

OpenVDB at DWA

DreamWorks Animation

Jeff Budsberg
Head of FX

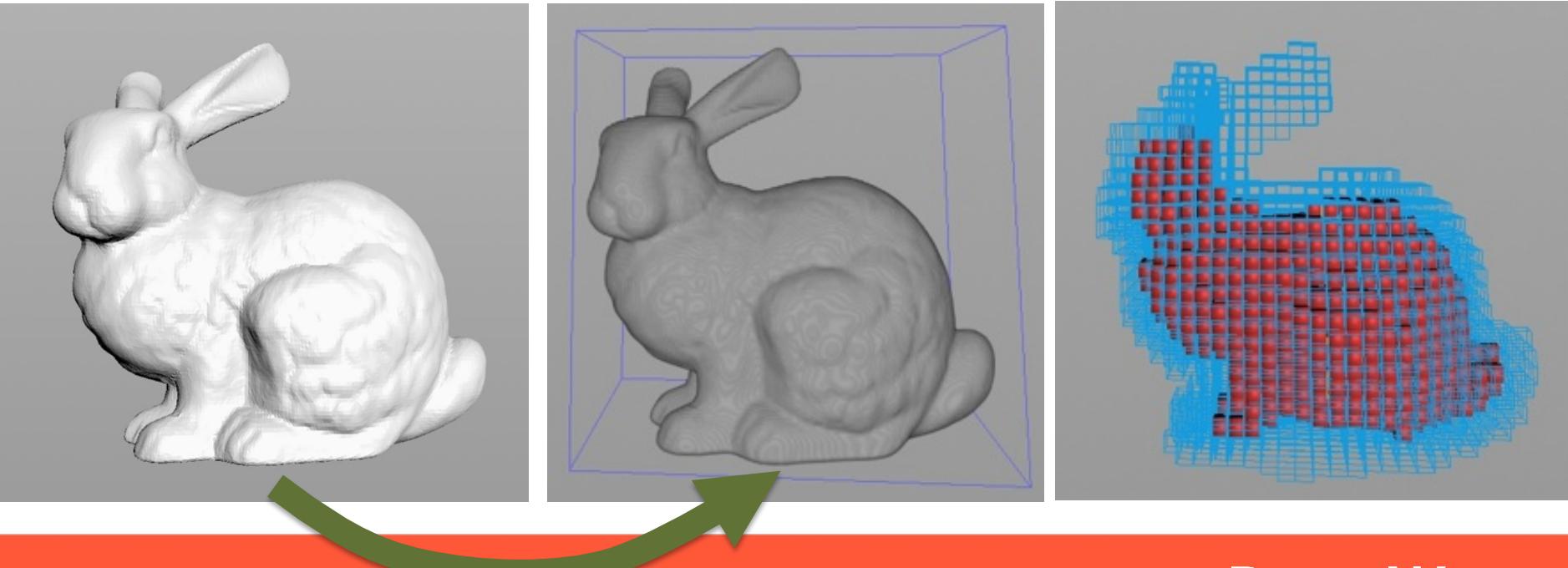
Talk Overview

- Introduction
 - Applications
 - Clouds
 - Liquids
 - Advection
 - Fluids
 - Volume deformation
 - Fracture + RBD
 - Visualization
- + new tools!
- + tips & tricks!

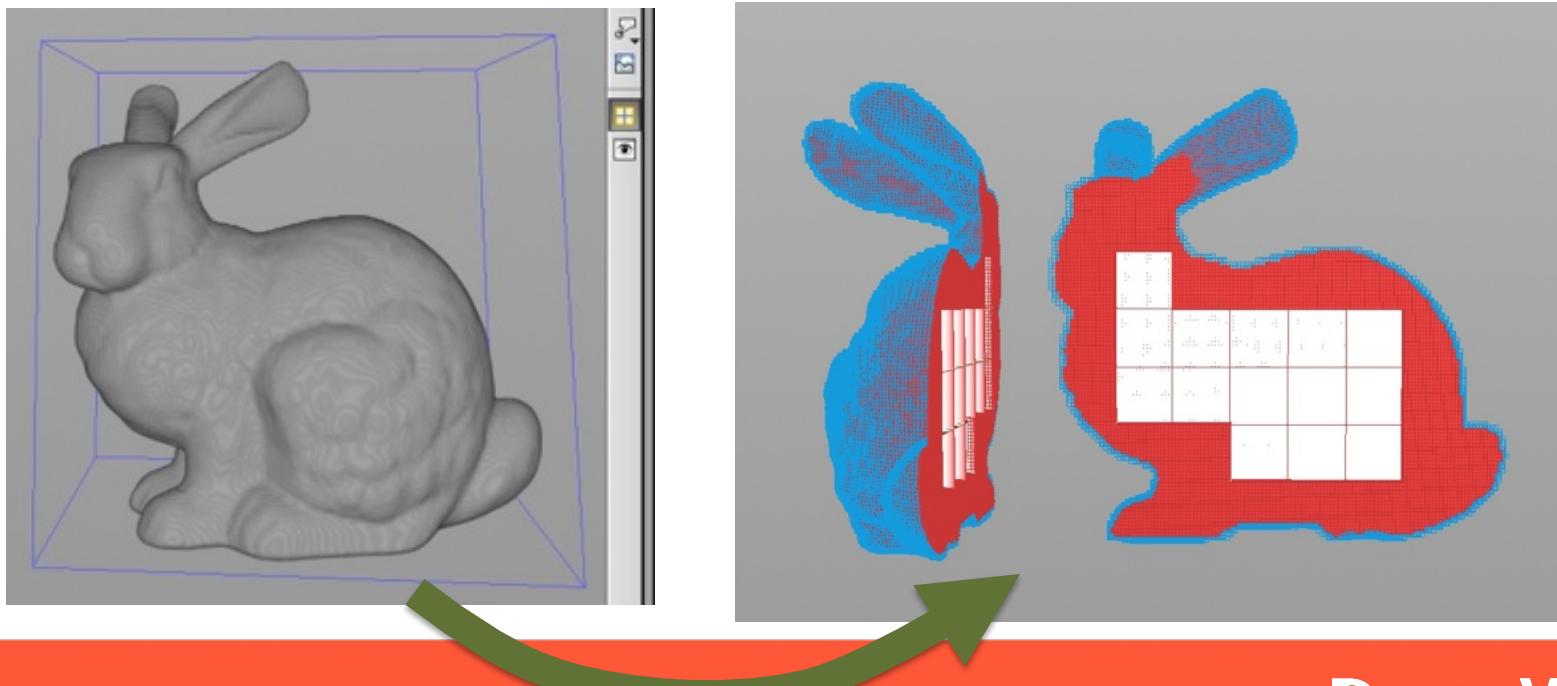
Introduction

- Powerful library
- Collection of flexible tools
 - Third-party
 - OpenVDB
 - Production

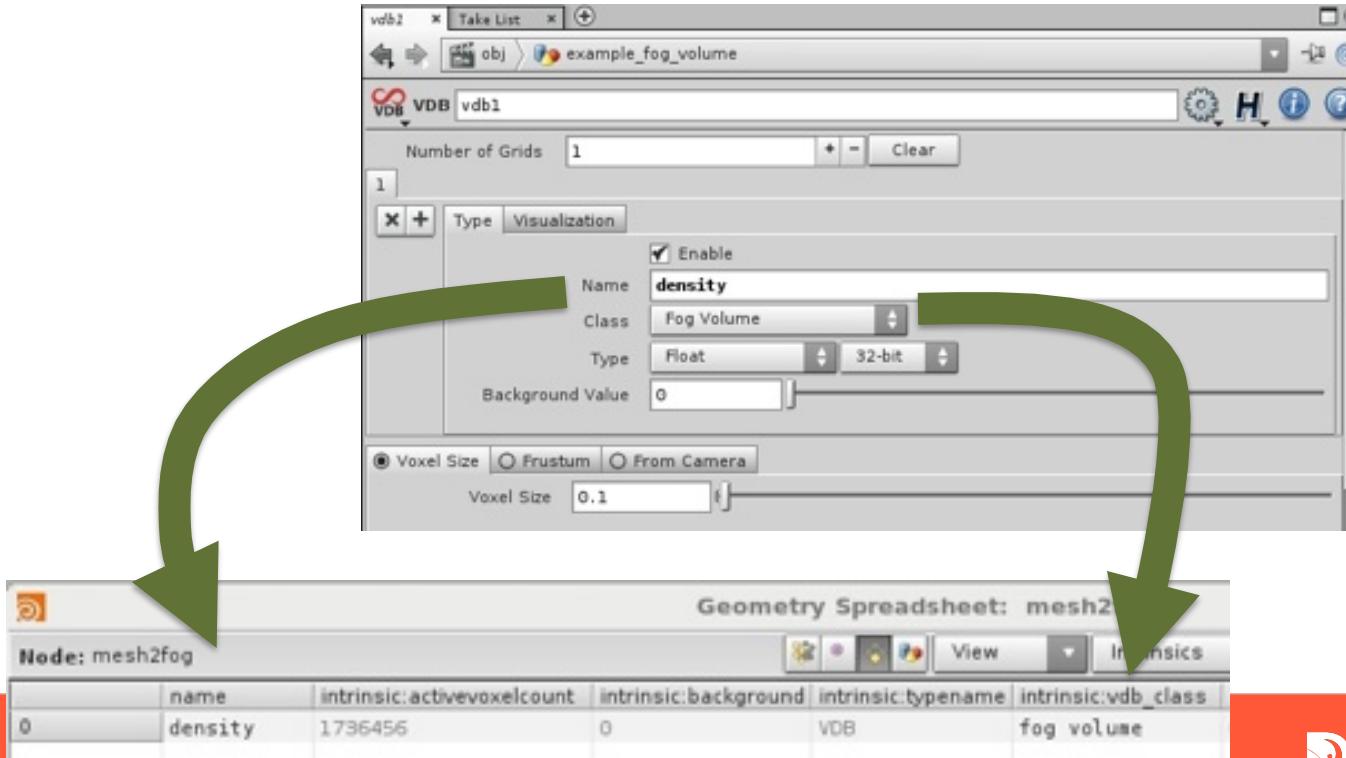
Volume Creation



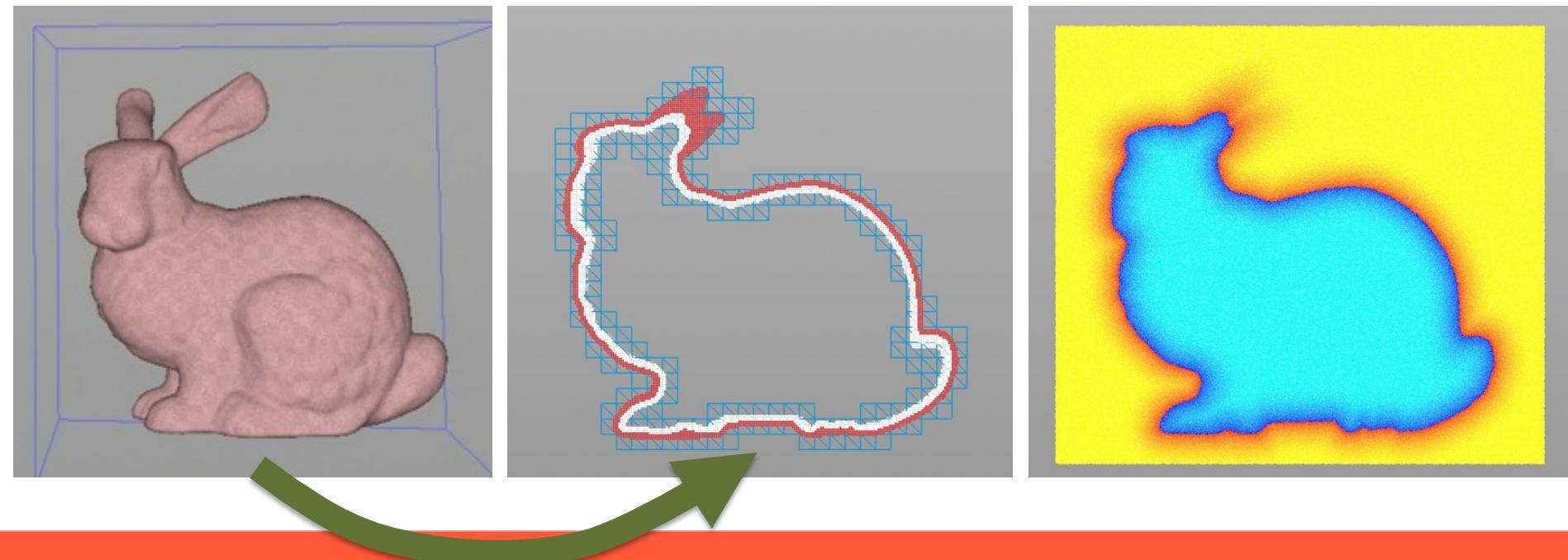
Volume Creation



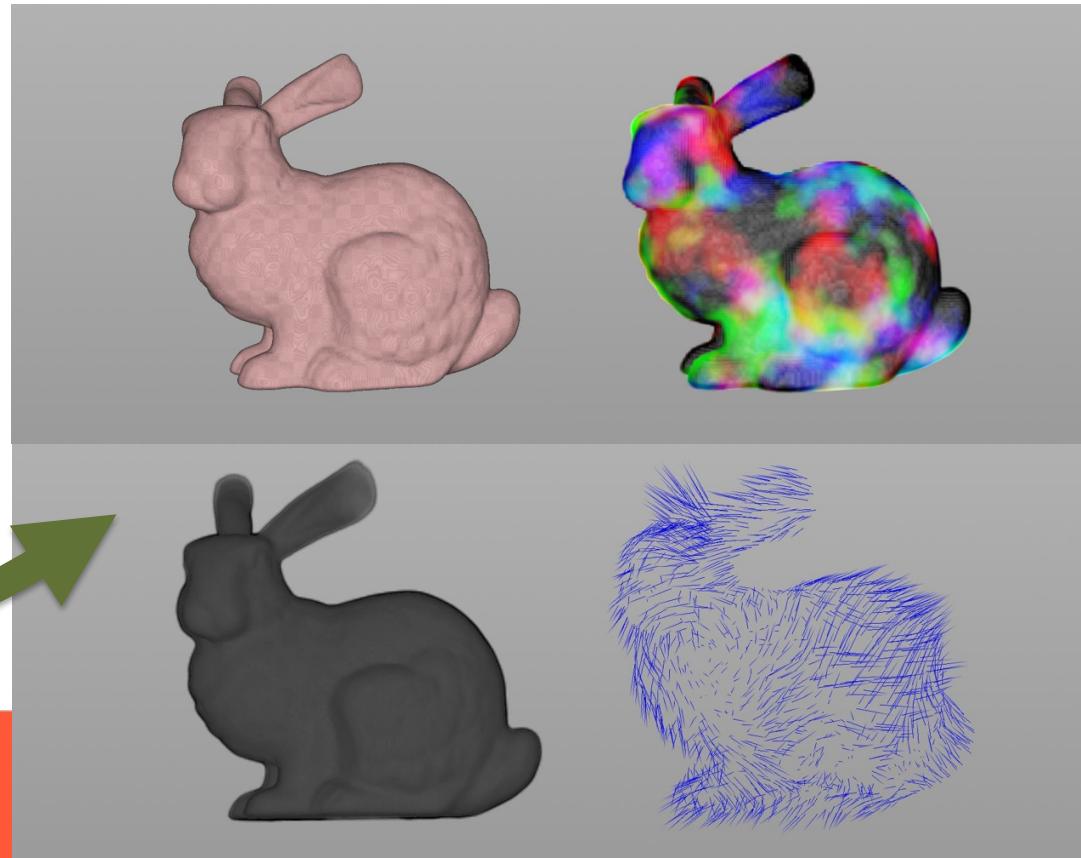
Volume Creation



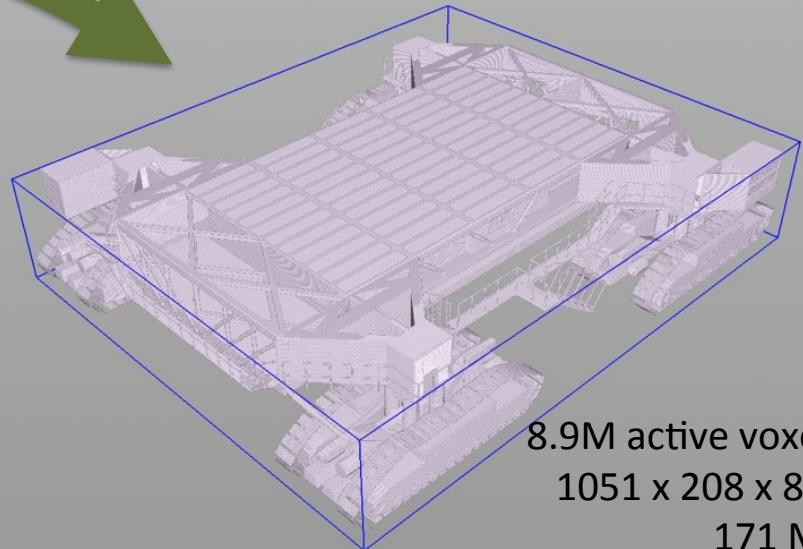
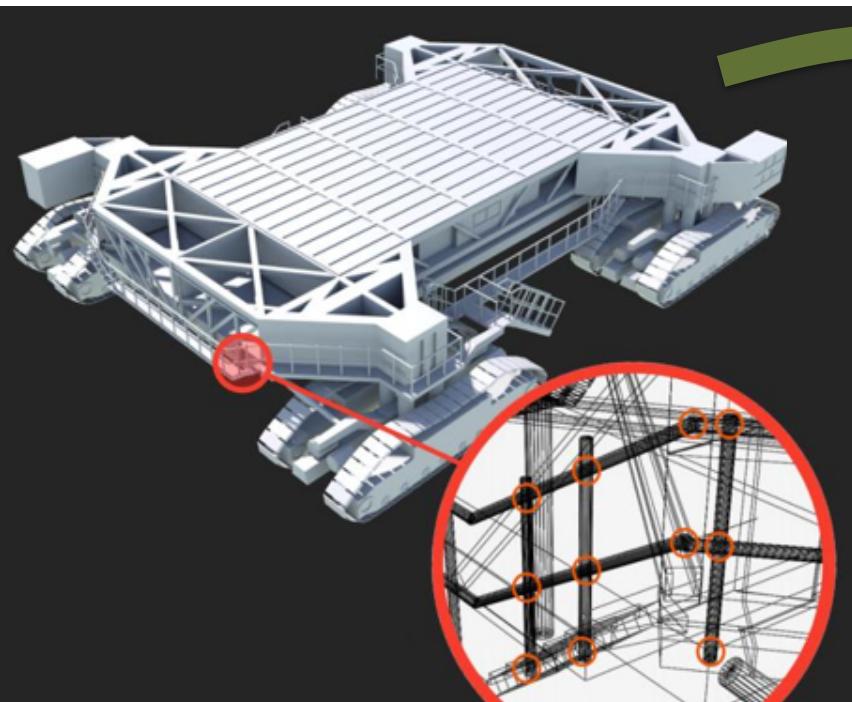
Level Sets



