
BUNGiE®

Halo Reach Effects Tech

Chris Tchou

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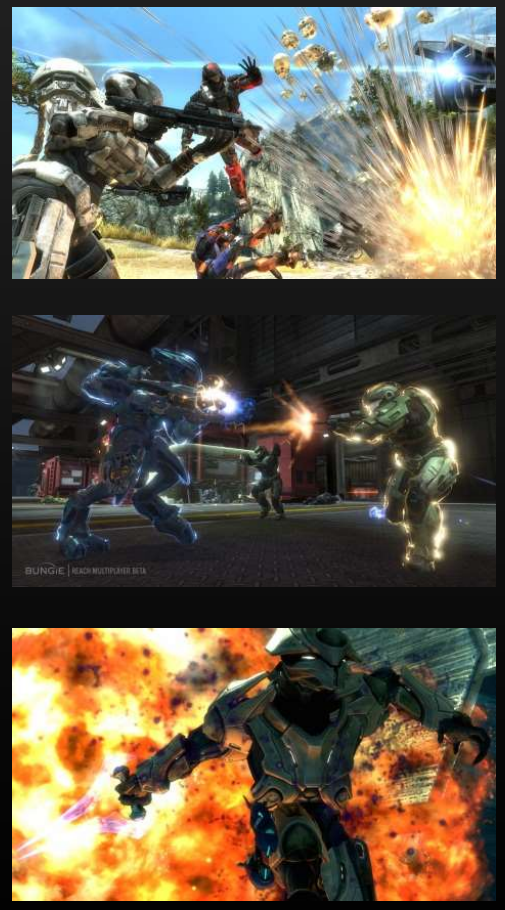
Effects Directions

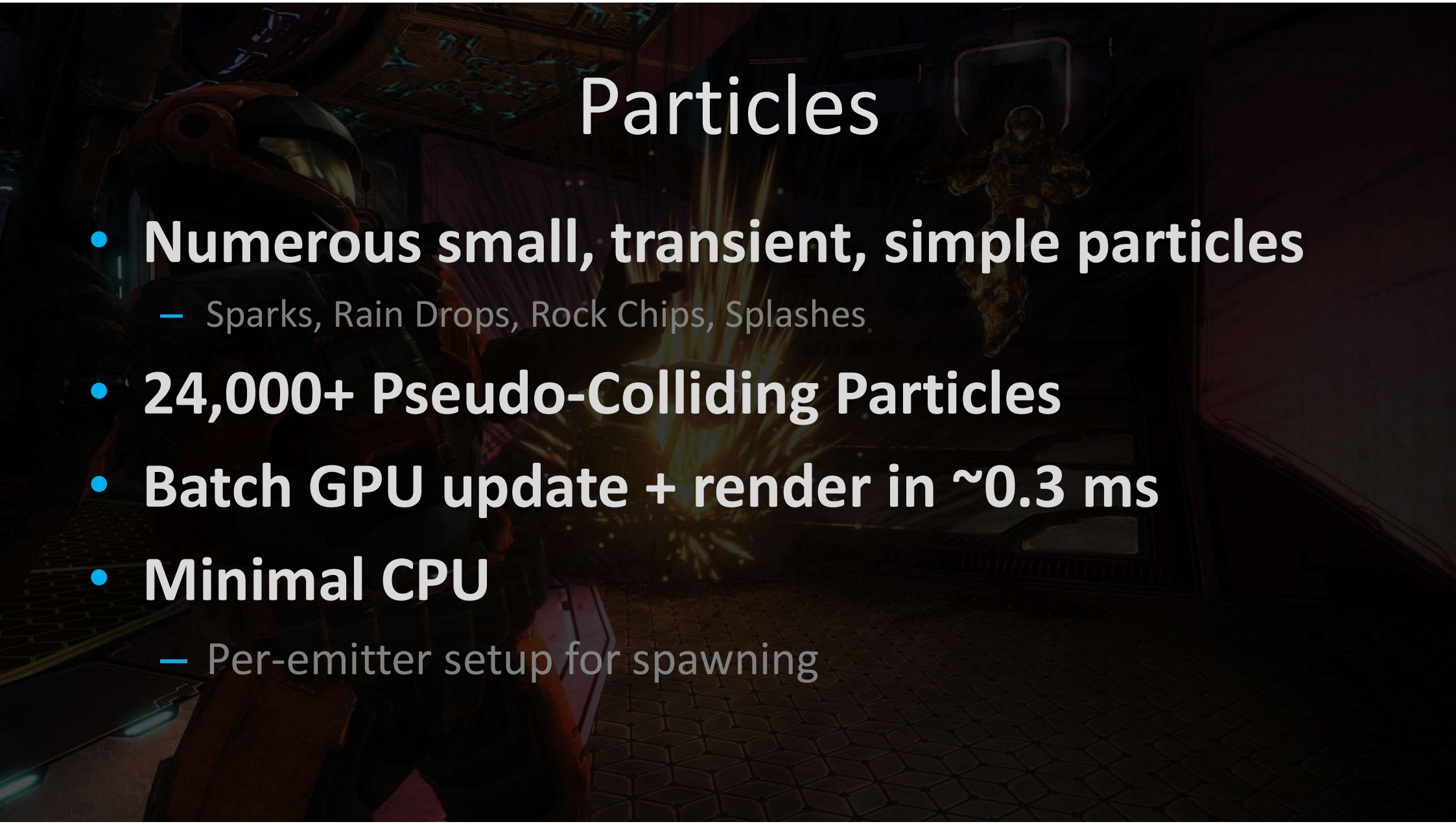
- Atmospheric
- Dense/Visceral
- Pretty
- Easy-To-Use
- Fast

Covered Techniques

- **Cheap Colliding Particles**
- **‘Shields’ & Depth Effects**
- **Low Resolution Transparents**




Particles!



Particles

- **Numerous small, transient, simple particles**
  - Sparks, Rain Drops, Rock Chips, Splashes
- **24,000+ Pseudo-Colliding Particles**
- **Batch GPU update + render in ~0.3 ms**
- **Minimal CPU**
  - Per-emitter setup for spawning

Dynamic Particle State

- **GPU data (28 bytes/particle)**

position.x	position.y	position.z	age

  - 32f
  - sign(age) signifies ‘at rest’ vs. ‘moving’ particles

velocity.x	velocity.y	velocity.z	Δ age

  - 16f

Dynamic Particle State

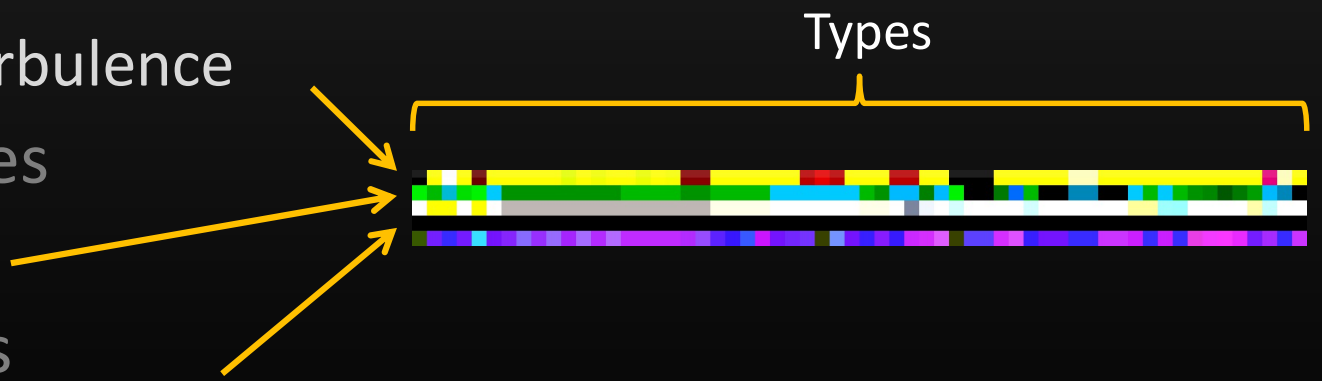
- **GPU data (28 bytes/particle)**

up.x	up.y	brightness	type

  - 8-bit integer
  - 2D rotation + scale (as up vector)
  - brightness encodes simple illumination
  - type points to static particle properties

Particle Types

- **Static type data stored in a library texture**
  - Physics properties
    - drag, gravity, turbulence
  - Collision properties
    - elasticity
  - Render properties
    - VS: size, orientation (velocity or screen facing), motion blur
    - PS: color tint, texture index

