

Where Are My Particles?

Debugging Techniques for VFX in Unreal 4

Dan Bruington & Brittany Hein
FXVille

Introduction

- Who are we?
- What is this talk? Who is it for?
- Unreal 4 Specific?

Who Are We?

Dan Bruington

Technical FX Artist at FXVille



Who Are We?

Brittany Hein

Senior FX Artist at FXVille





We're hiring!

Site: www.fxville.com

Email: jobs@fxville.com

What is this talk?

Topics we'll be covering:

- Using features of Blueprint to visualize / debug data
- Niagara features for understanding particles
- Materials techniques and built-in functions

Who is it for?

Knowing how to debug is important!



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Who is it for?

Niche discipline



Who is it for?

Content creator control



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

What is this talk? Who is it for?

Knowing “why” can lead to innovation



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19–23, 2021 | #GDC21

Unreal 4 Specific?

Examples using built-in workflows



Unreal 4 Specific?

Techniques broadly applicable, but methods may vary

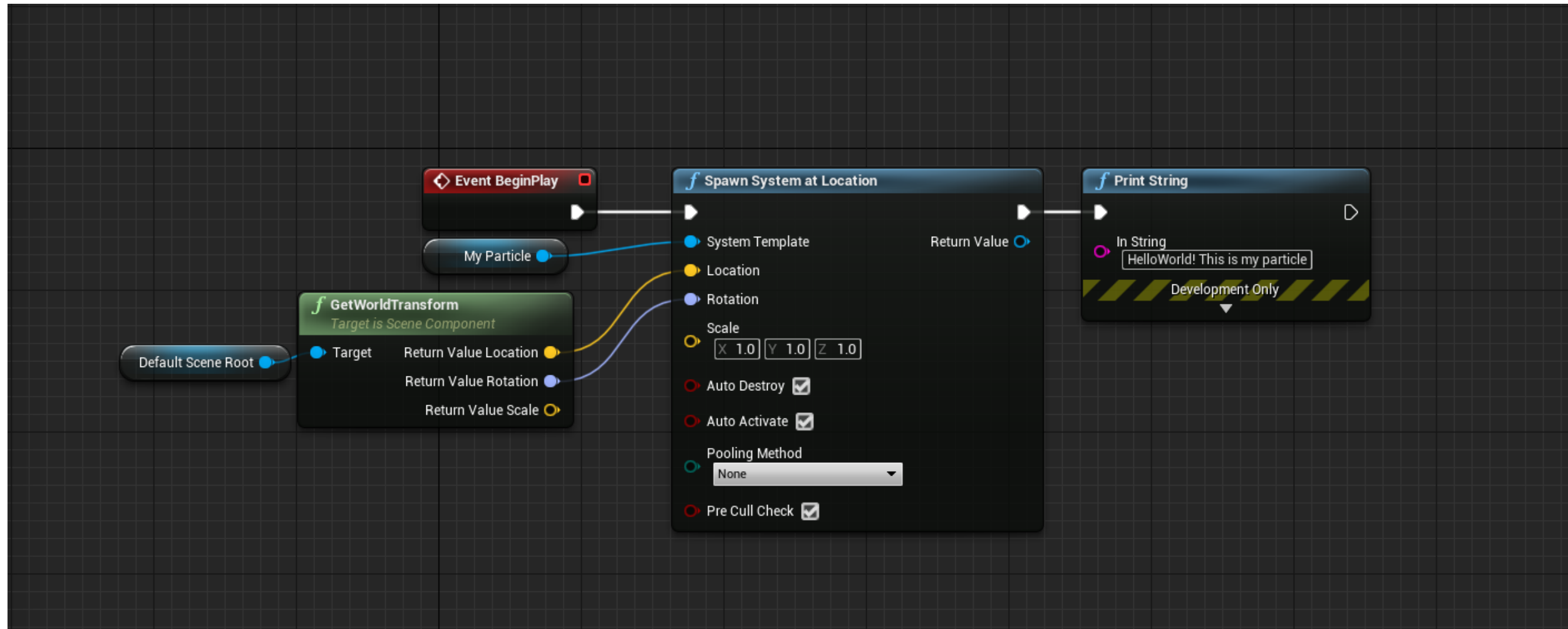


Blueprints

- What are they?
- Dynamic Materials
- Debugging variables
- Tool example: `DisplayParticleNames`

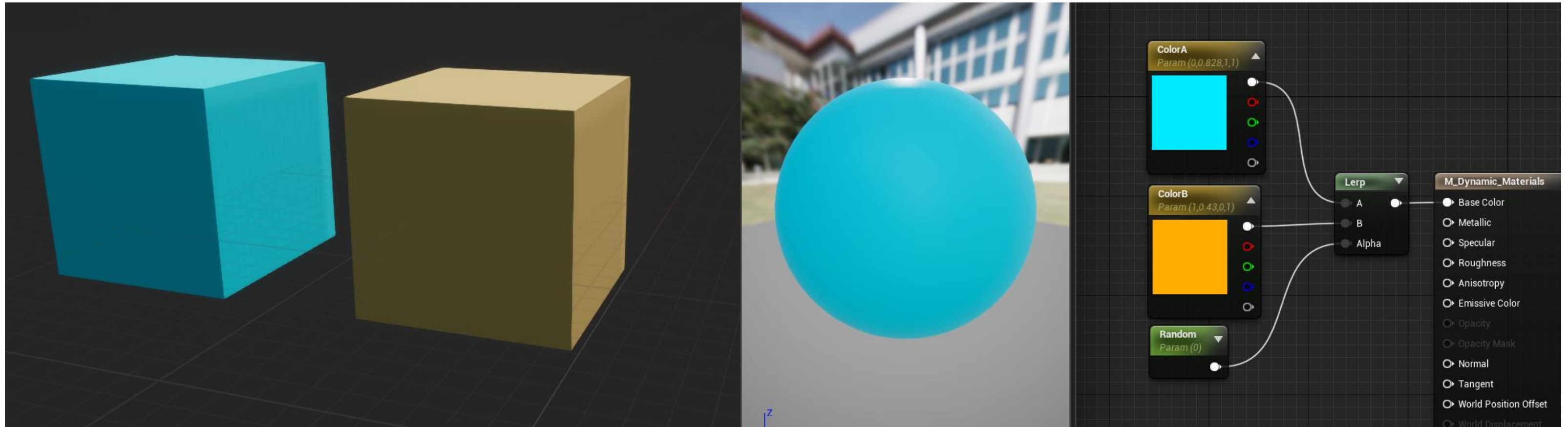
Blueprints

Unreal's node-based visual scripting



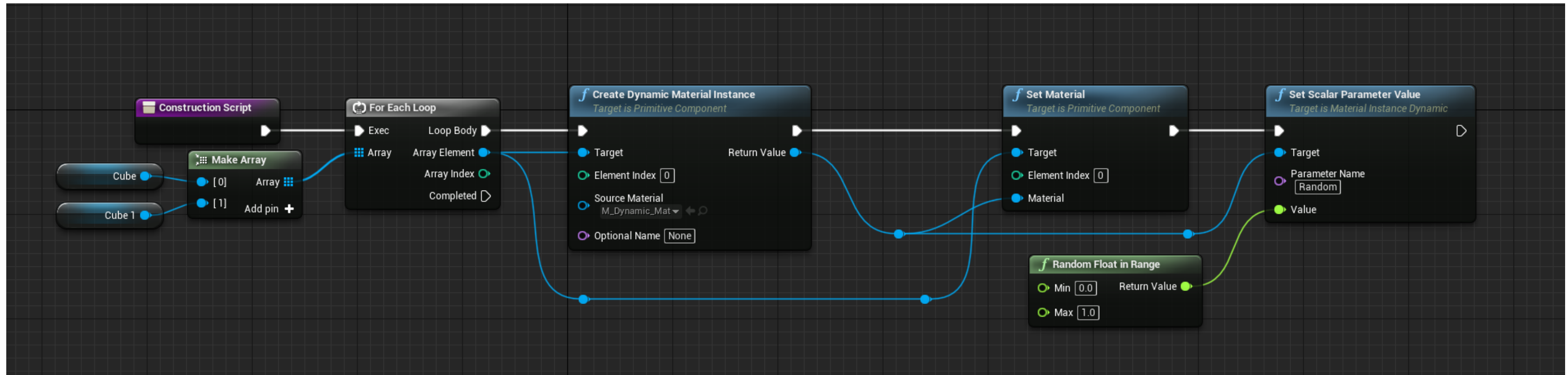
Blueprints

Creating dynamic materials



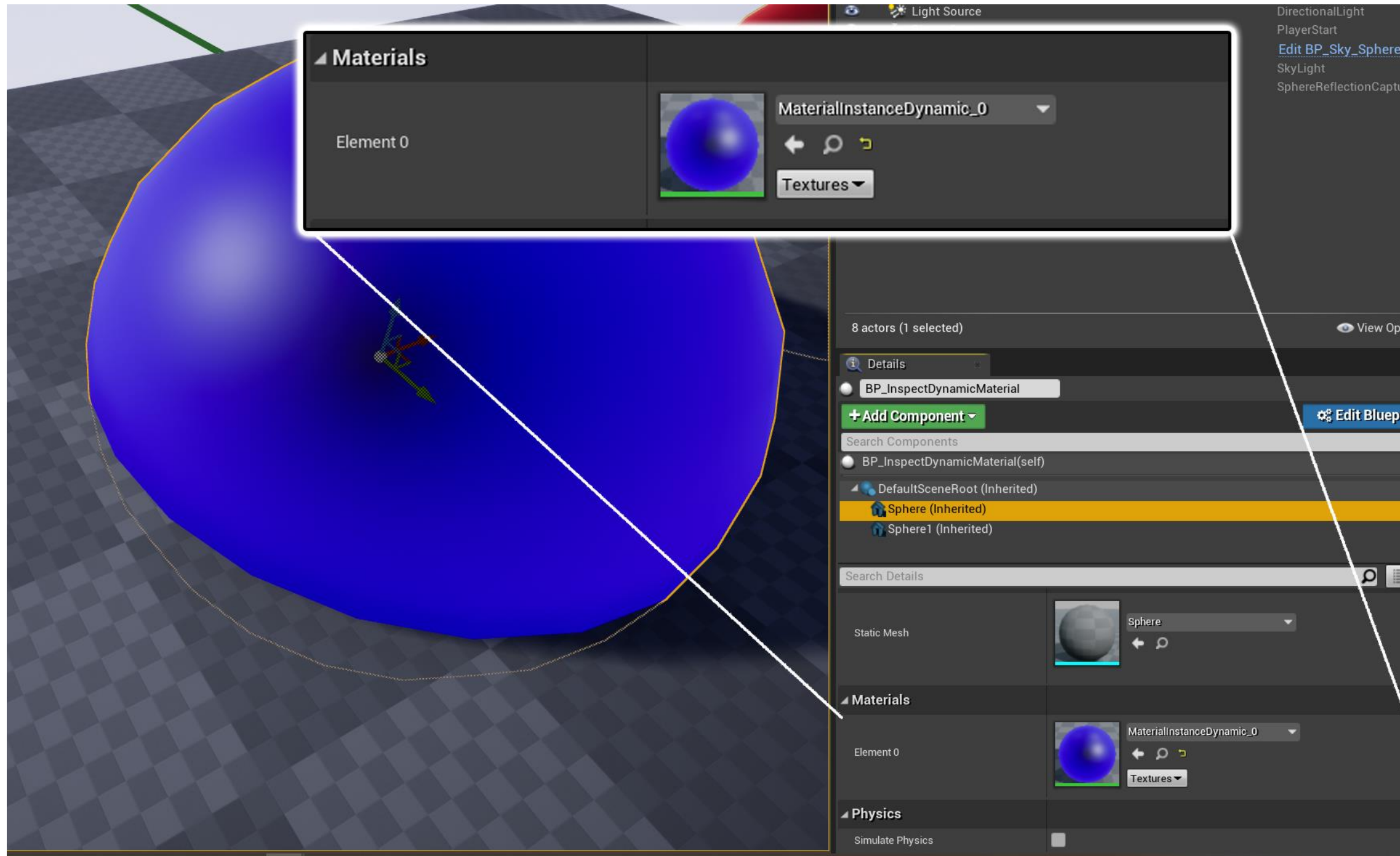
Blueprints

Assigning dynamic materials



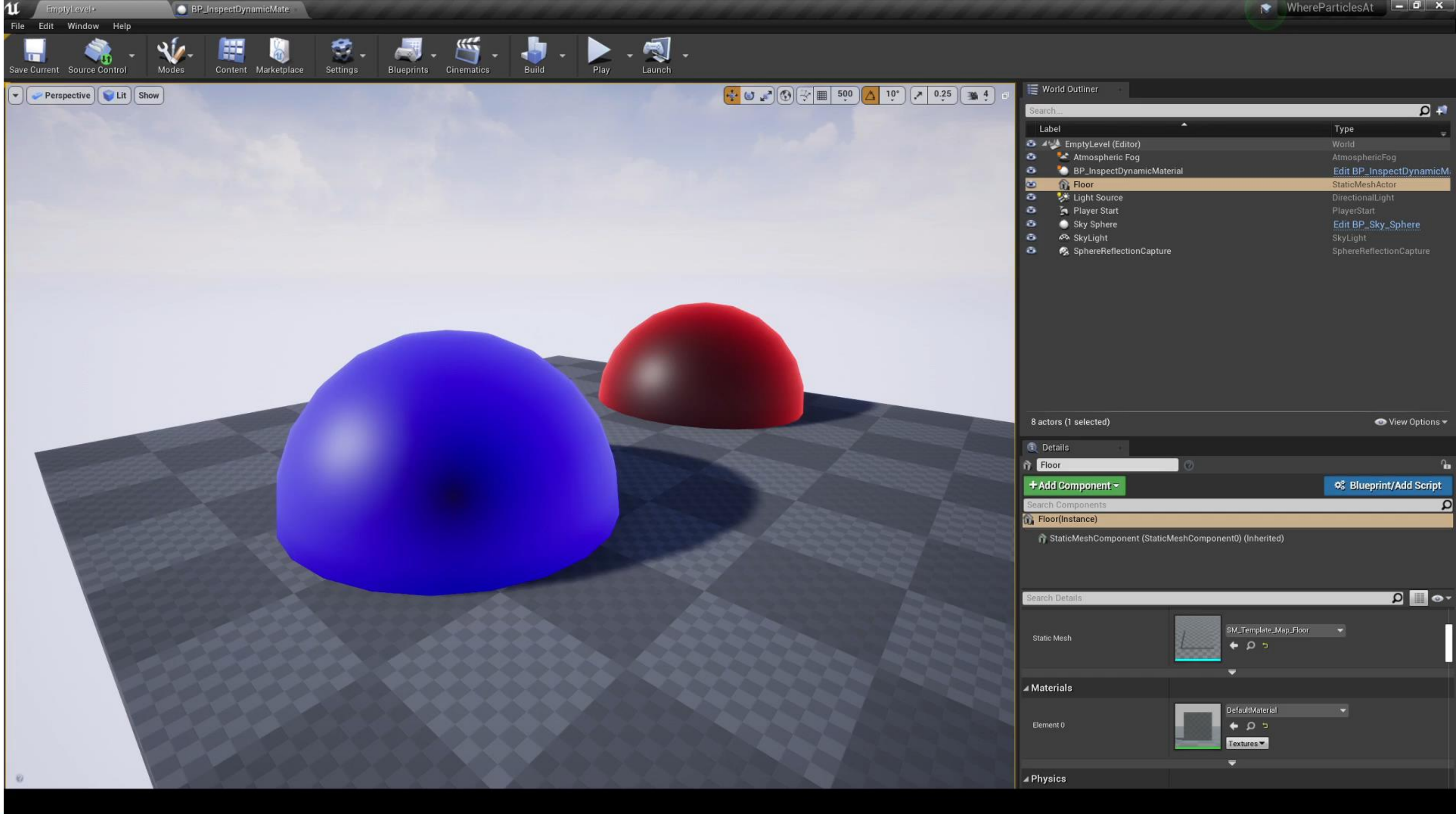
Blueprints

Viewing dynamic material parameters at runtime



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

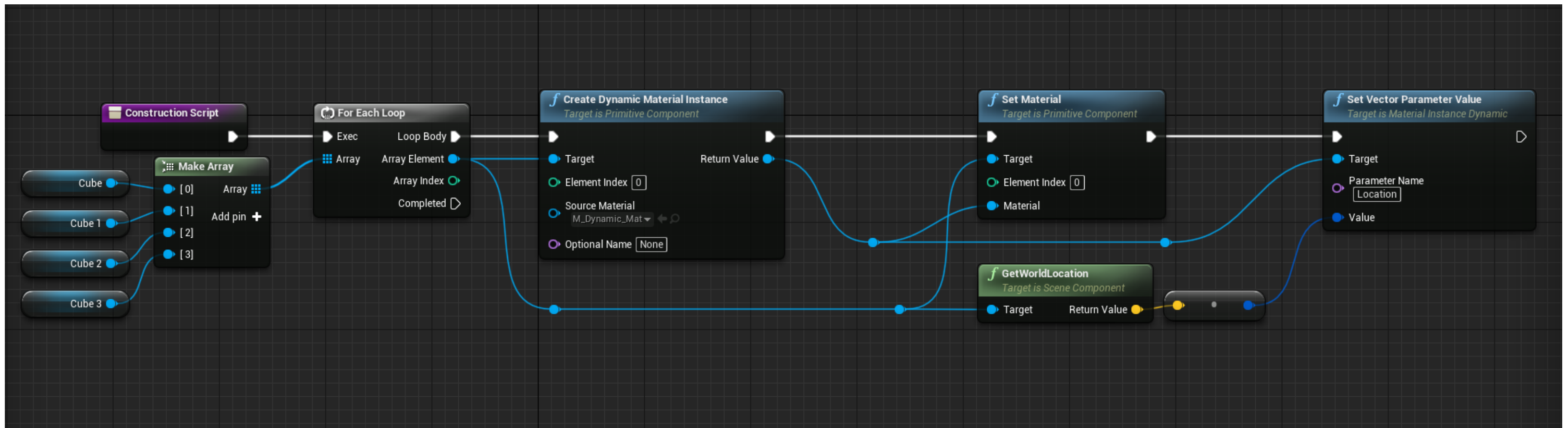


GDC[®]

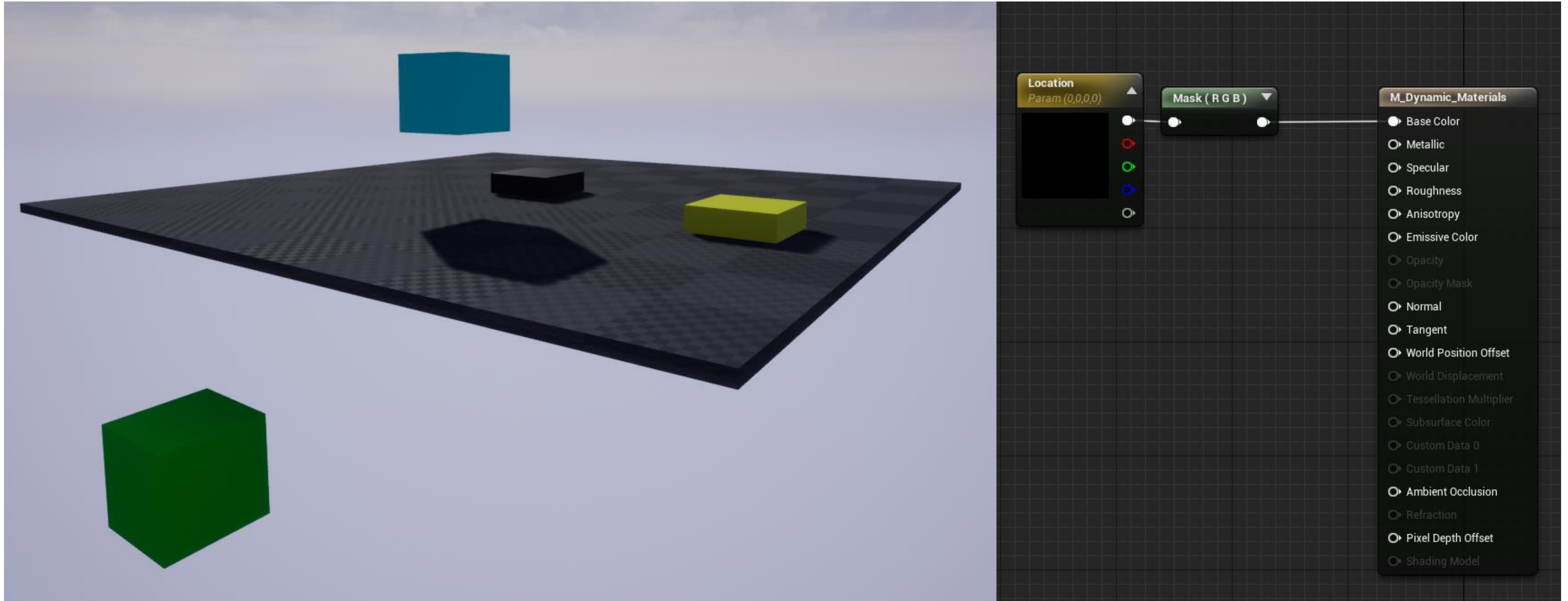
GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

