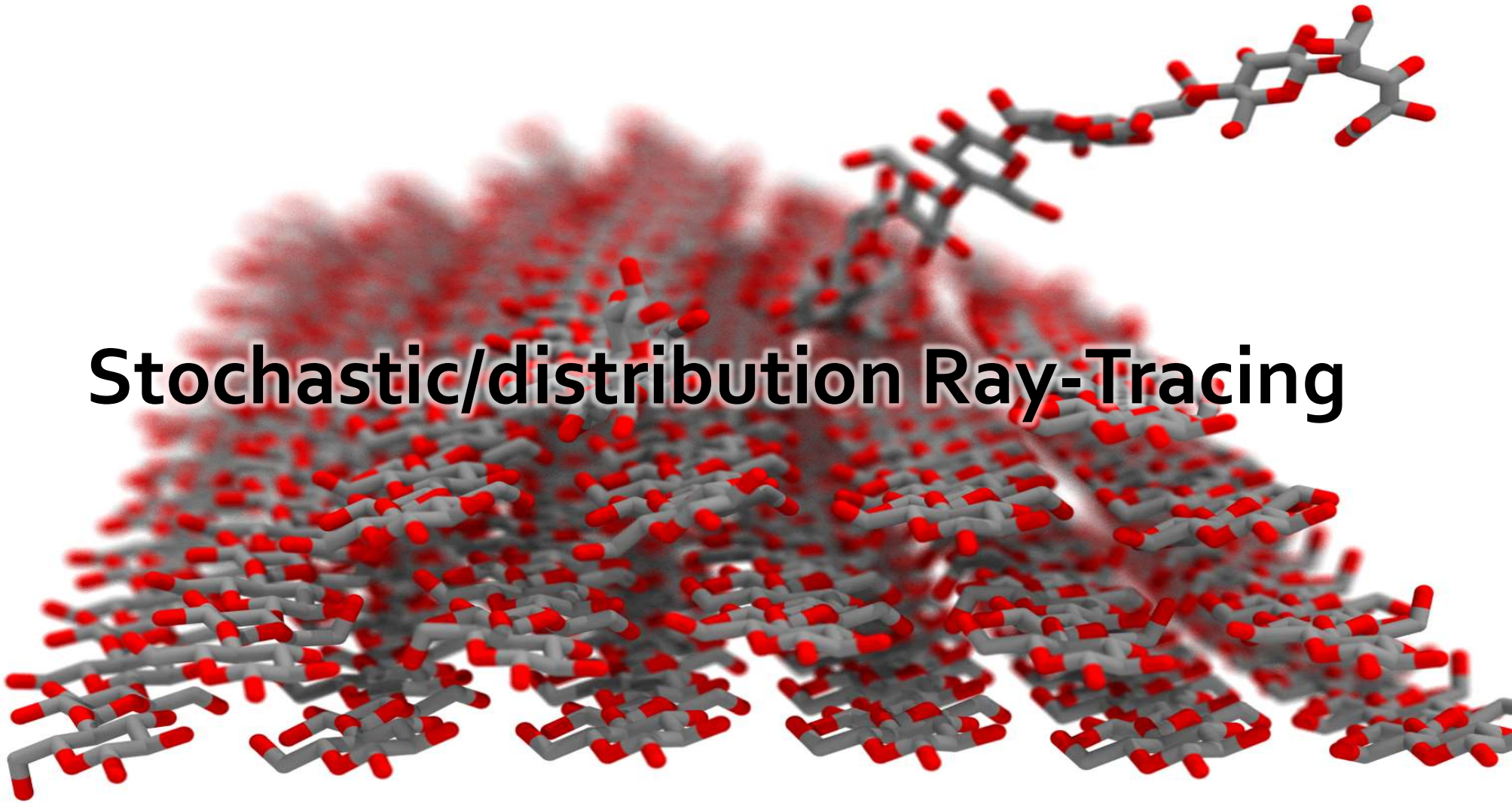
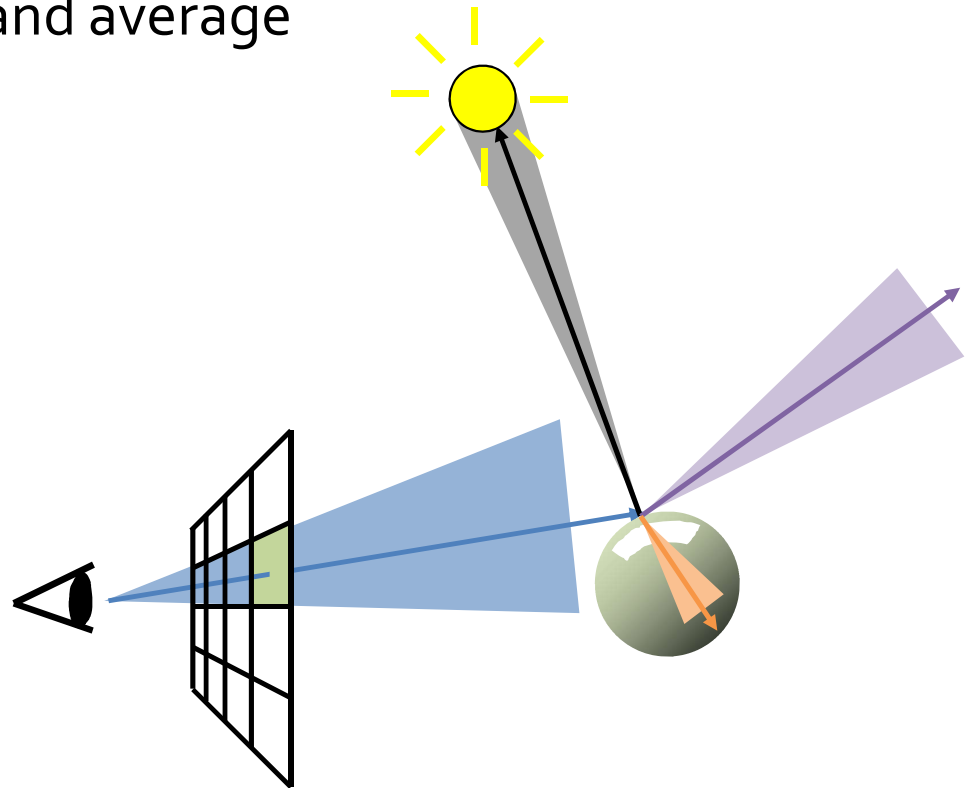