Arbitrary Grids

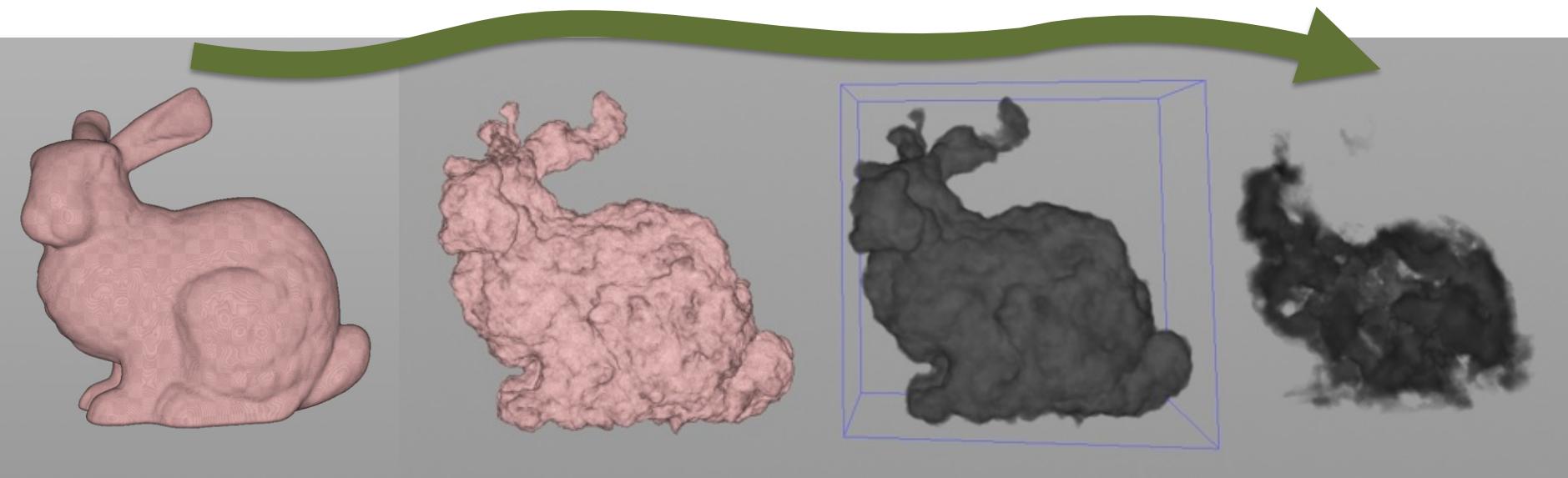


Level Sets



8.9M active voxels
1051 x 208 x 862
171 MB
2.7 sec

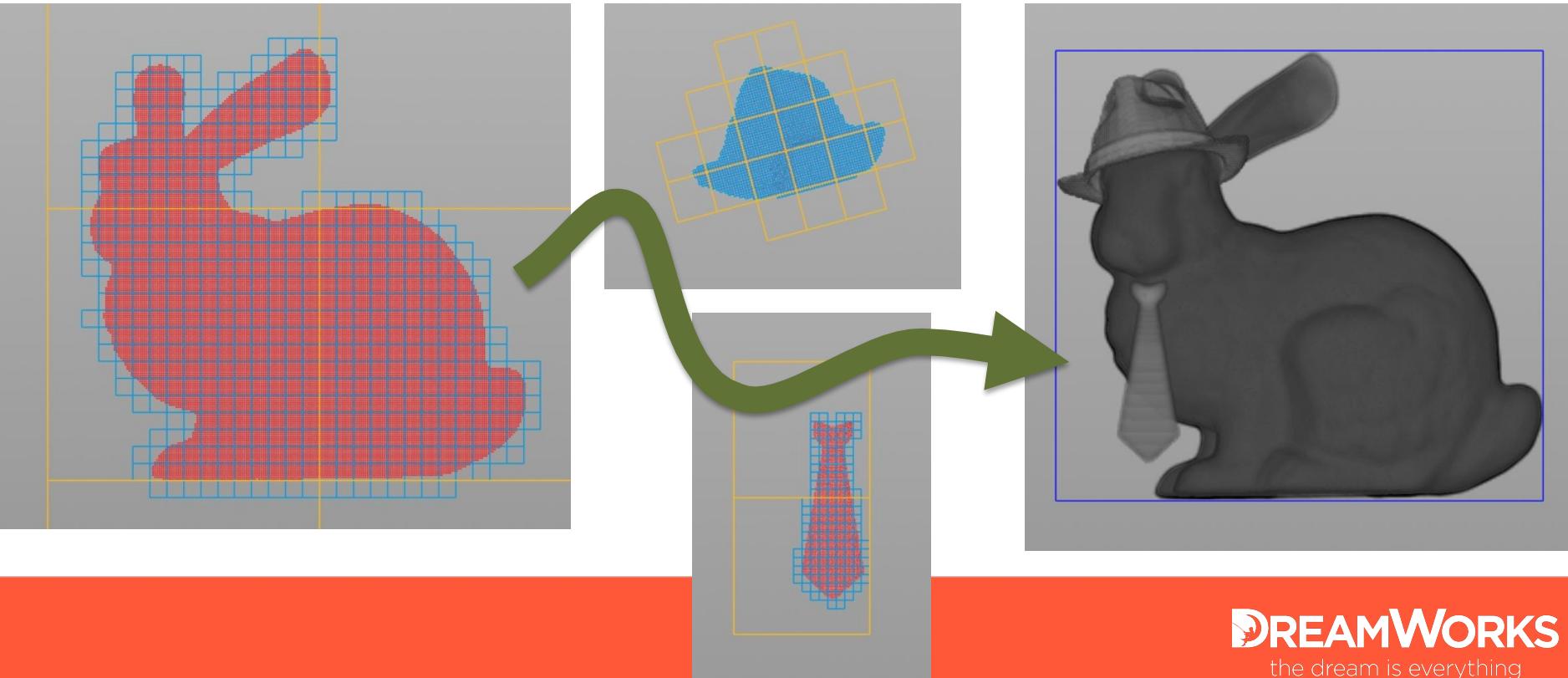
Volume Manipulation



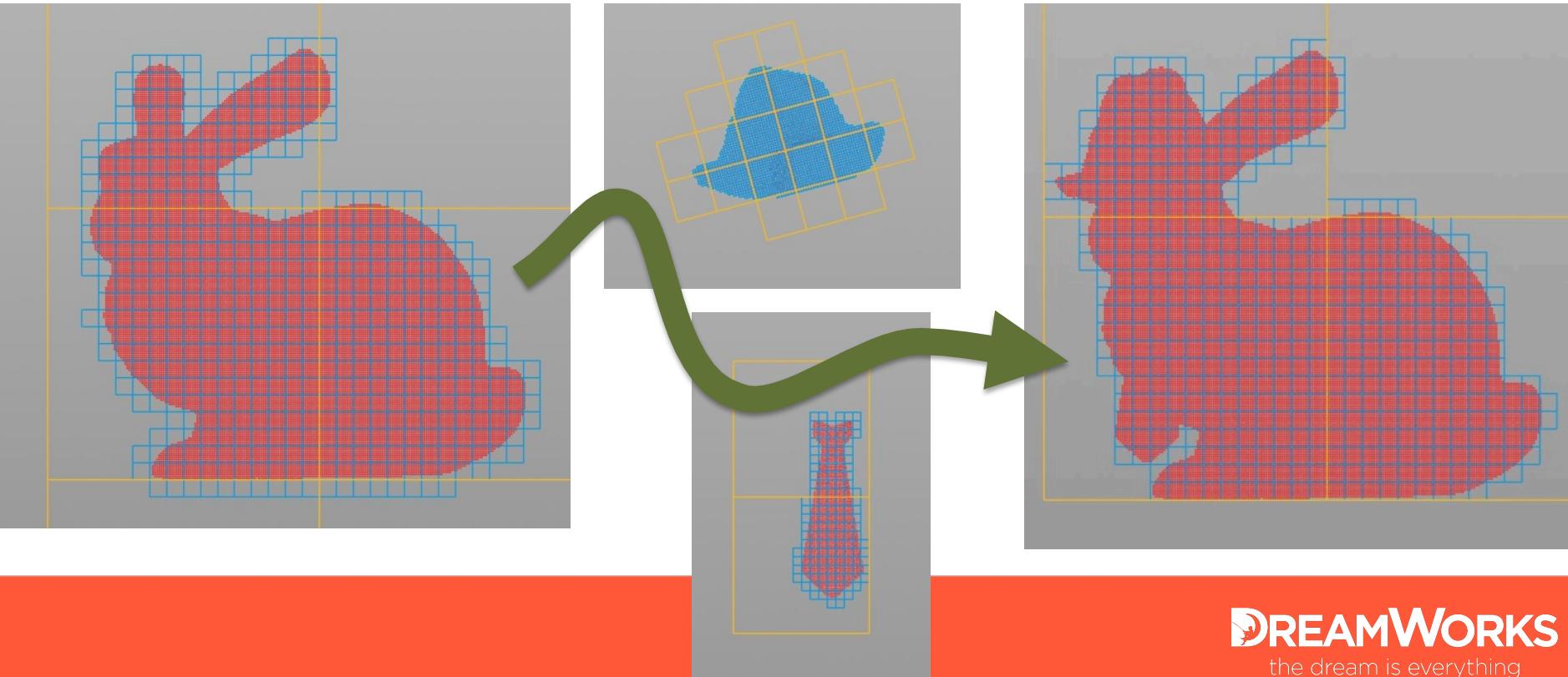
$\Phi += \text{noise(CPT)}$

$\Phi *= \text{noise(P)}$

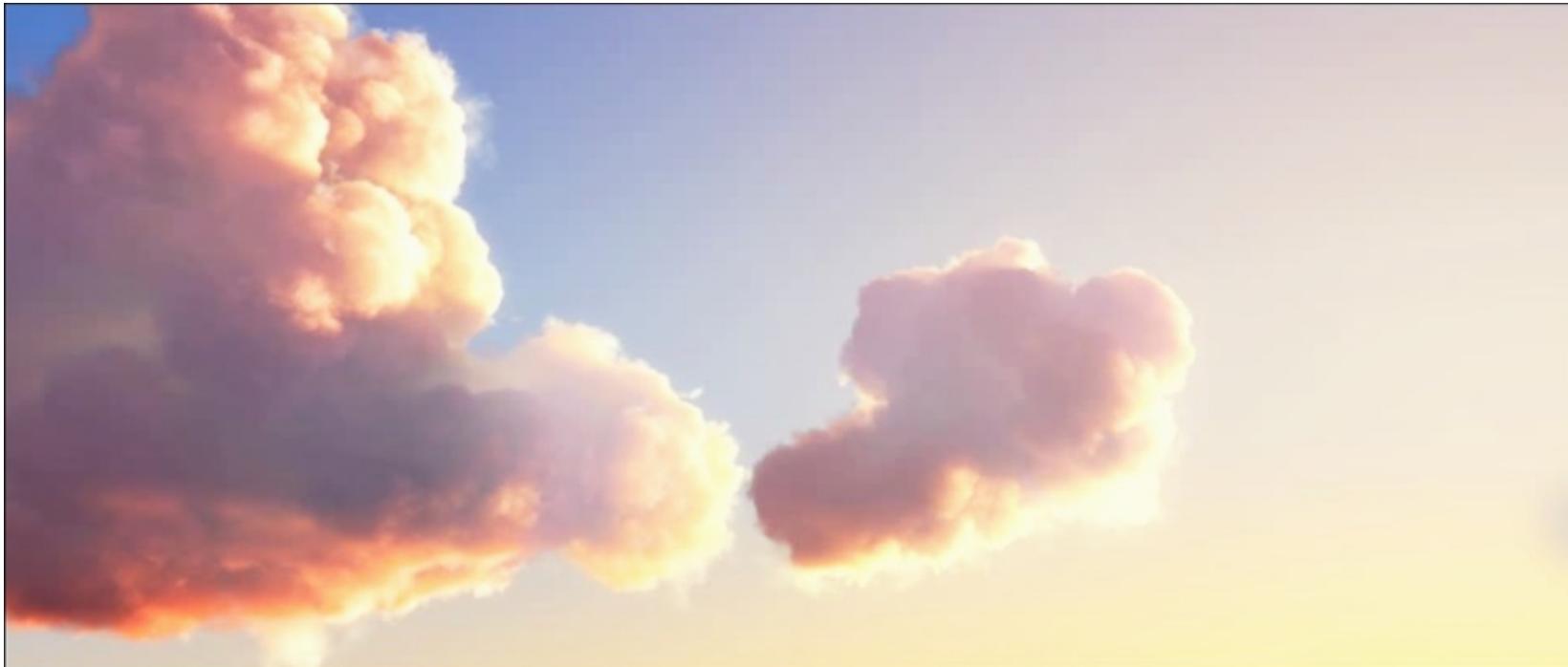
Combining Grids



Combining Grids



Clouds



Miller, B., Museth, K., Penney, D. and Bin Zafar, N. Cloud modeling and rendering for Puss in Boots. Siggraph Talk, 2012

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Clouds



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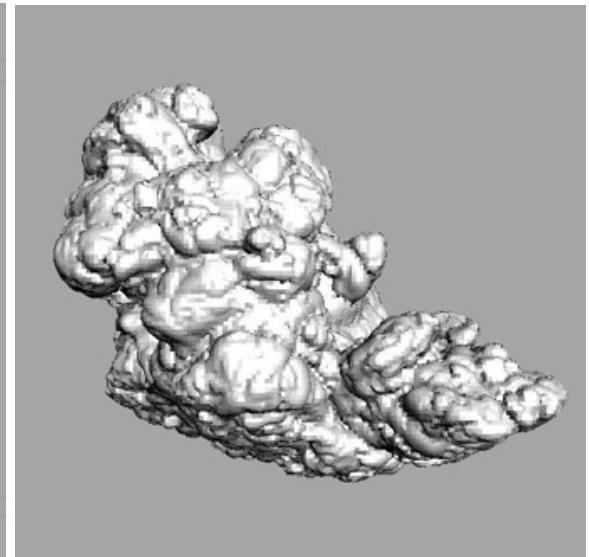
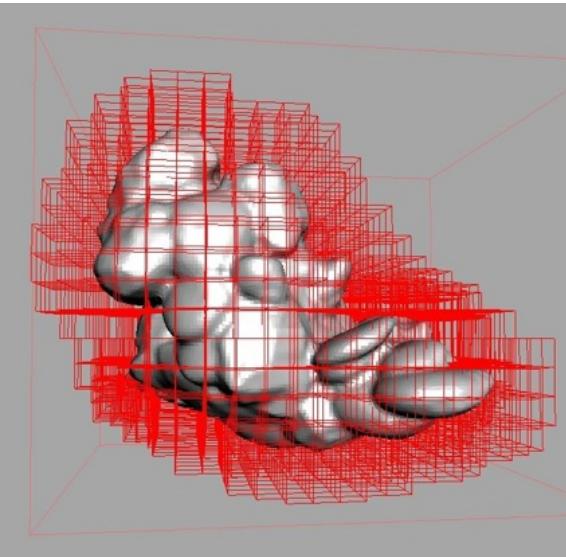
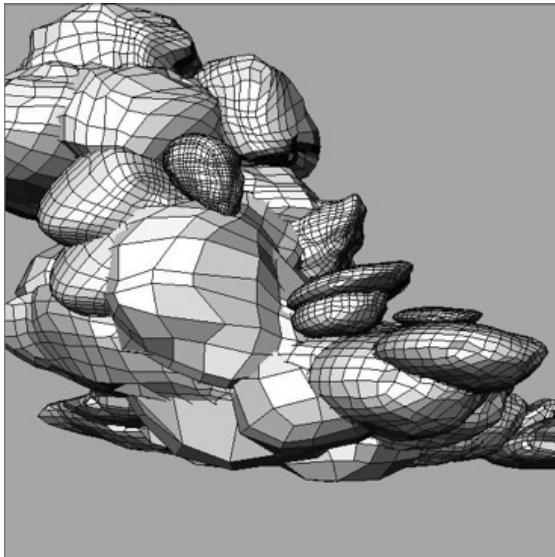


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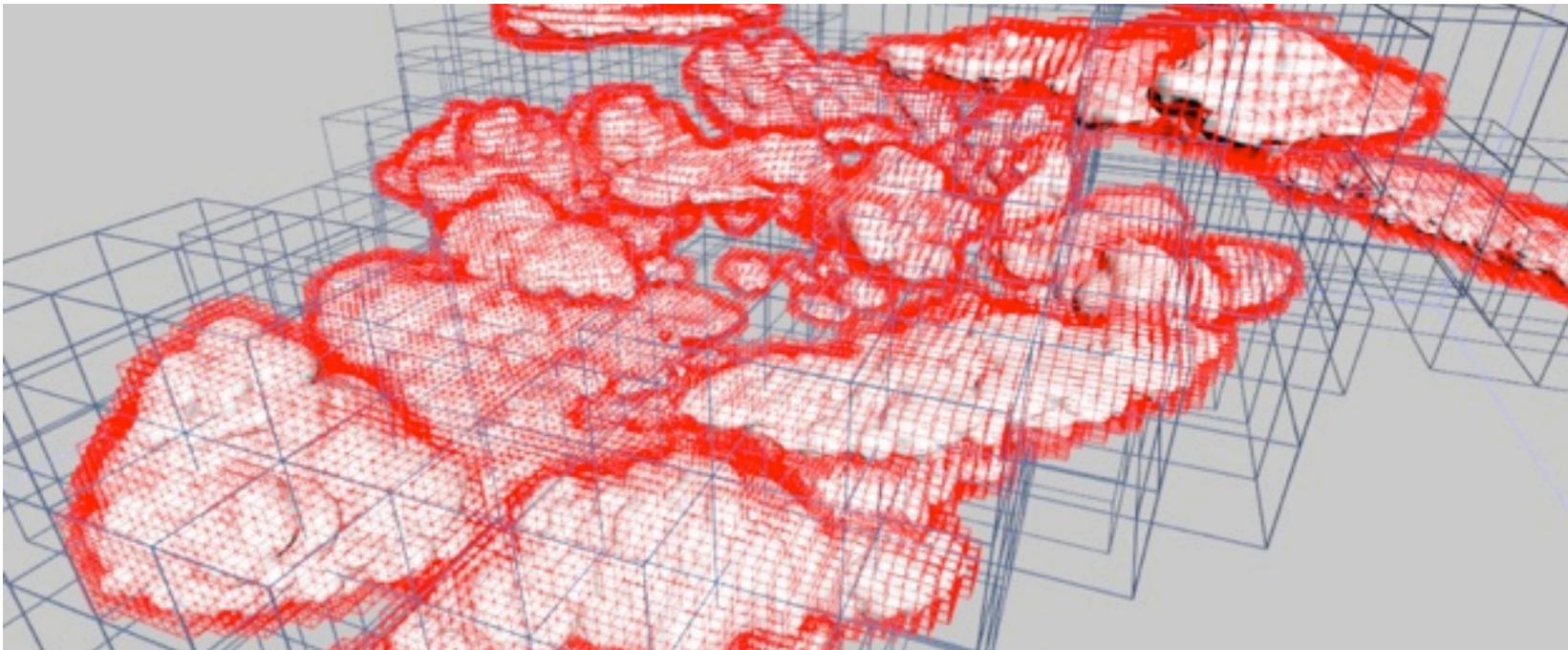
Cloud Modeling



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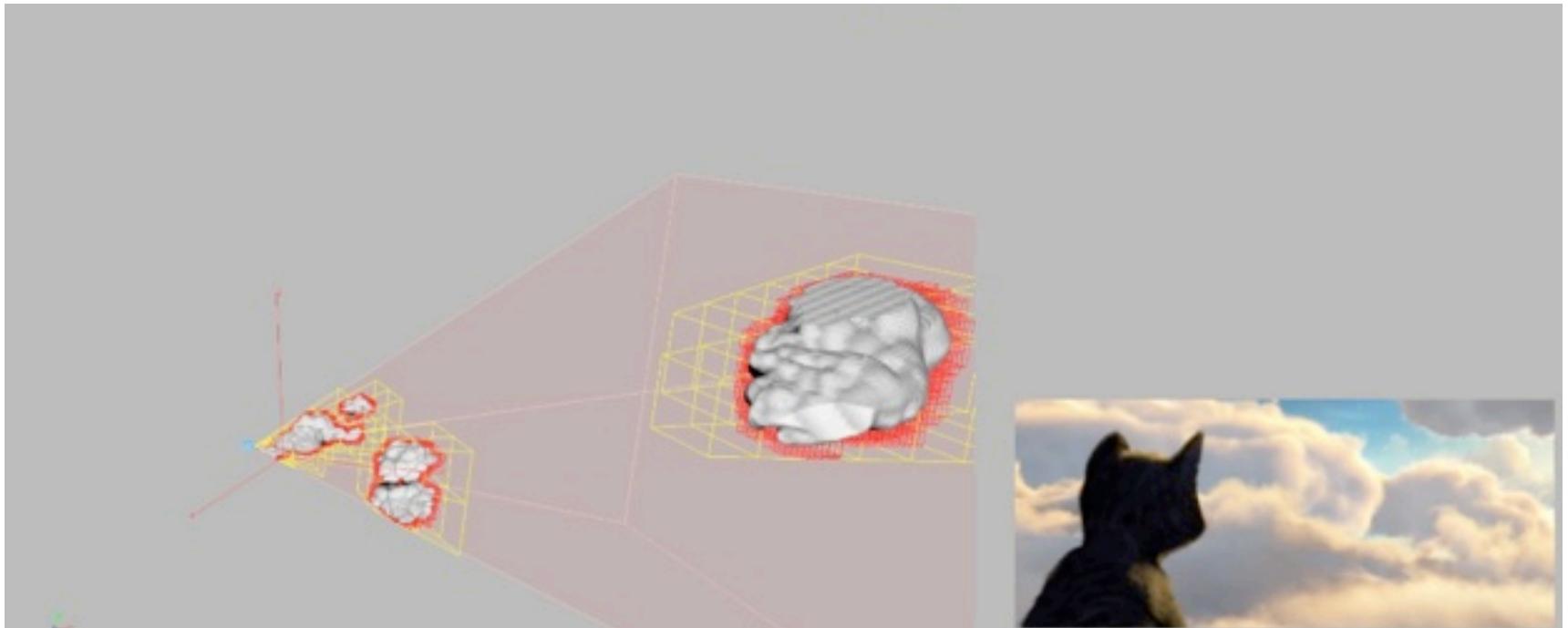
Cloud Modeling



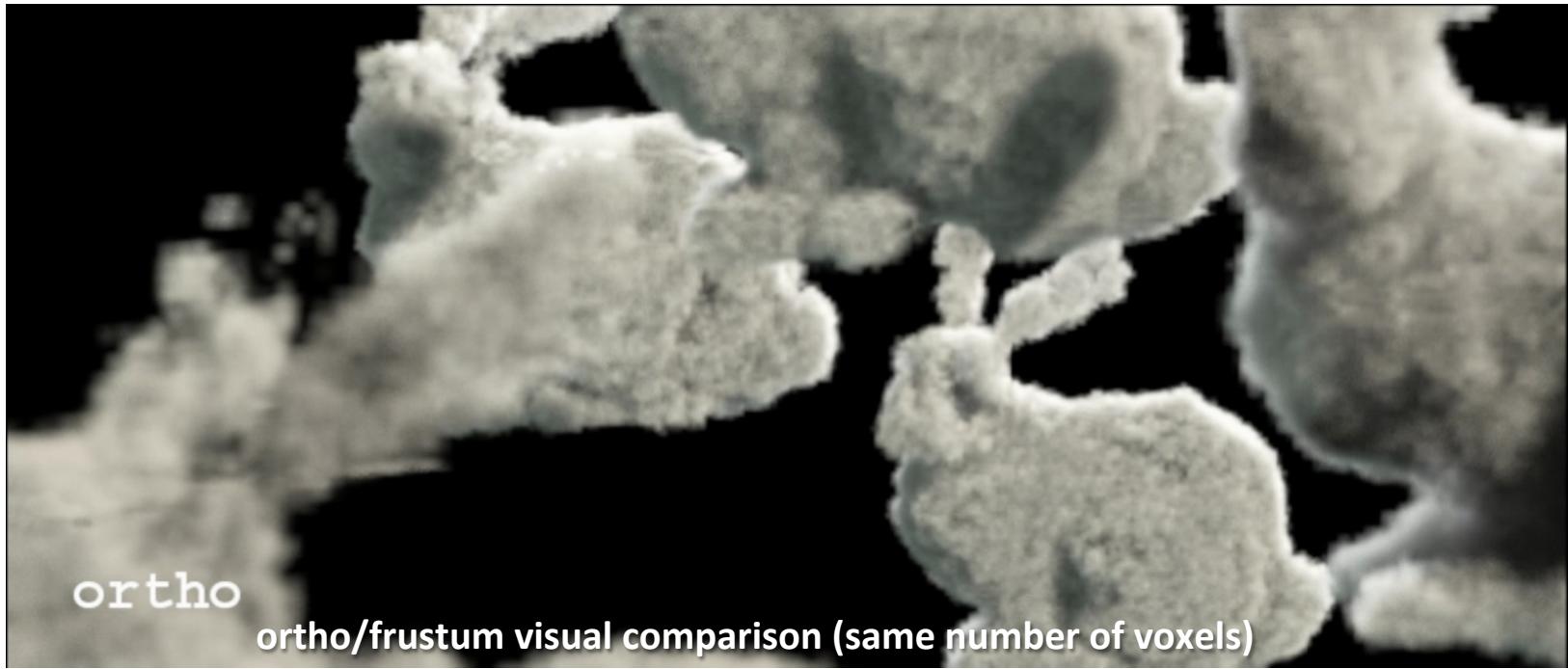
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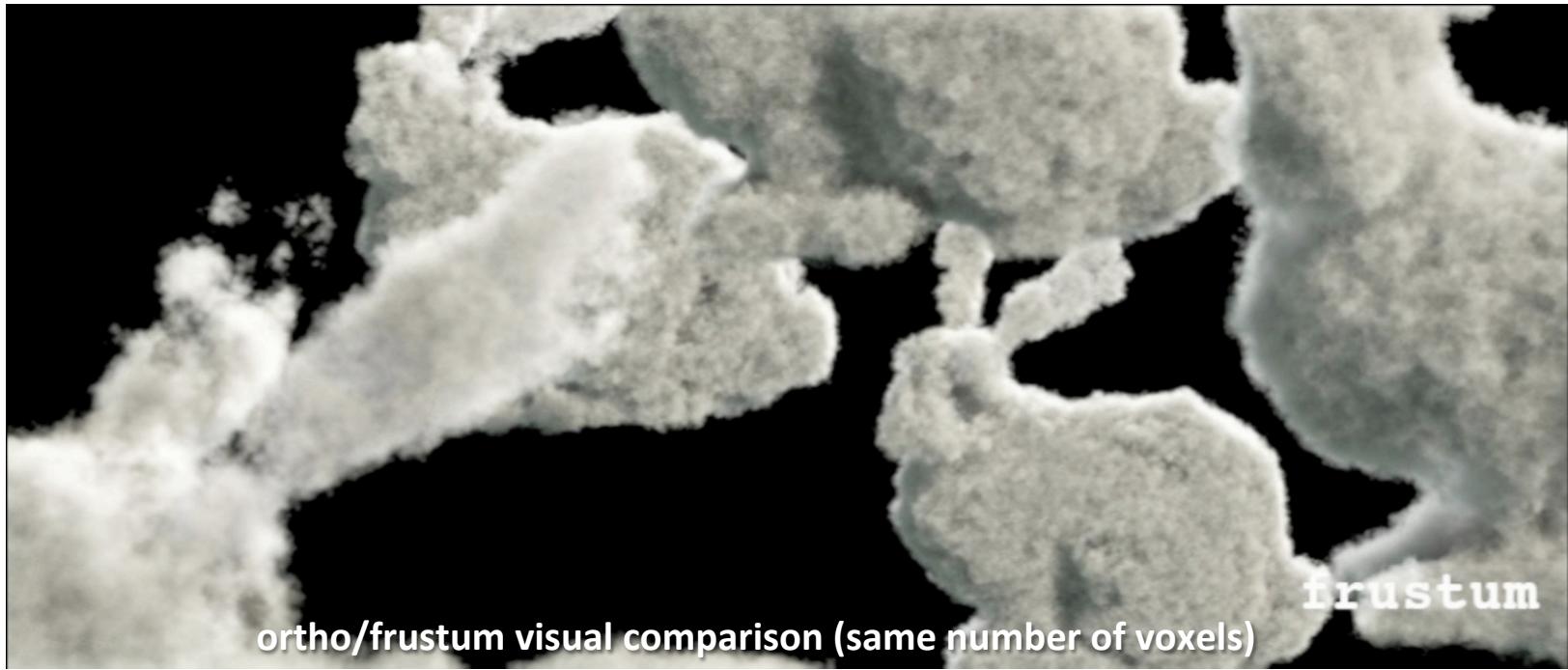
Frustum Buffers



