Rendering Revolution

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Agenda

- Rendering 101
- Rendering: GPU and CPU
- Rendering Revolution Examples

RENDERING 101

Rendering 101: Image-space vs. Ray-tracing rendering

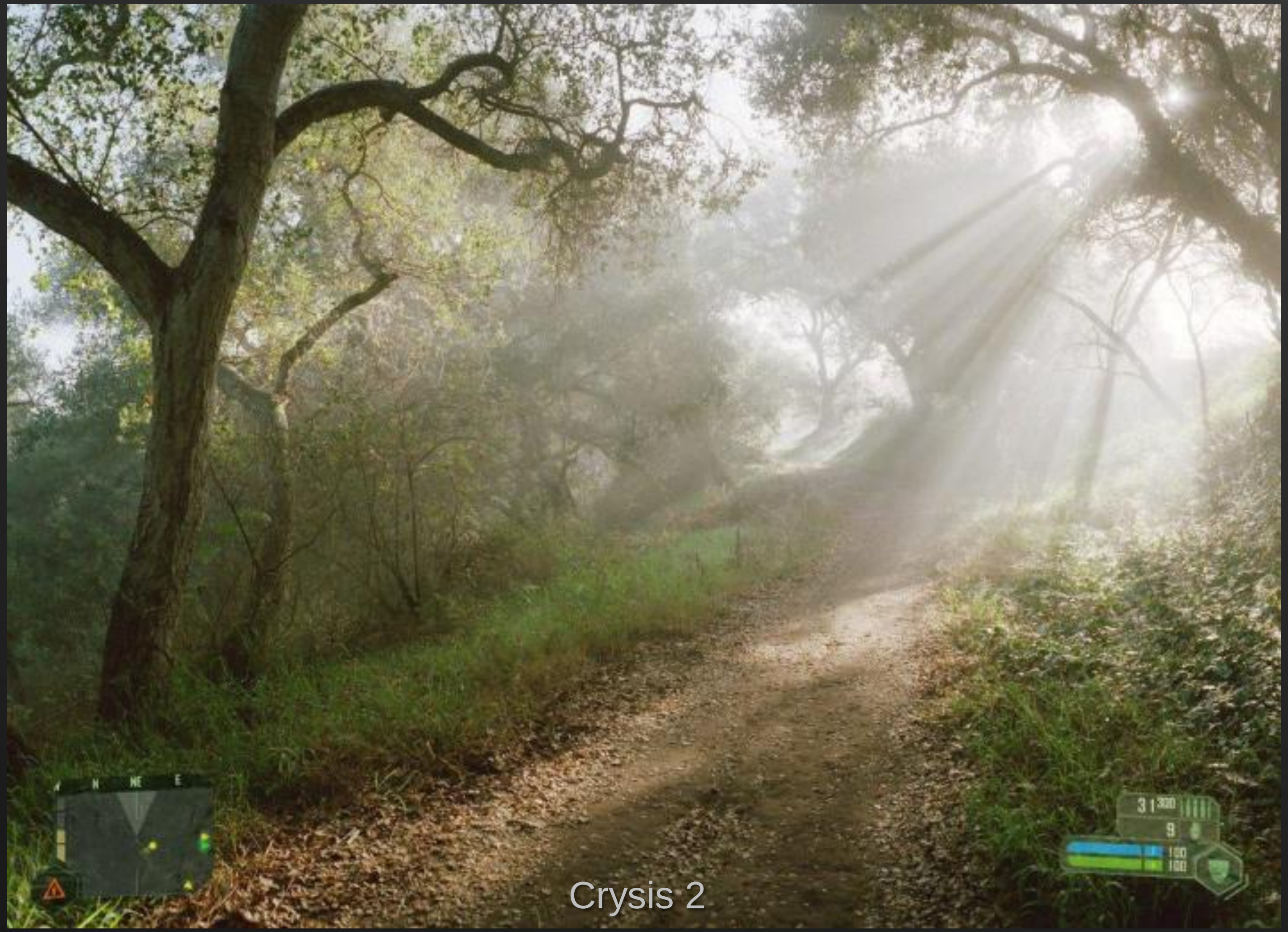
- Image-space
  1. Project polygons onto an image plane
  2. “Shade” each “image space” point

- Ray-tracing
  1. Cast a ray from the virtual focal point through an image plane into space
  2. Discover what point the ray hits first
  3. “Shade” that point
  4. Send more rays if required


Ilion Studios


Alex Roman

Rendering 101: Image-space Algorithms



Z-buffer: doesn't mean it can't be realistic

- Z-Buffer
  - GPU brute force method (OpenGL and DirectX)
  - Paint polygons to image plane pixels, keep point with closest depth value, shade that point
- Scan-line
  - More sophisticated approach dealing with "spans" for the hidden-surface computation
  - Used for "final-frame" rendering
  - Similar approach to shading as Z-Buffer
- A-Buffer
  - Similar to Z-Buffer, but uses micro polygons for a more accurate "final-frame" rendering
  - Typically used for feature film animation (Pixar Renderman)

