



Mastering Physically Based Shading in Unity 5

Renaldas Zioma / Unity

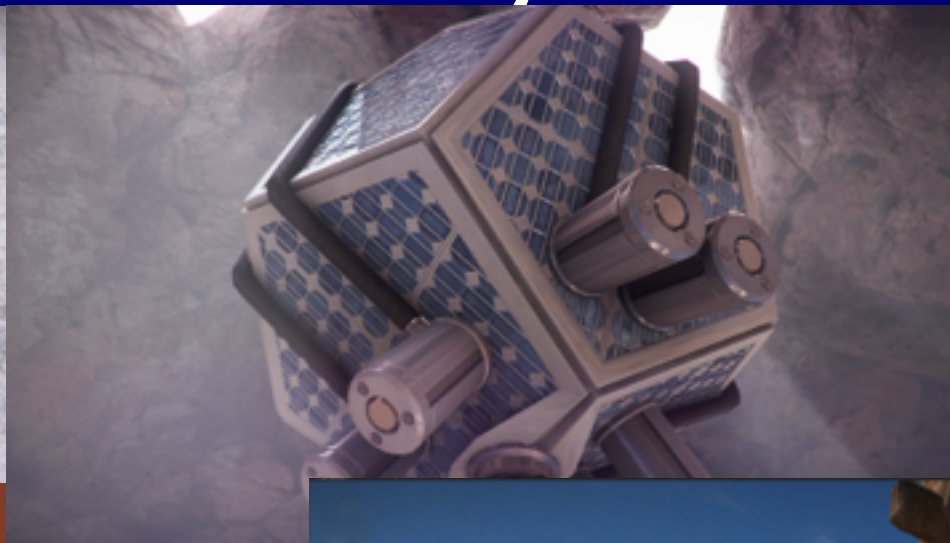
Erland Körner / Unity

Wes McDermott / Allegorithmic

@__ReJ__

Physically Based Shading in Unity 5

UNITE
2014



One shader



Our past



- Butterfly Effect demo
- Inspiration from Mental Images Architectural (MIA) shader
- Inspiration from Disney SIGGRAPH'12 talk
- Secret Aim: look identical /w Marmoset Toolbag 2

Natural Materials

- Metals
- Non-metals (Dielectrics)
 - monolithic materials: plastic, rock, water ...
 - cloth
 - organic

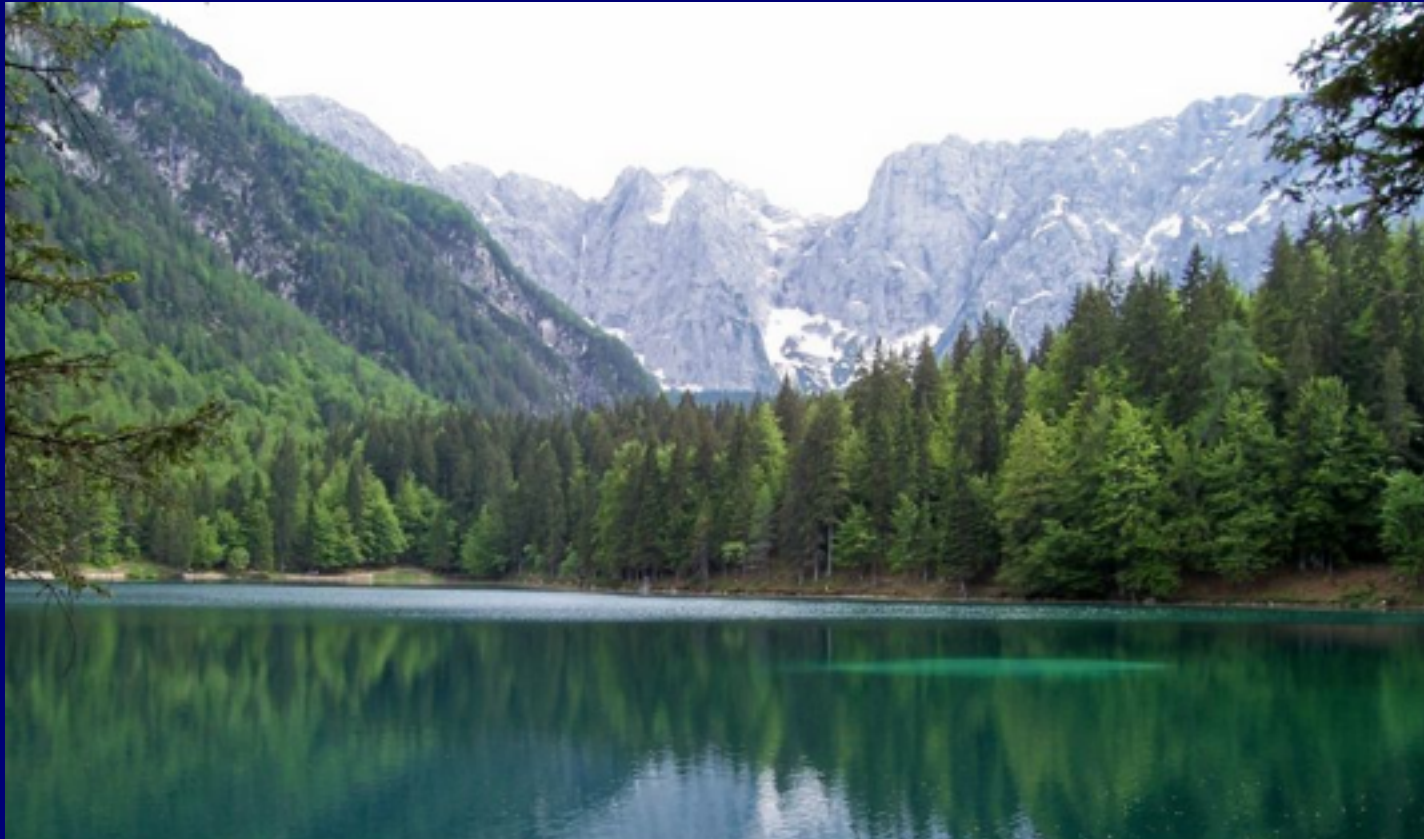


VS



Dielectrics

- Most objects in natural environments are **dielectrics**



Dielectrics

Distinguishing Traits

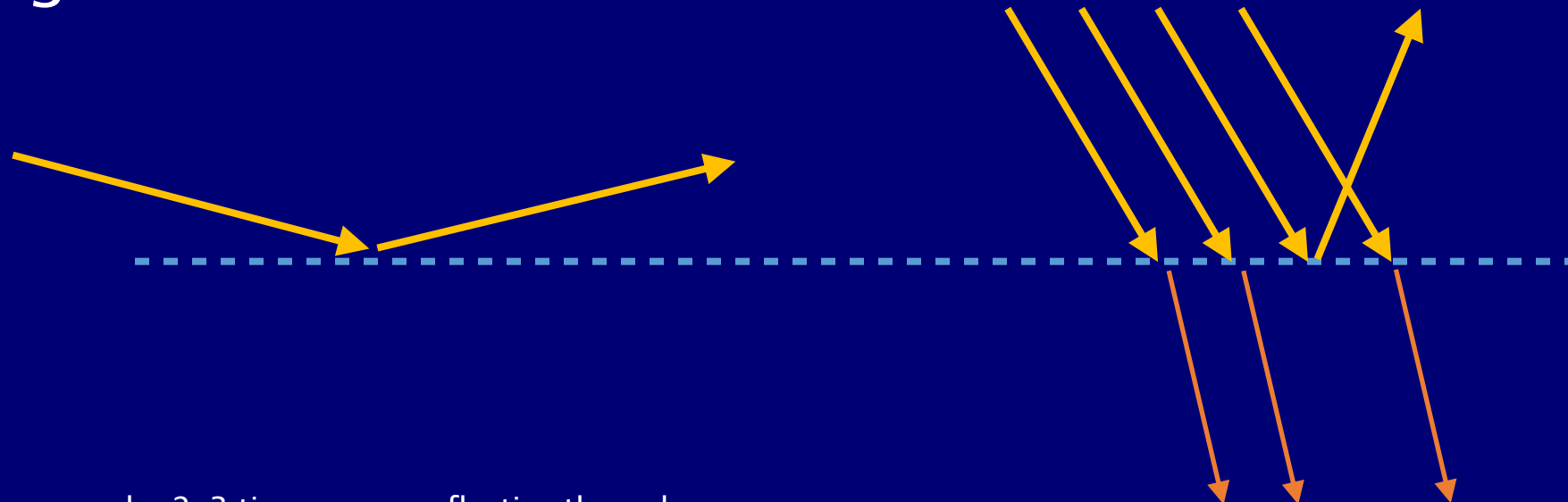
- Hard to see your own image in the reflection
- Much more reflective on the edge
 - Augustin **Fresnel** (1788–1827)



Dielectrics

All are almost the same

- Surface reflects almost* the same fraction of light for any dielectric
- Light penetrates the surface
 - on atomic level a lot of space for light photons to pass through
- Light is scattered under the surface

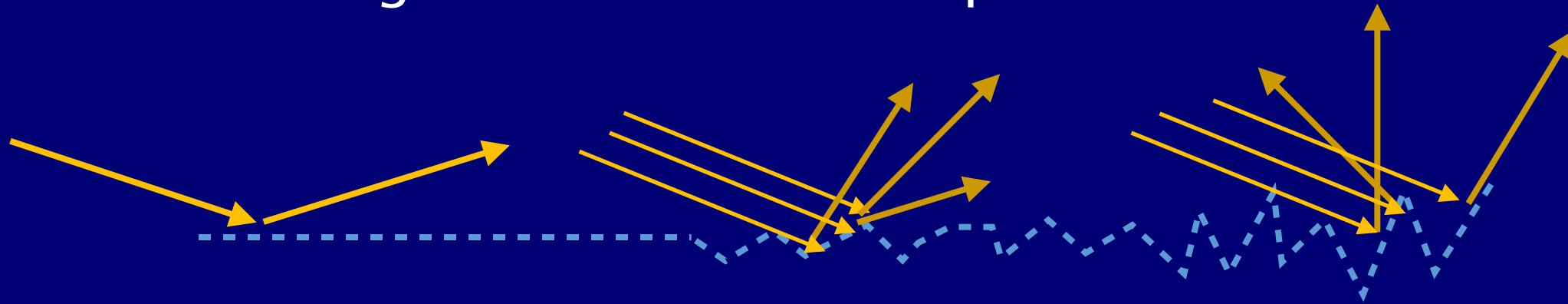


* though gems can be 2–3 times more reflective than glass

Dielectrics

Specular Reflection

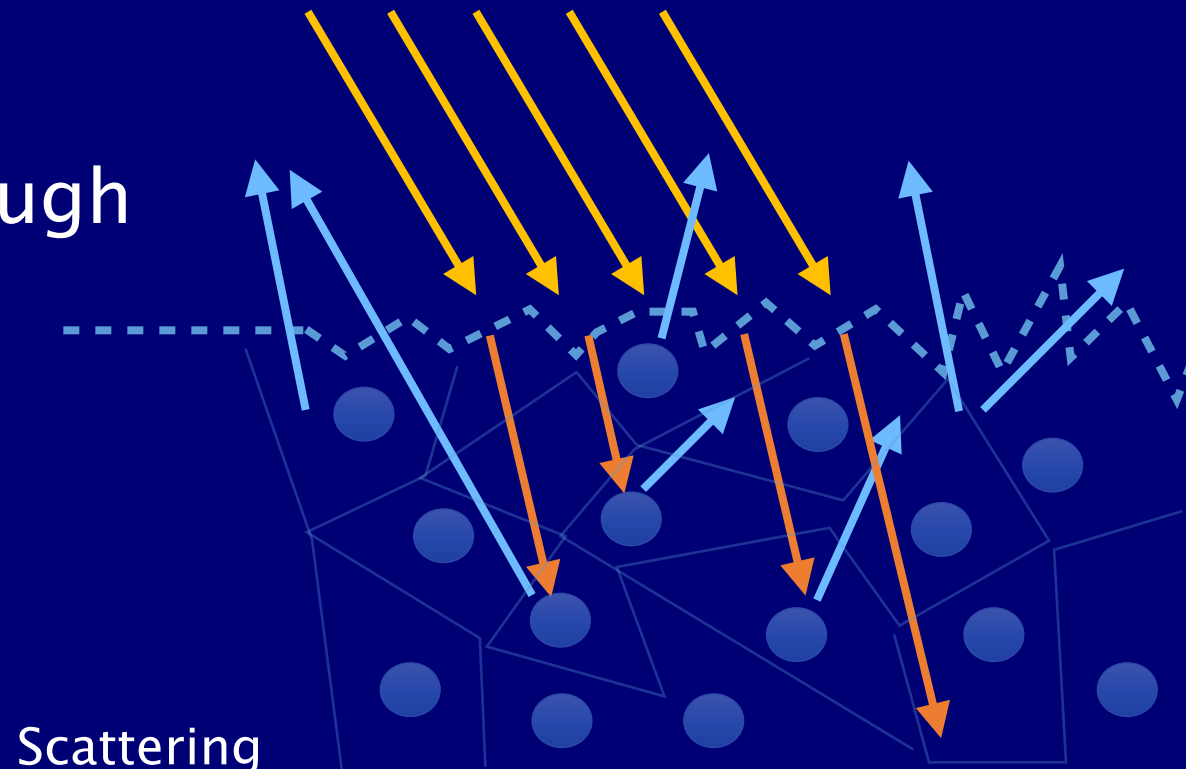
- Light bounces off the surface
 - NO color change!
- Surface irregularities will affect spread of the bounce



Dielectrics

Diffuse Reflection

- Subsurface scattering
- Crystallites, cells, fibers – will absorb and reflect light
 - different color
 - random directions
- Otherwise light just passes through
 - liquids, some plastics, gems



Dielectrics

Why then they look different?

