Efficient Energy-Compensated VPLs using Photon Splatting

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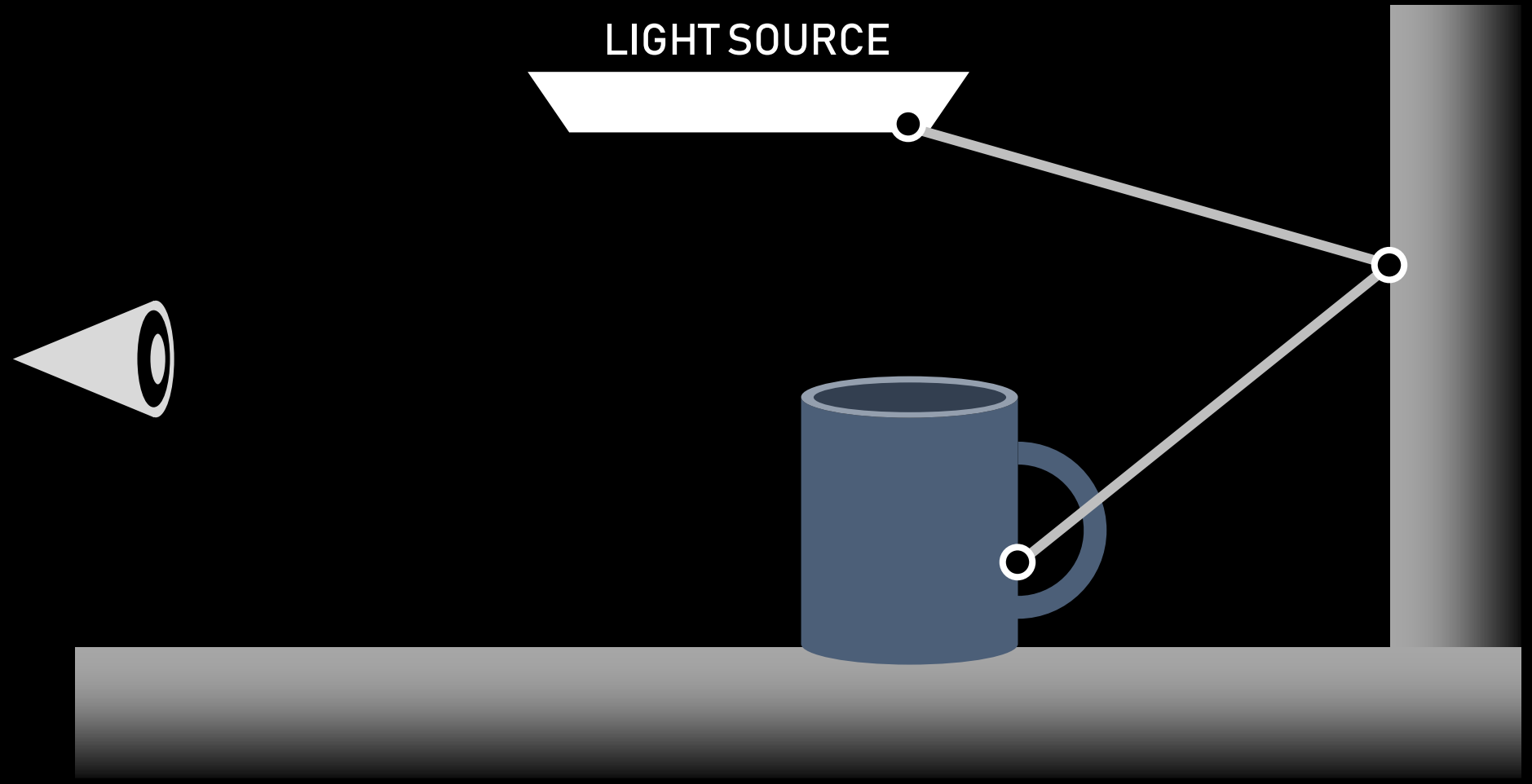
Instant Radiosity with VPLs (Keller et al. 1997)



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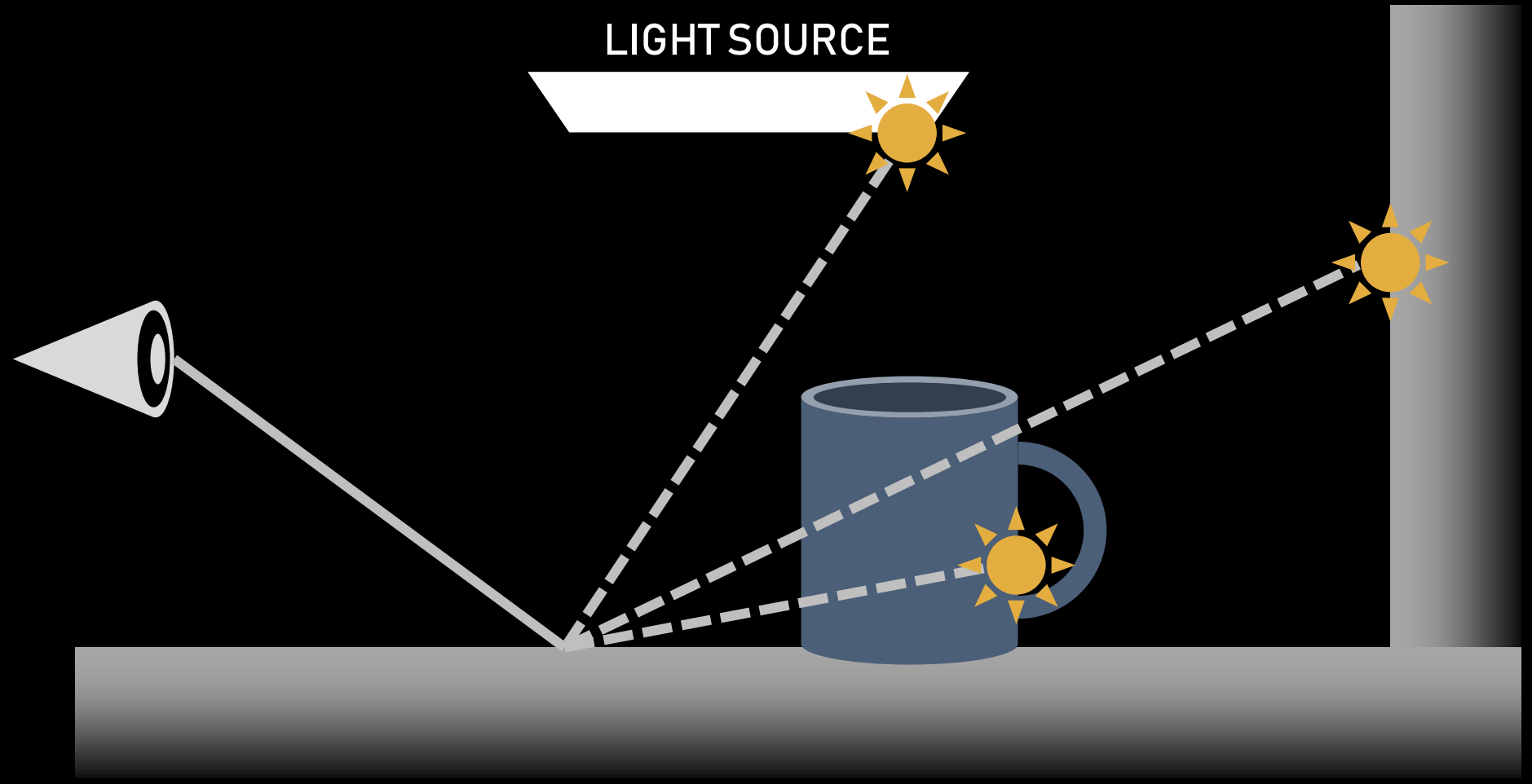

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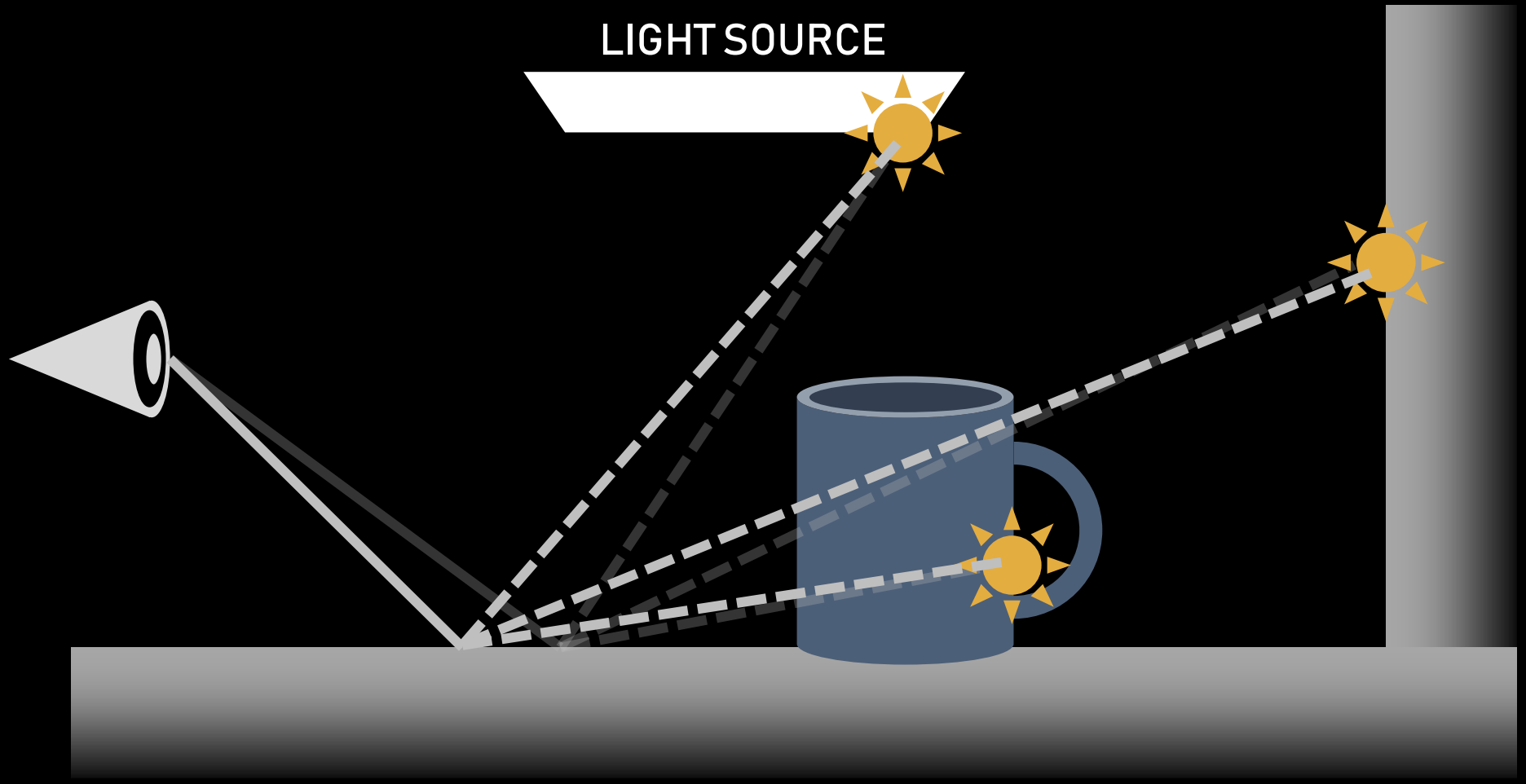

Instant Radiosity with VPLs

Advantages

- Reuses light subpaths across pixels efficiently
- Can be used with several scalable techniques
  (MRCS - Hašan et al. 2007, LightCuts - Walter et al. 2005, 2006, Ou and Pellacini 2011, …)

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  (MRCS - Hašan et al. 2007, LightCuts - Walter et al. 2005, 2006, Ou and Pellacini 2011, …)

Disadvantages

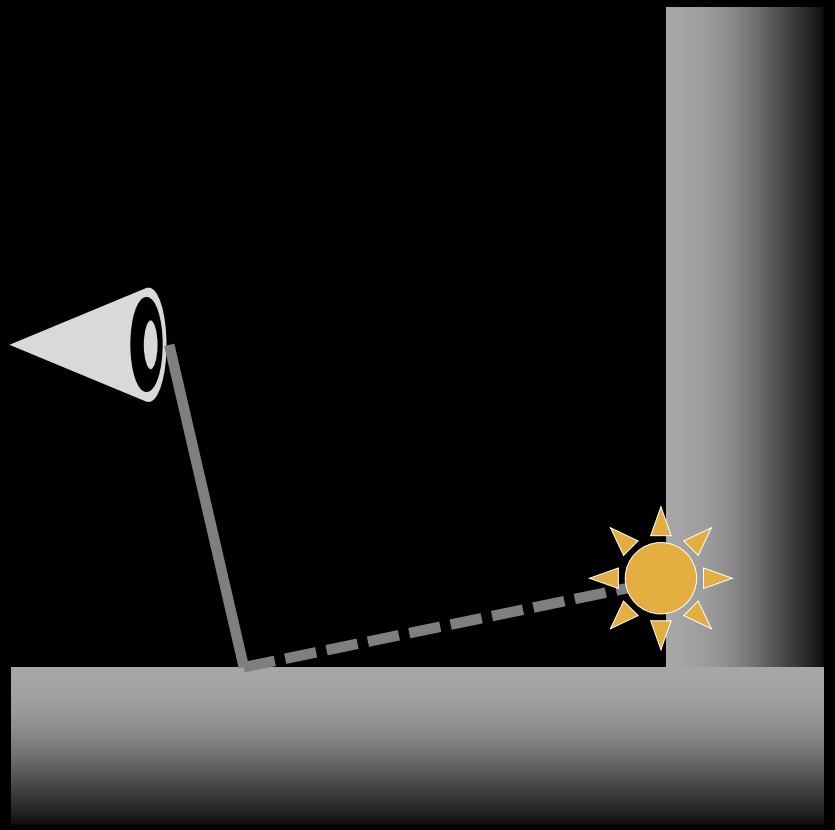
- Contains weak singularities

Instant Radiosity with VPLs

RESULT
(500 light subpaths)

REFERENCE

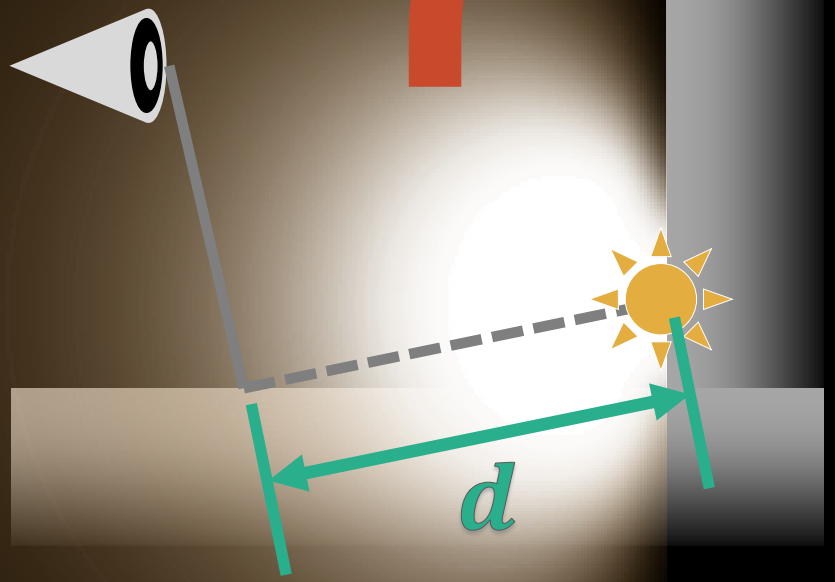
Cause of weak singularities



Cause of weak singularities

Geometry term

$$\frac{\cos(\theta)\cos(\phi)}{d^2}$$



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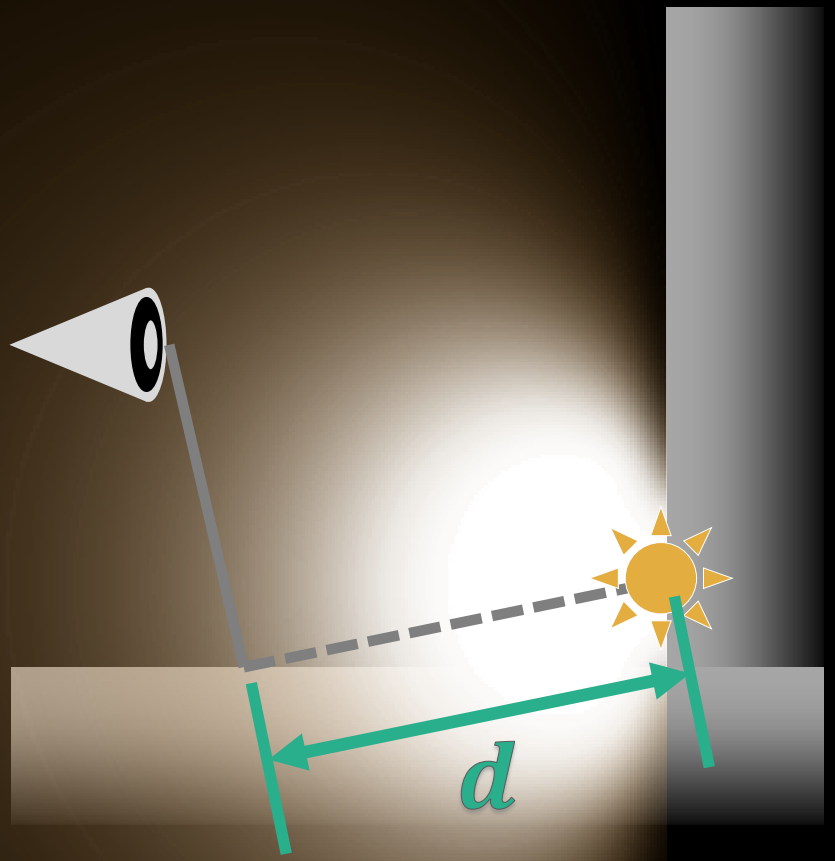