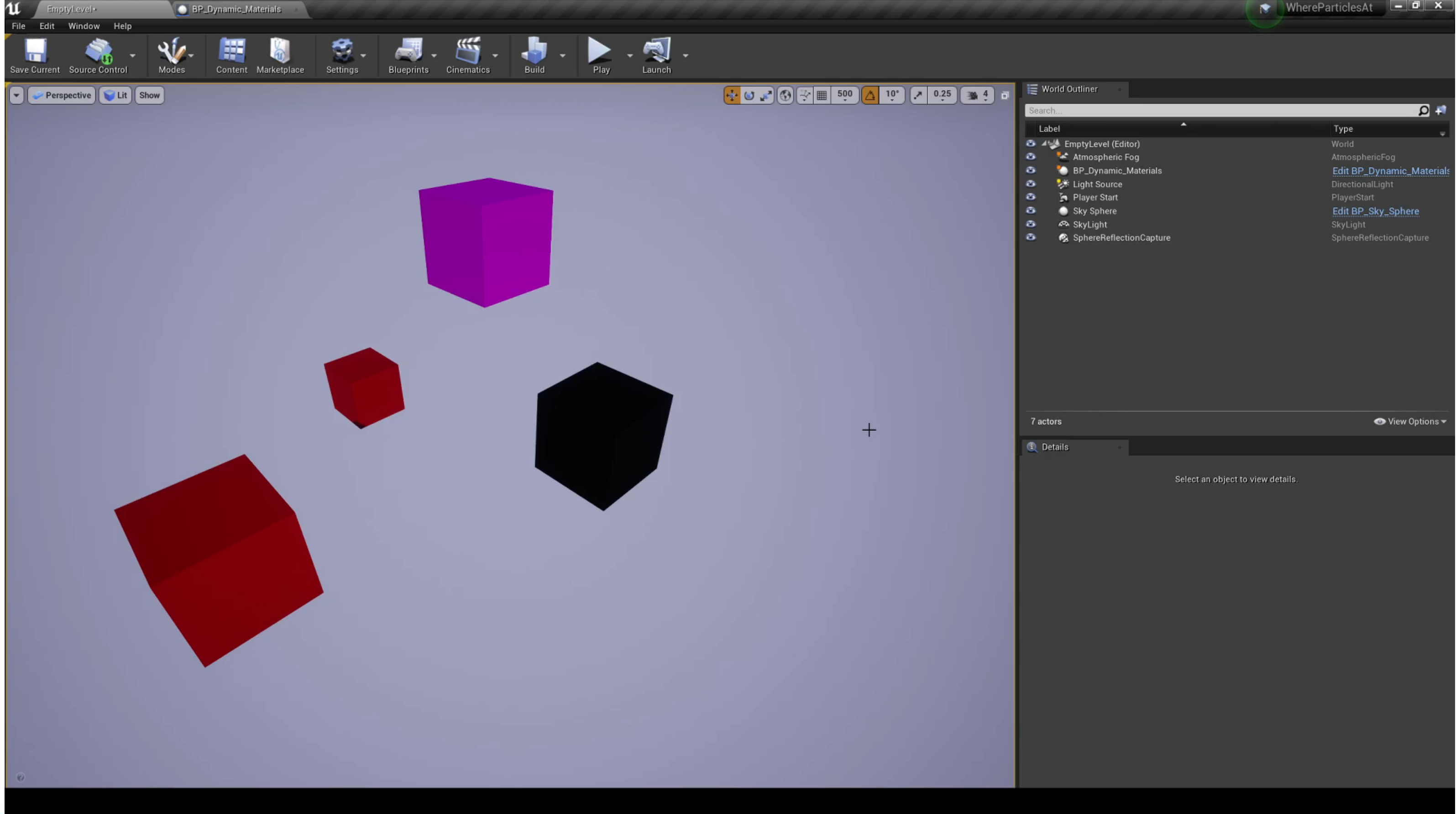
Blueprints

Sending debug parameters on dynamic materials



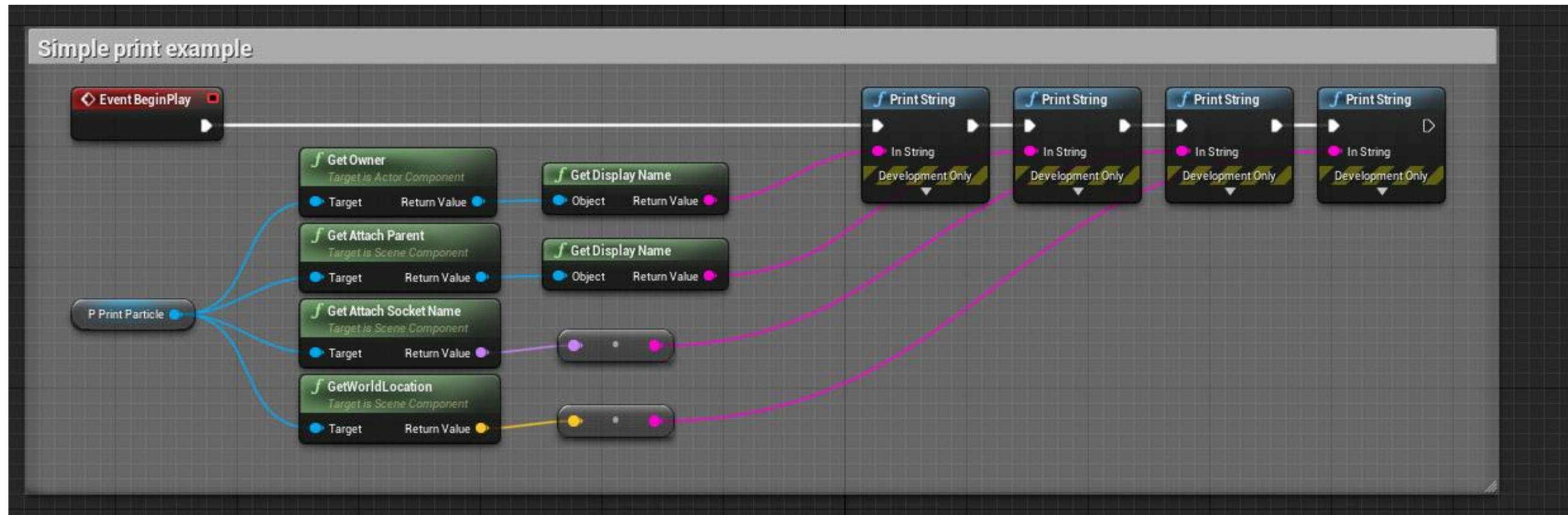
Blueprints





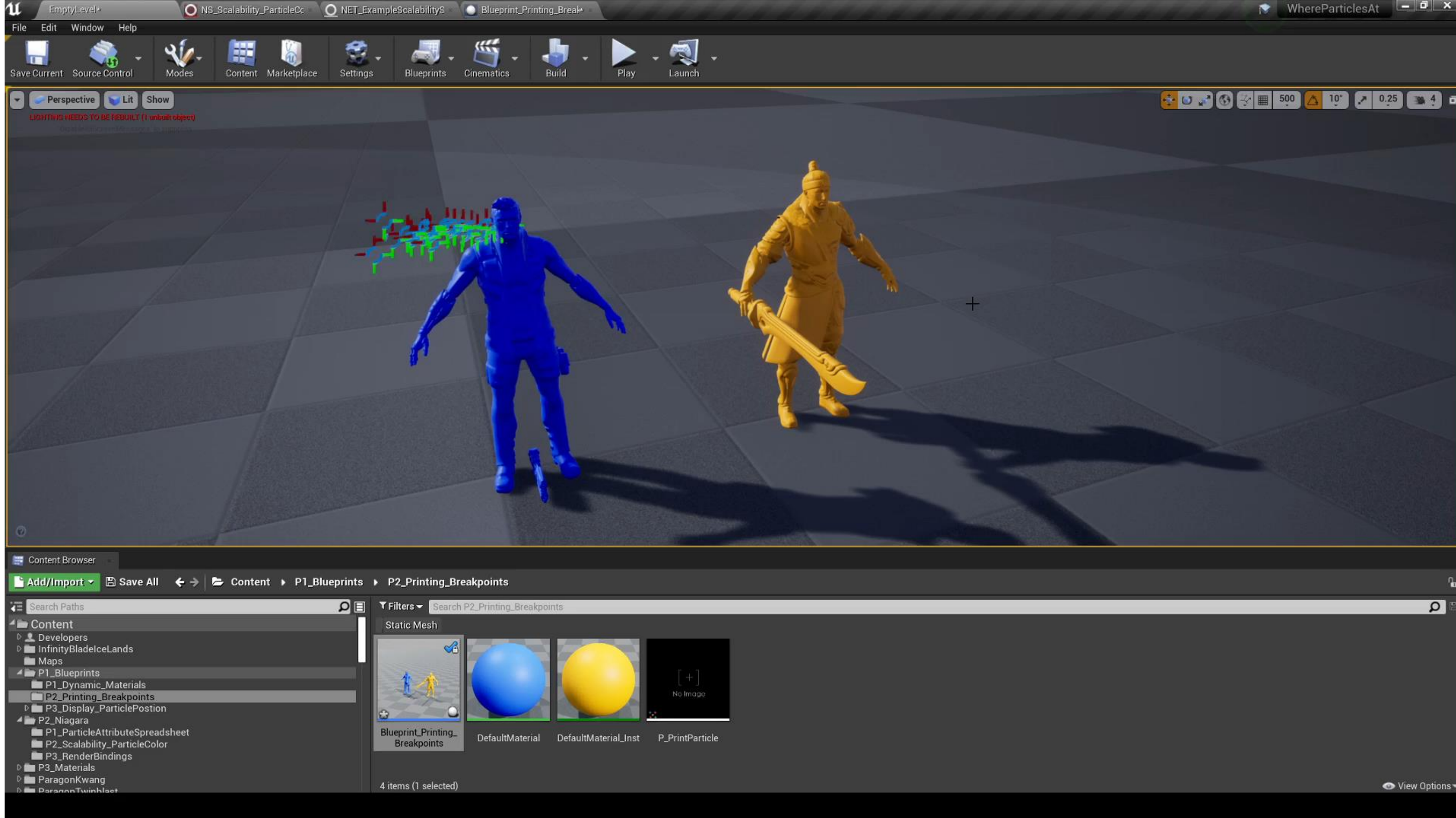
Blueprints

Debugging variables: Print string!



GDC³⁵

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21



EmptyLevel+ Blueprint_Printing_Break...

File Edit Asset View Debug Window Help

Components

+ Add Component Search

Blueprint_Printing_Breakpoints(self)

DefaultSceneRoot

- TwinBlast
- KwangSunrise
- P_PrintParticle

My Blueprint

+ Add New Search

Graphs

- EventGraph
 - Event BeginPlay
 - Event ActorBeginOverlap
 - Event Tick

Functions (18 Overridable)

- ConstructionScript

Macros

Variables

Components

- P_PrintParticle
- KwangSunrise
- TwinBlast
- DefaultSceneRoot

Event Dispatchers

Compile Save Browse Find Hide Unrelated Class Settings Class Defaults Simulation Play No debug object selected Debug Filter

Viewport Construction Scrip Event Graph

Perspective Lit 10 10 0.25

Blueprint_Printing_Breakpoints > Event Graph Zoom -1

Get information on a randomly spawned particle

Event BeginPlay

Pick a random character to attach to

- Twin Blast
- Kwang Sunrise
- Make Array
 - [0]
 - [1]
 - Add pin +
- Random Integer in Range
 - Min 0
 - Max 1
- GET

P Print Particle

AttachComponentToComponent

Target is Scene Component

- Target
- Parent
- Socket Name
- Location Rule
 - Keep Relative
- Rotation Rule
 - Keep Relative
- Scale Rule
 - Keep Relative
- Weld Simulated Bodies
 - ☒

Return Value

Pick a random socket to attach to

- Make Literal Name
 - Value Chest
 - Return Value
- Make Literal Name
 - Value Root
 - Return Value
- Random Integer in Range
 - Min 0
 - Max 1
- Make Array
 - [0]
 - [1]
 - Add pin +
- GET

BLUEPRINT

Compiler Results

[1780.23] Compile of Blueprint_Printing_Breakpoints successful! [in 47 ms] (//Game/P1_Blueprints/P2_Printing_Breakpoints/Blueprint_Printing_Breakpoints.Blueprint_Printing_Breakpoints)

Clear



GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

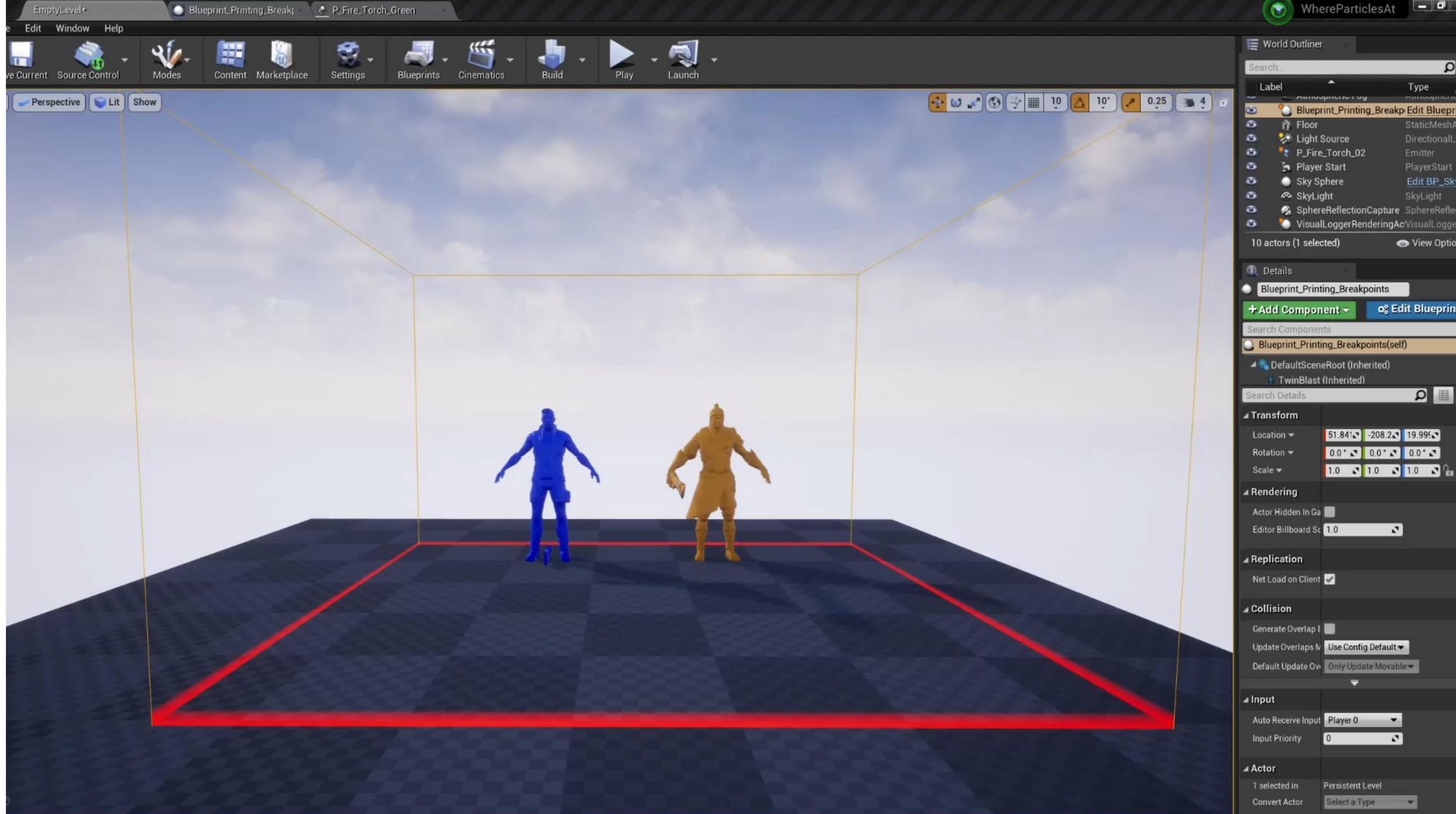
Print String

Tips:

Use print string for values that change rapidly.

Use append string to combine multiple pieces of data.

Also, you can color code them!

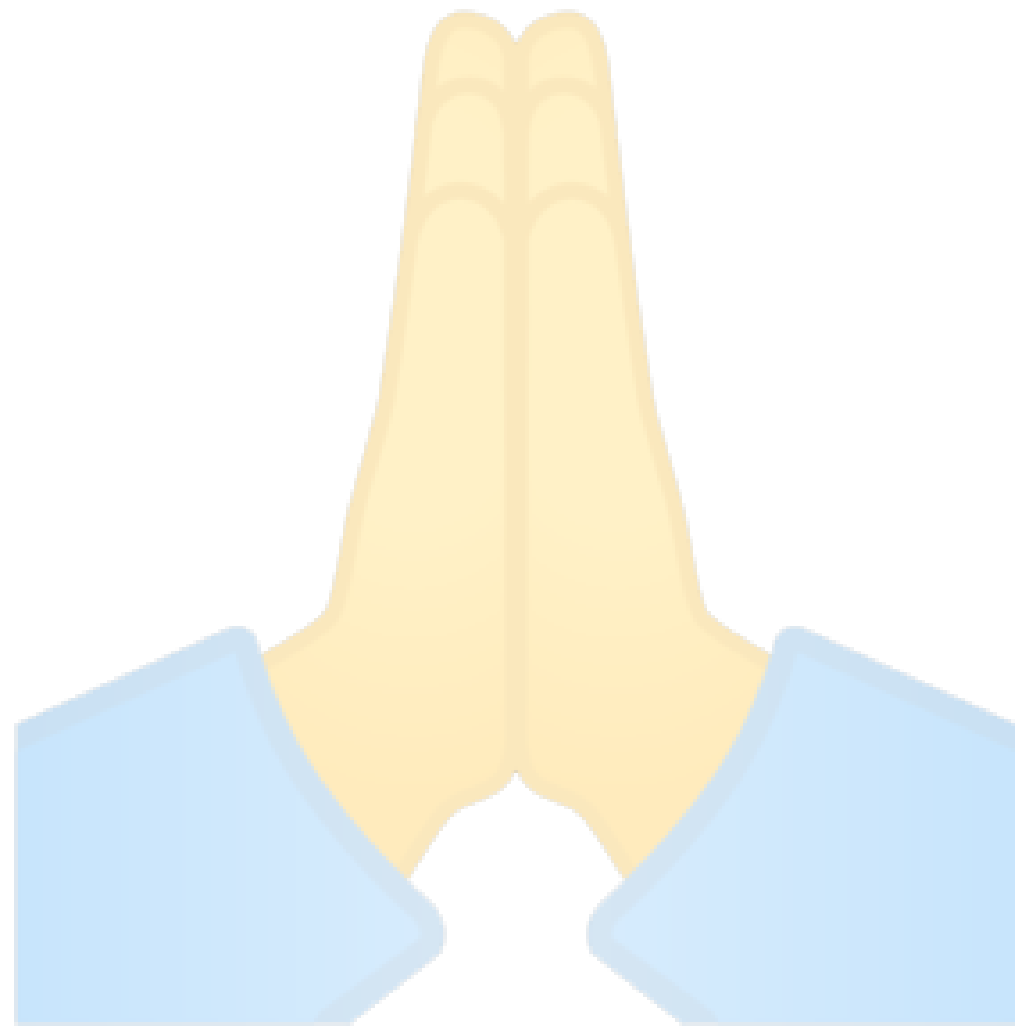


GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

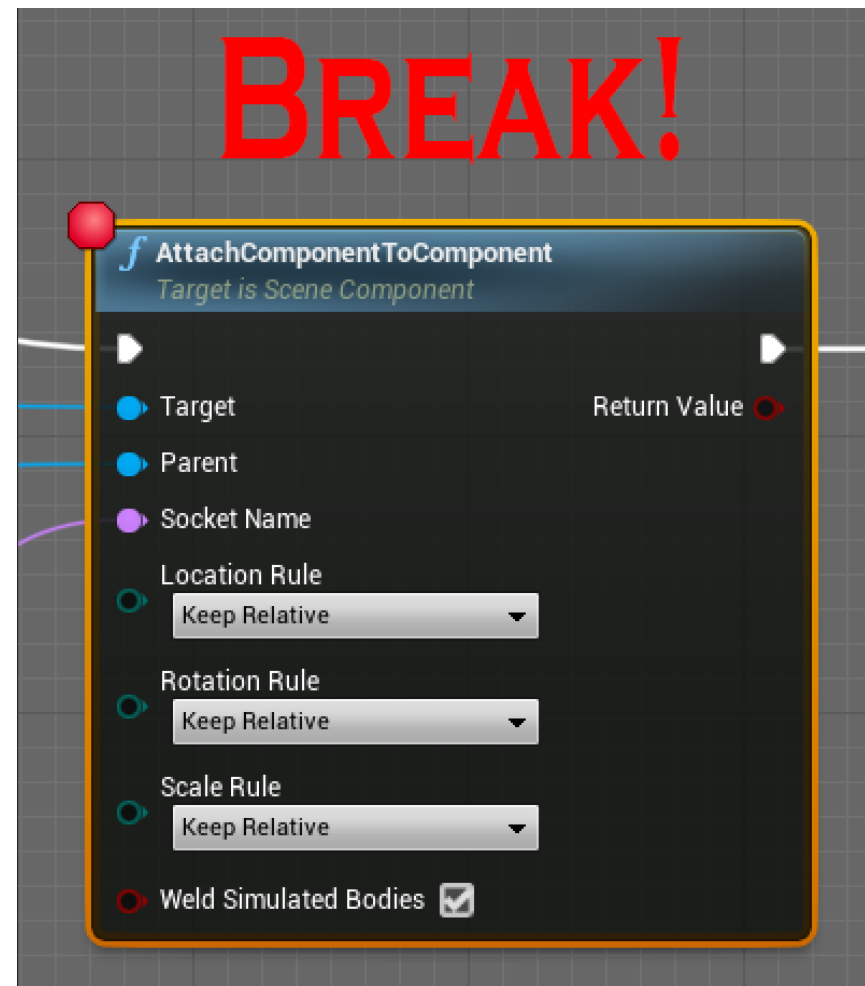
Blueprints

Be a friend, don't check in too much debug Print String!



Blueprints

Debugging variables: Breakpoints!