Stochastic/distribution Ray-Tracing



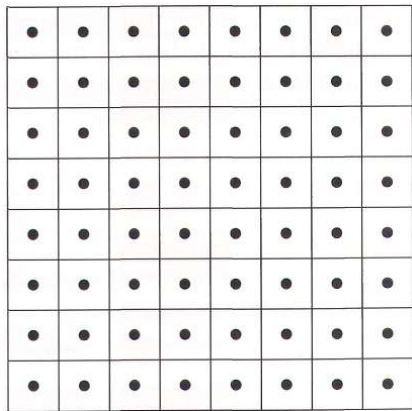
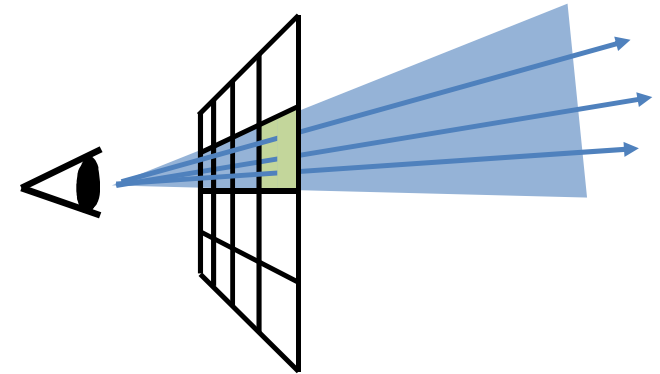
Stochastic/distribution Ray-Tracing

- Apply distribution-based sampling to parts of the ray-tracing algorithm
 - Send multiple perturbed rays and average
- Rendering of "soft" phenomena
 - Anti-aliasing
 - Soft shadows
 - Glossy reflections
 - Depth of field
 - Motion blur

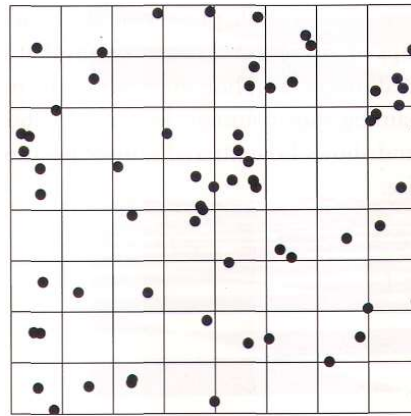


Anti-Aliasing

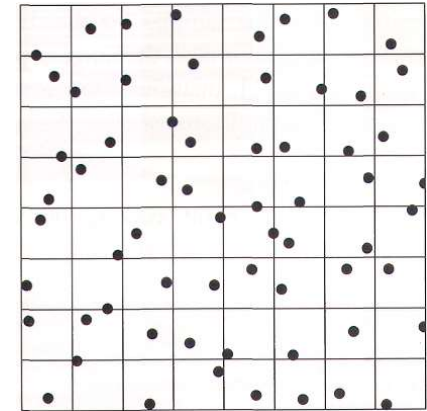
- Shoot many rays per pixel
- Average retrieved colors
- Methods



