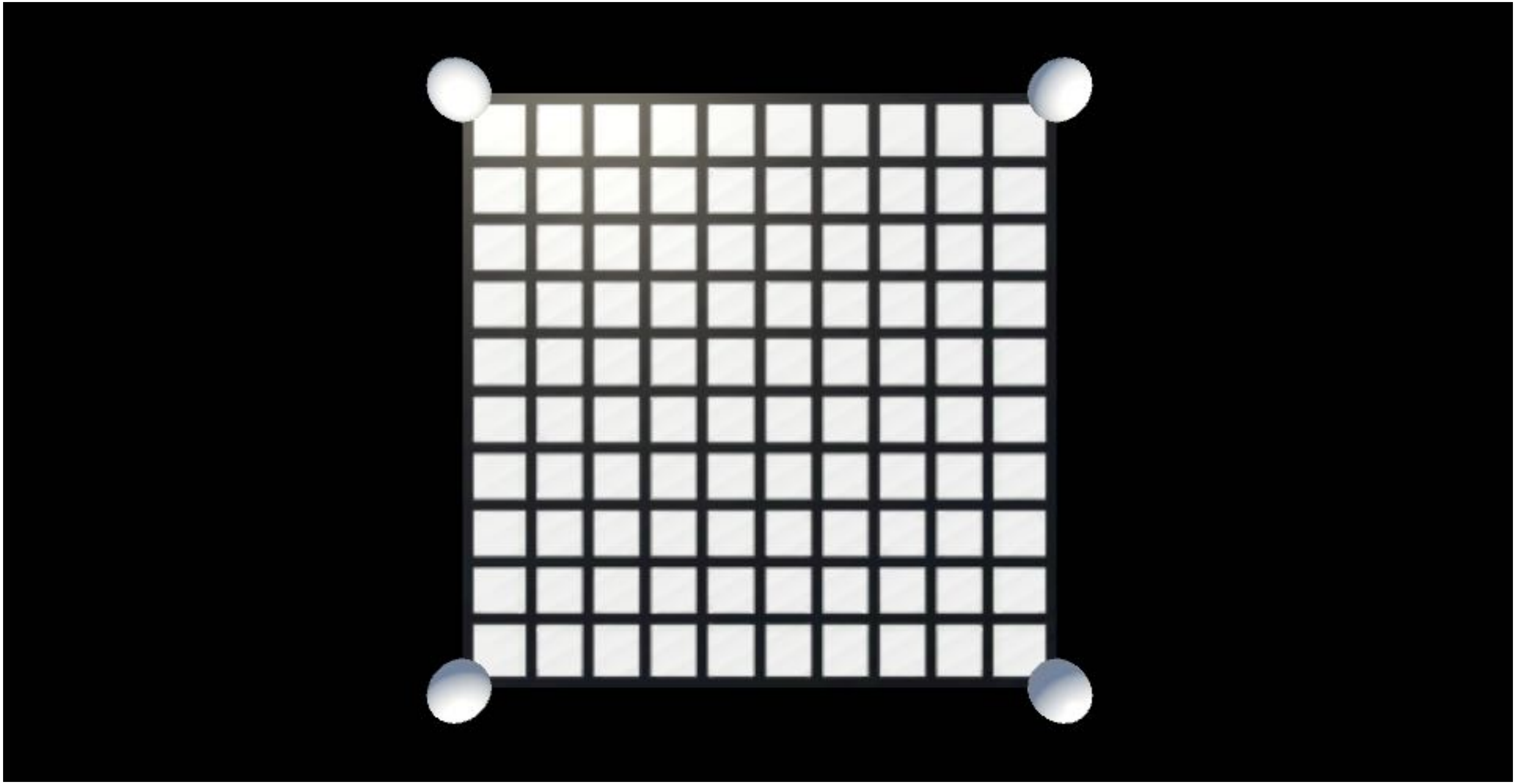
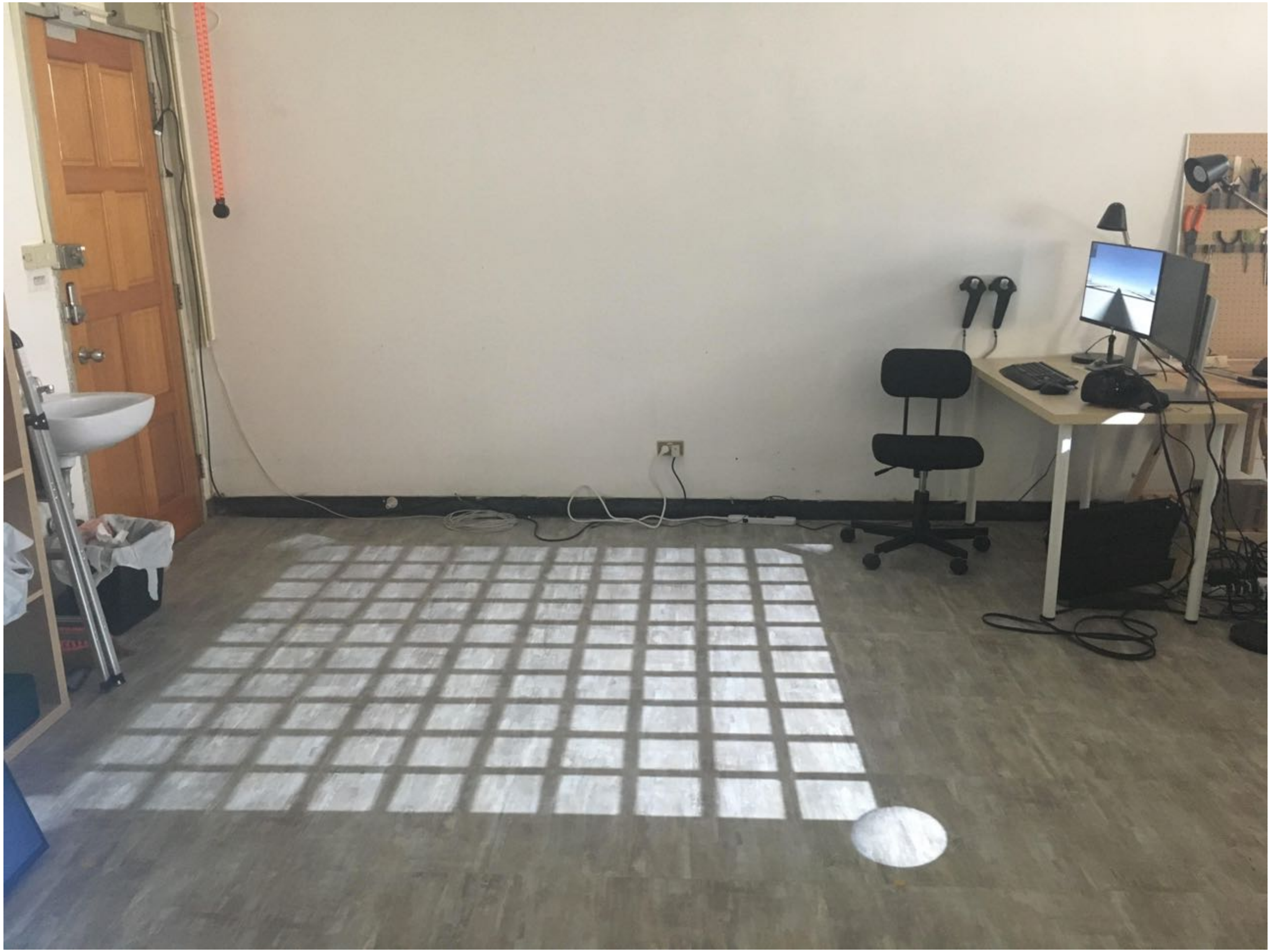
Interaction Design & Virtual Reality

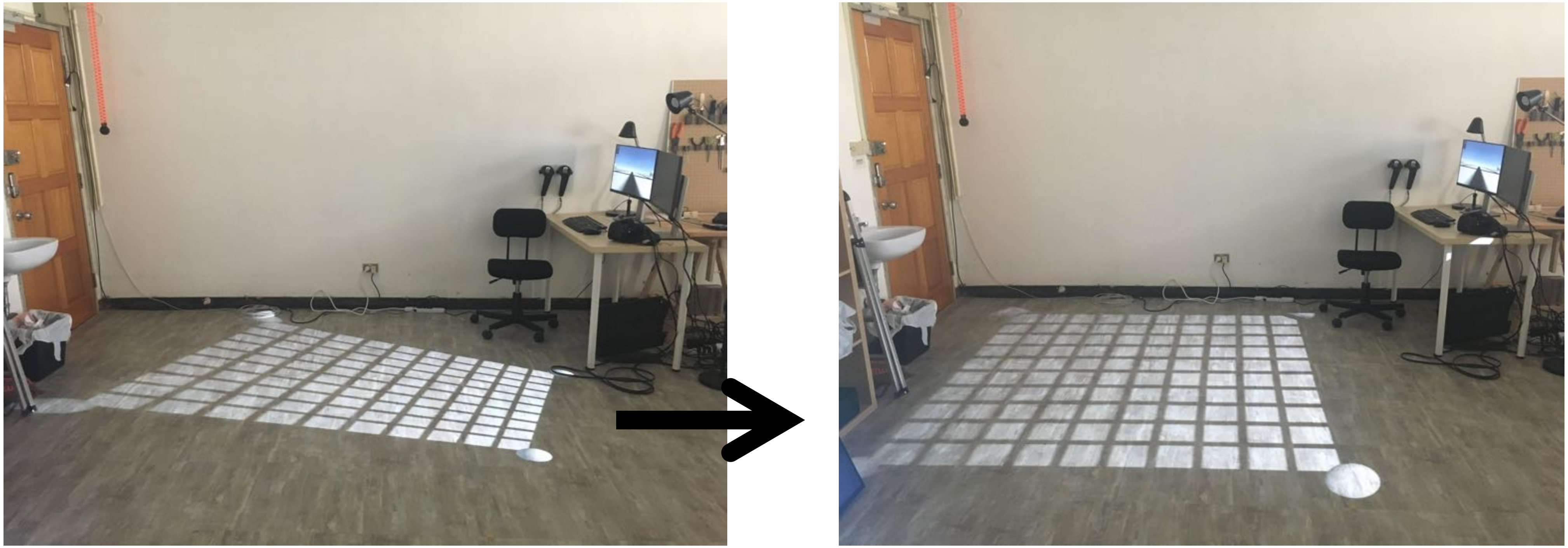
Liwei chan 詹力韋
Assistant Prof.

