

PATH GUIDING IN PRODUCTION

JIŘÍ VORBA
WETA DIGITAL

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PHOTOGRAPHY AND RECORDING PROHIBITED





MOTIVATION

- Hundreds of core hours
- MC slow convergence

$$\frac{\sigma}{\sqrt{N}}$$

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- Hundreds of core hours
- MC slow convergence
- Faster HW?
- Denoising – needs better samples
- Importance sampling

$$\frac{\sigma}{\sqrt{N}}$$

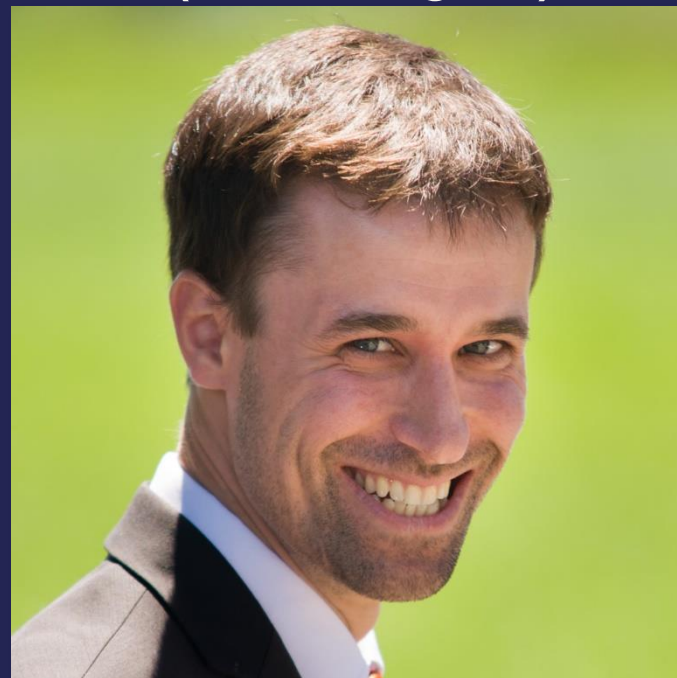
RELATION TO RENDERING METHODS

- Unidirectional path tracer
- Bidirectional methods
- Gradient methods
- MCMC

PRESENTERS

Jiří Vorba

(Weta Digital)



Johannes Hanika

(KIT / Weta Digital)



Sebastian Herholz

(University of Tübingen)



Thomas Müller

(NVIDIA)



Jaroslav Křivánek

(Charles University, Prague / Chaos Czech)



Alexander Keller

(NVIDIA)



SYLLABUS

- 14:00 – Opening Statements and Introduction [Jiří Vorba]
- 14:10 – Guiding Indirect Illumination [Jiří Vorba]
- 14:20 – Bayesian Inference in Many-Light Sampling [Jaroslav Křivánek]
- 14:45 – Guiding and Shadow Rays [Alexander Keller]
- 15:15 – “Practical Path Guiding” in Production [Thomas Müller]
- 15:45 – Break (15 minutes)

SYLLABUS

- 16:00 – Volumetric Path Guiding [Sebastian Herholz]
- 16:30 – Guiding in Path Space [Johannes Hanika]
- 17:00 - Guided Photon Emission [Jiří Vorba]
- 17:05 – 17:15 - Open Problems and Future Work [Jiří Vorba]

GOALS

- Overview of existing methods
- Sharing practical experience
- Share open problems with researchers

