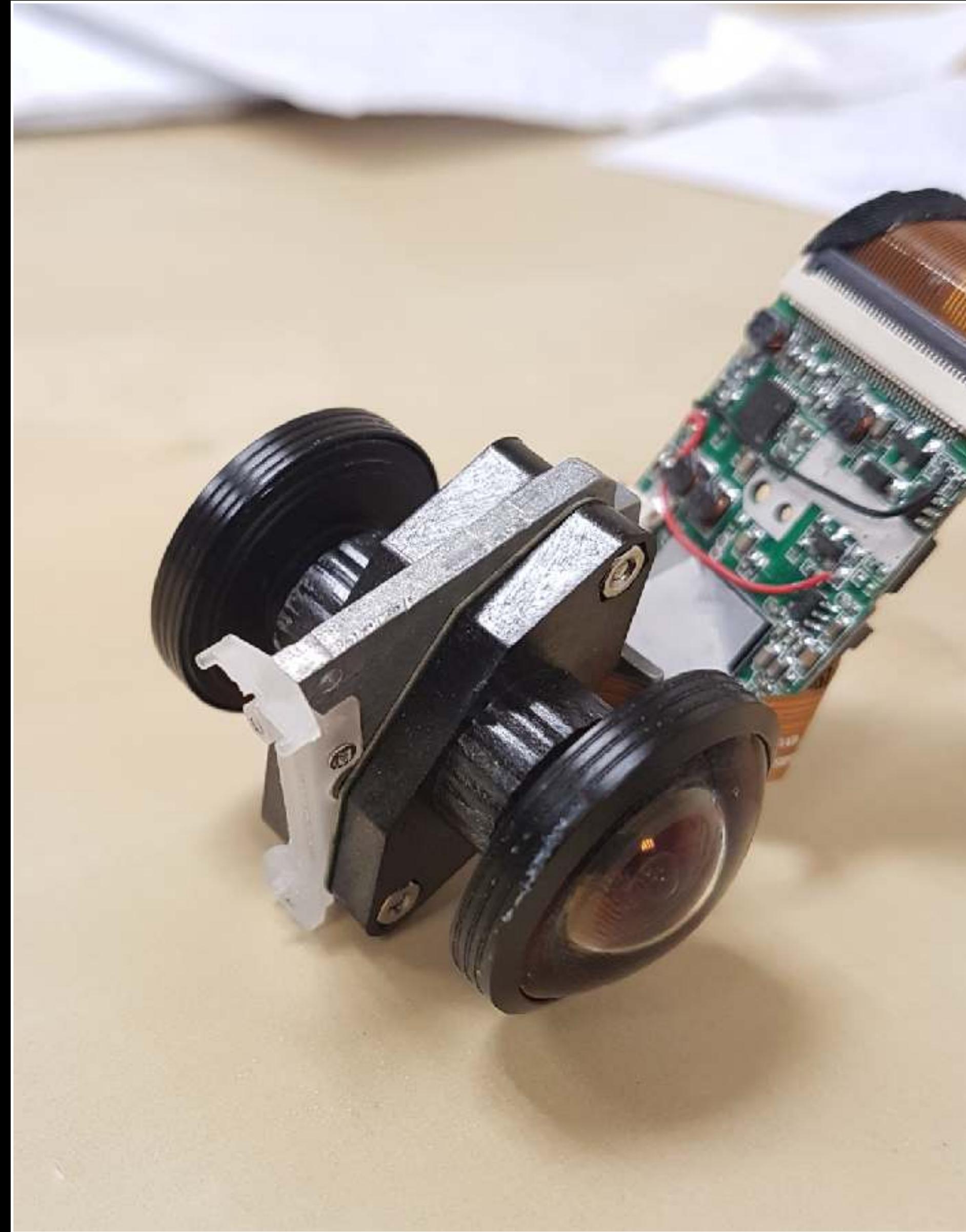
Disadvantages:

Doesn't capture whole 360x180 field of view

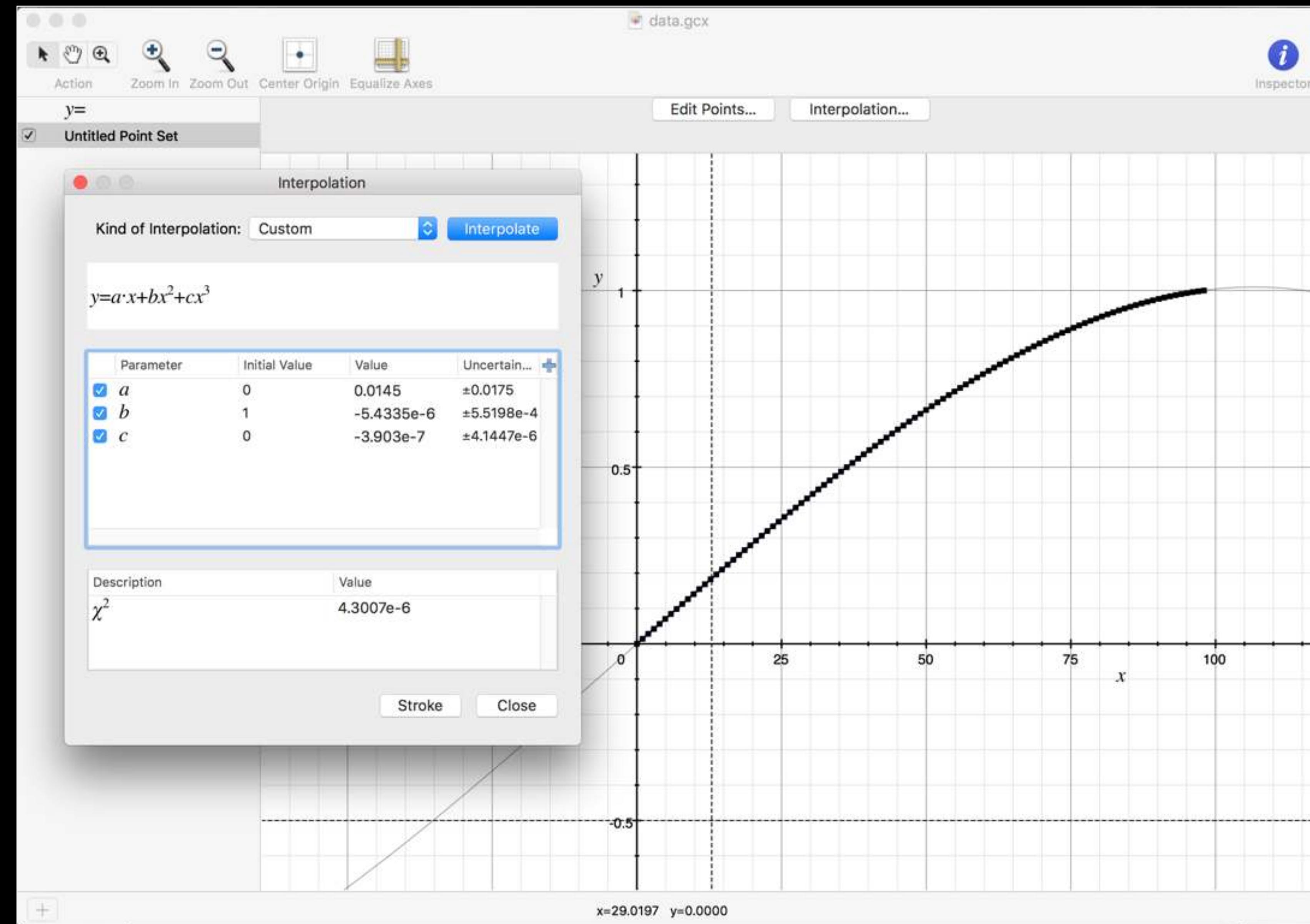
Doesn't scale!

