360 video

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http://paulbourke.net/ECU2019/

Agenda

Examples from authors projects

Image projections
(Perspective - Fisheye - Cylindrical panorama - Cube maps - Equirectanglar panorama)

Camera summary
(One - Two - More than two)

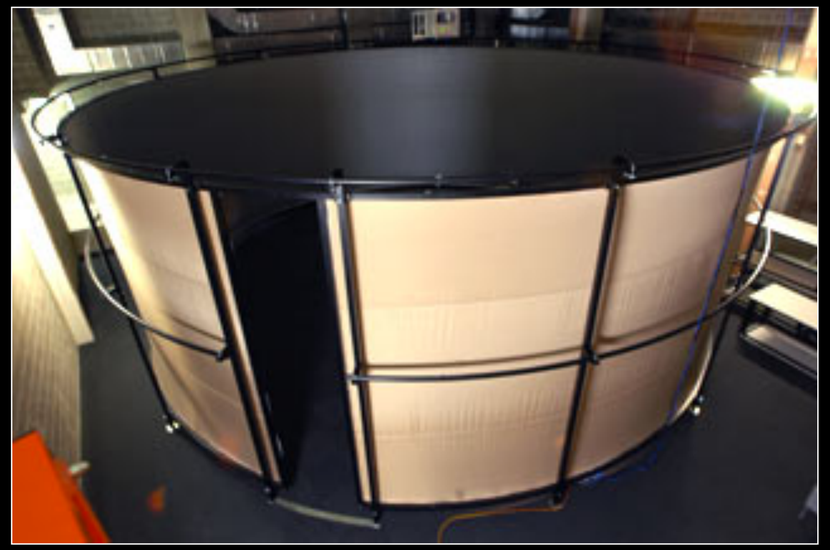
The fundamental problem
(Parallax)

