

The Technology of Uncharted: Drake's Fortune

Naughty Dog

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UNCHARTED

NAUGHTY DOG



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Introduction

- Project Code Name: 'BIG'
- 3 year project
- Pre-production: ~ 10 people for 12 months
- ~ 70 people + ~ 5 contractors
- 6 designers, 18 programmers, ~ 50 artists

Development

- Started the project with ZERO line of code
- Prototyped shaders on PC
- Animation was priority #1
- Over-designed our first set of tools

Tools

- Keep them SIMPLE!!!
- Few tools rather than a big über tool
- Expand your current set of tools

Cygwin

- Like a linux shell
- Helps controlling people's environment
- All tools must be run from Cygwin

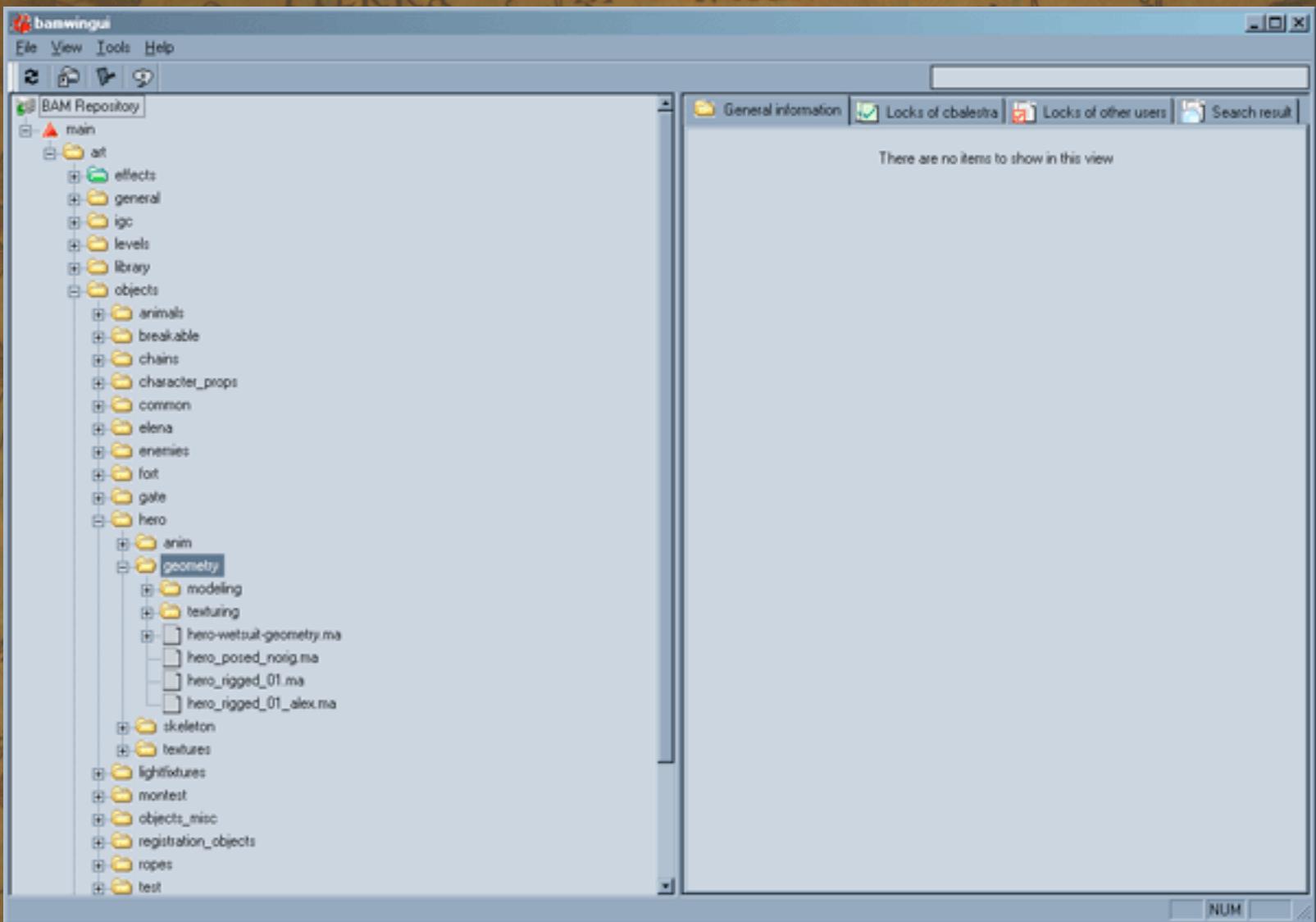
BAM

- Asset Manager
- Everything on the network
- Linux server - symlinks
- Check-out, Check-in but NO SYNC

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TIERRA DI NORIMBERGA



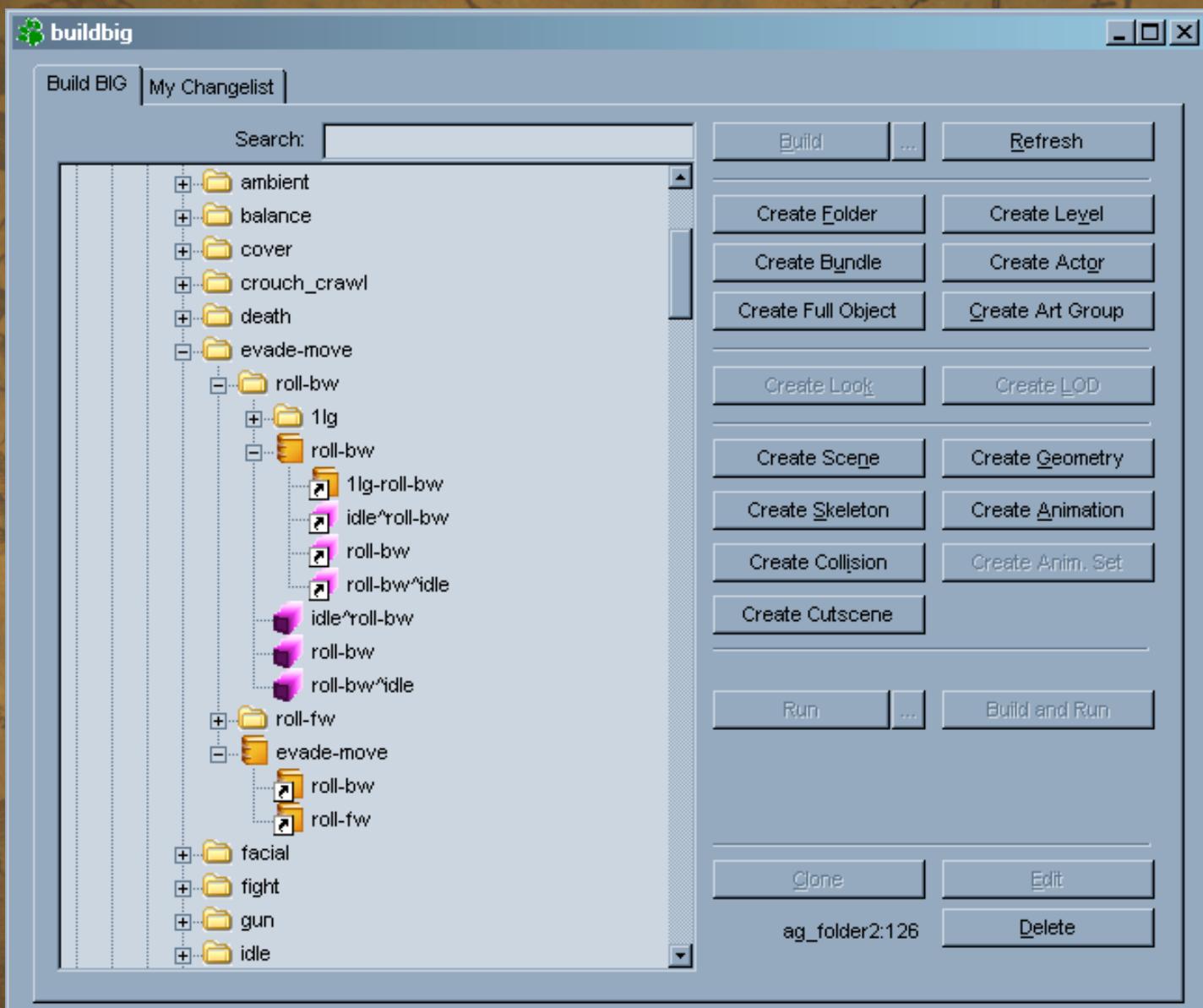
General information Locks of cbalestra Locks of other users Search result

There are no items to show in this view.