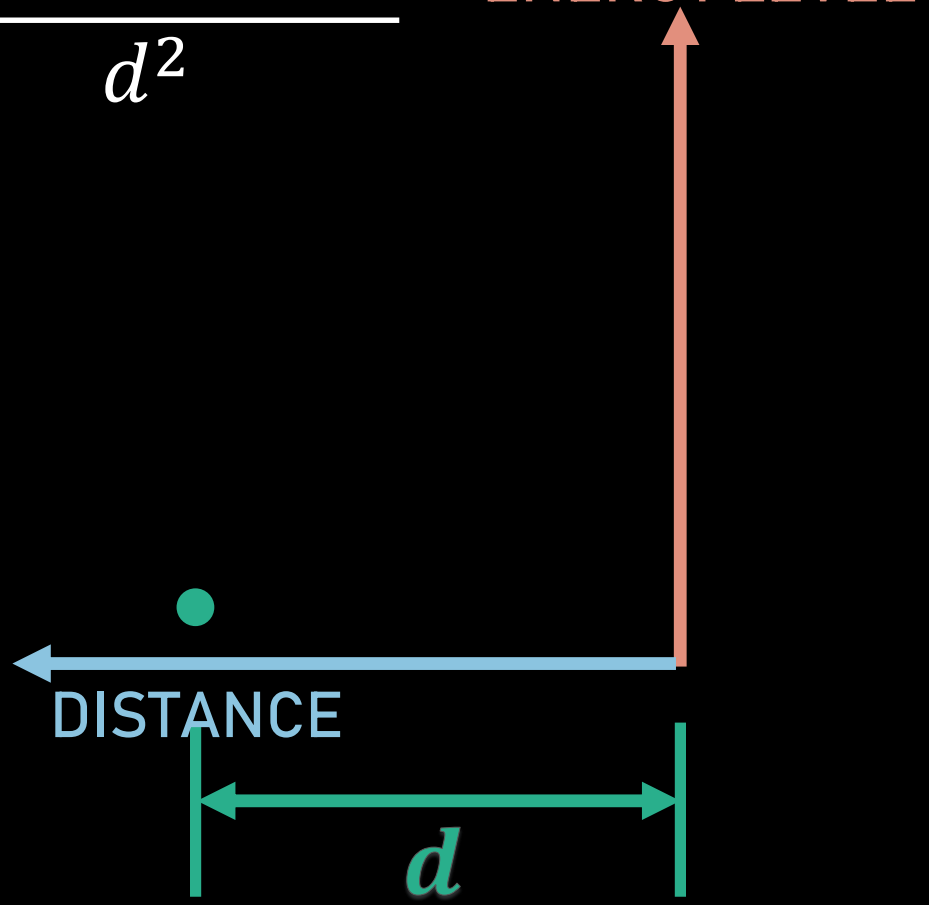

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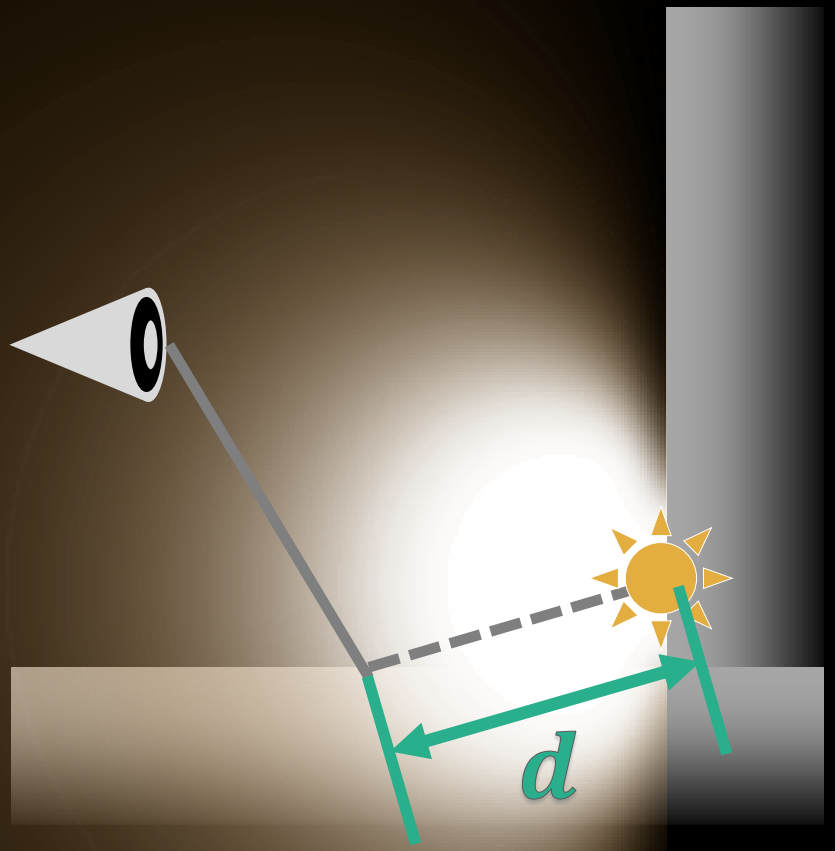

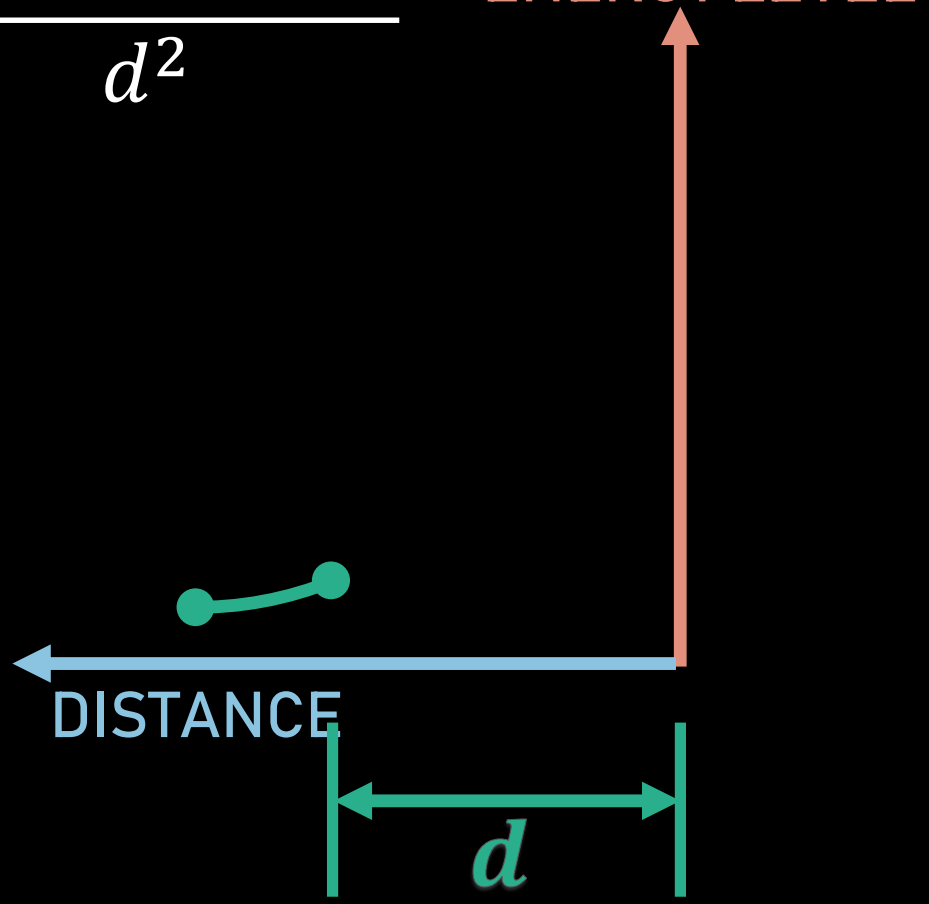

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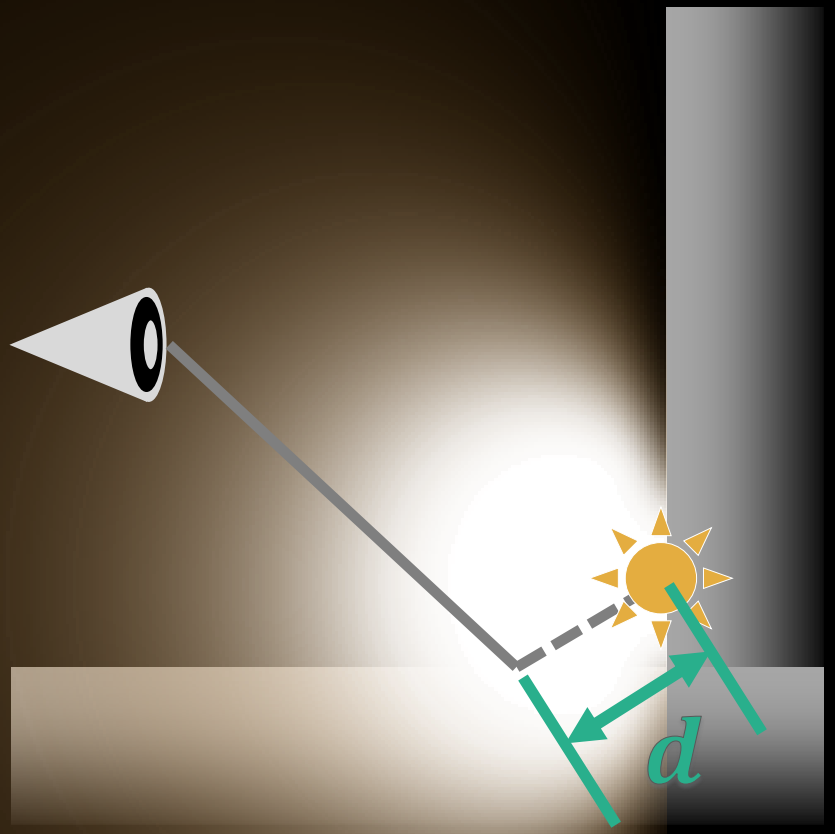

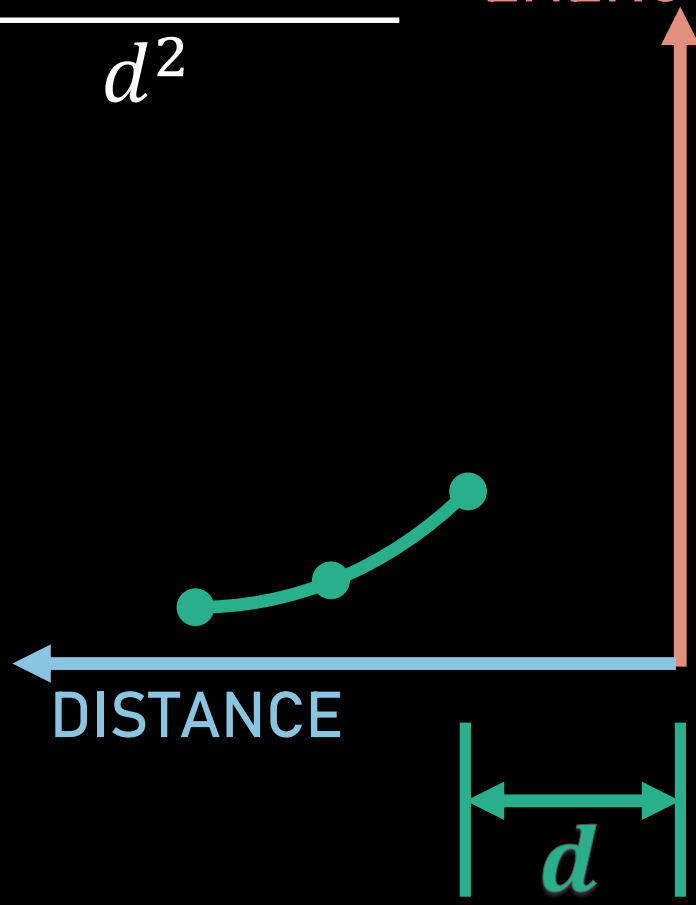

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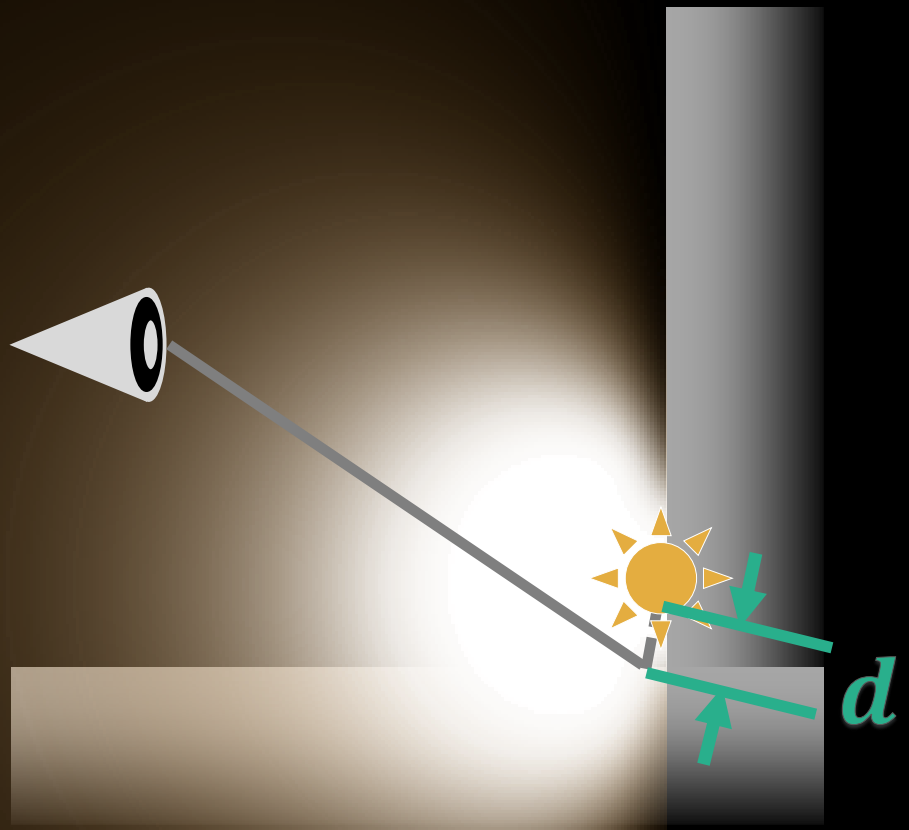

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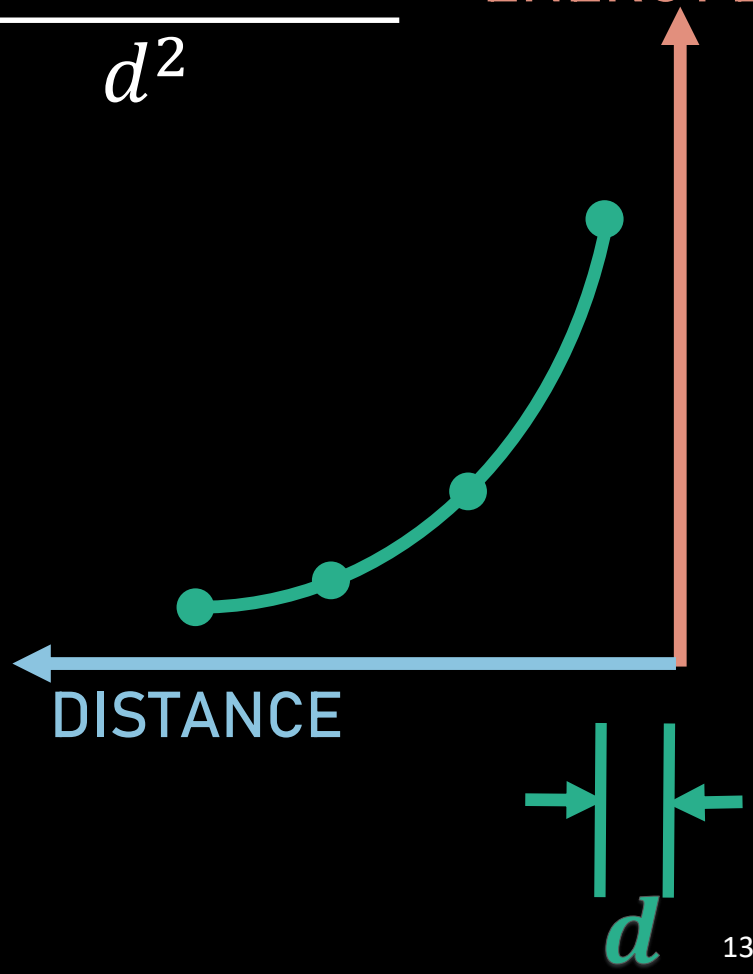

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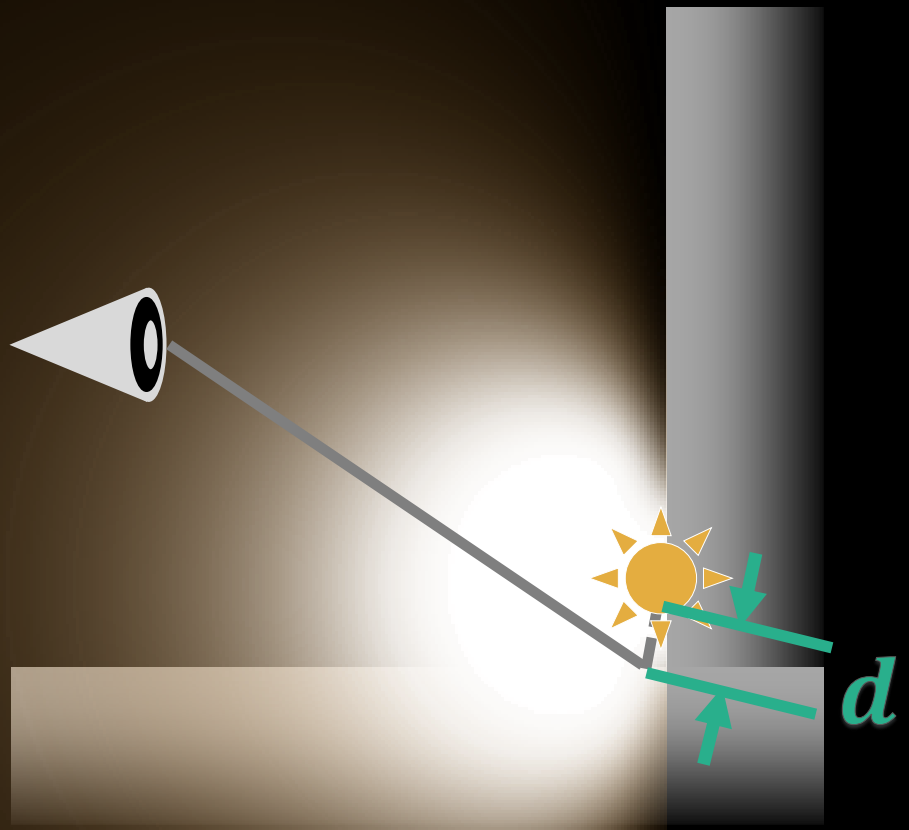

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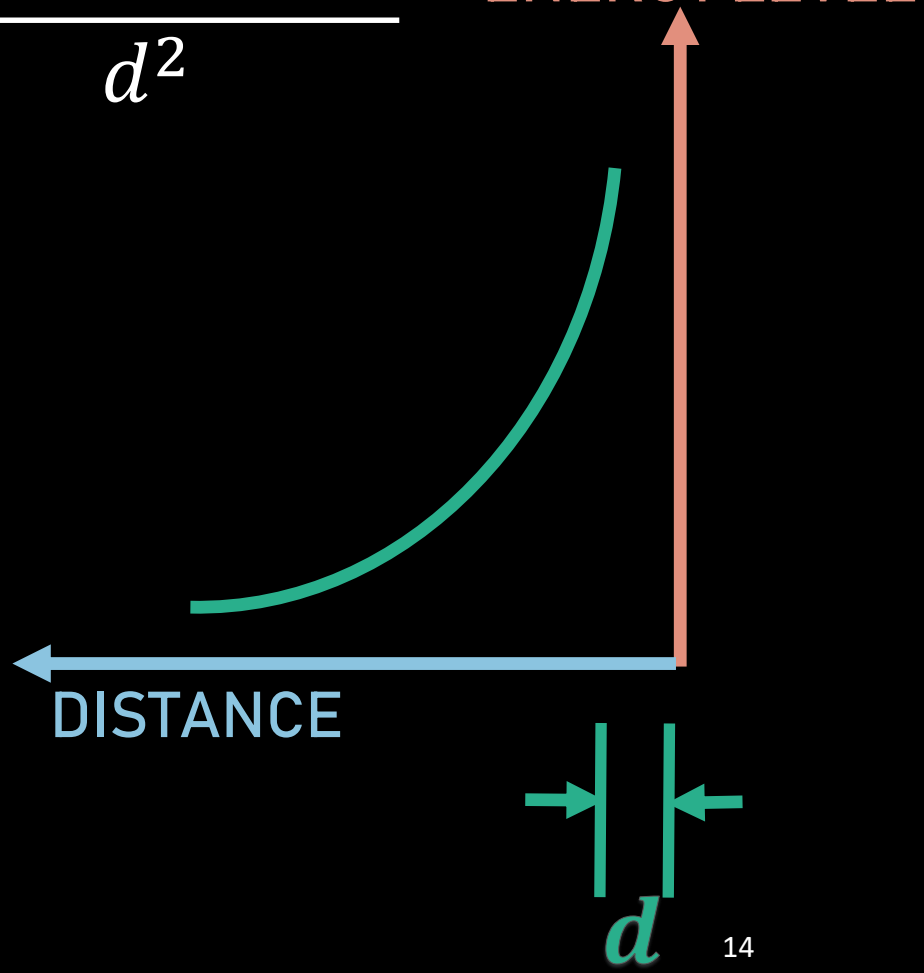

