LIGHTING HANDBOOK

Filippo Fanciotti

Before getting into the specific lighting topic, few words must be spent on the subject of rendering, since the light management is strictly connected to this phase.

The image produced by any rendering engine is the result of the combination of many parameters, therefore any result is unique and requires the management of a lot of data; that's why it is mandatory to adopt a systematic workflow from the beginning, that includes incremental saving and a good storage system. In other words, each time you touch something in the render options, take note of that change and save that step, otherwise it will be very hard to get back to a previous solution. A due note musts be addressed to the software you are working with.

The Music Lesson
Johannes Vermeer
1662-1665
oil on canvas
74.6 cm × 64.1 cm
Royal Collection, St. James's
Palace, London

The Vermeer's Music Lesson,
Lighting variation: candlelight
Filippo Fanciotti
november 2017
Rhino, Vray, Photoshop
1230 x 1465 pixels
EPFL, ENAC, LAPIS

Light management

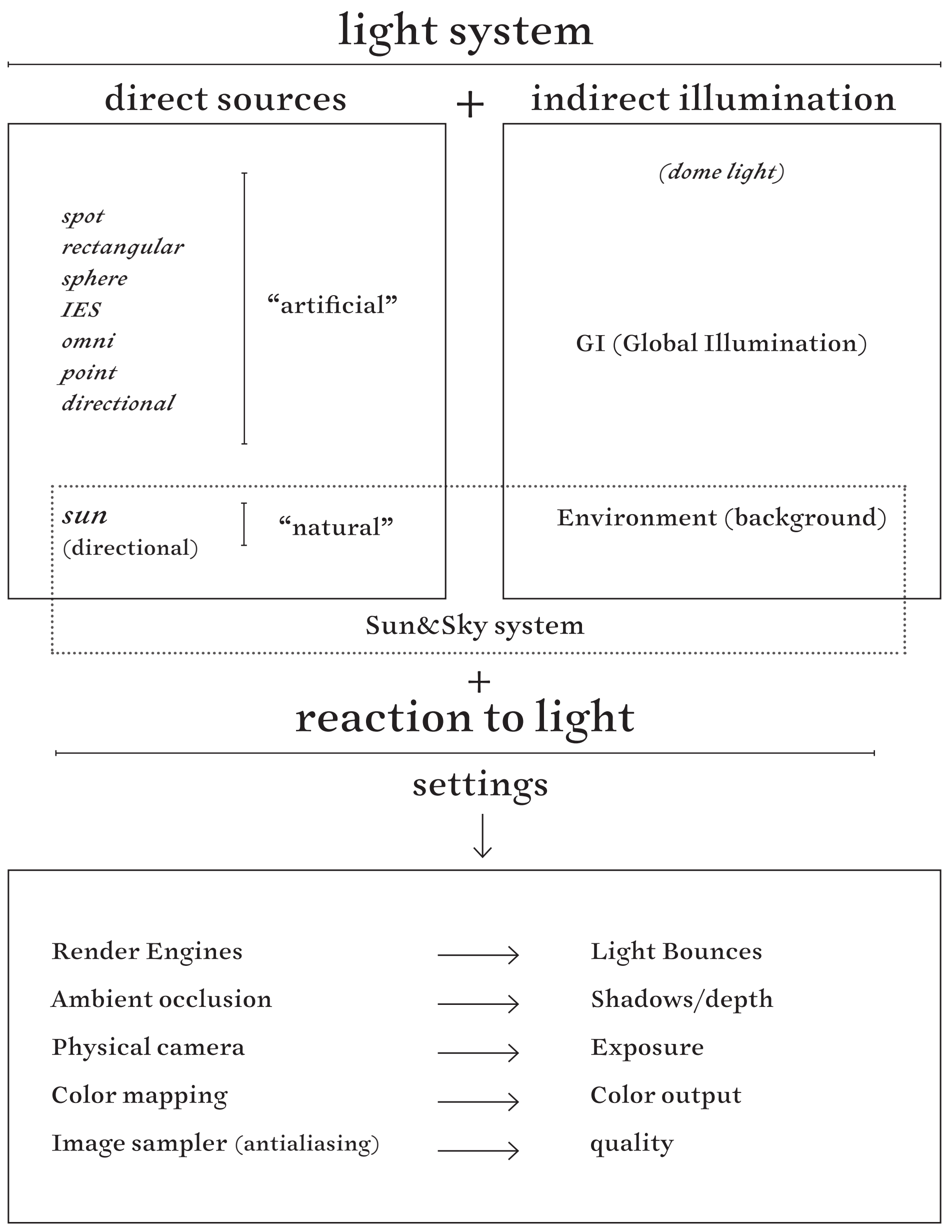
Vray - as you have probably noticed is the one I use the most - is a very complex but complete program, thus giving me the chance to present and discuss a wide fan of topics in this handbook. The following pages will often directly refer to some parameters proper of that software and which perhaps don't even exist in the one you are using; so, as you have already done with the *Matière handbook*, I kindly ask you to abstract the concepts behind those specific instructions and learn how to navigate any other rendering engine. If you are a beginner in the rendering world, at this link you have a list of "*The Most Popular Rendering Software Used by Architects and Designers*".

Any engine has its own its strengths and weaknesses, the important thing is to understand what they are and compensate for any gaps with a good post-production or, possibly, consider using a more complete software in order not to limit yourself in the search for the best result desired.

The diagram on the right shows the package of fields required to manage a lighting environment within a scene. The location of this settings changes, again, from software to software: here I propose a subdivision which is coherent with *Vray* and which - in my opinion - is pretty logical.

Two main sets of tools influence light result: the *light system* (including both *direct sources* and *indirect illumination*) and the settings to balance the *reaction* to those light sources.

Although in many cases it will be more than enough to properly set up a *Sun and Sky System* in cooperation with a *Physical Camera* and the *Global Illumination* algorithm (as explained in the following pages), in other situations you may have to introduce other sources, being them proper artificial lights or "fake lights" to increase some effects, light up small parts of the scene and so on.



Ray tracing

Have you ever wondered how light works in renderings? *Ray tracing* is a technique for generating an image by tracing the path of light through pixels in an image plane, simulating the effects of its encounters with virtual objects.

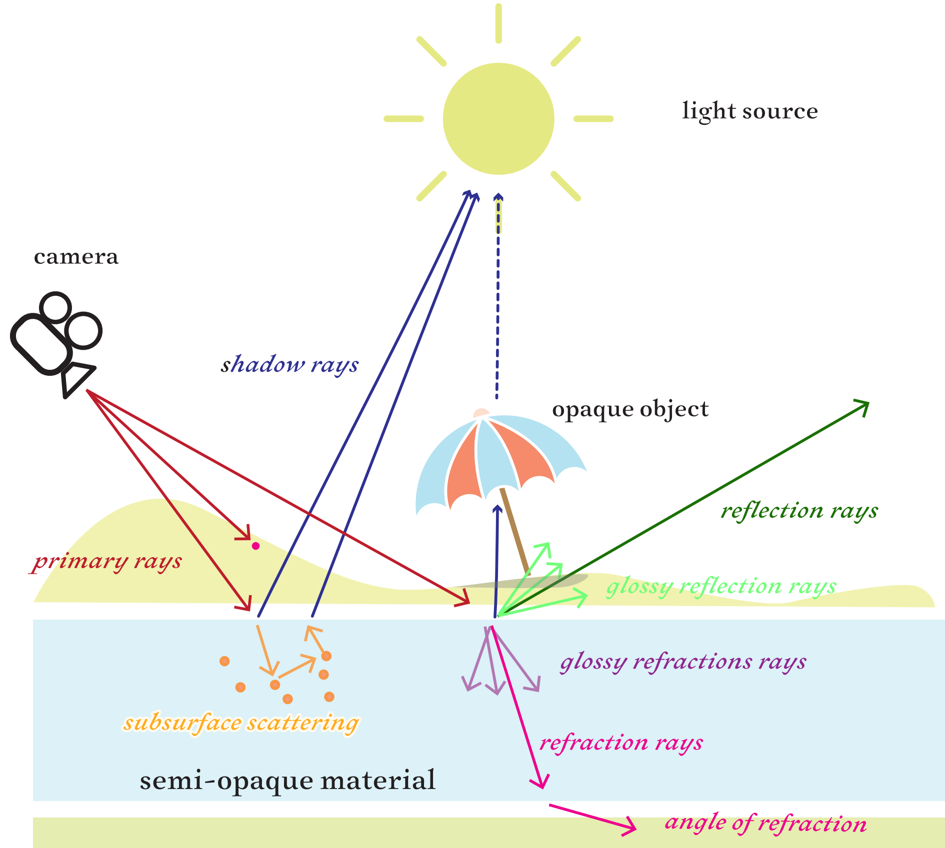
The diagram on the right shows how the basic effects are generated. *Primary rays* (red) are always traced from the camera into the scene in order to determine what will be visible in the final image.

To create the direct illumination and shadows *«Shadow rays»* (blue) are traced from each rendered point to each light in the scene. If the rays hit a light, the point is illuminated based on the light's settings. If they hit an object, the point is shaded.

