

HDR Rendering

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HDR Rendering

- Introduction to HDR
- Luma
- HDR in Luma

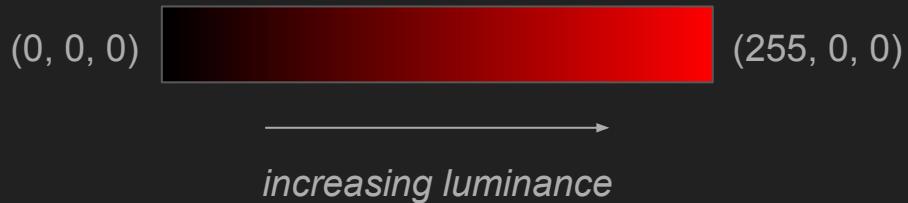
Introduction to HDR



https://en.wikipedia.org/wiki/High-dynamic-range_rendering#/media/File:Lost_Coast_HDR_comparison.png

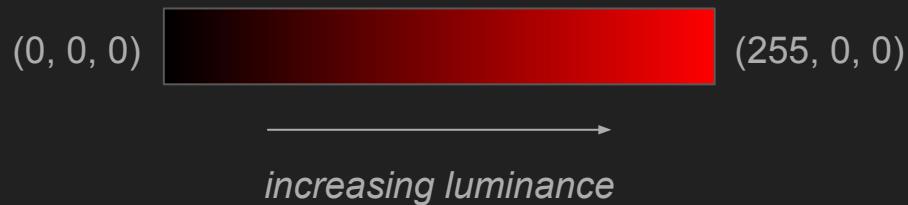
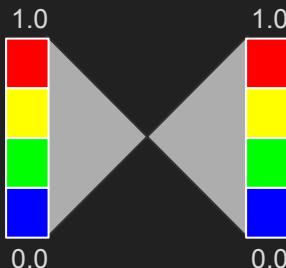
Luminance

- Eyes adapt to a broad range
- Devices display a limited range
- Integrated with our concept of “color”



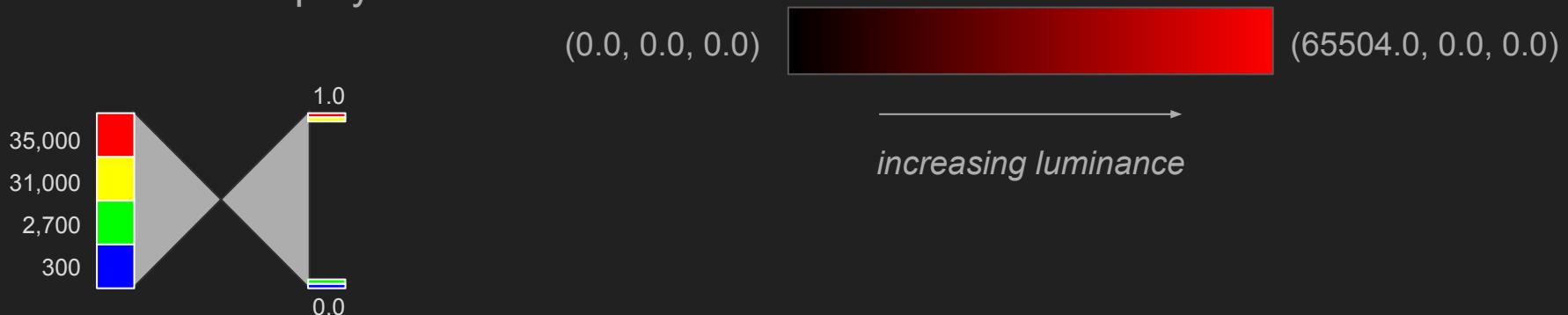
LDR Textures

- Low Dynamic Range
- Store luminance in a 0.0 - 1.0 range
- Scaled to whatever range a device can display
- Good for display
- Bad for processing



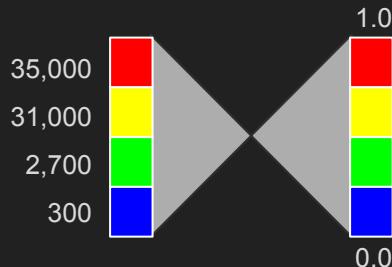
HDR Textures

- High Dynamic Range
- Store actual luminance values
- Floating point textures, LOGLUV
- Good for processing
- Bad for display



Tonemapping

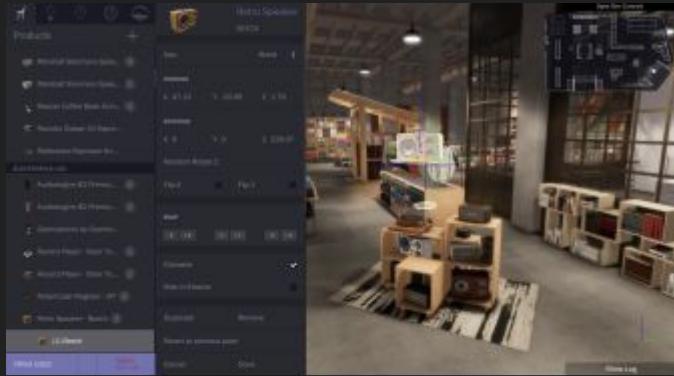
- HDR → LDR
- Reduce dynamic range
- Retain contrast between luminance values



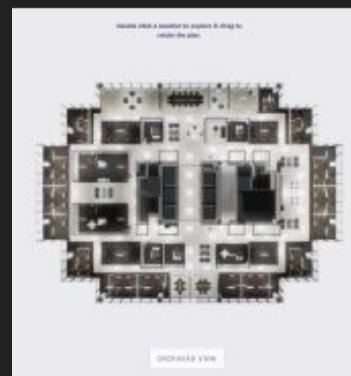
"Photographic Tone Reproduction for Digital Images"

