



GPU Particle Simulation for Games

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Introduction

- For years games use graphical particles to add visual effects
- For years games use physical simulation to create immersive interactive worlds
- Technologies like CUDA or DirectCompute allow general GPU computation
- Combine these to create GPU particle simulation engines



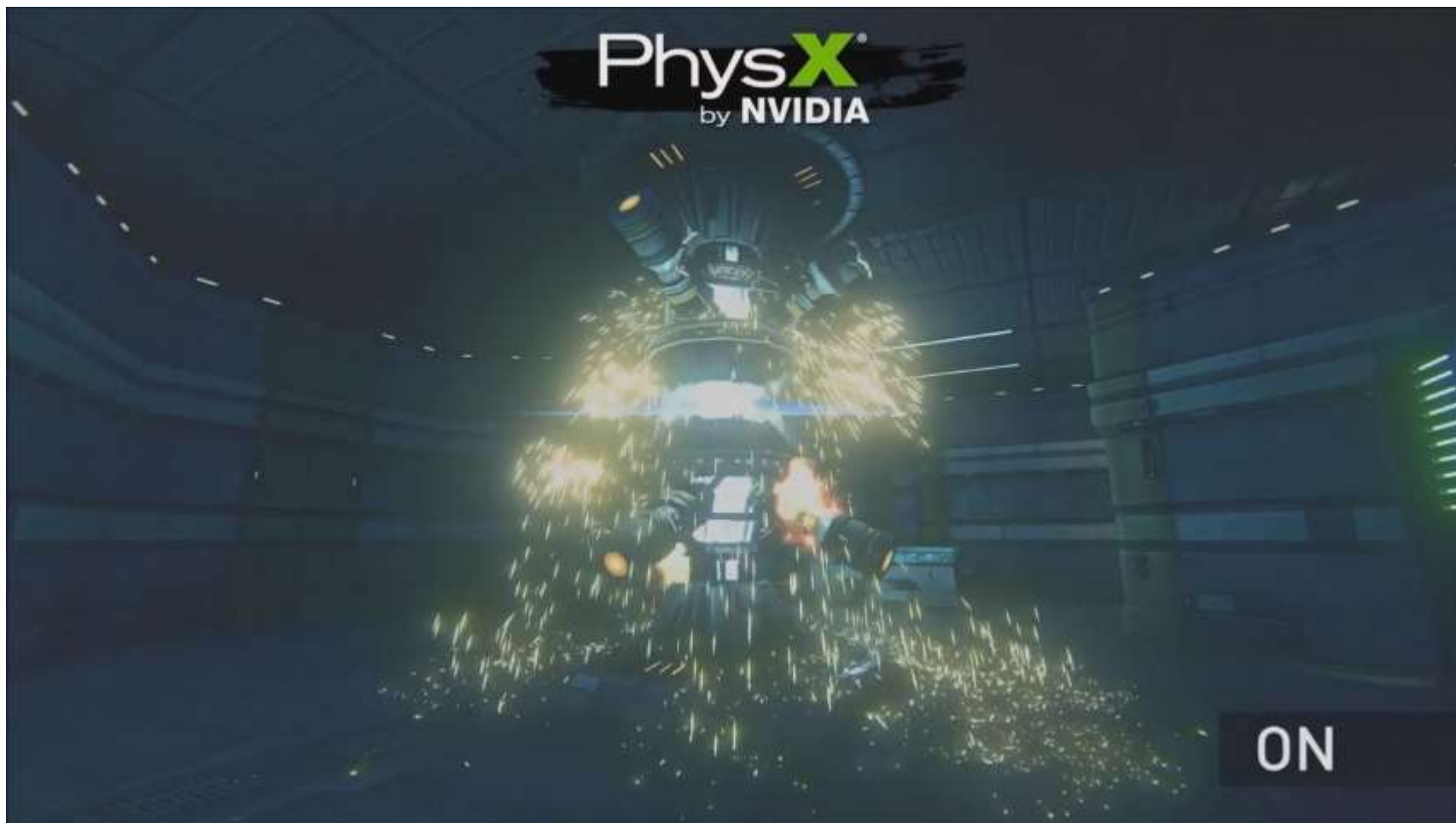
GPU Particle Collision

- Simulate massive amounts of particles interacting with the game environment
 - Debris from weapon impacts
 - Sparks
- Non-interacting spheres
- Use Collision Normal to Orient Non-spherical Shapes





