

HDR Rendering

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HDR Rendering

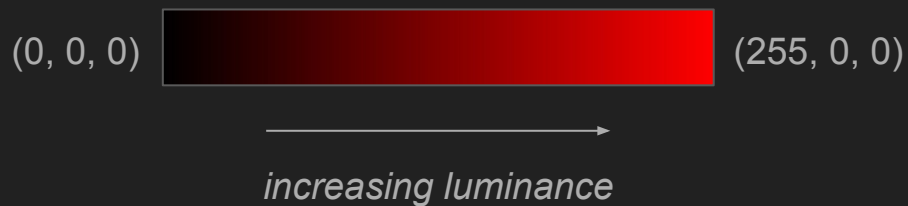
- Introduction to HDR
- Luma
- HDR in Luma

Introduction to HDR



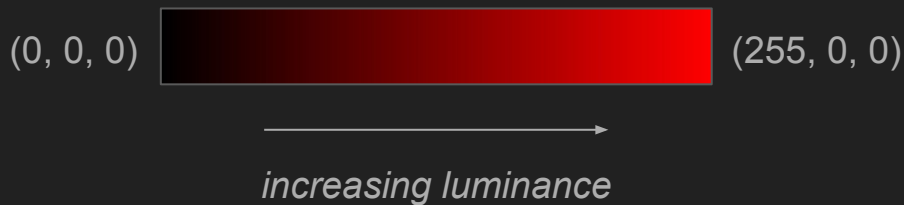
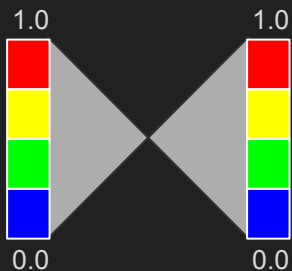
Luminance

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



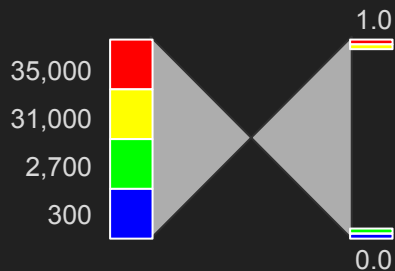
LDR Textures

- 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

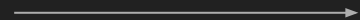
- High Dynamic Range
- Store actual luminance values
- Floating point textures, LOGLUV
- Good for processing
- Bad for display



(0.0, 0.0, 0.0)



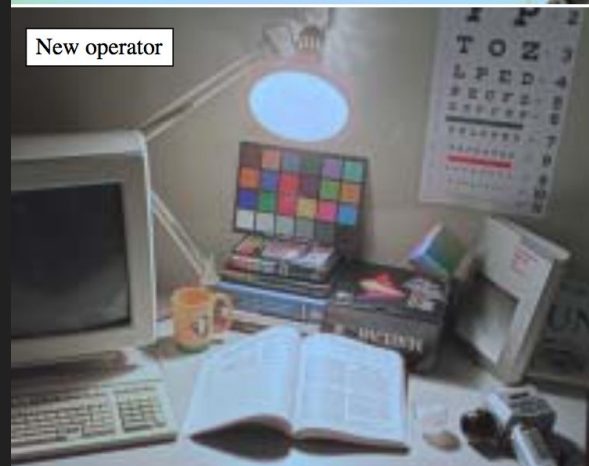
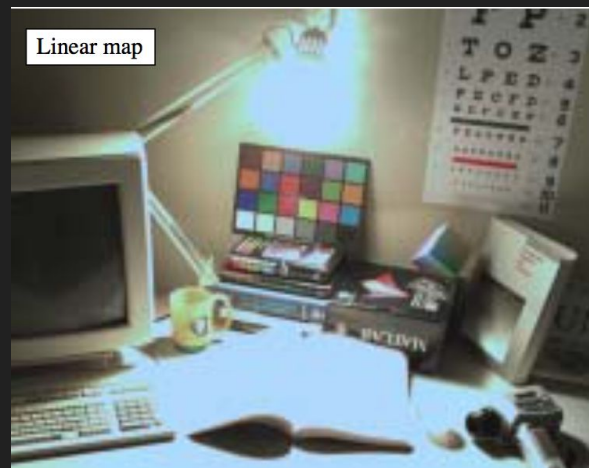
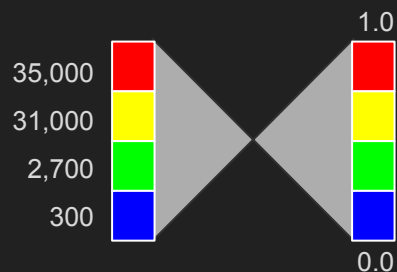
(65504.0, 0.0, 0.0)



increasing luminance

Tonemapping

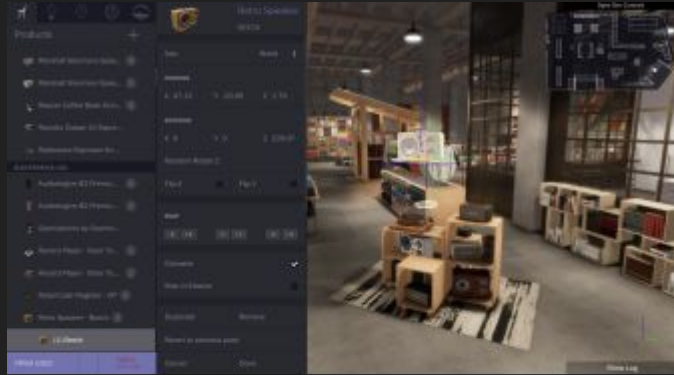
- HDR $\rightarrow$ LDR
- Reduce dynamic range
- Retain contrast between luminance values



“Photographic Tone Reproduction for Digital Images”

