KILLZONE®

SHADOW FALL

Lighting
Killzone : Shadow Fall

Michal Drobot

Senior Tech Programmer

Guerrilla Games

Intro

- Guerrilla Games is SCEE studio based in Amsterdam
- Working on two Playstation 4 titles:
  - Killzone: Shadow Fall
  - New IP
- Killzone: Shadow Fall is a launch tile
- Annouced during Playstation 4 reveal
  - Running on target 1080p 30fps

Focus

- Physically Based Lighting
- Physically Based Area Lights
- Rendering Pipeline

Motivation

- Killzone 3
  - Shipped in 2011
  - Matured PS3 technology
  - Considered one of generation visual benchmark titles
- Killzone : Shadow Fall
  - Next generation launch title
- How does it compare?

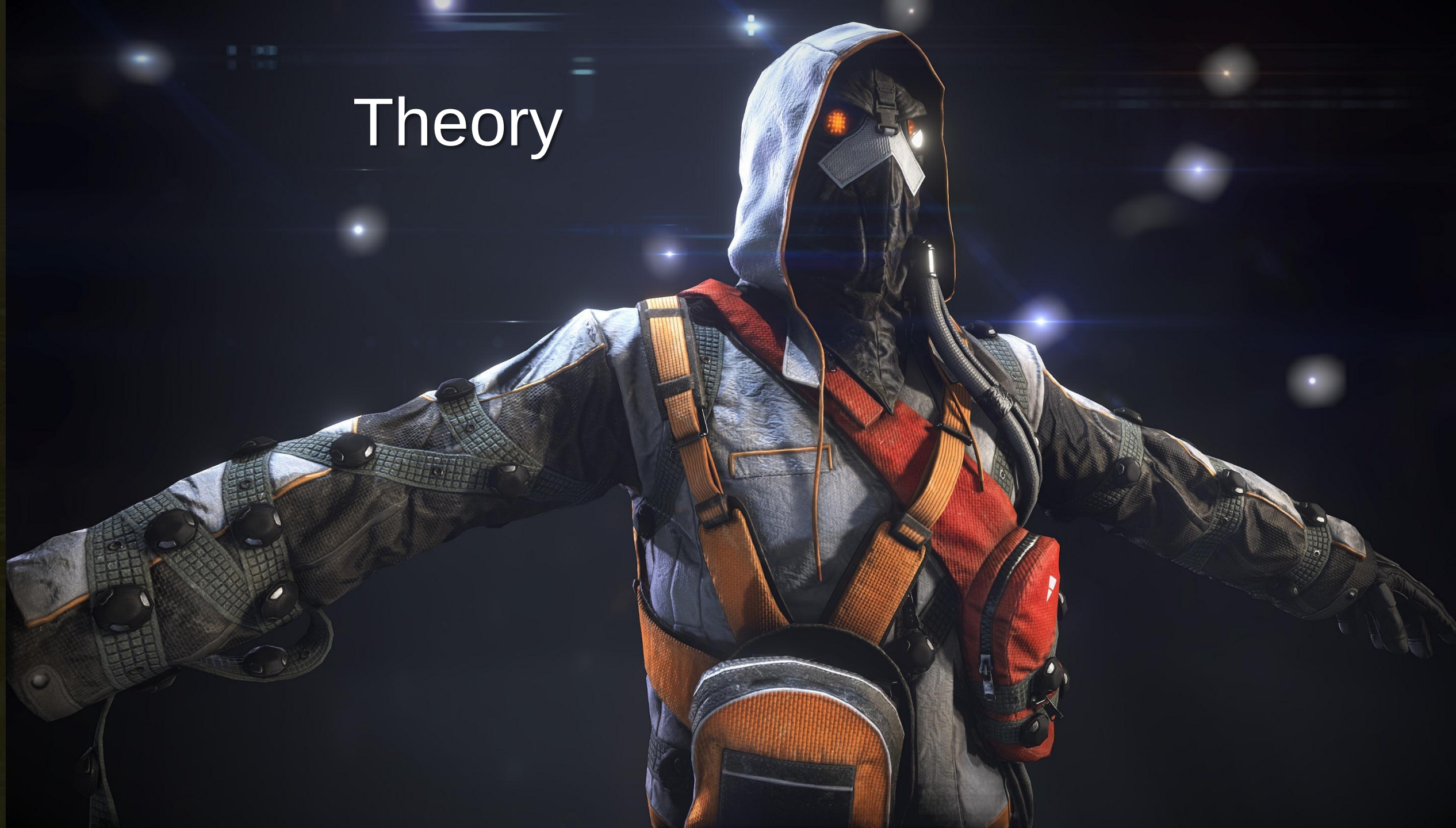

256
3

Generation change

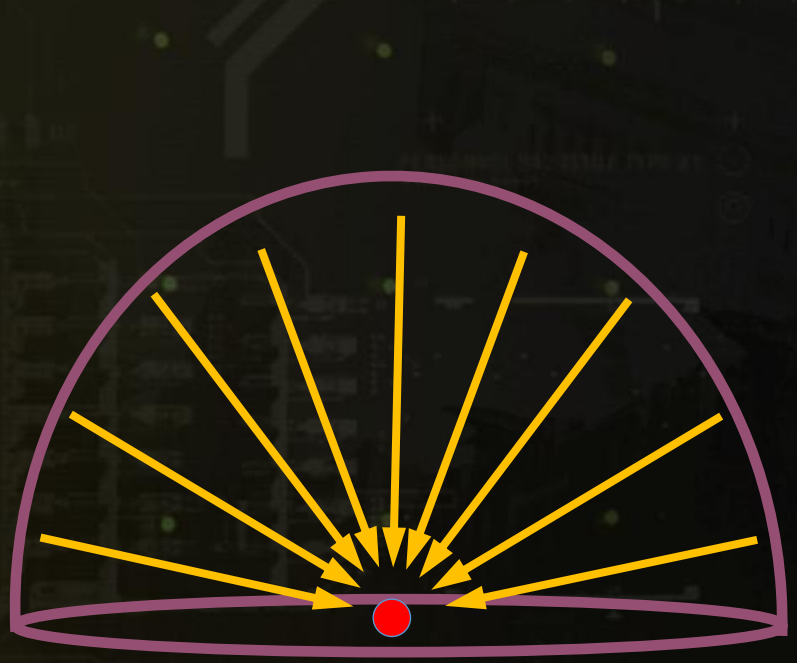
Motivation

- Physically Based Lighting
  - Easier to achieve hyperrealism / photorealism
  - Consistent look in different HDR environments
  - Simple material interface for artists
  - Easy troubleshooting and extension

Theory



Light Flux



Irradiance (E)

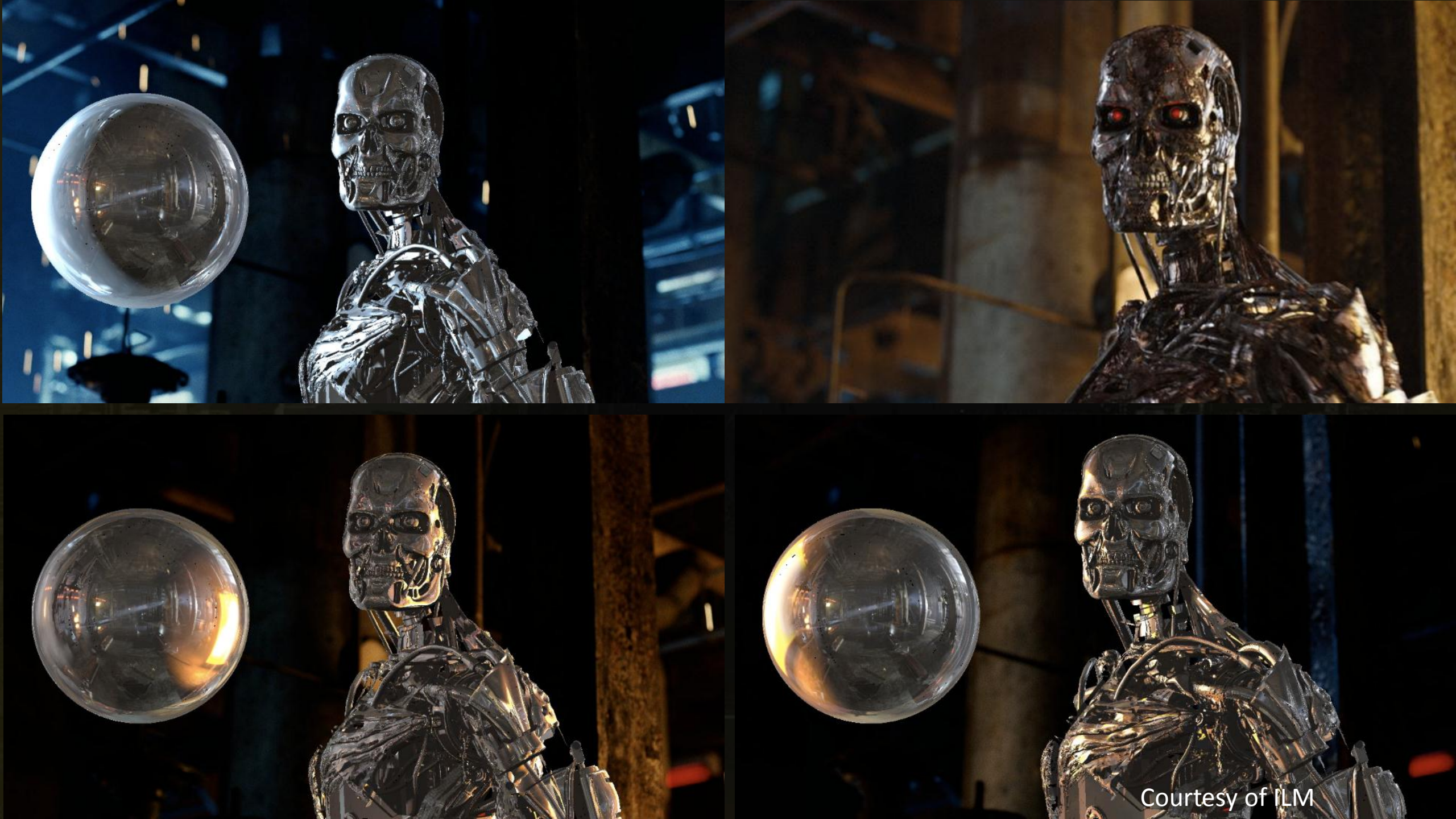
Radiance (L)

- Irradiance = integrated light incoming from all directions (diffuse)
- Radiance = light incoming from one direction (specular reflection)

Image Based Lighting (IBL)

Courtesy of ILM

Courtesy of ILM


Courtesy of ILM

Physically Based Lighting Model

- Physically Based Shading Model
  - Responsible for surface response to incoming light depending on various surface physical properties
- Physically Based Lights
  - Responsible for light flux calculation in the scene depending on various lights with physical properties

Physically Based Shading : Real life examples

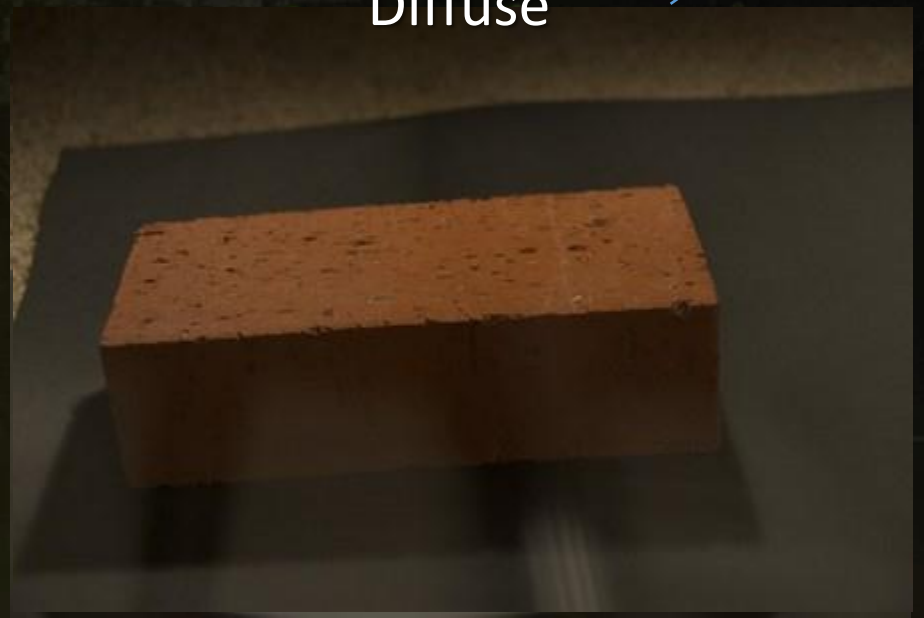
- Specular
  - Dominant part of visible lighting
  - Every material exhibits specular lighting
  - Angle dependent
  - Material type dependant

