

# **NVIDIA APEX: From Mirror's Edge to Pervasive Cinematic Destruction**

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# Agenda



- **Mirror's Edge Case study** (Anders Caspersson)
  - **PhysX in Mirror's Edge**
- **Introduction to APEX**
  - **A Scalable Dynamics Framework**
- **APEX Destruction Module**
  - **In-depth Demonstration**
- **APEX Turbulence Module**
  - **Sneak Preview**

# PhysX in Mirror's Edge



 MIRROR'S  
EDGE™

ICE

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# Mirror's Edge PC Trailer



# Background



- **PC version gets pushed out**
- **How can we enhance it?**
- **Problem: The game world felt very static**
- **PhysX would help to bring life and immersion**

# Challenges



- **Time – 5 weeks from start to 0 bugs**
  - **We could not get everything we wanted**
- **We did not want to affect the game play**
  - **We had to restrict ourselves to visual enhancements**
- **Matching the static lighting**
  - **We ended up lighting each asset individually in separate lighting channels**
- **The art direction**
  - **Everything should be stylish and clean**

# The glass sculpture



# The glass sculpture



The image displays the Unreal Engine interface for configuring a particle system. The main viewport shows a vertical glass sculpture effect composed of blue, translucent glass shards. The interface is divided into several panels:

- Class Browser:** Shows four classes: *ClassSpray* (17 instances), *ClassSprayFAST* (17 instances), *Dust* (11 instances), and *ClassMesh01* (7 instances).
- Properties Panel:** Lists various parameters for the particle system, including *Required*, *Spawn*, *Lifetime*, *Initial Size*, *Initial Velocity*, *Acceleration*, *SubImage Index*, *Mesh RotRate/Life*, *Mesh Material*, *Color Over Life*, *Size By Life*, *Initial Location+*, and *Initial Rotation*.
- Properties Panel (ParticleSystem):** Shows settings for the particle system, including *SystemUpdateMode* (EPSUM\_RealTime), *UpdateTime\_FPS* (60.000000), *WarmupTime* (0.000000), *SecondsBeforeInactive* (0.000000), *LODMethod* (PARTICLESYSTEMLODMETHOD\_Automatic), *LODDistanceCheckTime* (5.000000), *ThumbnailWarmup* (1.000000), and *bUseRealTimeThumbnail* (unchecked).
- Unreal Curve Editor:** Shows a graph for *ColorOverLife* and *AlphaOverLife* curves. The *AlphaOverLife* curve is a smooth, bell-shaped curve starting at 0.00, peaking at 1.00, and ending at 0.00. The *ColorOverLife* curve is a constant red line at 1.00.



# The glass sculpture



UnrealEngine: PS\_FX\_Breaking\_LightStructure\_Fracture\_01

Preview: PS\_FX\_Cracking\_LightStructure\_Fracture\_01

ClassSpray	ClassSprayFAST	Dust	ClassMesh01
17	17	10	7
Required	Required	Required	Mesh Data
Spawn	Spawn	Spawn	Spawn
Lifetime	Lifetime	Lifetime	Lifetime
Initial Size	Initial Size	Initial Size	Initial Size
Initial Velocity	Initial Velocity	Initial Color	Initial Velocity
Acceleration	Acceleration	Initial Velocity	Acceleration+
SubImage Index	SubImage Index	Acceleration	Color Over Life
Mesh RotRate/Life	Mesh RotRate/Life	Initial Rotation	Initial Location
Mesh Material	Mesh Material	Size By Life	Init Mesh RotRate
Color Over Life	Color Over Life	Initial RotRate	Init Mesh Rotation
Size By Life	Size By Life	Color Over Life	Velocity/Life
Initial Location+	Initial Location+	SubImage Index	
Initial Rotation	Initial Rotation	Initial Location	

Properties: PS\_FX\_Cracking\_LightStructure\_Fracture\_01

**ParticleSystem**

- SystemUpdateMode: EPSUM\_RealTime
- UpdateTime\_FPS: 60.000000
- WarmupTime: 0.000000
- SecondsBeforeInactive: 0.000000

**LOD**

- LODMethod: PARTICLESYSTEMLODMETHOD\_Automatic
- LODDistanceCheckTime: 5.000000

**Thumbnail**

- ThumbnailWarmup: 1.000000
- bUseRealTimeThumbnail:

Unreal Curve Editor: PS\_FX\_Cracking\_LightStructure\_Fracture\_01

ColorOverLife: 1.00

AlphaOverLife: 0.50

SpawnRate: 0.00

SpawnRate: -0.50

# The glass sculpture



The image displays the Unreal Engine interface for a particle system named "PS\_FX\_Cracking\_LightStructure\_Fracture\_01". The main viewport shows a vertical column of blue, crystalline particles resembling a glass sculpture. The interface includes a toolbar, a preview window, and several panels for configuring the particle system.

**Particle System Configuration:**

Property	Particle Emitter 1 (Dust)	Particle Emitter 2 (Orange)	Particle Emitter 3 (Purple)	Particle Emitter 4 (White)
Required	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Spawn	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Lifetime	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Size	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Color	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Velocity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Acceleration	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Rotation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Size By Life	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial RotRate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Color Over Life	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SubImage Index	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Location	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

**Properties: PS\_FX\_Cracking\_LightStructure\_Fracture\_01**

- PhysXParSys: PhysXParticleSystemPX\_GlassEffects.Glass\_Sculpture
- PhysXRotationMethod: PMRM\_Spherical
- FluidRotationCoefficient: 0.800000
- VerticalLod: (WeightForFifo=1.000000,WeightForSpawnLod=1.000000,SpawnLodRateLifeBias=1.00)
- Mesh: StaticMeshPX\_GlassEffects.Meshes.S\_FX\_Pieces\_BreakingSculpture\_04
- CastShadows:
- DoCollisions:
- bOverrideMaterial:
- MeshAlignment: PSMA\_MeshFaceCameraWithRoll
- b3DDrawMode:
- ModuleEditorColor: [Color Picker]

**Unreal Curve Editor: PS\_FX\_Cracking\_LightStructure\_Fracture\_01**

Curve Name	Value
ColorOverLife	1.00
AlphaOverLife	1.00
SpawnRate	0.50
SpawnRate	0.00
SpawnRate	-0.50

