Radiometry II

cs348b
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Administrivia

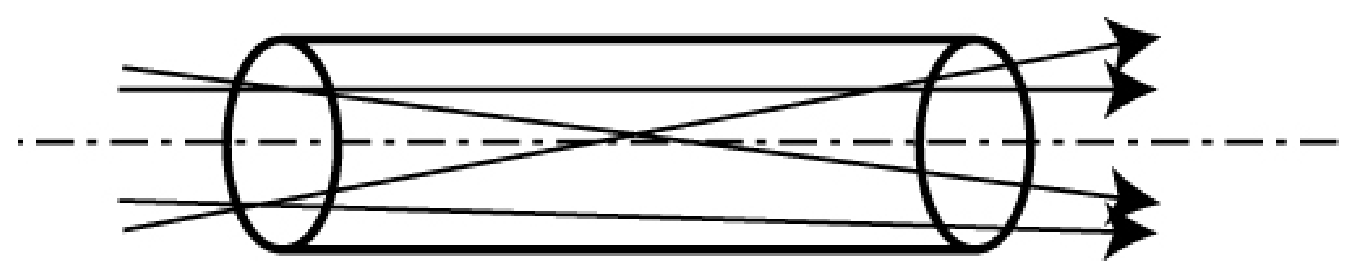
- HW1 due today
- HW2 goes out today

Overview

- Counting and representing rays
- Form factors
- Data structures for light
- Tone reproduction

Throughput = Measuring Rays

- Infinitesimal beam of rays defined by two differential surfaces

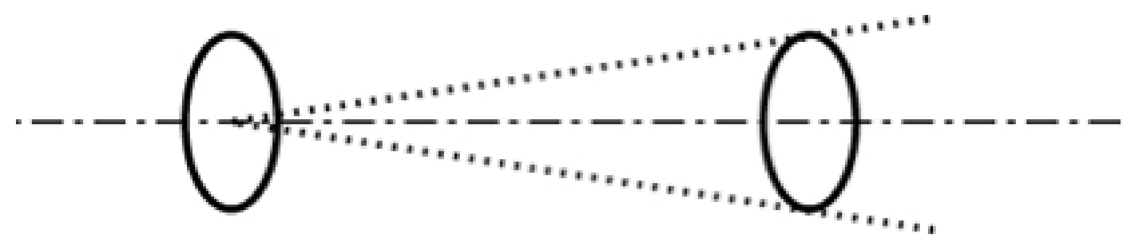


$$dT = \frac{dA_1 dA_2}{r^2}$$

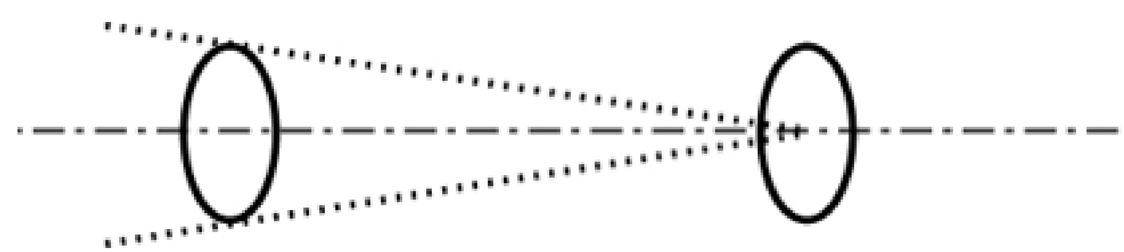
Measure is the number of rays in the beam.
Quantity is known as throughput

Throughput

- Can parameterize multiple ways



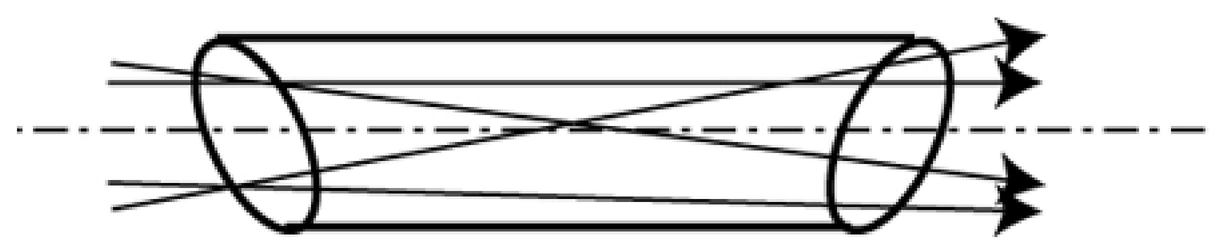
$$dT = dA_1 d\omega_1 \qquad d\omega_1 = dA_2/r^2$$



$$dT = dA_2 d\omega_2 \qquad d\omega_2 = dA_1/r^2$$

Throughput

- Can tilt the surfaces...