Luma

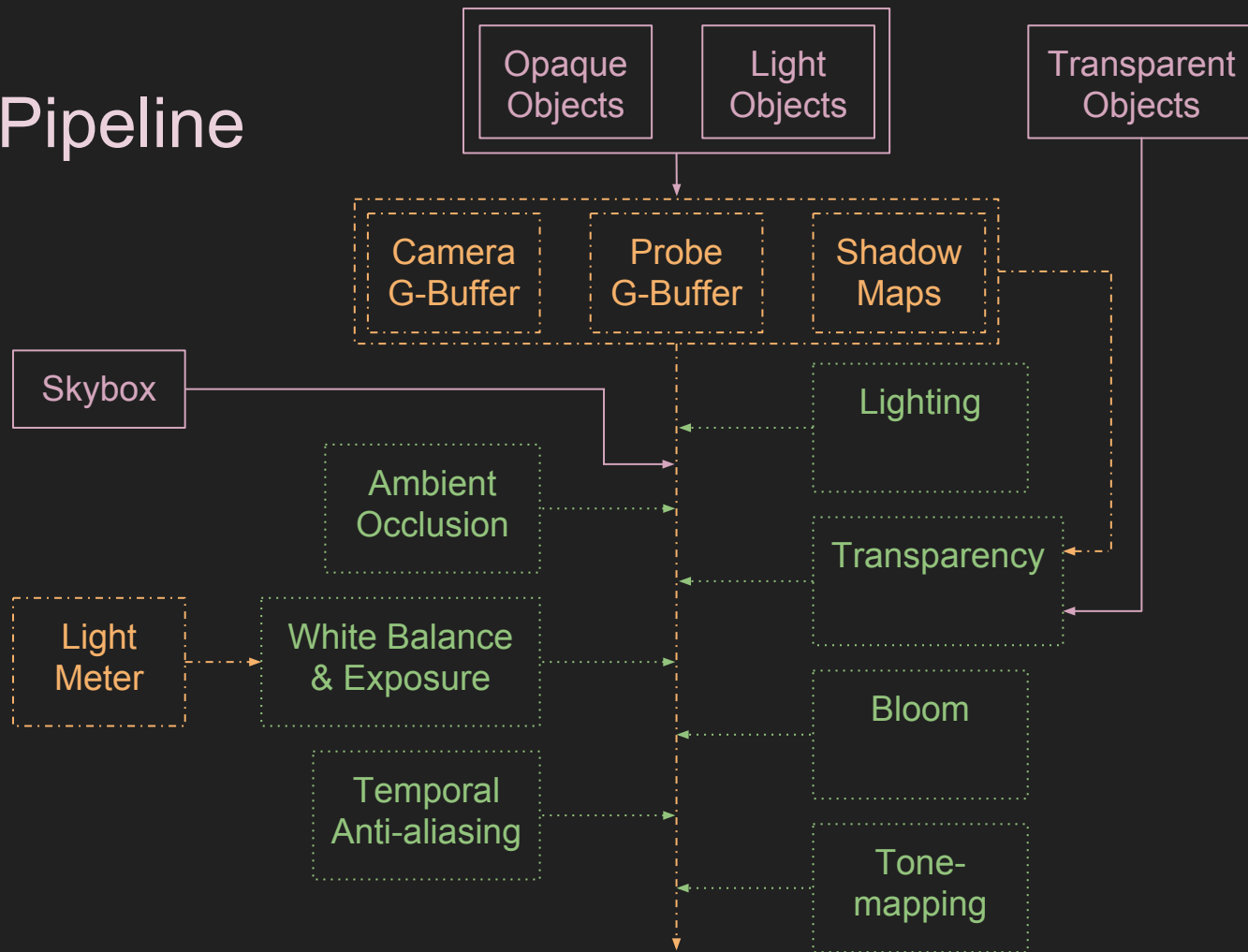
Floored Build



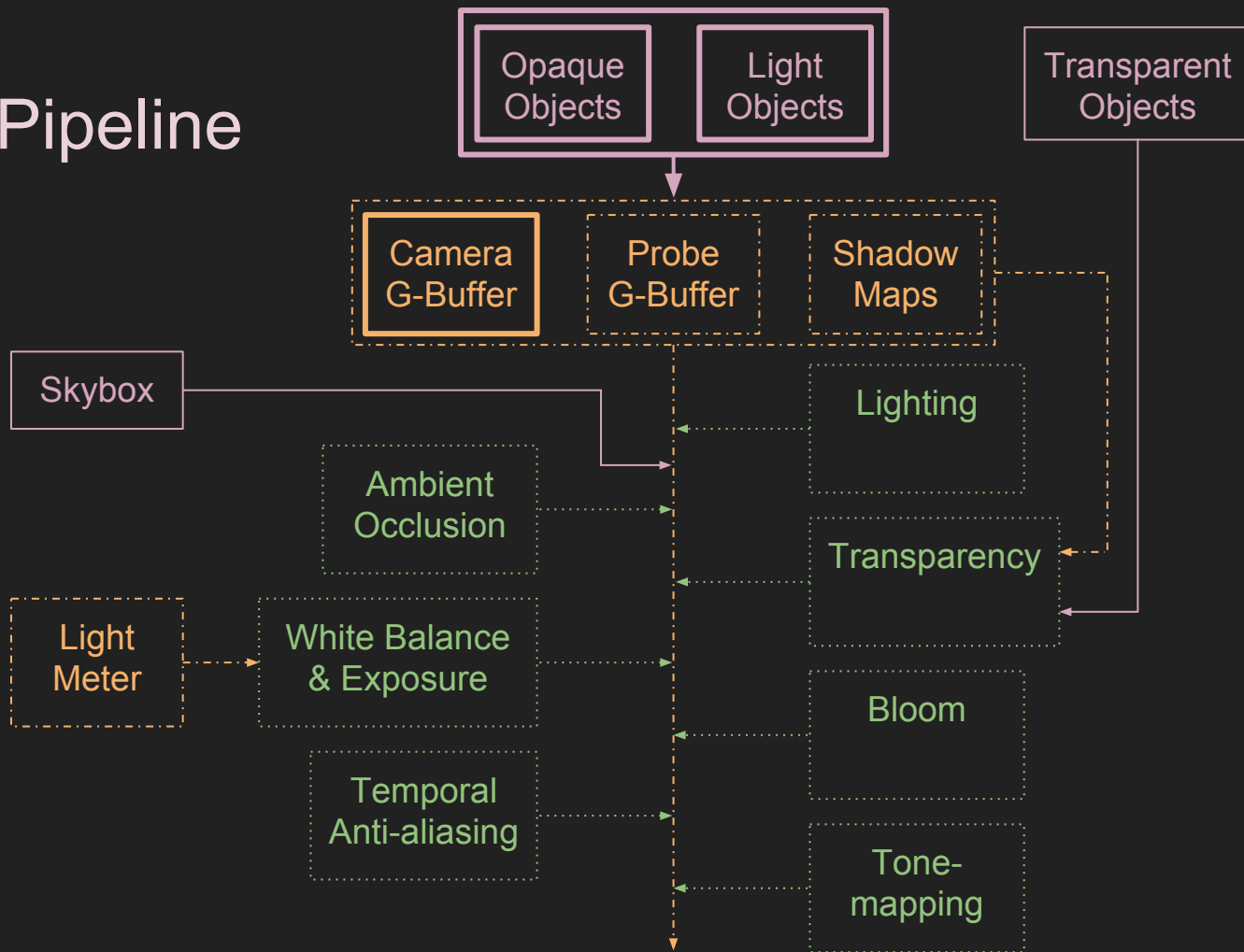
Floored Plans

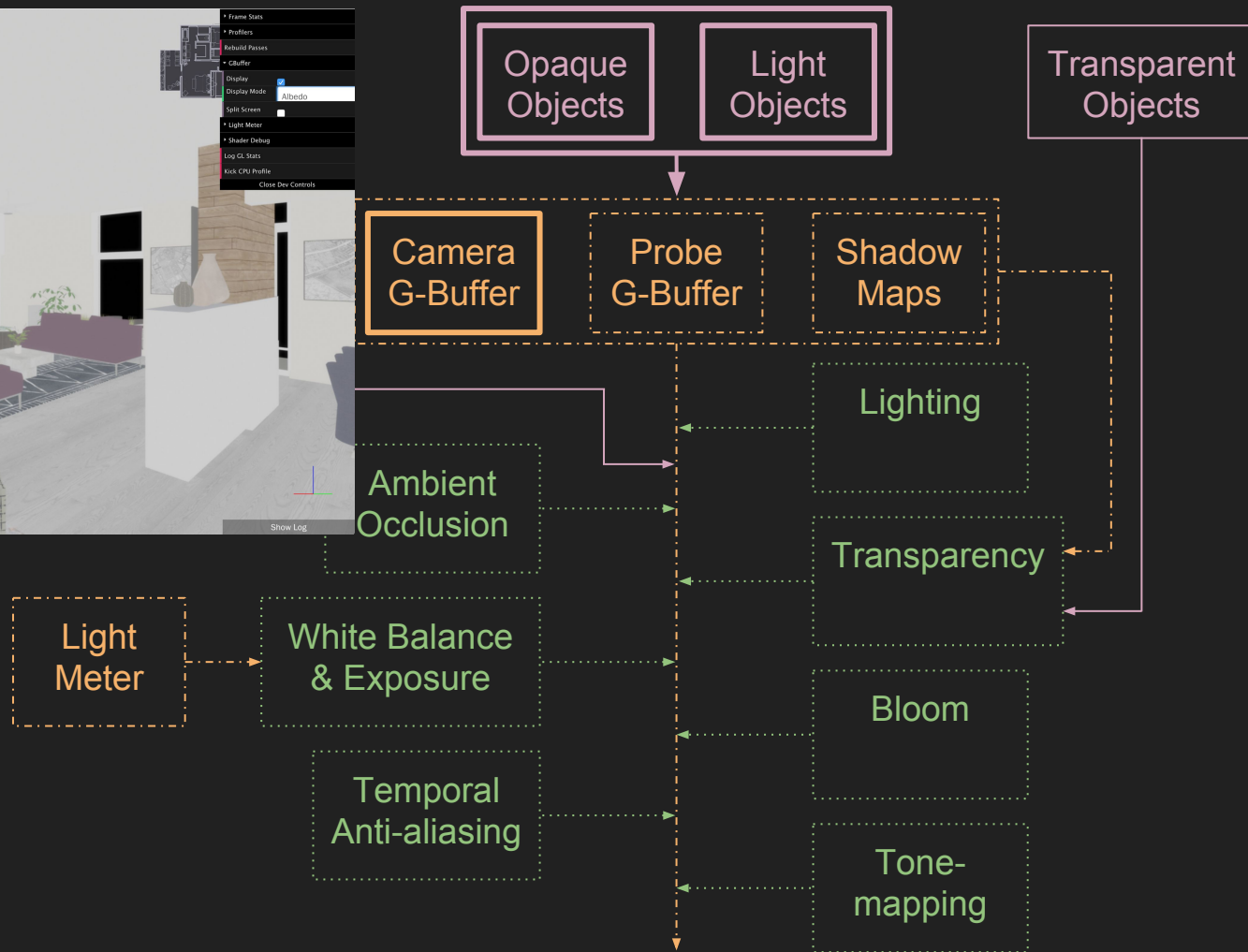


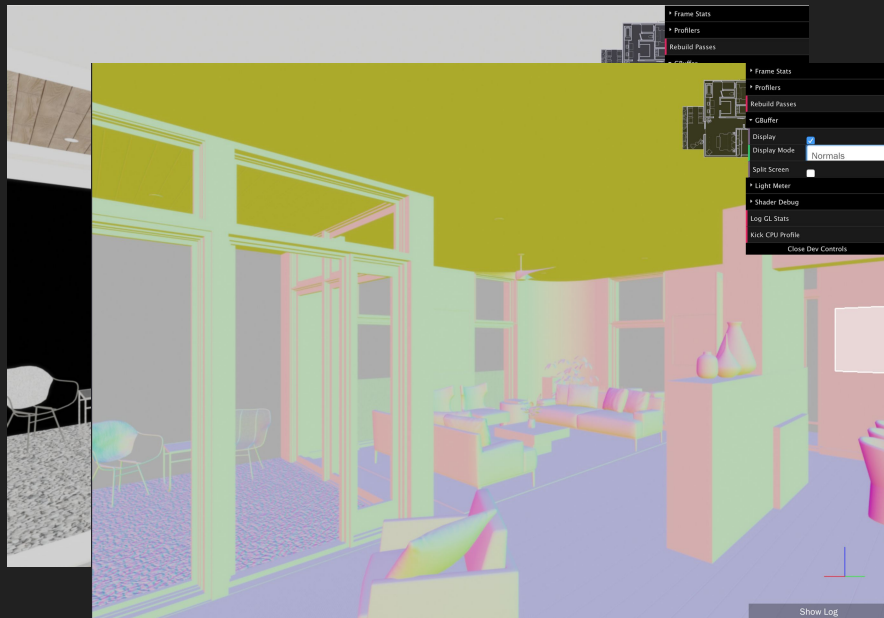
Rendering Pipeline



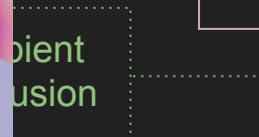
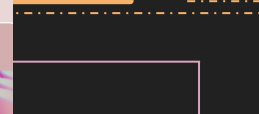
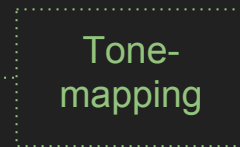
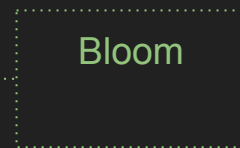
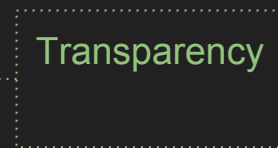
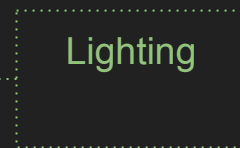
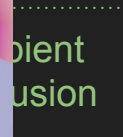
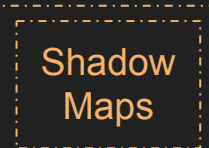
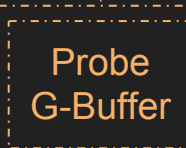
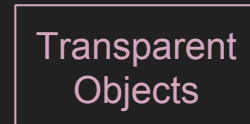
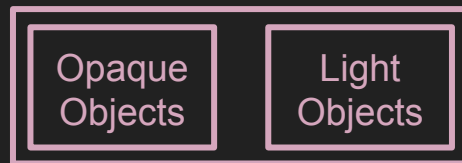
Rendering Pipeline