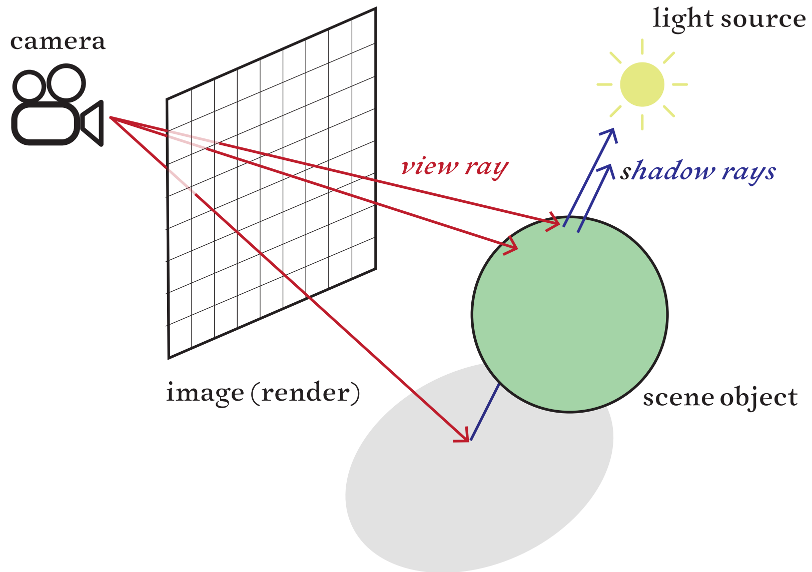
Reflection rays (dark green) are traced in the direction of the reflection vector which depends on the type of reflection - *fresnel* or *normal* and the *index of reflection IOR* of the material. The direction of the *Refraction rays* (pink) depends only on the *index of refraction IOR* of the material.

To create *glossy reflections (light green)* or *glossy refractions (purple)*, many rays are traced in a cone (the spread of the cone depends on the glossiness amount.)

Subsurface scattering (orange) and translucency effects are generated by tracing rays inside the geometry.



Ray tracing process: light behaviour and interpretation.



Ray tracing: translation of info on a bidimensional image.

Indirect illumination
GI (Global Illumination)

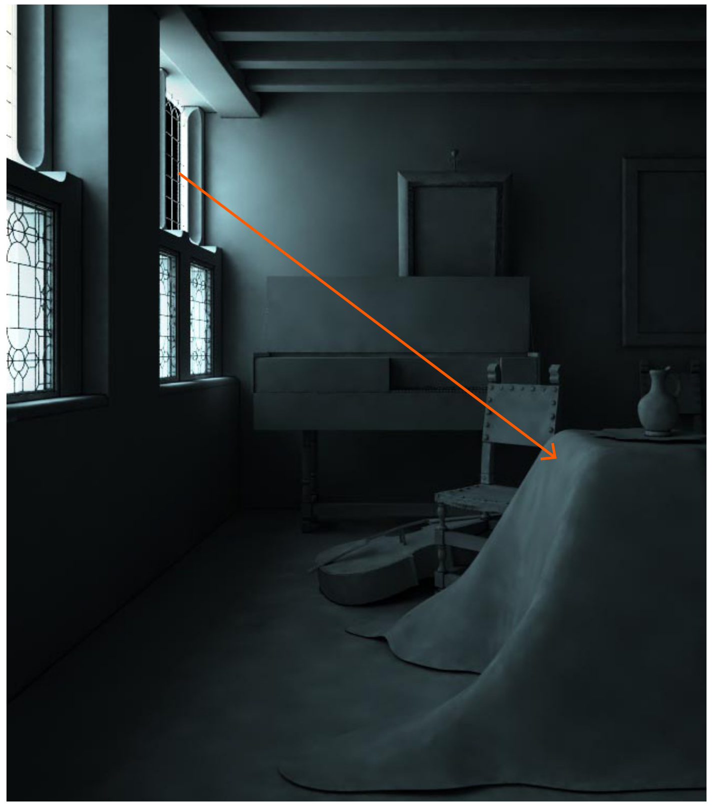
To understand the setups of *global illumination* it is worth to find out what is *indirect illumination*, and why it is important to photo-realistic rendering.

Global illumination is the name given to sum up a collection of algorithms which take into account not only the light coming directly from a light source (known as *direct illumination*), but also all the subsequent cases in which light rays from that source are reflected by other elements in the scene, (*indirect illumination*).

This process adds to the final image a lot more informations. The easiest way to understand how it works is to imagine the final image - the render output - as obtained by superimposing separate render elements (being them shadows, colors, lights, information about transparency and so on) each on other according to a package of given rules explicit in the algorithm.

In other words, think of the final rendering as a set of separate images with different informations (if you are familiar with *Photoshop*, more or less it is what happens with the overlaying of different layers with a specific blending mode). In fact, you can also decide to export those layers (such as *alpha channel*, *material ID*, *diffuse*, *reflections* and so on) separately.

Indirect illumination is one of these layers, which adds to the overall result the information about the indirect light present in scene.



Above, the first image shows a rendering with direct light computation only (GI not enabled). The absence of GI generates unnatural darkness on areas where there is no direct light hitting an item. The second Rendering has been performed with the direct light and indirect light enabled (GI). The previously dark areas become lightened because of global illumination, the arrows show the path of light;

Indirect illumination
Light bounces

The indirect illumination controls are divided into two large sections:

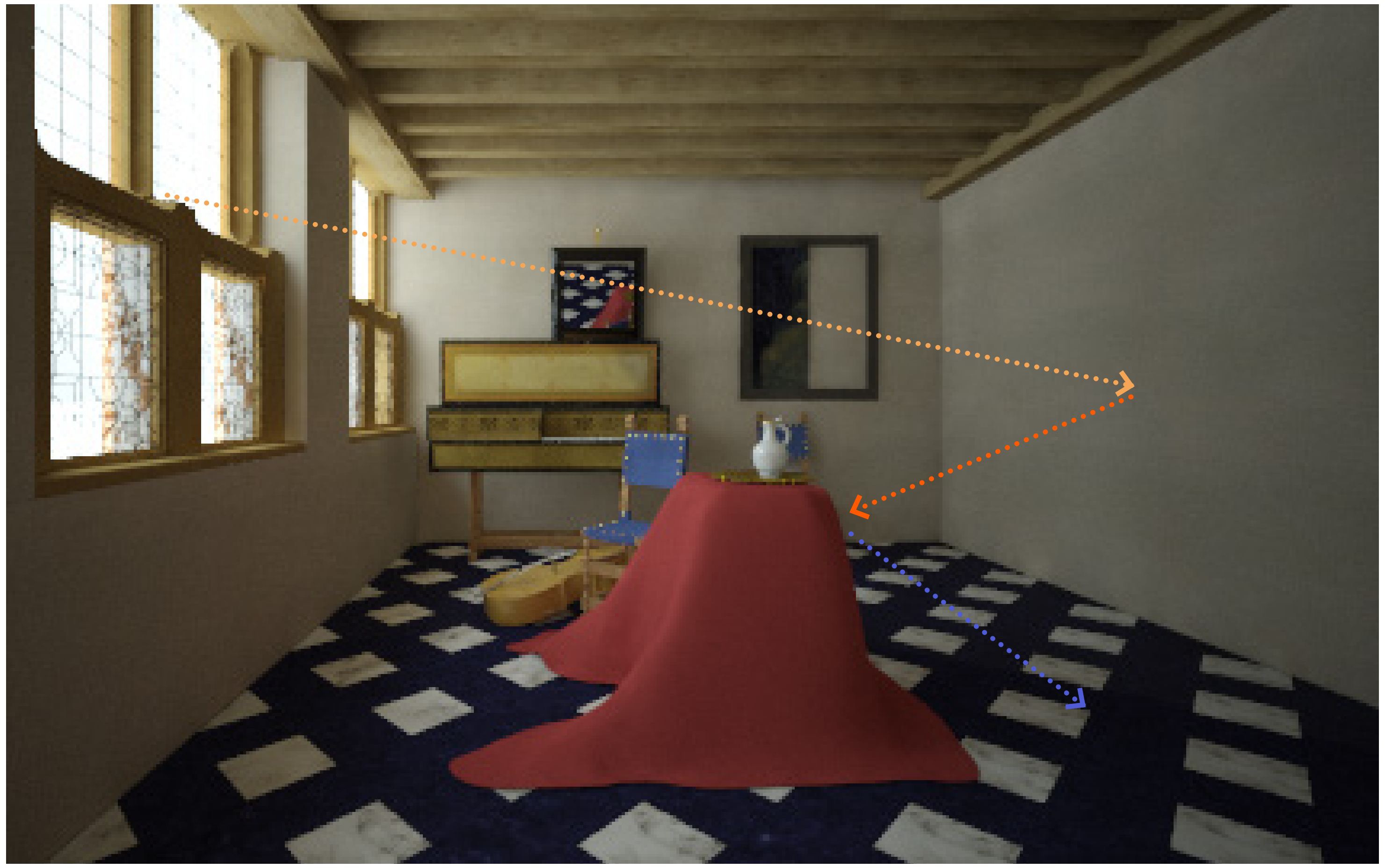
- *Primary bounces*

A primary diffuse bounce occurs when a shaded point is directly visible by the camera, or through specular reflective or refractive surfaces. It is the light which bounces after the direct light hits a surface. Usually these bounces have the greatest effect on the scene in terms of the indirect lighting.

- *Secondary bounces*

A secondary bounce occurs when a shaded point is used in GI calculations, after the primary bounce. As light bounces around a scene, its intensity - and therefore its affect on the final illumination - becomes less and less. With exteriors secondary bounces have a relatively insignificant effect, while in interior scenes become as important as primary ones, being them the ones able to enlight dark areas.

The image below shows the behaviour of light according to Global illumination algorithm: firstly the *direct light* (orange arrow)strikes the wall and lits it. Then the reflected light from the wall lits the carpet and the pavement: this first bounce (red) it's named *Primary bounce*. So the light reflecting from the carpet and the pavement lits the pavement and bottom of the wall (blue) and it's called *Secondary bounce*. Theoretically this process goes on and on and the photons keep bouncing, practically a render engine simplifies all of these bounces in a more or less sophisticated secondary bouncing, according to render engine chosen by the user (and explained in the following page).



