Sharing Physically Based Materials Between Renderers with MDL

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Lutz Kettner Senior Manager, Advanced Rendering and Materials

Agenda

Introduction to NVIDIA Material Definition Language MDL

Matching the appearance of a single material within different rendering techniques

Defining physically-based materials

Measured materials

MDL eco-system

Demo of the material exchange

Become part of the eco-system

Outlook

What is NVIDIA MDL?

The **NVIDIA Material Definition Language (MDL)**

is technology developed by NVIDIA ARC

to define *physically-based* materials

for its rendering solutions

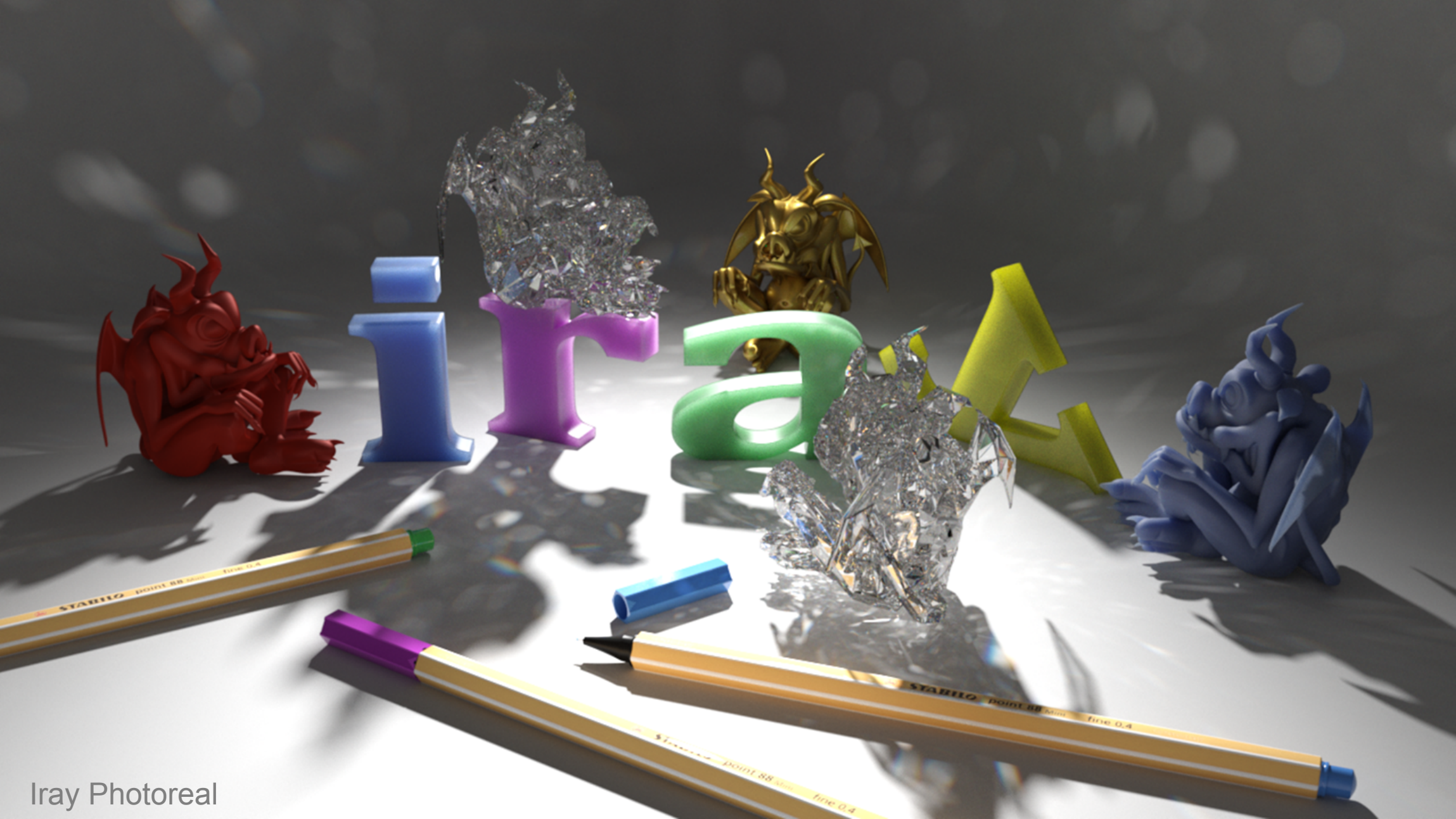
central for *physically-based* rendering


B TZ 2012
Iray Photoreal
Path Tracing


MDL Material Sample
Material Collection, interior design 2014
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Sample 6
MECHANICAL
PANTRY
FAMILY RM
Iray Photoreal


Iray Photoreal
courtesy of Delta Tracing

Iray Photoreal



Iray Photoreal


Iray Photoreal

MDL Usage Example

Explorer Desk

Iray Photoreal

See also http://vimeo.com/86594867

Iray 2015

Rendering Modes

Realtime | **Interactive** | **Photoreal**

60 FPS ⟷ 15 FPS*

20 FPS ⟷ 2 FPS*.

10 FPS ⟷ Minutes

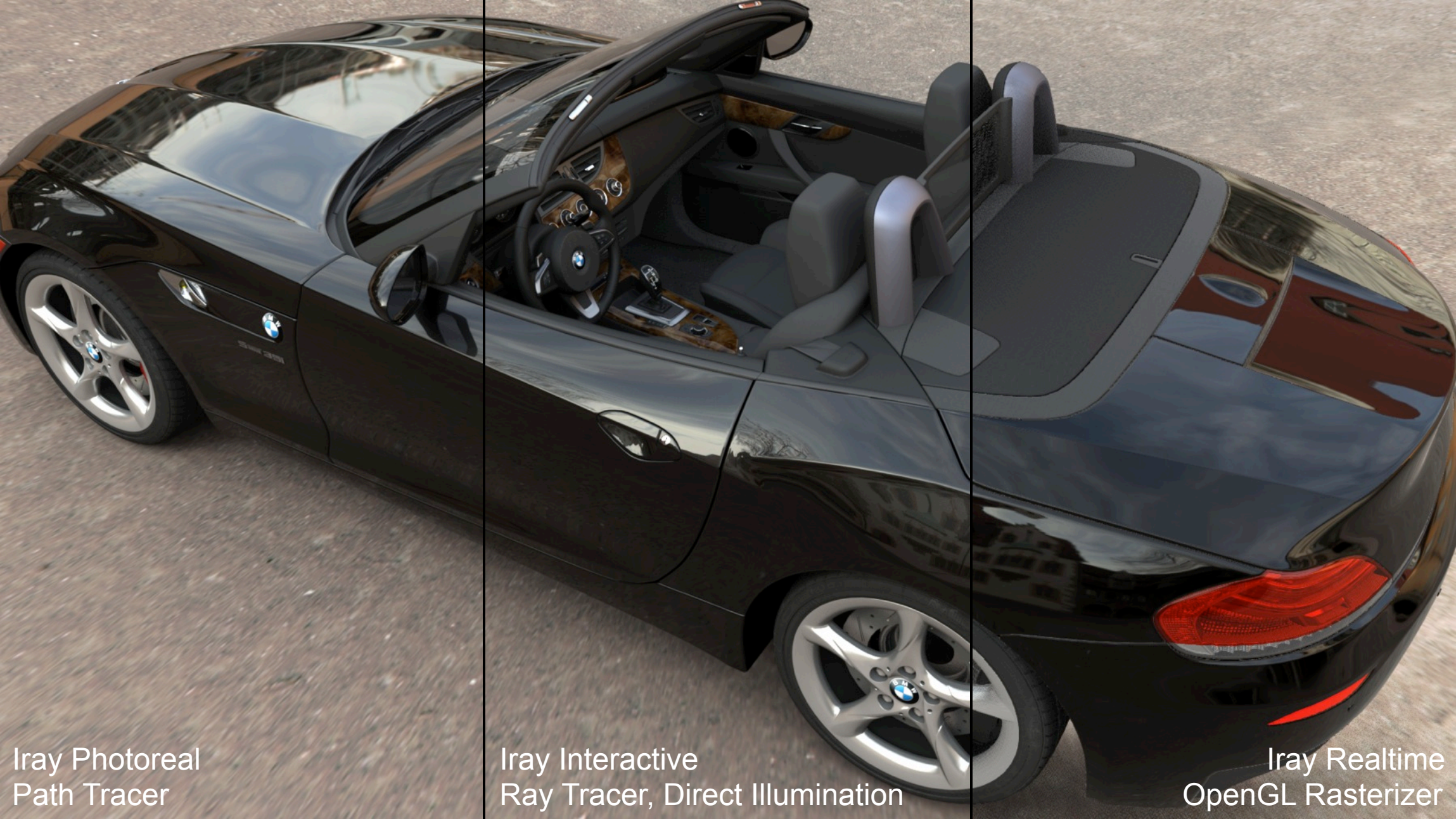
Shares Scene Database and Material Description for a consistent look

