

GO | PROCEDURAL

Building Fluid Solvers from Scratch

Jeff Lait

Senior Mathematician

Agenda



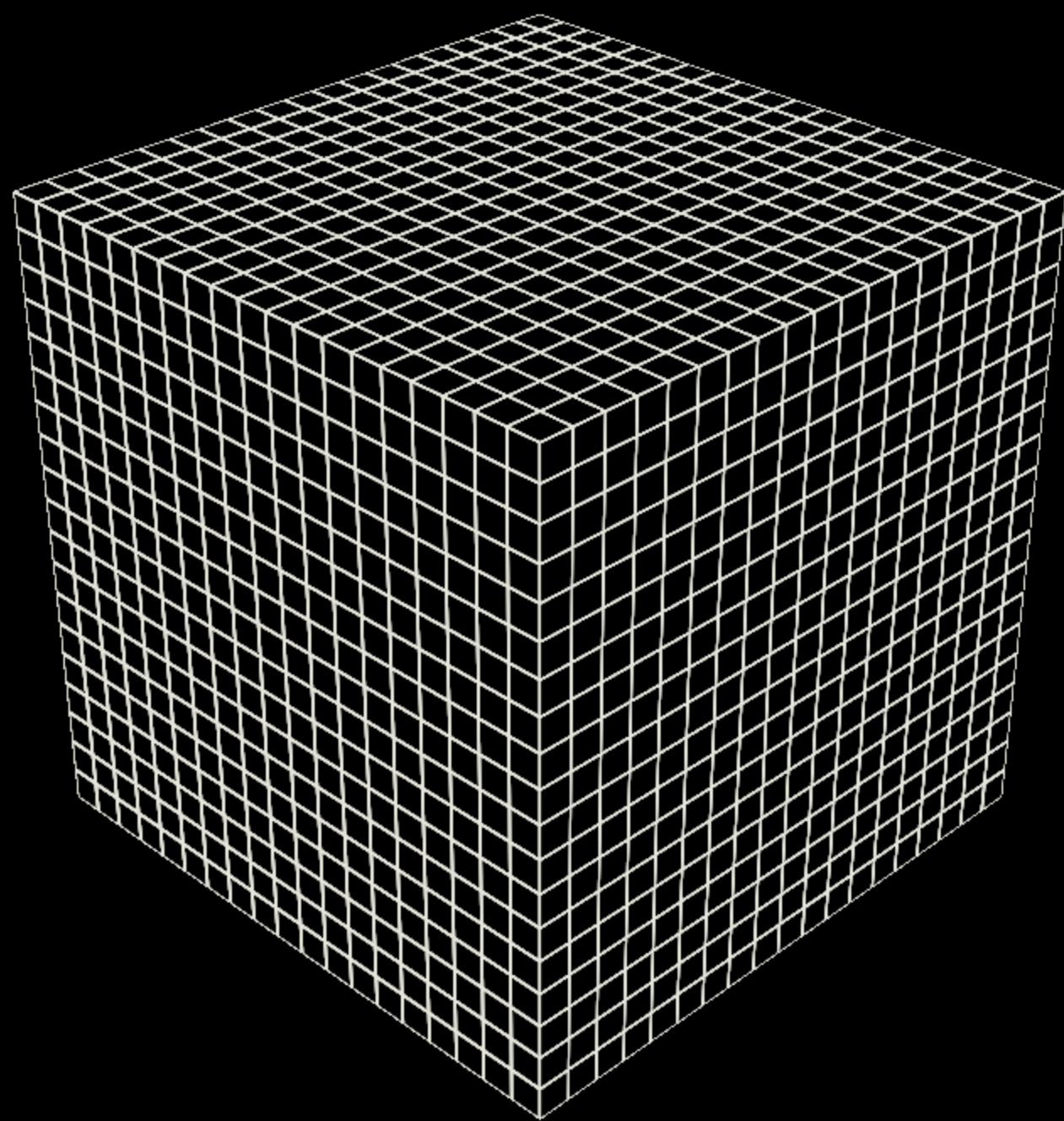
Presenter:
Jeff Lait,
Senior Mathematician

- **Glossary** – Terms and Definitions
- **Smoke** – Building a Volumetric Smoke Solver
- **Liquid** – Building a FLIP Fluid Solver

Glossary

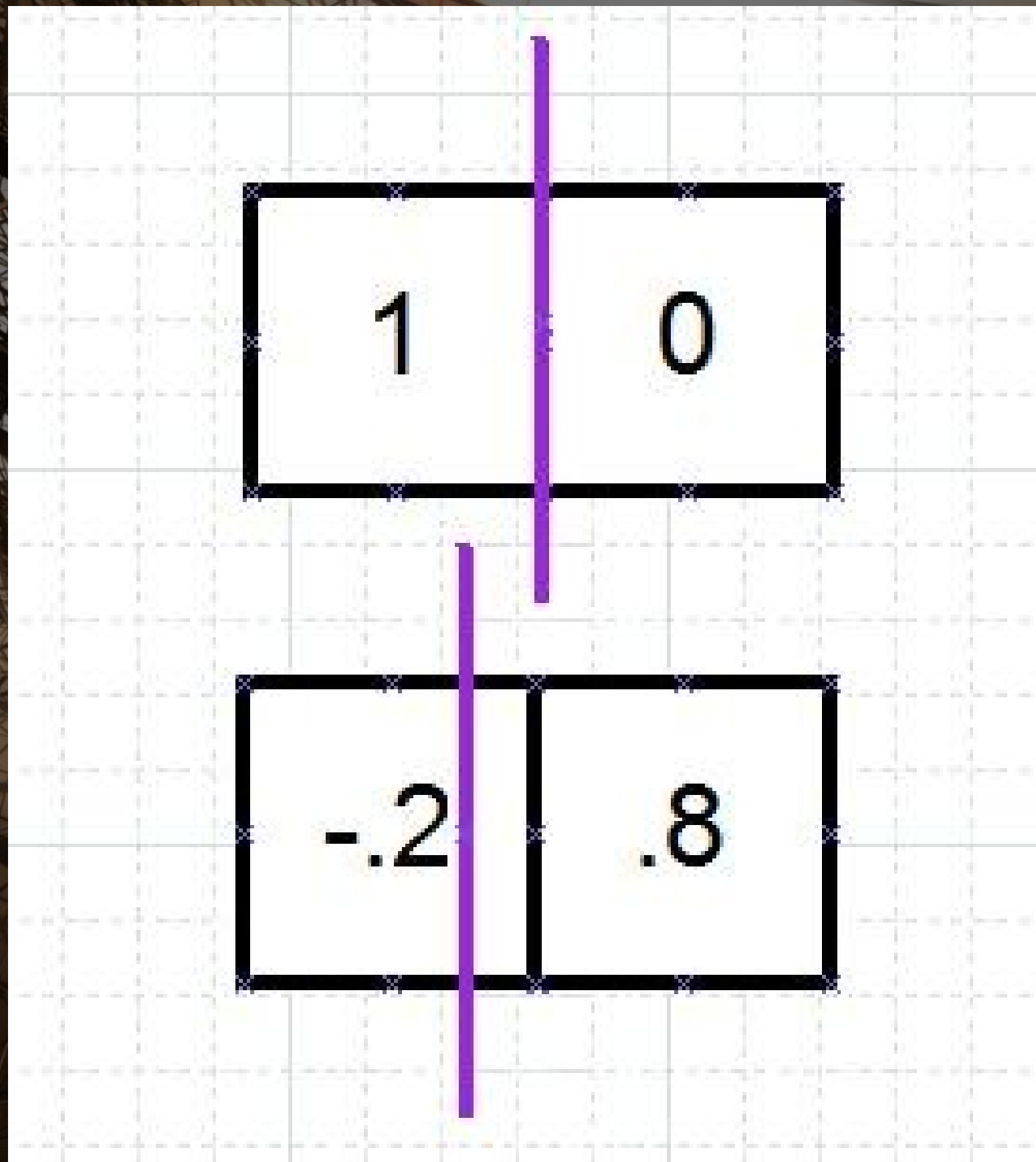
- Grids, Volumes, and Fields
- Fog Volumes vs SDFs
- Eulerian vs Lagrangian
- Vector Fields, Scalar Fields
- Advection
- Divergence
- Microsolvers