Indirect illumination
Render engines (*Vray*)

The possibility to chose among several rendering engines can considerably alter the result of a render; any of them has its own method for calculating light info in a pixel of space, therefore some are more accurate than others and, most of all, more appropriated for some situations. Here I quickly introduce the main.

There are normally 4 options for Primary Engine (depending on the *Vray* version): *Irradiance Map, Photon Map, Brute force* and *Light Cache*, while only 3 options for Secondary Engine: *Photon Map, Brute Force* and *Light Cache*.

- *Light Cache*

The calculation starts from the camera; it computes 100 bounces by default (if you put it in the primary bounces, it's actually computing secondary bounces too.) Advantages : few settings + renders faster than other engines + good for interiors and exteriors.

- *Irradiance Map*

It efficiently speeds up GI calculations; basically the irradiance map calculations can find out which parts of the scene need accurate GI calculations and which parts don't: IR map computes indirect illumination only at some points in the scene, and interpolate for the rest of the points. very fast. noise reduced. some details in indirect lighting can be lost or blurred.

- *Brute Force*

This method computes the GI in every single shaded point. So even on very flat surfaces where lighting is very even, every point will be calculated. This is of course very slow, but also very exact. Great for exteriors, very slow for interiors + tends to produce noise.

good combinations:

primary = IR map
secondary = brute force

primary = IR map
secondary = light cache

primary = brute force
secondary = light cache

Primary : Irradiance Map;
Secondary : Brute Force

Primary : Irradiance Map;
Secondary : Photon Map

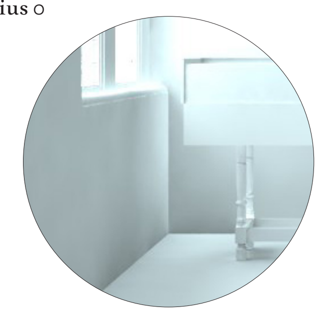
Indirect illumination
Ambient Occlusion

Ambient occlusion is a shading method used in computer graphics that helps to give realism to local reflection models, since it takes into account the light attenuation in occluded volumes. It's a global method, ie the illumination of each point is a function of the geometry of the scene. In any case it is a rough approximation of the whole GI; the appearance generated by ambient occlusion alone is similar to that of an object on a cloudy day.

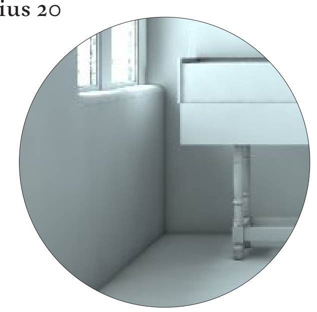
Practically AO simulates shadows occurring in the cracks/ crevices of any object, when GI is cast out onto a scene. The soft shadows produced by AO help to define the separation between objects (specially on the floor) in your scene, adding a high level of realism.

Subdivs determines the number of samples used for calculating AO(Low values might introduce noise)

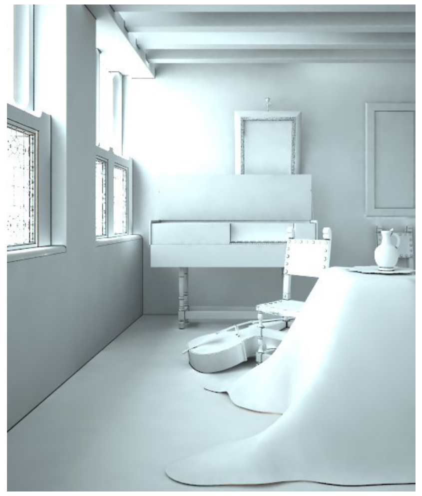
amount 0
subdivisions 0
radius 0



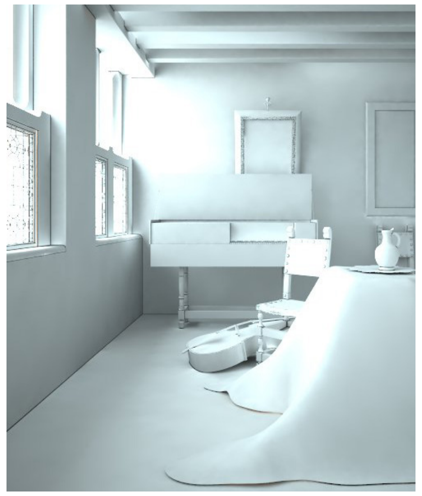
amount 1
subdivisions 24
radius 20



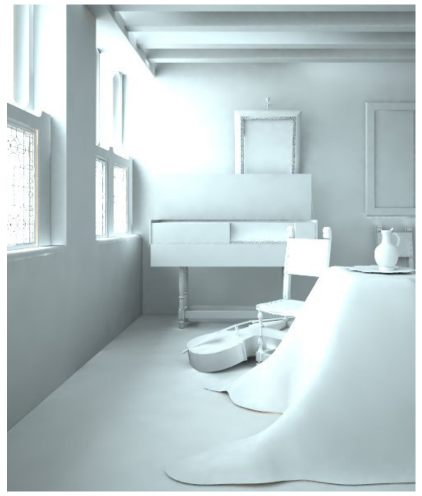
amount 0
subdivisions 0
radius 0



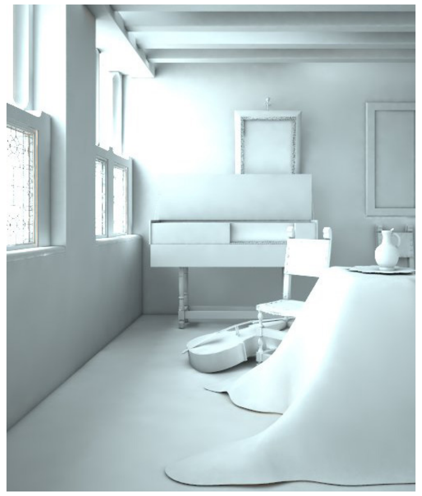
amount 10
subdivisions 24
radius 1



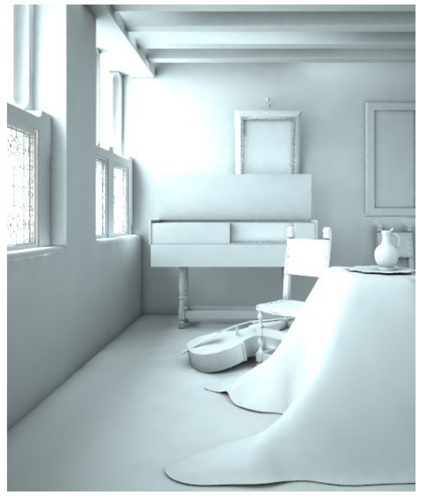
amount 5
subdivisions 24
radius 1



amount 1
subdivisions 24
radius 1



amount 1
subdivisions 24
radius 10



amount 1
subdivisions 24
radius 20

Indirect illumination
Sky system

The *Sky texture map* is used as an environment map (a map ideally applied to an immense dome surrounding your scene) to help simulate outdoor lighting; it behaves very much like a *HDRI environment map* (we'll see them soon). The texture can change its appearance based on the position of the Sun.

In *Vray* Sun and Sky work together and sky is funcion of the Sun; in the following lines I quickly explain how to create a sky system in *Vray:*

- Enable *GI* (otherwise the sky can't work)
- in the *Vray options/ environment* : click on the *"m"* next to GI; go to *texture editor / Type /* select *TexSky / light source* : select sun1 (or the named sun you created for the scene); this setting tells your render engine where the sun direction is coming from.
- uncheck *Override Sun's Parameters* (so the sun and the sky work together)
- Repeat this process for the *Background*.

>>> bug troubleshoot <<< always fix *Gamma Correction*. No gamma correction = dark sky + inaccurate colors. In order to gamma correct images both the *inputs* (textures and colors) and *output* need to be adjusted. Go to *Global Switches* / check *Correct RGB* and *Correct LDR Textures*. To adjust the output change the *Gamma* value from 1 to 2.2

N.B. The *sun&Sky system* works properly in conjunction with the *Physical Camera*. To balance its intense brightness (also to capture the correct colors of the sky) you don't have to adjust the intensity of the Sun; you must set a proper exposure of the scene with the physical camera instead, by adjusting the *F-stop*, *shutter speed* and *ISO*. (we'll see these features in the following pages)

notice how the temperature of the light changes according to the sky chosen in the three images below: in the first case the Vermeer music lesson has been used as a sky (why not?), in the second scene I used a 60s interior room and, in the third scene, a diffuse color.

environment
GI : texSky (Sun2)
Background : Vermeer music lesson

environment
GI : texSky (Sun2)
Background : 60s interior picture

environment
GI : texSky (Sun2)
Background : texSky (Sun2)

Indirect illumination
Sky system, Environmental light

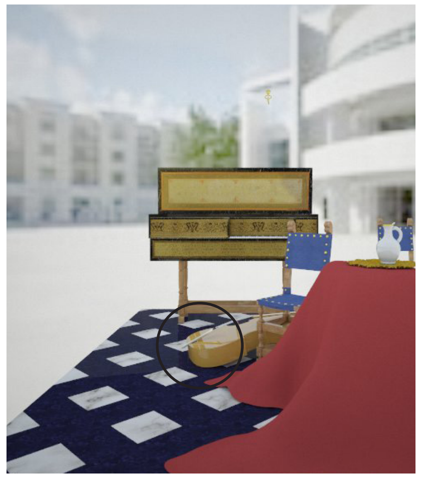
An *HDRI (High Dynamic Range Image)* is a panoramic photograph that covers the entire field of vision and contains a large amount of data (typically 32 bits per pixel per channel) which can be used to emit light into a scene. *HDRI images* can be used as *Environment light* source, providing the illumination for the scene based on the colors and intensity of the image.