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

Miscellaneous topics

Examples

iCinema



Hashibektashi, Turkiye

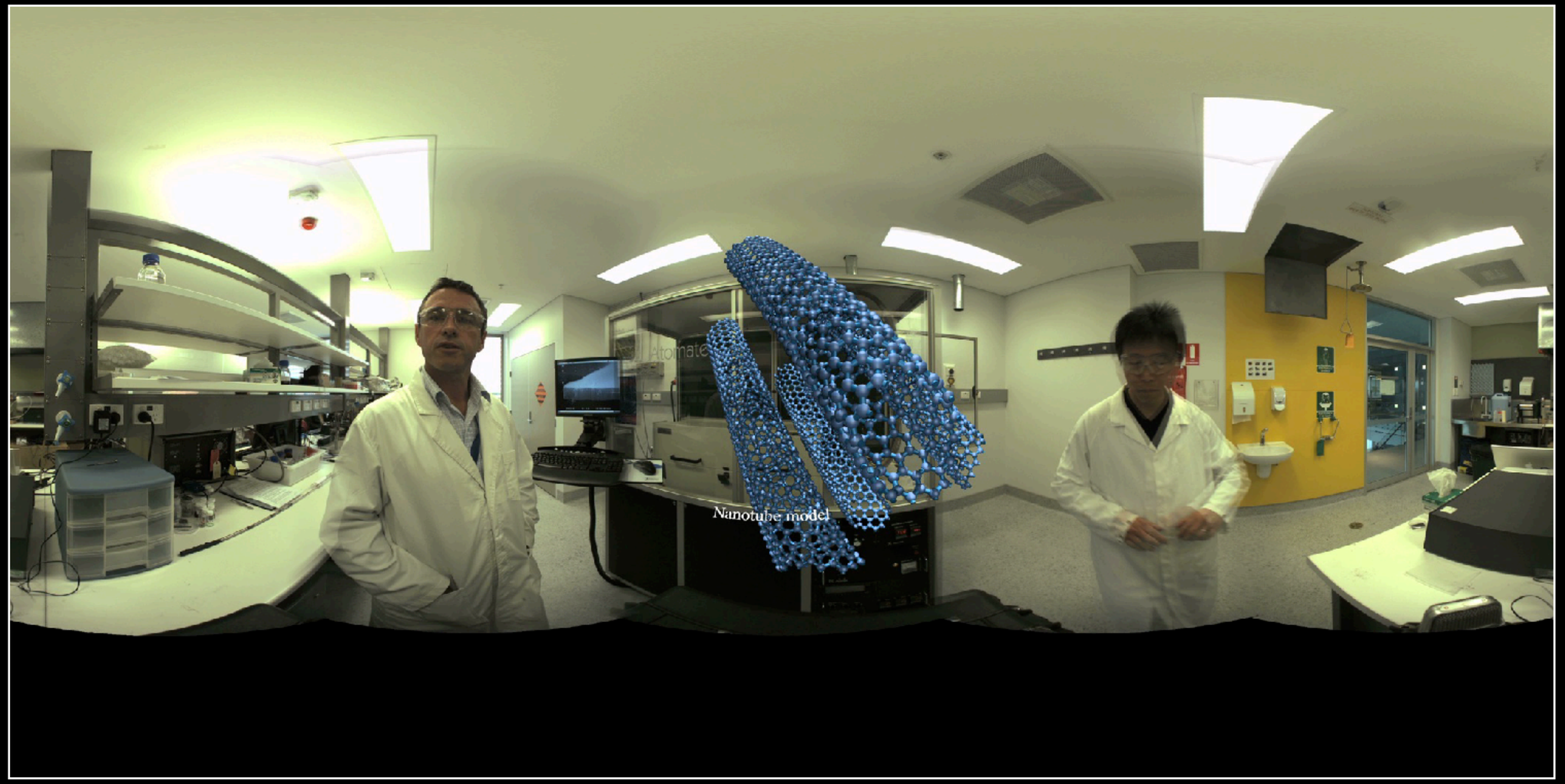
Whirling Dervish, Turkiye

Jiao festival, Hong Kong

Karratha iron ore ship loader

Mah Meri, Malaysia

Endevour replica entering Freemantle



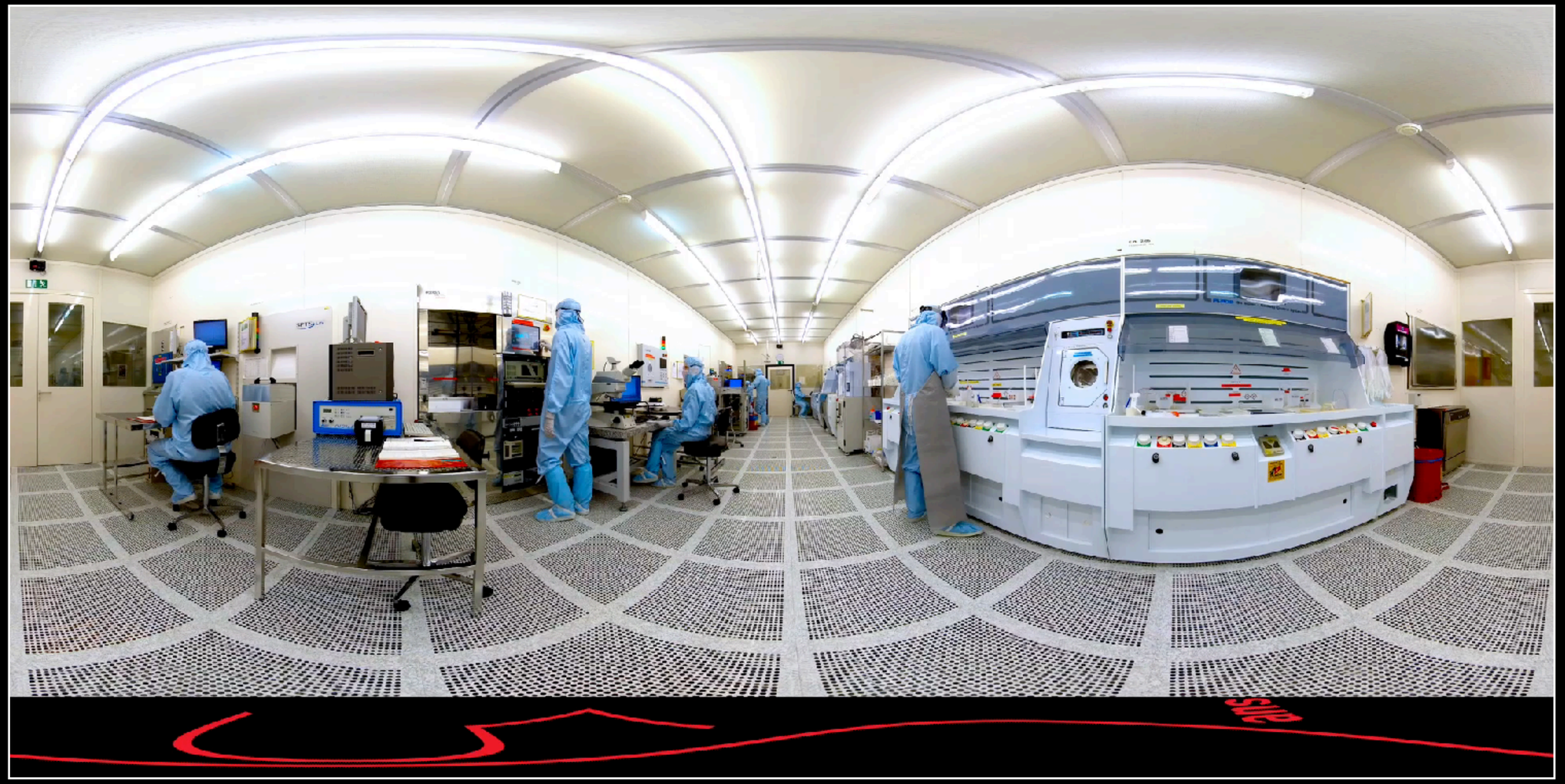
Nanotechnology, Wollongong

Sheep shearing, Barossa valley

Pig farming in Hong Kong

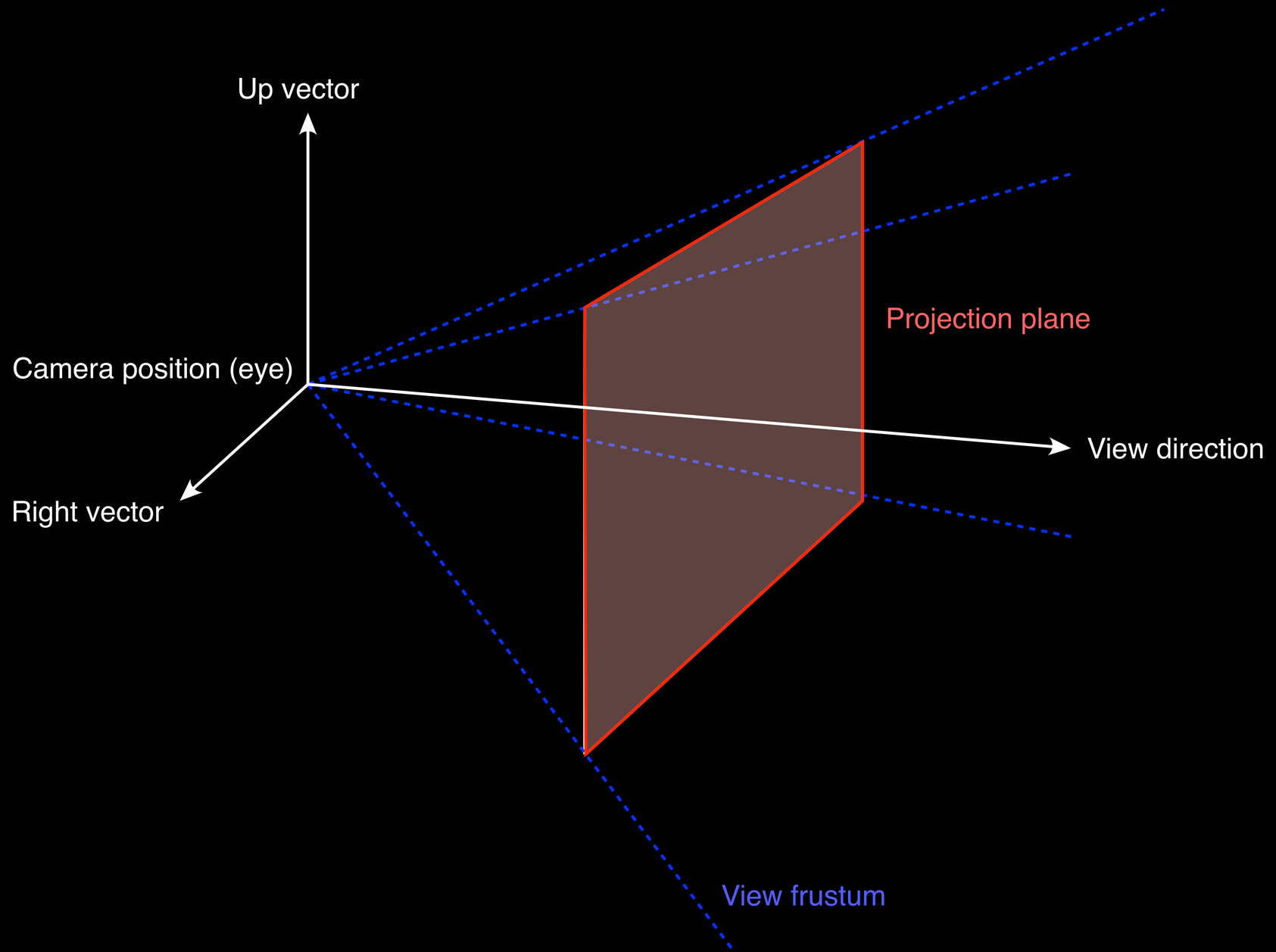
Sahet-Jetavana, India

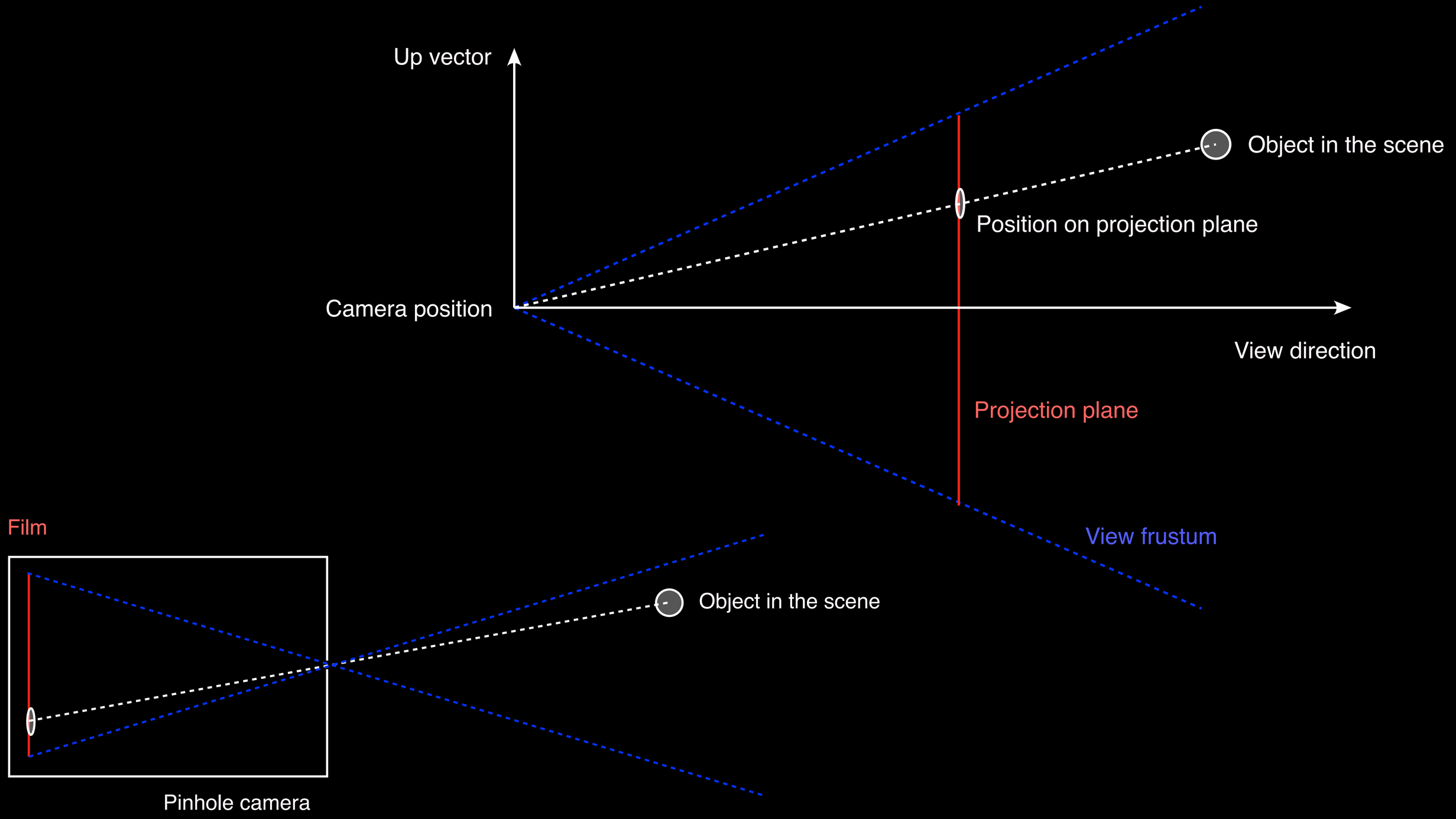
Clothing Buddha, India

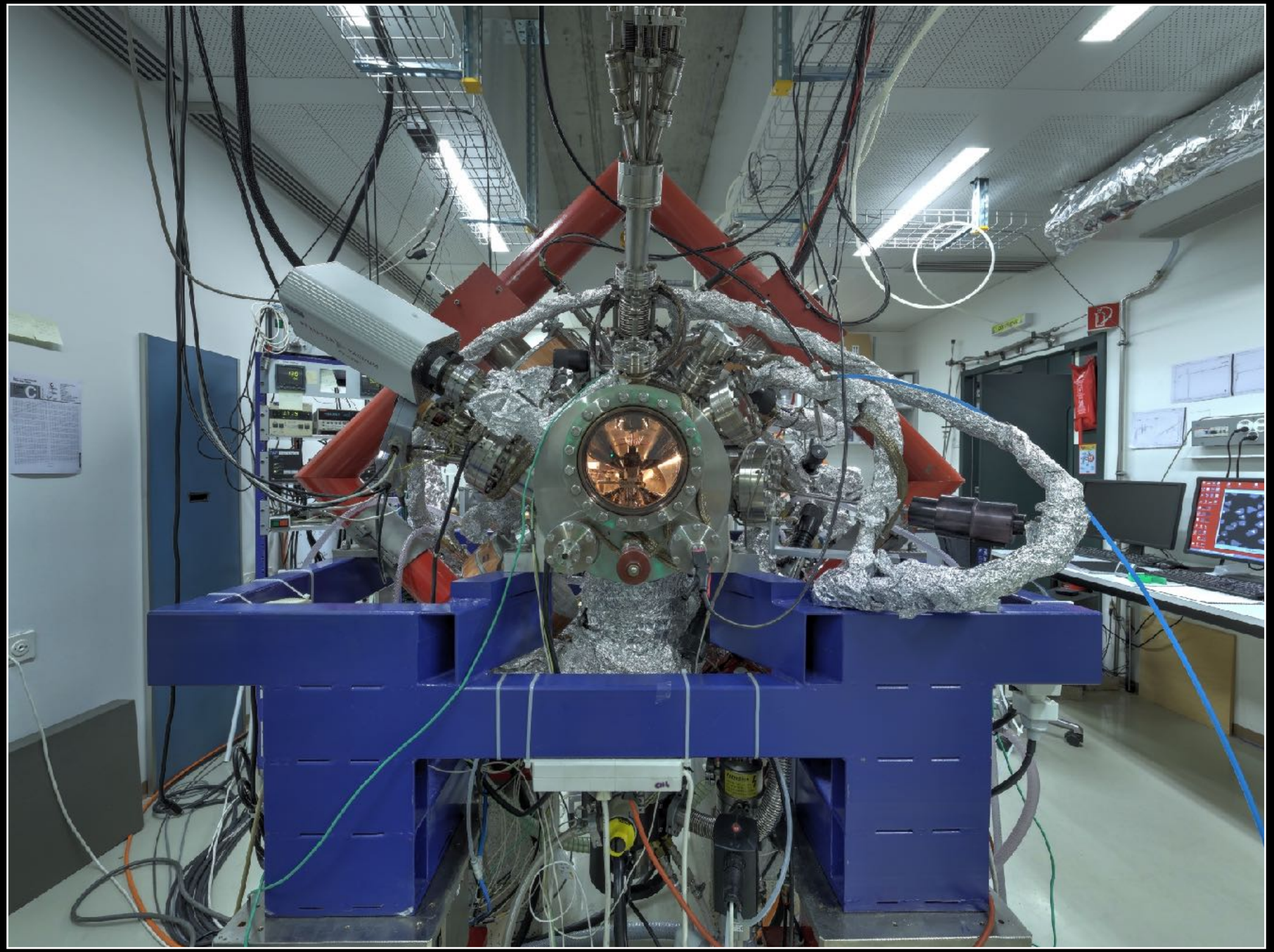


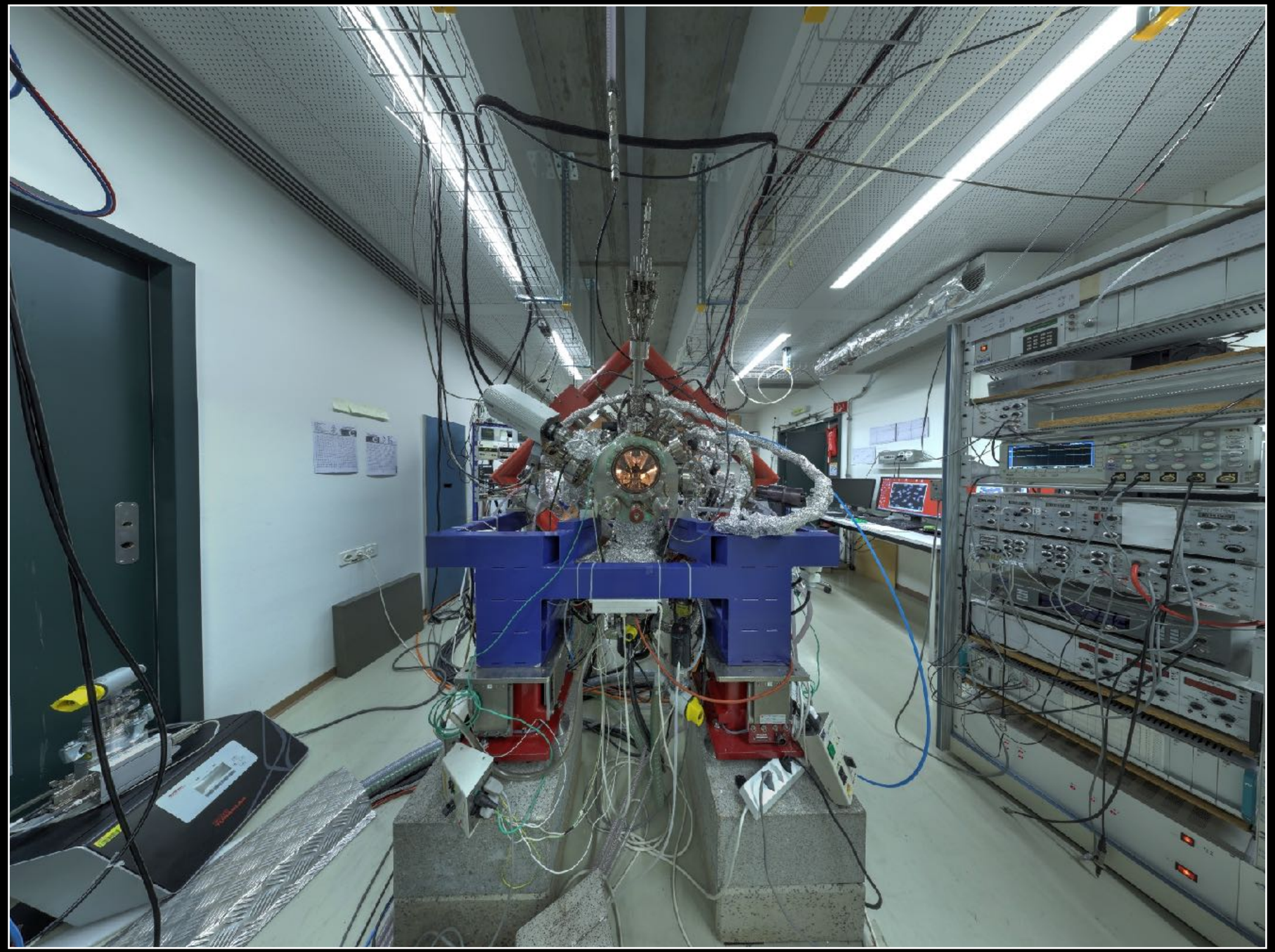
Micro and Nano Technology, EPFL, Switzerland

Image projections - Perspective




Up vector
Object in the scene
Position on projection plane
Camera position
View direction
Projection plane
View frustum
Film
Object in the scene
Pinhole camera





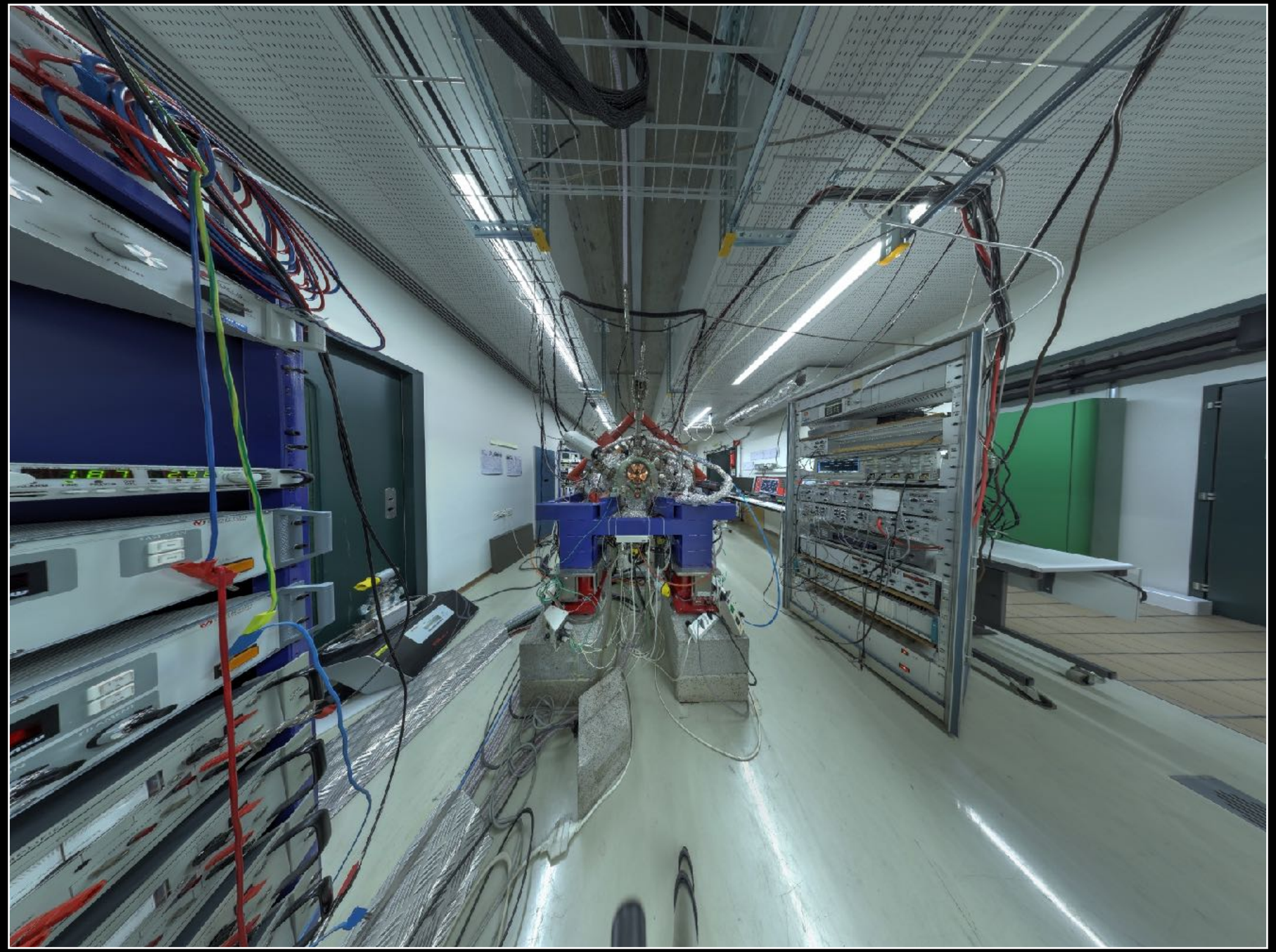
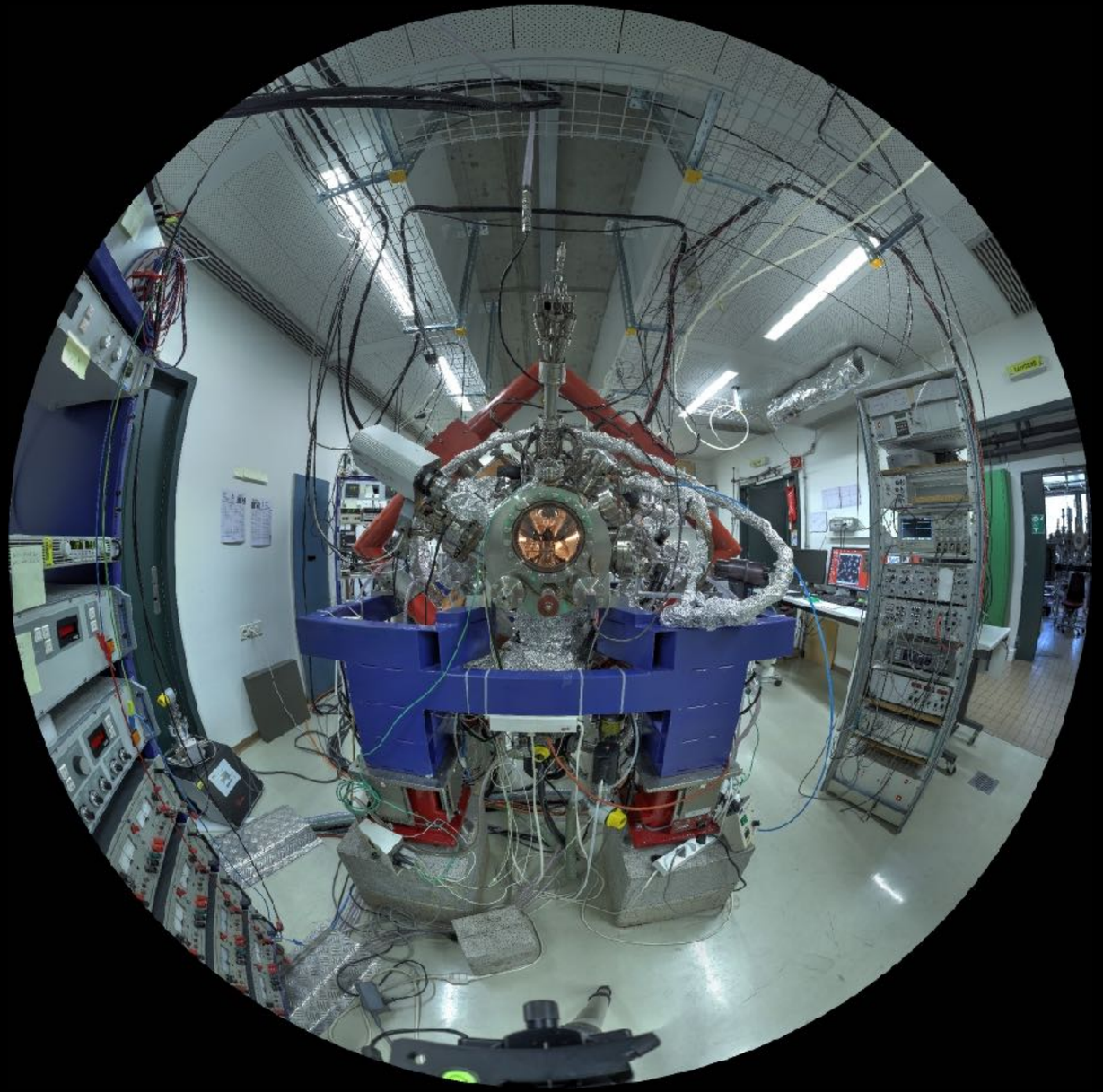
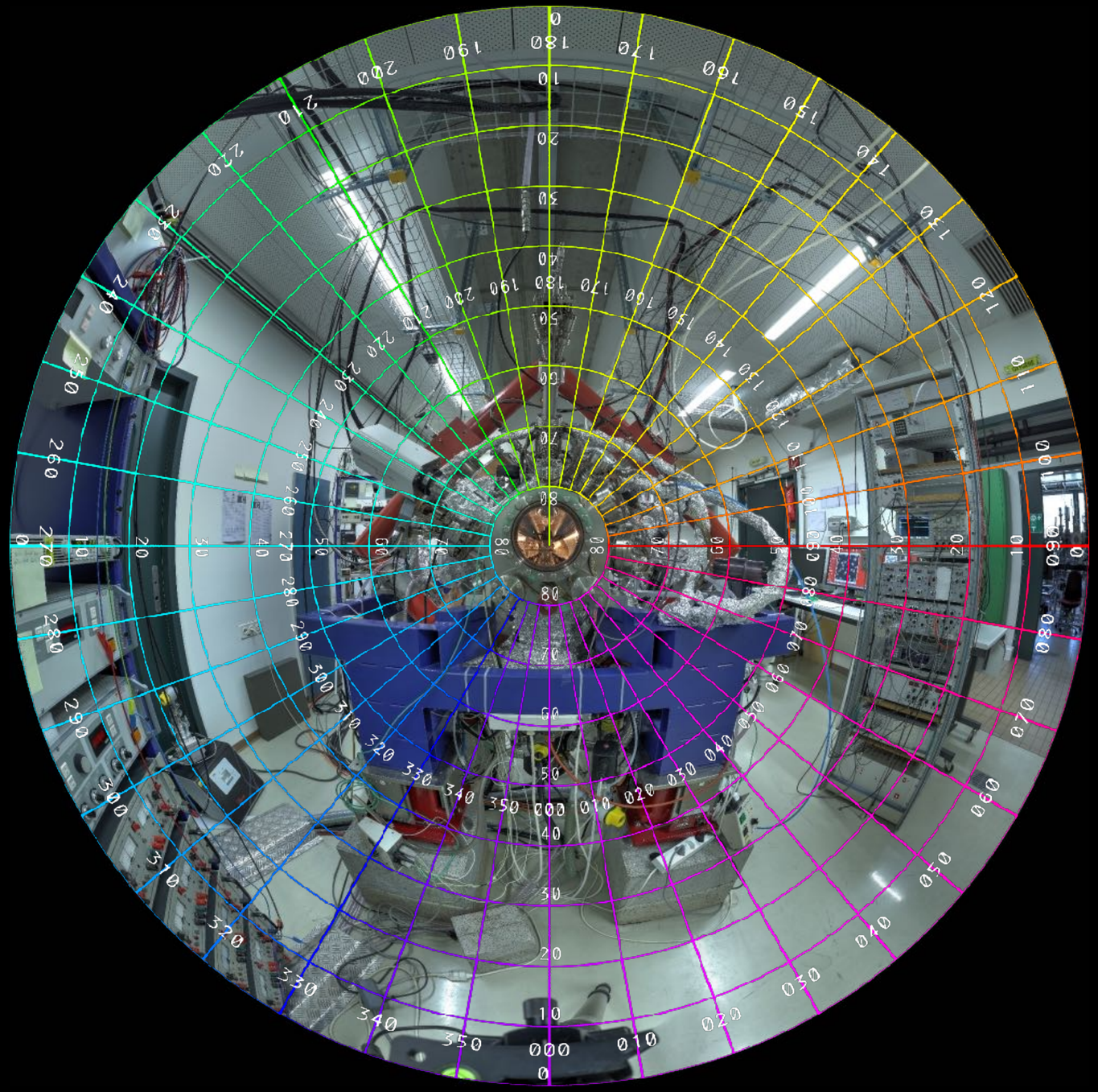
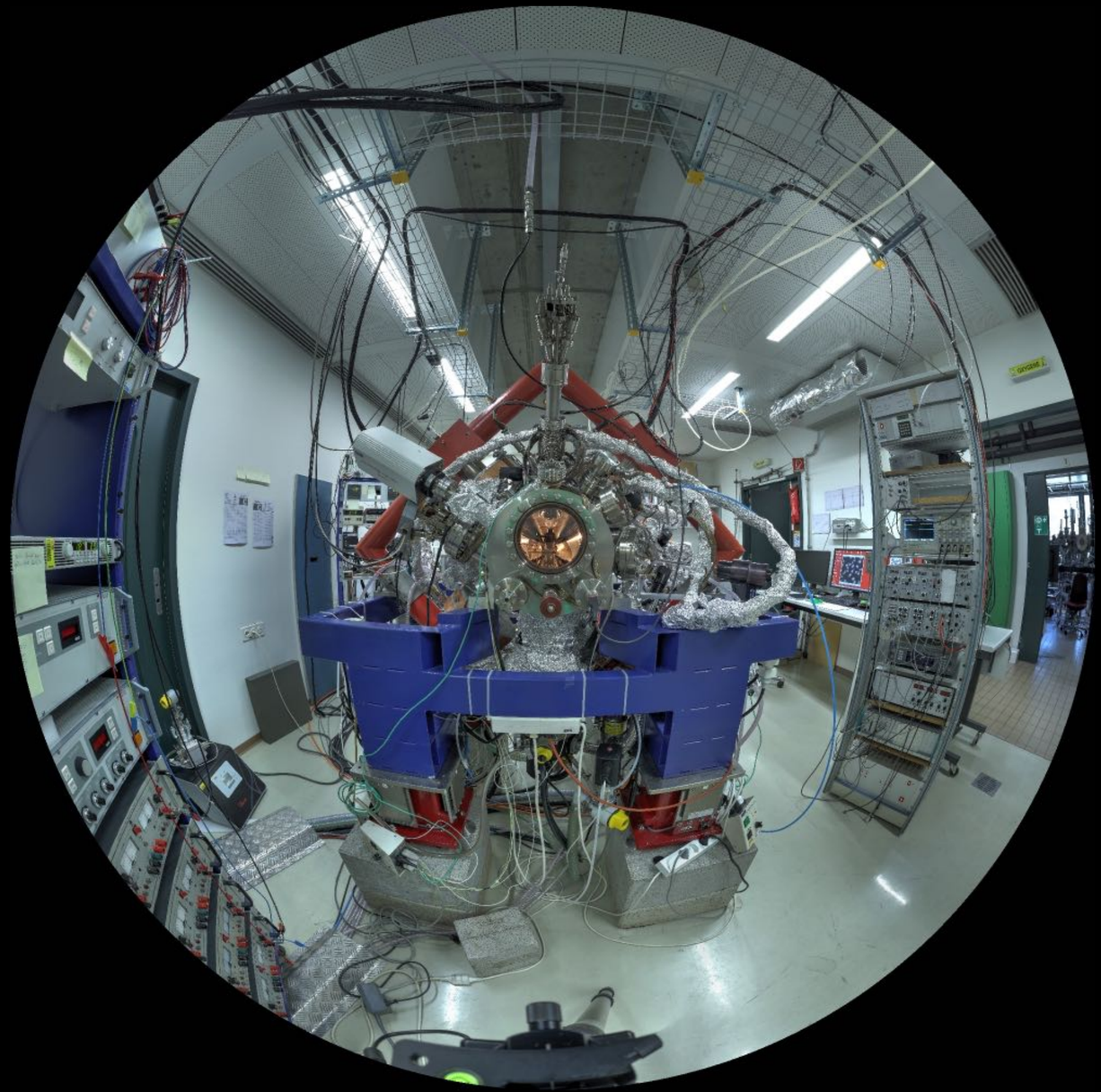