Diffuse

Specular

Courtesy of John Hable

Diffuse



Specular

Courtesy of John Hable

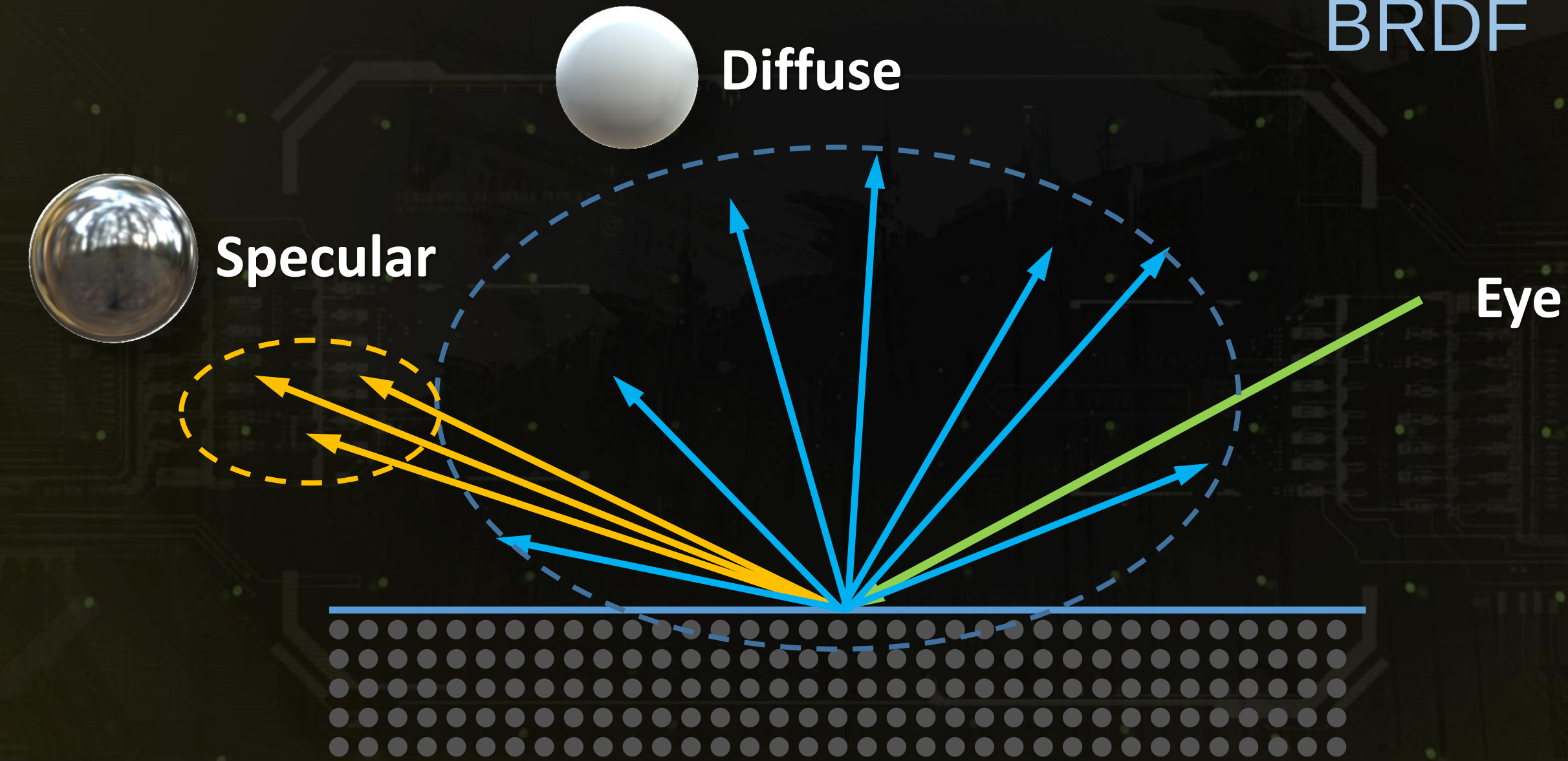
Diffuse

Specular

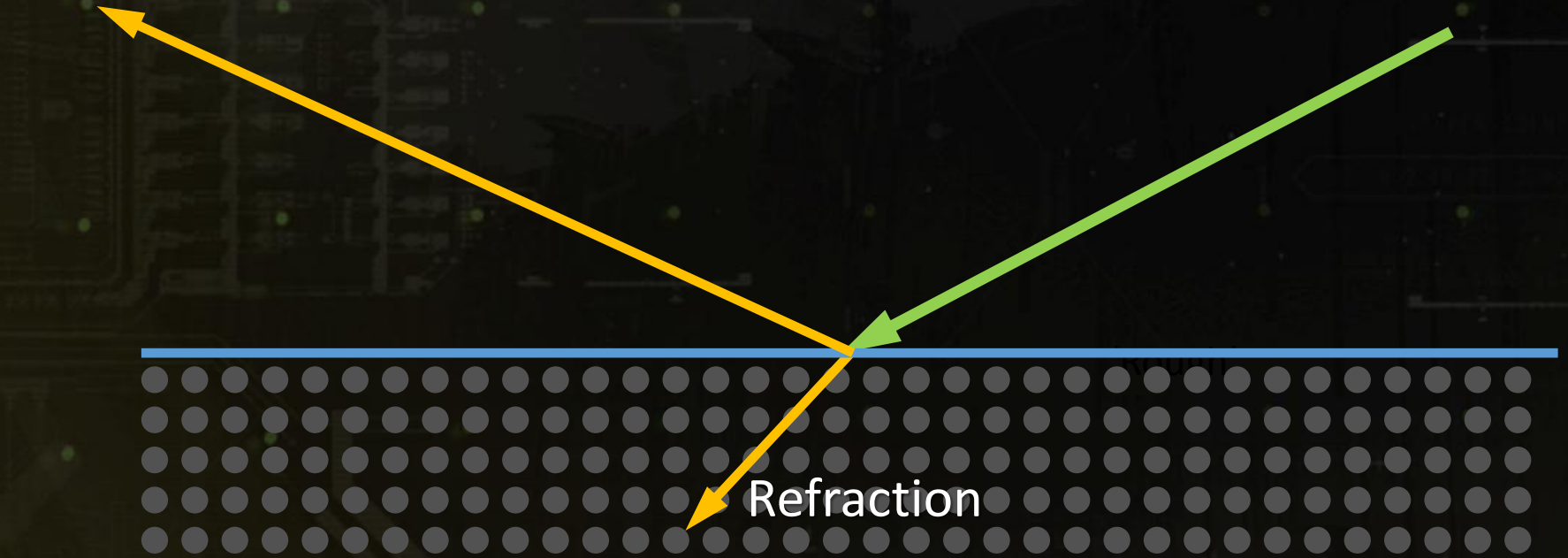
Courtesy of John Hable

Courtesy of John Hable

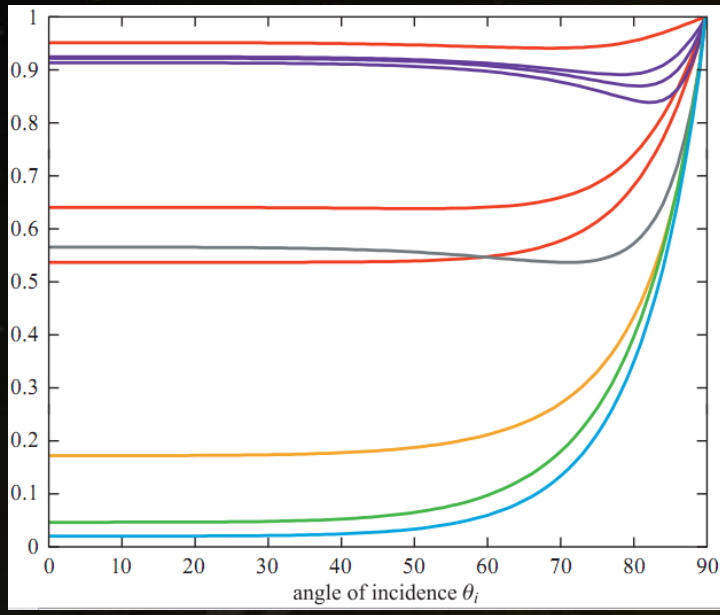
BRDF



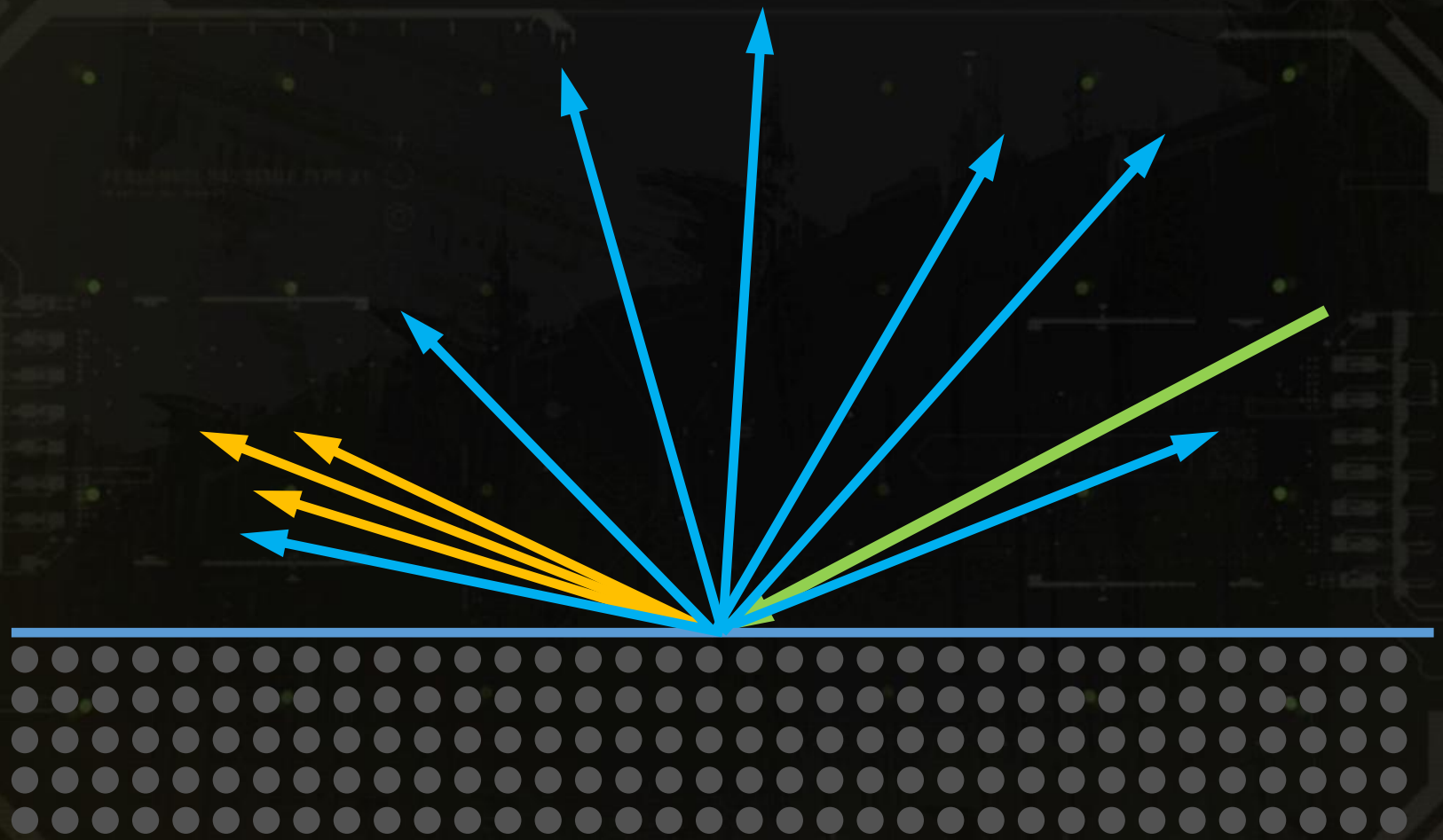
Fresnel


Reflection
Refraction

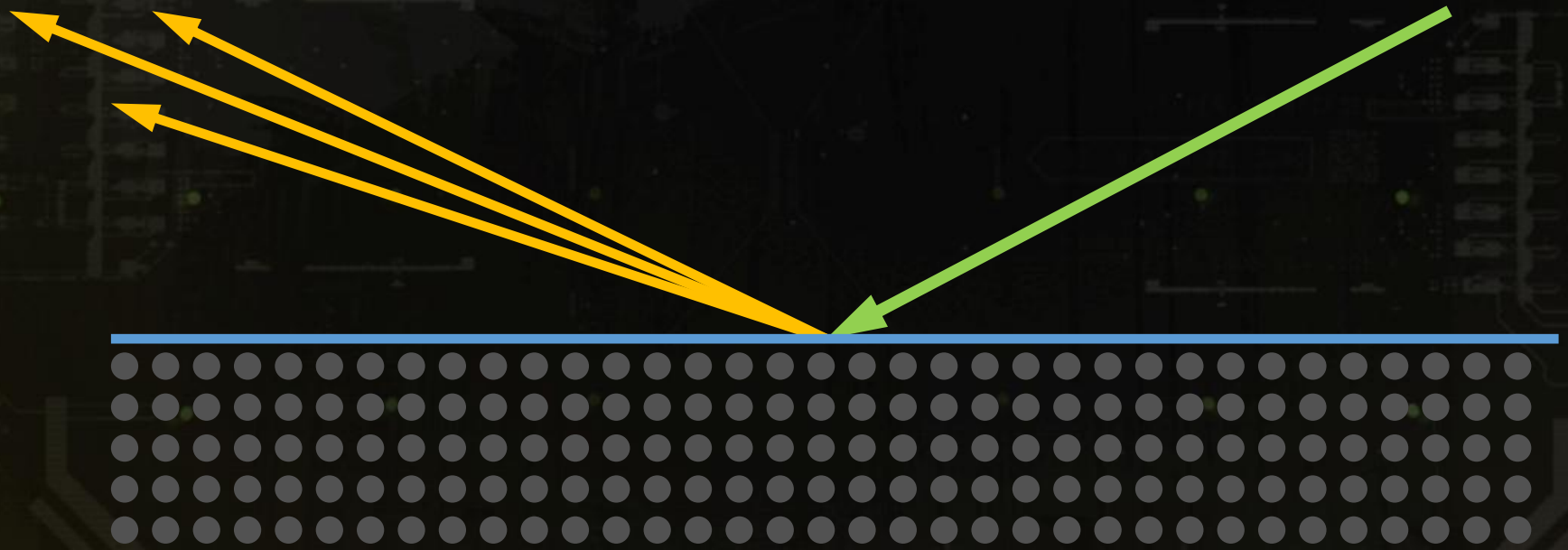

copper
aluminum
iron
diamond
glass
water


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
angle of incidence θ_i

Non metals

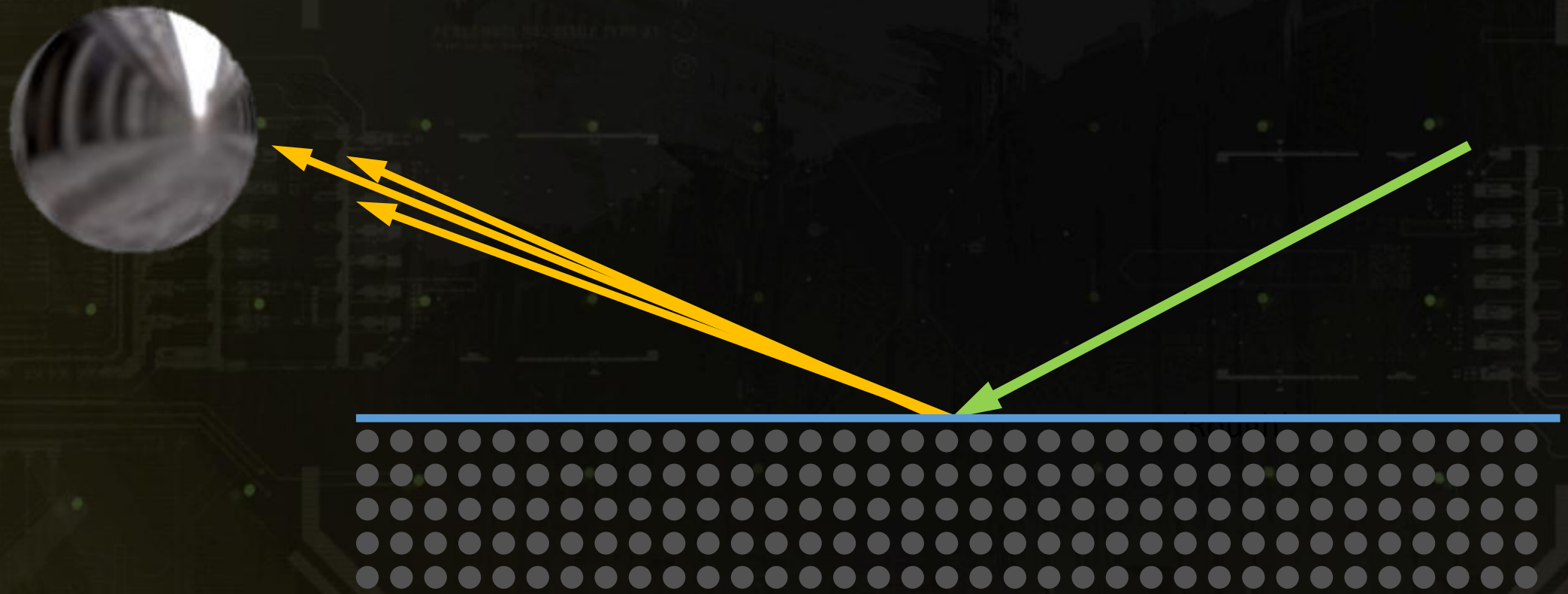


Metals



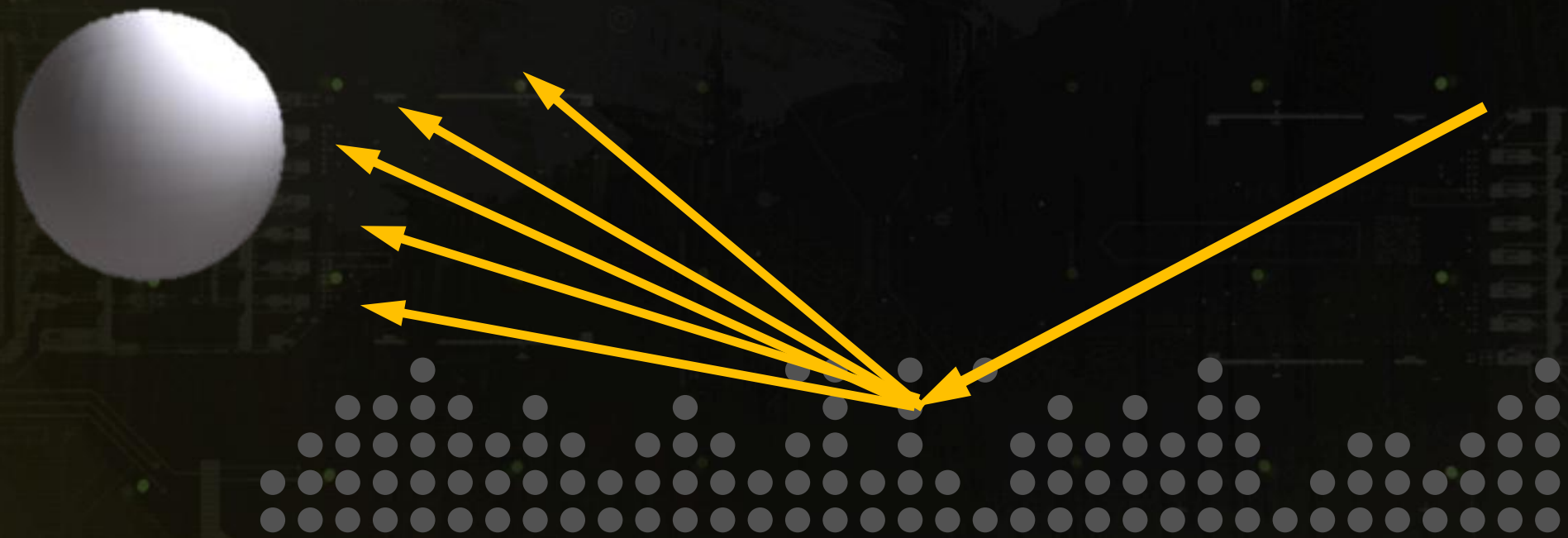
Roughness

‘Smooth’



Roughness

‘Smooth’

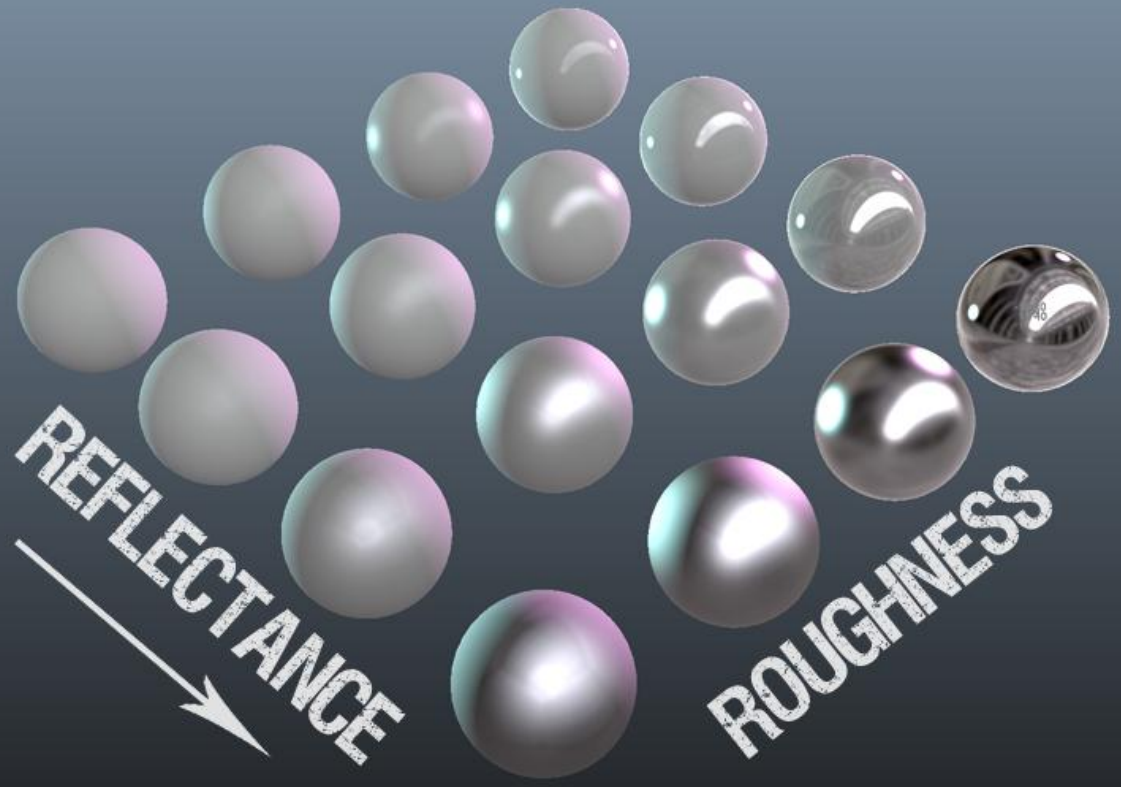


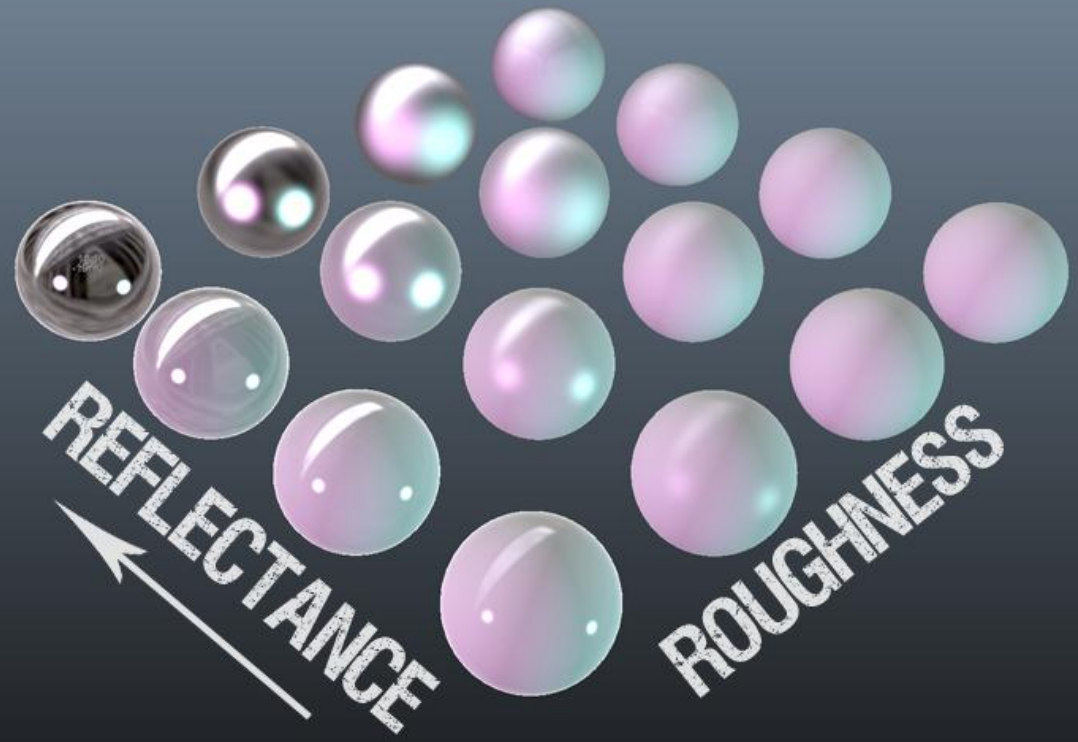
Visibility / Self Shadowing

Non - Energy Conservative

Energy Conservative

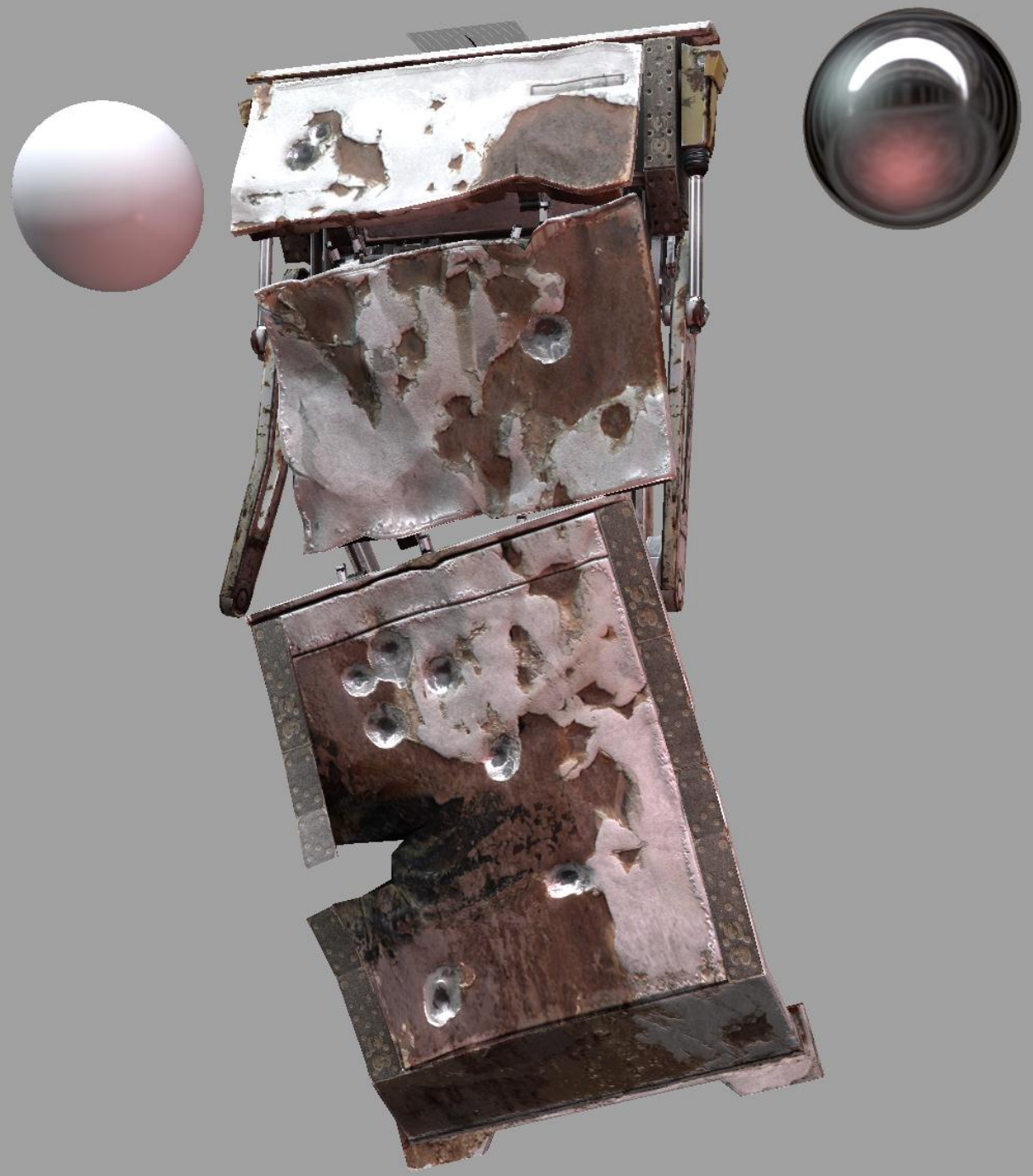

ROUGHNESS
TITANIUM
GOLD
COPPER
SILVER

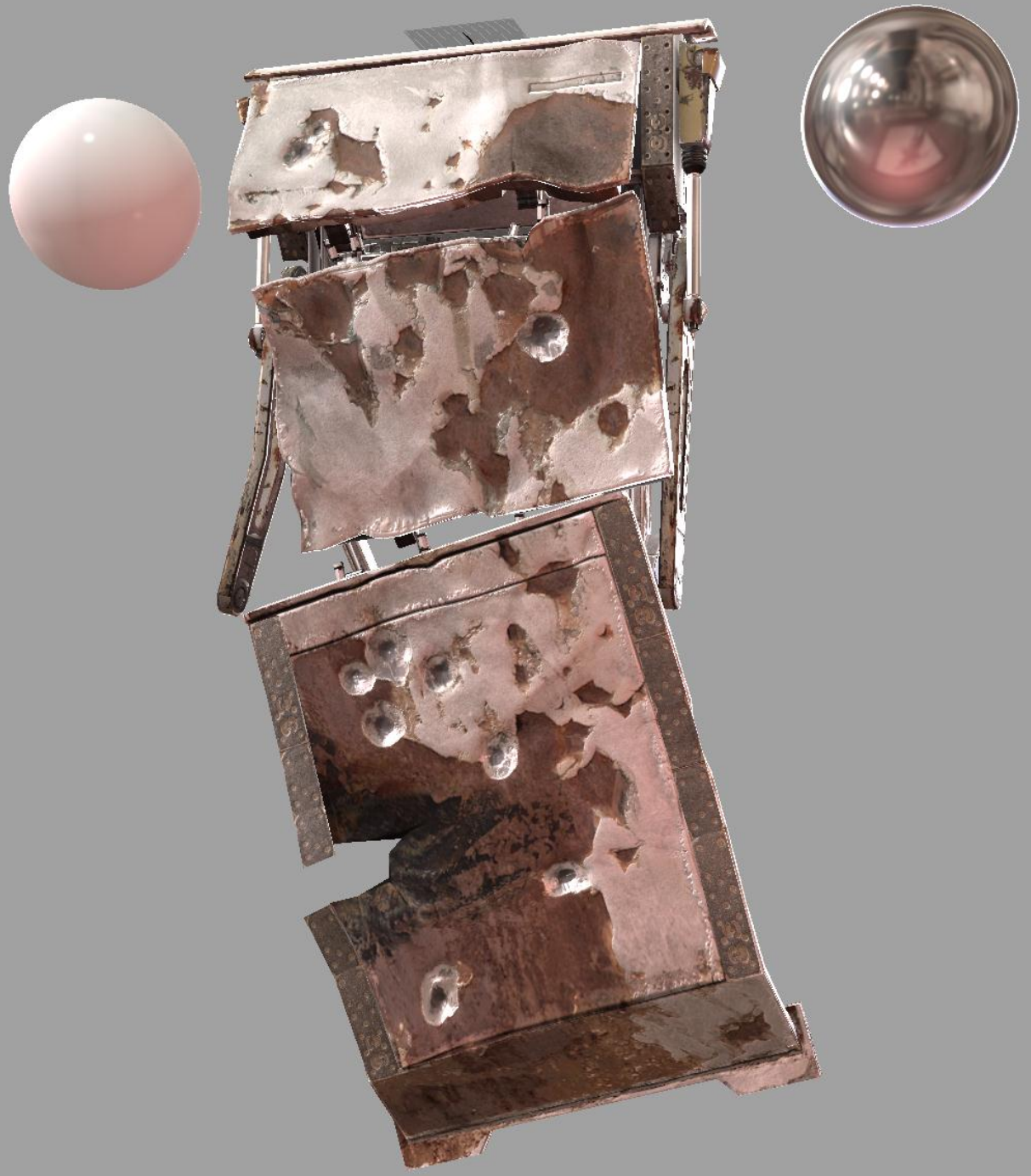

REFLECTANCE
ROUGHNESS


REFLECTANCE
ROUGHNESS

Workflow

- 3 main parameters
  - Albedo (RGB8)
  - Roughness (R8)
  - Specular Reflectance (RGB8)
- Material response
  - Decoupled from Lighting
  - Works in any light environment
- Review assets in different IBL lighting environments