Grids, Volumes and Fields



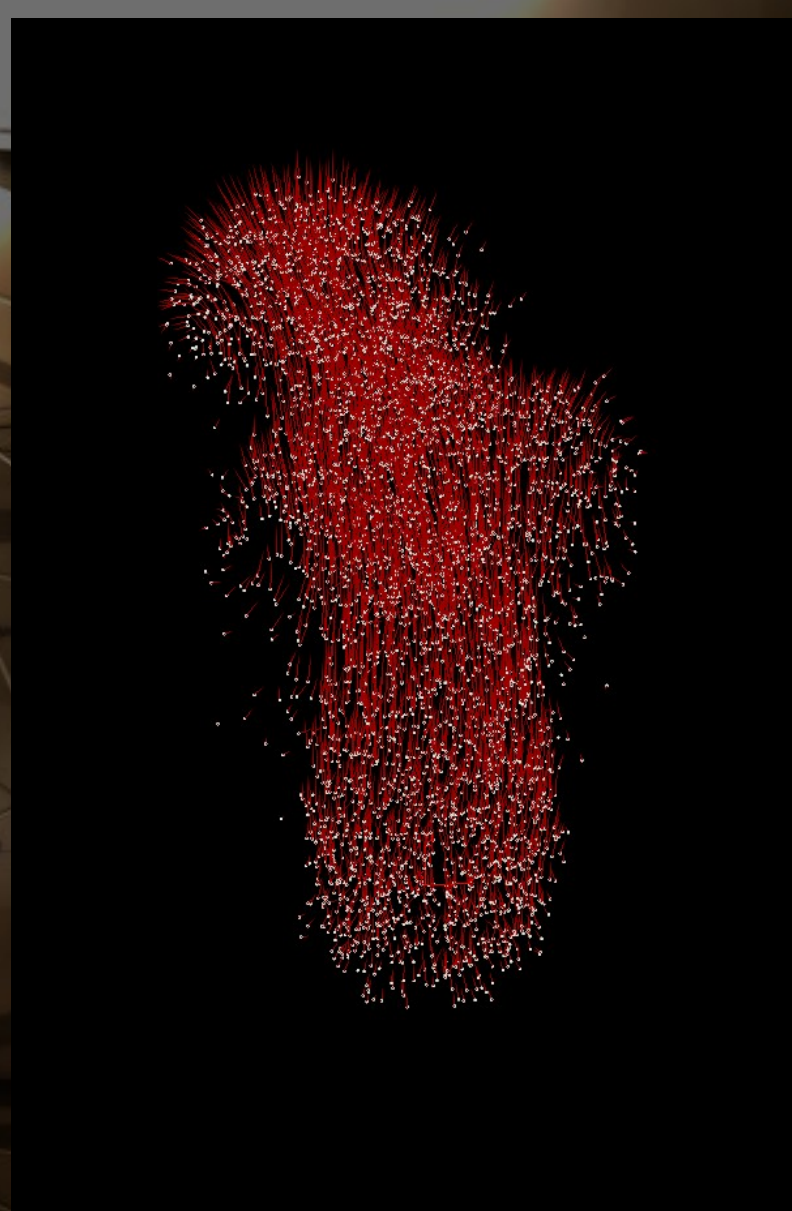
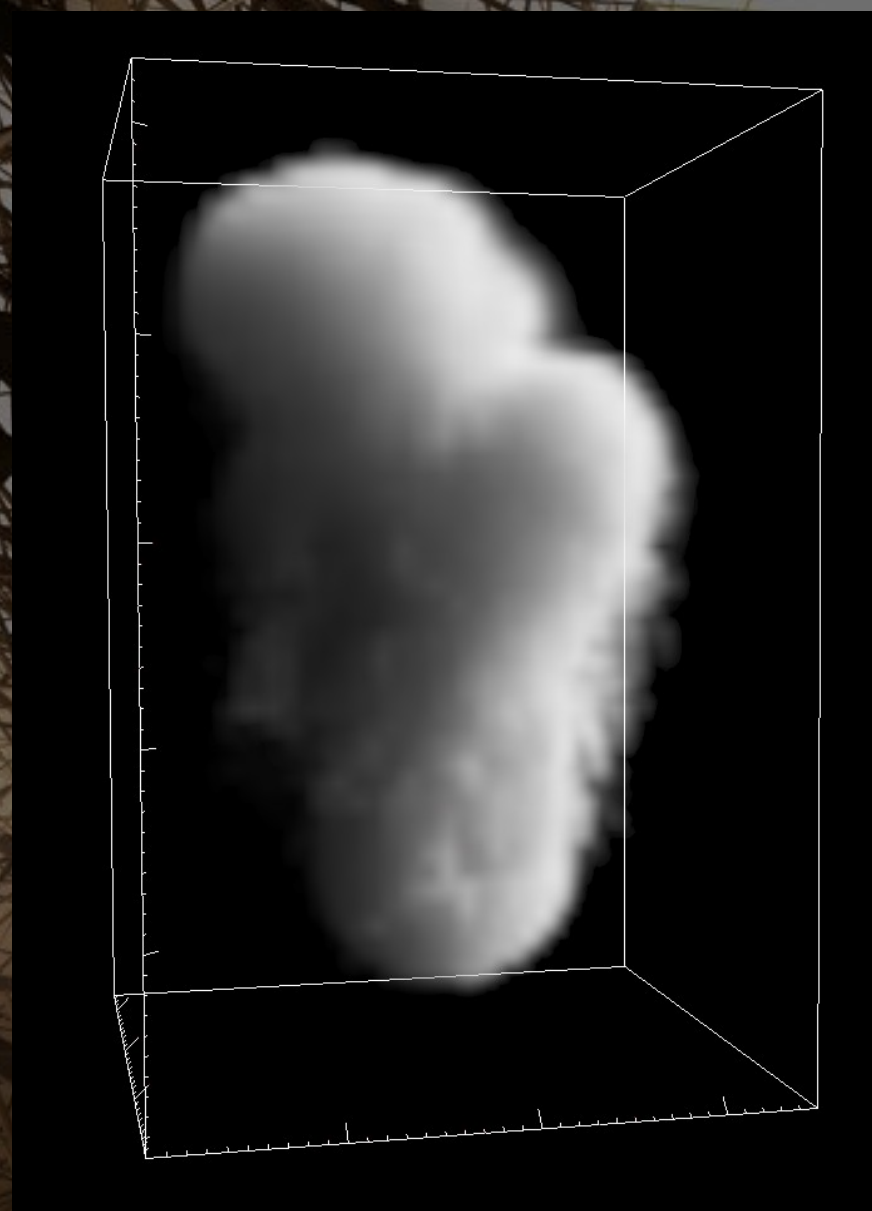
- Grids: 3d texture maps
- Volumes: Grids in SOPs
- Fields: Grids in DOPs

Fog Volumes vs SDFs



- Fog Volumes are like traditional texture map stores 1 if object is there, 0 if not.
- SDFs, “Signed Distance Fields”, store negative for present, positive for absent
- Zero crossing no longer restricted to voxel boundaries.
- Maintain sharp edges
- Fast to compute minimum distance and direction