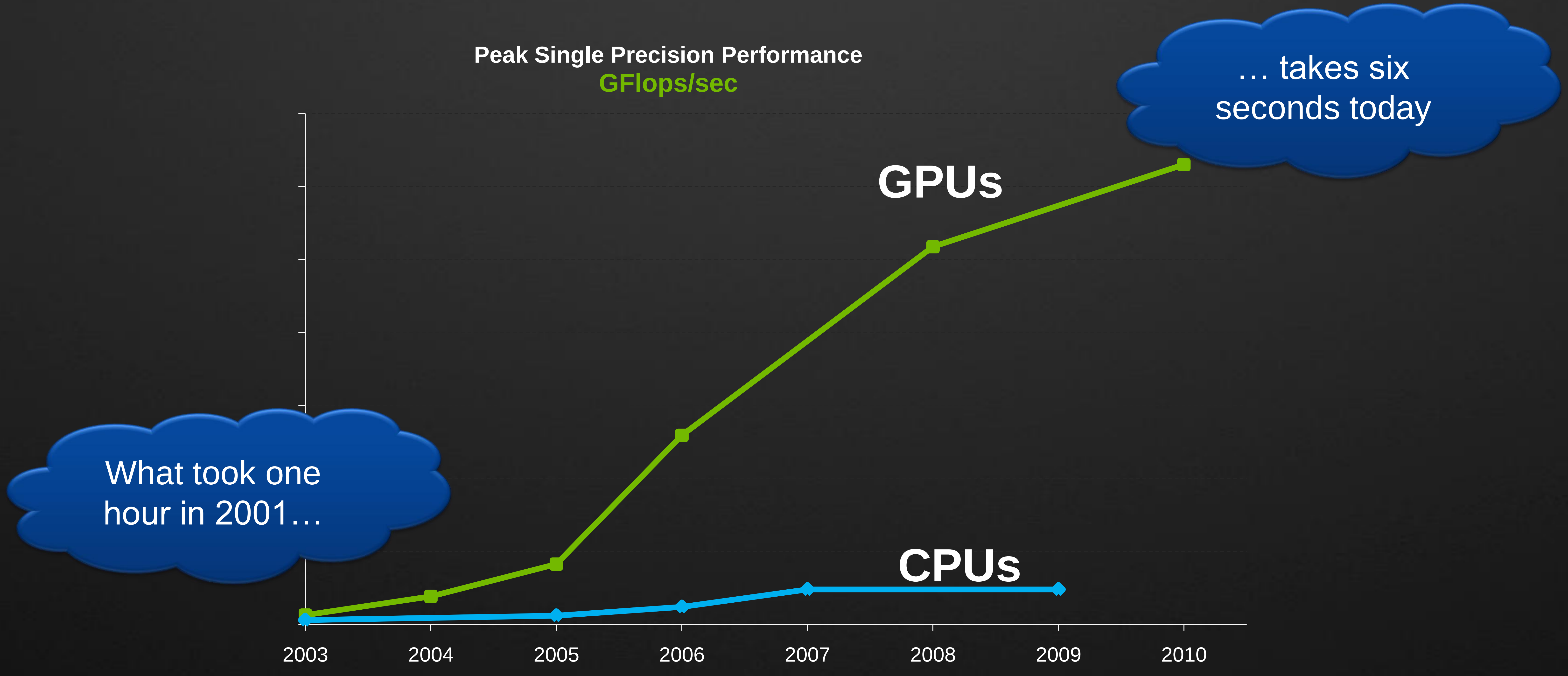
Rendering 101: Ray-tracing Shading Algorithms

- *Note: The use of ray-tracing for shading is the defining characteristic, not the use of ray-tracing to find the first intersection point*

- Ray-traced shading
  - Forward algorithms: from eye then into the environment, until a light source is encountered
  - Backward algorithms: from light sources into the environment until they reach the eye
  - Combined algorithms: trace rays in both directions find out where they meet
- Biased Algorithms
  - Approximate full global illumination through interpolation (examples: final gather, photon mapping, caustic mapping)
  - Final accuracy is limited by the approximations and interpolations used
- Unbiased Algorithms
  - Compute full global illumination to any desired accuracy
  - Use path tracing to explore the environment on a per-sample basis