Luma

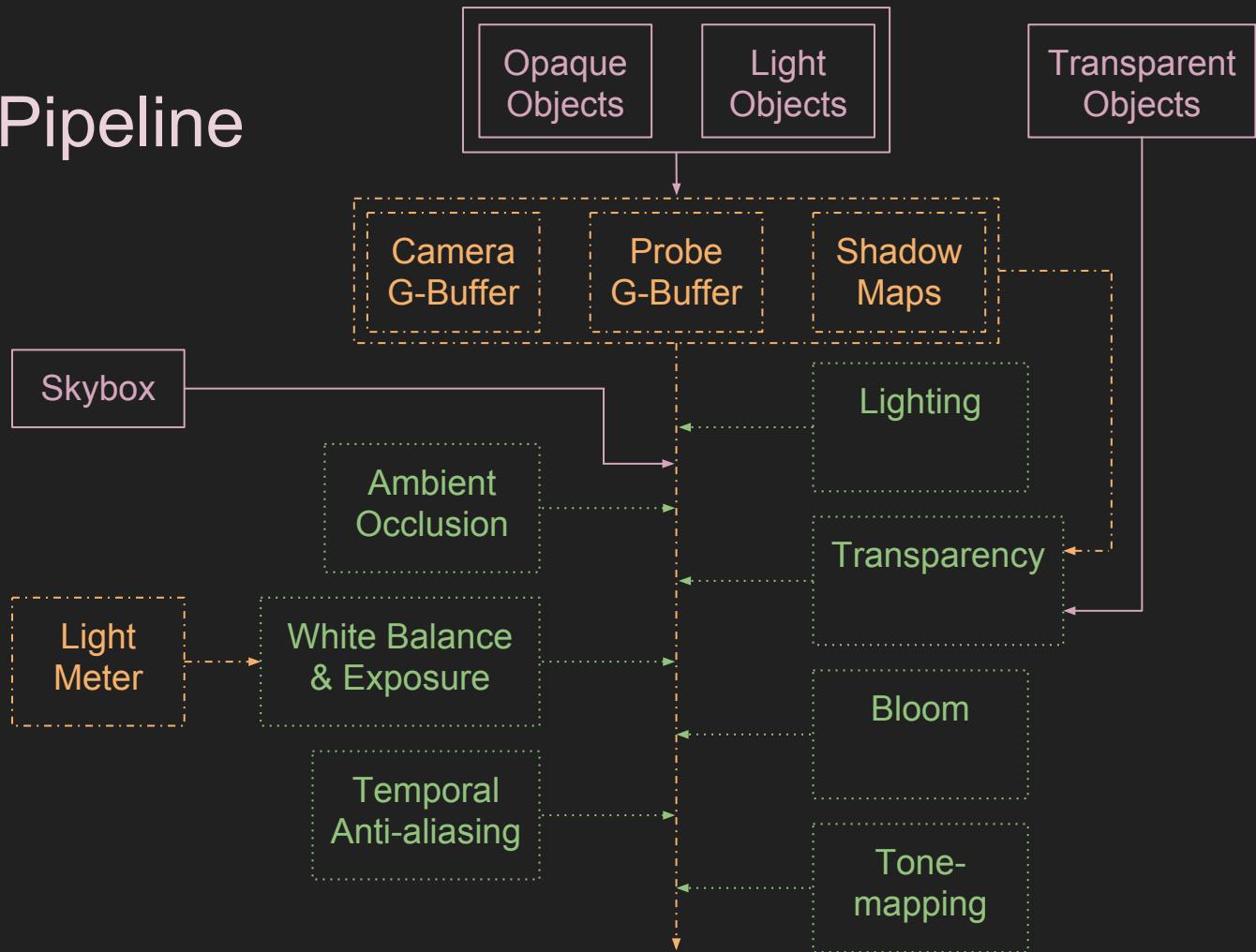
Floored Build



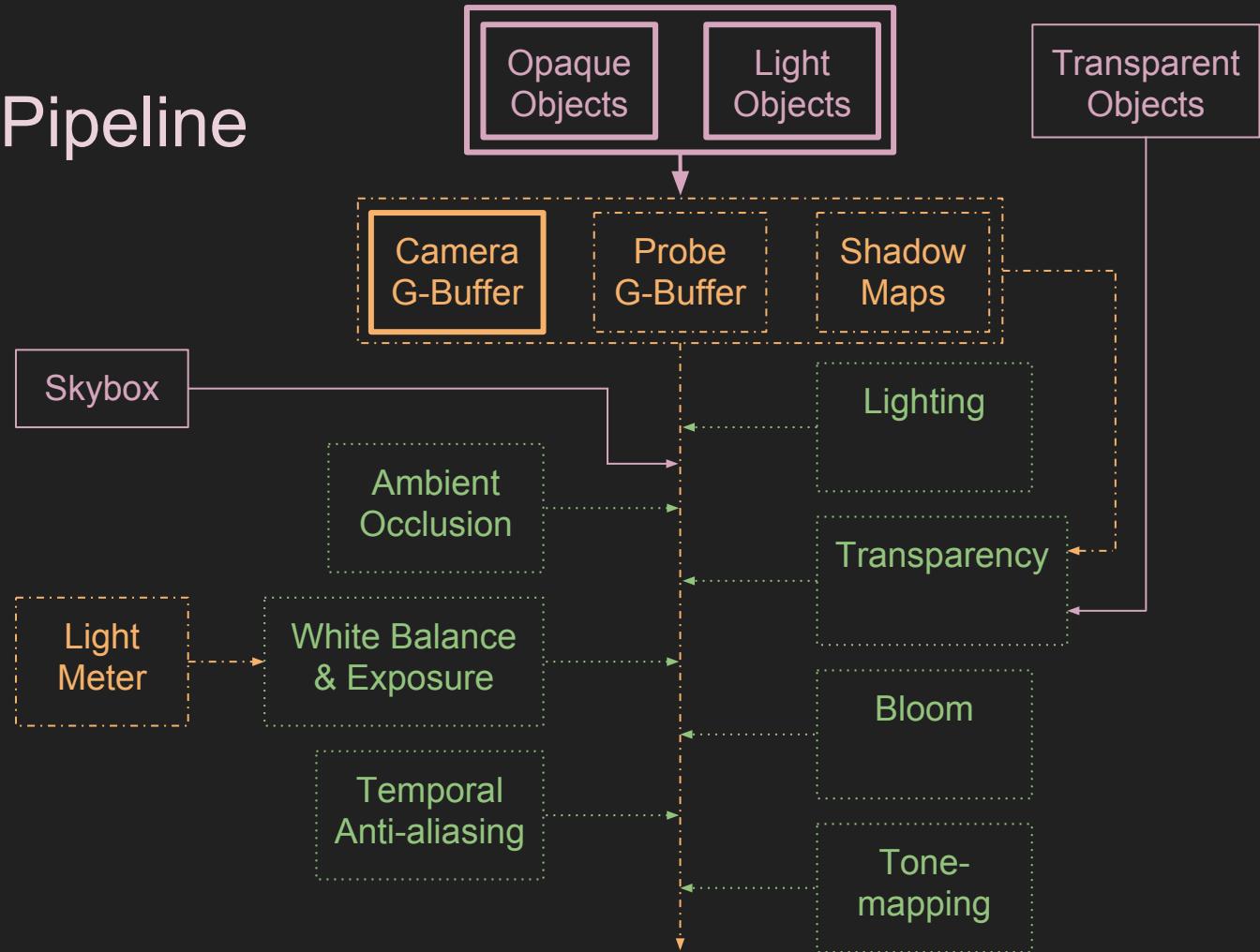
Floored Plans



Rendering Pipeline



Rendering Pipeline





Camera
G-Buffer

Probe
G-Buffer

Shadow
Maps

Ambient
Occlusion

Light
Meter

White Balance
& Exposure

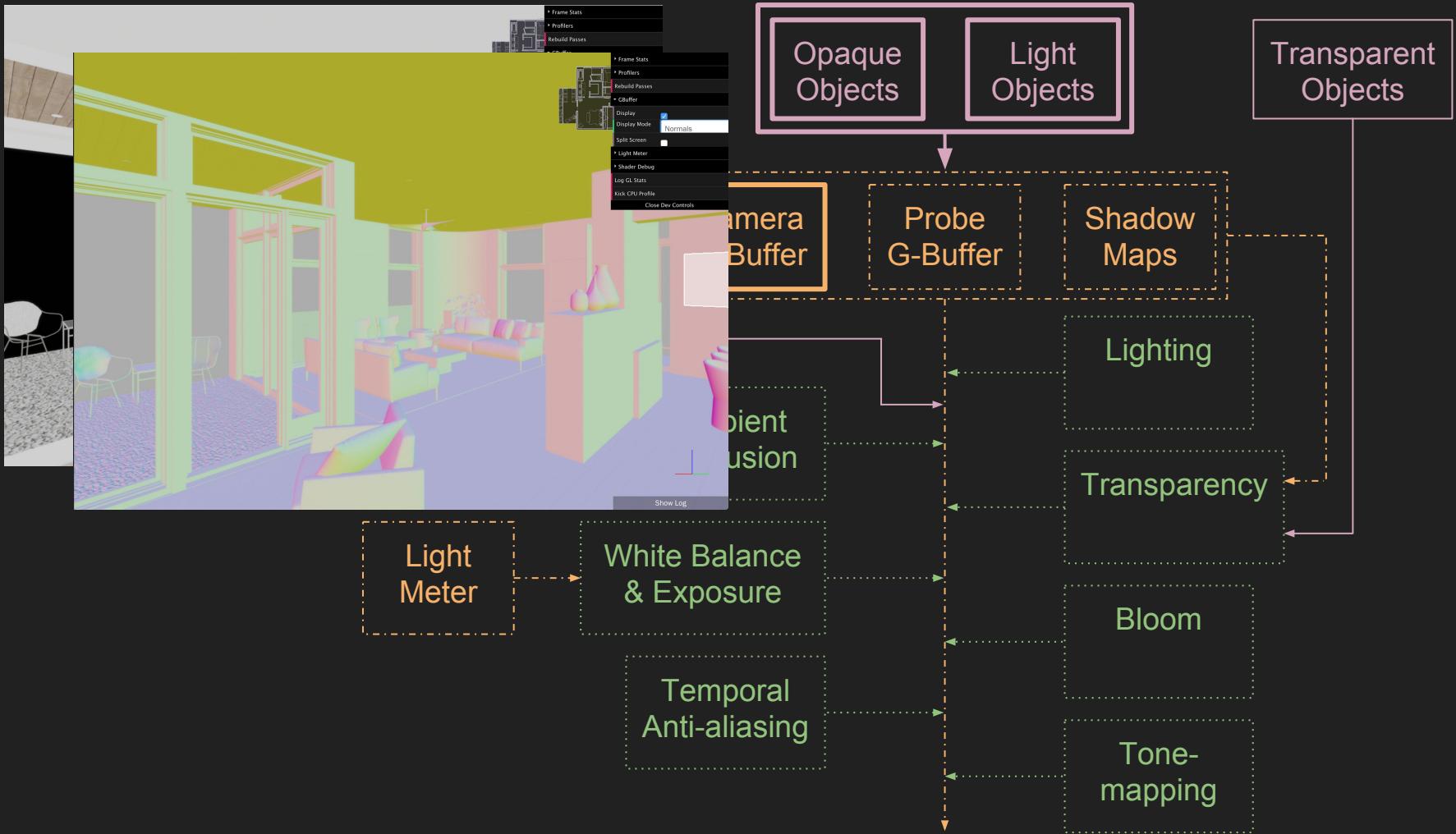
Temporal
Anti-aliasing

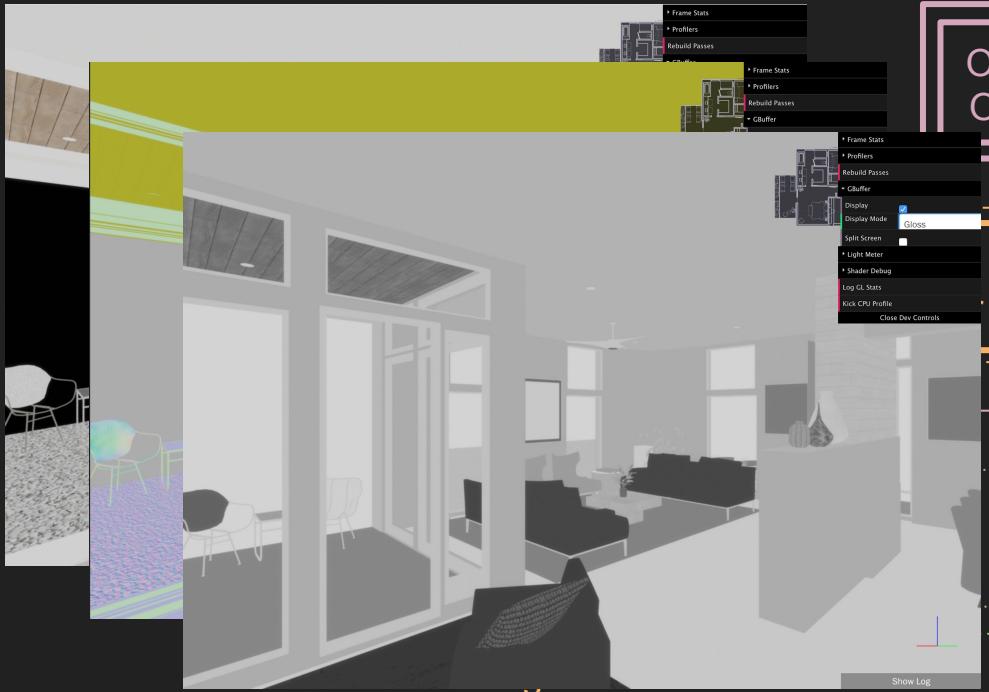