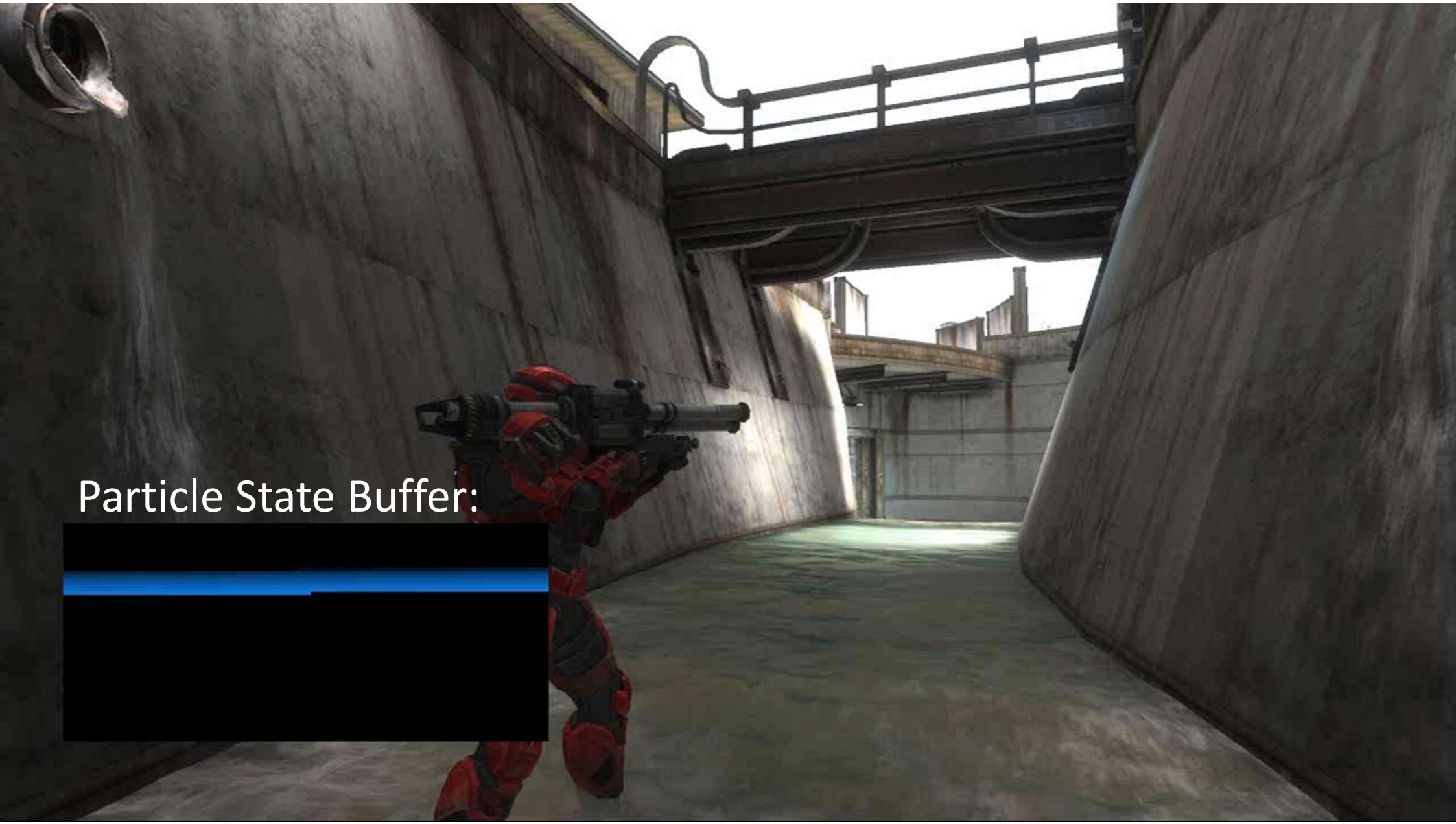


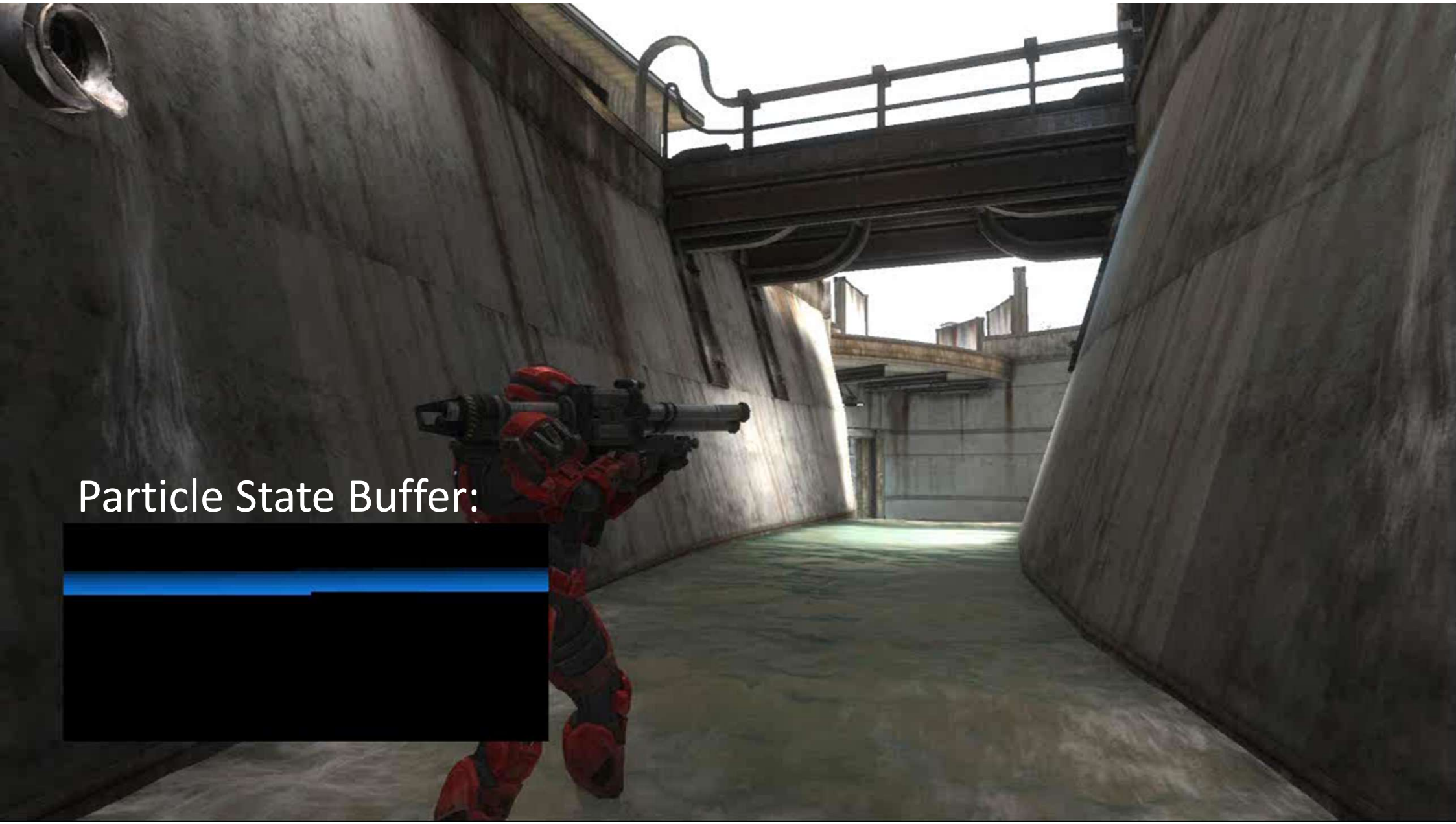
Particle Render

- **Single GPU draw call to render all particles**
- **Read particle state + type texture**
- **Create particle card geometry in VS**
- **Apply render properties in PS**

Particle Spawning

- **For each emitter:**
  - CPU determines spawn count
  - CPU issues GPU draw to the dynamic state buffer
- **GPU generates new particle state**
  - Sample randomly from a texture, and apply artist transform
  - Default textures have random values
  - Custom textures can generate complex spawn shapes


Particle State Buffer: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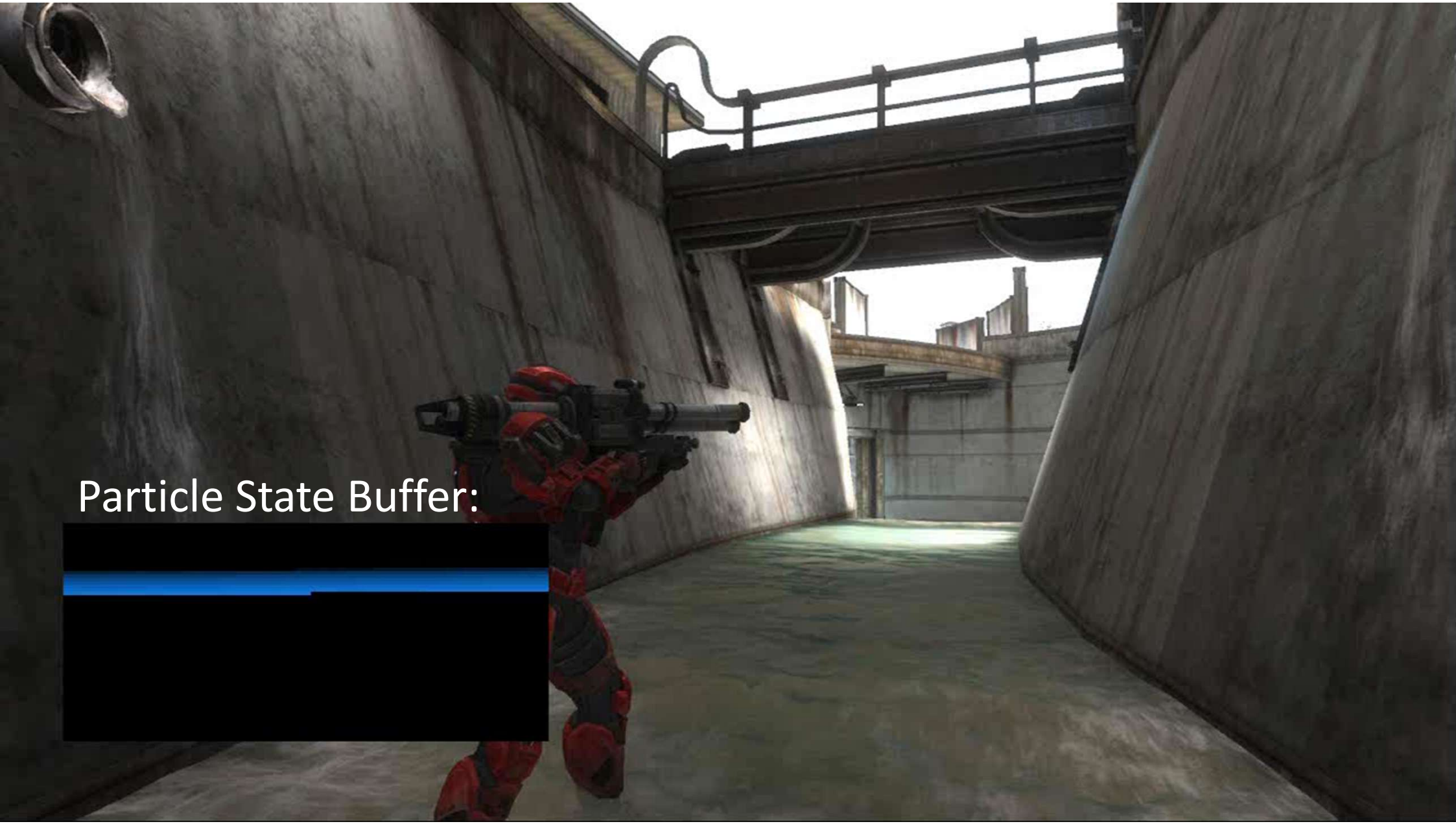
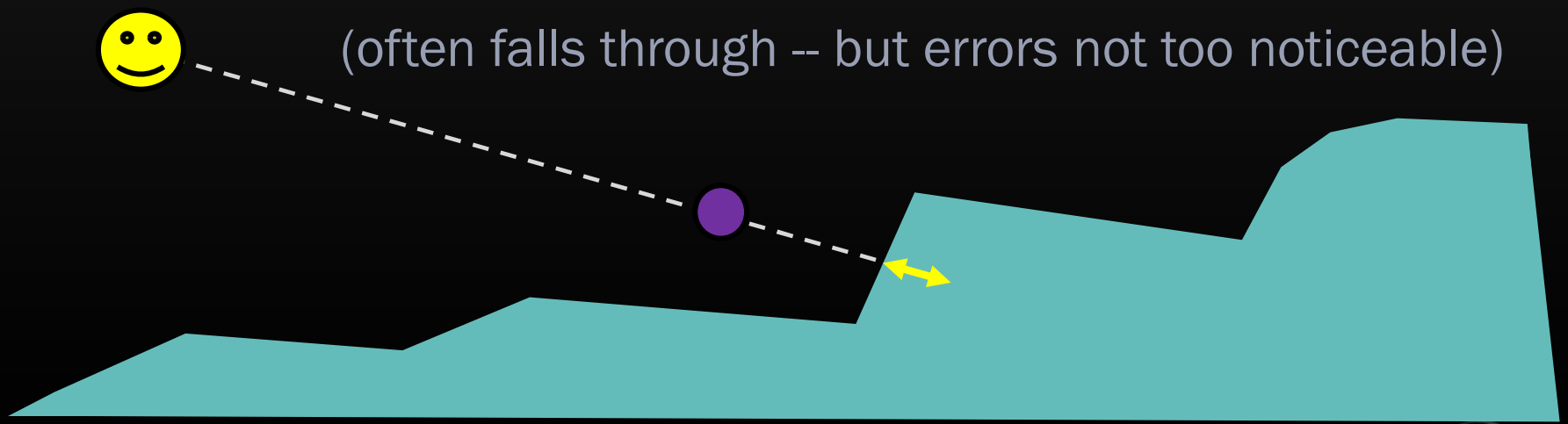