INTRODUCTION

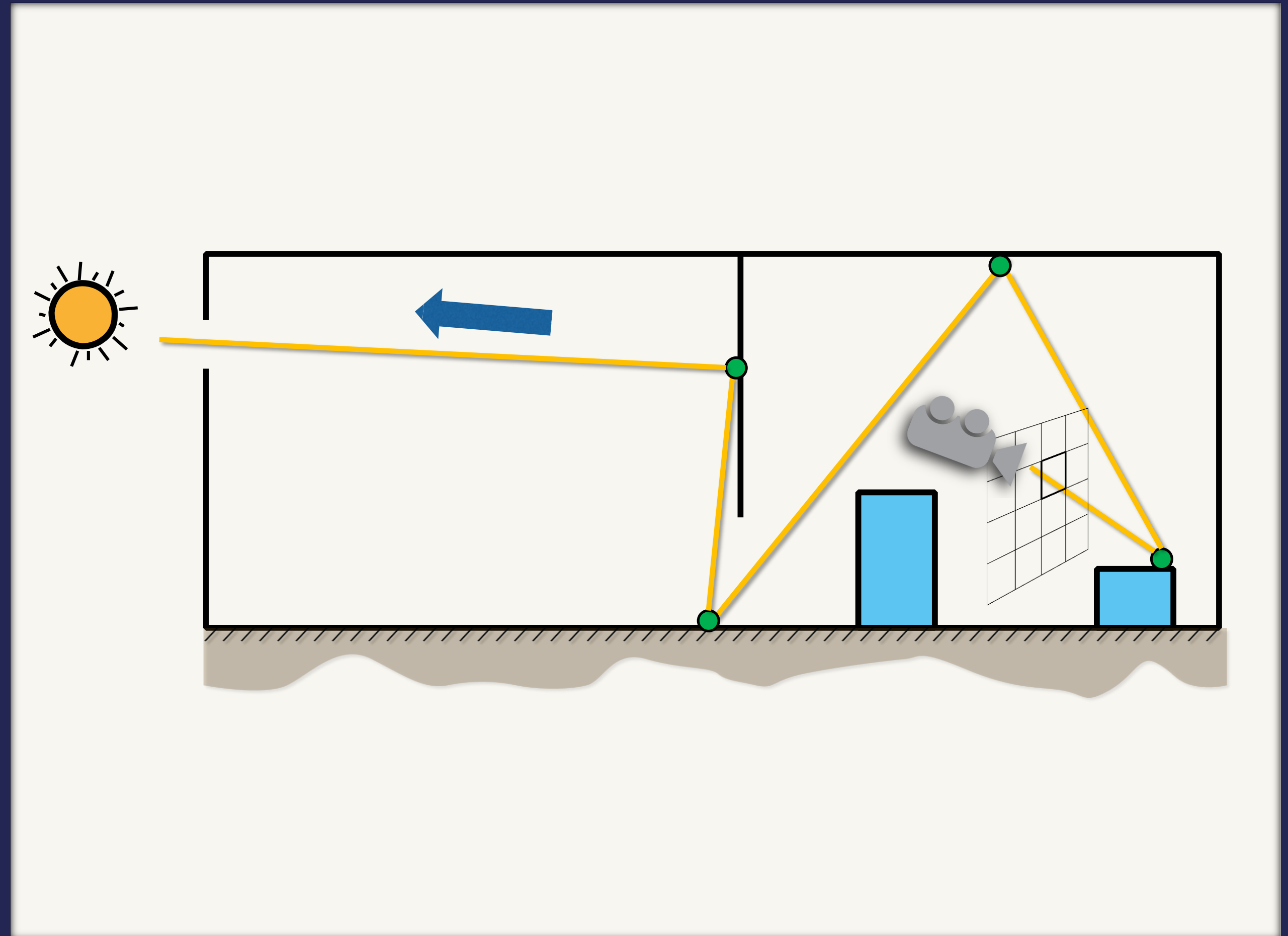
What is path guiding

PATH GUIDING

- What is path guiding?
 - Set of **adaptive** path sampling techniques aware of the scene content

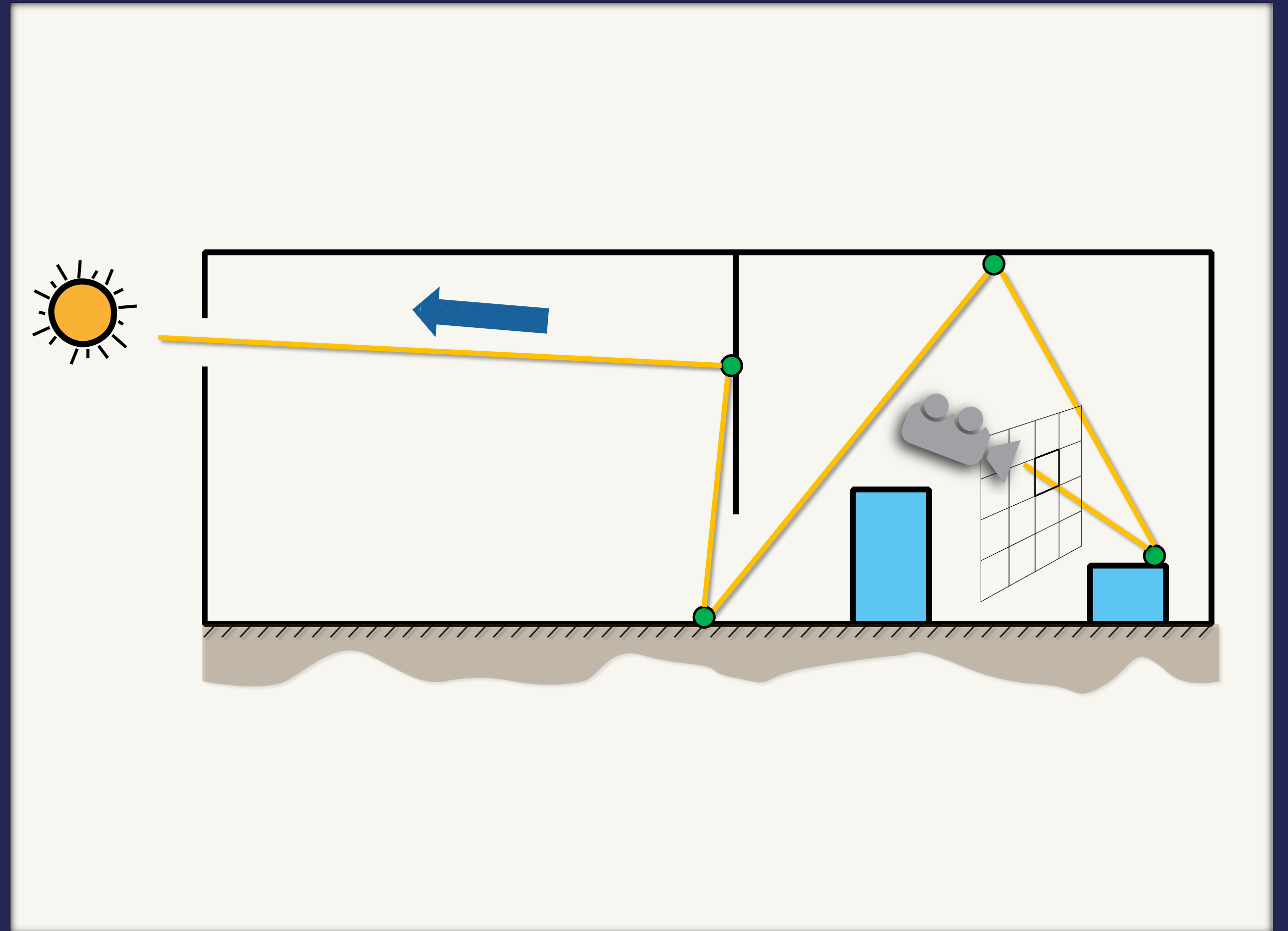
PATH TRACING

- Averaging of many sampled paths
- Efficiency depends on a few sampling decisions



