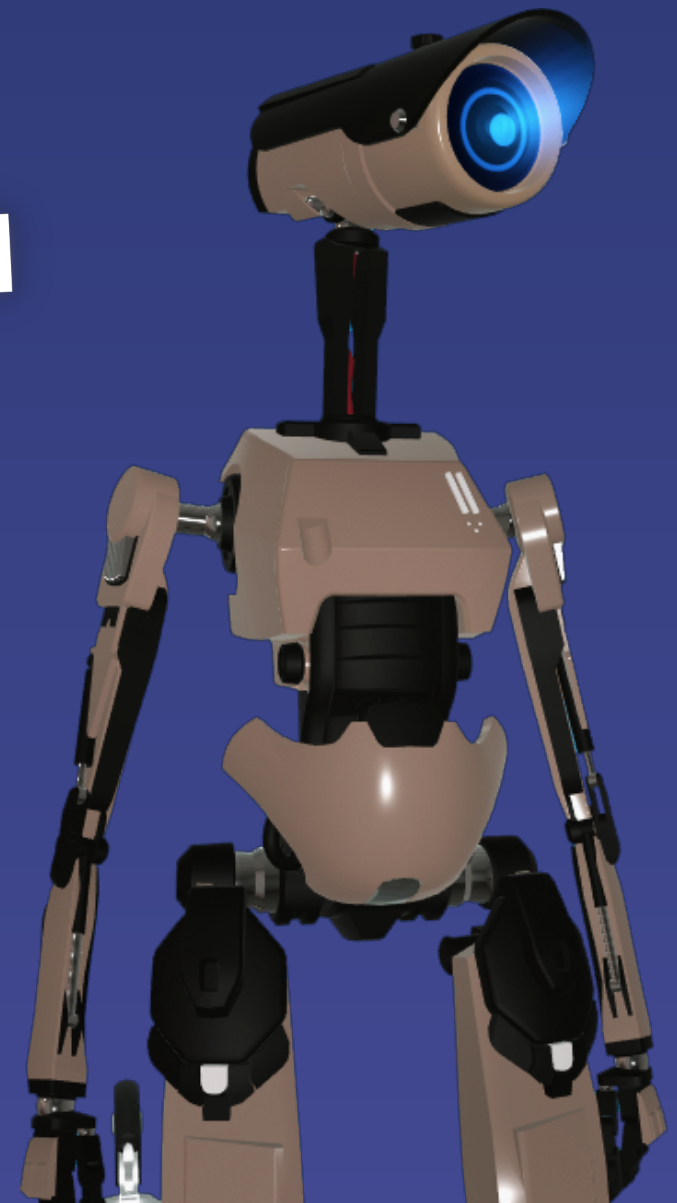
Spatial Audio in BUDGET CUTS.

Jonas Kjellberg Lakulish Antani



Spatial Audio in BUDGET CUTS.

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Senior VR Audio R&D at Valve Software