Regular sampling

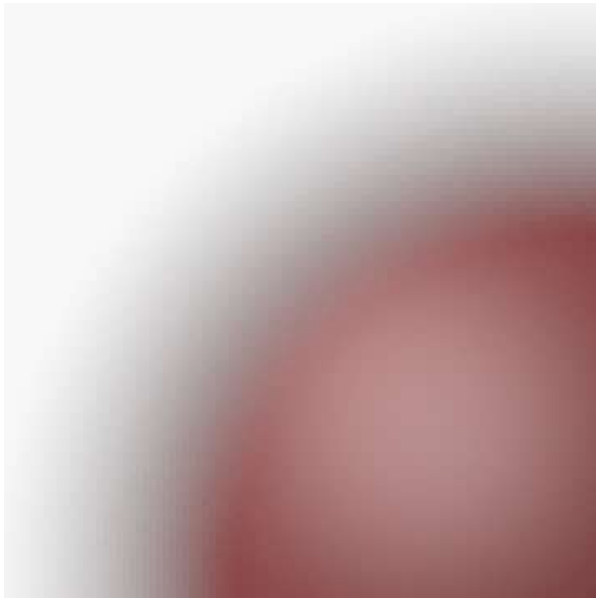


Random Sampling



Stratified Sampling

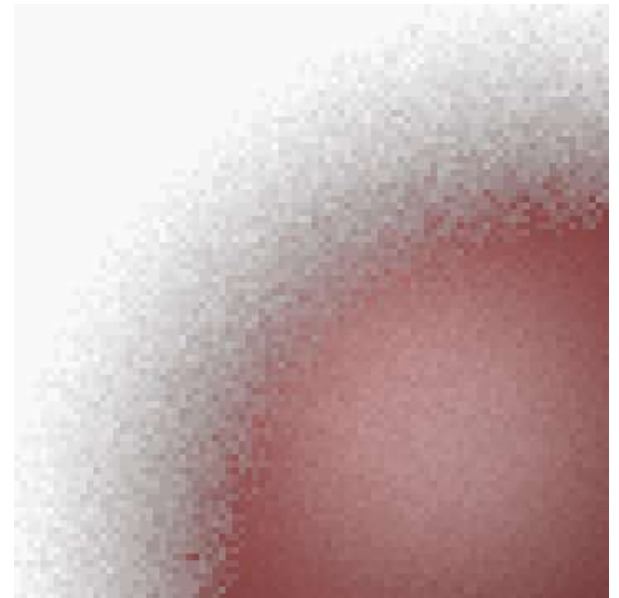
Anti-Aliasing – Examples



Reference



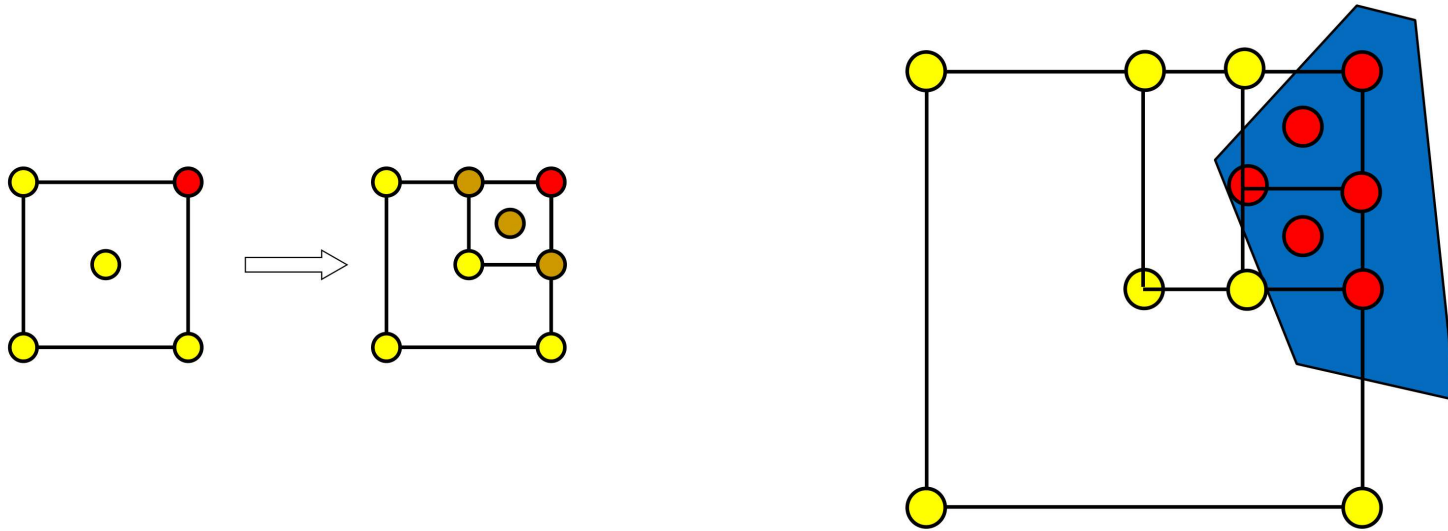
Random Sampling



Stratified Sampling

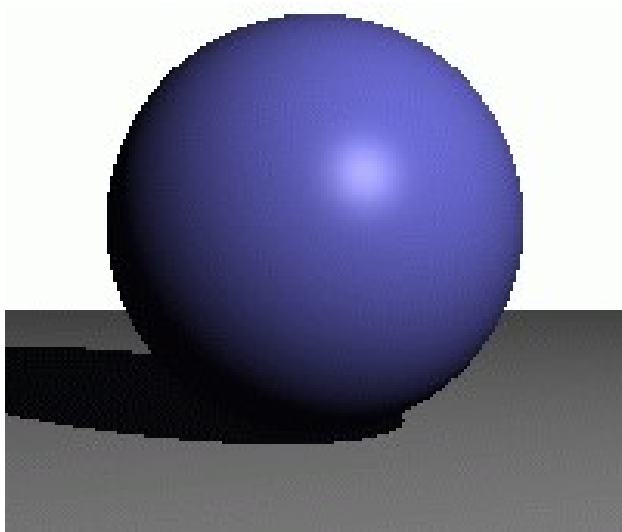
Anti-Aliasing – Adaptive Supersampling

- Shoot more rays only in case of large differences in color

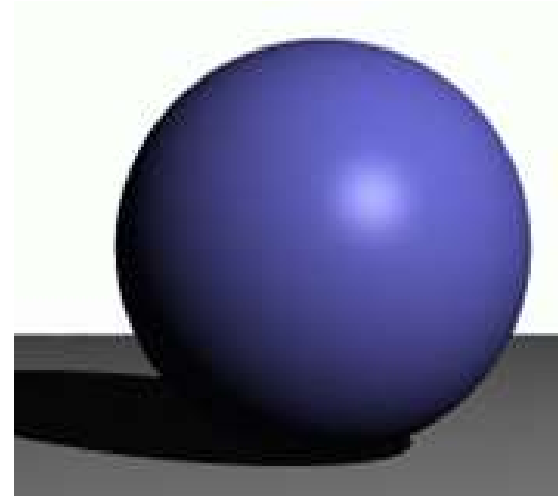


Anti-Aliasing – Examples

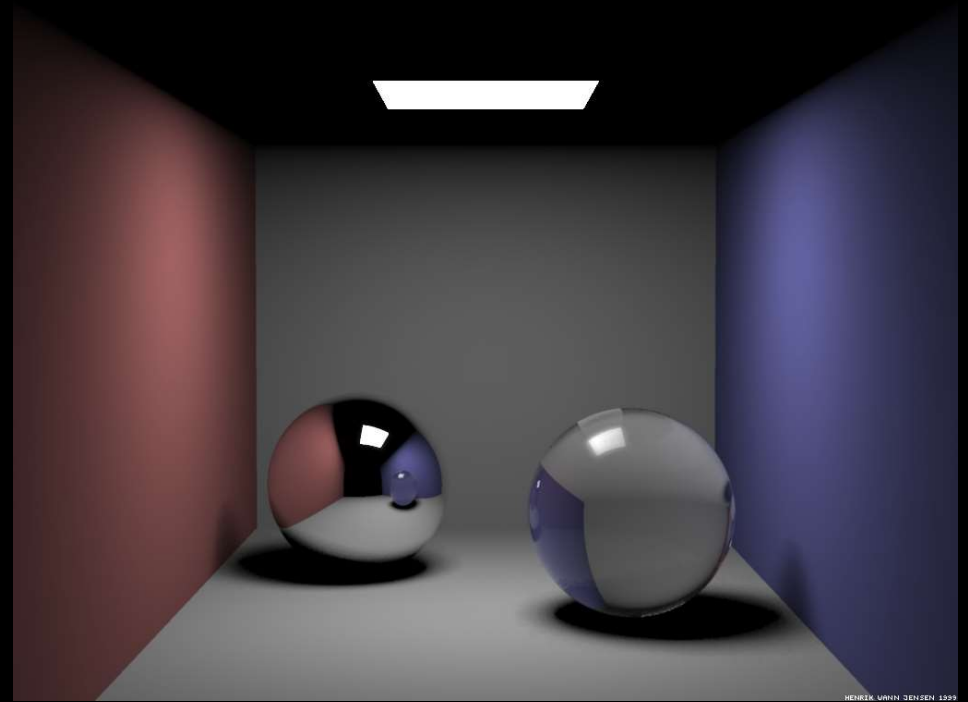
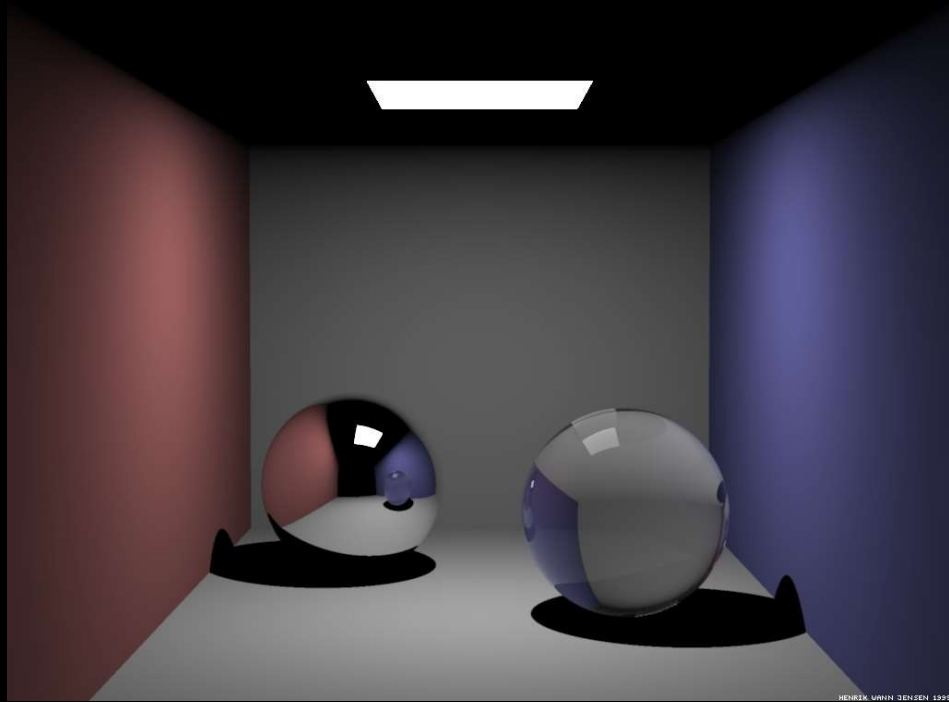
Aliasing