Common Materials within easy to create material catalogues


Iray Realtime
OpenGL Rasterizer


Iray Interactive
Ray Tracer, Direct Illumination


Iray Photoreal
Path Tracing


Iray Photoreal
Path Tracer
Iray Interactive
Ray Tracer, Direct Illumination
Iray Realtime
OpenGL Rasterizer

Traditional Shading Language Parts

Texturing

- Texture lookups
- Procedurals
- uv-transforms
- Projectors
- Noise functions
- Math functions
- Render state

Material Definition

- Glossy reflection
- Transparency
- Translucency

Material Implementation

- Light loops / Trace N rays
- OIT / ray-continuation
- Ray-marching

MDL

Renderer

Procedural Programming Language

- Texture lookups
- Procedurals
- uv-transforms
- Projectors
- Noise functions
- Math functions
- Render State

Declarative Material Definition

- Glossy reflection
- Transparency
- Translucency

Rasterizer

- Light loops
- OIT

Raytracer

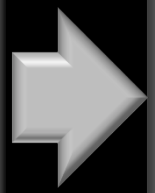
- Trace N rays

Pathtracer

- Ray-marching

MDL

Procedural Programming Language



Declarative Material Definition

Renderer

Rasterizer

- Light loops
- OIT

Raytracer

- Trace N rays

Pathtracer

- Ray-marching

MDL

Procedural Programming Language → Declarative Material Definition

MDL is not a Shading Language

MDL defines what to compute, *not* how to compute it

- no programmable shading
- no light loops or access to illumination
- no trace call
- no sampling
- no camera dependence

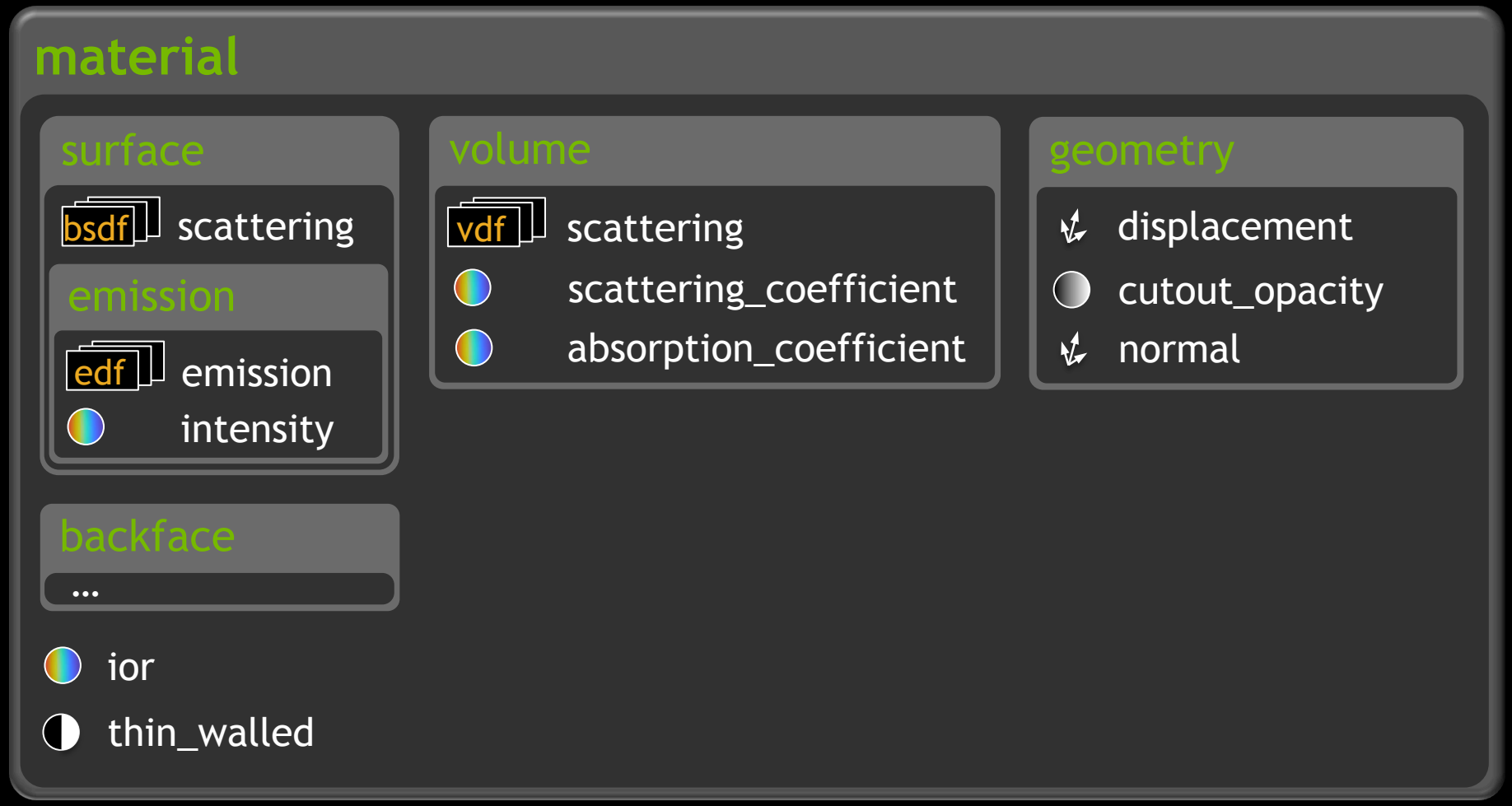
Renderer

Rasterizer
- Light loops
- OIT

Raytracer
- Trace N rays

Pathtracer
- Ray-marching

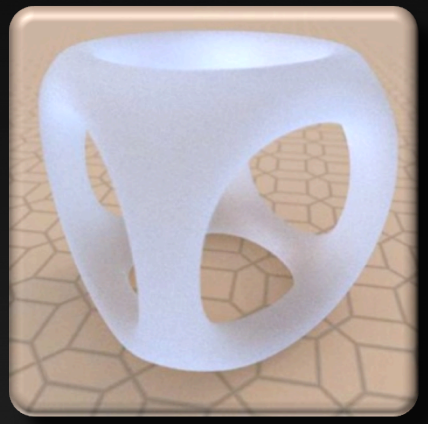
MDL Material Model



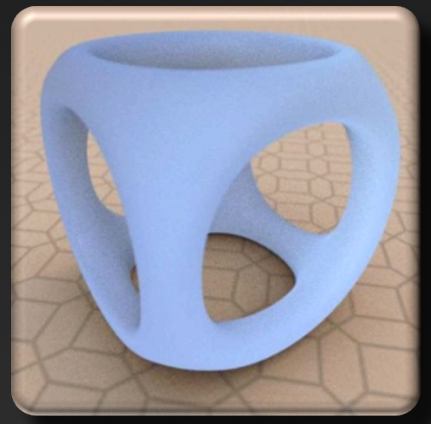
MDL Elemental Distribution Functions

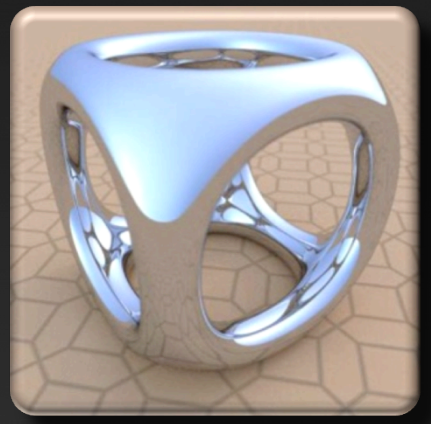
Bidirectional
Scattering
Distribution
Functions