GPU Particle Simulation





Fluid Simulation - SPH

- SPH = Smoothed Particle Hydrodynamics
- Simulate fluids such as liquids or gases
- Rendering
 - Explicit surface rendering for fluids
 - Sprite-based methods for smoke or fog
- Exmaples:
 - Viscous liquids such as blood or goo
 - Gases like smoke



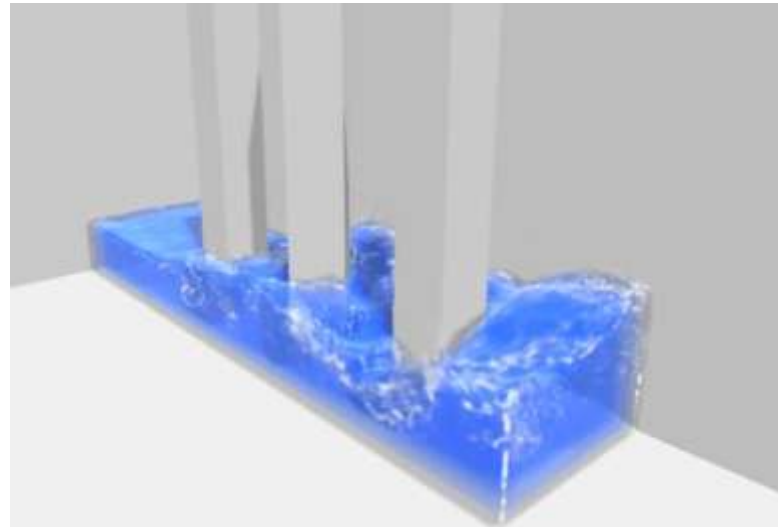
Fluids Simulation Example





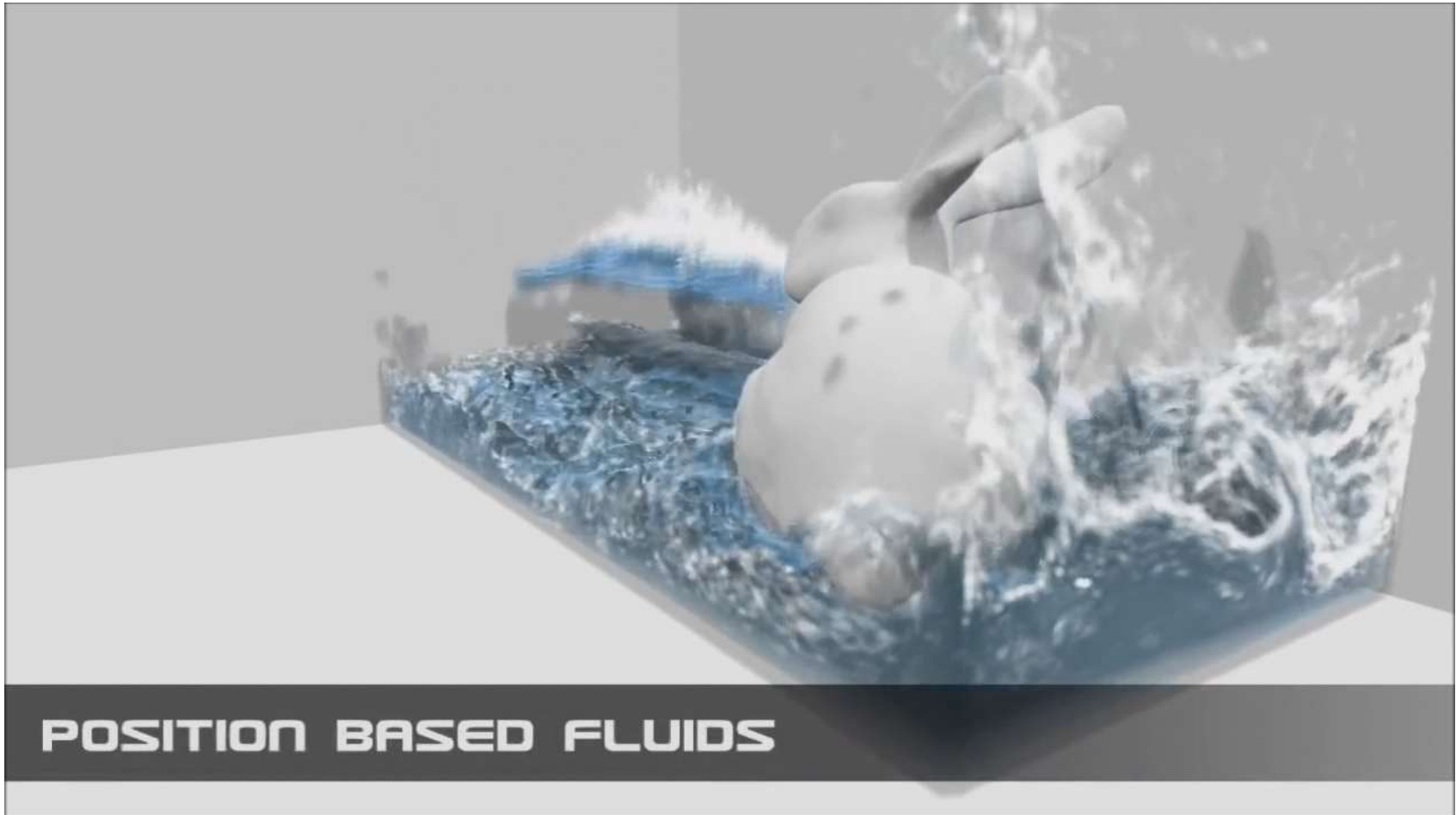
Position-based Fluids

- Stable for large timesteps, making it more
- Suitable for real-time simulation
- Supports surface tension
- Supports collision
- Similar uses to SPH





Position-based Fluids Example





Turbulence

- Grid-based fluid simulation
