

Real-time global illumination in interactive applications and games

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GEOMETRY – VISIBILITY – ILLUMINATION

GAMETOOLS

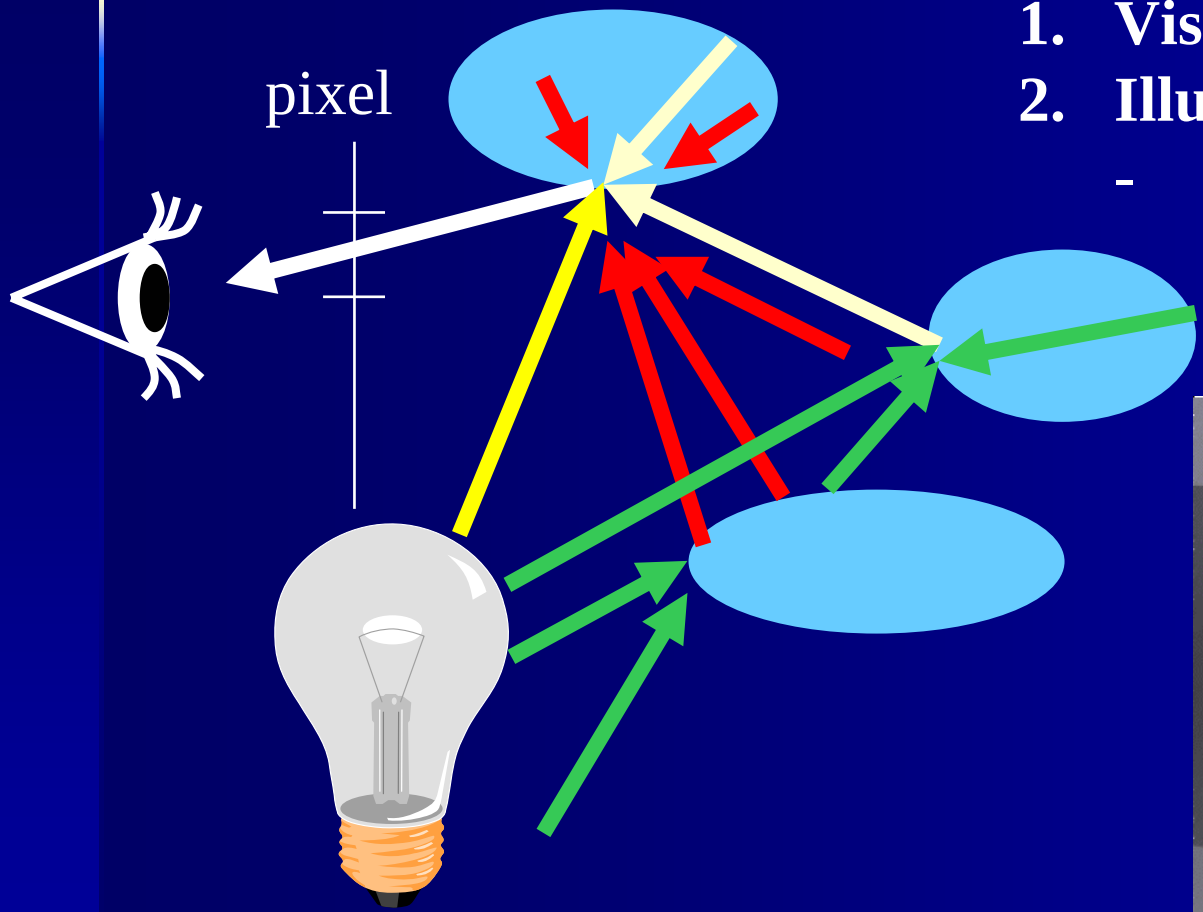
Motto

In theory, there is no difference between theory and practice.

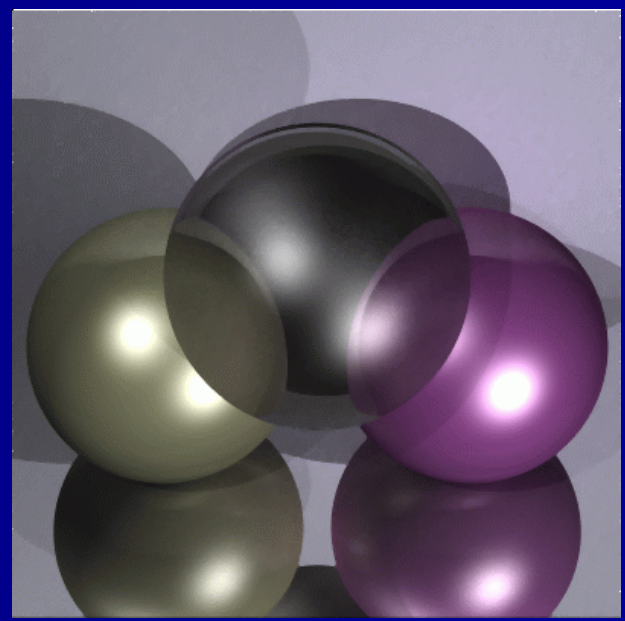
In practice, there is.

$$L(\mathbf{x},\omega) = L^e(\mathbf{x},\omega) + \int_{\Omega'} L(\mathbf{y},\omega') f_r(\omega',\mathbf{x},\omega) \cos^+ \theta'_{\mathbf{x}} \, d\omega',$$

Global Illumination rendering

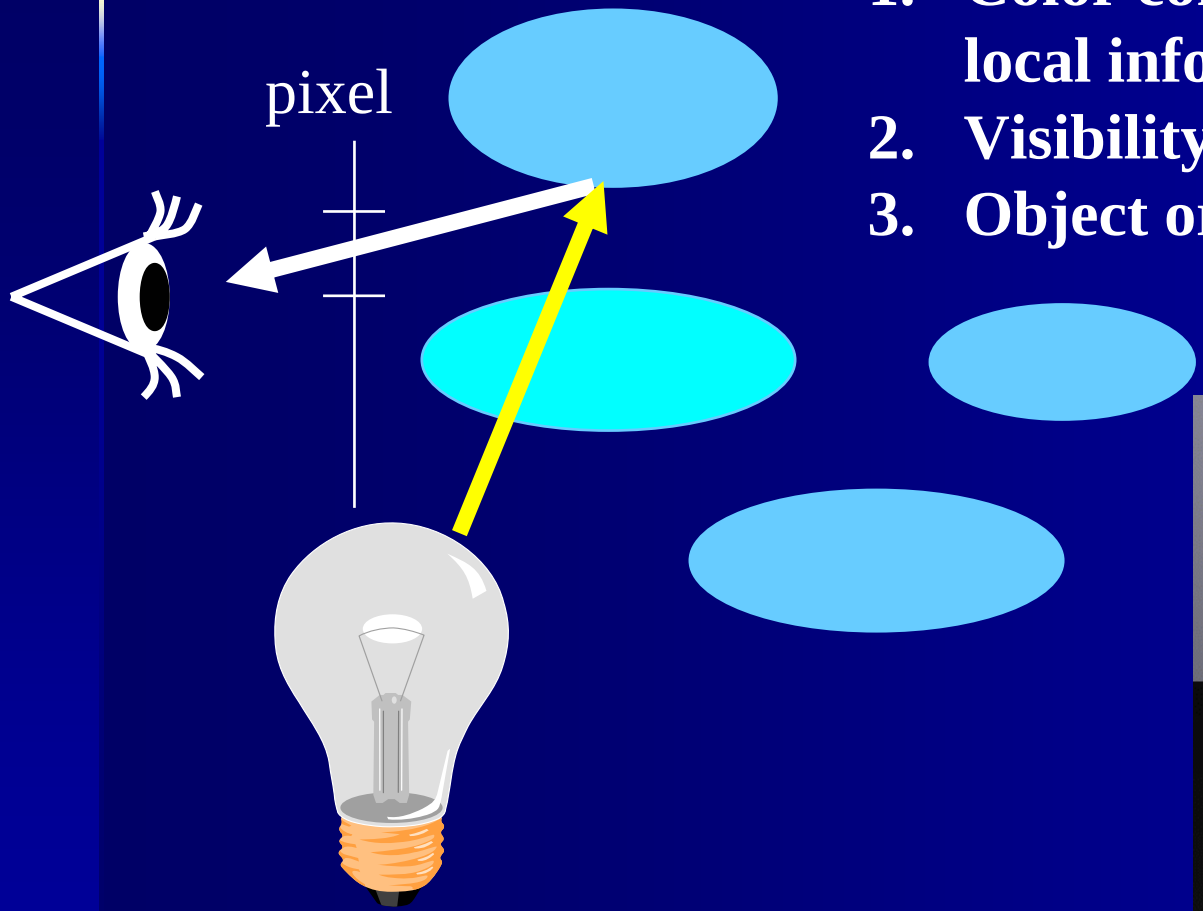


1. **Visibility determination**
2. **Illumination computation**
   - **New visibility and Illumination tasks**

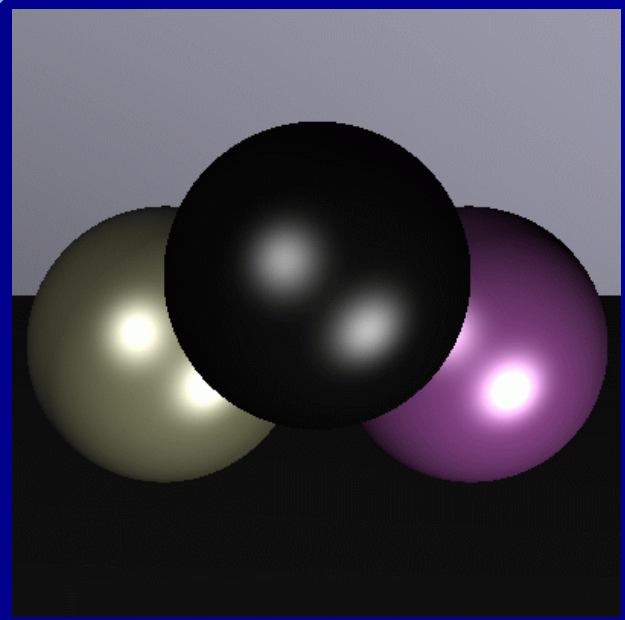


$$L(\mathbf{x},\omega) = L^e(\mathbf{x},\omega) + \sum_l L_l^{in}(\mathbf{x}) f_r(\omega_l', \mathbf{x}, \omega) \cos^+ \theta_l',$$

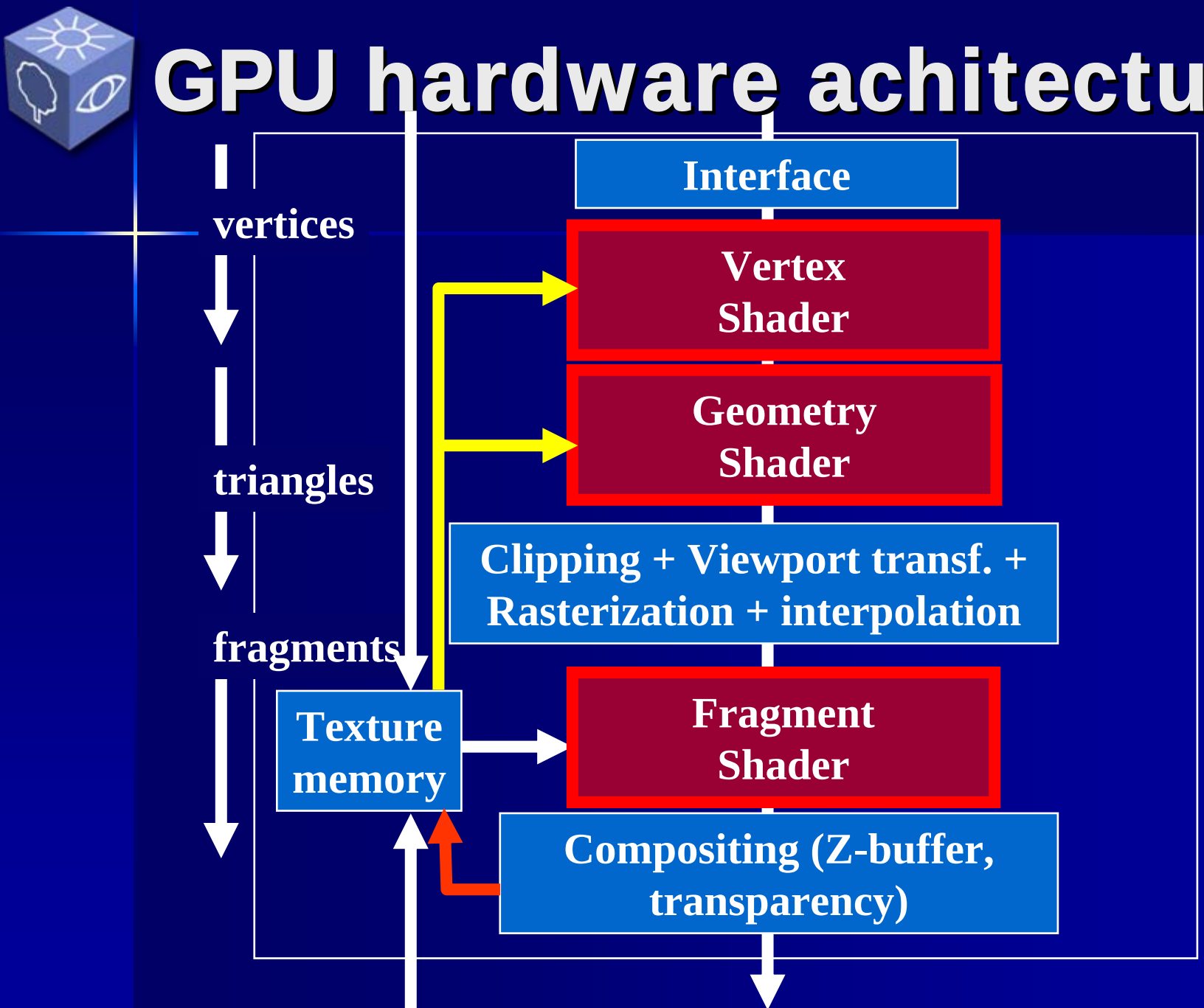
Pure Local Illumination



1. **Color computation uses just local information**
2. **Visibility only from the camera**
3. **Object order is free**