If you want the objects to reflect the *HDR image Environment* as well, you can assign the same HDR image to the *Environment Background*, and make sure the *UVW* is set to Environment (Vray).

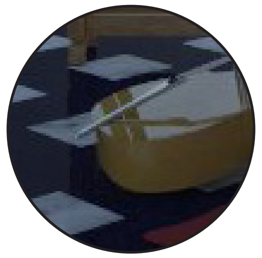
Bitmap (normal image) can be also used as Environment light source, although it can't generate the dynamic environment provided by HDRI; anyway, as long as you pick the right Bitmap and properly manage the Intensity, it can still be a very good Environment light source.

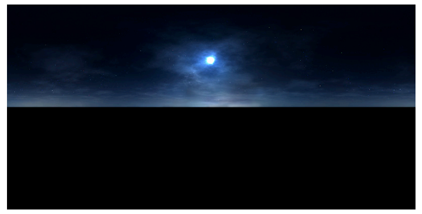
In the following images, notice the influence of the HDRI used as environmental light affect reflections and light temperature.

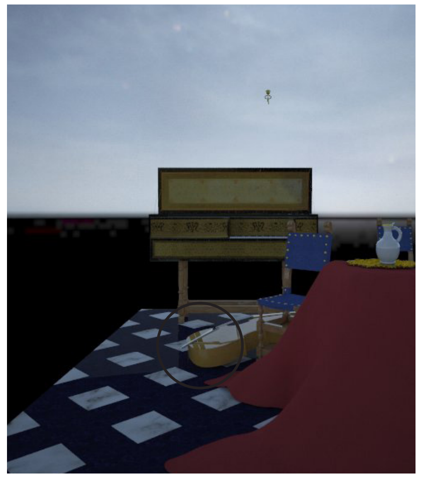
environment
GI & Background : HDRI 01



environment
GI & Background : HDRI 02







environment
GI & Background : HDRI 03

Indirect illumination
Sky system, Night Environment

The creation of a realistic, efficient night environment is often a big challenge, specially if you don't make use of the afvantages of environmental images; no matter how dark you want your scene to be, it is highly recommended to use the sky to emit some light (even more than what you need) and than setting exposure both in physical camera settings and post-production: it is always easier to subtract light that to add it.

an example of night HDRI. I used this image as envoronmental light (Vray sky) to produce the image on the left page and all the nocturnes.

The Vermeer's Music Lesson,
Lighting variation: in blue
Filippo Fanciotti
november 2017
Rhino, Vray, Photoshop
1230 x 1465 pixels
EPFL, ENAC, LAPIS

environment skylight HDRI 03
gamma 1

environment skylight HDRI 03
gamma 2

environment skylight HDRI 03
gamma texture manipulation>
color correction 214, 255, 255

Direct sources
Sun system

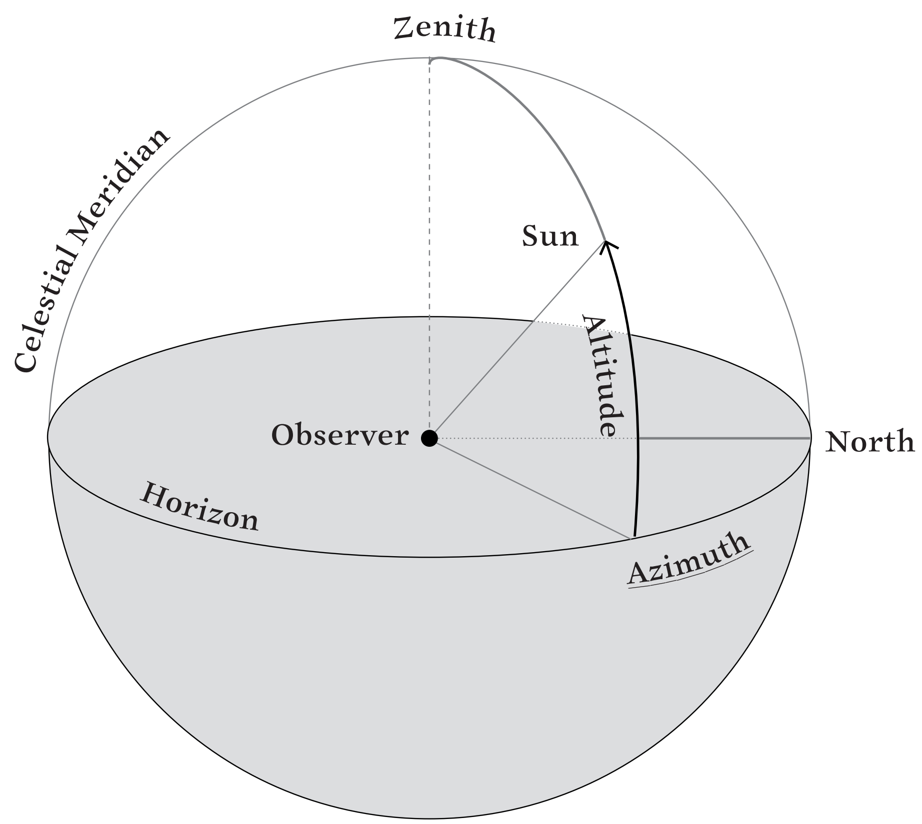
The Sun is a particulat type of directional light(we'll see them in the following pages); in most cases the only source you will put in your scene.

There are two ways to control the sun position:

- *Georeferenced position:* by specifying the location of the model in space and time in the year (including the hour of the day), the sun will automatically be oriented according to its very specific position. This tool is extremely useful to recreate a precise exposure condition, to control the shadows projection and the general orientation of an object.

- *Manual control*: allows to manually control the parameters hidden behind the option described above; the *Azimuth* balances the compass direction of the sun in degrees (North=0, East=90), while the *Altitude* sets the height of the sun above the horizon in degrees (Sunrise or Sunset=0).

While it doesn't matter where you put it in the scene, mind that the Sun is extremely sestitive and even smooth variations of its azimuth or altitude can lead to great changes.



Sun properties

- *Size* matters : a bigger sun affects the amount of blurriness of shadows, while a smaller one produces more defined shadows;

- *Turbidity* changes the amount of dust in the air (haziness). Lower values correspond to the haziness you can have under a clear blue sky (such in the country side), while higher values produce an orangish atmosphere (such in a city environment).

- *Intensity* affects the strenght of the sun. In some rendering engines like Vray you can manage the light intensity through the multiplier.

- *Ozone* changes the color of the sun itself from a slightly yellow tone (low value) to a slightly blue tone.

- *Bias* offsets the position of the shadows (if = 0.0 shadows may leak on the object).

- *Subdivs*: low values (such as 8) produce crispy shadows, higher values (24/32) produce smooth shadows (>longer rendering time).

- *Color* defines the color of the light source, in this case of the sun. Mind this paramater is hypersensitive : HSV (0,0,0) = total black; HSV (0,0,1) = blackish OK ; HSV (0,0,5) = overexposed result.

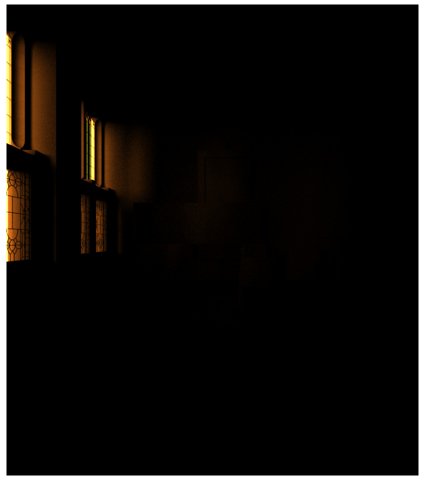
Direct sources
Sun system , Altitude variations

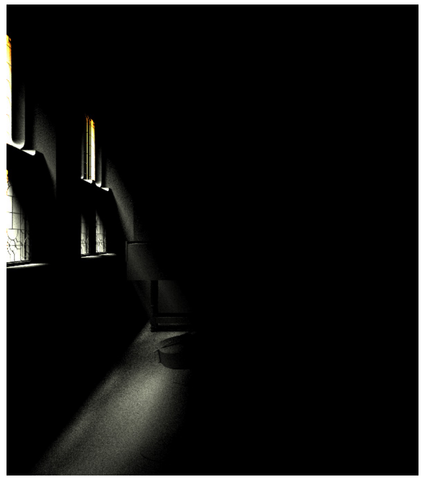
increasing the altitude you change the height of the sun above the horizon. measured in degrees (Sunrise/Sunset = 0° ; Zenith = 90°).

azimuth 184°
altitude 4°

azimuth 184°
altitude 35°

azimuth 184°
altitude 81°





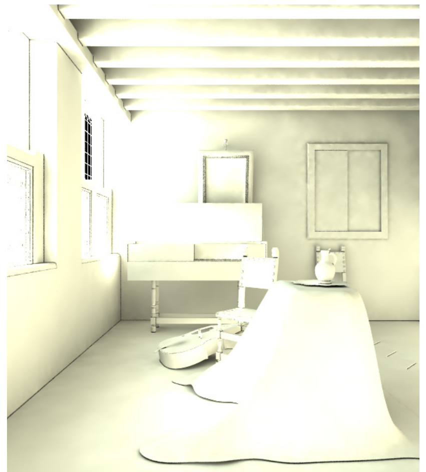
Direct sources
Sun system, Azimuth variations

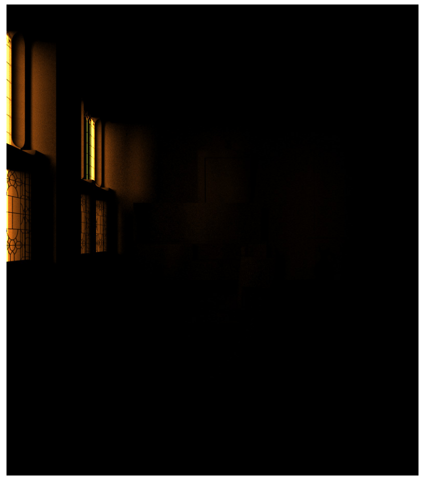
modifies the compass direction of the sun in degrees; it starts from the North (=0°) then East (=90°), South (=180°) and West (=270°).

