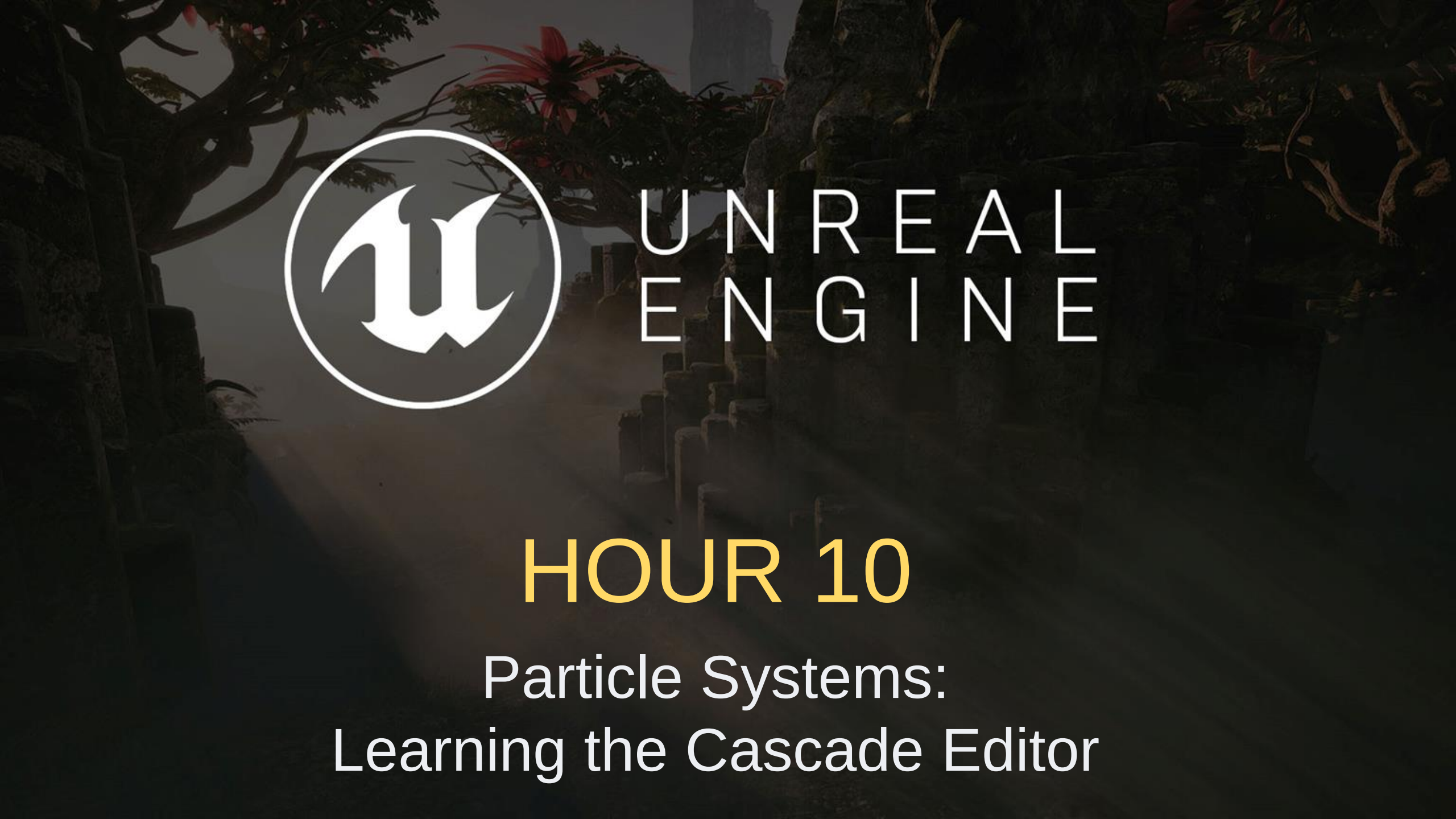


HOUR 10

Particle Systems: Learning the Cascade Editor

INTRODUCTION

This lecture introduces you to the Cascade Editor and basic concepts needed for working with particles in UE4.

You will learn about the different types of particles in UE4 and how to use the Cascade Editor to create and control them.

Particle Systems are the building blocks of visual effects and are used for anything from explosions to leaves floating in the wind to creating fantasy effects for spells.

LECTURE GOALS AND OUTCOMES

Goals

The goals of this lecture are to

- Learn about Particle Systems
- Learn how to work with the Cascade Editor
- Understand data types
- Learn how to use Emitters and modules
- Learn how to set up Materials for Particle Systems

Outcomes

By the end of this lecture you will be able to

- Create a new Particle System asset
- Create a new Emitter
- Add modules to Emitters
- Create a Material for use with Particle Systems

WHAT IS A PARTICLE?

A *particle* is a point in space that follows a set of defined parameters that determine its location and visual attributes over time.

Particles are typically controlled by forces such as gravity and drag and are usually represented by a quad polygon called a Sprite.

Unreal Engine 4 also allows particles to be built using Static Meshes.

Particle Systems in Unreal Engine 4

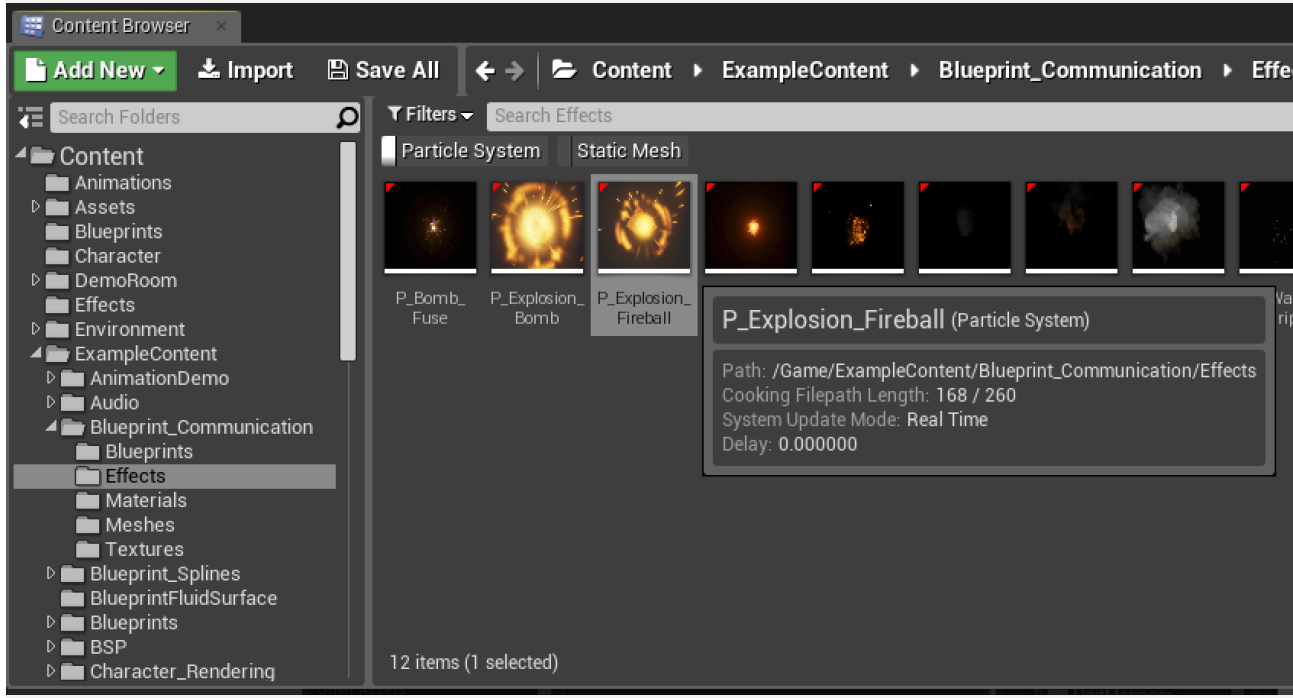
When starting out with particles in UE4, there are three things to be familiar with:

- Particle System assets
- Emitter Actors
- The Cascade Editor

PARTICLE SYSTEM ASSETS

The Particle System asset is the base asset class for particles found in the Content Browser.

Particle System assets are edited in the Cascade Editor.

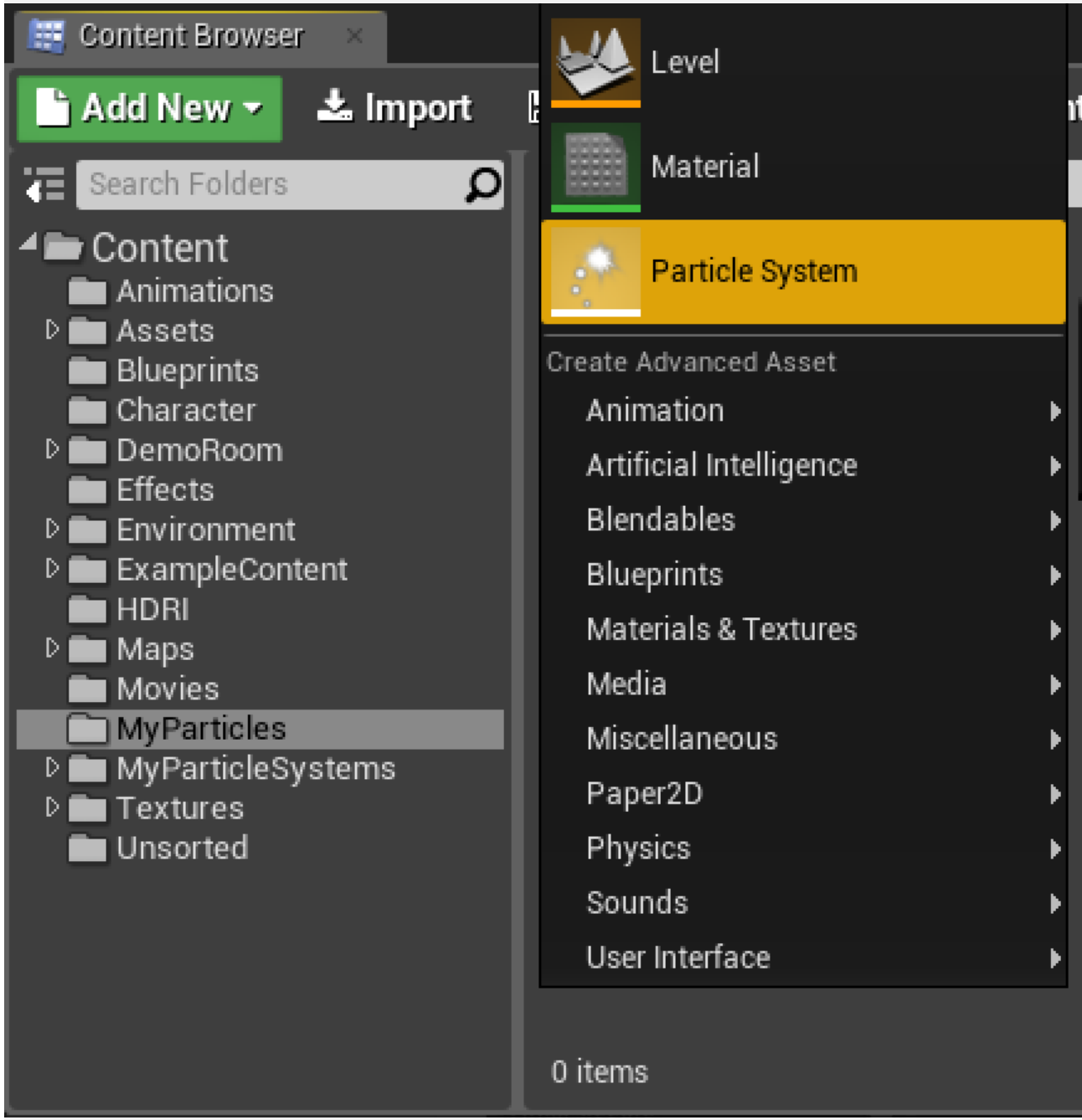


PARTICLE SYSTEM ASSETS

Particle System assets are first created in the Content Browser.

To create a Particle System, left-click the Add New button in the Content Browser and select Particle System, or right-click in the Content Browser's asset view and select Particle System from the context menu.

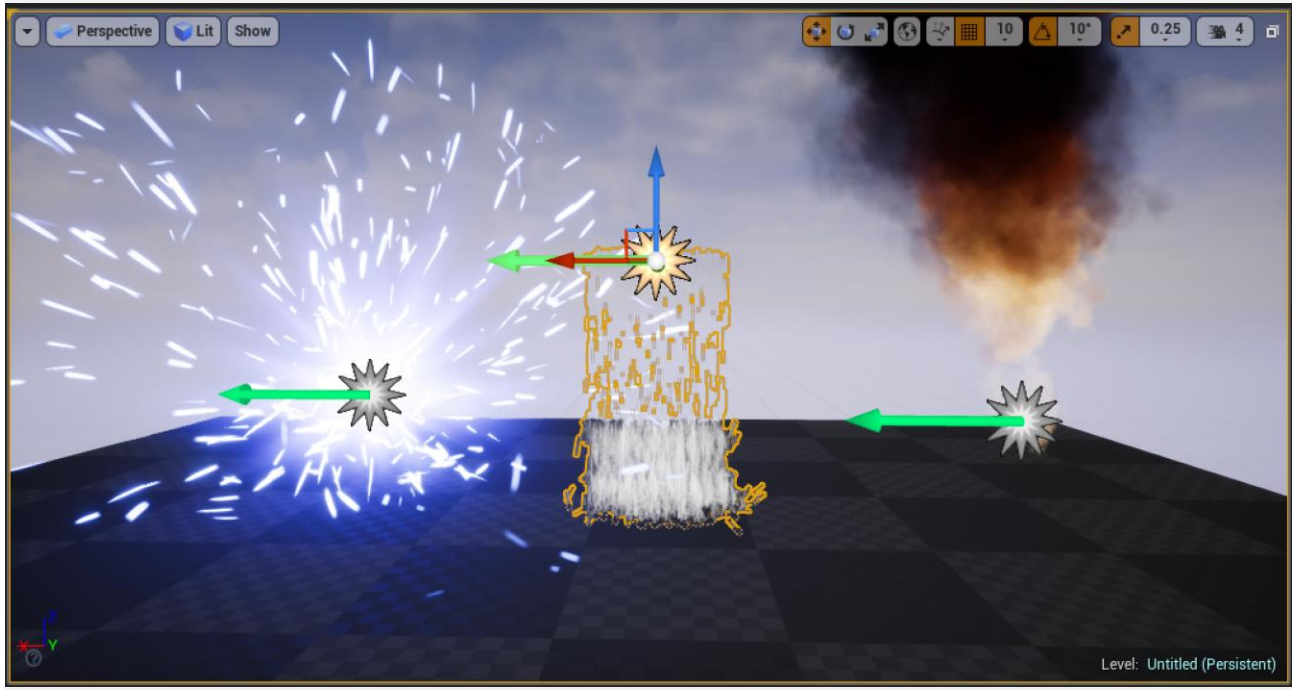
Once created, the name of the new Particle System will be highlighted, awaiting a new name.