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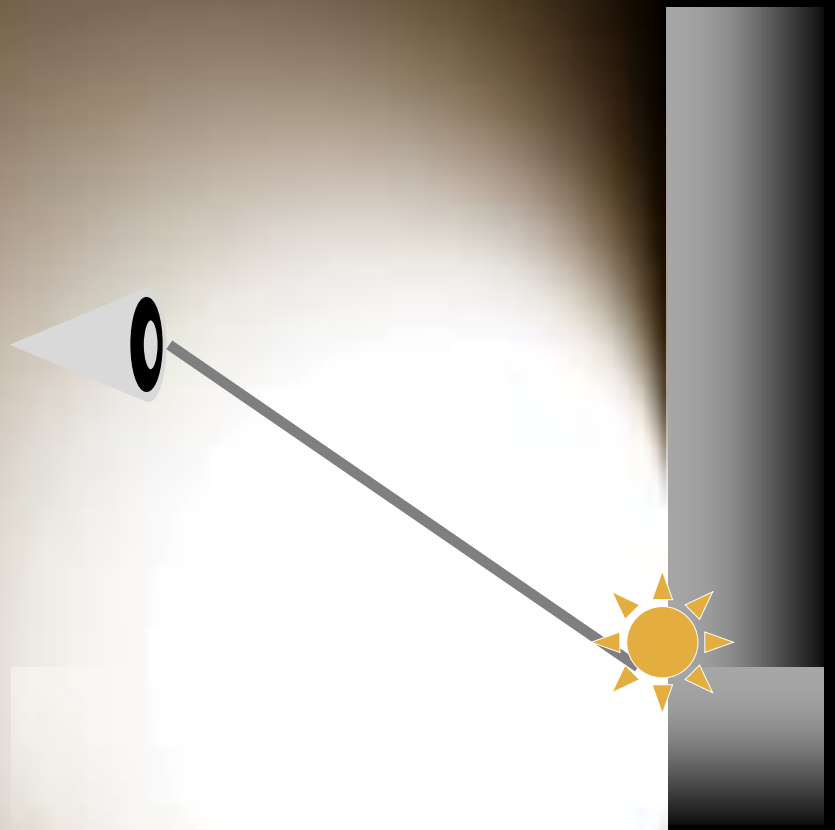

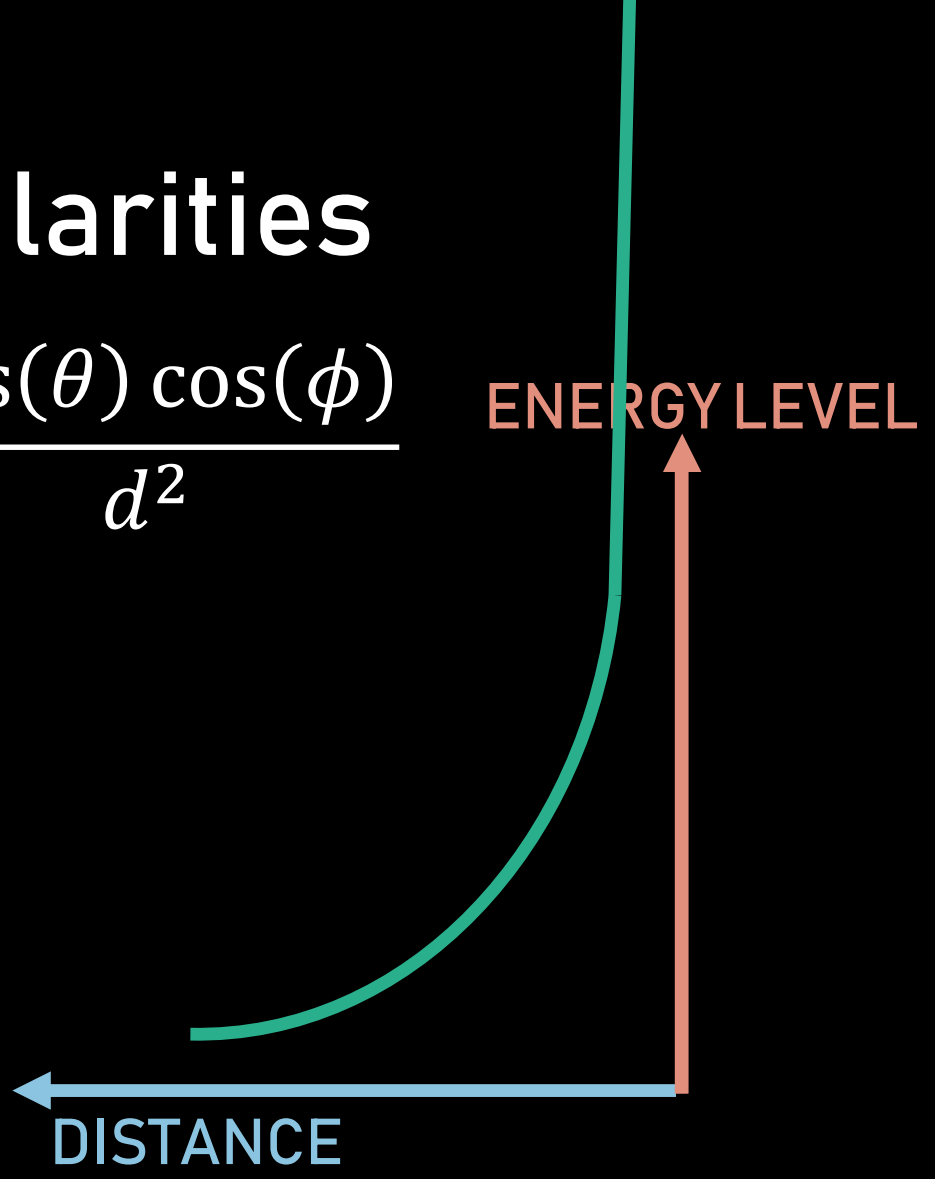

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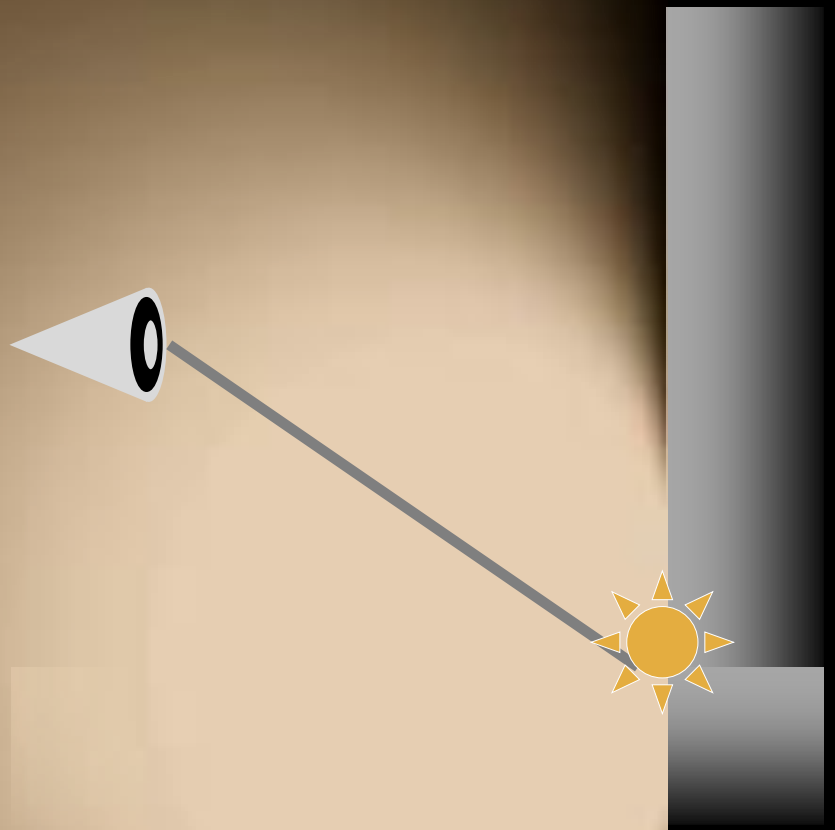

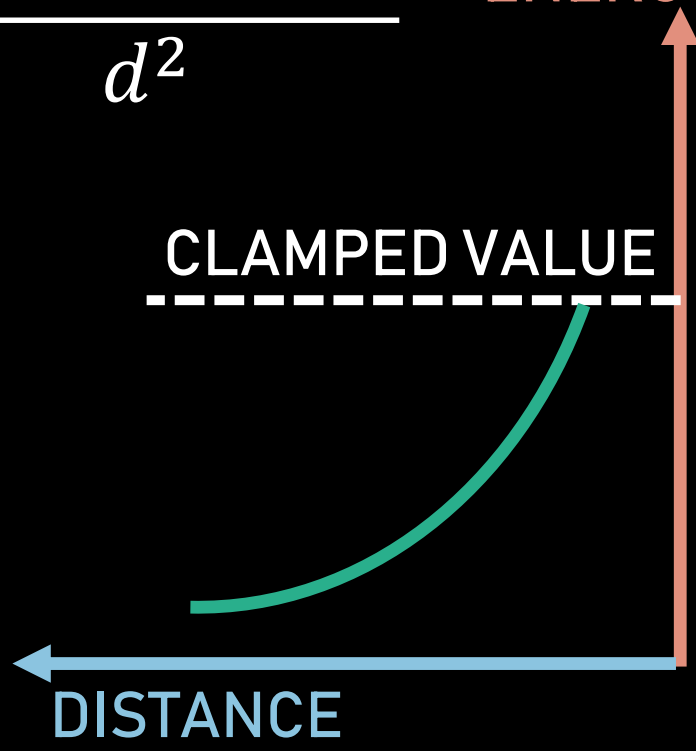

Instant Radiosity with "clamped" VPLs

CLAMPED RESULT
(500 light subpaths)

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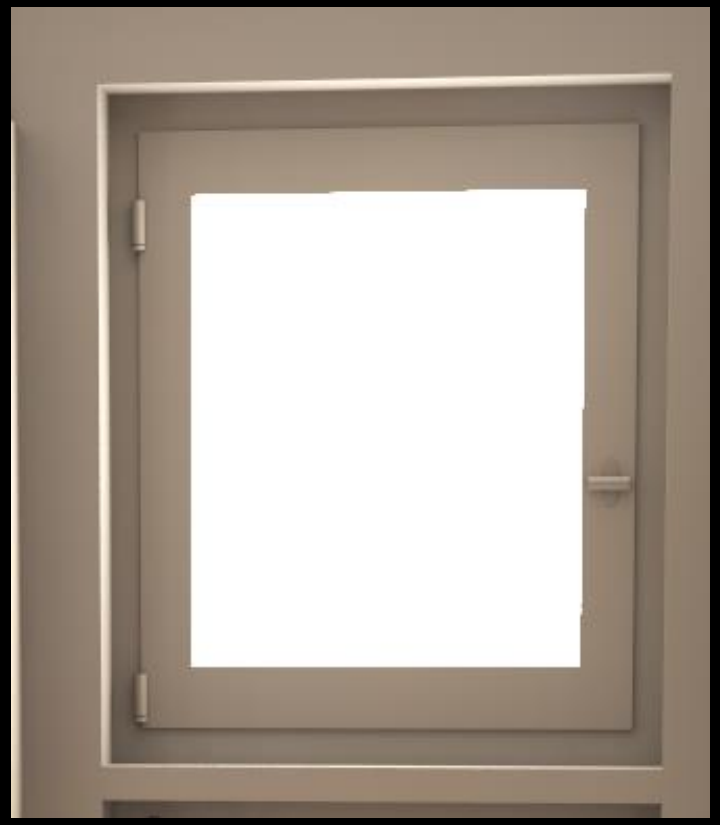

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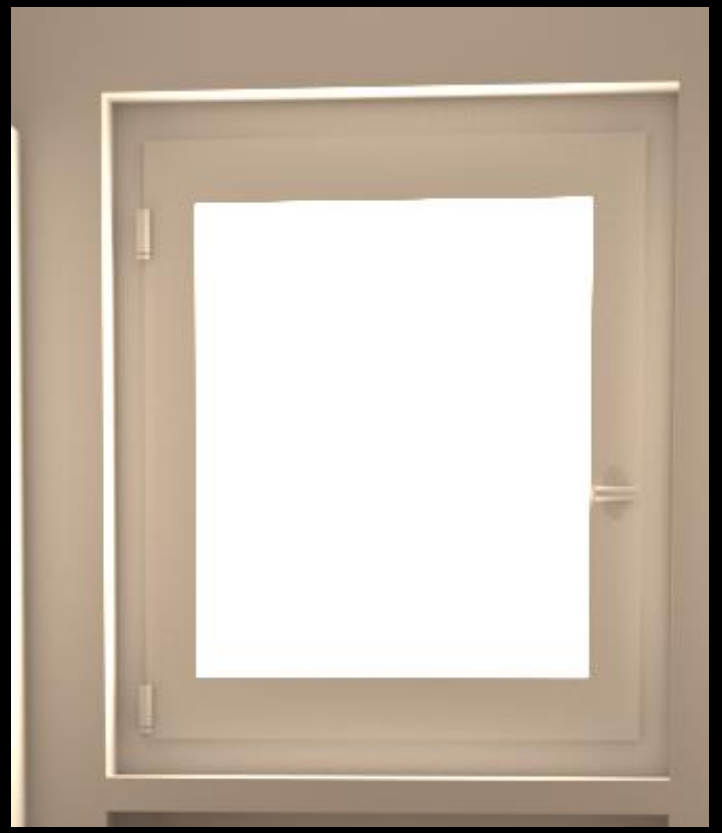

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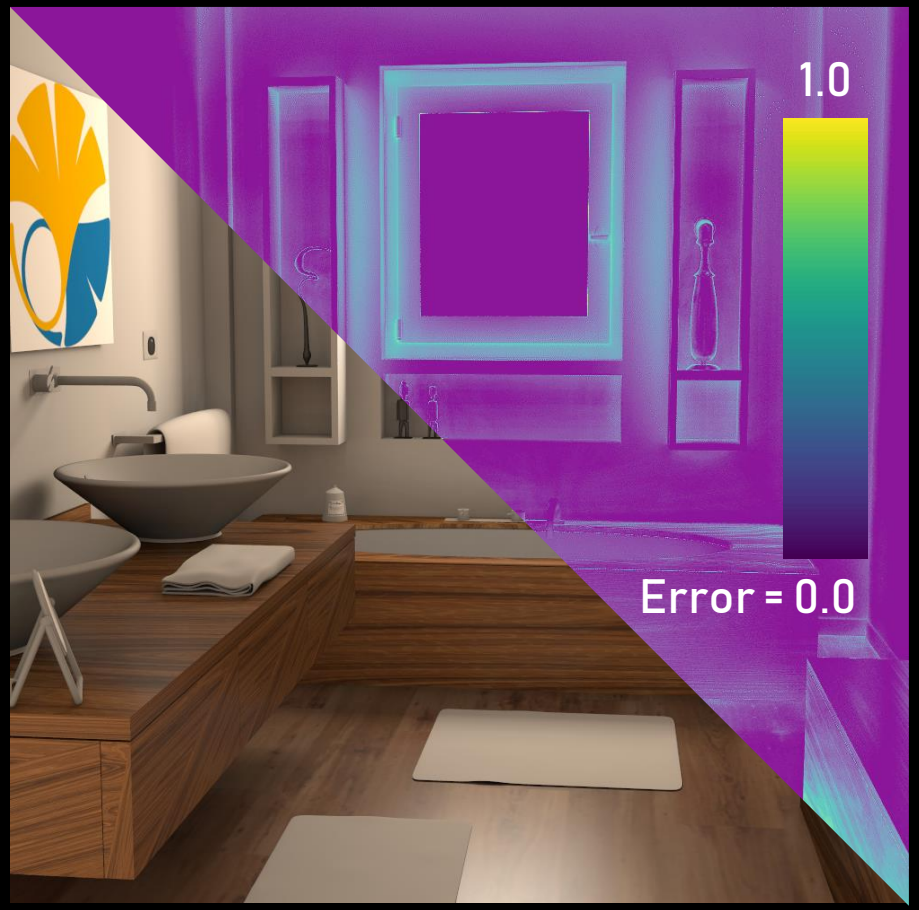

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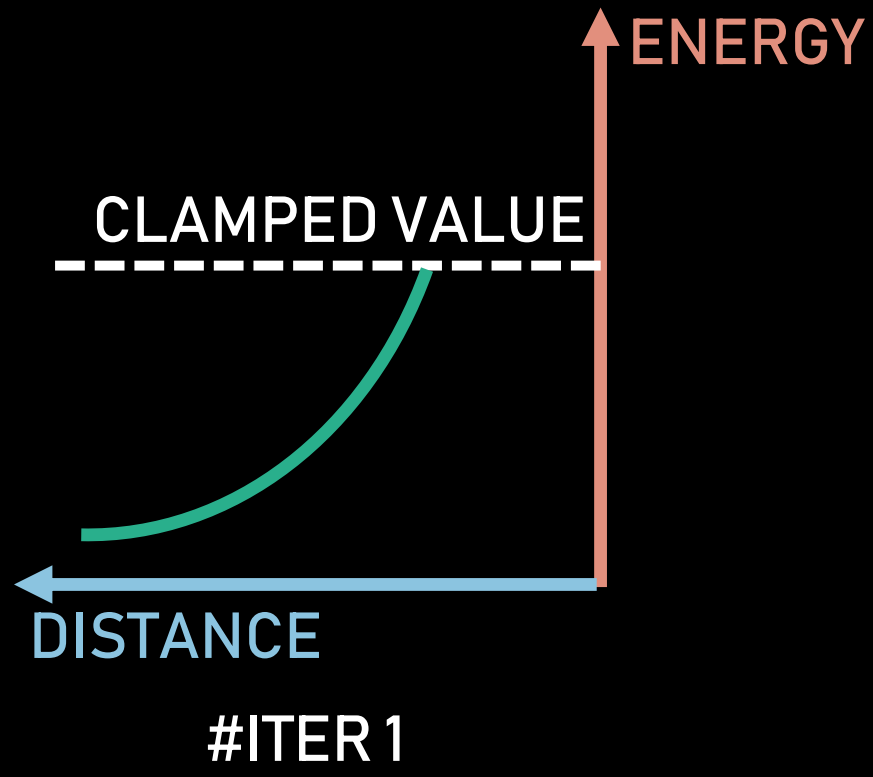
Related work

Progressive Lightcuts (Davidovič et al. 2012)



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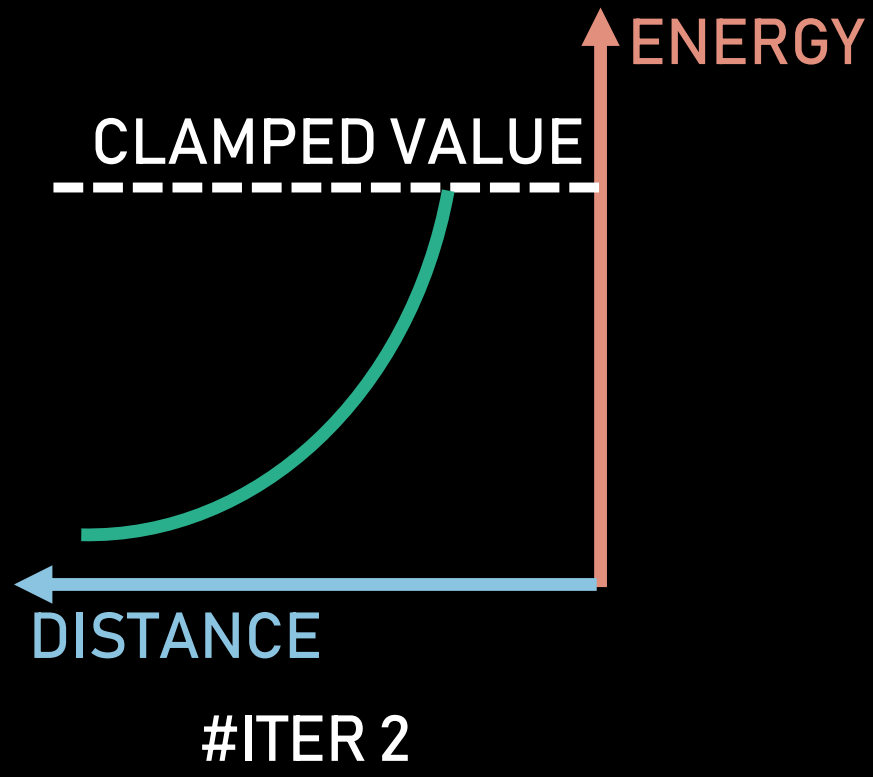

