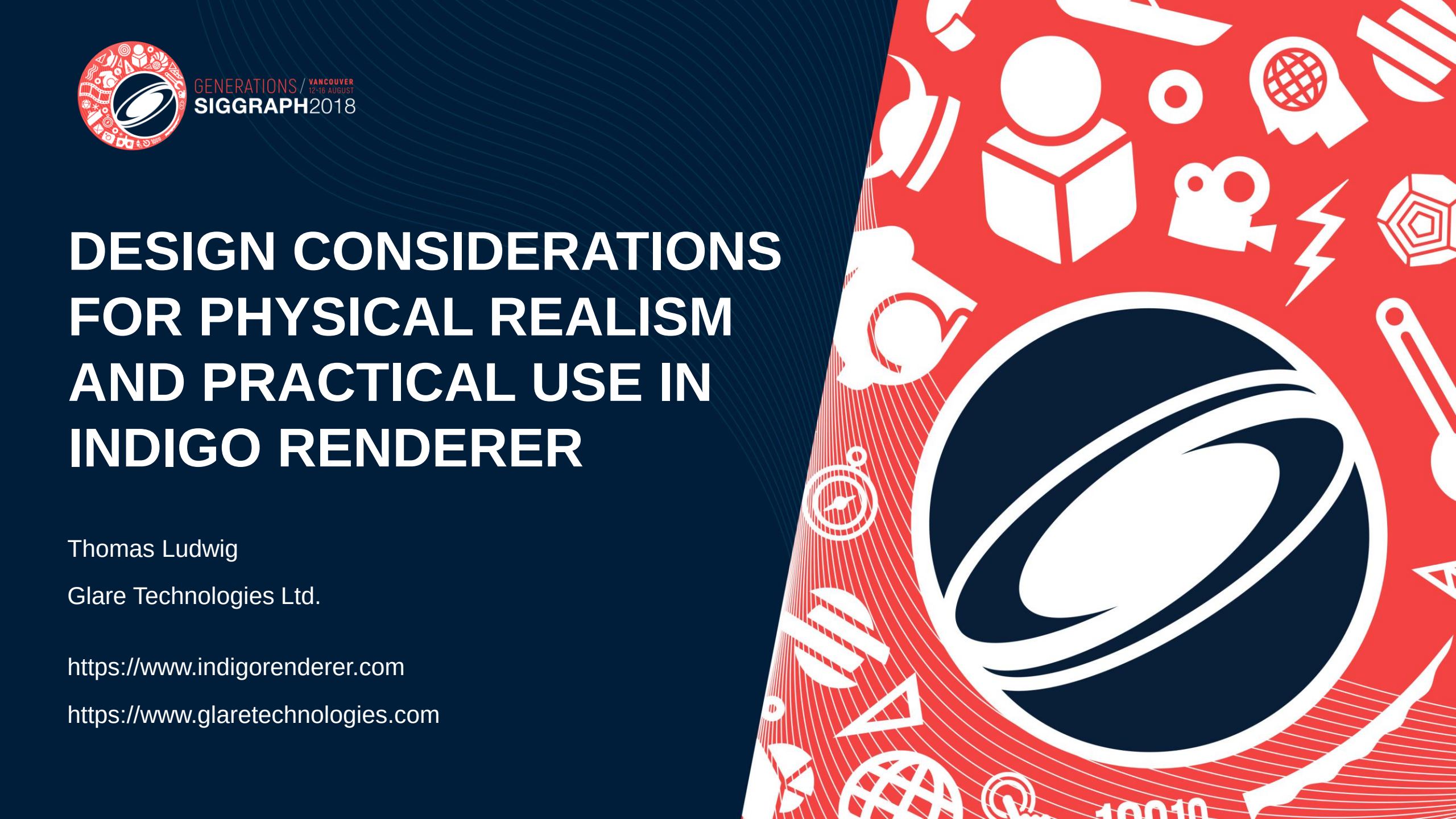

DESIGN CONSIDERATIONS FOR PHYSICAL REALISM AND PRACTICAL USE IN INDIGO RENDERER

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https://www.indigorenderer.com

https://www.glaretechnologies.com

OVERVIEW

- History and context
- Motivation
- Difficulty of caustics and indirect lighting
- From a user's point of view…
- From a developer's point of view…
- Avoid complex algorithms
- GPU rendering benefits and challenges
- Conclusion