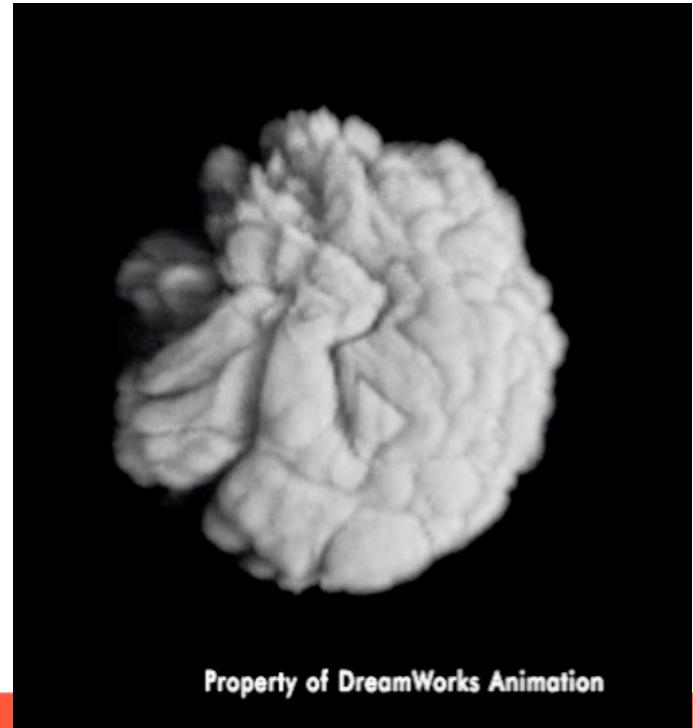
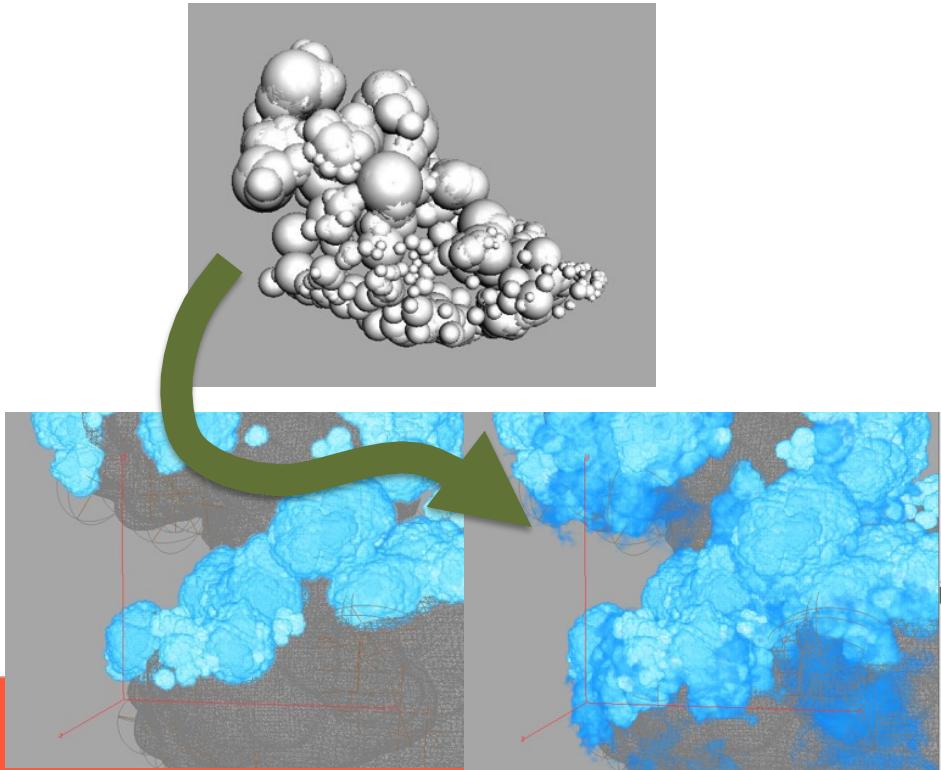
Frustum Buffers



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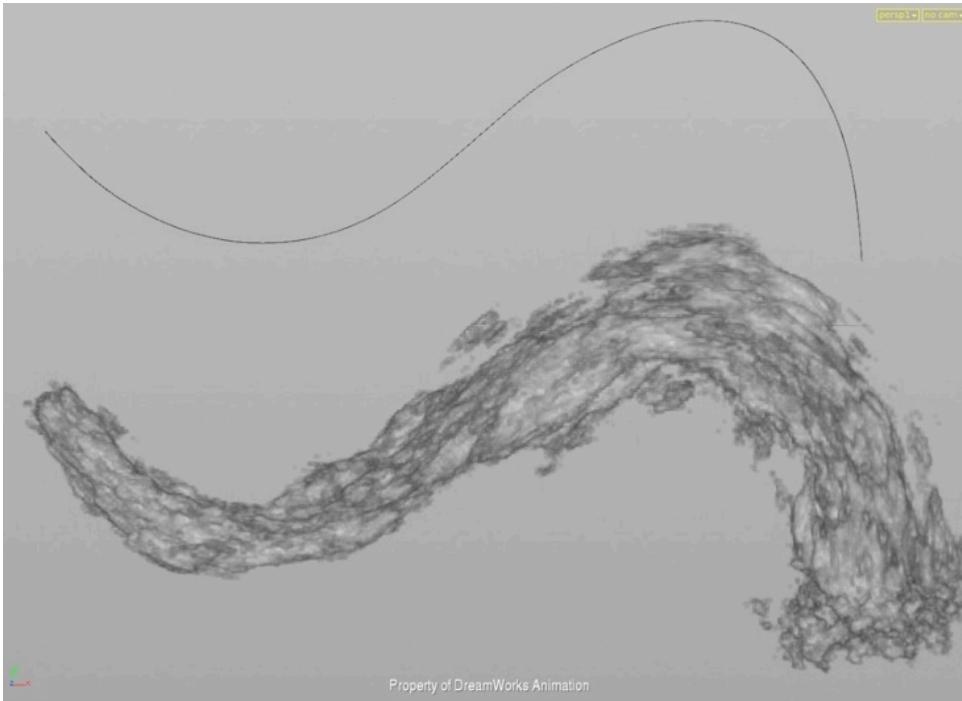
Raster Primitives



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Raster Primitives



Raster Primitives



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Raster Primitives



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Liquids



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Budsberg, J., Losure, M., Museth, K., Baer, M. Liquids in The Croods. DigiPro, 2013

Losure, M. Surreal Night Swimming in Home. Siggraph Dailies, 2015

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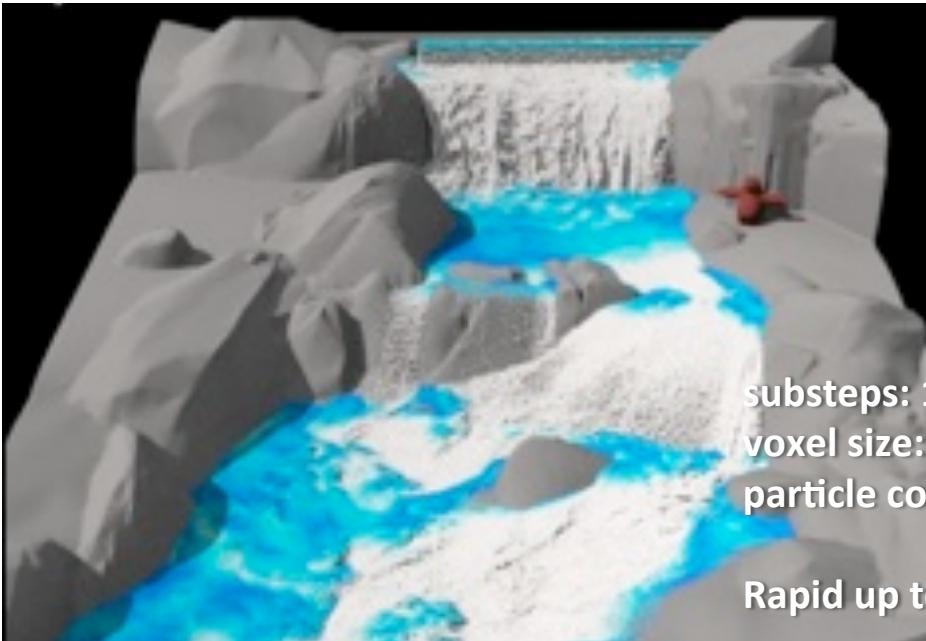
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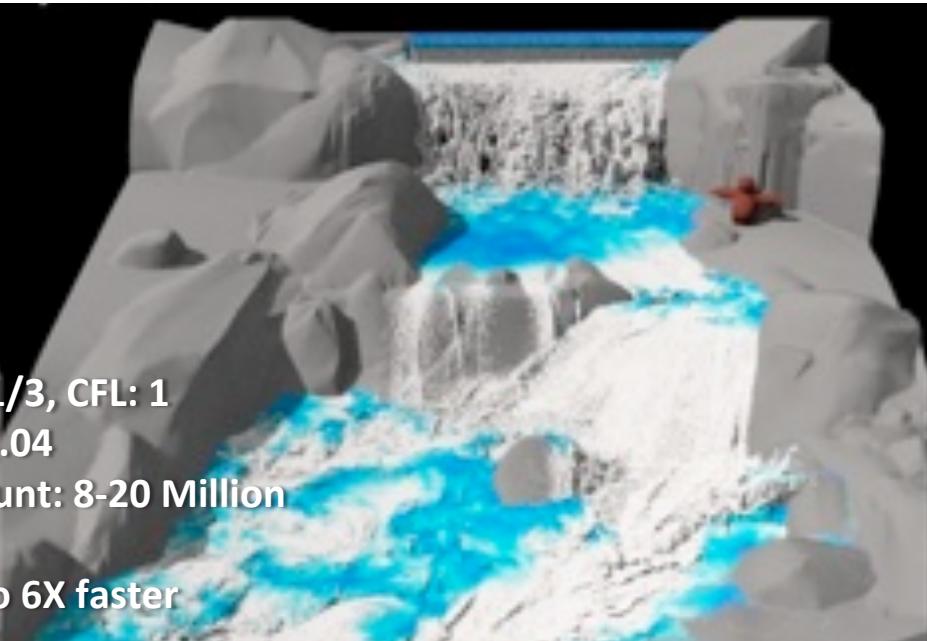
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Solvers

DWA Rapid



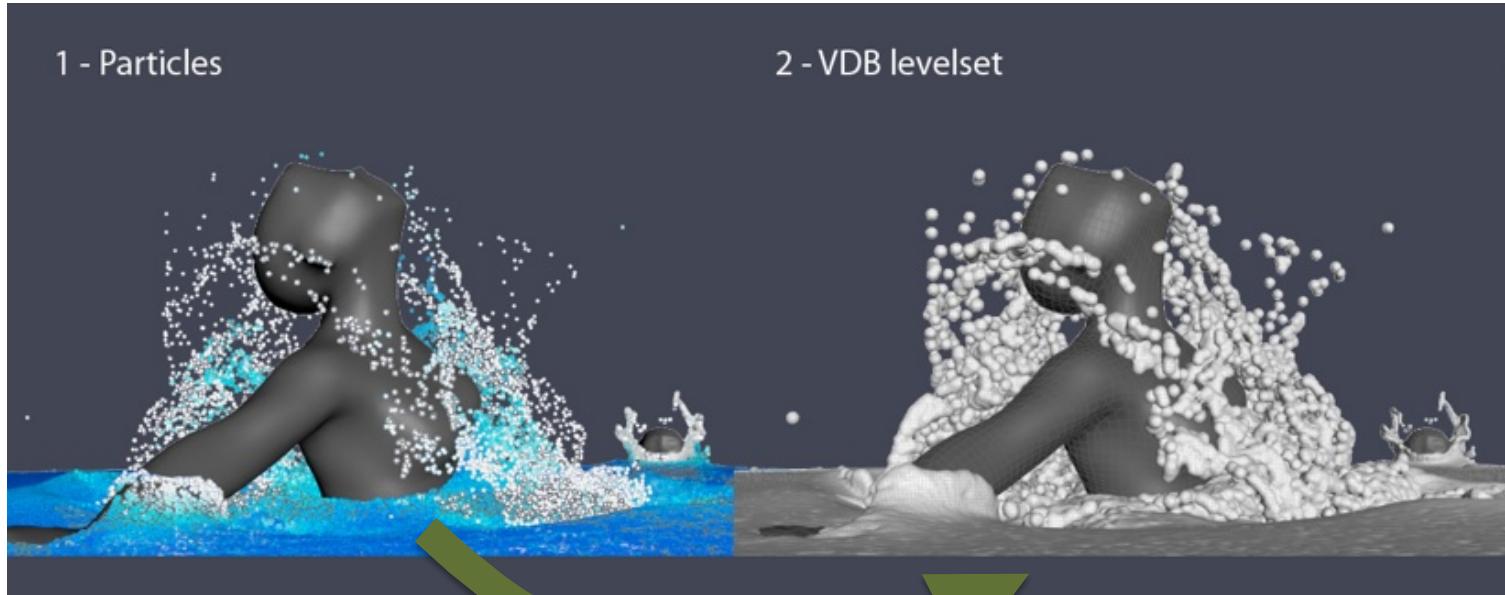
Houdini 13 FLIP



substeps: 1/3, CFL: 1
voxel size: .04
particle count: 8-20 Million

Rapid up to 6X faster

Particle to Level Set

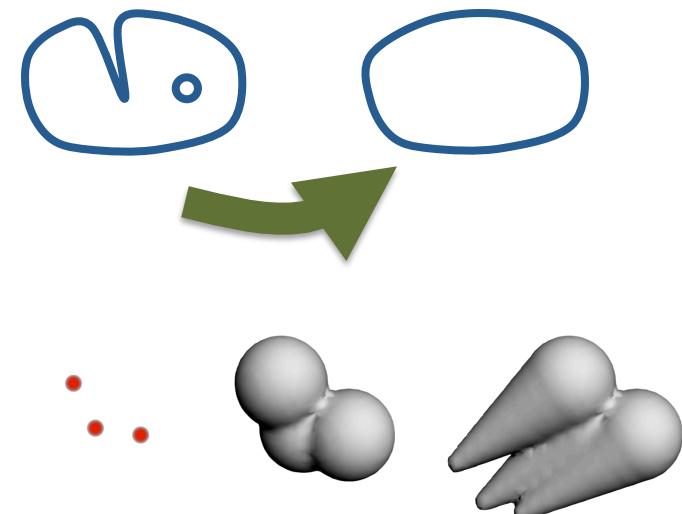


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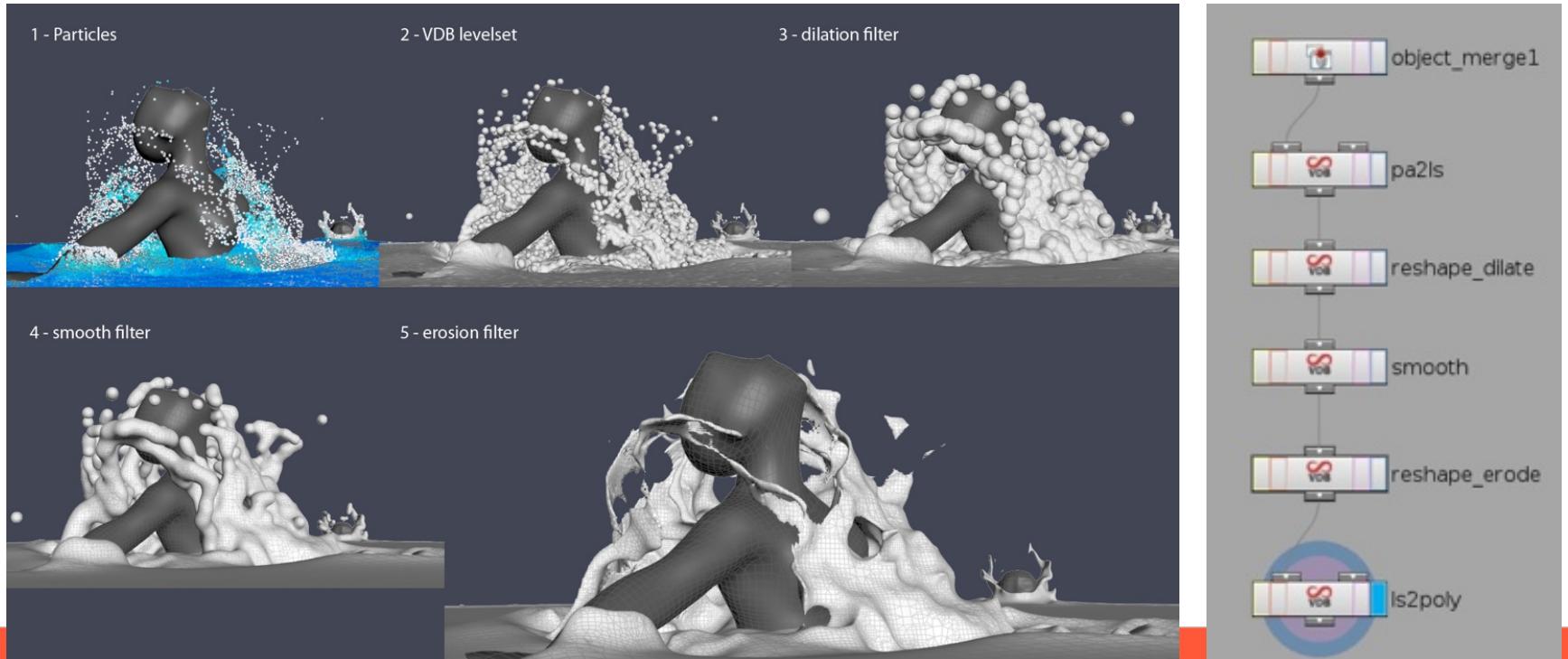
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Particle to Level Set

- Artists want control
 - Remove artifacts / holes
 - Accentuate sharp features
 - Smooth flat areas
 - And make it fast!



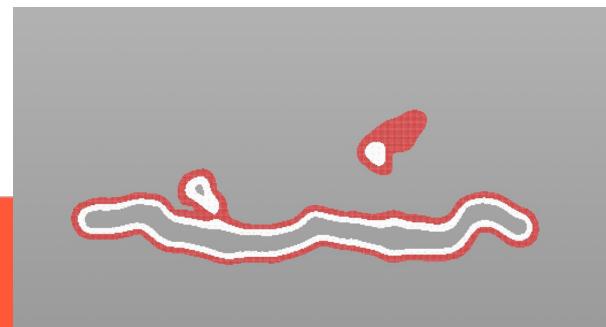
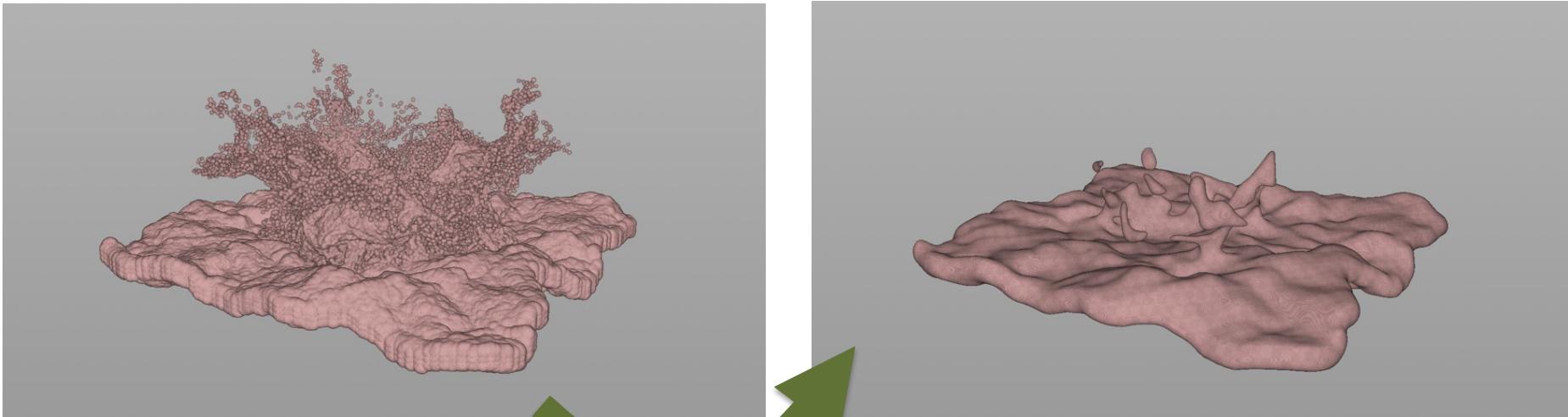
LS Filtering / Morphological Ops



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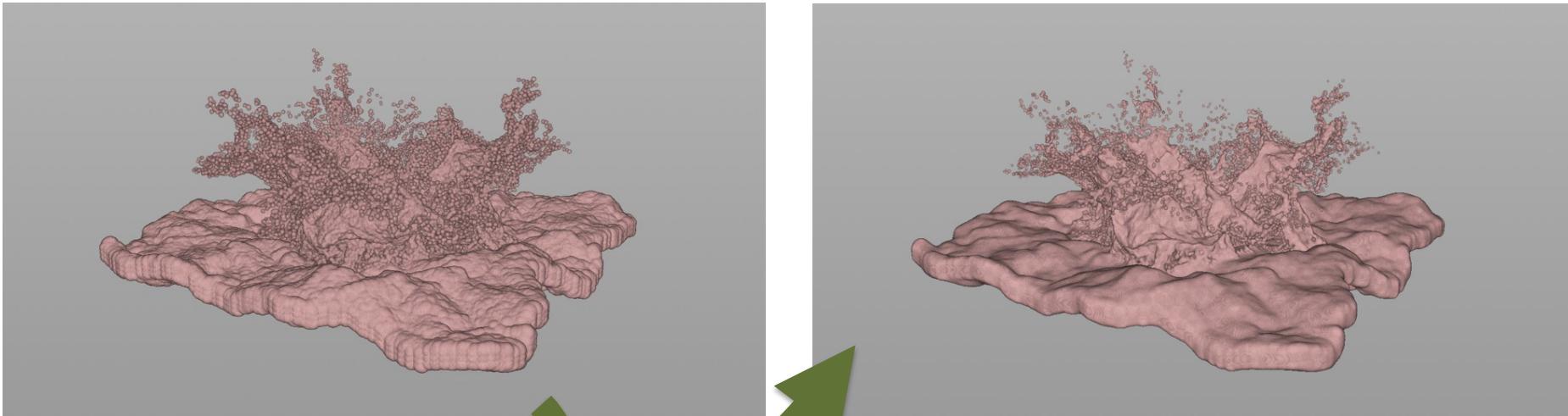
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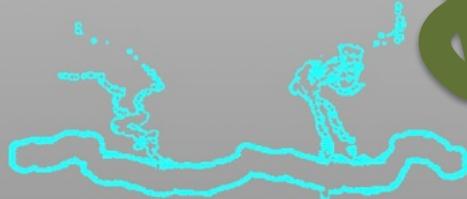


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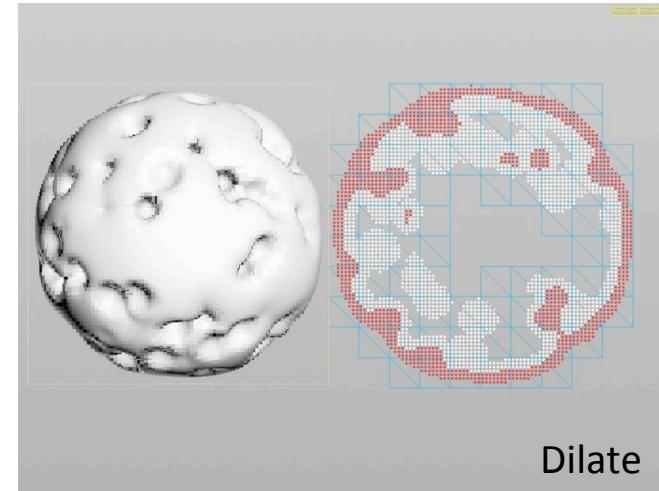
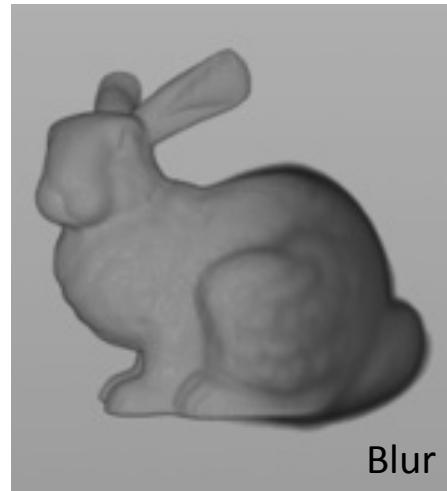
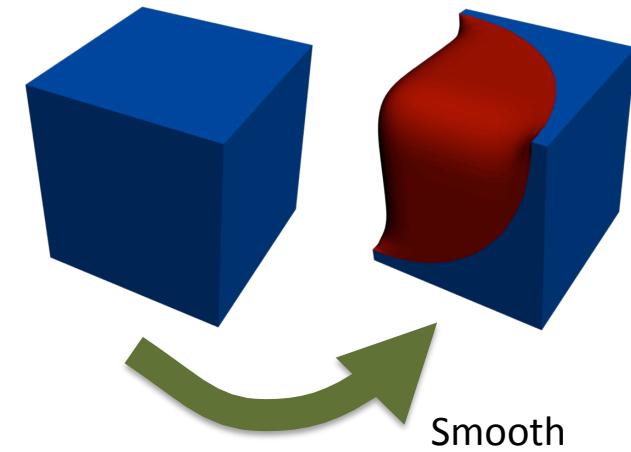


