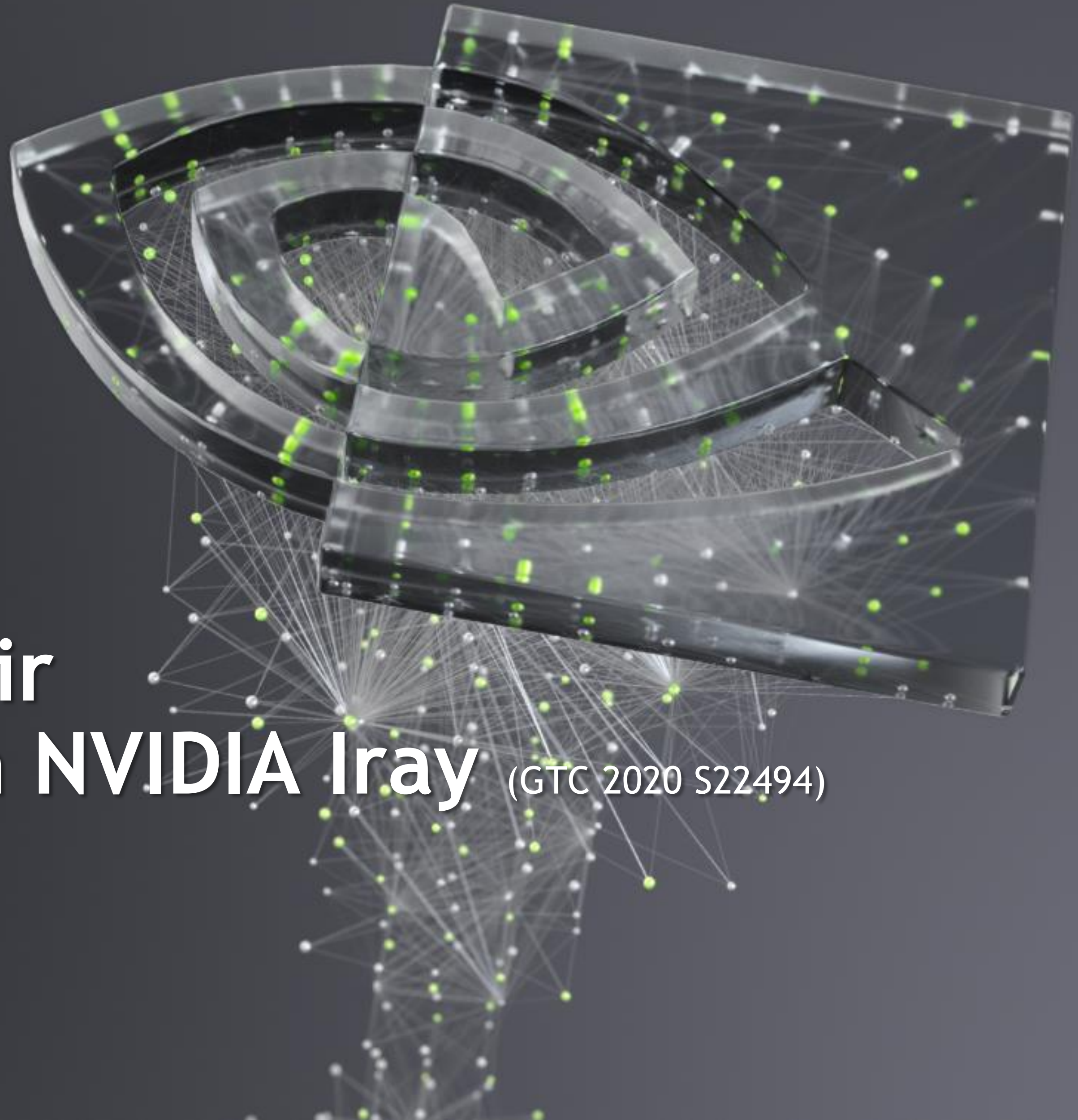
RTX-accelerated Hair brought to Life with NVIDIA Iray (GTC 2020 S22494)



Carsten Waechter, March 2020

What is Iray?