Anti-Aliasing

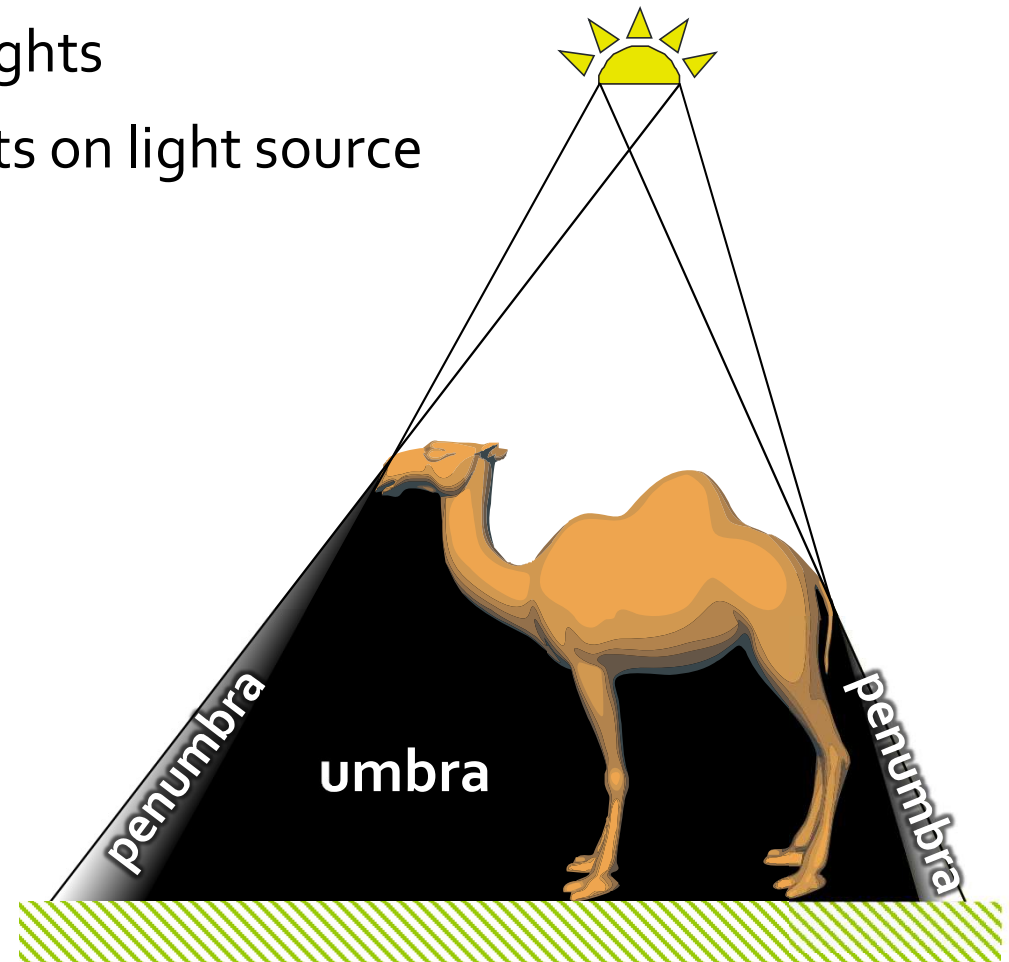
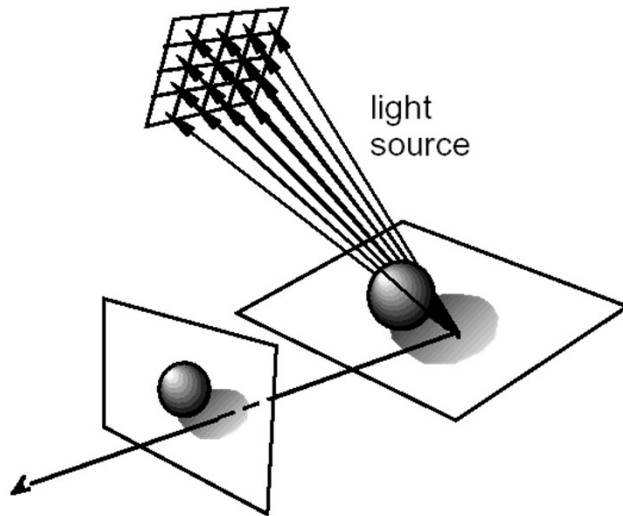