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

EmptyLevel* Blueprint_Printing_Break* Parent class: A

Edit Asset View Debug Window Help

Components

Add Component

Blueprint_Printing_Breakpoints

DefaultSceneRoot

TwinBlast

KwangSunrise

P_PrintParticle

Scene

My Blueprint

Add New Search

Graphs

EventGraph

Functions (18 Overridable)

ConstructionScript

Macros

Variables

Components

Event Dispatchers

Compile Save Browse Find Hide Unrelated Class Settings Class Defaults Simulation Play Debug Filter

Blueprint_Printing_Breakpoints

Viewports Construction Script Event Graph

Blueprint_Printing_Breakpoints > Event Graph

Zoom -2

Get information on a randomly spawned particle

Event BeginPlay

Pick a random character to attach to

Twin Blast

Kwang Sunrise

Make Array

[0]

[1]

Array

Add pin

GET

Random Integer in Range

Min 0

Max 1

Return Value

P Print Particle

AttachComponentToComponent

Target is Scene Component

Target

Parent

Socket Name

Location Rule

Keep Relative

Rotation Rule

Keep Relative

Scale Rule

Keep Relative

Weld Simulated Bodies

P Print Particle

Pick a random socket to attach to

Make Literal Name

Value Chest

Return Value

Make Literal Name

Value Root

Return Value

Random Integer in Range

Min 0

Max 1

Return Value

Make Array

[0]

[1]

Array

Add pin

GET

BLUEPRINT

Compiler Results

[8996.31] Compile of Blueprint_Printing_Breakpoints successful! [in 72 ms] (/Game/P1_Blueprints/P2_Printing_Breakpoints/Blueprint_Printing_Breakpoints.Blueprint_Printing_Breakpoints)

Clear



GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Blueprint Tool

Display Particle Positions



GDC[®]

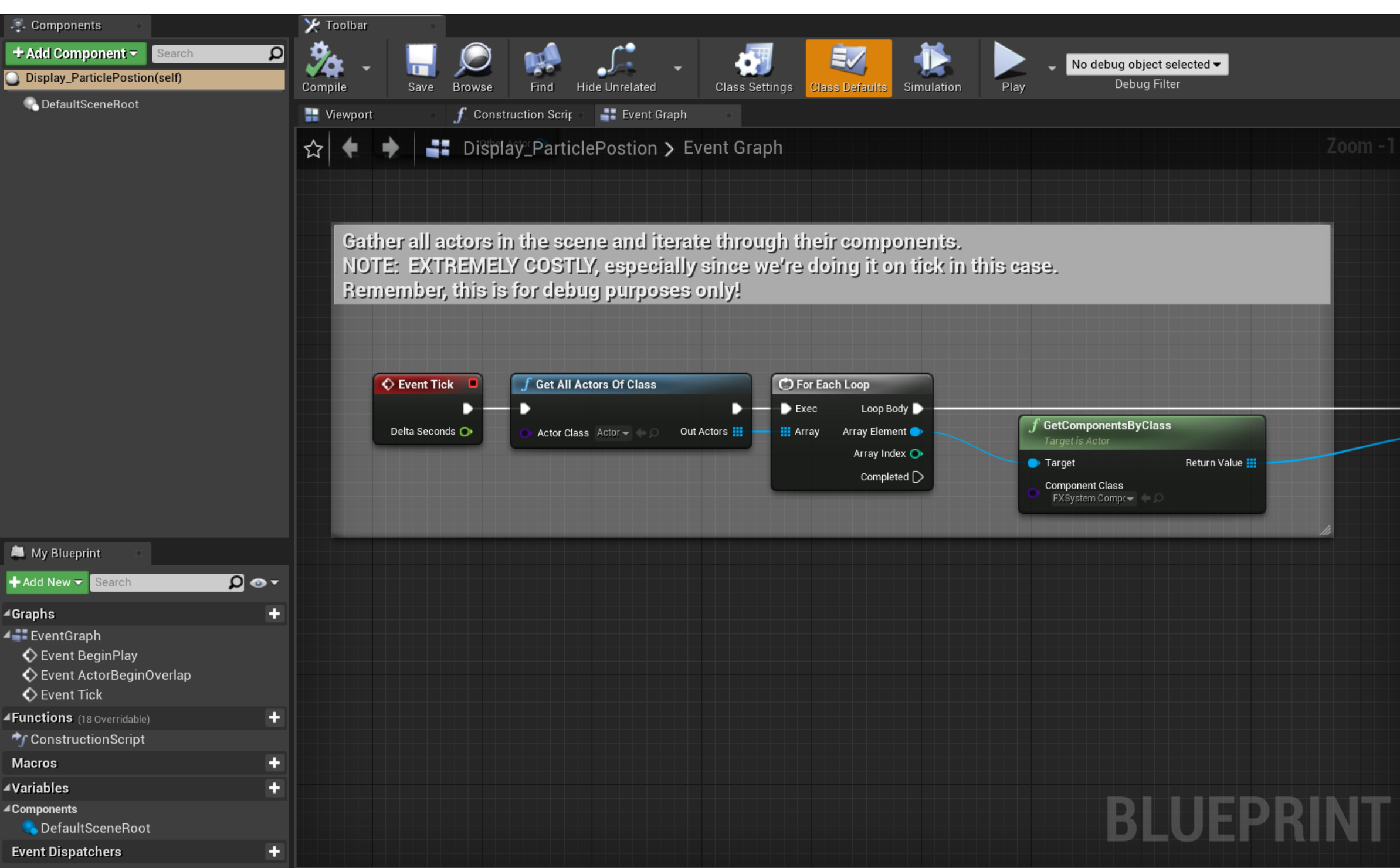
GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Display Particle Positions

Goal: While playing the game, I want to know what particle systems are active in specific locations.

Sometimes you see a particle and it is not clear where it came from, or what system it's in, and ejecting and finding it in the outliner is non-trivial.

Solution: A blueprint that we can place in the level that will display the names of particle systems at their origins.



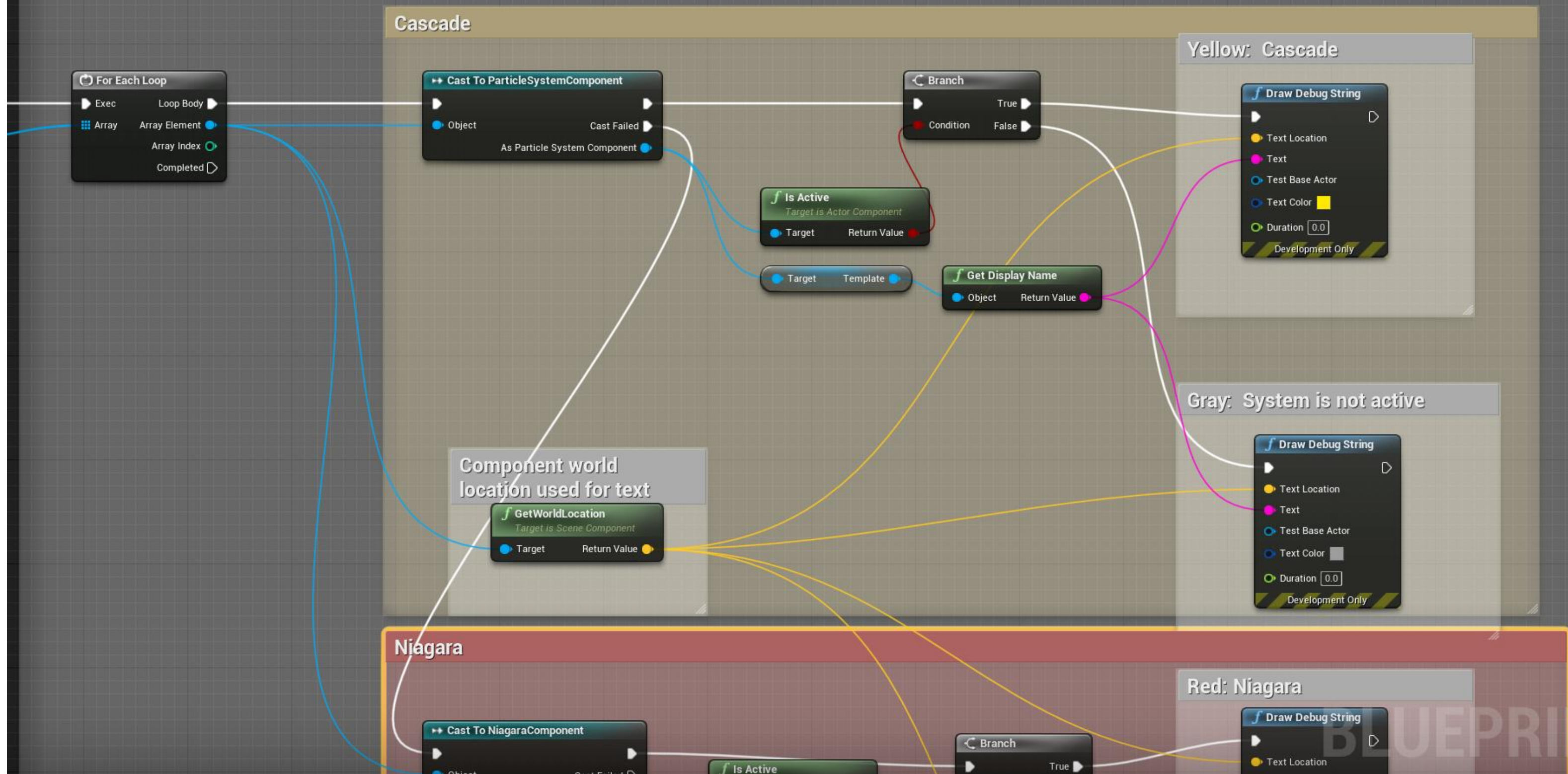
High level concept:

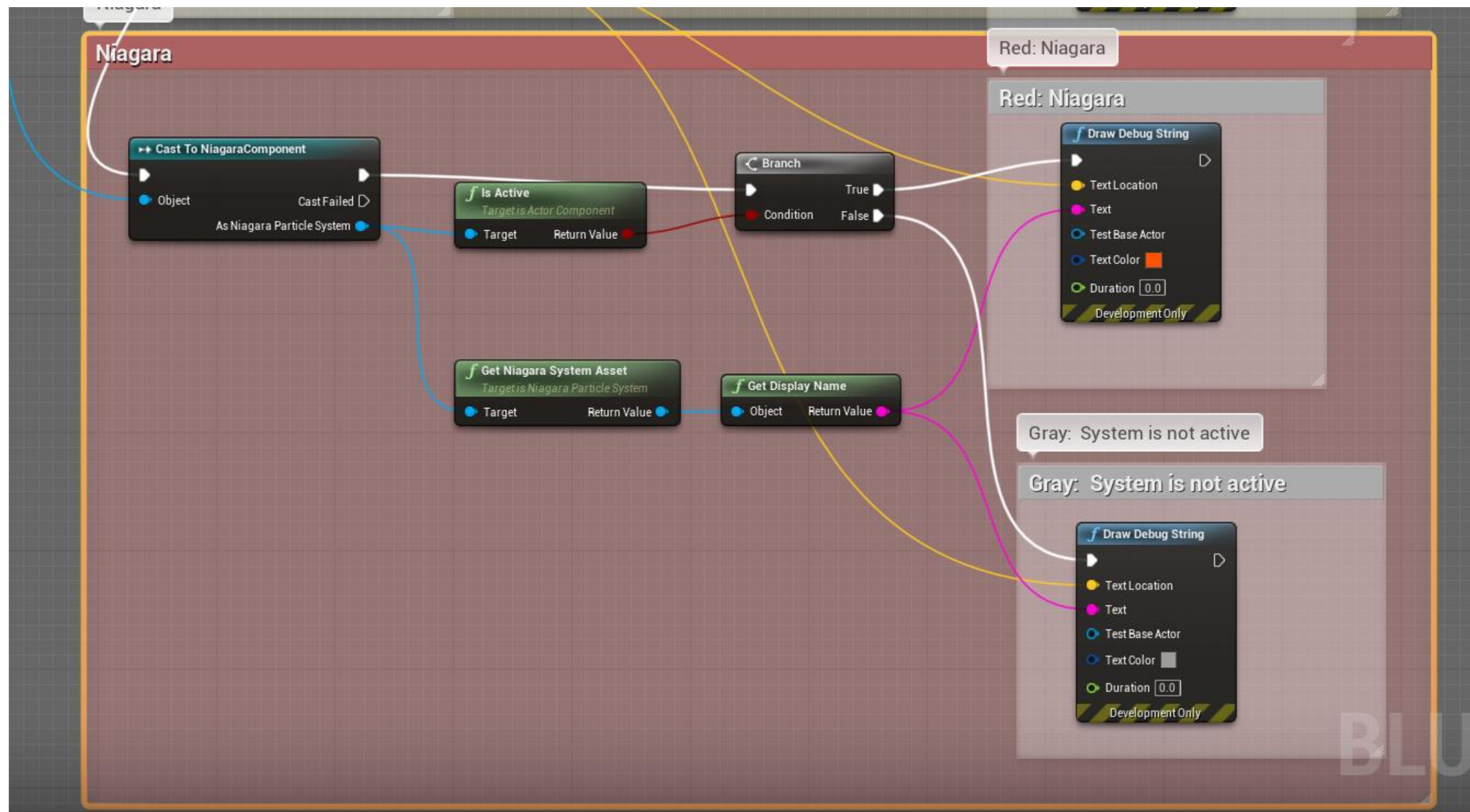
-Gather all actors in the scene

-Iterate through their FXSystemComponents

-DisplayDebugText at their component locations

For each particle component, display its template name in space at the component's location.





DebugParticleNamesMap • Display_ParticlePostion

File Edit Asset View Debug Window Help

Components

- + Add Component
- Display_ParticlePostion(self)
- DefaultSceneRoot

Toolbar

- Compile
- Save
- Browse
- Find
- Hide Unrelated
- Class Settings
- Class Defaults
- Simulation
- Play
- No debug object selected
- Debug Filter

Viewport

- Construction Script
- Event Graph

Display_ParticlePostion > Event Graph

Zoom 1:1

This node is disabled and will not be called. Drag off pins to build functionality.

Event ActorBeginOverlap

Other Actor

Gather all actors in the scene and iterate through their components.
NOTE: EXTREMELY COSTLY, especially since we're doing it on tick in this case.
Remember, this is for debug purposes only!

For each par

My Blueprint

- + Add New
- Search

Graphs

- EventGraph
 - Event BeginPlay
 - Event ActorBeginOverlap
 - Event Tick

Functions (18 Overridable)

- ConstructionScript

Macros

Variables

Components

- DefaultSceneRoot

Event Dispatchers

Event Tick

Delta Seconds

Get All Actors Of Class

Actor Class Actor

Out Actors

For Each Loop

Exec

Loop Body

Array

Array Element

Array Index

Completed

GetComponentsByClass

Target is Actor

Target

Return Value

Component Class FXSystem Compoi

For Each

Exec

Array

BLUEPRINT

Compiler Results

Find Results

[2908.40] Compile of Display_ParticlePostion successful! [in 53 ms] (/Game/P1_Blueprints/P3_Display_ParticlePostion/Display_ParticlePostion.Display_ParticlePostion)

Clear

Details

Search Details

Graph Node

Comment Niagara

Comment

Comment

Font Size 18

Show Bubb

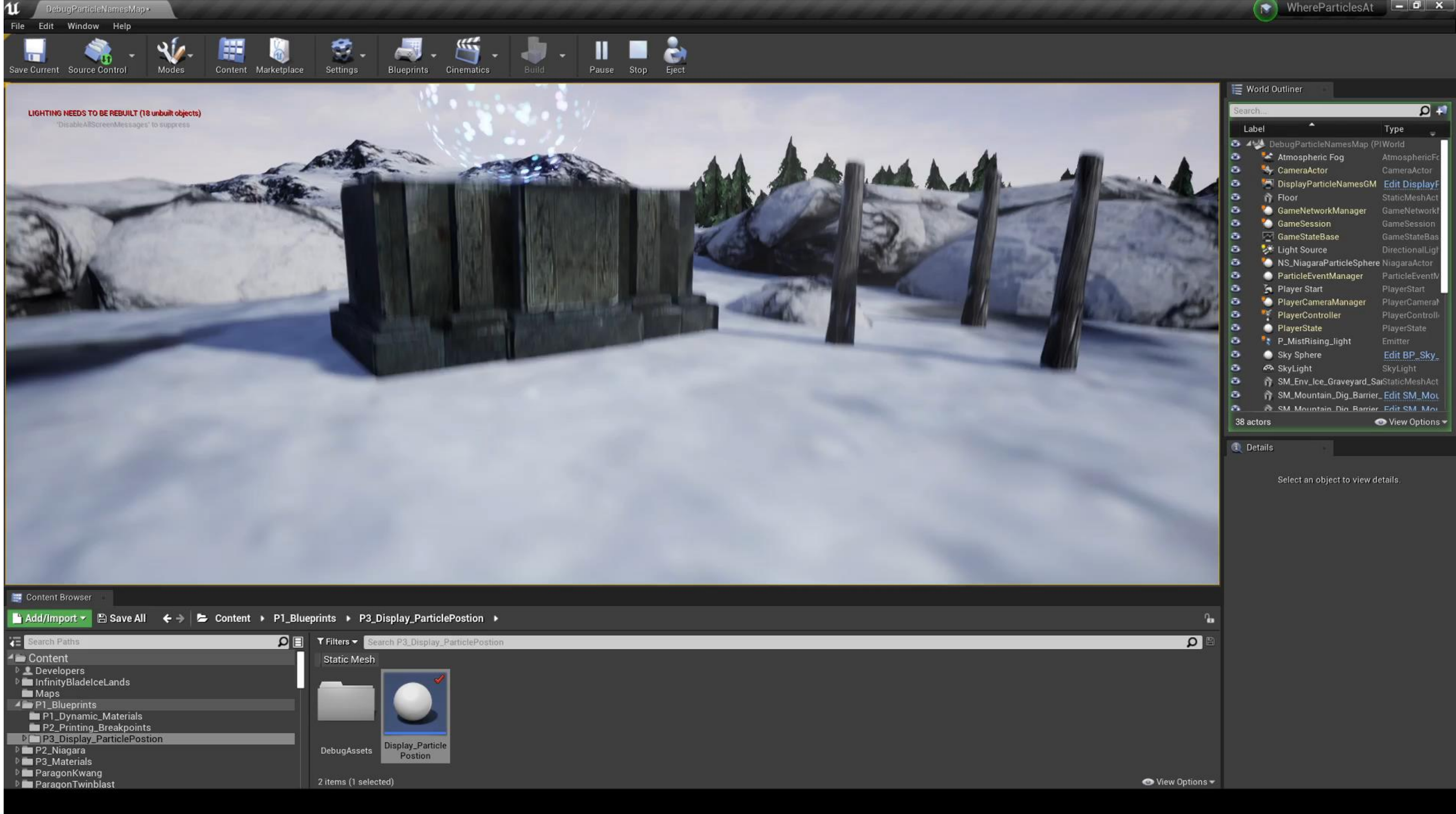
Color Bubb

Move Mod Group Movement



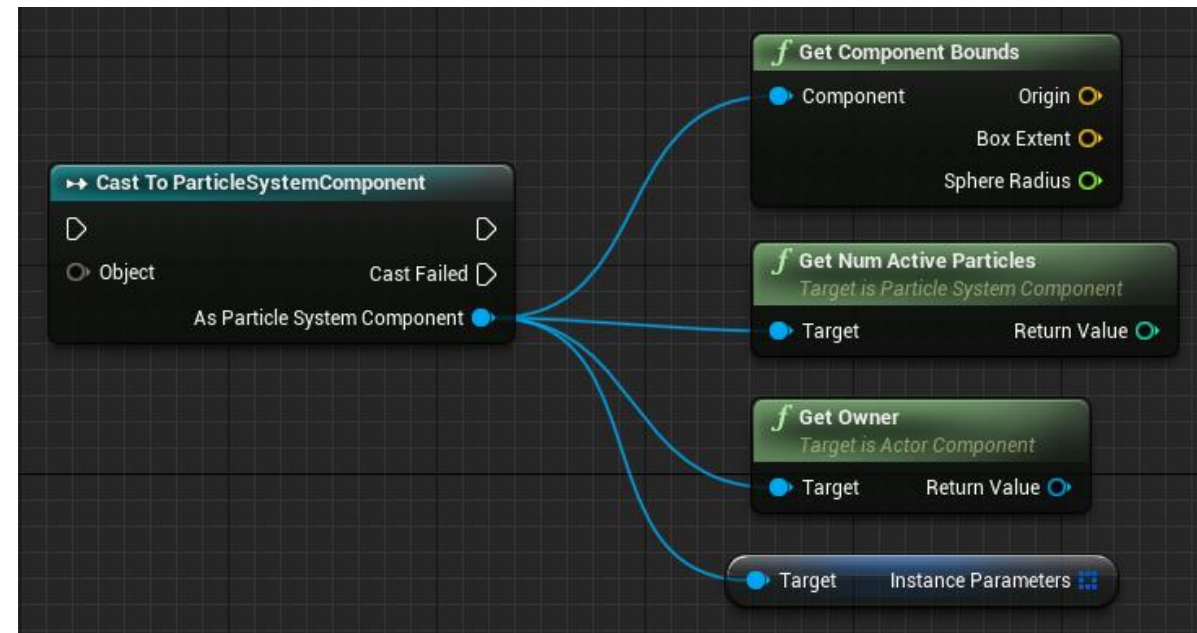
GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21



Display Particle Positions

- Display Bounds
- Point to Owning Actors
- Various Info: Active Particles, Instance Parameters

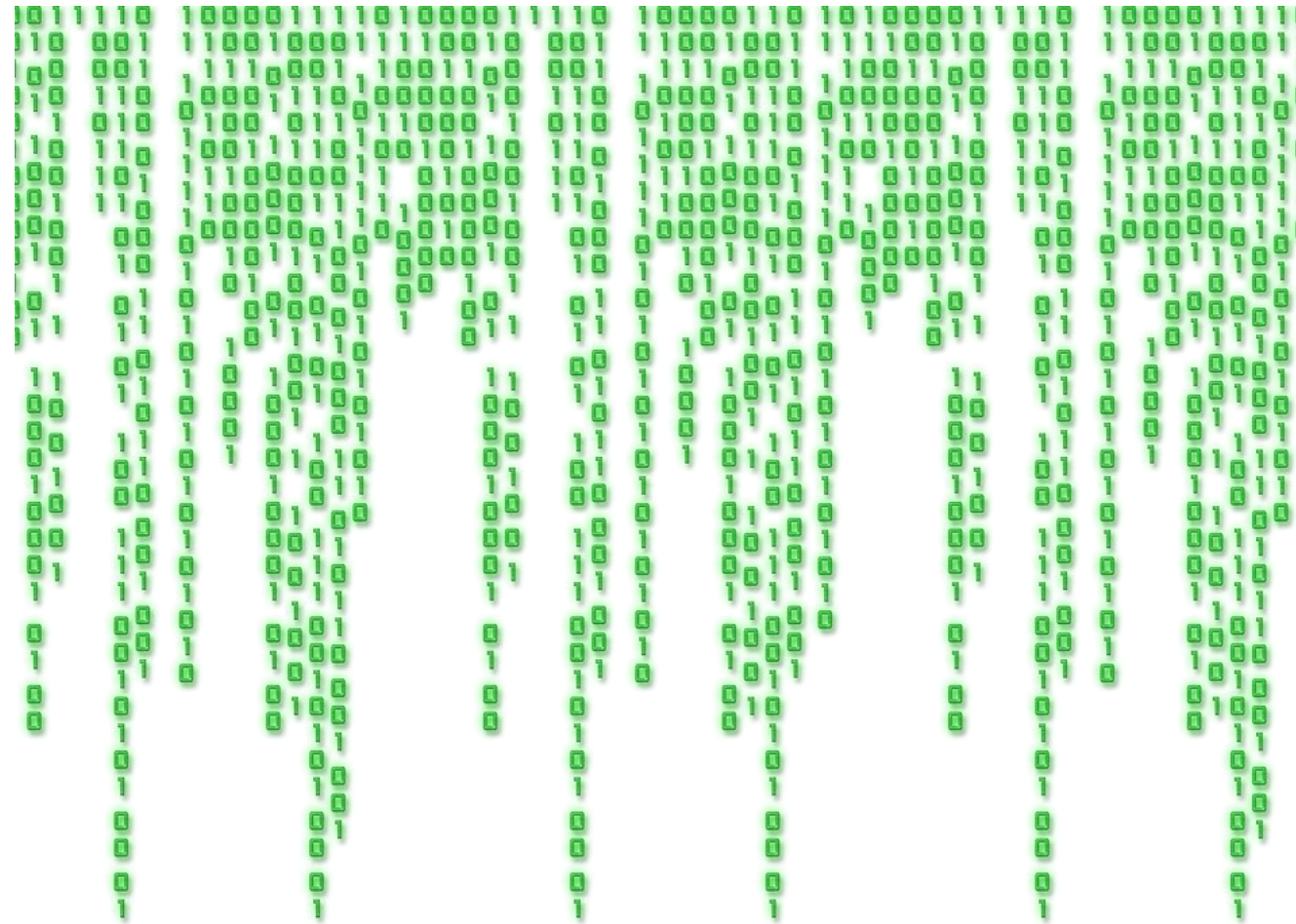


Niagara

- What is it?
- Using the Particle Attribute Spreadsheet
- Scalability Settings and Debugging
- Renderer bindings