Dual cameras



















Dual camera merits

Advantages:

Small - Single blend line - Higher resolution than single camera

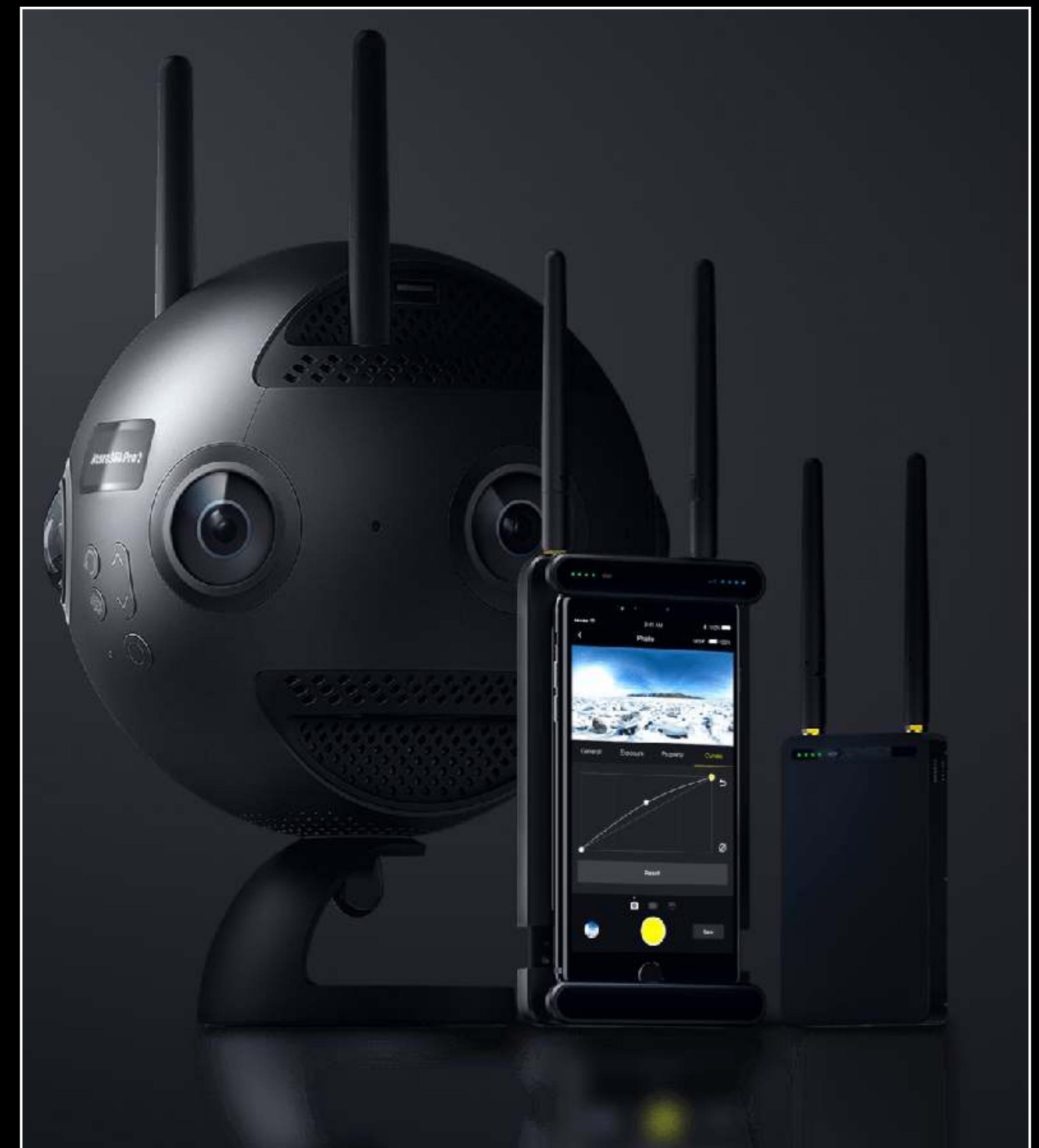
Disadvantages:

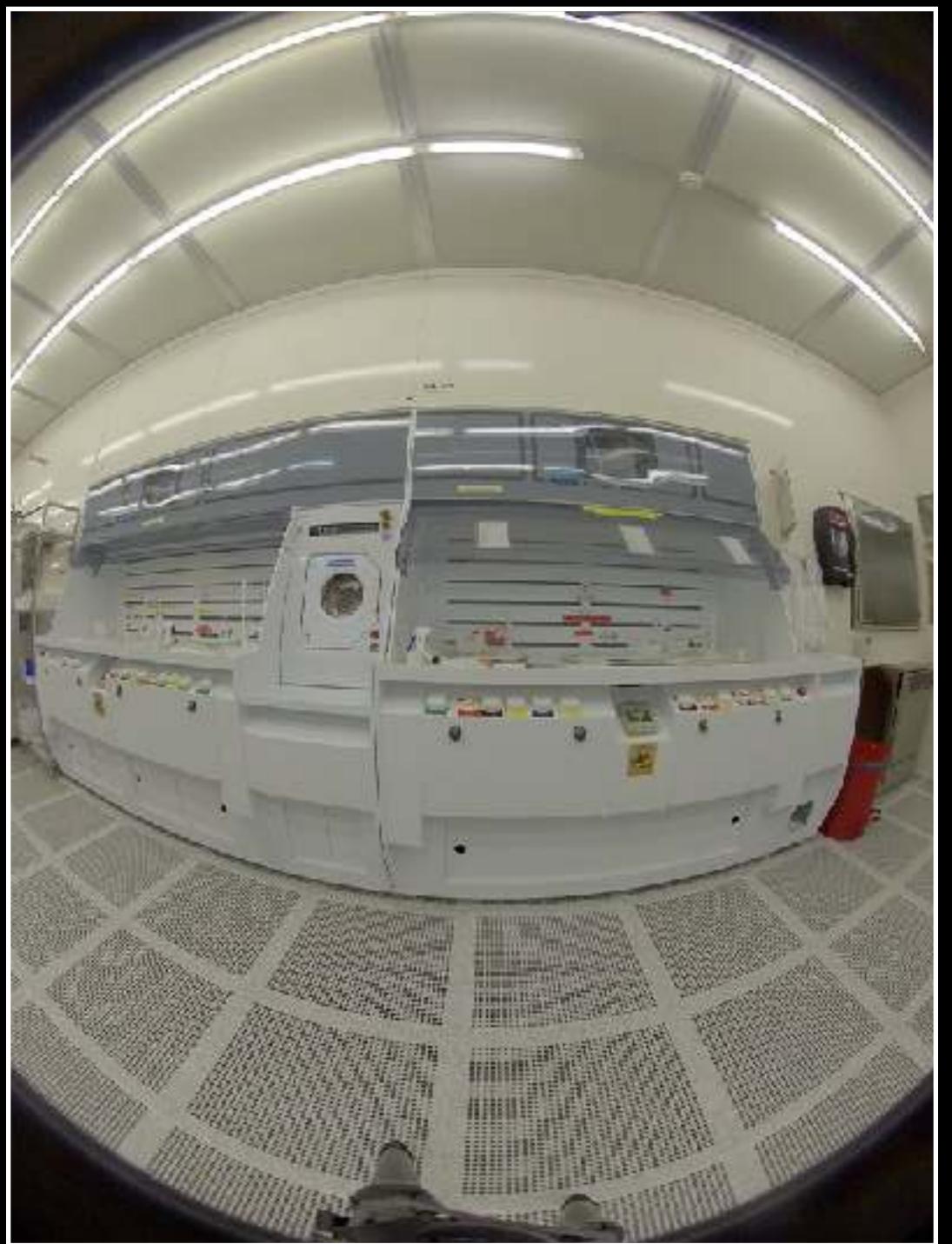
Doesn't scale!

Cannot support stereoscopic 3D

Multiple cameras (>2)

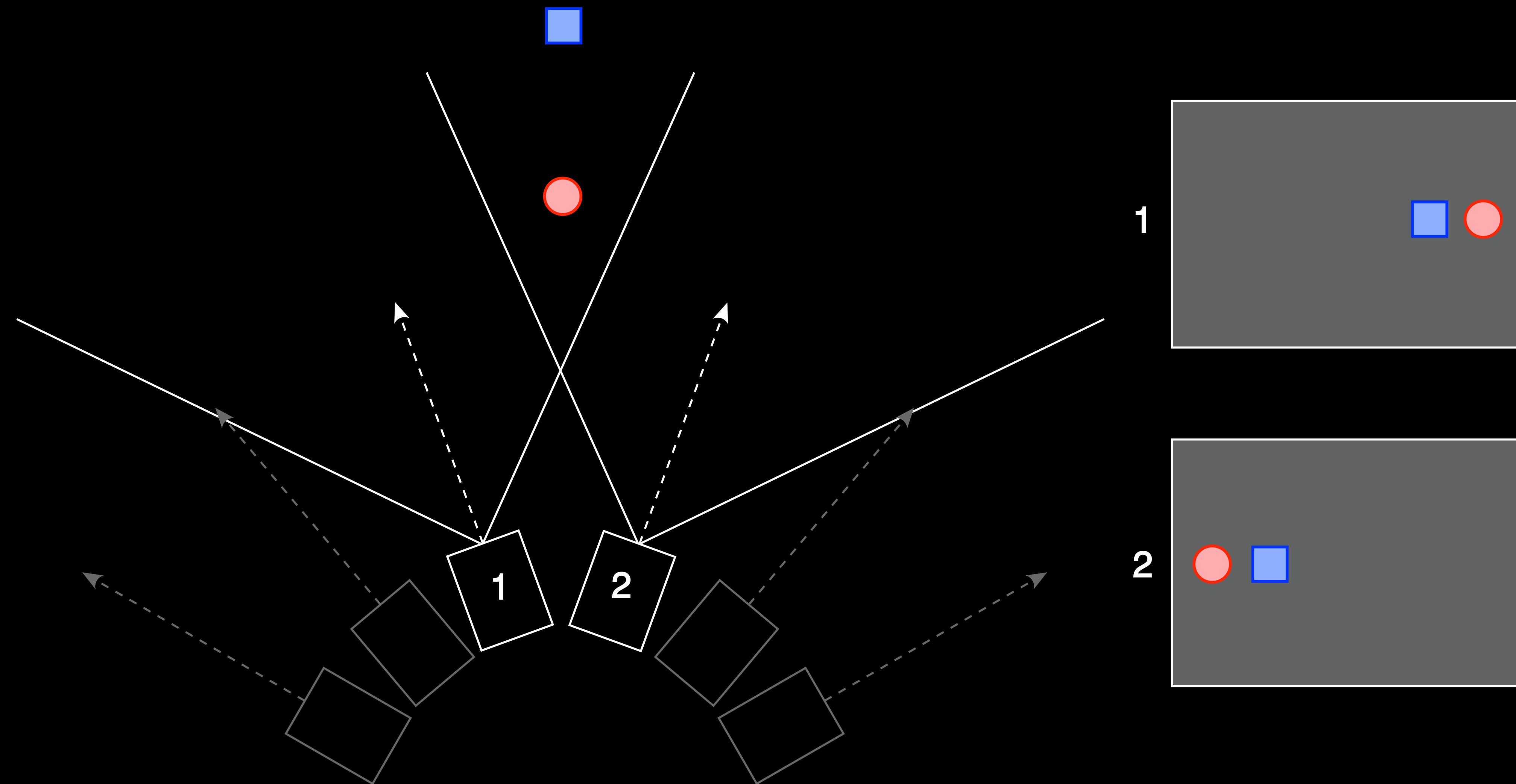
- Will focus on the Insta360Pro2
- 6 Camera/lenses
- One microSD card per camera
- Maximum resolution 7680 x 3840 @ 30fps
- Long range live feed and control
- Built in stabilisation