# The glass sculpture



The image displays the Unreal Engine interface for a particle system named 'PS\_FX\_Cracking\_LightStructure\_Fracture\_01'. The main viewport shows a 3D scene with a glowing, shattering glass sculpture. The interface is divided into several panels:

- Top Panel:** Shows the particle system hierarchy with three 'Particle Emitter' components (Dust, 204, 204, 204) and their associated 'ParticleModuleTypeDataM' modules.
- Properties Panel (Left):** Displays the settings for the selected particle system:
  - PhysXParSys: PhysXParticleSystemPX\_GlassEffects.Glass\_Sculpture
  - PhysXRotationMethod: PMRM\_Spherical
  - FluidRotationCoefficient: 0.800000
  - VerticalLod: (WeightForFifo=1.000000,WeightForSpawnLod=1.000000,SpawnLodRate%LifeBias=1.00)
  - Mesh: StaticMeshPX\_GlassEffects.Meshes.S\_FX\_Pieces\_BreakingSculpture\_04
  - CastShadows:
  - DoCollisions:
  - bOverrideMaterial:
  - MeshAlignment: PSMA\_MeshFaceCameraWithRoll
  - b3DDrawMode:
  - ModuleEditorColor: [Color Picker]
- Unreal Curve Editor (Right):** Shows a graph for the 'SpawnRate' parameter over time. The graph has a Y-axis from -1.00 to 1.00 and an X-axis from 0.00 to 1.50. The curve starts at 0.00, rises to a peak of 1.00 at approximately 0.25, and then gradually decays towards 0.00.

# The glass sculpture



The image displays the Unreal Engine interface for a project titled "UnrealCascade: PX\_Breaking\_LightStructure\_Fracture\_01". The main viewport shows a dark scene with a dense field of blue, glass-like particles. A vertical yellow line is overlaid on the particles. The interface includes a top toolbar, a menu bar (Edit, View, Window), and a preview window showing "PS\_FX\_Cracking\_LightStructure\_Fracture\_01".

On the right side, there are three "Particle Emitter" components, each with a "204" count. Below them is a table of properties for each emitter:

Property	Emitter 1 (Dust)	Emitter 2 (Orange)	Emitter 3 (Purple)	Emitter 4 (White)
Required	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Spawn	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Lifetime	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Size	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Color	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Velocity	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Acceleration	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Rotation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Size By Life	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial RotRate	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Color Over Life	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
SubImage Index	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Initial Location	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

At the bottom left, the "Properties" panel for "PS\_FX\_Cracking\_LightStructure\_Fracture\_01" is visible, showing settings for "PhysXParSys" (PhysXParticleSystemPX\_GlassEffects.Glass\_Sculpture), "PhysXRotationMethod" (PMRM\_Spherical), "FluidRotationCoefficient" (0.800000), and "Mesh" (StaticMeshPX\_GlassEffects.Meshes.S\_FX\_Pieces\_BreakingSculpture\_04). The "ModuleEditorColor" is set to a blue color.

At the bottom right, the "Unreal Curve Editor" for "PS\_FX\_Cracking\_LightStructure\_Fracture\_01" is open, showing a graph for "ColorOverLife" and "AlphaOverLife". The "ColorOverLife" curve is a horizontal line at 1.00. The "AlphaOverLife" curve is a horizontal line at 0.50. The "SpawnRate" is set to 0.00.

# The glass sculpture



The image displays the Unreal Engine 4 interface for a particle system named 'PS\_FX\_Cracking\_LightStructure\_Fracture\_01'. The main viewport shows a 3D scene with a central glass sculpture that has shattered into many small, blue-tinted fragments. A yellow bounding box is visible around the sculpture.

The interface includes several panels:

- Top Panel:** Shows the particle system's components, including 'Dust' (17 particles) and two 'Particle Emitter' components (17 and 83 particles).
- Properties Panel (Left):** Displays the settings for the 'PhysXParticleSystem' 'PX\_GlassEffects.Glass\_Sculpture'. Key settings include:
  - PhysXRotationMethod: PMRM\_Spherical
  - FluidRotationCoefficient: 0.500000
  - Mesh: StaticMesh\_PX\_GlassEffects.Meshes.S\_FX\_Pieces\_BreakingSculpture\_04
  - MeshAlignment: PSMA\_MeshFaceCameraWithRoll
  - ModuleEditorColor: (Blue)
- Unreal Curve Editor (Bottom Right):** Shows a graph for 'SpawnRate' over 'Life' (0.00 to 1.50). The curve starts at 0.00, rises to a peak of 0.50 at approximately 0.25 life, and then decays back to 0.00 by 1.00 life.

# The glass sculpture



The image displays the Unreal Engine interface for a simulation titled "UnrealCascade: PX\_Breaking\_LightStructure\_Impact\_01". The main viewport shows a 3D scene with a central glass sculpture and a large pile of blue and grey particles. The interface includes a toolbar, a scene view, and several panels.

**Scene View:** Shows a 3D scene with a central glass sculpture and a large pile of blue and grey particles. The scene is rendered in a dark environment.

**Particle System Hierarchy:** Located at the top right, it shows several particle emitters and their associated data modules. The emitters are labeled "Dust" (17), "Particle Emitter" (17), and "Particle Emitter" (83). The data modules include "ParticleModuleTypeDataM" and "ParticleModuleTypeDataM".

**Properties Panel:** Located at the bottom left, it shows the properties for the selected particle system "PhysXPParSys". The properties include:

- PhysXPParSys: PhysXPParticleSystemPX\_GlassEffects.Glass\_Sculpture
- PhysXRotationMethod: PMRM\_Spherical
- FluidRotationCoefficient: 0.500000
- VerticalLod: (WeightForFifo=1.000000,WeightForSpawnLod=1.000000,SpawnLodRate%LifeBias=1.00)
- Mesh: StaticMeshPX\_GlassEffects.Meshes.S\_PX\_Pieces\_BreakingSculpture\_04
- CastShadows:
- DoCollisions:
- bOverrideMaterial:
- MeshAlignment: PSMA\_MeshFaceCameraWithRoll
- b3DDrawMode:
- ModuleEditorColor: [Color Picker]

**Unreal Curve Editor:** Located at the bottom right, it shows a graph for the "ColorOverLife" and "AlphaOverLife" properties. The graph has a Y-axis ranging from -1.00 to 1.00 and an X-axis ranging from 0.00 to 1.50. The "ColorOverLife" curve starts at 1.00 and decreases to 0.00. The "AlphaOverLife" curve starts at 1.00 and decreases to 0.00. The "SpawnRate" is set to 0.50.