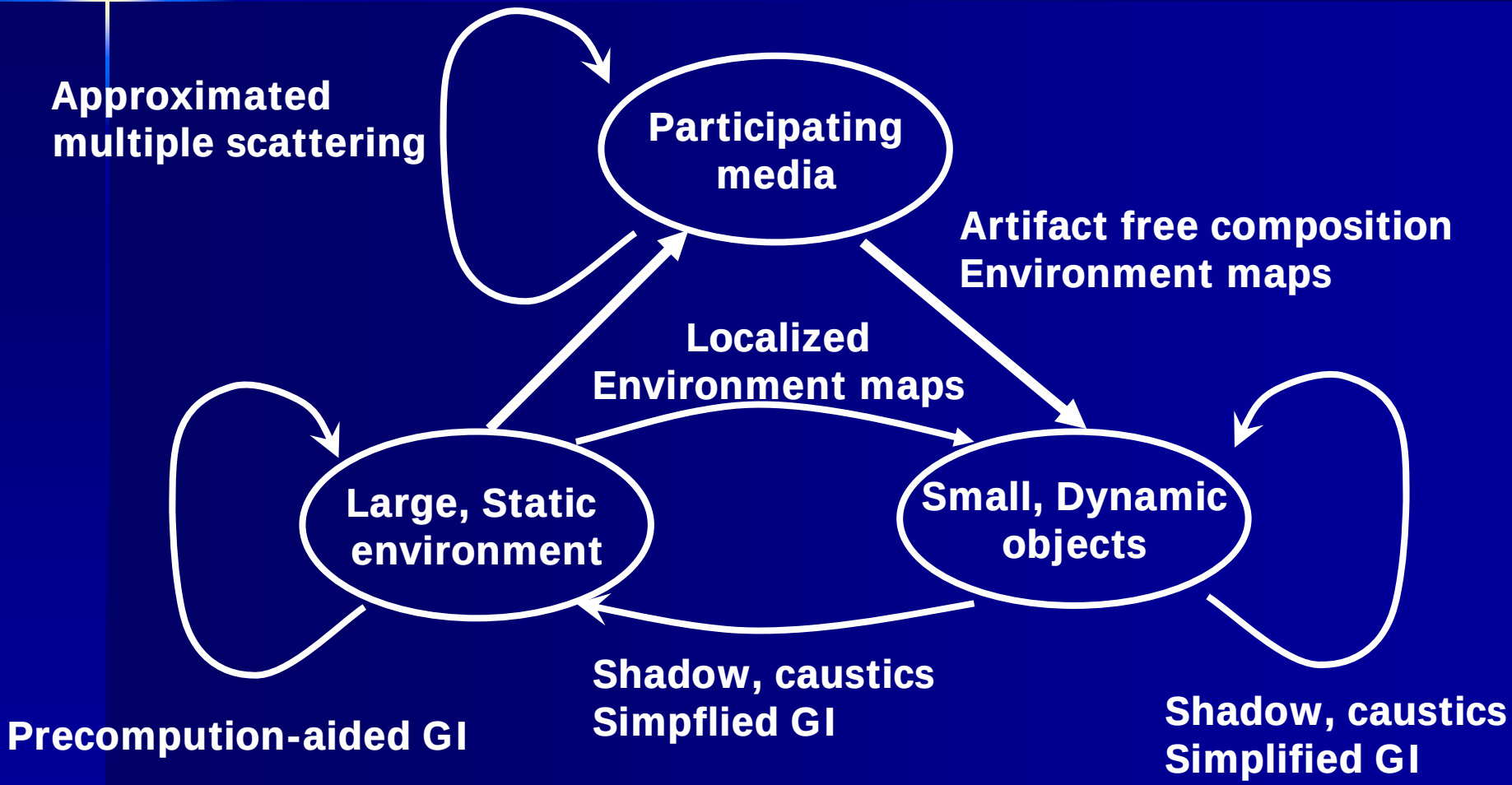
GPU hardware achitecture



Keys to GPUGI

- Importance, reuse, and pre-computation
- Simplification
- Exploit the GPU
  - **Multipass rendering**
    - Results of a previous pass can only be used
  - **Render-to-texture**
    - Results of one pass can be used by another pass
  - **Floating point textures**
    - HDR radiance and geometric data in texture memory

Simplified GI



Beyond local illumination

Local illumination
Variance Shadow maps

Localized Environment maps
Localized Diffuse/glossy irradiance maps

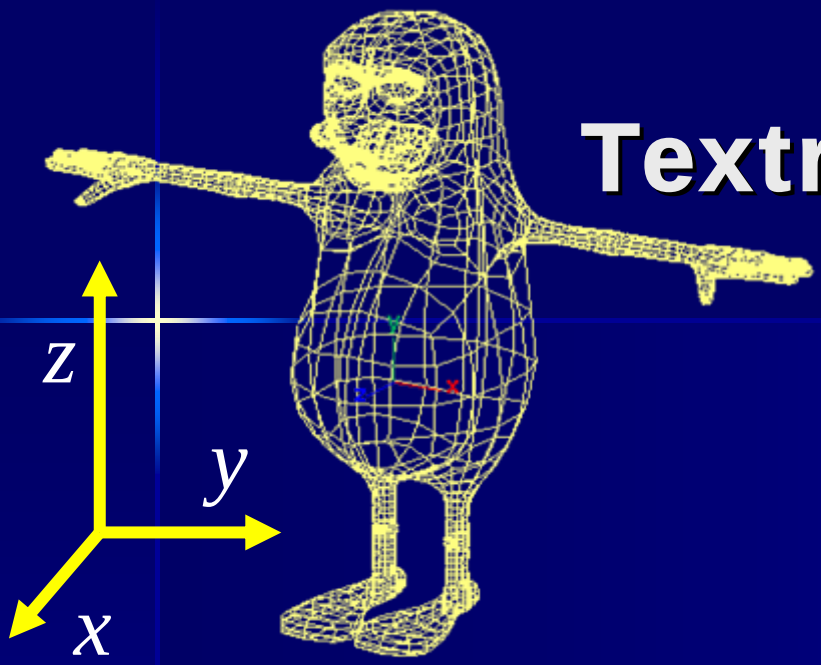
Obscurances,
ambient occlusion,

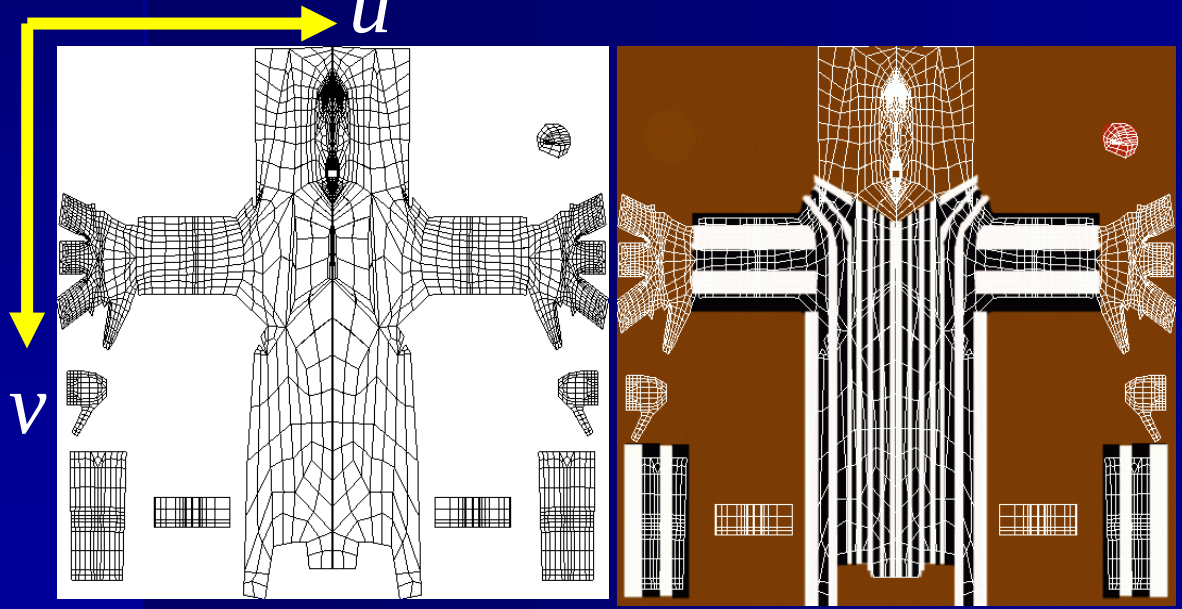
Light path maps

Photon map,
light cube map

Map, Texture

Textrure atlas = unfolding

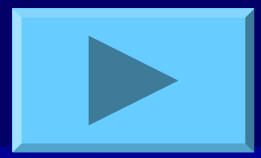


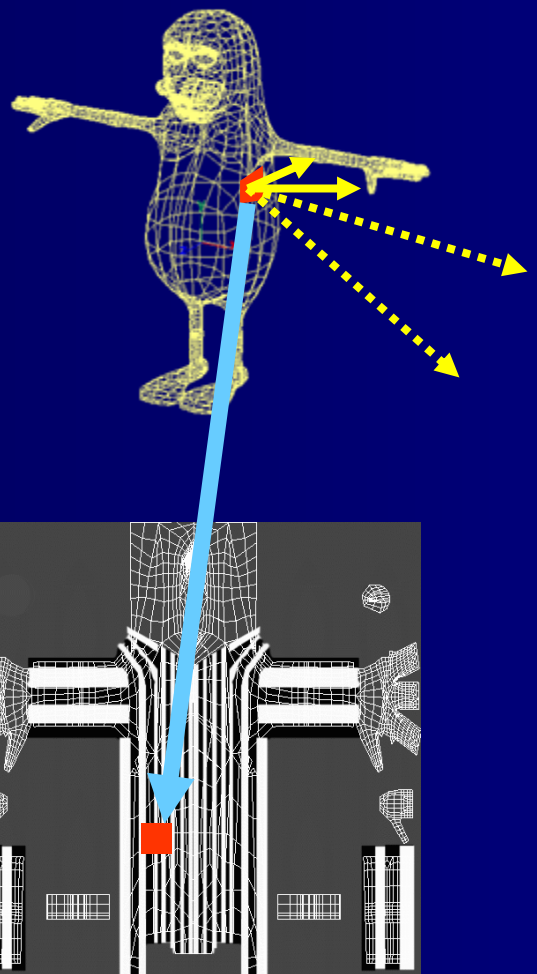


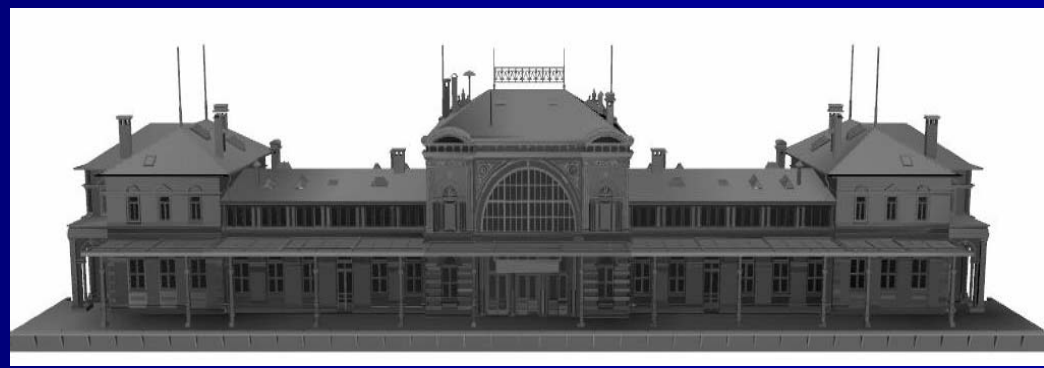
1. Pre-computation aided methods

- Obscurances, ambient occlusion
- Light maps
- Light path maps

Fake methods (obscurances, ambient occlusion)

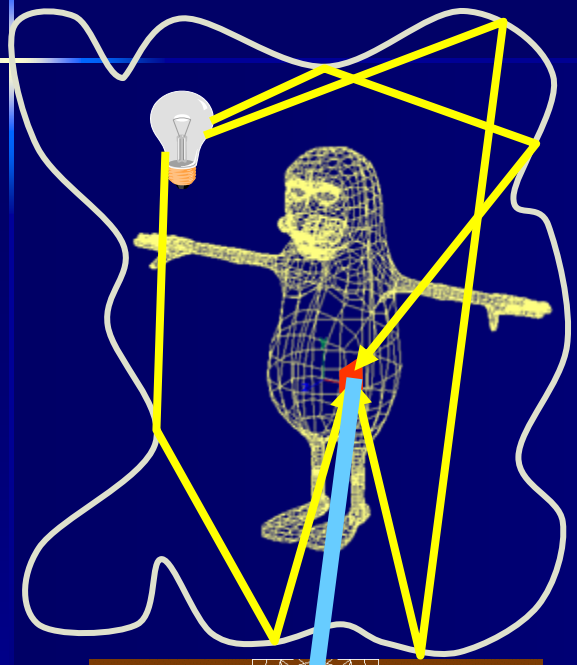






Good for macrostructure and mesostructure

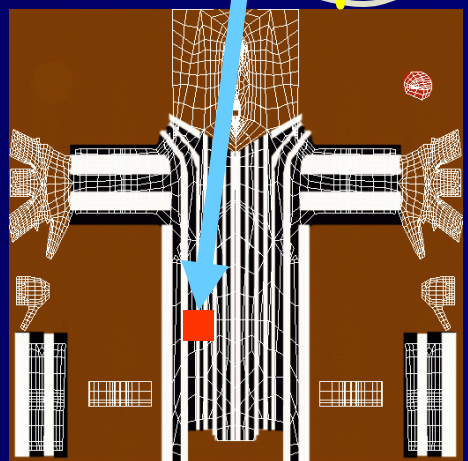
Light maps

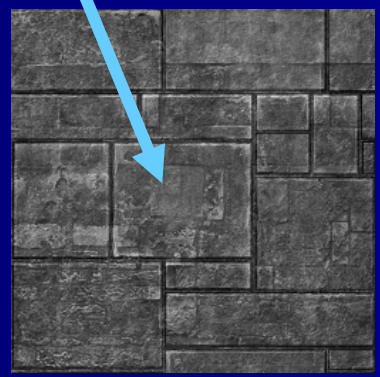


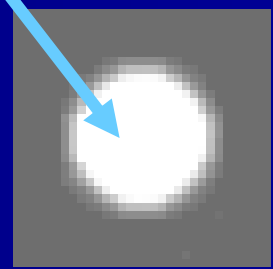
$$\int_{\Omega} L^{in}(x,\omega')\, f(x)\cos\theta' d\omega' =$$

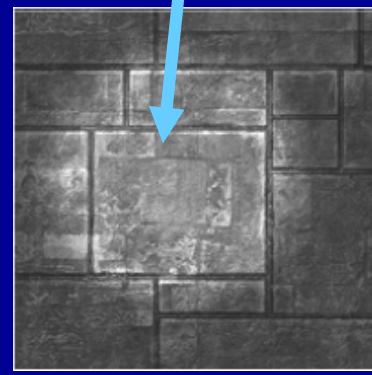
$$f(x)\boxed{\int_{\Omega} L^{in}(x,\omega')\cos\theta' d\omega'} = L(x)$$