 - Start by simulating turbulent flow of a fluid
 - Add GPU particle simulation with collision
 - Use the fluid simulation to apply forces to particles
 - Result is particles that move in interesting ways, and react with the environment





Turbulence Smoke Effects

- Turbulence simulation can enhance smoke effects
- Start by simulating turbulent fluid
- Add GPU simulated particles moving in the fluid
- Render as self-shadowed particles
- Move objects through the fluid to create a convincing smoke effect
- Enhance with PSM - Particle Shadow Mapping



PSM Example





Turbulence Examples

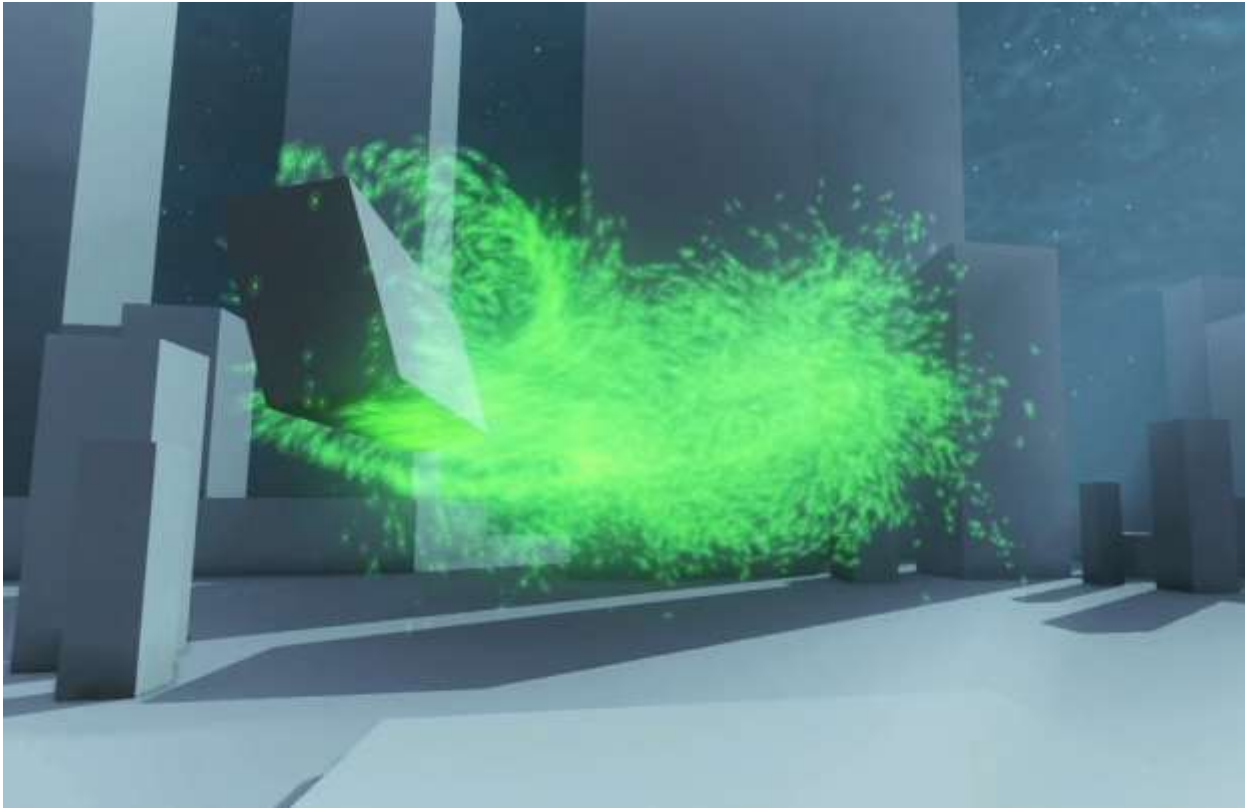
- Moving the fluid creates interesting motion on its own