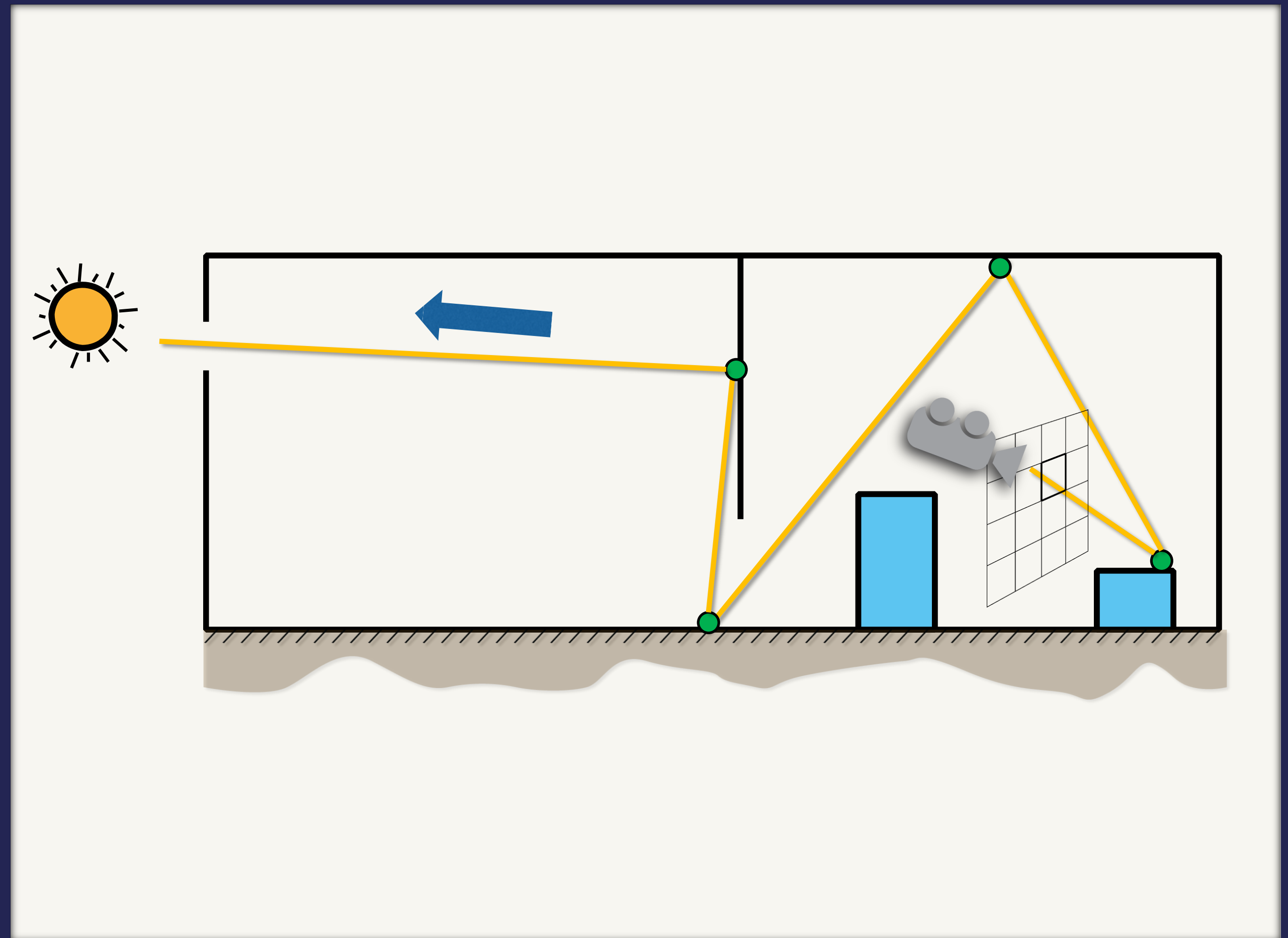
SAMPLING DECISIONS

- Directional sampling (BSDF)



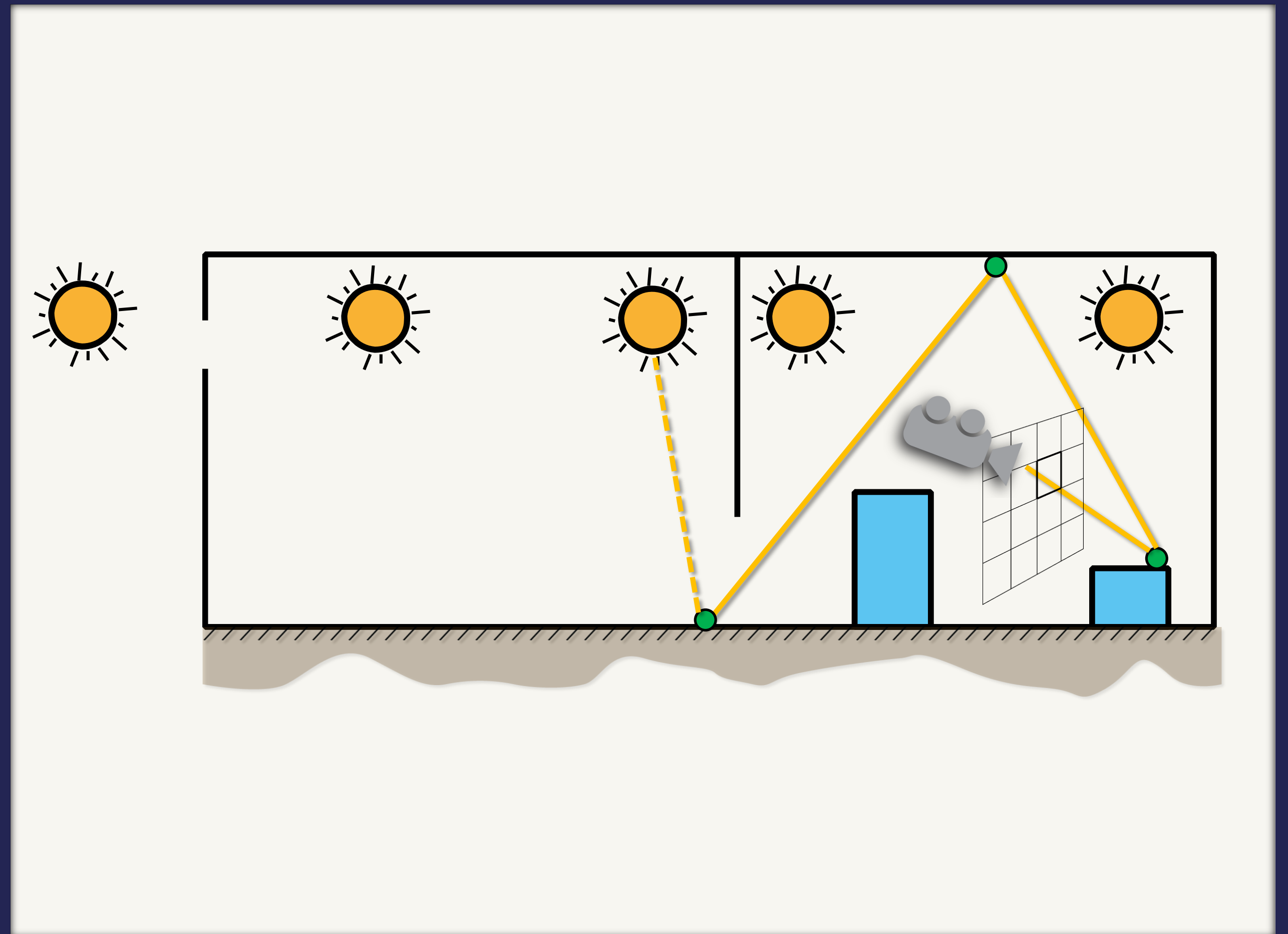
SAMPLING DECISIONS

- Directional sampling (BSDF)
- Termination (Path length)