EMITTER ACTORS

An Emitter Actor is an instance of a Particle System asset placed in a Level.

To place an Emitter Actor, click a Particle System asset in the Content Browser and drag it into the Level Editor’s Viewport.



Notes

- When an Emitter Actor is placed in a Level, you will see that it immediately activates.
- By default, all particles are active. This activation is set by a parameter called Auto Activate under the Emitter Actor’s Properties tab in the Details panel.
- Once an Emitter Actor has been placed in a Level, select the Emitter Actor and go to Activation in the Details panel to toggle Auto Activate on or off. While this parameter can be manually set, it can also be controlled through Blueprints.
- Any Emitter Actor with Auto Activate set to True will automatically start when the Level is played.

CASCADE EDITOR

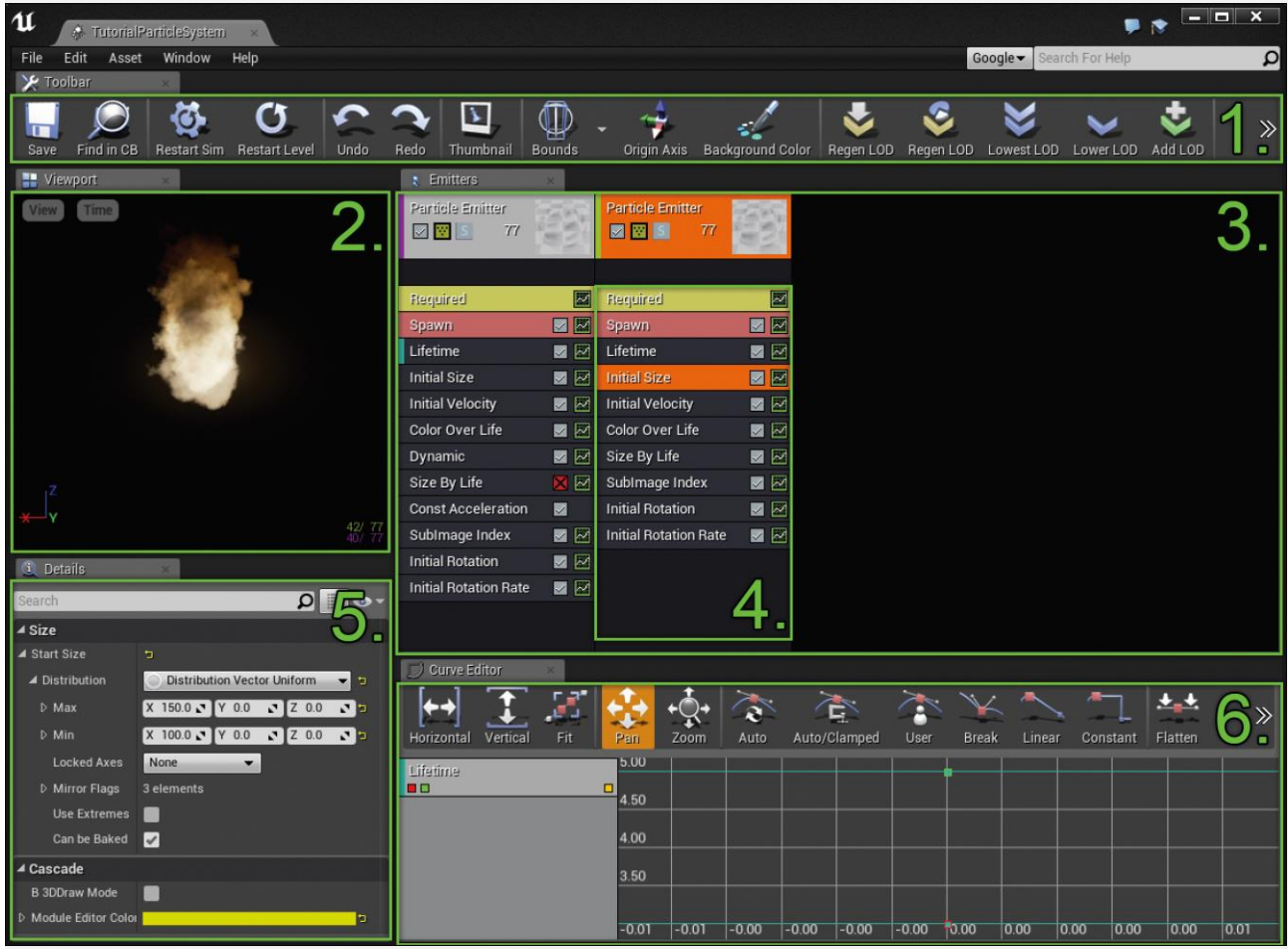
Interface

CASCADE EDITOR INTERFACE

To open up the Cascade Editor, double-click a Particle System asset in the Content Browser.

The Cascade Editor layout consists of six sections:

1. Toolbar
2. Viewport panel
3. Emitters panel
4. Modules panel
5. Details panel
6. Curve Editor panel



TOOLBAR

The toolbar contains visualization and navigation tools for the Cascade Editor.

The table on the right lists some of the controls and their function.

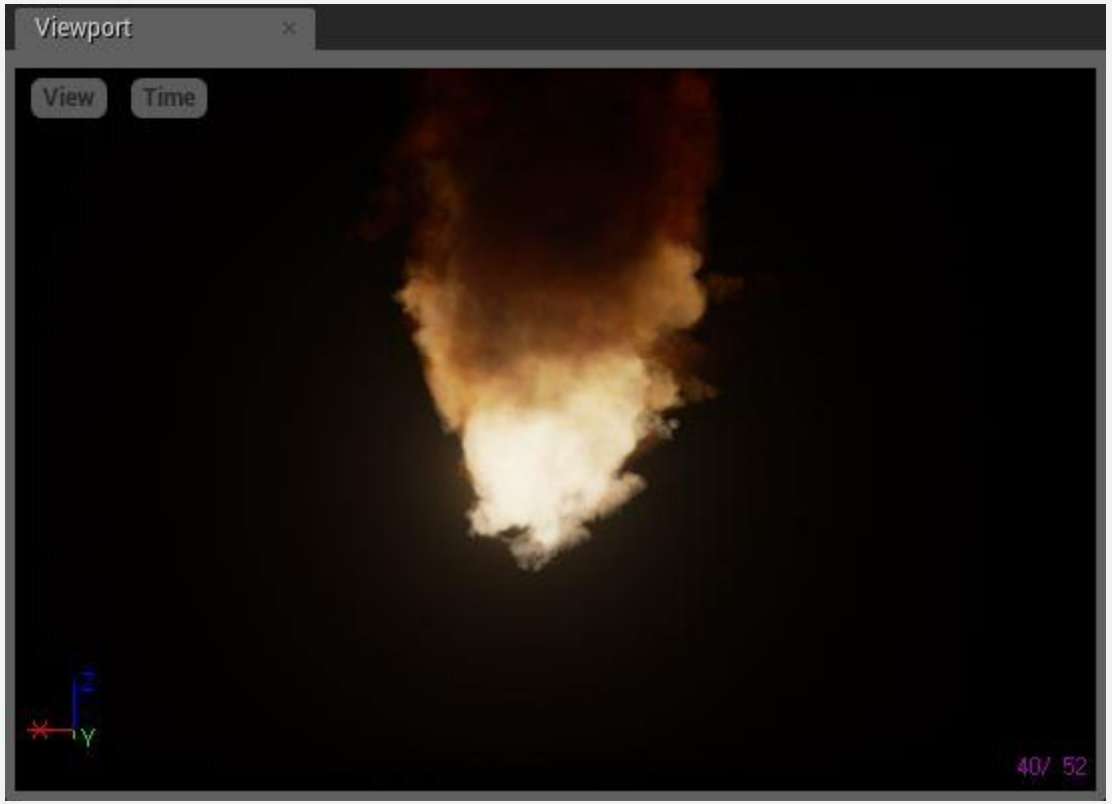
Control	Description
Save	Saves the current Particle System asset.
Find in CB	Locates the current Particle System asset in the Content Browser.
Restart Sim	Resets the simulation in the Viewport window. This can also be done by pressing the spacebar.
Restart Level	Resets the Particle System and any instance of the system in the Level.
Undo	Undoes the previous operation. You can also use Ctrl+Z.
Redo	Redoes the previously undone operation. You can also use Ctrl+Y.
Save Thumbnail Image	Saves the viewpoint from the Viewport panel's camera out as the thumbnail for the Particle System in the Content Browser.
Toggle Bounds	Toggles the display of the Particle System's current bounds in the Viewport panel.
Bounds Options	Allows for the setup of fixed bounds for GPU Sprite Particle Systems. Fixed bounds limit the distance GPU Sprite particles can travel.
Toggle Origin Axis	Shows or hides the origin axis in the particle Viewport window.

VIEWPORT PANEL

The Viewport panel gives you a rendered preview of the current Particle System just as it would appear when rendered in-game.

It provides real-time feedback on changes made to the Particle System in Cascade.

The Viewport panel can also render in unlit, Texture density, overdraw, and wireframe view modes and show information such as the current bounds of the Particle System.



VIEWPORT PANEL

The table on the right shows how the Viewport panel can be navigated via the mouse and keyboard.

Control	Action
LMB	Tumbles the camera around the Particle System.
MMB	Pans the camera around the Particle System.
RMB	Rotates the camera.
Alt+LMB	Orbits the Particle System.
Alt+RMB	Dollies the camera toward and away from the Particle System.
F key	Focuses on the Particle System.
L key+LMB	Rotates lighting. Only works on particles using lit Materials. Unlit particles (most flames, sparks, and so on) will see no effect.

EMITTERS PANEL

The Emitters panel contains each Particle Emitter contained within the Particle System currently open in Cascade.

From here you can add, select, and work with the various particle modules that control the look and behavior of the Particle System.

Right-clicking on an empty column will allow you to create a new Emitter.

EMITTERS PANEL

The Emitter list contains a horizontal arrangement of all the Emitters within the current Particle System.

There can be any number of Emitters within a single Particle System, each generally handling a different aspect of the overall effect (for instance, one Emitter for fire, a second for smoke, and a third for debris).

EMITTERS PANEL

Each column in the Emitters Panel represents a single Particle Emitter, and each is made up of an Emitter block at the top. The Emitter block contains the primary properties of the Emitter.

The modules beneath each Emitter block control various aspects of particle behavior.

EMITTERS PANEL

The controls and commands that apply in the Emitter list are shown in the table on the right.

Control	Operation
Left-click	Selects an Emitter or module.
Left-click+drag (on a module)	Moves a module from one Emitter to another.
Shift+left-click+drag (on a module)	Instances a module between Emitters, which is expressed as a + next to the module name, and the modules will share the same color.
Ctrl+left-click+drag (on a module)	Copies a module from the source Emitter to the target one.
Right-click	Opens the context menu. Right-clicking an empty column allows for creation of a new Emitter. Right-clicking on an Emitter allows you to perform various functions on the Emitter itself, as well as add new modules.
Left and right arrow keys	With an Emitter selected, these keys will reposition the Emitter farther to the left or right in the Emitter list.

MODULES PANEL

The basic structure of a Modules panel can be broken down as follows:

1. **Emitter column**: Each column is a defined Emitter assigned to the Particle System.
2. **Emitter block**: This box at the top of each Emitter contains the controls and primary properties for the Emitter itself, such as the type of Emitter and the Emitter's name, along with other primary properties.
3. **Module list**: Descending from the Emitter block is a list of all of the modules that define the look and behavior of the Emitter. All Emitters will have a Required module, after which there may be any number of modules to further define behavior.

MODULES PANEL

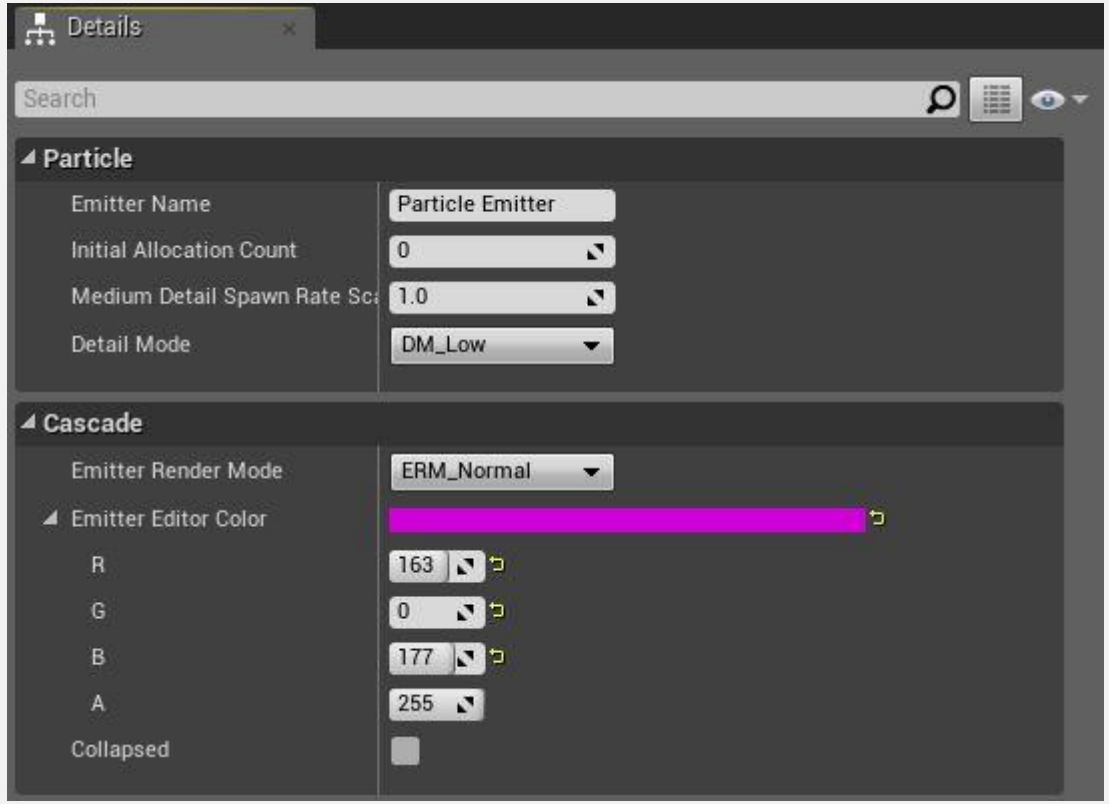
The Module list is rather straightforward. It is a vertical list of modules assigned to each Emitter.