$$dT = \frac{dA_1 \cos\theta_1 dA_2 \cos\theta_2}{r^2}$$

Types of Throughput

- Infinitesimal beam

$$dT(dA_1, dA_2) = \frac{\cos\theta_1 \cos\theta_2}{r^2} dA_1 dA_2$$

- Differential-finite beam

$$T(dA_1, A_2) dA_1 = \int_\Omega \cos\theta d\omega(x) dA_1 = \int_{A_2} \frac{\cos\theta_1 \cos\theta_2}{r^2} dA_2(x) dA_1$$

- Finite-finite beam

$$T(A_1, A_2) = \int_{A_1} \int_{A_2} \frac{\cos\theta_1 \cos\theta_2}{r^2} dA_1(x_1) dA_2(x_2) = \int_{A_1} \int_\Omega \cdots dA_1 d\omega$$

Conservation of Throughput

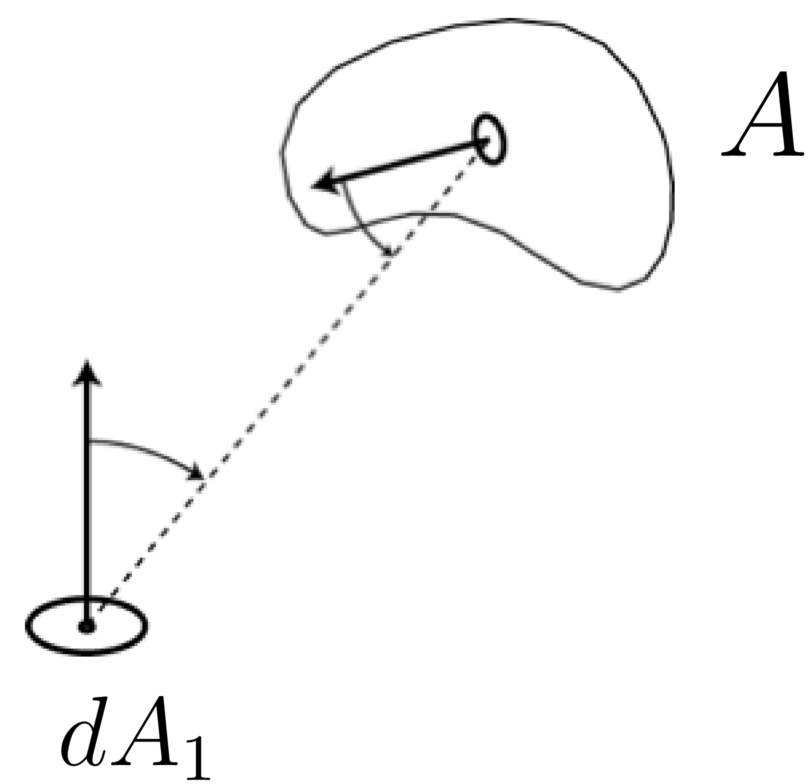
- Rays are conserved through free space
  - No attenuation or scattering
- η^2 times throughput remains constant
  - Reflection
  - Refraction
  - Continuously varying i.o.r.
- Thence, conservation of radiance
  - Power is conserved
  - Throughput is conserved

Differential Form Factor

- Probability of ray leaving dA hitting A

$$Pr(A|dA_1) = \frac{T(dA_1, A)dA_1}{T(dA_1)} = \frac{T(dA_1, A)dA_1}{\pi dA_1} = \frac{T(dA_1, A)}{\pi}$$

$$= \int_A \frac{\cos\theta \cos\theta}{r^2} dA(x)$$

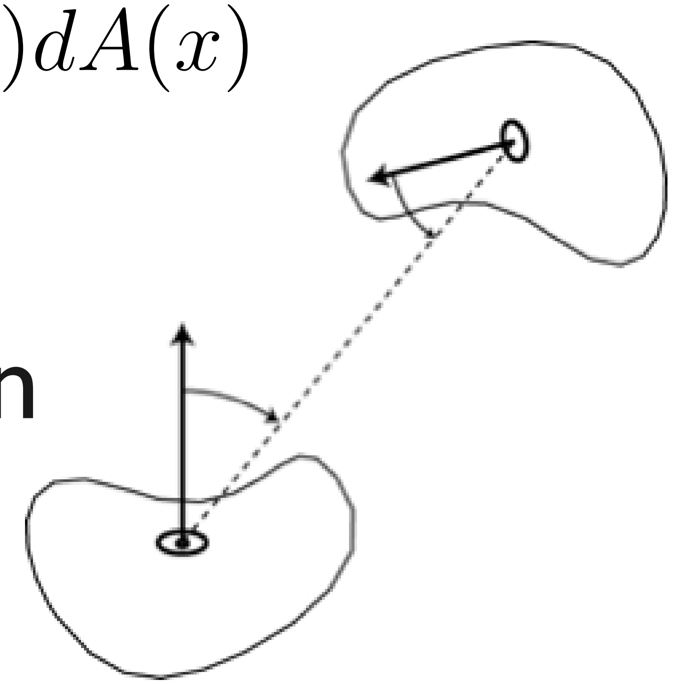


Form Factor

- Probability of ray leaving A hitting A’

$$Pr(A|A) = \frac{T(A, A)}{T(a)}$$
$$= \frac{1}{A\pi} \int_A \int_A \frac{\cos\theta \cos\theta}{r^2} dA(x) dA(x)$$