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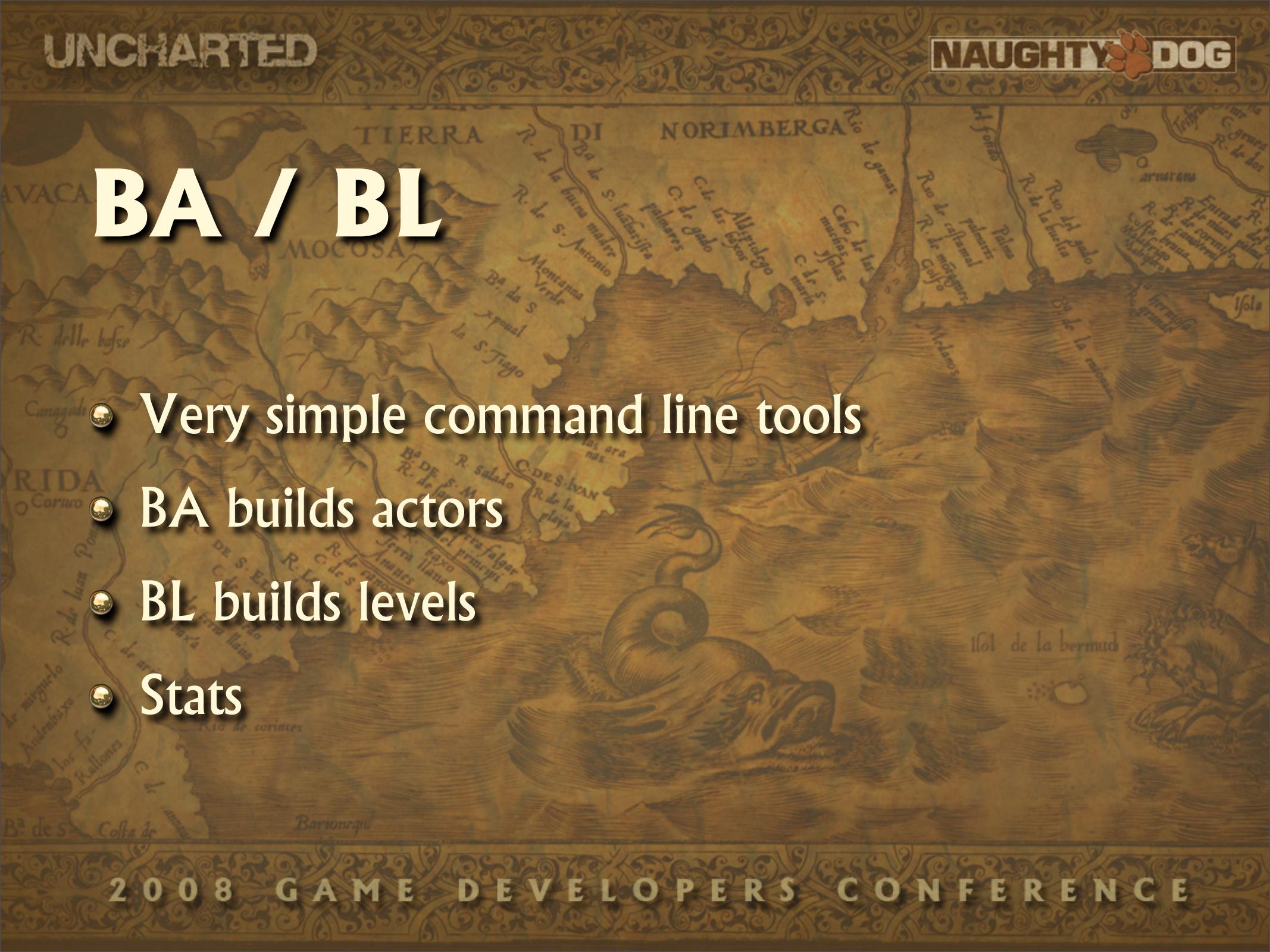
BuildBig

- GUI tool to describe what actors and levels are made of
- All the data and change lists stored in MySQL:
Bad idea!!
- Switching to text files and Perforce



BA / BL

- Very simple command line tools
- BA builds actors
- BL builds levels
- Stats

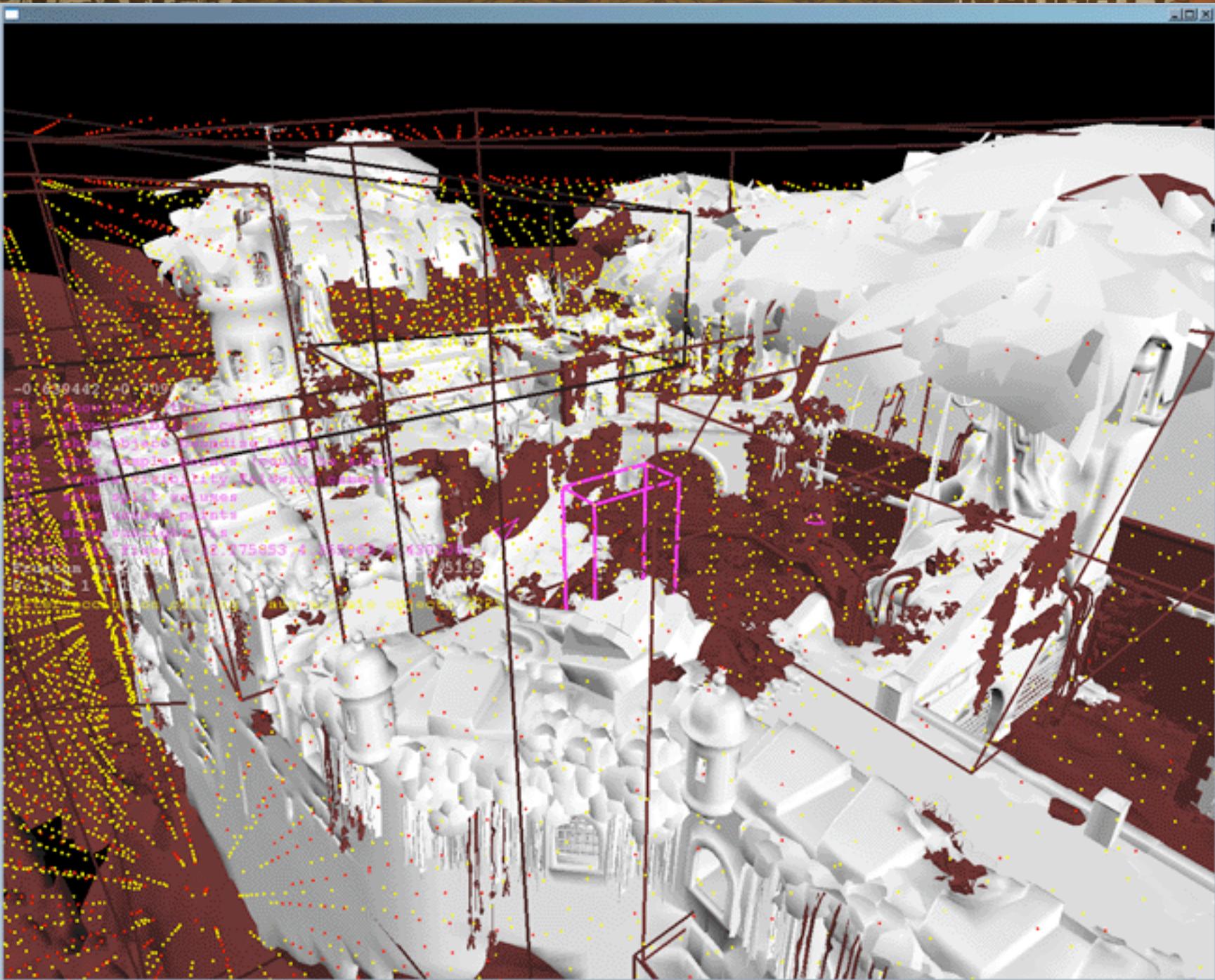


Visibility

- During BL a PVS is pre-computed per level
- Rendering the level with OpenGL from sample points
- Computed once a day and re-used cache
- Split boxes
- Can easily add sample points

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Distributed build

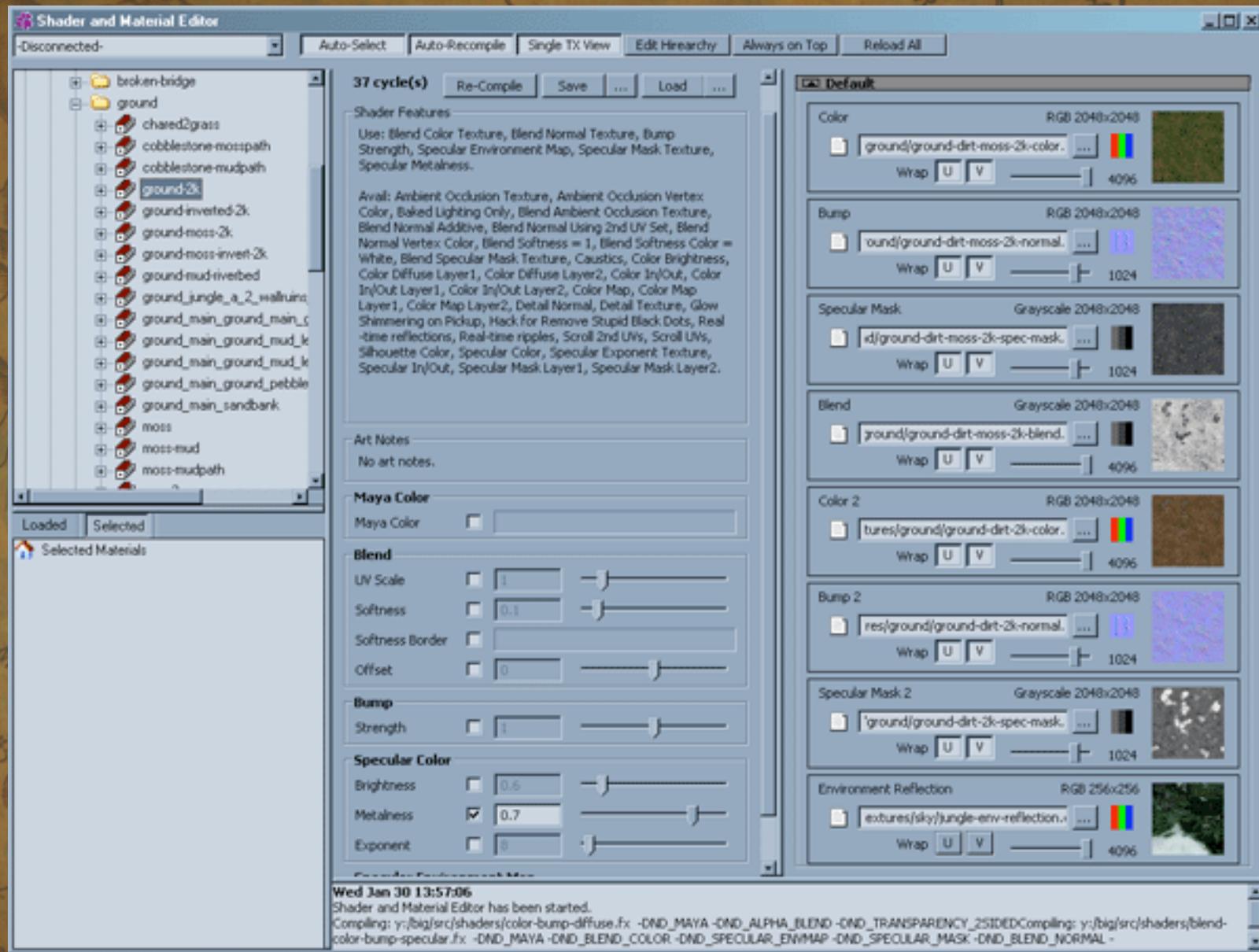
- Using Naughty Dog Distributed System
- Very simple
- Runs command line tools
- Everything stored in MySQL