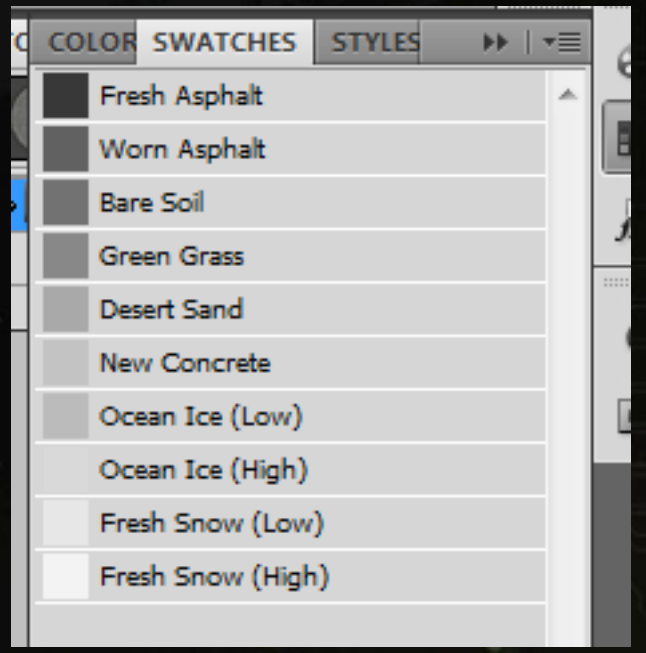





Diffuse
Rough
(0.0)
Smooth
(1.0)

Material properties

- Measured values for most materials
  - Available in physical tables
- Every material can be roughly defined by those parameters
- We provided them as Photoshop color swatches
- Base for hand painted textures



Use case

- Material
  - Old iron plate
  - Covered in paint
  - Scratches
  - Bullet holes
  - Rust

Simplified Roughness texture

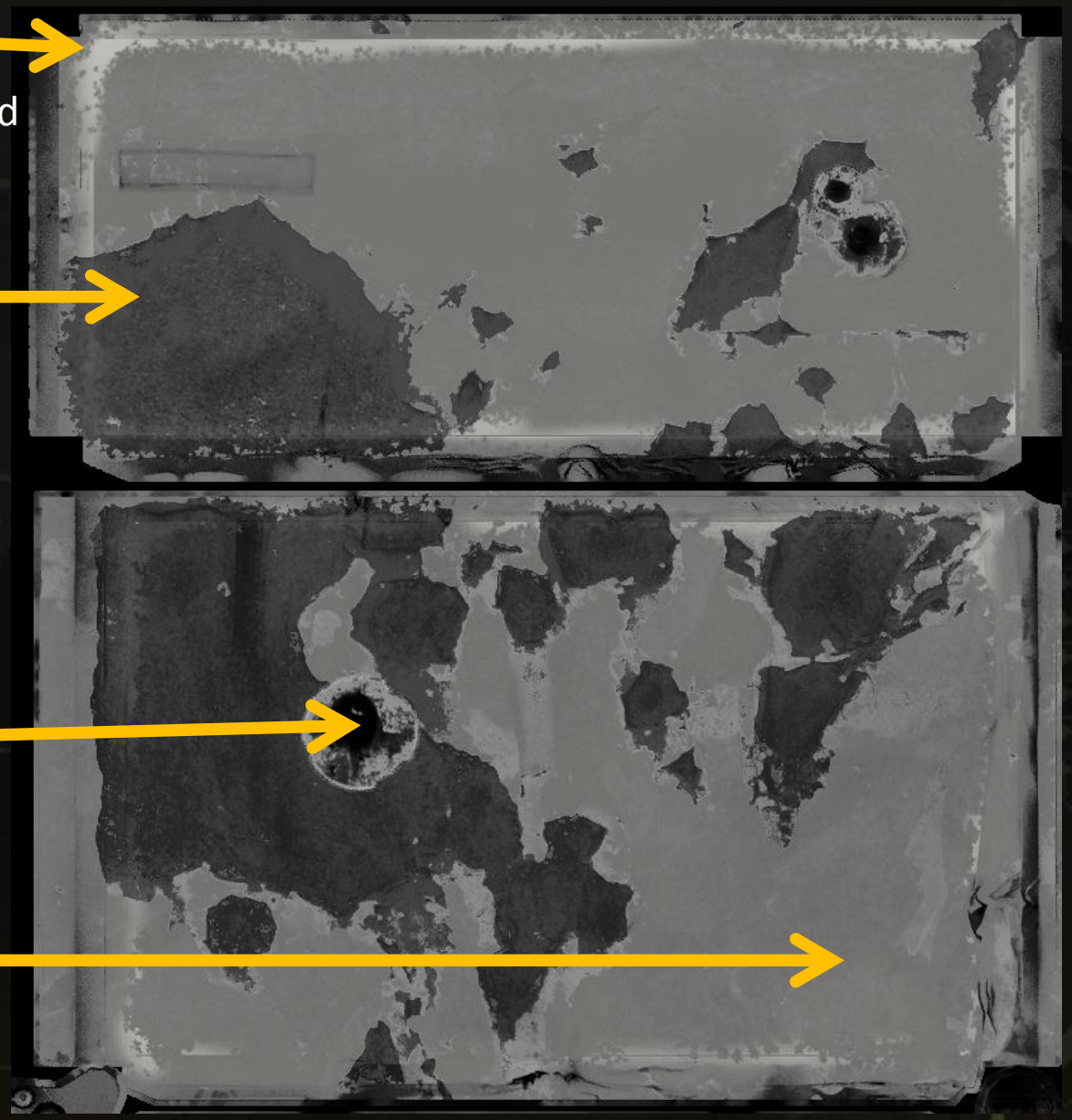
Thin old paint, scratched,
showing off iron underneath
Due weathering effects smoothened
R = High

Pure rust
R = very low

Rusting metal
R = mixed, sparkles of
medium smooth metal

Bullet hole
High temperature smoothens iron
(due to impact energy)
R = very high

Pure old paint
R = medium



Simplified Specular Reflectance texture

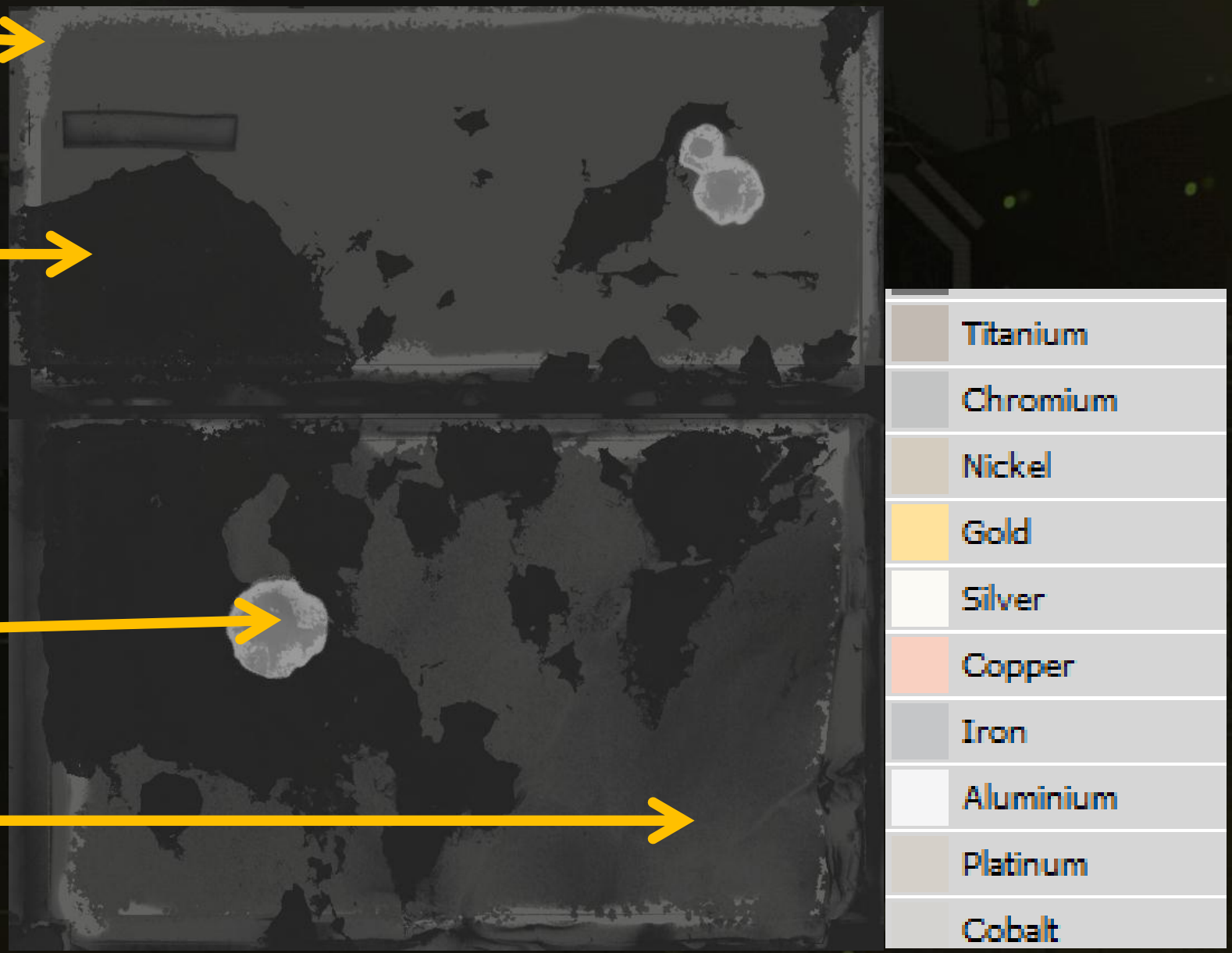
Thin old paint, scratched,
showing off iron underneath
SR = Low Iron

Pure rust, non metal
SR = Low, non metal

Rusting metal,
SR = Medium, non metal,
Sparkles of Low Iron

Bullet hole exposes pure Iron
SR = Iron

Pure paint
SR = Low, Medium, High non metal,
Depends on paint type
Old paint = Low
New paint = Medium / High



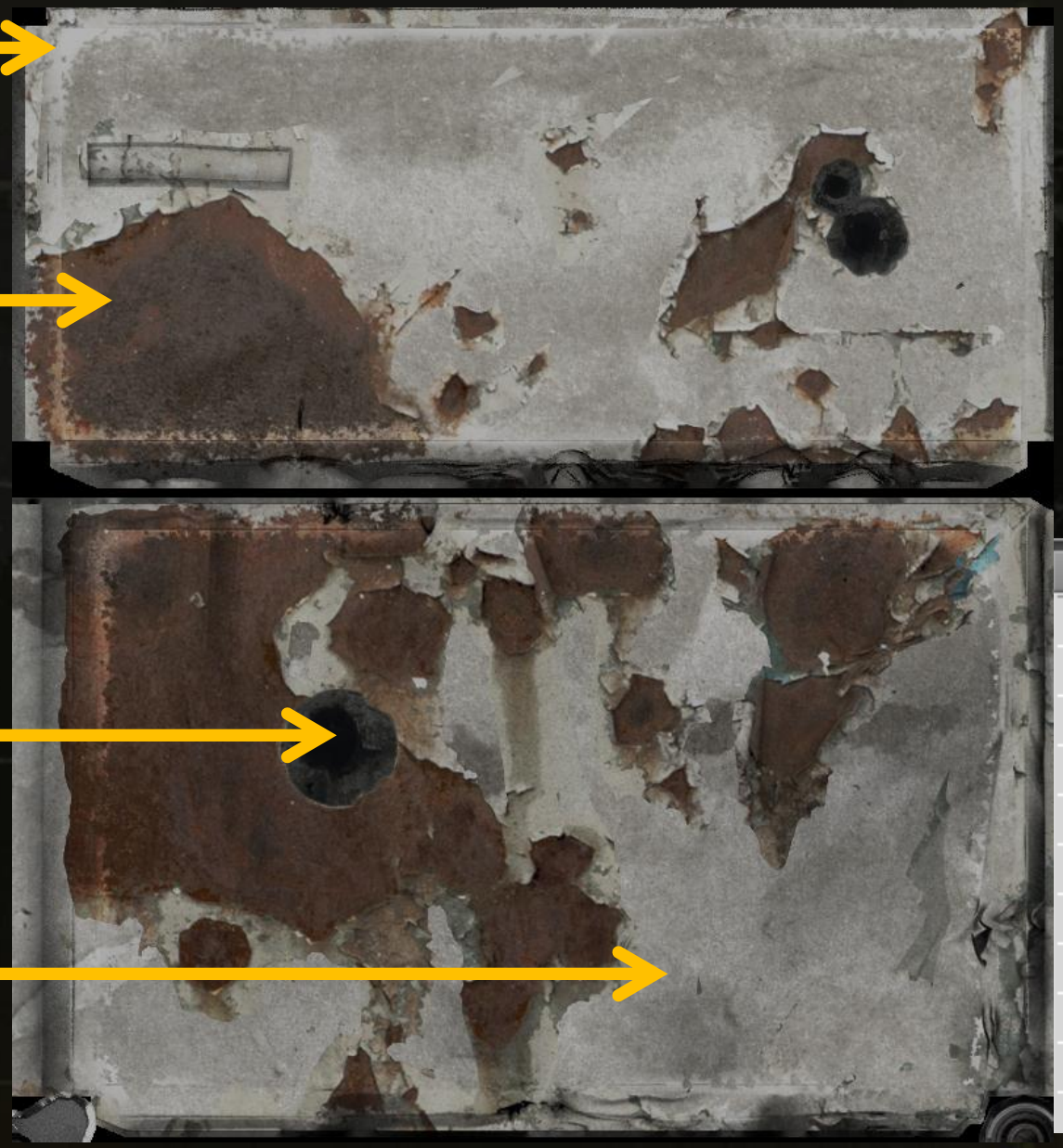
Simplified Albedo texture

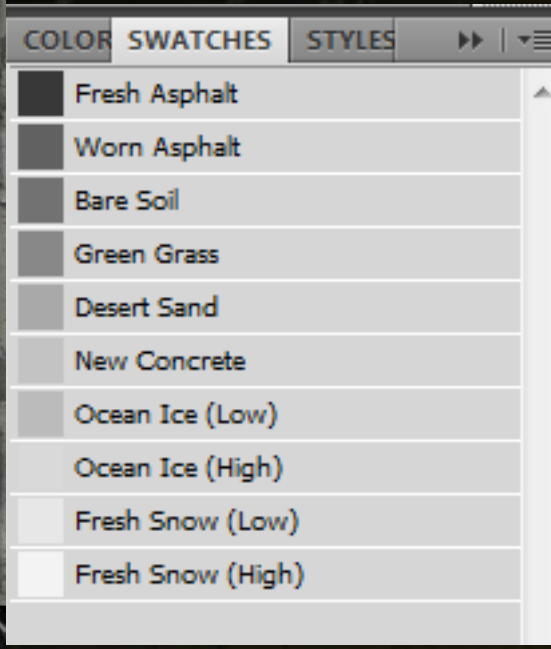
White thin old paint, scratched,
showing off iron underneath
A = Dark gray (showing off metal)

Pure rust,
A = Rusty in range of old concrete

Bullet hole exposes pure Iron
A = Very dark (metal)

White old paint
A = White in albedo range of concrete
(light gray)

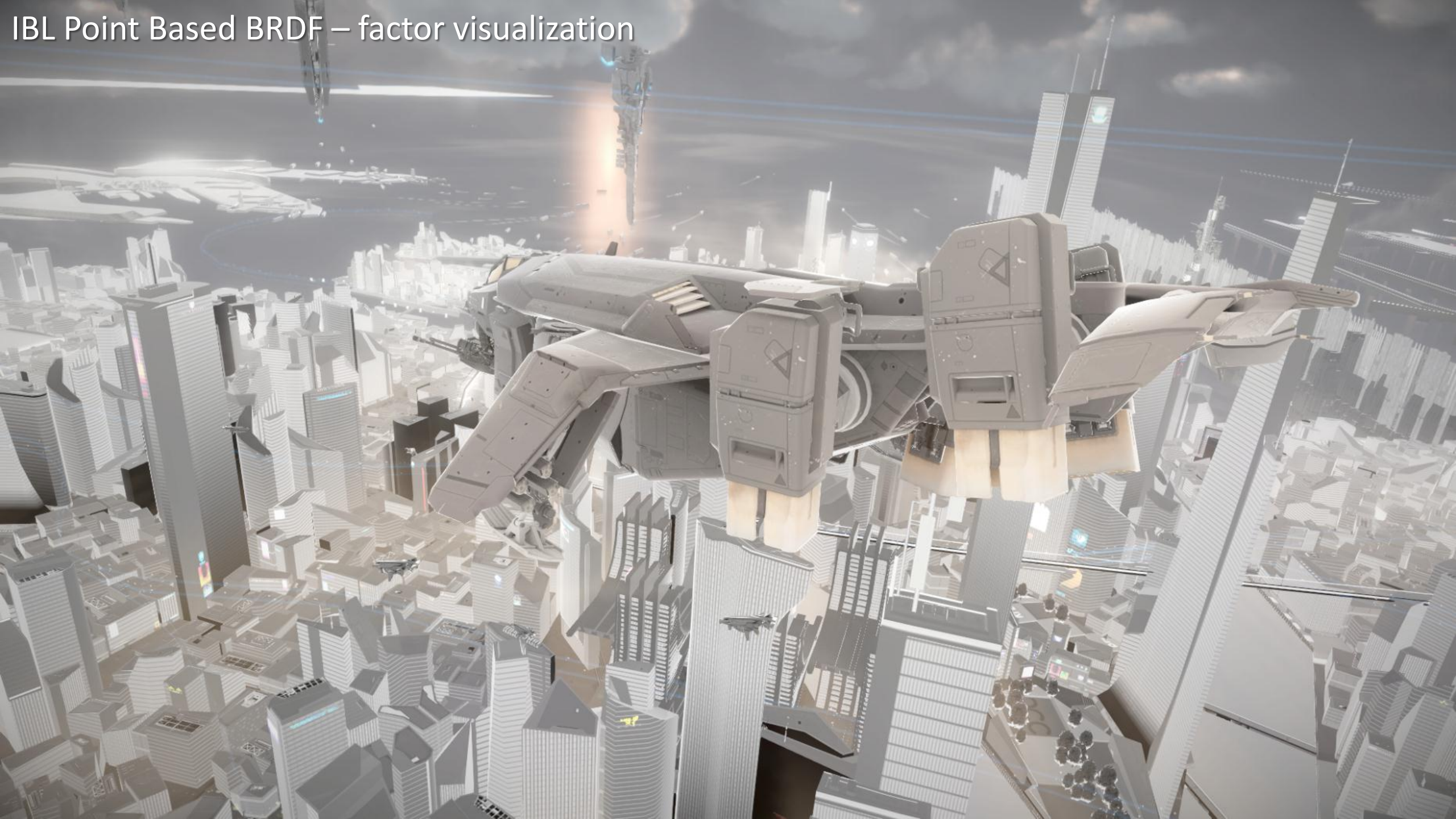




- Shadow Fall BRDF
- Based on Cook-Torrance
  - Fresnel
  - Smith Schlick Visiblity Function
  - Normalization based on Specular Reflectance
  - Roughness as Specular Importance Cone Angle
- Approximate translucency
  - Density maps
  - Translucency diffusion maps