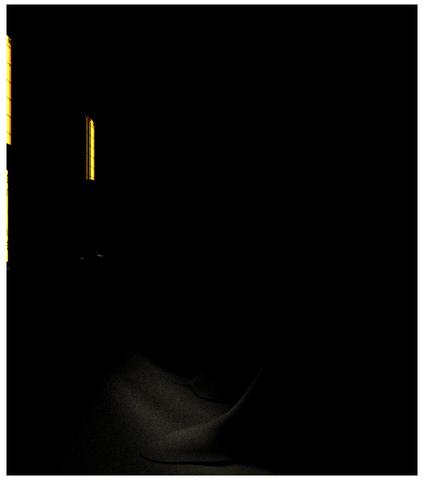
azimuth 184°
altitude 4°

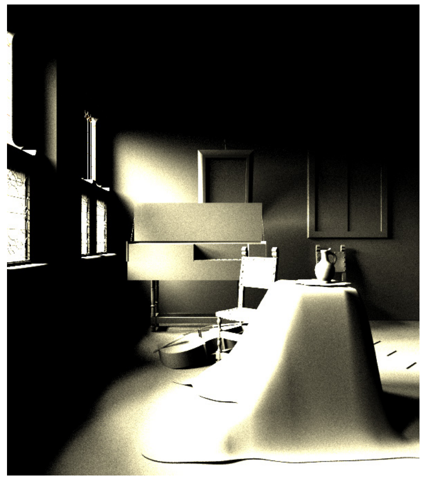
azimuth 0°
altitude 4°

azimuth 270°
altitude 4°









Direct sources
Sun system , Ozone variations

changes the color of the sun itself from a yellowish tone to a slightly blue tone.

As you may notice, in the following images the amount of Ozone doesn't affect much the total light of the scene; this is because the direct light (second raw of images below) is pretty marginal in this render if compared to GI, which of course is not influenced by any Sun parameters.

ozone 0.5

ozone 0

ozone 1

Direct sources
Sun system, Turbidity variations

This parameter changes the amount of dust in the air (haziness). Lower values = clear blue sky (such in the country side) ; Higher values = orangish atmosphere (city).

turbidity 2

turbidity 8

turbidity 20

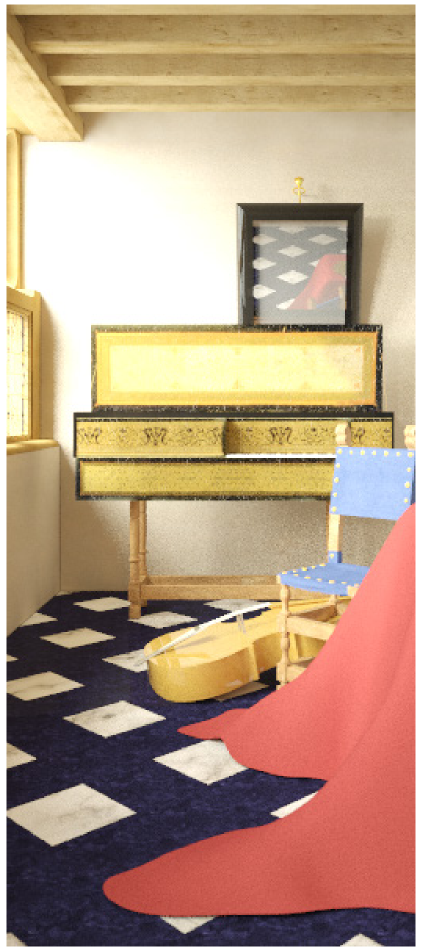
Direct sources
Sun system, Size variations

The Sun's behaviour - just like any other dimensional light source - is affected by the size, with a particular influence of the shadows blurryness. Bigger Sun > blurrier shadows

size 100

size 10

size 1



Shadows

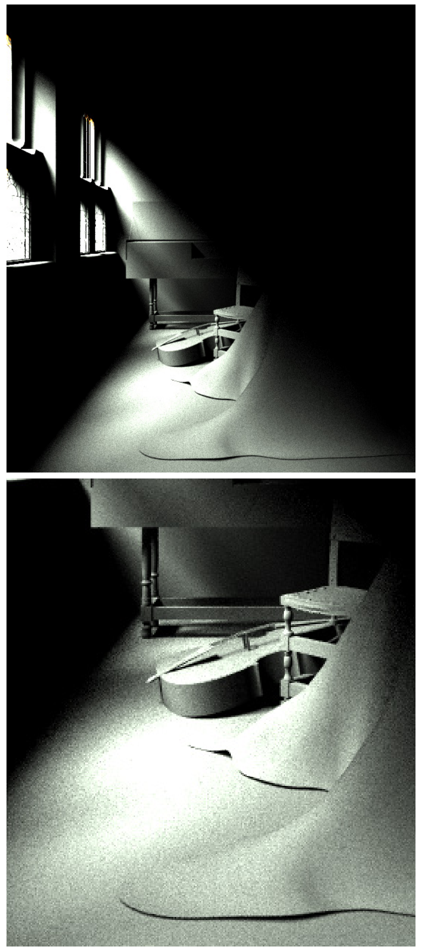
The images in the current page show the noise produced by a different value given to the shadow bias, being it a measure for the maximum amount of samples (rays) that the Render Engine will use to compute the quality of shadows.

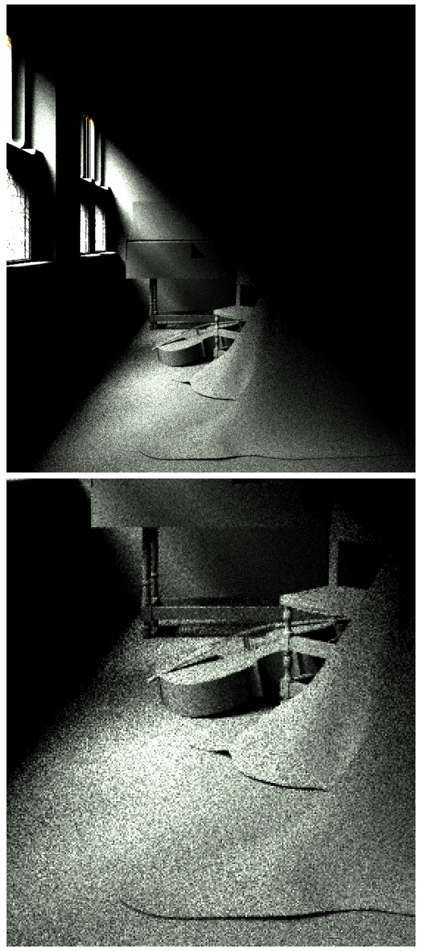
There is not a singular way to control strength, quality or any other feature of shadows, as they are the result of the combination of many variables. Below I listed the main parameters - scattered in the settings menu - you have to care about in order to handle the shadows' appereance.

- *Subdivisions* control the quality of shadows. by default are set to 8: to improve quality (24 is a good value). Higher numbers > better shadows > more time to render. (When set it to 32, you can get the almost perfect shadow without any noise).
- *Radius* for Shadow edge > When using certain light sources, the shadow edge may appear too sharp. To improve it, increase/decrease the Radius under Shadow dialog box.
- *Size* of light sources > Increasing the size of the sun / light source the shadows will be softer (with 1.0 value they may appear crispy).
- *Ambient occlusion shading* they're are actually fake indirect shadows added into the render by rays that get cast out from each surface on your geometry.
- *color* affects shadows' darkness (you can even colorize your shadows) N.B. color is hypersensitive : HSV (0,0,0) = total black; HSV (0,0,1) = blackish OK ; HSV (0,0,5) = overexposed result

shadow bias 40

shadow bias 16





Direct sources, types and parameters

There are two main kinds of direct sources: the sun system (we've just discussed) and the so-called artificial lights.

Each type of light source has specific features and behavior, therefore it's fundamental to understand when using one instead of another. The main ones you can find are:

- Spot light
- Sphere light
- Rectangular light
- Omni light
- IES light
- Point light

[check the chart in appendix F for a comparison among the light types in Vray].

Lighting dialog box

Each light content is different. Other then color, brightness (through the multiplier button) and shadow, each light source also owns other parameters, the main are:

- *Intensity* defines the intensity of light. If managed through *Scalar*, *Luminance*, *Radiance* methods, the intensity of light depends on the size of the light source (of course for dimensional lights); on the other hand, with *Luminous or Radiant Power* systems, the intensity of the light doesn't depend on its size.

- *Decay* manages the behavior of light distancing away from the light source. With *Inverse Square intensity* light decays inversely proportional to the square of the distance from the light (this is the normal behavior of light). *No decay* is unnatural, but can be useful to force a light source to be constant from source to any point in space.