Shaders

- Über Shader file
- #define = feature
- Not great for dependencies
- Compiled during BA/BL
- Each actor or level contains its shader code

Material Editor

- GUI tool connected to Maya to create shaders
- Artists select an .fx file and choose features
- Artists loved it but ...
- Not very stable, data & change list stored in MySQL
- Working on connecting it with the game

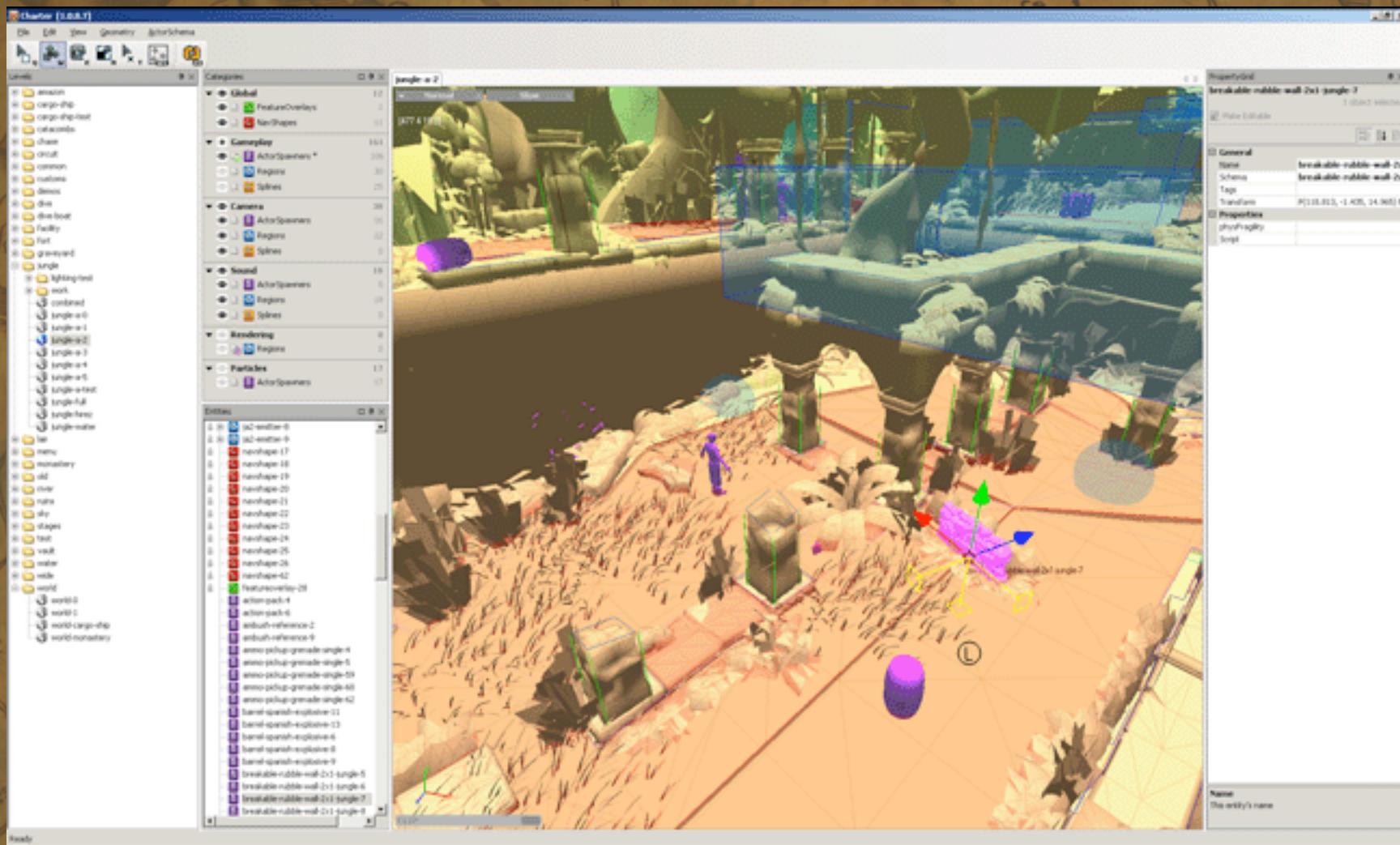


Charter

- GUI tool to create game-play contents
- Maya too slow
- Regions, Nav-Meshes, Spawners, Cover points...
- Quick iteration time

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DC

Data Compiler

- LISP based
- Original design was to create data structures
- Added scripting
- Render settings, AI, animation, region scripts
- Realtime linking

Static Lighting

- Global illumination
- Direct color, indirect color and direction per vertex
- Light probes for objects
- Too slow, couldn't distribute

TAME

- GUI tool to manage text localization
- HELPED US A LOT!!!
- Producers in Europe and Japan can manage everything without us
- MySQL

Filter

Name Id	Text	Last Update
00A_01A_SEQUENCE_01	I'm here off the coast of Panama,	2007-06-05 11:47:29
00A_01A_SEQUENCE_02	where we've just recovered what we believe	2007-08-06 17:09:08
00A_01A_SEQUENCE_03	to be the coffin of legendary explorer Sir Francis Drake,	2007-08-06 17:09:31
00A_01A_SEQUENCE_04	who was buried at sea over 400 years ago.	2007-08-06 17:09:58
00A_01A_SEQUENCE_05	Are you sure you wanna be defiling	2007-08-06 17:10:13
00A_01A_SEQUENCE_06	your ancestor's remains like that?	2007-08-06 17:10:36
00A_01A_SEQUENCE_07	You make it sound so dirty. (laughs)	2007-08-06 17:10:50
00A_01A_SEQUENCE_08	Besides, I thought you didn't believe me.	2007-08-06 17:11:10
00A_01A_SEQUENCE_09	Well, I did do my research.	2007-08-06 17:11:25
00A_01A_SEQUENCE_10	And apparently, Francis Drake didn't have any children.	2007-08-06 17:11:41
00A_01A_SEQUENCE_11	Well, history can be wrong, you know.	2007-08-06 17:11:57
00A_01A_SEQUENCE_12	For example - you can't defile an empty coffin.	2007-08-06 17:12:10
00A_01A_SEQUENCE_13	What the hell?	2007-08-06 17:12:25
00A_01A_SEQUENCE_14	(laughs) You devil.	2007-08-06 17:12:37
00A_01A_SEQUENCE_15	What is it? C'mon, hold it up -	2007-08-06 17:12:57
00A_01A_SEQUENCE_16	No, no, no - no way.	2007-08-06 17:13:12
00A_01A_SEQUENCE_17	The deal was for a coffin, that's it.	2007-08-06 17:13:26
00A_01A_SEQUENCE_18	Wait a minute, if my show	2007-08-06 17:13:44
00A_01A_SEQUENCE_19	-hadn't've funded this expedition, you wouldn't've- \ -Hey, hey...	2007-10-08 00:38:11
00A_01A_SEQUENCE_20	You got your story, lady.	2007-08-06 17:14:21
00A_01A_SEQUENCE_21	-Look, Mr. Drake, you signed a contract. \ -(laughs)	2007-08-06 17:14:40
00A_01A_SEQUENCE_22	-I have a right to see every single thing that- \ -Whoa whoa...	2007-08-06 17:15:25
00A_01A_SEQUENCE_23	Could you hold that thought?	2007-08-06 17:16:35
00A_01A_SEQUENCE_24	Sully? Uh, we got some trouble. Hurry it up.	2007-08-06 17:18:12
00A_01A_SEQUENCE_25	Okay, okay - what's going on?	2007-08-06 17:18:31
00A_01A_SEQUENCE_26	Uh... Pirates.	2007-08-06 17:18:51
00A_01A_SEQUENCE_27	Pirates?!	2007-08-06 17:19:08
00A_01A_SEQUENCE_28	Yeah, the modern kind. They don't take prisoners.	2007-08-06 17:20:04
00A_01A_SEQUENCE_29	...least not male prisoners.	2007-08-06 17:20:33
00A_01A_SEQUENCE_30	Wait, what are you talking about?	2007-08-06 17:20:50
00A_01A_SEQUENCE_31	Uh, sh- shouldn't we call the authorities or something?	2007-08-06 17:21:04

Welcome to TAME

Fileserver

- We love linux
- Linux is fast
- The game connects to our own file system running under linux using the debug port
- 80 MB/sec

Programmer Pipeline

- Linux again!!