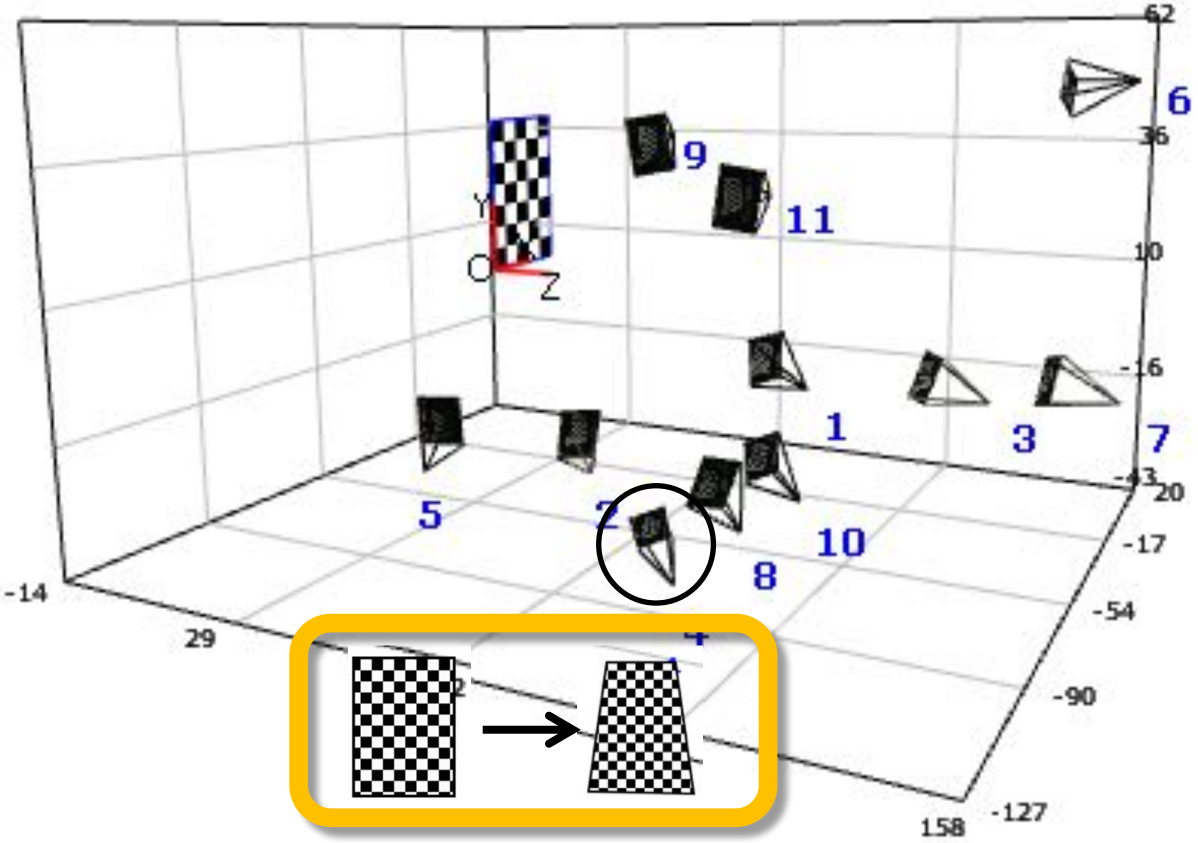
2016.11.29

FloorProjection







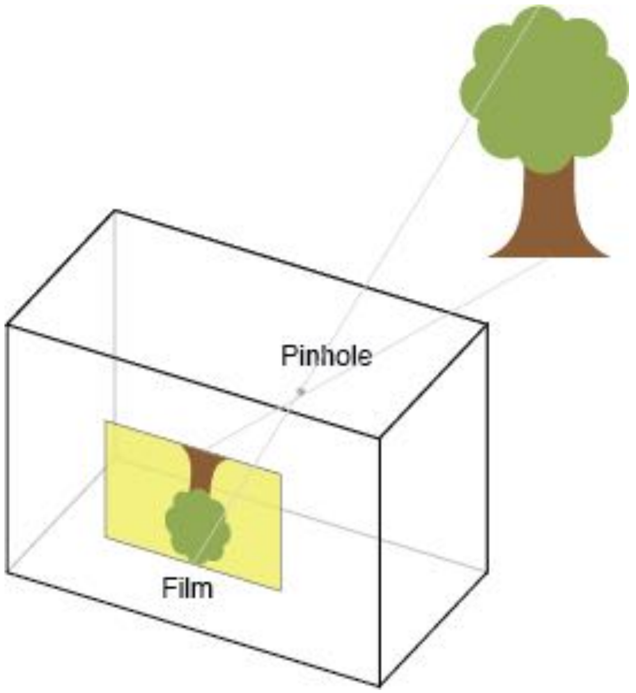


When projecting,
Apply the transformation in advance.
This transformation is called an **extrinsic matrix** of a camera.
This operation is also called **homographic transformation**.

Intrinsic Matrix

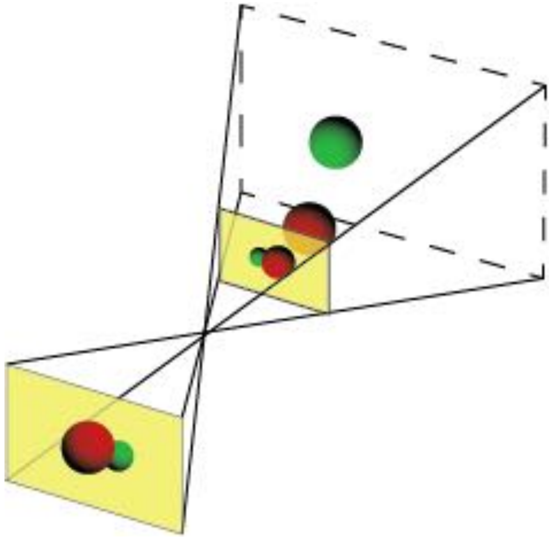
http://ksimek.github.io/2013/08/13/intrinsic/

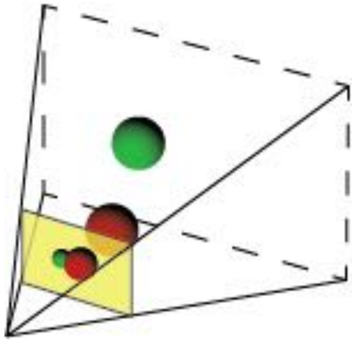
Pinhole Camera



$$K = \begin{pmatrix} f_x & s & x_0 \\ 0 & f_y & y_0 \\ 0 & 0 & 1 \end{pmatrix}$$

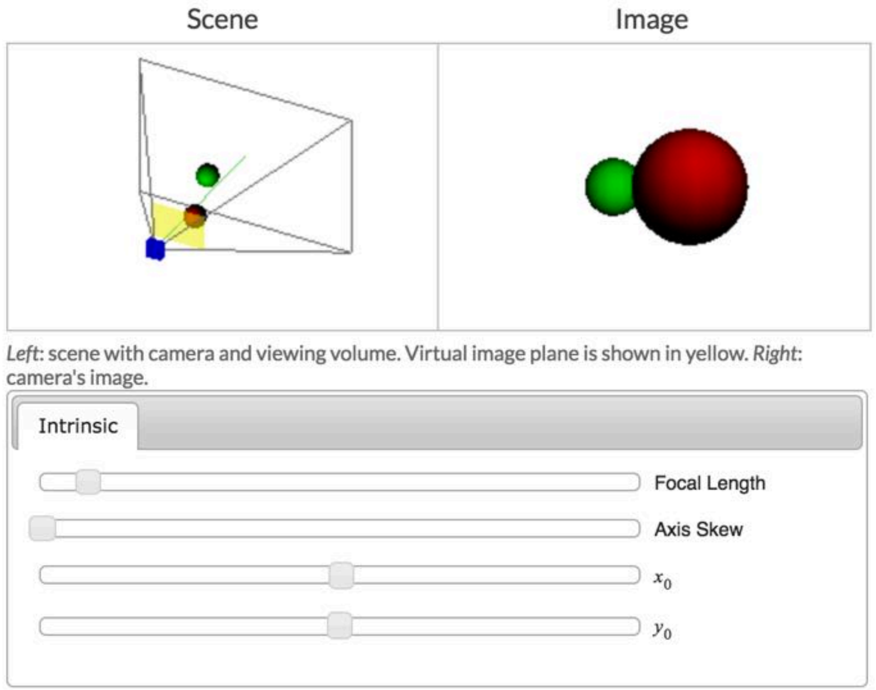
Focal Length, fx**,** fy
Principal Point Offset, , x0**,** y0
Axis Skew, s





With more intuitive representation

DEMO



Left: scene with camera and viewing volume. Virtual image plane is shown in yellow. *Right*: camera's image.