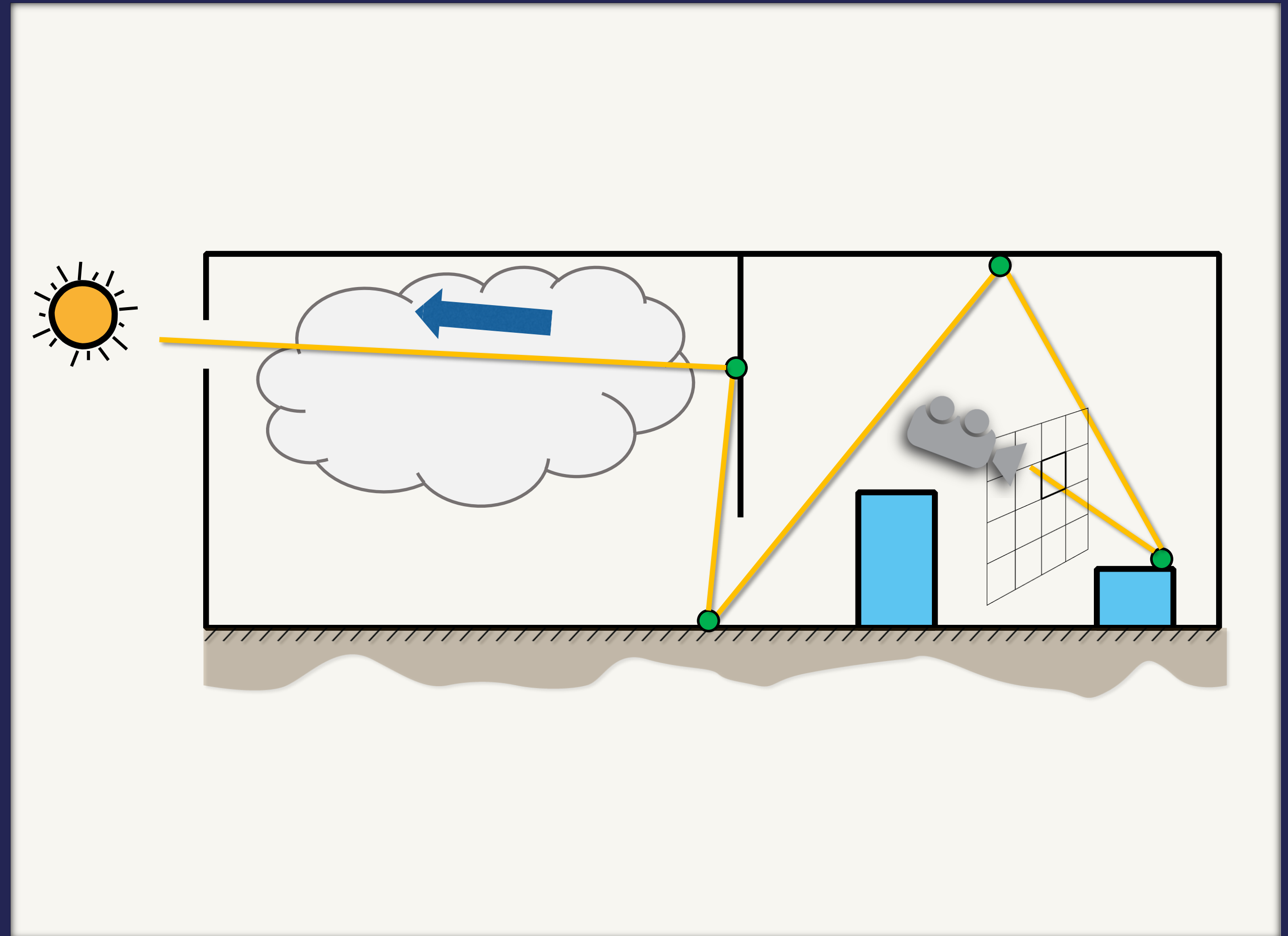
SAMPLING DECISIONS

- Directional sampling (BSDF)
- Termination (Path length)
- Light sampling (Next-event estimation)