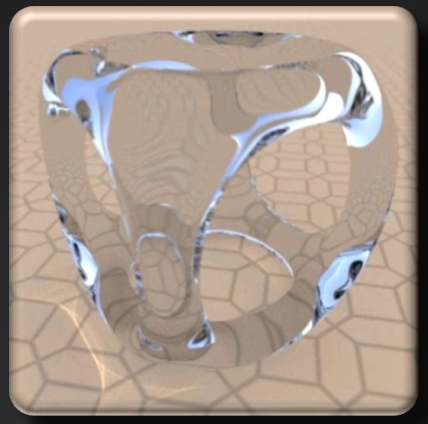

Diffuse Reflection


Diffuse Transmission


Simple Glossy


Backscattering Glossy


Specular
Pure Reflection

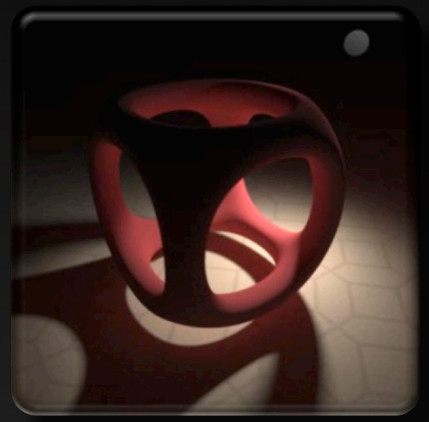

Specular Reflection
& Transmission


Measured BSDF

MDL Elemental Distribution Functions

Emissive Distribution Functions

Diffuse



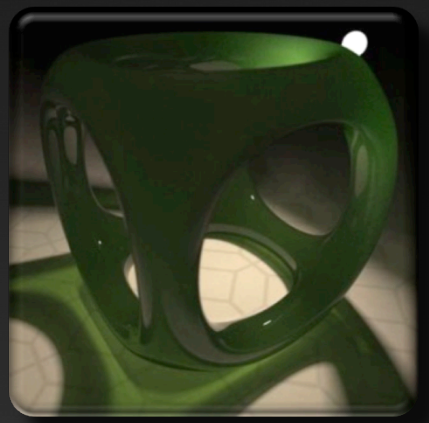
Spot

IES Profile

Volume Distribution Functions

Anisotropic
Absorption & SSS

Anisotropic + IOR
& Internal Scattering



Anisotropic
w/ Light

MDL Distribution Function Modifiers

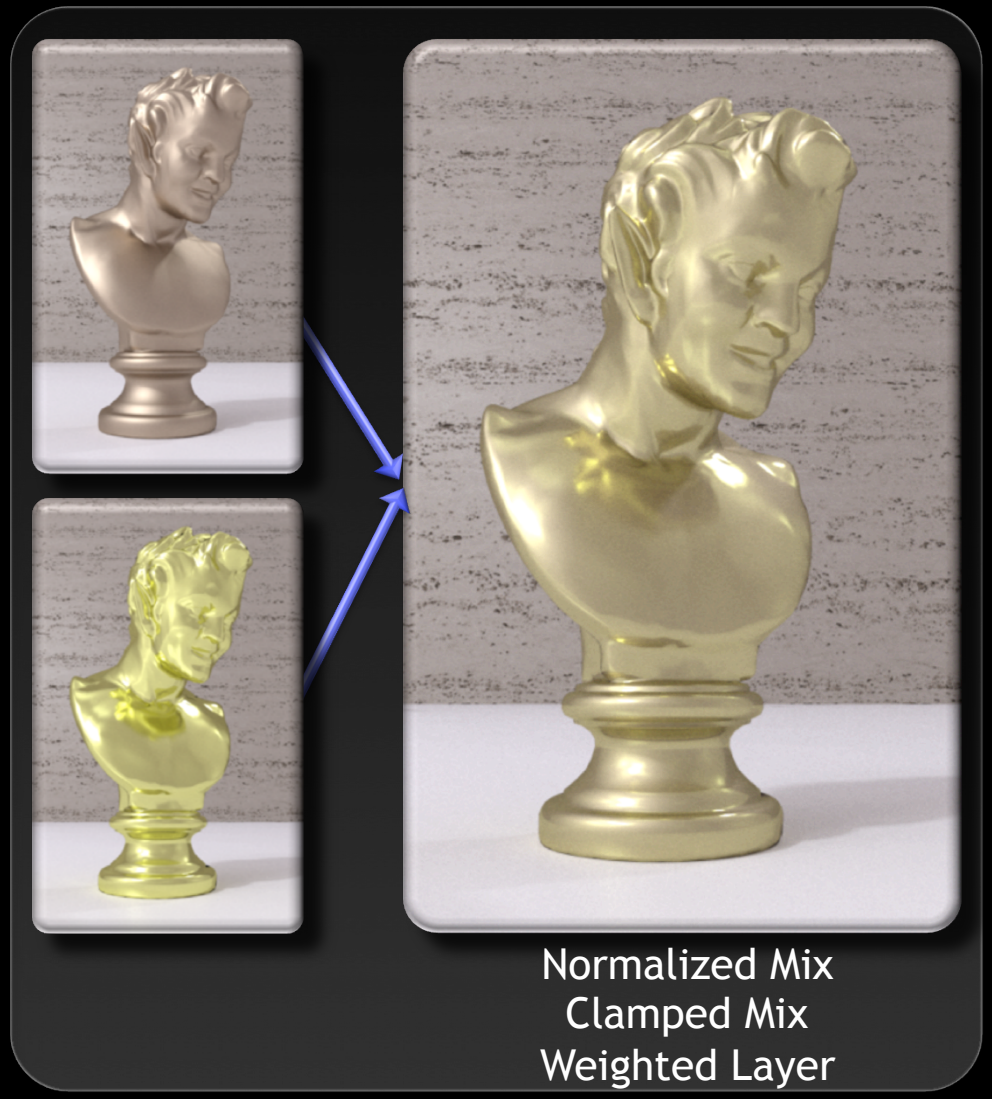
Tint

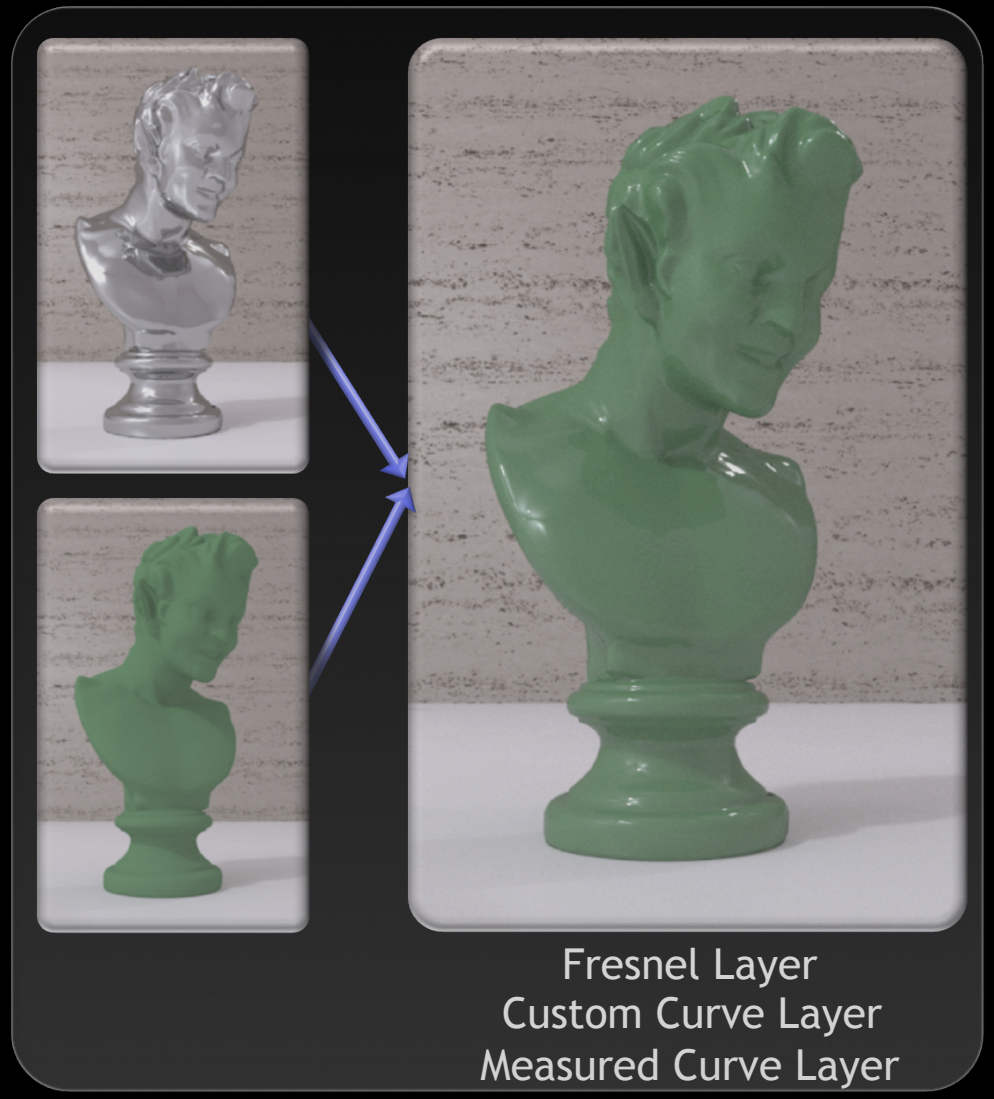
Thin Film

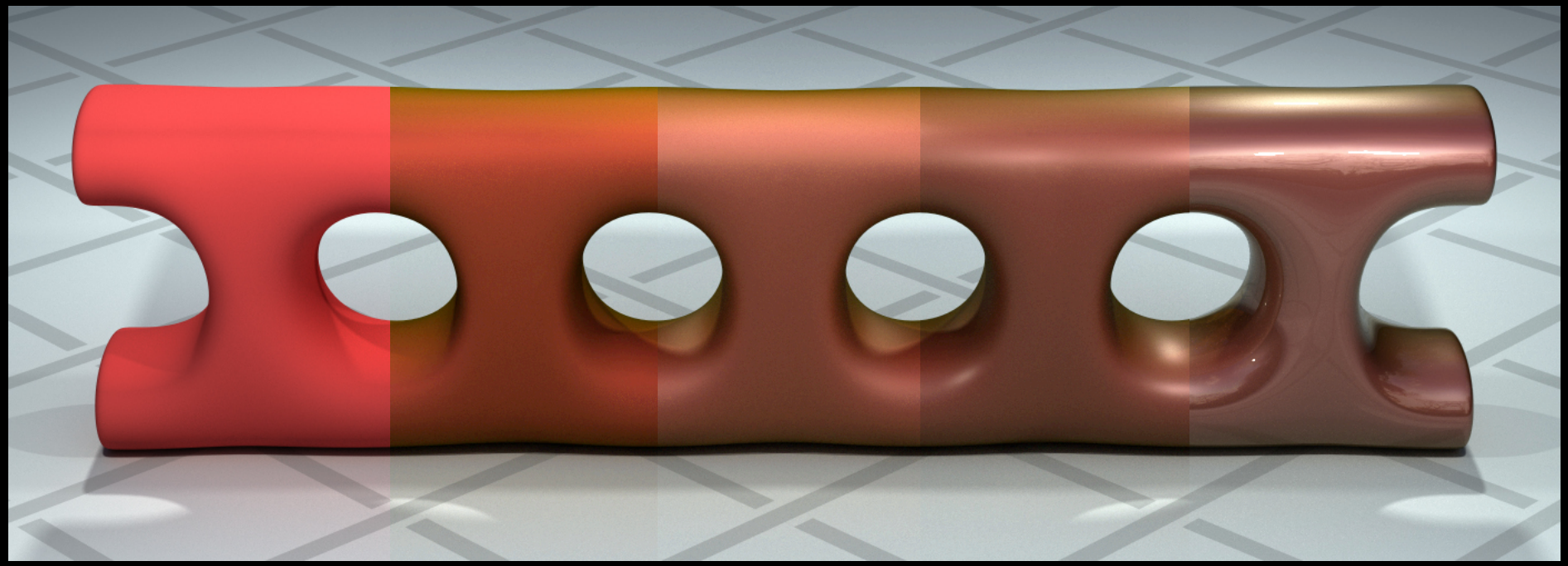
Directional Factor

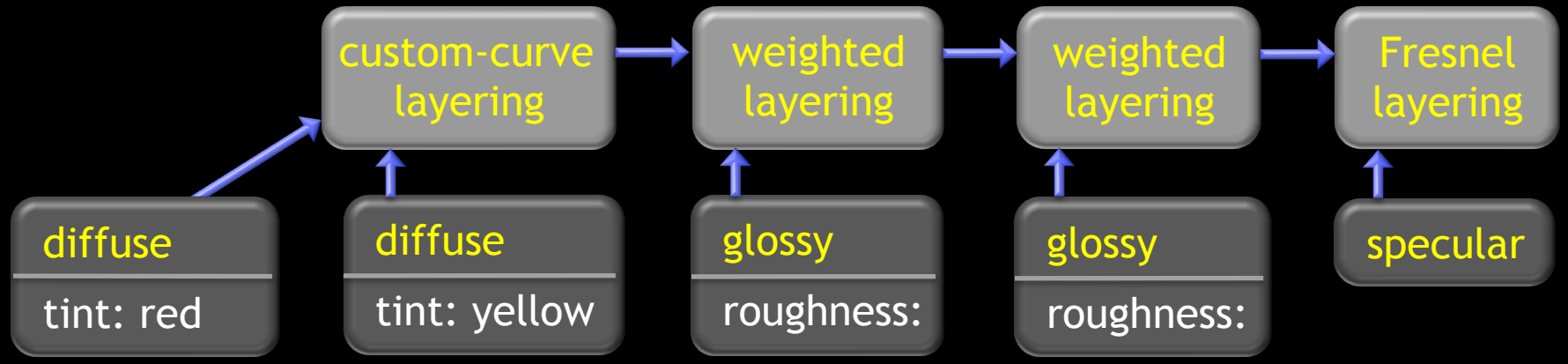
Measured Curve Factor

MDL Distribution Function Combiners



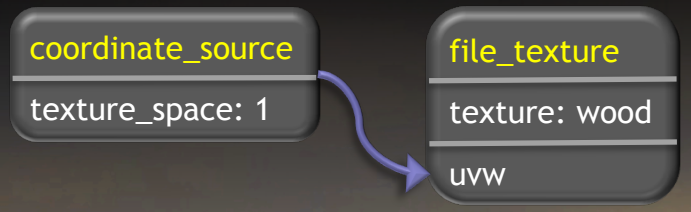





custom-curve layering
weighted layering
weighted layering
Fresnel layering
diffuse