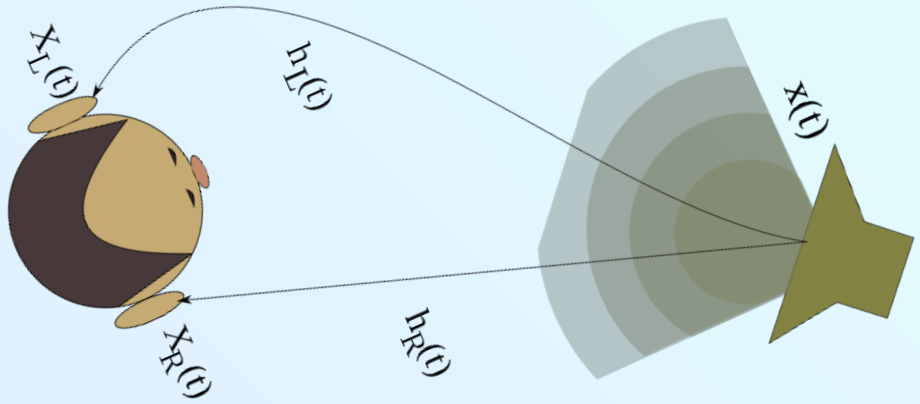
Jonas Kjellberg

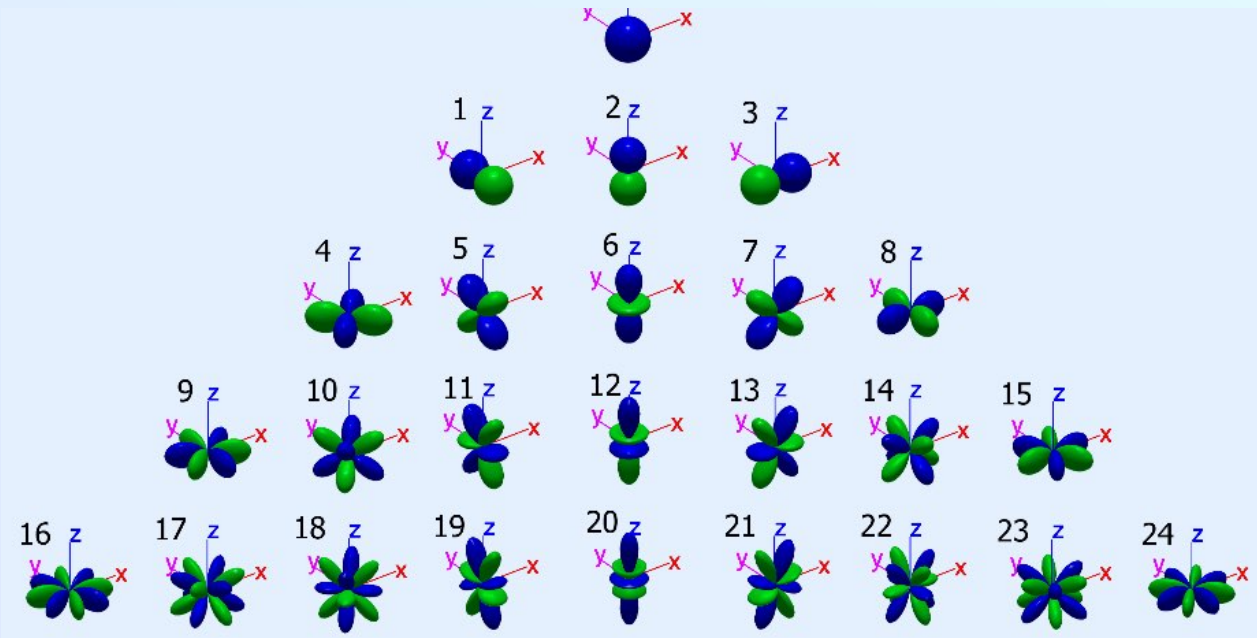
CTO Gestrument (music middleware)

Composer/Audio designer

What is spatial audio?