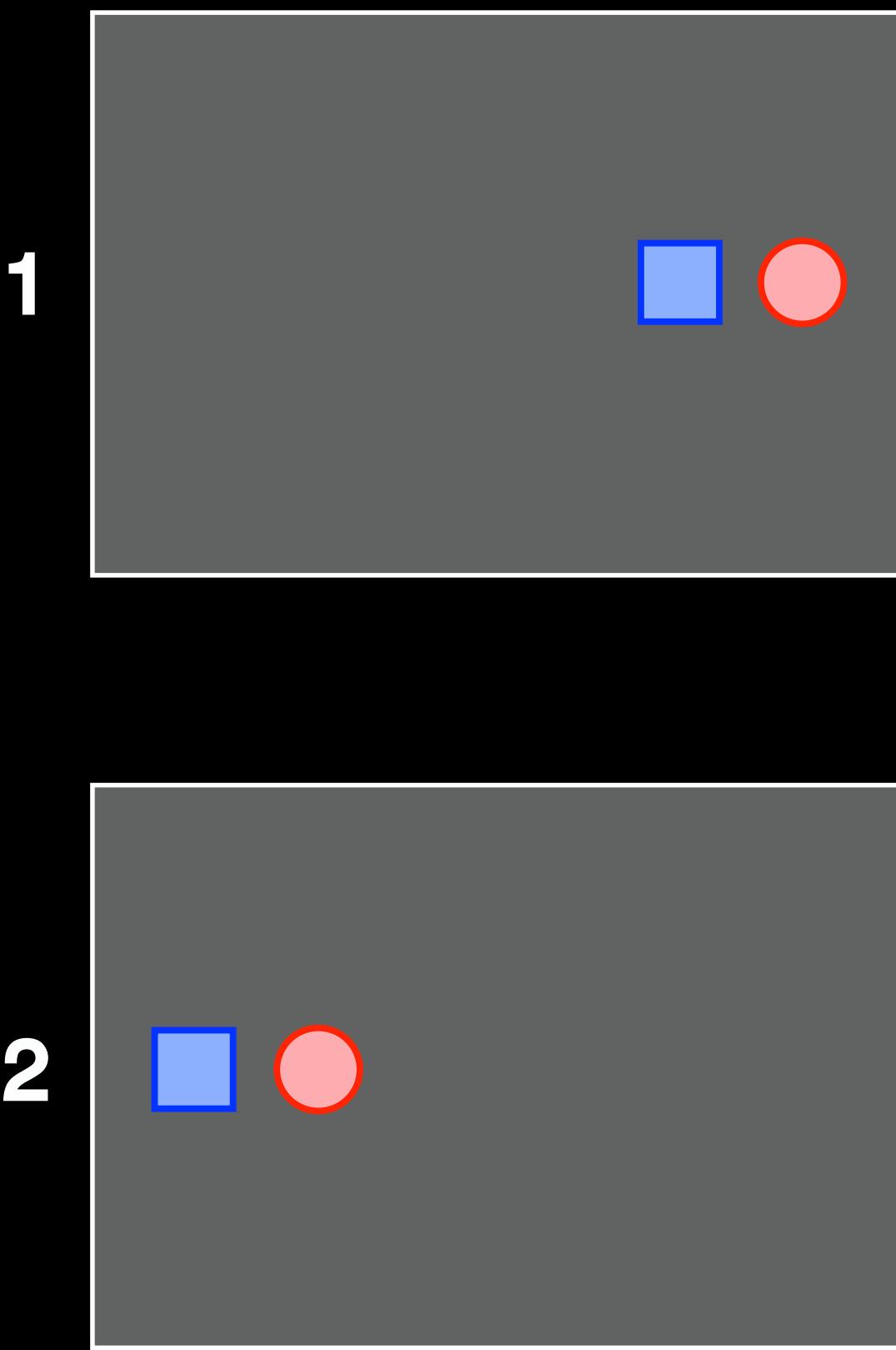
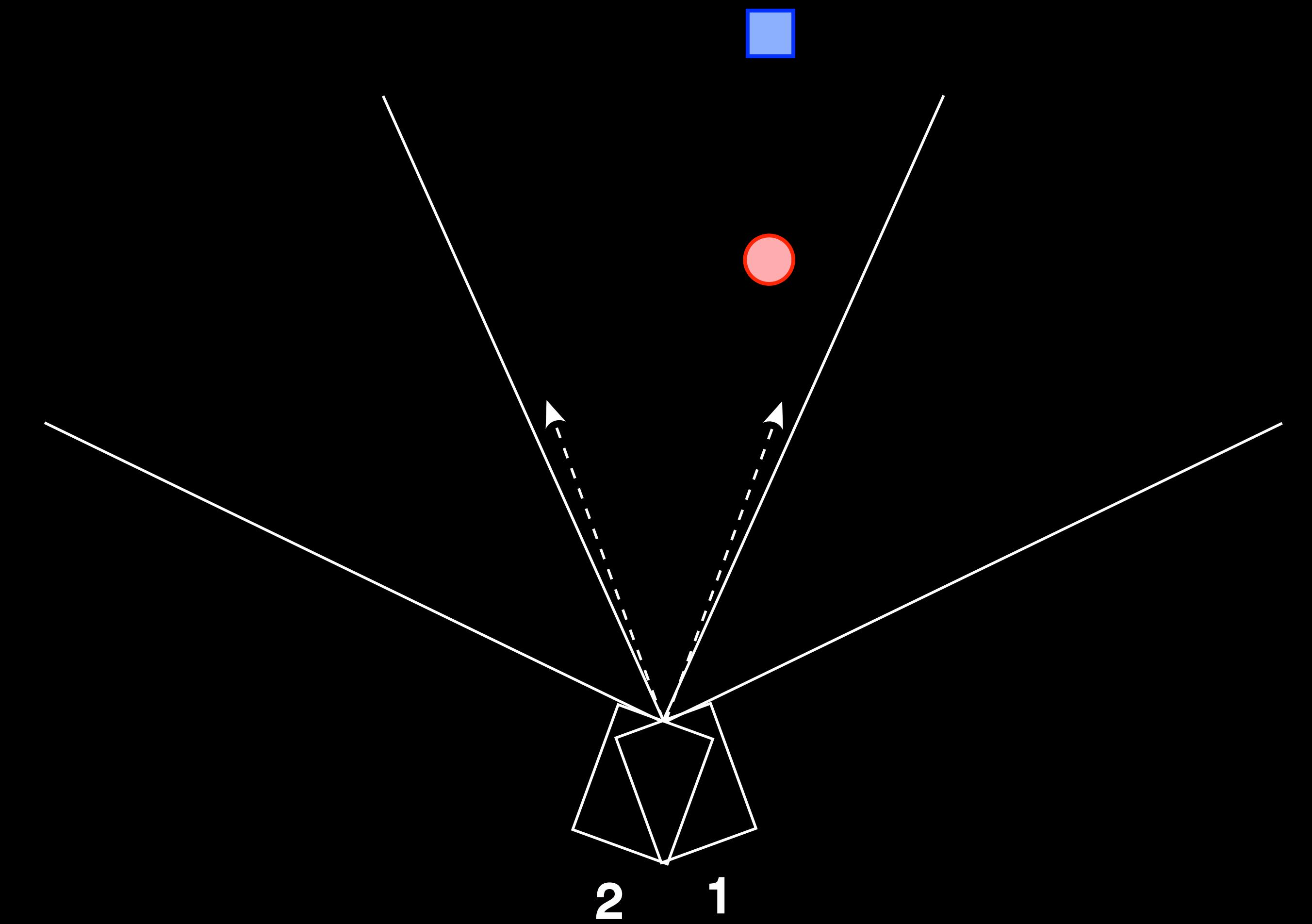