Mask

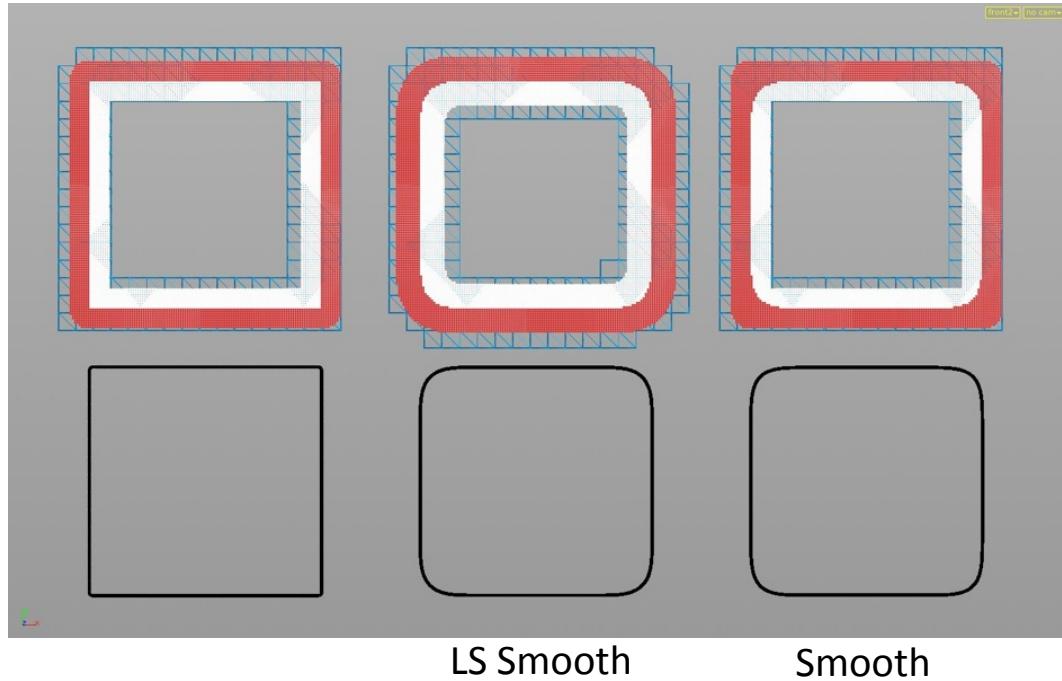


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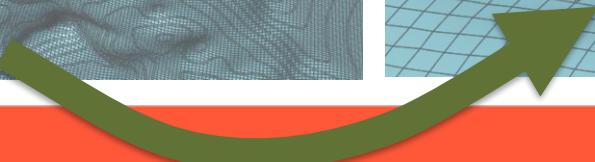
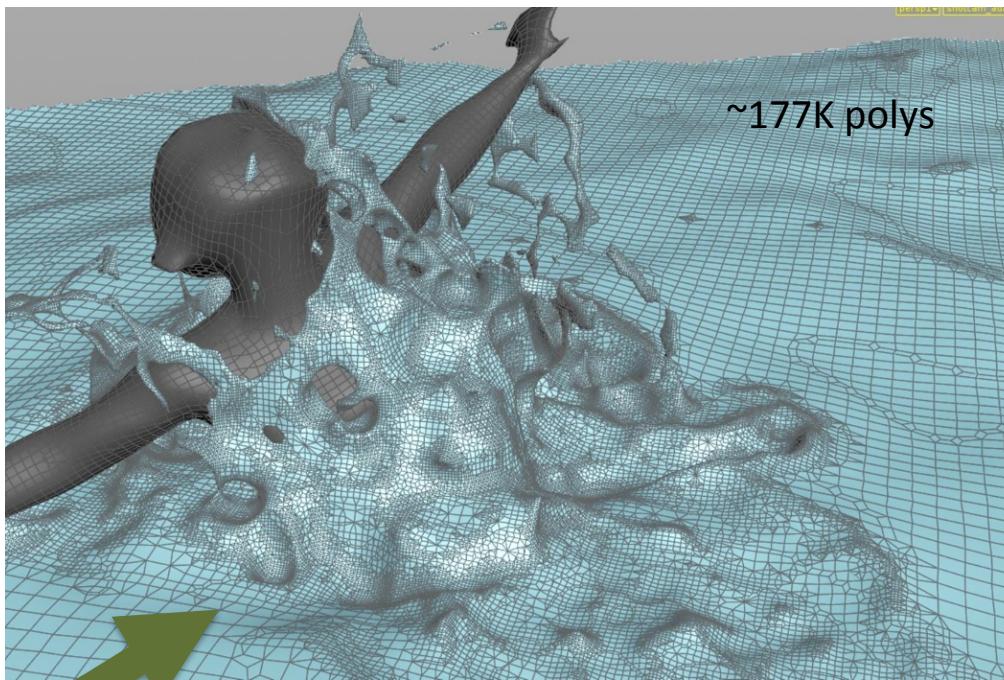
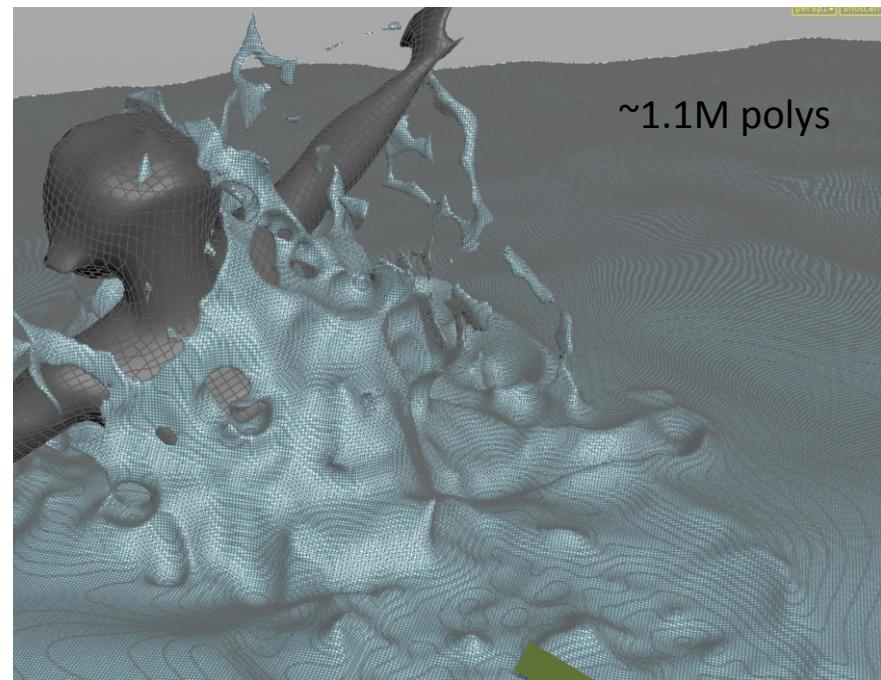
LS Filtering / Morphological Ops



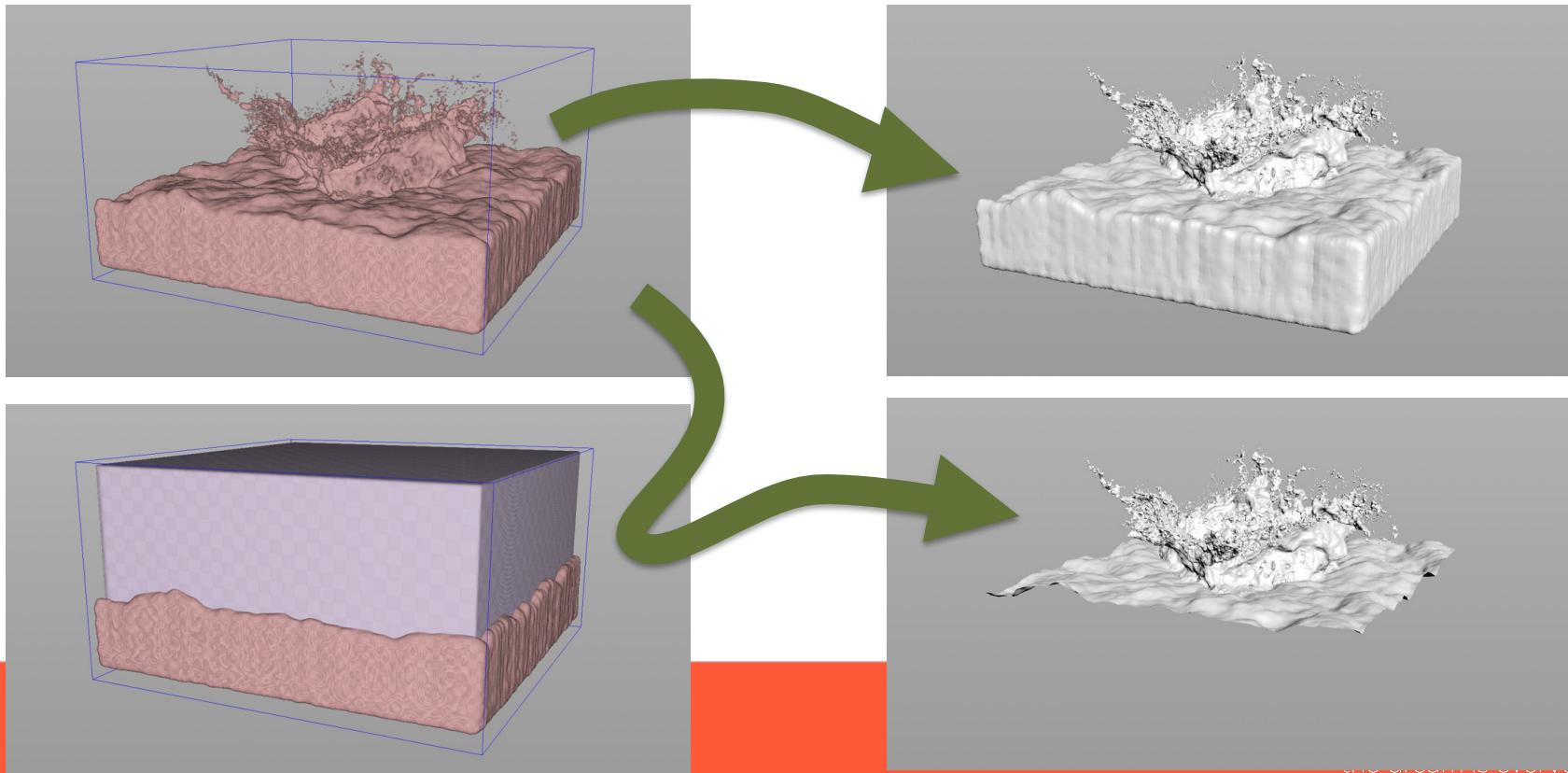
LS Filtering / Morphological Ops



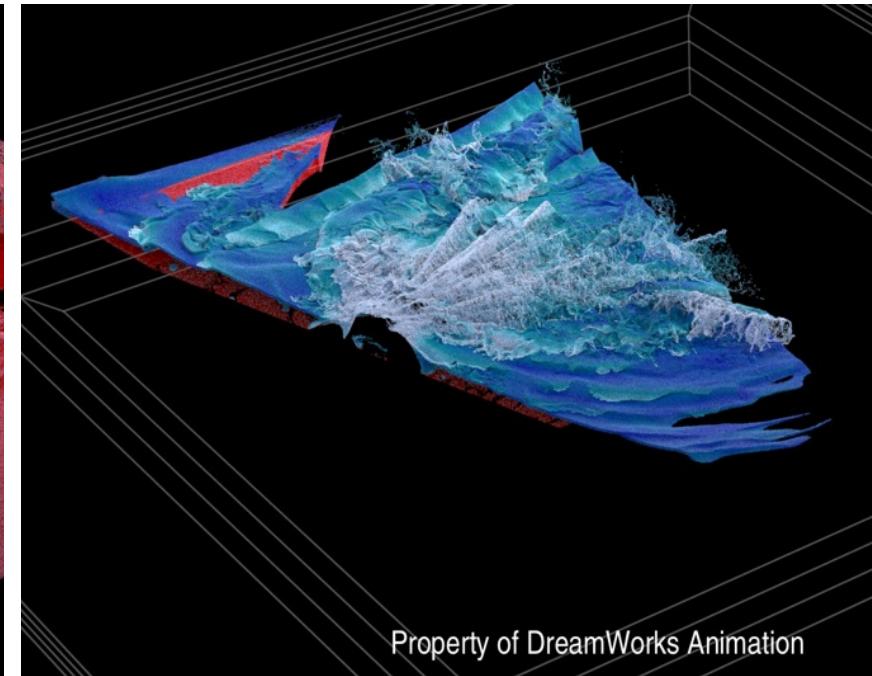
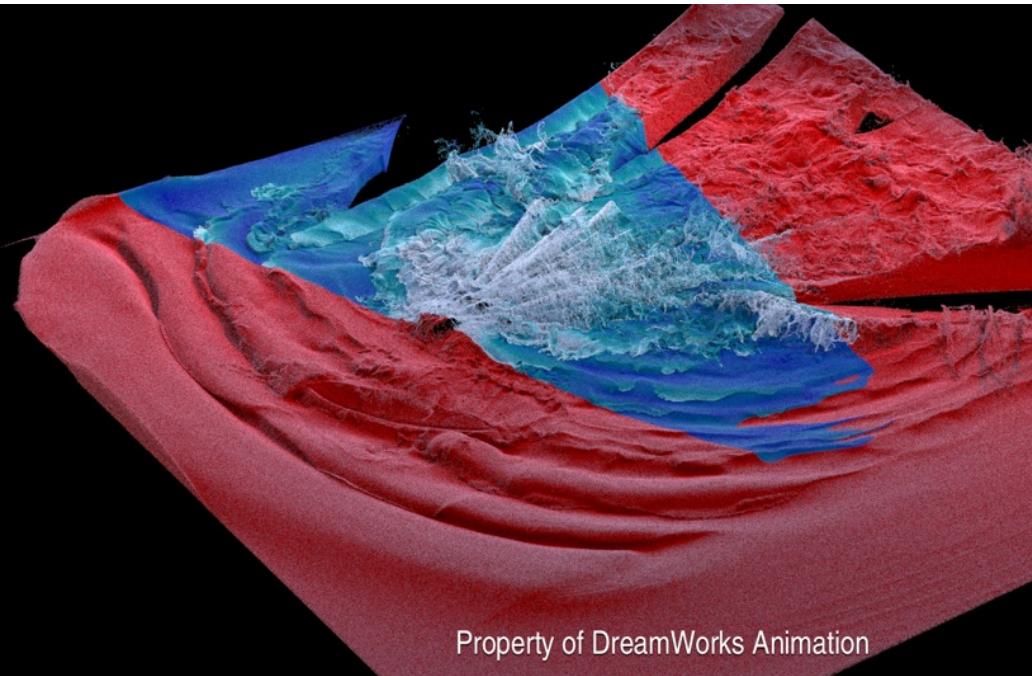
Adaptive meshing



Masked Meshing



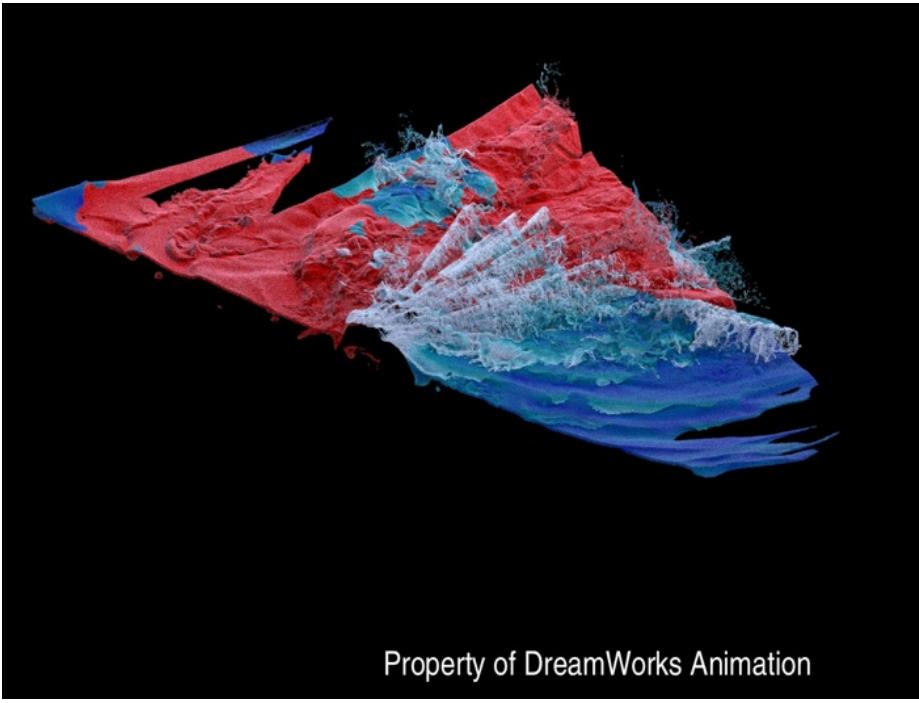
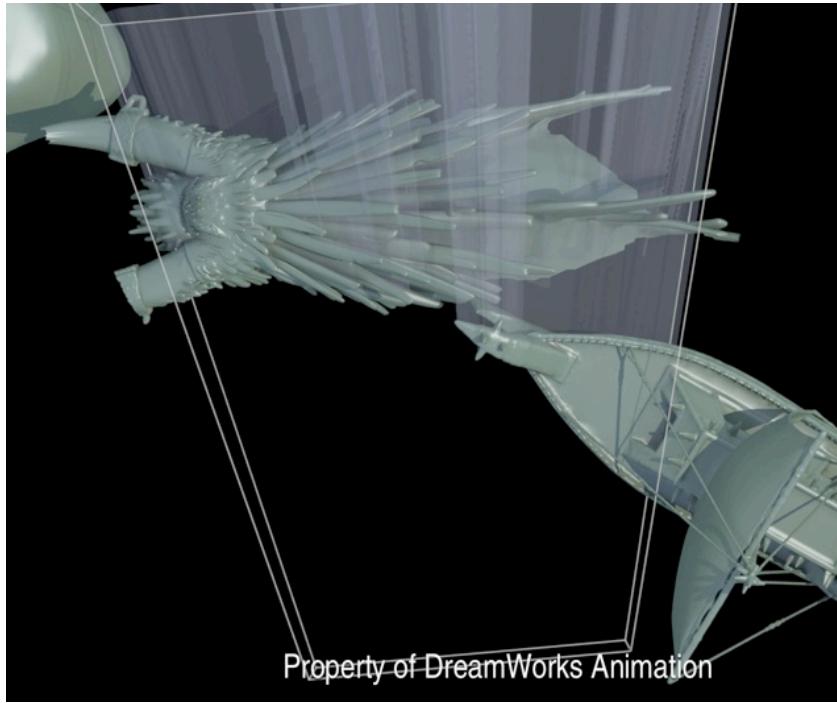
Simplification Masks



Van Opstal, B., Janin, L., Museth, K. Large Scale Simulation and Surfacing of Water and Ice in How to Train Your Dragon 2, Siggraph Talk, 2014

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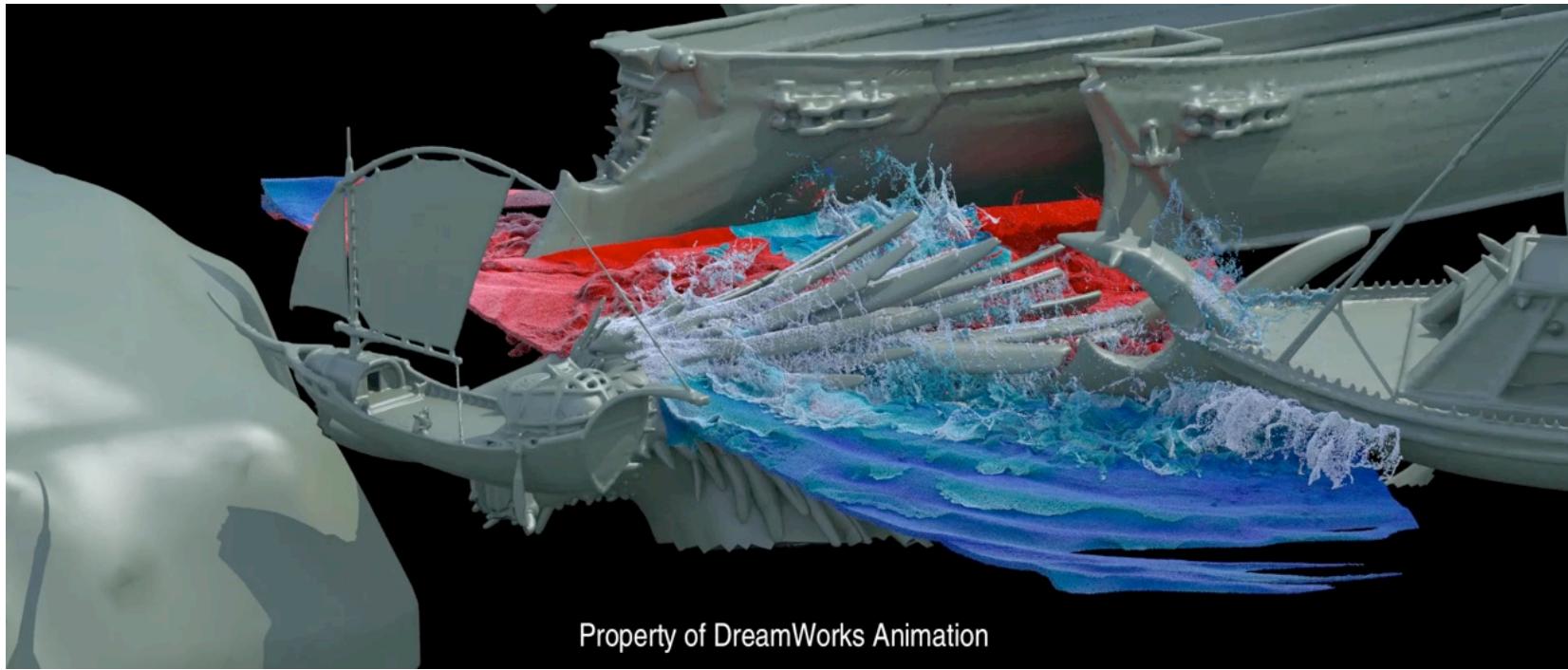
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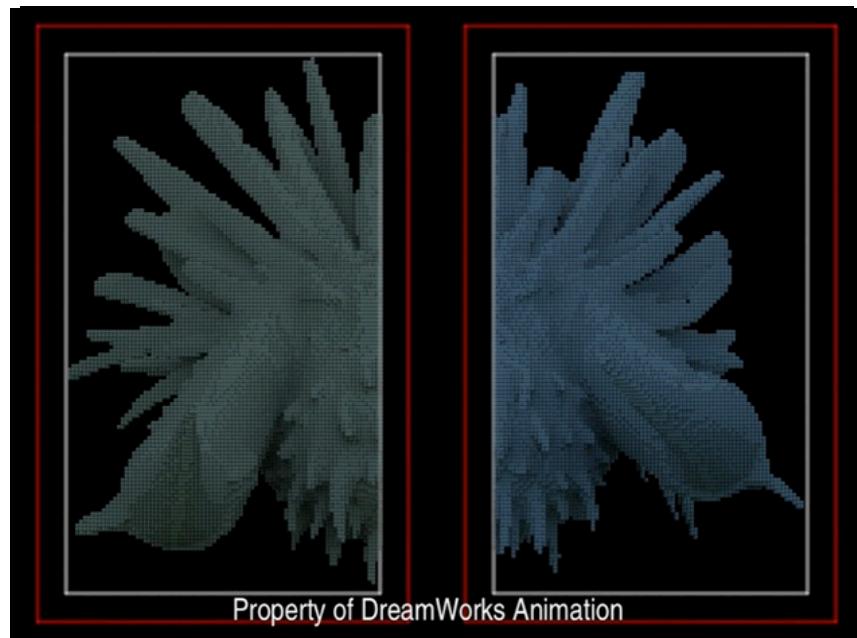
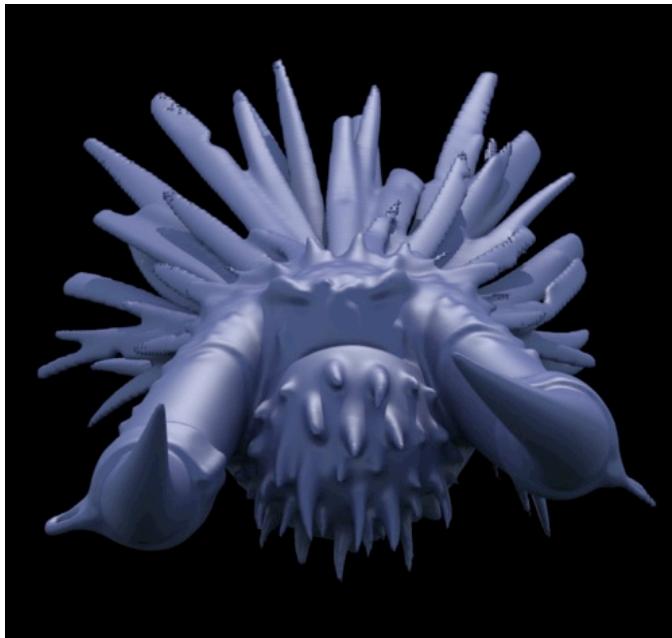


