

# Using HDR Panoramas

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## Introduction

The LightLab project attempts to improve the integration of technology into design education via the medium of light. The final stage of this integration involves two distinct approaches: combining lighting data with visual design and numerical analysis with conventional design software.

The first is accomplished by the use of the produced HDR panoramas as lighting sources within 3D design software for final visual rendering. Fortunately, almost all 3D design suites can simply and easily accept HDR panoramas as lighting sources, and the next section details on-line resources for many of the common 3D packages. The University of Brighton, School of Architecture & Design primarily uses two 3D creation suites: Cinema4D and Blender, and this document also details the use of HDR panoramas in these two packages.

Numerical analysis is achieved by the use of the Lighting Visualiser (*LiVi*) scripts, written by the project co-ordinator, Dr Ryan Southall, that sit within Blender's interface and communicate with the Radiance lighting simulation suite. Results of the lighting analysis are then brought back into Blender for visualisation. The *LiVi* scripts are available in the Resources section of this web portal and their use is described in this document.

This document uses the same figure referencing convention as the other documents on this website; the first character within square brackets refers to the figure number, and the second to the labelled element of the image.

## Resources for Common 3D packages

Almost all the common 3D creation suites now have the capability to load HDR panoramas as lighting sources for virtual scenes. HDR panoramas come in two main geometric formats: angular/light probe and polar/latitude-longitude, and image format OpenEXR(.exr) and Radiance RGBE (.hdr). Hugin can create both geometric types (see the Creating HDR document) or both types of format can be converted between each other by using the projective transformation/file save capabilities of Luminance-hdr (<http://qtpfsgui.sourceforge.net>). The formats accepted by common 3D packages is shown in table 1.

Program	Version	Renderer	Geomterirc format	Image format
3D Studio Max	2009	Native	Lat-Long	hdr/exr
		V-Ray	Angular/Lat-Long	hdr/exr
		Mental Ray	Angular/Lat-Long	hdr/exr
Maya	2011	Native	Angular/Lat-Long	hdr/exr
		Mental Ray	Angular/Lat-Long	hdr/exr
	8.5	Native	Lat/Long	hdr
Lightwave	8	Native	Angular/Lat-Long	hdr/exr

Table 1: Accepted panorama formats

## 3D Studio Max

- With native renderer
  - <http://www.bluesfear.com/submittuts/3d/3/index.php>

- With V-Ray renderer
  - [http://www.zwischendrinn.com/tutorials/hdr\\_scene\\_setup\\_tutorial.pdf](http://www.zwischendrinn.com/tutorials/hdr_scene_setup_tutorial.pdf)
- With Mental Ray renderer
  - <http://www.youtube.com/watch?v=wiaS9tc9kaQ>
  - <http://www.tutorialblogger.info/hdri-in-mental-ray-for-3d-studio-max-tutorial/>

## Maya

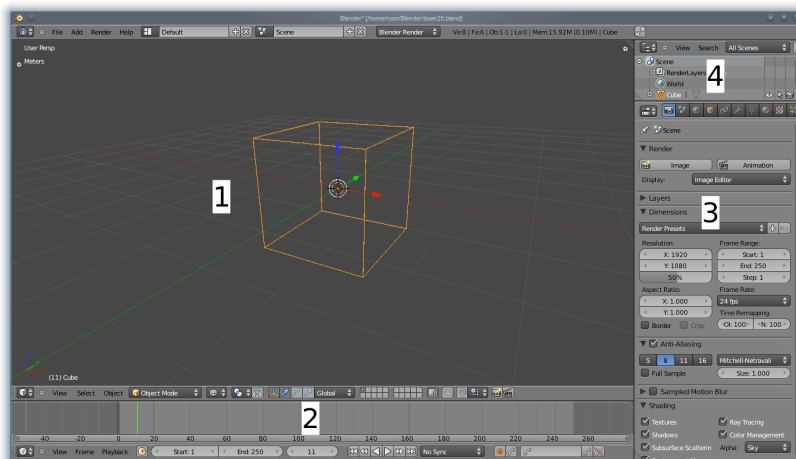
- With native renderer
  - <http://www.youtube.com/watch?v=ytvaBWqowck&feature=related>
- With Mental Ray
  - <http://www.youtube.com/watch?v=tmnZsspvmE>
  - <http://www.youtube.com/watch?v=P4H860st09M&feature=related>