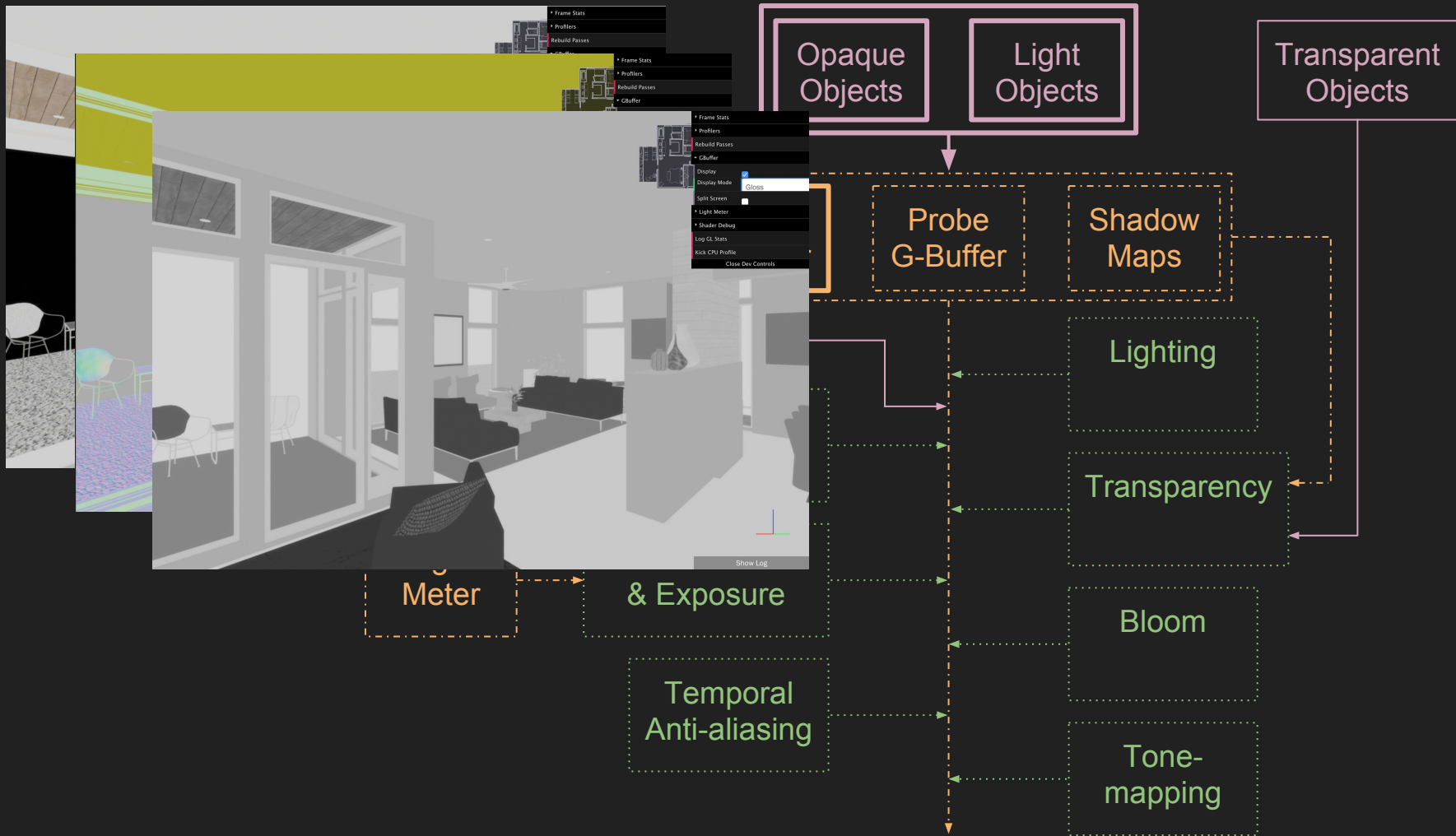


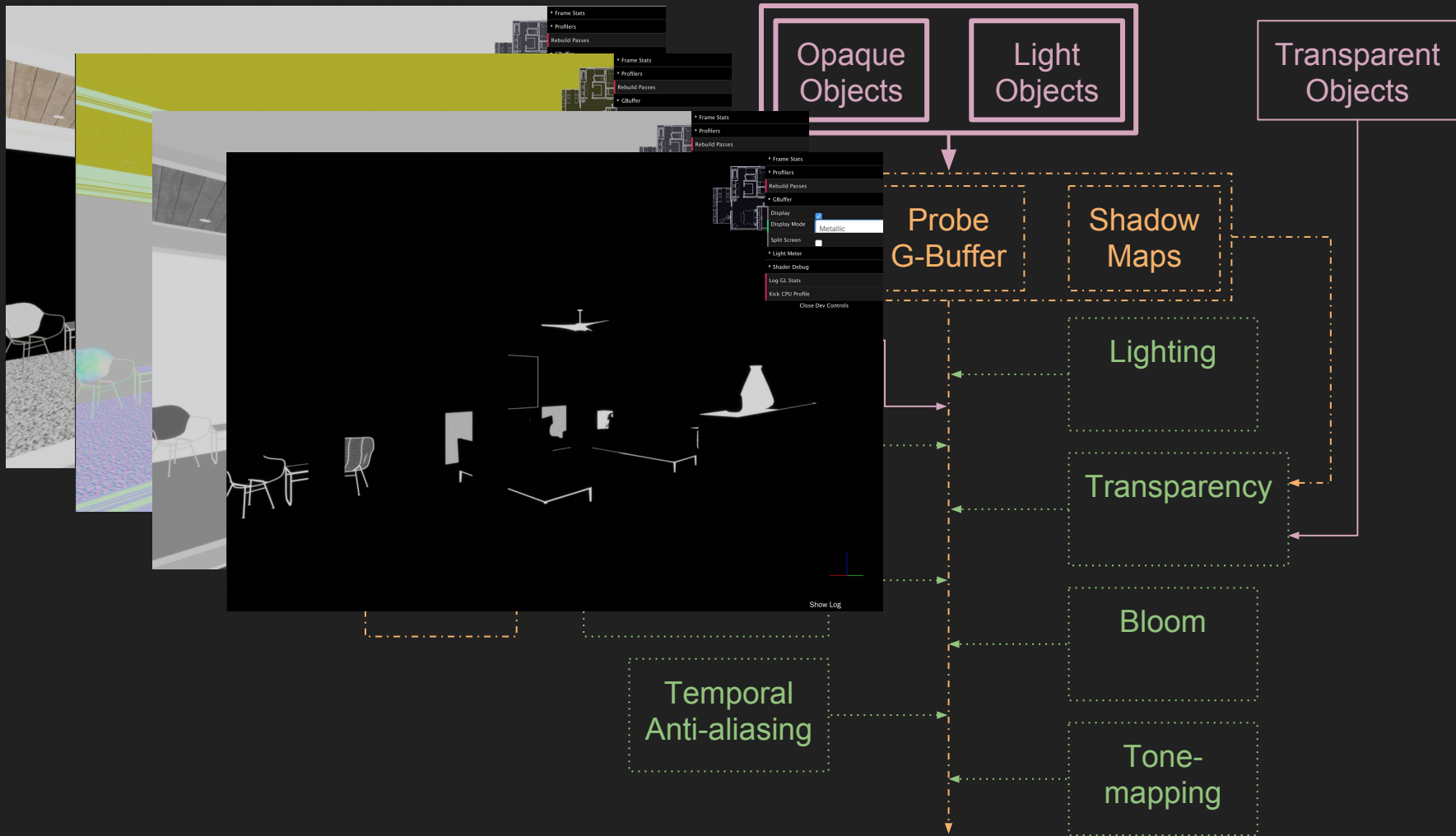




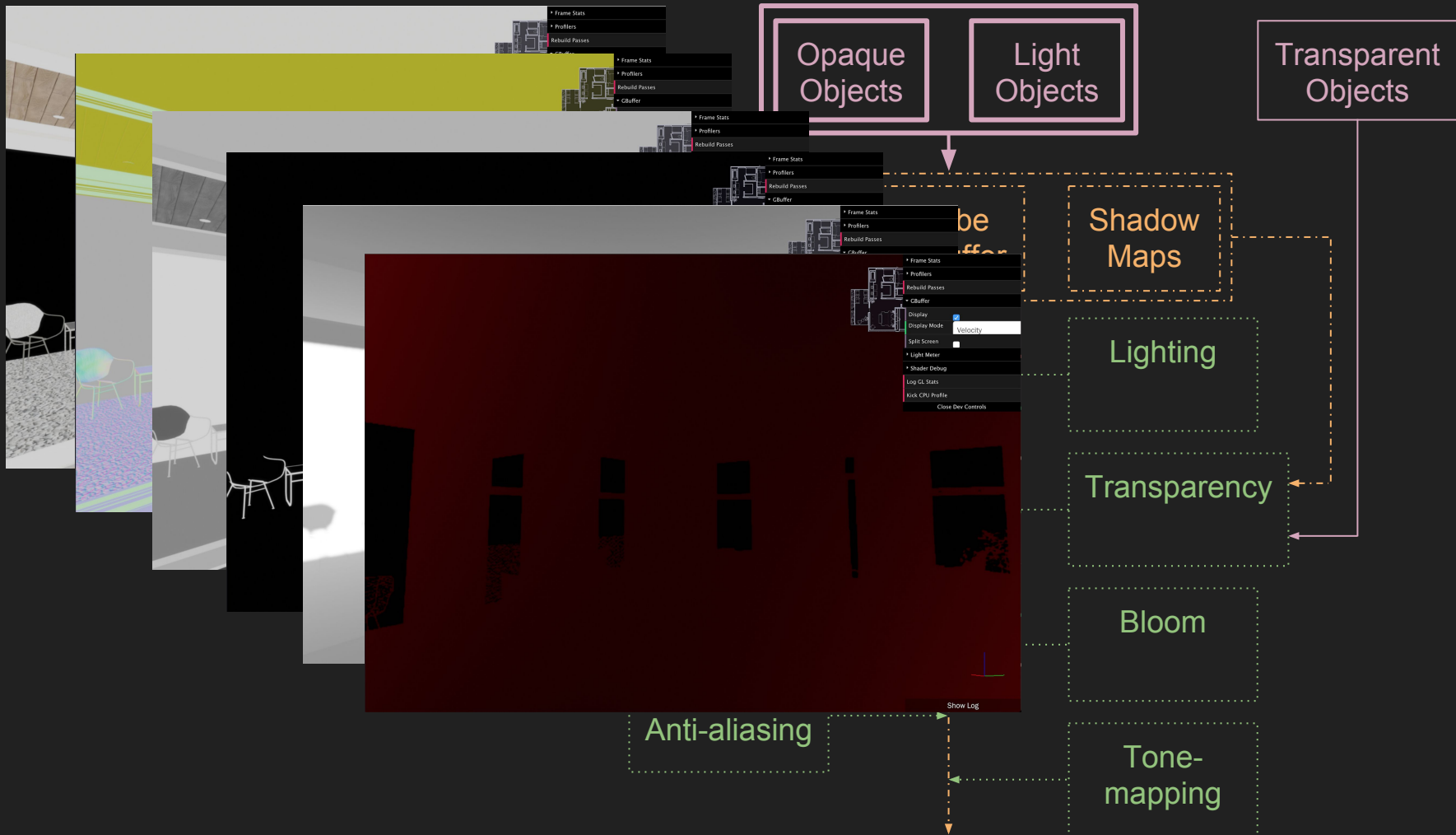
- Frame Stats
- Profilers
- Rebuild Passes
- Frame Stats
- Profilers
- Rebuild Passes
- GBuffer
- Display
- Display Mode ☒ Normals
- Split Screen ☐
- Light Meter
- Shader Debug
- Log GL Stats
- Kick CPU Profile
- Close Dev Controls