Particle State Buffer:

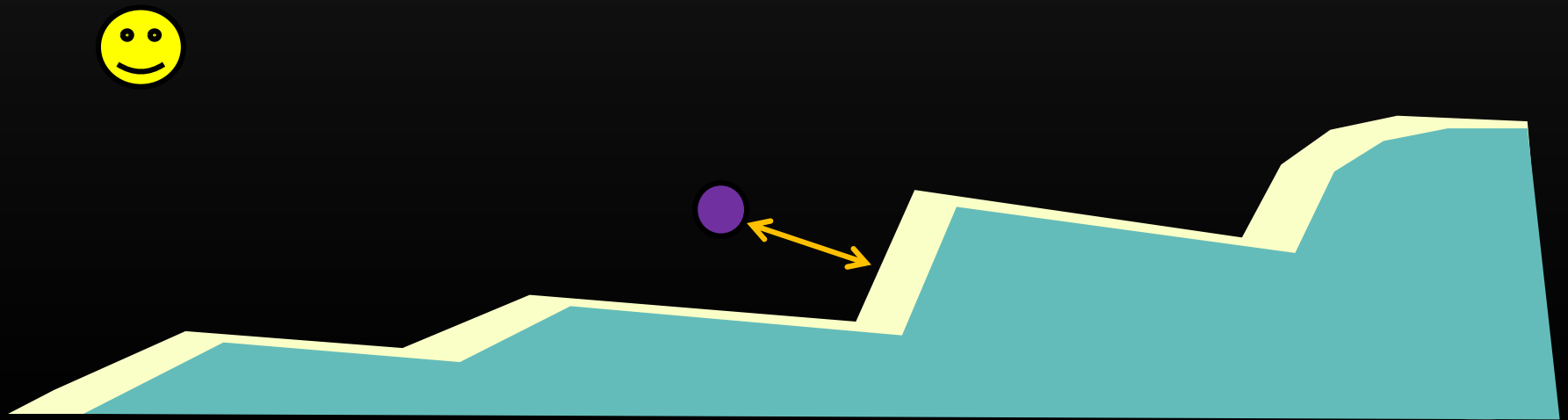
Particle Collision

- **Sample depth buffer for local collision**
  - Particles collide in a range behind the depth buffer
  - Only bounces on-screen, against visible surfaces

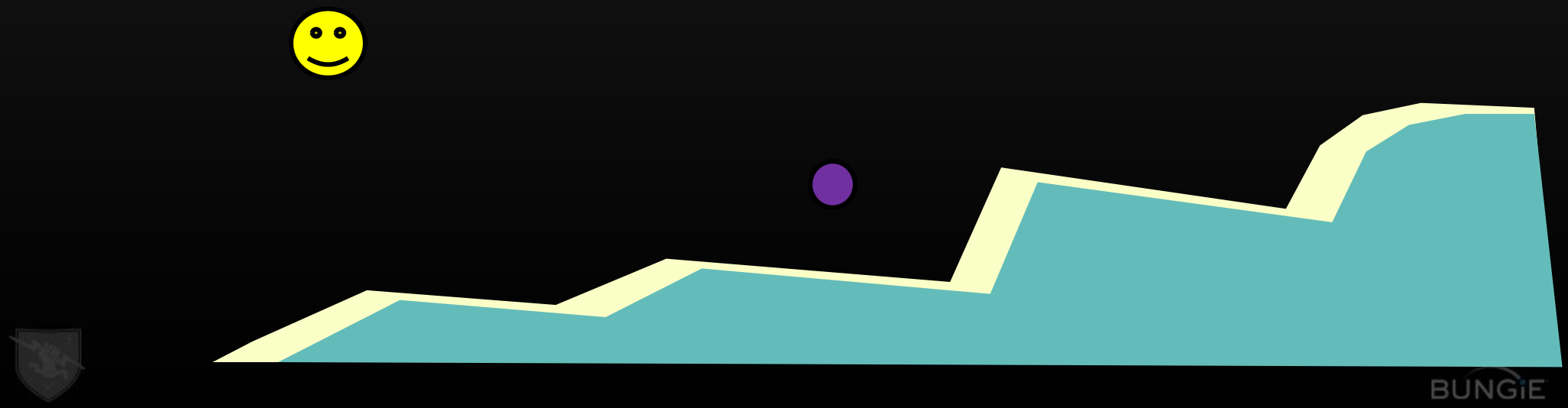


Particle Collision

- **‘At rest’ particles don’t move**
  - If not close to depth sample, set to ‘moving’
  - Allows them to fall if the surface moves