# The glass sculpture



The image displays the Unreal Engine interface for a simulation titled "PX\_Breaking\_LightStructure\_Impact\_01". The main viewport shows a 3D scene with a central vertical glass sculpture and numerous blue, crystalline particles scattered around it. The interface includes a top toolbar, a scene view, and several panels.

**Scene View:** Shows a 3D perspective view of the glass sculpture and its surrounding particles. A wireframe bounding box is visible around the central structure.

**Particle System Hierarchy:** Located in the top right, it lists several particle emitters: "Dust" (17 particles), "Particle Emitter" (17 particles), and "Particle Emitter" (83 particles). Below this is a table of properties for each emitter.

Property	Dust	Particle Emitter (17)	Particle Emitter (83)
Required	Required	Required	Required
Spawn	Spawn	Spawn	Spawn
Lifetime	Lifetime	Lifetime	Lifetime
Initial Size	Initial Size	Initial Size	Initial Size
Initial Velocity	Initial Color	Initial Velocity	Initial Velocity
Acceleration	Initial Velocity	Initial Location	Initial Location
SubImage Index	Acceleration	Init Mesh Rotation	Init Mesh Rotation
Mesh RotRate/Life	Initial Rotation	Init Mesh RotRate	Init Mesh RotRate
Mesh Material	Size By Life	Initial Color	Initial Color
Color Over Life	Initial RotRate		
Size By Life	Color Over Life		
Initial Location+	SubImage Index		
Initial Rotation	Initial Location		

**Properties Panel:** Located at the bottom left, it shows the properties for the selected particle system "PhysXParSys".

- PhysXParSys: PhysXParticleSystemPX\_GlassEffects.Glass\_Sculpture
- PhysXRotationMethod: PMRM\_Spherical
- FluidRotationCoefficient: 0.500000
- VerticalLod: (WeightForFifo=1.000000,WeightForSpawnLod=1.000000,SpawnLodRateVsLifeBias=1.00)
- Mesh: StaticMeshPX\_GlassEffects.Meshes.S\_FX\_Pieces\_BreakingSculpture\_04
- CastShadows:
- DoCollisions:
- bOverrideMaterial:
- MeshAlignment: PSMA\_MeshFaceCameraWithRoll
- b3DDrawMode:
- ModuleEditorColor: [Color Picker]

**Unreal Curve Editor:** Located at the bottom right, it shows a graph for the "ColorOverLife" and "AlphaOverLife" properties. The graph has a time axis from 0.00 to 1.50 and a value axis from -1.00 to 1.00. The "ColorOverLife" curve starts at 1.00 and decreases to 0.00. The "AlphaOverLife" curve starts at 0.50 and decreases to 0.00. The "SpawnRate" is set to 0.00.

# Particles summary



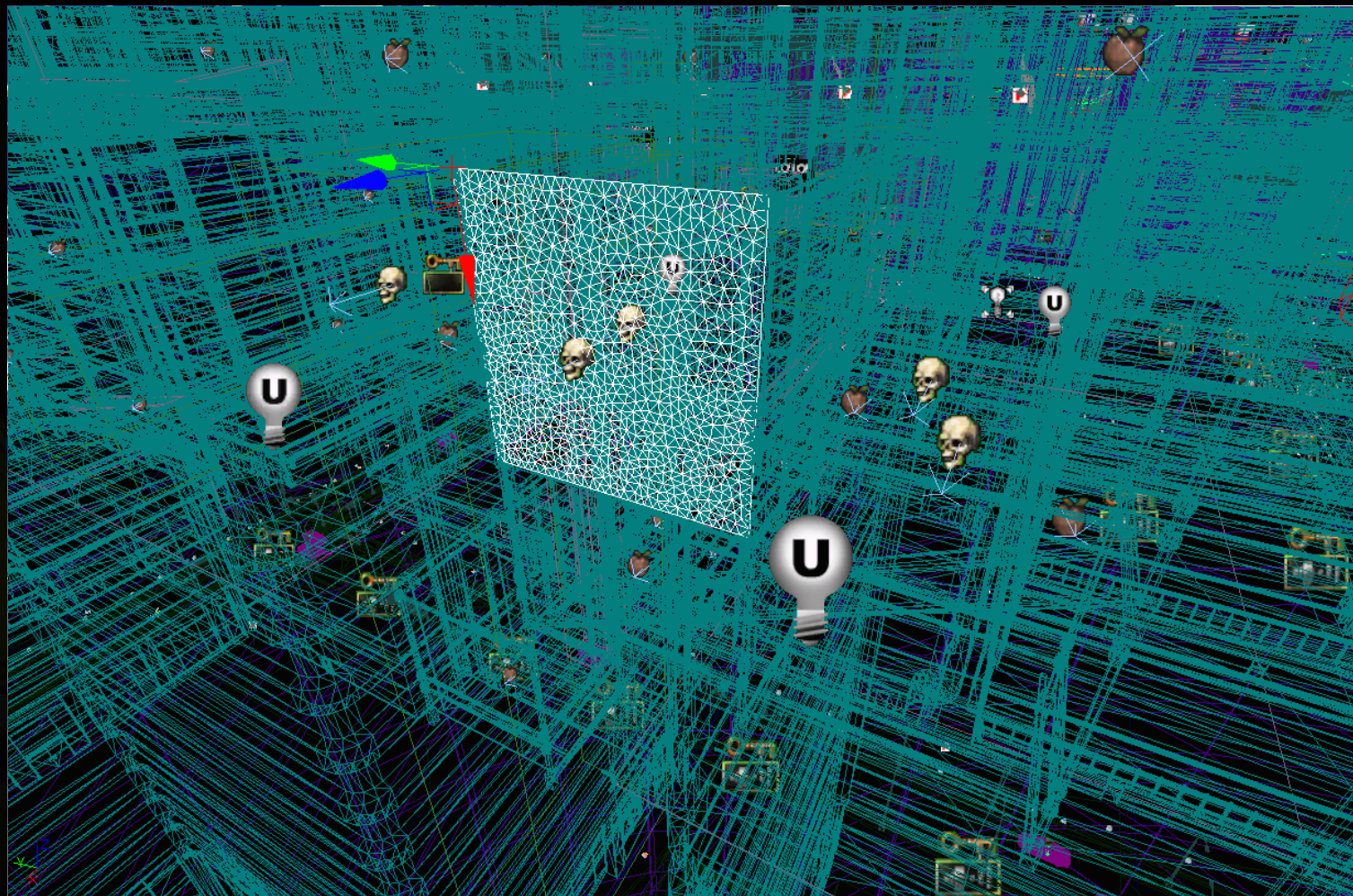
- Huge number of mesh or sprite particles
- Full physical interaction with world and player
- Edited as usual in Unreal Cascade
- Used for
  - Impact effects
  - Glass destruction
  - Trash
  - Smoke