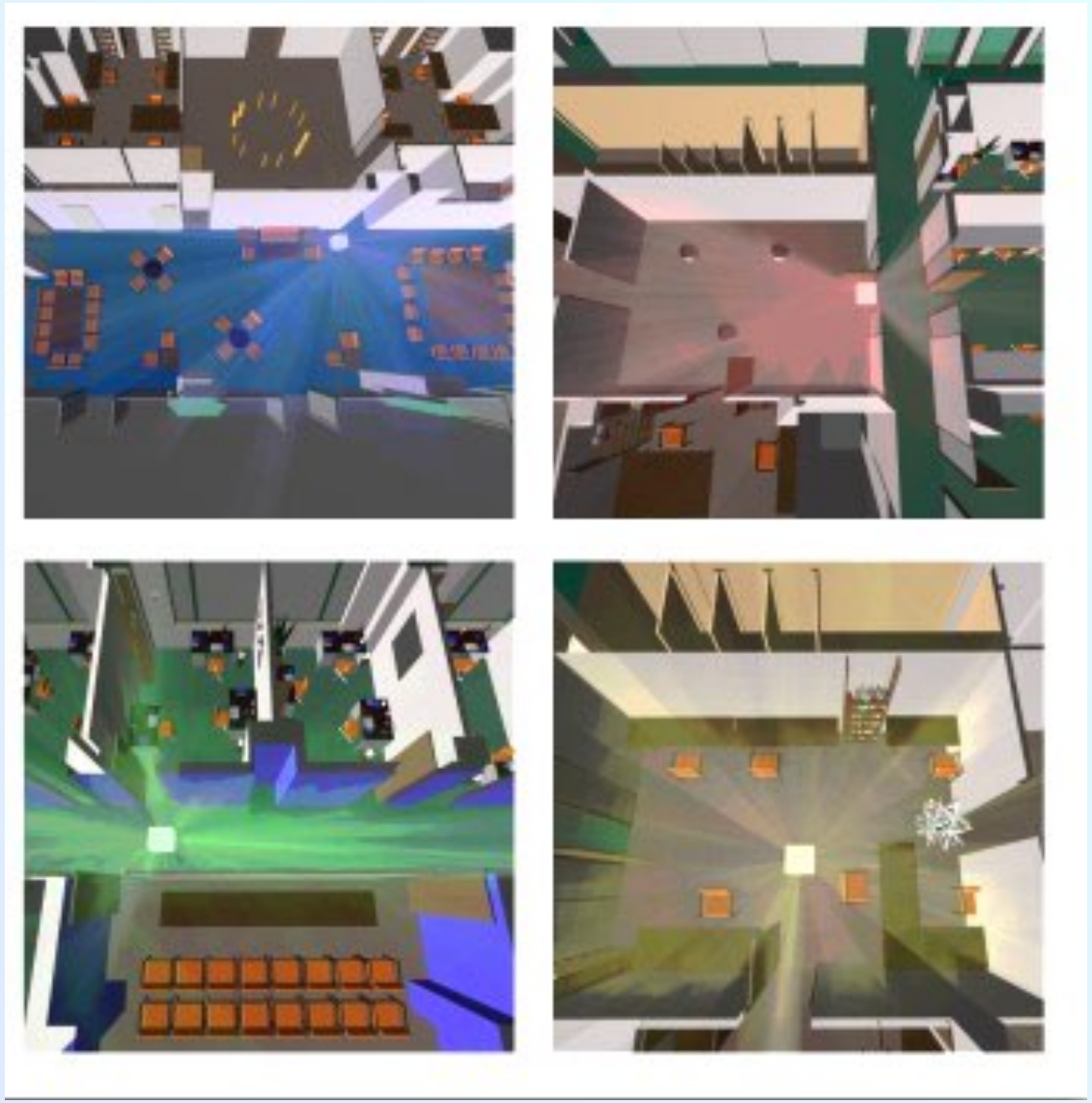
- HRTF
  Model effects of ear and head shape on how we perceive sound
- Ambisonics
  Spherical representation of sound field – 360 video for sound





What is spatial audio?

- Distance cues
  Sounds get quieter, more muffled, hear more of the room
- Room size cues, reverb
  Very important for presence



http://gamma.cs.unc.edu/SOUND/

What is spatial audio?

- Sound propagation
  Sound flowing through openings, reflecting off walls

http://gamma.cs.unc.edu/SOUND/

Why spatial audio now?

- Immersion is critical to VR
- Most VR users listen over headphones
- Spatial audio is now computationally feasible


BUDGET
CUTS.


BUDGET
CUTS.

BUDGET CUTS.