IBL Point Based BRDF

IBL Point Based BRDF – factor visualization



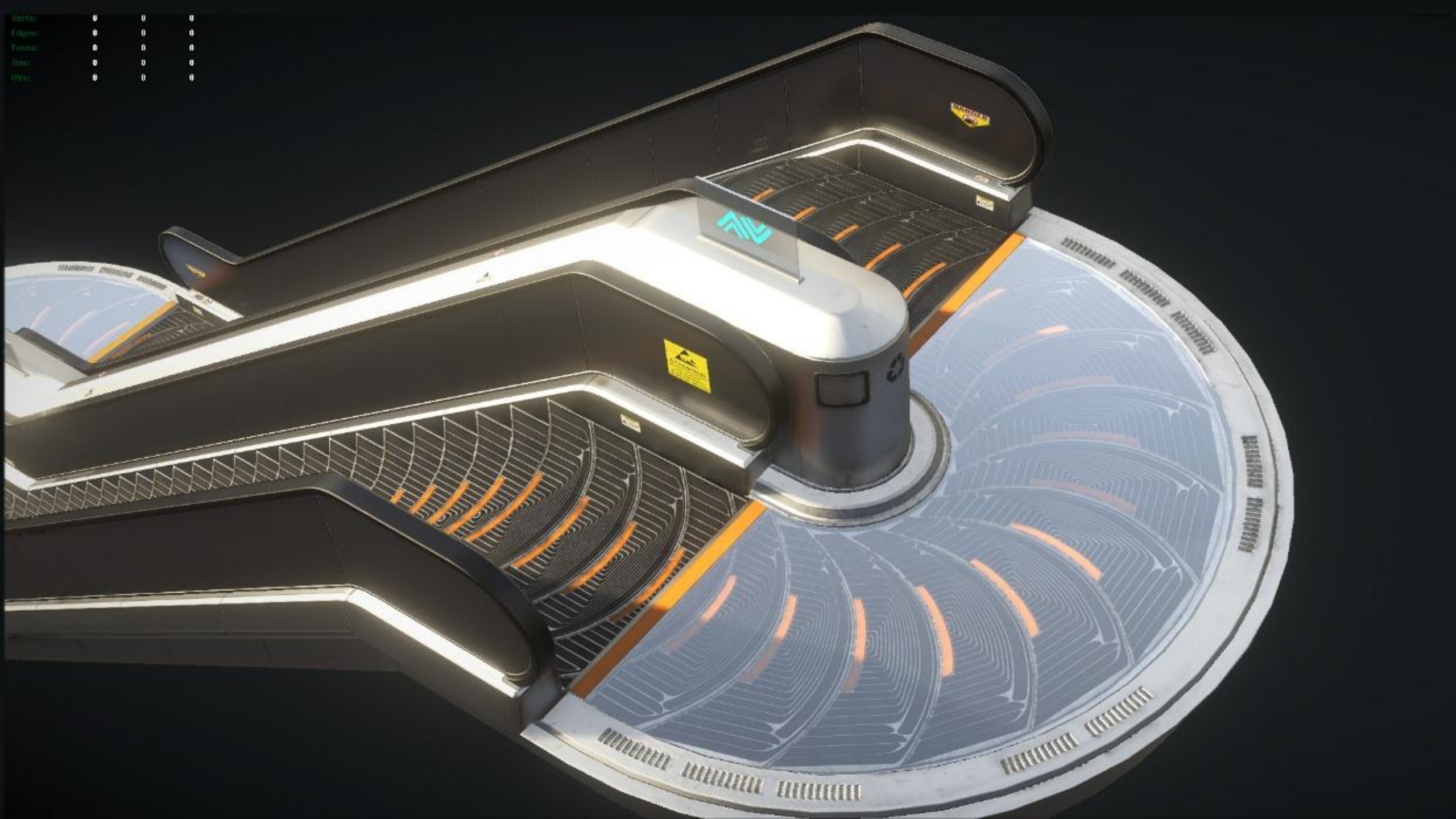
IBL Ambient BRDF – factor visualization

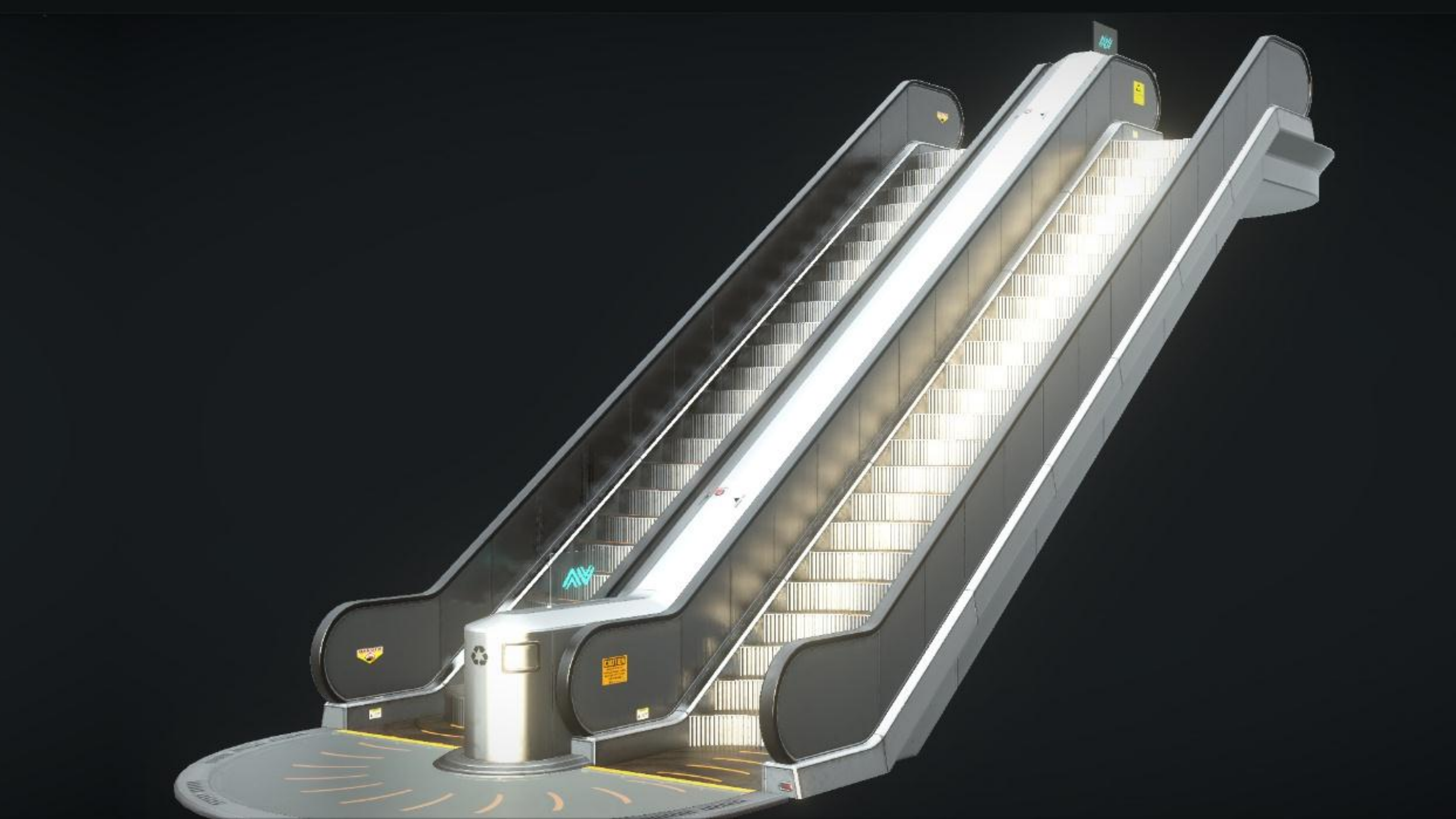
IBL Ambient BRDF

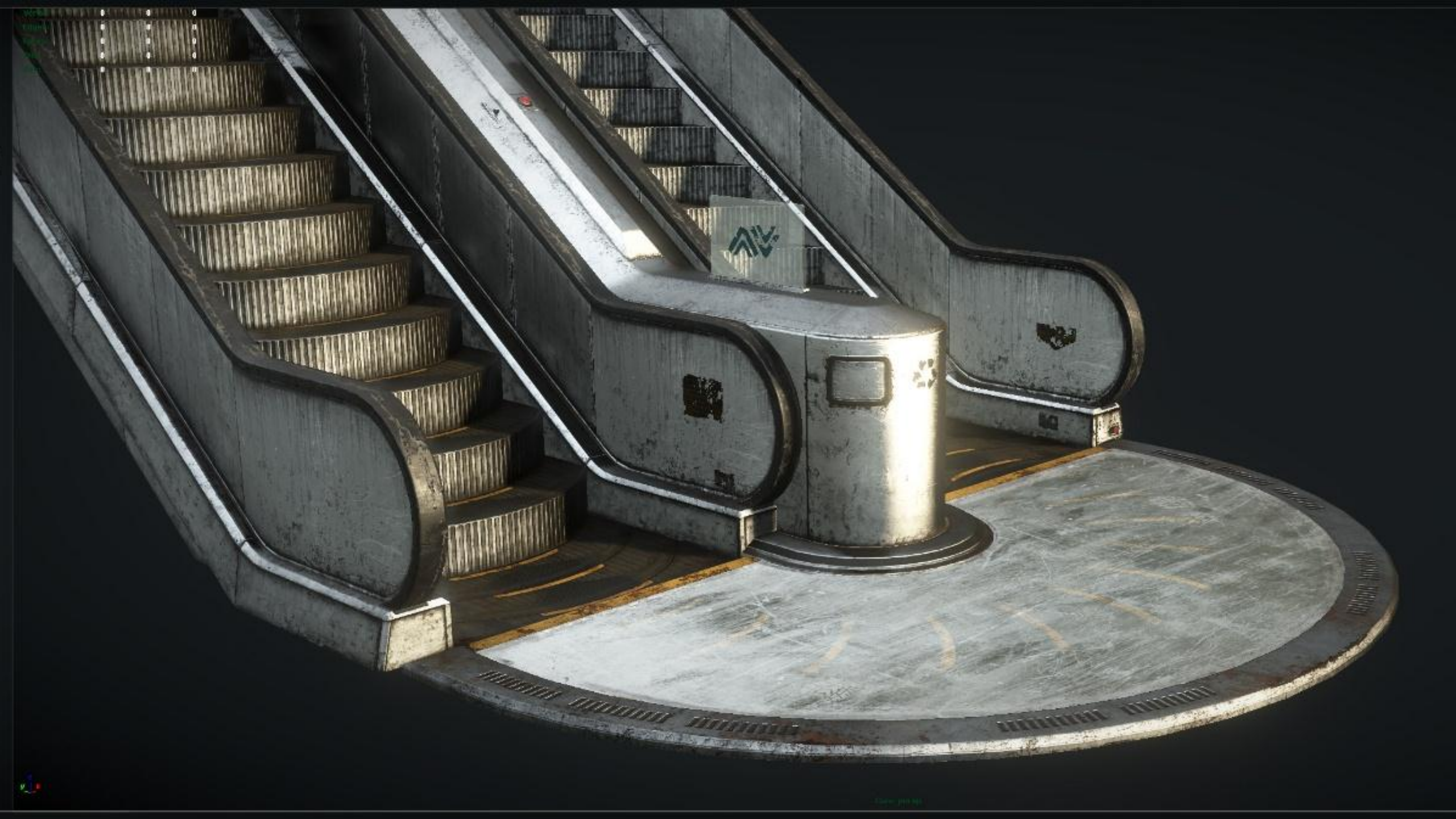
IBL Point Based BRDF

IBL Ambient BRDF

- Big step for the studio
- Artists had to adapt
- Training and workshops
- Production and Quality Win