Irradiance

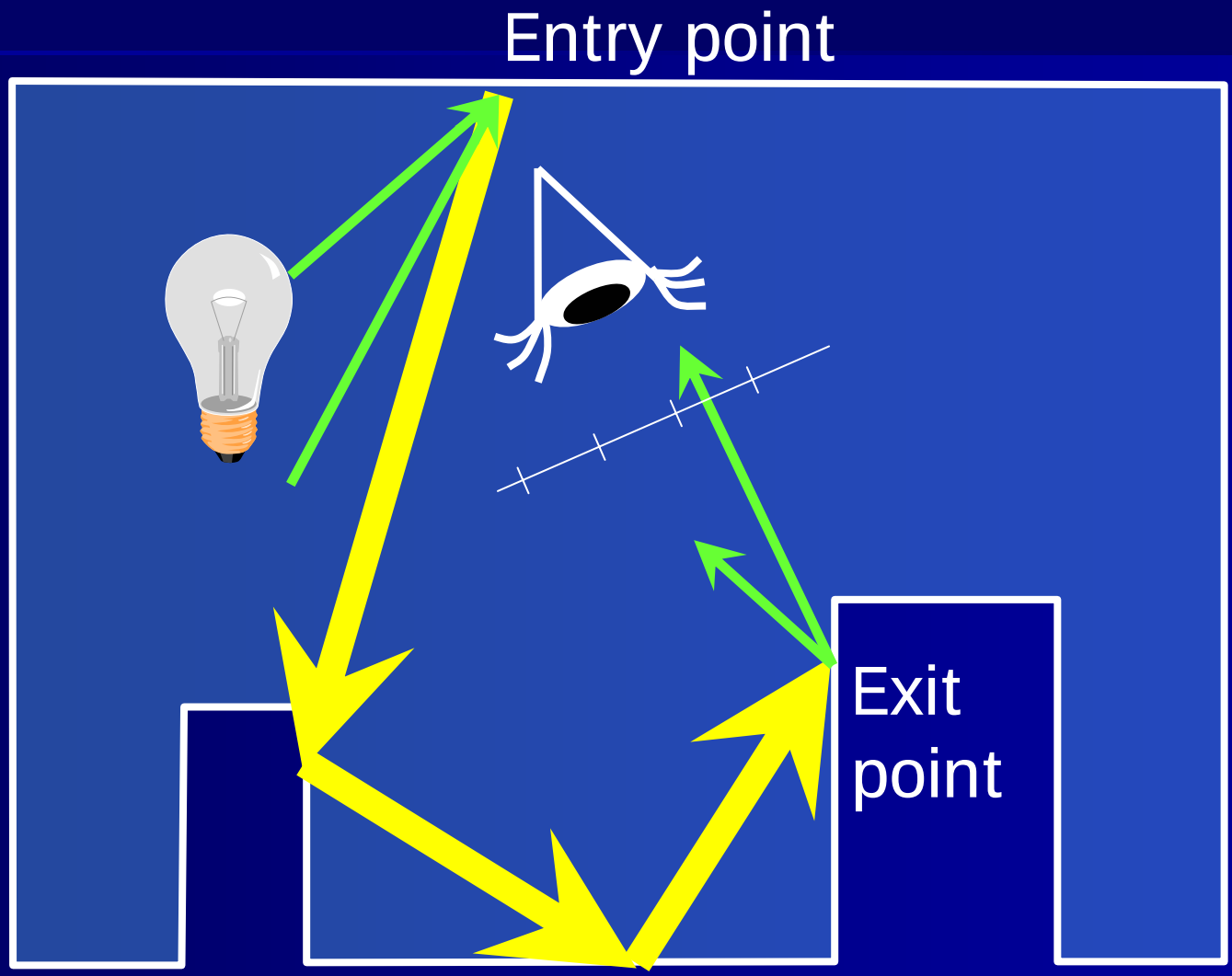






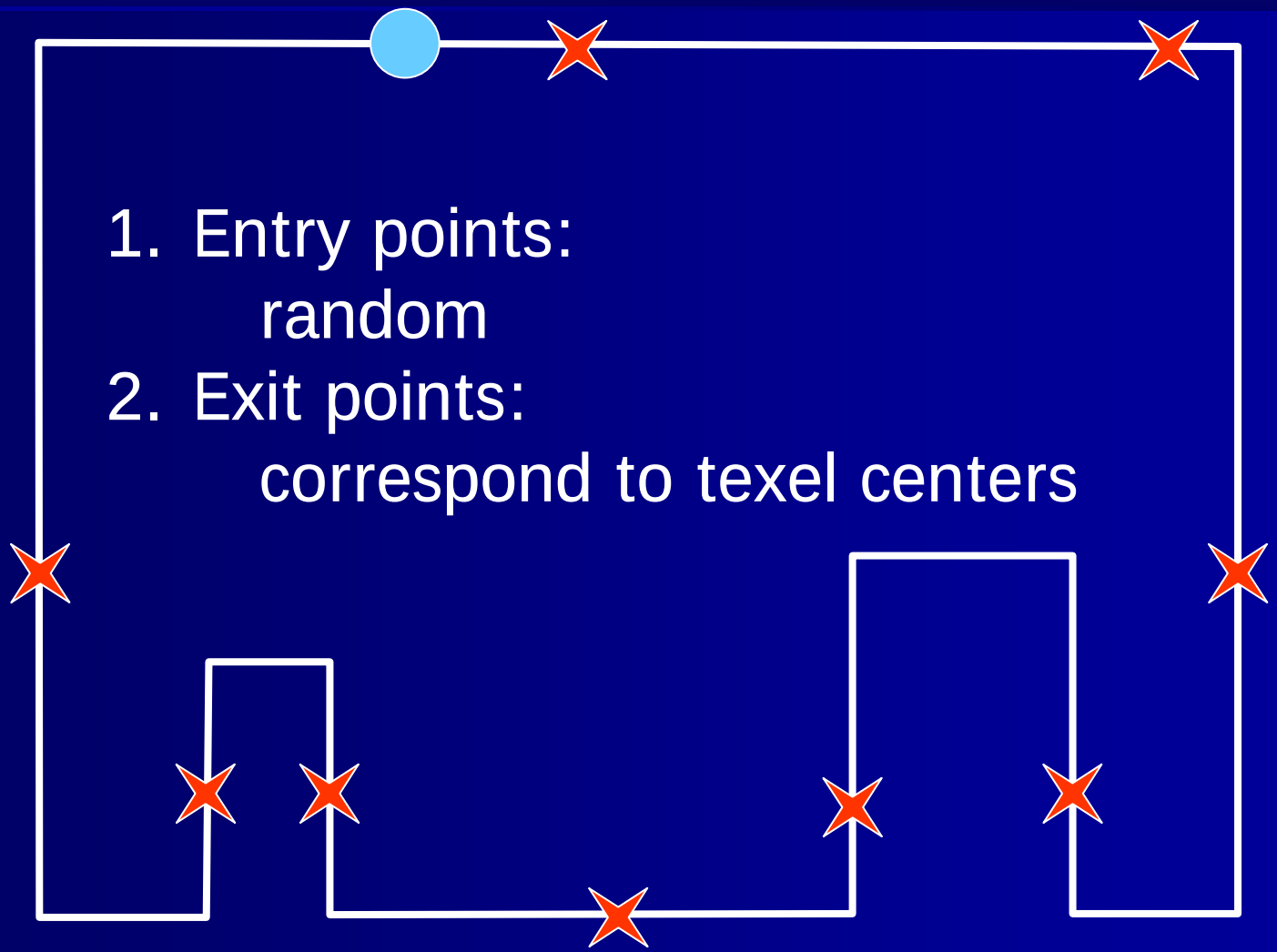


Allowing dynamic lighting

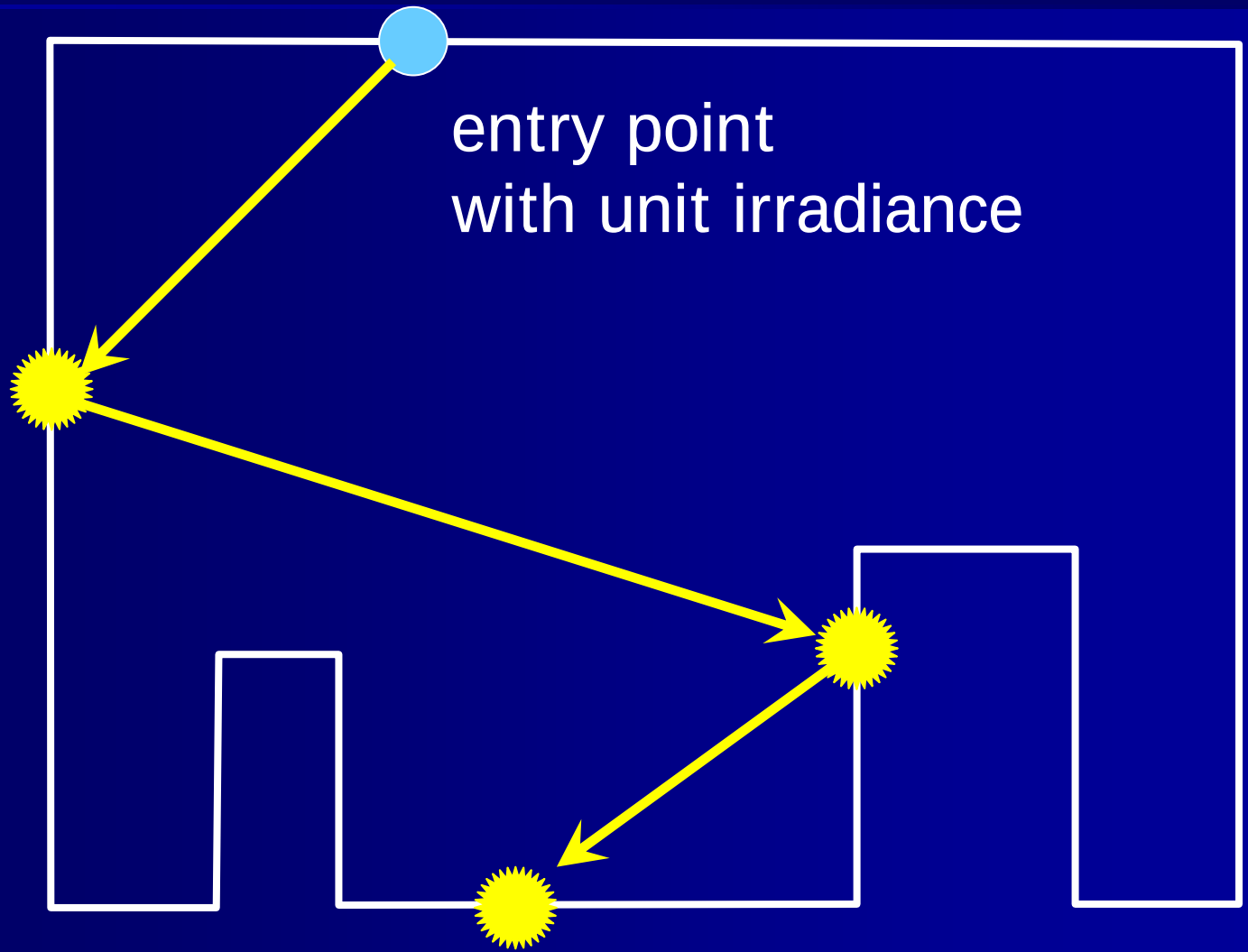


Preprocessing: Exit points

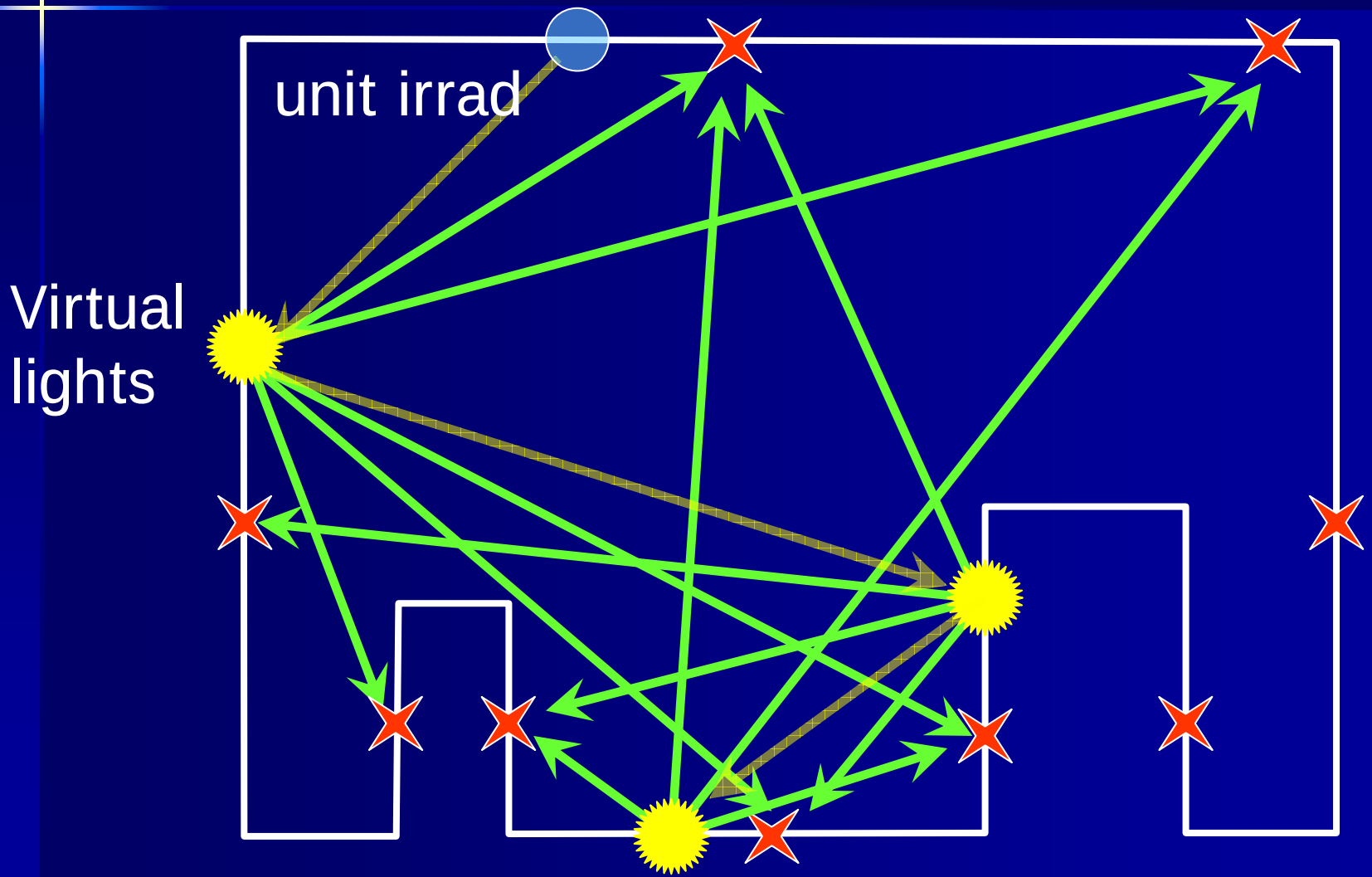
1. Entry points:
   random
2. Exit points:
   correspond to texel centers