Features

Stealth

Deadly Robots

Knives and scissors

Room scale gameplay

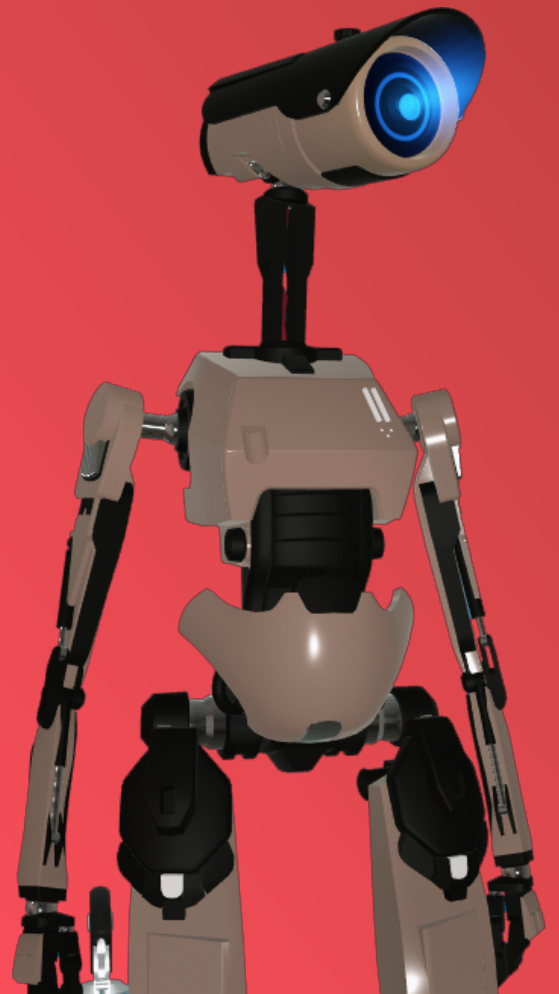
Novel Teleportation/Portal mechanic

BUDGET CUTS.

The Importance of Spatial Audio

- Enemy positions / patrol routes
- Information about geometry
- Gameplay cues
- Immersion

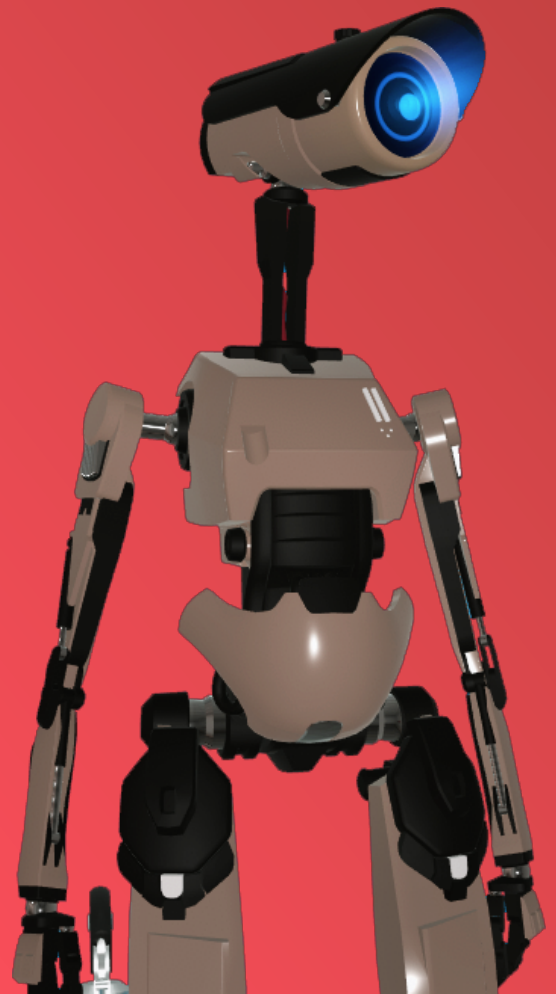
BUDGET CUTS.



Reflections as core gameplay cues

- Guided stealth gameplay
  - Avoidance
  - Timing
  - Strategy
- Estimations of uncharted territory
  - Room size
  - NPC and Enemy positions

BUDGET CUTS.