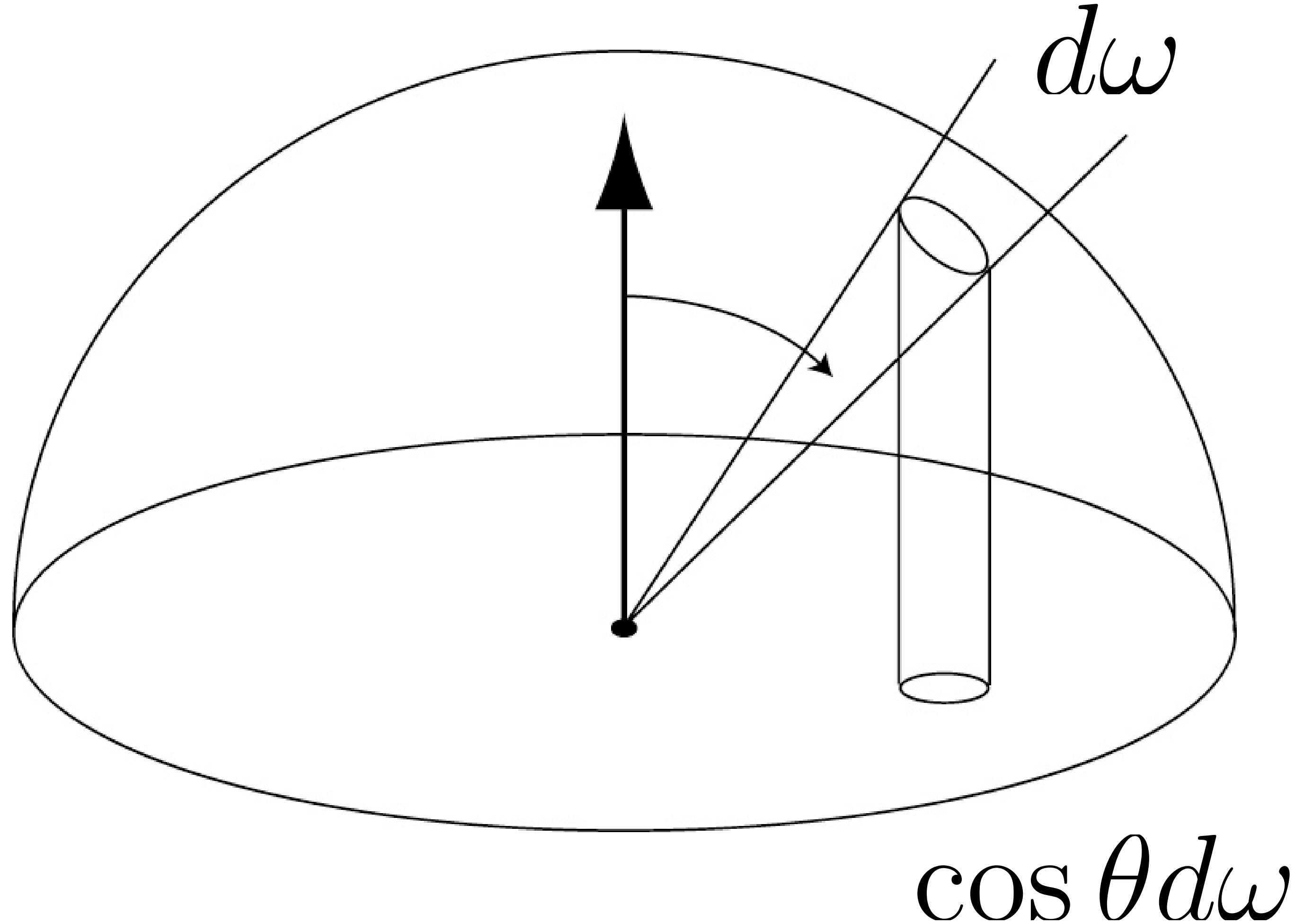
What is the f.f. from A’ to A in terms of this one?