Lighting

Transparency

Bloom

Tone-
mapping





Probe G-Buffer

Shadow Maps

Lighting

Transparency

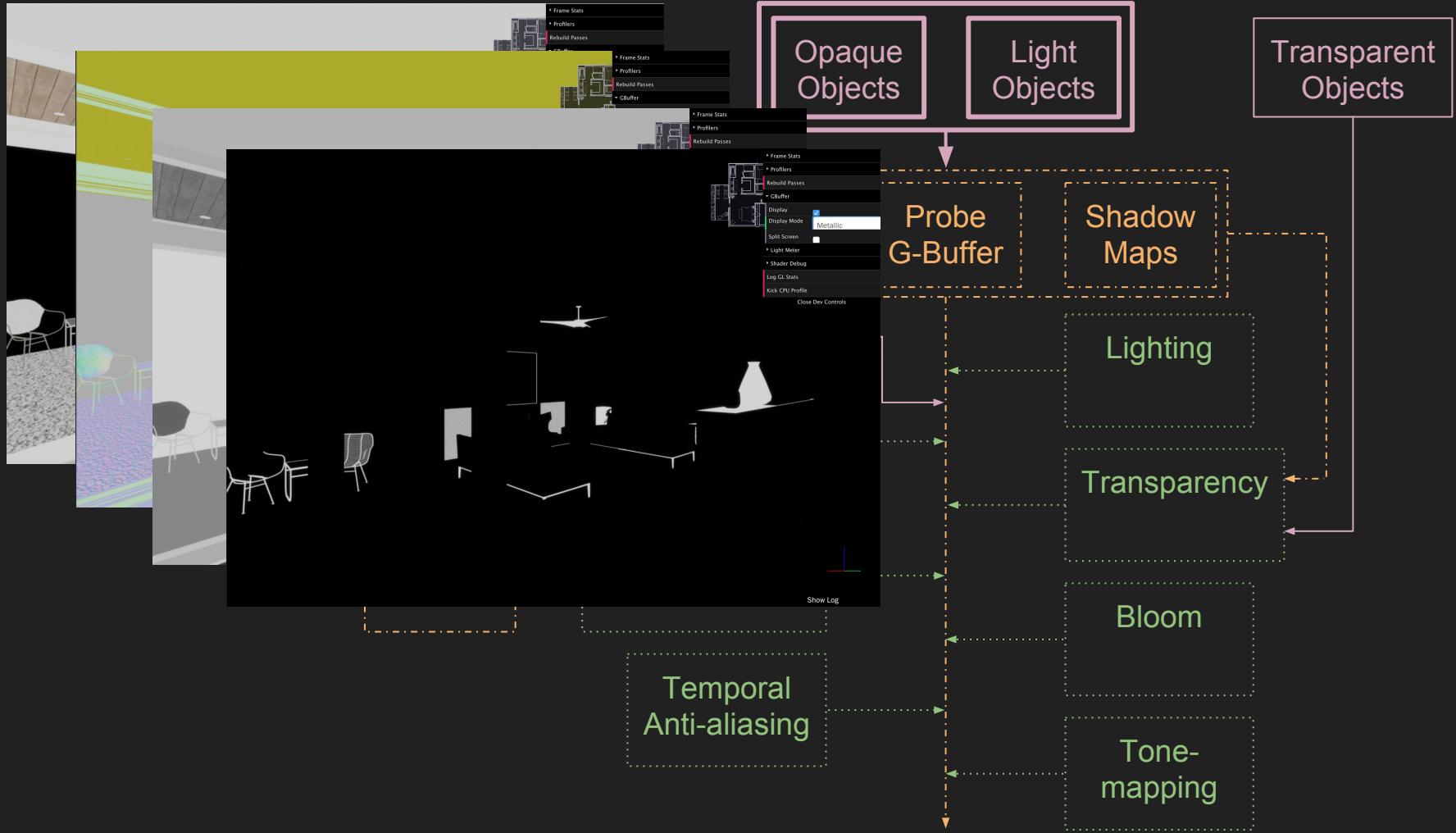
Bloom

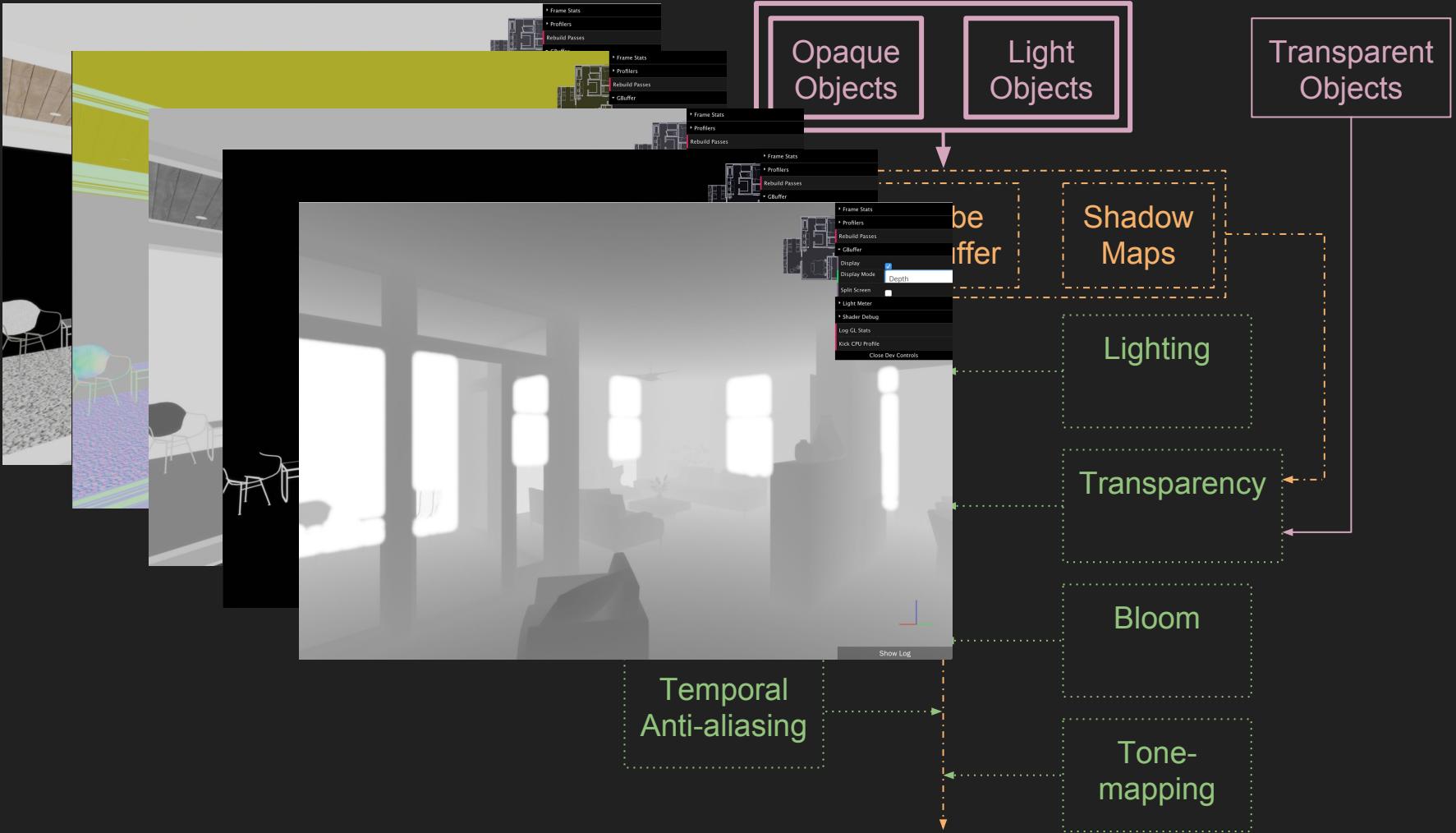
Tone-mapping

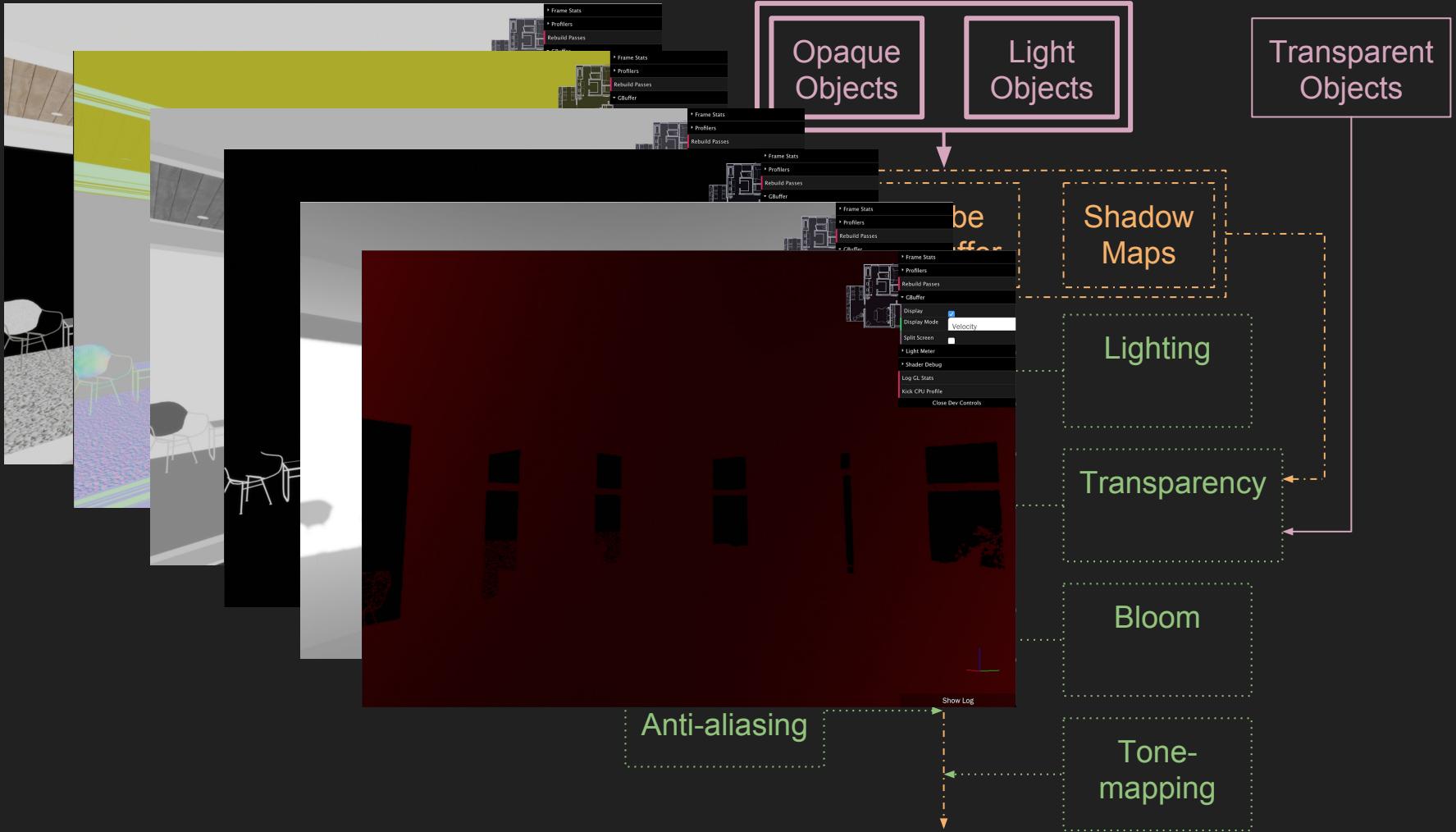
Meter

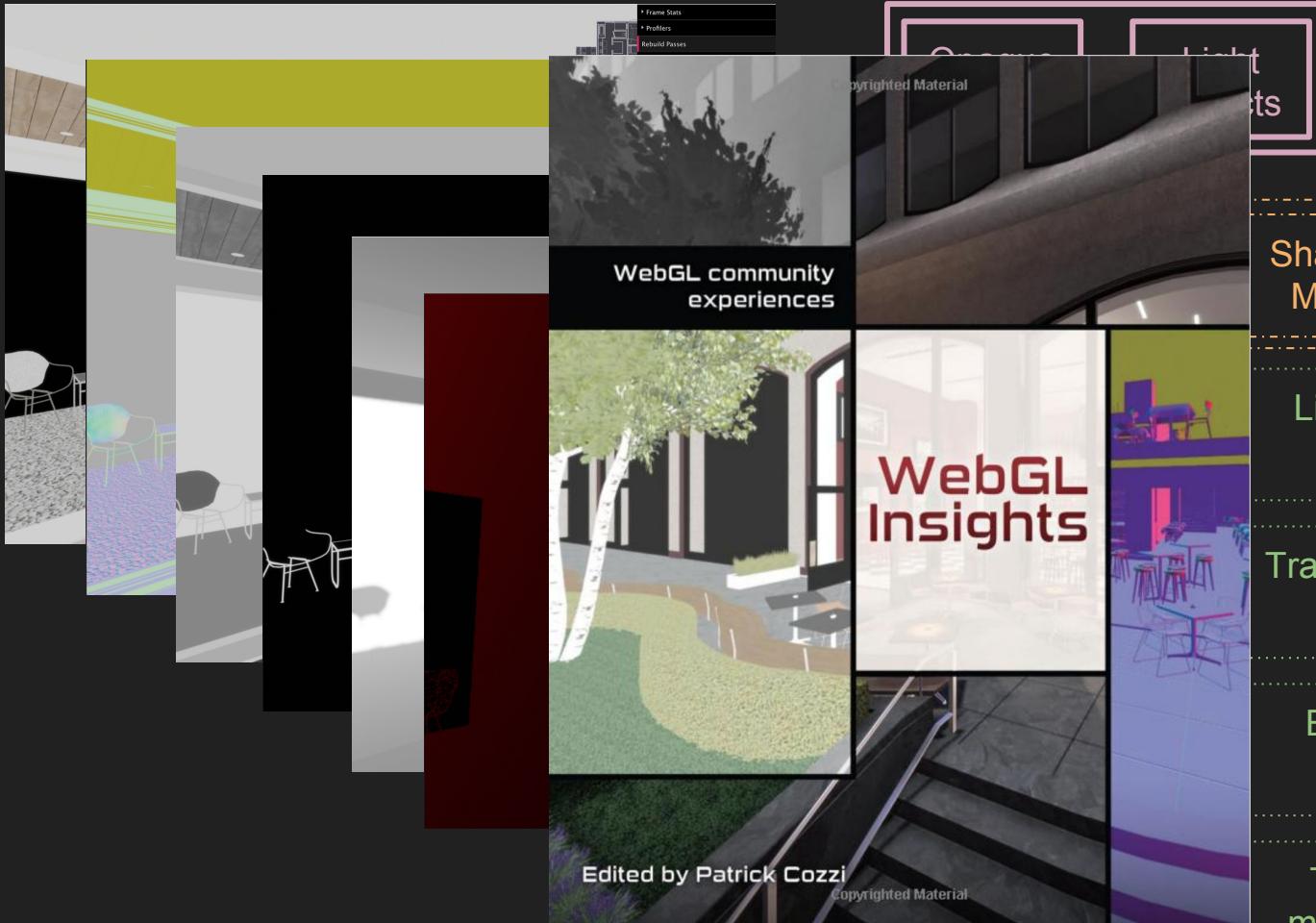
& Exposure

Temporal
Anti-aliasing









Transparent
Objects

Shadow