- Surface micro-structure
 - rough vs smooth
- Diffuse reflection (absorption & scattering)
 - we perceive it as a **color** of material
- **Slight** variation in amount of light bounced in **specular reflection**
 - sometimes denoted as **F0**
 - governed by the **Index Of Refraction** of material
 - 2–4% (IOR 1.3 .. 1.8)
 - gems are outliers 7%–13% (IOR 1.2 .. 2.6)

Metals



Metals

Distinguishing Traits

- Very good mirrors (if smooth)
- Colored reflection
- Surface is impenetrable to light
 - can't be transparent *

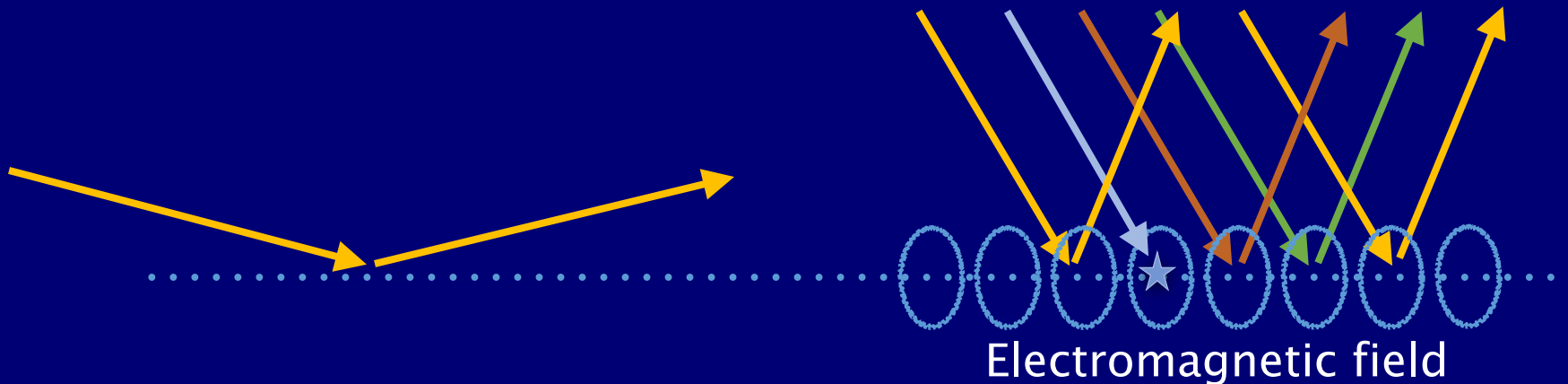


* well, actually some metals can be made into semi-transparent, if really really thin!

Metals

Specular Reflection

- Lots of **free** electrons!
 - light is bounced back
 - “prevent” light penetrating the surface
- Fraction of light is absorbed at the surface
 - color tinted reflection



Metals

What makes different looking metals

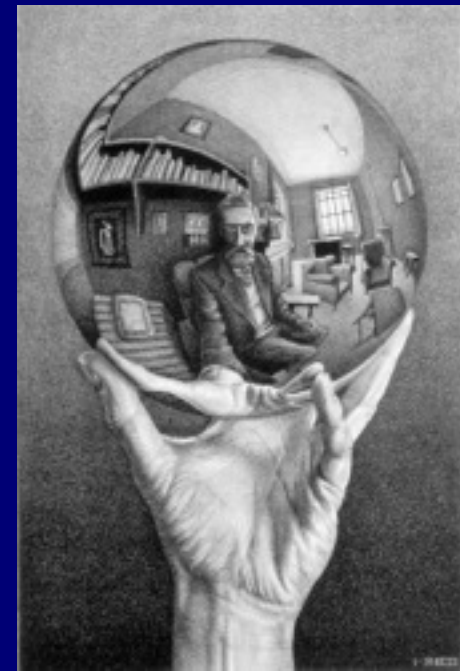
- Color of **specular reflection**
 - we perceive it as a **color** of metal
- Surface micro-structure
 - rough vs polished



Half-correct summary*

- Metals
 - No diffuse
 - Very strong specular
 - Colored specular (reddish, yellowish)
- Non-metals
 - Strong Fresnel
 - Very weak specular at normal incidence
 - Monochromatic specular
 - Colored diffuse (any color)

* works only for pure materials



Materials are rarely pure or ideal

UNITE
2014



Materials are rarely pure or ideal

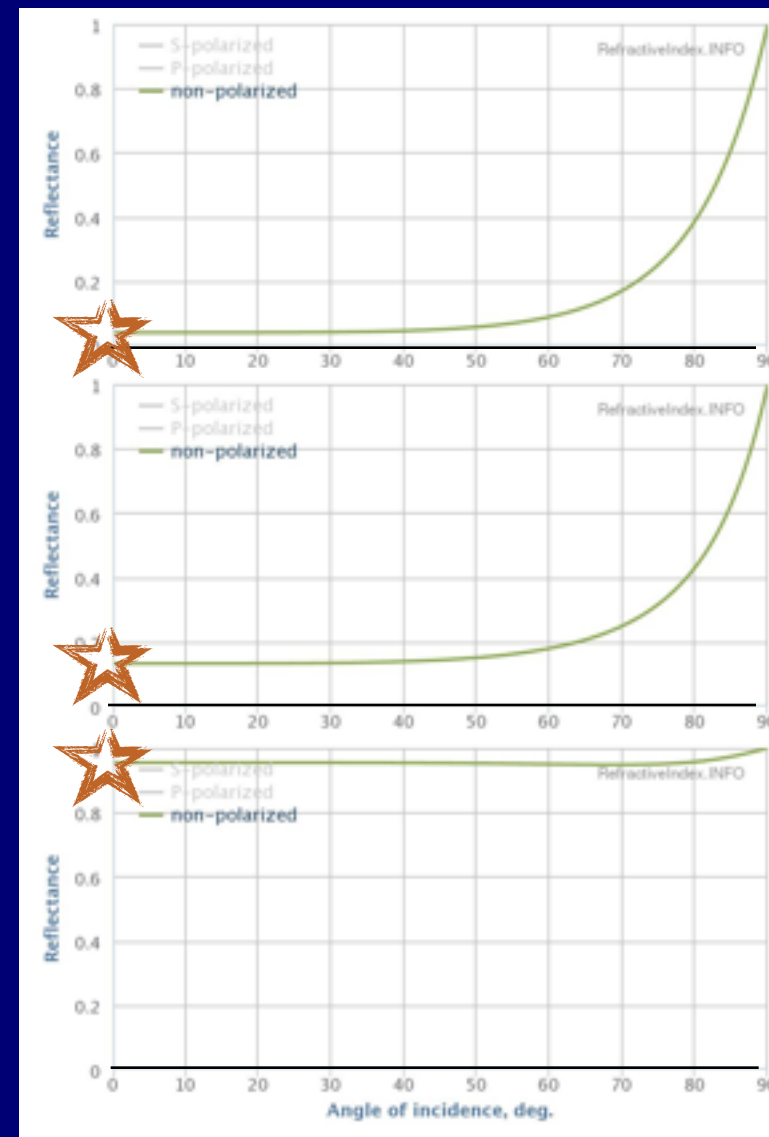
- Metals
 - ~~No diffuse~~ – rust, oxidization, mix /w other materials ...
- Non-metals
 - ~~Strong Fresnel~~ – not for rough surfaces
 - ~~Very weak specular at normal incidence~~
 - ~~Monochromatic specular~~
 - Multilayer materials can have stronger tinted specular
 - dielectric mirrors, cloths like tarpaulin, vegetation ...

Materials are rarely pure or ideal

- That is why we pick Diffuse+Specular workflow
 - but there are definite upsides in the Metallic workflow too!
- btw, some call this workflow:
 - Albedo+Reflectivity
 - Specular+Gloss

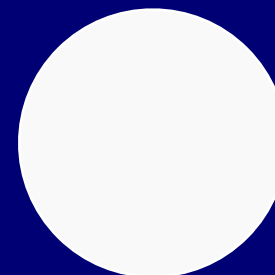
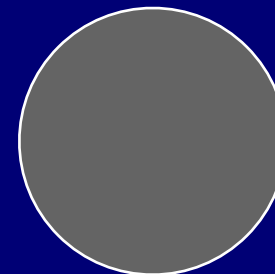
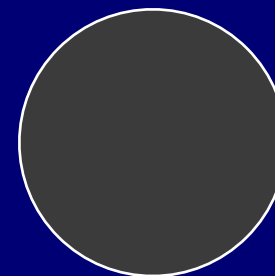
So what is this Specular, again?

- Controls **reflectivity** at **normal incidence**
- Plastic (IOR 1.5)
 - 4%
- Some Crystal (IOR 2.1)
 - 13%
- Aluminium
 - 95%



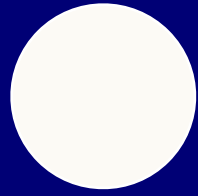
So what is this Specular, again?

- Plastic (IOR 1.5)
 - 4% in **Linear**
 - (59, 59, 59) in **sRGB**
- Some Crystal (IOR 2.1)
 - 13%
 - (100, 100, 100) in **sRGB**
- Silver
 - 95%
 - (249, 249, 249) in **sRGB**

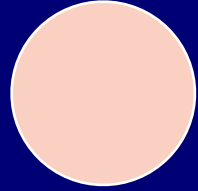


So what is this Specular, again?

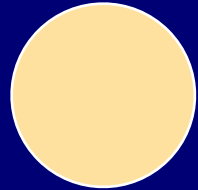
- Silver



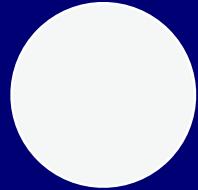
- Copper



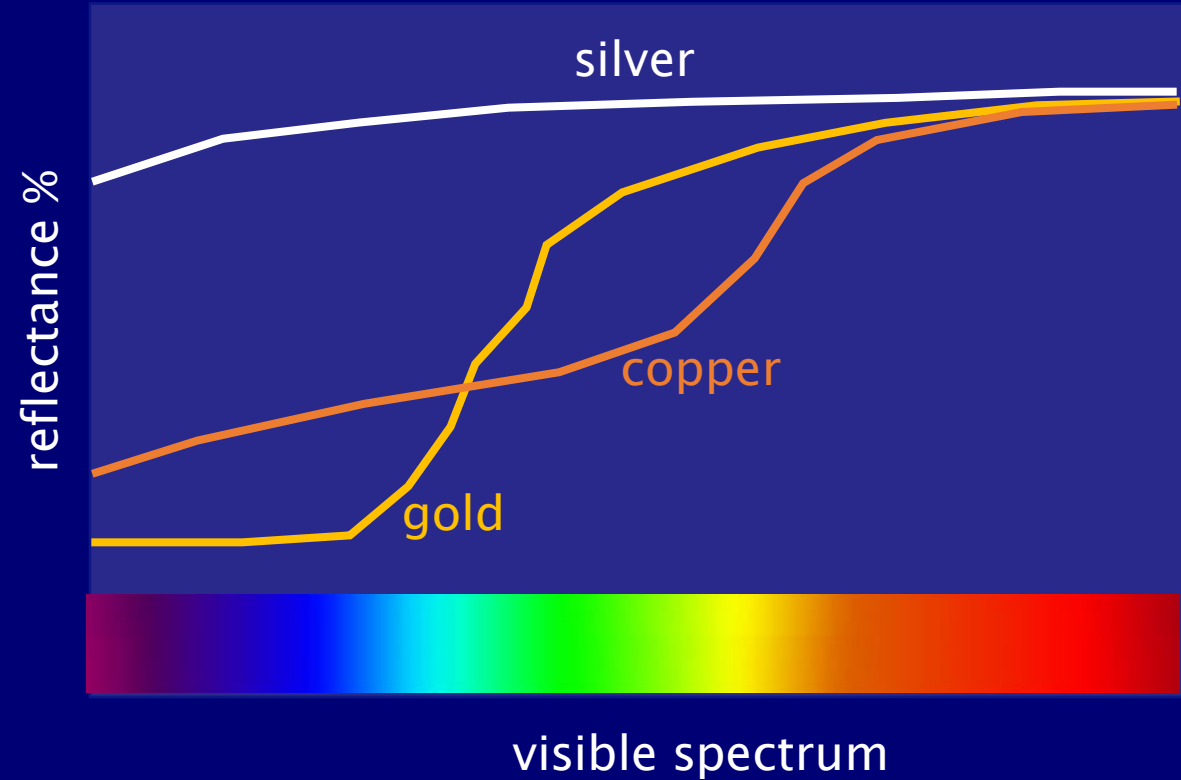
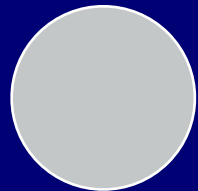
- Gold