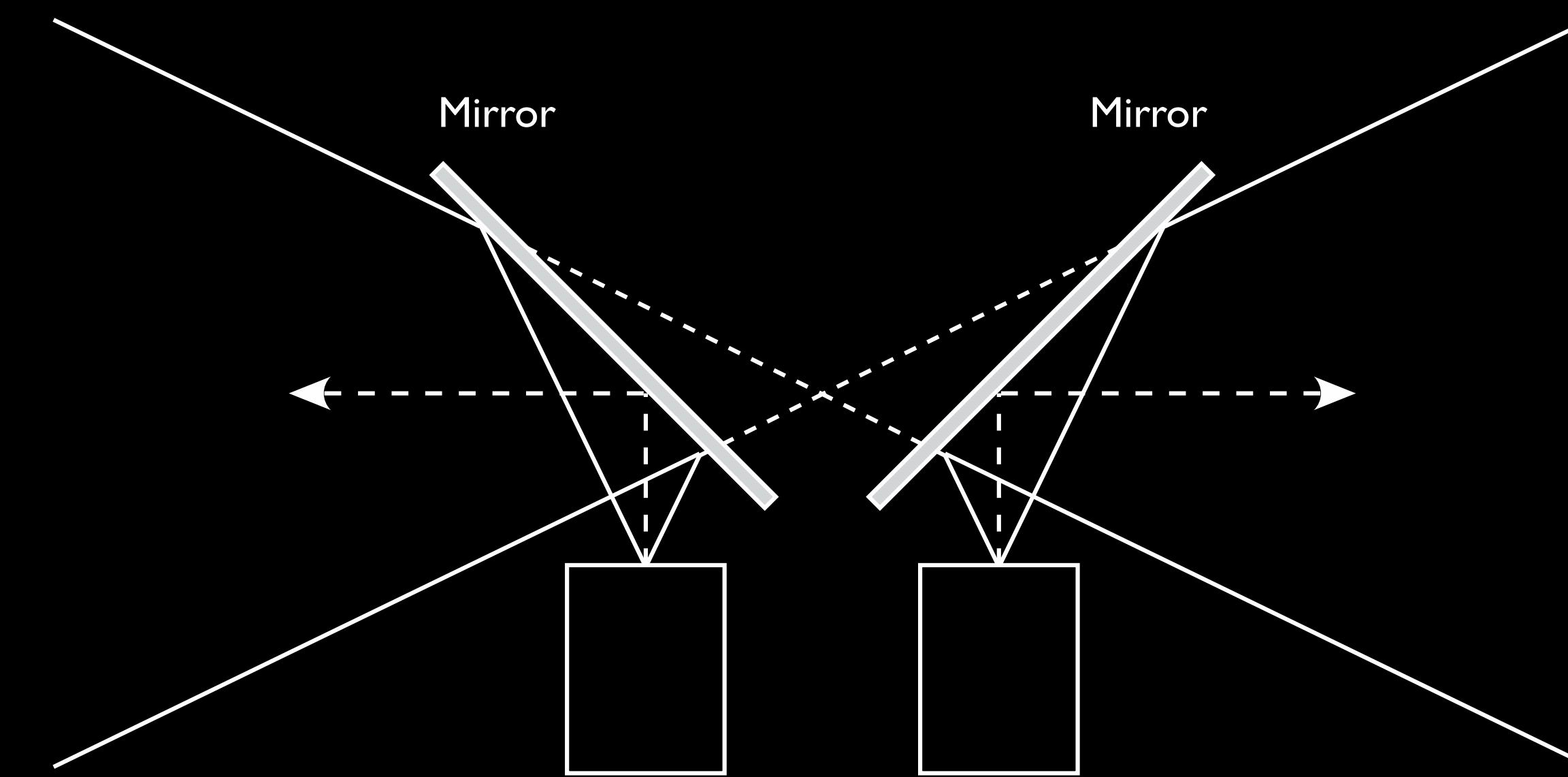
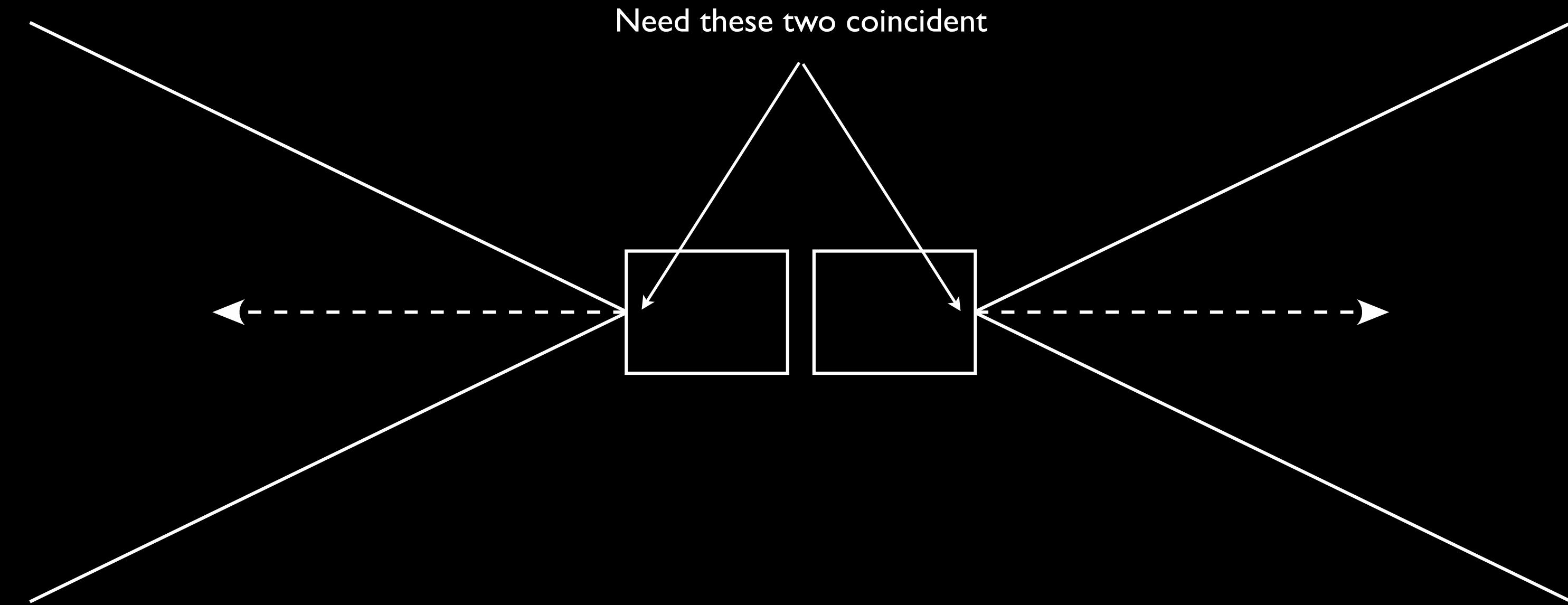