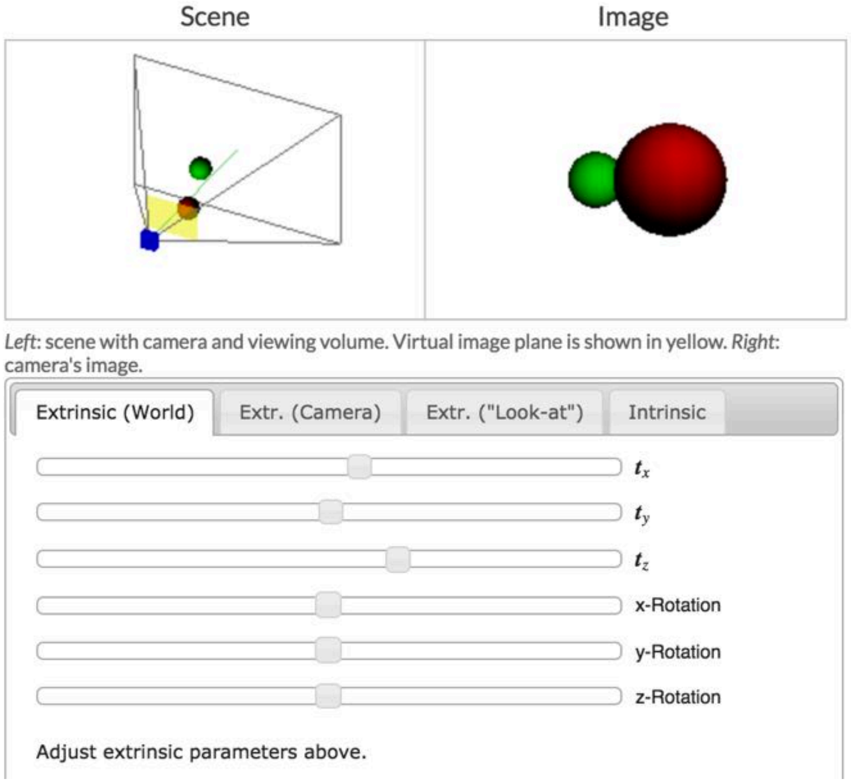
http://ksimek.github.io/2013/08/13/intrinsic/

$$K = \begin{pmatrix} f_x & s & x_0 \\ 0 & f_y & y_0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$= \underbrace{\begin{pmatrix} 1 & 0 & x_0 \\ 0 & 1 & y_0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{2D Translation}} \times \underbrace{\begin{pmatrix} f_x & 0 & 0 \\ 0 & f_y & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{2D Scaling}} \times \underbrace{\begin{pmatrix} 1 & s/f_x & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{2D Shear}}$$

Extrinsic Matrix

http://ksimek.github.io/2012/08/22/extrinsic/

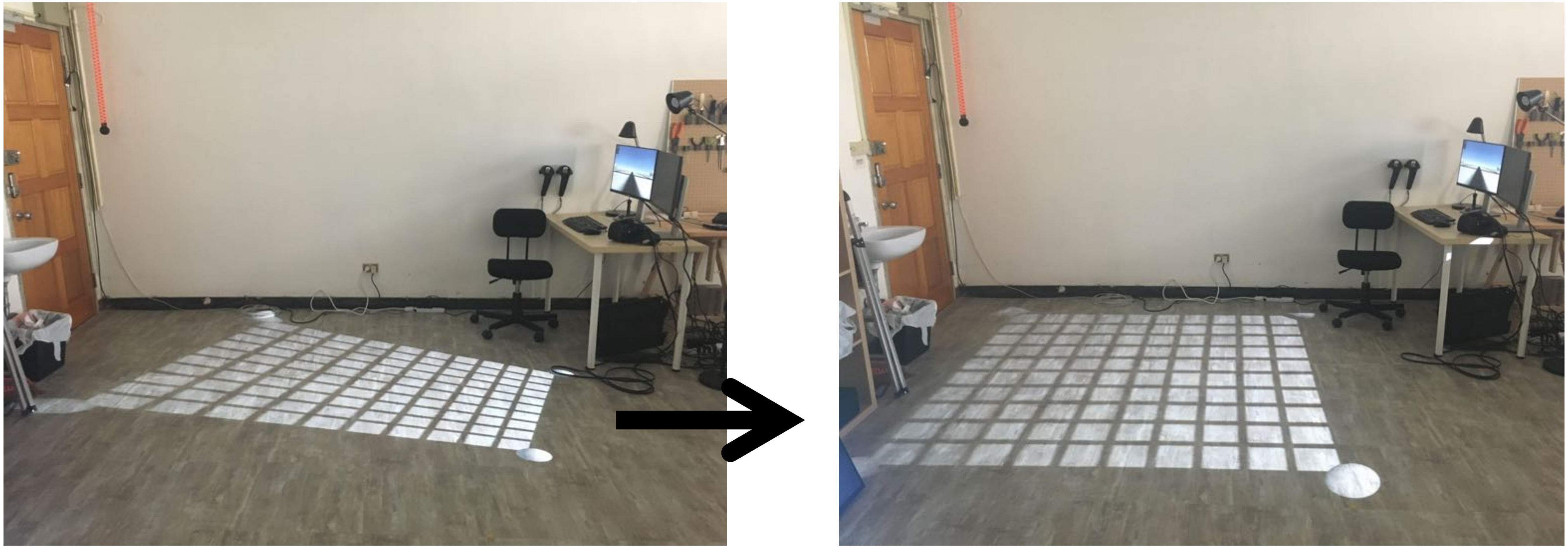


Left: scene with camera and viewing volume. Virtual image plane is shown in yellow. *Right*: camera's image.

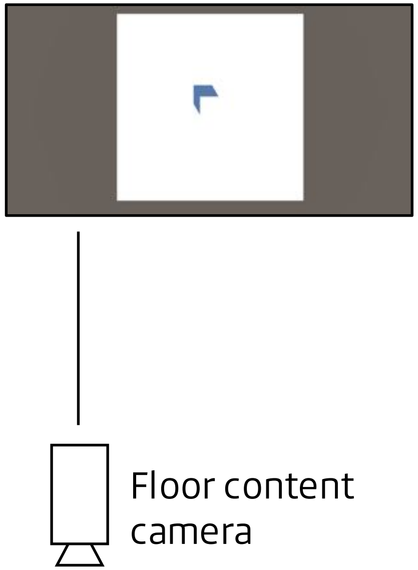
Adjust extrinsic parameters above.

$$[R \mid \boldsymbol{t}] = \left[\begin{array}{ccc|c} r_{1,1} & r_{1,2} & r_{1,3} & t_1 \\ r_{2,1} & r_{2,2} & r_{2,3} & t_2 \\ r_{3,1} & r_{3,2} & r_{3,3} & t_3 \end{array}\right]$$

$$\begin{aligned} \left[\begin{array}{c|c} R & \boldsymbol{t} \\ \hline \boldsymbol{0} & 1 \end{array}\right] &= \left[\begin{array}{c|c} I & \boldsymbol{t} \\ \hline \boldsymbol{0} & 1 \end{array}\right] \times \left[\begin{array}{c|c} R & \boldsymbol{0} \\ \hline \boldsymbol{0} & 1 \end{array}\right] \\ &= \left[\begin{array}{ccc|c} 1 & 0 & 0 & t_1 \\ 0 & 1 & 0 & t_2 \\ 0 & 0 & 1 & t_3 \\ \hline 0 & 0 & 0 & 1 \end{array}\right] \times \left[\begin{array}{ccc|c} r_{1,1} & r_{1,2} & r_{1,3} & 0 \\ r_{2,1} & r_{2,2} & r_{2,3} & 0 \\ r_{3,1} & r_{3,2} & r_{3,3} & 0 \\ \hline 0 & 0 & 0 & 1 \end{array}\right] \end{aligned}$$