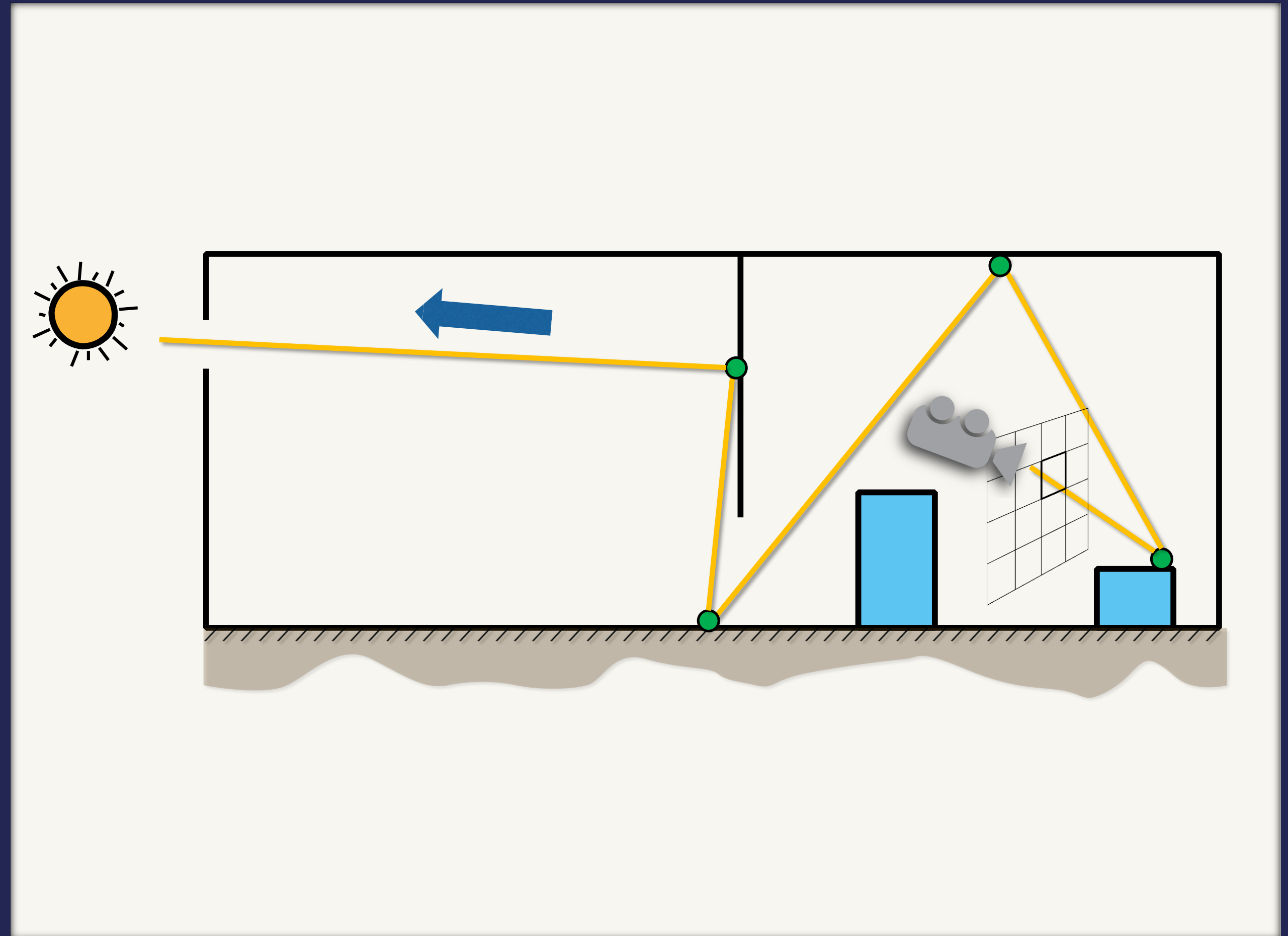
SAMPLING DECISIONS

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- Termination (Path length)
- Light sampling (Next-event estimation)