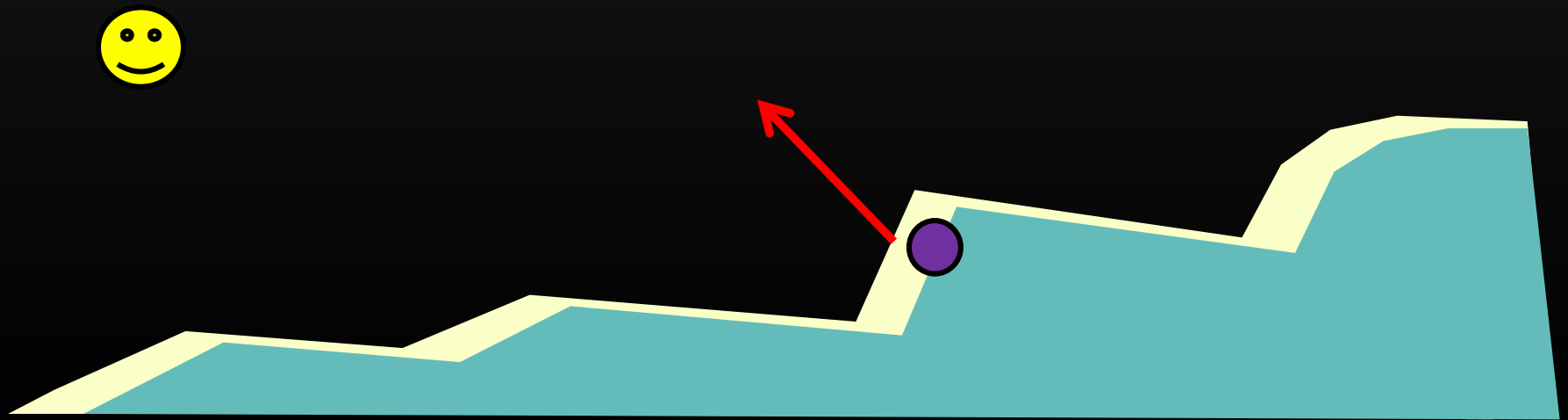


Particle Collision



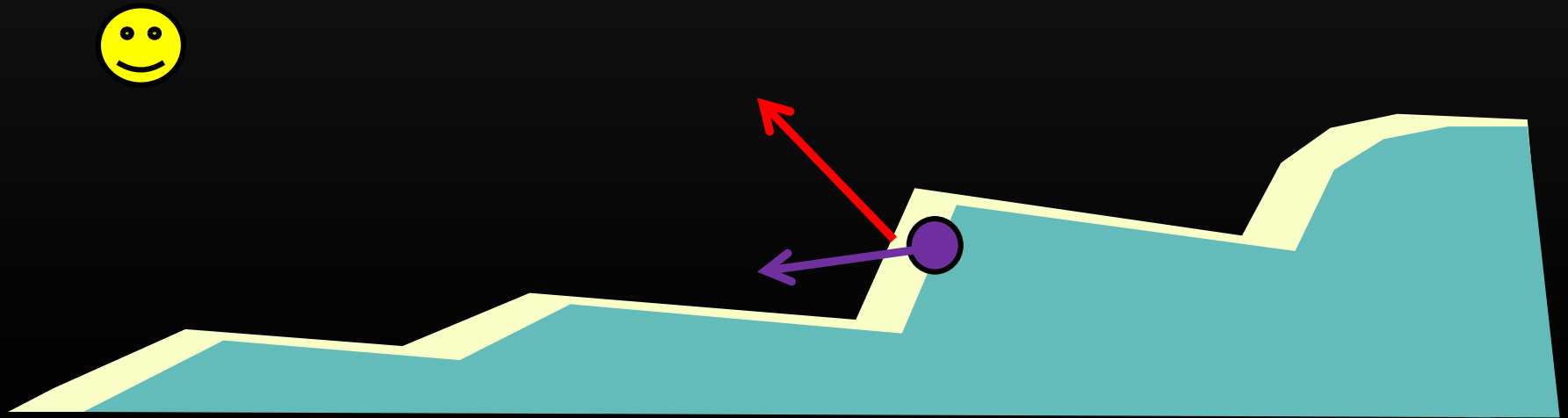
Particle Collision

- **Sample normal buffer**



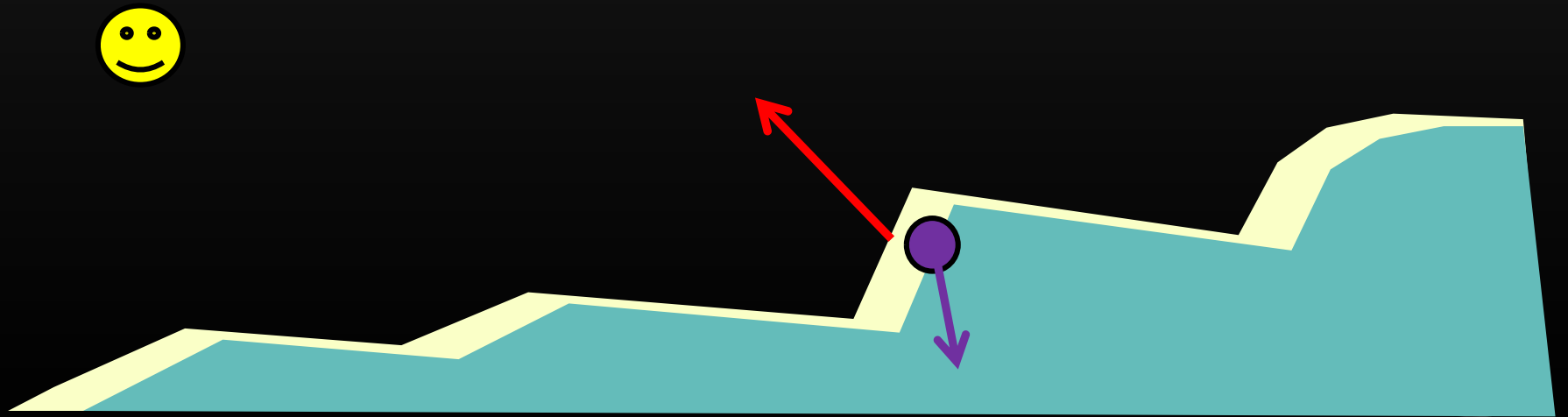
Particle Collision

- **Compare normal + particle velocity**
- **Outgoing particles are destroyed**
  - Stops particles from bleeding through visible surfaces



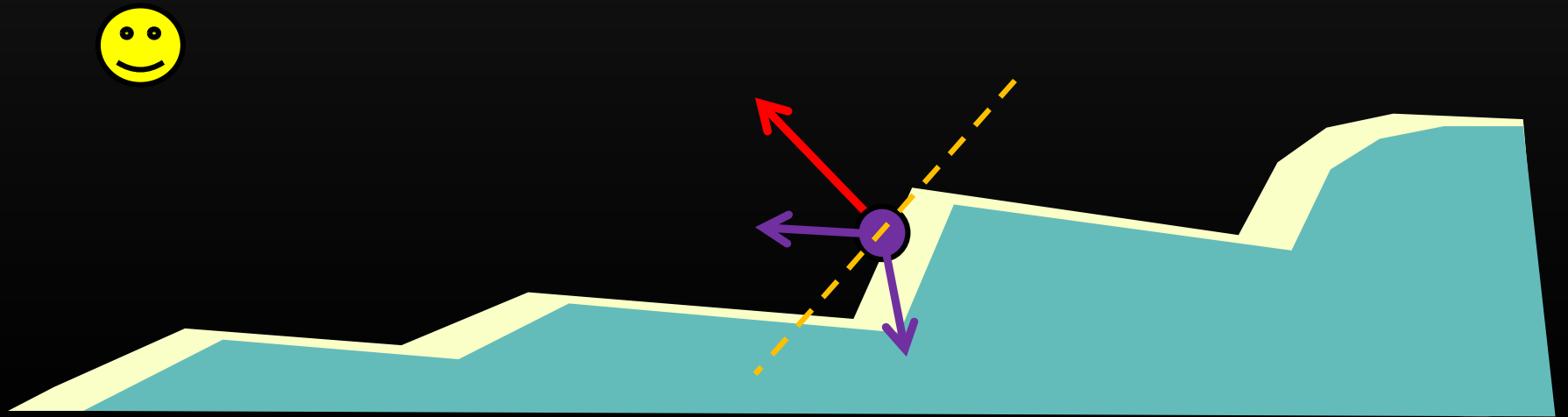
Particle Collision

- **Incoming particles are bounced:**
  - Ensure particle is not embedded:
  - Re-project position onto surface



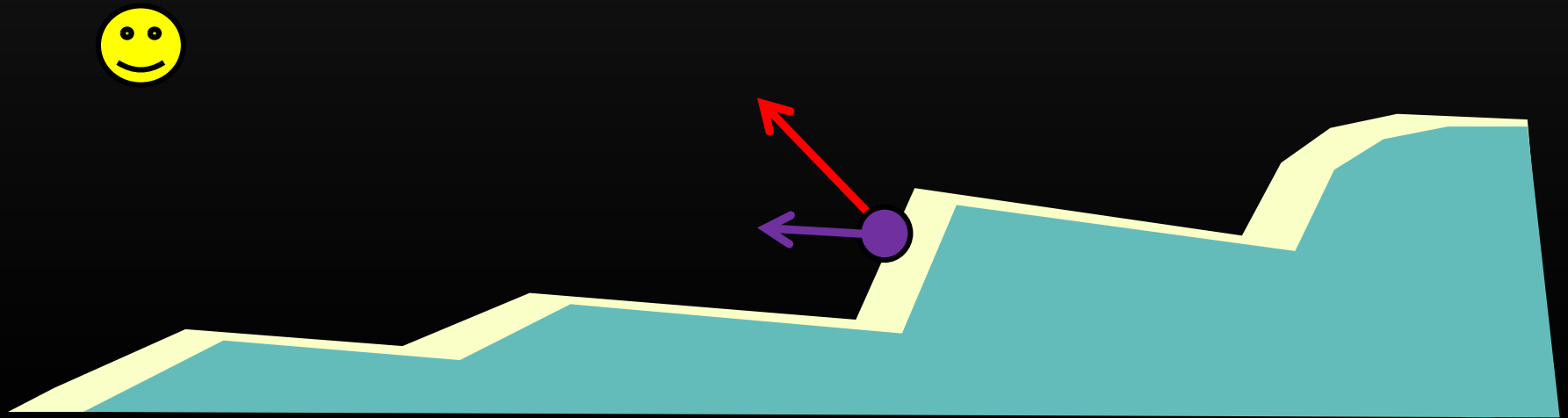
Particle Collision

- **Incoming particles are bounced:**
  - Reflect velocity around normal
  - Reduce velocity by elasticity



Particle Collision

- **Incoming particles are bounced:**
  - Switch particle type (optional)
  - If velocity is below a threshold, set ‘at rest’



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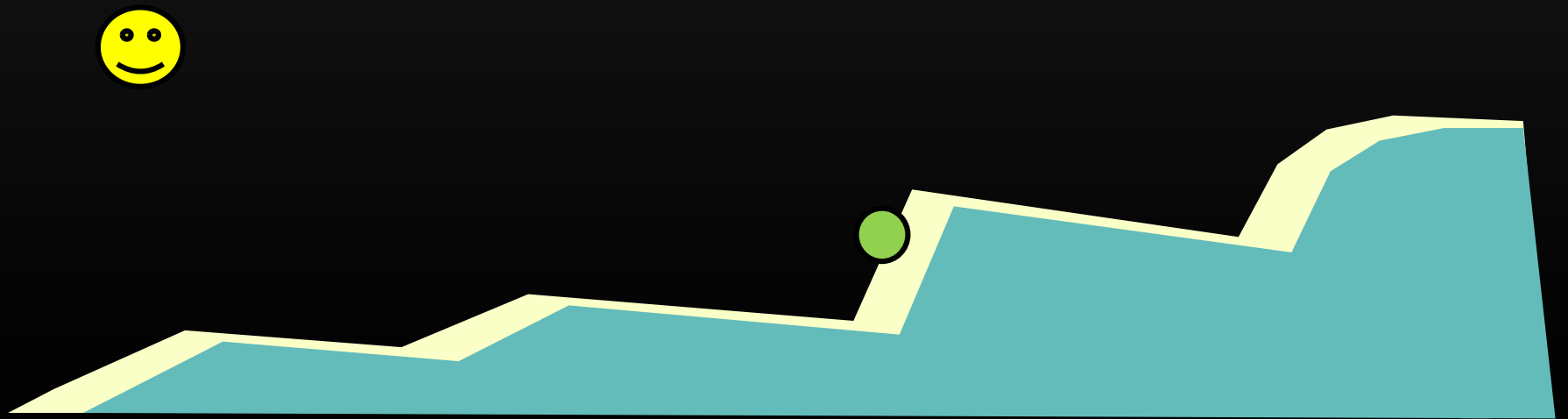