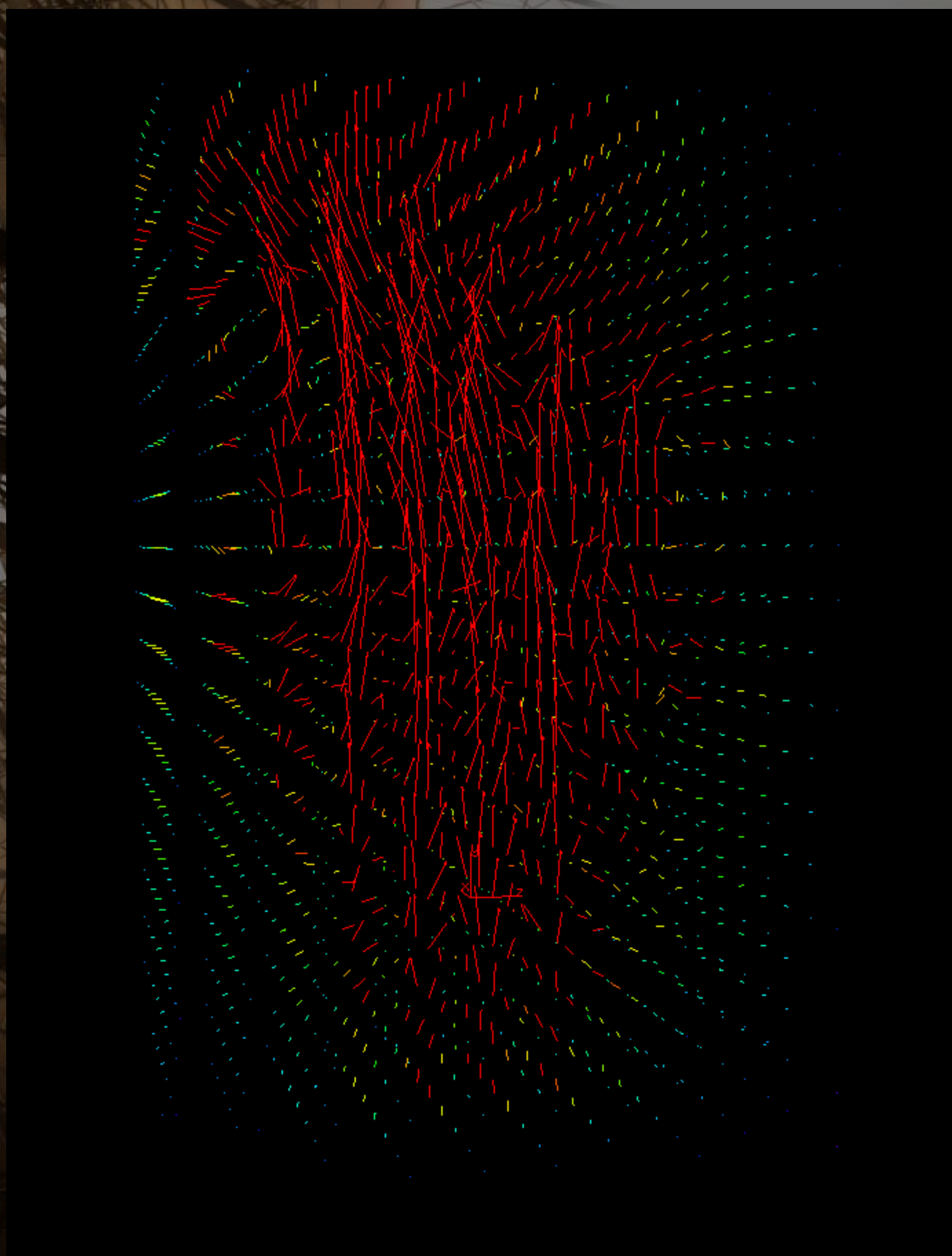
Eulerian vs Lagrangian



- Eulerian: Storing values on grids
- Lagrangian: Storing values on particles
- Traditional particle systems are Lagrangian

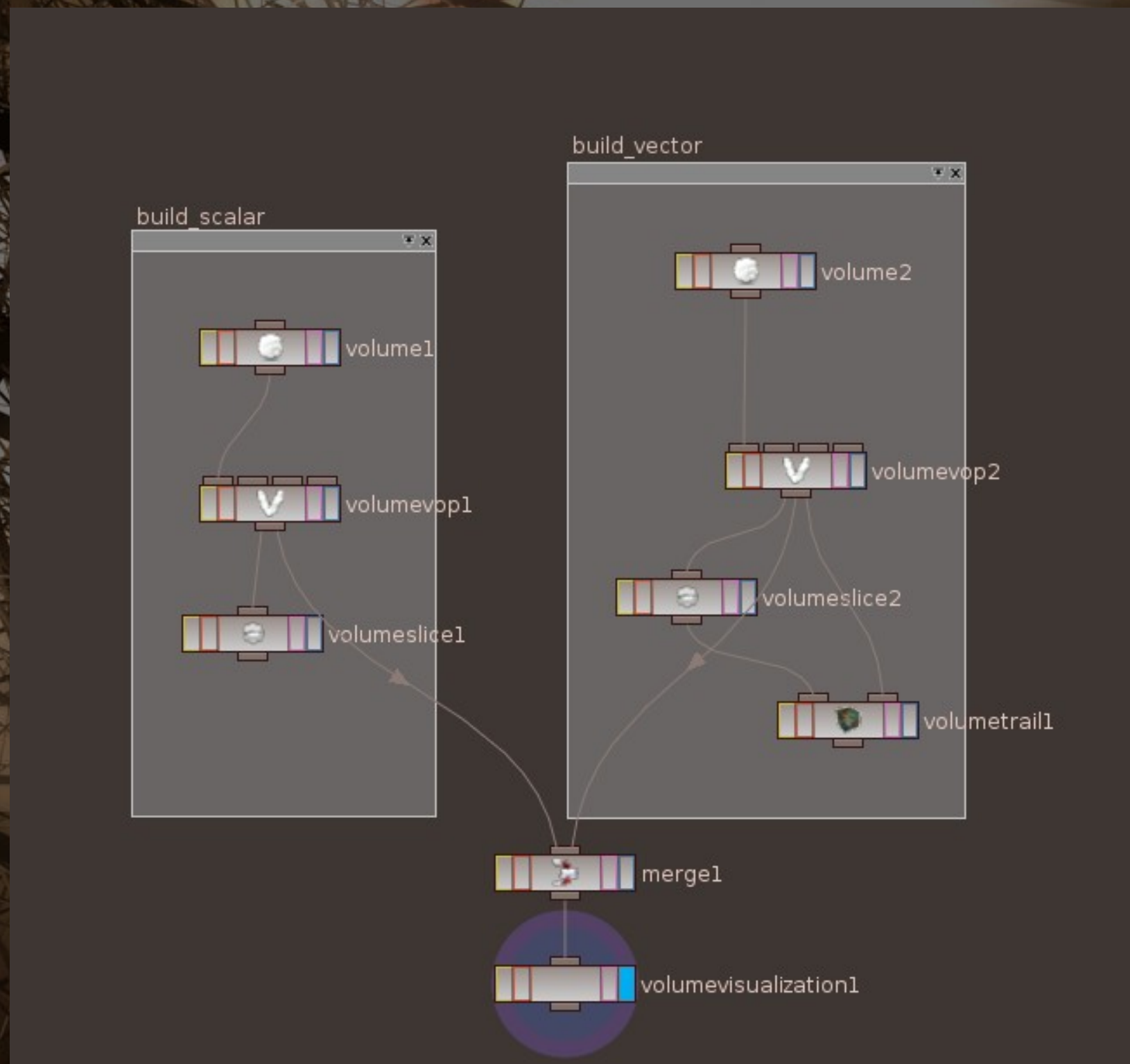
Vector vs Scalar Fields

- Vector fields store three floats per voxel. Examples: Color, Velocity, Force
- Scalar fields store a single float per voxel. Examples: Density, Temperature, Masks