Niagara

Extremely powerful, lots of data visible to you

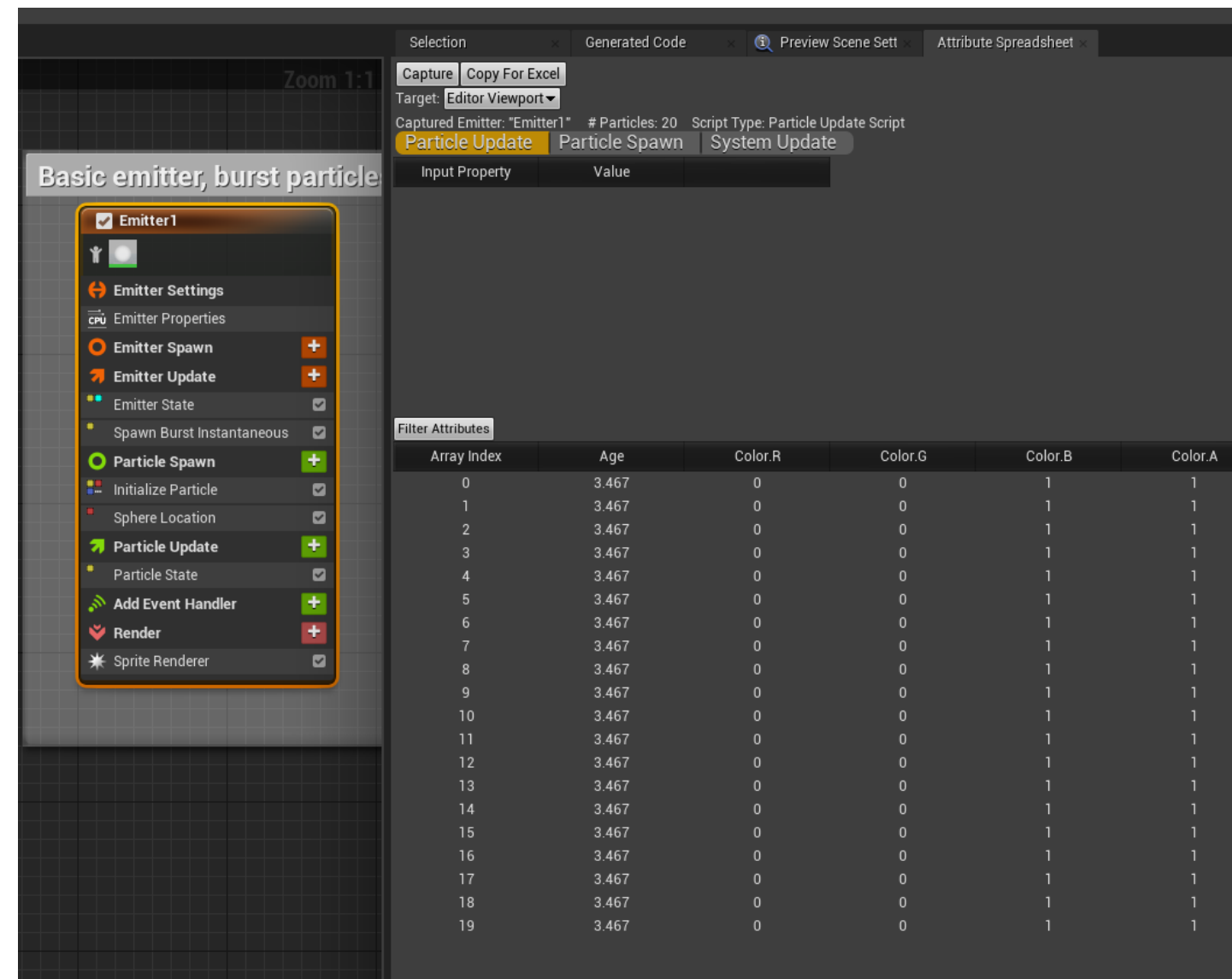
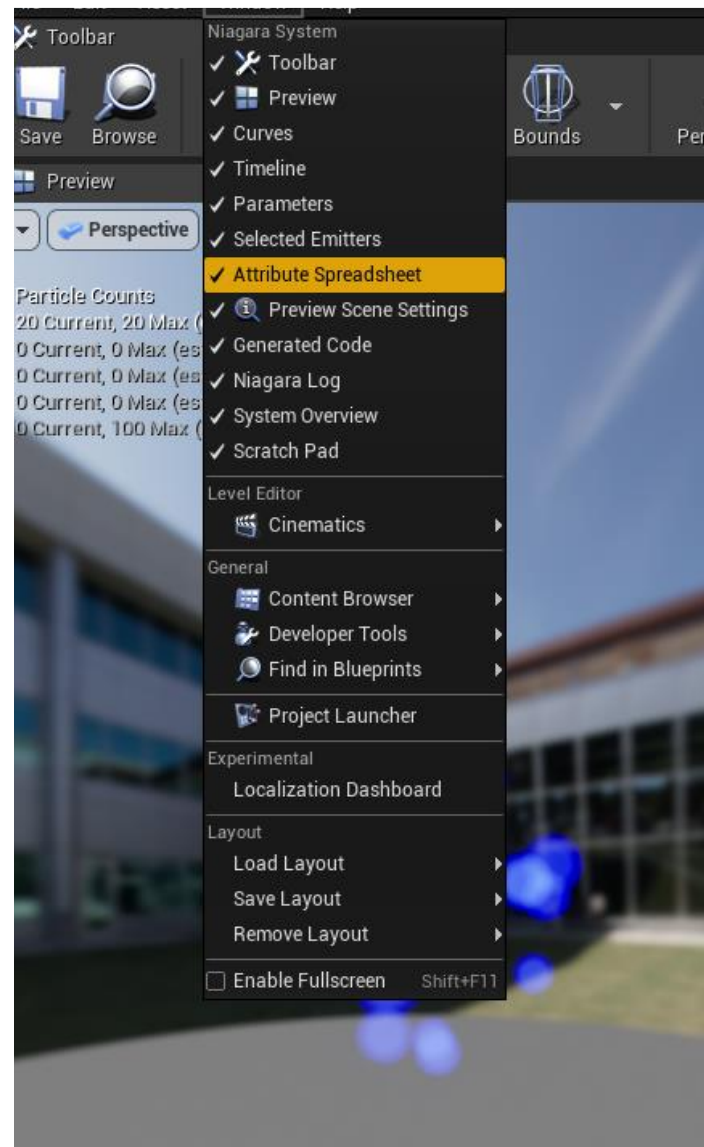


GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Niagara

The Particle Attribute Spreadsheet

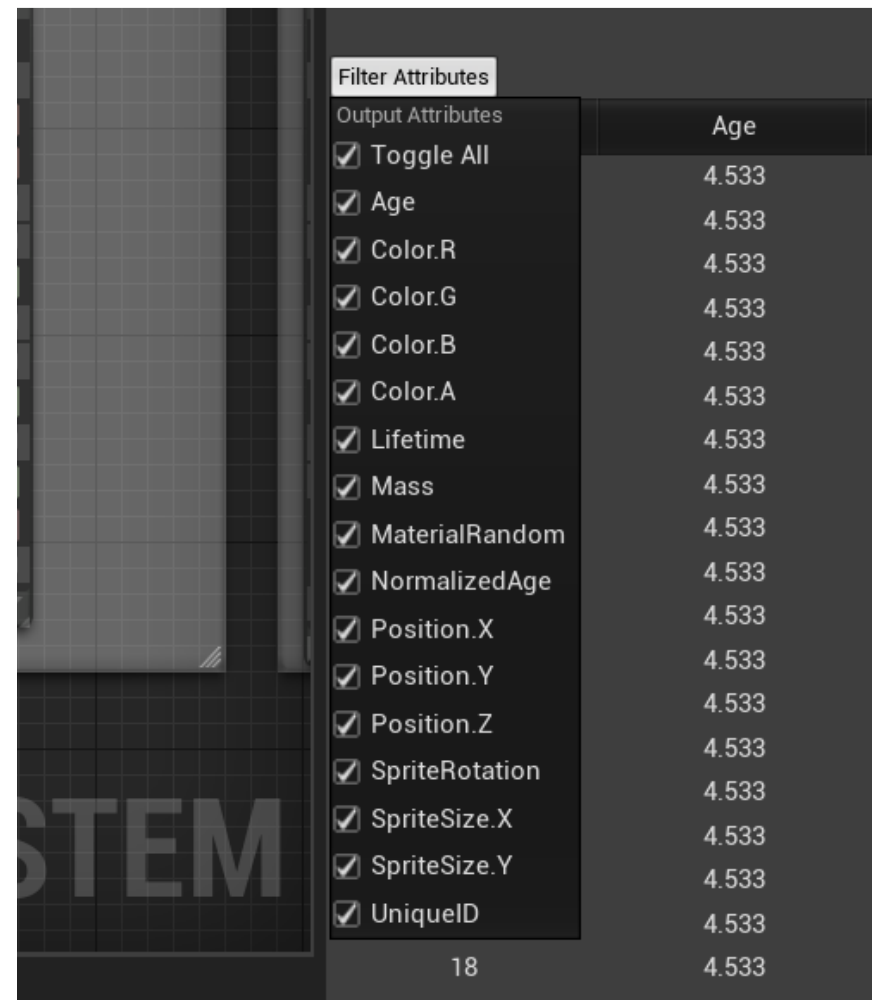


GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Niagara

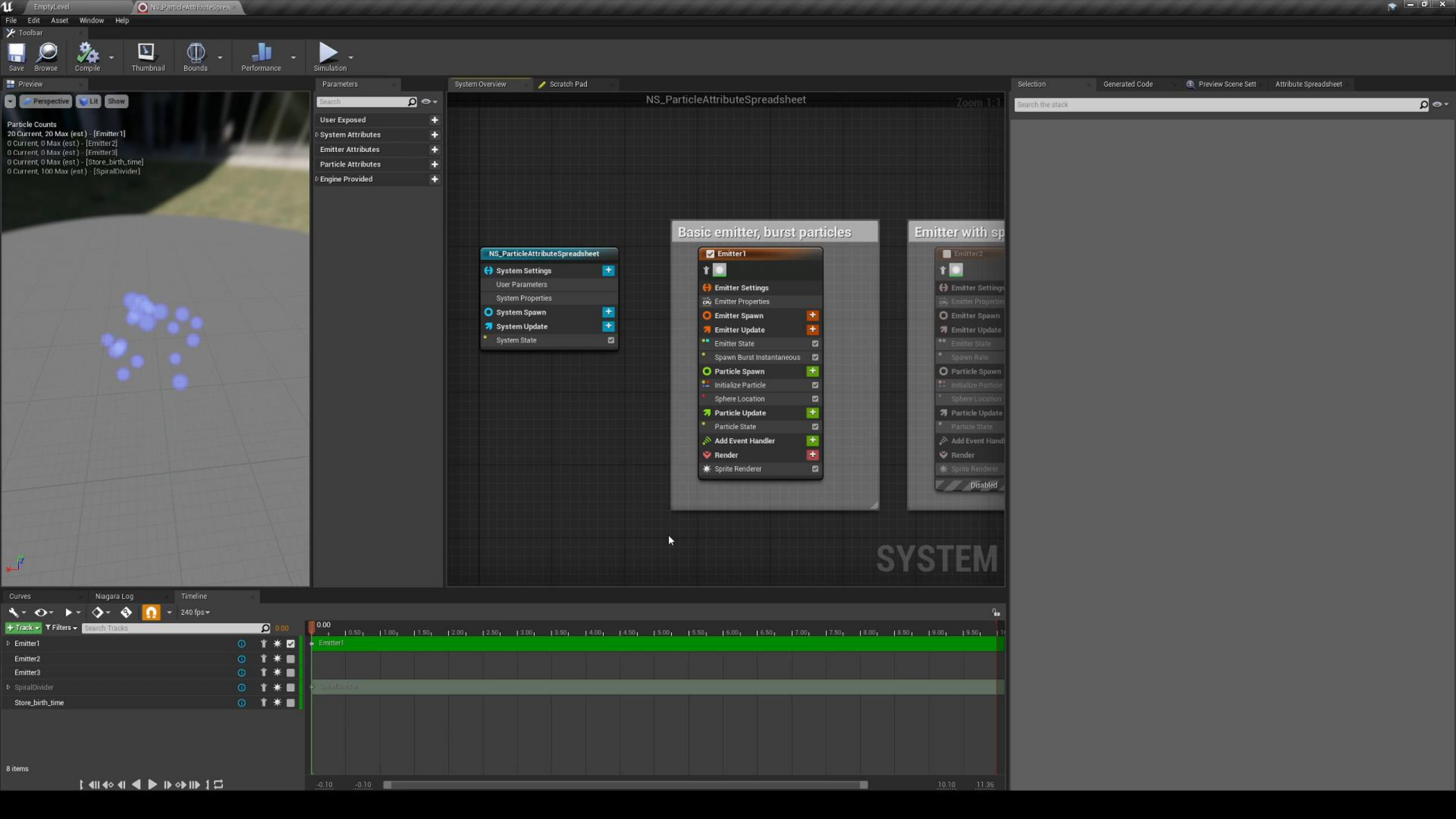
The Particle Attribute Spreadsheet- Filtering



The screenshot shows the 'Filter Attributes' window in the Niagara particle system editor. It displays a list of attributes with checkboxes and their corresponding values. The 'Age' column shows a value of 4.533 for all attributes.

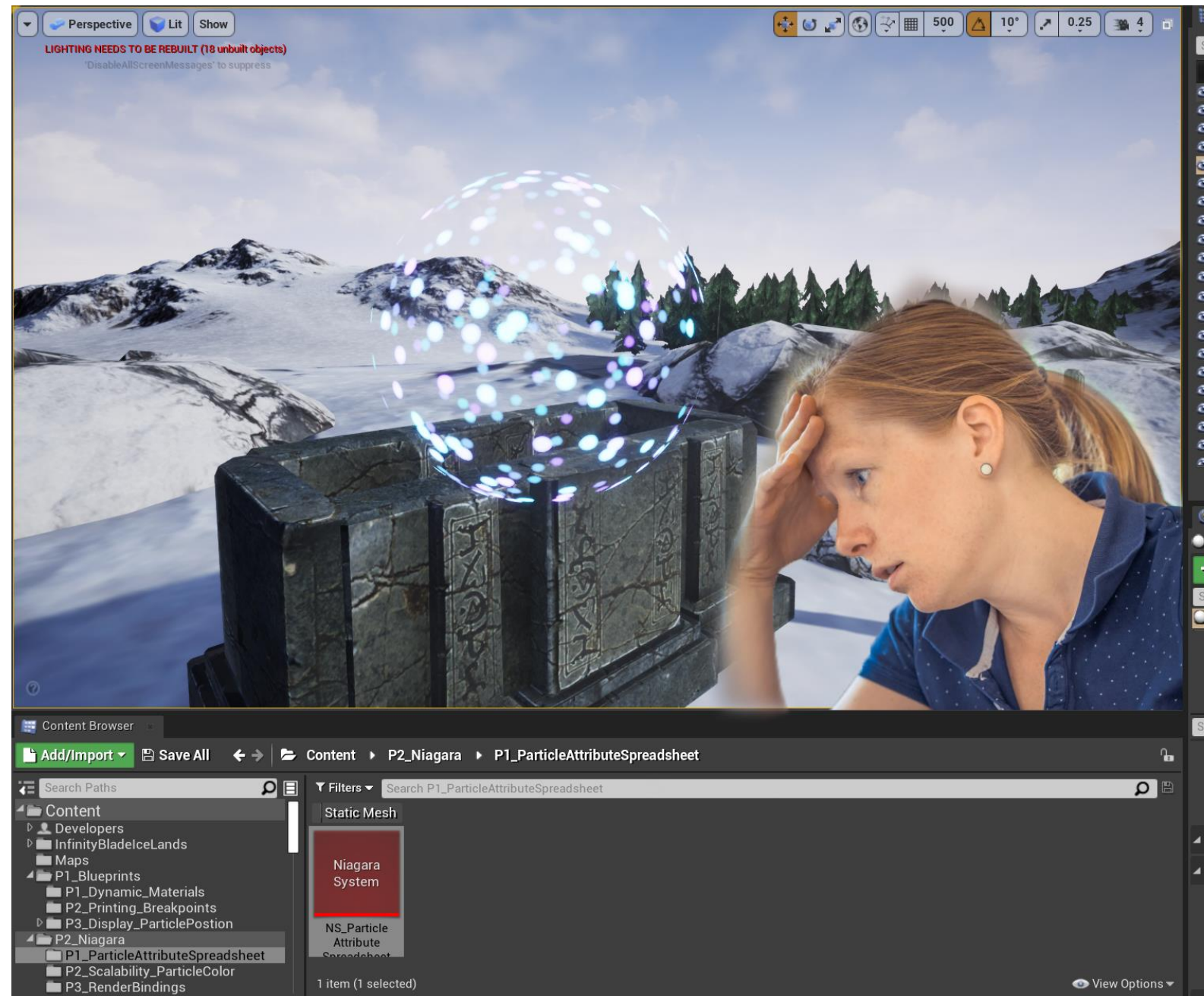
Filter Attributes	Age
☒ Toggle All	4.533
☒ Age	4.533
☒ Color.R	4.533
☒ Color.G	4.533
☒ Color.B	4.533
☒ Color.A	4.533
☒ Lifetime	4.533
☒ Mass	4.533
☒ MaterialRandom	4.533
☒ NormalizedAge	4.533
☒ Position.X	4.533
☒ Position.Y	4.533
☒ Position.Z	4.533
☒ SpriteRotation	4.533
☒ SpriteSize.X	4.533
☒ SpriteSize.Y	4.533
☒ UniqueID	4.533

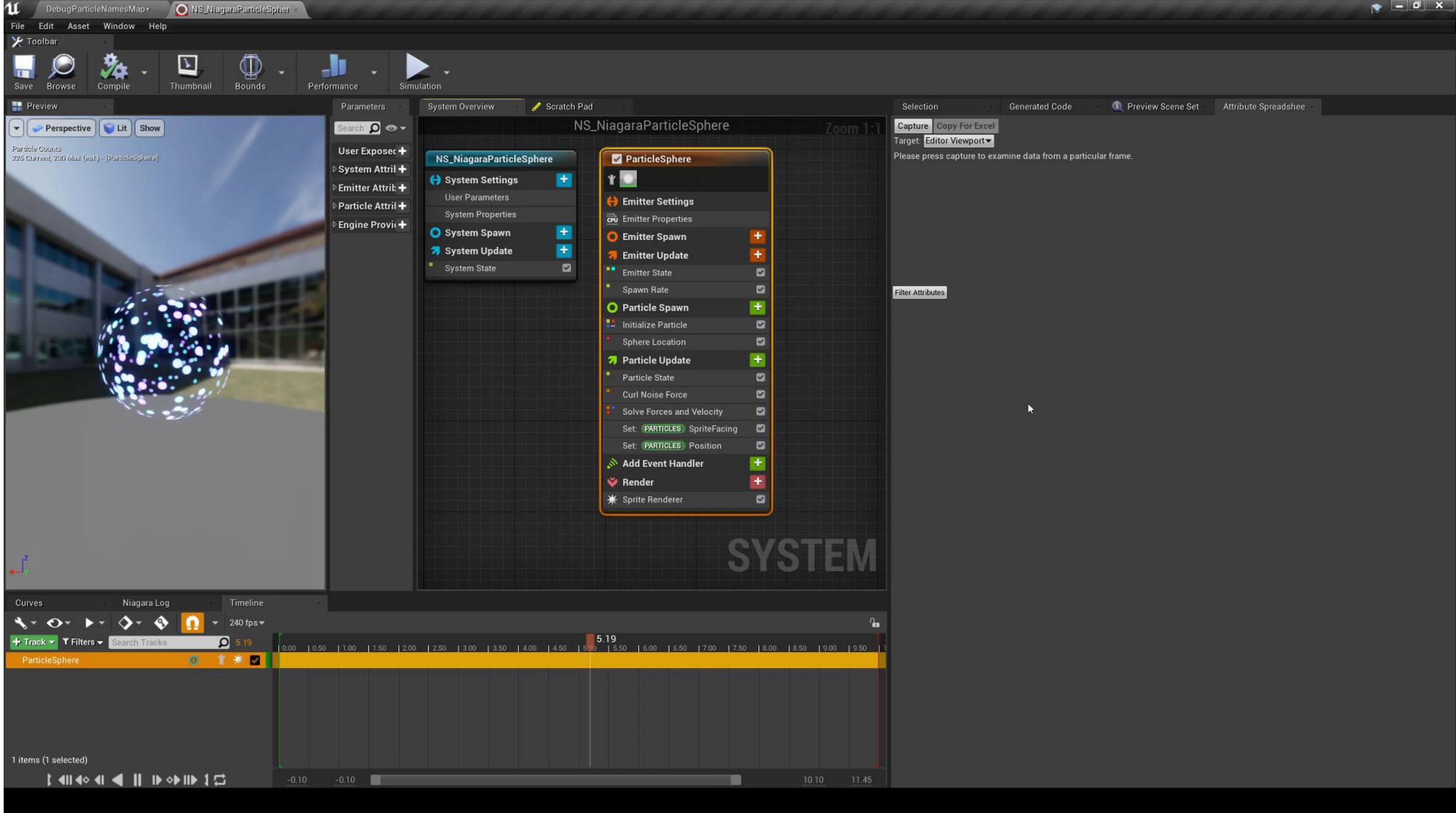




Niagara

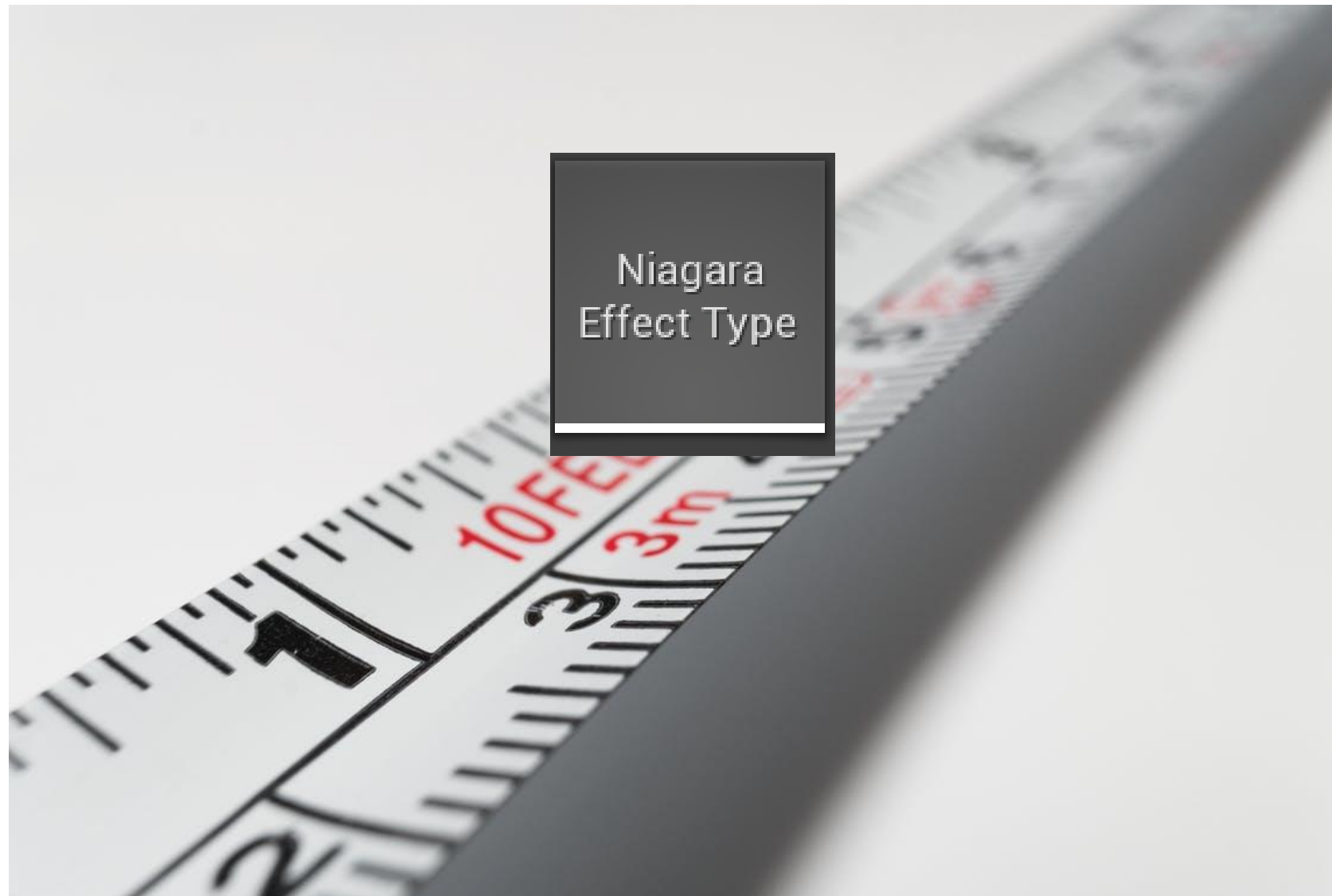
The Particle Attribute Spreadsheet- Capture source