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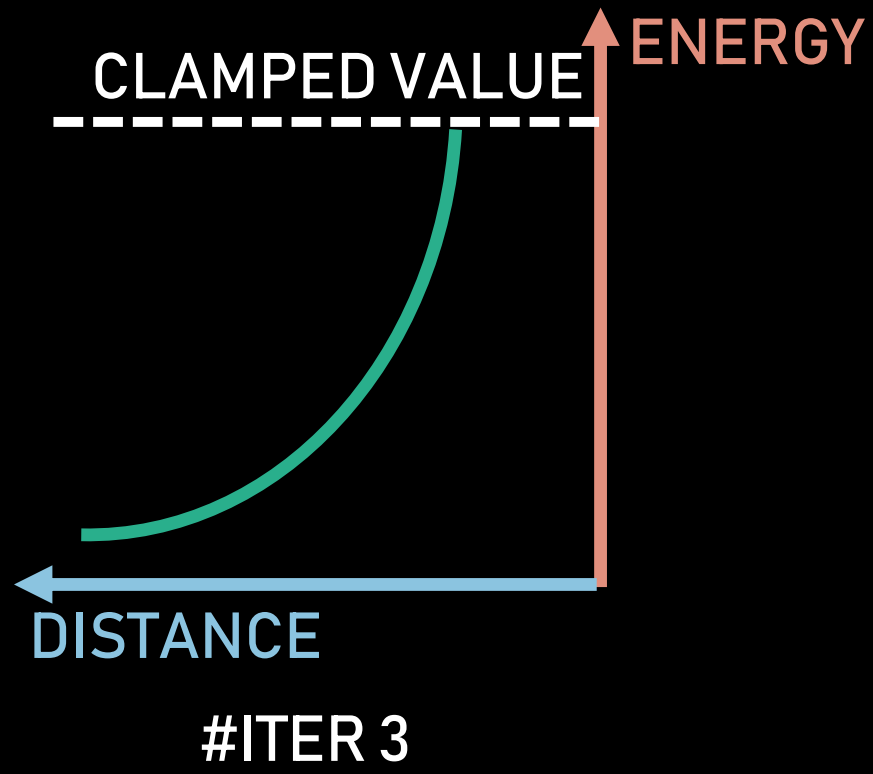
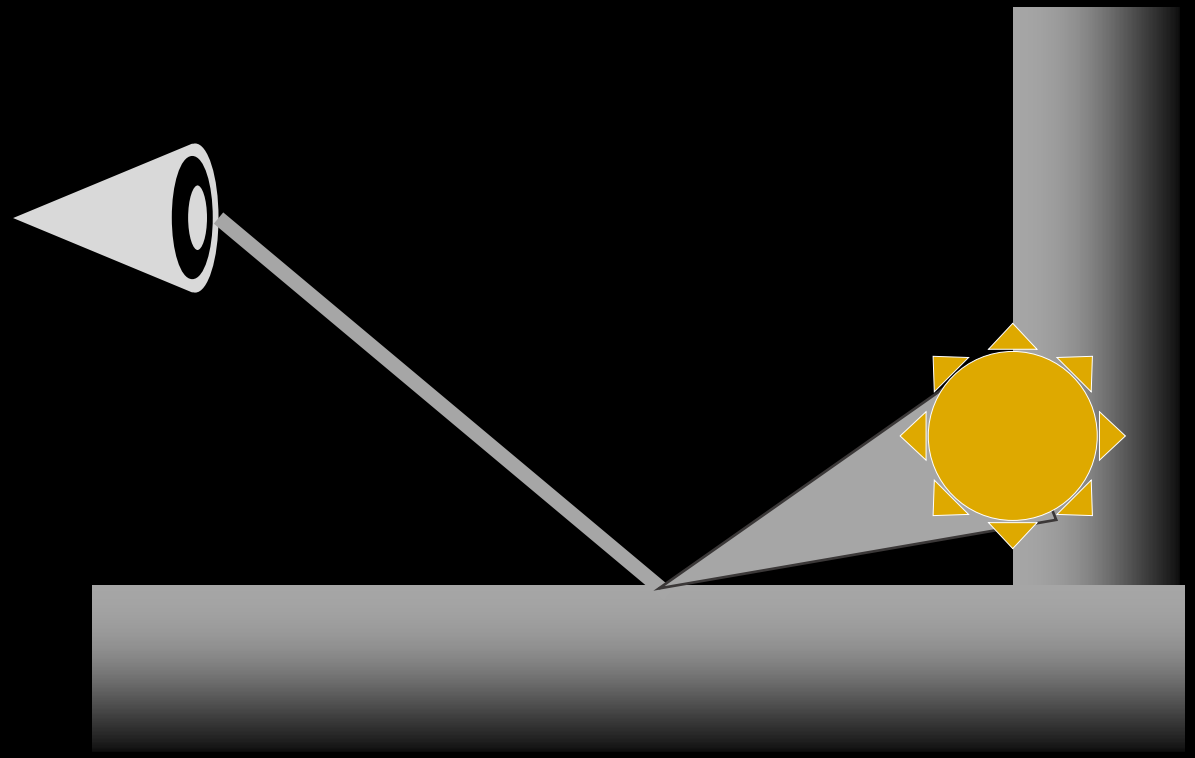


Related work

Virtual Spherical Lights (Hašan et al. 2009)



Related work

Illumination in the Presence of Weak Singularities (Kollig and Keller 2004)

Related work

Screen-Space Bias Compensation (SSBC), (Novák et al. 2011)

Ours

Based on these following observations:

- Light vertices can be used as VPLs or photons
- Photon density estimation is singularities free

Global illumination using photon maps
(Jensen 1996)

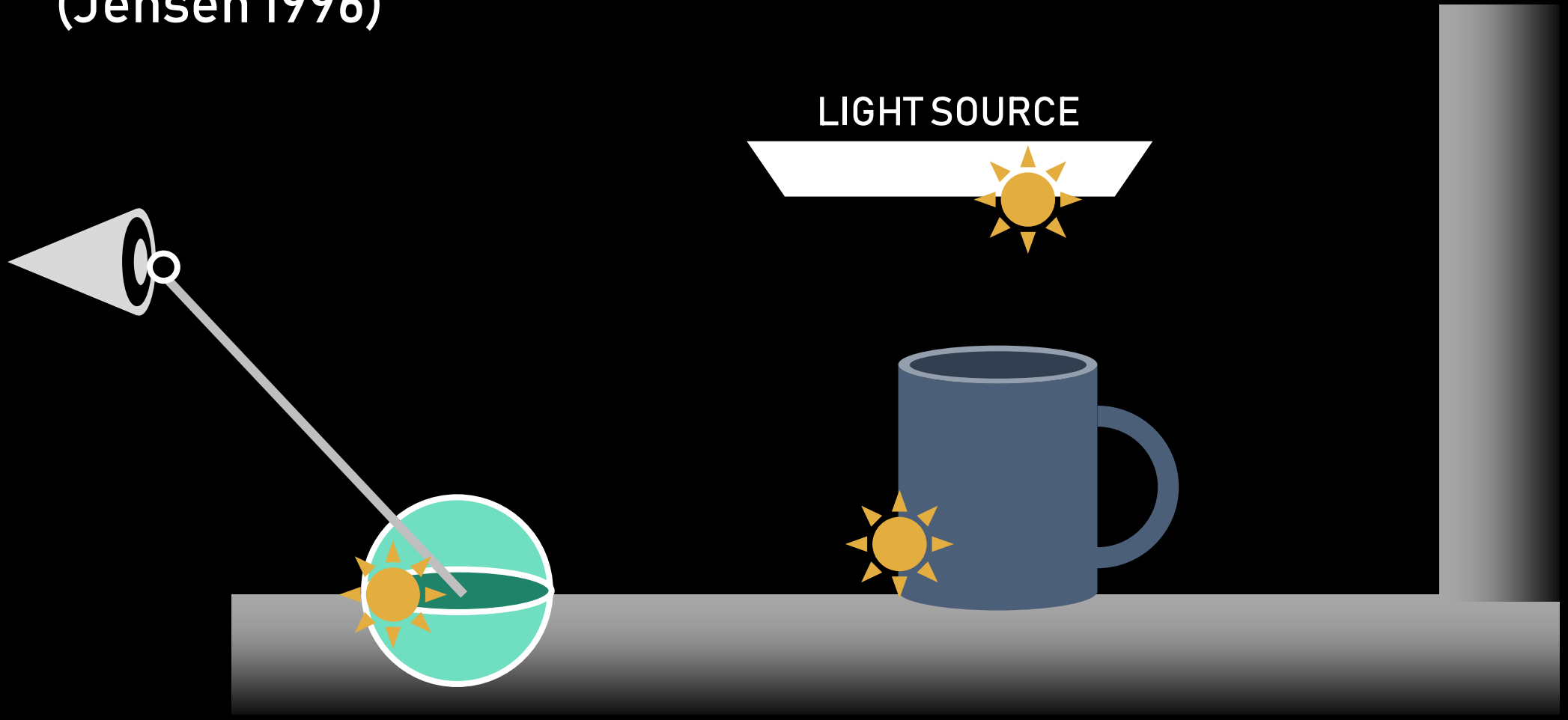
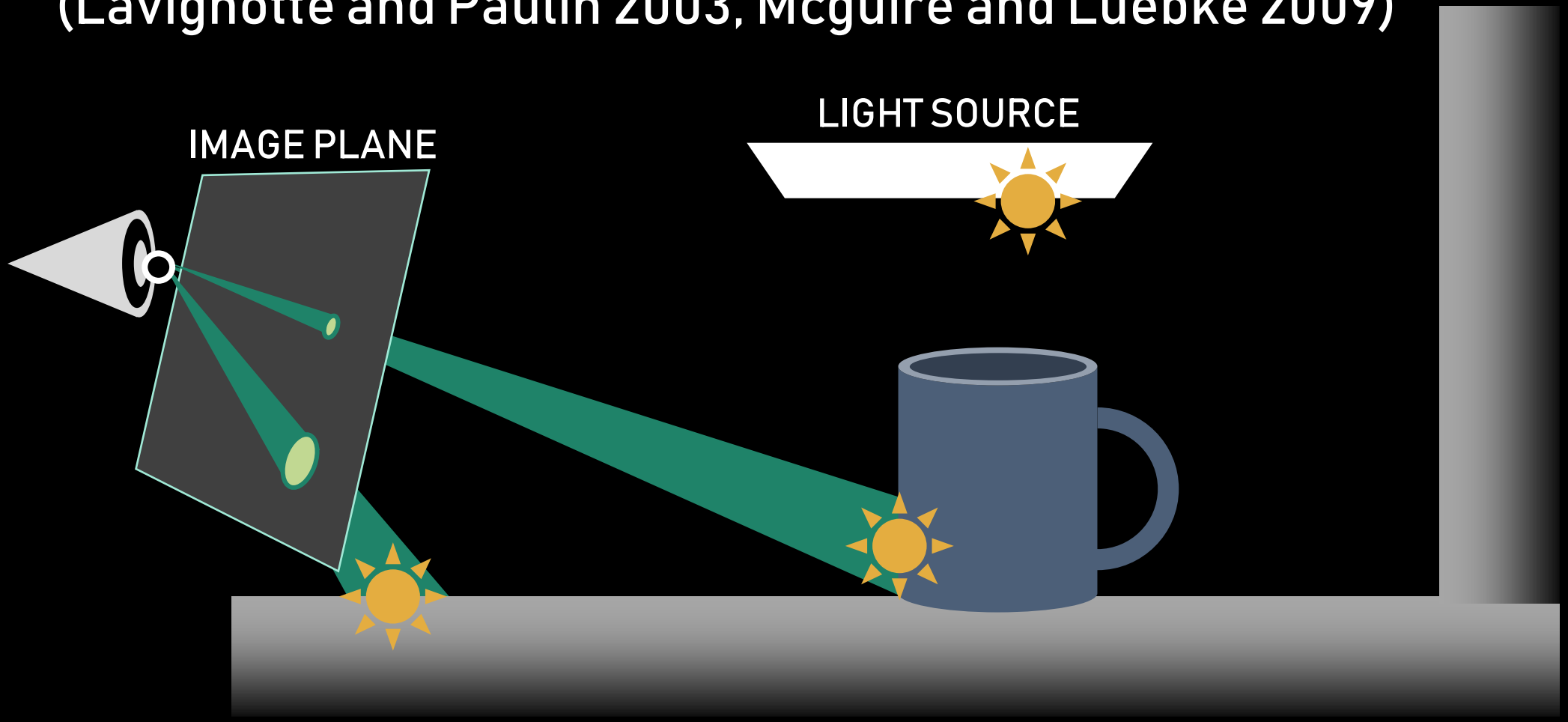


Image Space Photon Splatting
(Lavignotte and Paulin 2003, Mcguire and Luebke 2009)



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Based on these following observations:

- Light vertices can be used as VPLs or photons
- Photon Mapping is singularities free
- Instant Radiosity is efficient
- Photon Splatting is efficient

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- Light vertices can be used as VPLs or photons
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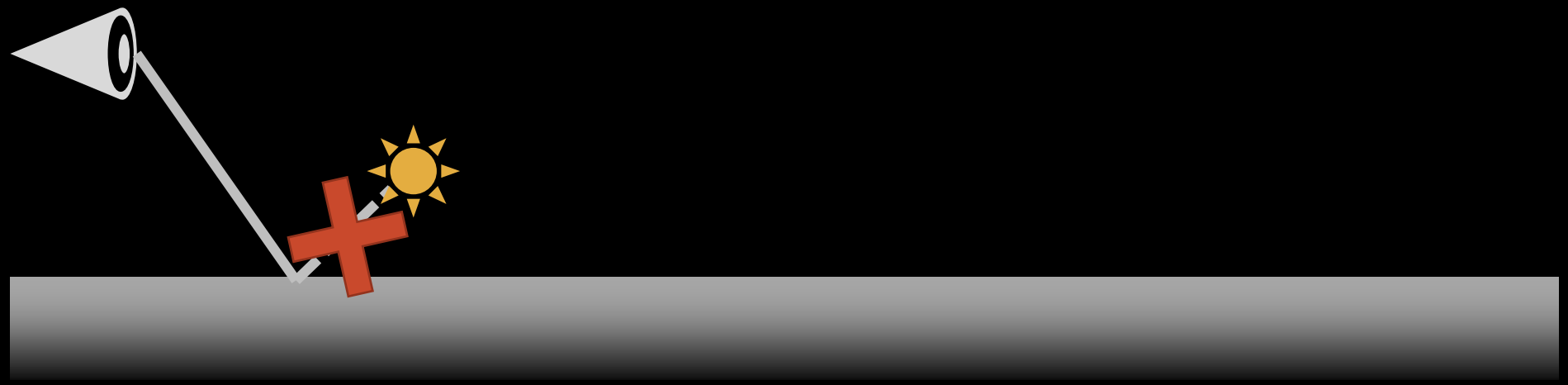
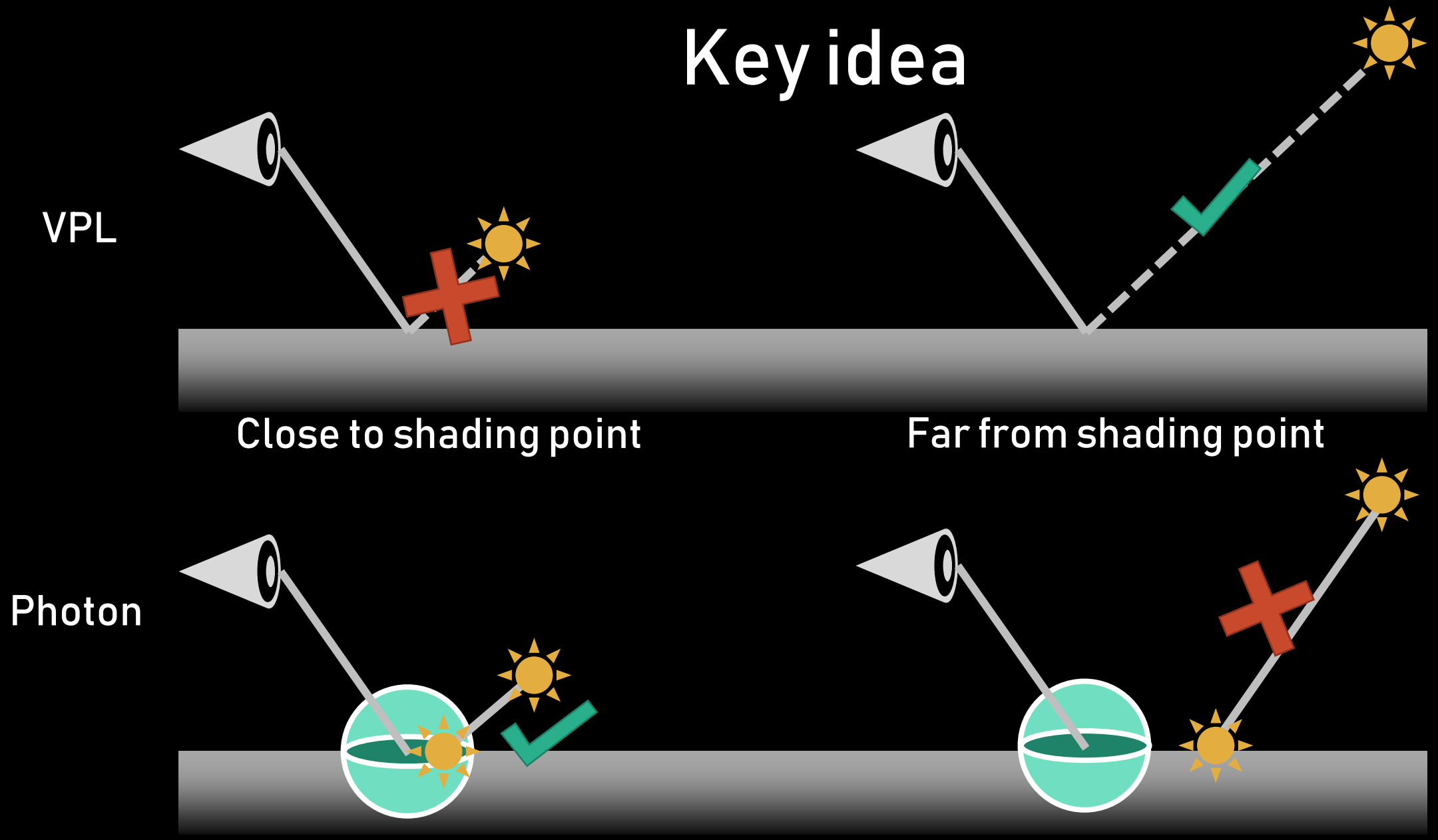
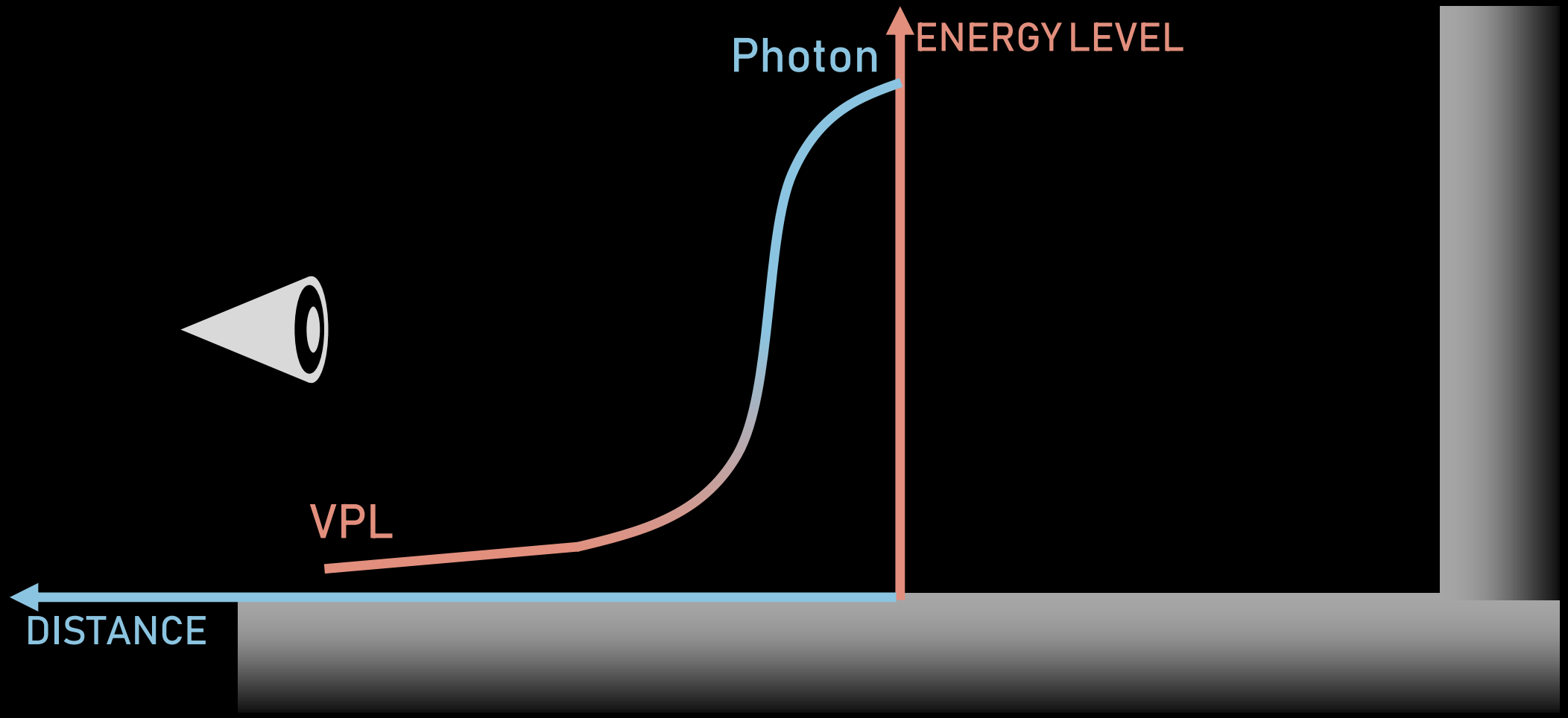
Key idea : switches between VPL and Photon when appropriate!