Building Smoke Solvers

Creating Volumes



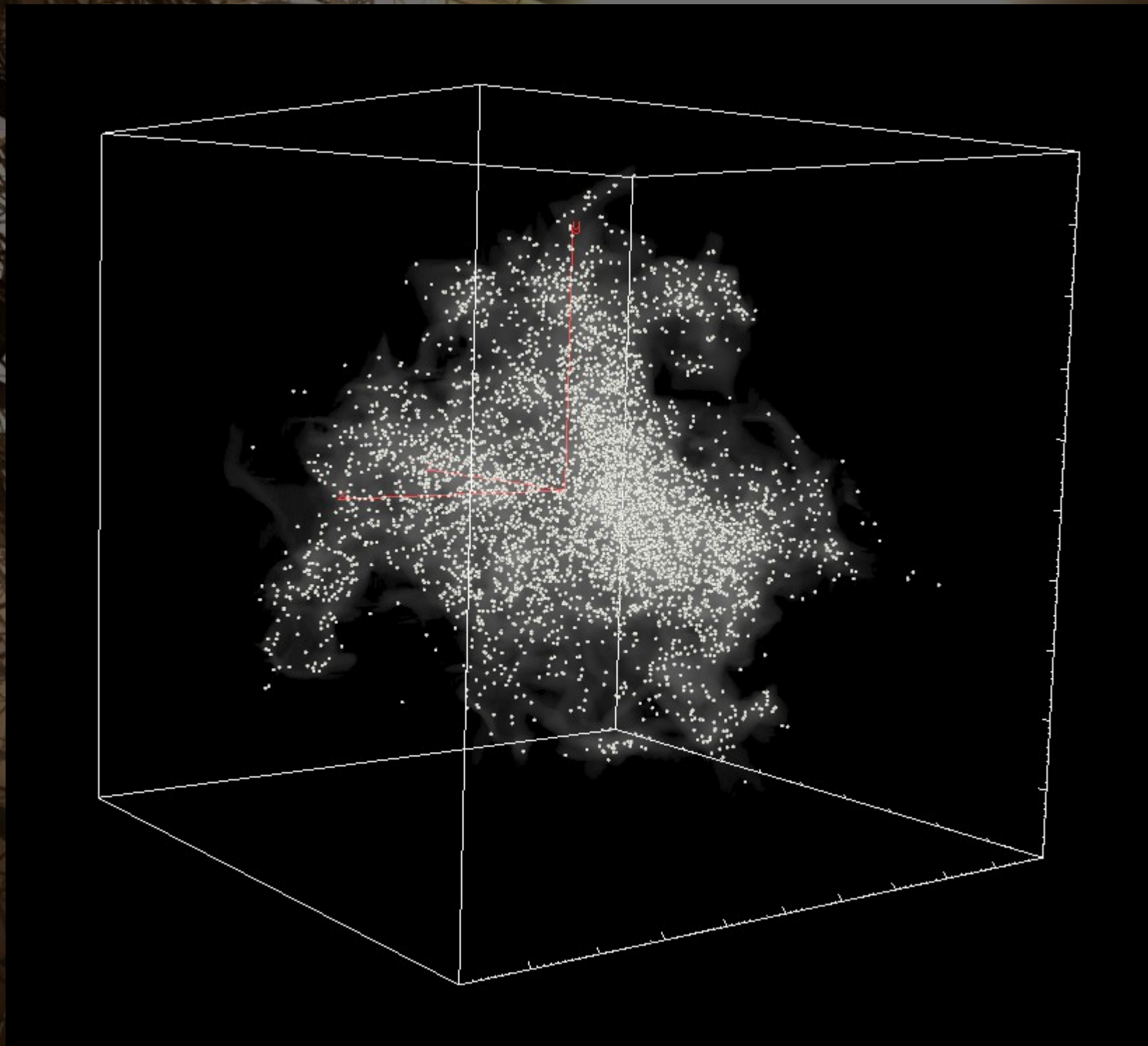
- Creating Volumes
- Creating Velocity Volumes
- Visualizing

MicroSolvers



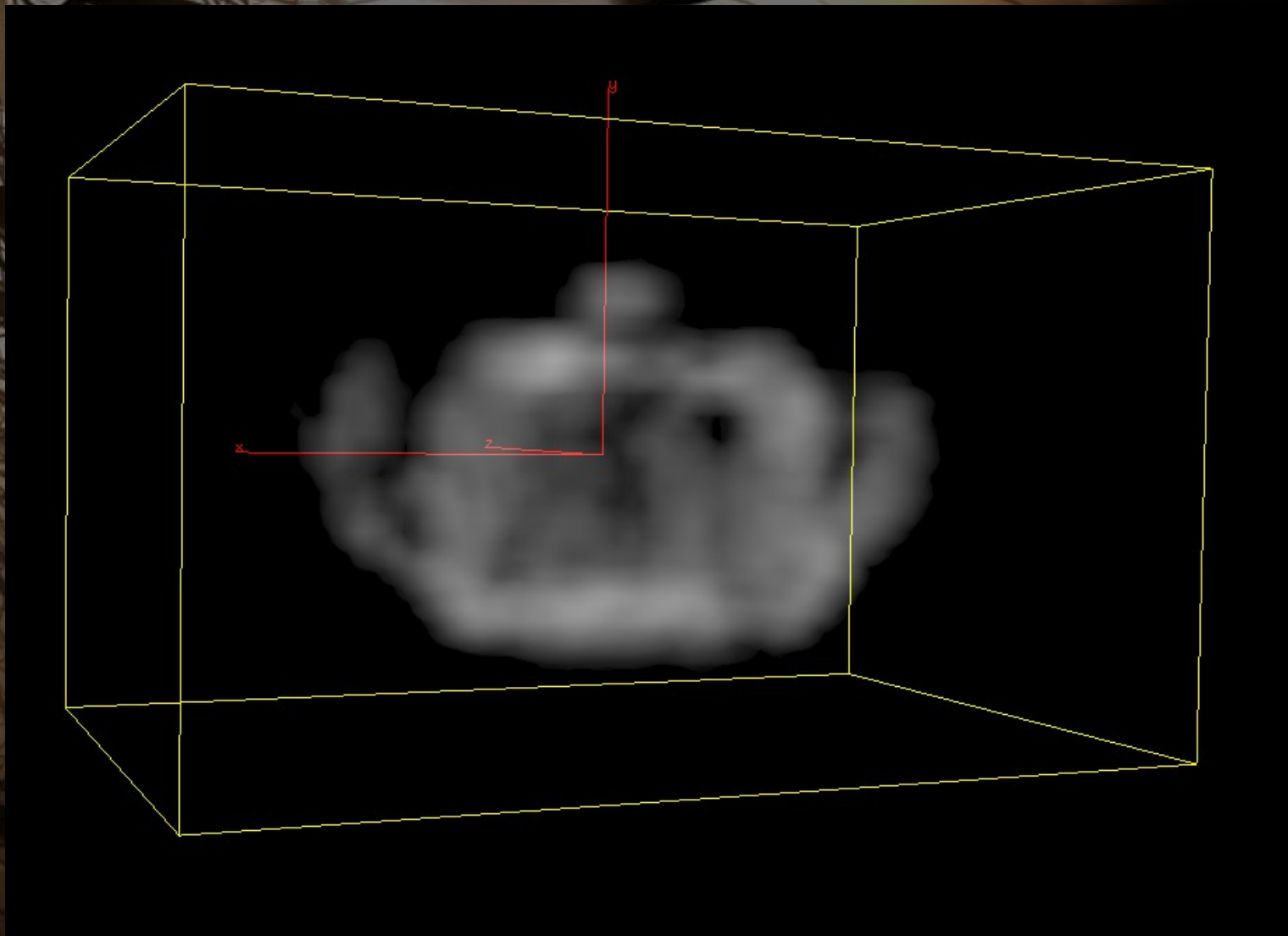
- Structure of a DOP net
- Importing Data
- Solving