- Aluminum



- Iron



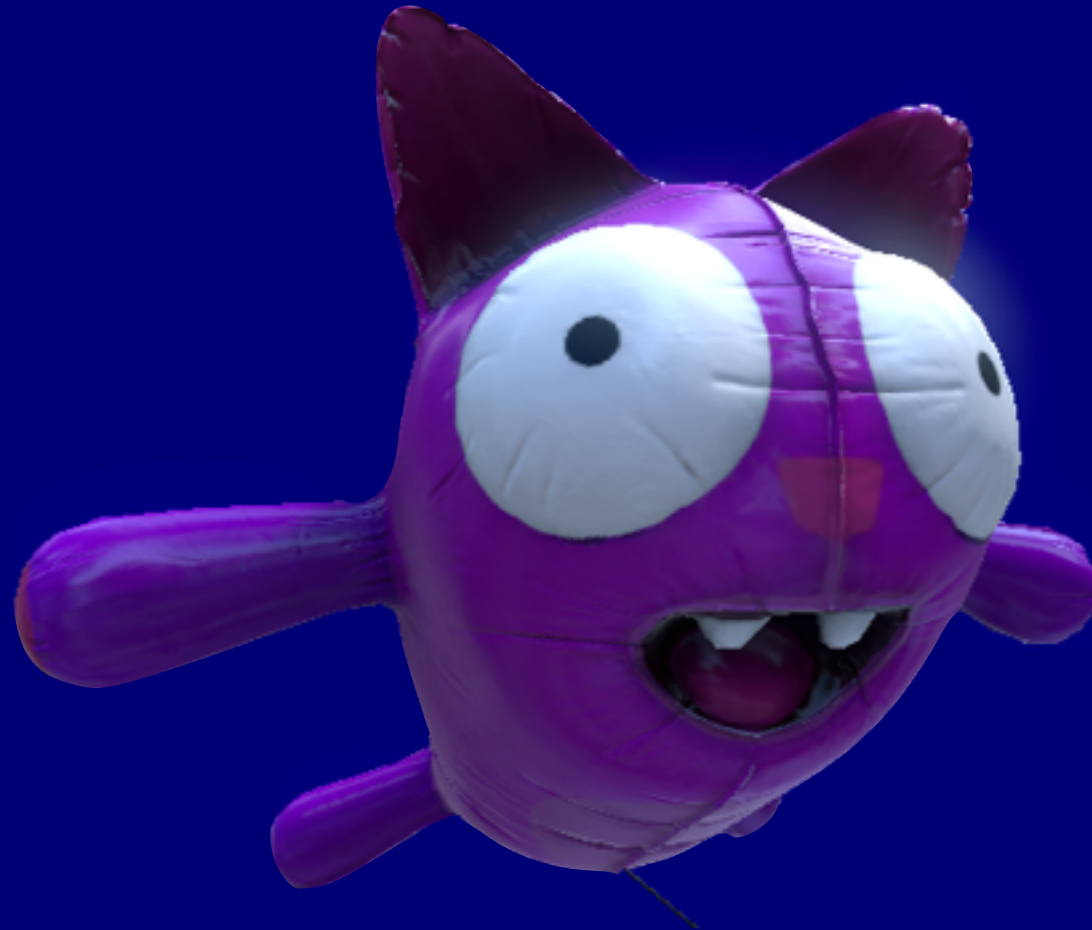
Smoothness

- Controls **Fresnel** – reflectivity at **grazing** angle
- Controls **blurriness** of reflection
- Very rough surfaces
 - Disney diffuse
 - cloth



Standard shader break down

UNITE
2014



Direct Light

UNITE
2014



Diffuse reflection



Indirect Light

UNITE
2014



+ Indirect Light * A0



+ Fresnel



Metallic Reflections



(or) Dielectric Reflections



Reflections /w Smoothness



Reflections * Specular



+ Reflections * Specular * AO



= Final result



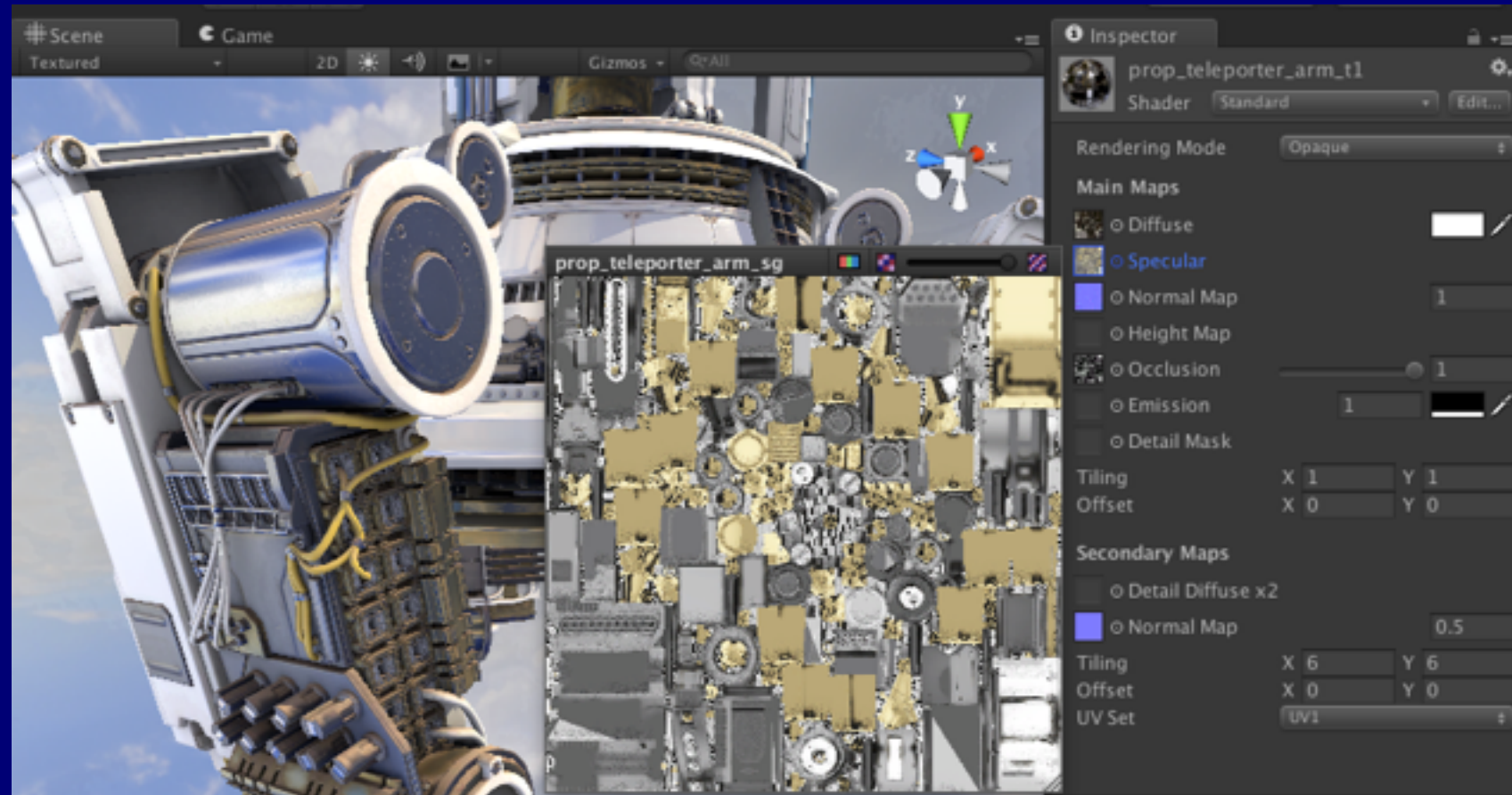
What are the benefits!?

- Accurate, realistic material representation
- Consistent and predictable workflow and artwork
- For everyday materials
- ...but also stylised look