Soft Shadows

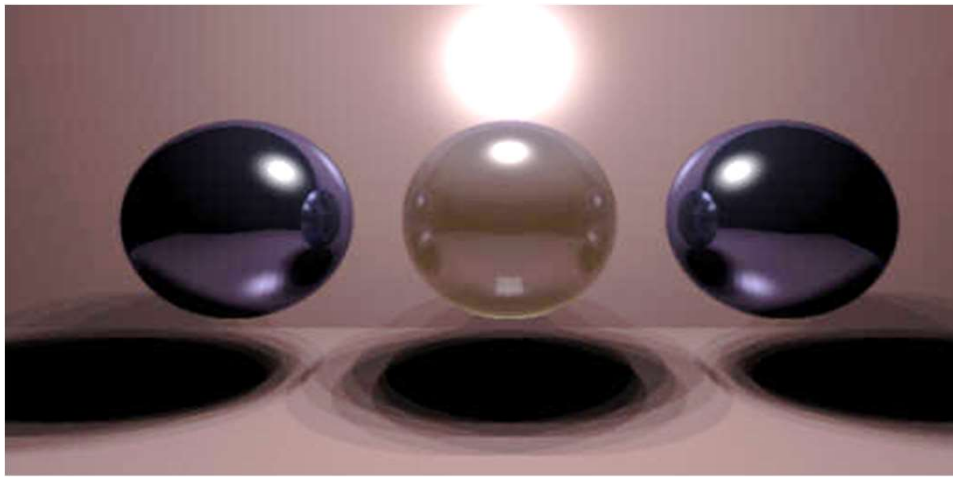


Soft Shadows

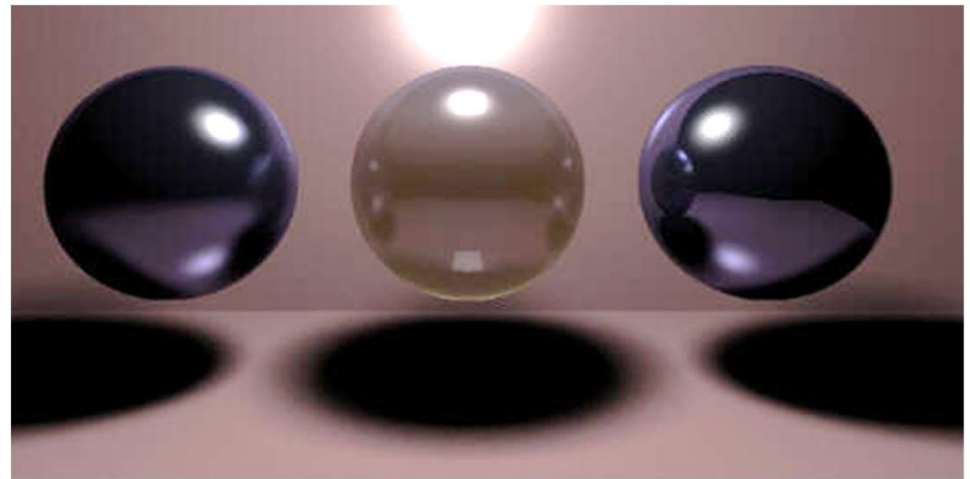
- Soft shadows are created by area lights
- Trace shadow rays to multiple points on light source



Soft Shadows



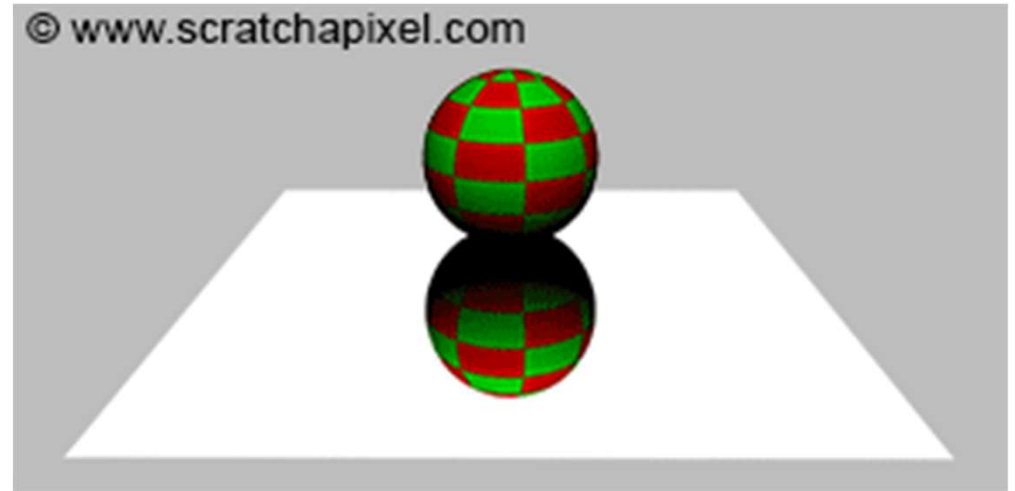
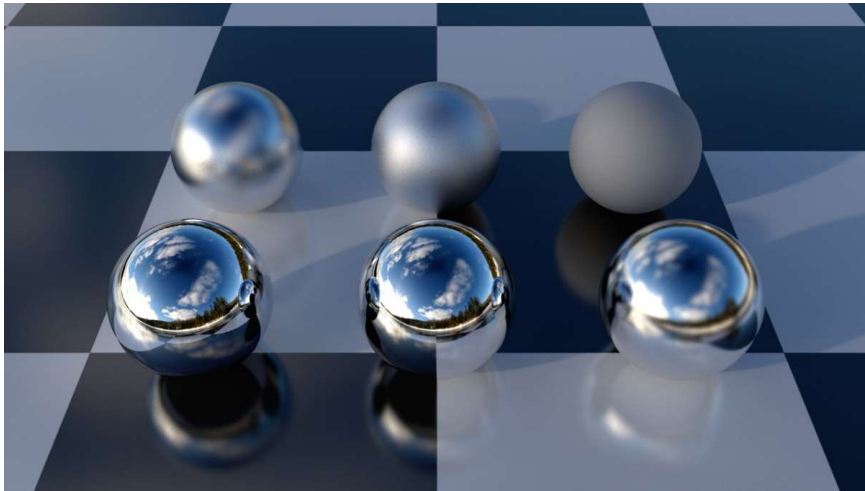
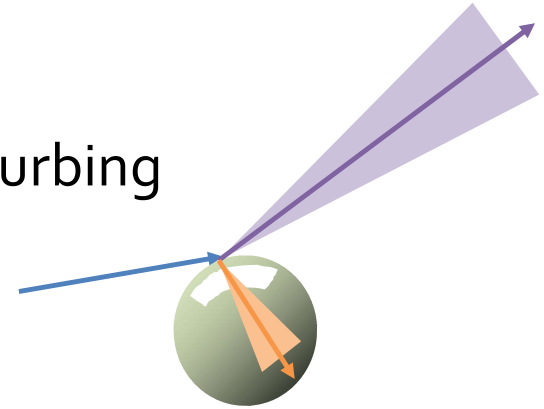
9 shadow rays (3*3 grid)



16.384 shadow rays (128*128 grid)