Occlusion as core gameplay cue

Hiding from enemies

- Can tell when an enemy is close, but behind a wall
- Can also tell when an enemy is **no longer behind the wall and can see you!**

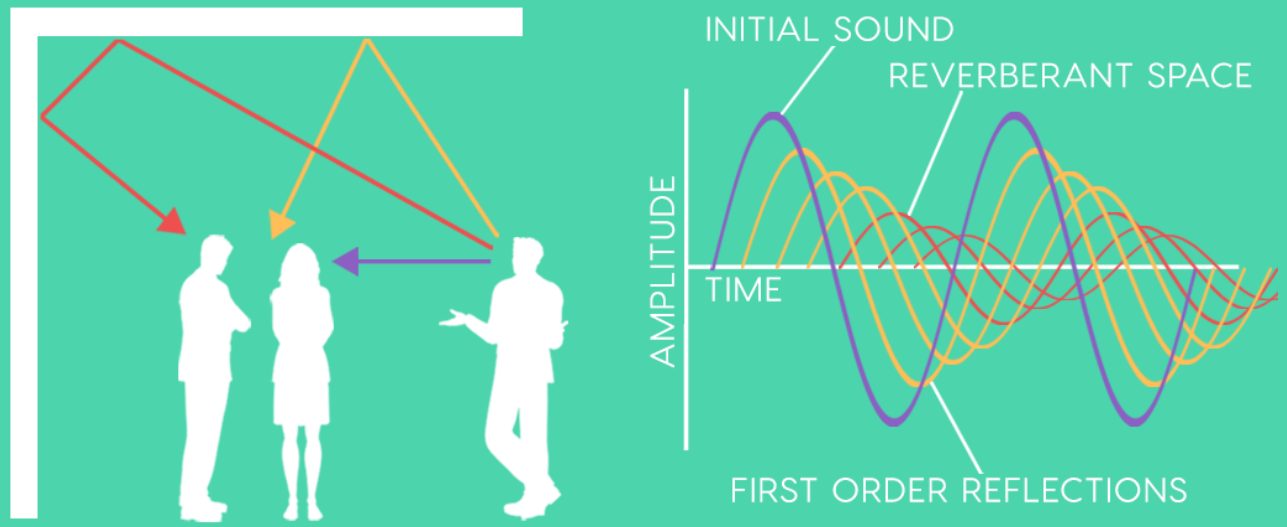
Preview of what we did

- Early sound paths calculated through a custom portals system
- Listener centric reverb using ray tracing
- Careful “faking” of ambience and music spatialization using Ambisonics reverb

Real-time Reflections

- Want to model sound propagation from each source
  - Needs to react to how sources move
- Problem: Real-time sound propagation is CPU-hungry
  - Some games can solve this with multi-core or GPU acceleration
  - We need to make do with one CPU core

Real-time Reflections



Problem:
Real-time sound propagation uses too much CPU

Solution:
Restrict to early reflections only

- Reverb handled separately
- Enough for the gameplay cues we care about

“Portals”

Problem:
Latency when short sounds are spawned

- Footsteps, gunshots, etc.
- Unity recreates data structures every time audio clip plays

Solution:
Use portals to model sound propagation

- Manually placed in doors, windows, vents
- Check for paths from source to listener via portal, much cheaper than ray tracing
- Developed specifically for Budget Cuts

Reverb

Problem:
Real-time early reflections OR Portals don’t model reverb tails

- So no impression of room size

Solution:
Add real-time physics-based reverb

- Sound propagation from listener to itself

Directional reverb, rotational latency

- Problem: Real-time physics-based reverb distorts the perceived room shape
  - When you're near a wall, the whole room sounds smaller

- Solution: Make the reverb *directional*
  - Reflections are panned to where they come from
  - When you're near a wall, you hear strong reflections from the wall
  - Reinforces the sense of being close to a wall

Directional reverb, rotational latency

- Problem: Noticeable latency when the player looks around
  - Reverb updates at 2-10 Hz, obvious rotational latency if reverb is strongly directional
  - Need to somehow decouple rotational and translational updates

- Solution: Ambisonics!
  - Reverb is encoded in Ambisonics, anchored to world space
  - After convolution, fast rotate to match listener's orientation (updates at audio frame rate)