HISTORY AND CONTEXT

- Basis is Veach's thesis [1], inspired by Maxwell Render
- Need for specialised product, “max quality” implementation
  - Make it accessible to non-CG specialists

HISTORY AND CONTEXT

- Basis is Veach's thesis [1], inspired by Maxwell Render
- Need for specialised product, “max quality” implementation
  - Make it accessible to non-CG specialists
- Indigo Renderer
  - Emphasis on quality and simplicity
  - (Volumetric) unidirectional and bidirectional path tracing
  - Optional Kelemen PSS-MLT [2] on top for most difficult scenes
  - Truly unbiased - 10k path depth, bidir on by default
  - Mainly archviz and productviz customers

MOTIVATION

- Archviz / productviz has different requirements and allowances
  - Can assume scene fits in memory,
    allows bidir methods and GPU
  - Demand highest final quality, quick previews
- Keep algorithms simple as possible
  - Need to exploit huge GPU resources
  - GPU unidir is already quite complex!

Unidir vs bidir (2.5 mins on AMD ThreadRipper), scene by Giorgio Luciano & polygonmanufaktur.de

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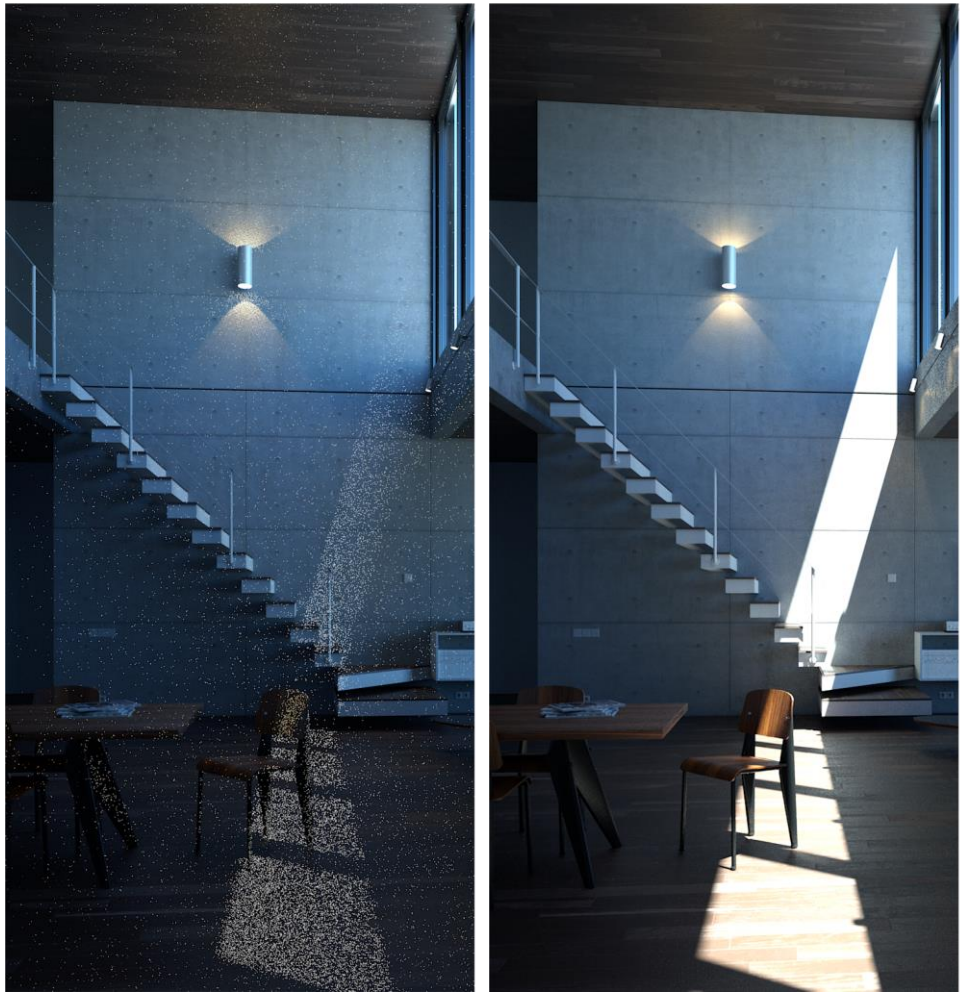
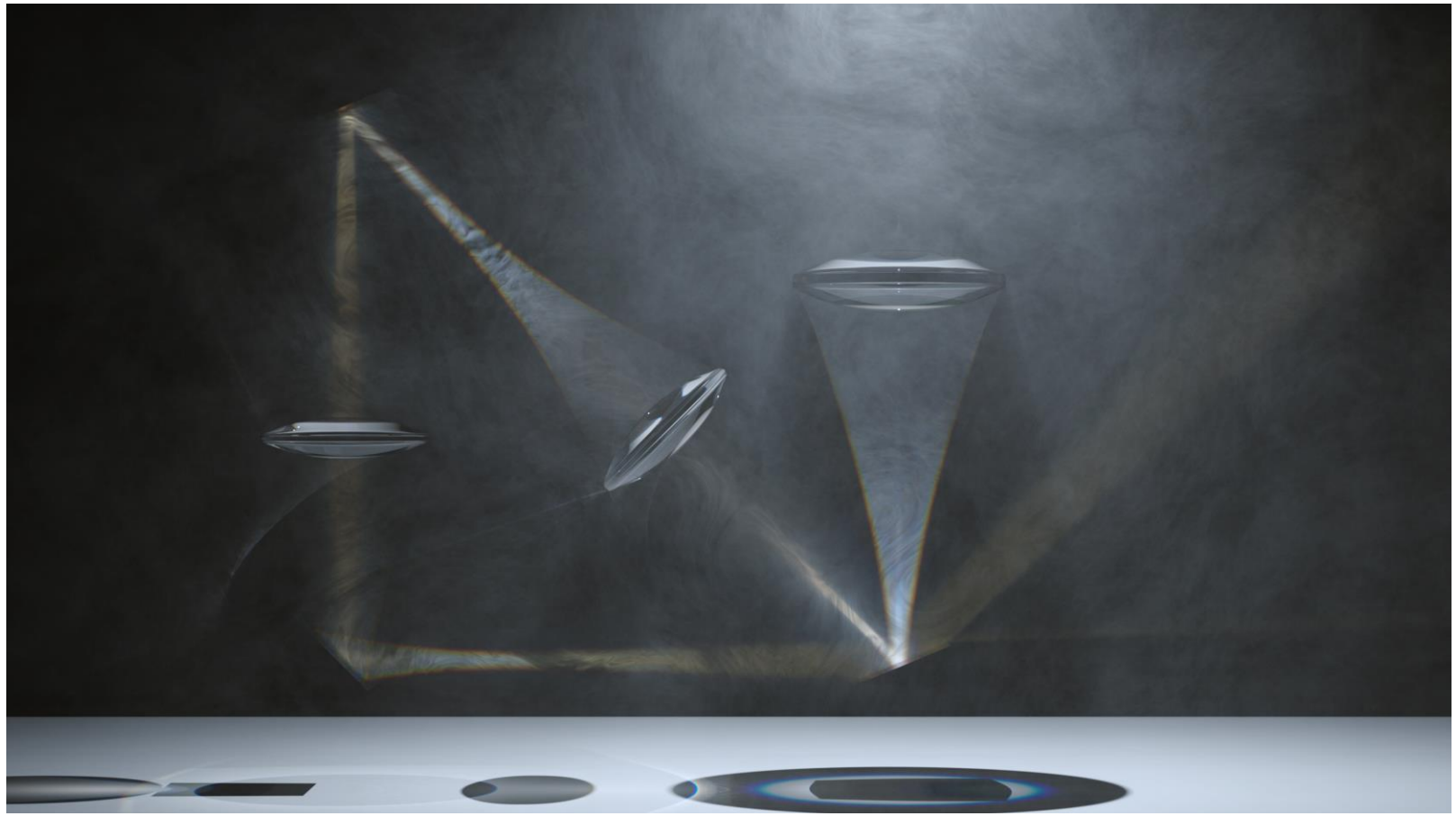
  - GPU unidir is already quite complex!
- Interior renders much more efficient
  - Difficult to sample localised reflected light with eye paths
  - Light paths induce perfect distribution