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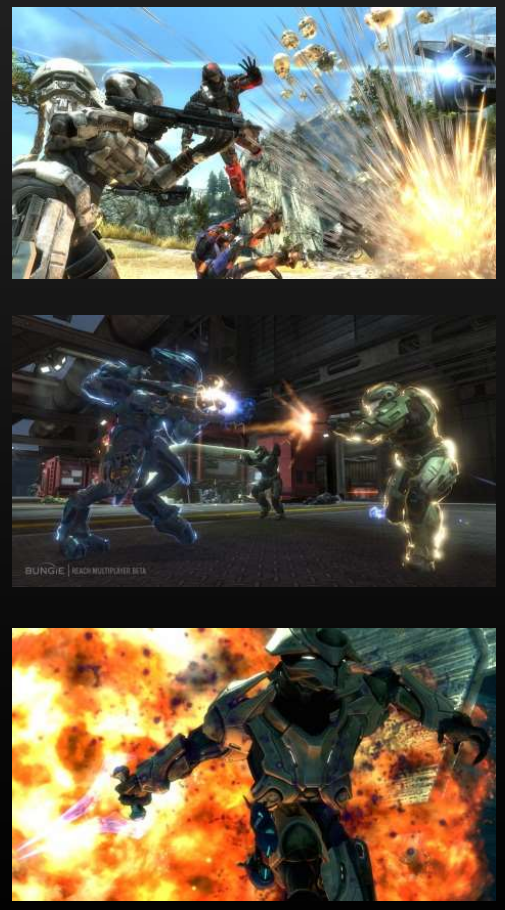
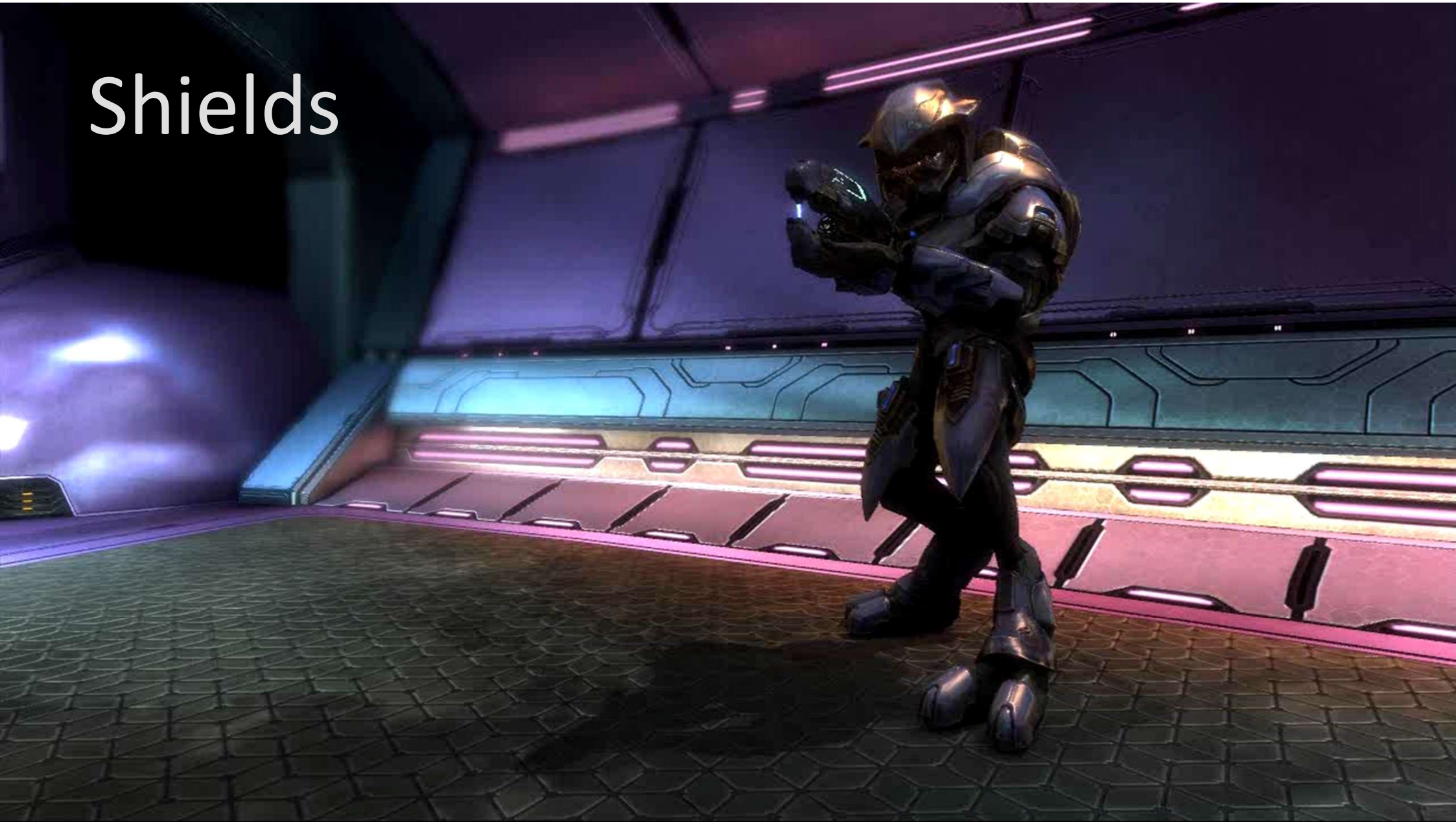