Preprocessing: Transfer from entry to exit points

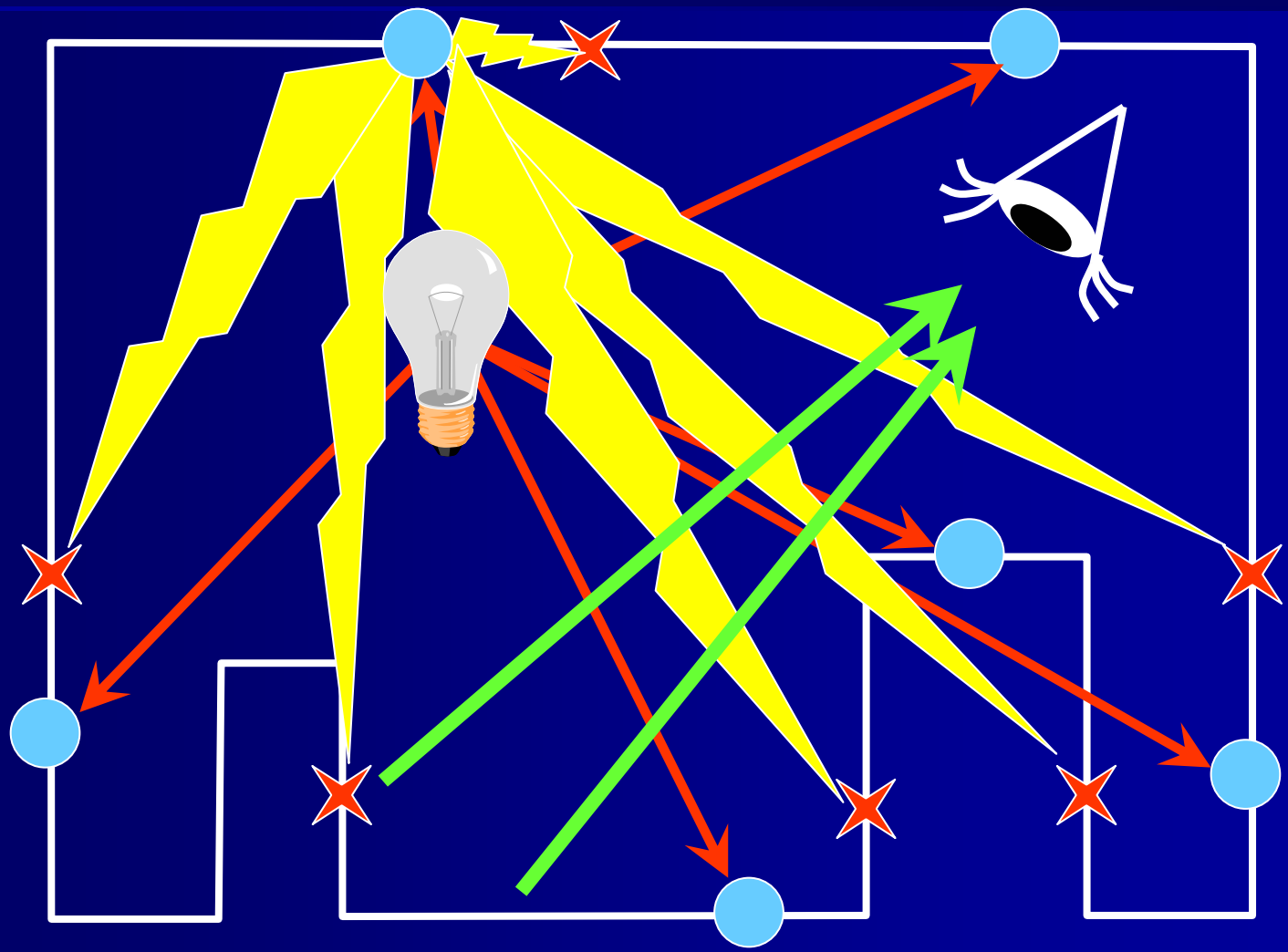


Preprocessing: Reference point illumination




50.07 fps @ 640 x 480
Vsync off (640x480), X8R8G8B8 (D24X8)
HAL (hw vp): NVIDIA GeForce 6800 GT
www.fraps.com
Tone scale
35.52
Show Help
Move light
Look from light
Entry points
Turbo
PRM
[R] Reset
[X] Save
[L] Load

Having the transfer factors



Results: Room with stairs

16K entries
32 clusters
4Mb per obj

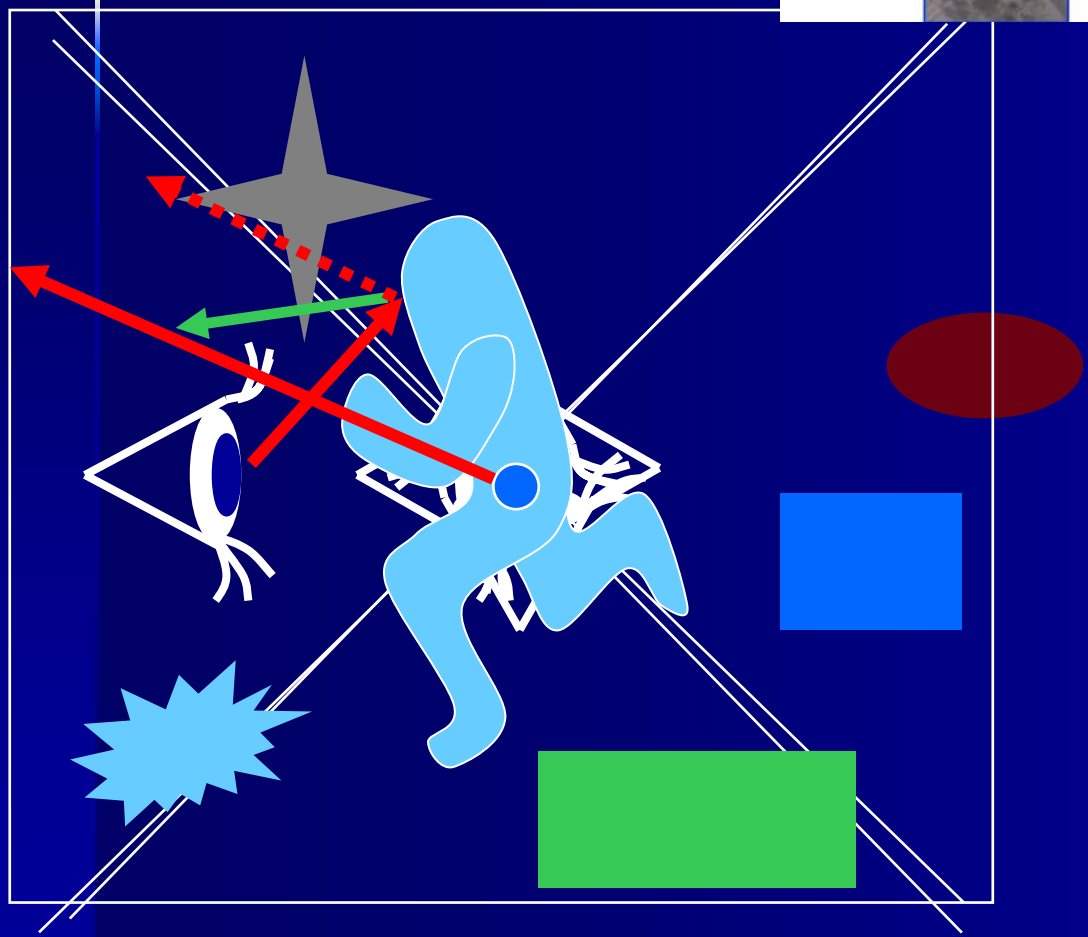
50 FPS

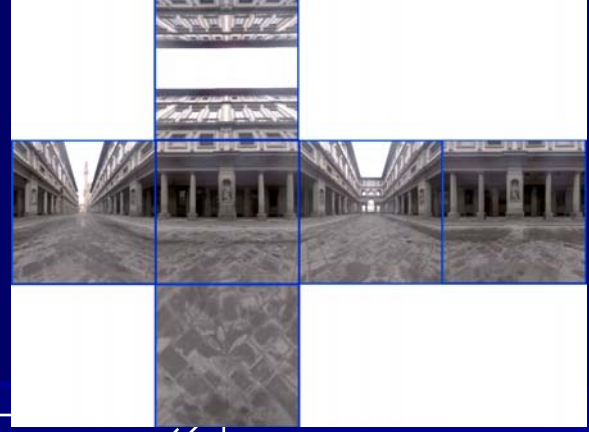
2. Environment map based techniques

- Specular reflections and refractions
- Diffuse/glossy indirect illumination

- Global/localized approaches

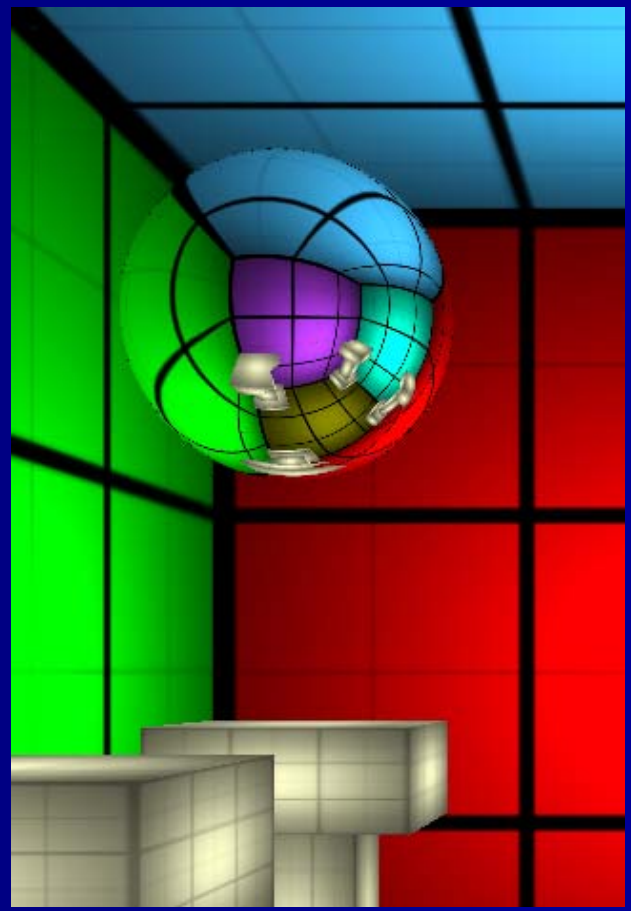
Environment mapping





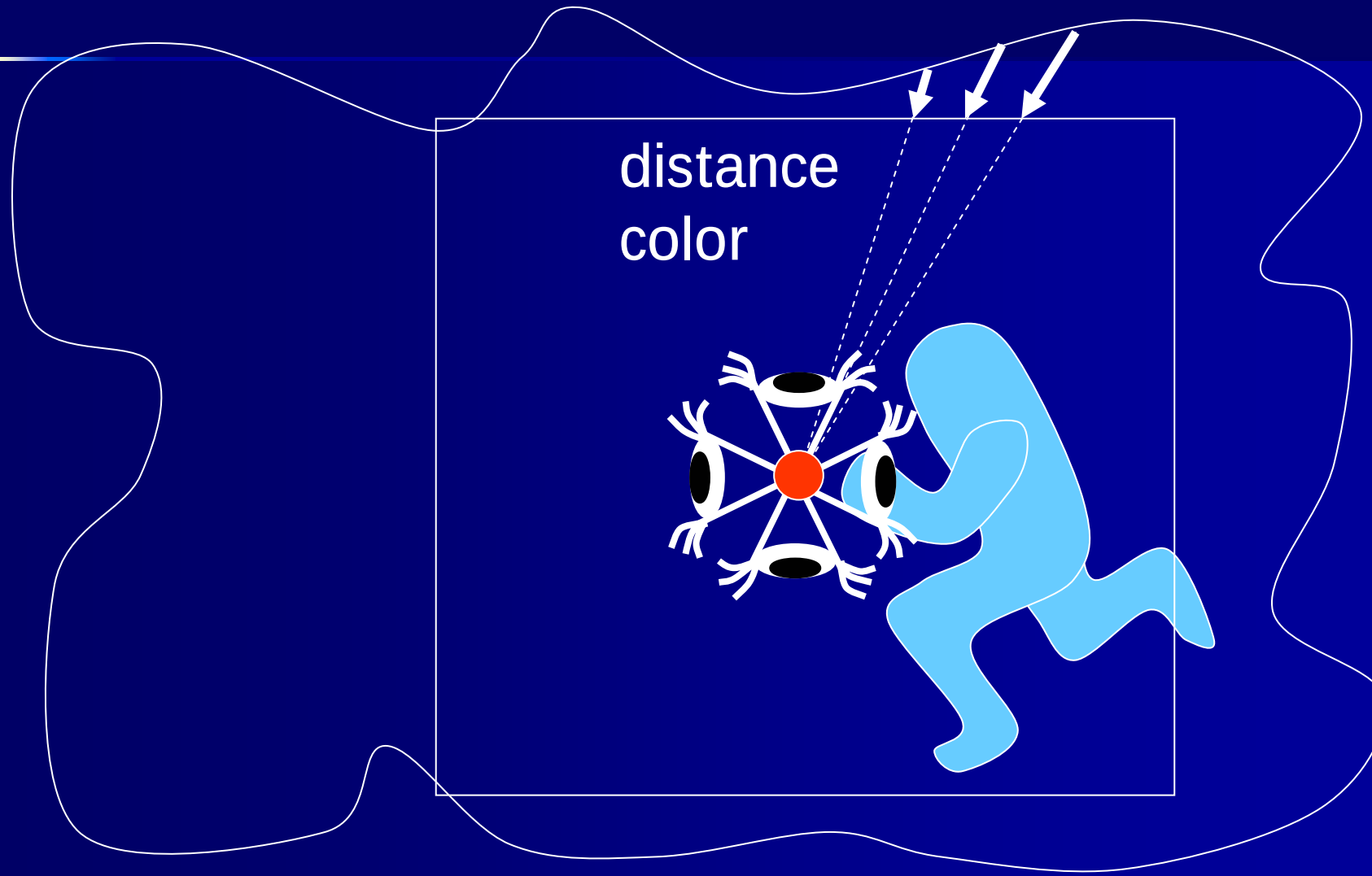
Problems of environment map based reflections