- 1 linux box for every 2 programmers

- Putty

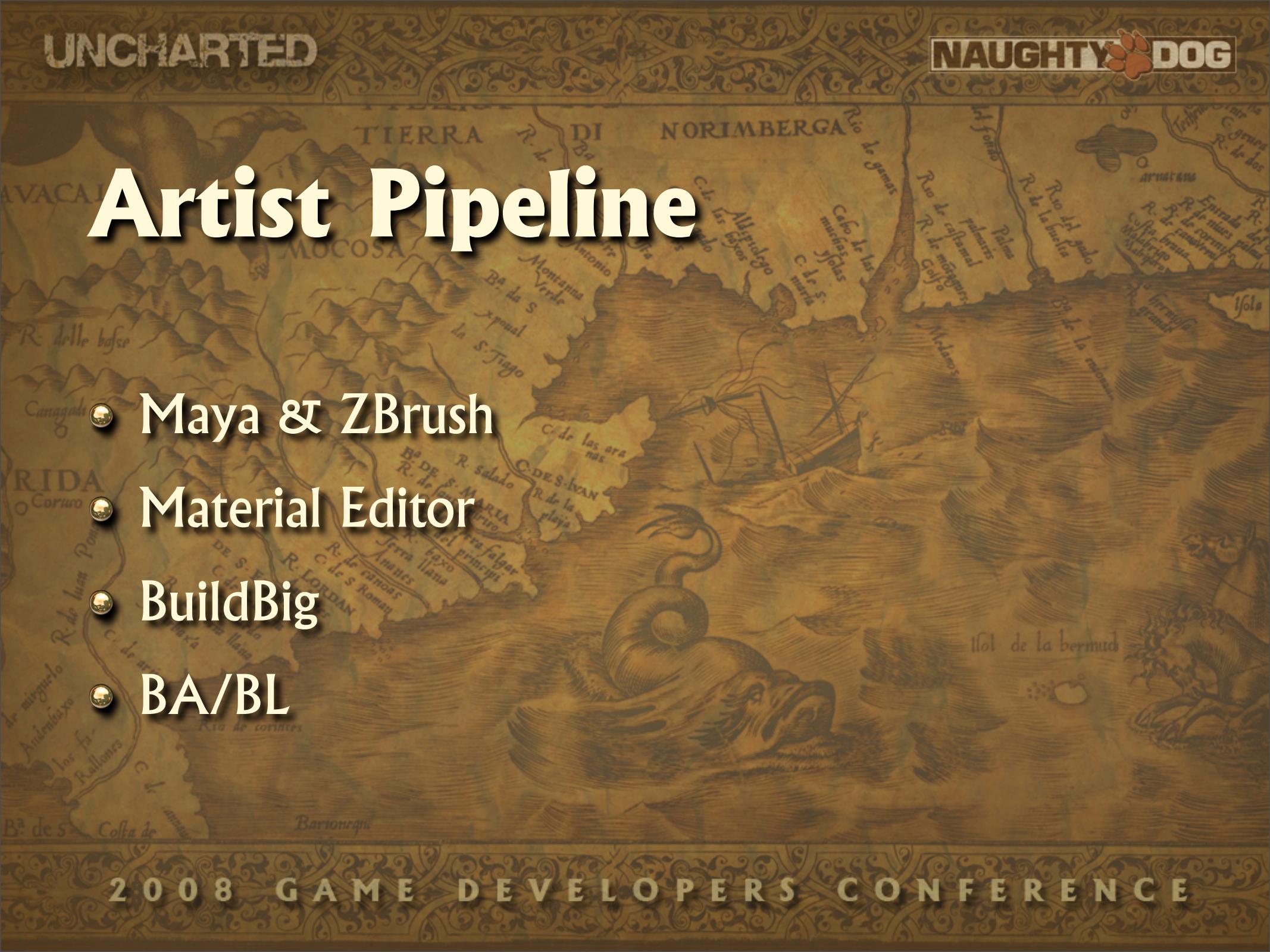
- It's FAST!!!