Production Rendering on CUDA

Bring ray tracing based production / simulation quality rendering to GPUs

New paradigm: ***Push Button*** rendering (open up new markets)

Plugins for

3ds Max Maya Rhino SketchUp …

In Production since > 10 Years

SUBSTANCE DESIGNER

SUBSTANCE PAINTER

SIEMENS NX

SOLIDWORKS

CATIA

Daz 3D

migenius amazon …

…

What is Iray?

NVIDIA testbed and inspiration for new tech

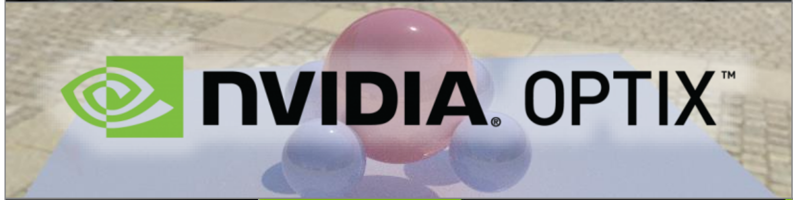
NVIDIA Material Definition Language (MDL)
evolved from internal material representation into public SDK

NVIDIA OptiX 7
co-development, verification and guinea pig

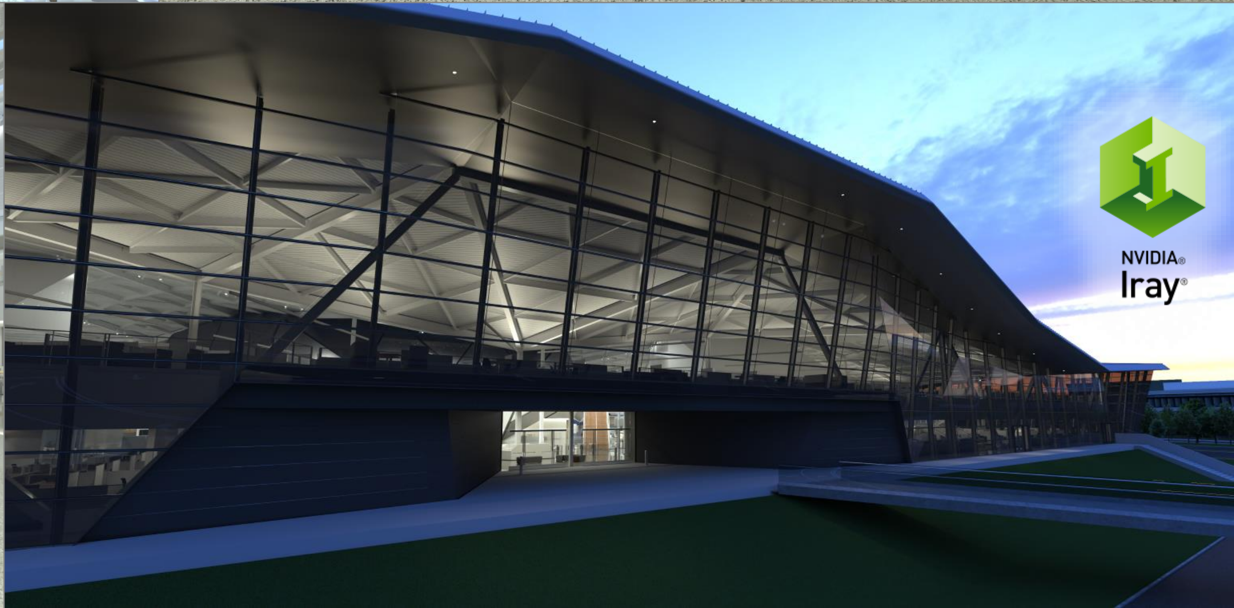
NVIDIA RTX / RT Cores
scene- and ray-dumps to drive hardware requirements

NVIDIA Maxwell…NVIDIA Turing (& future) enhancements
profiling/experiments resulting in new features/improvements

Design and test/verify NVIDIA's new Headquarter (in VR)
close cooperation with Gensler



Simulation Quality



iray legacy

Artistic Freedom

How Does it Work?