- *Sampling* is needed to control the render quality. *Photon Subdivs* is a parameter which sets the amount of photons of the light source; Lower values may produce some noise, but will speed up the rendering time; Higher values garantee smoother results, of course causing longer rendering time.

- *Shadow bias* controls the offset of shadows; *Bias* shifts the shadow toward or away from the shadow-casting objects. Mind that by setting too low values your shadows can leak, produce moiré patterns or make annoying out-of-place dark areas. On the other hand, too high values let shadows "detach" from the object.

- *Subdivisions* is the main parameter to manage the quality of the shadows. Lower values (i.e. in between 8 and 16) can produce noise (useful for faster render tests); Higher values (i.e. 24/32) will make you shadows smoother (longer time again). Normally, for a final render, I set up the subdivions up to 24.

How to make a abat-jour light

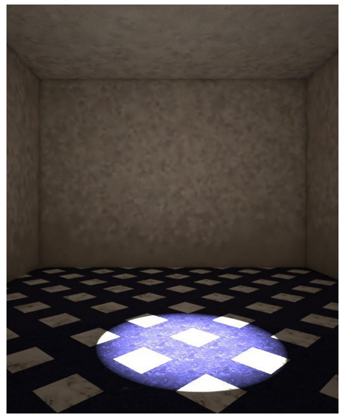
The page on the left shows the Vermeer music lesson with a night environment - the same used for the first lighting variation, so a night enviromental HDRI mapping the sky as main light source - with the introuduction of an artificial light source. Now, the software doesn't know what an abat-jour is, so each time we want to create a particular light we must combine the sources we have in order to mimic its behaviour or - like i did here -to create our own imaginary atmosphere. More specifically, here I created two point lights - one internally, one outside the lamp - with the same intensity; what gives the overall atmosphere this vibe is the *Inverse Square decay* parameter: as mentioned above, with this setting on light decays inversely proportional to the square of the distance from the light, which is the normal behavior of light) in combination with a photon map for secondary bouces (12 bumps).

point light internal lamp : 2000 (square inverse decay; subs 700) | point light external lamp : 2000 (square inverse decay; subs 700) | iso 70, Shutter speed 2, fnumber 16 | Secondary bounces : photon map (12 bounces)

Direct sources, some examples

the image on the left combines an invisible rectangular light - placed on the last window - together with the Sun. The extra light strengthens the shadows, artificially adding a second one as it happens in Vermeer's painting. As mentioned more times, there are several way to reach a certain result, here you have an experimental attempt to intensify an effect difficult to reach with only diffuse light.

Point light
intensity 1000 (scalar)



Spot light

Sphere light
intensity 1.0 (scalar)

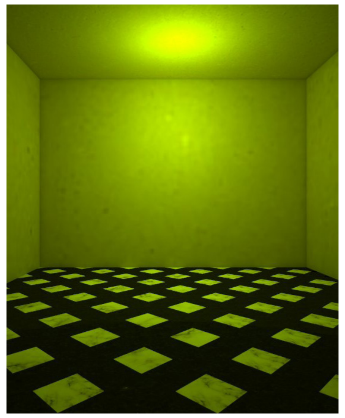
Sphere light
intensity 10 (scalar)

Point light
intensity 10000 (scalar)

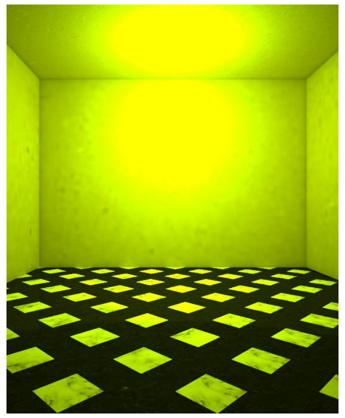
Rectangular light
intensity 10 (scalar)

Rectangular light
intensity 5 (scalar)

Rectangular light
intensity 10 (scalar)



Point light
intensity 10000 (scalar)
charteuse color



Point light
int. 100 W (rad. power)
charteuse color

Rectangular light
intensity 10 (scalar)
invisible + double sided

Rectangular light
intensity 10 (scalar)
invisible

Direct sources
cande light

in the following lines I'll show you how to create a candle light using both lights and materials. First of all you need the image of a candle fire, like the one I attach here on the right.

creation of the emissive flame

1. create rectangular surface (same size of flame.jpg, fig.2)
2. create a new material : new standard material > add emissive layer: use as map (flame.jpg, fig.2) ; use as transparency map (flame_ black&white.jpg, fig.3). Here I used as emissive power a value of 10. Enable double sided and remove diffuse layer
3. add a point light behind the flame (in this case I used a candle with intensity 1.5)

creation of the glossy candle (When you light a candle the wax itself reflects the light inside and appear to glow)

1. new twosided material : both front and back based on diffuse white material, change the 'Val' number to 70 ('Hue' and 'Sat' = 0).
2. create a point light and place it within the candle (in this case I set the intensity to 10).

So, when it's about the light elements, we actually need:

- point light within candle:1.5
- point light behind flame : 10
- emissive power of flame : 10

As you can see in the image here above, a pure rendering baked from Vray for Rhino, no post-production was really needed to create this light. This result coudn't be reached with Photoshop, specially when it's about the shadows, the reflections on the surrounding elements.

fig.2 : flame.jpg

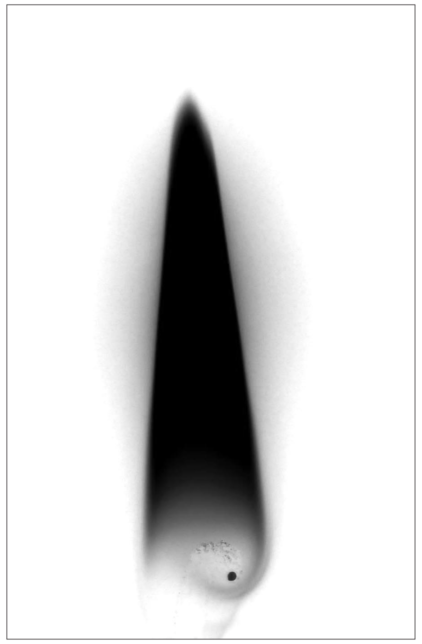


fig.3 : flame_black&white.jpg

Reaction to light
Exposure

In photography, exposure is the amount of light per unit area reaching a photographic film or electronic image sensor, as determined by three aspects :

- *Film speed (ISO)*

the sensitivity of the film/ sensor. This parameter determines the sensitivity of the film and so the brightness of the image. If the film speed (ISO) is high (film is more sensitive to the light), the image is brighter. Lower ISO values mean that the film is less sensitive and produces a darker image. The ISO values have a linear relationship (which is not the case with both aperture and shutter speed).

- *F-number*

the size of the opening that allows light to pass to the film or sensor. This parameter controls the aperture size of the camera. Lowering the f-number value increases the aperture size and so makes the image brighter, since more light enters the camera. In reverse, increasing the f-number makes the image darker, as the aperture is closed.

- *Shutter speed*

the amount of time that the light is allowed to affect the sensor. This parameter expresses the exposure time in which the light is allowed to affect the sensor of the Physical camera. The parameter expresses itself as 1/x (a value of 10 = a shutter speed of 1/10 of a second). Therefore a larger value actually means that the shutter speed is faster, and that will translate to a darker image.

ISO 140
F-number 16
Shutter speed 0.016

ISO 90
F-number 22
Shutter speed 1

ISO 90
F-number 16
Shutter speed 0.5

ISO 140
F-number 45
Shutter speed 0.125

ISO 140
F-number 22
Shutter speed 0.033

ISO 140
F-number 45
Shutter speed 0.125

Exposure, ISO

ISO 120
ISO 200

Exposure, F number

F NUMBER 22
F NUMBER 16

Exposure, Shutter Speed

SHUTTER SPEED 0.5
SHUTTER SPEED 0.016

FILM SPEED (ISO)

the sensitivity of the film/sensor

larger ISO

↓

greater sensitivity to light.

↓

brighter result

ISO 200

ISO 120

F-NUMBER

the size of the opening that allows light to pass to the film or sensor.

Smaller values

↓

larger opening, more light

↓

brighter result

f-number 16

f-number 8

SHUTTER SPEED

the amount of time that the light is allowed to affect the sensor.

Longer amount of time

↓

more light allowed

↓

brighter result.

shutter speed 1

shutter speed 0.125

APPENDIX A
correct exposure

EV	*f*-number												
	1.0	1.4	2.0	2.8	4.0	5.6	8.0	11	16	22	32	45	64
−6	60	2 m	4 m	8 m	16 m	32 m	64 m	128 m	256 m	512 m	1024 m	2048 m	4096 m
−5	30	60	2 m	4 m	8 m	16 m	32 m	64 m	128 m	256 m	512 m	1024 m	2048 m
−4	15	30	60	2 m	4 m	8 m	16 m	32 m	64 m	128 m	256 m	512 m	1024 m
−3	8	15	30	60	2 m	4 m	8 m	16 m	32 m	64 m	128 m	256 m	512 m
−2	4	8	15	30	60	2 m	4 m	8 m	16 m	32 m	64 m	128 m	256 m
−1	2	4	8	15	30	60	2 m	4 m	8 m	16 m	32 m	64 m	128 m
0	1	2	4	8	15	30	60	2 m	4 m	8 m	16 m	32 m	64 m
1	1/2	1	2	4	8	15	30	60	2 m	4 m	8 m	16 m	32 m
2	1/4	1/2	1	2	4	8	15	30	60	2 m	4 m	8 m	16 m
3	1/8	1/4	1/2	1	2	4	8	15	30	60	2 m	4 m	8 m
4	1/15	1/8	1/4	1/2	1	2	4	8	15	30	60	2 m	4 m
5	1/30	1/15	1/8	1/4	1/2	1	2	4	8	15	30	60	2 m
6	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8	15	30	60
7	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8	15	30
8	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8	15
9	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4	8
10	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2	4
11	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2
12	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1
13	1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2
14		1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4
15			1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8
16				1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15
17					1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30
18						1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60
19							1/8000	1/4000	1/2000	1/1000	1/500	1/250	1/125
20								1/8000	1/4000	1/2000	1/1000	1/500	1/250
21									1/8000	1/4000	1/2000	1/1000	1/500
EV	1.0	1.4	2.0	2.8	4.0	5.6	8.0	11	16	22	32	45	64
	f-number												

EV = ISO (values 1/100)

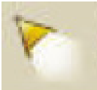
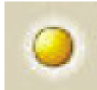
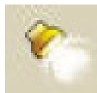
The first chart shows the right Exposure time (Shutter Speed, in seconds "s" or minutes "m"), for various Exposure Values (EV = Film Speed = ISO) and aperture size of the camera (f-speed).