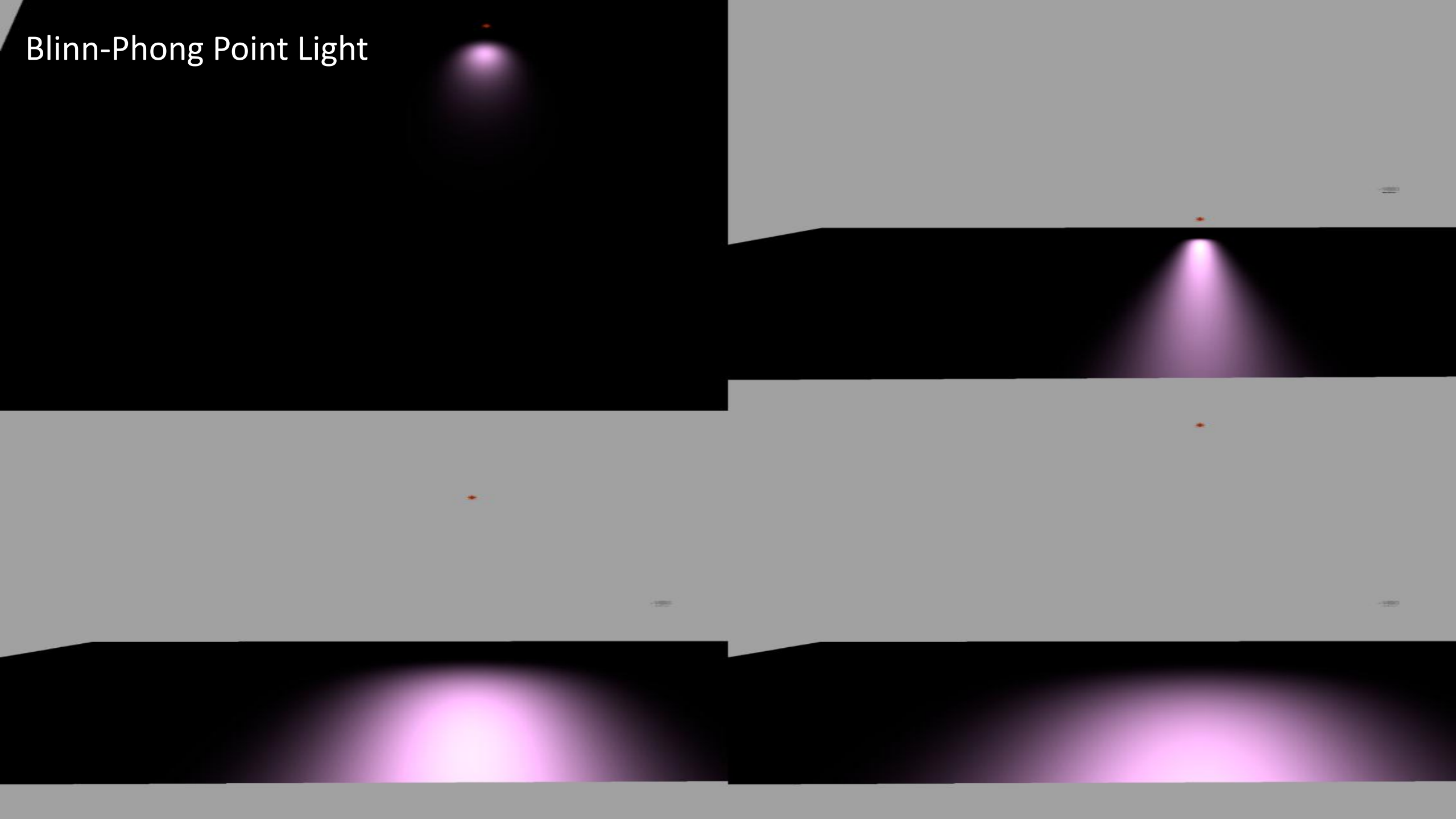


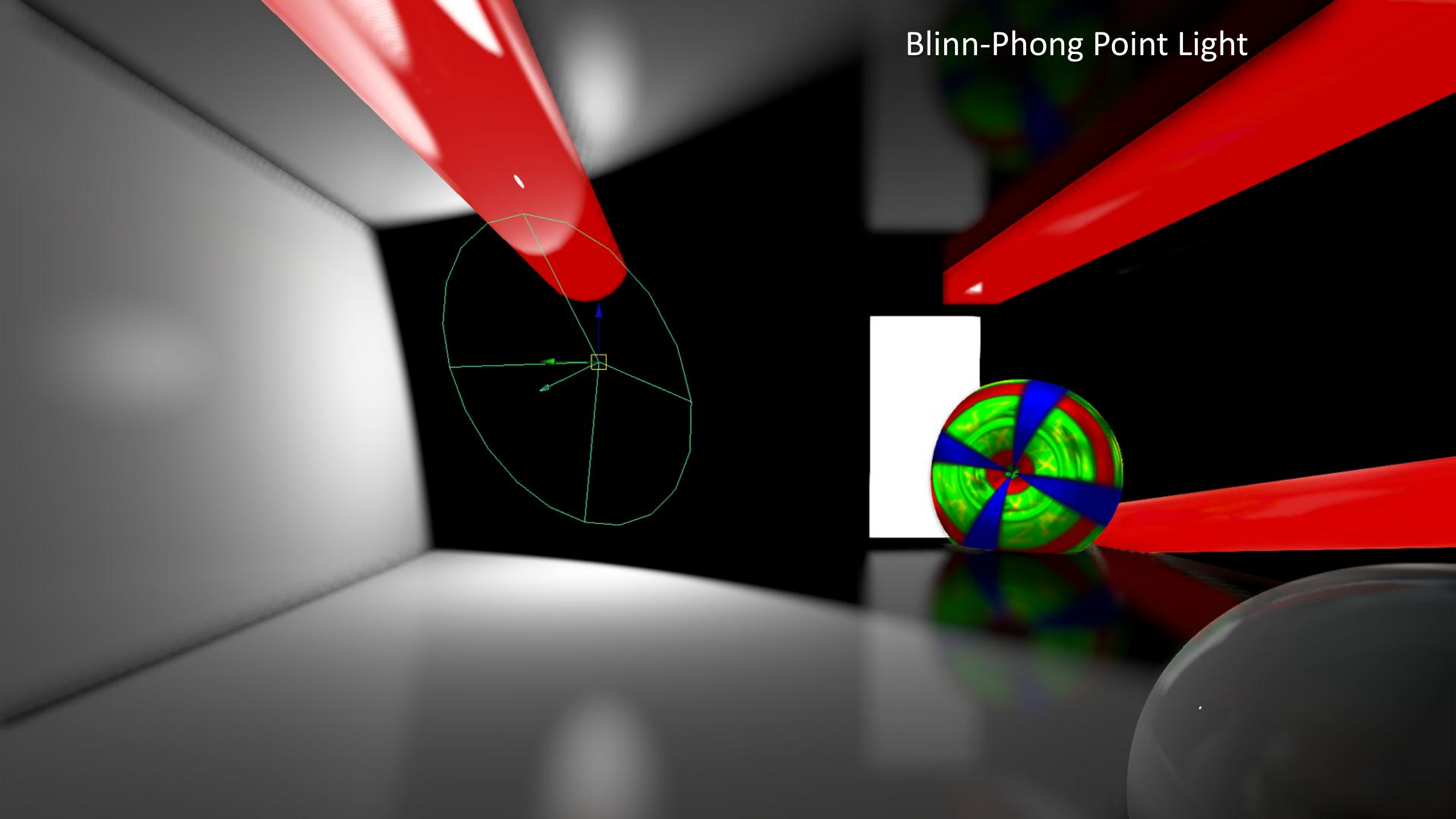




Physically Based Lights

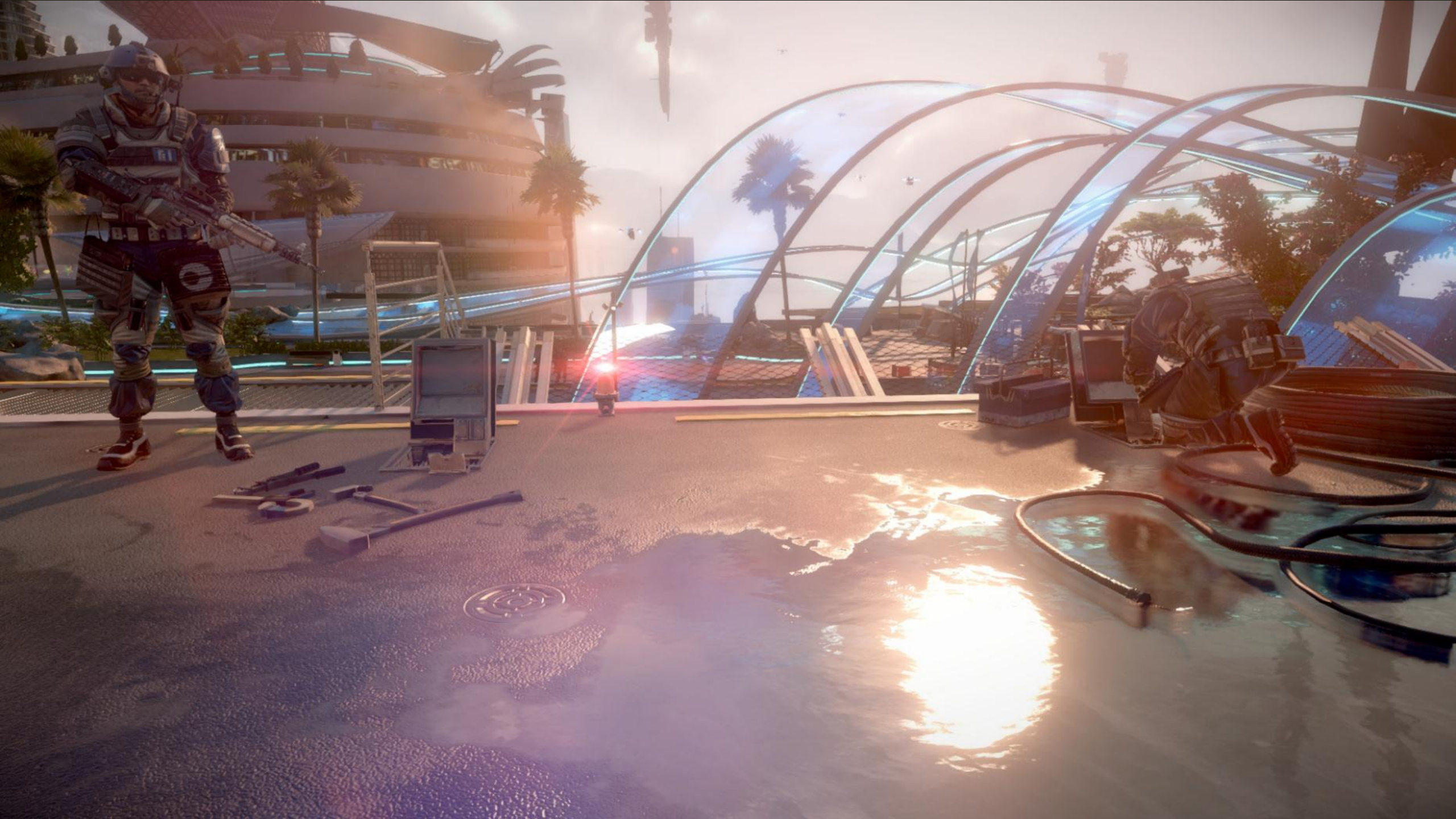
Blinn-Phong Point Light

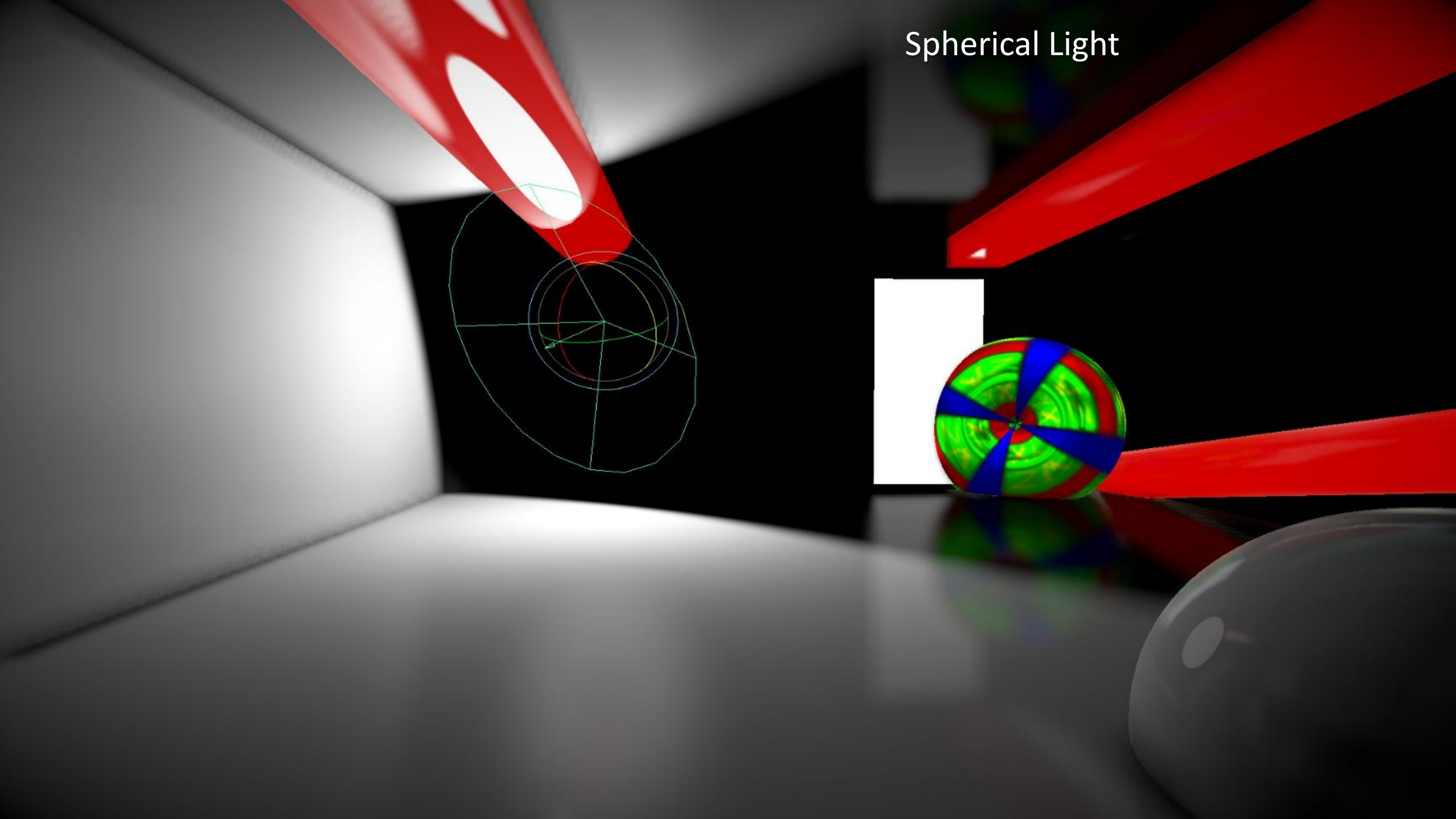


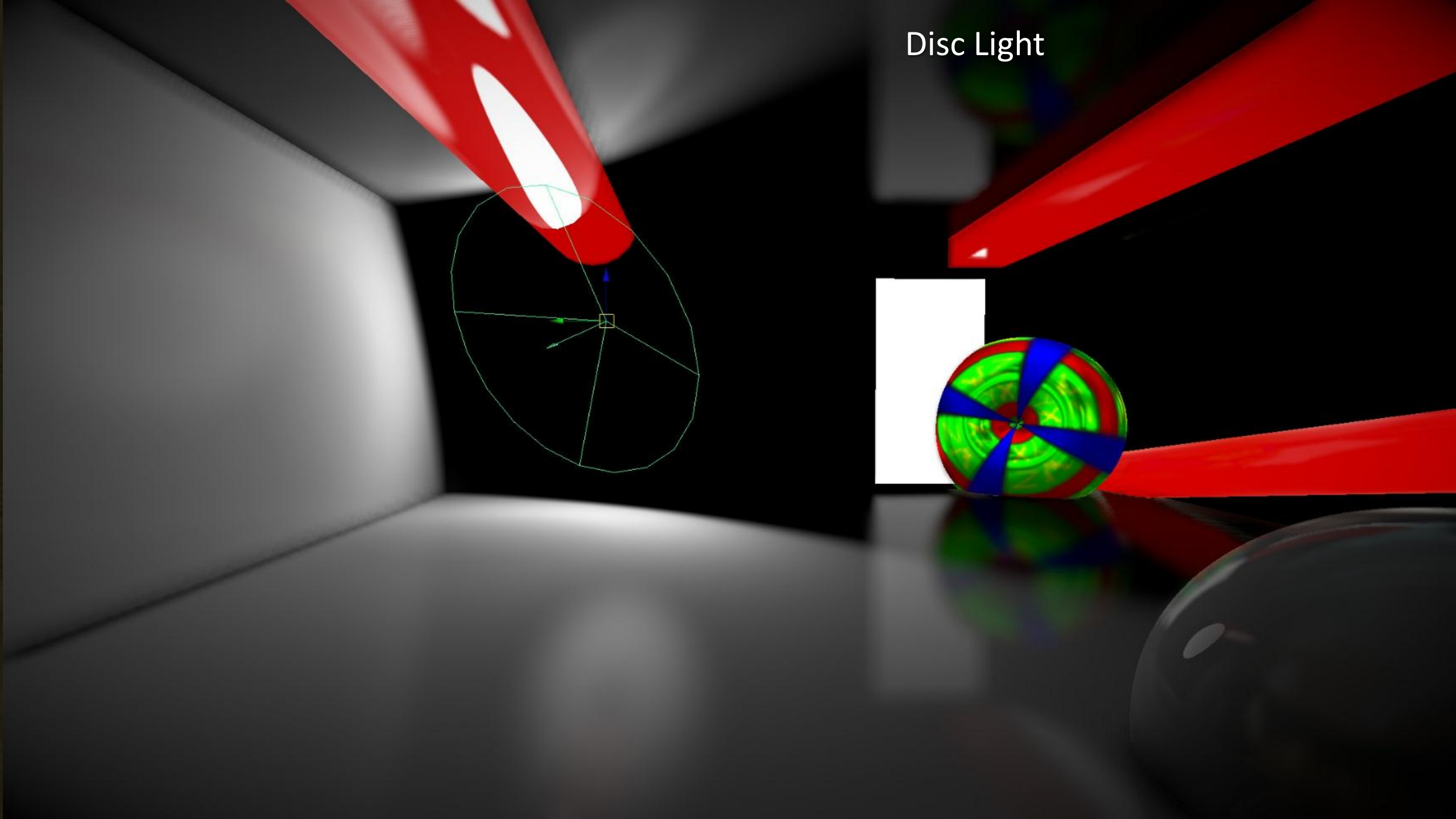

Blinn-Phong Point Light

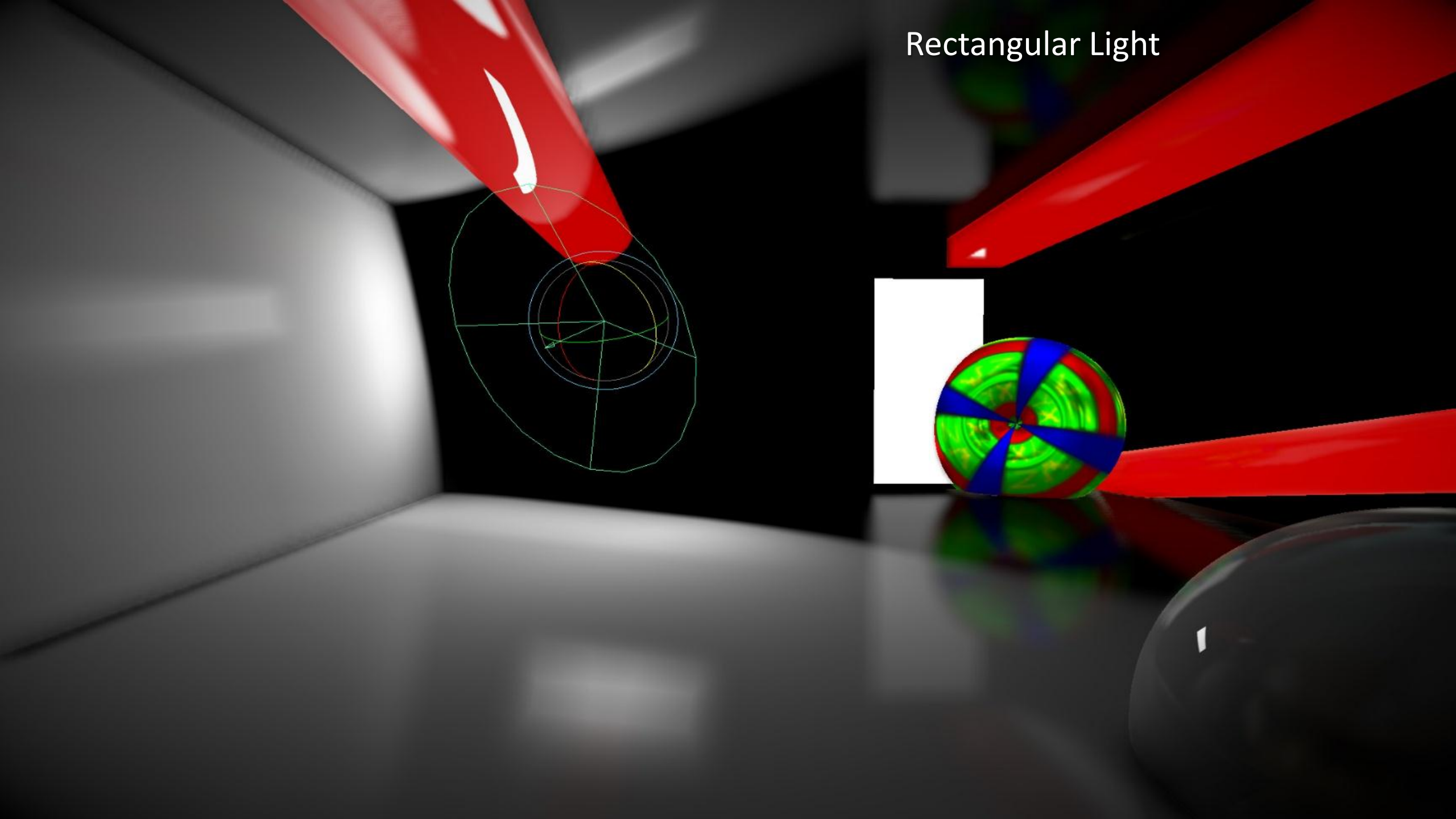
Area Lights

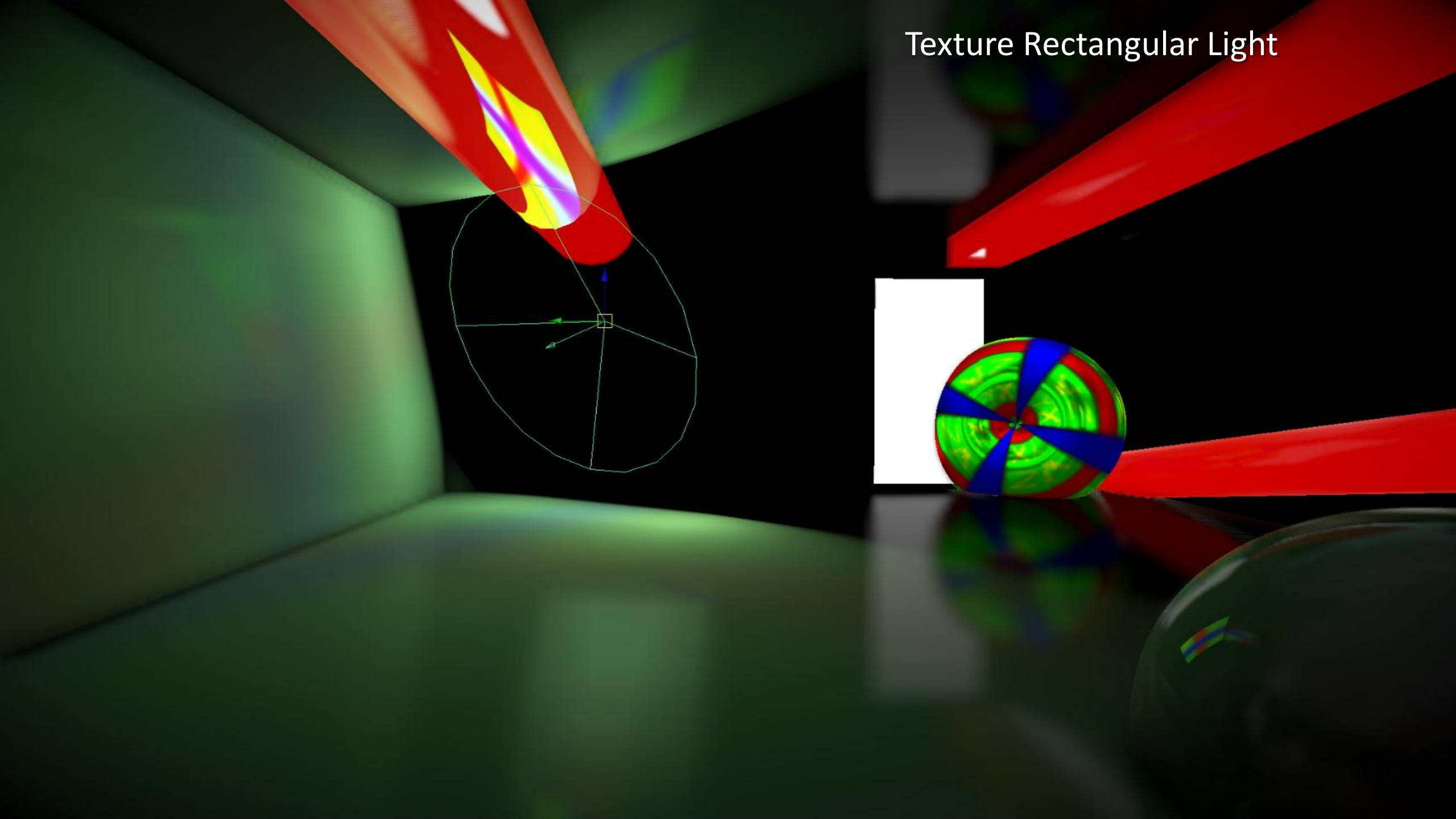
- Every light source
  - Size
  - Shape
  - Intensity
- Art
  - Photography
  - Light Direction