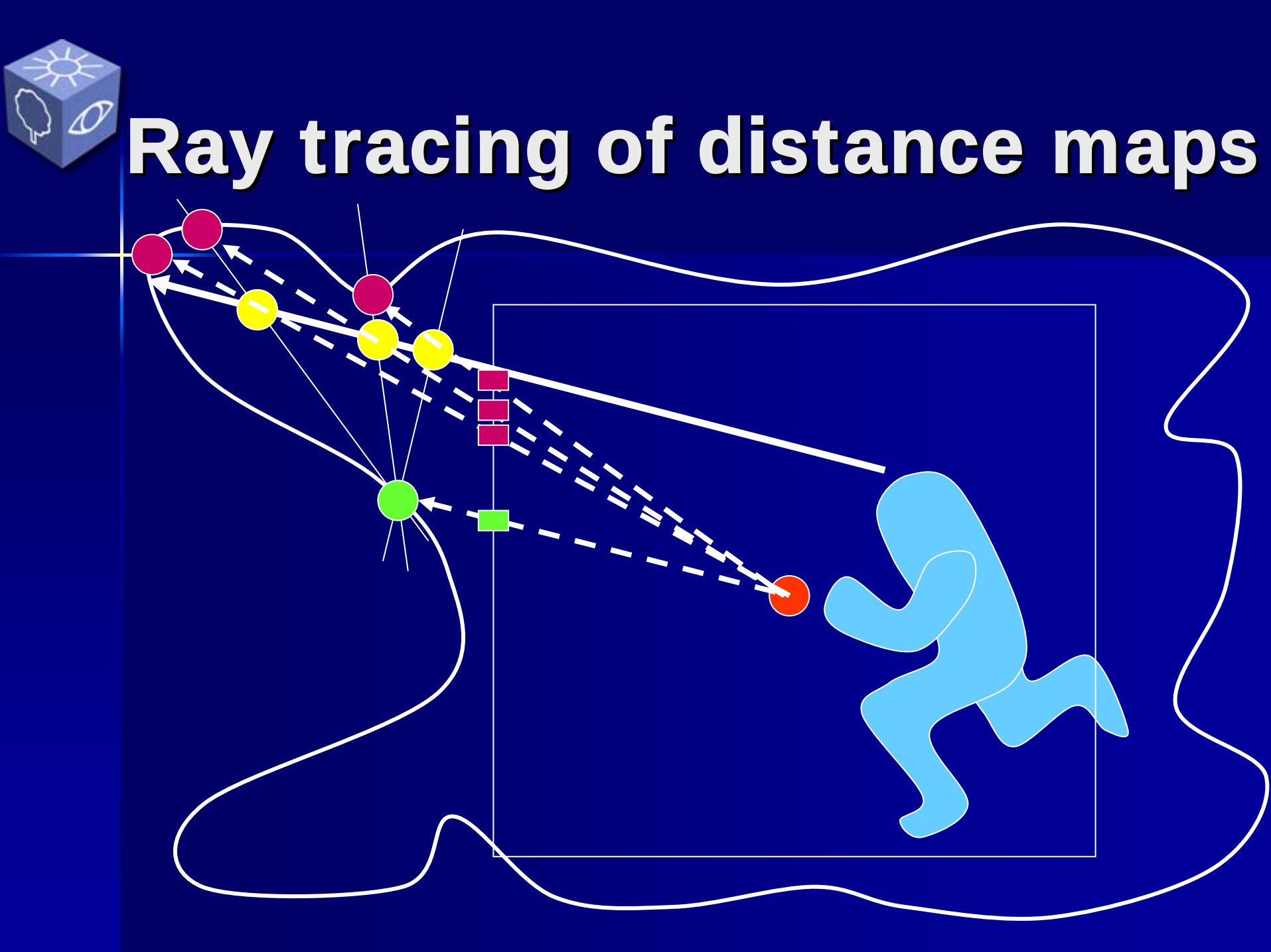
Environment map



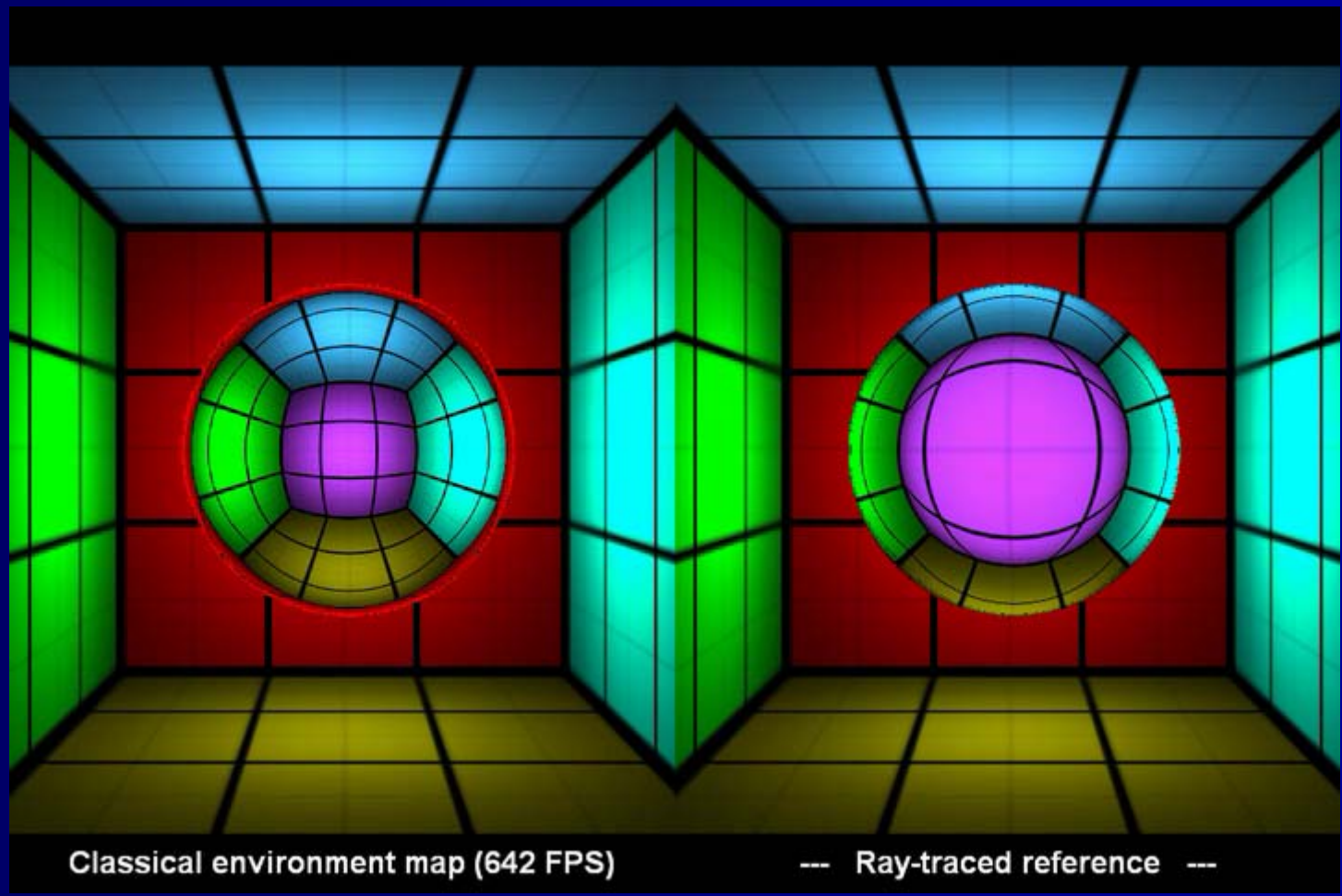
Reference

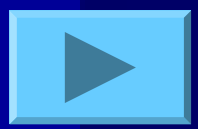
Localization: distance map




Ray tracing of distance maps

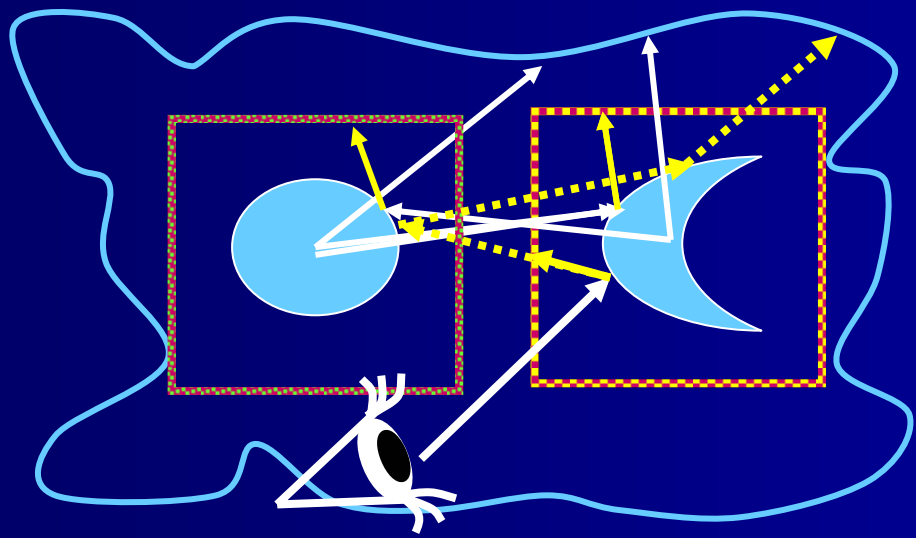
Comparison of Localized Refrections





Multiple interreflections

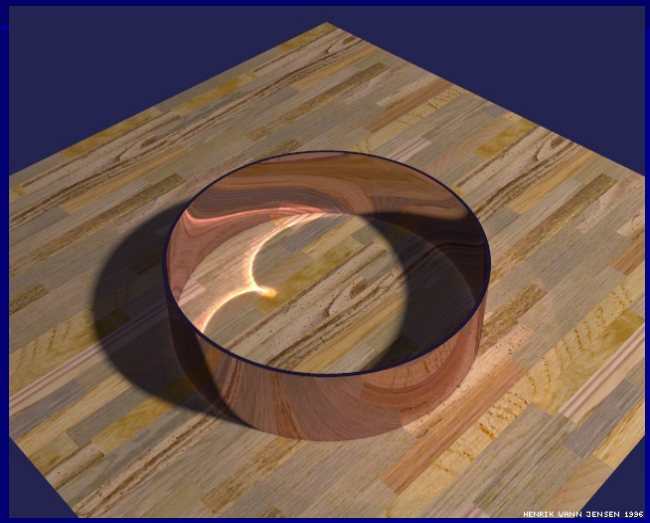
- So far we decomposed the scene to the reflector and to the “rest”
- If all reflectors have their own distance map, it is correct.