RENDERING TECH: GPU AND CPU

Exponential Change in GPUs



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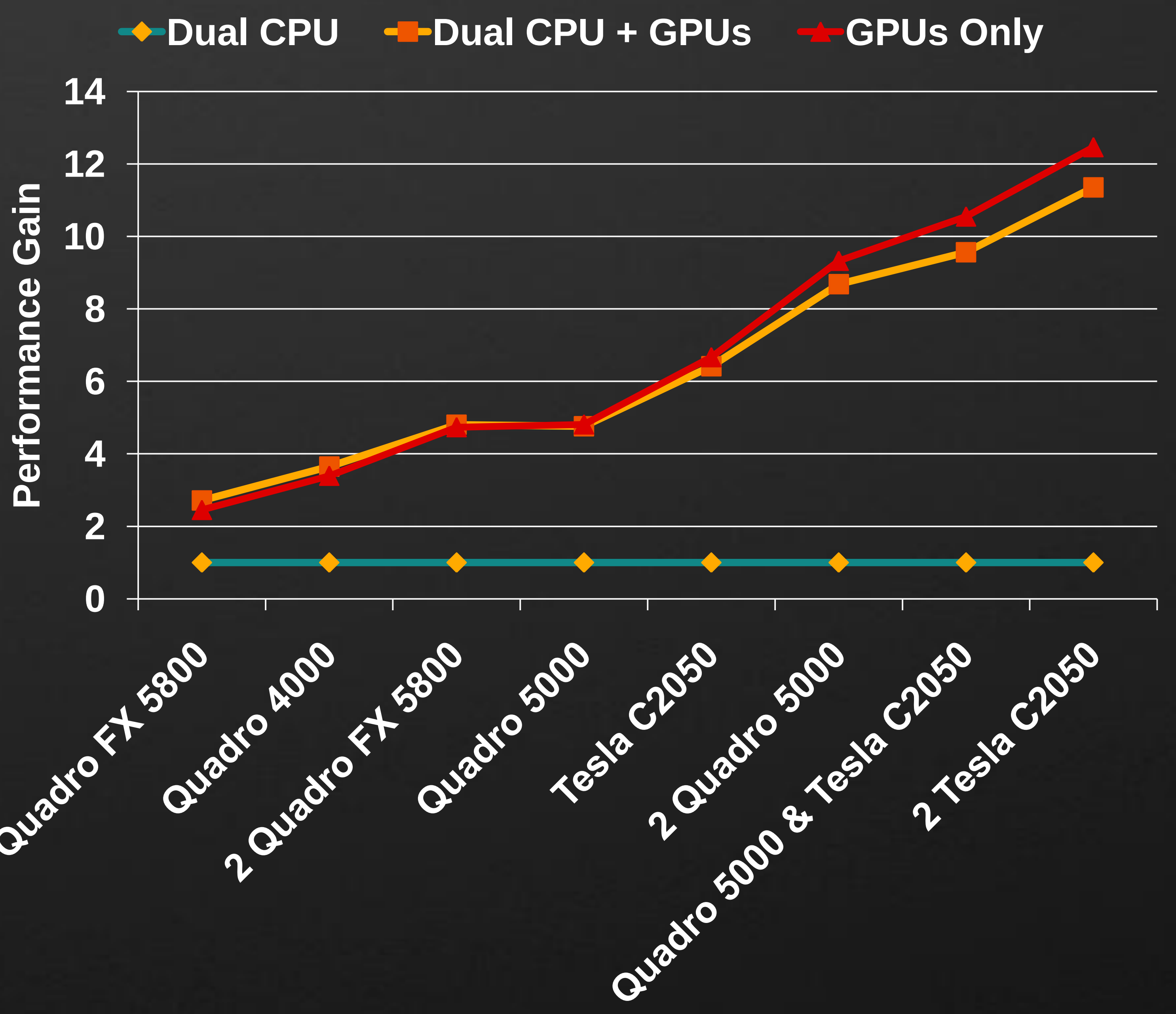
Taking advantage of GPUs for photorealism

- GPU Characteristics
  - Lots of raw floating point computation – if you can utilize it!
  - Minimize memory bandwidth and divergence
  - Very large number of simple processors, do the same thing in a highly parallel manner
  - Limit staged computation
  - For efficiency, must keep 100,000 threads active

- Effect on rendering algorithm choices
  - Favors unbiased algorithms – no approximation, more computation = more samples, no interpolation or pre-computation
  - Simple, versus complex, path tracers
  - Get the sampling theory right
  - Make sure it scales across multiple GPUs and CPUs
  - Do not load/unload scene data from the GPU memory, entire scene (geometry + texture maps) must fit

Results: how iray leverages the GPU

- Scales well across threads and GPUs
- Mixed computation (GPUs and CPUs)
- Images converge to a photorealistic solution with full global illumination - excellent shadow detail, no light bleeding
- No interpolation artifacts in the resulting images
- No user-specified, scene-specific rendering parameters required
- Rapid preview of global illumination results



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RENDERING EXAMPLES

User concerns: easier

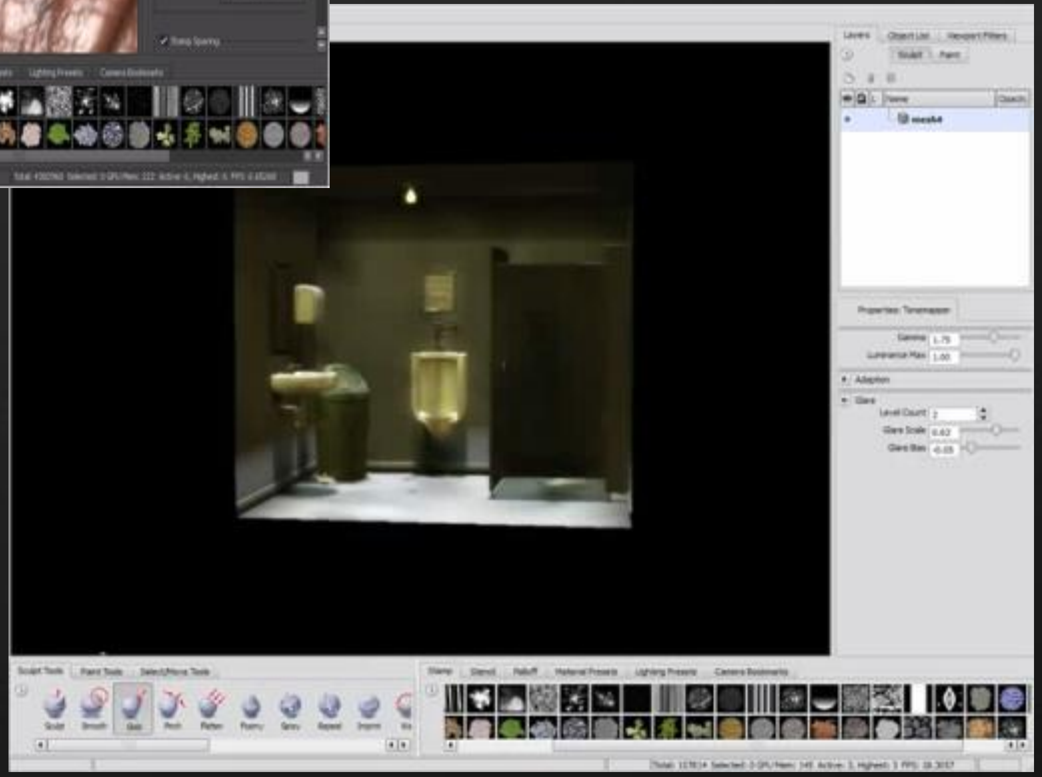
- Reducing setup complexity
- Physically accurate results
- Predictability
- Workflow integration
- What You See is What You Render (WYSWYR)