## Detailed Visual Workflow

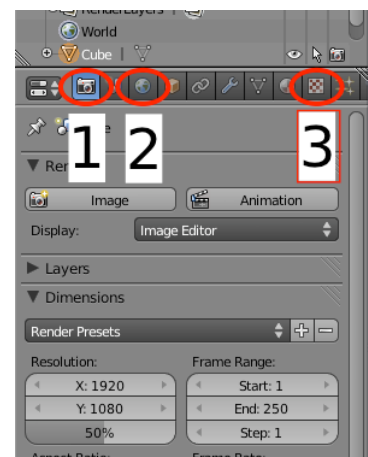
### Blender

This tutorial uses version 2.57 of Blender, although the workflow should be the same or similar for later versions including the 2.6 release. Blender is a free and multi-platform 3D suite and is available from the *Blender* website. Many on-line resources and tutorials are available describing how to use various aspects of Blender, one of the most complete being the Blender Basics 4th edition book available from this link. The user would be expected to be familiar with the basics of using Blender before following the workflow presented beneath.

Upon starting Blender a screen similar that shown in figure 1a should be displayed with the main 3D View [1a.1], animation timeline below [1a.2], properties panel on the right [1a.3] and outliner in the upper right corner [1a.4] all visible. It is the 'Render' [1b.1], 'World' [1b.2] and 'Texture' [1b.3] tabs within the properties panel that will be used the most to enable HDR lighting.



(a) Main Blender interface



(b) Properties panel

Figure 1: Blender interface

To set up an HDR panorama as an illumination source first make sure any lights have been deleted as the HDR file supplies all the lighting for the scene, then click on the 'World' tab followed by the 'Texture' tab.