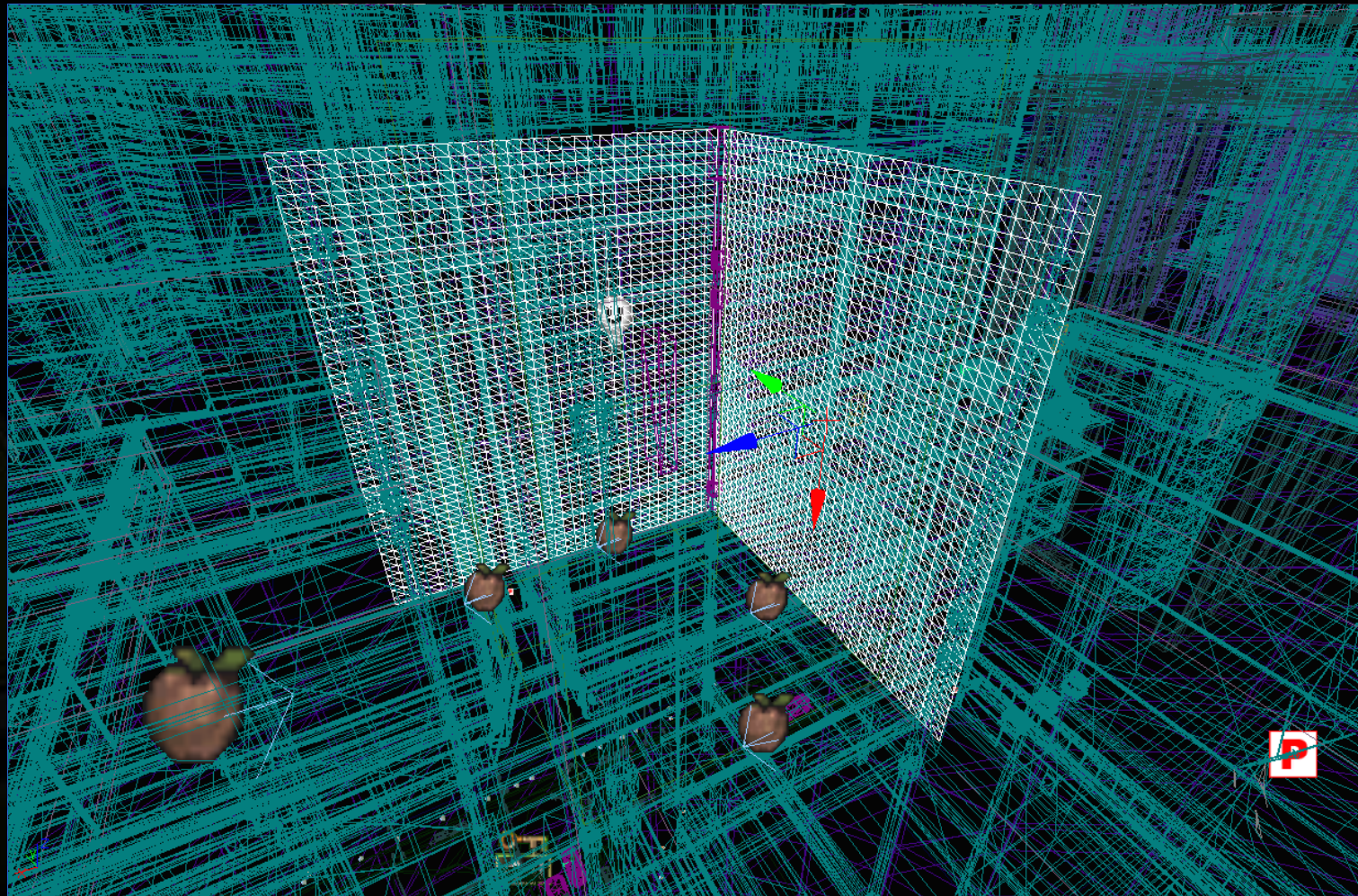
# “Heat” Level



# “Heat” Level



# “Heat” Level



# Cloth summary



- **1000 – 1500 vertices**
- **Tearing**
- **Skeletal meshes created in Max, Maya**
- **Edited in Unreal AnimSet Editor**
- **Used for**
  - **Tarp**
  - **Plastic sheets**
  - **Plastic curtains**
  - **Banners**
  - **Paper stuck in vents**

# Before / After



# Conclusions



- **PhysX enabled us to quickly enhance the visuals of the game and make the world come alive**
- **The user immersion was greatly enhanced**
- **Could have played a bigger part if implemented earlier**
- **Scaling would have helped**
  - **We had to tune the effects for low spec hardware**
  - **We could have had even more detail on high end machines**
- **We wish APEX had been available**