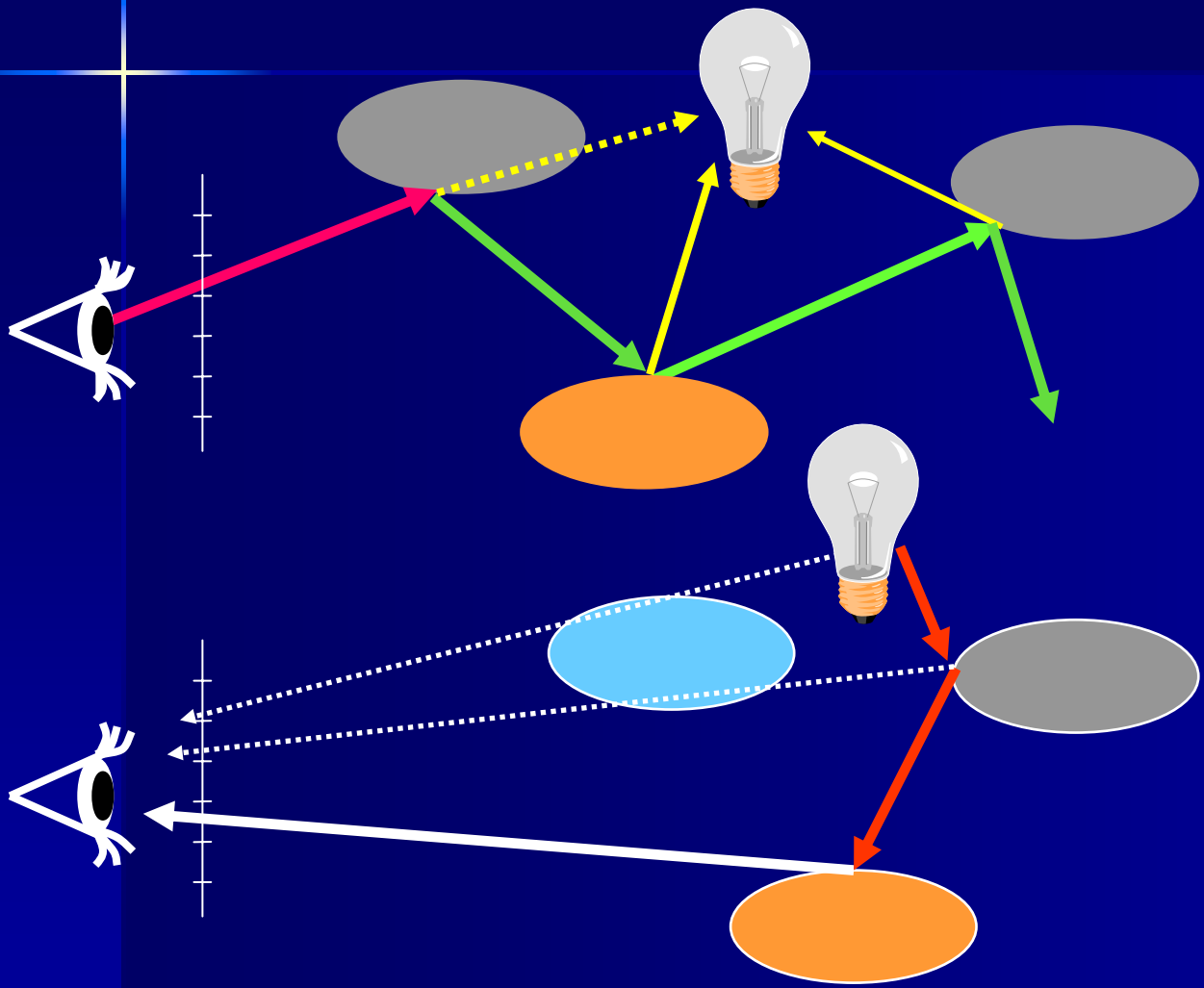
Frame 2

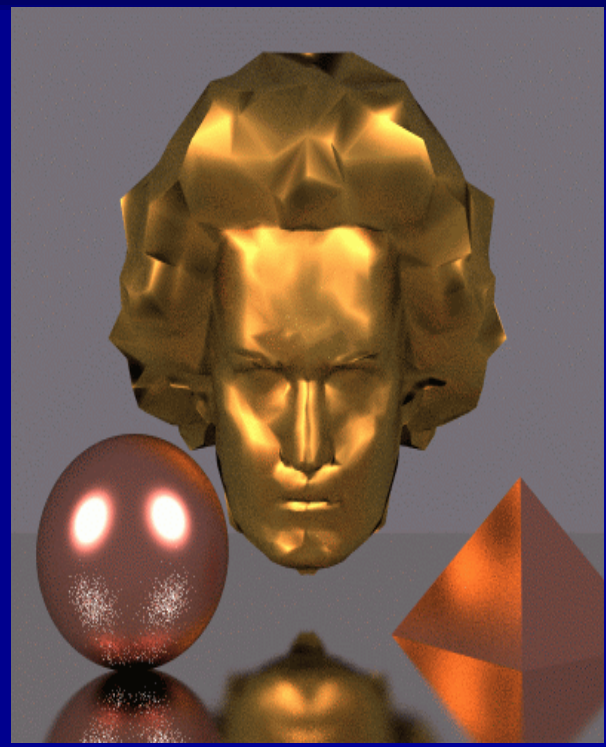
With multiple distance maps

Caustics-Causticus-Kaustikos

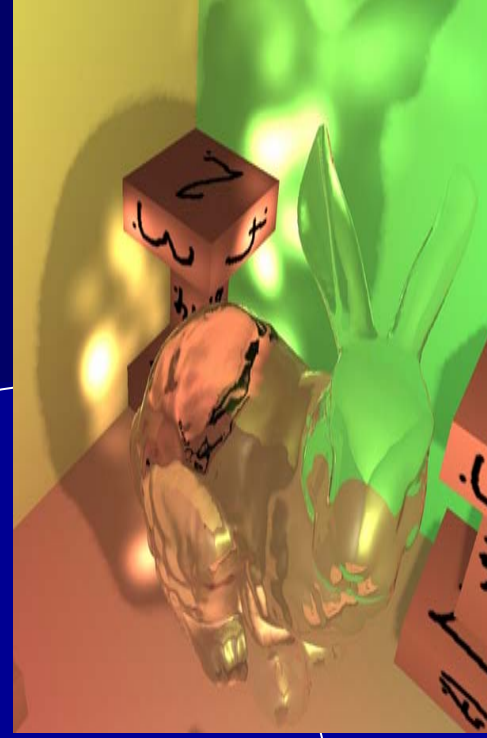


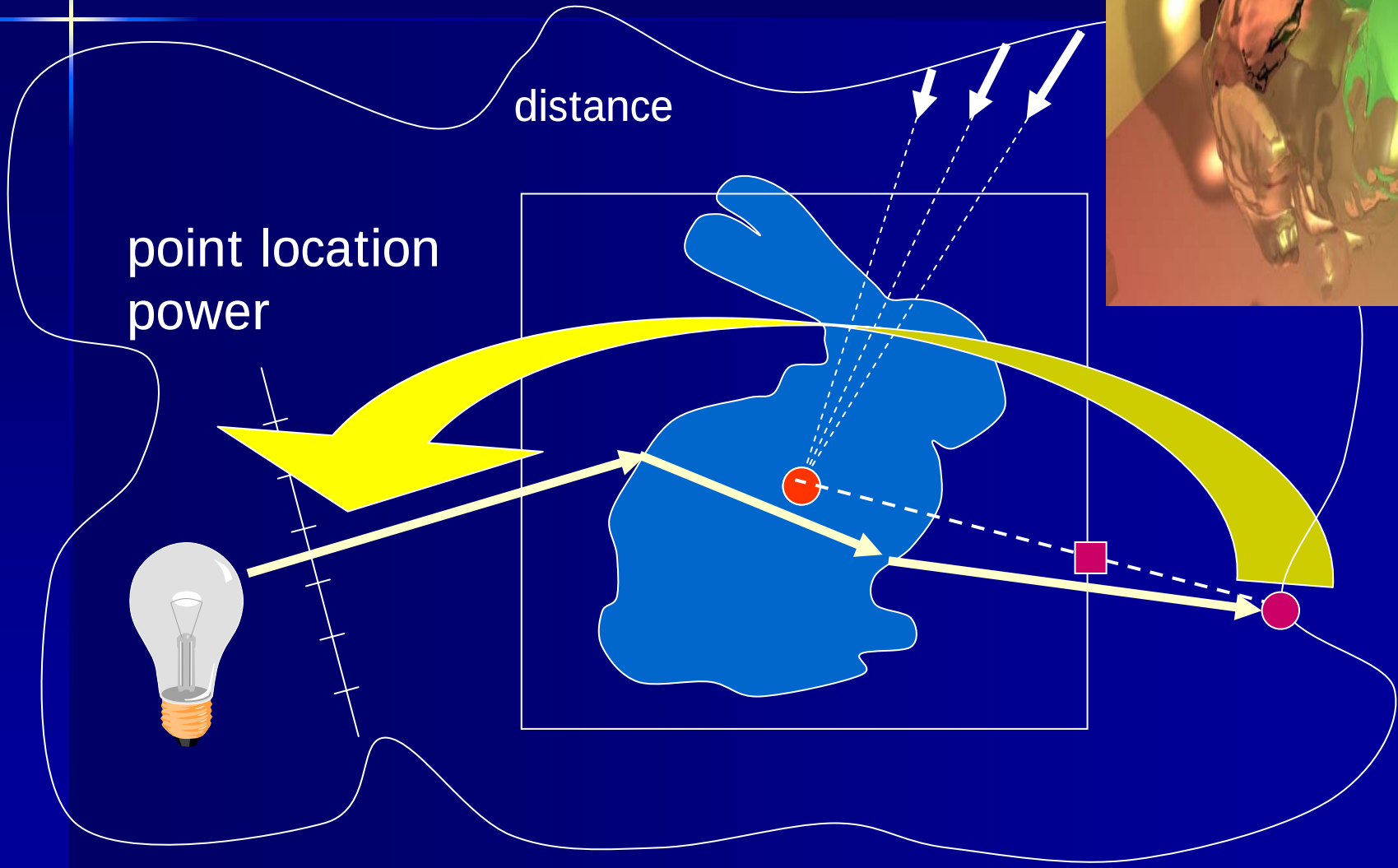
Caustic path generation





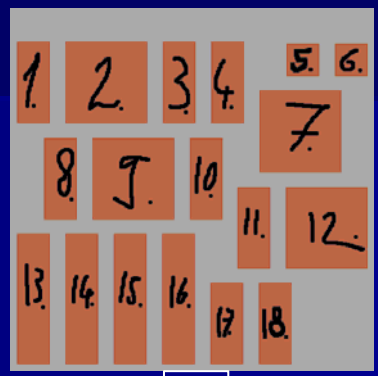
Caustics



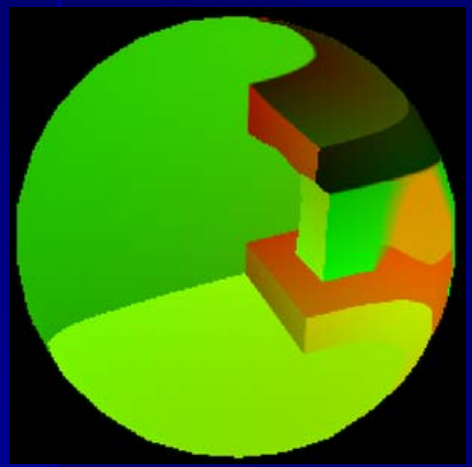


Texture modulation

Quads or points
with dummy pos



Texture uv of
photon positions

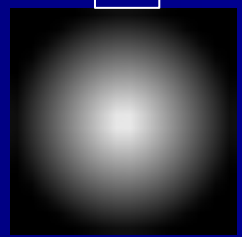


256 x 256

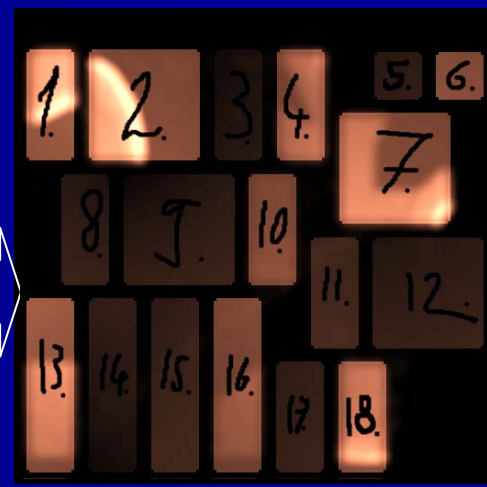
Vertex
shader

Pixel
shader

Billboard
positions

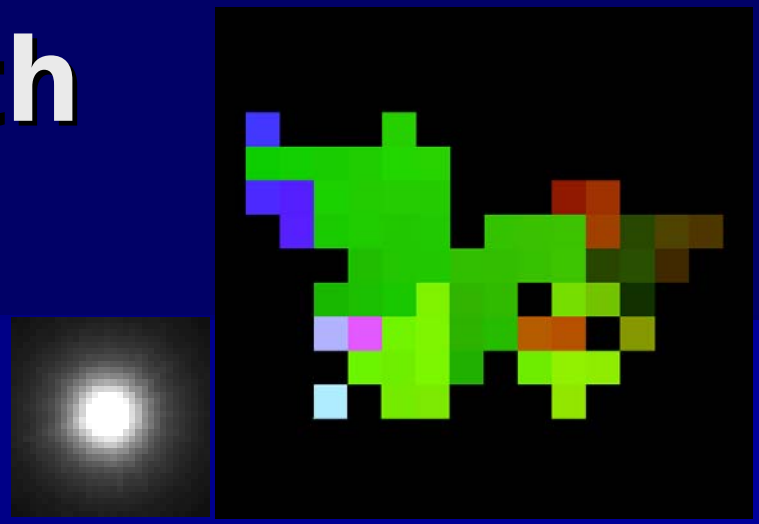


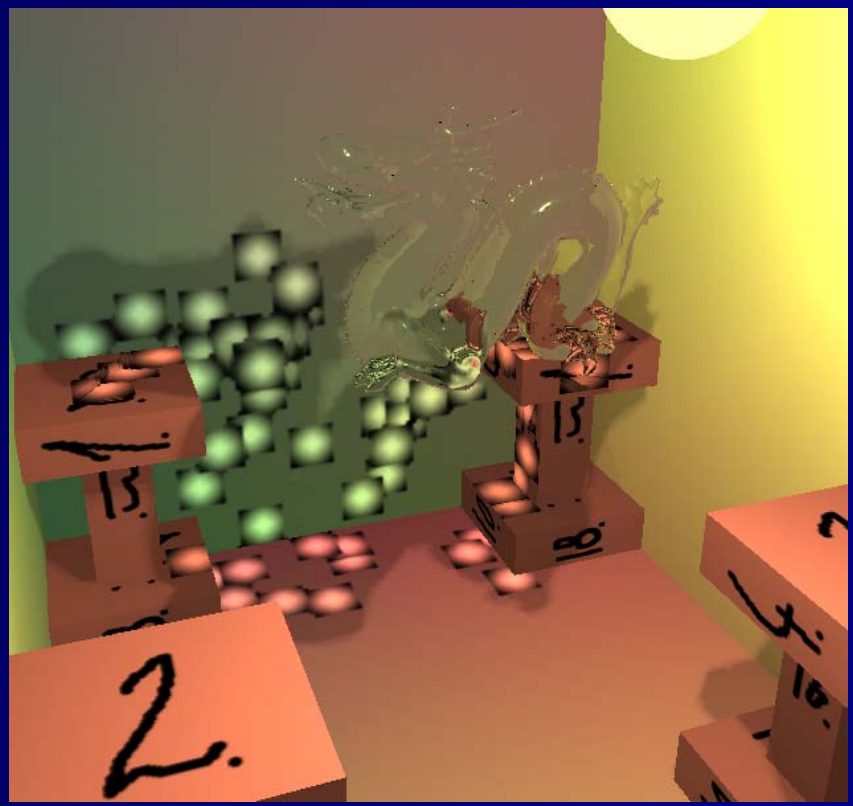
filter

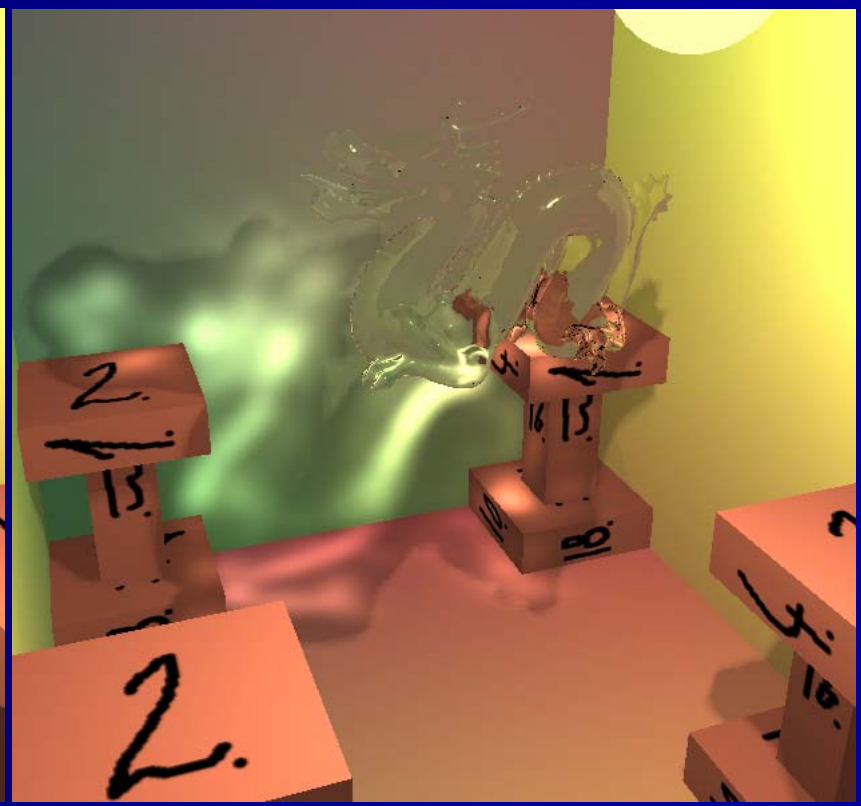


Lit texture or