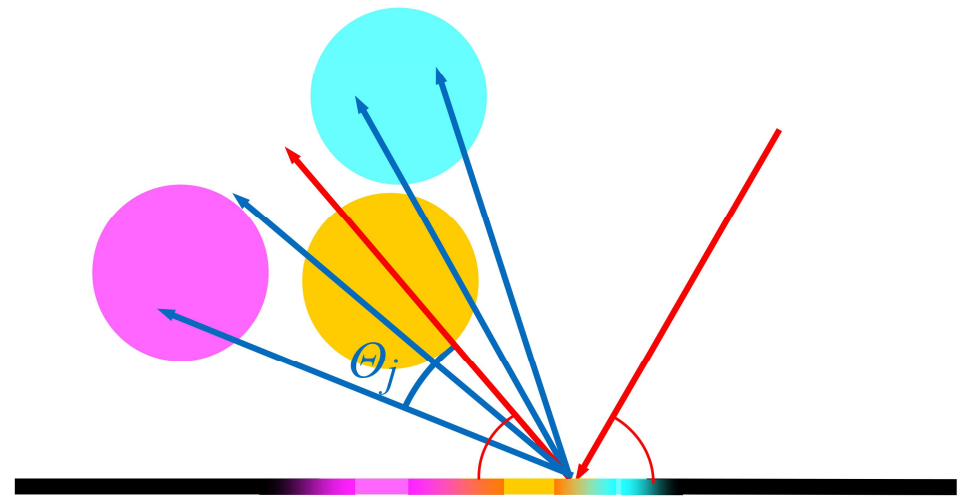
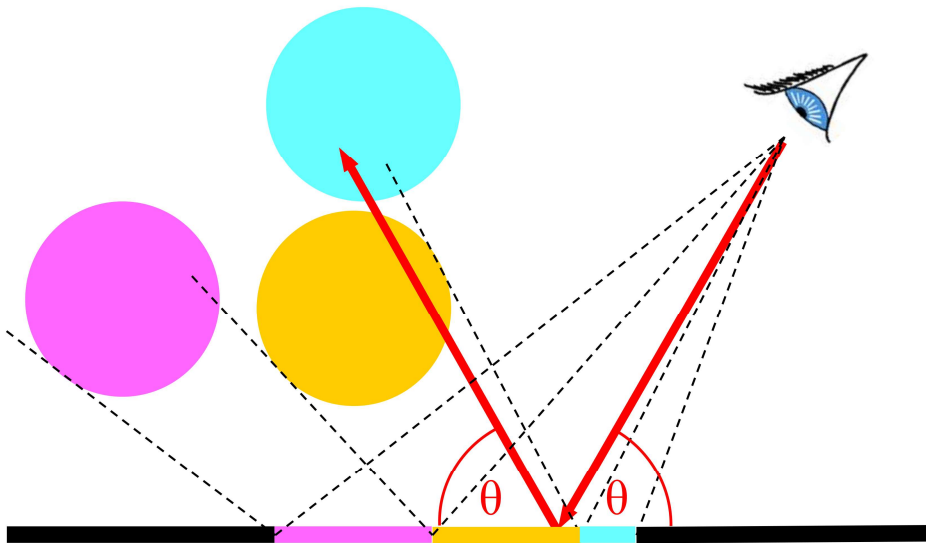
Gloss/Translucency

- Produce blurry reflections/refractions by randomly perturbing reflection/refraction rays from their "true" directions



Gloss/Translucency

- So far, exactly 1 reflected ray
- Shoot many “reflected” rays
- Accumulate, weighted by power-cosine law (Phong) $\cos^p \theta_j$