- Free-path sampling (Volumes)



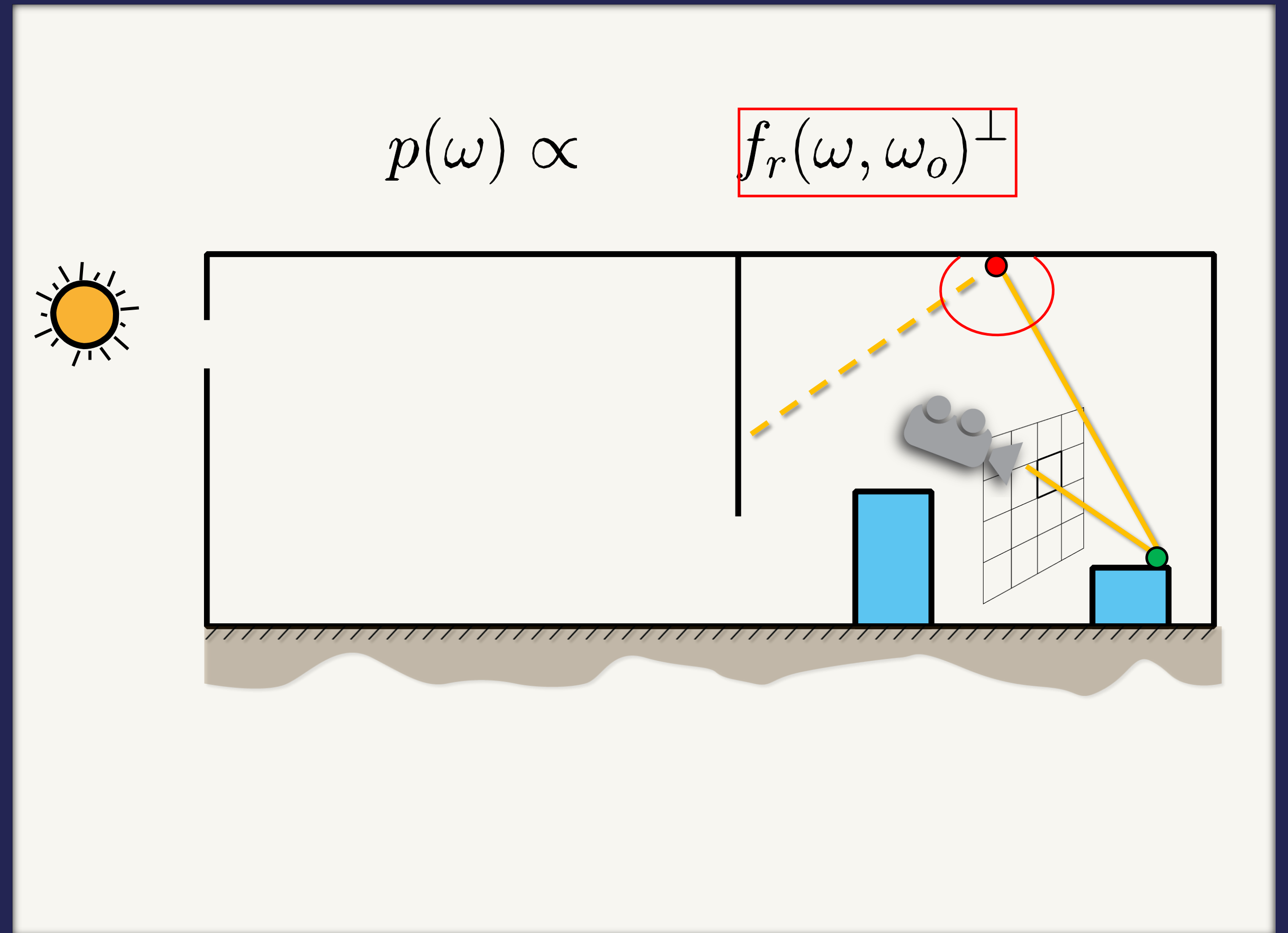
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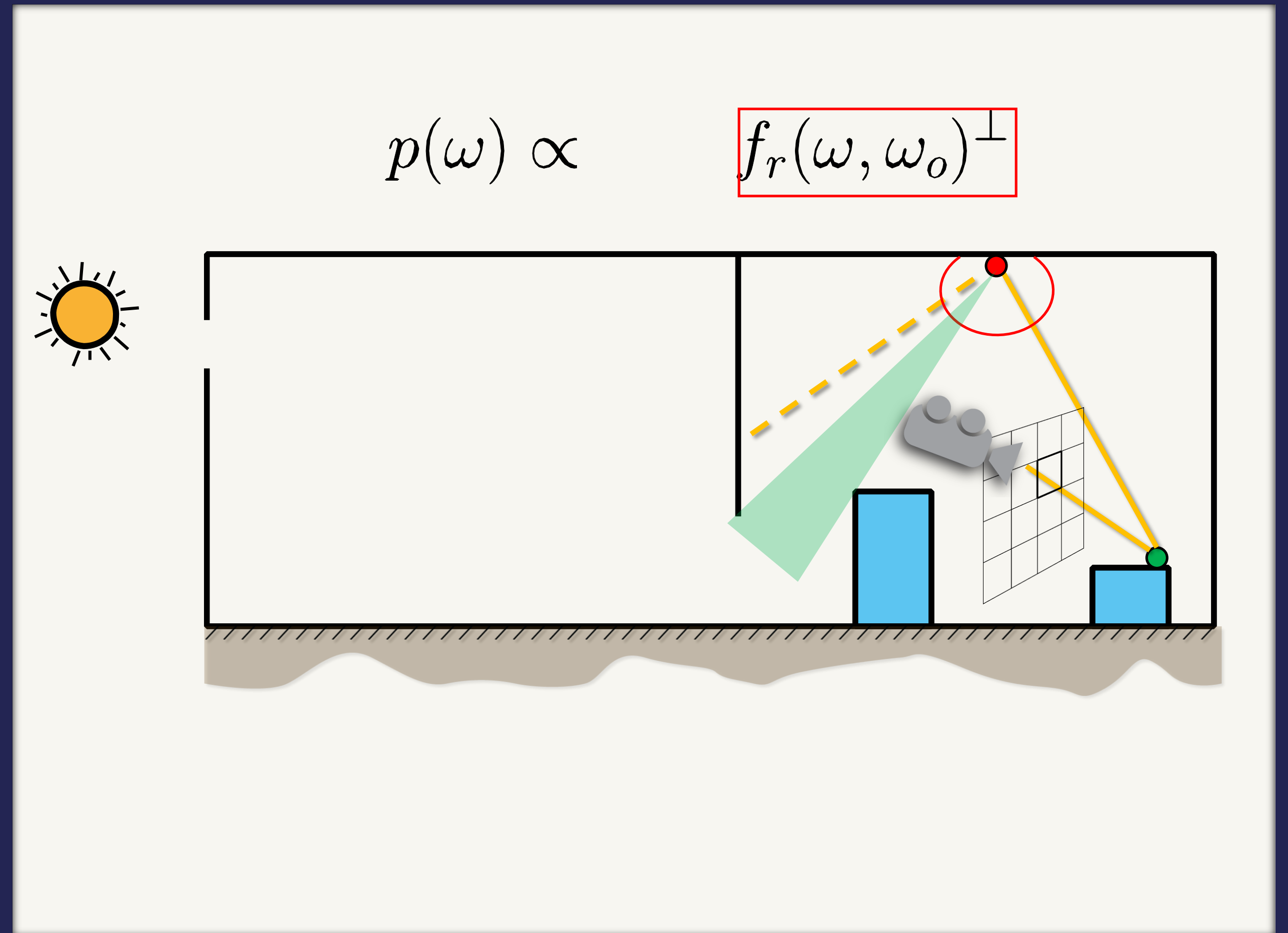
DIRECTIONAL SAMPLING