Image projections - Fisheye







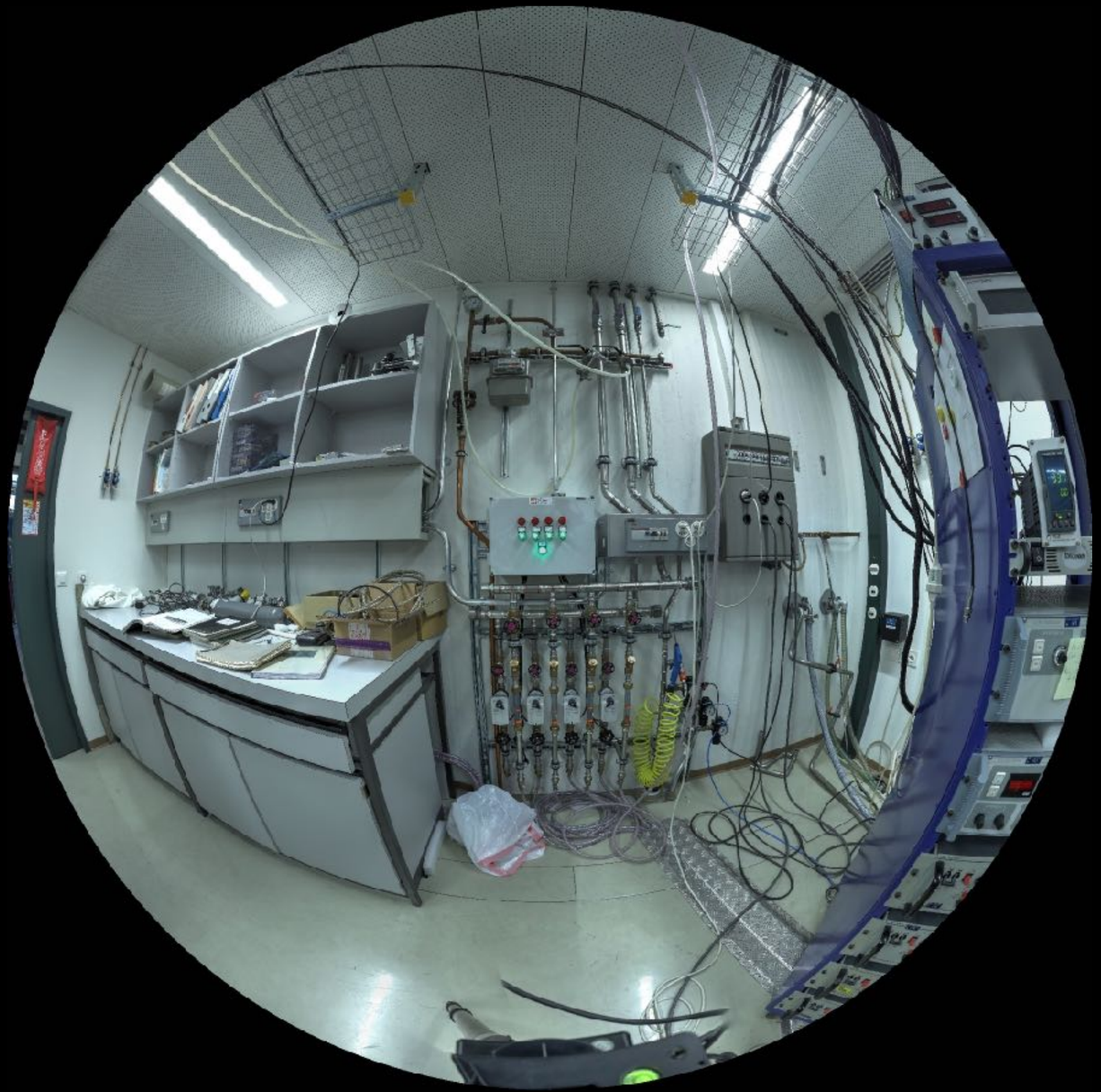
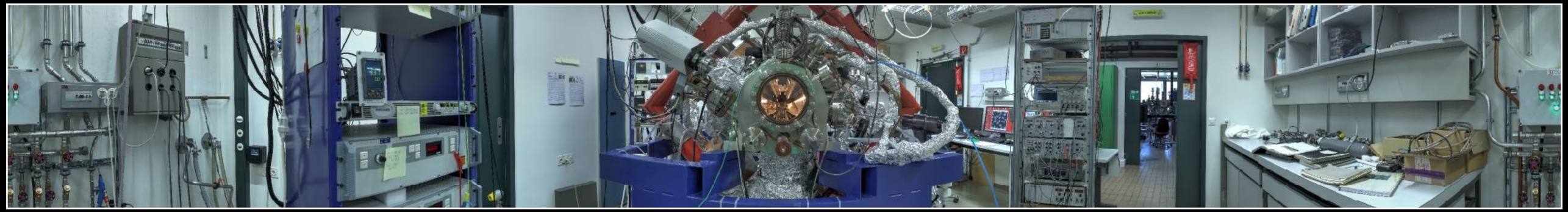
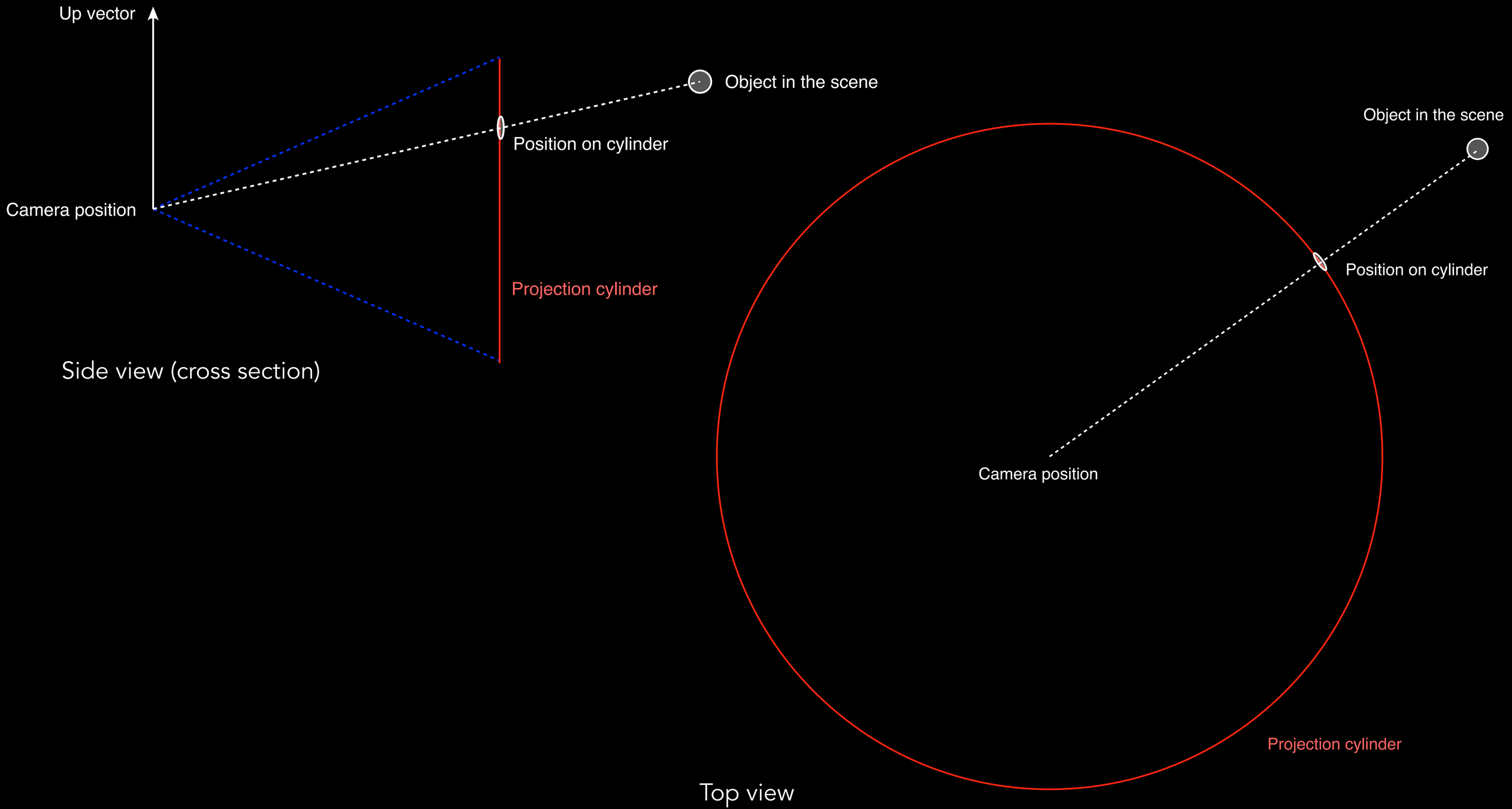


Image Projections - Cylindrical panorama



360 degrees


Up vector
Object in the scene
Position on cylinder
Camera position
Projection cylinder
Side view (cross section)
Object in the scene
Position on cylinder
Camera position
Projection cylinder
Top view

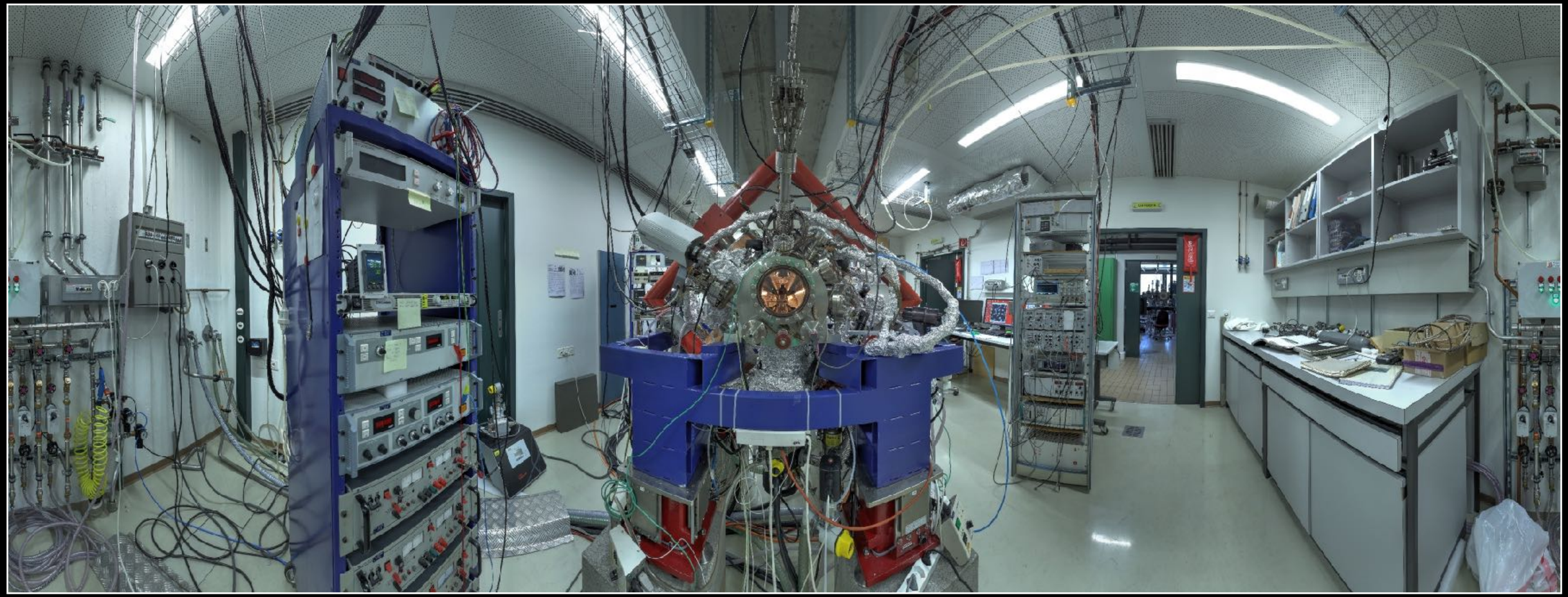
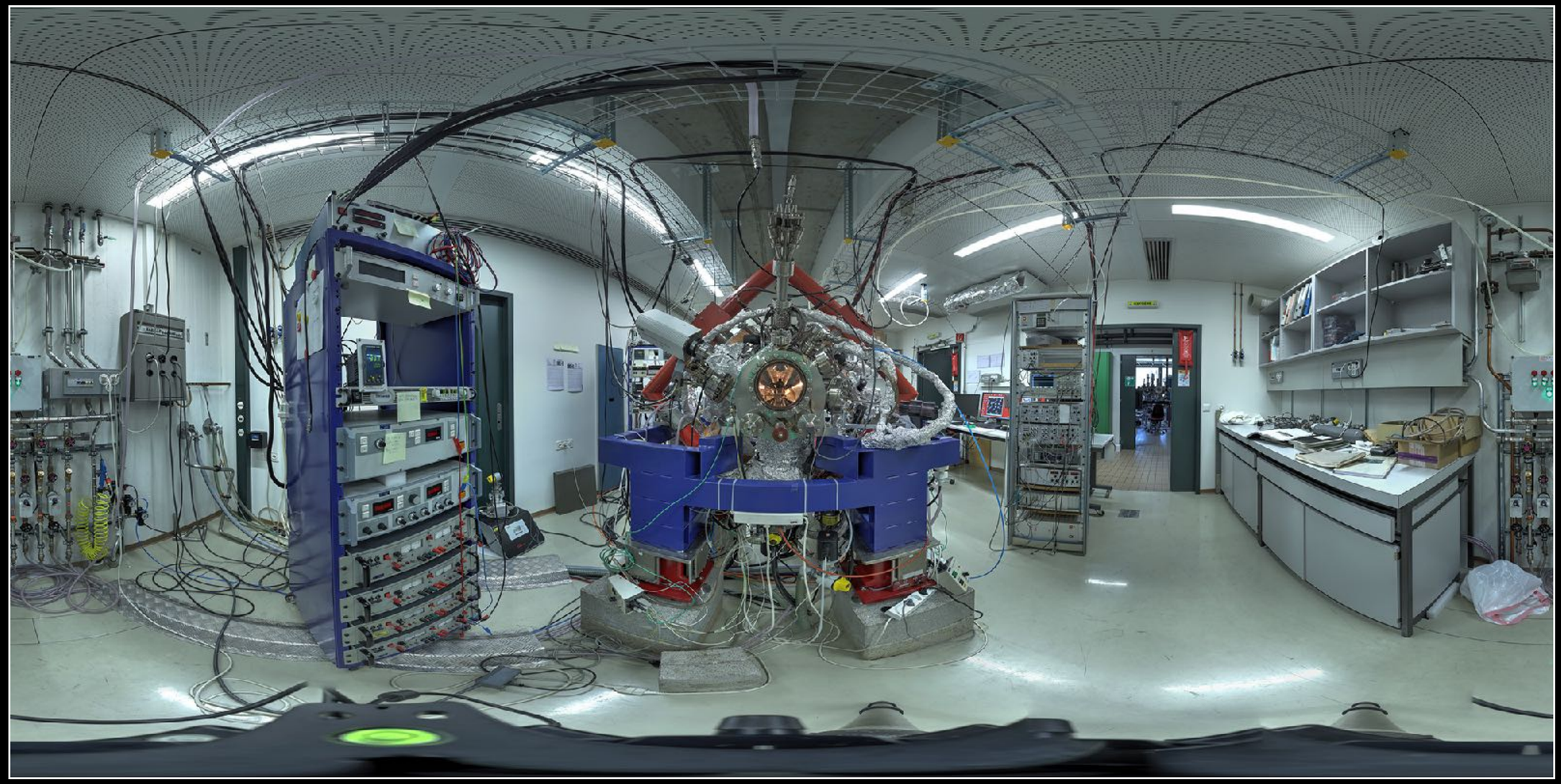


Image projections - Cubemaps

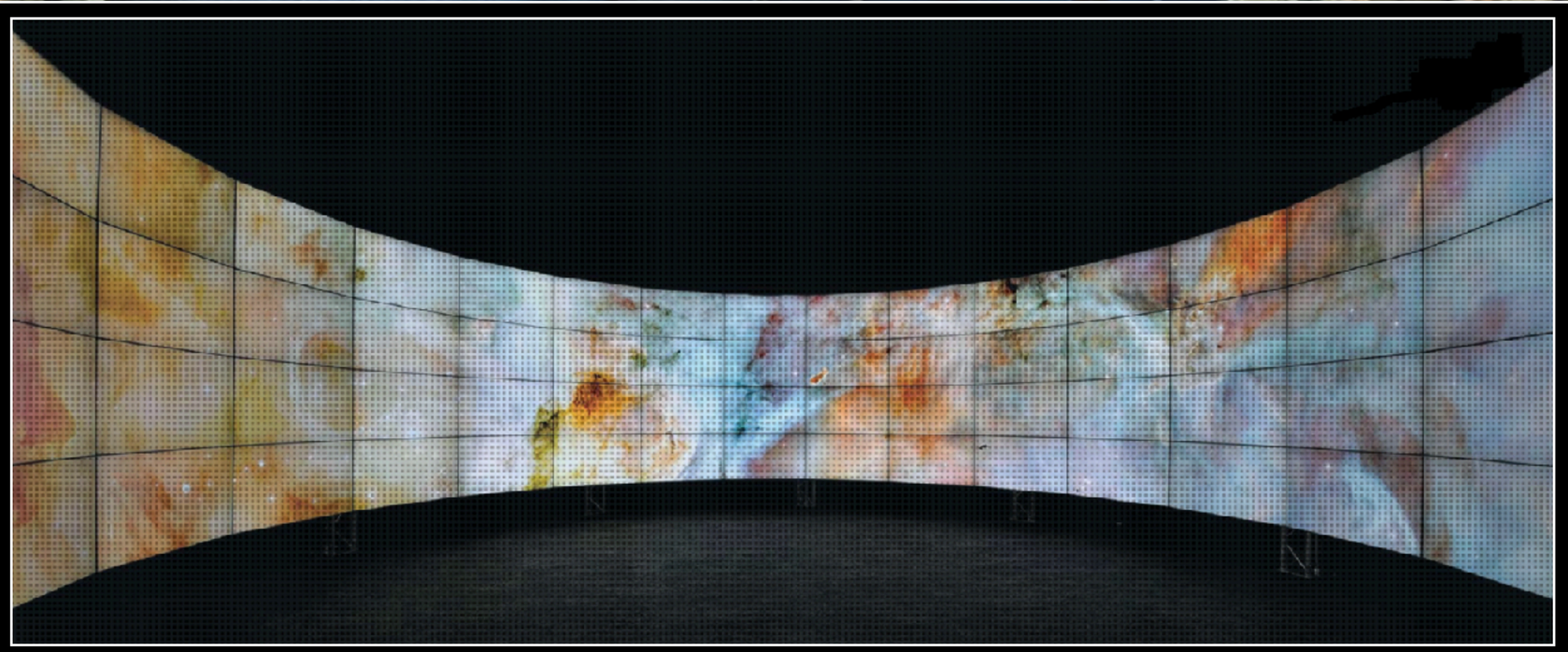
Image Projections - Equirectangular



180 degrees

360 degrees

So what …?