Right-clicking on an Emitter will bring up a list of potential actions you can perform directly to the Emitter, such as changing the Emitter's name or type, as well as adding various behavior modules to the Emitter.

DETAILS PANEL

The Details panel contains a standard UE4 details window. The properties displayed in this pane depend on what is currently selected in the Emitters panel.

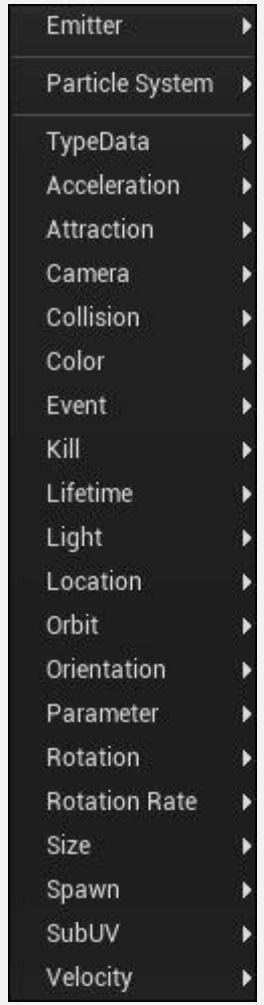
For instance, if a module is selected, the properties for that particular module are displayed.



COMMON MODULES

There are a large number of modules, some of which are standard and already assigned when a new Emitter is created. Some modules are specific to the type data of the Emitter, and others are specific to what they have an effect on during the life of the particle.

The image on the right shows common modules that can be assigned to an Emitter.



COMMON MODULES

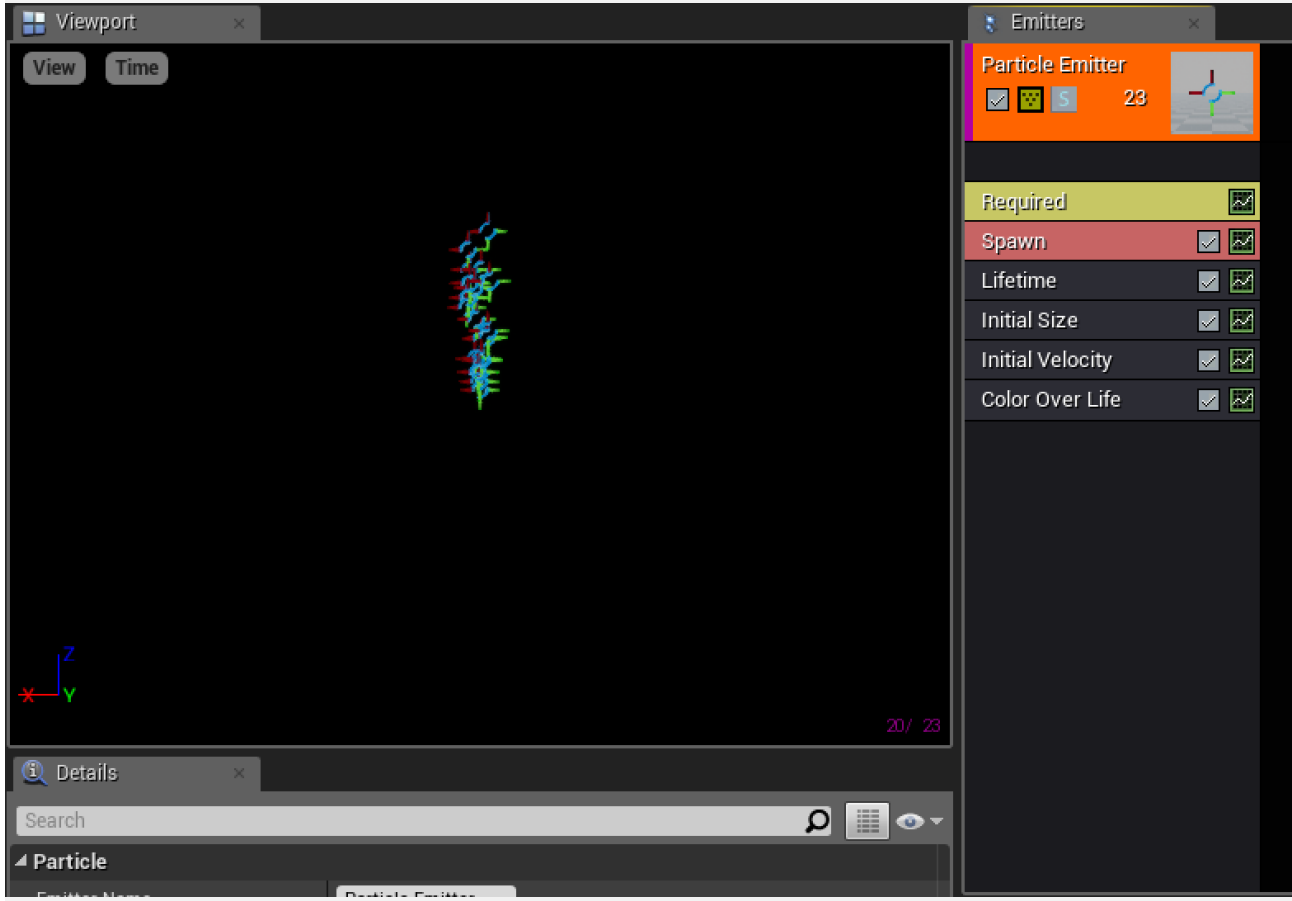
When an Emitter is first added to a Particle System, there are seven default modules, three of which are always required for a Particle System to function.

Required modules:

- Type Data
- Required
- Spawn

Default modules:

- Lifetime
- Initial Size
- Initial Velocity
- Color Over Life



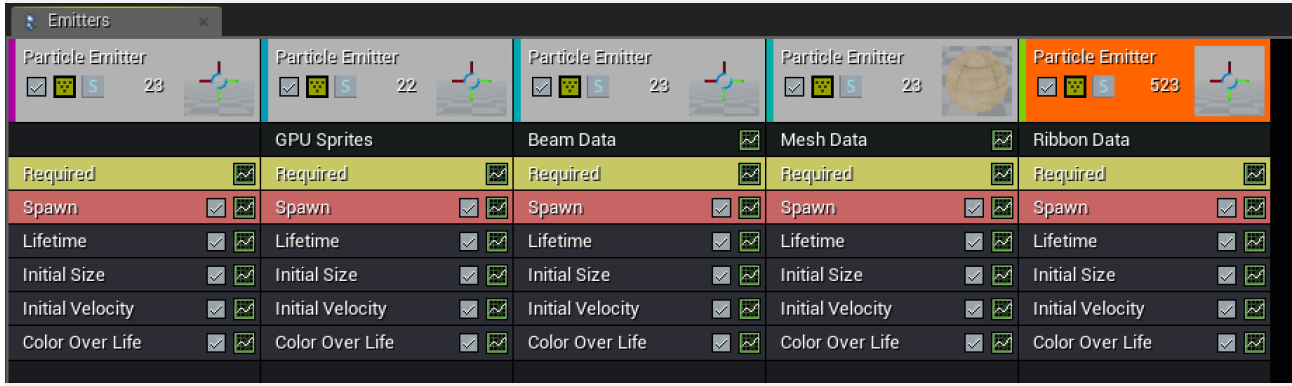
TYPE DATA MODULE

The Type Data module is represented as a black bar below the Emitter block.

If the Emitter type data is set to Sprite, nothing is displayed.

If you change the type data to something other than Sprite, the name will show up in the bar.

If you select this module, the Details panel will display properties specific to the type data.



Distribution Types

While each module has its own unique properties depending on how it effects the particles it contains, you will find some consistency across most modules, such as in the distribution type properties.

Distributions are a set of float or vector data types for handling data in specialized ways, such as using a range for a value, or interpolating a value along a curve. Any time your Particle System requires randomization or the ability for some particle aspect to change over time, you will use a distribution to control that property.

Many of the properties found within modules in Cascade can have different distributions applied to them. The actual value for that property is then set within the distribution type.

Distribution Types

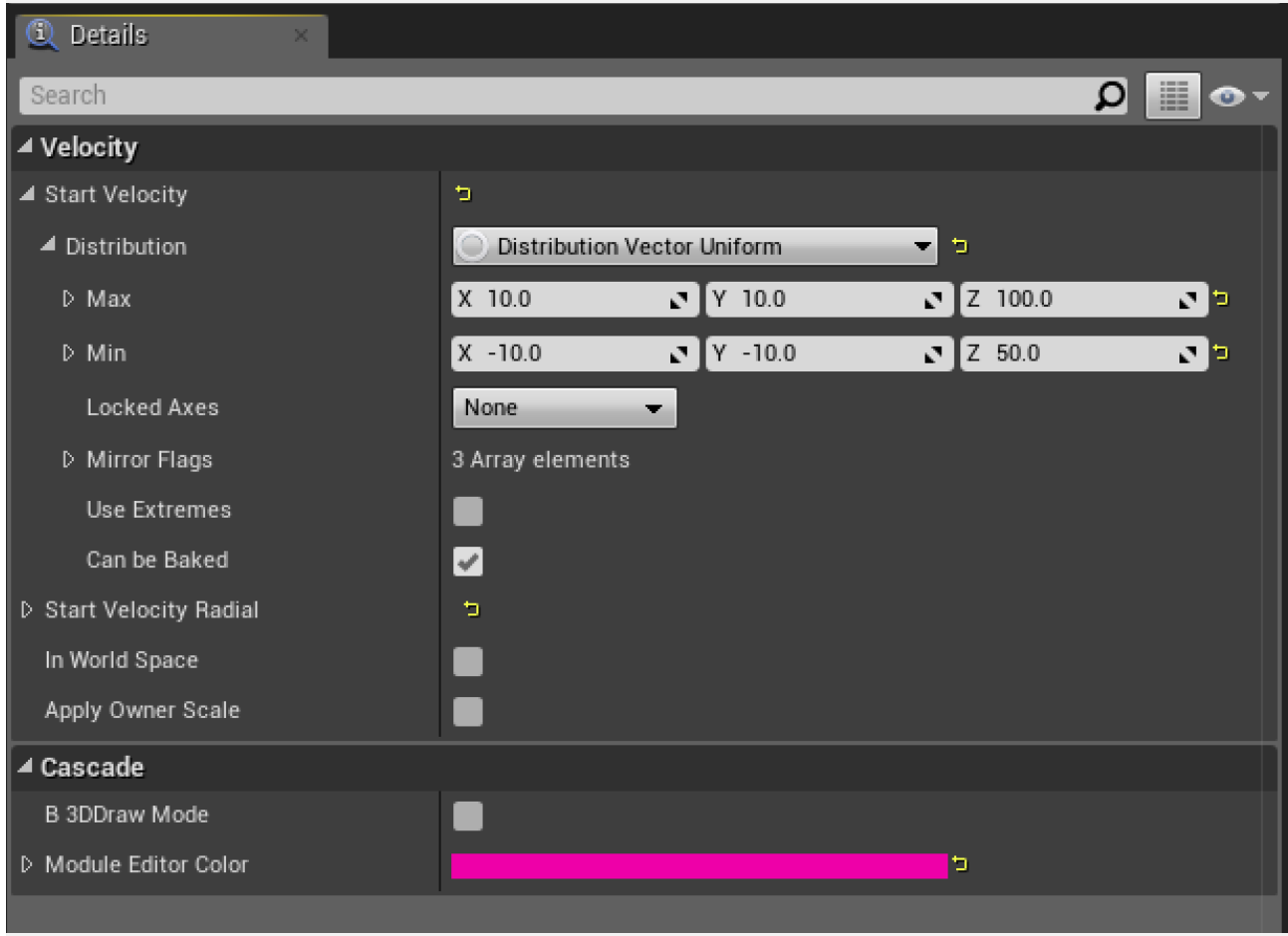
There are five primary distribution types:

- **Constant**: This designates a single static value that does not change in any way.
- **Uniform**: A uniform distribution provides a minimum and maximum value, outputting a random selection from between (and including) the two values.
- **Constant curve**: A constant curve distribution provides a single curve over which a value interpolates over time. In this case, time generally refers to the duration between the birth and death of a particle, or the start and stop times for particle emission. This distribution type requires the use of the Curve Editor panel.
- **Uniform curve**: A uniform curve distribution provides a minimum and maximum curve. The final value is chosen from the point along a graph that sits between these two curves. This distribution type requires the use of the Curve Editor panel.
- **Parameter**: This type of distribution allows a property to be parameterized so that it can be manipulated externally via Blueprints, Matinee, or some other means.

DISTRIBUTION TYPES

Each distribution type exists separately for float and vector data type values. For instance, both Float Uniform Curve and Vector Uniform Curve distributions exist.

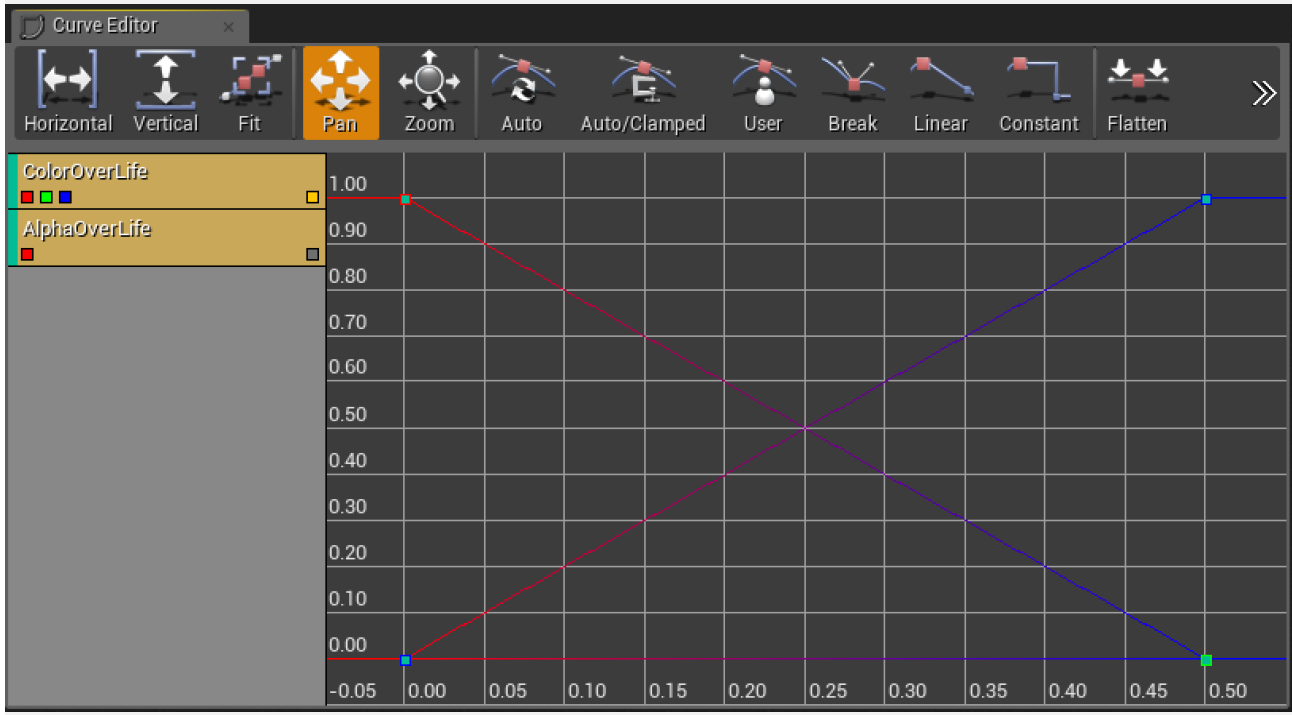
A float or a vector distribution is governed by the type of property being controlled. For example, you would control color (a vector value for RGB) via a Vector Uniform distribution, but life span (a single float value) would be controlled via a Float Uniform.