Turbulence Example

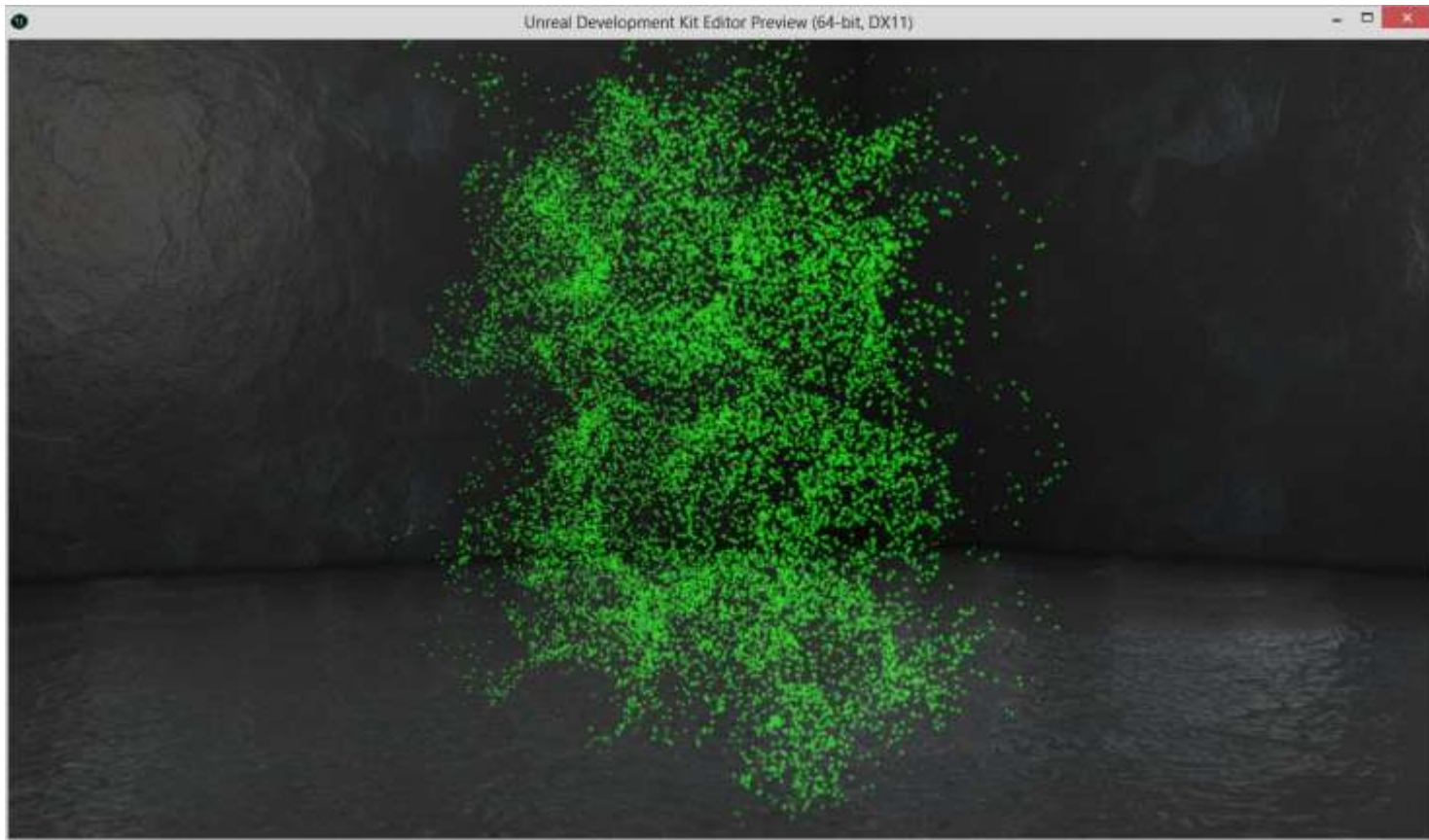
- Moving objects through the fluid stirs up vortices