Motion



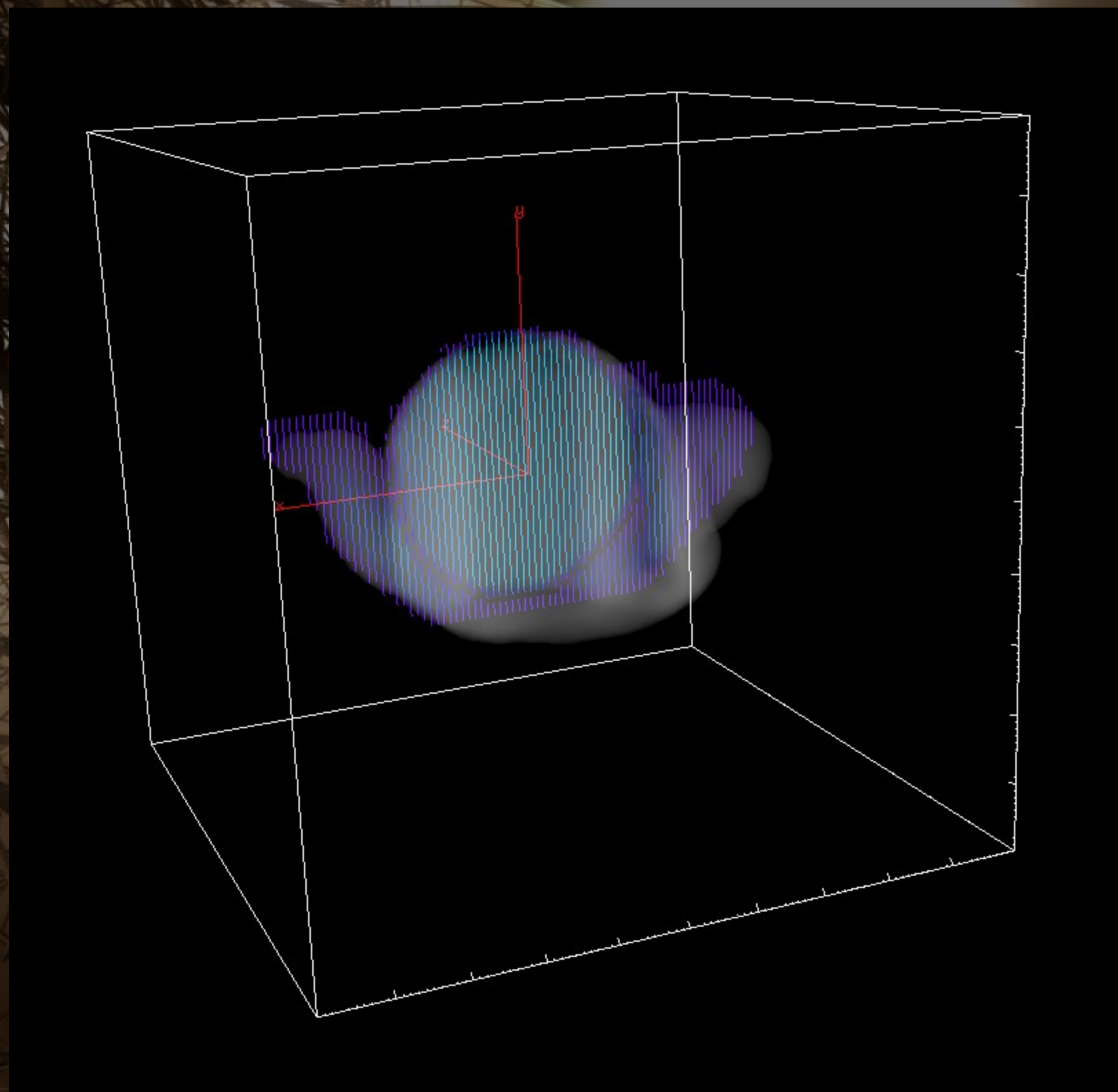
- Advecting Particles
- Advecting Fields

Source Density



- Iso Offset
- Volume VOPs
- Fluid Source

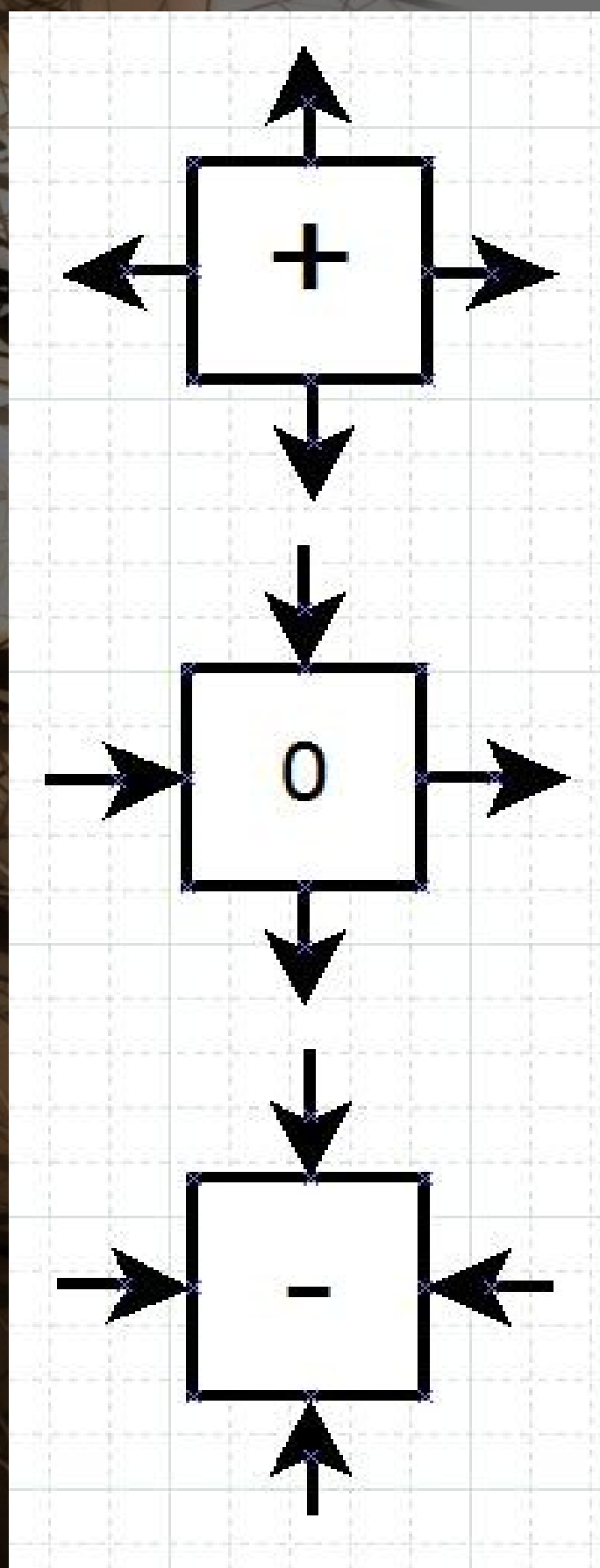
Source Velocity



- Pumps
- Masks
- Gravity

What is Divergence?

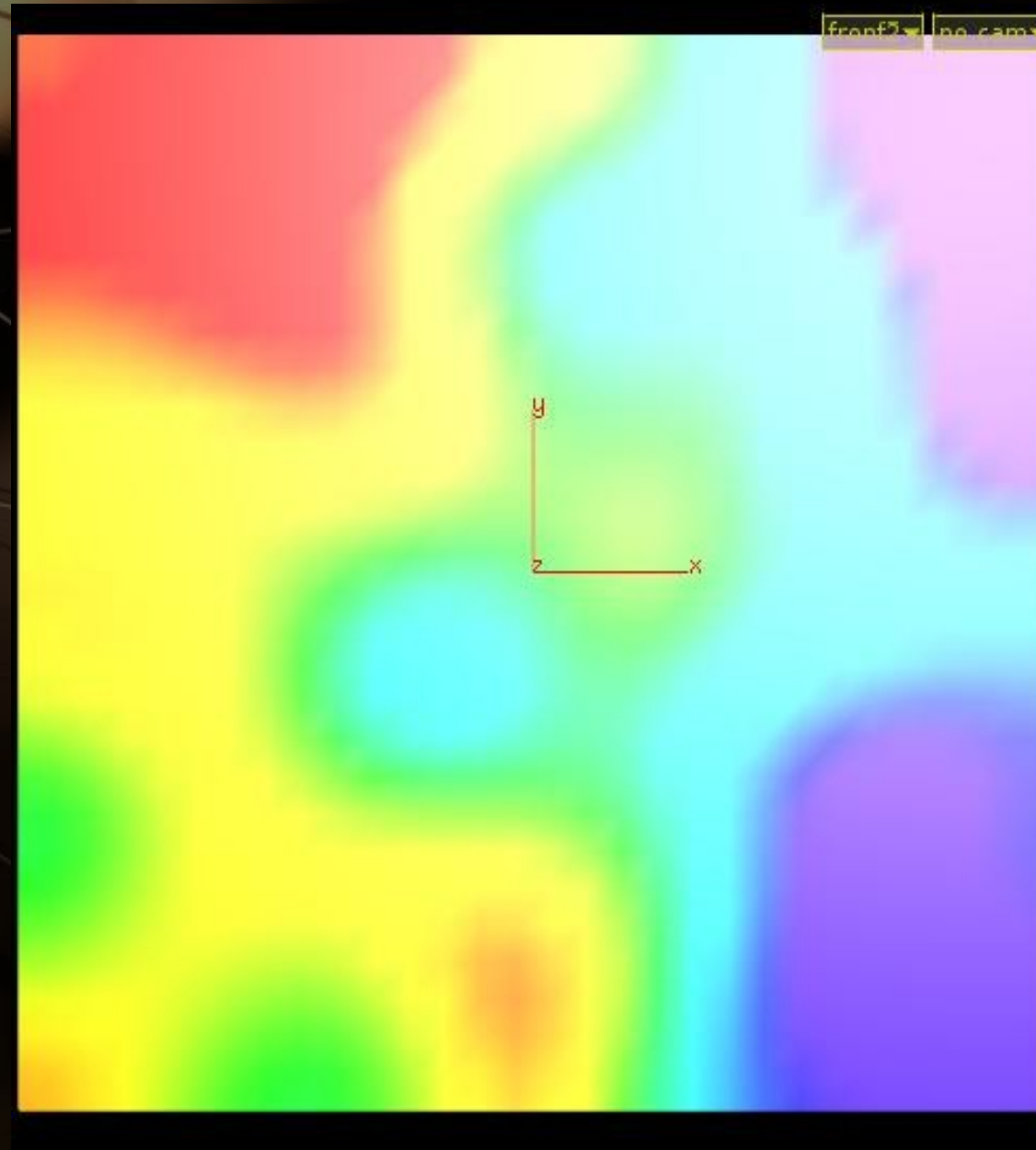
- Measure of imbalance in velocity field
- Divergence at center can be measured by comparing ingoing and outgoing velocities of boundary of cell
- Incompressible fluids should have zero divergence
- Zero divergence fields have “swirl”, “shear”, and “translate” factors. They do not have a “scale” factor