Key idea

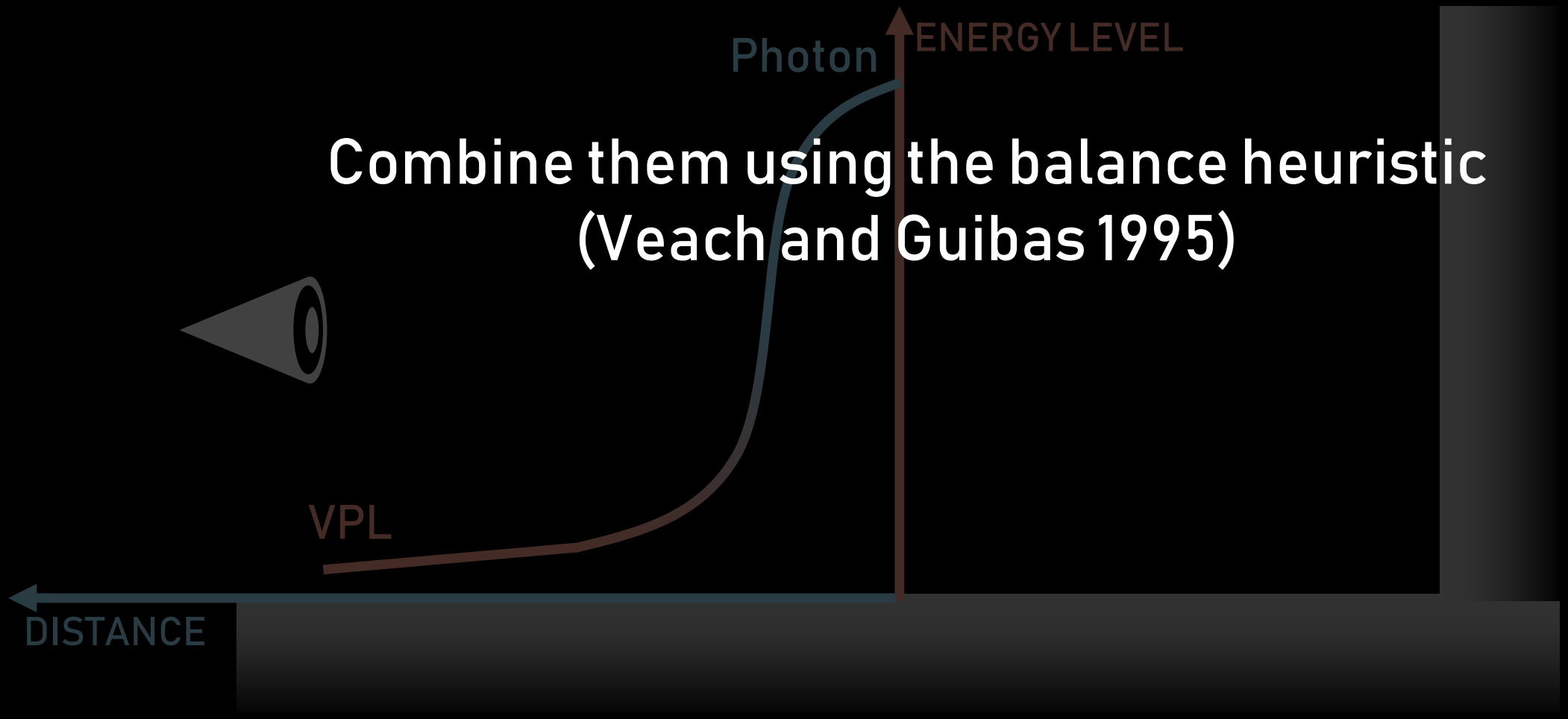


Key idea



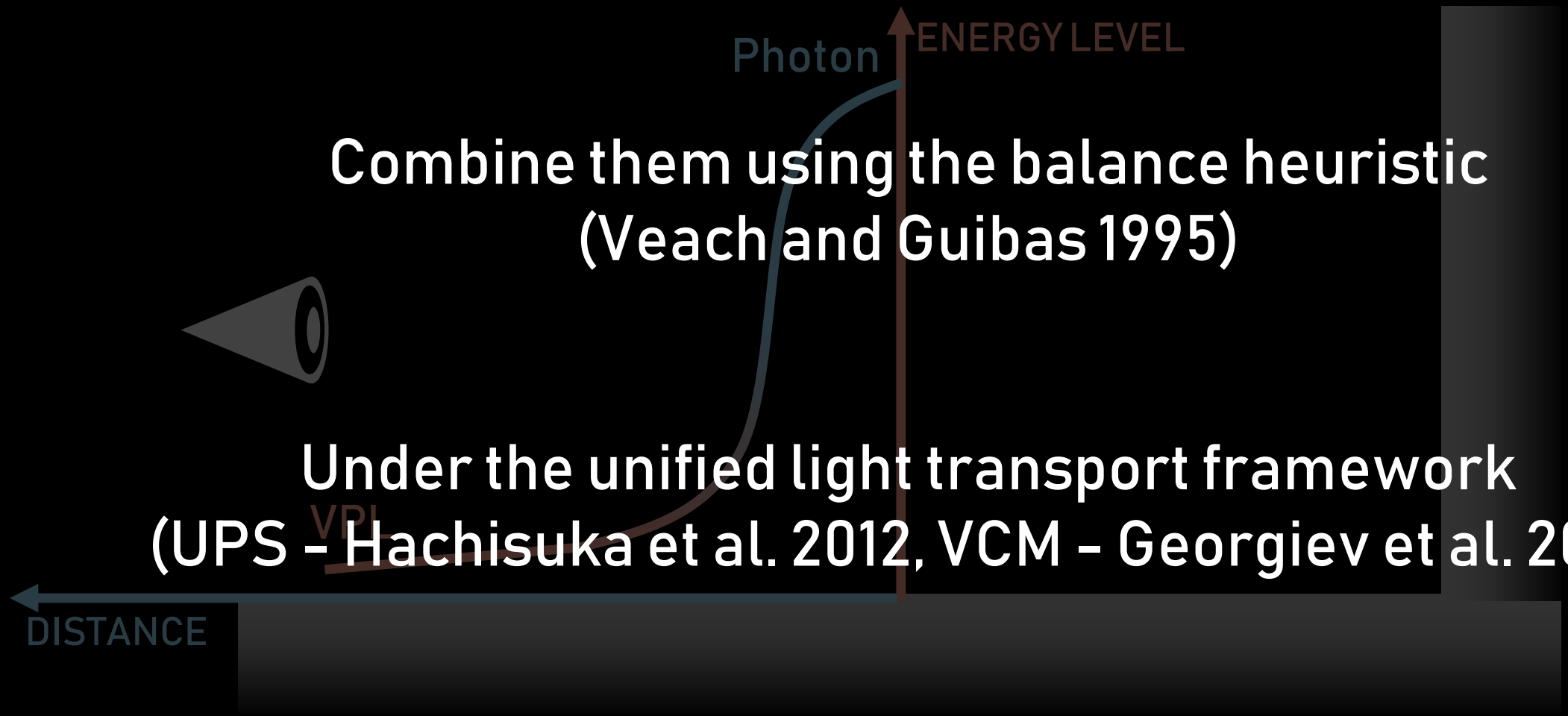

Photon
ENERGY LEVEL
VPL
DISTANCE

Ours



Combine them using the balance heuristic
(Veach and Guibas 1995)

Ours

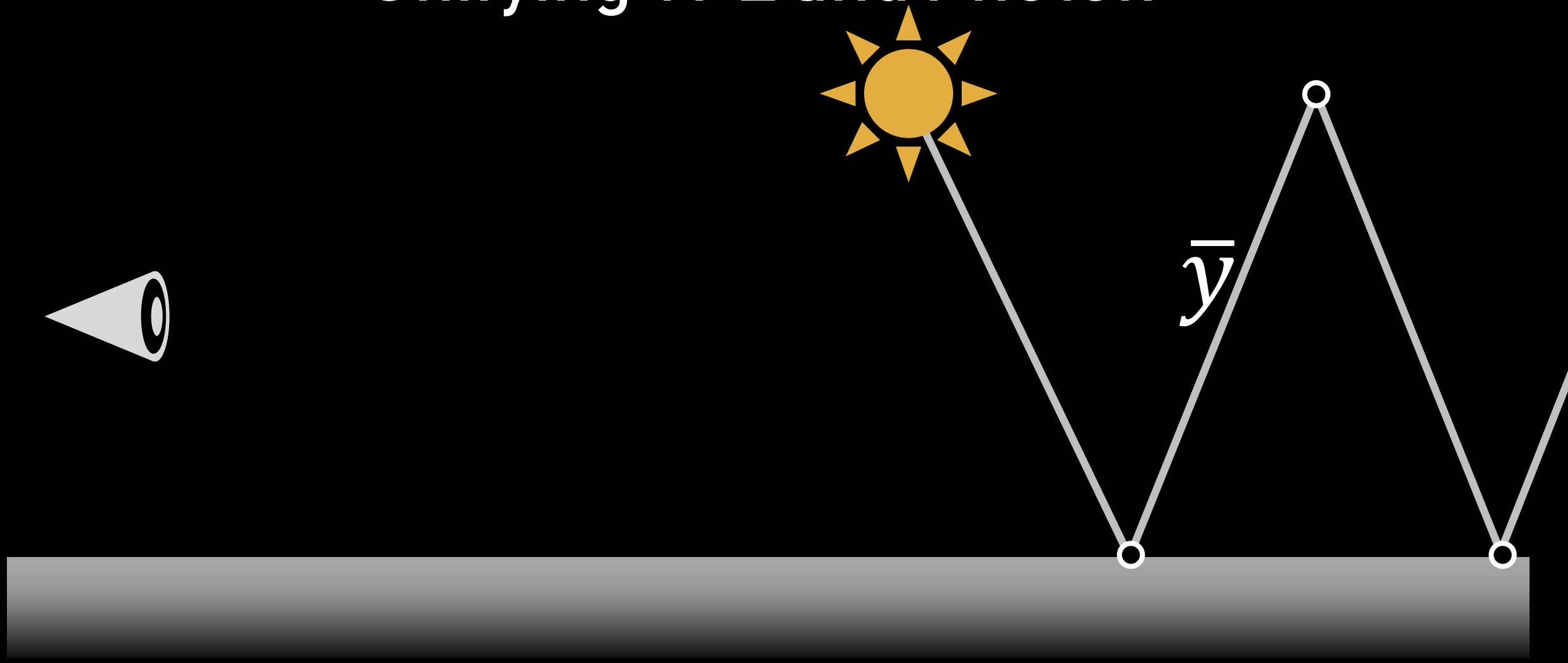


Combine them using the balance heuristic
(Veach and Guibas 1995)

Under the unified light transport framework
(UPS – Hachisuka et al. 2012, VCM – Georgiev et al. 2012)

Unifying VPL and Photon

Unifying VPL and Photon - VPL



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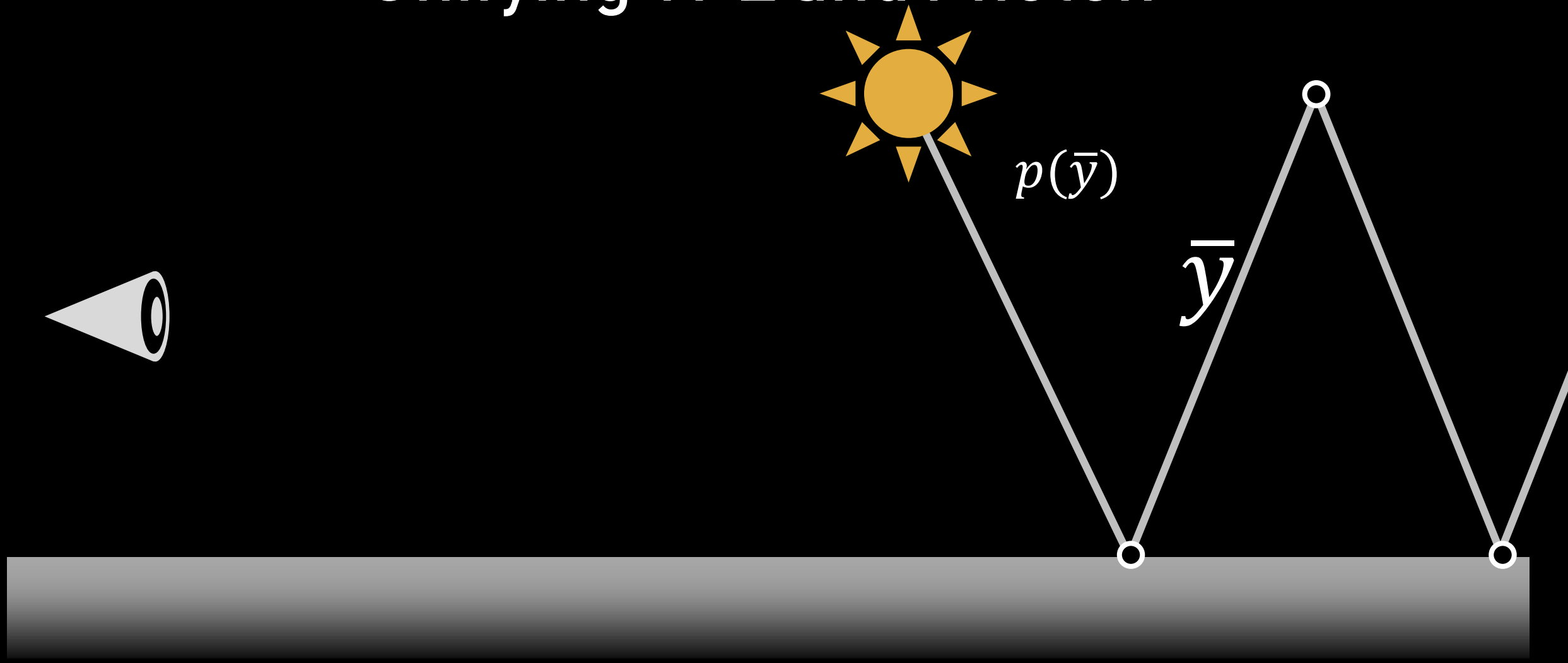

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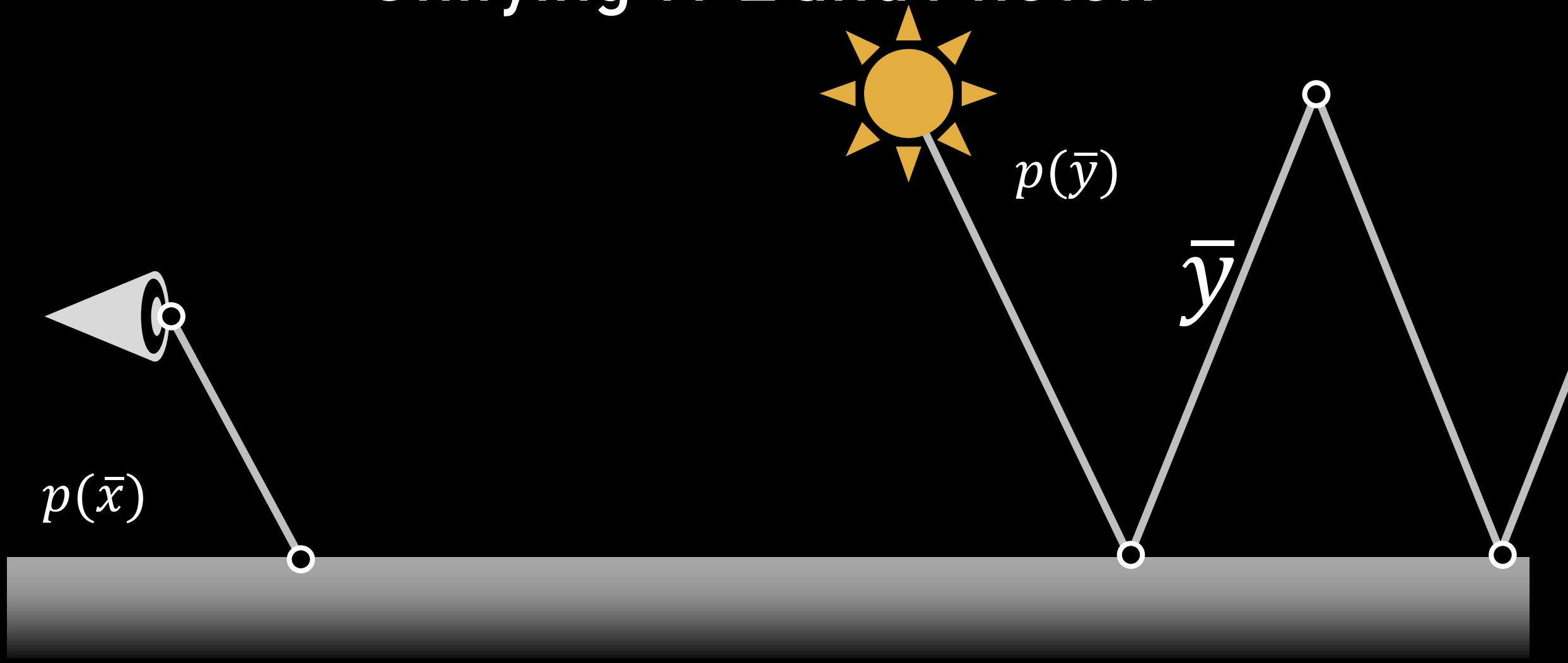