- Multithreaded build

- SN Debugger & Gcm Replay

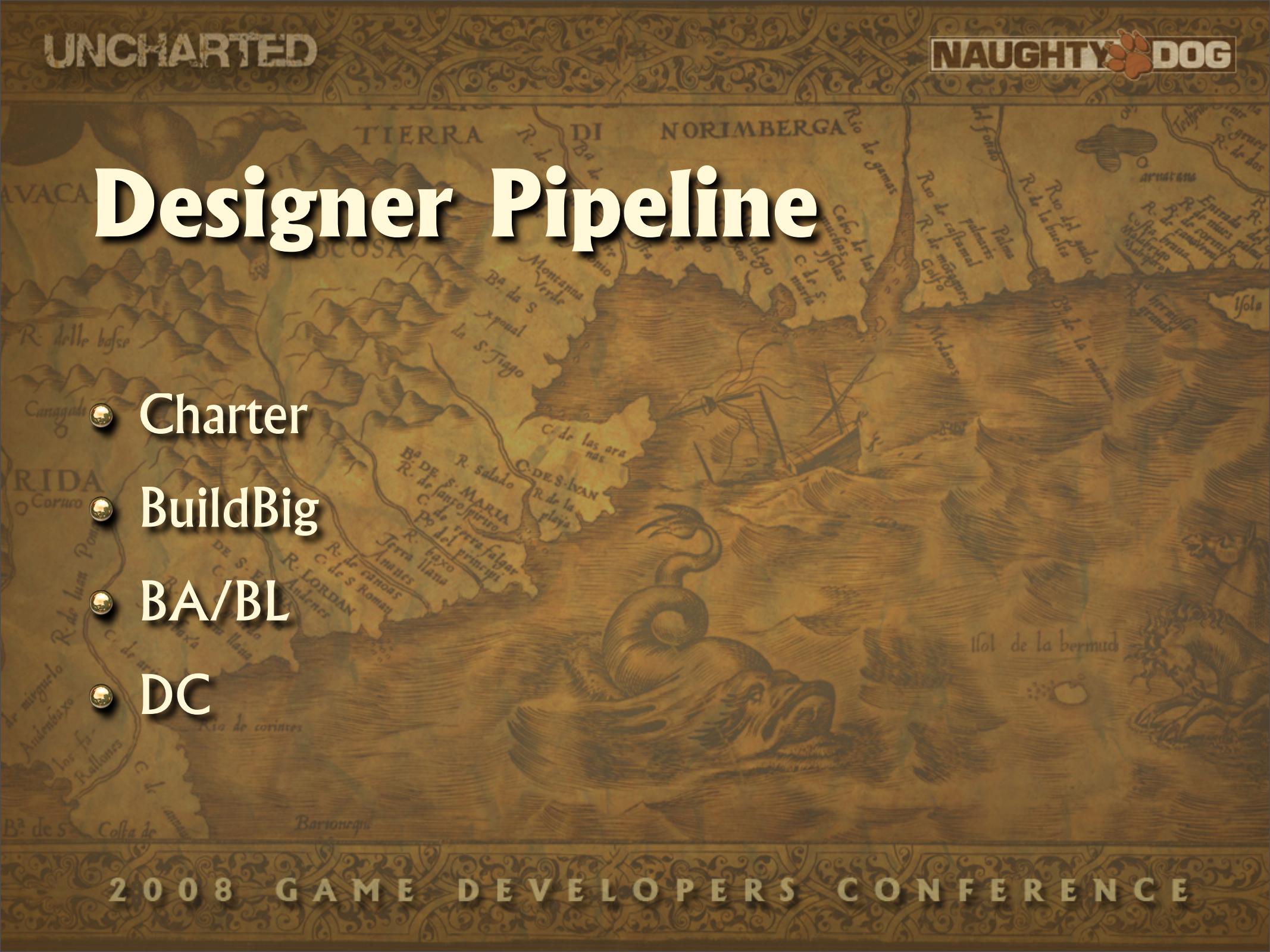
Artist Pipeline

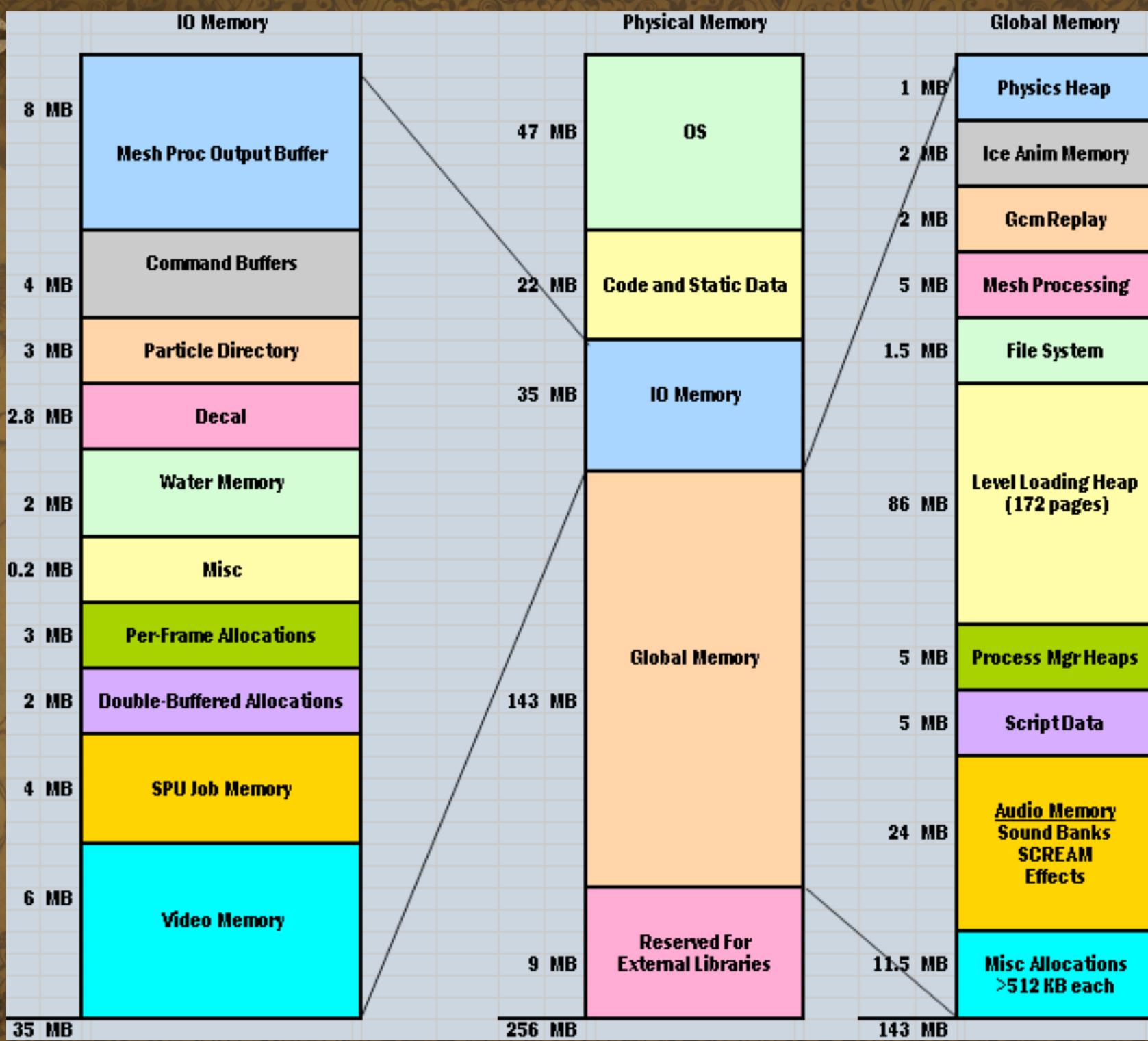
- Maya & ZBrush
- Material Editor
- BuildBig
- BA/BL



Designer Pipeline

- Charter
- BuildBig
- BA/BL
- DC





FIOS

- All IO done with FIOS
- Everything is compressed using Edge
- We stream a lot and all the time: levels, actors, sounds, music, textures
- Pre-cache

Loading Scheme

- Levels and actors are .pak files
- .pak file is made of pages
- Heap of 172 pages
- No fragmentation

Texture Streaming

- Having a hard-drive on every PS3 is **HUGE**
- Very easy to do ... 3 days of work
- Adds a lot to the quality of your game
- Everyone must stream textures!
- Defragment memory every frame

Texture Defragmentation

Step 1



Step 2



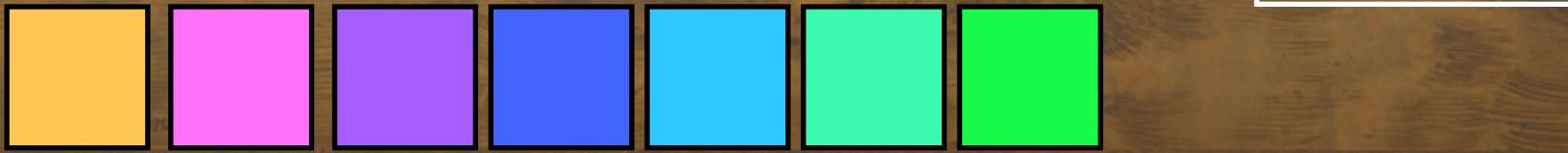
Step 3



Step 4



Step 5



Collisions

- Sphere, Capsule, Convex Polytope
- Concave Geometry, kd-tree Polygon soup
- SPU elf per Shape
- 32 Objects per Batch
- ~ 500 asynchronous ray-cast every frame

Physics

- World split into Islands
- One SPU job (solver) per island
- Successive Relaxation LCP solver
- General constraint system: rag-doll
- Constraints & limits derived from “range-of-motion” animation

SPUs

- Scene traversal
- Geometry processing
- Spherical Harmonics to cube maps
- Particle simulation
- Water
- Animations
- Decompression
- Collisions
- Physics
- Path Finding

Animation

- Using SPUs to decompress and blend animation tree
- Blend tree up to 25 animations (Drake)
- Use DC to describe animation states
- Layered animation system

Scene Traversal

- Visibility frustum culling
- PVS lookup
- Sorting
- Render set up
- Mesh processing set up

Scene Traversal

- Visibility frustum culling - SPU
- PVS lookup - SPU
- Sorting - PPU
- Render set up - PPU
- Mesh processing set up - SPU

Mesh Processing

- Use SPUs to offload RSX
- Decompression
- Skinning
- Back-face culling
- Also used to collide with rendered geometry:
decals, IK, some gameplay collisions

Scene Rendering

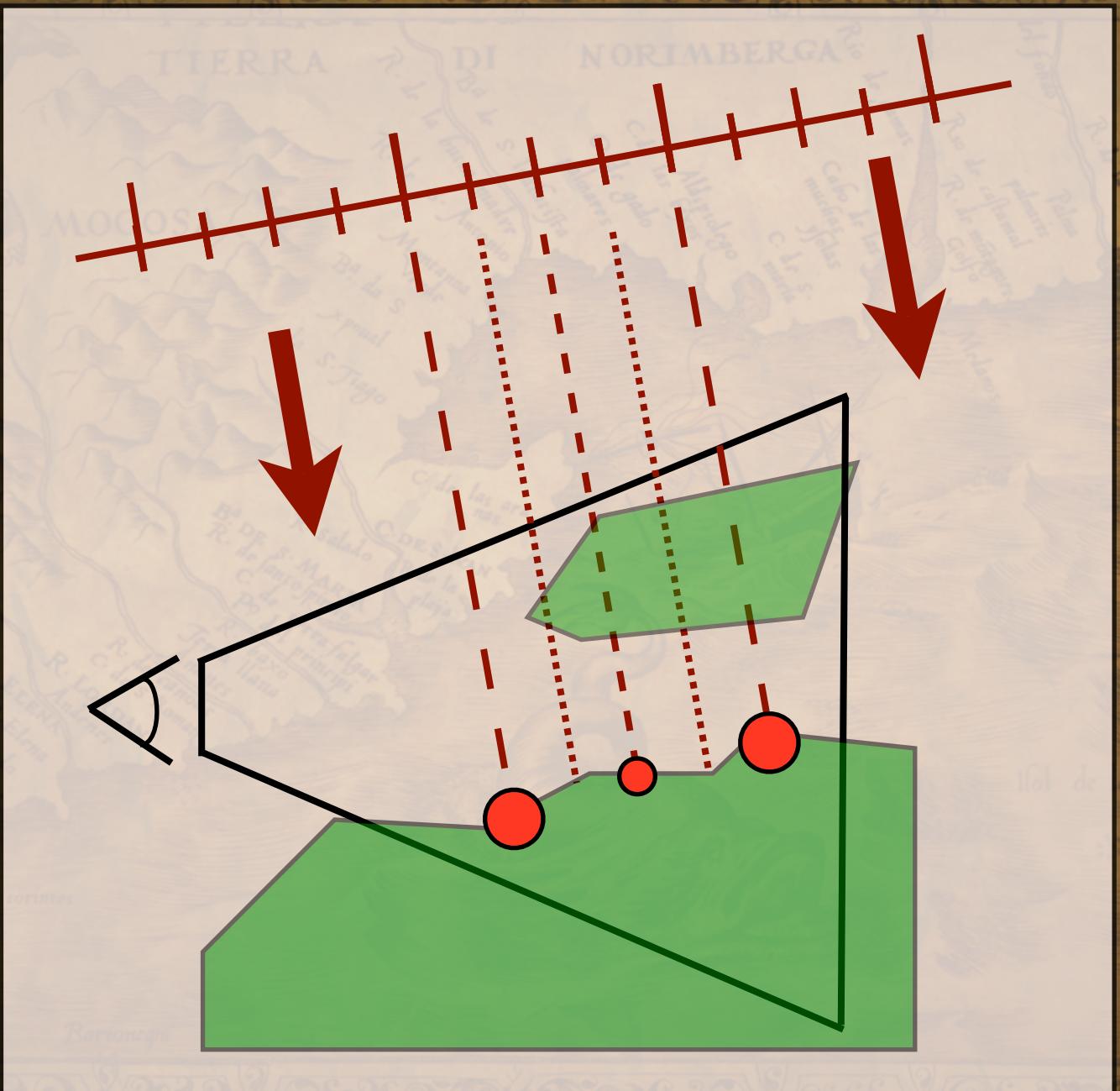
- Shadows
- Dynamic Lighting
- Opaque Geometry
- Alpha Blend Geometry
- Post Processing effects