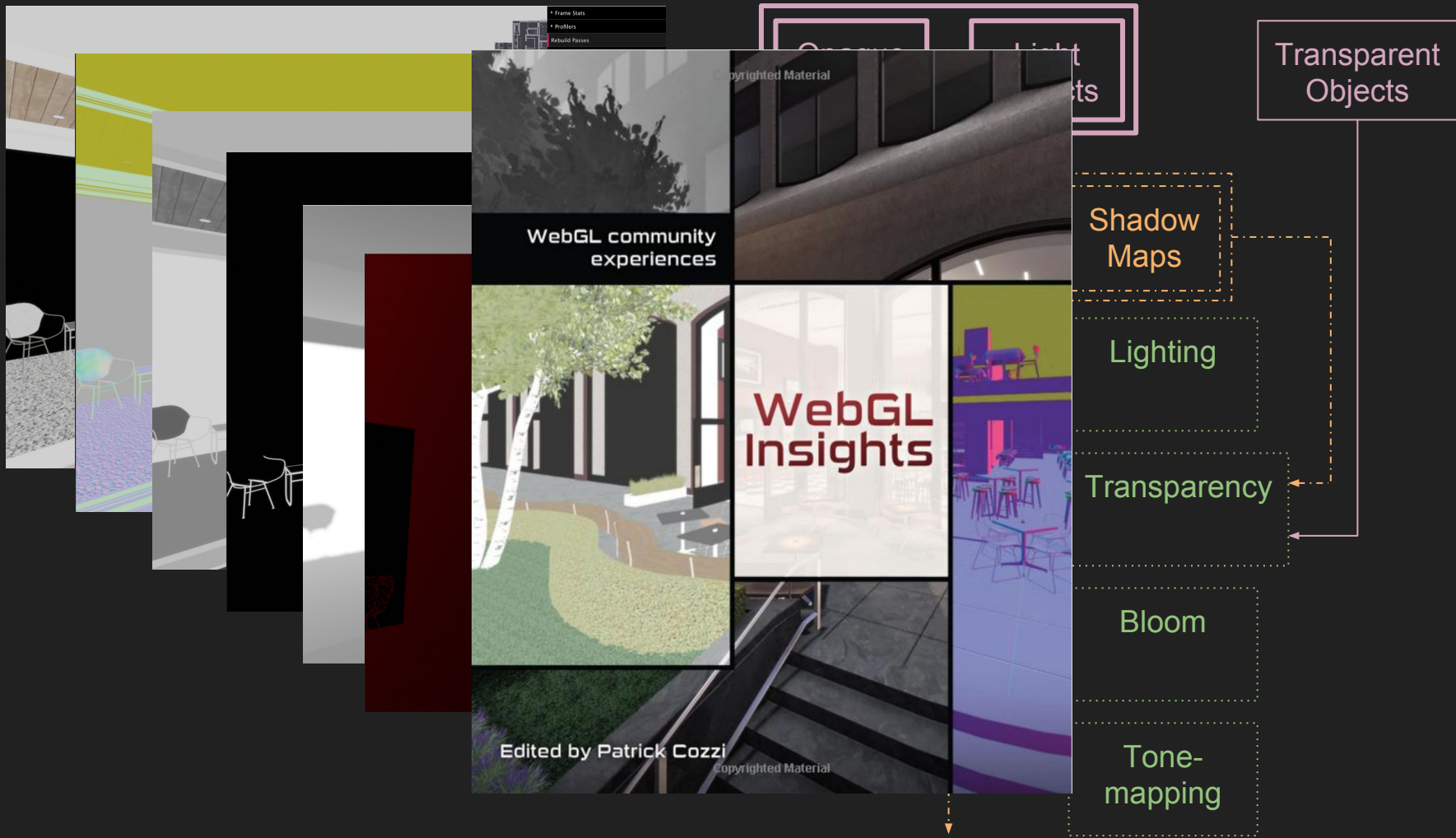




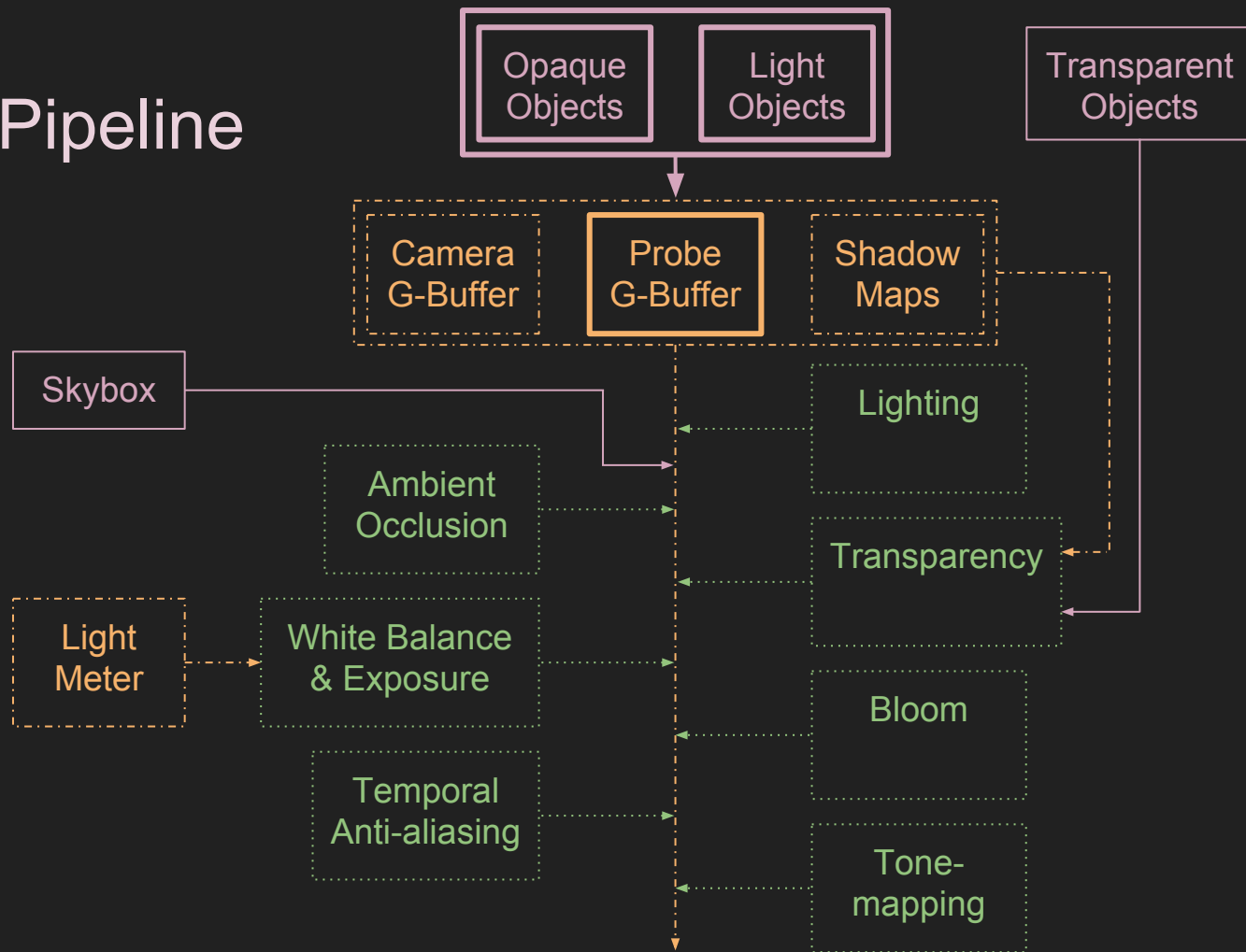




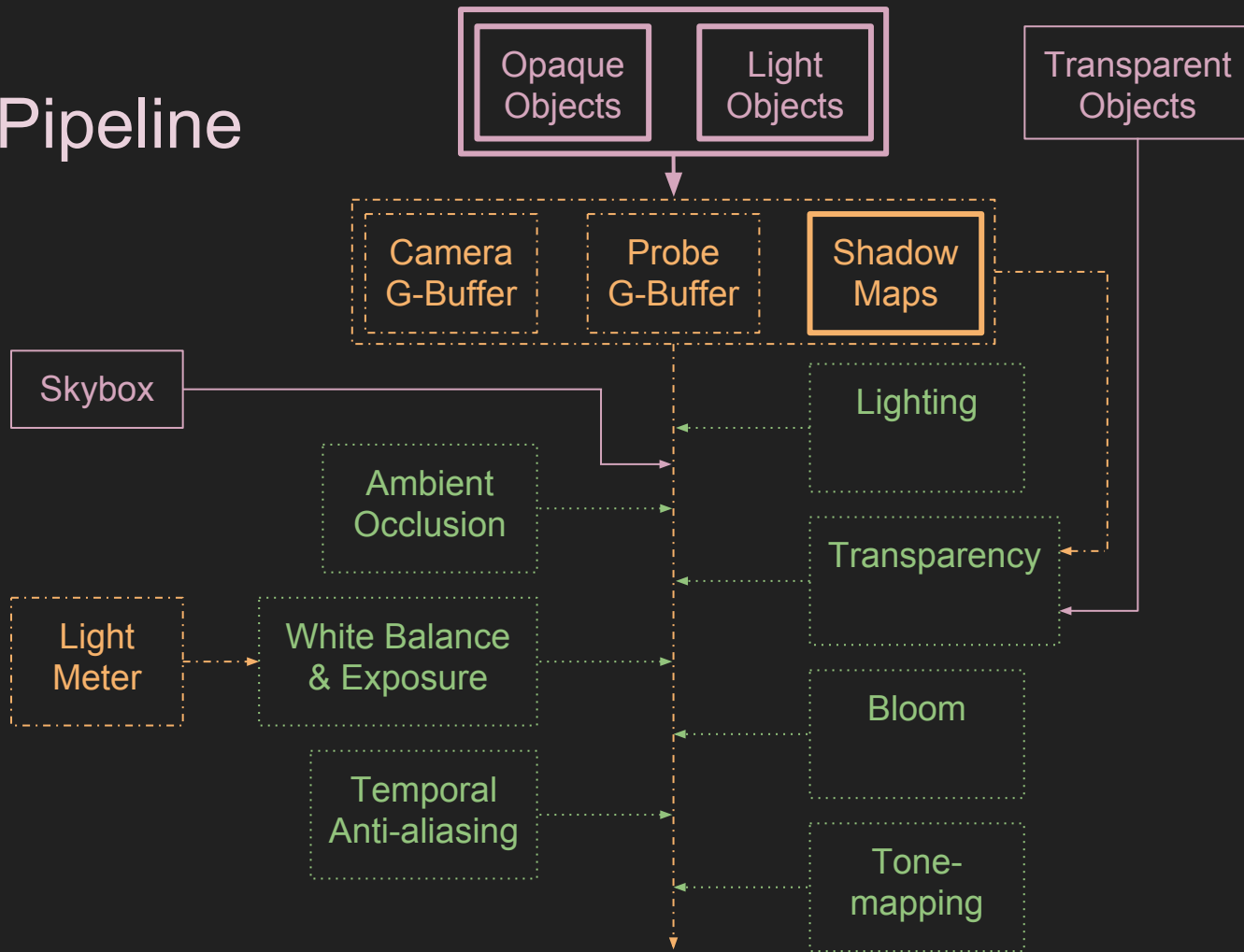




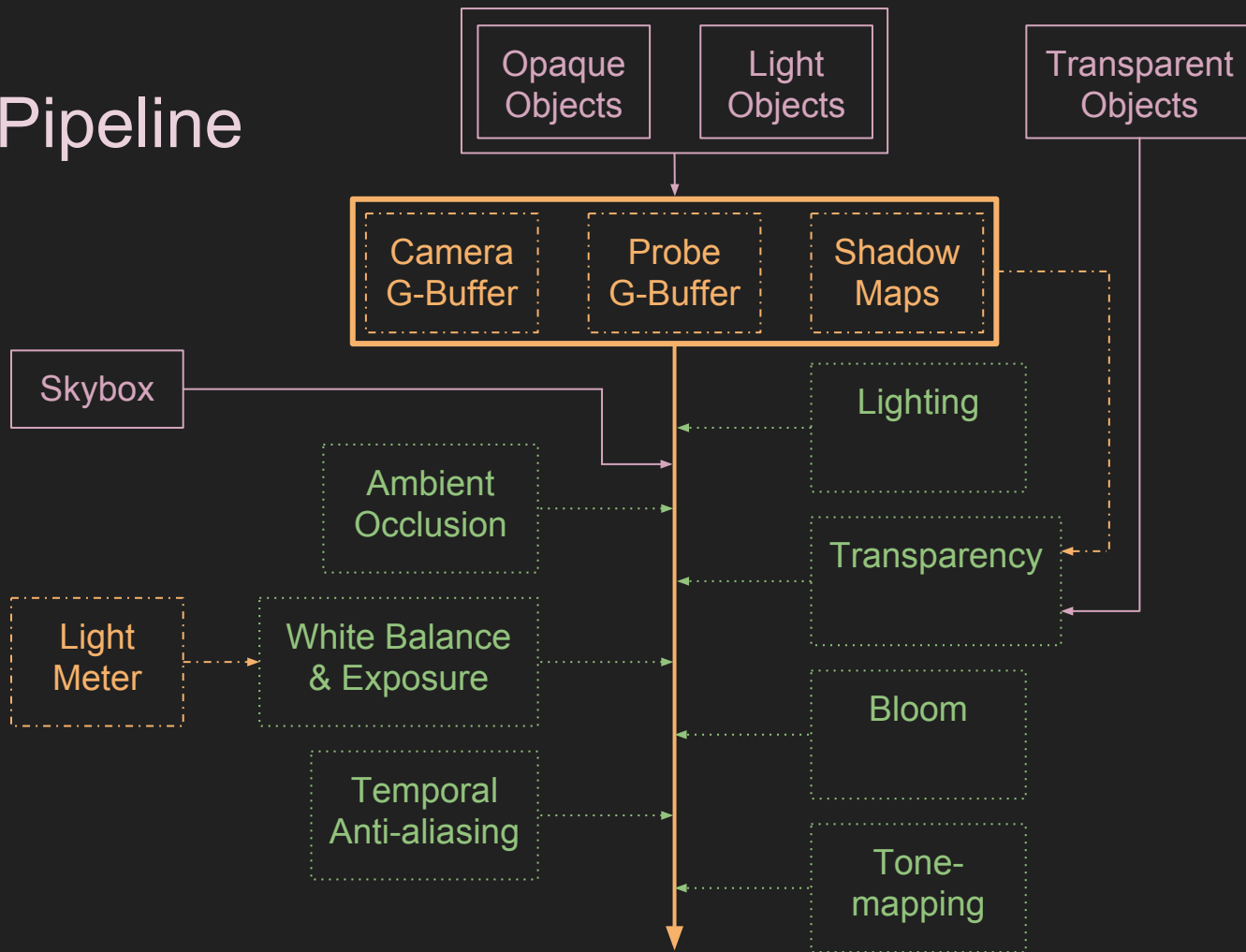
Rendering Pipeline



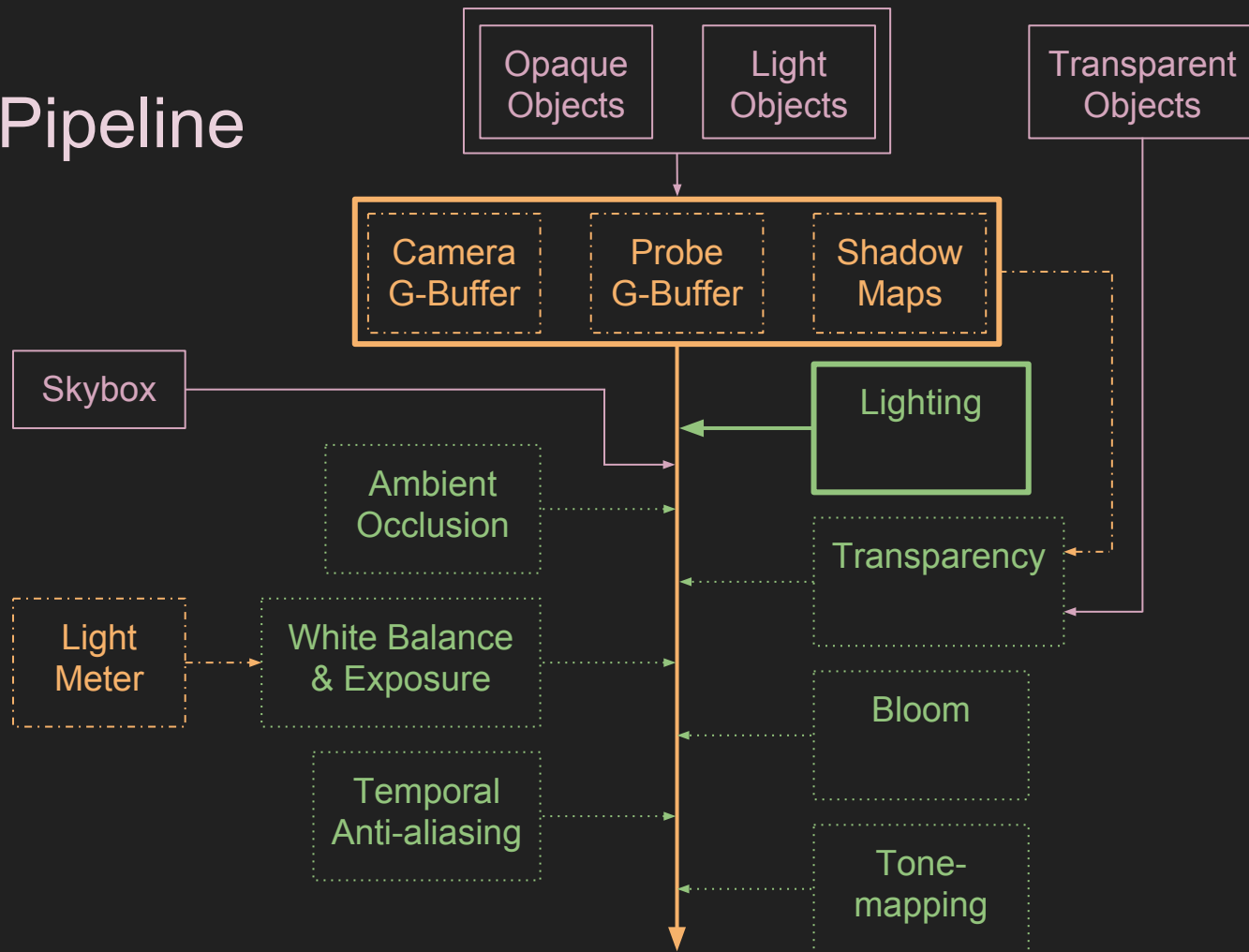
Rendering Pipeline



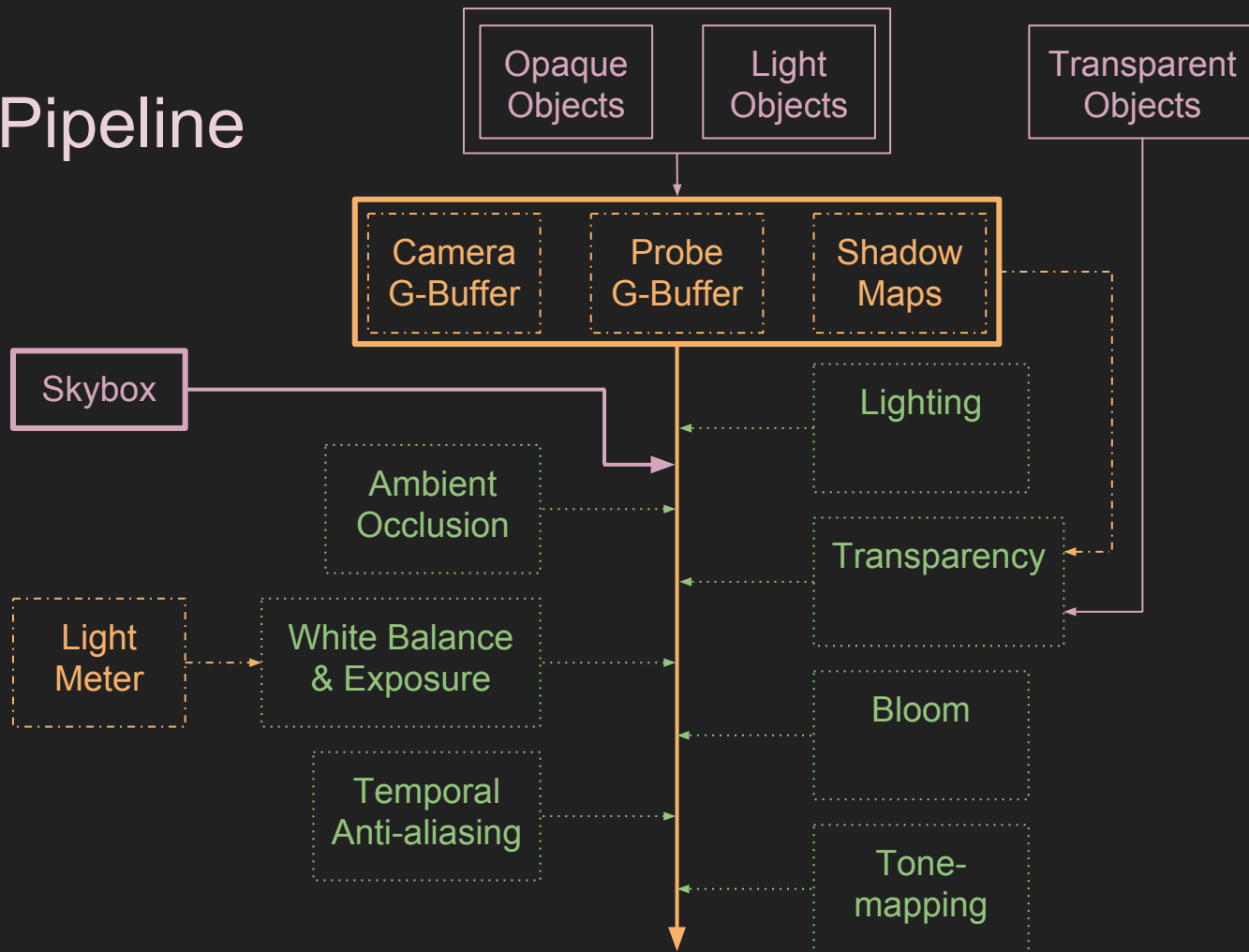
Rendering Pipeline



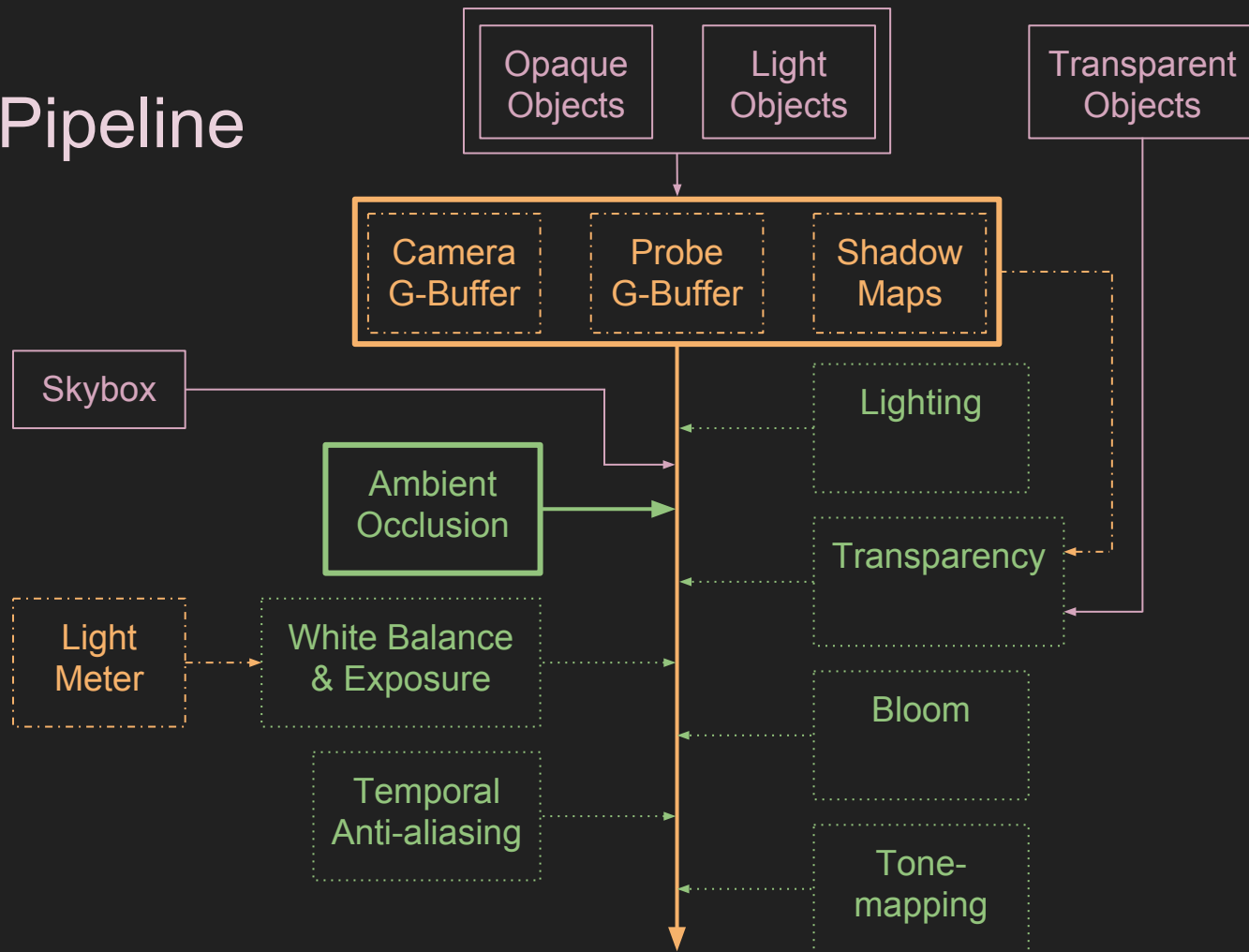
Rendering Pipeline



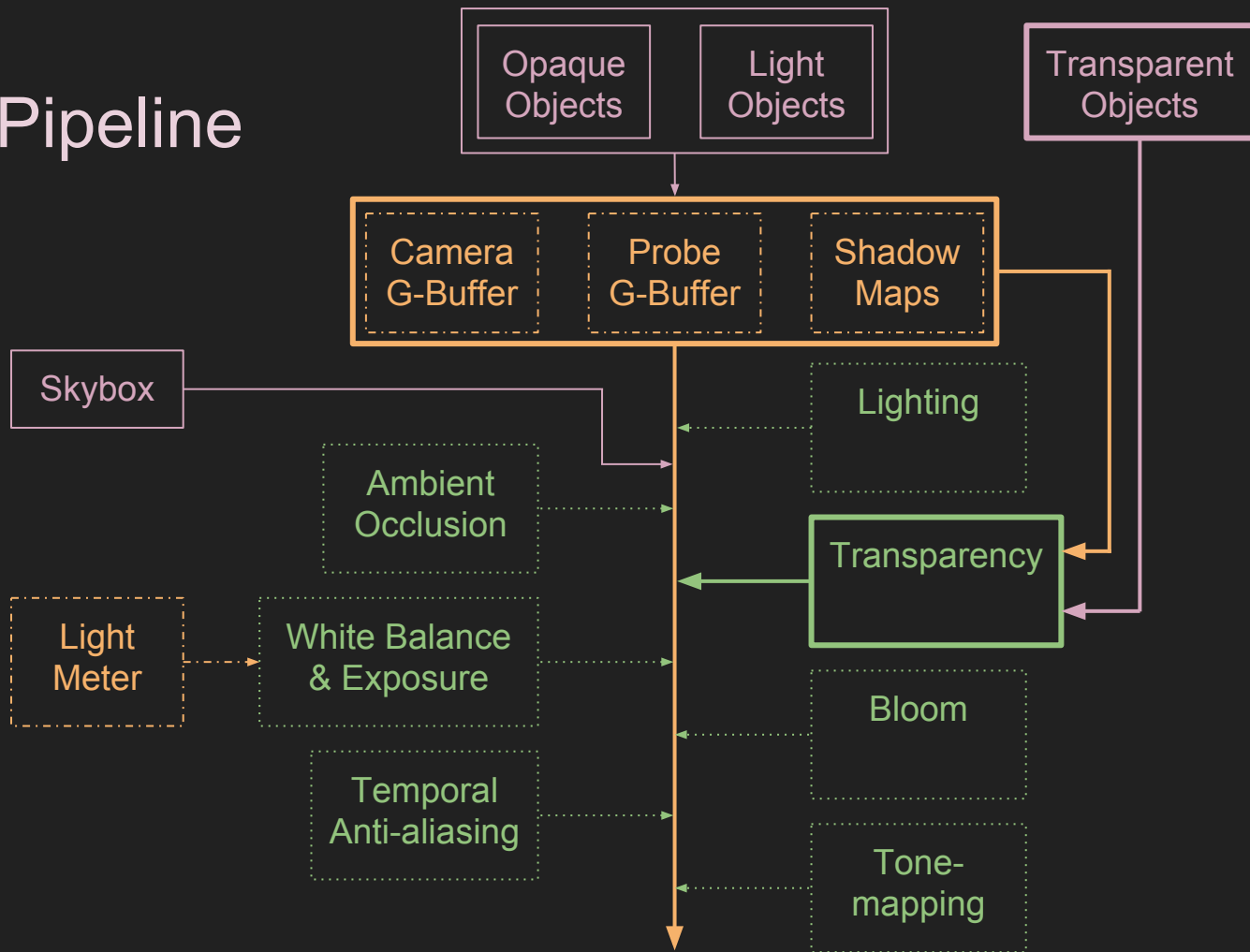