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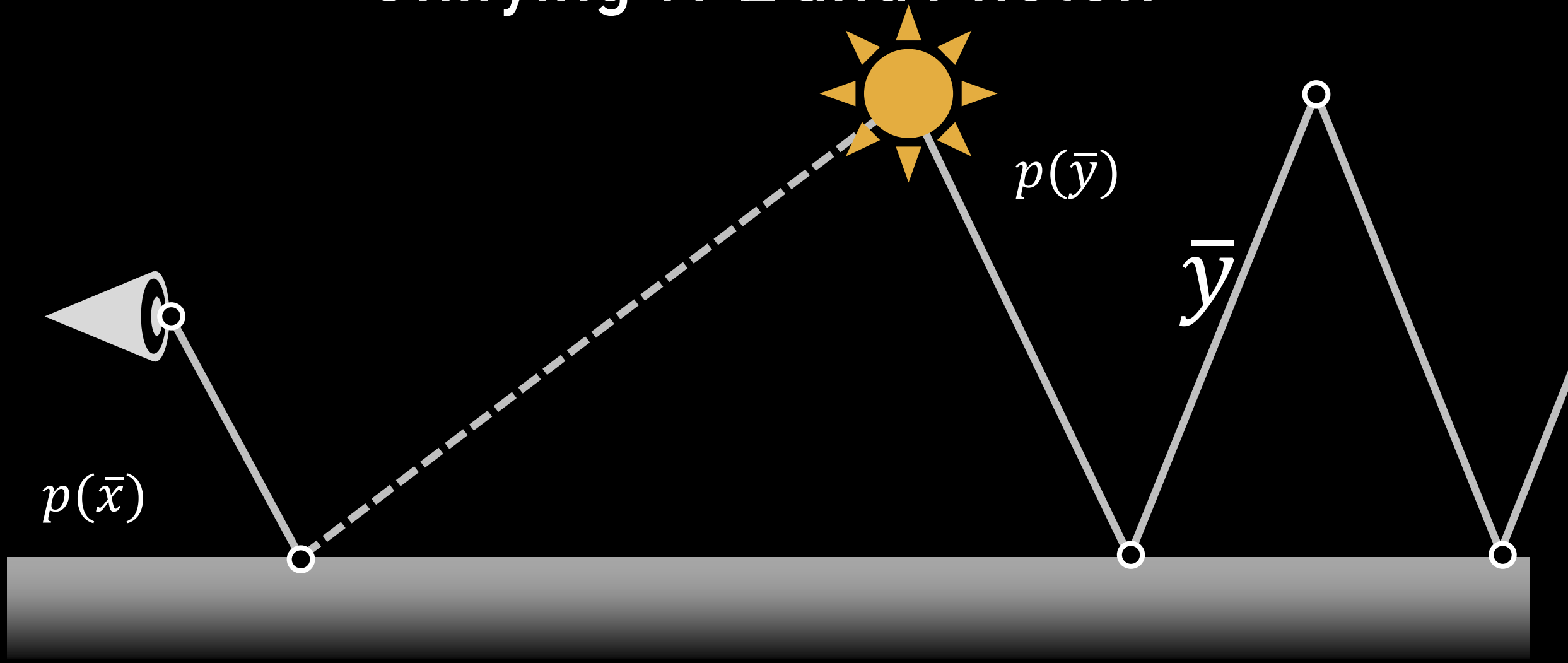

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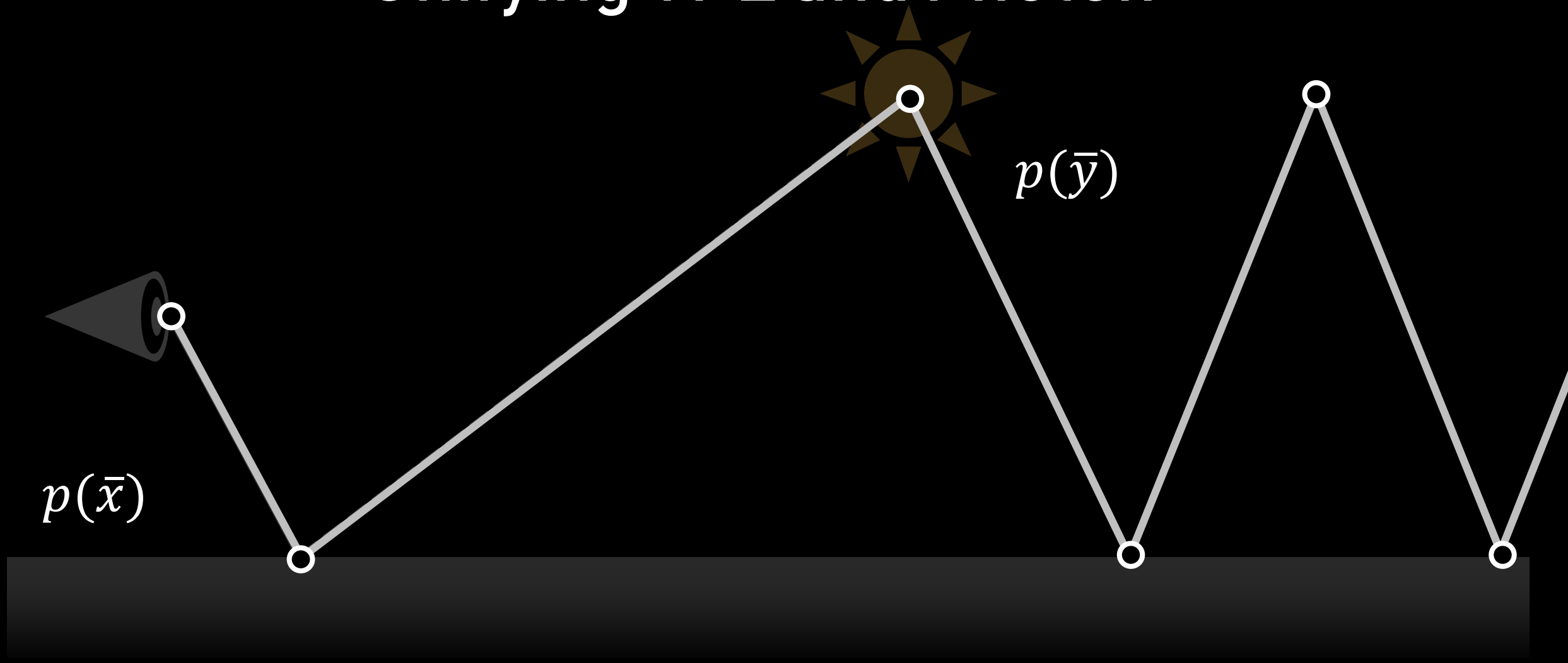

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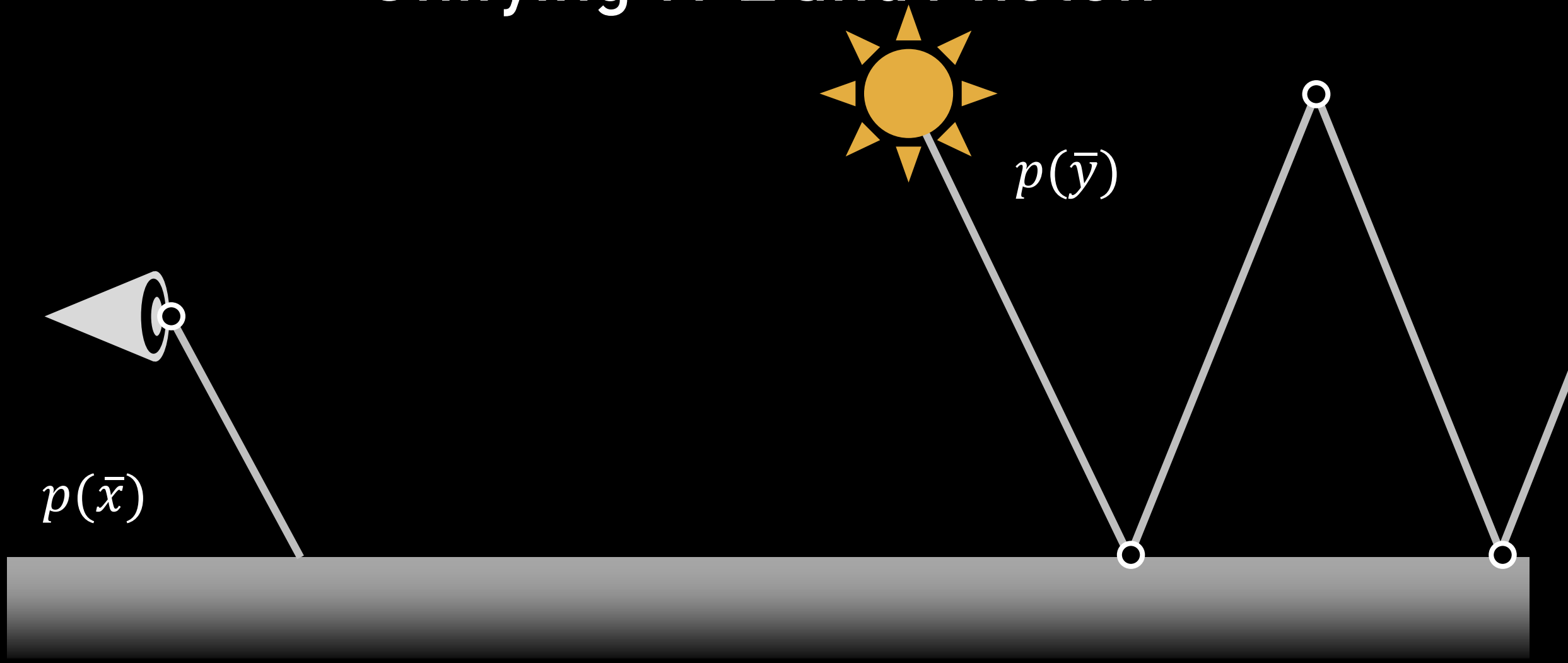

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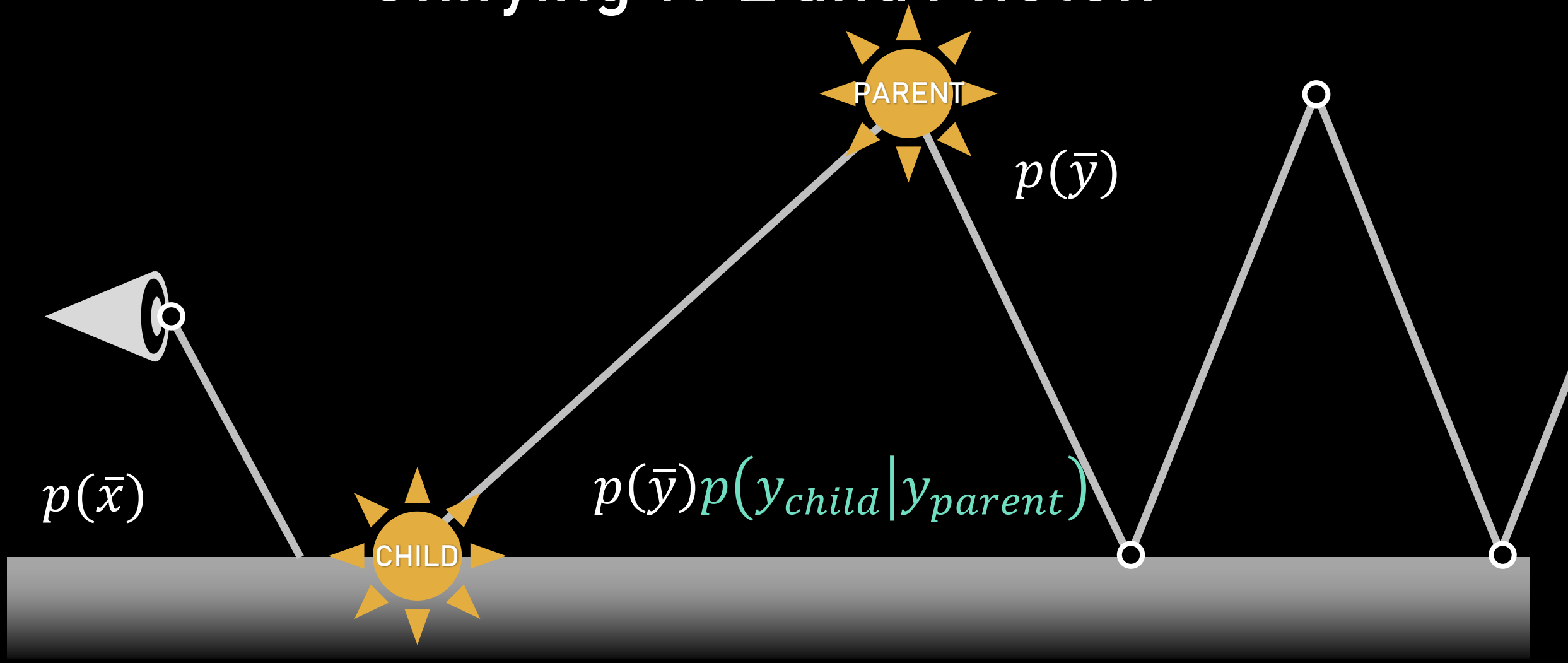

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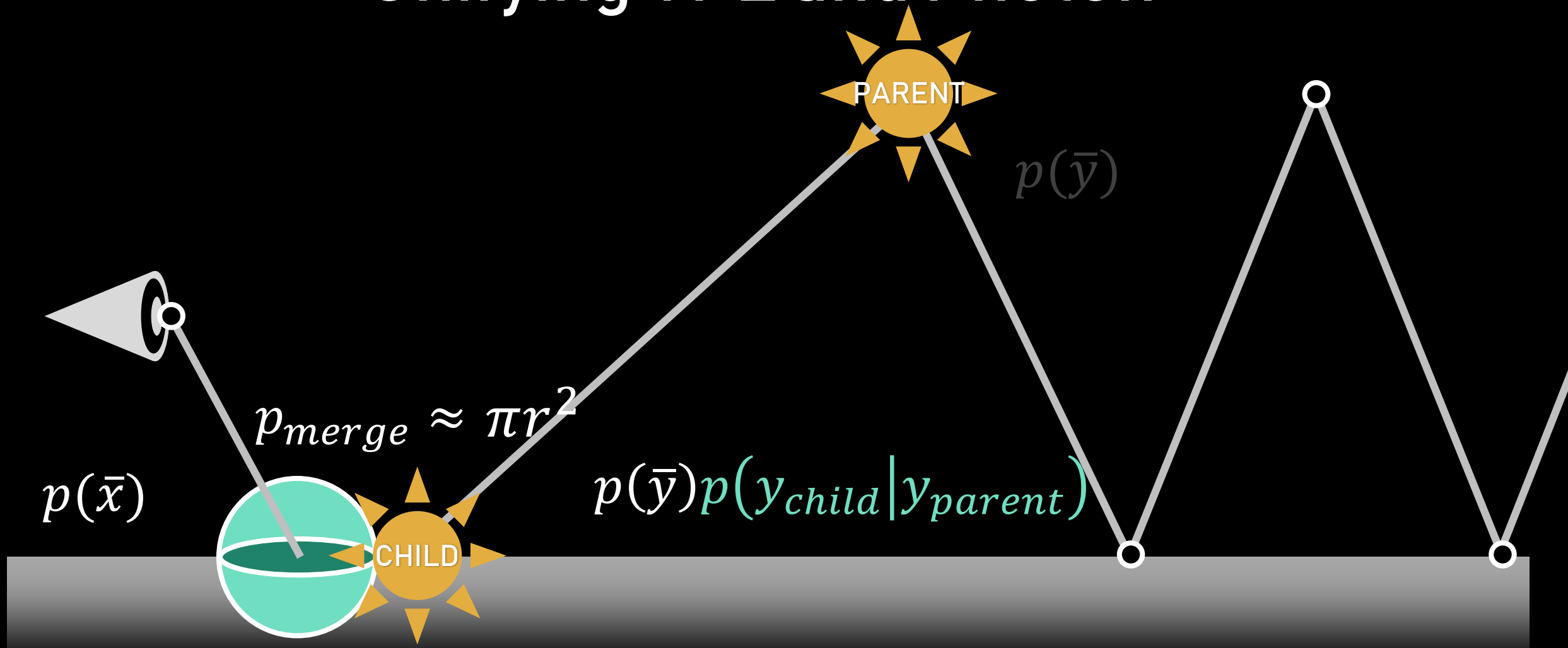

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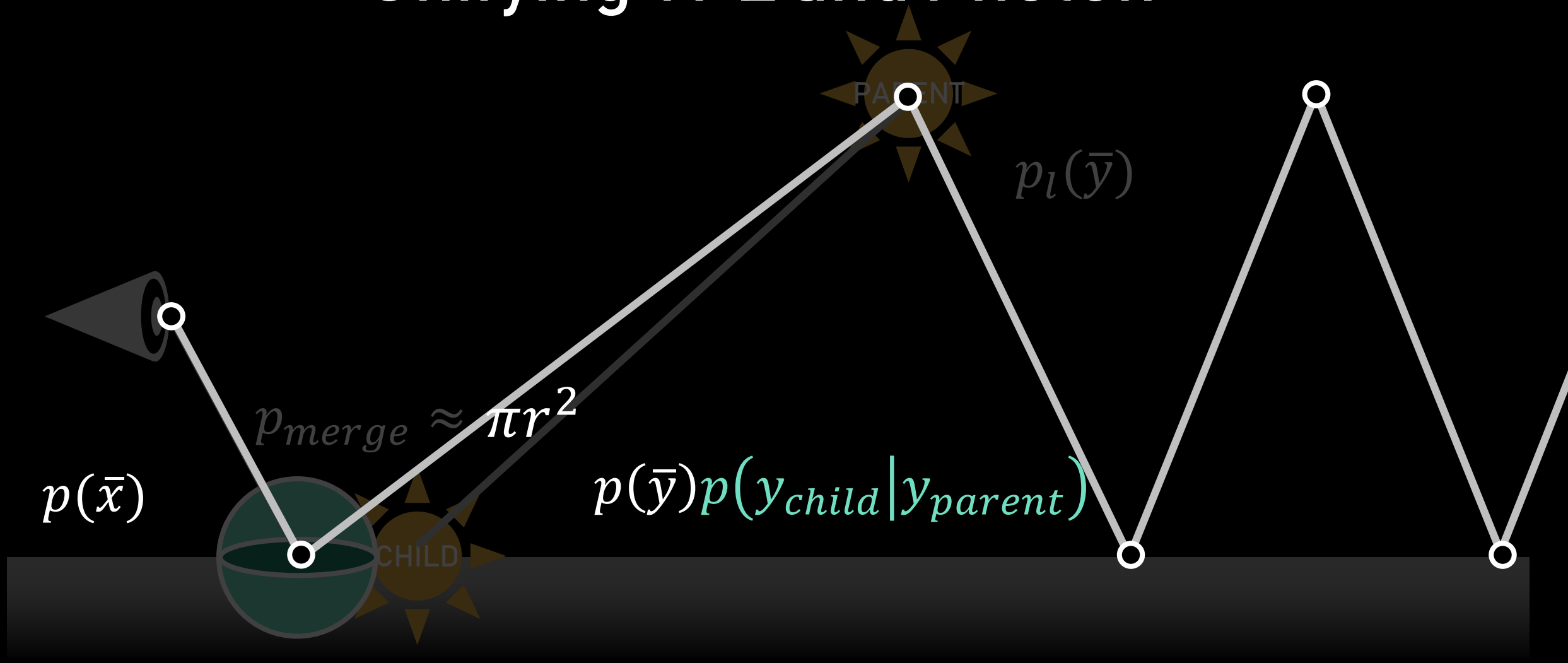

Mixture of VPLs and Photons

$$w_{vpl}(\overline{xy}) = \frac{N_{vpl}\, p_{vpl}(\overline{xy})}{N_{vpl}\, p_{vpl}(\overline{xy}) + N_{pm}\, p_{pm}(\overline{xy})}$$

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$$= \frac{N_{vpl}}{N_{vpl} + N_{pm}\pi r^2 p\left(y_{child} \middle| y_{parent}\right)}$$

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Geometry term $\frac{\cos(\theta)\cos(\phi)}{d^2}$