CURVE EDITOR PANEL

The final panel to look at is the Curve Editor panel, which consists of three key areas:

- Toolbar
- Track list
- Graph

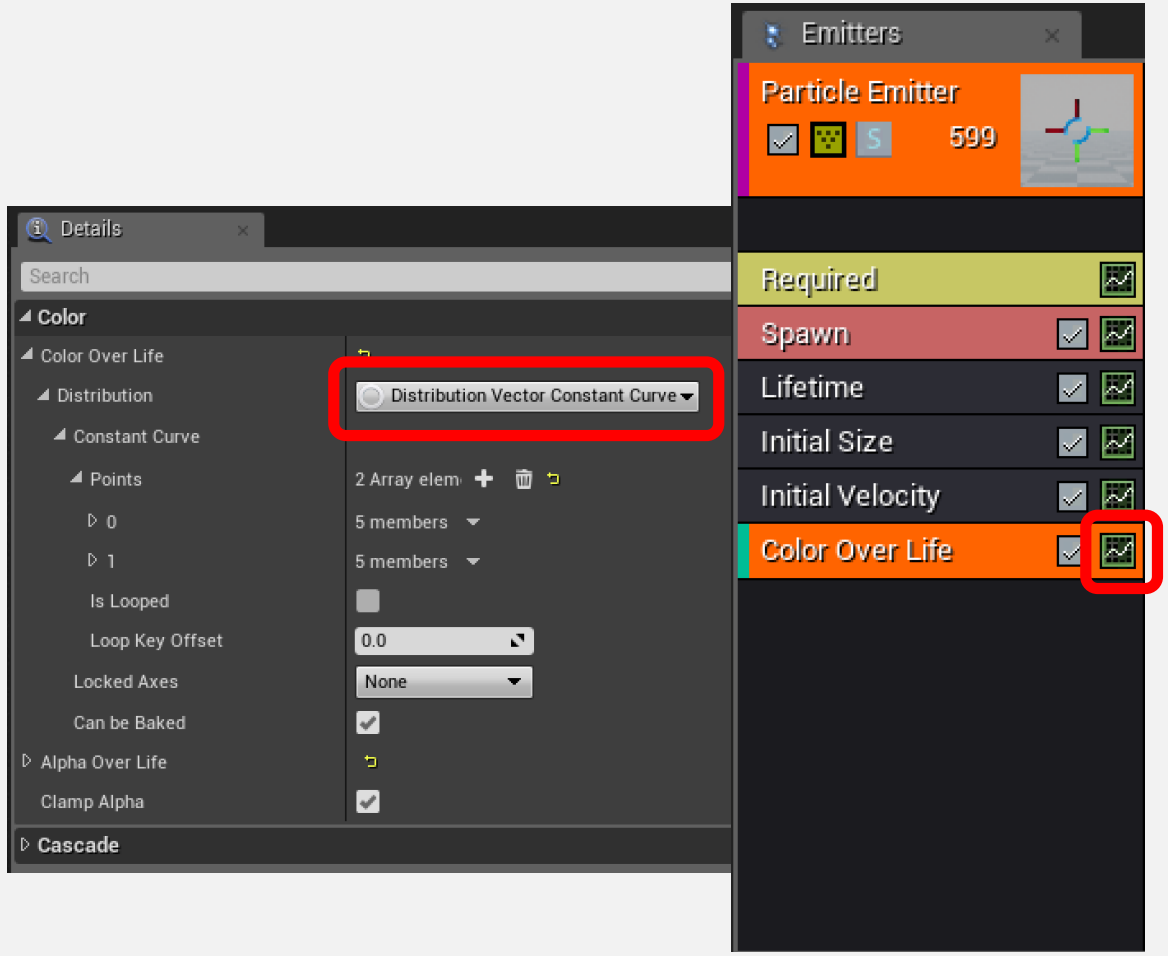


CURVE EDITOR PANEL

For module properties to take advantage of the Curve Editor in Cascade, they must have two things:

- A distribution type that is set to a constant curve or uniform curve
- At least one point

To view module properties, click on the graph icon to the right of a module's name in the Modules panel.



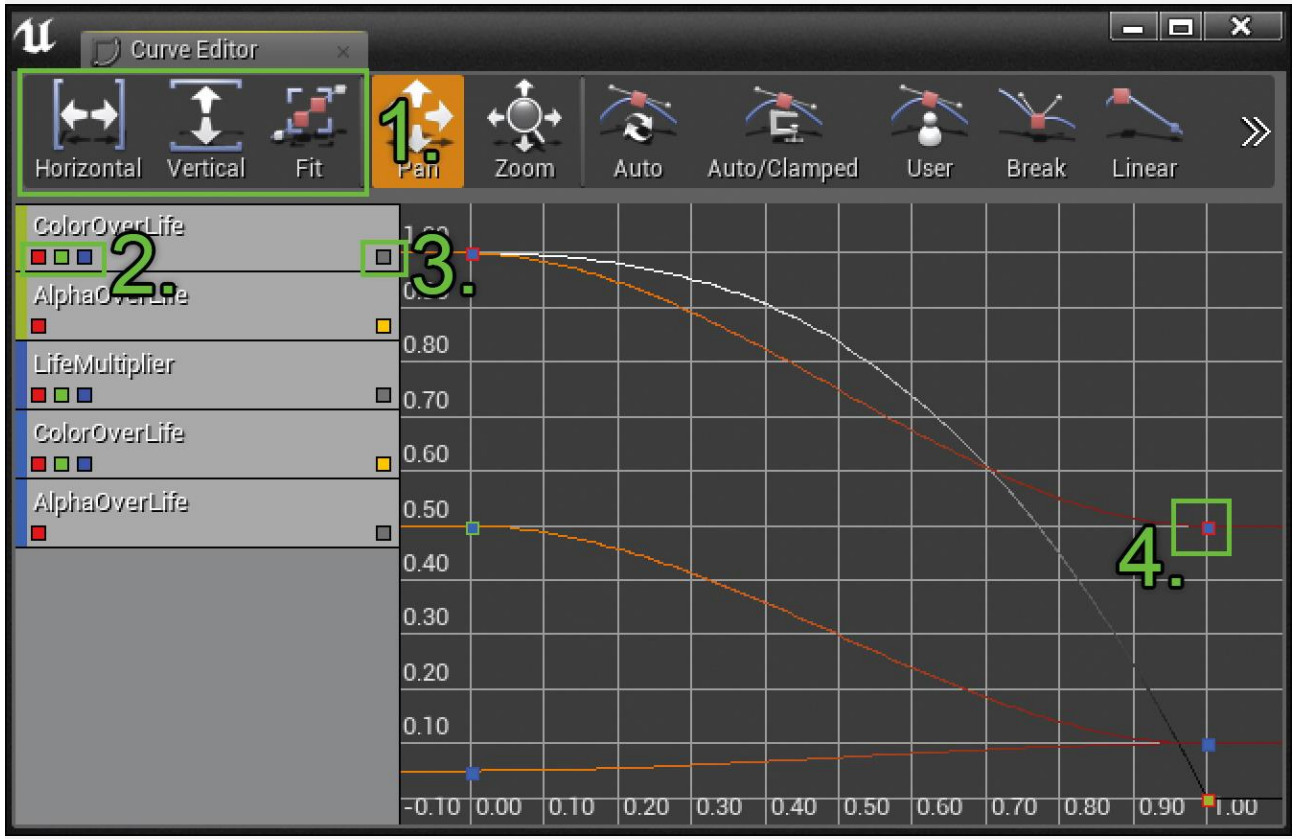
CURVE EDITOR PANEL

When you set a distribution type to a uniform or constant curve, you will need to add keyframes for the curve to be displayed in the graph. A point is a keyframe.

CURVE EDITOR PANEL: TOOLBAR

The toolbar has buttons for many tools that are necessary for handling and manipulating curves.

The first three buttons highlighted to the right (***1.***) are the framing tools, which are used to quickly set the Curve Viewport to match the minimum and maximum values of all visible curves.

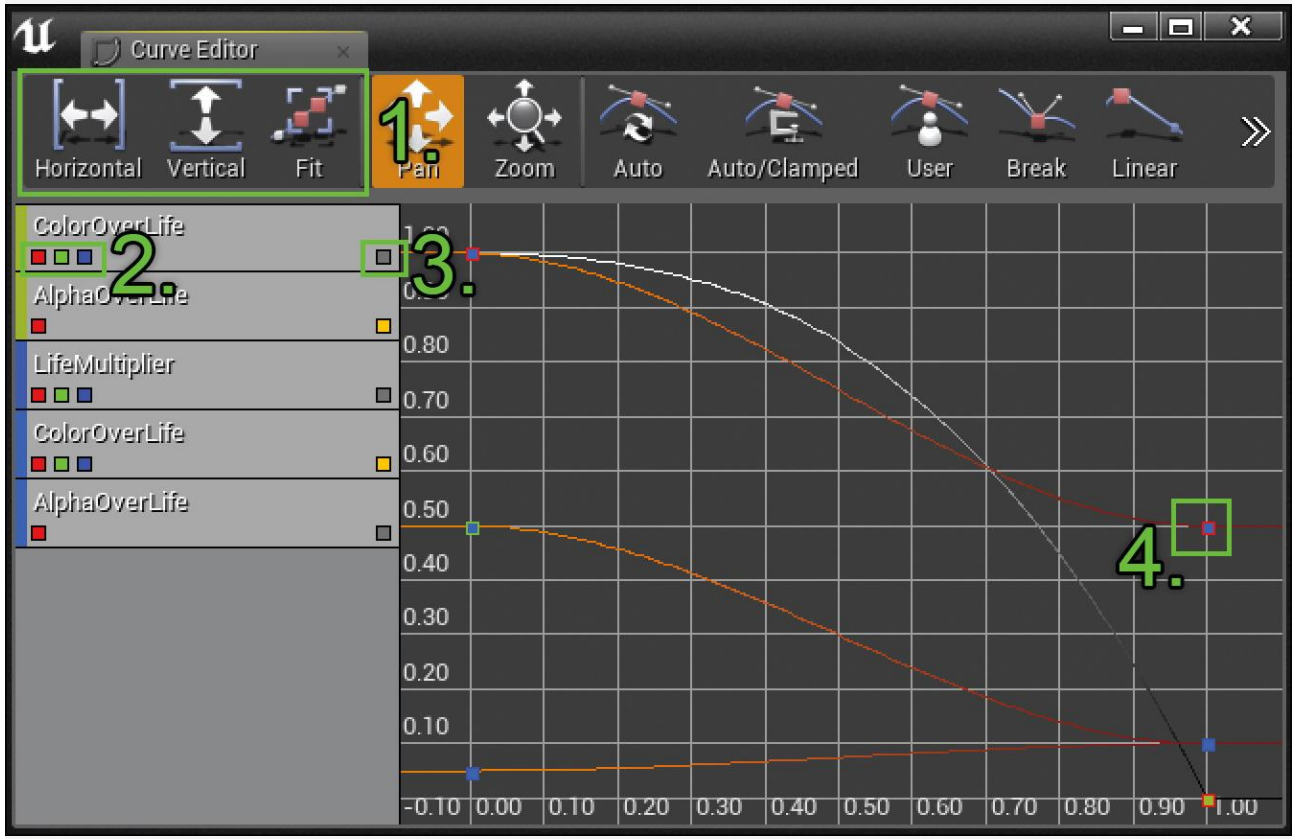


CURVE EDITOR PANEL: TRACK LIST

Each gray box in the track list represents a property of a module that has been assigned to the Curve Editor.

Each curve distribution is either a singular float curve or a set of curves that make up a vector distribution. In the case of a vector distribution, the three red, green, and blue boxes (***2.***) can be used to visualize individual channels of the vector. When you click any of these boxes, the matching curve in the Editor is either enabled or disabled.

