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Shutter Efficiency & Temporal Sampling

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MotionBlur

- Do Some!





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Focal Plane Shutters

- Two curtains which move across the film plane.
- Each part of the film is exposed at a different time
- Andrew Glassner



Jacques-Henri Lartigues



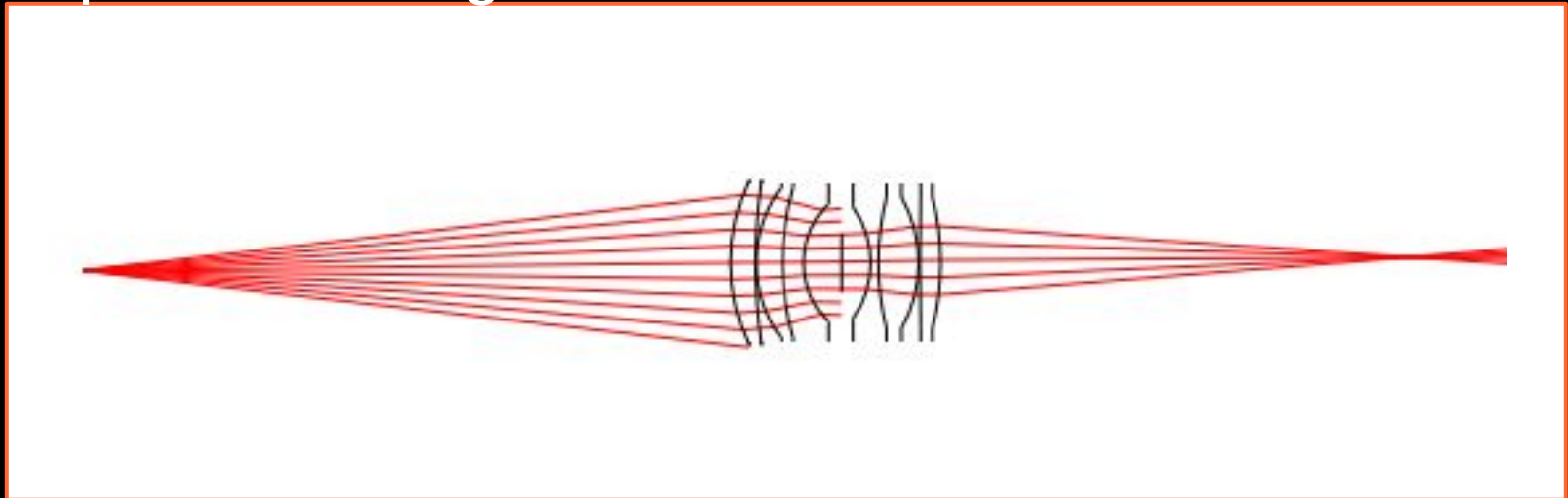
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Leaf Shutters

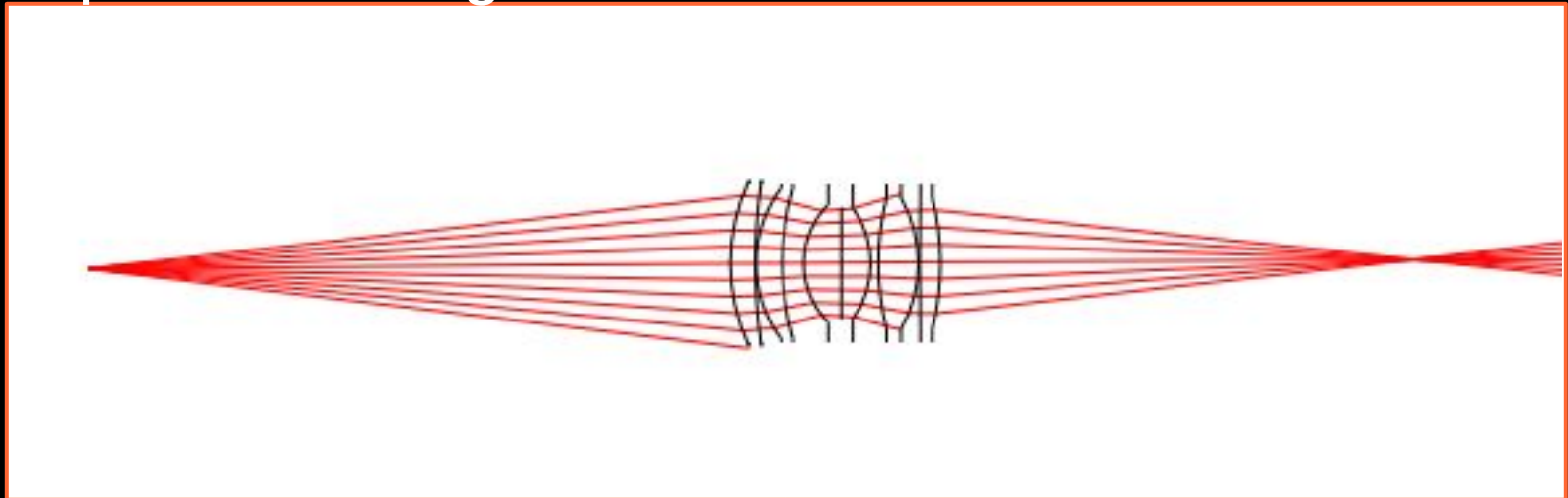
- Embedded in the Lens
- All parts of the image exposed at once.
- Requires time to open and close
 - Aperture changes over time.