99% physically based Path Tracing

To guarantee simulation quality and ***Push Button***

- Limit shortcuts and good enough hacks to minimum
- Brute force (spectral) simulation
  - no intermediate filtering
  - scale over multiple GPUs and hosts even in interactive use
- Two-way path tracing from camera and (opt.) lights
- Use NVIDIA Material Definition Language (MDL)
- NVIDIA AI Denoiser to clean up remaining noise

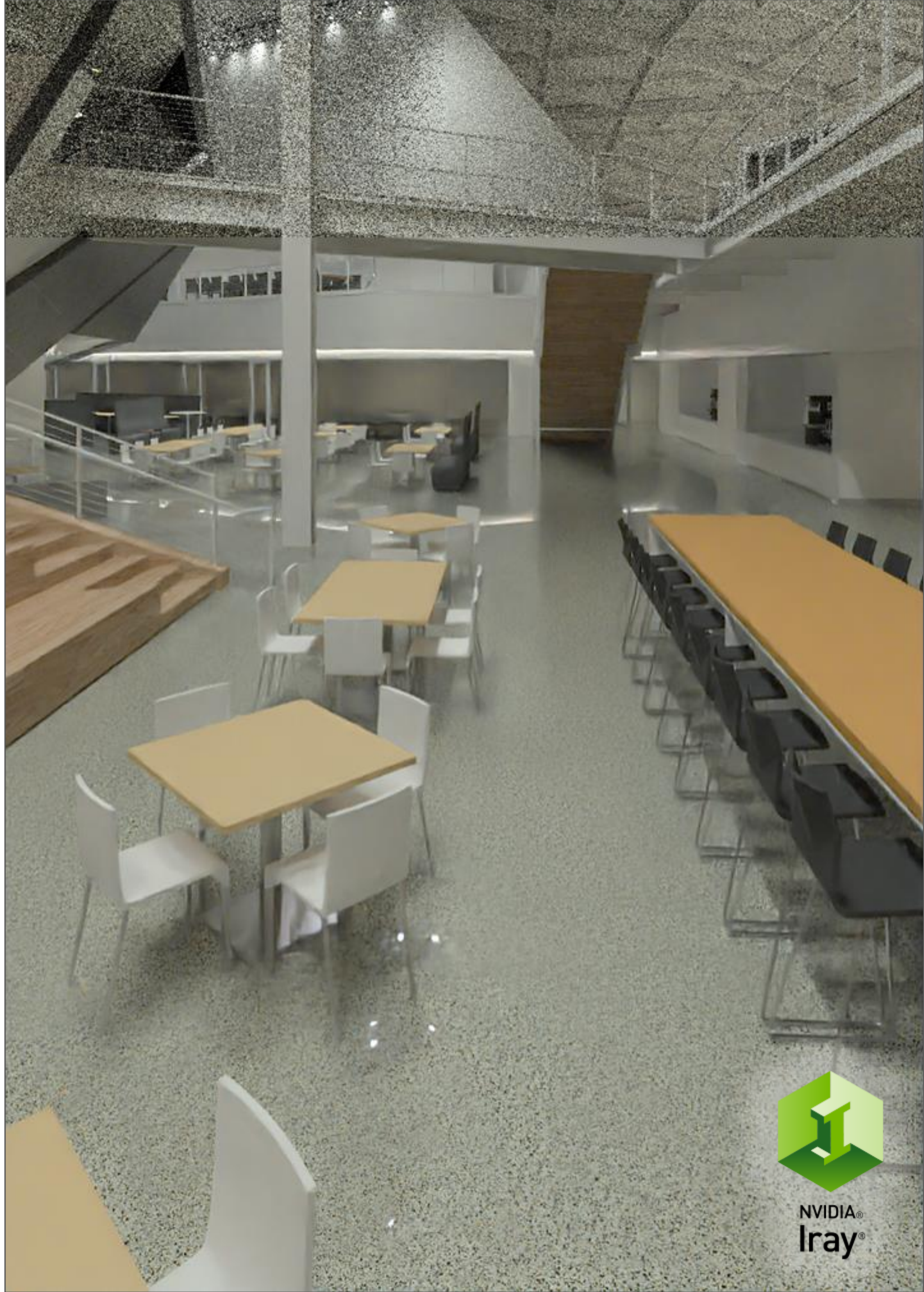
NVIDIA
Iray

How Does it Work?

99% physically based Path Tracing

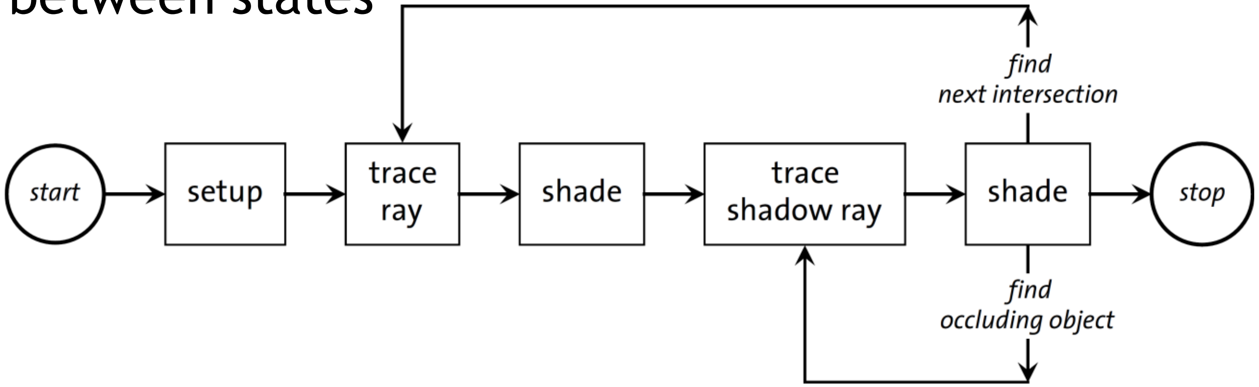
To guarantee simulation quality and ***Push Button***

- Limit shortcuts and good enough hacks to minimum
- Brute force (spectral) simulation
  - no intermediate filtering
  - scale over multiple GPUs and hosts even in interactive use
- Two-way path tracing from camera and (opt.) lights
- Use NVIDIA Material Definition Language (MDL)
- NVIDIA AI Denoiser to clean up remaining noise



Wavefront Architecture

From Megakernel	to State Machine
Follows each path to completion	Small progress on each path per step
One path at a time	Millions of *active* paths at a time
Single CUDA (mega-)kernel	Multiple smaller CUDA kernels (states) specialized on parts of the simulation (state machine)
	Global memory (*AoSoA* layout) to *communicate* between states