User concerns: faster

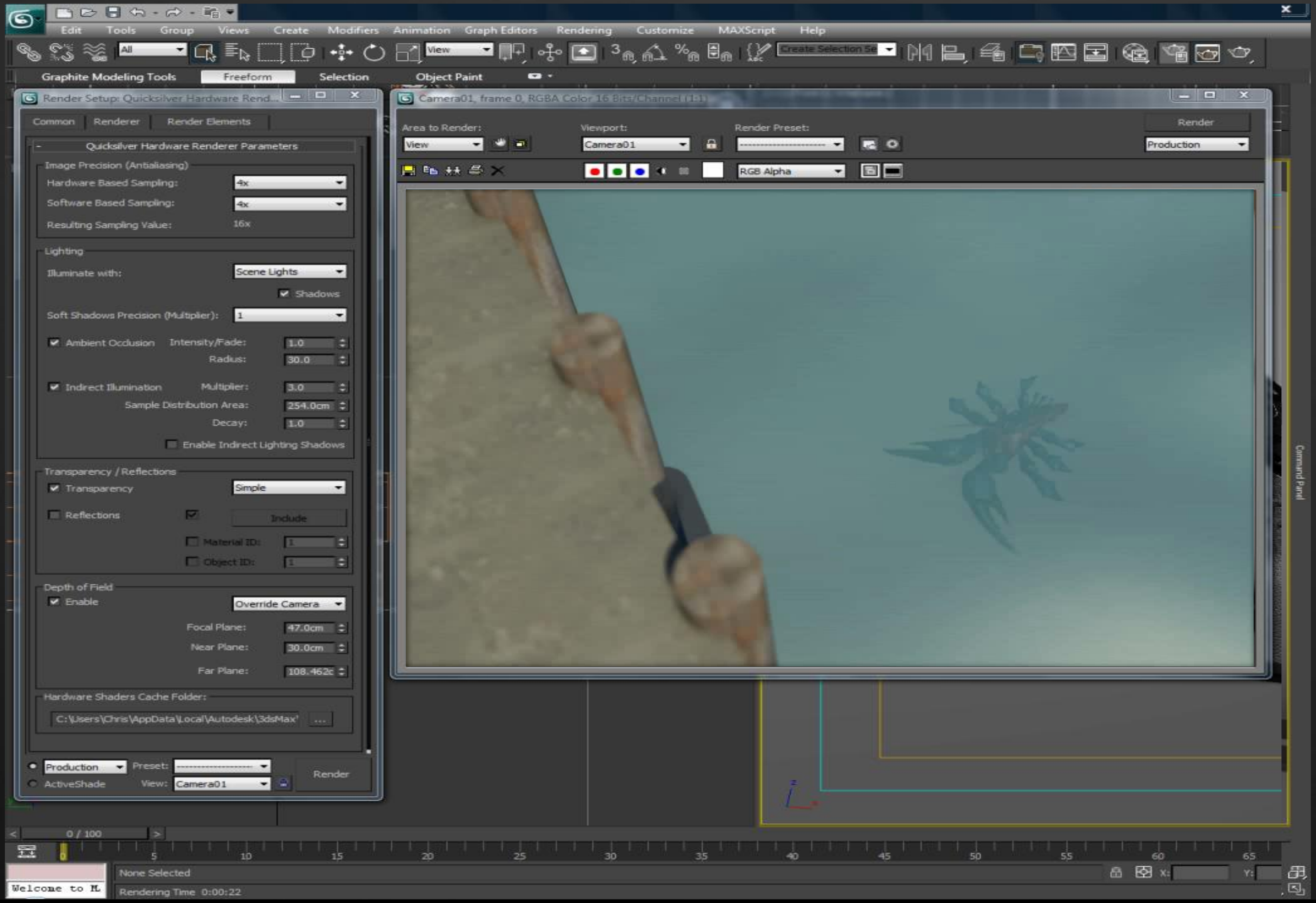
- Leveraging game engine technology (DirectX, OpenGL)
- Leveraging GPU resources (CUDA, OpenCL)
- Leveraging the GPU to accelerate other problems
  - Cloth (PhysX)
  - Particles (PhysX example)
- Leveraging the cloud (“unlimited” resources)

Example: Autodesk Mudbox (OpenGL)

- GPU drives interactive visual fidelity
  - Dense meshes (50M triangles)
  - Large textures (4K resolution)
  - Bump, specular and vector displacement maps
  - Screen-space ambient occlusion (SSAO)
  - Depth of Field (DOF)
- Painting textures (affected polygons render into the texture)
- Compositing paint layers with different blend modes
- Calculating the 3d coordinate, face index, vertex index of the point under the cursor
- Real time posing of high resolution meshes - all vertex displacements are applied using the GPU



Example: 3ds Max *Quicksilver* (DirectX)



- GPU used for Z-buffer rendering acceleration
- Between 3X and 50X faster than SW ray-tracing
- MetaSL: same shader in viewport as rendering
- Depth Of Field shader
- SSAO
- HW and SW anti-aliasing
- Indirect lighting support
- Limited render elements
- Object-level reflections
- Does not do ray tracing