Disconnect between flat and spatialized

- Problem: “Normal” stereo/mono sounds suddenly feel flat

Disconnect between flat and spatialized

- Problem: “Normal” stereo/mono sounds suddenly feel flat
  - Music feel lifeless
- Solution: Fake things up!
  - Diegetic music sources (speakers etc)
  - Phasing effects on music track mix
- Preferred solution:
  - B-format playback which will rotate

Disconnect between flat and spatialized

- Problem: “Normal” stereo/mono sounds suddenly feel flat
  - Ambiance tracks ruins immersion
- Solution: Fake things up!
  - Mono ambiances/noise loops through ambisonics reverb
- Preferred solution:
  - B-format playback which will rotate

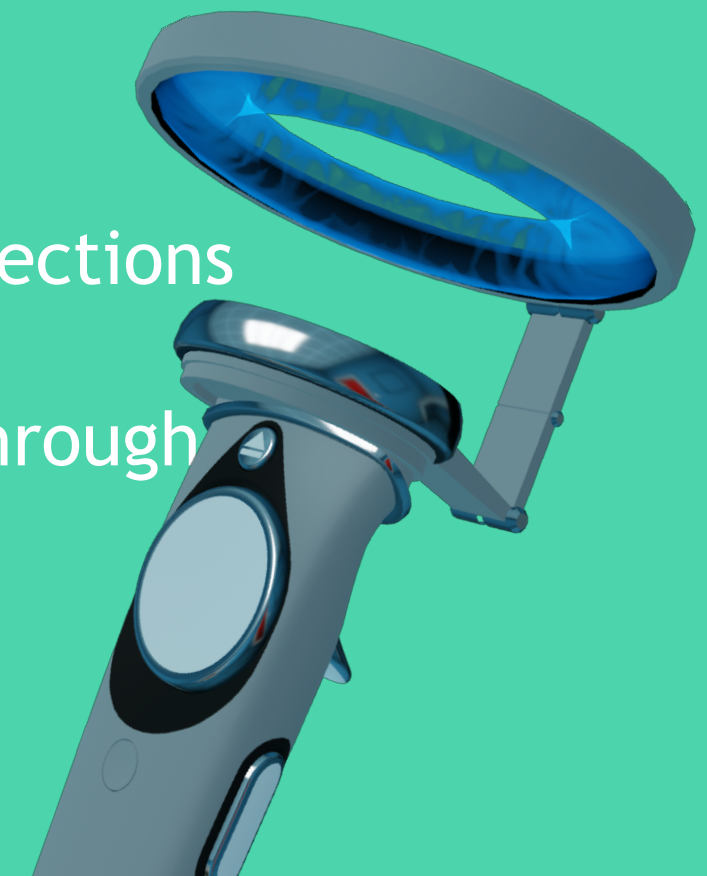
Dangers of New Tech

- Free as in expensive
  - Most spatial audio plugins are free to use!
  - With great power comes poor performance.
- Beta software
  - No community
  - Limited documentation
  - Bugs

NOT A PLUG AND PLAY SOLUTION

Summary of Compromises

- Split sound propagation into:
  - source-dependent early reflections
  - listener-centric reverb
- Manual portal placement involved in early reflections
- Ambiences generated by piping mono tracks through Ambisonics reverb