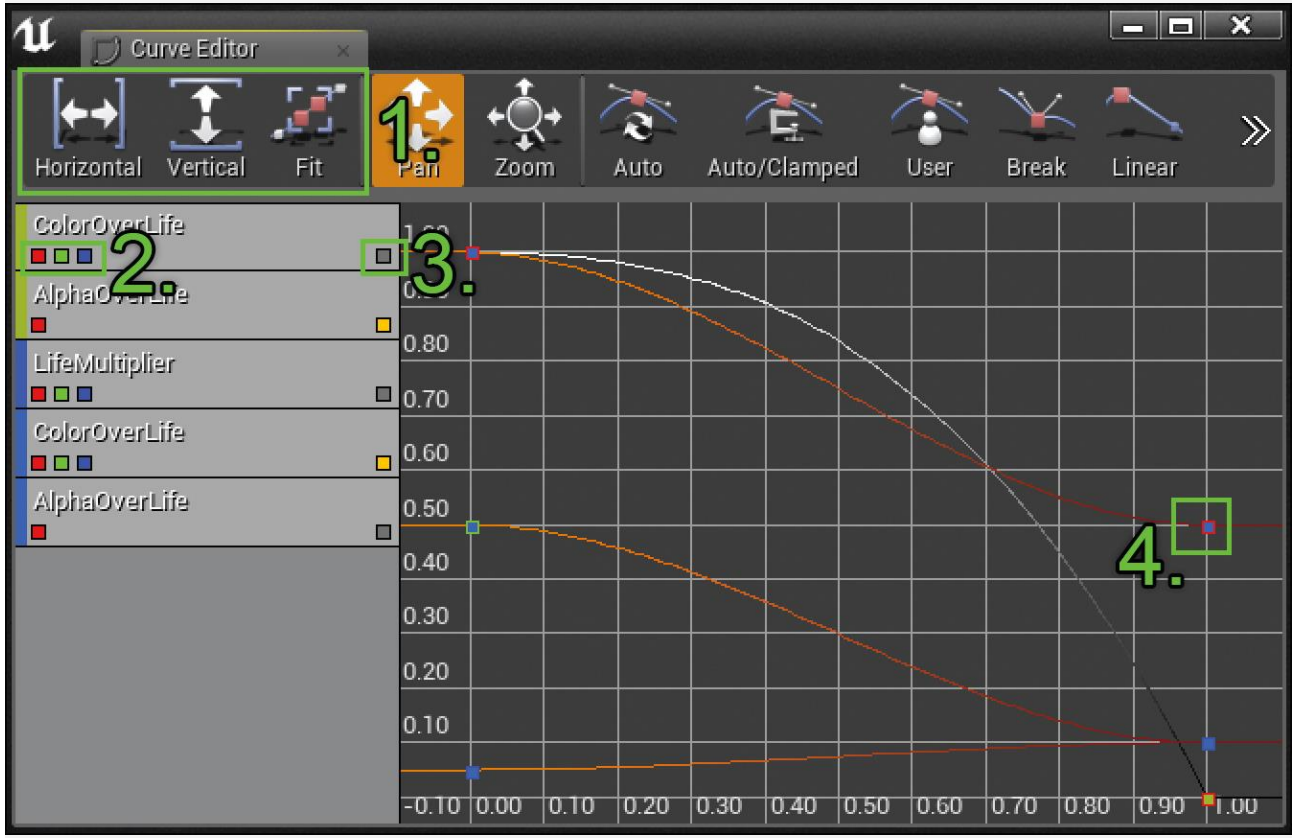
The box in the lower right corner of a track (***3.***) enables or disables the visualization of all channels of the associated property. You can use it to disable the display of all curves in a property with one click.



CURVE EDITOR PANEL: GRAPH

The graph displays a change in value over time. The value is represented on the left side of the graph, and time is represented at the bottom.

Value changes over time are stored as keyframes (***4.***).



Notes

- The lifetime of a particle is set with the Lifetime module.
- If the Lifetime module has a distribution type of Float Uniform, each particle emitted will pick a random value from a min/max range to determine its life span. This means every particle emitted will have a different life span.
- For example, if the Min value is 10 seconds and the Max value is 100 seconds, one particle might live for 15 seconds and another for 30 seconds. This is a great way to add randomness to the effect and make it feel more organic.
- Because the lifetime of each particle emitted will vary, time in the graph editor has to represent lifetime as a normalized percentage. This means that keyframes in the graph editor should range in time between 0 and 1, where 0 is the birth and 1 is 100% of life, meaning death. So regardless of the actual lifetime of each particle, the effect will apply.

CURVE EDITOR PANEL

The process of adding keyframes and navigating around the Curve Editor can take some getting used to. The controls listed in the table on the right are used when working with the Curve Editor.

Control	Description
Click+drag on the background	Pans view around.
Mouse scroll	Zooms in and out.
Click a keyframe	Selects the keyframe.
Ctrl+click a keyframe	Toggles selection of a keyframe.
Ctrl+click a curve	Adds a new keyframe at the clicked location.
Ctrl+click+drag	Moves the current selection.
Ctrl+Alt+click+drag	Creates box selection.
Ctrl+Alt+Shift+click+drag	Creates box selection and adds to current selection.

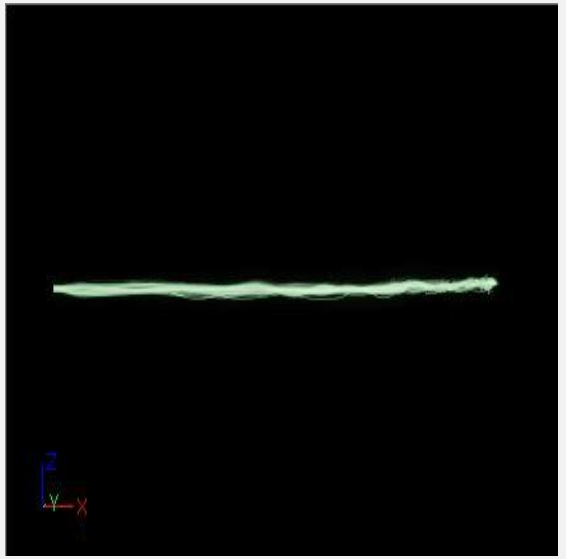
PARTICLE DATA TYPES

PARTICLE DATA TYPES

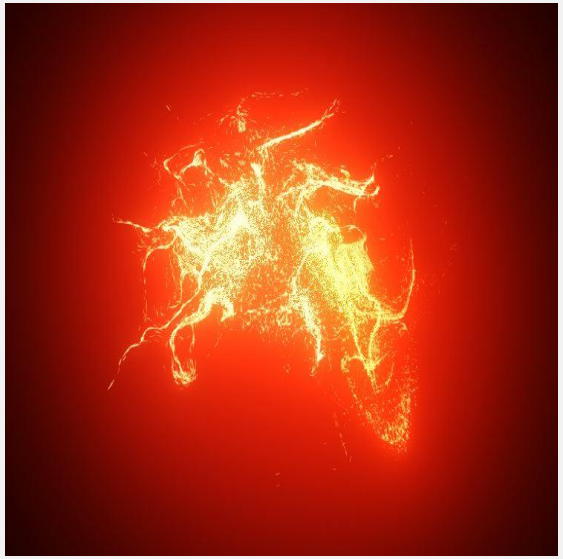
In UE4, there are six different particle types defined by the Type Data module:

- Sprite
- GPU Sprite
- Beam
- Mesh
- Ribbon
- Anim Trail

Beam

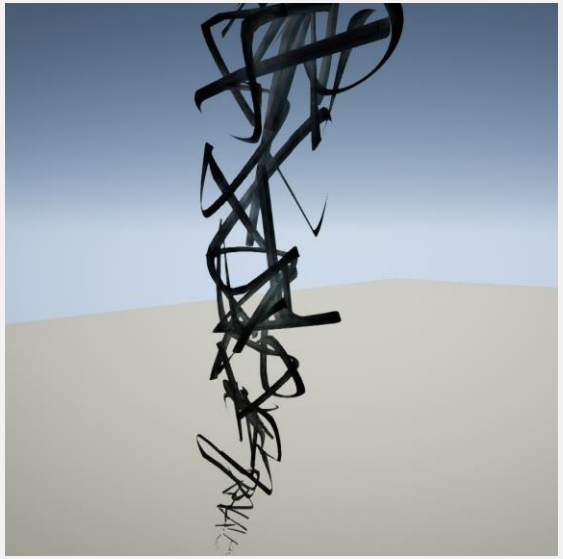


GPU Sprites



Mesh

Ribbon

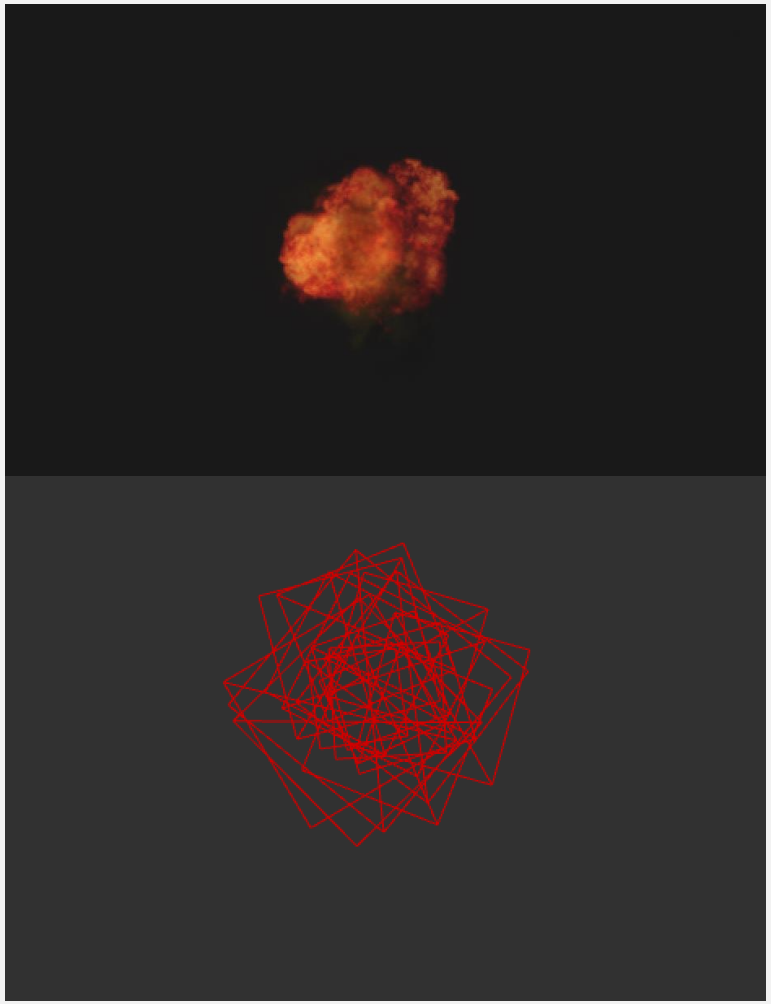


SPRITE

Sprites are the most basic type of Emitter and the most frequently used.

Sprite particles are emitted as polygonal Sprites (two-polygon cards) that always face the camera. They are useful for smoke, fire, and a wide variety of other effects.

Sprites use the CPU to calculate their simulation.



GPU SPRITE

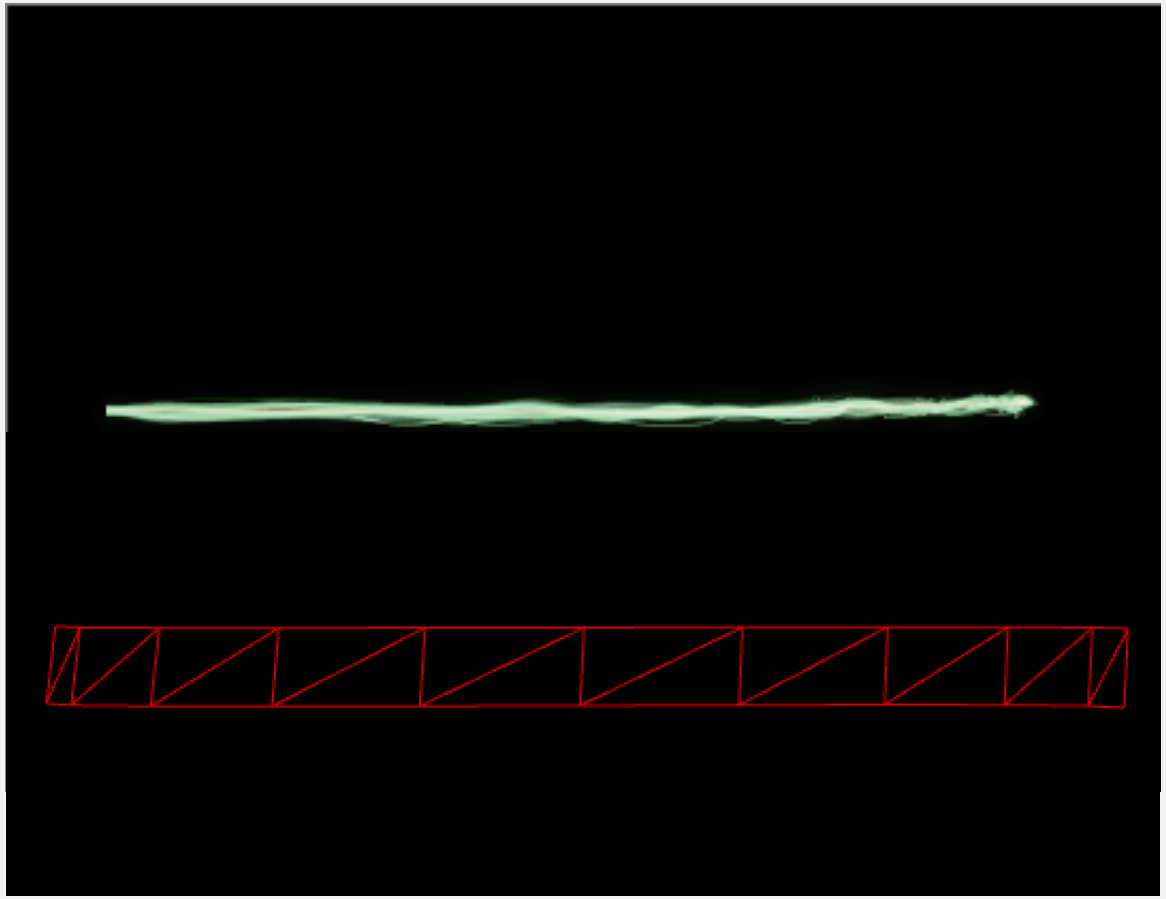
GPU Sprites are a special type of particle in which the bulk of runtime calculation is passed off to the GPU.

This boosts the number of possible particles in a frame from the several thousand possible with CPU particles to several *hundred thousand*, depending on the type of GPU in the target system.