Shields




Halo 3

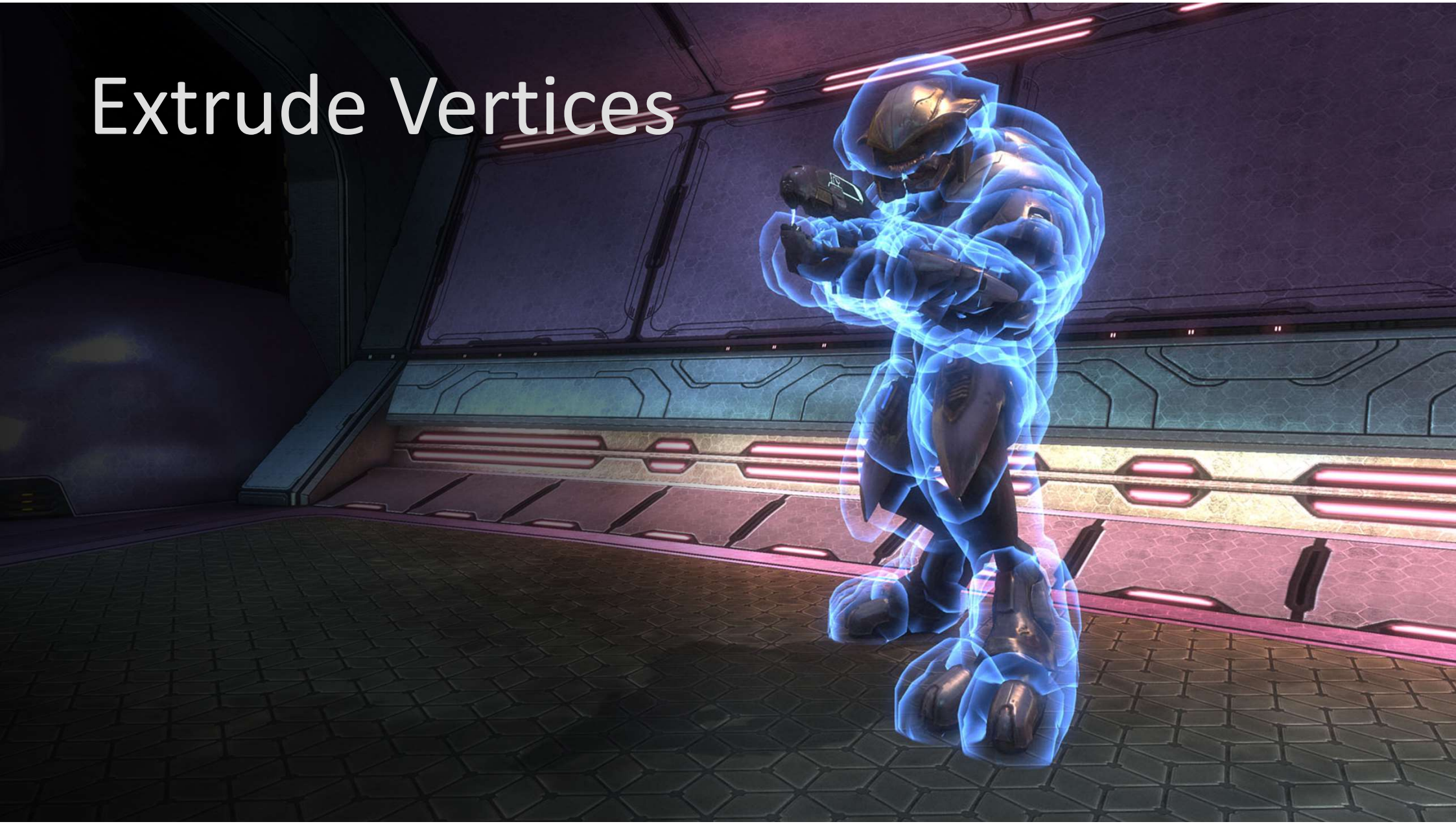

Consistent Look
BUNGiE | REACH MULTIPLAYER BETA


Don’t Hide Characters
BUNGiE

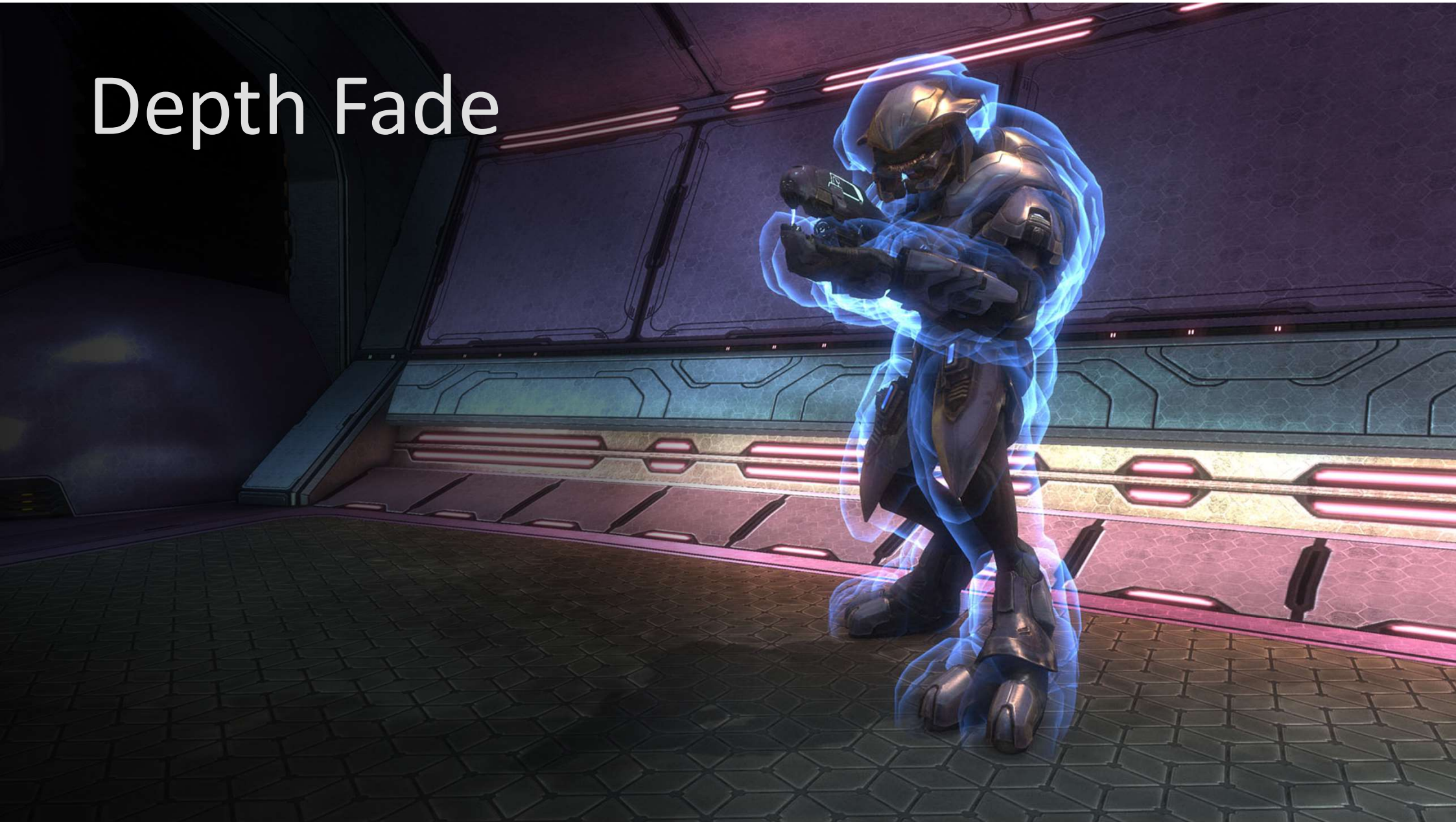

High Readability
BUNGIE

Minimal Art Overhead

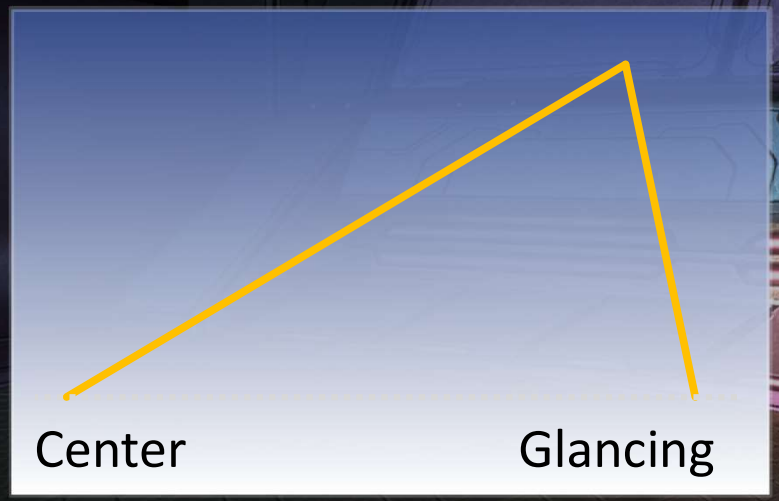
Extrude Vertices



Depth Fade



Custom Edge Fade



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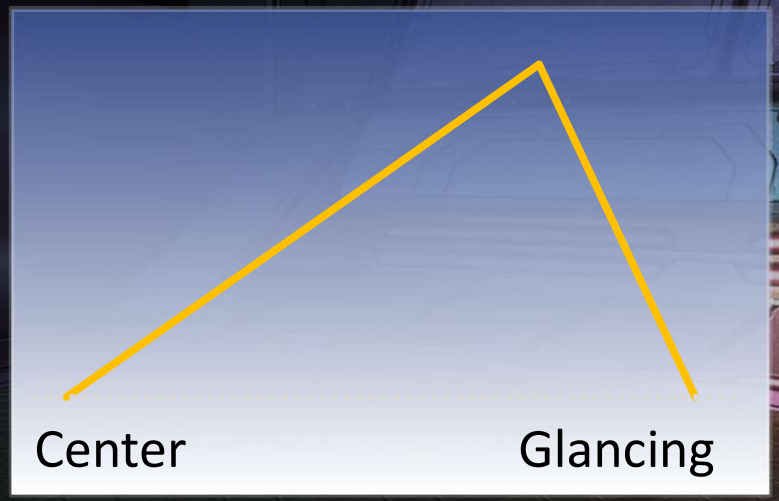

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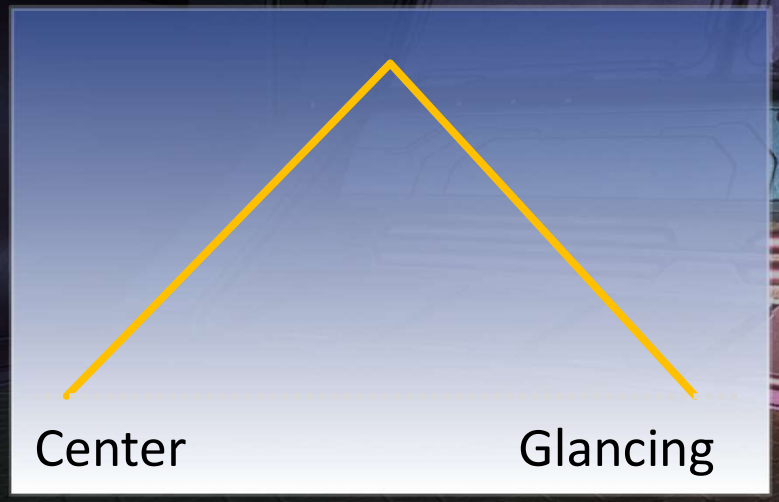

Custom Edge Fade

Depth Fade Plasma


Shield Doors
UNSC


Area Boundaries

Covered Techniques

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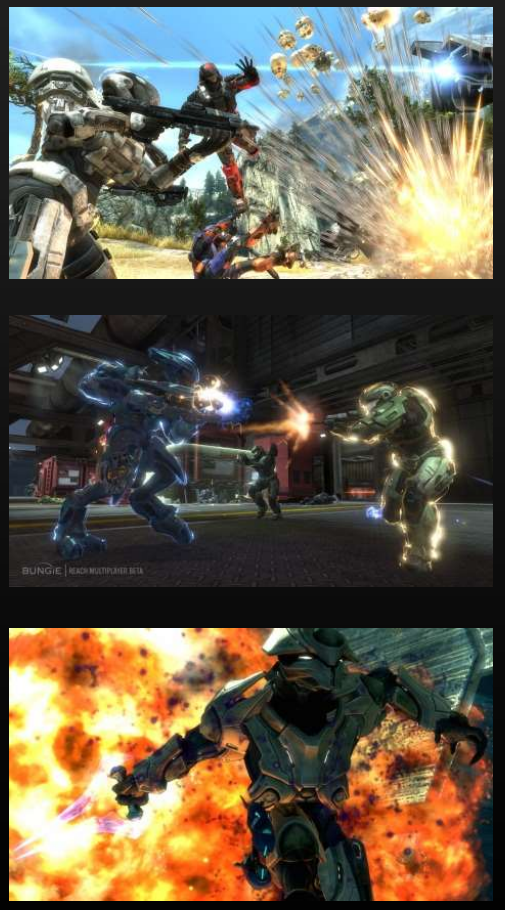

Overdraw Costs

- **Too many layers?**
  - Limited by fill rate & pixel shader
- **Render Fewer Pixels!**
  - Low resolution
  - Alias buffer as 4x MSAA
  - But want smooth upsampling…

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Reach Low Res Transparents

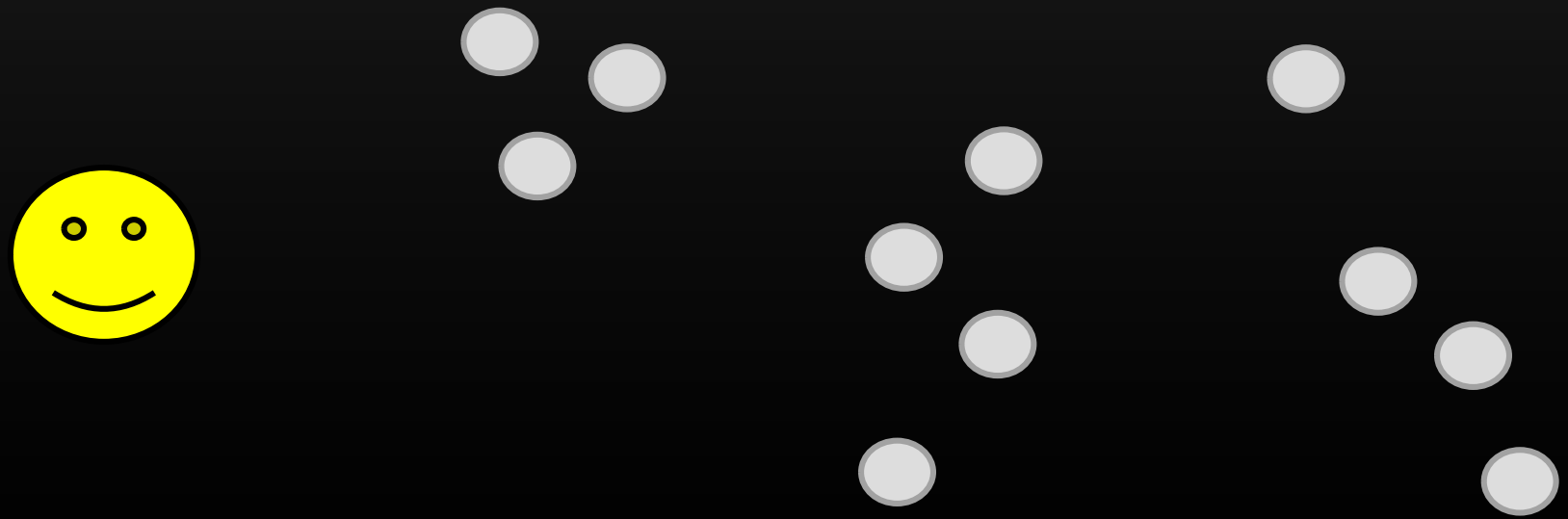
- **Render to separate buffer**
  - 1/2 resolution, 4x MSAA, use existing depth buffer
- **Inline with normal high-res transparency**
- **Low -> High transition: resolve and composite**
  - Smooth bilinear upsampling ☺
  - Transitions are expensive! ☹