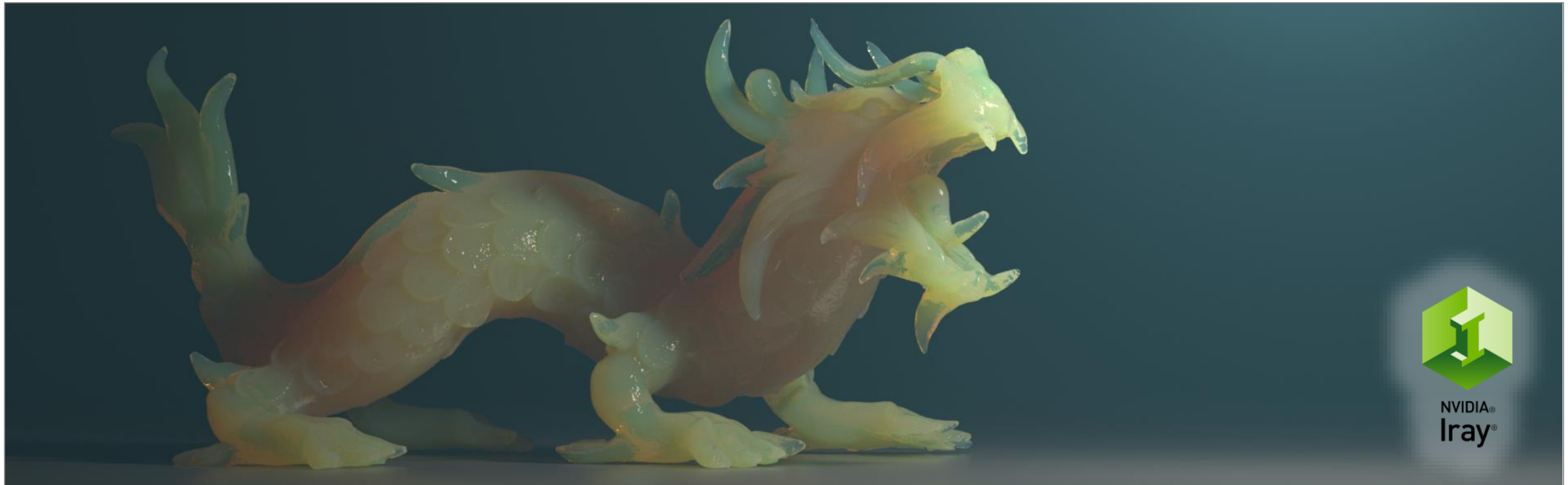
Iray on OptiX 7

Wavefront Architecture

All kernel variants that need to trace rays are now executed through OptiX 7

Path-/Light-Tracer main trace kernels

incl. SSS code and shortcuts for state machine early outs



Iray on OptiX 7

Wavefront Architecture

All kernel variants that need to trace rays are now executed through OptiX 7

- Path-/Light-Tracer main trace kernels
  - incl. SSS code and shortcuts for state machine early outs
- Path-/Light-Tracer shadow trace kernels
  - incl. few shortcuts for state machine early outs
- Rounded Corners
- Light-Tracer lens connection

All other kernels stay on plain CUDA implementations / kernel launches (for now)

Iray on OptiX 7

Wavefront Architecture

Split up the Tail-megakernel into 2 new kernels

- Trace rays + the *remainder* of the state machine

Majority of code in `__raygen__`

- One single `optixTrace()` call, no branching, for best performance
- (except for Tail-trace- and rounded corners kernels)

`__closesthit__` directly fills wavefront state, no payload communication

Compile time / Pipeline setup 7-10 secs (with warm cache 0.1-0.2 secs)

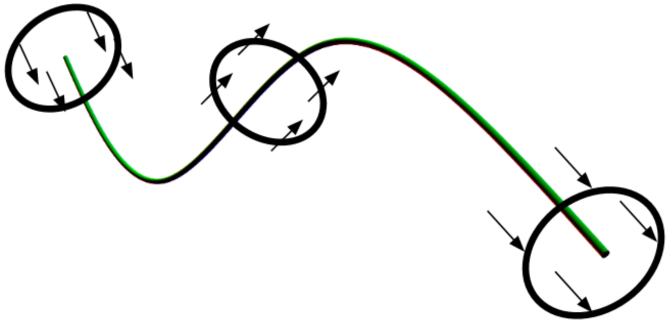
~21k lines of PTX

New in 2020.0 : Curves / Fibers

NVIDIA®
Iray®

How Does it Work?