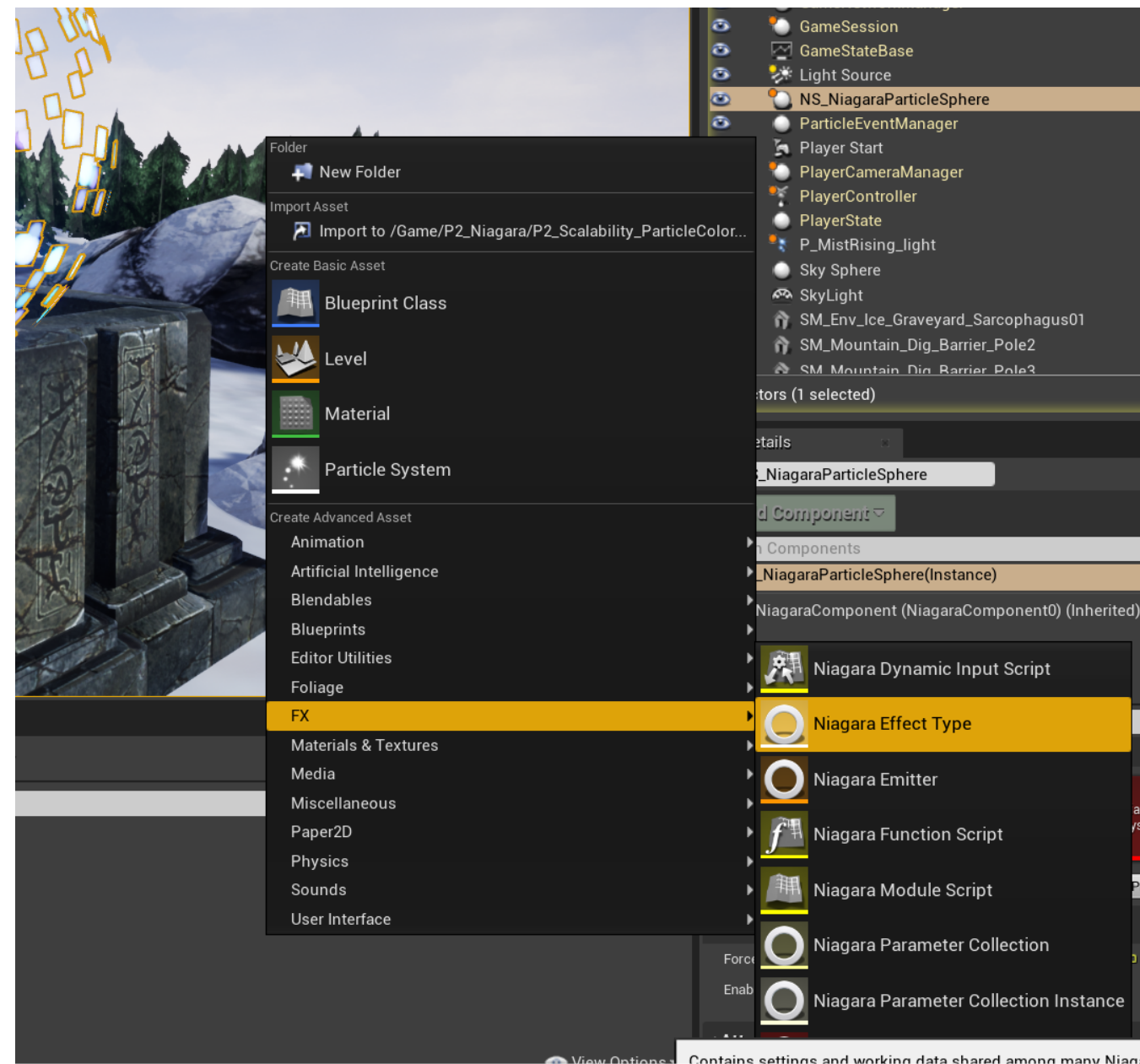
Niagara

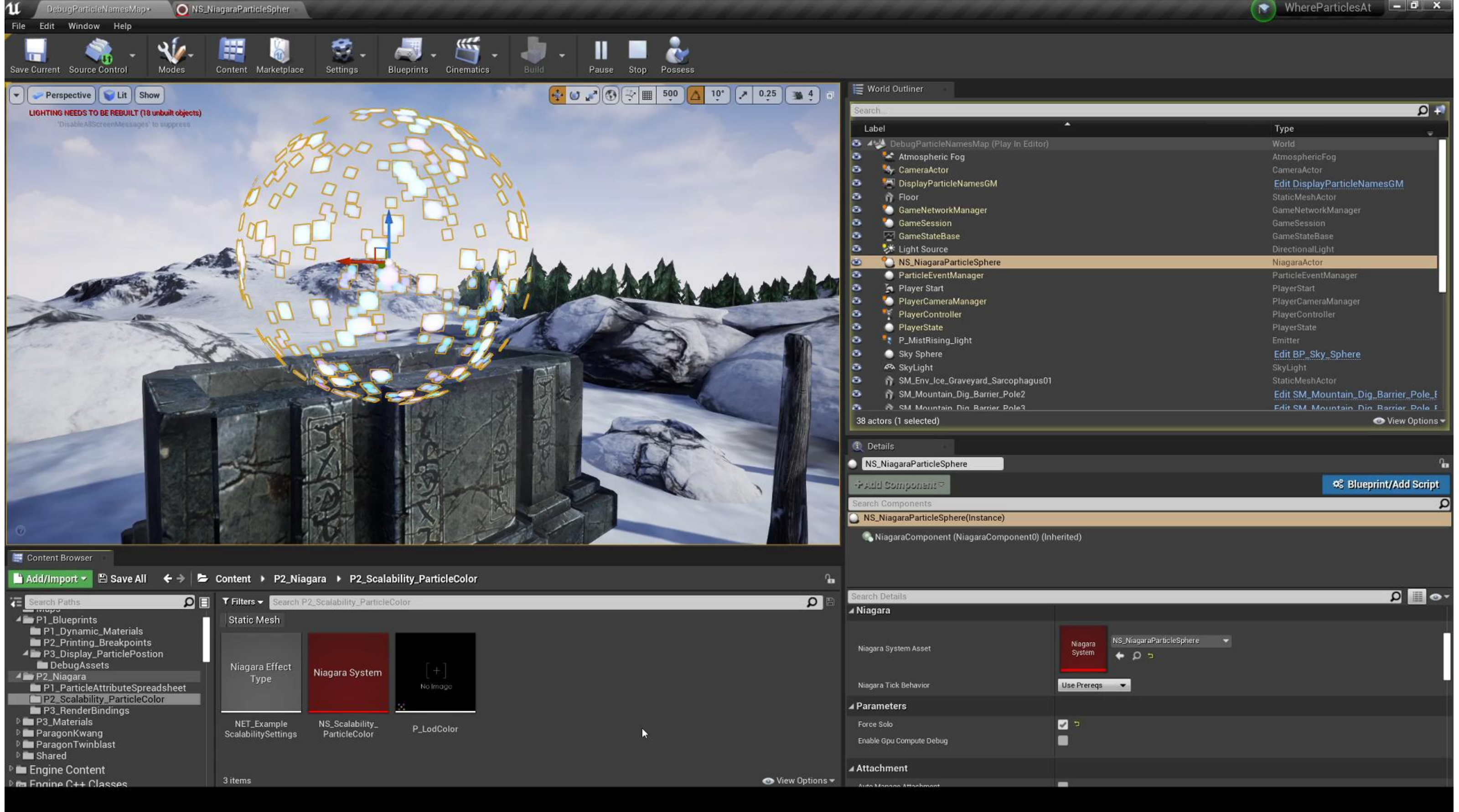
Scalability Settings



Niagara

Scalability Settings – Niagara Effect Types

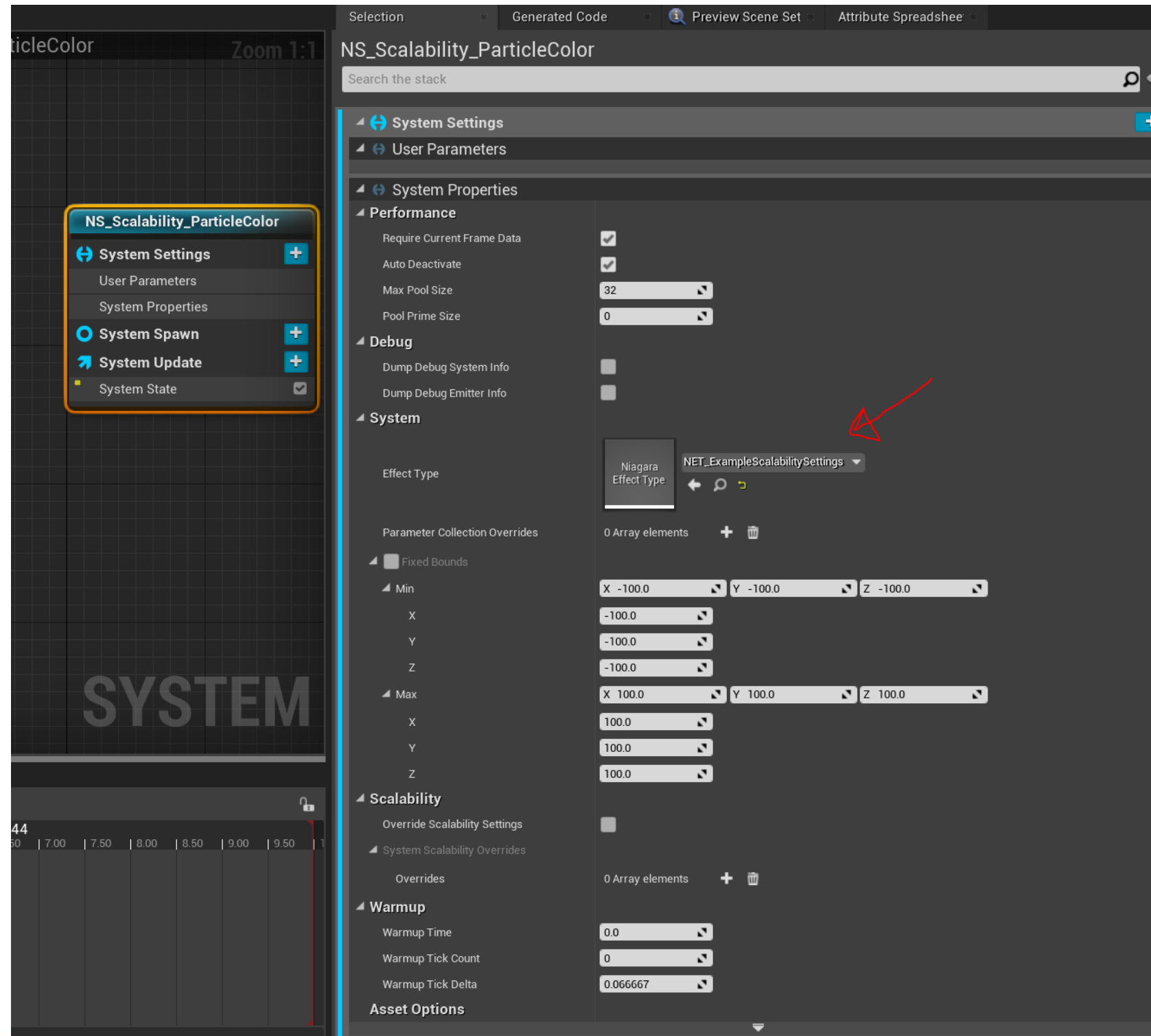


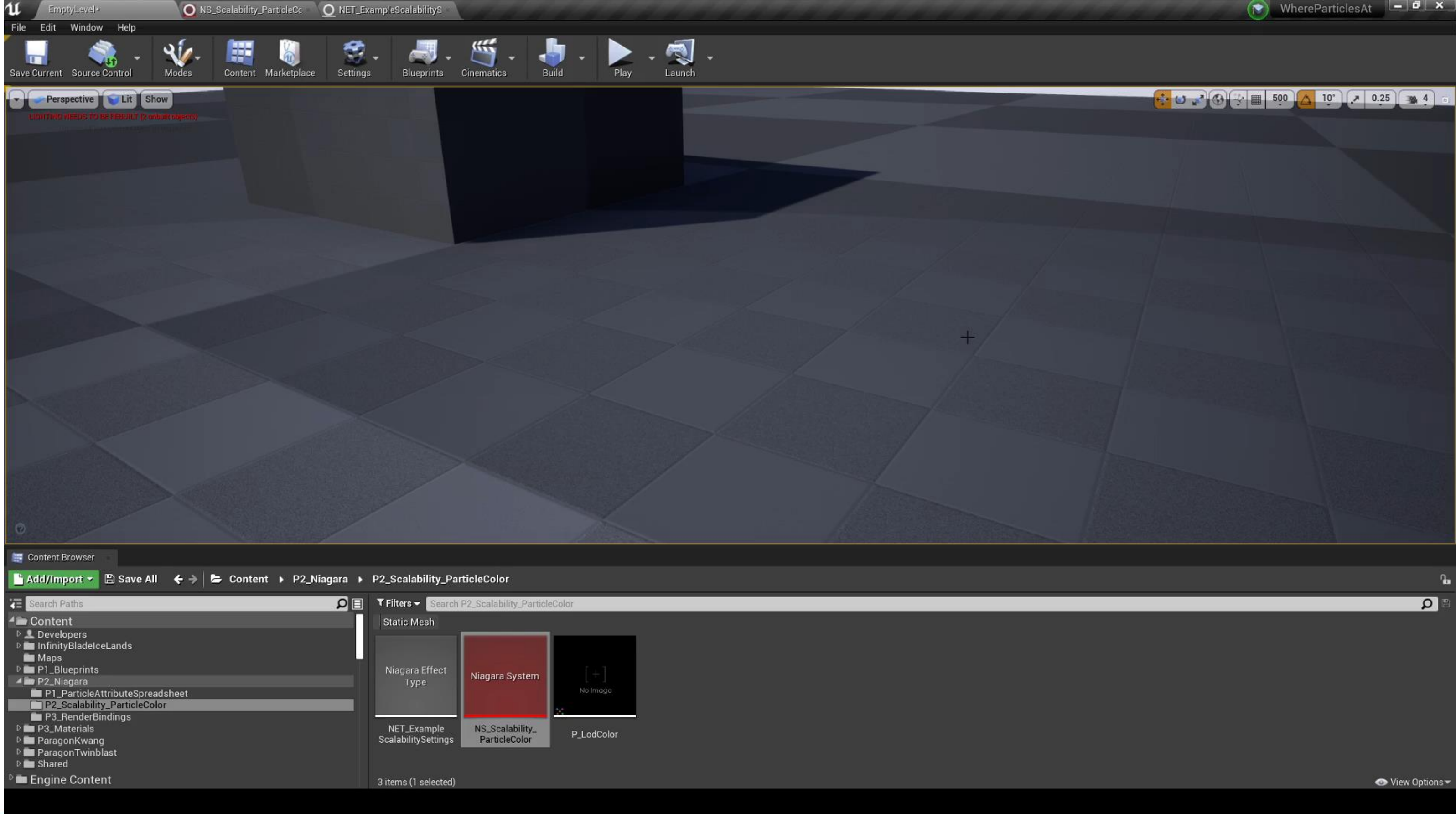


GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Scalability Settings – Reading NET values in your systems