BEAM

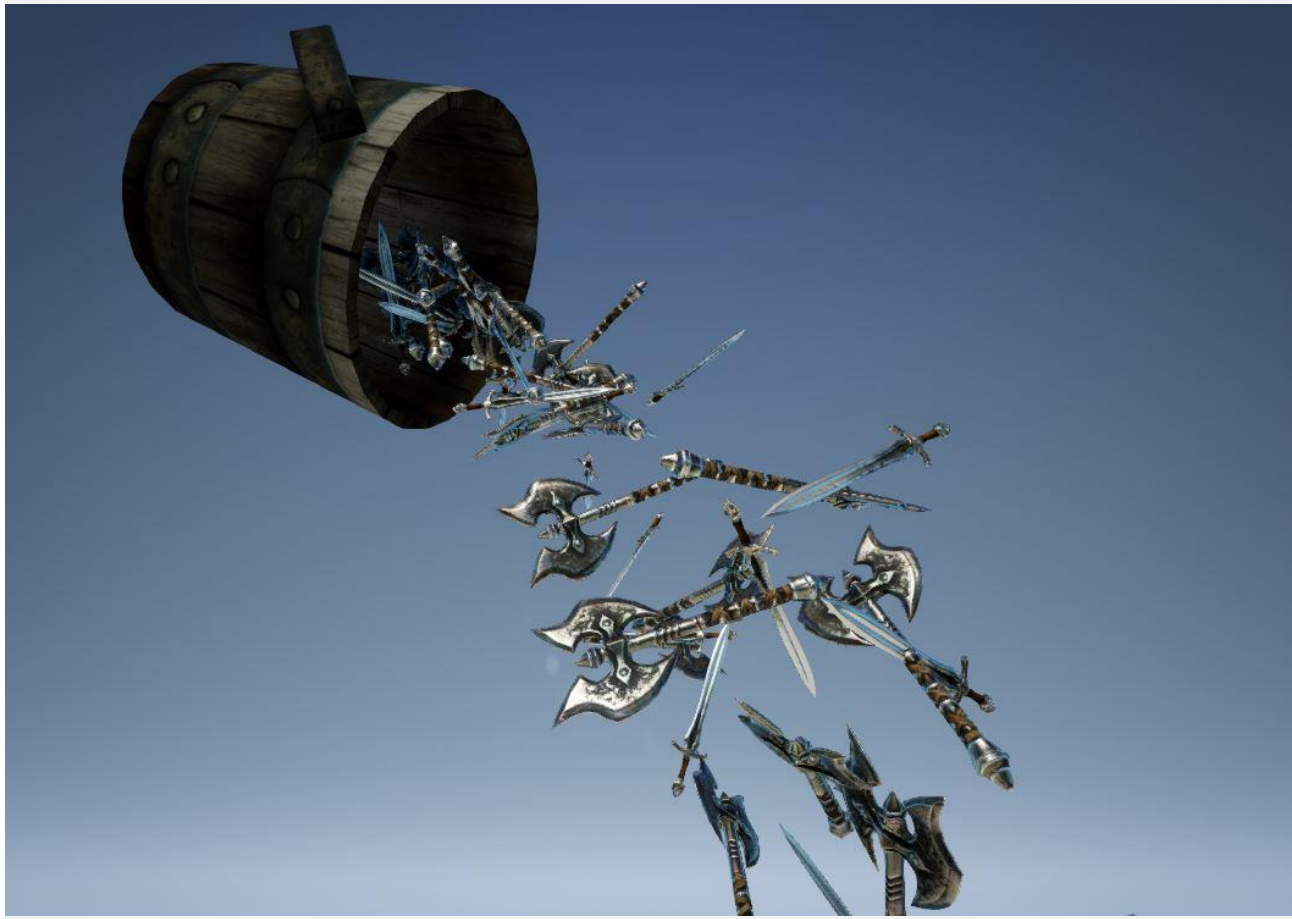
The Beam Type Data module indicates that the Emitter should output beams—connecting particles to form a stream between a source point, such as the Emitter, and a target point, such as a particle or Actor.

By default, it consists of a single quad polygon referred to as a sheet that always faces the camera and is stretched between two points. Segmentation can be added.



MESH

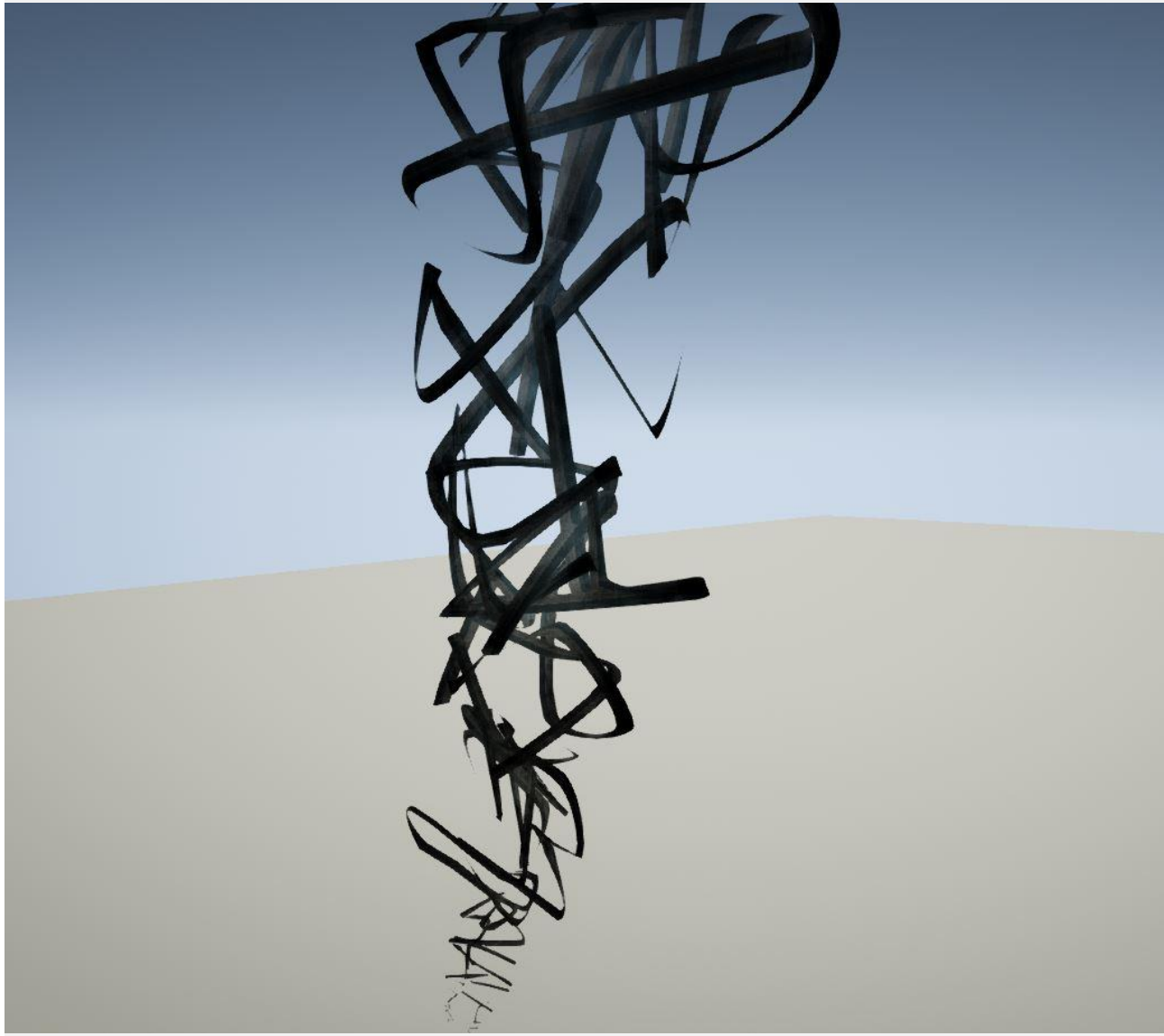
The Mesh Type Data module indicates that the Emitter should use Static Mesh instances rather than Sprite particles. This type of Emitter is great to use for effects such as shrapnel or debris.



RIBBON

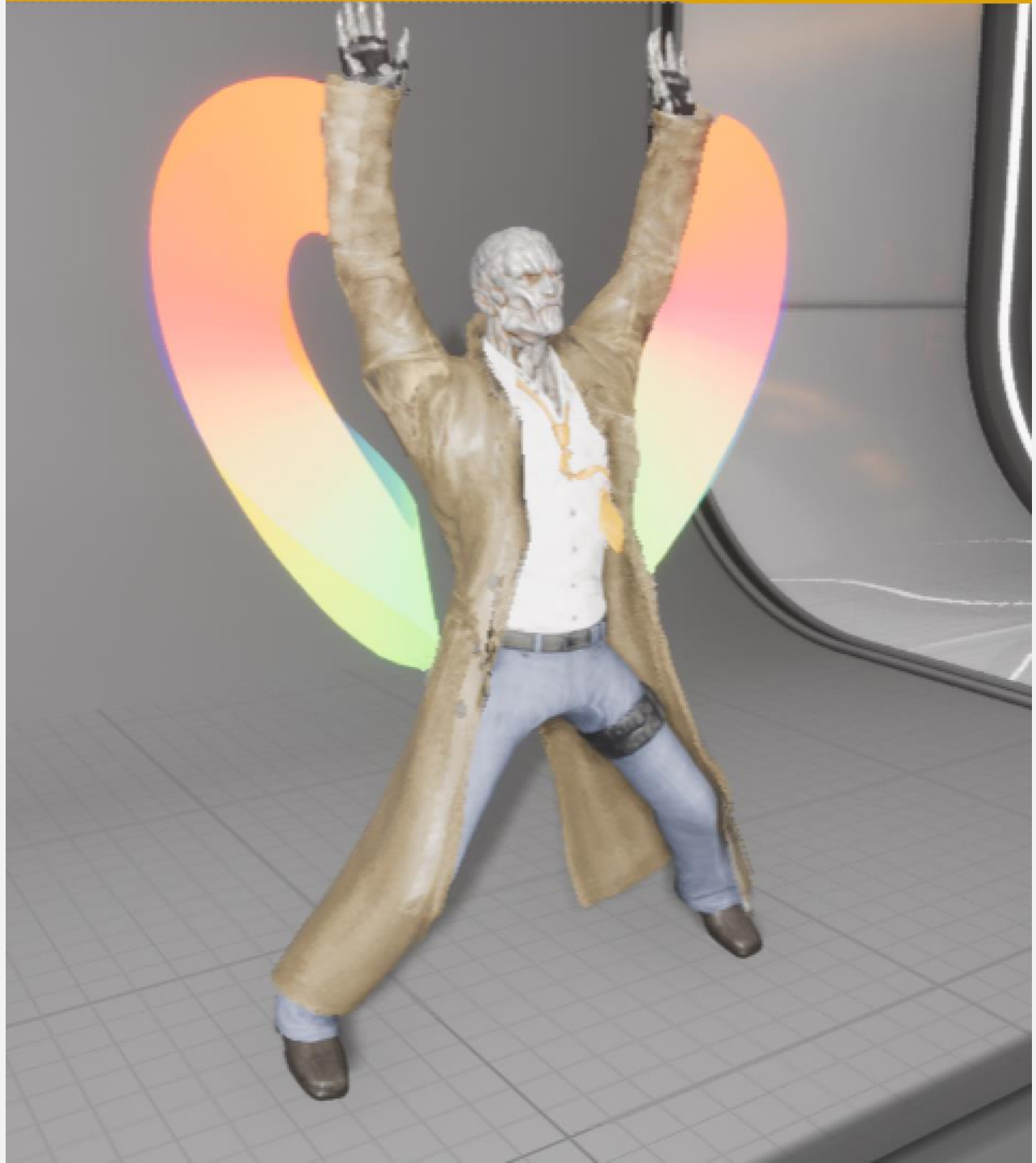
The Ribbon Type Data module indicates that the Emitter should output trails—connecting particles to form ribbons.

Particles are connected in the order of their birth. Therefore, the more erratic the initial velocity pattern of the particles, the more chaotic the ribbon.



ANIM TRAIL

The Anim Trail Type Data module is similar to Ribbon and Beam but designed specifically to work with Skeletal Meshes.



PARTICLE LIFE CYCLE

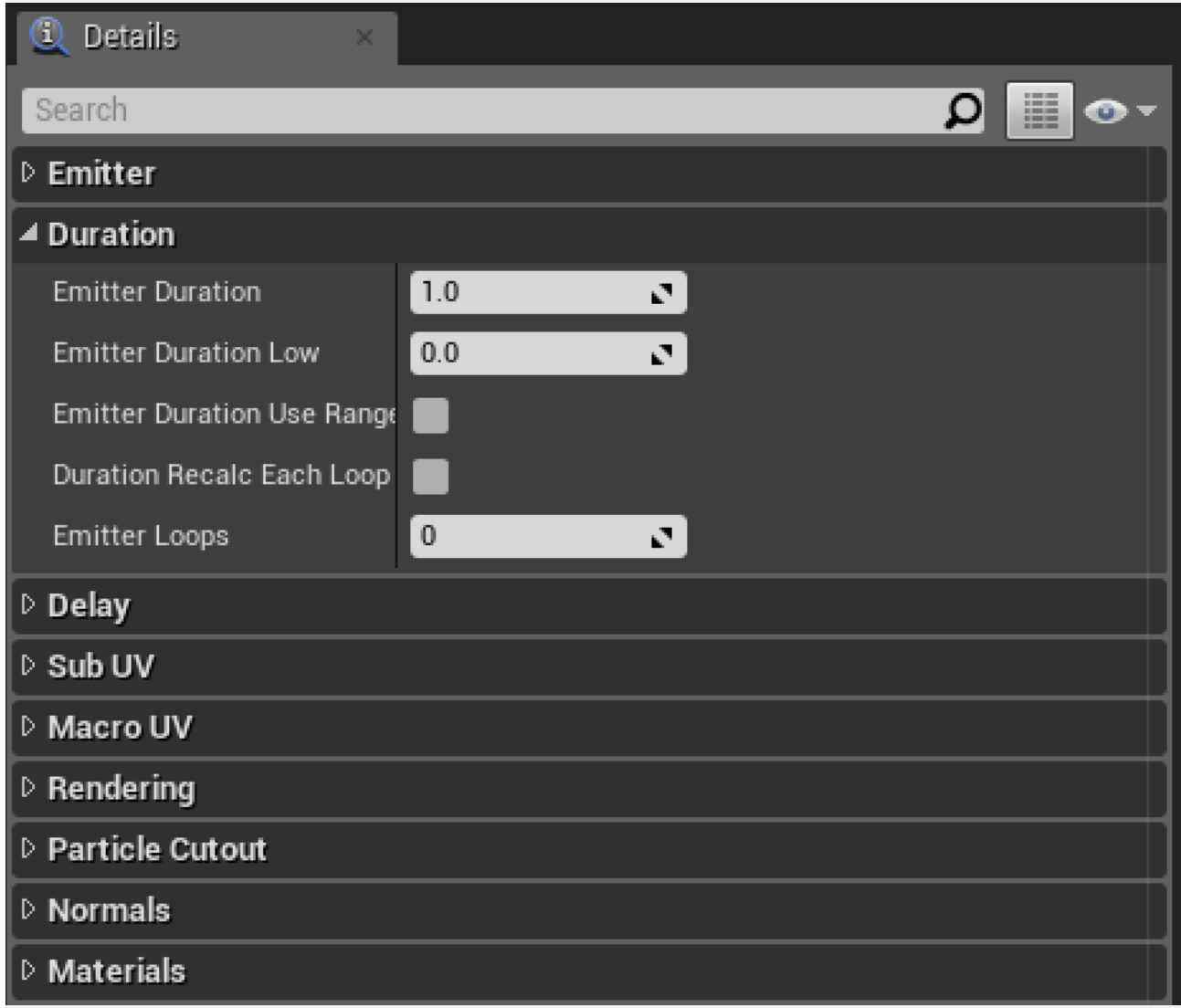
PARTICLE LIFE CYCLE

Every Emitter in a Particle System has a duration. The duration is how long in seconds the Emitter will run before it loops. Emitters can loop a set number of times or continuously.