Coop development on new OptiX 7.1 curve API



Iray 2020.0 exposes a subset

- Cubic B-Spline Basis

  With vertex sharing (saves memory & bandwidth)

  X curves combined into 1 connected fiber

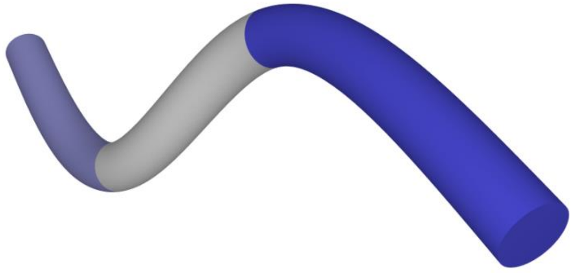
- ISV responsible for conversion from spline bases to B-spline

  Memory cost: no vertex sharing

  Bezier and anything compatible, e.g., Catmull-Rom, Hermite, …

- Intersection code based on (improved) NVIDIA research tech

  Fast, High Precision Ray/Fiber Intersection using Tight, Disjoint Bounding Volumes *Nikolaus Binder and Alexander Keller*



How Does it Work?

Fiber rendering

Material and Texture inputs

- MDL 1.6 hair BSDF

  A Practical and Controllable Hair and Fur Model for Production Path Tracing *Chiang et al.*

- Texture space

  0: 1D along fiber [0..1]

  1: per fiber: either user provided or
  (by default) origin position of fiber in world space (1D, 2D or 3D)

  2: per vertex: user provided (1D, 2D or 3D)

How Does it Work?

Fiber rendering

Intersection

- Separate hierarchies for triangles and fibers
- First trace triangle scene, then fibers for efficiency
- When using MDL hair BSDF

  “Teleport” intersection point to other side of the fiber, along normal, to be used as exit point

  BSDF is supposed to handle most internal effects

- Continue with self intersection handling code

  A Fast and Robust Method for Avoiding Self-Intersection
  Carsten Waechter and Nikolaus Binder

When Does it Not Work?

Fiber rendering

Internal rays

- Current implementation limitation: Rays starting inside a fiber will lead to undefined results, as considered solid
- Thus: Secondary rays from fiber hits should be launched from outside any fibers, which is difficult to detect (e.g. millions of hairs)
- This limitation will hopefully vanish soon (newer OptiX 7 releases)
- Artifacts usually (e.g. millions of hairs) not visible though

How Fast is it?