Sun Light Shadow

- Tried a lot of solutions: problems!
- Simple idea by Guerilla(Killzone)
- Reduce flickering: fixed world space sample points
- SSM: orthographic shadow map
- Cascaded shadow maps

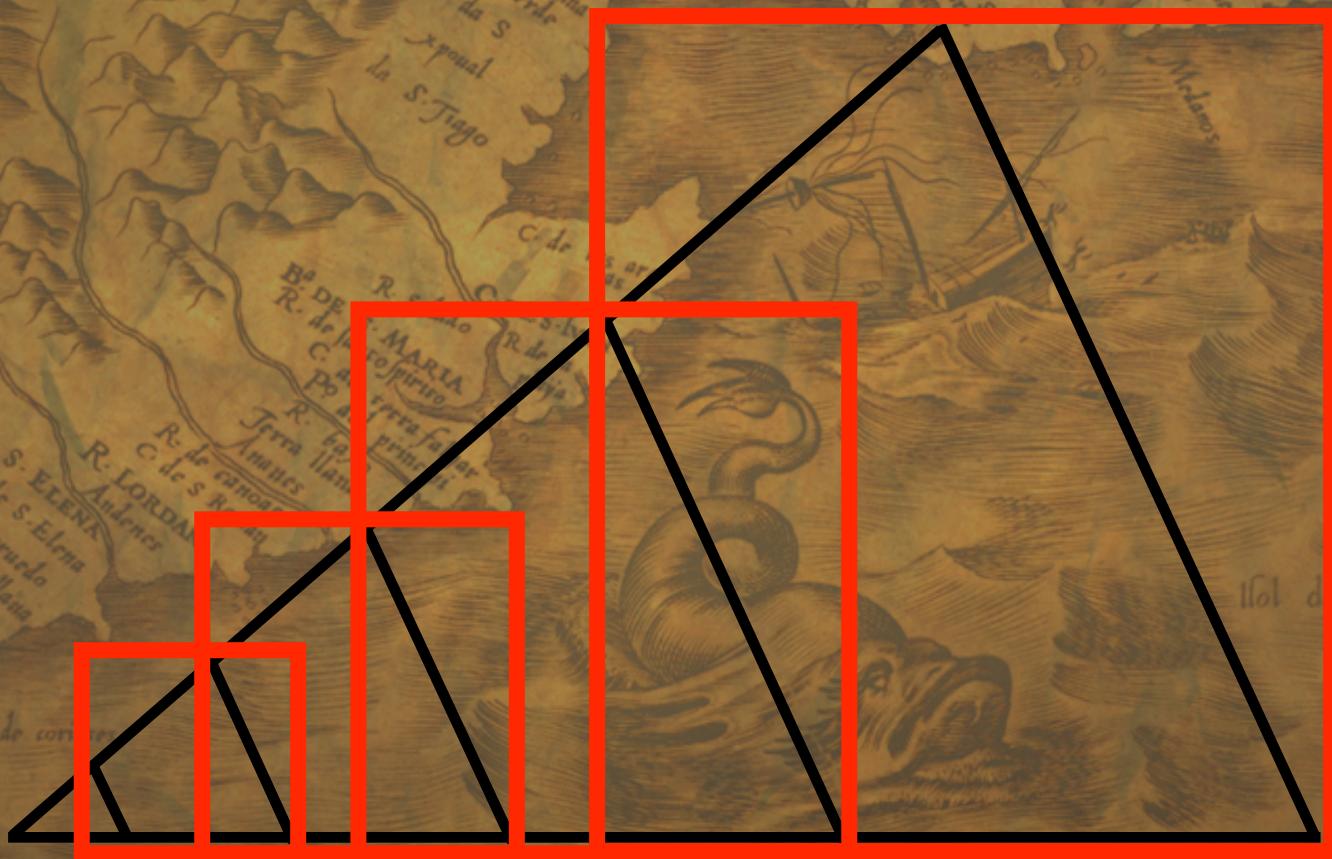
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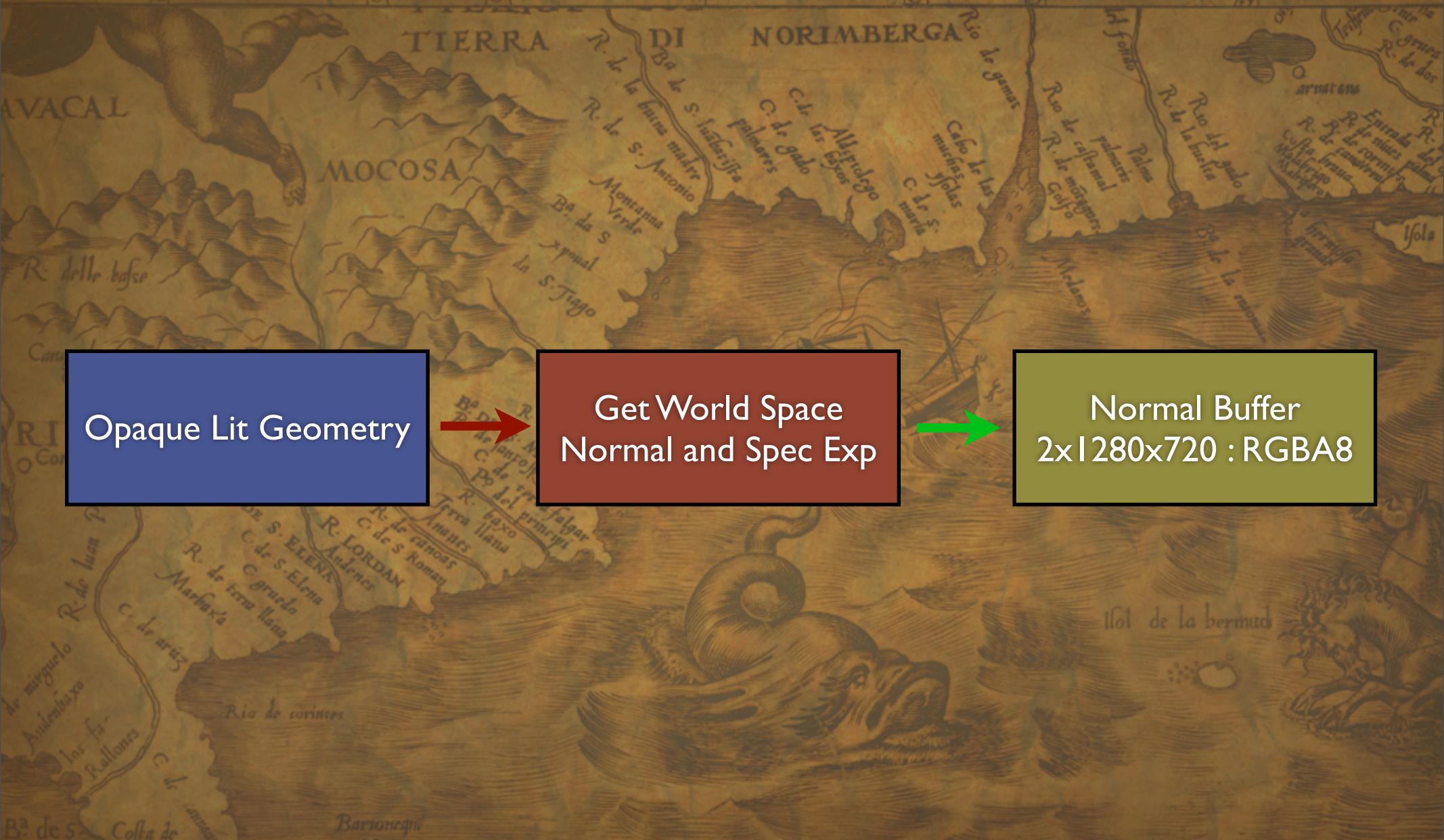
Cascaded Shadow Maps