Optimizing Transitions

- **Use low-res only when you expect savings**
  - Automatic switch for flagged transparents
- **Stencil touched areas to reduce composite fill**
- **Limit transitions by bucketing during sort**
  - N buckets means at most N-1 transitions
  - N = 3 worked well

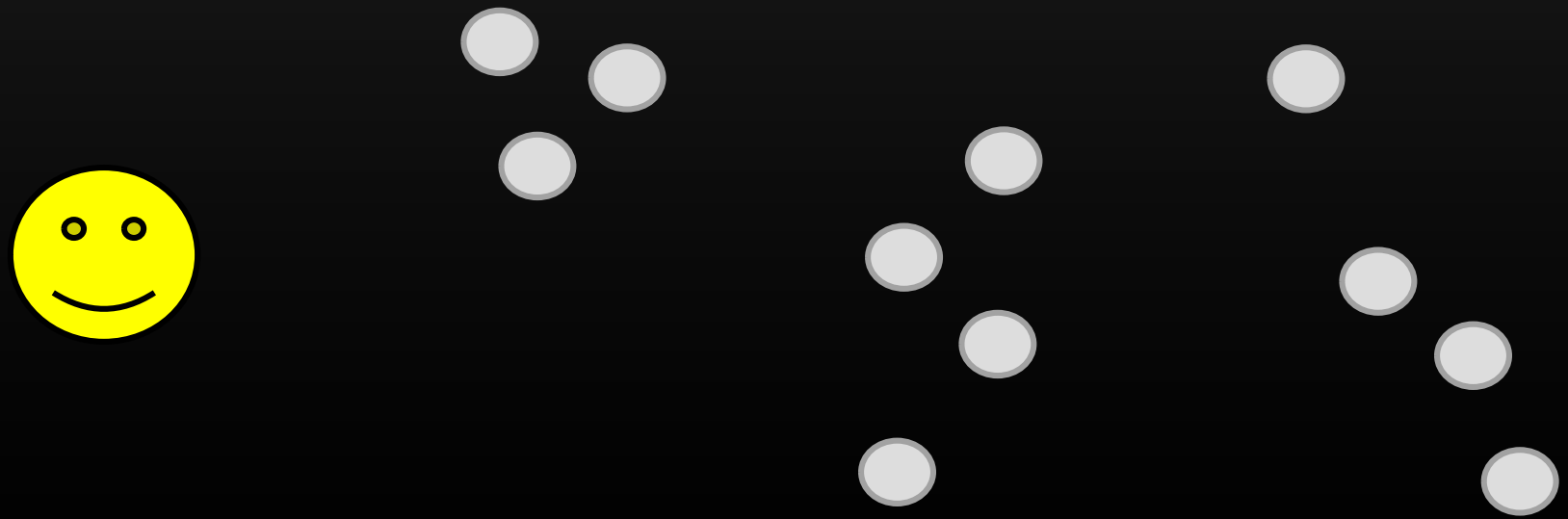
Well-Behaved Bucketing

- **How to group these to minimize sort pops?**



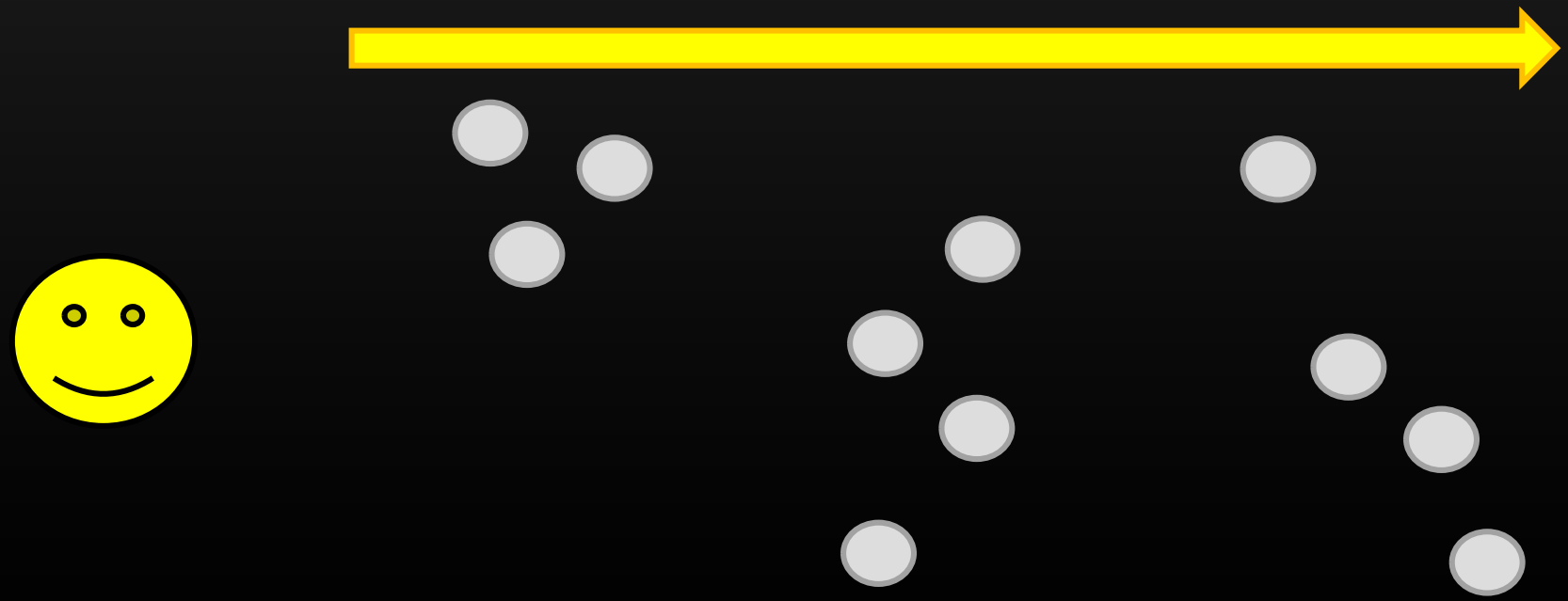
Best Behaved Bucketing

- **For N buckets, find (N-1) largest gaps**



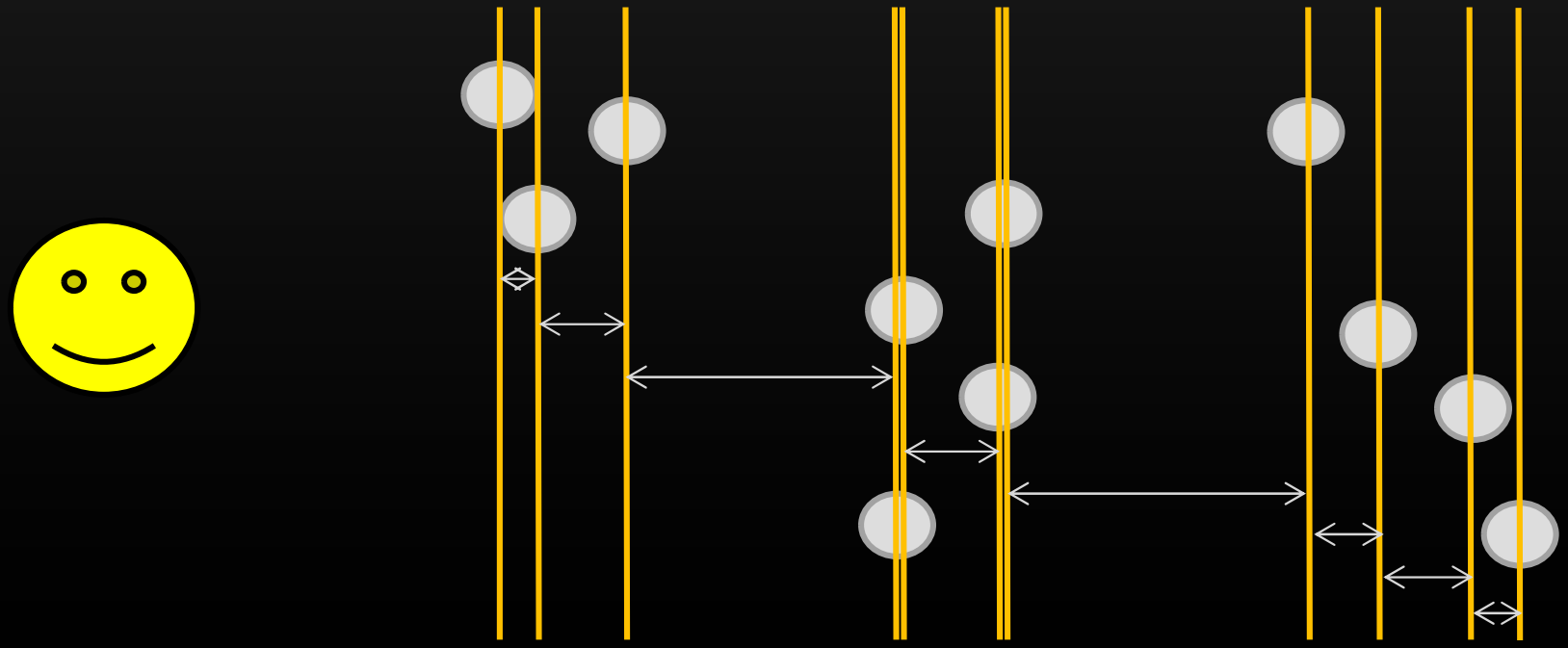
Best Behaved Bucketing

- **Sort by Depth**



Best Behaved Bucketing

- **Distance between neighbor elements**
  - Use heap to grab (N-1) largest



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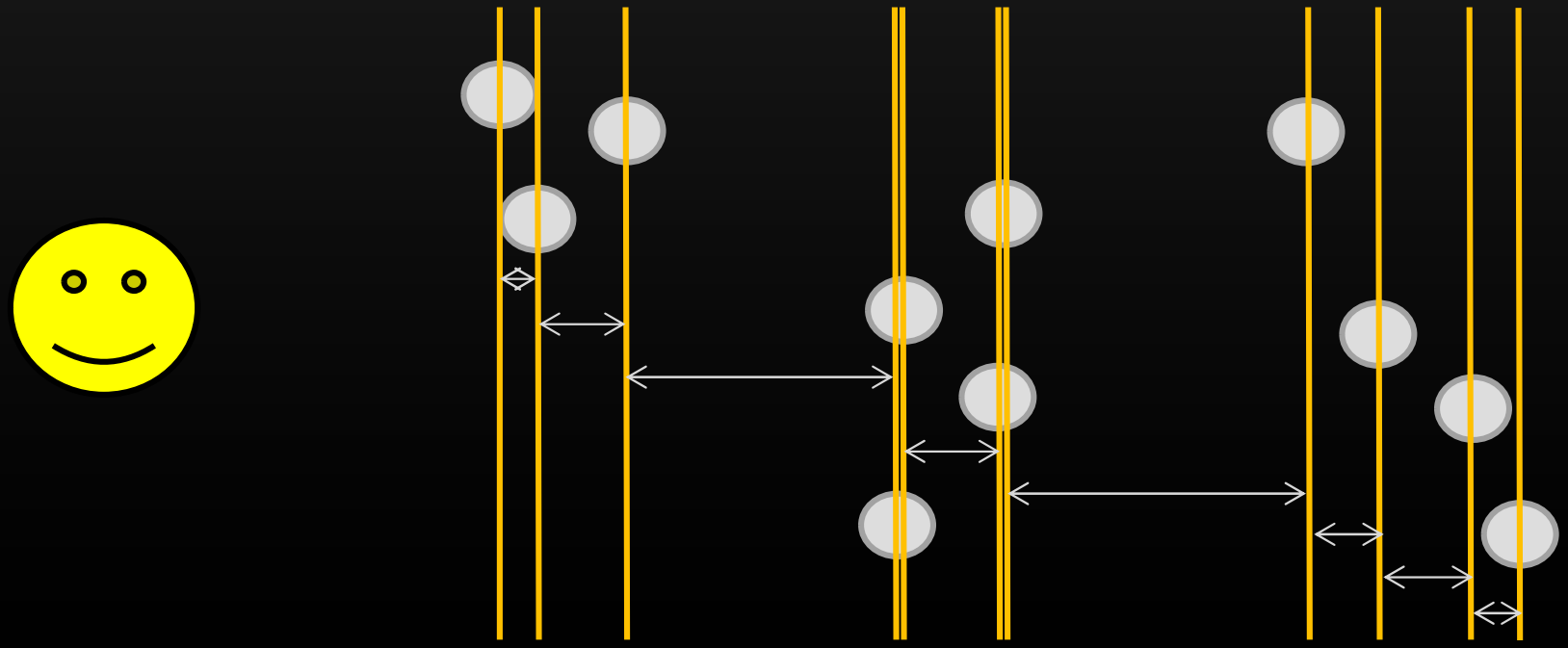

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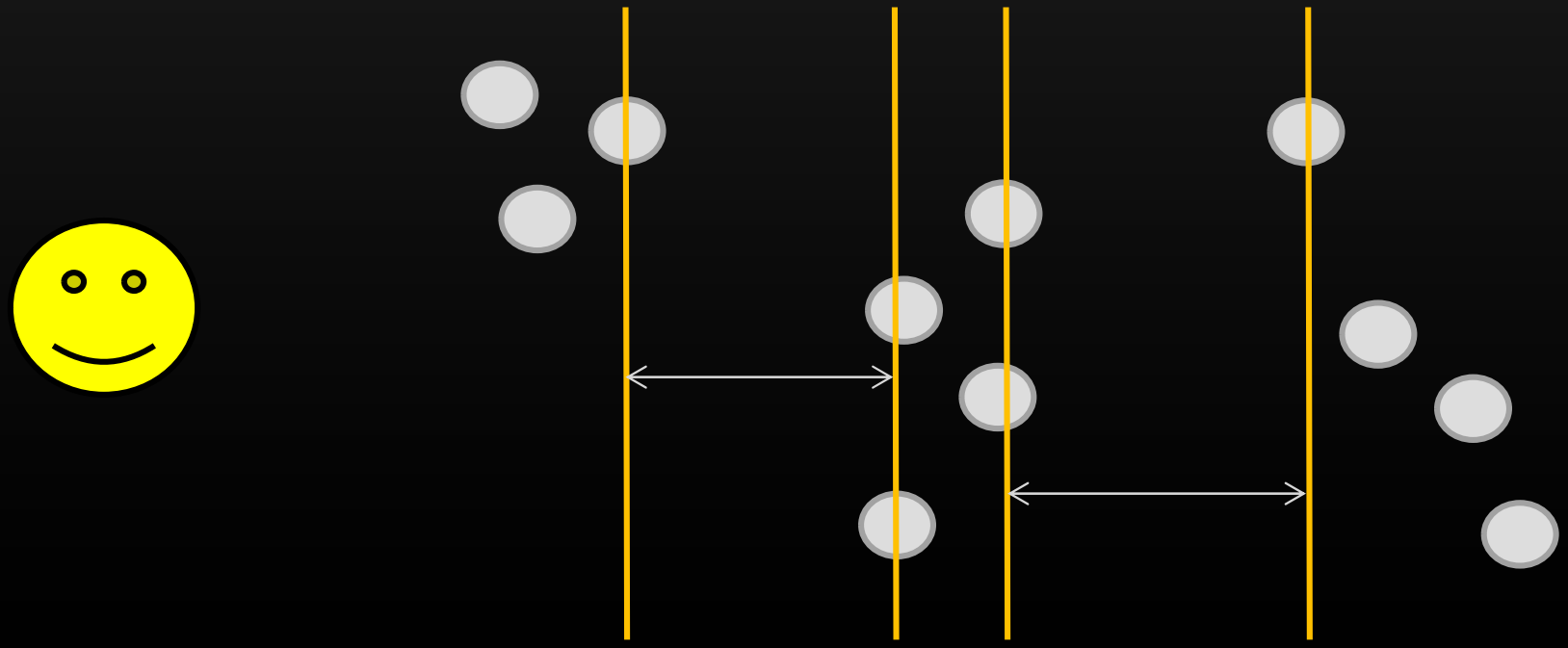