# Introduction to APEX



# Pervasive Cinematic Destruction: UT3 + APEX



0  
1st / 0

105





# Scalable Dynamics Content

APEX Destruction



APEX Vegetation



APEX Clothing



APEX Turbulence



# APEX Vegetation



# APEX Clothing

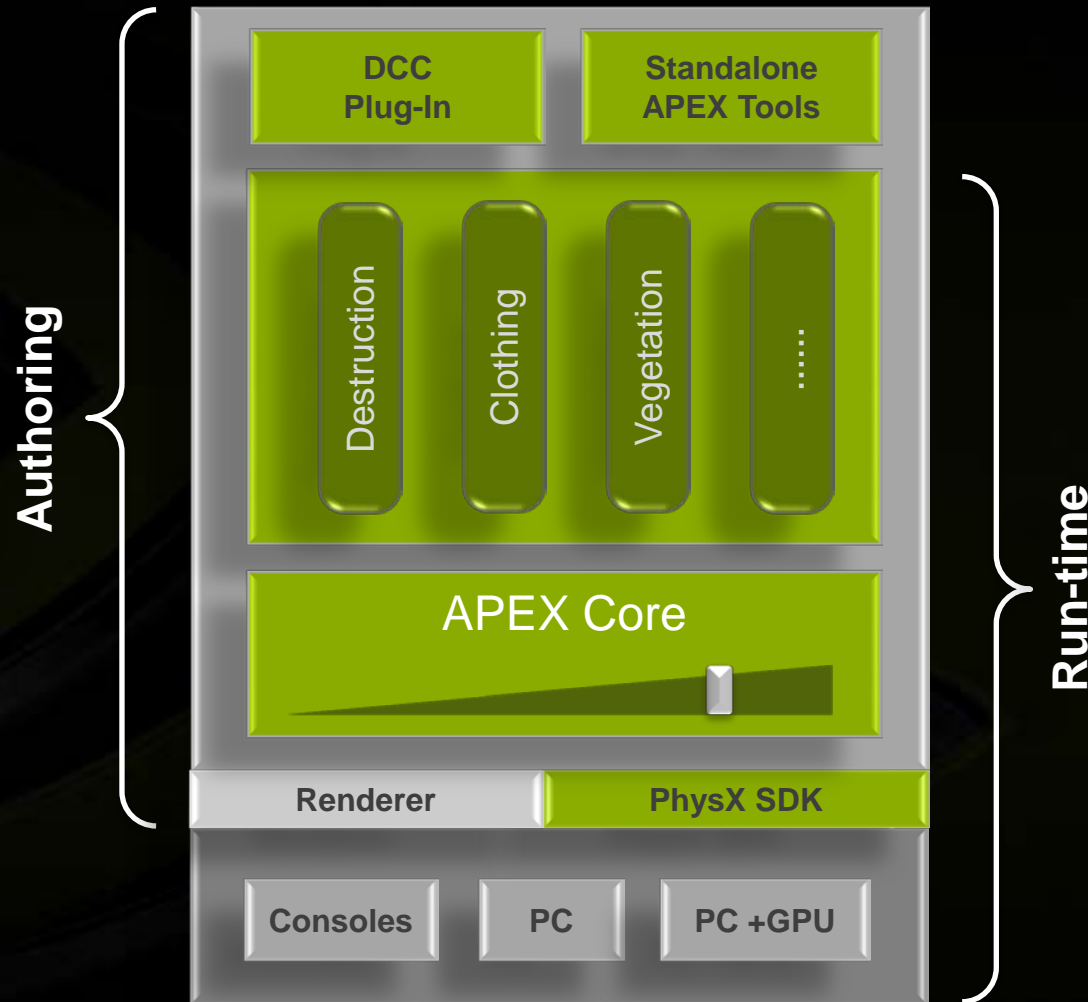


# What is APEX?



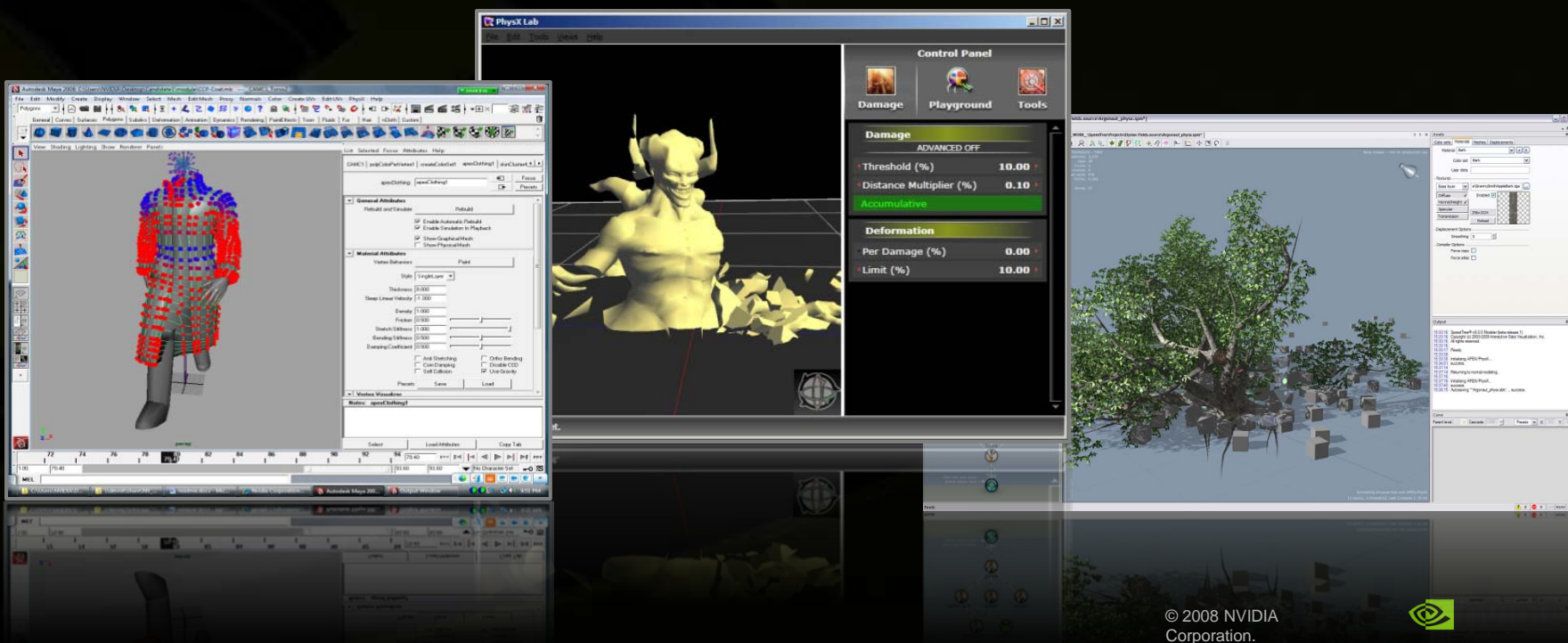
- **APEX is a “Scalable Dynamics Framework”**
  - ***Scalable:*** Content adapts to different hardware capabilities
  - ***Dynamics:*** The way things move and interact
  - ***Framework:*** A structured environment
- **APEX consists of two major components:**
  - **Authoring:**
    - High-level authoring of dynamic systems
    - DCC plugins, standalone tools, and game engine plugins
  - **Runtime:**
    - A modular SDK – minimal integration into game engine
    - Leverages PhysX for simulations