- BRDF importance sampling
- Challenge: Indirect illumination, visibility



DIRECTIONAL SAMPLING

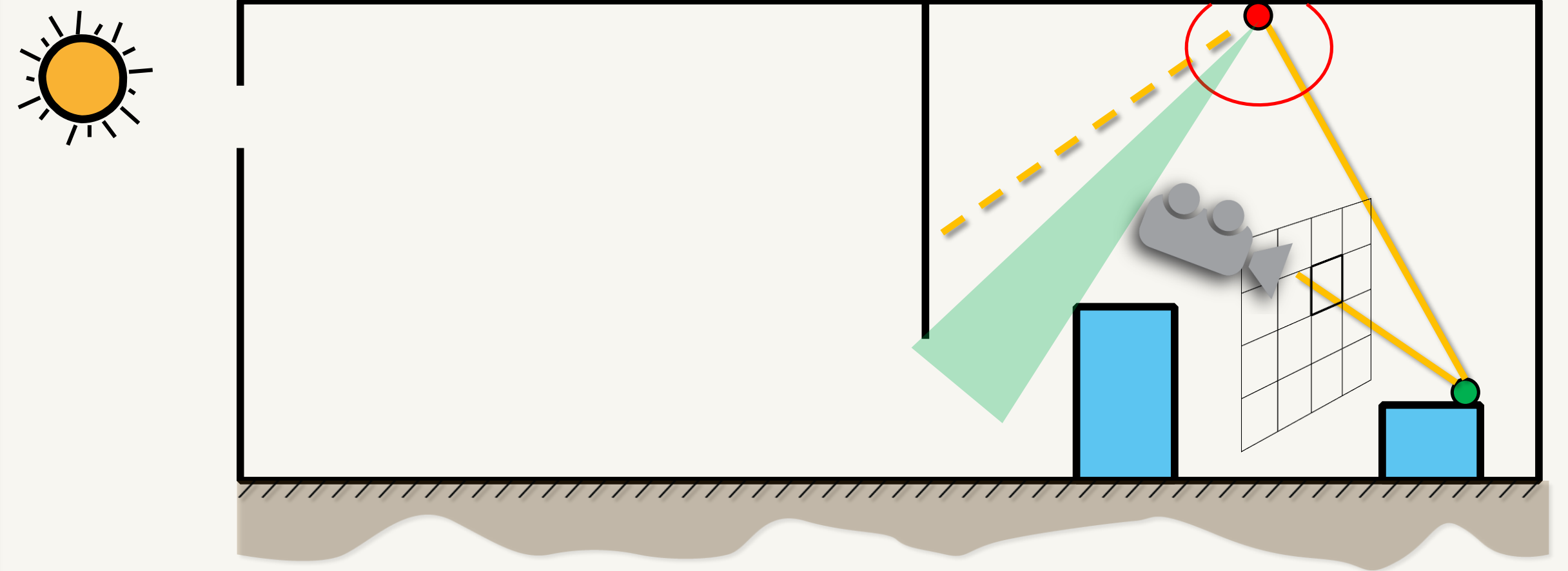
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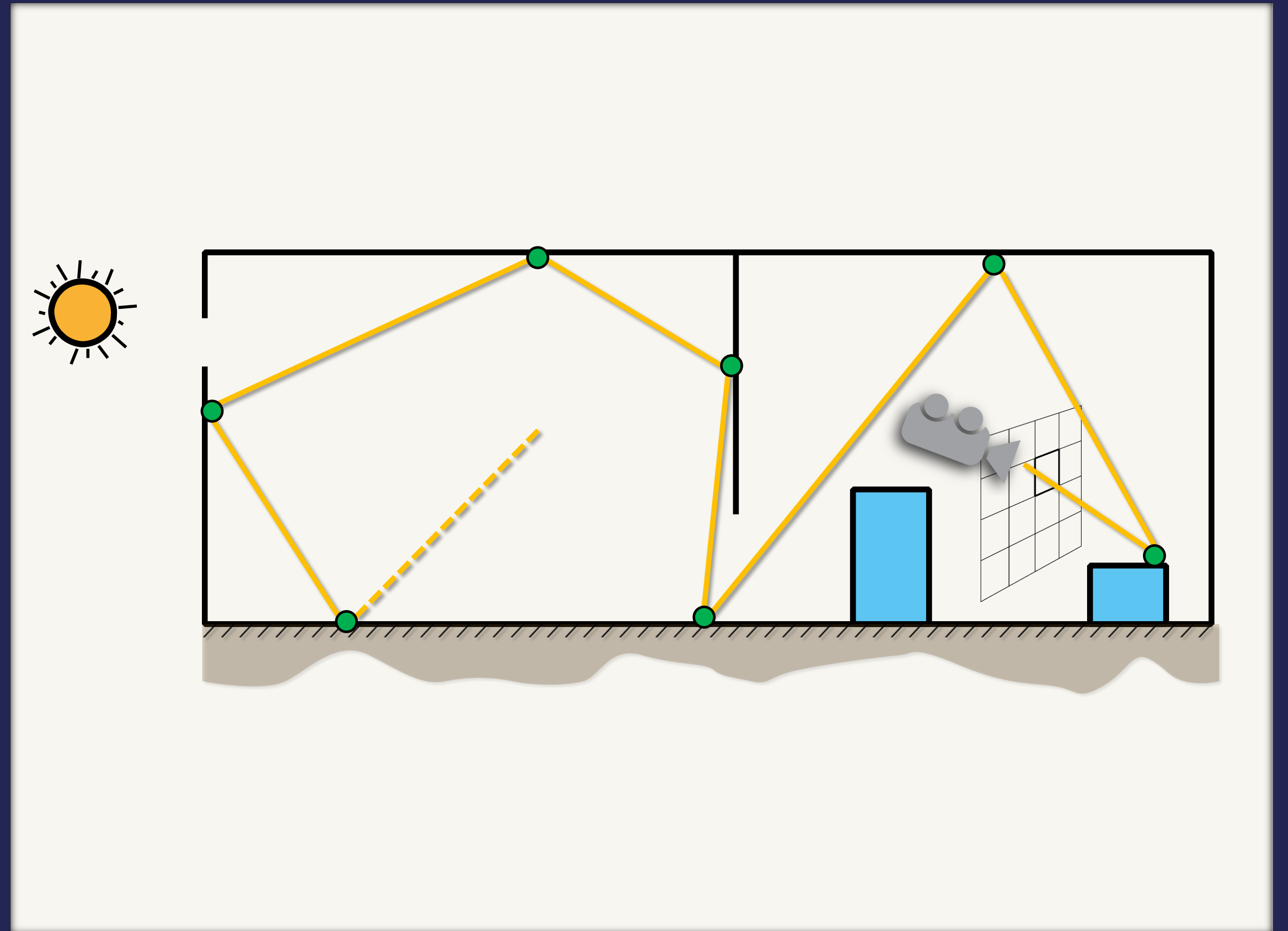
- BRDF importance sampling
- Challenge: Indirect illumination, visibility
- We don't know radiance!