Maps

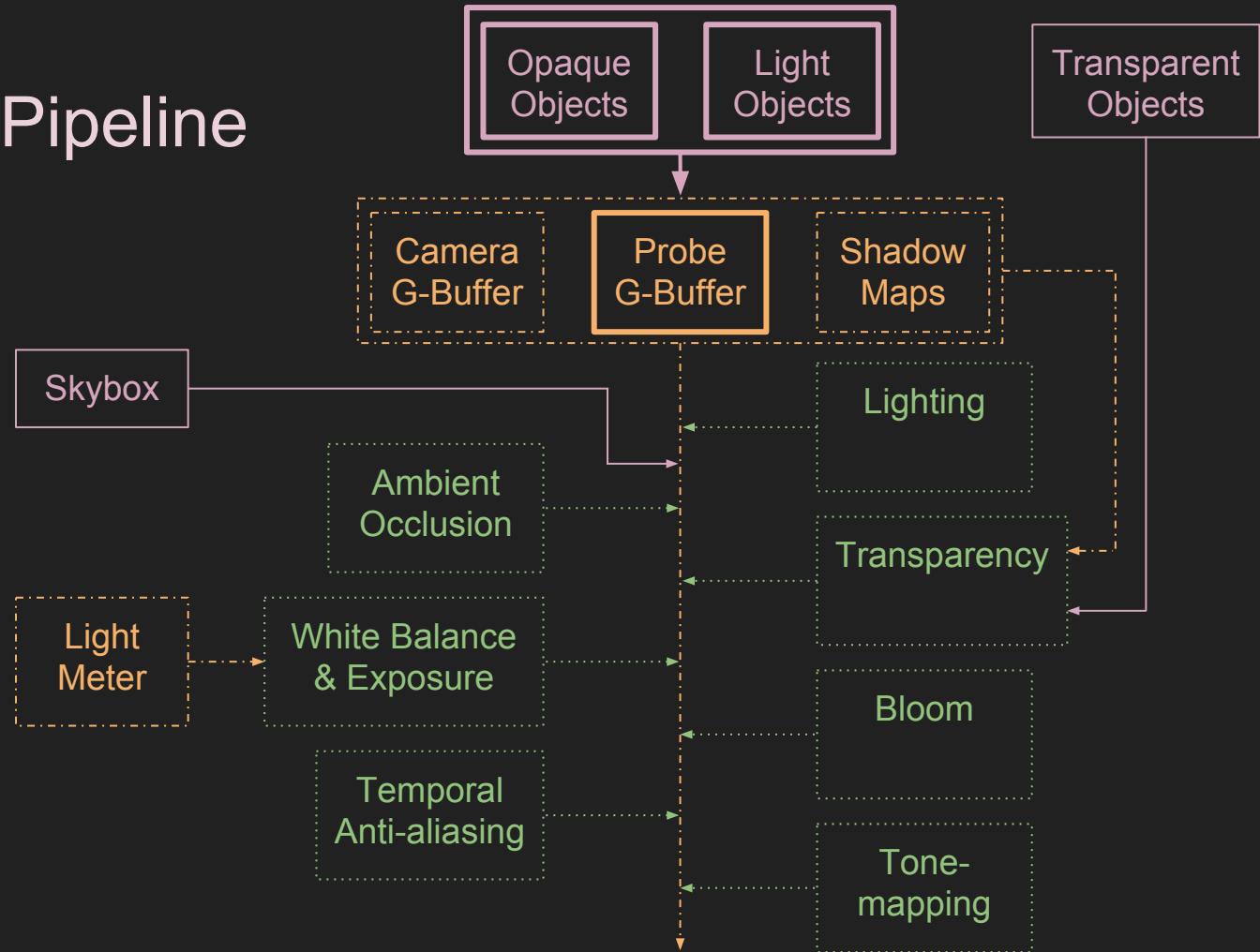
Lighting

Transparency

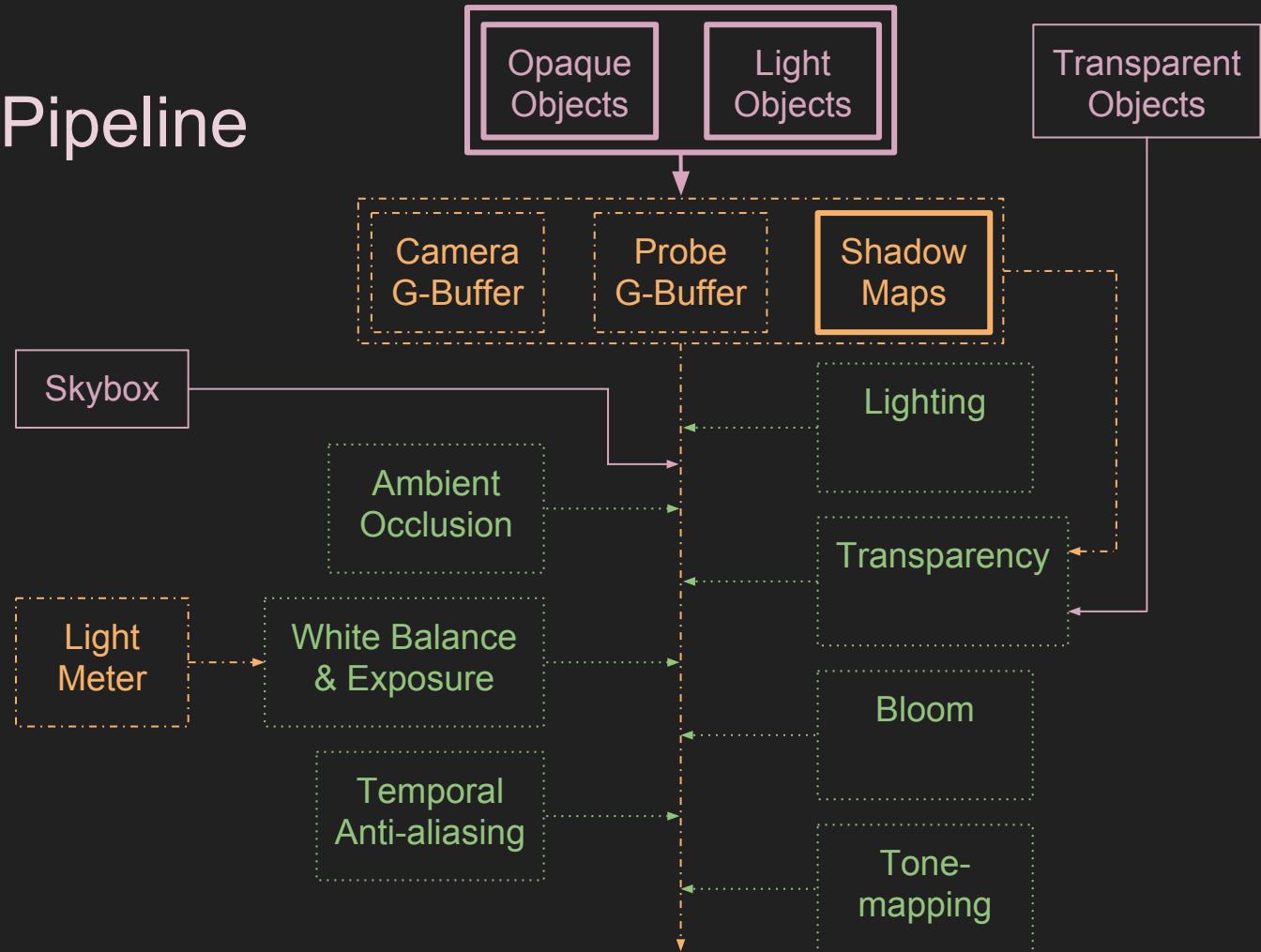
Bloom

Tone-
mapping

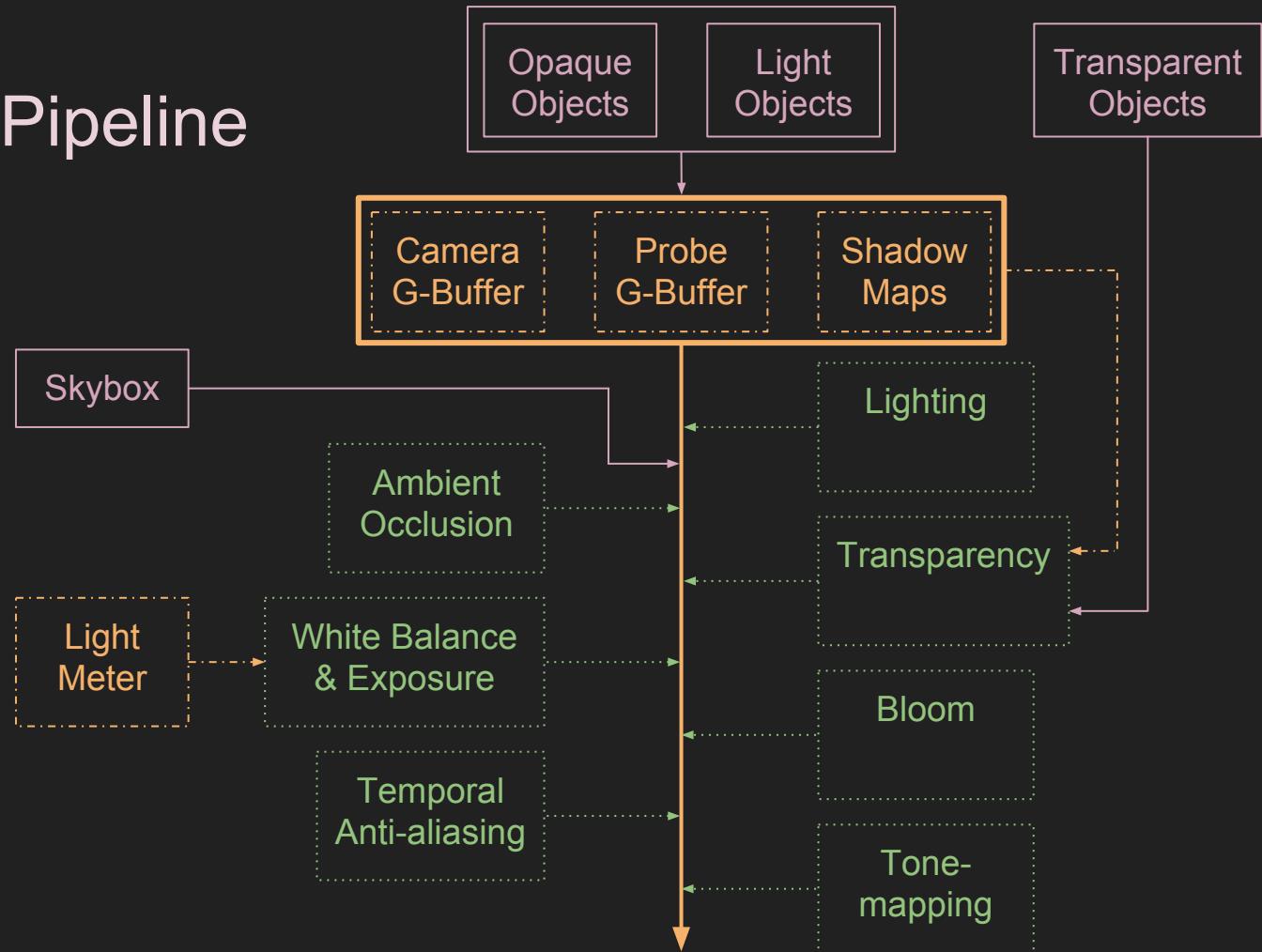
Rendering Pipeline



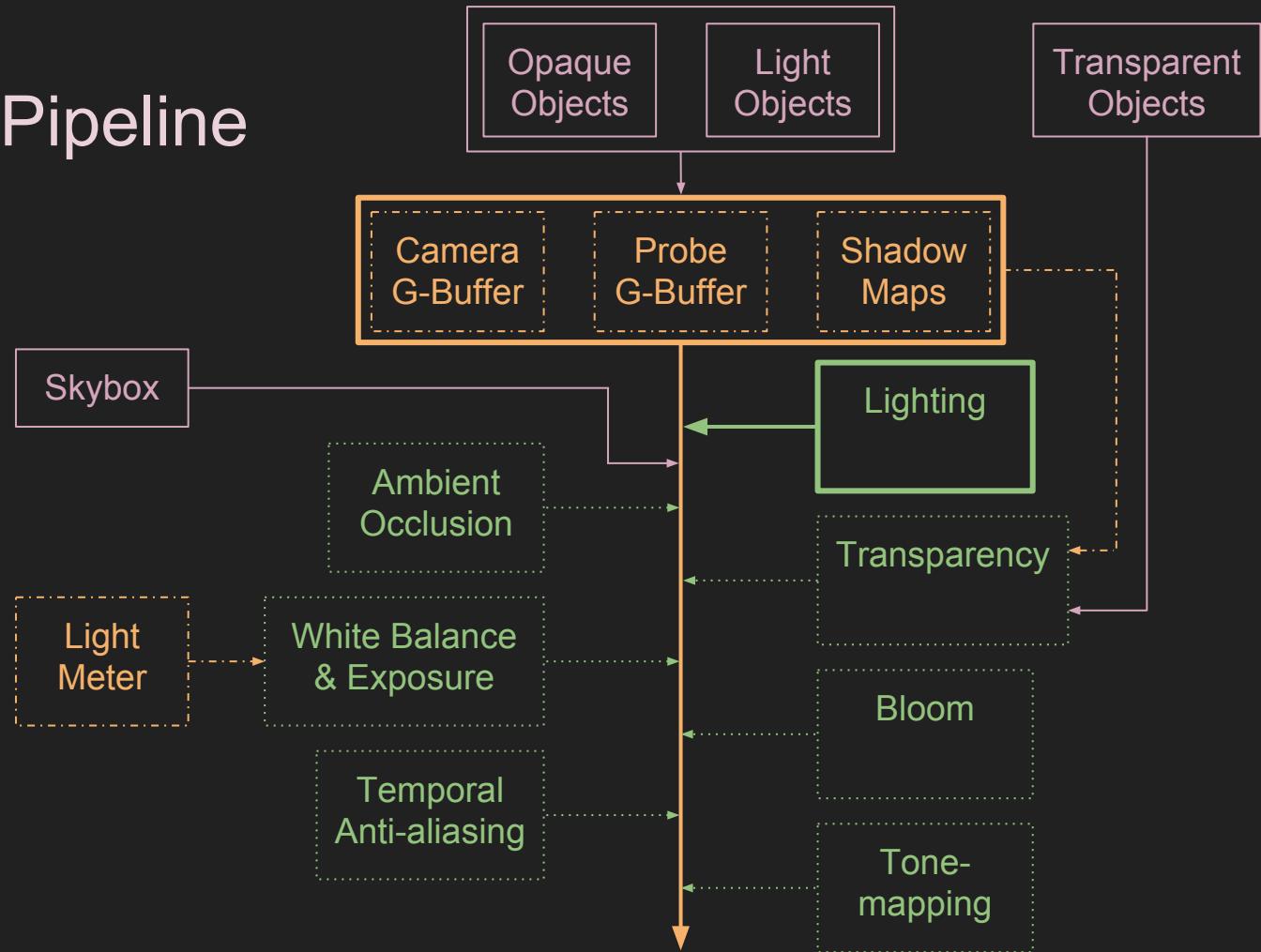
Rendering Pipeline



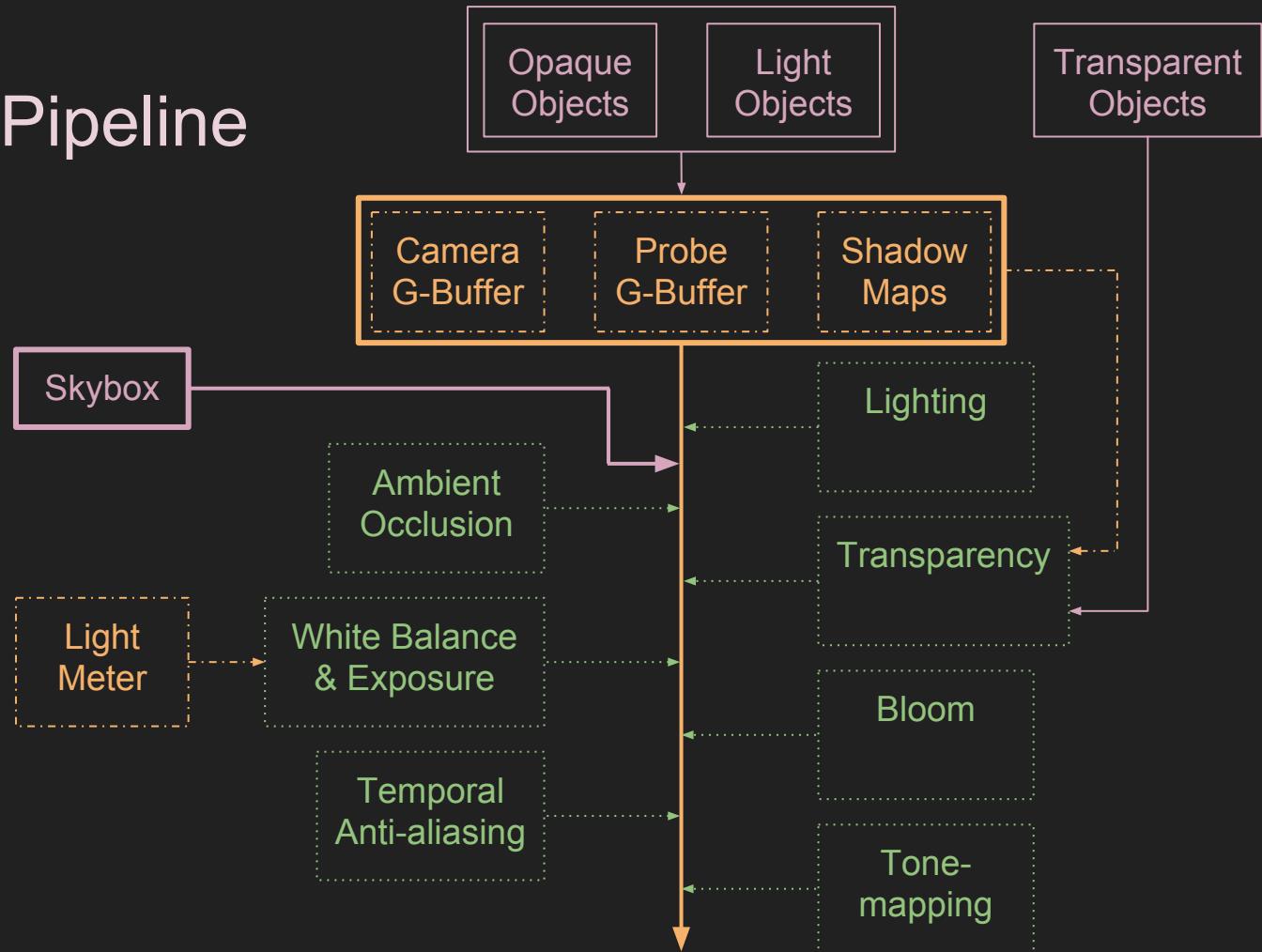
Rendering Pipeline



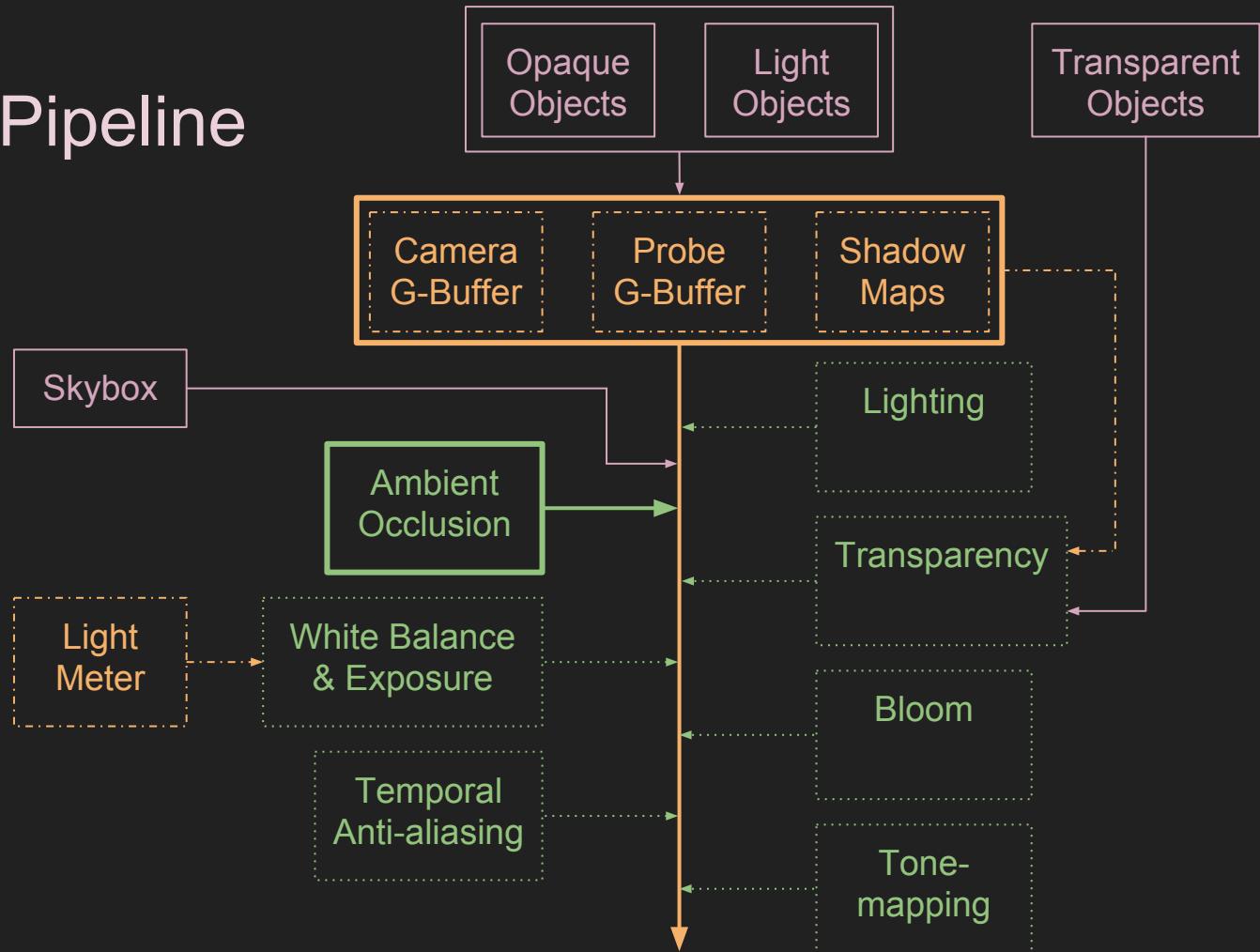