Rendering Pipeline



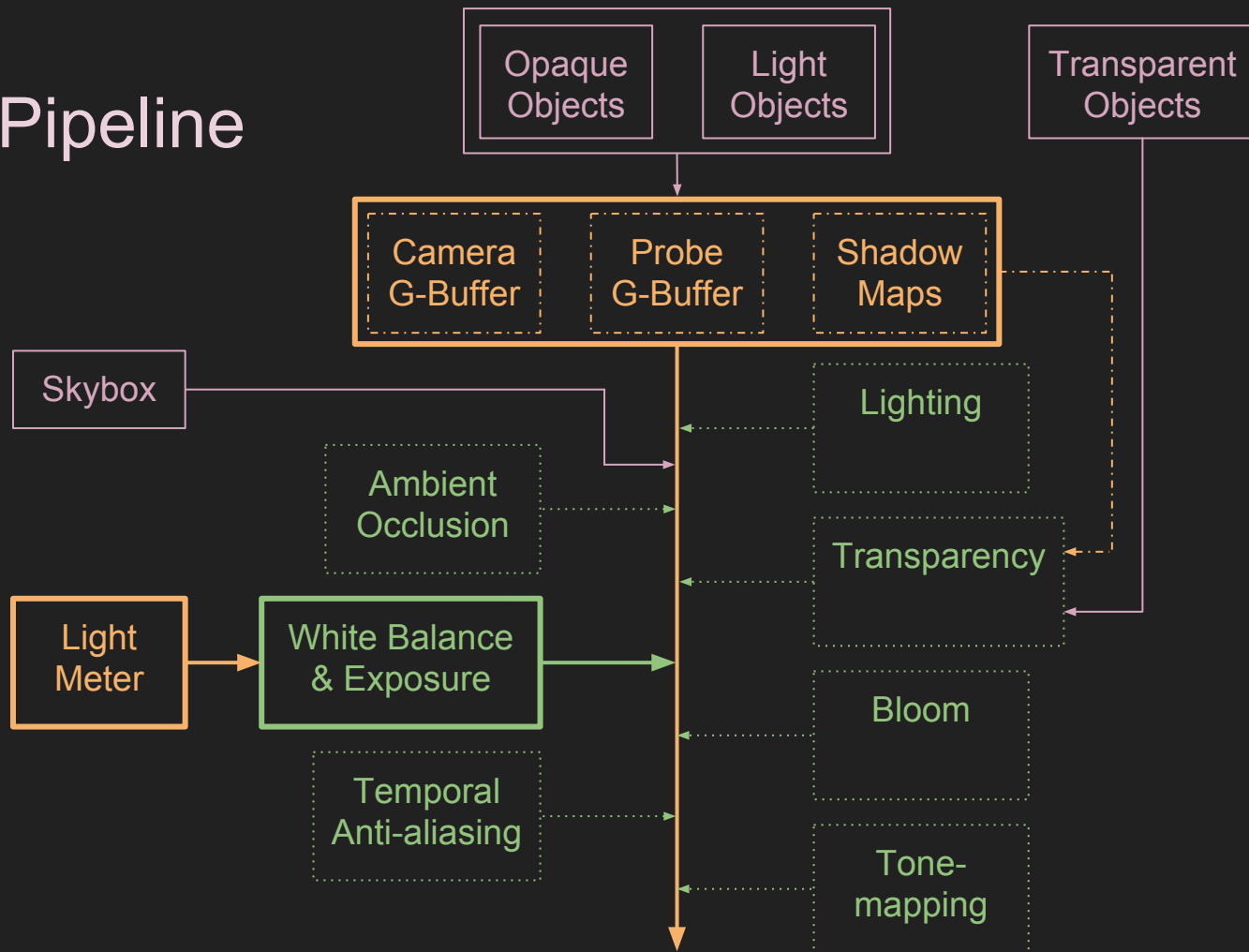
Rendering Pipeline



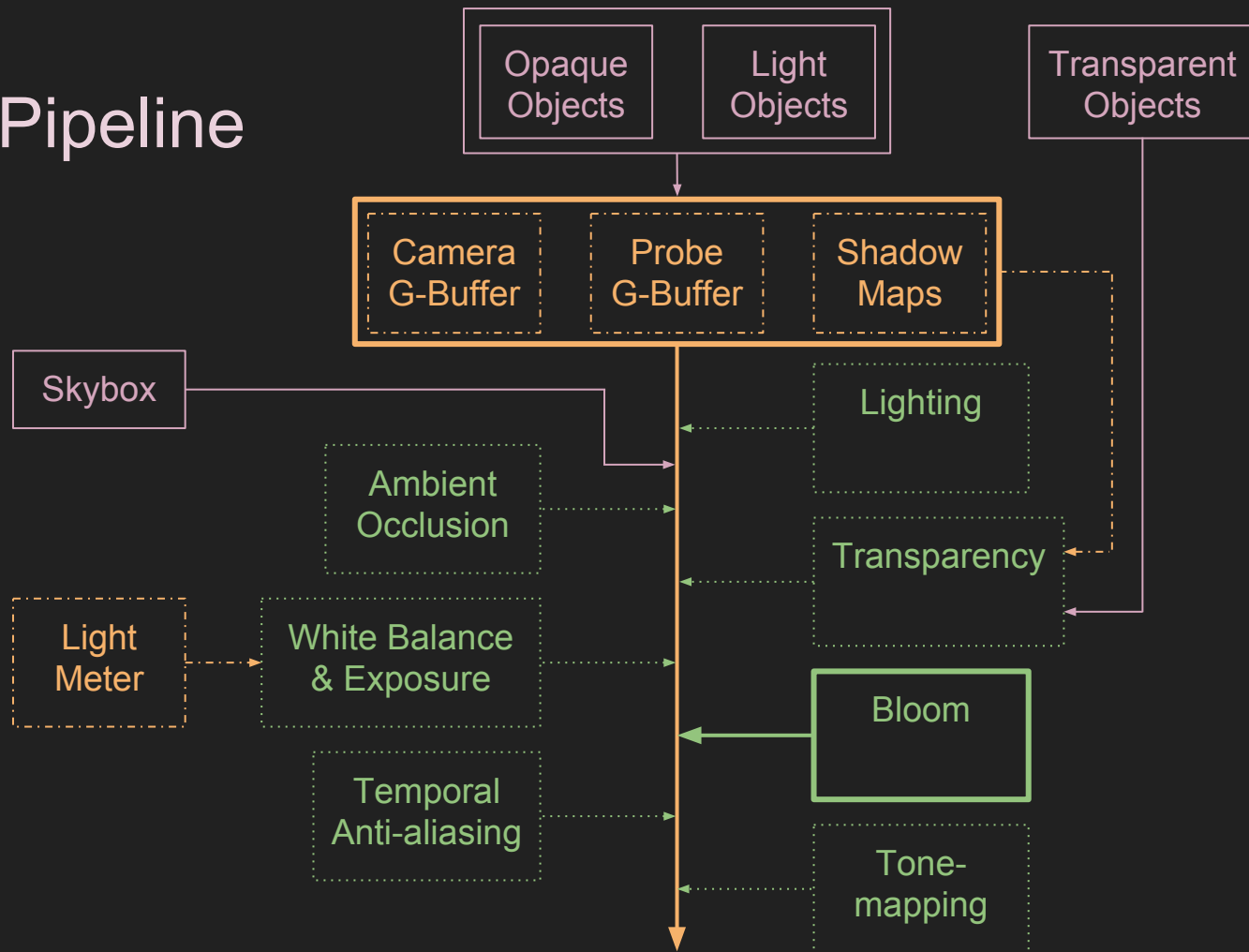
Rendering Pipeline



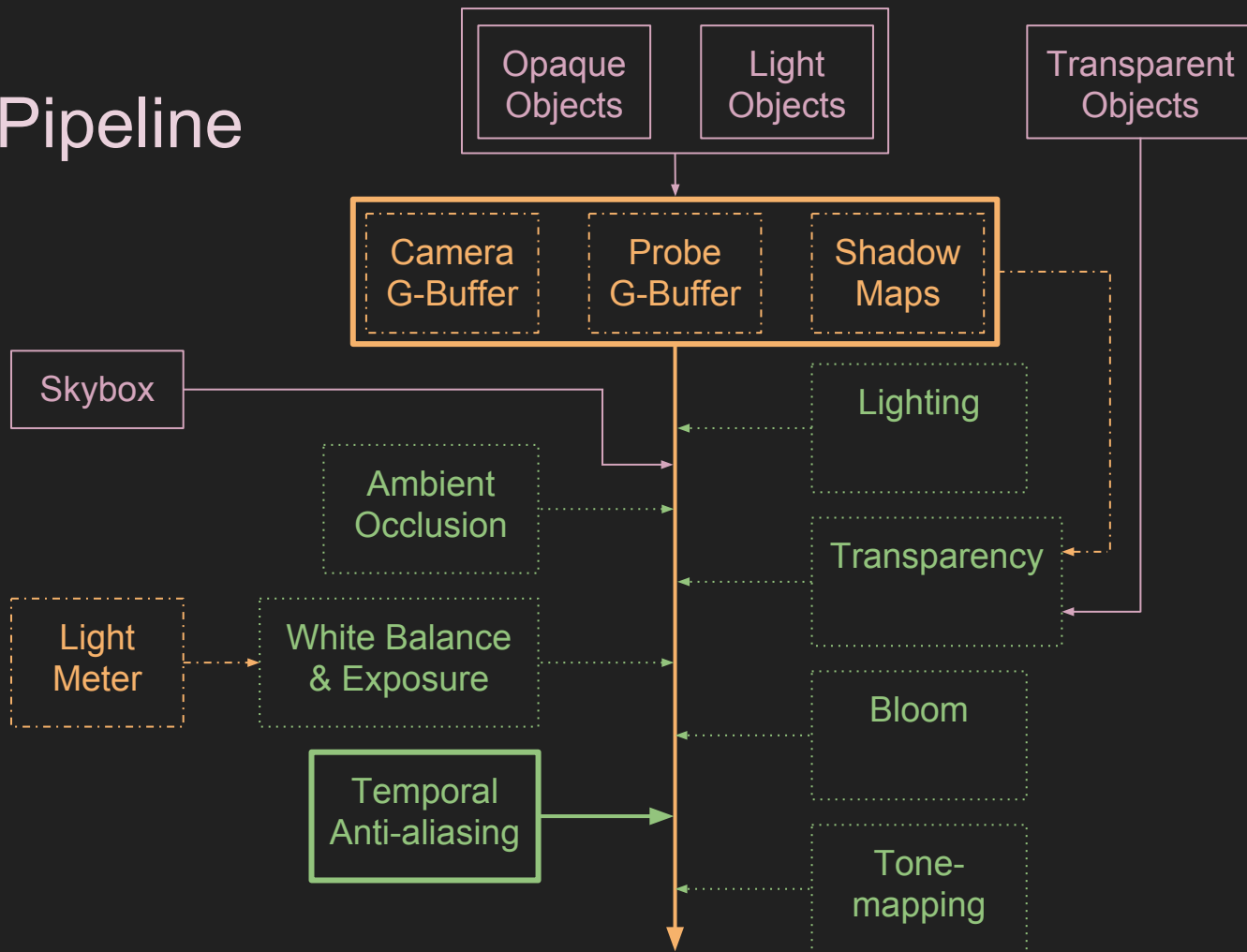
Rendering Pipeline



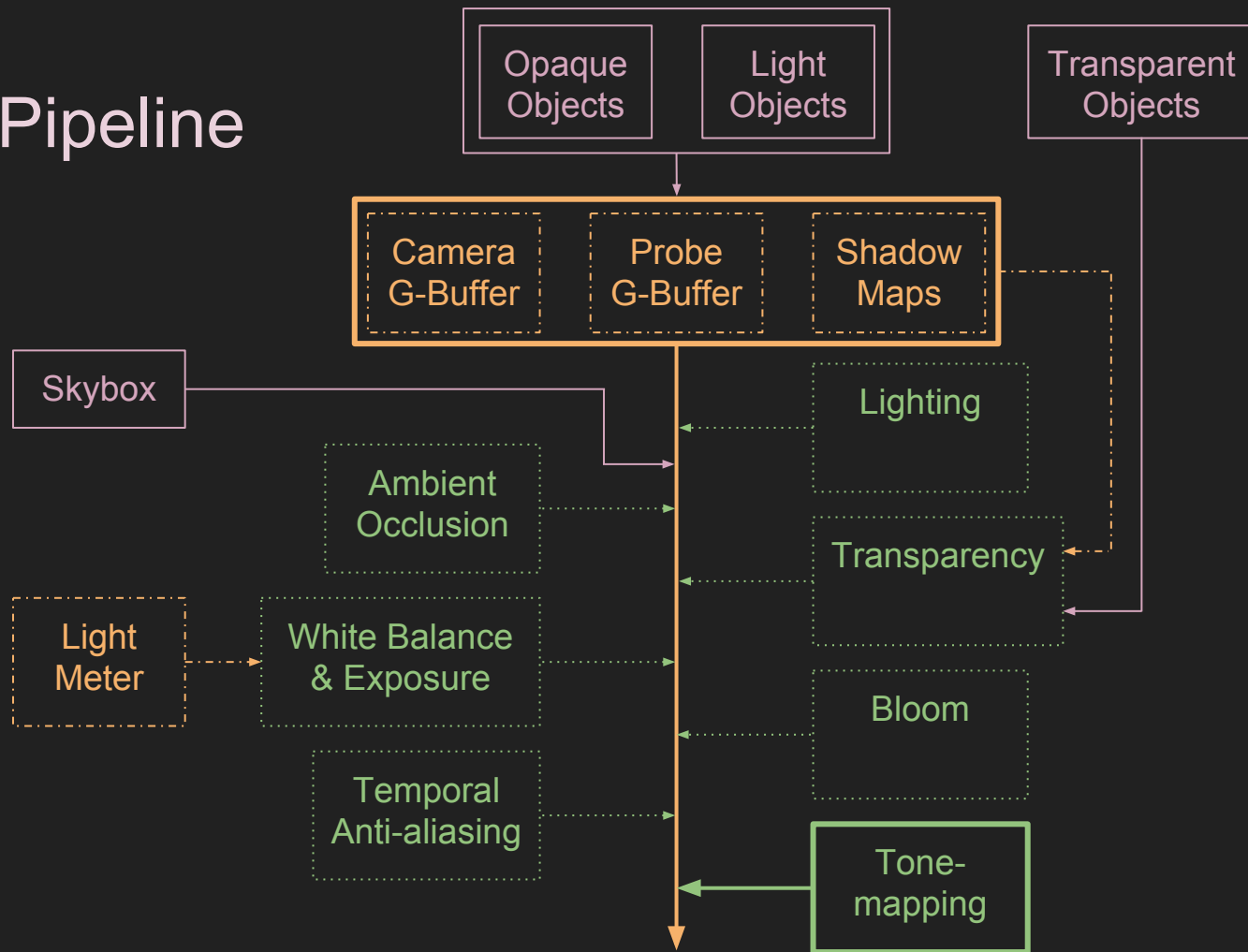
Rendering Pipeline



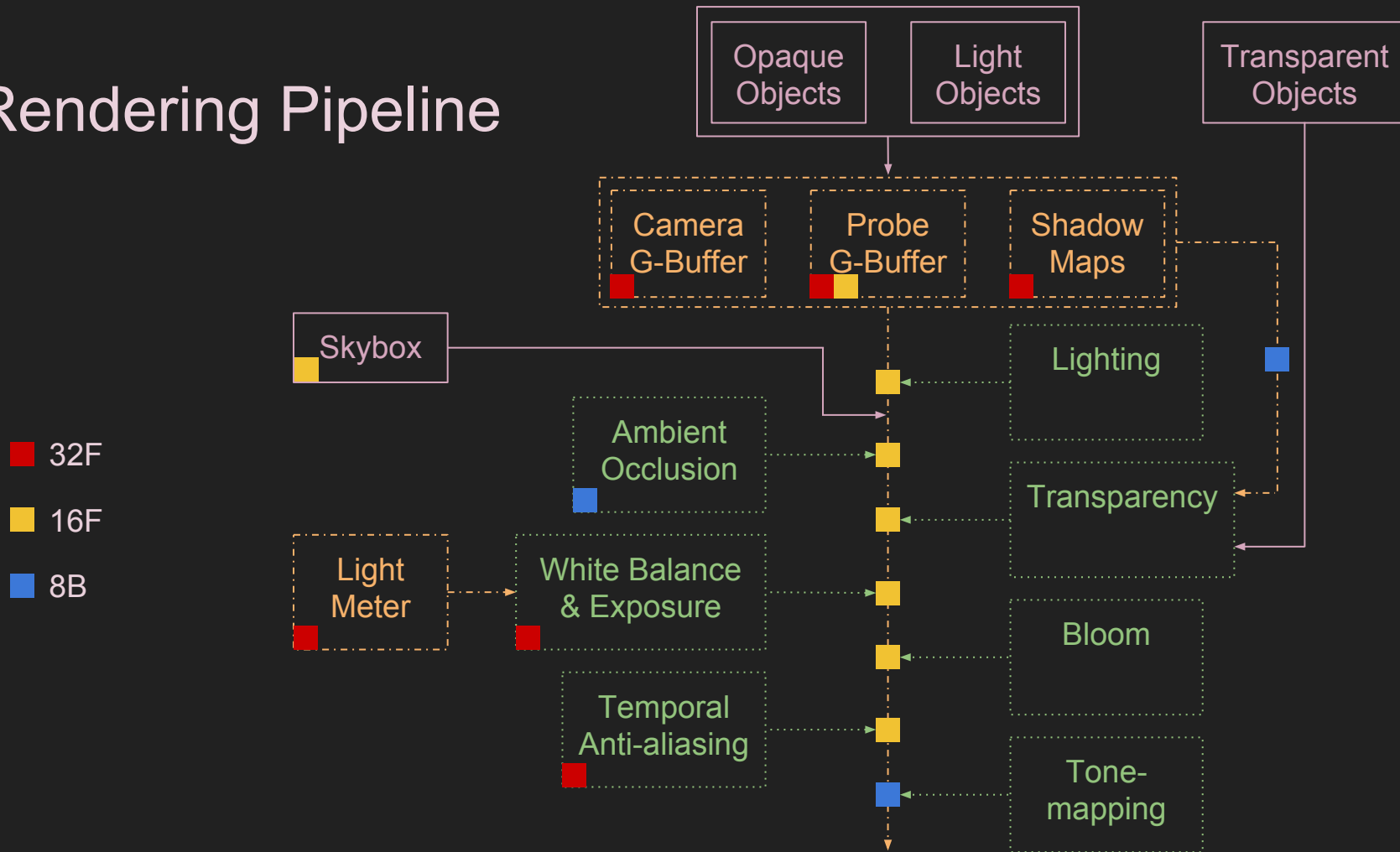
Rendering Pipeline



Rendering Pipeline



Rendering Pipeline



HDR in Luma





Rendering Pipeline



Lights

G Buffer

Lights