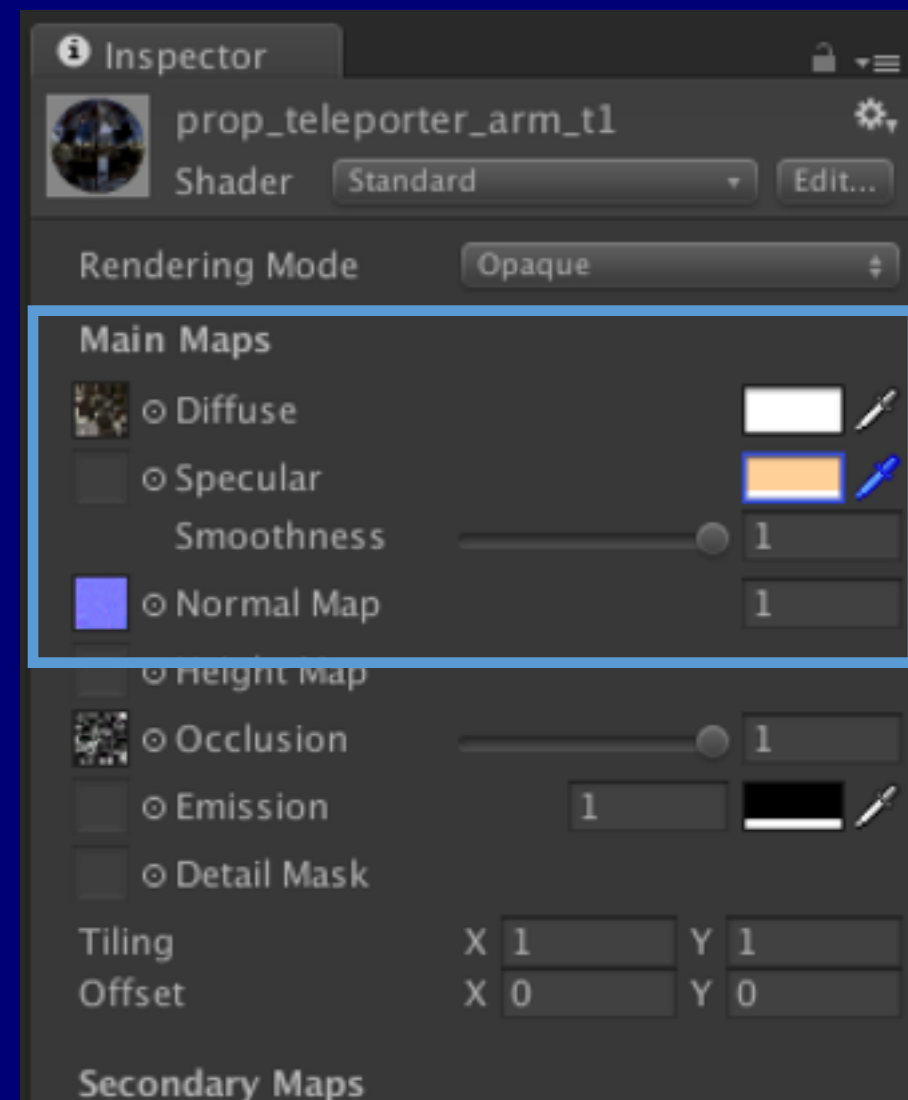
The Standard shader

- Compact
- Folds
- Thumbnails
 - Expandable



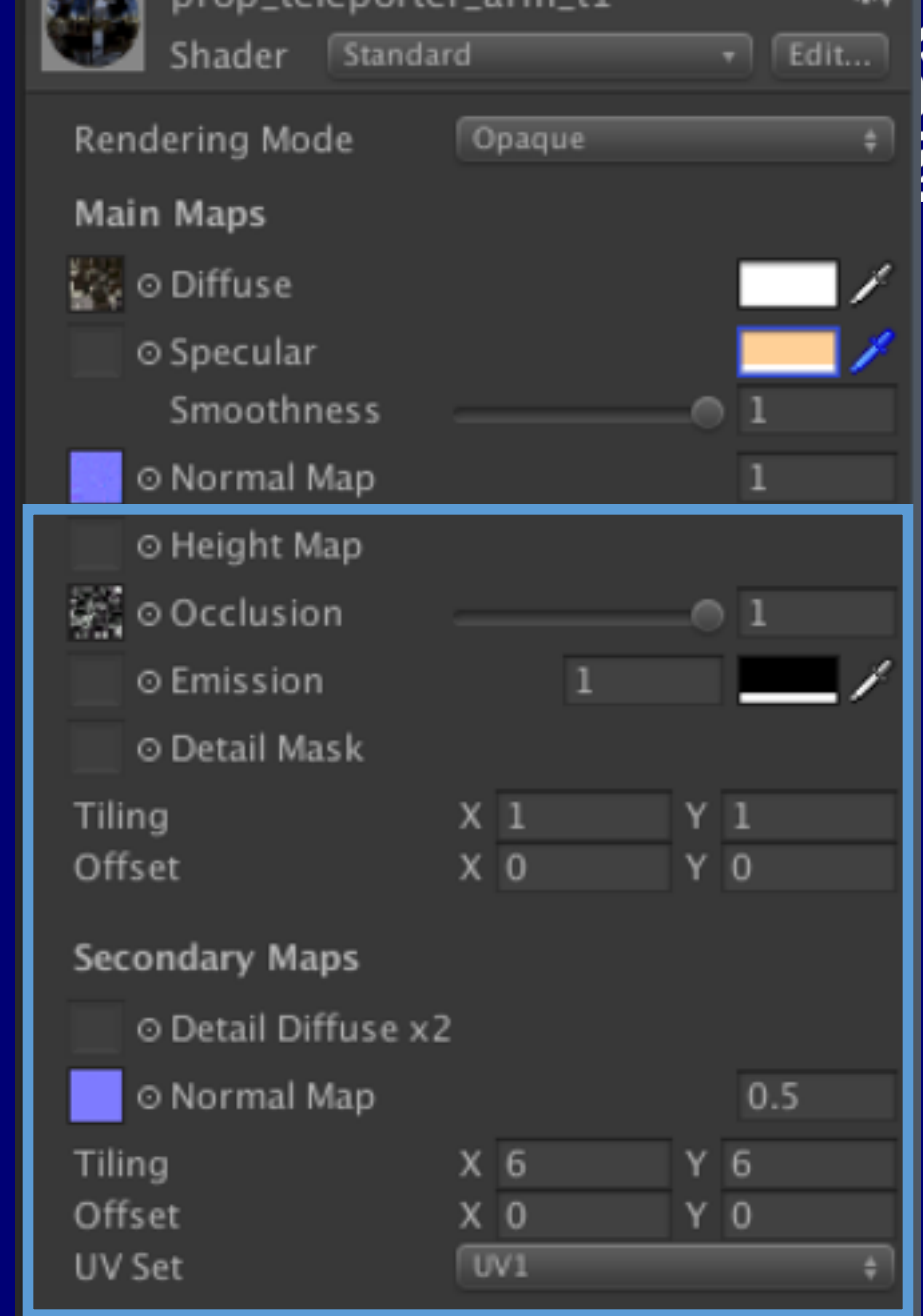
Standard shader – Primary inputs

- Diffuse [RGB]
- Specular [RGB]
 - defines material type
- Smoothness [greyscale A]
 - character of the surface
- Normal Map [Tangent Space]



Additionally...

- Occlusion [greyscale]
- Height map – Parallax [greyscale]
- Emission – HDR range [RGB]
- UV set selection
- Detail maps (overlay)
 - Diffuse and Normal maps
 - Blended with Mask texture
- Opaque, Cut-out, Transparent



Detail overlay

UNITE
2014



UV set selection and Masking



Normalmap overlay



Emission

UNITE
2014



Lighting in 5.0

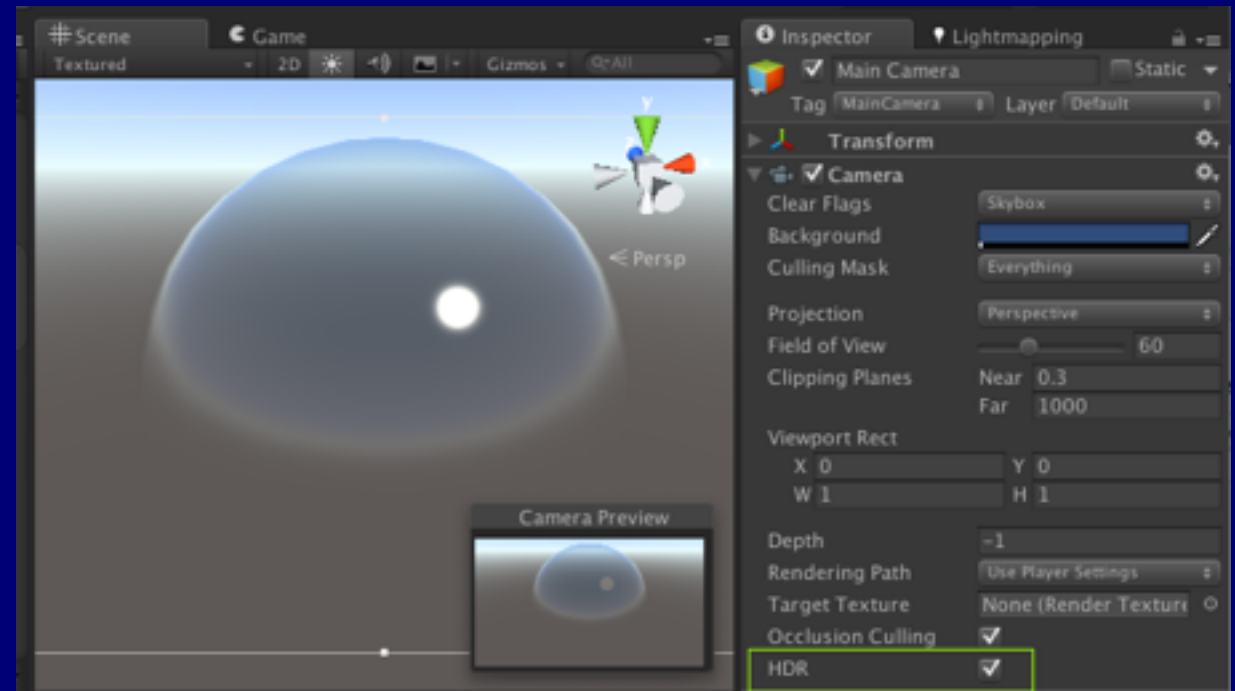
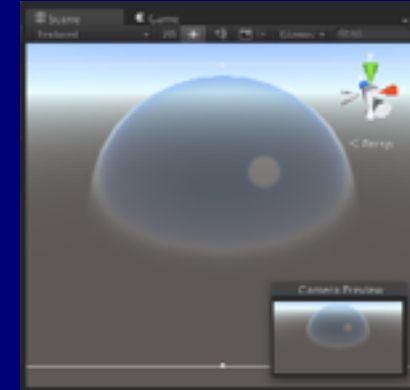
- Lights
- Environment
 - ambient probe
 - light probes
 - default reflection
 - reflection probes
- Lightmaps
- HDR IBL

	Global	Localized
Diffuse	Ambient Probe	Light Probes
Specular	Default Reflection	Reflection Probes



Environment lighting

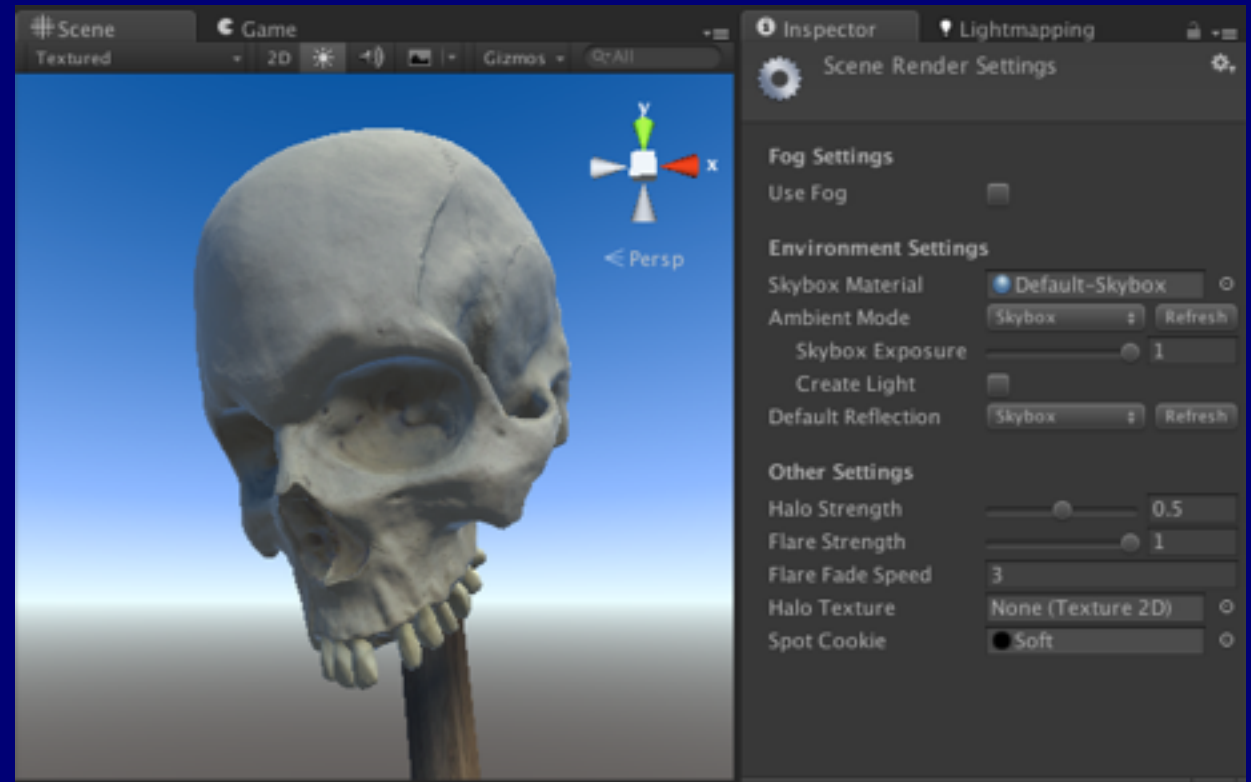
- Ties materials into environment
- Lights must match surrounding
- Exposure
 - HDR on Main camera
 - ...in scene view
 - ...tone mapping too