Rendering Pipeline



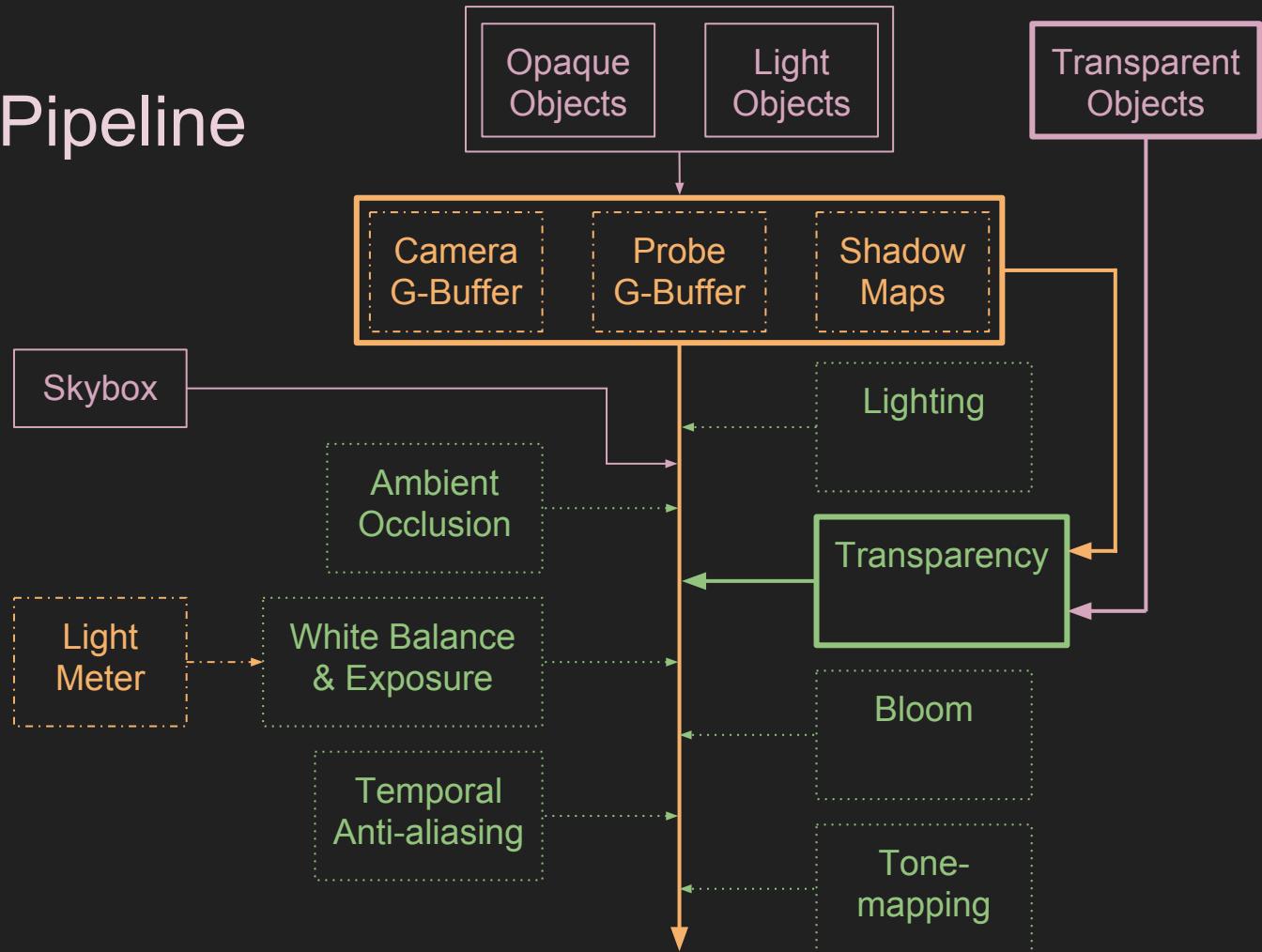
Rendering Pipeline



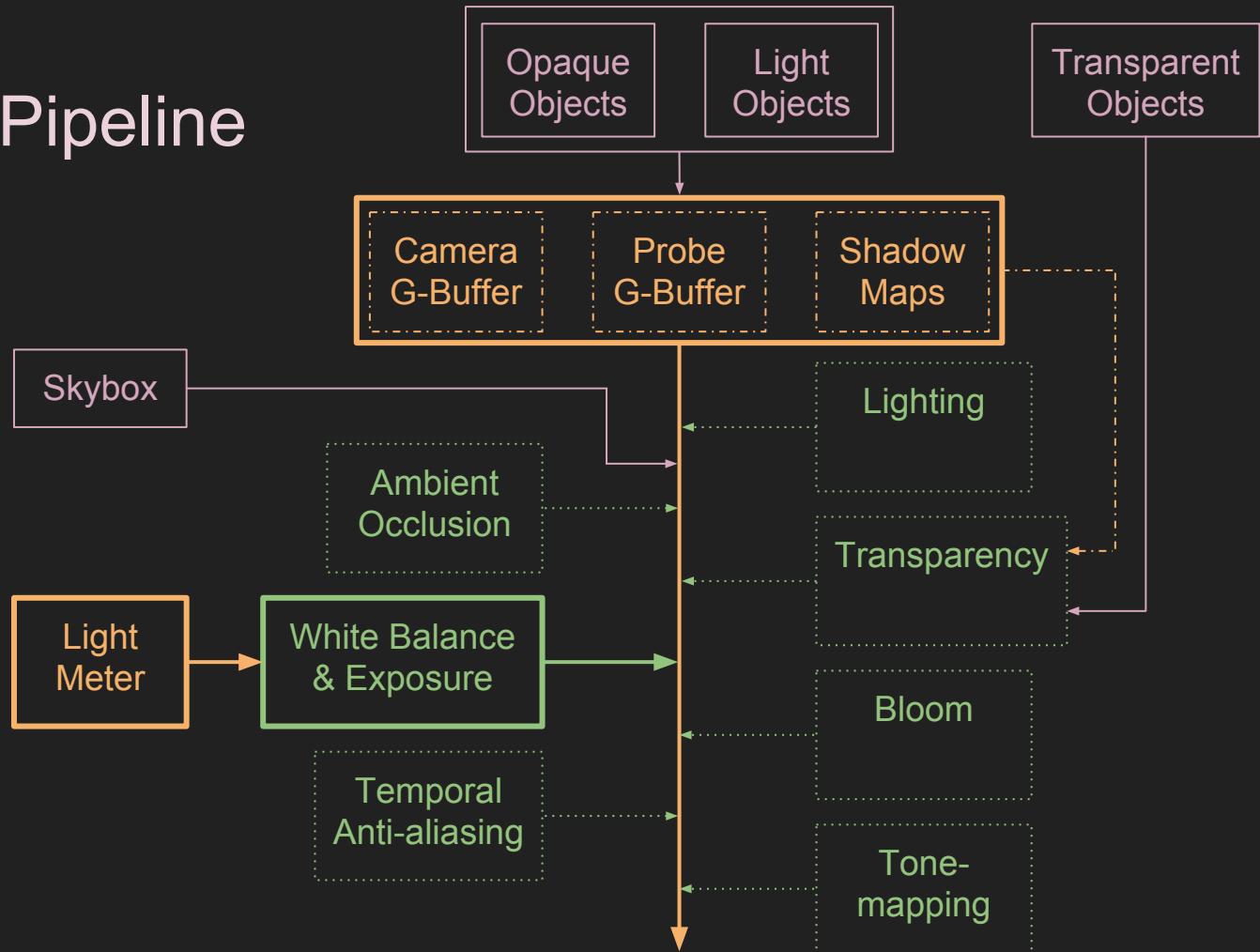
Rendering Pipeline



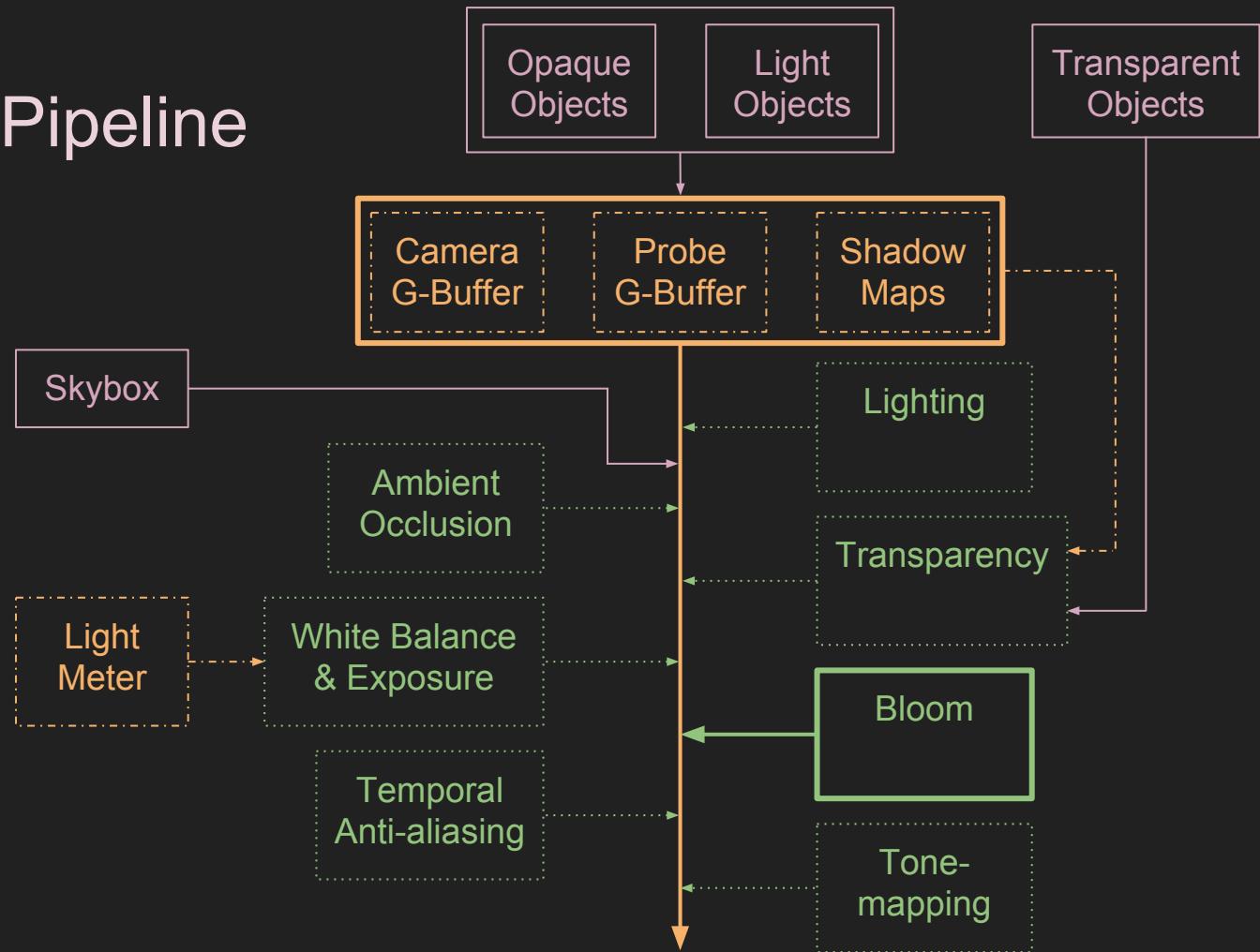
Rendering Pipeline



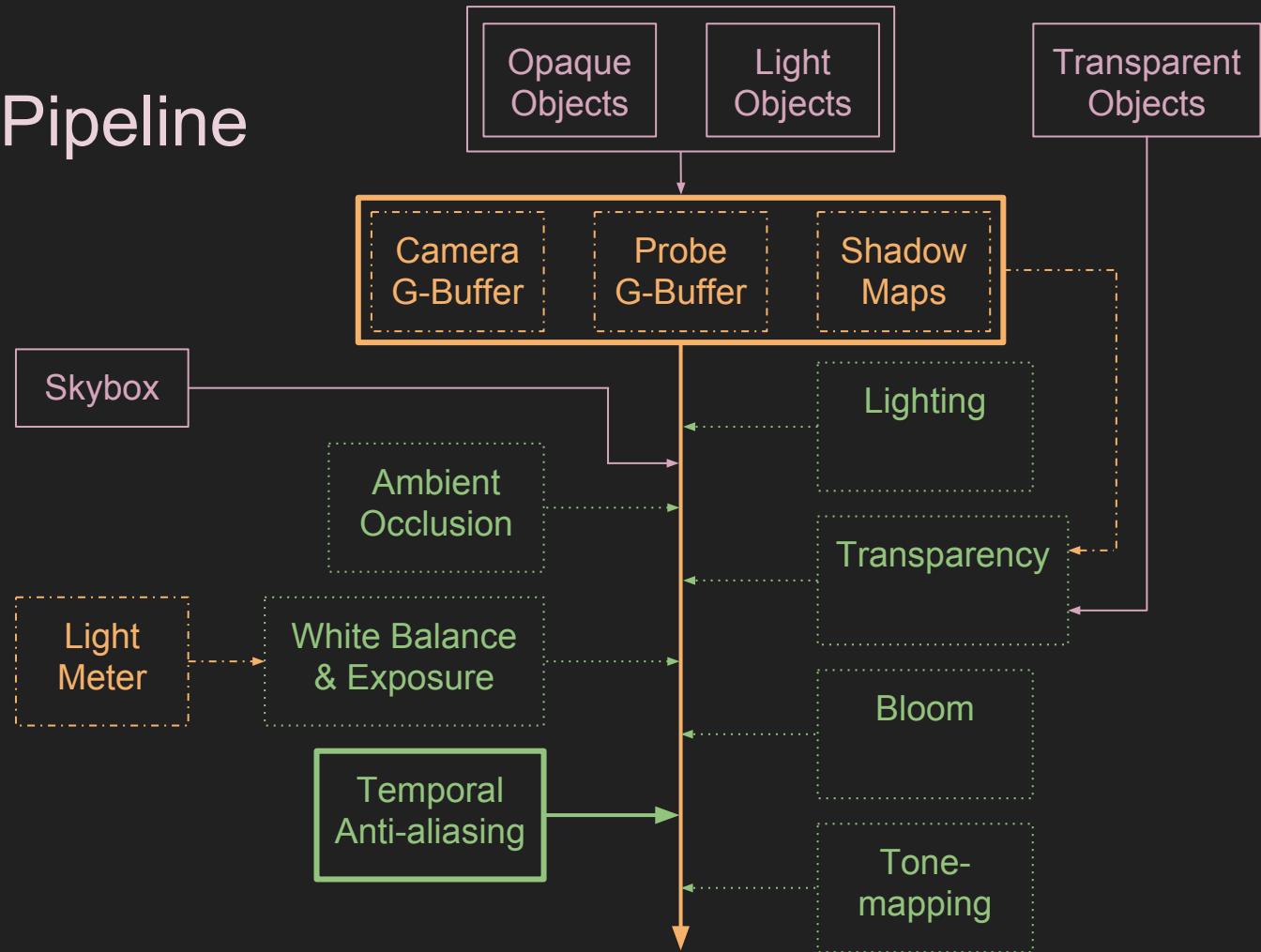
Rendering Pipeline



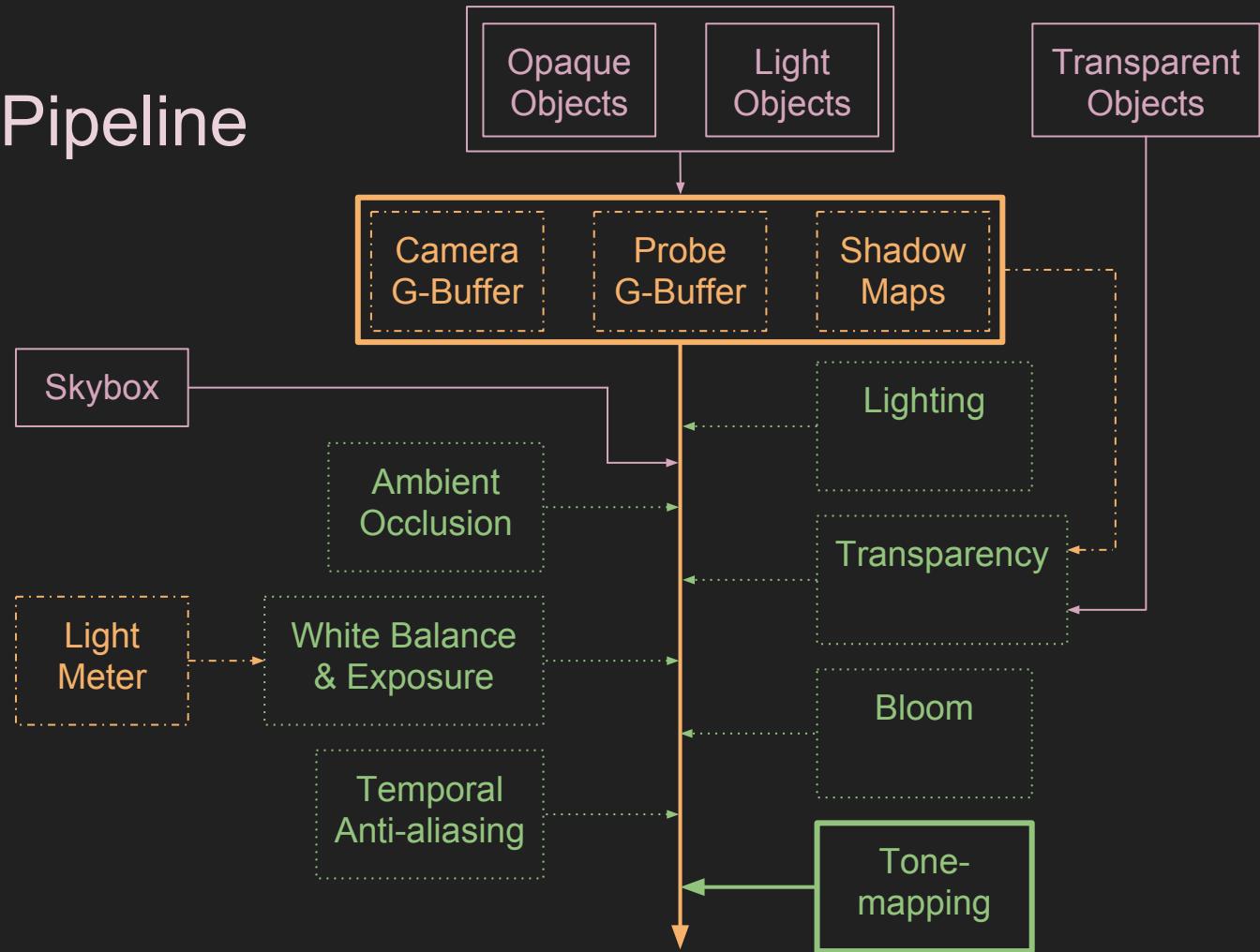
Rendering Pipeline



Rendering Pipeline