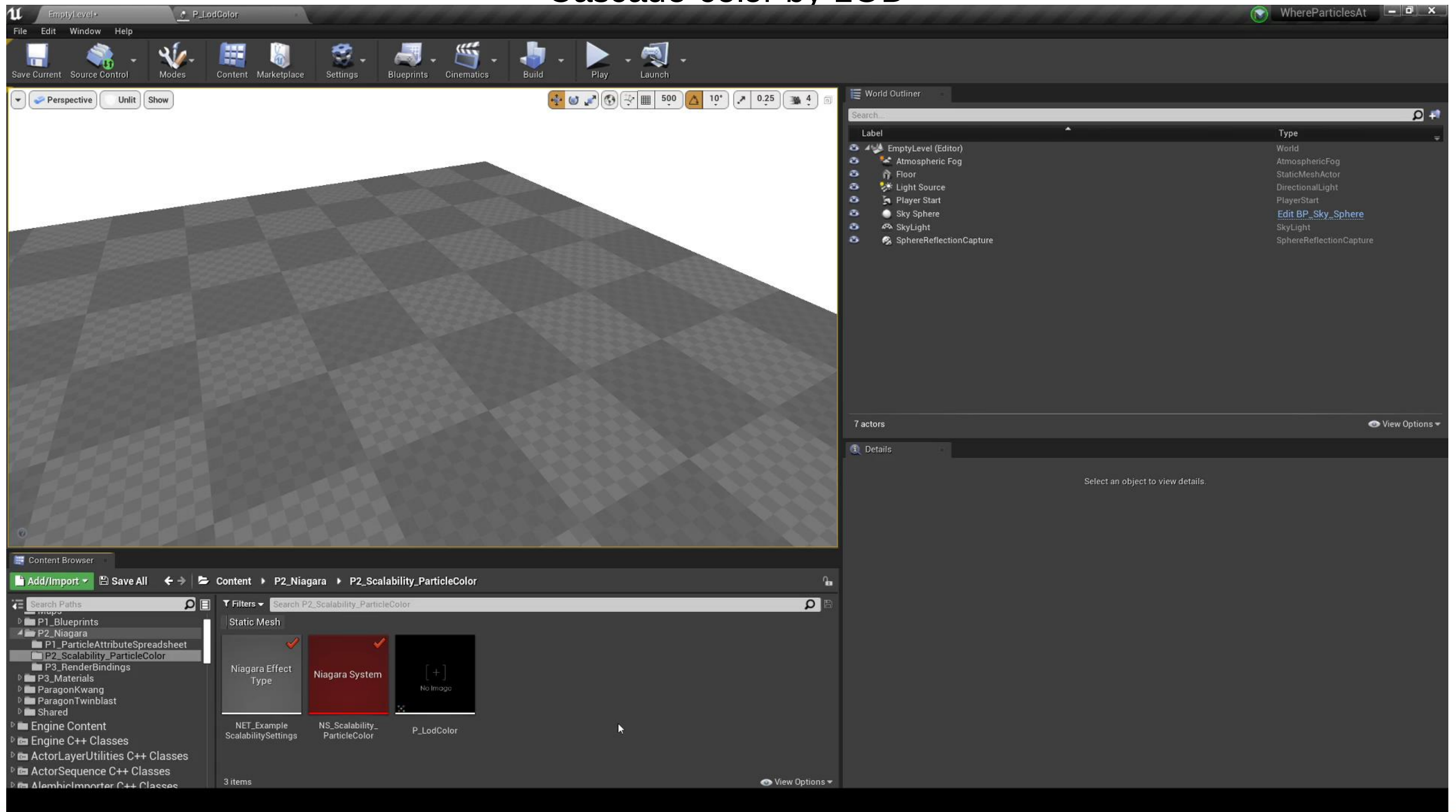




GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

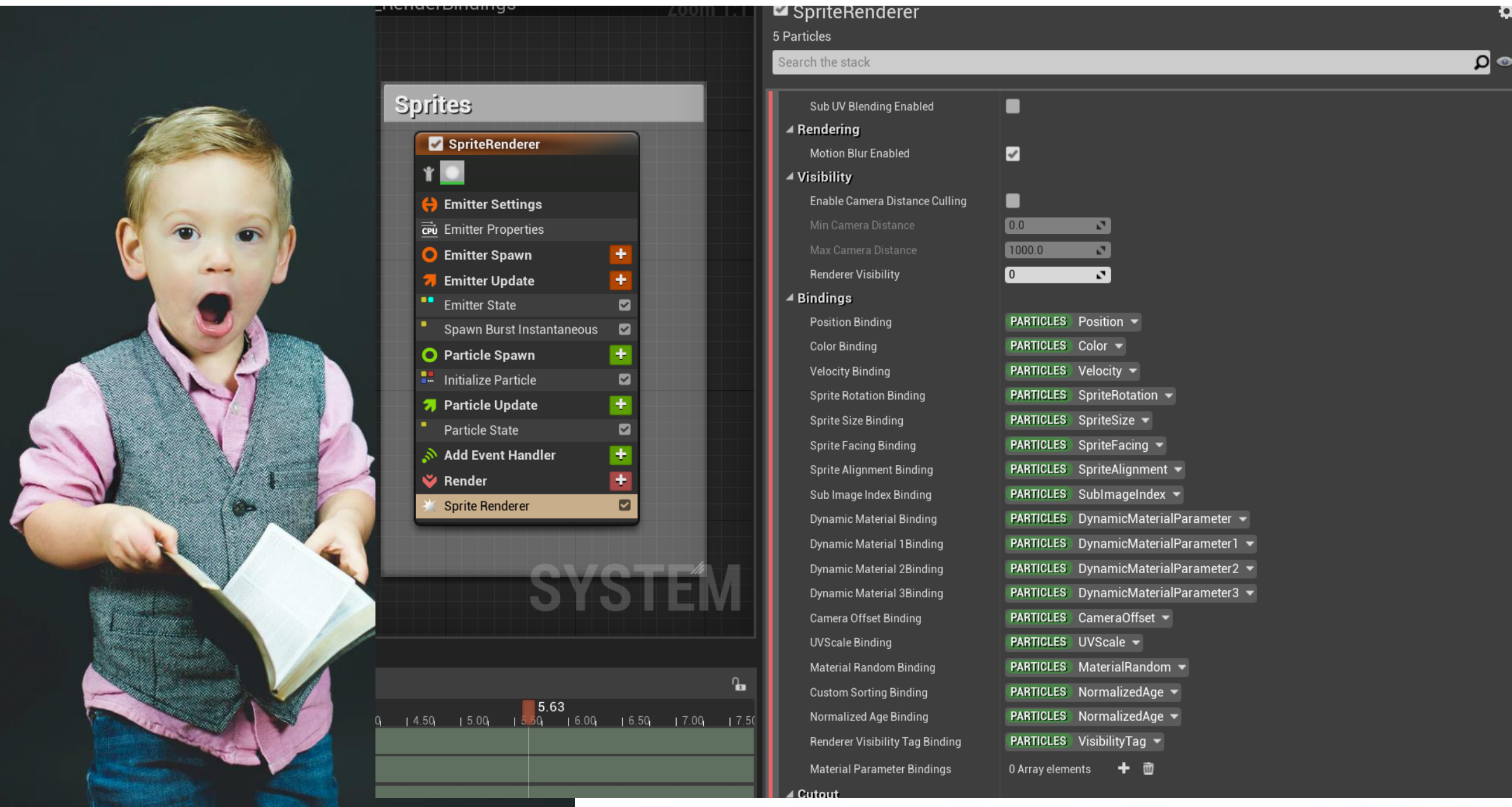
Cascade color by LOD



GDC

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Renderer Bindings



Sprite Renderer Bindings and their Data Types

Position Binding	PARTICLES Position ▾	Vector3
Color Binding	PARTICLES Color ▾	Linear color
Velocity Binding	PARTICLES Velocity ▾	Vector3
Sprite Rotation Binding	PARTICLES SpriteRotation ▾	Float
Sprite Size Binding	PARTICLES SpriteSize ▾	Vector2D
Sprite Facing Binding	PARTICLES SpriteFacing ▾	Vector3
Sprite Alignment Binding	PARTICLES SpriteAlignment ▾	Vector3
Sub Image Index Binding	PARTICLES SubImageIndex ▾	Float
Dynamic Material Binding	PARTICLES DynamicMaterialPa	Vector4
Dynamic Material 1Binding	PARTICLES DynamicMaterialPa	Vector4
Dynamic Material 2Binding	PARTICLES DynamicMaterialPa	Vector4
Dynamic Material 3Binding	PARTICLES DynamicMaterialPa	Vector4
Camera Offset Binding	PARTICLES CameraOffset ▾	Float
UVScale Binding	PARTICLES UVScale ▾	Vector2D
Material Random Binding	PARTICLES MaterialRandom ▾	Float
Custom Sorting Binding	PARTICLES NormalizedAge ▾	Float
Normalized Age Binding	PARTICLES NormalizedAge ▾	Float
Renderer Visibility Tag Binding	PARTICLES VisibilityTag ▾	Int
Material Parameter Bindings	0 Array elements + 🗑	



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Mesh Renderer Bindings

Position Binding	PARTICLES Position ▾	Vector3
Color Binding	PARTICLES Color ▾	Linear color
Velocity Binding	PARTICLES Velocity ▾	Vector3
Mesh Orientation Binding	PARTICLES MeshOrientation ▾	Quaternion
Scale Binding	PARTICLES Scale ▾	Vector3
Sub Image Index Binding	PARTICLES SubImageIndex ▾	Float
Dynamic Material Binding	PARTICLES DynamicMaterialPa ▾	Vector4
Dynamic Material 1Binding	PARTICLES DynamicMaterialPa ▾	Vector4
Dynamic Material 2Binding	PARTICLES DynamicMaterialPa ▾	Vector4
Dynamic Material 3Binding	PARTICLES DynamicMaterialPa ▾	Vector4
Material Random Binding	PARTICLES MaterialRandom ▾	Float
Custom Sorting Binding	PARTICLES NormalizedAge ▾	Float
Normalized Age Binding	PARTICLES NormalizedAge ▾	Float
Camera Offset Binding	PARTICLES CameraOffset ▾	Float
Renderer Visibility Tag Binding	PARTICLES VisibilityTag ▾	Int



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

EmptyLevel NS_RenderBindings

File Edit Asset Window Help

Toolbar

Save Browse Compile Thumbnail Bounds Performance Simulation

Preview Parameters System Overview Scratch Pad

Perspective Lit Show

Particle Counts

- 0 Current, 6 Max (est) - [SpriteRenderer]
- 0 Current, 6 Max (est) - [MeshRenderer]
- 1 Current, 1 Max (est) - [Emitter_Loop_Clock]
- 0 Current, 250 Max (est) - [DisplayPositionAsColor]

Search

User Exposed +

- System Attrib +
- Emitter Attrib +
- Particle Attrib +
- Engine Provic +

Binding Arbitrary Data

Emitter_Loop_Clock

- Emitter Settings
- Emitter Properties
- Emitter Spawn
- Emitter Update
- Emitter State
- Spawn Burst Instantaneous
- Particle Spawn
- Initialize Particle
- Particle Update
- Particle State
- Set: PARTICLES LoopedAgeRotation
- Add Event Handler
- Render
- Sprite Renderer

DisplayPositionAsColor

- Emitter Settings
- Emitter Properties
- Emitter Spawn
- Emitter Update
- Emitter State
- Spawn Burst Instantaneous
- Particle Spawn
- Initialize Particle
- Sphere Location
- Set: PARTICLES DebugColor
- Particle Update
- Particle State
- Add Event Handler
- Render
- Sprite Renderer

Disabled

SYSTEM

Selection Generated Code Preview Scene Set Attribute Spreadsheet

Emitter_Loop_Clock

1 Particles

Search the stack

Emitter Settings

Emitter Properties

Emitter Spawn

Emitter Update

Emitter State

- Life Cycle Mode: Self
- Inactive Response: Complete (Let Particles Finish then K)
- Loop Behavior: Infinite
- Loop Duration: 5.0
- Recalculate Duration Each Loop
- Loop Delay: 0.0

Scalability

- Scalability Mode: System

Spawn Burst Instantaneous

- Spawn Count: 1
- Spawn Time: 0.0
- Spawn Probability: 1.0

Particle Spawn

Initialize Particle

Point Attributes

- Lifetime Mode: Direct Set
- Lifetime: 5.0
- Color Mode: Unset
- Position Mode: Simulation Position
- Position Offset: X 0.0 Y 0.0 Z 0.0
- Mass Mode: Unset / (Mass of 1)

Sprite Attributes

- Sprite Size Mode: Unset
- Sprite Rotation Mode: Unset
- Sprite UV Mode: Unset

Curves Niagara Log Timeline

240 fps

Track Filters Search Tracks

DisplayPositionAsColor

Emitter_Loop_Clock

MeshRenderer

SpriteRenderer

9 items (1 selected)

Timeline

0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00 7.50

4.06

-0.10 -0.10 7.72 11.45

Materials

- Why debug through materials?
- Using Emissive Color to display data
- Math nodes to manipulate value ranges
- Displaying scalar and vector data

Materials

Display your data by drawing it!



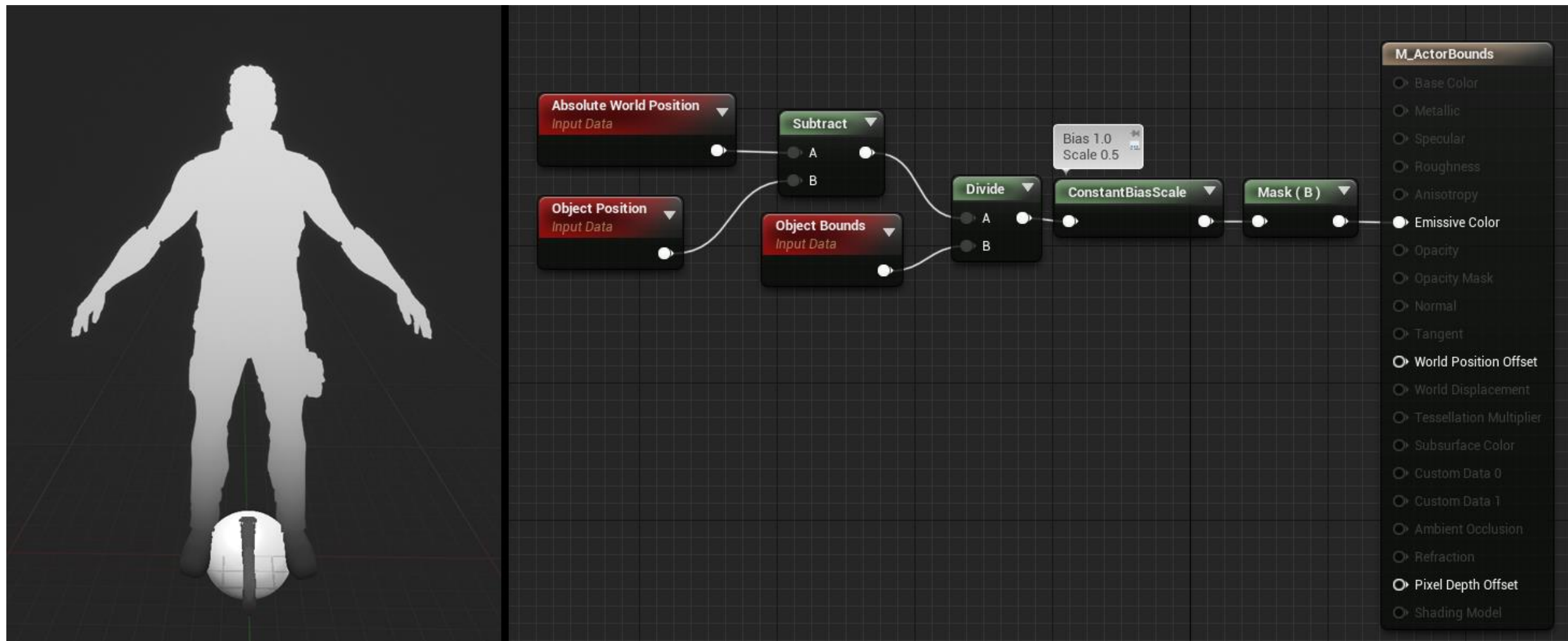
Materials

“Just output that as the color please.”



Materials

Object Bounds

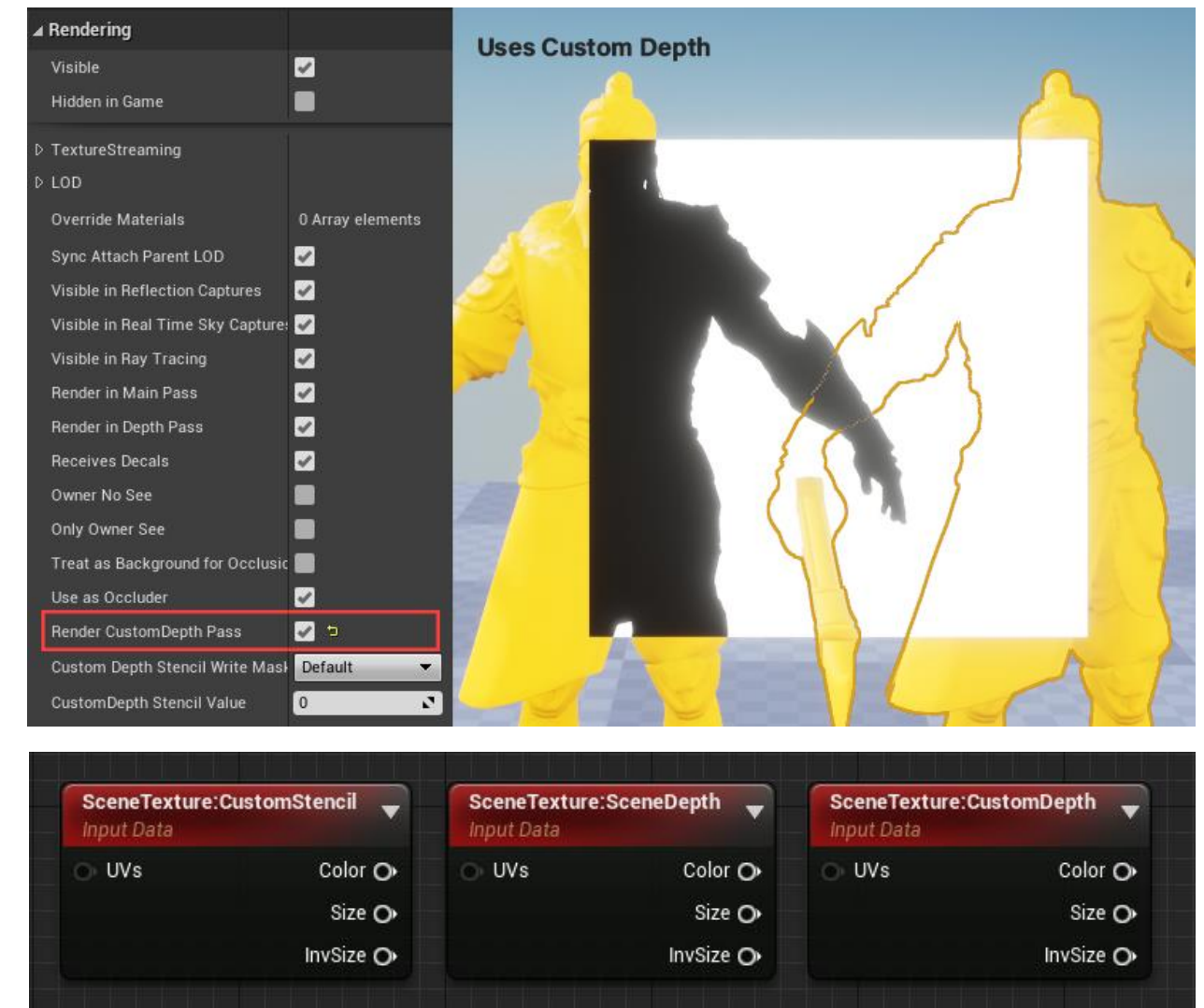
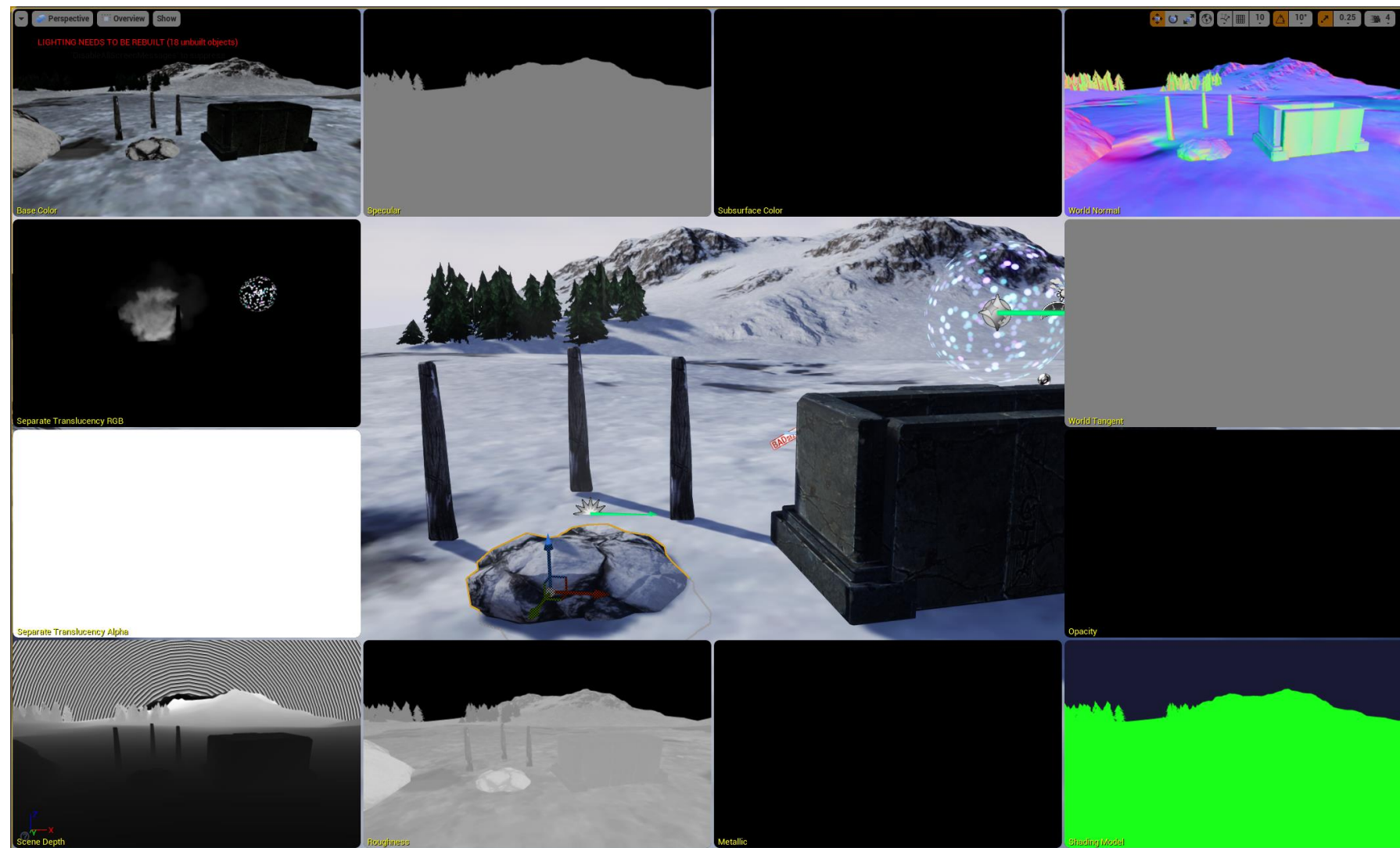


GDC[®]

GAME DEVELOPERS CONFERENCE | July 19–23, 2021 | #GDC21

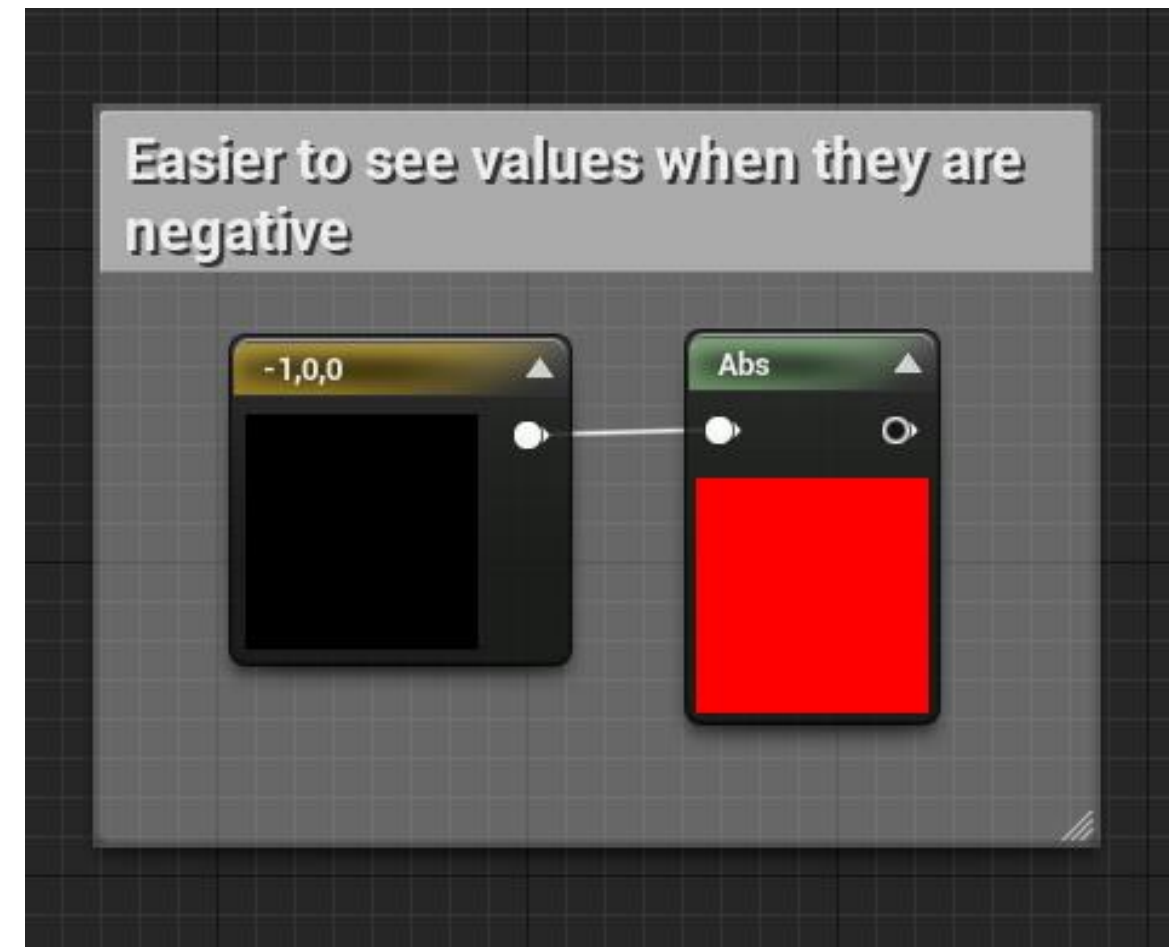
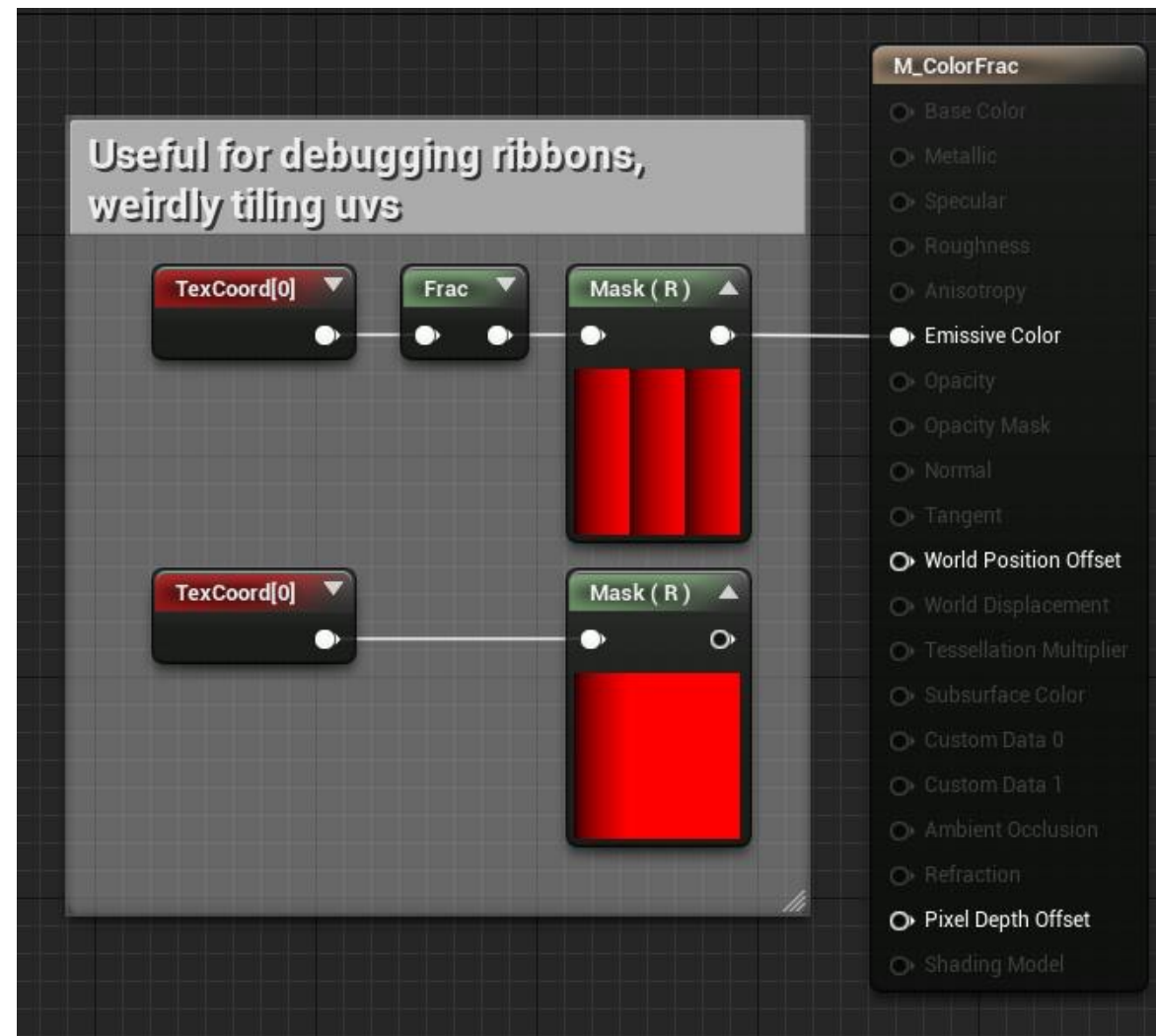
Materials