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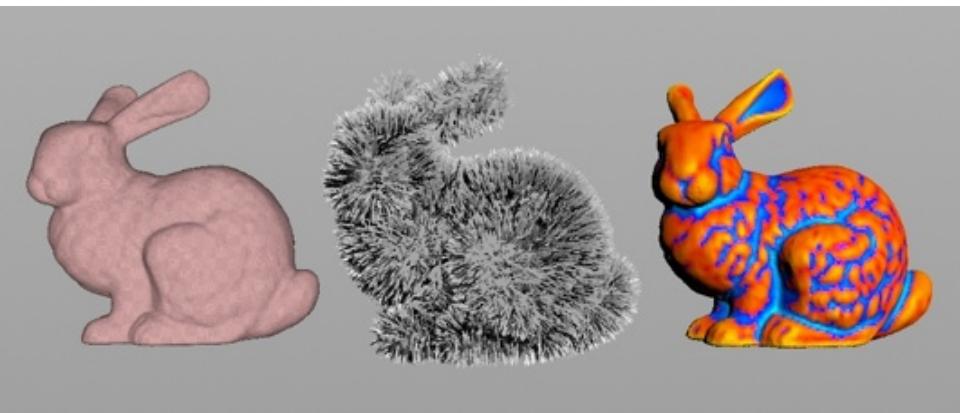
Distributed Filtering



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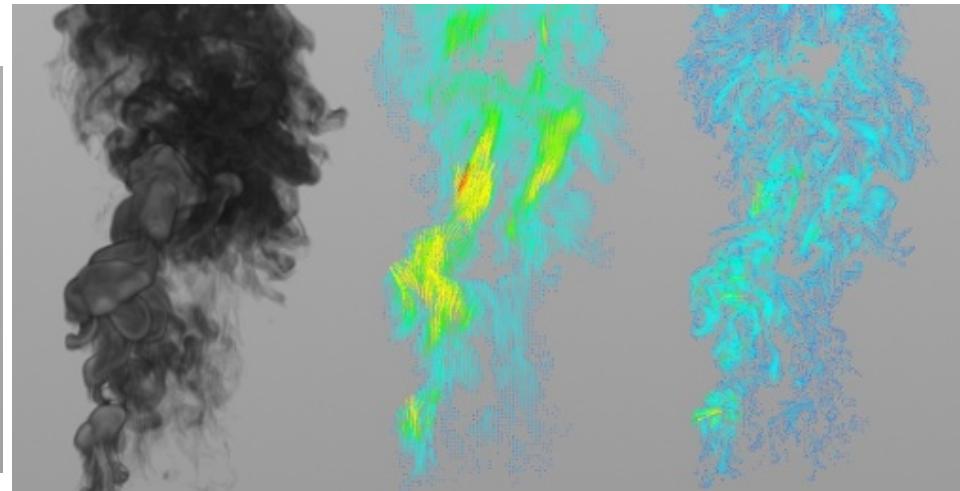
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Grid Analysis



gradient

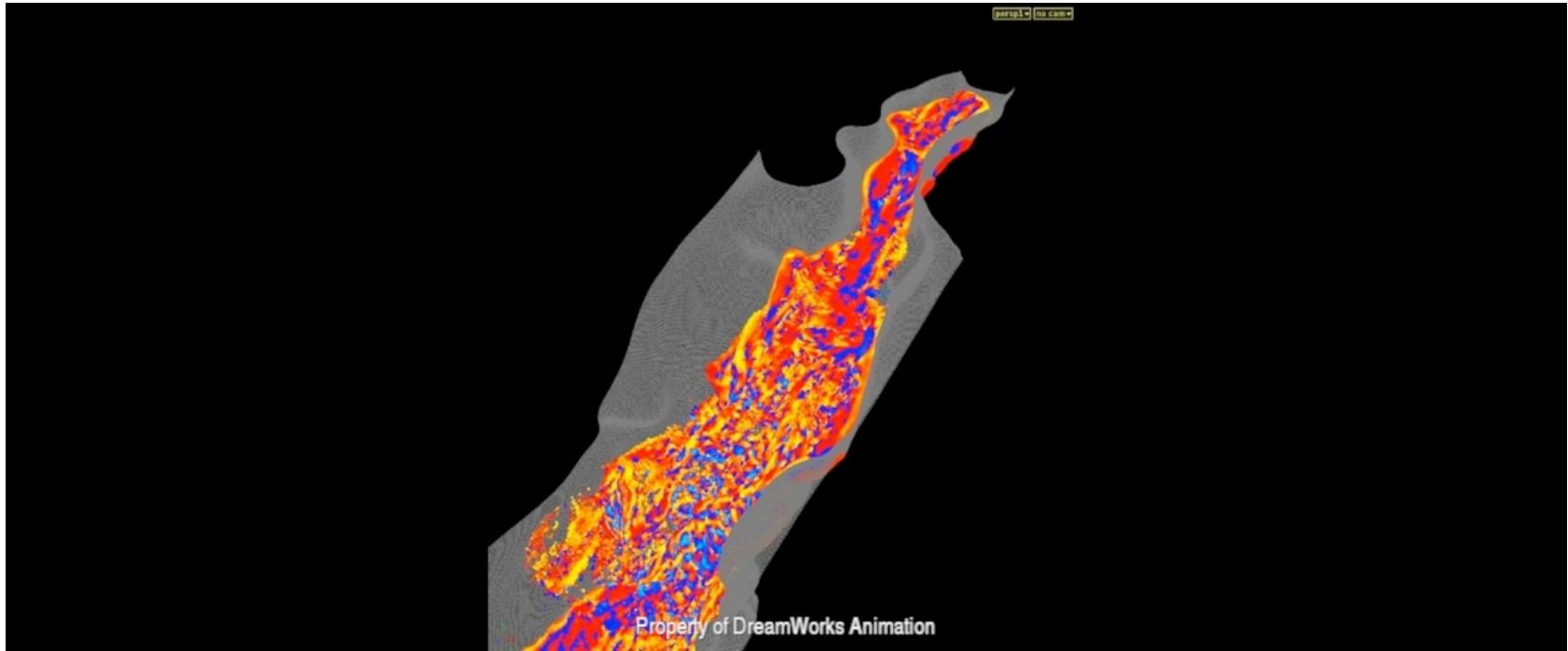
curvature



velocity

vorticity

Grid Analysis

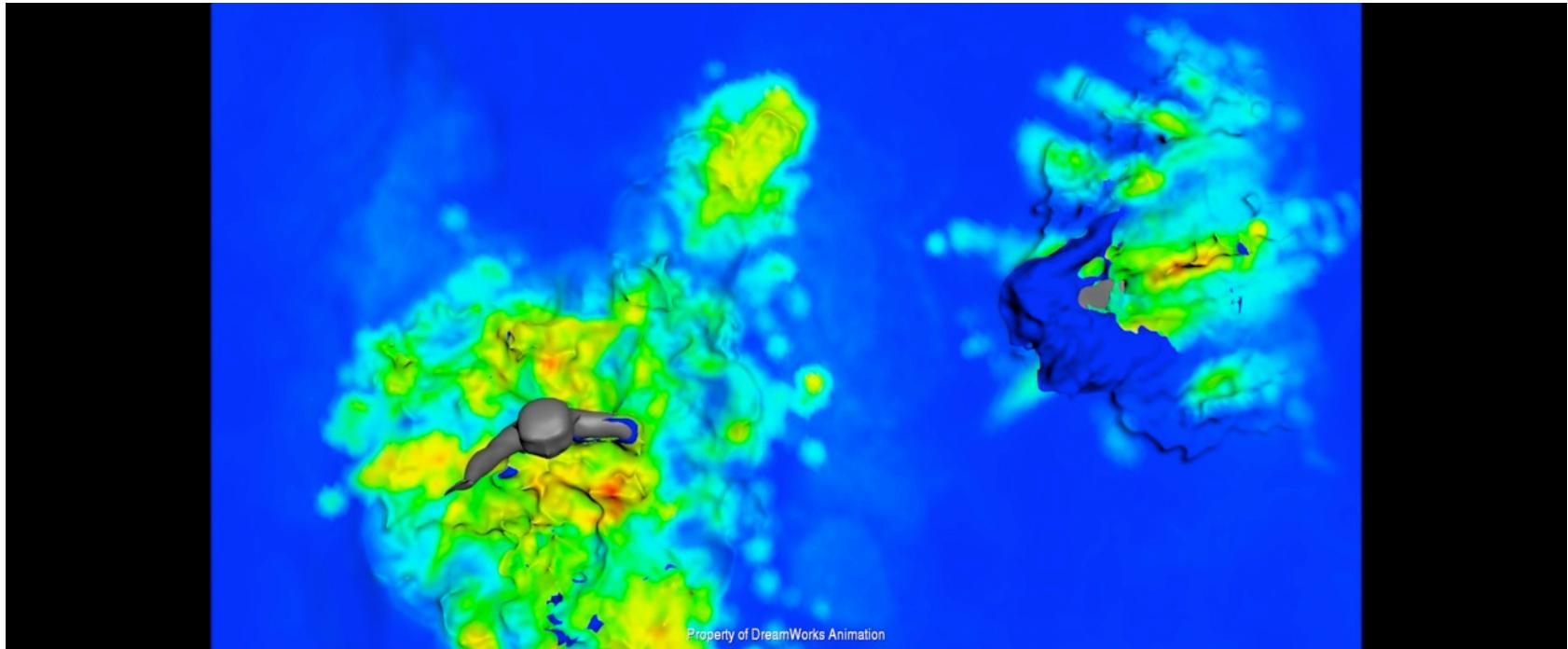


Grid Analysis



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Grid Analysis



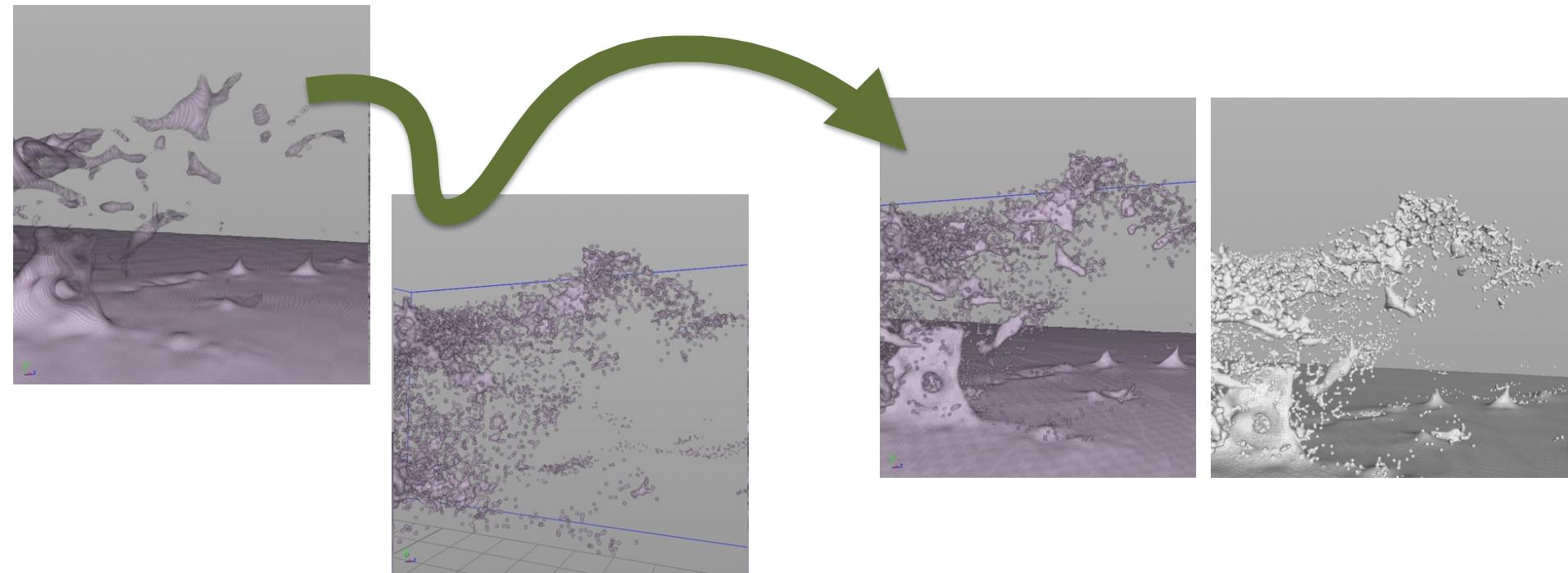
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Grid Analysis

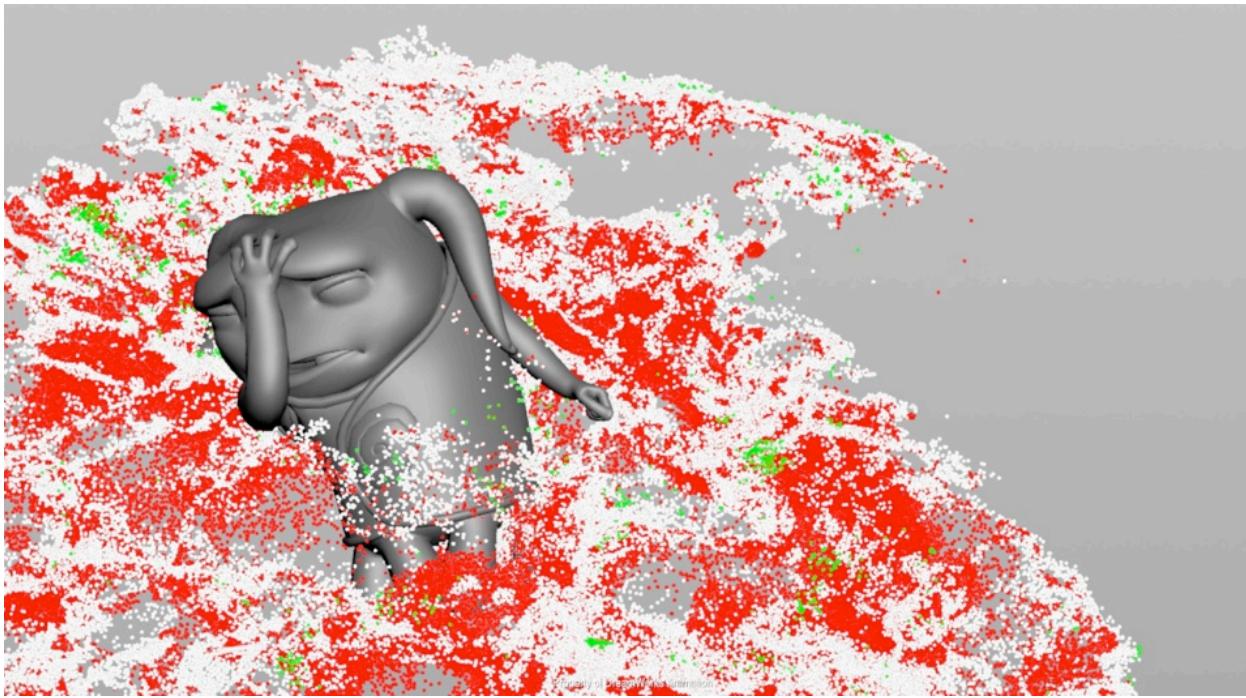


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Secondary Elements



Secondary Elements



Losure, M. Surreal Night Swimming in Home. Siggraph Dailies, 2015

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Secondary Elements



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Secondary Elements



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Vector Fields

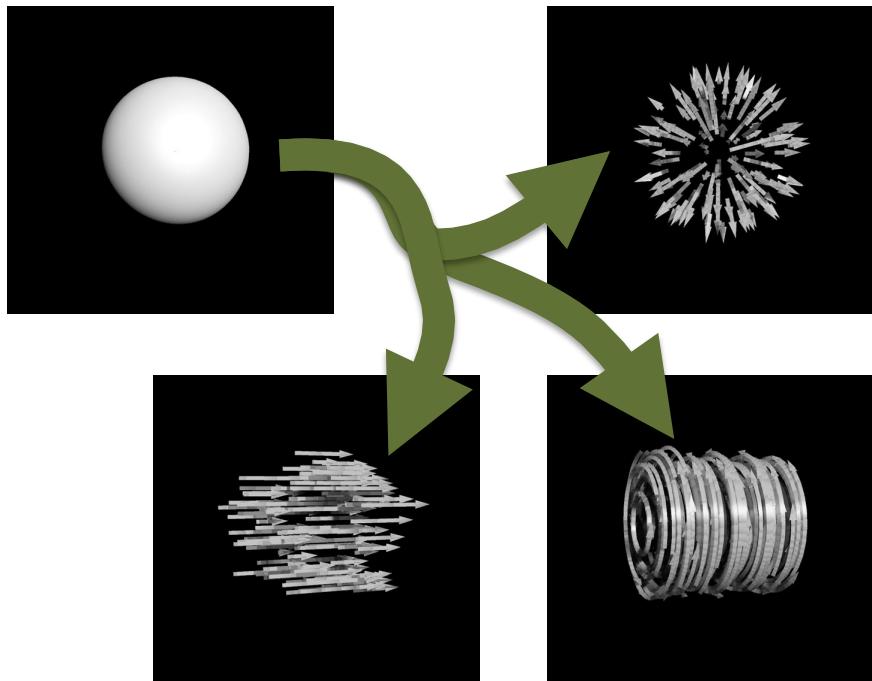
The image displays a 3D vector field simulation on the left, featuring a complex, swirling pattern of white lines on a gray background, representing flow direction and magnitude. To the right is a screenshot of the VEXBuilder software interface, which is used for creating visual effects. The interface shows a node graph with the following components and connections:

- volumevopglobal1**: A volume node with various parameters like density, size, and center.
- vectorfloat1**: Converts a vector input into a float value.
- mulconst1**: Multiplies the float value by a constant (0.01).
- mulconst2**: Multiplies the float value by another constant (0.01).
- const1(0)**: A constant node set to 0.
- floattovec1**: Converts the float value back into a vector.
- bind1(v)**: A binding node that links the output vector to the volume's "Combined Value" parameter.

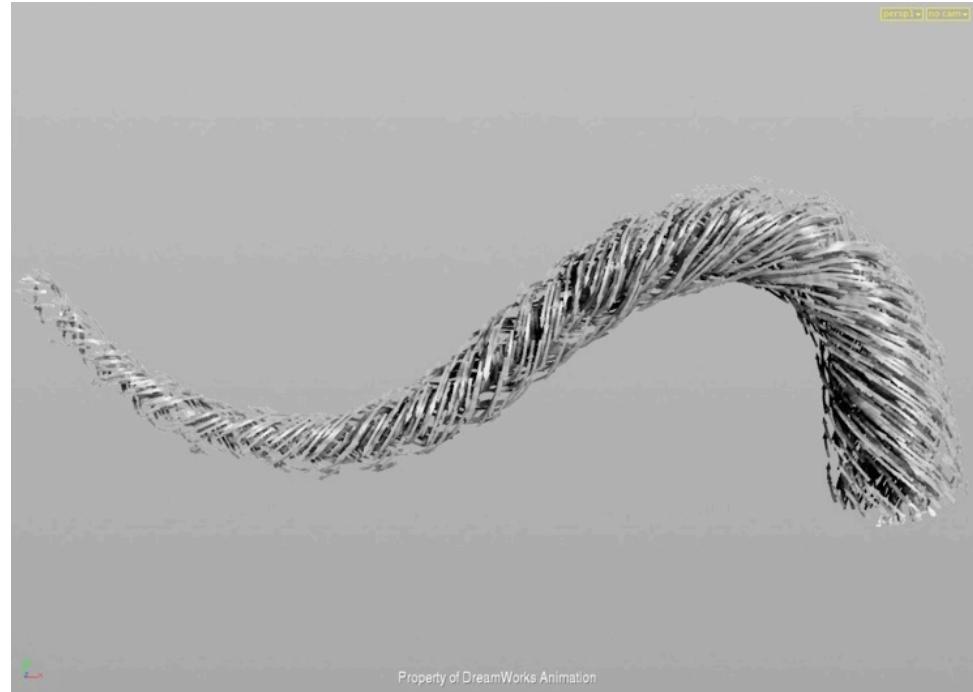
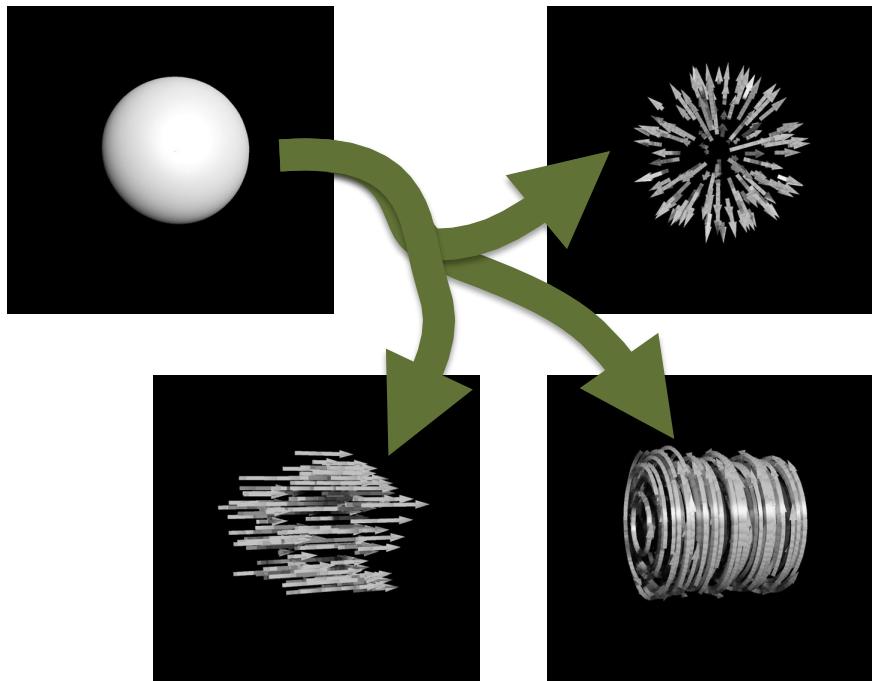
The connections show a feedback loop where the output of the volume is fed back into its own inputs, and the final output is used to modify the volume's properties.