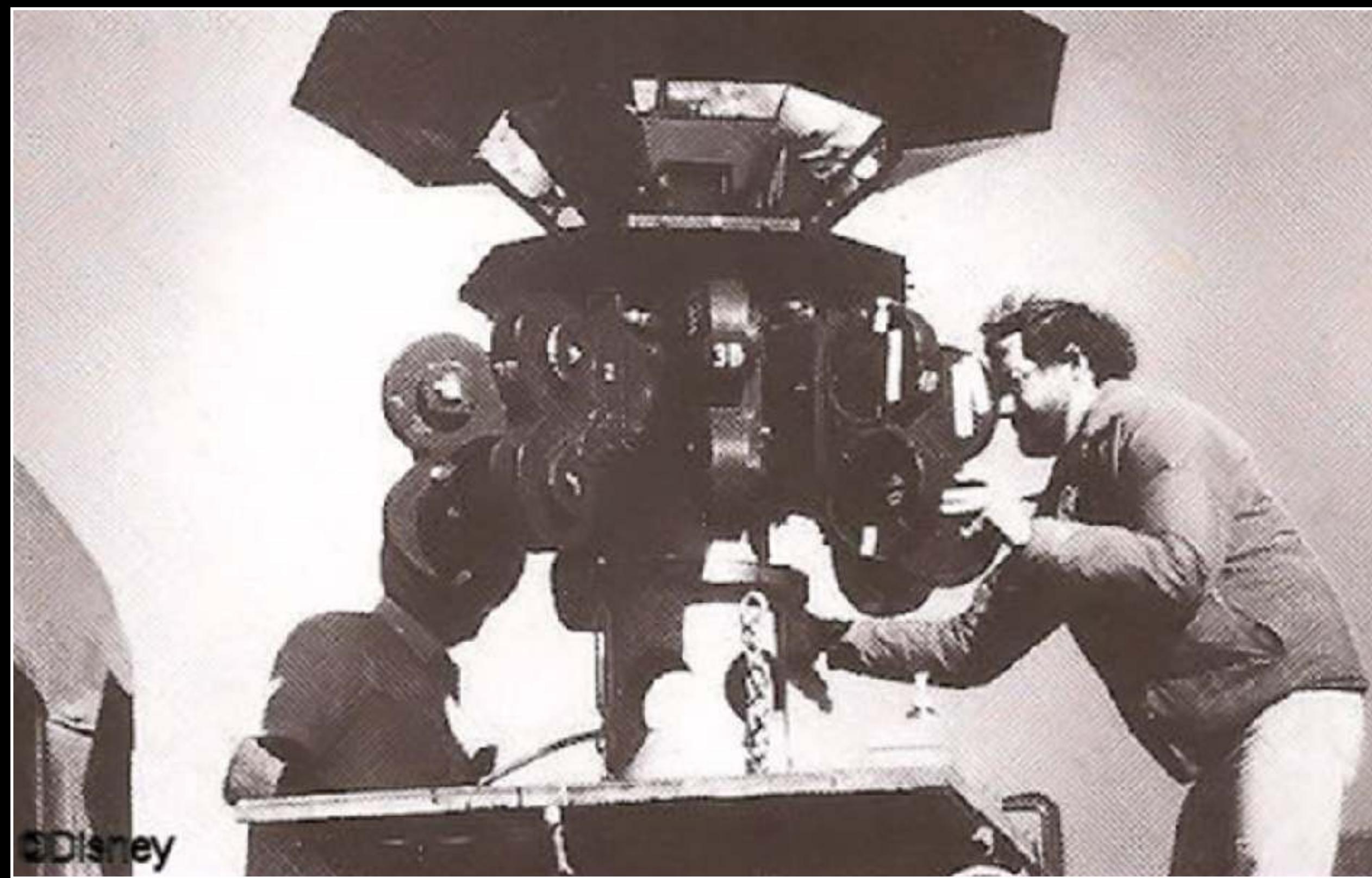
The fundamental problem





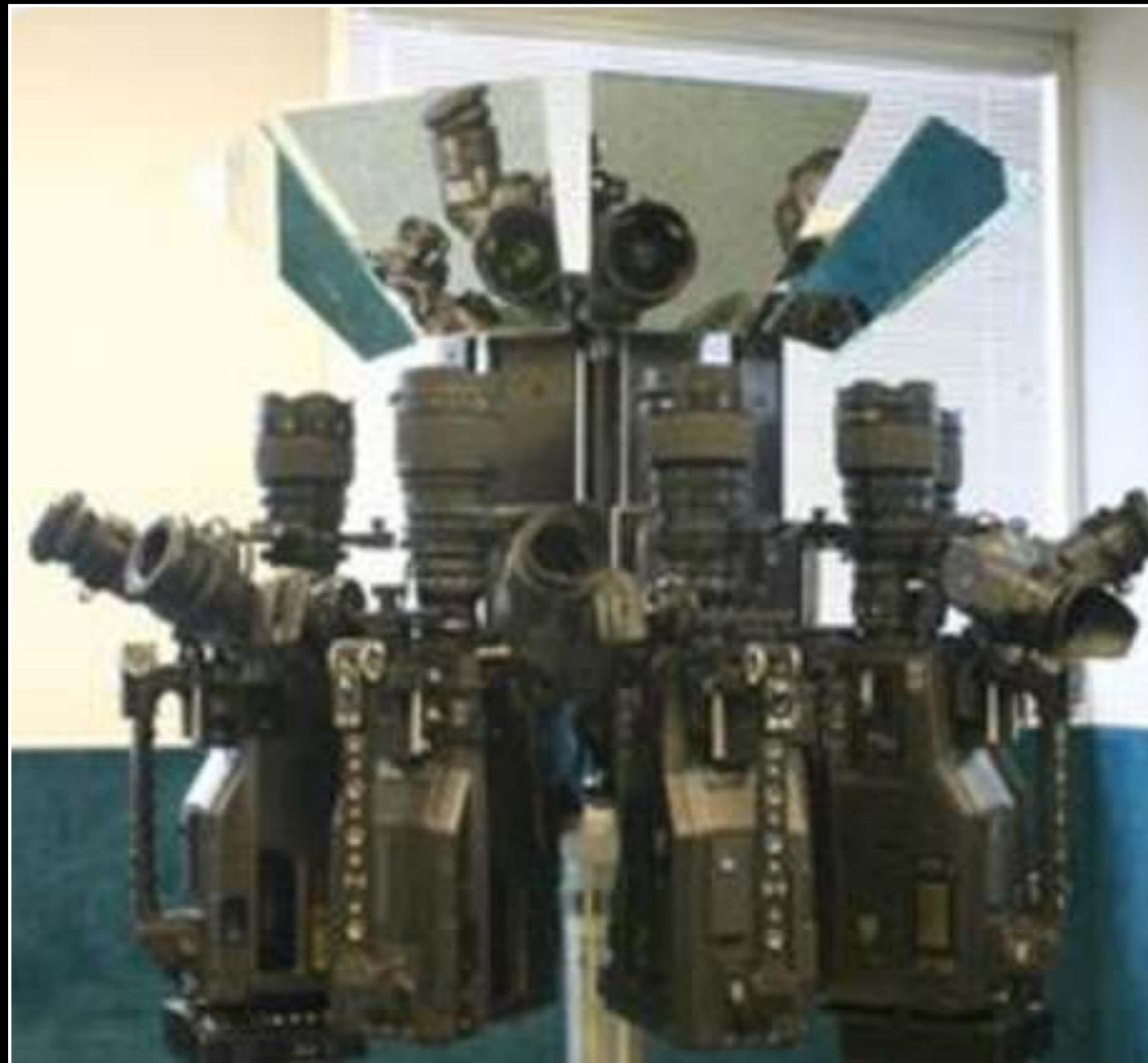
Solutions - Mirrors

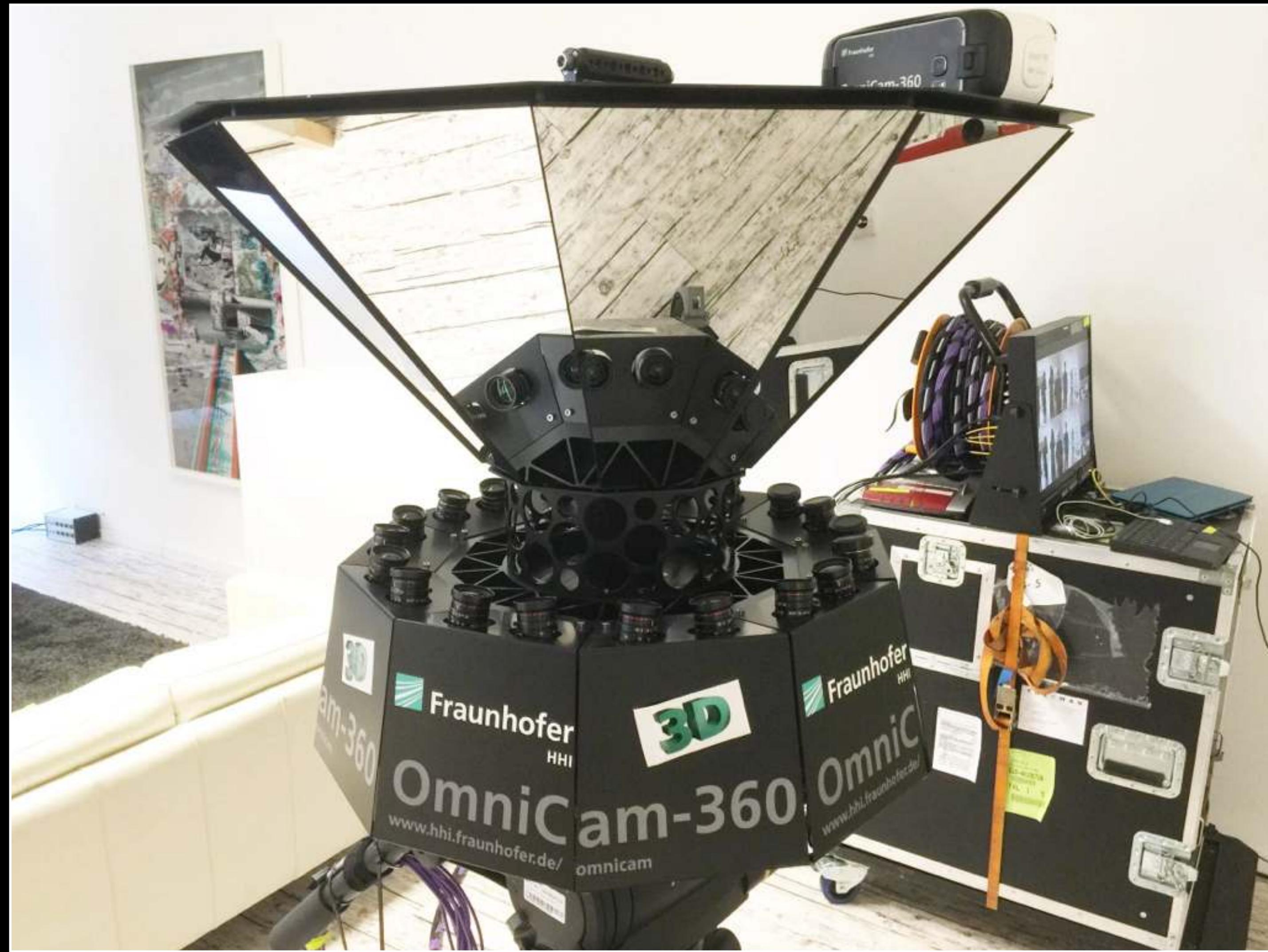




Circlorama camera #2 (Disney)