Leaf Shutters

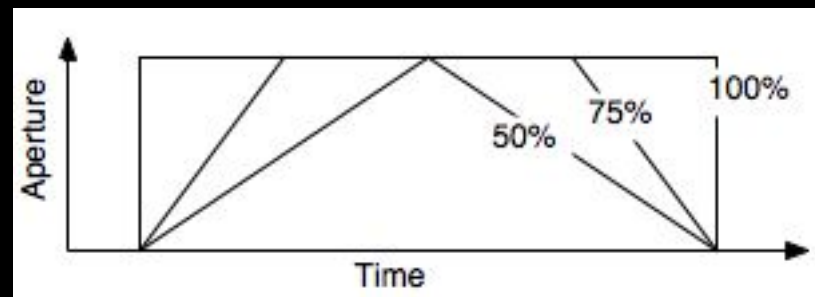
- Embedded in the Lens
- All parts of the image exposed at once.
- Requires time to open and close
 - Aperture changes over time.





Shutter Efficiency

- Small shutters are a good approximation to the standard CG model.
- Large shutters take time to open and close.
- Actual Exposure as a percentage of the theoretical exposure.



100%



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75%



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50%



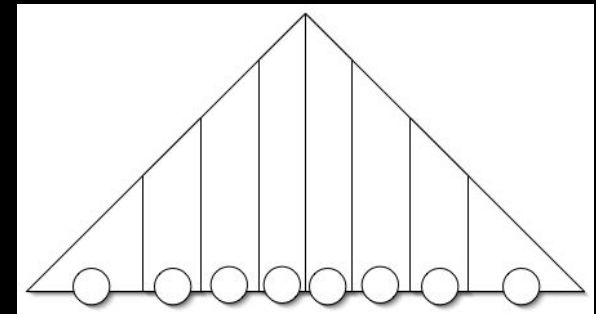
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Ray Tracing

- Sample scene at different times
- Weight Samples?
- Adjust Sample Distribution
 - `calcSampleTime(n)`
- Incorporate Depth of Field effects too?
 - Just make sure rays go through aperture