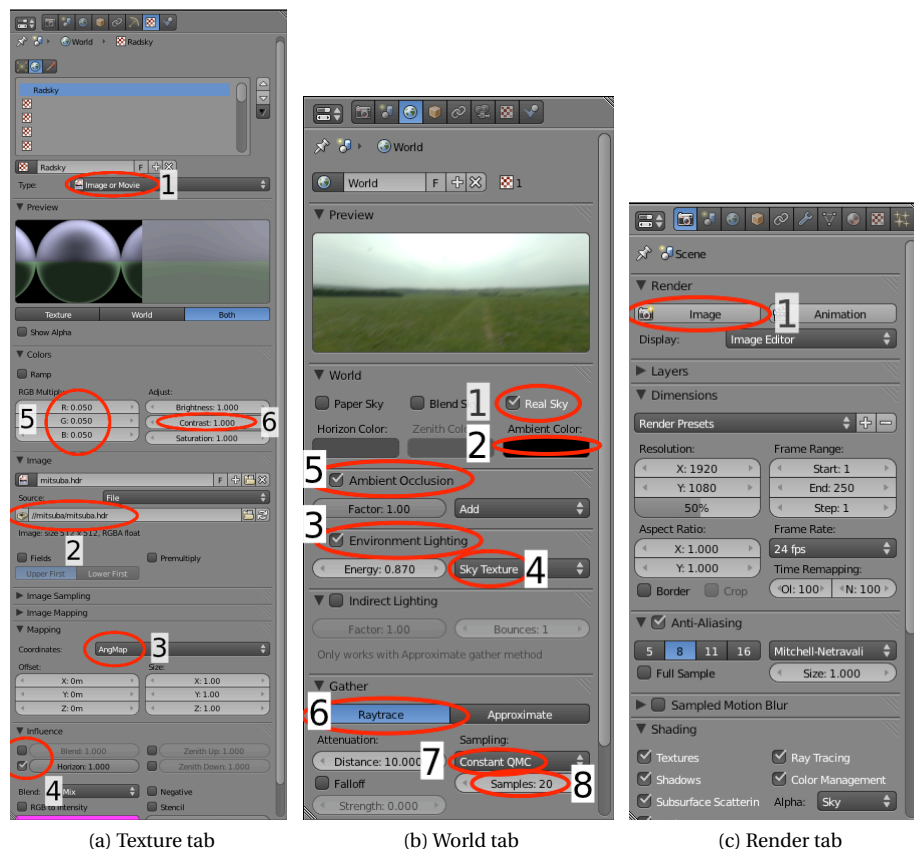


Figure 2: Blender tabs

Here a texture can be selected for the world background. If no textures have been created previously an empty list of textures should be visible. Click on 'New' and change the type from 'Clouds' to 'Image or Movie' [2a.1]. In the 'Image' section navigate to the HDR file [2a.2] which must be in angular or light-probe format, although it can be in either and exr or hdr file. In the 'Mapping' section for 'Co-ordinates' select 'AngMap' [2a.3] and in the 'Influence' section deselect 'Blend' and select 'Horizon' [2a.4]. In the preview window at the top of the texture tab is a display of the hdr image. If it is all white go into the 'Colours' section and turn down the rgb colours [2a.5]. A value of 0.001 for each is usually fine. While here turn up the contrast value to 5 [2a.6]. Now go to the 'World' tab and in the 'World' section select 'Real Sky' [2b.1] and make sure 'Ambient Colour' [2b.2] is black. Activate the 'Environment Lighting' section [2b.3], and here select 'Sky Texture' [2b.4], and 'Ambient Occlusion' section [2b.5]. In the 'Gather' section make sure 'Raytrace' [2b.6] is selected and 'Constant QMC' [2b.7] is selected under 'Sampling'. The number of samples [2b.8] selected controls the quality of the final render; higher is better. The 3D scene to be illuminated can be brought in to Blender from another package or created within Blender from scratch. Once the geometry and camera is in place, and the desired material characteristics have been defined, go to the 'Render' tab and click on the 'Image' button [2c.1] in the 'Render' section to render the scene.



Figure 3: Final Render

## Cinema4D

To use HDR panoramas in Cinema4D as a lighting source a sky needs to be created. A material needs to be associated with the sky, and the material in turn needs to have an image texture applied to it which is the HDR image. Like Blender, Cinema4D accepts angular format panoramas in either OpenEXR (.exr) or Radiance (.hdr) format. First create a sky with the 'Light' menu at the top of the screen (figure 4.1). Once a sky has been created a sky material will automatically be created and associated with it. This material will be visible in the bottom left of the main screen ((figure 4.2). Double click on this material, or go to the 'File' - 'Edit material' menu entry above, to edit it.