(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)

References Cited

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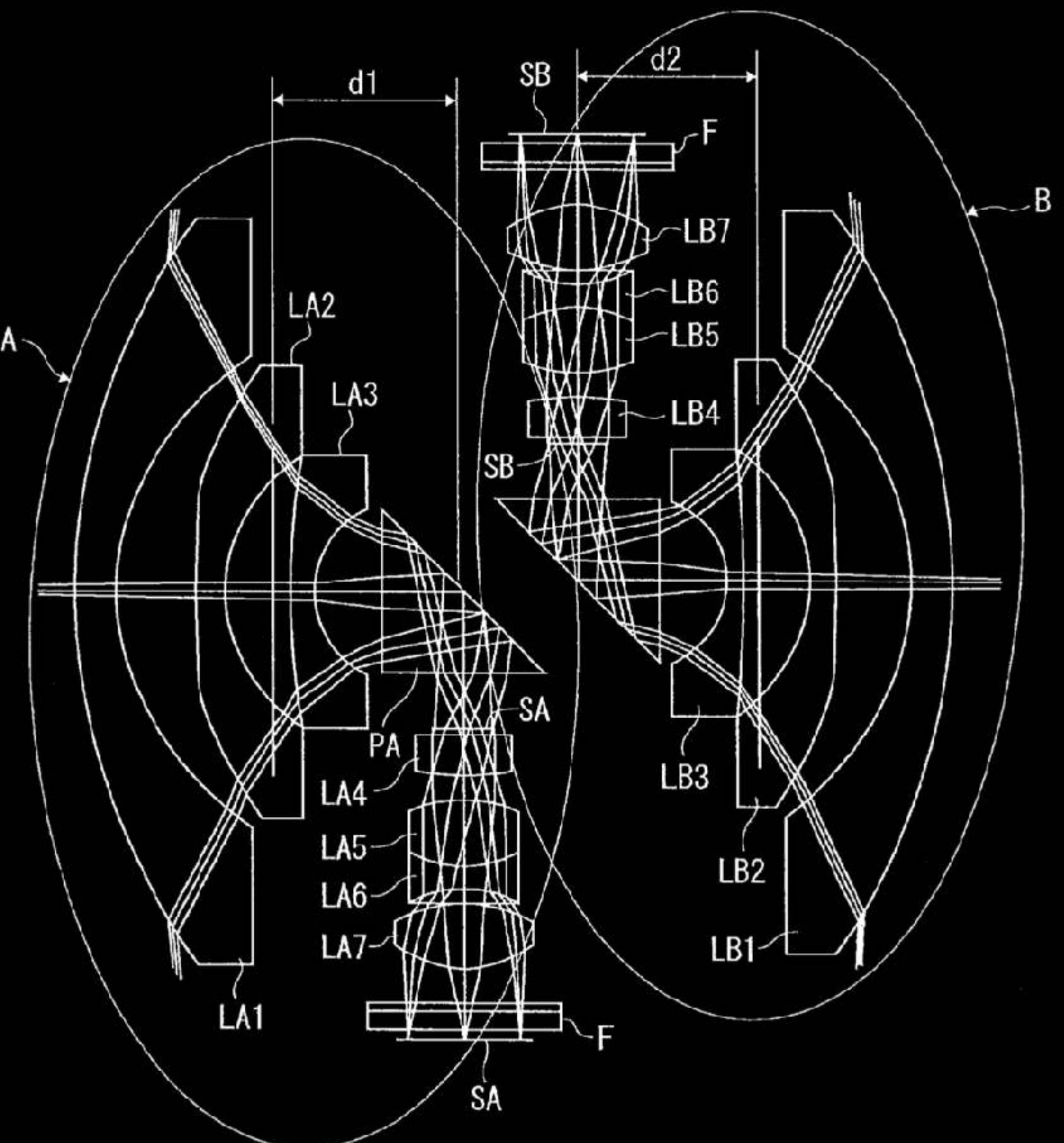
3,283,653 A 11/1966 Tokarzewski
7,154,551 B2 * 12/2006 Kuriyama et al. 348/335
(Continued)

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JP 2007-164079 6/2007

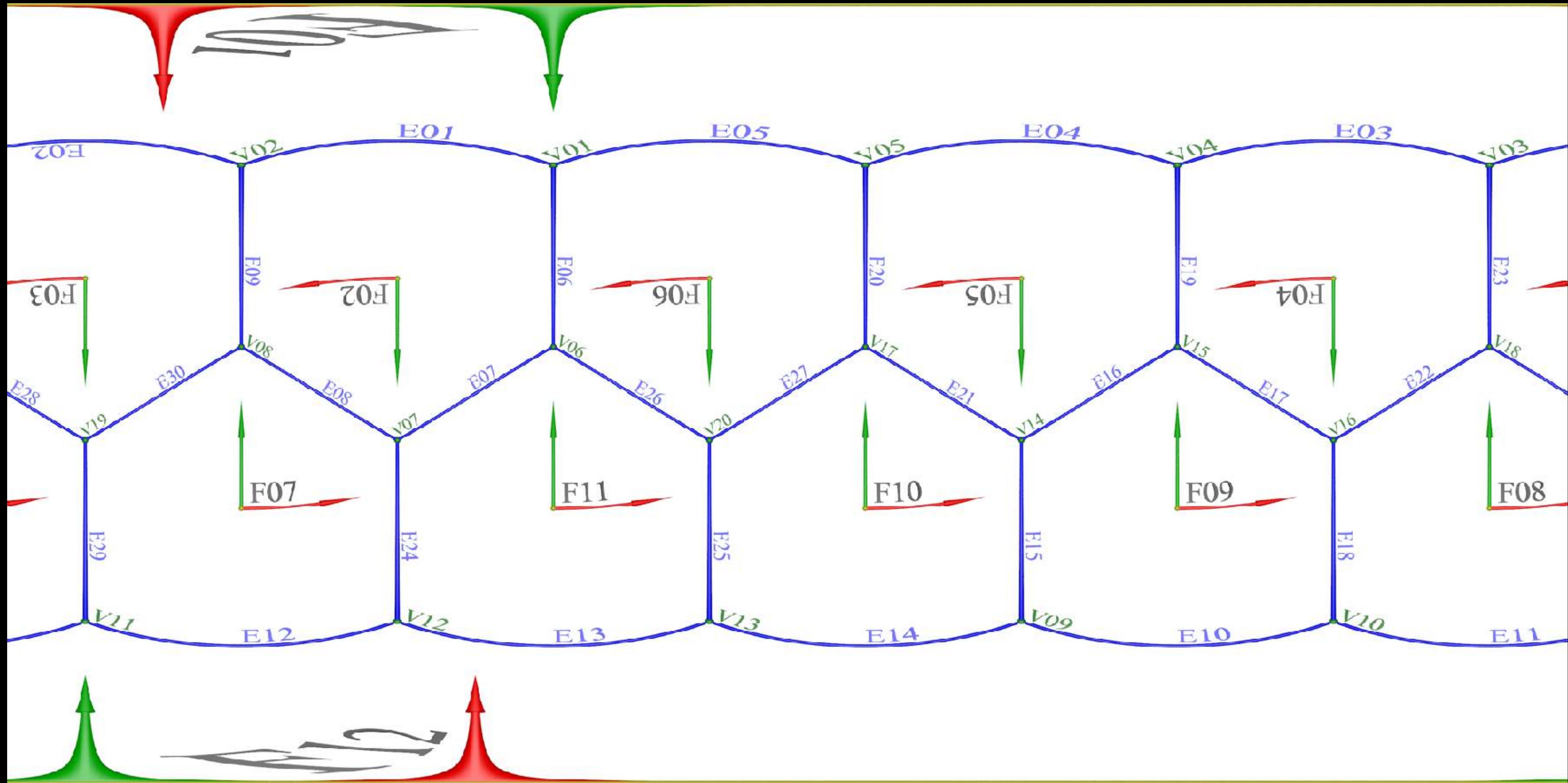
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FIG. 1