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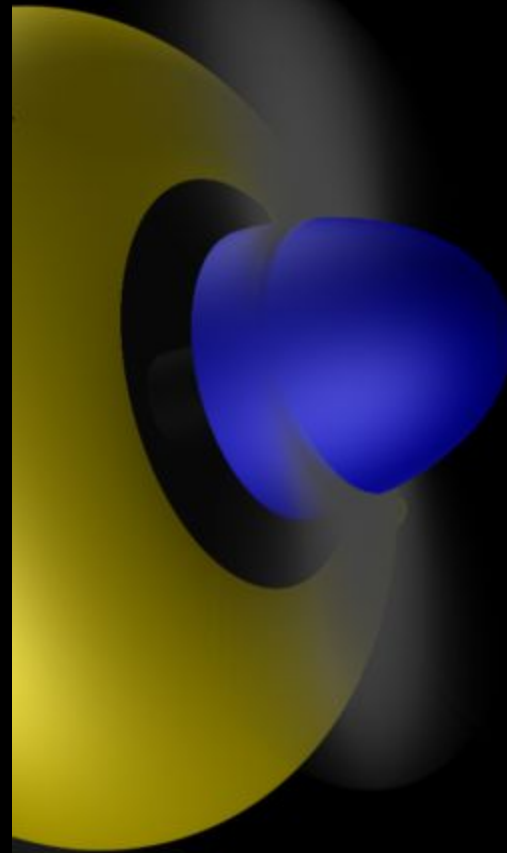
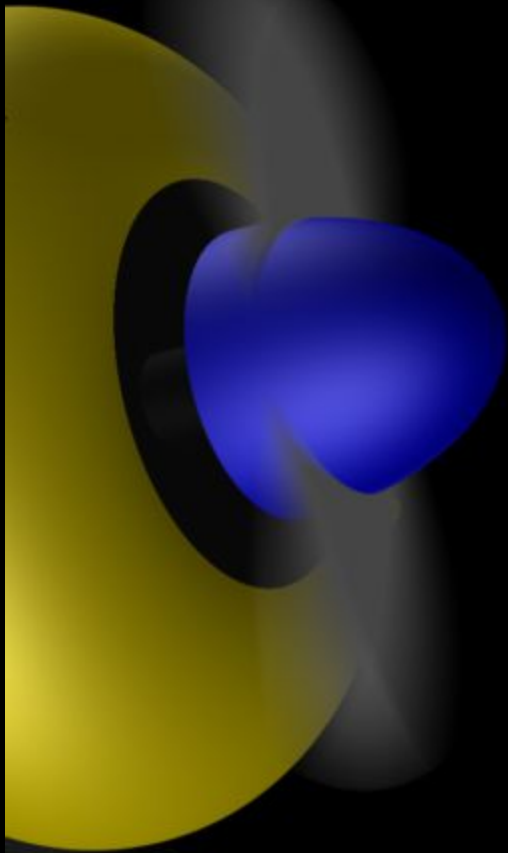
Reyes Implementation

- Shade Once
- Add Motion in Sampling Loop
- Shading at $t=0$ is a bad choice!
- Use $t=0.5$
- Less artifacts even for regular motion blur

Example



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Temporal Sampling

- The (old) high efficiency shutter is a box filter
- The low efficiency shutter is a tent filter
- Tent filters are better than Box filters



Time Domain

- High frequency blocked
 - (less artifacts)
- Low frequency pass
 - (more detail)

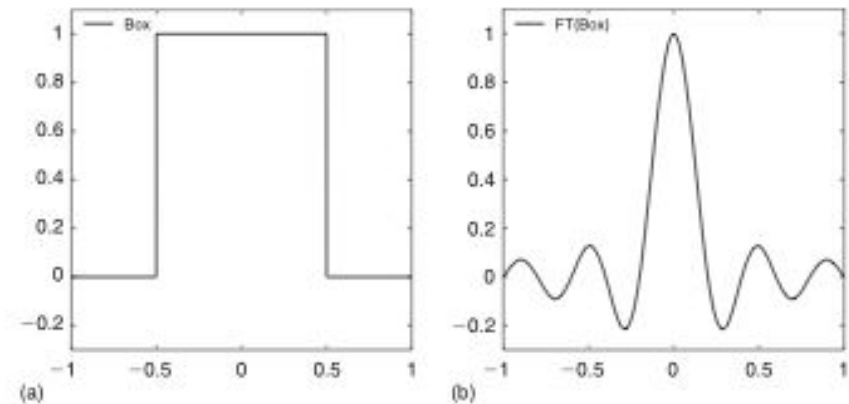


Figure 8.8 A box filter (a) time domain, (b) frequency domain.