University of the Sunshine Coast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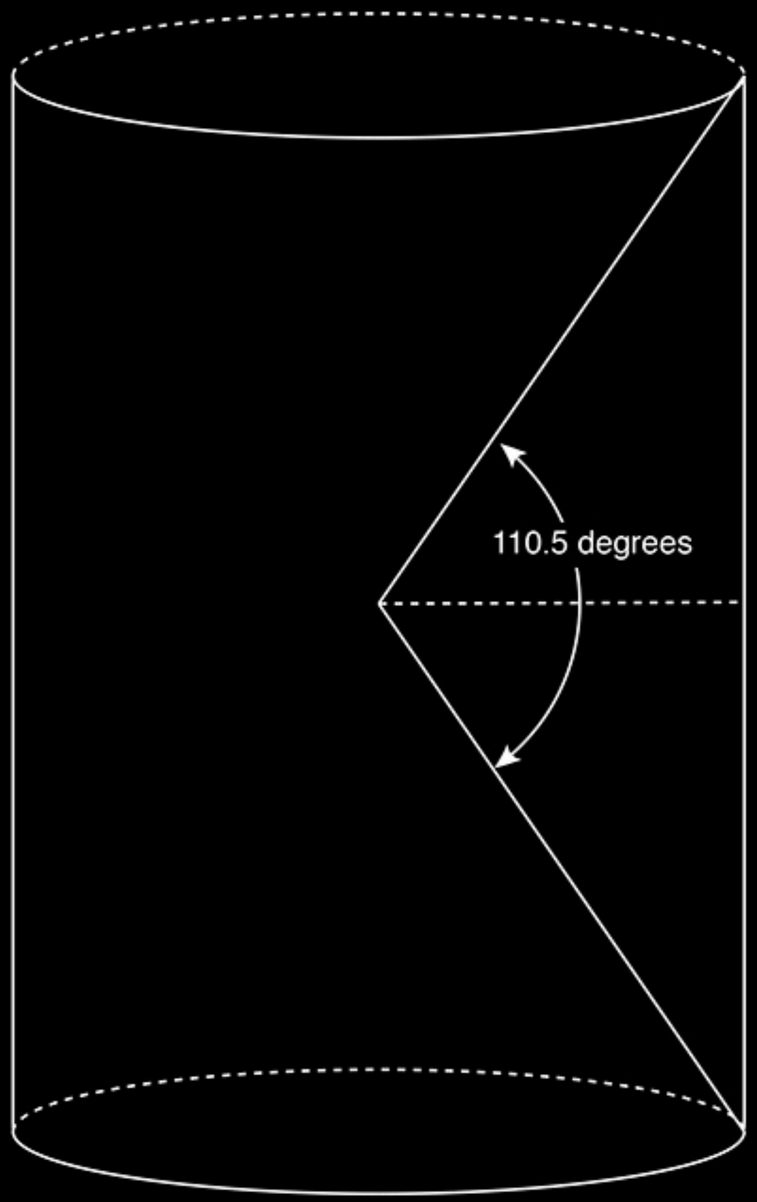
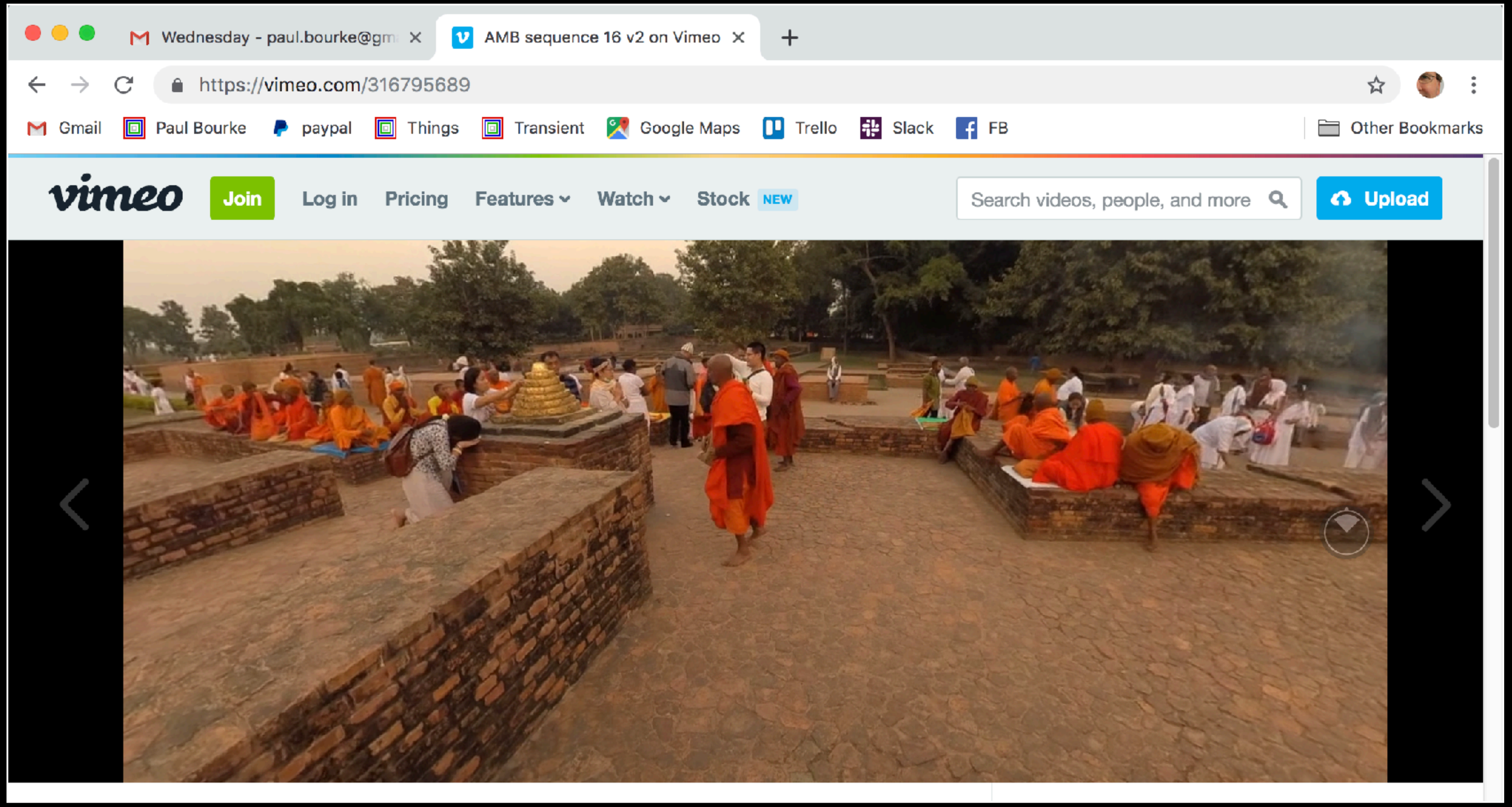