Buffers (Scene Depth, Custom Depth)

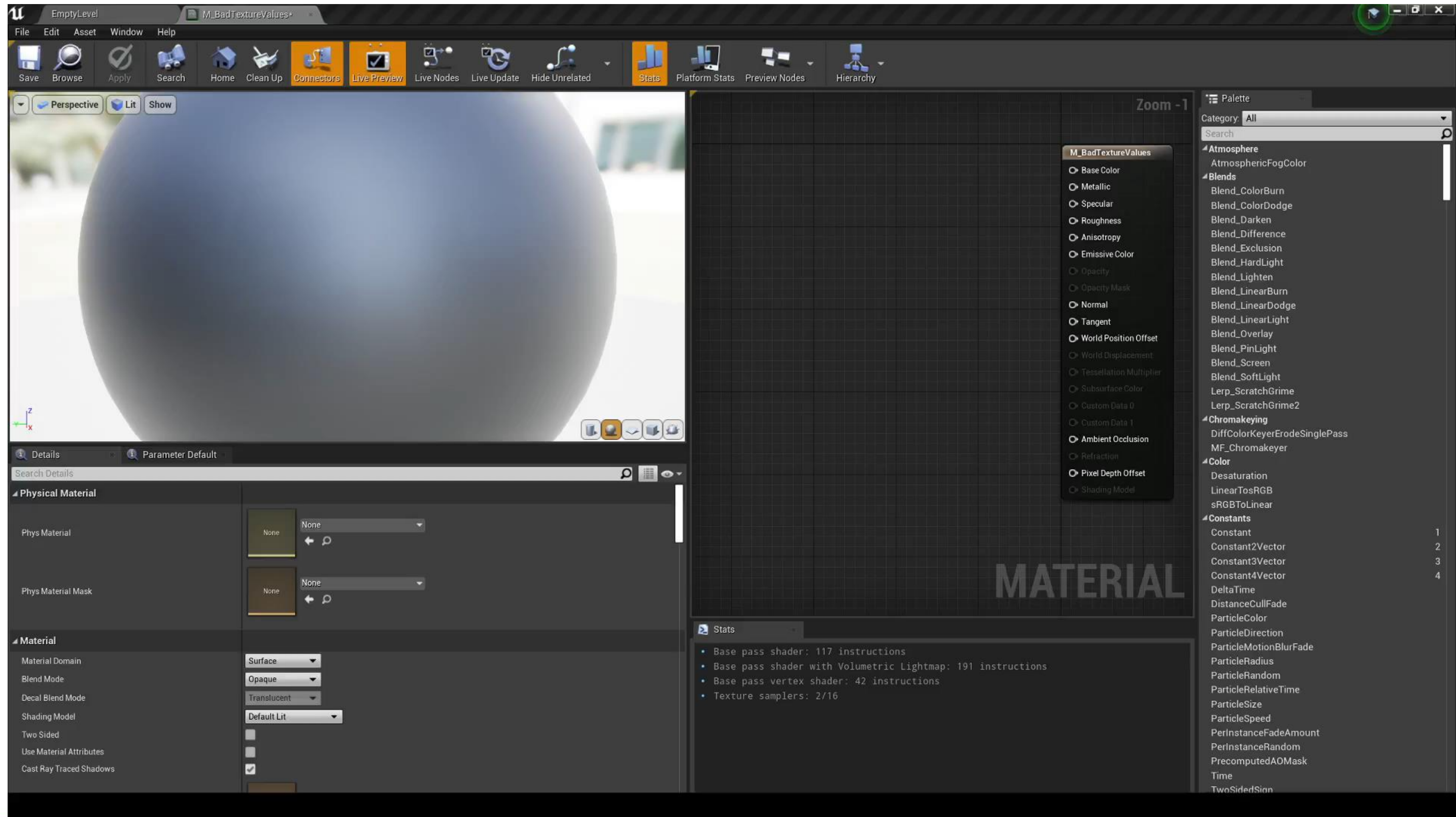


Materials

Frac, Abs, and other manipulations



Fracing a modified texture value to see its ranges

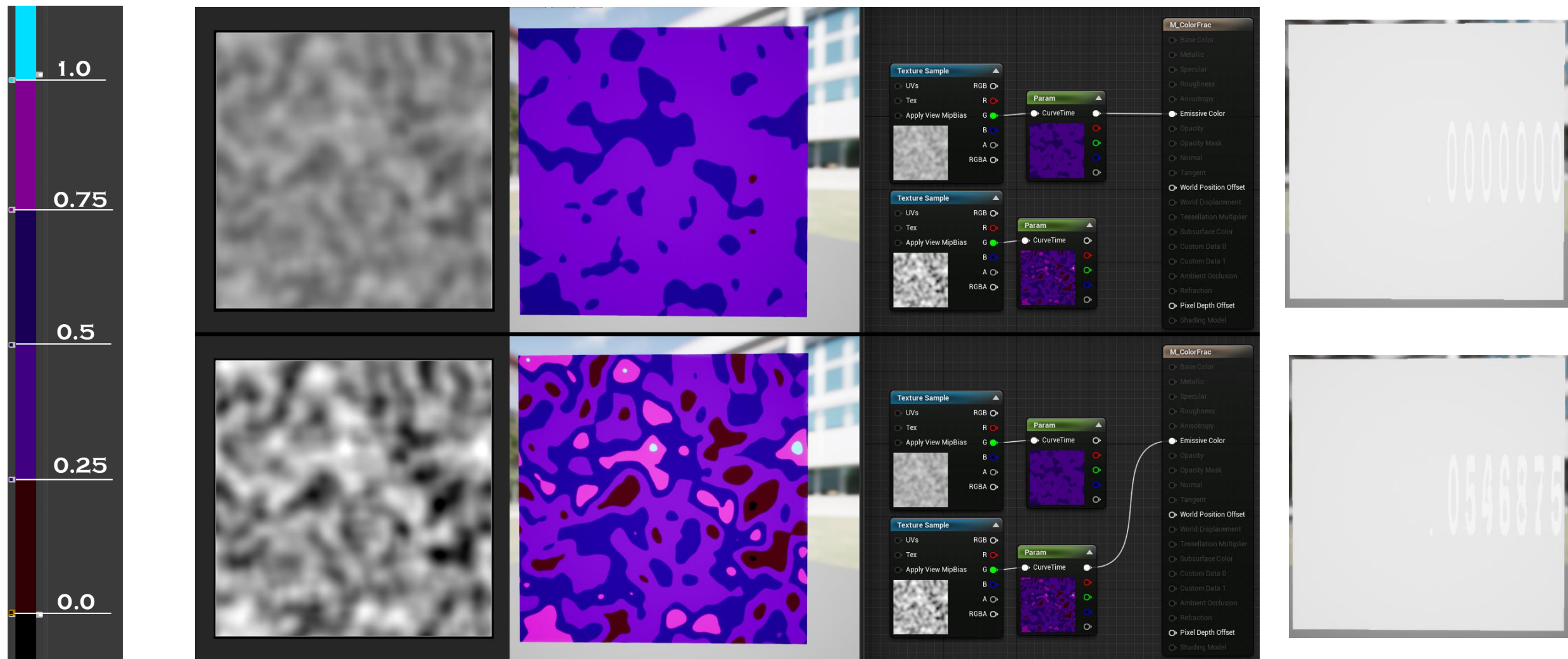


GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

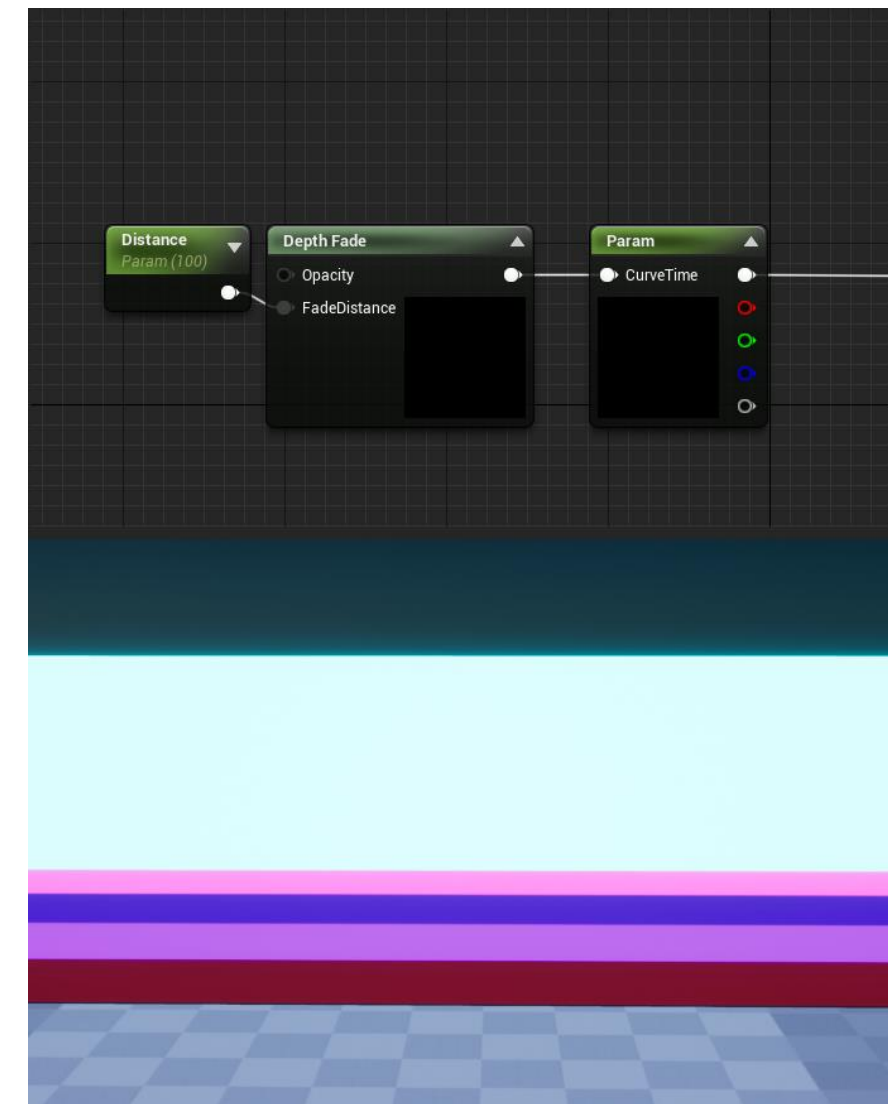
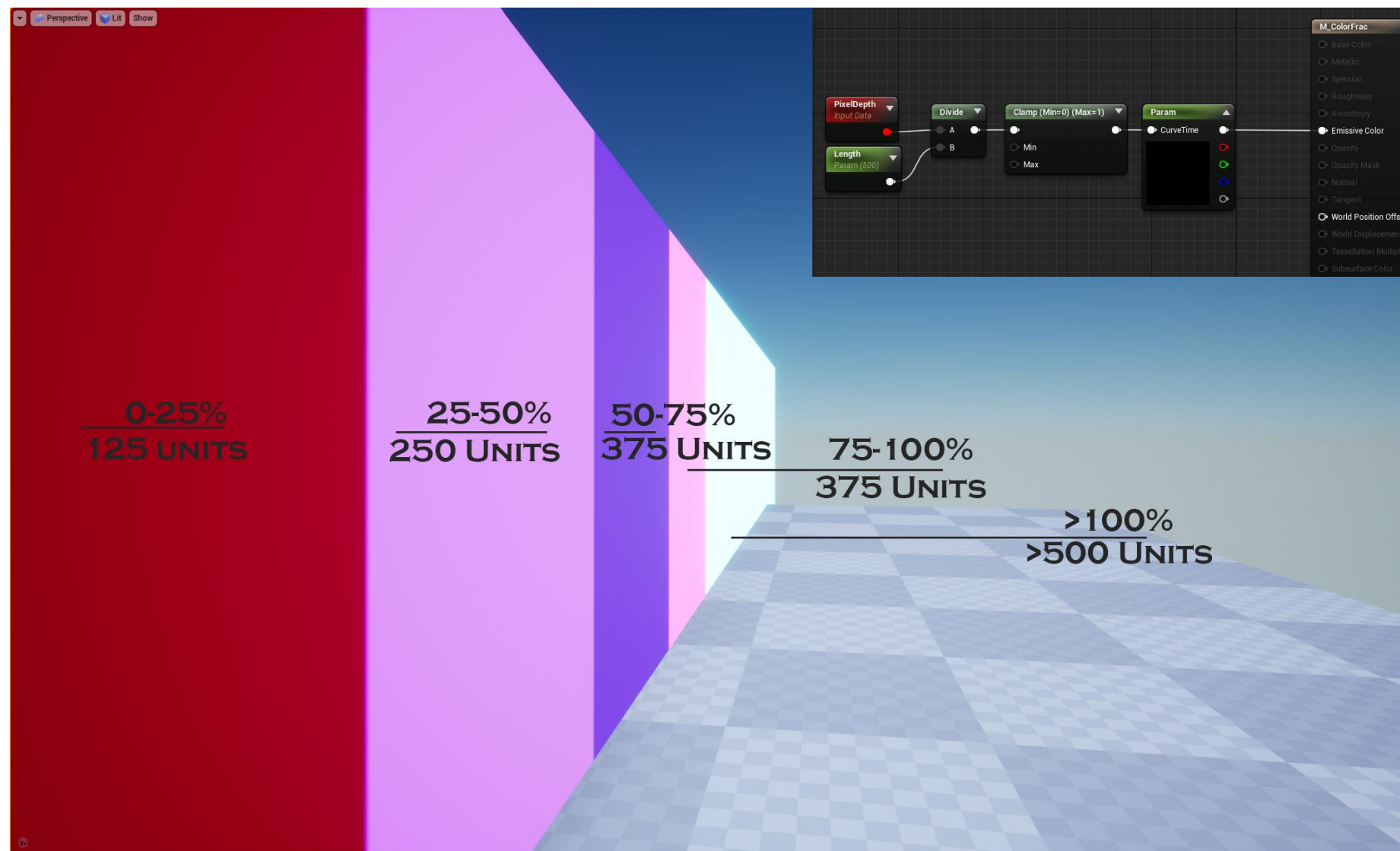
Materials

Color Curves or Gradient Textures



Materials

Distance fades / Camera Distances

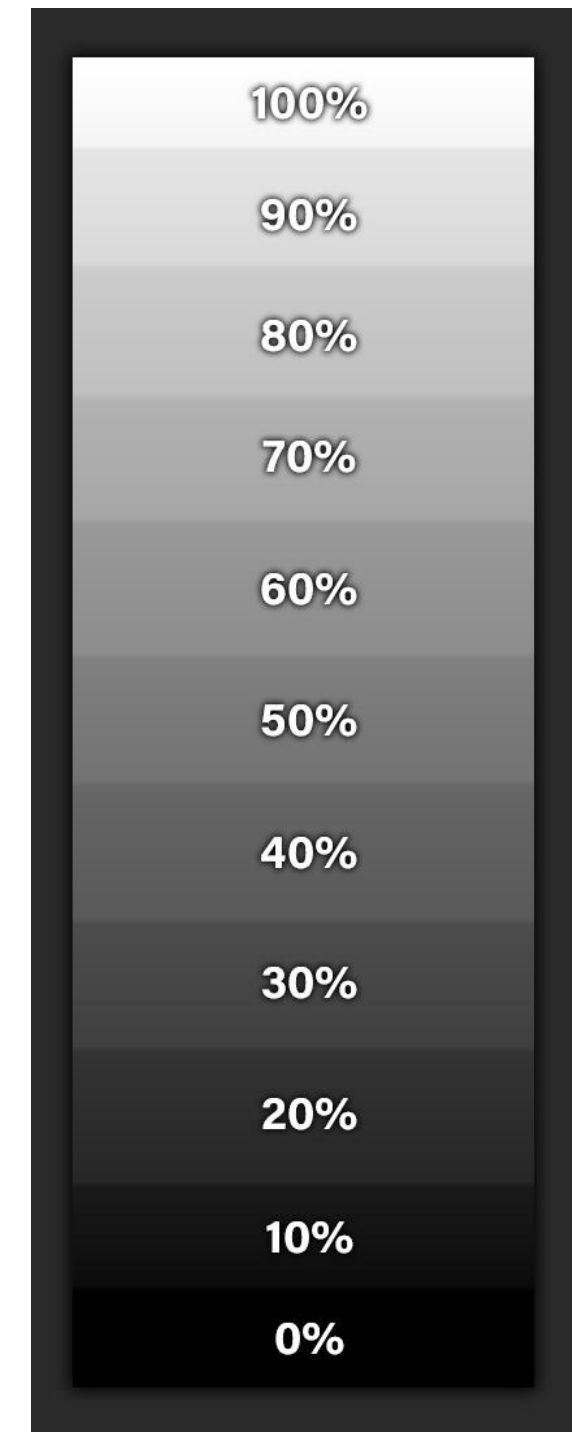
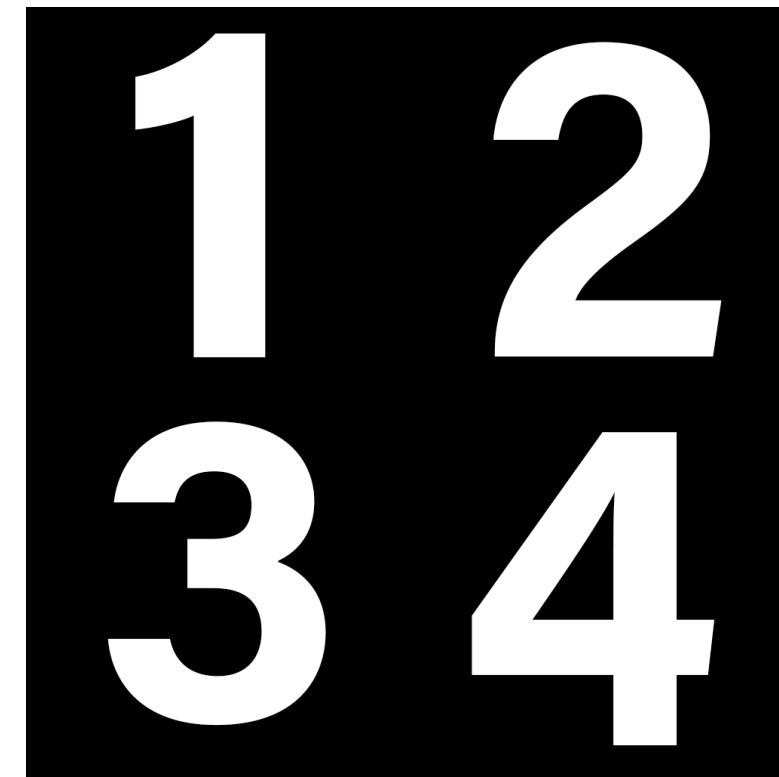
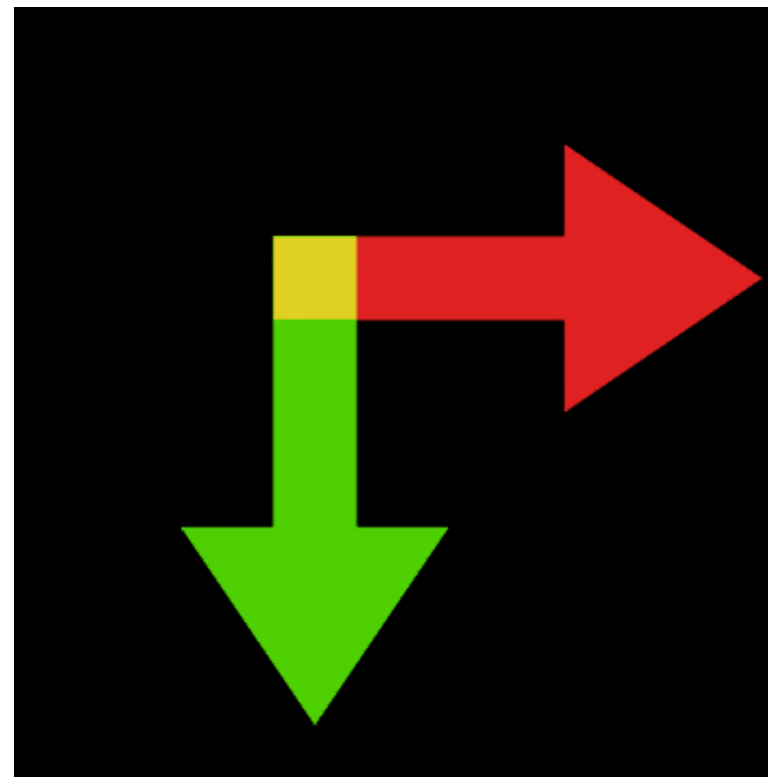
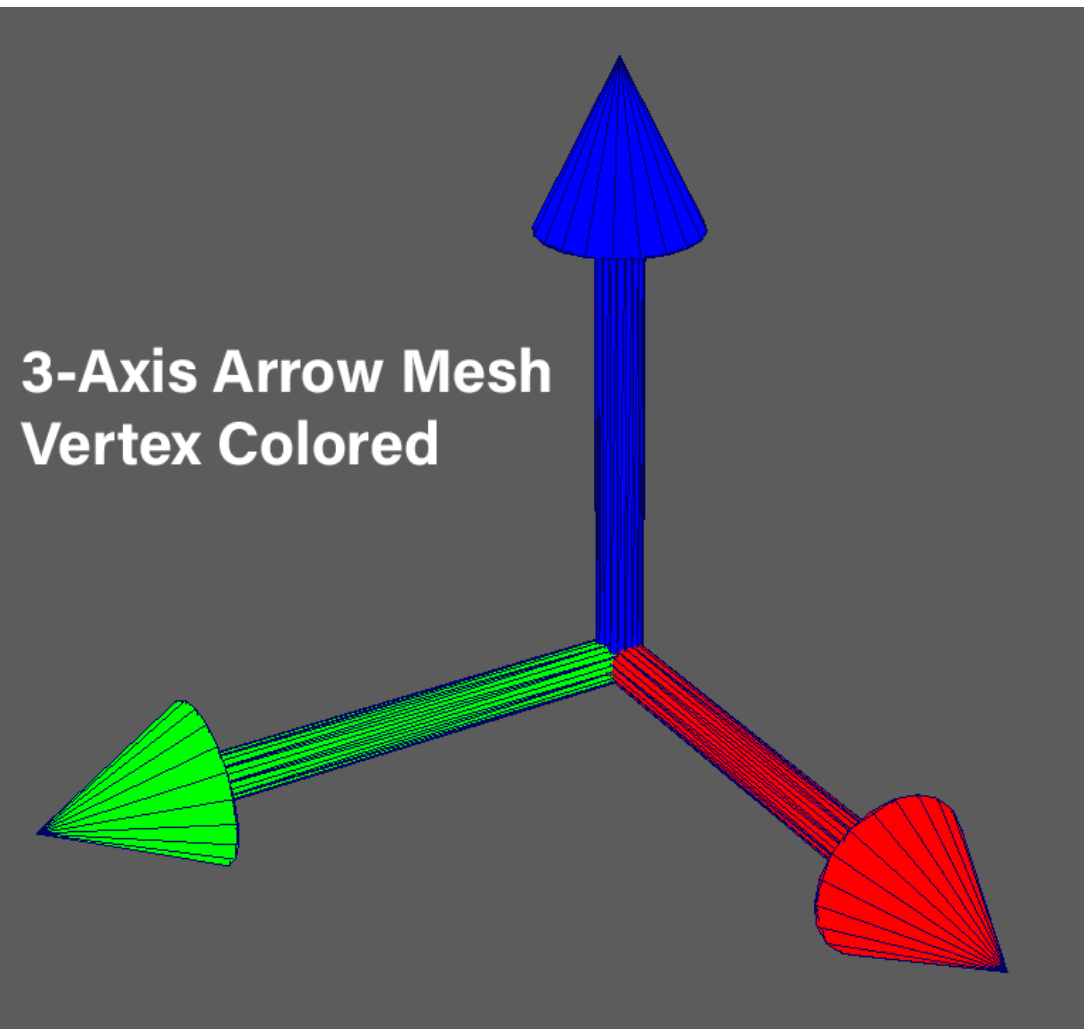