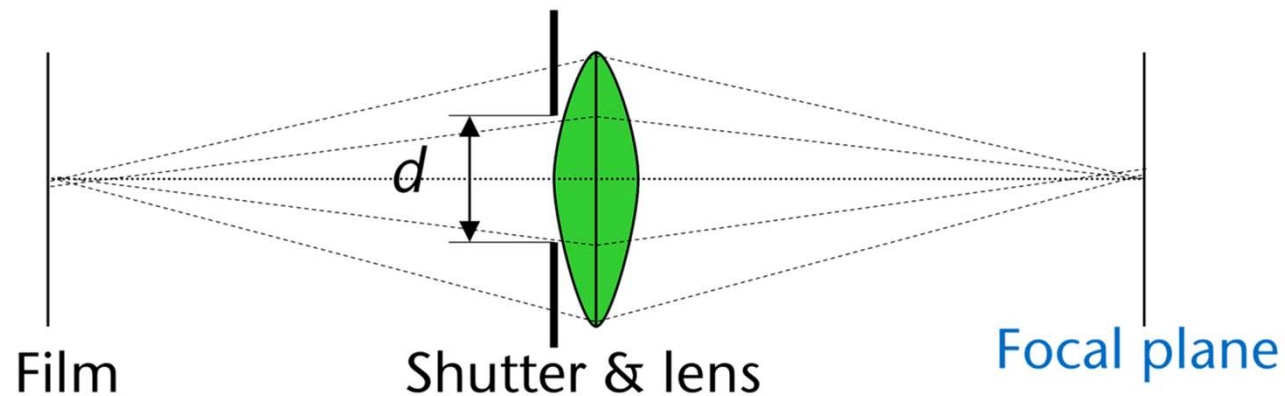


Gloss/Translucency



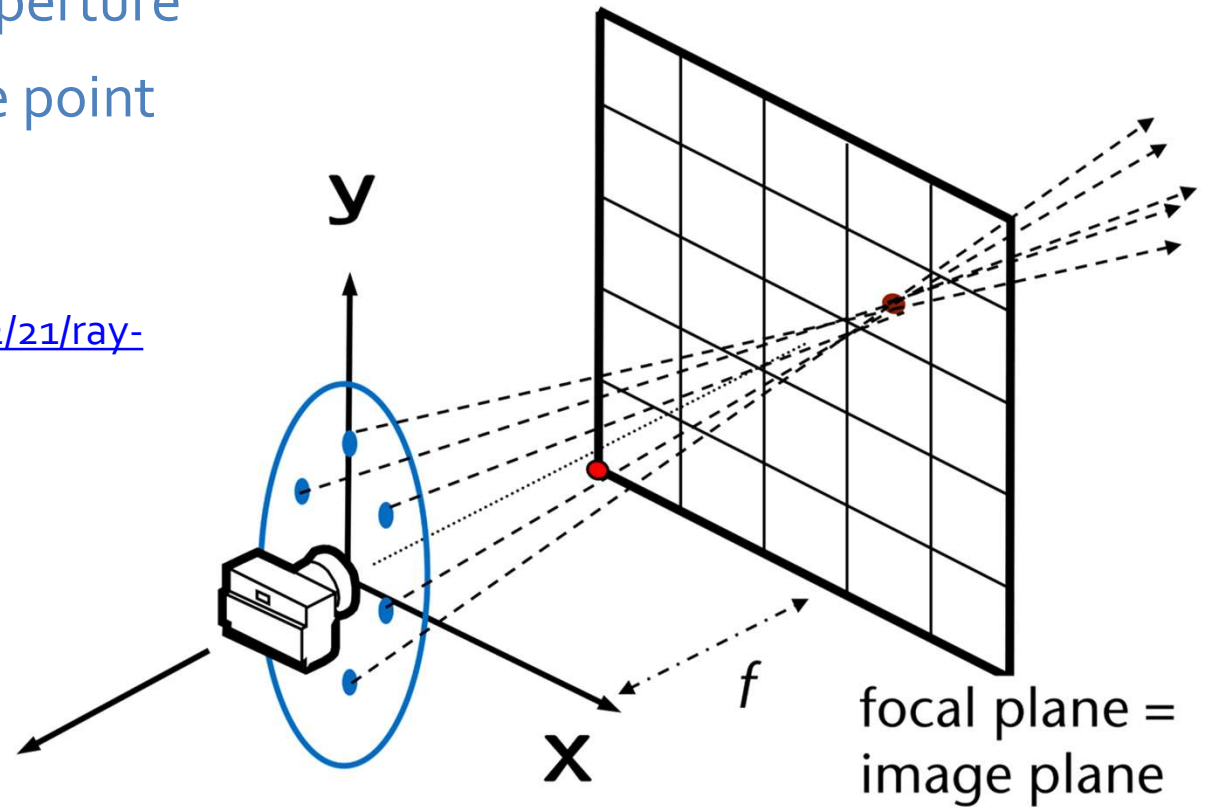
Depth of Field

- So far: ideal pin-hole camera model
- For depth-of-field, we need to model real cameras

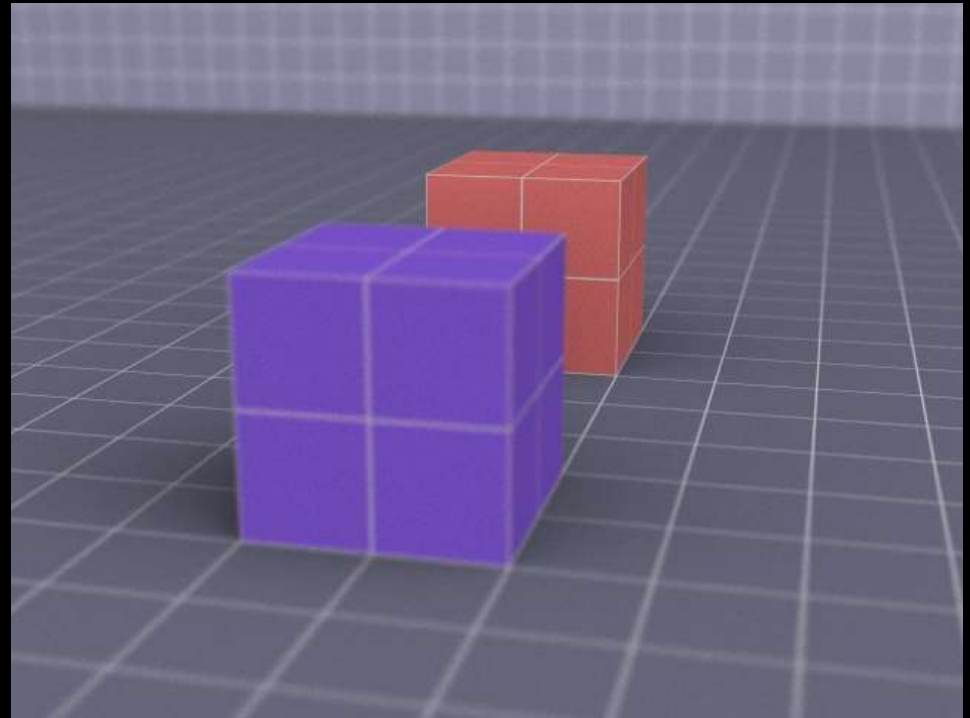
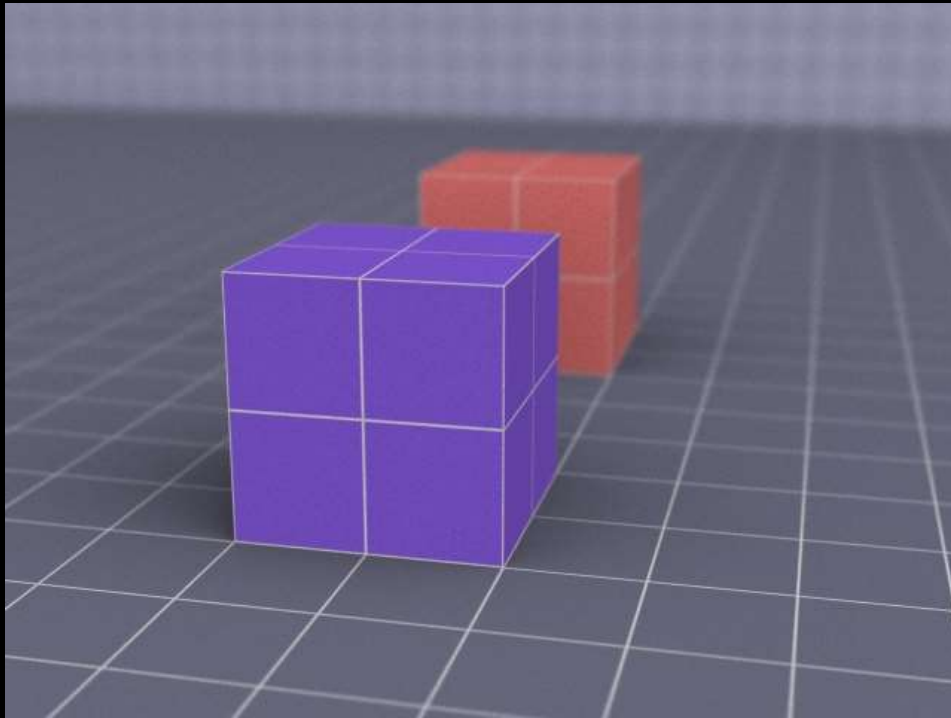