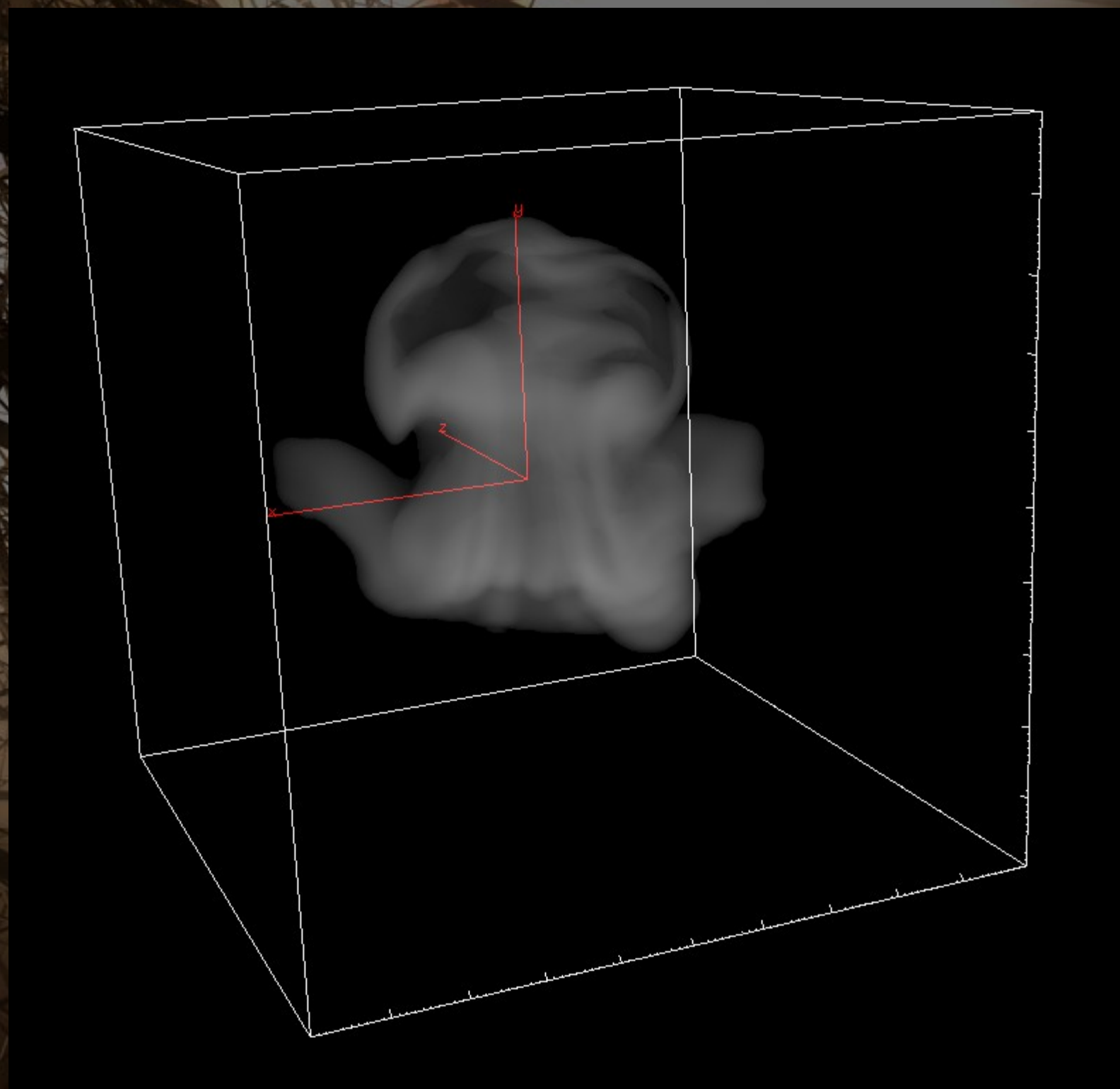
Removing Divergence

- “Scale” components can be represented as a pressure field
- Find a pressure field that removes our divergence
- Changing one cell, however, affects neighbouring cells!
- Entire fluid is coupled and needs to be solved at once

Divergence in Pictures



Velocity Advection

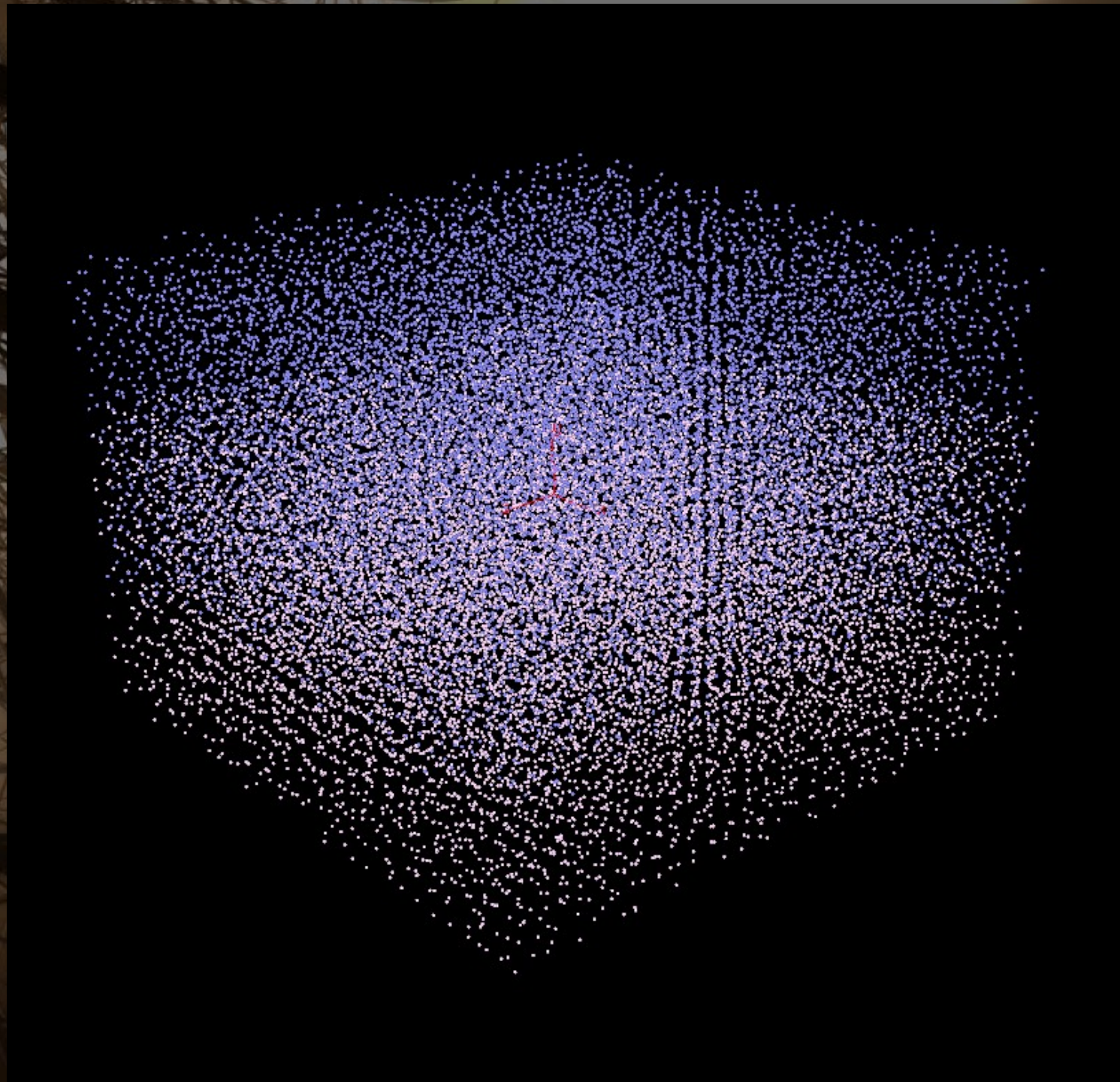


- Because the velocity is stored in a grid, it does not move with the air.
- Thus, for momentum effects, we have to move it with itself!