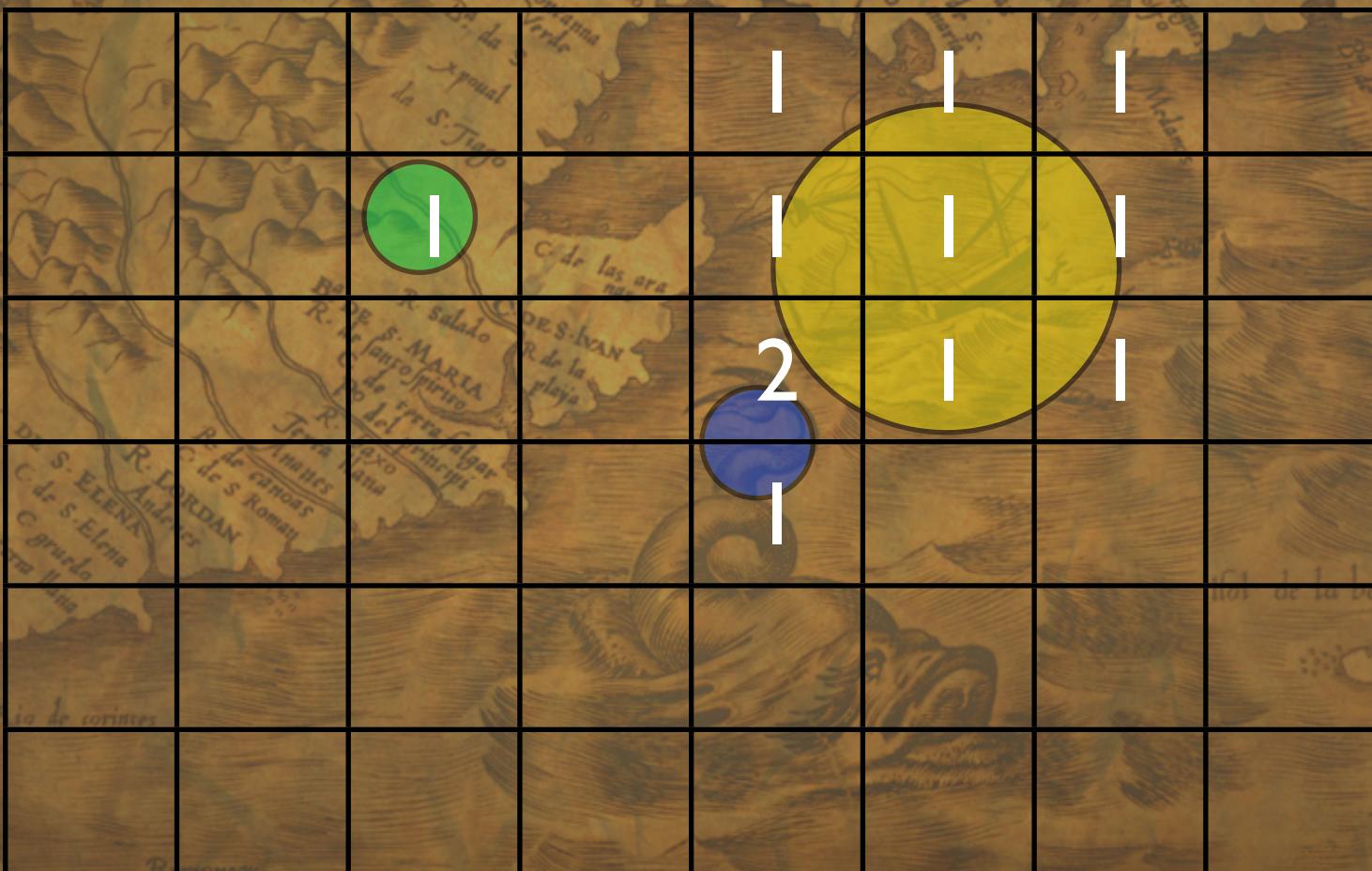


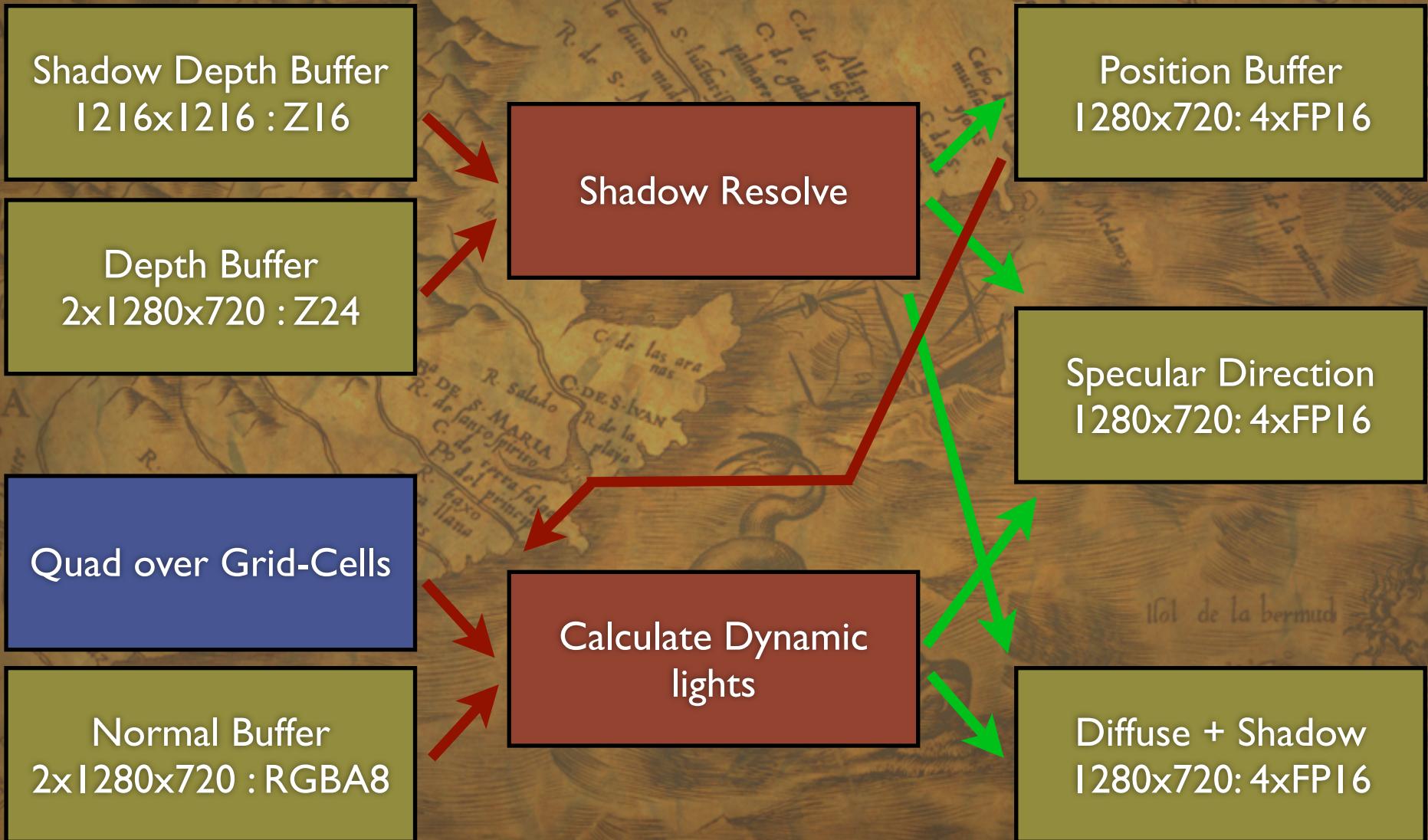
Dynamic Lighting

- Render opaque dynamically lit geometry: world normal + specular exponent in screen space
- Divide the screen into a grid
- Find which lights intersect each cell
- Render quads over each cell calculating up to 8 lights per pass: results in a light buffer



Dynamic Lighting





Opaque Rendering

- Shadowing and lighting already done
- Material processing + direct lighting
- Output is HDR (logluv)
- Pixel shader bound: vertex processing mostly done on SPUs
- Dithering out some geometry