$$F(x, y, z) = \hat{y}x - \hat{x}y$$

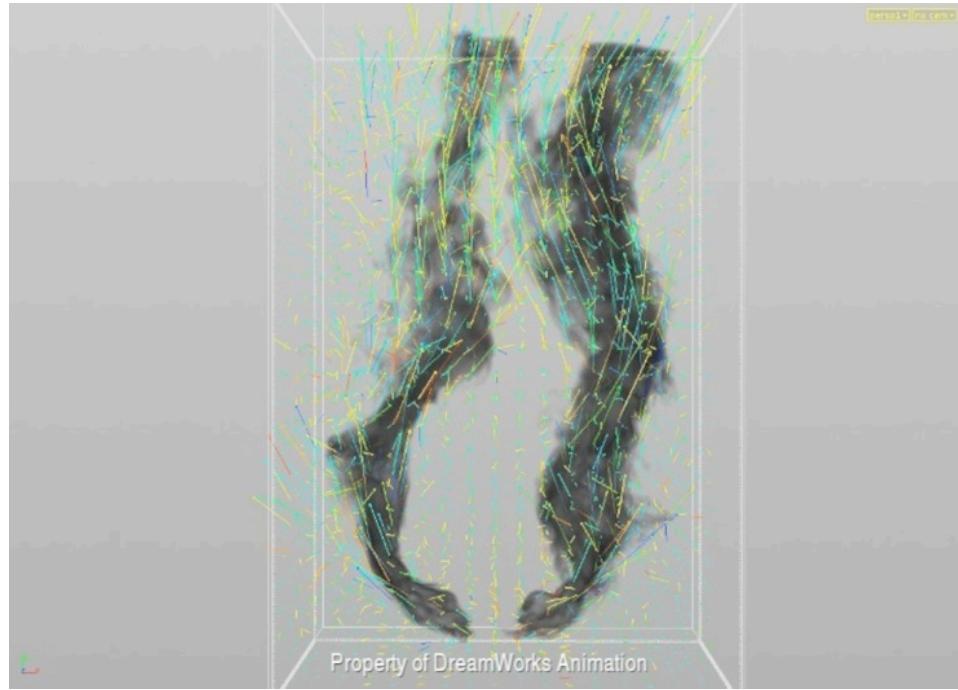
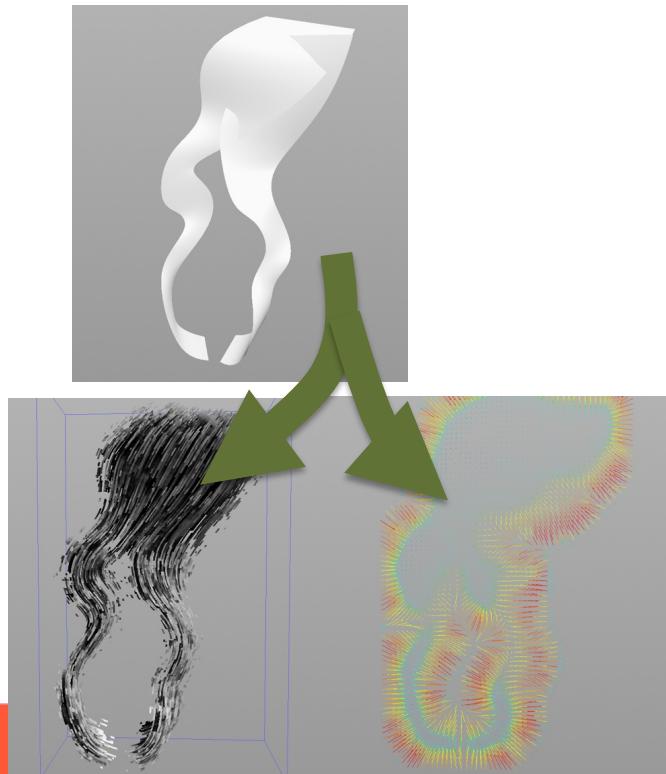
Vector Fields



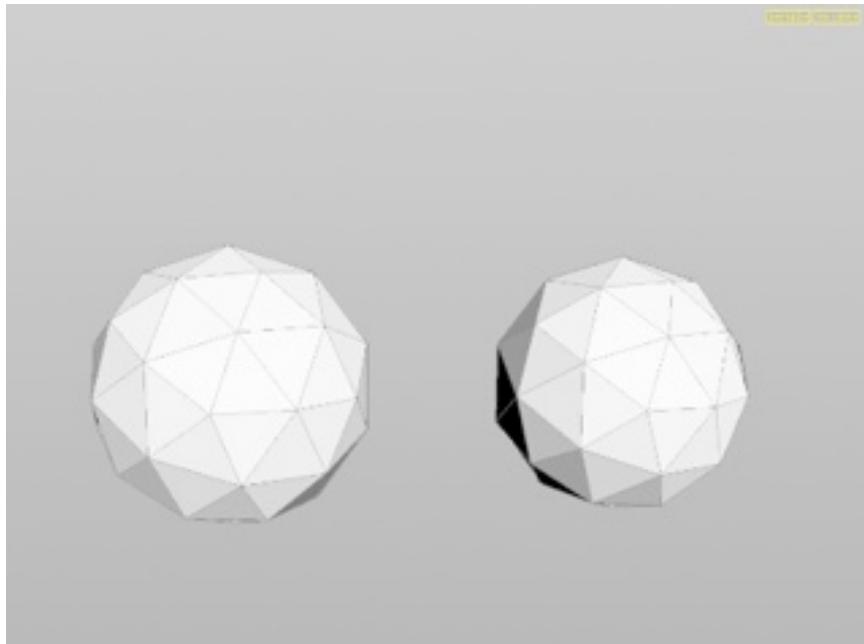
Vector Fields



Flow fields

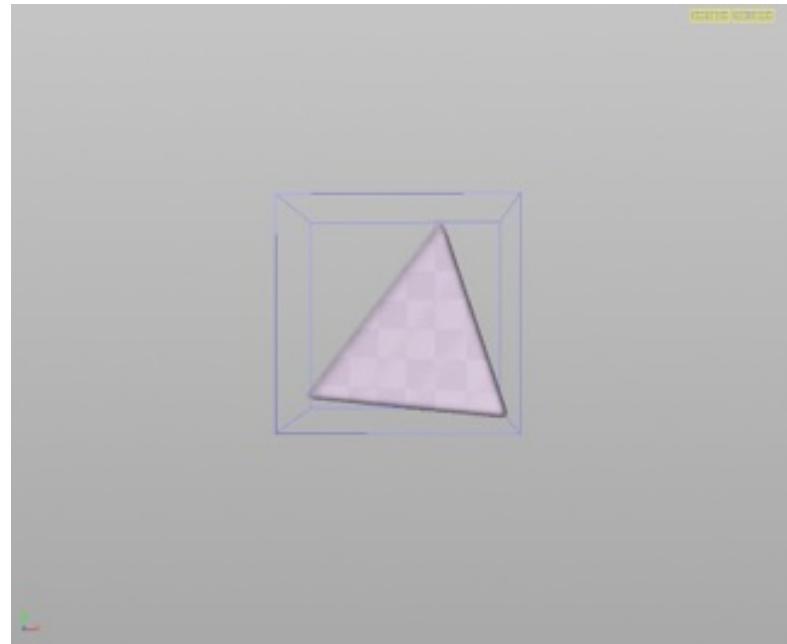


Advection



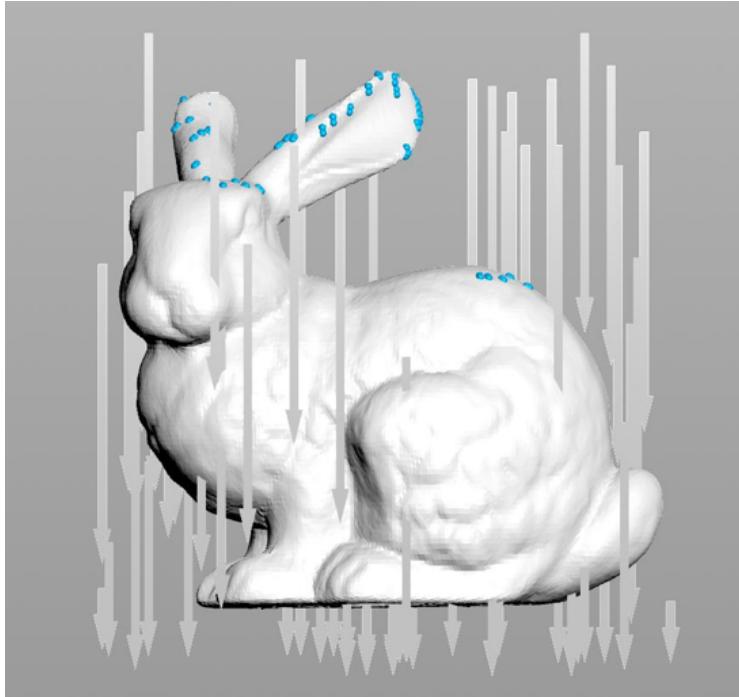
Forward Euler

Runge-Kutta 4th order



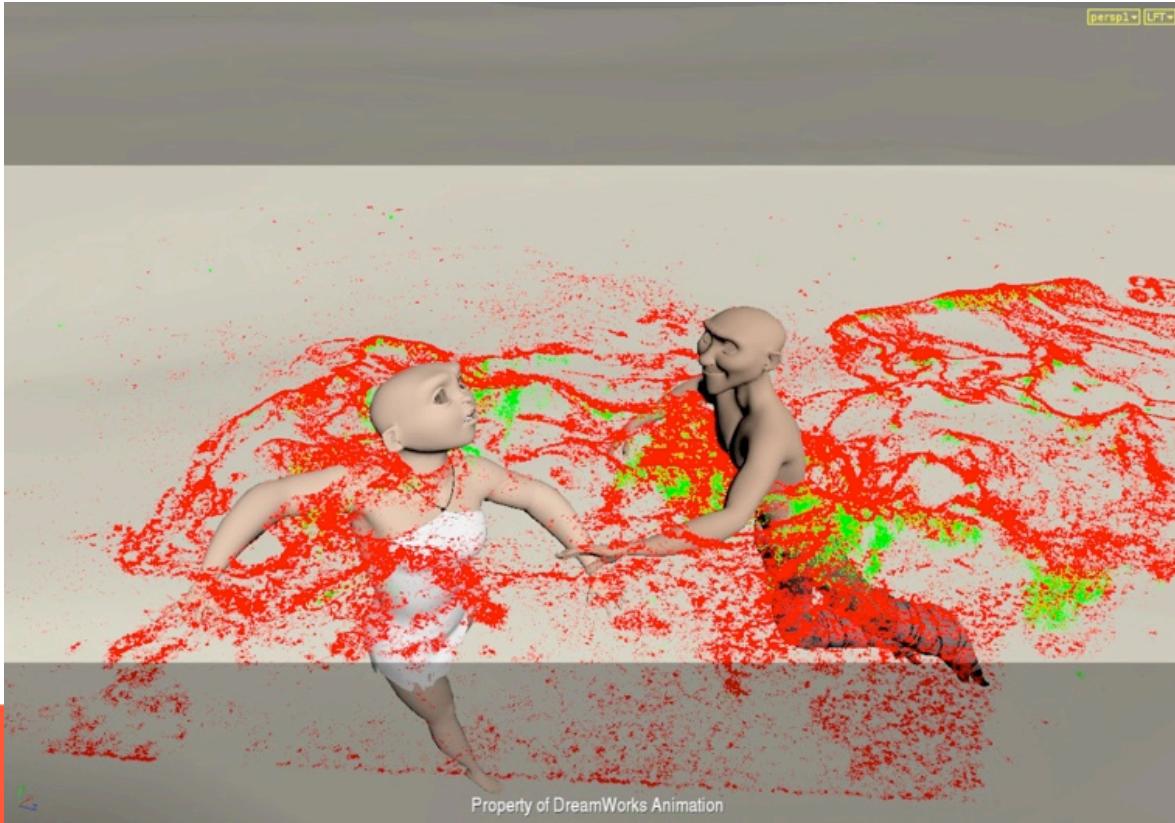
Level Set

Constrained Advection



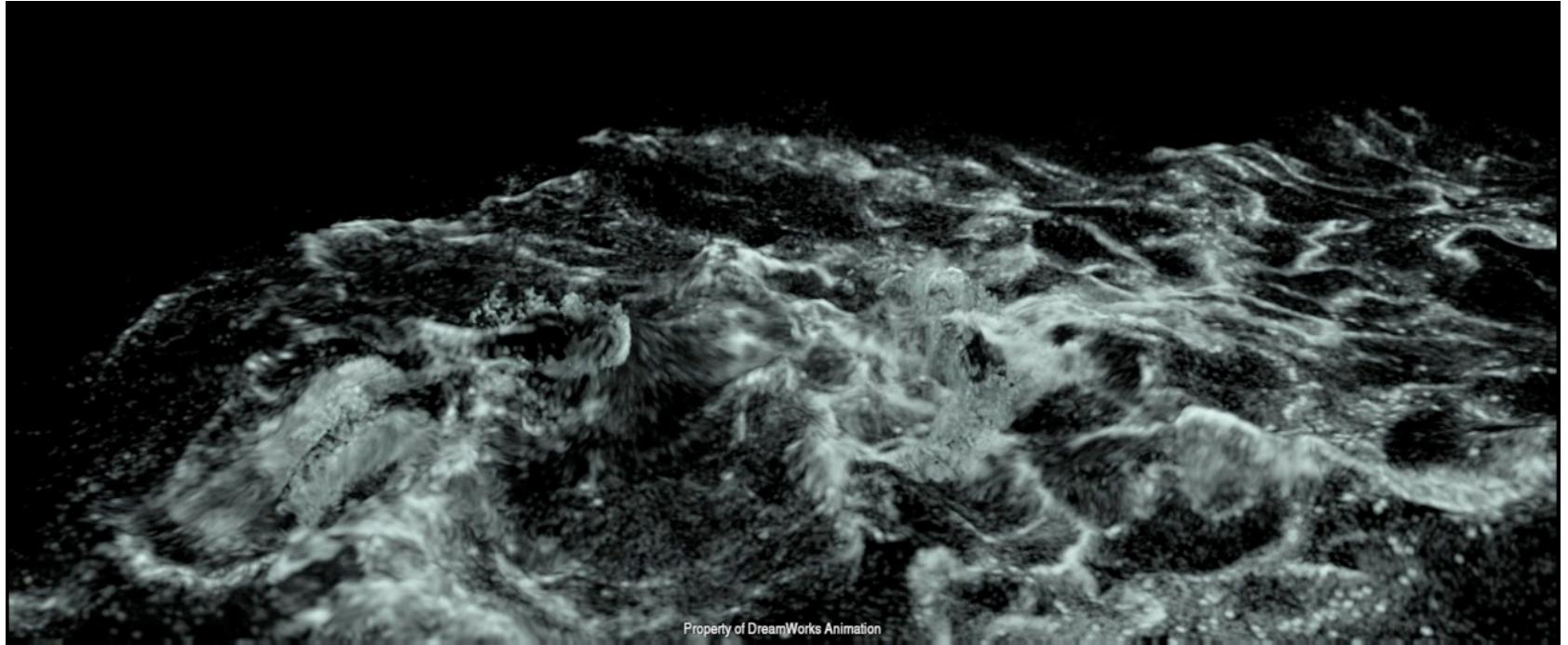
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Constrained Advection



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Constrained Advection



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Flow fields



Lipton, D., Museth, K., Sutherland, B. Jack's Frost: Controllable Magic Frost Sim. for Rise of The Guardians. Siggraph 2013
Ghoniem, A. and Museth, K. Hair growth by means of sparse volumetric modeling and advection. Siggraph 2013

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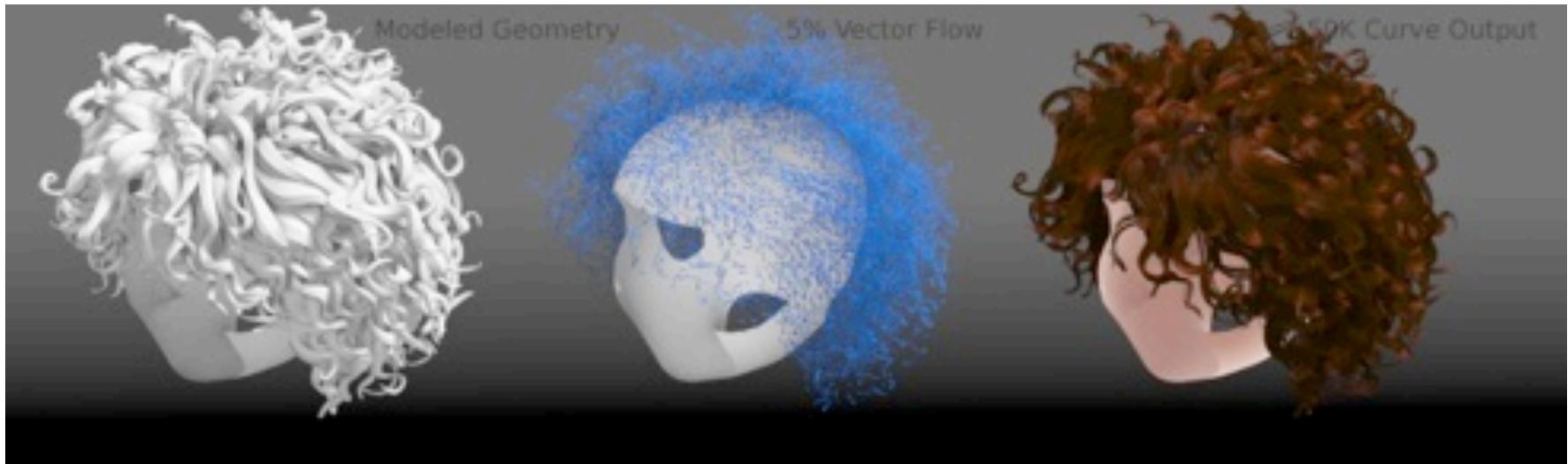
Flow fields



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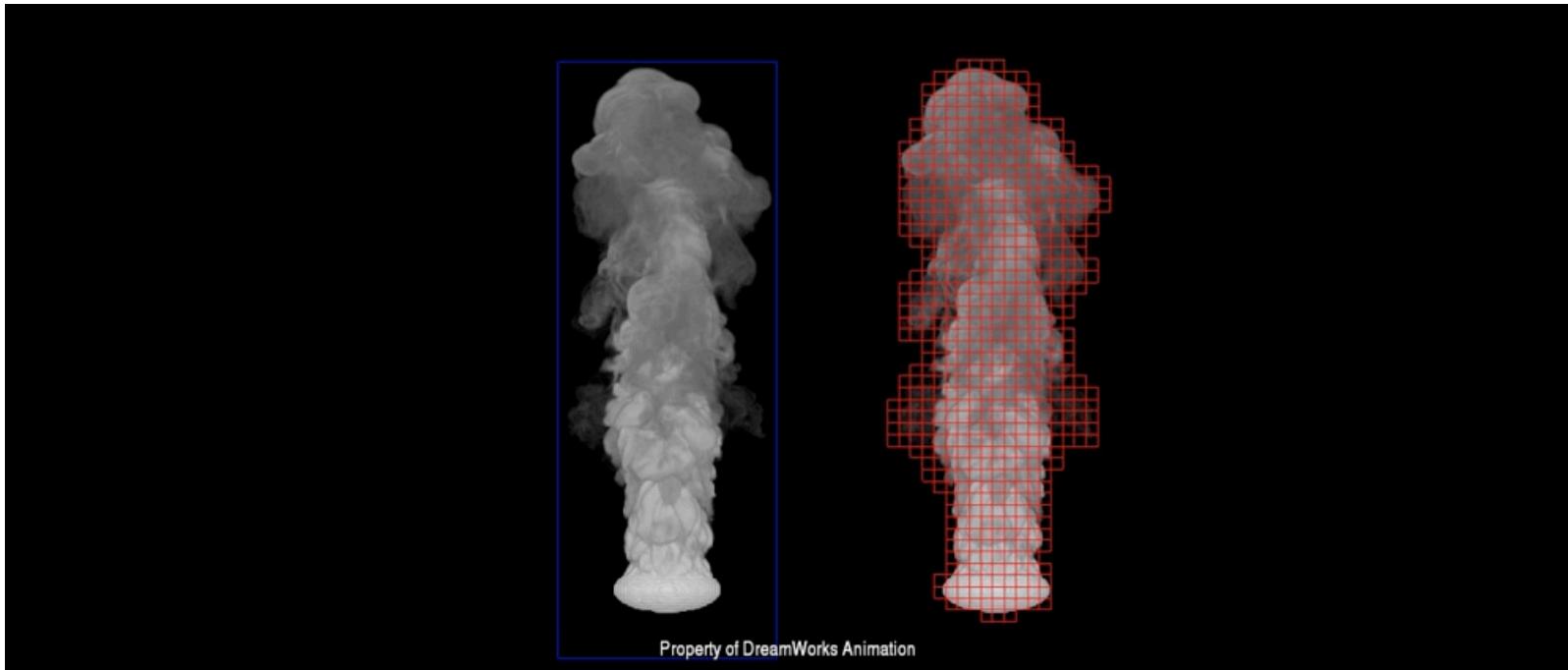
Flow fields



Lipton, D., Museth, K., Sutherland, B. Jack's Frost: Controllable Magic Frost Sim. for Rise of The Guardians. Siggraph 2013
Ghoniem, A. and Museth, K. Hair growth by means of sparse volumetric modeling and advection. Siggraph 2013

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Fluid Simulation



Property of DreamWorks Animation

Henderson, R. Scalable Fluid Simulation in Linear Time on Shared Memory Multiprocessors.
DigiPro, 2012

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Fluid Simulation



Property of DreamWorks Animation

Lee, F. Snow in How To Train Your Dragong 2. Siggraph Dailies, 2015
Mayer, Jason. Pyro in The Croods. Siggraph Dailies, 2013.

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Fluid Simulation



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Fluid Simulation

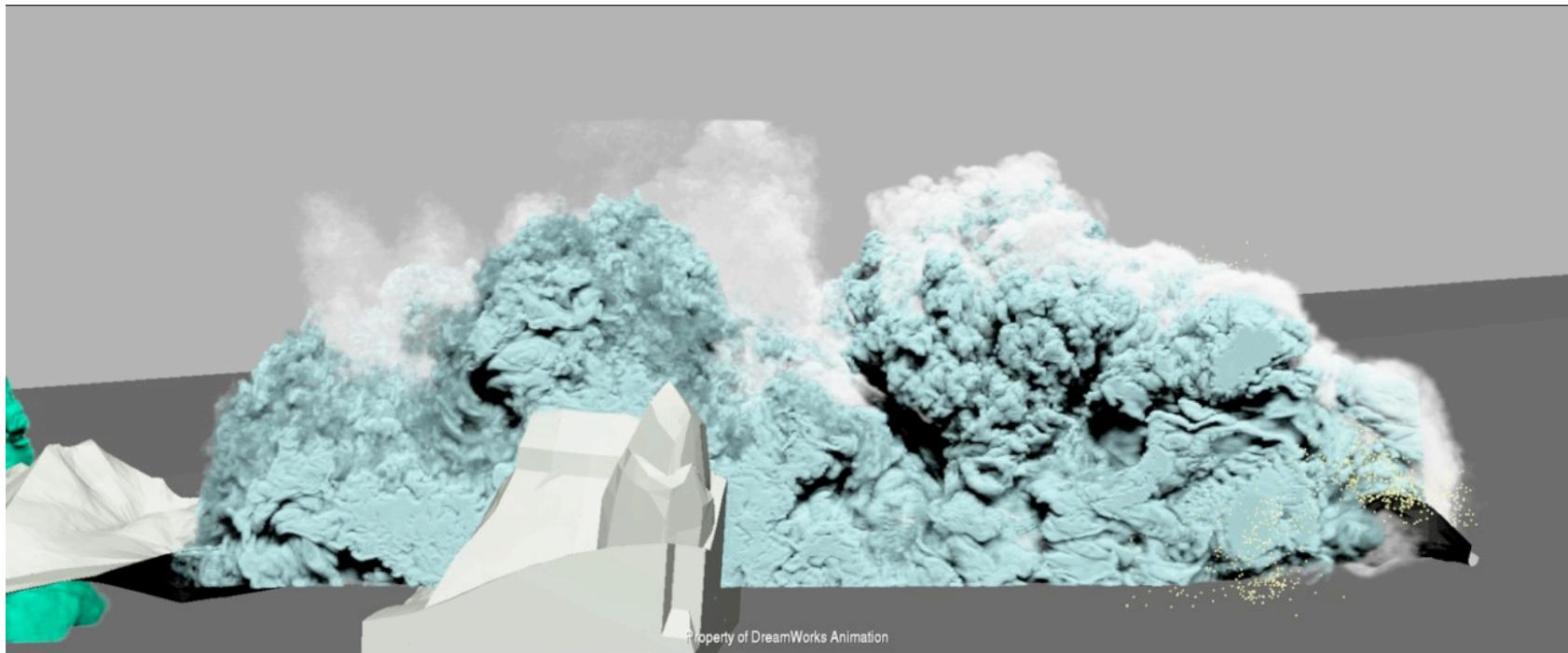


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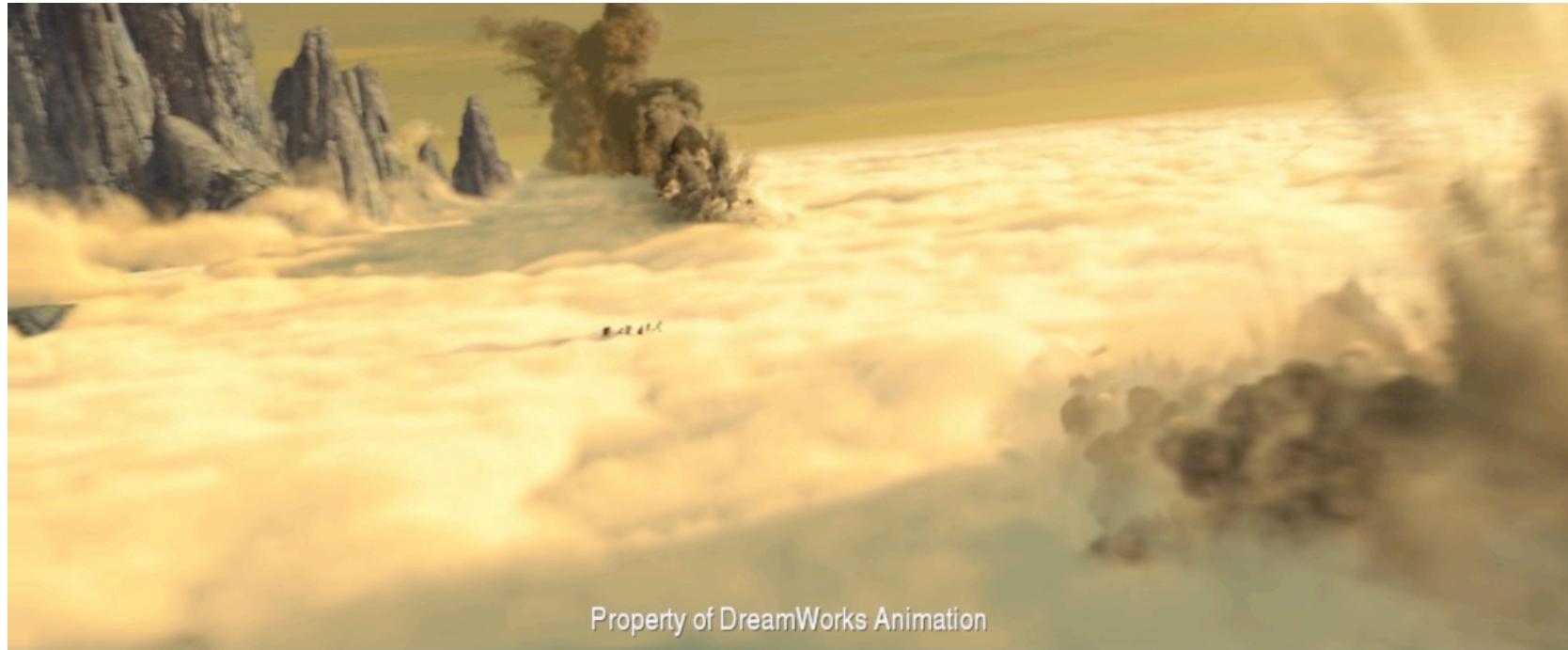
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Volume Stamping