Turbulence Example

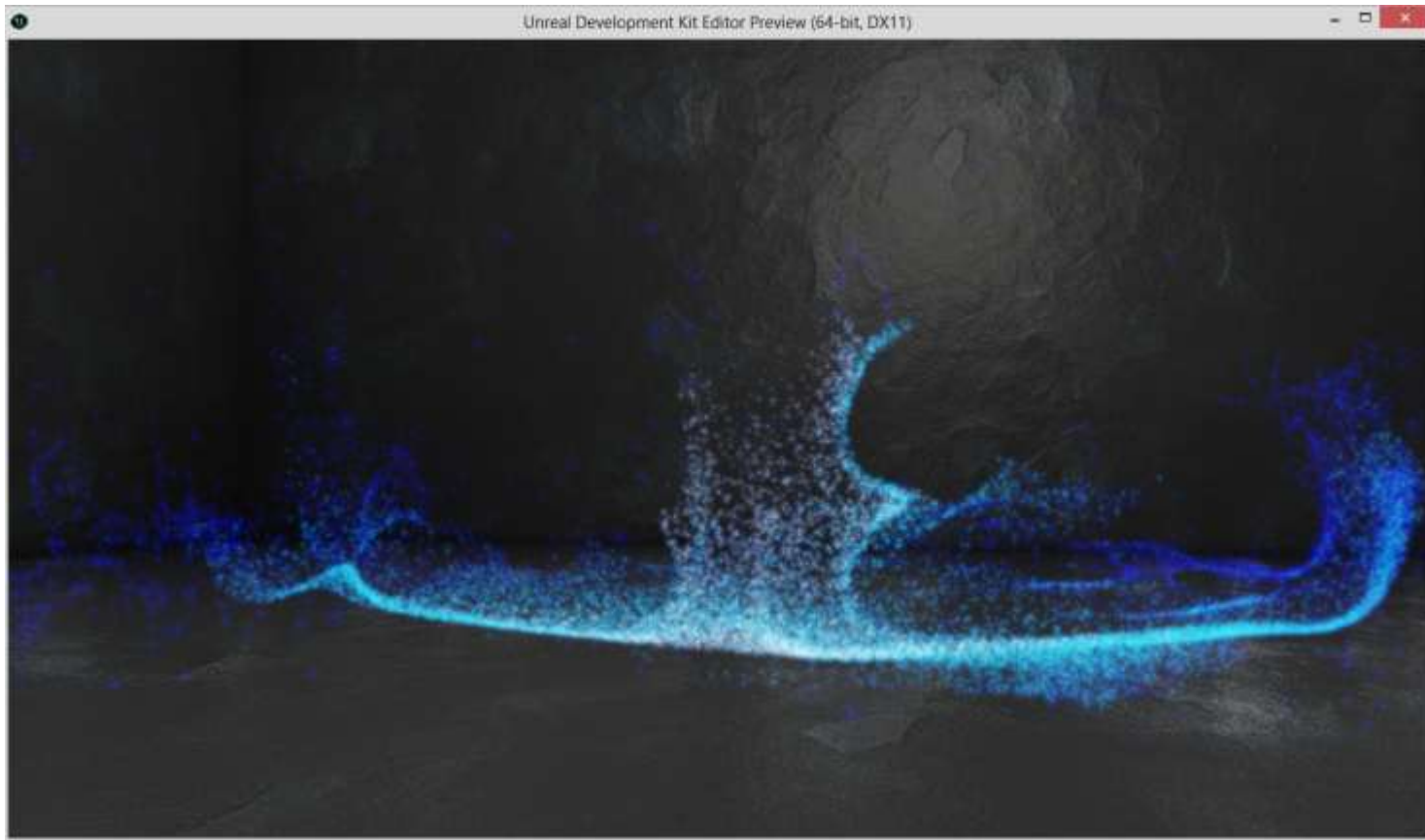
- Add built-in noise to have vortices from the beginning of simulation





Turbulence Example

- Heat sources stir the fluid as well





Turbulence

- You can Layer other force fields
 - Jets pushing through the fluid
 - Attractive or repulsive forces
 - Radial force fields
 - Noise fields



Turbulence in Games

- Hawken, PlanetSide 2 ...





Turbulence Authoring

- We want to give the artist tools to:
 - See rendering of particles as it will be seen in the game
 - Layer multiple particle simulation objects to create the final effect
 - Package all of these together to make an effect that can replicated throughout the game
 - See the results of changes in real time





Turbulence Authoring

- Layer multiple particle simulation objects to create the final effect
 - Particle simulation with collision
 - Emitter to create the particles in the appropriate way
 - Turbulence fluid simulation
 - Other fields such as heat sources or noise fields
 - Particle rendering options





Q&A