Parameterizing Rays

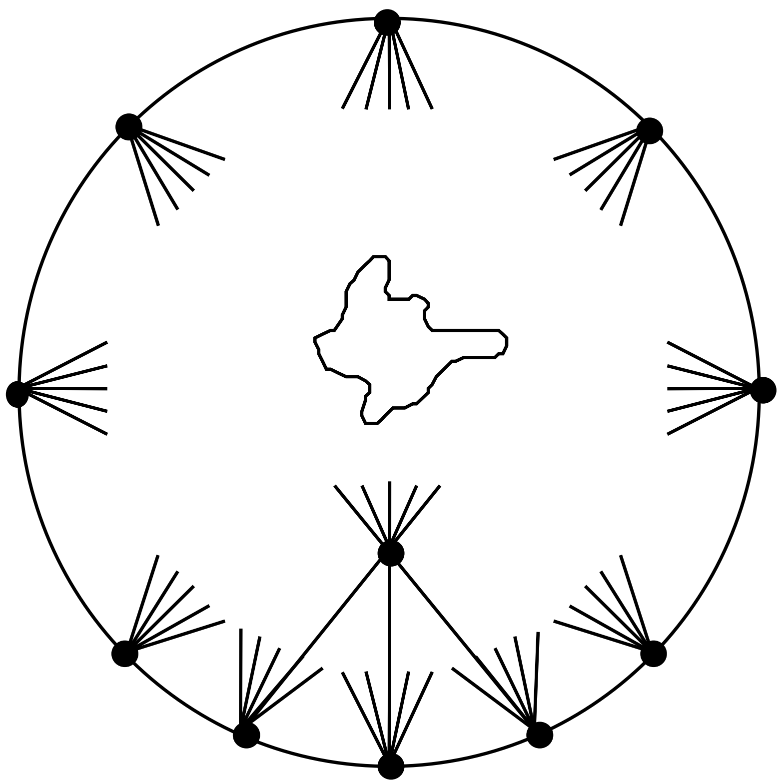
- How many dimensions?
  - Line segments: 6D
  - Rays: 5D
  - Rays in free-space: 4D
- Parameterizations
  - Plane x directions
  - Sphere x directions