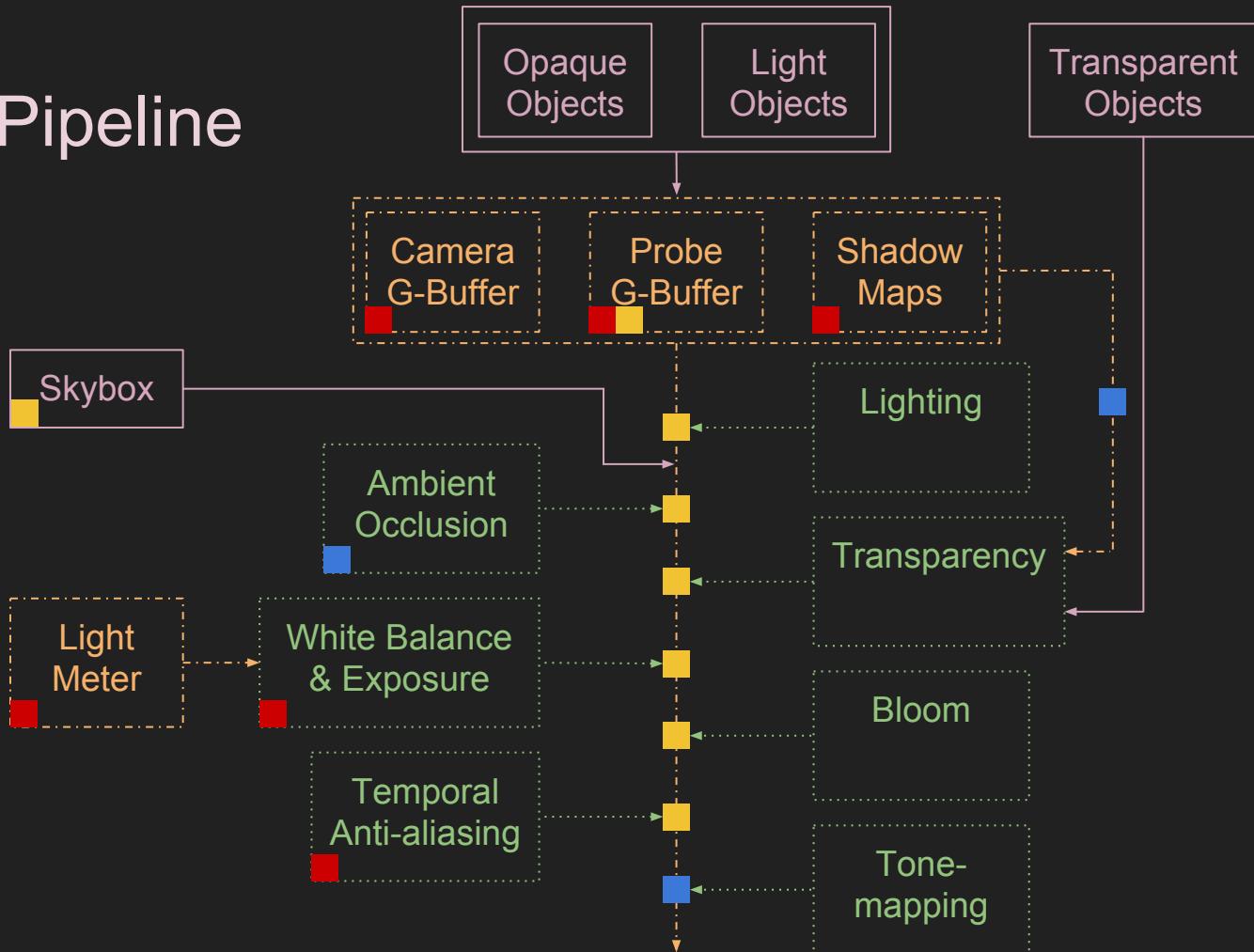


Rendering Pipeline



Rendering Pipeline

- 32F
- 16F
- 8B



HDR in Luma





Rendering Pipeline

- 
- G Buffer
 - Lights
 - Emission
 - Sky
 - Indirect Light
 - Light Meter
 - Transparency
 - Exposure
 - Temporal AA
 - Bloom
 - Tonemapping

Lights

G Buffer
Lights
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Sky