110.5 degrees


coles

Fisheye

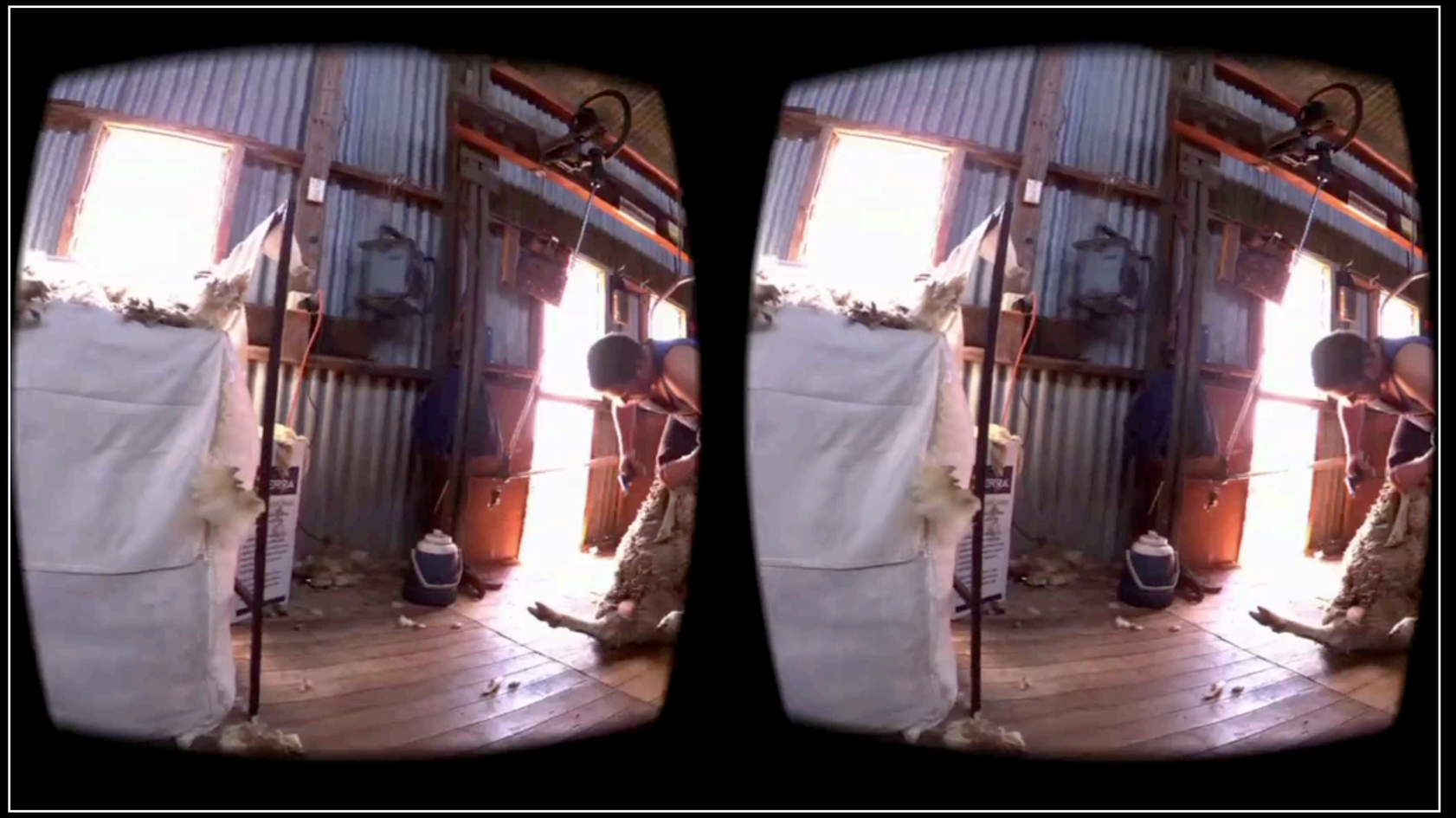

Fit for Life
TREADMILLS

Perspective




Oculus


VIVE
VIVE



Camera summary


SHOCKPROOF 2m/6.6ft
4K
WiFi


RICOH


Insta360 Air


00:06
5.7K 30 FPS


4K UHD


5.3K 30
00:01


MODE
OK
NFC
Wi Fi
SPLASH PROOF

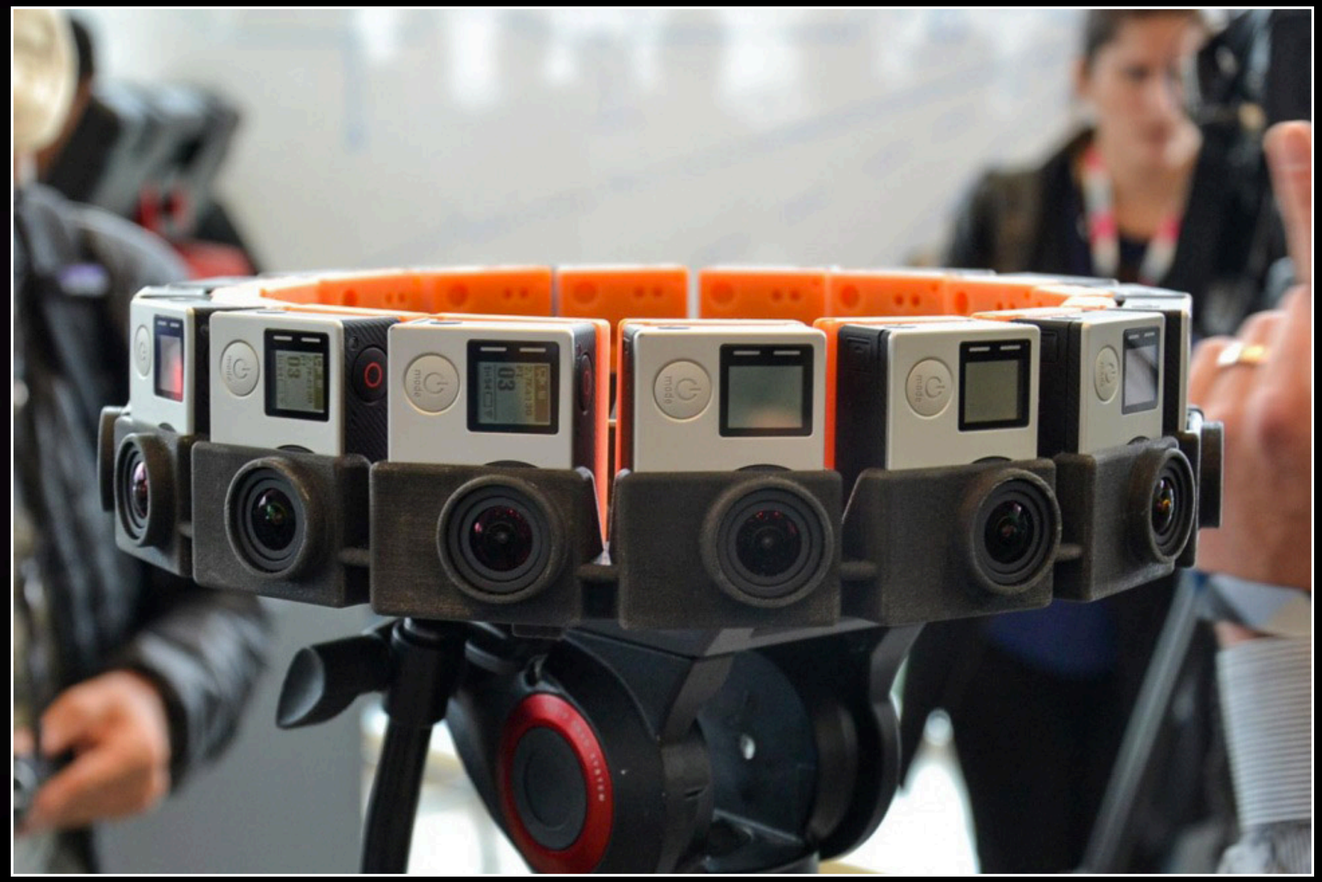

KANDAO

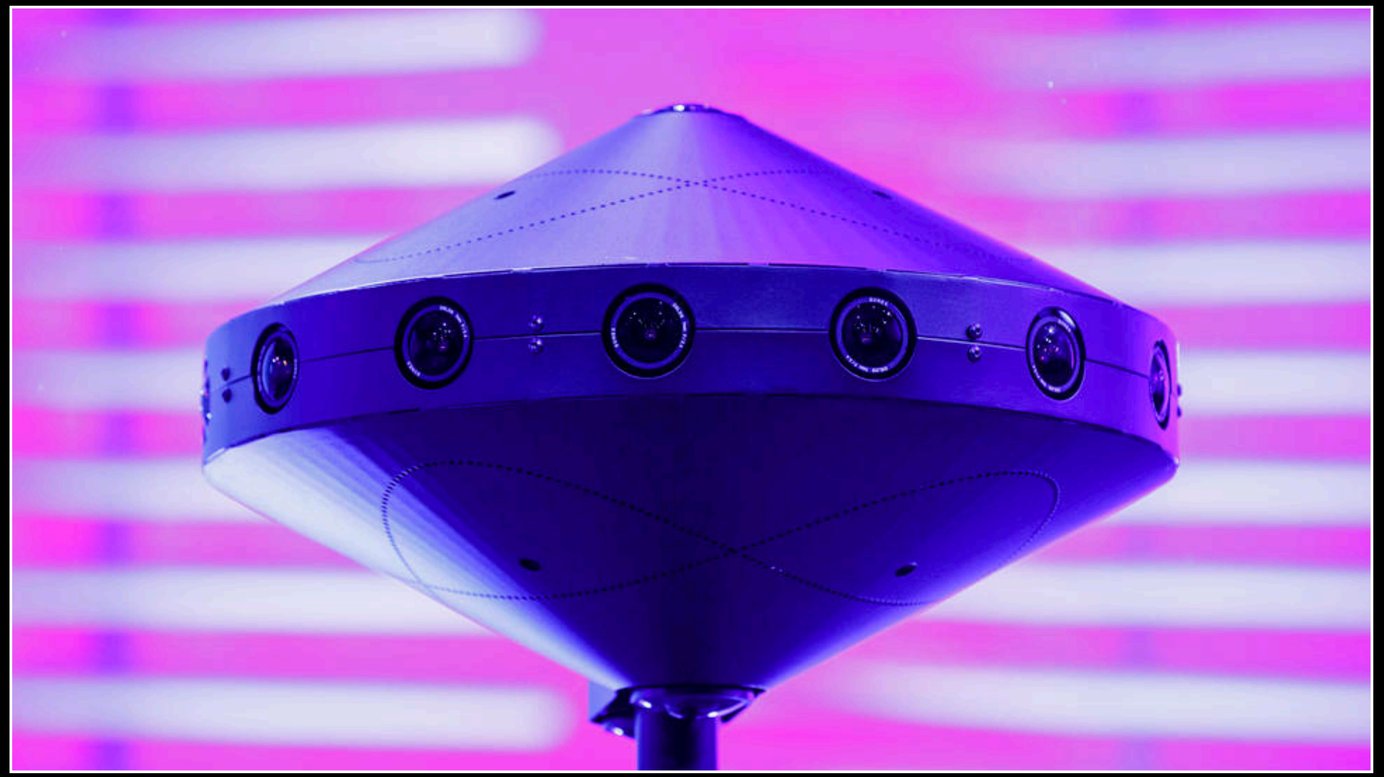

VUZE


yi


F4


JAUNT



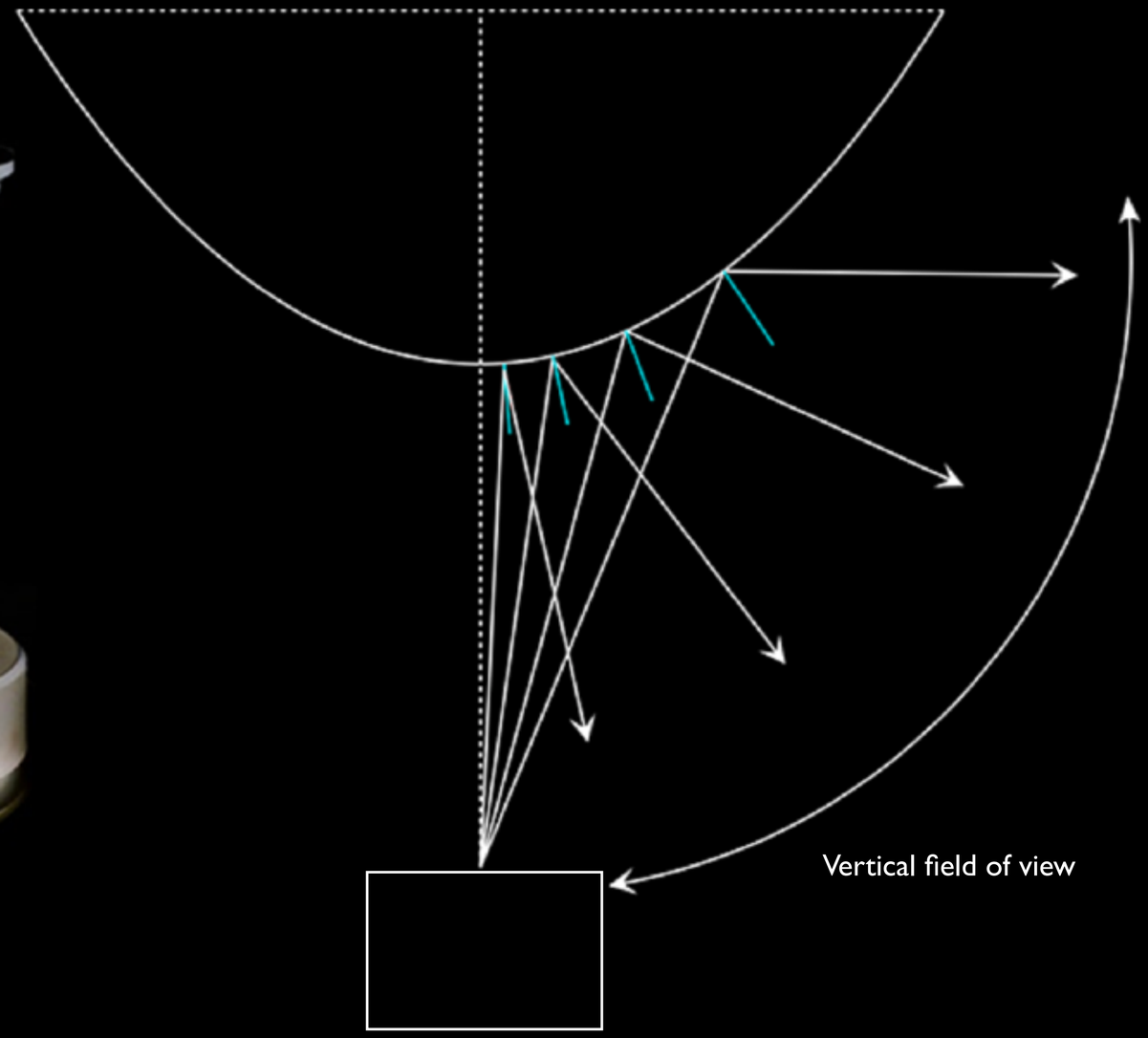


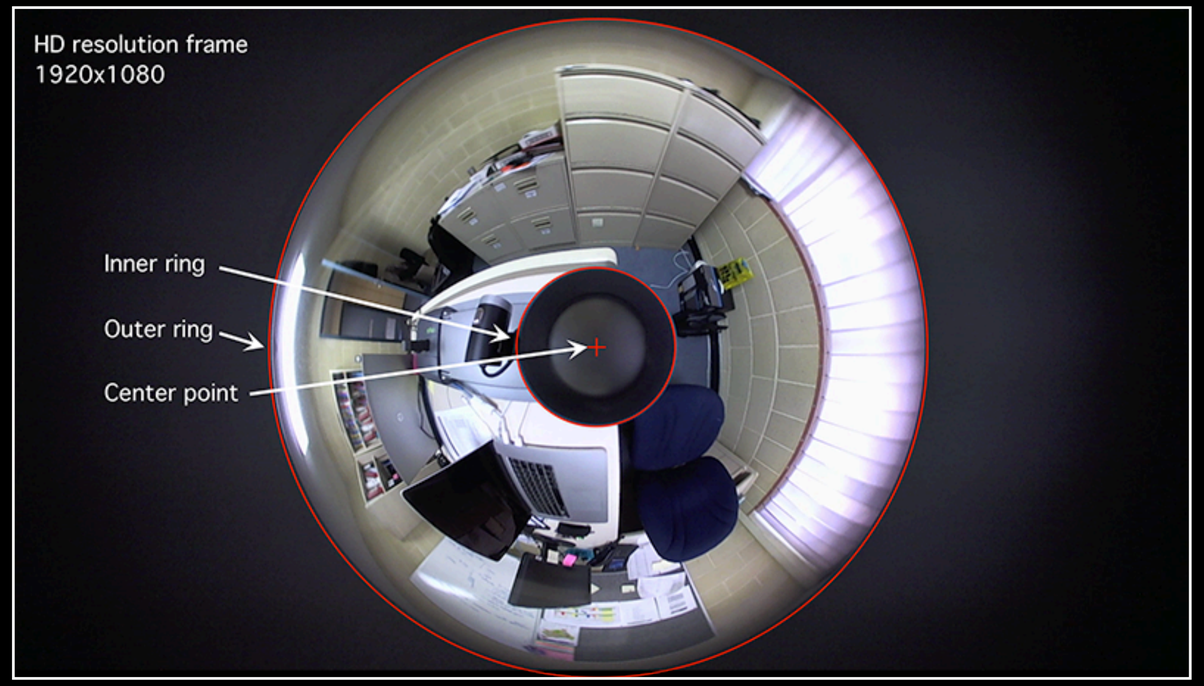
Ladybug-3

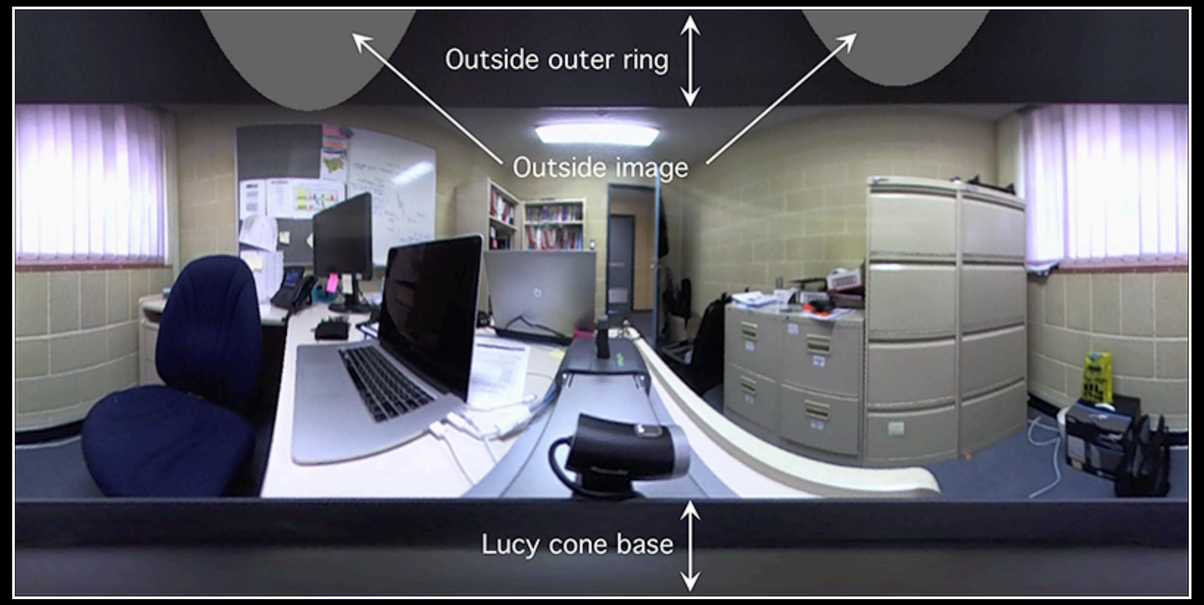
Insta360Pro-2

Garmin Virb

Single camera




HD resolution frame
1920x1080
Inner ring
Outer ring
Center point


Outside outer ring
Outside image
Lucy cone base


pano pro
a virtual tour in just one photo
www.pano-pro.com

Entaniya 250 degree fisheye

Single camera merits

Advantages:

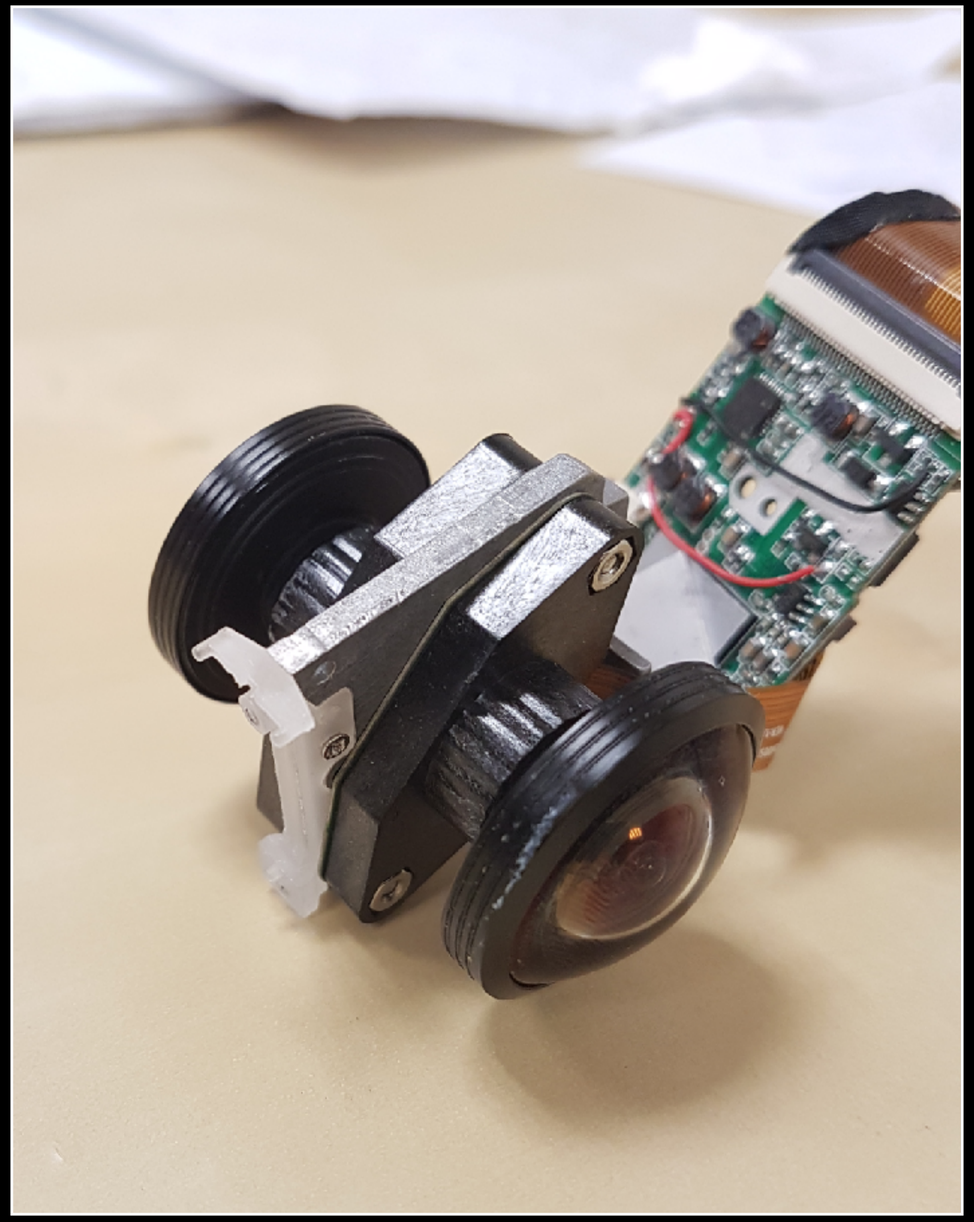
Simple - Small - No blending - No parallax errors

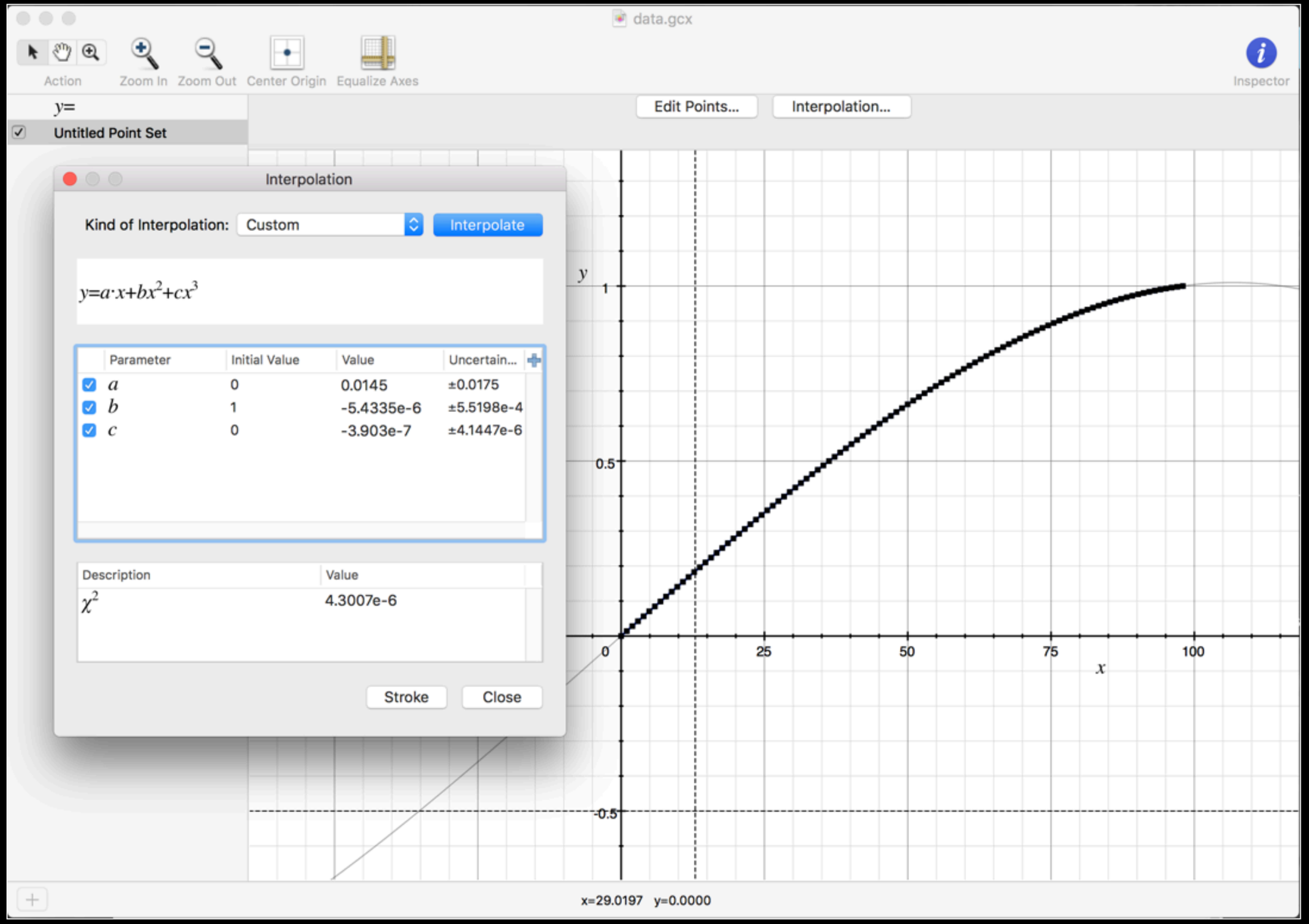
Disadvantages:

Doesn’t capture whole 360x180 field of view

Doesn’t scale!

Dual cameras




data.gcx
Action
Zoom In
Zoom Out
Center Origin
Equalize Axes
Inspector
y=
Untitled Point Set
Edit Points...
Interpolation...
Interpolation
Kind of Interpolation: Custom
Interpolate
y=a·x+bx²+cx³
Parameter
Initial Value
Value
Uncertain...
a 0 0.0145 ±0.0175
b 1 -5.4335e-6 ±5.5198e-4
c 0 -3.903e-7 ±4.1447e-6
Description
Value
χ² 4.3007e-6
Stroke
Close
y
1
0.5
0
-0.5
25
50
75
100
x
x=29.0197 y=0.0000

Dual camera merits

Advantages:

Small - Single blend line - Higher resolution than single camera

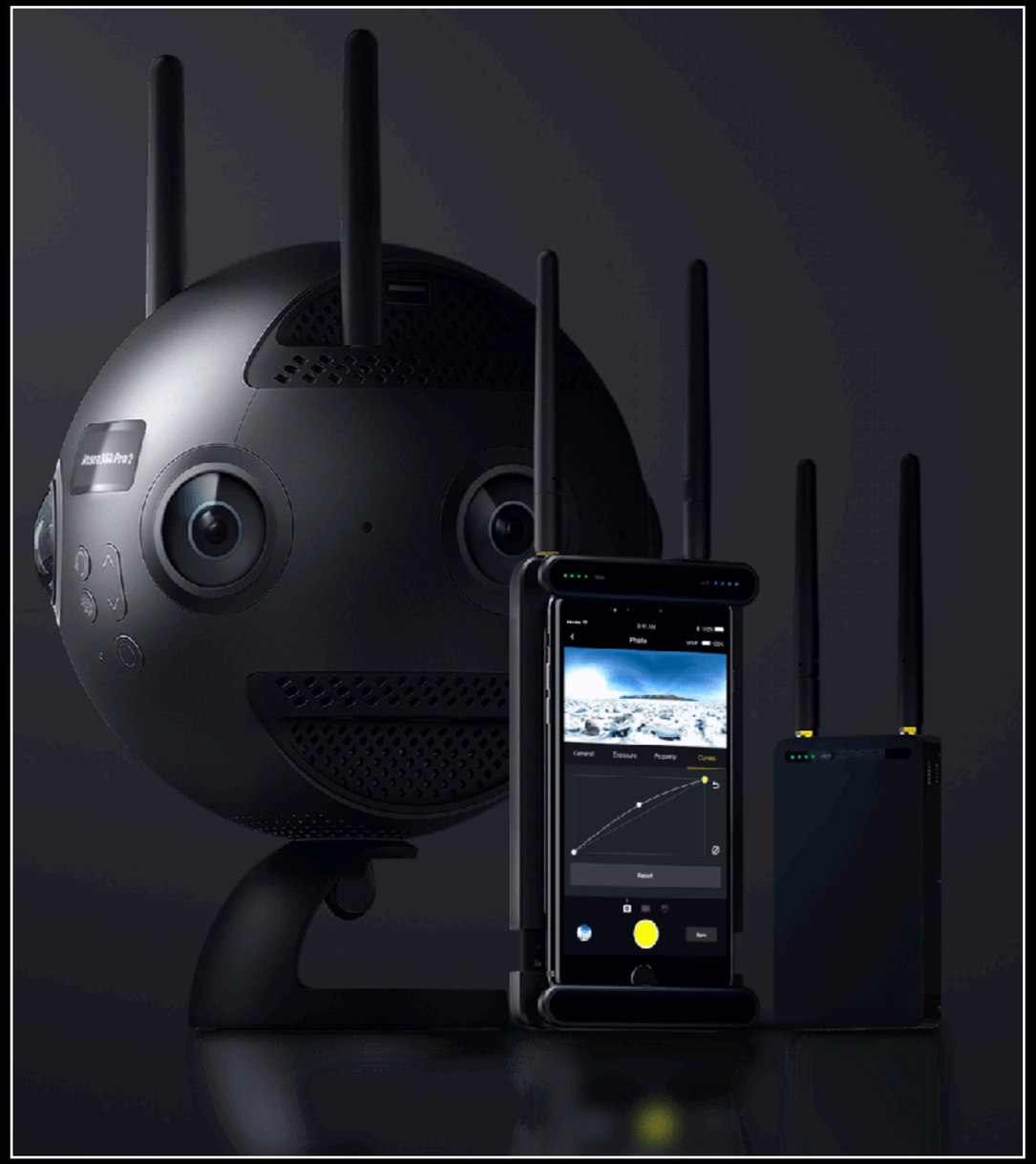
Disadvantages:

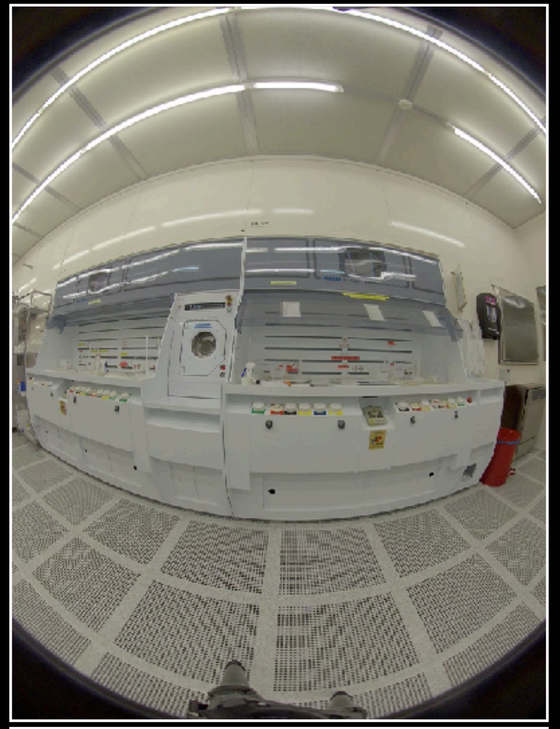
Doesn’t scale!