GDC³⁵

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

Materials

Useful Test Assets

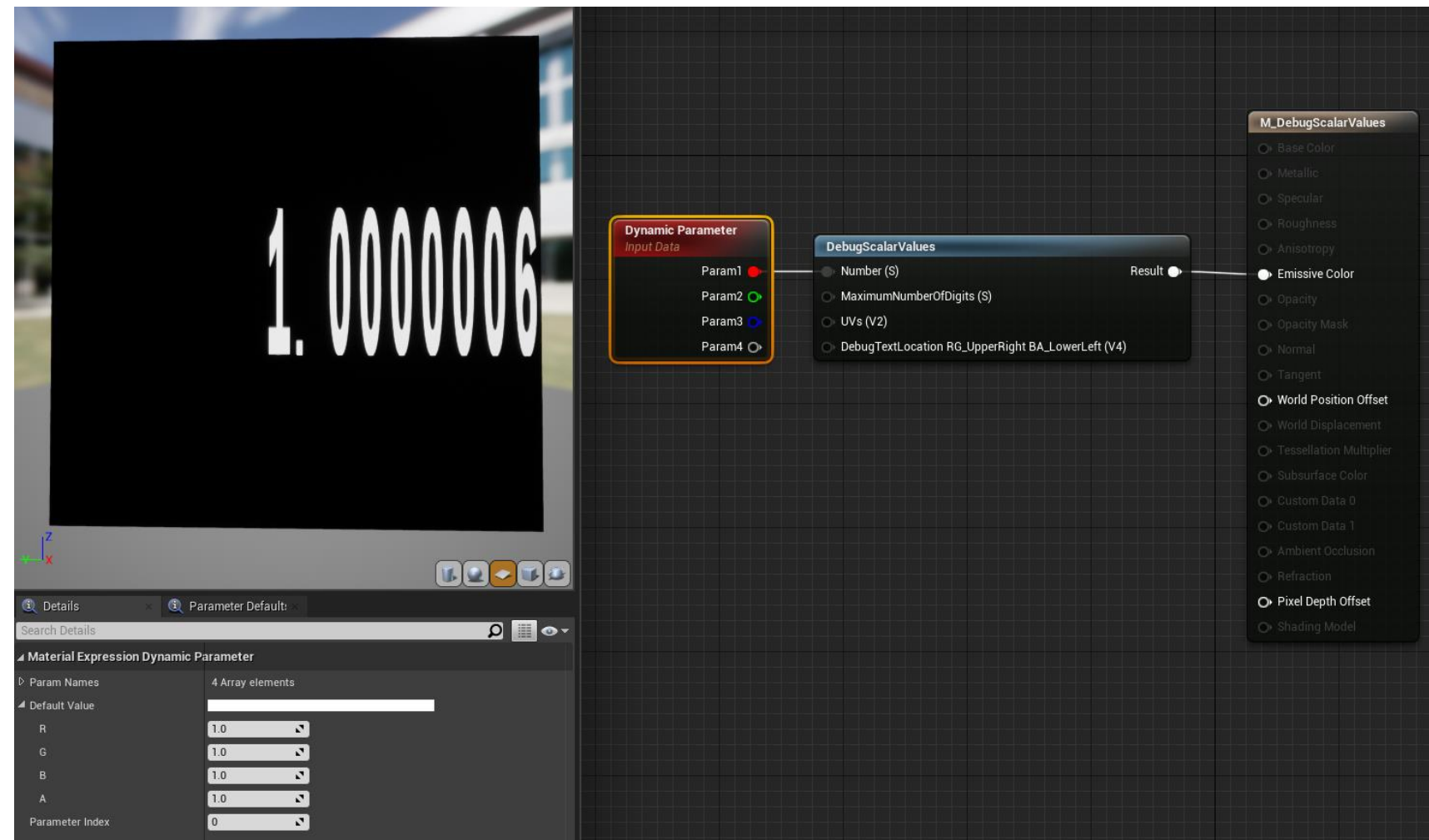


GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21

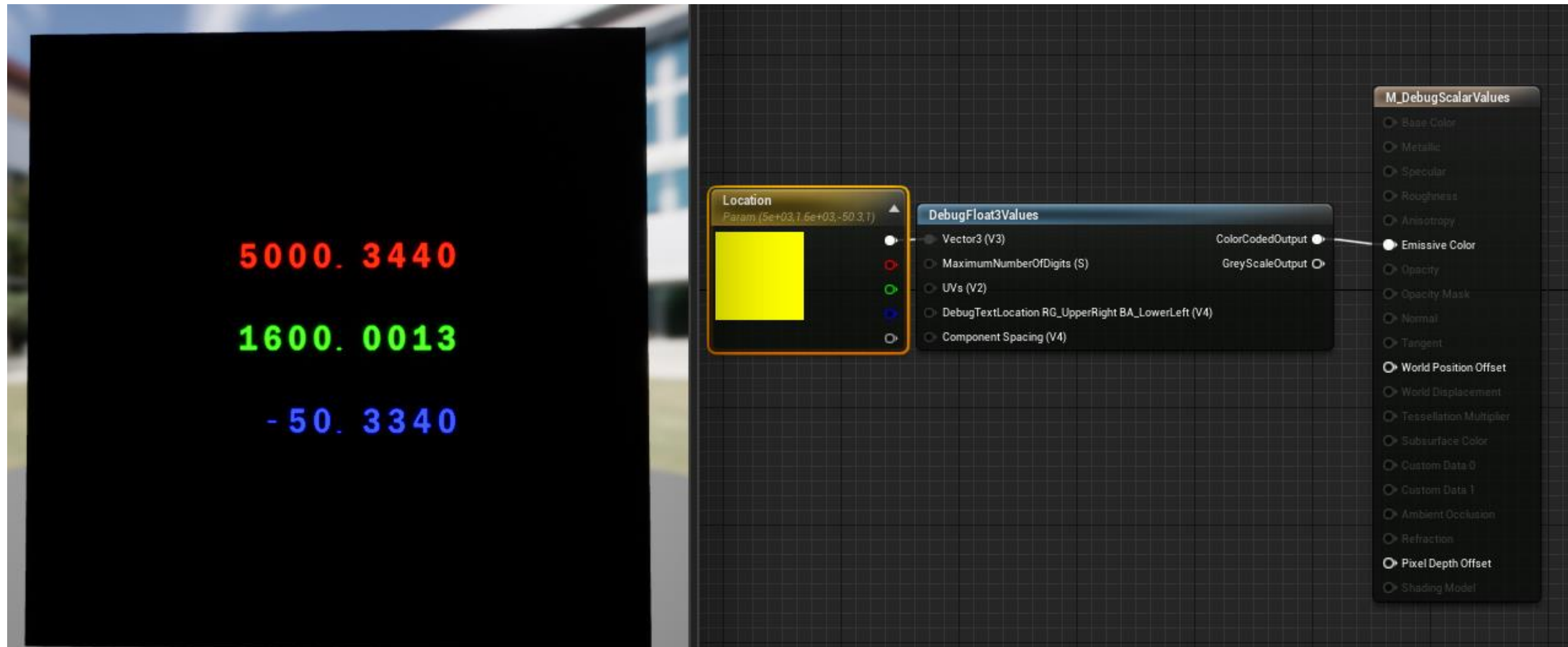
Materials

DebugScalarValues



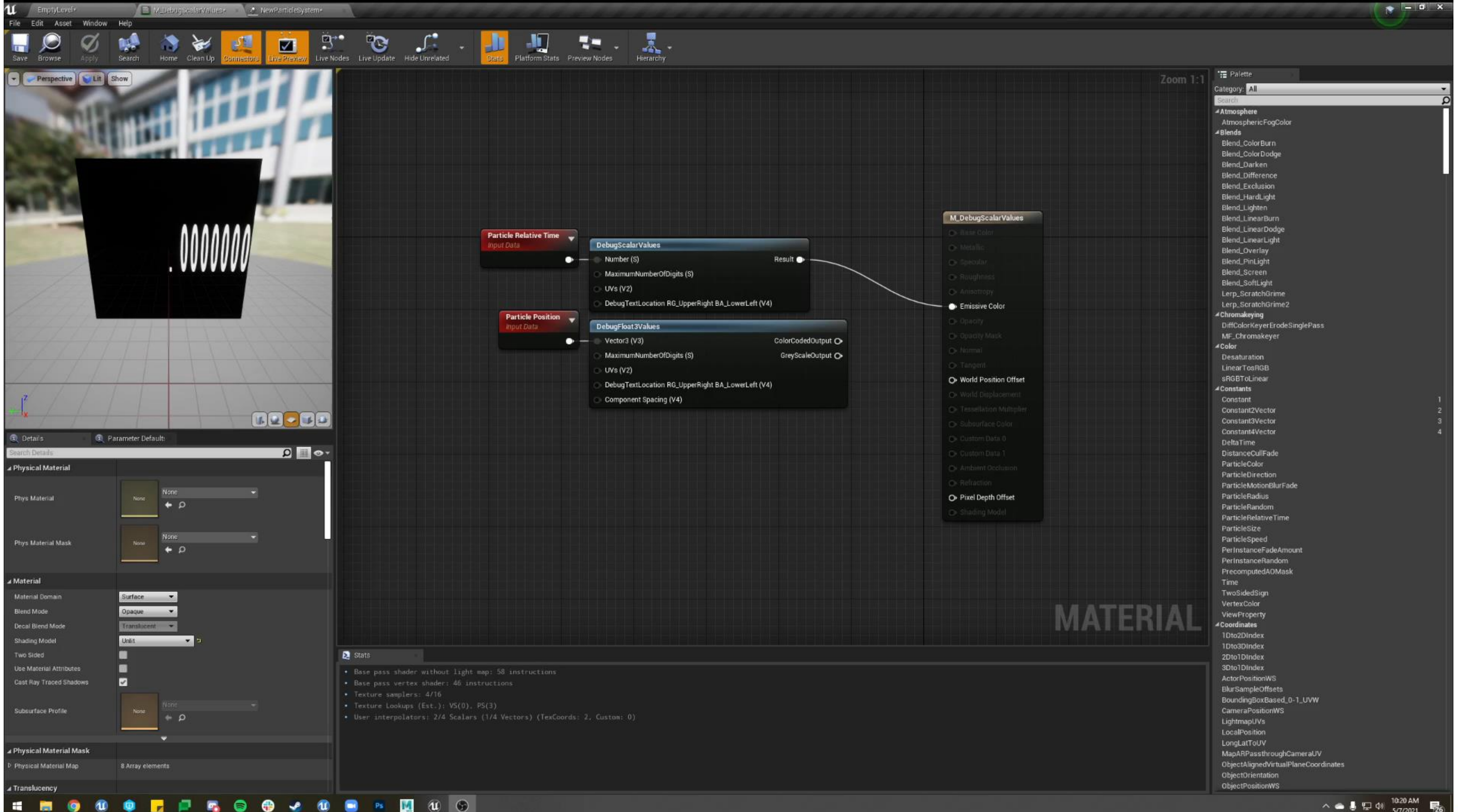
Materials

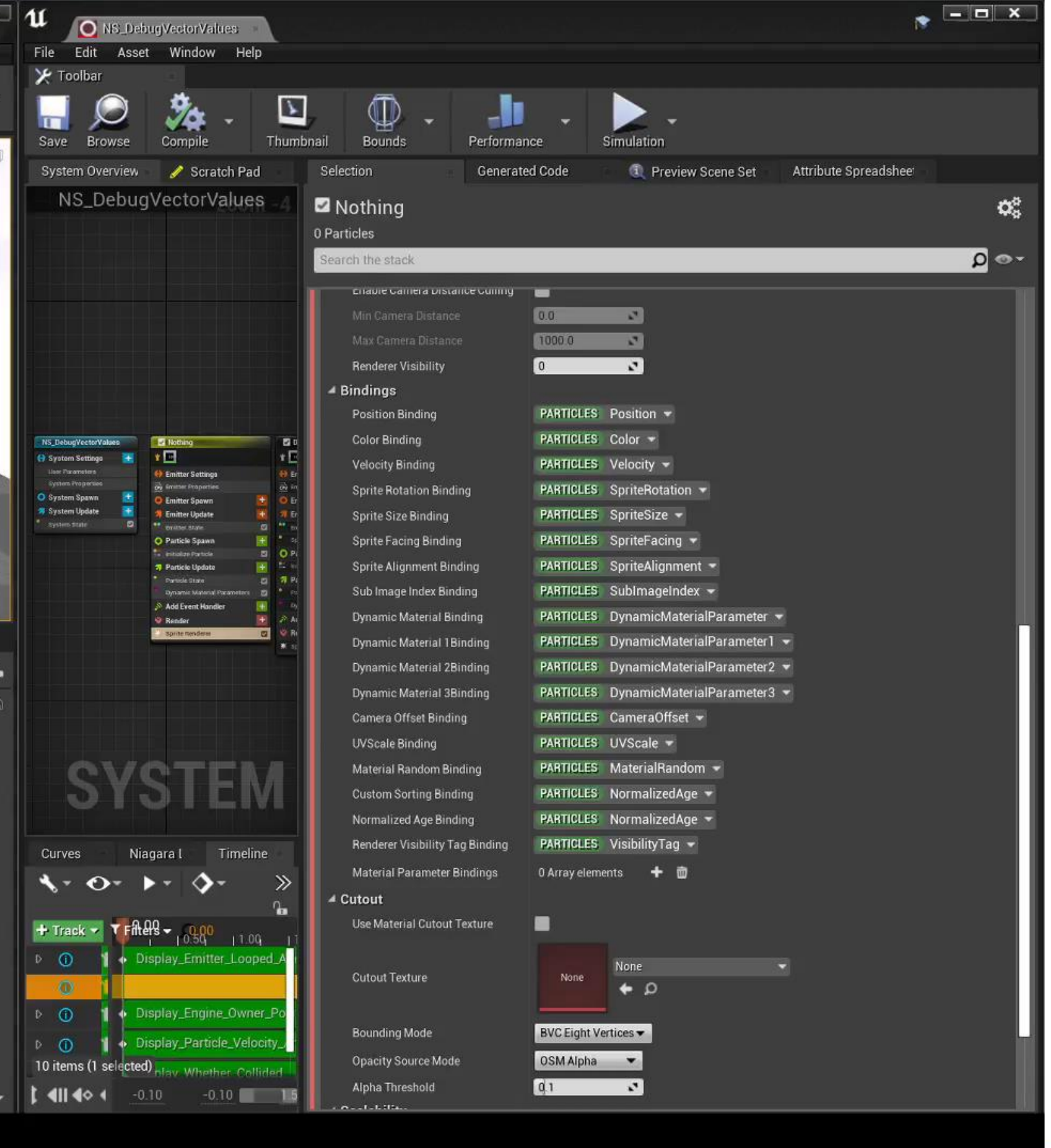
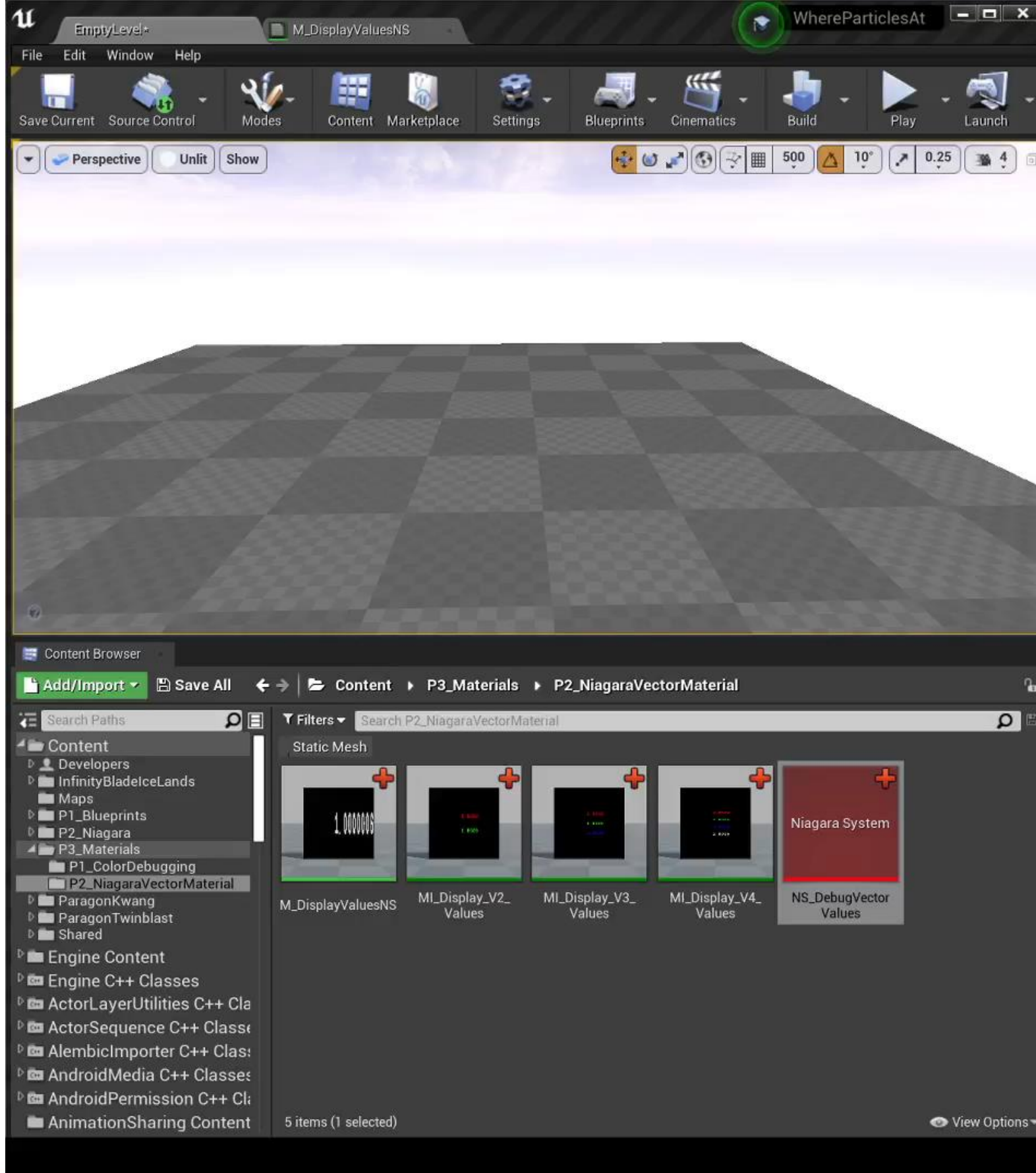
DebugVector[x]Values



GDC[®]

GAME DEVELOPERS CONFERENCE | July 19-23, 2021 | #GDC21





Summed up!



- Fix your stuff, when you can!
- When you can't, if it's an engine bug, maybe you can write a good bug.
- Have real data to talk to your friendly tech artist or graphics programmer to get help
- Be empowered to make more complex content!

Acknowledgements

All our excellent client studios

RealTimeVFX

Forums & Discord

And many more!

Thank you!

Dan Bruington
dbruington@fxville.com

Brittany Hein
bhein@fxville.com