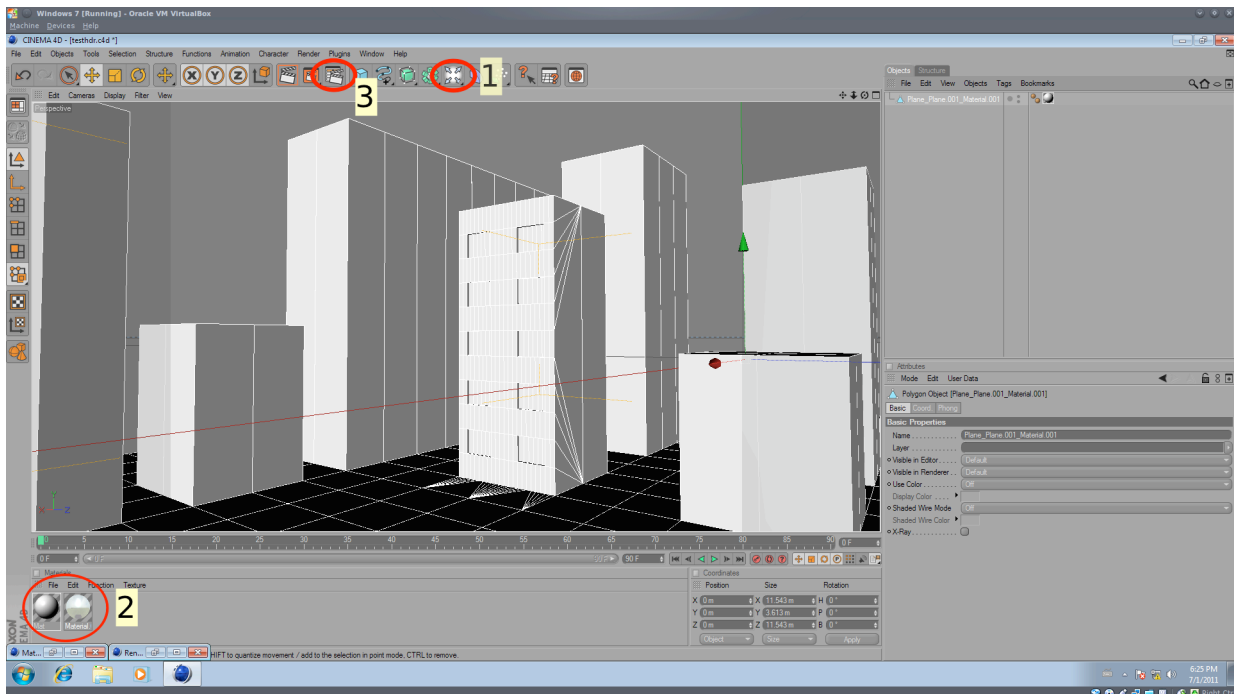


Figure 4: Cinema 4D interface

The material edit dialogue box shows a list of characteristics that the material can have. As we are using this material as a source of illumination, only the luminance item in the list should be selected. With the luminance

section open select the angular format HDR file with the file open dialogue (5a.2). If the image appears too dark or too light modify the brightness (5a.3) and and mix strength (5a.4) until it looks correct.

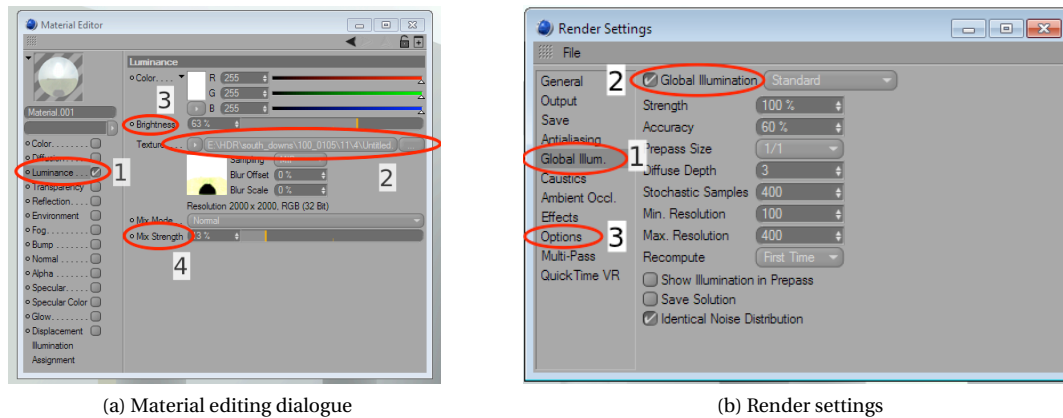


Figure 5: Cinema 4D settings

Open the render settings dialogue by clicking the button in the toolbar (4.3). In the list of render parameters select global illumination (5b.1) and tick the checkbox at the top of the displayed settings panel (5b.2). Good example values for the other global illumination settings are also shown in figure 5b. Enter the options (5b.3) settings panel and de-select 'Autolight'. Always disable 'Autolight' when using HDR illumination sources.

The final render in Cinema 4D with the above settings is shown below in figure 6.



Figure 6: Cinema 4D final render

## Numerical analysis

### Introduction & Installation

To enable easier numerical analysis of lighting levels delivered by HDR, or other, skies a set of Python scripts have been written collectively called the Lighting Visualiser (*LiVi*). The *LiVi* scripts are loaded into Blender where they create additional menus that control the export of scene geometry, calculation and display of results for the lighting simulation suite *Radiance*. *Radiance* is a command line set of tools that, for the beginner, are not easy to use, and it's use in architectural education contexts has been shown to be problematic. The *LiVi* scripts therefore represent a useful tool for the simplification of numerical lighting analysis with *Radiance*.

The *LiVi* scripts are available as a zip file from the Resources section of the HIDE web portal, but are at this time limited to mac OS X platform. The *LiVi* zip file also contains the Blender and *Radiance* programs within one folder called blender-26. Simply copy this folder to the main mac 'Applications' folder to install.