Duration is controlled in the Required module.

If an Emitter runs through a set number of loops, it simply deactivates itself.

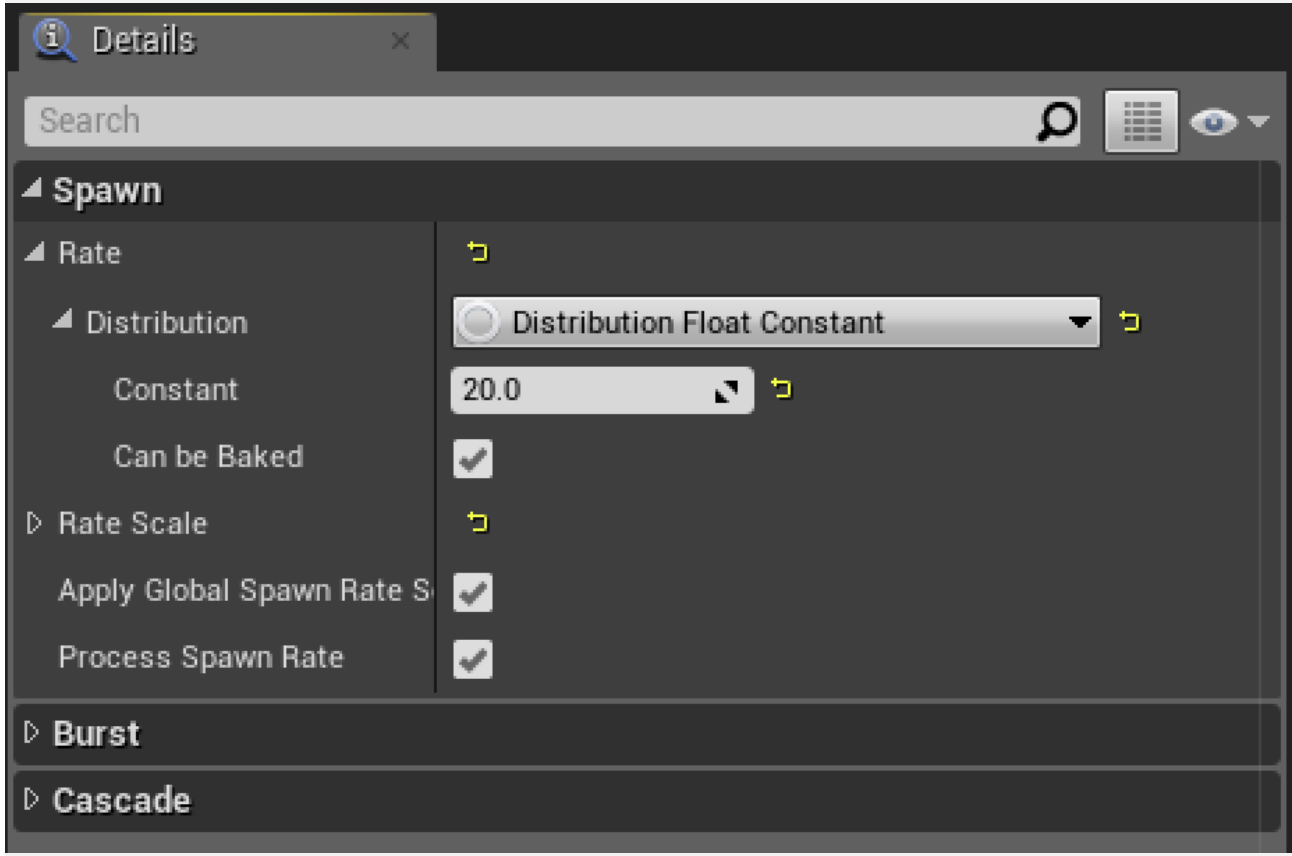
If an Emitter is set to run continuously by setting the Emitter Loops property to 0, it will continue to play unless it is told to deactivate itself.



PARTICLE LIFE CYCLE

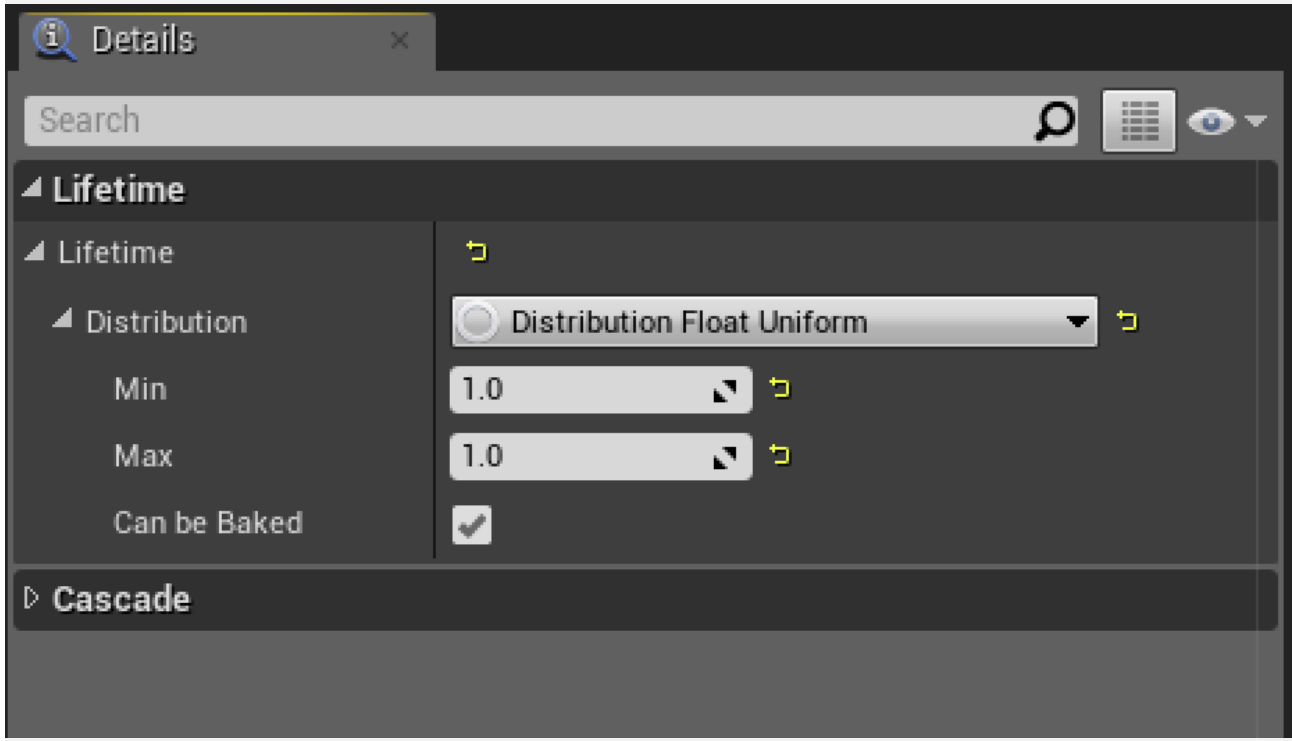
The birth of a particle is controlled with the Spawn module, which determines how many particles are spawned into the world over one loop of the Emitter's duration.

Particles can be spawned at a constant rate over the Emitter loop cycle or all at once, which is called a burst.



PARTICLE LIFE CYCLE

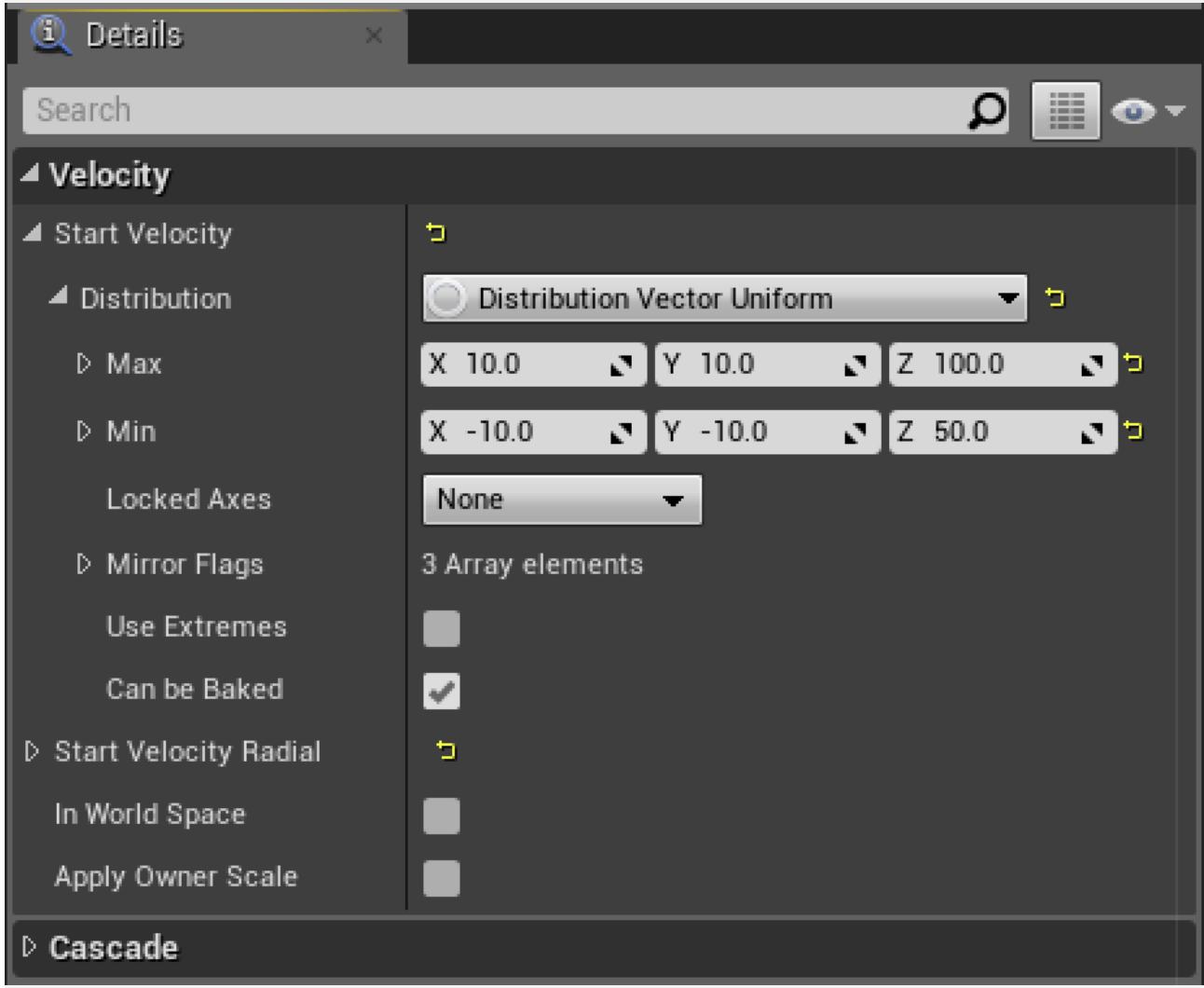
Every particle emitted over the duration of the Emitter’s loop also has its own life span, determined by the Lifetime module.



PARTICLE LIFE CYCLE

When a particle is spawned into the world, it needs to have an initial velocity determined by the Initial Velocity module.

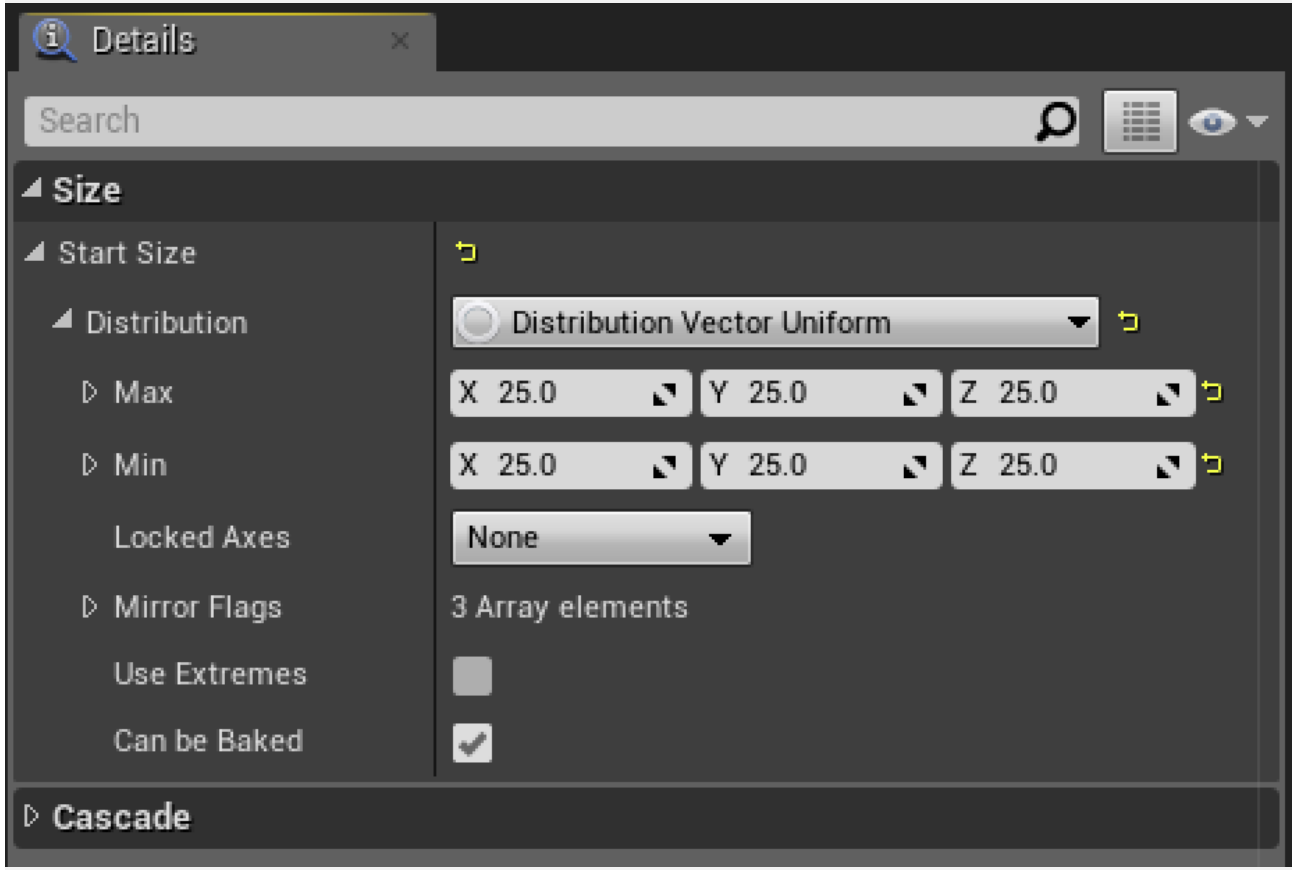
You specify the speed of the particles using a Distribution Vector Uniform variable type. This lets you define a Min and Max for the velocity vector, giving variation to your Particle System.