Unidir vs bidir (8 mins on Intel i7-8700K), scene by MAD IMAGERY

MOTIVATION

- No contest in optical simulations



Lenses Experiment by Raphael Rau / Silverwing VFX, rendered with bidir MLT @ 4K, clean image in 45 mins on 4 GHz 8-core

DIFFICULTY OF CAUSTICS AND INDIRECT LIGHTING

- Caustic and indirect illumination common in archviz
  - Glass bulbs, lampshades, mirrors and windows
  - Illumination from IES profiles and detailed lights
- Often approximated
  - Biased methods, limited path depth, increasing roughness with glossy scatters

Dowling by Aaron Crozier / bubs

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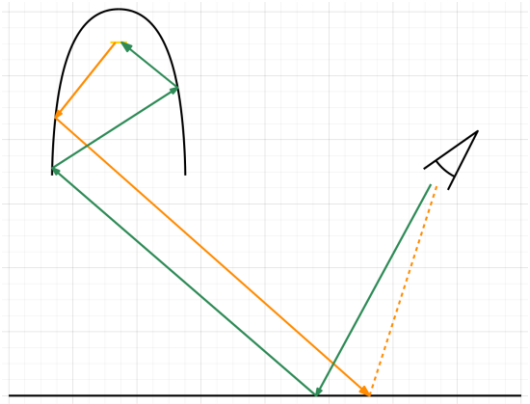
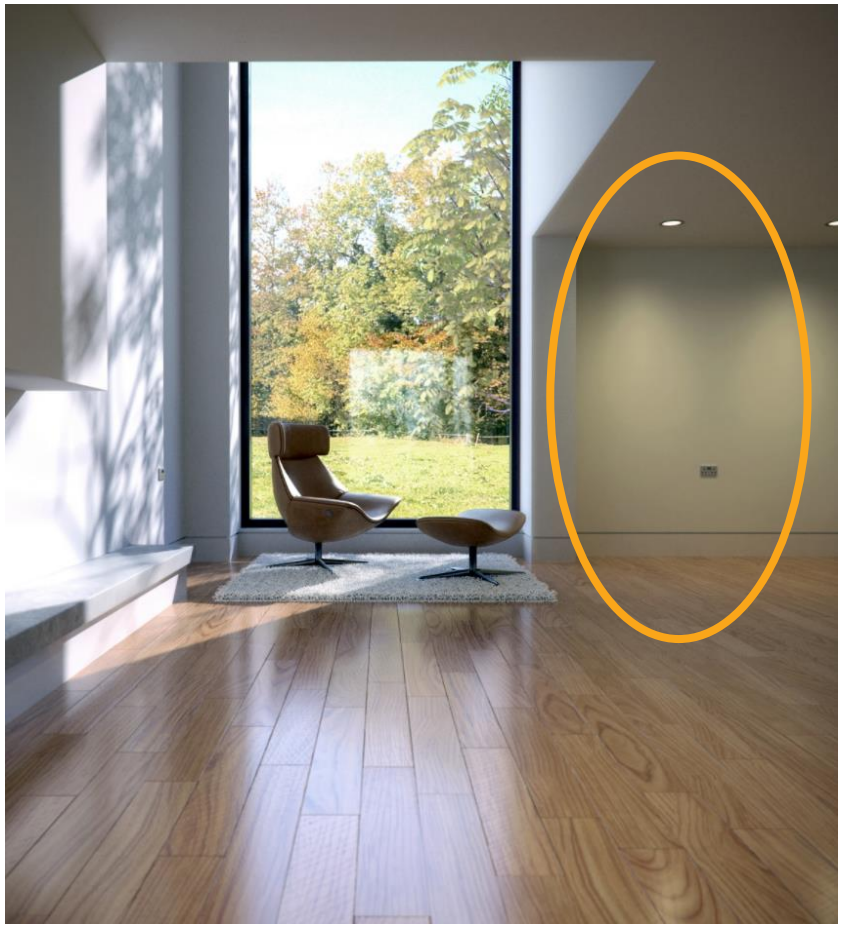
  - Glass bulbs, lampshades, mirrors and windows
  - Illumination from IES profiles and detailed lights
- Often approximated
  - Biased methods, limited path depth, increasing roughness with glossy scatters
- But what if it's modelled accurately?
  - Difficult to sample from eye paths:





Dowling by Aaron Crozier / bubs

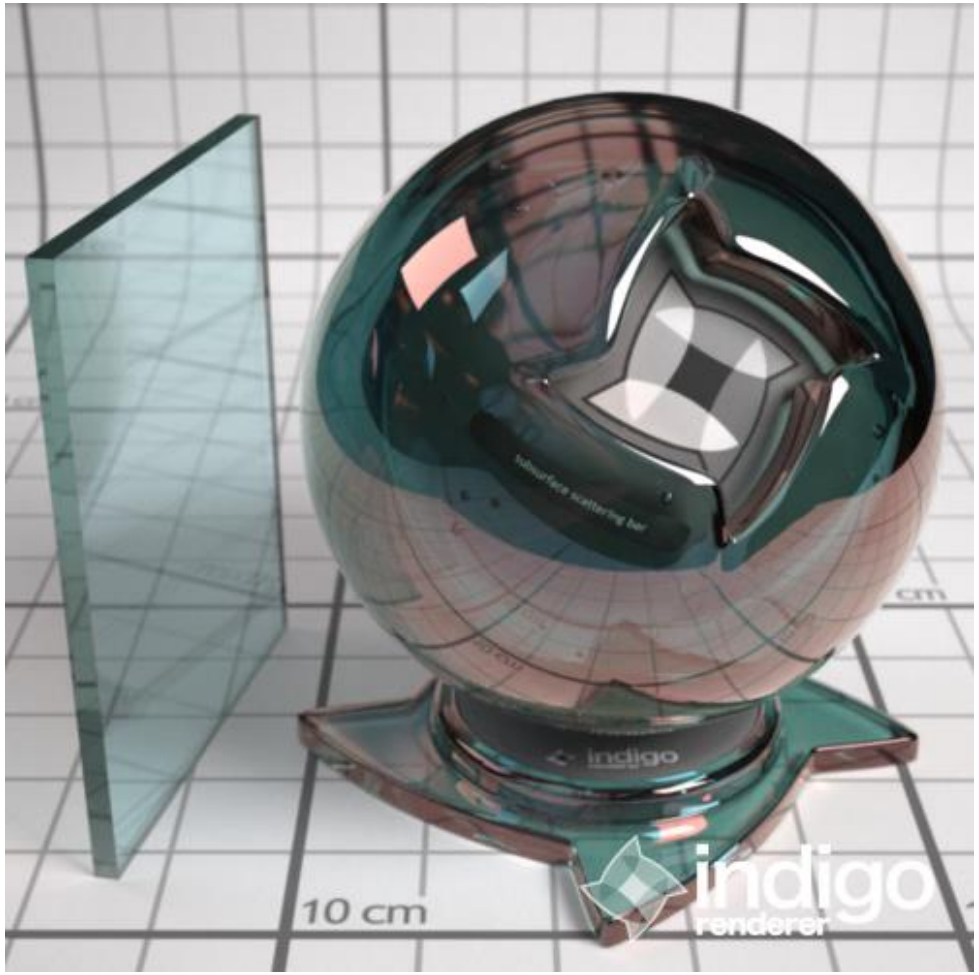
FROM A USER'S POINT OF VIEW...