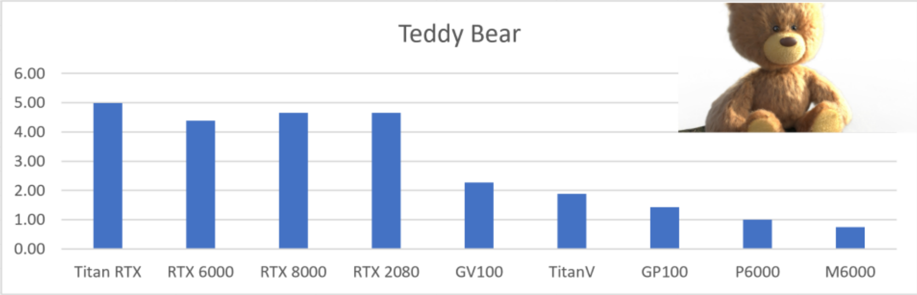
Benchmark

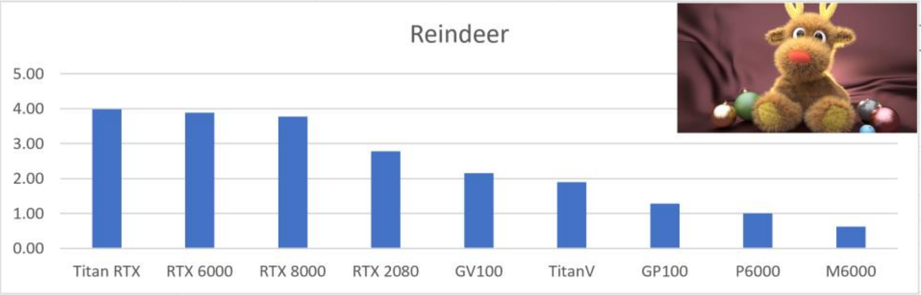
Absolute: < 1min beauty FullHD

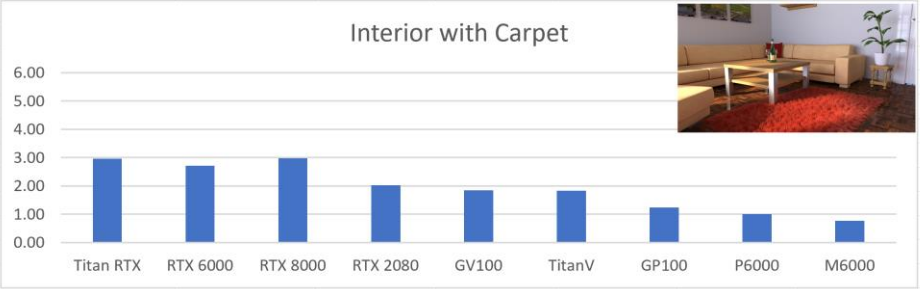
> 6 million fibers + MDL hair BSDF

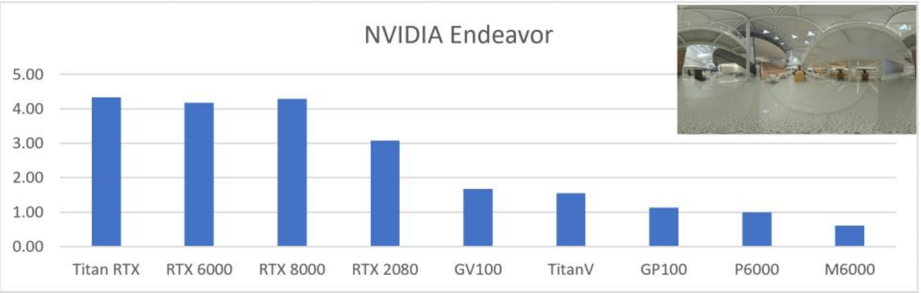
Benchmarking different generations

- Exceptional performance increase
  - Comparing RTX on vs off
- And even when comparing exceptional triangle scenes
- So (usually) no need to triangulate for performance









Questions?