$$p(\omega) \propto L(\omega) f_r(\omega, \omega_o)^\perp$$



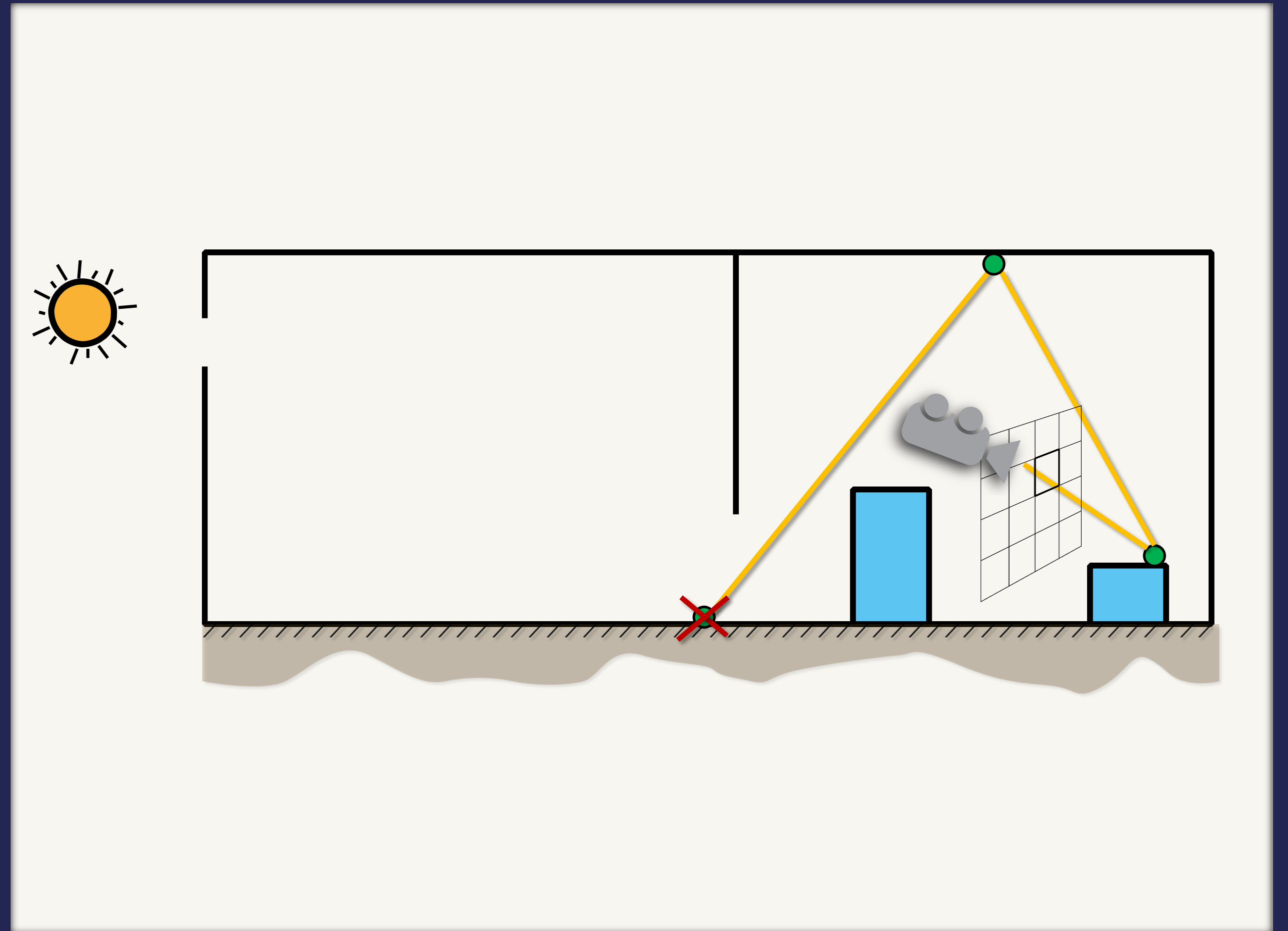
PATH LENGTH

- Ideally short paths, but not shorter



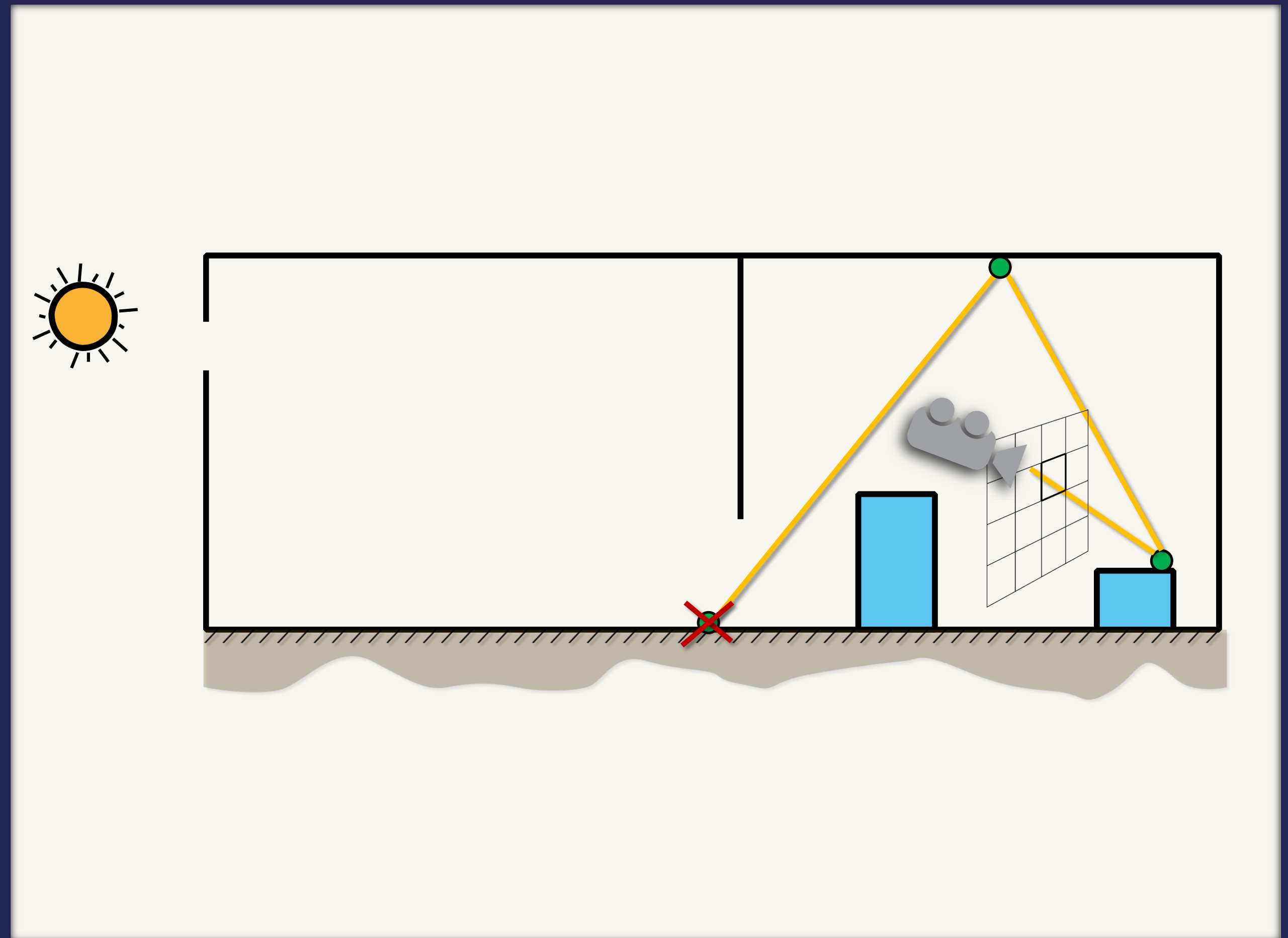
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PATH LENGTH

- Ideally short paths, but not shorter
- Russian roulette: albedo based



KEY TO EFFICIENCY

- We need **global** knowledge (5D radiance)

$$L(\mathbf{x}, \omega)$$

ZERO-VARIANCE DECISIONS

- Optimal sampling decisions

$$L(\mathbf{x}, \omega)$$

ZERO-VARIANCE DECISIONS

- Optimal sampling decisions
- Example: perfect scattering

$$L(\mathbf{x}, \omega)$$

$$p(\omega|\mathbf{x}) \propto \boxed{L(\mathbf{x}, \omega)} f_r(\mathbf{x}, \omega, \omega_o)^\perp$$

ZERO-VARIANCE DECISIONS

- Optimal sampling decisions
- Example: perfect scattering
- Radiance is not known!

$$L(\mathbf{x}, \omega)$$

$$p(\omega|\mathbf{x}) \propto L(\mathbf{x}, \omega) f_r(\mathbf{x}, \omega, \omega_o)^\perp$$

LEARNING

- Radiance not known a-priory
- Learning **approximation** from samples
- Improved importance sampling

PATH GUIDING

- How to **represent** the knowledge?
- How to **learn** from samples?
- How to **exploit** it in the simulation?