Light map

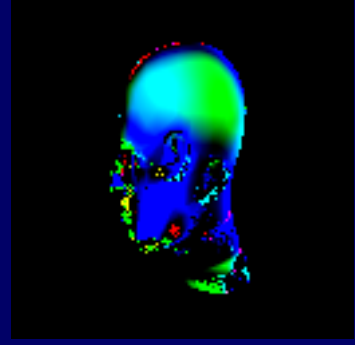
Summation with alpha blending

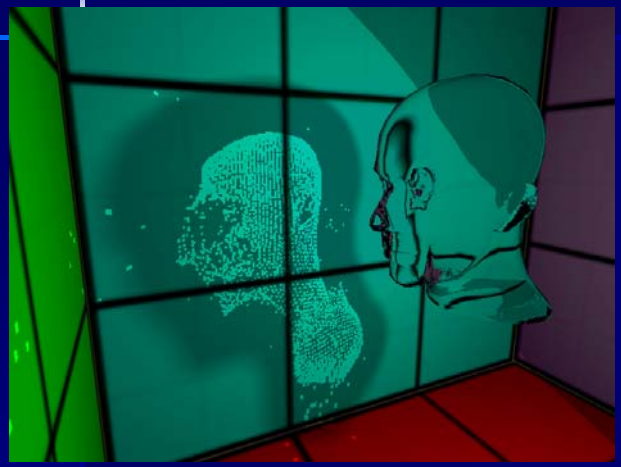


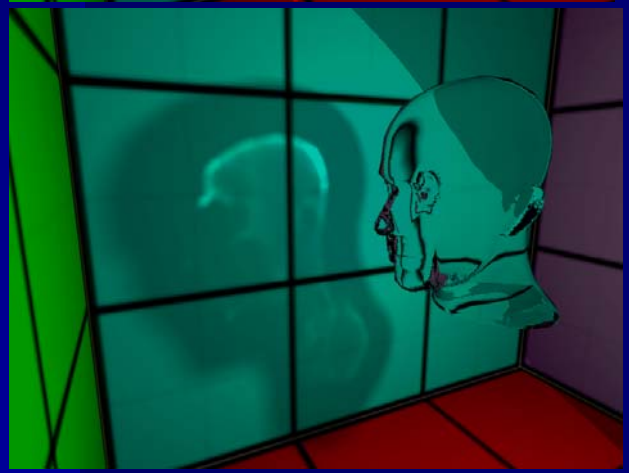


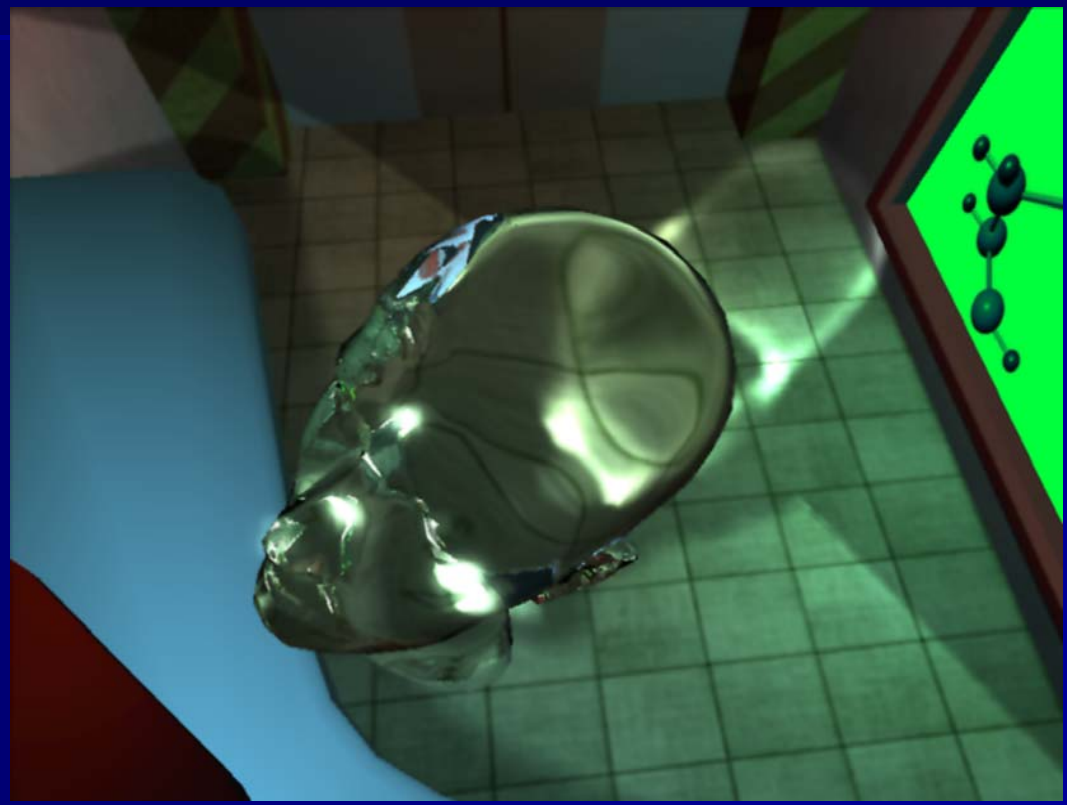


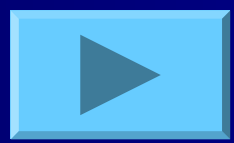
Results (triangle)



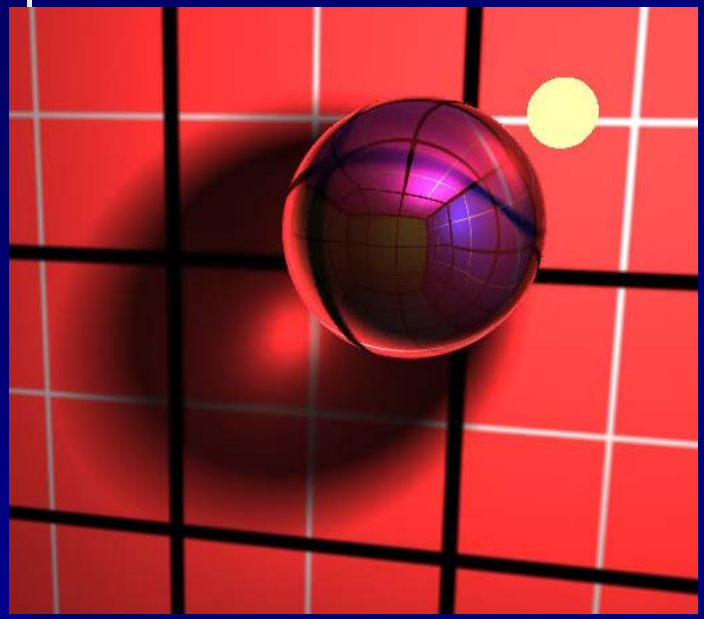


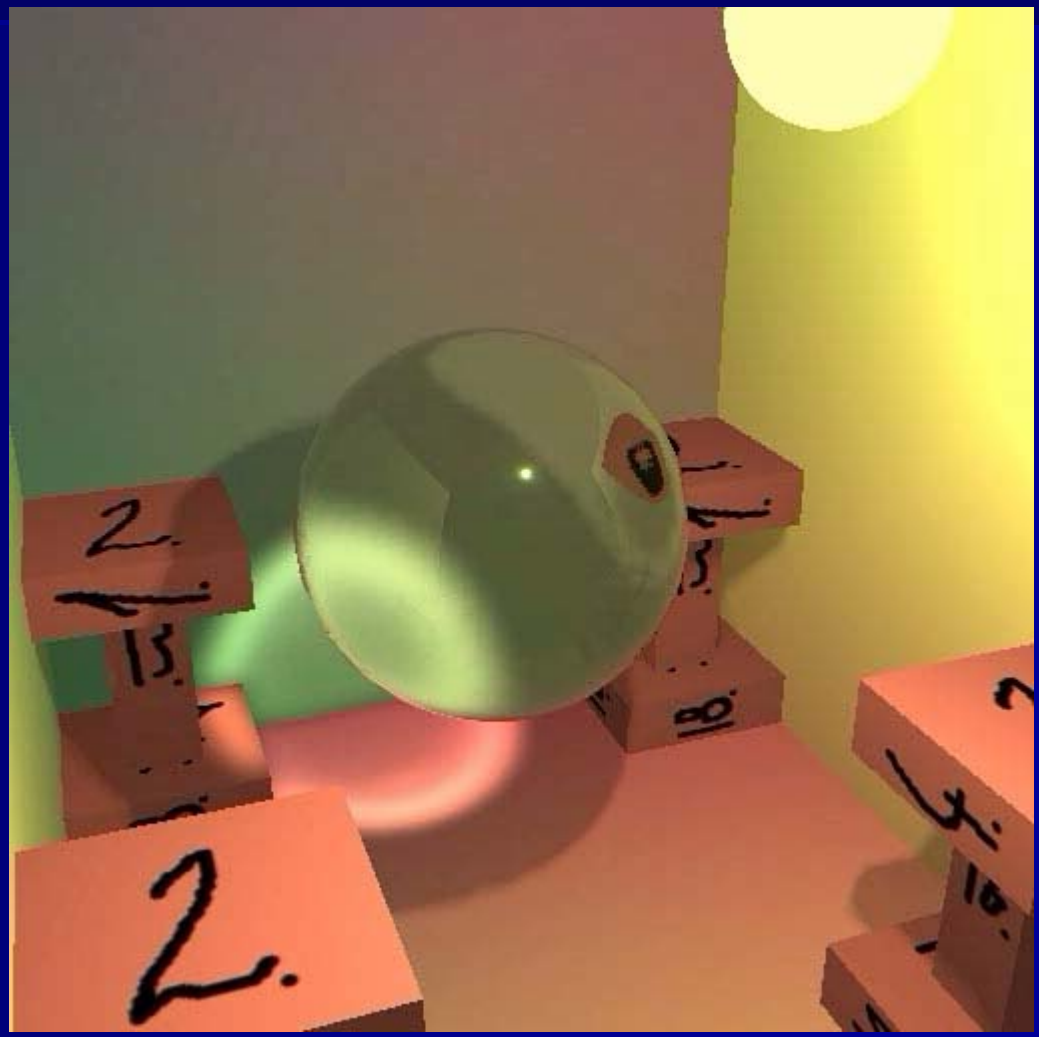




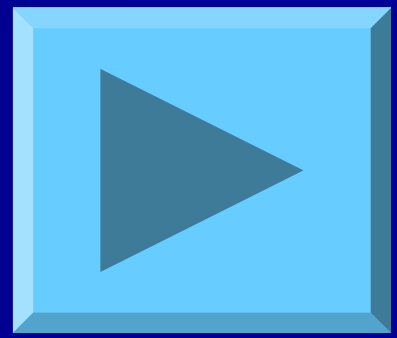


Results (billboards)



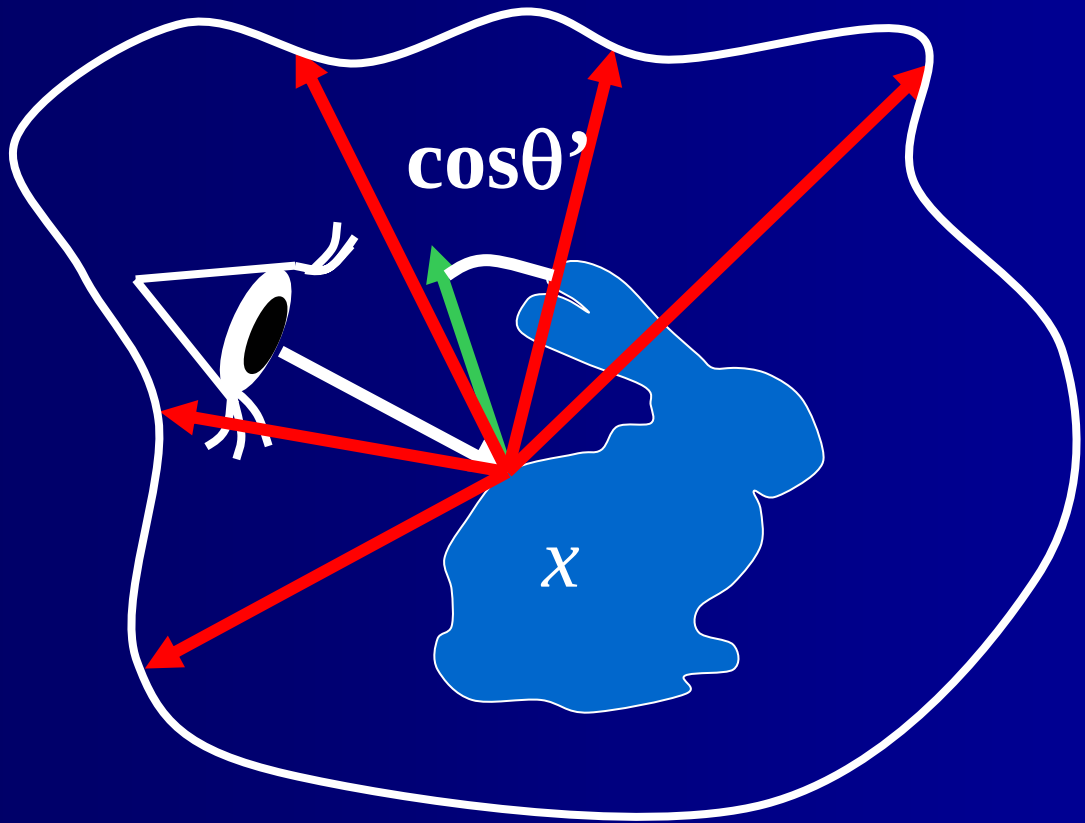


Application: Ray-tracing effects in games

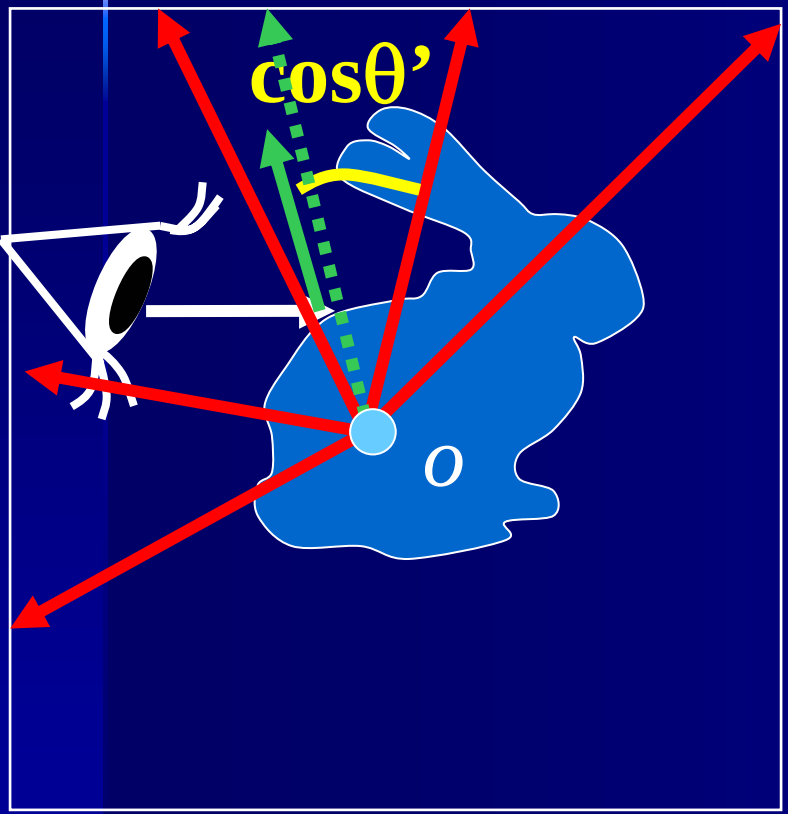


Diffuse / glossy reflection

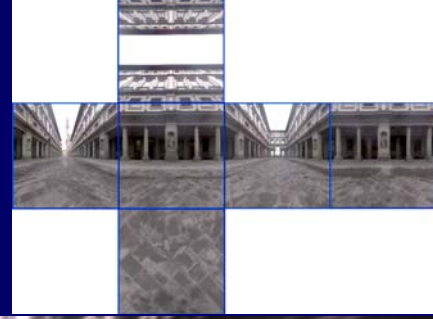
$$L(x, \omega_o) = \int_\Omega L^{in}(y,\omega_i)\, f(\omega_i,x,\omega_o)\, \cos\theta'\, d\omega_i$$