Acknowledgments

Iray Team / NVIDIA ARC Berlin

More Information

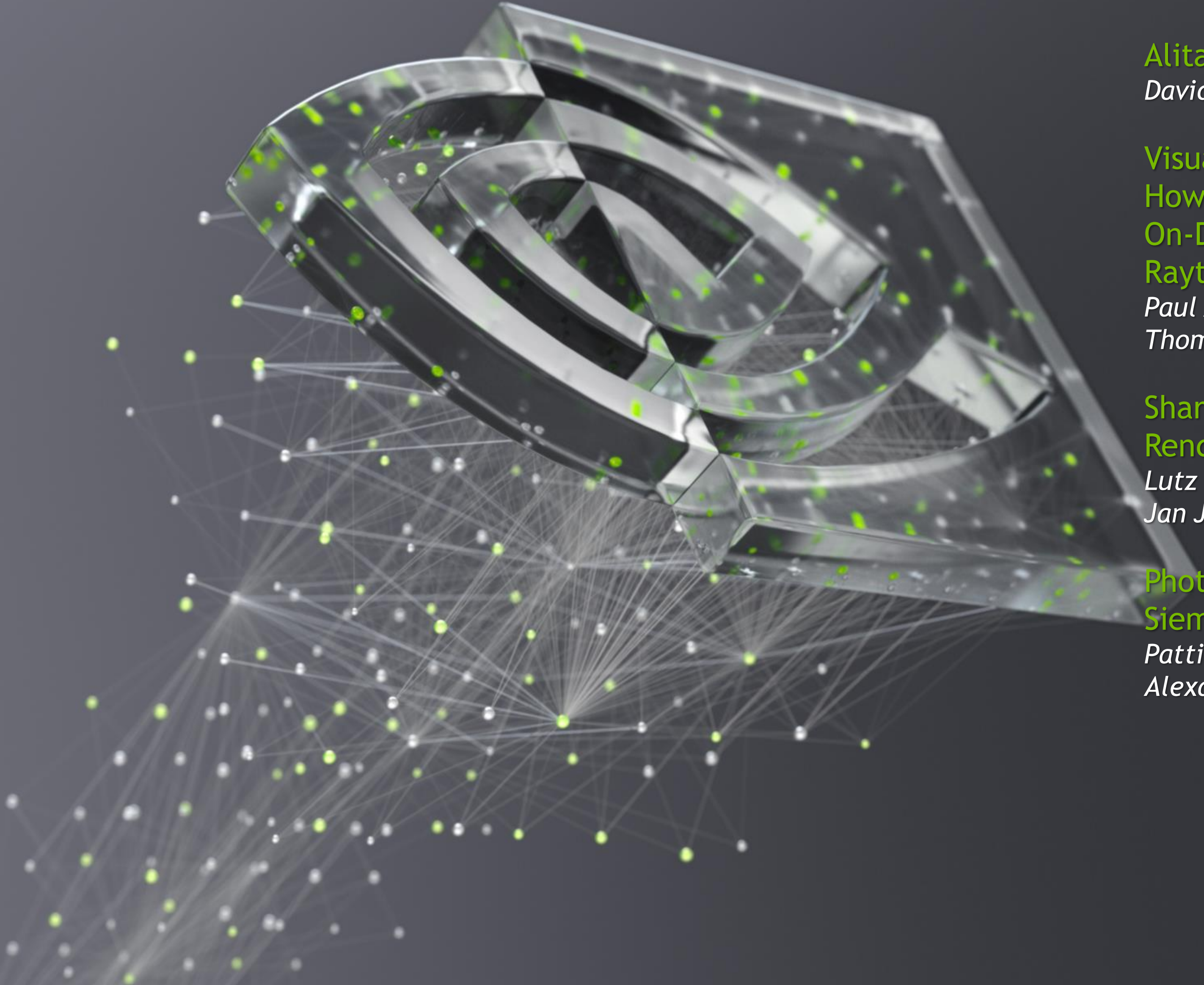
Techreport: *The Iray Light Transport Simulation and Rendering System*
https://arxiv.org/pdf/1705.01263.pdf

https://raytracing-docs.nvidia.com/iray/index.html

Render: Jeff Patton Software: 3ds Max / iRay Model: TurboSquid/SQUIRE

Image courtesy of MBUSA

Image courtesy of MBUSA



Other sessions featuring Iray

Alita, Substance, and RTX [S22395]
David Crabtree, Build Lead, DNEG

Visuals as a Service (VaaS): How Amazon and Others Create and Use Photoreal On-Demand Product Visuals with RTX Real-Time Raytracing and the Cloud [S21290]
Paul Arden, CEO, migenius
Thomas Dideriksen, Senior Software Developer, Amazon

Sharing Physically Based Materials Between Renderers with MDL [S21220]
Lutz Kettner, Director, Adv. Rendering and Materials, NVIDIA
Jan Jordan, Senior Software Product Manager, NVIDIA

Photoreal Design Workflows with NVIDIA Iray: the Siemens Experience [S22454]
Patti Longwinter, Senior Product Manager, Siemens
Alexander Fuchs, Senior Software Product Manager, NVIDIA

NVIDIA