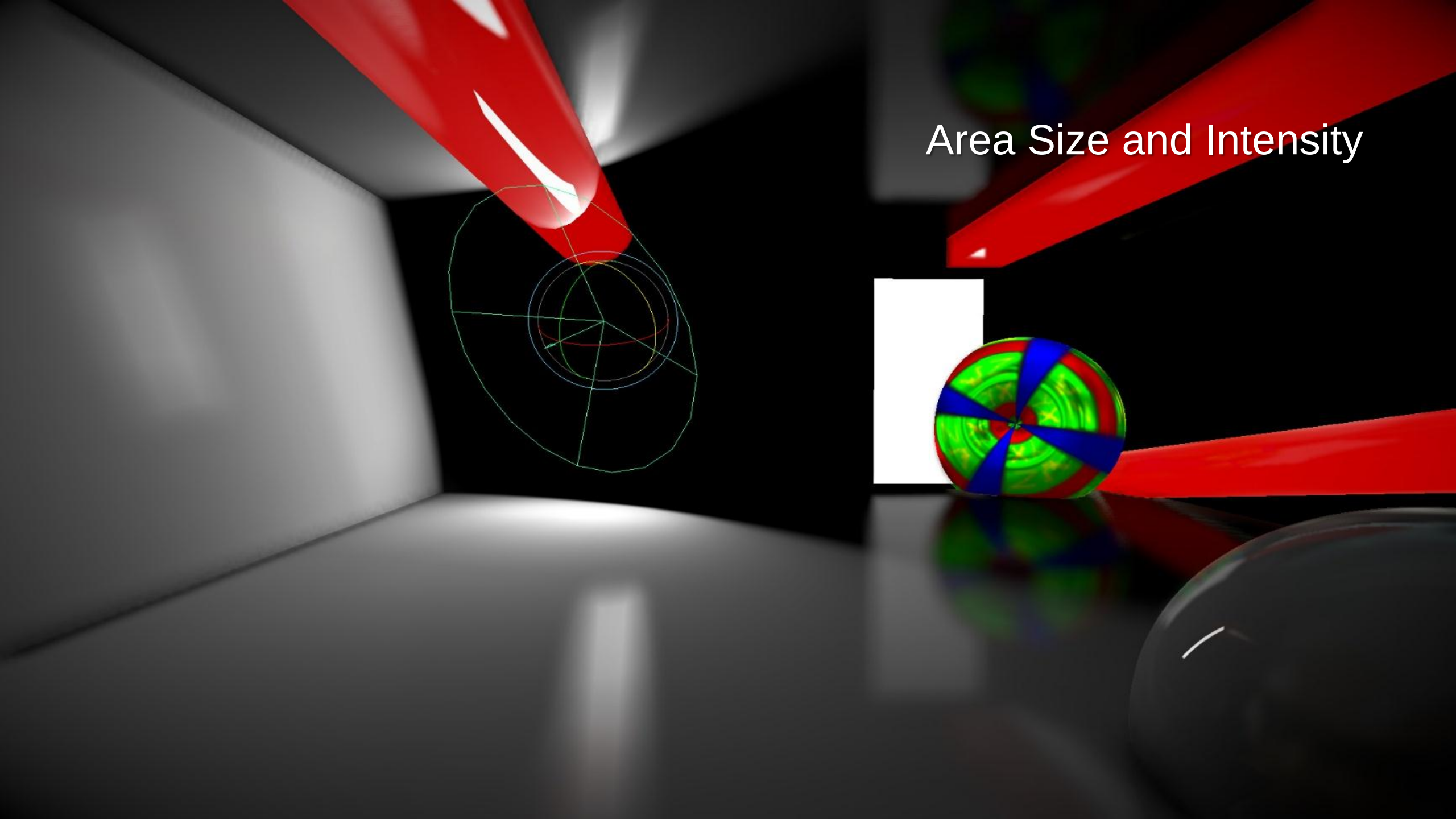


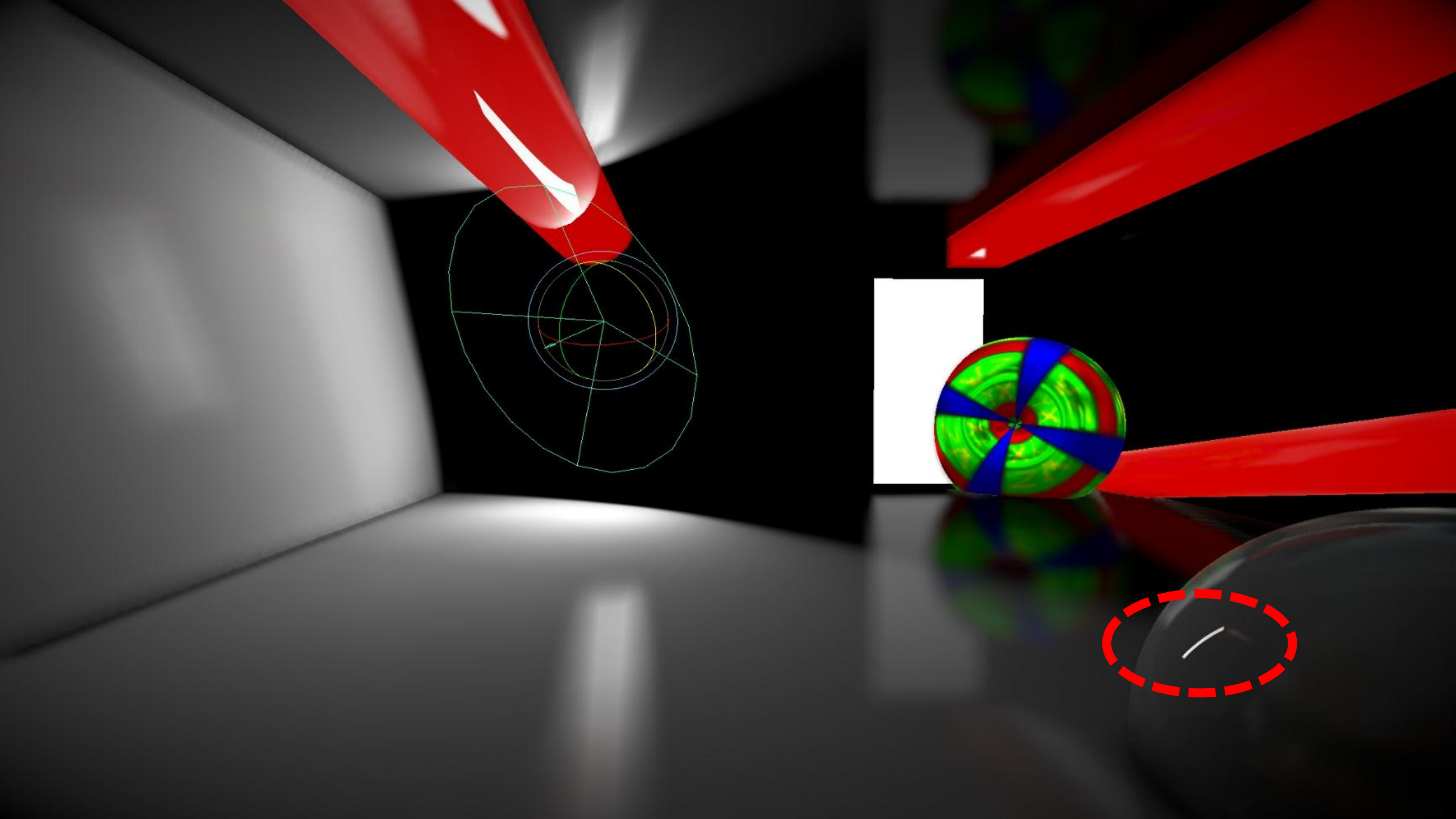

Spherical Light

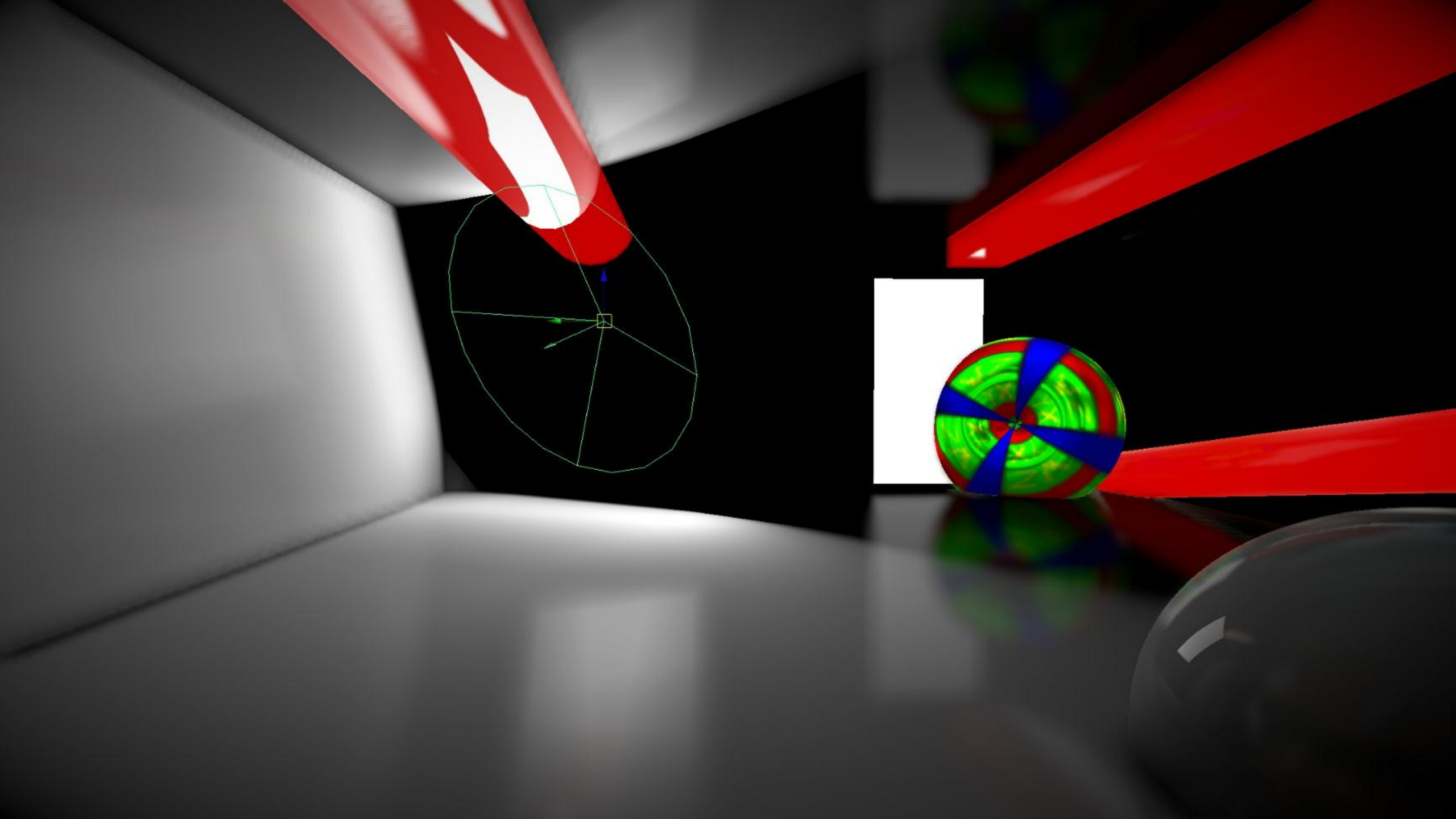

Disc Light

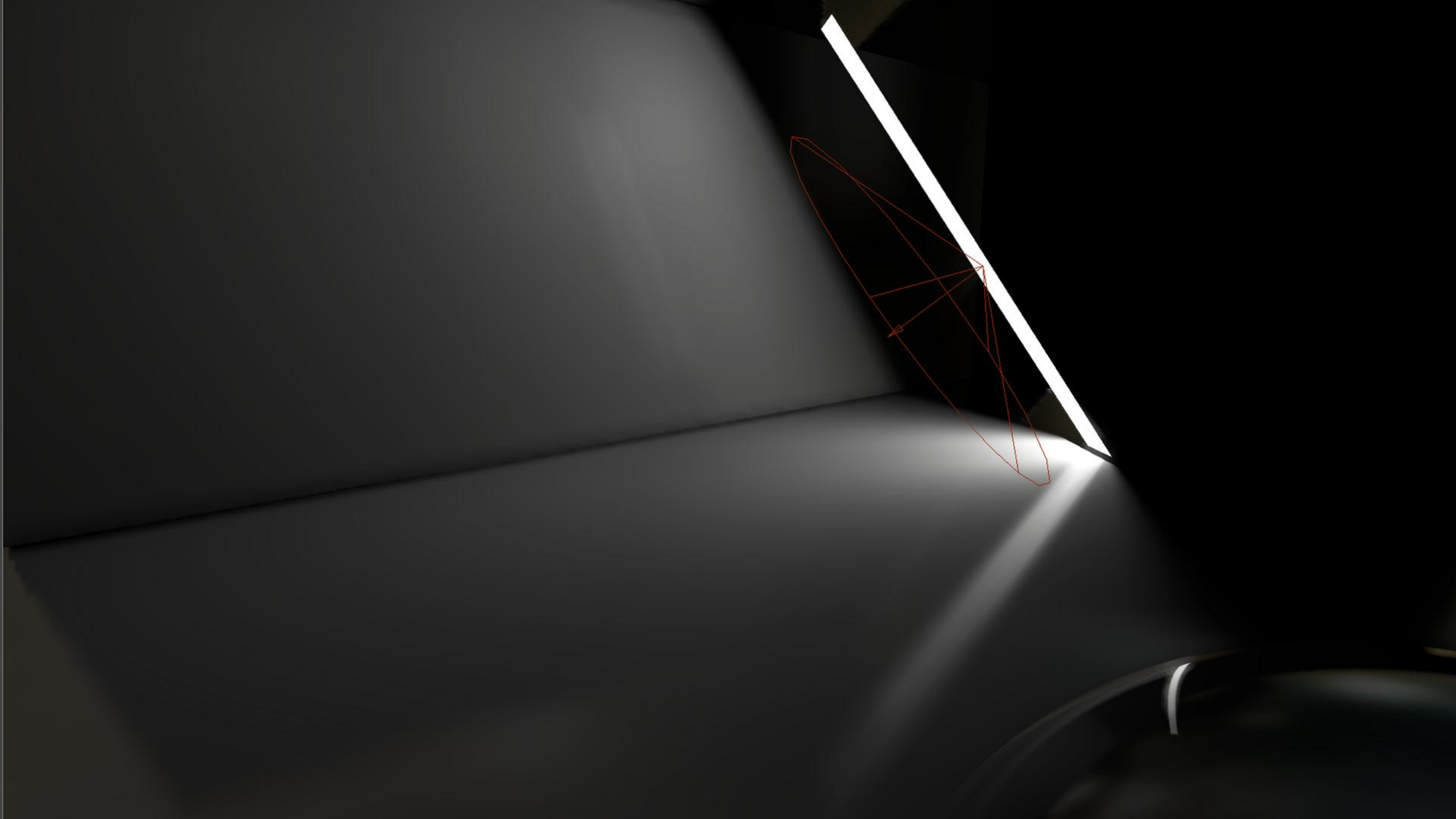

Rectangular Light

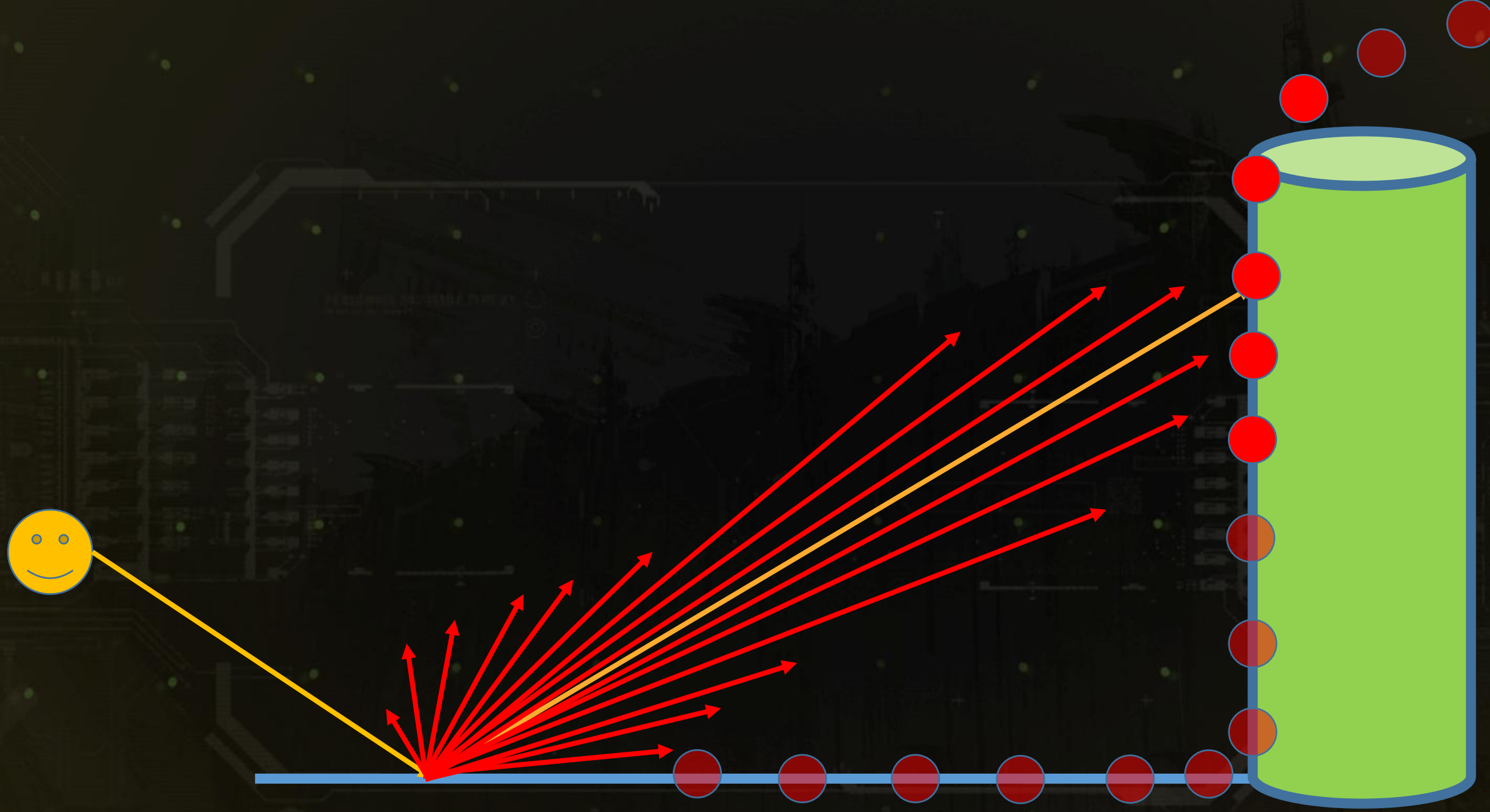

Texture Rectangular Light


Area Size and Intensity

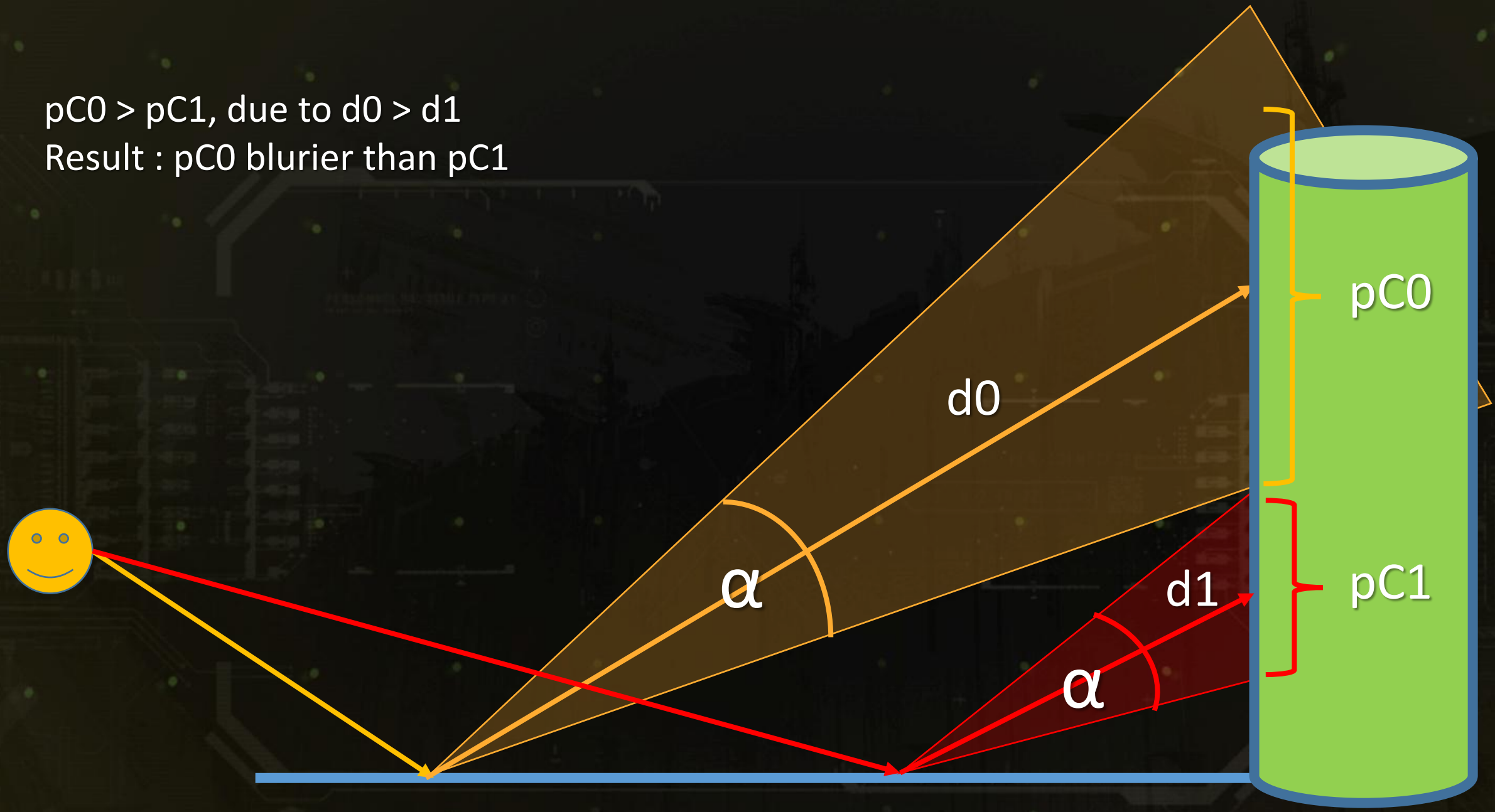


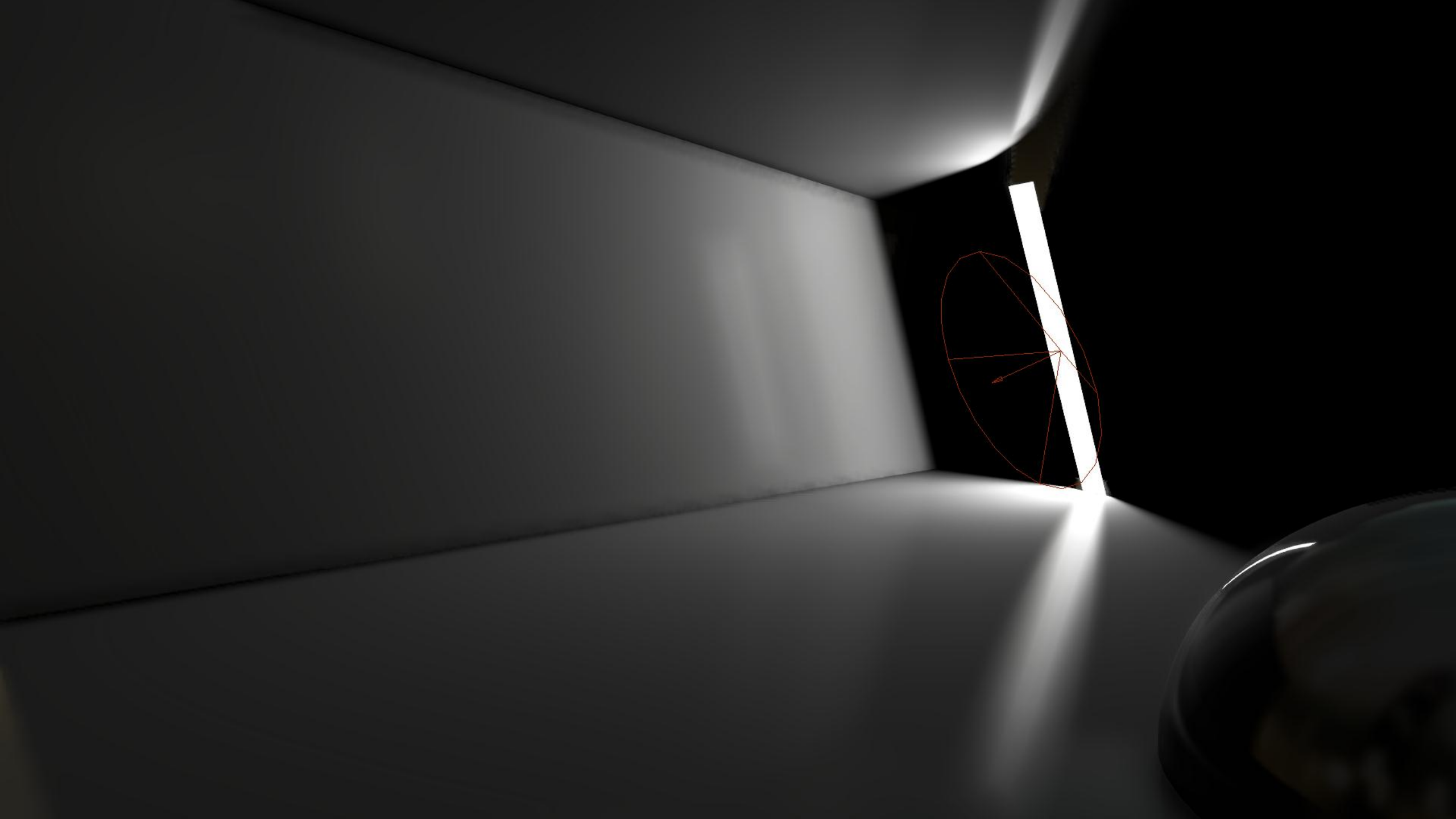






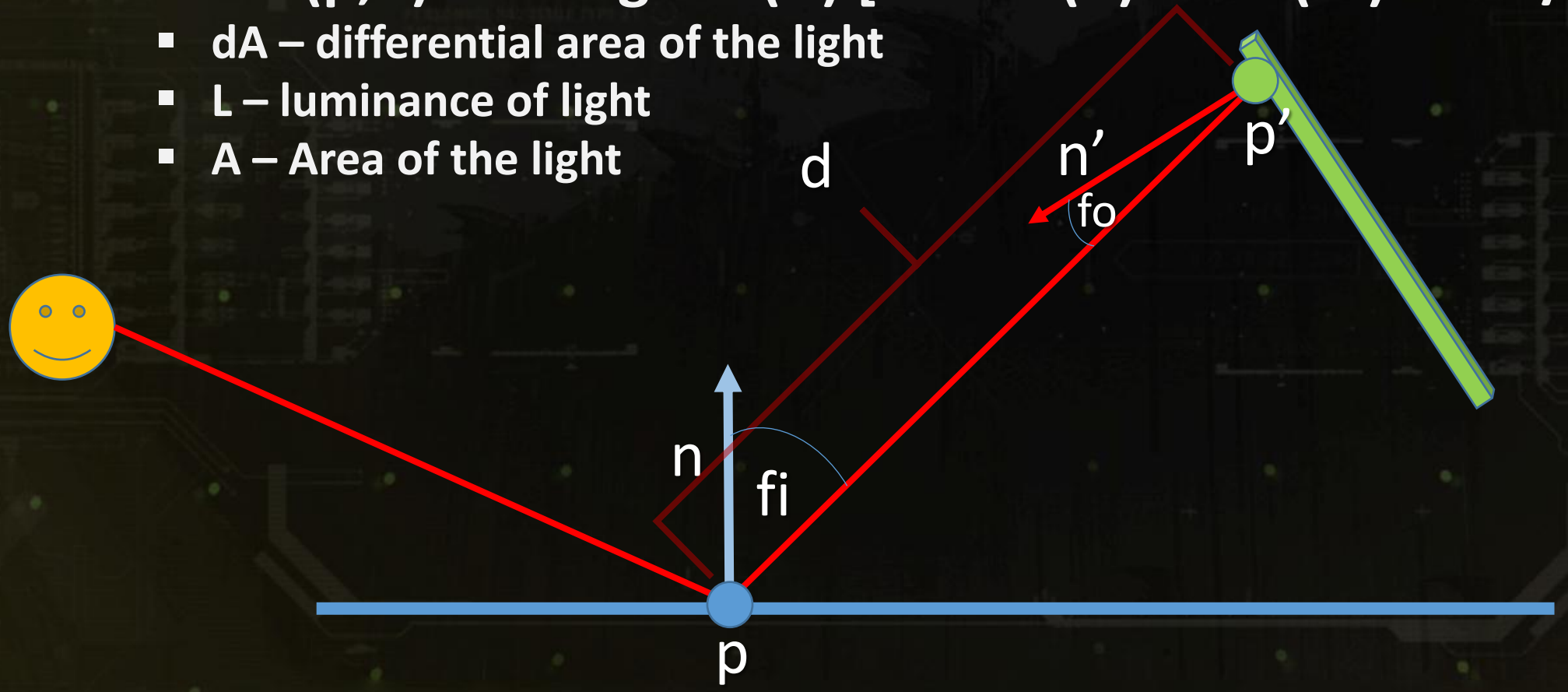
pC0 > pC1, due to d0 > d1
Result : pC0 blurier than pC1





Irradiance Integral

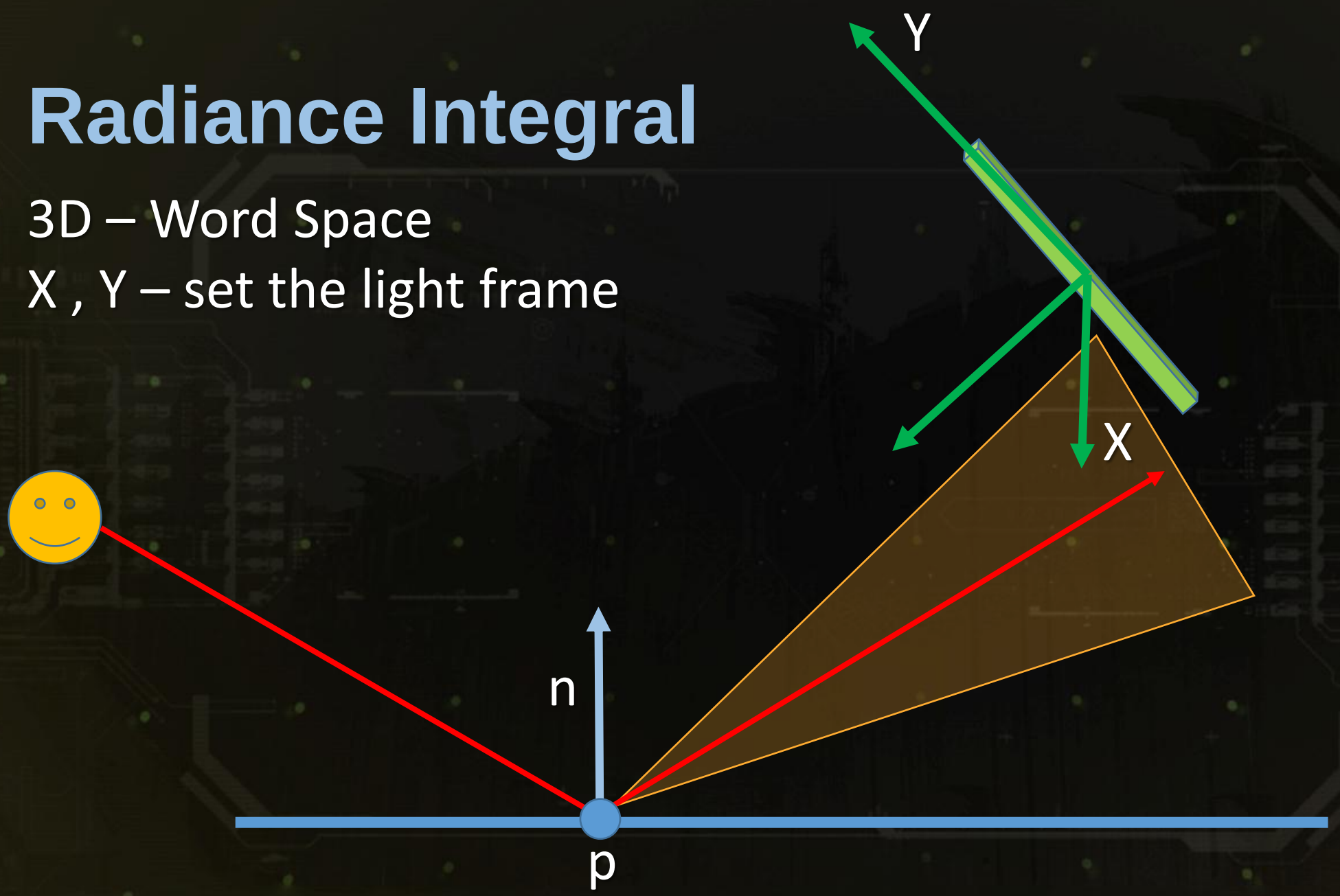
- DA : I(p,n) = Integrate(A) [L * cos(fi) * cos(fo) * dA / d^2]
  - dA – differential area of the light
  - L – luminance of light
  - A – Area of the light