tint: red
diffuse
tint: yellow
glossy
roughness:
glossy
roughness:
specular

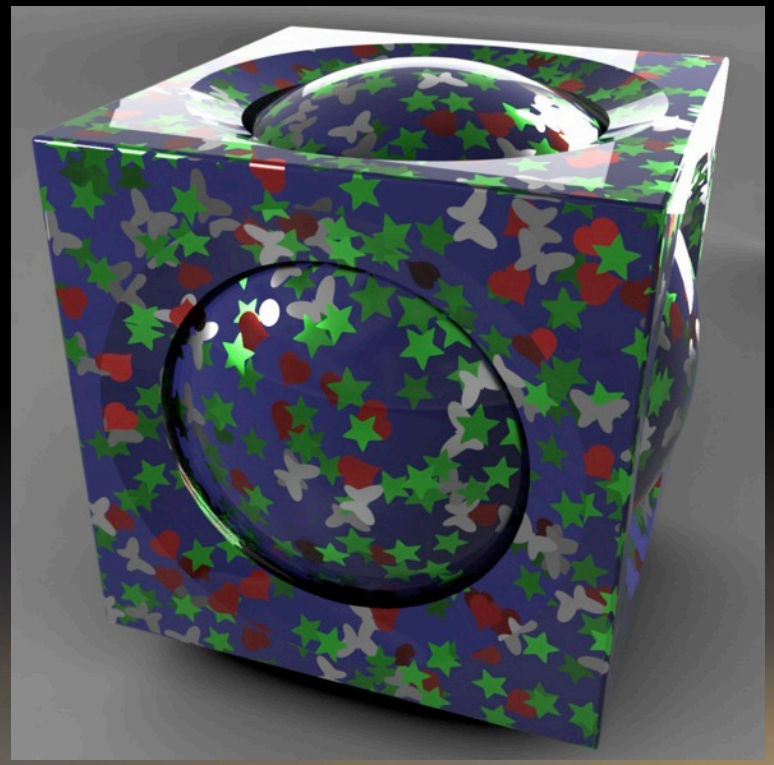
MDL Procedural Programming Language

- C-like language for function definitions
- Function results feed into material and function parameters
- “Shader graphs” are equivalent to function call graphs




```
↔  file_texture( texture: wood,
                 uvw: coordinate_source( texture_space: 1) )
```

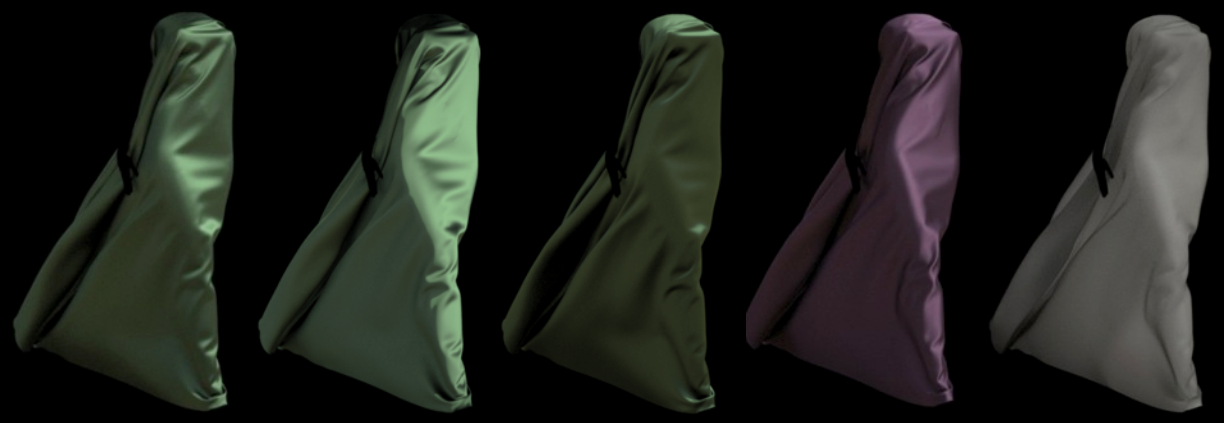
MDL Practical examples



MDL Handbook

mdlhandbook.com

Example

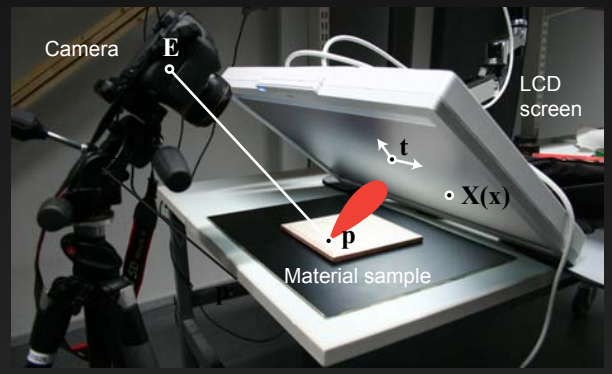


4 anisotropic glossy highlights + translucency

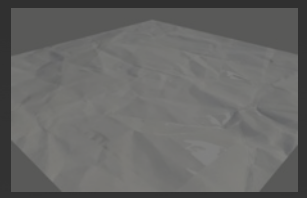
MDL

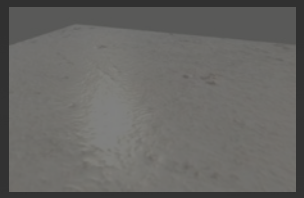
Measured Materials

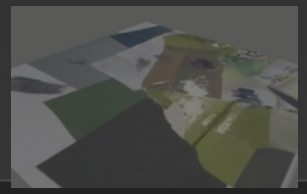
Fast scan for believable materials

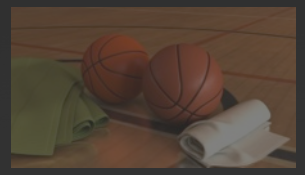


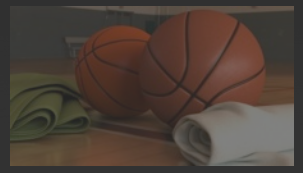
Quantitative measurements for predictive rendering