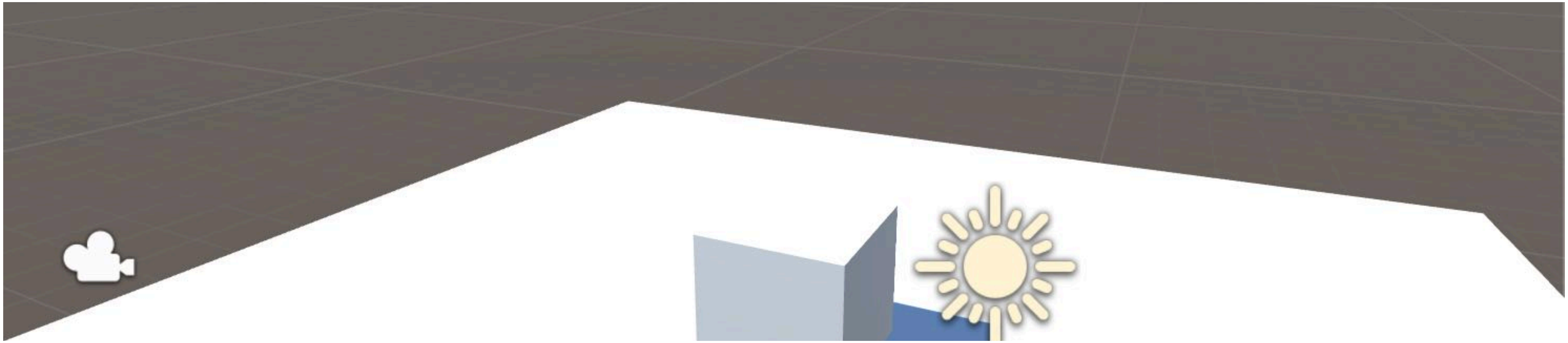


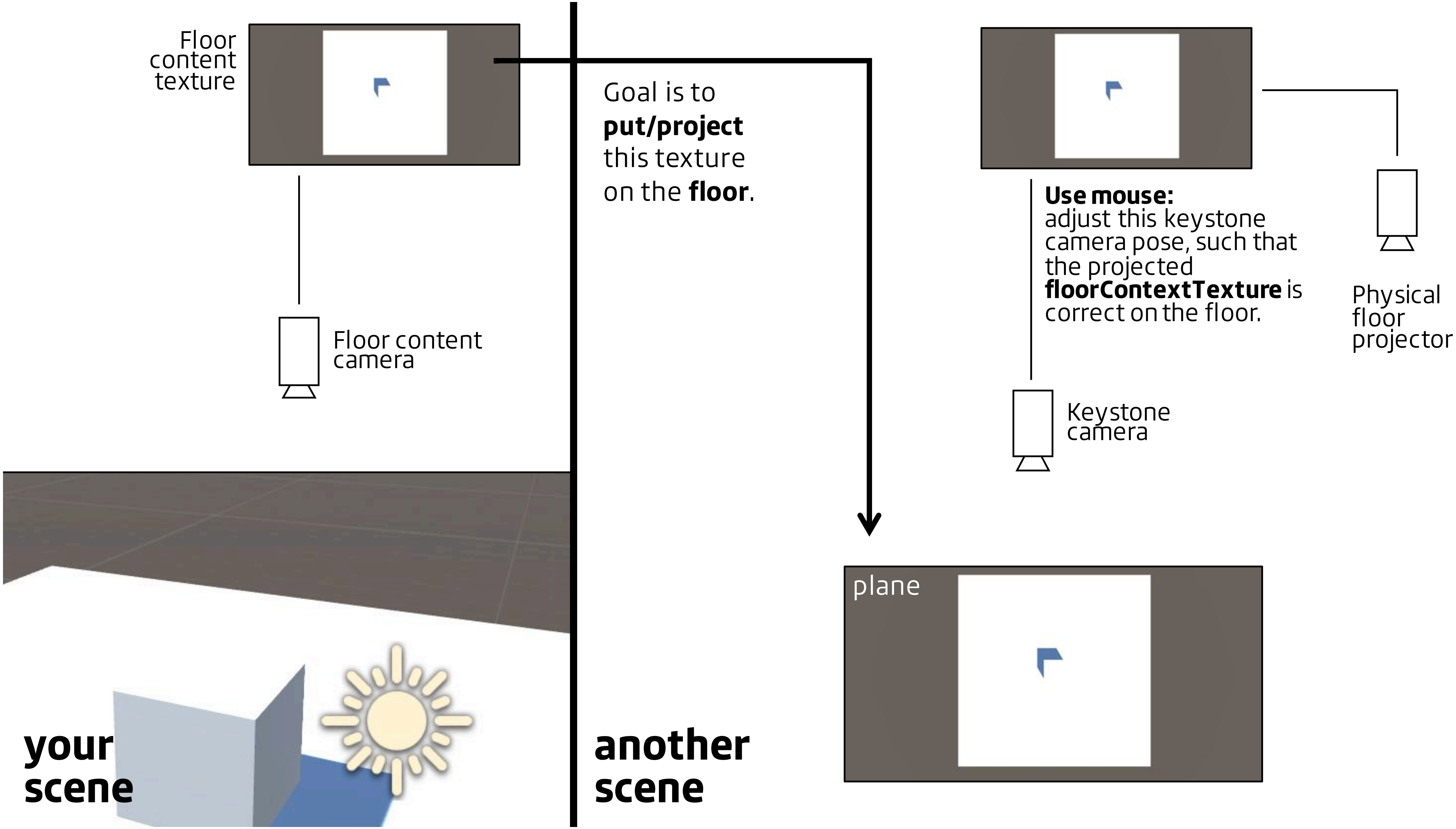
Change to a camera pose
Such that when the projector



Floor content texture **(RenderTexture)**

Floor content camera





Floor content texture

Floor content camera

your scene

Goal is to **put/project** this texture on the **floor**.

another scene

plane

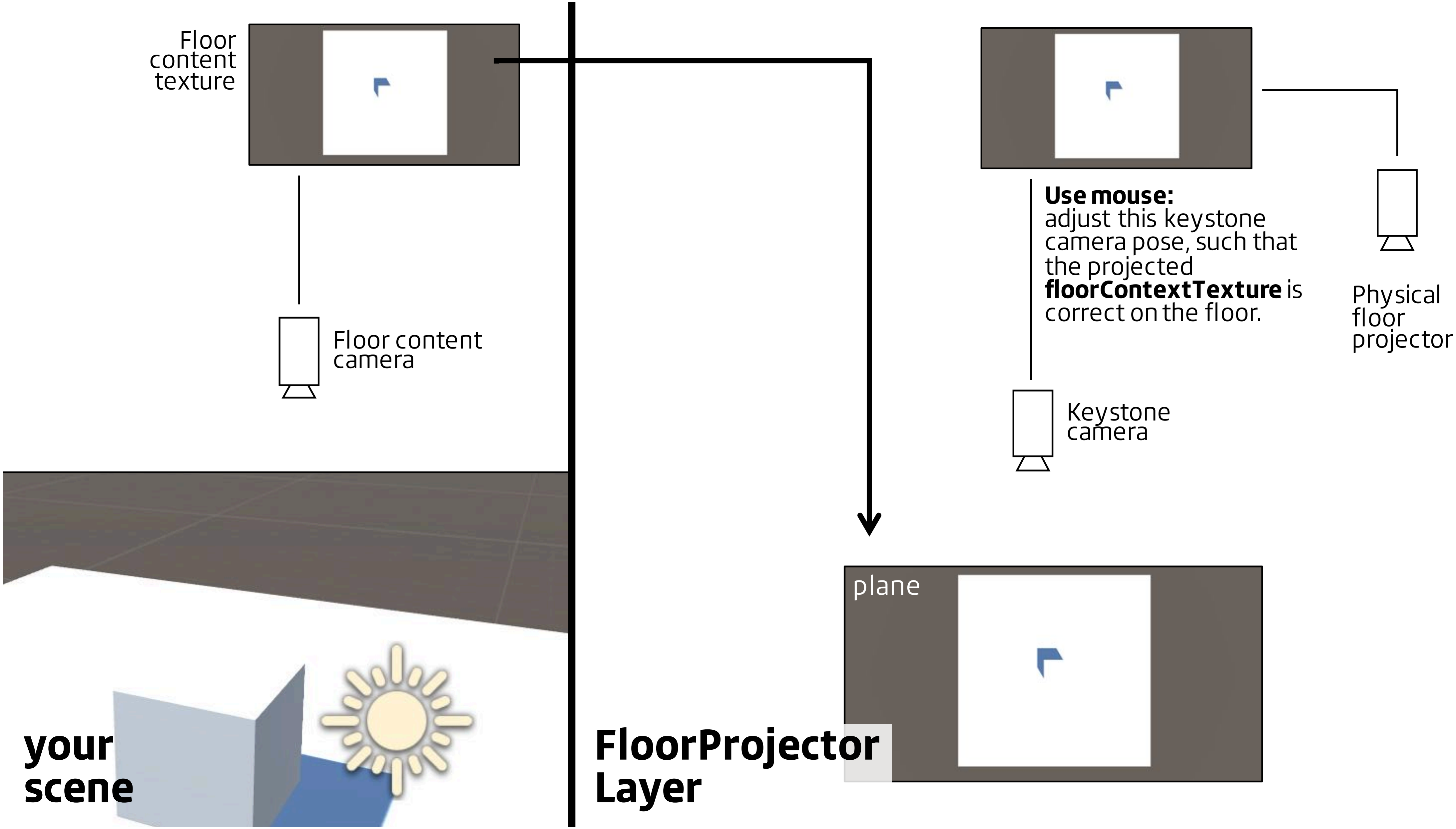
Keystone camera

Use mouse:
adjust this keystone camera pose, such that the projected **floorContextTexture** is correct on the floor.

Physical floor projector

Instead of an independent
“another” scene,

we add **layer (e.g.,** FloorProjector)
to separate the scene



Floor content texture

Floor content camera

Use mouse: adjust this keystone camera pose, such that the projected **floorContextTexture** is correct on the floor.

Physical floor projector

Keystone camera

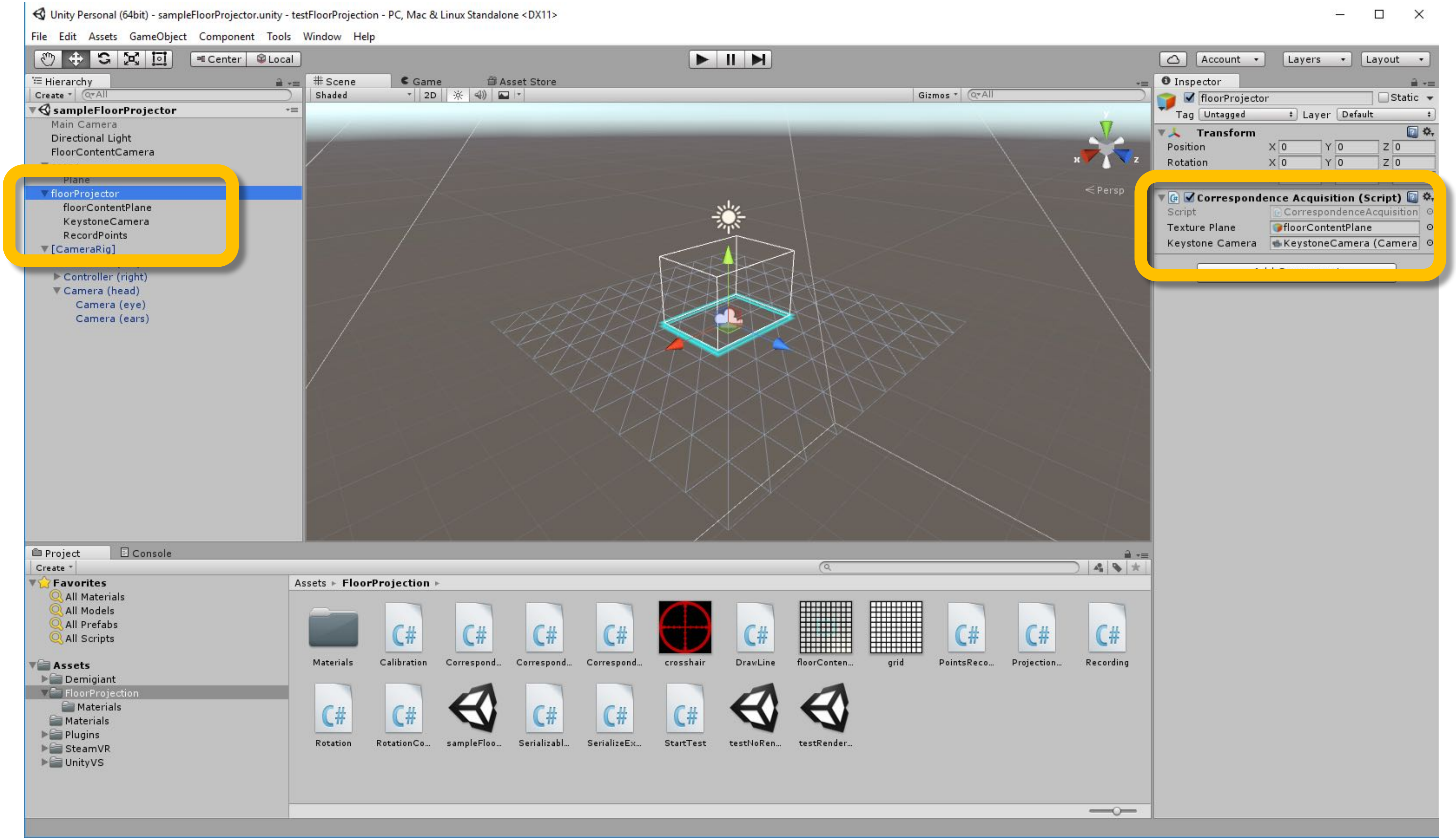
plane

your scene

FloorProjector Layer

STEPs for integration:

1. Import floorProject.package
2. Add Tad “CalibrationSphere”
3. Add Layer “FloorProjector”
4. Go to Edit -> Project Settings -> Players, switch to **.NET 2.0**.
5. Double check
   - FloorContentCamera: Target Display -> Display 1
   - FloorContentCamera: Target Eye -> None
   - KeystoneCamera: Target Display -> Display 2
   - KeystoneCamera: Target Eye -> None
6. **Adapt FloorContentCamera pose for your application.**



Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

floorProjector

Tag Untagged Layer Default

Transform

Position X 0 Y 0 Z 0

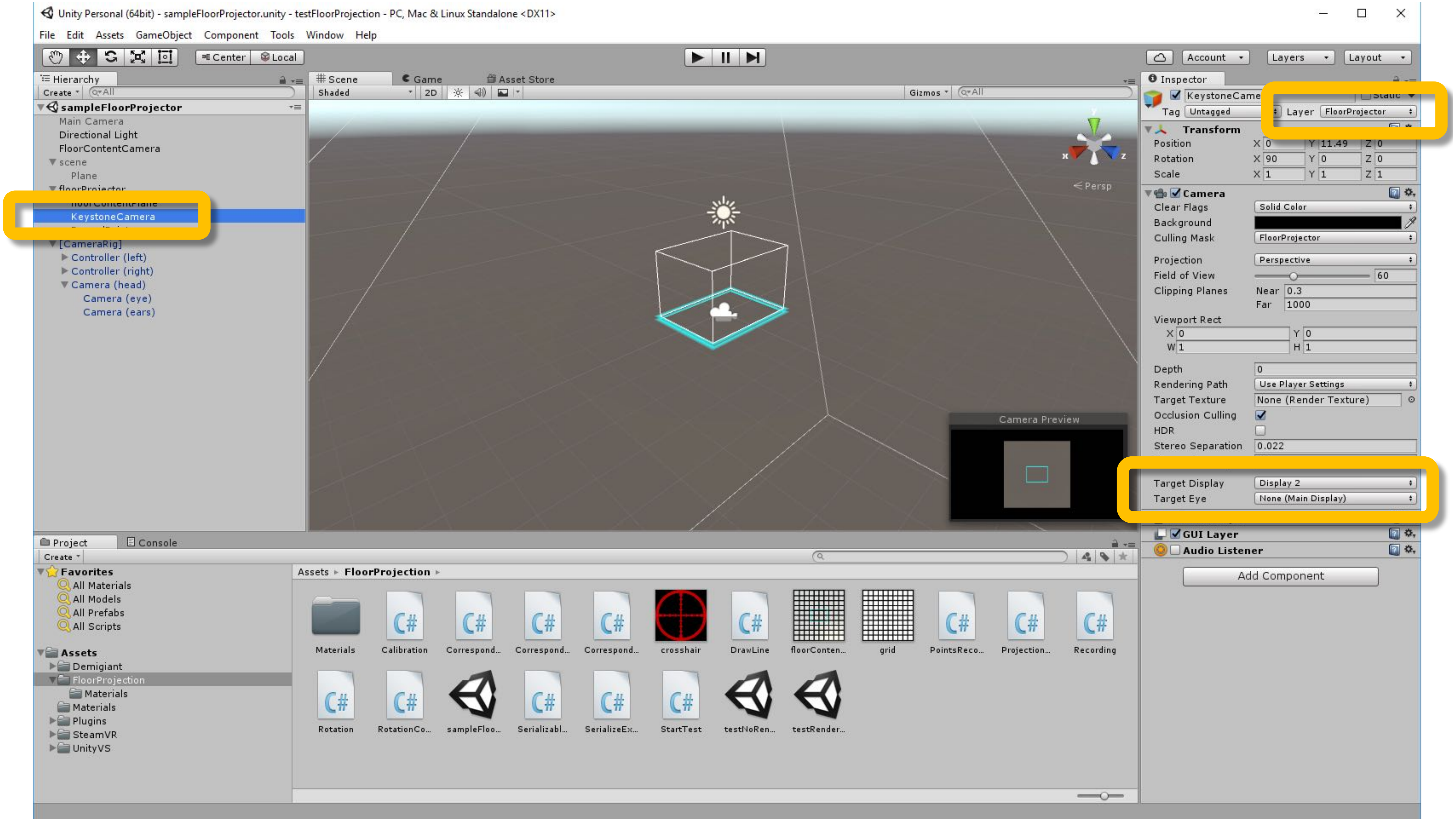
Rotation X 0 Y 0 Z 0

Correspondence Acquisition (Script)

Script CorrespondenceAcquisition

Texture Plane floorContentPlane

Keystone Camera KeystoneCamera (Camera



Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

sampleFloorProjector
- Main Camera
- Directional Light
- FloorContentCamera
- scene
  - Plane
- floorProjector
  - floorContentPlane
  - KeystoneCamera
- [CameraRig]
  - Controller (left)
  - Controller (right)
  - Camera (head)
    - Camera (eye)
    - Camera (ears)

KeystoneCamera Static
Tag Untagged Layer FloorProjector

Transform
Position X 0 Y 11.49 Z 0
Rotation X 90 Y 0 Z 0
Scale X 1 Y 1 Z 1

Camera
Clear Flags: Solid Color
Background:
Culling Mask: FloorProjector
Projection: Perspective
Field of View: 60
Clipping Planes: Near 0.3, Far 1000
Viewport Rect: X 0 Y 0, W 1 H 1
Depth: 0
Rendering Path: Use Player Settings
Target Texture: None (Render Texture)
Occlusion Culling: ☑
HDR: ☐
Stereo Separation: 0.022
Target Display: Display 2
Target Eye: None (Main Display)

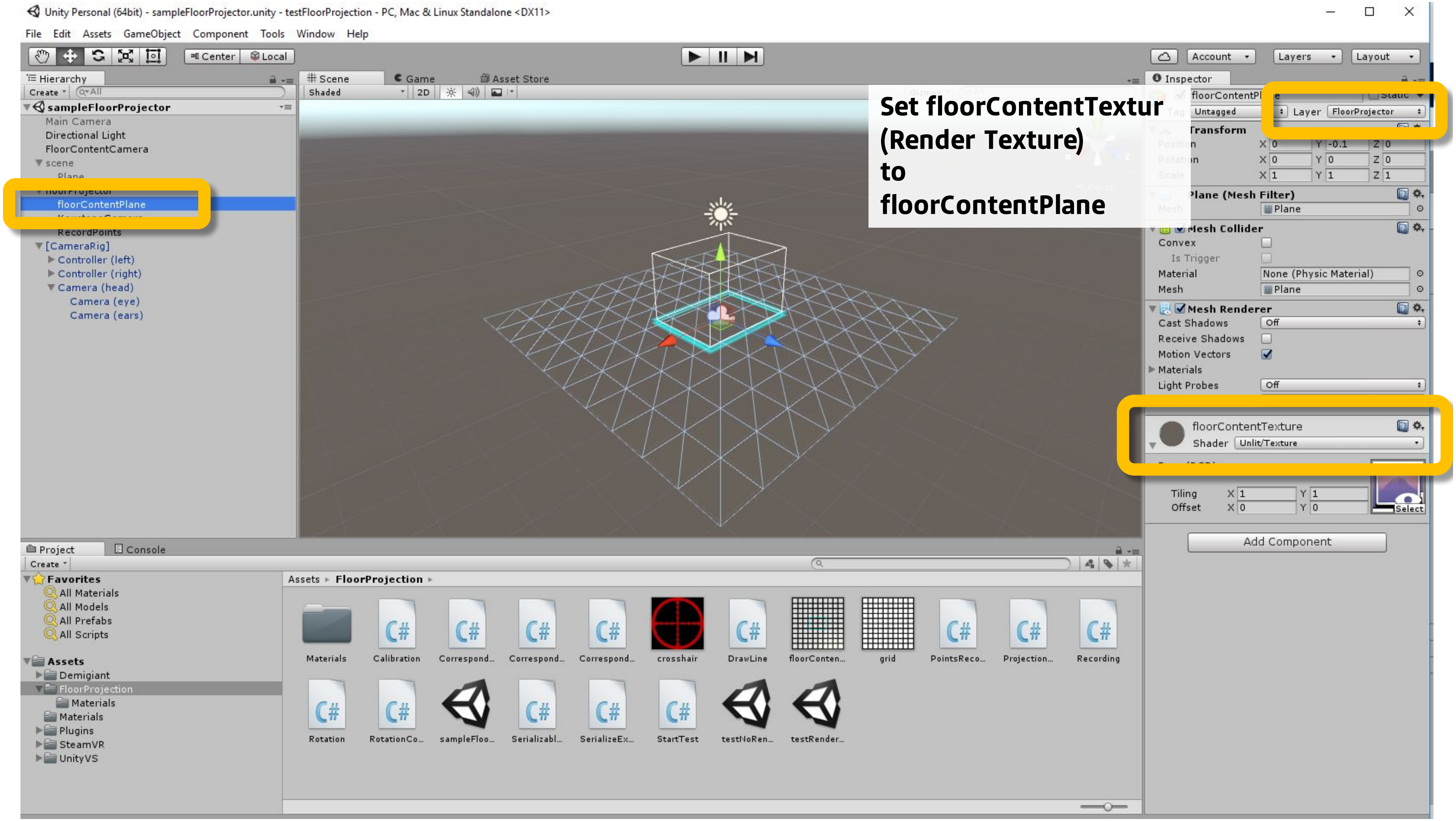
☑ GUI Layer
☐ Audio Listener

Favorites
- All Materials
- All Models
- All Prefabs
- All Scripts

Assets
- Demigiant
- FloorProjection
  - Materials
- Materials
- Plugins
- SteamVR
- UnityVS

Assets ▸ FloorProjection ▸

Materials, Calibration, Correspond..., Correspond..., Correspond..., crosshair, DrawLine, floorConten..., grid, PointsReco..., Projection..., Recording, Rotation, RotationCo..., sampleFloo..., Serializabl..., SerializeEx..., StartTest, testNoRen..., testRender...



Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

File Edit Assets GameObject Component Tools Window Help

Hierarchy

- sampleFloorProjector
  - Main Camera
  - Directional Light
  - FloorContentCamera
  - scene
    - Plane
  - floorProjector
    - floorContentPlane
    - KeystoneCamera
    - RecordPoints
  - [CameraRig]
    - Controller (left)
    - Controller (right)
    - Camera (head)
      - Camera (eye)
      - Camera (ears)

Inspector

floorContentPlane — Tag: Untagged — Layer: FloorProjector

Transform

Position	X 0	Y -0.1	Z 0
Rotation	X 0	Y 0	Z 0
Scale	X 1	Y 1	Z 1

Plane (Mesh Filter)

Mesh: Plane

Mesh Collider

Convex: □

Is Trigger: □

Material: None (Physic Material)

Mesh: Plane

Mesh Renderer

Cast Shadows: Off

Receive Shadows: □

Motion Vectors: ☑

Materials

Light Probes: Off

floorContentTexture

Shader: Unlit/Texture

Tiling X 1 Y 1

Offset X 0 Y 0

Add Component

Project

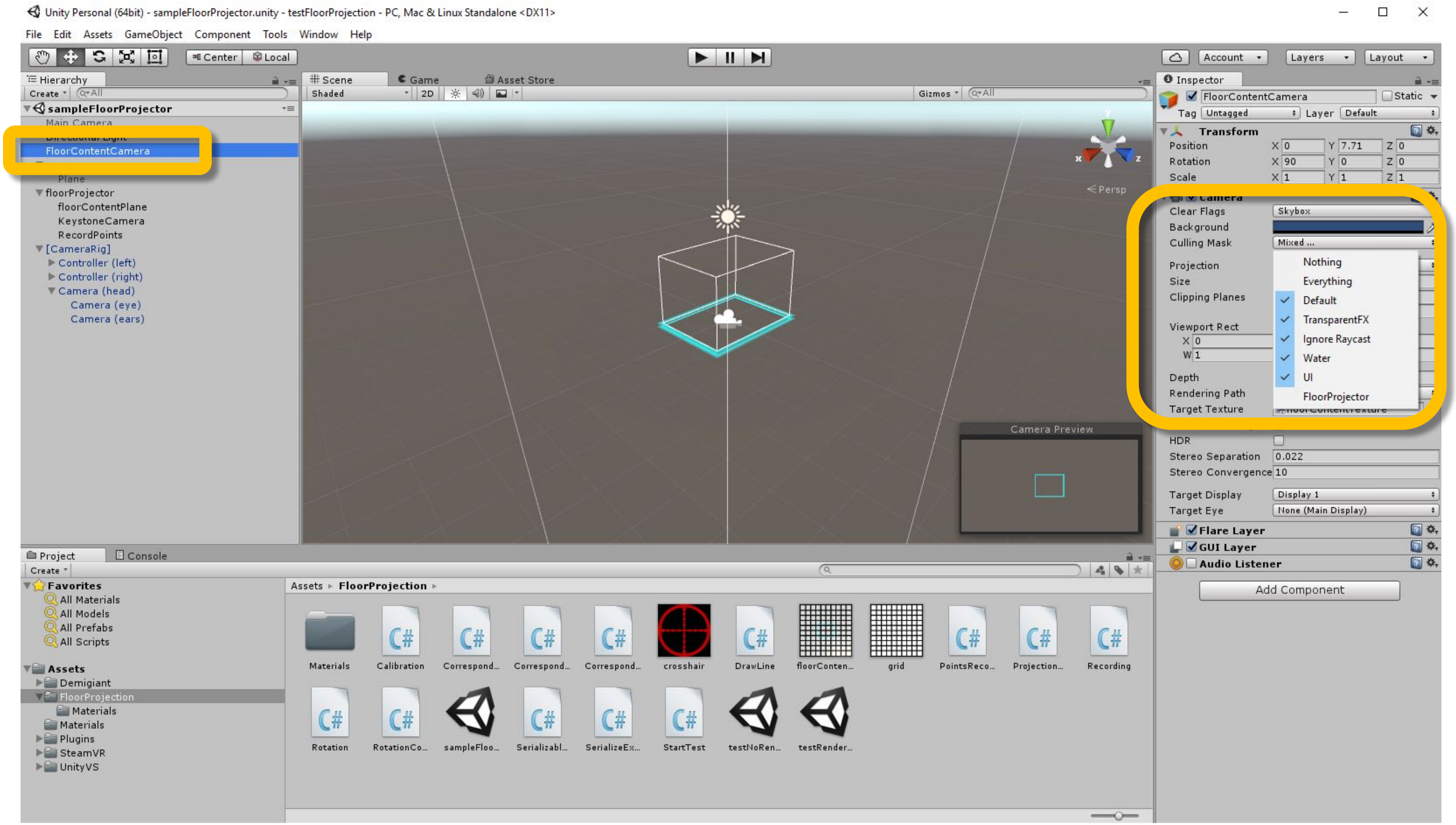
Assets ▸ FloorProjection ▸

Favorites: All Materials, All Models, All Prefabs, All Scripts

Assets: Demigiant, FloorProjection, Materials, Materials, Plugins, SteamVR, UnityVS

Materials, Calibration, Correspond..., Correspond..., Correspond..., crosshair, DrawLine, floorConten..., grid, PointsReco..., Projection..., Recording, Rotation, RotationCo..., sampleFloo..., Serializabl..., SerializeEx..., StartTest, testNoRen..., testRender...

Set floorContentTextur (Render Texture) to floorContentPlane



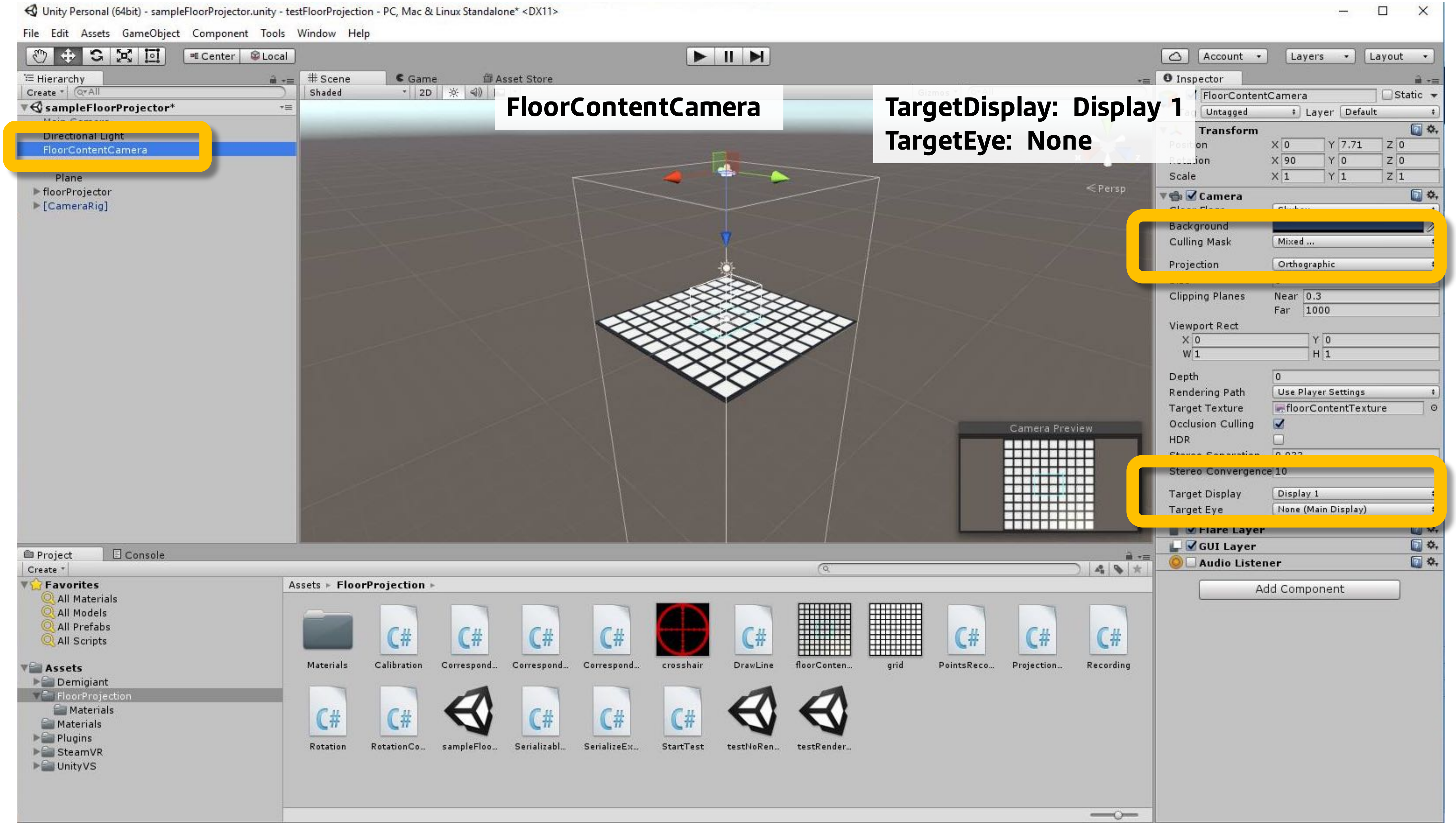
Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