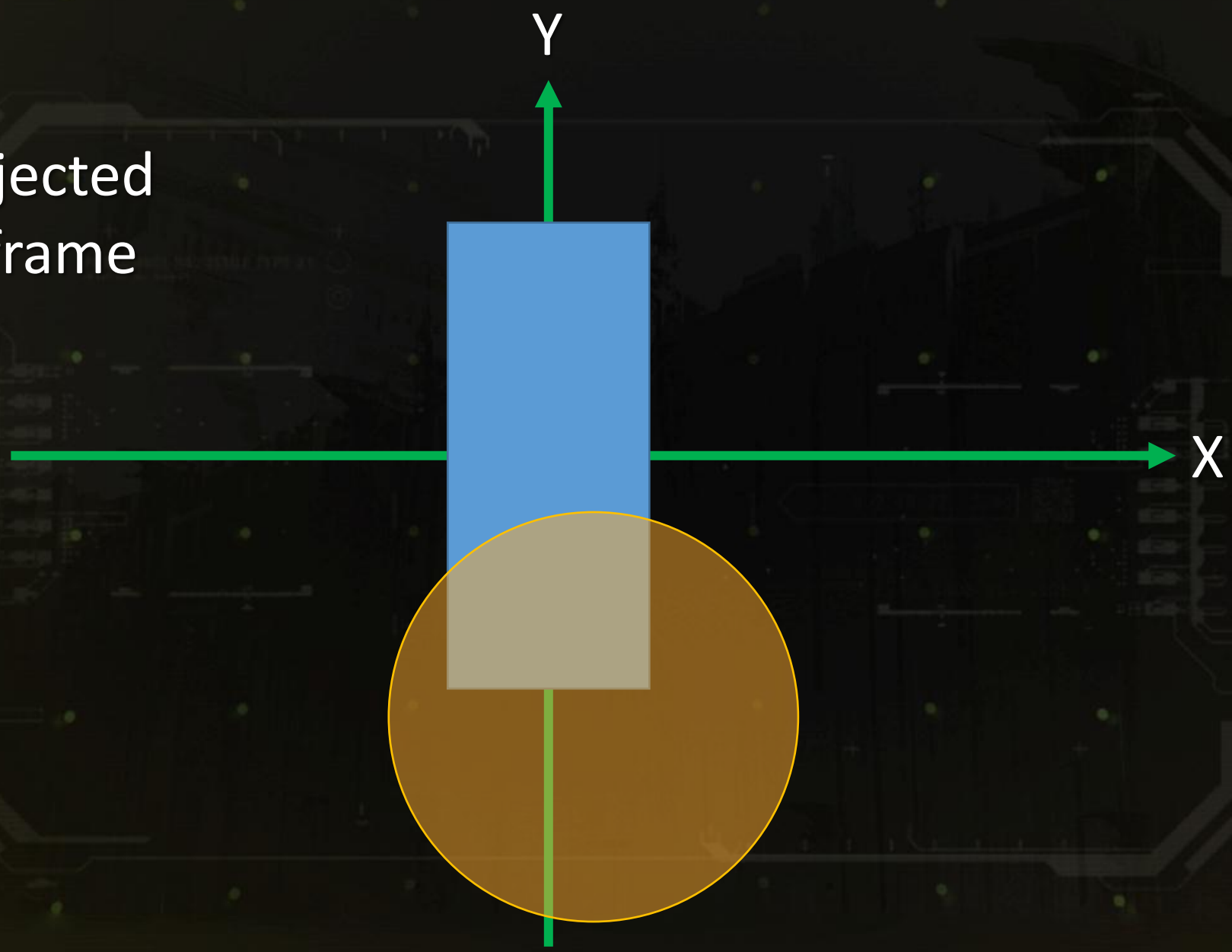
Radiance Integral

3D – Word Space

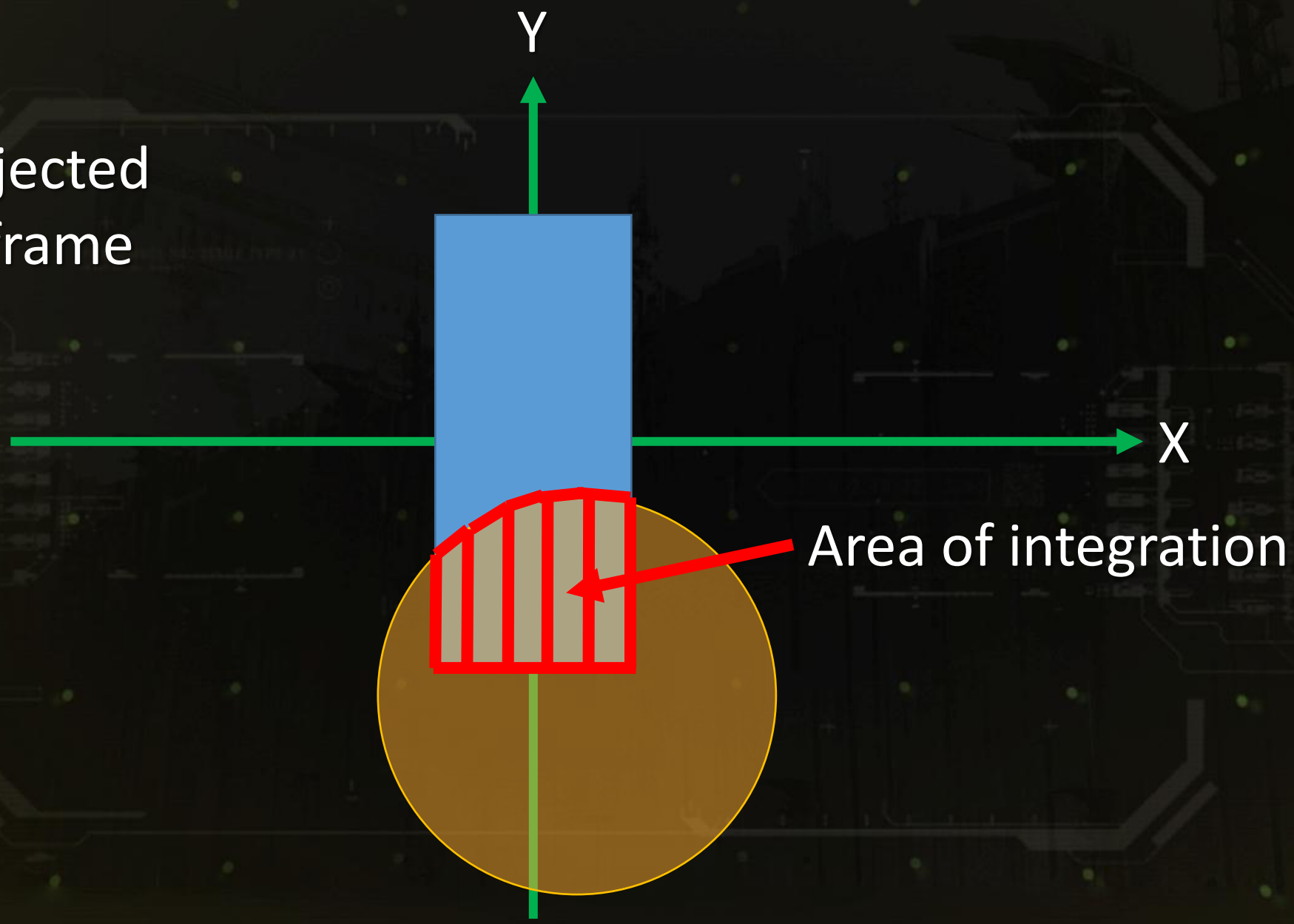
X , Y – set the light frame

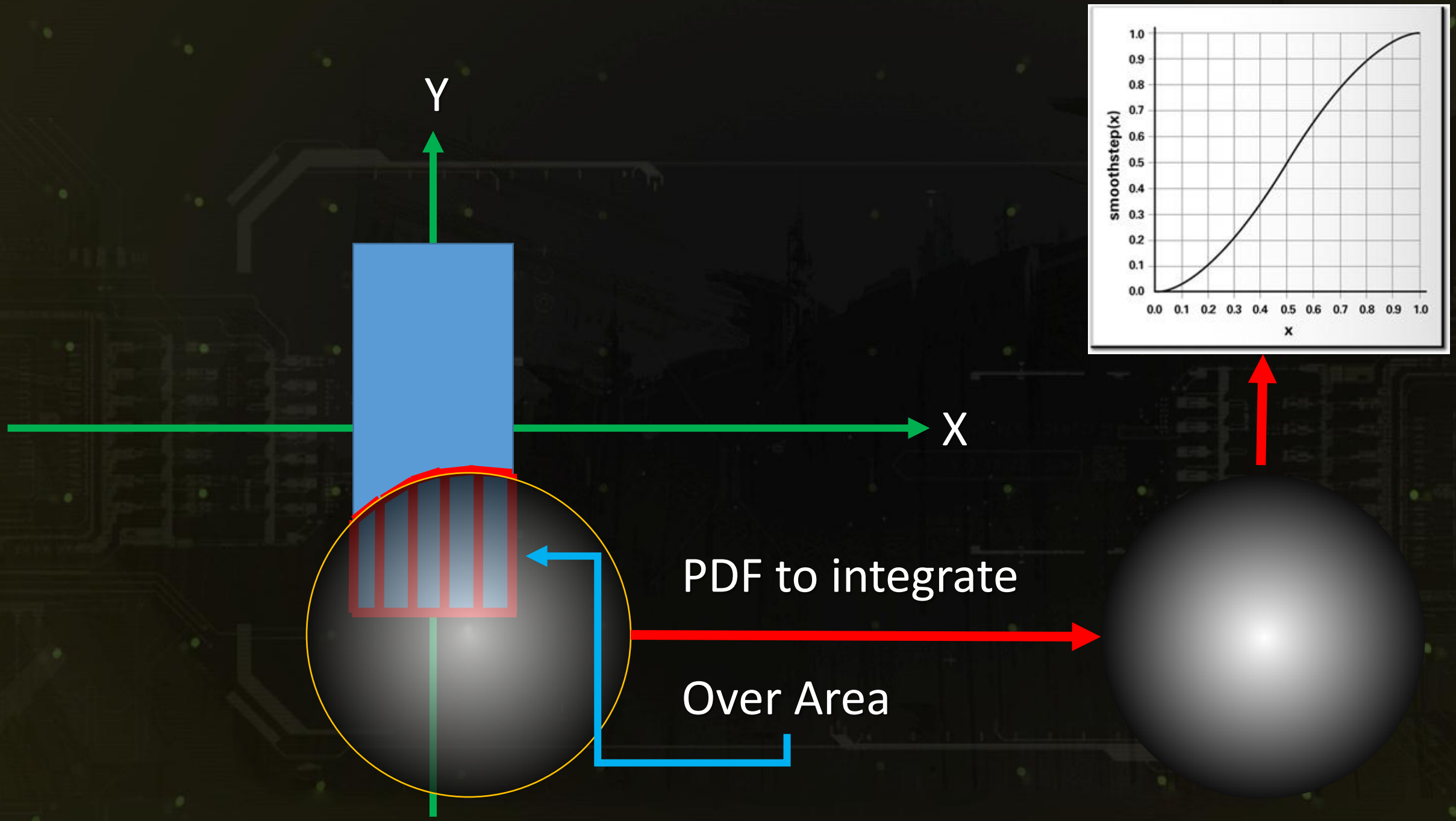


2D – projected
on light frame

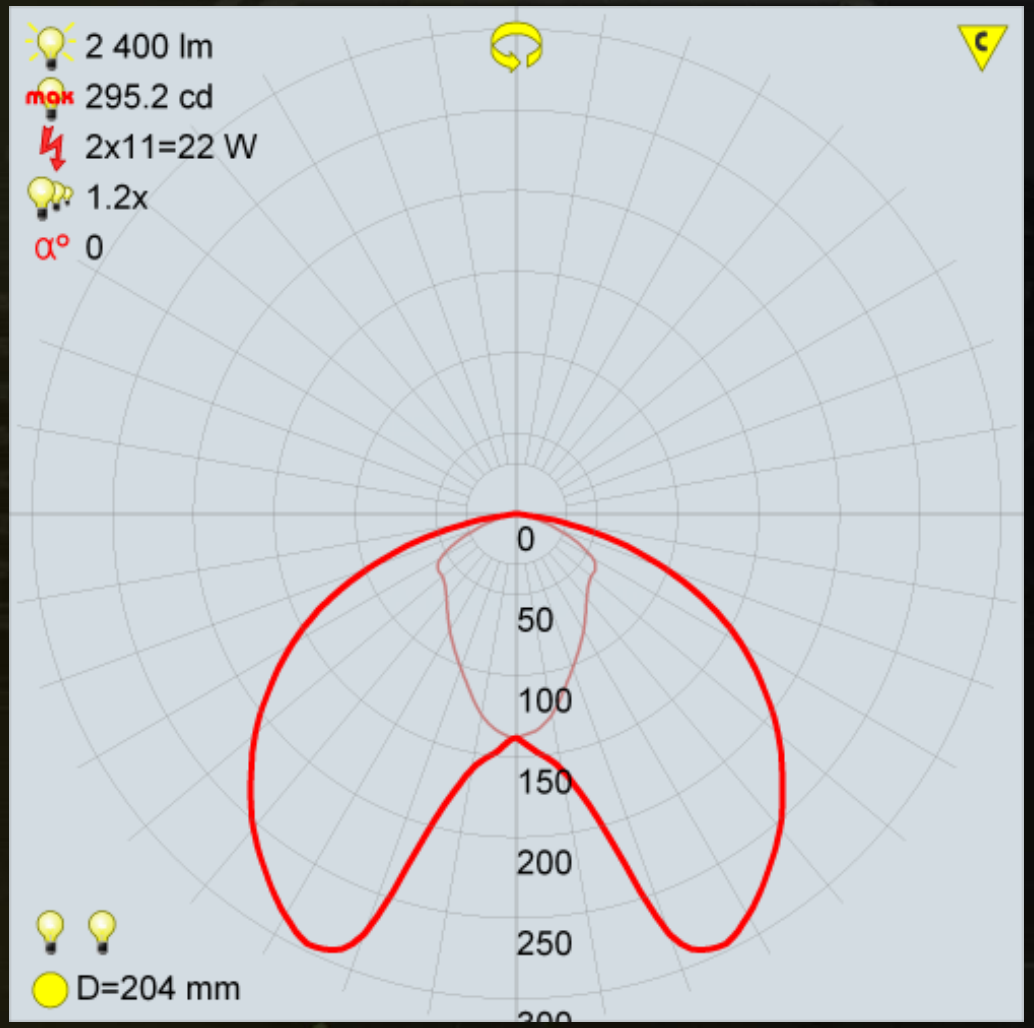


2D – projected
on light frame

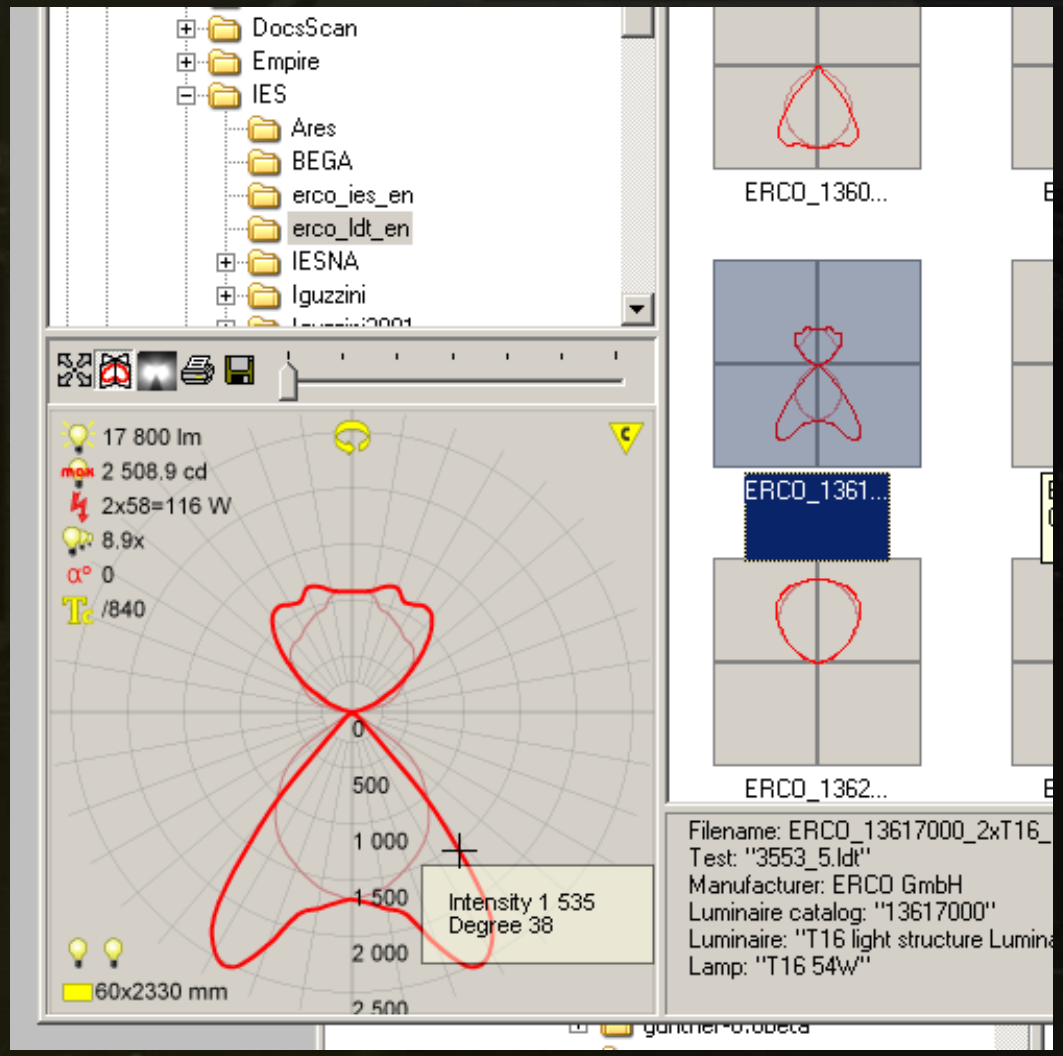


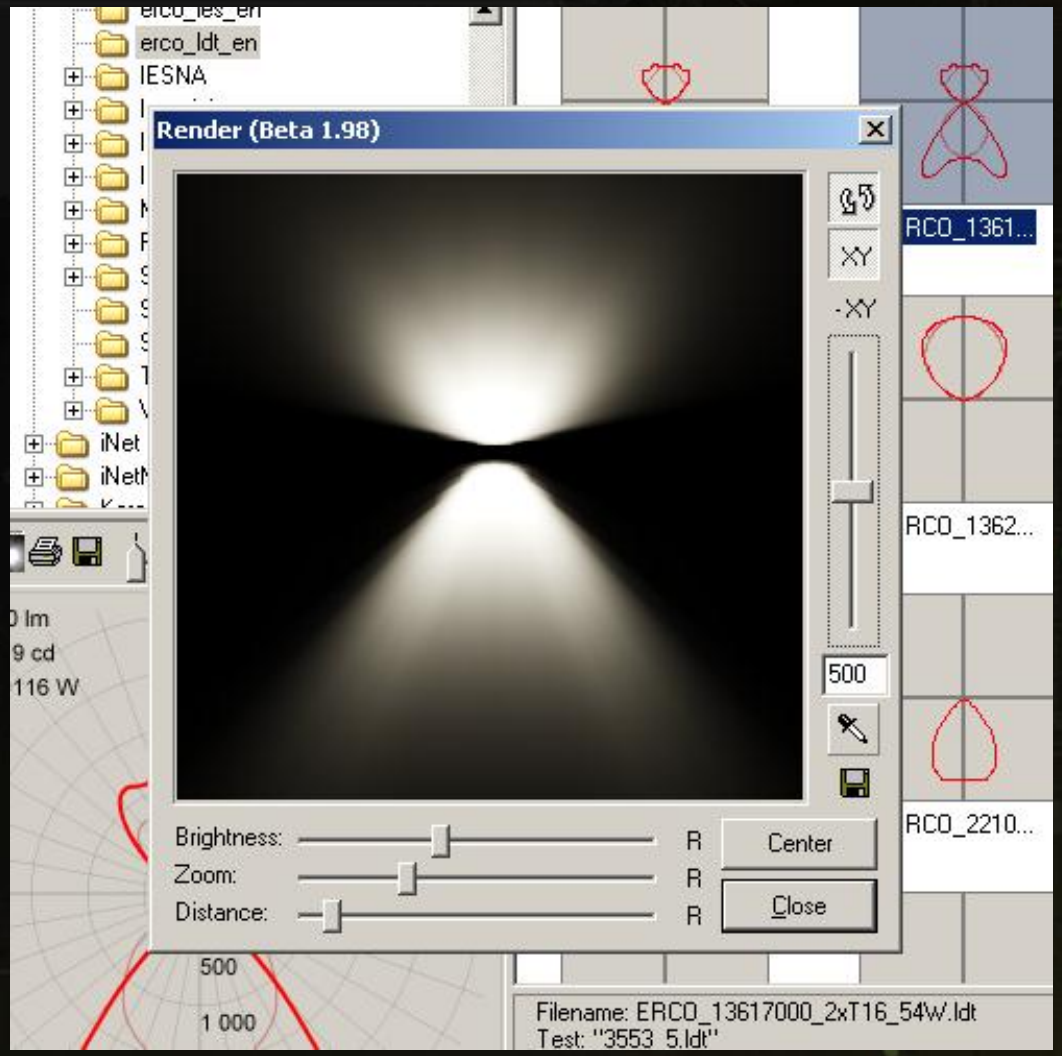

Y
X
PDF to integrate
Over Area
smoothstep(x)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
x