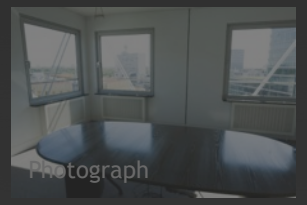


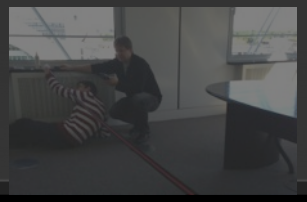












Spatially Varying (SV)BRDF

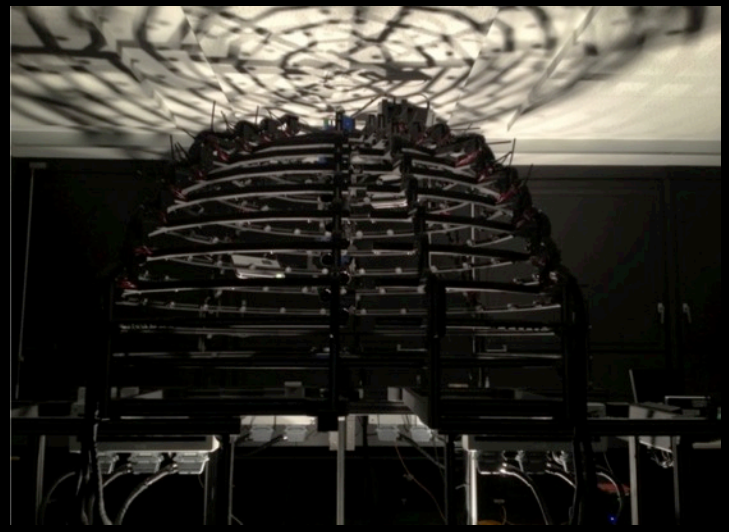
- Analytic material model
- Measurement drives model parameters

Practical SVBRDF Capture In The Frequency Domain, SIGGRAPH 2013

Miika Aittala and Jaakko Lehtinen, Aalto University, NVIDIA Research
Tim Weyrich, University College London

BTF Measurement Technology from X-Rite

Total Appearance Capture (TAC)



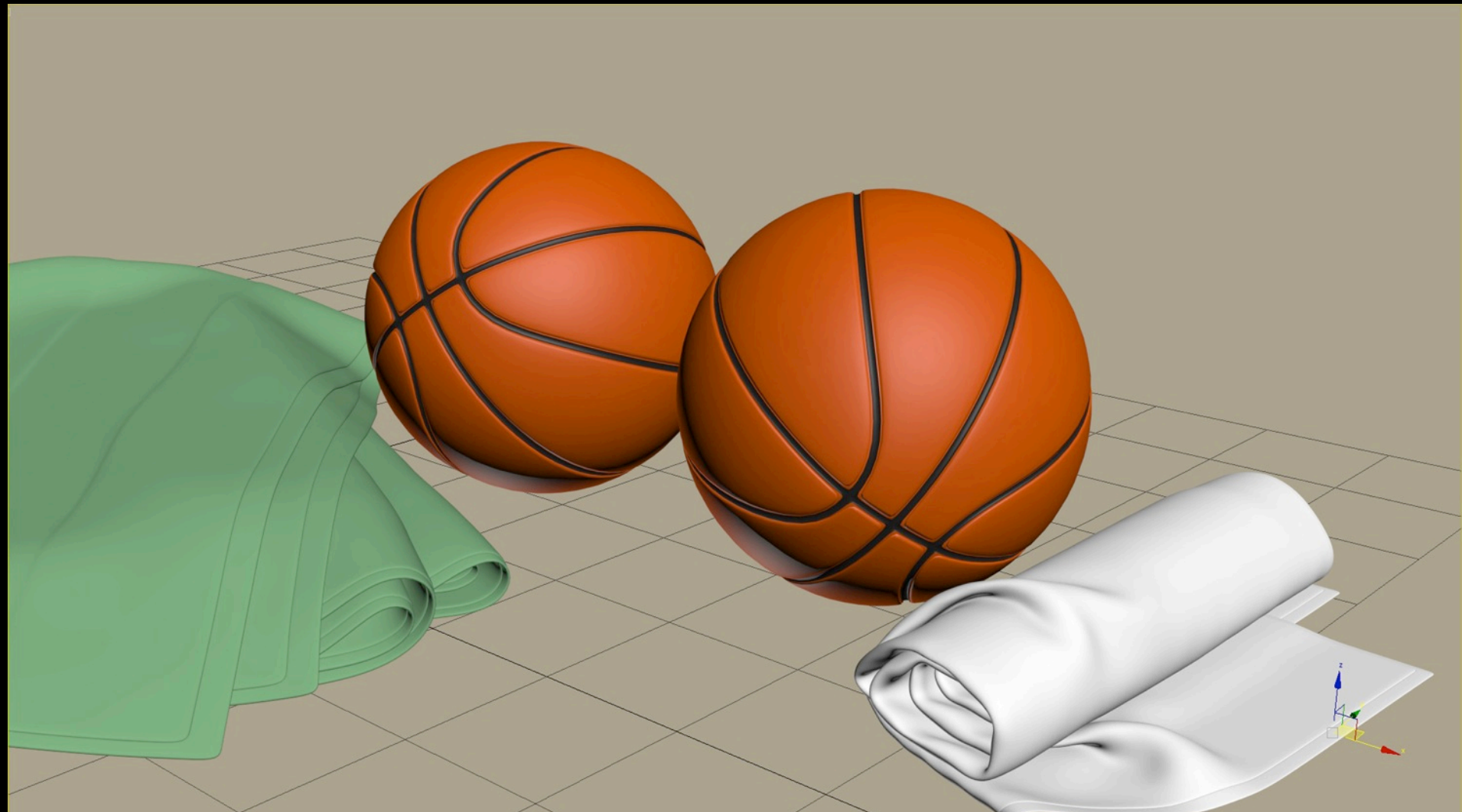
Dome TAC

TAC7 Prototype

- Measurement stored in Appearance eXchange Format (AxF)
- Iray supports the base profile (SVBRDF representation) of AxF