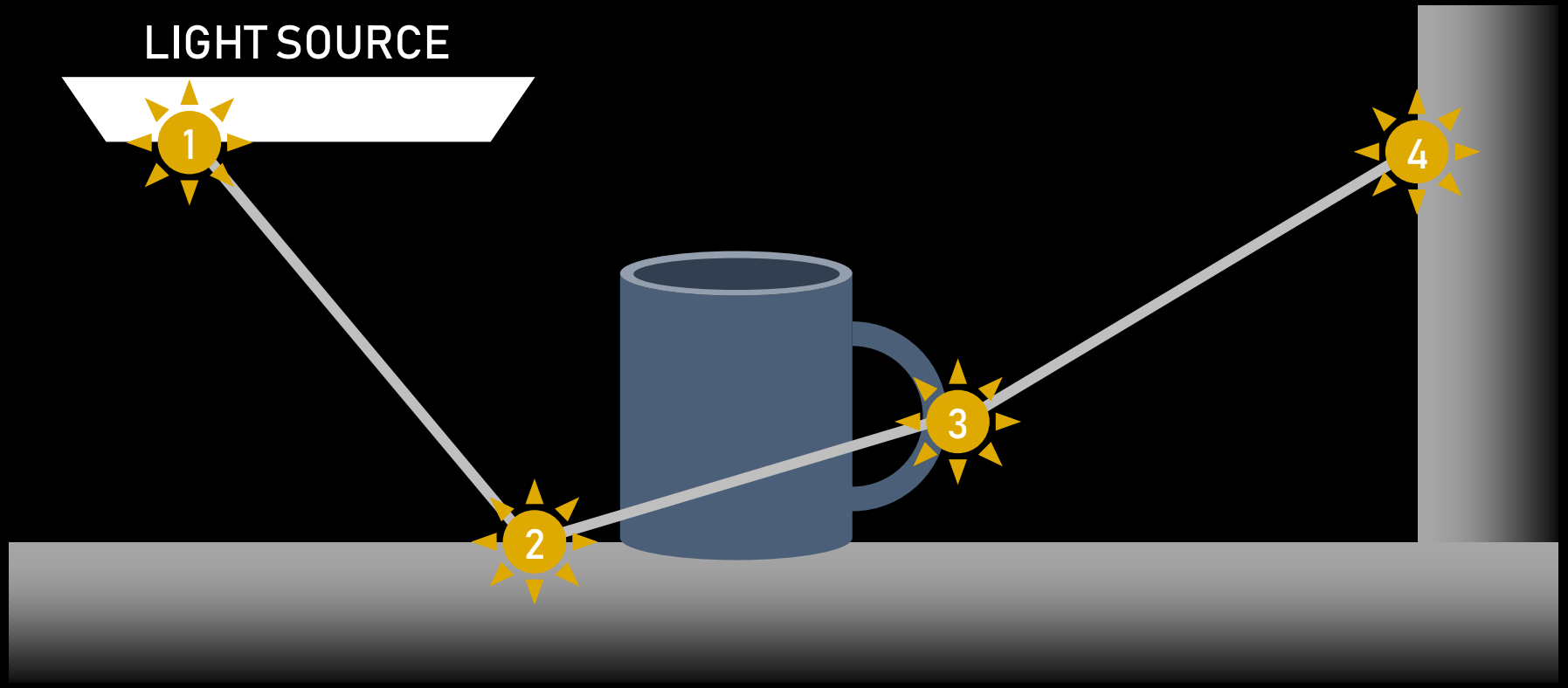
Progressive

$$w_{vpl}(\overline{xy}) = \frac{N_{vpl}\, p_{vpl}(\overline{xy})}{N_{vpl}\, p_{vpl}(\overline{xy}) + N_{pm}\, p_{pm}(\overline{xy})}$$

$$= \frac{N_{vpl}}{N_{vpl} + N_{pm}\, \pi r^2 p\left(y_{child} \middle| y_{parent}\right)}$$

(Hachisuka et al. 2008, Hachisuka et al. 2009, Knaus and Zwicker 2011)

Implementation



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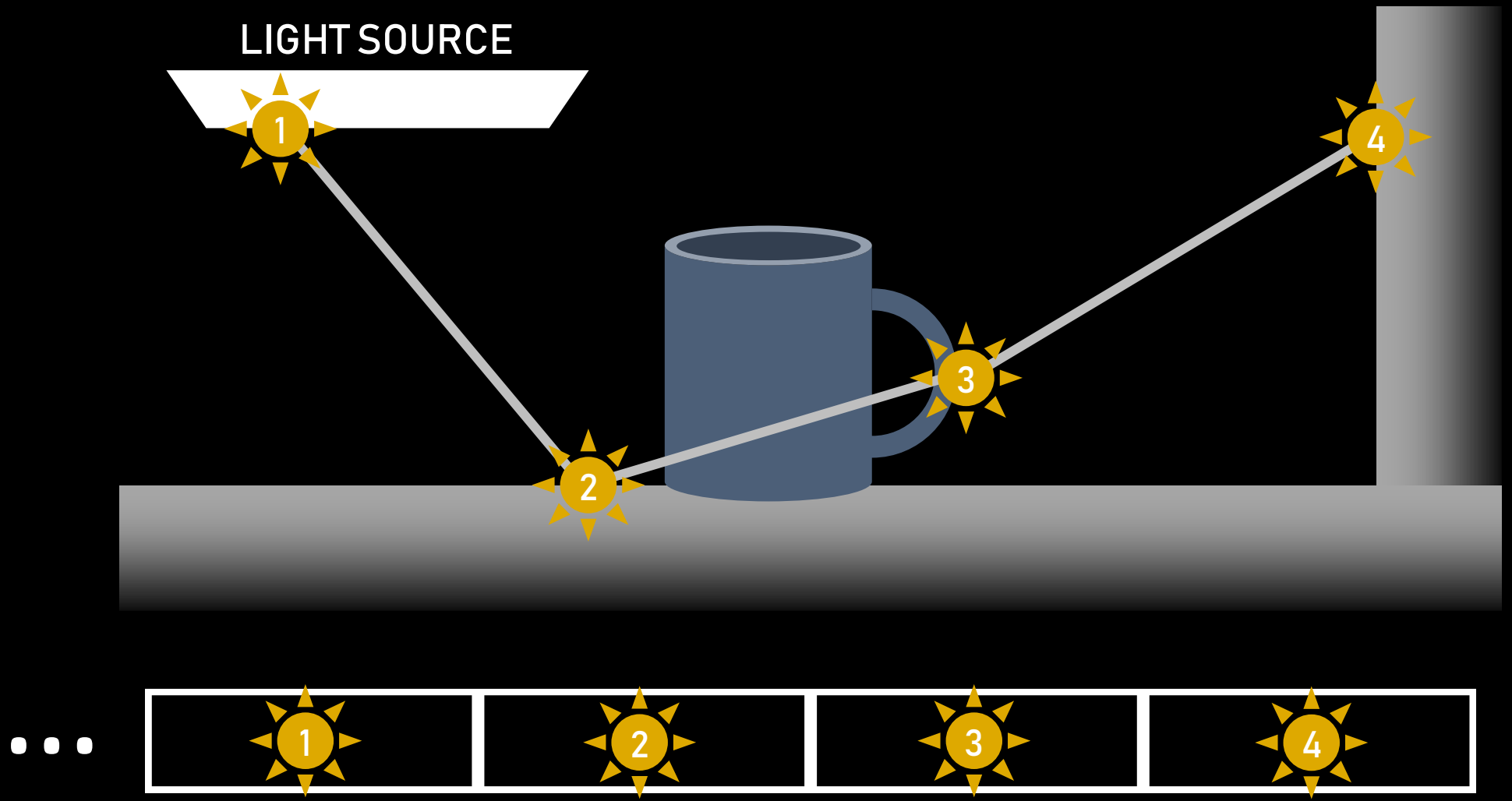

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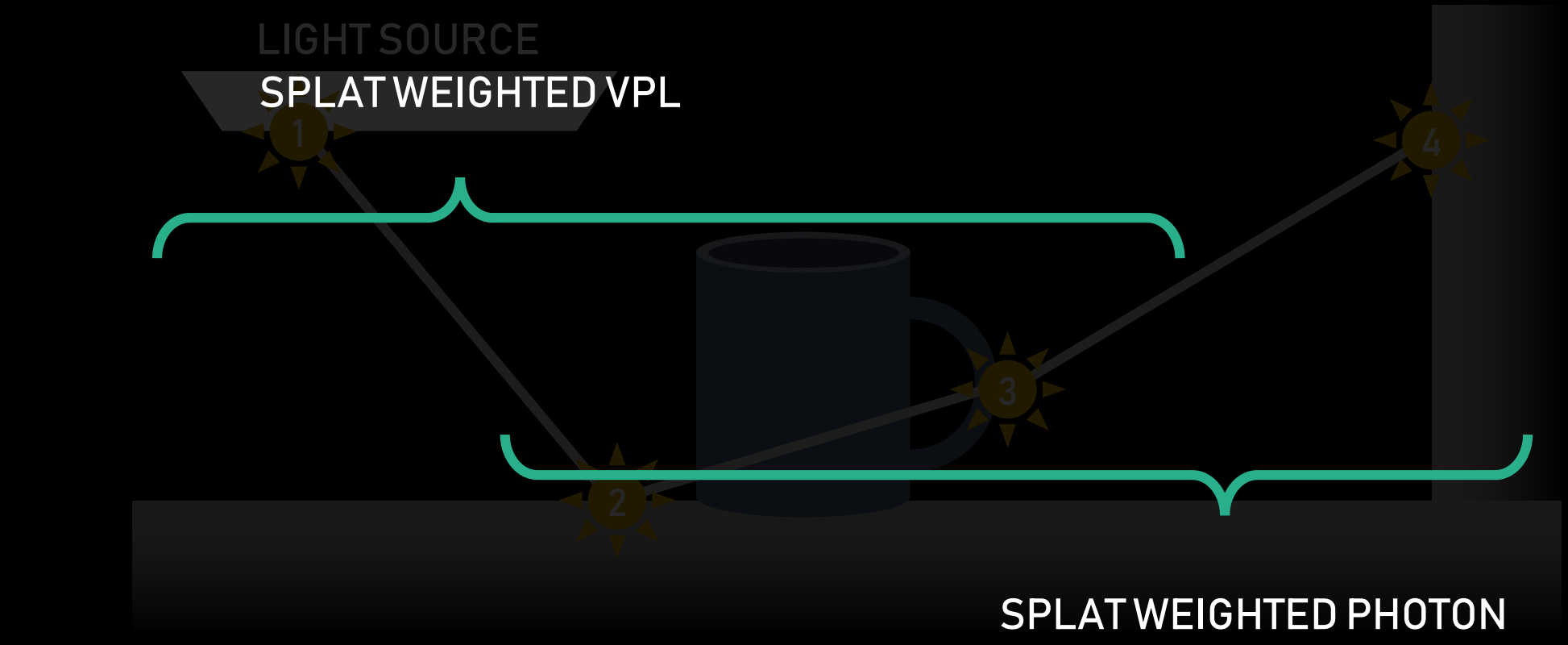
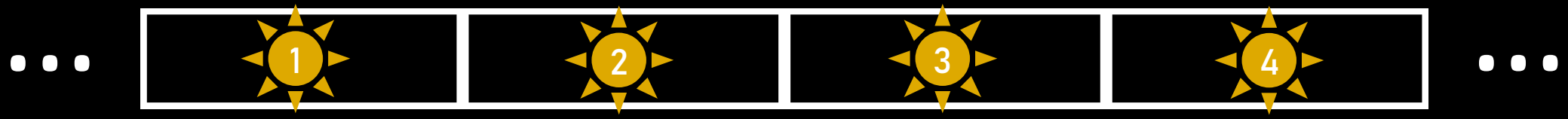
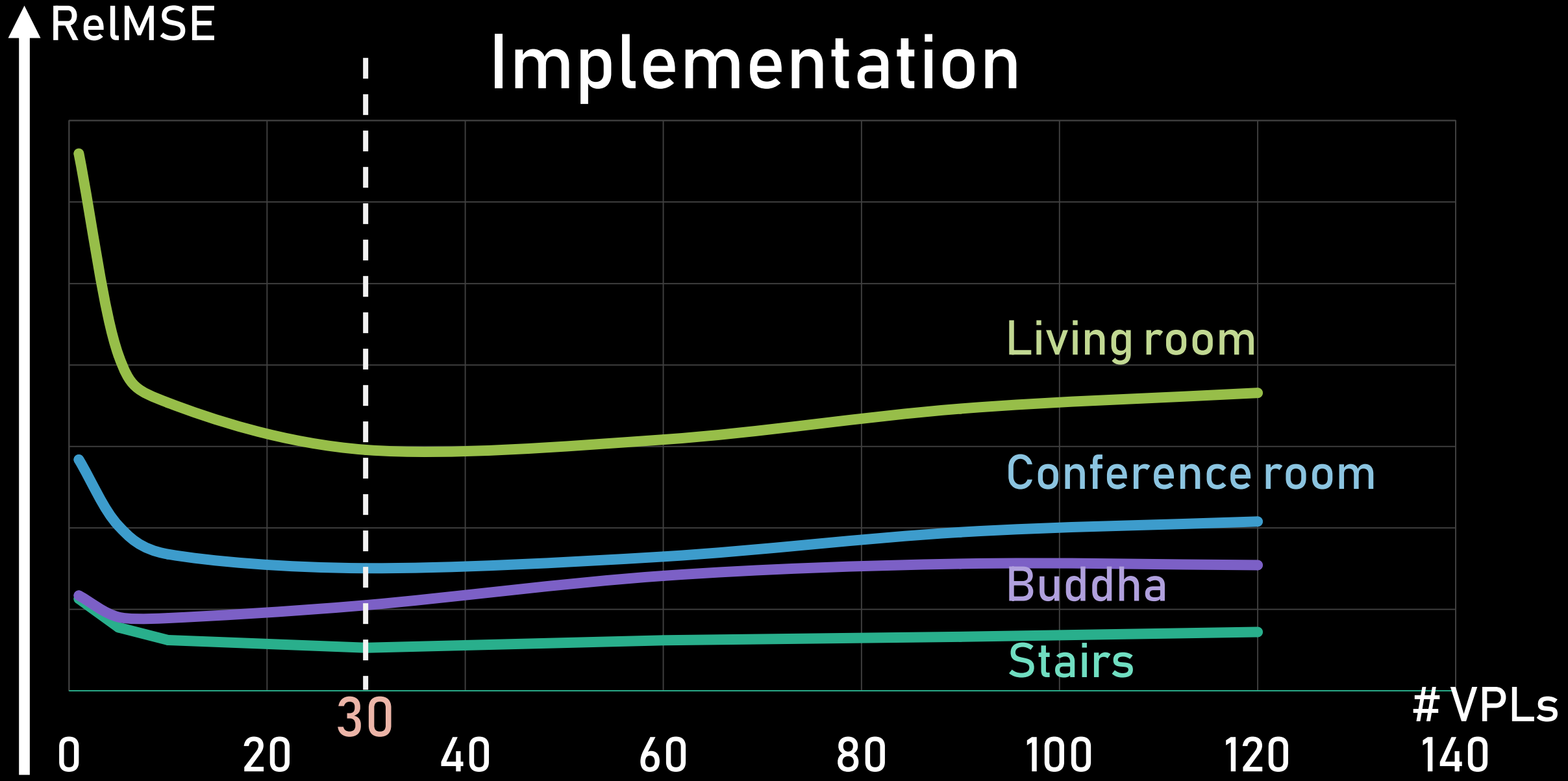




Implementation

$\frac{\text{Splat weighted VPLs}}{\text{light subpath}}$	2.83 ms
$\frac{\text{Splat weighted Photons}}{\text{light subpath}}$	1.71×10^{-4} ms

Implementation



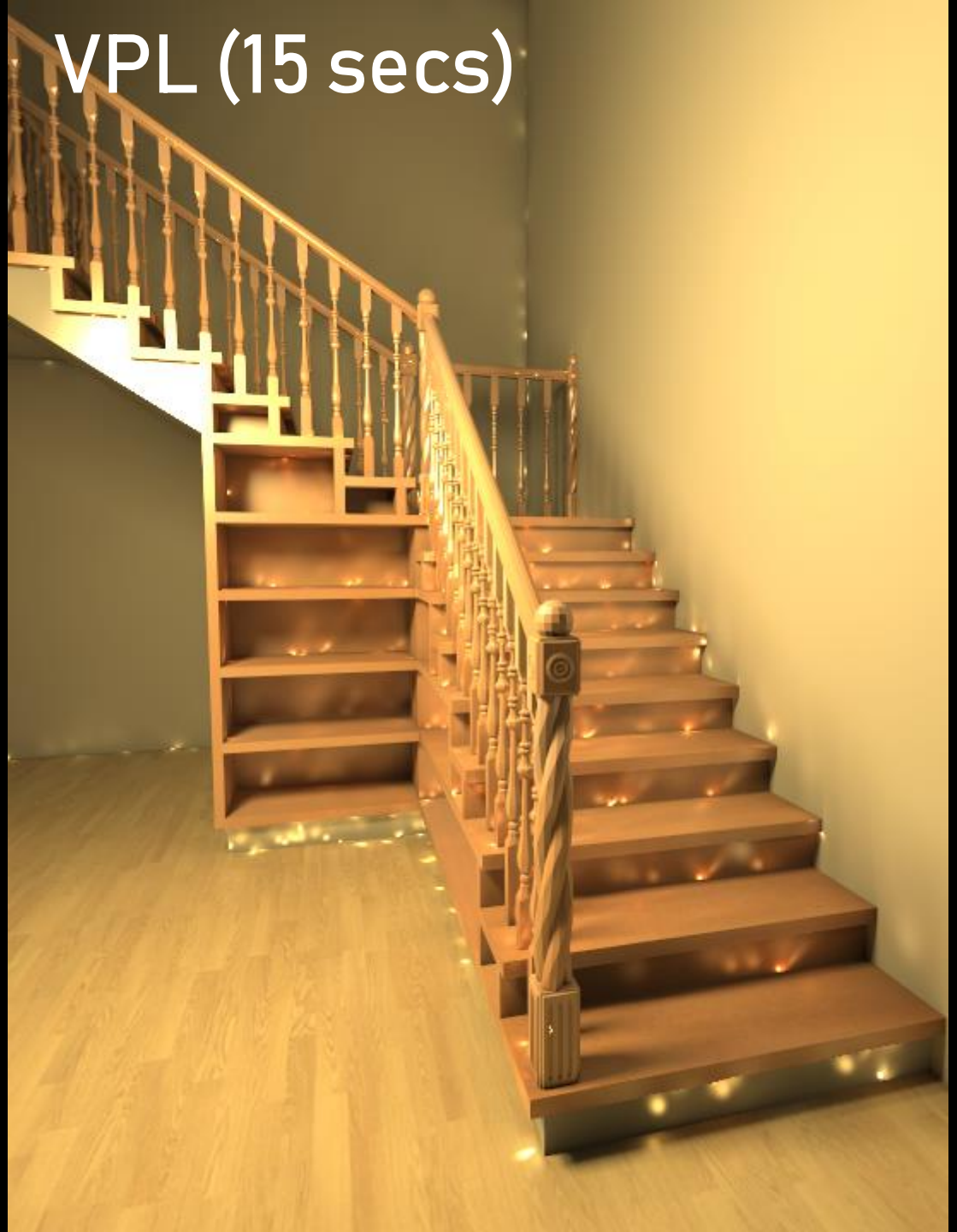
Implementation

$$\frac{\text{Splat weighted VPLs}}{\text{light subpath}} \quad 2.83 \quad \text{ms}$$

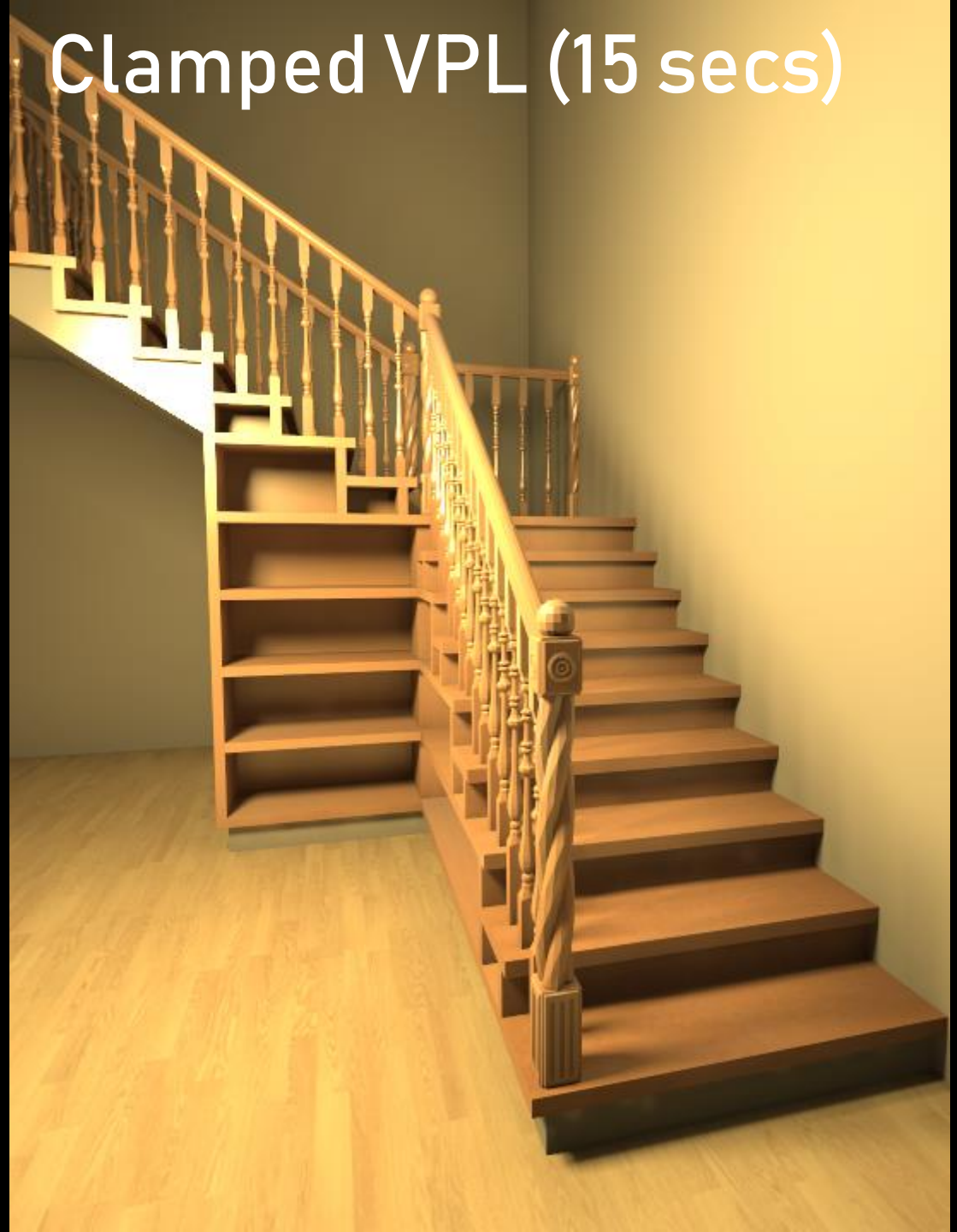
$$\frac{\text{Splat weighted Photons}}{\text{light subpath}} \quad 1.71 \times 10^{-4} \quad \text{ms}$$

$$\frac{\text{Splat } 300000 \text{ Photons : } 30 \text{ VPLs}}{1 \text{ iteration}}$$