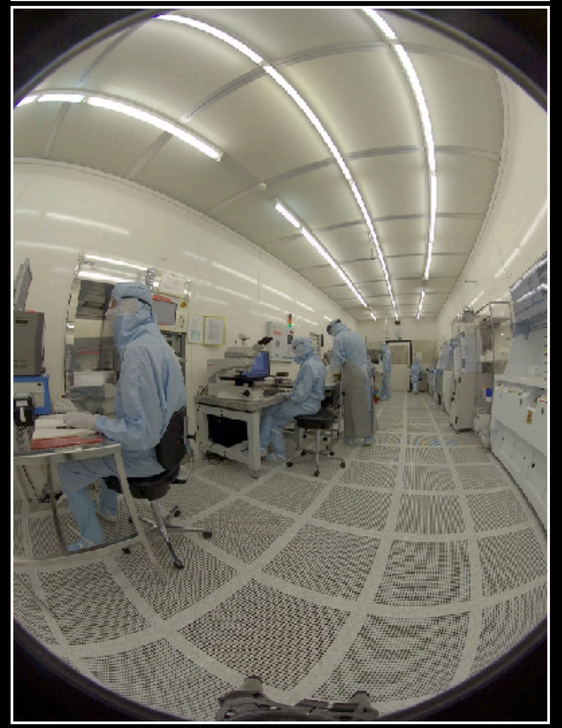
Cannot support stereoscopic 3D

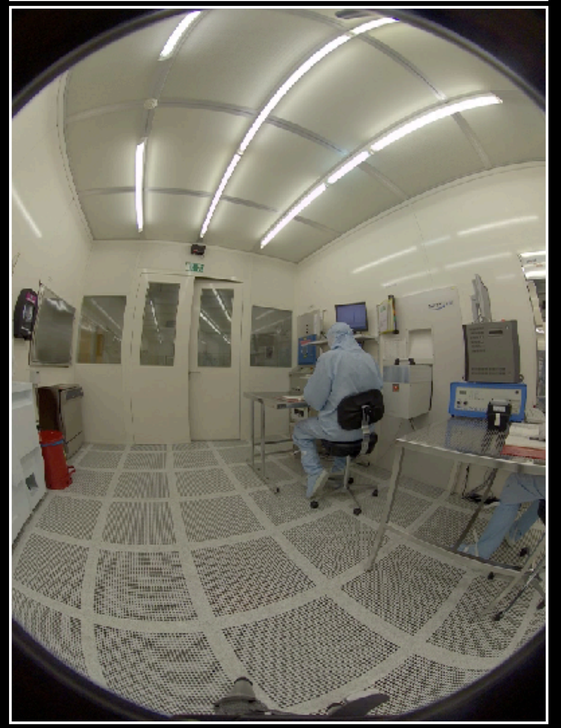
Multiple cameras (>2)

- 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

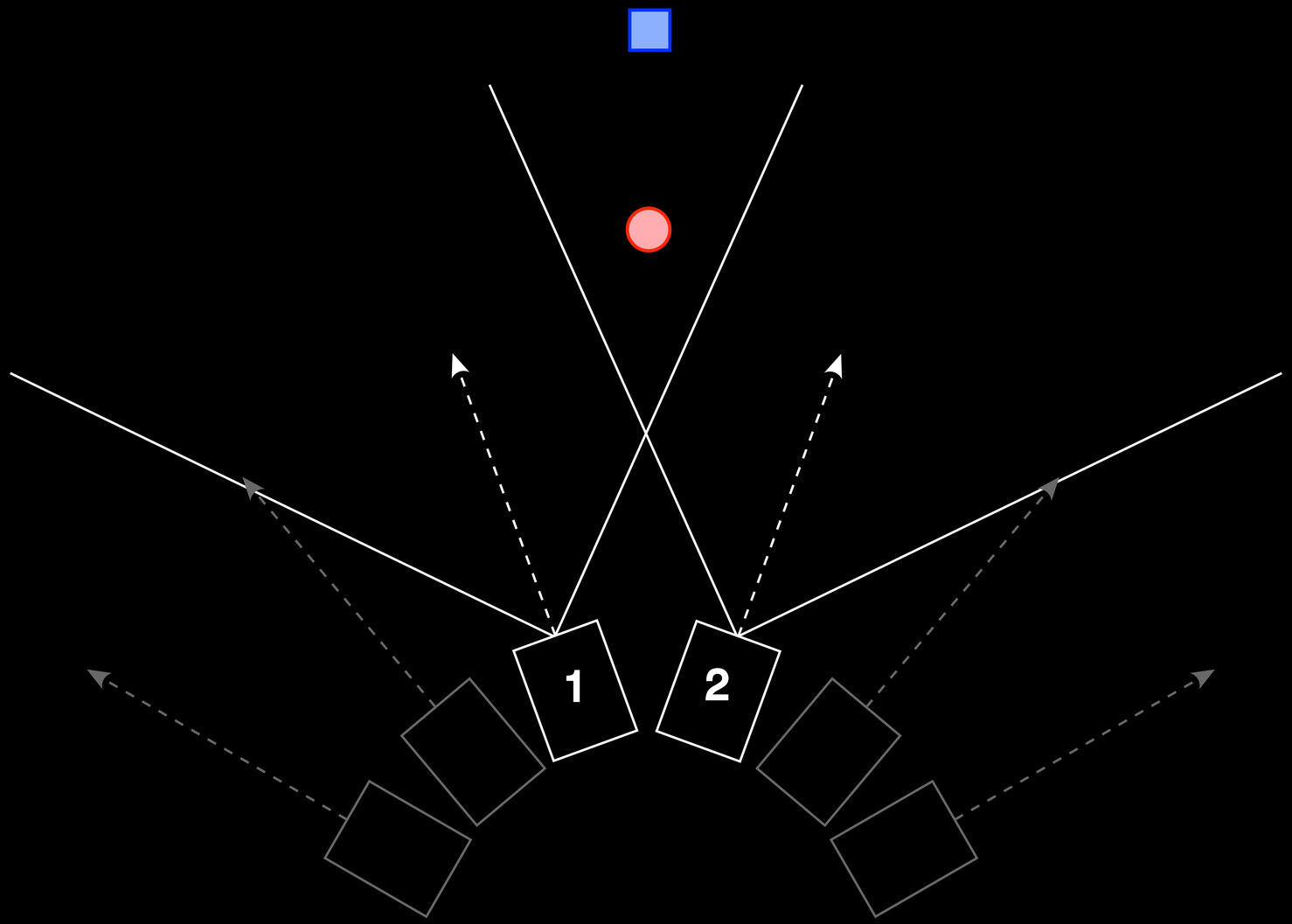


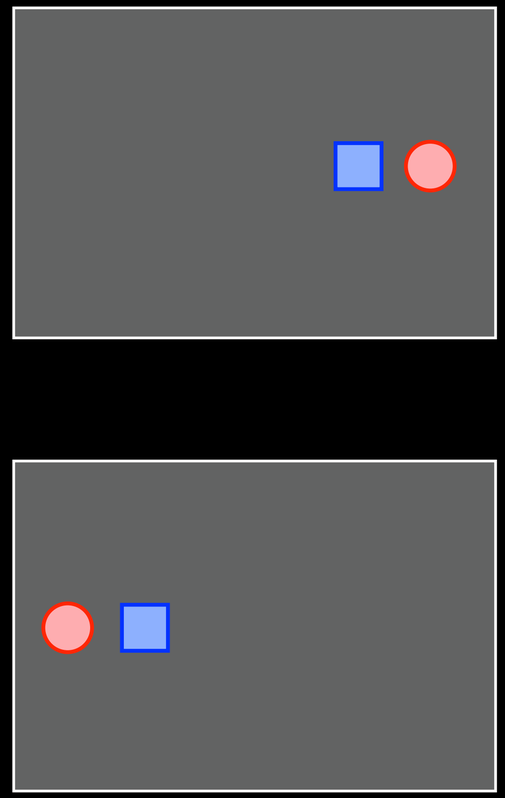



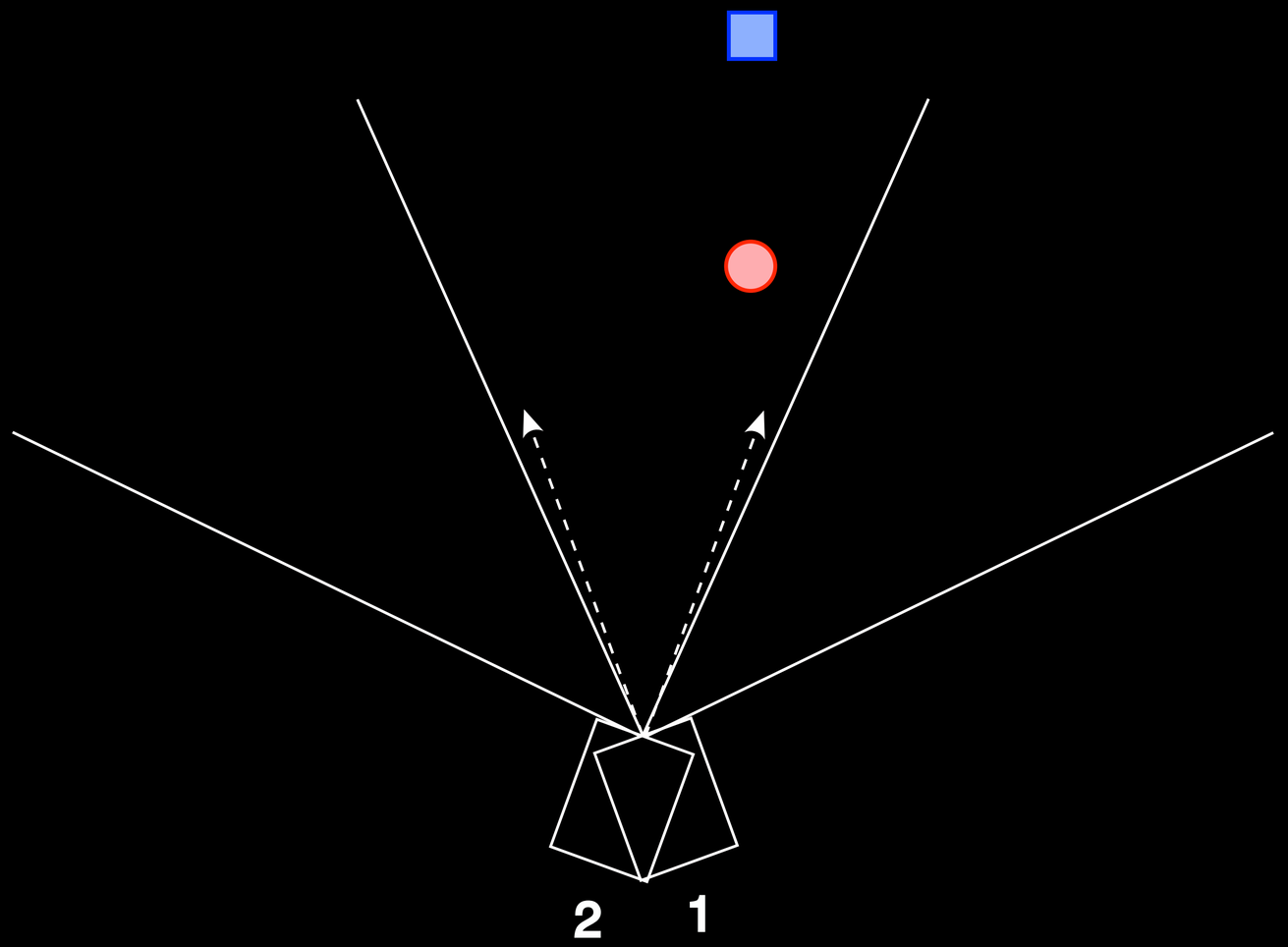




The fundamental problem



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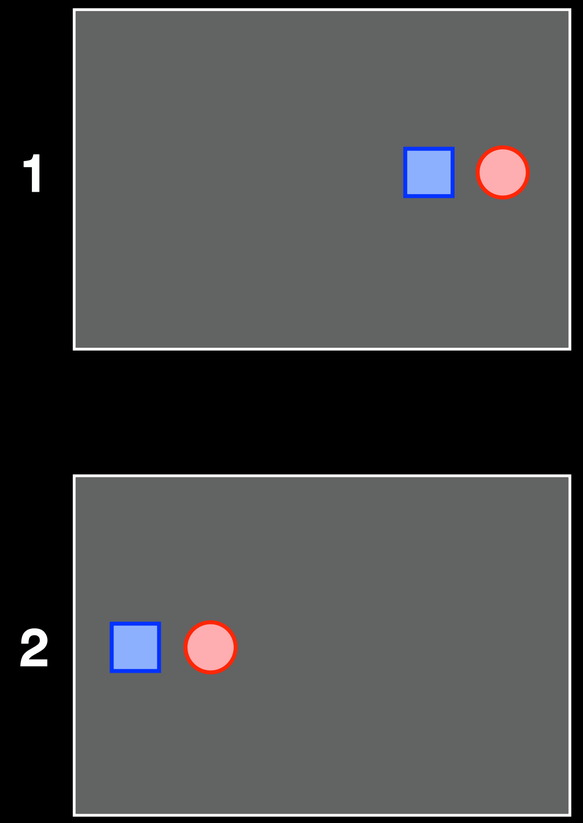
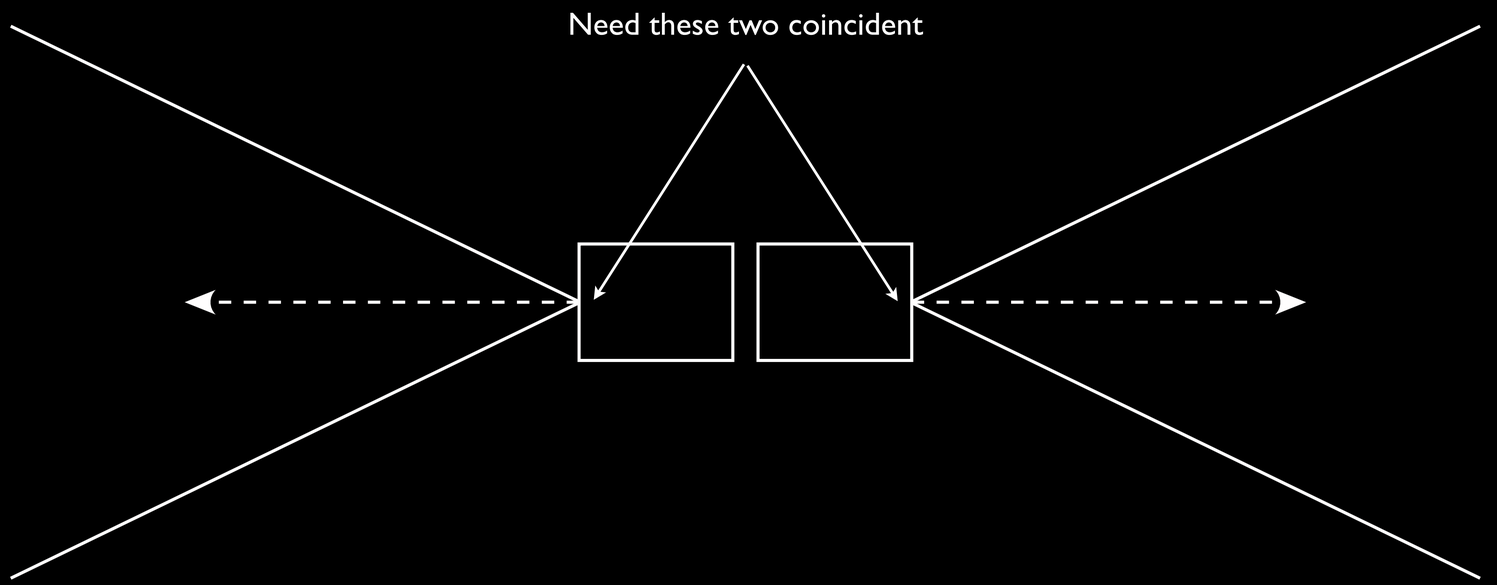
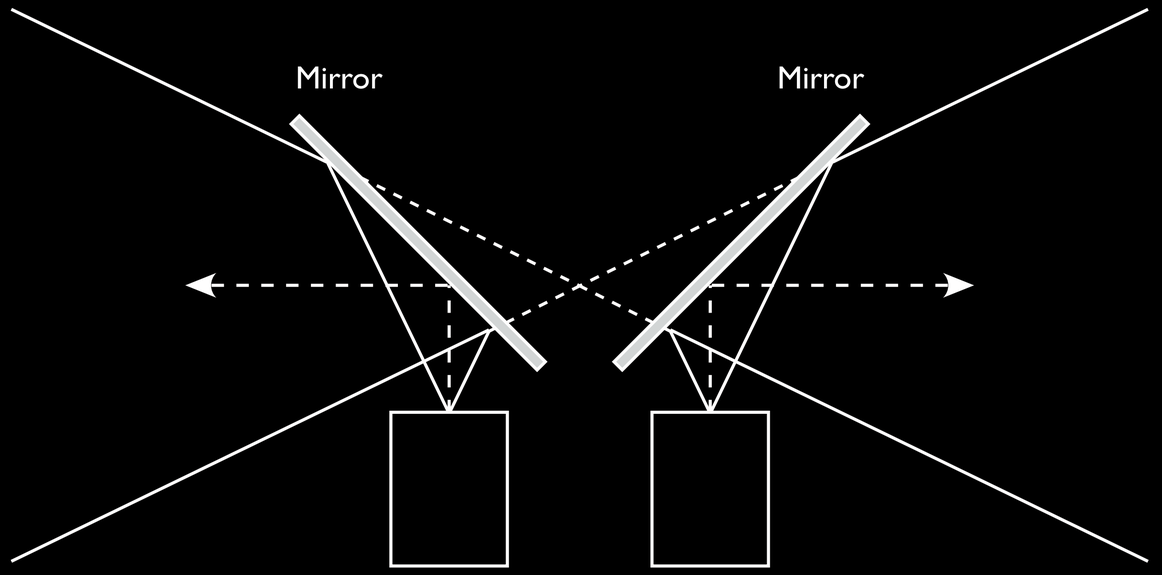
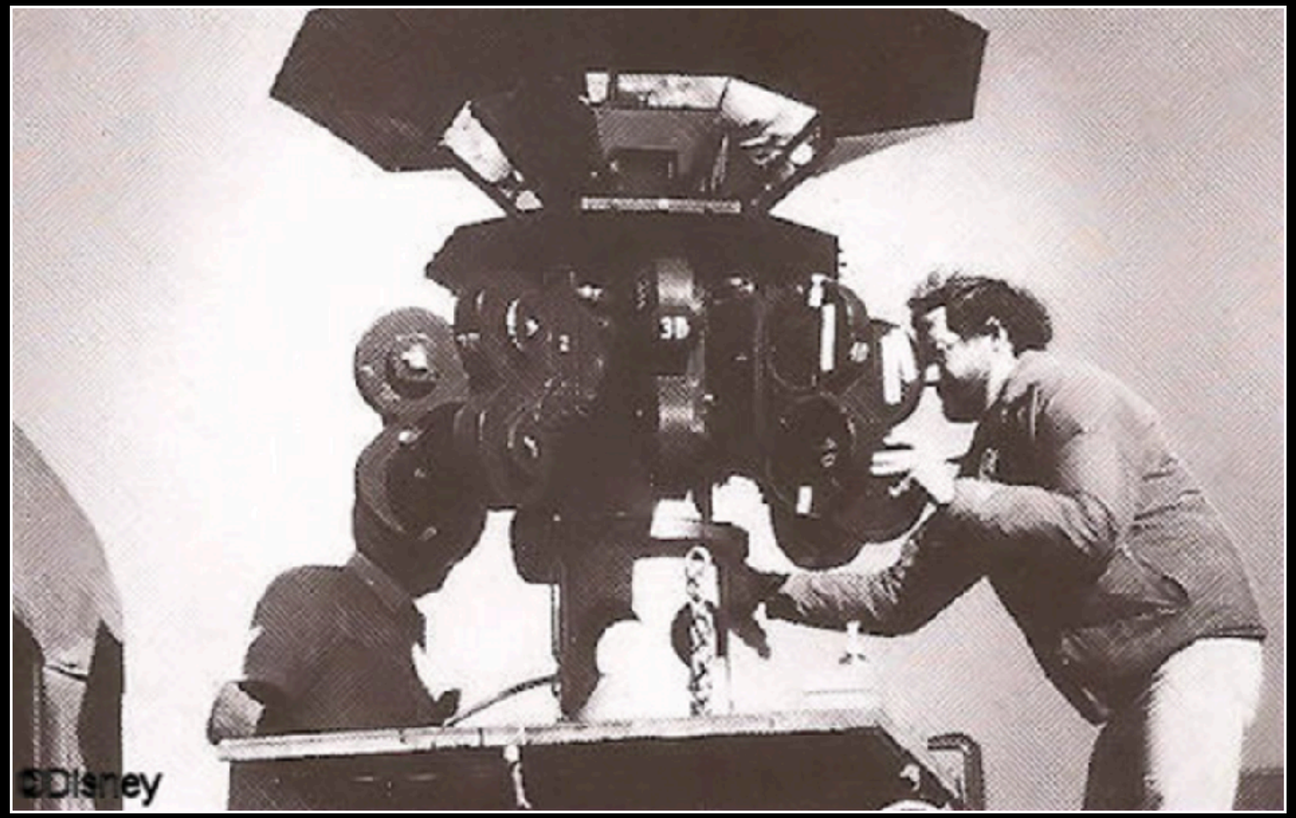
1