Emission

Sky

Indirect Light

Light Meter

Transparency

Exposure

Temporal AA

Bloom

Tonemapping



Lights

Interactions between
light and materials
happen in HDR











Luminance (cd/m²)

<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

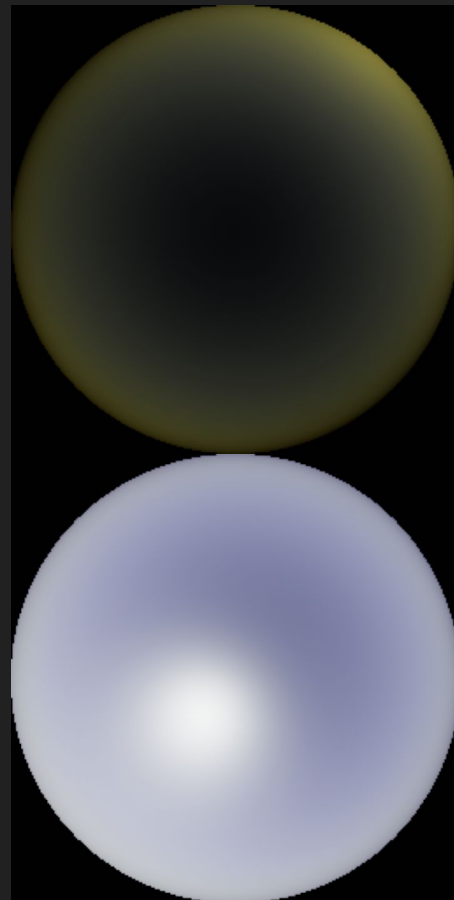
Hosek-Wilkie analytical model

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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Light Meter