The second chart shows the proper exposure value to set according to a specific environmental condition, such as weather and scenery (indoor, outdoor, ...)

Those two charts are extremely useful, since these are constant, fixed values: a given aperture/shutter speed combination will always result in the same EV. Always.

source 1
source 2

Lighting Condition	EV_{100}
Daylight	
Light sand or snow in full or slightly hazy sunlight (distinct shadows)[a]	16
Typical scene in full or slightly hazy sunlight (distinct shadows)[a, b]	15
Typical scene in hazy sunlight (soft shadows)	14
Typical scene, cloudy bright (no shadows)	13
Typical scene, heavy overcast	12
Areas in open shade, clear sunlight	12
Outdoor, Natural light	
Rainbows	
Clear sky background	15
Cloudy sky background	14
Sunsets and skylines	
Just before sunset	12–14
At sunset	12
Just after sunset	9–11
The Moon,[c] altitude > 40°	
Full	15
Gibbous	14
Quarter	13
Crescent	12
Moonlight, Moon altitude > 40°	
Full	−3 to −2
Gibbous	−4
Quarter	−6
Aurora borealis and australis	
Bright	−4 to −3
Medium	−6 to −5
Milky Way galactic center	−11 to −9
Outdoor, Artificial Light	
Neon and other bright signs	9–10
Night sports	9
Fires and burning buildings	9
Bright street scenes	8
Night street scenes and window displays	7–8
Night vehicle traffic	5
Fairs and amusement parks	7
Christmas tree lights	4–5
Floodlit buildings, monuments, and fountains	3–5
Distant views of lighted buildings	2
Indoor, Artificial Light	
Galleries	8–11
Sports events, stage shows, and the like	8–9
Circuses, floodlit	8
Ice shows, floodlit	9
Offices and work areas	7–8
Home interiors	5–7
Christmas tree lights	4–5

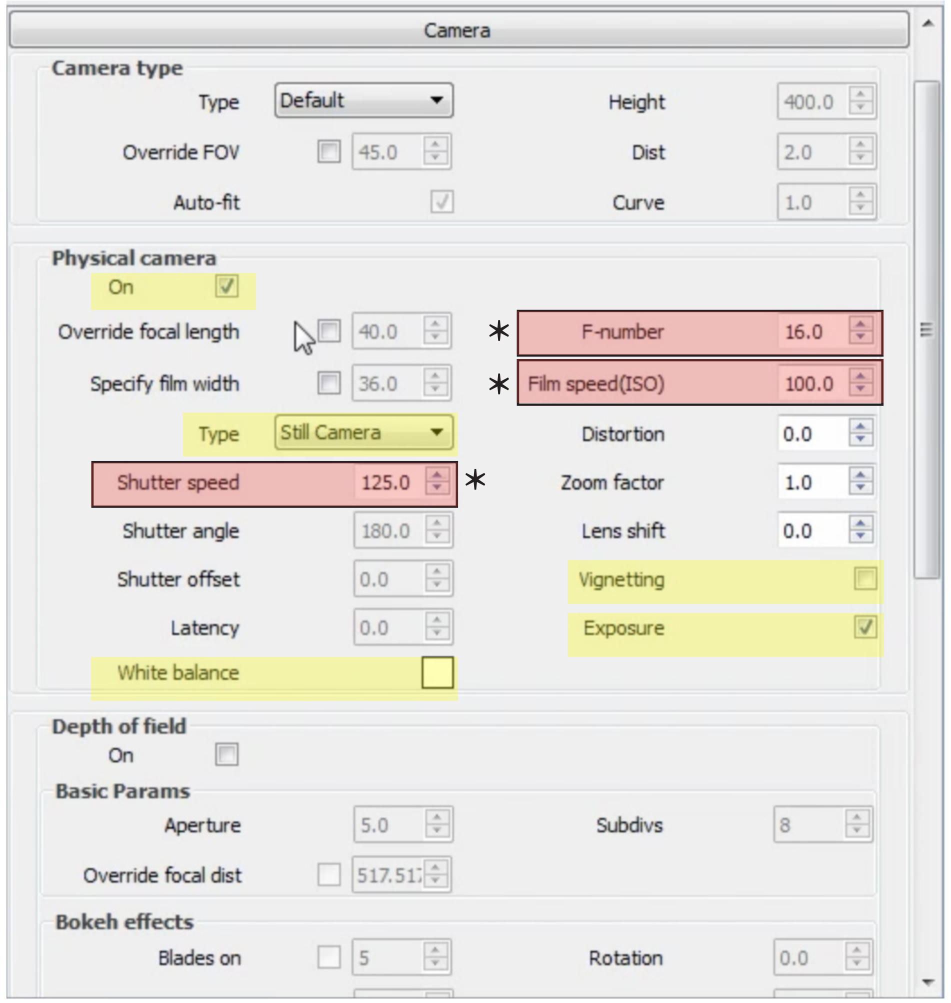
      

SPOT	SPHERE	RECTANGULAR	OMNI	IES	DIRECTIONAL	POINT	LIGHT / PARAMETERS
=	=	=	=	=	=	=	INTENSITY
linear inverse inverse sq penumbre falloff	on / off	on / off	linear inverse inverse sq	on / off	-	linear inverse inverse sq	DECAY
area spec legacy	affect reflections	affect reflections	-	area spec	-	-	AREA
=	=	=	=	=	=	=	SAMPLING
bias radius subdivs color	bias color	bias color	bias radius subdivs color	soft color bias subdivs	radius color bias subdivs	radius color bias subdivs	SHADOWS
more	more	more	more	more	more		about

allows the camera's reaction to light to mimic what a camera would do in the real world > much more natural reaction to light + control over the lighting of your scene.

- *Physical camera*: ALWAYS ON (if OFF nothing works)
- *Type*: Use still camera for rendering an image. The other two, cinematic and video, are for animations.
- *White Balance*: useful to compensate the color of the sun light in certain conditions. (always better to leave it pure white and fix the white balance in post).
- *Exposure*: ALWAYS ON (if OFF nothing works)
- *Vignetting*: produces a smooth dark effect around the image (better to do it in post).

*** these are the three aspects that dictate the resulting affect of the light.



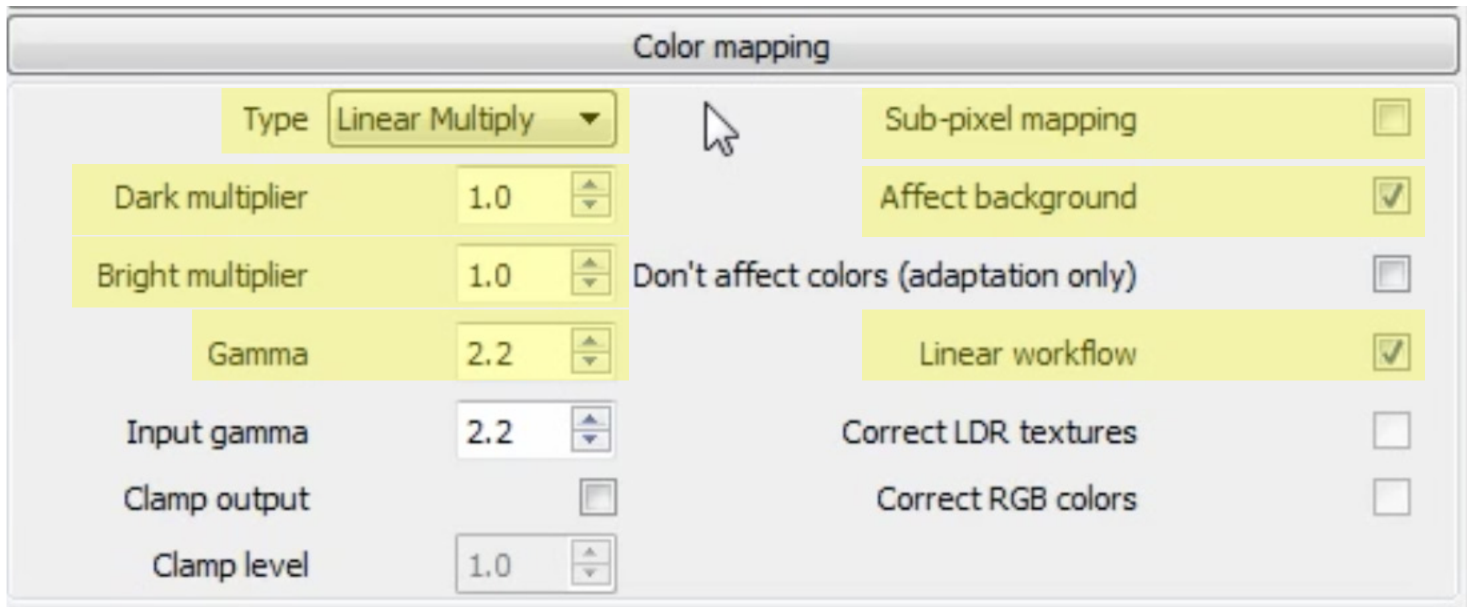
It adjusts how color are displayed. When Vray determines a color value for a given pixel this value is then interpreted based on the type of mappings in use.