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Lights

Interactions between
light and materials
happen in HDR











Luminance (cd/m^2)

<http://www.hdrlabs.com/sibl/archive.html>



Intensity

Log scale intensity unit matches human perception

Lights (point, area, directional, emission) authored in Intensity

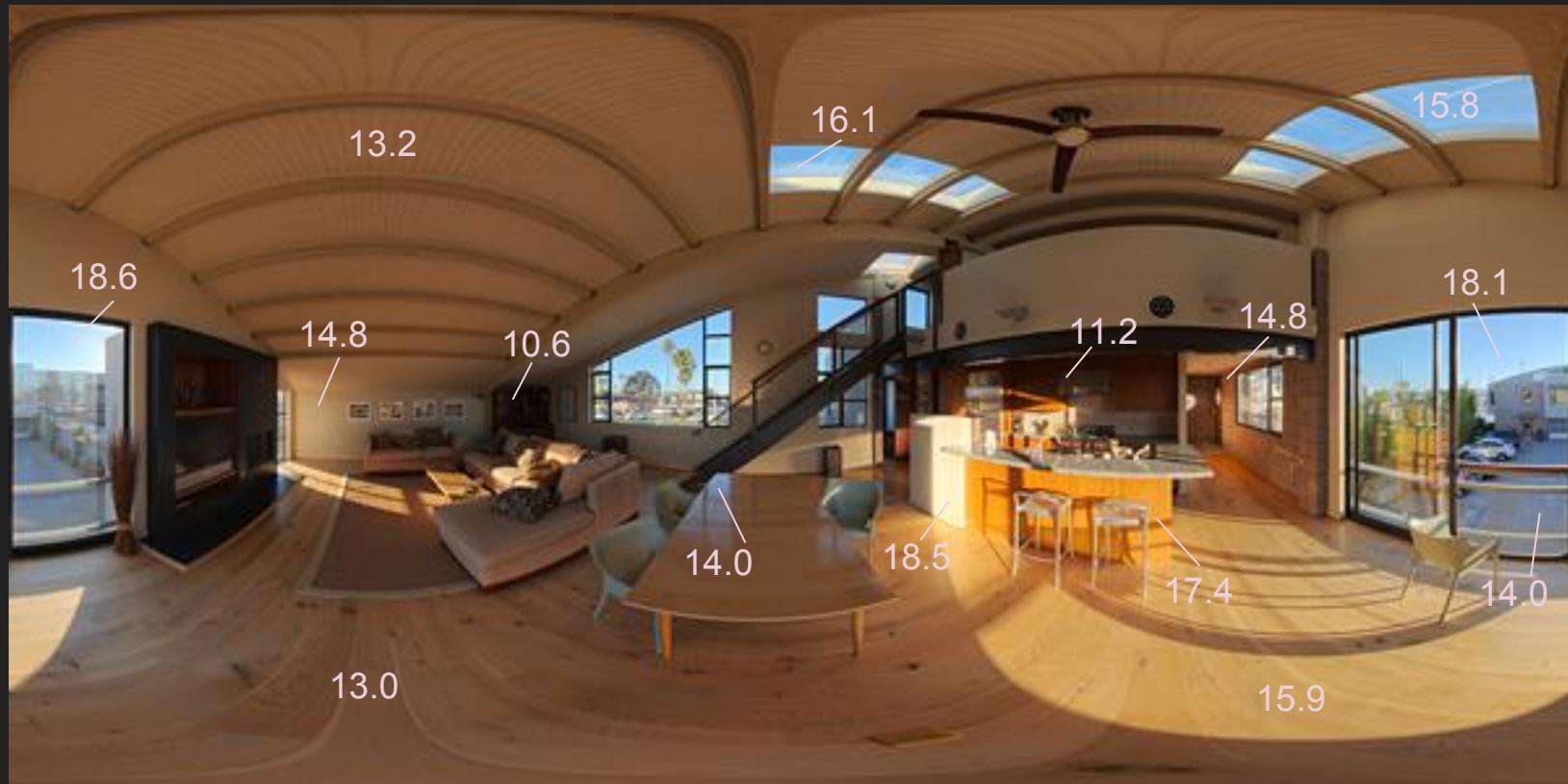
Easy conversion from Luminance:

$\log_2(\text{luminance in cd/m}^2) + 3$

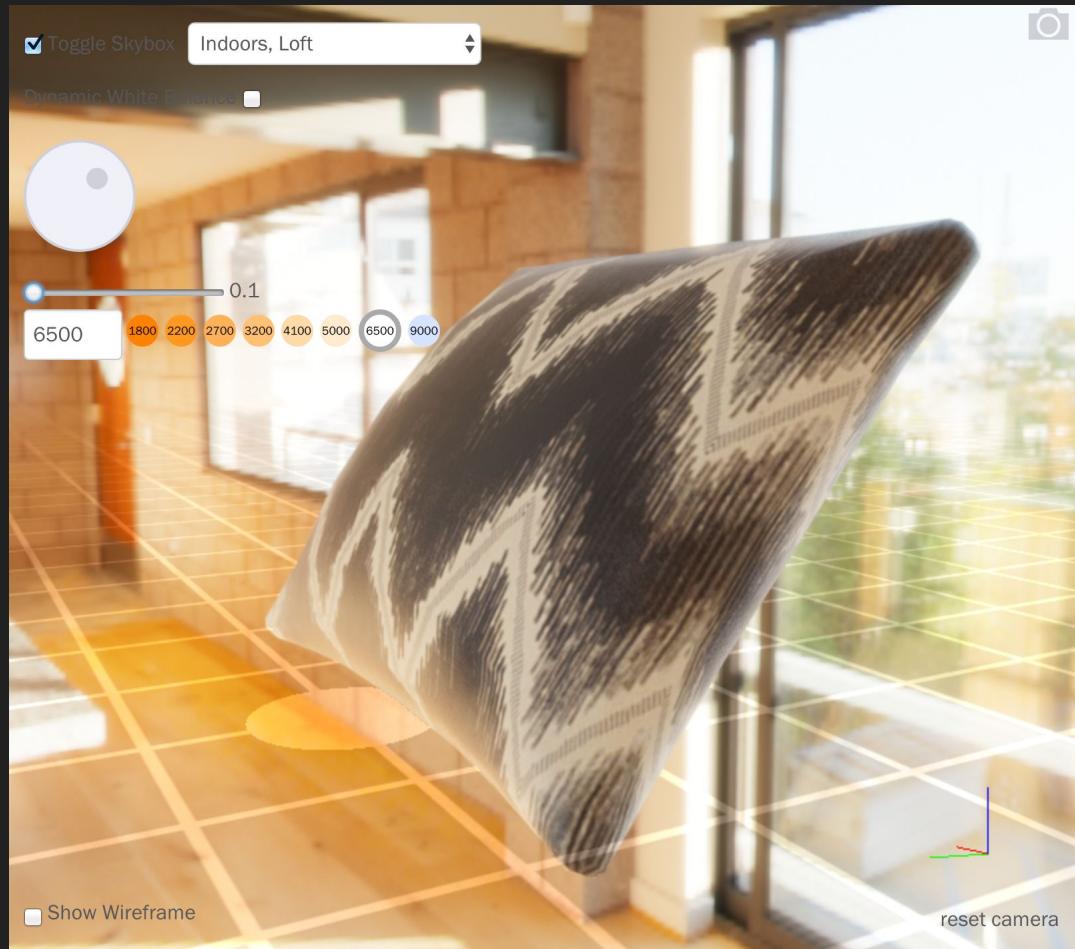
(same as converting luminance to EV at ISO100)

Intensity

<http://www.hdrlabs.com/sibl/archive.html>



Light Demo



Sky and Sun Model

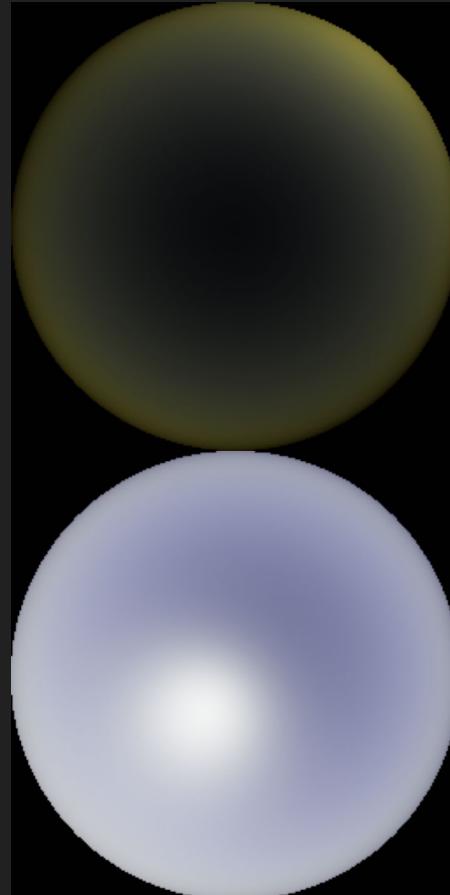
Hosek-Wilkie analytical model

3 Controls only:

- Sun direction
- Turbidity (aerosol particle density)
- Ground albedo (reflectivity)

Clear Sky: 7-8 kcd/m²

Sun: 600-1,600,000 kcd/m²



Sky and Sun Model



Dynamic Exposure

G Buffer
Lights
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Sky
Indirect Light
Light Meter
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Temporal AA
Bloom
Tonemapping



Camera method

Exposure:

- Quantified by Exposure Value (EV)
- Combination of 1) shutter speed 2) aperture size **f-stop** 3) film sensitivity **ISO**
- **stops**: powers of 2

Kevin McCoy -- Wikipedia: <https://commons.wikimedia.org/wiki/File:StLouisArchMultExpEV-4.72.JPG>



-4 stops



-2 stops



+2 stops



+4 stops

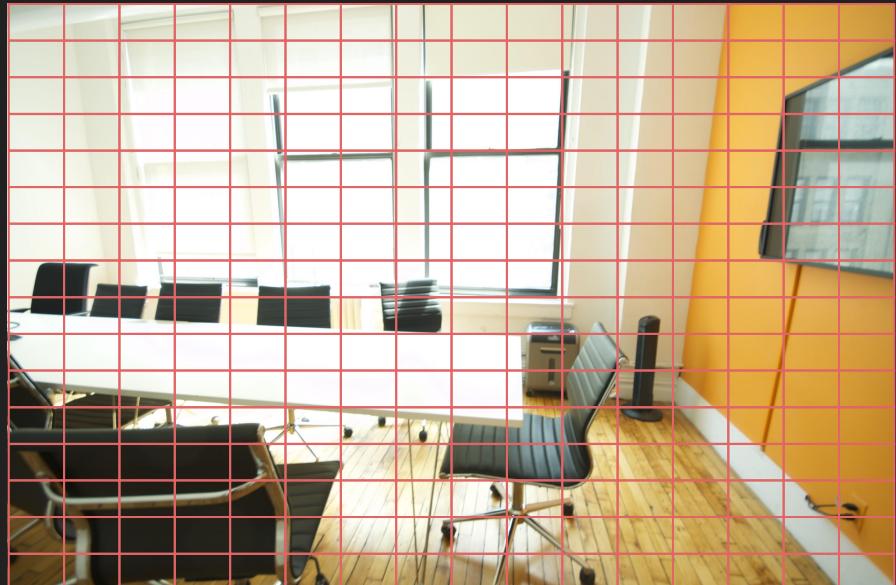
Camera method: Auto-Exposure

Light Metering

- Camera detects mean luminance

Matrix Metering for Auto-Exposure

- Divide frame into multiple regions
- Use smart/proprietary algorithm to choose a mean luminance



Light Meter

1. Scatter: Collect luminance at samples distributed in frame
2. Gather: Trim samples, then find average luminance (using histogram)



Local Adaptation

5 x 3 grid, exposure per block

Block exposures blended together by Unnormalized Bilateral Filter



Dynamic White Balance



Dynamic White Balance



Bloom

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Bloom

Airy Disk diffraction pattern occurs in eye or camera

Gaussian blur used to simulate this effect

Only affects bright areas



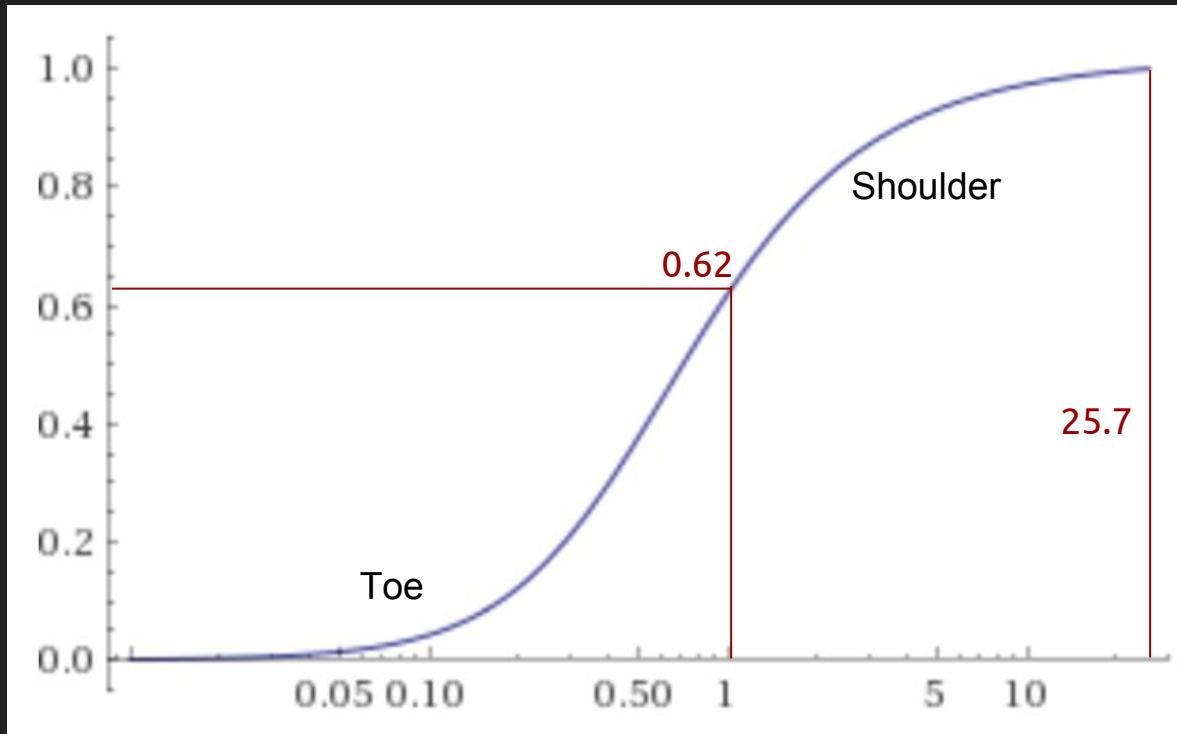
Roman Napreyev -- https://commons.wikimedia.org/wiki/File:Rubinar-1000_plus_2x_K-1_telekonn_Airy_disk_1.jpg
Dean Pemberton -- <https://commons.wikimedia.org/wiki/File:HrdiBloomExample.jpg>

Tonemapping

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Choosing a Curve

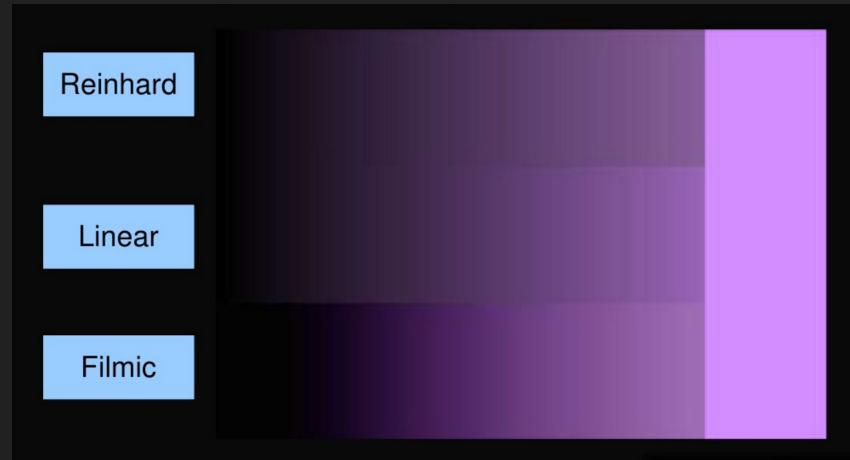


Great in-depth post at <http://filmicworlds.com/blog/filmic-tonemapping-with-piecewise-power-curves>

Uncharted 2 Filmic Tonemapper

Filmic means:

- Simulates film response
- Crisp blacks, saturated dark tones, and soft unclipped highlights



John Hable -- Uncharted 2: HDR Lighting <http://www.gdcvault.com/play/1012351/Uncharted-2-HDR>

Applying curve to RGB channels in parallel over-saturates brights

ACES Tonemapper



acescentral.com

ACES: Industry standard for Color Management

Carefully crafted filmic curve for displaying HDR images on LDR output devices

Adjusts in perceptually-aligned color space

Has been adopted in gaming, including in Unreal Engine
Our code comes from [Stephen Hill](#)

Uncharted 2 Filmic Tonemapper



ACES Tonemapper



Demo that scene!

Career Advice

- Job Search
 - Showcase your work (github, personal site, twitter)
 - Reach out to companies
- Interviewing
 - Research and express interest in the company
 - Communication is important during technical problem solving
- On the Job
 - Say what you want to work on
 - Diversify your work experience

We're hiring!

bina.carroll@cbre.com



Questions?

CBRE