FloorContentCamera
Tag Untagged Layer Default

Transform
Position X 0 Y 7.71 Z 0
Rotation X 90 Y 0 Z 0
Scale X 1 Y 1 Z 1

Camera
Clear Flags Skybox
Culling Mask Mixed ...
Viewport Rect X 0 W 1
Target Texture floorContentTexture
HDR □
Stereo Separation 0.022
Stereo Convergence 10
Target Display Display 1
Target Eye None (Main Display)
☑ Flare Layer
☑ GUI Layer
□ Audio Listener

Culling Mask:
Nothing
Everything
✓ Default
✓ TransparentFX
✓ Ignore Raycast
✓ Water
✓ UI
FloorProjector



FloorContentCamera

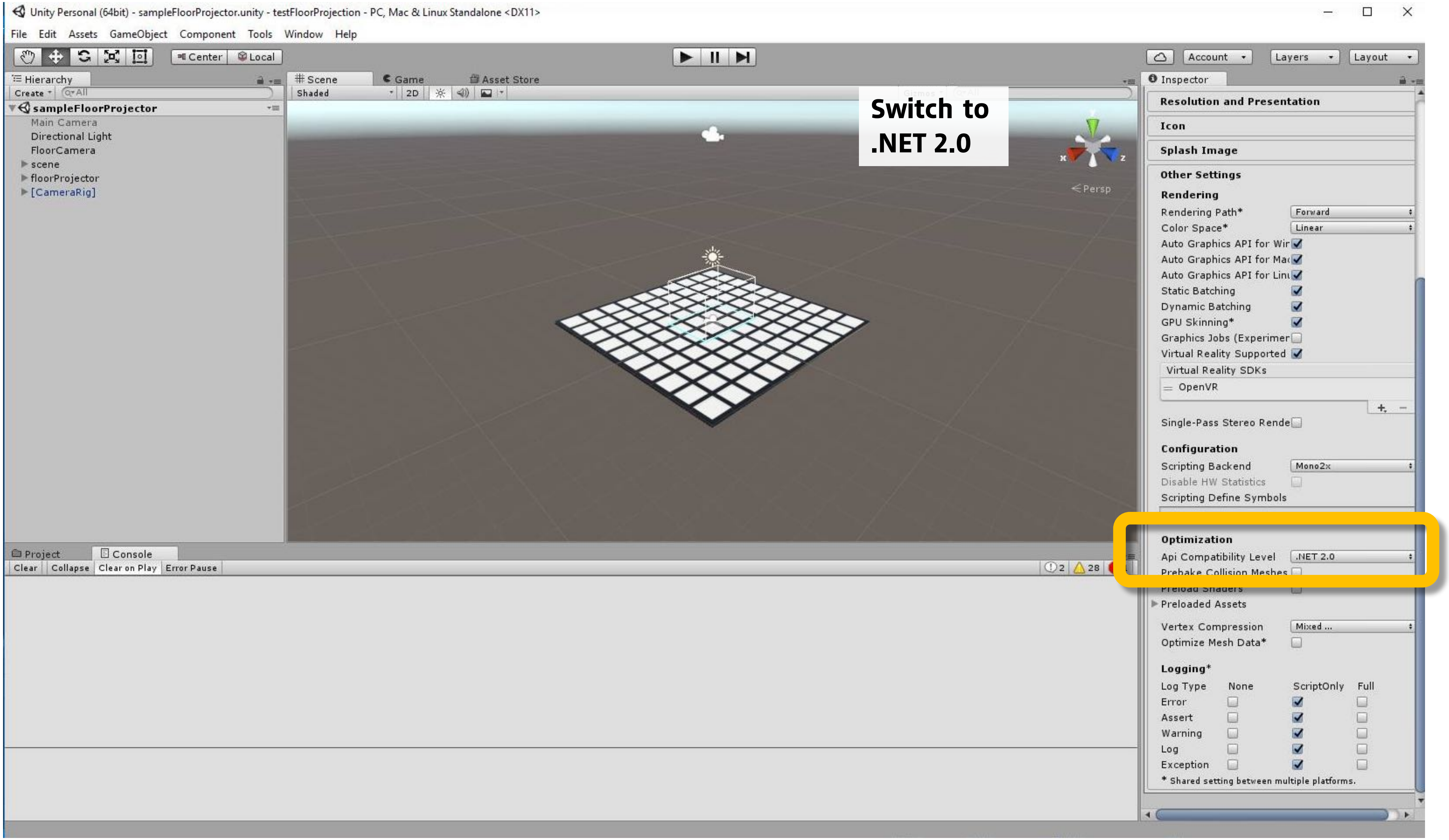
TargetDisplay: Display 1
TargetEye: None

Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone* <DX11>

FloorContentCamera
Untagged Layer Default

Transform
Position X 0 Y 7.71 Z 0
Rotation X 90 Y 0 Z 0
Scale X 1 Y 1 Z 1

Camera
Background
Culling Mask: Mixed ...
Projection: Orthographic
Clipping Planes: Near 0.3, Far 1000
Viewport Rect: X 0, Y 0, W 1, H 1
Depth: 0
Rendering Path: Use Player Settings
Target Texture: floorContentTexture
Occlusion Culling: ☑
HDR: □
Stereo Convergence: 10
Target Display: Display 1
Target Eye: None (Main Display)



Switch to .NET 2.0

Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

Resolution and Presentation

Icon

Splash Image

Other Settings

Rendering

Rendering Path* Forward

Color Space* Linear

Auto Graphics API for Wir ☑

Auto Graphics API for Ma ☑

Auto Graphics API for Lin ☑

Static Batching ☑

Dynamic Batching ☑

GPU Skinning* ☑

Graphics Jobs (Experimer □

Virtual Reality Supported ☑

Virtual Reality SDKs

OpenVR

Single-Pass Stereo Rende □

Configuration

Scripting Backend Mono2x

Disable HW Statistics □

Scripting Define Symbols

Optimization

Api Compatibility Level .NET 2.0

Prebake Collision Meshes □

Preload Shaders □

Preloaded Assets

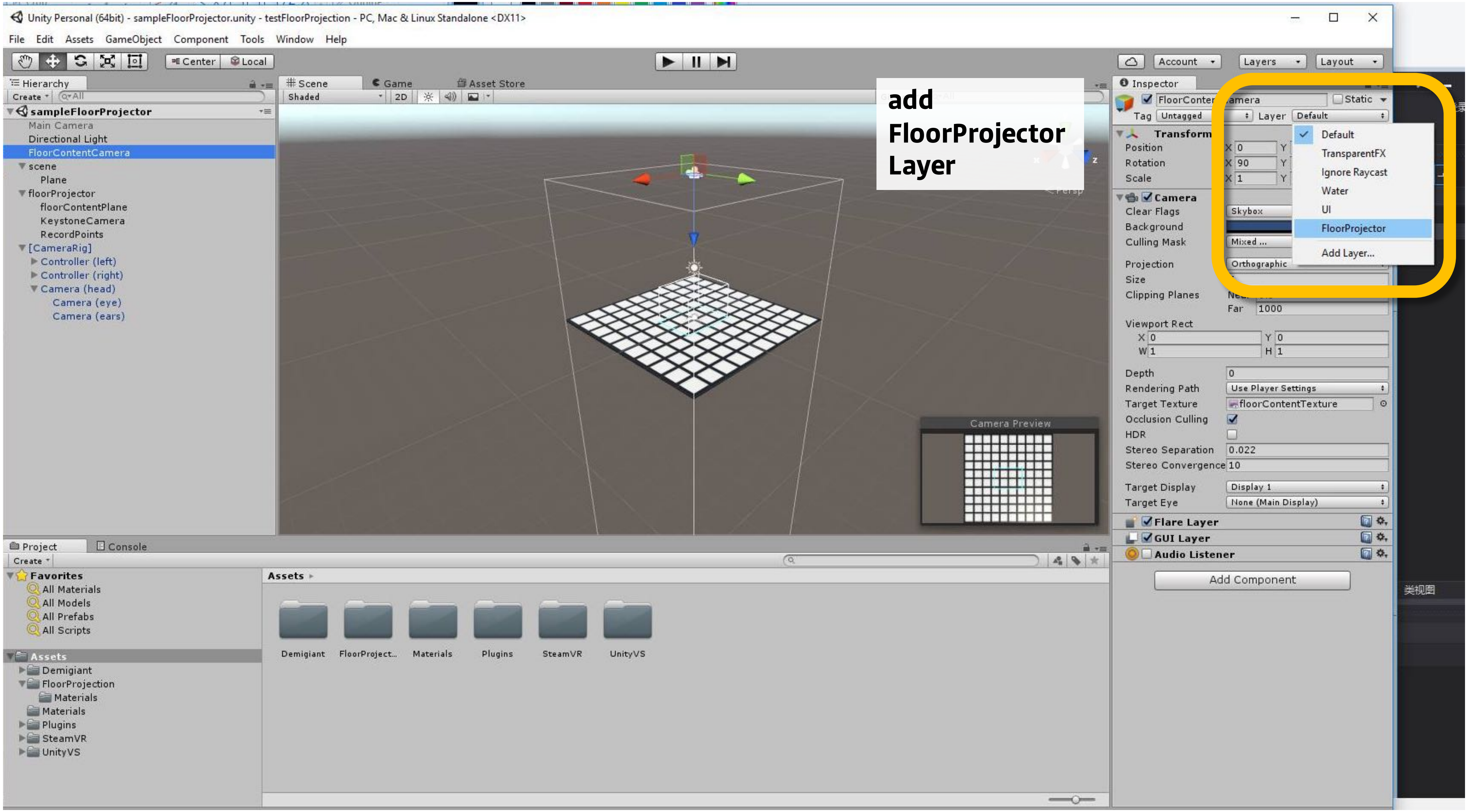
Vertex Compression Mixed ...