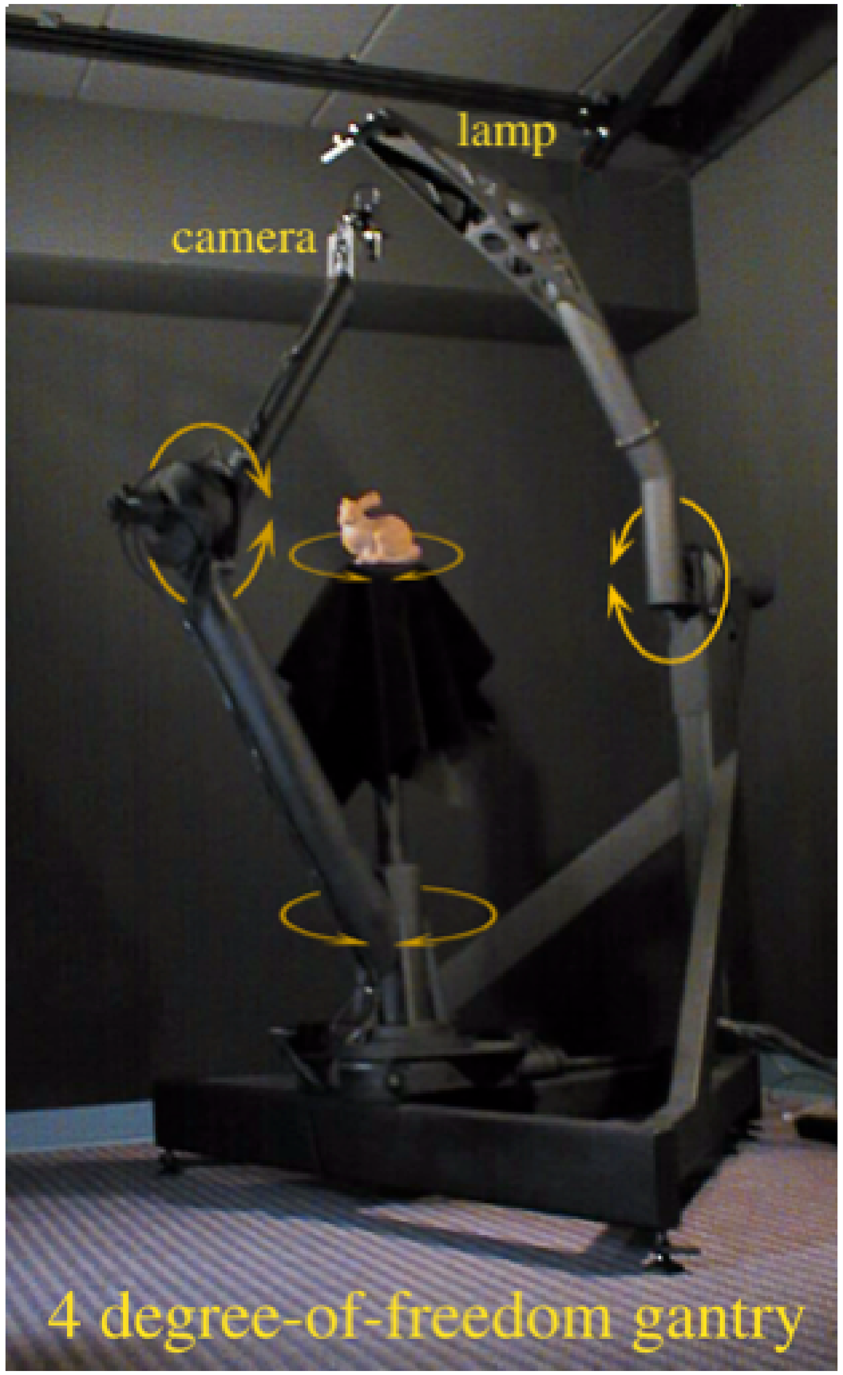
Projected Solid Angle



Data Structures for Light

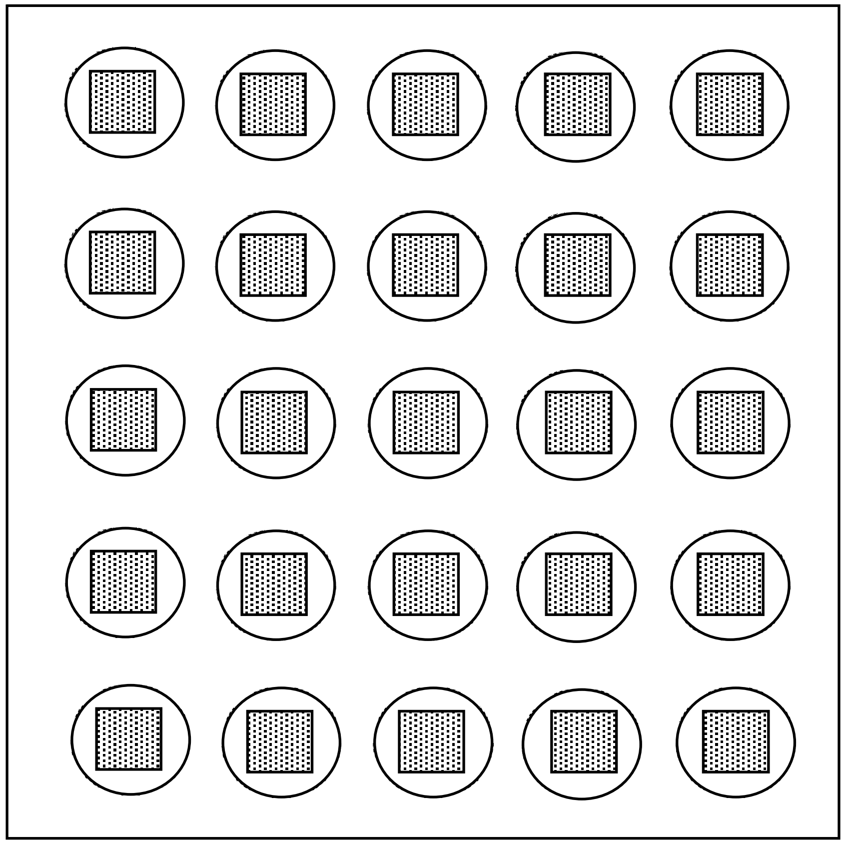
- Spherical light field





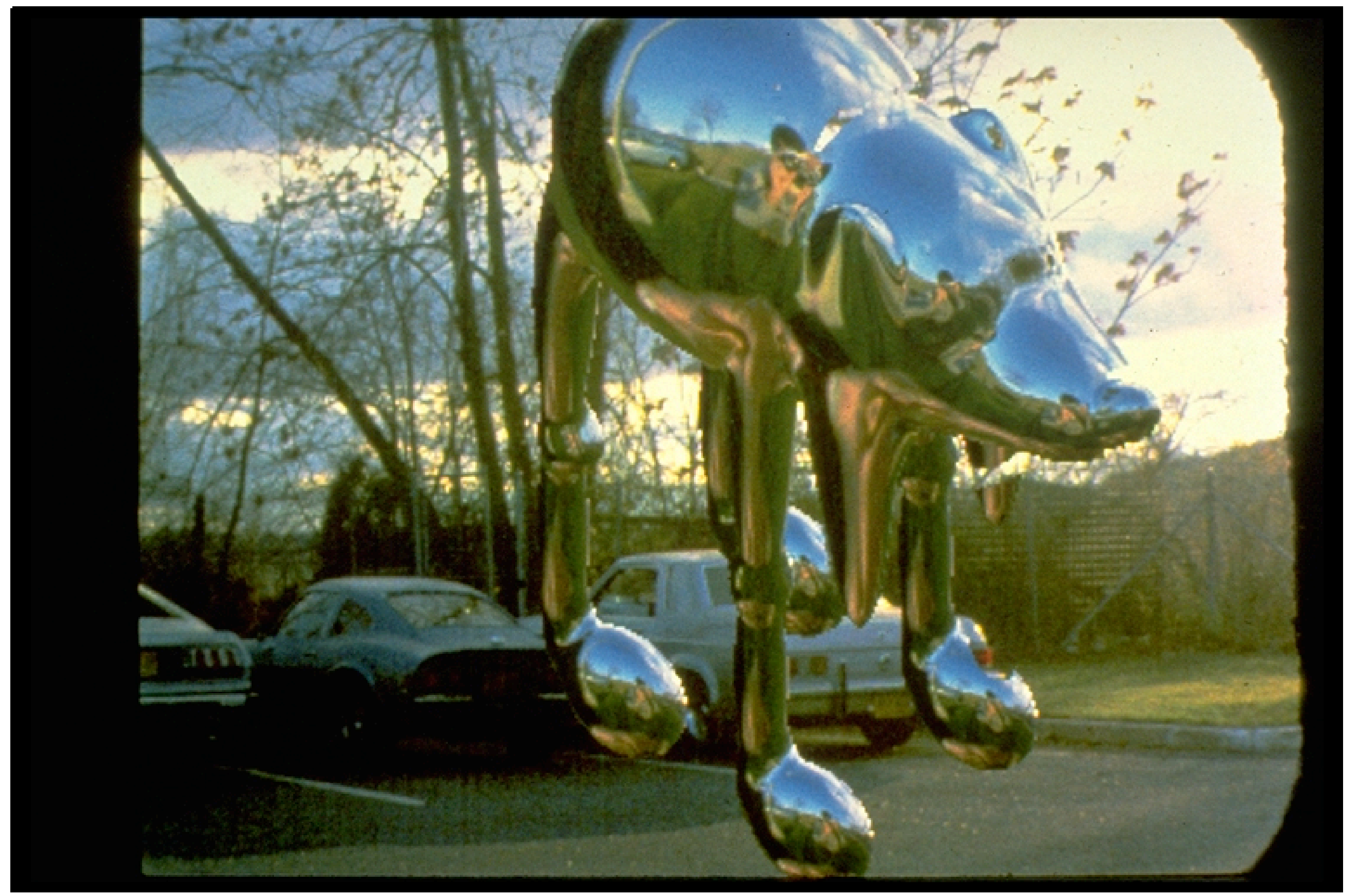
Data Structures for Light