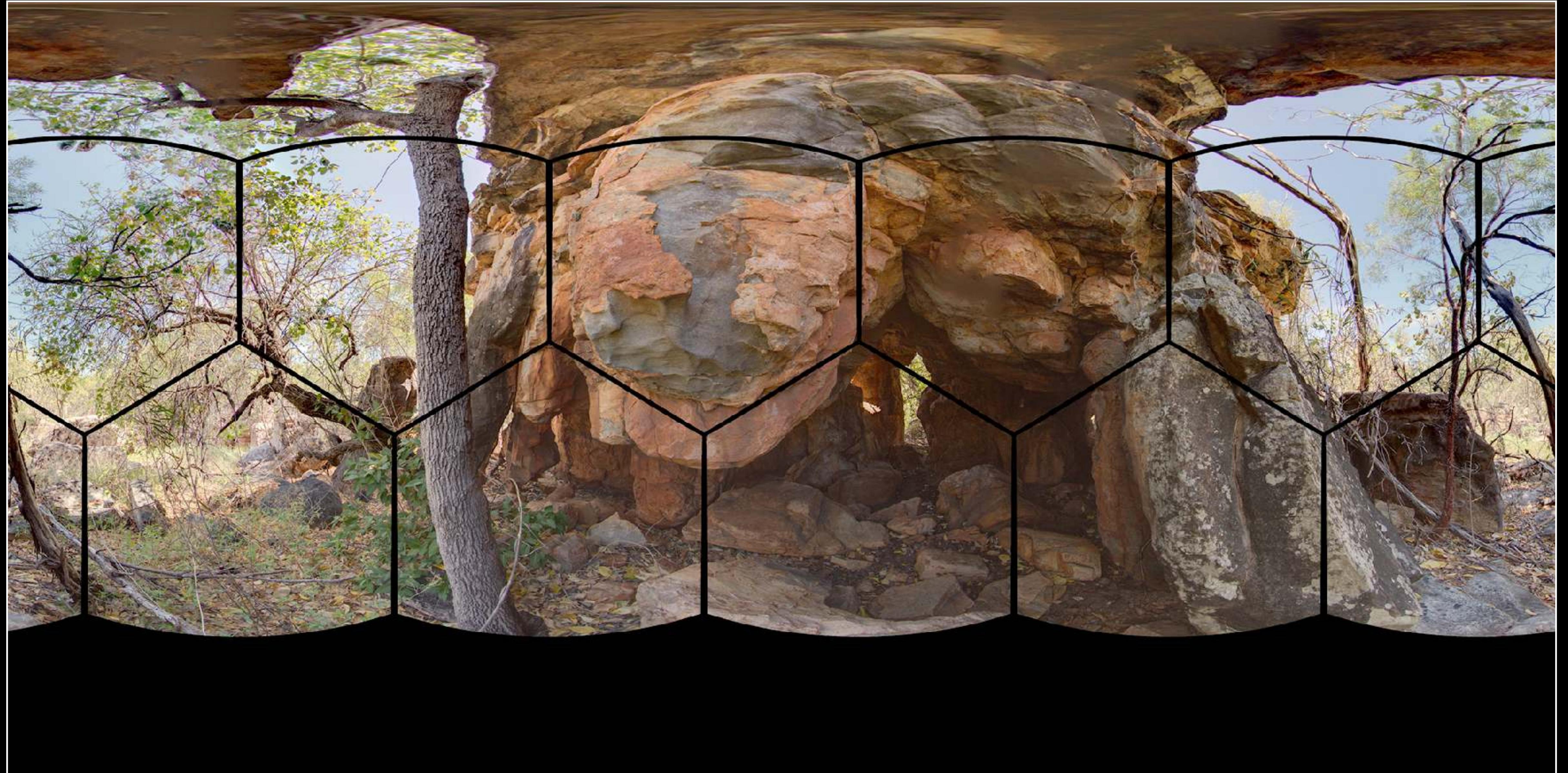


Solutions - Custom Optics









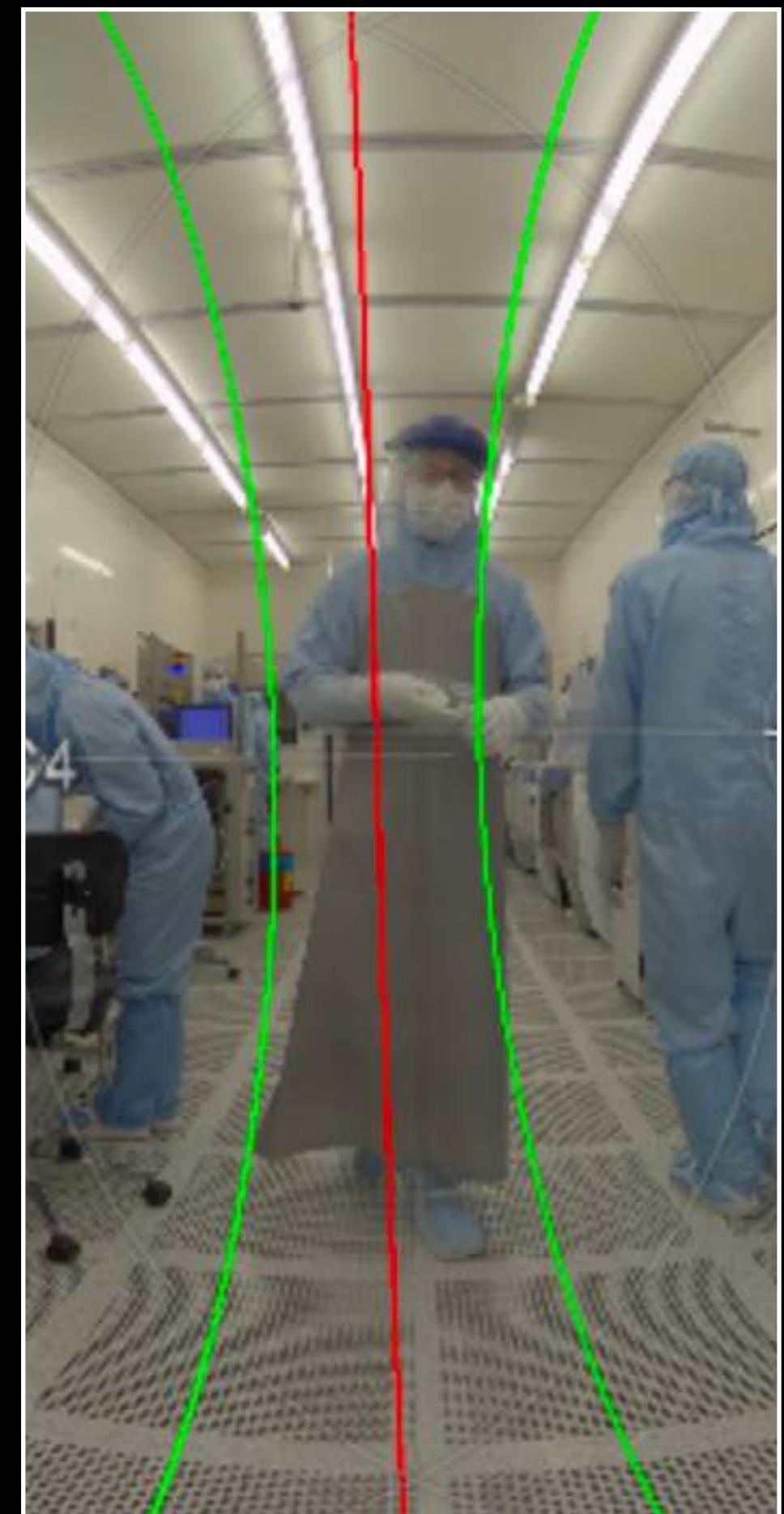
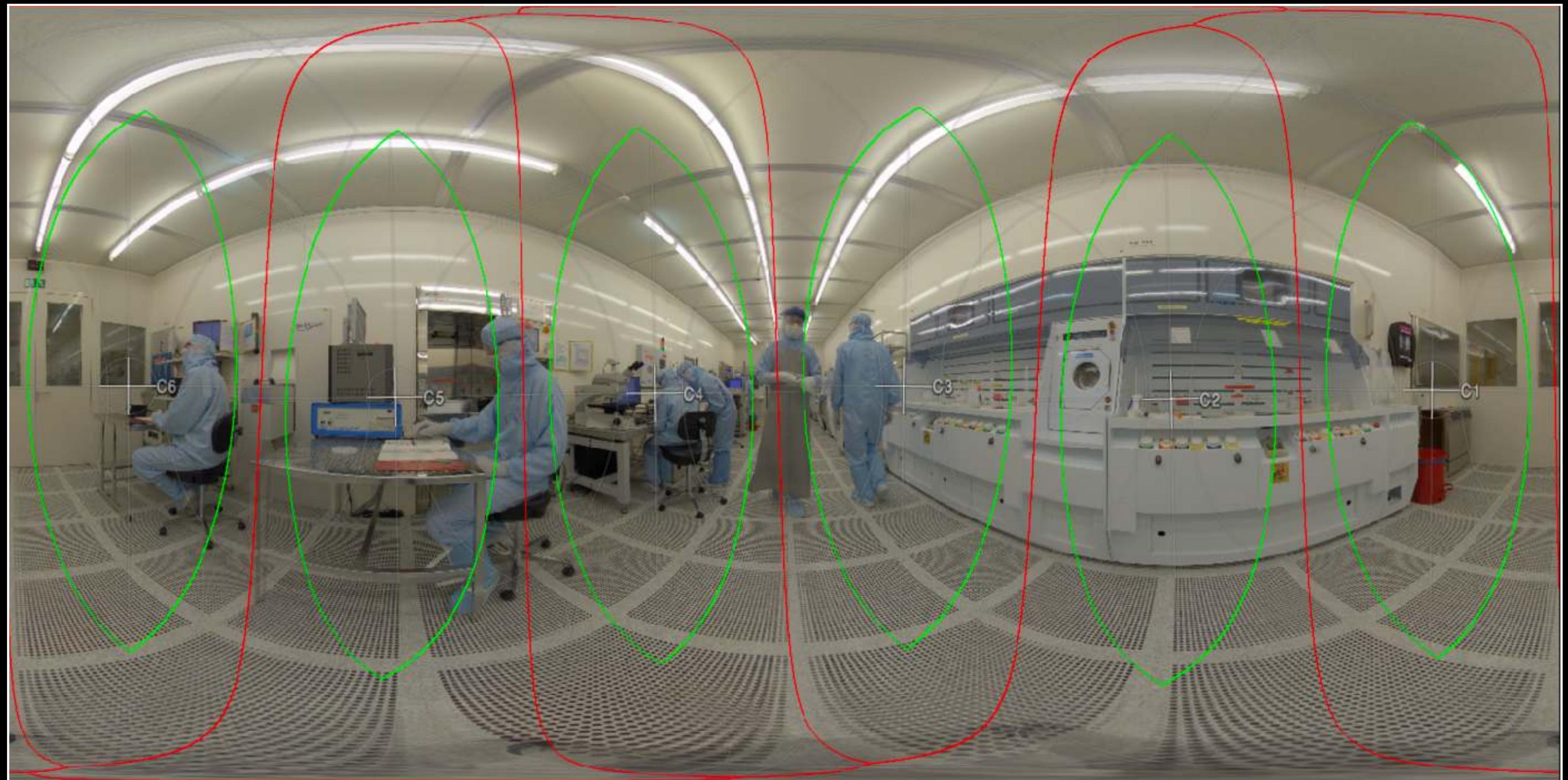