1
2

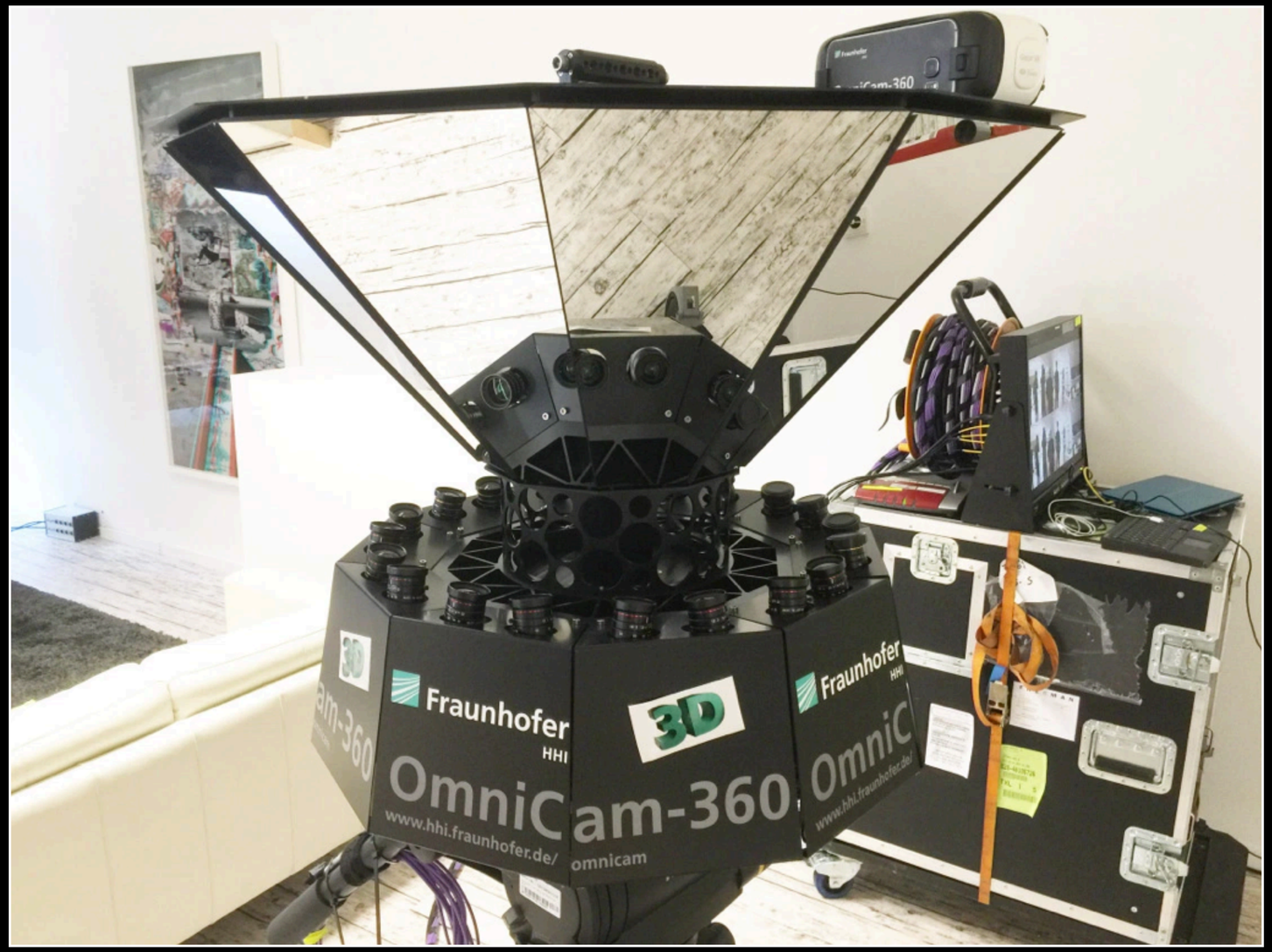
Solutions - Mirrors







Circlorama camera #2 (Disney)


Fraunhofer
HHI
OmniCam-360
www.hhi.fraunhofer.de/omnicam
3D


2
17
1

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

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

(75) Inventors: **Kensuke Masuda**, Kawasaki (JP); **Noriyuki Terao**, Sendal (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

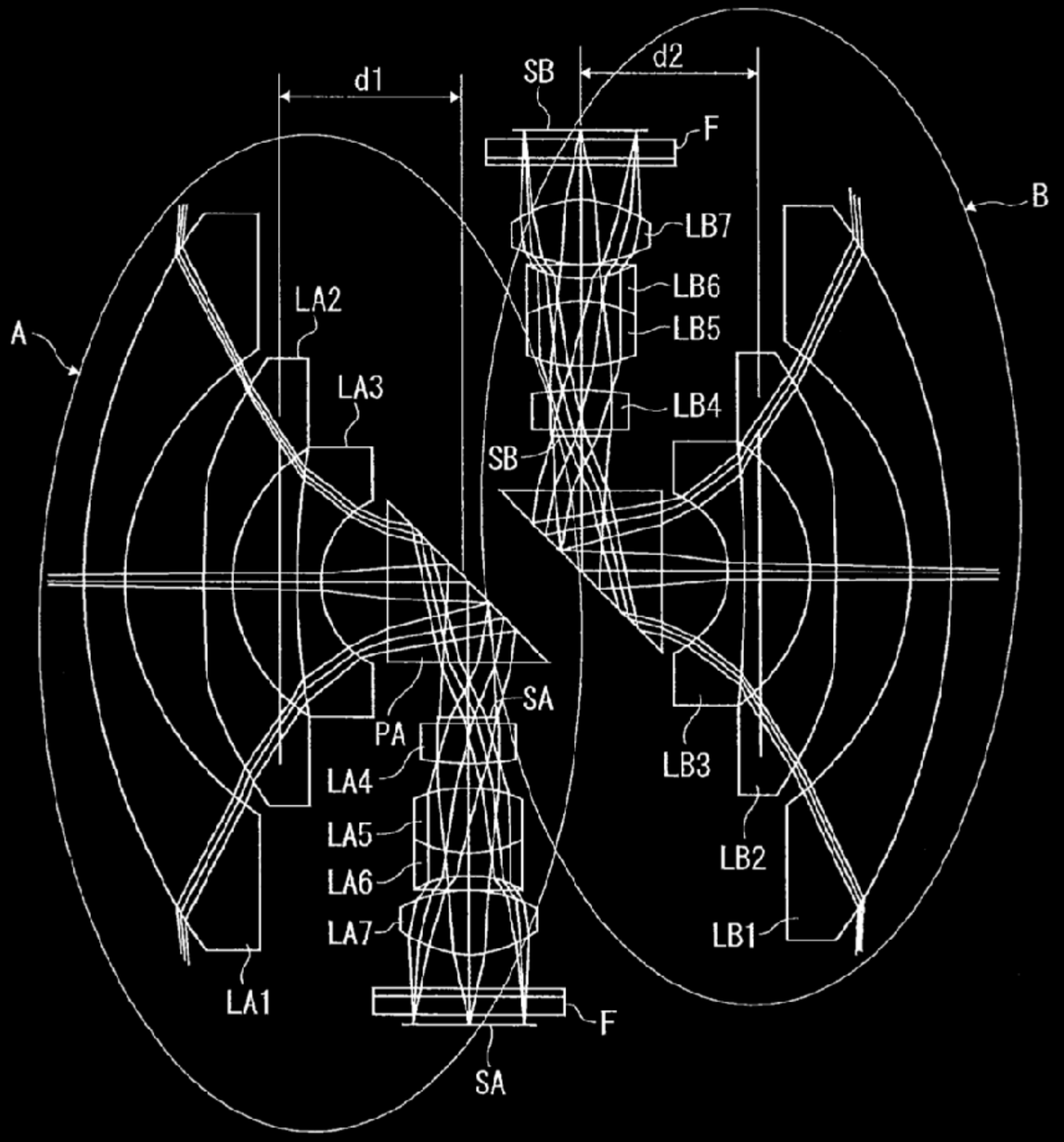
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2006-098942 4/2006
JP 2007-164079 6/2007

(Continued)

FIG. 1



Solutions - Custom Optics

E01
E02
E03
E04
E05
V01
V02
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V04
V05
F02
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F04
F05
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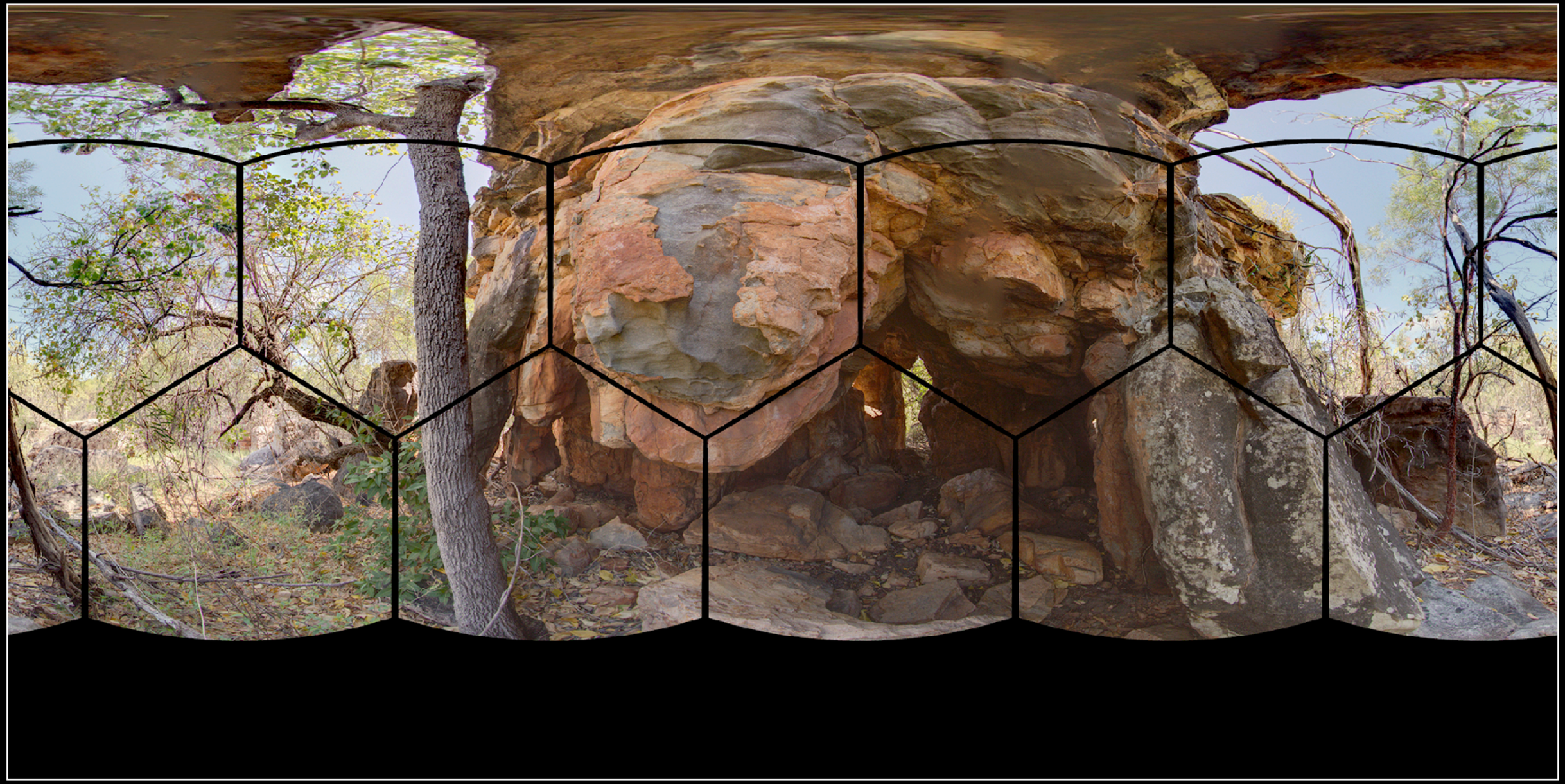
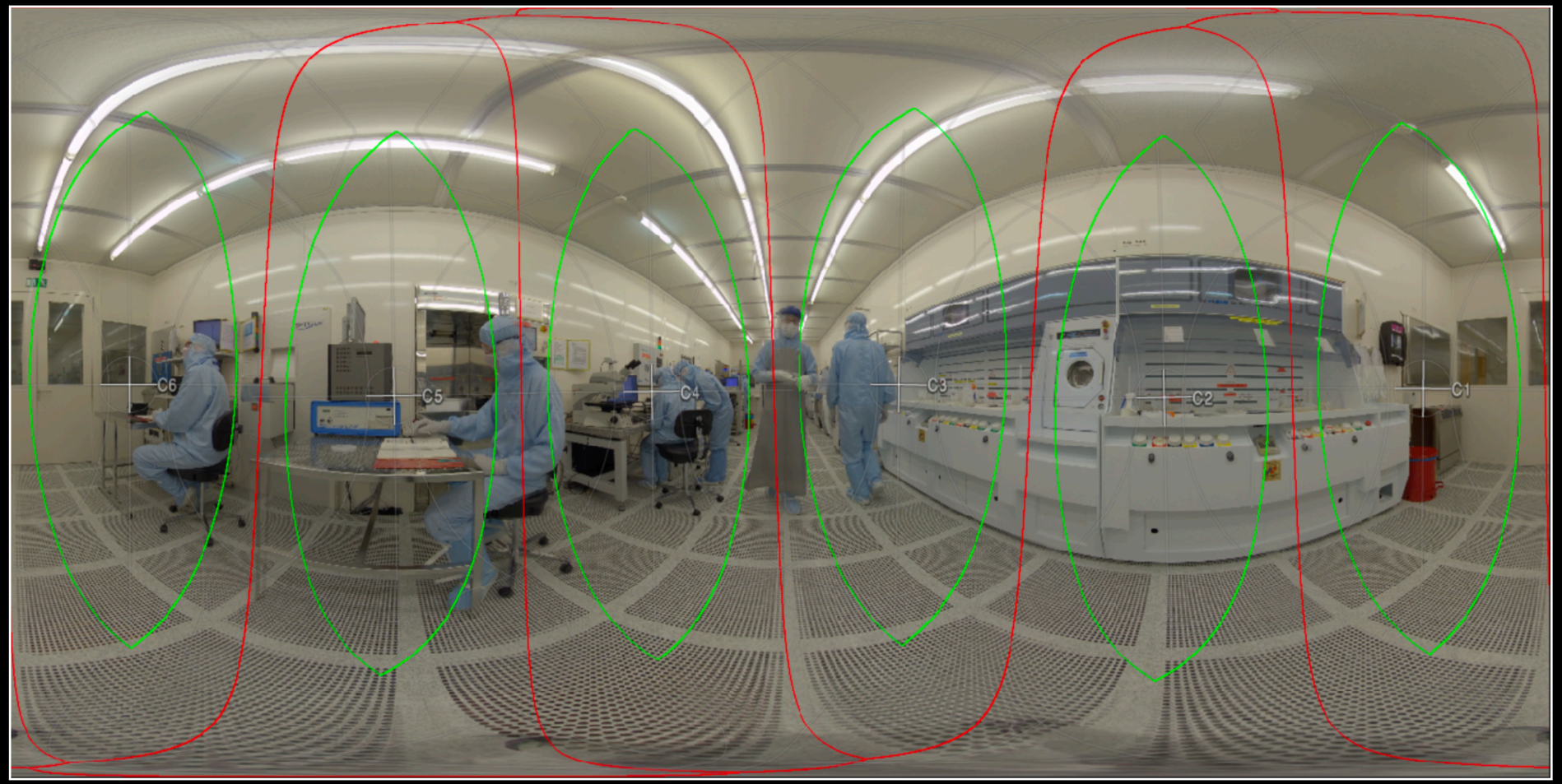
E14
E00
E12