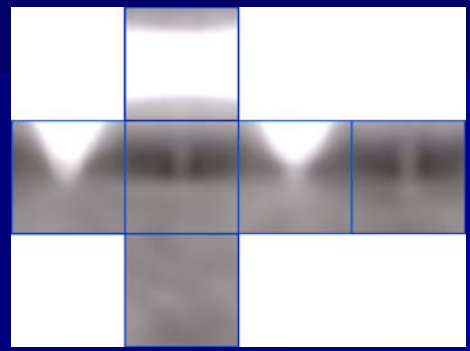


Diffuse / Glossy reflections



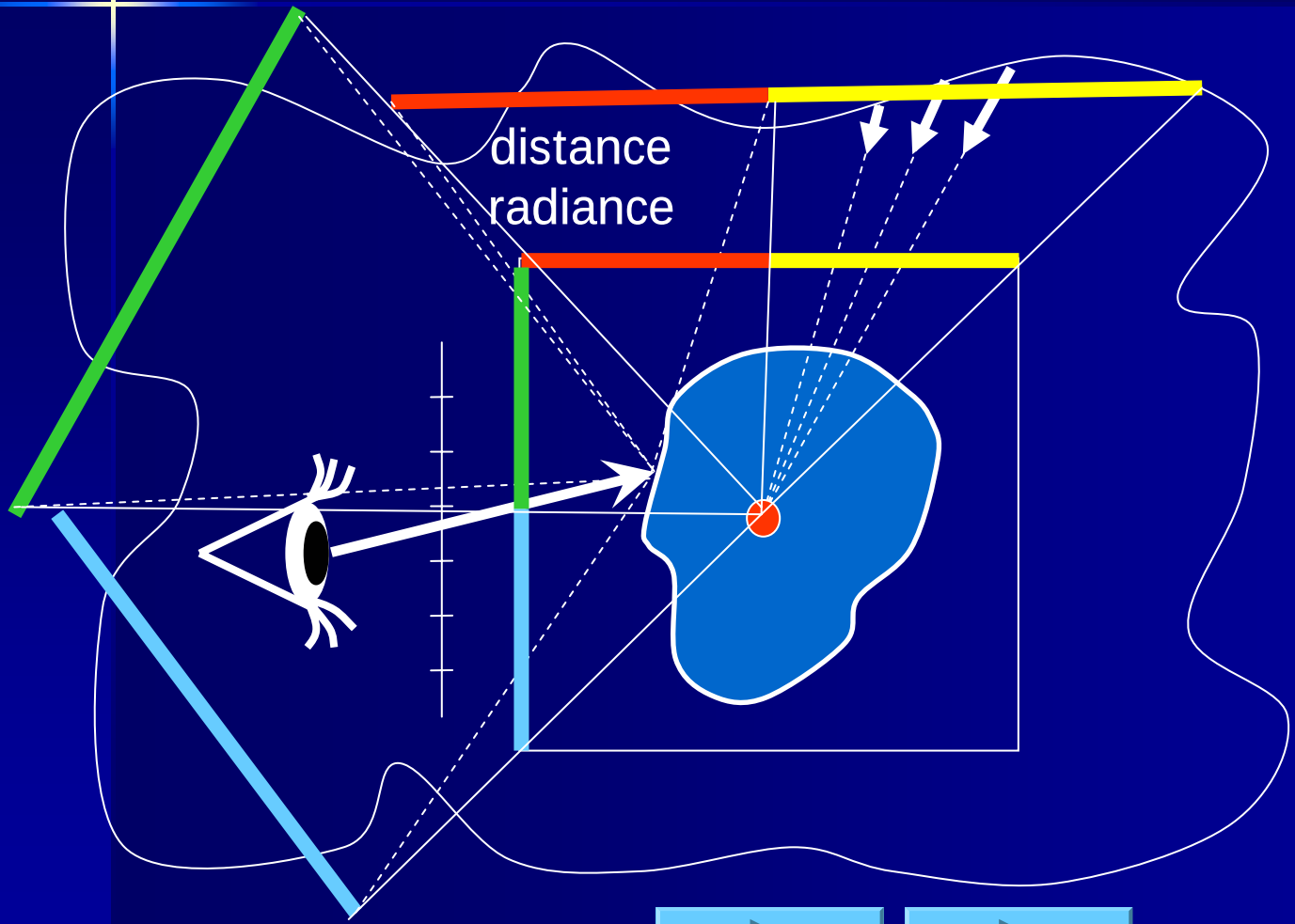
$$\int_{\Omega} L^{in}(o,\omega_i)\cos\theta'\, d\omega_i$$

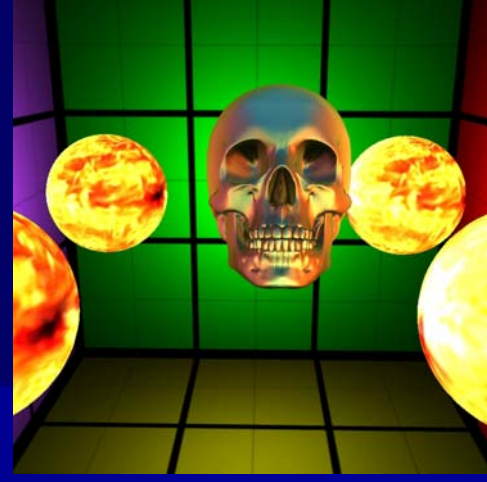


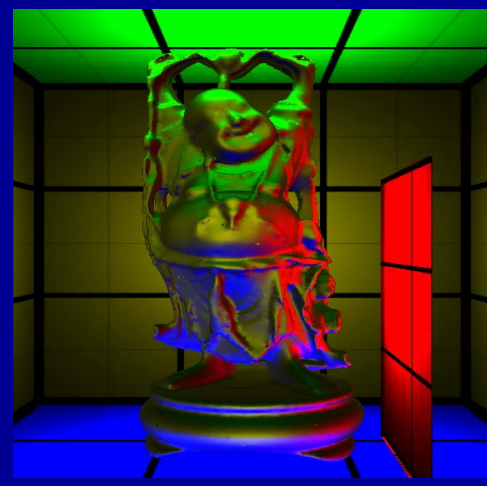


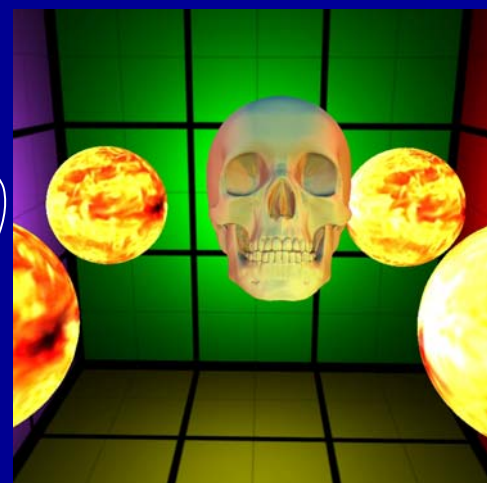
No self-occlusions!

Localized diffuse / glossy maps









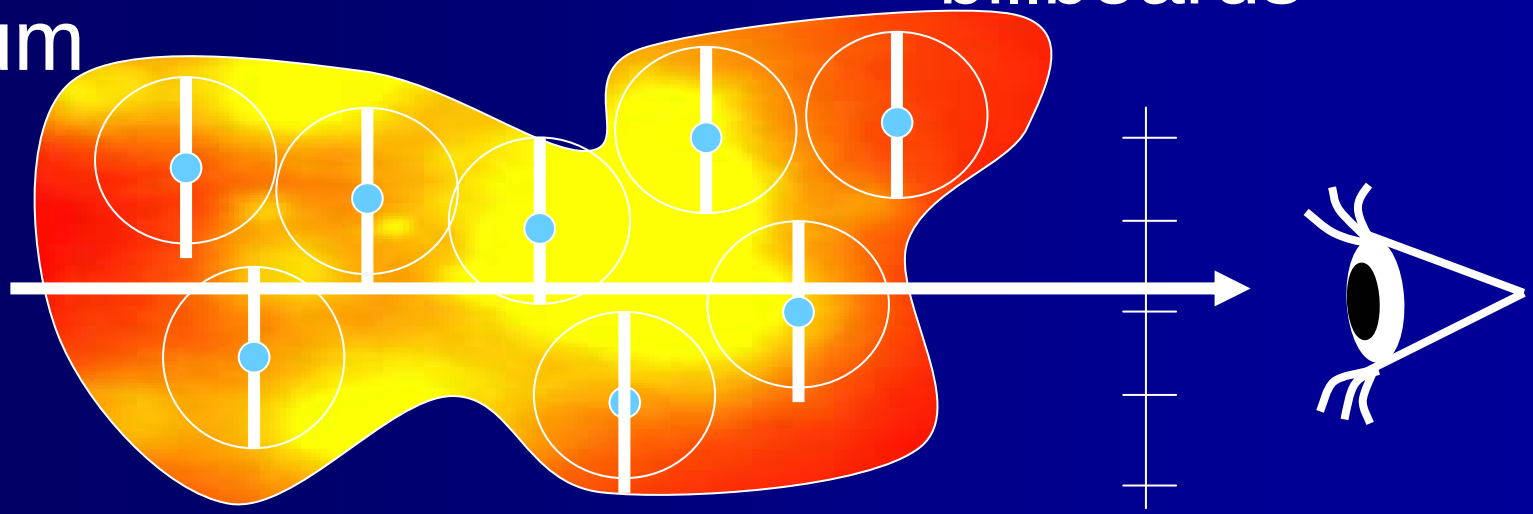
$$\frac{dL(s,\omega)}{ds} = -\tau L(s,\omega) + \tau(1-a)L^{e}(s,\omega) + \tau a \int_{\Omega'} L^{in}(s,\omega')P(\omega',\omega)\, d\omega'.$$

3. Participating media

Participating medium

Particles

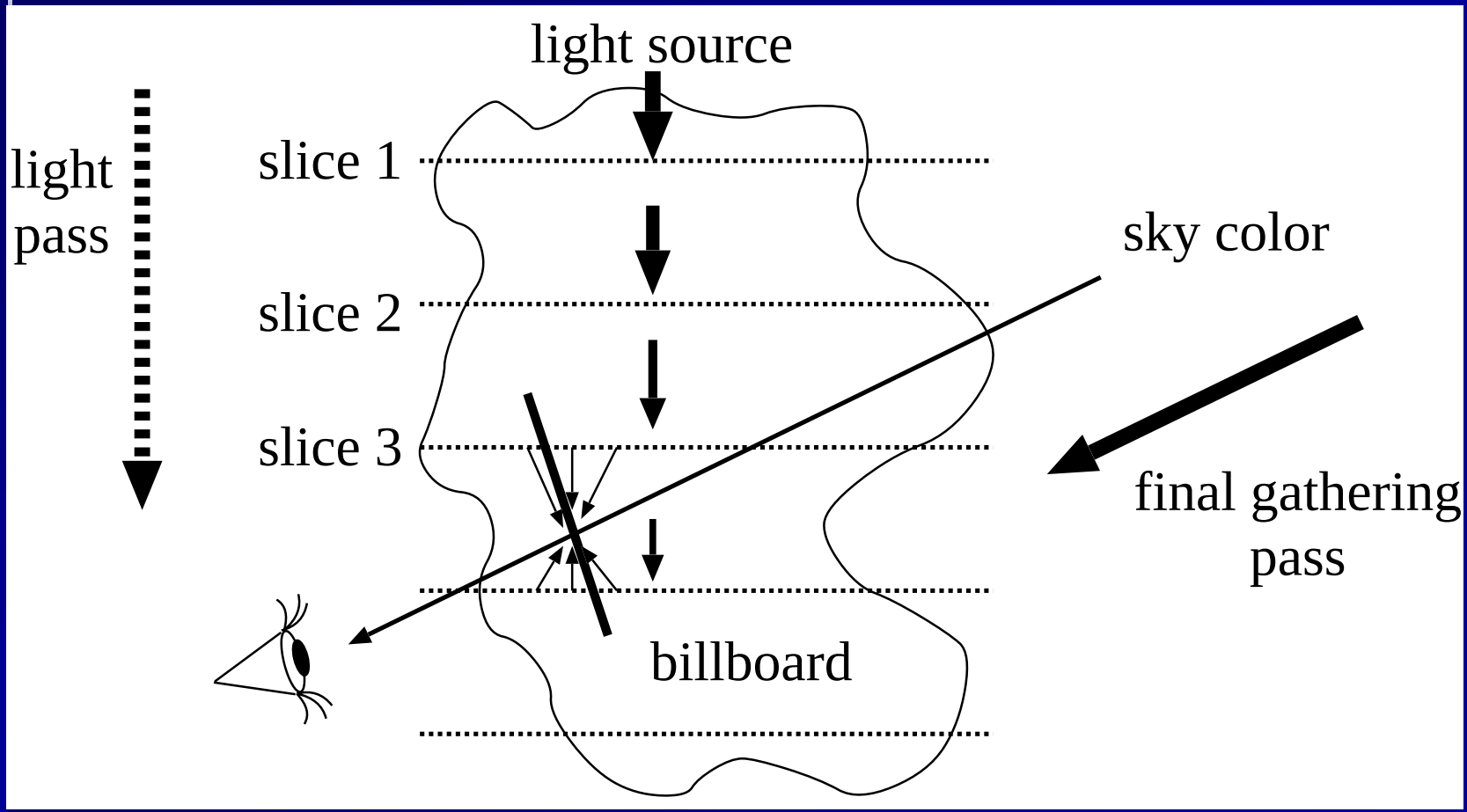
billboards



$$L(j,\vec{\omega}) = I(j,\vec{\omega})\cdot(1-\alpha_j) + \alpha_j \cdot C_j + E_j(\vec{\omega})$$

Outgoing radiance — **Incoming radiance** — **transparency** — **In-scattering term** — **Emission**

Illuminating participating media: inscattering term



Explosions

	Particles
Dust:	16
Fire:	135
Smoke:	112

	FPS
Spherical:	70
Planar:	80

Shaded smoke