Types of Color Mapping

- *Reinhard* is a blend between Exponential Mapping and Linear Mapping. (The result is linear mapping when the Burn value is 1.0; and when the is 0.0, the result is Exponential Mapping.)
- *Linear Multiply* the color will not be changed from the generated value to the displayed value (the best one, it allows to include the whole color spectrum)
- Exponential, HSV Exponential, Intensity Exponential change color intensity to avoid brightness troubleshoot.

Parameters

- *Dark & Bright multiplier* : leave it to 1.0 (no surprises).
- *Gamma Correction* : bug > set it to 2.2.
- *Sub pixel mapping* : ON when you see white dots in the image
- *Affect background + Linear workflow* : ON (so anything happening in the rendering in fact of color correction happens in surroundings too)



APPENDIX C
Vray settings, Image Sampler

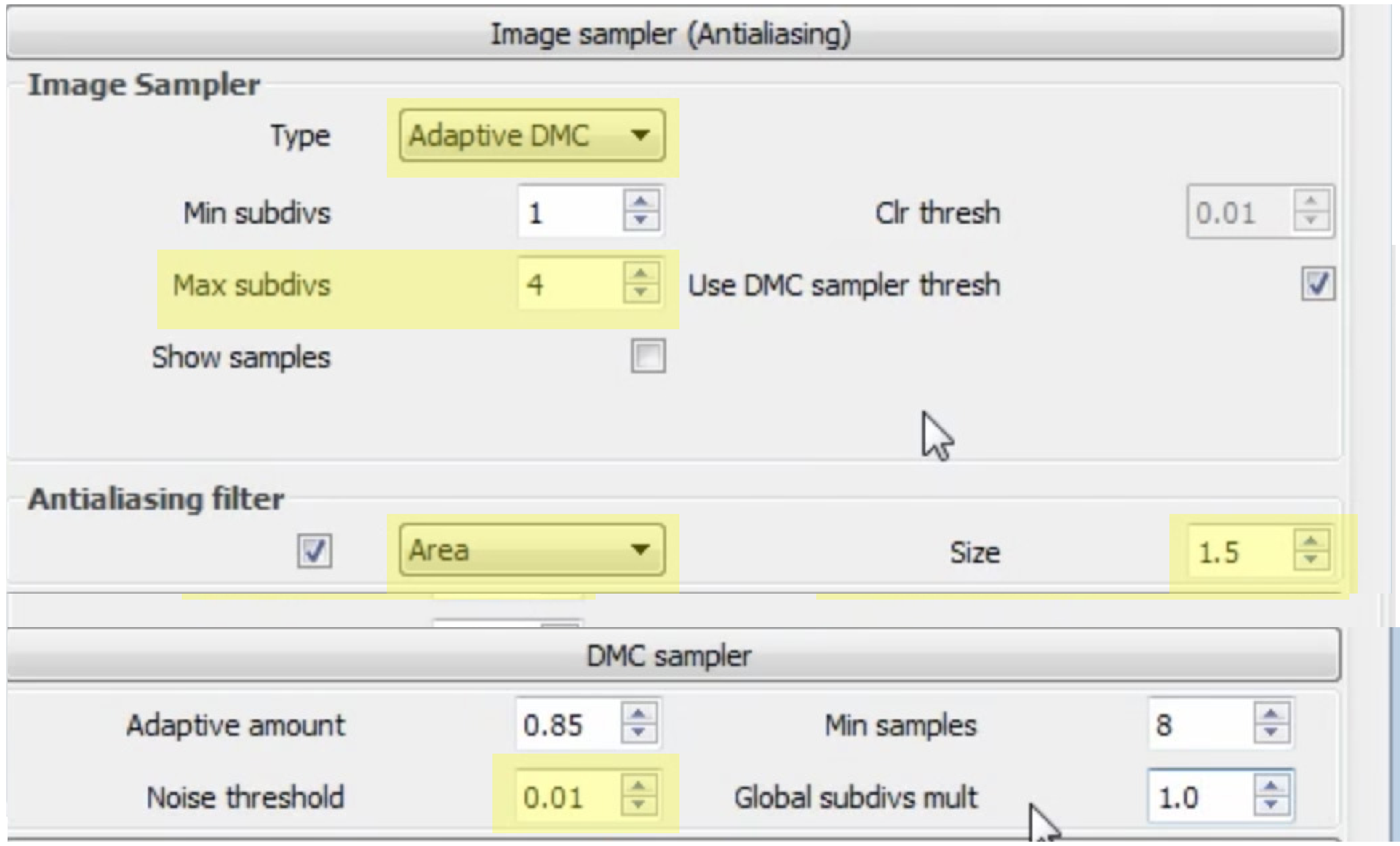
Has to do with blurriness, in particular how Pixels' edges blur into each other.

You're not able to perceive it when the image is very big (many pixels > small effect), therefore you can switch it off and save time.

- *Antialiasing filter* : *Area* is ok > set size to 1.5 (which means the infos containes in one sq pixel will blur into 1/2 of the nearby pixels).

Type :

- *Adaptive DMC* : the most accurate method of light calculation in Vray > useful for scenes with a lot of small details > longer time to render.
- *Adaptive subdivisions* : quicker (N.B. you may have RAM problems)
- *Fixed Rate* : very good but extremely slow



APPENDIX D
terminology

Some rendering vocabulary

- *Area Lights*

Area light is a term describing a non-point light source. These types of light sources produce area shadows.

- *Area Shadows (Soft Shadows)*

Area shadows are blurred shadows (or shadows with blurred edges) that are caused by non-point light sources (Area lights).

- *HDRI (High Dynamic Range Image)*

A High Dynamic Range Image is an image containing high-dynamic range colors (with components exceeding the range 0.0-1.0, or 0-255). This type of images is often used as an environment map to light the scene with natural light.

- *Importance Sampling*

Importance sampling is a technique for basing the number of samples required for evaluating a blurry value, on the effect that value has on the final result. For example, dark materials require fewer samples for evaluating GI than bright materials; dim area lights can do with less samples than bright lights etc.

- *Irradiance Map*

The irradiance map is a special cache where Vray keeps precalculated GI samples. During the rendering process when Vray needs a particular GI sample it computes it by interpolating the nearest precalculated GI samples stored in the irradiance map. Once computed, the Irradiance map can be saved in a file and reused in subsequent renderings. This can be especially useful for camera fly-through animations.

- *(Quasi) Monte Carlo Sampling*

Monte Carlo sampling is a method for numerical computation of integrals of functions by evaluating these functions at a number of random points. Quasi Monte Carlo sampling is a modification of this method, which instead of randomly generated points uses points forming a low-discrepancy sequence, which are more evenly distributed than purely random ones. This is the method used to evaluate complex things like global illumination, blurry reflections, depth of field, motion blur and image anti aliasing.

- *Photon, Photon Map*

This is a simulation of a real world photons (a photon is a light particle). In order to produce caustics effects Vray traces certain amount of photons that come out of the light sources. Then the results are stored in a photon map and used during the rendering process so that highly realistic caustic effects are produced.

- *Subdivs (Subdivisions)*

a measure for the maximum amount of samples (rays) that Vray will use to compute a certain value. The maximum number of samples is proportional to the square of the subdivs value. For example, if the subdivs value of a glossy reflection is 5, Vray will never make more than 5 x 5 = 25 samples to evaluate the reflection.

- *Cutoff Threshold*

specifies a threshold limit for the light intensity, N.B. Below this value the light source will not be computed; useful in scenes with many lights, where you want to limit the effect of the lights to some distance around them. Larger values cut away more from the light; lower values make the light range larger.

Lighting Units

- *Default (scalar)*

- color + multiplier determine the visible color of the light without any conversion. The light surface will appear with the given color in the final image when seen directly by the camera.

- *Luminous power (lm)*

- total emitted visible light power measured in lumen. When ON, the intensity of the light will not depend on its size. (I.e. A typical 100W incandescent light bulb emits about 1500 lumen of light.)

- *Luminance (lm/m2/sr)*

- visible light surface power measured in lumen per square meter per steradian. When ON, the intensity of the light depends on its size.

- *Radiant power (W) -*

total emitted visible light power measured in watts. When ON, the intensity of the light does not depend on its size.

- *Radiance (W/m²/sr) -*

visible light surface power measured in watts per square meter per steradian. When this setting is used, the intensity of the light depends on its size.

Decay

Decay controls the behavior of the light intensity from the distance of the light source. Normally the light intensity is inversely proportional to the square of the distance from the light (surfaces that are farther from the light are darker than surfaces which are closer to the light). The possible values are:

- *Linear*

the intensity doesn't decay with distance.

- *Inverse Square*

intensity decays inversely proportional to the square of the distance from the light. (This is the normal behavior of light.)

- *Penumbra Falloff*

determines the transition from full strength to no lighting inside the light cone.

- *Affect diffuse/specular*

determines if the light is affecting the diffuse/reflective properties of the materials.

- *Area Specular*

When Off the particular light will be rendered as a point light in the specular reflections.