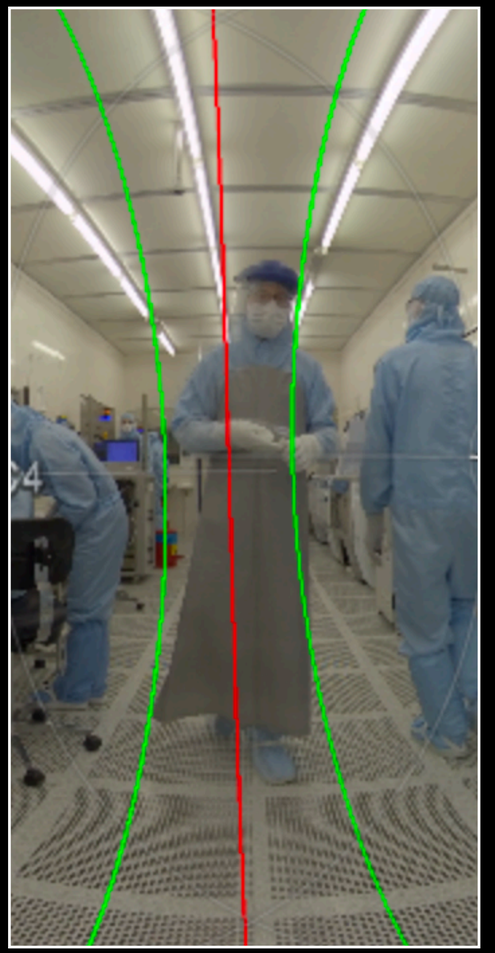


Solutions - Optical Flow

- 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 fps
Origin_1
Origin_2
Origin_3
Origin_4
Origin_5
Origin_6
Sync
Stitch
Color
Positions
Edge Points
00:02:48:24
Options
Use Optical Flow
Fill Holes
Black
Stitch Feathe
20.000
Convergence
0.000
Gamma Curve
ITU-BT 709 / ITU-BT 2020
Input Levels
Auto
Vertical Balan
Vignetting
Optical Flow
Camera Defaults
Input Cameras
Edge Points
Output Camera
Mapping
LatLong
Yaw:
152.000
Pitch:
0.000
Roll:
0.000
Focal Length
Offset X:
Offset Y:
Undistort a:
Undistort b:
Undistort c:


C6
C5
C4
C3
C2
C1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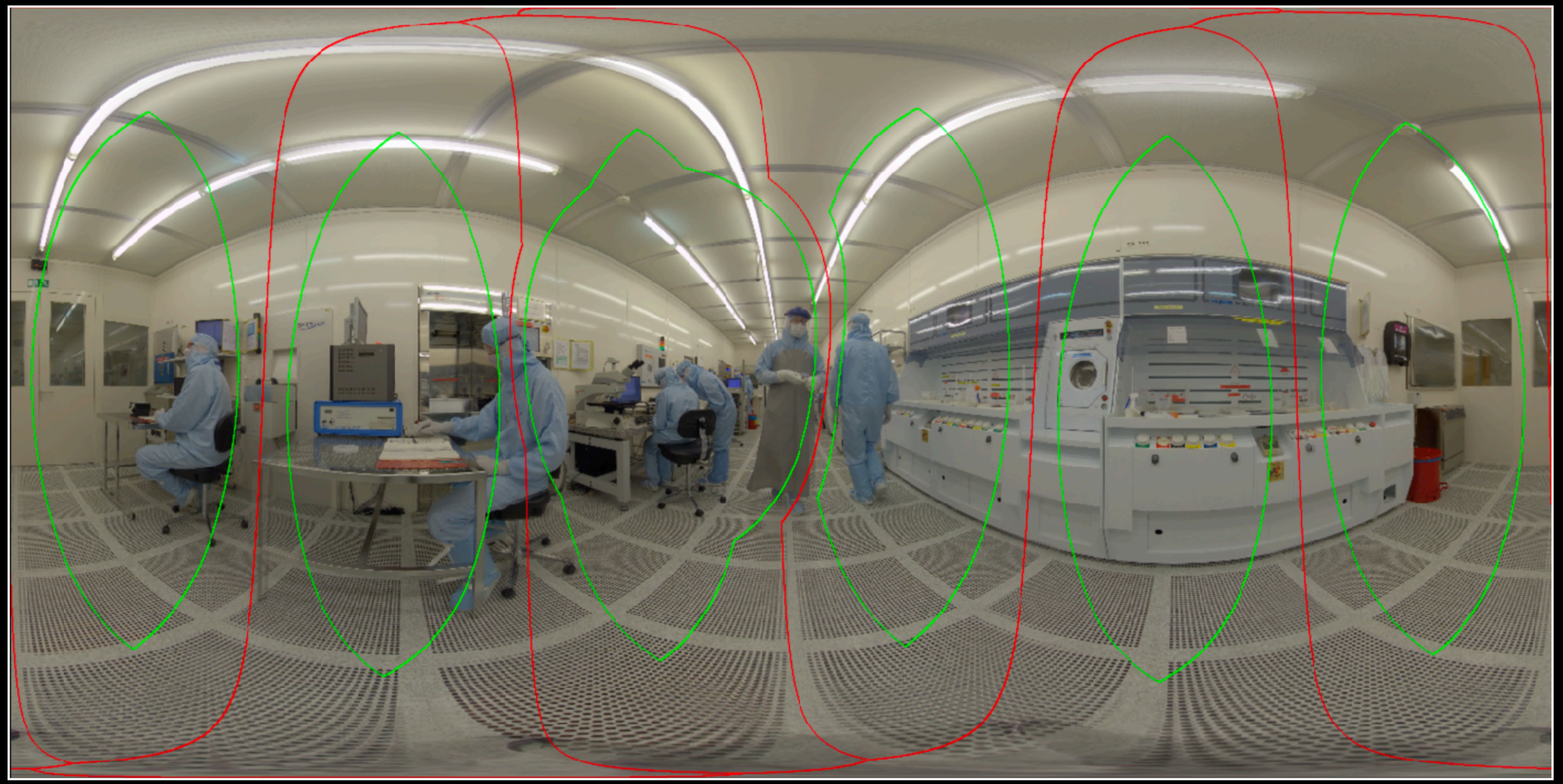
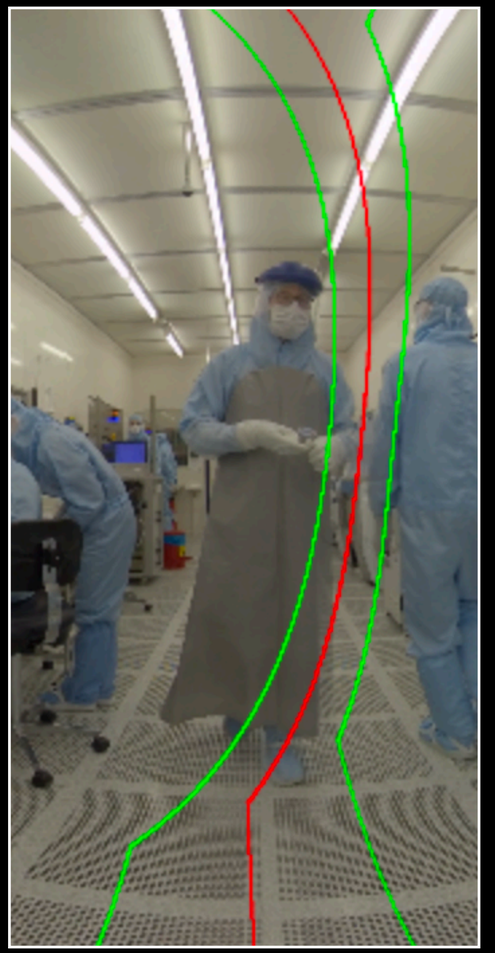


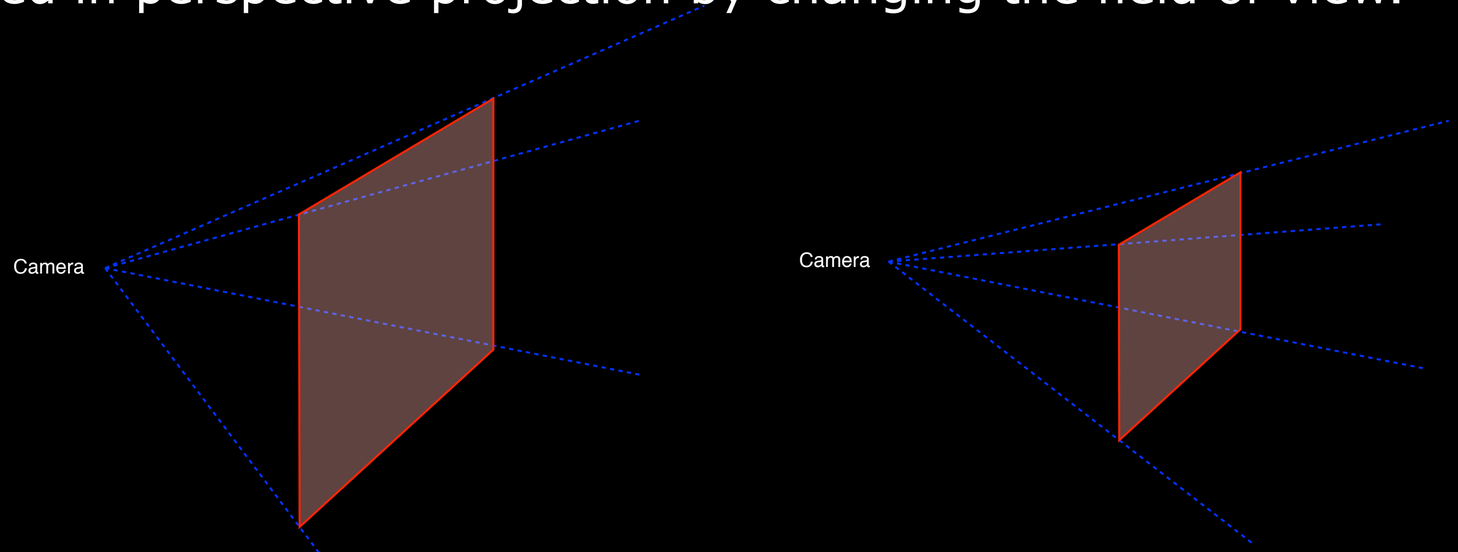


Miscellaneous topics - Resolution

- 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 “4K”, 3840 or true 4K 4096.
- Where most of the multiple camera (>2) is at is 8K.
  Including 8K in stereo3D.
- A few cameras are starting to be related at 12K.
- Most cameras to date have been just 8 bit, a few now and on the horizon are 10 ro 12 bit.

Miscellaneous topics - Zooming

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



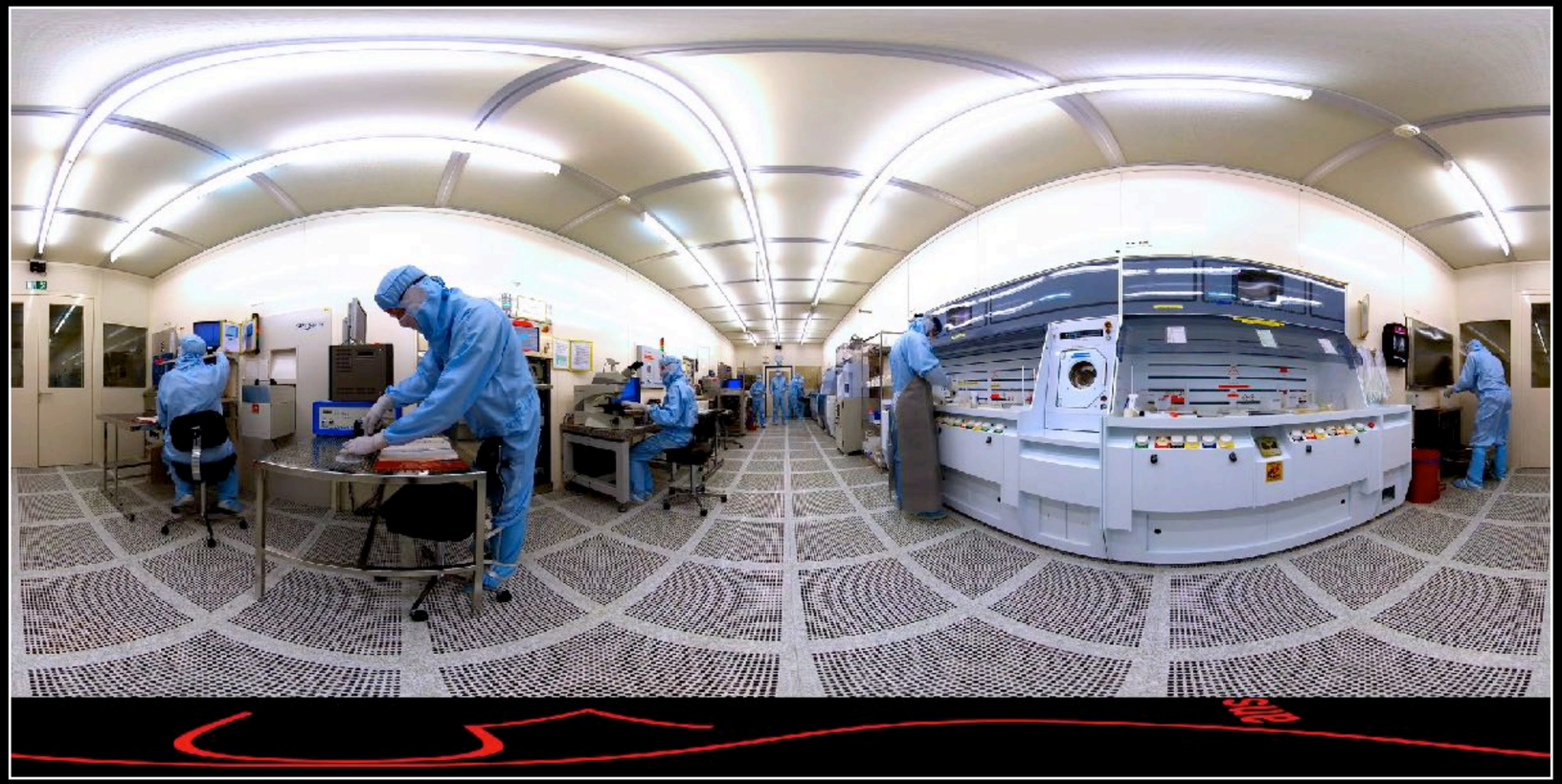
- To magnify something or to see more detail the camera needs to move closer towards it.

- 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



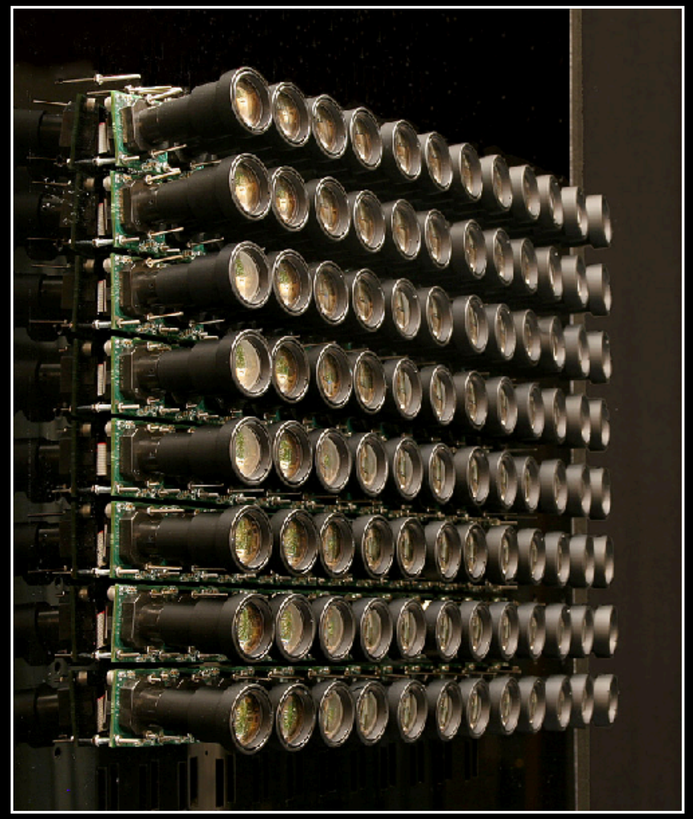

50 ans

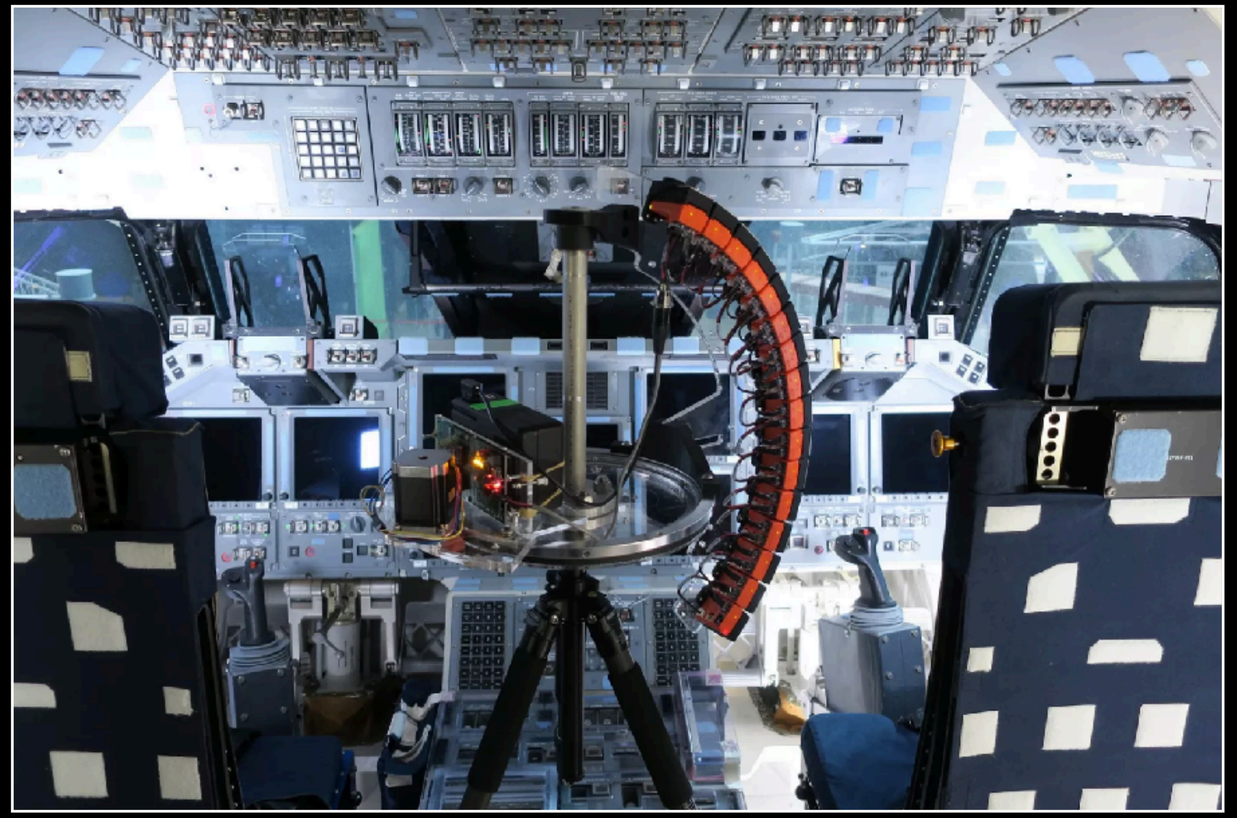
Stereoscopic (VR)

- 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.

The future

- Lightfield capture
  - Not only can one look around, but can move ones head for a different viewpoint.
  - Other magic can occur, like refocussing in post production.
  - Rigs for 360 only for static scenes at this stage.





End - Questions?