Future Work

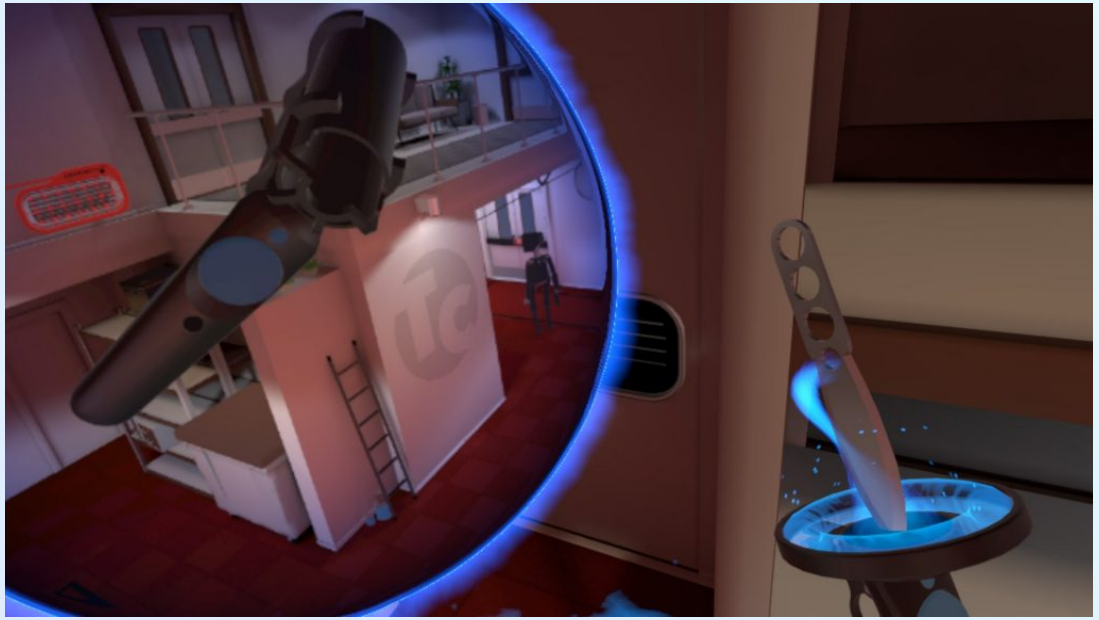

Acquisitions
Always believe that something
AM-AZING
will probably never happen.

Better solution for reflections/portals

- Optimize ray traced early reflections
  - Performance spikes fixed in Unity 2019.1
- More general, flexible portals/pathing
  - Try to automate portal placement in some way
  - Model diffraction through portals

Near-field HRTF

- HRTFs measured for sources close to the head (< 1m)
- Near-field sources have distinct inter-ear differences compared to far-field sources
- Portal gun waved close to the head should sound more realistic

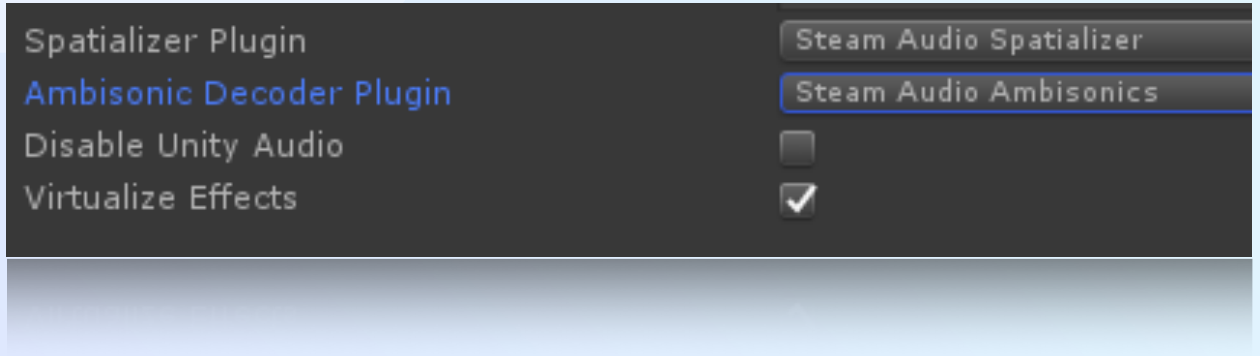


More control over reverb

- More artistic control over physics-based reverb
  - Possibly as a post-process
- More control over when physics-based reverb is calculated
  - After shooting a portal, start calculating reverb for where the portal ball lands

Ambisonics for ambiences

- Standard spatialization technique for ambiences and diegetic music
- Automatically responds to head rotation
- Now shipping in Steam Audio 2.0-beta.17



Conclusions

- Expensive performance wise
- Bleeding edge: Requires a lot of effort

+ Important for VR immersion
+ Imperative for VR stealth games
+ “Next gen” audio experience

Crucial to start integrating early!