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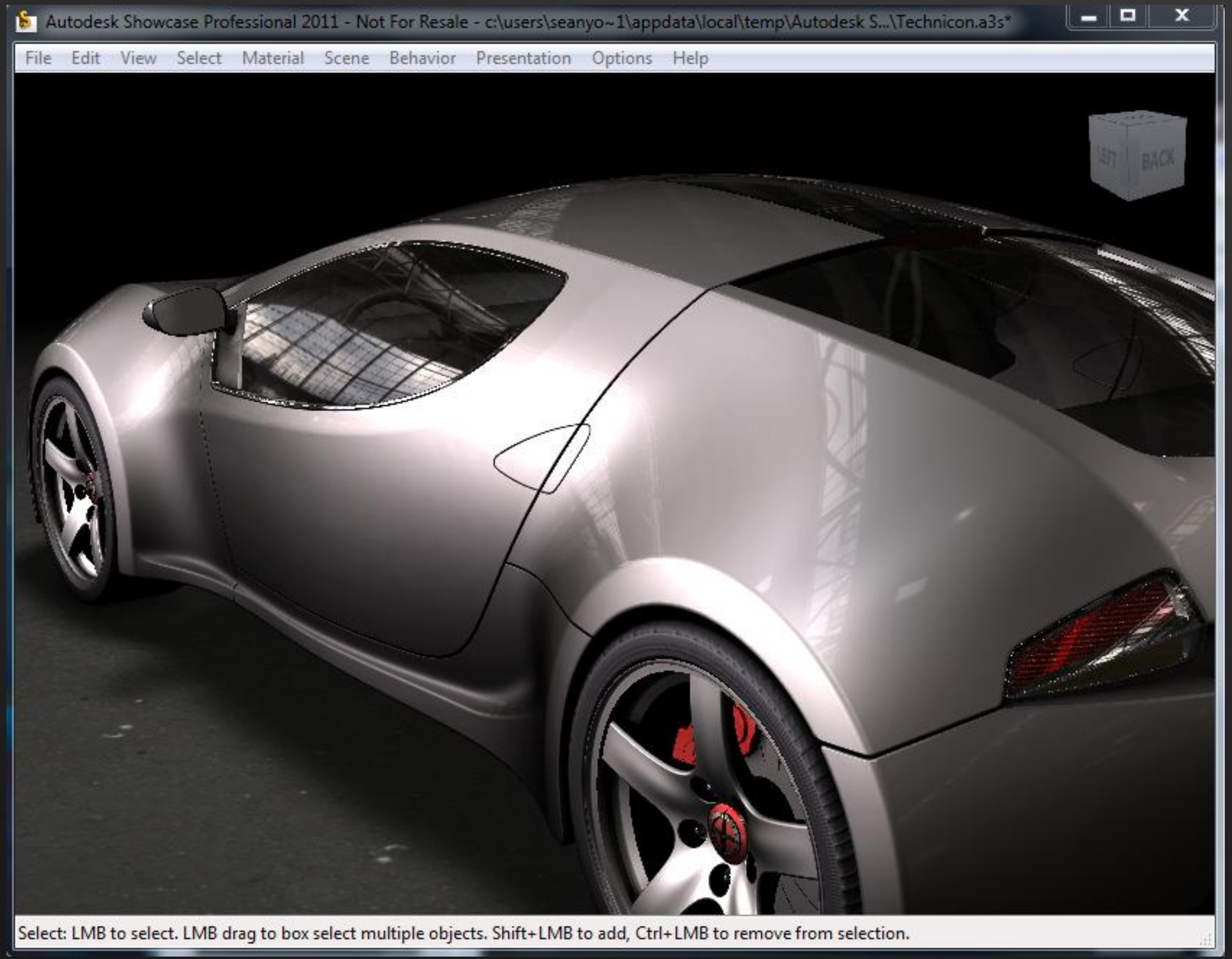
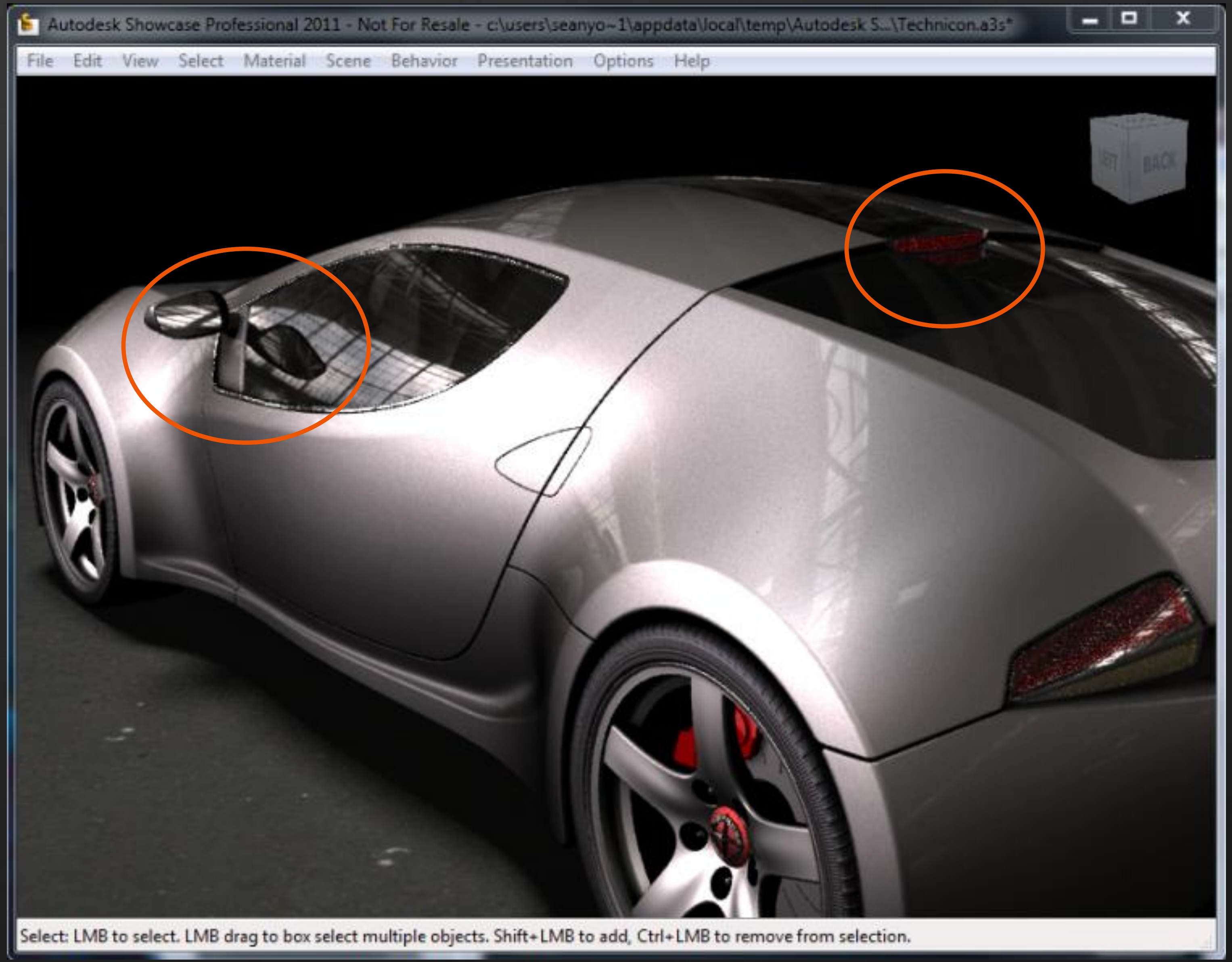
WYSWYR: Autodesk Showcase