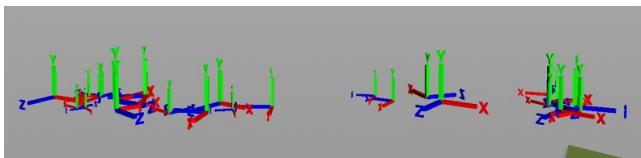
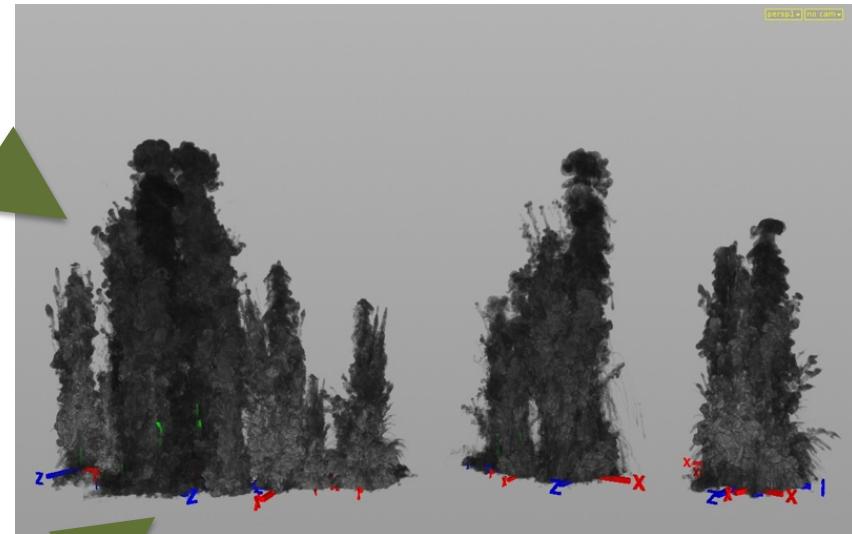
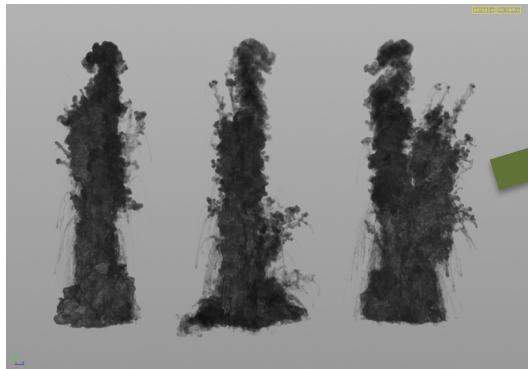
Property of DreamWorks Animation

Volume Stamping

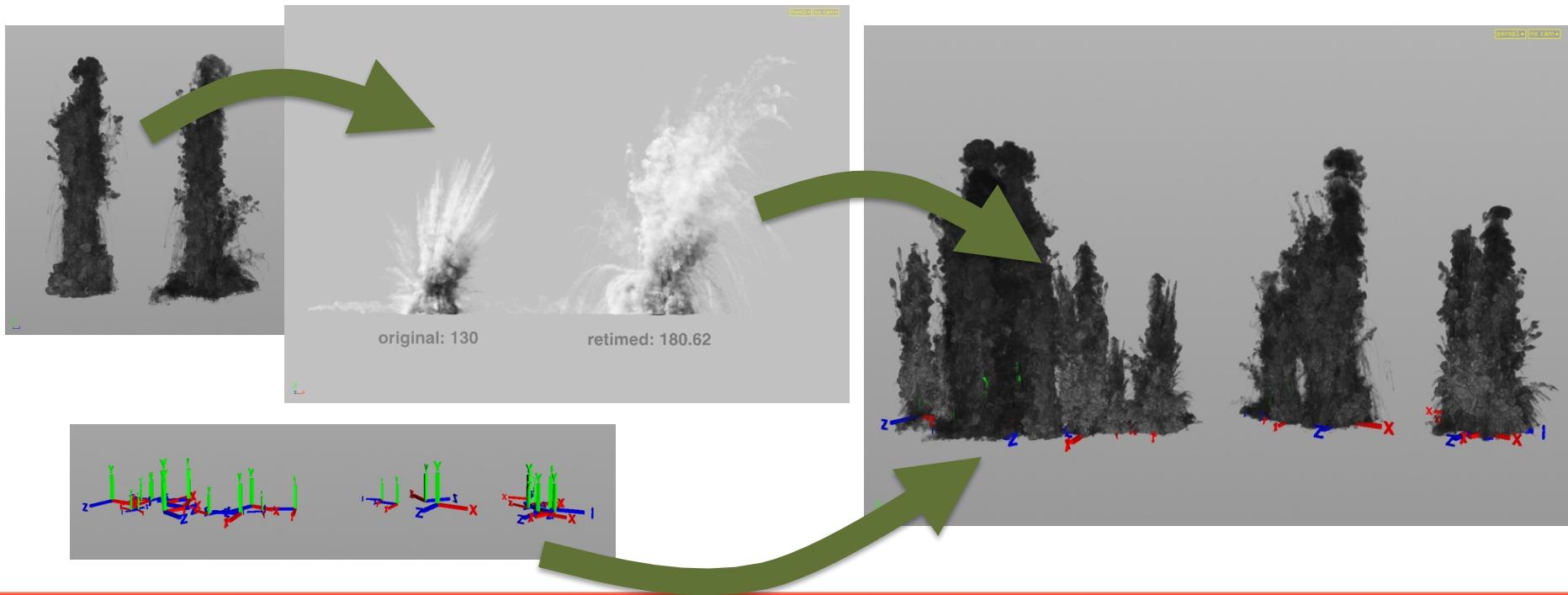


Property of DreamWorks Animation

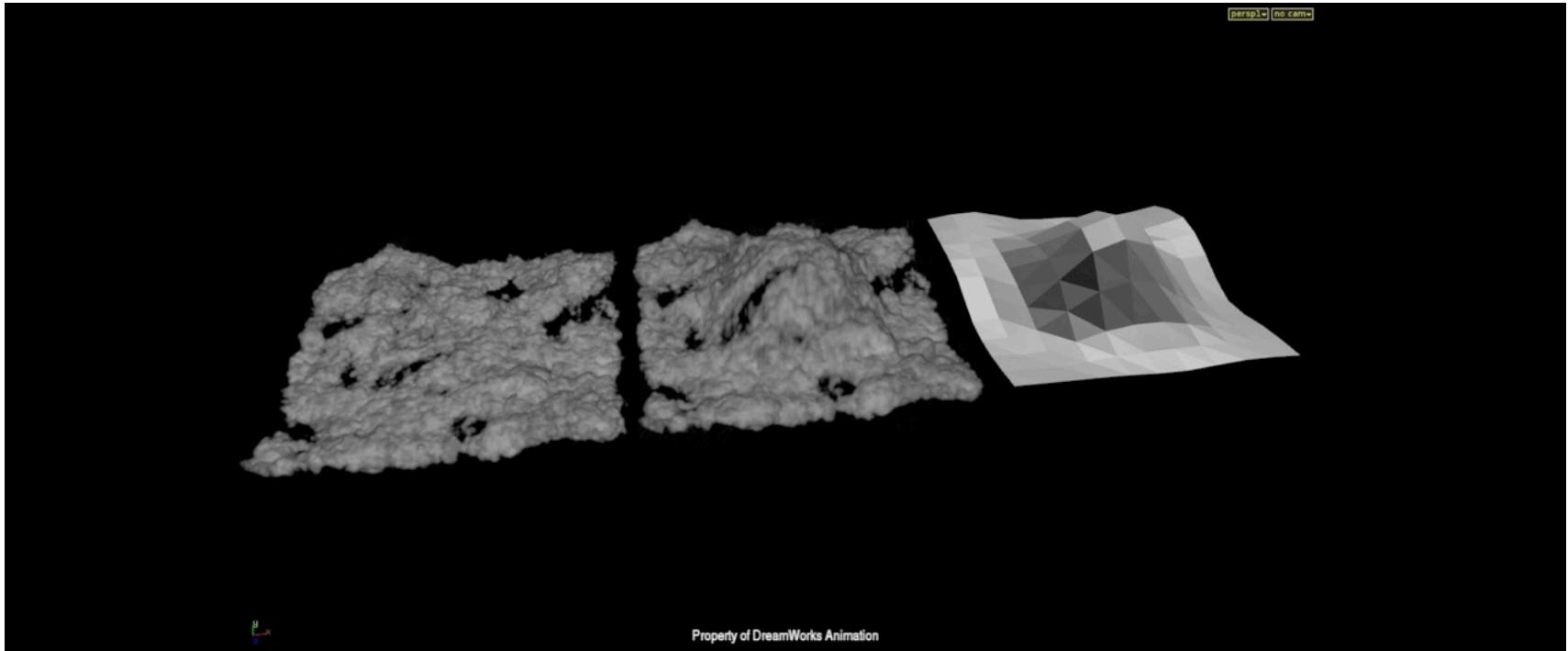
Volume Stamping



Volume Stamping



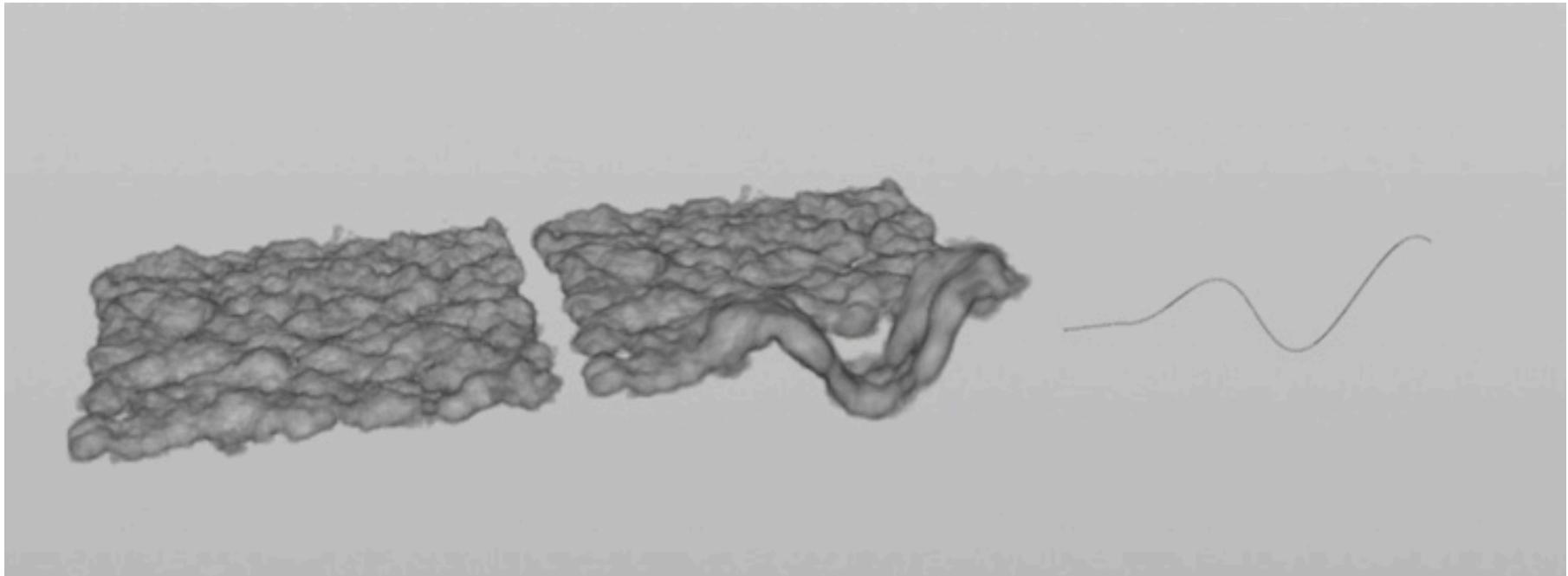
Volume deformation



Volume deformation



Volume deformation



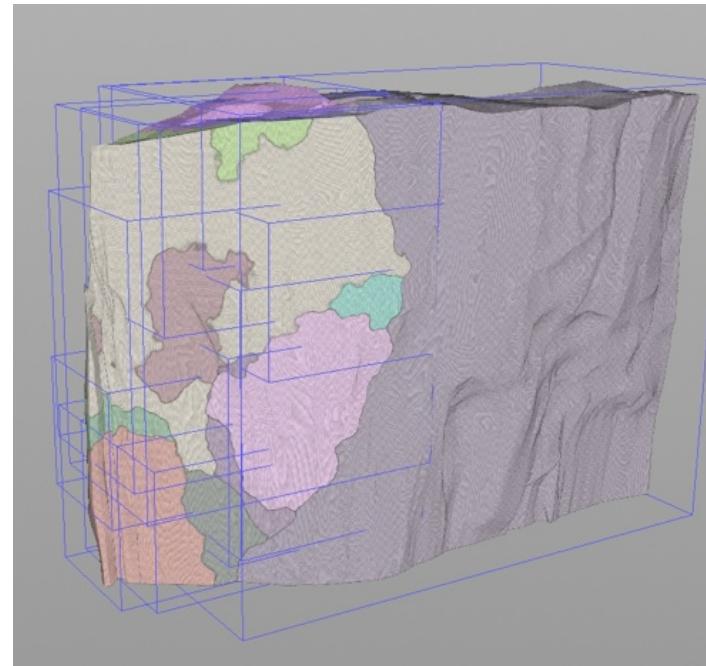
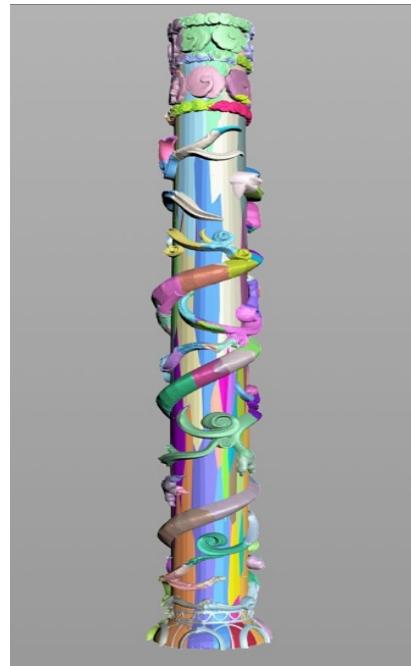
Volume deformation



Volume Fracture

Desire better-looking fractures

- Art-directed shapes
- Organic
- Concave
- Interlocking



Volume Fracture



Property of DreamWorks Animation

Alden, M., Melich, G. and Museth, K. Efficient and seamless volumetric fracture.
Siggraph Talk, 2012

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Volume Fracture



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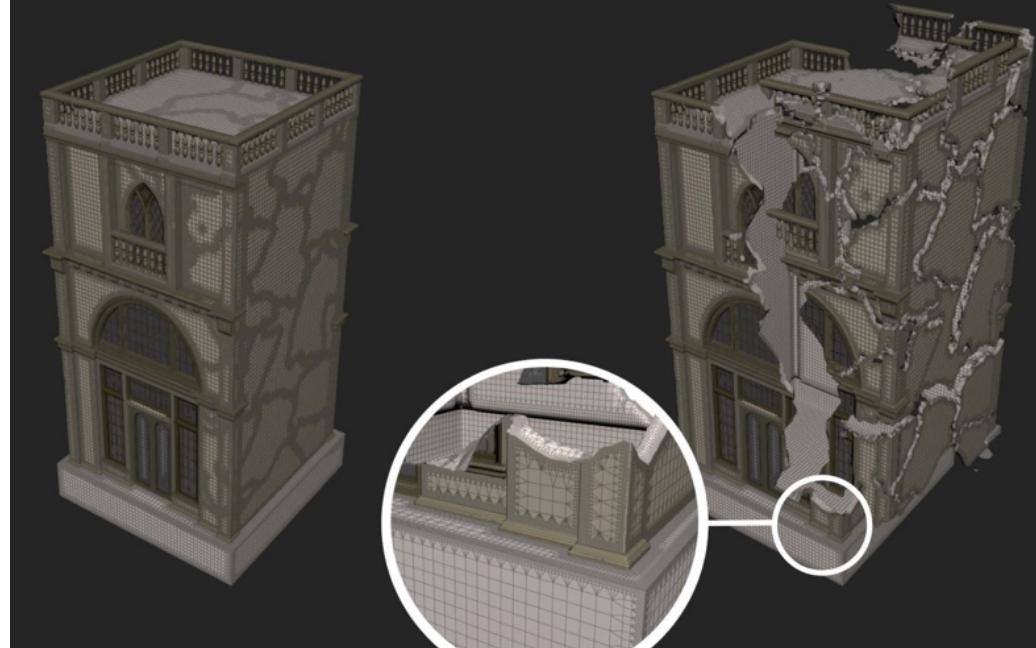
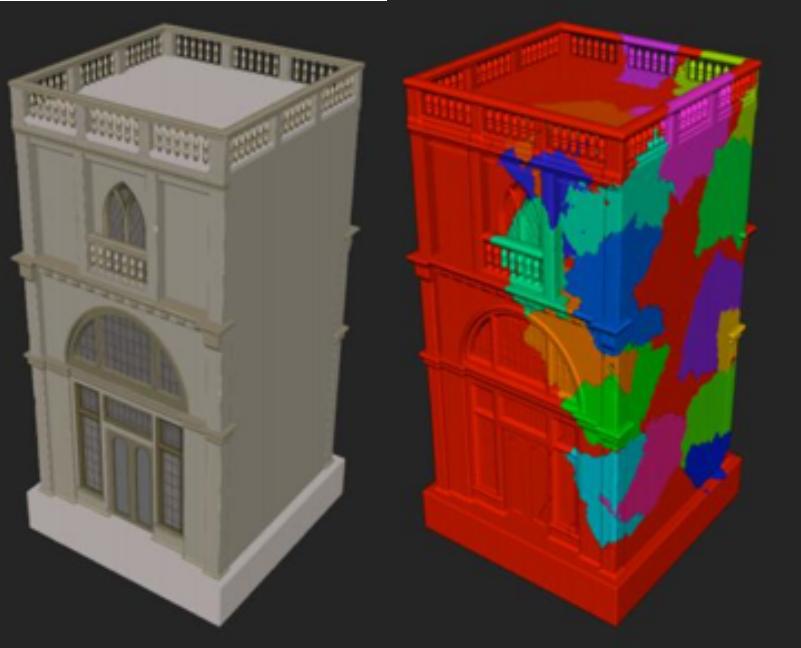


Property of DreamWorks Animation

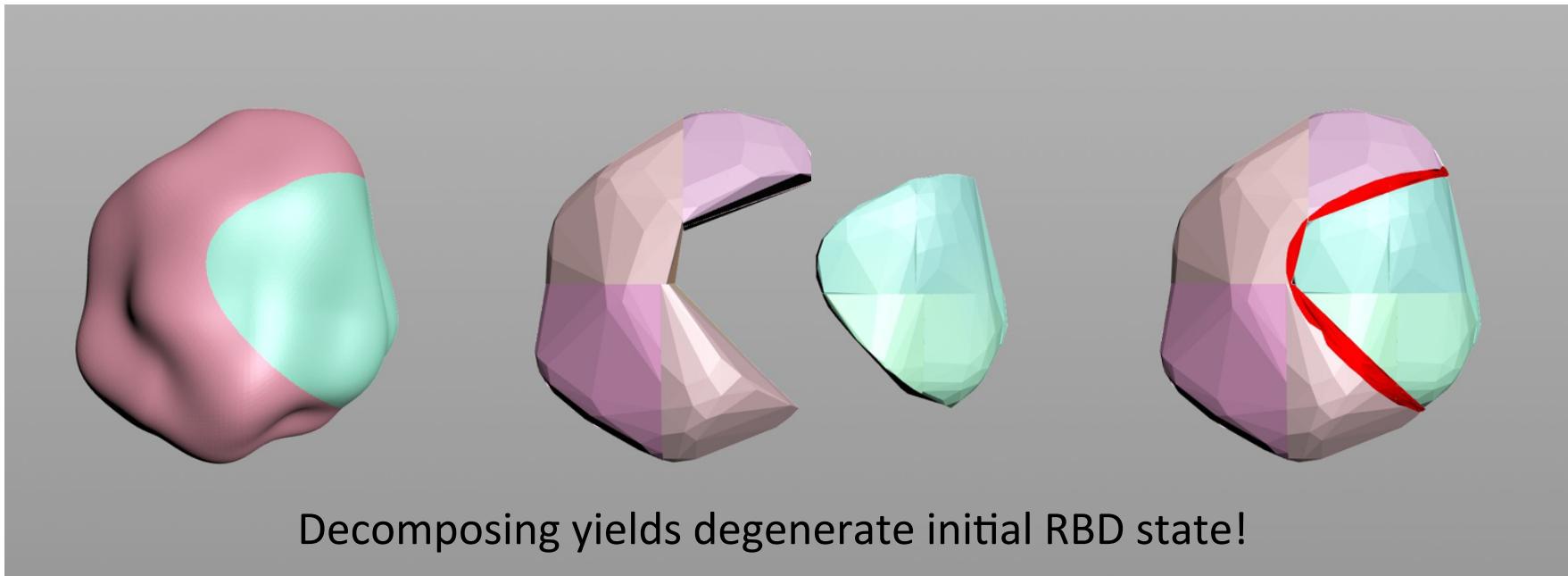
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Siggraph Talk, 2012

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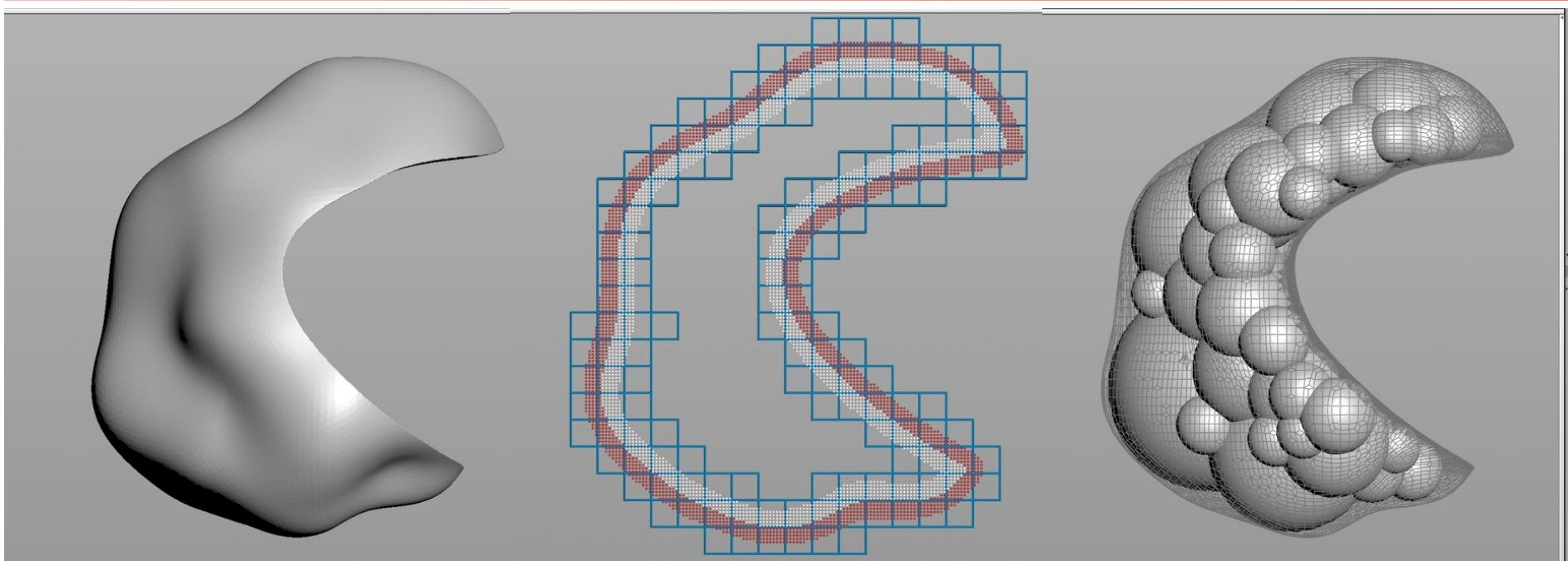


Proxy Generation



Decomposing yields degenerate initial RBD state!