Optimize Mesh Data* □

Logging*

Log Type	None	ScriptOnly	Full
Error	□	☑	□
Assert	□	☑	□
Warning	□	☑	□
Log	□	☑	□
Exception	□	☑	□

* Shared setting between multiple platforms.



add FloorProjector Layer

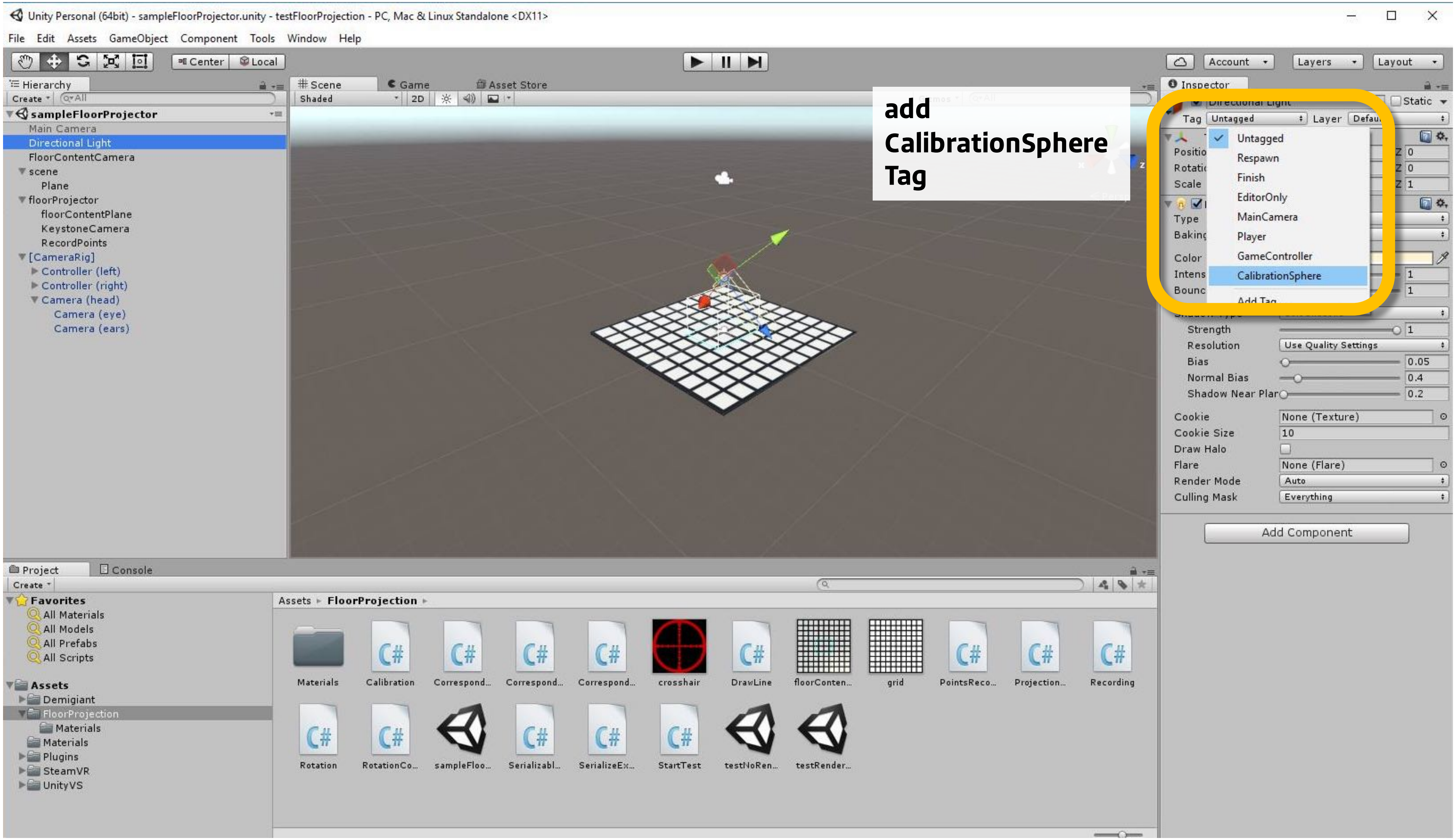
Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

FloorContentCamera
Tag Untagged
Layer Default

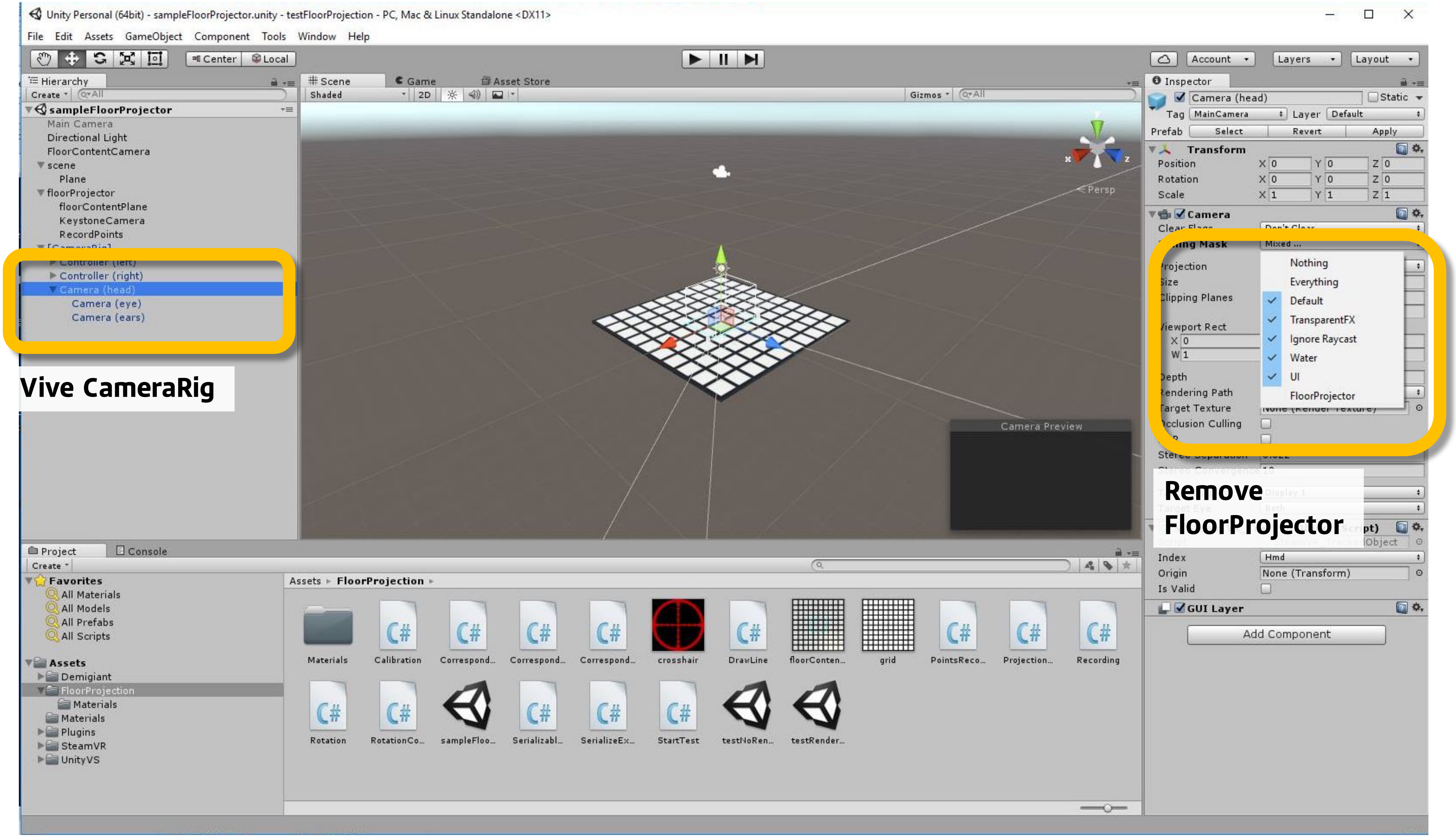
Transform
Position X 0
Rotation X 90
Scale X 1

Camera
Clear Flags Skybox
Culling Mask Mixed ...
Projection Orthographic
Clipping Planes Far 1000
Viewport Rect X 0 Y 0 W 1 H 1
Depth 0
Rendering Path Use Player Settings
Target Texture floorContentTexture
Occlusion Culling ☑
HDR □
Stereo Separation 0.022
Stereo Convergence 10
Target Display Display 1
Target Eye None (Main Display)

☑ Flare Layer
☑ GUI Layer
□ Audio Listener



add CalibrationSphere Tag



Unity Personal (64bit) - sampleFloorProjector.unity - testFloorProjection - PC, Mac & Linux Standalone <DX11>

File Edit Assets GameObject Component Tools Window Help

Hierarchy

- sampleFloorProjector
  - Main Camera
  - Directional Light
  - FloorContentCamera
  - scene
    - Plane
  - floorProjector
    - floorContentPlane
    - KeystoneCamera
    - RecordPoints
  - [CameraRig]
    - Controller (left)
    - Controller (right)
    - Camera (head)
      - Camera (eye)
      - Camera (ears)

Vive CameraRig

Inspector

☑ Camera (head) □ Static

Tag MainCamera Layer Default

Prefab Select Revert Apply

Transform

Position X 0 Y 0 Z 0

Rotation X 0 Y 0 Z 0

Scale X 1 Y 1 Z 1

☑ Camera

Clear Flags Don't Clear

Culling Mask Mixed ...

- Nothing
- Everything
- ✓ Default
- ✓ TransparentFX
- ✓ Ignore Raycast
- ✓ Water
- ✓ UI
- FloorProjector

Remove FloorProjector

Index Hmd

Origin None (Transform)

Is Valid □

☑ GUI Layer

Add Component

Project

Assets ▸ FloorProjection ▸