- GPU drives interactive visual fidelity
  - Bump maps
  - Screen-space ambient occlusion (SSAO)
- Image-based lighting (IBL)
- Environment mapping
- Integration with CPU ray-tracing

WYSWYR: Autodesk Showcase



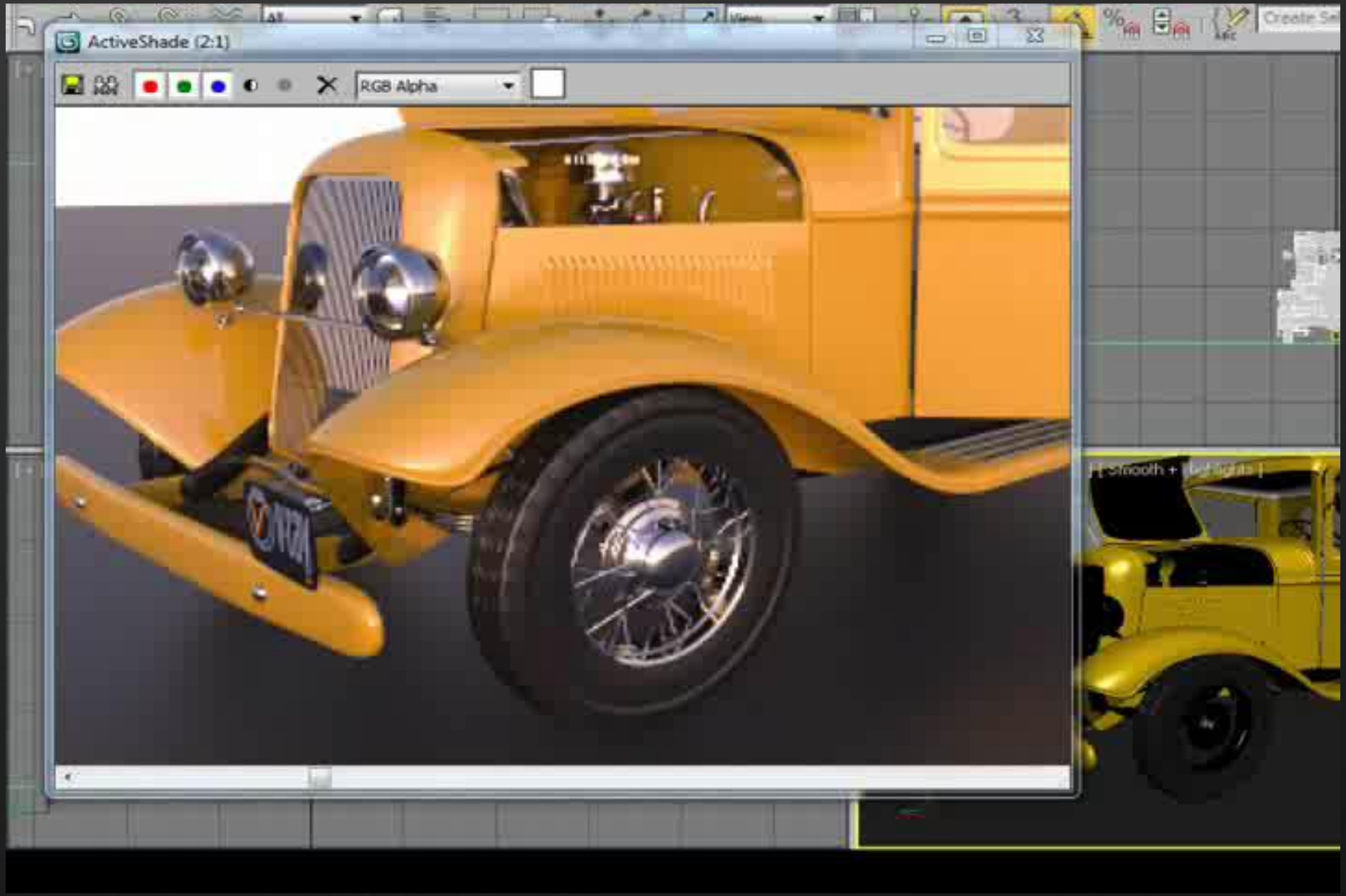
GPU: Real-time, 30fps



CPU: Ray tracing

Chaos Group: V-rayRT GPU

- Integrated inside 3ds Max and Maya
- ActiveShade in 3ds Max and IPR renderer in Maya
- GPU support is written in OpenCL
- Pure raytracer
- Geometry - currently only triangle meshes
- Shading
  - Physically based shaders (VRayMtl)
    - Glossy reflections/refractions
  - Bitmap textures
  - Bump mapping
  - Opacity mapping
- Camera:
  - Support for Depth Of Field (DOF) with bokeh effects
  - Vignetting
  - Vertical shift
- V-Ray-specific lights
  - Area lights (sphere, rectangle, mesh light)
  - Dome light, supports efficient Image Based Lighting (IBL)
  - IES lights with web profiles
  - VRaySun and VRaySky
- Point lights – omni and spot lights
- Directional lights
- Global illumination through path tracing



mental images: iray rendering in Autodesk 3ds Max

- A new Production Renderer for 3ds Max
  - *Available to subscription customers only*

- Unbiased path-tracer with many advanced features
  - Guaranteed to converge to full global illumination solution without approximations (no interpolation)
  - No rendering settings: "point-and-shoot"
  - Patented QMC sampling
    - Faster convergence than random sampling
    - No sampling artifacts between animation frames
    - Quick early progressive preview of final frame appearance
  - Importance sampling for faster convergence in complex lighting situations

- Ideal for visualization
  - Architectural studies (interiors and exteriors)
  - Automotive/Transport
  - Consumer Product Design