Opaque Geometry

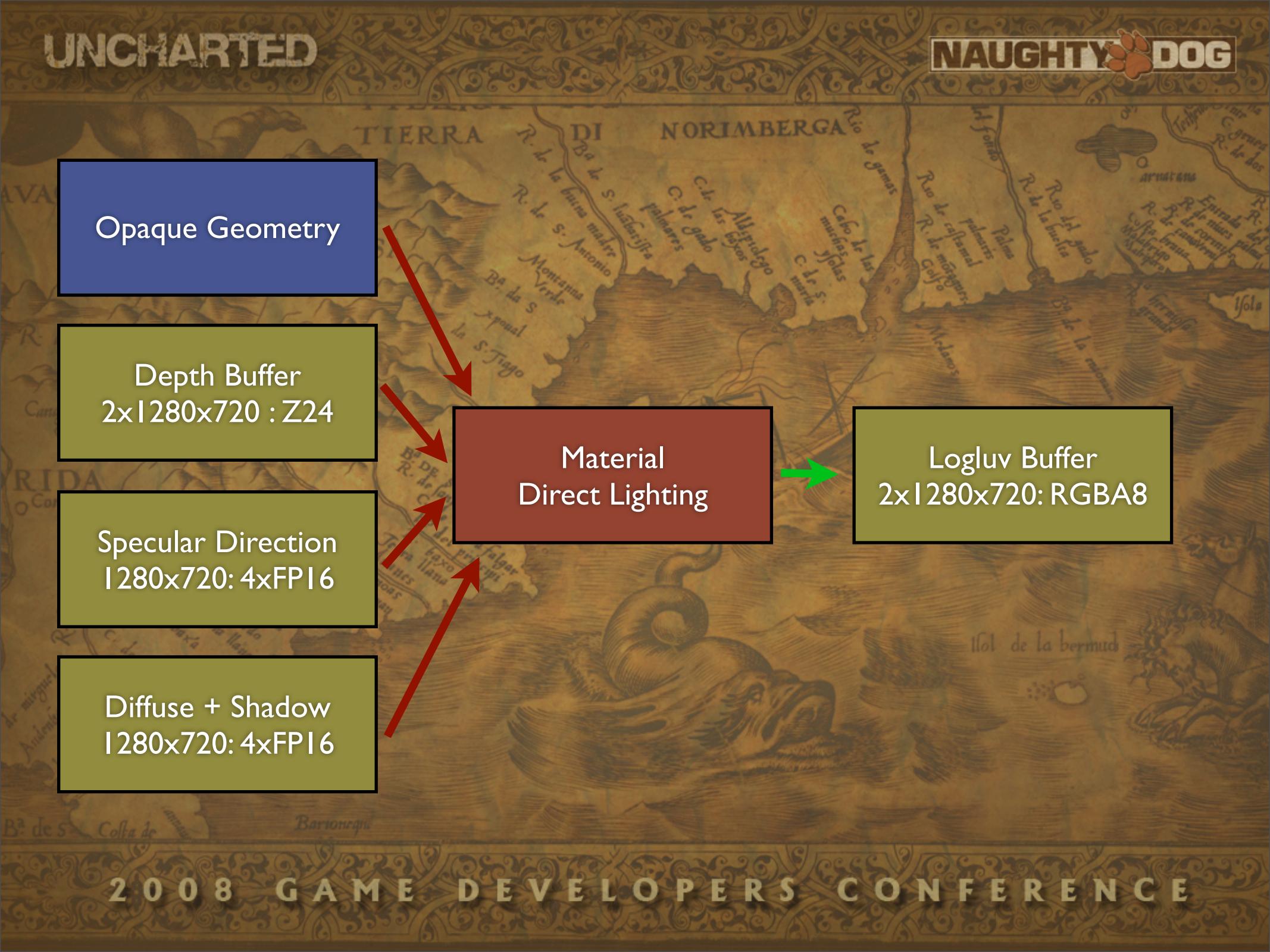
Depth Buffer
2x1280x720 : Z24

Specular Direction
1280x720: 4xFP16

Diffuse + Shadow
1280x720: 4xFP16

Material
Direct Lighting

Logluv Buffer
2x1280x720: RGBA8





Alpha-blended Geometry

- Rendered to FP16 1x buffer
- Water
- Particles
- Glass

Water Meshes

Shadow Depth Buffer
1216x1216 : Z16

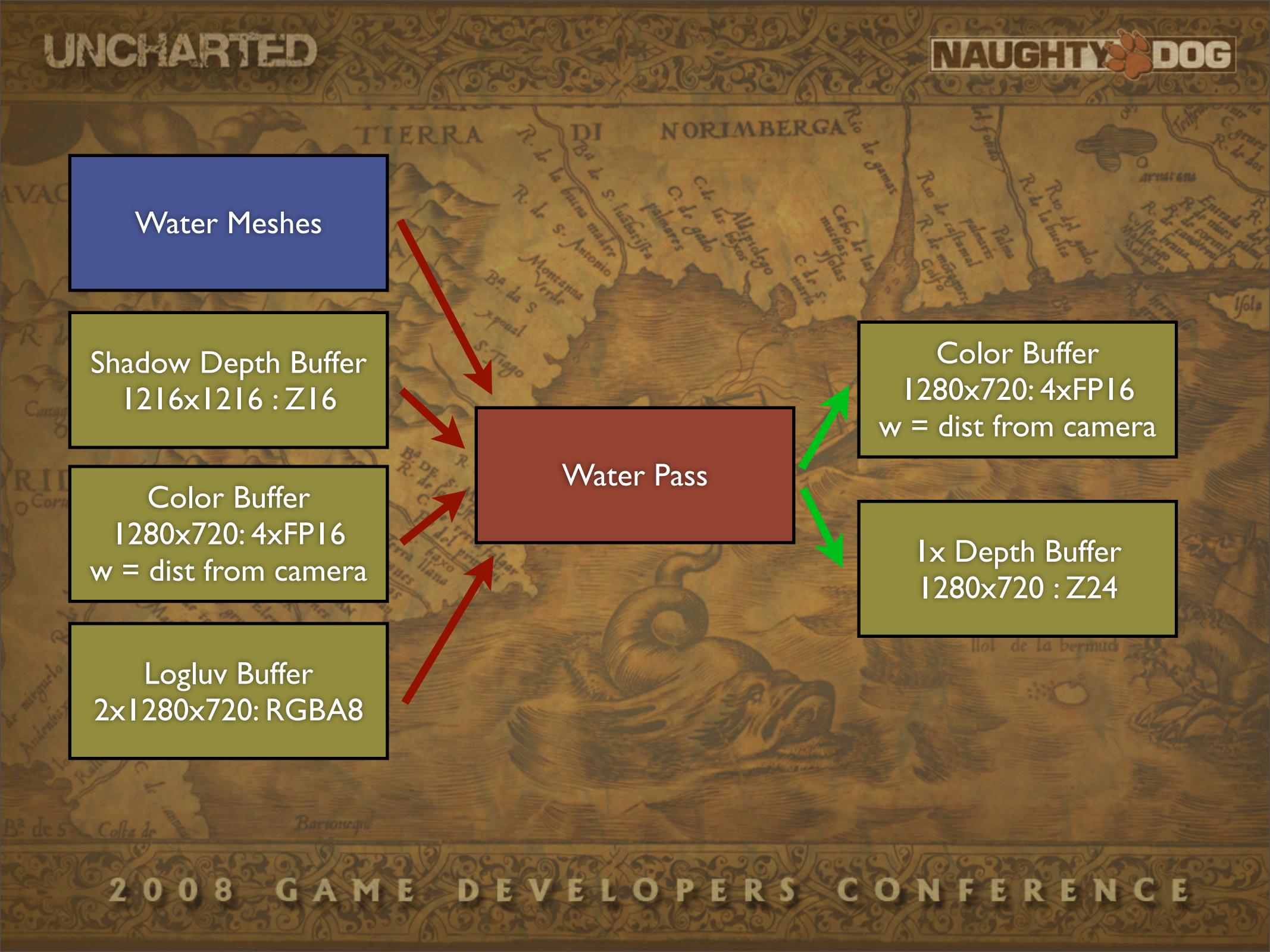
Color Buffer
1280x720: 4xFP16
 $w = \text{dist from camera}$

Logluv Buffer
2x1280x720: RGBA8

Water Pass

Color Buffer
1280x720: 4xFP16
 $w = \text{dist from camera}$

1x Depth Buffer
1280x720 : Z24

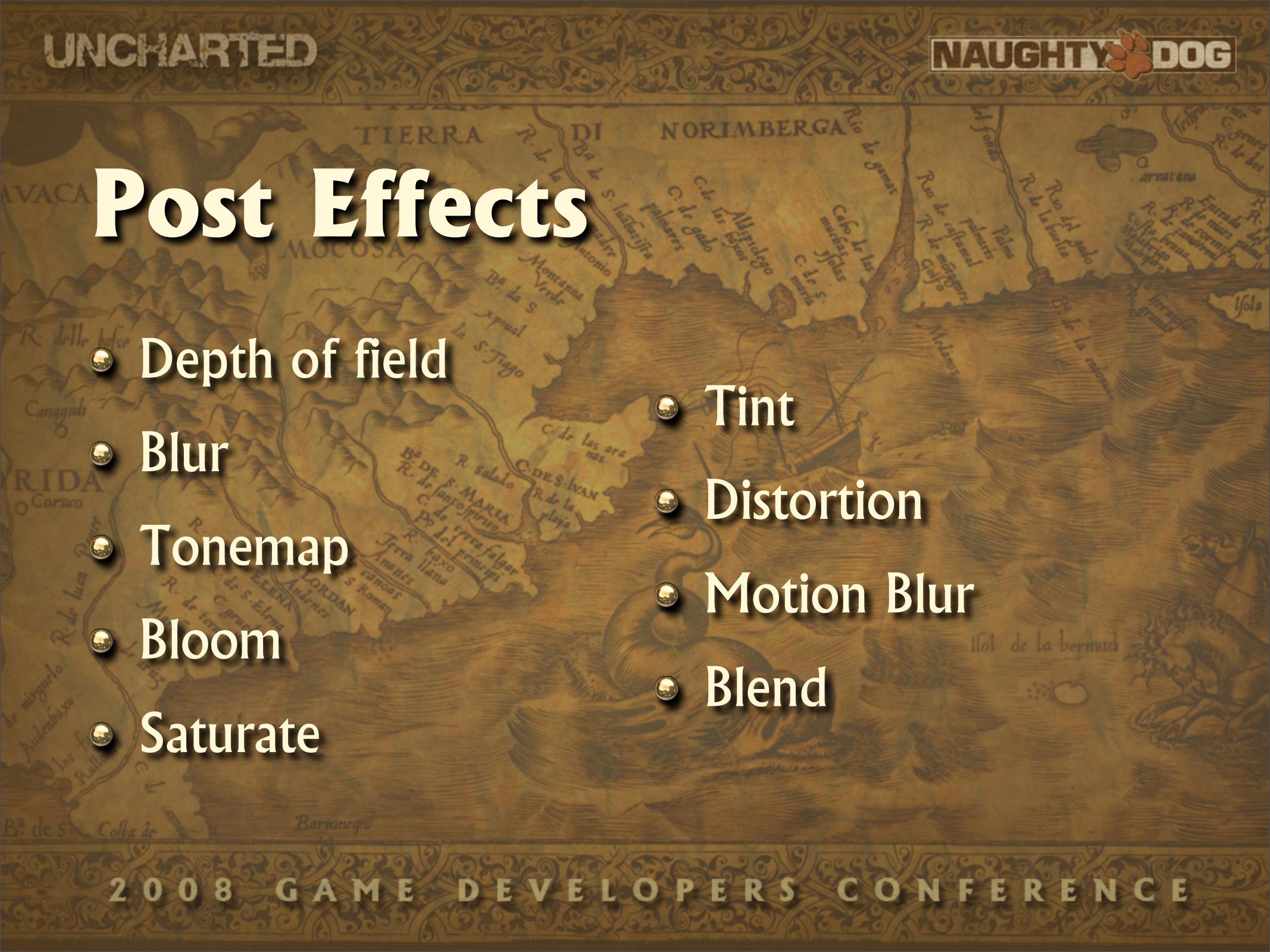


Particles

- Simulation and rendering set up done on SPUs
- Wrote specific shaders
- Switch to down sample buffer on frame rate spike

Post Effects

- Depth of field
- Blur
- Tonemap
- Bloom
- Saturate
- Tint
- Distortion
- Motion Blur
- Blend





KEEPIIT SIMPLE!

WE'RE HIRING!!!!

- if you're extremely talented ...
- candace_walker@naughtydog.com

Thank you

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