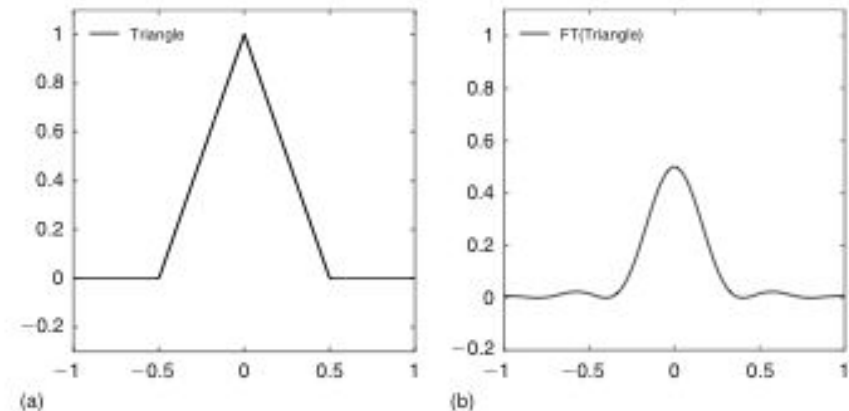
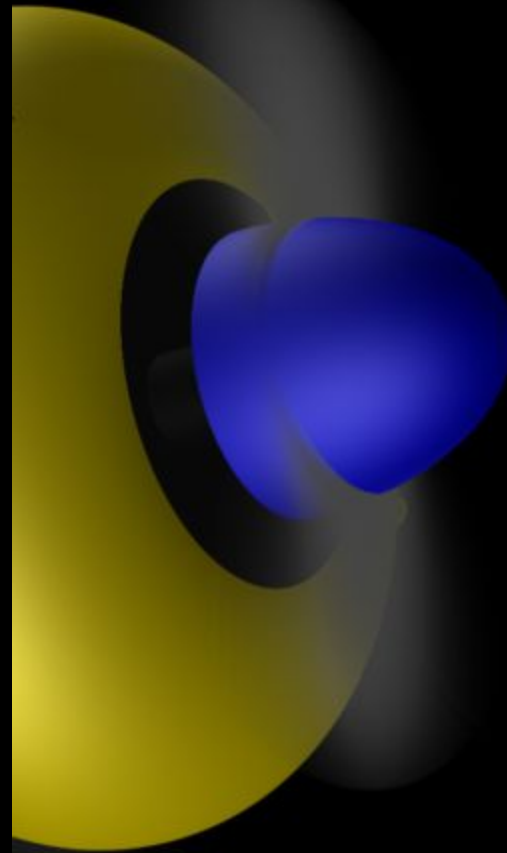
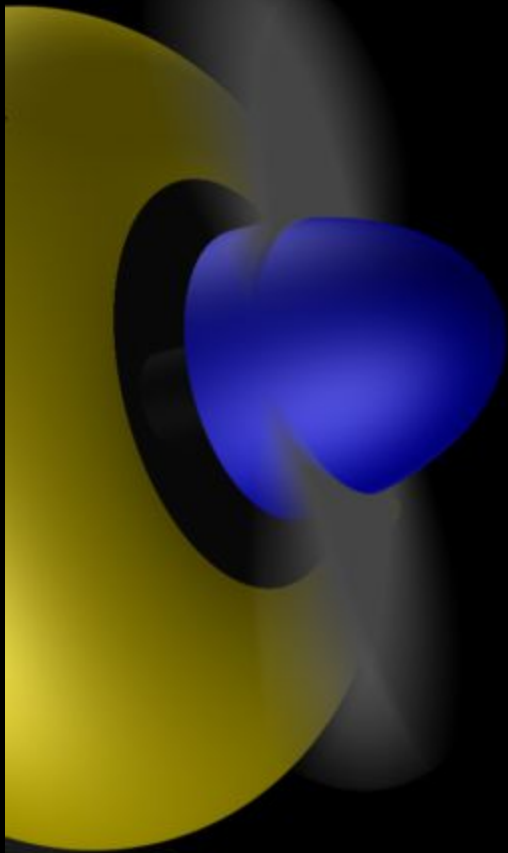


Figure 8.9 A triangle filter (a) time domain, (b) frequency domain.

Example



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Better Filters

- The low efficiency shutter is a better filter, and produces better images.
- Requires a larger support
 - Frames Temporaly overlay
- More advanced filters require very large supports.

Animation



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Conclusions

- Low efficiency shutters produce better temporal sampling.
- Temporal Sampling is important.
- Make *better* images.
- Can be implemented at zero cost.
- Needs to be supported in rendering systems, just as much as spacial sampling.