## Installation

The *LiVi* scripts have been ported to the latest version of *Blender*. A zip archive for Mac OS X (10.6 & 10.6) is available from Resources section of the HIDE web portal that contains *Blender*, *LiVi*, and the *Radiance* lighting simulation suite. Once downloaded place the whole directory within the zip file, currently called blender-26, into the Mac 'Applications' folder. Blender can then either be started by clicking on the Blender icon within the directory, or for convenience, dragging it onto the dock.

## Interface

Upon starting Blender an interface screen like the one in Figure 1a should be displayed. The 3D view is the main window, with the properties panels on the right and the animation time-line below. Shown in Figure 1 is the material tab within the properties panels. It is within this tab that the material definitions are set.

Initially go to 'File' - 'User Preferences' to change some of the default settings. By default objects in Blender are selected by right clicking on them, whilst left click positions the 3D cursor and the middle mouse button rotates around the scene. If left click select is preferred then in the user preferences dialogue select the 'Input' tab and on the left will be a 'Select With' option which can be changed to 'Left'. If *Blender* is installed on a laptop with no numpad selecting the 'Emulate Numpad' option just below this will make 1, 3, 7 and 0 the front, side, top and camera views respectively. In the 'Interface tab' 'Auto Depth', 'Zoom to Mouse position', 'Rotate Around Selection' and 'Auto Perspective' can also be selected. Now select the 'Add-ons' tab at the top. In the list of add-ons available in the Import-Export section is a listing for the Lighting Visualiser (*LiVi*). Other import-export formats that can be activated are also here, so choose also the format of any geometry that will be imported into *Blender*. Tick the box next to the *LiVi*, and any other, entries and then click 'Set as default' at the bottom of the window. With the cursor in the 3D view of the main *Blender* application screen hit the 'n' key to toggle the view panel on the right of the 3D view. At the bottom of this view panel sits the *LiVi* interface. It is also a good idea to press 't' to toggle the tools panel on the left of the 3D view area. Figure 7 shows the *Blender* interface with the tools menu, *LiVi* control panel and the material tab selected in the properties window.

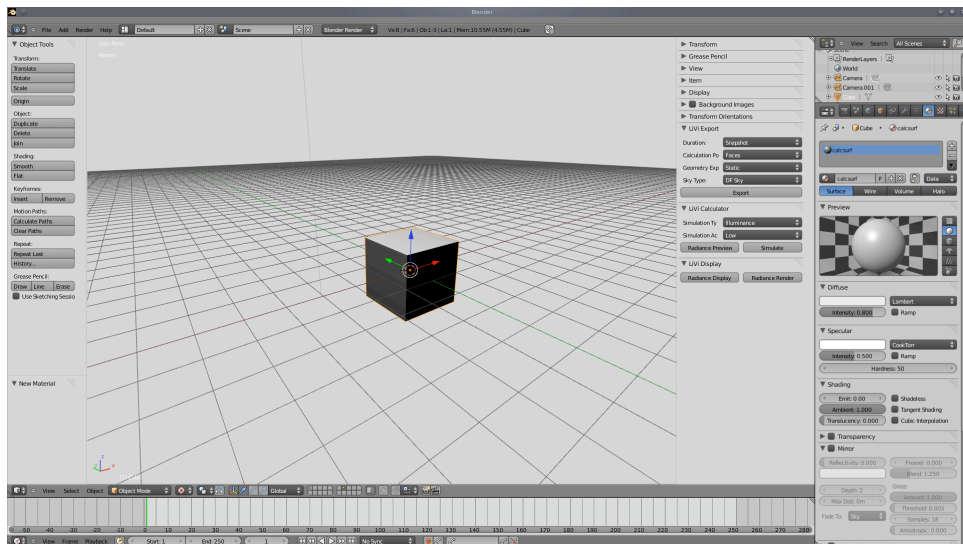


Figure 7: Modified Blender Interface

The *LiVi* interface is split into three sections: *LiVi* Export, *LiVi* Calculation and *LiVi* Display shown in figure 8.

The analysis process works from top to bottom: export, simulate and finally display. In the export panel we have the option to set the time duration of the simulation (currently only snapshot works). Set whether the vertices or faces of our sensing geometry are to act as the sensing points (faces is a good default), whether our geometry is static or animated (currently only static works), and the type of sky. Below these options is the export button.