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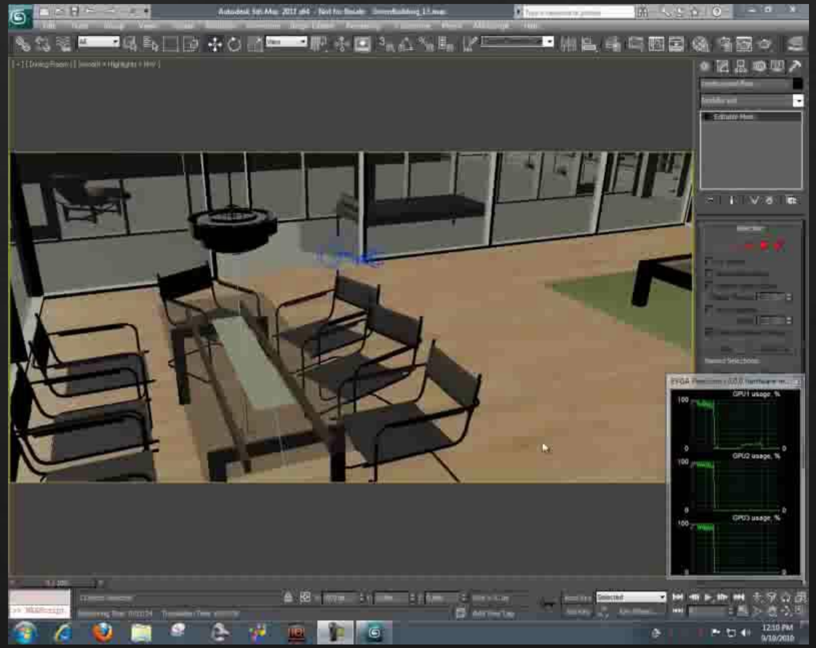
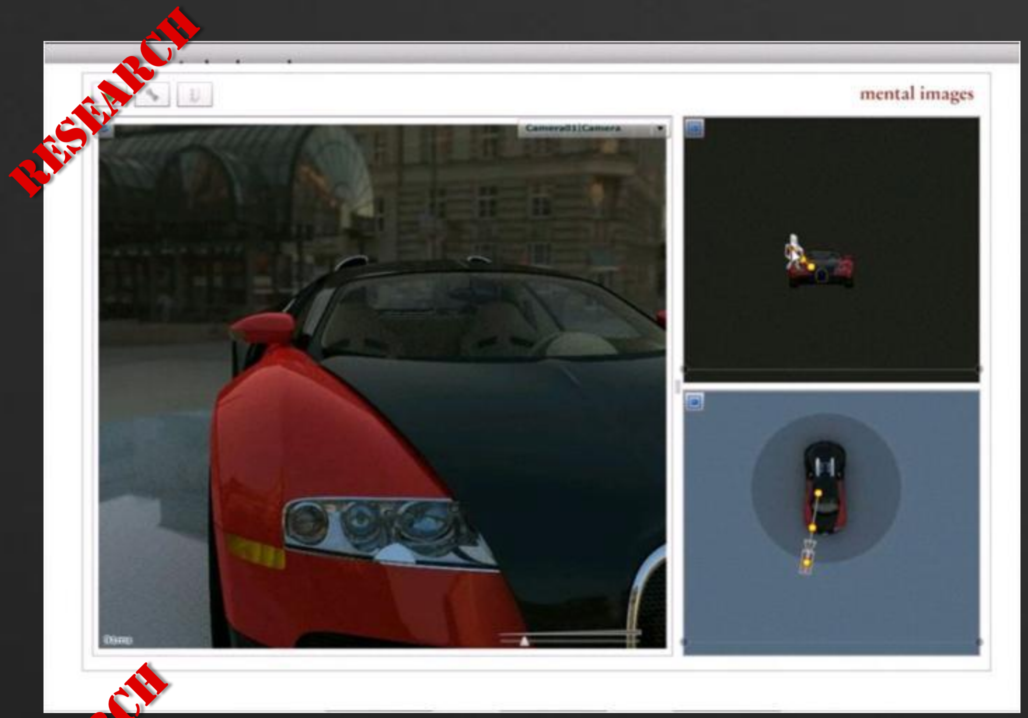
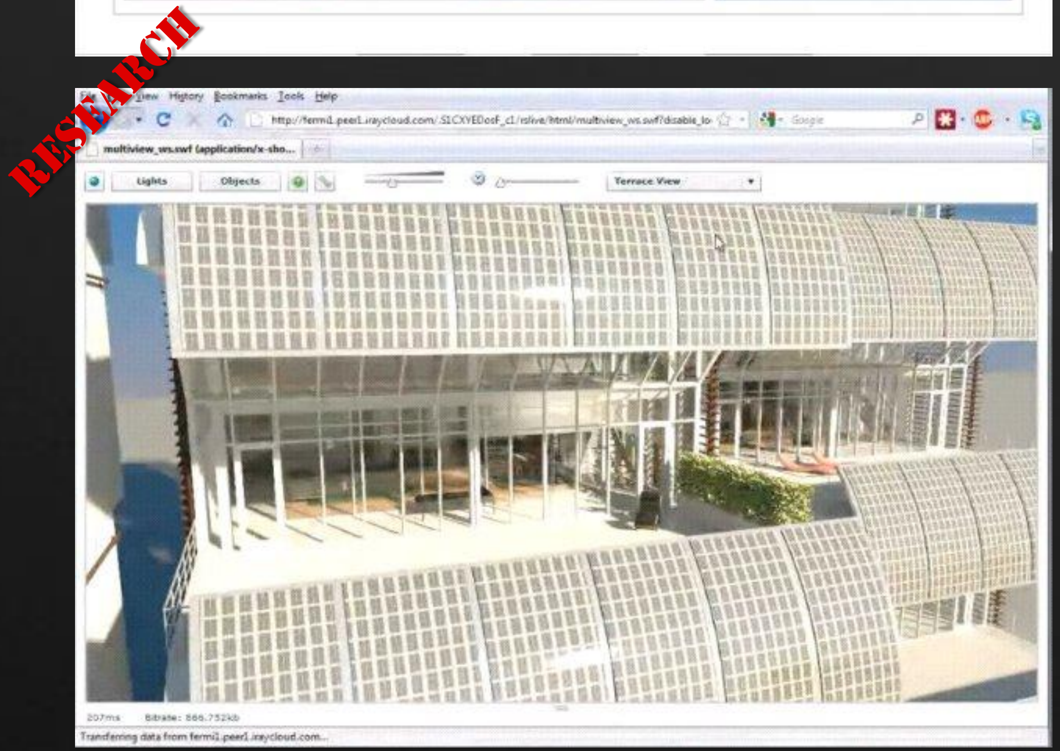
iray supports 3ds Max standard scene elements

- Materials support: matched to what ships with 3ds Max:
- Lights: supports standard & advanced lights
  - Photometric, IES profile, Area, Point, Spot, Directional lights
  - HDR environment maps, domes, Sun/Sky model
  - Emissive surfaces (additional color)
- Map Support:
  - Bump maps
  - Diffuse, specular, transparency, refraction, reflection, anisotropy, etc.
  - Map blends, 2D noise, 3d noise
- Geometry: all 3ds Max geometry, including displacement geometry
- Cameras: full 3ds Max camera support
  - Depth of field is “free”
- Standard Max exposure controls, etc.



Tech demo: iray and 3ds Max in the "cloud"





- ***Not** part of 3ds Max subscription offering*
- Mental image's iray is especially suited to cloud computing:
  - iray linearly scales across cloud hardware – interactive rendering becomes possible
  - No render settings means anyone can do it – collaborative workflows become possible
  - iray scenes published via 3ds Max predictably render on the cloud with iray

Note: Technology demonstration implemented on a 32 Fermi GPU cluster at PEER1 with RealityServer running iray, scenes exported directly from 3ds Max.

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Rendering Revolution

- Advancements in GPU computing power is changing the face of rendering
- Rendering is getting *easier* and *faster*
- A few companies involved in the rendering revolution:
  - Mental images: iray
  - Autodesk: Mudbox, Showcase, 3ds Max, Maya
  - Chaos Group: VrayRT GPU
  - StudioGPU: MachStudio Pro
  - Caustic Graphics: Brazil
  - Refractive Software, Octane Render
  - Bunkspeed (iray)

area.autodesk.com/renderingr