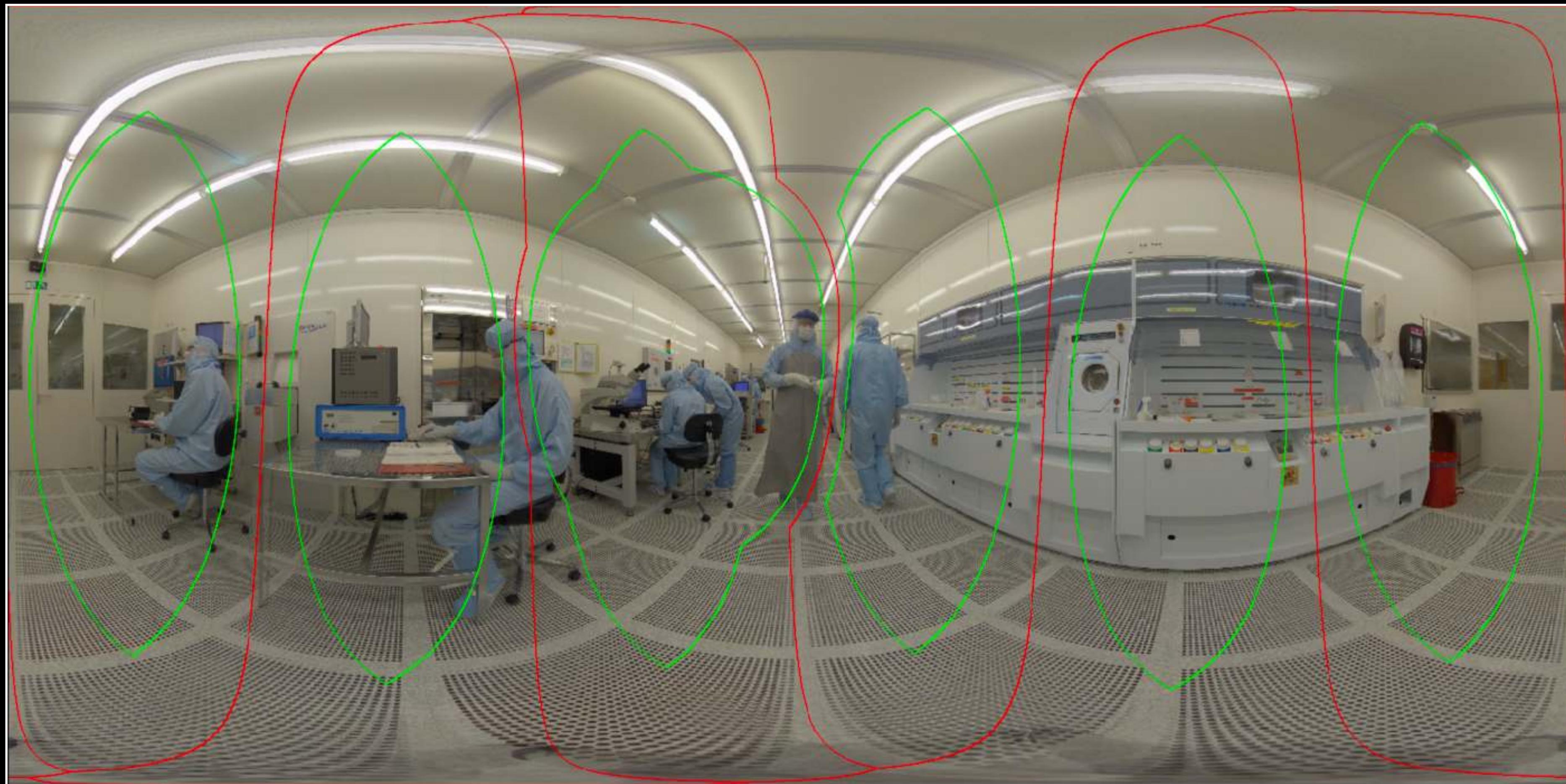
Solutions - Optical Flow

- 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.
- Perhaps one of the 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
- Zooming
- Wrapping
- Non-linear space
- Dynamic range
- Hiding
- Stereoscopic 360 video

State of the art: Resolution



4K

**State of the art circa 2010
Commodity cameras per 2015**



5.7K

Current commodity cameras



8K

Current state of the art

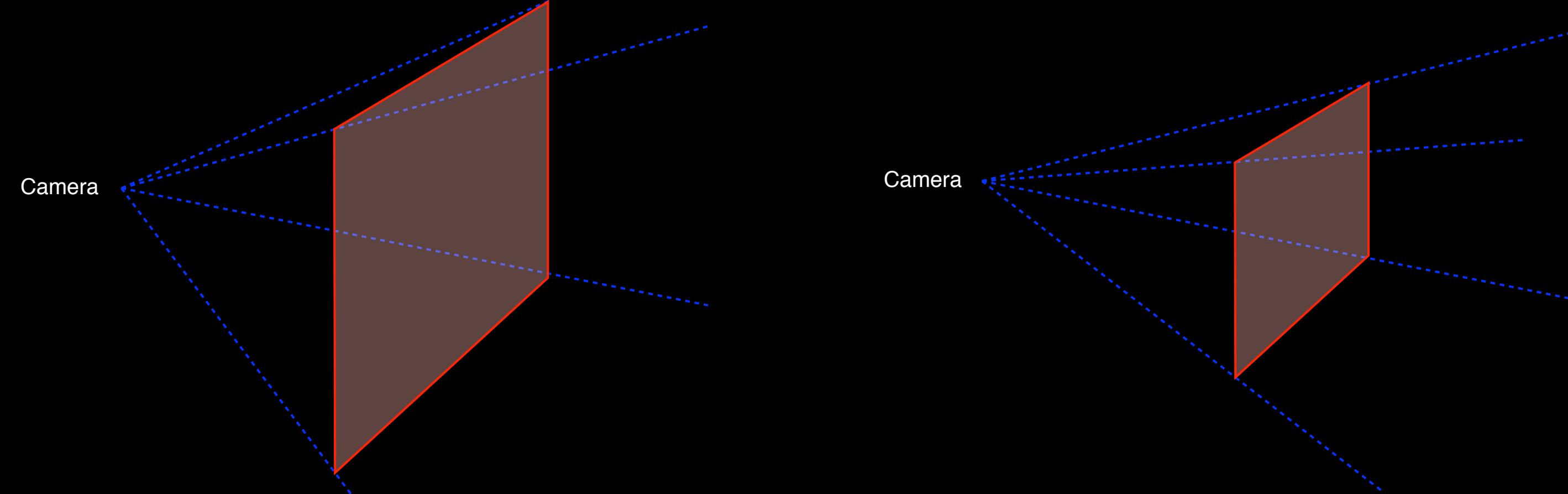


11K

Leading cameras

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 - dynamic range

- Colour fidelity, depth and dynamic range more important than for standard limited field of view video.
- One is capturing everything, if outside during the day then the sun is always in shot.
- Increasingly once cameras get above 8K the more important metric is bit depth.

Miscellaneous topics - Hiding

- There is no place for the traditional shoot for boom mics, lighting, choreographer, director, etc.

Room for ambisonic microphone

Room for radially outfacing lights
or microphones



Stereoscopic (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.
- Happy to take questions on this now or later.

End - Questions?