PARTICLE LIFE CYCLE

To define the size particles spawn at, use the Initial Size module.

Like Initial Velocity, you use a Distribution Vector Uniform variable to allow for size variation between the Min and Max values.



MATERIALS FOR PARTICLES

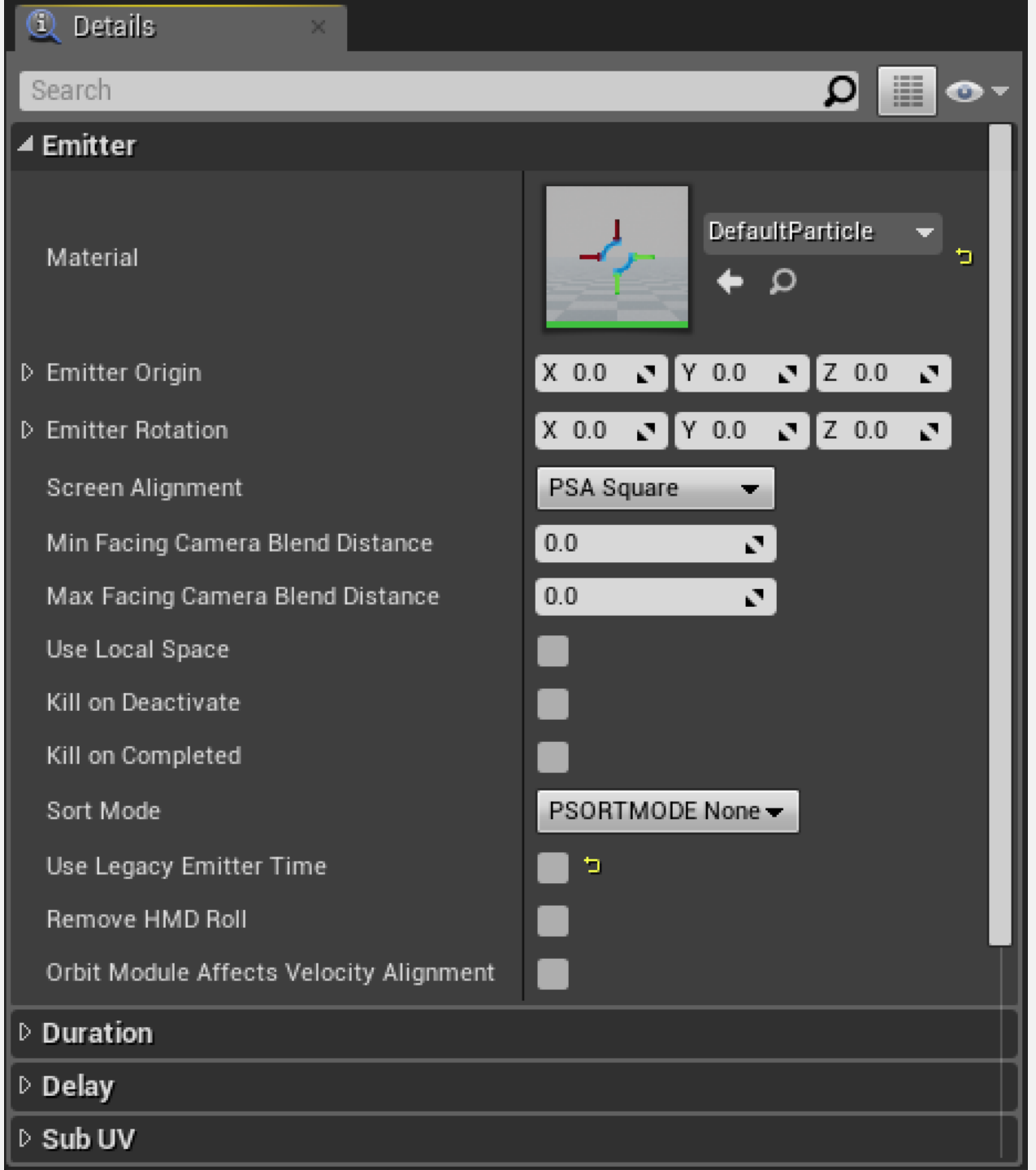
MATERIALS FOR PARTICLES

While most modules control particle transforms, there are a few that work directly with the Emitter’s assigned Material.

Understanding the interaction between Emitters and the Materials assigned to them is an important part of creating a great particle effect.

MATERIALS FOR PARTICLES

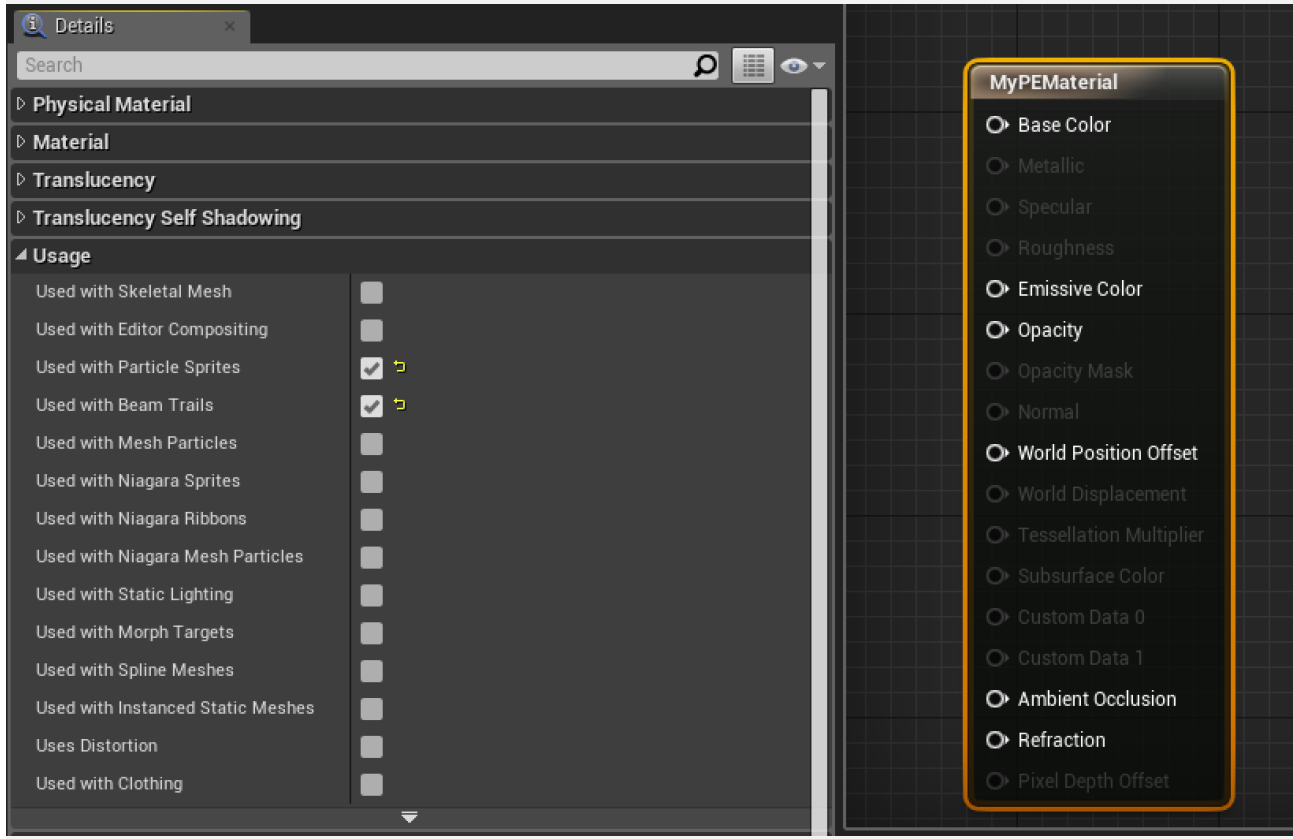
A Material is assigned to the Emitter in the Required module. The Emitter then applies the Material to each particle emitted.



MATERIALS FOR PARTICLES

When you create a new Material to use with particles, you should tell the Editor how it will be used.

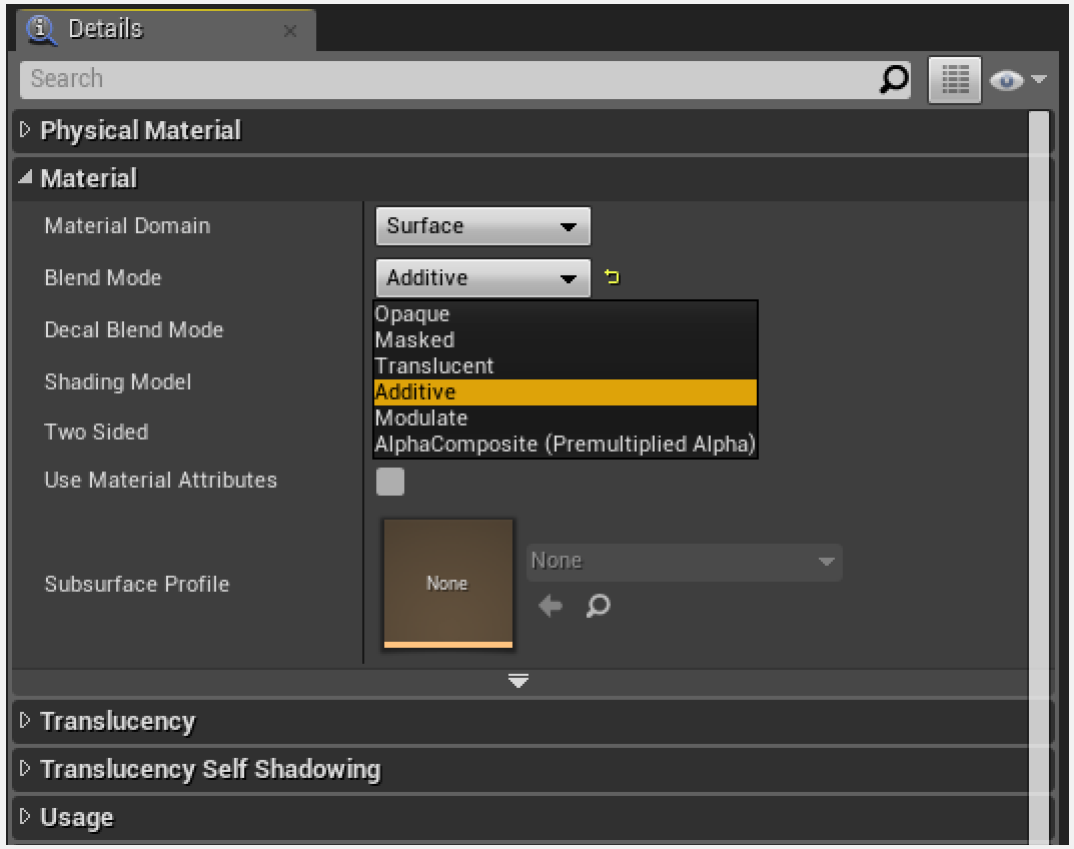
With the Material open in the Material Editor, select the master Material node and in the Details panel look for the Usage tab. Here you will see a few toggles that have to do with particles.



MATERIALS FOR PARTICLES

The next thing to consider is the Material Blend Mode. This property is important because it affects how each of the particles blend with one another when overlapping.

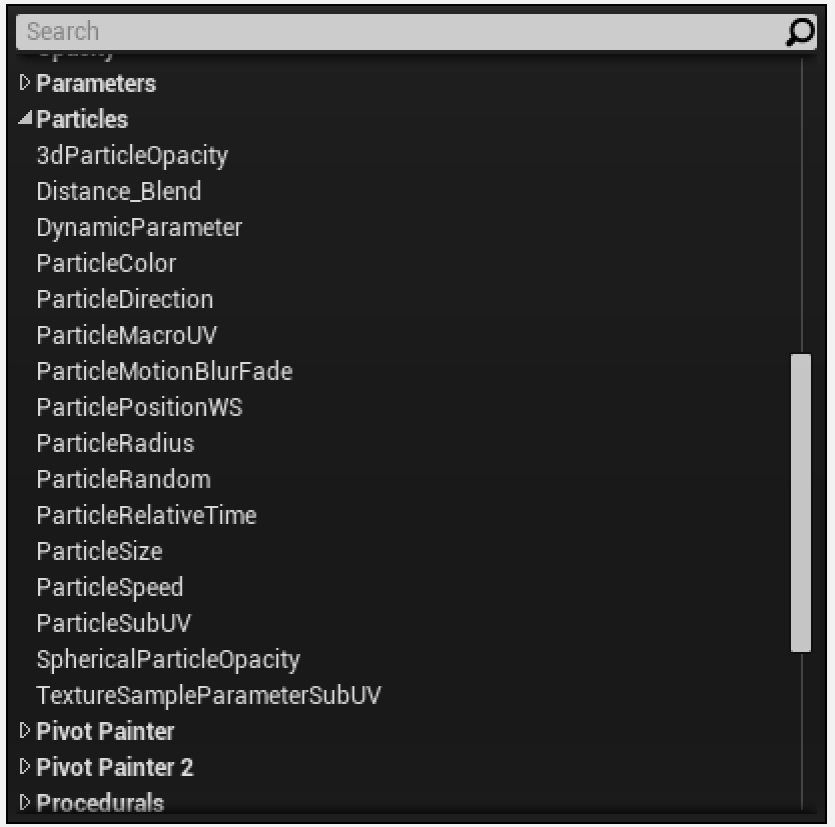
While any of the Blend Modes technically work, Additive and Translucent are typically most effective. The proper Blend Mode is ultimately determined by the effect you are trying to create.



MATERIALS FOR PARTICLES

Once you have a Material set up, the next thing to be aware of are the Material expressions that work directly with Particle Emitters.

There are quite a few, but for a basic setup, ParticleColor is a good one to start with because it works directly with the Color Over Life module.



MATERIALS FOR PARTICLES

The example on the right shows a basic Material set for use with particles.

The Particle Color input node is used to modulate the Texture as well as the opacity.