Light Setups

Default, Simple, Out-of-the-Box

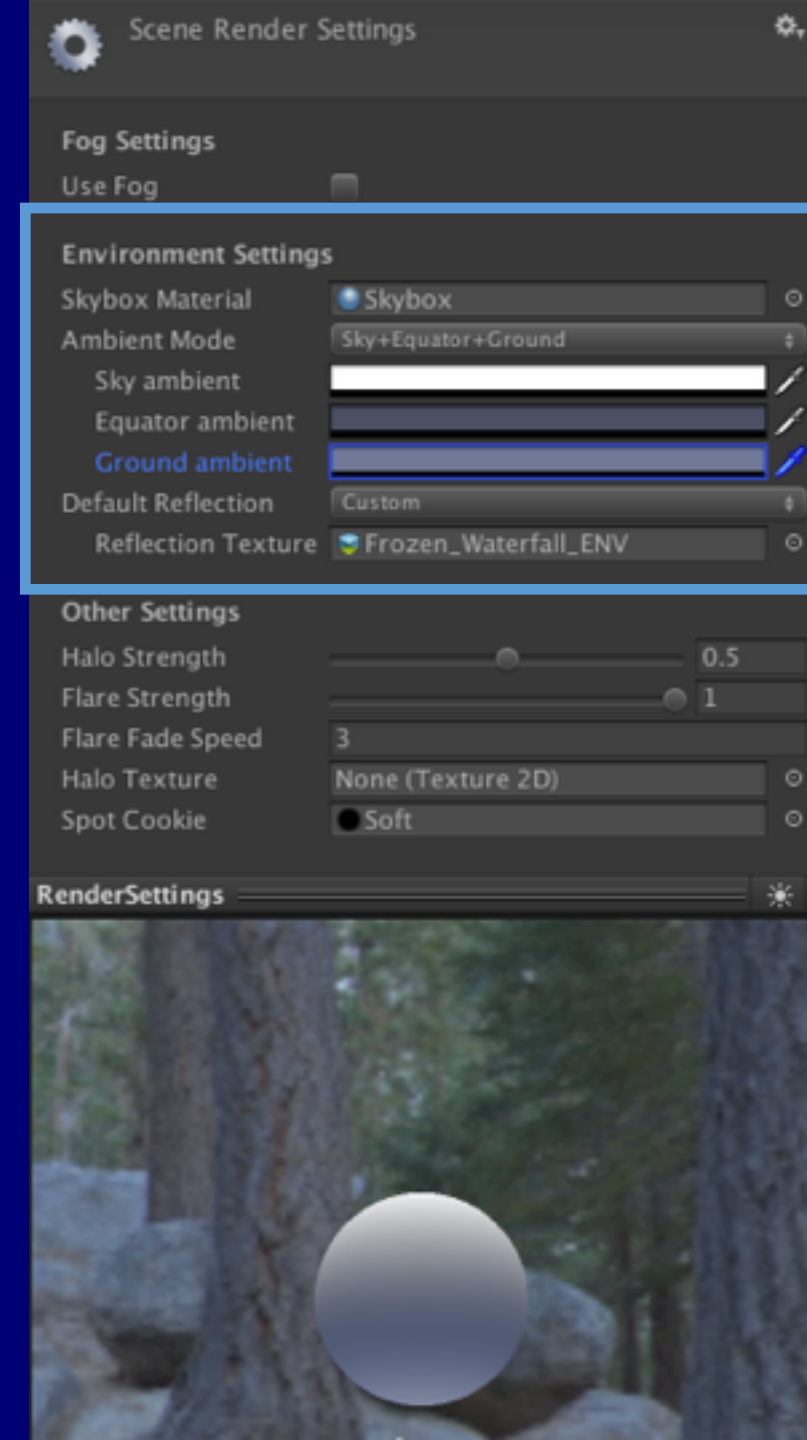
- Auto generated from Skybox
 - Directional light
 - Specular reflection
 - Ambient probe



Light Setups

Custom Image Based

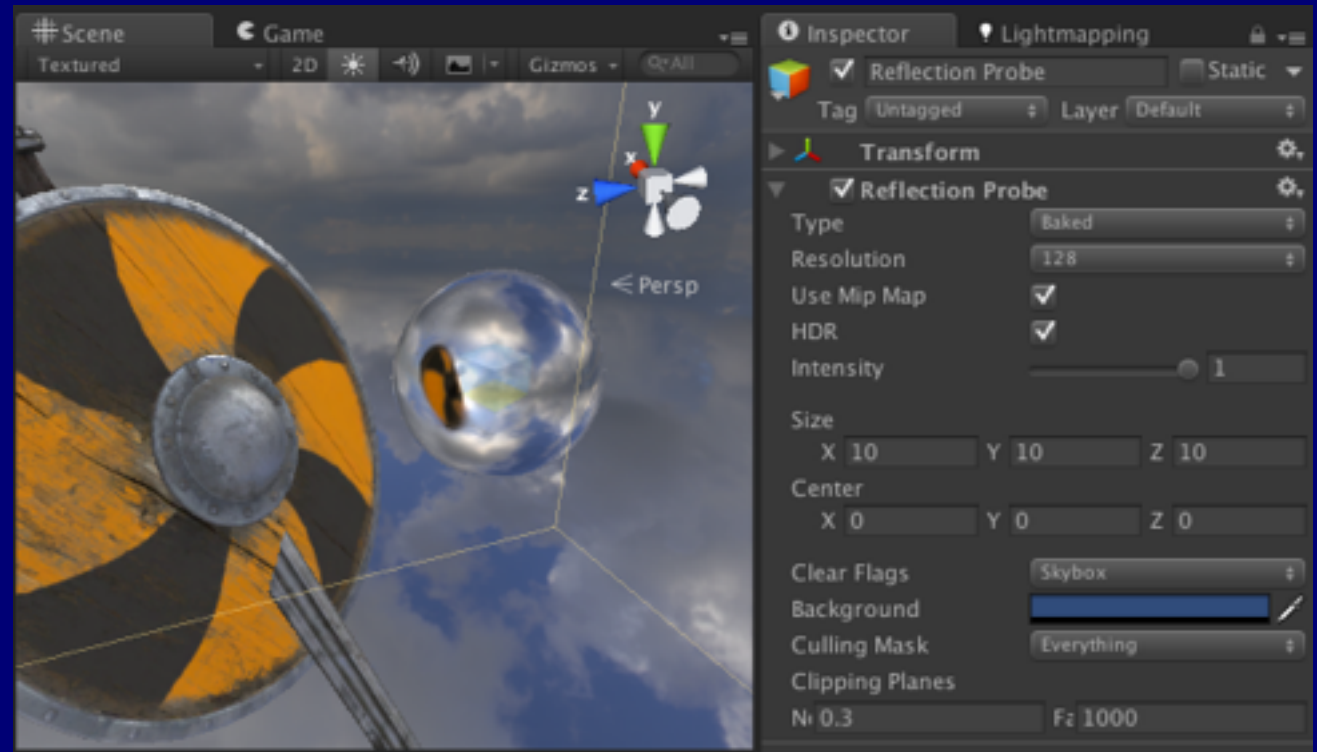
- Specify your own IBL texture
- Use “Specular Convolution” in Texture Import settings
- Setup your own ambient probe
 - Top, Equator, Bottom
 - Or script code



Light Setups

Reflection Probes, Light Probes and cubemaps

- Reflection Probes – convolved HDR Specular cubemaps
- HDR Texture import
 - .hdr and .exr formats
- Up to 8K resolution



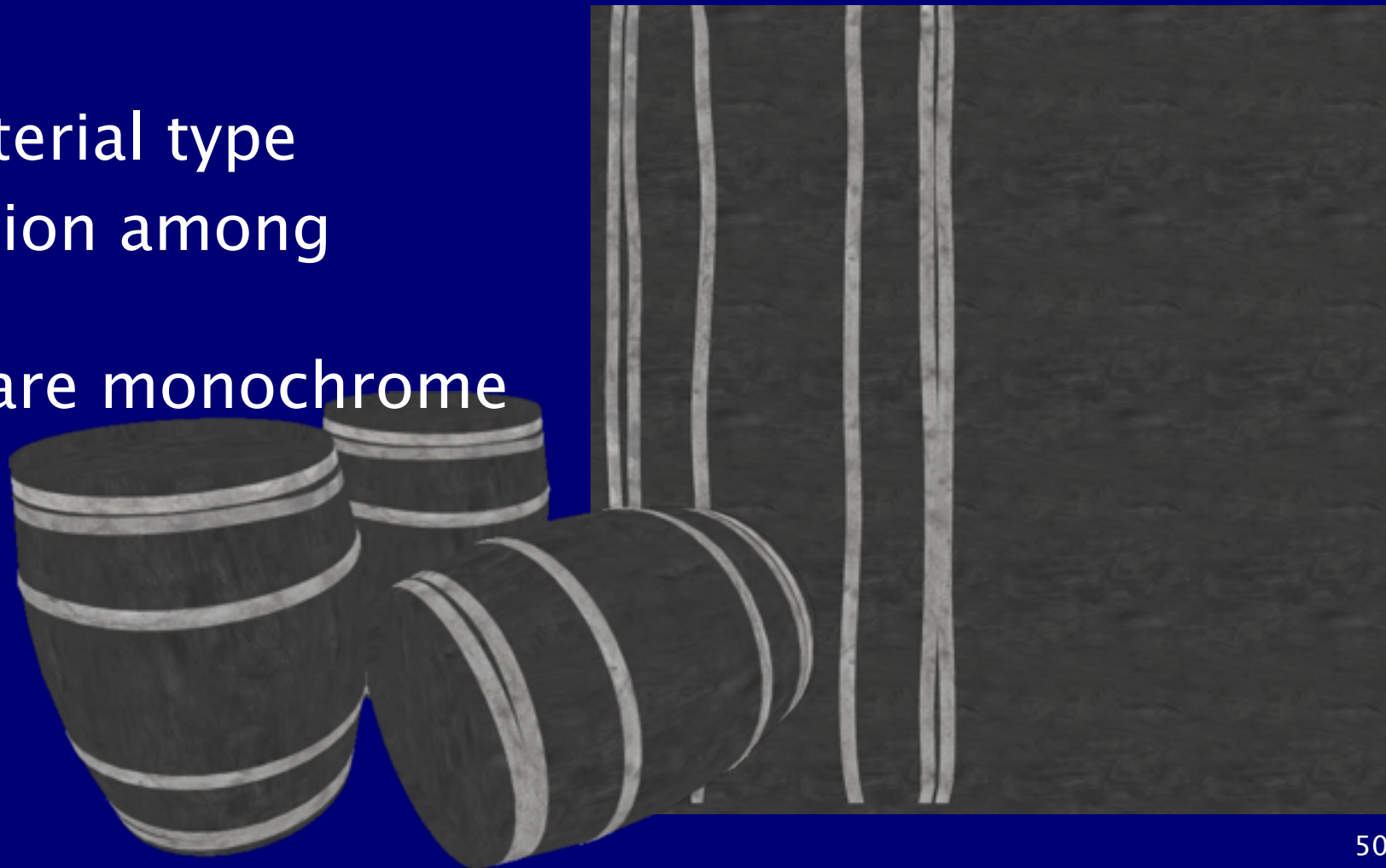
Painted Texture Example

- Diffuse / Albedo
 - No lighting information
 - Metals are typically dark



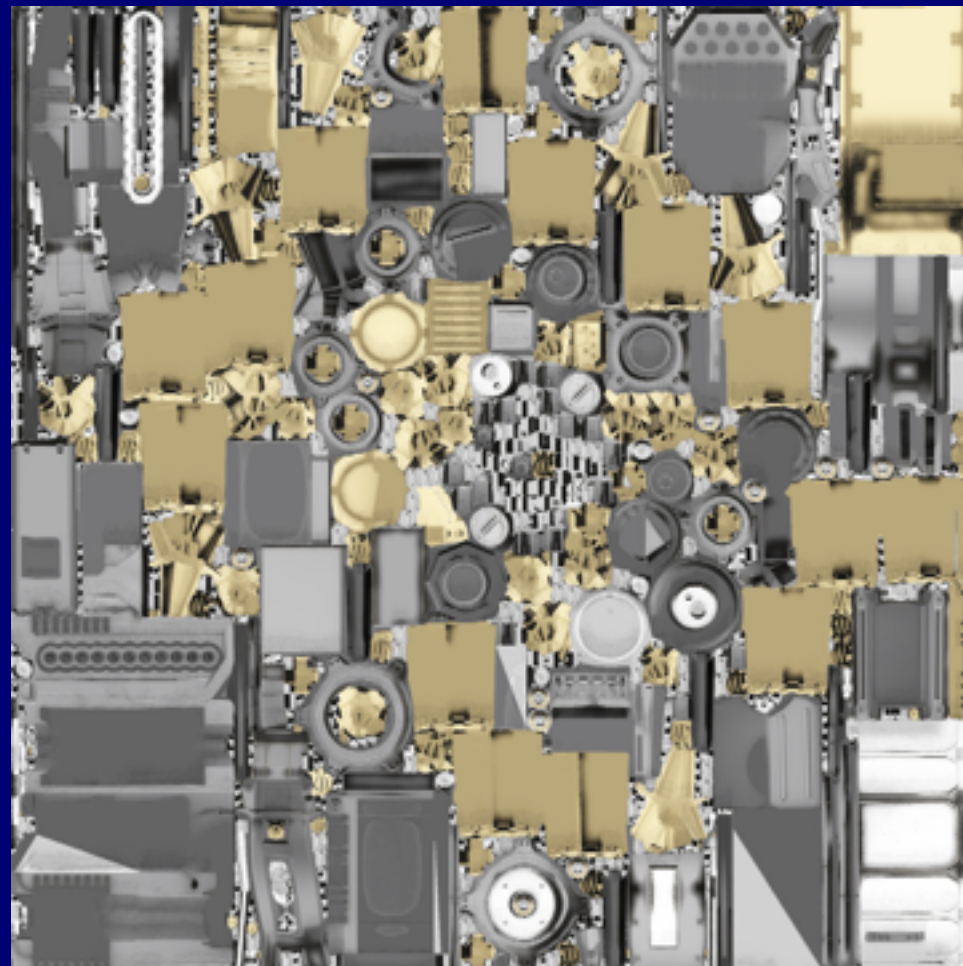
Painted Texture Example

- Specular
 - Defines material type
 - Small variation among dielectrics
 - Dielectrics are monochrome greyscale