# APEX Architecture



# APEX is Artist Focused

- Artist level abstractions of dynamic systems
  - “Destructible bunker” vs. “collection of bricks”
- Intuitive and easy to use

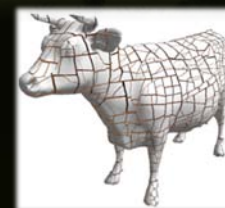


# APEX Solves Problems

- Requirement for significant programmer involvement limits artists' productivity
- **APEX Solution: Provide a "high-level" interface to artists which allows for turnkey content creation**
- Customizing content to different platforms is expensive
- **APEX Solution: All modules provide built-in content scaling**
- Cross-functional issues can severely limit the amount of dynamic content
- **APEX Solution: Framework provides rendering "fast path" and manages complex dynamic content**

# APEX is easy to integrate

- Already integrated into leading game engines
  - UE3, Gamebryo, Hero Engine, ...
- APEX modules are Plug & Play
  - Clothing, Vegetation, Destruction
  - More modules in development
- APEX is already used for AAA content
  - Licensed by major publishers
  - NVIDIA developed APEX modules are free for PhysX developers





# APEX Destruction Module In-Depth Demonstration

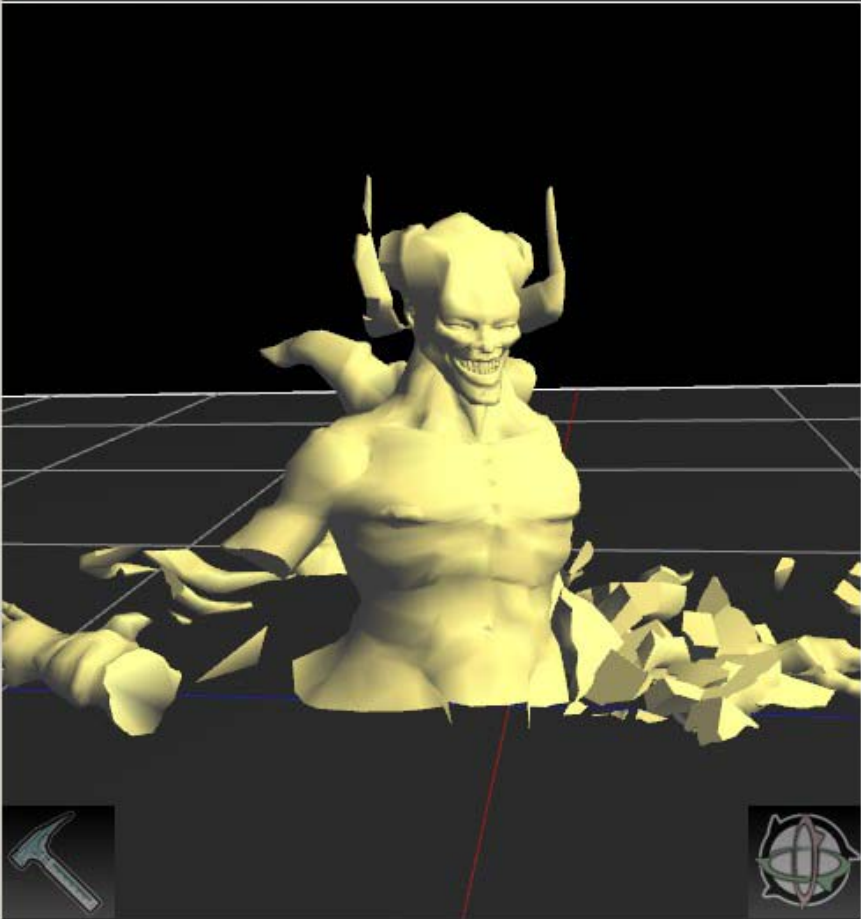


# PhysX Lab






PhysX Lab

File Edit Tools Views Help



**Control Panel**

 **Damage**  **Playground**  **Tools**

**Damage**

ADVANCED OFF

Threshold (%) **10.00**



Distance Multiplier (%) **0.10**

**Accumulative**

**Deformation**

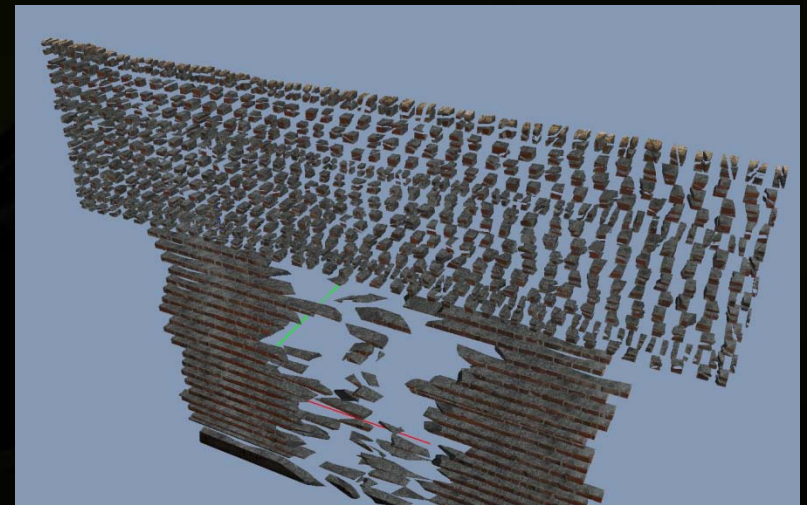
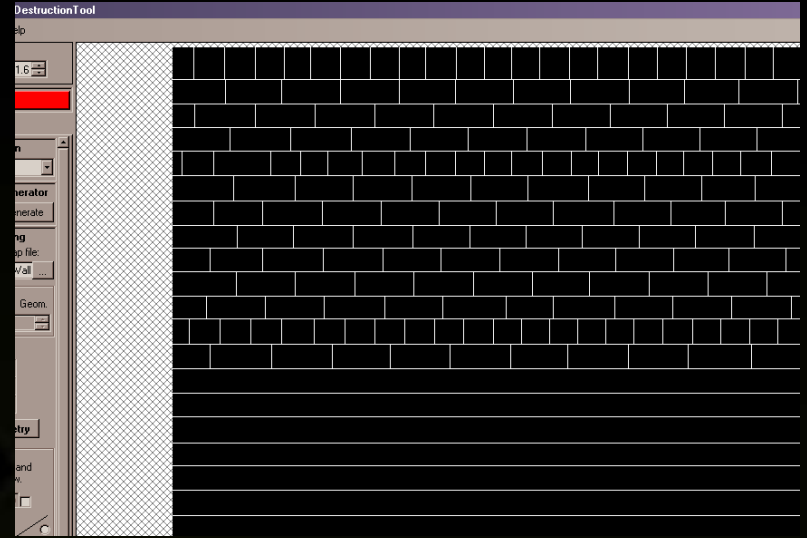
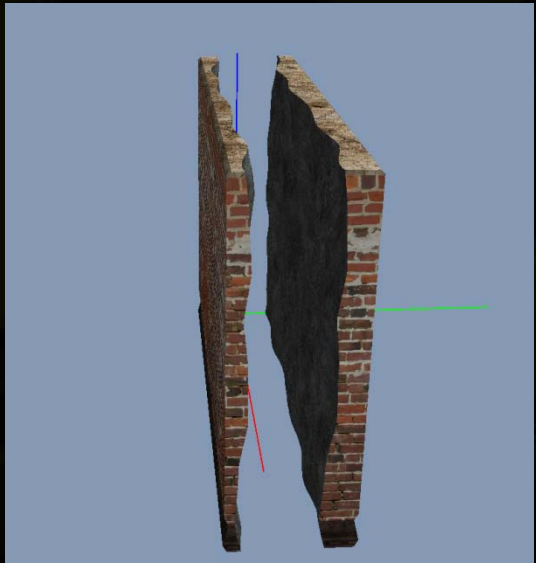
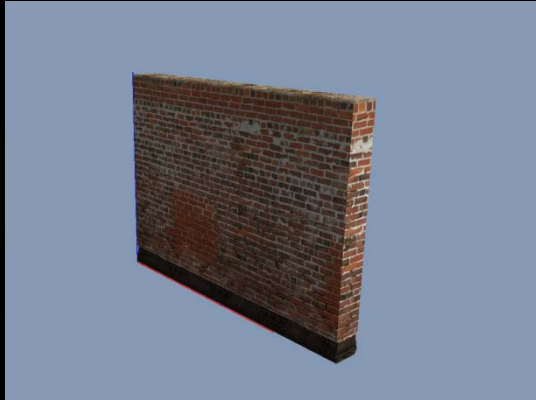
Per Damage (%) **0.00**

Limit (%) **10.00**

Simulation reset.