Proxy Generation



Budsberg, J., Bin Zafar, N., Alden, M. Elastic and Plastic Deformations with Rigid Body Dynamics. Siggraph Talk, 2014

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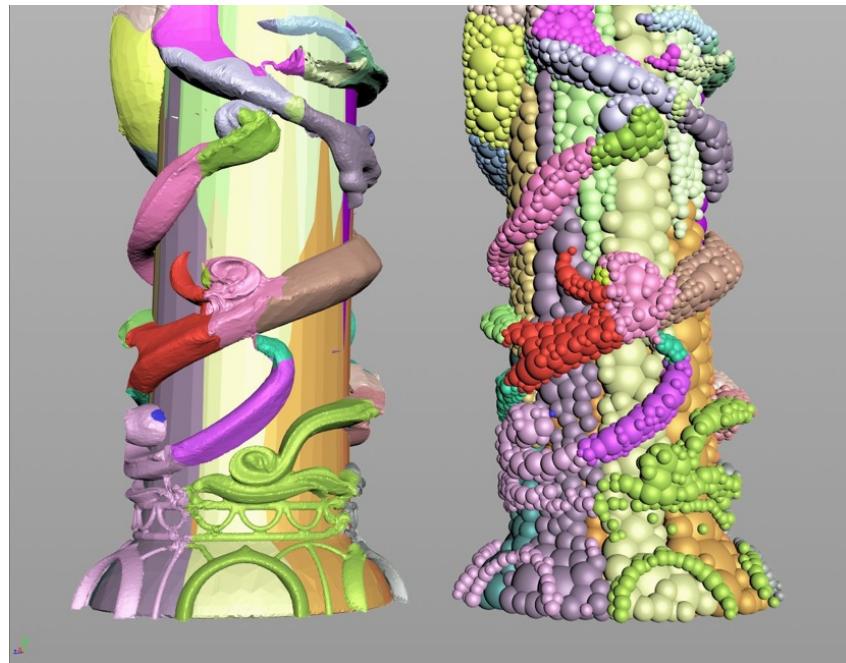
Proxy Generation

Robust

- Concave features, holes, self-intersections
- Proxy always inside

Fast

- Takes full advantage of multi-threaded hardware



Budsberg, J., Bin Zafar, N., Alden, M. Elastic and Plastic Deformations with Rigid Body Dynamics. Siggraph Talk, 2014

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Elastic Deformation

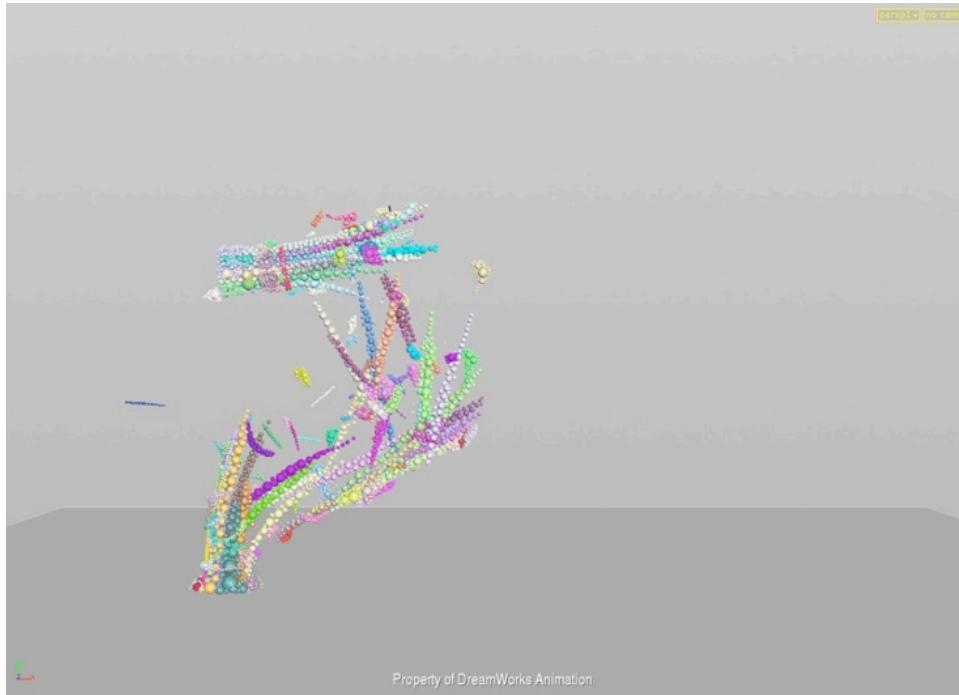


Property of DreamWorks Animation

Budsberg, J., Bin Zafar, N., Alden, M. Elastic and Plastic Deformations with Rigid Body Dynamics. Siggraph Talk, 2014

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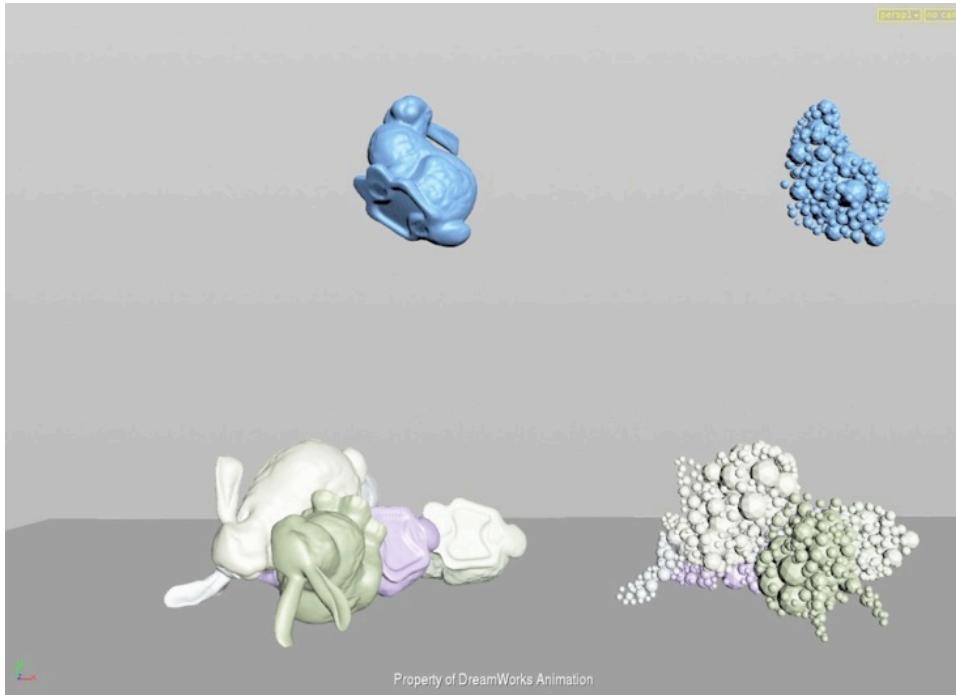
Elastic Deformation



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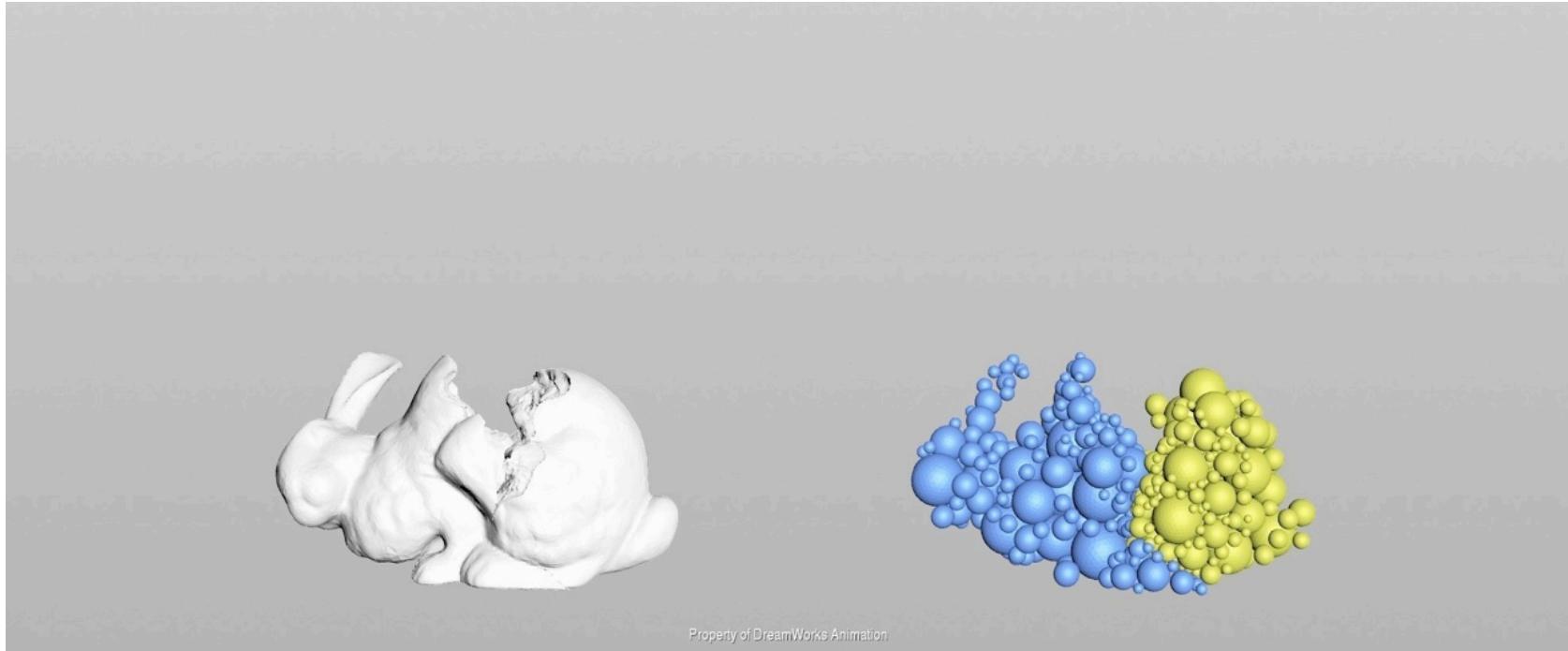
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Elastic Deformation



Property of DreamWorks Animation

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Collisions

Many options!

- Watertight polygonal
- Level set
- Spheres

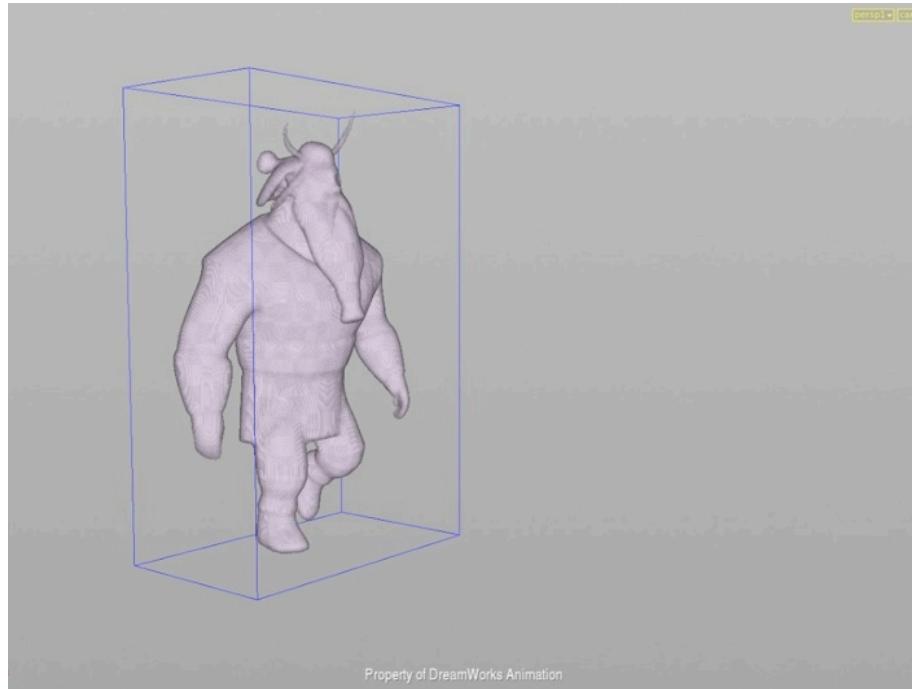


Property of DreamWorks Animation

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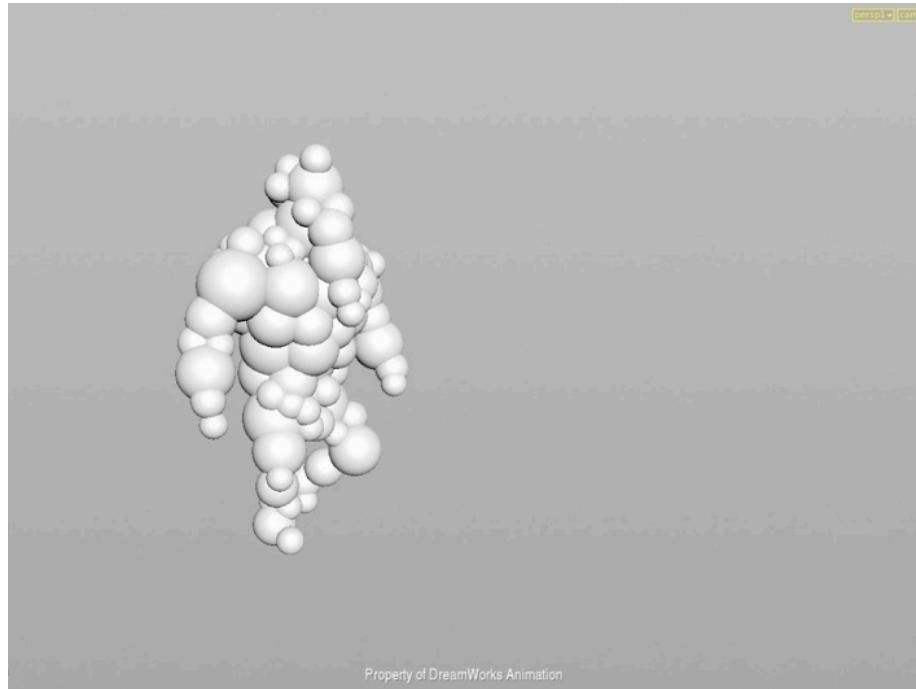


Property of DreamWorks Animation

Collisions

Many options!

- Watertight polygonal
- Level set
- Spheres



Property of DreamWorks Animation

Visualization

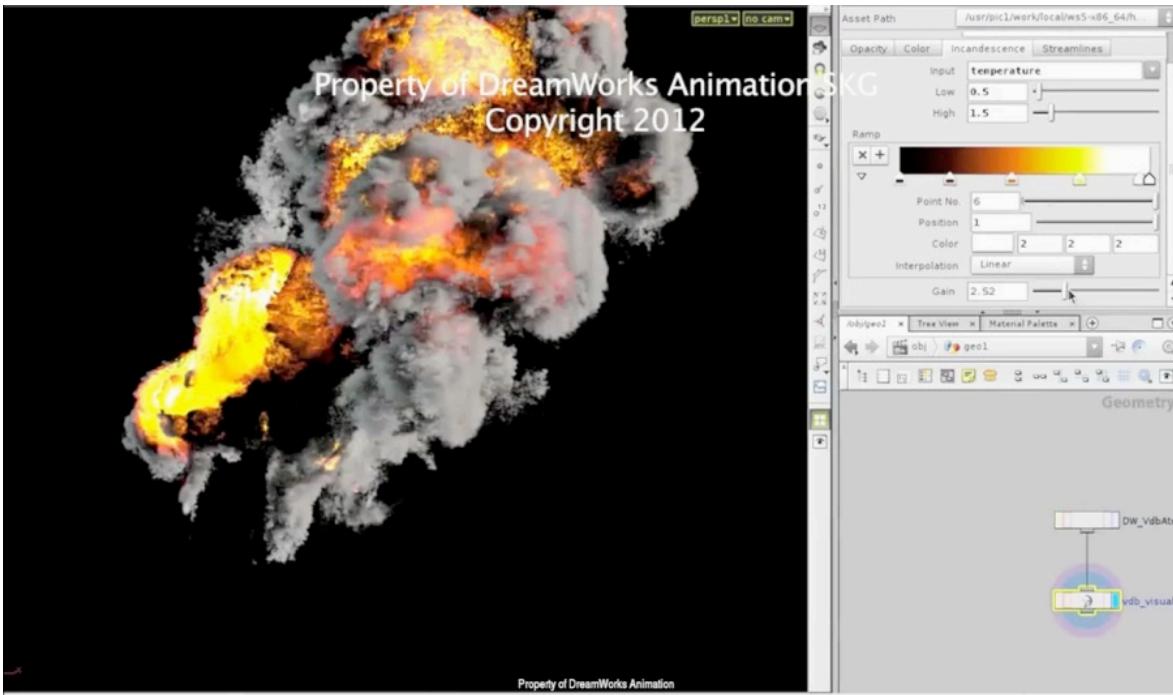


Property of DreamWorks Animation

Matthews, M. Amorphous: An OpenGL Sparse Volume Renderer. ACM Siggraph Talks, 2012

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Visualization



Matthews, M. Amorphous: An OpenGL Sparse Volume Renderer. ACM Siggraph Talks, 2012

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Visualization

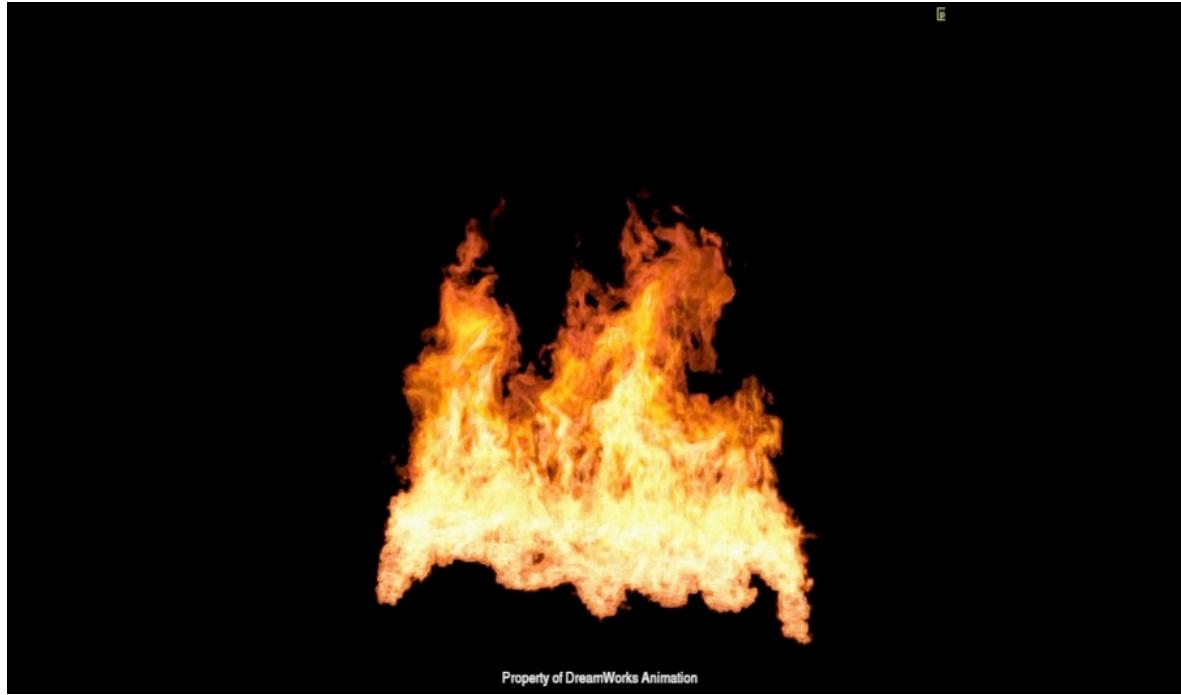


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Visualization



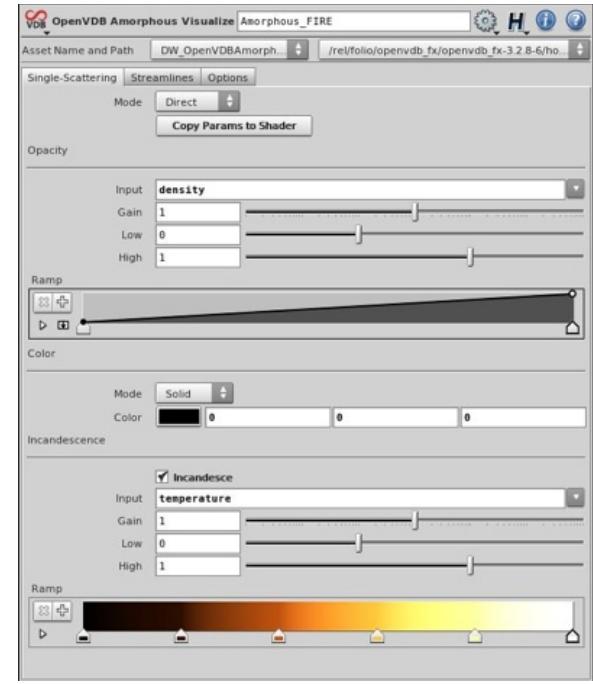
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Visualization



Matthews, M. Amorphous: An OpenGL Sparse Volume Renderer. ACM Siggraph Talks, 2012

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Conclusion

- Tons of applications
- Modular toolset
- Fast & efficient operations on huge datasets
- Easy to make new tools

A vertical strip on the left side of the slide featuring a close-up of Po's face from the movie Kung Fu Panda. He has his signature black and white fur, large green eyes, and a slightly grumpy expression.

Thanks!

FX R+D

- Ken Museth
- Mihai Alden
- David Hill
- Peter Cucka

Michael Losure
Baptiste Van Opstal
Mark Matthews

A close-up, slightly angled view of Po's face and upper body. He has his signature black and white fur, green eyes, and a small brown tuft on his head. He is wearing a traditional yellow and red sash.

Questions?

Forget to ask something?
www.openvdb.org/forum