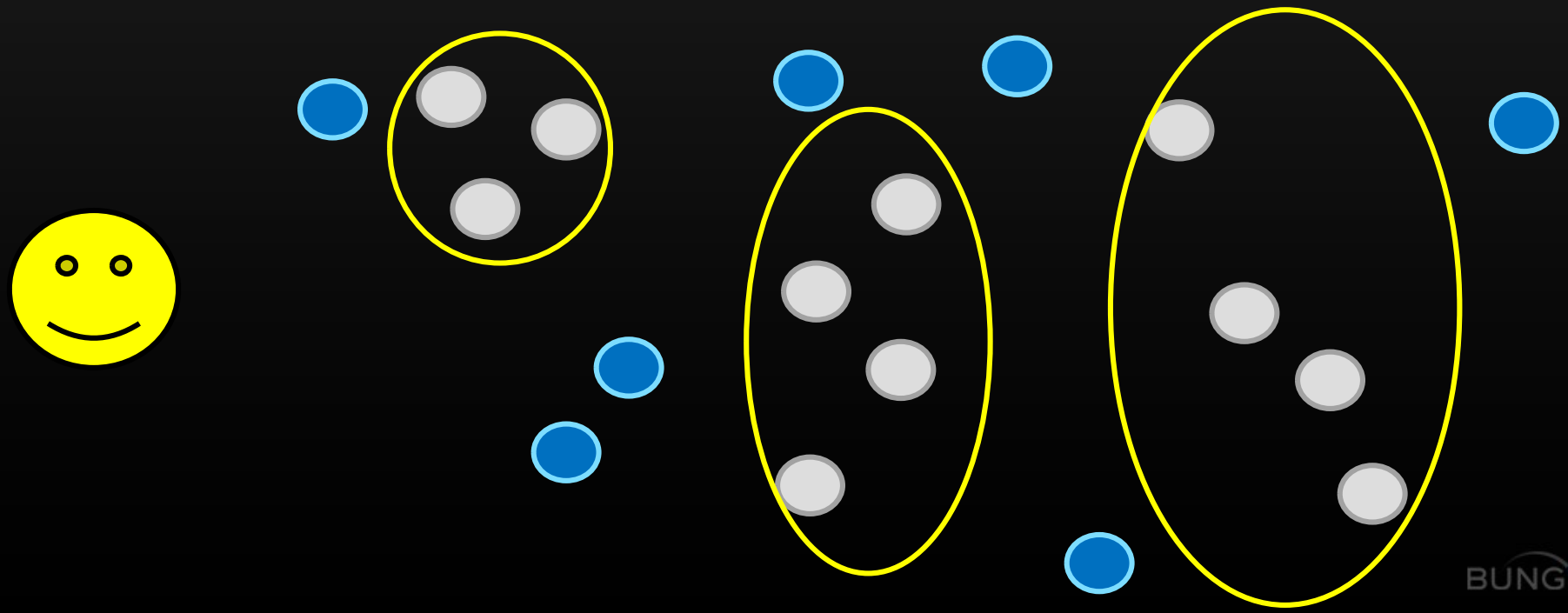


Best Behaved Bucketing

- **Divide at these gaps**
  - Render each group together, mixed in with high-rez content




SW
W
NW
25m

Covered Techniques

- **Cheap Colliding Particles**
- **‘Shields’ & Depth Effects**
- **Low Resolution Transparents**

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Summary

- **Understand the desires of your content guys**
  - Big explosions, smoke, stuff flying everywhere!
- **Figure out where they are limited and fix!**
- **You can often sacrifice correctness for speed**
  - And minimize artifacts with work arounds
- **Depth buffer is incredibly useful**


E
SE
S
SW
4
LARZ
Lars
02
6:11
Firefight
01
6
3859
25m
Circle

We’re hiring!

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Chris Tchou
ctchou@bungie.com

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