# Authoring - Fracture Maps



# UE3 Testlevel – Various Destruction



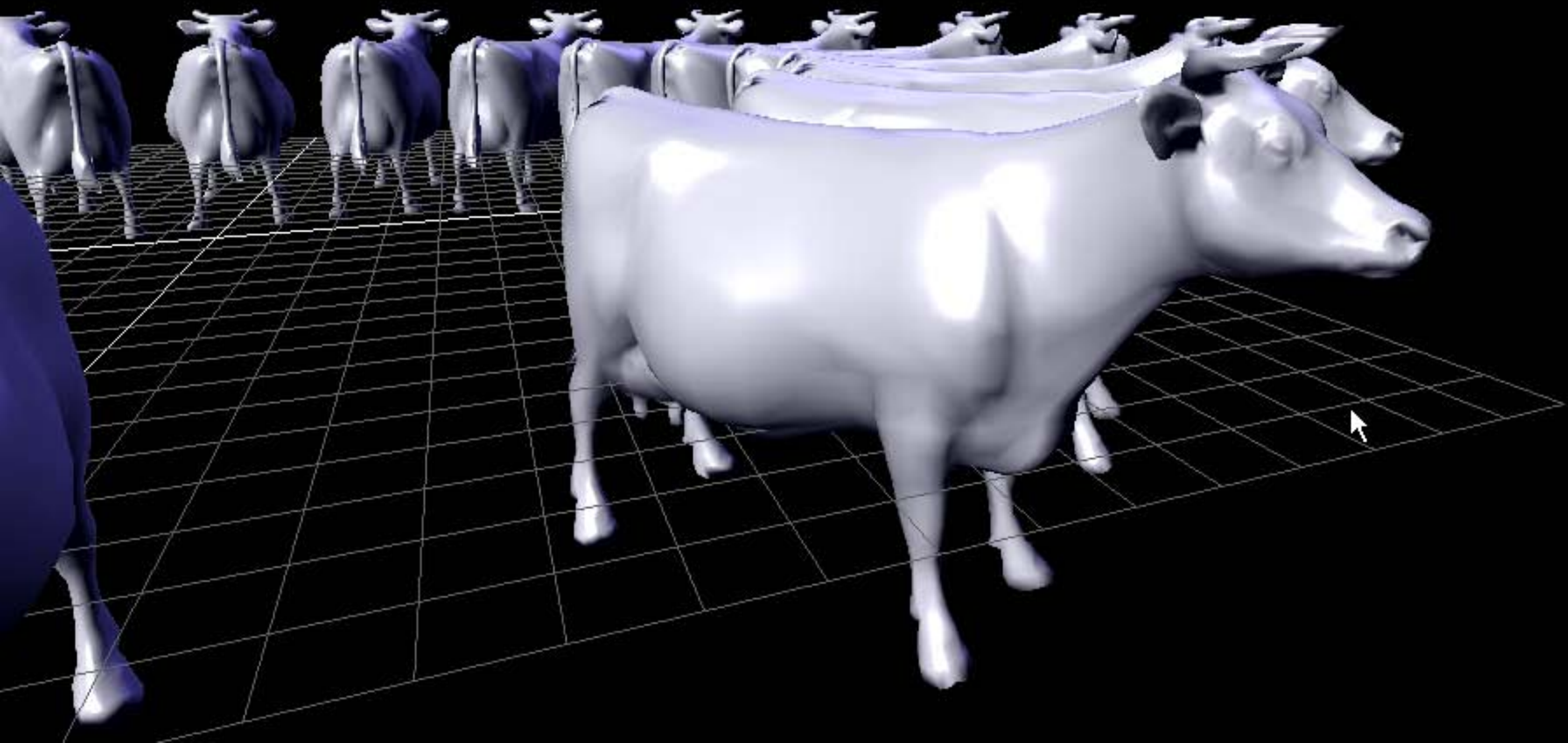
# UE3 Testlevel – Wooden Fence



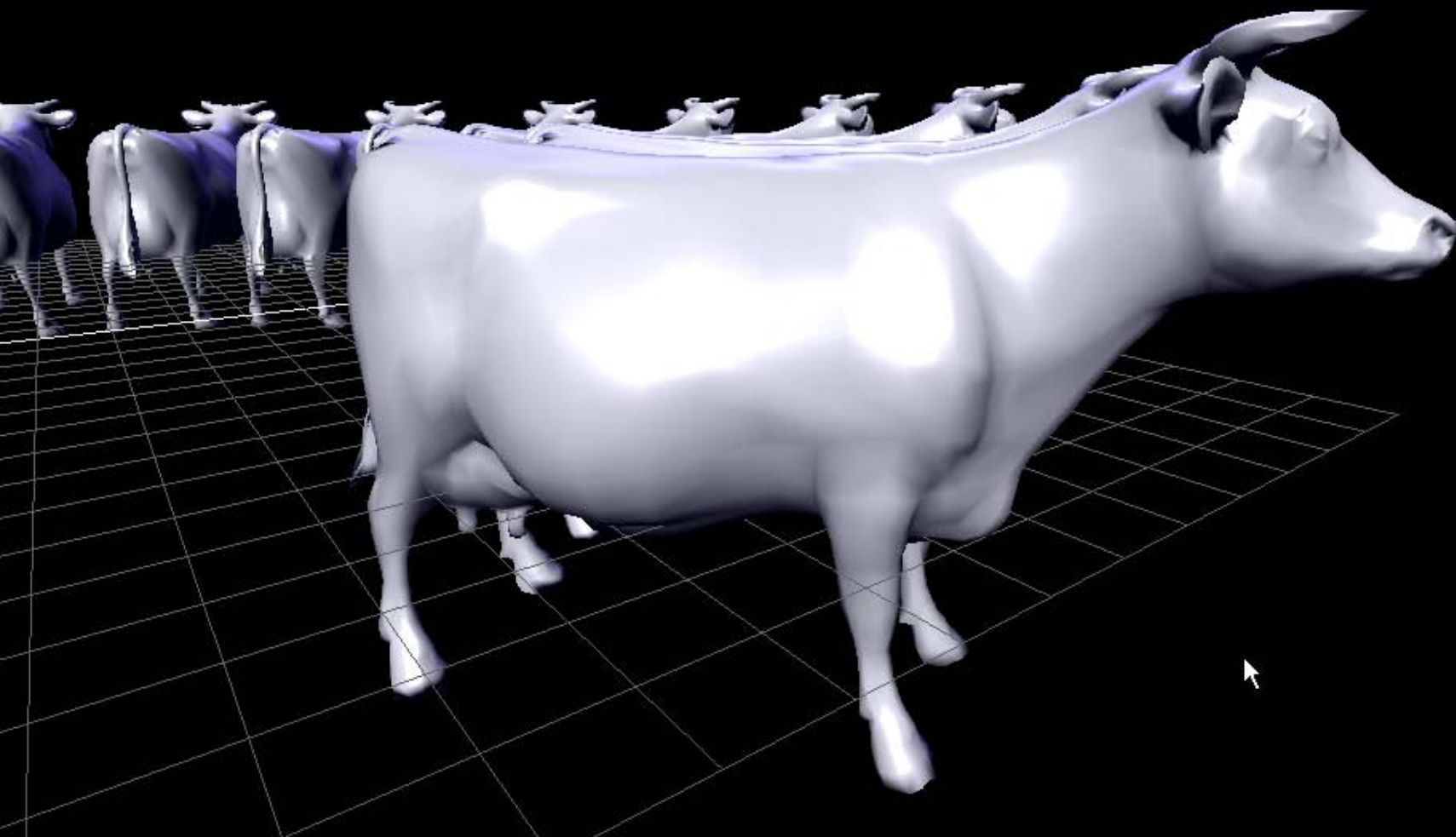
# UE3 Testlevel – Complex Buildings



# Scalability: "Low Setting"



# Scalability: "High Setting"





# **APEX Turbulence Module**

## **Sneak Preview**



# SPH Particle Smoke



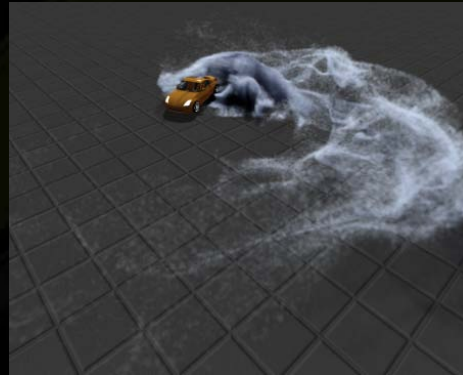
- **Already in games, e.g. Mirror's Edge**
- **Integrated into UE3**



# APEX Turbulence



- **High definition Turbulence**
  - Residual dust from destruction
  - Smoke Grenades and other weapon effects
  - Supernatural effects – e.g. ghost like
  - Snow storms or snow trails
  - Exhaust smoke from car or spinning/braking tires



# APEX Turbulence – Live Demo



# APEX Summary



- **APEX is a Scalable Dynamics Framework**
- **APEX is artist focused**
- **APEX is easy to use**
- **APEX is modular**
- **APEX solves problems**
- **APEX is easy to integrate**
- **APEX is already used to create AAA content**
  
- **Start using APEX now:**
  - **Sign up today for the Beta program**
    - *Come to our special session*
    - *Tonight, 6:00 p.m.*
  - **Email us: *devrel@nvidia.com***

# How To Reach Us



- **During GDC**

- **Expo Suite 656, West Hall**
- **Developer Tool Open Chat, 1:30 to 2:30 pm (25<sup>th</sup>-27<sup>th</sup>)**
- **Come to our special session on APEX:**
  - *Wednesday, March 25<sup>th</sup>, 6:00 – 8:00 p.m.*

- **Online**

- **Twitter:** `nvidiadeveloper`
- **Website:** <http://developer.nvidia.com>
- **Forums:** <http://developer.nvidia.com/forums>