IES Light Profiles

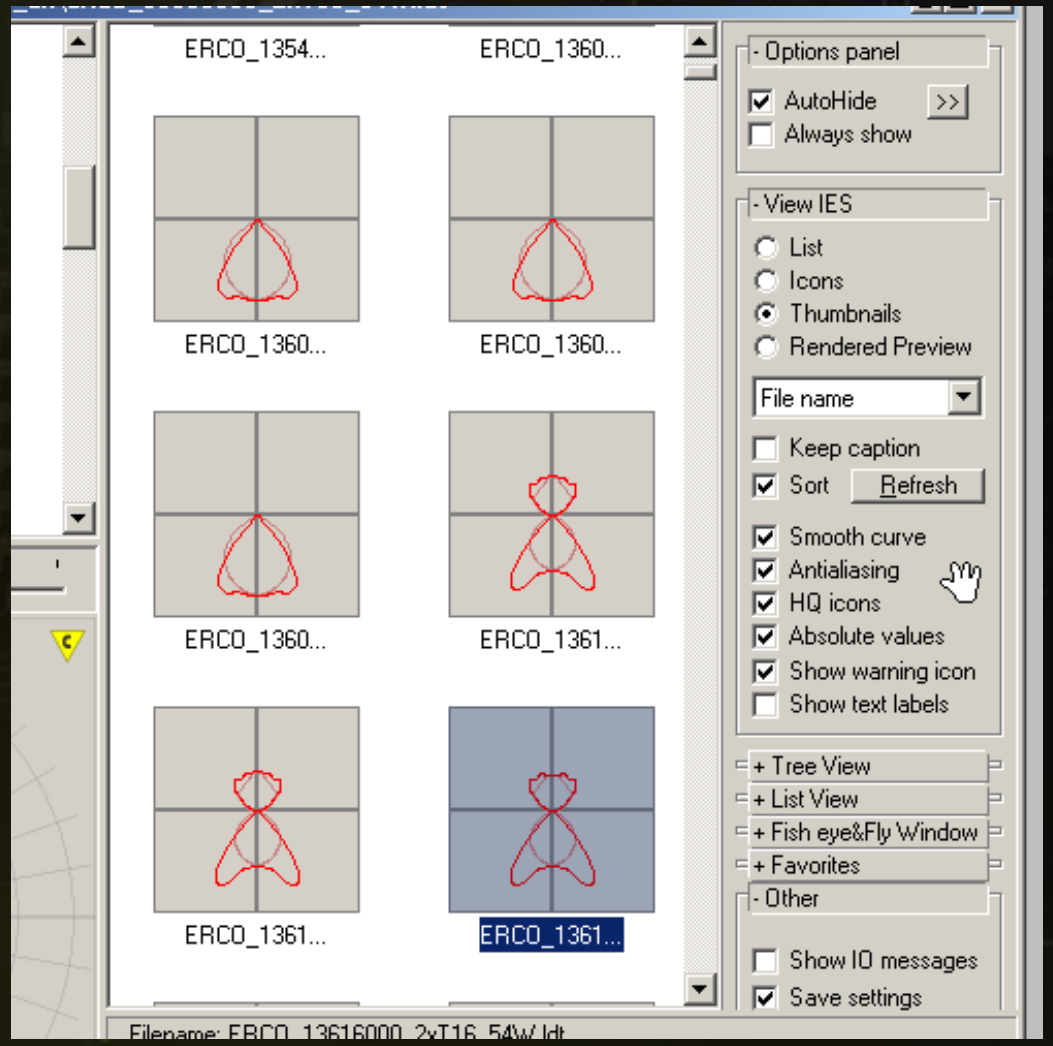


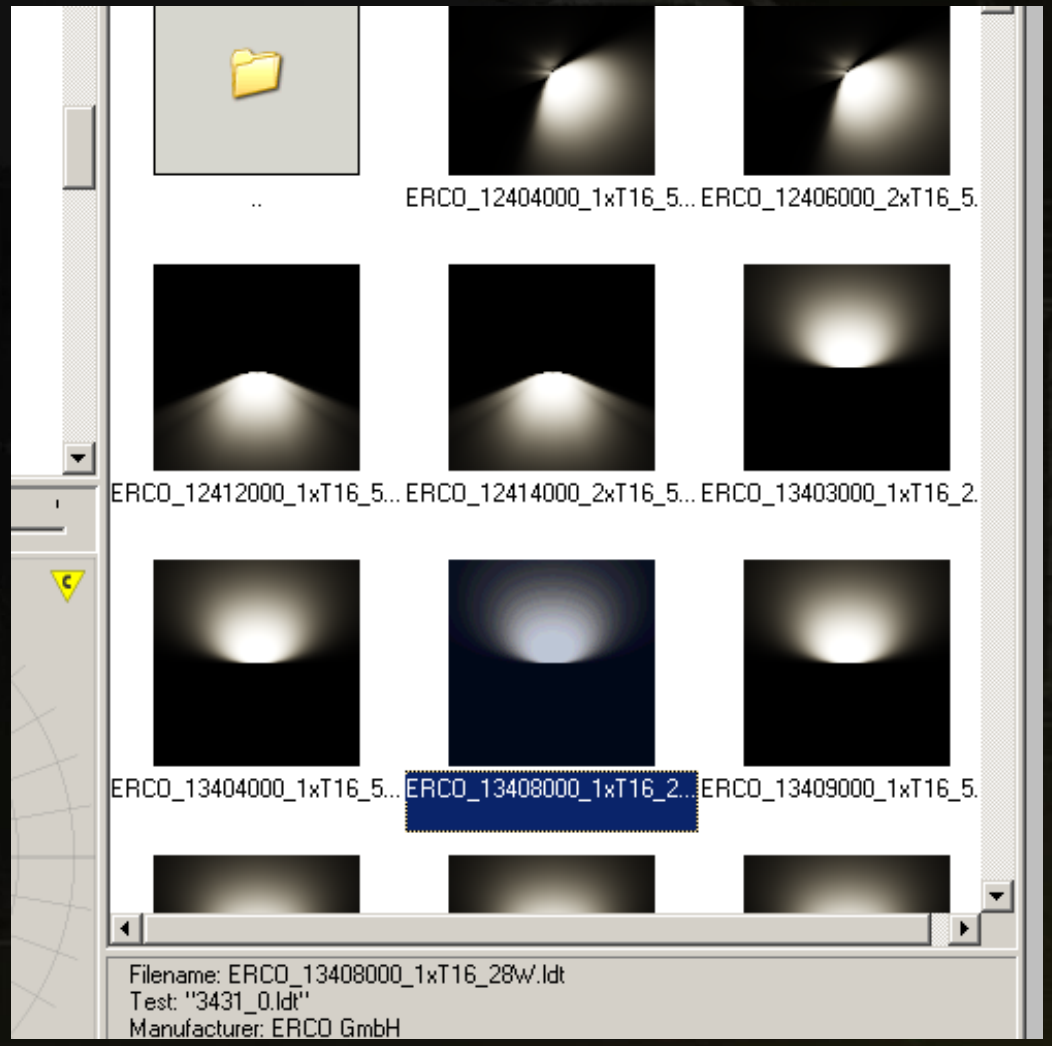
IES Light Profiles





IES Light Profiles






VSA

Lighting Pipeline Overview

IBL Reflection System

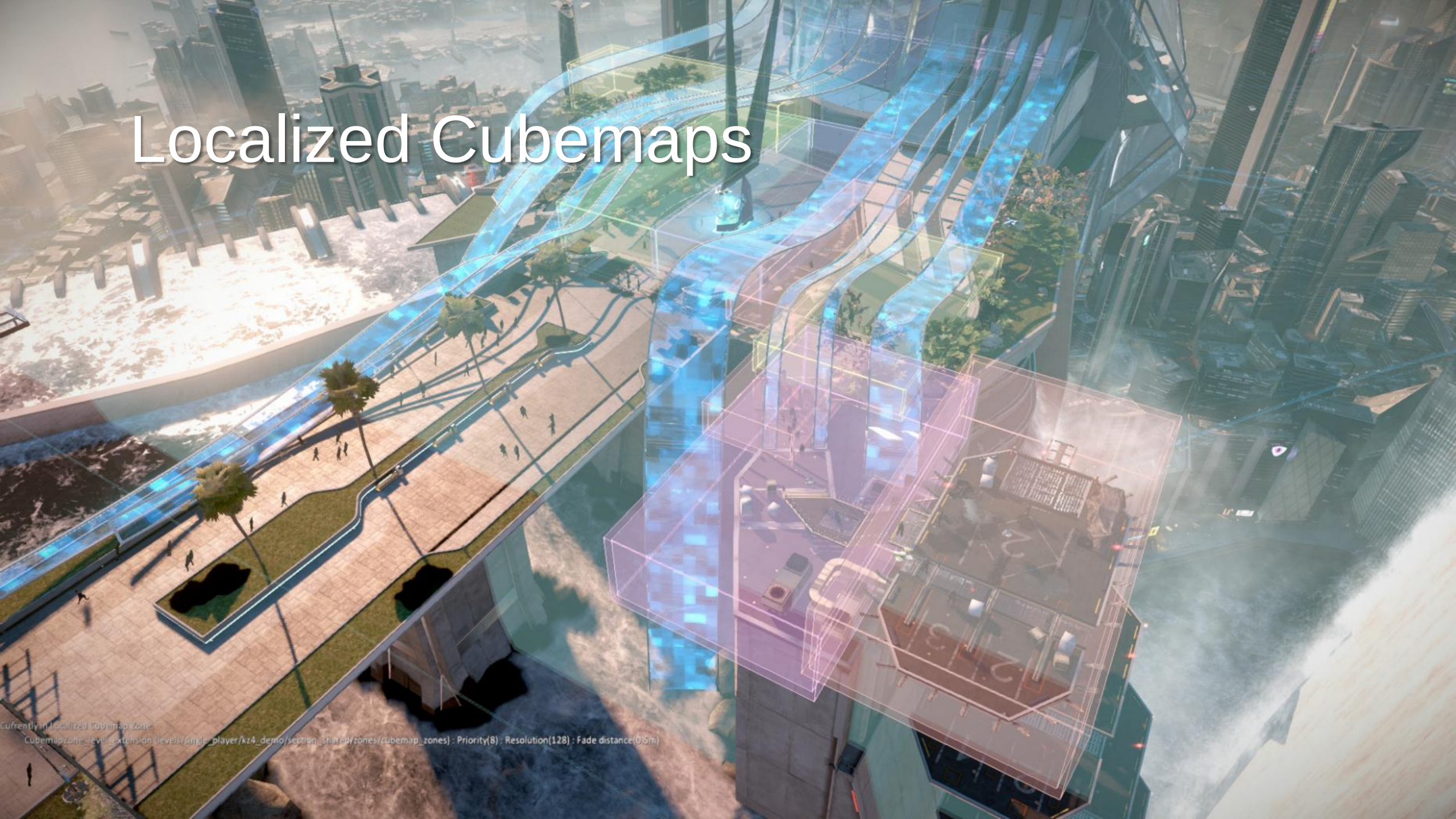
- 3 Tier Reflection Raytrace system
  - Realtime Glossy Reflections
  - Localized Cubemaps
  - Skybox

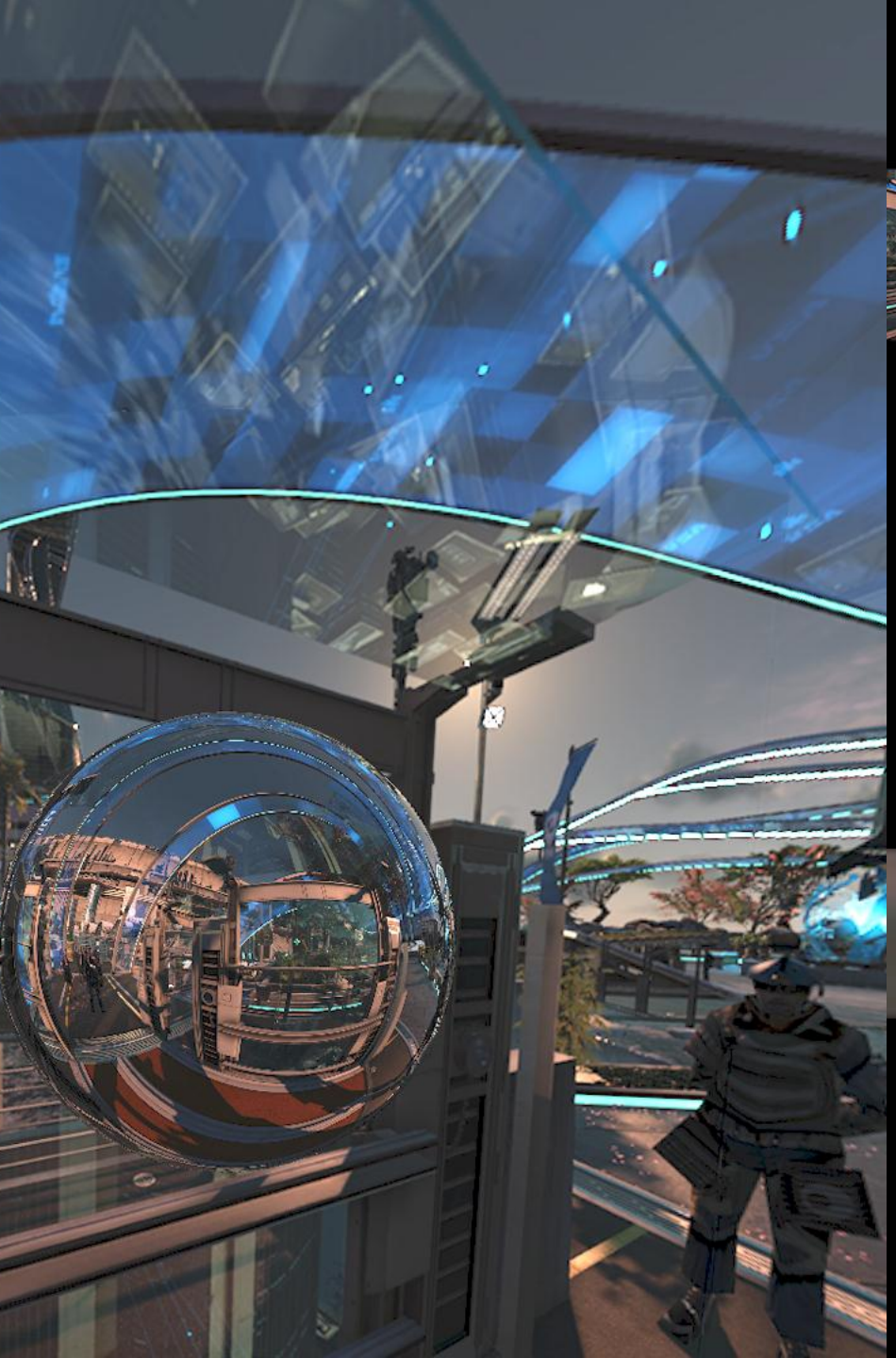

ACCESS
GRANTED
LUCAS KELLAN

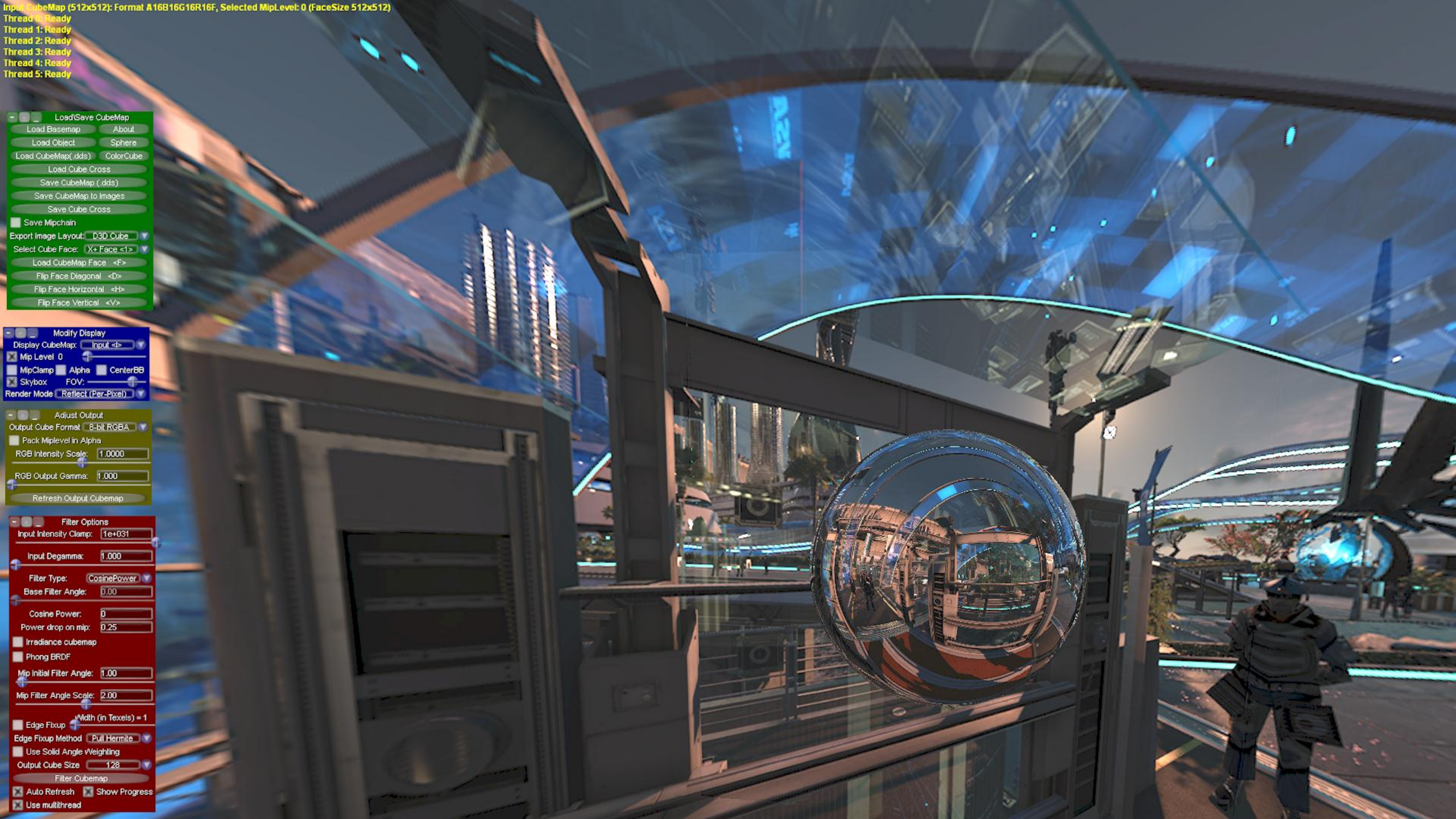

ACCESS
GRANTED
LUCAS KELLAN

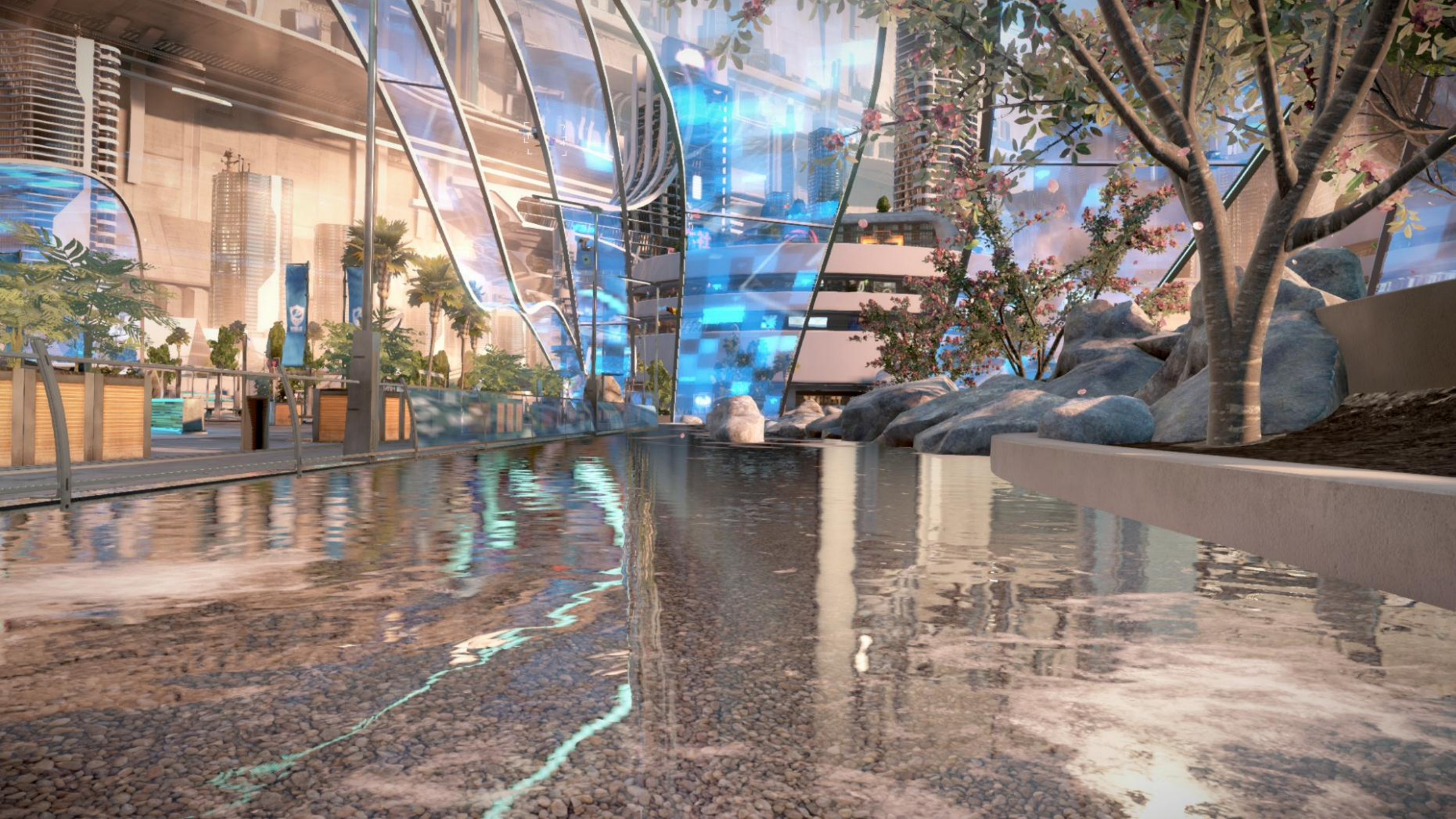

ACCESS
GRANTED
LUCAS KELLAN

Localized Cubemaps






Input CubeMap (512x512): Format A16B16G16R16F, Selected MipLevel: 0 (FaceSize 512x512)
Thread 0: Ready
Thread 1: Ready
Thread 2: Ready
Thread 3: Ready
Thread 4: Ready
Thread 5: Ready
Load\Save CubeMap
Load Basemap
About
Load Object
Sphere
Load CubeMap(.dds)
ColorCube
Load Cube Cross
Save CubeMap (.dds)
Save CubeMap to Images
Save Cube Cross
Save Mipchain
Export Image Layout: D3D Cube
Select Cube Face: X+ Face <1>
Load CubeMap Face <F>
Flip Face Diagonal <D>
Flip Face Horizontal <H>
Flip Face Vertical <V>
Modify Display
Display CubeMap: Input <I>
Mip Level 0
MipClamp
Alpha
CenterBB
Skybox
FOV:
Render Mode Reflect (Per-Pixel)
Adjust Output
Output Cube Format 8-bit RGBA
Pack Miplevel in Alpha
RGB Intensity Scale: 1.0000
RGB Output Gamma: 1.000
Refresh Output Cubemap
Filter Options
Input Intensity Clamp: 1e+031
Input Degamma: 1.000
Filter Type: CosinePower
Base Filter Angle: 0.00
Cosine Power: 0
Power drop on mip: 0.25
Irradiance cubemap
Phong BRDF
Mip Initial Filter Angle: 1.00
Mip Filter Angle Scale: 2.00
Width (in Texels) = 1
Edge Fixup
Edge Fixup Method Pull Hermite
Use Solid Angle Weighting
Output Cube Size 128
Filter Cubemap
Auto Refresh
Show Progress
Use multithread



IBL Render Pass Breakdown


Baked Lightmaps Diffuse + Dynamic Lights

Ambient BRDF

Cubemaps


Lightmap Diffuse + Dynamic Lights + Ambient BRDF * Cubemaps

Real Time Glossy Reflections

Real Time Glossy Reflections : Mask

Final composite of IBL based lighting

Takeaway

- Physically Based Lighting
  - Higher quality
  - Faster asset production
  - Asset reuse in different environments
- Physical Area Lights
  - Time to say goodbye to point lights
  - Easier workflow
  - High quality results
- Real Time Reflections
  - Important visual clue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References

- Real Time Rendering 3rd Edition by Tomas Akenine-Moller, Eric Haines, Naty Hoffman
- Physically Based Rendering, Second Edition: From Theory To Implementation by Matt Pharr
- Industrial Light & Magic
- John Hable blog - http://filmicgames.com/