Iray 2015

X-Rite AXF Support



Iray 2015

X-Rite AXF Support

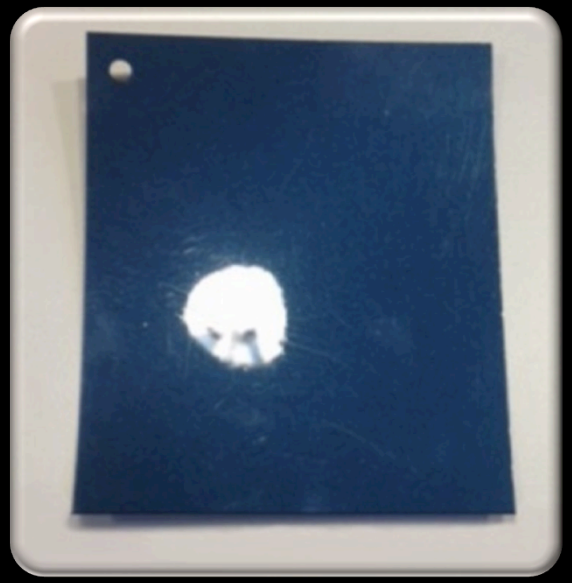
Iray 2015

X-Rite AXF Support

Iray 2015

X-Rite AXF Support

Measured isotropic BSDFs



Radiant Zemax: Imaging Sphere

Measured isotropic BSDFs

- Scanned BSDF

Measured isotropic BSDFs

- Clear coat added with a specular BSDF layer

Measured isotropic BSDFs

- Scratches added with another layer for a bump map

Measured isotropic BSDFs

MDL

Additional Benefits

Physically-based materials are an easy-to-use paradigm

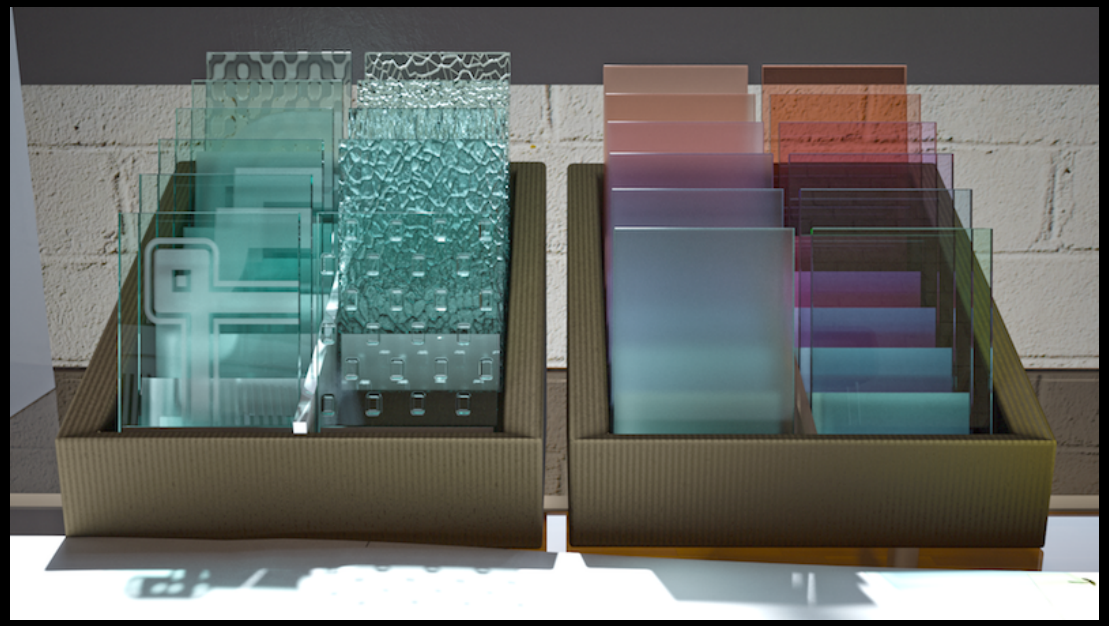
Supports modern rendering algorithms

Allows simple compilers and early optimizations

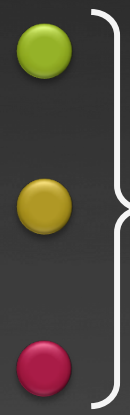
Enables fast renderers, especially on parallel architectures

GPU friendly

Supports material catalogs



Light Path Expressions



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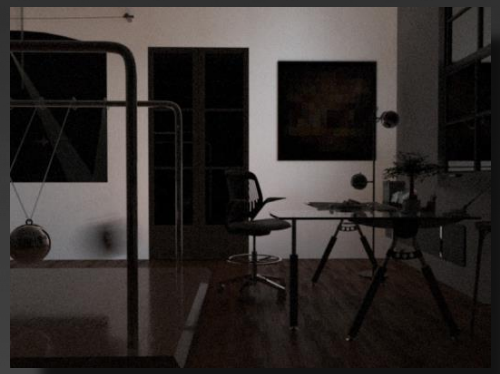
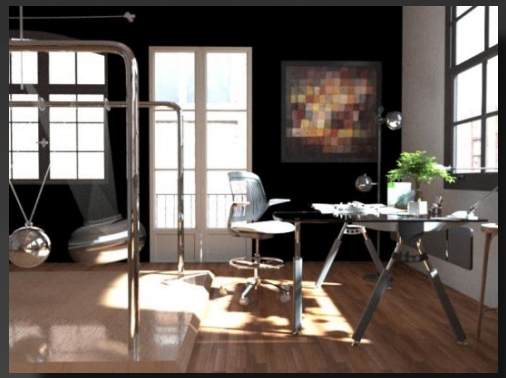
Paths that interact with wall



+

Paths that do not



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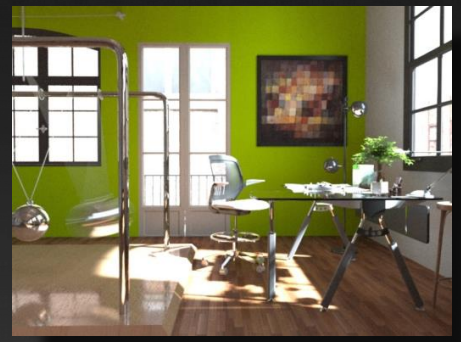
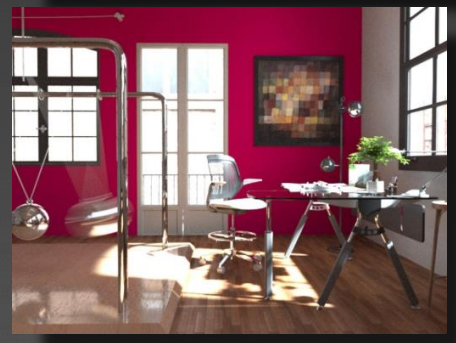


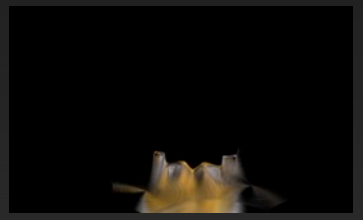


Edit the Wall Color easily in Post -
and get proper reflections and color bounce

MDL Complement Light Path Expressions

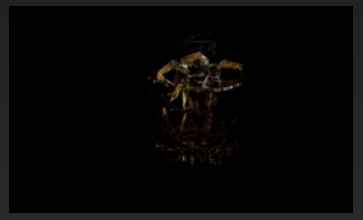
LPEs can select individual DF components

Light falling onto the ground without first passing through the glass



Caustics cast by the glass

Specular reflections on the glass



Specular reflections on the ice cube

All remaining interactions

MDL – past, present and future

June 2011

First Ideas, influence from mental ray shader API, MetaSL

May 2012

Kick-off of MDL Spec

Jan 2013

MDL 1.0, shipment with Iray 2013

Jan 2014

MDL 1.1, support for measured data

Bunkspeed, Catia start using MDL

May 2014

Made Specification public

Jan 2015

MDL 1.2, resource handling, units

Support in mental ray, exposed in Autodesk 3ds Max, Maya

2015

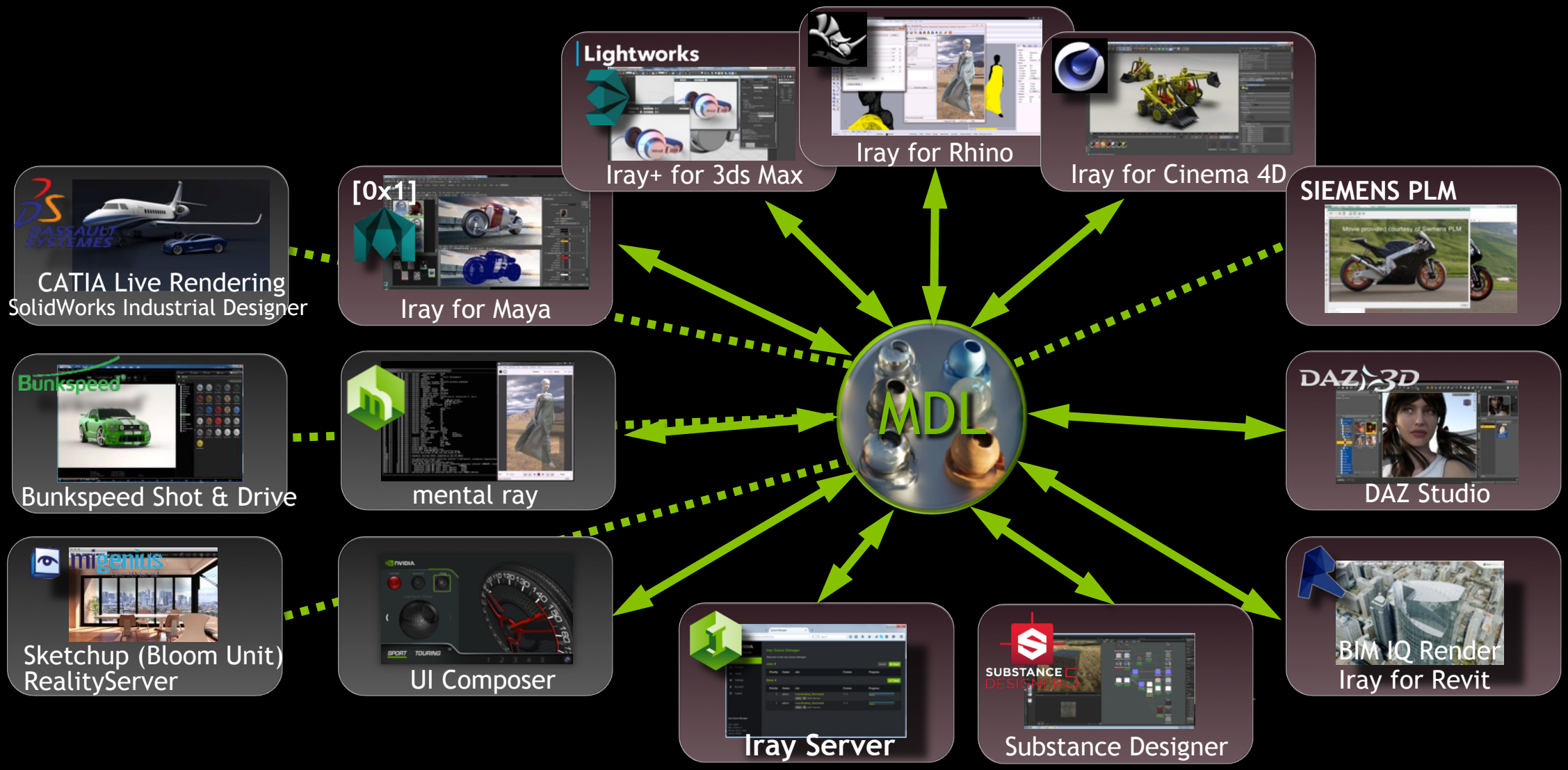
NVIDIA Iray plugins, DAZ 3d, Allegorithmic Substance Designer, NVIDIA essentials material library

MDL 1.3, editing workflows

2016

Watch out for announcements @ Siggraph!