- Two plane parameterization

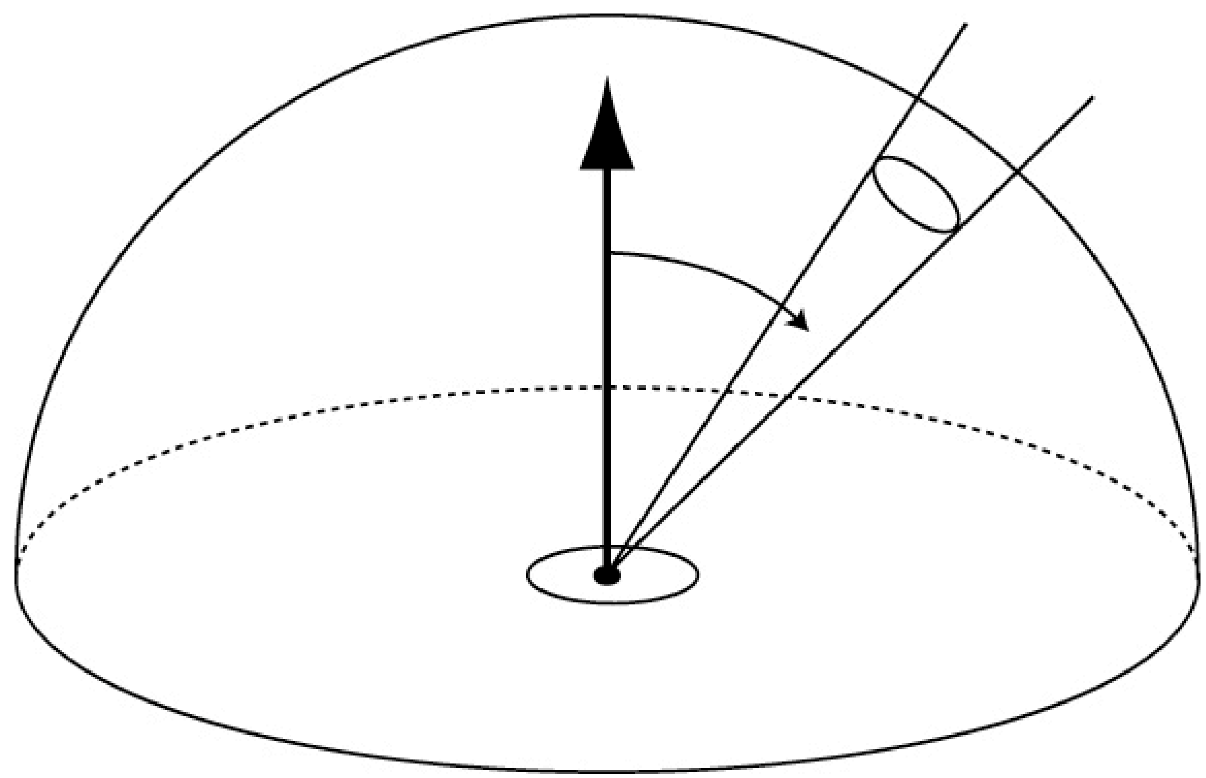


Data Structures for Light

- Environment maps

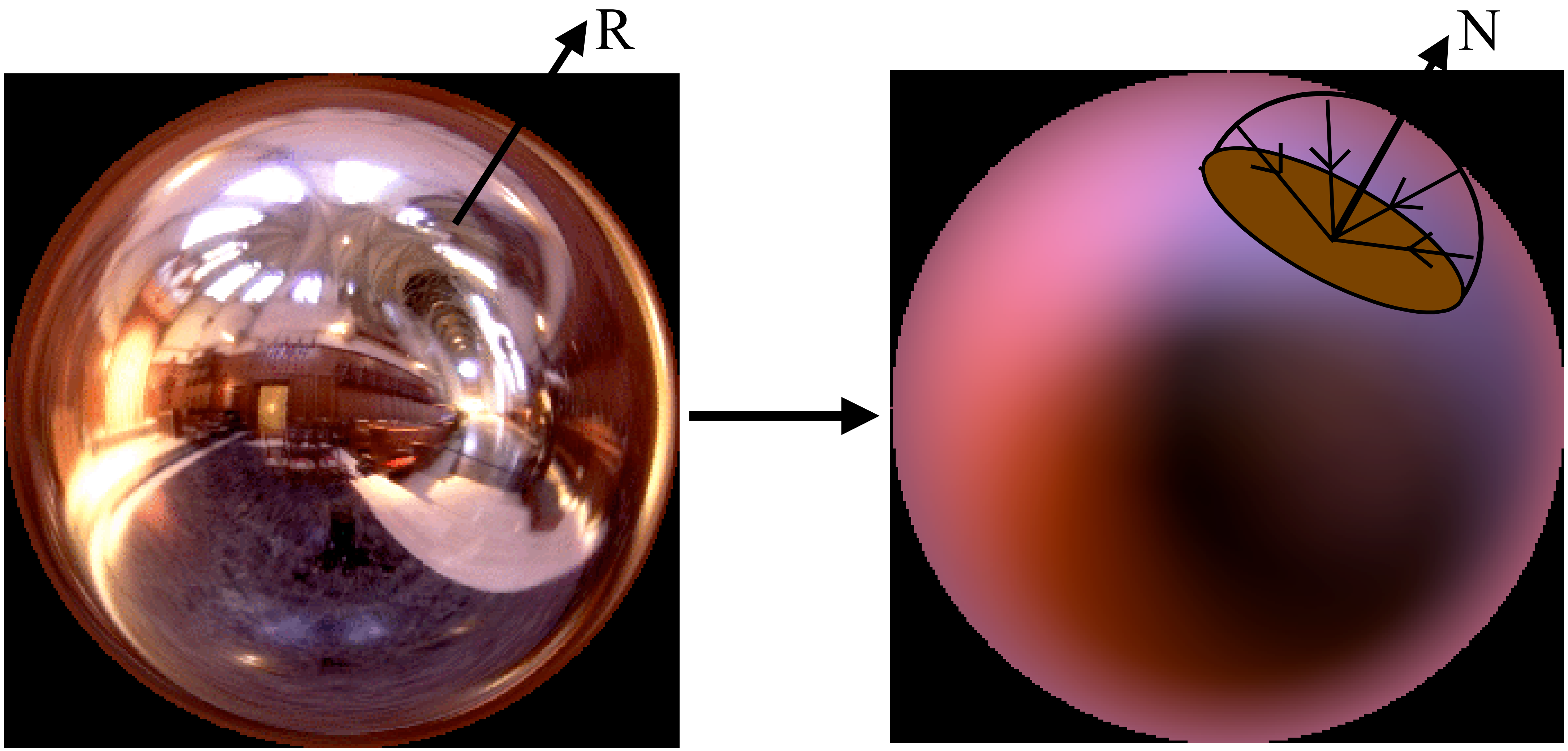


Hemispherical Irradiance



$$E = \int_{\Omega} L(\omega) \cos\theta d\omega$$

Irradiance Environment Maps



Tone Mapping

- Computer displays: ~1-100 nits
- Real scenes:
  - 600,000 sun at horizon
  - 8,000 clear sky
  - 100-1000 typical office
  - 1-10 street lighting
  - 0.25 cloudy moonlight