Depth of Field

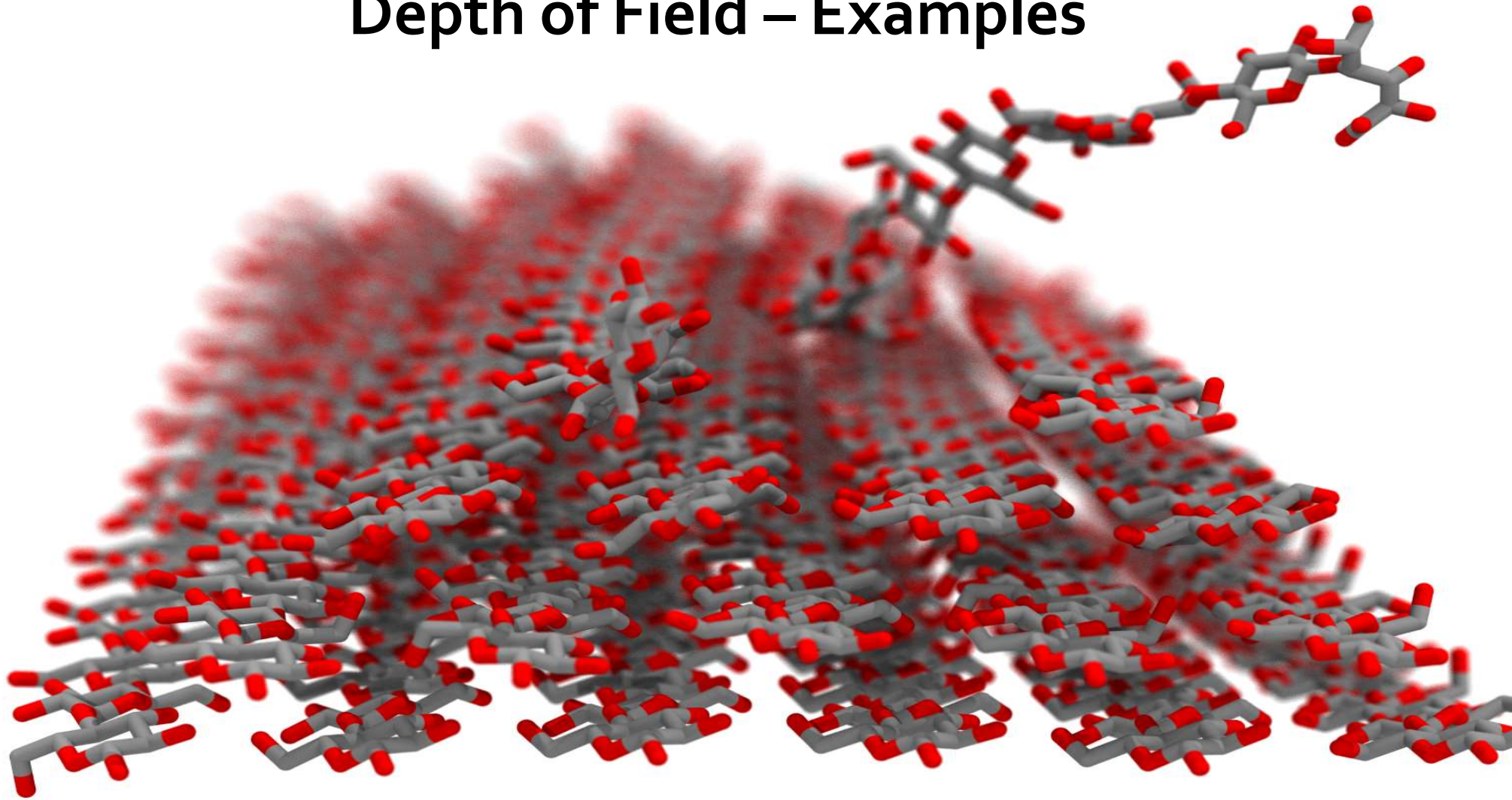
- Sample the whole shutter aperture
- Shoot ray from each sample point through focal plane point
- Details of implementation
steveharveynz.wordpress.com/2012/12/21/ray-tracer-part-5-depth-of-field



Depth of Field – Examples

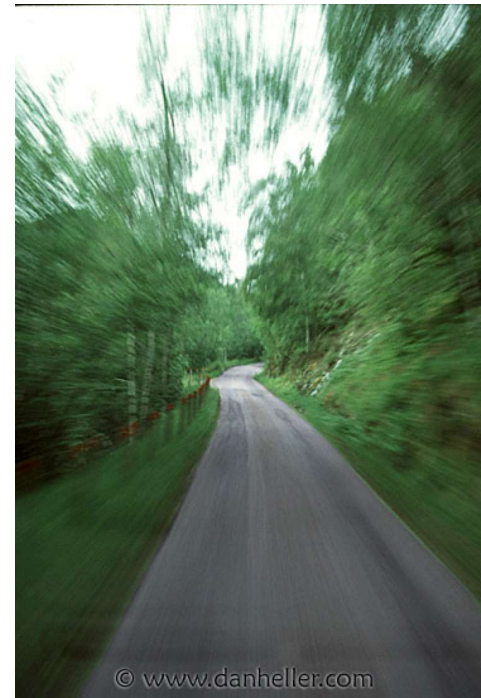


Depth of Field – Examples



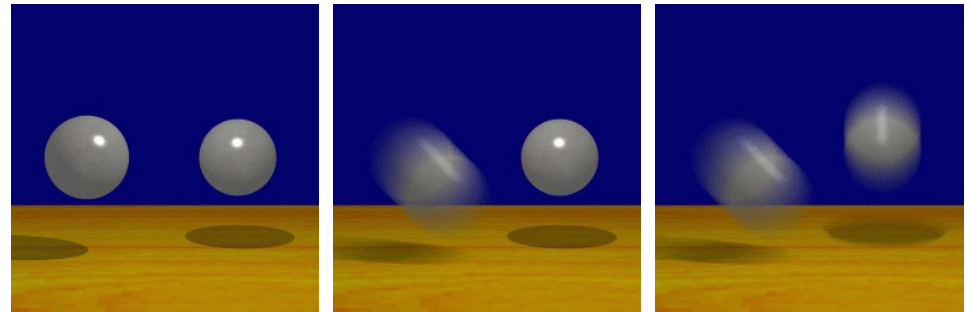
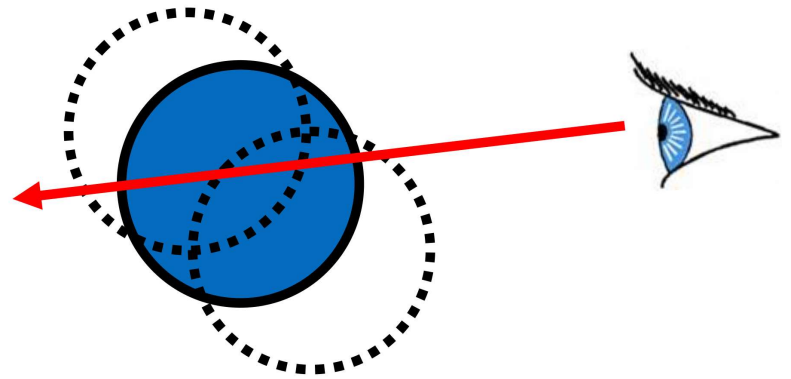
Depth of Field – Shutter Speed Artifacts

- A slower shutter speed means the shutter is open for more time
- This can result in motion blur



Motion Blur

- Goal: compute “average” image for time interval, during which objects move
- Sample time interval and shoot one ray per point in time t
- Ray-object intersections, use positions $P(t)$
- Average color of all rays for one pixel





Pixar 1984; [fxguide.com/featured/1984 - pool balls 25 years later](https://www.fxguide.com/featured/1984-pool-balls-25-years-later)