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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

G Buffer

Lights

Emission

Sky

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Light Meter

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Exposure

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Tonemapping



Bloom

Airy Disk diffraction pattern occurs in eye or camera

Gaussian blur used to simulate this effect

Only affects bright areas



Tonemapping

G Buffer

Lights

Emission

Sky

Indirect Light

Light Meter

Transparency

Exposure

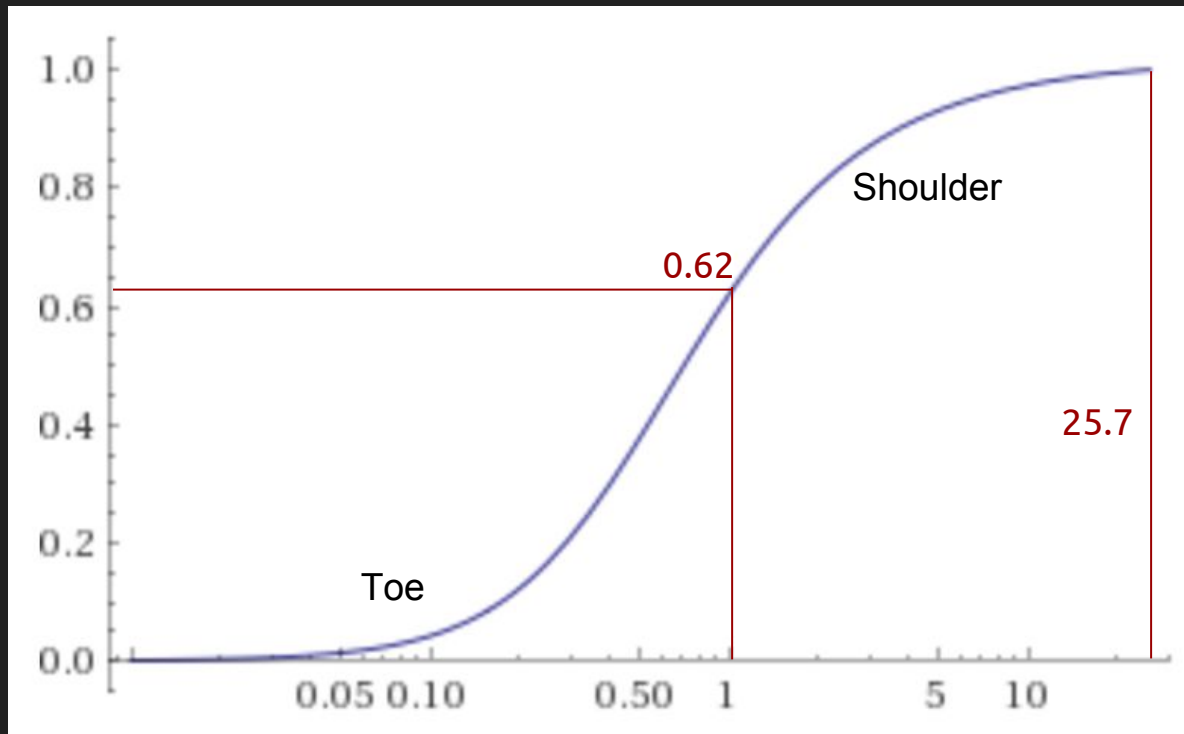
Temporal AA

Bloom

↓ Tonemapping



Choosing a Curve

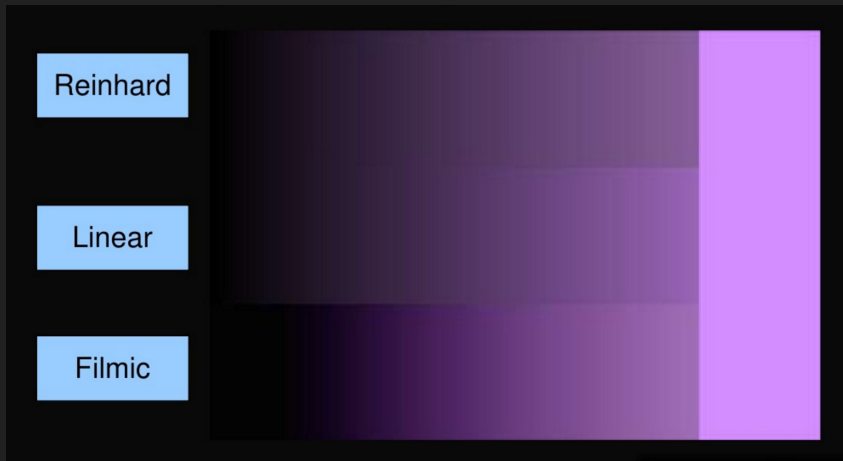


Great in-depth post at <http://filmicworlds.com/blog/filmic-tonemapping-with-piecewise-power-curves>

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