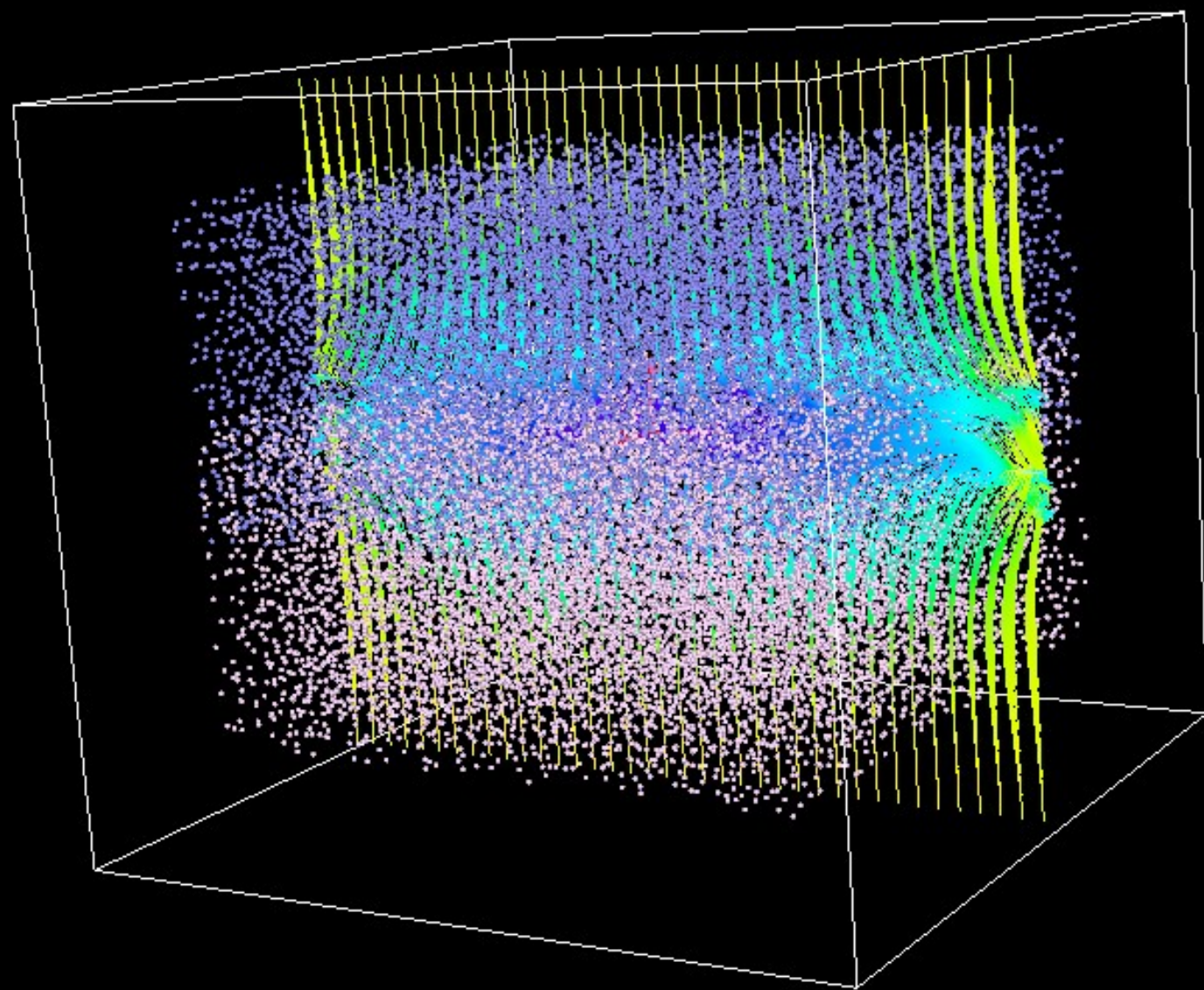
Building Fluid Solvers

Particle Systems

- Lagrangian Solution
- All data stored on particles

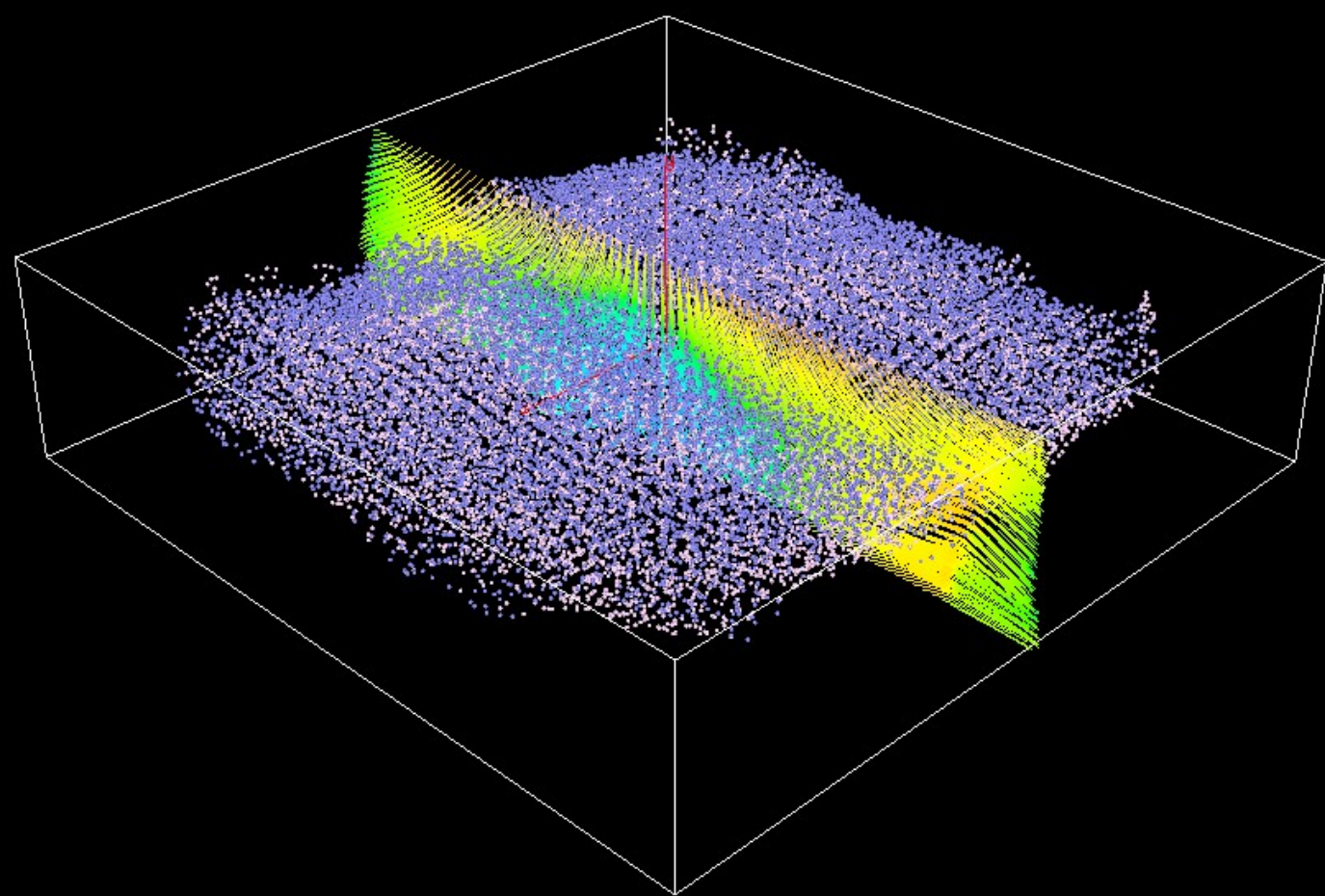


Removing Divergence



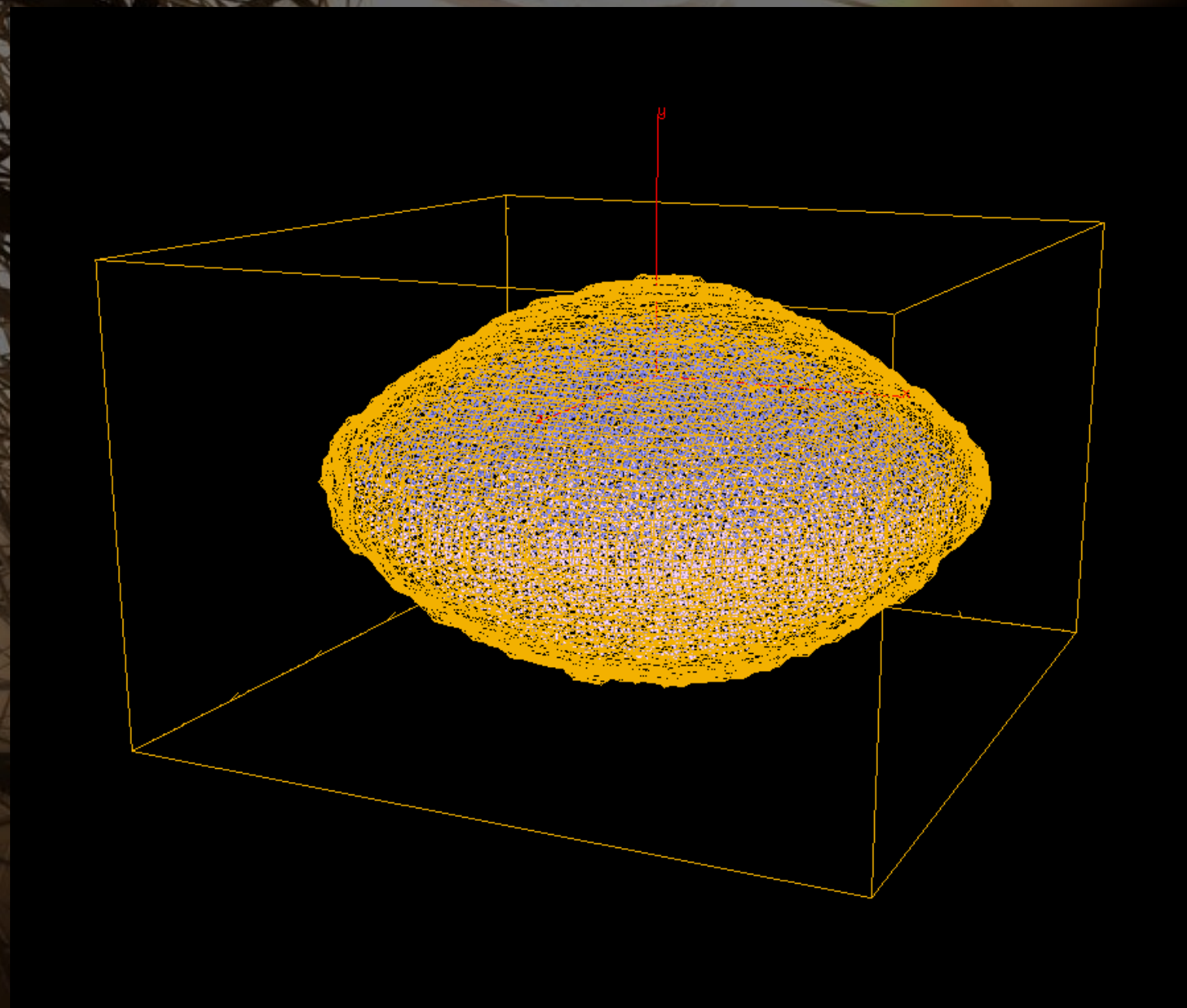
- Use Eulerian solution
- Copy values into resized grids

Updating Particles