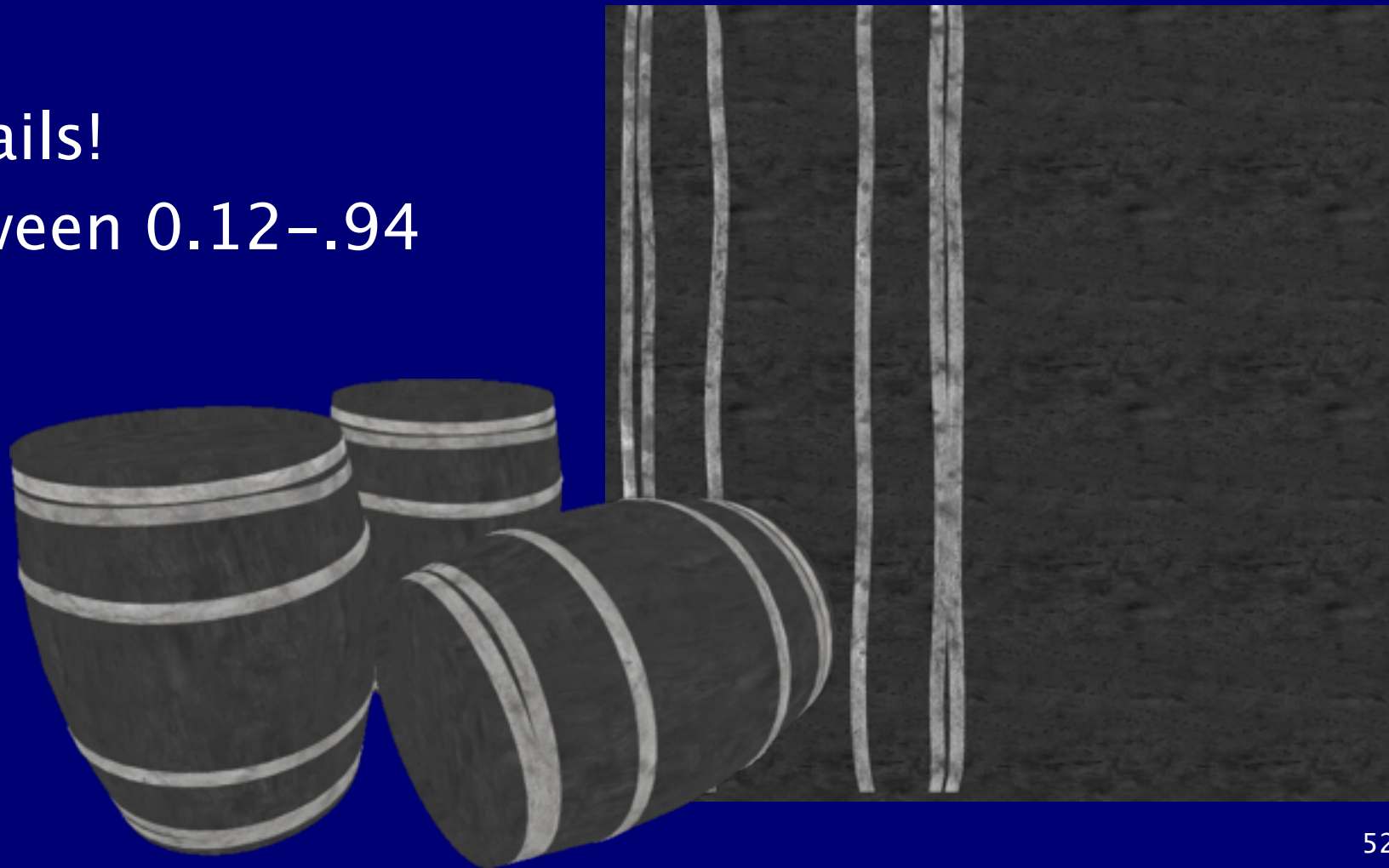
Painted Texture Example

- Specular, continued...
 - Similar hue as Diffuse if metal
 - Suggested range 40–75 sRGB for non-metals.
 - 155–255 sRGB for metals



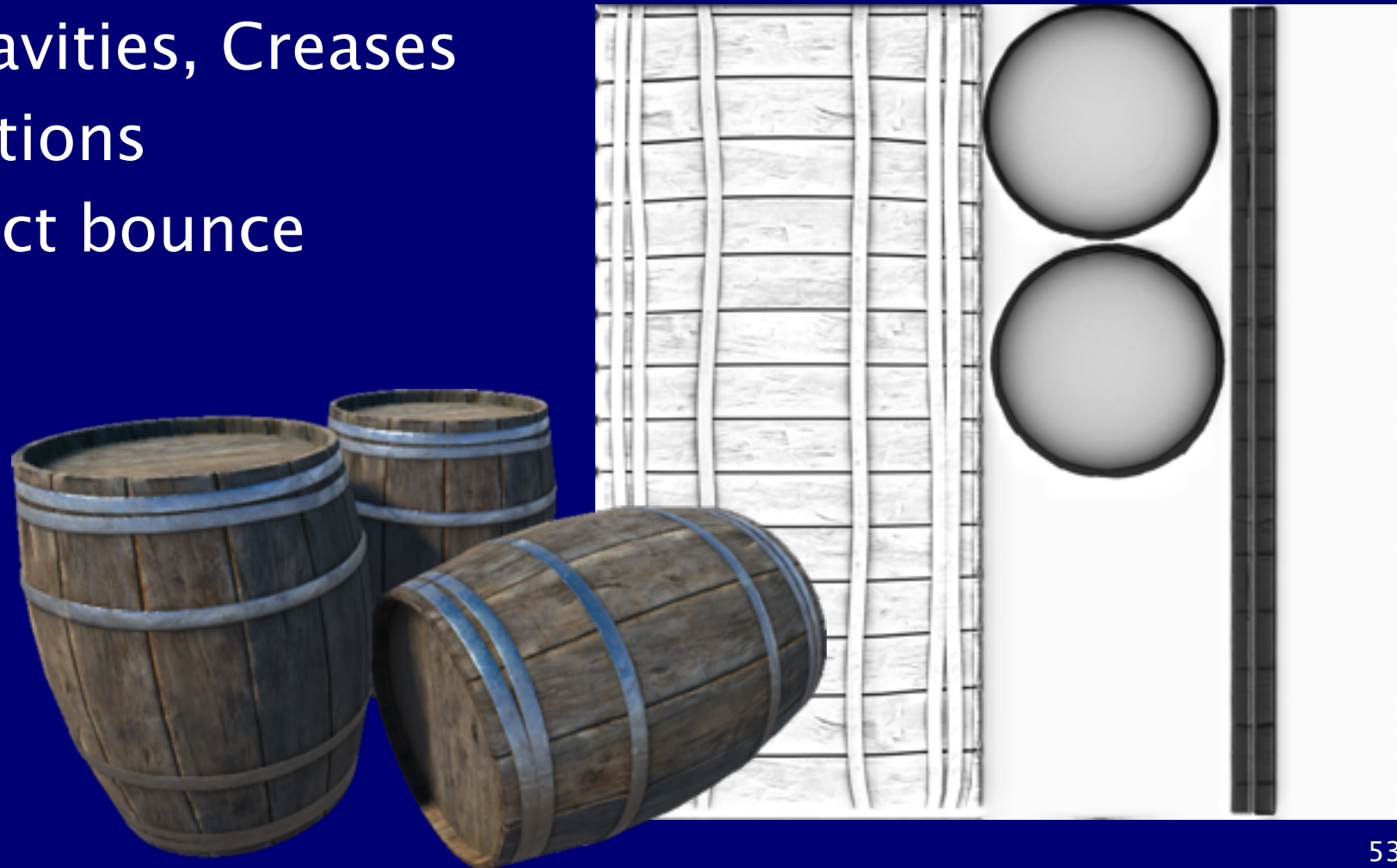
Painted Texture Example

- Smoothness
 - Lots of details!
 - Range between 0.12–.94



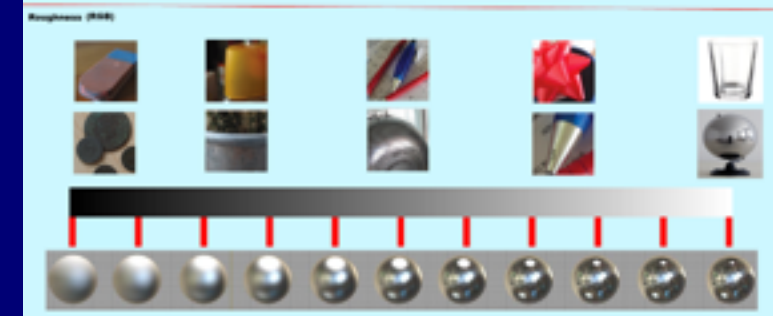
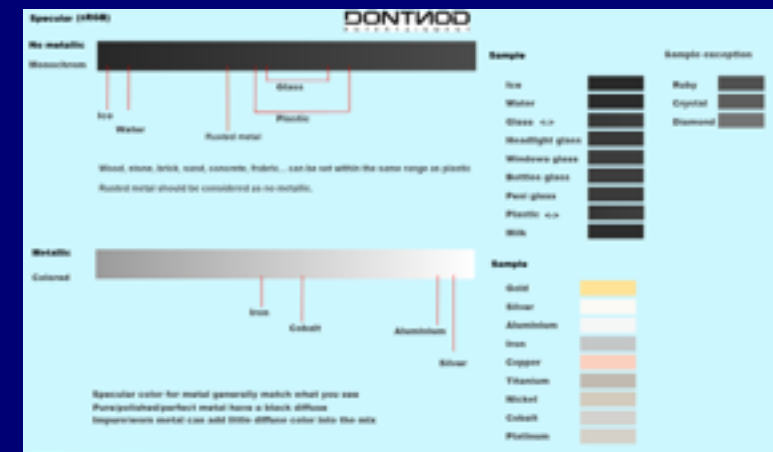
Painted Texture Example

- Occlusion – Cavities, Creases
 - Mask reflections
 - Mask indirect bounce



Obtaining texture data

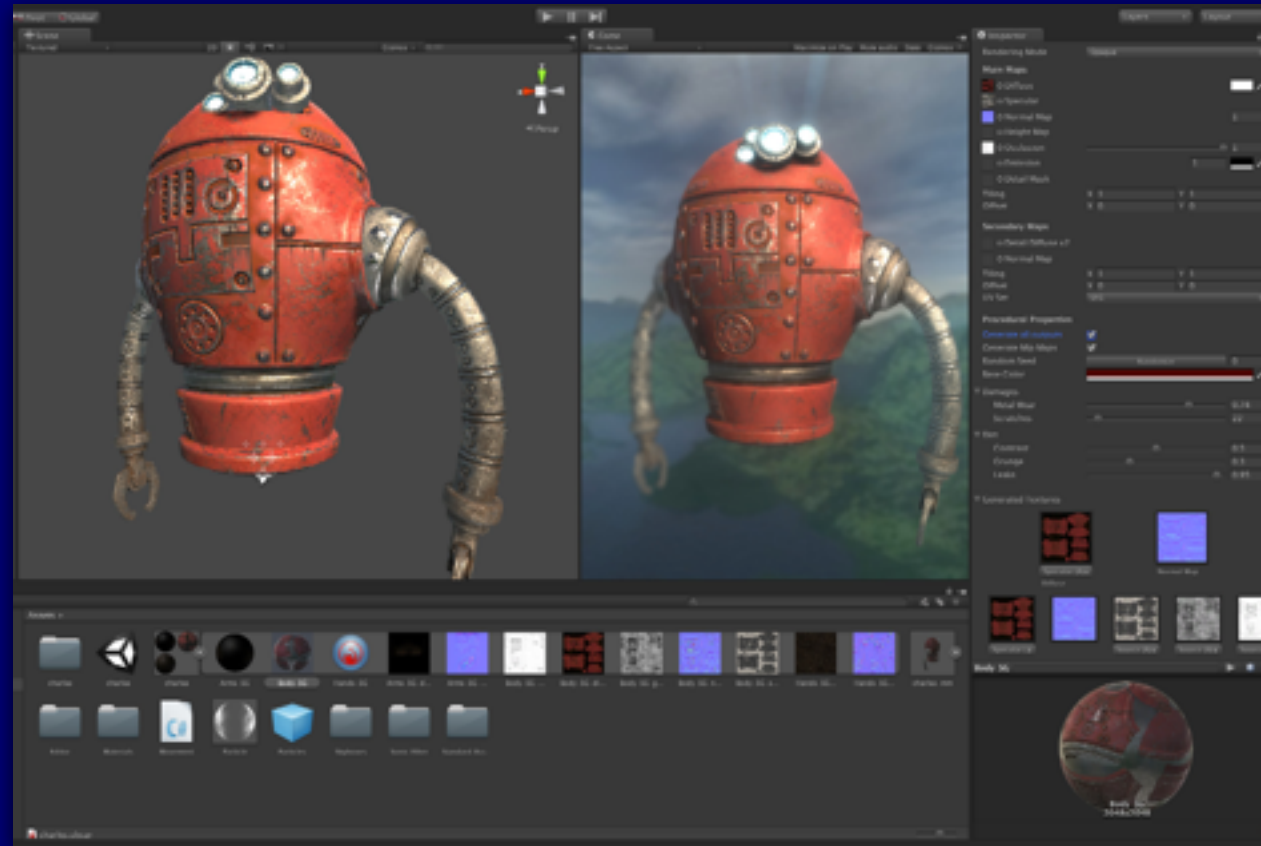
- Scanned – “scientific method”
 - Quixel Megatexture, Substance DB, Surface mimic, ...
- Hand painted
 - Time-consuming to match values
 - Need to remove lighting information
 - Reference charts (DontNod, Quixel, ...)
- Procedural
 - Substance, among others...