Once we have exported we can select the type of metric to be evaluated and the level of simulation accuracy. Below these options are buttons to preview the scene from the cameras perspective with Radiance directly and run the simulation.

Once a simulation has been run we can display the results in the 3D view with the 'Radiance Display' button. To see the results on the calculation geometry the geometry has to be selected in the 3D view and 'Vertex Paint' mode selected at the bottom of the 3D view (where the object and edit mode drop down menu is). 'Vertex Paint' mode can also be toggled with the 'v' key. If a number of simulations are carried out the legend may become unclear as they are overwritten. Press 'F7' to clear the legend before pressing 'Radiance Display' button again.



Figure 8: *LiVi* interface panels

## Usage

### External geometry

If bringing in geometry from another program then in the main 'File - Import' menu item entries for the file formats activated in the user preferences should be available. Pick the correct file format and navigate to the file you want to import. File formats like wavefront OBJ and 3DS are good as they maintain some level of object data from the previous program. It is important that objects with different materials are designated as separate objects with different materials in the original program so that the material characteristics for the separate objects in Blender can be changed individually.

Another point to remember is that positive y is North, and positive z is up, so rotate model appropriately.

Once the geometry has been imported it should appear in the 3D view. If not then the scale of the object might be an issue so press '.' on the numpad of the keyboard to centre in on the new geometry.

### Materials

For a simulation to take place a number of things are required to be exported. Most importantly at least one object must have a material with 'calcsurf' in it's name. The material can be called 'calsurf1', 'tablecalcsurf' etc as long as 'calcsurf' is in the name somewhere. The object itself can be existing geometry or geometry created specifically to be calculation points. If creating specific geometry a 2D plane, with a number of faces within it, is usually fine. Results are only per face so more faces means finer results. To create this plane in Blender press 'shift - A' in the 3D view in object mode. A menu will appear where you can add a 'Mesh - Plane'. Once created the plane can be scaled, press 's', moved, press 'g' or rotated press 'r'. Refer to a wealth of information on the Internet about Blender object manipulation for further details. The plane should not be hidden by existing geometry so if, for example, sensing lighting values near the floor the plane should be just above the existing floor surface. Once the plane is in the desired place press 'tab' to go into edit mode and press 'w' to subdivide the plane to give as many sensor points as required. The number of subdivisions is controlled at the bottom of the tools menu which can be toggled on the left of the 3D view by pressing 't'. Press 'tab' again to leave edit mode when done.



Definition of materials is done in the materials tab, located to the left of the texture tab (1b.3). The tab itself is shown in figure 9.

If material definitions have come in from an imported 3ds or OBJ file format then a list of materials should be available already associated with objects in the scene. These imported materials should have the approximate colour characteristics of the original materials, but specular or any texturing are likely to be lost. You can see this list of project materials by selecting the sphere icon to the left of the material name (9.9). By selecting objects in the 3D view a live preview of the associated material should appear in the materials tab. Most of the settings in the materials tab are self explanatory and any changes required to correct the material back to its original characteristics should be made here. These material settings are also translated into material definitions that *Radiance* can understand when the model is exported. The rules defining which material definitions in *Blender* become which material in *Radiance* are set out in table 2. In the table the materials are in descending priority so if the conditions for an antimatter material are met then that will be created even if subsequent material conditions are met too. The simulation takes the Radiance materials and not the Blender materials for the calculation so it is important to play with these to get the right material for your object. The live preview in Blender is a good indicator of what the radiance material will look like, as is the view generated by the 'Radiance Preview' button. For final confirmation when the 'Export' button is pressed a directory is created in the same directory, and has the same name, as the *Blender* file. Within this directory is a file called '*Blender filename*'.mat which describes the Radiance material definitions. Looking up the *Blender* material name in this file will show the type of *Radiance* material designated to it. Colours are automatically converted so a red material in Blender will become a red plastic, metal, glass etc material in Radiance. After any material or geometry changes the export button must be clicked to update the files. The main Blender material characteristics that create certain Radiance materials are:

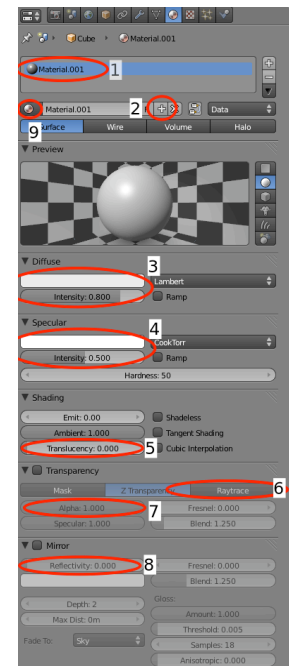


Figure 9: Material tab

- Diffuse colour and intensity (9.3) - The colour diffusely reflected from the material. High diffuse values usually means a good reflector with a matt or rough finish like white plastic or paint.
- Specular colour, intensity and hardness (9.4) - The colour directionally reflected from the object, it's strength and directionality. Implies a shiny finish.
- Translucency (9.5) - Controls the diffuse transmission of light through the material e.g frosted glass.
- Opacity/Transparency (9.6 and 9.7) - Opacity is known as Alpha (Alpha = 0 is invisible). For glass and clear plastics.
- Mirror (9.8) - Clear reflections from polished or mirrored surfaces.

To create a material for sensing surfaces, select the surfaces in the 3D view and create a new material by clicking on the '+' icon to the right of the material name (9.2) in the material panel. Give this material a name with 'calcsurf' in it. If the new calculation surface is not to be a part of the lighting calculation then give it an antimatter Radiance material by specifying the requisite Blender material characteristics i.e. select 'Transparency' - 'Raytrace' - 'Alpha' = 0 in the materials panel. Otherwise specify the required material. If using existing geometry for the calculation surface simply rename the material of that geometry to have 'calcsurf' in it. Make sure however that the material is only applied to the surfaces intended to be calculation surfaces or else other portions of the model with the same material will also become calculation surfaces.

## Simulation

Once any material changes have been made click export and move onto the calculation panel. Here you can preview the scene in Radiance, but note that there will have to be a camera in the scene for this to work. If the Radiance window that pops up is all black or white then select the window and press 'e' then 'enter' and click



Blender material	Radiance material	Notes
Set 'Transparency' - 'Raytrace' - 'Alpha' = 0	Antimatter	An invisible material in Radiance. Good for calculation surfaces
Set 'Mirror' - 'Reflectivity' > 0.99	Mirror	Perfect mirror
Set 'Transparency' - 'Raytrace' - 'Alpha' > 0.01 'IOR' = 1.52	Glass	Typical Glass
Set 'Transparency' - 'Raytrace' - 'Alpha' < 1.0, Set 'Translucency' > 0	Translucent	Lets through diffuse light
Set 'Transparency' - 'Raytrace' - 'Alpha' > 0.01 'IOR' not = 1.52	Dielectric	Similar to glass but with differing IOR
Set 'Mirror' - 'Reflectivity' < 0.99	Metal	Specular and diffuse reflections are the same colour
None of the above	Plastic	No strong reflections. Covers most materials.

Table 2: Blender - Radiance materials conversion

with the mouse on the white/black area. This will normalise the exposure level of the image for better viewing. If the image is still black after this check that external light can reach the part of the model being viewed through transparent, or open, areas.

If the scene looks as expected then the metric required and the simulation accuracy can be set. The metrics available are Illuminance (in Lux), Irradiance (in  $W/m^2$ ) and Daylight Factor (in %), although Daylight Factor is only available if a DF sky has been selected in the export panel. Daylight Factors are useful for general building daylighting analysis whilst Lux is better for more specific time or space based analysis. After pressing the 'Simulate' button the interface will become unresponsive until the calculation has finished and a message appears at the top of the Blender window to that effect.

## Display

Once the simulation has finished the 'Radiance Display' button can be pressed which will bring up the metric legend. The calculation surfaces should be joined into one object, automatically selected and placed into vertex paint mode for visualisation. All other geometry will be placed into wire-frame mode. Solid shading can be toggled with the 'z' key. Vertex paint mode can be toggled with the 'v' key. Camera viewpoint can now be rendered by pressing the 'Image' button in the 'Render' tab (1b.1). If a legend key is required in the render it is suggested that a screengrab of the 3D view is taken and the legend key from that image copy and pasted into the render image.