MDL in Commercial Products



Focus on Material exchange

Freely choose where to author material content

create

modify

consume

Become Part of the Eco-System

Integrate Iray

MDL is included

Write your own compiler

Based on the freely available MDL Specification

License the MDL SDK

MDL SDK can be licensed independently of Iray.

Become Part of the Eco-System

Integrate Iray

MDL is included

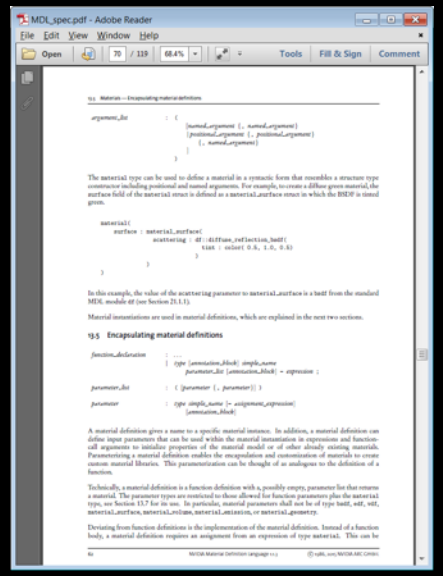
Lightworks

NVIDIA's partner in bringing Iray to your application

Decades of experience helping companies with custom integrations

Become Part of the Eco-System

Write your own compiler



MDL Specification can be downloaded @

http://www.nvidia-arc.com/products/iray/mdl-materials.html

MDL conformance test suite, available October 2015

Syntactic conformance tests

Semantic conformance tests

Become Part of the Eco-System

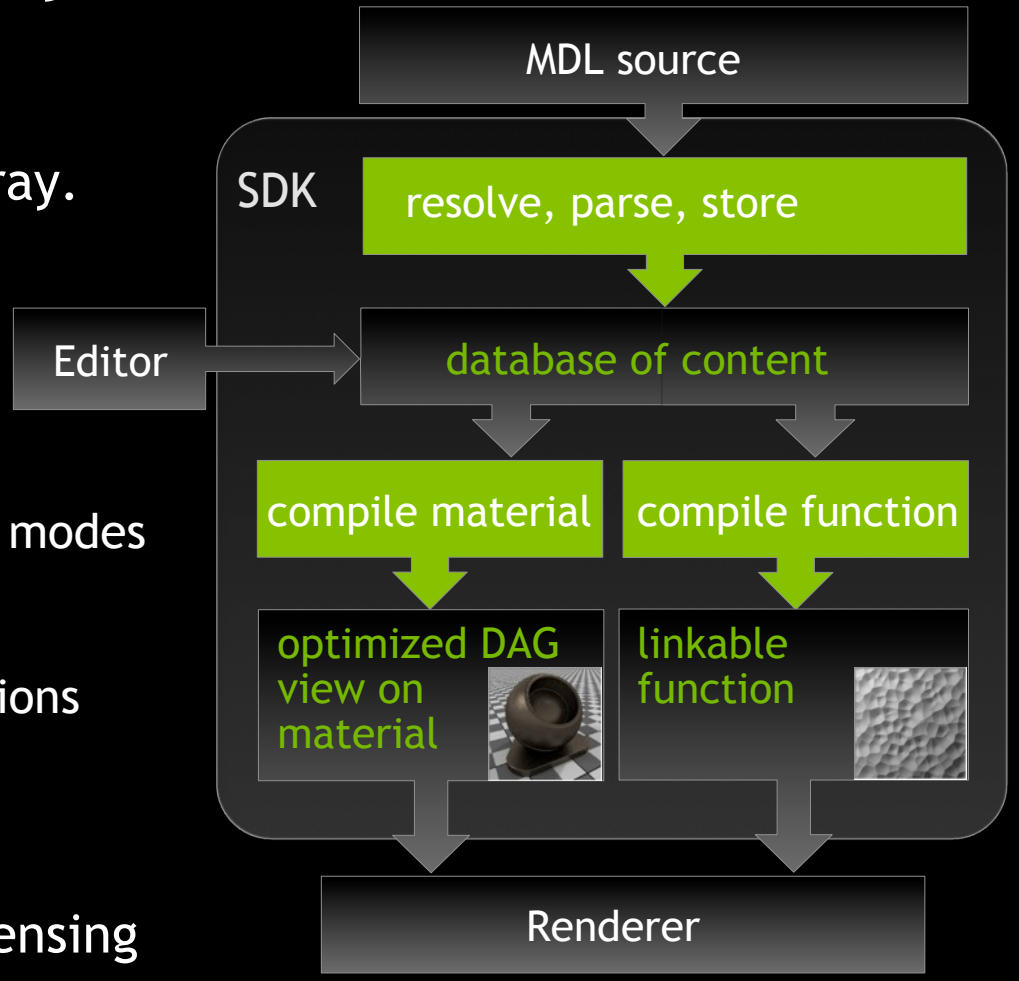
License the MDL SDK

MDL SDK can be licensed independently of Iray.

Features:

- MDL 1.2
- DB view on available definitions
- DAG view on materials, several compilation modes
- MDL editing features
- Backends for compilation of texturing functions
  - PTX
  - LLVM IR
  - GLSL

Contact us for details on availability and licensing



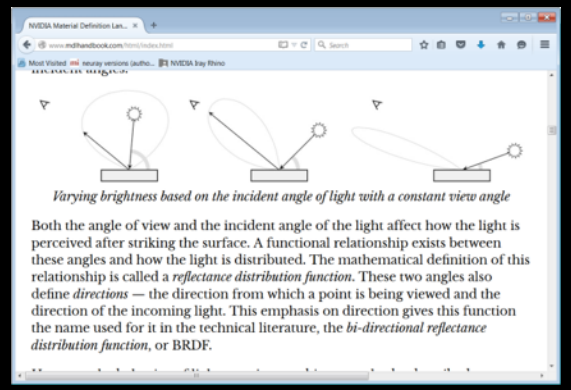
…and enjoy MDL content

Learn to write your own materials

MDL Handbook

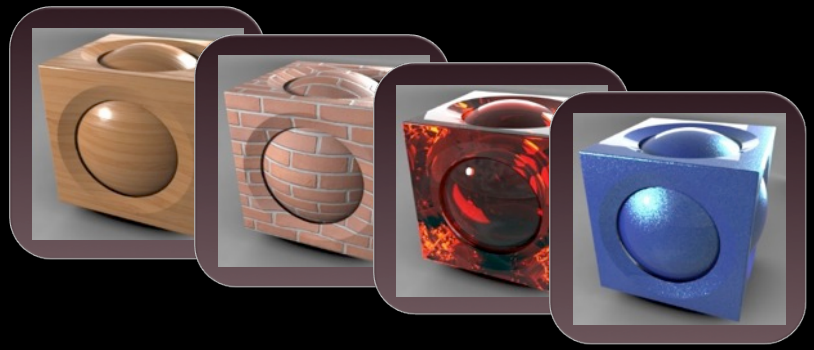
http://www.mdlhandbook.com/

30+ new pages since GTC 2015



Varying brightness based on the incident angle of light with a constant view angle

Both the angle of view and the incident angle of the light affect how the light is perceived after striking the surface. A functional relationship exists between these angles and how the light is distributed. The mathematical definition of this relationship is called a *reflectance distribution function*. These two angles also define *directions* — the direction from which a point is being viewed and the direction of the incoming light. This emphasis on direction gives this function the name used for it in the technical literature, the *bi-directional reflectance distribution function*, or BRDF.