Case Study

Procedural workflow with Substance

UNITE
2014



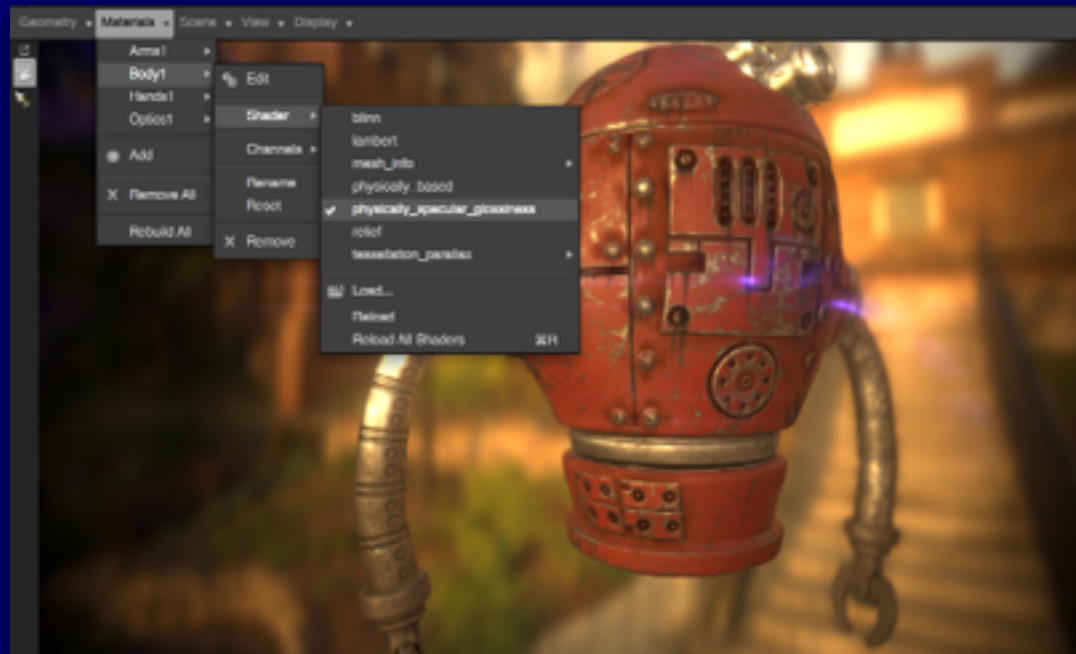
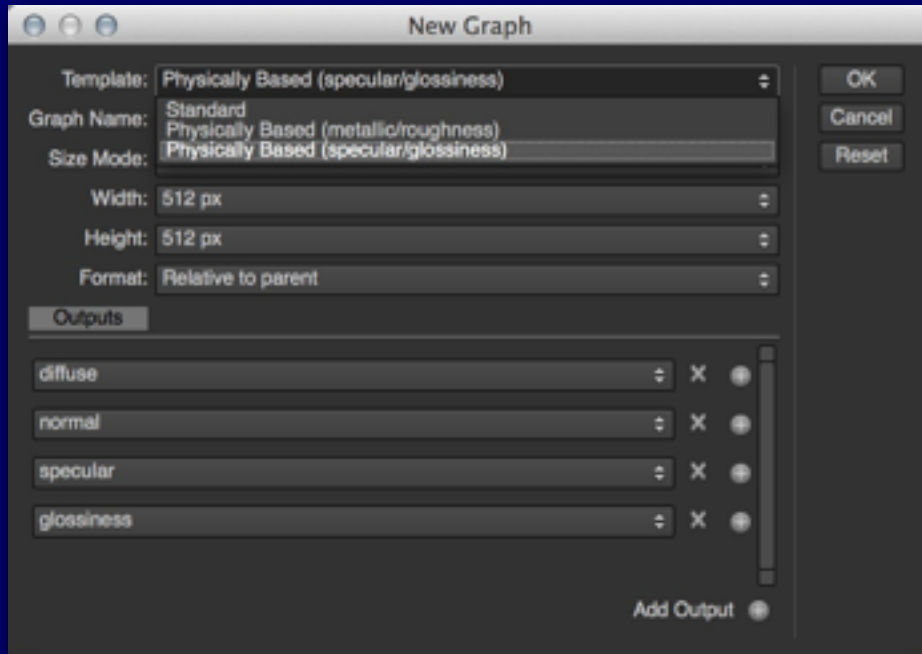
Substance

- Specialize in texture creation tools built around Physically Based Shading
- Substance file : streamlined solution for using PBS in Unity
 - Input doesn't matter : content packaged as Substance
 - Automatically connect outputs to shader
 - Exposed parameters with runtime support



Physically Based Templates

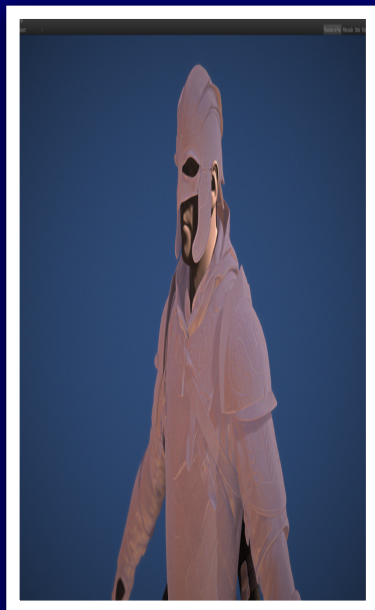
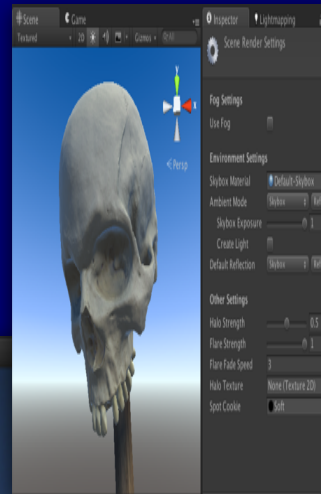
- Supports Metal/Rough, Spec/Gloss and Custom PBR
- Based on Disney Principled GGX BRDF
*cross-checked by AAA game studios



Material Workflow

Substance Designer

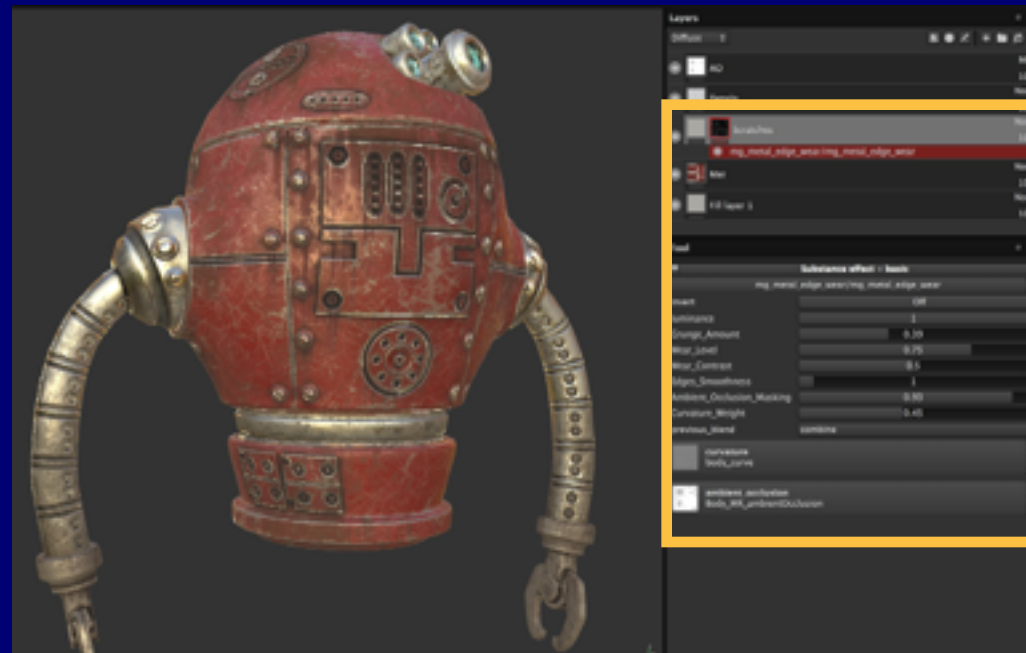
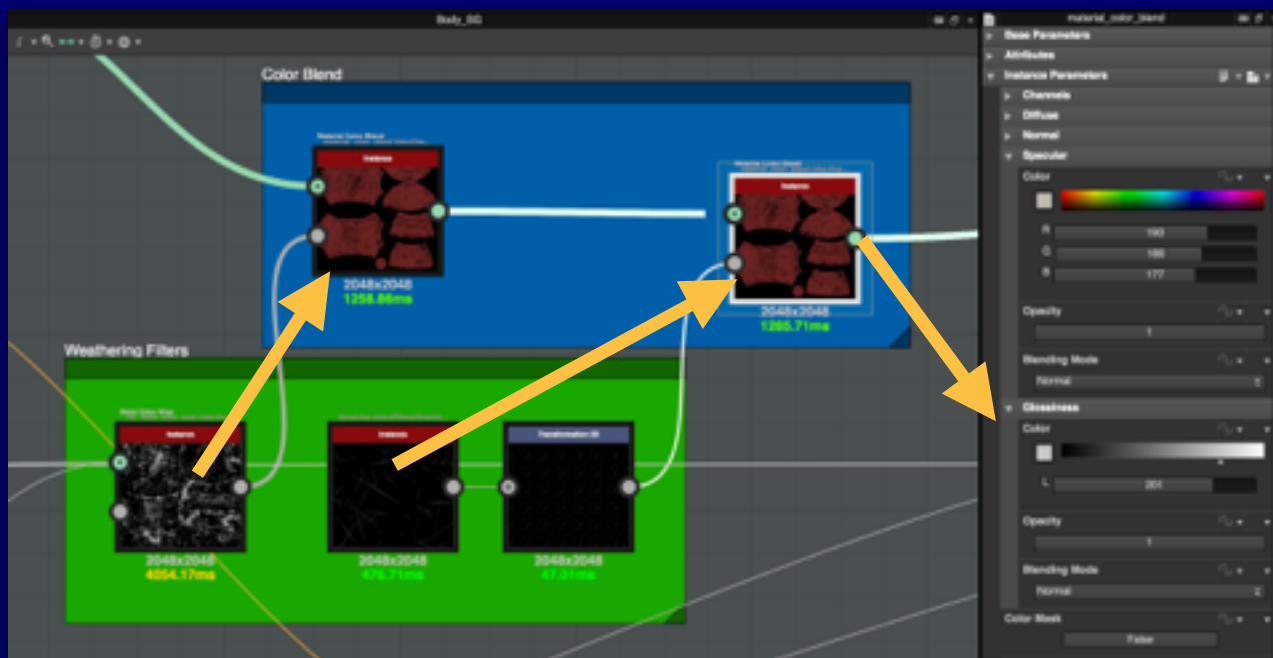
- Material Blending