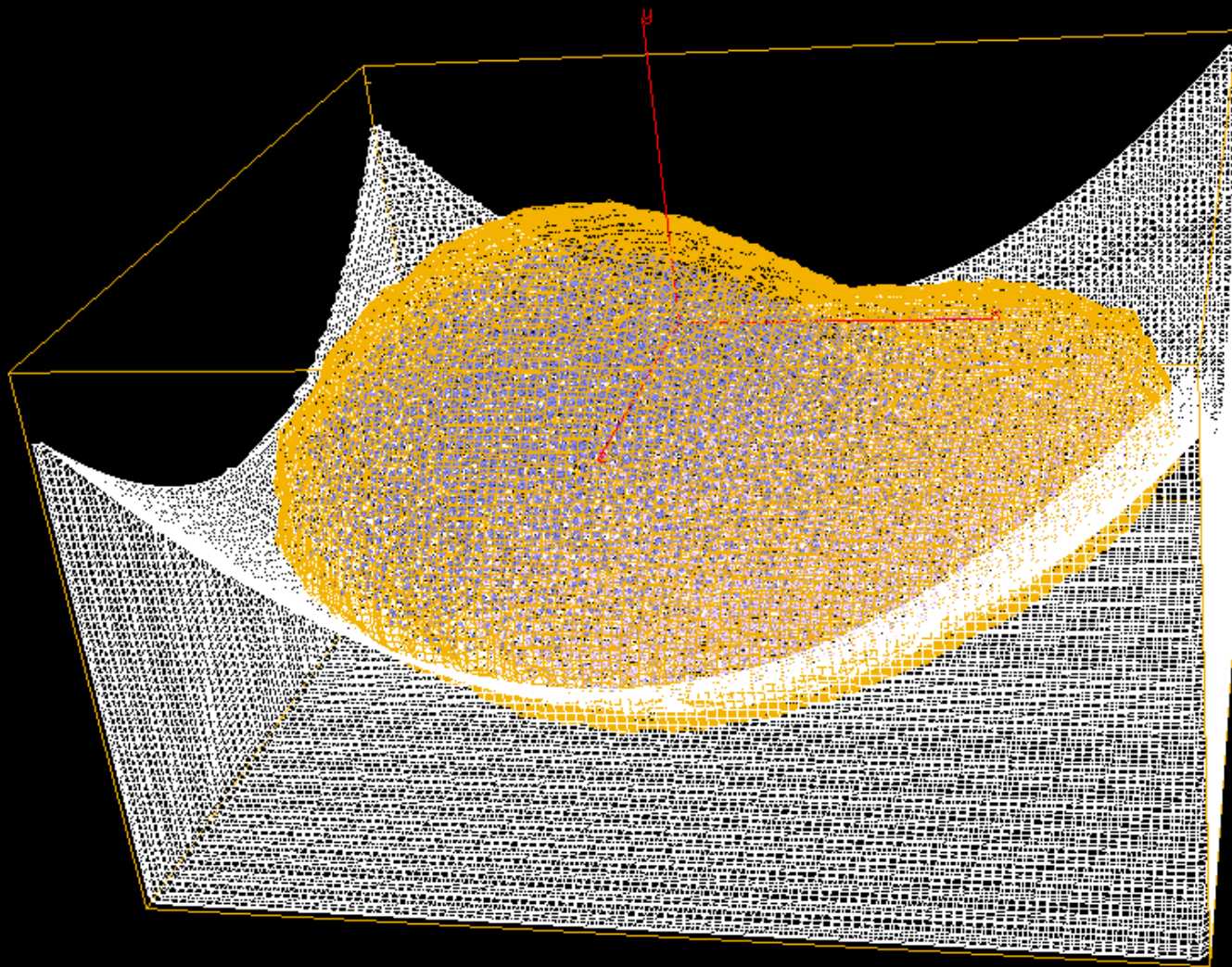
- FLIP vs PIC

Free Surfaces



- Building surface
- Restricting projection

Collisions



- Building collisions
- Enforcing collision velocities
- Restricting projection to collision

DISCUSSION

SIDE EFFECTS
SOFTWARE

GO | PROCEDURAL

Download Houdini Apprentice

www.sidefx.com/apprentice