- Compute power gets cheaper over time, human time does not
- Fast on modern hardware
- Bidir by default means less to think about
  - Safest default without scene-based optimisation

Unidir vs bidir (5 mins), scene by Filippo Scarso / pibuz

FROM A USER'S POINT OF VIEW...

- Compute power gets cheaper over time, human time does not
- Fast on modern hardware
- Bidir by default means less to think about
  - Safest default without scene-based optimisation
- Example: partnership with Saint-Gobain Glass
  - Verified spectral model for several glass types
  - Available on the online material database
  - Can now easily be used in high accuracy archviz, both interior and exterior shots



Saint-Gobain Glass Cool-Lite SKN 165

FROM A DEVELOPER'S POINT OF VIEW...

- Bidir is more difficult to implement and maintain
  - Unphysical hacks trickier
    - Section planes
    - Shadow catcher

Scene by polygonmanufaktur.de

FROM A DEVELOPER'S POINT OF VIEW...

- Bidir is more difficult to implement and maintain
  - Unphysical hacks trickier
    - Section planes
    - Shadow catcher
    - Invisible to camera
  - Non-symmetric scattering, normal smoothing
  - Naive implementation is O(N^4),
    can be optimised to O(N^2) [3]

Scene by Oscar Johansson

AVOID COMPLEX ALGORITHMS

- Complex can mean:
  - Difficult to implement robustly, e.g. Veach-MLT vs PSS-MLT
  - Difficult to understand settings exposed to users, e.g. irradiance caching
  - Difficult to predict behaviour, e.g. flickering in animation

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  - Difficult to understand settings exposed to users, e.g. irradiance caching
  - Difficult to predict behaviour, e.g. flickering in animation
- Bidir is as powerful as you can get before getting exotic
  - Proven highly efficient mix of direct and indirect techniques
  - Embarrassingly parallel, albeit with incoherent splats for light paths
- Needs to work on GPU eventually too

GPU RENDERING BENEFITS AND CHALLENGES

- Huge performance boost for unidir PT (fully) on GPU
  - Tried hybrid CPU+GPU, always bottlenecked
  - Multi GPU performance is incredible
  - Nvidia announced dedicated ray tracing units in GeForce RTX, 10 gigarays / sec!
- GPU bidir in future
  - Requires more stages in wavefront path tracing [4]
- Even more memory limited
  - 12 GB on GPU versus 128 GB on CPU practical in 2017
  - Out-of-core would add large amount of complexity
  - Still want in-memory codepath for simpler scenes

THANK YOU

- References:
  - [1] Veach thesis “Robust Monte Carlo Methods for Light Transport Simulation”
  - [2] Kelemen et al. “Simple and Robust Mutation Strategy for Metropolis Light Transport Algorithm”
  - [3] van Antwerpen thesis “Unbiased physically based rendering on the GPU”
  - [4] Laine et al. “Megakernels Considered Harmful: Wavefront Path Tracing on GPUs”