Material Workflow

Substance Designer and Substance Painter

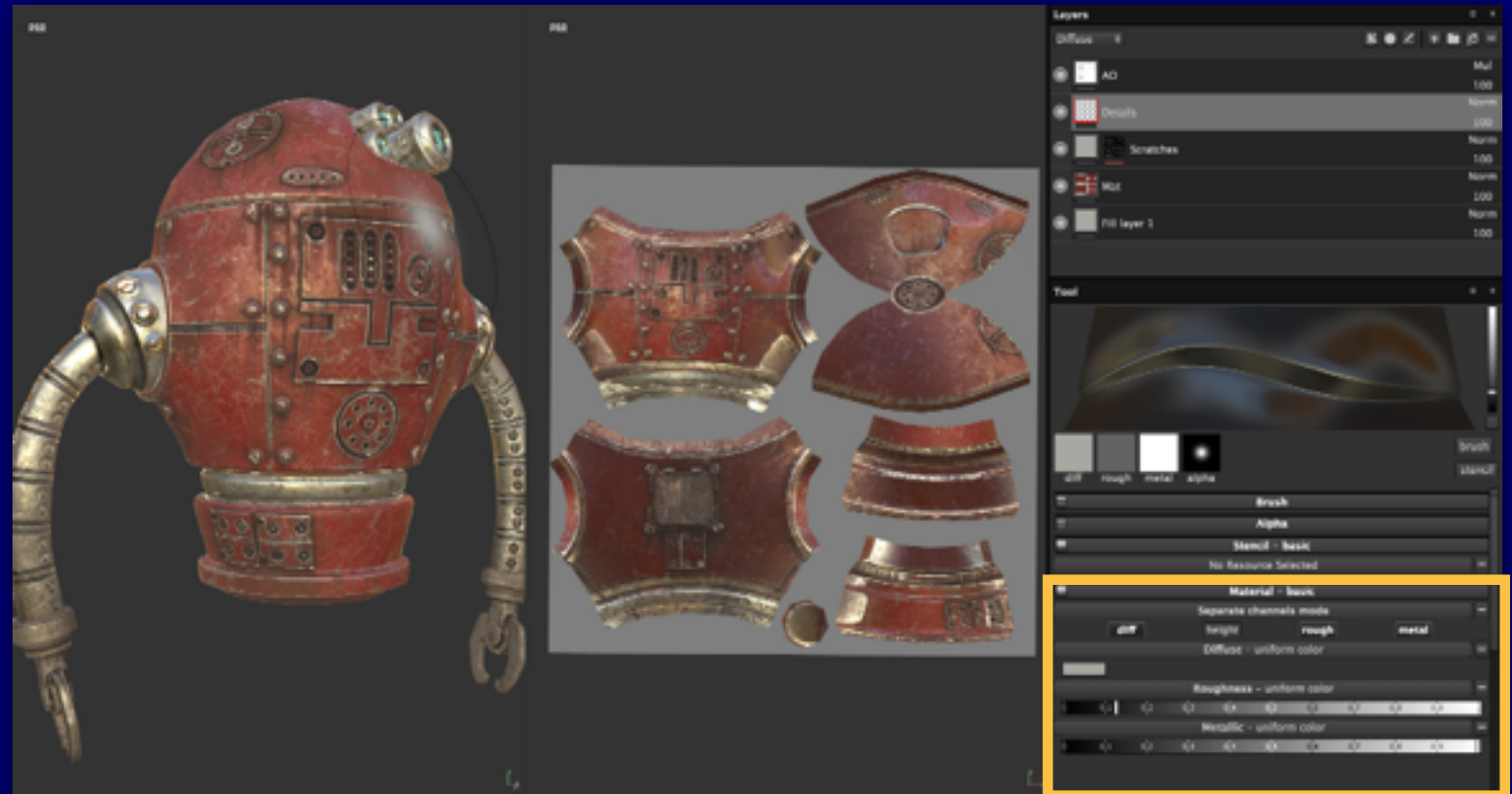
- Weathering Filters : Propagate effect across multiple channels



Material Painting

Substance Painter

- Paint across multiple channels
- 100% Non-Destructive
- Export to Unity



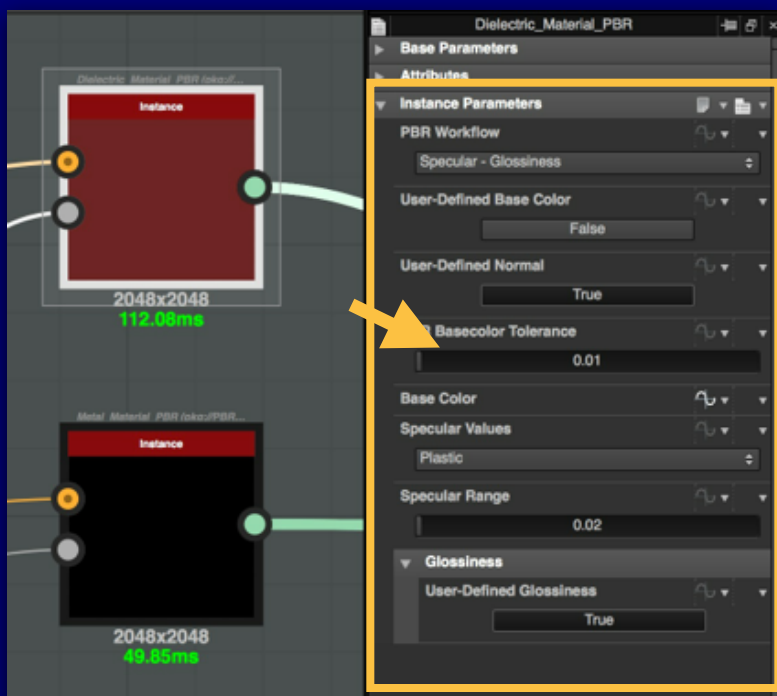
Substance Database

- Growing library of PBR materials as Substances
 - Hand-painted
 - Procedural
- Custom database

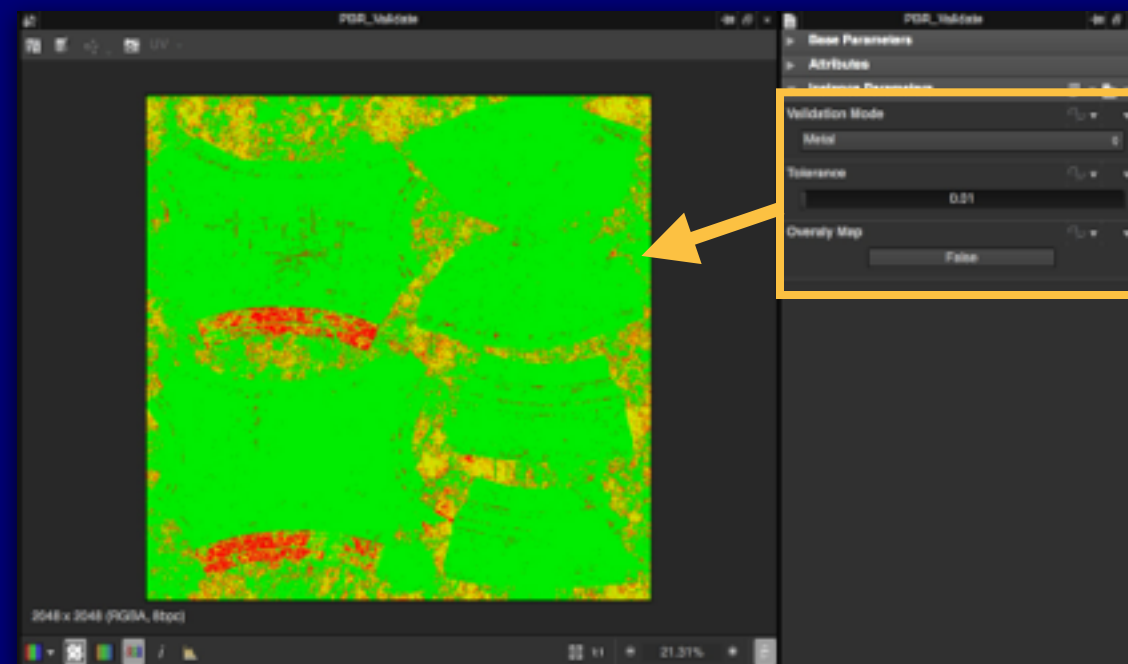


Custom Tools

- PBS Materials
 - Dielectric
 - Metal
- PBS Map Validation



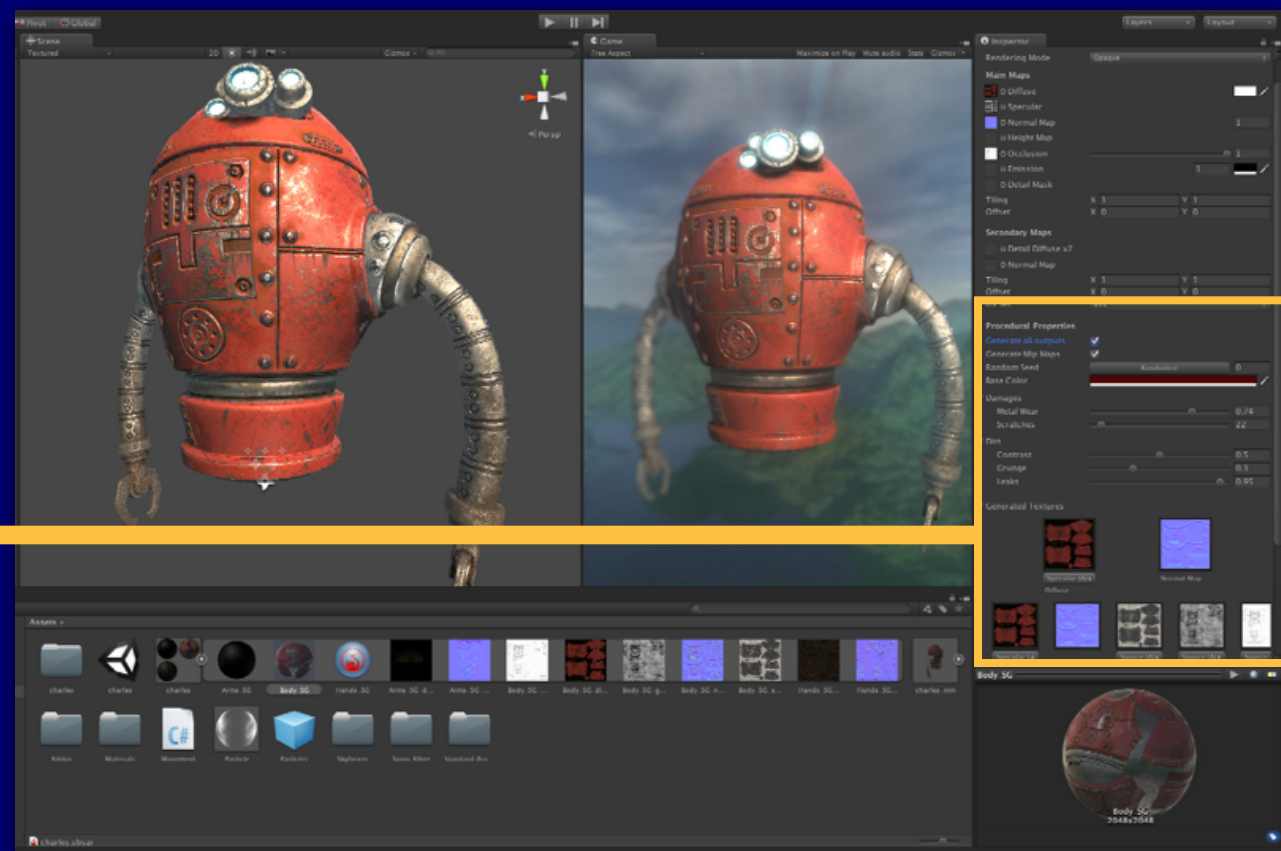
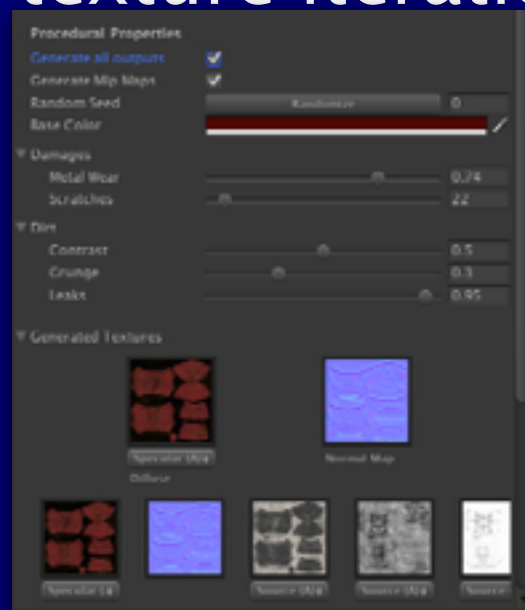
Custom Nodes



PBR Validation Node

Native Unity Support

- Reduce texture package size
- Change parameters at runtime
- Quick texture iterations



Q&A