Use content already available

Load MDL content from other applications

NVIDIA vMaterials

Library of initially 100+, verified materials

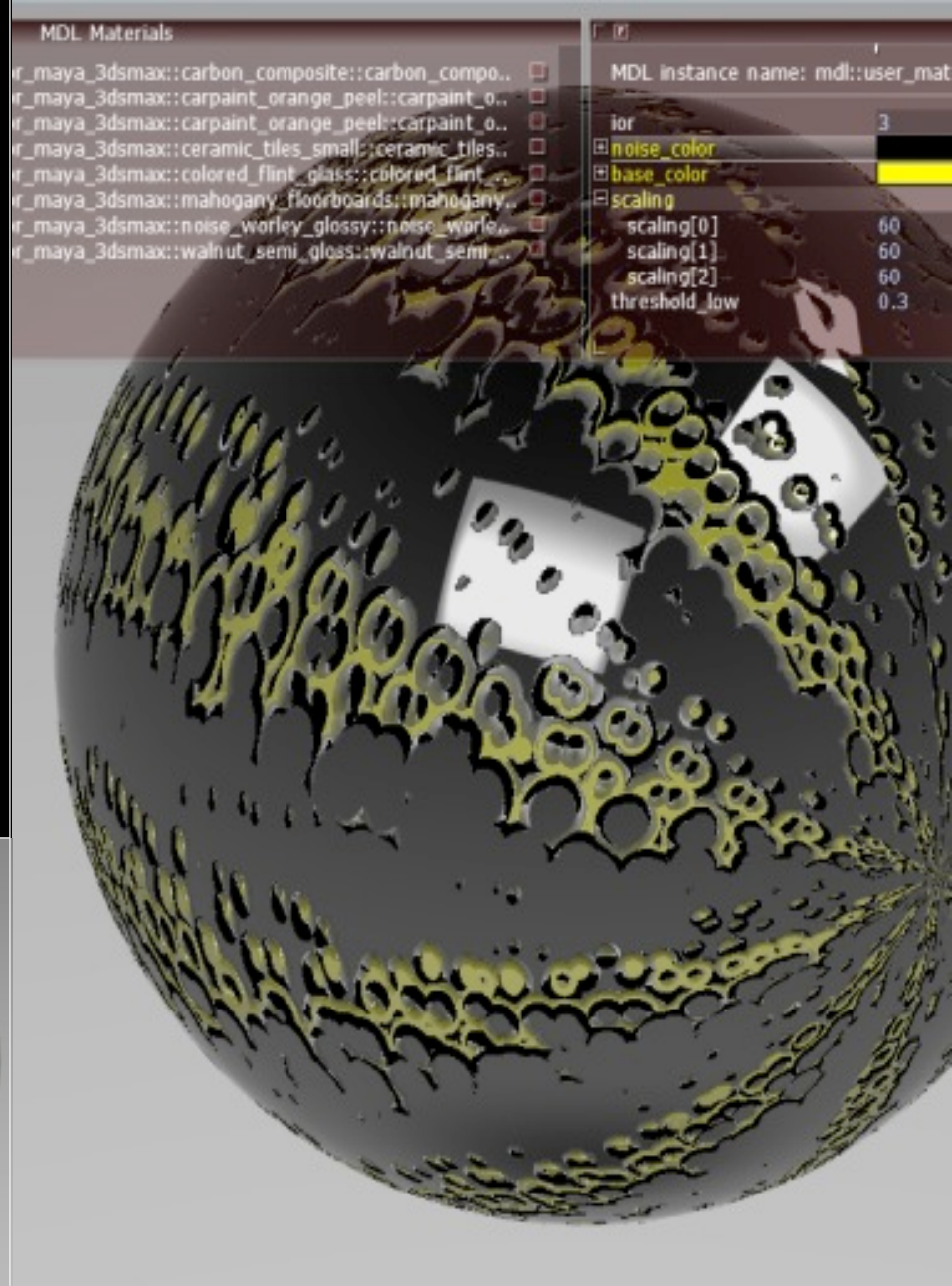
MDL in a Viewport

Interpretation <-> JIT compilation

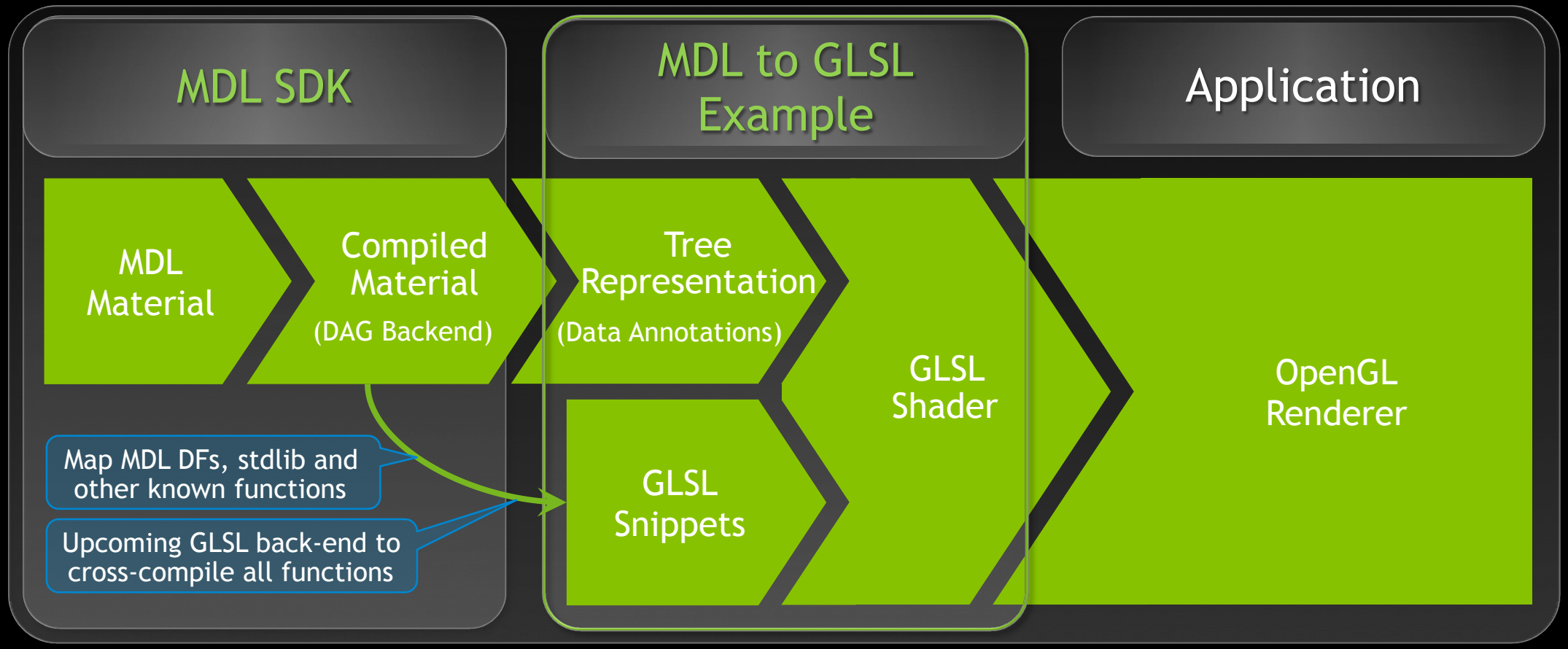
1. Ubershader in Iray Photoreal

2. On demand shader generation, example code

Cross-compilation of MDL functions to GLSL coming in MDL SDK



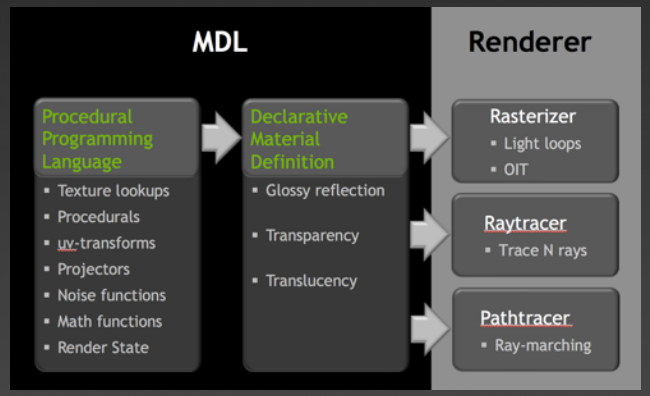
MDL to GLSL Example Code



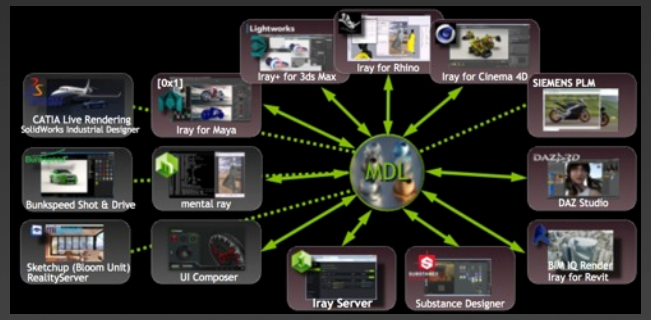
MDL

Takeaways

What is MDL



MDL Eco-system



Become part of the Eco-system

- MDL Specification
- MDL SDK
- MDL to GLSL Code Example
- MDL Conformance Test Suite

More Information

www.nvidia-arc.com ➔ Iray ➔ MDL

Demos and Talks at NVIDIA booth on the show floor