Result

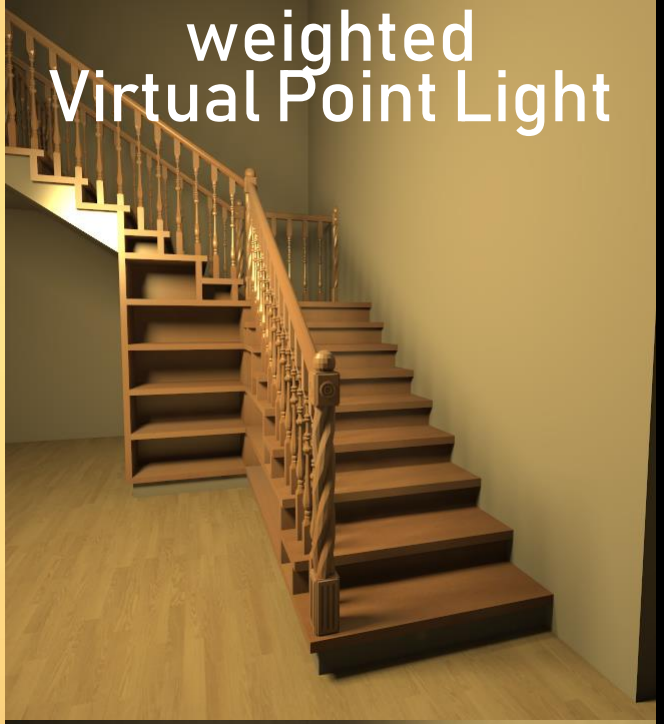

VPL (15 secs)

Clamped VPL (15 secs)



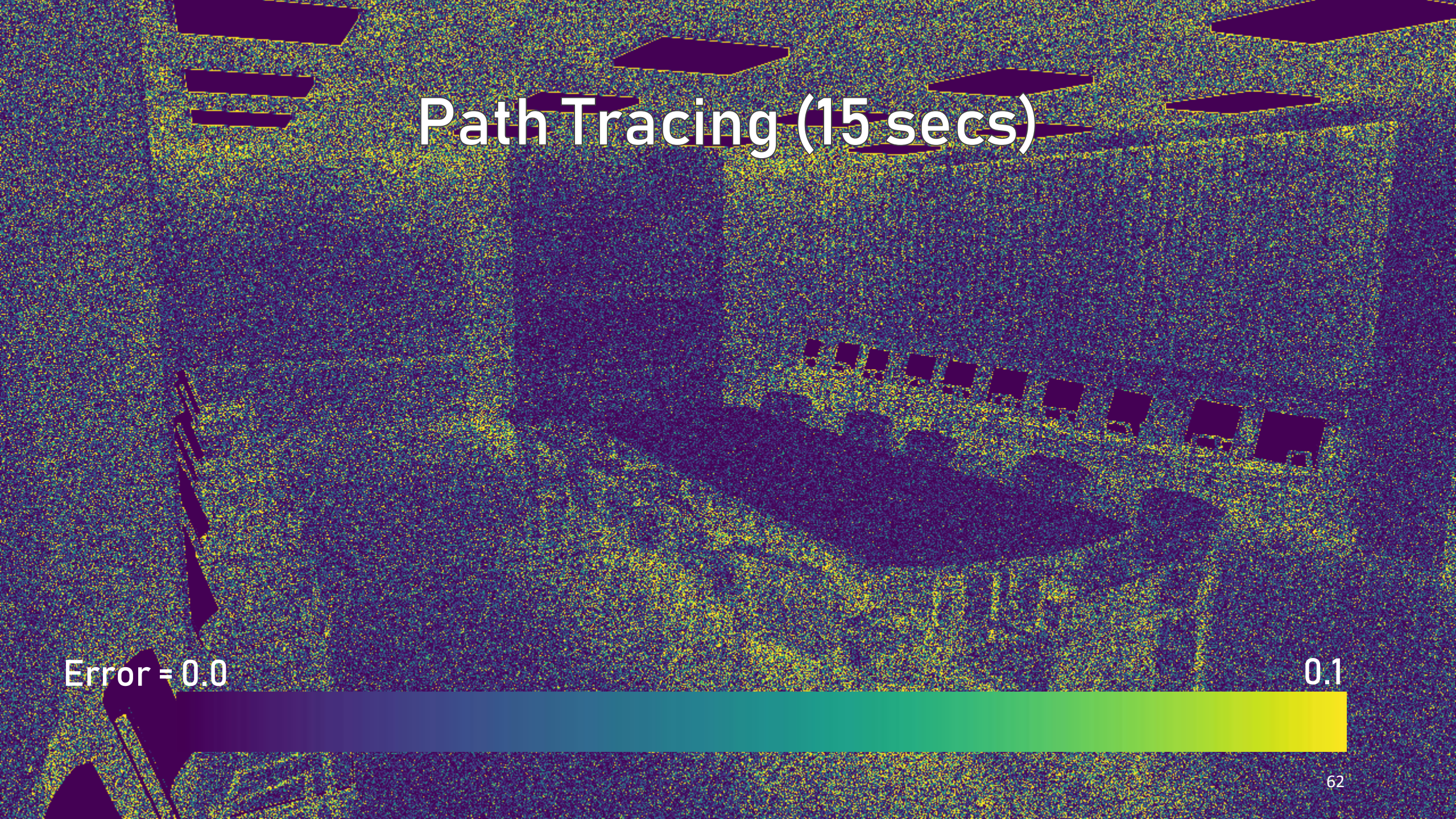

Ours (15 secs)


Ours (15 secs)


weighted
Virtual Point Light


weighted
Photon Splatting


Path Tracing (15 secs)


Path Tracing (15 secs)
Error = 0.0
0.1


Virtual Point Light (15 secs)

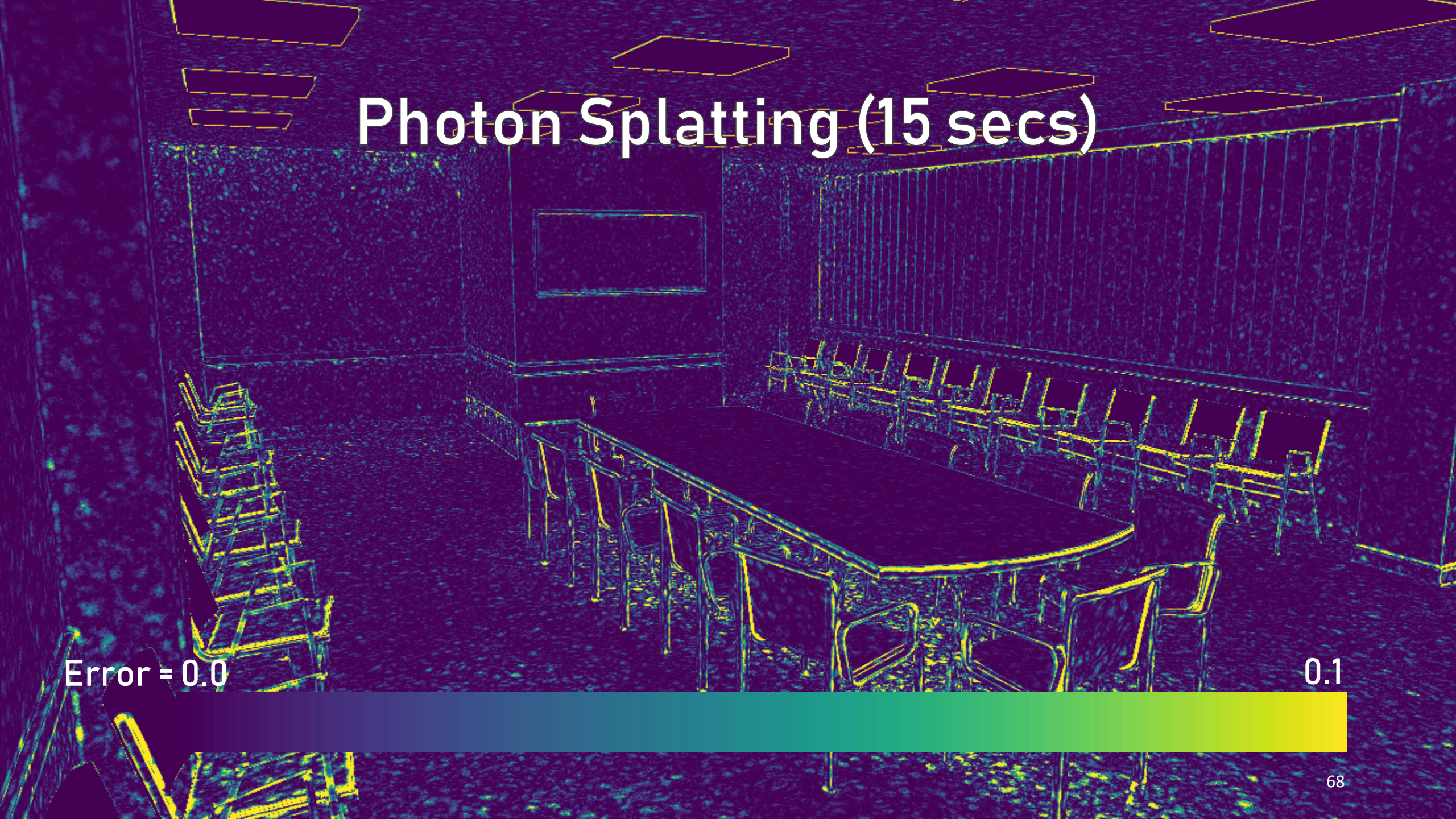
Virtual Point Light (15 secs)


Virtual Spherical Light (15 secs)

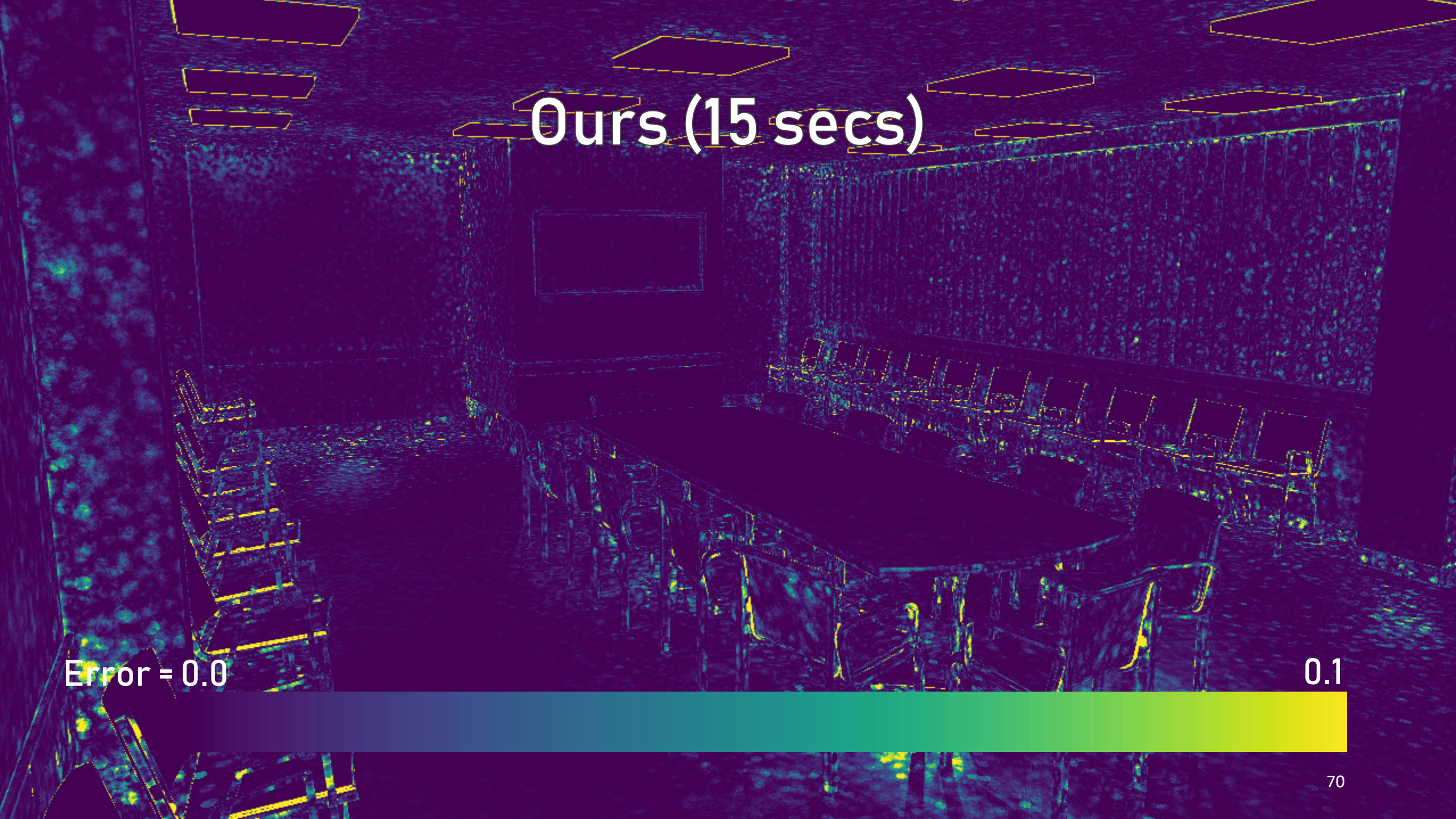
Virtual Spherical Light (15 secs)


Photon Splatting (15 secs)

Photon Splatting (15 secs)




Ours (15 secs)


Ours (15 secs)
Error = 0.0
0.1

Reference

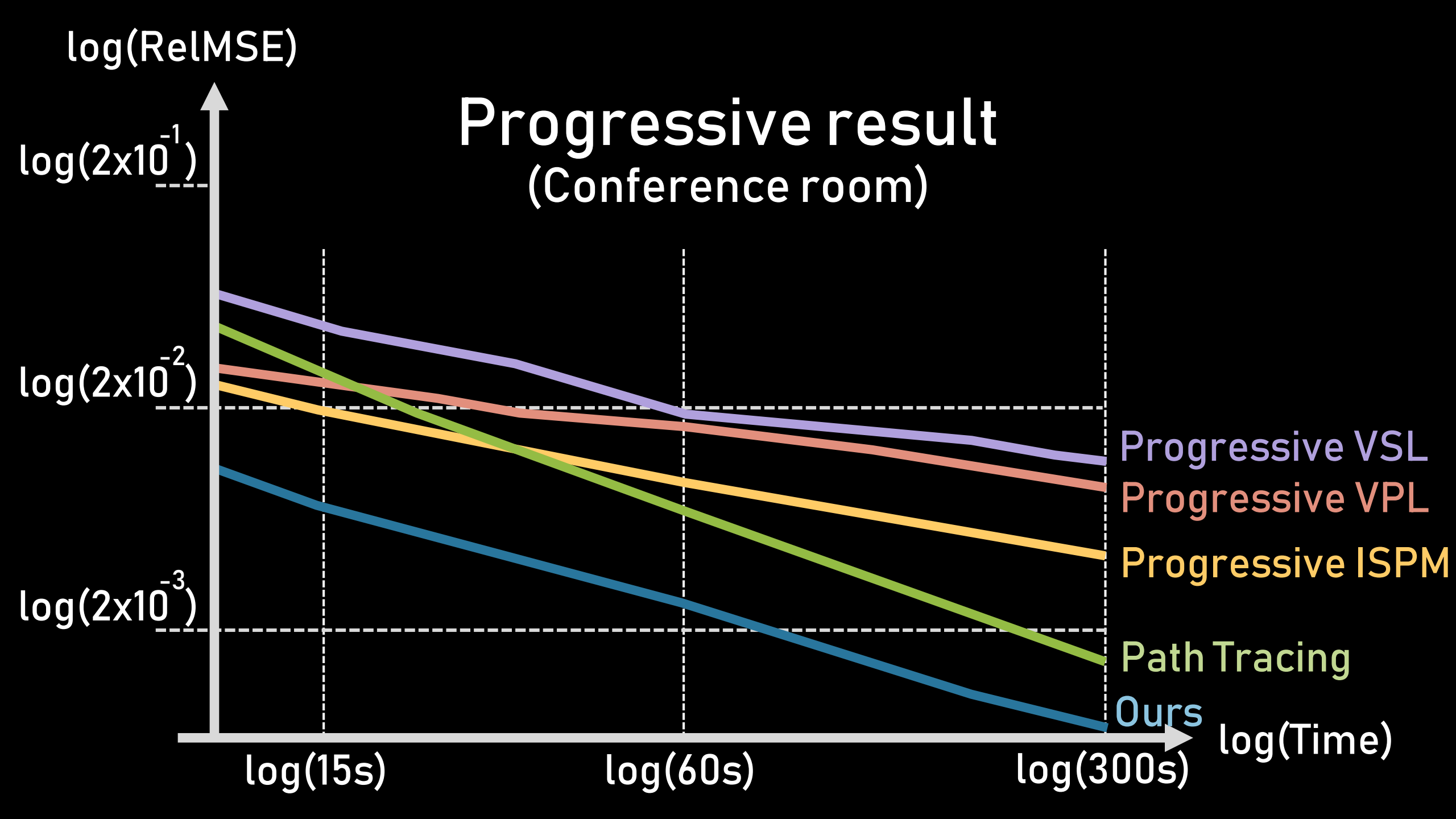

VPL
VSL
ISPM
Ours


VPL
VSL
ISPM
Ours


VPL
VSL
ISPM
Ours


VPL
VSL
ISPM
Ours

Progressive result


log(RelMSE)
Progressive result
(Conference room)
log(2x10^-1)
log(2x10^-2)
log(2x10^-3)
Progressive VSL
Progressive VPL
Progressive ISPM
Path Tracing
Ours
log(Time)
log(15s)
log(60s)
log(300s)

Limitations

- Is not efficient at rendering camera-visible glossy surfaces
- Is not trivial to find tight error bound and compute optimal weight with LightCuts (but still usable)
- Competitive to PT-NEE in the scene that
  - Has high frequency textures (limitation of VPL)
  - Has the light sources that are visible to much of the geometry

Future work

- Improves the light vertices distribution
- Investigate if it is applicable to volume rendering (VRL – Novák et al. 2012, Photon Beam – Jarosz et al. 2011)

Thank you

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- All materials will be available at www.jamorn.me/evplp