$$\int_\lambda V(\lambda) L(\lambda) d\lambda$$

Approaches to Tone Mapping

- Spatially uniform vs spatially varying?
  - Doesn't need to be monotonic
- Preserving just noticeable differences (JNDs)

$$\Delta Y(Y_a) = 0.0594 \times (1.219 + Y_a^{0.4})^{2.5}$$

- Histogram methods

Approaches to Tone Mapping

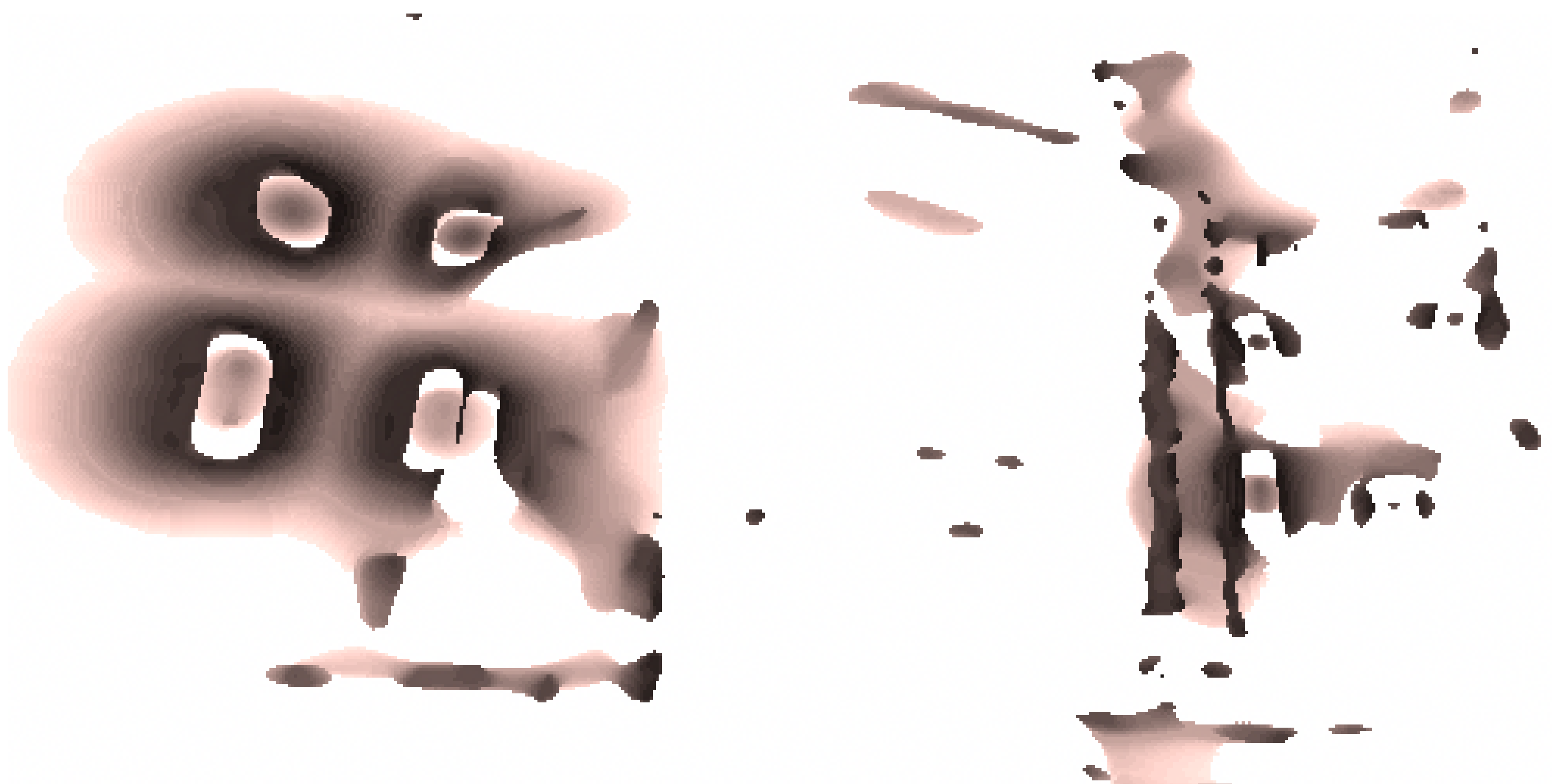
- How to compute adaptation luminance?
  - Average
  - log average
  - spatially varying: uniform radius
  - spatially varying: varying radius

Tone Mapping

- Uniform radius for adaptation luminance gives halo artifacts

Tone Mapping

- Computing radius based on local contrast



Tone Mapping

- Demos...